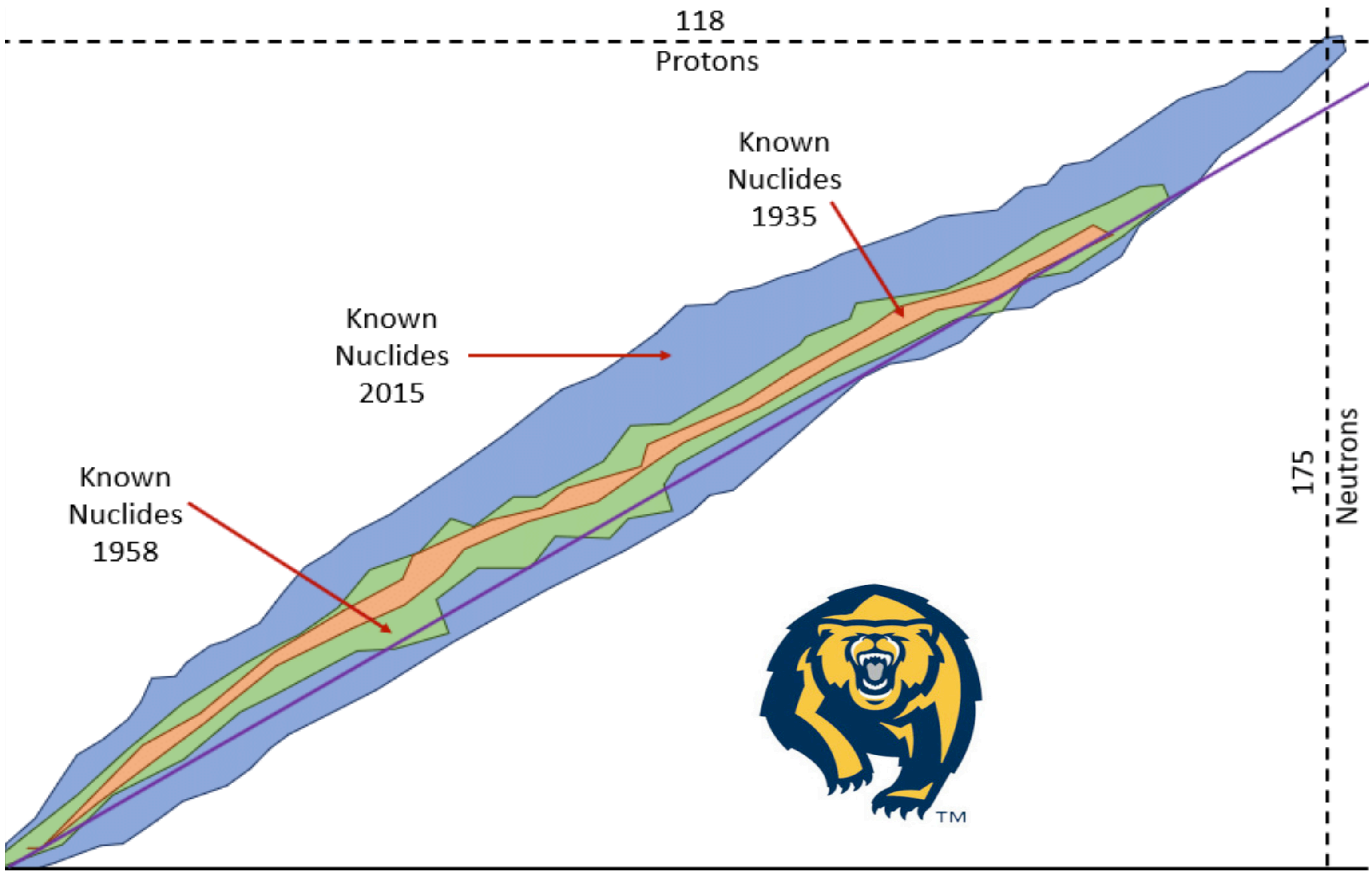
BEA$_p$R Database

BErkeley Alpha and proton Radioactivity



Explanation of Tables

The explanations below apply to all tables and figures.

All energy units are given in MeV unless otherwise stated.

Energies of emitted particles are reported in the center of mass frame unless otherwise stated.

A blank space in a table indicates the values is unknown.

—– indicates that the value is not energetically possible.

A value of "obs" indicates the decay has been observed, but a numeric value is not known.

The 8 digit combination of numbers and letters at the start of each reference refers to the Nuclear Science References (NSR) database keynumber for that reference [2011Pr03].

Unless otherwise stated, all Q and S values are taken from [2021Wa16] or deduced from values therein. If values for S_p and $Q_{\varepsilon\alpha}$ calculated using p and α energies are within error bars of the value from [2021Wa16], the latter is used, otherwise the values from particle energy is used and noted.

Unless otherwise stated, all J^π values are taken from ENSDF.

The values for E_{level}(emitter) are deduced from the energy of the emitted particle, the S_p of the emitter and the final level in the daughter.

Energy values in the daughter are rounded to the nearest 0.1 keV, and coincident γ-rays to 1 keV if known to better precision.

The data set with the higher statistics has been preferentially used in the individual nuclide tables unless otherwise stated.

Uncertainities in all cases are defined as $9.0(10) \equiv 9.0 \pm 1.0$.

Hindrance Factors (HF) and nuclear radius parameters (R_0) are calculated using the AlphaHF program written by Jun Chen (part of the ENSDF Analysis and Utility Programs available at https://nds.iaea.org/public/ensdf)

In the figures for each T_z, $T_{1/2}$ amd J^π values are taken from ENSDF.

T_z	(N-Z)/2
J^π	Spin and parity of the parent nucleus
$T_{1/2}$	The half-life of the parent nucleus
Q_ε	Total electron capture energy Q_ε=M(A,Z) - M(A, Z-1)
$Q_{\varepsilon p}$	Total energy available for β^+-p; $Q_{\varepsilon p}$=M(A,Z) - M(A-1, Z-2) - ^{1}H
$Q_{\varepsilon 2p}$	Total energy available for β^+-2p; $Q_{\varepsilon 2p}$=M(A,Z) - M(A-2, Z-3) - 2^{1}H
$Q_{\varepsilon 3p}$	Total energy available for β^+-3p; $Q_{\varepsilon 3p}$=M(A,Z) - M(A-3, Z-4) - 3^{1}H
$Q_{\varepsilon\alpha}$	Total energy available for β^+-α emission; Q_α= M(A,Z) - M(A-4, Z-3) - ^{4}He
S_p	Total energy available for direct one proton emission; S_p= -M(A,Z) + M(A-1, Z-1) - ^{1}H
S_{2p}	Total energy available for direct two proton emission; S_p= -M(A,Z) + M(A-2, Z-2) - 2^{1}H
#	Value from systematics [2021Wa16]
$BR_{\beta p}$	Measured branching ratio for β^+-p emission
$BR_{\beta 2p}$	Measured branching ratio for β^+-delayed two proton emission
$BR_{\beta 3p}$	Measured branching ratio for β^+-delayed three proton emission
BR_α	Measured branching ratio for direct α emission
$BR_{\beta\alpha}$	Measured branching ratio for β^+-delayed α emission
$BR_{\beta F}$	Measured branching ratio for β^+ delayed fission
BR_p	Measured branching ratio for direct one proton emission, not including β-delayed multiple proton emission
BR_{2p}	Measured branching ratio for direct two proton emission
BR_{SF}	Measured branching ratio for spontaneous fission
$E_p(c.m.)$	Energy (MeV) of the emitted proton in the center of mass frame
$E_p(lab)$	Energy (MeV) of the emitted proton in the laboratory frame
E_{2p}	Sum energy (MeV) of the 2 emitted protons in β^+-2p decay in the center of mass frame
E_{3p}	Sum energy (MeV) of the 3 emitted protons in β^+-3p decay in the center of mass frame
E_α(c.m.)	Energy of the emitted α particle in the center of mass frame
E_α (lab)	Energy (MeV) of the emitted α in the laboratory frame
I_p(rel)%	Relative intensity of the direct or β^+-delayed p transition with the largest transition set to 100%
I_p(abs)%	Absolute intensity of the direct or β^+-delayed p transition per 100 decays.
I_{2p}	Intensity of the β^+-2p transition
I_{3p}	Intensity of the β^+-3p transition
I_α(rel)%	Relative intensity of the direct or β^+-delayed α transition with the largest transition set to 100%
I_α(abs)%	Absolute intensity of the direct or β^+-delayed α transition per 100 decays
$E_{emitter}$(nuclide)	Energy (MeV) of the state fed by β^+-decay that emits a proton, the level energy is calculated from the particle energy and the particle separation energy taken from [2021Wa16]. For levels de-excited by more than one proton transition, E_{level} (emitter) is the weighted average.
$E_{daughter}$(nuclide)	Energy (MeV) of the state fed by the charged particle emission
coincident γ-rays	Energies (MeV) of gamma-rays coincident with the emitted heavy charged particles (p,α)
R_0	nuclear radius parameter
HF	Hindrance Factor

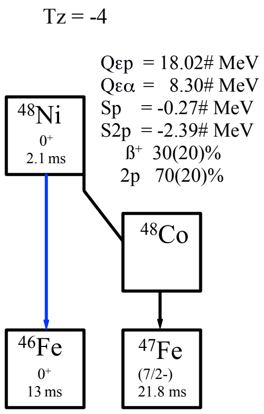


Fig. 1: Known experimental values for heavy particle emission of the T_z= -4 nuclei.

Last updated 3/17/23

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = -4 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon 3p}$	$Q_{\varepsilon\alpha}$	Experimental
^{48}Ni	0^+	$2.1^{+1.4}_{-0.6}$ ms	16.45(66)#	18.02(66)#	30(20)%	16.02(43)#	15.82(42)#	8.30(52)#	[**2014Po05, 2011Po09**]

Table 2
Particle separation and emission from the even-Z, T_z = -4 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	BR_{1p}	S_{2p}	BR_{2p}	Q_α	Experimental
^{48}Ni	-0.27(74)#		-2.39(30)#	70(20)%	-4.83(5)*	[**2014Po05, 2011Po09**, 2005Do20]

* Prediction from Ref. [2013Ti01].

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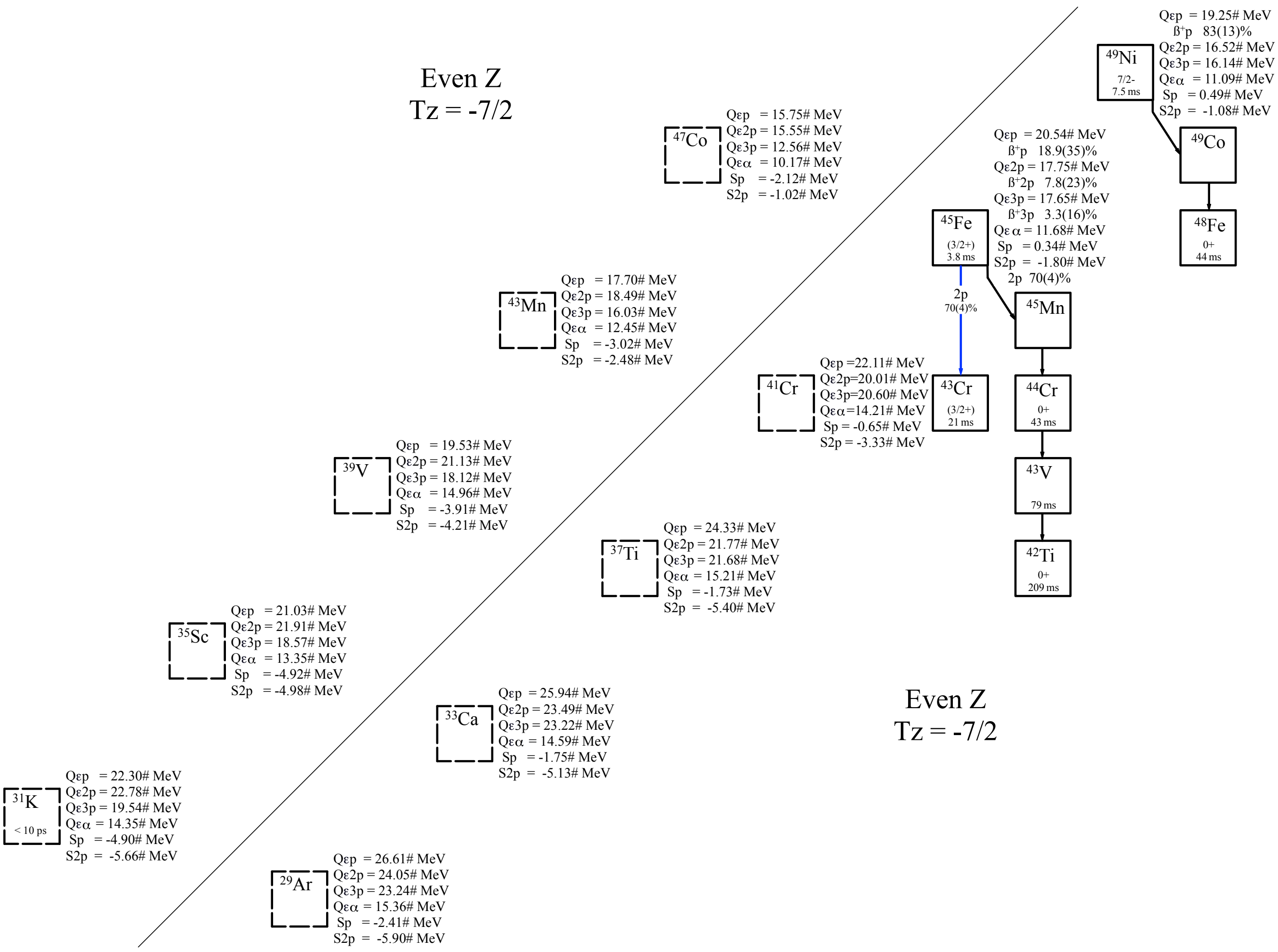

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= -7/2 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = -7/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$BR_{\beta 2p}$	$Q_{\varepsilon 3p}$	$BR_{\beta 3p}$	$Q_{\varepsilon\alpha}$	Experimental
^{29}Ar			23.95(48)#	26.61(47)#		24.05(44)#		23.24(44)#		15.36(59)#	
^{33}Ca			23.49(40)#	25.94(40)#		23.49(40)#		23.22(40)#		24.59(44)#	
^{37}Ti			21.39(50)#	24.33(40)#		21.77 (40)#		21.68(40)#		15.21(45)#	
^{41}Cr			20.10(45)#	22.11(41)#		20.01(40)#		20.60(40)#		14.21(50)#	
^{45}Fe	(3/2$^+$)	3.76(22) ms	19.39(41)#	20.54(29)#	18.9(35)%*	17.75(28)#	7.8(23)%*	17.65(28)#	3.3(16)%*	11.68(34)#	[**2012As02, 2012Au08**, 2016ChZV, 2011Bl01, 2009Gr07, 2009Mi29, 2008Mi03, 2007Mi36, 2005Do20, 2007Gi10, 2005Bl31, 2005Gi15, 2002Pf02, 2002Gi09, 2001Gi01, 1996Bl21]
^{49}Ni	7/2$^-$	7.5(10) ms	18.31(78)#	19.25(61)#	83(13)%	16.52(60)#		16.14(60)#		1.09(67)#	[**2007Do17**, 1996Bl21]

* deduced from values in [2007Mi36]

Table 2
Particle emission from the even-Z, T_z = -7/2 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	BR_{1p}	S_{2p}	BR_{2p}	Q_α	Experimental
^{29}Ar	-2.41(35)#	——	-5.90(18)#		-8.03(63)#	
^{33}Ca	-1.75(57)#	——	-5.13(45)#		-9.36(59)#	
^{37}Ti	-1.73(50)#	——	-5.40(45)#		-8.29(57)#	
^{41}Cr	-0.65(50)#	——	-3.33(45)#		-7.19(57)#	
^{45}Fe	0.34(41)#	——	-1.21(5)*	70(4)%**	-8.43(49)#	[**2012As02, 2012Au08, 2007Mi36**, 2011Bl01, 2009Gr07, 2009Mi29, 2008Mi03, 2007Gi10, 2005Do20, 2005Bl31, 2005Gi15, 2002Pf02, 2002Gi09]
^{49}Ni	0.49(78)#	——	-1.08(78)#		-8.30(66)#	

* from [2012Au08], [2021Wa16] lists -1.80(20)#.
** [2007Mi36].
*** Prediction from Ref. [2013Ti01].

Table 3
direct 2 proton emission from ^{45}Fe*, $T_{1/2}$ = 3.76(22) ms, BR_p =100%.

E_{2p}(c.m.)	I_{2p}(abs)	$E_{daughter}$(^{43}Cr)
1.21(5)	100%	0.0

* All values from [2012Au08].

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Odd Z
Tz = -7/2

^{47}Co
Qεp = 17.75# MeV
Sp = -2.12# MeV
S2p = -1.02# MeV

^{43}Mn
Qεp = 19.34# MeV
Sp = -3.02# MeV
S2p = -2.48# MeV

^{39}V
Qεp = 19.53# MeV
Sp = -3.91# MeV
S2p = -4.21# MeV

^{35}Sc
Qεp = 21.03# MeV
Sp = -4.92# MeV
S2p = -4.98# MeV

^{31}K
Qεp =22.30# MeV
Sp = -2.15 MeV
S2p = -5.66# MeV

Fig. 1: Known experimental values for heavy particle emission of the odd T_z= -7/2 nuclei.

Last updated 3/17/23

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = -7/2 nuclei

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon 3p}$	$Q_{\varepsilon\alpha}$	Experimental
^{31}K		<10 ps	22.94(36)#	22.30(30)#		22.78(30)#	19.54(30)#	14.35(50)#	**[2019Ko18]**
^{35}Sc			21.91(45)#	21.03(45)#		21.91(40)#	18.57(40)#	13.35(45)#	
^{39}V			20.07(45)#	19.53(45)#		21.13(40)#	18.12 (40)#	14.96(45)#	
^{43}Mn			19.34(45)#	17.70(45)#		18.49(40)#	16.03(40)#	12.45(45)#	
^{47}Co			17.75(78)#	15.75(61)#		15.55(60)#	12.56(60)#	10.17(63)#	

Table 2
Particle emission from the odd-Z, T_z = -7/2 nuclei

Nuclide	S_p	BR_{1p}	S_{2p}	Q_α	Experimental
^{31}K	-2.15(15)*	100%	-5.66(35)#		
^{35}Sc	-4.92(50)#		-4.980(45)#	-9.59(50)#	
^{39}V	-3.91(50)#		-4.21(50)#	-6.96(57)#	
^{43}Mn	-3.02(50)#		-2.48(45)#	-7.63(57)#	
^{47}Co	-2.12(67)#		-1.02(67)#	-9.18(72)#	

* From [2019Ko18], [2021Wa16] lists -4.90(35)#.

Table 3
direct proton emission from ^{31}K*, $T_{1/2}$ = <10 ps, BR_p =100%.

E_p(c.m.)	I_p(abs)	$E_{daughter}$(^{30}Ar)
2.15(15)	100%	0.0

* All values from [2019Ko18].

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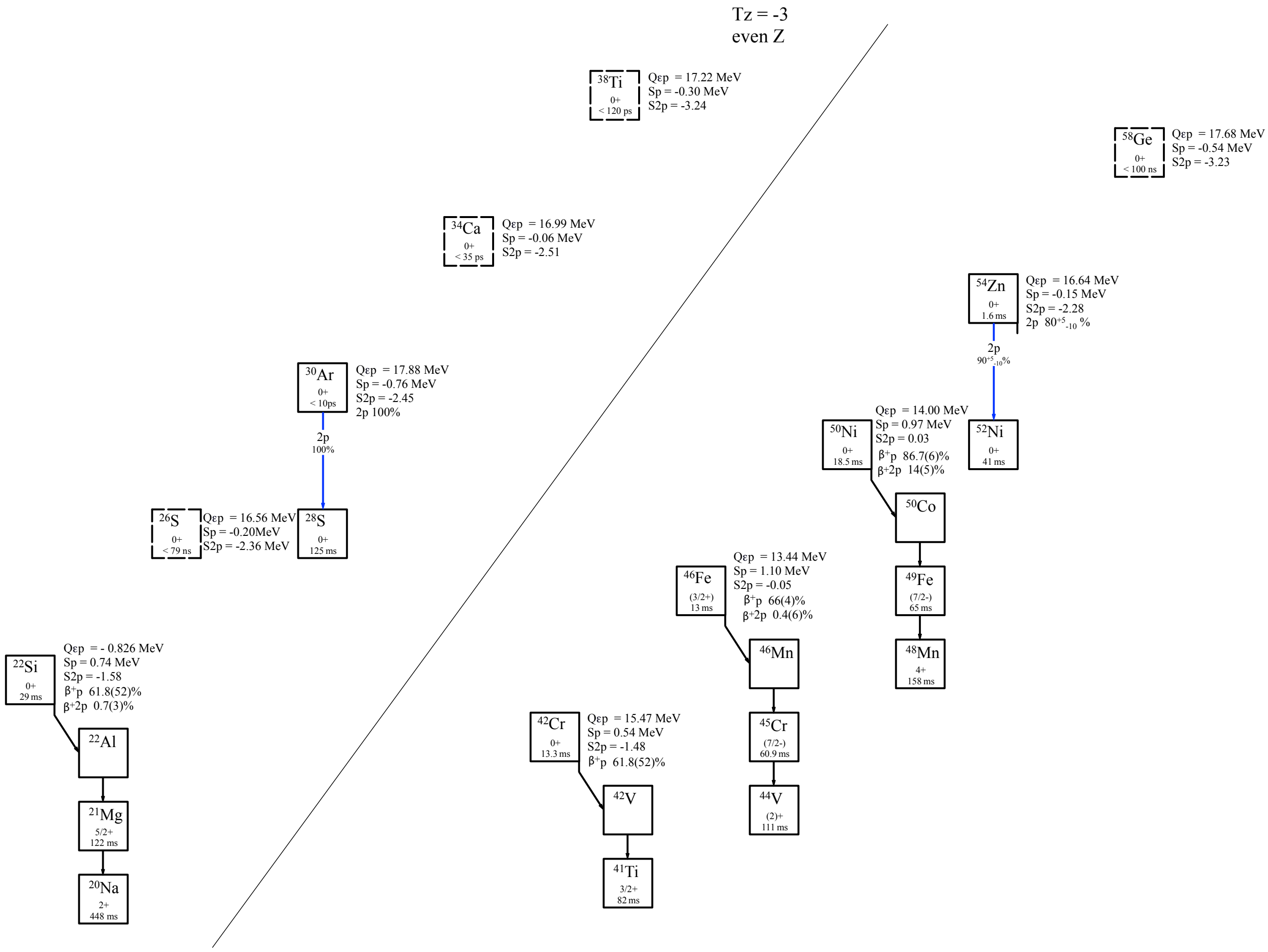

Fig. 1: Known experimental values for heavy particle emission of the even Z T_z= -3 nuclei.

Last updated 3/17/23

Table 1
Observed and predicted β-delayed particle emission from the even Z, T_z = -3 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^{π}	$T_{1/2}$	Q_{ε}	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$BR_{\beta 2p}$	$Q_{\varepsilon 3p}$	$Q_{\varepsilon \alpha}$	Experimental
^{22}Si	0^+	28.6(14) ms*	15.44(64)#	15.45(50)#	61.8(52)%*	12.21(50)#	0.7(3)%**	10.02(50)#	6.18(51)#	[**2020Le16, 2017Xu01**, 2022Ci04, 1997Cz02, 1996Bl11]
^{26}S	0^+	< 79 ns	16.71(63)#	16.56(60)#		13.15(60)#		11.29(60)#	7.06(72)#	[**2011Fo08**]
^{30}Ar	0^+	< 10 ps	17.40(18)#	17.88(18)		14.64(18)		12.59(18)#	8.67(27)#	[**2019Ko18, 2016Xu08, 2015Mu13**]
^{34}Ca	0^+	< 35 ns	16.11(36)#	16.99(30)#		13.64(30)#		12.07(30)#	7.79(30)#	
^{38}Ti	0^+	< 120 ns	15.62(36)#	17.22(30)#		14.21(30)#		12.55(30)#	10.17(36)#	[**1996Bl21**]
^{42}Cr	0^+	13.3(10) ms***	14.68(36)#	15.47(30)#	94.4(50)%	13.01(30)#		12.48(30)#	8.89(36)#	[**2007Do17, 2001Gi01**]
^{46}Fe	0^+	13.0(20) ms***	13.63(31)#	13.44(30)#	66(4)%[@]	10.44(30)#	0.4(6)%[@]	8.66(30)#	6.41(36)#	[**2014Po05, 2007Do17**, 1992Bo37]
^{50}Ni	0^+	18.5(12) ms***	14.13(52)#	14.00(50)#	86.7(6)%[a]	11.26(50)#	14(5)%	9.24(50)#		[**2007Do17**, 2003Ma34]
^{54}Zn	0^+	$1.59^{+0.60}_{-0.35}$ ms	15.54(45)#	16.64(22)#	[b]	14.07(22)#		12.62(22)#	9.47(26)#	[**2011As08, 2005Bl15**]
^{58}Ge	0^+	<100 ns	15.96(58)#	17.68(54)#		16.47(50)#		15.89(50)#	11.24(64)#	[**2016Bl05**]

* [2020Le16]
** [2017Xu01].
*** [2007Do17]
[@] [2014Po05]
[a] Energies of individual proton peaks not reported in [2007Do17, 2003Ma34].
[b] Events were measured in [2011As08, 2005Bl15] consistent with β-delayed proton emission.

Table 2
Particle emission from even Z, T_z = -3 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	BR_{1p}	S_{2p}	BR_{2p}	Q_{α}	Experimental
^{22}Si	0.74(78)#	——	-1.58(50)#			
^{26}S	-0.20(72)#		-2.36(60)#		-8.39(78)#	
^{30}Ar	-0.76(13)#		$-2.45^{+0.05}_{-0.10}$*	100%	-8.03(63)#	[**2019Ko18**, 2016Xu08, 2015Mu13]
^{34}Ca	-0.06(36)#		-2.51(30)#		-9.61(35)#	
^{38}Ti	-0.30(42)#		-3.24(30)#		-5.95(42)#	
^{42}Cr	0.54(36)#		-1.48(31)#		-6.74(42)#	
^{46}Fe	1.10(42)#		-0.05(30)#		-8.28(42)#	
^{50}Ni	0.97(71)#		0.03(51)#		-7.09(58)#	
^{54}Zn	-0.15(55)#		-2.28(20)	90^{+5}_{-10}%	-4.67(55)#	[**2011As08**]
^{58}Ge	-0.54(64)#		-3.23(64)		-4.30(55)#	[**2011As08**]

* [2019Ko18]

Table 3
β-p emission from ^{22}Si*, $T_{1/2}$= 28.6(14) ms, $BR_{\beta p}$ = 61.8(52)%

E_p(c.m.)	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{22}Al)**	$E_{daughter}$(^{21}Mg)***	coincident γ-rays***
0.71(5)	12(3)	5.3(10)	0.902(403)	0.202(4)	0.202
1.95(5)	100(15)	43.0(46)	2.142(403)	0.202(4)	0.202
2.15(5)	31(6)	13.5(21)	2.142(403)	0	——

*All values taken from [2020Le16] except where noted. [1997Cz02, 1996Bl11] reported protons with energies of 1.63(5) and 2.10(5) meV which were nor observed in [2020Le16].

** Calculated from proton energies and S_p (^{22}Al) = -10(400) keV [2021Wa16]. For levels de-excited by more than one proton transition, E_{level} (emitter) is the weighted average.

*** Values from measured γ energy in [2020Le16].

Table 4
β-2p emission from ^{22}Si*, $T_{1/2}$= 28.6(14) ms, $BR_{\beta 2p}$ =0.7(3)%.

E_{2p}(c.m.)	I_p(abs)	$E_{emitter}$ (^{22}Al)	$E_{daughter}$(^{20}Na)	coincident γ-rays
5.600(70)	0.007(3)	8.83(41)	0	——

*All values taken from [2017Xu01] except where noted.
** Calculated from two proton energy and S_{2p} (^{22}Al) = 3230(400)# keV [2021Hu06].

Table 5
β-p emission from ^{42}Cr*, $T_{1/2}$= 13.3(10) ms**, $BR_{\beta p}$ = 94.4(50)%.

E_p(c.m.)	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{42}V)	$E_{daughter}$(^{41}Ti)	coincident γ-rays
1.537(35)	31(25)	14(11)			
1.951(20)	100(34)	45(15)			
2.551(30)	31(25)	14(11)			
3.186(20)	26(14)	11.8(64)			
3.806(20)	21(14)	9.5(61)			

* Energies and relative intensities are taken from [2001Gi01]. Absolute intensities are calculated from the relative intensities modified by the total branching ratio from [2007Do17].

** [2007Do17].

Table 6
β-p emission from ^{46}Fe*, $T_{1/2}$= 13.0(20) ms, $BR_{\beta p}$ = 78.7(38)%

E_p(c.m.)	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{46}Mn)**	$E_{daughter}$(^{45}Cr)	coincident γ-rays
≈0.75***	12(7)	1.2(7)			
≈1.05***	16(8)	1.6(8)			
1.457(28)	100(30)	10(3)			
1.692(23)	40(40)	4(4)			
3.272(23)	61(25)	6.1(25)			
4.239(33)	79(32)	7.9(32)	4.92(9)+x	0.494+x	0.494

*All values taken from [2007Do17] except where noted.

** Calculated from proton energies and S_p (^{46}Mn) = 190(90)# keV [2021Hu06].

*** Possible transitions from [2014Po05].

Table 7
β-2p emission from ^{50}Ni*, $T_{1/2}$= 18.5(12) ms, $BR_{\beta 2p}$ =24(5)%.

E_{2p}(c.m.)	I_p(abs)	$E_{emitter}$ (^{50}Co)**	$E_{daughter}$(^{48}Mn)	coincident γ-rays
1.972(13)	14(5)	4.82(13)	0	——

*All values taken from [2007Do17] except where noted.

** Calculated from two proton energy and S_{2p} (^{50}Co) = 2870(130)# keV [2021Hu06].

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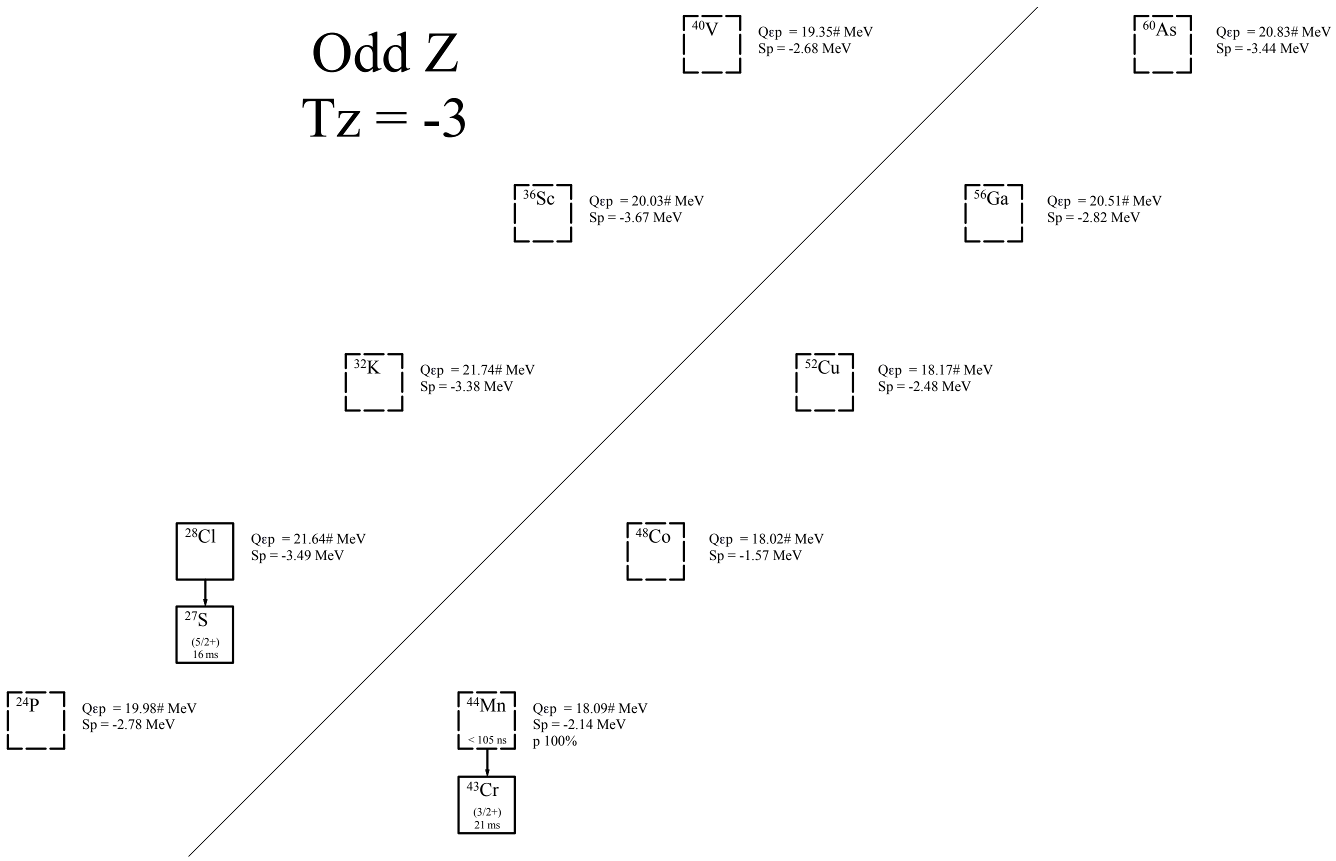

Fig. 1: Known experimental values for heavy particle emission of the odd Z T_z= -3 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the odd Z, T_z = -3 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon 3p}$	$Q_{\varepsilon\alpha}$	Experimental
^{24}P			23.28(50)#	19.98(50)#		19.84(50)#	14.34(50)#		
^{28}Cl			24.20(53)#	21.64(50)#		20.83(50)#	15.32(50)#	15.10(50)#	
^{32}K			24.19(40)#	21.74(40)#		21.47(40)#	16.18(40)#	15.50(43)#	
^{36}Sc			22.60(20)#	20.03(30)#		19.95(30)#	15.29(30)#	15.93(30)#	
^{40}V			21.46(31)#	19.35(30)#		19.95(30)#	15.40(30)#	16.50(30)#	
^{44}Mn		< 105 ns	20.88(30)#	18.09(30)#		17.99(30)#	14.24(30)#	14.03(31)#	[**1992Bo07**]
^{48}Co			19.74(51)#	18.02(66)#		16.62(50)#	11.75(50)#	12.73(50)#	
^{52}Cu			20.68(61)#	18.17(60)#		18.02(60)#	13.87(60)#	13.71(61)#	
^{56}Ga			21.55(64)#	20.51(52)#		20.86(50)#	16.95(50)#	16.30(51)#	
^{60}As			21.89(50)#	20.83(43)#		22.08(40)#	19.80(40)#	17.33(57)#	

Table 2
Particle emission from odd Z, T_z = -3 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	BR_{1p}	S_{2p}	BR_{2p}	Q_α	Experimental
^{24}P	-2.78(71)#		-1.24(64)#			
^{28}Cl	-1.60(8)*	100%	-2.72(54)#		-8.18(71))#	[**2018Mu18**]
^{32}K	-3.38(45)#		-2.74(40)#		-8.71(64)#	
^{36}Sc	-3.67(36)#		-2.79(36)#		-8.26(50)#	
^{40}V	-2.68(36)#		-2.14(36)#		-6.11(42)#	
^{44}Mn	-2.14(36)#	100%**	-0.50(36)#		-7.43(42)#	[**1992Bo07**]
^{48}Co	-01.57(71)#		0.43(51)#		-8.16(58)#	
^{52}Cu	-2.48(78)#		-1.23(61)#		-6.03(78)#	
^{56}Ga	-3.14(64)#		-2.82(64)#		-4.39(78)#	
^{60}As	-3.44(57)#		-3.32(50)#		-4.23(64)#	

* from [2018Mu18], -3.49(30)# in [2021Wa16].
** Inferred from Half-life.

Table 3
direct proton emission from ^{28}Cl*, BR_p =100%.

E_{parent}	E_p(c.m.)	E_p(lab)	I_p(abs)	$E_{daughter}$(^{27}S)
0.0	1.60(8)	1.54(8)	100%	0.0
1.60	3.20(6)	3.09(6)	100%	0.0

* All values from [2018Mu18].

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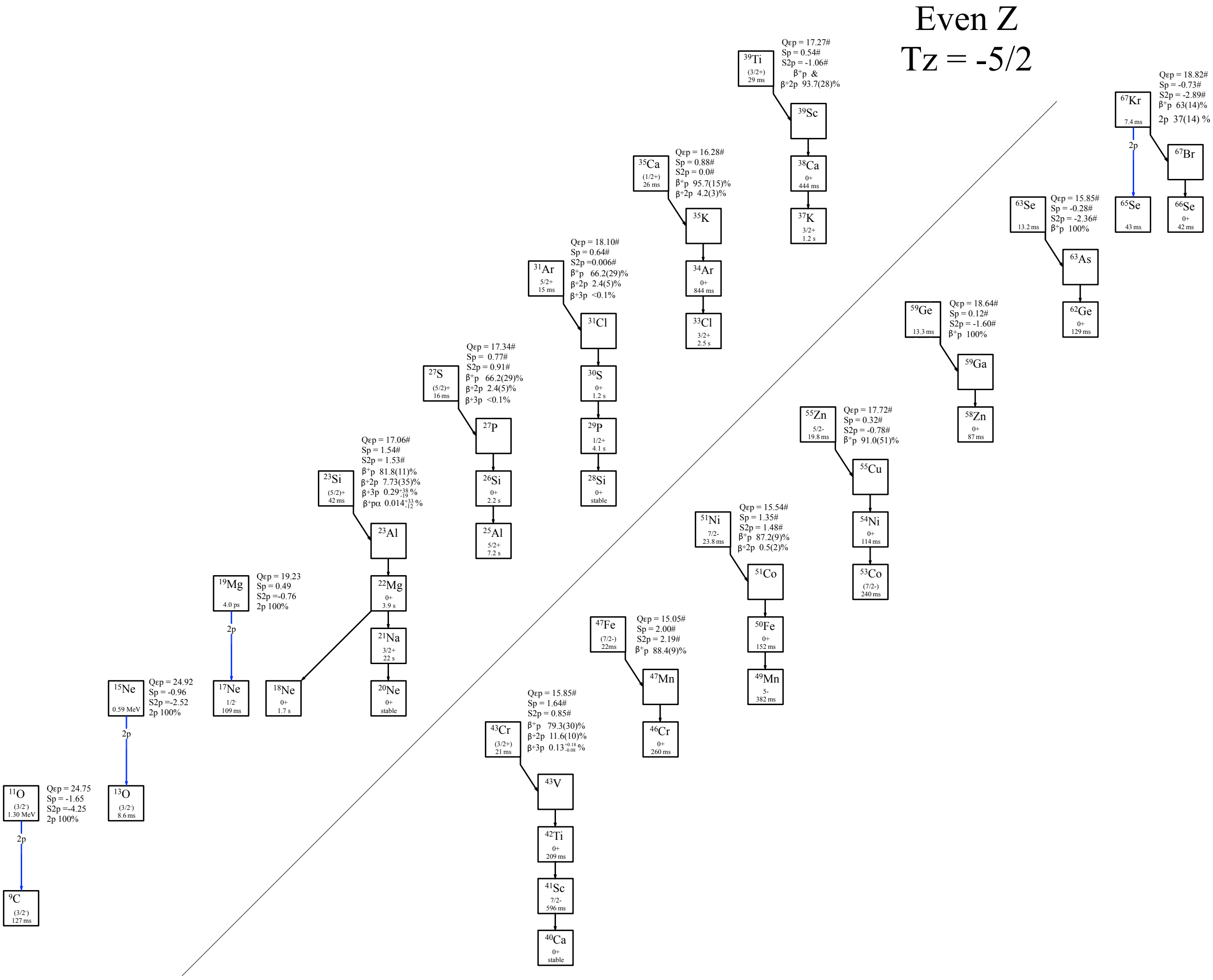

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= -5/2 nuclei.

Last updated 3/17/23

Table 1
Observed and predicted β-p, β-2p, and β-3p emission from the even-Z T_z = -5/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$BR_{\beta 2p}$	$Q_{\varepsilon 3p}$	$BR_{\beta 3p}$	$Q_{\varepsilon\alpha}$	Experimental
^{11}O	(3/2$^-$)	1.30 MeV	23.37(6)	24.75(6)		20.75(6)		17.637(65)		11.24(64)#	[**2019We03**]
^{15}Ne		0.59 MeV	23.65(7)	24.92(7)		20.30(7)		18.35(7)		13.43(67)#	[**2014Wa09**]
^{19}Mg		4.0(15) ps	18.910(60)	19.23(60)		15.31(60)		14.71(60)		12.85(60)	[2007Mu15]
^{23}Si*	(5/2)$^+$	42.3(4) ms	17.20(50)#	17.06(50)#	81.8(11)%**	11.56(50)#	7.73(35)%**	9.13(50)#	$0.029^{+0.038}_{-0.019}$%**	8.60(50)#	[**2022Ci04, 2018Wa05, 1997Cz02, 1997Bl04**]
^{27}S	(5/2)$^+$	16.3(2) ms***	18.15(40)#	17.34(40)#	62.2(29)%[@]	11.83(40)#	2.4(5)%***	9.56(40)#	<0.1%	8.32(40)#	[**2021Sh23, 2020Su05, 2019Su14, 2017Ja05**, 2001Ca60, 1991Bo32]
^{31}Ar	5/2$^+$	15.1(3) ms[@@]	18.36(20)#	18.10(20)#	68.3(3)%	13.71(20)#	9.0(2)%	10.96(20)#	0.07(2)%	9.57(20)#	@@@
^{35}Ca	(1/2$^+$)	25.7(2) ms	16.36(20)#	16.28(20) #	95.7(15)%	11.62(20)#	4.2(3)%	9.34(20)#		9.80(20)#	[**2016Ci05, 1999Tr04**, 1985Ay01]
^{39}Ti	(3/2$^+$)	28.5(9) ms	16.67(20)#	17.27(20)#	93.7(28)%[a]	12.72(20)#	[a]	10.87(20)#		11.25(20)#	[**2007Do17, 1992Mo15**, 2001Gi01, 1990De43]
^{43}Cr	(3/2$^+$)	21.2(7) ms	15.95(21)#	15.85(20)#	79.3(30)%	12.09(20)#	11.6(10)%	11.01(20)#	$0.13^{+0.18}_{-0.08}$%	9.78(20)#	[**2012Au08, 2007Do17**, 2011Po01, 2001Gi01, 1992Bo37]
^{47}Fe	(7/2$^-$)	21.9(2) ms	15.44(50)#	15.05(50)#	88.4(9)%	10.18(50)#		8.55(50)#		8.37(50)#	[**2007Do17**, 1992Bo37]
^{51}Ni	7/2$^-$	23.8(2) ms	15.69(50)#	15.54(50)#	87.2(9)%[b]	11.39(50)#	0.50(2)%[c]	9.30(50)#		8.50(80)#	[**2012Au08, 2007Do17**]
^{55}Zn	5/2$^-$	19.8(13) ms	17.37(43)#	17.72(40)#	91.0(51)%	13.81(40)#		12.20(40)#		10.65(40)#	[**2007Do17**]
^{59}Ge		13.3(17) ms	17.39(43)#	18.64(40)#	100%	16.36(40)#		15.67(40)#		12.85(53)#	[**2017GoZT**, 2016Go26, 2015Ci06]
^{63}Se		13.2(39) ms	16.65(54)#	18.00(52)#	100%	15.70(50)#		15.46(50)#		14.49(53)#	[**2017GoZT**, 2016Go26]
^{67}Kr		7.4(30) ms	16.98(52)#	18.82(47)#	63(14)%[d]	16.81(43)#		16.90(42)#		15.52(47)#	[**2017GoZT**, 2016Go26]

* In addition a branching ratio for β-pα is reported as $0.014^{+0.033}_{-0.012}$% [2022Ci04].
** [2022Ci04]
*** [2021Sh23]
[@] From [2021Sh23] plus two high energy peaks from [2001Ca60].
[@@] [2015Li20]
@@@ [**2015Li20, 2000Fy01, 1998Ax02, 1992Ba01**, 2019Ko29, 2018Mu18, 2016Ci05, 2016Ma17, 2014Ko17, 2014Ko34, 2013Ko13, 2002Fy01, 2002Bo29, 1999Fy01, 1999Th09, 1998Ax01, 1998Mu06, 1991Bo32, 1990Bo24, 1989Re02]].
[a] Mixture of β-p and β-2p [2007Do17], β-xp is expected to be 100% as ^{39}Sc is unbound to proton emission S$_p$= -597(24) keV [2021Wa21].
[b] [2007Do17].
[c] [2012Au08].
[d] β-daughter ^{67}Br is unbound to proton emission.

Table 2
Particle emission from the even-Z T_z = -5/2 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_p$	S$_{2p}$	BR$_{2p}$	Q$_\alpha$	Experimental
^{11}O	-1.65(40)	-4.25(6)	100%		[**2019We03**]
^{15}Ne	-0.96(8)	-2.52(7)	100%	-9.95(9)	[**2014Wa09**]
^{19}Mg	0.49(11)	-0.760(50)	100%	-10.80(90)	[**2018Xu04, 2016Xu08, 2015Mu13, 2012Mu05, 2009Mu17, 2007Mu15**]
^{23}Si	1.54(64)#	1.53(50)#	——	-10.31(50)#	
^{27}S	0.77(45)#	0.91(40)#	——	-8.88(64)#	
^{31}Ar	0.64(20)#	0.006(34)*		-8.59(45)#	
^{35}Ca	0.88(28)#	0.00(20)#		-8.56(28)#	
^{39}Ti	0.54(28)#	-1.06(20)#		-5.12(28)#	
^{43}Cr	1.64(28)#	0.85(20)#	——	-6.90(28)#	
^{47}Fe	2.00(51)#	2.19(50)#	——	-7.58(54)#	
^{51}Ni	1.35(52)#	1.48(50)#	——	-6.95(71)#	
^{55}Zn	0.32(57)#	-0.78(40)#		-5.04(64)#	
^{59}Ge	0.12(50)#	-1.60(45)#	<0.2%	-4.53(57)#	[**2017GoZT**]
^{63}Se	-0.28(58)#	-2.36(58)#	<0.5%	-2.91(64)#	[**2017GoZT**]
^{67}Kr	-0.73(58)#	-2.89(30)#	37(14)%	-1.13(66)#	**2017GoZT**, 2016Go26]

* from [2018Mu18], [2021Wa16] lists 0.64(20)#

Table 3
β-p Emission from ^{23}Si*, $T_{1/2}$= 42.3(4) ms, $BR_{\beta p}$ = 81.8(11) %[c]

E_p(c.m.)	I_p(rel)%	I_p(abs)%	$E_{emitter}$ (^{23}Al)**	$E_{daughter}$(^{22}Mg)***	coincident γ-rays***
0.300(90)[c]	$0.45^{+0.22}_{-0.15}$	$0.12^{+0.06}_{-0.04}$			
0.654(31)	9.1(4)	2.4(1)	0.795(31)	0	——
1.333(28)	21.8(14)	5.78(37)	1.474(28)	0	——
1.657(37)	17(2)	4.6(6)	1.798(37)	0	——
2.356(29)	100(5)	26.5(14)	3.744(29)	1.247	1.247
2.764(35)	36.4(4)	9.64(10)	4.152(35)	1.247	1.247
3.024(36)	31.9(14)	8.5(4)	3.165(36)	0	——
3.592(44)	27.2(8)	7.2(2)	3.733(44)	0	——
—— 3.811(51)[a]	23.4(4)	6.2(1)[a]	3.952(51)	0	
4.235(39)	18.8(4)	4.99(10)	4.376(39)	0	——
4.781(41)	10.1(7)	2.7(2)	4.922(41)	0	——
5.545(82)[a]			5.686(82)	0	——
8.680(70)[b]	1.5(4)	0.4(1)[b]	8.821(70)	0	——
9.670(70)[b]	0.4(2)	0.11(4)[b]	9.811(70)	0	——
10.410(70)[b]	0.3(1)	0.07(3)[b]	10.551(70)	0	——
10.930(80)[b]	0.3(1)	0.09(3)[b]	11.071(80)	0	——
11.620(100)[b]	0.1(1)	0.03(2)[b]	11.761(100)	0	——

* Weighted average of [2018Wa05] and [1997Bl04, 1997Cz02], except where noted.

** Calculated from proton energies [1997Bl04] and Sp (^{23}Al) = 140.9(4) keV [2021Hu06]. For levels de-excited by more than one proton transition, E_{level} (emitter) is the weighted average.

*** Values from adopted levels in ENSDF [2015Ba27].

[a] [2018Wa05].

[b] [1997Bl04].

[c] [2022Ci04].

Table 4
β-2p emission from ^{23}Si*, $BR_{\beta 2p}$ = 7.73(35)%[@].

$E_{2p}(c.m.)$	I_{2p}(rel)%	I_{2p}(abs)%	$E_{emitter}$ (^{23}Al)**	$E_{daughter}$(^{21}Na)***	coincident γ-rays***
5.858(55)	100	1.85(20)	11.78(7)	0.3319(10)	0.332
6.052(55)	86(20)	1.60(20)	11.78(7)	0	——

* Weighted average of [2018Wa05] and [1997Bl04, 1997Cz02].

** Determined from ^{23}Si β-p emission.

*** Values from adopted levels in ENSDF [2015Fi05].

[@] [2022Ci04].

Table 5
β-p emission from ^{27}S*, $T_{1/2}$= 16.3(2) ms[b], $BR_{\beta p}$ = 62.2(29)%

$E_p(c.m.)$	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{27}P)[a]	$E_{daughter}$(^{26}Si)[@]	coincident γ-rays[@]
0.318(8)	100(9)	23.1(21)	1.125(12)	0	—
0.762(8)	38.5(61)	8.9(1)	1.569(12)	0	—
0.913(9)	6.5(18)	1.5(3)	4.507(13)	2.7871(1)	0.9889, 1.7922, 2.7870
1.054(9)	7.8(18)	1.8(3)	1.861(13)	0	—
1.282(9)	4.8(12)	1.1(2)	4.876(13)	2.7871(1)	0.9889, 1.7922, 2.7870
1.676(9)	2.6(18)	0.6(3)	5.270(13)	2.7871(1)	0.9889, 1.7922, 2.7870
1.86(12)	1.3(18)	0.3(3)	4.464(15)	1.7973	1.7973
1.951(11)	3.5(18)	0.8(3)	5.545(14)	2.7871(1)	0.9889, 1.7922, 2.7870
2.128(10)	4.3(18)	1(3)	5.722(13)	2.7871(1)	0.9889, 1.7922, 2.7870
2.264(9)	24.7(49)	5.7(8)	5.858(13)	2.7871(1)	0.9889, 1.7922, 2.7870
2.417(11)	6.9(24)	1.6(4)	5.021(14)	1.7973	1.7973
2.576(11)	5.6(24)	1.3(4)	6.170(14)	2.7871(1)	0.9889, 1.7922, 2.7870
2.717(10)	2.6(12)	0.6(2)	3.524(13)	0	—
2.808(10)	8.7(31)	2(5)	6.402(13)	2.7871(1)	0.9889, 1.7922, 2.7870
2.953(12)	4.8(24)	1.1(4)	6.547(15)	2.7871(1)	0.9889, 1.7922, 2.7870
3.03(12)	4.3(18)	1(3)	6.624(15)	2.7871(1)	0.9889, 1.7922, 2.7870
3.121(11)	4.8(24)	1.1(4)	6.715(14)	2.7871(1)	0.9889, 1.7922, 2.7870
3.238(11)	6.1(24)	1.4(4)	5.842(14)	1.7973	1.7973
3.475(12)	3.5(18)	0.8(3)	7.069(15)	2.7871(1)	0.9889, 1.7922, 2.7870
3.720(11)	1.7(12)	0.4(2)	6.324(14)	1.7973	1.7973
3.786(11)	1.7(12)	0.4(2)	7.380(14)	2.7871(1)	0.9889, 1.7922, 2.7870
3.95(11)	1.7(6)	0.4(1)	6.554(14)	1.7973	1.7973
4.05(11)	5.2(18)	1.2(3)	6.654(14)	1.7973	1.7973
4.26(15)	1.7(12)	0.4(2)	6.864(17)	1.7973	1.7973
4.399(15)	2.2(12)	0.5(2)	7.993(17)	2.7871(1)	0.9889, 1.7922, 2.7870
4.693(15)	1.7(12)	0.4(2)	8.287(17)	2.7871(1)	0.9889, 1.7922, 2.7870
4.84(12)	2.2(12)	0.5(2)	7.444(15)	1.7973	1.7973
7.80(40)***	5.4(19)	1.4(5)%***			
10.56(40)***	3.4(15)	0.9(4)%***	13.164(400)	1.7973	1.7973

* From [2019Su14] unless otherwise stated.
** [2017Ja05]
*** [2001Ca60] (above energy threshold for [2019Su14].
[@] Values from adopted levels in ENSDF [2016Ba18].
[a] Calculated from proton energies and S_p (^{27}P) = 7807(9) keV [2021Hu06].
[b] [2021Sh23].

Table 6
β-2p emission from ^{27}S*, $BR_{\beta 2p}$ = 2.4(5)%

$E_{2p}(c.m.)$	I_{2p}(rel)	I_{2p}(abs)	$E_{emitter}$ (^{27}P)**	$E_{daughter}$(^{25}Al)[@]	coincident γ-rays[@]
6.372(15)	100	0.7(3)%	12.693(17)	0	——

* All values taken from [2021Sh23], a 5.3 MeV transition from [2017Ja05] was not observed.
** Calculated from two proton energy and S_{2p} (^{27}P) = 6321(9) keV [2021Hu06].

Table 7
β-p emission from ^{31}Ar*, $T_{1/2}$= 15.1(3) ms[e], $BR_{\beta p}$ = 68.3(3)%**.

$E_p(c.m.)$	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{31}Cl)	$E_{daughter}$(^{30}S)[d]	coincident γ-rays[d]
0.461(15)[b]	0.49(16)[b]	0.14(5)	0.725(15)	0	——
0.779(15)[b]	3.0(3)[b]	0.87(9)	3.254(15)	2.2106(5)	2.211
0.844(15)[ab]	4.2(4)	1.2(1)			
1.006(15)[b]	1.4(2)[b]	0.41(6)	1.270(15)	0	——
1.169(5)[ab]	2.7(16)[b]	0.78(46)	6.651(6)	5.2174(7)	2nd proton emitted
1.251(4)	1.7(5)	0.49(14)	6.651(6)	5.136(2)	2.2106, 2.925
1.343(13)[a]	0.70(11)	0.20(3)	6.825(13)	5.2174(7)	2nd proton emitted
1.463(2)	34.0(3)	9.88(9)	1.7527(4)	0	——
1.554(2)	6.2(2)	1.80(6)	4.029(4)	2.2106(5)	2.211
1.698(2)	2.88(14)	0.84(4)	5.364(4)	3.4026(5)	1.192, 2.211, 3.402
1.880(3)[a]	3.0(4)	0.87(11)	7.361(4)	5.2174(7)	2nd proton emitted
1.932(3)	0.8(2)	0.23(6)	5.599(4)	3.4026(5)	1.192, 2.211, 3.402
1.987(3)[a]	0.44(14)	0.13(4)	7.469(4)	5.2174(7)	2nd proton emitted
2.075(3)	10.0(2)	2.91(6)	5.742(4)	3.4026(5)	1.192, 2.211, 3.402
2.153(2)	100.0	29.1(2)	2.417(4)	0	——
2.328(2)	4.0(3)	1.16(9)	2.592(4)	0	——
2.405(4)	5.1(4)	1.48(11)	2.669(5)	0	——
2.977(3)	0.99(13)	0.29(4)	6.644(4)	3.4026(5)	1.192, 2.211, 3.402
3.121(3)	1.08(14)	0.31(4)	5.595(4)	2.2106(5)	2.211
3.258(4)	0.44(10)	0.13(3)	5.733(5)	2.2106(5)	2.211
3.357(4)	1.17(15)	0.34(4)	3.621(5)	0	——
3.546(3)	0.89(11)	0.26(3)	7.477(4)	3.6675(10)	1.4566, 2.211
3.680(11)	3.6(8)	1.0(2)	7.346(11)	3.4026(5)	1.192, 2.211, 3.402
3.755(3)	6.1(8)	1.8(2)	4.019(4)	0	——
3.933(4)[a]	0.53(13)	0.15(4)	9.414(5)	5.2174(7)	2nd proton emitted
4.032(3)	2.22(14)	0.65(4)	6.507(4)	2.2106(5)	2.211
4.164(3)	7.0(2)	2.03(6)	6.639(4)	2.2106(5)	2.211
4.340(4)[a]	1.09(18)	0.32(5)	12.295(5)	7.693(4)	2nd proton emitted
4.432(4)[a]	0.31(8)	0.09(2)	12.295(5)	7.598(4)	2nd proton emitted
4.535(5)[a]	0.59(11)	0.17(3)	12.295(5)	7.485(4)	2nd proton emitted
4.778(9)[b]	0.7(2)[b]	0.20(6)	5.042(9)	0	——
4.888(5)	1.68(18)	0.49(5)	7.361(6)	2.2106(5)	2.211
5.454(5)	17.6(3)	5.06(9)	5.716(6)	0	——
5.820(9)[a]	0.31(5)	0.09(1)	12.286(9)	5.389(2)	2nd proton emitted
6.150(7)[a]	0.19(6)	0.05(2)	12.256(8)	5.843(5)	2nd proton emitted
6.251(9)	0.51(12)	0.15(3)	6.515(9)	0	——
6.350(7)	0.51(12)	0.15(3)	6.614(8)	0	——
6.599(7)[a]	0.26(5)	0.08(1)	12.252(8)	5.389(2)	2nd proton emitted
6.758(8)[a]	0.84(11)	0.24(3)	12.239(9)	5.2174(7)	2nd proton emitted
7.182(9)	0.70(9)	0.20(2)	7.446(9)	0	——
7.310(16)	0.49(7)	0.14(2)	7.574(9)	0	——
8.362(12)	0.25(4)	0.07(1)	12.295(6)	3.6675(10)	1.457, 2.211
8.625(15)	0.51(6)	0.15(2)	12.295(6)	3.4026(5)	1.192, 2.211, 3.402
9.155(19)	0.22(19)	0.064(55)	9.419(19)	0	——
9.809(20)	0.30(4)	0.087(12)	12.284(20)	2.2106(5)	2.211
12.042(28)	0.23(11)	0.067(32)	12.310(25)	0	——
12.253(29)	0.034(3)	0.010(1)	12.517(29)	0	——

*All values are taken from [2000Fy01] except where indicated. (Values from [2016Ma17] are listed as preliminary and are not included in this table).
** From [2015Li20].
[a] Single proton from a β-2p decay.
[b] [1998Ax02]
[c] Calculated from proton energies and S_p (^{31}Cl) = 264(3) keV [2021Hu06].
[d] Values from adopted levels in ENSDF [2010Ba29].
[e] [2015Li20].

Table 8
β-2p emission from ^{31}Ar*, $BR_{\beta 2p}$ = 9.0(2)%**

$E_{2p}(c.m.)$	I_{2p}(rel)	I_{2p}(abs)	$E_{emitter}$ (^{31}Cl)***	$E_{daughter}$(^{29}P)@	coincident γ-rays@
5.680(20)	48(23)	0.61(11)	12.295(5)	1.9539(2)	1.954, 0.570, 1.384
6.230(20)	56(23)	0.71(12)	12.295(5)	1.3836(1)	1.384
7.635(25)	100	1.26(20)	12.295(5)	0	——

*All values are taken from [1998Ax02] except where indicated.
** From [2015Li20].
*** Determined from ^{31}Ar β-p emission.
@ Values from adopted levels in ENSDF [2012Ba18].

Table 9
β-3p emission from ^{31}Ar, $BR_{\beta 2p}$ = 0.07(2)%**.

E$_{3p}(c.m.)$*	I_{3p}(rel)	I_{3p}(abs)**	$E_{emitter}$ (^{31}Cl)***	$E_{daughter}$(^{29}Si)	coincident γ-rays
5.03(29)	100	0.07(2)	12.295(5)	0	——

* [1992Ba01].
** [1998Ax02].
*** Determined from ^{31}Ar β-p emission.

Table 10
β-p emission from ^{35}Ca*, T$_{1/2}$= 25.7(2) ms, $BR_{\beta p}$ = 95.7(15)%**.

E_p(c.m.)	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{35}K)***	$E_{daughter}$(^{34}Ar)@	coincident γ-rays@
1.427(5)	100	48.5(13)	1.511(5)	0	——
1.909-2.647^a	11(2)	5.4(9)	4.084-4.822	2.0911(3)	2.091
1.909-2.647^a	2.1(8)	1.0(4)	5.280-6.018	3.2877(5)	1.197, 2.091, 3.286
1.909-2.647^a	4.1(14)	2.0(7)	5.866-6.604	3873(3)	1.782, 2.091, 0.585, 1.197
2.727(13)	12.4(10)	6.0(5)	4.902(13)	2.0911(3)	2.091
2.947-3.500^a	4.5(6)	2.2(3)	5.122-5675	2.0911(3)	2.091
3.592(25)	6.2(6)	3.0(3)	3.676(25)	0	——
3.822(36)	7.8(6)	3.8(3)	3.906(36)	0	——
4.041(71)	6.0(6)	2.9(3)	6.216(71)	2.0911(3)	2.091
4.570(48)	6.0(6)	2.9(3)	4.654(48)	0	——
4.754(38)	8.7(8)	4.2(4)	4.838(38)	0	——
5.018(71)	8.0(6)	3.9(3)	5.102(71)	0	——
5.294(48)	1.5(4)	0.72(18)	5.378(48)	0	——
5.466(48)	1.26(31)	0.61(15)	5.550(48)	0	——
5.616(37)	2.95(35)	1.43(17)	5.700(37)	0	——
5.834(60)	2.9(4)	1.40(19)	5.918(60)	0	——
5.983-6.649^a	2.25(35)	1.09(17)	6.067-6.733	0	——
6.783(22)	7.8(4)	3.8(2)	8.958(22)	2.0911(3)	2.091
7.131-7.887^a	2.3(4)	1.1(2)	4.084-7.971	0	——
8.802(89)	0.85(12)	0.41(6)	8.886(89)	0	——

* All values are taken from [1999Tr04], except where noted.
** From [2016Ci05].
*** Calculated from proton energies and S$_p$ (^{35}K) = 83.6(5) keV [2021Wa16].
@ Values from adopted levels in ENSDF [2012Si06].
^{a} unresolved multiplet

Table 11
β-2p emission from ^{35}Ca*, $BR_{\beta 2p}$ = 4.2(3)%**.

E$_{2p}$(c.m.)	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{35}K)****	$E_{daughter}$(^{33}Cl)	coincident γ-rays
4.305(26)	100	4.2(3)	9.053(27)	0	——

* All values are taken from [1999Tr04], except where noted.
** From [2016Ci05].
*** Calculated from two-proton energy and S$_{2p}$ (^{35}K) = 4747.5(6) keV [2021Hu06].

Table 12
β-p emission from ^{39}Ti*, $T_{1/2}$ = 28.5(9) ms, $BR_{\beta p}$ = 93.7(28)%**.

E_p(c.m.)	I_p(rel)***	I_p(abs)***	$E_{emitter}$ (^{39}Sc)	$E_{daughter}$(^{38}Ca)	coincident γ-rays[@]
3.27(2)	70(20)	7(2)			
5.17(3)[a]	100(30)	10(3)			

* All values taken from [2007Do17], except where noted.
** Mixture of β-p and β-2p [2007Do17], β-xp is expected to be 100% as ^{39}Sc is unbound to proton emission S_p= -597(24) keV [2021Hu06].
*** Note that there is considerable disagreement between the published works in this nucleus, and many β-p transitions are unknown.
[a] Possible two proton peak from the β-2p decay of 39Ti to the ground state of ^{37}K [2001Gi01, 1992Mo15].

Table 13
β-2p emission from ^{39}Ti*

E_{2p}(c.m.)	I_{2p}(rel)	I_{2p}(abs)	$E_{emitter}$ (^{39}Sc)	$E_{daughter}$(^{37}K)**	coincident γ-rays **
≈2.50	≈100			2.1702(1)	2.170
≈4.75	≈55			0	——

* All values taken from [1992Mo15], except where noted.
** Value from adopted levels in ENSDF [2012Ca15].

Table 14
β-p emission from ^{43}Cr*,$T_{1/2}$ = 21.2(7) ms, $BR_{\beta p}$ = 79.3(30)%**.

E_p(c.m.)	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{43}V)***	$E_{daughter}$(^{42}Ti)	coincident γ-rays
1.014(17)	8(1)	0.6(1)			
1.614(34)	30(15)	2.1(11)			
1.812(15)	100	7.1(12)			
2.179(17)	66(10)	4.7(7)			
2.753(19)	17(6)	1.2(4)			
3.138(17)	48(10)	3.4(7)			
3.382(25)	14(6)	1.0(4)			
3.744(27)	42(20)	3.0(14)			
4.671(26)	63(11)	4.5(8)			

* All proton energies, intensity and half-life values taken from [2007Do17].
** From [2012Au08]. [2007Do17] gives a value of 92.5(28)% for the sum of β-p and β-2p.
*** Calculated from proton energies and S_p (^{43}V) = 100(40) keV [2021Hu06].

Table 15
β-2p emission from ^{43}Cr*, $BR_{\beta 2p}$ = 12.09(40)%**.

E_{2p}(c.m.)	I_{2p}	$E_{emitter}$ (^{43}V)***	$E_{daughter}$(^{41}Sc)	coincident γ-rays
4.348(16)		8.198(43)	0	——

* All values taken from [2007Do17] except where noted.
** [2012Au08].
*** Calculated from two-proton energy and S_{2p} (^{43}V) = 3850(40) keV [2021Hu06].

Table 16
β-p emission from ^{47}Fe*, $T_{1/2}$ = 21.5(7) ms, $BR_{\beta p}$ = 88.4(9)%.

E_p(c.m.)	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{47}Mn)**	$E_{daughter}$(^{46}Cr)	coincident γ-rays
1.548(19)	36(13)	1.9(7)			
1.718(20)	75(23)	4.0(12)			
1.864(15)	100	5.3(7)	5.44(3)	1.9871(3)	0.892, 1.095
2.462(29)	36(13)	1.9(7)			
3.973(20)	83(23)	4.4(12)	7.55(4)	3.1965(6)	0.892, 1.095
5.000(215)	38(8)	2.0(4)	7.38(4)[a]	1.9871(3)	0.892, 1.095
6.104(24)	70(13)	3.7(7)	7.38(4)[a]	0.8922(1)	0.829

* All values taken from [2007Do17], except where noted.
** Calculated from proton energy and S_p (^{47}Mn) = 380(30) keV [2021Hu06].
[a]IAS state [2007Do17].

Table 17
β-p Emission from ^{51}Ni*, $T_{1/2}$ = 23.8(2) ms, $BR_{\beta p}$ = 87.2(9)%*.

E_p(c.m.)	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{51}Co)**	$E_{daughter}$(^{50}Fe)***	coincident γ-rays***
1.084(41)	14(9)	1.3(8)			
1.356(23)	17(6)	1.5(5)			
1.859(20)	35(10)	3.0(9)			
2.234(18)	21(6)	1.8(5)			
2.515(28)	55(25)	4.8(22)			
2.915(17)	46(10)	4.0(9)			
3.121(31)	24(12)	2.1(10)			
3.421(23)	6(5)	0.5(4)			
3.709(29)	17(6)	1.5(5)			
3.929(24)	13(7)	1.1(6)			
4.415(27)	6(3)	0.5(3)			
4.662(16)	100	8.7(8)	6.664(52)	1.8515(5)	0.765, 1.087
5.664(30)	10(5)	0.9(4)			

* All values taken from [2007Do17], except where noted.
** Calculated from proton energy and S_p (^{51}Co) = 150(50) keV [2021Hu06].
*** Values from adopted levels in ENSDF [2011El01].

Table 18
β-p Emission from ^{55}Zn*, $T_{1/2}$ = 19.8(13) ms, $BR_{\beta 2p}$ = 91.0(51)%.

E_p(c.m.)	I_p	$E_{emitter}$ (^{55}Cu)	$E_{daughter}$(^{54}Ni)	coincident γ-rays
4.689(38)	obs	≈7.30*	2.5-2.6**	

* All values taken from [2007Do17], except where noted.
** The emitted proton is assumed to be from IAS in ^{55}Cu at ≈7.300 MeV to the second excited state in ^{54}Ni which is expected to be ≈2.5-2.6 MeV.

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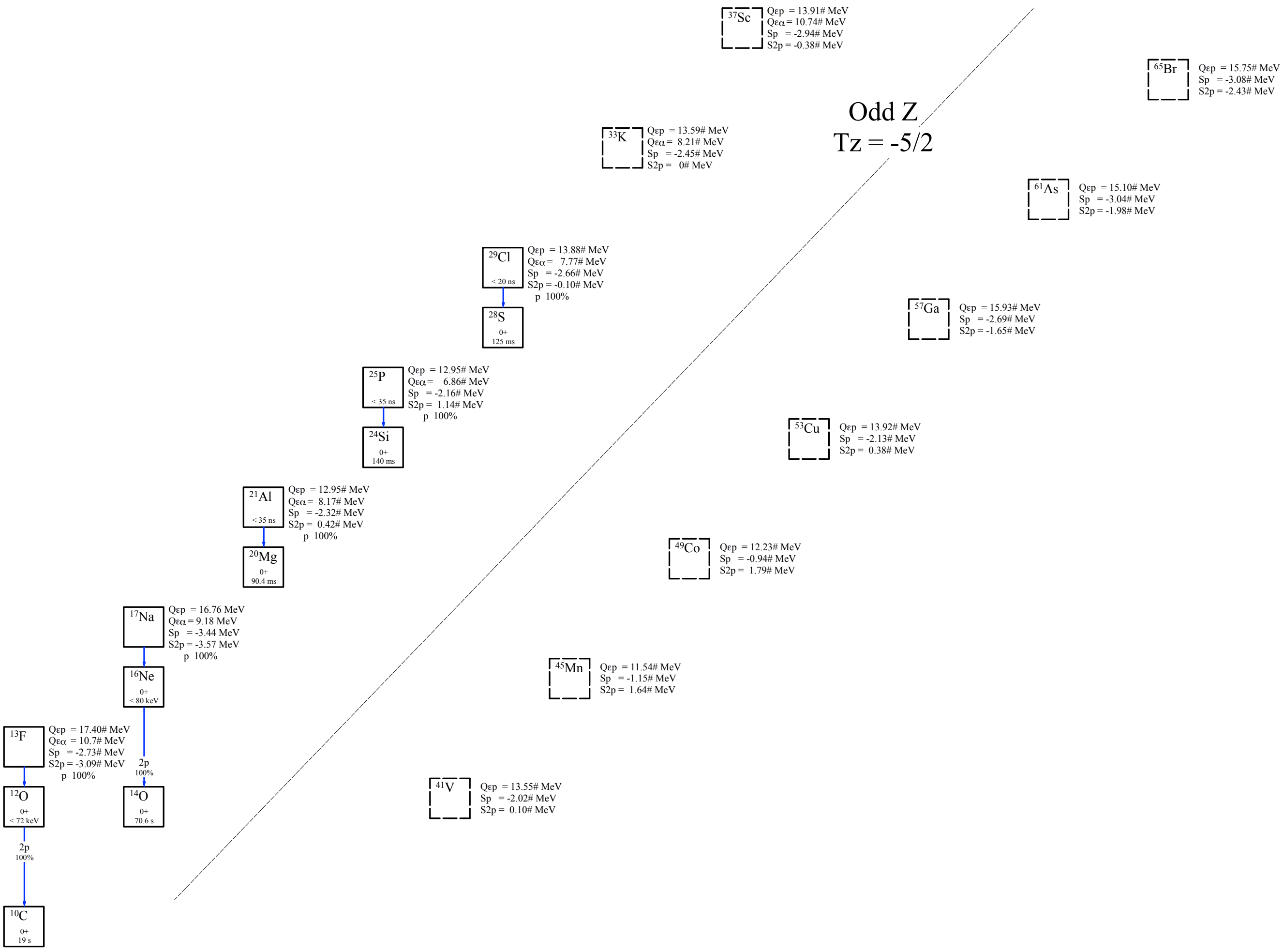

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= -5/2 nuclei.

Last updated 3/17/23

Table 1
Observed and predicted β-delayed particle emission from the odd-Z T_z = -5/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$BR_{\beta 2p}$	$Q_{\varepsilon 3p}$	$Q_{\varepsilon\alpha}$	Experimental
^{13}F			18.92(50)#	17.40(50)#		16.80(50)#		8.11(50)#	10.7(50)#	[**2021Ch19**]
^{17}Na			18.22(6)	16.76(6)		17.29(6)#		9.99(6)#	9.18(6)	[**2017Br07**]
^{21}Al		< 35ns	16.19(60)#	12.95(60)#		10.76(60)#		4.35(60)#	8.17(60)#	[**1997Au04**]
^{25}P		< 35 ns	16.36(40)#	12.95(40)#		11.09(40)#		3.50(40)#	6.86(40)#	[**1997Au04**]
^{29}Cl		< 20 ns	17.12(19)#	13.88(19)#		11.83(19)#		4.36(19)#	7.77(19)#	[**2015Mu13**]
^{33}K			16.93(20)#	13.59(20)#		12.00(20)#		5.87(20)#	8.21(20)#	
^{37}Sc			16.92(30)#	13.91(30)#		12.25(30)#		6.35(30)#	10.74(30)#	
^{41}V			16.01(20)#	13.55(20)#		13.02(20)#		7.24(20)#	11.02(20)#	
^{45}Mn			14.54(30)#	11.54(30)#		9.76(30)#		5.27(30)#	8.29(30)#	
^{49}Co			14.97(50)#	12.23(50)#		10.21(50)#		5.43(50)#	7.31(50)#	
^{53}Cu		< 130 ns	16.49(50)#	13.92(50)#		12.47(50)#		7.62(50)#	9.19(50)#	[**2005Bi15**]
^{57}Ga			17.14(45)#	15.93(40)#		15.35(40)#		10.73(40)#	11.80(40)#	
^{61}As			16.59(42)#	15.10(36)#		15.44(30)#		12.60(30)#	12.93(36)#	
^{65}Br			16.53(58)#	15.75(54)#		15.85(50)#		13.63(50)#	14.88(58)#	

Table 2
Particle emission from the odd-Z T_z = -5/2 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	BR_p	S_{2p}	Q_α	Experimental
^{13}F	-2.73(50)#	100%	-3.09(50)#		[**2021Ch19**]
^{17}Na	-3.44(6)	100%	-3.57(6)	-9.740(10)	[**2017Br07**]
^{21}Al	-2.32(60)#	100%	0.42(60)#	-10.06(60)#	[**1997Au04**]
^{25}P	-2.16(40)#	100%	1.14(40#	-9.32(72)#	[**1997Au04**]
^{29}Cl	-2.66(10)#	100%	-0.10(19)#	-8.59(44)#	[**2015Mu13**]
^{33}K	-2.45(20)#		0(200)#	-8.91(28)#	
^{37}Sc	-2.94(30)#		-0.38(30)#	-6.19(36)#	
^{41}V	-2.02(21)#		0.10(20)#	-5.90(36)#	
^{45}Mn	-1.15(30)#		1.64(30)#	-7.72(36)#	
^{49}Co	-0.94(51)#		1.79(50)#	-7.23(58)#	
^{53}Cu	-2.13(51)#		0.38(50)#	-5.79(71)#	
^{57}Ga	-2.69(57)#		-1.65(43)#	-4.70(64)#	
^{61}As	-3.04(42)#		-1.98(35)#	-4.22(50)#	
^{65}Br	-3.08(71)#		-2.43(54)#	-1.72(58)#	

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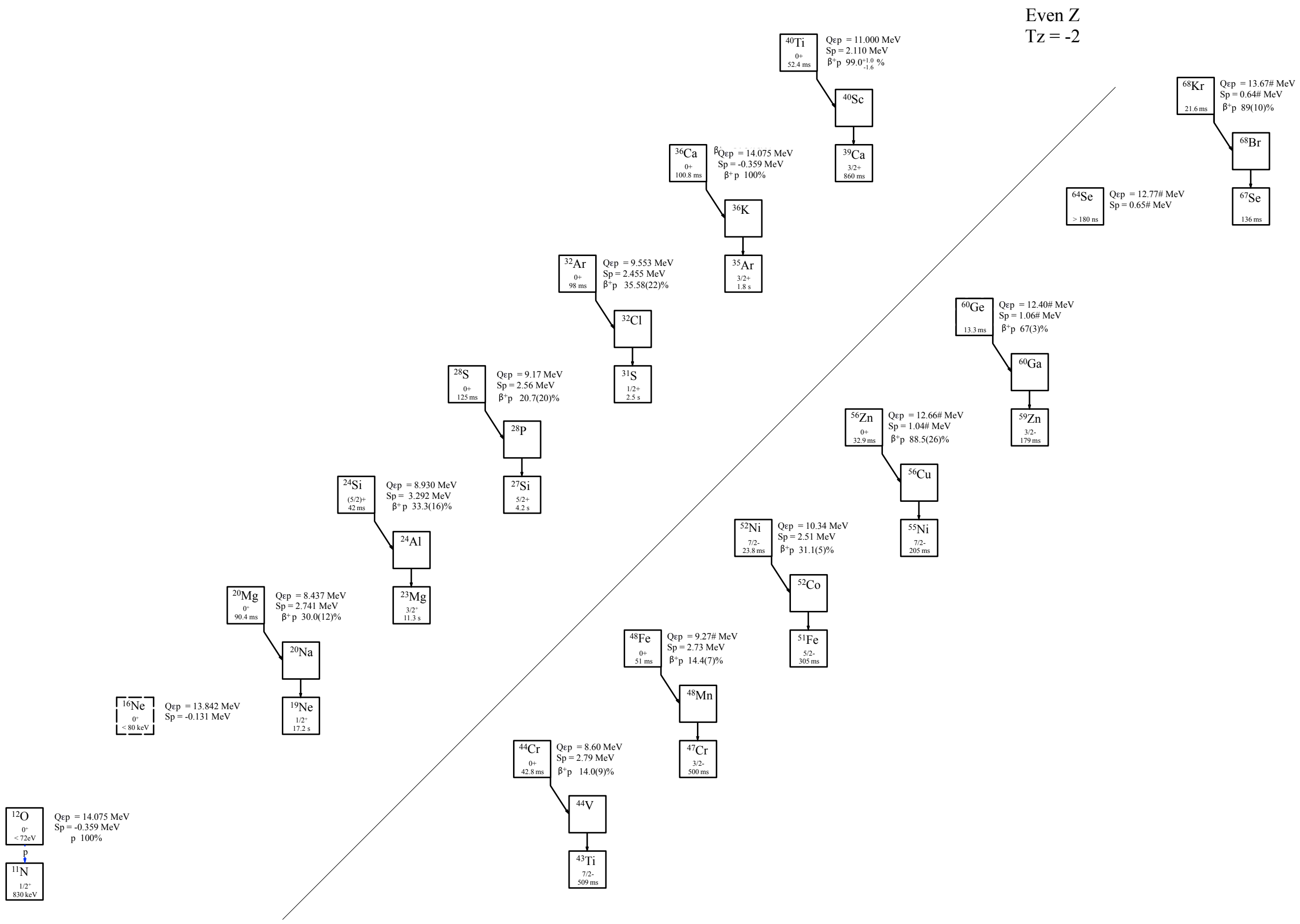

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= -2 nuclei.

Last updated 3/17/23

Table 1
Observed and predicted β-delayed particle emission from the even Z, T_z = -2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$BR_{\beta 2p}$	$Q_{\varepsilon 3p}$	$Q_{\varepsilon\alpha}$	Experimental
^{12}O	0^+	$<$ 72 keV	14.675(12)	14.075(12)		5.384(12)		-1.202(12)	6.666(12)	[**2012Ja11**]
^{16}Ne	0^+	$<$ 80 keV	13.312(21)	13.842(20)		6.546(20)		-1.005(20)	4.224(20)	[**2008Mu13**]
^{20}Mg	0^+	90.4(6) ms	10.627(2)	8.437(2)	30.0(12)%	2.027(2)		-3.580(2)	4.378(5)	[**1995Pi03**, 2019Gl02, 2016Lu13, 2012Wa15]
^{24}Si	0^+	141.4(15) ms	10.794(19)	8.930(19)	33.3(16)%	1.349(19)		-5.390(19)	1.469(19)	[**2011Ic06**, 2020Lo05, 2016Su22, 2015Su15, 2001Ba07, 1998Cz01, 1997Cz02]
^{28}S	0^+	125(10) ms	11.22(16)	9.17(16)	20.7(20)%	1.702(160)		-4.604(160)	1.69(16)	[**1989Po10**]
^{32}Ar	0^+	98(2) ms	11.134(2)	9.553(2)	35.58(22)%	3.423(2)		-2.172(2)	2.523(2)	[**2021Bl02, 2008Bh08, 1985Bj01**, 2002Fy01, 2020Ar04, 1999Ad10, 1999Th09, 1993Sc16, 1985Bj01, 1977Ha29]
^{36}Ca	0^+	100.8(20) ms	10.970(40)	9.310(40)	54.3(18)%	3.412(40)		-1.731(40)	4.46(4)	[**2015Su01**, 2007Do17, 2001Lo11, 1997Tr05, 1995Tr02]
^{40}Ti	0^+	52.4(3) ms	11.530(70)	11.000(70)	99.0^{+10}_{-16}%	5.233(70)		0.091(70)	6.002(70)	[**2007Do17**, 2001Gi01, 1990De43, 1998Bh12, 1998Li46, 1998Le45, 1997Tr11, 1997Li25]
^{44}Cr	0^+	42.8(6) ms	10.390(50)	8.600(50)	14.0(9)%	4.123(50)		-0.149(50)	4.678(50)	[**2007Do17**, 2020Fu05, 2014Po05]
^{48}Fe	0^+	51(3) ms[b]	11.290(90)	9.270(90)#	14.4(7)%	4.488(90)		-0.867(90)	3.373(90)	[**2016Or03, 2014Po05**, 2016Ru04] [**2007Do17**, 1996Fa09]
^{52}Ni	0^+	42.8(3) ms	11.780(80)	10.340(80)	31.1(5)%	5.489(80)		0.905(80)	4.312(80)	[**2016Or03**, 2007Do17, 1994Fa06]
^{56}Zn	0^+	32.9(8) ms	13.24(40)#	12.66(40)#	88.5(26)%	8.04(40)	6.55(40)#	3.69(40)		[**2016Or03**, 2015Or02, 2014Or04, 2014Or03, 2007Do17]
^{60}Ge	0^+	25.0(3) ms	12.06(36)#	12.40(30)#	67(3)%	9.56(30)#	$<$14%	6.69(30)#	8.68(30)#	[**2021Or01**, 2016Ci01]
^{64}Se	0^+	$>$180 ns	12.67(54)#	12.77(50)#		10.55(50)#		7.62(50)#	10.31(54)#	[**2005St34**]
^{68}Kr	0^+	21.6(33) ms	13.17(56)#	13.67(51)#	89^{+11}_{-10}%	11.82(50)#		8.98(50)#	11.48(54)#	[**2017GoZT**, 2016Bl05]

Table 2
Particle emission from the even Z, T_z = -2 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	BR_{2p}	Q_α	Experimental
^{12}O	-0.359(13)	-1.737(12)	100%	-5.476(22)	[**2012Ja11**]
^{16}Ne	-0.131(25)	-1.401(20)		-10.451(24)	
^{20}Mg	2.741(11)	2.418(2)	——	-8.934(21)	
^{24}Si	3.292(19)	3.433(19)	——	-9.157(20)	
^{28}S	2.56(16)	3.36(16)	——	-9.10(16)	
^{32}Ar	2.455(4)	2.719(2)	——	-8.70(16)	
^{36}Ca	2.57(4)	2.65(4)	——	-6.68(4)	
^{40}Ti	2.110(70)	1.510(70)	——	-4.970(80)	
^{44}Cr	2.790(70)	2.900(50)	——	-6.850(90)	
^{48}Fe	2.73(10)	3.110(90)	——	-7.010(110)	
^{52}Ni	2.51(10)	2.660(80)	——	-6.98(12)	
^{56}Zn	1.04(43)#	0.69(40)#	——	-5.26(41)#	
^{60}Ge	1.06(35)#	-0.19(30)#	——	-4.57(50)#	
^{64}Se	0.65(54)#	-0.70(52)#	——	-1.75(58)#	
^{68}Kr	0.64(40)#	-1.46(54)#	——	-1.19(71)#	

Table 3
β-p emission from ^{20}Mg[a], $BR_{\beta p}$ = 30.3(14)%*.

E_p(c.m.)	I_p(rel)%	I_p(abs)%	$E_{emitter}$ (^{20}Na)	$E_{daughter}$(^{19}Ne)[b]	coincident γ-rays[b]
0.805(2)[c]	100(3)	10.6(3)[c]	2.995(2)	0	——
1.067(18)[d]	6.6(9)	0.70(9)	4.793(18)	1.5360(4)	1.298, 0.238
1.210(250)[f]	0.14(3)	0.0149(35)	7.433(250)	4.0329(24)	4.033, 1.298, 0.238
1.423(16)[d]	0.4(1)	3.8(10)	3.855(10)	0.2383(1)	0.238
1.622(4)	18.0(28)	1.9(3)	4.087(4)	0.2751(1)	0.275
1.666(10)[c]	48(3)	5.1(3)[c]	3.855(10)	0	——
1.853(40)	0.3(2)	0.03(2)	5.533(17)	1.5360(4)	1.298, 0.238
1.905(5)	1.2(4)	0.13(4)	5.603(5)	1.5076(3)	1.232, 0.275
1.907(3)[c]	4.5(4)	0.48(4)[c]	4.097(3)	0	——
2.120(70)	1.03(7)	0.11(1)	5.817(19)	1.5076(3)	1.232, 0.275
2.335(14)[e]	5.2(7)	0.6(1)[e]	4.800(14)	0.2751(1)	0.275
2.344(18)	2.9(8)	0.31(8)	4.772(18)	0.2383(1)	0.238
2.560(14)	3.1(9)	0.33(9)	6.286(14)	1.5360(4)	1.298, 0.238
2.567(4)	21.7(19)	2.3(2)	4.758(4)	0	——
2.620(14)	3.8(19)	0.4(2)	6.318(14)	1.5076(3)	1.232, 0.275
2.700(230)[f]	2.0(1)	0.212(7)[f]	6.505(250)	1.6156(5)	1.616, 1.377, 1.341, 0.275, 0.238
2.782(13)	4.4(7)	0.47(7)	6.508(13)	1.5360(4)	1.298, 0.238
2.830(16)	0.95(28)	0.10(3)	6.528(16)	1.5076(3)	1.232, 0.275
3.033(12)	4.4(8)	0.46(8)	5.498(12)	0.2751(1)	0.275
3.096(17)	5.1(8)	0.54(8)	5.532(17)	0.2383(1)	0.238
3.389(19)	3.5(6)	0.37(6)	5.817(19)	0.2383(1)	0.238
3.389(18)	0.76(19)	0.08(2)	5.854(18)	0.2751(1)	0.275
3.813(14)[c]	2.7(8)	0.28(8)[c]	6.281(14)	0.2751(1)	0.275
3.820(12)	4.2(5)	0.44(5)	6.242(12)	0.2383(1)	0.238
4.033(12)	2.9(7)	0.31(7)	6.496(4)	0.2751(1)	0.275
4.051(2)	8.3(9)	0.9(1)[e]	6.242(4)	0	——
4.053(12)	2.8(19)	0.3(2)	6.481(12)	0.2383(1)	0.238
4.305(4)[c]	9.7(6)	1.02(7)[c]	6.496(4)	0	——
4.347(20)	2.6(8)	0.27(8)	6.775(20)	0.2383(1)	0.238
4.544(15)	3.0(1)	0.319(10)	6.734(15)	0	——
4.993(16)	0.75(28)	0.08(3)	7.183(16)	0	——

[a] Values taken from [2016Lu13], except where noted.
[b] Values from adopted levels in ENSDF [1995Ti07].
[c] Weighted average of [2016Lu13], [1995Pi03] and [2017Su05].
[d] Weighted average of [1995Pi03] and [2017Su05].
[e] Weighted average of [2016Lu13] and [2017Su05].
[f] [2019Gl02].

Table 4
β-p emission from ^{24}Si, $T_{1/2}$ = 141.4(15) ms*, $BR_{\beta p}$ = 33.3(16)%**.

E_p(c.m.)[a]	I_p(rel)%	I_p(abs)%[b]	$E_{emitter}$ (^{24}Al)	$E_{daughter}$(^{23}Mg)[c]	coincident γ-rays[c]
1.125(15)	50(4)	5.7(4)	2.989(15)	0	——
1.497(13)	100(7)	11.3(8)	3.361(13)	0	——
1.723(13)	38(4)	4.3(4)	5.944(13)	2.3570(7)	0.451, 1.906, 2.358
2.021(10)	9.2(9)	1.0(1)	6.242(10)	2.3570(7)	0.451, 1.906, 2.358
2.515(9)	5.8(7)	0.65(8)	4.379(9)	0	——
2.826(7)	12(2)	1.4(2)	4.691(7)	0	——
3.104(8)	8.7(9)	0.98(10)	4.968(8)	0	——
3.510(10)[d]	6(1)	0.68(10)[d]	5.374(10)	0	——
3.938(26)[b]	9.4(18)	1.1(2)	5.802(26)	0	——
4.082(7)	59(5)	6.6(6)	5.947(7)	0	——
4.370(9)	15(2)	1.7(2)	6.234(9)	0	——
4.615(11)[d]	2.3(4)	0.26(4)[d]	6.479(11)	0	——
4.863(11)[d]	0.6(2)	0.07(2)[d]	6.727(11)	0	——

* Weighted average of 143.4(22)ms [2015Su15] and 140.5(15)ms [2011Ic06].
** [2011Ic06]
[a] Weighted average of [2015Su22, 2015Su15], [2009Ic05, 2011Ic06], [1998Ba53] and [1998Cz01], except where noted.
[b] Weighted average of [2015Su12] and [2009Ic05], except where noted.
[c] Values from adopted levels in ENSDF [2021Ba01].
[d] Only reported in [1998Ba53]. No I_p or energy error bars on the energy are assigned in the paper.
[e] Only reported in [2009Ic05].

Table 5
β-p emission from ^{28}S*, $T_{1/2}$ = 125(10) ms, $BR_{\beta p}$ = 20.7(20)%.

E_p(c.m.)	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{25}Al)**	$E_{daughter}$(^{24}Mg)[@]	coincident γ-rays[@]
1.260(25)	20(3)	1.4(4)			
1.510(25)	30(5)	2.1(6)			
1.695(30)	24(3)	1.7(4)			
1.892(30)	19(3)	1.3(3)			
2.195(30)	15(3)	1.0(3)			
2.630(25)	22(3)	1.6(4)			
2.872(30)***	25(3)	1.75(4)	5.779(30)	0.9574(2)	0.957
3.095(20)***	100	7.0(15)	5.817(20)	0.7809(2)	0.781
3.570(30)	13(2)	0.9(2)			
3.835(20)***	28(3)	2.0(4)	5.750(20)	0	——

* All values taken from [1989Po10], except where noted.
** Calculated from proton energies and S_p (^{28}P) = 2052.2(12) keV [2021Wa16].
*** [1989Po10] list these three transitions as depopulating a 5.900(21) MeV IAS.
[@] Values from adopted levels in ENSDF [2011Ba29].

Table 6
β-p emission from ^{32}Ar, $T_{1/2}$ = 98(2) ms*, $BR_{\beta p}$ = 35.58(22)%**

E_p(c.m.)[a]	I_p(rel)%	I_p(abs)%[g]	$E_{emitter}$ (^{32}Cl)	$E_{daughter}$(^{31}S)[b]	coincident γ-rays[b]
0.6273(46)	1.876(39)	0.385(8)	2.2084(46)	0	——
0.9416(50)[c]	0.070(40)[c]	0.014(8)	3.7716(50)	1.24887(9)	1.2489(1)
1.2501(42)	1.557(112)	0.319(23)	4.0801(42)	1.24887(9)	1.2489(1)
1.731(12)[d]	0.143(65)[d]	0.029(13)	4.561(12)	1.24887(9)	1.2489(1)
2.1906(37)[e]	17.66(30)[e]	3.62(7)	3.7717(37)	0	——
2.2152(36)[f]	1.286(41)[f]	0.264(9)	5.0452(36)	1.24887(9)	1.2489(1)
2.4729(32)[f]	0.58(11)[f]	0.119(22)	5.3029(32)	1.24887(9)	1.2489(1)
2.5016(37)[e]	35.28(47)[e]	7.24(11)	4.0827(37)	0	——
2.5935(30)	3.26(25)	0.668(51)	5.4235(30)	1.24887(9)	1.2489(1)
2.7006(86)[d]	0.247(63)[d]	0.051(13)	5.5306(86)	1.24887(9)	1.2489(1)
2.8656(54)	0.429(80)	0.088(16)	5.6956(54)	1.24887(9)	1.2489(1)
3.2178(43)[e]	0.136(12)[e]	0.028(2)	4.7989(43)	0	——
3.218(11)[d]	0.090(22)[d]	0.018(5)	6.0483(11)	1.24887(9)	1.2489(1)
3.4621(22)	100	20.51(17)	5.0432(22)	0	——
3.6996(44)	0.270(34)	0.055(7)	6.5296(44)	1.24887(9)	1.2489(1)
3.722.3(82)[d]	0.394(58)[d]	0.081(12)	5.3034(82)	0	——
3.7675(37)	0.325(23)	0.067(5)	6.5975(37)	1.24887(9)	1.2489(1)
3.8481(44)[e]	0.413(46)[e]	0.085(9)	5.4292(44)	0	——
3.9052(39)[f]	0.300(98)[f]	0.062(20)	6.7352(39)	1.24887(9)	1.2489(1)
4.1208(46)	0.926(50)	0.190(10)	5.7019(46)	0	——
4.4825(41)	0.138(33)	0.028(7)	7.3125(41)	1.24887(9)	1.2489(1)
4.4838(30)	0.496(18)	0.102(4)	6.0649(30)	0	——
4.6728(30)	0.457(21)	0.094(4)	6.2539(30)	0	——
4.7754(32)	0.165(30)	0.034(6)	7.6054(32)	1.24887(9)	12489(1)
5.0246(43)	0.259(24)	0.053(5)	7.8546(43)	1.24887(9)	1.2489(1)
5.1391(89)	0.063(17)	0.013(4)	6.7202(89)	0	——
5.7403(40)	0.547(25)	0.112(5)	7.3214(40)	0	——
5.8683(85)	0.022(8)	0.005(2)	7.4494(85)	0	——
6.0116(60)	0.423(32)	0.087(7)	7.592(60)	0	——
6.2677(88)	0.109(8)	0.022(2)	7.8488(88)	0	——
6.572(13)	0.057(7)	0.012(1)	8.153(13)	0	——

* [1985Bj01]
** [2008Bh08]
[a] Values are a weighted average of [2021Bl02], [2008Bh08], and [1985Bj01] except as indicated.
[b] Values from adopted levels in ENSDF [2013Ou01].
[c] [2008Bh08]
[d] [2021Bl02]
[e] Weighted average of [2021Bl02] and [1985Bj01]
[f] Weighted average of [2021Bl02] and [2008Bh08]
[g] Absolute values were determined by setting the sum of the relative intensities equal to the measured β-p branching ratio. Note that if there are a significant amount of unobserved transitions in the measured β-p branching ratio, these values will be lower.

Table 7
β-p emission from ^{36}Ca*, $T_{1/2}$ = 100.8(20) ms**, $BR_{\beta p}$ = 54.3(18)%

E_p(c.m.)[a]	I_p(rel)%	I_p(abs)%	$E_{emitter}$ (^{36}K)[b]	$E_{daughter}$(^{35}Ar)[c]	coincident γ-rays[c]
1.444(8)	<10.8	<4.1	4.290(23)	1.184	1.184
1.704(23)	25(3)	9.3(8)	3.358(23)	0	——
2.628(8)	100(3)	37(1)	4.290(23)	0	——
2.798(23)	9.7(14)	3.5(5)	4.457(23)	0	——
3.011(37)	2.8(8)	1.0(3)	4.644(46)	0	——
3.591(23)	1.7(6)	0.6(2)	5.250(23)[d]	0	——
4.102(69)	2.5(6)	0.9(2)	5.761(69)[d]	0	——
4.274(46)	4.7(8)	1.7(3)	5.919(46)	0	——
5.136(69)	0.8(3)	0.3(1)	6.791(69)	0	——

* All values from [2001Lo11], except where noted.
** Weighted average of 100.0(24) [2015Su01], 100.1(23) [2007Do11], and 102(2) [1997Tr05].
[a] Calculated using $E_{emitter}$ energies from [2001Lo11] and S_p(^{36}K) = 1.658.9(8) [2021Wa16].
[b] Values taken from a weighted average of [2001Lo11] and [1997Tr05] except where noted.
[c] Values from adopted levels in ENSDF [2011Ch48].
[d] [2011Lo11]

Table 8
β-p emission from ^{40}Ti*, $T_{1/2}$ = 52.4(3) ms**, $BR_{\beta p}$ = 95.8(13)%**

E_p(c.m.)	I_p(rel)%	I_p(abs)%	$E_{emitter}$ (^{40}Sc) [a]	$E_{daughter}$(^{39}Ca)[c]	coincident γ-rays[c]
0.248(80)[b]	4.4(14)	1.3(4)[b]	3.246(80)	2.4685(9)	2.469
0.410(60)[b]	2.4(10)	0.7(3)[b]	3.408(60)	2.4685(9)	2.469
0.766(36)	1.6(6)	0.5(2)	3.764(36)	2.4685(9)	2.469
0.975(86)[b]	2.7(11)	0.8(3)[b]	4.531(86)	3.026(3)	3.026
1.139(20)	1.8(6)	0.53(18)	4.138(20)	2.4685(9)	2.469
1.359(7)	12(2)	3.6(6)	4.357(8)	2.4685(9)	2.469
1.649(17)	1.3(6)	0.38(19)	4.647(17)	2.4685(9)	2.469
1.745(6)	80(2)	23.8(6)	2.274(7)	0	——
1.896(14)	4.8(13)	1.4(4)	4.895(14)	2.4685(9)	2.469
2.007(21)	2.9(14)	0.86(34)	5.005(21)	2.4685(9)	2.469
2.079(28)	1.5(6)	0.44(17)	5.077(28)	2.4685(9)	2.469
2.215(6)	100(2)	29.8(7)	2.754(7)	0	——
2.401(10)	6.5(13)	1.95(41)	2.931(10)	0	——
2.607(16)	3.1(7)	0.9(2)	3.137(16)	0	——
2.676(60)[b]	3.5(14)	1.1(4)[b]	3.205(60)	0	——
2.798(16)	2.0(6)	0.58(17)	3.328(16)	0	——
3.033(47)	0.4(4)	0.1(1)	3511(40)	0	——
3.117(8)	5.8(7)	1.7(2)	3.647(9)	0	——
3.251(8)	7.0(10)	2.1(3)	3.781(9)	0	——
3.325(41)[d]	0.4(4)	0.1(1)	3.855(41)	0	——
3.531(21)	1.4(5)	0.43(14)	4.061(21)	0	——
3.576(25)	1.1(5)	0.33(16)	4.106(25)	0	——
3.732(8)	6.9(7)	2.1(2)	4.262(9)	0	——
3.830(7)	73(3)	22(1)	4.359(8)	0	——
3.987(11)	6.2(9)	1.9(3)	4.516(11)	0	——
4.120(10)	5.3(11)	1.6(3)	4.650(10)	0	——
4.291(18)	2.4(7)	0.7(2)	4.821(18)	0	——
4.483(23)	1.8(9)	0.53(26)	5.013(23)	0	——
4.547(31)	1.4(9)	0.42(27)	5.076(31)	0	——
4.689(28)[d]	0.4(4)	0.1(1)	5.219(28)	0	——
4.823(60)[b]	1.8(7)	0.55(21)[b]	5.352(60)	0	——
5.035(40)[b]	0.7(3)	0.20(7)[b]	5.564(40)	0	——
5.163(22)	0.8(3)	0.24(9)	5.693(22)	0	——
5.473(19)	0.7(2)	0.21(7)	6.002(19)	0	——
5.588(60)[b]	0.6(4)	0.17(10)[b]	6.117(60)	0	——
5.887(60)[b]	0.34(20)	0.10(6)[b]	6.417(60)	0	——

* Values are from [1998Bh12] except where indicated. Values from [1998Bh12] were preferentially used because of the better energy resolution than [1998Li46].

** [2007Do17]

[a] Calculated from proton energies and S_p (^{40}Sc) = 529.6(29) keV [2021Wa16].

[b] [1998Li46]

[c] Values from adopted levels in ENSDF [2006Si02].

[d] Transition is questionable, as I_p is consistent with zero.

Table 9
β-p emission from ^{44}Cr[a], $T_{1/2}$ = 42.8(6) ms, $BR_{\beta p}$ = 14.0(9)%

E_p	I_p(rel)%	I_p(abs)%	$E_{emitter}$ (^{44}V)[e]	$E_{daughter}$(^{43}Ti)
0.759(26)[b]	31(12)	0.6(2)[b]		
0.908(11)	100(15)	2.0(3)[c]	2.689(14)[d]	0
1.384(12)	63(19)	1.3(3)[c]		
1.741(15)	28(18)	0.6(3)[c]		

[a] Values from [2007Do17] except where indicated. Many of the delayed protons have not been measured resulting in a total intensity for individual protons to be lower than the total β^+-p intensity. Other experimental β^+-p reference: [1992Bo37].

[b] [2014Po05]

[c] Weighted average of [2007Do17] and [2014Po05]

[d] Assigned as the IAS [2007Do17]

[e] Calculated from proton energy and S_p (^{44}V) = 1781(9) keV [2021Wa16].

Table 10

β-p emission from ^{48}Fe*, $T_{1/2}$ = 51(3) ms**,$BR_{\beta p}$ = 14.4(7)%**.

E_p(c.m.)	I_p(rel)%	I_p(abs)%	$E_{emitter}$ (^{48}Mn)***	$E_{daughter}$(^{47}Cr)	coincident γ-rays
1.018(10)	100	4.8(3)	3.041(12)	0	——
1.186(10)	21(6)	1.0(3)	3.209(12)	0	——
1.477(10)	38(6)	1.8(3)	3.500(12)	0	——
1.601(10)	19(6)	0.9(3)	3.624(12)[@]	0[@]	——
1.695(10)	27(4)	1.3(2)	3.718(12)	0	——
2.281(10)	25(6)	1.2(3)	4.304(12)[@]	0[@]	——
2.381(10)	19(8)	0.9(4)	4.404(12)	0	——
2.499(10)	27(10)	1.3(5)	4.522(12)	0	——
2.737(10)	17(3)	0.8(1)	4.760(12)	0	——

* All values taken from [2016Or03], except as noted.

** From [2016Or03]. Others: 15.9(6)% [2007Do17], > 2.5% [1996Fa09].

*** Calculated from proton energy and S_p (^{48}Mn) = 2023(6) keV [2021Wa16].

[@] Possibly decaying to 98 keV state in ^{47}Cr, with resulting E_{level} (emitter) 98 keV higher [2016Or03].

Table 11

β-p emission from ^{52}Ni*, $BR_{\beta p}$ = 31.1(5)%.

E_p(c.m.)	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{52}Co)**	$E_{daughter}$(^{51}Fe)	coincident γ-rays
1.048(10)	53.3(7)	7.30(9)	2.492(11)	0	——
1.352(10)	100	13.7(2)	2.796(11)	0	——
1.575(10)	8.5(3)	1.17(4)	3.019(11)	0	——
1.681(10)	11.0(3)	1.50(4)	3.125(11)	0	——
1.836(10)	3.1(2)	0.42(3)	3.280(11)	0	——
1.949(10)	9.3(2)	1.28(3)	3.393(11)	0	——
2.061(10)	8.3(2)	1.14(3)	3.505(11)	0	——
2.802(10)	7.4(2)	1.01(3)	4.246(11)	0	——
2.888(10)	1.3(2)	0.18(2)	4.332(11)	0	——
3.451(10)	0.80(7)	0.11(1)	4.895(11)	0	——

* All values taken from [2016Or03], except as noted.

** Calculated from proton energy and S_p (^{52}Co) = 1444(5) keV [2021Wa16].

Table 12

β-p emission from ^{56}Zn*, $BR_{\beta p}$ = 88.5(26)%.

E_p(c.m.)	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{56}Cu)**	$E_{daughter}$(^{55}Ni)	coincident γ-rays
0.831(10)	13(2)	3.0(4)	1.414(12)	0	——
1.131(10)	100	23.8(11)	1.714(12)	0	——
1.977(10)	19(4)	4.6(8)	2.560(12)	0	——
2.101(10)	72(5)	17.1(9)	2.684(12)	0	——
2.863(10)	89(6)	21.2(10)	3.446(12)	0	——
2.948(10)	79(6)	18.8(10)	3.531(12)	0	——

* All values taken from [2016Or03], except where noted.

** Calculated from proton energy and S_p (^{56}Cu) = 583(6) keV [2021Wa16].

Table 13
β-p emission from ^{60}Ge*, $BR_{\beta p}$ = 67(3)%*.

E_p(c.m.)	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{60}Ga)**	$E_{daughter}$(^{59}Zn)	coincident γ-rays
0.820(13)	8.5(12)	2.8(4)	0.910(20)	0	——
1.076(23)	12.1(15)	4.0(5)	1.166(27)	0	——
1.359(19)	15.5(12)	5.1(4)	1.449(24)	0	——
1.684 (17)	12.7(9)	4.2(3)	1.774(23)	0	——
2.067(15)	30.9(15)	10.2(5)	2.620(21)	0.4633(1)	0.4633(1)
2.522 (15)	100(3)	33(1)	2.612(21)	0	——
2.981(23)	9.7(9)	3.2(3)	3.071(27)	0	——
3.490(22)	5.8(6)	1.9(2)	3.580(27)	0	——

* All values taken from [2021Or01], except where noted.
** Calculated from proton energy and S_p (^{60}Ga) = 90(15) keV [2021Or01].

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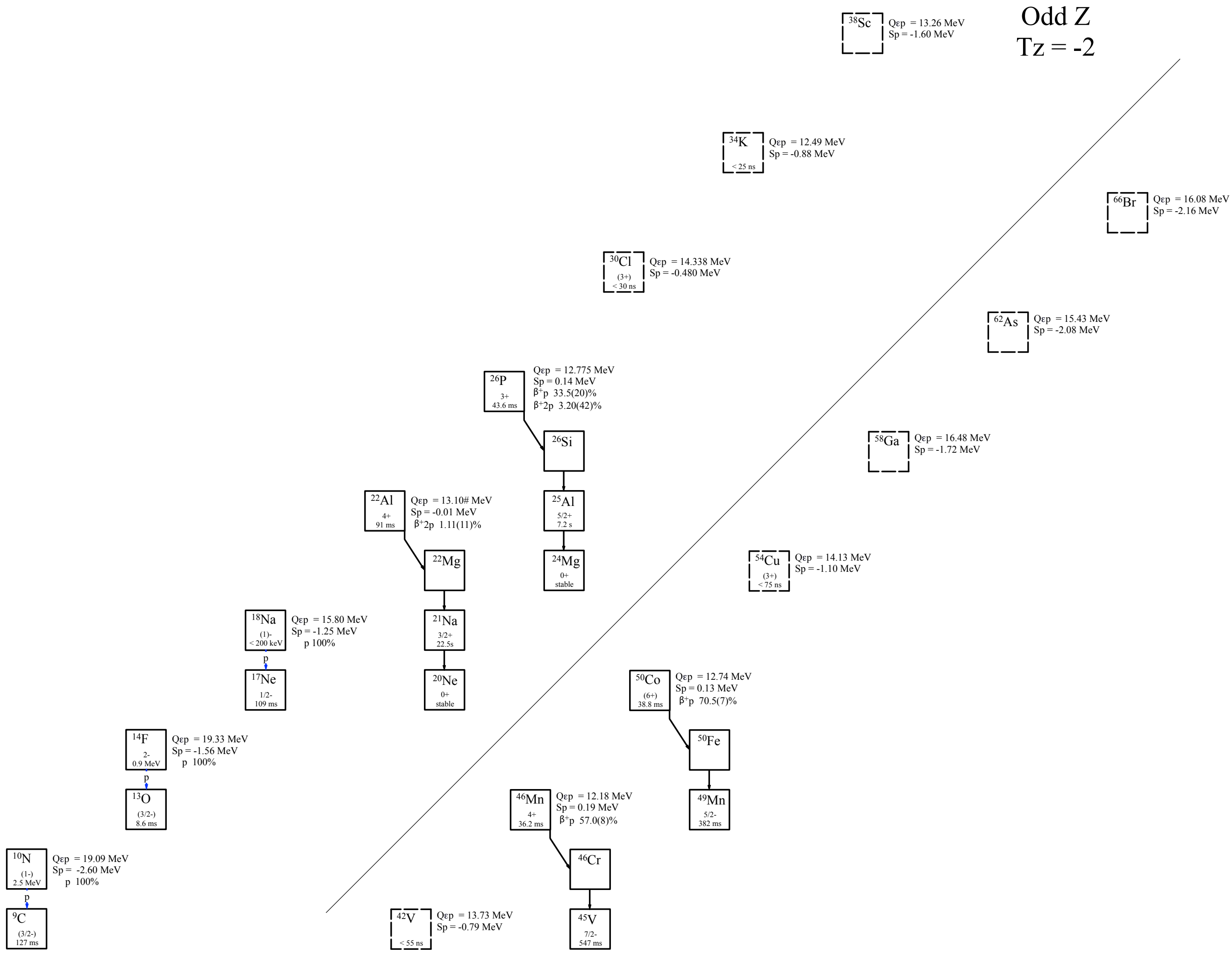

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= -2 nuclei.

Last updated 3/17/23

Table 1
Observed and predicted β-delayed particle emission from the odd Z, T_z = -2 nuclei. Unless otherwise stated, all Q-values values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$BR_{\beta 2p}$	$Q_{\varepsilon 3p}$	$Q_{\varepsilon\alpha}$	$BR_{\beta\alpha}$	Experimental
^{10}N	(1$^-$)	$2.5^{+2.0}_{-1.5}$ MeV	23.10(40)	19.09(40)		19.28(40)		2.03(40)	18.00(40)		[**2017Ho10**]
^{14}F	2$^-$	0.91(10) MeV	23.96(4)	19.33(4)		17.382(40)		1.425(40)	13.836(40)		[**2010Go16**]
^{18}Na	(1)$^-$	<0.2 MeV	19.72(9)	15.80(9)		15199(90)		3.072(90)	14.607(90)		[**2012Mu05**]
^{22}Al	4$^+$	91.1(5) ms	18.60(40)#	13.10(40)#	54.5(25)%	10.66(40)#	1.10(11)%	-2.18(40)#	10.46(40)#	0.038(17)%	[**2006Ac04**, 1997Bl03, 1982Ca16]
^{26}P	3$^+$	43.6(3) ms	18.285(61)*	12.775(61)**	33.5(20)%	10.505(61)**	3.20(42)%	-1.37(20)#	9.225(61)**		[**2022Li66, 2020Li06, 2017Ja05**, 2015Sc16, [2004Th09, 1983Ho23, 1983Ca06]
^{30}Cl	(3$^+$)	<30 ns	18.734(24)	14.338(24)		11.590(24)		0.005(24)	8.95(20)		
^{34}K		<25 ns	17.16(20)#	12.49(20)#		10.22(20)#		1.35(20)#	10.41(20)#		
^{38}Sc			17.81(20)#	13.26(20)#		11.40(20)#		2.90(20)#	11.70(20)#		
^{42}V		<55 ns	17.49(20)#	13.73(20)#		12.65(20)#		4.32(20)#	12.01(20)#		
^{46}Mn	4$^+$	36.2(4) ms	17.050(90)	12.180(90)	57.0(8)%	10.551(90)		1.901(90)	12.01(20)		[**2007Do17**, 2001Gi01, 1992Bo37]
^{50}Co	(6$^+$)	38.8(2) ms	16.89(13)	12.74(13)	70.5(7)%	10.65(13)#		2.55(13)#	9.46(13)		[**2007Do17**, 1996Fa09]
^{54}Cu	(3$^+$)	< 75 ns	18.04(40)#	14.13(40)#		12.51(40)#		5.14(40)#	10.81(40)#		
^{58}Ga			18.76(30)#	16.48(30)#		15.79(30)#		8.62(30)#	13.31(30)#		
^{62}As			17.72(33)#	15.43(30)#		15.18(30)#		10.07(30)#	15.46(30)#		
^{66}Br			18.09(45)#	16.08(41)#		16.17(40)#		11.11(40)#	16.15(42)#		

* Taken from [2022Li66], 18.11(20)# in [2021Wa16].
** Deduced from Q_ε [2022Li66] of ^{26}P, and daughter values from [2021Wa16].

Table 2
Particle emission from the odd Z, T_z = -2 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	BR_{1p}	S_{2p}	Q_α	Experimental
^{10}N	-2.60(40)	100%	-1.30(40)	-10.95(20)#	[**2017Ho10**]
^{14}F	-1.560(40)	100%	-0.050(40)	-9.26(400	[**2010Go16, 2012Go11**]
^{18}Na	-1.250(90)	100%	0.220(90)	-9.35(10)	[**2012Mu05, 2018Xu04**]
^{22}Al	-0.01(40)#		3.23(40)#	-9.26(41)#	[**2006Ac04**]
^{26}P	0.14(20)#		3.56(20)#	-9.65(45)#	
^{30}Cl	-0.480(20)		2.756(24)	-8.72(20)#	
^{34}K	-0.88(20)#		2.46(20)#	-8.32(20)#	
^{38}Sc	-1.60(20)#		1.41(20)#	-5.45(28)#	
^{42}V	-0.79(20)#		1.67(20)#	-5.80(28)#	
^{46}Mn	0.19(90)		3.19(90)	-7.22(21)#	
^{50}Co	0.13(13)		2.87(13)	-7.60(15)	
^{54}Cu	-1.10(40)#		1.47(40)#	-6.08(42)#	
^{58}Ga	-1.72(36)#		-0.51(30)#	-4.73(50)#	
^{62}As	-2.08(42)#		-0.59(36)#	-3.31(42)#	
^{66}Br	-2.16(30)#		-1.39(45)#	-1.57(50)#	

Table 3
β-p emission from ^{22}Al*, $T_{1/2}$ = 91.1(5) ms, $BR_{\beta p}$ = 54.5(25)%

E_p(c.m.)	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{22}Mg)**	$E_{daughter}$(^{21}Na)***	coincident γ-rays***
0.475(8)	25.6(42)	4.73(63)	6.311(8)	0.3319(1)	0.332
0.721(8)	40(7)	7.4(10)	6.225(8)	0	——
0.975(8)	1.4(3)	0.25(5)	6.479(8)	0	——
1.033(8)	16(2)	3.00(34)	6.869(8)	0.3319(1)	0.332
1.223(8)	4.05(66)	0.75(10)	6.727(8)	0	——
1.299(8)	100	18.51(17)	7.135(8)	0.3319(1)	0.332
1.551(10)	4.38(96)	0.81(16)	7.055(10)	0	——
1.753(8)	2.4(5)	0.45(8)	7.257(8)	0	——
2.072(8)	2.59(45)	0.48(7)	7.576(8)	0	——
2.503(10)	3.46(77)	0.64(13)	8.007(10)	0	——
2.583(8)	26.4(28)	4.89(24)	8.419(8)	0.3319(1)	0.332
2.838(8)	11.4(12)	2.11(9)	8.342(8)	0	——
3.088(8)	10.2(10)	1.89(7)	8.592(8)	0	——
3.484(8)	11.8(14)	2.18(15)	8.988(8)	0	——
4.017(8)	5.6(19)	1.04(33)	9.521(8)	0	——
4.224(9)	4.5(7)	0.84(11)	9.728(9)	0	——
4.464(8)	13.6(15)	2.52(14)	9.968(8)	0	——
4.912(10)	1.5(17)	0.27(32)	10.416(10)	0	——
5.177(13)	1.6(6)	0.29(11)	10.681(13)	0	——
5.667(8)	1.9(6)	0.35(11)	14.012(3)@	2.8291(7)	1.113, 1.384, 2.497, 0.332
5.808(49)	3.0(2)	0.18(55)	11.312(49)	0	——
5.909(56)	1.1(34)	0.21(62)	11.413(56)	0	——
6.774(8)	2.2(7)	0.41(12)	14.012(3)@	1.7161(3)	1.384, 0.332
7.517(11)	1.8(4)	0.33(7)	13.021(11)	0	——

* All values taken from [2006Ac04], except where noted.
** Calculated from proton energies and S_p (^{22}Al) = 5504.10(16) keV [2021Wa16].
*** Values from adopted levels in ENSDF [2015Fi05].
@ Assigned as IAS.

Table 4
β-2p emission from ^{22}Al*, $BR_{\beta 2p}$ = 1.10(11)%

E_{2p}(c.m.)	I_{2p}(rel)	I_{2p}(abs)	$E_{emitter}$ (^{22}Mg)	$E_{daughter}$(^{20}Ne)***	coincident γ-rays@
4.464(8)	100	0.69(8)	13.997(8)**	1.6337	1.634
6.085(8)	59(12)	0.41(7)	14.012(3)**	0	——

* All values taken from [2006Ac04], except where noted.
** Assigned as IAS.
*** Values from adopted levels in ENSDF [1998Ti06].

Table 5
β-α emission from ^{22}Al*, $BR_{\beta\alpha}$ = 0.038(17)%

E_α(c.m.)	I_α(abs)	$E_{emitter}$ (^{22}Mg)**	$E_{daughter}$(^{18}Ne)***	coincident γ-rays***
4.017(8)	0.038(17)	12.160(8)	1.8873(2)	1.887

* All values taken from [2006Ac04].
** Calculated from α energies and S_α (^{22}Mg) = 8142.5(4) keV [2021Wa16].
*** Values from adopted levels in ENSDF [1995Ti07].

Table 6
β-p emission from ^{26}P*, $T_{1/2}$=43.6(3) ms, $BR_{\beta p}$ = 33.5(20)%**.

E_p(c.m.)[@@]	I_p(rel)	I_p(abs)[@@]	$E_{emitter}$ (^{26}Si)***	$E_{daughter}$(^{25}Al)[@]	coincident γ-rays[@]
0.412(2)	100(7)	17.96(90)	5.926(2)	0	——
0.778(3)	4.3(5)	0.78(7)	6.292(3)	0	——
0.866(2)	9.5(10)	1.71(15)	6.380(2)	0	——
1.248(2)	8.4(8)	1.51(12)	6.762(2)	0	——
1.499(2)	5.5(5)	0.99(7)	7.958(2)	0.9449(5)	0.493, 0.945
1.638(3)	3.6(4)	0.65(6)	7.604(3)	0.4517(5)	0.452
1.798(4)	1.1(3)	0.20(5)	8.251(3)	0.9449(5)	0.452, 0.493
1.983(2)	13.3(11)	2.39(16)	7.497(2)	0	——
2.139(4)	3.0(8)	0.54(14)	9.429(3)	1.7895(5)	0.452, 0.493, 1.338
2.288(3)	8.2(9)	1.47(12)	9.429(3)	1.6125(5)	1.612
2.541(6)	0.5(2)	0.09(3)			
2.593(13)	1.5(3)	0.27(6)	8.559(13)	0.4517(5)	0.452
2.638(18)	0.6(2)	0.11(4)	8.152(18)	0	——
2.732(4)	2.6(4)	0.47(6)	8.251(4)	0	——
2.855(17)	<0.8(2)	<0.14(4)			
2.908(11)	0.3(3)	0.06(5)	9.367(11)	0.949(5)	0.452, 0.493
2.968(5)	1.8(3)	0.32(5)	9.419(4)	0.949(5)	0.452, 0.493
3.097(6)	1.7(4)	0.31(6)	10.401(6)	1.7895(5)	0.452, 0.493, 0.845, 1.790
3.258(4)	1.9(2)	0.23(4)	9.717(4)	0.949(5)	0.452, 0.493
3.766(9)	2.0(4)	0.36(7)	9.732(9)	0.4517(5)	0.452
3.817(6)	0.7(3)	0.13(5)	10.291(3)	0.949(5)	0.452, 0.945
3.879(3)	4.4(6)	0.79(12)			1.369
3.920(5)	6.7(9)	1.21(14)	9.419(4)	0	——
4.097(5)	<2.1(3)	<0.37(4)			
4.719(6)	1.3(2)	0.24(4)	10.685(6)	0.4517(5)	0.452
4.793(3)	3.0(4)	0.54(6)	10.291(3)	0	——
4.858(4)	2.5(3)	0.44(5)	10.824(4)	0.4517(5)	0.452
5.751(3)[@@@]	4.5(8)	0.81(14)[@@@]	13.055(2)[@@@a]	1.7895(5)	0.452, 0.493, 0.845, 1.790
5.921(4)[@@@]	2.4(5)	0.43(9)[@@@]	13.055(2)[@@@a]	1.6125(5)	1.625
6.401(10)[@@@]	0.40(32)	0.072(57)[@@@]	11.912(4)[@@@]	0.0	—
6.587(6)[@@@]	0.67(12)	0.12(2)[@@@]	13.055(2)[@@@a]	0.9449(5)	0.493, 0.945
7.075(16)[@@@]	1.0(2)	0.18(3)[@@@]	13.055(2)[@@@a]	0.4517(5)	0.452
7.54394)[@@@]	1.6(2)	0.29(4)[@@@]	13.055(2)[@@@a]	0.0	—
7.854(6)[@@@]	0.39(11)	0.07(2)[@@@]	13.380(13)[@@@]	0.0	—

* All values taken from [2004Th09], except where noted.
** From [2017Ja05].
*** Calculated from proton energies and S_p (^{26}Si) = 5514.00(11) keV [2021Wa16]. For levels de-excited by more than one proton transition, E_{level} (emitter) is the weighted average.
[@] Values from adopted levels in ENSDF: B. Singh Janurary 2018, http://www.nndc.bnl.gov/ensdf/
[@@] [2020Li06] report the 5 protons up to 1.5 MeV with energies/ Intensities(abs):
E_p(keV) / I_p (abs)%
0.418(8) / 11.1(12)
0.787(8) / 0.74(17)
0.870(8) / 1.44(30)
1.256(8) / 1.45(21)
1.507(9) / 0.80(18)
[@@@] [2022Li66].
[a] IAS.

Table 7
β-2p emission from ^{26}P*, $BR_{\beta 2p}$ = 3.2(4)%.

E_{2p}(c.m.)	I_{2p}(rel)	I_{2p}(abs)	$E_{emitter}$ (^{26}Si)	$E_{daughter}$(^{24}Mg)	coincident γ-rays
2.758(7)	15.1(6)	0.18(11)	11.912(4)	1.369	1.369
3.902(3)	53(21)	0.63(22)	13.055(2)**	1.369	1.369
4.125(5)	24(10)	0.29(10)	11.912(4)	0.0	—
4.250(10)	61(21)	0.72(21)	13.380(13)	1.369	1.369
5.277(4)	100(20)	1.19(24)	13.055(2)**	0.0	—
5.630(20)	16(7)	0.19(7)	13.380(13)	0.0	—

* All values taken from [2022Li66].
** IAS

Table 8
β-p emission from ^{46}Mn*, $T_{1/2}$=36.2(4) ms, $BR_{\beta p}$ = 57.0(8)%.

E_p(c.m.)	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{46}Cr)**	$E_{daughter}$(^{45}V)***	coincident γ-rays***
1.224(12)	28(6)	1.8(3)			
2.358(13)	26(7)	1.7(4)			
3.003(13)	100	6.5(9)	9.144(11)	1.2722(4)	1.272, 0.886, 0.329, 0.055
3.494(25)	54(12)	3.5(6)	9.144(11)	0.7972(5)	0.411, 0.329, 0.055, 0.741
4.254(15)	85(15)	5.5(9)	9.144(11)	0	——

* All values taken from [2007Do17], except where noted.

** IAS. Listed energy is the weighted average calculated from proton energies and S_p (^{46}Cr) = 4874(11) keV [2021Wa16].

*** Values from adopted levels in ENSDF [2008Bu01].

Table 9
β-p emission from ^{50}Co*, $T_{1/2}$=38.8(2) ms, $BR_{\beta p}$ = 70.5(7)%.

E_p(c.m.)	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{50}Fe)	$E_{daughter}$(^{49}Mn)***	coincident γ-rays***
1.874(16)	2.4(5)	1.0(2)	8.473(12)**	2.4813(4)	0.940, 0.482, 1.279, 0.798, 0.261
2.044(14)	7.3(15)	3.0(6)			
2.296(27)	2.2(7)	0.9(3)			
2.770(12)	100	41.1(24)	8.473(12)**	1.54131(25)	0.482, 1.279, 0.798, 0.261

* All values from [2007Do17], except where noted. Many of the delayed protons have not been measured resulting in a total intensity for individual protons to be lower than the total β^+-p intensity.

** IAS. Listed energy is the weighted average calculated from proton energies and S_p (^{50}Fe) = 4146(9) keV [2021Wa16].

*** Values from adopted levels in ENSDF [2008Bu17].

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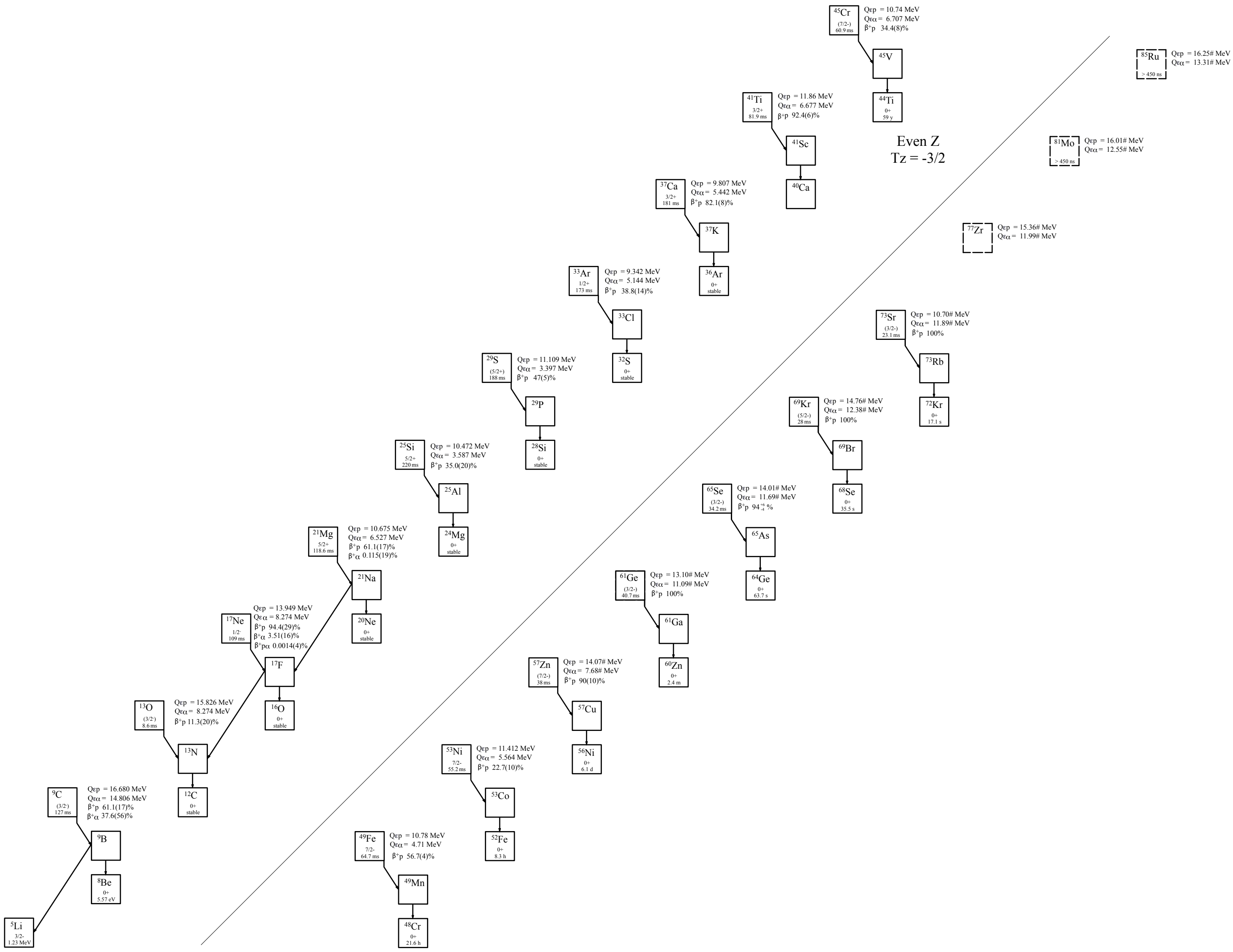

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= -3/2 nuclei.

Last updated 7/27/23

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = -3/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon 3p}$	$Q_{\varepsilon\alpha}$	$BR_{\beta\alpha}$	Experimental
^{9}C	(3/2$^-$)	126.5(9) ms	16.495(23)	16.680(2)	61.1(17)%*	-0.574(2)	-10.548(2)	14.806(50)	37.6(56)%**	[**2001Be51, 2001Bu05, 1972Es05**, 2004Ti06, 2000Ge09, 1988Mi03, 1972Es05, 1971EsZR, 1971EsZW, 1965Ha09]
^{13}O	(3/2$^-$)	8.58(5) ms	17.770(10)	15.826(10)	11.3(20)%	-0.131(10)	-11.360(10)	8.274(10)	0.078(6)%***	[**2023Bi03, 2005Kn02, 1990As01**, 1971EsZR, 1970Es03, 1966Ce02, 1965Mc09, 1963Ba63]
^{17}Ne	1/2$^-$	109.3(6) ms	14.5488(4)	13.9485(4)	94.4(29)%	1.8211(4)	-8.3865(4)	8.7300(5)	3.51(16)%$^@$	[**2002Mo19, 1988Bo39**, 2002Ch61, 1971EsZR, 1971Ha05, 1967Es02, 1966Es04, 1965Ha20, 1964Da13, 1964Fl03, 1964Mc16, 1963Ba63, 1963Ka36]
^{21}Mg	5/2$^+$	118.6(5) ms	13.0887(8)	10.657(1)	20.9(13)%	-2.187(1)	-10.180(1)	6.527(1)	0.115(19)%$^{@@}$	[**2015Lu12**, 2015Lu13, 1992Go10, 1985Zh05, 1974ScZL, 1973Go06, 1973GoZL, 1973Se08, 1973SeYM, 1965Ha20, 1965Mc01, 1964Fl03, 1963Ba63, 1963Ka36]
^{25}Si	5/2$^+$	220(4) ms	12.743(10)	10.472(10)	35.0(20)%	-1.221(10)	-10.015(10)	3.587(10)		[**2021Su03**, 2004Th09, 1993Ro06, 1992Ha28, 1985Zh05, 1975ScZC, 1974SeZL, 1974SeZM, 1973GoZL, 1973SeYM, 1966Ha22, 1966Re07, 1966Re15, 1965Ha20, 1965Mc01 1963Ba63, 1963Mc08]
^{29}S	(5/2$^+$)	187(6) ms	13.858(13)	11.109(13)	47(5)%	-0.475(13)	-8.747(13)	3.397(13)		[**1985Zh05, 1979Vi01**, 1978ViZT, 1978ViZT, 1973Go06, 1973GoZL 1964Ha45, 1967Fi10]
^{33}Ar	1/2$^+$	173.0(20) ms	11.6190(6)	9.3423(4)	38.8(14)%	0.4782(4)	-6.8183(4)	5.1435(6)		[**2010Ad03**, 2014Ko17, 2002Fy01, 2000Ga61, 1999Th09, 1996Ho24, 1993Sc16, 1987Bo21, 1971EsZR, 1971Ha05, 1966Po12, 1965Ha08, 1964Re08]
^{37}Ca	3/2$^+$	181.1(10) ms	11.6641(6)	9.8065(6)	82.1(8)%	1.299(1)	-5071(1)	5.442(1)		[**1997Tr05, 1991Ga23**, 2015Su01, 1997Ka10, 1995Tr03, 1974Se11, 1966Po12, 1964Ha42, 1964Re08]
^{41}Ti	3/2$^+$	81.9(5) ms	12.945(28)	11.860(28)	92.4(6)%$^{@@@}$	3.531(28)	-2.850(28)	6.677(28)		[**2015Sh16, 2007Do17,1998Bh12, 1998Li46, 1974Se11, 1997Tr11**, 2014Ka01, 1997Ho12, 1998Jo20, 1985Zh05, 1973Go06, 1966Po12, 1964Re08]
^{45}Cr	(7/2$^-$)	60.9(4) ms	12.370(40)	10.74(4)	34.4(8)%	2.100(40)	-2.830(40)	6.707(40)		[**2007Do17**, 1987Ki14, 1974Ja10]
^{49}Fe	7/2$^-$	64.7(3) ms	12.869(24)	10.782(25)	56.7(4)%	2.678(24)	-2.490(24)	4.710(24)		[**2007Do17**, 2002Pf03, 1996Fa09, 1970Ce02]
^{53}Ni	7/2$^-$	55.2(7) ms	13.029(25)	11.412(13)	22.7(10)%^{a}	4.0354(25)#	-1.237(25)	5.564(25)		[**2016Su10, 2007Do17**, 2013Su07, 1993Xu04, 1978ViZT]
^{57}Zn	(7/2$^-$)	43.6(2) ms	14.76(20)#	14.07(20)#	90(10)%	6.90(20)#	1.84(20)#	7.68(20)#		[**2022Sa20, 2020Ci04, 2007Bl09, 2002Jo09** 2002Lo13, 1979Vi01]
^{61}Ge	(3/2$^-$)	40.7(4) ms	13.35(30)#	13.10(30)#	78(3)%	7.99(30)#	4.57(30)#	11.09(30)#		[**2017GoZT, 2007Bl09**, 2002Lo13, 1987Ho01, 1978ViZT]
^{65}Se	(3/2$^-$)	34.2(2) ms	13.92(31)#	14.01(30)#	94^{+6}_{-4}%	8.95(30)#	6.28(30)#	11.69(30)#		[**2017GoZT, 2011Ro47**, 1993Ba12, 1978ViZT]
^{69}Kr	(5/2$^-$)	28(1) ms	14.12(30)#	14.76(30)#	100%^{b}	9.87(30)#	7.60(30)#	12.38(30)#		[**2011Ro47, 2014De41**, 2017GoZT]
^{73}Sr	(3/2$^-$)	23.1(14) ms	14.06(40)#	14.70(40)#	100%^{c}	9.97(40)#	8.11(40)#	11.89(40)#		[**2019Si33, 2020Ho17**, 2020Ho06, 1993Ba61]
^{77}Zr			14.84(45)#	15.36(40)#		11.04(40)#	8.87(40)#	11.99(40)#		
^{81}Mo		>450 ns	14.90(64)#	16.01(58)#		11.76(51)#	9.85(50)#	12.55(54)#		[**2017Su26**]
^{85}Ru		>450 ns	15.22(64)#	16.25(58)#		12.40(53)#	11.12(50)#	13.31(64)#		[**2017Su26**]

* Branching ratio is taken from [2001Bu05], normalized to the 54.1(15)% proton transition from the ground state of ^{9}B from Ref. [2001Be51]. The β-delayed p emission from ^{9}C ends in ^{8}Be which then decays into 2 α particles. Therefore this decay can be called β-p2α emission.

** The β-delayed α emission from ^{9}C ends in ^{5}Li which is proton unbound. Therefore this decay can be called β-αp emission.

*** [2023Bi03] report a value of 0.078(6)% for β-delayed 3αp decay. This value is a combination of both $^{13}\mathrm{O}\xrightarrow{\beta}{}^{13}\mathrm{N}\xrightarrow{p}{}^{12}\mathrm{C}\xrightarrow{\alpha}{}^{8}\mathrm{Be}\xrightarrow{2\alpha}$ and $^{13}\mathrm{O}\xrightarrow{\beta}{}^{13}\mathrm{N}\xrightarrow{\alpha}$-^{9}B $\xrightarrow{p}$ ^{8}Be$\xrightarrow{2\alpha}$.

$^@$ In addition a $BR_{\beta p\alpha}$ = 0.0014(4)% is reported [2002Mo19].

@@ In addition a $BR_{\beta p\alpha}$ = 0.016(3)% is reported [2015Lu12].
@@@ Weighted average of 91.6(6)% [2007Do17], 95.3(23)% [1998Bh12], and 100.3(22)% [1997Tr11].
[a] Weighted average of 23.4(10)% [2007Do17] and 22.0(10)% [2016Su10].
[b] Expected to be 100% as the daughter ^{69}Br is unbound by 640(40) keV [2017Wa10].
[c] Expected to be 100% as the daughter ^{73}Rb is unbound by 570(20) keV [2017Wa10].

Table 2
Particle emission from the even-Z, T_z = -3/2 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	Experimental
^{9}C	1.2996(24)	1.436(2)	-10.65(200)#	
^{13}O	1.512(10)	2.112(10)	-8.220(10)	
^{17}Ne	1.464(5)	0.933(1)	-9.040(10)	
^{21}Mg	3.2356(13)	5.4261(8)	-8.0215(8)	
^{25}Si	3.413(10)	5.277(10)	-9.501(19)	
^{29}S	3.236(13)	5.288(13)	-9.347(16)	
^{33}Ar	3.3386(7)	4.9197(5)	-8.715(13)	
^{37}Ca	3.0079(7)	4.667(1)	-6.177(1)	
^{41}Ti	2.463(28)	2.993(28)	-4.986(28)	
^{45}Cr	3.000(40)	4.780(40)	-6.240(50)	
^{49}Fe	2.743(25)	4.766(25)	-7.660(40)	
^{53}Ni	2.576(26)	4.020(25)	-7.310(30)	
^{57}Zn	1.21(20)#	1.79(20)#	-5.34(20)#	
^{61}Ge	1.49(36)#	1.15(30)#	-3.67(36)#	
^{65}Se	0.78(36)#	0.68(30)#	-1.66(42)#	
^{69}Kr	0.64(40)#	0.14(31)#	-1.55(42)#	
^{73}Sr	0.91(64)#	0.20(42)#	-2.24(50)#	
^{77}Zr	0.64(50)#	-0.44(46)#	-2.08(57)#	
^{81}Mo	0.33(64)#	-0.73(58)#	-2.29(64)#	
^{85}Ru	0.22(64)#	-1.13(64)#	-1.60(71)#	

Table 3
β-p Emission from ^{9}C, $T_{1/2}$=126.5(9) ms@@, $BR_{\beta p}$ = 61.1(17)%**

E_p*	I_p(rel)	I_p(abs)**	$E_{emitter}$ (^{9}B)***	$E_{daughter}$(^{8}Be)***	coincident γ-rays
0.1858(9)	100	58(11)	0	0	100% α
2.529(30)	0.23(3)	0.136(14)	2.34(3)	0	100% α
3.113(20)	0.18(1)	0.112(6)	2.93(20)	0	100% α
3.25(30)	8.6(9)	5.0(5)	3.10(30)	0	100% α
5.4(14)	1.2(6)	0.72(36)	$5.3^{+1.4}_{-0.5}$	0	100% α
9.32(40)	2.1(7)	1.2(4)	$12.16^{+0.03}_{-0.4}$	3.03	100% α
12.35(40)	0.084(19)	0.049(6)	$12.16^{+0.03}_{-0.4}$	0	100% α
13.526(20)	1.7(9)x 10^{-5}	9.3(5)x 10^{-6}	13.34(20)	0	100% α
14.22(10)	0.069(7)	0.07(2)	14.03(10)	0	100% α
@	0.38(20)	0.22(12)			100% α

* E_p values calculated from E_{level} (emitter) [2001Bu05] and S_p = -0.1858(9) MeV [2021HWa16].
** Branching ratio is taken from [2001Bu05], normalized to the 54.1(15)% proton transition from the ground state of ^{9}B from Ref. [2001Be51].
*** From (table 3 and figure 7) in [2001Bu05].
@ Background states [2001Be51].
@@ [1972Es05]

Table 4
β-α emission from ^{9}C, $BR_{\beta\alpha}$ = 37.6(56)%**

E_α*	I_α (rel)	I_α (abs)***	$E_{emitter}$ (^{9}B)***	$E_{daughter}$(^{5}Li)	coincident γ-rays
0.653(58)	100(19)	29.3(56)	2.34(3)	0	100% proton
1.237(53)	0.61(33)	0.18(9)	2.93(20)	0	100% proton
1.37(30)	0.11(3)	0.031(4)	3.1(3)	0	100% proton
$3.6^{+1.4}_{-0.5}$	1.7(9)	0.49(25)	$5.3^{+1.4}_{-0.5}$	0	100% proton
10.47(40)	12.0(10)	3.5(3)	12.16(40)	0	100% proton
12.34(11)	0.61(33)	0.18(9)	14.03(10)	0	100% proton
10.58@	0.18(12)	0.06(4)@	12.16(40)	1.49@	100% proton
#	0.105(5)	0.035(2)			100% proton

* E_α values deduced from $E_{emitter}$ (^{9}B) [2001Bu05] and Q_α = -1.690(50) MeV [2021Wa16].
** Branching ratio is taken from [2001Bu05], normalized to the 54.1(15)% proton transition from the ground state of ^{9}B from Ref. [2001Be51].
*** From (table 3 and figure 7) in [2001Bu05] unless otherwise stated.
# Background states [2001Be51].
@ From [2001Be51].

Table 5
β-p emission from ^{13}O*, $T_{1/2}$= 8.58(5) ms@, $BR_{\beta p}$ = 10.9(20)%.

E_p	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{13}N)	$E_{daughter}$(^{12}C)**	coincident γ-rays**
1.006(6)	2.4(3)	0.23(5)	7.376(9)***	4.4389(3)	4.438
1.5597(10)	100	9.5	3.502(2)***	0	——
2.591(6)	4.5(3)	0.43(8)	8.918(11)***	4.4389(3)	4.438
3.175(6)	1.06(11)	0.10(2)	9.476(8)***	4.4389(3)	4.438
5.445(6)	0.09(4)	0.009(4)	7.376(9)***	0	——
7.030(6)	5.3(4)	0.50(10)	8.918(11)***	0	——
7.396(53)	0.011(2)	0.0010(3)	15.300(200)	7.6542(2)	3.215, 4.438
7.614(6)	1.40(13)	0.13(3)	9.476(8)***	0	——
8.714(53)	0.030(5)	0.003(1)	15.0646(4)***	4.4389(3)	4.438
9.78(6)	0.15(4)	0.040(14)	11.700(30)***	0	——
11.32(9)	0.11(9)	0.010(9)	13.26(10)	0	——
13.152(53)	0.049(7)	0.005(1)	15.0646(4)***	0	——
13.5(4)	0.04(3)	0.004(3)	15.300(200)	0	——

* All values taken from [2005Kn02], except where noted.
** Values from adopted levels in ENSDF [2017Ke05].
*** Values from adopted levels in ENSDF [1991Aj01].
@ [1990As01]

Table 6
β-p Emission from ^{17}Ne*, $T_{1/2}$ = 109.3(5) ms$^{@}$, $BR_{\beta p}$ = 94.4(29)%

E_p	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{17}F)***	$E_{daughter}$(^{16}O)$^{@@}$	coincident γ-rays$^{@}$
0.358	<0.10	<0.049	8.075	7.1169(1)	7.115
0.47	0.066(59)	0.033(29)	10.655	9.585(11)	9.582, 6.916, 2.688
0.48	3.06(24)	1.51(9)	8.197	7.1169(1)	7.115
0.557	< 0.12	<0.058	8.074	6.9171(6)	6.916
0.560	<0.0037	<0.0018	10.032	8.8719(5)	2.742, 6.129, 1.755, 7.115
0.680	3.61(27)	1.78(13)	8.197	6.9171(6)	6.916
0.719	1.28(6)	0.63(3)	8.436	7.1169(1)	7.115
0.720	$< 2.8 \times 10^{-6}$	$< 1.4 \times 10^{-6}$	10.905	9.585(11)	9.582, 6.916, 2.688
0.918	1.28(6)	0.63(3)	8.435	6.9171(6)	6.916
1.002	0.029(8)	0.014(4)	11.187	9.585(11)	9.582, 6.916, 2.688
1.108	2.53(10)	1.25(5)	8.825	7.1169(1)	7.115
1.19	< 0.020	< 0.02	10.662	8.8719(5)	2.742, 6.129, 1.755, 7.115
1.307	2.47(11)	1.22(5)	8.824	6.9171(6)	6.916
1.344	0.16(15)	0.080(7)	8.075	6.129(89)	6.129
1.425	0.91(6)	0.45(3)	8.075	6.0494(1)	**
1.44	$< 3.1\times10^{-4}$	<0.00015	10.912	8.8719(5)	2.742, 6.129, 1.755, 7.115
1.47	0.97(23)	0.48(12)	8.200	6.129(89)	6.129
1.55	$< 3.3\times10^{-5}$	$<1.6\times10^{-5}$	8.200	6.0494(1)	**
1.706	4.83(17)	2.38(8)	8.436	6.1299	6.129
1.721	0.24(4)	0.12(2)	11.193	8.8719(5)	2.742, 6.129, 1.755, 7.115
1.73	0.62(4)	0.31(2)	9.447	7.1169(1)	7.115
1.786	0.70(3)	0.35(2)	8.436	6.0494(1)	**
1.93	1.83(7)	0.90(4)	9.447	6.9171(6)	6.916
2.095	0.16(2)	0.08(1)	8.825	6.1299	6.129
2.175	3.45(20)	1.7(1)	8.825	6.0494(1)	**
2.313	< 0.026	<0.013	10.027	7.1169(1)	7.115
2.504	0.31(3)	0.15(2)	3.104	0	
2.51	0.22(2)	0.11(1)	10.030	6.9171(6)	6.916
2.72	0.295(20)	0.15(1)	9.450	6.1299	6.129
2.8	0.93(5)	0.46(3)	9.450	6.0494(1)	**
2.94	< 0.011	<0.006	10.657	7.1169(1)	7.115
3.14	< 0.015	<0.008	10.657	6.9171(6)	6.916
3.19	0.23(2)	0.112(8)	10.907	7.1169(1)	7.115
3.3	0.034(10)	0.017(5)	10.030	6.1299	6.129
3.38	0.90(5)	0.45(3)	10.030	6.0494(1)	**
3.39	0.12(2)	0.057(9)	10.907	6.9171(6)	6.916
3.476	0.37	0.18	11.193	7.1169(1)	7.115
3.676	0.009(3)	0.004(1)	11.193	6.9171(6)	6.916
3.93	< 0.07	<0.035	10.660	6.1299	6.129
4.01	1.20(7)	0.59(4)	10.660	6.0494(1)	**
4.04	28.6(6)	14.1(8)	4.640	0	
4.18	< 0.07	<0.035	10.910	6.1299	6.129
4.26	1.20(7)	0.59(3)	10.910	6.0494(1)	**
4.463	0.50(2)	0.245(10)	11.193	6.1299	6.129
4.543	0.090(7)	0.045(3)	11.193	6.0494(1)	**
4.888	100(5)	49.4(27)	5.488	0	——
5.437	15.1(8)	7.5(4)	6.037	0	——
7.475	9.7(5)	4.8(3)	8.075	0	——
7.6	0.39(3)	0.19(1)	8.200	0	——
7.836	1.25(7)	0.62(4)	8.436	0	——
8.225	0.81(5)	0.40(2)	8.825	0	——
8.85	0.043(4)	0.022(2)	9.450	0	——
9.43	0.043(4)	0.021(2)	10.030	0	——
10.06	0.004(2)	0.0021(2)	10.660	0	——
10.31	0.028(4)	0.014(2)	10.910	0	——
10.5924	0.13(1)	0.063(4)	11.193	0	——
11.65	0.004(2)	0.0021(8)	12.250	0	——

* All values taken from [2002Mo19], error bars for energies are not given.
** E0 transition
*** Calculated from alpha energies and S_p (^{17}F) = 600.27(25) keV [2021Wa16].
@ [1988Bo39]
@@ Values from adopted levels in ENSDF [1993Ti07].

Table 7
β-α emission from ^{17}Ne*, $BR_{\beta\alpha}$ = 3.51(16)%.

E_α	I_α (rel)	I_α (abs)	$E_{emitter}$ (^{17}F)***	$E_{daughter}$(^{13}N)[@]	coincident γ-rays
1.827	0.08(4)**	0.002(1)**	11.193	3.547(4)	3.547
1.872			11.193	3.502(2)	3.502
2.256	100(6)	2.7(2)	8.075	0	
2.381	10.3(8)	0.28(2)	8.2	0	
2.617	4.4(3)	0.12(1)	8.436	0	
3.006	8.5(6)	0.23(2)	8.825	0	
3.63	2.7(2)	0.074(5)	9.45	0	
4.21	2.4(2)	0.065(5)	10.03	0	
4.84	0.031(28)	0.00085(76)	10.66	0	
5.09	0.55(7)	0.025(2)	10.91	0	
5.374	0.12(3)	0.003(1)	11.193	0	

* All values taken from [2002Mo19], error bars for energies are not given.
** Sum of I_α for E_α = 1.827 and 1.872.
*** Calculated from proton energies and S_α (^{17}F) = 5818.7(4) keV [2021Wa16].
[@] Values from adopted levels in ENSDF [1991Aj01]

Table 8
β-αp emission from ^{17}Ne*, $Q_{\varepsilon\alpha p}$ = 6.787(1) MeV, $BR_{\beta\alpha p}$ = 0.0014(4)%.

E_α	$E_{\alpha-emitter}$(^{17}F)	E_p	$E_{p-emitter}$(^{13}N)	E_{final}(^{12}C)	coincident γ-rays
3.0089	11.193	0.422	2.365	0	——

* All values taken from [2002Mo19], uncertainties for energies are not given.

Table 9
β-p emission from ^{21}Mg*, $T_{1/2}$ = 118.6(5) ms, $BR_{\beta p}$ = 20.9(13)%.

E_p	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{21}Na)***	$E_{daughter}$(^{20}Ne)[@]	coincident γ-rays[@]
0.396(10)	3.91(45)	0.22(3)	4.468(10)	1.6337	1.634
0.906(10)	2.0(5)	0.11(3)	8.303(10)	4.9665(2)	1.634, 3.333
0.919(21)	0.28(3)	0.016(2)	8.975(10)[a]	5.6214(17)	1.634, 3.987
0.937(10)	19.4(5)	1.10(3)	7.609(10)	4.2477(11)	1.634, 2.614
1.102(10)	3.34(6)	0.19(3)	3.544(10)	0	——
1.316(10)	20.01(15)	1.13(1)	5.380(10)	1.6337	1.634
1.427(10)	2.84(11)	0.16(1)	8.135(10)	4.2477(11)	1.634, 2.614
1.564(10)	4.66(9)	0.26(1)	8.975(10)[a]	4.9665(2)	1.634, 3.333
1.630(10)	2.95(17)	0.17(1)	8.303(10)	4.2477(11)	1.634, 2.614
1.861(10)	44.05(24)	2.50(2)	4.294(10)	0	——
2.037(10)	100.0(4)	5.66(2)	4.468(10)	0	——
2.144(10)	4.58(14)	0.26(1)	6.165(10)	1.6337	1.634
2.263(11)	3.79(55)	0.22(3)	6.341(11)	1.6337	1.634
2.302(10)	0.73(20)	0.04(1)	8.975(10)[a]	4.247(11)	1.634, 2.614
2.587(10)	20.89(24)	1.18(2)	5.020(10)	0	——
3.443(10)	34.6(31)	1.96(18)	5.884(10)	0	——
3.585(11)	8.0(15)	0.45(9)	7.609(11)	1.6337	1.634
4.055(10)	33.58(2.45)	1.90(14)	6.468(10)	0	——
4.257(10)	1.99(20)	0.11(1)	8.303(10)	1.6337	1.634
4.356(10)	1.94(19)	0.11(1)	8.397(10)	1.6337	1.634
4.769(10)	10.9(8)	0.62(5)	8.827(10)	1.6337	1.634
4.913(10)	24.29(176)	1.4(1)	8.975(10)[a]	1.6337	1.634
5.171(12)	5.63(75)	0.32(4)	7.609(12)	0	——
5.868(10)	1.56(18)	0.09(1)	8.303(10)	0	——
5.983(10)	1.37(13)	0.078(7)	8.397(10)	0	——
6.388(11)	2.86(29)	0.16(2)	8.827(11)	0	——
6.537(10)	8.85(65)	0.50(4)	8.975(10)[a]	0	——
7.20(30)	0.05(2)	0.003(1)	9.725(30)	0	——

* All values are taken from [2015Lu12], except where noted.
*** Energy levels from 2015Lu12 based on proton energies and known resonances in ^{20}Ne [1981Fe05, 1969Bl03, 1964Va10, 2004Fi10].
[@] Values from adopted levels in ENSDF [1998Ti06].
[a] IAS [2015Lu12].

Table 10
β-α emission from ^{21}Mg*, $BR_{\beta\alpha}$ = 0.115(19)%.

E$_\alpha$	I$_\alpha$ (rel)	I$_\alpha$ (abs)	$E_{emitter}$ (^{21}Na)	$E_{daughter}$(^{17}F)	coincident γ-rays
2.201(27)	0.11(1)	0.0062(5)	8.827(27)	0	——
2.397(10)	1.79(5)	0.100(3)	8.975(10)	0	——
2.700(43)	0.10(1)	0.0056(6)	9.725(30)	0.495	0.495
3.060(81)	0.04(1)	0.0022(6)	9.725(30)	0	——

* Values are taken from [2015Lu12].

Table 11
β-$p\alpha$ emission from ^{21}Mg*, $Q_{\varepsilon p\alpha}$ = 5.927(1) MeV, $BR_{\beta p\alpha}$ = 0.016(3)%.

E_p (c.m.)	E$_{p-emitter}$ (^{21}Na)	E$_\alpha$(c.m.)	E$_{\alpha-emitter}$ (^{20}Ne)	E$_{final}$(^{16}O)	coincident γ-rays
0.921(21)	8.975(10)	0.882(18)	8.054(18)	0	

* Values are taken from [2015Lu12].

Table 12
β-p emission from ^{25}Si*, T$_{1/2}$ = 220(4) ms$^@$, $BR_{\beta p}$ = 35.0(20)%

E_p	I_p(rel)%^{b}	I_p(abs)%	$E_{emitter}$ (^{25}Al)**	$E_{daughter}$(^{24}Mg)***	coincident γ-rays**
0.4020(9)	59(17)	6.1(15)	2.6733(6)	0	——
0.554(10)	4.8(25)	0.49(25)	4.192(4)	1.369	1.369
0.724(4)	0.3(15)	0.036(15)	7.240(3)	4.238	1.369, 2.870, 4.238
0.9437(11)	17(5)	1.7(5)	4.582(2)	1.369	1.369
1.037(16)	1.6(6)	0.16(6)	7.422(5)	4.123	1.369, 2.754
1.268(5)	4.0(22)	0.41(22)	4.906(4)	1.369	1.369
1.380(5)	3.7(14)	0.38(14)	7.901(2)	4.238	1.369, 2.870, 4.238
1.492(6)	2.5(13)	0.26(13)	7.901(2)	4.123	1.369, 2.754
1.584(3)	2.9(16)	0.30(16)	3.8591(8)	0	——
1.684(12)	1.7(10)	0.18(10)	8186(3)	4.238	1.369, 2.870, 4.238
1.794(3)	5.0(20)	0.51(19)	8.186(3)	4.123	1.369, 2.754
1.9243(20)	25(8)	2.6(7)	4.192(4)	0	——
2.164(3)	17(5)	1.7(4)	5804(4)	1.369	1.369
2.3100(9)	15(4)	1.5(3)	4.582(2)	0	——
2.453(25)	0.40(12)	0.040(11)	6063(7)	1.369	1.369
2.486(25)	1.0(3)	0.10(3)	6.170(2)	1.369	1.369
2.632(10)	0.50(12)	0.048(10)	4.906(4)	0	
3.006(11)	4.1(25)	0.42(25)	6.650(5)	1.369	1.369
3.236(6)	4.1(16)	0.42(16)	6.877(7)	1.389	1.369
3.327(4)	5(3)	0.5(3)	5.597(6)	0	——
3.464(3)	35(15)	3.6(15)	7.118(5)	1.369	1.369
3.606(4)	10(5)	1.0(5)	7.240(3)	1.369	1.369
3.896(8)	2.9(10)	0.3(1)	6.170(2)	0	——
4.257(3)	100(14)	10.3(14)	7.901(2)	1.369	1.369
4.345(17)	4.4(16)	0.45(15)	7.936(20)	1.369	1.369
4.551(5)	2.9(10)	0.3(1)	8.186(3)	1.369	1.369
4.614(9)	0.30(12)	0.035(11)	6.909(10)	0	——
4.614(9)	0.30(12)	0.035(11)	6.909(10)	0	——
4.845(4)	11(8)	1.1(8)	7.118(5)	0	——
4.980(4)	2.7(23)	0.28(23)	7.240(3)	0	——
5.382(11)	2.2(14)	0.23(14)	7.646	0	——
5.549(15)	3.1(10)	0.32(9)	7.819(20)	0	——
5.6288(15)	21(7)	2.2(6)	7.901(2)	0	——
6.798(5)	1.3(10)	0.13(10)	9.073(7)	0	——
7.000(25)	0.10(2)	0.0127(17)	9.275(25)$^{@@}$	0	——
7.141(30)	0.10(2)	0.0127(17)	9.415(30)$^{@@}$	0	——

* average of all data from [2021Su03], [1993Ro06], [1992Ha28], [1985Zh05], taken from table 3 of [2021Su03],
** Values from adopted levels in ENSDF [2009Fi05] except where noted.
*** Values from adopted levels in ENSDF [2007Fi14].
$^@$ Weighted average of 225(6) ms [1965Mc01] and 218(4) ms [1966Re07].
$^{@@}$ [1985Zh05].

Table 13

β-p emission from ^{29}S*, $T_{1/2}$ = 187(6) ms, $BR_{\beta p}$ = 47(5)%.

E_p(c.m.)	I_p(rel)%	I_p(abs)%[@@]	$E_{emitter}$ (^{29}P)	$E_{daughter}$(^{28}Si)**	coincident γ-rays**
0.766[@]	22(2)	3.4(3)	5.294(6)	1.779	1.779
1.042(25)	1.0(4)	0.16(6)	8.389(13)	4.619	1.779, 2.838
1.302(10)	24(3)	3.8(4)	5.826(8)	1.779	1.779
1.829(15)	2.4(3)	0.38(5)	6.357(15)	1.779	1.779
1.978(15)	1.9(3)	0.30(4)	6.506(15)	1.779	1.779
2.206[@]	75(3)	11.9(4)	4.955(9)	0	——
2.545[@]	3.4(3)	0.53(4)	5.294(6)	0	——
2.621(10)	6.8(5)	1.08(7)	7.149(10)	1.779	1.779
2.986(15)	0.52(10)	0.082(15)	7.514(15)	1.779	1.779
3.067(15)	1.14(13)	0.18(2)	5.826(8)	0	
3.212(15)	1.14(13)	0.18(2)	5.961(15)	0	——
3.326(15)	1.01(13)	0.16(2)	6.075(15)	0	——
3.414(15)	2.2(2)	0.34(3)			
3.579(15)	2.4(3)	0.38(5)	6.328(15)	0	——
3.715(15)	1.3(3)	0.21(4)	8.243(11)	1.779	1.779
3.853[@]	14.8(9)	2.34 12	8.389(13)	1.779	1.779
3.905(15)	4.5(4)	0.71(6)	6.654(15)	0	——
4.008(20)	1.7(4)	0.27(6)	8.535(14)	1.779	1.779
4.335(20)	6.8(5)	1.08(7)	7.085(20)	0	——
4.493(20)	2.1(3)	0.33(4)	7.242(20)	0	——
4.640(25)	1.6(3)	0.25(4)	7.389(25)	0	——
4.852(20)	1.7(3)	0.27(4)	9.394(17)	1.779	1.779
5.008(20)	1.5(3)	0.23(4)	7.757(20)	0	——
5.359(15)	4.4(5)	0.69(7)	8.108(15)	0	——
5.493(15)	5.8(5)	0.92(7)	8.243(11)	0	——
5.632[@]	100(3)	15.8(4)	8.389(13)	0	——
5.784(20)	5.5(5)	0.87(7)	8.535(14)	0	——
6.062(30)	0.89(19)	0.14(3)	8.811(20)	0	——
6.676(30)	1.0(2)	0.16(3)	9.394(17)	0	——
6.965(50)***	0.10(2)***	0.016(3)	9.714(50)	0	——
7.105(30)***	0.21(2)***	0.033(3)	9.854(30)	0	——
7.343(30)***	0.12(1)***	0.019(2)	10.092(30)	0	——
7.789(30)***	0.18(1)***	0.028(2)	10.538(30)	0	——

* All values taken from [1979Vi01] except where noted.

** Values from adopted levels in ENSDF [2013Ba53].

*** [1985Zh05].

[@] Proton peaks that were used as energy calibrations.

[@@] Deduced by evaluator from beta branching (table 2 in [1979Vi01]) and proton branching ratios from these states (tables 3 and 4 in [1979Vi01]).

Table 14
β-p emission from ^{33}Ar*, $T_{1/2}$ = 173(2) ms, $BR_{\beta p}$ = 38.8(14)%**

E_p	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{33}Cl)***	$E_{daughter}$(^{32}S)@	coincident γ-rays@
0.786(10)	0.065(6)	0.0202(17)	5.307(4)	2.2306(2)	2.230
1.358(8)	0.54(4)	0.168(9)	5.866(8)	2.2306(2)	2.230
1.696(2)	1.33(64)	0.41(20)	3.973(2)	0	——
1.717(6)	0.019(4)	0.0060(11)	7.762(3)	3.7784(10)	1.549, 2.230
1.744(6)	0.107(11)	0.0332(32)	6.254(3)	2.2306(2)	2.230
1.819(5)	0.026(4)	0.0081(13)	6.326(5)	2.2306(2)	2.230
1.837(2)	1.52(10)	0.471(22)	4.113(2)	0	——
2.087(5)	0.014(2)	0.0043(7)	6.595(5)	2.2306(2)	2.230
2.166(3)	8.81(56)	2.73(12)	4.442(3)	0	——
2.442(6)	0.004(1)	0.0012(3)	8.491(5)	3.7784(10)	1.549, 2.230
2.444(5)	0.049(4)	0.0153(12)	6.951(5)	2.2306(2)	2.230
2.559(2)	1.17(8)	0.362(17)	4.835(2)	0	——
2.795(7)	0.022(4)	0.0069(12)	7.292(3)	2.2306(2)	2.230
2.830(3)	0.156(16)	0.0483(44)	5.107(3)	0	——
2.898(10)	0.045(5)	0.00141(14)	7.405(10)	2.2306(2)	2.230
2.976(7)	0.121(13)	0.0376(35)	7.484(7)	2.2306(2)	2.230
3.033(4)	0.24(2)	0.0748(55)	5.310(4)	0	
3.049(7)	0.116(12)	0.0359(32)	7.557(7)	2.2306(2)	2.230
3.110(10)	0.0023(7)	0.0007(2)	9.153(4)	3.7784(10)	1.549, 2.230
3.162(6)	0.0145(65)	0.0045(20)	7.666(3)	2.2306(2)	2.230
3.272(3)	100	31.0(14)	5.549(3)	0	——
3.455(4)	0.296(16)	0.0918(48)	5.731(4)	0	——
3.577(6)	0.171(15)	0.0531(40)	8.077(3)	2.2306(2)	2.230
3.625(6)	0.048(8)	0.0150(25)	8.132(6)	2.2306(2)	2.230
3.688(5)	0.027(5)	0.0085(16)	8.183(3)	2.2306(2)	2.230
3.978(3)	2.37(15)	0.735 (34)	6.254(3)	0	——
4.049(5)	0.026(4)	0.0082(13)	8.558(4)	2.2306(2)	2.230
4.341(5)	0.021(3)	0.00645(80)	8.848(5)	2.2306(2)	2.230
4.465(8)	0.0046(13)	0.00142(40)	8.969(5)	2.2306(2)	2.230
4.614(5)	0.0118(19)	0.00367(55)	9.119(4)	2.2306(2)	2.230
4.646(6)	0.0151(21)	0.00467(62)	9.153(4)	2.2306(2)	2.230
4.866(5)	0.0025(3)	0.00079(10)	7.143(5)	0	——
5.012(4)	0.031(3)	0.0097(8)	7.292(3)	0	——
5.077(6)	0.0021(5)	0.00066(16)	9.584(6)	2.2306(2)	2.230
5.196(4)	0.723(51)	0.224(12)	7.473(4)	0	——
5.260(4)	0.152(18)	0.047(5)	7.537(4)	0	——
5.388(4)	0.0742(84)	0.0234(24)	7.666(3)	0	——
5.483(3)	0.0268(41)	0.0083(12)	7.760(3)	0	——
5.799(3)	0.400(29)	0.124(7)	8.077(3)	0	——
5.902(3)	0.297(21)	0.092(5)	8.183(3)	0	——
6.038(9)	0.0092(14)	0.00284(40)	8.315(9)	0	——
6.199(10)	0.0032(5)	0.00100(15)	8.491(5)	0	——
6.291(10)	0.0445(52)	0.0138(15)	8.558(4)	0	——
6.542(8)	0.0017(3)	0.00053(9)	8.819(8)	0	——
6.589(10)	0.0009(3)	0.00027(8)	8.865(10)	0	——
6.683(10)	0.0332(39)	0.0103(10)	8.969(5)	0	——
6.835(10)	0.0055(8)	0.00170(23)	9.119(4)	0	——
6.865(9)	0.0016(3)	0.00049(10)	9.142(9)	0	——
6.925(9)	0.00012(3)	0.0032(4)	9.202(9)	0	——
7.01-7.12	0.00074(29)	0.00023(9)		0	——
7.12-7.22	0.00023(10)	0.00007(3)		0	——
7.22-7.32	0.00103(14)	0.00032(4)		0	——
7.43-7.53	0.00039(10)	0.00012(3)		0	——
7.53-7.63	0.00032(10)	0.00010(3)		0	——
7.63-7.73	0.00026(10)	0.00008(3)		0	——
7.73-8.25	0.00019(10)	0.00006(3)		0	——
8.25-9.28	0.00013(10)	0.00004(3)		0	——

* All values taken from [2010Ad03], except where noted.
** From [2010Ad03]. Other: 38.7(10)% [1987Bo21].
*** Energy calculated from proton energies and S_p (^{33}Cl) = 2276.8(4) keV [2021Wa16]. For levels de-excited by more than one proton transition, E_{level} (emitter) is the weighted average.
@ Values from adopted levels in ENSDF [2011Ou01].

Table 15
β-p emission from ^{37}Ca, $T_{1/2}$ = 181.1(10) ms*, $BR_{\beta p}$ = 82.1(8)%**

E_p***	I_p(rel)@@	I_p(abs)@	$E_{emitter}$ (^{37}K)**	$E_{daughter}$(^{36}Ar)@@@	coincident γ-rays@@@
0.418(5)	a@	a@	6.6040(47)	4.3291(7)	2.359, 1.970
0.585(2)	b@	b@	4.4128(13)	1.9704(1)	2.359, 1.970
0.893(2)	11(1)	5.2(5)	2.7501(8)	0	
1.223(2)	c@	c@	5.0506(13)	1.9704(1)	1.970
1.293(2)	d@	d@	5.1202(16)	1.9704(1)	1.970
1.382(2)	≈0.4	≈0.2	3.2394(18)	0	——
1.438(4)	e@	e@	7.4733(33)	4.1783(1)	2.208, 1.970
1.496(2)	f@	f@	5.3230(18)	1.9704(1)	1.970
1.596(3)	0.124(28)	0.058(13)	5.423.7(30)	1.9704(1)	1.970
1.765(3)	6.9(4)	3.2(2)	3.6222(25)	0	——
1.796(3)	g@	g@	5.6234(24)	1.9704(1)	1.970
1.983(3)	7.5(4)	3.5(2)	3.8402(31)	0	——
2.187(3)	h@	h@	6.0142(28)	1.9704(1)	1.970
2.264(3)	i@	i@	6.0915(28)	1.9704(1)	1.970
2.334(9)	0.13(4)	0.06(2)	4.191(9)	0	——
2.566(2)	2.4(1)-b@	1.10(5)-b@	4.4128(13)	0	——
2.604(4)	j@	j@	6.4313(33)	1.9704(1)	1.970
2.638(4)	3.0(2)	1.4(1)	4.4955(39)	0	——
3.159(5)	2.1(21)	1.0(10)	5.0161(43)	0	——
3.194(2)	100-c@	46.7-c@	5.0506(13)	0	——
3.263(2)	18.2(9)-d@	8.5(4)-d@	5.1202(16)	0	——
3.411(5)	k@	k@	7.2380(47)	1.970	1.970
3.466(2)	1.20(9)-f@	0.56(4)-f@	5.3230(18)	0	——
3.500(7)	0.11(2)	0.052(7)	5.3570(66)	0	——
3.541(4)	l@	l@	7.2380(47)	1.9704(1)	1.970
3.589(5)	0.28(2)	0.13(1)	5.4459(47)	0	——
3.608(5)	0.47(4)	0.22(2)	5.4648(46)	0	——
3.646(4)	e'@	e'@	7.4733(33)	1.9704(1)	1.970
3.712(5)	0.084(15)	0.039(7)	5.5693(45)	0	——
3.766(3)	0.32(4)-g@	0.15(2)-g@	5.6234(24)	0	——
3.804(5)	0.21(2)	0.10(1)	7.6315(47)	1.9704(1)	1.970
3.931(5)	0.12(2)	0.054(8)	5.7882(49)	0	——
3.978(4)	m@	m@	7.8053(37)	1.9704(1)	1.970
4.007(5)	0.21(2)	0.1(1)	7.8343(46)	1.9704(1)	1.970
4.075(5)	0.39(4)	0.18(2)	5.9316(46)	0	——
4.157(3)	1.24(9)-h@	0.58(4)-h@	6.0142(28)	0	——
4.234(3)	0.80(6)-i@	0.37(3)-i@	6.0915(28)	0	——
4.466(5)	0.30(2)	0.14(1)	6.3228(48)	0	——
4.557(5)	0.163(3)	0.076(12)	6.4144(48)	0	——
4.574(4)	0.28(4)-j@	0.13(2)-j@	6.4313(33)	0	——
4.747(5)	0.13(6)-a@	0.06(3)-a@	6.6040(47)	0	——
4.826(5)	0.043(9)	0.020(4)	6.6827(47)	0	——
4.882(5)	0.017(4)	0.008(2)	6.7389(47)	0	——
4.966(5)	0.032(9)	0.015(4)	6.8229(47)	0	——
5.116(5)	0.34(4)	0.16(2)	6.9729(47)	0	——
5.216(5)	0.24(2)	0.11(1)	7.0727(47)	0	——
5.325(4)	0.64(15)	0.30(7)	7.1823(35)	0	——
5.381(5)	0.099(15)-k@	0.046(7)-k@	7.238(5)	0	——
5.511(4)	0.45(4)-l@	0.21(2)-l@	7.3685(33)	0	——
5.616(4)	0.75(9)-e-e'@	0.35(4)-e-e'@	7.4733(33)	0	——
5.685(5)	0.045(9)	0.021(4)	7.5423(47)	0	——
5.803(5)	0.073(15)	0.034(7)	7.6598(49)	0	——
5.948(4)	0.34(4)-m@	0.16(2)-m@	7.8053(37)	0	——
6.170(5)	0.084(15)	0.039(7)	8.0273(53)	0	——

* [1997Tr05].
** [1991Ga23].
*** E_p values deduced from ^{37}K level [1991Ga23] and S(p)=1857.0(14) [2021Wa16] for ^{37}K.
@ Sum of unresolved proton intensities from the emitting state. [1991Ga23] recorded multiple decays from the state with B(GT) values, but did not record individual proton branching ratios.
@@ I_p values from [2012Ni01] based on B(GT) values [1991Ga23].
@@@ Values from adopted levels in ENSDF [2012Ni01].

Table 16
β-p emission from ^{41}Ti*, $T_{1/2}$ = 81.9(5) ms[@], $BR_{\beta p}$ = 92.4(6)%[@@].

E_p	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{41}Sc)**	$E_{daughter}$(^{40}Ca)***	coincident γ-rays***
0.771(12)	3.3(25)	0.86(66)	5.762(12)	3.9044	3.904
1.011(2)	19.78(12)	5.15(3)	2.096(2)	0	——
1.280(15)	3.92(73)	1.02(19)	6.270(15)	3.9044	——
1.581(2)	18.28(19)	4.76(5)	2.666(2)	0	——
1.627(10)	2.61(8)	0.68(2)	2.712(10)	0	——
1.888(40)	2.99(12)	0.78(3)	6.893(28)	3.9044	3.904
2.026(10)	1.98(69)	0.52(18)	6.464(10)	3.3526(1)	3.353
2.131(25)	2.99(8)	0.78(2)	6.953(25)	3.7367(1)	3.737
2.328(3)	15.67(8)	4.08(2)	3.413(3)	0	——
2.472(3)	8.96(8)	2.33(2)	3.559(3)	0	——
2.604(13)	2.35(50)	0.61(13)	3.689(13)	0	——
2.721(8)	4.10(12)	1.07(3)	3.806(8)	0	——
2.873(8)	2.5(6)	0.66(16)	3.958(8)	0	——
3.159(4)	62.7(3)	16.33(6)	4.244(4)	0	——
3.232(19)	3.0(7)	0.78(18)	4.317(19)	0	——
3.422(9)	2.61(8)	0.68(2)	4.507(9)	0	——
3.570(9)	2.5(2)	0.65(6)	4.655(9)	0	——
3.690(5)	5.9(6)	1.55(16)	4.775(5)	0	——
3.750(8)	11.6(4)	3.01(10)	4.868(4)	0	——
3.843(4)	28.4(3)	7.39(7)	4.928(5)	0	——
3.928(8)	3.0(5)	0.78(14)	5.013(8)	0	——
3.987(18)	2.7(5)	0.71(12)	5.072(18)	0	——
4.294(4)	13.8(7)	3.59(17)	5.379(4)	0	——
4.410(12)	1.49(8)	0.39(2)	5.495(12)	0	——
4.495(6)	5.8(6)	1.5(2)	5.580(6)	0	——
4.683(7)	2.4(4)	0.62(9)	5.768(7)	0	——
4.754(4)	14.93(19)	3.89(5)	5.839(4)	0	——
4.800(10)	4.48(12)	1.17(3)	5.885(10)	0	——
4.853(3)	100.00(8)	26.05(2)	5.938(3)	0	——
4.951(10)	7.84(19)	2.04(5)	6.036(10)	0	——
4.999(17)	3.3(4)	0.86(9)	6.084(15)	0	——
5.068(11)	3.2(4)	0.83(10)	6.153(11)	0	——
5.288(14)	3.0(4)	0.79(10)	6.373(14)	0	——
5.349(40)	2.4(5)	0.63(13)	6.434(40)	0	——
5.498(60)	1.40(8)	0.36(2)	6.583(60)	0	——
5.587(40)	2.2(5)	0.58(13)	6.672(40)	0	——
5.743(14)	2.8(15)	0.73(38)	6.828(14)	0	——
5.861(14)	1.0(4)	0.27(10)	6.946(14)	0	——
6.096(20)	0.75(19)	0.19(5)	7.181(20)	0	——
6.274(19)	0.56(19)	0.15(5)	7.359(19)	0	——
6.530(38)	0.37(12)	0.10(3)	7.615(38)	0	——
6.893(60)	0.28(10)	0.073(25)	7.978(60)	0	——

* Values are from a weighted average of [1998Bh12, 1998Li46, 1997Ho12, 1974Se11, 2015Sh16], except where noted.
** Energy calculated from proton energies and S_p (^{41}Sc) = 1084.93(7) keV [2021Wa16].
*** Values from adopted levels in ENSDF [2017Ch09].
[@] [2015Sh16].
[@@] Weighted average of 91.6(6)% [2007Do17], 95.3(23)% [1998Bh12], and 100.3(22)% [1997Tr11].

Table 17
β-p emission from ^{45}Cr*, $T_{1/2}$ = 60.9(4) ms, $BR_{\beta p}$ = 34.4(8)%

E_p	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{45}V)**	$E_{daughter}$(^{44}Ti)***	coincident γ-rays***
0.945(31)	2.0(15)	0.4(3)			
1.303(25)	2.6(10)	0.5(2)			
1.468(27)	2.0(15)	0.4(2)			
1.609(28)	2.0(15)	0.4(2)			
2.087(9)	100	19.6(15)	4.796(9)	1.0831(1)	1.083

* All values taken from [2007Do17] except where noted.
** Energy calculated from proton energies and S_p (^{45}V) = 1626.8(11) keV [2021Wa16].
*** Values from adopted levels in ENSDF [2011Ch39].

Table 18

β-p emission from ^{49}Fe*, $T_{1/2}$ = 64.7(3) ms, $BR_{\beta p}$ = 56.7(4)%

E_p	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{49}Mn)	$E_{daughter}$(^{48}Cr)**	coincident γ-rays**
1.120(39)	3.8(14)	1.3(5)	3.921	0.7522(1)	0.752
1.321(24)	0.6(3)	0.2(1)			
1.544(17)	4.3(7)	1.5(3)	4.380	0.7522(1)	0.752
1.975(13)	100	34.5(2)	4.809	0.7522(1)	0.752

* Values are taken from [2007Do17], energy and intensity values are from a weighted average of [2007Do17, 1996Fa09, 1970Ce02]:

** Values from adopted levels in ENSDF [2006Bu08].

Table 19

β-p emission from ^{53}Ni*, $T_{1/2}$ = 55.2(7) ms, $BR_{\beta p}$ = 22.7(10)%$^{@@}$

E_p	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{53}Co)***	$E_{daughter}$(^{52}Fe)$^{@}$	coincident γ-rays$^{@}$
1.077(28)	15(4)	0.8(2)			
1.251(27)	15(4)	0.8(2)			
1.639(22)	33(4)	1.8(2)			
1.921(7)**	100	5.5(4)	4.395(7)	0.8495(1)	0.849
2.111(24)	44(6)	2.4(3)			
2.399(26)	59(9)	3.2(5)			

* Values are from [2007Do17], except where noted.

** [2016Su10].

*** Energy calculated from proton energies and S_p (^{53}Co) = 1616.3(17) keV [2021Wa16].

$^{@}$ Values from adopted levels in ENSDF [2015Ya15].

$^{@@}$ Weighted average of 23.4(10)% [2007Do17] and 22.0(10)% [2016Su10].

Table 20

β-p emission from ^{57}Zn*, $T_{1/2}$ = 38(2) ms, $BR_{\beta p}$ = 90(10)%**.

E_p	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{57}Cu)***	$E_{daughter}$(^{56}Ni)$^{@}$	coincident γ-rays$^{@}$
1.168(15)	16(4)	3.5(12)	4.559(15)	2.7006(7)	2.701
1.685(17)	4(2)	0.9(5)	2.375(17)	0	——
1.836(15)	36(6)	8(2)	2.526(15)	0	——
1.902(12)	100(10)	22(5)	5.293(12)	2.7006(7)	2.701
2.531(16)	66(8)	14.5(36)	3.221(16)	0	——
3.092(21)	25(5)	5.5(16)	3.782(21)	0	——
3.514(24)	11(3)	2.4(8)	4.204(24)	0	——
3.684(25)	6(2)	1.3(5)	4.374(25)	0	——
3.871(26)	3(2)	0.7(5)	4.561(26)	0	——
4.474(30)	7(3)	1.5(7)	5.164(30)	0	——
4.595(29)	81(9)	18(4)	5.300(29)	0	——

* Values are taken from [2002Jo09] except where noted.

** From [2007Bl09]. Other: $>$65% [1979Vi01].

*** Energy calculated from proton energies and S_p (^{57}Cu) = 690.3(4) keV [2021Wa16].

$^{@}$ Values from adopted levels in ENSDF [2011Hu08].

Table 21

β-p emission from ^{61}Ge*, $T_{1/2}$ = 40.7(4) ms, $BR_{\beta p}$ = 78(3)%**.

E_p	I_p(abs)	$E_{emitter}$ (^{61}Ga)***	$E_{daughter}$(^{60}Zn)	coincident γ-rays
3.169(11)	62(4)	3.419(50)	0	——

* All values taken from [2017GoZT], except where noted.

** Weighted ave of [2017GoZT] and [2007Bl09].

*** Energy calculated from proton energy and S_p (^{61}Ga) = 250(40) keV [2021Wa21].

Table 22
β-p emission from ^{65}Se*, $T_{1/2}$ = 34.2(2) ms, $BR_{\beta p}$ = 94^{+6}_{-4}%.

E_p	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{65}As)***	$E_{daughter}$(^{64}Ge)$^@$	coincident γ-rays$^@$
2.642(15)	40(5)	18(2)	3.448(57)	0.9017(3)	0.902
3.532(16)	100(5)	44(2)	3.448(57)	0	——
3.77(3)**					

* All values taken from [2017GoZT], except where noted.
** from [2011Ro47] only
*** Energy calculated from proton energies and S_p (^{65}As) = -90(80) keV [2021Wa16]. Value shown is the weighted average of the two transitions.
$^@$ Values from adopted levels in ENSDF [2011Hu08].

Table 23
β-p emission from ^{69}Kr, $T_{1/2}$ = 28(1) ms*, $BR_{\beta p}$ = 100%.

E_p	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{69}Br)	$E_{daughter}$(^{68}Se)$^@$	coincident γ-rays$^@$
0.641(42)*	3.6(9)	1.9(5)*	0*	0	——
0.751**$^{+.132}_{-.042}$	1.0(2)	0.5(1)**	0+x**	0	——
2.939(22)*	100	52.5(65)*	3.153(45)***	0.8538(2)	0.854

* [2014De41].
** [2011Ro47]
*** Energy calculated from proton energies and S_p (^{69}Br) = -640(40) keV [2021Wa16].
$^@$ Values from adopted levels in ENSDF [2012Mc02].

Table 24
β-p emission from ^{73}Sr*, $T_{1/2}$ = 23.1(14) ms, $BR_{\beta p}$ = 100%**.

E_p	I_p(rel)%	I_p(absb)%	$E_{emitter}$ (^{73}Rb)***	$E_{daughter}$(^{72}Kr)	coincident γ-rays
0.64(4)	5(3)$^@$	2(1)$^@$	0.0	0.0	——
1.15(4)	10(5)$^@$	4(2)$^@$			
3.14(2)	61(6)	24(9)	3.21(5)	0.709	0.709
3.85(2)	100	39(7)	3.21(5)	0	——

* All values taken from [2019Si33], except where noted.
** Expected to be 100% as the daughter ^{73}Rb is unbound by 570(20) keV [2017Wa10].
*** Energy calculated from proton energies and S_p (^{73}Rb) = -640(40) keV [2021Wa16].
$^@$ Estimated from Fig 1 of [2020Ho17].

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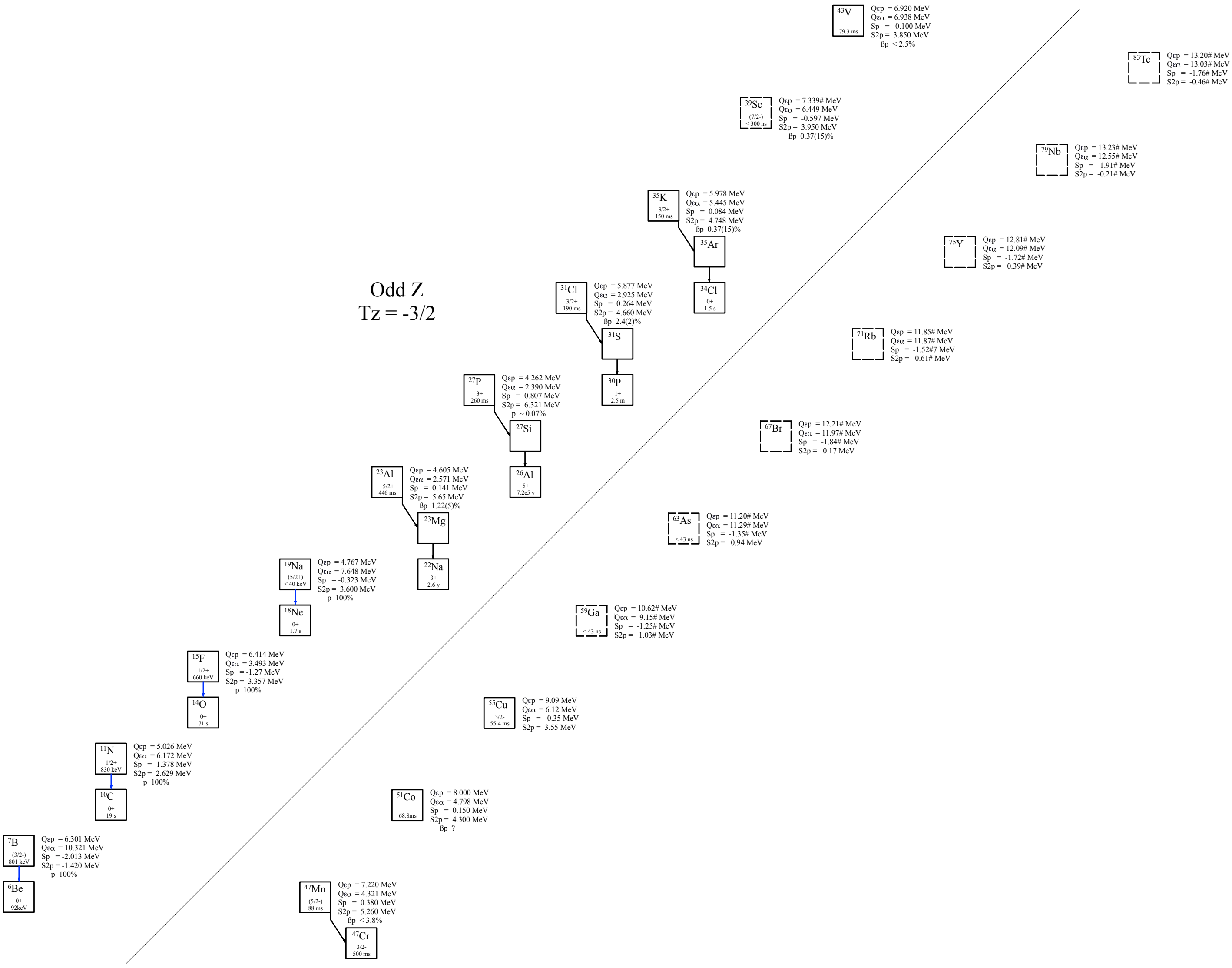

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= -3/2 nuclei.

Last updated 3/17/23

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = -3/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon 3p}$	$Q_{\varepsilon\alpha}$	Experimental
^{7}B	(3/2$^-$)	801(20) keV	11.908(25)	6.301(25)		1.868(32)	-19.51(21)	10.321(25)	[**2011Ch32**]
^{11}N	1/2$^+$	830(30) keV	13.716(5)	5.026(5)		-1.561(5)	-18.447(5)	6.172(5)	[**2006Ca05**, 2000Ma62, 1996Ax01]
^{15}F	1/2$^+$	660(20) keV	13.711(14)	6.414(14)		-1.136(14)	-18.669(14)	3.493(14)	[**2010Mu12**, 2006AcZY]
^{19}Na	(5/2$^+$)	<40 keV	11.177(11)	4.767(11)		-0.840(11)	-14.622(11)	7.648(11)	[**2010Mu12**, 2006AcZY]
^{23}Al	5/2$^+$	446(6) ms*	12.2217(3)	4.6405(4)	1.22(5)%	-2.0981(3)	-15.1014(3)	2.5711(4)	[**2011Sa15, 2011Ki26, 2006Ia03**, 2015Su15, 2014Ka01, 2000Pe28, 1995Ti08, 1972Go03, 1971GoZH]
^{27}P	(5/2)$^+$	260(80) ms	11.725(9)	4.262(9)	≈0.07%	-2.044(9)	-14.108(9)	2.390(9)	[**1996Og01,1985Ay02**, 1983Ay02]
^{31}Cl	3/2$^+$	190(1) ms	12.008(3)	5.877(3)	2.4(2)%	0.282(3)	-11.705(3)	2.925(3)	[**2022Bu14, 2011SaZM**, 2018Be12, 2016Sa60, 2014Ka01, 2006Ka11, 1996Og01, 1985Ay02, 1983Ay02, 1982Ay01]
^{35}K	3/2$^+$	150(25) ms	11.8744(9)	5.9782(5)	0.37(15)%	0.8349(5)	-8735(1)	5.445(1)	[**1980Ew02**]
^{39}Sc	(7/2-)	<300ns	13.110(24)	7.339(24)#		2.197(24)	-6.521(40)	6.449(24)	[**1994Bl10**]
^{43}V		79.3(24) ms	11.400(40)	6.920(40)	<2.5%***	2.640(40)	-6.251(40)	6.938(40)	[**2007Do17**]
^{47}Mn	(5/2$^-$)	88.0(13) ms	12.000(30)	7.220(30)	>1.7%	1.862(30)	-6.621(30)	4.321(31)	[**1996Fa09**]
^{51}Co		68.8(19) ms	12.850(50)	8.000(50)	<3.8%***	3.414(50)	-4.729(50)	4.798(50)	[**2007Do17**]
^{55}Cu	3/2$^-$	55.4(18) ms	13.70(16)	9.09(16)	?[@]	4.73(16)	-2.80(16)	6.12(16)	[**2017GoZT**, 2013Tr09, 2007Do17]
^{59}Ga		<43 ns	13.46(17)#	10.62(17)#		7.75(17)#	0.41(17)#	9.15(17)#	[**2005St29**]
^{63}As	(3/2$^-$)	< 43 ns	13.420(20)#	11.20(20)#		8.27(20)#	2.98(20)#	11.29(20)#	[**2005St29**]
^{67}Br			14.05(31)#	12.21(30)#		9.37(30)#	4.44(30)#	11.97(30)#	
^{71}Rb			14.04(42)#	11.85(40)#		9.57(40)#	4.74(40)#	11.87(41)#	
^{75}Y			14.80(37)#	12.81(30)#		10.15(30)#	5.38(30)#	12.09(33)#	
^{79}Nb			15.12(58)#	13.23(58)#		11.58(50)#	6.96(50)#	12.55(55)#	
^{83}Tc			15.02(64)#	13.20(58)#		11.62(51)#	7.96(50)#	13.03(58)#	

* [2006Ia03].
** [2011SaZM].
*** Not observed.
[@] Reported as 15.0(43)% in [2007Do17], but [2013Tr09] and [2017GoZT] report no observation of delayed protons despite having much higher statistics.

Table 2
Particle emission from the odd-Z, T_z = -3/2 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	BR_{1p}	S_{2p}	Q_α	experimental
^{7}B	-2.013(26)	100%	-1.420(60)	-3.42(200)#	[**2011Ch32**]
^{11}N	-1.378(5)	100%	2.629(5)	-5.736(26)	[**2006Ca05**,1996Ax01, 2000Ma62]
^{15}F	-1.27(14)	100%	3.357(14)	-10.224(15)	[**2010Mu12**, 2006AcZY]
^{19}Na	-0.323(11)	100%	3.600(11)	-6.062(18)	[**2010Mu12**, 2006AcZY]
^{23}Al	0.1409(4)	——	5.6450(3)	-8.606(11))	
^{27}P	0.807(9)	——	6.321(9)	-9.832(9)	
^{31}Cl	0.264(3)	——	4.660(3)	-8.800(10)	
^{35}K	0.0836(5)	——	4.7475(6)	-6.563(3)	
^{39}Sc	-0.597(24)		3.950(24)	-5.425(24)	
^{43}V	0.100(40)	——	3.850(40)	-6.170(50)	
^{47}Mn	0.380(30)	——	5.260(30)	-7.070(50)	
^{51}Co	0.150(50)	——	4.300(50)	-7.200(60)	
^{55}Cu	-0.35(16)		3.55(16)	-6.72(16)	
^{59}Ga	-1.25(18)#		1.03(17)#	-4.55(23)#	
^{63}As	-1.35(24)#		0.94(20)#	-2.17(26)#	
^{67}Br	-1.84(36)#		0.17(31)#	-1.45(36)#	
^{71}Rb	-1.52(45)#		0.61(40)#	-2.19(50)#	
^{75}Y	-1.72(32)#		0.39(30)#	-1.96(50)#	
^{79}Nb	-1.91(64)#		-0.21(54)#	-2.26(58)#	
^{83}Tc	-1.76(64)#		-0.46(64)#	-2.09(71)#	

Table 3
β-p emission from ^{23}Al*, $T_{1/2}$ = 446(6) ms[@@], $BR_{\beta p}$ = 1.22(5)%**.

E_p	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{23}Mg)***	$E_{daughter}$(^{22}Na)	coincident γ-rays
0.206(11)	32(6)	0.14(3)	7.787(11)	0	——
0.267(9)	42(8)	0.18(4)	7.848(9)	0	——
0.337(14)	8(2)	0.03(1)	7.918(14)	0	——
0.443(14)	4(2)	0.02(1)	8.025(14)	0	——
0.579(8)	65(2)	0.28(1)	8.160(8)	0	——
0.866(8)	100	0.41(1)	8.447(8)	0	——
1.204(8)	0.04(1)	0.02(1)	8.785(8)	0	——
1.338(9)	6(1)	0.02(1)	8.919(9)	0	——
1.419(10)	4(1)	0.02(1)	9.000(10)	0	——
1.520(5)*	0.7(2)	0.0032(6)	9.101(5)	0	
1.561(9)		0.03(1)	9.142(9)	0	——
1.729(25)	4(1)	0.02(1)	9.310(25)	0	——
1.843(9)	11(1)	0.05(1)	9.424(9)	0	——
1.887(5)[@]		0.0084(6)[@]	9.468(5)	0	——
2.023(5)[@]		0.0025(3)[@]	9.604(5)[@]	0	——
2.100(7)[@]		0.0008(2)[@]	9.682(7)[@]	0	——

* Values are taken from [2011Sa15], except where noted.
** From [2011Sa15]. Others: 0.46(23)% [2000Pe28], ≈1.1% [1995Ti08].
*** Energy calculated from proton energies and S_p (^{23}Mg) = 7581.25(14) keV [2021Wa16].
[@] [2011Ki26].
[@@] [2006Ia03].

Table 4
β-p emission from ^{27}P*, $T_{1/2}$ = 260(80) ms[@], $BR_{\beta p}$ = ≈0.07%.

E_p	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{27}Si) **	$E_{daughter}$(^{26}Al)***	coincident γ-rays
0.484(3)	9(2)	≈0.0063(14)	8.176(3)	0.2283	100% β^+
0.636(2)	97(3)	≈0.034(1)	8.327(2)	0.2283	100% β^+
0.759(2)	100	≈0.035	8.451(2)	0.2283	100% β^+
1.376(4)	7(2)	≈0.0025(7)	9.068(30)	0.2283	100% β^+

* All values taken from [1996Og01] except where noted.
** Energy calculated from proton energies and S_p (^{27}Si) = 7463.34(13) keV [2021Wa16].
*** Values from adopted levels in ENSDF [2016Ba18].
[@] [1985Ay02]

Table 5
β-p emission from ^{31}Cl*, $T_{1/2}$ = 190(1) ms, $BR_{\beta p}$ = 2.4(2)%.

E_p	I_p(rel)%	I_p(abs)%	$E_{emitter}$ (^{31}Cl)	$E_{daughter}$(^{30}P)	coincident γ-rays
0.260 ***	$0.063^{+9}_{-0.7}$	$8.3^{+1.2}_{-0.9}\times10^{-4}$	6.3902(7)	0	
0.806(2)	20.4(2)	0.367(6)	6.936(2)	0	
0.906(2)	12.4(2)	0.161(6)	7.037(2)	0	
1.026(2)	100(4)	1.31(2)	7.157(2)	0	
1.225(3)	2.7(1)	0.035(2)	7.355(3)	0	
1.390(17)	1.3(12)	0.017(16)	7.521(17)	0	
1.571(3)	21.0(4)	0.273(6)	7.702(3)	0	
1.647(17)	1.4(2)	0.019(25)	7.778(17)	0	
1.763(3)	6.4(2)	0.084(3)	7.894(3)	0	
1.891(3)	10.9(2)	0.143(3)	8.022(3)	0	
1.991(17)	1.4(1)	0.019(1)	8.122(17)	0	
2.139(17)	1.3(1)	0.017(1)	8.270(17)	0	
2.298(3)	2.3(1)	0.030(1)	8.429(3)	0	
2.362(17)	0.9(7)	0.011(1)	8.493(17)	0	
2.572(17)	0.91(6)	0.012(1)	8.703(17)	0	
2.729(17)	0.19(4)	0.002(1)	8.860(17)	0	
2.901(17)	0.3(1)	0.004(1)	9.031(17)	0	

* All values taken from [2011SaZM], except where noted.
** energy calculated from proton energies and S_p (^{31}S) = 6130.65(24) keV [2021Wa16].
*** From [2022Bu14].

Table 6
β-p emission from ^{35}K*, $T_{1/2}$ = 150(25) ms, $BR_{\beta p}$ = 0.37(15)%.

E_p	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{35}Ar)**	$E_{daughter}$(^{34}Cl)***	coincident γ-rays***
1.320(20)	16(3)	5.4(10)			
1.467(20)	100(8)	33.6(27)	7.503(20)	0.1464	0.146
1.601(20)	41(5)	13.8(17)	7.503(20)	0	——
1.755(20)	42(6)	14.1(20)			
1.930(20)	24(4)	8.1(14)			
2.038(20)	17(3)	5.7(10)	8.393(20)	0.4610	0.461
2.349(20)	23(4)	7.7(13)	8.393(20)	0.1464	0.146
2.496(20)	19(4)	6.4(13)	8.393(20)	0	——
2.651(20)	10(3)	3.4(10)			
2.890(20)	5.7(18)	1.9(6)			

*All values taken from [1980Ew02] except where noted.

** Listed energy calculated from proton energies and S_p (^{35}Ar) = 5896.2(7) keV [2021Wa16]. For levels de-excited by more than one proton transition, E_{level} (emitter) is the weighted average.

*** Values from adopted levels in ENSDF [2012Ni10].

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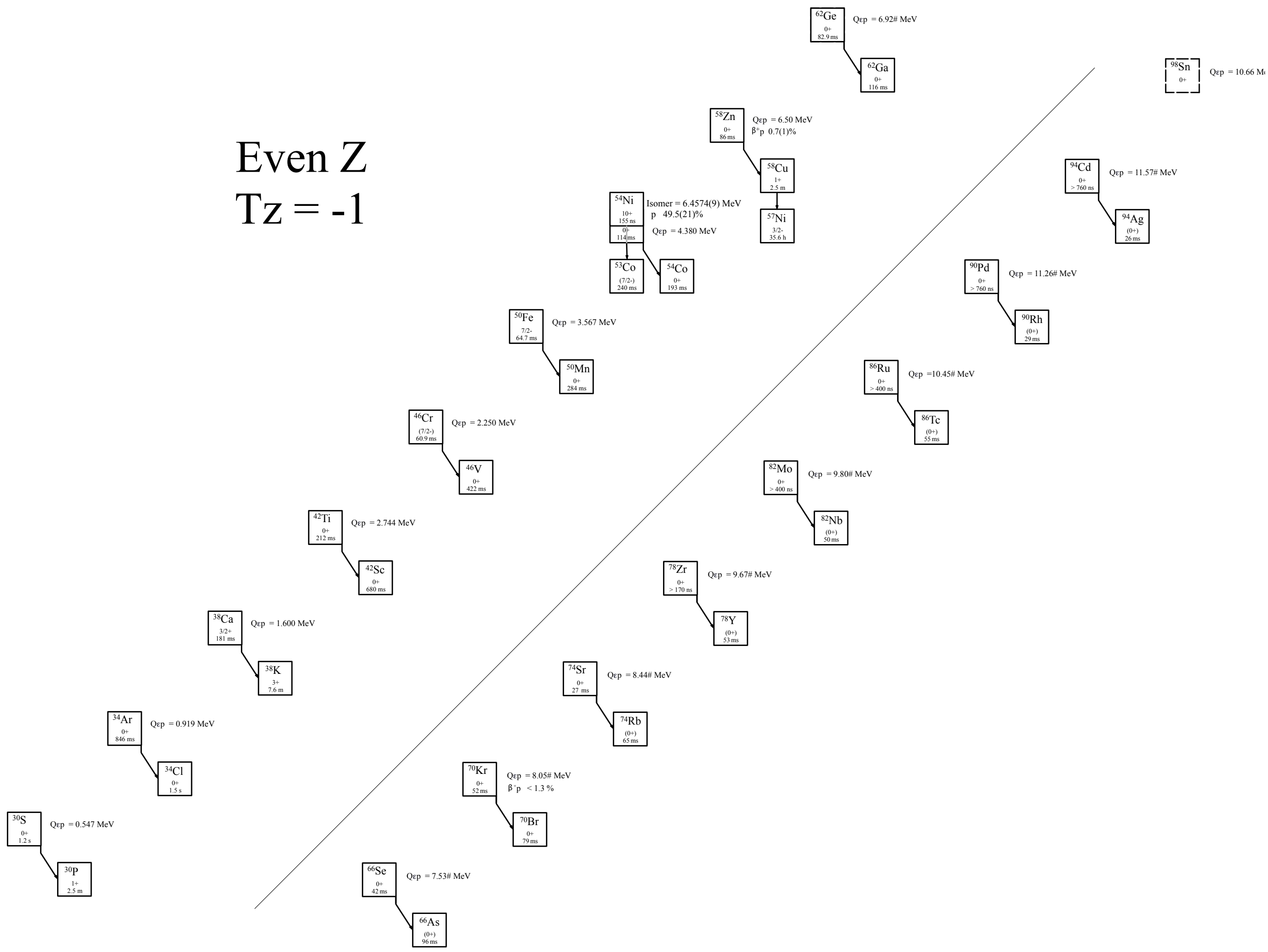

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_Z= -1 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = -1 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	Experimental
^{30}S		0^+	1.178(5) s	6.1416(2)	0.5471(4)		-11.7866(2)	[**1980Wi13**]
^{34}Ar		0^+	846.46(35) ms	6.06179(6)	0.9186(1)		-8.6514(1)	[**2020Ia01**]
^{38}Ca		0^+	443.63(35) ms	6.74226(6)	1.6002(3)		-7.1145(2)	[**2015Bl02**]
^{42}Ti		0^+	211.7(19) ms	7.01648(22)	2.7446(2)		-6.1469(3)	[**2015Mo01**]
^{46}Cr		0^+	224.3(13) ms	7.604(11)	2.250(11)		-6.234(11)	[**2015Mo01**]
^{50}Fe		0^+	152.1(6) ms	8.151(8)	3.567(9)		-4.576(5)	[**2017Ku12, 2017RuZX**]
^{54}Ni		0^+	114.2(3) ms	8.732(5)	4.380(5)		-3.145(5)	[**2012MoZW**]
^{54m}Ni	6.4574(9)	10^+	155(3) ns	15.189(5)	10.837(5)		3.312(5)	[**2021Gi18**, 2008Ru09]
^{58}Zn		0^+	86(2) ms*	9.370(50)	6.500(50)	0.7(1)%**	-0.838(50)	[**2020Ci04, 2017Ku12**, 2012OrZY, 2009Fu15, 2005Ka46, 2002Lo13, 1998Jo18]
^{62}Ge		0^+	82.9(14) ms	10.25(14)#	6.92(14)#		1.63(14)#	[**2014Gr10**]
^{66}Se		0^+	42(12) ms	10.37(20)#	7.53(20)#		2.60(20)#	[**2002Bl17**]
^{70}Kr		0^+	40(6) ms	10.33(20)#	8.05(20)#	$<$1.3%	3.22(20)#	[**2014Ro14**]
^{74}Sr		0^+	27(8) ms	11.09(10)#	8.44(10)#		3.65(10)#	[**2014He29**]
^{78}Zr		0^+	$>$170 ns	11.32(50)#	9.67(40)#		5.05(40)#	[**2001Ki13**]
^{82}Mo		0^+	$>$400 ns	11.44(50)#	9.80(41)#		6.20(40)#	[**2017Su26**]
^{86}Ru		0^+	$>$400 ns	11.80(50)#	10.45(40)#		6.85(40)#	[**2017Su26**]
^{90}Pd		0^+	$>$760 ns	11.92(45)#	11.26(50)#		7.38(40)#	[**2016Ce02**]
^{94}Cd		0^+	$>$760 ns	11.96(64)#	11.57(58)#		7.98(50)#	[**2016Ce02**]
^{98}Sn		0^+		11.55^c	10.66$^@$		7.40^b	

* [2017Ku12]
** [2020Ci04]
@ Predictions taken from [1995Mo29].

Table 2
Particle emission from the even-Z, T_z = -1 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	BR_p	S_{2p}	Q_α	$Q_{\varepsilon\alpha}$	$BR_{\beta\alpha}$	Experimental
^{30}S	4.3954(4)		7.14440(21)	-9.34317(23)	-4.2742(2)	——	
^{34}Ar	4.6639(4)		6.94070(8)	-6.74395(22)	-0.6024(1)	——	
^{38}Ca	4.54727(22)		6.4049(2)	-6.10513(21)	-0.0434(2)	——	
^{42}Ti	3.75096(27)		4.83589(27)	-5.4708(3)	1.2714(4)		
^{46}Cr	4.874(11)		6.501(11)	-6.792(11)	0.224(11)		
^{50}Fe	4.146(9)		6.233(11)	-7.430(14)	0.175(8)		
^{54}Ni	3.908(5)		5.524(5)	-7.227(10)	0.924(5)		
^{54m}Ni**	-2.549(5)	49.5(21)%	-0.933(5)	-0.779(10)	7.381(5)		[**2021Gi18, 2008Ru09**]
^{58}Zn	2.280(50)		2.970(50)	-5.450(50)	3.285(50)		
^{62}Ge	2.29(15)#		2.54(14)#	-2.27(15)#	7.10(14)#		
^{66}Se	2.01(22)#		1.92(20)#	-1.95(24)#	7.90(20)#		
^{70}Kr	2.13(21)#		1.49(20)#	-1.87(28)#	8.50(20)#		
^{74}Sr	2.11(11)#		1.47(10)#	-2.15(22)#	8.17(10)#		
^{78}Zr	1.70(45)#		1.18(40)#	-2.45(41)#	8.64(40)#		
^{82}Mo	1.30(57)#		0.19(50)#	-1.95(57)#	9.38(50)#		
^{86}Ru	1.21(57)#		0.18(50)#	-1.83(57)#	9.62(50)#		
^{90}Pd	1.35(54)#		-0.50(500)#	-2.36(57)#	9.44(50)#		
^{94}Cd	1.33(64)#		0.24(61)#	-3.16(64)#	8.77(54)#		
^{98}Sn	1.65*		1.31*	-4.57*	7.02*		

* Predictions taken from [1995Mo29].
** Excitation energy = 6.4574(9) MeV [2008Ru09].

Table 3
Direct proton emission from ^{54m}Ni*, Ex. = 6.4574(9) MeV, $T_{1/2}$ = 155(3) ns, BR_p = 49.5(21) %.

E_p(lab)	E_p(c.m.)	I_p(rel)	I_p(abs)	$E_{daughter}$(^{53}Co)	coincident γ-rays
1.1979(44)	1.2205(45)	100(5) %	28.4(13) %	1.3270(9)	1.327
2.5002(43)	2.5477(44)***	74(7) %	21.1(16) %	0.0	—

* All values taken from [2021Gi18].
** [2008Ru09].
*** [2021Gi18] uses the masses of ^{53}Co and ^{53m}Co From [2010Ka26] to get this value.

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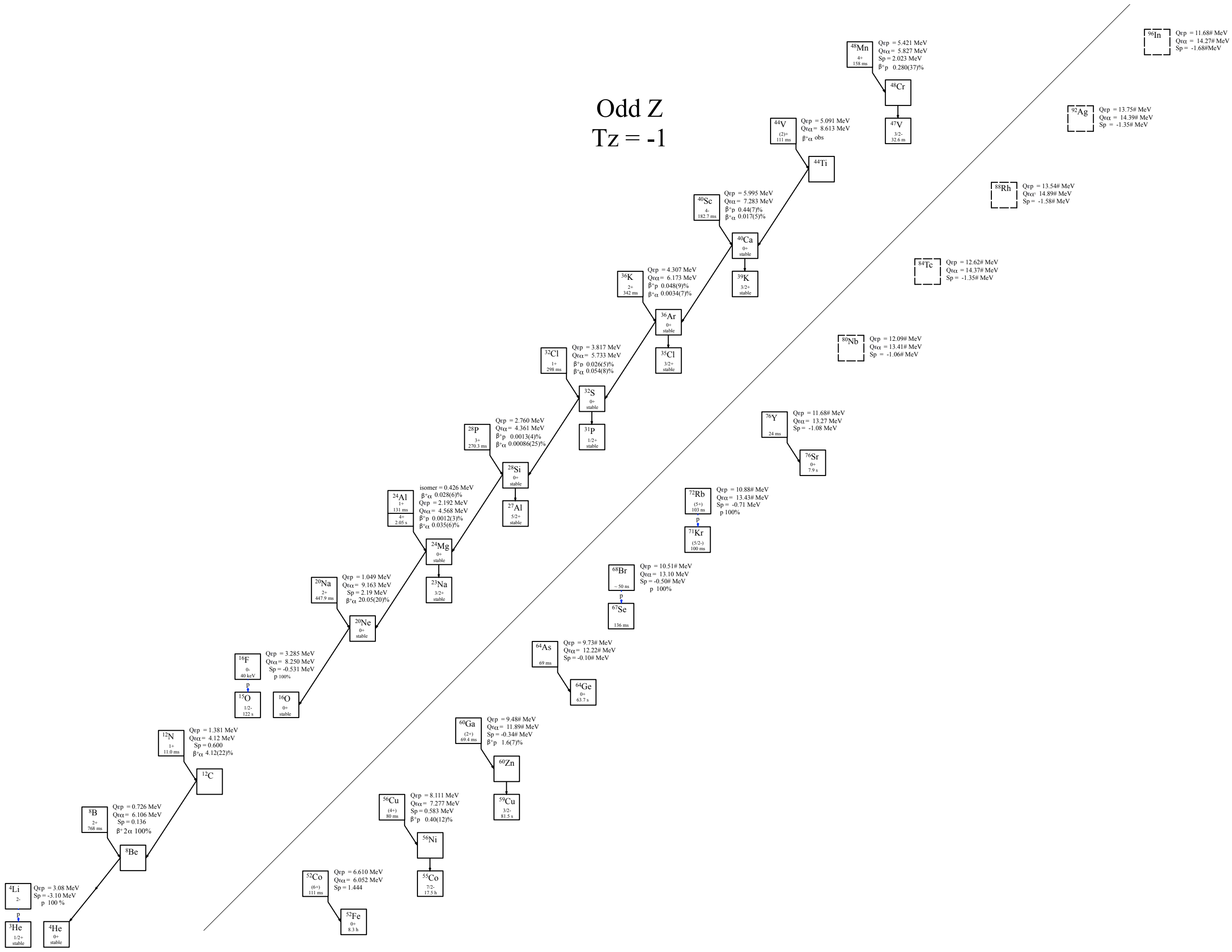

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= -1 nuclei.

Last updated 3/17/23

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = -1 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon \alpha}$	$BR_{\beta \alpha}$	Experimental
^{4}Li		2^-		22.90(21)	3.08(21)					
^{8}B		2^+	768(3) ms	17.980(1)	0.7255(10)		-9.248(1)	6.106(1)	100%	[**1988Aj01**, 1971Wi05, 1964Ma35]
^{12}N		1^+	11.000(16) ms	17.3881(10)	1.3814(10)		-9.847(1)	9.971(1)	4.12(22)%	[**2020Bi15**, 2020Bi11, 2009Hy01,2009Hy02, 2010Hy01]
^{16}F		0^-	40 (20) keV	15.412(5)	3.285(5)		-6.923(5)	8.250(5)		[**1993Ti07**, 2014Wu03]
^{20}Na		2^+	447.9(40) ms	13.8924(11)	1.0490(11)		-6.9447(11)	9.1625(11)	20.05(22)%	[**2021Wa06, 2013La22, 1989Cl02, 1972To08, 1972Mo08, 1971Go18**, 1989Ra17]
^{24}Al		4^+	2.053(4) s	13.8848(2)	2.19207(23)	0.0012(3)%	-6.6021(2)	4.5681(2)	0.035(6)%	[**1994Ba54**, 2011Ma88] **1979Ho08**
^{24m}Al	0.4258(1)	1^+	130.9(13) ms	14.3106(2)	2.6179(3)		-6.1763(2)	4.9939(2)	0.028(6)%	[**1994Ba54, 1979Ho08**, 2011Ma88, 1979Ho08]
^{28}P		3^+	270.3(5) ms	14.3449(11)	2.7600(11)	0.0013(4)%	-5.5114(11)	4.3607(11)	0.00086(25)%	[**1996Og01, 1968Ar03**, 1979Ho27]
^{32}Cl		1^+	298(1) ms	12.6808(6)	3.8169(6)	0.026(5)%	-3.4797(6)	5.7331(6)	0.054(8)%	[**1979Ho27**, 2008Bh08, 2018Ab06, 2012Me03, 1985Bj01]
^{36}K		2^+	342(2) ms	12.8144(3)	4.3074(3)	0.048(9)%	-2.0635(3)	6.1733(3)	0.0034(7)%	[**1996Il02, 1980Es01**, 1997Il03, 1980Ew01]
^{40}Sc		4^-	182.7(8) ms	14.3230(28)	5.9949(28)	0.44(7)%	-0.3866(28)	7.2831(28)	0.017(5)%	[**1982Ho09**, 1968Ar03, 1969Ve04, 1974Se11]
^{44}V		$(2)^+$	111(7) ms	13.4741(7)	5.091(7)		0.161(7)	8.613(7)	obs	[**1977Ha04, 1971Ce02**]
^{48}Mn		4^+	158.1(22) ms	13.525(10)	5.421(7)	0.280(37)%	0.253(7)	5.827(7)		[**1991Sz03**, 1987Se07]
^{52}Co		(6^+)	111(4) ms	13.988(5)	6.610(5)		1.339(5)	6.052(9)		[**2017Ku12**]
^{56}Cu		(4^+)	80(2) ms	15.278(6)	8.111(6)#	0.40(12)%	3.047(6)	7.277(6)		[**2001Bo54**, 2017Ku12]
^{60}Ga		(2^+)	69.4(2) ms	14.58(20)#	9.48(20)#	1.6(7)%	6.06(20)#	11.89(20)#		[**2021Or01**, 2017Ku12, 2001Ma96]
^{64}As			69.0(14) ms	14.78(20)#	9.73(20)#		7.06(20)#	12.22(20)#		[**2020Gi02**]
^{68}Br			35(5) ns	15.40(26)#	10.51(26)#		8.24(26)#	13.10(26)#		[**2019Wi08**, 1995Bl06, 1997Au04]
^{72}Rb		(5^+)	103(22) ns	15.61(50)#	10.88(50)#		9.02(50)#	13.43(50)#		[**2019Si33, 2017Su31**]
^{76}Y			24^{+12}_{-6} ms	16.00(30)#	11.68(30)#		9.50(30)#	13.27(30)#		[**2019Si33**]
^{80}Nb				16.34(50)#	12.09(41)#		10.18(40)#	13.41(40)#		
^{84}Tc				16.47(50)#	12.62(43)#		11.34(40)#	14.37(50)#		
^{88}Rh				17.48(50)#	13.54(40)#		12.67(40)#	14.89(50)#		
^{92}Ag			**	17.25(53)#	13.75(50)#		12.78(40)#	14.39(50)#		[**2016Ce02**]
^{96}In			**	17.48(65)#	14.53(64)#		13.43(50)#	14.27(61)#		[**2016Ce02**]

* Calculated from the sum of the β feeding to states [2020Bi15] above the alpha separation energy
** Observed at RIKEN with BigRIPS and ZDS that have a time of flight 760 ns [2016Ce02].

Table 2
Particle emission from the odd-Z, T_z = -1 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	BR_{1p}	S_{2p}	Q_α	Experimental
^{4}Li	-3.10(21)	100%	-6.80(200)#		[**1996Ed02**, 1990Br14, 1973Fr04]
^{8}B	0.1364(10)	——	5.7433(10)	-4.83(21)	
^{12}N	0.6003(10)	——	9.2905(10)	-8.0084(14)	
^{16}F	-0.531(5)	100%	6.766(5)	-9.088(5)	[**2014Wu03**, 1993Ti07]
^{20}Na	2.1905(11)	——	8.6006(12)	-6.250(5)	
^{24}Al	1.86411(23)	——	9.44536(26)	-9.3242(11)	
^{24m}Al$^{@}$	2.2899(3)	——	9.8712(3)	-9.7500(11)	
^{28}P	2.0523(12)	——	9.5157(11)	-9.52240(12)	
^{32}Cl	1.5811(5)	——	7.7118(6)	-8.6118(13)	
^{36}K	1.6589(8)	——	7.5550(3)	-6.5074(6)	
^{40}Sc	0.5296(29)	——	6.3005(28)	-5.5311(28)	
^{44}V	1.781(9)	——	6.265(7)	-5.710(8)	
^{48}Mn	2.023(6)	——	6.799(7)	-7.913(10)	
^{52}Co	1.444(5)	——	6.295(5)	-7.472(9)	
^{56}Cu	0.583(6)	——	5.198(6)	-6.711(8)	
^{60}Ga	-0.34(20)#		2.50(20)#	-3.39(20)#	
^{64}As	-0.10(20)#		2.12(20)#	-2.37(29)#	
^{68}Br	-0.50(25)#	100%**	1.34(26)#	-1.68(33)#	[**2019Wi08**, 1995Bl06, 1997Au04]
^{72}Rb	-0.71(52)#	100%**	1.48(50)#	-1.96(56)#	[**2019Si33, 2017Su31**]
^{76}Y	-1.08(37)#		0.91(30)#	-2.35(58)#	
^{80}Nb	-1.06(50)#		70.83(50)#	-2.60(50)#	
^{84}Tc	-1.35(57)#		0.47(50)#	-1.71(57)#	
^{88}Rh	-1.58(57)#		-0.13(50)#	-1.59(57)#	
^{92}Ag	-1.35(58)#	100%**	0.47(45)#	-3.10(57)#	[**2016Ce02**]
^{96}In	-1.68(76)#	100%**	0.27(64)#	-2.99(64)#	[**2016Ce02**]

@ Excitation energy = 0.4258(1) MeV.
** Inferred by half-life

Table 3
β-α emission from ^{20}Na*, $T_{1/2}$ = 447.9(40) ms$^{@}$, $BR_{\beta\alpha}$ =20.05(22) %.

E_α (c.m.)	I_α(rel)%	I_α(abs)%	$E_{emitter}$ (^{20}Ne)	$E_{daughter}$(^{16}O)***	coincident γ-rays
0.8915(17)	0.039(6)	0.0063(9)	5.6214(17)	0	——
1.5073(35)	0.0099(44)	0.0016(7)	12.367(35)	6.12989(4)	6.130
1.0579(26)	0.0099(31)	0.0016(5)	5.7877(26)	0	——
1.9902(5)	0.0149(44)	0.0024(7)	6.720(5)	0	——
2.6937(18)	100(4)	16.1(6)	7.4235(18)	0	——
3.1020(23)	4.3(3)	0.69(3)	7.8318(23)	0	——
3.324(7)**	0.074(6)	0.015(1)**	8.054(7)**	0	——
4.0402(50)	0.21(5)	0.034(8)	8.770(50)	0	——
4.7587(22)	1.91(13)	0.307(18)	9.4885(22)	0	——
5.5469(2)	17.4(10)	2.80(12)	10.2767(20)	0	——
5.8522(3)	0.53(3)	0.085(4)	10.582(3)	0	——
6.1117(22)	1.21(7)	0.195(8)	11.300(10)	0	——
6.383(7)**	0.055(7)	0.011(2)**	11.116(9)**	0	——
6.561(4)**	0.165(11)	0.033(2)**	11.291(4)**	0	——
6.5702(10)	0.217(15)	0.035(2)	11.870(50)	0	——
7.1402(50)	0.014(1)	0.0023(1)	12.367(35)	0	——

* All values taken from [2021Wa06], except where noted.
** [1989Cl02].
*** Values from adopted levels in ENSDF [1998Ti06].
@ Weighted average of 442(5) ms [1971Go18], 446(8) ms [1972Mo08], 448(4) ms [1972To08], and 452(4) ms [1989Cl02].

Table 4
β-p emission from ^{28}P*, $T_{1/2}$ = 270.3(5) ms***, $BR_{\beta p}$ = 0.0013(4)%.

E_p	I_p(rel)	I_p(abs)($\times 10^{-4}$)	$E_{emitter}$ (^{28}Si)**	$E_{daughter}$(^{27}Al)	coincident γ-rays
0.486(1)	6(1)	0.4(14)	12.071(1)	0	——
0.704(1)	100	6.8(21)	12.289(1)	0	——
0.859(1)	6(1)	0.41(14)	12.444(1)	0	——
0.988(1)	56(4)	3.8(12)	12.573(1)	0	——
1.129(1)	4(1)	0.27(11)	12.714(1)	0	——
1.314(1)	18(2)	1.2(4)	12.899(1)	0	——
1.506(4)	2(1)	0.14(8)	13.091(4)	0	——

*All values taken from [1996Og01], except where noted.
** Calculated from proton energies and S_α (^{28}Si) = 11584.90(5) keV [2021Wa16].
*** [1968Ar03]

Table 5
β-α emission from ^{28}P*, $BR_{\beta\alpha}$ = 0.00086(25)%.

E_α	I_α(rel)	I_α(abs)($\times 10^{-5}$)	$E_{emitter}$ (^{28}Si)**	$E_{daughter}$(^{24}Mg)	coincident γ-rays
1.528(1)	25(3)	8(2)	11.512(1)	0	——
1.671(1)	79(6)	24(7)	11.65(1)7	0	——
1.945(1)	<3	<0.9	11.929(1)	0	——
2.085(1)	15(4)	4(2)	12.069(1)	0	——
2.303(1)	14(5)	5(2)	12.287(1)	0	——
2.457(1)	100	31(9)	12.441(1)	0	——
2.563(1)	23(6)	7(3)	12.547(1)	0	——
2.738(1)	6(2)	1.8(8)	12.722(1)	0	——
2.912(1)	13(3)	4.0(15)	12.896(1)	0	——
3.107(1)	3(1)	0.9(4)	13.091(1)	0	——

*All values taken from [1996Og01], except where noted.
** Calculated from α energies and S_α (^{28}Si) = 9984.14(1) keV [2021Wa16].

Table 6
β-p emission from ^{32}Cl*, $T_{1/2}$ = 298(1) ms, $BR_{\beta p}$ = 0.026(5)%.

E_p	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{32}S)	$E_{daughter}$(^{31}P)	coincident γ-rays
0.787(5)	47(10)	0.0052(8)	9.651(5)	0	——
1.023(5)	100	0.0113(17)	9.887(5)	0	——
1.085(5)	17(4)	0.0019(4)	9.949(5)	0	——
1.367(5)	47(10)	0.0052(8)	10.231(5)	0	——
1.426(5)	7(2)	0.00078(2)	10.290(5)	0	——
1.916(5)	14(3)	0.0016(3)	10.780(5)	0	——

*All values taken from [1979Ho27], except where noted.
** Calculated from proton energies and S_p (^{32}S) = 8863.96 keV [2021Wa16].

Table 7
β-α emission from ^{32}Cl*, $T_{1/2}$ =$BR_{\beta\alpha}$ = 0.054(8)%.

E_α	I_α(rel)	I_α(abs)	$E_{emitter}$ (^{32}S)	$E_{daughter}$(^{28}Si)	coincident γ-rays
1.744(5)	3.7(8)	0.0011(2)	8.692(5)	0	——
1.912(5)	49(9)	0.0146(20)	8.860(5)	0	——
2.283(5)	0.7(3)	0.0002(1)	9.231(5)	0	——
2.515(5)	100	0.0300(42)	9.463(5)	0	——
2.762(5)	13(3)	0.0040(7)	9.710(5)	0	——
3.035(5)	2.3(5)	0.00069(20)	9.983(5)	0	——
3.345(5)	5.7(13)	0.0017(3)	10.293(5)	0	——
3.511(5)	0.8(3)	0.00024(10)	10.459(5)	0	——
3.583(5)	2.8(8)	0.00084(20)	10.531(5)	0	——
3.845(5)	1.7(4)	0.00051(10)	10.792(5)	0	——
4.115(5)	0.2(1)	0.00006(3)	11.063(5)	0	——

*All values taken from [1979Ho27], except where noted.
** Calculated from α energies and S_α (^{32}S) = 6947.66 keV [2021Wa16].

Table 8
β-p emission from ^{36}K*, $T_{1/2}$ = 342(2) ms**, $BR_{\beta p}$ = 0.048(14)%**.

E_p	I_p(rel)	I_p(abs) (X 10^{-4})	$E_{emitter}$ (^{36}Ar)**	$E_{daughter}$(^{35}Cl)	coincident γ-rays
0.5161(11)	0.33(9)	0.011(3)	9.023(1)	0	——
0.6405(14)	0.45(12)	0.015(4)	9.1475(14)	0	——
0.7133(8)	23.(6)	0.76(20)	9.2203(8)	0	——
0.876(1)	6.7(18)	0.22(6)	9.383(1)	0	——
0.9973(12)	100(27)	3.3(9)	9.5043(12)	0	——
1.2019(14)	0.18(6)	0.006(2)	9.7089(14)	0	——
1.2327(11)	0.73(18)	0.024(6)	9.7397(11)	0	——
1.308(2)	0.45(12)	0.015(4)	9.815(2)	0	——
1.3723(7)	13(3)	0.43(11)	9.8793(7)	0	——
1.4496(22)	0.30(9)	0.010(3)	9.9566(22)	0	——
1.928(10)	0.33(15)	0.011(5)	10.435(10)	0	——
2.049(10)	1.45(58)	0.048(19)	10.556(10)	0	——
2.107(10)	1.42(55)	0.047(18)	10.614(10)	0	——
2.528(10)	0.88(36)	0.029(12)	11.035(10)	0	——
2.715(10)	0.61(27)	0.020(9)	11.222(10)	0	——

*All values taken from [1996Il02], except where noted.
** [1980Es01]
*** Calculated from proton energies and S_p (^{36}Ar) = 8506.98(4) keV [2021Wa16].

Table 9
β-α emission from ^{36}K*, $BR_{\beta\alpha}$ = 0.031(6)%**.

E_α	I_α(rel)	I_α(abs) (X 10^{-6})	$E_{emitter}$ (^{36}Ar)***	$E_{daughter}$(^{32}S)	coincident γ-rays
1.712(3)	3.3(7)	0.5(1)	8.353(3)	0	——
1.757(3)	1.6(5)	0.24(8)	8.398(3)	0	——
2.208(3)	4.0(13)	0.6(2)	8.849(3)	0	——
2.268(3)	100(27)	15(4)	8.909(3)	0	——
2.508(3)	10(3)	1.5(4)	9.149(3)	0	——
2.721(3)	0.73(20)	0.11(3)	9.362(3)	0	——
2.827(3)	0.53(20)	0.08(3)	9.468(3)	0	——
3.068(3)	67(20)	10(3)	9.709(3)	0	——
3.355(3)	0.53(13)	0.08(2)	9.996(3)	0	——
3.566(3)	0.73(27)	0.11(4)	10.207(3)	0	——
3.688(3)	2.7(7)	0.4(1)	10.329(3)	0	——
3.808(3)	1.7(5)	0.26(7)	10.449(3)	0	——
3.923(3)	7.3(20)	1.1(3)	10.564(3)	0	——
3.958(3)	4.0(13)	0.6(2)	10.599(3)	0	——
4.065(4)	0.27(13)	0.04(2)	10.706(4)	0	——
4.217(3)	1.1(3)	0.17(5)	10.858(3)	0	——
4.330(4)	0.23(10)	0.034(15)	10.971(4)	0	——
4.417(3)	1.9(5)	0.28(8)	11.058(3)	0	——
4.597(4)	0.40(13)	0.059(20)	11.238(4)	0	——

*All values taken from [1996Il02], except where noted.
** [1980Es01]
*** Calculated from α energies and S_α (^{36}Ar) = 6640.92(3) keV [2017Wa10].

Table 10
β-p Emission from ^{40}Sc*, $T_{1/2}$ =182.7(8) ms**, $BR_{\beta p}$ = 0.44(7)%.

E_p	I_p(rel)	I_p(abs) (X 10^{-4})	$E_{emitter}$ (^{40}Ca)	$E_{daughter}$(^{39}K)***	coincident γ-rays
1.032(3)	65(14)	7.2(11)	9.360(3)	0	——
1.087(8)	40(9)	4.40(75)	9.415(8)	0	——
1.098(6)	50(12)	5.50(95)	9.427(6)	0	——
1.123(3)	100.00	11.0(17)	9.451(3)	0	——
1.273(3)	29(6)	3.2(5)	9.601(3)	0	——
1.482(4)	8(2)	0.88(15)	9.810(4)	0	——
1.501(8)	2.4(7)	0.26(7)	9.829(8)	0	——
1.592(3)	4.5(11)	0.50(9)	9.920(3)	0	——
1.650(5)	0.8(5)	0.092(5)	9.978(5)	0	——
1.721(4)	3.8(10)	0.42(9)	10.049(4)	0	——
1.797(4)	1.2(4)	0.13(4)	10.125(4)	0	——
1.882(4)	12.6(28)	1.39(22)	10.210(4)	0	——
2.003(4)	0.42(19)	0.046(2)	10.331(4)	0	——
2.037(8)	0.27(19)	0.03(2)	10.365(8)	0	——
2.118(4)	2.(6)	0.28(5)	10.446(4)	0	——
2.143(4)	8.5(18)	0.94(14)	10.471(4)	0	——
2.175(4)	11.4(25)	1.25(19)	10.504(4)	0	——
2.253(5)	1.5(4)	0.17(4)	10.582(5)	0	——
2.268(10)	0.32(19)	0.035(20)	10.596(10)	0	——
2.364(5)	0.7(3)	0.076(30)	10.692(5)	0	——
2.426(8)	0.8(3)	0.092(30)	10.754(8)	0	——
2.447(5)	11.6(26)	1.28(20)	10.775(5)	0	——
2.485(9)	0.74(30)	0.081(3)	10.813(9)	0	——
2.520(5)	3.5(6)	0.38(2)	10.8548(5)	0	——
2.581(5)	0.32(19)	0.035(20)	10.909(5)	0	——
2.628(8)	1.82(46)	0.20(4)	10.956(8)	0	——
2.644(7)	1.82(46)	0.20(4)	10.972(7)	0	——
2.709(7)	0.63(21)	0.069(20)	11.037(7)	0	——
2.786(6)	1.00(31)	0.11(3)	11.114(6)	0	——
2.813(6)	2.09(49)	0.23(4)	11.142(6)	0	——
2.888(5)	6.2(14)	0.68(11)	11.216(5)	0	——
2.987(5)	0.46(20)	0.051(20)	11.315(5)	0	——
3.089(7)	0.25(19)	0.028(20)	11.417(7)	0	——
3.123(9)	0.75(22)	0.083(20)	11.451(9)	0	——
3.287(10)	0.22(10)	0.024(10)	11.615(10)	0	——
3.393(10)	0.66(29)	0.073(30)	11.721(10)	0	——
3.463(10)	0.24(19)	0.026(20)	11.791(10)	0	——
3.676(10)	0.09(9)	0.01(1)	12.004(10)	0	——
3.706(10)	0.22(10)	0.024(10)	12.034(10)	0	——
3.743(10)	0.11(9)	0.012(10)	12.071(10)	0	——

*All values taken from [1982Ho09], except where noted.
** [1968Ar03]
*** Calculated from proton energies and S_p (^{40}Ca) = 8328.18(2) keV [2021Wa16].

Table 11
β-α emission from ^{40}Sc*, $BR_{\beta-\alpha}$ = 0.017(5)%.

E_α	I_α(rel)	I_α(abs)	$E_{emitter}$ (^{40}Ca)**	$E_{daughter}$(^{36}Ar)	coincident γ-rays
2.321(6)	14.9(5)	8.8(2)	9.361(6)	0	——
2.911(8)	2.7(2)	1.6(1)	9.951(8)	0	——
3.089(8)	3.2(2)	1.9(1)	10.129(8)	0	——
3.113(8)	5.4(2)	3.2(1)	10.153(8)	0	——
3.152(8)	3.6(2)	2.1(1)	10.192(8)	0	——
3.424(7)	13.2(4)	7.8(2)	10.464(7)	0	——
3.480(7)	14.1(4)	8.3(2)	10.520(7)	0	——
3.559(7)	11.7(4)	6.9(2)	10.599(7)	0	——
3.684(5)	100.0	59(12)	10.724(5)	0	——
3.779(7)	7.1(4)	4.2(2)	10.819(7)	0	——
3.947(12)	1.9(2)	1.1(1)	10.986(12)	0	——
4.048(12)	1.7(2)	1.0(1)	11.088(12)	0	——
4.164(5)	64.4(19)	38(8)	11.204(5)	0	——
4.266(7)	4.1(2)	2.4(1)	11.305(7)	0	——
4.431(7)	6.1(2)	3.6(1)	11.471(7)	0	——
4.509(6)	11.2(4)	6.6(2)	11.549(6)	0	——
4.622(7)	3.9(2)	2.3(1)	11.662(7)	0	——
4.687(7)	1.5(2)	0.9(1)	11.726(7)	0	——
4.800(6)	4.7(2)	2.8(1)	11.840(6)	0	——
4.958(7)	8.5(4)	5.0(2)	11.998(7)	0	——
5.021(9)	2.7(2)	1.6(1)	12.061(9)	0	——

* All values taken from [1982Ho09], except where noted.
** Calculated from α energies and S_α (^{40}Ca) = 7039.78(3) keV [2021Wa16].

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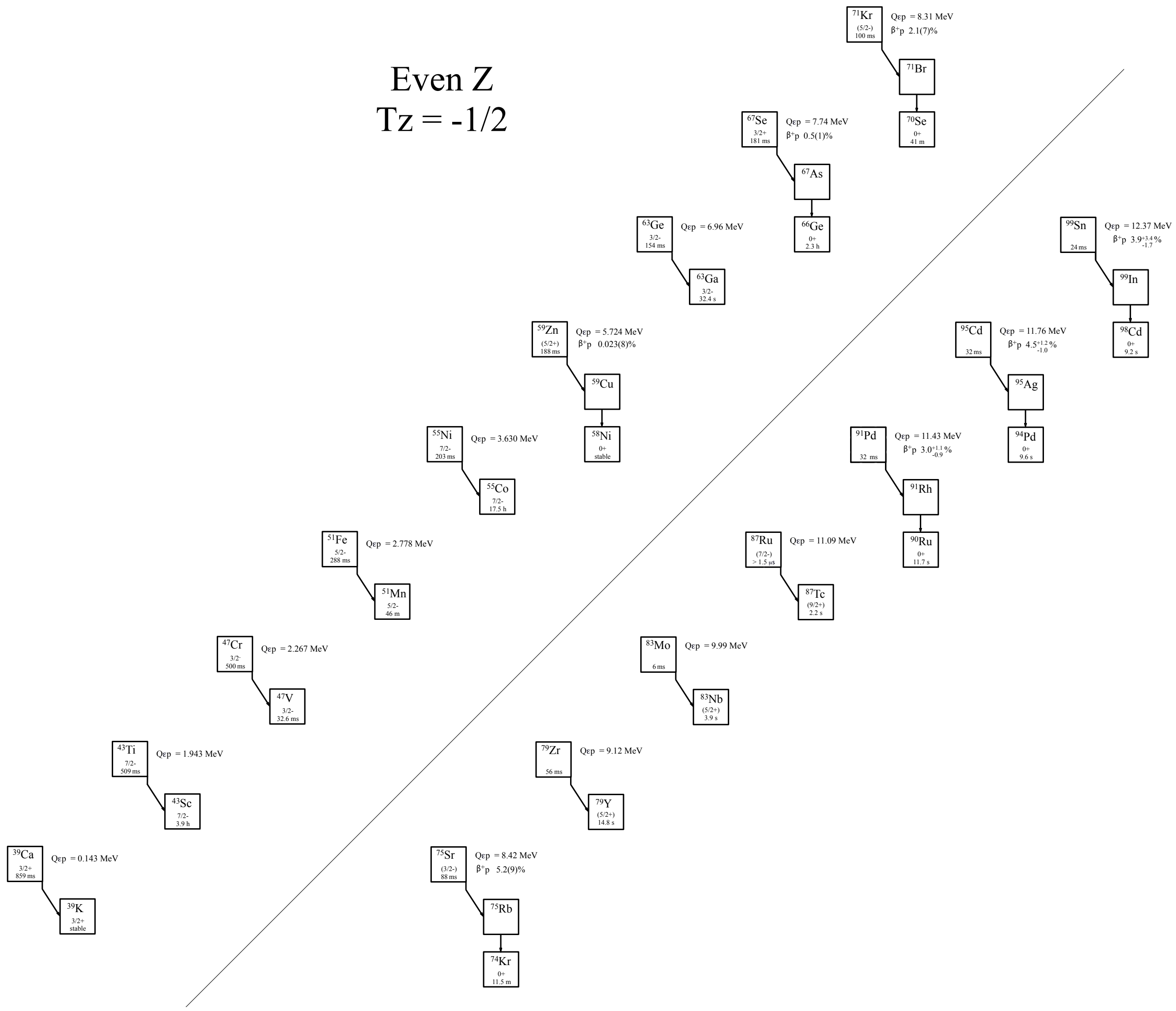

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= -1/2 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z =-1/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J^πvalues for ^{39}Ca, ^{43}Ti, ^{47}Cr, ^{51}CFe, and ^{55}Ni are taken from ENSDF.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{39}Ca	3/2$^+$	859.4(16) ms	6.5245(6)	0.1431(6)		-10.099(1)	-0.694(1)	[**1977Az01**]
^{43}Ti	7/2$^-$	509(5) ms	6.8673(6)	1.943(6)		-8.3345(7)	2.066(7)	[**1987Ho14**]
^{47}Cr	3/2$^-$	508(10) ms	7.444(5)	2.276(5)		-8.069(5)	-0.800(65)	[**1985Bu07**]
^{51}Fe	5/2$^-$	288(6) ms	8.0540(14)	2.77832(14)		-6.805(2)	-0.607(1)	[**2017Ku12**]
^{55}Ni	7/2$^-$	203(2) ms	8.9640(6)	3.6297(6)		-5.2237(8)	0.482(1)	[**2017Ku12**]
^{59}Zn	3/2$^-$	174(2) ms*	9.1428(6)	5.7242(7)	0.023(8)%	-2.4480(9)	4.389(1)	[**1981Ho19, 2017Ku12**, 1984Ar12]
^{63}Ge	3/2$^-$	153.6(11) ms*	9.630(40)	6.960(40)		0.486(40)	7.014(40)	[**2017GoZT, 2017Ku12**, 2014Ro14, 2002Bl17]
^{67}Se	(5/2-)	133(4) ms	10.010(70)	7.740(70)	0.5(1)%	1.500(70)	7.542(70)	[**1995Bl23**, 2002Lo13, 2002Bl17, 2014Ro14]
^{71}Kr	(5/2$^-$)	100(3) ms	10.18(13)	8.31(13)	2.1(7)%	2.20(13)	7.83(13)	[**1997Oi01**, 1995Bl23]
^{75}Sr	(3/2$^-$)	88(3) ms	10.60(22)	8.42(22)	5.2(9)%	2.45(22)	7.46(22)	[**1995Bl23**, 2003Hu01]
^{79}Zr		56(30) ms	11.03(31)#	9.12(30)#		3.48(30)#	8.02(30)#	[**1999Bl08**]
^{83}Mo		6^{+30}_{-3} ms	11.27(43)#	9.99(40)#		4.80(40)#	9.04(41)#	[**2001Ki13**]
^{87}Ru		>1.5 us	11.96(40)#	11.09(40)#		5.97(40)#	9.46(43)#	[**1995Le14, 1995Ry03**]
^{91}Pd		32(3) ms	12.40(30)#	11.43(42)#	$3.0^{+1.1}_{-0.9}$ %	6.65(42)#	9.10(42)#	[**2018Pa20**, 1995Le14, 1995Ry03]
^{95}Cd		32(3) ms	12.85(400)#	11.76(57)#	$4.5^{+1.2}_{-1.0}$ %	7.37(57)#	9.09(64)#	[**2018Pa20**, 2017Da07, 2016Ce02]
^{99}Sn		24(4) ms	13.40(50)#	12.37(58)#	$3.9^{+3.4}_{-1.7}$ %	8.35(58)#	9.51(71)#	[**2018Pa20**]

* [2017Ku12]

Table 2
Particle emission from the even Z, T_z = -1/2 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α
^{39}Ca	5.7709(6)	10.9130(6)	-6.6603(9)
^{43}Ti	4.484(6)	8.756(6)	-4.458(6)
^{47}Cr	4.776(5)	10.131(5)	-7.672(8)
^{51}Fe	4.8513(14)	9.44348(26)	-8.051(5)
^{55}Ni	4.6149(7)	8.9664(18)	-7.5717(16)
^{59}Zn	2.8368(7)	5.7097(8)	-4.3046(10)
^{63}Ge	2.220(40)	5.150(40)	-2.130(40)
^{67}Se	1.840(70)	4.680(70)	-2.08(80)
^{71}Kr	2.19(13)	4.47(13)	-2.17(15)
^{75}Sr	1.99(22)	4.64(22)	-2.72(25)
^{79}Zr	1.89(42)#	3.55(30)#	-2.58(37)#
^{83}Mo	1.82(50)#	3.39(41)#	-2.00(50)#
^{87}Ru	1.45(50)#	2.80(40)#	-1.82(57)#
^{91}Pd	1.83(47)#	2.38(42)#	-2.87(58)#
^{95}Cd	1.94(69)#	2.65(68)#	-3.31(71)#
^{99}Sn	1.36(66)#	1.82(72)#	-3.35(81)#

Table 3
β-p Emission from ^{59}Zn*, $T_{1/2}$ = 174(2) ms**, $BR_{\beta p}$ = 0.023(8)%.

E_p	I_p(rel)%	I_p(abs) (X 10^{-5})%	E_{level} (emitter)***	E_{level}(daughter)	coincident γ-rays
0.929(10)	16(8)	7(3)	4.348(10)	0	
1.081(5)	31(14)	14(5)	4.500(5)	0	
1.286(10)	9(7)	4(3)	4.705(10)	0	
1.354(10)	9(7)	4(3)	4.773(5)	0	
1.400(5)	51(21)	23(7)	4.819(5)	0	
1.809(5)	100	45(13)	5.228(5)	0	
1.848(5)	58(24)	26(8)	5.267(5)	0	
1.889(5)	38(17)	17(6)	5.308(5)	0	
2.060(5)	36(15)	16(5)	5.479(5)	0	
2.125(5)	62(27)	28(9)	5.544(5)	0	
2.220(10)	24(11)	11(4)	5.639(10)	0	
2.235(10)	22(11)	10(4)	5.654(10)	0	
2.289(10)	18(8)	8(3)	5.708(10)	0	
2.452(15)	36(17)	16(6)	5.871(15)	0	
2.497(15)	11(5)	5(2)	5.916(15)	0	

* All values taken from [1981Ho19], except where noted.
** [2017Ku12]
*** Calculated from proton energies and S_p (^{59}Cu) = 3418.6(4) keV [2021Wa16].

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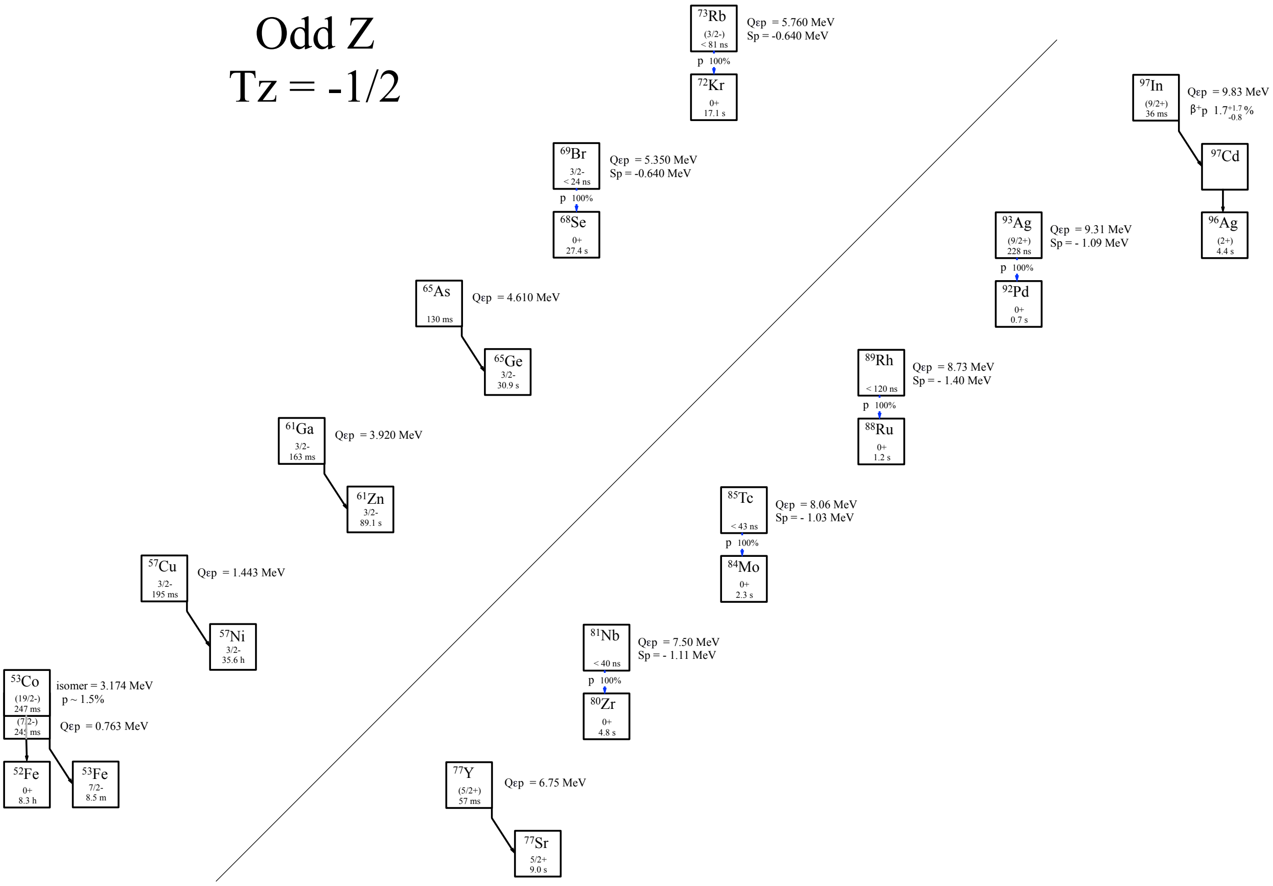

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= -1/2 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z =-1/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J$^\pi$ values for ^{57}Cu, and ^{61}Ga are taken from ENSDF.

Nuclide	Ex	J^π	$T_{1/2}$	Q$_\varepsilon$	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{53}Co		(7/2$^-$)	245(3) ms	8.2881(4)	0.7630(24)		-5.7867(17)	0.248(3)	[**2017Ku12**]
^{53m}Co	3.1752(23)	(19/2$^-$)	245(102) ms	11.403(8)	2.321(8)		-2.613(8)	3.422(8)	[**2023SaXX**, 2015Sh16, 1972Ce01, 1976Vi02, 1971Ce01, 1970Ce04]
^{57}Cu		3/2$^-$	195(4) ms	8.7749(4)	1.4425(5)		-4.4056(6)	1.214(2)	[**2017Ku12**]
^{61}Ga		3/2$^-$	163(5) ms	9.210(40)	3.920(40)	<0.25%**	-0.551(40)	6.529(40)	[**2017Ku12**, 2002We07]
^{65}As			130.3(6) ms	9.540(80)	4.610(80)		0.695(80)	6.984(82)	[**2017GoZT**, 2002Lo13]
^{69}Br		3/2$^-$	<24ns	10.180(40)	5.350(40)	7.793(40)	1.836(40)	7.793(40)	[**2014De41**]
^{73}Rb		(3/2$^-$)	< 81 ns	10.540(40)	5.760(40)		2.559(40)	8.00(40)	[**2020Ho17, 2020Ho06**1]
^{77}Y		(5/2$^+$)	57 $^{+22}_{-12}$ ms	11.37(20)#	6.75(20)#	7.69(20)#	3.31(20)#	7.69(20)#	[**2002Fa13**]
^{81}Nb			< 40 ns	11.16(41)#	7.50(40)#		4.54(40)#	9.02(40)#	[**2017Su26**]
^{85}Tc			< 43 ns	11.66(40)#	8.06(40)#		5.48(40)#	9.25(41)#	[**2017Su26**]
^{89}Rh			< 120 ns	12.72(36)#	8.73(36)#		6.66(36)#	9.435(36)#	[**2016Ce02**]
^{93}Ag		(9/2$^+$)	228(16) ns	12.58(55)#	9.31(40)#		7.26(40)#	9.54(40)#	[**2016Ce02**]
^{97}In		(9/2$^+$)	36(6) ms	13.34(58)#	9.83(41)#	1.7$^{+1.7}_{-0.8}$ %	8.00(40)#	9.17(55)#	[**2018Pa20**, 2016Ce02, 2011StZV]
^{97m}In	0.61(18)	(1/2$^-$)	120(110) μs	13.95(61)#	10.44(45)#		8.61(44)#	9.78(58)#	[**2018Pa20**]

* Deduced from Sp(^{53}Co) and p energy.
** Not observed.

Table 2
Particle emission from the odd-Z, T_z = -1/2 nuclei, Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_p$	BR$_{1p}$	S$_{2p}$	Q$_\alpha$	Experimental
^{53}Co	1.6163(17)	——	8.9941(17)	-7.464(3)	
^{53m}Co	-1.580(30)	1.3(1)%	5.798(30)	-4.267(30)	[**2023SaXX**, 2015Sh16, 1972Ce01, 1976Vi02, 1971Ce01, 1970Ce04]
^{57}Cu	0.6903(4)	——	7.8570(5)	-7.0746(18)	
^{61}Ga	0.250(40)	——	5.350(40)	-2.250(40)	
^{65}As	-0.090(80)		4.970(80)	-2.230(90)	
^{69}Br	-0.640(40)	100%	4.250(40)	-1.750(90)	[**2014De41**, 2011Ro18, 2011Ro47]
^{73}Rb	-0.640(40)	100%	4.090(40)	-2.180(60)	[**2020Ho06, 2020Ho17**, 2017Su31]
^{77}Y	-0.52(20)#		3.80(20)#	-2.85(21)#	
^{81}Nb	-1.11(50)#	100 %*	3.14(41)#	-2.35(45)#	[**2017Su26**, 2016Ce02, 2001Ki13]
^{85}Tc	-1.03(50)#	100 %*	2.82(43)#	-1.91(57)#	[**2017Su26**, 2016Ce02
^{89}Rh	-1.40(20)#	100 %*	2.54(36)#	-2.23(54)#	[**2016Ce02**]
^{93}Ag	-1.09(53)#	100 %*	2.41(50)#	-3.17(54)#	[**2016Ce02**]
^{97}In	-0.89(57)#		2.06(57)#	-3.42(57)#	
^{97m}In	-1.50(60)#	100 %	1.45(60)#	2.81(60)#	[**2018Pa20**]

* Inferred by half-life

Table 3
Direct proton emission from ^{53m}Co*, Ex = 3.1752(23) MeV, T$_{1/2}$ =250(10) ms, BR$_p$ 1.3(1) %.

E_p(c.m.)	E_p(lab)	I_p(rel)	I_p(abs)	$E_{daughter}$(^{52}Fe)	coinc γ-rays
0.7095(16)	0.6961(16)	1.90(29)%	0.025(4)%	0.849	0.849
1.5589(16)	1.5295(16)	100%	1.3(1) %	0.0	——

* All values taken from [2023SaXX].

Table 4
Direct proton emission from ^{69}Br*, $T_{1/2}$ = <24 ns, $BR_p \approx 1.5$ %.

E_p(c.m.)	E_p(lab)	I_p(abs)	$E_{emitter}$ (^{69}Br)	$E_{daughter}$(^{68}Se)
0.641(42)	0.632(42)	100 %	0	0

* All values taken from [2014De41].

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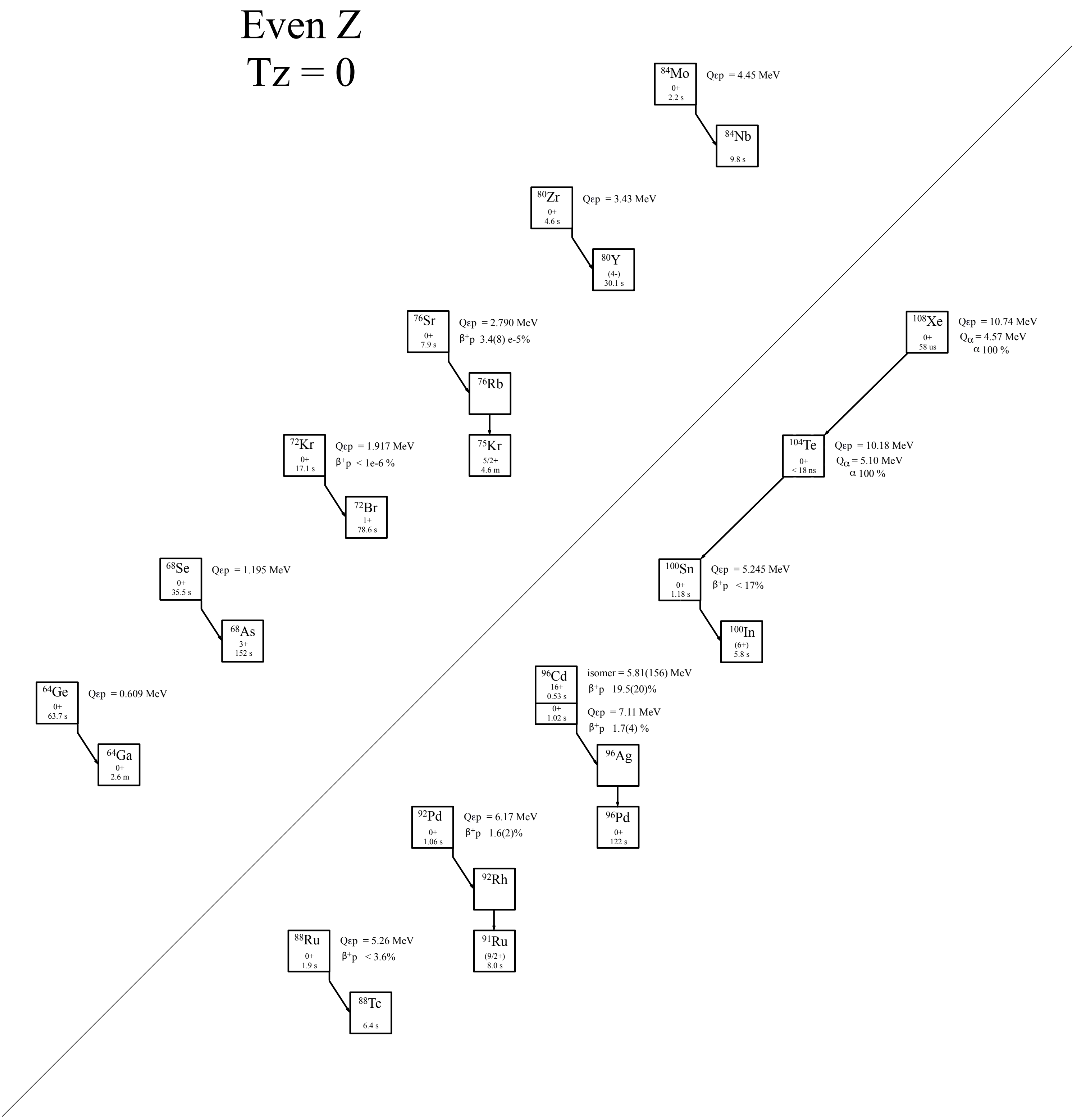

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= 0 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = 0 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	Ex	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{64}Ge		0^+	63.7(25) s	4.517(4)	0.609(4)		-6.107(4)	1.604(4)	[**1974Ro16**]
^{68}Se		0^+	35.5(7) s	4.7051(19)	1.195(4)		-5.044(1)	2.218(2)	[**1994Ba50**]
^{72}Kr		0^+	17.1(2) s	5.121(8)	1.917(8)	$<1\times10^{-6}$%	-4.185(8)	2.529(8)	[**2003Pi03, 2015Br17**]
^{76}Sr		0^+	7.89(7) s	6.230(30)	2.790(40)	$3.4(8)\times10^{-5}$%	-3.540(31)	2.387(30)	[**2004De24**, 2013Pe13]
^{80}Zr		0^+	4.6(6) s	6.39(30)#	3.43(30)#		-2.40(30)#	3.29(30)#	[**2003Au02**]
^{84}Mo		0^+	2.2(2) s	7.02(30)#	4.45(30)#		-0.68(30)#	4.55(30)#	[**2009St04**]
^{88}Ru		0^+	1.9(5) s	7.33(30)#	5.26(30)#	<3.6%	0.22(30)#	4.43(30)#	[**2019Pa16**, 2001Ki13]
^{92}Pd		0^+	1.06(3) s	8.22(35)	6.17(35)	1.6(2)%	1.37(35)	4.47(35)	[**2019Pa16**]
^{96}Cd		0^+	1.02(6) s	8.94(40)#	7.11(41)#	1.7(4)%	2.76(41)#	5.00(41)#	[**2019Pa16**, 2017Da07, 2012Lo08]
^{96m}Cd	5.81(156)	16^+	0.53(3) s	14.7(16)#	12.9(16)#	19.5(29)%	8.6(16)#	10.8(16)	[**2019Pa16**, 2017Da07]
^{100}Sn		0^+	1.18(8) s	7.03(24)	5.245(7)	<17%	1.34(24)	4.94(26)	[**2019Lu08, 1997Su06**, 2012Hi07, 2012Lo08, 2008Ba53]
^{104}Te		0^+	<18 ns	9.67(33)#	10.18(33)#		6.49(32)	12.12(32)	[**2018Au04**, 2019Xi06]
^{108}Xe		0^+	58^{+106}_{-23} μs		10.74(39)#		9.27(38)	14.25(39)#	[**2018Au04**, 2019Xi06, 2008Ko04]

Table 2
Particle emission from the even-Z, T_z = 0 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{64}Ge	5.057(4)	7.725(4)	-2.566(4)	—–	
^{68}Se	4.8912(7)	7.1604(25)	-2.299(4)	—–	
^{72}Kr	4.727(10)	6.589(8)	-2.176(8)	—–	
^{76}Sr	4.320(30)	6.490(30)	-2.91(71)	—–	
^{80}Zr	4.25(31)#	6.16(30)#	-2.94(30)#	—–	
^{84}Mo	3.85(34)#	5.13(30)#	-1.84(42)#	—–	
^{88}Ru	3.94(30)#	4.91(30)#	-2.59(42)#	—–	
^{92}Pd	3.50(46)#	4.47(35)	-2.86(46)#	—–	
^{96}Cd	2.96(57)#	4.05(41)#	-3.22(54)#	—–	
^{96m}Cd	-2.85(16)#	-1.76(16)#	1.88(16)#		
^{100}Sn	3.06(38)#	4.09(25)	-4.00(48)#	—–	
^{104}Te	0.25(44)#	-0.73(33)	5.10(21)	100%	[**2019Xi06, 2018Au04**]
^{108}Xe	0.49(48)#	-1.01(39)#	4.57(21)	100%	[**2018Au04**, 2019Xi06, 2008Ko04]

Table 3
β-p Emission from ^{96m}Cd*, $T_{1/2}$ = 0.53(3) s, $BR_{\beta p}$ = 19.5(29)%.

E_p	I_p(rel)%	I_p(abs)%	$E_{emitter}$ (^{96}Ag)	$E_{daughter}$(^{95}Pd)	coincident γ-rays
**	22(14)	2.1(14)		4.751	0.130, 0.691, 0.821, 1.375
**	72(42)	7.0(42)		4.071	0.130, 0.691, 0.821, 1.375
**	100(62)	9.8(62)		2.696	0.130, 0.691, 0.821

* All values taken from [2019Pa16].
** Unresolved multiplet (Ep ≈ 1.5-6 MeV) - see Fig 8 in ref. [2019Pa16].

Table 4
direct α emission from ^{104}Te*, $J^\pi = 0^+$, $T_{1/2}$ =<18 ns, BR_α =100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{100}Sn)	coincident γ-rays	R_0 (fm)	HF
5.096(20)	4.90(20)	100%	0^+	0.0	—–	$1.890^{+.058}_{-.035}$	>0.41

* All values from [2018Au04].

Table 5
direct α emission from ^{108}Xe*, $J^{\pi} = 0^{+}$, $T_{1/2} = 58^{+106}_{-23}$ μs, BR_{α} =100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{104}Te)	coincident γ-rays	R_0 (fm)	HF
4.569(20)	4.40(20)	100%	0^{+}	0.0	—–	$2.046^{+0.060}_{-0.036}$	0.75(30)

* All values from [2018Au04].

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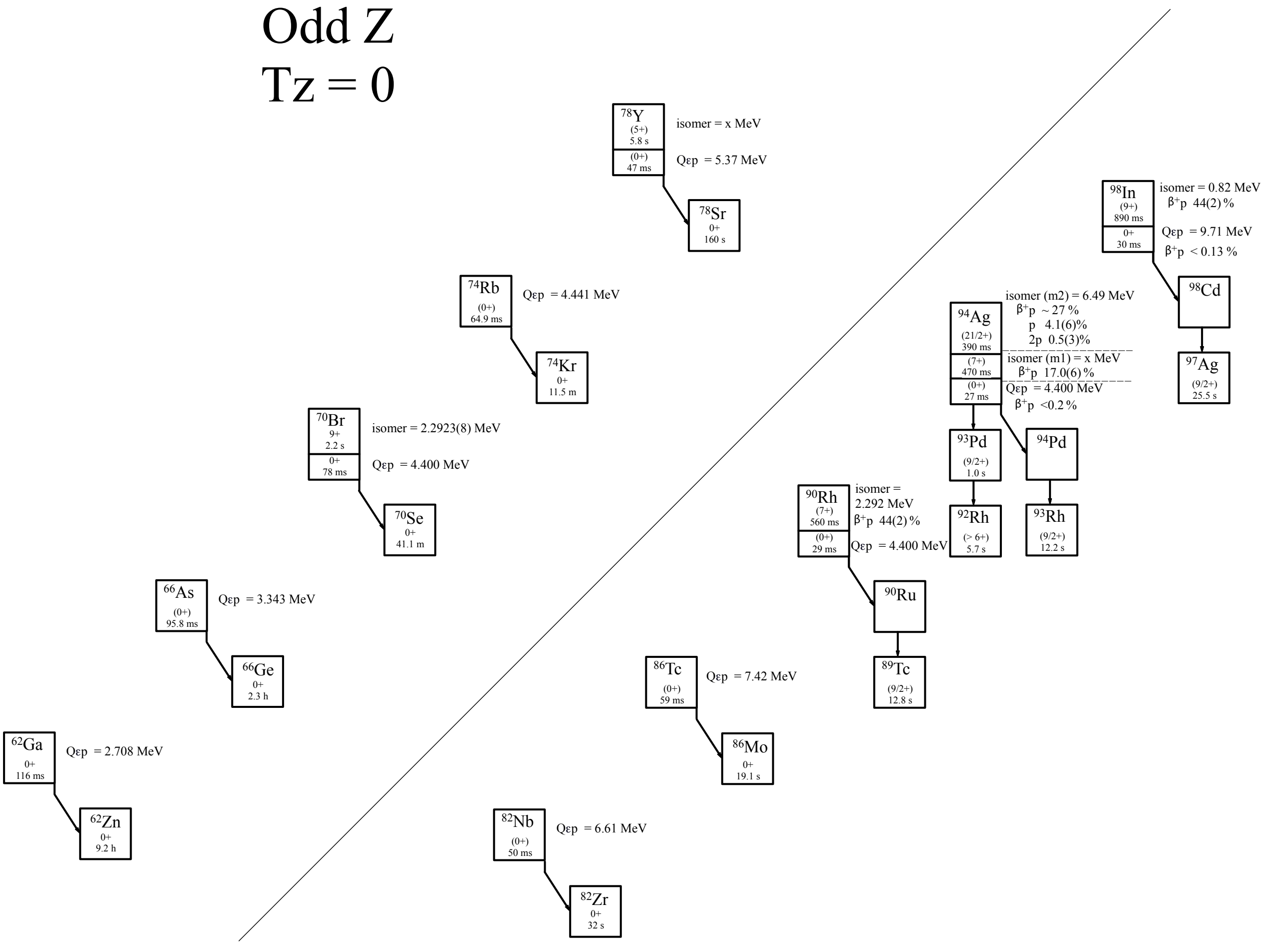

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Observed and predicted β-delayed particle emission from the odd-Z, $T_z = 0$ nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{62}Ga		0^+	116.121(21) ms	9.1811(4)	2.7081(11)		-2.0918(7)	5.8169(7)	[**2008Be21**]
^{66}As		(0^+)	95.77(23) ms	9.582(6)	3.343(6)		-0.599(5)	6.718(5)	[**2014Ro14**]
^{70}Br		0^+	78.42(51) ms	10.504(15)	4.400(40)		0.975(25)	7.756(15)	[**2017Mo18**]
^{74}Rb		(0^+)	64.9(5) ms	10.416(3)	4.441(7)		1.374(4)	7.589(3)	[**2013Du14**]
^{78}Y		(0^+)	47(5) ms	11.00(30)#	5.37(30)#		2.27(30)#	7.74(30)#	[**2007Na13**]
^{82}Nb		(0^+)	50(4) ms	11.80(30)#	6.61(30)#		3.92(30)#	8.940(30)#	[**1999Lo07, 1998Lo17**]
^{86}Tc		(0^+)	59^{+8}_{-7} ms	12.54(30)#	7.42(30)#		5.274(300)#	9.619(30)#	[**2002Fa13**]
^{90}Rh		(0^+)	29(3) ms	13.25(20)#	8.47(30)#		6.48(20)#	10.06(20)#	[**2019Pa16**]
^{90m}Rh	x	(7^+)	0.56(2) s	13.25(20)# + x	8.47(30)# + x	9.6(10)%	6.48(20)#+x	10.06(20)#+x	[**2019Pa16**]
^{94}Ag		(0^+)	27(2) ms	13.70(40)#	9.32(40)#	<0.2%	7.32(40)	10.01(40)#	[**2019Pa16**, 2004Mu30, 1994Sc35]
^{94m1}Ag	x	(7^+)	0.47(1) s	13.70(40)# + x	9.32(40)# + x	17.0(6)%	$7.313\# + x$	10.01(40)#+x	[**2019Pa16, 2004Mu30**, 1994Sc35]
^{94m2}Ag	6.49(63)#	$(21/2^+)$	0.39(4) s	20.19(75)#	15.81(75)#	≈27%	13.81(75)#	16.50((75)#	[**2004Mu30, 005Mu15**, 2007Ro16, 2006Mu03]
^{98}In		0^+	30(1) ms	13.73(30)#	9.71(31)#	<0.13%	7.70(30)#	9.77(30)#	[**2019Pa16**, 2012Lo08]
^{98m}In	0.82(73)	(9^+)	0.89(2) s	14.55(79)#	10.53(79)#	44(2)%	8.52(79)#	9.77(30)#+x	[**2019Pa16**]
^{102}Sb				13.84(41)#	10.16(40)#		8.52(40)#	14.12(40)#	
^{106}I				14.92(41)#	13.43(40)#		13.75(40)#	19.21(41)#	

Table 2
Particle emission from the odd-Z, $T_z = 0$ nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	BR_{1p}	S_{2p}	BR_{2p}	Q_α	Experimental
^{62}Ga	2.927(16)	—	8.2197(17)		-2.7441(7)	
^{66}As	2.836(6)	—	7.770(6)		-2.463(6)	
^{70}Br	2.280(15)	—	7.109(15)		-1.825(16)	
^{74}Rb	2.653(7)	—	7.432(3)		-2.915(15)	
^{78}Y	1.66(30)#	—	6.27(30)#		-2.68(30)#	
^{82}Nb	1.57(31)#	—	5.24(30)#		-2.06(42)#	
^{86}Tc	1.35(30)#	—	4.95(30)#		-2.19(42)#	
^{90}Rh	0.55(20)#	—	4.54(20)#		-2.49(36)#	
^{90m}Rh	0.55(20)#-x	—	4.54(20)#-x		-2.49(36)#+x	
^{94}Ag	0.71(55)#	—	3.98(40)#		-3.19(45)#	
^{94m1}Ag	0.71(55)#-x	—	3.98(40)#-x		-3.19(45)#+x	
^{94m2}Ag	-5.78(84)#	4.1(6)%	-2.50(75)#	0.5(3)%	3.00(77)#	[**2006Mu03, 2005Mu15**]
^{98}In	0.46(52)#		3.97(32)#		-3.93(50)#	
^{98m}In	0.46(52)# -x	—	3.97(32)# -x		-3.93(50)# +x	
^{102}Sb	-1.92(50)#		1.50(40)#		0.38(50)#	
^{106}I	-2.22(50)#		-1.42(41)#		5.38(57)#	

Table 3
β-p emission from ^{90m}Rh*, Ex. = unk, $T_{1/2}$ =0.56(2) s, $BR_{\beta p}$ = 9.6(10)%.

E_p(c.m.)	I_p(rel)%	I_p(abs)%	$E_{emitter}$ (^{90}Ru)	$E_{daughter}$(^{89}Tc)	coincident γ-rays
**	37(21)	2.6(15)		0.796	0.796
**	100(56)	7.0(40)		0	—

* All values taken from [2019Pa16].
** Unresolved multiplet (Ep ≈ 1.5-6 MeV) - see Fig 8 in ref. [2019Pa16].

Table 4
β-p emission from ^{94m1,94m2}Ag*, $T_{1/2}$ (^{94m1}Ag)=0.47(1) s[@], $T_{1/2}$(^{94m2}Ag) =390(40) ms

E_p(c.m.)**	I_p(rel)%**	$E_{emitter}$ (^{94}Pd)	$E_{daughter}$(^{89}Tc)	coincident γ-rays
	3.3(7)		0.0	—–
	1.7		0.2401(1)	0.241
	0.4		0.622(1)	0.622
	6.8		0.8529(1)	0.853
	3.0		0.8942(1)	0.894
	0.3		1.4510(7)	0.557, 0.894, 1.451
	0.3		1.4637(8)	0.570, 0.894, 1.464
	0.5		1.7184(5)	1.718
	1.3		1.7189(1)	0.853, 0.866
	0.7		2.1978(5)***	2.198
	0.3		2.5951(2)	0.333, 0.542, 0.853, 0.866
	0.2		2.8905(3)	0.295, 0.333, 0.542, 0.853 0.866
	0.1		3.5430(4)	0.295, 0.333, 0.542, 0.653 0.853, 0.866, 0.948
	0.1		4.0887(3)	0.295, 0.333, 0.542, 0.546 0.653, 0.853, 0.866, 0.948 1.494
	0.3		4.7084(11)	0.159, 0.295, 0.297, 0.333 0.542, 0.853, 0.866, 1.361
	0.1		4.7489(4)	0.138, 0.295, 0.333, 0.497 0.542, 0.522, 0.853, 0.866 1.362, 1.494
	0.8		5.4469(5)	0.138, 0.295, 0.333, 0.497 0.542, 0.522, 0.698, 0.853 0.866, 1.362, 1.494
	0.6		5.6938(5)	0.138, 0.247, 0.295, 0.333 0.497, 0.542, 0.522, 0.698 0.853, 0.866, 1.362, 1.494
	0.4		6.5797(6)	0.138, 0.191, 0.247, 0.295 0.333, 0.497, 0.542, 0.522 0.698, 0.853, 0.866, 1.362 1.494
	0.4		6.7099(7)***	0.130, 0.138, 0.191, 0.247 0.295, 0.333, 0.497, 0.542 0.522, 0.698, 0.853, 0.866 1.362, 1.494

* All values taken from [2004Mu30] and are a combination of the (7^*) and (21^+) isomers. The ratio of the the two is estimated to be is estimated to be 89% and 11%, respectively.

** Individual proton energies not measured. Intensities in daughter inferred by gammas and TAS measurements [2004Mu30].

***tentative assignment

[@] [2019Pa16]

[@@] [2004Mu30]

Table 5
direct proton emission from ^{94m2}Ag*, Ex = 6.49(63)#**, $T_{1/2}$ =390(40) ms***, BRp =4.1(6)%.

E_p(c.m.)	E_p(lab)	I_p (rel)%	I_p(abs)%	$E_{daughter}$(^{93}Pd)	coincident γ-rays
0.790(30)	0.781(30)	86 (28)	1.9(5)	4.994	0.167, 0.196, 0.208, 0.275, 0.349, 0.361, 0.887, 0.984, 0.991, 1.096, 1.132
1.010(30)	0.999(30)	100(18)	2.2(4)	4.751	0.167, 0.196, 0.208, 0.275, 0.349, 0.361, 0.403, 0.614, 0.887, 0.984, 0.991, 1.096

* All values from [2005Mu13], except where noted.

** Excitation Energy = 6.49(63)# MeV, based on Q_p = 5.78(30) MeV [2005Mu13] and S_p (^{94}Ag) = 0.71(55) MeV # [2021Wa16].

*** [2004Mu30]

Table 6
direct 2-proton emission from ^{94m2}Ag*, Ex = 6.49(63)#**, $T_{1/2}$ =390(40) ms***, BR_{2p} =0.5(3)%.

E_{2p}(c.m.)	E_{2p}(lab)	I_{2p}(abs)%	$E_{daughter}$(^{92}Rh)	coincident γ-rays
1.90(10)	1.860(10)	0.5(3)	1.549	0.235, 0.278, 0.364, 0.672, 1.036

* All values from [2005Mu13], except where noted.
** Excitation Energy = 6.49(63)# MeV, based on Q_p = 5.78(30) MeV [2005Mu13] and S_p (^{94}Ag) = 0.71(55) MeV # [2021Wa16].
*** [2004Mu30]

Table 7
β-p Emission from ^{98m}In*, Ex = 0.82(73) MeV, $T_{1/2}$ = 30(1) ms, $BR_{\beta p}$ = 44(2)%.

E_p	I_p(rel)%	I_p(abs)%	$E_{emitter}$ (^{98}Cd)	$E_{daughter}$(^{97}Ag)	coincident γ-rays
**	61(14)	9.7(22)		2.343	0.290, 0.763, 1.290
**	100(22)	15.8(36)		2.053	0.763, 1.290
**	78(17)	12.3(27)		2.020	0.602, 0.730, 1.290, 1.470
**	36(31)	5.7(49)		1.290	1.290

* All values taken from [2019Pa16].
** Unresolved multiplet (Ep ≈ 1.5-6 MeV) - see Fig 8 in ref. [2019Pa16].

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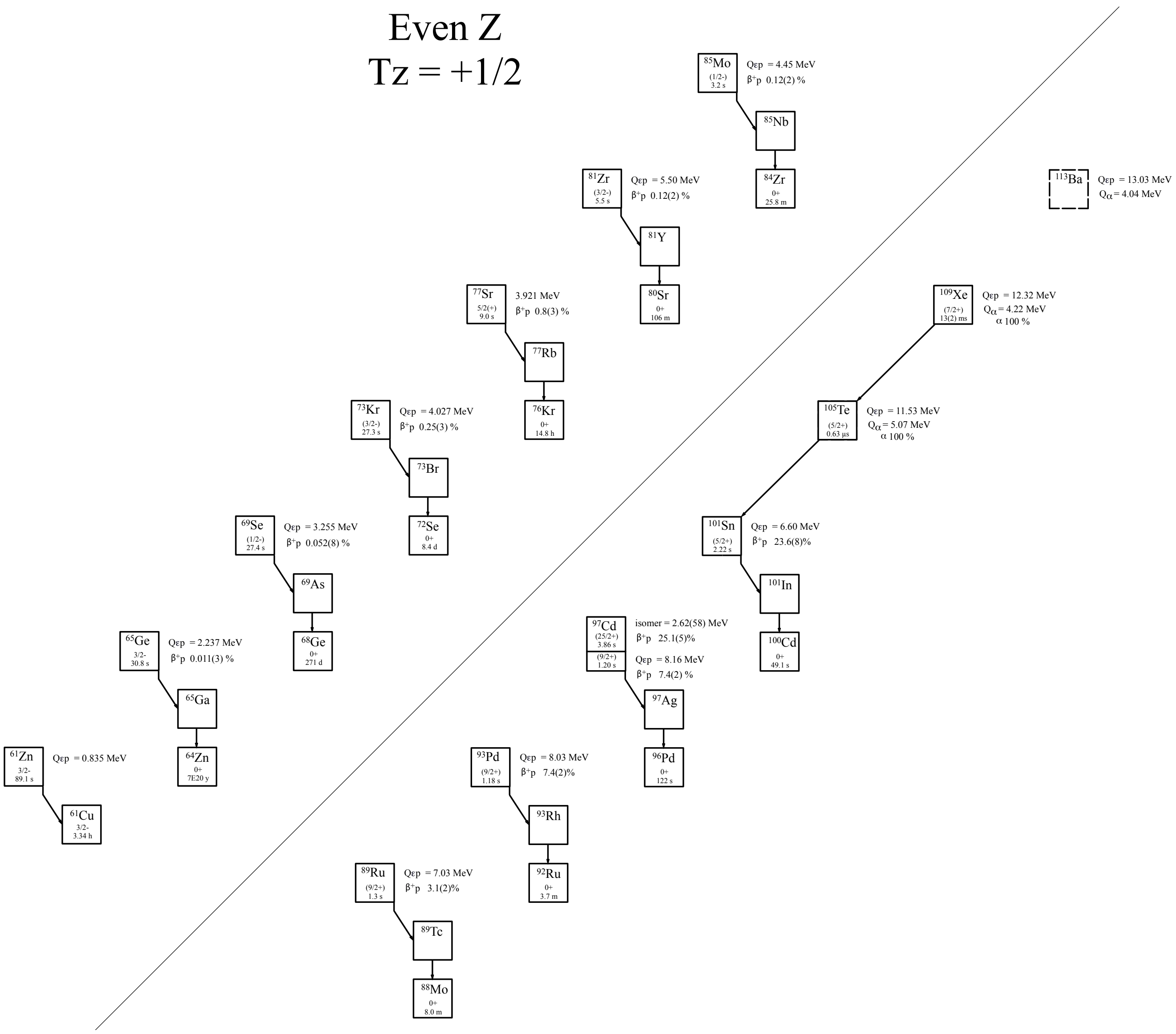

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +1/2 nuclei.

Last updated 3/20/23

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +1/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. The J^πvalue for ^{61}Zn is taken from ENSDF.

Nuclide	Ex	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{61}Zn		3/2$^-$	89.1(2) s	5.635(16)	0.835(16)		-8.67(16)	0.572(16)	[**1972Du09**]
^{65}Ge		3/2$^-$	30.8(7) s	6.1793(23)	2.2368(23)	0.011(3)%	-5.476(2)	3.045(2)	[**1987Vi01**, 2000Gi11, 1976Ha29]
^{69}Se		(1/2$^-$)	27.4(2) s	6.680(30)	3.2551(24)	0.052(8)%	-4.134(2)	3.798(2)	[**2000Gi11**, 1988De28, 1977Ma24, 1976Ha22, 1976Ha29]
^{73}Kr		(3/2$^-$)	27.3(10) s	7.094(9)	4.027(7)	0.25(3)%	-3.237(8)	4.133(31)	[**2000Gi11**, 1999Mi17, 1981Ha44, 1972Ho20, 1976Ha29]
^{77}Sr		5/2$^{(+)}$	9.0(2) s	7.027(8)	3.921(9)	0.08(3)%	-3.274(9)	3.418(11)	[**2000Gi11**, 1976Ha29]
^{81}Zr		(3/2$^-$)	5.5(4) s	8.190(90)	5.500(90)	0.12(2)%	-1.295(90)	4.886(90)	[**1999Hu05**, 2005Xu04, 1997Hu15, 1977Ce05, 1976HaWO]
^{85}Mo		(1/2$^-$)	3.2(2) s	8.770(16)	6.623(17)	0.14(2)%	0.118(25)	5.778(17)	[**1999Hu05**, 2005Xu04, 1997Hu15, 1976HaWO]
^{89}Ru		(9/2$^+$)	1.31(3) s	9.025(25)	7.028(25)	3.1(2) %	0.927(25)	5.486(24)	[**2019Pa16, 2012Lo08**, 2005Xu04, 1999Li33]
^{93}Pd		(9/2$^+$)	1.18(2) s	10.03(37)	8.03(37)	7.4(2)%	2.43(37)	5.990(30)	[**2019Pa16**, 2012Lo08, 2005Xu04, 2001Xu05, 2000Sc31]
^{97}Cd		(9/2$^+$)	1.20(7) s	10.17(42)	8.16(42)	7.4(2)%	3.03(42)	5.87(42)	[**2019Pa16**, 2012Lo08, 1982Ku15]
^{97m}Cd	2.62(58)	(25/2$^+$)	3.86(6) s	12.79(72)	10.78(72)	25.1(5)%	5.65(72)	8.49(72)	[**2019Pa16**, 2012Lo08, 2011Lo09]
^{101}Sn		(5/2$^+$)	2.22(5) s	8.24(30)	6.60(30)	23.6(8)%	1.82(30)	8.17(30)	[**2019Pa16, 2012Lo08**, 2020Pa25, 2007Ka15, 2007Se04, 1995Ja16]
^{105}Te		(5/2$^+$)	0.62(7) μs	11.20(30)	11.53(30)		7.24(30)	13.31(30)	[**2006Li41**, 2010Da17, 2019Xi06, 2007Li83, 2007LiZP, 2006Se08]
^{109}Xe		(7/2$^+$)	13(2) ms	11.50(30)	12.32(30)		9.91(30)	15.42(30)	[**2006Li41**, 2019Xi06, 2010Da17, 2007Li83, 2007LiZP, 2006Li41, 2006Se08]
^{113}Ba				12.06(30)#	13.03(30)#		10.67(30)#	15.54(30)#	

* Excitation Energy = 2.62(58) MeV [2019Pa16].

Table 2
Particle emission from the even-Z, T_z = +1/2 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{61}Zn	5.293(16)	9.770(16)	-2.690(16)	——	
^{65}Ge	4.9344(26)	8.8427(27)	-2.554(16)	——	
^{69}Se	4.8292(24)	8.339(5)	-2.3814(26)	——	
^{73}Kr	4.779(7)	7.983(7)	-2.542(7)	——	
^{77}Sr	4.613(8)	8.058(11)	-3.677(10)	—	
^{81}Zr	3.670(90)	6.620(90)	-2.150(90)	——	
^{85}Mo	3.605(16)	6.176(17)	-2.140(90)	——	
^{89}Ru	3.988(25)	6.063(24)	-3.285(29)	——	
^{93}Pd	3.270(37)	5.32(37)	-3.04(37)	——	
^{97}Cd	3.51(43)	5.35(42)	-4.18(56)	——	
^{97m}Cd	0.89(72)	2.73(72)	-1.56(81)	——	
^{101}Sn	3.42(30)	4.95(30)	-2.00(52)	——	
^{105}Te	0.81(32)	0.30(32)	5.069(3)	100%	[**2010Da17**, 2019Xi06, 2006Li41, 2006Se08]
^{109}Xe	0.69(32)	0.09(32)	4.217(7)	100%	[**2010Da17**, 2019Xi06, 2006Li41, 2006Se08]
^{113}Ba	0.58(32)#	-0.23(32)#	4.04(42)#		

Table 3
β-p emission from ^{93}Pd*, $T_{1/2}$ = 1.18(2) s, $BR_{\beta p}$ = 7.4(2)%.

E_p	I_p(rel)%	I_p(abs)%	$E_{emitter}$ (^{93}Rh)	$E_{daughter}$(^{92}Ru)	coincident γ-rays
**	< 5.5	<0.3		2.672	0.817, 0.865, 0.990
**	14(3)	0.74(15)		1.855	0.865, 0.990
**	100(7)	5.3(4)		0.865	0.865
**	≈25(7)	≈1.3(4)		0.0	

* All values taken from [2019Pa16].
** Unresolved multiplet (Ep ≈ 1.5-5 MeV) - see Fig 8 in ref. [2019Pa16].

Table 4
β-p emission from ^{97}Cd*, $T_{1/2}$ = 1.20(7) s, $BR_{\beta p}$ = 7.4(2)%.

E_p	I_p(rel)%	I_p(abs)%	$E_{emitter}$ (^{97}Ag)	$E_{daughter}$(^{96}Pd)	coincident γ-rays
**	4.7(23)	0.16(7)		3.342	1.415, 1.972
**	19.6(52)	0.64(17)		2.391	0.192, 0.684, 1.415
**	100(23)	3.3(8)		2.099	0.684, 1.415
**	73(27)	2.4(9)		1.415	1.415
**	30(27)	1.0(9)		0.0	—

* All values taken from [2019Pa16].
** Unresolved multiplet (Ep ≈ 1.5-6 MeV) - see Fig 8 in ref. [2019Pa16].

Table 5
β-p emission from ^{97m}Cd*, Ex = 2.62(58) MeV, $T_{1/2}$ = 3.86(6) s, $BR_{\beta p}$ =25.1(5)%.

E_p	I_p(rel)%	I_p(abs)%	$E_{emitter}$ (^{97}Ag)	$E_{daughter}$(^{96}Pd)	coincident γ-rays
**	15.4(18)	2.16(25)		5.282	0.106, 0.423, 0.684, 1.253, 1.415, 1.499
**	58.4(13)	8.18(24)		4.574	0.106, 0.423, 0.684, 0.790, 1.253, 1.415
**	100(7)	14(1)		3.784	0.106, 0.423, 0.684, 1.253, 1.415

* All values taken from [2019Pa16].
** Unresolved multiplet (Ep ≈ 1.5-5 MeV) - see Fig 8 in ref. [2019Pa16].

Table 6
direct α emission from ^{105}Te*, J^π = 5/2$^+$, $T_{1/2}$ = 0.62(7) μs**, BR_α =100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{101}Sn)	coincident γ-rays	R_0 (fm)	HF
4.898(3)	4.711(3)	100(4)%	89(4)%	5/2$^+$	0.172(2)	0.172	1.696(74)	3^{+5}_{-2}
5.073(20)	4.880(20)	12(4)%	11(4)%	7/2$^+$	0.0	—	1.696(74)	100^{+18}_{-7}

* All values from [2010Da17], except where noted
** [2006Li47]

Table 7
direct α emission from ^{109}Xe*, J^π = 5/2$^+$, $T_{1/2}$ = 13(2) ms**, BR_α =100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{105}Te)	coincident γ-rays	R_0 (fm)	HF
4.059(10)	3.910(10)	45(8)%	31(7)%	7/2$^+$	0.150(3)	0.150	1.65(12)	3^{+12}_{-3}
4.218(4)	4.063(4)	100(10)%	69(7)%	5/2$^+$	0.0	—	1.65(12)	7^{+30}_{-6}

* All values from [2010Da17], except where noted.
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Odd Z
Tz = +1/2

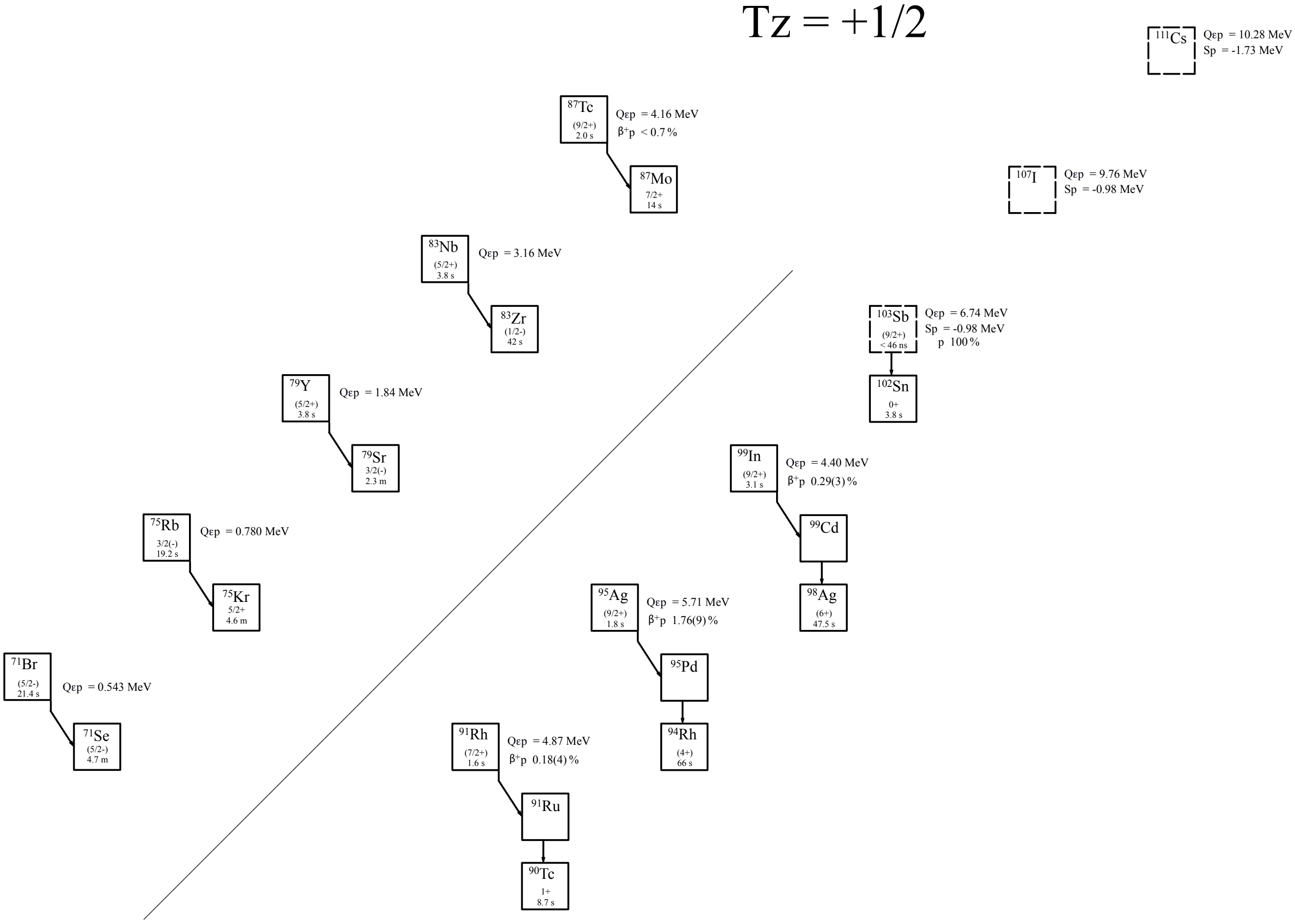

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +1/2 nuclei.

Last updated 3/20/23

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +1/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J^π values for ^{71}Br, ^{75}Rb, ^{79}Y, ^{83}Nb, are taken from ENSDF.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{71}Br	(5/2$^-$)	21.4(6) s	6.644(6)	0.543(6)		-3.979(5)	3.747(6)	[**1982Ha32**]
^{75}Rb	3/2$^{(-)}$	19.2(10) s*	7.105(8)	0.780(6)		-3.570(7)	3.503(3)	[**1983Ke08, 1977Da04**]
^{79}Y	(5/2$^+$)	14.9(6)	7.680(80)	1.840(80)		-2.209(80)	4.099(80)	[**1992Mu12**]
^{83}Nb	(5/2$^+$)	3.8(2)	8.30(16)	3.16(16)		-0.66(16)	5.45(16)	[**2009St04**]
^{87}Tc	(9/2$^+$)	2.0(3) s	9.195(5)	4.155(7)	<0.7%	0.907(7)	5.797(7)	[**2019Pa16**, 2001Ki13, 2000StZU]
^{91}Rh	(7/2$^+$)	1.60(2) s	9.67(30)#	4.87(30)#	0.18(4)%**	1.87(30)#	5.89(30)#	[**2019Pa16**, 2012Lo08]
^{95}Ag	(9/2$^+$)	1.80(7) s	10.06(40)#	5.71(40)#	1.76(9)%	2.73(40)#	5.90(40)#	[**2019Pa16**, 2012Lo08, 1994Sc35]
^{99}In	(9/2$^+$)	3.11(6) s	8.56(30)#	4.40(30)#	0.29(3)%	1.85(30)#	6.16(30)#	[**2020Pa25, 2019Pa16**, 2012Lo08]
^{103}Sb		< 46 ns	10.42(32)#	6.74(30)#		4.59(30)#	10.84(30)#	[**2017Su26**, 2013Su23, 1995Ry03]
^{107}I			11.23(32)#	9.76(30)#		9.33(30)#	15.24(32)#	
^{111}Cs			11.62(23)#	10.28(21)#		10.24(20)#	15.34(22)#	

* Weighted average of 21.4(10) s [1983Ke08] and 17.0(10) s [1977Da04].
** Decay from combination of ground state and (1/2$^-$) isomer.

Table 2
Particle separation and emission from the odd-Z, T_z = +1/2 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	BR_{1p}	S_{2p}	Q_α	$Q_{\varepsilon\alpha}$	Experimental
^{71}Br	1.861(6)	—	7.970(30)	-2.340(5)		
^{75}Rb	2.1758(23)	—	8.151(7)	-3.141(6)		
^{79}Y	1.920(80)	—	7.550(80)	-3.010(80)		
^{83}Nb	1.29(16)	—	6.48(16)	-2.23(18)		
^{87}Tc	0.868(5)	—	5.988(6)	-2.50(16)		
^{91}Rh	0.98(30)#	—	5.75(30)#	-3.30(30)#		
^{95}Ag	1.09(40)#	—	5.47(40)#	-3.76(50)#		
^{99}In	1.03(30)#	—	5.05(30)#	-3.90(50)#		
^{103}Sb	-0.98(32)#	100 %	2.70(30)#	2.28(42)#		[**2017Su26**, 2013Su23, 1995Ry03
^{107}I	-1.50(32)#		-0.010(300)#	4.82(42)#		
^{111}Cs	-1.73(22)#		-0.20(20)#	4.11(36)#		

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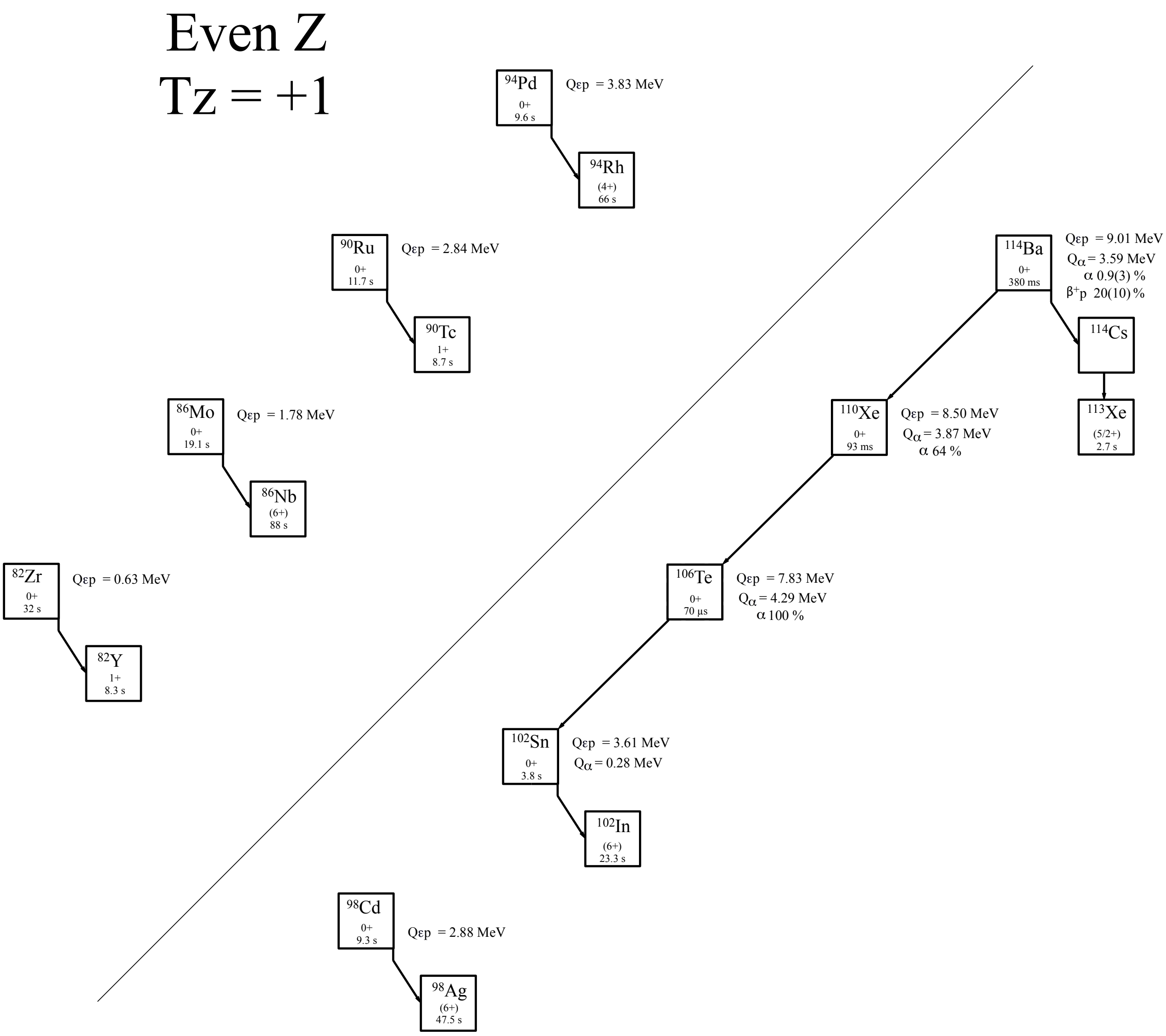

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +1 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +1 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{82}Zr	0^+	32(5) s	4.450(6)	0.625(4)		-6.017(3)	0.886(3)	[**1982Li17**]
^{86}Mo	0^+	19.1(3) s	5.023(6)	1.775(7)		-4.795(5)	1.528(6)	[**2005Ka39**]
^{90}Ru	0^+	11.7(9) s	5.841(4)	2.842(5)		-3.292(60)	1.825(6)	[**2004De40**]
^{94}Pd	0^+	9.6(2) s	6.805(5)	3.825(5)		-1.754(5)	2.198(4)	[**2006Ba55**]
^{98}Cd	0^+	9.3(1) s	5.430(40)	2.880(50)	<0.029%	-2.530(51)	2.843(50)	[**2019Pa16**, 1997Ra22, 1996He25]
^{102}Sn	0^+	3.8(2) s	5.76(10)	3.61(10)		-1.37(10)	5.72(10)	[**2002Fa13**]
^{106}Te	0^+	$70\ ^{+20}_{-15}$ μs	8.25(10)	7.83(10)		3.39(10)	10.05(10)	[**2016Ca33**, 2005Ja03, 2002Ma19, 1994Pa11, 1981Sc17]
^{110}Xe	0^+	93(3) ms	8.55(12)	8.50(10)		5.95(10)	12.13(10)	[**2016Ca33, 2007Sa36**, 2002Ma19, 1993HeZV, 1992HeZU, 1981Sc17]
^{114}Ba	0^+	380^{+190}_{-110} ms	8.78(13)	9.01(10)	20(10)%	6.58(10)	12.14(12)	[**2016Ca33**, 2002Ma19, 1997Ja12, 2003Mb01, 2001Ro35, 1995Gu10]

Table 2
Particle emission from the even-Z, T_z = +1 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{82}Zr	5.190(6)	7.881(4)	-2.865(8)	—–	
^{86}Mo	5.120(5)	7.267(6)	-2.922(3)	—–	
^{90}Ru	4.778(5)	6.775(5)	-3.198(5)	—–	
^{94}Pd	4.379(5)	6.379(5)	-3.643(6)	—–	
^{98}Cd	4.020(50)	6.030(50)	-3.960(50)	—–	
^{102}Sn	3.68(10)	5.32(10)	0.28(11)		
^{106}Te	1.49(10)	1.17(10)	4.290(9)	100%	[**2016Ca33, 1994Pa11**, 2005Ja03, 2002Ma19, 1981Sc17]
^{110}Xe	1.54(10)	0.72(10)	3.872(9)	64(35)%	[**2016Ca33**, 2002Ma19, 2007Sa36, 1993HeZS, 1992HeZU, 1981Sc17]
^{114}Ba	1.43(10)	0.46(10)	3.592(19)	0.9(3)%	[**2016Ca33**, 2002Ma19, 2003Mb01, 2001Ro35, 1997Ja12, 1995Gu10]

Table 3
direct α emission from ^{106}Te*, $J^\pi = 0^+$, $T_{1/2} = 70\ ^{+20}_{-15}\ \mu$s**, BR_α =100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{102}Sn)	coincident γ-rays	R_0 (fm)	HF
4.290(9)	4.128(9)	100%	100%	0^+	0.0	—-	1.684(49)	0.94(27)

* All values from [1994Pa11], except where noted.
** [2016Ca33].

Table 4
direct α emission from ^{110}Xe*, $J^\pi = 0^+$, $T_{1/2}$ = 93(3) ms**, BR_α =64(35)%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{106}Te)	coincident γ-rays	R_0 (fm)	HF
3.860(20)	3.720(20)	100%	64(35)%	0^+	0.0	—-	1.655(47)	$0.9^{1.1}_{-0.3}$

* All values from [2016Ca33],except where noted
** [2007Sa36].

Table 5
direct α emission from ^{114}Ba*, J^{π} = 0^{+}, $T_{1/2}$ = 380^{+190}_{110} ms, BR_{α} =0.9(3)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{110}Xe)	coincident γ-rays	R_0 (fm)	HF
3.610(20)	3.480(20)	100%	0.9(3)%	0^{+}	0.0	—-	1.700(47)	$1.2^{1.5}_{-0.8}$

* All values from [2016Ca33].

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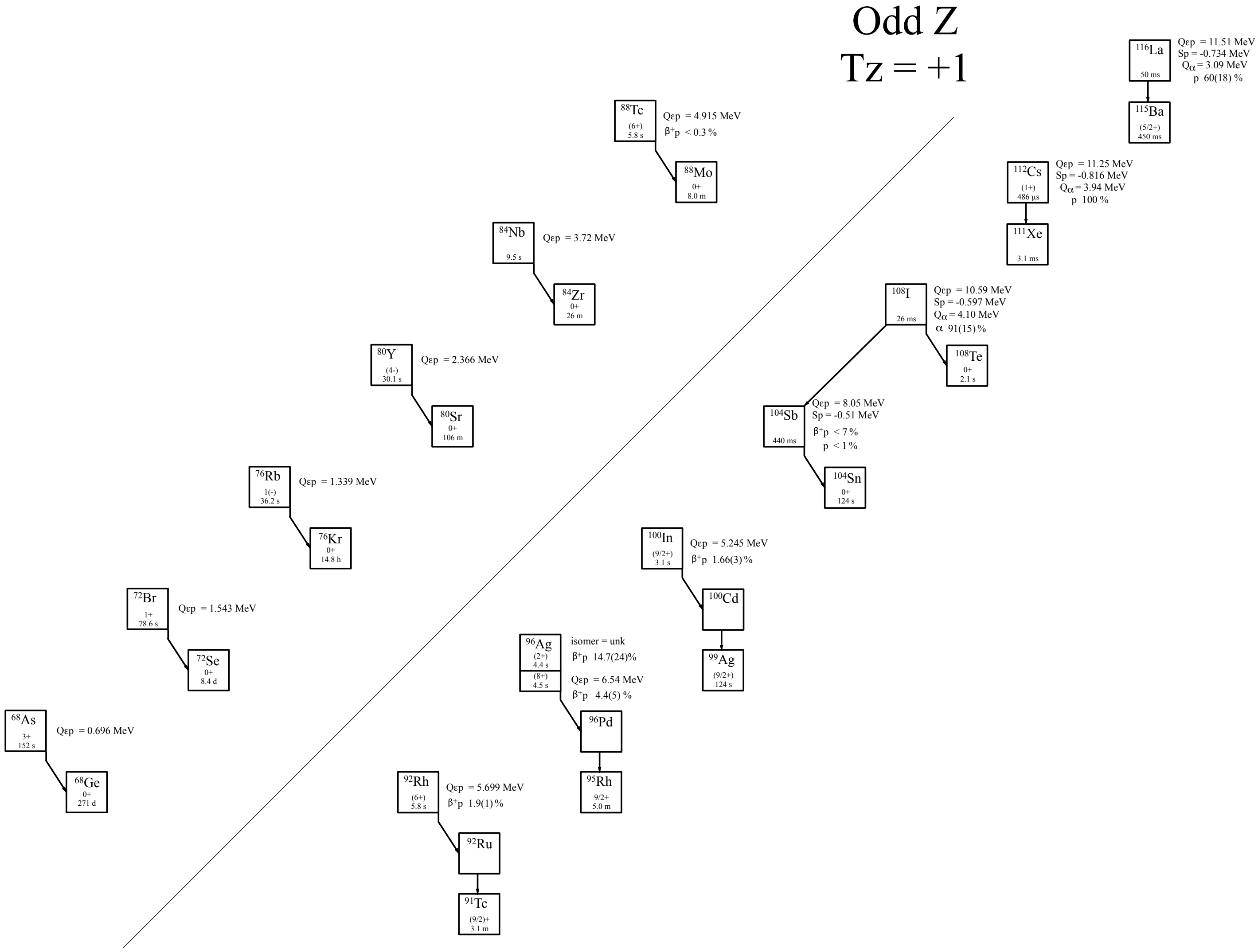

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +1 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +1 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J$^\pi$values for ^{68}As, ^{72}Br, ^{76}Rb, ^{80}Y, ^{84}Tc are taken from ENSDF.

Nuclide	Ex	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{68}As		3$^+$	151.5(9) s	8.0843(26)	0.6957(22)		-4.5733(19)	4.685(2)	[**1977Pa13**]
^{72}Br		1$^+$	78.6(24) s	8.8064(22)	1.543(4)		-3.0778(13)	5.492(2)	[**1974Co14**]
^{76}Rb		1$^{(-)}$	36.2(2) s	8.535(4)	1.339(4)		-2.8439(9)	4.964(2)	[**1993Al03**]
^{80}Y		(4$^-$)	30.1(5) s	9.163(7)	2.366(7)		-1.548(6)	5.441(7)	[**1998Do04**]
^{84}Nb			9.5(10) s	10.228(6)	3.723(19)		0.238(6)	6.692(3)	[**2003Do01**]
^{88}Tc		(6$^+$)	5.8(4) s*	11.016(6)	4.915(8)	<0.3%*	1.721(6)	7.327(6)	[**2019Pa16**]
^{92}Rh		(6$^+$)	5.7(1) s	11.302(5)	5.699(5)	1.9(1)%	2.596(5)	7.263(6)	[**2019Pa16**, 2012Lo08, 2005Xu04, 2001Xu05]
^{96}Ag		(8$^+$)	4.46(4) s	11.670(90)	6.540(90)	4.4(5) %	3.496(90)	7.366(90)	[**2019Pa16**, 2012Lo08, 2003Ba39, 1997Sc30]
^{96m}Ag	x	(2$^+$)	4.395(85) s	11.67+x	6.540+x	14.7(24)%	3.496+x	7.366+x	[**2019Pa16**, 2012Lo08, 2003Ba39, 1997Sc30]
^{100}In		(6$^+$)	5.62(6) s	10.164(28)	5.245(7)	1.66(3)%	2.565(6)	9.580(5)	[**2019Pa16**, 2012Lo08, 2002Pl03, 1995Sz01]
^{104}Sb			440^{+150}_{-110} ms	12.33(10)#	8.05(10)#	<7%	5.78(10)#	12.47(10)#	[**1996FaZZ**, 2019Au02, 1995Le14, 1995Sc28]
^{108}I			26.4(8) ms	13.01(10)#	10.59(10)#		10.01(10)#	16.43(10)#	[**2019Pa16**, 1996IkZZ, 1994Pa11, 1991Pa05]
^{112}Cs		(1$^+$)	486(37) μs**	13.61(12)#	11.25(12)#		11.24(12)#	16.94(12)#	[**2012Ca03, 2012Wa10**, 1996IkZZ, 1994Pa12]
^{116}La			50(22) ms	13.48(20)#$^@$	11.51(20)#$^@$		11.61(20)#$^@$	16.75(20)#$^@$	[**2022Zh76**]

* Combined result for ground state and isomer.
** Weighted average of 506(55) μs [2012Wa10] and 470(50) μs [2012Ca03].
$^@$ Mass excess of ^{116}La is calculated to be -40897(200)# keV (-40050(320)# keV in [2021Wa16]) from the emitted proton energy and the mass excess for ^{115}Ba of -48920(200)# keV [2021Wa16]. This value is compared to the mass excess of the daughter from [2021Wa16] to deduce the value shown.

Table 2
Particle emission from the odd-Z, T_z = +1 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_p$	BR$_{1p}$	S$_{2p}$	Q$_\alpha$	BR$_\alpha$	Experimental
^{68}As	3.510(5)	—	9.7487(21)	-2.4866(23)	—	
^{72}Br	3.2042(30)	—	9.3057(17)	-2.5921(21)	—	
^{76}Rb	3.444(8)	—	9.769(6)	-3.8423(14)	—	
^{80}Y	2.957(10)	—	8.791(7)	-3.094(6)	—	
^{84}Nb	2.571(6)	—	7.708(6)	-2.471(6)	—	
^{88}Tc	2.074(5)	—	7.114(7)	-2.901(4)	—	
^{92}Rh	2.048(5)	—	6.852(4)	-3.754(6)	—	
^{96}Ag	1.83(9)	—	6.18(9)	-2.93(64)	—	
^{96m}Ag	1.83-x		6.18-x	-2.93+x	—	
^{100}In	1.5360(27)	—	5.690(30)	-2.090(90)	—	
^{104}Sb	-0.510(20	<1%	3.18(10)#	2.46(10)#		[**2019Au02**]
^{108}I	-0.597(13)	<1%	0.88(10)#	4.099(5)	100%	[**2019Au02**, 1994Pa11]
^{112}Cs	-0.816(4)	100%	0.53(13)#	3.940(20)**		[**2012Ca03, 2012Wa10**, 1996IkZZ, 1994Pa12]
^{116}La	-0.734(9)**	60(18)%	0.79(20)#$^@$	3.09(20)#$^@$		[**2022Zh76**]

* [2019Au02]
** From [2022Zh76], -1.58(38)# in [2021Wa16].
$^@$ Mass excess of ^{116}La is calculated to be -40897(200)# keV (-40050(320)# keV in [2021Wa16]) from the emitted proton energy and the mass excess for ^{115}Ba of -48920(200)# keV [2021Wa16]. This value is compared to the mass excess of the daughter from [2021Wa16] to deduce the value shown.

Table 3
direct α emission from ^{108}I*, J^π = , $T_{1/2}$= 26.4(8) ms, BR_α = 99.50(21)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{105}Te)	coincident γ-rays
4.097(10)	3.945(10)	99.50(21)%		0.0	—

* All values from [2019Au02].

Table 4
direct proton emission from ^{108}I*, J^π = , BR_p =0.50(21)%.

E_p(c.m.)	E_p(lab)	I_p(absb)	J^π_f	$E_{daughter}$(^{111}Xe)	coincident γ-rays
0.597(13)	0.591(13)	0.50(21)%	(5/2$^+$)	0.0	—

* All values from [2019Au02].

Table 5
direct proton emission from ^{112}Cs*, J^π = $T_{1/2}$ = 486(37) μs**, BR_p =100%.

E_p(c.m.)	E_p(lab)	I_p(rel)	I_p(abs)	J^π_f	$E_{daughter}$(^{111}Xe)	coincident γ-rays
0.716(20)	0.710(20)	≈ 10%	≈ 9%			
0.817(5)	0.810(5)	100%	≈91%		0.0	—

* All values from [2012Wa10], except where noted.
** Weighted average of 506(55) μs [2012Wa10] and 470(50) μs [2012Ca03].

Table 6
direct proton emission from ^{116}La*, J^π = $T_{1/2}$ = 50(22) ms, BR_p = 60(18)%.

E_p(c.m.)	E_p(lab)	I_p(abs)	J^π_f	$E_{daughter}$(^{115}Ba)	coincident γ-rays
0.734(9)	0.718(9)	60(18)%	(5/2$^+$)	0.0	—

* All values from [2022Zh76].

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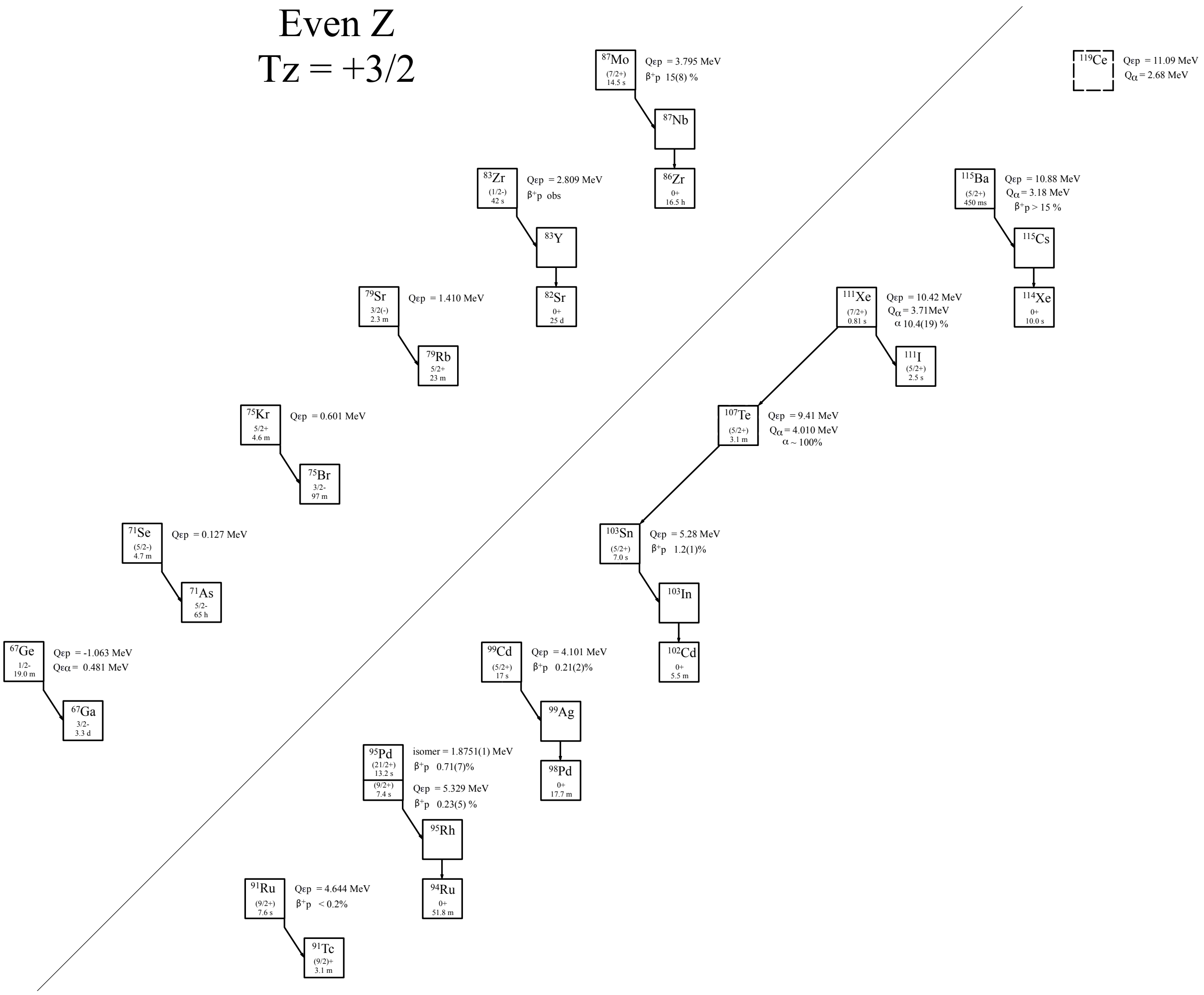

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +3/2 nuclei.

Last updated 3/20/23

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +3/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J^πvalues for ^{67}Ge, ^{71}Se, ^{75}Kr, ^{79}Sr, ^{83}Zr are taken from ENSDF.

Nuclide	Ex	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{67}Ge		1/2$^-$	19.0(3) m	4.205(4)	-1.063(4)	——	-9.988(4)	0.481(4)	[**1969Ba07**]
^{71}Se		(5/2$^-$)	4.74(5) m	4.747(5)	0.1266(29)		-8.397(3)	1.308(3)	[**1980Te01**]
^{75}Kr		5/2$^+$	4.60(7) m	4.783(9)	0.601(8)		-7.949(9)	1.144(9)	[**1995BeZS**]
^{79}Sr		3/2$^{(-)}$	2.31(6) m	5.323(8)	1.410(7)		-6.823(8)	1.202(8)	[**1981Li12**]
^{83}Zr		(1/2$^-$)	42(2) s	6.294(20)	2.809(9)	obs	-5.033(8)	2.466(6)	[**2015Mc01**1983Ha06]
^{87}Mo		(7/2$^+$)	14.5(3) s	6.990(7)	3.795(5)	15(8)%	-3.621(19)	2.896(19)	[**1997Hu07**, 1983Ha06, 1981Mi15]
^{91}Ru		(9/2$^+$)	7.6(2) s	7.747(3)	4.644(4)	<0.2%*	-2.192(24)	3.209(7)	[**2019Pa16**, 1983Ha06]
^{95}Pd		(9/2$^+$)	7.4(5) s	8.375(5)	5.329(4)	0.23(5)%	-0.938(3)	3.596(4)	[**2019Pa16**]
^{95m}Pd	1.8751(1)	(21/2$^+$)	13.2(4) s	10.250(5)	7.204(4)	0.71(7)%	−0.937(3)	5.471(4)	[**2019Pa16**, 1982Ku15,1982No06,
^{99}Cd		(5/2$^+$)	17(1) s	6.781(6)	4.101(5)	0.21(2)%	-1.909(40)	5.985(4)	[**2019Pa16**, 1978El09, 1982Ku15]
^{103}Sn		(5/2$^+$)	7.0(2) s	7.54(10)#	5.28(10)#	1.2(1)%	-0.33(10)#	7.20(10)#	[**2005Ka34**, 2004Mu32, 1981Ti03]
^{107}Te		(5/2$^+$)	3.1(1) ms	10.00(10)#	9.41(10)#		4.40(10)#	11.55(10)#	[**1994Pa11**, 2019Au02, 2020Ca01, 2004Ha59, 2002Se10, 1981Sc17, 1991He21, 1979Sc22]
^{111}Xe		(7/2$^+$)	0.81(20) s	10.43(12)#	10.42(12)#		7.15(12)#	13.71(12)#	[**2010Da17**, 1994Pa11, 2012Ca03 2020Ca01, 1993HeZS, 1991He21, 1981Sc17]
^{115}Ba		(5/2$^+$)	0.45(5) s	10.78(23)#	10.88(20)#	>15%	7.62(20)#	13.61(20)#	[**1997Ja12**, 1995Gu01]
^{119}Ce				11.20(58)#	11.09(54)#		8.09(50)#	13.46(51)#	

* Combination of ground state and (1/2$^-$) isomer.
** Excitation energy = 1.8751(1) MeV.

Table 2
Particle emission from the even-Z, T_z = +3/2 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{67}Ge	6.239(4)	11.340(4)	-2.885(5)	——	
^{71}Se	6.102(3)	10.624(3)	-2.898(5)	——	
^{75}Kr	6.324(10)	10.674(11)	-3.602(9)	——	
^{79}Sr	5.833(8)	9.888(8)	-3.581(11)	——	
^{83}Zr	5.137(8)	8.961(7)	-2.857(10)	——	
^{87}Mo	5.040(6)	8.288(7)	-3.398(7)	——	
^{91}Ru	4.8041(24)	7.803(4)	-3.780(4)	——	
^{95}Pd	4.347(5)	7.327(4)	-4.151(4)	——	
^{95m}Pd	2.472(5)	5.419(4)	-2.276(4)	——	
^{99}Cd	4.150(30)	6.703(5)	-2.390(3)	——	
^{103}Sn	3.69(10)#	5.83(10)#	0.41(10)#		
^{107}Te	1.47(10)#	1.90(10)#	4.010(5)#	70(30)%*	[**2019Au02, 2002Se10, 1991He21, 1981Sc17, 1979Sc22**, 2020Ca01, 2004Ha59, 1994Pa11]
^{111}Xe	1.34(13)#	1.38(12)#	3.719(10)**	10.4(19)%	[**12012Ca03**, 2020Ca01, 2010Da17, 1994Pa11, 1993HeZS, 1991He21, 1981Sc17]
^{115}Ba	1.52(22)#	1.30(20)#	3.18(23)#		
^{119}Ce	1.49(58)#	0.94(56)#	2.68(54)#		

* The short half-life suggests BR_α is ≈ 100%.
** From [2010Da070], 3.710(60)# in [2021Wa16].

Table 3
direct α emission from ^{107}Te, J^{π} = (5/2^{+}), $T_{1/2}$ = 3.1(1) ms$^{@}$, BR_{α} =70(30)%*.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{110}Xe)	coincident γ-rays	R_0 (fm)	HF
3.836(7)**	3.692(7)	0.67(13)%	0.47(9)%	(7/2^{+})	0.1680(1)	0.1680(1)	1.672(31)	50^{+5}_{-2}
4.004(6)***	3.854(6)	100%	70(30)%	(5/2^{+})	0.0	—-	1.672(31)	$2.4^{+2.3}_{-1.2}$

@ [1994Pa11].
* [1981Sc17].
** [2002Se10].
*** Weighted average of 3.982(15) [1979Sc22], 4.012(10) [1991He21] and 4.007(10) [2019Au02].

Table 4
direct α emission from ^{111}Xe*, J^{π} = (7/2^{+}), $T_{1/2}$ = 0.81(20) s**, BR_{α} =10.4(19)%***.

E_{α}(c.m.)	E_{α}(lab)**	I_{α}(rel)*	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{107}Te)	coincident γ-rays	R_0 (fm)	HF
3.631(15)	3.500(15)	58(32)%	3.8(22)%	(7/2^{+})	0.0903(4)	0.0903(4)	1.663(61)	7^{+11}_{-5}
3.719(10)	3.582(10)	100(32)%	6.5(24)%	(5/2^{+})	0.0	—–	1.663(61)	14^{+21}_{-9}

* All values from [2012Ca03] except where noted.
** [2010Da17]
*** [1979Sc22]

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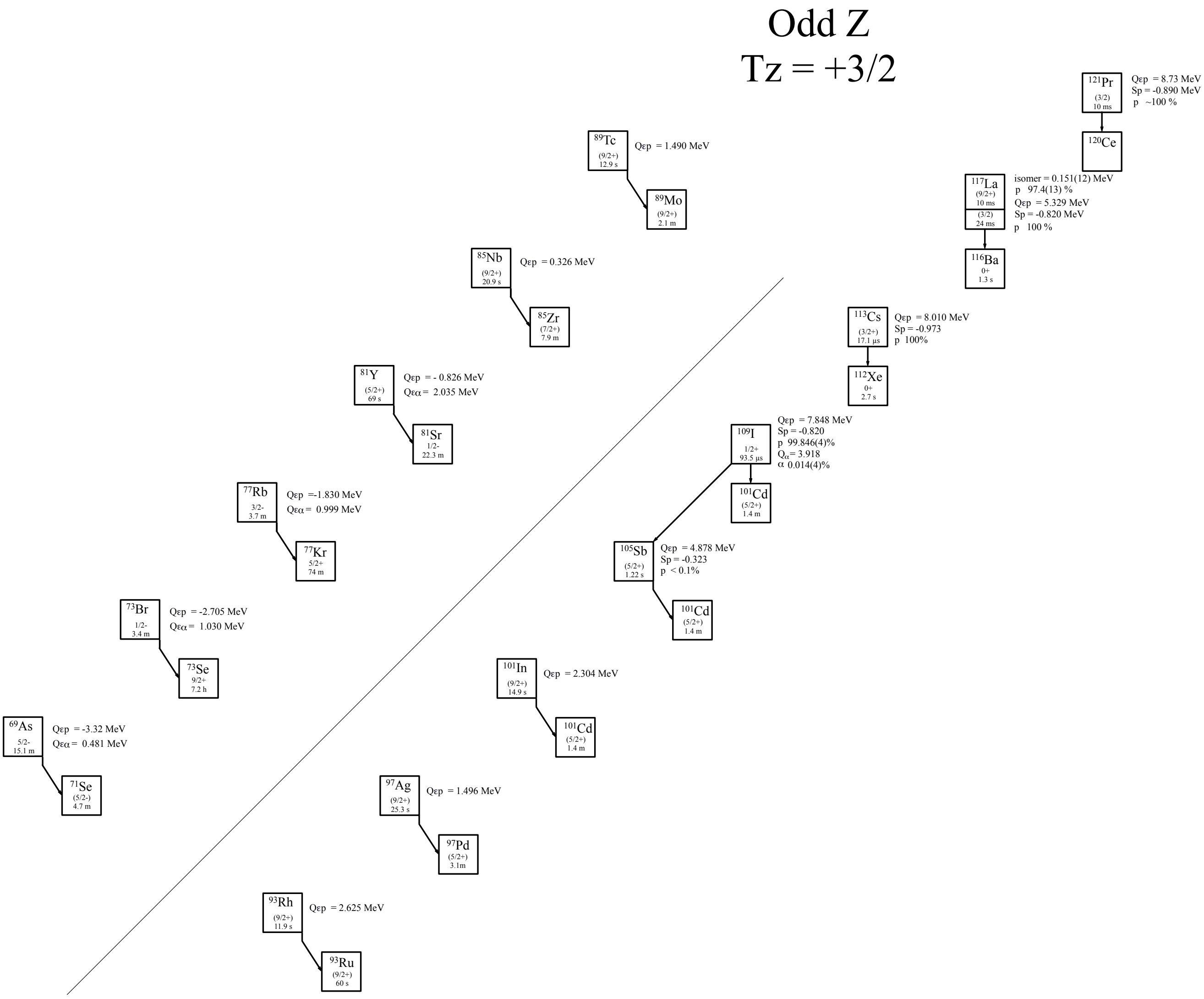

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +3/2 nuclei.

Last updated 3/20/23

Table 1

Observed and predicted β-delayed particle emission from the odd-Z, T_z = +3/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J$^{\pi}$values for ^{69}As, ^{73}Br, ^{77}Rb, ^{81}Y, ^{85}Nd, ^{89}Tc, ^{93}Rh, ^{97}Ag are taken from ENSDF.

Nuclide	Ex	J^{π}	$T_{1/2}$	Q_{ε}	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{69}As		5/2$^-$	15.1(3) m	3.990(30)	-3.320(30)	——	-9.808(20)	0.377(20)	[**1979Su02**]
^{73}Br		1/2$^-$	3.4(2) m	4.582910)	-2.705(8)	——	-8.317(7)	1.030(7)	[**1987He21**]
^{77}Rb		3/2$^-$	3.78(4) m	5.3390(24)	-1.830(9)	——	-7.212(1)	0.999(7)	[**1993Al03**]
^{81}Y		(5/2$^+$)	69.0(11) s	5.815(6)	-0.826(6)	——	-5.849(6)	2.032(5)	[**1993Mi11**]
^{85}Nb		(9/2$^+$)	20.9(7) s	6.896(8)	0.326(6)		-4.060(8)	2.823(5)	[**1988Ku14**]
^{89}Tc		(9/2$^+$)	12.8(9) s	7.620(5)	1.490(60)		-2.626(6)	3.355(7)	[**1991He04**]
^{93}Rh		(9/2$^+$)	11.9(7) s	8.205(3)	2.625(4)		-1.381(7)	3.578(5)	[**2004De40**]
^{97}Ag		(9/2$^+$)	25.3(3) s	6.902(13)	1.495(16)		-2.024(16)	3.888(12)	[**1997Sc30**]
^{101}In		(9/2$^+$)	14.9(12) s	7.292(12)	2.304(13)	<1.7%	-0.940(13)	6.836(13)	[**2019Pa16**, 1997Sz04]
^{105}Sb		(5/2$^+$)	1.22(11) s	9.323(22)	4.878(23)	<0.1%	2.059(22)	9.397(22)	[**2007Ma35, 1997Sh13**, 2007MaZB, 2005Li47, 2005LiZY, 1995Sc28,1995Sc33, 1994Ti03]
^{109}I		1/2$^+$	93.5(3) μs	10.043(8)	7.484(9)		6.261(9)	13.240(8)	[**2007Ma35**, 2019Au02, 2012Ca03, 1995Ho26, 2007MaZB, 1999Yu02, 1997IkZZ, 1995Ho26, 1993HeZS, 1993Se04, 1991He21, 1987FaZT, 1987Gi02, 1984Fa04]
^{113}Cs		(3/2$^+$)	17.1(2) μs	10.439(11)	8.010(13)		7.244(11)	13.525(10)	[**2015Wa02**, 1995Ho26, 1994Pa12, 2012Ca03, 2012Wa10, 2002Ry02, 1998GrZT, 1998GrZZ, 1993HeZS, 1987Gi02, 1987FaZT, 1984Fa04]
^{117}La		(3/2$^+$)	20.1(25) ms	11.19(32)#	8.48(22)#		7.81(20)#	13.51(20)#	[**2022Zh76, 2011Li28**, 2001Ma69, 2001So02, 2007LiZR]
^{117m}La	0.151(12)	(9/2$^+$)	10(5) ms	11.34(32)#	8.63(22)#		7.96(20)#	13.66(20)#	[**2001So02**]
^{121}Pr		(3/2)	10^{+6}_{-3} ms	11.14(64)#	8.73(58)#		8.46(54)#	13.46(56)#	[**2005Ro19**, 2007DaZU, 1972Bo28]

Table 2

Particle emission from the odd-Z, T_z = +3/2 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_p$	BR$_{1p}$	S$_{2p}$	Q$_\alpha$	BR$_\alpha$	Experimental
^{69}As	3.420(30)	——	10.810(30)	-2.880(30)	——	
^{73}Br	3.067(7)	——	10.330(8)	-2.960(30)	——	
^{77}Rb	3.106(4)	——	10.301(4)	-3.610(7)	——	
^{81}Y	2.690(6)	——	9.488(6)	-3.307(6)	——	
^{85}Nb	2.147(7)	——	8.652(19)	-4.072(7)	——	
^{89}Tc	1.997(5)	——	8.098(8)	-3.540(6)	——	
^{93}Rh	2.000(4)	——	7.603(4)	-4.042(5)	——	
^{97}Ag	2.010(13)	——	7.141(13)	-4.317(12)	——	
^{101}In	1.639(12)	——	6.410(13)	-0.066(17)	——	
^{105}Sb	-0.323(22)	< 0.1%	3.961(24)	2.104(25)		[**2007Ma35, 1997Sh13**, 2007MaZB, 2005Li47, 2005LiZY, 1995Sc28, 1995Sc33, 1994Ti03]
^{109}I	-0.820(4)	99.846(4)%	1.597(8)	3.918(21)	0.014(4)%	[**2007Ma35, 1995Ho26**, 2019Au02, 2012Ca03, 2007Ma35, 1999Yu02, 1997IkZZ, 1995Ho26, 1993HeZS, 1993Se04, 1991He21, 1987FaZT, 1987Gi02, 1984Fa04]
^{113}Cs	-0.9728(22)	100%	1.389(10)	3.483(8)		[**1995Ho26**, 2015Wa02, 1994Pa12, 2012Ca03, 2012Wa10, 2010Ho16,2002Ry02, 1998GrZT, 1998GrZZ, 1993HeZS, 1993HeZV, 1987Gi02, 1987FaZT, 1984Fa04]
^{117}La	-0.820(3)	100%	1.15(23)#	3.07(20)#		[**2022Zh76, 2011Li28**, 2001So02, 2011Ma69, 2007LiZR, 2003ScZZ]
^{117m}La	-0.970(3)	100%	1.30(23)#	3.22(20)#		[**2001So02**]
^{121}Pr	-0.890(10)	≈ 100%	1.11(58)#	2.30(54)#		[**2005Ro19**, 2007DaZU, 1972Bo28]

Table 3
direct proton emission from ^{109}I*, J^π = 1/2$^+$, $T_{1/2}$ = 93.5(2) μs**, BR_p =99.846(4)%.

E_p(c.m.)	E_p(lab)	I_p(abs)	J^π_f	$E_{daughter}$(^{108}Te)	coincident γ-rays
0.8202(40)	0.8126(40)	99.846(4)%	0^+	0.0	——

* All Values from [1995Ho26], except where noted.
** [2007Ma15].

Table 4
direct α emission from ^{109}I, J^π = 1/2$^+$, BR_α =0.014(4)%*.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{105}Sb)	coincident γ-rays	R_0 (fm)	HF
3.915(20)	3.774(20)	100%	0.014(4)%	(5/2$^+$)	0.0	——	1.658(30)	31^{+22}_{-14}

* All Values from [2007Ma15].

Table 5
direct proton emission from ^{113}Cs*, J^π = (3/2$^+$), $T_{1/2}$ = 17.1(2) μs**, BR_p =100%.

E_p(c.m.)	E_p(lab)	I_p(abs)	J^π_f	$E_{daughter}$(^{112}Xe)	coincident γ-rays
0.969(3)	0.960(3)	100%	0^+	0.0	——

* All values from [1995Ho26], except where noted
** [2015Wa02].

Table 6
direct proton emission from ^{117}La, J^π = (3/2$^+$), $T_{1/2}$ = 20.7(25) ms*, BR_p = ≈100%.

E_p(c.m.)	E_p(lab)	I_p(abs)	J^π_f	$E_{daughter}$(^{116}Ba)	coincident γ-rays
0.819(3)	0.812(3)**	≈100%	0^+	0.0	——

* Weighted average of 20.1(25) ms [2011Li28] and 21.6(31) ms [2022Zh76].
** Weighted average of 0808(5) MeV [2022Zh76] and 0.813(3) MeV [2011Li28].

Table 7
direct proton emission from ^{117m}La, Ex = 0.151(12) MeV, J^π = (9/2$^+$),$T_{1/2}$ = 10(5) ms, BR_p =100%

E_p(c.m.)	E_p(lab)	I_p(abs)	J^π_f	$E_{daughter}$(^{116}Ba)	coincident γ-rays
0.941(10)	0.933(10)	97.4(13)%	0^+	0.0	——

* All values from [2001So02], transition not observed in [2011Li28].

Table 8
direct proton emission from ^{121}Pr*, J^π =(3/2), $T_{1/2}$ = 10^{+6}_{-3} ms, BR_p ≈ 100%.

E_p(c.m.)	E_p(lab)	I_p(abs)	J^π_f	$E_{daughter}$(^{120}TCe)	coincident γ-rays
0.889(10)	0.882(10)	≈100%	0^+	0.0	——

* All values from [2005Ro19].

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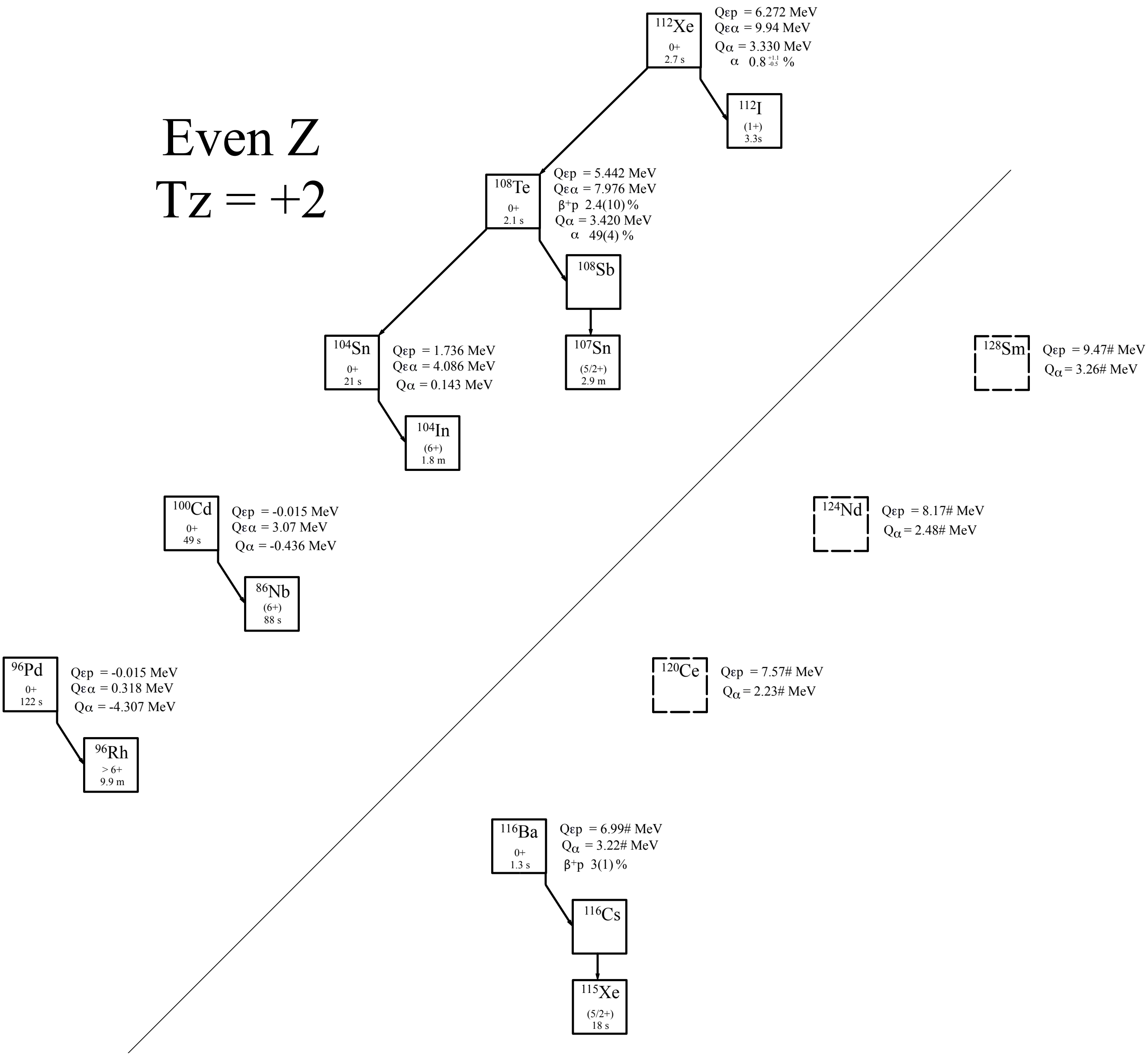

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +2 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{96}Pd	0^+	122(2) s	3.504(11)	-0.015(10)	—	-6.603(6)	0.318(5)	[**1982Ku15**]
^{100}Cd	0^+	49.1(5) s	3.943(5)	0.699(5)		-5.598(12)	3.068(10)	[**1989Ry02**]
^{104}Sn	0^+	21(1) s	4.556(8)	1.736(6)		-3.958(10)	4.086(8)	[**1985Ra19**]
^{108}Te	0^+	2.1(1) s	6.664(8)	5.442(8)	2.4(10)%	0.248(13)	7.976(8)	[**1979Sc22**, 2019Au02, 2019Xi06, 1994Pa11, 1993HeZS, 1985Ti02, 1965Ma12]
^{112}Xe	0^+	2.7(8) s	7.037(13)	6.272(10)		2.846(10)	9.940(90)	[**1979Sc22**, 1994Pa11, 1978Ro19]
^{116}Ba	0^+	1.3(2) s	7.66(22)#	6.99(20)#	3(1)%	3.68(20)#	10.06(20)#	[**1997Ja12**]
^{120}Ce	0^+		7.84(58)#	7.57(54)#		4.10(50)#	9.89(51)#	
^{124}Nd	0^+		8.32(64)#	8.17(58)#		5.13(58)#	10.32(58)#	
^{128}Sm	0^+		9.07(58)#	9.47(58)#		6.59(54)#	11.58(64)#	

Table 2
Particle emission from the even-Z, T_z = +2 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	BR_{1p}	S_{2p}	Q_α	BR_α	Experimental
^{96}Pd	5.132(6)	—	8.178(5)	-4.307(5)	—	
^{100}Cd	4.771(6)	—	7.452(5)	-0.436(5)	—	
^{104}Sn	4.284(11)	—	6.545(6)	0.143(6)		
^{108}Te	2.417(7)	—	3.006(7)	3.445(4)*	49(4)%	[**1994Pa11, 1991He21,**1993HeZS, 1981Sc17]
^{112}Xe	2.362(10)	—	2.374(11)	3.330(6)	$0.8^{+1.1}_{-0.5}$ %	[**1994Pa11**, 1978Ro19, 1992HeZU, 1981Sc17]
^{116}Ba	1.97(23)#	—	1.87(20)#	3.22(30)#		
^{120}Ce	2.00(58)#	—	2.11(54)#	2.23(54)#		
^{124}Nd	1.89(64)#	—	1.53(64)#	2.48(71)#		
^{128}Sm	1.13(64)#	—	0.35(58)#	3.26(71)#		

* From α decay to ground state of ^{104}Sn [1991He21], 3.420(8) in [2021Wa16].

Table 3
direct α emission from ^{108}Te, $J^\pi = 0^+$, $T_{1/2}$ = 2.1(1) s*, BR_α =49(4) %**.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{104}Sn)	coincident γ-rays	R_0 (fm)	HF
3.445(4)	3.318(4)***	100%	49(4) %**	0^+	0.0	—	1.6315(80)	1.50(14)

* [1979Sc22].
** [1994Pa11].
*** [1991He21].

Table 4
direct α emission from ^{112}Xe*, $J^\pi = 0^+$, $T_{1/2}$ = 2.7(8) s**, BR_α =$0.8^{+1.1}_{-0.5}$ %.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{108}Te)	coincident γ-rays	R_0 (fm)	HF
3.335(7)	3.216(7)	100%	$0.8^{+1.1}_{-0.5}$ %	0^+	0.0	—	1.6671(75)	2^{+4}_{-1}

* All Values from [1994Pa11], except where noted.
** [1979Sc22].

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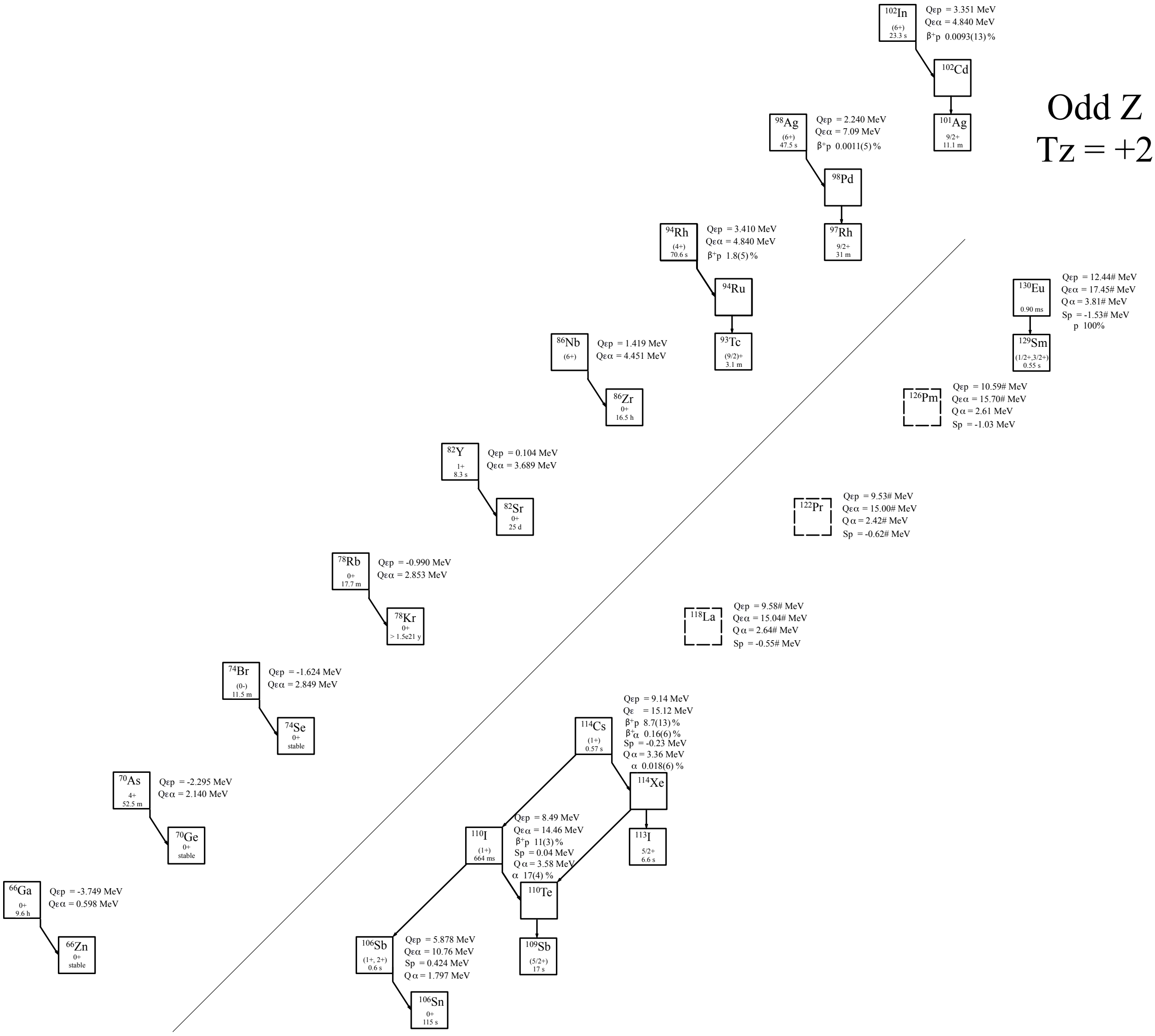

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +2 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J$^{\pi}$values for ^{66}Ga, ^{70}As, ^{74}Br, ^{78}Rb, ^{82}Y, ^{86}Nb ^{90}Tc, are taken from ENSDF.

Nuclide	J^{π}	$T_{1/2}$	Q$_{\varepsilon}$	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon \alpha}$	BR$_{\beta\alpha}$	Experimental
^{66}Ga	0^{+}	9.57(6) h	5.1755(8)	-3.7490(12)	—	-11.203(1)	0.598(1)		[**1956Ru45**]
^{70}As	4^{+}	52.5(3) m	6.2281(16)	-2.295(2)	—	-8.905(2)	2.140(2)		[**1968Bo40**]
^{74}Br	(0^{-})	11.5(1) m	6.925(6)	-1.624(7)	—	-7.280(6)	2.849(6)		[**1975Sc07**]
^{78}Rb	0^{+}	17.66(3) m	7.243(3)	-0.990(4)	—	-6.261(3)	2.853(3)		[**1981Ba40**]
^{82}Y	1^{+}	8.3(2) s	7.946(8)	0.104(7)		-4.749(5)	3.689(5)		[**1998Oi02**]
^{86}Nb	(6^{+})	88(1) s	8.835(7)	1.419(20)		-3.062(5)	4.451(8)		[**1985Wa10**]
^{90}Tc	(8^{+})	49.2(4) s	9.448(4)	2.612(24)		-1.674(5)	4.819(4)		[**1981Ox01**]
^{94}Rh	(4^{+})	70.6(6) s	9.676(5)	3.410(4)	1.8(5)%	-0.677(3)	4.840(4)		[**1982Ku15**]
^{98}Ag	(6^{+})	47.5(3) s	8.250(30)	2.240(50)	0.0011(5)%	-1.568(30)	7.089(30)		[**1996He25, 1997Ra22**, 1982Ku15]
^{102}In	(6^{+})	23.3(1) s	8.965(5)	3.351(7)	0.0093(13)%	-0.060(19)	8.201(7)		[**1995Sz01**]
^{106}Sb	(1^{+}, 2^{+})	0.6(2) s	10.880(9)	5.878(13)		2.917(7)	10.76(7)		[**2005So06**]
^{110}I	(1^{+})	664(24) ms	11.760(60)	8.490(60)	11(3)%	7.022(60)	14.459(60)	1.1(3)%	[**1977Ki11, 1981Sc17**, 1994Pa11, 1985Ti02]
^{114}Cs	(1^{+})	0.57(2) s	12.400(90)	9.140(90)	8.7(13)%	8.300(90)	15.115(90)	0.16(6)%	[**1985Ti02, 1978Ro19**]
^{118}La			12.58(36)#	9.58(31)#		8.85(30)#	15.04(30)#		
^{122}Pr			13.09(64)#	10.12(58)#		9.53(58)#	15.00(54)#		
^{126}Pm			13.63(5)#	11.03(58)#		10.59(58)#	15.70(64)#		
^{130}Eu		$0.90^{+0.49}_{-0.29}$ ms	14.19(67)#	12.38(62)#		12.44(58)#	17.45(62)#		[**2004Da04**]

Table 2
Particle emission from the odd-Z, T_z = +2 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_{p}$	BR$_{1p}$	S$_{2p}$	Q$_{\alpha}$	BR$_{\alpha}$	Experimental
^{66}Ga	5.101(1)	—	12.877(1)	-3.361(1)	—	
^{70}As	7.781(1)	—	17.921(2)	-5.077(1)	—	
^{74}Br	4.350(9)	—	11.636(7)	-3.379(6)	—	
^{78}Rb	4.055(4)	—	11.224(10)	-4.072(7)	—	
^{82}Y	3.825(6)	—	10.467(6)	-3.554(6)	—	
^{86}Nb	3.248(8)	—	9.818(7)	-3.495(8)	—	
^{90}Tc	2.999(4)	—	9.130(60)	-4.015(6)	—	
^{94}Rh	2.980(4)	—	8.560(5)	-4.608(4)	—	
^{98}Ag	2.550(30)	—	7.960(30)	-2.580(30)	—	
^{102}In	2.147(5)	—	7.135(7)	-0.050(30)	—	
^{106}Sb	0.424(8)	—	4.869(9)	1.797(9)		
^{110}I	0.040(60)	—	2.600(50)	3.536(10)*	17(4)%	[**1981Sc17, 1991He21, 1978Ro19**, 1994Pa11, 1985Ti02]
^{114}Cs	-0.230(90)		2.200(90)	3.360(60)	0.018(6)%	[**1994Pa11, 1985Ti02, 1981Sc17**, 1980Ro04, 1978Ro19, 1996He25]
^{118}La	-0.55(39)#		2.16(32)#	2.64(31)#		
^{122}Pr	-0.62(64)#		1.79(58)#	2.42(58)#		
^{126}Pm	-1.03(64)#		1.18(64)#	2.610(71)#		
^{130}Eu	-1.028(15)**	100%	-0.13(62)#	3.81(74)#		[**2004Da04**, 2003SeZZ, 2002Ma61]

* From α decay to ground state of ^{106}Sb [1991He21, 1978Ro19], 3.580(50) in [2021Wa16].
** From p emission to the ground state of ^{129}Sm [2004Da04], -1.53(20)# in [2021Wa16].

Table 3
direct α emission from ^{110}I, J$^{\pi}$ = (1^{+}), T$_{1/2}$ = 664(24) ms*, BR_{α} = 17(4)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J$^{\pi}_{f}$	$E_{daughter}$(^{106}Sb)	coincident γ-rays
3.536(10)	3.447(10)***	100%	17(4)%**	(1^{+}, 2^{+})	0.0	—

*Weighted average of 0.69(4) s [1977Ki11] and 0.65(3) s [1981Sc17].
** [1981Sc17]
*** Weighted average of 3.457(10) [1991He21], and 3.424(15) [1978Ro19].

Table 4
direct α emission from ^{114}Cs, J^{π} = (1$^+$), $T_{1/2}$ = 0.57(2) s*, BR_{α} = 0.018(6)%*

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_f	$E_{daughter}$(^{110}I)	coincident γ-rays
3.351(30)**	3.233(30)	100%	0.018(6)%***	(1$^+$)	0.0	——

* [1978Ro19].
** Weighted average of 3.239(30) [1981Sc17], and 3.226(30) MeV [1980Ro04].
*** [1994Pa11]

Table 5
β-p emission from ^{114}Cs*, $BR_{\beta p}$ = 8.7(13)%.

E_p(c.m.)	I_p(rel)	I_p(abs)	$E_{emitter}$ (^{114}Xe)	$E_{daughter}$(^{113}I)	coincident γ-rays
	14.4(43)%	1.25(19)%			0.0307(5)
	11.7(1.2)%	1.02(15)%			0.121.2(5)
	7.5(8)%	0.65(10)%			0.2388(5)
	3.2(8)%	0.28(14)%			0.4004(5)
	3.9(10)%	0.34(5)%			0.4035(5)

* All values from [1985Ti02].

Table 6
β-α emission from ^{114}Cs*, $BR_{\beta p}$ = 0.16(6)%.

E_{α}(c.m.)	I_{α}(rel)	I_{α}(abs)	$E_{emitter}$ (^{114}Xe)	$E_{daughter}$(^{110}Te)	coincident γ-rays
	17(8)%	0.027(10)%		0.6572(3)	0.6572(3)

* All values from [1985Ti02].

Table 7
direct proton emission from ^{130}Eu*, J^{π} = $T_{1/2}$ = $0.90^{+0.49}_{-0.29}$ ms, BR_p = 100%.

E_p(c.m.)	E_p(lab)	I_p(abs)	J^{π}_f	$E_{daughter}$(^{129}Sm)	coincident γ-rays
1.028(15)	1.020(15)	100%	(1/2$^+$, 3/2$^+$)	0.0	——

*All values from [2004Da04].

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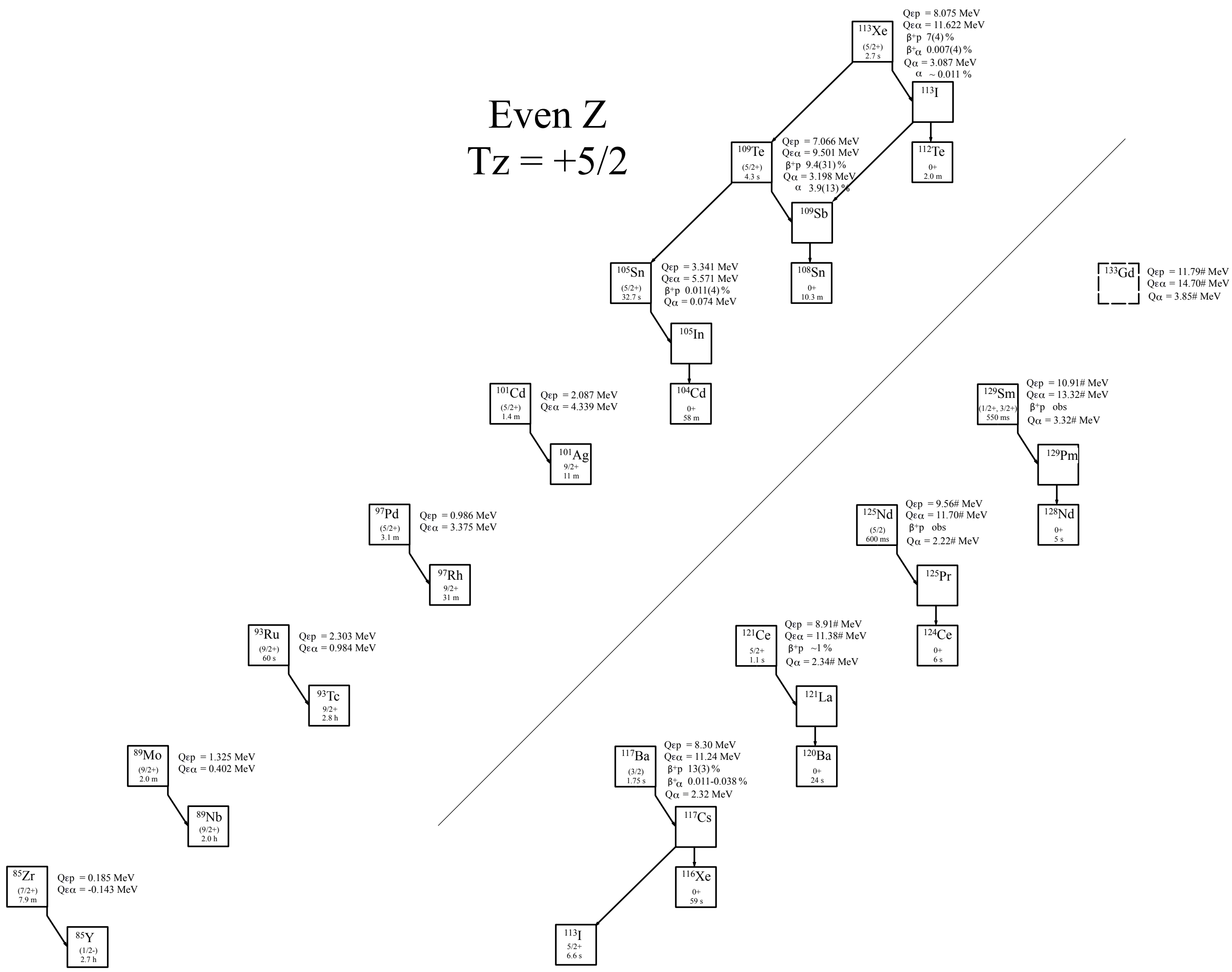

Fig. 1: Known experimental values for heavy particle emission of the even-Z, T_z = +5/2 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +5/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J$^\pi$values for ^{85}Zr, ^{89}Mo, ^{93}Ru, ^{81}Y, ^{97}Pd, ^{101}Cd, ^{93}Rh, ^{125}Nd, ^{129}Sm are taken from ENSDF.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	$BR_{\beta\alpha}$	Experimental
^{85}Zr	(7/2$^+$)	7.85(4) m	4.667(20)	0.185(7)		-8.682(6)	-0.143(8)		[**1972Tu07**]
^{89}Mo	(9/2$^+$)	1.98(14) m	5.611(24)	1.325(7)		-6.575(4)	0.402(19)		[**1985Be12**]
^{93}Ru	(9/2$^+$)	59.7(6) s	6.389(2)	2.303(2)		-5.157(4)	0.984(24)		[**1976De37**]
^{97}Pd	(5/2$^+$)	3.1(1) m	4.790(40)	0.986(5)		-6.363(7)	3.375(5)		[**1980Go11**]
^{101}Cd	(5/2$^+$)	1.37(5) m	5.498(5)	2.087(18)		-4.830(19)	4.339(40)		[**1980Ka05**]
^{105}Sn	(5/2$^+$)	32.7(5) s	6.303(11)	3.341(4)	0.011(4)%	-3.113(6)	5.571(6)		[**2006Ka44**]
^{109}Te	(5/2$^+$)	4.3(1) s	8.536(7)	7.066(7)	9.4(31)%	1.274(11)	9.501(11)	< 0.00443%	[**1985Ti02, 2002Re28, 1977Bo15, 1977Ki11, 1967Ka01**, 2019Xi06, 1981Sc17, 1979Sc22, 1977Ki11, 1973Bo20]
^{113}Xe	(5/2$^+$)	2.74(8) s	8.916(11)	8.075(11)	7(4)%	4.055(11)	11.622(9)	0.007(4)%	[**1985Ti02, 2005Ja10**, 2013Pr01, 1981Sc17, 1979Sc22, 1978Ro19]
^{117}Ba	(3/2)	1.75(7) s	9.04(26)	8.30(25)	13(3)%	4.30(25)	11.24(25)	0.011-0.038%	[**1997Ja12, 1985Ti02**, 1978Bo20]
^{121}Ce	5/2$^+$	1.1(1) s	9.50(50)#	8.91(50)#	≈1%	5.04(40)#	11.38(40)#		[**2005Xu04, 1997Li19**, 2002XuZZ]
^{125}Nd	(5/2)	0.60(15) s	10.00(50)#	9.56(50)#	obs	6.00(45)#	11.70(50)#		[**1999Xu05**, 2005Xu04]
^{129}Sm	(1/2$^+$, 3/2$^+$)	0.55(10) s	10.85(58)#	10.91(54)#	obs	7.63(54)#	13.32(58)#		[**1999Xu05**, 2005Xu04]
^{133}Gd			11.18(58)#	11.79(58)#		9.13(54)#	14.70(58)#		

Table 2
Particle emission from the even-Z, T_z = +5/2 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{85}Zr	6.5780(5)	10.956(9)	-4.072(7)	—	
^{89}Mo	6.130(60)	10.246(6)	-4.265(8)	—	
^{93}Ru	5.580(4)	9.586(7)	-4.627(4)	—	
^{97}Pd	5.407(11)	8.926(11)	-3.014(5)	—	
^{101}Cd	4.987(5)	8.32(5)	-0.456(5)	—	
^{105}Sn	4.444(7)	7.264(4)	0.074(4)		
^{109}Te	2.559(7)	3.781(7)	3.198(6)	3.9(13)%	[**1985Ti02, 1981Sc17, 1979Sc22**]
^{113}Xe	2.429(12)	3.194(9)	3.087(8)	≈0.011%	[**1985Ti02**]
^{117}Ba	2.70(27)	8.30(25)	2.32(25)		[**1997Ja12, 1985Ti02**]
^{121}Ce	2.41(50)#	8.91(50)#	2.34(47)#		
^{125}Nd	2.21(57)#	2.36(50)#	2.22(57)#		
^{129}Sm	1.40(58)#	1.00(58)#	3.32(64)#		
^{133}Gd	1.15(64)#	0.36(64)#	3.85(71)#		

Table 3
direct α emission from ^{109}Te, J$^\pi$ = (5/2$^+$), $T_{1/2}$ = 4.3(1) s*, BR_α = 3.9(13)%.**

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{105}Sn)	coincident γ-rays	R_0 (fm)	HF
3.197(15)	3.080(15)***	100%	3.9(13)%	(5/2$^+$)	0.0	—	1.650(60)	$0.8^{+1.2}_{-0.5}$

* Weighted average of 4.2(2) s [1967Ka01], 4.9(4) s [1977Bo15] , 4.1(2) s [1977Ki11] , and 4.6(3) s [2002Re28].
** From 1981Sc17].
*** From [1979Sc22].

Table 4
direct α emission from ^{113}Xe*, J$^\pi$ = (5/2$^+$), $T_{1/2}$ = 2.74(8) s, BR_α = ≈ 0.011%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{109}Te)	coincident γ-rays	R_0 (fm)	HF
3.095(16)	2.985(15)	100%	≈0.011%	(5/2$^+$)	0.0	—	1.68(12)	3^{+11}_{-2}

* All values from [1985Ti02].

Table 5
β-p emission from ^{113}Xe*, $BR_{\beta p}$ = 7(4)%.

E_p(c.m.)	I_p(rel)	$E_{emitter}$ (^{113}I)	$E_{daughter}$(^{112}Te)	coincident γ-rays
	32(2)%		0.0	—–
	60(3)%		0.689	0.689
	≈ 4%		1.476	0.787, 0.689
	≈ 4%		1.484	0.794, 0.689

* All values from [2005Ja10].

Table 6
β-p emission from ^{117}Ba*, $T_{1/2}$ = 1.75(7) s, $BR_{\beta p}$ = 13(3)%.

E_p(c.m.)	I_p(rel)	$E_{emitter}$ (^{117}I)	$E_{daughter}$(^{116}Xe)	coincident γ-rays
	51(4))%		0.0	—–
	41(4)%		0.394	0.394
	8(2)%		1.016	0.622. 0.394

* All values from [1985Ti02].

Table 7
β-p emission from ^{121}Ce*, $T_{1/2}$ = 1.1(1) s**, $BR_{\beta p}$ = ≈ 1%.

E_p(c.m.)	I_p(rel)	$E_{emitter}$ (^{121}La)	$E_{daughter}$(^{120}Ba)	coincident γ-rays
2.5-6.0			0.0	—–
2.5-6.0	80%		0.1858	0.1858
2.5-6.0			0.5438	0.3578, 0.1858

* All values from [2005Xu04] except where noted.
** [1997Li19]

Table 8
β-p emission from ^{125}Nd*, $T_{1/2}$ = 0.60(15) s, $BR_{\beta p}$ = obs.

E_p(c.m.)	I_p(rel)	$E_{emitter}$ (^{125}Pr)	$E_{daughter}$(^{124}Ce)	coincident γ-rays
2.5-6.5	100%		0.1419	0.1419
2.5-6.5	26(6)%		0.4478	0.3059, 0.1419
2.5-6.5	<3%		0.8919	0.4441, 0.3059, 0.1419

* All values from [1999Xu05].

Table 9
β-p emission from ^{129}Sm*, $T_{1/2}$ = 0.55(10) s, $BR_{\beta p}$ = obs.

E_p(c.m.)	I_p(rel)	$E_{emitter}$ (^{129}Pm)	$E_{daughter}$(^{128}Nd)	coincident γ-rays
2.0-6.0	100%		0.1337	0.1337
2.0-6.0	<10%		0.44245	0.2908, 0.1337

* All values from [1999Xu05].

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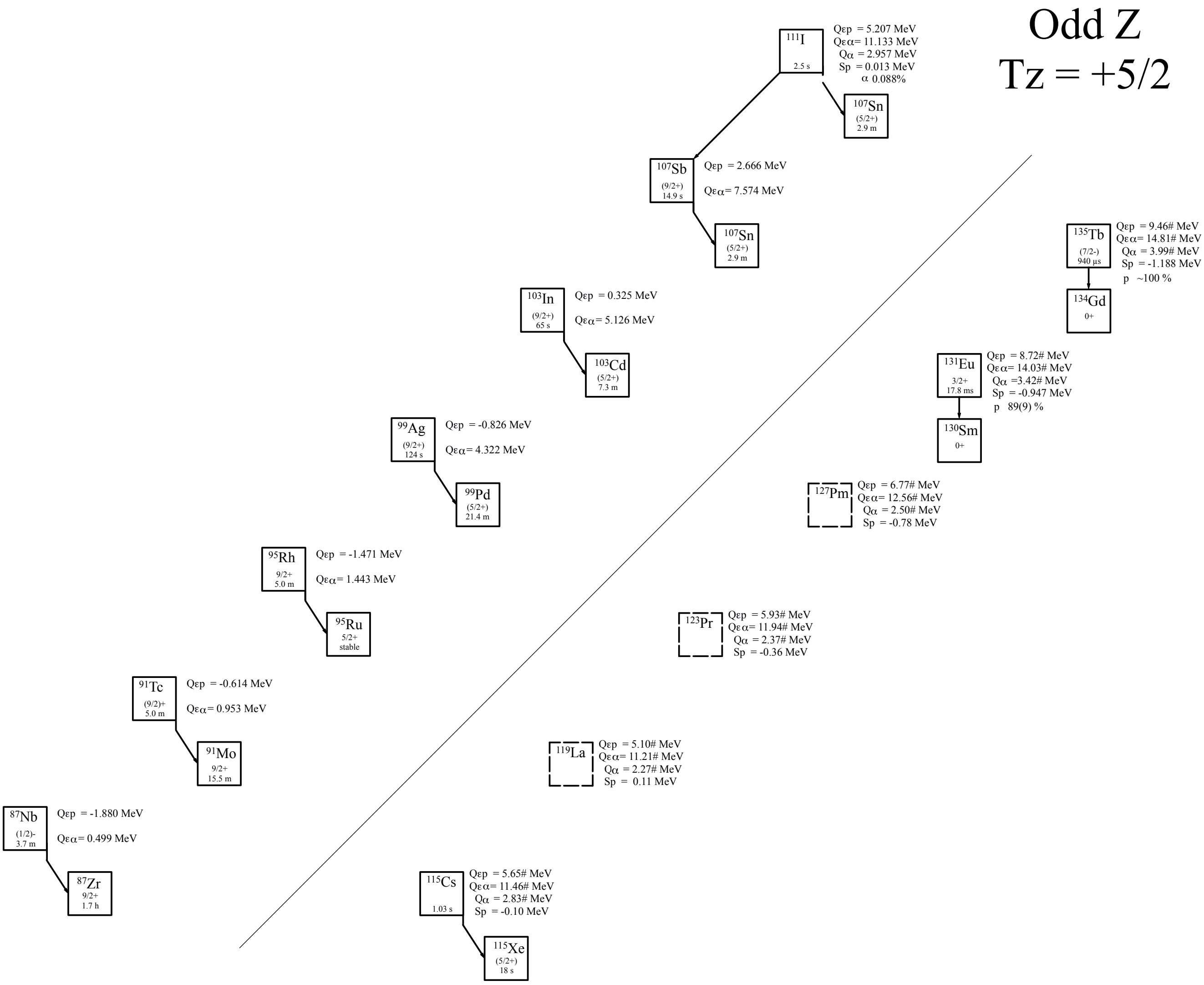

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +5/2 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +5/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	$BR_{\varepsilon\alpha}$	Experimental
^{87}Nb	(1/2)$^-$	3.7(1) m	5.473(8)	-1.880(16)	—	-7.349(8)	0.499(10)		[**1974Vo03**]
^{91}Tc	(9/2)$^+$	3.14(2) m	6.222(7)	-0.614(4)	—	-5.887(4)	0.953(5)		[**1976De37**]
^{95}Rh	9/2$^+$	5.02(10) m	5.117(10)	-1.471(6)	—	-6.112(4)	1.443(7)		[**1975We03**]
^{99}Ag	(9/2)$^+$	124(3) s	5.470(8)	-0.826(13)	—	-5.169(7)	4.322(12)		[**1981Hu03**]
^{103}In	(9/2$^+$)	65(7) s	6.019(9)	0.325(12)		-3.778(10)	5.126(10)		[**1978Lh01**]
^{107}Sb	5/2$^+$	4.0(2) s	7.859(7)	2.666(13)		-0.897(4)	7.574(4)		[**2002Re14**]
^{111}I		2.5(2) s	8.634(8)	5.207(8)		3.098(9)	11.133(7)		[**1977Ki11**]
^{115}Cs		1.03(10) s	8.96(10)#	5.65(10)#	0.2(1)%	4.07(10)#	11.46(10)#	0.010(5)%	[**2023DaXX**, 2020DaZX, 1978Da07]
^{119}La			9.57(36)#	5.10(30)#		4.59(30)#	11.21(30)#		
^{123}Pr			10.06(50)#	7.02(50)#		5.93(42)#	11.94(45)#		
^{127}Pm			10.60(50)#	7.73(45)#		6.77(45)#	12.56(50)#		
^{131}Eu	3/2$^+$	17.8(19) ms	10.82(57)#	8.72(45)#		8.34(45)#	14.03(50)#		[**1999So17**]
^{135}Tb	(7/2$^-$)	$0.94^{+0.33}_{-0.22}$ ms	11.20(57)#	9.46(50)#		9.60(50)#	14.81(57)#		[**2004Wo07**]

Table 2
Particle emission from the odd-Z, T_z = +5/2 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	BR_{1p}	S_{2p}	Q_α	BR_α	Experimental
^{87}Nb	3.194(8)	—	10.610(20)	-4.094(20)	—	
^{91}Tc	3.103(4)	—	9.939(24)	-4.537(7)	—	
^{95}Rh	3.046(5)	—	9.312(4)	-4.779(5)	—	
^{99}Ag	2.680(8)	—	8.690(40)	-0.797(7)	—	
^{103}In	2.262(9)	—	7.876(10)	-0.345(11)	—	
^{107}Sb	0.589(7)	—	5.591(11)	1.554(10)		
^{111}I	0.013(8)	—	4.192(12)	3.270(10)*	0.088%	[**1979Sc22**, 1978Ro19, 1977Ki11, 1993HaZS, 1981Sc17]
^{115}Cs	-0.10(10)#		3.16(10)#	2.83(10)#		
^{119}La	0.11(36)#		3.10(31)#	2.26(32)#		
^{123}Pr	-0.36(57)#		2.62(50)#	2.37(50)#		
^{127}Pm	-0.78(50)#		1.82(50)#	2.50(57)#		
^{131}Eu	-0.947(5)	89(9)%	0.86(50)#	3.42(57)#		[**1999So17**, 1998Da03, 2000SeZX]
^{135}Tb	-1.188(7)	≈100%	0.40(50)#	3.99(57)#		[**2004Wo07**, 2005Se21, 2003SeZZ, 2002DaZV]

* Deduced from α-decay; 2.957(12) MeV in [2021Wa16].

Table 3
direct α emission from ^{111}I*, J^π = , $T_{1/2}$ = 2.5(2) s**, BR_α = ≈ 0.088%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{107}Sb)	coincident γ-rays	R_0 (fm)	HF
3.270(10)	3.152(10)	100%	0.088%	5/2$^+$	0	—	1.655(91)	20^{+5}_{-2}

* All values from [1979Sc22], except where noted.
** [1977Ki11]

Table 4
direct p emission from ^{131}Eu*, $T_{1/2}$ = 17.8(19) ms, BR_p = 89(9)%.

E_p(c.m.)	E_p(lab)	I_p(rel)	I_p(abs)	$E_{daughter}$(^{130}Sm)	coincident γ-rays
0.817(7)	0.811(7)	32(6)%	28(7)%	0.212	0.212
0.939(7)	0.932(7)	100(6)%	89(11)%	0.0	—

* All values from [1999So17].

Table 5
direct p emission from ^{135}Tb*, $T_{1/2}$ = $0.94^{+0.33}_{-0.22}$ ms, BR_p = ≈ 100%.

E_p(c.m.)	E_p(lab)	I_p(rel)	I_p(abs)	$E_{daughter}$(^{134}Gd)	coincident γ-rays
1.188(7)	1.179(7)	100%	≈ 100%	0.0	—

* All values from [2004Wo07].

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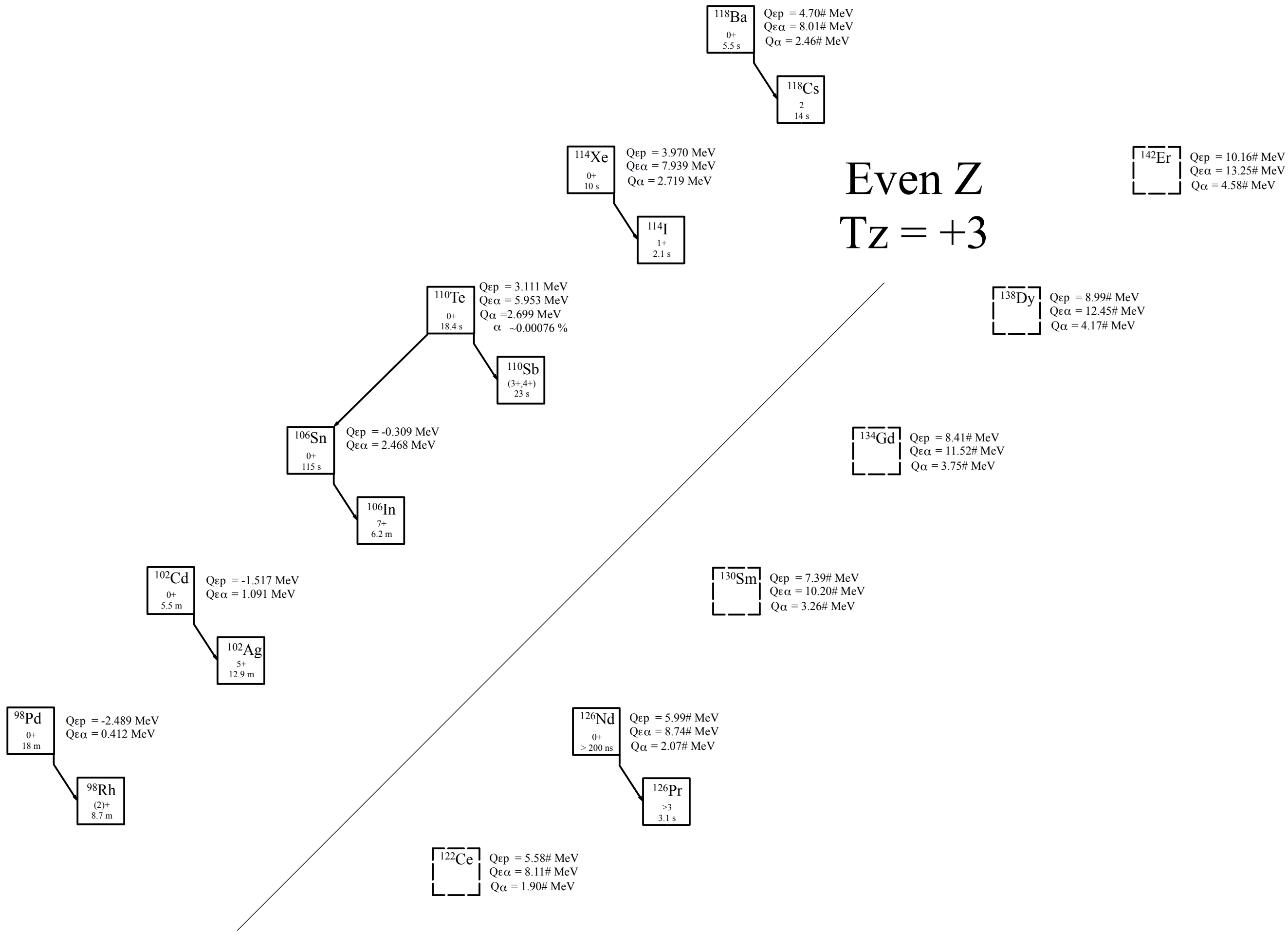

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +3 nuclei.

Last updated 3/21/23

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +3 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{98}Pd	0^+	17.7(4) m	1.854(13)	-2.489(5)	——	-10.077(7)	0.412(6)	[**1972Ga12**]
^{102}Cd	0^+	5.5(5) m	2.587(8)	-1.517(5)	——	-8.647(18)	1.091(12)	[**1969Ha03**]
^{106}Sn	0^+	115(5) s	3.254(13)	-0.309(5)	——	-6.816(6)	2.468(10)	[**1988Ba10**]
^{110}Te	0^+	18.4(8) s	5.220(9)	3.111(10)		5.953(14)	5.953(14)	[**1977Ki11**]
^{114}Xe	0^+	10.0(4) s	5.553(23)	3.970(30)		7.939(13)	7.939(13)	[**1977Ki11**]
^{118}Ba	0^+	5.5(2) s	6.21(20)#	4.70(20)#		8.01(20)#	8.01(20)#	[**1997Ja12**]
^{122}Ce			6.67(50)#	5.58(43)#		8.1140)#	8.11(40)#	
^{126}Nd	0^+	> 200 ns	6.94(36)#	5.99(36)#		8.74(42)#	8.74(42)#	[**2000So11**]
^{130}Sm			7.77(45)#	7.39(45)#		10.20(45)#	10.20(44)#	
^{134}Gd			8.27(50)#	8.41(50)#		11.52(45)#	11.52(44)#	
^{138}Dy			8.67(59)#	8.99(59)#		12.45(58)#	12.45(58)#	
^{142}Er			9.32(64)#	10.16(58)#		13.25(58)#	13.25(58)#	

Table 2
Particle emission from the even-Z, T_z = +3 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{98}Pd	6.012(36)	9.819(5)	-1.162(6)	——	
^{102}Cd	5.614(5)	9.025(18)	-0.764(5)	——	
^{106}Sn	5.002(11)	7.963(5)	-0.119(5)	——	
^{110}Te	3.268(8)	4.738(8)	2.723(15)*	≈0.00076%	[**1981Sc17**, 1977Ki11, 2000De11]
^{114}Xe	3.255(14)	4.096(14)	2.719(13)		
^{118}Ba	3.00(21)#	3.73(20)#	2.46(20)#		
^{122}Ce	2.97(50)#	3.56(50)#	1.90(45)#		
^{126}Nd	2.60(42)#	3.04(42)#	2.07(50)#		
^{130}Sm	1.81(50)#	1.75(45)#	3.26(50)#		
^{134}Gd	1.58(50)#	0.97(50)#	3.75(57)#		
^{138}Dy	1.25(64)#	0.42(59)#	4.17(64)#		
^{142}Er	0.86(64)#	-0.32(64)#	4.58(71)#		

* Deduced from α energy, 2.699(8) MeV in [2021Wa16].

Table 3
direct α emission from ^{110}Te*, $J^\pi = 0^+$, $T_{1/2}$ = 18.4(8) s, $BR_\alpha = \approx 0.00076\%$.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{106}Sn)	coincident γ-rays	R_0 (fm)	HF
2.723(15)	2.624(15)	0.00076%	0^+	0.0	——	1.64(11)	≈2.5

* All values from [1981Sc17].

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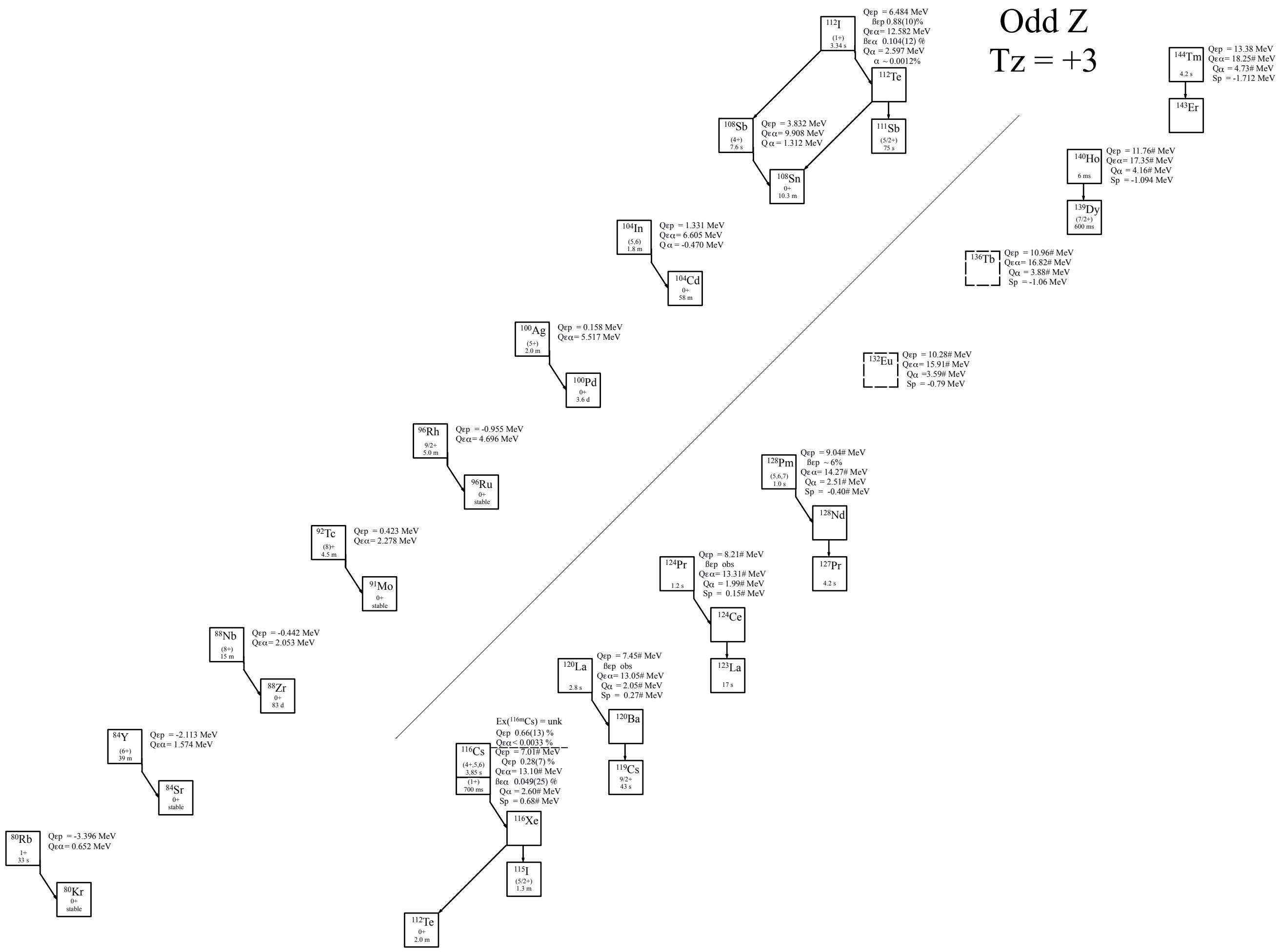

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +3 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +3 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J$^{\pi}$values for ^{80}Rb, ^{84}Y, ^{88}Nb, ^{92}Tc, ^{96}Rh, ^{100}Ag, ^{104}In, ^{108}Sb, are taken from ENSDF.

Nuclide	Ex	J^{π}	$T_{1/2}$	Q$_{\varepsilon}$	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	BR$_{\beta\alpha}$	Experimental
^{80}Rb		1^{+}	33.4(7) s	5.718(2)	-3.396(2)	—	-9.728(2)	0.652(2)		[**1993Al03**]
^{84}Y		(6^{+})	39(1) m	6.755(4)	-2.113(5)	—	-7.880(4)	1.574(4)		[**1981DeZD**]
^{88}Nb		(8^{+})	14.56(11) m	7.46(60)	-0.442(58)	—	-6.225(60)	2.053(58)		[**2009Ga02**]
^{92}Tc		(8^{+})	4.5(1) m	7.883(3)	0.423(4)		-4.781(3)	2.278(6)		[**1985Be12**]
^{96}Rh		6^{+}	9.9(1) m	6.393(10)	-0.955(11)	—	-5.852(10)	4.696(10)		[**1975Gu01**]
^{100}Ag		(5)$^{+}$	2.0(1) m	7.075(18)	0.158(20)		-4.491(8)	5.517(5)		[**1980Ha20**]
^{104}In		(5,6)	1.80(3) m	7.786(6)	1.331(7)		-2.858(6)	6.605(19)		[**1995Sz01**]
^{108}Sb		(4^{+})	7.6(3) s	9.625(8)	3.832(11)		0.109(5)	9.098(6)		[**1997Sh13**]
^{112}I		(1^{+})	3.42(11)s	10.504(13)	6.484(14)	0.88(10)%	4.201(17)	12.582(11)	0.104(12)%	[**1985Ti02**]
^{116}Cs		(1^{+})	0.70(4) s	11.00(10)#	7.01(10)#	0.28(7)%**	5.27(10)#	13.10(10)#	0.049(25)%**	[**1977Bo28**, 1985Ti02, 1978Da07, 1978Ka17, 1976Bo36, 1975Bo11]
^{116m}Cs	0.10(6)*		3.85(13) s	11.08(10)#	7.11(10)#	0.66(13)%**	5.37(10)#	13.18(12)#	<0.0033%**	[**1977Bo28**, 1985Ti02, 1978Da07, 1978Ka17]
^{120}La			2.8(2) s	11.32(42)#	7.45(30)#	obs	5.93(30)#	13.05(30)#		[**1984Ni03**]
^{124}Pr			1.2(2) s	11.77(50)#	8.21(45)#	obs	6.88(40)#			[**1986Wi15**]
^{128}Pm			1.0(3) s	12.31(36#)	9.04(36)#	≈6%	8.02(30)#	13.31(50)#	14.27(42)#	[**2005Xu04**, 1999Xu05]
^{132}Eu				12.94(50)#	10.28(45)#		9.82(40)#	15.91(45)#		
^{136}Tb				13.19(58)#	10.96(54)#		10.90(54)#	16.82(58)#		
^{140}Ho			6(3) ms	13.51(64)#	11.52(58)#		11.76(54)#	17.35(58)#		[**1999Ry04**]
^{144}Tm		9^{+}***	$1.9\,^{+1.2}_{-0.5}$ μs	14.45(45)#	12.60(50)#		18.25(57)#	13.38(83)#		[**2005Gr32**]

* Excitation energy is unknown, Estimated from systematics to be 100(60) keV [2003Au02].

** There are large discrepancies between the three studies [1985Ti02], [1978Da07] and [1977Bo28]. The β-p to β-α ratios reported for the 3.85 s isomer are 200(80), 47(20 and > 200 respectively. For the 0.7 s isomer, the ratio is 16(4) [1985Ti02], 4.7(18) [1977Bo28], and no value is reported by [1978Da07]. This is somewhat consistent if the value reported by [1978Da07] arises from a combination of the 0.7 and 3.8 s isomers. Individual branching ratios for β-p and β-α are not reported by [1985Ti02].

*** [2022Si09]

Table 2
Particle separation and emission from the odd-Z, T_z = +3 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_{p}$	BR$_{1p}$	S$_{2p}$	Q$_{\alpha}$	BR$_{\alpha}$	Experimental
^{80}Rb	5.022(4)	—	13.301(4)	-4.311(10)	—	
^{84}Y	4.386(8)	—	12.285(5)	-4.144(5)	—	
^{88}Nb	4.113(58)	—	11.466(60)	-4.702(58)	—	
^{92}Tc	4.006(7)	—	10.842(5)	-5.179(58)	—	
^{96}Rh	3.519(14)		10.107(11)	-3.187(10)	—	
^{100}Ag	3.244(7)	—	9.541(13)	-0.875(11)	—	
^{104}In	2.820(6)	—	8.514(10)	-0.470(8)	—	
^{108}Sb	1.222(8)	—	6.415(13)	1.312(8)		
^{112}I	0.765(12)	—	4.192(12)	2.957(12)	≈0.0012%	[**1985Ti02**, 1978Ro19]
^{116}Cs	0.68(10)#	—	3.98(18)#	2.60(10)#		[**1985Ti02, 1978Da07, 1977Bo28**, 1978Ka17]
^{116m}Cs	0.60(12)#	—	3.90(33)#	2.70(12)#		[**1985Ti02, 1978Da07, 1977Bo28**,1978Ka17]
^{120}La	0.27(36)#		3.74(30)#	2.05(32)#		
^{124}Pr	0.15(50)#		3.19(50)#	1.99(50)#		
^{128}Pm	-0.40(42)#		2.47(36)#	2.51(50)#		
^{132}Eu	-0.79(57)#		1.310(45)#	3.59(50)#		
^{136}Tb	-1.06(64)#		0.68(58)#	3.88(64)#		
^{140}Ho	-1.094(10)	100%	0.30(58)#	4.16(71)#		[**1999Ry04**, 1999BaZR, 1999RyZZ, 1998BaZU]
^{144}Tm	-1.712(16)	100%	-0.51(57)#	4.73(64)#		[**2005Gr32**, 2005Bi24]

Table 3
direct α emission from ^{112}I*, J^{π} = (1^{+}), $T_{1/2}$ = 3.42(11)s**, BR_{α} = ≈0.0012%***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{139}Dy)	coincident γ-rays
2.987(30)	2.880(30)	≈0.0012%***	($5/2^{+}$)	0.0	—

* All values from [1981Sc17], except where noted.
** [1985Ti02].
*** [1978Ro19].

Table 4
direct p emission from ^{140}Ho*, J^{π} = $T_{1/2}$ = 6(3) ms, BR_{p} = 100%.

E_{p}(c.m.)	E_{p}(lab)	I_{p}(rel)	I_{p}(abs)	J^{π}_{f}	$E_{daughter}$(^{139}Dy)	coincident γ-rays
1.094(10)	1.086(10)	100%	100%	($7/2^{+}$)	0.0	—

* All values from [1999Ry04].

Table 5
direct p emission from ^{144}Tm*, J^{π} = 9^{+}, $T_{1/2}$ = $1.9\ ^{+1.2}_{-0.5}$ μs, BR_{p} = 100%.

E_{p}(c.m.)	E_{p}(lab)	I_{p}(rel)	I_{p}(absb)	J^{π}_{f}	$E_{daughter}$(^{143}Er)	coincident γ-rays
1.430(25)	1.440(25)	≈ 29%	≈ 29%			
1.700(16)	1.712(16)	≈ 71%	≈ 71%			

* All values from [2005Gr32].

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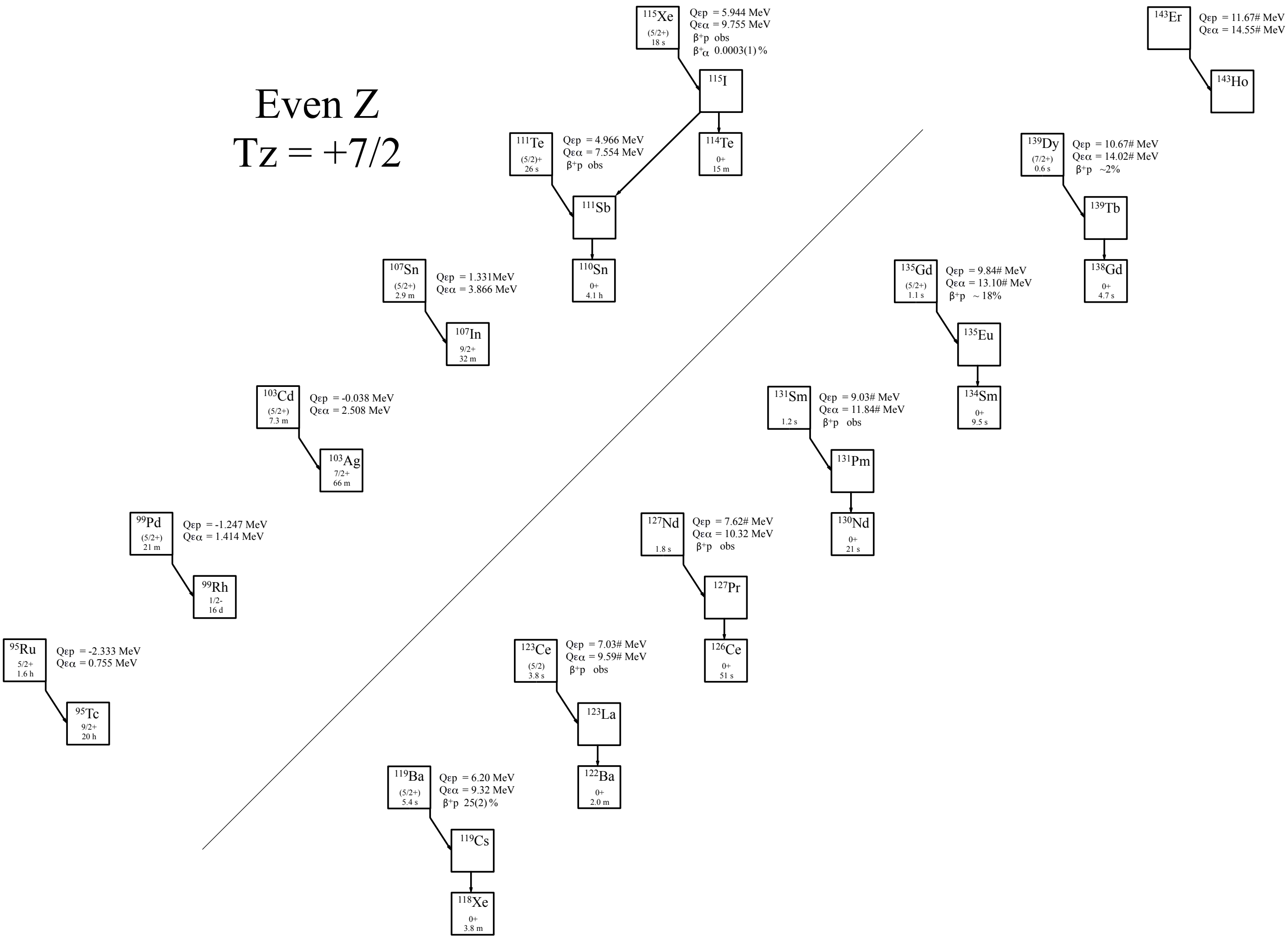

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +7/2 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +7/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. All J^π values are taken from ENSDF

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	$BR_{\beta\alpha}$	Experimental
^{95}Ru	5/2$^+$	1.64(1) h*	2.564(11)	-2.333(10)		-10.823(10)	0.755(10)		[**1968Pi03, 1970Bo22**]
^{99}Pd	(5/2$^+$)	21.4(2) m	3.402(19)	-1.247(8)		-9.536(7)	1.414(7)		[**1969Ph01**]
^{103}Cd	(5/2$^+$)	7.3(1) m	4.151(4)	-0.038(2)		-7.817(6)	2.508(20)		[**1969Ha03**]
^{107}Sn	(5/2$^+$)	2.90(5) m	5.054(11)	1.331(5)		-6.019(7)	3.866(7)		[**1976Hs01, 1974Ho17**]
^{111}Te	(5/2)$^+$	26.2(6) s	7.249(11)	4.966(15)	obs	-1.676(8)	7.554(12)		[**1967Ka01**, 2005Sh24, 1967Bo41, 1967Bo43]
^{115}Xe	(5/2$^+$)	18(4) s	7.680(30)	5.944(27)	obs	1.182(21)	9.755(15)	0.0003(1)%	[**1971Ho07**, 1972Ho18]
^{119}Ba	(5/2$^+$)	5.4(3) s	7.71(20)	6.20(20)	25(2)%	1.27(20)	9.32(20)		[**1975Bo11**,1976Bo36, 1978Bo20], 1979Ew02
^{123}Ce	(5/2)	3.8(2) s	8.37(36)#	7.03(30)#	obs	2.24(30)#	9.59(30)#		[**1984Ni03, 1988WiZN**]
^{127}Nd		1.8(4) s	8.63(36)#	7.62(30)#	obs	3.27(30)#	10.32(36)#		[**1987WiZM**, 1983Ni05, 1986Wi15]
^{131}Sm		1.2(2) s	9.49(45)#	9.03(40)#	obs	4.92(40)#	13.10(45)#		[**1986Wi15**, 1987WiZM]
^{135}Gd	(5/2$^+$)	1.1(2) s	9.9(45)#	9.84(45)#	≈18%	6.58(40)#	14.02(54)#		[**2005Xu04**, 1996Xu07]
^{139}Dy	(7/2$^+$)	0.6(2) s	10.43(58)#	10.67(54)#	≈2%	7.87(50)#	14.55(50)#		[**2005Xu04**, 2002XuZZ, 1996Xu07]
^{143}Er			10.89(50)#	11.67(83)#		8.80(41)#			

* Weighted average of 1.65(2) h [1968Pi03] and 1.63(2) h [1970Bo22].

Table 2
Particle emission from the even-Z, T_z = +7/2 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{95}Ru	6.588(10)	11.229(10)	-3.674(11)		
^{99}Pd	6.297(13)	10.640(6)	-1.150(11)		
^{103}Cd	5.694(8)	9.797(5)	-0.894(5)		
^{107}Sn	5.193(13)	8.756(5)	-0.286(6)		
^{111}Te	3.427(9)	5.535(10)	2.500(8)		
^{115}Xe	3.307(23)	4.888(31)	2.506(14)		
^{119}Ba	3.47(20)	4.98(20)	1.64(20)		
^{123}Ce	3.03(42)#	4.12(33)#	1.88(36)#		
^{127}Nd	2.88(36)#	3.83(36)#	1.95(42)#		
^{131}Sm	2.10(45)#	2.48(45)#	3.21(50)#		
^{135}Gd	1.74(50)#	1.60(50)#	3.61(57)#		
^{139}Dy	1.39(58)#	1.07(58)#	4.12(64)#		
^{143}Er	1.20(56)#	0.36(50)#	4.12(64)#		

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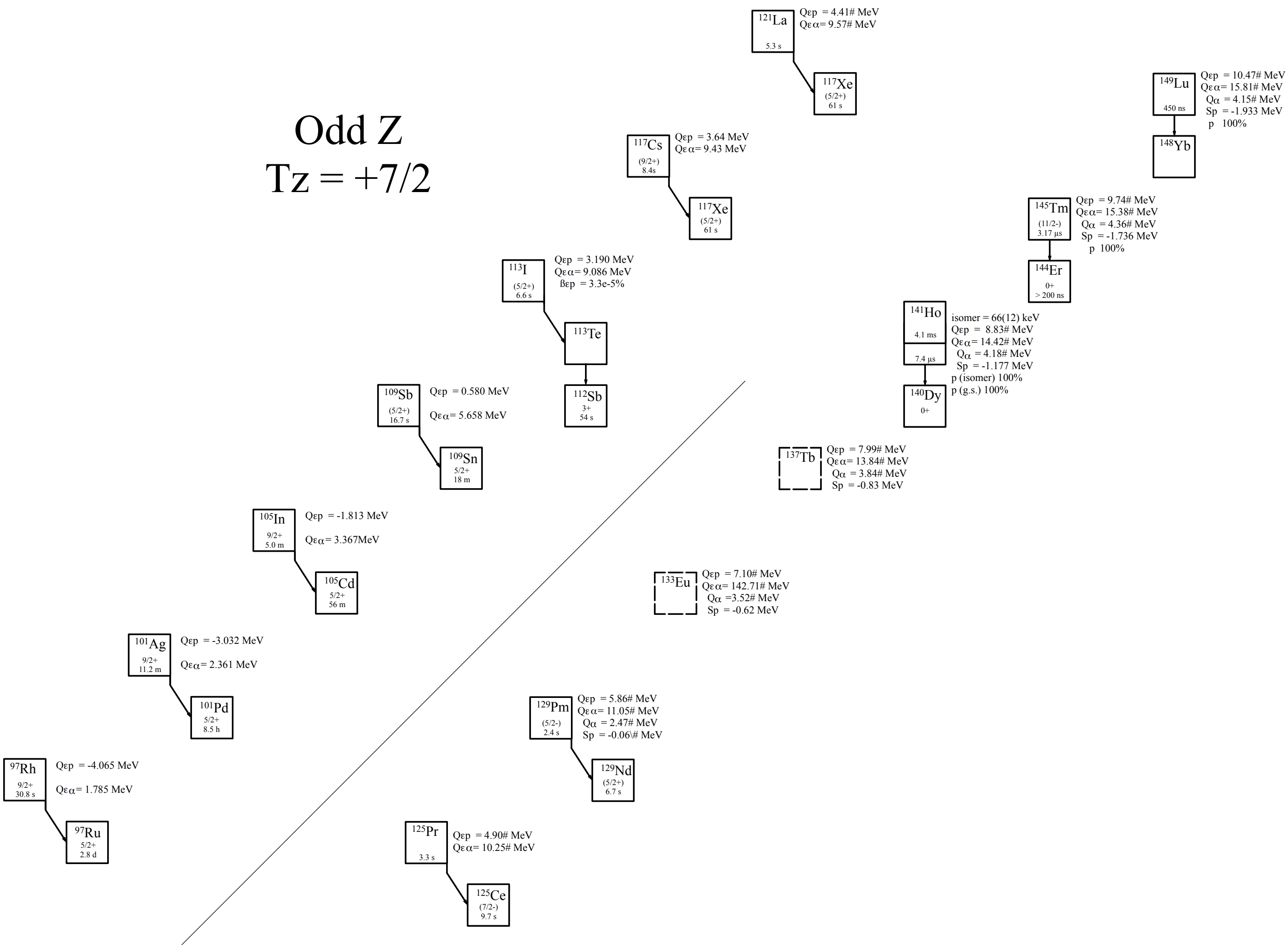

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +7/2 nuclei.

Last updated 3/21/23

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +7/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J^{π} values for ^{97}Rh, ^{101}Ag, ^{105}In, ^{109}Sb, ^{113}I, ^{117}Cs, ^{129}Pm are taken from ENSDF.

Nuclide	Ex	J^{π}	$T_{1/2}$	Q_{ε}	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{97}Rh		9/2$^+$	30.8(6) s*	3.52(40)	-4.065(36)	—	-9.464(35)	1.785(35)	[**1975Pl05, 1974Oh07**]
^{101}Ag		9/2$^+$	11.2(1) m	4.098(7)	-3.032(19)	—	-8.287(5)	2.361(6)	[**1966Pa14**]
^{105}In		9/2$^+$	5.07(7) m	4.693(10)	-1.813(11)	—	-6.762(10)	3.367(11)	[**1984Ve01**]
^{109}Sb		(5/2$^+$)	16.67(15) s	6.379(9)	0.580(10)		-3.839(6)	5.658(5)	[**1982Jo03**]
^{113}I		(5/2$^+$)	6.6(2) s	7.228(29)	3.190(20)	≈3.3e-5%	0.241(10)	9.086(11)	[**1981Sc17, 1977Ki11**]
^{117}Cs		(9/2$^+$)	8.4(6) s	7.690(60)	3.639(98)		0.992(68)	9.429(68)	[**1986Ma41**]
^{121}La			5.3(2) s	8.56(33)#	4.41(30)#		2.03(30)#	9.57(30)#	[**1988Se08**]
^{125}Pr			3.3(7) s	8.59(36)#	4.90(31)#		3.01(30)#	10.25(33)#	[**1995Os03**]
^{129}Pm		(5/2$^-$)	2.4(9) s	9.2(36)#	5.86(30)#		4.22(30)#	11.05(36)#	[**2004Xu05**]
^{133}Eu				10(42)#	7.10(33)#		5.95(30)#	12.71(36)#	
^{137}Tb				10.25(50)#	7.99(45)#		7.31(43)#	13.84(50)#	
^{141}Ho			4.1(1) ms	11.02(50)#	8.83(90)#		8.69(45)#	14.42(50)#	[**2008Ka16**]
^{141m}Ho	0.066(12)		7.4(3) μs	11.09(50)#	8.90(90)#		14.49(50)#	8.76(45)#	[**2008Ka16**]
^{145}Tm		(11/2$^-$)	3.17(20) μs	11.66(28)#	9.74(20)#		10.01(20)#	15.38(36)#	[**2007Se06**
^{149}Lu			$0.45^{+0.17}_{-0.10}$ μs	12.32(30)#**	10.47(30)#**		11.02(40)#**	15.81#**	[**2022Au01**]

* Weighted average of 30.3(9) m [1975Pl05] and 31.1(8) m [1974Oh07].
** Deduced from proton energy and daughter values from [2021Wa16].

Table 2
Particle separation and β-α emission from the odd-Z, T_z = +7/2 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	BR_p	S_{2p}	Q_{α}	Experimental
^{97}Rh	3.806(35)		11.154(36)	-1.416(35)	
^{101}Ag	3.411(18)		10.328(20)	-1.162(36)	
^{105}In	2.961(10)		9.416(11)	-0.731(11)	
^{109}Sb	1.470(8)		7.262(11)	0.965(12)	
^{113}I	0.841(12)		4.861(12)	2.707(10)	
^{117}Cs	0.735(64)		4.733(69)	2.202(63)	
^{121}La	0.59(42)#		4.46(30)#	1.88(31)#	
^{125}Pr	0.44(42)#		4.00(36)#	1.70(42)#	
^{129}Pm	-0.06(36)#		3.22(39)#	2.47(42)#	
^{133}Eu	-0.62(42)#		2.04(36)#	3.52(42)#	
^{137}Tb	-0.83(50)#		1.40(45)#	3.84(60)#	
^{141}Ho	-1.177(7)	100%	0.81(50)#	4.18(57)#	[**1998Da03, 1999Ry04, 2008Ka16**, 2007KaZO, 2005Bi24, 2003BaZZ, 2002Kr04, 2001Se03, 2000SeZW, 1999BaZR, 1999RyZZ, 1999SeZY]
^{141m}Ho	-1.243(14)	100%	0.74(50)#	4.25(57)#	*
^{145}Tm	-1.736(7)	100%	0.11(36)#	4.36(45)#	[**2007Se06**, 2003Ka04, 2001Ry02, 1998Ba13, 2007SeZR, 2005Bi24, 2005RoZY, 2005Se26, 2004SeZW, 2003BaZZ, 2001Ry01, 2001Ry02, 1999BaZR]
^{149}Lu	-1.933(20)	100%	0.388(29)#**	4.15(20)#**	[**2022Au01**]

* References for ^{141m}Ho are the same as ^{141}Ho.
** Deduced from proton energy and daughter values from [2021Wa16].

Table 3
direct p emission from ^{141}Ho*, J^{π} = $T_{1/2}$ =4.1(1) ms, BR_p = 100%.

E_p(c.m.)	E_p(lab)	I_p(rel)	I_p(absb)	J^{π}_f	$E_{daughter}$(^{140}Dy)	coincident γ-rays
0.975(10)	0.968(10)	0.9(2)%	0.9(2)%	(2$^+$)	0.202(2)	0.202(2)
1.177(8)	1.169(8)	100%	99.1(2)%	0$^+$	0.0	—

* All vaues from [2008Ka16].

Table 4
direct p emission from ^{141m}Ho*, Ex = 66(12) keV, J$^{\pi}$ = T$_{1/2}$ = 7.4(3) μs, BR_p = 100%.

E_p(c.m.)	E_p(lab)	I_p(rel)	I_p(absb)	J_f^{π}	$E_{daughter}$(^{140}Dy)	coincident γ-rays
1.037(10)	1.030(10)	≈1%	≈1%	(2$^+$)	0.202(2)	0.202(2)
1.244(9)	1.235(9)	100%	≈99%	0$^+$	0.0	—

* All values from [2008Ka16].

Table 5
direct p emission from ^{145}Tm*, J$^{\pi}$ = (11/2$^-$), T$_{1/2}$ =3.17(20) μs**, BR_p = 100%.

E_p(c.m.)	E_p(lab)	I_p(rel)	I_p(absb)	J_f^{π}	$E_{daughter}$(^{144}Er)	coincident γ-rays
1.410(10)	1.400(10)	10.6(15)%	9.6(15)%	2$^+$	0.330	0.330
1.740(8)	1.728(10)	100%	90.4(15)%	0$^+$	0.0	—

* Values from [2003Ka04] except where noted.
** [2007Se06]

Table 6
direct p emission from ^{149}Lu*, J$^{\pi}$ = T$_{1/2}$ =$0.45^{+0.17}_{-0.10}$ μs, BR_p = 100%.

E_p(c.m.)	E_p(lab)	I_p(rel)	I_p(absb)	J_f^{π}	$E_{daughter}$(^{148}Yb)	coincident γ-rays
1.933(20)	1.920(20)	100%	100%	0$^+$	0.0	—

* All values from [2022Au01].

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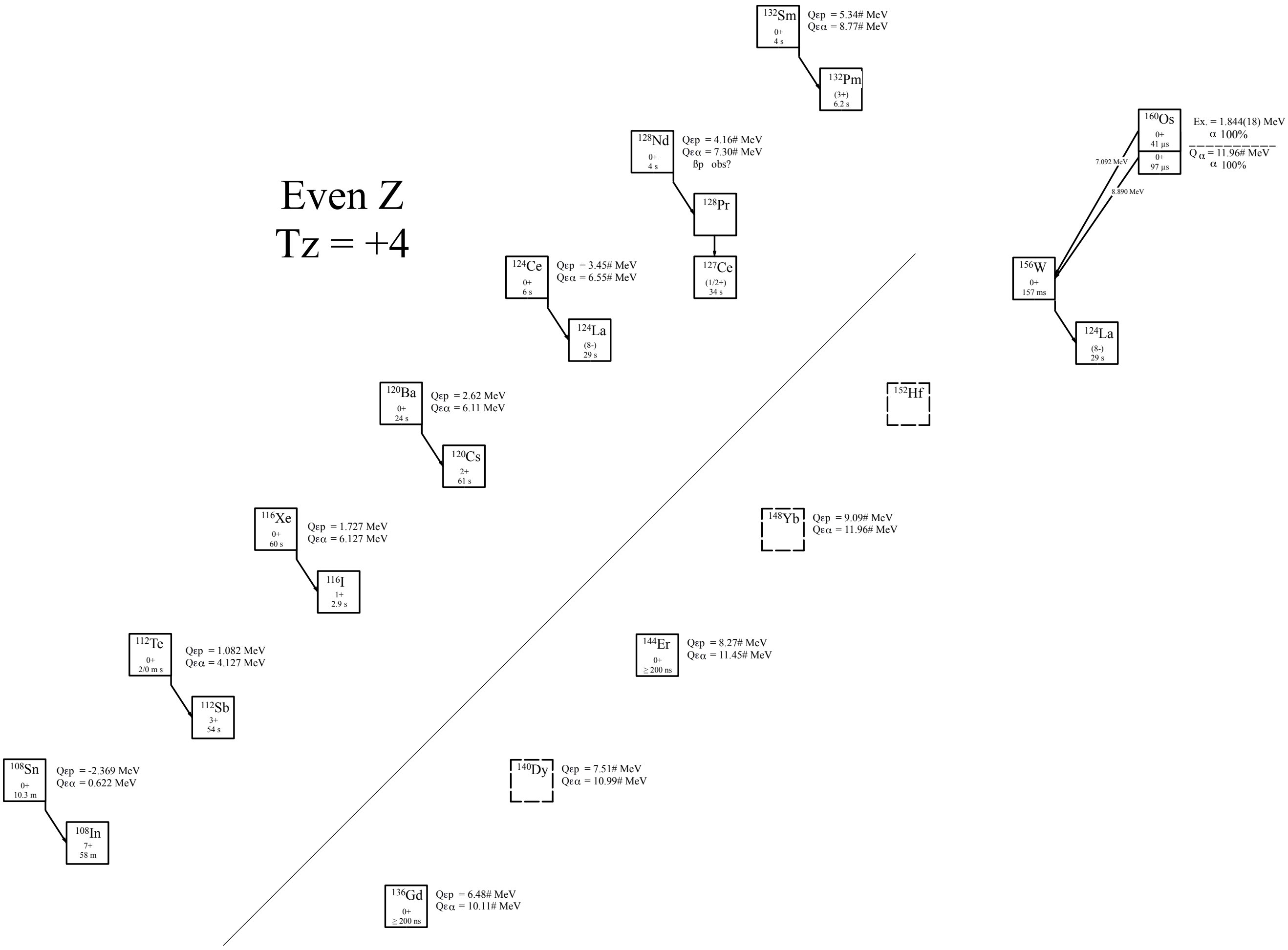

Fig. 1: Known experimental values for heavy particle emission of the even-Z, T_z= +4 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +4 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. All J$^{\pi}$ values are taken from ENSDF.

Nuclide	J^{π}	$T_{1/2}$	Qε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental	
^{108}Sn		0$^+$	10.30(8) m	2.05(10)	-2.369(6)		-9.705(6)	0.622(7)	[**1978Hs01**]
^{112}Te		0$^+$	2.0(2) m	4.031(20)	1.082(10)		-5.675(14)	4.127(12)	[**1976Wi11**]
^{116}Xe		0$^+$	60(2) s	4.37(80)	1.727(31)		-3.128(24)	6.127(22)	[**1974Ha10**]
^{120}Ba		0$^+$	24(2) s	5.00(30)	2.62(30)		-2.50(30)	6.11(31)	[**1992Xu04**]
^{124}Ce		0$^+$	6(2) s	5.34(30)#	3.45(30)#		-1.35(30)#	6.55(30)#	[**1978Bo32**]
^{128}Nd		0$^+$	4(2) s	5.8(20)#	4.16(20)#	obs?*	-0.13(22)#	7.30(21)#	[**1983Ni05**]
^{132}Sm		0$^+$	4.0(3) s	6.49(34)#	5.34(30)#		1.46(31)#	8.77(30)#	[**1989McZU**]
^{136}Gd		0$^+$	≥200 ns	7.15(36)#	6.48(34)#		3.10(30)#	10.11(33)#	[**2000So11**]
^{140}Dy		0$^+$		7.65(90)#	7.51(45)#		4.34(40)#	10.99(45)#	
^{144}Er		0$^+$	≥200 ns	8.00(20)#	8.27(20)#		5.37(73)#	11.45(82)#	[**2000So11**]
^{148}Yb		0$^+$		8.54(40)#	9.09(40)#		6.43(40)#	11.96(40)#	
^{152}Hf		0$^+$							
^{156}W		0$^+$	157^{+57}_{-34} ms						[**2023Br10**]
^{160}Os		0$^+$	97^{+97}_{-32} μs						[**2023Br10**]
^{160m}Os	1.844(18)	(8$^+$)	41^{+15}_{-9} μs						[**2023Br10**]

* Uncertain, may be from ^{128}Pr [1983Ni05]

Table 2
Particle emission from the even-Z, T_z = +4 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_p$	BR$_p$	S$_{2p}$	Q$_\alpha$	BR$_\alpha$	Experimental
^{108}Sn	5.792(11)	—	9.516(5)	-0.526(6)		
^{112}Te	4.020(12)	—	6.303(16)	2.078(10)		
^{116}Xe	3.998(32)	—	5.735(27)	2.096(15)		
^{120}Ba	3.87(30)	—	5.39(30)	1.73(30)		
^{124}Ce	3.55(36)#	—	4.89(30)#	1.55(42)#		
^{128}Nd	3.28(28)#	—	4.29(20)#	1.96(36)#		
^{132}Sm	2.66(36)#	—	3.12(30)#	2.97(36)#		
^{136}Gd	2.23(36)#	—	2.29(36)#	3.63(42)#		
^{140}Dy	1.99(50)#	—	1.75(45)#	3.84(50)#		
^{144}Er	1.85(36)#	—	1.07(75)#	3.80(45)#		
^{148}Yb	1.54(40)#	—	0.49(40)#	3.95(45)#		
^{152}Hf						
^{156}W						
^{160}Os				7.724(15)*	100%	[**2023Br10**]
^{160m}Os				9.18(10)*	100%	[**2023Br10**]

* Deduced from α energy [2023Br10].

Table 3
direct α emission from ^{160}Os*, J$^{\pi}$ = 0$^+$, T$_{1/2}$ = 97^{+97}_{-32} μs, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)%	J$^{\pi}_{f}$	$E_{daughter}$(^{156}W)	coincident γ-rays	R$_0$ (fm)]	HF
7.274(15)	7.092(15)	100%	0$^+$	0.0	—	1.5597(29)	$1.8^{+1.8}_{-0.6}$

* All values from [2003BrXX].

Table 4
direct α emission from ^{160m}Os*, Ex. = 1.844(18) MeV, J$^{\pi}$ = 8$^+$, T$_{1/2}$ = 41^{+15}_{-9} , BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)%	J$^{\pi}_{f}$	$E_{daughter}$(^{156}W)	coincident γ-rays	R$_0$ (fm)]	HF
9.118(10)	8.890(10)	100%	0$^+$	0.0	—	1.5597(29)	2.6(10) × 10^4

* All values from [2003BrXX].

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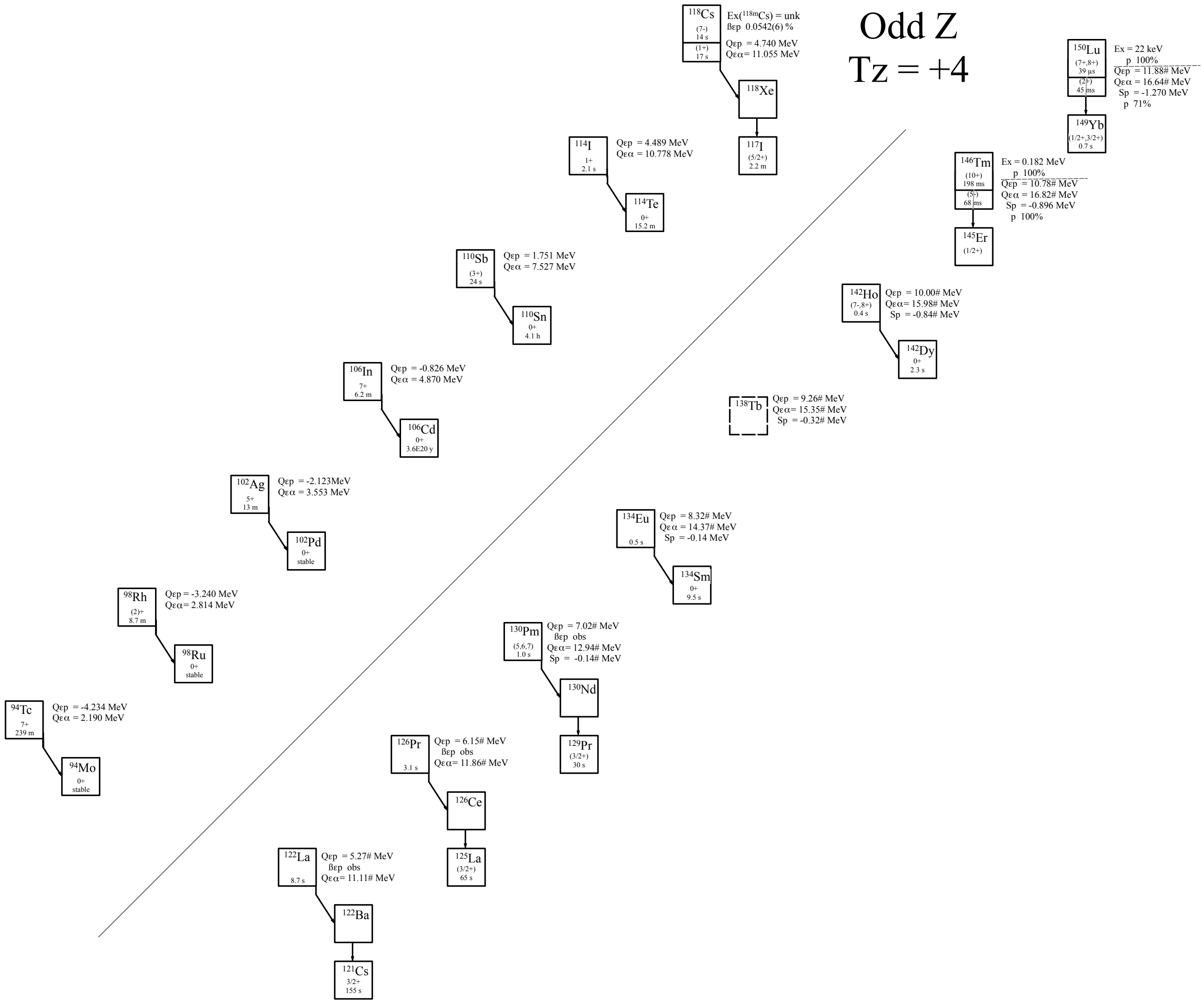

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +4 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +4 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J^π

Nuclide	Ex	J^π	$T_{1/2}$	Q$_\varepsilon$	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{94}Tc		7^+	293(1) m	4.256(4)	-4.234(4)	—	-10.277(4)	2.189(4)	[**1963Ma21**]
^{98}Rh		$(2)^+$	8.7(1) m	5.05(10)	-3.240(13)	—	-8.958(12)	2.814(12)	[**1956Ka25**]
^{102}Ag		5^+	13.0(4) m	5.656(8)	-2.123(10)	—	-7.597(8)	3.553(10)	[**1967Ch05**]
^{106}In		7^+	6.2(1) m	6.524(12)	-0.826(13)	—	-5.791(12)	4.870(12)	[**1978Hu06**]
^{110}Sb		(3^+)	24.0(3) s	8.392(15)	1.751(7)		-2.775(6)	7.257(6)	[**1976Ox01**]
^{114}I		1^+	2.1(2) s	9.25(30)	4.489(26)		1.438(20)	10.778(24)	[**1977Ki11**]
^{118}Cs		2	14(2) s	9.67(16)	4.740(29)	0.0542(6)%*	2.276(27)	11.055(28)	[**1995Ki07, 1977Bo28, 1977Ge03**, 1978Da07]
^{118m}Cs	x	(7^-)	17(3) s	9.67(16)+x	4.740(29)+x	0.0542(6)%*	2.276(27)+x	11.055(28)+x	[**1995Ki07, 1977Bo28, 1977Ge03**, 1978Da07]
^{122}La			8.7(7) s	10.07(30)#	5.27(30)#	obs	3.05(30)#	11.11(30)#	[**1984Ni03**, 1988WiZN]
^{126}Pr			3.14(22) s	10.50(20)#	6.15(20)#	obs	4.19(20)#	11.86(20)#	[**2002Ka66, 1983Ni05**]
^{130}Pm			2.6(2) s	11.13(20)#	7.02(20)#	obs	5.49(20)#	12.93(20)#	[**1999Xi03, 1985Wi07**]
^{134}Eu			0.5(2) s	11.58(36)#	8.32(30)#		7.05(31)#	14.37(30)#	[**1989Vi04**]
^{138}Tb				12.06(36)#	9.26(30)#		8.63(30)#	15.35(36)#	
^{142}Ho		$(7^-, 8^+)$	0.4(1) s	12.87(83)#	10.00(41)#		15.98(45)#	9.95(40)#	[**2005Xu04**, 2002Xu11, 2001Xu02]
^{146}Tm		(5^-)	68(3) ms	13.27(20)#	10.78(20)#		10.94(20)#	16.64(76)#	[**2006Ta08, 2005Bb02, 2003Gi10, 2001Ry01**, 2001Ry02, 2005Ro40, 2005Se26, 2007BaZQ, 2007DaZU, 2005Bi24, 2005RoZY, 1995PeZY, 1993Li18, 1993WoZY]
^{146m}Tm***	0.182(4)	(10^+)	198(3) ms	13.45(20)#	10.96(20)#		11.12(20)#	16.82(76)#	[**2006Ta08**]
^{150}Lu		(2^+)	45(3) ms**	14.06(42)#	11.88(36)#		12.13(30)# 1993WoZY]	17.13(30)#	[**2003Gi10, 2000Gi01**]
^{150m}Lu	0.022(6)***	$(1^-, 2^-)$	$39^{+8}_{-6}\mu$s	14.09(42)#	11.91(36)#		12.16(30)# 1993WoZY]	17.15(30)#	[**2003Gi10, 2000Gi01**]

* Mixture of ground state and isomer [1995Ki07, 1977Ge03].

** Weighted average of 43(5) ms [2003Ro21], 49(5) ms [2000Gi01].

*** Excitation Energy = 22(6) keV, deduced from the weighted average of the difference in energies of the protons feeding the ground state of ^{149}Yb; 16(9) keV [2000Gi10] and 25(7) keV [2003Ro21].

Table 2
Particle emission from the odd-Z, T_z = +4 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	BR_p	S_{2p}	Q_α	Experimental
^{94}Tc	4.640(4)	—	12.283(4)	-3.922(5)	
^{98}Rh	4.344(12)	—	11.932(13)	-1.442(13)	
^{102}Ag	4.104(9)	—	11.234(20)	-1.496(14)	
^{106}In	3.563(12)	—	10.070(13)	-0.786(15)	
^{110}Sb	2.109(10)	—	7.908(10)	0.733(14)	
^{114}I	1.581(34)	—	5.618(27)	2.386(21)	
^{118}Cs	1.513(16)	—	5.567(76)	1.805(24)	
^{118m}Cs	1.513(16)-x	—	5.567(76)-x	1.805(24)+x	
^{122}La	1.087(33)#	—	5.23(23)#	1.44(30)#	
^{126}Pr	0.96(28)#	—	4.64(20)#	1.80(36)#	
^{130}Pm	0.38(28)#	—	3.72(20)#	2.43(28)#	
^{134}Eu	-0.14(42)#		2.71(34)#	3.24(36)#	
^{138}Tb	-0.32(42)#		1.94(36)#	3.78(42)#	
^{142}Ho	-0.84(50)#		1.35(90)#	3.93(50)#	
^{146}Tm	-0.896(6)#	100%	1.02(20)#	3.77(45)#	[**2006Ta08, 2005Bb02, 2003Gi10, 2001Ry01**, 2001Ry02, 2005Ro40, 2005Se26, 2007BaZQ, 2007DaZU, 2005Bi24, 2005RoZY, 1995PeZY, 1993Li18, 1993WoZY]
^{146m}Tm	-1.078(7)#	71%	0.84(20)#	3.95(45)#	*
^{150}Lu	-1.270(2)	**	0.58(30)#	3.86(36)#	[**2003Ro21, 2003Gi10, 2000Gi01**, 1999BaZR, 1993Se04, 1993WoZY]
^{150m}Lu	-1.292(2)#	100%***	0.60(30)#	3.88(36)#	**

* References for the isomer are the same as the ground state.
** β-decay from ^{150}Lu not measured. Using the calculated β-decay $T_{1/2}$ = 155 ms from [1997Mo25], I_p = 71(2) %.
*** Implied from the short $T_{1/2}$.

Table 3
direct p emission from ^{146}Tm*, J^π = (5$^-$), $T_{1/2}$ = 68(3)ms, BR_p = 100%.

E_p(c.m.)	E_p(lab)	I_p(rel)%	I_p(absb)%	J^π_f	$E_{daughter}$(^{145}Er)	coincident γ-rays
0.938(4)	0.932(4)	20.0(13)%	13.6(9)%	(11/2$^-$)	0.253	
1.016(4)	1.009(4)	26.8(16)%	18.3(12)%	(3/2$^+$)	0.175	
1.191(1)	1.18391)	100(3)%	68.1(27)%	(1/2$^+$)	0.0	—

* All values from [2006Ta08].

Table 4
direct p emission from ^{146m}Tm*, Ex = 0.182(4) MeV, J^π = (10$^+$), $T_{1/2}$ = 198(3)ms, BR_p = 100%.

E_p(c.m.)	E_p(lab)	I_p(rel)	I_p(absb)	J^π_f	$E_{daughter}$(^{145}Er)	coincident γ-rays
0.889(8)	0.883(8)	1.0(4)%	1.0(4)%	(13/2$^-$)	0.484	
1.120(1)	1.112(1)	100(1)%	99(1)%	(11/2$^-$)	0.253	

* All values from [2006Ta08].

Table 5
direct p emission from ^{150}Lu*, J^π = (2$^+$), $T_{1/2}$ = 45(3)ms**, BR_p = ***.

E_p(c.m.)	E_p(lab)	I_p(rel)	I_p(absb)	J^π_f	$E_{daughter}$(^{149}Yb)	coincident γ-rays
1.261(4)	1.253(4)	100%	71(2)%***	(1/2$^+$)	0.0	—

* All values from [2000Gi01],except where noted.
** Weighted average of 43(5) ms [2003Ro21], 49(5) ms [2000Gi01].
*** β-decay from ^{150}Lu not measured. Using the calculated β-decay $T_{1/2}$ = 155 ms from [1997Mo25], I_p = 71(2) %.

Table 6
direct p emission from ^{150m}Lu*, J^{π} = $(1^{-}, 2^{-})$, $T_{1/2}$= 39^{+8}_{-6}, BR_p = 100%.

E_p(c.m.)	E_p(lab)	I_p(rel)	I_p(absb)	J^{π}_{f}	$E_{daughter}$(^{149}Yb)	coincident γ-rays
1.277(8)	1.268(8)	100%	100%	(1/2^{+})	0.0	—

* All values from [2000Gi01].

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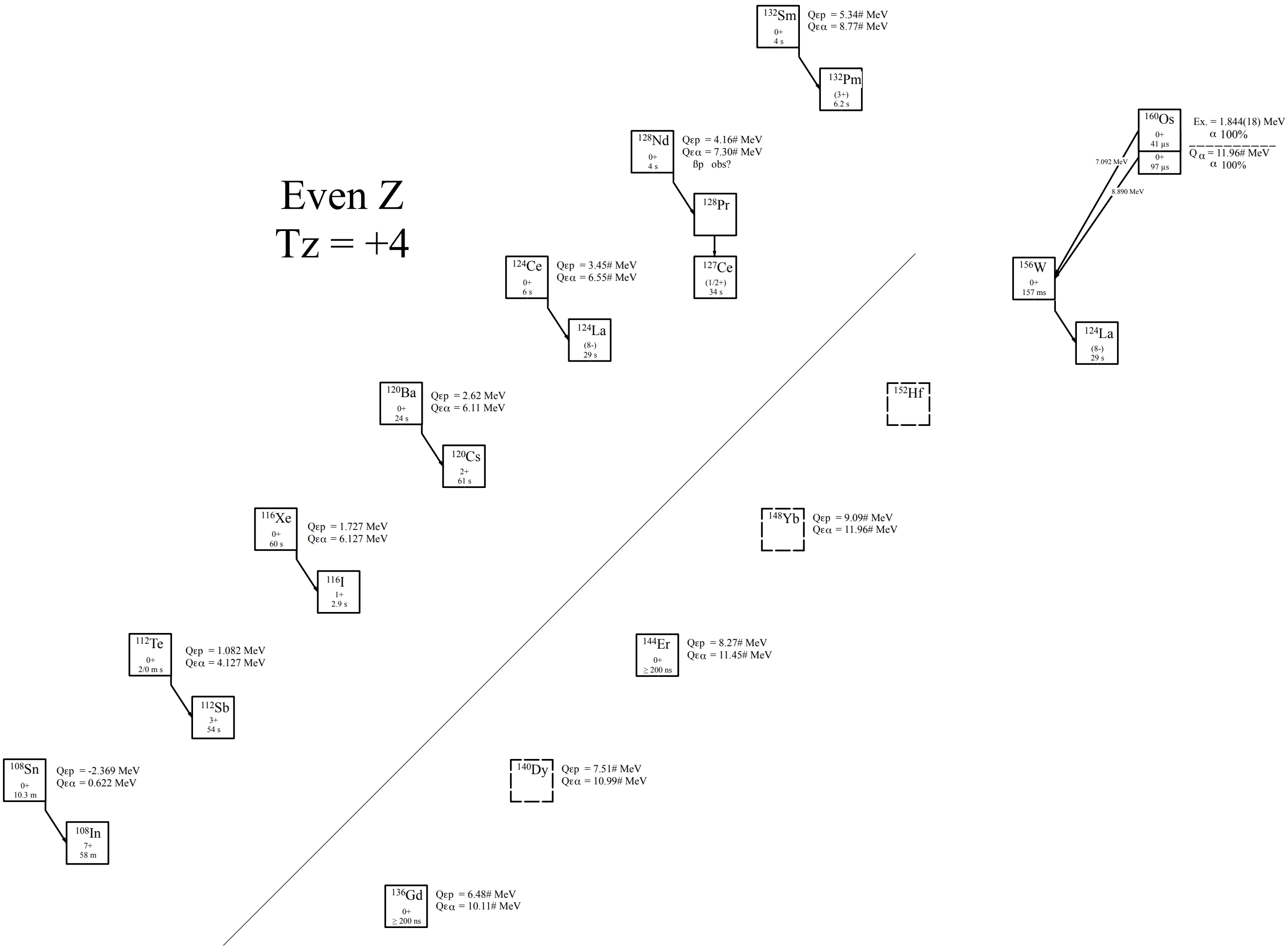

Fig. 1: Known experimental values for heavy particle emission of the even-Z, T_z= +4 nuclei.

Last updated 3/21/23

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +4 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. All J$^{\pi}$ values are taken from ENSDF.

Nuclide	J^{π}	$T_{1/2}$	Qε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental	
^{108}Sn		0$^+$	10.30(8) m	2.05(10)	-2.369(6)		-9.705(6)	0.622(7)	[**1978Hs01**]
^{112}Te		0$^+$	2.0(2) m	4.031(20)	1.082(10)		-5.675(14)	4.127(12)	[**1976Wi11**]
^{116}Xe		0$^+$	60(2) s	4.37(80)	1.727(31)		-3.128(24)	6.127(22)	[**1974Ha10**]
^{120}Ba		0$^+$	24(2) s	5.00(30)	2.62(30)		-2.50(30)	6.11(31)	[**1992Xu04**]
^{124}Ce		0$^+$	6(2) s	5.34(30)#	3.45(30)#		-1.35(30)#	6.55(30)#	[**1978Bo32**]
^{128}Nd		0$^+$	4(2) s	5.8(20)#	4.16(20)#	obs?*	-0.13(22)#	7.30(21)#	[**1983Ni05**]
^{132}Sm		0$^+$	4.0(3) s	6.49(34)#	5.34(30)#		1.46(31)#	8.77(30)#	[**1989McZU**]
^{136}Gd		0$^+$	≥200 ns	7.15(36)#	6.48(34)#		3.10(30)#	10.11(33)#	[**2000So11**]
^{140}Dy		0$^+$		7.65(90)#	7.51(45)#		4.34(40)#	10.99(45)#	
^{144}Er		0$^+$	≥200 ns	8.00(20)#	8.27(20)#		5.37(73)#	11.45(82)#	[**2000So11**]
^{148}Yb		0$^+$		8.54(40)#	9.09(40)#		6.43(40)#	11.96(40)#	
^{152}Hf		0$^+$							
^{156}W		0$^+$	157^{+57}_{-34} ms						[**2023BrXX**]
^{160}Os		0$^+$	97^{+97}_{-32} μs						[**2023BrXX**]
^{160m}Os	1.844(18)	(8$^+$)	41^{+15}_{-9} μs						[**2023BrXX**]

* Uncertain, may be from ^{128}Pr [1983Ni05]

Table 2
Particle emission from the even-Z, T_z = +4 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_p$	BR$_p$	S$_{2p}$	Q$_\alpha$	Experimental
^{108}Sn	5.792(11)	—	9.516(5)	-0.526(6)	
^{112}Te	4.020(12)	—	6.303(16)	2.078(10)	
^{116}Xe	3.998(32)	—	5.735(27)	2.096(15)	
^{120}Ba	3.87(30)	—	5.39(30)	1.73(30)	
^{124}Ce	3.55(36)#	—	4.89(30)#	1.55(42)#	
^{128}Nd	3.28(28)#	—	4.29(20)#	1.96(36)#	
^{132}Sm	2.66(36)#	—	3.12(30)#	2.97(36)#	
^{136}Gd	2.23(36)#	—	2.29(36)#	3.63(42)#	
^{140}Dy	1.99(50)#	—	1.75(45)#	3.84(50)#	
^{144}Er	1.85(36)#	—	1.07(75)#	3.80(45)#	
^{148}Yb	1.54(40)#	—	0.49(40)#	3.95(45)#	
^{152}Hf					
^{156}W					
^{160}Os			7.724(15)*	100%	[**2023BrXX**]
^{160m}Os			9.18(10)*	100%	[**2023BrXX**]

* Deduced from α energy [2023BrXX].

Table 3
direct α emission from ^{160}Os*, J$^{\pi}$ = 0$^+$, T$_{1/2}$ = 97^{+97}_{-32} μs, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)%	J$^{\pi}_f$	$E_{daughter}$(^{156}W)	coincident γ-rays	R$_0$ (fm)]	HF
7.274(15)	7.092(15)	100%	0$^+$	0.0	—	1.5597(29)	$1.8^{+1.8}_{-0.6}$

* All values from [2003BrXX].

Table 4
direct α emission from ^{160m}Os*, Ex. = 1.844(18) MeV, J$^{\pi}$ = 8$^+$, T$_{1/2}$ = 41^{+15}_{-9} , BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)%	J$^{\pi}_f$	$E_{daughter}$(^{156}W)	coincident γ-rays	R$_0$ (fm)]	HF
9.118(10)	8.890(10)	100%	0$^+$	0.0	—	1.5597(29)	2.6(10) × 10^4

* All values from [2003BrXX].

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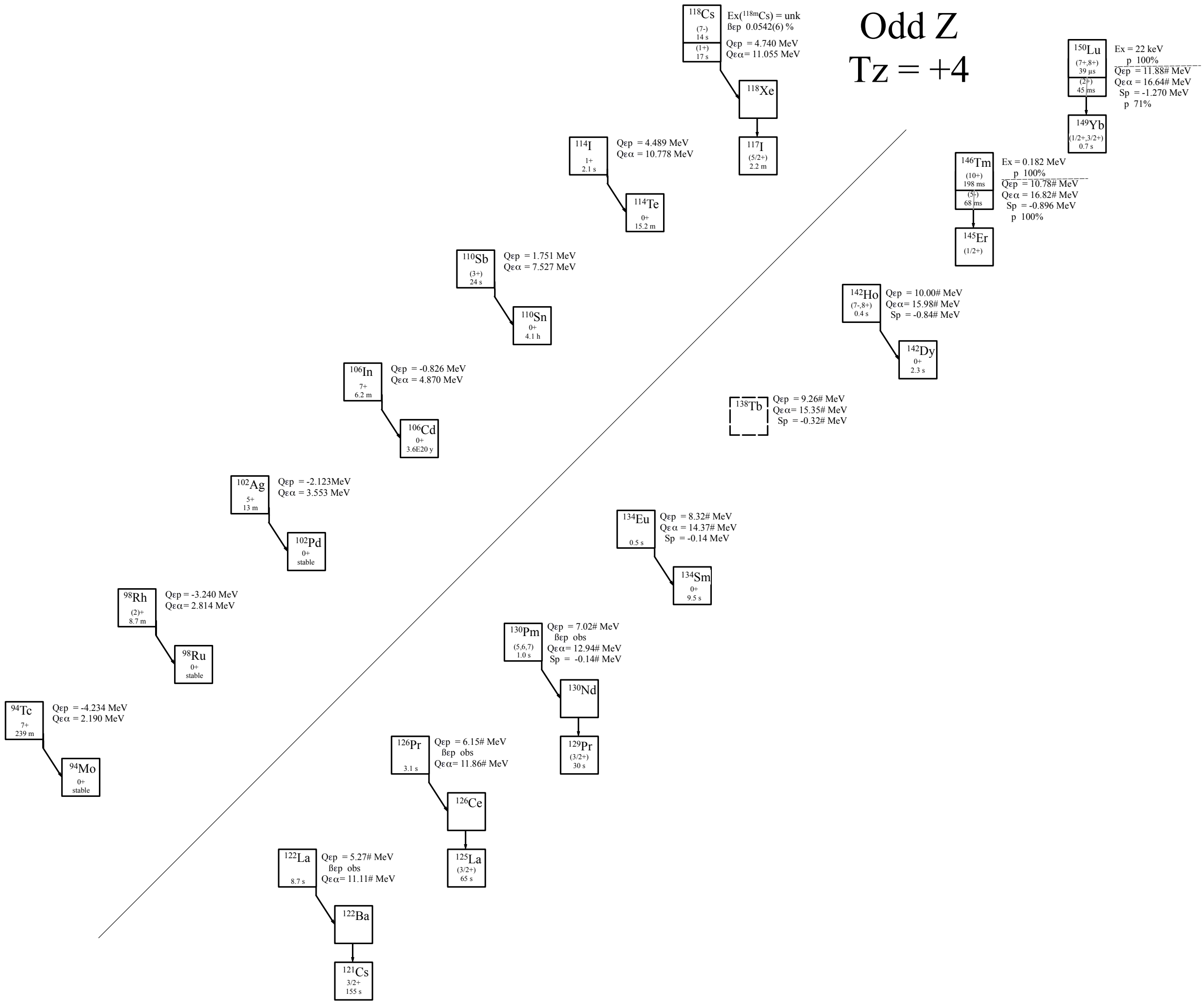

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +4 nuclei.

Last updated 3/21/23

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +4 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J^π

Nuclide	Ex	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{94}Tc		7^+	293(1) m	4.256(4)	-4.234(4)	—	-10.277(4)	2.189(4)	[**1963Ma21**]
^{98}Rh		$(2)^+$	8.7(1) m	5.05(10)	-3.240(13)	—	-8.958(12)	2.814(12)	[**1956Ka25**]
^{102}Ag		5^+	13.0(4) m	5.656(8)	-2.123(10)	—	-7.597(8)	3.553(10)	[**1967Ch05**]
^{106}In		7^+	6.2(1) m	6.524(12)	-0.826(13)	—	-5.791(12)	4.870(12)	[**1978Hu06**]
^{110}Sb		(3^+)	24.0(3) s	8.392(15)	1.751(7)		-2.775(6)	7.257(6)	[**1976Ox01**]
^{114}I		1^+	2.1(2) s	9.25(30)	4.489(26)		1.438(20)	10.778(24)	[**1977Ki11**]
^{118}Cs		2	14(2) s	9.67(16)	4.740(29)	0.0542(6)%*	2.276(27)	11.055(28)	[**1995Ki07, 1977Bo28, 1977Ge03**, 1978Da07]
^{118m}Cs	x	(7^-)	17(3) s	9.67(16)+x	4.740(29)+x	0.0542(6)%*	2.276(27)+x	11.055(28)+x	[**1995Ki07, 1977Bo28, 1977Ge03**, 1978Da07]
^{122}La			8.7(7) s	10.07(30)#	5.27(30)#	obs	3.05(30)#	11.11(30)#	[**1984Ni03**, 1988WiZN]
^{126}Pr			3.14(22) s	10.50(20)#	6.15(20)#	obs	4.19(20)#	11.86(20)#	[**2002Ka66, 1983Ni05**]
^{130}Pm			2.6(2) s	11.13(20)#	7.02(20)#	obs	5.49(20)#	12.93(20)#	[**1999Xi03, 1985Wi07**]
^{134}Eu			0.5(2) s	11.58(36)#	8.32(30)#		7.05(31)#	14.37(30)#	[**1989Vi04**]
^{138}Tb				12.06(36)#	9.26(30)#		8.63(30)#	15.35(36)#	
^{142}Ho		$(7^-, 8^+)$	0.4(1) s	12.87(83)#	10.00(41)#	15.98(45)#	9.95(40)#		[**2005Xu04**, 2002Xu11, 2001Xu02]
^{146}Tm		(5^-)	68(3) ms	13.27(20)#	10.78(20)#		10.94(20)#	16.64(76)#	[**2006Ta08, 2005Bb02, 2003Gi10, 2001Ry01**, 2001Ry02, 2005Ro40, 2005Se26, 2007BaZQ, 2007DaZU, 2005Bi24, 2005RoZY, 1995PeZY, 1993Li18, 1993WoZY]
^{146m}Tm***	0.182(4)	(10^+)	198(3) ms	13.45(20)#	10.96(20)#		11.12(20)#	16.82(76)#	[**2006Ta08**]
^{150}Lu		(2^+)	45(3) ms**	14.06(42)#	11.88(36)#		12.13(30)# 1993WoZY]	17.13(30)#	[**2003Gi10, 2000Gi01**]
^{150m}Lu	0.022(6)***	$(1^-, 2^-)$	$39^{+8}_{-6}\mu$s	14.09(42)#	11.91(36)#		12.16(30)# 1993WoZY]	17.15(30)#	[**2003Gi10, 2000Gi01**]

* Mixture of ground state and isomer [1995Ki07, 1977Ge03].

** Weighted average of 43(5) ms [2003Ro21], 49(5) ms [2000Gi01].

*** Excitation Energy = 22(6) keV, deduced from the weighted average of the difference in energies of the protons feeding the ground state of ^{149}Yb; 16(9) keV [2000Gi10] and 25(7) keV [2003Ro21].

Table 2
Particle emission from the odd-Z, T_z = +4 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	BR_p	S_{2p}	Q_α	Experimental
^{94}Tc	4.640(4)	—–	12.283(4)	-3.922(5)	
^{98}Rh	4.344(12)	—–	11.932(13)	-1.442(13)	
^{102}Ag	4.104(9)	—–	11.234(20)	-1.496(14)	
^{106}In	3.563(12)	—–	10.070(13)	-0.786(15)	
^{110}Sb	2.109(10)	—–	7.908(10)	0.733(14)	
^{114}I	1.581(34)	—–	5.618(27)	2.386(21)	
^{118}Cs	1.513(16)	—–	5.567(76)	1.805(24)	
^{118m}Cs	1.513(16)-x	—–	5.567(76)-x	1.805(24)+x	
^{122}La	1.087(33)#	—–	5.23(23)#	1.44(30)#	
^{126}Pr	0.96(28)#	—–	4.64(20)#	1.80(36)#	
^{130}Pm	0.38(28)#	—–	3.72(20)#	2.43(28)#	
^{134}Eu	-0.14(42)#		2.71(34)#	3.24(36)#	
^{138}Tb	-0.32(42)#		1.94(36)#	3.78(42)#	
^{142}Ho	-0.84(50)#		1.35(90)#	3.93(50)#	
^{146}Tm	-0.896(6)#	100%	1.02(20)#	3.77(45)#	[**2006Ta08, 2005Bb02, 2003Gi10, 2001Ry01**, 2001Ry02, 2005Ro40, 2005Se26, 2007BaZQ, 2007DaZU, 2005Bi24, 2005RoZY, 1995PeZY, 1993Li18, 1993WoZY]
^{146m}Tm	-1.078(7)#	71%	0.84(20)#	3.95(45)#	*
^{150}Lu	-1.270(2)#	**	0.58(30)#	3.86(36)#	[**2003Ro21, 2003Gi10, 2000Gi01**, 1999BaZR, 1993Se04, 1993WoZY]
^{150m}Lu	-1.292(2)#	100%***	0.60(30)#	3.88(36)#	**

* References for the isomer are the same as the ground state.
** β-decay from ^{150}Lu not measured. Using the calculated β-decay $T_{1/2}$ = 155 ms from [1997Mo25], I_p = 71(2) %.
*** Implied from the short $T_{1/2}$.

Table 3
direct p emission from ^{146}Tm*, J^π = (5$^-$), $T_{1/2}$ = 68(3)ms, BR_p = 100%.

E_p(c.m.)	E_p(lab)	I_p(rel)%	I_p(absb)%	J^π_f	$E_{daughter}$(^{145}Er)	coincident γ-rays
0.938(4)	0.932(4)	20.0(13)%	13.6(9)%	(11/2$^-$)	0.253	
1.016(4)	1.009(4)	26.8(16)%	18.3(12)%	(3/2$^+$)	0.175	
1.191(1)	1.18391)	100(3)%	68.1(27)%	(1/2$^+$)	0.0	—–

* All values from [2006Ta08].

Table 4
direct p emission from ^{146m}Tm*, Ex = 0.182(4) MeV, J^π = (10$^+$), $T_{1/2}$ = 198(3)ms, BR_p = 100%.

E_p(c.m.)	E_p(lab)	I_p(rel)	I_p(absb)	J^π_f	$E_{daughter}$(^{145}Er)	coincident γ-rays
0.889(8)	0.883(8)	1.0(4)%	1.0(4)%	(13/2$^-$)	0.484	
1.120(1)	1.112(1)	100(1)%	99(1)%	(11/2$^-$)	0.253	

* All values from [2006Ta08].

Table 5
direct p emission from ^{150}Lu*, J^π = (2$^+$), $T_{1/2}$ = 45(3)ms**, BR_p = ***.

E_p(c.m.)	E_p(lab)	I_p(rel)	I_p(absb)	J^π_f	$E_{daughter}$(^{149}Yb)	coincident γ-rays
1.261(4)	1.253(4)	100%	71(2)%***	(1/2$^+$)	0.0	—–

* All values from [2000Gi01],except where noted.
** Weighted average of 43(5) ms [2003Ro21], 49(5) ms [2000Gi01].
*** β-decay from ^{150}Lu not measured. Using the calculated β-decay $T_{1/2}$ = 155 ms from [1997Mo25], I_p = 71(2) %.

Table 6
direct p emission from ^{150m}Lu*, J^π = $(1^-, 2^-)$, $T_{1/2}$= 39^{+8}_{-6}, BR_p = 100%.

E_p(c.m.)	E_p(lab)	I_p(rel)	I_p(absb)	J^π_f	$E_{daughter}$(^{149}Yb)	coincident γ-rays
1.277(8)	1.268(8)	100%	100%	$(1/2^+)$	0.0	—

* All values from [2000Gi01].

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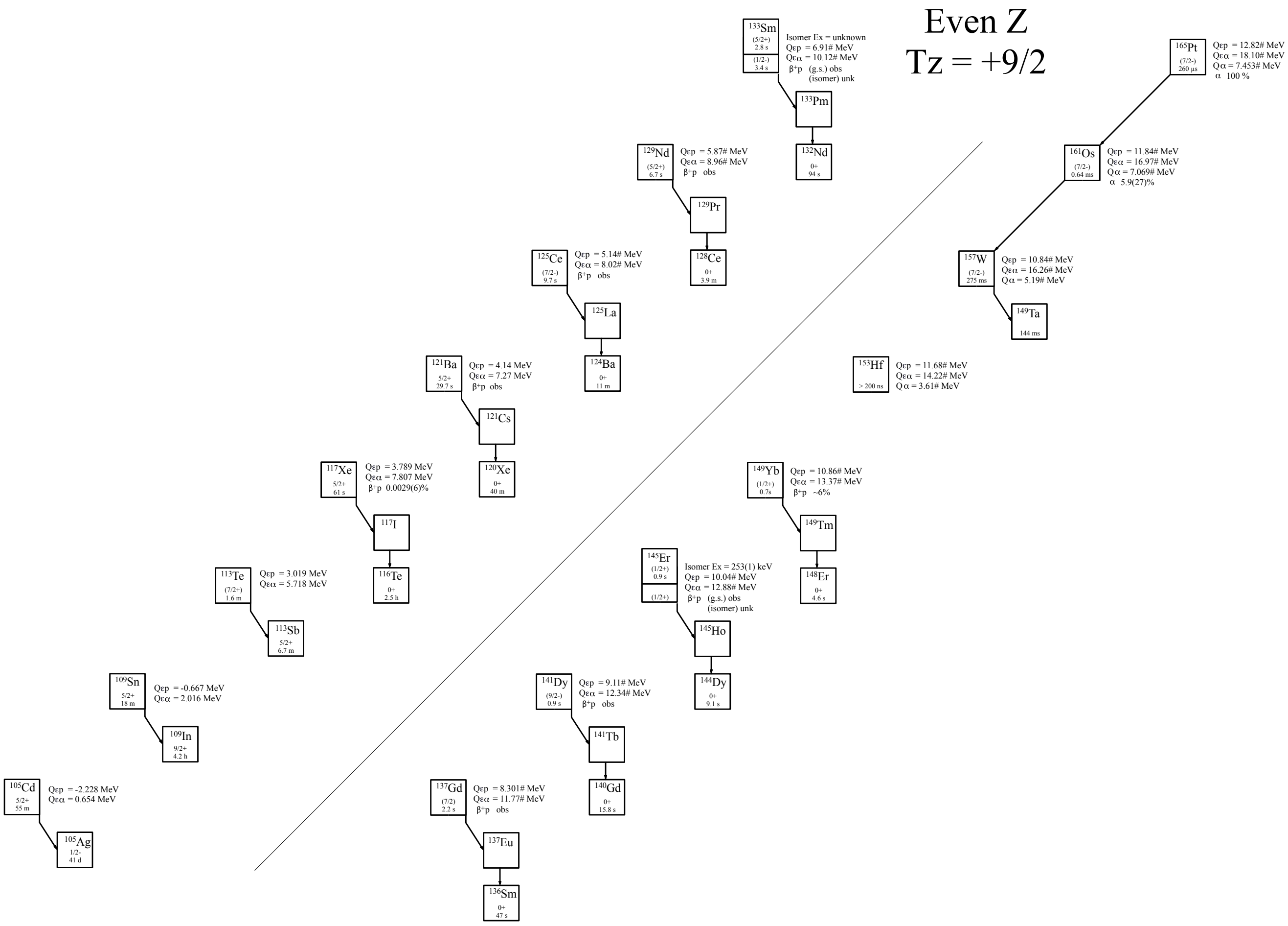

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +9/2 nuclei.

Last updated 3/21/23

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +9/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. All J^{π} values taken from ENSDF.

Nuclide	Ex	J^{π}	$T_{1/2}$	Q_{ε}	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{105}Cd		5/2$^+$	55.4(4) m*	2.737(4)	-2.228(2)	—	-10.880(3)	0.654(6)	[**1953Jo20, 1968Bo25, 1969St18**]
^{109}Sn		5/2$^+$	18.1(2) m**	3.859(9)	-0.667(8)	—	-8.801(8)	2.016(9)	[**1969Ba04, 1972Ba41, 1956Pe56**]
^{113}Te		(7/2$^+$)	1.6(2) m	6.07(30)	3.019(28)		-4.533(28)	5.718(28)	[**1976Wi11**]
^{117}Xe		5/2($^+$)	61(2) s	6.253(28)	3.789(26)	0.0029(6)%	-1.760(19)	7.807(20)	[**1971Ho07**]
^{121}Ba		5/2($^+$)	29.7(15) s	6.36(14)	4.14(14)	obs	-1.545(144)	7.27(14)	[**1974Ka31**]
^{125}Ce		(7/2$^-$)	9.9(5) s***	7.10(20)#	5.14(20)#	obs	-0.19(20)#	8.02(20)#	[**1998Be64, 1983Ni05, 1986Wi15**]
^{129}Nd		(5/2$^+$)	6.7(4) s	7.40(20)#	5.87(20)#	obs	0.94(20)#	8.96(20)#	[**2010Xu12, 1985Wi07**, 2011MaZL, 1977Bo02]
^{133}Sm	y$^@$	(1/2$^-$)	3.4(5) s^a	8.18(30)#	6.91(30)#	obs	2.49(30)#	10.12(30)#	[**2006Xu07,2001Xu04, 1993BrZU**, 1985Wi07, 1977Bo02]
^{133m}Sm$^@$	x$^@$	(5/2$^+$)	2.8(5) s	8.18(30)#+x	6.91(30)#+x	obs	2.49(30)#+x	10.12(30)#+x	[**2006Xu07, 2001Xu04**, 1985Wi07, 1977Bo02]
^{137}Gd		(7/2)	2.2(2) s	8.93(30)#	8.301(30)#	obs	4.27(31)#	11.77(30)#	[**2005Xu04**]
^{141}Dy		(9/2$^-$)	0.9(2) s	9.16(32)#	9.11(30)#	obs	5.44(30)#	12.34(30)#	[**2006Xu03**, 1984Ni03, 1986Wi15]
^{145}Er		(1/2$^+$)		9.88(20)#	10.04(20)#	obs	6.60(21)#	12.88(23)#	[**2010Ma20**]
^{145m}Er$^{@@}$	0.253(1)	(1/2$^+$)	0.9(3) s	10.13(20)#	10.29(20)#	obs	6.86(21)#	13.13(23)#	[**2010Ma20, 2006Ta08, 1989Vi02**, 1988WiZN]
^{149}Yb		(1/2$^+$)	0.7(2) s	10.61(36)#	10.86(30)#	≈6%	7.849(30)#	13.37(30)#	[**2005Xu04**]
^{153}Hf			> 200 ns	11.08(34)#	11.68(34)#		8.89(30)#	14.22(36)#	[**2006Xu07**]
^{157}W		(7/2$^-$)	275(40) ms	9.91(43)#	10.84(43)#		8.28(40)#	6.26(423)#	[**2019Hi06, 2010Bi03**, 2008PaZV]
^{161}Os		(7/2$^-$)	640(60) μs	10.65(43)#	11.84(43)#		9.67(40)#	16.97(43)#	[**2010Bi03**, 2019Hi06, 2008BiZT, 2008PaZV]
^{165}Pt		(7/2$^-$)	0.26^{+26}_{-9} ms	11.28(43)#	12.82(43)#		11.11(40)#	18.10(43)#	[**2019Hi06**]

* Weighted average of 54.7(8) m [1953Jo20], 57.0(6) m [1968Bo25] and 56.0(5) [1969St18].
** Weighted average of 518.0(2) m [1969Ba04], 18.3(3) m [1972Ba41] and 18.1(3) m [1956Pe56].
*** Weighted average of 10.5(5) s [1998Be64], 8.9(7) s [1983Ni05] and 9.2(10 s [1986Wi15].
^{a} Weighted average of 3.2(7) s [2006Xu07] , 3.4(5) s [2001Xu04], 3.7(7) s [1993BrZU].
$^@$ The relative energy placement of the two isomers is unknown.

Table 2
Particle separation and emission from the even-Z, T_z = +9/2 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_p$	BR$_p$	S$_{2p}$	Q$_\alpha$	BR$_\alpha$	Experimental
^{105}Cd	6.506(4)	—	11.455(2)	-1.327(5)	—	
^{109}Sn	5.799(12)	—	10.218(8)	-0.721(8)	—	
^{113}Te	4.037(33)	—	6.986(28)	1.858(29)		
^{117}Xe	4.054(76)	—	6.701(30)	1.737(30)		
^{121}Ba	4.15(142)	—	6.53(14)	1.02(14)		
^{125}Ce	3.69(20)#	—	5.58(20)#	1.66(24)#		
^{129}Nd	3.33(20)#	—	4.97(20)#	1.86(28)#		
^{133}Sm	2.89(33)#	—	4.04(30)#	2.72(36)#		
^{133m}Sm*	2.89(33)#-x	—	4.04(30)#-x	2.72(36)#+x		
^{137}Gd	2.26(36)#	—	2.93(34)#	3.59(42)#		
^{141}Dy	2.19(85)#	—	2.33(36)#	3.41(42)#		
^{145}Er	1.92(20)#	—	1.65(20)#	3.72(36)#		
^{145m}Er**	1.67(20)#	—	1.90(20)#	3.97(36)#		
^{149}Yb	1.85(30)#	—	1.30(30)#	3.49(36)#		
^{153}Hf	1.17(36)#	—	0.34(43)#	3.61(42)#		
^{157}W	0.98(50)#	—	-0.04(50)#	5.19(50)#		
^{161}Os	0.61(50)#	—	-0.66(50)#	7.069(11)#	5.9(27)%	[**2010Bi03**, 2019Hi06, 2008BiZT]
^{165}Pt	0.12(51) #		-1.44(50)#	7.453(14)#	100%	[**2019Hi06**]

Table 3
direct α emission from ^{161}Os*, J^{π} = (7/2^{-}), $T_{1/2}$= 640(60) μs, BR_{α} = 5.9(27)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(absb)	J^{π}_{f}	$E_{daughter}$(^{157}W)	coincident γ-rays
6.747(30)	6.580(30)	100%	5.9(27)%	(9/2^{-})	0.318	
7.066(12)	6.890(12)	100%	5.9(27)%	(7/2^{-})	0.0	—

* All values from [2010Bi03].

Table 4
direct p emission from ^{165}Pt*, J^{π} = (7/2^{-}), $T_{1/2}$= 0.26^{+26}_{-9} μs, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{p}(abs)	J^{π}_{f}	$E_{daughter}$(^{161}Os)	coincident γ-rays	R_0 (fm)	HF
7.453(14)	7.272(14)	100%	100%	(7/2^{-})	0.0	—	1.551(19)	$2.6^{+1.5}_{-1.2}$

* All values from [2019Hi06].

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Odd Z
Tz = +9/2

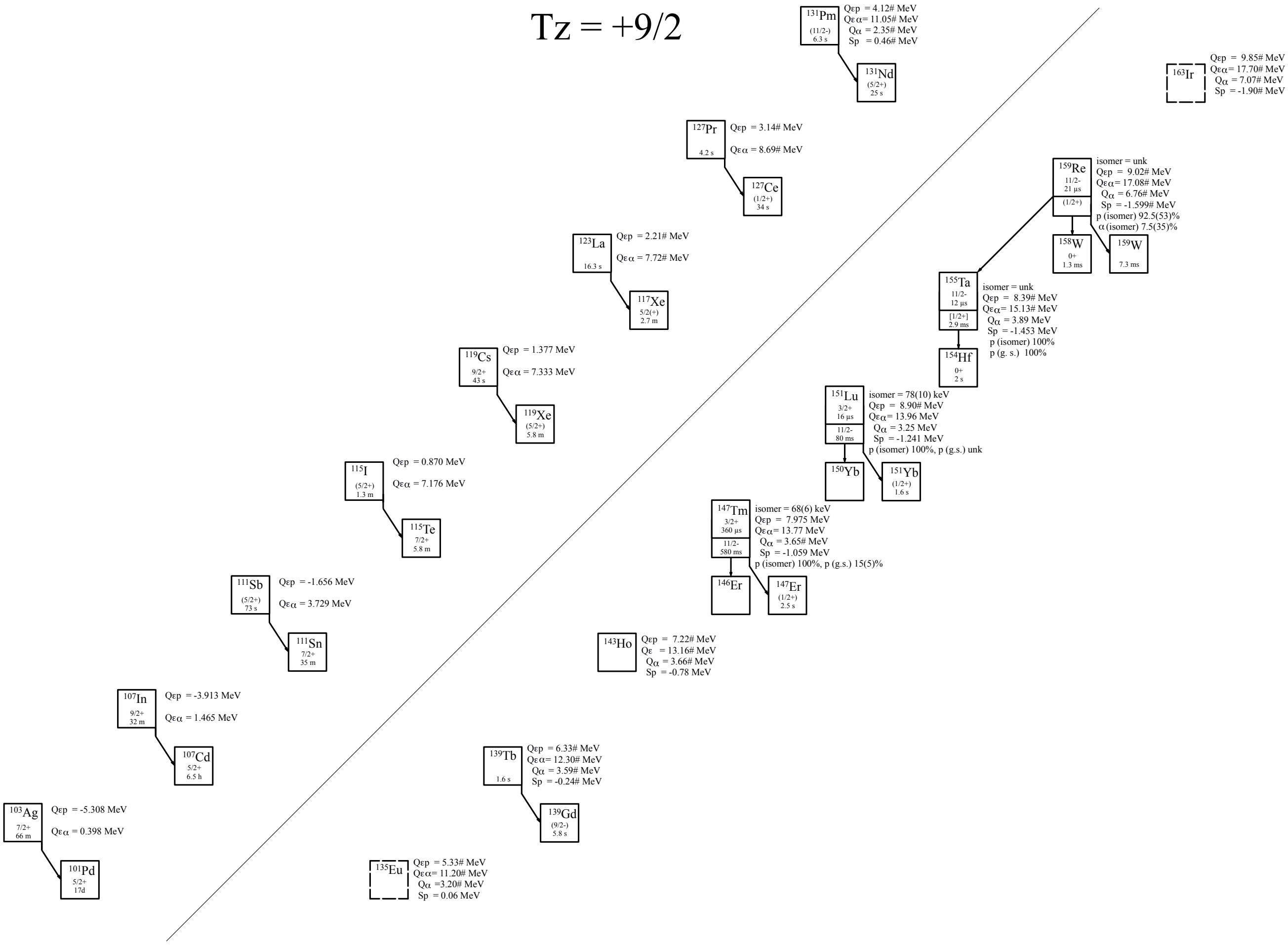

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +9/2 nuclei.

Last updated 3/21/23

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +9/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J$^{\pi}$ values for ^{103}Ag, ^{107}in, ^{111}Sb, ^{115}I, ^{119}Cs, ^{123}La, ^{127}Pr, ^{131}Pm, ^{135}Eu, ^{139}Tb, ^{143}Ho are taken from ENSDF.

Nuclide	Ex	J^{π}	$T_{1/2}$	Qε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon \alpha}$	Experimental
^{103}Ag		7/2$^+$	65.7(7) m	2.654(4)	-5.308(8)	—	-11.423(4)	0.398(4)	[**1975Di09**]
^{107}In		9/2$^+$	32.4(3) m	3.424(10)	-3.913(10)	—	-9.727(10)	1.465(10)	[**1973Ny03**]
^{111}Sb		(5/2$^+$)	73(1) s	5.102(10)	-1.656(15)	—	-6.910(9)	3.729(9)	[**1976Wi10**]
^{115}I		(5/2$^+$)	1.3(2) m	5.72(40)	0.870(35)		-2.588(29)	7.176(29)	[**1969Ha03**]
^{119}Cs		9/2$^+$	43.0(2) s	6.489(17)	1.377(24)		-1.788(19)	7.333(31)	[**1984IcZY**]
^{123}La			16.3(3) s	7.00(20)#	2.21(20)#		-0.75(20)#	7.72(20)#	[**1992Ic02**]
^{127}Pr			4.2(3) s	7.44(20)#	3.14(22)#		0.55(20)#	8.69(20)#	[**1995Gi12**]
^{131}Pm		(11/2$^-$)	6.3(8) s	8.00(20)#	4.12(21)#		1.94(20)#	9.78(20)#	[**1999Ga41**]
^{135}Eu				8.71(25)#	5.327(20)#		3.61(20)#	11.20(20)#	
^{139}Tb			1.6(2) s	9.50(36)#	6.33(30)#		5.28(30)#	12.30(34)#	[**1999Xi04**]
^{143}Ho				10.12(30)#	7.22(76)#		6.60(30)#	13.16(36)#	
^{147}Tm		11/2$^-$	615(45) ms	10.63(40)	7.975(9)		7.690(9)	13.770(15)	[**1993Se04, 1993To02**]
^{147m}Tm	0.068(6)*	3/2$^+$	375(5) μs	10.70(40)	8.043(11)		7.758(11)	13.838(16)	[**2023Au03**]
^{151}Lu		11/2$^-$	78(1) ms	11.24(43)#	8.90(36)#		8.86(30)#	13.88(30)	[**2015Ta12**]
^{151m}Lu	0.078(10)*	3/2$^+$	17(1) μs	11.32(43)#	8.98(36)#		8.894(30)#	13.96(32)	[**2015Ta12**
^{155}Ta		(1/2$^+$)	$2.9^{+1.5}_{-1.1}$ ms	10.32(42)#	8.39(36)#		8.59(36)#	15.13(43)	[**2007Pa27**]
^{155m}Ta	x	11/2$^-$	12^{+4}_{-3} μs	10.32(42)#+x	8.39(36)#+x		8.59(36)#+x	15.13(43)+x	[**1999Uu01**]
^{159}Re		(1/2$^+$)		10.63(43)#	9.02(37)#		9.47(37)#	17.08(43)#	
^{159m}Re	x	11/2$^-$	21(4) μs	10.63(43)#+x	9.02(37)#+x		9.47(37)#+x	17.08(43)#+x	[**2006Jo10**]
^{163}Ir				11.03(50)#	9.85(45)#		10.62(45)#	17.70(50)#	

* From difference in Sp.

Table 2
Particle separation and emission from the odd-Z, T_z = +9/2 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_p$	BR$_p$	S$_{2p}$	Q$_\alpha$	BR$_\alpha$	Experimental
^{103}Ag	4.189(4)	—	11.968(7)	-1.643(20)	—	
^{107}In	3.723(10)	—	11.074(11)	-1.189(10)	—	
^{111}Sb	2.284(16)	—	8.925(10)	0.305(13)		
^{115}I	1.737(38)	—	6.499(34)	2.074(30)		
^{119}Cs	1.515(17)	—	6.444(29)	1.608(32)		
^{123}La	1.33(20)#	—	6.13(13)#	1.23(20)#		
^{127}Pr	1.01(20)#	—	5.36(20)#	1.68(28)#		
^{131}Pm	0.46(20)#	—	4.58(20)#	2.35(28)#		
^{135}Eu	0.06(28)#		3.32(20)#	3.20(28)#		
^{139}Tb	-0.24(36)#		2.56(30)#	3.59(36)#		
^{143}Ho	-0.78(79)#		2.09(32)#	3.66(42)#		
^{147}Tm	-1.059(3)	15(5)%	1.432(10)	3.65(30)		[**1993Se04, 1993To02**, 2023Au03, 2008Ra03, 2007Ra37, 2007HeZV, 2007RaZZ, 2004SeZW, 1997Se03, 1995Ho26, 1995PeZY, 1993WoZY, 1988ToZW, 1984HoZN, 1983La27, 1982Kl03]
^{147m}Tm	-1.127(7)	100%	1.500(12)	3.72(31)		[**1993Se04**, 2023Au03, 1993To02, 1997Se03, 1995PeZY, 1995Ho26, 1995PeZY, 1993WoZY]
^{151}Lu	-1.232(4)*	**	0.94(36)	3.25(30)		[**2015Ta12**, 1999Bi14, 1997Mo25, 1993Se04, 1982Ho04, 2017Wa18, 2017Wa47, 2013Pr05, 2007LiZR, 2003Pr05, 2003YuZW, 1999BaZR, 1998BaZU, 1982Ho04]
^{151m}Lu	-1.319(10)	100%	1.02(37)	3.33(32)		[**2015Ta12**, 2017Wa18, 2017Wa47, 1999Bi14, 1997Mo25, 1993Se04, 2013Pr05, 2007LiZR, 2003YuZW, 1999BaZR, 1999BaZZ]
^{155}Ta	-1.453(15)	100%	0.19(334)	3.89(42)		[**2007Pa27**]
^{155m}Ta	-1.453(15)-x	100%	0.19(33)-x	3.89(42)+x		[**1999Uu01**]
^{159}Re	-1.599(53)#		-0.21(34)#	6.76(55)#		
^{159m}Re	-1.599(53)#-x	92.5(35)%	-0.21(34)#-x	6.76(55)#+x	7.5(35)%	[**2007Pa27**, 2006Jo10, 2007JoZX, 2007PaZT]
^{163}Ir	-1.90(50)#		-0.95(43)#	7.07(50)#		

* Deduced from proton energy, -1.241(2) MeV in [2021Wa16].
** β-decay branch not measured.

Table 3
direct p emission from ^{147}Tm*, J^π = 11/2$^-$, $T_{1/2}$ = 615(45) ms**, BR_p = 15(5)%.

E_p(c.m.)	E_p(lab)	I_p(rel)	I_p(absb)	J^π_f	$E_{daughter}$(^{146}Er)	coincident γ-rays
1.071(33)	1.0510(33)***	100%	15(5)%	0^+	0.0	—–

* All values from [1993To02], except where noted.
** Weighted average of 580(70) ms [1993Se04], and 640(60) ms [1993To02].
*** [1993Se04].

Table 4
direct p emission from ^{147m}Tm*, Ex = 68(6) keV, J^π = 3/2$^+$, $T_{1/2}$ = 360(40) ms, BR_p = 100%.

E_p(c.m.)	E_p(lab)	I_p(rel)	I_p(absb)	J^π_f	$E_{daughter}$(^{146}Er)	coincident γ-rays
1.1315(39)	1.1108(39)	100%	100%	0^+	0.0	—–

* All values from [1993Se04].

Table 5
direct p emission from ^{151}Lu*, J^π = 11/2$^-$, $T_{1/2}$= 78(1) ms.

E_p(c.m.)	E_p(lab)	I_p(rel)	I_p(absb)	J^π_f	$E_{daughter}$(^{150}Yb)	coincident γ-rays
1.240(4)	1.232(4)			0^+	0.0	—–

* All values from [2015Ta12].

Table 6
direct p emission from ^{151m}Lu*, Ex = 78(10) keV, J^π = 3/2$^+$, $T_{1/2}$= 17(1) μs, BR_p = 100%.

E_p(c.m.)	E_p(lab)	I_p(rel)	I_p(absb)	J^π_f	$E_{daughter}$(^{150}Yb)	coincident γ-rays
1.294(4)	1.285(4)	100%	100%	0^+	0.0	—–

* All values from [2015Ta12].

Table 7
direct p emission from ^{155}Ta*, J^π = (1/2$^+$), $T_{1/2}$= 2.9^{+15}_{-11} ms, BR_p = 100%.

E_p(c.m.)	E_p(lab)	I_p(rel)	I_p(absb)	J^π_f	$E_{daughter}$(^{154}Hf)	coincident γ-rays
1.453(15)	1.444(15)	100%	100%	0^+	0.0	—–

* All values from [2007Pa27].

Table 8
direct p emission from ^{155m}Ta*, Ex = unk., J^π = 11/2$^-$, $T_{1/2}$= 12^{+4}_{-3} μs, BR_p = 100%.

E_p(c.m.)	E_p(lab)	I_p(absb)	J^π_f	$E_{daughter}$(^{154}Hf)	coincident γ-rays
1.776(10)	1.765(10)	100%			

* All values from [1999Uu01].

Table 9
direct p emission from ^{159m}Re*, Ex = unk., J^π = 11/2$^-$, $T_{1/2}$= 21(4) μs, BR_p = 92.5(35)%.

E_p(c.m.)	E_p(lab)	I_p(rel)	I_p(absb)	J^π_f	$E_{daughter}$(^{158}W)	coincident γ-rays
1.816(20)	1.805(20)	100%	92.5(35)%	0^+	0.0	—–

* All values from [2006Jo10].

Table 10
direct α emission from ^{159m}Re*, Ex = unk., J^{π} = 11/2^{-}, $T_{1/2}$= 21(4) μs**, BR_{α} = 7.5(35)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{p}(absb)	J^{π}_{f}	$E_{daughter}$(^{155}Ta)	coincident γ-rays
6.950(26)	6.776(26)	100%	7.5(35)%	0^{+}	0.0	—–

* All values from [2007Pa27], except where noted.
** [2006Jo10]

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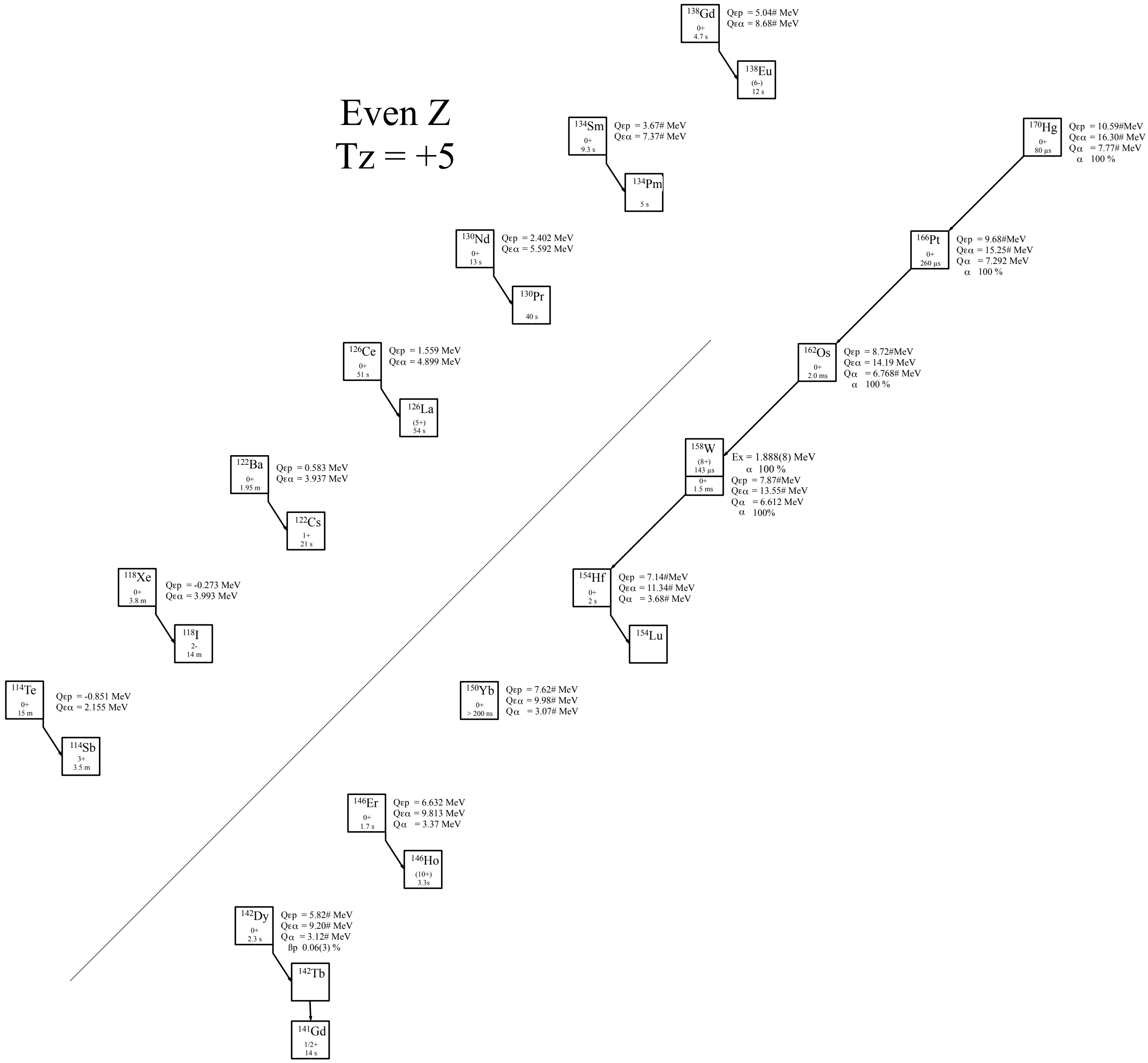

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +5 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +5 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{114}Te		0^+	15.2(7) m	2.610(30)	-0.851(24)	—	-8.477(25)	2.155(27)	[**1976Wi11**]
^{118}Xe		0^+	3.8(9) m	2.892(22)	-0.273(17)	—	-5.835(12)	3.993(22)	[**1976Be61**]
^{122}Ba		0^+	1.95(15) m	3.540(40)	0.583(30)		-5.440(32)	3.937(34)	[**1978Bo32**]
^{126}Ce		0^+	51.0(4) s	4.150(90)	1.559(30)		-3.657(29)	4.899(44)	[**2002Ko02**]
^{130}Nd		0^+	13(3) s	4.580(70)	2.402(40)		-2.549(61)	5.952(95)	[**2000Xu08**]
^{134}Sm		0^+	9.3(8) s	5.39(20)#	3.67(20)#		-0.73(20)#	7.37(21)#	[**1990Ko25**]
^{138}Gd		0^+	4.7(9) s	6.09(20)#	5.04(20)#		0.93(21)#	8.68(21)#	[**1999Xi04**]
^{142}Dy		0^+	2.3(3) s	6.44(20)#	5.82(73)#	0.06(3) %	2.29(73)#	9.20(73)#	[**1991Fi03**, 1986Wi15]
^{146}Er		0^+	1.7(6) s	6.916(9)	6.632(9)		3.468(29)	9.813(70)	[**1993To05**]
^{150}Yb		0^+	$\geq$ 200 ns	7.66(36)#	7.62(30)#		4.58(31)#	9.98(30)#	[**2000So11**]
^{154}Hf		0^+	2(1) s	6.94(36)#	7.14(36)#		4.41(31)#	11.34(36)#	[**1981Ho10**]
^{158}W		0^+	1.5(2) ms	7.43(36)#	7.87(36)#		5.43(31)#	13.55(36)#	[**2000Ma95**]
^{158m}W	1.888(8)	(8^+)	143(19) μs	9.32(36)#	9.76(36)#		7.32(31)#	15.44(36)#	[**2000Ma95**]
^{162}Os		0^+	2.05(10) ms	7.95(36)#	8.72(36)#		6.75(31)#	14.19(36)#	[**2000Mu95**]
^{166}Pt		0^+	260^{+100}_{-60} μs	8.52(36)#	9.68(36)#		8.11(31)#	15.25(36)#	[**2019Hi06**]
^{170}Hg		0^+	80^{+40}_{-4} μs	9.12(36)#	10.59(36)#		9.504(31)#	16.30(36)#	[**2019Hi06**]

Table 2
Particle emission from the even-Z, T_z = +5 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	BR_p	S_{2p}	Q_α	BR_α	Experimental
^{114}Te	4.762(30)	—	7.813(24)	1.527(28)		
^{118}Xe	4.929(28)	—	7.393(26)	1.386(27)		
^{122}Ba	4.796(31)	—	7.014(308)	1.045(30)		
^{126}Ce	4.350(38)	—	6.309(31)	1.363(40)		
^{130}Nd	4.112(41)	—	5.640(40)	1.799(40)		
^{134}Sm	3.26(20)#	—	4.53(20)#	2.80(20)#		
^{138}Gd	2.80(20)#	—	3.43(20)#	3.29(28)#		
^{142}Dy	2.87(74)#	—	2.92(73)#	3.12(76)#		
^{146}Er	2.49(10)	—	2.330(10)	3.37(73)		
^{150}Yb	2.18(36)#	—	1.93(30)#	3.07(30)#		
^{154}Hf	1.64(34)#	—	1.04(34)#	3.68(42)#		
^{158}W	1.39(34)#	—	0.45(34)#	6.612(3)	100 %	[**2000Ma95**, 2005Se11, 1996Pa01, 1989Ho12]
^{158m}W	-0.50(34)#		-1.44(34)#	8.503(8)	100 %	[**2000Ma95**, 2005Se11, 2017Jo09, 1996Pa01, 1989Ho12]
^{162}Os	0.95(34)#	—	-0.25(34)#	6.768(3)	100 %	[**2000Mu95**, 2004Jo12, 1996Bi07, 1989Ho1]
^{166}Pt	0.48(34)#	—	-1.06(34)#	7.292(7)	100 %	[**2019Hi06**, 1996Bi07]
^{170}Hg	0.09(42)#		-1.85(34)#	7.773(30)*	100 %	[**2019Hi06**]

* From [2019Hi06], 7.77(31)# in [2021Wa16].

Table 3
direct α emission from ^{158}W*, J^π = 0^+, $T_{1/2}$= 1.5(2) ms, BR_α = 100 %.

E_α(c.m.)	E_α(lab)	I_p(absb)	J^π_f	$E_{daughter}$(^{154}Hf)	coincident γ-rays	R_0 (fm)	HF
6.612(3)	6.445(3)	100%	0^+	0.0	—	1.557(10)	1.0

* All values from [2000Ma95].

Table 4
direct α emission from ^{158m}W*, Ex = 1.888(8) MeV, J^π = 0^+, $T_{1/2}$= 143(19) μs, BR_α = 100 %.

E_α(c.m.)	E_α(lab)	I_p(absb)	J^π_f	$E_{daughter}$(^{154}Hf)	coincident γ-rays	R_0 (fm)	HF
8.501(7)	8.286(7)	100%	0^+	0.0	—	1.557(10)	1.0

* All values from [2000Ma95].

Table 5
direct α emission from ^{162}Os*, J^{π} = 0^{+}, $T_{1/2}$= 2.05(10) ms, BR_{α} = 100 %.

E_{α}(c.m.)	E_{α}(lab)	I_p(absb)	J^{π}_{f}	$E_{daughter}$(^{158}W)	coincident γ-rays	R_0 (fm)	HF
6.767(3)	6.600(3)	100%	0^{+}	0.0	—–	1.561(3)	1.0

* All values from [2000Ma95].

Table 6
direct α emission from ^{166}Pt*, J^{π} = 0^{+}, $T_{1/2}$= 260^{+100}_{-60} μs, BR_{α} = 100 %.

E_{α}(c.m.)	E_{α}(lab)	I_p(absb)	J^{π}_{f}	$E_{daughter}$(^{162}Os)	coincident γ-rays	R_0 (fm)	HF
7.294(8)	7.118(8)	100%	0^{+}	0.0	—–	1.555(26)	1.0

* All values from [2019Hi06].

Table 7
direct α emission from ^{170}Hg*, J^{π} = 0^{+}, $T_{1/2}$=80^{+40}_{-4} μs, BR_{α} = 100 %.

E_{α}(c.m.)	E_{α}(lab)	I_p(absb)	J^{π}_{f}	$E_{daughter}$(^{168}Pt)	coincident γ-rays	R_0 (fm)	HF
7.773(30)	7.590(30)	100%	0^{+}	0.0	—–	1.532(38)	1.0

* All values from [2019Hi06].

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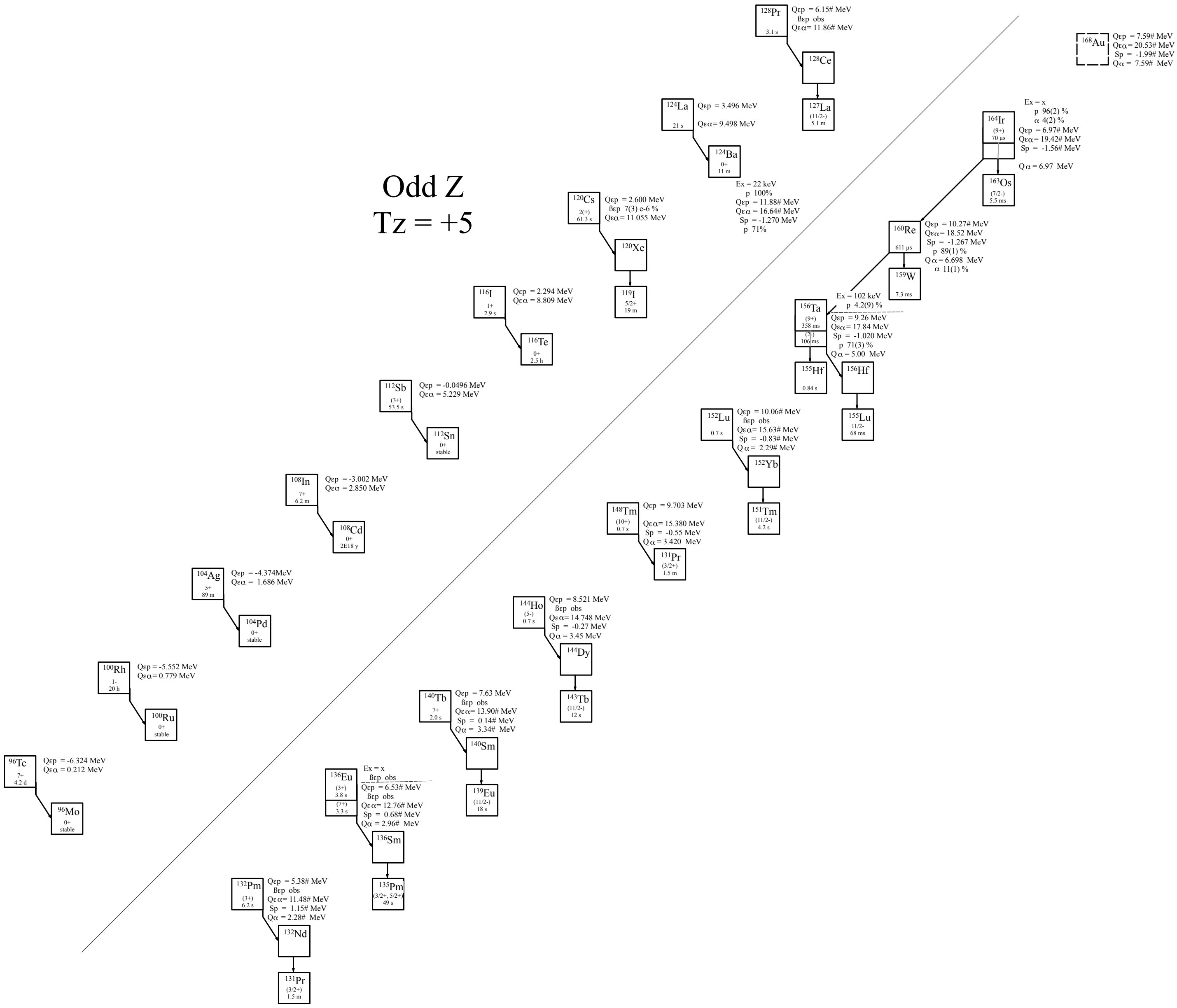

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +5 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +5 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. All J$^\pi$ values are taken from ENSDF.

Nuclide	Ex	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	$BR_{\varepsilon\alpha}$	Experimental
^{96}Tc		7^+	4.20(4) d	0.259(5)	-6.324(5)	—	-13.130(5)	0.212(5)		[**1950Co69**]
^{100}Rh		1^-	20.2(1) h	3.636(18)	-5.552(18)	—	-12.053(18)	0.779(18)		[**1995KeZZ**]
^{104}Ag		5^+	89.2(10) m	4.279(4)	-4.374(5)	—	-10.588(4)	1.686(4)		[**1971Mu22**]
^{108}In		7^+	58.0(12) m	5.133(9)	-3.002(9)	—	-8.790(9)	2.850(9)		[**1975Fl01**]
^{112}Sb		(3^+)	53.5(5) s	7.056(18)	-0.496(18)	—	-5.829(18)	5.229(18)		[**1972Si28**]
^{116}I		1^+	2.91(15) s	7.840(80)	2.294(77)		-1.439(75)	8.809(75)		[**1976Go02**]
^{120}Cs		$2^{(+)}$	61.3(14) s	8.284(15)	2.600(24)	$7(3)\times10^{-6}$%	-0.776(21)	8.950(26)	$2.0(4)\times10^{-5}$%	[**1975Ho09**, 1969Ch18]
^{124}La*			21(4) s	8.830(60)	3.496(58)		0.518(58)	9.489(58)		[**1997As05**]
^{128}Pr			3.1(3) s	9.200(40)	4.276(40)	obs	1.761(32)	10.334(32)		[**1985Wi07**]
^{132}Pm		(3^+)	6.2(6) s	9.8(150)#	5.38(156)#	obs	3.22(15)#	11.48(15)#		[**1988WiZN**]
^{136}Eu		(7^+)	3.3(3) s	10.57(20)#	6.53(21)#	obs	4.82(20)#	12.76(20)#		[**1989Vi04**]
^{136m}Eu	x	(3^+)	3.8(3) s	10.57(20)#+x	6.53(21)#+x	obs	4.82(20)#+x	12.76(20)#+x		[**1989Vi04**]
^{140}Tb		7^+	2.0(5) s	11.30(80)	7.63(80)	obs	6.44(80)	13.90(80)#		[**2006Xu03**, 1991Fi03, 1986Wi15]
^{144}Ho		(5^-)	0.7(1) s	11.961(11)	8.521(52)	obs	7.772(29)	14.748(29)		[**1986Wi15**]
^{148}Tm		(10^+)	0.7(2) s	12.714(14)	9.703(11)		9.212(12)	15.380(13)		[**1982No08**]
^{152}Lu			0.7(1)s	12.85(25)#	10.06(20)#	obs	9.83(20)#	15.63(20)#		[**1988Ni02**]
^{156}Ta		(2^-)	106(4) ms	11.82(34)#	9.26(30)#		9.35(30)#	17.84(34)		[**2011Da12**
^{156m}Ta	0.102(7)	(9^+)	333^{+25}_{-22} ms	11.92(34)#	9.36(30)#		9.45(30)#	17.94(34)		[**2023Br10**]
^{160}Re			611(7) μs	12.45(34)#	10.27(30)#		10.65(30)#	8.52(34)		[**2011Da12**]
^{164}Ir				12.94(35)#	11.23(32)#		11.94(32)#	19.42(35)#		
^{164m}Ir	x	(9^+)	70(10) μs	12.94(35)#+x	11.23(32)#+x		11.94(32)#+x	19.42(35)#+x		[**2014Dr02**]
^{168}Au				13.54(43)#	12.31(40)#		13.38(40)#	20.53(43)#		

* Possibly not the ground state

Table 2
Particle separation and emission from the odd-Z, T_z = +5 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	BR_p	S_{2p}	Q_α	BR_α	Experimental
^{96}Tc	5.399(5)	—	14.031(5.)	-1.793(5)	—	
^{100}Rh	5.255(18)	—	13.737(18)	-2.194(19)	—	
^{104}Ag	4.948(4)	—	12.911(8)	-1.950(19)	—	
^{108}In	4.418(9)	—	11.755(9)	-1.428(10)	—	
^{112}Sb	2.949(19)	—	9.707(21)	0.096(20)		
^{116}I	2.647(80)	—	7.502(78)	1.753(77)		
^{120}Cs	2.383(14)	—	7.496(22)	1.107(76)		
^{124}La	1.893(58)	—	6.692(66)	1.205(58)		
^{128}Pr	1.640(42)	—	5.935(95)	1.503(64)		
^{132}Pm	1.15(15)#	—	5.03(16)#	2.28(15)#		
^{136}Eu	0.68(25)#	—	4.06(20)#	2.96(25)#		
^{136m}Eu	0.68(25)#-x	—	4.06(20)#-x	2.96(25)#+x		
^{140}Tb	0.14(82)#		3.31(80)#	3.34(82)#		
^{144}Ho	-0.27(16)		2.63(70)	3.45(80)		
^{148}Tm	-0.55(40)		2.105(12)	3.420(13)		
^{152}Lu	-0.83(36)#		1.51(28)#	2.92(20)#		
^{156}Ta	-1.020(4)	71(3) %	0.91(36)	5.00(36)		[**2011Da12**, 2023Br10, 1996Pa01, 1992Pa05, 1993Li34, 1993WoZY]
^{156m}Ta	-1.122(4)	4.2(9) %	0.90(36)	5.10(36)		[**1996Pa01, 1993Li34**, 2023Br10, 2011Da12, 1992Pa05]
^{160}Re	-1.267(7)	89(1) %	0.34(36)	6.698(4)	11(1) %	[**2011Da12**, 2001Ke05, 1996Pa01,1995PeZY, 1993WoZY, 1992Pa05]
^{164}Ir	-1.56(10)#		-0.39(38)#	6.97(10)#		
^{164m}Ir	-1.56(10)#-x*	96(2) %	-0.39(38)#-x	6.97(10)#+x**	4(2) %	[**2014Dr02**, 2002Ma61, 2001Ke05, 2001DaZU]
^{168}Au	-1.99(50)#		-1.26(45)#	7.59(51)#		

* Q_p from the isomer is 1.825(5) MeV, suggesting the the isomer excitation = 265(100) keV assuming decay to the ground state of ^{163}Os.
** Q_α from the isomer is 7.052(14) MeV, and assuming decay to the 184(1) keV (9^+) level of ^{160}Re would give an isomer excitation = -102(100) keV. This suggests that the value given for Q_α from [2021Wa19] is too small.

Table 3
direct p emission from ^{156}Ta*, J^π = (2$^-$), $T_{1/2}$= 106(4) ms, BR_p = 71(3)%.

E_p(c.m.)	E_p(lab)	I_p(absb)	J^π_f	$E_{daughter}$(^{155}Hf)	coincident γ-rays
1.018(5)	1.011(5)(14)	71(3) %	(7/2$^-$)	0.0	—–

* All values from [2011Da12].

Table 4
direct p emission from ^{156m}Ta*, Ex = 102(7) keV, J^π = (9$^+$), $T_{1/2}$= 358(45) ms**, BR_p = 4.2(9)%.

E_p(c.m.)	E_p(lab)	I_p(absb)	J^π_f	$E_{daughter}$(^{155}Hf)	coincident γ-rays
1.113(8)	1.106(8)***	4.2(9)%	(7/2$^-$)	0.0	—–

* All values from [1996Pa01], except where noted.
** Weighted average of 320(80) ms [1993Li34] and 375(54) ms [1996Pa01].
** Weighted average of 1.108(8) MeV [1996Pa01] and 1.103(12) MeV [1993Li34].

Table 5
direct p emission from ^{160}Re*, J^π = , $T_{1/2}$= 611(7) μs, BR_p = 89(1) %.

E_p(c.m.)	E_p(lab)	I_p(absb)	J^π_f	$E_{daughter}$(^{159}W)	coincident γ-rays
1.272(6)	1.264(6)	89(1) %		0.0	—–

* All values from [2011Da12].

Table 6
direct α emission from ^{160}Re*, J^π = , $T_{1/2}$= 611(7) μs, BR_α = 11(1) %.

E_α(c.m.)	E_α(lab)	J^π_f	I_p(absb)	$E_{daughter}$(^{156}Ta)	coincident γ-rays
6.697(4)	6.530(4)	100%	(2$^-$)	((1/2$^+$)0.0	—–

* All values from [2011Da12].

Table 7
direct p emission from ^{164m}Ir*, Ex = unk, J^π = (9$^+$), $T_{1/2}$= 70(10) μs, BR_α = 96(2) %.

E_p(c.m.)	E_p(lab)	I_p(absb)	J^π_f	$E_{daughter}$(^{163}Os)	coincident γ-rays
1.826(6)	1.814(6)	96(2) %	(7/2−)	0.0	—–

* All values from [2014Dr02].

Table 8
direct α emission from ^{164m}Ir*, Ex = unk, J^π = (9$^+$), $T_{1/2}$= 70(10) μs, BR_α = 4(2) %.

E_α(c.m.)	E_α(lab)	I_p(abs)	J^π_f	$E_{daughter}$(^{160}Re)	coincident γ-rays
7.052(10)	6.550(10)	100%		0.184**	0.096, 0.038, 0.050?***

* All values from [2014Dr02], except where noted.
** [2014Dr02] assign the α decay as L=0, populating the $\pi h_{11/2}$ state in ^{160}Re (from [2011Da01].
*** Existence of this γ is implied but not observed in [2011Da01]

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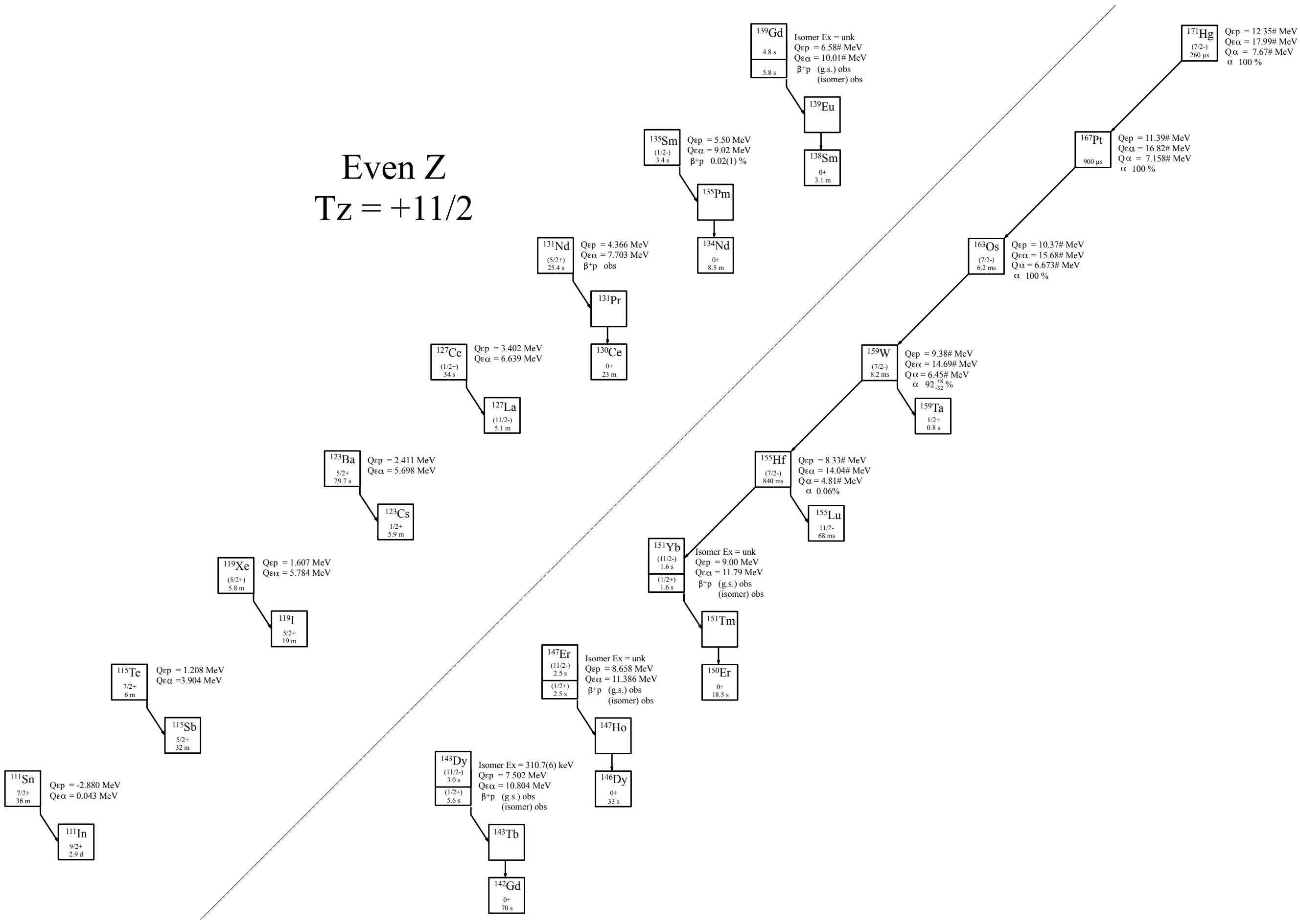

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +11/2 nuclei.

Last updated 3/22/23

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +11/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J^π values for ^{111}Sn, ^{115}Te, ^{119}Xe, ^{123}Ba, ^{127}Ce are taken from ENSDF.

Nuclide	Ex	J^π	$T_{1/2}$	Qε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{111}Sn		7/2$^+$	35.8(8) m	2.453(6)	-2.880(5)	—	-11.797(5)	0.043(6)	[**1969Sh11**]
^{115}Te		7/2$^+$	6.0(1) m	4.940(30)	1.208(28)		-7.274(28)	3.904(28)	[**1972Sh37**]
^{119}Xe		(5/2$^+$)	5.8(3) m	4.983(24)	1.607(21)		-4.733(13)	5.784(19)	[**1976Be61**]
^{123}Ba		(5/2$^+$)	2.4(4) m*	5.389(17)	2.411(16)		-3.987(13)	5.698(25)	[**1975Ar31, 1962Pr09**]
^{127}Ce		(1/2$^+$)	34(2) s	5.920(40)	3.402(31)		-2.468(30)	6.639(31)	[**1996Ge07**]
^{131}Nd		(5/2$^+$)	25.5(10) s**	6.530(50)	4.366(39)	obs	-1.022(35)	7.703(38)	[**1986Wi15, 1999Ga41, 1993Al03**,1977Bo02]
^{135}Sm		(3/2$^+$, 5/2$^+$)	10.3(5) s	7.21(18)	5.50(16)	0.02(1)%	0.50(16)	9.02(16)	[**1989Vi04**, 1977Bo02]
^{139}Gd			5.8(9) s	7.77(20)#	6.58(20)#	obs	1.86(20)#	10.01(21)#	[**1999Xi04, 1983Ni05**]
^{139m}Gd	x		4.8(9) s	7.77(20)#+x	6.58(20)#+x	obs	1.86(20)#+x	10.01(21)#+x	[**1999Xi04, 1983Ni05**]
^{143}Dy		(1/2$^+$)	5.6(10) s	8.250(50)	7.502(31)	obs	3.179(18)	10.804(19)	[**2003Xu04**, 1984Ni03, 1983Ni05]
^{143m}Dy	0.3107(6)	(11/2$^-$)	3.0(3) s	8.561(50)	7.833(31)	obs	3.1490(18)	11.115(19)	[**2003Xu04**]
^{147}Er		(1/2$^+$)	≈2.5 s	9.150(40)	8.658(39)	obs	5.21(12)	11.386(64)	[**2010Ma20**, 2011MaZL, 2010Ma27,1988WiZN, 1987ToZU, 1984ScZT]
^{147m}Er	x	(11/2$^-$)	2.5(2) s	9.150(40)+x	8.658(39)+x	obs	5.21(12)+x	11.386(64)+x	[**2010Ma20**, 2011MaZL, 2010Ma27, 1988WiZN, 1987ToZU, 1984ScZT]
^{151}Yb		(1/2$^+$)	1.6(1) s	9.23(30)	9.00(30)	obs	5.53(30)	11.79(30)	[**1989Ni02**, 1986To12]
^{151m}Yb	x	(11/2$^-$)	1.6(1) s	9.23(30)+x	9.00(30)+x	obs	5.53(30)+x	11.79(30)+x	[**1989Ni02**, 1986To12]
^{155}Hf		(7/2$^-$)	840(30) ms	8.24(30)#	8.33(30)#		5.09(30)#	14.04(30)#	[**1981HoZM, 2011Sa59**]
^{159}W		(7/2$^-$)	8.2(7) ms	9.01(30)#	9.38(30)#		6.43(30)#	14.69(30)	[**1996Pa01**]
^{163}Os		(7/2$^-$)	$6.2^{+1.3}_{-0.9}$ms	9.67(30)#	10.37(30)#		7.86(30)#	15.68(30)#	[**2019Hi06**
^{167}Pt			0.90(13) ms***	10.32(31)#	11.39(31)#		9.33(31)#	16.82(31)	[**2019Hi06, 1996Pa01, 1996Bi07**]
^{171}Hg			59^{+36}_{-16} μs	10.90(31)#	12.35(31)#		10.86(31)#	17.99(31)	[2004Ke06]

* Weighted average of 2.7(4) m [1975Ar31] and 2.0(5) m [1962Pr09].
** Weighted average of 26.6(17) s [1999Ga41], and 25.0(12) s [1993Al03].
*** Weighted average of 1.1(2) ms [2019Hi06], 0.9(3) ms [2004Ke06], and 0.91(16) ms [1996Bi07].

Table 2
Particle emission from the even-Z, T_z = +11/2 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_p$	S$_{2p}$	Q$_\alpha$	BR$_\alpha$	Experimental
^{111}Sn	6.758(13)	12.012(6)	-1.373(6)	—	
^{115}Te	4.855(34)	8.313(28)	1.451(28)		
^{119}Xe	5.112(22)	8.277(17)	0.843(30)		
^{123}Ba	4.799(36)	7.752(16)	0.715(16)		
^{127}Ce	4.295(95)	6.888(31)	1.251(31)		
^{131}Nd	3.882(70)	6.058(39)	1.786(40)		
^{135}Sm	3.38(16)	5.10(16)	2.49(16)		
^{139}Gd	3.17(20)#	4.22(20)#	2.80(25)#		
^{139m}Gd	3.17(20)#-x	4.22(20)#-x	2.80(25)#+x		
^{143}Dy	2.90(70)	3.52(24)	3.04(20)#		
^{143m}Dy	2.59(70)	3.21(24)	3.35(20)#		
^{147}Er	2.659(39)	2.94(39)	3.136(40)		
^{147m}Er	2.659(39)-x	2.94(39)-x	3.136(40)+x		
^{151}Yb	2.34(36)#	2.38(30)	2.64(30)		
^{151m}Yb*	2.34(36)#-x	2.38(30)-x	2.64(30)+x		
^{155}Hf	1.93(36)#	1.73(36)#	4.81(43)#	0.06%	[**1981HoZM**]
^{159}W	1.605(36)#	1.16(36)#	6.451(4)	92^{+8}_{-23}%	[**1996Pa01, 1981Ho10**, 2019Hi06, 2011Sa59, 1981HoZM]
^{163}Os	1.17(36)#	0.41(36)#	6.673(7)	100%	[**2019Hi06, 1996Pa01**, 1996Bi07, 1981Ho10, 2004Ke06]
^{167}Pt	0.74(37)#	-0.42(37)#	7.160(60)	100%	[**2019Hi06, 1996Pa01, 1996Bi07**, 1981Ho10
^{171}Hg	0.245(37)#	-1.23(37)#	7.668(15)	100%	[**2004Ke06**]

Table 3
direct α emission from ^{155}Hf*, J^{π} = (7/2^{-}), $T_{1/2}$ = 840(30) ms**, BR_{α} = 0.06 %.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{151}Yb)	coincident γ-rays	R_0 (fm)	HF
4.900	4.774	0.06%	(1/2^{+})	0.0	—–		

* All values from [1981HoZM], except where noted.
** [2011Sa59].

Table 4
direct α emission from ^{159}W*, J^{π} = (7/2^{-}), $T_{1/2}$ = 8.2(7) ms, BR_{α} = 92^{+8}_{-23} %.

E_{α}(c.m.)	E_{α}(lab)	I_{p}(abs)	J^{π}_{f}	$E_{daughter}$(^{155}Hf)	coincident γ-rays	R_0 (fm)	HF
6.457(5)	6.295(5)**	92^{+8}_{-23} %	(7/2^{-})	0.0	—–	1.5566(82)	$2.2^{+0.5}_{-0.4}$

* All values from [1996Pa01].
** Weighted average of 6.292(5) MeV [1996Pa01] and 6.299(6) MeV [1981Ho10].

Table 5
direct α emission from ^{163}Os*, J^{π} = (7/2^{-}), $T_{1/2}$ = $6.2^{+1.3}_{-0.9}$ms, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{p}(abs)	J^{π}_{f}	$E_{daughter}$(^{159}W)	coincident γ-rays	R_0 (fm)	HF
6.666(12)	6.503(12)	100%	(7/2^{-})	0.0	—–	1.5537(37)	1.28(31)

* All values from [2019Hi06].
** Weighted average of 6.512(19) MeV [1996Pa01] and 6.499(12) keV [2019Hi06].

Table 6
direct α emission from ^{167}Pt, J^{π} = , $T_{1/2}$ = 0.90(13) ms**, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{p}(abs)	J^{π}_{f}	$E_{daughter}$(^{163}Os)	coincident γ-rays	R_0 (fm)	HF
7.163(7)	6.983(7)**	100%	(7/2^{-})	0.0	—–	1.555(10)	$1.5^{+0.4}_{-0.3}$

* Weighted average of 1.1(2) ms [2019Hi06], 0.9(3) ms [2004Ke06], and 0.91(16) ms [1996Bi07].
** Weighted average of 6.985(8) MeV [2019Hi06], 6.979(7) [2004Ke06], and 6.988(10) MeV [1996Bi07].

Table 7
direct α emission from ^{171}Hg*, J^{π} = , $T_{1/2}$ = 59^{+36}_{-16} μs, BR_{α} = 100 %.

E_{α}(c.m.)	E_{α}(lab)	I_{p}(abs)	J^{π}_{f}	$E_{daughter}$(^{167}Pt)	coincident γ-rays	R_0 (fm)	HF
7.667(12)	7.488(12)	100%		0.0	—–	1.541(24)	$0.5^{+0.5}_{-0.4}$

* All values from [2004Ke06].

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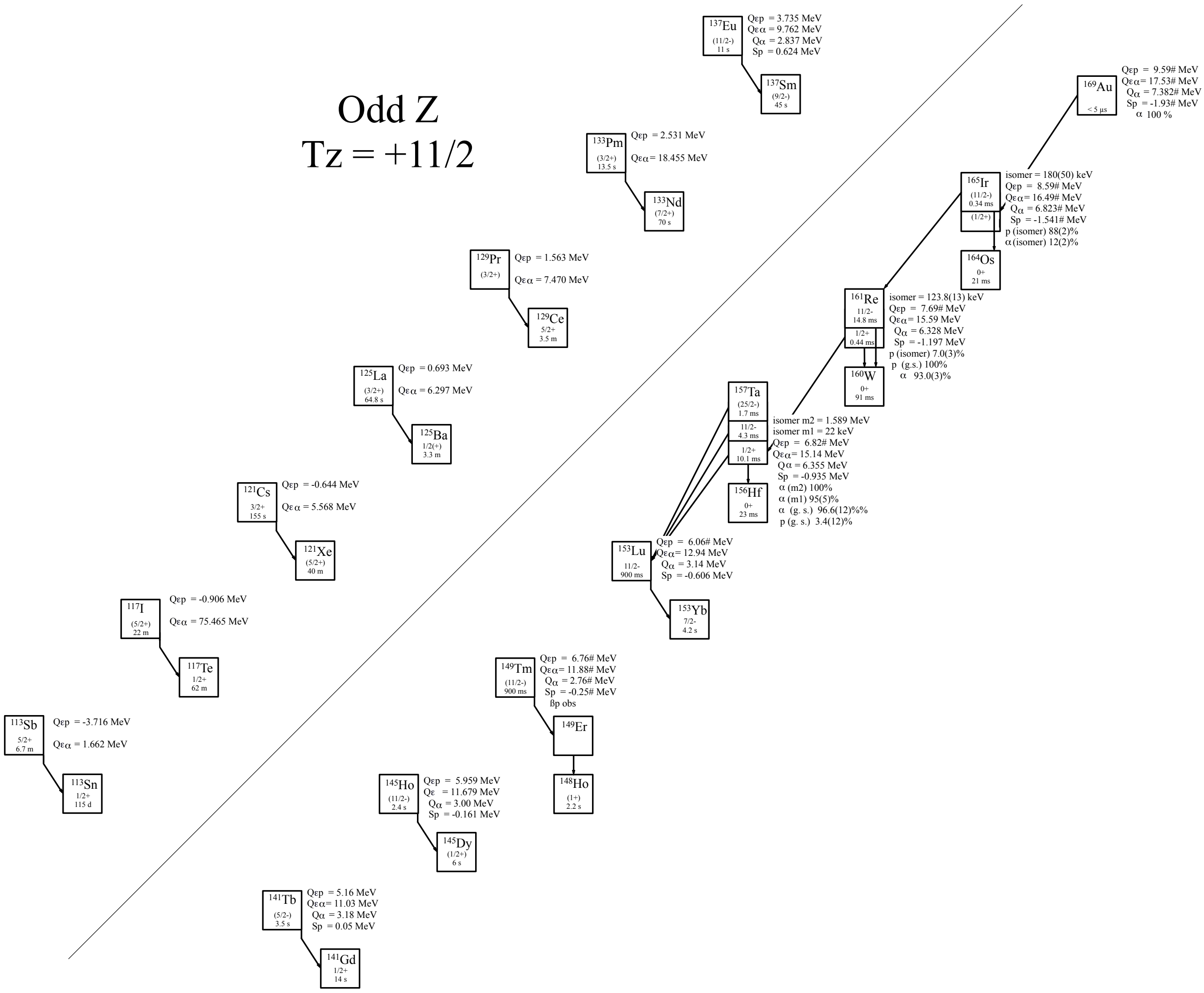

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +1/2 nuclei.

Last updated 3/22/23

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +11/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J^π values for ^{113}Sb, ^{117}I ^{121}Cs, ^{125}La, ^{119}Pr, ^{133}Pm, ^{137}Eu, ^{141}Tb, ^{145}Ho, ^{149}Tm are taken from ENSDF.

Nuclide	Ex	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{113}Sb		5/2$^+$	6.67(7) m	3.911(17)	-3.716(18)		-9.743(17)	1.662(17)	[**1976Wi10**]
^{117}I		(5/2$^+$)	22.2(4) m	4.657(28)	-0.906(26)		-4.983(26)	5.465(26)	[**1985Le10**]
^{121}Cs		3/2$^+$	155(4) s	5.379(14)	-0.644(21)		-4.498(16)	5.568(20)	[**1991Ge02**]
^{125}La		(3/2$^+$)	64.8(12) s	5.909(28)	0.693(28)		-3.089(28)	6.297(28)	[**1992Ic02**]
^{129}Pr		(3/2$^+$)		6.510(40)	1.563(62)		-1.534(32)	7.470(32)	
^{133}Pm		(3/2$^+$)	13.5(3) s*	6.920(70)	2.531(58)		-0.277(60)	8.455(58)	[**1995Br21, 1977Bo02**]
^{137}Eu		(11/2$^-$)	11(2) s	7.846(29)	3.735(69)		1.490(20)	9.762(47)	[**1982No15**]
^{141}Tb		(5/2$^-$)	3.5(2) s	8.68(11)	5.16(12)		3.26(11)	11.03(11)	[**1989Gi06**]
^{145}Ho		(11/2$^-$)	2.4(1) s	9.122(10)	5.959(29)		4.53(20)	11.679(21)	[**1989Vi02**]
^{149}Tm		(11/2$^-$)	0.9(2) s	9.80(20)#	6.76(22)#	obs	5.68(20)#	11.88(20)#	[**1987To12**]
^{153}Lu		11/2$^-$	0.9(2) s	8.78(25)#	6.06(14)#		5.31(15)#	12.94(15)#	[**1989Ni04**]
^{157}Ta		1/2$^+$	10.1(4) ms	9.26(25)#	6.82(14)#		6.33(15)#	15.14(25)#	[**1997Ir01**]
^{157m1}Ta	0.022(5)	11/2$^-$	4.3(1) ms	9.28(25)#	6.84(14)#		6.35(15)#	15.16(25)#	[**1996Pa01, 1997Ir01**]
^{157m2}Ta	1.589(10)	(25/2$^-$)	1.7(1) ms	10.85(25)#	8.41(14)#		7.92(15)#	16.73(25)#	[**1996Pa01**]
^{161}Re		1/2$^+$	0.44(1) ms	9.66(25)#	7.69(14)#		7.43(15)#	15.59(25)#	[**1997Ir01**]
^{161m}Re	0.1238(13)	11/2$^-$	14.8(3) ms	9.78(25)#	7.81(14)#		7.55(15)#	15.71(28)#	[**2006La16**]
^{165}Ir		(1/2$^+$)		10.15(26)#	8.59(15)#		8.74(17)#	16.49(26)#	
^{165m}Ir	0.18(5)	(11/2$^-$)	340(40) μs	10.33(26)#	8.77(15)#		8.92(17)#	16.67(26)#	[**2014Dr02**]
^{169}Au			<5 μs	10.68(36)#	9.59(30)#		10.13(31)#	17.53(36)#	[**2019Uu01**]

* Weighted average of 15(3) s [1995Br21] and 12(3) s [1977Bo02].

Table 2
Particle emission from the odd-Z, T_z = +11/2 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_p$	BR$_p$	S$_{2p}$	Q$_\alpha$	BR$_\alpha$	Experimental
^{113}Sb	3.051(17)	—–	10.603(18)	-0.352(18)	—–	
^{117}I	2.464(35)	—–	8.013(30)	1.553(31)		
^{121}Cs	2.219(19)	—–	7.903(26)	0.911(29)		
^{125}La	1.959(29)	—–	7.294(29)	0.918(30)		
^{129}Pr	1.529(41)	—–	6.455(40)	1.561(40)		
^{133}Pm	1.271(56)	—–	5.685(69)	1.941(58)		
^{137}Eu	0.624(13)	—–	4.662(83)	2.837(50)		
^{141}Tb	0.05(11)		3.72(11)	3.18(11)		
^{145}Ho	-0.161(10)		3.279(52)	3.00(11)		
^{149}Tm	-0.25(20)#		2.76(20)#	2.76(20)#		
^{153}Lu	-0.606(10)		2.18(15)	3.14(25)#		
^{157}Ta	-0.935(10)	3.4(12) %	1.63(15)	6.355(6)	96.6(12)%	[**1997Ir01**, 1996Pa01]
^{157m1}Ta	-0.957(11)		1.41(16)	6.377(8)	95^{+5}_{-12}%	[**1997Ir01, 1996Pa01**, 1981HoZM, 1979Ho10]
^{157m2}Ta	-2.524(140)		0.04(18)	7.944(12)	100%	[**1996Pa01**]
^{161}Re	-1.197(5)	100%	0.98(15)	6.328(7)		**1997Ir01**, 2006La16, 1996Pa01, 2011Sa59, 2001Ke05, 1979Ho10]
^{161m}Re	-1.300(14)	7.0(3) %	0.86(15)	6.162(15)	93.0(3)%	**2006La16, 1997Ir01, 1996Pa01**, 2011Sa59, 2001Ke05, 1995DeZY, 1981HoZM, 1979Ho10]
^{165}Ir	-1.541(50)#		0.17(16)#	6.823(50)#		
^{165m}Ir	-1.721(71)#	88(2)%	-0.10(17)#	7.003(71)#	12(2)%	[**2014Dr02, 1997Da07**]
^{169}Au	-1.93(33)#	≈ 100%	-0.71(30)#	7.382(34)#		[**2019Uu01**]

Table 3
direct p emission from ^{157}Ta*, J$^\pi$ = 1/2$^+$, T$_{1/2}$ = 10.1(4) ms, BR_p = 3.4(12) %.

E_p(c.m.)	E_p(lab)	I_p(absb)	J$^\pi_f$	$E_{daughter}$(^{156}Hf)	coincident γ-rays
0.933(7)	0.927(7)	3.4(12)%	0$^+$	0.0	—–

* All values from [1997Ir01], except where noted.

Table 4
direct α emission from ^{157}Ta*, J^{π} = 1/2^{+}, $T_{1/2}$ = 10.1(4) ms, BR_{α} = 96.6(12) %.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{153}Lu)	coincident γ-rays	R_0 (fm)	HF
6.277(4)	6.117(4)	96.6(12)%	1/2^{+}	80(5)	?	1.5551(66)	$0.73^{+0.11}_{-0.10}$

* All values from [1997Ir01].

Table 5
direct α emission from ^{157m1}Ta*, Ex = 22(5) keV**, J^{π} = (11/2^{-}), $T_{1/2}$ = 4.3(1) ms, BR_{α} = 95^{+5}_{-12}%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{153}Lu)	coincident γ-rays	R_0 (fm)	HF
6.375(4)	6.213(4)	95^{+5}_{-12}%	11/2^{-}	0.0	—	1.5551(66)	$1.56^{+0.23}_{-0.20}$

* All other values from [1996Pa01], except where noted.
** [1997Ir01]

Table 6
direct α emission from ^{157m2}Ta*, Ex = 1.589(10) MeV, J^{π} = (25/2^{-}), $T_{1/2}$ = 1.7(1) ms, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{153}Lu)	coincident γ-rays	R_0 (fm)	HF
7.946(8)	7.744(8)	100%	11/2^{-}	0.0	—	1.5551(66)	$2.07(29)\times10^{4}$

* All values from [1996Pa01].

Table 7
direct p emission from ^{161}Re*, J^{π} = 1/2^{+}, $T_{1/2}$ = 0.44(1) ms, BR_{p} = 100 %.

E_{p}(c.m.)	E_{α}(lab)	I_{p}(abs)	J^{π}_{f}	$E_{daughter}$(^{160}W)	coincident γ-rays
1.199(6)	1.192(6)	100%	0^{+}	0.0	—

* All values from [1997Ir01].

Table 8
direct p emission from ^{161m}Re*, Ex = 123.8(13) keV**, J^{π} = 1/2^{+}, $T_{1/2}$ = 14.8(3) ms, BR_{p} = 7.0(3) %.

E_{p}(c.m.)	E_{p}(lab)	I_{p}(abs)	J^{π}_{f}	$E_{daughter}$(^{160}W)	coincident γ-rays
1.199(2)	1.192(2)**	7.0(3)%	0^{+}	0.0	—

* All values from [2006La16], except where noted.
** [1997Ir01].

Table 9
direct α emission from ^{161m}Re*, Ex = 123.8(13) keV**,J^{π} = 11/2^{-}, $T_{1/2}$ = 14.8(3) ms, BR_{α} = 93.0(3) %.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{157}Ta)	coincident γ-rays	R_0 (fm)	HF
6.429(6)	6.269(6)***	93.0(3)%	11/2^{-}	0.022	—	1.5580(46)	1.30(13)

* All values from [2006La16], except where noted.
** [1997Ir01].
*** Weighted average of 6.265(6) MeV [1996Pa01], and 6.272(6) MeV [2006Pa01].

Table 10
direct p emission from ^{165m}Ir, Ex = 180(50) keV*, J^π = 11/2$^-$, $T_{1/2}$ = 340(40) μs*, BR_p = 88(2)%*.

E_p(c.m.)	E_p(lab)	I_p(abs)	J^π_f	$E_{daughter}$(^{164}Os)	coincident γ-rays
1.733(7)	1.707(7)**	88(2)%*	0^+	0.0	—

* [2014Dr02]
** [1997Da07]

Table 11
direct α emission from ^{165m}Ir, Ex = 180(50) keV*, J^π = (11/2$^-$), $T_{1/2}$ = 340(40) μs*, BR_α = 12(2)%*.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{161}Re)	coincident γ-rays	R_0 (fm)	HF
6.882(7)	6.715(7)**	12(2)%*	11/2$^-$	0.1238	—	1.551(11)	$1.2^{+0.5}_{-0.4}$

* [2014Dr02]
** [1997Da07]

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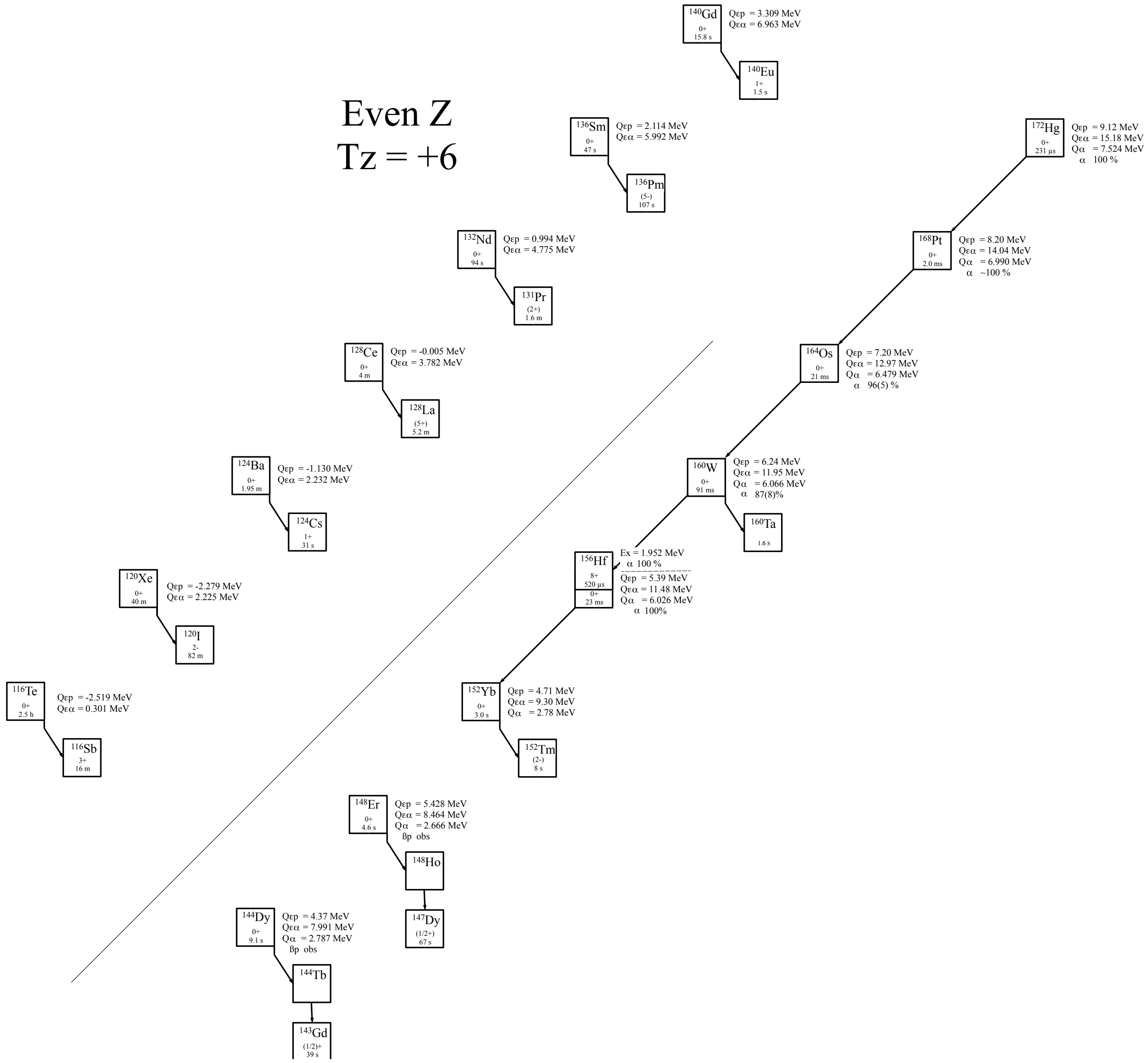

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +6 nuclei.

Last updated 3/21/23

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +6 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{116}Te		0^+	2.50(2) h	1.558(25)	-2.519(24)	——	-11.272(24)	0.301(25)	[**1961Fi05**]
^{120}Xe		0^+	40(1) m	1.575(19)	-2.279(14)	——	-8.754(12)	2.225(13)	[**1965An05**]
^{124}Ba		0^+	10.5(5) m	2.651(15)	-1.130(16)	——	-7.588(14)	2.232(20)	[**1975Ra03**]
^{128}Ce		0^+	4.0(1) m	3.090(60)	-0.005(30)	——	-5.761(30)	3.782(29)	[**2000Li08**]
^{132}Nd		0^+	94(6) s*	3.800(40)	0.994(41)		-4.376(35)	4.775(60)	[**1992Le09, 1995Bu11**]
^{136}Sm		0^+	47(2) s	4.360(70)	2.114(23)		-2.861(24)	5.992(31)	[**1988Ke03**]
^{140}Gd		0^+	15.8(4) s	5.200(60)	3.309(30)		-1.446(30)	6.963(75)	[**1991Fi03**]
^{144}Dy		0^+	9.1(5) s	5.798(29)	4.37(20)	obs	0.161(31)	7.991(52)	[**1986Wi05**]
^{148}Er		0^+	4.6(2) s	6.510(80)	5.428(14)	obs	1.707(46)	8.464(30)	[**1988To03**]
^{152}Yb		0^+	3.03(6) s	5.45(14)	4.71(15)		1.010(15)	9.30(17)	[**1987To02**]
^{156}Hf		0^+	23(1) ms	5.88(14)	5.39(15)		2.03(15)	11.48(16)	[**1996Pa01**]
^{156m}Hf	1.952(6)**	8^+	520(10) μs	7.83(15)	7.34(16)		3.98(16)	13.43(17)	[**2018Pa37**]
^{160}W		0^+	91(5) ms	6.49(14)	6.24(15)		3.31(15)	11.95(16)	[**1996Pa01**]
^{164}Os		0^+	21(1) ms	7.05(14)	7.20(16)		4.78(16)	12.97(16)	[**1996Pa01**]
^{168}Pt		0^+	2.04(16) ms***	7.66(14)	8.20(17)		6.25(17)	14.04(16)	[**2009Gi06, 2004Ke06, 1998Ki20, 1996Bi07**]
^{172}Hg		0^+	231(9) μs	8.26(14)	9.12(17)		7.54(18)	15.18(16)	[**2009Sa27**]

* Weighted average of 105(10) s [1992Le09] and 88(7) s [1995Bu11].

** Deduced from α center of mass energies of the isomer (7980(5) MeV) [2018Pa37] and ground state (6.028(4)MeV) [1996Pa01] decays, that both feed the ground state of ^{152}Yb.

*** Weighted average of 1.98(16) ms [2009Gi06], 2.1(2) ms [2004Ke06], 2.0(2) ms [1998Ki20], and 2.0(4) ms [1996Bi07].

Table 2
Particle separation and emission from the even-Z, T_z = +6 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	BR_p	S_{2p}	Q_α	BR_α	Experimental
^{116}Te	5.549(29)	——	9.282(248)	0.966(24)		
^{120}Xe	5.684(25)	——	9.060(22)	0.666(27)		
^{124}Ba	5.335(17)	——	8.313(17)	0.658(17)		
^{128}Ce	4.927(38)	——	7.442(31)	1.131(31)		
^{132}Nd	4.414(53)	——	6.581(37)	1.683(37)		
^{136}Sm	4.038(84)	——	5.742(17)	2.190(27)		
^{140}Gd	3.673(31)	——	4.862(30)	2.604(31)		
^{144}Dy	3.440(52)	——	4.189(29)	2.787(29)		
^{148}Er	3.011(11)	——	3.502(12)	2.666(13)		
^{152}Yb	2.79(15)	——	3.02(15)	2.78(15)		
^{156}Hf	2.56(15)	——	2.47(15)	6.026(3)	100%	[**1996Pa01**, 2018Pa37, 2011Da12, 1981HoZM, 1979Ho10, 1978ReZZ]
^{156m}Hf	0.61(16)	——	0.52(16)	7.978(7)	100%	**2018Pa37**, 1996Pa01, 2011Da12, 1981HoZM]
^{160}W	2.18(15)	——	1.81(15)	6.066(5)	87(8)%	[**1996Pa01**, 1981Ho10, 1979Ho10, 1978ReZZ]
^{164}Os	1.71(15)	——	1.00(15)	6.479(5)	96^{+4}_{-5}%	[**2008Bi15, 1996Pa01**, 1996Bi07, 1981Ho10]
^{168}Pt	1.23(15)	——	0.16(15)	6.990(3)	≈ 100%*	[**2009Gi06, 2004Ke06**, 1998Ki20, 1996Bi07, 1981Ho10]
^{172}Hg	0.79(15)	——	-0.66(15)	7.524(6)	100%*	[**2009Sa27**, 2004Ke06, 1999Se14, 1998NiZW]

* Not measured, deduced from half-life.

Table 3
direct α emission from ^{156}Hf*, $J^\pi = 0^+$, $T_{1/2}$ = 23(1) ms, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{152}Yb)	coincident γ-rays	R_0 (fm)	HF
6.028(4)	5.873(4)	100%	0^+	0.0	——	1.5536(31)	0.99(4)

* All values from [1996Pa01].

Table 4
direct α emission from ^{156m}Hf*, Ex = 1.952(6) MeV**, J$^{\pi}$ = 8^{+}, T$_{1/2}$ = 520(10) μs, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{152}Yb)***	coincident γ-rays***	R$_0$ (fm)	HF
6.098(15)	5.942(15)	0.0038(23)%	0.0038(23)%	3^{-}	1.8901(6)	1.531, 0.359	1.5536(31)	$1.0^{+1.6}_{-0.4}\times10^{3}$
6.439(15)	6.274(15)	0.0064(30)%	0.0064(30)%	2^{+}	1.5314(5)	1.531	1.5536(31)	$1.1^{+1.0}_{-0.4}\times10^{4}$
7.980(5)	7.775(5)	100%	99.990(4)%	0^{+}	0.0	—	1.5536(31)	$1.65(3)\times10^{4}$

* All values from [2018Pa37], unless otherwise noted.
** Deduced from α center of mass energies of the isomer (7980(5) MeV) [1996Pa37] and ground state (6.028(4)MeV) [1996Pa01] decays, that both feed the ground state of ^{152}Yb.
*** Values taken from [2013Ma77].

Table 5
direct α emission from ^{160}W*, J$^{\pi}$ = 0^{+}, T$_{1/2}$ = 91(5) ms, BR_{α} = 87(8)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{156}Hf)	coincident γ-rays	R$_0$ (fm)	HF
6.072(10)	5.920(10)	100%	0^{+}	0.0	—	1.5533(77)	1.06(11)

* All values from [1996Pa01].

Table 6
direct α emission from ^{164}Os*, J$^{\pi}$ = 0^{+}, T$_{1/2}$ = 21(1) ms, BR_{α} = 96^{+4}_{-5}%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{160}W)	coincident γ-rays	R$_0$ (fm)	HF
6.479(7)	6.321(7)	96^{+4}_{-5}%	0^{+}	0.0	—	1.5504(56)	0.95(6)

* All values from [1996Pa01], except where noted.
** [2008Bi05].

Table 7
direct α emission from ^{168}Pt, J$^{\pi}$ = 0^{+}, T$_{1/2}$ = 2.04(16) ms*, BR_{α} = ≈ 100%***.

E_{α}(c.m.)	E_{α}(lab)**	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{164}Os)	coincident γ-rays	R$_0$ (fm)	HF
6.987(3)	6.821(3)	≈ 100%	0^{+}	0.0	—	1.5578^{+45}_{-42}	0.97(8)

* Weighted average of 1.98(16) ms [2009Gi06], 2.1(2) ms [2004Ke06], 2.0(2) ms [1998Ki20], and 2.0(4) ms [1996Bi07].
** Weighted average of 6.823(3) MeV [2009Gi06], and 6.820(4) MeV [2004Ke06].
*** Not measured, deduced from half-life.

Table 8
direct α emission from ^{172}Hg*, J$^{\pi}$ = 0^{+}, T$_{1/2}$ = 231(9) μs, BR_{α} = 100%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{168}Pt)	coincident γ-rays	R$_0$ (fm)	HF
7.523(7)	7.348(7)	100%	0^{+}	0.0	—	1.5574(32)	0.99(4)

* All values from [2009Sa27].
** Not measured, deduced from half-life.

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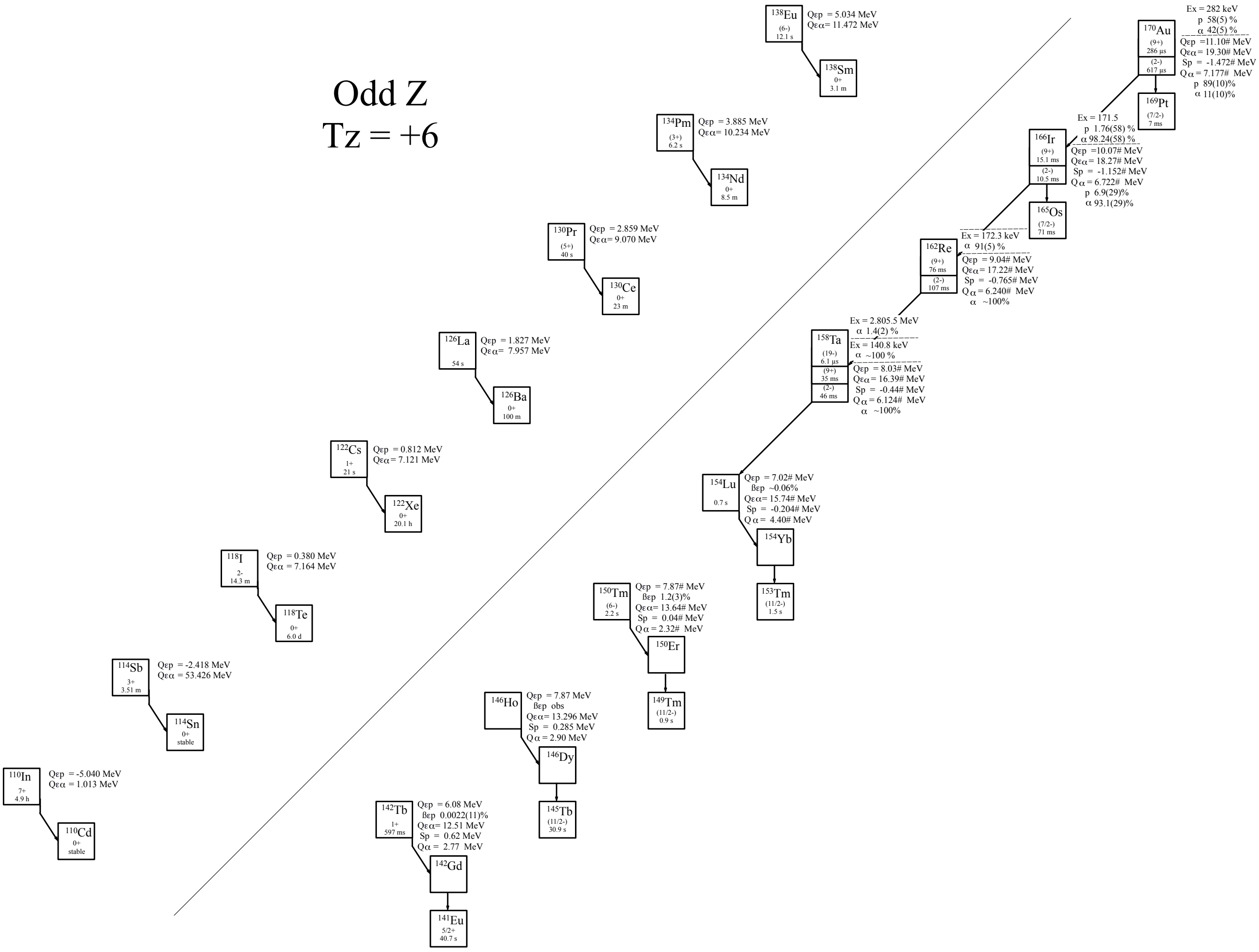

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +6 nuclei.

Last updated 3/22/23

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +6 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J$^{|pi}$ values for ^{110}In, ^{114}Sb, ^{118}I, ^{122}Cs, ^{126}La, ^{130}Pr, ^{134}Pm, ^{138}Eu are taken from ENSDF.

Nuclide	Ex	J^{π}	$T_{1/2}$	Q$_{\varepsilon}$	$Q_{\varepsilon p}$	BR$_{\beta p}$	Q$_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{110}In		7^{+}	4.9(1) h	3.878(12)	-5.040(12)	——	-11.524(12)	1.013(12)	[**1975Bu24**]
^{114}Sb		3^{+}	3.51(4) m	6.063(20)	-2.418(20)	——	-8.500(20)	3.426(20)	[**1976Wi10**]
^{118}I		2^{-}	14.3(1) m	6.720(27)	0.380(21)		-4.023(20)	7.164(20)	[**1969Ha03**]
^{122}Cs		1^{+}	21.18(19) s	7.210(40)	0.812(34)		-3.361(34)	7.121(38)	[**1993Al03**]
^{126}La			54(2) s	7.700(90)	1.827(91)		-1.884(91)	7.957(91)	[**2002Ko02**]
^{130}Pr		(5^{+})	40.0(4) s	8.250(70)	2.859(68)		-0.384(64)	9.070(65)	[**1988Ba42**]
^{134}Pm		(2^{+})	≈5 s	8.880(40)	3.885(44)		1.127(47)	10.234(50)	[**1988KeZX**]
^{138}Eu		(6-)	12.1(6) s	9.750(30)	5.034(31)		2.872(30)	11.472(30)	[**1985Ch25**]
^{142}Tb		1^{+}	597(17) ms	10.40(70)	6.08(70)	0.0022(11)%	4.32(70)	12.51(70)	[**1991Fi03**]
^{146}Ho		(6-)	2.8(5) s	11.317(9)	7.87(11)	obs	5.943(29)	13.296(29)	[**2010Ma37**, 2011MaZL, 1986Wi05, 1988ToZW, 1988WiZN, 1986Wi15, 1987WiZM]
^{150}Tm		(6^{-})	2.20(7) s	11.34(20)#	7.87(20)#	1.2(3)%	6.79(20)#	13.64(20)#	[**1988Ni02**]
^{154}Lu		(2^{-})		10.27(20)#	7.02(20)#		6.26(20)#	15.74(20)#	
^{154m}Lu	x	(9^{+})	1.16(5) s	10.27(20)#+x	7.02(20)#+x	≈0.06%	6.26(20)#+x	15.74(20)#+x	[**1988Vi02**]
^{158}Ta		(2^{-})	46(4) ms	10.98(20)#	8.03(20)#		7.57(20)#	16.39(20)#	[**2014Ca03**]
^{158m1}Ta	0.1408(87)	(9^{+})	35(1) ms	11.12(20)#	8.17(20)#		7.74(20)#	16.53(22)#	[**1996Pa01**]
^{158m2}Ta	2.8055(4)	(19^{-})	6.1(1) μs	13.79(20)#	10.84(20)#		10.38(20)#	19.20(20)#	[**2014Ca04**]
^{162}Re		(2^{-})	107(13) ms	11.55(20)#	9.04(20)#		8.91(20)#	17.22(20)	[**1997Da07**]
^{162m}Re	0.1723(80)	(9^{+})	76(6) ms*	11.72(20)#	9.21(20)#		9.08(20)#	17.39(22)	[**2016Ca15**]
^{166}Ir		(2^{-})	10.5(22) ms	12.13(20)#	10.07(20)#		10.35(20)#	18.27(20)	[**1997Da07**]
^{166m}Ir	0.1715(61)	(9^{+})	15.1(9) ms	12.30(20)#	10.24(20)#		10.52(20)#	18.44(20)	[**1997Da07**]
^{170}Au		(2^{-})	286^{+50}_{-40} μs	12.60(20)#	11.10(20)#		11.71(20)#	19.30(20)	[**2004Ke06**]
^{170m}Au	0.282(10)	(9^{+})	617^{+50}_{-40} μs	12.82(20)#	11.38(20)#		11.99(20)#	19.58(20)	[**2004Ke06**]

* Weighted average of 66(7) ms [1996Pa01] and 84.6(62) ms [1997Da07].

Table 2
Particle emission from the odd-Z, T_z = +6 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_{p}$	BR$_{p}$	S$_{2p}$	Q$_{\alpha}$	BR$_{\alpha}$	Experimental
^{110}In	5.255(12)	——	13.44(11)	-1.952(12)	——	
^{114}Sb	3.457(20)	——	11.084(20)	-0.452(23)	——	
^{118}I	3.165(24)	——	8.727(20)	1.101(28)		
^{122}Cs	2.953(35)	——	8.976(37)	0.401(39)		
^{126}La	2.593(91)	——	7.810(91)	0.746(97)		
^{130}Pr	2.177(70)	——	7.128(84)	1.37(11)		
^{134}Pm	1.720(63)	——	6.114(51)	1.987(77)		
^{138}Eu	1.047(40)	——	5.158(75)	2.589(50)		
^{142}Tb	0.62(70)	——	4.15(70)	2.77(70)		
^{146}Ho	0.285(9)	——	3.448(29)	2.90(70)		
^{150}Tm	0.04(20)#		3.08(21)#	2.32(20)#		
^{154}Lu	-0.204(14)#		2.52(21)#	4.40(28)#		
^{154m}Lu	-0.204(14)#-x		2.52(21)#-x	4.40(28)#+x		
^{158}Ta	-0.448(13)		2.00(21)#	6.124(4)	≈ 100%	[**2014Ca03**, 1997Da07, 1996Pa01, 1981HoZM, 1978ReZZ]
^{158m1}Ta*	-0.4589(16)		2.14(23)#	6.265(10)	≈ 100%	[**2019Pa27, 1996Pa01**, 2014Ca03, 1997Da07, 2015Ca04, 2016Ca15, 1981HoZM]
^{158m2}Ta**	-3.254(13)		-0.67(21)#	8.930(4)	1.4(2)%	**2016Ca15, 2014Ca03**, 1997Da07, 1996Pa01, 1979Ho10, 1981HoZM, 1978ReZZ]
^{162}Re	-0.765(11)		1.21(21)#	6.240(5)	≈100%*	[**1997Da07**]
^{162m}Re***	-0.937(19)		1.04(22)#	6.412(9)	91(5)%**	[**2016Ca15, 1997Da07, 1996Pa01**, 1979Ho10, 1981HoZM, 1978ReZZ]
^{166}Ir	-1.152(8)	6.9(29)%	0.41(21)#	6.722(6)	93.1(29)%	[**1997Da07**, 1996Pa01, 2004Ke06, 1981Ho10, 1995DaZX, 1981HoZM]
^{166m}Ir^{a}	-1.324(10)	1.76(58)%	0.24(21)#	6.894(8)	98.24(58)%	[**1997Da07**, 1996Pa01, 2004Ke06, 1981Ho10, 1995DaZX, 1981HoZM]
^{170}Au	-1.472(12)	89(10)%	-0.39(21)#	7.177(15)	11(10)%	[**2004Ke06**, 2002LeZZ]
^{170m}Au^{b}	-1.754(16)	58(5)%	-0.67(21)#	7.459(18)	42(5)%	[**2004Ke06**, 2002Ma61, 2002LeZZ, 2003SeZZ, 2001DaZU]

* No evidence for α-decay from ^{162}W (arising from the β-decay of ^{162}Re were observed [1997Da07].
** Weighted average of 85(9)% [1996Pa01] and 94(6)% [1997Da07].

Table 3
direct α emission from ^{158}Ta*, J^{π} = (2^-), $T_{1/2}$ = 46(4) ms, $BR_{\alpha} \approx$ 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(absb)	J^{π}_{f}	$E_{daughter}$(^{154}Lu)	coincident γ-rays	R_0 (fm)**	HF
6.123(5)	5.968(5)	100%	(2^-)	0.0	—–	1.5534(83)	1.76(34)

* All values from [2014Ca03]
** Interpolated between 1.5535(31) fm ^{156}Hf and 1.5533(77) fm ^{160}W.

Table 4
direct α emission from ^{158m1}Ta*, Ex = 140.8(87) keV, J^{π} = , $T_{1/2}$ = 35(1) ms**, $BR_{\alpha} \approx$ 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{154}Lu)	coincident γ-rays	R_0 (fm)@	HF
6.136(4)	5.981(4)	0.1031(25)%	0.099(24)%	(8,9,10^+)	0.126(11)***	0.060	1.5534(83)	$1.5^{+0.7}_{-0.5}\times10^3$
6.177(4)	6.021(4)	2.8(5)%	2.7(5)%	(8^+)	0.088(11)***	0.022	1.5534(83)	78^{+27}_{-21}
6.198(4)	6.041(4)	100%	96^{+2}_{-13}%	(9^+)	0.066(11)***		1.5534(83)	$2.7^{+0.8}_{-0.6}$

* All values from [2019Pa27], except where noted.
** [1996Pa01].
*** Deduced from α energy.
@ Interpolated between 1.5535(31) fm ^{156}Hf and 1.5533(77) fm ^{160}W.

Table 5
direct α emission from ^{158m2}Ta*, Ex = 2805.5(4) keV, J^{π} = (19^-), $T_{1/2}$ = 6.1(1) μs, BR_{α} = 1.4(2)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{154}Lu)	coincident γ-rays	R_0 (fm)***	HF
8.869(11)	8.644(11)	1.4(2)%	(9^+)	0.066(11)**		1.5534(83)	6.5(11)$\times10^3$

* All values from [2014Ca03].
** Deduced from α energy.
*** Interpolated between 1.5535(31) fm ^{156}Hf and 1.5533(77) fm ^{160}W.

Table 6
direct α emission from ^{162}Re*, J^{π} = (2^-), $T_{1/2}$ = 107(13) ms, BR_{α} = $\approx$ 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{158}Ta)	coincident γ-rays	R_0 (fm)**	HF
6.239(5)	6.086(5)	100%	(2^-)	0.0	—–	1.5519(83)	$1.7^{+0.4}_{-0.3}$

* All values from [1997Da07].
** Interpolated between 1.5533(77) fm ^{160}W and 1.5504(56) ^{164}Os.

Table 7
direct α emission from ^{162m}Re*, Ex = 172.3(80) keV***, J^{π} = , $T_{1/2}$ = 76(6) ms**, BR_{α} = 91(5) %@.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{158}Ta)	coincident γ-rays	R_0 (fm)@@@	HF
6.190(16)	6.037(16)	$\approx$ 0.3%	$\approx$ 0.3%@@	(10^+)	0.207(18)	0.066	1.5519(83)	$\approx$240
6.271(5)	6.116(5)	100%	100%	(9^+)	0.141(9)	—–	1.5519(83)	1.7(4)

* All values from [2016Ca15], except where noted.
** Weighted average of 66(7) ms [1996Pa01] and 84.6(62) ms [1997Da07].
*** Deduced by evaluator from Fig 2 in [2016Ca15].
@ Weighted average of 85(9)% [1996Pa01] and 94(6)% [1997Da07].
@@ [1997Da07]
@@@ Interpolated between 1.5533(77) fm ^{160}W and 1.5504(56) ^{164}Os.

Table 8
direct p emission from ^{166}Ir*, J^{π} = (2$^-$), $T_{1/2}$ = 10.5(22) ms, BR_p = 6.9(29)%.

E_p(c.m.)	E_p(lab)	I_p(abs)	J^{π}_f	$E_{daughter}$(^{165}Os)	coincident γ-rays
1.152(8)	1.145(8)	6.9(29)%	(7/2$^-$)	0.0	—

* All values from [1997Da07].

Table 9
direct α emission from ^{166}Ir*, J^{π} = , $T_{1/2}$ = 10.5(22) ms, BR_{α} = 93.1(29)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_f	$E_{daughter}$(^{162}Re)	coincident γ-rays	R_0 (fm)**	HF
6.724(6)	6.562(6)	93.1(29)%	(2$^-$)	0.0	—	1.5541(72)	1.6(4)

* All values from [1997Da07].
** Interpolated between 1.5504(56) ^{164}Os and 1.5578(45) ^{168}Pt.

Table 10
direct p emission from ^{166m}Ir*, Ex = 171.5(61) keV, J^{π} = (9$^+$), $T_{1/2}$ = 15.1(9) ms, BR_p = 1.76(58)%.

E_p(c.m.)	E_p(lab)	I_p(abs)	$E_{daughter}$(^{165}Os)	coincident γ-rays	
1.340(8)	1.316(8)	1.76(58)%	(2$^-$)	0.0	—

* All values from [1997Da07].

Table 11
direct α emission from ^{166m}Ir*, Ex = 171.5(61) keV, J^{π} = (9$^+$), $T_{1/2}$ = 15.1(9) ms, BR_{α} = 98.24(58)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_f	$E_{daughter}$(^{162}Re)	coincident γ-rays	R_0 (fm)**	HF
6.723(5)	6.561(5)	98.24(58)%	(9$^+$)	0.172(8)		1.5541(72)	2.2(4)

* All values from [1997Da07].
** Interpolated between 1.5504(56) ^{164}Os and 1.5578(45) ^{168}Pt.

Table 12
direct p emission from ^{170}Au*, J^{π} = (2$^-$), $T_{1/2}$ = 286^{+50}_{-40} μs, BR_p = 89(10)%.

E_p(c.m.)	E_p(lab)	I_p(abs)	J^{π}_f	$E_{daughter}$(^{169}Pt)	coincident γ-rays
1.472(12)	1.463(12)	89(10)%	(7/2$^-$)	0.0	—

* All values from [2004Ke06].

Table 13
direct α emission from ^{170}Au*, J^{π} = (2$^-$), $T_{1/2}$ = 286^{+50}_{-40} μs, BR_{α} = 11(10)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_f	$E_{daughter}$(^{166}Ir)	coincident γ-rays	R_0 (fm)**	HF
7.170(10)	7.001(10)	89(10)%	(2$^-$)	0.0	—	1.5576(55)	2^{+25}_{-1}

* All values from [2004Ke06].
** Interpolated between 1.5578(45) ^{168}Pt and 1.5574(32) ^{172}Hg.

Table 14
direct p emission from ^{170m}Au*, Ex = 282(10) keV, J^{π} = (9$^+$), $T_{1/2}$ = 617^{+50}_{-40} μs, BR_p = 58(5)%.

E_p(c.m.)	E_p(lab)	I_p(abs)	J^{π}_f	$E_{daughter}$(^{169}Pt)	coincident γ-rays
1.753(6)	1.743(6)	58(5)%	(7/2$^-$)	0.0	—

* All values from [2004Ke06].

Table 15
direct α emission from ^{170m}Au*, Ex = 282(10) keV, J^{π} = (9^{+}) , $T_{1/2}$ = 617^{+50}_{-40} μs, BR_{α} = 42(5)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{166}Ir)	coincident γ-rays	R_0 (fm)**	HF
7.278(6)	7.107(6)	42(5)%	(9^{+})	0.172(6)		1.5576(55)	1.2(4)

* All values from [2004Ke06].
** Interpolated between 1.5578(45) ^{168}Pt and 1.5574(32) ^{172}Hg.

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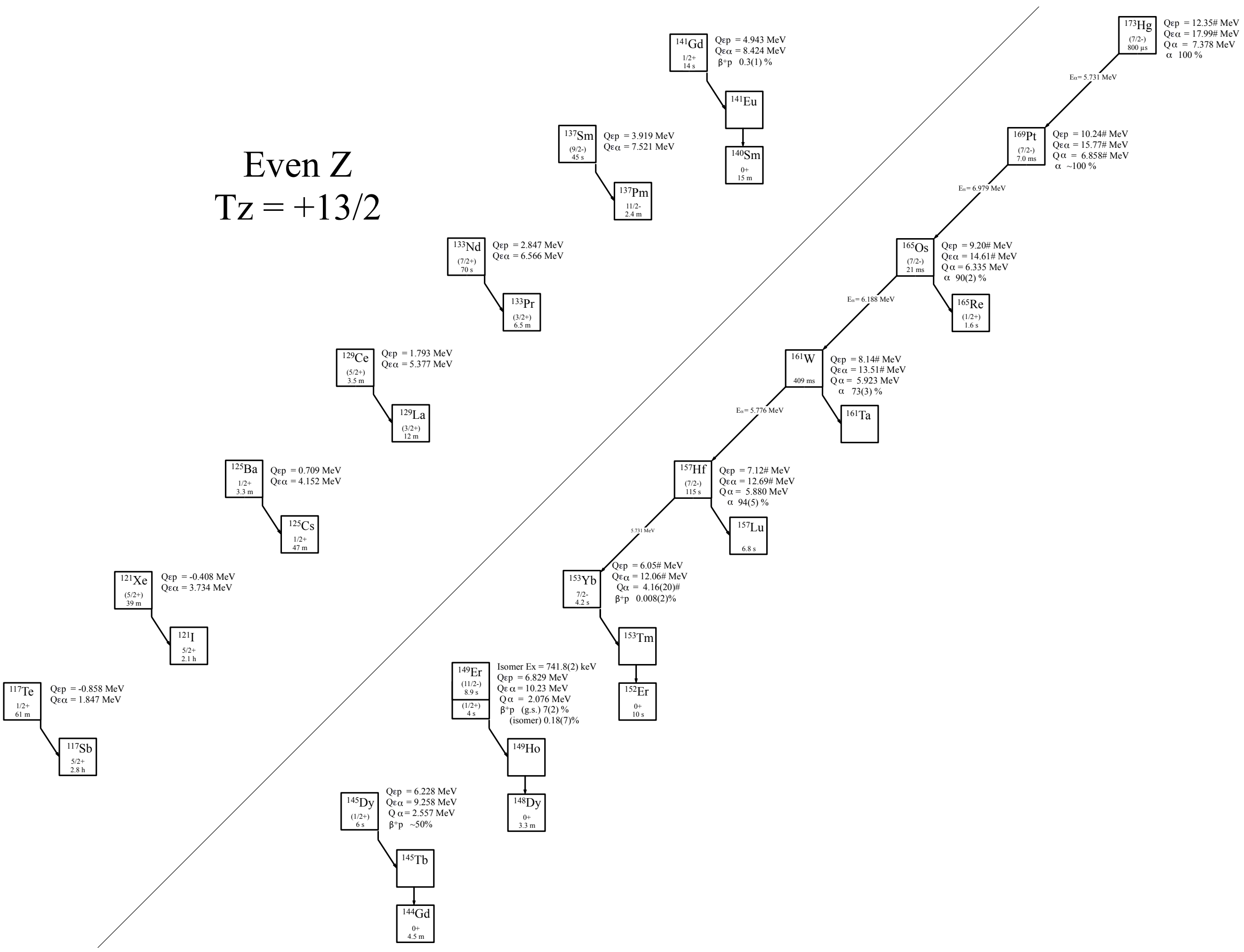

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +13/2 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +13/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{117}Te		1/2$^+$	61(2) m	3.544(13)	-0.858(13)	—	-10.137(13)	1.847(13)	[**1961Fi05**]
^{121}Xe		(5/2$^+$)	38.8(6) m	3.765(11)	-0.408(10)	—	-7.583(12)	3.734(13)	[**1969Bu07**]
^{125}Ba		1/2$^+$	3.3(4) m*	4.421(13)	0.709(11)		-6.304(12)	4.152(12)	[**1975Ar31, 1968Da09**]
^{129}Ce		(5/2$^+$)	3.5(3) m	5.040(40)	1.793(28)		-4.625(28)	5.377(29)	[**1993Al03**]
^{133}Nd		(7/2$^+$)	70(10) s	5.610(50)	2.847(51)		-3.141(54)	6.566(51)	[**1977Bo02**]
^{137}Sm		(9/2$^-$)	45(1) s	6.080(30)	3.919(31)		-1.634(31)	7.521(31)	[**1983AlZO**]
^{141}Gd		1/2$^+$	14(4) s	6.701(23)	4.943(23)	0.3(1)%	-0.301(24)	8.424(24)	[**1989Gi06**, 1986Wi15]
^{145}Dy		(1/2$^+$)	6(2) s	8.16(11)	6.228(29)	≈50%	1.421(13)	9.258(14)	[**1993To04**, 1984ScZT]
^{149}Er		(1/2$^+$)	4(2) s	7.900(30)	6.829(29)	7(2)%	2.423(29)	10.23(11)	[**1989Fi01**, 1984ScZT]
^{149m}Er*	0.7418(2)	(11/2$^-$)	8.9(2) s	8.642(30)	7.571(29)	0.18(7)%	3.165(29)	10.97(11)	[**1989Fi01**, 1984To07, 1984ScZT]
^{153}Yb		7/2$^-$	4.2(2) s	6.81(20)#	6.05(20)#	0.008(2)%	1.89(20)#	12.06(20)#	[**1988Wi05**]
^{157}Hf		(7/2$^-$)	115(1) s	7.59(20)#	7.12(20)#		3.19(20)#	12.69(20)#	[**1996Pa01**]
^{161}W			409(18) ms	8.27(20)#	8.14(20)#		4.62(20)#	13.51(20)#	[**1996Pa01**]
^{165}Os		(7/2$^-$)	21(1) ms	8.91(20)#	9.20(20)#		6.21(20)#	14.61(20)#	[**1996Pa01**]
^{169}Pt		(7/2$^-$)	7.0(2) ms	9.63(20)#	10.24(20)#		7.79(20)#	15.77(20)#	[**2004Ke04**]
^{173}Hg		(7/2$^-$)	0.80(8) ms	10.17(20)#	11.16(20)#		9.17(20)#	17.001(20)#	[**2012Od01**]

* Weighted average of 3.5(4) m [1975Ar31] and 3.0(5) m 1968Da09].

Table 2
Particle emission from the even-Z, T_z = +13/2 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{117}Te	5.562(14)	9.640(13)	0.808(14)		
^{121}Xe	6.023(18)	9.876(13)	0.190(17)		
^{125}Ba	5.217(14)	8.999(15)	0.387(15)		
^{129}Ce	4.951(61)	8.047(30)	0.957(30)		
^{133}Nd	4.394(55)	7.202(57)	1.530(54)		
^{137}Sm	4.111(75)	6.356(34)	1.916(55)		
^{141}Gd	3.527(55)	5.422(23)	2.343(35)		
^{145}Dy	3.163(29)	4.59(20)	2.557(21)		
^{149}Er	3.039(88)	4.12(29)	2.076(29)		
^{149m}Er	3.781(88)	4.86(29)	2.818(29)		
^{153}Yb	2.73(21)#	3.47(20)#	4.16(20)#		
^{157}Hf	2.44(21)#	2.93(20)#	5.880(3)	94(5)%*	[**1996Pa01. 1979Ho10**, 1989Wo02, 1981HoZM] 1973Ea01, 1965Ma14]
^{161}W	1.972(208)#	2.23(20)#	5.923(4)	73(3)%	[**1996Pa01. 1981Ho10**, 1989Ho02, 1981HoZM]
^{165}Os	1.563(208)#	1.42(21)#	6.335(6)	90(2)%	[**2008Bi15, 1996Pa01**. 2013Dr06, 2002Pa03 [1997Da07, 1991Se01, 1981Ho10, 1978Ca11, 1978CaZF, 1977Ca23]
^{169}Pt	1.087(208)#	0.54(22)#	6.858(5)	≈ 100%	[**2004Ke06, 1999Se14**, 2012Od01, 2009Go16] [2008Bi15, 1996Pa01, 1981Ho10]
^{173}Hg	0.632(208)#	-0.23(22)#	7.378(4)	100%	[**2012Od01**, 2009Sa27, 2004Ke04, 1999Se14] [1998NiZW]

* Weighted average of 95(5)% [1996Pa01] and 91(7)% [1979Ho10].

Table 3
direct α emission from ^{157}Hf, $T_{1/2}$= 115(1) s*, BR_α = 94(5)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}$(^{153}Yb)	coincident γ-rays	R_0 (fm)	HF
5.881(4)	5.731(4)***	94(5)%**	0.0	—	1.5573(31)	1643(14)

* [1996Pa01]
** Weighted average of 95(5)% [1996Pa01] and 91(7)% [1979Ho10].
** Weighted average of 5.729(4) MeV [1996Pa01] and 5.735(5) MeV [1979Ho10].

Table 4
direct α emission from ^{161}W*, $T_{1/2}$= 409(18) ms, BR_α = 73(3)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}$(^{157}Hf)	coincident γ-rays	R_0 (fm)	HF
5.923(5)	5.776(5)**	73(3)%	0.0	—	1.5636(62)	$1.80^{+0.28}_{-0.24}$

* All values from [1996Pa01], except where noted.
** Weighted average of 5.775(5) MeV [1996Pa01] and 5.777(5) MeV [1979Ho10], adjusted to 5.776(5) in [1991Ry01].

Table 5
direct α emission from ^{165}Os*, $T_{1/2}$= 21(1) ms, BR_α = 90(2)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}$(^{161}W)	coincident γ-ray	R_0 (fm)	HF
6.342(7)	6.188(7)	90(2)%**	0.0	—	1.5570(38)	0.41(4)

* All values from [1996Pa01], except where noted.
** [2008Bi15].

Table 6
direct α emission from ^{169}Pt*, $T_{1/2}$= 7.0(2) ms, BR_α = ≈ 100%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}$(^{165}Os)	coincident γ-rays	R_0 (fm)	HF
6.853(3)	6.691(3)	≈ 100%**	0.0	—	1.5602(24)	1.37(8)

* All values from [2004Ke06], except where noted.
** [1999Se14].

Table 7
direct α emission from ^{173}Hg*, $T_{1/2}$= 800(80) μs, BR_α = 100%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}$(^{169}Pt)	coincident γ-rays	R_0 (fm)	HF
7.379(5)	7.208(5)	100%	0.0	—	1.5524(75)	$1.22^{+0.23}_{-0.21}$

* All values from [2010Od01].

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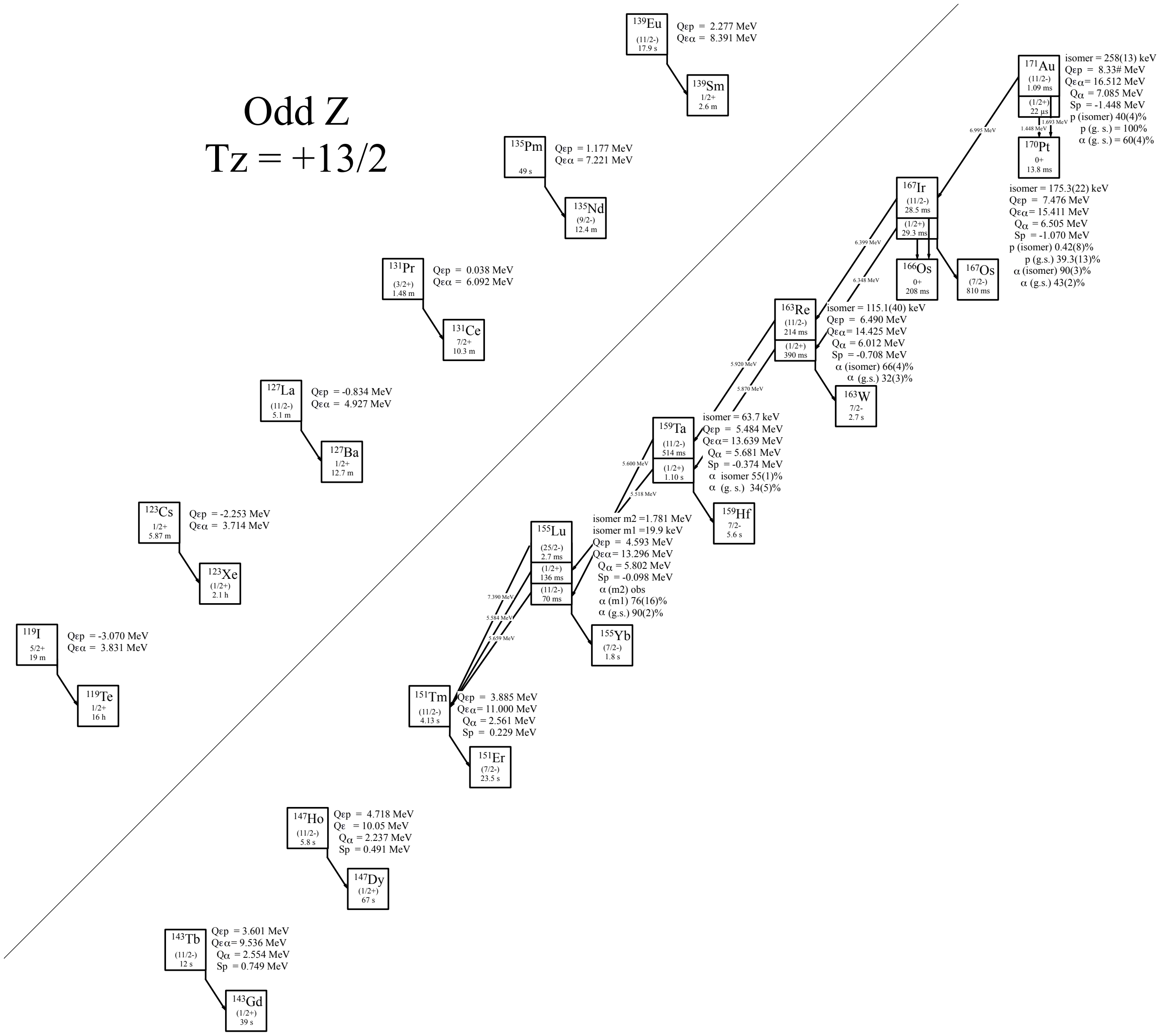

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +13/2 nuclei.

Last updated 3/22/23

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +13/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J$^{|pi}$ values for ^{119}I, ^{123}Cs, ^{127}La, ^{131}Pr, ^{135}Pm, ^{139}Eu, ^{143}Tb, ^{147}Ho, ^{151}Tm are taken from ENSDF

Nuclide	Ex	J^{π}	$T_{1/2}$	Q_{ε}	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{119}I		5/2^{+}	19.0(2) m*	3.405(23)	-3.070(22)	—	-7.958(22)	3.831(22)	[**1968Se05, 1969La33**]
^{123}Cs		1/2^{+}	5.87(5) m	4.205(15)	-2.253(13)	—	-7.078(29)	3.714(14)	[**1993Al03**]
^{127}La		(11/2^{-})	5.1(1) m	4.922(28)	-0.834(28)	—	-5.275(26)	4.927(28)	[**1992Ic02**]
^{131}Pr		(3/2^{+})	1.48(2) m	5.410(60)	0.038(54)		-3.818(48)	6.092(48)	[**1983AkZZ**]
^{135}Pm			49(3) s	6.150(90)	1.177(85)		-2.222(85)	7.221(89)	[**1989Ko07**]
^{139}Eu		(11/2^{-})	17.9(6) s	6.982(17)	2.227(18)		-0.392(18)	8.391(23)	[**1986De35**]
^{143}Tb		(11/2^{-})	12(1) s	7.81(21)	3.601(59)		0.937(52)	9.536(52)	[**1986Re11**]
^{147}Ho		(11/2^{-})	5.8(4) s	8.439(10)	4.718(45)		2.592(20)	10.05(20)	[**1982No08**]
^{151}Tm		(11/2^{-})	4.13(11) s	7.495(25)	3.885(16)		2.344(21)	11.000(21)	[**1988Ba02**]
^{155}Lu		(11/2^{-})	70(1) ms	7.958(25)	4.593(16)		3.344(21)	13.296(25)	[**1996Pa01**]
^{155m1}Lu	0.199(62)	(1/2^{+})	136(9) ms	7.978(25)	4.613(16)		3.364(21)	13.316(25)	**1996Pa01, 1997Da07**]
^{155m2}Lu	1.781(2)	(25/2^{-})	2.71(3) ms	9.739(25)	6.374(16)		5.125(21)	15.097(25)	**1996Pa01**]
^{159}Ta		(1/2^{+})	1.10(10) s	8.413(26)	5.484(17)		4.403(23)	13.639(26)	**1996Pa01**]
^{159m}Ta	0.0637(52)	(11/2^{-})	514(9) ms**	8.477(26)	5.548(18)		4.467(24)	13.703(26)	**1997Da07, 1996Pa01**]
^{163}Re		(1/2^{+})	390(72) ms	8.910(60)	6.490(64)		5.736(30)	14.425(25)	[**1997Da07**]
^{163m}Re	0.1151(40)	(11/2^{-})	214(5) ms	9.025(60)	6.605(64)		5.851(30)	14.540(25)	[**1997Da07**]
^{167}Ir		(1/2^{+})	29.3(6) ms	9.430(80)	7.476(88)		7.211(32)	15.411(61)	[**2005Sc22**]
^{167m}Ir	0.1753(22)	(11/2^{-})	28.5(6) ms***	9.650(80)	7.651(88)		7.386(32)	15.586(61)	[**2005Sc22, 2004Ke06, 1997Da07**]
^{171}Au		(1/2^{+})	22^{+3}_{-2} μs	9.900(80)#	8.33(10)#		8.583(33)#	16.512(84)	[**2004Ke06**]
^{171m}Au	0.258(13)	(11/2^{-})	1.09(3) ms	10.158(81)#	8.59(10)#		8.5841(35)#	16.770(85	[**2004Ke06**]

* Weighted average of 19.3(2) m [1968Se05] and 18.2(3) m [1969La33].
** Weighted average of 500(11) ms [1997Da07], and 544(16) ms [1996Pa01].
*** Weighted average of 30.0(6) ms [1997Da07], 25.7(8) ms [2004Ke06], and 28.7(33) ms [2005Sc22].

Table 2
Particle emission from the odd-Z, T_z = +13/2 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	BR_p	S_{2p}	Q_{α}	BR_{α}	Experimental
^{119}I	3.376(28)		9.716(23)	0.801(27)		
^{123}Cs	2.978(16)		9.376(13)	0.309(25)		
^{127}La	2.515(29)		8.384(27)	0.723(29)		
^{131}Pr	2.167(55)		7.555(52)	1.171(54)		
^{135}Pm	1.705(84)		6.703(84)	1.813(95)		
^{139}Eu	1.189(18)		5.903(19)	2.239(84)		
^{143}Tb	0.749(58)		5.071(53)	2.554(53)		
^{147}Ho	0.491(8)		3.94(11)	2.237(51)		
^{151}Tm	0.229(9)		3.704(23)	2.561(20)		
^{155}Lu	-0.098(8)		3.150(23)	5.802(2)	90(2)%	[**2016Ca42, 1997Da01, 1996Pa01, 1979Ho10**, 2018Pa37, 1998DiZY, 1993Li34, 1993ToZX,1991To09, 1990AbZW, 1989Ho12, 1989HoZX, 1984Gr14, 1981HoZM]
^{155m1}Lu	-0.078(10)		3.130(23)	5.822(6)	76(16)%	[**2016Ca42, 1997Da07, 1996Pa01, 1991To09**]
^{155m2}Lu	1.683(12)		1.369(23)	7.583(6)	obs	[**1996Pa01**, 2016Ca42, 1993Li34 1981HoZM]
^{159}Ta	-0.374(9)		2.578(23)	5.681(6)	34(5)%	**1997Da07, 1996Pa01**]
^{159m}Ta	-0.438(10)		2.514(24)	5.745(8)	55(1)%	**1997Da07, 1996Pa01**, 2002Ro17, 1979Ho10]
^{163}Re	-0.708(6)		1.802(31)	6.012(8)	32(3)%	[**1997Da07**]
^{163m}Re	-0.823(7)		1.687(31)	6.127(9)	66(4)%	[**1997Da07**, 1996Pa01, 1979Ho10]
^{167}Ir	-1.070(4)	39.3(13)%	0.991(30)	6.505(3)	43(2)%	[**2005Sc22, 1997Da07**, 2001Ke05, 1996Pa01, 1995DaZX, 1981Ho10]
^{167m}Ir	-1.185(6)	0.42(8)%	0.876(30)	6.620(5)	90(3)%	**2005Sc22, 2004Ke06, 1997Da07**, 1995DaZX,1981Ho10]
^{171}Au	-1.448(10)	100%	0.047(31)	7.085(11)		[**2004Ke06, 1999Po09**, 2003Bb21]
^{171m}Au	-1.706(16)	40(4)%*	-0.211(34)	7.343(17)	60(4)%*	[**2004Ke06, 1999Po09, 1997Da07**, 2003Bb21, 1995DaZX]

* Weighted average from [2004Ke06] BR_p = 34(4)% and [1997Da07]. BR_p = 46(4) %.

Table 3
direct α emission from ^{155}Lu, J^{π} = (11/2$^-$), $T_{1/2}$ = 70(1) ms*, BR_{α} = 90(2)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{151}Tm)	coincident γ-rays		
5.809(5)	5.659(5)***	90(2)%**	(11/2$^-$)	0.0	——	1.5533(22)	1.38(9)

* [1996Pa01]
** [1997Da07]
*** Weighted average of 5.661(5) MeV [2016Ca42], 5661(4) MeV [1997Da07], 5.655(5) [1996Pa01], and 5.656(6) MeV [1979Ho10].

Table 4
direct α emission from ^{155m1}Lu, Ex = 19.9(62) keV*, J^{π} = (1/2$^+$), $T_{1/2}$ = 136(9) ms**, BR_{α} = 76(16)%*.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{151}Tm)	coincident γ-rays		
5.732(4)	5.584(4)***	76(16)%**	(1/2$^+$)	0.096(9)$^{@}$		1.5533(22)	$1.6^{+0.6}_{-0.4}$

* [1997Da07]
** [1996Pa01]
*** Weighted average of 5.586(5) MeV [2016Ca42], 5.586(4) MeV [1997Da07], 5.584(5) [1996Pa01], and 5.579(5) MeV [1991To09].
$^{@}$ Deduced from isomer energy, and α energies of ground state and isomer.

Table 5
direct α emission from ^{155m2}Lu*, Ex = 1.781(2) MeV, J^{π} = (25/2$^-$), $T_{1/2}$ = 2.71(3) ms, BR_{α} = obs.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{151}Tm)	coincident γ-rays	
7.586(5)	7.390(5)	(11/2$^-$)	(11/2$^-$)	0.0?	——	1.5533(22)

* All values from [1996Pa01].

Table 6
direct α emission from ^{159}Ta, J^{π} = , $T_{1/2}$ = 1.10(10) s*, BR_{α} = 34(5) %**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{155m}Lu)	coincident γ-rays
5.660(4)	5.518(4)***	34(5) %	19.9(62)		

* [1996Pa01].
** [1997Da07].
*** Weighted average of 5.519(4) MeV [1997Da07] and 5.516(5) MeV [1996Pa01].

Table 7
direct α emission from ^{159m}Ta*, Ex = 63.7(52) keV, J^{π} = , $T_{1/2}$ = 514(9) ms**, BR_{α} = 55(1) %.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{155}Lu)	coincident γ-rays
5.746(3)	5.600(3)	55(1)%	0.0	——	

* All values from [1997Da07], except where noted.
** Weighted average of 500(11) ms [1997Da07], and 544(16) ms [1996Pa01].

Table 8
direct α emission from ^{163}Re*, J^{π} = , $T_{1/2}$ = 390(72) ms, BR_{α} = 32(3) %.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{159}Ta)	coincident γ-rays
6.018(4)	5.870(4)	32(30%	0.0	——	

* All values from [1997Da07].

Table 9
direct α emission from ^{163m}Re*, Ex = 115.1(40) keV, J^{π} = , $T_{1/2}$ = 214(5) ms, BR_{α} = 66(4)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{159m}Tm)	coincident γ-rays
6.069(3)	5.920(3)	66(4)%	0.0637(52)		

* All values from [1997Da07].

Table 10
direct p emission from ^{167}Ir*, J^{π} = , $T_{1/2}$ = 29.3(6) ms, BR_{p} = 39.3(13)%.

E_{p}(c.m.)	E_{p}(lab)	I_{p}(abs)	$E_{daughter}$(^{166}Os)	coincident γ-rays
1.068(6)	1.062(6)	39.3(13)%	0.0	——

* All values from [2015Sc22], except where noted.

Table 11
direct α emission from ^{167}Ir*, J^{π} = , $T_{1/2}$ = 29.3(6) ms , BR_{α} = 43(2)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{163}Re)	coincident γ-rays
6.504(3)	6.348(3)	43(2)%	0.0	——	

* All values from [2005Sc22].

Table 12
direct p emission from ^{167m}Ir*, Ex = 175.3(22) keV, J^{π} = , $T_{1/2}$ = 28.5(6) ms**, BR_{p} = 0.42(8)%.

E_{p}(c.m.)	E_{p}(lab)	I_{p}(abs)	$E_{daughter}$(^{166}Os)	coincident γ-rays
1.251(7)	1.243(7)***	0.42(8)%	0.0	——

* All values from [2005Sa22], except where noted.
** Weighted average of 30.0(6) [1997Da07], 25.7(8) ms [2004Ke06], and 28.7(33) ms [2005Sc22].
** Weighted average of 1.238(7) MeV [1997Da07], and 1.248)7) MeV [2005Sc22].

Table 13
direct α emission from ^{167m}Ir, Ex = 175.3(22) keV*, J^{π} = , $T_{1/2}$ = 28.5(6) ms**, BR_{α} = 90(3) %***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{163m}Re)	coincident γ-rays
6.556(3)	6.399(3)***	90(3)%	0.1151(40)		

* [1997Da07].
** Weighted average of 30.0(6) ms [1997Da07], 25.7(8) ms [2004Ke06], and 28.7(33) ms [2005Sc22].
*** [2005Sc22].
*** Weighted average of 6.410(3) MeV [1997Da07] and 6.394(2) MeV [2004Ke06].

Table 14
direct p emission from ^{171}Au*, J^{π} = , $T_{1/2}$ = 22^{+3}_{-2} μs, BR_{p} = 100%.

E_{p}(c.m.)	E_{p}(lab)	I_{p}(abs)	$E_{daughter}$(^{170}Pt)	coincident γ-rays
1.448(12)	1.439(12)	100%	0.0	——

* All values from [2004Ke06], except where noted.
** Weighted average of 1.437(12) MeV [2004Ke06] and 1.444(17) MeV [1999Po09].

Table 15
direct p emission from ^{171m}Au, Ex = 258(13) keV*, J$^{\pi}$ = , $T_{1/2}$ = 1.09(3) ms*, BR_p = 40(4)%**.

E_p(c.m.)	E_p(lab)	I_p(abs)	$E_{daughter}$(^{170}Pt)	coincident γ-rays
1.703(6)	1.693(6)***	40(4)%	0.0	——

* [2004Ke06].
** Weighted average of 34(4)% [2004Ke06], and 46(4)% [1997Da07].
*** Weighted average of 1.694(6) MeV [2004Ke06], and 1.692(6) MeV [1999Po09, 1997Da07].

Table 16
direct α emission from ^{171m}Au*, Ex = 258(13) keV, J$^{\pi}$ = , $T_{1/2}$ = 1.09(3) ms,BR_{α} = 60(4)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_f	$E_{daughter}$(^{167m}Ir)	coincident γ-rays
7.162(4)	6.995(4)	60(4)%	0.1753(22)		

* [2004Ke06].
** Weighted average from [2004Ke06] BR_{α} = 66(4)% and [1997Da07]. BR_{α} = 54(4) %.

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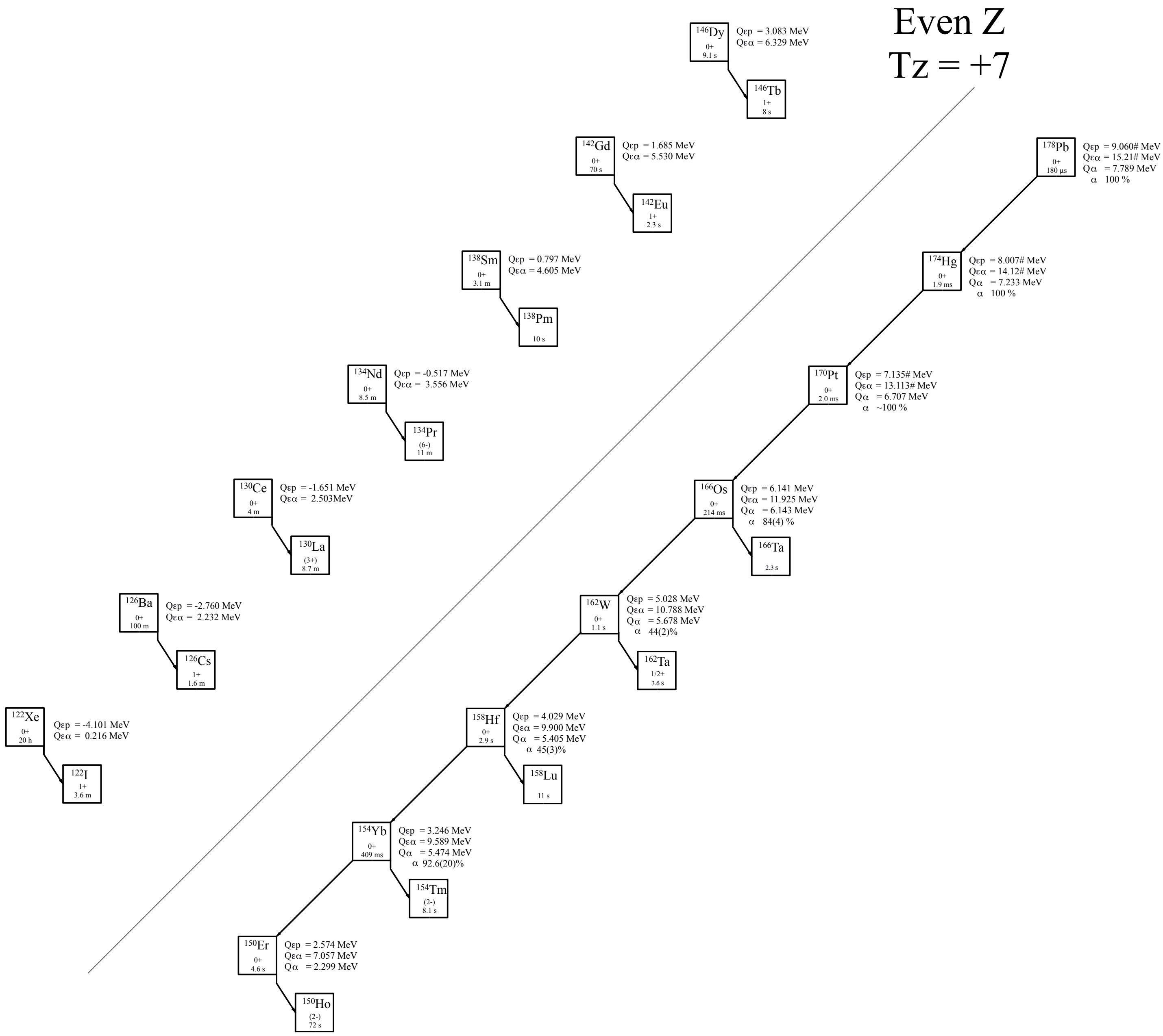

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +7 nuclei.

Last updated 3/23/23

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +7 nuclei. Unless otherwise stated, all Q-values and separation energies values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{122}Xe	0^+	20.1(1) h	0. 724(12)	-4.101(28)	——	-11.516(13)	0.216(12)	[**1965An05**]
^{126}Ba	0^+	100(2) m	1.681(16)	-2.760(13)	——	-9.883(13)	0.984(14)	[**1976Pa11**]
^{130}Ce	0^+	22.9(5) m	2.200(40)	-1.651(30)	——	-8.069(28)	2.503(30)	[**1996Xu04**]
^{134}Nd	0^+	8.5(15) m	2.882(24)	-0.517(20)	——	-6.501(38)	3.556(29)	[**1970Ab07**]
^{138}Sm	0^+	3.1(2) m	3.417(17)	0.797(17)		-4.735(16)	4.605(24)	[**1983GaZT**]
^{142}Gd	0^+	70.2(6) s	4.350(40)	1.685(29)		-3.325(37)	5.530(30)	[**1991Fi03**]
^{146}Dy	0^+	33.2(7) s	5.210(50)	3.083(21)		-1.514(13)	6.329(31)	[**1993Al03**]
^{150}Er	0^+	18.5(7) s	4.115(14)	2.574(19)		-1.872(21)	7.507(48)	[**1981NoZY**]
^{154}Yb	0^+	409(2) ms	4.495(14)	3.246(20)		-0.905(21)	9.589(22)	[**1996Pa01**]
^{158}Hf	0^+	2.85(7) s	5.110(15)	4.029(21)		0.154(23)	9.900(23)	[**1996Pa01**]
^{162}W	0^+	1.13(3) s*	5.780(60)	5.028(29)		1.693(60)	10.788(23)	[**1981Ho10, 2015Li24**]
^{166}Os	0^+	214(6) ms**	6.410(90)	6.141(31)		3.273(33)	11.925(66)	[**1996Pa01, 2015Li24**]
^{170}Pt	0^+	13.9(2) ms***	6.88(10)#	7.135(32)#		4.918(36)#	13.113(90)#	[**2004Ke06, 1998Ki20, 1996Bi07**]
^{174}Hg	0^+	$1.9^{+0.4}_{-0.3}$ ms	7.42(10)#	8.007(66)#		6.160(38)#	14.12(10)#	[**1999Se14, 1997Uu01**]
^{178}Pb	0^+	180^{+130}_{-50} μs$^@$	8.19(10)#	9.060(88)#		7.516(40)#	15.21(10)#	[**2016Ba60, 2003BaZO**]

* Weighted average of 1. 39(4) s [1981Ho10] and 0. 99(3) s [2015Li24].
** Weighted average of 220(7) ms [1996Pa01] and 210(6) ms [2015Li24].
*** Weighted average of 14. 0(2) ms [2004Ke06], 13. 5(3) ms [1998Ki20], 14. 7(5) ms [1996Bi07].
$^@$ Value from maximum likelihood method combining 2 events (147, 202 μs) from [2003BaZO] and 4 events (127, 166, 365, 588 μs) from [2016Ba60].

Table 2
Particle emission from the even-Z, T_z = +7 nuclei. Unless otherwise stated, all Q-values and separation energies values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{122}Xe	6.398(12)	10.571(11)	-0.089(21)	——	
^{126}Ba	5.869(15)	9.580(13)	0.260(17)		
^{130}Ce	5.388(35)	8.632(28)	0.822(31)		
^{134}Nd	4.998(17)	7.756(24)	1.352(30)		
^{138}Sm	4.714(18)	6.876(17)	1.724(17)		
^{142}Gd	4.323(31)	6.082(31)	2.113(30)		
^{146}Dy	3.44(11)	5.373(29)	1.980(29)		
^{150}Er	3.474(21)	4.550(19)	2.299(18)		
^{154}Yb	3.248(21)	4.010(19)	5.474(2)	92.6(20)%*	[**1996Pa01, 1988Vi02, 1979Ho10**, 1989Wo02, 1988KaZK, 1981HoZM, 1978AfZZ, 1977Ha48, 1964Ma45]
^{158}Hf	2.952(21)	3.415(20)	5.405(3)	45(3)%	[**1996Pa01, 1979Ho10**, 2000Di18, 1996HiZX, 1989Wo02, 1981HoZM, 1965Ma14]
^{162}W	2.510(30)	2.638(20)	5.678(2)	44(2)%	[**1996Pa01, 1981Ho10, 2015Li24** 1989Wo02, 1982De11, 1981HoZM, 1979Ho10, 1975To05, 1974Sc35]
^{166}Os	2.061(30)	1.774(20)	6.143(3)	84(4)%**	[**2015Li24, 2008Bi15, 1996Pa01, 1981Ho10**, 1991Se01, 1978Ca11, 1978ReZZ, 1977Ca23]
^{170}Pt	1.495(30)	0.882(21)	6.707(3)	≈ 100%	[**2004Ke06, 1998Ki20, 1996Bi07**, 2004GoZZ, 1997Uu01, 1993ToZY, 1982En03, 1981Ho10]
^{174}Hg	1.098(30)	0.112(22)	7.233(6)	100%***	[**1999Se14, 1997Uu01**, 2016Ba60, 2004GoZZ, 1998NiZW]
^{178}Pb	0.375(32)	-0.780(26)	7.789(13)	100%***	[**2016Ba60, 2003BaZO**]

* Weighted average of 92(2)% [1996Pa01], 92.8(20)% [1988Vi02], and 93(2)% [1979Ho10].
** [2008Bi15].
*** Not measured, inferred from $T_{1/2}$.

Table 3
direct α emission from ^{154}Yb, $J^\pi = 0^+$, $T_{1/2}$ = 409(2) ms*, BR_α = 90(3) %***.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{150}Er)	coincident γ-rays	R_0 (fm)	HF
5.474.4(21)**	5.332.2(21)	92.6(20)%***	0^+	0.0	——	1.5559(33)	1.0

* [1996Pa01].
** [1988Vi02].
*** Weighted average of 92(2)% [1996Pa01], 92.8(20)% [1988Vi02], and 93(2)% [1979Ho10].

Table 4
direct α emission from ^{158}Hf*, J^{π} = 0^{+}, $T_{1/2}$ = 2.85(7) s, BR_{α} = 45(3) %.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{154}Yb)	coincident γ-rays	R_0 (fm)	HF
5.406(4)	5.269(4)	45(3)%	0^{+}	0.0	—	1.5615(46)	1.0

* All values from [1996Pa01].

Table 5
direct α emission from ^{162}W, J^{π} = 0^{+}, $T_{1/2}$ = 1.13(3)s*, BR_{α} = 44(2) %**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{158}Hf)	coincident γ-rays	R_0 (fm)	HF
5.679(5)	5.539(5)***	44(2)%**	0^{+}	0.0	—	1.5712(39)	1.0

* Weighted average of 1.39(4) s [1981Ho10] and 0.99(3) s [2015Li24].
** [1996Pa01].
*** Weighted average of 5.541(5) MeV [1996Pa01] and 5.538(5) MeV [1981Ho10] adjusted to 5.537(5) MeV in [1991Ry01].

Table 6
direct α emission from ^{166}Os, J^{π} = 0^{+}, $T_{1/2}$ = 214(6) ms*, BR_{α} = 84(4) %**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{162}W)	coincident γ-rays	R_0 (fm)	HF
6.138(6)	5.991(6)***	44(2)%**	0^{+}	0.0	—	1.5690(43)	1.0

* Weighted average of 220(7) ms [1996Pa01] and 210(6) ms [2015Li24].
** [2008Bi15].
*** Weighted average of 6.000(6) MeV [1996Pa01] and 5.981(6) MeV [1981Ho10].

Table 7
direct α emission from ^{170}Pt, J^{π} = 0^{+}, $T_{1/2}$ = 13.9(2) ms*, BR_{α} = $\approx$ 100%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{166}Os)	coincident γ-rays	R_0 (fm)	HF
6.707(2)	6.549(2)***	$\approx$ 100%**	0^{+}	0.0	—	1.5648(11)	1.0

* Weighted average of 14.0(2) ms [2004Ke06], 13.5(3) ms [1998Ki20], 14.7(5) ms [1996Bi07].
** Not measured, inferred from $T_{1/2}$.
*** [2004Ke06].

Table 8
direct α emission from ^{174}Hg, J^{π} = 0^{+}, $T_{1/2}$ = $1.9^{+0.4}_{-0.3}$ ms*, BR_{α} = 100%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{170}Pt)	coincident γ-rays	R_0 (fm)	HF
7.233(6)	7.067(6)***	100%**	0^{+}	0.0	—	1.549^{+13}_{-10}	1.0

* [1999Se14].
** Not measured, inferred from $T_{1/2}$.
*** Weighted average of 7.066(8) MeV [1999Se14], 7.069(11) MeV [1997Uu01].

Table 9
direct α emission from ^{178}Pb, J^{π} = 0^{+}, $T_{1/2}$ = 180^{+130}_{-50} μs*, BR_{α} = 100%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{174}Hg)	coincident γ-rays	R_0 (fm)	HF
7.788(30)	7.613(30)***	100%**	0^{+}	0.0	—	1.557^{+68}_{-30}	1.0

* Value from maximum likelihood method combining 2 events (147, 202 μs) from [2003BaZO] and 4 events (127, 166, 365, 588 μs) from [2016Ba60].
** Not measured, inferred from $T_{1/2}$.
*** Weighted average of 7.615(30) MeV [2003BaZO], and 7.610(30) MeV [2016Ba60].

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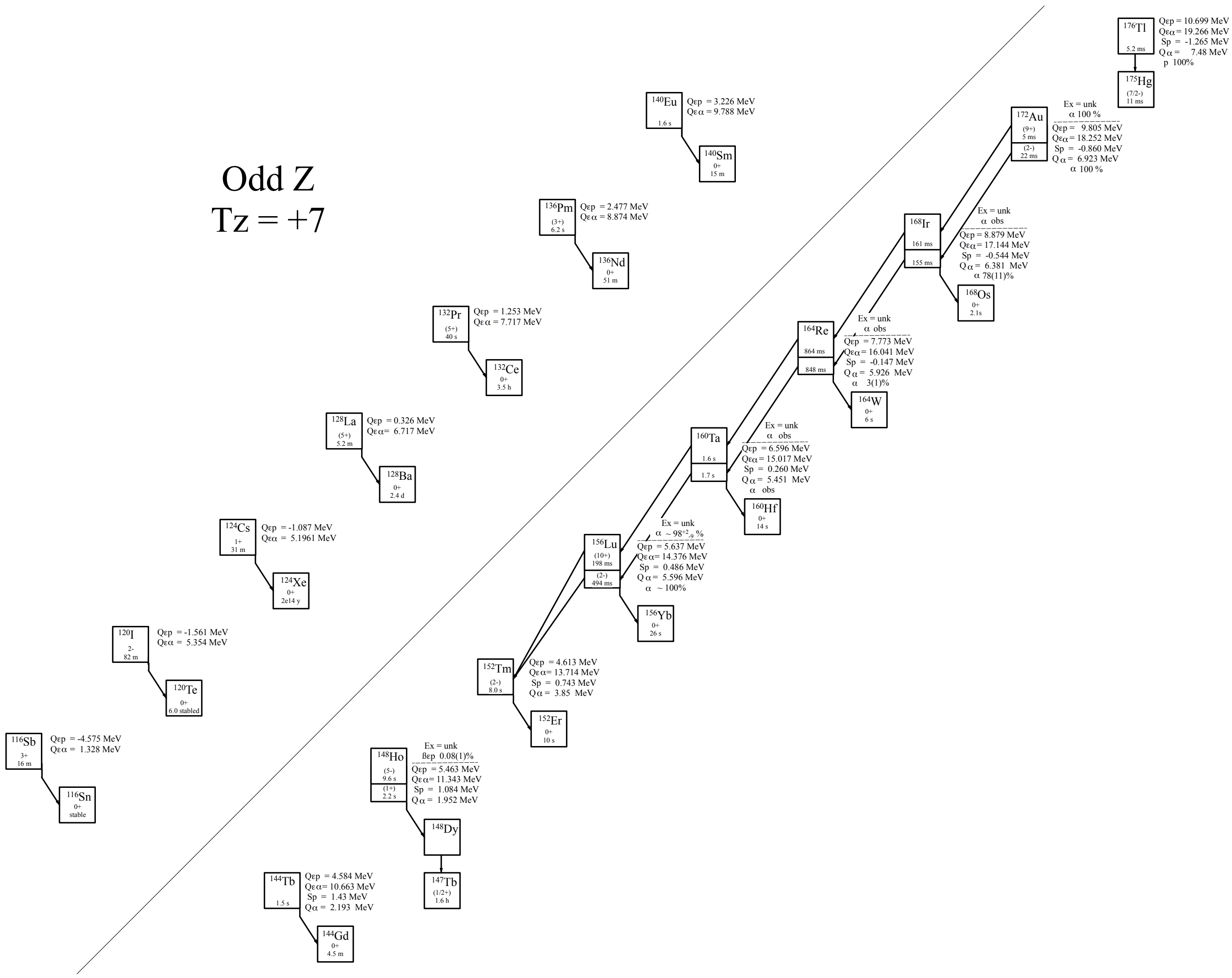

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +7 nuclei.

Last updated 3/23/23

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +7 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. All J^{π} values are taken from ENSDF.

Nuclide	Ex	J^{π}	$T_{1/2}$	Q_{ε}	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{116}Sb		3^+	16.2(12) m	4.704(5)	-4.575(5)	—	-11.385(5)	1.328(5)	[**1967Ha27**]
^{120}I		2^-	81.7(2) m	5.615(15)	-1.561(17)	—	-6.672(15)	5.354(15)	[**2000Ho19**]
^{124}Cs		1^+	30.9(5) m	5.926(9)	-1.087(10)	—	-6.006(9)	5.196(9)	[**1993Al03**]
^{128}La*		(5^+)	5.2(4) m	6.740(50)	0.326(55)		-4.057(54)	6.617(54)	[**1977Zo02**]
^{132}Pr		(2^-)	1.6(3) m	7.240(40)	1.253(40)		-2.549(29)	7.717(29)	[**1987Ko24**]
^{136}Pm*		(2^+)	30-150 s	8.030(70)	2.477(70)		-0.915(72)	8.874(72)	[**1989Vi04**]
^{140}Eu		1^+	1.51(2) s	8.470(50)	3.226(53)		0.453(53)	9.788(53)	[**1991Fi03**]
^{144}Tb			1.5(10) s	9.390(40)	4.584(30)		2.036(28)	10.663(31)	[**1982No08**]
^{148}Ho		(1^+)	2.2(1) s	9.870(80)	5.463(84)		3.517(84)	11.343(88)	[**1982No08**]
^{148m}Ho	x	(5^-)	9.59(15) s	9.870(80)+x	5.463(84)+x	0.08(1)%	3.517(84)+x	11.343(88)+x	[**1988To03**]
^{152}Tm		(2^-)	8.0(10) s	8.780(50)	4.613(55)		3.011(54)	13.714(55)	[**1982No13**]
^{156}Lu		(2^-)	494(12) ms	9.570(50)	5.637(55)		4.327(54)	14.376(55)	[**1996Pa01**]
^{156m}Lu	x	(10^+)	198(2) ms	9.570(50)+x	5.637(55)+x		4.327(54)+x	14.376(55)+x	[**1996Pa01**]
^{160}Ta*			1.7(2) s	10.120(60)	6.596(66)		5.608(55)	15.017(55)	[**1996Pa01**]
^{160m}Ta	x		1.55(4) s	10.120(60)+x	6.596(66)+x		5.608(55)+x	15.017(55)+x	[**1996Pa01**]
^{164}Re			848^{+140}_{-105} ms	10.760(60)	7.773(67)		7.118(55)	16.041(55)	[**2009Ha42**]
^{164m}Re	x		864^{+150}_{-110} ms	10.760(60)+x	7.773(67)+x		7.118(55)+x	16.041(55)+x	[**2009Ha42**]
^{168}Ir			155(40) ms**	11.330(60)#	8.879(68)#		8.643(56)#	17.144(56)	[**2009Ha42, 1996Pa01**]
^{168m}Ir	x		161(21) ms	11.330(60)#	8.879(68)#		8.643(56)#	17.144(56)+x	[**2009Ha42, 1996Pa01**]
^{172}Au			22^{+6}_{-4} ms	11.790(60)	9.805(68)		10.030(57)	18.252(57)	[**2009Ha42**]
^{172m}Au	x		5(1) ms***	11.790(60)	9.805(68)		10.030(57)	18.252(57)+x	**2009Ha42, 1996Pa01, 1993Se09**]
^{176}Tl			$5.2^{+3.0}_{-1.4}$ ms	12.370(80)	10.699(92)		11.324(84)	19.266(84)	[**2004Ke06**]

* Possibly isomeric state.
** Weighted average of 222^{+60}_{-45} ms [2009Ha42] and 125(40) ms [1996Pa01].
*** Weighted average of 9^{+2}_{-1}ms [2009Ha42], 6.3(15) ms [1996Pa01], and 4(1) ms [1993Se09].

Table 2
Particle emission from the odd-Z, T_z = +7 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	BR_p	S_{2p}	Q_{α}	BR_{α}	Experimental
^{116}Sb	4.077(5)		12.830(5)	-1.257(7)		
^{120}I	3.854(17)		10.329(15)	0.650(16)		
^{124}Cs	3.782(13)		10.240(11)	-0.419(18)		
^{128}La*	3.096(56)		8.853(55)	0.691(55)		
^{132}Pr	2.808(44)		8.178(39)	0.973(62)		
^{136}Pm*	2.245(72)		7.220(72)	1.633(75)		
^{140}Eu	1.895(53)		6.650(53)	1.759(86)		
^{144}Tb	1.43(20)		5.637(41)	2.193(59)		
^{148}Ho	1.084(84)		4.805(95)	1.952(88)		
^{148m}Ho	1.084(84)-x		4.805(95)-x	1.952(88)+x		
^{152}Tm	0.743(56)		4.352(56)	3.85(10)		
^{156}Lu	0.486(57)		3.850(56)	5.596(3)	≈ 100%	[**1996Pa01**, 1991PoZZ, 1981HoZM, 1979Ho10]
^{156m}Lu**	0.486(57)-x		3.850(56)-x	5.596(3)+x	98^{+2}_{-9}%	[**2019Pa27, 1996Pa01**, 1991PoZZ, 1981HoZM, 1979Ho10]
^{160}Ta	0.260(57)		3.189(56)	5.451(5)	obs	[**1996Pa01**]
^{160m}Ta	0.260(57)-x		3.189(56)-x	5.451(5)+x	obs	[**1996Pa01**, 1992Ha10, 1988MeZY, 1987HaZO, 1987ScZH, 1986Ru05, 1981HoZM, 1979Ho10
^{164}Re	-0.147(80)		2.269(84)	5.926(5)	obs	[**2009Ha42, 1996Pa01, 1979Ho10**, 1981Ho10, 1979Ho10]
^{164m}Re**	-0.147(80)-x		2.269(84)-x	5.926(5)+x	3(1)%	[**2009Ha42**]
^{168}Ir	-0.544(98)		1.41(10)	6.381(9)	obs	[**2009Ha42, 1996Pa01**, 1982De11, 1981DeZA, 1981DeZL, 1978Ca11, 1978CaZF]
^{168m}Ir	-0.544(98)-x		1.41(10)-x	6.381(9)+x	78(11)%**	[**2009Ha42, 1996Pa01**]
^{172}Au	-0.860(99)		0.71(12)	6.923(10)	100%	[**2009Ha42**]
^{172m}Au	-0.860(99)-x	<2%	0.71(12)-x	6.923(10)+x	100%	[**2009Ha42, 1996Pa01, 1993Se09**]
^{176}Tl	-1.265(18)	100%	-0.07(13)	7.48(10)		[**2004Ke06**]

* Possibly isomeric state.
** Weighted average of 75(11)% [2009Ha42] and 82(14)% [1996Pa01].

Table 3
direct α emission from ^{156}Lu*, J^{π} = (2^{-}), $T_{1/2}$ = 494(12) ms, BR_{α} = ≈ 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{152}Tm)	coincident γ-rays
5.593(10)	5.450(10)	≈ 100%	(2^{-})	0.0	—

* All values from [1996Pa01].

Table 4
direct α emission from ^{156m}Lu*, Ex = unk., J^{π} = (10^{+}), $T_{1/2}$ = 198(2) ms, BR_{α} = 98^{+2}_{-9}%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{152}Tm)	coincident γ-rays
5.589(5)	5.446(5)	0.057(10)%	0.056(10)%		0.1148(5)	0.115
5.707(4)	5.561(4)	100%	98^{+2}_{-9}%	(9^{+})	0.0	—

* All values from [2019Pa27], except where noted.
** [1996Pa01].

Table 5
direct α emission from ^{160}Ta*, J^{π} = , $T_{1/2}$ = 1.7(2) s, BR_{α} = obs.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{156}Lu)	coincident γ-rays
5.449(5)	5.313(5)	obs			

* All values from [1996Pa01].

Table 6
direct α emission from ^{160m}Ta*, Ex = unk., J^{π} = , $T_{1/2}$ = 198(2) ms, BR_{α} = obs.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{156}Lu)	coincident γ-rays
5.552(5)	5.413(5)	obs		**	

* All values from [1996Pa01].
** α-α coincident with 5.561 MeV α from ^{156m}Lu.

Table 7
direct α emission from ^{164}Re*, J^{π} = , $T_{1/2}$ = 848^{+140}_{-105} ms**, BR_{α} = obs.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{160}Ta)	coincident γ-rays
5.926(7)	5.781(7)***	obs			

* All values from [2009Ha42], except where noted.
** Other values: 38(16) ms [1996Pa01], 880(240) ms [1979Ha10].
*** Weighted average of 5.780(10) MeV [2009Ha42], 5.784(7) MeV [1996Pa01], and 5.778(10) MeV [1979H010].

Table 8
direct α emission from ^{164m}Re*, Ex = unk., J^{π} = , $T_{1/2}$ = 864^{+150}_{-110} ms, BR_{α} = 3(1)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{160}Ta)	coincident γ-rays
5.764(10)	5.623(10)	3(1)%		**	

* All values from [2009Ha421].
** α-α coincident with 5.413 MeV α from ^{160m}Ta.

Table 9
direct α emission from ^{168}Ir, J^π = , $T_{1/2}$ = 155(40) ms*, BR_α = obs.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{164}Re)	coincident γ-rays
6.381(10)	6.229(10)**	obs			

* Weighted average of 222^{+60}_{-45} ms [2009Ha42] and 125(40) ms [1996Pa01].
** Weighted average of 6.230(10) MeV [2009Ha42], and 6.227(15) MeV [1996Pa01].

Table 10
direct α emission from ^{168m}Ir*, Ex = unk., J^π = , $T_{1/2}$ = 161(21) ms**, BR_α = 78(11)%***.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{164}Re)	coincident γ-rays
6.474(10)	6.320(10)	42(11)%	22(10)%		@	
6.413(10)	6.260(10)	100%	53(5)%		@	0.069

* All values from [2009Ha421], except where noted.
** [1996Pa01].
*** Weighted average of 75(11)% [2009Ha42] and 82(14)% [1996Pa01].
@ α-α coincident with 5.623 MeV α from ^{164m}Re.

Table 11
direct α emission from ^{172}Au, J^π = , $T_{1/2}$ = 22^{+6}_{-4} ms, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{168}Ir)	coincident γ-rays
6.923(10)	6.762(10)	100%			

* All values from [2009Ha42].

Table 12
direct α emission from ^{172m}Au*, Ex = unk., J^π = , $T_{1/2}$ = 5(1) ms**, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(rel)***	I_α(abs)***	J^π_f	$E_{daughter}$(^{168}Ir)	coincident γ-rays
6.962(10)	6.800(10)	18(8)%	15(7)%		@	
7.034(10)	6.870(10)	100%	85(7)%		@	0.073, 0.065

* All values from [2009Ha421], except where noted.
** Weighted average of 9^{+2}_{-1}ms [2009Ha42], 6.3(15) ms [1996Pa01], and 4(1) ms [1993Se09].
*** Based on Fig. 2e of [2009Ha42].
@ α-α coincident with 6.260 MeV α from ^{168m}Ir.

Table 13
direct p emission from ^{176}Tl, J^π = , $T_{1/2}$ = $5.2^{+3.0}_{-1.4}$ ms, BR_p = 100%.

E_p(c.m.)	E_p(lab)	I_p(abs)	J^π_f	$E_{daughter}$(^{175}Hg)	coincident γ-rays
1.265(18)	1.258(18)	100%		0.0	

* All values from [2004Ke06].

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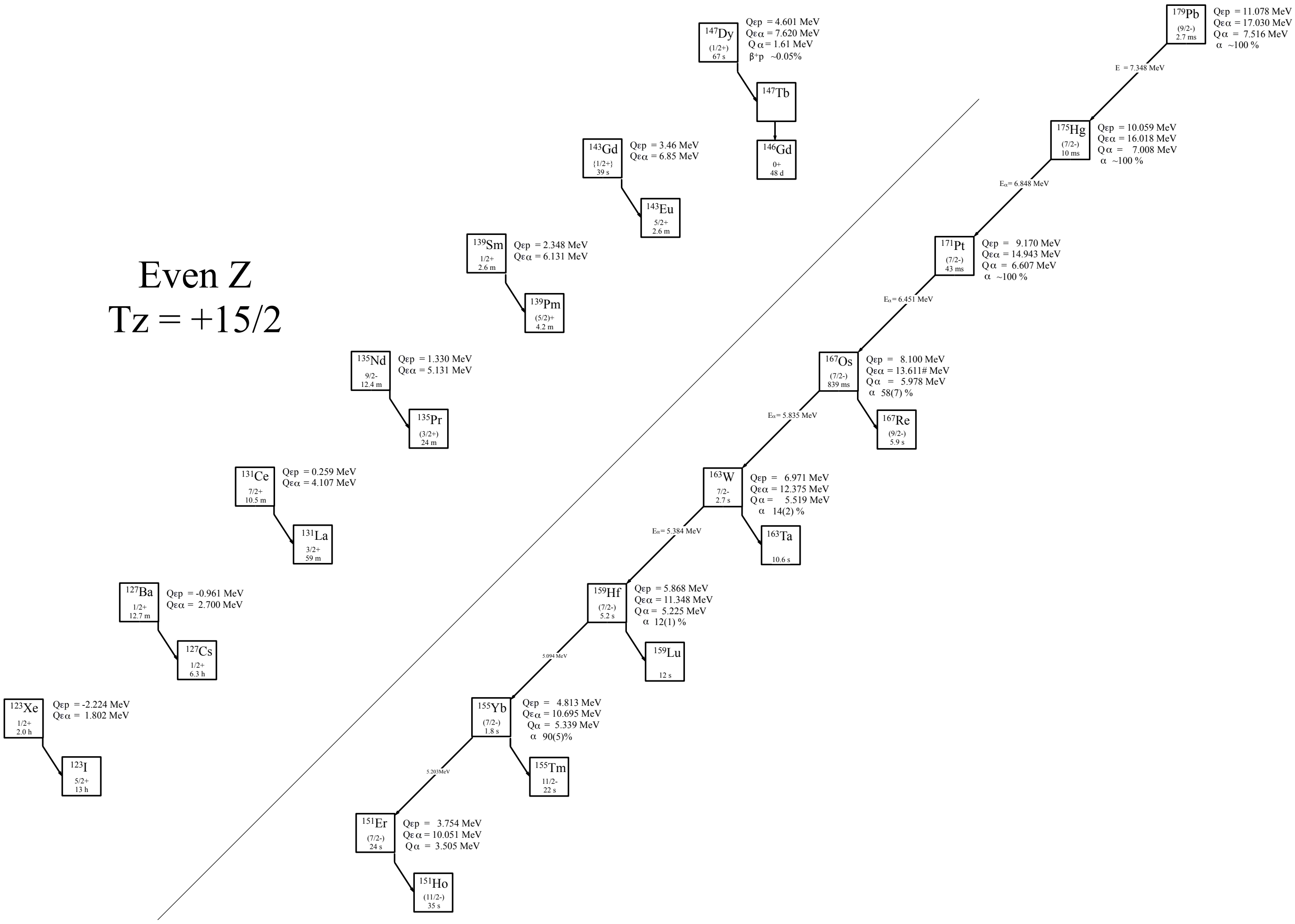

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +15/2 nuclei.

Last updated 12/8/22

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +15/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J$^{|pi}$ values for ^{123}Xe, ^{127}Ba, ^{131}Ce, ^{135}Md ^{139}Sm, ^{143}Gd, ^{147}Dy, ^{151}Er are taken from ENSDF

Nuclide	J^{π}	$T_{1/2}$	Q_{ε}	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{123}Xe	1/2$^+$	2.040(9) h	2.694(10)	-2.224(10)	—	-10.227(10)	1.802(12)	[**2021Ze01**]
^{127}Ba	1/2$^+$	12.7(4) m	3.422(13)	-0.961(11)		-8.560(11)	2.700(12)	[**1976Be11**]
^{131}Ce	7/2$^+$	10.5(6) m	4.060(40)	0.259(33)		-6.787(33)	4.107(33)	[**1966No05**]
^{135}Nd	9/2$^-$	12.4(6) m	4.722(22)	1.330(28)		-5.297(34)	5.131(34)	[**1975Wi11**]
^{139}Sm	1/2$^+$	2.57(10) m	5.121(17)	2.348(16)		-3.756(14)	6.131(16)	[**1982De06**]
^{143}Gd	(1/2$^+$)	39(2) s	6.01(20)	3.46(20)		-2.29(20)	6.85(20)	[**1978Fi02**]
^{147}Dy	(1/2$^+$)	67(7) s	6.547(12)	4.601(10)	≈0.05%	-0.782(9)	7.620(14)	[**1984To07**, 1988WiZN]
^{151}Er	(7/2$^-$)	23.8(20) s*	5.356(18)	3.754(17)		-1.356(17)	10.051(18)	[**1988Ba02, 1970To16**
^{155}Yb	(7/2$^-$)	1.79(2) s**	6.123(19)	4.813(17)		-0.068(17)	10.695(19)	[**1991To08, 1996Pa01**]
^{159}Hf	(7/2$^-$)	5.2(1) s	6.860(40)	5.868(19)		1.279(33)	11.348(20)	[**1996Pa01**]
^{163}W	7/2$^-$	2.7(1) s***	7.630(70)	6.971(59)		3.076(65)	12.375(70)	[**2010Sc02, 1979Ho10, 1973Ea01**]
^{167}Os	(7/2$^-$)	839(5) ms	8.340(90)	8.100(81)		4.771(82)	13.611(89)#	[**2010Sc02**]
^{171}Pt	(7/2$^-$)	43(3) ms	8.950(90)	9.170(82)		6.365(82)	14.943(90)	[**1996Pa01**]
^{175}Hg	(7/2$^-$)	10.2(4) ms$^{@}$	9.430(90)	10.059(82)		7.721(82)	16.018(90)	[**2017Ba46, 2002Ro17**]
^{179}Pb	(9/2$^-$)	2.7(2) ms	10.320(90)	11.078(82)		9.019(82)	17.030(90)	[**2017Ba46**]

* Weighted average of 23(2) s [1970To16] and 24.6(20)s [1988Ba02].
** Weighted average of 1.75(5) s [1991To08] and 1.80(2) s [1996Pa01].
*** Weighted average of 2.6(1) s [2010Sc02], 3.0(2) s [1979Ho10] and 2.5(3) s [1973Ea01].
$^{@}$ Weighted average of 9.6(4) ms [2017Ba46], and 10.8(4) ms [2002Ro17].

Table 2
Particle separation and emission from the even-Z, T_z = +15/2 nuclei. Unless otherwise stated, all Q-values and separation energies values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_{α}	BR_{α}	Experimental
^{123}Xe	6.458(11)	11.283(28)	-0.491(12)	—	
^{127}Ba	5.756(15)	10.197(11)	0.005(15)		
^{131}Ce	5.370(42)	9.226(34)	0.685(35)		
^{135}Nd	4.975(28)	8.373(25)	1.070(38)		
^{139}Sm	4.755(16)	7.374(16)	1.408(22)		
^{143}Gd	4.211(203)	6.88(20)	1.72(20)		
^{147}Dy	3.721(46)	5.847(22)	1.61(20)		
^{151}Er	3.609(22)	5.150(19)	3.505(19)		
^{155}Yb	3.364(22)	4.614(19)	5.339(2)	90(5)%	[**1996Pa01, 1991To08, 1979Ho10, 1977Ha48**, 1992Al18, 1992AlZM, 1992AlZY, 1990KaZM, 1990Po13, 1989KaYU, 1988KaZK, 1987KaZI, 1982Bo04, 1981HoZM, 1980Da09, 1978AfZZ, 1973BoXL, 1973BoXW, 1964Ma45]
^{159}Hf	2.929(23)	4.011(20)	5.225(3)	12(1)%	[**1996Pa01, 1992Ha10, 1979Ho10**, 1983Fa03, 1996HiZX, 1981HoZM, 1978Ca11, 1973To02, 1973ToZU, 1972ToZC, 1996HiZX, 1996HiZX, 1972ToZL]
^{163}W	2.416(86)	3.171(63)	5.519(5)*	14(2)%**	[**2010Sc02, 1996Pa01, 1979Ho10, 1975To01, 1973Ea01**, 1978Ca11, 1982De11, 1981DeZA, 1981DeZL, 1981HoZM, 1973Ea011975To05, 1972EaZU]
^{167}Os	1.95(12)#	2.215(85)#	5.978(5)***	58(7)%$^{@}$	[**2010Sc22, 1996Pa01, 1982En03, 1981Ho10**, 2009Od02, 1978Ca11, 1978ReZZ, 1977Ca13]
^{171}Pt	1.57(13)	1.322(85)	6.607(3)	≈ 100%$^{@@}$	[**1996Pa01, 1981De22, 1981Ho10**, 2010Sc02, 2006Jo04, 2005Jo18, 2003Ba32, 2002Ro17, 1997Uu01, 1993ToZY, 1982En03, 1981DeZB]
^{175}Hg	1.20(13)	0.61(10)	7.008(4)$^{@@@}$	≈ 100%$^{@@}$	[**2017Ba46, 2002Ro17**, 1997Uu01, 1996Pa01, 1984ScZQ, 1983Sc24]
^{179}Pb	0.62(13)	-0.25(12)	7.516(4)^{a}	≈ 100%$^{@@}$	[**2017Ba46**, 2010An01]

* Deduced from α energy, 5.520(60) in [2021Wa16].
** Weighted average of 15(2)% [2010Sc22], and 13(2)% [1996Pa01].
*** Deduced from α energy, 5.985(56)# in [2021Wa16].
$^{@}$ Weighted average of 58(12)% [1981Ho10], 76(10% [1982En03], and 49(7)% [1996Pa01].
$^{@@}$ Inferred from half-life.
$^{@@@}$ Deduced from α energy, 7.072(5) in [2021Wa16].
^{a} Deduced from α energy, 7.596(5) in [2021Wa16].

Table 3
direct α emission from ^{155}Yb, $T_{1/2}$= 1.79(2) s*, BR_α = 90(5)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)***	$E_{daughter}$(^{151}Er)	coincident γ-rays	R_0 (fm)	HF
5.341(4)	5.203(4)**	90(5)%**	0.0	—–	1.5767(66)	$1.79^{+0.26}_{-0.24}$

* Weighted average of 1.75(5) s [1991To08] and 1.80(2) s [1996Pa01].
** [1991To08].
*** Weighted average of 5.202 MeV [1991To08], 5.206(5) MeV [1979Ho10], and 5.202(10) MeV [1977Ha48] (adjusted to 5.203(10) MeV in [1991Ry01]).

Table 4
direct α emission from ^{159}Hf, $T_{1/2}$= 5.2(1) s*, BR_α = 12(1)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)***	$E_{daughter}$(^{155}Yb)	coincident γ-rays	R_0 (fm)	HF
5.226(5)	5.094(5)***	12(1)%**	0.0	—–	1.5552(96)	$0.96^{+0.21}_{-0.19}$

* [1996Pa01].
** [1979Ho10].
*** Weighted average of 5.095(5) MeV [1979Ho10] (adjusted to 5.094(10) MeV in [1991Ry01]) , 5.088(6) MeV [1992Ha10], and 5.098(5) MeV [1996Pa01].

Table 5
direct α emission from ^{163}W, $T_{1/2}$= 2.7(1) s*, BR_α = 14(2)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)***	$E_{daughter}$(^{159}Hf)	coincident γ-rays	R_0 (fm)	HF
5.519(5)	5.383(5)***	14(2)%**	0.0	—–	1.568(13)	$1.5^{+0.5}_{-0.4}$

* Weighted average of 2.6(1) s [2010Sc02], 3.0(2) s [1979Ho10] and 2.5(3) s [1973Ea01]
** Weighted average of 15(2)% [2010Sc22], and 13(2)% [1996Pa01].
*** Weighted average of 5.385(5) MeV [1973Ea01], 5.383(6) MeV [2010Sc02], 5383(6) MeV [1996Pa01] and 5.384(5) MeV [1979Ho10] (adjusted to 5.382(5) MeV in [1991Ry01]).

Table 6
direct α emission from ^{167}Os, $T_{1/2}$= 839(5) ms*, BR_α = 58(7)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)***	$E_{daughter}$(^{163}W)	coincident γ-rays	R_0 (fm)	HF
5.978(5)	5.835(5)***	58(7)%**	0.0	—–	1.5653(46)	$1.30^{+0.23}_{-0.19}$

* [2010Sc02].
** Weighted average of 58(12)% [1981Ho10], 76(10% [1982En03], and 49(7)% [1996Pa01].
*** [1996Pa01].

Table 7
direct α emission from ^{171}Pt, $T_{1/2}$= 43(3) ms*, BR_α = $\approx$ 100%**.

E_α(c.m.)	E_α(lab)	I_α(abs)***	$E_{daughter}$(^{167}Os)	coincident γ-rays	R_0 (fm)	HF
6.607(4)	6.453(4)***	$\approx$ 100%**	0.0	—–	1.5607(30)	1.34(13)

* [1996Pa01].
** Inferred from half-life.
*** Weighted average of 6.453(4) MeV [1981De22] and 6.448(5) MeV [1981Ho10], (adjusted to 6452(5) MeV in [1991Ry01]).

Table 8
direct α emission from ^{175}Hg, $T_{1/2}$= 10.2(4) ms*, BR_α = ≈ 100%**.

E_α(c.m.)	E_α(lab)	I_α(abs)***	$E_{daughter}$(^{171}Pt)	coincident γ-rays	R_0 (fm)	HF
7.008(4)	6.848(4)***	≈ 100%**	0.0	—–	1.5469(98)	$1.02^{+0.22}_{-0.19}$

* Weighted average of 9.6(4) ms [2017Ba46], and 10.8(4) ms [2002Ro17].
** Inferred from half-life.
*** [2017Ba46].

Table 9
direct α emission from ^{179}Pb*, $T_{1/2}$= 2.7(2) ms, BR_α = ≈ 100%**.

E_α(c.m.)	E_α(lab)	I_α(abs)***	$E_{daughter}$(^{175}Hg)	coincident γ-rays	R_0 (fm)	HF
7.516(4)	7.348(5)	≈ 100%**	0.0	—–	1.532(20)	$1.6^{+0.8}_{-0.5}$

* All values from [2017Ba46].
** Inferred from half-life.

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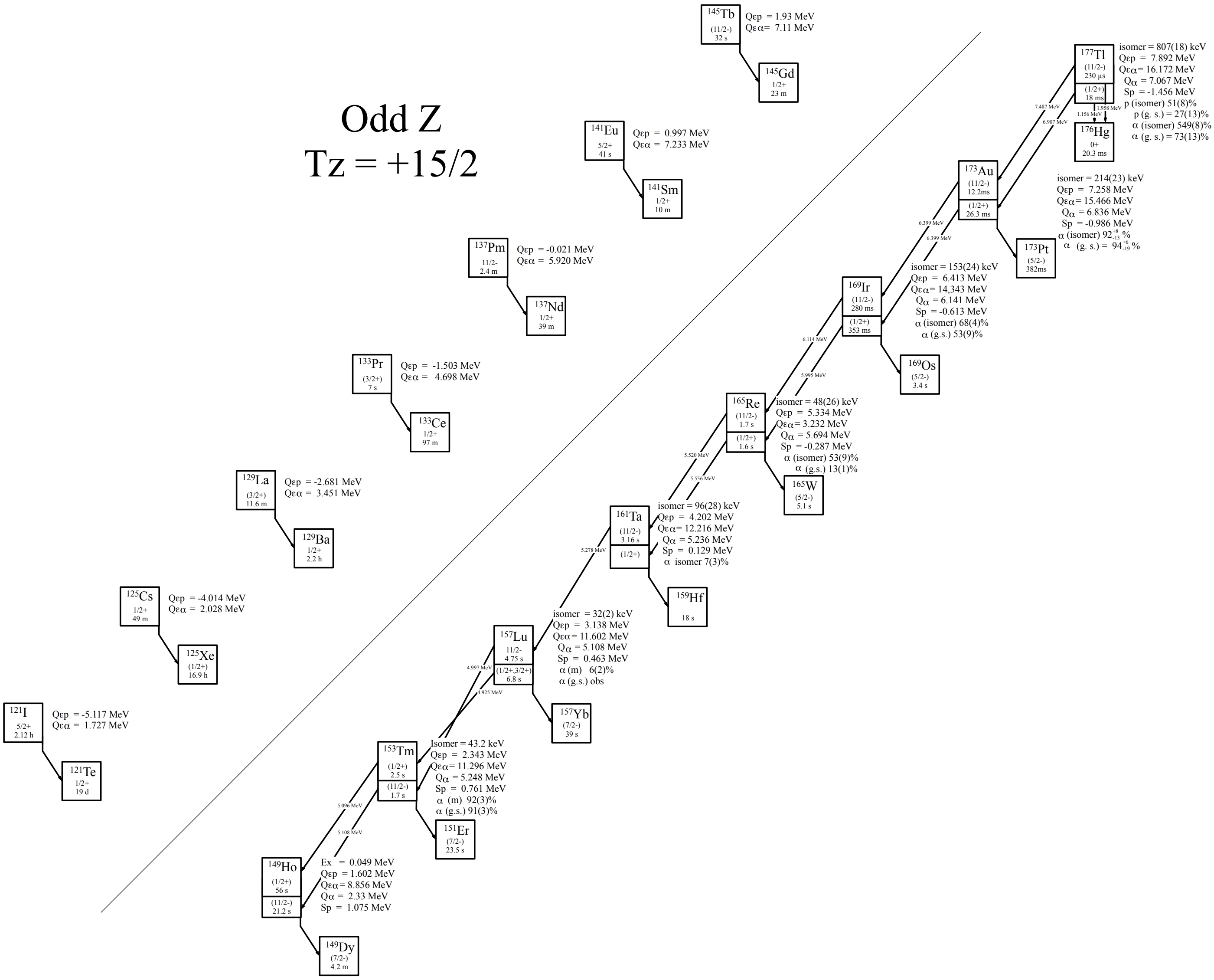

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +15/2 nuclei.

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +15/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. $J^{|pi}$ values for ^{121}I, ^{125}Cs, ^{129}La, ^{133}Pr, ^{137}Pm, ^{141}Eu, ^{145}Tb, ^{149}Ho, are taken from ENSDF.

Nuclide	Ex	J^{π}	$T_{1/2}$	Q_{ε}	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{121}I		5/2$^+$	2.12(1) h	2.297(26)	-5.117(9)	—	-10.759(5)	1.727(5)	[**1965An05**]
^{125}Cs		1/2$^+$	49(5) m	3.110(8)	-4.014(8)	—	-9.497(8)	2.028(27)	[**1962Pr09**]
^{129}La		(3/2$^+$)	7(3) s	3.737(22)	-2.681(22)	—	-7.581(21)	3.451(21)	[**1970Ab07**]
^{133}Pr		(3/2$^+$)	6.5(3) m	4.481(21)	-1.500(40)	—	-5.837(13)	4.698(16)	[**1972ArZP**]
^{137}Pm		11/2$^-$	2.4(1) m	5.511(18)	-0.021(17)	—	-4.034(17)	5.920(21)	[**1975No08**]
^{141}Eu		5/2$^+$	41.4(7) s	6.008(14)	0.997(27)		-2.487(30)	7.233(17)	[**1993Al03**]
^{145}Tb*		(11/2$^-$)	31.6(6) s	6.53(11)	1.93(11)		-1.460(111)	7.11(11)	[**1992Al03**]
^{149}Ho		(11/2$^-$)	21.1(2) s	6.048(13)	1.602(15)		-0.867(12)	8.856(23)	[**1993Al03**]
^{153}Tm		(11/2$^-$)	1.7(2) s	6.494(13)	2.343(16)		0.202(12)	11.296(15)	[**1989Ko02**]
^{153m}Tm	0.0432(2)	(1/2$^+$)	2.5(2) s	6.537(13)	2.386(16)		0.245(12)	11.337(15)	[**1988ScZV, 1989Ko02**]
^{157}Lu		(1/2$^+$, 3/2$^+$)	6.8(5) s**	7.012(14)	3.138(17)		1.191(14)	11.602(15)	[**1991Le15, 1991To09**]
^{157m}Lu	0.032(2)	(11/2$^-$)	4.75(10) s	7.044(14)	3.170(17)		1.223(14)	11.634(15)	[**1991Le15**]
^{161}Ta		(1/2$^+$)		7.540(30)	4.202(62)		2.477(30)	12.216(27)	
^{161m}Ta	0.096(28)***	(11/2$^-$)	3157^{+74}_{-79} ms	7.636(41)	4.298(68)		2.573(41)	12.312(39)	[**2005Sc22**]
^{165}Re		(1/2$^+$)	1.6(6) s	8.248(30)	5.334(37)		4.032(35)	13.232(33)	[**2012Th13**]
^{165m}Re	0.048(26)	(11/2$^-$)	1.74(6) s	8.200(40)	5.382(45)		4.080(44)	13.280(42)	[**2012Th13, 1999Po09**]
^{169}Ir		(1/2$^+$)	3.53(4) s	8.630(30)	6.413(39)		5.422(30)	14.343(35)	[**2005Sc22**]
^{169m}Ir	0.153(24)	(11/2$^-$)	280(3) ms	8.783(38)	6.567(46)		5.575(38)	14.496(42)	[**2005Sc22, 1999Po09**]
^{173}Au		(1/2$^+$)	26.3(12) ms	9.100(70)	7.258(40)		6.887(29)	15.466(35)	[**2012Th13**]
^{173m}Au	0.214(23)	(11/2$^-$)	12.2(1) ms	9.314(74)	7.472(46)		7.101(37)	15.680(42)	[**2012Th13, 1999Po09**]
^{177}Tl		(1/2$^+$)	18(5) ms	9.440(90)	7.892(40)		7.791(29)	16.172(67)	[**1999Po09**]
^{177m}Tl	0.807(18)	(11/2$^-$)	230(40) μs	10.247(92)	8.699(44)		8.598(34)	16.979(69)	[**1999Po09**]

* Possibly not the ground state.
** Weighted average of 9.6(8) s [1991Le5] and 5.7(5) s [1991To09].
*** From Q_{α} values for ^{161,161m}Ta [2012Th13] and 32(3) keV for the excitation energy of ^{157m}Lu.

Table 2
Particle separation and emission from the odd-*Z*, T_z = +15/2 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	BR_p	S_{2p}	Q_α	BR_α	Experimental
^{121}I	4.172(4)	—	11.348(8)	-0.031(10)	—	
^{125}Cs	3.711(8)	—	10.725(9)	-0.269(9)	—	
^{129}La	3.243(21)	—	9.661(22)	0.341(23)		
^{133}Pr	2.758(24)	—	8.746(31)	0.961(25)		
^{137}Pm	2.163(18)	—	7.715(18)	1.440(18)		
^{141}Eu	1.759(18)	—	7.003(19)	1.722(18)		
^{145}Tb*	1.929(114)	—	6.74(11)	1.10(11)		
^{149}Ho	1.075(12)	—	5.481(14)	2.33(11)		
^{153}Tm	0.761(12)	—	4.928(15)	5.248(1)	91(3)%	[**1989Ko02, 1982De11, 1982Bo04, 1996Pa01**, 1989Wo02, 1988To13, 1988ScZW, 1988ScZO, 1988ScZV, 1979Be52, 1979Ho10, 1978AfZZ, 1973BoXL, 1973BoXW]
^{153m}Tm	0.718(12)	—	4.885(15)	5.291(1)	92(3)%	[**1988To13, 1988ScZV, 1989Ko02**, 1996Pa01, 1989Wo02, 1988ScZW, 1988ScZO, 1982Bo04, 1982De11, 1979Be52, 1979Ho10, 1978AfZZ, 1973BoXL, 1973BoXW]
^{157}Lu	0.463(12)	—	4.392(16)	5.108(3)	obs	[**1991Le15, 1991To09**, 1993ToZY]
^{157m}Lu	0.431(12)	—	4.360(16)	5.140(3)	6(2)%	[**1996Pa01, 1991Le15, 1992Ha10, 1983To01, 1979Ho10**, 1991Le15, 1991To09, 1993ToZY, 1981HoZM, 1979Al16, 1979Be52, 1979BeYR, 1978AfZZ, 1977Ha49, 1972GaZR]
^{161}Ta	0.129(23)	—	3.648(45)	5.406(28)**		
^{161m}Ta	0.031(36)	—	3.552(53)	5.332(37)	7(3)%	[**2012Th13, 2005Sc22, 1996Pa01, 1992Ha10, 1979Ho10**, 1986Ru05, 1988MeZY, 1987HaZO, 1984Gr14, 1981HoZM]
^{165}Re	-0.287(23)		2.703(45)	5.694(6)	14(8)%	[**2012Th13**], 2005Sc22]
^{165m}Re	-0.335(35)		2.655(52)	5.742(27)	13(1)%	[**2012Th13**, 2005Sc22, 1996Pa01, 1981Ho10]
^{169}Ir	-0.613(22)		1.838(46)	6.141(4)	53(9)%***	[**2012Th13, 2005Sc22, 1999Po05**, 1996Pa01, 1984ScZQ, 1981DeZA, 1978Ca11, 1978CaZF, 1978ReZZ]
^{169m}Ir	-0.766(33)		1.685(52)	6.294(24)	68(4)%$^{@}$	[**2012Th13, 2005Sc22, 1999Po05, 1996Pa01**]
^{173}Au	-0.986(21)		0.998(45)	6.891(4)$^{@@}$	94^{+6}_{-19} %	[**2012Th13, 1999Po09**, 2001Ko14, 1996Pa01, 1984ScZQ, 1983Sc24]
^{173m}Au	-1.200(31)		0.784(51)	7.105(23)	92^{+8}_{-13} %	[**2012Th13, 1999Po09**, 2001Ko14]
^{177}Tl	-1.156(19)	27(13)%	0.51(44)	7.067(7)	73(13)%	[**1999Po09**]
^{177m}Tl	-1.963(26)	51(8)%	-0.30(44)	7.874(19)	49(8)%	[**1999Po09**, 2004Ke04]

* Possibly not the ground state.
** Deduced from α energy, 5.236(24) in [2021Wa16].
*** Weighted average of 50(18)% [1999Po09], 57(9)% [2012Th13], and 42(15)% [2005Sc22].
$^{@}$ Weighted average of 84(8)% [1999Po09], 78(6)% [2012Th13], 72(13)% [1996Pa01], and 59(4)% [2005Sc22].
$^{@@}$ Deduced from α energy, 6.836(5) in [2021Wa16].

Table 3
direct α emission from ^{153}Tm, $T_{1/2}$= 1.7(2) s*, BR_α = 91(3)%*.

E_α(c.m.)	E_α(lab)	I_α(abs)*	$E_{daughter}$(^{149}Ho)	coincident γ-rays	R_0 (fm)	HF
5.247(2)	5.110(2)**	91(3)%	0.0	—	1.5621(20)	1.40(18)

* [1989Ko02]
** Weighted average of 5.111(2) MeV [1982De11], 5.103(3) MeV [1982Bo04] (adjusted to 5.108(3) in [1991Ry02]), and 5.112(5) MeV [1996Pa01].

Table 4
direct α emission from ^{153m}Tm*, Ex = 43.2(2) keV**, $T_{1/2}$= 2.5(2) s***, BR_α = 92(3)%**.

E_α(c.m.)	E_α(lab)	I_α(rel)***	I_α(abs)***	$E_{daughter}$(^{149}Ho)	coincident γ-rays	R_0 (fm)	HF
4.709(10)	4.586(10)	@	@	0.564	0.344, 0.171	1.5621(20)	$<6.4\times10^3$
5.034(15)	4.902(15)	@@	@@	0.220	0.171	1.5621(20)	$<1.6\times10^4$
5.233(4)	5.096(4)	100%	≈ 100%	0.049		1.5621(20)	1.76(17)

* All values from [1988To13], unless otherwise stated.
** [1989Ko02].
*** [1988ScZV].
@ [1988To13] lists this transition as a possible doublet to the 5/2$^+$ 564 keV state from both the 11/2$^-$ ground state and 1/2$^+$ isomer, however the change in spin greatly favors decay from the 1/2$^+$ isomer. I_α4.586/I_α(5.096 + 5.108) = 4.5(6)$\times$0^{-5} [1988To13].
@@ [1988To13] lists this transition as a possible doublet to the 3/2$^+$ 220 keV keV state from both the 11/2$^-$ ground state and 1/2$^+$ isomer, however the change in spin greatly favors decay from the 1/2$^+$ isomer. I_α4.902/ I_α(4.586 + 5.108) = 1.8(4)$\times10^{-5}$ [1988To13].

Table 5
direct α emission from ^{157}Lu*, $T_{1/2}$= 6.8(5) s**, BR_α = obs.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}$(^{153}Tm)	coincident γ-rays
5.054(5)	4.925(5)	obs	0.043	

* All values from [1991Le15], except where noted.
** Weighted average of 9.6(8) s [1991Le5] and 5.7(5) s [1991To09].

Table 6
direct α emission from ^{157m}Lu, Ex = 32(2) keV*, $T_{1/2}$= 4.75(10) s*, BR_α = 6(2)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}$(^{153}Tm)	coincident γ-rays	R_0 (fm)	HF
5.129(2)	4.998(2)***	6(2)%	0.0	——	1.5787(76)	$2.7^{+1.5}_{-0.8}$

* [1991Le15].
** [1979Ho10].
*** Weighted average of 4.997(4) MeV [1996Pa01], 4.998(5) MeV [1991Le15], 4.995(6) MeV [1992Ha10], 4.999(5) MeV [1983To01] (adjusted to 5.003(3) in [1991Ry02]), and 4.994(5) MeV [1979Ho10] (adjusted to 4.999(3) in [1991Ry02]).

Table 7
direct α emission from ^{161m}Ta, Ex = 96(28) keV, $T_{1/2}$= 3157^{+74}_{-79} ms*, BR_α = 7(3)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}$(^{157}Lu)	coincident γ-rays	R_0 (fm)	HF
5.278(2)	5.147(2)***	6(2)%	0.032	——	1.560(11)	$0.7^{+0.7}_{-0.3}$

* [2005Sc22].
** [2012Th13].
*** Weighted average of 5.140(7) MeV [1996Pa01], 5.149(5) MeV [1992Ha10], 5.142(6) MeV [2012Th13], 5.151(4) MeV [2005Sc22], and 5.148(5) MeV [1996Ru05].

Table 8
direct α emission from ^{165}Re*, $T_{1/2}$= 1.6(6) s, BR_α = 14(8)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}$(^{161}Ta)	coincident γ-rays	R_0 (fm)	HF
5.694(6)	5.556(6)	14(8)%	0.0	——	1.566(11)	2^{+4}_{-1}

* All values from [2012Th13].

Table 9
direct α emission from ^{165m}Re*, Ex = 48(26) keV**, $T_{1/2}$= 1.74(6) s, BR_α = 13(1)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}$(^{161}Ta)	coincident γ-rays	R_0 (fm)	HF
5.657(6)	5.520(6)	13(1)%	0.096		1.566(11)	$1.5\ ^{+0.4}_{-0.3}$

* All values from [2012Th13], except where noted.
** [1999Po09].

Table 10
direct α emission from ^{169}Ir, $T_{1/2}$= 353(4) ms*, BR_α = 53(9)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}$(^{165}Re)	coincident γ-rays	R_0 (fm)	HF
6.141(4)	5.995(4)***	53(9)%**	0.0	—–	1.5639(39)	$1.0\ ^{+0.6}_{-0.3}$

* [2012Th13].
** Weighted average of 50(18)% [1999Po09], 57(9)% [2012Th13], and 42(15)% [2005Sc22].
*** Weighted average of 6.005(8) MeV [1999Po09], and 5.993(4) MeV [2005Sc22].

Table 11
direct α emission from ^{169m}Ir*, Ex = 153(24) keV**, $T_{1/2}$= 280(3) ms***, BR_α = 68(4)%*$^{@}$.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}$(^{165}Re)	coincident γ-rays	R_0 (fm)	HF
6.263(3)	6.114(3)$^{@@}$	68(4)%***	0.048		1.5639(39)	1.85(18)

* All values from [2012Th13], except where noted.
** [1999Po09].
*** [2005Sc22].
$^{@}$ Weighted average of 84(8)% [1999Po09], 78(6)% [2012Th13], 72(13)% [1996Pa01], and 59(4)% [2005Sc22].
$^{@@}$ Weighted average of 6.106(5) MeV [1999Po09], 6.119(9) MeV [1996Pa01], and 6.117(3) MeV [2005Sc22].

Table 12
direct α emission from ^{173}Au, $T_{1/2}$= 26.3(12) ms*, BR_α = 94^{+6}_{-19} %*.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}$(^{169}Ir)	coincident γ-rays	R_0 (fm)	HF
6.891(4)	6.732(4)**	94^{+6}_{-19} %*	0.0	—–	1.5529(80)	$2.9^{+0.6}_{-0.5}$

* [2012Th13].
** [1999Po09].

Table 13
direct α emission from ^{173m}Au, Ex = 214(23) keV*, $T_{1/2}$= 12.2(1) ms**, BR_α = 92^{+8}_{-13} %**.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}$(^{169}Ir)	coincident γ-rays		
6.891(4)	6.732(4)*$^{@}$	92^{+8}_{-13} %**	0.153		1.5529(80)	$1.43^{+0.27}_{-0.24}$

* [1999Po09].
** [2012Th13].

Table 14
direct α emission from ^{177}Tl*, $T_{1/2}$= 18(5)ms, BR_α = 73(13)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}$(^{173}Au)	coincident γ-rays	R_0 (fm)	HF
7.067(7)	6.907(7)	73(13)%	0.0	—–	1.545(21)	$1.6^{+1.2}_{-0.8}$

* All values taken from [1999Po09].

Table 15
direct p emission from ^{177}Tl*, $T_{1/2}$= 18(5)ms, BR_p = 27(13)%.

E_p(c.m.)	E_p(lab)	I_p(abs)	$E_{daughter}$(^{176}Hg)	coincident γ-rays
1.163(20)	1.156(20)	27(13)%	0.0	—

* All values taken from [1999Po09].

Table 16
direct α emission from ^{177m}Tl*, Ex = 807(18) keV, $T_{1/2}$= 230(40) μs, BR_α = 49(8)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}$(^{173}Au)	coincident γ-rays	R_0 (fm)	HF
7.660(13)	7.487(13)	49(8)%	0.214		1.545(21)	$2.2^{+1.4}_{-1.0}$

* All values taken from [1999Po09].

Table 17
direct p emission from ^{177m}Tl*, Ex = 807(18) keV, $T_{1/2}$= 230(40) μs, BR_p = 51(8)%.

E_p(c.m.)	E_p(lab)	I_p(abs)	$E_{daughter}$(^{176}Hg)	coincident γ-rays
1.969(10)	1.958(10)	51(8)%	0.0	—

* All values taken from [1999Po09].

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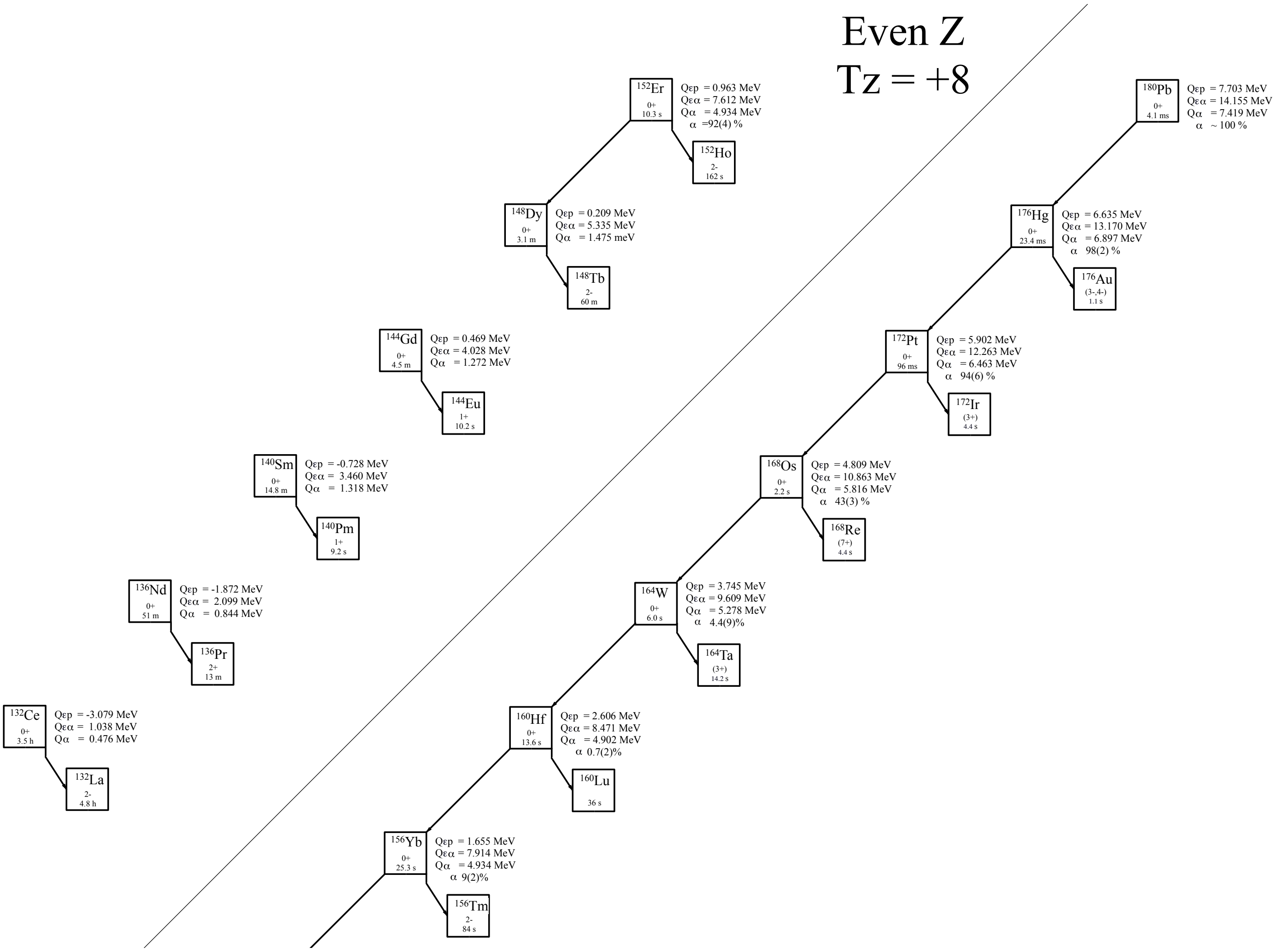

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +8 nuclei.

Last updated 3/23/23

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +8 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{132}Ce	0^+	3.51(11) h	1.250(40)	-3.079(20)		-10.147(22)	1.038(21)	[**1976Ge10**]
^{136}Nd	0^+	50.65(33) m	2.141(16)	-1.872(16)		-8.559(23)	2.099(38)	[**1975Br16**]
^{140}Sm	0^+	14.82(10) m	2.756(27)	-0.728(30)		-6.905(16)	3.460(17)	[**1972De23**]
^{144}Gd	0^+	4.47(6) m	3.860(30)	0.469(28)		-5.196(37)	4.028(37)	[**1991Tu01**]
^{148}Dy	0^+	3.1(1) m	2.678(10)	0.209(9)		-5.320(11)	5.335(14)	[**1975To03**]
^{152}Er	0^+	10.3(1) s	3.104(10)	0.963(9)		-3.972(12)	7.612(15)	[**1982Bo04**]
^{156}Yb	0^+	25.3(5) s*	3.569(13)	1.655(11)		-3.204(12)	7.914(16)	[**2011Es03, 1983Mi01, 1982To14, 1979Ho10, 1970To16**]
^{160}Hf	0^+	13.6(2) s	4.330(60)	2.606(20)		-1.813(27)	8.471(17)	[**1995Hi12**]
^{164}W	0^+	6.0(3) s**	5.047(30)	3.745(27)		0.018(76)	9.609(58)	[[**1979Ho10, 1975To05, 1973Ea01**]
^{168}Os	0^+	2.2(1)*** s	5.800(30)	4.809(21)		1.525(30)	10.863(30)	[**1996Pa01, 1982En03**]
^{172}Pt	0^+	96(3) ms	6.270(30)	5.902(21)		3.219(15)	12.263(33)	[**1996Pa01**]
^{176}Hg	0^+	21.3(8) ms$^@$	6.740(30)	6.635(22)		4.423(16)	13.170(34)	[**2009An20, 2004GoZZ, 2002Ro17, 1999To11, 1999Po09**]
^{180}Pb	0^+	4.1(3) ms	7.450(70)	7.703(31)		5.784(16)	14.155(35)	[**2010Ra12**]

* Weighted average of 24(1) s[1970To16], 26.1(7) s [2011Es03], 25.8(10) s [1977Ha48], 26.0(5) s [1978AfZZ], 23.6(13) s [1983Mi01], and 23(1) s [1982To14].
** Weighted average of 6.3(5) s [1973Ea01], 5.5(5) s [1975To05], 6.4(8) s [1979Ho10].
*** Weighted average of 2.2(1) s [1982En03], and 2.1(1) s [1996Pa01].
$^@$ Weighted average of 20(3) ms [2009An20], 22(1) ms [2004GoZZ], 20(2) ms [2002Ro17], 20(3) ms [1999To11], and 21(4) ms [1999Po09].

Table 2
Particle separation and emission from the even-Z, T_z = +8 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{132}Ce	5.988(35)	9.790(20)	0.476(20)		
^{136}Nd	5.552(17)	8.944(24)	0.844(24)		
^{140}Sm	5.244(18)	8.017(17)	1.318(17)		
^{144}Gd	4.807(30)	7.356(28)	1.272(31)		
^{148}Dy	4.406(12)	6.352(10)	1.475(29)		
^{152}Er	4.166(12)	5.769(10)	4.934(2)	92(4)%*	[**1982Bo04, 1982De11, 1987To02, 1979Ho10**, 1982Ba75, 1982To14, 1981HoZM, 1977Ha48, 1970To16
^{156}Yb	3.929(14)	5.239(11)	4.810(4)	9(2)%	[**1996Pa01, 1983Mi01, 1982To14, 1979Ho10, 1978AfZZ, 1977Ha48, 1979To16**, 2011Es03, 1970ToZS, 1970ToZU]
^{160}Hf	3.519(39)	4.507(12)	4.902(3)	0.7(2)%	[**1995Hi12, 1992Ha10**, 1996Pa01, 1996HiZX, 1979Ho10, 1973To02, 1970ToZU, 1970ToZY]
^{164}W	2.990(39)	3.645(13)	5.278(2)	4.4(9)%**	[**1996Pa01, 1979Ho10, 1975To05, 1973Ea01**, 1994TeZZ, 1982De11, 1981DeZA, 1976ToZP, 1974Sc35, 1972EaZU]
^{168}Os	2.450(41)#	2.685(14)	5.816(3)	43(3)%***	[**2004GoZZ, 1996Pa01, 1995Hi02, 1984Sc06, 1982De11, 1982En03**, 1978Ca11, 1978Sc26, 1977Ca23]
^{172}Pt	1.984(40)#	1.759(14)	6.463(4)	94(6)%	[**2004GoZZ, 1996Pa01, 1981De22**, 2002Ro17, 1993ToZY, 1984ScZQ, 1982En03]
^{176}Hg	1.670(40)#	1.045(15)	6.897(6)	98(2)%	[**2004GoZZ, 1999Po09**, 2010Ju02, 2009An02, 2002Ro17, 1999To11, 1998Mu25, 1996Pa01, 1993ToZY, 1990SeZW, 1984ScZQ, 1983Sc24]
^{180}Pb	0.960(41)	0.204(16)	7.419(5)	≈100%$^@$	[**2010Ra12, 2009An20**, 2010Ju02, 1999To11, 1998ToZW, 1996To08]

* Weighted average of 93(4)% [1979Ho10] and 90(4)% , 94(4)% [1987To01].
** Weighted average of 5(1)% [1996Pa01] and 2.6(17)% [1979Ho10].
*** Weighted average of 36(4)% [2004GoZZ], 40(3)% [1996Pa01], and 49(3)% [1982En03].
$^@$ Deduced from short half-life.

Table 3
direct α emission from ^{152}Er, $J^{\pi} = 0^{+}$, $T_{1/2}$ = 10.3(1) s*, BR_{α} = 92(4)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{148}Dy)	coincident γ-rays	R_0 (fm)	HF
4.935(2)	4.805(2)***	92(4)%**	0^{+}	0.0	—–	1.5668(28)	1.00(5)

* [1982Bo04].
** Weighted average of 93(4)% [1979Ho10] and 90(4)% , 94(4)% [1987To01].
*** Weighted average of 4.799(3) MeV [1982Bo04] (adjusted to 4.805(3) in [1991Ry02]), 4.804(2) MeV [1982De11], and 4.808(5) MeV [1979Ho10].

Table 4
direct α emission from ^{156}Yb*, $J^{\pi} = 0^{+}$, $T_{1/2}$ = 25.3(5) s**, BR_{α} = 9(2)%***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{152}Er)	coincident γ-rays	R_0 (fm)	HF
4.810(4)	4.687(4)	9(2)%	0^{+}	0.0	—–	1.592(15)	$1.09^{+0.34}_{-0.22}$

* All values from [1996Pa01], except where noted.
** Weighted average of 24(1) s[1970To16], 26.1(7) s [2011Es03], 25.8(10) s [1977Ha48], 26.0(5) s [1978AfZZ], 23.6(13) s [1983Mi01], and 23(1) s [1982To14].
*** [1983Mi01].

Table 5
direct α emission from ^{160}Hf*, $J^{\pi} = 0^{+}$, $T_{1/2}$ = 13.6(2) s, BR_{α} = 0.7(2)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{156}Yb)	coincident γ-rays	R_0 (fm)	HF
4.902(6)	4.779(6)**	0.7(2)%	0^{+}	0.0	—–	1.549(19)	$1.0^{+0.4}_{-0.2}$

* All values from [1995Hi12], except where noted.
** [1992Ha10]

Table 6
direct α emission from ^{164}W, $J^{\pi} = 0^{+}$, $T_{1/2}$ = 6.0(3) s*, BR_{α} = 4.4(9)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{160}Hf)	coincident γ-rays	R_0 (fm)	HF
5.278(3)	5.140(3)***	4.4(9)%	0^{+}	0.0	—–	1.576(15)	$0.8^{+0.3}_{-0.2}$

* Weighted average of 6.3(5) s [1973Ea01], 5.5(5) s [1975To05], 6.4(8) s [1979Ho10].
** Weighted average of 5(1)% [1996Pa01] and 2.6(17)% [1979Ho10].
*** Weighted average of 5.148(6) MeV [1996Pa01], 5.153(5) MeV [1973Ea01], 5.146(5) MeV [1975To05], and 5.148(5) MeV [1979Ho10].

Table 7
direct α emission from ^{168}Os, $J^{\pi} = 0^{+}$, $T_{1/2}$ = 2.2(1) s*, BR_{α} = 43(3)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{164}W)	coincident γ-rays	R_0 (fm)	HF
5.817(3)	5.678(3)***	43(4)%	0^{+}	0.0	—–	1.5627(48)	1.03(11)

* Weighted average of 2.2(1) s [1982En03], and 2.1(1) s [1996Pa01].
** Weighted average of 36(4)% [2004GoZZ], 40(3)% [1996Pa01], and 49(3)% [1982En03].
*** Weighted average of 5.674(8) MeV [1995Hi02], 5.662(8) MeV [1984Sc06], and 5.680(3) MeV [1982De11].

Table 8
direct α emission from ^{172}Pt, J^{π} = 0^{+}, $T_{1/2}$ = 96(3) ms*, BR_{α} = 94(6)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{168}Os)	coincident γ-rays	R_0 (fm)	HF
6.466(3)	6.315(3)***	43(4)%	0^{+}	0.0	—–	1.5583(40)	0.99(7)

* [1996Pa01].
** [2004GoZZ].
*** Weighted average of 6.317(5) MeV [2004GoZZ], and 6.314(4) MeV [1982De11].

Table 9
direct α emission from ^{176}Hg, J^{π} = 0^{+}, $T_{1/2}$ = 21.3(8) ms*, BR_{α} = 98(2)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{172}Pt)	coincident γ-rays	R_0 (fm)	HF
6.906(5)	6.749(5)***	98(2)%	0^{+}	0.0	—–	1.5446(30)	1.02(4)

* Weighted average of 20(3) ms [2009An20], 22(1) ms [2004GoZZ], 20(2) ms [2002Ro17], 20(3) ms [1999To11], and 21(4) ms [1999Po09].
** [2004GoZZ].
*** Weighted average of 6.755(5) MeV [2004GoZZ], and 6.740(6) MeV [1999Po09].

Table 10
direct α emission from ^{180}Pb*, J^{π} = 0^{+}, $T_{1/2}$ = 4.1(3) ms, BR_{α} = ≈100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{176}Hg)	coincident γ-rays	R_0 (fm)	HF
7.419(7)	7.254(7)	≈100%	0^{+}	0.0	—–	1.5194(46)	0.98(7)

* All values from [2010Ra12].

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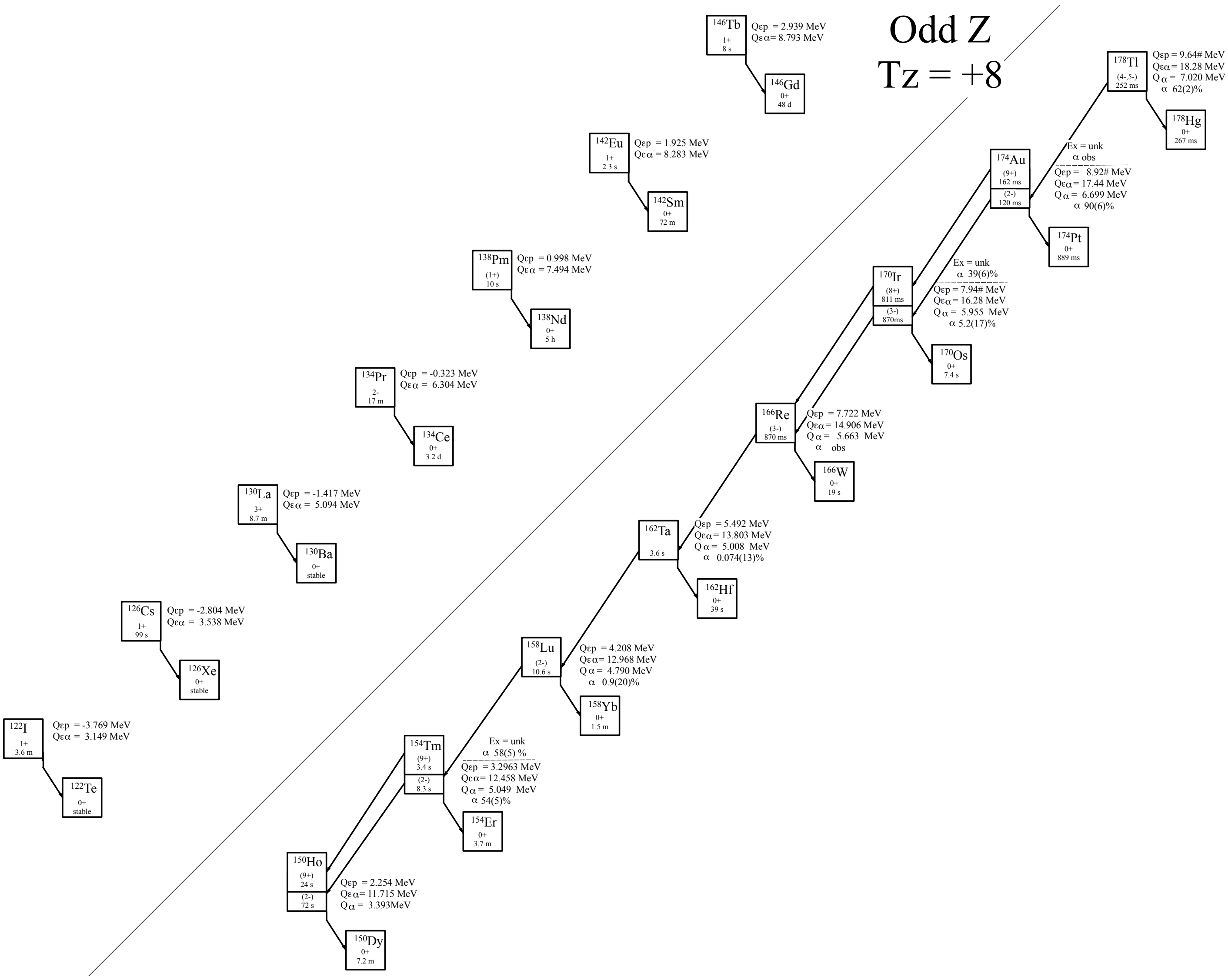

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +8nuclei.

Last updated 12/12/22

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +8 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J$^{|pi}$ values for ^{122}I, ^{126}Cs, ^{130}La, ^{134}Pr, ^{138}Pm, ^{142}Eu, ^{146}Tb, ^{150}Ho, are taken from ENSDF.

Nuclide	Ex	J^{π}	$T_{1/2}$	Q$_{\varepsilon}$	$Q_{\varepsilon p}$	Q$_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	BR$_{\varepsilon F}$	Experimental
^{122}I		1^{+}	3.63(6) m	4.234(5)	-3.769(5)	-9.559(5)	3.149(5)		[**1970LaZX**]
^{126}Cs		1^{+}	98.6(10) s	4.796(10)	-2.804(10)	-8.404(10)	3.538(10)		[**1969Ch18**]
^{130}La		3^{+}	8.7(1) m	5.629(26)	-1.417(26)-	-6.345(26)	5.094(26)		[**1963Ya05**]
^{134}Pr		2^{-}	17(2) m	6.305(29)	-0.323(35)	-4.671(20)	6.304(20)		[**1967Cl02**]
^{138}Pm		(1^{+})	10(2) s	7.103(16)	0.998(14)	-2.984(12)	7.494(23)		[**1983Al06**]
^{142}Eu		1^{+}	2.34(12) s	7.673(30)	1.925(33)	-1.630(30)	8.283(32)		[**1991Fi03**]
^{146}Tb		1^{+}	8(4) s	8.320(40)	2.939(45)	-0.376(45)	8.793(45)		[**1982No08**]
^{150}Ho		(2^{-})	72(4) s	7.364(14)	2.254(15)	-0.254(14)	11.715(15)		[**1982No08**]
^{154}Tm		(2^{-})	8.3(3) s	8.178(15)	3.296(15)	1.113(15)	12.458(15)		[**1982Bo04**]
^{154m}Tm	x	(9^{+})	3.35(5) s	8.178(15)+x	3.296(15)+x	1.113(15)+x	12.458(15)+x		[**1982Bo04**]
^{158}Lu		(2^{-})	10.6(3) s	8.797(17)	4.208(32)	2.422(29)	12.968(16)		[**1983Ge08**]
^{162}Ta			3.60(15) s	9.390(60)	5.492(69)	3.804(64)	13.803(64)		[**1992Ha10**]
^{166}Re		(3^{-})*	2.4(2) s**	10.050(90)	6.722(89)	5.403(90)	14.906(89)		[**1992Me10, 1984Sc06, 1978Sc26**]
^{170}Ir		(3^{-})	870^{+180}_{-120} ms	10.74(10)#	7.94(10)#	7.13(10)#	16.28(10)		[**2002Ro17**]
^{170m}Ir	x	(8^{+})	811(18) ms	10.74(10)#+x	7.94(10)#+x	7.13(10)#+x	16.28(10)+x		[**2007Ha45**]
^{174}Au		(2^{-})	120(20) ms	11.26(10)#	8.92(10)#	8.61(10)#	17.44(10)		[**1983Sc24**]
^{174m}Au	x	(9^{+})	162(3) ms	11.26(10)#+x	8.92(10)#+x	8.61(10)#+x	17.44(10)+x		[**2004GoZZ**]
^{178}Tl		$(4^{-}, 5^{-})$	252(20) ms	11.70(10)#	9.64(10)#	9.74(10)#	18.28(10)	0.15(6)%	[**2013Li49**]

* [2004GoZZ]
** Weighted average of 2.3(2) [1992Me10], 2.8(3) s [1984Sc06] and 2.2(4) s [1978Sc26].

Table 2
Particle separation and emission from the odd-Z, T_z = +8 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_{p}$	S$_{2p}$	Q$_{\alpha}$	BR$_{\alpha}$	Experimental
^{122}I	4.825(26)	12.240(9)	-0.508(6)	—	
^{126}Cs	4.440(10)	11.564(11)	-0.696(12)	—	
^{130}La	3.855(28)	10.274(26)	0.298(28)		
^{134}Pr	3.399(26)	9.382(42)	0.674(33)		
^{138}Pm	2.619(16)	8.152(16)	1.189(23)		
^{142}Eu	2.664(31)	7.675(39)	1.181(32)		
^{146}Tb	2.126(49)	6.722(46)	1.120(54)		
^{150}Ho	1.541(17)	5.987(19)	3.393(47)		
^{154}Tm	1.249(17)	5.400(19)	5.094(3)	54(5)%	[**1997To12, 1982Bo04, 1979Ho10**, 1995Wa32, 1995WaZN, 1995WaZR, 1993ToZX, 1992Po14, 1981De22, 1981HoZM, 1979Be52, 1973BoVZ, 1973BoXW, 1973BoXL, 1964Ma45, 1963Ma13]
^{154m}Tm*	1.249(17)-x	5.400(19)-x	5.094(3)+x	58(5)%	[**1997To12, 1982Bo04, 1982De11, 1979Ho10**, 1995Wa32, 1995WaZN, 1995WaZR, 1993ToZX, 1992Po14, 1991VaZZ, 1989KaYU, 1984ToZT, 1981De22, 1981HoZM, 1979Be52, 1973BoVZ, 1973BoXW, 1973BoXL, 1964Ma45, 1963Ma13]
^{158}Lu	1.081(19)	4.956(21)	4.790(5)	0.91(20)%	[**1992Ha10, 1983Ge08, 1983To01**, 1992Po14, 1982RaZZ, 1981RaZH, 1980Al14, 1980AlZN, 1979Al16, 1979AlZM, 1979Be52]
^{162}Ta	0.755(68)	4.089(85)	5.008(5)$^{@}$	0.074(13)%**	[**1992Ha10, 1986Ru05**, 2011Gh08, 1988MeZY, 1987HaZO, 1987ScZH, 1987ScZL]
^{166}Re	0.265(92)#	3.132(93)	5.663(4)$^{@@}$	obs	[**1996Pa01, 1992Me10, 1984Sc06, 1982De11, 1978Sc26**, 1992MeZW, 1984Gr14, 1981DeZA, 1981DeZL]
^{170}Ir	-0.25(11)	1.97(11)#	5.955(5)***	5.2(17)%	[**2004GZZ, 2002Ro17**, 1996Pa01]
^{170m}Ir*	-0.25(11)-x	1.97(11)#-x	5.955(5)+x	39(6)%	[**2004GoZZ**, 2002Ro17, 1996Pa01, 1984Gr14, 1982De11, 1978ReZZ, 1978Sc26, 1978Ca11, 1977Ca23, 1977ScYH
^{174}Au	-0.59(12)	1.26(11)#	6.699(7)	90(6)%	[**2002Ro17, 2004GoZZ**]
^{174m}Au	-0.59(12)-x	1.26(11)#-x	6.699(7)+x	obs	[**2004GoZZ**, 2002Ro17, 1996Pa01, 1992Ha10, 2000KoZN, 1984ScZQ, 1983Sc24]
^{178}Tl	-0.87(13)	0.67(11)#	7.020(10)	62(2)%	[**2013Li49**, 2002Ro17, 2001RoZW, 1997Ca13]

* Excitation is unknown.
** Weighted average of 0.081(13)% [1992Ha10] and 0.065(14)% [1986Ru05].
*** Deduced from α energy, 6.230(50)# in [2021Wa16].
$^{@}$ Deduced from α energy, 5.010(60) in [2021Wa16].
$^{@@}$ Deduced from α energy, 5.520(60) in [2021Wa16].

Table 3
direct α emission from ^{154}Tm*, $T_{1/2}$= 8.3(3) s**, BR_α = 54(5)%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	$E_{daughter}$(^{150}Ho)	coincident γ-rays	R_0 (fm)	HF
4.975(15)	4.846(15)@	0.45(20)%**	0.24(11)%**	0.131	0.131	1.5815(15)@@	180^{+16}_{-6}
5.093(3)	4.961(3)***	100%**	58(5)%**	0.0	—	1.5815(15)@@	3.4(4)

* All values from [1997To12], except where noted.
** [1982Bo04].
*** Weighted average of 4.959(5) MeV [1979Ho10] (adjusted to 4.964(5) MeV in [1999Ry01]) and 4.955(3) MeV [1982Bo04] (adjusted to 4.960(3) MeV in [1999Ry01])
@ Reported as 4.825(15) MeV in [1997To12], which lists the 100% peak as 4.956(3) MeV based on data that was not adjusted in [1991Ry01]. The value adopted here is 5 keV higher, therefore the energy of the fine structure peak was adjusted accordingly.
@@ Interpolated between 1.567(3) fm ^{152}Er and 1.596(15) fm ^{156}Yb.

Table 4
direct α emission from ^{154m}Tm*, Ex = unk, $T_{1/2}$= 3.35(5) s**, BR_α = 58(5)%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	$E_{daughter}$(^{150}Ho)	coincident γ-rays	R_0 (fm)	HF
4.975(15)	4.846(15)@	0.24(5)%**	0.14(3)%**	0.197 + x	0.197	1.5815(15)@@	150^{+50}_{-30}
5.172(2)	5.037(2)***	100%**	58(5)%**	x	—	1.5815(15)@@	2.98(28)

* All values from [1997To12], except where noted.
** [1982Bo04].
*** Weighted average of 5.035(5) MeV [1979Ho10] (adjusted to 5.040(5) MeV in [1999Ry01]), 5.037(2) MeV [1981De22] and 5.030(3) MeV [1982Bo04] (adjusted to 5.036(3) MeV in [1999Ry01]).
@ Reported as 4.840(15) MeV in [1997To12], which lists the 100% peak as 5.031(3) MeV based on data that was not adjusted in [1991Ry01]. The value adopted here is 6 keV higher, therefore the energy of the fine structure peak was adjusted accordingly.
@@ Interpolated between 1.567(3) fm ^{152}Er and 1.596(15) fm ^{156}Yb.

Table 5
direct α emission from ^{158}Lu, $T_{1/2}$= 10.6(3) s*, BR_α = 0.91(20)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}$(^{154}Tm)	coincident γ-rays	R_0 (fm)	HF
4.789(5)	4.668(5)***	0.91(20)%**	0.0	—	1.573(24)@	$0.7^{+0.5}_{-0.3}$

* [1983Ge03].
** [1992Ha10].
*** Reported as 4.666(5) MeV [1983To01] (adjusted to 4.668(5) MeV in [1999Ry01]).
@ Interpolated between 1.596(15) fm ^{156}Yb, and 1.549(19) fm ^{160}Hf.

Table 6
direct α emission from ^{162}Ta*, $T_{1/2}$= 3.60(15) s, BR_α = 0.074(13)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}$(^{158}Lu)	coincident γ-rays	R_0 (fm)	HF
5.008(5)	4.884(5)	0.074(13)%**	0.0	—	1.563(24)***	$3.8^{+2.4}_{-1.6}$

* All values from [1992Ha10], unless otherwise noted.
** Weighted average of 0.081(13)% [1992Ha10] and 0.065(14)% [1986Ru05].
*** Interpolated between 1.549(19) fm ^{160}Hf and 1.576(15) fm ^{164}W,

Table 7
direct α emission from ^{166}Re, $T_{1/2}$= 2.4(2) s*, BR_α =obs.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}$(^{162}Ta)	coincident γ-rays	R_0 (fm)	HF
5.663(4)	5.527(4)**	obs	0.0	—	1.569(16)	5^{+5}_{-3}

* Weighted average of 2.3(2) [1992Me10], 2.8(3) s [1984Sc06] and 2.2(4) s [1978Sc26].
** [1982De11].
*** Interpolated between 1.576(15) fm ^{164}W and 1.5627(48) fm ^{168}Os.

Table 8
direct α emission from ^{170}Ir, $T_{1/2}$= 870^{+180}_{-120} ms*, BR_α = 5.2(17)%*.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}$(^{166}Re)	coincident γ-rays	R_0 (fm)	HF
5.955(5)	5.815(5)**	5.2(17)%*	0.0	—	1.5605(62)	$4.5^{+3.1}_{-1.7}$

* [2002Ro17].
** [2004GoZZ].
*** Interpolated between 1.5627(48) fm ^{168}Os and1.5583(40) fm ^{172}Pt.

Table 9
direct α emission from ^{170m}Ir*, Ex. = unk., $T_{1/2}$= 811(18) ms, BR_α = 39(6)%**.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	$E_{daughter}$(^{166}Re)	coincident γ-rays	R_0 (fm)	HF
6.094(10)	5.951(10)	≈30***	≈5***	0.175+x	0.175, 0.122, 0.110, 0.075, 0.069, 0.053		
6.152(10)	6.007(10)	≈80***	≈14***	0.122+x	0.122, 0.069, 0.053		
6.199(10)	6.053(10)	100***	≈17***	0.075+x	0.075		
6.268(10)	6.121(10)	≈25***	≈4***	x			

* All values from [2007Ha45], except where noted.
** [2004GoZZ].
*** Relative intensities not given in [2007Ha45], estimated by evaluator from Fig 5b.

Table 10
direct α emission from ^{174}Au, $T_{1/2}$= 120(20) ms*, BR_α = 90(6)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}$(^{170}Ir)	coincident γ-rays	R_0 (fm)	HF
6.701(5)	6.547(5)***	90(6)%**	0.0	—	1.5525(50)@	3.3(7)

* [1983Sc24].
** [2002Ro17].
** [2004GoZZ].
@ Interpolated between 1.5583(40) fm ^{172}Pt and 1.5466(30) fm ^{176}Hg.

Table 11
direct α emission from ^{174m}Au, $T_{1/2}$= 162(3) ms, BR_α = obs.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	$E_{daughter}$(^{170}Ir)	coincident γ-rays	R_0 (fm)	HF
6.584(5)	6.433(5)			0.191+x	0.191		
6.623(5)	6.471(5)			0.153+x	0.153		
6.773(15)	6.618(15)			x			

* All values from [2004GoZZ].

Table 12
direct α emission from ^{178}Tl*, $T_{1/2}$= 252(20) ms, BR_α = 62(2)%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	$E_{daughter}$(^{174}Au)	coincident γ-rays	R_0 (fm)	HF
6.747(10)	6.595(10)	34(7)	15(3)	0.273	0.273, 0.163	1.533(55)**	$2.6^{+1.0}_{-0.7}$
8.847(10)	6.693(10)	100	43(3)	0.173	0.173, 0.163	1.533(55)**	2.09(12)
7.010(10)	6.852(10)	9(5)	4(2)	0.0	—	1.533(55)**	100^{+120}_{-40}

* All values from [2013Li49].
** Interpolated between 1.5466(30) fm ^{176}Hg and 1.5194(46) fm ^{180}Pb.

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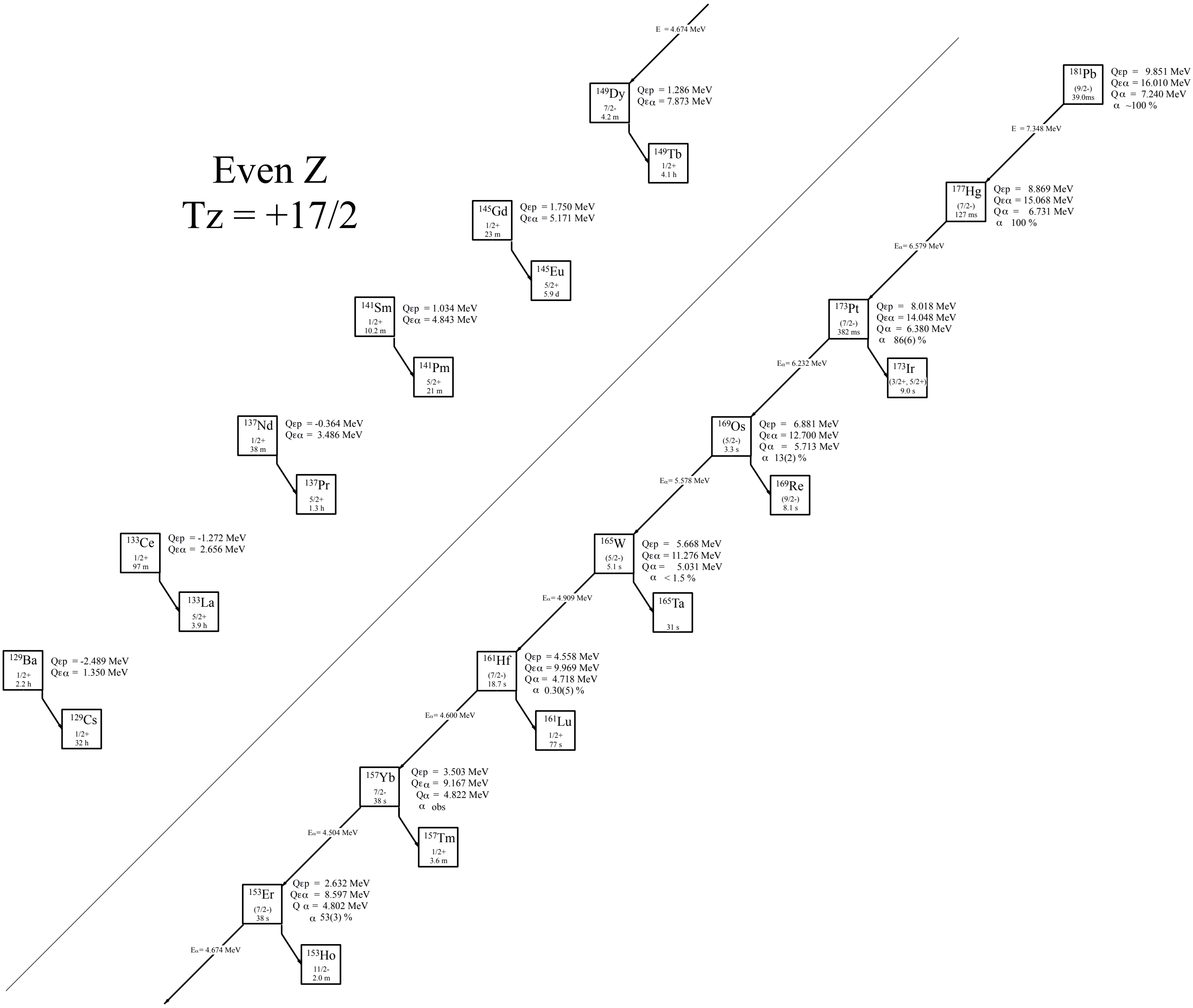

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +17/2 nuclei.

Last updated 3/23/23

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +17/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. $J^{|pi}$ values for ^{129}Ba, ^{133}Ce, ^{137}Nd, ^{141}Sm, ^{145}Gd, ^{149}Dy, are taken from ENSDF

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{129}Ba	1/2$^+$	2.23(11) h	2.438(11)	-2.489(11)	——	-10.656(11)	1.350(11)	[**1972Ta02**]
^{133}Ce	1/2$^+$	97(4) m	3.080(30)	-1.272(16)	——	-8.941(16)	2.656(17)	[**1967Ge08**]
^{137}Nd	1/2$^+$	38.5(15) m	3.618(14)	-0.364(12)	——	-7.518(15)	3.486(30)	[**1973Bu18**]
^{141}Sm	1/2$^+$	10.2(2) m	4.589(16)	1.034(9)		-5.683(9)	4.843(12)	[**1977Ke03**]
^{145}Gd	1/2$^+$	23.0(4) m	5.065(20)	1.750(20)		-4.544(20)	5.171(24)	[**1982Fi01**]
^{149}Dy	7/2$^-$	4.2(2) m	3.795(9)	1.286(9)		-4.727(10)	7.873(10)	[**1993Al03**]
^{153}Er	(7/2$^-$)	37.1(2) s	4.545(10)	2.362(10)		-3.421(10)	8.597(10)	[**1982Bo04**]
^{157}Yb	7/2$^-$	37.9(9) s*	5.289(30)	3.503(27)		-1.958(21)	9.167(12)	[**1978AfZZ, 1977Ha48, 1970To16**]
^{161}Hf	(7/2$^-$)	18.7(5) s	6.250(40)	4.558(24)		-0.323(36)	9.969(36)	[**1995Hi12**]
^{165}W	(5/2$^-$)	5.1(5) s	6.987(29)	5.668(30)		1.352(38)	11.276(38)	[**1975To05**]
^{169}Os	(5/2$^-$)	3.3(3) s	7.686(28)	6.881(29)		3.050(38)	12.700(29)	[**1995Hi02**]
^{173}Pt	(5/2$^-$)	382(2) ms	8.330(60)	8.018(65)		4.736(69)	14.048(64)	[**2004GoZZ**]
^{177}Hg	(7/2$^-$)	127(2) ms	8.770(90)	8.869(86)		6.041(86)	15.068(85)	[**2002Ro17**]
^{181}Pb	(9/2$^-$)	39.0(9) ms**	9.690(90)	9.851(86)		7.300(86)	16.010(86)	**2009An20, 2005CaZV**]

* Weighted average of 37(2) s [1978AfZZ], 38.6(10) s [1977Ha48], 34(3) s [1970To16].
** Weighted average of 36(2) ms [2009An20] and 39.6(9) ms [2005CaZV].

Table 2
Particle separation and emission from the even-Z, T_z = +17/2 nuclei

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{129}Ba	6.418(12)	11.318(11)	-0.286(11)	——	
^{133}Ce	5.984(40)	10.317(16)	0.218(19)		
^{137}Nd	5.533(16)	9.546(16)	0.409(20)		
^{141}Sm	5.011(26)	8.495(29)	1.225(15)		
^{145}Gd	4.596(22)	7.987(20)	0.582(21)		
^{149}Dy	4.446(15)	6.915(9)	2.808(22)		
^{153}Er	4.151(15)	6.292(10)	4.802(1)	53(3)%	**1996Pa01, 1982Bo04, 1981De22, 1978Ho10, 1977AfZZ**, 1988KaZK, 1988ScZO, 1981HoZM, 1980Da09, 1977Ha48, 1975ToZT, 1974Sc35, 1974To07, 1974ToZN, 1973BoXL, 1970To16, 1970Ma18
^{157}Yb	3.874(18)	5.789(12)	4.622(6)	obs	[**1983Al09, 1979Ho10, 1978AfZZ, 1977Ha48, 1970To16**, 1981HoZM, 1970ToZS, 1970ToZU, 1970ToZY]
^{161}Hf	3.335(61)	5.060(29)	4.718(7)*	0.30(5)%	[**1995Hi12, 1992Ha10, 1973To12**, 1996HiZX, 1973ToZU
^{165}W	2.867(38)	4.170(36)	5.031(5)	< 1.5%	[**1979Ho10, 1975To05**, 1981HoZM, 1976ToZP]
^{169}Os	2.217(40)	3.208(32)	5.713(3)	13(2)%	[**1995Hi02**, 2004GoZZ, 1996Pa01, 1984Sc06, 1982En03, 1982De11, 1981DeZO, 1981DeZL, 1978Sc26, 1972To19]
^{173}Pt	1.846(71)	2.217(66)	6.380(5)***	86(6)%	[**2004GoZZ**, 2014ThZZ, 2009An20, 2002Ro19, 1996Pa01, 1993ToZY, 1993ToZX, 1982En03, 1981De22, 1981DeZB, 1979Ha10, 1975Ca39, 1973Ga08, 1966Si08]
^{177}Hg	1.544(91)	1.645(87)	6.731(5)$^@$	100%	[**2009An20, 2004GoZZ, 1996Pa01**. 2003Me20, 2002Ro17, 1991Se01, 1990SeZW, 1976HaYQ, 1976HoZD, 1975Ca39]
^{181}Pb	1.01(11)	0.756(90)	7.240(7)	≈100%	**2009An20, 2005CaZV**, 2005CaZY, 2004CaZW, 1996To01, 1995ToZU, 1989To01, 1986Ke03]

* Deduced from α energy, 4.679(25) in [2021Wa16].
** Deduced from α energy, 5.030(32) in [2021Wa16].
*** Deduced from α energy, 6.361(58) in [2021Wa16].
$^@$ Deduced from α energy, 6.736(56) in [2021Wa16].

Table 3
direct α emission from ^{153}Er, J^π = (7/2$^-$), $T_{1/2}$ = 37.1(2) s*, BR_α = 53(3)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{149}Dy)	coincident γ-rays	R_0 (fm)	HF
4.799(2)	4.674(2)***	53(3)%**	7/2$^-$	0.0	——	1.5584(94)	$1.21^{+0.23}_{-0.20}$

* [1982Bo04].
** [1979Ho10].
*** Weighted average of 4.674(4) [1996Pa01], 4.676(2) [1981De22], and 4.671(3) [1978AfZZ],

Table 4
direct α emission from ^{157}Yb, J^π = 7/2$^-$, $T_{1/2}$ = 37.9(9) s*, BR_α = obs.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{153}Er)	coincident γ-rays	R_0 (fm)	HF
4.622(10)	4.504(10)**		(7/2$^-$)	0.0	—–	1.563(27)	

* Weighted average of 37(2) s [1978AfZZ], 38.6(10) s [1977Ha48], 34(3) s [1970To16].
* Weighted average of 4.504(10) MeV [1983Al09], 4.505(10) MeV [1979Ho10], 4.504(10) MeV [1978AfZZ], 4.507(10) MeV [1977Ha48], and 4.500(10) MeV [1970To16].

Table 5
direct α emission from ^{161}Hf, J^π = (7/2$^-$), $T_{1/2}$ = 18.7(5) s*, BR_α = 0.30(5)%*.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{157}Yb)	coincident γ-rays	R_0 (fm)	HF
4.718(7)	4.600(7)**	0.30(5)%*	7/2$^-$	0.0	—–	1.567(12)	$0.49^{+0.17}_{-0.14}$***

* [1995Hi12].
** Weighted average of 4.604(10) MeV [1995Hi12], 4.599(7) MeV [1992Ha10], and 4.600(10) MeV [1973To12].
*** This low value for HF may indicate that the BR for α-decay is slightly higher than reported in [1995Hi12].

Table 6
direct α emission from ^{165}W, J^π = (5/2$^-$), $T_{1/2}$ = 5.1(5) s*, BR_α = <1.5%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{161}Hf)	coincident γ-rays	R_0 (fm)	HF
5.031(5)	4.909(5)*	<1.5%**	(7/2$^-$)	0.0	—–	1.541(20)	>0.08***

* [1975To05].
** [1979Ho10].
*** This unphysical HF value indicates that the α branching ratio is much lower. A value of BR_α =0.12% gives a value of 1.0.

Table 7
direct α emission from ^{169}Os*, J^π = (5/2$^-$), $T_{1/2}$ = 3.3(3) s*, BR_α = 13(2)%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{165}W)	coincident γ-rays	R_0 (fm)	HF
5.642(8)	5.508(8)	15%	2.0(3)%	(7/2$^-$)	0.072	0.028?, 0.043, 0.072	1.5627(60)	8
5.670(10)	5.536(10)	10%	1.3(2)%	(3/2$^-$)	0.043	0.043	1.5627(60)	15
5.713(8)	5.578(8)	100%	10(2)%	(5/2$^-$)	0.0	—–	1.5627(60)	2.4

* All values from [1995Hi02].

Table 8
direct α emission from ^{173}Pt*, J^π = (5/2$^-$), $T_{1/2}$ = 382(2) ms, BR_α = 86(6)%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{169}Os)	coincident γ-rays	R_0 (fm)	HF
6.211(5)	6.067(5)	≈1%	≈1%		0.171(7)	0.171	1.5565(36)	50^{+5}_{-2}
6.244(5)	6.100(5)	≈1%	≈1%		0.136(7)	0.136	1.5565(36)	60^{+7}_{-2}
6.278(5)	6.133(5)	≈2%	≈2%		0.102(7)		1.5565(36)	40^{+5}_{-2}
6.380(5)	6.232(5)	100%	82(6)%	(5/2$^-$)	0.0	—–	1.5565(36)	2.22(24)

* All values from [2004GoZZ].

Table 9
direct α emission from ^{177}Hg, J^{π} = (7/2^{-}), $T_{1/2}$ = 127(2) ms*, BR_{α} = 100%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{173}Pt)	coincident γ-rays	R_0 (fm)	HF
6.731(5)	6.579(5)***	100%	(5/2^{-})	0.0	—–	1.55433(52)	$1.48^{+0.17}_{-0.16}$

* [2002Ro17].
** [2009An20]
*** Weighted average of 6.580(5) MeV [2004GoZZ] and 6.577(9) MeV [1996Pa01].

Table 10
direct α emission from ^{181}Pb, J^{π} = (9/2^{-}), $T_{1/2}$ = 39.0(9) ms*, BR_{α} = ≈100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{177}Hg)	coincident γ-rays	R_0 (fm)	HF
7.174(10)	7.015(10)**	100%	9/2^{-}	0.077	0.077	1.5139(54)	$1.47^{+0.17}_{-0.16}$

** Weighted average of 36(2) ms [2009An20] and 39.6(9) ms [2005CaZV].
** Weighted average of 7.016(15) MeV [2009An10] and 7.015(10) MeV [2005CaZV].

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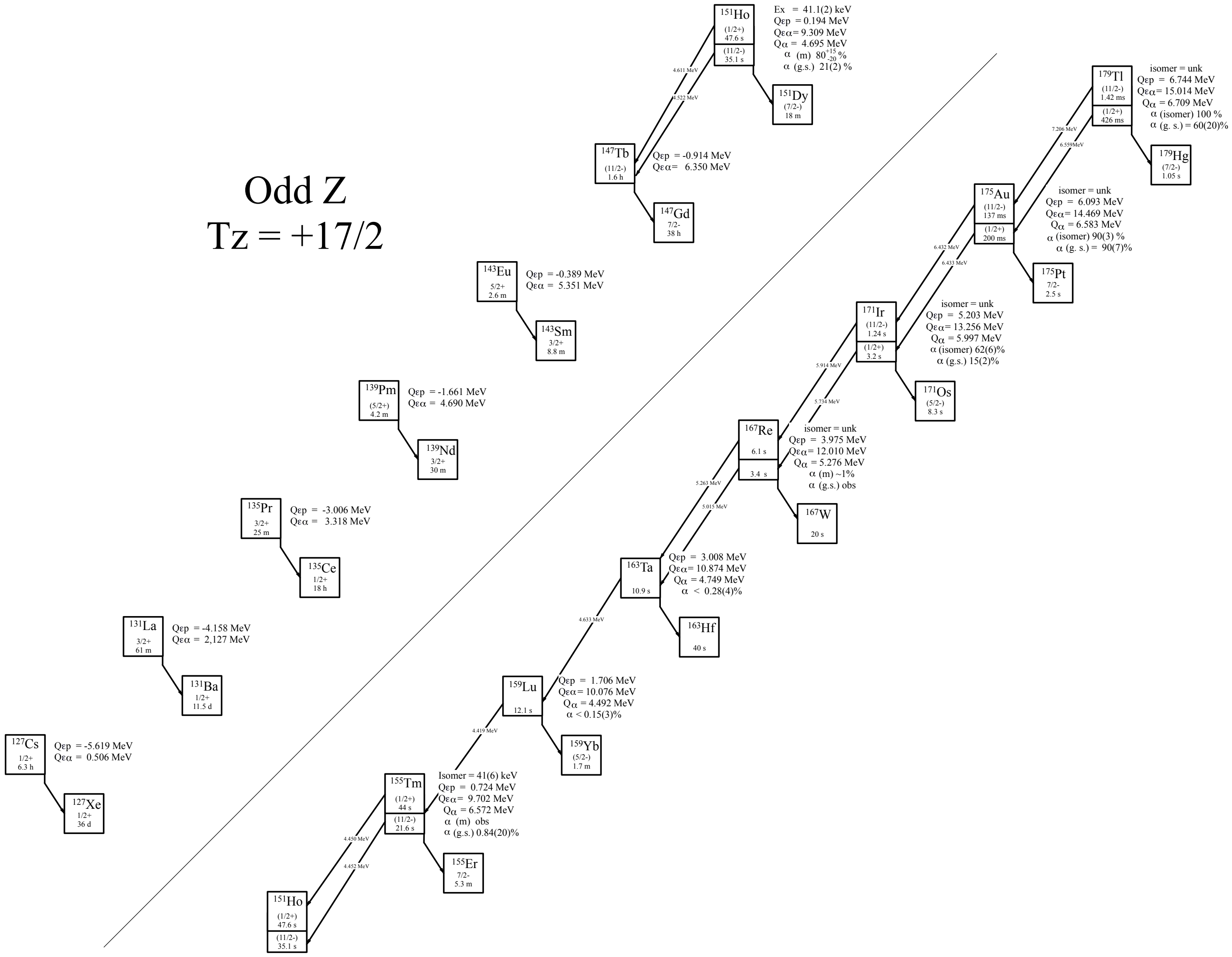

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +17/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. $J^{|pi}$ values for ^{127}Cs, ^{131}La, ^{135}Pr, ^{139}Pm, ^{143}Eu, ^{147}Tb, are taken from ENSDF.

Last updated 3/23/23

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +17/2 nuclei

Nuclide	Ex	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{127}Cs		1/2$^+$	6.25(10) h	2.081(6)	-5.619(6)	-11.796(6)	0.506(6)	[**1954Ma54**]
^{131}La		3/2$^+$	61(2) m	2.910(28)	-4.158(29)	-9.651(28)	2.127(28)	[**1960Cr01**]
^{135}Pr		3/2$^+$	25.4(5) m	3.680(16)	-3.006(23)	-7.960(12)	3.318(12)	[**1970Ab07**]
^{139}Pm		(5/2$^+$)	4.15(5) m	4.516(26)	-1.661(17)	-6.160(14)	4.690(17)	[**1977De06**]
^{143}Eu		5/2$^+$	2.57(3) m	5.276(11)	-0.389(26)	-4.628(11)	5.351(30)	[**1993Al03**]
^{147}Tb		(1/2$^+$)	1.64(3) h	4.614(8)	-0.914(10)	-4.669(8)	6.350(9)	[**1997Wa04**]
^{151}Ho		(11/2$^-$)	35.1(2) s	5.130(9)	0.194(11)	-3.074(9)	9.309(9)	[**1982Bo04**]
^{151m}Ho	0.0411(2)	(1/2$^+$)	47.6(13) s*	5.171(9)	0.265(11)	-3.071(9)	9.350(9)	[**1991To08, 1982Bo04, 1982Ba75**]
^{155}Tm		(11/2$^-$)	21.6(2) s	5.583(12)	0.724(13)	-2.061(11)	9.702(10)	[**1991To08**]
^{155m}Tm	0.041(6)	(1/2$^+$)	44(4) s	5.624(13)	0.765(14)	-2.020(12)	9.743(11)	[**1991To08, 1990Po13**]
^{159}Lu			12.1(10) s**	6.120(40)	1.706(45)	-0.873(46)	10.076(38)	[**1992Ha10, 1980Al04**]
^{163}Ta			10.9(12) s***	6.730(50)	3.008(84)	0.722(41)	10.874(42)	[**1992Ha10, 1985Li14**]
^{167}Re			3.4(4) s	7.260(40)#	3.975(49)#	2.223(49)#	12.010(48)#	[**1992Me10**]
^{167m}Re	x$^@$		6.1(2) s	7.260(40)#+x	3.975(49)#+x	2.223(49)#+x	12.010(48)#+x	[**1992Me10, 1984Sc06**]
^{171}Ir		(1/2$^+$)	$3.2^{+1.7}_{-0.7}$ s	7.890(40)	5.203(40)	3.928(41)	13.256(43)	[**2013An01**]
^{171m}Ir	x	(11/2$^-$)	1.24(4) s$^{@@}$	7.890(40)+x	5.203(40)+x	3.928(41)+x	13.256(43)+x	[**2023Zh03, 2014Pe02, 2013An01**]
^{175}Au		(1/2$^+$)	200(3) ms	8.300(40)	6.093(40)	5.457(41)	14.469(43)	[**2017Ba46**]
^{175m}Au	x	(11/2$^-$)	137(1) ms$^{@@@}$	8.300(40)+x	6.093(40)+x	5.457(41)+x	14.469(43)+x	[**2017Ba46, 2011Wa37**]
^{179}Tl		(1/2$^+$)	426(10) ms	8.660(50)	6.744(40)	6.523(41)	15.014(43)	[**2017Ba46**]
^{179m}Tl^a		(11/2$^-$)	1.42(3) ms^a	8.660(50)	6.744(40)	6.523(41)	15.014(43)	[**2017Ba46, 2010An01**]

* Weighted average of 47.9(13) s [1982Bo14], 47(2) s [1982Ba75].
** Weighted average of 12.3(10)s [1980Al14] and 9.2(35) s [1992Ha10].
*** Weighted average of 10.5(18)s [1985Li14] and 11.2(16) s [1992Ha10].
$^@$ May be the ground state.
$^{@@}$ Weighted average of 1.14(5) s [2014Pe02], 1.4(1) s [2013An01],and 1.28(4) [2023Zh03].
$^{@@@}$ Weighted average of 136(1) ms [2017Ba46] and 139(2) ms [2011Wa37].
^{a} Weighted average of 1.40(3) ms [2017Ba46], and 1.46(4) ms [2010An01].

Table 2
Particle separation and emission from the odd-Z, T_z = +17/2 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	BR_p	S_{2p}	Q_α	BR_α	Experimental
^{127}Cs	4.383(6)		11.982(6)	-0.722(7)		
^{131}La	3.801(28)		10.848(28)	0.046(28)		
^{135}Pr	3.392(24)		10.019(30)	0.408(30)		
^{139}Pm	2.773(18)		8.877(16)	1.010(18)		
^{143}Eu	2.548(11)		8.296(18)	0.835(17)		
^{147}Tb	1.946(9)		7.329(9)	1.074(14)		
^{151}Ho	1.602(9)		6.712(9)	4.695(2)	21(2)%	[**1987Li09, 1990Po13, 1991To08, 1982Ba75, 1982Bo04, 1982De11**, **1979Ho10, 1974Sc19, 1963Ma17**, 1996Pa01, 1995Wa31, 1995WaZO, 1995WaZS, 1991VaZY, 1990KaZM, 1990VaZO, 1989KaYU, 1989KaZK, 1989KaZI, 1989PoZR, 1973BoXL, 1973BoXW, 1970Ma23, 1961Ma40, 1960Ma47]
^{151m}Ho*	1.561(9)		6.671(9)	4.736(2)	80^{+15}_{-20}%	[**1987Li09, 1991To08, 1982Ba75, 1982Bo04, 1981De22, 1979Ho10**, 1963Ma17 1995Wa31, 1995WaZO, 1995WaZS, 1991VaZY, 1990Po13, 1990KaZM, 1990VaZO, 1989KaYU, 1989KaZK, 1989KaZI, 1989PoZR, 1974Sc19, 1974ToZN, 1974ToZQ, 1973BoXL, 1973BoXV, 1970Ma23, 1970To16, 1961Ma40, 1960Ma47]
^{155}Tm	1.310(11)		6.192(11)	4.572(5)	0.84(20)%	[**1991To08, 1992Ha10, 1990Po13, 1971To10**, 1991VaZT, 1990KaZM, 1990PoZU, 1989KaYU, 1988KaZK, 1987KaZI, 1988KaZK, 1978AfZZ, 1977Ag01]
^{155m}Tm	1.269(12)		6.151(12)	4.613(8)	obs	[**1991To08, 1992Ha10, 1990Po13, 1971To10**, 1991VaZY, 1990KaZM, 1990PoZU, 1989KaYU, 1988KaZK, 1989KaZI, 1988KaZK, 1978AfZZ, 1977Ag01]
^{159}Lu	0.988(38)		5.577(47)	4.492(39)	<0.15(3)%	[**1992Ha10, 1980Al04**, 1980AlZN]
^{163}Ta	0.655(39)		4.550(47)	4.749(5)	<0.28(4)%	[**1992Ha10, 1986Ru05**, 1988MeZY, 1987HaZO, 1983Sc18]
^{167}Re	0.235(41)#		3.564(42)#	5.276(13)#	obs	[**1992Me10**, 1992MeZW]
^{167m}Re***	0.235(41)#-x		3.564(42)#-x	5.276(13)#+x	≈1%	[**1992Me10**, 1992MeZW, 1984Sc06]
^{171}Ir	-0.225(40)		2.581(40)	5.997(12)	15(2)%	[**2013An01**]
^{171m}Ir$^{@}$	-0.225(40)-x		2.581(40)-x	5.997(12)+x	62(6)%	[**2023Zh03, 2014Pe02, 2013An01**, 2010An01, 2002Ro17, 1996Pa01, 1992Sc16, 1982De11, 1981DeZL, 1978Ca11, 1978Sc26]
^{175}Au	-0.625(40)		1.713(40)	6.583(3)	90(7)%	[**2017Ba46, 2013An10**, 2010An01, 2002Ro17, 1996Pa01, 1983Sc24]
^{175m}Au$^{@}$	-0.625(40)-x		1.713(40)-x	6.583(3)+x	90(3)%	[**2017Ba46, 2011Wa37, 2010An01**, 2013An10, 2004GoZZ, 2002Ro17, 1996Pa01, 1983Sc24]
^{179}Tl	-0.757(40)		1.302(40)	6.709(3)	60(20)%	[**2017Ba46, 2013An10**, 2002Ro17, 1998To14, 1996Pa01, 1983Sc24]
^{179m}Tl$^{@}$	-0.757(40)		1.302(40)	6.709(3)	100%	[**2017Ba46, 2010An01**, 2002Ro17, 1998To14, 1996Pa01, 1983Sc24]

* Excitation energy = 41.1(2) keV [1991To08].
** Excitation energy = 41(6) keV [1990Po13].
*** Excitation is unknown, may be the ground state.
@ Excitation is unknown.

Table 3
direct α emission from ^{151}Ho, J^π = (11/2$^-$), $T_{1/2}$ = 35.1(2) s*, BR_α = 21(2)%**.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	$J_f^{\pi\,@@@}$	$E_{daughter}$(^{147}Tb)	coincident γ-rays	R_0 (fm)	HF
4.335(6)	4.220(6)$^{@}$	0.36(4)%$^{@}$	0.076(8)%	(5/2$^+$)	0.354$^{@}$	0.101, 0.253	1.5642(20)	$9.3^{+1.7}_{-1.3}$
4.435	4.318$^{@@}$	< 0.01%$^{@}$	< 0.002%	(3/2$^+$)	0.254			
4.645(2)	4.522(2)***	100%$^{@}$	21(2)%		0.0506(9)$^{@}$	(11/2$^-$)	1.5642(20)	1.60(17)
4.689	4.565$^{@@}$	< 0.7%$^{@}$	< 0.15%	(1/2$^+$)	0.0			

* [1982Bo04].
** Weighted average of 28(7)% [1991To08], 22(3)% [1990Po13], 22(3)% [1982Bo75], 18(5)% [1979Ho10], 18(5)% [1974Sc19], and 20(5)% [1963Ma17].
*** Weighted average of 4.523(3) MeV [1982Bo04] (adjusted to 4.529(3) MeV in [1999Ry01]), 4.524(5) MeV [1979Ho10] (adjusted to 4.524(5) MeV in [1999Ry01]), and 4.521(3) MeV [1981De22].
@ [1987Li09]
@@ Transition not observed.
@@@ [2022Ni03].

Table 4
direct α emission from ^{151m}Ho, Ex = 41.1(2) keV**, J$^{\pi}$ = (1/2$^+$), T$_{1/2}$ = 47.6(13) s*, BR_α = 80^{+15}_{-20}%**.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	$J_f^{\pi\ @@@}$	$E_{daughter}$(^{147}Tb)	coincident γ-rays	R$_0$ (fm)	HF
4.376(6)	4.260(6)$^@$	0.26(4)%$^@$	0.076(8)%	(5/2$^+$)	0.354$^@$	0.101, 0.253	1.5642(20)	$7.9^{+2.8}_{-1.8}$
4.478	4.359$^{@@}$	< 0.05%$^@$	< 0.01%	(3/2$^+$)	0.254			
4.682	4.558$^{@@}$	< 1.1%$^@$	< 0.2%	(11/2$^-$)	0.0506(9)			
4.736(2)	4.611(2)***	100%$^@$	80^{+15}_{-20}%	(1/2$^+$)	0.0		1.5642(20)	1.7^{+5}_{-3}

** Weighted average of 47.9(13) s [1982Bo14], 47(2) s [1982Ba75].
** [1991To08].
*** Weighted average of 4.523(3) MeV [1982Bo04] (adjusted to 4.529(3) MeV in [1999Ry01]), 4.524(5) MeV [1979Ho10] (adjusted to 4.524(5) MeV in [1999Ry01]), and 4.521(3) MeV [1981De22].
$^@$ [1987Li09]
$^{@@}$ Transition not observed.
$^{@@@}$ [2022Ni03].

Table 5
direct α emission from ^{155}Tm, J$^{\pi}$ = (11/2$^-$), T$_{1/2}$ = 21.6(2) s*, BR_α = 0.84(20)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{151}Ho)	coincident γ-rays	R$_0$ (fm)	HF
4.570(8)	4.452(8)***	0.84(20)%**	(11/2$^-$)	0.0	1.573(14)	$1.2^{+0.5}_{-0.4}$	

* [1991To08].
** Weighted average of 1.2(6)% [1990Po13] and 2.1(3)% (adjusted to 0.80(21)% by evaluator in 2009Si01).
*** From [1992Ha10]. [1991To08] report that the ground state and isomer have nearly identical α energies. Their measured T$_{1/2}$ value of 26(3) s indicates that this value is mostly from the 11/2$^-$ ground state decay.

Table 6
direct α emission from ^{155m}Tm, Ex = 41(6) keV**, J$^{\pi}$ = (1/2$^+$), T$_{1/2}$ = 44(4) s**, BR_α = obs*.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{151}Ho)	coincident γ-rays	R$_0$ (fm)	HF
4.568(10)	4.450(10)***			0.0411(2)		1.573(14)	

** [1991To08].
** [1990Po13].
*** Unresolved doublet from [1991To08] who report that the ground state and isomer have nearly identical α energies.

Table 7
direct α emission from ^{159}Lu, J$^{\pi}$ = , T$_{1/2}$ = 12.1(10) s*, BR_α = <0.15(3)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{155}Tm)	coincident γ-rays	R$_0$ (fm)	HF
4.533(10)	4.419(10)***	<0.15(3)%**		?		1.539(29)	

* Weighted average of 12.3(10)s [1980Al14] and 9.2(35) s [1992Ha10].
** [1992Ha10], based on comparison of the α intensity to the reported [1980Al14] intensities of the 151 keV γ-ray.
*** Weighted average of 4.420(10) MeV [1980Al14] and 4.417(10) MeV [1992Ha10].

Table 8
direct α emission from ^{163}Ta, J$^{\pi}$ = , T$_{1/2}$ = 10.9(12) s*, BR_α = <0.28(4)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{159}Lu)	coincident γ-rays	R$_0$ (fm)	HF
4.750(10)	4.633(10)***	<0.28(4)%**		0.0	—	1.575(13)	$0.17^{+0.07\ @}_{-0.05}$

* Weighted average of 10.5(18)s [1985Li14] and 11.2(16) s [1992Ha10].
** [1992Ha10], based on comparison of the α intensity to the reported [1985Li14] intensities of the 449 and 451 keV γ doublet.
*** Weighted average of 4.630(10) MeV [1986Ru05] and 4.635(7) MeV [1992Ha10].
$^@$ This unphysical result likely indicaties that the absolute γ-ray intensities are much weaker than the reported relative ones.

Table 9
direct α emission from ^{167}Re*, J^{π} = , $T_{1/2}$ = 3.4(4) s, BR_{α} = obs.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{163}Ta)	coincident γ-rays	R_0 (fm)	HF
5.138(10)	5.015(10)			?		1.540(14)	

* All values from [1992Me10].

Table 10
direct α emission from ^{167m}Re*, Ex = unk., J^{π} = , $T_{1/2}$ = 6.1(2) s**, BR_{α} = ≈1%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{163}Ta)	coincident γ-rays	R_0 (fm)	HF
5.392(10)	5.263(12)			0.0?		1.540(14)	$2.9^{+3.2}_{-1.3}$

* All values from [1992Me10], except where noted.
** [1984Sc06].

Table 11
direct α emission from ^{171}Ir*, J^{π} = (1/2^{+}), $T_{1/2}$ = $3.2^{+1.7}_{-0.7}$ s, BR_{α} =15(2)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{167}Re)	coincident γ-rays	R_0 (fm)	HF
5.871(7)	5.734(7)	15(2)%		x		1.5595(50)	

* All values from [2013An01].

Table 12
direct α emission from ^{171m}Ir, Ex = unk., J^{π} = (11/2^{-}), $T_{1/2}$ =1.24(4) s**, BR_{α} = 62(6)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{167}Re)	coincident γ-rays	R_0 (fm)	HF
6.061(4)	5.919(4)	100%	53(5)%***		0.0921(2)	0.0921(2)	1.5595(50)	
6.155(5)	6.011(5)	15(2)%	9(1)%	(11/2^{-})	0.0	—–	1.5595(50)	

* All values from [2023Zh03]. except where noted.
** Weighted average of 1.14(5) s [2014Pe02], 1.4(1) s [2013An01],and 1.28(4) [2023Zh03].
*** [2014Pe02].

Table 13
direct α emission from ^{175}Au*, J^{π} = (1/2^{+}), $T_{1/2}$ = 200(3) ms, BR_{α} =90(7)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{171}Ir)	coincident γ-rays	R_0 (fm)	HF
6.583(4)	6.433(4)	90(7)%**	(11/2^{-})	x		1.5504(54)	

* All values from [2017Ba46], except where noted.
** [2013An10].

Table 14
direct α emission from ^{175m}Au, Ex = unk., J^{π} = (11/2^{-}), $T_{1/2}$ =1.19(5) s*, BR_{α} = 90(3)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{171}Ir)	coincident γ-rays	R_0 (fm)	HF
6.583(4)	6.432(4)***	90(3)%**	(1/2^{+})	0.0	—–	1.5504(54)	

* Weighted average of 136(1) ms [2017Ba46] and 139(2) ms [2011Wa37].
** [2010An01].
*** Weighted average of 6.433(4) MeV [2017Ba46], 6.430(6) MeV [2011Wa37], and 6.432(5) MeV [2010An01].

Table 15
direct α emission from ^{179}Tl, J^{π} = (1/2$^+$), $T_{1/2}$ = 426(10) ms*, BR_{α} =60(2)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{175}Au)	coincident γ-rays	R_0 (fm)	HF
6.709(4)	6.559(4)	60(2)%**	(1/2$^+$)	0.0	—–	1.5297(36)	2.16(19)

* [2017Ba46].
** [2013An10].

Table 16
direct α emission from ^{179m}Tl, Ex = unk., J^{π} = (11/2$^-$), $T_{1/2}$ =1.42(3) ms*, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{175}Au)	coincident γ-rays	R_0 (fm)	HF
7.258(10)	7.096(10) @	25(11)%	20(9)%@		x + 0.113		1.5297(36)	
7.371(4)	7.206(4)***	100(25)%	80(20)%@	(11/2$^-$)	x		1.5297(36)	

* Weighted average of 1.40(3) ms [2017Ba46], and 1.46(4) ms [2010An01].
** [2010An01].
*** Weighted average of7.206(4) MeV [2017Ba46], and 7.207(5) MeV [2010An01].
@ [1998To14].

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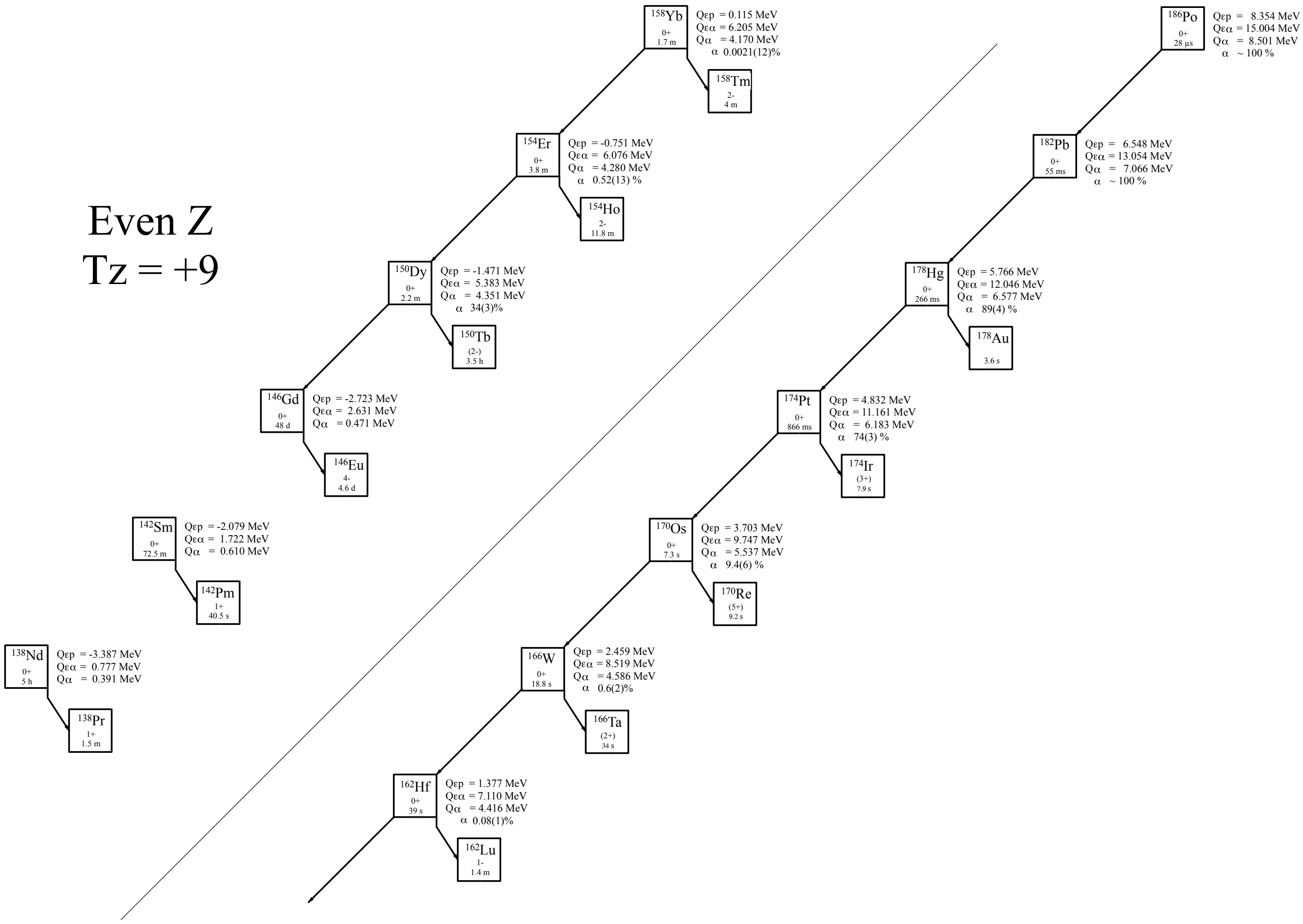

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +9 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +9 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J$^\pi$ values for ^{138}Nd, ^{142}Sm, and^{146}Gd are taken from ENSDF.

Nuclide	J^π	$T_{1/2}$	Q$_\varepsilon$	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	BR$_{\beta F}$	Experimental
^{138}Nd	0^+	5.04(9) h	1.112(15)	-3.387(12)	0.777(23)		[**1970Ho25**]
^{142}Sm	0^+	72.49(5) m	2.160(24)	-2.079(3)	1.722(10)		[**1966Ma15**]
^{146}Gd	0^+	48.27(10) d	1.032(7)	-2.723(4)	2.631(24)		[**1970Ch09**]
^{150}Dy	0^+	2.17(2) m	1.796(8)	-1.471(5)	5.383(7)		[**1973Bi06**]
^{154}Er	0^+	3.75(12) m	2.034(9)	-0.751(6)	6.076(9)		[**1974PeZS**]
^{158}Yb	0^+	1.65(20) m	2.694(26)	0.115(28)	6.205(11)		[**1977Ha48**]
^{162}Hf	0^+	39.8(4) s	3.660(80)	1.377(17)	7.110(27)		[**1995Hi12**]
^{166}W	0^+	18.8(4) s	4.210(30)	2.459(30)	8.519(76)		[**1989Hi04**]
^{170}Os	0^+	7.3(2) s*	4.978(15)	3.703(18)	9.747(30)		[**2004GoZZ, 1995Hi02, 1982En03**]
^{174}Pt	0^+	866(5) ms**	5.468(15)	4.832(18)	11.161(15)		[**2014Pe02, 2004GoZZ, 1996Pa01, 1982En03**]
^{178}Hg	0^+	266(3) ms***	5.988(15)	5.766(18)	12.046(16)		[**2002Ro17, 2000Ko01**]
^{182}Pb	0^+	55(5) ms	6.503(17)	6.548(20)	13.054(16)		[**1999To11**]
^{186}Po	0^+	28^{+16}_{-6} μs	7.247(25)	8.354(24)	15.004(22)		[**2013An13**]

* Weighted average of 7.2(2) s [2004GoZZ], 7.9(3) s [1995Hi02], and 7.1(2) s [1982En03],
** Weighted average of 930(30) ms [2014Pe02], 857(5) ms [2004GoZZ], 890(20 ms [1996Pa01], and 900(10) ms [1982En03],
*** Weighted average of 269(3) ms [2002Ro17] and 262(4) ms [2000Ko01].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the even-Z, T_z = +9 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_p$	S$_{2p}$	Q$_\alpha$	BR$_\alpha$	Experimental
^{138}Nd	6.104(14)	10.087(12)	0.391(23)		
^{142}Sm	5.748(14)	9.303(4)	0.610(12)		
^{146}Gd	5.383(5)	8.698(4)	0.471(4)		
^{150}Dy	5.110(5)	7.618(4)	4.351(2)	34(3)%*	[**1974To07, 1973Bi06, 1973BoXL, 1968Go32**] 1981HoZM, 1977Ha48, 1974ToZN, 1974ToZQ, 1974PeZS, 1970Ma23, 1968Go13, 1964Ma19, 1960To05]
^{154}Er	4.882(7)	7.065(6)	4.280(3)	0.52(13)%**	[**1974To07, 1974PeZS, 1973BoXL, 1968Go13**, 1988KaZK, 1982Bo04, 1978AfZZ, 1978VrZY, 1975ToZT, 1974ToZN, 1975ToZT, 1970Ma23, 1963Ma18]
^{158}Yb	4.589(29)	6.376(26)	4.170(7)	0.0021(12)%	[**1992Ha10, 1977Ha48**, 1979Ho10, 1976Gi15]
^{162}Hf	3.895(29)	5.583(11)	4.416(5)	0.008(1)%	[**1995Hi12, 1992Ha10, 1983To01, 1982Sc15**] 1992HeZV]
^{166}W	3.329(17)	4.647(18)	4.856(4)	0.6(2)%	[**1979Ho10, 1975To05**, 1987ScZL, 1984ScZQ, 1981HoZM, 1976ToZP]
^{170}Os	2.805(15)	3.611(16)	5.537(3)	9.4(6)%***	[**2004GoZZ, 1996Pa01, 1995Hi02, 1982De11 1982En03**, 2002Ro17, 1984Sc06, 1981DeZA, 1981DeZL, 1978Sc26, 1972To06, 1972ToZC, 1972ToZL, 1972ToZW]
^{174}Pt	2.338(15)	2.652(16)	6.183(3)	74(3)%	[**2004GoZZ, 2004Go38, 1996Pa01, 1979Ha10**, 2002Ro17, 1982En03, 1981DeZB, 1973Ga08 1966Si08]
^{178}Hg	2.059(15)	1.959(17)	6.577(3)	89(4)%	[**2012Ve04, 2004GoZZ, 2000Ko01, 1979Ha10** 2019Ma08, 2009An20, 2003An13, 2002Ro17, 1999To11, 1996Pa01, 1991Se01, 1976HaYQ, 1976HoZD, 1971Ha03]
^{182}Pb	1.315(15)	1.152(17)	7.066(6)	≈100%$^@$	[**2000Je09, 1999To11, 1987To09, 1986Ke05**, 2013An13, 1988ToZV, 1988ToZW, 1984SeZQ, 1982HeZM]
^{186}Po	0.952(83)	-0.575(22)	8.501(14)	100%$^@$	[**2013An13**, 2005AnZY]

* Weighted average of 31(3)% and 36(3)% [1974To07].
** Weighted average of 0.59(16)% and 0.47(13)% [1974To07].
*** Weighted average of 10(3)% [2004GoZZ], 8.6(5)% [1996Pa01], 992)% [1995Hi02], and 12(1)% [1982En03].
$^@$ Inferred from Half-life.

Table 3
direct α emission from ^{150}Dy, J^{π} = 0^{+}, $T_{1/2}$ = 7.17(2) m*, BR_{α} = 34(3)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{146}Gd)	coincident γ-rays	R_0 (fm)	HF
4.348(3)	4.232(3)	34(3)%**	0^{+}	0.0	—	1.5648(57)	1.0

* [1973Bi06].
** Weighted average of 31(3)% and 36(3)% [1974To07].

Table 4
direct α emission from ^{154}Er, J^{π} = 0^{+}, $T_{1/2}$ = 3.75(12) m*, BR_{α} = 0.52(13)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{150}Dy)	coincident γ-rays	R_0 (fm)	HF
4.279(5)	4.168(5)***	5.2(13)%**	0^{+}	0.0	—	1.556(18)	1.0

* [1974PeZS].
** Weighted average of 5.9(16)% and 4.7(13)% [1974To07].
*** Reported as 4.166(5) MeV [1968Go13] (adjusted to 4.168(5) MeV in [1999Ry01]).

Table 5
direct α emission from ^{158}Yb, J^{π} = 0^{+}, $T_{1/2}$ = 1.65(20) m*, BR_{α} = 0.0021(12)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{154}Er)	coincident γ-rays	R_0 (fm)	HF
4.171(10)	4.065(10)***	0.0021(12)%**	0^{+}	0.0	—	1.523(51)	1.0

* [1977Ha48].
** [1992Ha10].
*** weighted average of 4.059(12) MeV [1992Ha10] and 4.069 MeV [1977Ha48].

Table 6
direct α emission from ^{162}Hf*, J^{π} = 0^{+}, $T_{1/2}$ = 39.8(4) s, BR_{α} = 0.008(1)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{158}Yb)	coincident γ-rays	R_0 (fm)	HF
4.417(9)	4.308(9)**	0.008(1)%	0^{+}	0.0	—	1.583(10)	1.0

* All values from [1995Hi12], except where noted.
** Weighted average of 4.307(10) MeV [1995Hi12], 4.305(9) MeV [1992Ha10], 4.311(10) MeV [1983To01], and 4.308(10) MeV [1982Sc15].

Table 7
direct α emission from ^{166}W, J^{π} = 0^{+}, $T_{1/2}$ = 18.8(4) s*, BR_{α} = 0.6(2)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{162}Hf)	coincident γ-rays	R_0 (fm)	HF
4.865(5)	4.739(5)**	0.6(2)%**	0^{+}	0.0	—	1.660(23)	1.0

* [1989Hi04].
** [1979Ho10].
*** [1975To05].

Table 8
direct α emission from ^{170}Os, J^{π} = 0^{+}, $T_{1/2}$ = 7.3(2) s*, BR_{α} = 9.4(6)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{166}W)	coincident γ-rays	R_0 (fm)	HF
5.539(4)	5.409(4)***	9.4(6)%**	0^{+}	0.0	—	1.5615(43)	1.0

* Weighted average of 7.2(2) s [2004GoZZ], 7.9(3) s [1995Hi02], and 7.1(2) s [1982En03],
** Weighted average of 10(3)% [2004GoZZ], 8.6(5)% [1996Pa01], 992)% [1995Hi02], and 12(1)% [1982En03].
*** Weighted average of 5.410(5) MeV [2004GoZZ], 5.411(4) MeV [1982De11], and 5.405(5) MeV [1982En03].

Table 9
direct α emission from ^{174}Pt*, J^{π} = 0^+, $T_{1/2}$ = 866(5) ms**, BR_{α} =74(3)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_f	$E_{daughter}$(^{170}Os)	coincident γ-rays	R_0 (fm)	HF
5.898(5)	5.762(5)	<1%	<0.7%	2^+	0.287	0.2867	1.5553(31)	>6.6
6.182(5)	6.040(5)***	100%	73(1)%	0^+	0.0	—	1.5553(31)	1.0

* All values from [2004GoZZ], except where noted.
** Weighted average of 930(30) ms [2014Pe02], 857(5) ms [2004GoZZ], 890(20 ms [1996Pa01], and 900(10) ms [1982En03],
*** [2004GoZZ] and [2004Go38].

Table 10
direct α emission from ^{178}Hg, J^{π} = 0^+, $T_{1/2}$ = 266(3) ms*, BR_{α} = 89(4)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_f	$E_{daughter}$(^{174}Pt)	coincident γ-rays	R_0 (fm)	HF
6.577(3)	6.429(3)***	89(4)%**	0^+	0.0	—	1.5422(27)	1.0

* Weighted average of 269(3) ms [2002Ro17] and 262(4) ms [2000Ko01].
** [2012Ve04].
*** Weighted average of 6.429(5) MeV [2004GoZZ], 6.429(4) MeV [2000Ko01] and 6.430(6) MeV [1979Ha10].

Table 11
direct α emission from ^{182}Pb, J^{π} = 0^+, $T_{1/2}$ = 55(5) ms*, BR_{α} = ≈100%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_f	$E_{daughter}$(^{178}Hg)	coincident γ-rays	R_0 (fm)	HF
7.066(10)	6.910(10)***	≈100%**	0^+	0.0	—	1.5163(61)	1.0

* [1999To11].
** Inferred from half-life.
*** Weighted average of 6.911(10) MeV [2000Je09], 6.895(10) MeV [1999To11], 6.919(15) MeV [1987To09] and 6.921(10) MeV [1986Ke05].

Table 12
direct α emission from ^{186}Po*, J^{π} = 0^+, $T_{1/2}$ = 28^{+16}_{-6} μs, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_f	$E_{daughter}$(^{182}Pb)	coincident γ-rays	R_0 (fm)	HF
8.503(15)	8.320(15)	100%	0^+	0.0	—	1.487(43)	1.0

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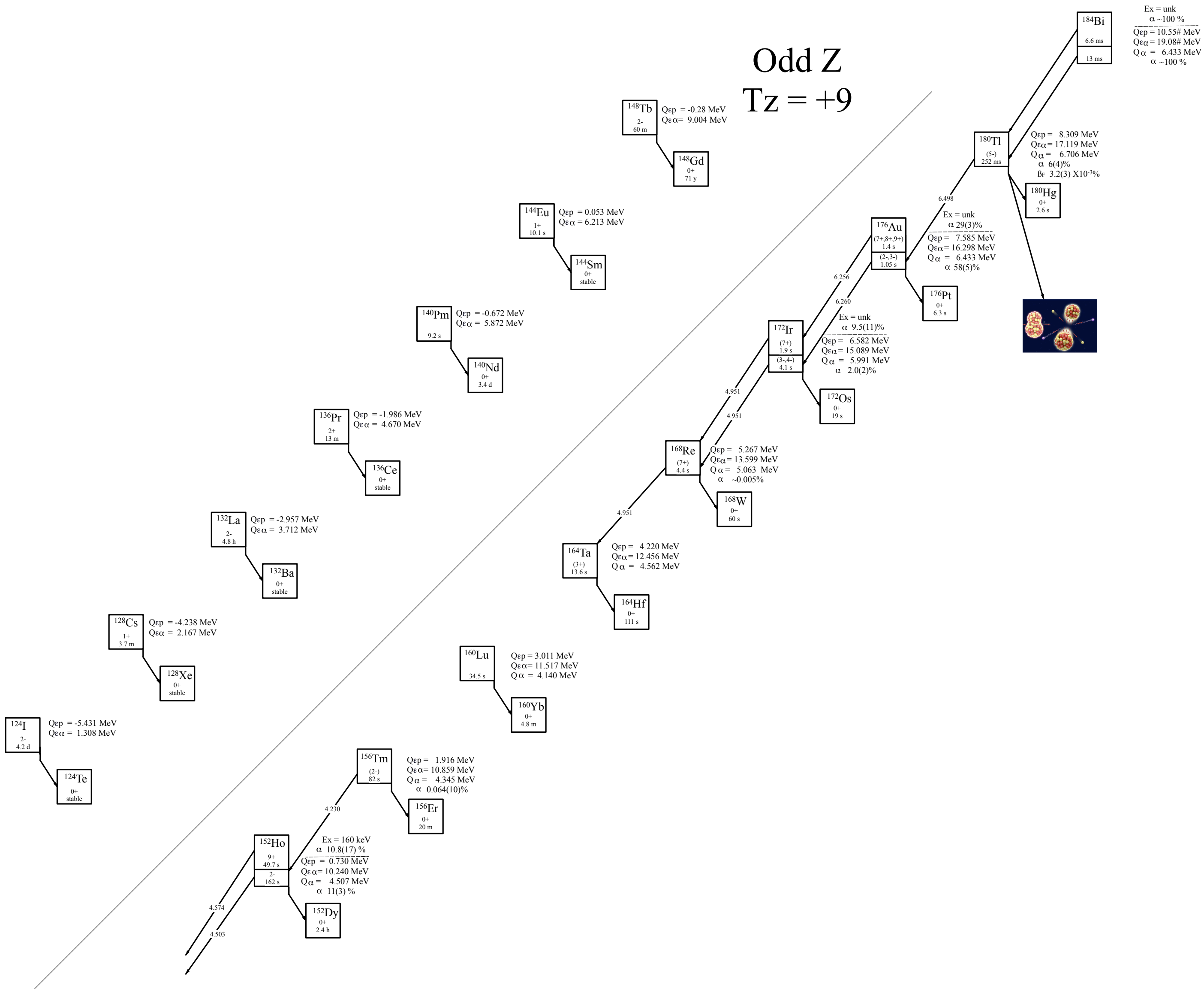

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +9 nuclei.

last updated 1/23/23

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +9 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J$^{\pi}$ values for ^{124}I, ^{128}Cs, ^{132}La, ^{136}Pr, ^{140}Pm, ^{144}Eu, ^{148}Tb, ^{164}Ta, are taken from ENSDF.

Nuclide	Ex	J^{π}	$T_{1/2}$	Q$_{\varepsilon}$	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	BR$_{\beta F}$	Experimental
^{124}I		2$^-$	4.1760(3) d	0.303(1.9)	-5.431(2)	1.308(2)		[**1992Wo03**]
^{128}Cs		1$^+$	3.66(2) m	3.929(5)	-4.238(6)	2.167(6)		[**1976He04**]
^{132}La		2$^-$	4.8(2) h	4.710(40)	-2.957(36)	3.712(36)		[**1960Wa03**]
^{136}Pr		2$^+$	13.1(1) m	5.168(11)	-1.986(15)	4.670(12)		[**1971Ke07**]
^{140}Pm			9.2(2) s	6.045(24)	-0.672(24)	5.872(24)		[**1968Bl14**]
^{144}Eu		1$^+$	10.1(1) s	6.346(11)	0.053(11)	6.213(11)		[**1976Ke01**]
^{148}Tb		2$^-$	60(1) m	5.732(13)	-0.281(13)	9.004(13)		[**1975SpZU**]
^{152}Ho		2$^-$	161.8(3) s	6.513(13)	0.730(13)	10.240(13)		[**1982Bo04**]
^{152m}Ho	0.160(1)	9$^+$	49.7(3) s*	6.673(13)	0.890(13)	10.400(13)		[**1987LiZY, 1987StZU, 1982Ba75, 1982Bo04, 1978AfZZ**]
^{156}Tm		2$^-$	82(3) s**	7.377(27)	1.916(23)	10.859(15)		[**1982To14, 1981Ga36**]
^{160}Lu			34.5(15) s	7.890(60)	3.011(63)	11.517(62)		[**1979Al16**]
^{164}Ta		(3$^+$)	13.6(2) s	8.540(30)	4.220(40)	12.456(28)		[**1983Sc18**]
^{168}Re		(7$^+$)	4.4(1) s	9.100(30)	5.267(42)	13.599(35)		[**1992Me10**]
^{172}Ir		(3$^-$, 4$^-$)	4.1(2) s	9.860(30)	6.582(43)	15.089(35)		[**2023Zh03**]
^{172m}Ir	x	(7$^+$)	1.89(5) s	9.860(30)+x	6.582(43)+x	15.089(35)+x		[**2023Zh03**]
^{176}Au***	y	(2$^-$,3$^-$)	1.046(11) s	10.410(40)+y	7.585(35)+y	16.298(36)+y		[**2021Ha37, 2004GoZZ**]
^{176m}Au***	x	(7$^+$, 8$^+$, 9$^+$)	1.36(2) s	10.410(40)+x	7.585(35)+x	16.298(36)+x		[**2021Ha37, 2004GoZZ**]
^{180}Tl		(5$^-$)		10.860(70)	8.309(71)	17.119(71)	3.2(3)$\times10^{-3}$%	[**2011El07**]
^{184}Bi***	y		13(2) ms	12.31(12)#+y	10.55(12)#+y	19.08(12)#+y		[**2003An27, 2003AnZZ**]
^{184m}Bi***	x		6.6(15) ms	12.31(12)#+x	10.55(12)#+x	19.08(12)#+x		[**2003An27, 2003AnZZ**]

* Weighted average of 49.5(3) s [1982Ba75], 49.7(4) s [1982Bo04] and 50.0(5) s [1978AfZZ].
** Weighted average of 80(3) s [1982To14] and 86(4) s 1981Ga36].
*** The relative ordering of the ^{176}Au and ^{184}Bi isomers are unknown.

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +9 nuclei. Unless otherwise stated, all S and Q-values and separation energies are taken from [2021Wa16].

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{124}I	5.483(2)	13.608(3)	-1.372(8)	—	
^{128}Cs	4.900(7)	12.599(7)	-0.992(6)	—	
^{132}La	4.334(36)	11.402(37)	-0.217(37)	—	
^{136}Pr	4.013(15)	10.700(23)	-0.042(38)	—	
^{140}Pm	3.484(37)	9.661(26)	0.703(27)		
^{144}Eu	3.391(11)	9.056(26)	0.168(27)		
^{148}Tb	2.469(13)	7.997(14)	2.657(16)		
^{152}Ho	2.141(13)	7.077(15)	4.507(1)	11(3)%	[**1987LiZY, 1987StZU, 1982Bo04, 1982To14, 1977Ha48, 1974Sc19**, 1983Ml01, 1982Ba75, 1981De11, 1981Ga36, 1981GaZO, 1983GaZR, 1980BaYV, 1978AfZZ, 1975ScZG, 1974PeZS, 1974ToZN, 1974ToZQ, 1973BoXL, 1970Ma23, 1967Ha34, 1963Ma17, 1961Ma40, 1960Ma47]
^{152m}Ho*	1.981(13)	6.901(15)	4.667(1)	10.8(17)%*	[**1987LiZY, 1987StZU, 1982Ba75, 1982Bo04, 1981Ga36, 1979To09, 1978AfZZ**, 1983Ml01, 1981Ga36, 1981GaZO, 1980BaYV, 1975ScZG, 1974Sc19, 1974ToZN, 1974ToZQ, 1973BoXL]
^{156}Tm	1.914(15)	6.773(16)	4.345(7)	0.064(10)%	[**1982To14, 1981Ga36**, 1992Po14, 1991VaZZ 1989KaYU, 1983Mi01, 1981GaZR, 1980AfZZ, 1971To10, 1971ToZP, 1971ToZR, 1971ToZX, 1970ToZS, 1970ToZY]
^{160}Lu	1.725(59)	6.145(62)	4.140(59)	$\leq 10^{-4}$%	[**1981Ga36, 1981GaZR**]
^{164}Ta	1.302(38)	5.029(80)	4.562(63)		
^{168}Re	0.991(36)	4.275(42)	5.063(13)	≈0.005%	[**1992Me10**, 1992MeZW]
^{172}Ir	0.371(37)	3.053(34)	5.991(10)	2.0(2)%	[**2023Zh03, 2021Ha32, 2014An10, 1992Sc16**, 2017An16, 2004GoZZ]
^{172m}Ir***	0.371(37)-x	3.053(34)-x	5.991(10)+x	9.5(11)%	[**2023Zh03, 2021Ha32, 2014An10, 1992Sc16**, 2017An16, 2014Pe02, 2004GoZZ, 1996Pa01, 1992MeZW, 1984Gr14, 1982De11, 1982DeZA, 1978Sc26, 1967Si02]
^{176}Au$^{@}$	0.101(38)-y	2.313(35)-y	6.433(7)+x	58(5)%	[**2021Ha32, 2014An10**, 2017An16, 2004GoZZ]
^{176m}Au$^{@}$	0.101(38)-x	2.313(35)-x	6.433(7)+x	29(3)%	**2021Ha32, 2014An10**, 2017An16, 2013KoZR, 2004GoZZ, 2002Ro17, 1990KaZI, 1990SEZW, 1984ScZQ, 1984Gr14, 1975Ca06, 1974CaYE]
^{180}Tl	-0.254(75)	1.665(71)	6.706(62)	6(4)%	[**2017An16**, 2013Le08, 2013KoZR, 2010An13 2003An27, 2003AnZZ, 1998To14, 1993LaZT]
^{184}Bi	-1.55(13)#-y	-0.00(12)#-y	8.22(10)#+y	≈ 100%**	[**2003An27, 2003AnZZ**]
^{184}Bi	-1.55(13)#-x	-0.00(12)#-x	8.22(10)#+x	≈ 100%**	[**2003An27, 2003AnZZ**]

* Weighted average of 11(2)% [1981Ga36] and 10.5(30)% [1979To09].
** Inferred from half-life.

Table 3
direct α emission from ^{152}Ho*, $J^\pi = 2^-$, $T_{1/2}$ = 161.8(3) s**, BR_α = 11(3)%***.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{148}Tb)$^{@}$	coincident γ-rays	R_0 (fm)$^{@@}$	HF
4.224	4.113	<2%	<0.2%	3^+	0.281	0.110, 0.102, 0.086	1.566(19)	>3.3
4.308	4.195	<2%	<0.2%	3^-	0.195	0.110, 0.086	1.566(19)	>11
4.326	4.212	<2%	<0.2%	2^+	0.178	0.178	1.566(19)	>50
4.395	4.279	<2%	<0.2%	4^-	0.110	0.110	1.566(19)	>120
4.505(3)	4.386(3)	100%	11(3)%***	2^-	0.0	—	1.566(19)	$2.9^{+1.6}_{-1.0}$

* All Values from [1987StZU], except where noted.
** [1982Bo14].
*** From [1977Ha48]. A value of 3(1)% was reported in [1982To14], which would result in a HF = 11^{+7}_{-4} for the 4.386 MeV α transition.
$^{@}$ [2014Ni05].
$^{@@}$ Interpolated between 1.565(6) fm ^{150}Dy and 1.556(18) fm ^{154}Er.

Table 4
direct α emission from ^{152m}Ho*, Ex = 160(1) keV, J^{π} = 9^{+}, $T_{1/2}$ = 49.7(3) s**, BR_{α} = 10.8(17)%***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{148}Tb)$^{@}$	coincident γ-rays	R_0 (fm)$^{@@}$	HF
4.258	4.146	<2%	<0.2%	8^{+}	0.406	0.318, 0.238. 0.078	1.566(19)	>1.7
4.336	4.222	<2%	<0.2%	7^{+}	0.328	0.238	1.566(19)	>16
4.574(3)	4.454(3)	100%	10.8(17)%***	(9^{+})	0.0901(7)		1.566(19)	$2.1^{+1.0}_{-0.7}$

* All Values from [1987StZU], except where noted.
** Weighted average of 49.5(3) s [1982Ba75], 49.7(4) s [1982Bo04] and 50.0(5) s [1978AfZZ].
*** Weighted average of 11(2)% [1981Ga36] and 10.5(30)% [1979To09].
$^{@}$ [2014Ni05].
$^{@@}$ Interpolated between 1.565(6) fm ^{150}Dy and 1.556(18) fm ^{154}Er.

Table 5
direct α emission from ^{156}Tm, J^{π} = 2^{-}, $T_{1/2}$ = 82(3) s*, BR_{α} = 0.064(10)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{152}Ho)	coincident γ-rays	R_0 (fm)$^{@}$	HF
4.341(10)	4.230(10)	0.064(10)%**	2^{-}	0.0	—–	1.540(54)$^{@}$	$1.5^{+2.7}_{-1.0}$

* Weighted average of 80(3) s [1982To14] and 86(4) s and [1981Ga36].
** [1981Ga36].
*** [1982To14].
$^{@}$ Interpolated between 1.556(18) fm ^{154}Er and 1.523(51) ^{158}Yb.

Table 6
direct α emission from ^{168}Re*, J^{π} = (7^{+}), $T_{1/2}$ = 4.4(1) s, BR_{α} = ≈0.005%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{164}Ta)	coincident γ-rays	R_0 (fm)$^{@}$	HF
4.951(13)	4.833(13)	≈0.005%		0.1118	0.1118	1.611(23)$^{@}$	≈ 11

* All values from [1992Me10].
** Interpolated between 1.660(23) fm ^{166}W and 1.562(4) ^{170}Os.

Table 7
direct α emission from ^{172}Ir*, J^{π} = (3^{-}, 4^{-}), $T_{1/2}$ = 4.1(2) s, BR_{α} = 2.0(2)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{168}Re)	coincident γ-rays	R_0 (fm)$^{@}$	HF	
5.636(5)	5505(5)	31(8)%	0.36(6)%		0.1360(2) +x	0.1360(2)	1.559(5)$^{@}$	13^{+5}_{-4}
5.648(5)	5.517(5)	13(3)%	0.15(3)%		0.1230(2) +x	0.1230(2)	1.559(5)$^{@}$	37^{+18}_{-10}
5.669(5)	5.537(5)	100(17)%	1.15(2)%		0.1028(3) +x	0.1028(3)	1.559(5)$^{@}$	$5.9^{+2.0}_{-1.4}$
5.679(5)	5.547(5)	30(7)%	0.34(6)%		0.0894(3) +x	0.0894(3)	1.559(5)$^{@}$	23^{+10}_{-6}

* All values from [2023Zh03], unless otherwise noted.
** [1992Sc16].
*** Interpolated between 1.562(4) ^{170}Os and 1.5553(31) ^{174}Pt.

Table 8
direct α emission from ^{172m}Ir*, Ex = unk., J^{π} = (7^{+}), $T_{1/2}$ = 2.0(1) s**, BR_{α} = 9.5(11)%***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{168}Re)	coincident γ-rays	R_0 (fm)$^{@}$	HF
5.892(7)	5.755(7)	<0.05%	<0.004%		0.224(1)	0.224(1)	1.559(5)$^{@@}$	>7×10^{3}
5.957(10)	5.818(4)	100%	8.8(10)%		0.1621(2)	0.1621(2)	1.559(5)$^{@@}$	$7.1^{+1.5}_{-1.3}$
6.125(15)	5.983(15)$^{@}$	8(2)%	0.8(2)%	(7^{+})	0.0	—–	1.559(5)$^{@@}$	420^{+23}_{-13}

* All values from [2023Zh03], unless otherwise noted.
** [1992Sc16].
*** [2014An10].
$^{@}$ Only observed in [2021Ha32].
$^{@@}$ Interpolated between 1.562(4) ^{170}Os and 1.5553(31) ^{174}Pt.

Table 9
direct α emission from ^{176}Au*, J^{π} = (2^-,3^-), $T_{1/2}$ = 1.046(11) s**, BR_{α} = 58(5)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{172}Ir)	coincident γ-rays	R_0 (fm)@	HF
5.933	5.798	<0.44%	<0.25%		0.500	0.500	1.5488(41)***	>12
6.192(15)	6.052(15)	3.1(2)%	1.6(2)%		0.2366	0.2366	1.5488(41)***	21(3)
6.281(10)	6.138(10)	6.7(6)%	3.5(4)%		0.1515	0.1515	1.5488(41)***	21^{+4}_{-3}
6.300	6.157	<0.9%	0.46(4)%		0.1266	0.1266	1.5488(41)***	>200
6.406(5)	6.260(5)	100%	52(5)%	(2^-, 3^-)	0.025		1.5488(41)***	4.4(5)

* All values from [2021Ha32], unless otherwise noted. The relative ordering of the ^{176}Au isomers in unknown.
** [2004GoZZ].
*** Interpolated between 1.5553(31) ^{174}Pt and1.5422(27) ^{178}Hg.

Table 10
direct α emission from ^{176m}Au*, Ex = unk., J^{π} = (7^+, 8^+, 9^+), $T_{1/2}$ = 1.36(2) s**, BR_{α} = 29(5)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{172m}Ir)	coincident γ-rays	R_0 (fm)@	HF
6.221(5)	6.080(5)	55(4)%	9.6(17)%	(7^+, 8^+, 9^+)	0.2116+x	0.2116	1.5488(41)***	$5.6^{+1.4}_{-1.0}$
6.256(5)	6.114(5)	100%	17(3)%		0.1752+x	0.1752	1.5488(41)***	$4.3^{+1.1}_{-0.8}$
6.426(10)	6.280(10)	12(2)%	2.0(5)%		x		1.5488(41)***	170^{+60}_{-40}

* All values from [2021Ha32], unless otherwise noted. The relative ordering of the ^{176}Au isomers in unknown.
** [2004GoZZ].
*** Interpolated between 1.5553(31) ^{174}Pt and1.5422(27) ^{178}Hg.

Table 11
direct α emission from ^{180}Tl*, J^{π} = (5^-), $T_{1/2}$ = 1.09(1) s**, BR_{α} = 6(4)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{176}Au)	coincident γ-rays (keV)	R_0 (fm)***	HF
6.006(8)	5.873(8)	0.25(6)%	0.006(4)%		0.695	695.1(5), 491.2(4), 486.1(3), 361.7(2), 333(1), 209.9(2), 204.8(2)	1.5293(67)	100^{+230}_{-40}
6.021(8)	5.887(8)	0.30(6)%	0.0072(50)%		0.678	677.5(7), 570.3(3), 472.5(4), 467.9(4), 209.9(2), 204.8(2)	1.5293(67)	100^{+220}_{-40}
6.113(8)	5.977(8)	0.40(6)%	0.0096(66)%		0.596	595.9(5), 391.2(3), 386.5(3), 317.1(2), 279.6(3), 209.9(2), 204.8(2)	1.5293(67)	160^{+180}_{-40}
6.131(8)	5.995(8)	0.18(3)%	0.0042(29)%		0.570	570.3(3), 317.1(2), 253(1), 209.9(2), 204.8(2)	1.5293(67)	500^{+1350}_{-70}
6.152(8)	6.015(8)	0.13(3)%	0.003(2)%		0.553	553.2(3)	1.5293(67)	800^{+180}_{-40}
6.186(9)	6.049(9)	0.08(3)%	0.0018(14)%		0.526	526.1(4)	1.5293(67)	$1.7^{+5.0}_{-0.8}\times10^3$
6.226(9)	6.088(9)	0.08(3)%	0.0018(14)%		0.473	473.4(4)	1.5293(67)	$3.0^{+8.0}_{-1.0}\times10^3$
6.307(8)	6.167(8)	0.23(5)%	0.00054(38)%		0.398	397.9(3)	1.5293(67)	$1.9^{+4.5}_{-0.8}\times10^3$
6.333(7)	6.192(7)	2.26(32)%	0.054(37)%		0.372	204.8(2), 167.6(2)	1.5293(67)	200^{+50}_{-10}
6.340(7)	6.199(7)	43.5(50)%	1.0(7)%		0.362	361.7(2), 317.1(2), 209.9(2), 204.8(2), 151.7(2), 112.2(2), 107.1(2)	1.5293(67)	13^{+28}_{-6}
6.387(7)	6.245(7)	63(7)%	1.5(10)%		0.317	317.1(2), 209.9(2), 204.8(2), 112.2(2), 107.1(2)	1.5293(67)	14^{+29}_{-6}
6.492(7)	6.348(7)	9.1(11)%	0.22(15)%		0.210	209.9(2)	1.5293(67)	30^{+50}_{-10}
6.498(7)	6.354(7)	100(9)%	2.4(16)%		0.205	204.8(2)	1.5293(67)	20^{+50}_{-10}
6.702(7)	6.553(7)	32(3)%	0.77(0.52)%	(2^-,3^-)	0.0	——	1.5293(67)	400^{+900}_{-200}

* All Values from [2017An16], except where noted.
** [2011El07].
*** Interpolated between 1.5422(27) ^{178}Hg and 1.5163(61) ^{182}Pb.

Table 12
direct α emission from ^{184}Bi*, J^{π} = , $T_{1/2}$ = 13(2) ms, BR_{α} =≈ 100%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{180}Tl)	coincident γ-rays (keV)
7.28-7.51	7.12-7.35***				
7.354(20)	7.194(20)			0.124	

* All Values from [2003An27], except where noted. The relative ordering of the ^{184}Bi isomers in unknown.
** Inferred from half-life.
*** Complex structure with contributions from many α-decays.

Table 13
direct α emission from ^{184m}Bi*, J^{π} = , $T_{1/2}$ = 6.6(15) ms, BR_{α} =≈ 100%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{180}Tl)	coincident γ-rays (keV)
7.90-8.02	7.73-7.85***				
7.380(15)	7.220(15)			0.449	
7.610(35)	7.445(35)				

* All Values from [2003An27], except where noted. The relative ordering of the ^{184}Bi isomers in unknown.
** Inferred from half-life.
*** Complex structure with contributions from many α-decays.

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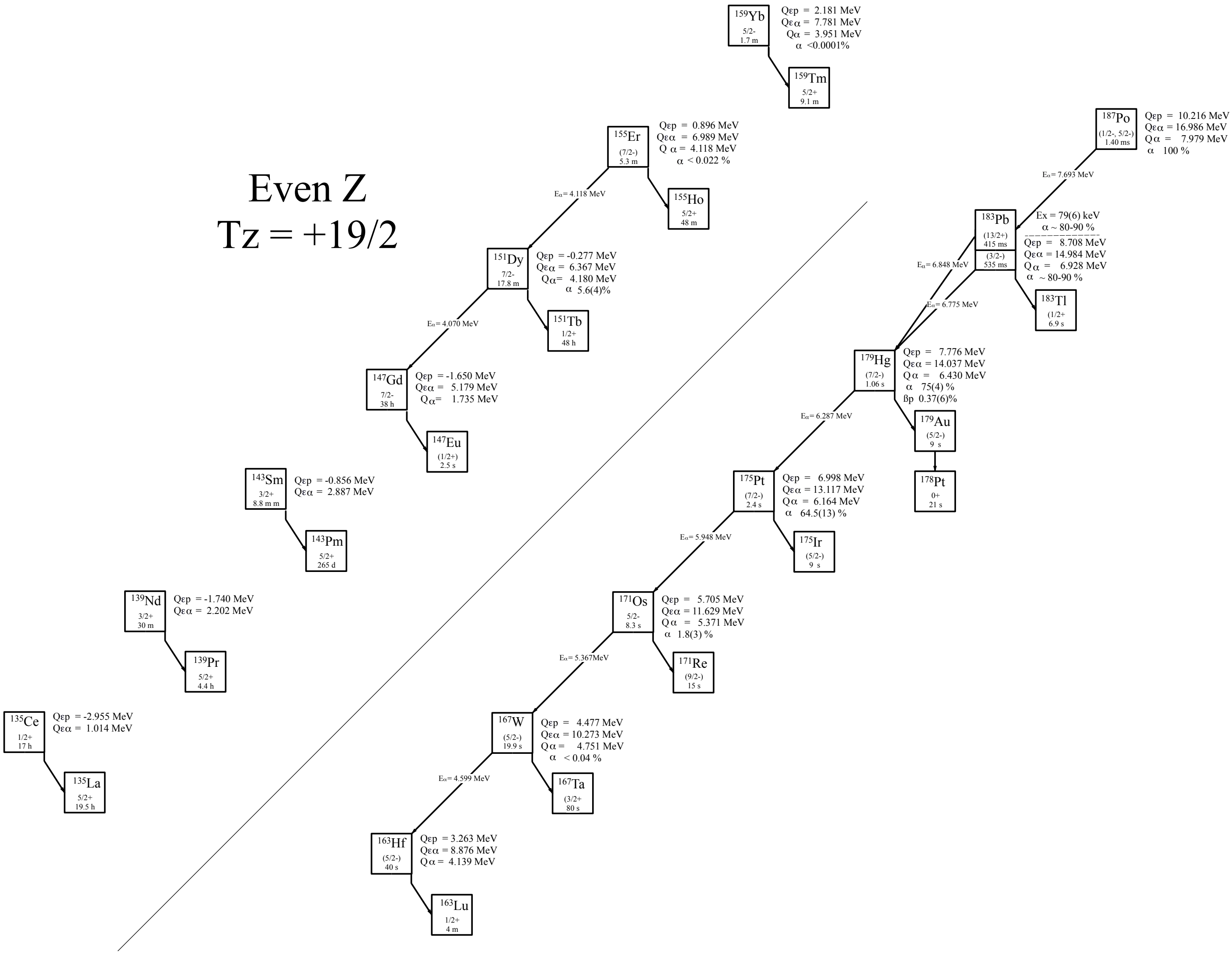

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +19/2 nuclei.

Last updated 2/10/23

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +19/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J$^\pi$ values for ^{135}Ce, ^{139}Nd, ^{143}Sm, ^{147}Gd, ^{159}Yb, ^{163}Hf are taken from ENSDF.

Nuclide	Ex	J^π	$T_{1/2}$	Q$_\varepsilon$	$Q_{\varepsilon p}$	BR$_{\beta p}$	$Q_{\varepsilon\alpha}$	Experimental
^{135}Ce		1/2$^+$	17.8(3) h	2.027(5)	-2.955(10)		1.014(10)	[**1976Ge10**]
^{139}Nd		3/2$^+$	29.7(5) m	2.812(28)	-1.740(28)		2.202(29)	[**1967La19**]
^{143}Sm		3/2$^+$	8.83(1) m	3.444(4)	-0.856(2)		2.887(5)	[**1968Bl13**]
^{147}Gd		7/2$^-$	38,06(12) h	2.188(3)	-1.650(3)		5.179(3)	[**1969Ch32**]
^{151}Dy		7/2$^-$	17.8(2) m*	2.871(5)	-0.277(7)		6.367(4)	[**1978MoZH, 1973Bi06, 1965Ma51, 1964Ma19**]
^{155}Er		(7/2$^-$)	5.3(3) m	3.831(18)	0.896(9)		6.989(7)	[**1969To06**]
^{159}Yb		5/2$^-$	1.72(10) m	4.740(30)	2.181(31)		7.781(25)	[**1993Al03**]
^{163}Hf		(5/2$^-$)	40.0(6) s	5.520(40)	3.263(30)		8.876(38)	[**1982Sc15**]
^{167}W		(5/2$^-$)	19.9(5) s	6.260(30)	4.477(34)		10.273(34)	[**1989Me02**]
^{171}Os		5/2$^-$	8.3(2) s	6.950(30)	5.705(23)		11.629(33)	[**1995Hi02**]
^{175}Pt		(7/2$^-$)	2.43(4) s	7.686(22)	6.998(21)		13.117(34)	[**2014Pe02**]
^{179}Hg		(7/2$^-$)	1.06(4) s	8.060(30)	7.776(30)	0.37(6)%***	14.037(31)	[**2002Ko09, 2002Ro17, 1971Ha03, 1971Ho07**]
^{183}Pb		(3/2$^-$)	535(30) ms	9.010(30)	8.708(31)		14.984(31)	[**2002Je09**]
^{183m}Pb	0.079(6)	(13/2+)	415(20) ms	9.089(30)	8.787(31)		15.063(31)	[**2002Je09**]
^{187}Po		(1/2$^-$, 5/2$^-$)	1.40(25) ms	9.210(30)	10.216(34)		16.986(34)	[**2006An11**]

* Weighted average of 17.5(5) m [1978MoZH], 16.9(5) m [1973Bi06], 17.7(5) m [1965Ma51] and 18.0(2) m [1964Ma19].
** Weighted average of 1.00(5) s [2002Ko09], 1.08(9) s [2002Ro17], and 1.09(4) s [1971Ha03].
*** [1971Ho17] reports I$_{\beta p}$p/I$_\alpha$ = 0.28(4)%. Combining this value with BR$_\alpha$= 75(4)% [2012Ve04] results in BR$_{\beta p}$ = 0.37(6)%

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the even-Z, T_z = +19/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_p$	S$_{2p}$	Q$_\alpha$	BR$_\alpha$	Experimental
^{135}Ce	6.687(22)	11.641(10)	-0.362(10)		
^{139}Nd	6.177(29)	10.676(28)	0.174(29)		
^{143}Sm	5.665(24)	9.904(4)	0.075(28)		
^{147}Gd	5.528(6)	9.283(1)	1.735(2)		
^{151}Dy	4.936(8)	8.203(4)	4.180(3)	5.6(4)%	[**1974To07, 1982Bo04, 1978MoZH, 1973Bi06**, **1965Ma51, 1964Ma19**, 1990KaZM, 1989KaYU, 1988KaZK, 1987KaZI, 1985Ne09, 1982De11, 1981HoZM, 1979Ho10, 1978AfZZ, 1975ToZT, 1974ToZN, 1974ToZQ, 1973BoXL, 1972OkZZ, 1968Go13, 1967Go32, 1960Ma47]
^{155}Er	4.859(10)	7.644(7)	4.118(5)	<0.022(7)%	[**1974To07**, 1990Po13, 1990KaZM, 1978AfZZ, 1975ToZT, 1974PeZS, 1970Ma23, 1969To06]
^{159}Yb	4.419(31)	6.998(32)	3.951(18)	<0.0001%***	[**1995Hi12**]
^{163}Hf	3.727(79)	6.013(30)	4.139(31)		
^{167}W	3.284(34)	5.036(34)	4.751(30)	<0.04(1)%	[**1991Me05, 1989Me02**]
^{171}Os	2.682(22)	3.957(24)	5.371(4)	1.8(3)%*	[**1995Hi02, 1979Ha10**, 2004GoZZ, 1996Pa01, 1978Sc26, 1976HoZD, 1972To06, 1972ToZC, 1972ToZL, 1972ToZO, 1972ToZW]
^{175}Pt	2.212(22)	2.848(24)	6.164(4)	64.5(13)%	[**2014Pe02, 1979Ha10**, 2004GoZZ, 2002Ko09, 1996Pa01, 1986Ke03, 1982De11, 1981DeZA, 1981DeZL, 1976HoZD, 1973Ga08, 1971Ha03, 1970Ha18, 1966Si08]
^{179}Hg	1.919(30)	2.140(33)	6.430(4)**	75(4)%	[**2012Ve04, 2002Ko09, 1979Ho10**, 2002Ro17, 1996Pa01, 1982HeZM, 1971Ha03, 1971Ho17, 1970Ha18, 1969NaZT, 1968De01]
^{183}Pb	1.542(31)#	1.497(33)#	6.928(7)	obs$^@$	[**2002Je09, 1989To01**, 2012Ve04, 1987To09, 1986Ke03, 1980Sc09]
^{183m}Pb	1.463(31)#	1.418(33)#	7.007(9)	obs$^@$	[**2002Je09, 1989To01**, 1987To09, 1986Ke03, 1984ScZQ, 1980Sc09]
^{187}Po	1.320(37)	0.213(36)	7.979(15)	100%	[**2006An11**, 2007An19, 2005An17, 2005AnZY]

* Weighted average of 1.9(3)% [1995Hi02] and 1.7(3)% [1979Ha10].
** Deduced from α energy, 6.351(31) in [2021Wa16].
*** Not observed.
$^@$ Not measured, expected to be 80-90% based on half-life.

Table 3
direct α emission from ^{151}Dy, J^{π} = 7/2$^-$, $T_{1/2}$ = 17.8(2) m*, BR_α = 5.6(4)**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{147}Gd)	coincident γ-rays	R_0 (fm)	HF
4.184(3)	4.070(3)***	5.6(4)**	7/2$^-$	0.0	—–	1.5706(33)	1.92(20)

* Weighted average of 17.5(5) m [1978MoZH], 16.9(5) m [1973Bi06], 17.7(5) m [1965Ma51] and 18.0(2) m [1964Ma19].
** [1974To07].
*** From 4.67(3) MeV [1982Bo04], adjusted to 4070(3) in [1991Ry01].

Table 4
direct α emission from ^{155}Er*, J^{π} = (7/2$^-$),$T_{1/2}$ = 5.3(3) m**, BR_α = <0.022(7)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{151}Dy)	coincident γ-rays	R_0 (fm)	HF
4.118(5)	4.012(5)	<0.022(7)%	7/2$^-$	0.0	—–	1.546(21)	>2.9

* All values from [1974To07], except where noted.
** [1969To06].

Table 5
direct α emission from ^{167}W*, J^{π} = (5/2$^-$), $T_{1/2}$ = 19.9(5) s, BR_α = < 0.04(1)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{163}Hf)	coincident γ-rays	R_0 (fm)	HF
4.671(13)	4.559(13)**	0.04(1)%	(5/2$^-$)	***		1.548(28)	$0.9^{+1.3}_{-0.6}$ @

* All values from [1989Me02], except where noted.
** [1991Me05].
*** Assumed to feed the ground state of ^{163}Hf in [1989Me02]. However, using the Q_α from this value gives a HF value of 0.16, indicating that it likely feeds an excited state or the value for BR_α is much smaller.
@ Calculated using 4.751(30) MeV [2021Wa16] for Q_α.

Table 6
direct α emission from ^{171}Os*, J^{π} = 5/2$^-$,$T_{1/2}$ = 8.3(2) s, BR_α = 1.8(3)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{167}W)	coincident γ-rays	R_0 (fm)	HF	
5.290(10)	5.166(10)	7.0%***	(7/2$^-$)	0.12(3)%	0.079	0.079***	1.5721(95)	$7.7^{+3.0}_{-2.1}$
5.367(7)	5.241(7)	100%***	(5/2$^-$)	1.68(3)%	0.0	—–	1.5721(95)	$1.3^{+0.4}_{-0.3}$

* All values from [1995Hi02], except where noted.
** Weighted average of 1.9(3)% [1995Hi02] and 1.7(3)% [1979Ha10].
*** Uncertainties not given in [1995Hi02].

Table 7
direct α emission from ^{175}Pt*, J^{π} = (7/2$^-$), $T_{1/2}$ = 2.43(4) s, BR_α = 64.5(13)%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{171}Os)	coincident γ-rays	R_0 (fm)	HF
5.950(4)	5.814(4)	7.3(16)%	4.0(9)%	(7/2$^-$, 9/2$^-$)	0.2112(5)	0.2112(5), 0.1341(4), 0.0767(3)	1.5574(37)	$6.6^{+2.1}_{-1.4}$
5.955(4)	5.819(4)	1.3(4)%	0.7(2)%	(9/2$^-$)	0.2079(5)	0.2079(5), 0.1308(4), 0.0767(3)	1.5574(37)	38^{+16}_{-9}
6.087(4)	5.948(4)	100(1)%	55.0(5)%	(7/2$^-$)	0.0767(3)	0.0767(3)	1.5574(37)	1.71(15)
6.162(4)	6.021(4)	8.7(15)%	4.8(8)%	(5/2$^-$)	0.0	—–	1.5574(37)	40^{+9}_{-7}

* All values from [2014Pe02], except where noted.

Table 8
direct α emission from ^{179}Hg, J^{π} = (7/2^{-}), $T_{1/2}$ = 1.06(4) s*, BR_{α} = 75(4)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{175}Pt)	coincident γ-rays	R_0 (fm)	HF	
6.430(4)	6.287(4)	75(4)%**	(7/2^{-})		0.0	—	1.5367(27)	1.26(12)

* Weighted average of 1.00(5) s [2002Ko09], 1.08(9) s [2002Ro17], and 1.09(4) s [1971Ha03].
** [2112Ve04].

Table 9
direct α emission from ^{183}Pb*, J^{π} = (3/2^{-}),$T_{1/2}$ = 535(30) ms, BR_{α} = obs**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{179}Hg)	coincident γ-rays	R_0 (fm)	HF
6.717(10)	6.570(10)	39(6)%	(3/2^{-})		0.217	0.217	1.5067(87)	$1.7^{+0.5}_{-0.4}$***
6.926(7)	6.775(7)	100(7)%	(7/2^{-})		0.0	—	1.5067(87)	$3.9^{+0.9}_{-0.8}$***

* All values from [2002Je01], except where noted.
** Not measured, expected to be 80-90% based on half-life.
*** Value based on a 100% *alpha* branching ratio for ^{183}Pb.

Table 10
direct α emission from ^{183m}Pb*, Ex = 79(6) keV, J^{π} = ,$T_{1/2}$ = 415(20) ms, BR_{α} = obs**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{179}Hg)	coincident γ-rays	R_0 (fm)	HF
6.848(5)	6.698(5)	100(6)%	(13/2^{+})		0.172	0.0061, 0.111	1.5067(87)	$1.12^{+0.24}_{-0.20}$***
7.013(11)	6.860(11)	3(1)%	(7/2^{-})		0.0	—	1.5067(87)	140^{+90}_{-50}***

* All values from [2002Je01], except where noted.
** Not measured, expected to be 80-90% based on half-life.
*** Value based on a 100% *alpha* branching ratio for ^{183}Pb.

Table 11
direct α emission from ^{187}Po*, J^{π} = (1/2^{-}, 5/2^{-}), $T_{1/2}$ = 1.40(25) ms, BR_{α} = 100%***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{183}Pb)	coincident γ-rays	R_0 (fm)	HF
7.693(15)	7.528(15)	100%	100%	(1/2^{-})	0.286(1)	0.286(1)	1.487(13)	$0.29^{+0.11}_{-0.09}$ @
7.979	7.808	<2%**	<2%**	(3/2^{-})	0.0	—	1.487(13)	>100

* All values from [2006An11].
** A single event at this energy was pbserved observed.
*** Inferred from half-life.
@ The very low value for HF may indicate that the decay of ^{187}Po has other unobserved transitions.

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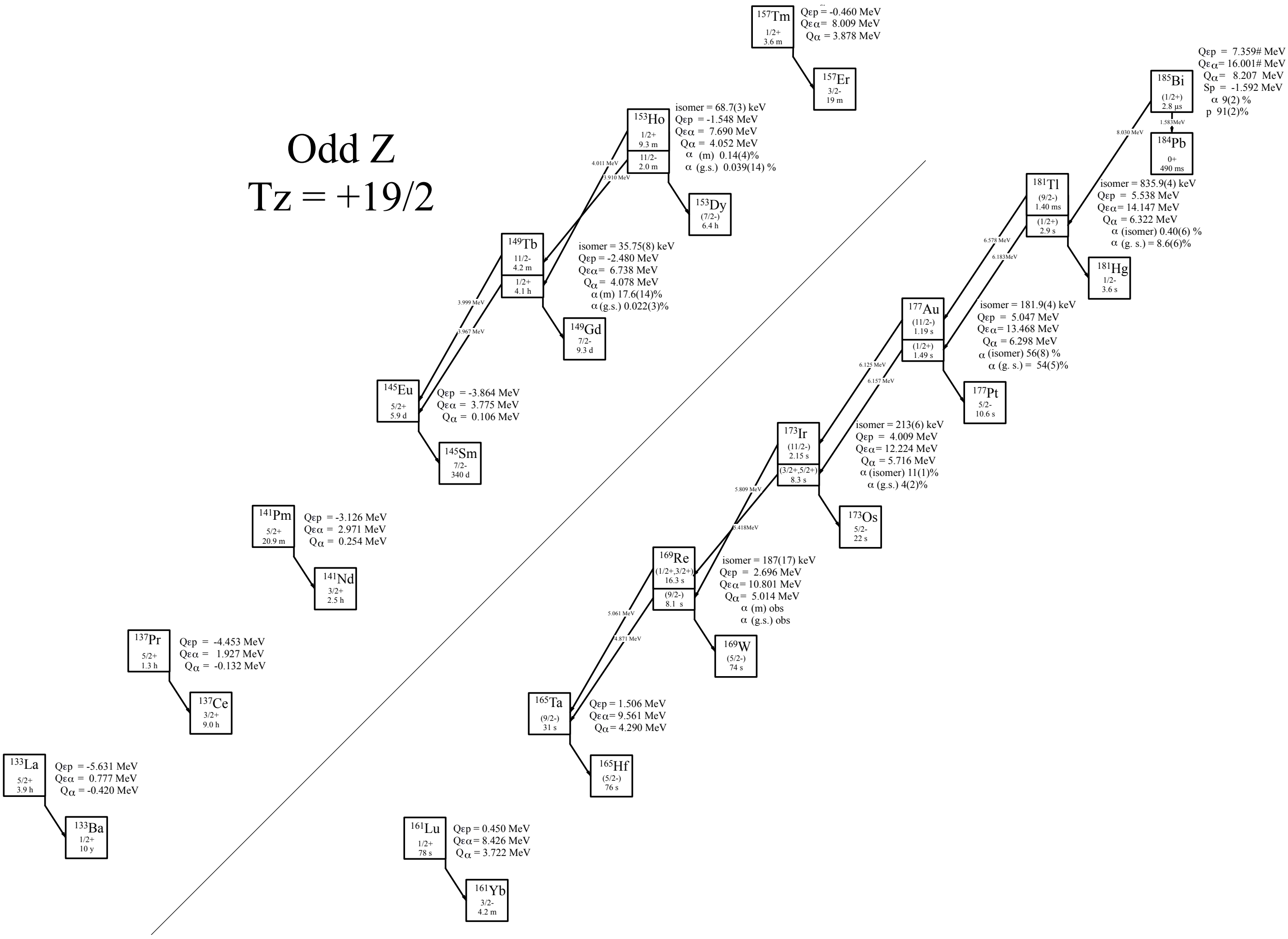

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +19/2 nuclei.

last updated 3/27/23

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +19/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J^π values for ^{133}La, ^{137}Pr, ^{141}Pm, ^{145}Eu, ^{153}Ho are taken from ENSDF.

Nuclide	Ex	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	$BR_{\beta F}$	Experimental
^{133}La		$5/2^+$	4.0 h	2.059(28)	-5.631(28)	0.777(28)		[**1973Re05**]
^{137}Pr		$5/2^+$	1.28(3) h	2.717(8)	-4.453(54)	1.927(8)		[**1973Bu18**]
^{141}Pm		$5/2^+$	20.90(5) m	3.669(14)	-3.126(15)	2.971(14)		[**1967Bl27**]
^{145}Eu		$5/2^+$	5.93(4) d	2.660(2.7)	-3.864(4)	3.775(4)		[**1980Ho33**]
^{149}Tb		$1/2^+$	4.13(5) h*	3.639(4)	-2.480(11)	6.738(4)		[**1960To10, 1968St09**]
^{149m}Tb	0.03578(8)	$11/2^-$	4.16(4) m	3.675(4)	-2.516(11)	6.774(4)		[**2022Si28, 1973Bi06**]
^{153}Ho		$11/2^-$	2.02(3) m	4.131(6)	-1.584(40)	7.690(6)		[**1993Al03**]
^{153m}Ho	0.0687(3)	$1/2^+$	9.3(5) m	4.200(6)	-1.515(40)	7.759(6)		[**2020Ni06, 1967Ha34**]
^{157}Tm		$1/2^+$	3.6(3) m	4.700(40)	-0.460(48)	8.009(28)		[**1976La03**]
^{161}Lu		$1/2^+$	78(2) s	5.270(30)	0.450(43)	8.426(39)		[**1983Ge08**]
^{165}Ta		$(9/2^-)$	31.0(15) s	5.790(30)	1.506(31)	9.561(20)		[**1982Li17**]
^{169}Re		$(9/2^-)$	8.1(3) s	6.509(19)	2.696(30)	10.801(30)		[**1992Me10, 1992MeZW**]
^{169m}Re	0.187(17)	$(1/2^+, 3/2^+)$	16.3(8) s	6.696(25)	2.883(34)	10.988(34)		[**2021Ha32, 1992Me10, 1992MeZW**]
^{173}Ir		$(3/2^+, 5/2^+)$	8.3(3) s**	7.170(18)	4.009(37)	12.224(19)		[**2004GoZZ, 1992Bo21, 1992Sc16**]
^{173m}Ir	0.213(6)	$(11/2^-)$	2.150(47) s***	7.386(19)	4.222(37)	12.437(20)		[**2021Ha32, 2004GoZZ, 1992Sc16**]
^{177}Au		$(1/2^+)$	1.486(20) s@	7.825(18)	5.047(13)	13.468(18)		[**2021Ha32, 2009An14, 2004GoZZ, 2001Ko14**]
^{177m}Au	0.1819(4)	$(11/2^-)$	1.186(12) s@@	8.843(18)	6.056(13)	13.650(18)		[**2021Ha32, 2001Ko14**]
^{181}Tl		$(1/2^+)$	2.9(1) s	7.862(18)	5.538(10)	14.147(18)		[**2018Cu04**]
^{181m}Tl^e	0.8359(4)	$(9/2^-)$	1.40(3) ms	7.862(18)	5.538(10)	14.983(18)		[**2009An14**]
^{185}Bi		$(1/2^+)$	2.8^{+23}_{-10} μs	9.310(80)#	7.359(82)#	16.001(82)#		[**2021Do08**]

* Weighted average of 4.10(5) h [1960To10] and 4.15(5) h [1968St09].
** Weighted average of 9.8(14) s [1992Sc16], 8.1(3) s [1992Bo21] and 10(1) [2004GoZZ].
*** Weighted average of 2.20(5) s [1992Sc16] and 2.105(47) s [2004GoZZ].
@ Weighted average of 1.501(20) s [2021Ha32], 1.53(7) s [2009An14], 1.462(32) s [2004GoZZ], and 1.462(32) s [2001Ko14].
@@ Weighted average of 1.193(13) s [2021Ha32], and 1.180(12) s [2001Ko14].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +19/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	BR_p	S_{2p}	Q_α	BR_α	Experimental
^{133}La	4.348(28)	—	12.017(28)	-0.420(28)	—	
^{137}Pr	3.982(8)	—	11.136(12)	-0.132(29)	—	
^{141}Pm	3.555(14)	—	10.272(14)	0.254(16)		
^{145}Eu	3.315(3)	—	9.609(4)	0.106(14)		
^{149}Tb	2.508(3)	—	8.522(4)	4.078(2)	17.6(14)%*	[**1978Ja14, 1974To07, 1968Ch30, 1968St09, 1967Go32, 1960To10**, 1996Pa01, 1981KoZL, 1979Ho10, 1978AfZZ, 1974PeZS, 1974ToZN, 1974ToZO, 1974ToZQ, 1873Bi06, 1973BoXW, 1972OkZZ, 1968Wi21, 1967Ch28, 1968Ch32, 1965Gr28, 1964Da20, 1961Ma39, 1961St15, 1960To10]]
^{149m}Tb	2.472(3)	—	8.486(4)	4.114(2)	0.022(3)%**	[**1974To07, 1973Bi06, 1964Ma14**, 1973BoXW, 1974ToZN, 1974ToZO, 1974ToZQ, 1968Go13, 1967Go32, 1963Ma17, 1960Ma47]
^{153}Ho	2.183(7)	—	7.966(6)	4.052(4)	0.039(14)%***	[**1974ToZN**, 1978AfZZ, 1974ToZQ, 1974Sc19, 1971To01,1964Ma10, 1961Ma40, 1960Ma47]
^{153m}Ho	2.114(7)	—	7.897(6)	4.121(4)	0.14(4)%[@]	[**1974ToZN**, 1974Sc19, 1974PeZS, 1974ToZQ, 1971ToZX, 1970ToZS, 1970ToZY, 1968Go13, 1967Ha34 1963Ma17, 1961Ma40]
^{157}Tm	1.787(37)	—	7.247(33)	3.878(28)		
^{161}Lu	1.688(28)	—	6.570(40)	3.722(40)		
^{165}Ta	1.318(20)	—	5.634(31)	4.290(31)		
^{169}Re	0.805(16)	—	4.636(30)	5.014(13)	obs	[**1992Me10, 1992MeZW**]
^{169m}Re	0.618(23)	—	4.449(34)	5.101(21)	obs	[**1992Me10, 1992MeZW**, 1984Sc06, 1982De11, 1981DeZA, 1981DeZL, 1978Ca11]
^{173}Ir	0.314(15)	—	3.596(30)	5.716(9)	4(2)%	[**2021Ha32, 2004GoZZ, 1992Bo21, 1992Sc16** 2009An14, 1992MeZW]
^{173m}Ir	0.101(16)	—	3.383(30)	5.929(11)	11(1)%[@@]	[**2021Ha32, 2004GoZZ, 1996Pa01, 1992Sc16 1982De11**, 2009An14, 1992MeZW, 1986Ke03, 1967Si02]
^{177}Au	-0.099(14)		2.729(16)	6.298(4)	54(5)%[@@@]	[**2021Ha32, 2009An14, 2004GoZZ, 2001Ko14**, 2000KoZN, 1996Pa01, 1991Se01, 1990KaZI, 1984Gr14, 1975Ca06, 1973Ga08, 1968Si01]
^{177m}Au	-0.099(14)		2.729(16)	6.298(4)	56(8)%	[**2021Ha32, 2001Ko14**, 2009An14, 2004GoZZ 2000KoZN, 1996Pa01, 1991Se01, 1990KaZI, 1984Gr14, 1975Ca06, 1973Ga08, 1968Si01]
^{181}Tl	-0.999(14)		1.552(15)	6.322(4)	8.6(6)%	[**2018Cu04, 2009An14, 1998To14**, 1993BoZK 1992BoZO, 1992BlZW,1984ScZQ]
^{181m}Tl	-0.163(14)		2.388(15)	7.158(4)	0.40(6)%	[**2009An14**, 1998To14, 1984ScZQ]
^{185}Bi	-1.592(5)[b]	91(2)%[a]	0.226(82)#	8.207(15)[b]	9(2)%[c]	[**2021Do08, 2004An07**, 2001Po05, 2000PoZY, 1996Da06, 1995DaZX]

* Weighted average of 15.8(14)% [1978Ja14] and 22.6(23)% [1968Ch30].
** Weighted average of 0.020(4)% [1973Bi06] and 0.0225(25)% [1964Ma14].
*** Weighted average of 0.034(17)% and 0.051(25)% [1974ToZN].
[@] Weighted average of 0.12(5)% and 0.18(8)% [1974ToZN].
[@@] Weighted average of 7(2)% [1996Pa01], 12(1)% [1992Sc16] and 14(3)% [2004GoZZ].
[@@@] Weighted average of 40(6)% [2009An14] and 64(5)%5 [2021Ha32].
[a] Weighted average of 92(2)% [2021Do08], and 90(2)% [2004An07].
[b] Deduced from α and p energies; S_p = -1.527(81)#, and Q_α = 8.138(81)# in [2021Wa16]. Combining the p energy and the mass excess of ^{184}Pb gives -2.171(14) MeV for the mass excess of ^{185}Bi. The α energy and mass excess of ^{181}Tl gives -2.167(17) MeV, resulting in a weighted average of -2.169(11) MeV; -2.240(80)# in [2021Wa16].
[c] Weighted average of 8(2)% [2021Do08], and 10(2)% [2004An07].

Table 3
direct α emission from ^{149}Tb, J^{π} = 1/2^{+}, $T_{1/2}$ = 4.13(5) h*, BR_{α} = 17.6(14)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{145}Eu)	coincident γ-rays	R_0 (fm)	HF
3.745(5)	3.644(5)***	0.03(1)%	0.0068(23)%@	7/2^{+}	0.330	0.330	1.5656(18)	130^{+70}_{-30}
4.076(5)	3.967(5)***	100%@	17.6(14)%**	5/2^{+}	0.0	—–	1.5656(18)	5.9(7)

* Weighted average of 4.10(5) h [1960To10] and 4.15(5) h [1968St09].
** Weighted average of 15.8(14)% [1978Ja14] and 22.6(23)% [1968Ch30].
*** [1967Go32].
@ [1968Ch30].

Table 4
direct α emission from ^{149m}Tb, Ex = 35.75(8) keV , J^{π} = 11/2^{-}, $T_{1/2}$ = 4.16(4) m**, BR_{α} = 0.022(3)%***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{145}Eu)	coincident γ-rays	R_0 (fm)	HF
4.109(7)	3.999(7)@	0.22(3)%***	5/2^{+}	0.0	—–	1.5656(18)	127^{+26}_{-21}

* [2022Si28].
** [1973Bi06].
*** Weighted average of 0.020(4)% [1973Bi06] and 0.0225(25)% [1964Ma14].
@ [1974To07].

Table 5
direct α emission from ^{153}Ho, J^{π} = 11/2^{-}, $T_{1/2}$ = 2.02(3) m*, BR_{α} = 0.039(14)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{149m}Tb)	coincident γ-rays	R_0 (fm)	HF
4.070(5)	3.910(5)***	0.039(14)%**	11/2^{-}	0.036		1.565(11)	$1.5^{+0.9}_{-0.5}$

* [1993Al03].
** Weighted average of 0.034(17)% and 0.051(25)% [1974ToZN].
*** [1974ToZN].

Table 6
direct α emission from ^{153m}Ho, Ex = 68.7(3) keV*, J^{π} = 1/2^{+}, $T_{1/2}$ = 9.3(5) m**, BR_{α} = 0.14(4)%***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{149}Tb)	coincident γ-rays	R_0 (fm)	HF
4.119(5)	4.011(5)@	0.14(4)%***	1/2^{+}	0.0	—–	1.565(11)	$4.1^{+2.2}_{-1.3}$

* [2020Ni06].
** [1967Ha34].
*** Weighted average of 0.12(5)% and 0.18(8)% [1974ToZN].
@ [1974ToZN].

Table 7
direct α emission from ^{169}Re*, J^{π} = (9/2^{-}), $T_{1/2}$ = 8.1(3) s, BR_{α} = obs.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{165}Ta)	coincident γ-rays	R_0 (fm)	HF
4.814(12)	4.700(12)			0.175		1.571(21)	
4.989(12)	4.871(12)			0.0?		1.571(21)	

* All values taken from [1992Me10].

Table 8
direct α emission from ^{169m}Re*, Ex = 187(7) keV, J^{π} = (1/2$^+$, 3/2$^+$), $T_{1/2}$ = 16.3(8) s, BR_{α} = obs.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{149}Tb)	coincident γ-rays	R$_0$ (fm)	HF
5.184(10)	5.061(10)			x		1.571(21)	

* All values taken from [1992Me10].

Table 9
direct α emission from ^{173}Ir, J^{π} = (3/2$^+$, 5/2$^+$), $T_{1/2}$ = 8.3(3) s*, BR_{α} = 4(2)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{169}Re)	coincident γ-rays	R$_0$ (fm)	HF
5.546(4)	5.418(4)***	4(2)%**	(1/2$^+$, 3/2$^+$)	0.187(7)		1.5691(81)	$1.3^{+1.4}_{-0.5}$

* Weighted average of 9.8(14) s [1992Sc16], 8.1(3) s [1992Bo21] and 10(1) [2004GoZZ].
** [2004GoZZ].
*** [2021Ha32].

Table 10
direct α emission from ^{173m}Ir*, Ex = 213(16) keV, J^{π} = (11/2$^-$), $T_{1/2}$ = 2.150(47) s**, BR_{α} = 11(1)%***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{169}Re)	coincident γ-rays	R$_0$ (fm)	HF
5.809(5)	5.675(5)	100%	10(1)%	(11/2$^-$)	0.1362(2)		1.5691(81)	2.0(5)
5.953(15)	5.815(15)	6(1)%**	0.7(1) %	(9/2$^-$)	0.0	—	1.5691(81)	120^{+40}_{-30}

* All values taken from [2021Ha32], except where noted.
** Weighted average of 2.20(5) s [1992Sc16] and 2.105(47) s [2004GoZZ].
*** Weighted average of 7(2)% [1996Pa01], 12(1)% [1992Sc16] and 14(3)% [2004GoZZ].

Table 11
direct α emission from ^{177}Au, J^{π} = (1/2$^+$), $T_{1/2}$ = 1.486(20) s*, BR_{α} = 54(5)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{173}Ir)	coincident γ-rays	R$_0$ (fm)	HF
6.300(3)	6.157(3)***	54(5)%**	(3/2$^+$, 5/2$^+$)	0.0	—	1.5503(36)	2.56(31)

* Weighted average of 1.501(20) s [2021Ha32], 1.53(7) s [2009An14], 1.462(32) s [2004GoZZ], and 1.462(32) s [2001Ko14].
** Weighted average of 40(6)% [2009An14] and 64(5)%5 [2021Ha32].

Table 12
direct α emission from ^{177m}Au*, Ex. = 181.9(4) keV, J^{π} = (11/2$^-$), $T_{1/2}$ = 1.186(12) s**, BR_{α} = 56(8)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{173}Ir)	coincident γ-rays	R$_0$ (fm)	HF
6.069(12)	5.932(12)	1.2(5)%	0.67(28)%	(9/2$^-$)	0.424(13)	1.5503(36)	18^{+15}_{-6}	
6.267(5)	6.125(5)	98.8(5)%	55(8)%	(11/2$^-$)	0.213(16)	1.5503(36)	$1.5^{+0.4}_{-0.3}$	

* All values from [2021Ha32], except where noted.
** Weighted average of 1.193(13) s [2021Ha32], and 1.180(12) s [2001Ko14].

Table 13
direct α emission from ^{181}Tl*, J^{π} = (1/2$^+$), $T_{1/2}$ = 2.9(1) s, BR_{α} = 8.6(6)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{177}Au)	coincident γ-rays	R$_0$ (fm)	HF
6.323(5)	6.183(5)**	8.6(6)%	(1/2$^+$)	0.0	—	1.5209(44)	3.3(4)

* All values from [2018Cu04], except where noted.
** Weighted average of 6.183(7) MeV [2018Cu04], 6.181(7) MeV [2009An14], and 6.186(10) MeV [1998To14].

Table 14
direct α emission from ^{181m}Tl*, Ex. = 836.9(4) keV, J^π = (9/2$^-$), $T_{1/2}$ = 1.40(3) ms, BR_α = 0.40(6)%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{177}Au)	coincident γ-rays	R_0 (fm)	HF
6.727(7)	6.578(7)	96.0(7)%	0.38(6)%	(5/2$^+$)	0.431(16)	0.2415	1.5209(44)	$1.3^{+0.4}_{-0.3}$
6.972(15)	6.818(15)	1.4(7)%	0.006(3)%	(11/2$^-$)	0.189(16)		1.5209(44)	600^{+70}_{-30}
7.131(15)	6.9748(15)	2.6(7)%	0.010(3)%	(9/2$^-$)	0.031(16)		1.5209(44)	$1.1^{+0.6}_{-0.4}\times10^3$

* All values from [2009An14], except where noted.

Table 15
direct p emission from ^{185}Bi, J^π = (1/2$^+$), $T_{1/2}$ = 2.8^{+23}_{-10} μs*, BR_p = 91(2)%**.

E_p(c.m.)	E_p(lab)	I_p(abs)	J^π_f	$E_{daughter}$(^{184}Pb)	coincident γ-rays
1.592(5)	1.583(5)***	91(2)%**	0$^+$	0.0	—

* [2021Do08].
** Weighted average of 92(2)% [2021Do08], and 90(2)% [2004An07].
*** [2004An07].

Table 16
direct α emission from ^{185}Bi, J^π = (1/2$^+$), $T_{1/2}$ = 2.8^{+23}_{-10} μs*, BR_α = 9(2)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{181}Tl)	coincident γ-rays	R_0 (fm)	HF
8.207(15)	8.030(15)***	9(2)%**	(1/2$^+$)	0.0	—	1.496(13)	$0.5^{+0.7}_{-0.4}$

* [2021Do08].
** Weighted average of 8(2)% [2021Do08], and 10(2)% [2004An07].
*** [2004An07].

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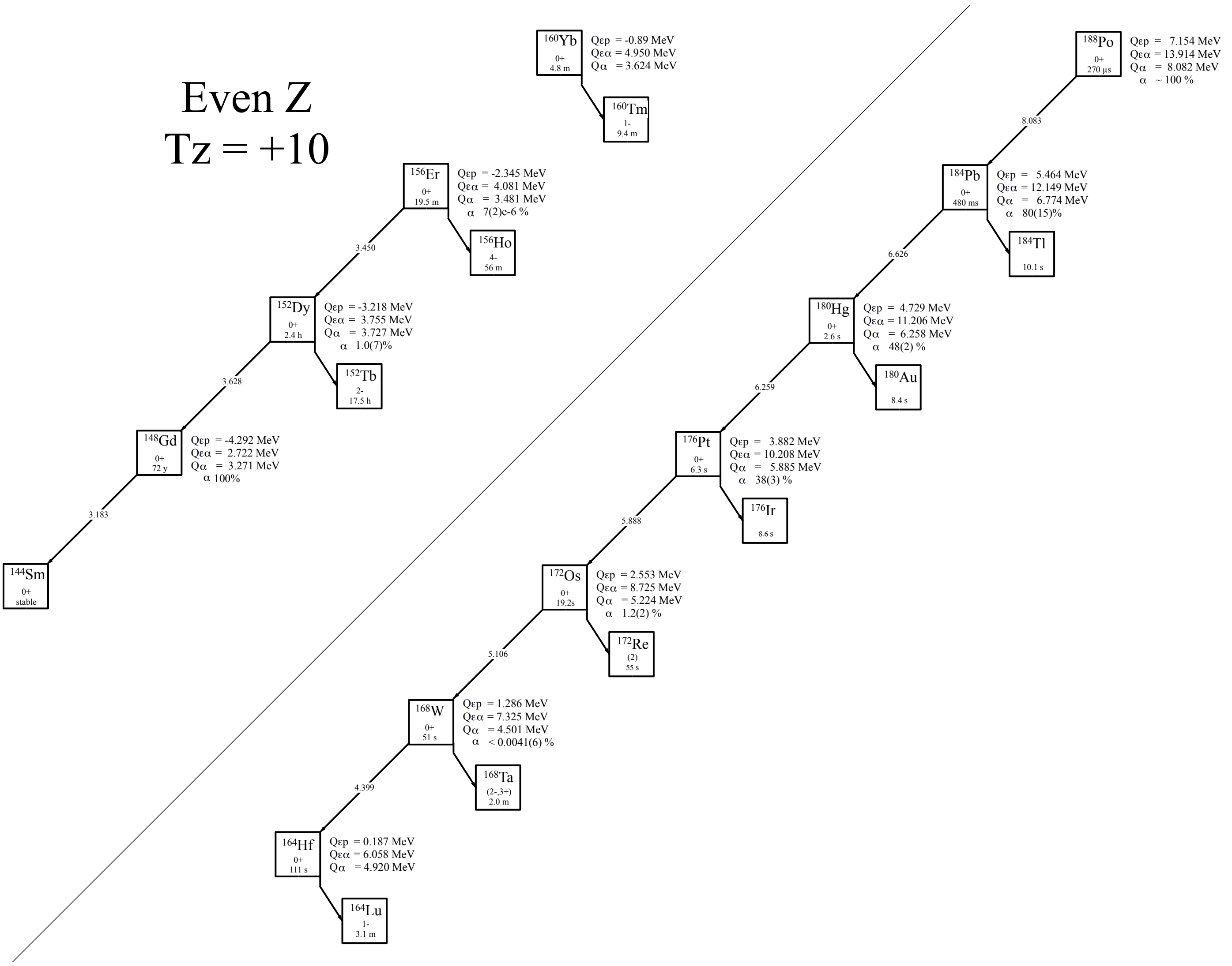

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +10 nuclei.

Last updated 2/28/23

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +10 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon\alpha}$	Experimental
^{148}Gd	0^+	72.1(10) y*	0.028(10)	-4.292(1)	—	2.722(3)	[**2023Ch23, 2003Fu10, 1981Pr06**, 2023ChXZ]
^{152}Dy	0^+	2.37(2) h	0.600(40)	-3.218(5)	—	3.755(11)	[**1965Ma14**]
^{156}Er	0^+	19.5(10) m	1.330(50)	-2.345(26)	—	4.081(47)	[**1975Al26**]
^{160}Yb	0^+	4.8(2) m	2.140(30)	-0.891(7)	—	4.950(39)	[**1969NeZW**]
^{164}Hf	0^+	111(8) s	2.820(30)	0.187(22)		6.058(36)	[**1989Hi04**]
^{168}W	0^+	51(2) s**	3.500(30)	1.286(31)		7.325(31)	[**1992HeZV, 1991Me05, 1990Me12**]
^{172}Os	0^+	19.2(9) s	4.320(40)	2.553(31)		8.725(31)	[**1995Hi02**]
^{176}Pt	0^+	6.33(15) s	4.948(15)	3.882(17)		10.208(38)	[**1973Ga08**]
^{180}Hg	0^+	2.56(2) s	5.375(14)	4.729(15)		11.206(15)	[**1993Wa03**]
^{184}Pb	0^+	480(25) ms	5.832(16)	5.464(15)		12.149(14)	[**1999To11**]
^{188}Po	0^+	270(30) μs	6.650(23)	7.154(21)		13.914(22)	[**2003Va16**]

* Weighted average of 86.9(39) y [2023Ch23], 70.9(10) y [2003Fu10], and 74.6(30) y [1981Pr06].
** Weighted average of 47(3) s [1992HeZV], 49(5) s [1991Me05] and 53(2) s [1990Me12].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the even-Z, T_z = +10 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{148}Gd	6.014(2)	9.851(3)	3.271(1)	100%	[**1973Go29**, 2023Ch23, 2023ChXZ 2003Fu10, 2002FuZW, 2001FuZY, 1981Pr06, 1973MiZU, 1966Fr11, 1962Si14, 1957SuXX, 1953Ra02]
^{152}Dy	5.783(6)	8.932(7)	3.727(4)	0.100(7)%*	[**1974To07, 1967Go32, 1965Ma14, 1962Si14** 1975ToZT, 1974PeZS, 1974ToZN, 1974ToZQ, 1964Ma19, 1964Ma42, 1960To05]
^{156}Er	5.461(30)	8.396(26)	3.541(10)**	7(2)×10^{-6}%***	[**2002KaZR, 1996ByZY, 1995KaZS**, 2002KaZO 1992KaZP, 1989KaYU, 1978BiZF]
^{160}Yb	4.882(28)	7.437(26)	3.624(25)		
^{164}Hf	4.316(32)	6.575(22)	3.920(17)		
^{168}W	3.831(31)	5.612(31)	4.501(11)	<4.1(6)×10^{-3}%	[**1991Me05**, 1992HeZV]
^{172}Os	3.282(31)	4.531(18)	5.224(7)	1.2(2)%$^@$	[**2004GoZZ, 1996Pa01, 1995Hi02, 1971Bo06**]
^{176}Pt	2.828(18)	3.516(16)	5.885(2)	38(3)%$^{@@}$	[**1996Pa01, 1982De11, 1979Ha10, 1974Ho26, 1973Ga08**, 1982Bo04, 1966Si08]
^{180}Hg	2.551(17)	2.831(16)	6.258(2)	48(2)%	[**1999To11, 1993Wa03**, 2010An13, 1996Pa01, 1993WaZO, 1987La23, 1986Si19, 1982HeZM. 1979Ha10, 1977Hu05, 1974Ho26, 1970Ha18. 1969NaZT, 1969NaZU, 1968De01]
^{184}Pb	1.753(16)	2.053(16)	6.774(3)	80(15)%	[**2004An07, 1999To11**. 2001Po05, 1998Co27, 1998ToZW, 1987To09, 1982HeZM, 1980Du02, 1980Sc09]
^{188}Po	1.450(22)	0.441(23)	8.082(15)	100%$^{@@@}$	[**2003Va16, 1999An52**, 2002VaZZ, 2000AnZZ]

* Weighted average of 0.94(9)% and 1.08(11)% [1974To07].
** From α energy, 3.481(25) MeV in [2021Wa16].
*** Weighted average of 1.2(3)×10^{-5}% [1996ByZY], and 5(2)×10^{-6}% [1995KaZS].
$^@$ Weighted average of 1.1(2)% [1995Hi02] and 1.4(3)% [2004GoZZ].
$^{@@}$ Weighted average of 42(4)% [1996Pa01] and 438(3)% [1979Ha10].
$^{@@@}$ Deduced from short half-life.

Table 3
direct α emission from ^{148}Gd, $J^\pi = 0^+$, $T_{1/2}$ = 72.1(10) y*, BR_α = 100%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}(^{144}$Sm)	coincident γ-rays	R_0 (fm)	HF
3.271198(24)	3.182787(24)***	100%**	0^+	0.0	—	1.5695(23)	0.961(13)

* Weighted average of 86.9(39) y [2023Ch23], 70.9(10) y [2003Fu10], and 74.6(30) y [1981Pr06].
** Only decay channel open.
*** 3.182787(24) MeV in [1973Go29], adjusted to 3.182680(24) MeV in [1991Fy01].

Table 4
direct α emission from ^{152}Dy, J^{π} = 0^{+}, $T_{1/2}$ = 2.37(2) h*, BR_{α} = 0.100(7)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{148}Gd)	coincident γ-rays	R_0 (fm)	HF
3.726(4)	3.628(4)***	1.0(7)%**	0^{+}	0.0	—	1.5796(54)	0.98(7)

* [1965Ma14].
** Weighted average of 0.94(9)% and 1.08(11)% [1974To07].
*** Weighted average of 3.627(8) MeV [1965Ma14] (adjusted to 3.630(8) MeV in [1991Ry01]), and 3.630(5) MeV [1965Ma14] (adjusted to 3.628(5) MeV in [1991Ry01]).

Table 5
direct α emission from ^{156}Er, J^{π} = 0^{+}, $T_{1/2}$ = 19.5(10) m*, BR_{α} = 7(2)$\times10^{-6}$%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{152}Dy)	coincident γ-rays	R_0 (fm)	HF
3.541(10)	3.450(10)***	7(2)$\times10^{-6}$%**	0^{+}	0.0	—	1.531(25)	$1.2^{+0.7}_{-0.4}$

* [1975Al26].
** Weighted average of 1.2(3)e^{-5}% [1996ByZY], and 5(2)e^{-6}% [1995KaZS].
*** [2002KaZR].

Table 6
direct α emission from ^{168}W*, J^{π} = 0^{+}, $T_{1/2}$ = 51(2) s*, BR_{α} = <4.1(6)$\times10^{-3}$%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{164}Hf)	coincident γ-rays	R_0 (fm)	HF
4.506(12)	4.399(12)	<4.1(6)$\times10^{-3}$%	0^{+}	0.0	—	1.580(35)	>0.86

* All values from [1991Me05], except where noted.
** Weighted average of 47(3) s [1992HeZV], 49(5) s [1991Me05] and 53(2) s [1990Me12].

Table 7
direct α emission from ^{172}Os, J^{π} = 0^{+}, $T_{1/2}$ = 19.2(9) s*, BR_{α} = 1.2(2)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{168}W)	coincident γ-rays	R_0 (fm)	HF
5.227(5)	5.106(5)***	1.2(2)%	0^{+}	0.0	—	1.583(13)	$1.14^{+0.29}_{-0.21}$

* [1995Hi02].
** Weighted average of 1.1(2)% [1995Hi02] and 1.4(3)% [2004GoZZ].
*** Weighted average of 5.109(5) MeV [2004GoZZ], 5.106(10) MeV [1996Pa01], 5.100(7) MeV [1995Hi02] and 5.105(10) MeV [1971Bo06].

Table 8
direct α emission from ^{176}Pt, J^{π} = 0^{+}, $T_{1/2}$ = 6.33(15) s*, BR_{α} = 39(3)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{172}Os)	coincident γ-rays	R_0 (fm)	HF
5.662(10)	5.534(10)***	0.26(13)%@	0.10(5)%	2^{+}	0.2277(10)	0.2277(10)	1.5597(42)	40^{+40}_{-20}
5.888(3)	5.754(3)@@	100%	39(3)%**	0^{+}	0.0	—	1.5571(45)	1.05(9)

* [1973Ga08].
** Weighted average of 42(4)% [1996Pa01] and 438(3)% [1979Ha10].
*** Weighted average of 5.537(10) MeV [1979Ha10] (adjusted to 5.536(10) MeV in [1991Ry01]) and 5.528(15) MeV [1974Ho26].
@ [1979Ha10].
@@ Weighted average of 5.753(3) MeV [1982De11] and 5.757(5) MeV [1974Ho26] (adjusted to 5.756(5) MeV in [1991Ry01]).

Table 9
direct α emission from ^{180}Hg*, $J^\pi = 0^+$, $T_{1/2}$ = 2.56(2) s, BR_α = 48(2)%**.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{176}Pt)***	coincident γ-rays***	R_0 (fm)	HF
5.818(5)	5.689(5)	≈0.01%	≈0.005%	0^+	0.443(1)	0.443(1), 0.2640(3), 0.179(1)	1.5324(24)	≈130
6.259(5)	6.120(5)	≈0.05%	≈0.024%	2^+	0.2640(3)	0.2640(3)	1.5324(24)	≈160
6.259(5)	6.120(5)	100%	48(2)%**	0^+	0.0	—	1.5324(24)	0.99(4)

* All values from [1993Wa03], except where noted.
** [1999To11].
*** [2006Ba16].

Table 10
direct α emission from ^{184}Pb*, $J^\pi = 0^+$, $T_{1/2}$ = 480(25) ms**, BR_α = 80(15)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{180}Hg)	coincident γ-rays	R_0 (fm)	HF
6.773(6)	6.626(6)	80(15)%	0^+	0.0	—	1.504(11)	$0.89^{+0.26}_{-0.18}$

* All values from [2004An07], except where noted.
** [1999To11].

Table 11
direct α emission from ^{188}Po*, $J^\pi = 0^+$, $T_{1/2}$ = 270(30) μs, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{180}Pb)	coincident γ-rays	R_0 (fm)	HF
7.513(26)	7.353(26)**	25(5) %	20(4)%	(0^+)	0.570(30)		1.4874(76)	$0.08^{+0.04}_{-0.03}$***
8.083(13)	7.911(13)$^@$	100%	80(4)%	0^+	0.0	—	1.4874(76)	0.99(12)

* All values from [2003Va16], except where noted.
** Weighted average of 7.355(35) MeV [2003Va16] and 7.350(40) MeV [1999An52].
*** The unphysically low value is as yet unexplained.
@ Weighted average of 7.910(15) MeV [2003Va16] and 7.915(25) MeV [1999An52].

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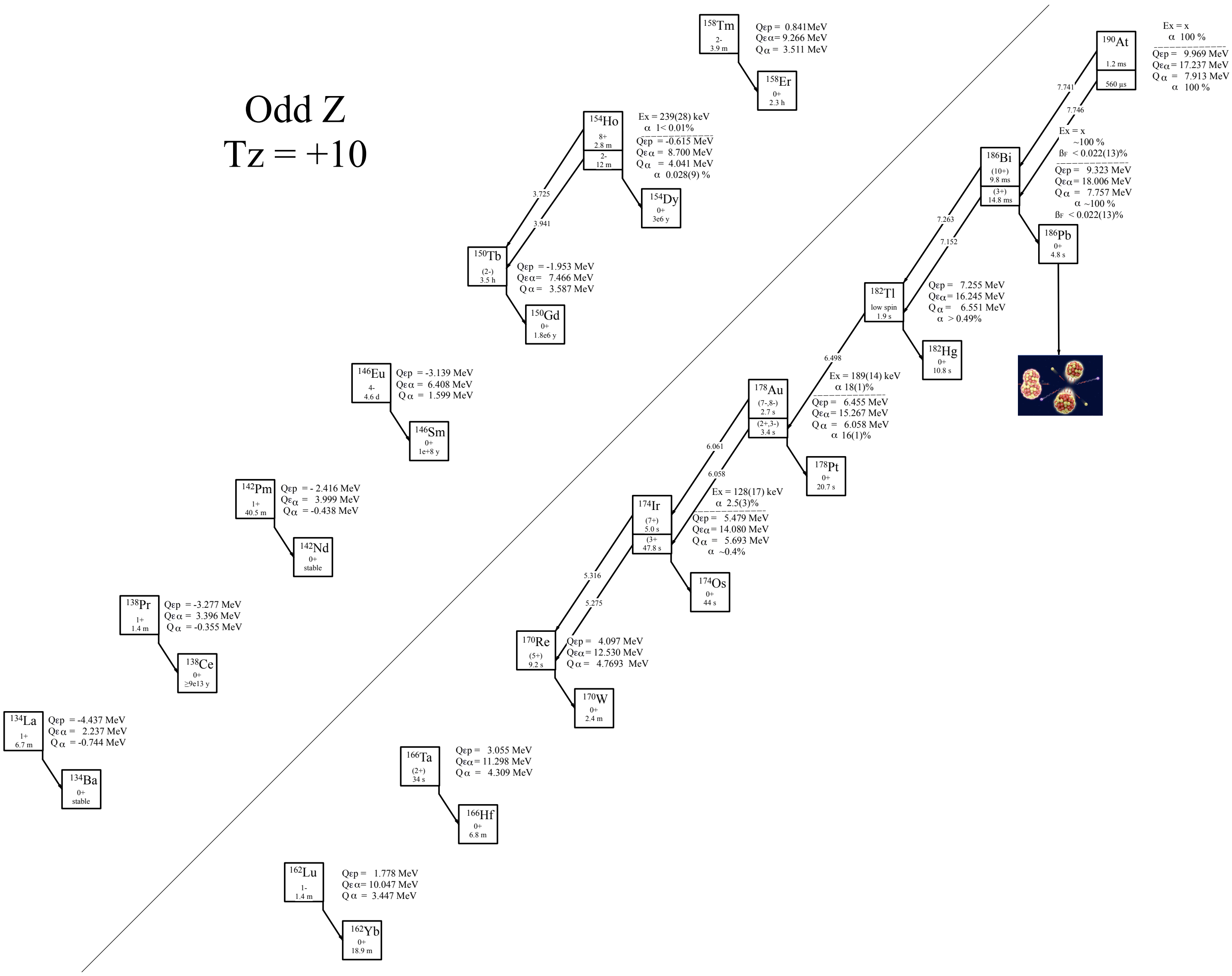

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +10 nuclei.

Last updated 7/26/2023

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, $T_z = +10$ nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J$^\pi$ values for ^{134}La, ^{138}Pr, ^{142}Pm, ^{146}Eu, ^{150}Tb, ^{154}Ho, ^{158}Tm, ^{162}Lu, ^{166}Ta, ^{170}Re are taken from ENSDF.

Nuclide	Ex	J^π	$T_{1/2}$	Q$_\varepsilon$	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	BR$_F$	Experimental
^{134}La		1^+	6.67(2) m	3.731(20)	-4.437(20)	2.237(20)		[**1968Bi02**]
^{138}Pr		1^+	1.44(8) m	4.437(10)	-3.277(10)	3.396(10)		[**1971Ju01**]
^{142}Pm		1^+	40.5(5) m	4.809(24)	-2.416(24)	3.999(24)		[**1970Ar17**]
^{146}Eu		4^-	4.62(4) d*	3.879(6)	-3.139(6)	6.408(6)		[**1970Ch09, 1964Ta11**]
^{150}Tb		(2^-)	3.48(16) h	4.658(8)	-1.953(8)	7.466(8)		[**1973Vy01**]
^{154}Ho		2^-	11.75(20 m	5.755(10)	-0.615(9)	8.700(10)		[**1993Al03**]
^{154m}Ho	0.239(28)**	8^+	2.80(13) m	5.994(30)	-0.376(29)	8.939(30)		[**1993Al03**]
^{158}Tm		2^-	3.94(6) m	6.600(30)	0.841(34)	9.266(26)		[**1993Al03**]
^{162}Lu		1^-	1.37(2) m	6.990(80)	1.778(80)	10.047(79)		[**1983Ge08**]
^{166}Ta		$(2)^+$	34.4(5) s	7.760(40)	3.055(39)	11.298(32)		[**1982Li17**]
^{170}Re		(5^+)	9.2(2) s	8.387(17)	4.097(30)	12.530(30)		[**1992Me10**]
^{174}Ir		(3^+)	7.8(6) s	9.209(15)	5.479(30)	14.080(17)		[**1992Bo21**]
^{174m}Ir	0.129(17)	(7^+)	5.0(2) s***	9.338(23)	5.608(34)	14.209(24)		[**2020Cu04, 1992Bo21, 1992Si16**]
^{178}Au		$(2^+, 3^-)$	3.4(5) s	9.694(14)	6.455(22)	15.267(14)		[**2020Cu04**]
^{178m}Au	0.189(14)	$(7^+, 8^-)$	2.7(5) s	9.883(20)	6.644(26)	15.456(20)		[**2020Cu04**]
^{182}Tl$^@$		low spin	1.9(1) s	10.250(15)	7.255(23)	16.245(16)		[**2016Va01**]
^{186}Bi$^{@@}$		(3^+)	14.8(8) ms	11.535(20)	9.323(27)	18.006(20)	0.022(13)%$^{@@@}$	[**2013La02, 2003An27**]
^{186m}Bi$^{@@}$	x	(10^+)	9.8(4) ms	11.535(20)+x	9.323(27)+x	18.006(20)+x	0.022(13)%$^{@@@}$	[**2013La02, 2003An27**]
^{190}At$^@$		low spin	$0.56^{+2.69}_{-0.16}$ms	11.756(24)^a	9.969(29)^a	17.237(29)^a		[**2023AnXX, 2023Ko10**]
^{190m}At	x	high spin	$1.2^{+1.3}_{-0.4}$ms^b	11.756(24)+x^a	9.969(29)+x^a	17.237(29)+x^a		[**2023AnXX, 2023Ko10**]

* Weighted average of 4.65(4) d [1970Ch09] and 4.59(4) d [1964Ta11].

** Based on α energies and the energy of the isomeric state in ^{150}Tb.

*** Weighted average of 5.0(4) s [1992Bo21], 4.9(3) s, 5.5(6) s [1992Si16].

$^@$ May not be the ground state.

$^{@@}$ The ordering of these states is unknown.

$^{@@@}$ Value is for a combination of the two isomers.

^{a} Deduced from mass excess of 7.193(20) for ^{190}At (deduced from the α energy and the mass of the daughter ^{186}Bi), and the mass excess for the daughter taken from [2021Wa16].

^{b} Weighted average of $2.67^{+3.65}_{-0.98}$ms [2023AnXX] and $1.0^{+1.4}_{-0.4}$ms [2023Ko10].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +10 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{134}La	4.954(20)	12.644(20)	-0.744(22)	—	
^{138}Pr	4.499(10)	11.669(54)	-0.335(22)	—	
^{142}Pm	4.239(24)	11.033(24)	-0.438(26)	—	
^{146}Eu	3.755(6)	10.279(6)	1.599(24)		
^{150}Tb	3.268(8)	9.386(12)	3.587(5)		
^{154}Ho	2.785(9)	8.500(41)	4.041(4)	0.028(9)%	[**1974Sc19**, 1982To14, 1981ZuZU, 1981ZuZY, 1978AfZZ, 1974PeZS, 1974ToZQ, 1971To01, 1971ToZR, 1970ToZS, 1970ToZY, 1968Go13, 1967Ha34]
^{154m}Ho	2.546(29)	8.261(50)	4.280(28)	<0.01%	[**1974Sc19**, 1971To01, 1968Go13]
^{158}Tm	2.579(37)	7.743(46)	3.511(27)		
^{162}Lu	2.286(77)	7.109(82)	3.447(79)		
^{166}Ta	1.751(40)	6.033(40)	4.309(80)		
^{170}Re	1.275(19)	5.088(30)	4.769(30)		
^{174}Ir	0.637(19)	3.797(37)	5.693(16)	≈0.4%	[**1992Sc16**]
^{174m}Ir	0.508(25)	3.668(41)	5.822(23)	2.5(3)%	[**1992Si16**, 1992MeZW, 1986Ke03, 1967Si02]
^{178}Au	0.222(18)	2.999(13)	6.058(5)	16(1)%	[**2020Cu04**, 2021Gi08, 1996Pa01, 1986Ke03, 1984Gr14, 1968Si01, 1965Si07]
^{178m}Au	0.033(23)	2.810(19)	6.247(15)	18(1)%	[**2020Cu04**, 2021Gi08]
^{182}Tl*	-0.045(19)	2.280(13)	6.551(6)	>0.49%	[**2016Va01**, 1993BoZK, 1992BlZW, 1991BoZZ, 1986Ke03]
^{186}Bi**	-1.107(23)	0.840(20)	7.757(12)	≈100%	[**2003An27**, 2003AnZZ, 1997Ba21]
^{186}Bi**	-1.107(23)-x	0.840(20)-x	7.757(12)+x	≈100%	[**2003An27**, 2003AnZZ, 1997Ba21, 1984ScZQ]
^{190}At*	-1.326(30)	0.190(23)$^@$	7.913(10)***	100%	[**2023AnXX, 2023Ko10**]
^{190m}At*	-1.326(30)-x$^@$	0.190(23)-x$^@$	7.913(10)+x***	100%	[**2023AnXX, 2023Ko10**]

* May not be the ground state.
** The ordering of these states is unknown.
*** From α energy to ^{186}Bi.
^{a} Deduced from mass excess of 7.193(20) for ^{190}At (deduced from the α energy and the mass of the daughter ^{186}Bi), and the mass excess for the daughter taken from [2021Wa16].

Table 3
direct α emission from ^{154}Ho*, $J^\pi = 2^-$, $T_{1/2}$ = 11.75(20 m**, BR_α = 0.028(9)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{150}Tb)	coincident γ-rays	R_0 (fm)	HF
4.046(5)	3.941(5)***	0.028(9)%	(2^-)	0.0	—	1.560(26)$^@$	9^{+7}_{-4}

* All values from [1974Sc19], except where noted.
** [1993Al03].
*** 3.937 MeV in [1974Sc19], adjusted to 3.941 meV in [1991Ry01].
$^@$ Interpolated between 1.5796(54) fm ^{152}Dy and 1.541(26) fm ^{156}Er.

Table 4
direct α emission from ^{154m}Ho*, Ex = 239(28) keV, $J^\pi = 8^+$, $T_{1/2}$ = 2.80(13) m**, BR_α = <0.01%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{150}Tb)	coincident γ-rays	R_0 (fm)	HF
3.824(5)	3.725(5)***	<0.01%	0.461(27)$^@$		1.560(26)$^{@@}$	>0.18	

* All values from [1974Sc19], except where noted.
** [1993Al03].
*** 3.721 MeV in [1974Sc19], adjusted to 3725 meV in [1991Ry01].
$^@$ [2013Ba31].
$^{@@}$ Interpolated between 1.5796(54) fm ^{152}Dy and 1.541(26) fm ^{156}Er.

Table 5
direct α emission from ^{174}Ir*, J^{π} = (3^{+}), $T_{1/2}$ = 7.8(6) s**, BR_{α} = ≈0.4%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{170}Re)	coincident γ-rays	R_0 (fm)$^{@}$	HF
5.399(10)	5.275(10)	≈0.4%	(3^{+})	0.289***	0.224, 0.193, 0.031	1.571(14)***	≈ 2.7$^{@@}$

* All values from [1992Sc16], except where noted.
** [1992Bo21].
*** Reported as decaying to a 224.7(3) keV state, which then cascades to the ground state in [1992Sc16]. However this would imply an isomer energy of 193(12) keV in contrast to the measured value of 129(17) keV [2020Cu04]. It is suggested that the α-decay is to a state 224.7-keV above an isomer in ^{170}Re with an energy of 64(20) keV [2020Cu04].
$^{@}$ Interpolated between 1.583(13) fm ^{172}Os and 1.5597(42) fm ^{176}Pt.
$^{@@}$ Calculated assuming the isomer decays to the 370-keV state in ^{150}Tb, (which then γ-cascades to the ground state), giving a Q_{α} = 5.688(23) MeV.

Table 6
direct α emission from ^{174m}Ir*, Ex = 193(12) keV, J^{π} = (7^{+}), $T_{1/2}$ = 5.0(2) s **, BR_{α} = 2.5(3)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{170}Re)***	coincident γ-rays	R_0 (fm)$^{@}$	HF
5.441(10)	5.316(10)	100%	2.2(3)%		0.3701(6)?	0.210, 0.190, 0.159, 0.020	1.571(14)$^{@}$	$0.52^{+0.21}_{-0.16}$
5.607(6)	5.478(6)$^{@@}$	≈13%	≈0.3%	(7/2^{+})	0.2103(2)?	0.210, 0.190, 0.020	1.571(14)$^{@}$	21^{+9}_{-7}

* All values from [1992Sc16], except where noted.
** Weighted average of 5.0(4) s [1992Bo21], 4.9(3) s, 5.5(6) s [1992Si16].
*** [2018Ba41].
$^{@}$ Interpolated between 1.583(13) fm ^{172}Os and 1.5597(42) fm ^{176}Pt.
$^{@@}$ [1967Si02].

Table 7
direct α emission from ^{178}Au*, J^{π} = (2^{+}, 3^{-}), $T_{1/2}$ = 3.4(5) s, BR_{α} = 16(1)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{174}Ir)	coincident γ-rays	R_0 (fm)**	HF
5.882(10)	5.750(10)	1.05(2)%	0.15(1)%		0.1748(5)	0.1748(5)	1.5460(48)**	41(8)
5.945(10)	5.811(10)	2.01(3)%	0.28(2)%		0.157(3)	0.157(3)	1.5460(48)**	39(8)
5.974(10)	5.840(10)	12.6(1)%	1.7(1)%		0.0900(3)	0.0900(3), 0.0828(3)	1.5460(48)**	8.0(15)
6.058(5)	5.922(5)	100%	13.8(9)%	(3^{+})	0.0	—	1.5460(48)**	2.4(5)

* All values from [2020Cu04].
** Interpolated between 1.5597(42) fm ^{176}Pt and 1.5324(24) fm ^{180}Hg.

Table 8
direct α emission from ^{178m}Au*, Ex = 189(14) keV, J^{π} = (7^{+}, 8^{-}), $T_{1/2}$ = 2.7(5) s, BR_{α} = 18(1)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{174}Ir)	coincident γ-rays	R_0 (fm)**	HF
5.648(7)	5.521(7)	1.16(3)%	0.18(1)%		0.601(17)	0.472(1)	1.5460(48)**	$0.54^{+0.17}_{-0.15}$
5.699(7)	5.571(7)	0.97(2)%	0.15(1)%		0.550(17)	0.421.4(10)	1.5460(48)**	$1.13^{+0.35}_{-0.32}$
5.973(10)	5.839(10)	6.87(7)%	1.07(6)%		0.277(17)	0.1392(3), 0.0912(3), 0.0568(3)	1.5460(48)**	2.8(8)
6.061(7)	5.925(7)	100%	15.5(9)%		0.186(17)	0.0568(3)	1.5460(48)**	$0.48^{+0.14}_{-0.13}$
6.114(10)	5.977(10)	6.83(14)%	1.06(6)%	(7^{+})	0.129(17)		1.5460(48)**	12^{+4}_{-3}

* All values from [2020Cu04].
** Interpolated between 1.5597(42) fm ^{176}Pt and 1.5324(24) fm ^{180}Hg.

Table 9
direct α emission from ^{182}Tl*, J^{π} = low soin, $T_{1/2}$ = 1.9(1) s, BR_{α} = >0.49%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{178}Au)	coincident γ-rays	R_0 (fm)**	HF
6.096(5)	5.962(5)	21(3)%	>0.042%		0.446	0.4461(14), 0.2658(2), 0.2322(3), 0.2067(1), 0.1692(3), 0.1129(1)	1.518(12)	<27
6.182(6)	6.046(6)	16(3)%	>0.032%		0.362	0.3615(1), 0.3126(1), 0.2967(3), 0.2478(7), 0.2318(2), 0.1975(8), 0.1827(3), 0.1693(2), 0.1534(2), 0.1317(4), 0.1129(1), 0.1020(5)	1.518(12)	<80
6.304(6)	6.165(6)	62(10)%	>0.12%		0.247	0.2472(5), 0.2322(1), 0.1975(2), 0.1823(2), 0.1692(1), 0.1329(4), 0.1187(3), 0.1129(2)	1.518(12)	<62
6.503(6)	6.360(6)	100%	>0.20%		0.046		1.518(12)	<230
6.550(10)	6.406(10	45(7)%	>0.09%	(2^{+}, 3^{-})	0.0	—	1.518(12)	<1600

* All values from [2016Va01].
** Interpolated between 1.5324(24) fm ^{180}Hg and 1.504(11) ^{184}Pb.

Table 10
direct α emission from ^{186}Bi*, J^{π} = (3^{+}), $T_{1/2}$ = 14.8(8) s, BR_{α} =≈100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{182}Tl)	coincident γ-rays
7.225-7.389	7.070-7.230**					0.087, 0.098, 0.133, 0.215, 0.238, 0.276, 0.281, 0.371, 0.380, 0.444, 0.520
7.236(15)	7.080(15)	28(14)%			0.520	0.520
7.276(15)	71.20(15)***					0.133
7.309 (15)	7.152(15)	100%			0.444	0.444
7.385(15)	7.226 (15)***					0.238

* All values from [2003An27].
** Unresolved multiplet.
*** May belong to the other isomer.

Table 11
direct α emission from ^{186m}Bi*, J^{π} = (10^{-}), $T_{1/2}$ = 9.8(4) s, BR_{α} =≈100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{182}Tl)	coincident γ-rays
7.423(5)	7.263(5)	100%	≈98%		0.1085	0.1085(5)
7.531(10)	7.369(10)**	<2%	<2%		0.0	—

* All values from [2003An27].
** Tentative assignment.

Table 12
direct α emission from ^{190}At*, J^{π} = low spin,$T_{1/2}$ = $0.56^{+2.69}_{-0.16}$ ms, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{186}Bi)	coincident γ-rays		
7.913(10)	7.746(10)	100%	(3^{+})	0.0	—	1.551(15)	$1.0^{+5.0}_{-0.4}$

* All values taken from [2023AnXX]. In that paper, the authors present two scenarios. In the first, two α transitions 7.746(10) MeV (25%) and 7.739(10) MeV de-excite the same state, indicating that the (10^{-}) ^{186m}Bi isomer has an energy of 7 keV. This however, results in large HF for the two transitions of 15 and 5 respectively. The 2nd scenario is reflected here, combined with data from [2023Ko10], resulting in mostly unhindered transitions from two isomers in ^{190}At.

Table 13
direct α emission from ^{190m}At, J^{π} = high spin, $T_{1/2} = 1.2^{+1.3}_{-0.4}$ ms*, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{186}Bi)	coincident γ-rays		
7.907(9)	7.741(9)**	100%	(10^{-})	x		1.551(15)	$2.1^{+2.4}_{-0.9}$

* Weighted average of $2.67^{+3.65}_{-0.98}$ms [2023AnXX] and $1.0^{+1.4}_{-0.4}$ms [2023Ko10].
** Weighted average of 7.739(10) MeV [2023AnXX] and 7.750(20) MeV [2023Ko10].

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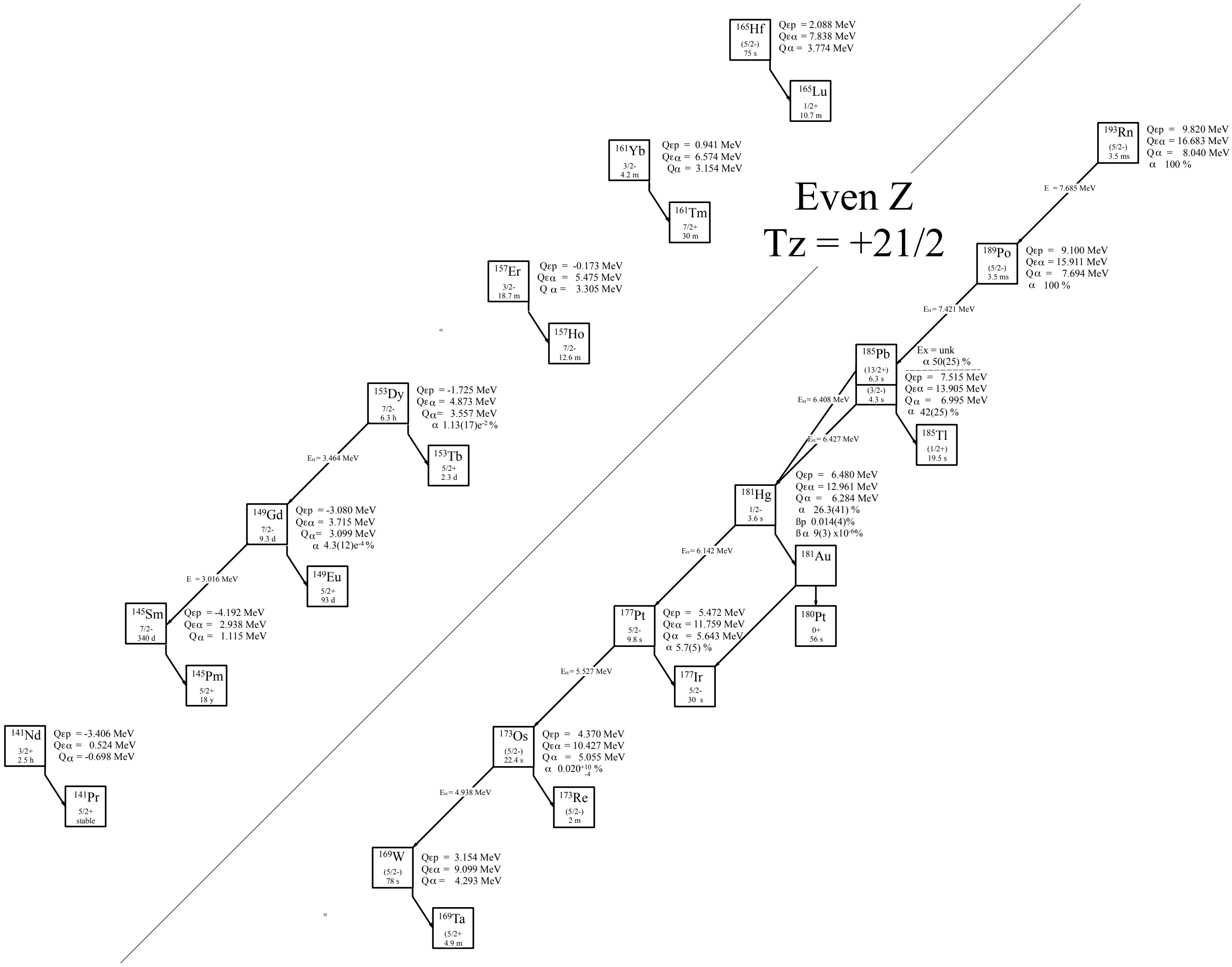

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +21/2 nuclei.

Last updated 3/28/23

Table 1

Observed and predicted β-delayed particle emission from the even-Z, T_z = +21/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J^π values for are taken from ENSDF.

Nuclide	Ex	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon\alpha}$	$BR_{\beta\alpha}$	Experimental
^{141}Nd		3/2$^+$	2.54(5) h	1.823(3)	-3.406(3)		0.524(4)		[**1961Ra06**]
^{145}Sm		7/2$^-$	340(3) d	0.616(3)	-4.192(1)		2.938(2)		[**1959Br65**]
^{149}Gd		7/2$^-$	9.25(10) d	1.314(4)	-3.080(3)		3.715(4)		[**1968Ch30**]
^{153}Dy		7/2$^-$	6.29(10) h	2.170(2)	-1.725(4)		4.873(6)		[**1970Ch09**]
^{157}Er		3/2$^-$	18.65(10) m	3.420(30)	-0.173(27)		5.475(27)		[**1984GrZL**]
^{161}Yb		3/2$^-$	4.2(2) m	4.060(30)	0.941(29)		6.574(28)		[**1974Ad10**]
^{165}Hf		(5/2$^-$)	75(3) s	4.810(40)	2.088(32)		7.838(40)		[**1981LiZM**]
^{169}W		(5/2$^-$)	78(6) s*	5.370(30)	3.154(32)		9.099(31)		[**1990Me12, 1992HeZV**]
^{173}Os		(5/2$^-$)	22.4(9) s	6.120(30)	4.370(32)		10.427(32)		[**1995Hi02**]
^{177}Pt		5/2$^-$	9.8(4) s	6.677(25)	5.472(19)		11.759(32)		[**1993Me13**]
^{181}Hg		1/2$^-$	3.6(1) s	7.210(25)	6.480(18)	0.014(4)%	12.961(25)	9(3)$\times10^{-6}$%	[**1979Ho10, 1975Ho02, 1971Ho07**, 1970HoZZ]
^{185}Pb		(3/2$^-$)	4.3(2) s	8.217(26)	7.515(19)		13.905(26)		[**2002An15**]
^{185m}Pb	x	(13/2$^+$)	6.3(4) s	8.217(26)+x	7.515(19)+x		13.905(26)+x		[**2002An15**]
^{189}Po		(5/2$^-$)	3.5(5) ms	8.640(30)	9.100(24)		15.911(30)		[**2005Va04**]
^{193}Rn			1.15(27) ms	9.110(30)	9.820(27)		16.683(33)		[**2006An36**, 2006AnZT]

* Weighted average of 76(6) s [1990Me12] and 80(6) s [1992HeZV].

Table 2

Particle separation, Q-values, and measured values for direct particle emission of the even-Z, T_z = +21/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{141}Nd	6.794(7)	11.812(4)	-0.698(3)	—	
^{145}Sm	6.524(3)	11.227(1)	1.115(3)		
^{149}Gd	6.119(10)	10.439(3)	3.099(3)	4.3(12)$\times10^{-4}$%	[**1967Go32, 1966Wi12, 1965Si06**, 1965Ma48]
^{153}Dy	5.715(40)	9.532(5)	3.557(5)*	0.0113(17)%	[**1974To07, 1967Go32**, 1978AfZZ, 1974PeZS, 1974ToZN, 1974ToZQ, 1965Ma51, 1964Ma19, 1960Ma47, 1960To05, 1958To27]
^{157}Er	5.164(47)	8.836(28)	3.305(27)		
^{161}Yb	4.822(36)	7.851(16)	3.154(31)		
^{165}Hf	4.282(40)	6.920(32)	3.774(32)		
^{169}W	3.813(32)	6.028(32)	4.293(32)		
^{173}Os	3.160(39)	4.930(32)	5.055(6)	$0.020^{+0.010}_{-0.004}$%	[**1995Hi02, 1971Bo06**, 1973Be67, 1971BoZK]
^{177}Pt	2.777(17)	3.843(19)	5.643(3)	5.7(5)%	[**1979Ha10**, 2004GoZZ, 1992MeZW, 1992Bo04, 1982HeZM, 1973BoXL, 1970Ha18, 1966Si08]
^{181}Hg	2.324(16)	2.971(17)	6.284(4)	26.3(41)%**	[**1979Ha10**, 1996Pa01, 1992BoZO, 1990SaZU, 1986Ke03, 1984ScZQ, 1982HeZM, 1970Ha18, 1969NaZT, 1969NaZU]
^{185}Pb	1.947(19)	2.314(18)	6.695(5)	42(25)%***	[**2005Va04, 2002An15**, 1984ScZQ, 1982HeZM, 1980Sc09, 1975Ca06, 1974CaYE]
^{185m}Pb	1.947(19)-x	2.314(18)-x	6.695(5)+x	50(25)%	[**2002Va15**, 2005Va04, 1975Ca06, 1974CaYE
^{189}Po	1.516(25)	1.013(23)	7.694(15)	≈ 100%$^@$	[**2005Va04**, 2000AnZZ, 1999An52]
^{193}Rn	1.172(38)	0.466(26)	8.040(12)	100%$^@$	[**2006An36**, 2006AnZT]

* From α energy, 3.559(4) in [2021Wa16].
** Sum of α intensities from [1979Ha10].
*** Weighted average of 50(25)% [2002AN15] and 34(25)% [2005Va04].
$^@$ Based on short Half-life.

Table 3

direct α emission from ^{149}Gd, J^π = 7/2$^-$, $T_{1/2}$ = 9.25(10) d*, BR_α = 4.3(12)$\times10^{-4}$%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{145}Sm)	coincident γ-rays	R_0 (fm)	HF
3.099(5)	3.016(5)***	4.3(12)$\times10^{-4}$%**	7/2$^-$	0.0	—	1.5722(55)	$2.5^{+1.1}_{-0.7}$

* [1968Ch30].
** Weighted average of 4.0(12)$\times10^{-4}$% [1966Wi12] and 4.6(15)$\times10^{-4}$% [19665Si06].
*** 3.018(5) MeV in [1967Go32] (adjusted to 3.016(5) MeV in 1999Ry01).

Table 4
direct α emission from ^{153}Dy, J^{π} = 7/2$^-$, $T_{1/2}$ = 6.29(10) h*, BR_{α} = 0.0113(17)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{149}Gd)	coincident γ-rays	R_0 (fm)	HF
3.394(5)	3.305(5)***	0.09(7)%**	2.12e^{-6}%	5/2$^-$	0.165	0.165	1.560(21)	50^{+190}_{-30}
3.557(5)	3.464(5)***	100%**	0.01133(17)%**	0.0	7/2$^-$	—	1.560(21)	$0.9^{+0.5}_{-0.3}$

* [1970Ch09].
** [1974To07].
*** [1967Go32].

Table 5
direct α emission from ^{173}Os, J^{π} = (5/2$^-$), $T_{1/2}$ = 22.4(9) s*, BR_{α} = 0.020^{+10}_{-4}%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{169}W)	coincident γ-rays	R_0 (fm)	HF
5.055(7)	4.938(7)*	0.01133(17)%**	(5/2$^-$)	0.0	—	1.562(24)	7^{+9}_{-4}

* [1995Hi02].
** [1971Bo06].

Table 6
direct α emission from ^{177}Pt*, J^{π} = (5/2$^-$), $T_{1/2}$ = 9.8(4) s**, BR_{α} = 5.7(5)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{173}Os)	coincident γ-rays	R_0 (fm)	HF
5.561(10)	5.435(10)	13(2)%	0.65(5)%	(7/2$^-$)	0.0916(1)***	0.0916***	1.563(37)	$3.9^{+1.2}_{-0.9}$
5.655(6)	5.527(6)	100(8)%	5.0(4)%	(5/2$^-$)	0.0	—	1.563(37)	$1.41^{+0.29}_{-0.24}$

* All values from [1979Ho10], except where noted.
** [1993Me13].
*** [1991Ka05].

Table 7
direct α emission from ^{181}Hg*, J^{π} = 1/2$^-$, $T_{1/2}$ = 3.6(1) s, BR_{α} =26.3(41)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{173}Os)	coincident γ-rays	R_0 (fm)	HF
6.050(10)	5.916(10)	5.2(24)%	1.2(5)%	(5/2$^-$)	0.2398(4)	0.0809, 0.0924, 0.1474, 0.1587, 0.2398	1.5250(33)	64^{+28}_{-17}
6.072(10)	5.938(10)	7.0(21)%	1.6(4)%	(3/2$^-$)	0.2142(5)	0.2142	1.5250(33)	27^{+10}_{-7}
6.142(5)	6.006(5)	100(17)%	23(4)%	(1/2$^-$)	0.1474(4)	0.1474	1.5250(33)	$0.87^{+0.32}_{-0.21}$
6.208(10)	6.071(10)	1.7(4)%	0.39(7)%		0.0810(4)	0.0810	1.5250(33)	23^{+11}_{-6}
6.287(10)	6.148(10)	0.57(16)%	0.13(3)%	(5/2$^-$)	0.0	—	1.5250(33)	70^{+60}_{-20}

* All values from [1979Ho10], except where noted.
** Sum of α intensities from [1979Ha10].

Table 8
direct α emission from ^{185}Pb*, J^{π} = (3/2$^-$), $T_{1/2}$ = 6.3(4) s, BR_{α} =42(25)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{173}Os)	coincident γ-rays	R_0 (fm)	HF
6.427(5)	6.288 (5)	100(4)%	24(14)%	(3/2$^-$)	0.269	0.269, 0.205	1.495(11)	$1.7^{+2.8}_{-0.8}$
6.629(5)	6.486 (5)	79(5)%	18(11)%	(3/2$^-$)	0.064		1.495(11)	13^{+22}_{-6}
6.693	6.548	<0.6%	<1.4%	1/2$^-$	0.0	—	1.495(11)	>700

* All values from [2002An15], except where noted.
** Weighted average of 50(250% [2002AN15] and 34(25)% [2005Va04].

Table 9
direct α emission from ^{185m}Pb*, Ex = unk, J^π = (13/2$^+$), $T_{1/2}$ = 4.3(2) s, BR_α =50(25)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{173}Os)	coincident γ-rays	R_0 (fm)	HF
6.550(5)	6.408 (5)	50(25)%	(13/2$^+$)	x		1.495(11)	$1.7^{+1.9}_{-0.7}$

* All values from [2002An15].

Table 10
direct α emission from ^{189}Po*, J^π = (7/2$^-$), $T_{1/2}$ = 3.5(5) ms, BR_α =100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{173}Os)	coincident γ-rays	R_0 (fm)	HF
7.416(15)	7.259(15)	100(21)%	80(12)%	(5/2$^-$)	0.280	0.280	1.4991(51)	$0.18^{+0.07}_{-0.05}$**
7.467(20)	7.309(20)	15(7)%	12(5)%		0.226	0.226	1.4991(51)	$1.8^{+1.8}_{-0.7}$
7.695(20)	7.53(20)	10(8)%	8(6)%	(3/2$^-$)	0.0	—	1.4991(51)	14^{+49}_{-7}

* All values from [2005Va04].
** The reason for this unphysically low value is unknown.

Table 11
direct α emission from ^{193}Rn*, J^π = , $T_{1/2}$ = 1.15(27) ms, BR_α =100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{173}Os)	coincident γ-rays	R_0 (fm)	HF
7.848(15)	7.685(15)	100(27)%	74(20)%		0.194	0.194	1.561(16)	$1.0^{+0.8}_{-0.5}$
8.042(20)	7.875(20)	35(19)%	26(12)%	(5/2$^-$)	0.0	—	1.561(16)	10^{+14}_{-6}

* All values from [20006An14].

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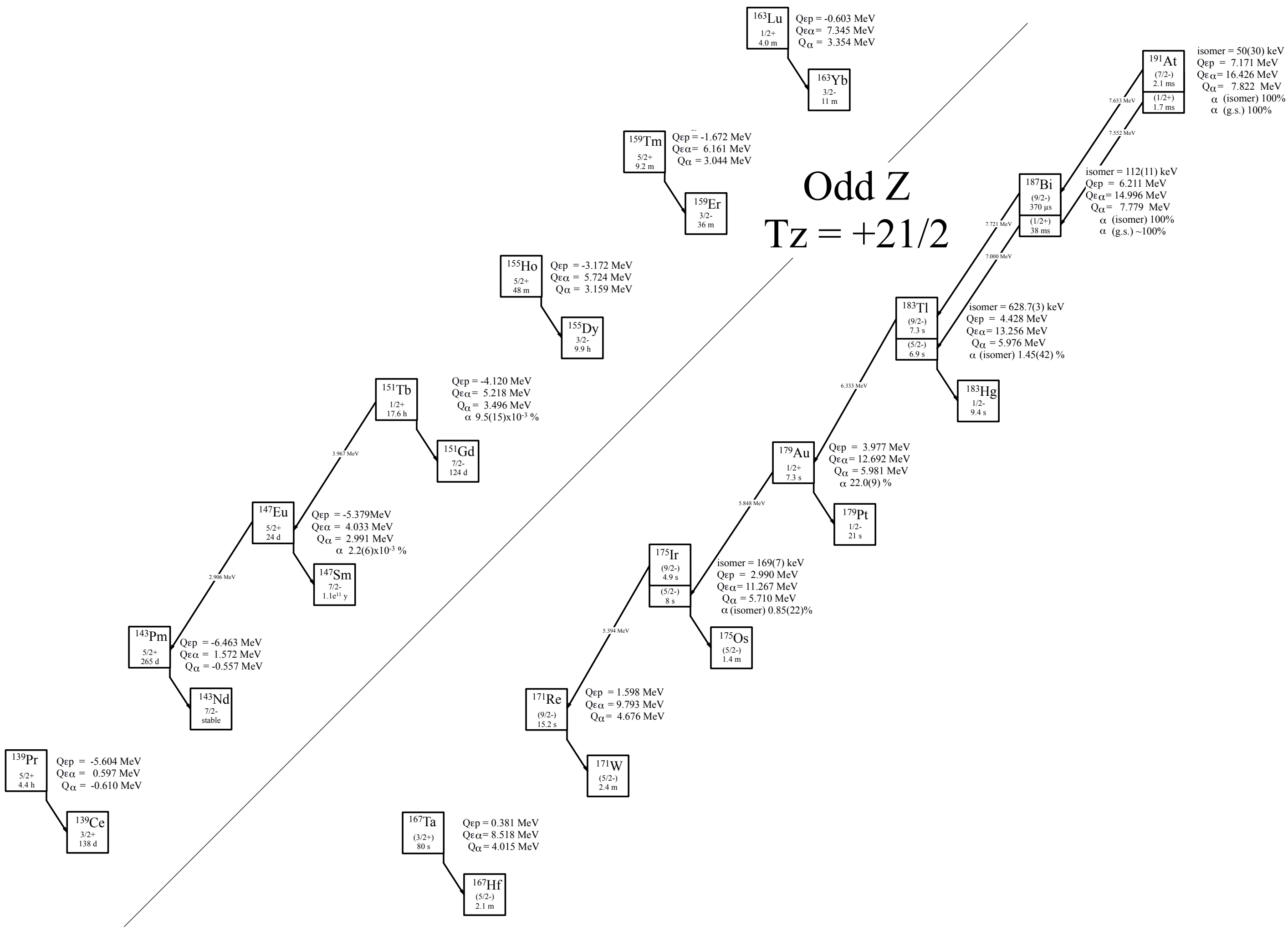

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +21/2 nuclei.

Last updated 3/29/23

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +21/2 values for are taken from ENSDF.

Nuclide	Ex	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{139}Pr		5/2$^+$	4.41(4) h	2.129(3)	-5.604(4)	0.597(4)	[**1968Li08**]
^{143}Pm		5/2$^+$	265(10) d	1.042(3)	-6.463(3)	1.572(4)	[**1963Pa21**]
^{147}Eu		5/2$^+$	24.1(6) d	1.721(2)	-5.379(5)	4.033(3)	[**1971Av09**]
^{151}Tb		1/2$^+$	17.609(14) h	2.565(4)	-4.120(7)	5.218(4)	[**1984Gr15**]
^{155}Ho		5/2$^+$	48(2) m	3.116(17)	-3.172(49)	5.724(18)	[**1972To07**]
^{159}Tm		5/2$^+$	9.15(17) m	3.991(28)	-1.672(39)	6.161(30)	[**1982By03**]
^{163}Lu		1/2$^+$	3.97(13) m	4.500(30)	-0.603(38)	7.345(28)	[**1983Ge08**]
^{167}Ta		(3/2$^+$)	80(4) s	5.120(40)	0.381(41)	8.518(32)	[**1992HeZV**]
^{171}Re		(9/2$^-$)	15.2(4) s	5.840(40)	1.598(40)	9.793(40)	[**1987Ru05**]
^{175}Ir		(1/2$^+$)	8(1) s	6.711(17)	2.990(31)	11.267(31)	[**2004GoZZ**]
^{175m}Ir	0.169(7)*	(9/2$^-$)	4.9(4) s	6.880(18)	3.159(32)	11.436(32)	[**2004GoZZ**]
^{179}Au		1/2$^+$	7.3(3) s	7.280(14)	3.977(22)	12.692(17)	[**2021Ha32**]
^{183}Tl		(5/2$^-$)	6.9(7) s	7.217(12)	4.428(21)	13.256(12)	[**1992BoZO**]
^{183m}Tl	0.6287(3)	(9/2$^-$)	53.3(3) ms	7.846(12)	5.077(21)	13.885(12)	[**2022Ve01, 2011Ve01**]
^{187}Bi		(1/2$^+$)	38(2) ms**	8.604(11)	6.211(23)	14.996(12)	[**2006An11, 1999Ba45**]
^{187m}Bi	0.112(11)	(9/2$^-$)	370(20) μs	8.716(16)	6.211(25)	14.996(16)	[**2006An11**]
^{191}At		(1/2$^+$)	$1.7^{+1.1}_{-0.5}$ ms	8.933(18)	7.171(26)	16.426(17)	[**2003Ke08**]
^{191m}At	0.050(30)	(7/2$^-$)	$2.1^{+0.4}_{-0.3}$ ms	8.983(35)	7.221(40)	16.476(34)	[**2003Ke08**]

* Excitation calculated as 169(7) keV, based on an unhindered α-decay of the ^{175}Ir isomer to the ground state of ^{171}Re, and the α-energy of the ^{175}Ir ground state to an unhindered to the 189.8 keV in ^{171}Re.

** Weighted average of 40(2) ms [2006An11] and 32(3) ms [1999Ba45].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +21/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{139}Pr	4.552(4)	12.266(4)	-0.610(10)	—	
^{143}Pm	4.300(3)	11.524(3)	-0.557(5)	—	
^{147}Eu	3.837(4)	10.855(3)	2.991(3)	0.0022(6)%	[**1967Go32, 1962Si14**, 1964To04, 1960To05, 1953Ra02]
^{151}Tb	3.148(7)	9.760(5)	3.496(4)	0.0095(15)%	[**1974To07, 1967Go32**, 1975ToZT, 1970ToZV, 1969To04, 1967Ko09, 1967Ch32, 1967Ch28, 1966Ch22, 1964Ma19, 1960Ma47, 1960To05, 1953Ra02]
^{155}Ho	2.935(19)	9.304(18)	3.159(18)		
^{159}Tm	2.556(38)	8.315(36)	3.044(33)		
^{163}Lu	2.259(32)	7.471(40)	3.354(40)		
^{167}Ta	1.781(40)	6.487(39)	4.015(40)		
^{171}Re	1.248(31)	5.538(40)	4.676(40)		
^{175}Ir	0.688(16)	4.419(31)	5.710(5)	0.85(22)%	[**2004GoZZ, 1986Ke03, 1967Si02**, 1992Sc16]
^{175m}Ir	0.518(17)	4.250(32)	5.879(9)*	≈ 70%**	[**2004GoZZ**]
^{179}Au	0.280(15)	3.519(23)	5.981(5)	22.0(9)%	[**2021Ha32, 1986Ke03**, 2004Ra28, 1996Pa01, 1980Da09, 1968De01, 1968Si01, 1965Si07]
^{183}Tl	0.299(14)	3.294(22)	5.976(9)		
^{183m}Tl	-0.330(14)	2.665(22)	6.605(9)	1.45(42)%	[**2022Ve01**, 2011Ve01, 2006An11, 2004Ra28, 1987To09, 1984ScZQ, 1980Sc09]
^{187}Bi	-1.009(15)	1.203(23)	7.779(4)	≈100%***	[**2006An11, 1999Ba45**, 2003Ke08, 1998DaZR, 1984ScZQ]
^{187m}Bi	-1.121(19)	1.091(25)	7.891(12)	≈100%***	[**2006An11, 1999Ba45**, 2003Ke08, 1998DaZR, 1984ScZQ]
^{191}At	-1.138(21)	0.649(26)	7.822(14)	100%$^@$	[**2003Ke08**, 2005Ke10, 2005Su03]
^{191m}At	-1.188(40)	0.599(40)	7.872(33)	100%$^@$	[**2003Ke08**, 2005Ke10, 2005Su03]

* Deduced from α energies, 5.431(31) MeV in [2021Wa16].

** Assuming an unhindered (HF =1.0) to the ground state of ^{171}Re.

*** Based on half-life.

Table 3
direct α emission from ^{147}Eu, J^{π} = 5/2^{+}, $T_{1/2}$ = 24.1(6) d*, BR_{α} = 0.0022(6)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{143}Pm)	coincident γ-rays	R_0 (fm)	HF	
2.987(5)	2.906(5)***	0.0022(6)%**	5/2^{+}	0.0	5/2^{+}	—	1.5813(49)	$0.63^{+0.27}_{-0.17}$

* [1971Au09].
** [1962Si14].
*** 2.908(5) MeV [1967Go32], adjusted to 2.906(5) MeV in [1991Ry01].

Table 4
direct α emission from ^{151}Tb, J^{π} = 1/2^{+}, $T_{1/2}$ = 17.609(14) h*, BR_{α} = 0.0095(15)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{147}Eu)	coincident γ-rays	R_0 (fm)	HF
3.268(5)	3.181(5)***	0.1%***	9.5(15)$\times10^{-6}$%**	7/2^{+}	0.2292	0.2292	1.5772(70)	81
3.500(5)	3.407(5)$^{@}$	100%***	90.0095(15)%**	5/2^{+}	0.0	—	1.5772(70)	$6.3^{+1.8}_{-1.4}$

* [1984Gr15].
** [1974To07].
*** 3.183(5) MeV [1967Go32], adjusted to 3.181(5) MeV in [1991Ry01].
$^{@}$ 3.409(5) MeV [1967Go32], adjusted to 3.407(5) MeV in [1991Ry01].

Table 5
direct α emission from ^{175}Ir, J^{π} = (1/2^{+}), $T_{1/2}$ = 8(1) s*, BR_{α} = 0.85(22)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{171}Re)	coincident γ-rays	R_0 (fm)	HF
5.520(5)	5.394(5)***	0.85(22)%**		0.1899(3)	0.1899(3)	1.550(19)	$3.3^{+2.7}_{-1.6}$

* [2004GoZZ].
** [1986Ke03].
*** Weighted average of 5.395(5) [2004GoZZ] and 5.393(5) MeV [1967Si02].
$^{@}$ [2018Ba33].

Table 6
direct α emission from ^{175m}Ir, Ex = 169(7) keV*, J^{π} = (9/2^{-}), $T_{1/2}$ = 4.9(4) s**, BR_{α} = ≈ 70%***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{171}ERe)	coincident γ-rays	R_0 (fm)	HF
5.879(5)	5.745(5)**	0.85(22)%**	(9/2^{-}) 0.0	—	1.550(19)	≈ 1.0	

* Excitation calculated as 169(7) keV, based on an unhindered α-decay of the ^{175}Ir isomer to the ground state of ^{171}Re, and the α-energy of the ^{175}Ir ground state to an unhindered to the 189.8 keV in ^{171}Re.
** [2004GoZZ].
*** Assuming an unhindered (HF =1.0) to the ground state of ^{171}Re.
$^{@}$ [2018Ba33].

Table 7
direct α emission from ^{179}Au*, J^{π} = 1/2^{+}, $T_{1/2}$ = 7.3(3) s, BR_{α} = 22.0(9)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{175}Ir)	coincident γ-rays	R_0 (fm)	HF
5.72810	5.600(10)	0.36(1)%	0.078(4)%		0.2603(7)	0.0261, 0.2342	1.5516(28)	38(4)
5.835(15)	5.705(15)	<0.16(7)%	<0.036(16)%		0.1460(7)	0.0261, 0.1199	1.5516(28)	$>270^{+23}_{-9}$
5.849(10)	5.718(10)	<0.98(31)%	< 0.22(7)%		0.1319(4)	0.0261, 0.1053, 0.1319	1.5516(28)	$>51^{+28}_{-15}$
5.982(4)	5.848(4)	100	22.0(9)%	(1/2^{+})	0.0	—	1.5516(28)	1.85(17)

* All values from [2021Ha32], except where noted.
** [1986Ke03].

Table 8
direct α emission from ^{183m}Tl*, Ex = 628.7(3) keV, J^{π} = (9/2$^-$), $T_{1/2}$ = 53.3(3) ms, BR_{α} = 1.45(42)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{179}Au)	coincident γ-rays	R_0 (fm)	HF
6.193(15)	6.058(15)	1.6(3)%	0.024(8)%	(9/2$^-$)	0.407(17)	0.0271, 0.0624, 0.0895, 0.2798	1.5108(76)	6^{+4}_{-2}
6.475(9)	6.333(9)	100(2)%	1.45(42)%	(9/2$^-$)	0.127(17)	0.0271, 0.0624, 0.0895	1.5108(76)	$1.3^{+0.7}_{-0.4}$
6.602(15)	6.458(15)	1.13 (31)%	0.016(7)%	(1/2$^+$)	0.0	—–	1.5108(76)	350^{+250}_{-120}

* All values from [2022Ve01], except where noted.

Table 9
direct α emission from ^{187}Bi*, J^{π} = (1/2$^+$), $T_{1/2}$ = 38(2) ms**, BR_{α} = ≈100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{183}Tl)	coincident γ-rays	R_0 (fm)	HF
7.156(5)	7.000(5)	100(5)%	88(4)%	(9/2$^-$)	0.625(7)		1.4864(88)	$0.43^{+0.10}_{-0.08}$
7.506(15)	7.342(15)	3.4(8)%	3.0(7)%	(3/2$^+$)	0.273(1)	0.273	1.4864(88)	170^{+70}_{-50}
7.782(5)	7.612 (5)	10.2(7)%	9.0(5)%	(1/2$^+$)	0.0	—–	1.4864(88)	390^{+80}_{-70}

* All values from [2006An11], except where noted.
** Weighted average of 40(2) ms [2006An11] and 32(3) ms [1999Ba45].

Table 10
direct α emission from ^{187m}Bi*, Ex = 112(11) keV, J^{π} = (9/2$^-$), $T_{1/2}$ = 370(20) μs, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{183}Tl)	coincident γ-rays	R_0 (fm)	HF
7.894(10)	7.721(10)	100%	(1/2$^+$)	0.0	—–	1.4864(88)	$0.72^{+0.16}_{-0.13}$

* All values from [2006An11], except where noted.

Table 11
direct α emission from ^{191}At*, J^{π} = (1/2$^+$), $T_{1/2}$ = 1.7^{+11}_{-5} ms, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{187}Bi)	coincident γ-rays	R_0 (fm)	HF
7.714(11)	7.552(11)	100%	(1/2$^+$)	0.112(20)		1.522(12)	0.41(29)

* All values from [2003Ke08].

Table 12
direct α emission from ^{191m}At*, Ex = 50(30) keV, J^{π} = (7/2$^-$), $T_{1/2}$ = 2.1^{+4}_{-3} ms, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{187}Bi)	coincident γ-rays	R_0 (fm)	HF
7.817(15)	7.653(15)	100(2)%	98(2)%	(7/2$^-$)	0.063(10)	0.063(10)	1.522(12)	$1.1^{+0.4}_{-0.3}$
7.880(15)	7.715(15)	2(2)%	2(2)%	(9/2$^-$)	0.0	—–	1.522(12)	1200(1100)

* All values from [2003Ke08].

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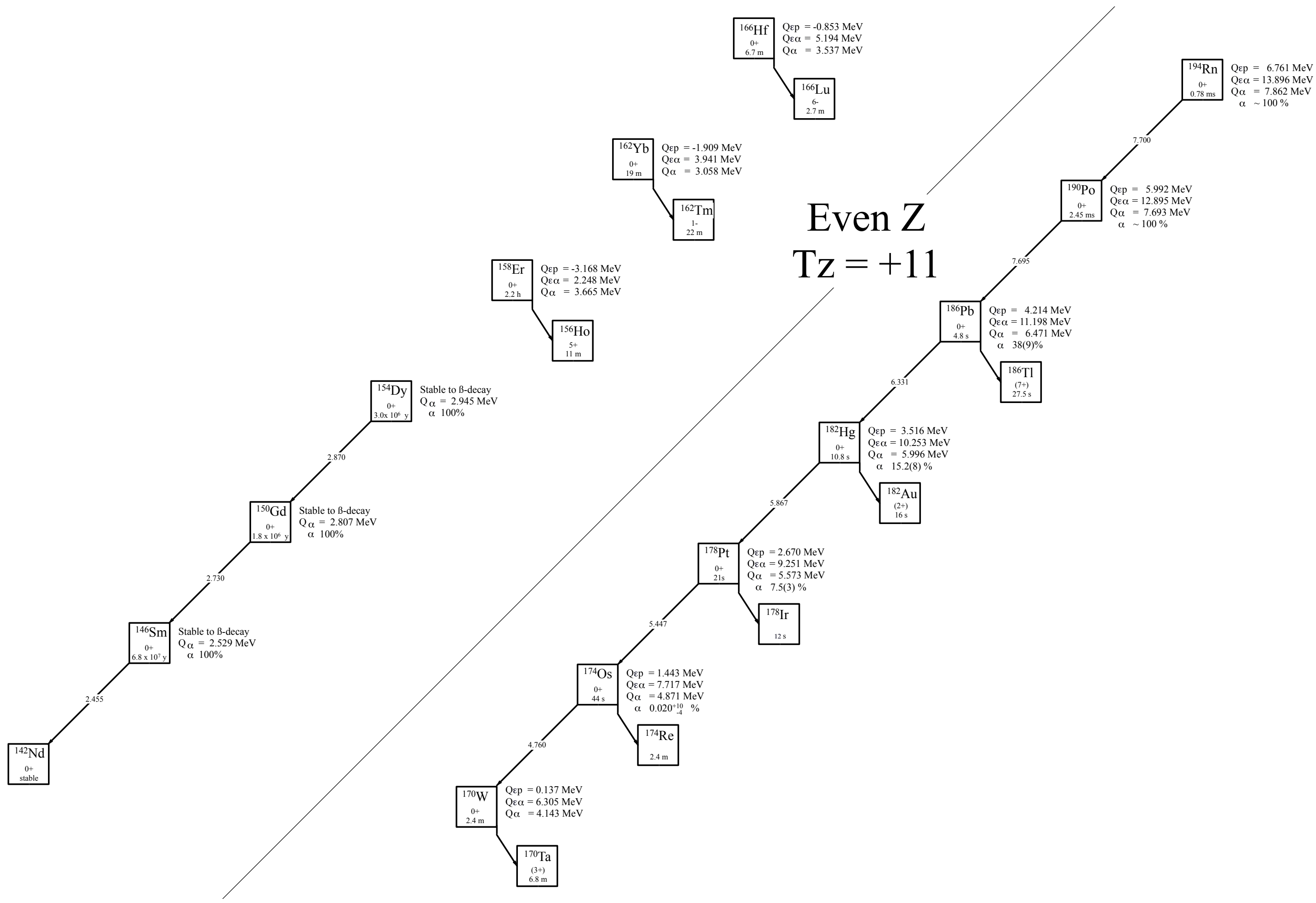

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +11 nuclei.

Last updated 4/4/23

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +11 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{146}Sm	0^+	6.8(7)×10^7 y	stable	—–	—–	[**2012Ki16**]
^{150}Gd	0^+	1.78(8)×10^6 y	stable	—–	—–	[**1966Fr11**]
^{154}Dy	0^+	3.0(15)×10^6 y	stable	—–	—–	[**1985HoZM**]
^{158}Er	0^+	2.24(10) h	0.880(40)	-3.168(26)	2.428(52)	[**1982Vy06**]
^{162}Yb	0^+	18.87(19) m	1.660(30)	-1.909(17)	3.941(31)	[**1972Ch23**]
^{166}Hf	0^+	6.77(30) m	2.160(40)	-0.853(39)	5.194(38)	[**1974De09**]
^{170}W	0^+	2.42(4) m	2.850(30)	0.137(31)	6.305(33)	[**1990Me12**]
^{174}Os	0^+	44(4) s*	3.678(30)	1.443(30)	7.717(30)	[**1972Be89, 1971Bo06**]
^{178}Pt	0^+	20.8(5) s**	4.257(21)	2.670(18)	9.251(30)	[**2000Ko16, 1982Bo14, 1980Sc09,** [**1968De01, 1966Si08**]
^{182}Hg	0^+	10.83(6) s	4.727(21)	3.516(17)	10.253(21)	[**1993Wa03**, 1993WaZO]
^{186}Pb	0^+	4.79(5) s	5.202(23)	4.214(18)	11.198(22)	[**1980Sc09**]
^{190}Po	0^+	2.45(5) ms	6.033(25)	5.992(19)	12.895(25)	[**2001An07, 2000An14**]
^{194}Rn	0^+	780(160)μs	6.441(29)	6.761(22)	13.896(27)	[**2006An36**]

* Weighted average of 44(4) s [1972Be89] and 42(6) s [1971Bo06].
** Weighted average of 20(2) s [2000Ko16, 21(1) s [1982Bo14], 19(2) s [1980Sc09], 21.2(8) s [1968De01] and 21.3(15) s [1966Si08].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the even-Z, T_z = +11 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{146}Sm	7.018(4)	11.826(3)	2.529(3)	100%*	[**1987Me08**, 2012Ki16, 1990Pe06, 1967Gu14, 1966Fr11, 1964Nu02, 1961Ma05, 1960Ka23, 1960Ma47, 1953Du21, 1952Lo20]
^{150}Gd	6.612(7)	11.006(6)	2.807(6)	100%*	[**1962Si14**, 1967Go32, 1966Fr11, 1965Og01, 1962Do13, 1960To05, 1953Ra02]
^{154}Dy	6.369(8)	10.265(7)	2.945(5)	100%*	[**1967Go32**, 1985HoZN, 1971Go08, 1965Ma51, 1962Ry03, 1961Ma18, 1960Ma47, 1958To27]
^{158}Er	5.760(34)	9.352(25)	2.665(26)		
^{162}Yb	5.211(32)	8.335(29)	3.058(29)		
^{166}Hf	4.706(39)	7.425(32)	3.537(32)		
^{170}W	4.289(31)	6.508(31)	4.143(31)		
^{174}Os	3.730(30)	5.476(30)	4.871(10)	$0.020^{+0.010}_{-0.004}$%	[**1971Bo06**, 1971BoZK]
^{178}Pt	3.239(22)	4.444(15)	5.573(2)	7.5(3)%	[**2000Ko16, 1980Sc09**, 1992MeZW, 1982HeZM, 1979Ha10, 1973BoXL, 1970Ha18, 1968De01, 1966Si08]
^{182}Hg	2.995(22)	3.725(14)	5.996(5)	15.2(8)%	[**1979Ha10, 1980Sc09**, 1993Wa03, 1993WaZO, 1982HeZM, 1970Ha18, 1969Ha03, 1968De11]
^{186}Pb	2.212(23)	2.914(15)	6.471(5)	38(9)%	[**1994Wa23, 1999An22**, 2000Va34, 1998DaZQ, 1997An09, 1997Ba25, 1984To09, 1980Sc09, 1974JoZU, 1974Le02, 1972Ga27]
^{190}Po	1.787(25)	1.330(17)	7.693(7)	100%***	[**2001An07, 2000An14**, 2000AnZZ, 1999An22, 1997An09, 1998DaZQ, 1997Ba25, 1996Ba35, 1988QuZZ]
^{194}Rn	1.497(27)	0.787(20)	7.862(10)	100%***	[**2006An36**, 2007An19, 2006AnZT]

* Only decay mode energetically possible.
** [1958To27] also report a 3.350(50) MeV α attributed to an isomeric state of ^{154}Dy. A later study [1971Go08] with far more statistics did not observe this.
*** based on short half-life.

Table 3
direct α emission from ^{146}Sm, $J^\pi = 0^+$,$T_{1/2}$=6.8(7)×10^7 y*, BR_α =100%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{142}Nd)	coincident γ-rays	R_0 (fm)	HF
2.524(4)	2.455(4)***	100%	0^+	0.0	—–	1.5930(74)	1.0

* [2012Ki16].
** Only decay mode energetically possible.
*** [1987Me08].

Table 4
direct α emission from ^{150}Gd, J^{π} =0^+ ,$T_{1/2}$=1.78(8)$\times 10^6$ y*, BR_α =100%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{142}Nd)	coincident γ-rays	R_0 (fm)	HF
2.805(10)	2.730(10)***	100%	0^+	0.0	—	1.5748(86)	1.0

* [1966Fr11].
** Only decay mode energetically possible.
*** [1962Si14].

Table 5
direct α emission from ^{154}Dy, J^{π} = 0^+,$T_{1/2}$=3.0(15)$\times 10^6$ y*, BR_α =100%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{142}Nd)	coincident γ-rays	R_0 (fm)	HF
2.947(5)	2.870(5)***	100%	0^+	0.0	—	1.541(36)	1.0

* [1985HoZM].
** Only decay mode energetically possible.
*** 2.872(5) MeV in [1967Go32], adjusted to 2.870(5) MeV in [1999Ry01].

Table 6
direct α emission from ^{174}Os*, J^{π} = 0^+,$T_{1/2}$=44(4) s**, BR_α =0.020^{+10}_{-4}%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{170}W)	coincident γ-rays	R_0 (fm)	HF
4.872(10)	4.760(10)	100%	0^+	0.0	—	1.540(34)	1.0

* All values from [1971Bo06], except where noted.
*** Weighted average of 44(4) s [1972Be89] and 42(6) s [1971Bo06].

Table 7
direct α emission from ^{178}Pt*, J^{π} = 0^+,$T_{1/2}$=20.8(5) s**, BR_α =7.5(3)%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{174}Os)	coincident γ-rays	R_0 (fm)	HF
5.411(8)	5.289(8)	3.6(4)	0.26(3)%	2^+	0.1586(1)***	0.1586(1)***	1.5708(31)	$5.0^{+0.9}_{-0.7}$
5.572(4)	5.447(4)	100(3)	7.2(9)%	0^+	0.0	—	1.5708(31)	1.0

* All values from [2000Ko16], except where noted.
** Weighted average of 20(2) s [2000Ko16, 21(1) s [1982Bo14], 19(2) s [1980Sc09], 21.2(8) s [1968De01] and 21.3(15) s [1966Si08].
*** [1999Br24].

Table 8
direct α emission from ^{182}Hg, J^{π} = 0^+,$T_{1/2}$=10.83(6) s*, BR_α =15.2(8)%**.

E_α(c.m.)	E_α(lab)	I_α(rel)***	I_α(abs)	J^π_f	$E_{daughter}$(^{178}Pt)	coincident γ-rays	R_0 (fm)	HF
5.578(10)	5.455(10)@	0.09(3)%	0.014(3)%	0^+	0.4210(6)	0.1703(1), 0.2506, 0.421	1.5176(41)	13^{+7}_{-4}
5.828(5)	5.700(5)@	0.58(16)%	0.09(2)%	2^+	0.1703(1)	0.1703(1)	1.5176(41)	28^{+15}_{-7}
5.999(5)	5.867(5)@	100(22)%	15(3)%	0^+	0.0	—	1.5176(41)	1.0

* [1993Wa03].
** [1980Sc09].
*** From α intensity ratios in [1979Ha10].
@ [1979Ha10].

Table 9
direct α emission from ^{186}Pb*, J^{π} = 0^{+},$T_{1/2}$=4.79(5) s**, BR_{α} =38(9)%***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)***	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{182}Hg)	coincident γ-rays	R_0 (fm)	HF
6.146(13)	6.014(13)	<0.20%	<0.076(18)%	(0^{+})	0.328		1.486(10)	>25
6.470(6)	6.331(6)	<100%	<38(9)%	0^{+}	0.0	—	1.486(10)	1.0

* All values from [1994Wa23], except where noted.
** [1980Sc09].
*** [1999An22].

Table 10
direct α emission from ^{190}Po*, J^{π} = 0^{+},$T_{1/2}$=2.45(5) ms, BR_{α} =100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{186}Pb)	coincident γ-rays	R_0 (fm)	HF
7.044(20)	6.896(20)	0.3(1%)	0.3(1)%	0^{+}	0.650		1.5114(26)	$2.5^{+1.3}_{-0.7}$
7.163(20)	7.012(20)	3.4(4)%	3.3(4)%	0^{+}	0.532		1.5114(26)	$0.58^{+0.09}_{-0.07}$
7.695(10)	7.533(10)	100.0(4)%	96.4(4)%	0^{+}	0.0	—	1.5114(26)	1.0

* All values from [2001An07, 2000An14].

Table 11
direct α emission from ^{194}Rn*, J^{π} = 0^{+},$T_{1/2}$=780(160)μs, BR_{α} =100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{186}Pb)	coincident γ-rays	R_0 (fm)	HF
7.862(10)	7.700(10)	100%	0^{+}	0.0	—	1.590(11)	1.0

* All values from [2006An36].

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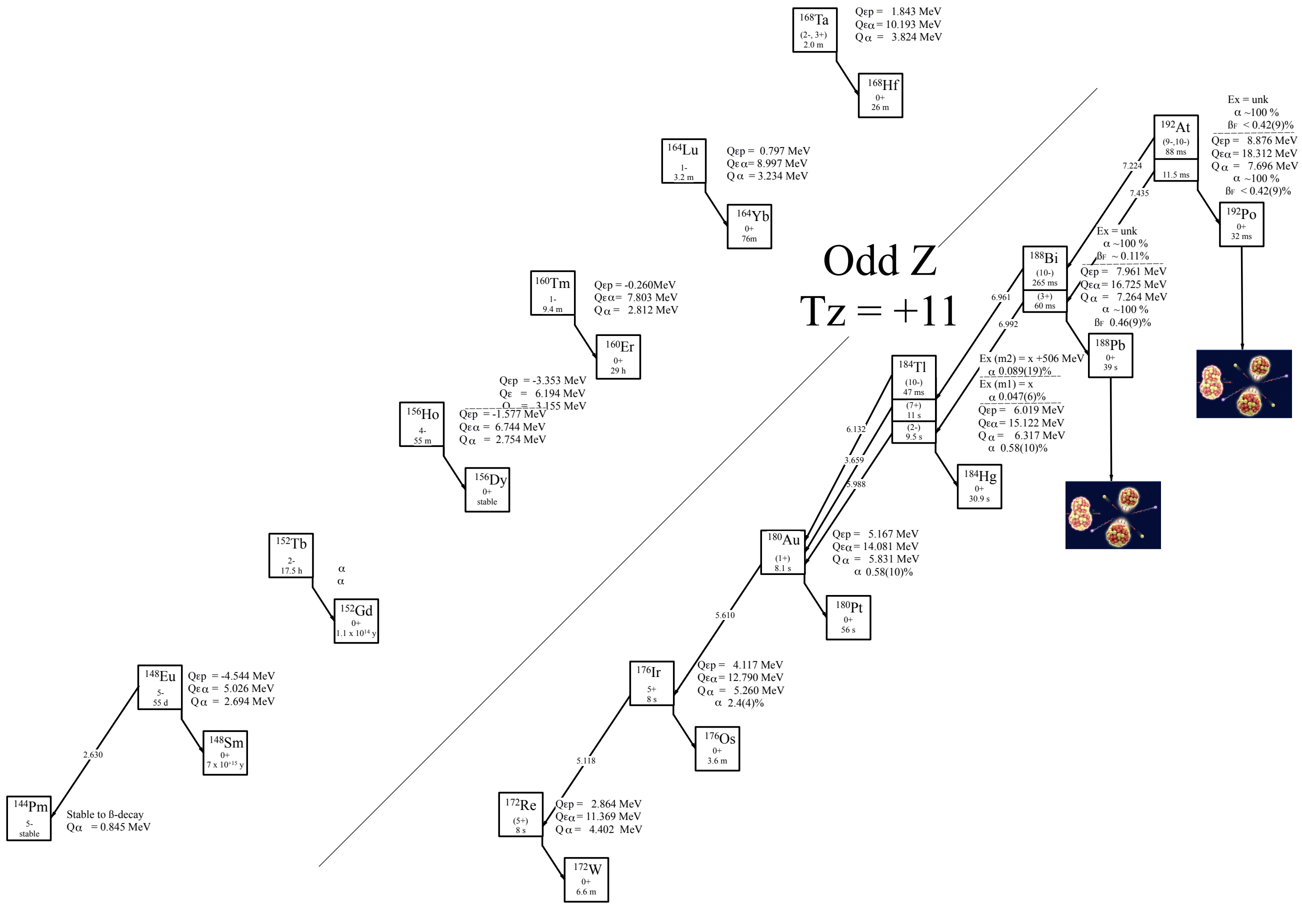

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +11 nuclei.

Last updated 4/4/23

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +11 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J^π values for ^{144}Pm, ^{148}Eu, ^{152}Tb, ^{156}Ho, ^{160}Tm, ^{164}Lu, ^{168}Ta, ^{172}Re are taken from ENSDF.

Nuclide	Ex	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	$BR_{\beta F}$	Experimental
^{144}Pm		5^-	363(14) d*	0.550(3)	-5.637(2)	4.233(3)		[**1963Pa21, 1964Bu13**
^{148}Eu		5^-	55.6(2) d	3.039(10)	-4.544(10)	5.026(10)		[**1980Ho33**]
^{152}Tb		2^-	17.5(1) h	3.990(40)	-3.353(40)	6.194(40)		[**1967Gr12**]
^{156}Ho		4^-	55(1) m	4.990(40)	-1.577(40)	6.744(38)		[**1966La11**]
^{160}Tm		1^-	9.4(4) m*	5.760(40)	-0.260(33)	7.803(33)		[**1970De13, 1975St12**]
^{164}Lu		1^-	3.15(3) m**	6.370(30)	0.797(28)	8.997(37)		[**1984Ad09, 1983Ge08, 1977Hu02**]
^{168}Ta		$(2^-, 3^+)$	2.0(1) m	6.970(40)	1.843(47)	10.193(32)		[**1989Hi04**]
^{172}Re		(5^+)	15(3) s	7.530(50)	2.864(45)	11.369(45)		[**1977Be66**]
^{176}Ir		5^+	8(1) s	8.249(14)	4.117(29)	12.790(29)		[**1967Si02**]
^{180}Au		(1^+)	8.1(3) s	8.804(11)	5.167(11)	14.081(12)		[**1977Hu05**]
^{184}Tl***	y	(2^-)	9.5(2) s	9.461(14)+y	6.019(14)+y	15.122(14)+y		[**2016Va01**]
^{184m1}Tl***	x	(7^+)	11(1) s	9.461(14)+x	6.019(14)+x	15.122(14)+x		[**2016Va01, 1976CoZH**]
^{184m2}Tl	x +0.506	(10^-)	47.1(7) ms	9.967(14)+x	6.525(14)+x	15.628(14)+x		[**2015Va10**]
^{188}Bi		(3^+)	60(3) ms	10.616(15)	7.961(14)	16.725(15)	0.46(9)%	[**2020An12, 2003An26**, 2013La02, 1993LaZT]
^{188m}Bi	x	(10^-)	265(10) ms	10.616(15)+x	7.961(14)+x	16.725(15)+x	≈0.11%	[**2020An12, 2003An26**, 2013La02, 1993LaZT]
^{192}At	y		11.5(6) ms	10.992(30)	8.876(29)	18.312(30)	0.42(9)%@	[**2006An04, 2013An03]**
^{192m}At	x	$(9^-, 10^-)$	88(6) ms	10.992(30)+x	8.876(29)+x	18.312(30)+x	0.42(9)%@	[**2006An04, 2013An03]**

* Weighted average of 377(16) d [1963Pa21] and 349(16) d [1964Bu13].
* Weighted average of 9.2(4) m [1970De13] and 9.5(4) m [1975St12].
** Weighted average of 3.12(3) m [1984Ad09], 3.15(8) m [1983Ge08] and 3.17(3) m [1977Hu02].
*** The ordering of the isomers is uncertain.
@ [2013An03] state that the measured $BR_{\beta F}$ is likely from the 88-ms isomer.

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +11 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{144}Pm	4.703(3)	12.208(3)	0.845(7)		
^{148}Eu	4.320(10)	11.421(11)	2.694(10)	9.4(28)×10^{-7}%	[**1964To04**]
^{152}Tb	3.817(40)	10.503(41)	3.155(41)		
^{156}Ho	3.671(40)	9.960(60)	2.754(55)		
^{160}Tm	3.029(33)	8.692(42)	2.812(50)		
^{164}Lu	2.637(32)	7.743(38)	3.234(43)		
^{168}Ta	2.215(40)	6.951(41)	3.824(40)		
^{172}Re	1.770(45)	6.007(45)	4.402(45)		
^{176}Ir	1.066(14)	4.787(29)	5.260(36)	2.4(4)%*	[**1967Si02, 1990Bo19, 1986Ke03**]
^{180}Au	0.646(9)	3.949(19)	5.831(7)	0.58(10)%	[**2020Ha24**] 2020Cu02,1993Wa03, 1986Ke03]
^{184}Tl	0.368(12)-y	3.157(21)-y	6.317(9)+y	1.22(30)%	[**2016Va01**, 1978CoYS, 1977ToZS, 1976Co24, 1976To06, 1976WoZJ]
^{184m1}Tl	0.368(12)-x	3.157(21)-x	6.317(9)+x	0.047(6)%	[2016Va01, 1976CoZH, 1978CoYS]
^{184m2}Tl	-0.138(12)+x	2.651(21)-x	6.823(9)+x	0.089(19)%	[**2016Va01, 2015Va10**]
^{188}Bi	-0.503(12)	1.890(24)	7.264(5)	≈100%**	[**2003An26**, 2006An04, 2003AnZZ, 1997Wa05, 1993An19, 1984ScZQ]
^{188m}Bi	-0.503(12)-x	1.890(24)-x	7.264(5)+x	≈100%**	[**2003An26**, 2006An04, 2003AnZZ, 1997Wa05, 1993An19, 1984ScZQ]
^{192}At	-0.706(29)	1.056(35)	7.696(26)	≈100%**	[**2006An04**, 2005AnZY]
^{192m}At	-0.706(29)-x	1.056(35)-x	7.696(26)+x	≈100%**	[**2006An04**, 2005AnZY]

* Weighted average of 3.1(6)% [1990Bo19], and 2.1(4)% [1986Ke03].
** Based on short half-life.

Table 3
direct α emission from ^{148}Eu*, $J^{\pi} = 5^{-}$, $T_{1/2}$ = 55.6(2) d**, BR_{α} =9.4(28)$\times10^{-7}$%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{144}Pm)	coincident γ-rays	R$_0$ (fm)***	HF
2.703(30)	2.630(30)	9.4(28)$\times10^{-7}$%	5^{-}	0.0	——	1.584(11)	4^{+5}_{-3}

* All values from [1964To04], except where noted.
** [1980Ho33].
*** Interpolated between 1.5930(74) fm ^{146}Sm and 1.5748(86) ^{150}Gd.

Table 4
direct α emission from ^{176}Ir*, $J^{\pi} = 5^{+}$, $T_{1/2}$ = 8(1) s, BR_{α} =2.4(4)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{172}Re)	coincident γ-rays	R$_0$ (fm)***	HF
5.237(10)	5.118(10)	2.4(4)%***	(5^{+})	0.0	——	1.556(34)	$0.06^{+0.06}_{-0.03}$ @

* All values from [1967Si02], except where noted.
** Weighted average of 3.1(6)% [1990Bo19], and 2.1(4)% [1986Ke03].
*** Interpolated between 1.540(34) fm ^{174}Os and 1.5708(31) ^{178}Pt.
@ The reason for this un-physically low HF value is unknown. A likely possibility is the observed peak at 5.118 MeV is an unresolved multiplet consisting of multiple α transitions and conversion electron summing.

Table 5
direct α emission from ^{180}Au*, J^{π} = (1^{+}), $T_{1/2}$ = 8.1(3) s**, BR_{α} =0.58(10)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{176}Ir)	coincident γ-rays	R$_0$ (fm)	HF
5.476(20)	5.354(20)	0.51(26)%	0.0012(6)%		0.338(20)		1.5442(51)	180^{+230}_{-80}
5.548(20)	5.425(20)	2.3(8)%	0.005(2)%		0.2648(9)	0.0365, 0.0415, 0.1778, 0.2188	1.5442(51)	90^{+60}_{-30}
5.610(10)	5.485(10)	100(10)%	0.23(5)%	(1^{+})	0.2052(9)	0.0365, 0.0415, 0.1089, 0.1180, 0.1599, 0.1957, 0.2052	1.5442(51)	4.0^{+14}_{-10}
5.637(15)	5.512(15)	8.5(18)%	0.019(4)%		0.1766(9)	0.0365, 0.0415, 0.0891, 0.1033	1.5442(51)	64^{+27}_{-18}
5.725(8)	5.598(8)	60.5(87)%	0.14(3)%		0.0875(8)	0.0365, 0.0415,	1.5442(51)	23^{+8}_{-6}
5.767(7)	5.639(7)	85(12)%	0.19(4)%		0.0460(7)	0.0365	1.5442(51)	25^{+8}_{-6}
≈5.804	≈5.675	<1.3%	<0.0029%		0.0095(7)		1.5442(51)	>2400
≈5.815	≈5.686	<1.3%	<0.0029%	5^{+}	0.0	——	1.5442(51)	>2700

* All values from [2020Ha24], except where noted.
** [1977Hu05].
*** Interpolated between 1.5708(31) ^{178}Pt and 1.5176(41) fm ^{182}Hg.

Table 6
direct α emission from ^{184}Tl*, J^{π} = (2^{-}), $T_{1/2}$ = 9.5(2) s, BR_{α} =1.22(30)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{180}Au)	coincident γ-rays
5.876(12)	5.748(12)	<0.4%	<0.0024%		x + 0.426	0.4260(5)
5.935(12)	5.810(12)	6.0(4)%	0.037(9)%		x + 0.365	0.3651(2), 0.3151(2), 0.2728(3), 0.1984(9)
6.097(13)	5.964(13)				x + 0.224	0.2243(3)
6.121(12)	5.988(12)	100%	0.61(15)%		x + 0.201	0.2013(3), 0.1842(1), 0.1785(1), 0.1263(1)
6.298(10)	6.161(10)	93(1)%	0.57(14)%		x + 0.017	

* All values from [2016Va01].

Table 7
direct α emission from ^{184m1}Tl*, J^{π} = (7^{+}), $T_{1/2}$ = 11(1) s**, BR_{α} =0.047(6)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{180}Au)	coincident γ-rays
5.785(5)	5.659(5)	0.047(6)%		z + 0.183	0.3633(6), 0.2618(3), 0.2577(3), 0.1757(3)

* All values from [2016Va01], except where noted.
** [1976CoZH].

Table 8
direct α emission from ^{184m2}Tl*, J^π = (10$^-$), $T_{1/2}$ = 47.1(7) ms**, BR_α =0.089(19)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{180}Au)	coincident γ-rays
6.268(19)	6.132(19)	0.089(19)%		z + 0.206	0.2059(2), 0.1626(1), 0.1079(2), 0.1013(6)

* All values from [2016Va01], except where noted.
** [2015Va10].

Table 9
direct α emission from ^{188}Bi*, J^π = (3$^+$), $T_{1/2}$ = 60(3) ms, BR_α =≈100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{184}Tl)	coincident γ-rays	R$_0$ (fm)**	HF
7.039(10)	6.889(10)	0.34(1)%		≈0.33	y + 0.216	0.099, 0.1175	1.4985(10)	≈100
7.144(5)	6.992(5)	100%	≈98%	(3$^+$)	y + 0.1775	0.1175	1.4985(10)	0.46(3)
7.260(5)	7.106(5)	2.1(2)%	≈2.0%	(2$^+$)	y	1.4985(10)	≈89	

* All values from [2003An26].
** Interpolated between 1.486(10) ^{186}Pb and 1.5114(26) fm ^{190}Po. Note this value is likely too low as Pb is a closed proton shell.

Table 10
direct α emission from ^{188m}Bi*, J^π = (10$^-$), $T_{1/2}$ = 265(10) ms, BR_α =≈100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{184}Tl)	coincident γ-rays	R$_0$ (fm)**	HF
6.961(5)	6.813(5)	100%	≈91%	(10$^-$)	0.500		1.4985(10)	≈0.8
7.147(15)	6.995(15)	1.5(5)%	≈1.4%		x + 0.320	0.0705, 0.249, 0.320	1.4985(10)	≈230
7.389(10)	7.232(10)	4.5(1)%	≈4.1%	(6$^+$)	x + 0.0705	0.0705	1.4985(10)	≈510
7.461(5)	7.302(5)	3.6(1)%	≈3.3%	(7$^+$)	x		1.4985(10)	≈1050

* All values from [2003An26], except where noted.
** Interpolated between 1.486(10) ^{186}Pb and 1.5114(26) fm ^{190}Po. Note this value is likely too low as Pb is a closed proton shell.

Table 11
direct α emission from ^{192}At*, J^π = , $T_{1/2}$ = 11.5(6) ms, BR_α =≈100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{188}Bi)	coincident γ-rays	R$_0$ (fm)**	HF
7.520(15)	7.363(15)	21(4)%	12(2)%		0.172(29)		1.551(12)	11^{+6}_{-4}
7.593(15)	7.435(15)	100(7)%	56(4)%		0.101(25)	0.036	1.551(12)	$4.0^{+1.7}_{-1.3}$
7.629(15)	7.470(15)	55(7)%	31(3)%		0.065(25)		1.551(12)	19^{+4}_{-3}
7.670-7.721	7.510-7.560	≤1.8(9)%	1.0(5)%	(3$^+$)	0.0	—		

* All values from [2006An04].
** Interpolated between 1.5114(26) fm ^{190}Po and 1.590(11) ^{194}Pb and Note this value is likely too low as Pb is a closed proton shell.

Table 12
direct α emission from ^{192m}At*, J^π = (9$^-$, 10$^-$), $T_{1/2}$ = 88(6) ms, BR_α =≈100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{188}Bi)	coincident γ-rays	R$_0$ (fm)**	HF
7.348(15)	7.195(15)	4.9(4)%	4.0(7)%		x +0.188	0.188	1.551(12)	70^{+40}_{-30}
7.378(15)	7.224(15)	100(4)%	82(3)%	(9$^-$, 10$^-$)	x + 0.165	0.165	1.551(12)	$4.2^{+1.9}_{-1.5}$
7.542(15)	7.385(15)	17.1(7)%	14(2)%	(10$^-$)	x		1.551(12)	80^{+40}_{-30}
7.670-7.721	7.510-7.560	≤1.8(9)%	1.0(5)%	(3$^+$)	0.0	—		

* All values from [2006An04].
** Interpolated between 1.5114(26) fm ^{190}Po and 1.590(11) ^{194}Pb and Note this value is likely too low as Pb is a closed proton shell.
*** unresolved multiplet.

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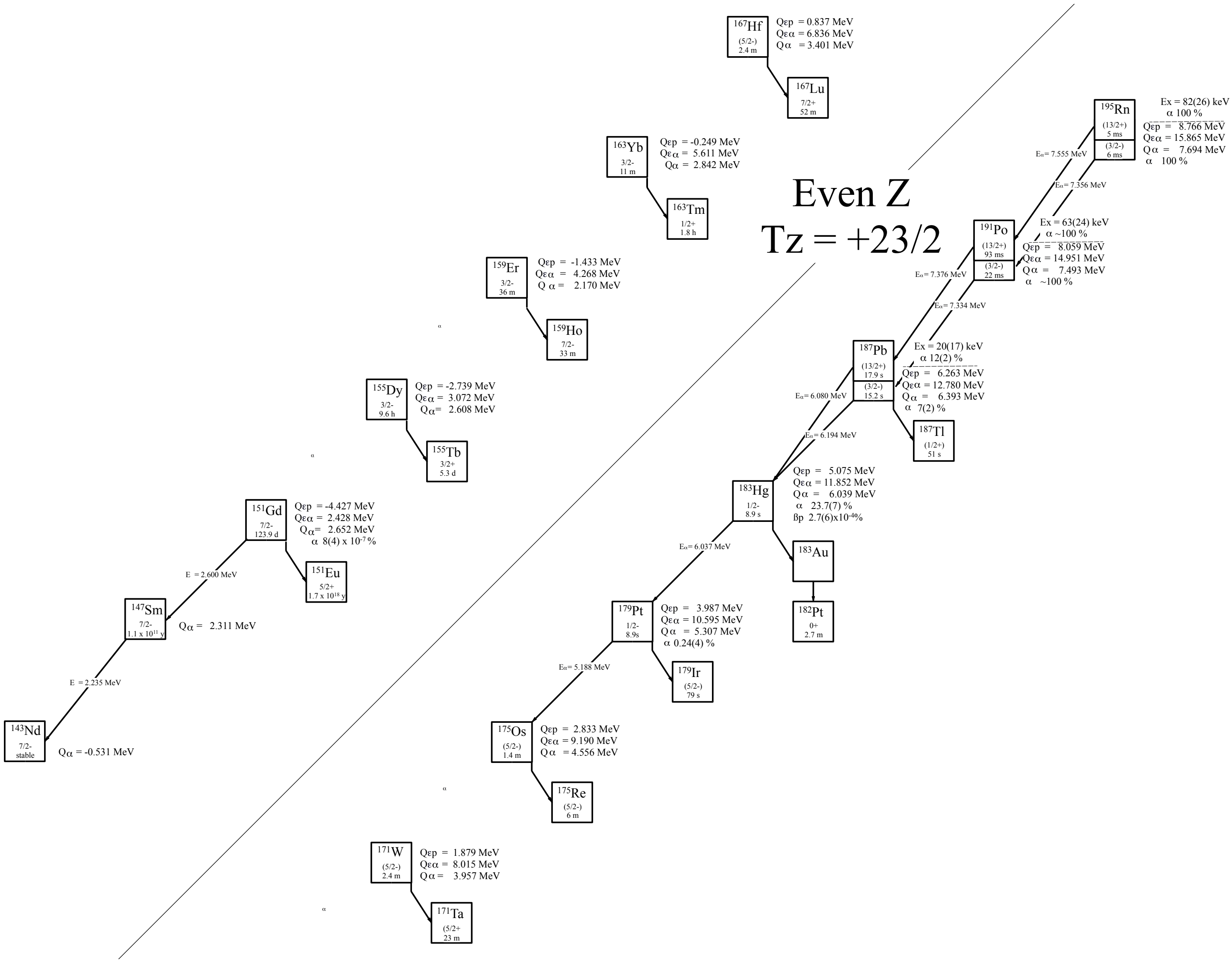

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +23/2 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +23/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J$^{\pi}$ values for ^{143}Nd, ^{147}Sm, ^{151}Gd, ^{155}Dy, ^{159}Er, ^{163}Yb, ^{167}Hf, ^{171}W, ^{175}Os are taken from ENSDF.

Nuclide	Ex	J^{π}	$T_{1/2}$	Qε	$Q_{\varepsilon p}$	BR$_{\beta p}$	$Q_{\varepsilon\alpha}$	Experimental
^{143}Nd		7/2$^-$	stable	stable	—	—	—	
^{147}Sm		7/2$^-$	1.068(9) × 10^{11} y*	stable	—	—	—	[**2010Su30, 2009Ko15**]
^{151}Gd		7/2$^-$	123.9(10) d	0.464(3)	-4.427(3)		2.428(3)	[**1984Gr15**]
^{155}Dy		3/2$^-$	9.59(10) h	2.095(2)	-2.739(10)		3.072(10)	[**1970Ch09**]
^{159}Er		3/2$^-$	36(1) m	2.769(2)	-1.443(4)		4.264(10)	[**1966La11**]
^{163}Yb		3/2$^-$	10.96(35) m	3.435(16)	-0.249(15)		5.611(15)	[**1972Ch23**]
^{167}Hf		(5/2$^-$)	2.05(5) m	4.060(50)	0.837(29)		6.836(28)	[**1973Me09**]
^{171}W		(5/2$^-$)	2.38(4) m	4.630(40)	1.879(40)		8.015(47)	[**1990Me12**]
^{175}Os		(5/2$^-$)	1.4(1) m	5.180(30)	2.833(30)		9.190(30)	[**1972Be89**]
^{179}Pt		1/2$^-$	21.2(4) s	5.814(13)	3.987(16)		10.595(29)	[**1993Me13, 1993MeZW**]
^{183}Hg		1/2$^-$	8.9(2) s	6.387(12)	5.075(15)	2.7(6)×10^{-4}%	11.852(12)	[**2022Hu09, 1971Ho07**, 1970HaZL, 1970HoZZ]
^{187}Pb		(3/2$^-$)	15.2(3) s	7.458(10)	6.263(13)		12.780(11)	[**1981Mi12**]
^{187m}Pb	0.020(17)**	(13/2$^+$)	17.9(2) s	7.478(20)	6.283(21)		12.800(20)	[**2022Hu09, 1981Mi12**]
^{191}Po		(3/2$^-$)	22(2) ms	8.171(10)	8.059(14)		14.951(11)	[**2002An16**]
^{191m}Po	0.063(24)***	(13/2$^+$)	93(3) ms	8.234(26)	8.122(28)		15.014(26)	[**2002An16**]
^{195}Rn		(3/2$^-$)	6^{+3}_{-2} ms	8.520(50)	8.766(53)		15.865(52)	[**2001Ke06, 2001Uu01**]
^{195m}Rn	0.082(26)$^{@}$	(13/2$^+$)	5^{+3}_{-2} ms	8.602(56)	8.848(59)		15.947(59)	[**2001Ke06, 2001Uu01**]

* Weighted average of 1.065(10) × 10^{11} y [2010Su30] and 1.070(9) × 10^{11} y [2009Ko15].
** Deduced from α and γ energies [2022Hu09, 1981Mi12] of the two isomers
*** Deduced from α energies [2002An16] and excitation energy of ^{187m}Pb. See table 8 for more detail.
$^{@}$ Deduced from α energies [2001Ke06] and excitation energy of ^{191m}Po.

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the even-Z, T_z = +23/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_p$	S$_{2p}$	Qα	BRα	Experimental
^{143}Nd	7.505(1)	13.149(1)	0.531(2)		
^{147}Sm	7.101(4)	12.412(1)	2.3113(5)	100%*	[**1970Gu14, 1966Ma05, 1962Si14, 1961Ma05, 1960Ka27**, 2017Wi01, 2010Su30, 2009Ko15, 2003Ki26, 2001Be81, 1992Ma26, 1987Al28, 1965Va16, 1964Do01, 1961Gr37, 1961Wr02, 1960Ka23, 1959Vo28, 1954Be69, 1954Le55, 1949Pi01, 1946Cu01, 1934Li03, 1934MaAA, 1933HeAA]
^{151}Gd	6.686(7)	11.631(3)	2.652(3)	8^{+8}_{-4}×10^{-7}%	[**1965Si06**]
^{155}Dy	6.288(46)	10.851(10)	2.608(10)		
^{159}Er	5.663(27)	9.714(6)	2.170(10)		
^{163}Yb	5.105(30)	8.671(17)	2.842(16)		
^{167}Hf	4.736(41)	7.750(39)	3.401(32)		
^{171}W	4.237(40)	6.947(40)	3.957(40)		
^{175}Os	3.721(30)	5.956(30)	4.556(30)		
^{179}Pt	3.303(20)	4.890(17)	5.307(7)**	0.24(4)%***	[**2021Ha32, 1980Sc09, 1970Ha18**, 1982Bo14, 1979Ha10, 1973BoXL, 1970Ho18, 1970HaZT, 1966Si08]
^{183}Hg	2.790(20)	4.001(15)	6.039(4)	23.7(7)%	[**2022Hu09, 1979Ha10**, 1992BoZO, 1984Ma41, 1980Sc09 1969NaZT, 1969NaZU, 1968De01]
^{187}Pb	2.393(21)	3.381(15)	6.393(6)	7(2)%	[**1999An36, 1981Mi12**, 1981MiZY, 1999An10, 1999An36 1974JoZU, 1974Le02, 1972Ga27]
^{187m}Pb	2.373(27)	3.361(23)	6.413(18)	12(2)%	[**2022Hu09, 1999An36, 1981Mi12**, 1981MiZY, 1999An10, 1999An36
^{191}Po	1.762(22)	1.803(16)	7.493(5)	≈100%$^{@}$	[**2002An19**, 2001Ke06, 2001Uu01, 1999An10, 1999An36, 1998DaZQ, 1997Ba25, 1993Qu03, 1988QuZZ]
^{191m}Po	1.699(33)	1.740(29)	7.556(25)	≈100%$^{@}$	[**2002An19**, 2001Ke06, 2001Uu01, 1999An10, 1999An36]
^{195}Rn	1.522(57)	1.202(54)	7.694(11)$^{@@}$	100%$^{@}$	[**2001Ke06, 2001Uu01**]
^{195m}Rn	1.440(63)	1.120(60)	7.776(28)	100%$^{@}$	[**2001Ke06, 2001Uu01**]

* Only decay channel energetically possible.
** Deduced from α energies, 5.412(9) MeV in [2021Wa16].
*** Weighted average of 0.21(4)% [1980Sc09] and 0.27(4)% [1970Ha18].
$^{@}$ Based on the short half-life.
$^{@@}$ Deduced from α energies, 7.694(51) MeV in [2021Wa16].

Table 3
direct α emission from ^{147}Sm, J^{π} = 7/2$^-$, $T_{1/2}$ =1.068(9) × 10^{11} y*, BR_{α} =100%.

E_{α}(c.m.)	E_{α}(lab)	, I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{143}Nd)	coincident γ-rays	R_0 (fm)	HF
2.298(3)	2.235(3)**	100%	7/2$^-$	0.0	—–	1.5895(97)	$1.42^{+0.32}_{-0.26}$

* Weighted average of 1.065(10) × 10^{11} y [2010Su30] and 1.070(9) × 10^{11} y [2009Ko15].
** Taken from [1999Ry01], based on weighted average 2.233(5) MeV [1970Gu14] (adjusted to 2.238(5) MeV), 2.31(5) [1966Ma05] (adjusted to 2.234(5) MeV), and 2.231(10) MeV [1962Si14] (adjusted to 2.230(10) MeV).

Table 4
direct α emission from ^{151}Gd*, J^{π} = 7/2$^-$, $T_{1/2}$ = 123.9(10) d, BR_{α} =8^{+8}_{-4}×10^{-7}%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{147}Sm)	coincident γ-rays	R_0 (fm)	HF
2.670(30)	2.600(30)	$0.8^{+0.8}_{-0.4}$%	7/2$^-$	0.0	—–	1.5745(66)	$0.7^{+0.9}_{-04}$

* All values from [1965Si06].

Table 5
direct α emission from ^{179}Pt*, J^{π} = 1/2$^-$, $T_{1/2}$ =21.2(4) s**, BR_{α} =0.24(4)%***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{175}Os)[@]	coincident γ-rays[@]	R_0 (fm)	HF
5.233(15)	5.116(15)	27.6(16)%	0.052(9)%		0.1756(2)	0.073, 0.102, 0.176	1.5588(47)	$0.80^{+0.22}_{-0.16}$
5.307(7)	5.188(7)	100.0(15)%	0.188(31)%	(5/2$^-$)	0.0	—–	1.5588(47)	$1.8^{+0.5}_{-0.4}$

* All values from [2021Ha32], except where noted.
** [19993Me13, 1993MeZW].
*** Weighted average of 0.21(4)% [1980Sc09] and 0.27(4)% [1970Ha18].
[@] [2004Ba89].

Table 6
direct α emission from ^{183}Hg*, J^{π} = 1./2$^-$,$T_{1/2}$ =8.9(2) s, BR_{α} =23.7(7)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)***	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{179}Pt)[@]	coincident γ-rays[@]	R_0 (fm)	HF
5.797(10)	5.670(10)**	≈0.28%	≈0.06%	7/2$^-$	0.241(1)	0.1528	1.5148(61)	≈24
5.950(10)	5.820(10)**	4.1(11)%	0.87(23)%	5/2$^-$	0.0874(10)	0.087	1.5148(61)	$8.1^{+3.5}_{-2.1}$
5.965(10)	5.835(10)**	5.8(22)%	1.24(47)%	3/2$^-$	0.0714(10)	0.071	1.5148(61)	7^{+5}_{-2}
6.037(5)	5.905(5)**	100(26)%	21.5(58)%	1/2$^-$	0.0	—–	1.5148(61)	$0.78^{+0.32}_{-0.20}$

* All values from [2022Hu09], except where noted.
** [1979Ha10].
*** Relative ratios taken from [1979Ha10].
[@] [2009Ba02].

Table 7
direct α emission from ^{187}Pb*, J^{π} = (3/2$^-$),$T_{1/2}$ =15.2(3) s, BR_{α} =7(2)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{183}Hg)	coincident γ-rays	R_0 (fm)	HF
6.124(10)	5.993(10)	67(7)%	4.7(14)%	(3/2$^-$)	0.275	0.067, 0.208, 0.275	1.4873(66)	$1.8^{+0.9}_{-0.5}$
6.329(10)	6.194(10)	100(7)%	7.0(21)%	3/2$^-$	0.067	0.067	1.4873(66)	9^{+4}_{-2}

* All values from [1981Mi12], except where noted.
** [1999An36].

Table 8
direct α emission from ^{187m}Pb*, Ex = 20(17) keV**, J^{π} = (13/2^{+}), $T_{1/2}$ =17.9(2) s, BR_{α} =12(2)%***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{183}Hg)$^{@}$	coincident γ-rays$^{@}$	R_0 (fm)	HF
6.213(4)	6.080(4)	12(2)%	(13/2^{-})	0.204(14)		1.4873(66)	$1.2^{+0.3}_{-0.2}$

* All values from [2022Hu09], except where noted.
** Deduced from α and γ energies [2022Hu09, 1981Mi12] of the two isomers
*** [1999An36].

Table 9
direct α emission from ^{191}Po*, J^{π} = ,$T_{1/2}$ =22(2) ms, BR_{α} =≈100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	J^{π}_{f}, I_{α}(abs)	$E_{daughter}$(^{187}Pb)	coincident γ-rays	R_0 (fm)	HF	
7.115(10)	6.966(10)	8.7(25)%	8.0(23)%	(3/2^{-})	0.375(1)	0.375(1)	1.5126(20)	$1.6^{+0.9}_{-0.5}$
7.491(5)	7.334(5)**	100(3)%	92(3)%**	(13/2^{+})	0.0	—	1.5126(20)	2.4(3)

* All values from [2002An16], except where noted.
** [2002An16] list two α transitions with nearly identical energies (7.334(5) and 7.336(15) MeV), with the former feeding the ground state and the latter as a crossover between the (3/2^{-}) ^{191}Po ground state feeding a state at 2(15) keV in the (13/2^{+}) ^{187}Pb ground state. A more recent work [2022Hu09] establishes the (13/2^{+}) ^{187}Pb state as an isomer. The 7.336(15) is taken from a background subtracted α_1 - α_2 coincidence spectrum (Fig. 5 in [2002An16]) with a 6.070 MeV α from the decay of ^{187m}Pb. Note that there may be a small peak at ≈ 6.97 MeV in this spectrum. The observed peak at 7.336 MeV may be due to random correlations of the large 7.334 MeV peak (see Fig 1 [2002An16]). This evaluation treats them as one peak at 7.334(5) MeV and an intensity equal to the sum.

Table 10
direct α emission from ^{191m}Po*, Ex = 63(24)** keV, J^{π} = ,$T_{1/2}$ =93(3) ms, BR_{α} =≈100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{187}Pb)	coincident γ-rays	R_0 (fm)	HF
6.935(15)	6.790(15)***	1.1(6)%	0.5(3)%7		0.657(24)	0.594(1)	1.5126(20)	30^{+40}_{-10}
6.961(15)	6.815(15)	21(4)%	10(2)%	(9/2^{+})	0.636(28)		1.5126(20)	$1.6^{+0.8}_{-0.5}$
7.035(5)	6.888(5)	80(17)%	38(8)%	(13/2^{+})	0.557(24)	0.494(2)	1.5126(20)	$0.8^{+0.4}_{-0.3}$
7.057(15)	6.909(15)	8.2(23)%	3.9(11)%	(9/2^{+})	0.535(24)	0.472(1)	1.5126(20)	9^{+5}_{-3}
7.534(15)	7.376(15)	100.0(5)%	47.6(15)%	(13/2^{+})	0.063(24)		1.5126(20)	27^{+8}_{-7}

* All values from [2002An16], except where noted.
** Deduced from α energies [2002An16] and excitation energy of ^{187m}Pb. See table 8 for more detail.
*** Labeled as tentative [2002An16].

Table 11
direct α emission from ^{195}Rn*, J^{π} = *3/2^{-}), $T_{1/2}$ =6^{+3}_{-2} ms, BR_{α} =100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{191}Po)	coincident γ-rays	R_0 (fm)	HF
7.694(11)	7.536(11)	100%	(3/2^{-})	0.0	—	1.588(13)	$3.2^{+1.5}_{-1.4}$

* All values from [2001Ke06, 2001Uu01].

Table 12
direct α emission from ^{195m}Rn*, Ex. = 82(26) keV**, J^{π} = (13/2^{+}),$T_{1/2}$ =5^{+3}_{-2} ms, BR_{α} =100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{191}Po)	coincident γ-rays	R_0 (fm)	HF
7.713(11)	7.555(11)	100%	(13/2^{+})	0.063(24)		1.588(13)	$3.6^{+1.8}_{-1.6}$

* All values from [2001Ke06, 2001Uu01], except where noted.
** Deduced from α energies [2001Ke06] and excitation energy of ^{191m}Po.

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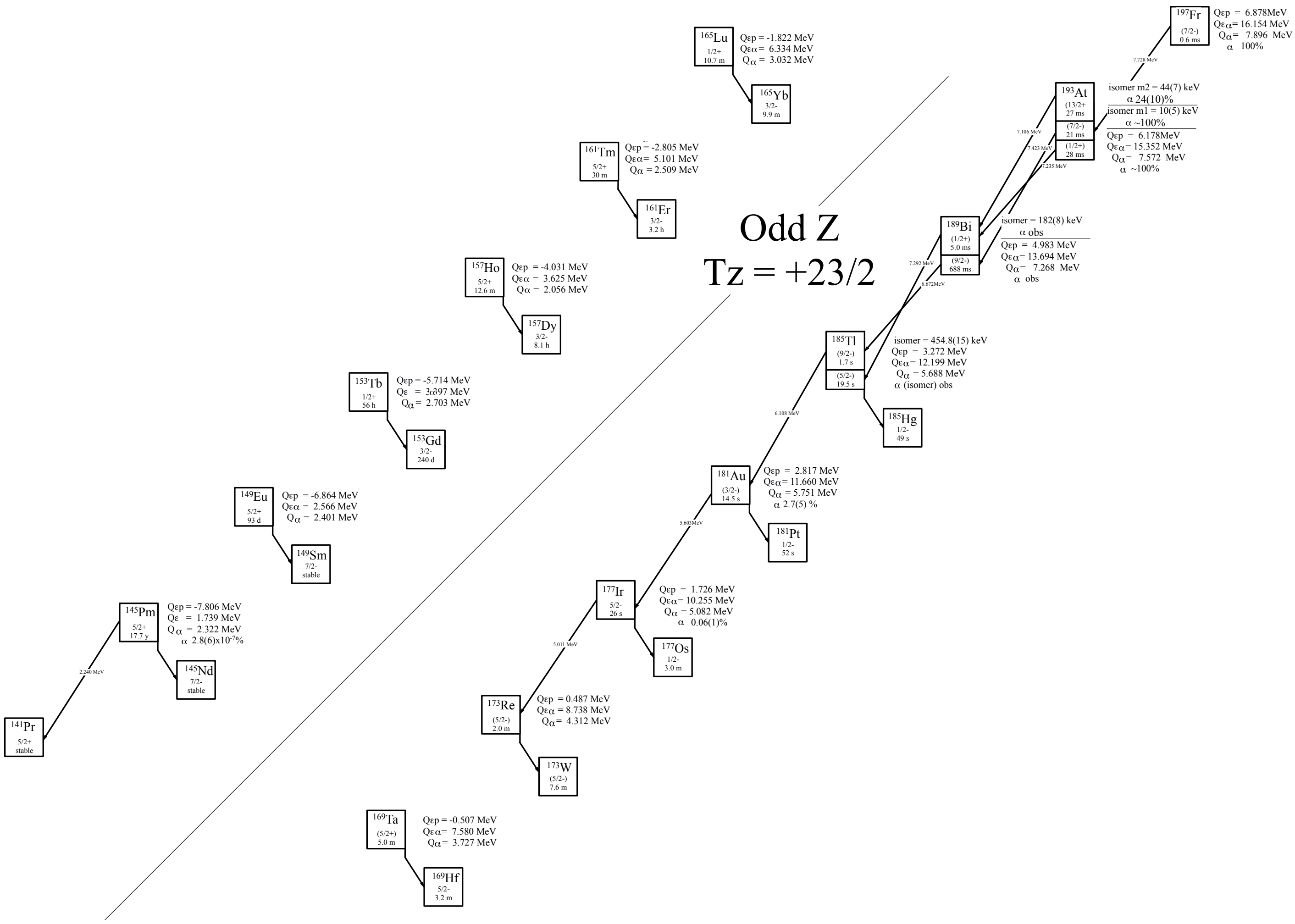

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +23/2 nuclei.

Last updated 4/27/23

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +23/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J^{π} values for ^{145}Pm are taken from ENSDF

Nuclide	Ex	J^{π}	$T_{1/2}$	Q_{ε}	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{145}Pm		5/2^{+}	17.7(4) y	0.165(3)	-7.806(3)	1.739(3)	[**1959Br65**]
^{149}Eu		5/2^{+}	93.1(4) d	0.695(4)	-6.864(7)	2.566(4)	[**1970Ch09**]
^{153}Tb		5/2^{+}	56.2(2) h	1.569(4)	-5.714(4)	3.397(4)	[**1970Ch09**]
^{157}Ho		7/2^{+}	12.6(2) m	2.592(24)	-4.031(24)	3.625(23)	[**1972To05**]
^{161}Tm		7/2^{+}	30.2(8) m	3.303(29)	-2.805(32)	5.101(28)	[**1993Al02**]
^{165}Lu		1/2^{+}	10.74(10) m	3.850(40)	-1.822(36)	6.334(28)	[**1982Ra19**]
^{169}Ta		(5/2^{+})	5.0(5) m	4.430(40)	-0.507(47)	7.580(39)	[**1969Ar22**]
^{173}Re		(5/2^{-})	1.98(26) m	5.170(40)	0.487(40)	8.738(40)	[**1986Sz05**]
^{177}Ir		5/2^{-}	26(2) s*	5.909(25)	1.726(34)	10.255(34)	[**1990Bo19, 1967Si02**]
^{181}Au		(3/2^{-})	14.5(4) s	6.510(24)	2.817(29)	11.660(25)	[**1995Bi01**]
^{185}Tl		(1/2^{+})	19.5(5) s	6.426(25)	3.272(30)	12.199(25)	[**1991BoZV**]
^{185m}Tl	0.4548(15)	(9/2^{-})	1.7(2) s	6.881(25)	3.727(30)	12.654(25)	[**1980ToZZ, 1976To06, 1977Si03**]
^{189}Bi		(9/2^{-})	688(3) ms	7.779(25)	4.983(36)	13.694(25)	[**2007DoZW**]
^{189m}Bi	0.182(8)	(1/2^{+})	5.0(1) ms	7.961(26)	5.165(37)	13.876(26)	[**2007DoZW**]
^{193}At		(1/2^{+})	28^{+5}_{-4} ms	8.258(26)	6.178(37)	15.352(26)	[**2003Ke08**]
^{193m1}At	0.010(5)**	(7/2^{-})	21(5) ms	8.268(26)	6.188(37)	15.362(26)	[**2003Ke08**]
^{193m2}At	0.044(7)**	(13/2^{+})	27^{+4}_{-3} ms	8.302(27)	6.222(38)	15.396(27)	[**2003Ke08**]
^{197}Fr		(7/2^{-})	$0.6^{+3.0}_{-0.3}$ ms	8.740(60)	6.878(64)	16.154(58)	[**2013Ka16**]

* Weighted average of 30(2) s [1990Bo19] and 26(2) s [1967Si02].
** Deduced from α energies.

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +23/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_{α}	BR_{α}	Experimental
^{145}Pm	4.808(3)	12.777(3)	2.322(3)	2.8(6)×10^{-7}%	[**1962Nu01**]
^{149}Eu	4.394(4)	11.977(4)	2.401(5)		
^{153}Tb	3.895(4)	11.238(4)	2.703(5)		
^{157}Ho	3.592(23)	10.160(25)	2.056(24)		
^{161}Tm	3.124(37)	9.147(28)	2.509(36)		
^{165}Lu	2.719(31)	8.292(27)	3.032(39)		
^{169}Ta	2.219(40)	7.342(47)	3.727(39)		
^{173}Re	1.746(40)	6.412(40)	4.312(40)		
^{177}Ir	1.205(23)	5.337(34)	5.082(34)	0.06(1)%	[**1990Bo19, 1967Si02**, 1986Ke03]
^{181}Au	0.730(22)	4.367(22)	5.751(3)	2.7(5)%	[**1995Bi01**, 1993BiZY, 1992BiZZ, 1990SaZU, 1984BrZR, 1984ScZQ, 1979Ha10, 1970Ha18, 1968De01, 1968Si01, 1965Si07]
^{185}Tl	0.702(23)	4.144(23)	5.688(5)		
^{185m}Tl	0.247(23)	43.689(23)	6.143(5)	obs	[**1980ToZZ, 1976To06**, 1992BlZW, 1991BoZV, 1980Sc09, 1977ToZS, 1976BoYC]
^{189}Bi	-0.457(23)	2.198(22)	7.268(3)	obs	[**1997Wa05, 2007DoZW**, 2001An11, 2000Sc46, 1998Kr23, 1997An09, 1995Ba75, 1995BaZP, 1993An19, 1985Co06, 1984ScZQ, 1978Va21, 1974Le02, 1973Ga08, 1973LiYK]
^{189m}Bi	-0.639(24)	2.016(23)	7.450(9)	83(5)%	[**1997Wa05, 2007DoZW, 1983Ke08**, 2001An11, 2000Sc46, 1998Kr23, 1997An09, 1995Ba75, 1995BaZP, 1993An19, 1985Co06, 1984ScZQ]
^{193}At	-0.710(24)	1.406(23)	7.572(7)	≈100%*	[**2003Ke08**]
^{193m1}At	-0.720(24)	1.396(23)	7.582(9)	≈100%*	[**2003Ke08**, 1995Le15]
^{193m2}At	-0.754(25)	1.362(24)	7.616(10)	24(10)%	[**2003Ke08**]
^{197}Fr	-0.990(58)	0.854(57)	7.888(15)**	100%*	[**2013Ka16**]

* Based on short half-life.
** Deduced from α energy, 7.896(53) in [2021Wa16].

Table 3
direct α emission from ^{145}Pm*, J^{π} = 5/2^{+},$T_{1/2}$ =17.7(4) y**, BR_{α} =2.8(6)×10^{-7}%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{141}Pr)	coincident γ-rays	R_0 (fm)	HF
2.304(40)	2.240(40)	100%	5/2^{+}	0.0	—–	1.5958(78)	$1.3^{+0.5}_{-0.3}$

* All values from [1962Nu01], except where noted.
** [1959Br65].

Table 4
direct α emission from ^{177}Ir, J^{π} = 5/2^{-}, $T_{1/2}$ =26(2) s*, BR_{α} =0.06(1)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{181}Au)	coincident γ-rays	R_0 (fm)	HF
5.126(10)	5.011(10)	100%	(5/2^{-})	0.0	—–			

* Weighted average of 30(2) s [1990Bo19] and 26(2) s [1967Si02].
** [1990Bo19].
*** [1067Si02].

Table 5
direct α emission from ^{181}Au*, J^{π} = (3/2^{-}),$T_{1/2}$ =14.5(4) s, BR_{α} =2.7(5)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{177}Ir)	coincident γ-rays	R_0 (fm)	HF
5.313(10)	5.196(10)	0.2 (1)%	2.4(13)×10^{-3}%		0.435		1.5322(52)	21^{+21}_{-8}
5.360(10)	5.242(10)	≈0.1%	≈1.2×10^{-3}%		0.390		1.5322(52)	≈ 80
5.421(5)	5.301(5)	0.6(1)%	7.1(18)×10^{-3}%		0.332		1.5322(52)	24^{+9}_{-6}
5.485(5)	5.364(5)	9(1)%	0.11(2)%		0.2659	0.0856, 0.1802, 0.2659	1.5322(52)	$3.3^{+1.1}_{-0.7}$
5.529(5)	5.407(5)	6(1)%	0.071(18)%	7/2^{-}	0.2231	0.052, 0.054, 0.0624, 0.0751, 0.0856, 0.0968, 0.1178, 0.1480, 0.1778, 0.2231	1.5322(52)	$8.0^{+3.0}_{-1.9}$
5.603(5)	5.479(5)	100(1)%	1.2(2)%	3/2^{-}	0.1480	0.052, 0.0624, 0.0.0856, 0.0968, 0.148	1.5322(52)	$1.1^{+0.3}_{-0.2}$
5.670(5)	5.545(5)	7(1)%	0.083(19)%	1/2^{-}	0.0856	0.0856	1.5322(52)	30^{+10}_{-7}
5.707(5)	5.581(5)	7(1)%	0.083(19)%		0.0453		1.5322(52)	45^{+16}_{-11}
5.753(5)	5.626(5)	98(1)%	1.2(2)%	5/2^{+}	0.0	—–	1.5322(52)	$5.2^{+1.5}_{-1.1}$

* All values from [1995Br01].

Table 6
direct α emission from ^{185m}Tl*, Ex = 454.8(15) keV**, J^{π} = (9/2^{-}), $T_{1/2}$ =14.5(4) s, BR_{α} =obs.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{177}Ir)	coincident γ-rays	R_0 (fm)	HF
6.108(5)	5.976(5)	100(6)%						
6.143(5)	6.010(5)	19(6)%						

* All values from [1976To09, 1980ToZZ], except where noted.
** [1977Si03].

Table 7
direct α emission from ^{189}Bi*, J^{π} = (9/2$^-$), $T_{1/2}$ = 688(5)s**, BR_{α} =obs***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{185}Tl)[@]	coincident γ-rays[@]	R_0 (fm)	HF
6.692(15)	6.55(15)	1.3(9)%	1.2(9)%	(11/2$^-$)	0.576(8)	1.5000(29)	1.5000(29)	19^{+57}_{-8}
6.816(5)	6.672(5)	100(2)%	95(2)%	(9/2$^-$)	0.4548(15)	0.169, 0.286	1.5000(29)	0.67(6)
6.981(7)	6.833(7)	1.4(6)%	1.3(6)%	(3/2$^+$)	0.286(1)	0.286	1.5000(29)	200^{+170}_{-60}
7.268(6)	7.114(6)	3.3(6)%	3.1(7)%	(1/2$^+$)	0.0	—	1.5000(29)	760^{+240}_{-160}

* All values from [1997Wa05], except where noted.
** [2007DoZW].
*** Assumed to be 100% in [1997Wa05]. This value is used in this table for I_{α}(abs) and HF.
[@] [2005Wu07].

Table 8
direct α emission from ^{189m}Bi*, Ex = 182(8) keV, J^{π} = (1/2$^+$), $T_{1/2}$ = 5.0(1)ms**, BR_{α} =obs***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{185}Tl)	coincident γ-rays	R_0 (fm)	HF
7.268(7)	7.114(7)	14(6)%	10(3)%		0.182(7)		1.5000(29)	$1.7^{+0.7}_{-0.4}$
7.450(6)	7.292(6)	100(3)%	73(5)%	(1/2$^+$)	0.0	—	1.5000(29)	0.90(9)

* All values from [1997Wa05], except where noted.
** [2007DoZW].

Table 9
direct α emission from ^{193}At*, J^{π} = (1/2$^+$),$T_{1/2}$ =28^{+5}_{-4} ms, BR_{α} =100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{189}Bi)	coincident γ-rays	R_0 (fm)	HF	
7.388(5)	7.235(5)	100%	(1/2$^+$)		0.182(8)		1.5519(62)	1.29(31)

* All values from [2003Ke08].

Table 10
direct α emission from ^{193m1}At*, Ex = 10(5) keV, J^{π} = (7/2$^-$), $T_{1/2}$ =21(5) ms, BR_{α} =100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{189}Bi)	coincident γ-rays	R_0 (fm)	HF
7.480(5)	7.325(5)	2(2)%	2(2)%	(7/2$^-$)	0.0946(5)		1.5519(62)	≈100
7.580(5)	7.423(5)	100%	98(2)%	(9/2$^-$)	0.0	—	1.5519(62)	4.1(11)

* All values from [2003Ke08].

Table 11
direct α emission from ^{193m2}At*, Ex = 44(7) keV, J^{π} = (13/2$^+$), $T_{1/2}$ =27^{+4}_{-3} ms, BR_{α} =24(10)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{189}Bi)	coincident γ-rays	R_0 (fm)	HF
7.256(5)	7.106(5)	24(10)%	(13/2$^+$)	0.357.6(5)		1.5519(62)	$2.0^{+1.9}_{-0.8}$

* All values from [2003Ke08].

Table 12
direct α emission from ^{197}Fr*, J^{π} = (7/2$^-$), $T_{1/2}$ =0.6^{+30}_{-3} ms, BR_{α} =100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{193}At)	coincident γ-rays	R_0 (fm)	HF
7.888(15)	7.728(15)	100%	(7/2$^-$)	0.010(5)		1.603(20)	0.53(27)

* All values from [2013Ka16].

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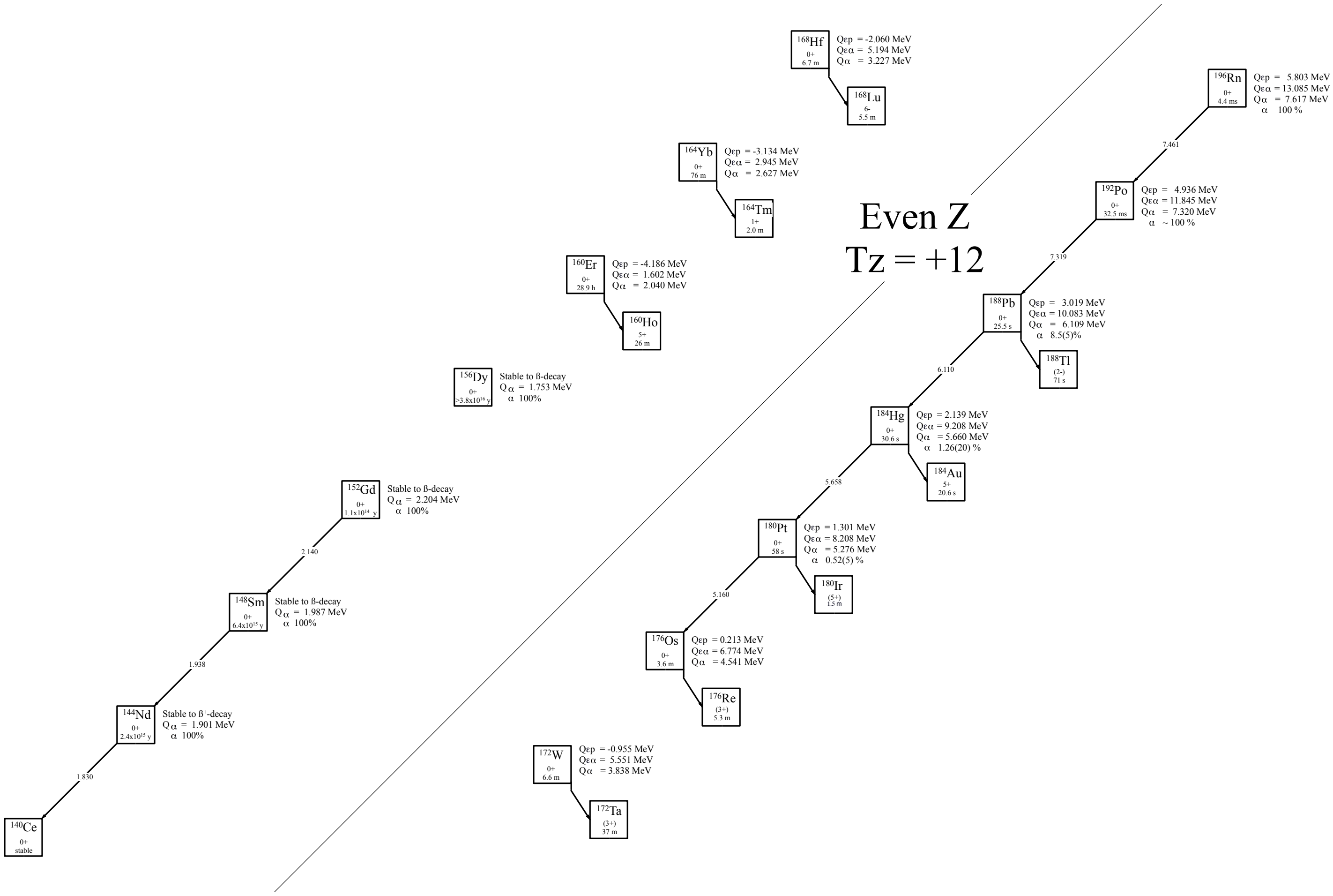

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +12 nuclei.

Last updated 5/10/23

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +12 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q$_\varepsilon$	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{144}Nd	0$^+$	2.4(2)×10^{15} y*	-2.332(3)	—–	—–	[**1961Ma05, 1987Al28, 1965Is01**]
^{148}Sm	0$^+$	$6.4^{+1.2}_{-1.3}\times10^{15}$ y	stable	—–	—–	[**2016Ca43**]
^{152}Gd	0$^+$	1.08(8)×10^{14} y	stable	—–	—–	[**1961Ma05**]
^{156}Dy	0$^+$	≥3.8×10^{16} y	stable	—–	—–	[**2011Be18**]
^{160}Er	0$^+$	28.58(9) h	0.318(29)	-4.186(24)	1.602(25)	[**1970Ka23**]
^{164}Yb	0$^+$	75.8(17) m	0.897(29)	-3.134(16)	2.945(21)	[**1972Ch23**]
^{168}Hf	0$^+$	25.92(20) m	1.710(50)	-2.060(28)	4.123(37)	[**1970Ch17**]
^{172}W	0$^+$	6.6(9) m	2.230(40)	-0.955(40)	5.551(47)	[**1990Me12**]
^{176}Os	0$^+$	3.6(5) m	2.930(30)	0.213(30)	6.774(30)	[**1970Ar15**]
^{180}Pt	0$^+$	58(3) s**	3.548(24)	1.301(18)	8.208(30)	[**1993Me13, 2020Cu02**]
^{184}Hg	0$^+$	30.6(3) s	3.974(24)	2.139(17)	9.208(24)	[**1972Fi12**]
^{188}Pb	0$^+$	25.5(1) s	4.530(30)	3.019(16)	10.083(24)	[**1993Wa03**]
^{192}Po	0$^+$	32.5(10) ms***	5.470(30)	4.936(13)	11.845(32)	[**1996Bi17, 2003Va16**]
^{196}Rn	0$^+$	$4.4^{+1.3}_{-0.9}$ ms	5.890(30)	5.803(15)	13.085(33)	[**2001Ke06**]

* Weighted average of 2.4(3)×10^{15} y [1961Ma05], 2.65(37)×10^{15} y [1987Al28] and 2.1(4)×10^{15} y [1965Is01].
** Weighted average of 60(3) s [1993Me13] and 56(3) s [2020Cu02].
*** Weighted average of 33.2(14) ms [1996Bi17] and 31.8(15) ms [2003Va16].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the even-Z, T_z = +12 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_p$	S$_{2p}$	Q$_\alpha$	BR$_\alpha$	Experimental
^{144}Nd	7.969(1)	13.793(2)	1.901(1)	100%	[**1965Is01**, 1961Br43, 1987Al28, 1961Ma05, 1956Po16, 1954Wa05]
^{148}Sm	7.583(0)	12.988(1)	1.987(1)	100%*	[**2016Ca43**, 1970Gu14, 1968Ko06, 1961Ma05, 1960Ka23]
^{152}Gd	7.343(1)	12.234(1)	2.204(1)	100%*	[**1961Ma05**, 1966Ka23, 1959Ri34, 1956Po16]
^{156}Dy	6.568(10)	11.401(18)	1.7530(3)		
^{160}Er	6.024(24)	10.235(24)	2.040(24)		
^{164}Yb	5.573(16)	9.256(15)	2.627(29)		
^{168}Hf	5.123(47)	8.345(29)	3.227(32)		
^{172}W	4.666(40)	7.421(40)	3.838(40)		
^{176}Os	4.132(30)	6.482(30)	4.541(30)		
^{180}Pt	3.637(14)	5.464(17)	5.276(5)	0.52(5)%	[**2020Cu02, 1993Me12**, 1968De01, 1966Si08]
^{184}Hg	3.442(13)	4.754(16)	5.660(4)	1.26(20)%	[**1994Wa23, 1970Ha18**, 1990Sc09, 1976To06, 1976WoZJ, 1972Fi12, 1970FiZZ, 1970HoZT, 1969NaZT, 1969NaZU]
^{188}Pb	2.655(13)	3.850(15)	6.109(3)	8.5(5)%**	[**1993Wa03, 1999An22, 2003Va16**, 1994Wa13, 1993WaZI, 1992Wa14, 1984To09, 1981To02, 1980ElZY, 1980Sc09, 1977De32, 1974JoZU, 1974Le02, 1973Ho01, 1973LiYK, 1972Ga27]
^{192}Po	2.116(13)	2.228(16)	7.320(3)	≈100%	[**2003Va16, 1998Al27**, 2005Uu03, 2004An23, 2003Wa05, 2002VaZZ, 2001Hu21, 2001Ju09, 2001Ke06, 2001Uu01, 1999An22, 1999Pa20, 1997Pu01, 1993Wa04, 1982LeZN, 1981Le23, 1981LeZU, 1977De32, 1977DeXF]
^{196}Rn	1.844(17)	1.598(19)	7.617(9)	100%***	[**2001Ke06**, 2001Uu01, 1997Pu01, 1996PuZZ, 1995Mo14, 1995NoZW]

* Only decay mode energetically possible.
** Weighted average of 9.3(8)% [1999An22] and 8.0(6)% [2003Va16].
*** Based on short half-life.

Table 3
direct α emission from ^{144}Nd, $J^{\pi} = 0^{+}$, $T_{1/2} = 2.4(2)\times10^{15}$ y*, BR_{α} =100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{140}Ce)	coincident γ-rays	R_0 (fm)	HF
1.882(20)	1.830(20)**	100%**	0^{+}	0.0	—	1.5986(81)	0.41(3)***

* Weighted average of $2.4(3)\times10^{15}$ y [1961Ma05], $2.65(37)\times10^{15}$ y [1987Al28] and $2.1(4)\times10^{15}$ y [1965Is01].
** [1965Is01].
*** The reason for this low value is unclear.

Table 4
direct α emission from ^{148}Sm*, $J^{\pi} = 0^{+}$, $T_{1/2}$= $6.4^{+1.2}_{-1.3}\times10^{15}$ y, BR_{α} =100%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{144}Nd)	coincident γ-rays	R_0 (fm)	HF
1.9873(5)	1.9376(5)	100%**	0^{+}	0.0	—	1.586(12)	1.02(1)

* All values from [2016Ca43].
** Only decay mode energetically possible.

Table 5
direct α emission from ^{152}Gd*, $J^{\pi} = 0^{+}$, $T_{1/2}$= $1.08(8)\times10^{14}$ y, BR_{α} =100%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{148}Sm)	coincident γ-rays	R_0 (fm)	HF
2.198(30)	2.140(30)	100%**	0^{+}	0.0	—	1.5741(45)	0.81(7)

* All values from [1961Ma05].
** Only decay mode energetically possible.

Table 6
direct α emission from ^{180}Pt*, $J^{\pi} = 0^{+}$, $T_{1/2}$= 58(3) s**, BR_{α} = 0.52(5)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{176}Os)	coincident γ-rays	R_0 (fm)	HF
5.277(5)	5.160(5)	0.52(5)%	0^{+}	0.0	—	1.5468(62)	1.01(11)

* All values from [2020Cu05], except where noted.
** Weighted average of 60(3) s [1993Me13] and 56(3) s [2020Cu02].

Table 7
direct α emission from ^{184}Hg, $J^{\pi} = 0^{+}$, $T_{1/2}$= 30.6(3) s*, BR_{α} = 1.26(20)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{180}Pt)	coincident γ-rays	R_0 (fm)	HF
5.167(15)	5.055(15)***	0.17(1)%@	0.0021(6)%	0^{+}	0.478	0.153	1.5120(81)	2.4(2)***
5.500(15)	5.380(15)**	0.40(8)%	0.005(1)%**	2^{+}	0.153	0.153	1.5120(81)	44^{+16}_{-9}
5.658(15)	5.535(15)**	100%	1.25(20)%**	0^{+}	0.0	—	1.5120(81)	$0.88^{+0.16}_{-0.13}$

* [1972Fi12].
** [1970Ha18].
*** [1994Wa23].
@ [1994Wa23] reports a HF of 2.4(2) for this transition which corresponds to a branching ratio of 0.17(1)% relative to the 5.525-MeV transition.

Table 8
direct α emission from ^{188}Pb*, J^{π} = 0^{+}, $T_{1/2}$= 25.5(1) s, BR_{α} = 8.5(5)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{184}Hg)	coincident γ-rays	R_0 (fm)	HF
5.736(10)	5.614(10)	0.10(1)%***	8.5(13)$\times10^{-3}$%	0^{+}	0.375	0.375	1.4885(12)	21(3)***
5.755(10)	5.633(10)	0.07(1)%***	4.8(11)$\times10^{-3}$%	2^{+}	0.367	0.367	1.4885(12)	34(7)***
6.110(10)	5.980(10)	100%	9.3(8)%	0^{+}	0.0	—	1.4885(12)	1.00(8)

* All values taken from [1993Wa03], except where noted.
** Weighted average of 9.3(8)% [1999An22] and 8.0(6)% [2003Va16].
*** The relative branching ratios are derived from the HF given by [1993Wa03].

Table 9
direct α emission from ^{192}Po, J^{π} = 0^{+}, $T_{1/2}$= 32.5(10) ms*, BR_{α} = ≈100%.

E_{α}(c.m.)	E_{α}(lab)@	I_{α}(rel)**	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{188}Pb)	coincident γ-rays	R_0 (fm)	HF
≈6.594	≈6.457**	≤0.005%	≤0.005%	0^{+}	0.725		1.51737(13)	≥ 51
6.741(7)	6.601(7)***	1.4(1)%	1.4(1)%	0^{+}	0.578		1.51737(13)	0.66(7)
7.319(4)	7.167(4)**	100.0(2)%	98.6(2)%	0^{+}	0.0	—	1.51737(13)	0.997(13)

* Weighted average of 33.2(14) ms [1996Bi17] and 31.8(15) ms [2003Va16].
** [2003Va16].
*** Weighted average of 6.611(7) MeV [1998Al27] and 6.591(7) [2003Va16].
@ In addition, [1998Al27] report a transition with E_{α} = 6.416(13) MeV. However, this was not observed in [2003Va16] and may have been the 6.420(20) MeV transition from the fine structure in the α-decay of ^{193}Po [2002Va13].

Table 10
direct α emission from ^{196}Rn*, J^{π} = 0^{+}, $T_{1/2}$= $4.4^{+1.3}_{-0.9}$ ms, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{192}Po)	coincident γ-rays	R_0 (fm)	HF
7.616(9)	7.461(9)	100%	0^{+}	0.0	—	1.585(15)	1.00(30)

* All values from [2001Ke06].

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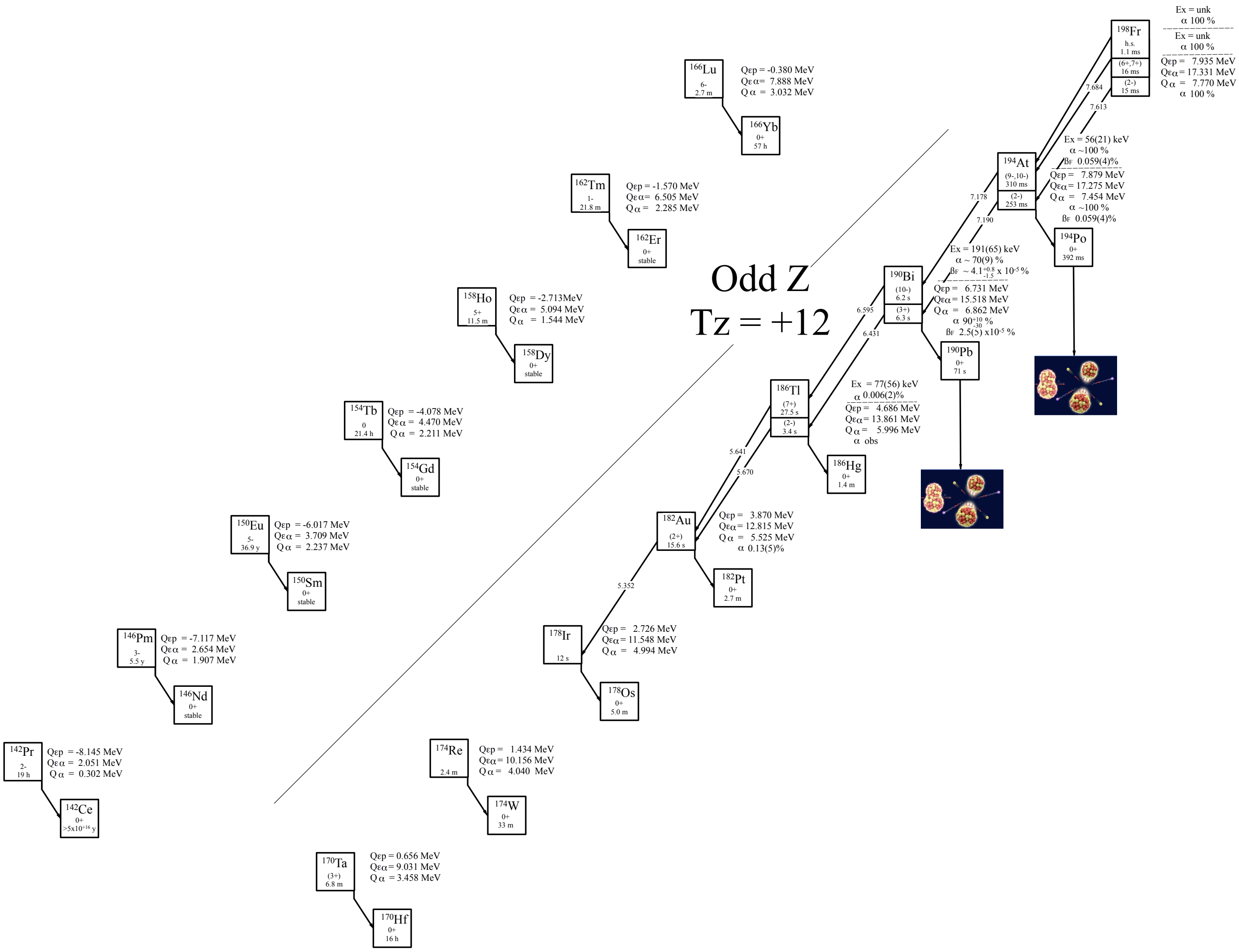

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +1/2 nuclei.

Last updated 5/8/23

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +12 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J$^\pi$ values for ^{142}Pr, ^{146}Pm, ^{150}Eu, ^{154}Tb, ^{158}Ho, ^{162}Tm, ^{166}Lu, ^{170}Ta, ^{174}Re, ^{178}Ir and ^{182}Au are taken from ENSDF.

Nuclide	Ex	J^π	$T_{1/2}$	Q$_\varepsilon$	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	BR$_{\beta F}$	Experimental
^{142}Pr		2$^-$	19.12(4) h*	2.164(1)	-8.145(4)	2.051(2)		[**1966Ot03, 1968La17**]
^{146}Pm		3$^-$	5.53(5) y	1.542(3)	-7.117(8)	2.654(5)		[**1967Bu12**]
^{150}Eu		5$^-$	36.9(9) y	0.972(4)	-6.017(6)	3.709(6)		[**1993Th04**]
^{154}Tb		0	21.4(5) h	0.240(50)	-4.078(45)	4.470(45)		[**1973La20**]
^{158}Ho		5$^+$	11.5(5) m	4.220(27)	-2.713(27)	5.094(27)		[**1962Sc10**]
^{162}Tm		1$^-$	21.77(26) m	4.857(26)	-1.570(26)	6.505(26)		[**1971Ch30**]
^{166}Lu		6$^-$	2.65(10) m	5.570(30)	-0.380(30)	7.888(30)		[**1974De09**]
^{170}Ta		(3$^+$)	6.76(6(m	6.120(40)	0.656(28)	9.031(29)		[**1976Le04**]
^{174}Re			2.40(15) m	6.550(40)	1.434(40)	10.156(40)		[**1977Ha24**]
^{178}Ir			12(2) s	7.290(23)	2.726(34)	11.548(34)		[**1973HaVR**]
^{182}Au		(2$^+$)	15.6(4) s	7.864(23)	3.870(19)	12.815(23)		[**1992Ro21**]
^{186}Tl		(2$^-$)	$3.4^{+0.5}_{-0.4}$ s	8.656(24)	4.686(21)	13.861(25)		[**2020St11**]
^{186m}Tl	0.077(56)	(7$^+$)	27.5(10) s	8.733(61)	4.763(60)	13.938(61)		[**1977Co21**]
^{190}Bi		(3$^+$)	6.3(1) s	9.821(24)	6.731(23)	15.518(24)	2.5(5) $\times$ 10^{-5}	[**2009An11, 1988Hu03**]
^{190m}Bi	0.191(65)	(10$^-$)	6.2(1) s	10.012(69)	6.922(69)	15.709(69)	$4.1^{+0.8}_{-1.5}\times 10^{-5}$	[**2009An11, 1988Hu03**]
^{194}At		(2$^-$)	253(10) ms	10.288(27)	7.879(25)	17.275(27)	0.059(4)%***	[**2014Gh09, 2009An11**, 2013An03]
^{194m}At	0.056(21)**	(9$^-$, 10$^-$)	310(8) ms	10.344(34)	7.935(33)	17.331(34)	0.059(4)%***	[**2014Gh09, 2009An11**, 2013An03]
^{198}Fr		(2$^-$)	15(3) ms	10.810(30)	8.644(32)	18.157(34)		[**2013Ka16, 2013Uu01**]
^{198m1}Fr	x	(6$^+$, 7$^+$)	16 $^{+13}_{-5}$ ms	10.810(30)+x	8.644(32)+x	18.157(34)+x		[**2013Uu01**]
^{198m2}Fr	y	h.s.	1.1(7) ms	10.810(30)+y	8.644(32)+y	18.157(34)+y		[**2013Ka16**]

* Weighted average of 19.14(5) h [1966Ot03] and 19.09(7) h [1968La17].
** Deduced from α-decay energies [2009An11].
*** value is acombination of the two isomers [2014Gh09].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +12 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_p$	S$_{2p}$	Q$_\alpha$	BR$_\alpha$	Experimental
^{142}Pr	5.644(1)	14.052(2)	0.302(2)		
^{146}Pm	5.311(4)	13.282(5)	1.907(4)		
^{150}Eu	4.945(6)	12.504(8)	2.237(7)		
^{154}Tb	4.563(45)	11.846(45)	2.211(46)		
^{158}Ho	4.052(27)	10.674(27)	1.544(53)		
^{162}Tm	3.565(27)	9.673(30)	2.285(38)		
^{166}Lu	3.015(40)	8.690(39)	3.032(40)		
^{170}Ta	2.710(40)	7.643(47)	3.458(41)		
^{174}Re	2.235(40)	6.921(40)	4.040(40)		
^{178}Ir	1.587(24)	5.769(34)	4.994(34)		
^{182}Au	1.211(23)	4.904(29)	5.525(4)	0.13(5)%	[**1995Bi01**, 1993BiZY, 1992BiZZ, 1979Ha10, 1970Ha18]
^{186}Tl	0.988(25)	4.142(30)	5.996(26)	obs	[**2020St11**]
^{186}Tl	0.911(62)	4.065(64)	6.073(63)	0.006(2)%	[**1977Co21, 1976Ij01**, 1977IjZZ, 1976ToZR, 1976To06]
^{190}Bi	0.041(25)	2.837(37)	6.862(3)	90^{+10}_{-30}%	[**2003An26, 1991Va04**, 2013Ny01, 2009An11, 2003AnZZ, 1997An09, 1993An19, 1988Hu03, 1985HuZY]
^{190m}Bi	-0.150(70)	2.646(375)	7.053(65)	70(9)%	[**2003An26, 1991Va04**, 2013Ny01, 2009An11, 2003AnZZ, 1997An09, 1993An19, 1988Hu03, 1985HuZY, 1974Le02, 1972Ga27]
^{194}At	-0.320(28)	1.760(38)	7.454(11)	$\approx$ 100%*	[**2009An11**, 2013Ka16, 2013Ny01, 2013Uu01, 1995Le15, 1984YaZY]
^{194m}At	-0.376(35)	1.648(43)	7.510(24)	$\approx$ 100%*	[**2009An11**, 2013Ka16, 2013Ny01, 2013Uu01]
^{198}Fr	-0.778(35)	1.087(43)	7.770(15)**	100%*	[**2013Ka16, 2013Uu01**]
^{198}Fr	-0.778(35)-x	1.087(43)-x	7.770(15)+x	100%*	[**2013Uu01**]
^{198}Fr	-0.778(35)-y	1.087(43)-y	7.770(15)+y	100%*	[**2013Ka16**]

* based on short half-life.
** Deduced from α energy, 7.869(20) in [2021Wa16].

Table 3
direct α emission from ^{182}Au*, J^{π} = (2^{+}), $T_{1/2}$= 15.6(4) s**, BR_{α} = 0.13(5)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{178}Ir)	coincident γ-rays	R_0 (fm)***	HF
5.402(5)	5.283(5)	10(1)%	0.009(4)%		0.123		1.529(10)	15^{+11}_{-5}
5.472(5)	5.352(5)	100(1)%	0.094(36)%	(2^{+})	0.0544	0.0544	1.529(10)	$3.3^{+2.3}_{-1.2}$
5.524(5)	5.403(5)	29(1)%	0.027(10)%		0.0	—	1.529(10)	21^{+15}_{-7}

* All values from [1995Bi01], except where noted.
** [1992Ro21].
*** Interpolated between 1.5468(62) fm ^{180}Pt and 1.5120(81) ^{184}Hg.

Table 4
direct α emission from ^{186}Tl*, J^{π} = (2^{-}), $T_{1/2}$= $3.4^{+0.5}_{-0.4}$ s, BR_{α} = obs.

E_{α}(c.m.)	E_{α}(lab)**	I_{α}(rel)	J^{π}_{f}	$E_{daughter}$(^{182}Au)	coincident γ-rays	R_0 (fm)***	HF
(5.647)	(5.526)	4.4%		0.2731	0.0253, 0.1041, 0.1294,0.1437, 0.2731	1.5002(82)	
(5.651)	(5.529)	5.3%		0.2702	0.0253, 0.1041, 0.1294,0.1408	1.5002(82)	
5.647(51)	5.670(51)	100%		0.129	0.0253, 0.1041, 0.1294	1.5002(82)	

* All values from [2020St11].
** [2020St11] report one α transition feeding a level at 129 keV in ^{182}Au. However, they report γ's in coincidence with an α multiplet from 4.550 to 6.500 MeV that arise from 273.1 and 270.2-keV levels in ^{182}Au. The intensities recorded here are based on the intensities of the coincident γ-rays.

Table 5
direct α emission from ^{186m}Tl, Ex = 77(56) keV, J^{π} = (7^{+}), $T_{1/2}$= 27.5(10) s*, BR_{α} = 0.006(2)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{182}Au)	coincident γ-rays	R_0 (fm)***	HF
5.765(10)	5.641(10)**	0.006(2)%**	2^{+}	0.0	—	1.5002(82)	160^{+90}_{-50}

* [1977Co21].
** [1976Ij01
*** Interpolated between 1.5120(81) fm ^{184}Hg and 1.4885(12) fm ^{188}Pb.

Table 6
direct α emission from ^{190}Bi*, J^{π} = (3^{+}), $T_{1/2}$= 6.3(1) s, BR_{α} = 90^{+10}_{-30}%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}***	$E_{daughter}$(^{186}Tl)	coincident γ-rays	R_0 (fm)@	HF
6.359(10)	6.225(10)	0.06(1)%	$0.054^{+0.011}_{-0.020}$%		0.507	0.213, 0.294	1.5029(12)	120^{+70}_{-9}
6.550(10)	6.412(10)	0.10(2)%	$0.09^{+0.02}_{-0.03}$%		0.314	0.314	1.5029(12)	720^{+380}_{-70}
6.569(5)	6.431(5)	100%	90^{+10}_{-30}%	(3^{+})	0.294	0.079, 0.105, 0.111	1.5029(12)	$0.90^{+0.40}_{-0.09}$
6.647(5)	6.507(5)**	0.24(8)%**	$0.22^{+0.08}_{-0.10}$%	(2^{-})	0.226	0.105, 0.111	1.5029(12)	700^{+300}_{-110}
6.753(10)	6.611(10)	2.2(3)%	$1.98^{+0.35}_{-0.71}$%	(4^{+})	0.105	0.105	1.5029(12)	200^{+100}_{-19}
6.860(10)	6.716(10)	1.5(2)%	$1.35^{+0.23}_{-0.48}$%	(2^{-})	0.0	—	1.5029(12)	710^{+390}_{-60}

* All values from[2003An26], except where noted.
** [1991Va04].
*** [2022Ba26].
@ Interpolated between 1.4885(12) fm ^{188}Pb and 1.51737(13) fm ^{192}Po.

Table 7
direct α emission from ^{190m}Bi*, J^{π} = (10^-), $T_{1/2}$= 6.2(1) s, BR_{α} = 70(9)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}***	$E_{daughter}$(^{186}Tl)	coincident γ-rays	R_0 (fm)@	HF
6.529(10)	6.392(10)	0.24(4)%	0.16(3)%		0.441	0.441	1.5029(12)	330^{+100}_{-60}
6.595(5)	6.456(5)	100%	67(9)%		0.374	0.374	1.5029(12)	$1.43^{+0.25}_{-0.19}$
6.611(10)	6.472(10)	0.41(7)%	0.28(6)%		0.356	0.895, 0.267, 0.385	1.5029(12)	410^{+130}_{-80}
6.687(10)	6.546(10)	0.046(8)%	0.031(7)%		0.281	0.281	1.5029(12)	$7.0^{+2.2}_{-1.4}\times10^3$
6.711(10)	6.570(10)	0.039(8)%	0.026(6)%		0.255	0.255	1.5029(12)	$1.0^{+0.4}_{-0.2}\times10^4$
6.879(10)	6.734(10)	1.5(2)%	1.01(19)%		0.0895	0.0895	1.5029(12)	$1.07^{+0.27}_{-0.18}\times10^3$
6.966(10)	6.819(10)	2.0(3)%	1.34(27)%		0.0	—	1.5029(12)	$1.7^{+0.5}_{-0.3}\times10^3$

* All values from[2003An26], except where noted.
** [1991Va04].
*** [2022Ba26].
@ Interpolated between 1.4885(12) fm ^{188}Pb and 1.51737(13) fm ^{192}Po.

Table 8
direct α emission from ^{194}At*, J^{π} = (2^-), $T_{1/2}$= 253(10) ms, BR_{α} = ≈ 100%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{190}Bi)	coincident γ-rays	R_0 (fm)***	HF
7.295(15)	7.145(15)	11(4)%	9(3)%		0.168(15)	0.0465, 0.076	1.551(15)	$7^{+5}_{-3}\times10^3$
7.341(15)	7.190(15)	100(5)%	83(3)%		0.121(15)	0.076	1.551(15)	10^{+4}_{-3}
7.419(15)	7.266(15)	8(4)%	7(3)%		0.045(15)		1.551(15)	220^{+200}_{-100}
7.464(15)	7.31(15)	>1.26%	>1.0(5)%	(3^+)	0.0	—	1.551(15)	$>2.1\times10^3$

* All values from [2009An11].
** Based on short half-life.
*** Interpolated between 1.51737(13) fm ^{192}Po and 1.585(15) fm ^{196}Rn.

Table 9
direct α emission from ^{194m}At*, Ex. = 56(21) keV, J^{π} = (9^-, 10^-),$T_{1/2}$= 310(8) ms, BR_{α} = ≈ 100%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{190}Bi)	coincident γ-rays	R_0 (fm)***	HF
7.053(15)	6.908(15)	1.3(4)%	1.0(3)%		0.465	0.274	1.551(15)	110^{+70}_{-40}
7.234(15)	7.085(15)	17(3)%	13(2)%		0.288	0.097	1.551(15)	34^{+14}_{-11}
7.285(15)	7.135(15)	10(3)%	8(2)%		0.231	0.40	1.551(15)	90^{+50}_{-30}
7.329(15)	7.178(15)	100(9)%	78(5)%	(10^-)	0.191		1.551(15)	12^{+5}_{-4}

* All values from [2009An11].
** Based on short half-life.
*** Interpolated between 1.51737(13) fm ^{192}Po and 1.585(15) fm ^{196}Rn.

Table 10
direct α emission from ^{198}Fr*, J^{π} = (2^-), $T_{1/2}$= 15(3) ms, BR_{α} = ≈ 100%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{194}At)	coincident γ-rays	R_0 (fm)	HF
7.770(15)	7.613(15)***	100%	(2^-)	0.0	—		

* [2013Ka16].
** Based on short half-life.
*** From [2013Uu01]. [2013ka16] report an α transition of ≈ 7.710 MeV and an unresolved multiplet from 7.470 and 7.920 MeV.

Table 11
direct α emission from ^{198m1}Fr*, Ex. = x, J^{π} = (6^+, 7^+), $T_{1/2}$= 16 $^{+13}_{-5}$ ms, BR_{α} = 100%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{194}At)	coincident γ-rays	R_0 (fm)	HF
7.842(15)	7.684(15)	100%	(6^+, 7^+)	x'			

* All values from [2013Uu01].

** Based on short half-life.

Table 12
direct α emission from ^{198m2}Fr*, Ex. = y, J^{π} = high spin, $T_{1/2}$= 1.1(7) ms, BR_{α} = 100%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{194}At)	coincident γ-rays	R_0 (fm)	HF
7.736-8.094	7.580-7.930***	100%		y'			

* All values from [2013Ka16].
** Based on short half-life.
*** Unresolved multiplet.

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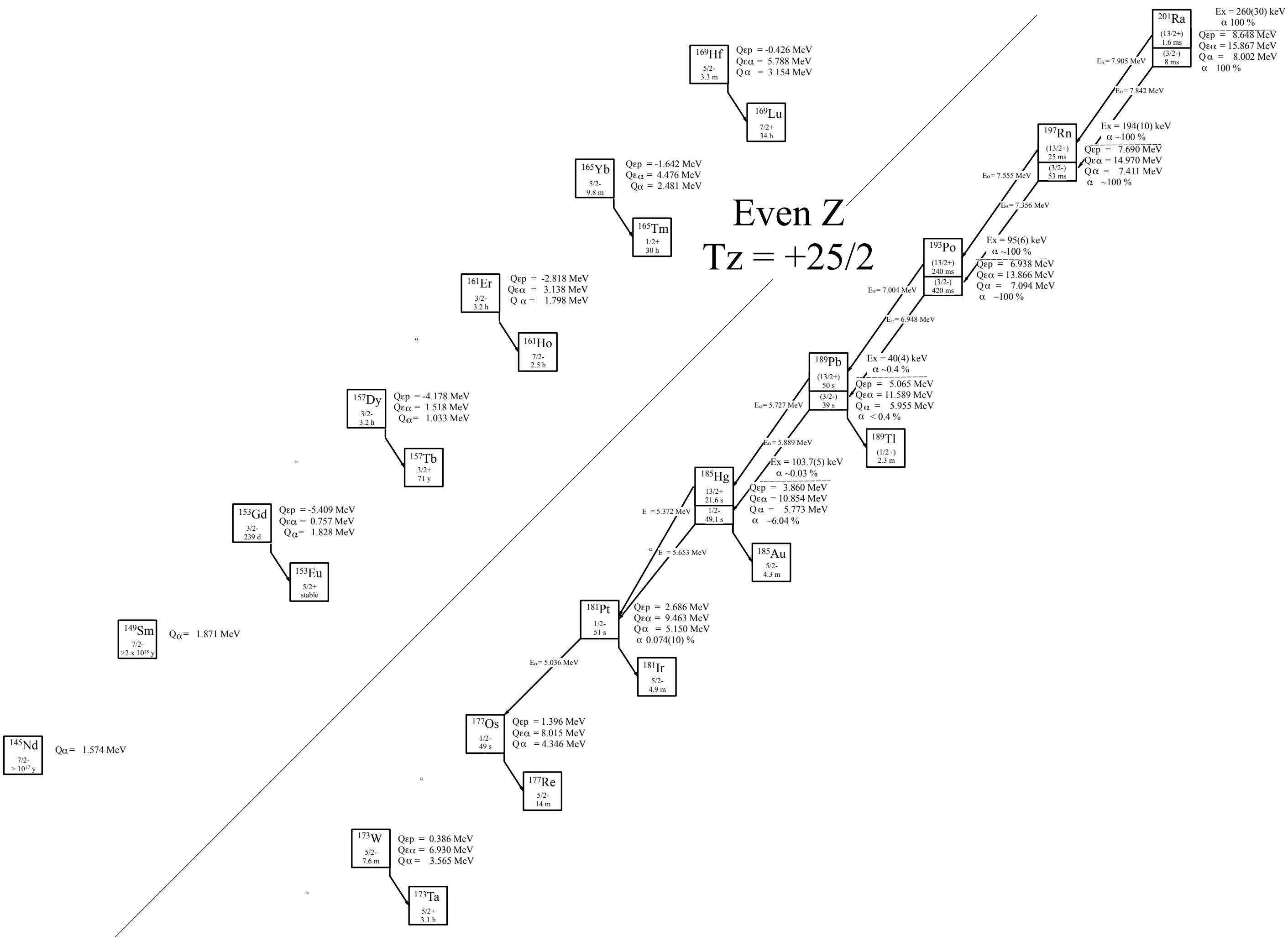

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +25/2 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +25/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{145}Nd		7/2$^-$	>10^{17} y	stable	—	—	**[1966Ka23]**
^{149}Sm		7/2$^-$	>2×10^{15} y	stable	—	—	**[1970Gu14]**
^{153}Gd		3/2$^-$	239.472(69) d	0.485(1)	-5.409(0)	0.757(2)	**[1992Un01]**
^{157}Dy		3/2$^-$	8.2(1) h	1.339(5)	-4.178(5)	1.518(5)	**[1953Ha81]**
^{161}Er		3/2$^-$	3.24(4) h	1.995(9)	-2.818(9)	3.138(9)	**[1972Wo08]**
^{165}Yb		5/2$^-$	9.8(5) m*	2.635(27)	-1.642(27)	4.476(27)	**[1968Ta05, 1967Pa04]**
^{169}Hf		5/2$^-$	3.26(5) m	3.366(28)	-0.426(28)	5.788(28)	**[1970Ch17]**
^{173}W		5/2$^-$	7.6(1) m	3.670(40)	0.386(37)	6.930(28)	**[1991KuZN]**
^{177}Os		1/2$^-$	3.1(2) m	4.310(30)	1.396(32)	8.015(32)	**[1972Be89]**
^{181}Pt		1/2$^-$	51(5) s	5.082(15)	2.686(21)	9.463(31)	**[1966Si08]**
^{185}Hg		1/2$^-$	49.1(10) s	5.674(14)	3.860(20)	10.854(15)	**[2013Sa43]**
^{185m}Hg	0.1037(5)**	13/2$^+$	21.6(15) s	5.778(14)	3.964(20)	10.958(15)	**[2013Sa43, 1982Bo27]**
^{189}Pb		(3/2$^-$)	39(8) s	6.772(16)	5.065(16)	11.589(14)	**[2013Sa43, 2009Sa09]**
^{189m}Pb	0.040(4)**	(13/2$^+$)	50(3) s	6.812(16)	5.105(16)	11.629(14)	**[2013Sa43, 2009Sa09]**
^{193}Po		(3/2$^-$)	420(40) ms	7.559(16)	6.938(16)	13.866(17)	**[2013Sa43]**
^{193m}Po	0.095(6)	(13/2$^+$)	240(10) ms	7.654(17)	7.033(17)	13.961(18)	**[2013Sa43]**
^{197}Rn		(3/2$^-$)	53^{+7}_{-5} ms	7.866(18)	7.690(17)	14.970(18)	**[2013Sa43, 2008An05]**
^{197m}Rn	0.194(10)	(13/2$^+$)	25^{+3}_{-2} ms	8.060(21)	7.884(20)	15.164(21)	**[2013Sa43, 2008An05]**
^{201}Ra		(3/2$^-$)	8^{+40}_{-4} ms	8.348(22)	8.648(21)	15.867(22)	**[2014Ka23]**
^{201m}Ra	0.260(30)	(13/2$^+$)	$1.6^{+7.7}_{-0.7}$ ms	8.608(37)	8.908(37)	16.127(37)	**[2014Ka23, 2005Uu02]**

* Weighted average of 9.0(5) m [1968Ta05] and 10.5(5) m [1967Pa04].
** [2013Sa43].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the even-Z, T_z = +25/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{145}Nd	7.970(2)	14.404(2)	1.574(1)		
^{149}Sm	7.559(6)	13.567(1)	1.871(1)		
^{153}Gd	7.283(1)	12.884(1)	1.828(1)		
^{157}Dy	6.623(6)	11.932(5)	1.033(5)		
^{161}Er	6.108(17)	10.612(9)	1.798(10)		
^{165}Yb	5.675(36)	9.706(27)	2.481(28)		
^{169}Hf	4.933(47)	8.705(28)	3.154(39)		
^{173}W	4.686(40)	7.874(40)	3.565(40)		
^{177}Os	4.183(32)	6.902(32)	4.346(32)		
^{181}Pt	3.693(26)	5.939(21)	5.150(5)	0.074(10)%	[**1995Bi01**, 1993BiZY, 1993Me13, 1992MeZW, 1966Si08
^{185}Hg	3.154(26)	4.988(20)	5.773(4)	≈6.04%	[**2013Sa43**, 1979Ha10, 1977Ij01, 1976GrZC, 1976GrZL, 1970Ha18, 1970Ma24, 1969Ha03, 1969NaZT, 1969NaZU, 1968De01, 1963Ka17, 1953Ra02]
^{185m}Hg	3.050(26)	4.884(20)	5.877(4)	≈0.030%	[**2013Sa43**, 1979Ha10, 1976GrZC, 1976GrZL, 1970Ha18]
^{189}Pb	2.797(33)	4.303(19)	5.915(4)	≤0.4%	[**2013Sa43**]
^{189m}Pb	2.757(33)	4.263(19)	5.955(4)	≈0.4%	[**2013Sa43, 1974Ho26**, 1993An19, 1974JoZU, 1974Le02, 1973LiYK, 1972Ga27]
^{193}Po	2.080(33)	2.612(16)	7.094(4)	≈ 100%*	[**2013Sa43, 2002Va13**, 1997Fo06, 1995Mo14, 1993Wa04, 1982LeZW, 1981Le23, 1977De32, 1977DeXF]
^{193m}Po	1.985(33)	2.517(17)	7.189(6)	≈ 100%*	[**2013Sa43, 2002Va13**, 1997Fo06, 1995Mo14, 1993Wa04, 1982LeZW, 1981Le23, 1977De32, 1977DeXF, 1967Si09, 1965Si22]
^{197}Rn	1.865(34)	1.951(17)	7.411(7)	≈ 100%*	[**2013Sa43, 2008An05**, 1996En01, 1996MoZV, 1995LeZY, 1995Mo14, 1995NoZW]
^{197m}Rn	1.865(34)	1.951(17)	7.411(7)	≈ 100%*	[**2013Sa43, 2008An05**, 2005Uu02, 1997Pu01, 1996En01, 1995LeZY, 1995NoZW]
^{201}Ra	1.486(37)	1.081(22)	8.002(12)	100%	[**2014Ka23**]
^{201m}Ra	1.746(48)	1.341(37)	8.362(32)	100%	[**2014Ka23, 2005Uu02**]

* Based on short half-life.

Table 3
direct α emission from ^{181}Pt*, J_i^π = 1/2$^-$, $T_{1/2}$= 51(5) s**, BR_α = 0.074(10)%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{177}Os)	coincident γ-rays	R_0 (fm)	HF
5.062(20)	4.95(20)	4%	0.0028(4)%		0.88(21)		1.5504(65)	14
5.150(5)	5.036(5)	100%	0.071(10)%	1/2$^-$	0.0	—	1.5504(65)	1.6(5)

* All values from [1995Bi01], except where noted.
** [1966Si08].

Table 4
direct α emission from ^{185}Hg*, J_i^π = 1/2$^-$, $T_{1/2}$= 49.1(10) s, BR_α = ≈6.04%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{181}Pt)	coincident γ-rays	R_0 (fm)	HF
5.692(5)	5.569(5)	4 %	≈0.24%	5/2$^-$	0.094	0.079, 0.094	1.506(13)	11
5.778(5)	5.653(5)	100%	≈5.8%	1/2$^-$	0.0	—		1.1

* All values from [2013Sa43].

Table 5
direct α emission from ^{185m}Hg*, Ex = 103.7(5) keV, J_i^π = 13/2$^+$, $T_{1/2}$= 21.6(15) s, BR_α = ≈0.030%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{181}Pt)	coincident γ-rays	R_0 (fm)	HF
5.491(8)	5.372(8)	100%	≈0.024%	(13/2$^+$)	0.381	0.0228, 0.405, 0.094, 0.105, 0.119, 0.159	1.506(13)	≈7
5.528(10)	5.408(10)	25%	≈0.006%	(11/2$^+$)	0.343	0.056, 0.727, 0.079, 0.094, 0.1206, 0.1607	1.506(13)	≈40
5.550	5.430	<25%	<0.006%	(11/2$^+$)	0.320	0.0228, 0.405, 0.044, 0.094, 0.119, 0.159	1.506(13)	>51

* All values from [2013Sa43], except where noted.

Table 6
direct α emission from ^{189}Pb*, J_i^π = (3/2$^-$), $T_{1/2}$= 39(8) s**, BR_α = ≤0.4%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{185}Hg)	coincident γ-rays	R_0 (fm)	HF
5.740(6)	5.619(6)	11%	≤0.04%		0.1739	0.026, 0.148, 0.174	1.4904(44)	≥1.6
5.889(5)	5.764(5)	100%	≤0.36%	(3/2$^-$)	0.026	0.026	1.4904(44)	≥4.3

* All values from [2013Sa43], except where noted.
** [2009Sa09].

Table 7
direct α emission from ^{189m}Pb*, Ex = 40(4) keV, J_i^π = , $T_{1/2}$= 50(3) s**, BR_α = ≈0.4%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{185}Hg)	coincident γ-rays	R_0 (fm)	HF
5.851(5)	5.727(5)	≈0.4%	(13/2$^+$)	0.1037	0.0124, 0.0260, 0.0653	1.4904(44)	≈3.3

* All values from [2013Sa43], except where noted.
** [2009Sa09].

Table 8
direct α emission from ^{193}Po*, J_i^π = (3/2$^-$), $T_{1/2}$= 420(40) ms, BR_α = ≈ 100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{189}Pb)	coincident γ-rays	R_0 (fm)	HF
6.556(20)	6.420(20)**	0.7(3)%	0.7(3)%***	(3/2$^-$)	0.539(20)	0.539	1.5125(26)	$3.5^{+3.3}_{-1.4}$
7.095(4)	6.948(4)	100.0(25)%	99.3(25)%***	(3/2$^-$)	0.0	—	1.5125(26)	2.37(27)

* All values from [2013Sa43], except where noted.
** [2013Sa43, 2002Va13].
*** [2003Va13].

Table 9
direct α emission from ^{193m}Po*, Ex = 95(6) keV, J_i^π = (13/2$^+$), $T_{1/2}$= 240(10) ms, BR_α = ≈ 100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{189}Pb)	coincident γ-rays	R_0 (fm)	HF
6.510(15)	6.375(15)**	0.8(3)%	0.8(3)%***	(13/2$^+$)	0.677(15)	0.637	1.5125(26)	$2.0^{+1.4}_{-0.7}$
7.152(4)	7.004(4)	100.0(35)%	99.2(35)%***	(13/2$^+$)	0.040(4)	—	1.5125(26)	3.20(28)

* All values from [2013Sa43], except where noted.
** [2013Sa43, 2002Va13].
*** [2003Va13].

Table 10
direct α emission from ^{197}Rn*, J_i^π = (3/2$^-$), $T_{1/2}$= 53^{+7}_{-5} ms**, BR_α = ≈ 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{193}Po)	coincident γ-rays	R_0 (fm)	HF
7.410(7)	7.260(7)	100%	(3/2$^-$)	0.0	—	1.5653(89)	$1.8^{+0.5}_{-0.4}$

* All values from [2013Sa43], except where noted.
** [2008An05].

Table 11
direct α emission from ^{197m}Rn*, Ex = 194(10) keV, J_i^π = (13/2$^+$), $T_{1/2}$= 25^{+3}_{-2} ms**, BR_α = ≈ 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{193}Po)	coincident γ-rays	R_0 (fm)	HF
7.509(8)	7.357(8)	100%	(13/2$^+$)	0.095(6)	—	1.5653(89)	$3.8^{+1.0}_{-0.9}$

* All values from [2013Sa43], except where noted.
** [2008An05].

Table 12
direct α emission from ^{201}Ra*, J_i^π = (3/2$^-$), $T_{1/2}$= 8^{+40}_{-4} ms, BR_α = ≈ 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{197}Rn)	coincident γ-rays	R_0 (fm)	HF
8.001(12)	7.842(12)	100%	(3/2$^-$)	0.0	—	1.590(18)	7^{+33}_{-3}

* All values from [2014Ka23].

Table 13
direct α emission from ^{201m}Ra*, Ex = 260(30) keV, J_i^π = (13/2$^+$), $T_{1/2}$= $1.6^{+7.7}_{-0.7}$ ms, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{197}Rn)	coincident γ-rays	R_0 (fm)	HF
8.066(20)	7.905(20)	100%	(13/2$^+$)	0.194(10)	—	1.590(18)	$2.1^{+10.0}_{-1.3}$

* All values from [2005Uu02].

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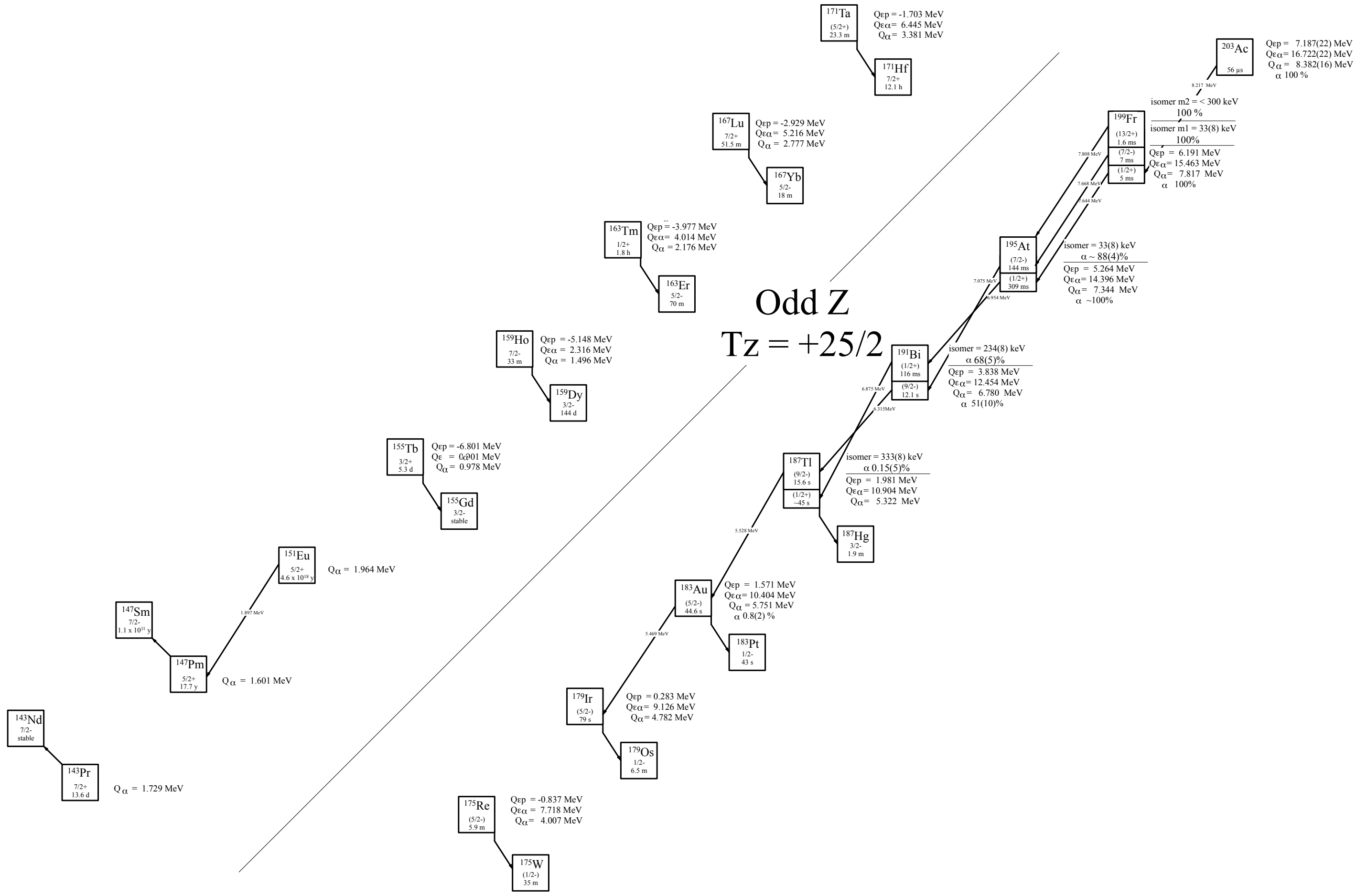

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +25/2 nuclei.

Last updated 2/6/2024

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +25/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{143}Pr		7/2$^+$	13.56(2) d*	-1.462(3)	—–	—–	[**1971Ba28, 1957Pe09, 1965Is01**]
^{147}Pm		7/2$^+$	2.62346(27) y	0.105(2)	-9.657(34)	0.139(3)	[**1999Po32**]
^{151}Eu		5/2$^+$	4.6(12) × 10^{18} y**	stable	—–	—–	[**2014Ca03**]
^{155}Tb		3/2$^+$	5.32(6) d	0.820(10)	-6.801(10)	0.901(10)	[**1970Ch09**]
^{159}Ho		7/2$^-$	33.05(11) m	1.838(3)	-5.148(3)	2.316(3)	[**1982Vy02**]
^{163}Tm		1/2$^+$	1.810(5) h	2.439(3)	-3.977(6)	4.014(6)	[**1982Vy02**]
^{167}Lu		7/2$^+$	51.5(10) m	3.060(40)	-2.929(39)	5.216(38)	[**1976Me06**]
^{171}Ta		(5/2$^+$)	23.3(3) m	3.710(40)	-1.703(33)	6.445(28)	[**1972Ch45**]
^{175}Re		(5/2$^-$)	5.89(5) m	4.340(40)	-0.837(40)	7.718(40)	[**1984Sz07**]
^{179}Ir		(5/2$^-$)	79(1) s	4.938(18)	0.283(30)	9.126(30)	[**1992Bo19**]
^{183}Au		(5/2$^-$)	44.6(19) s	5.582(17)	1.571(23)	10.404(18)	[**1995Bi01**]
^{187}Tl		(1/2$^+$)	≈ 45 s	5.674(15)	1.981(22)	10.904(16)	[**1981Mi12**]
^{187m}Tl	0.333(8)***	(9/2$^-$)	15.60(12) s	6.007(17)	2.314(23)	11.237(18)	[**1981Mi12**]
^{191}Bi		(9/2$^-$)	12.1(4) s$^@$	7.052(10)	3.838(10)	12.454(15)	[**2013Ny01, 2003Ke04**]
^{191m}Bi	0.234(8)	(1/2$^+$)	116(5) ms$^{@@}$	7.052(10)	3.838(10)	12.454(15)	[**2013Ny01, 2003Ke04, 1999An36**]
^{195}At		(1/2$^+$)	309(20) ms$^{@@@}$	7.646(11)	5.264(11)	14.396(12)	[**2013Ny01, 2003Ke04**]
^{195m}At	0.033(8)***	(7/2$^-$)	144(3) ms^a	7.679(14)	5.297(14)	14.429(14)	[**2013Ny01, 2003Ke04**]
^{199}Fr		(1/2$^+$)	5^{+7}_{-2} ms	8.331(16)	6.191(15)	15.463(15)	[**2013Uu01**]
^{199m1}Fr	0.057(26)***	(7/2$^-$)	7^{+3}_{-2} ms	8.388(16)	6.191(15)	15.463(15)	[**2013Uu01**]
^{199m2}Fr	≤0.300***	(13/2$^+$)	$1.6^{+1.6}_{-0.6}$ ms	≥8.631(31)	≥6.548(30)	≥15.811(30)	[**2013Uu01**]
^{203}Ac			56^{+269}_{-25} μs	8.977(23)^b	7.187(22)^b	16.722(22)^b	[**2024WaXX**]

* weighted average of 13.57(2) d [1971Ba28], 13.59(4) d [1957Pe09] and 13.55(2) d [1965Is01].
** Reported as 4.62 (95 stat.) (68 syst.) × 10^{18} y [2014Ca03].
*** Deduced from α energies.
$^@$ Weighted average of 11.7(4) s [2013Ny01] and 12.4(4) s [2003Ke04].
$^{@@}$ Weighted average of 114(6) ms [2013Ny01], 121^{+8}_{-7} ms [2003Ke04] and 115(10) ms [1999An36].
$^{@@@}$ Weighted average of 290(20) ms [2013Ny01] and 328(20) ms [2003Ke04].
^{a} Weighted average of 143(3) ms [2013Ny01] and 147(5) ms [2003Ke04].
^{b} Deduced from α energy and mass of daughter [2021Wa16].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +25/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{143}Pr	5.824(2)	14.716(4)	1.729(2)		
^{147}Pm	5.405(1)	13.994(7)	1.601(1)		
^{151}Eu	4.891(1)	13.167(2)	1.964(1)	100%*	[**2014Ca03**, 2012Pa16]
^{155}Tb	4.833(10)	12.461(10)	0.978(10)		
^{159}Ho	4.211(4)	11.144(3)	1.496(10)		
^{163}Tm	3.683(5)	10.110(6)	2.176(6)		
^{167}Lu	3.222(38)	9.174(37)	2.777(38)		
^{171}Ta	2.755(40)	8.216(28)	3.381(47)		
^{175}Re	2.350(40)	7.470(40)	4.007(40)		
^{179}Ir	1.826(17)	6.390(30)	4.782(30)		
^{183}Au	1.312(16)	5.306(11)	5.465(3)	0.8(2)%	[**1995Bi01**, 1992BiZZ, 1984BrZR, 1982Bo04, 1982BoZL, 1970Ha18, 1970Ma24, 1968De01, 1968Si01, 1965Si07]
^{187}Tl	1.195(14)	5.164(8)	5.322(7)		
^{187m}Tl	0.862(16)	4.831(11)	5.655(11)	0.15(5)%	[**1991Wa21, 1980Sc09**, 1976To06, 1976BoYC]
^{191}Bi	0.112(15)	3.201(11)	6.780(3)	51(10)%	[**2013Ny01, 2003Ke04, 1999An36**, 2000Sc46 1999Ta20, 1999TaZS, 1998Kr23, 1993An19, 1991Wa21, 1985Co06, 1982LeZN, 1978Va21, 1974Le02, 1972Ga27]
^{191m}Bi	-0.122(16)	2.967(13)	7.014(7)	68(5)%	[**2013Ny01, 2003Ke04, 1999An36**, 2024WaXX, 1993An19, 1991Wa21, 1985Co06, 1982LeZN, 1978Va21, 1974Le02, 1972Ga27]
^{195}At	-0.245(16)	2.164(12)	7.344(6)	≈100%	[**2013Ny01, 2003Ke04**, 2024WaXX, 1999Ta20, 1999TaZS, 1996PuZZ, 1995Le15, 1995NoZW, 1984YaZY]
^{195m}At	-0.278(18)	2.131(14)	7.377(10)	88(4)%	[**2013Ny01, 2003Ke04**, 1999Ta20, 1999TaZS,

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +25/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

					1996PuZZ, 1995Le15, 1995NoZW, 1984YaZY]
^{199}Fr	-0.713(19)	1.451(16)	7.817(10)	100%	[**2013Uu01**, 2024WaXX]
^{199m1}Fr	-0.770(32)	1.394(31)	7.874(28)	100%	[**2013Uu01**, 2013Ka16, 1999Ta20, 1999TaZS, 2024WaXX]
^{199m2}Fr	≤-1.013(19)	≤1.151(16)	≥8.117(10)	100%	[**2013Uu01**]
^{203}Ac	-1.214(26)***	0.589(23)***	8.382(16)**	100%	[**2024WaXX**]

* Only decay available.
** Deduced from α energy.
*** Deduced from α energy and mass of daughter [2021Wa16].

Table 3
direct α emission from ^{151}Eu*, J$^\pi$ = 5/2$^+$, T$_{1/2}$= 4.6(12) × 10^{18} y, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J$^\pi_f$	$E_{daughter}$(^{147}Pm)	coincident γ-rays	R$_0$ (fm)	HF
1.9489(86)	1.8973(86)	100%	7/2$^-$	0.0	—	1.583(16)	18^{+11}_{-9}

* All values from [2014Ca13].

Table 4
direct α emission from ^{183}Au*, J$^\pi$ = (5/2$^-$), T$_{1/2}$= 44.6(19) s, BR_α = 0.8(2)%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J$^\pi_f$	$E_{daughter}$(^{179}Ir)	coincident γ-rays	R$_0$ (fm)	HF
5.075(10)	4.964(10)	0.2(1)%	0.0016(9)%		0.394		1.5330(75)	6^{+8}_{-3}
5.198(10)	5.084(10)	0.4(1)%	0.0032(11)%		0.271		1.5330(75)	13^{+9}_{-4}
5.275(5)	5.160(5)	0.6(1)%	0.0048(14)%		0.1932	0.0925, 0.0997, 0.1932	1.5330(75)	23^{+12}_{-7}
5.469(5)	5.349(5)	100(1)%	0.8(2)%	(5/2$^-$)	0.0	—	1.5330(75)	$1.3^{+0.6}_{-0.4}$

* All values from [1995Bi01].

Table 5
direct α emission from ^{187m}Tl, Ex = 333(8) keV*, J$^\pi$ = (9/2$^-$), T$_{1/2}$ = 15.60(12) s**, BR_α = 0.15(5)%***.

E_α(c.m.)	E_α(lab)	I_α(abs)	J$^\pi_f$	$E_{daughter}$(^{183}Au)	coincident γ-rays	R$_0$ (fm)	HF
5.648(10)	5.528(10)@	0.15(5)%***	(9/2$^-$)	0.0124(4)@@		1.494(10)	$0.9^{+0.6}_{-0.4}$

* Deduced from α energies of ^{191}Bi decay.
** [1981Mi12].
*** [1991Wa21].
@ [1980Sc09].
@@ [2016Ba19].

Table 6
direct α emission from ^{191}Bi, J$^\pi$ = (9/2$^-$), T$_{1/2}$ = 12.1(4) s*, BR_α = 51(10)%**.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J$^\pi_f$	$E_{daughter}$(^{187}Tl)	coincident γ-rays	R$_0$ (fm)	HF
6.450(4)	6.315(4)***	100%@	49(10)%	(9/2$^-$)	0.333(8)	1.5030(34)	$1.1^{+0.4}_{-0.3}$	
6.723(15)	6.582(15)@	0.78%@	0.40%	(3/2$^+$)	0.300	0.300	1.5030(34)	200
6.783(7)	6.641(7)***	3%@	1.5(3)%	(1/2$^+$)	0.0	—	1.5030(34)	670

* Weighted average of 11.7(4) s [2013Ny01] and 12.4(4) s [2003Ke04].
** [2003Ke04].
*** [2013Ny01].
@ [1999An36].

Table 7
direct α emission from ^{191m}Bi, Ex = 234(8) keV*, J^{π} = (1/2$^+$), $T_{1/2}$ = 116(5) ms**, BR_{α} = 68(5)%***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{187}Tl)	coincident γ-rays	R_0 (fm)	HF
6.723(15)	6.582(15)	0.24%$^{@@}$	0.163(12)%	(3/2$^+$)	0.300	0.300	1.5030(34)	36
7.022(4)	6.875(4)$^{@}$	100%$^{@@}$	68(5)%	(1/2$^+$)	0.0	—–	71.5030(34)	1.03(12)

* Deduced from α energies.
** Weighted average of 114(6) ms [2013Ny01], 121^{+8}_{-7} ms [2003Ke04] and 115(10) ms [1999An36].
*** [2003Ke04].
@ [2013Ny01].
@@ [1999An36].

Table 8
direct α emission from ^{195}At, J^{π} = (1/2$^+$), $T_{1/2}$ = 309(20) ms*, BR_{α} = ≈100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{191}Bi)	coincident γ-rays	R_0 (fm)	HF
7.100(3)	6.954(3)**	≈100%	(1/2$^+$),	0.234(8)		1.5482(95)	$1.6^{+0.4}_{-0.3}$

* Weighted average of 290(20) ms [2013Ny01] and 328(20) ms [2003Ke04].
** Weighted average of 6.956(4) MeV [2013Ny01] and 6.953(3) MeV [2003Ke04]

Table 9
direct α emission from ^{195m}At, Ex = 33(8) keV, J^{π} = (7/2$^-$), $T_{1/2}$ = 144(3) ms*, BR_{α} = 88(4)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{191}Bi)	coincident γ-rays	R_0 (fm)	HF
7.223(3)	7.075(3)***	100%	84(4)%		0.1486	0.1486	1.5482(95)	49^{+13}_{-11}
7.373(4)	7.222(4)$^{@}$	4.7(5)%	4.0((5)%	(9/2$^-$)	0.0	—–	1.5482(95)	$7.2^{+1.6}_{-1.4}$

* Weighted average of 143(3) ms [2013Ny01] and 147(5) ms [2003Ke04].
** [2013Ny01].
*** Weighted average of 7.076(5) MeV [2013Ny01] and 7.075(4) MeV [2003Ke04]
@ Weighted average of 7.222(4) MeV [2013Ny01] and 7.221(4) MeV [2003Ke04]

Table 10
direct α emission from ^{199}Fr*, J^{π} = (1/2$^+$), $T_{1/2}$ = 5^{+7}_{-2} ms, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{195}At)	coincident γ-rays	R_0 (fm)	HF
7.801(20)	7.644(20)	100%	(1/2$^+$)	0.0	—-	1.576(11)	$1.7^{+2.4}_{-0.8}$

* All values from [2013Uu01].

Table 11
direct α emission from ^{199m1}Fr, Ex. = 57(26) keV, J^{π} = (7/2$^-$), $T_{1/2}$ = 7^{+3}_{-2} ms, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{195}At)	coincident γ-rays	R_0 (fm)	HF
7.825(15)	7.668(15)	100%		0.033(8)		1.576(11)	$2.8^{+1.4}_{-1.1}$

* All values from [2013Uu01].

Table 12
direct α emission from ^{199m2}Fr*, Ex. =≤300 keV, J^{π} = (13/2$^+$), $T_{1/2}$ = $1.6^{+1.6}_{-0.6}$ ms, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{195}At)	coincident γ-rays	R_0 (fm)	HF
7.968(20)	7.808(20)	100%	(13/2$^+$)			1.576(11)	≥1.7

* All values from [2013Uu01].

Table 13
direct α emission from ^{203}Ac*, $T_{1/2} = 56^{+269}_{-25}$ μs, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{199}Fr)	coincident γ-rays	R_0 (fm)	HF
8.382(16)	8.217(16)	100%					

* All values from [2024WaXX].

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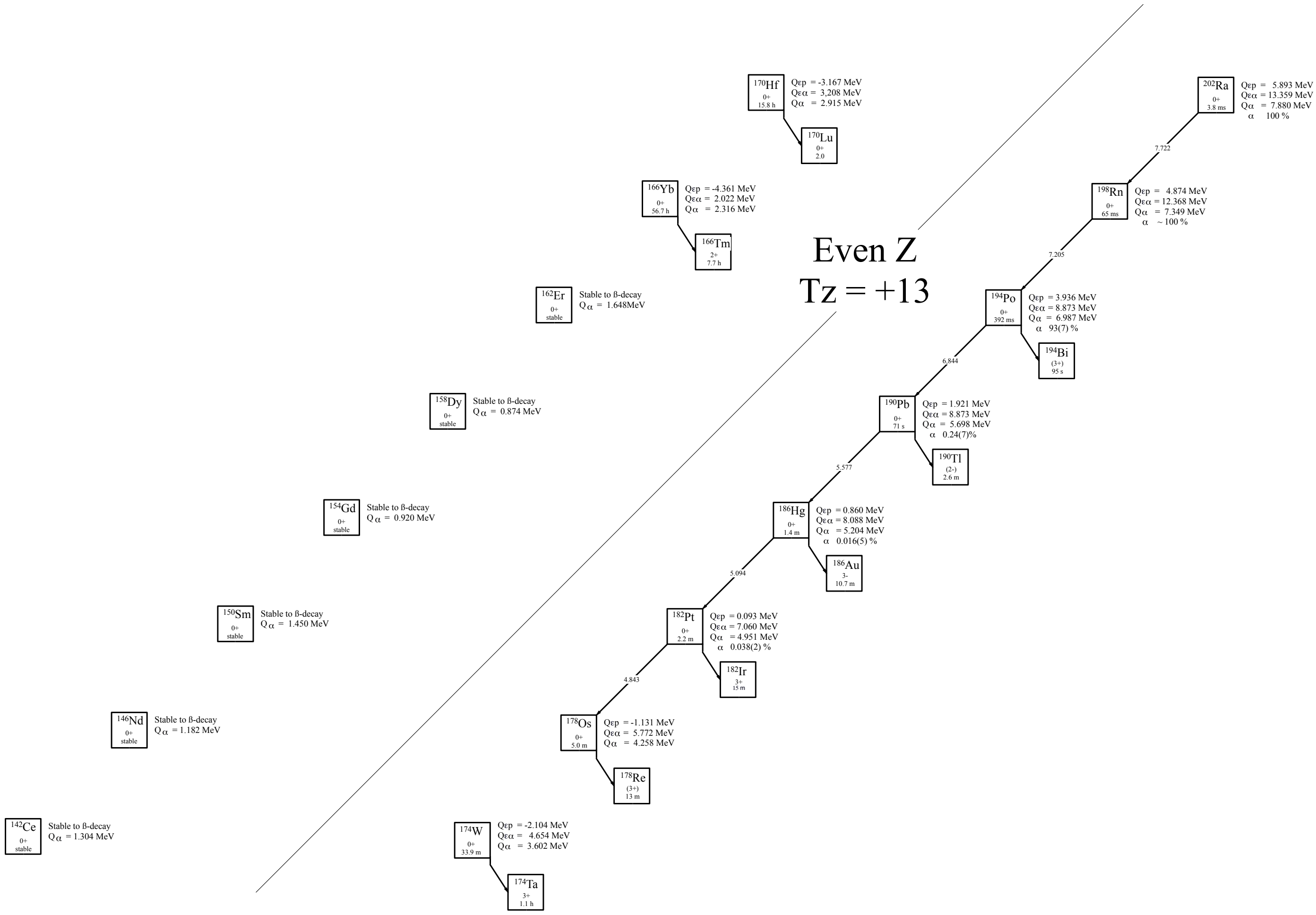

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +13 nuclei.

Last updated 5/29/23

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +13 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^{π}	$T_{1/2}$	Q_{ε}	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{142}Ce	0^+	stable	-4.509(6)	—	—	
^{146}Nd	0^+	stable	-4.256(30)	—	—	
^{150}Sm	0^+	stable	-3.454(20)	—	—	
^{154}Gd	0^+	stable	-1.968(2)	—	—	
^{158}Dy	0^+	stable	-0.963(3)	—	—	
^{162}Er	0^+	stable	-0.294(3)	—	—	
^{166}Yb	0^+	56.7(1) h	0.293(14)	-4.361(7)	2.022(8)	[**1970Ka13**]
^{170}Hf	0^+	15.82(15) h	1.050(30)	-3.167(28)	3.208(30)	[**1970Ch17**]
^{174}W	0^+	33.9(5) m*	1.510(40)	-2.104(40)	4.654(33)	[**1990Me12, 1985Sz03, 1964Sa22**]
^{178}Os	0^+	5.0(4) m	2.110(30)	-1.131(31)	5.772(31)	[**1972Be89**]
^{182}Pt	0^+	2.2(1) m	2.883(25)	0.093(29)	7.060(31)	[**1972Fi12**]
^{186}Hg	0^+	1.41(8) m**	3.176(24)	0.860(28)	8.088(24)	[**1970Ha18, 1969Ha03**]
^{190}Pb	0^+	71(1) s	3.950(14)	1.921(34)	8.873(24)	[**1996Ri12**]
^{194}Po	0^+	392(4) ms	5.018(14)	3.936(17)	10.937(15)	[**1993Wa04**]
^{198}Rn	0^+	65(2) ms***	5.478(14)	4.874(17)	12.368(14)	[**1999Ta03, 1995Bi17**]
^{202}Ra	0^+	$3.8^{+1.3}_{-0.8}$ ms	5.973(16)	5.893(18)	13.359(16)	[**2014Ka23**]

* Weighted average of 35.3(5) m [1990Me12], 33.2(9) m [1985Sz03] and 29(1) m [1964Sa22].
** Weighted average of 1.42(10) m [1970Ha18], and 1.38(13) m [1969Ha03].
*** Weighted average of 66^{+3}_{-2} ms [1999Ta03] and 63(2) ms [1995Bi17].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the even-Z, T_z = +13 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_{α}	BR_{α}	Experimental
^{142}Ce	8.892(5)	15.843(8)	1.304(2)		
^{146}Nd	8.589(7)	15.072(3)	1.182(2)		
^{150}Sm	8.276(2)	14.221(2)	1.450(1)		
^{154}Gd	7.628(1)	13.521(1)	0.920(1)		
^{158}Dy	6.932(2)	12.450(2)	0.874(2)		
^{162}Er	6.427(2)	11.240(1)	1.648(2)		
^{166}Yb	5.953(7)	10.229(7)	2.316(7)		
^{170}Hf	5.460(28)	9.252(28)	2.915(29)		
^{174}W	5.120(40)	8.403(37)	3.602(40)		
^{178}Os	4.564(31)	7.481(31)	4.258(31)		
^{182}Pt	3.994(14)	6.390(20)	4.951(5)	0.038(2)%	[**1995Bi01**, 1966Si08, 1963Gr08]
^{186}Hg	3.970(12)	5.785(19)	5.204(10)	0.016(5)%	[**1970Ha18**, 1996Ri12, 1993ToZY, 1969Ha03, 1969NaZT, 1969NaZU]
^{190}Pb	3.089(15)	4.796(14)	5.698(5)	0.24(7)%*	[**1996Ri12, 1992Wa14, 1984To09, 1974Ho26**, 1996Bi17, 1992WaZV, 1989De18, 1981El03, 1977De32, 1974Ho26, 1974JoZU, 1973LiYK 1972Ga27]
^{194}Po	2.409(15)	3.031(14.)	6.987(3)	93(7)%	[**1994Wa13, 1993Wa04, 1985Va03**, 2014Ka23, 2005Uu02, 1993WaZO, 1989De18, 1982LeZN, 1981Le23, 1977De32, 1967Si09, 1967Tr04, 1967Tr06]
^{198}Rn	2.164(16)	2.340(14)	7.349(4)	≈100%**	[**1995Bi17**, 2014Ka23, 1999Ta03, 1996En02, 1995BiZY, 1993Wa02, 1984Ca32]
^{202}Ra	1.803(18)	1.503(16)	7.880(7)	100%*	[**2014Ka23**, 2005Uu02, 1996Le09]

* Weighted average of 0.37(12)% [1992Wa14], 0.22(7)% [1984To09] and 0.21(7)% [1974Ho26].
** Based on short half-life.

Table 3
direct α emission from ^{182}Pt*, J_i^π = 0^+, $T_{1/2}$ = 2.2(1) m**, BR_α = 0.038(2)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{178}Os)	coincident γ-rays	R_0 (fm)	HF
4.952(5)	4.843(5)	0.038(2)%	0^+	0.0	——	1.5539(68)	1.0

* All values from [1995Bi01], except where noted.
** [1972Fi12].

Table 4
direct α emission from ^{186}Hg*, J_i^π = 0^+, $T_{1/2}$ = 1.41(8) m**, BR_α = 0.016(5)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{182}Pt)	coincident γ-rays	R_0 (fm)	HF
5.208(15)	5.094(15)	0.038(2)%	0^+	0.0	——	1.500(17)	1.0

* All values from [1970Ha18], except where noted.
** Weighted average of 35.3(5) m [1990Me12], 33.2(9) m [1985Sz03] and 29(1) m [1964Sa22].

Table 5
direct α emission from ^{190}Pb*, J_i^π = 0^+, $T_{1/2}$ = 71(1) s, BR_α =0.24(7)%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{186}Hg)***	coincident γ-rays***	R_0 (fm)	HF
5.169(12)	5.060(12)	0.014(6)%	$3.3(17)\times10^{-5}$%	0^+	0.5225(7)		1.4923(55)	23^{+26}_{-9}
5.297(5)	5.185(5)	0.084(15)%	$2.0(7)\times10^{-4}$%	2^+	0.4053	0.4053	1.4923(55)	18^{+10}_{-5}
5.697(5)	5.577(5)	100%	0.24(7)%	0^+	0.0	——	1.4923(55)	1.0

* All values from [1996Ri12], except where noted.
** Weighted average of 0.37(12)% [1992Wa14], 0.22(7)% [1984To09] and 0.21(7)% [1974Ho26].
*** [2022Ba26].

Table 6
direct α emission from ^{194}Po, J_i^π = 0^+, $T_{1/2}$ = 392(4) ms*, BR_α =93(7)%*.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{190}Pb)***	coincident γ-rays***	R_0 (fm)	HF
6.321(7)	6.191(7)**	0.24%	0.22%***	0^+	0.677(7)		1.724(13)	1.06
6.988(3)	6.844 (3)@	100.00%	93%***	0^+	0.0	——	1.724(13)	1.0

* [1993Wa04].
** [1985Va03].
*** [1994Wa13].
@ Values from [1991Ry01], based on weighted average of 6.847(10) MeV [1967Si09], 6.845(7) MeV (adjusted to 6.847(7) MeV) [1967Tr06], 6.840(5) MeV [1977De32] and 6.846(5) MeV [1985Va03].

Table 7
direct α emission from ^{198}Rn, J_i^π = 0^+, $T_{1/2}$ = 65(2) ms**, BR_α = $\approx$100%*.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{194}Po)***	coincident γ-rays***	R_0 (fm)	HF
7.035(8)	6.893(8)	0.07(2)%	0.07(2)%	2^+	0.3193(1)***	0.319	1.7622(23)	110^{+50}_{-30}
7.354(5)	7.205(5)	100%	99.93(2)%	0^+	0.0	——	1.7622(23)	1.0

* All values from [1995Bi17], except where noted.
** Weighted average of 66^{+3}_{-2} ms [1999Ta03] and 63(2) ms [1995Bi17].
*** [2021Ch50].

Table 8
direct α emission from ^{202}Ra*, $J_i^\pi = 0^+$, $T_{1/2} = 3.8^{+1.3}_{-0.8}$ ms, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{198}Rn)	coincident γ-rays	R_0 (fm)	HF
7.878(7)	7.722(7)	100%	0^+	0.0	—	1.794(23)	1.0

* All values from [2014Ka23]

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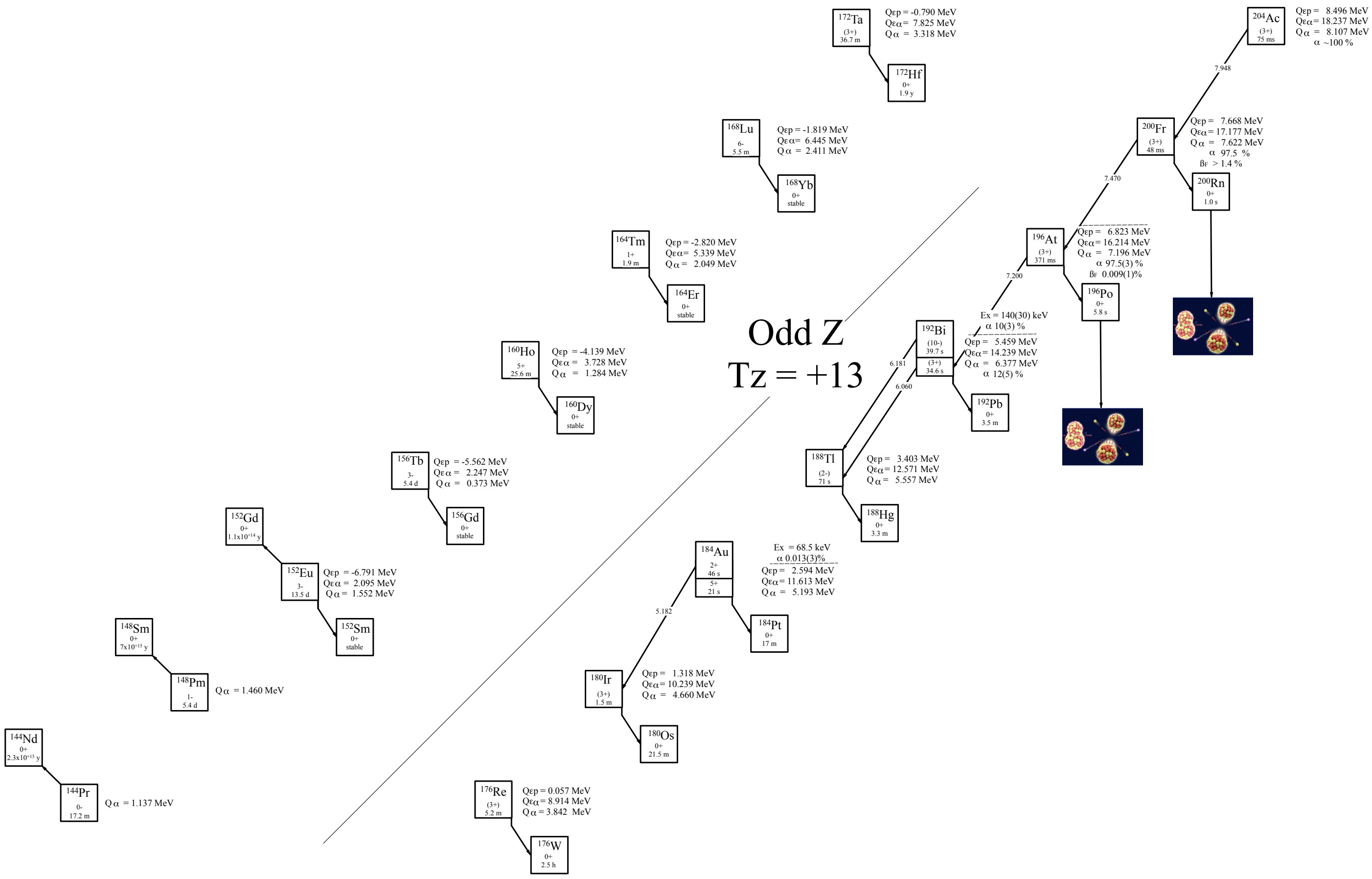

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +13 nuclei.

Last updated 4/4/23

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +13 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex.	J^{π}	$T_{1/2}$	Q_{ε}	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	$BR_{\beta F}$	Experimental
^{144}Pr*		0^-	17.27(4) m	-0.319(4)	—–	—–		[**1957Pe09**]
^{148}Pm*		1^-	5.370(15) d	0.542(6)	-8.711(17)	1.141(6)		[**1970Ca09**]
^{152}Eu**		3^-	13.506(8) d	1.874(1)	-6.791(5)	2.095(2)		[**2010Sc08**]
^{156}Tb		3^-	5.35(10) d	2.444(4)	-5.562(4)	2.247(4)		[**1959He44**]
^{160}Ho		5^+	25.6(3) m	3.290(15)	-4.139(15)	3.728(15)		[**1965St08**]
^{164}Tm		1^+	1.9(1) m***	4.034(25)	-2.820(25)	5.339(25)		[**1965Ba40, 1963Ra15, 1960Wi17**]
^{168}Lu		6^-	5.5(1) m	4.510(40)	-1.819(38)	6.445(38)		[**1972Ch44**]
^{172}Ta		(3^+)	36.7(4) m	5.070(40)	-0.790(28)	7.825(28)		[**1972Ch45**]
^{176}Re		(3^+)	5.2(4) m	5.580(40)	0.057(40)	8.914(37)		[**1977Ha24**]
^{180}Ir		(3^+)	1.5(1) m	6.379(27)	1.318(33)	10.239(35)		[**1972Ak03**]
^{184}Au		5^+	21(1) s	7.014(27)	2.594(33)	11.613(27)		[**1977Za03**]
^{184m}Au	0.06846(4)	2^+	46.4(10) s$^{@}$	7.082(27)	2.662(33)	11.681(27)		[**1977Za03, 1992Ro21, 1995Bi01**]
^{188}Tl		(2^-)	71(2) s	7.860(30)	3.403(37)	12.571(33)		[**1984Co17**]
^{192}Bi		(3^+)	34.6(7) s	9.020(30)	5.459(31)	14.239(31)		[**1991Va04**]
^{192m}Bi	0.140(30)	(10^-)	39.7(4) s$^{@@}$	9.160(42)	5.599(43)	14.379(43)		[**1988Hu03, 1991Va04, 2017Au03**]
^{196}At		(3^+)	371(5) ms	9.560(30)	6.823(31)	16.214(31)	$9(1)\times10^{-3}$%	[**2016Tr07**]
^{200}Fr		(3^+)	48(4) ms$^{@@@}$	10.130(30)	7.668(31)	17.177(31)	>1.4%	[**2014Ka23, 2005De01**]
^{204}Ac		(3^+)	75^{+23}_{-15} ms	10.600(34)^{a}	8.496(34)^{a}	18.237(34)^{a}		[**2022Hu12**]

* 100% β^- emitter.
** 72% β^+, 23% β^- emitter.
*** Weighted average of 2.0(1) m [1965Ba40], 1.8(1) m [1963Ra15] and 2.04(10) m [1960Wi17].
@ Weighted average of 48(1) s [1977Za03], 45(1) s [1992Ro21] and 45.8(18) s [1995Bi01].
@@ Weighted average of 39.6(4) s [1988Hu03], 40.6(9) s [1991Va04].
@@@ Weighted average of 46(4) ms [2014Ka23] and 49(4) ms [2005De01].
^{a} Deduced from ^{204}Ac α energy [2022Hu12] and values from [2021Wa16].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +13 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_{α}	BR_{α}	Experimental
^{144}Pr	6.433(3)	15.305(7)	1.137(3)		
^{148}Pm	6.008(6)	14.770(35)	1.460(6)		
^{152}Eu	5.601(1)	13.869(20)	1.552(6)		
^{156}Tb	5.310(4)	12.931(4)	0.373(4)		
^{160}Ho	4.504(15)	11.489(15)	1.284(15)		
^{164}Tm	4.031(25)	10.446(25)	2.049(29)		
^{168}Lu	3.772(38)	9.764(40)	2.411(45)		
^{172}Ta	3.188(40)	8.602(33)	3.318(47)		
^{176}Re	2.719(40)	7.900(40)	3.842(40)		
^{180}Ir	2.246(27)	6.902(35)	4.660(35)		
^{184}Au	1.834(26)	5.845(31)	5.193(5)*		
^{184m}Au	1.766(26)	5.777(31)	5.305(5)	0.013(3)%	[**1995Bi01**, 1995BiZZ, 1993BiZY, 1992BiZZ, 1970Ha18, 1970HaZT]
^{188}Tl	1.507(33)	5.199(37)	5.557(37)		
^{192}Bi	0.532(31)	3.746(31)	6.377(4)	12(5)%	[**1991Va04**, 2016Tr07, 2013Ny01, 1988Hu03, 1985HuZY, 1974Le02, 1972Ga27, 1970Ta14]
^{192m}Bi	0.393(43)	3.606(43)	6.517(30)	10(3)%	[**1991Va04, 1988Hu03**, 2016Tr07]
^{196}At	0.085(31)	2.468(31)	7.196(3)	97.5(3)%	[**2016Tr07**, 2022Hu12, 2019Gh11, 2014Ka23, 2013Ny01, 2005De01, 2004DeZV, 1997Pu01, 1996En01, 1995Mo14, 1967Tr04, 1967Tr06]
^{200}Fr	-0.404(31)	1.736(31)	7.622(4)	>97.5%	[**2014Ka23**, 2022Hu12, 2013Uu01, 2005De01, 2004DeZV, 1996En01, 1996MoZV, 1995LeZY, 1995Mo14, 1995NoZW]
^{204}Ac	-0.771(35)***	1.019(34)***	8.107(15)***	≈100%**	[**2022Hu12**]

* Deduced from α energy, 5.234(5) in [2021Wa16].
** Based on short half-life.
*** Deduced from ^{204}Ac α energy [2022Hu12] and values from [2021Wa16].

Table 3
direct α emission from ^{184m}Au*, J_i^π = 2^+, Ex = 68.46(4) keV**, $T_{1/2}$ = 46.4(10) s***, BR_α = 0.013(3)%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{180}Ir)	coincident γ-rays	R_0 (fm)@	HF
5.051(5)	4.980(5)	23(1)%	$1.4(3)\times10^{-3}$%		0.212	0.0897, 0.1304, 0.1717, 0.1838, 0.1979, 0.2124	1.527(18)	$4.7^{+2.7}_{-1.8}$
5.096(5)	5.024(5)	22(1)%	$1.3(3)\times10^{-3}$%		0.167	0.0502, 0.1426	1.527(18)	9^{+5}_{-3}
5.137(15)	5.065(15)	14(1)%	$9(2)\times10^{-4}$%		0.114	0.1135	1.527(18)	26^{+16}_{-10}
5.182(5)	5.109(5)	100(1)%	$6.1(14)\times10^{-3}$%		0.0804	0.0553, 0.0804	1.527(18)	$5.5^{+3.1}_{-2.1}$
5.261(5)	5.187(5)	55(1)%	$3.3(8)\times10^{-3}$%	(3^+)	0.0	—–	1.527(18)	27^{+15}_{-19}

* All values from [1995Bi01], except where noted.
** [2005Sa40].
*** Weighted average of 48(1) s [1977Za03], 45(1) s [1992Ro21] and 45.8(18) s [1995Bi01].
@ Interpolated between 1.5539(68) fm ^{182}Pt and 1.500(17) ^{186}Hg.

Table 4
direct α emission from ^{192}Bi*, J_i^π = (3^+), $T_{1/2}$ = 34.6(7) s, BR_α = 12(5)%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{188}Tl)	coincident γ-rays	R_0 (fm)**	HF
6.189(5)	6.060(5)	100%	11.6(5)%	(3^+)	0.1846	0.1846	1.608(14)	11^{+9}_{-5}
6.378(5)	6.245(5)	3.1(6)%	0.36(17)%	(2^-)	0.0	—–	1.608(14)	$2.1^{+20}_{-9}\times10^3$

* All values from [1991Va04], except where noted.
** Interpolated between 1.4923(55) fm ^{190}Pb and 1.724(13) ^{194}Po.

Table 5
direct α emission from ^{192m}Bi*, J_i^π = (10^-), Ex = 140(30) keV**, $T_{1/2}$ = 39.7(4) s***, BR_α = 120(3)%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{188}Tl)	coincident γ-rays	R_0 (fm)@	HF
6.181(5)	6.052(5)	100%	9.(3)%	10^-	0.337(30)	0.0336, 0.1031, 0.2688	1.608(14)	15^{+9}_{-5}
6.210(10)	6.081(10)	7.2(7)%	0.65(21)%	9^-	0.304(30)	0.1031, 0.2688	1.608(14)	280^{+160}_{-100}
6.386(5)	6.253(5)	0.6(2)%	0.05(2)%	6^+	0.138(30)	0.1031	1.608(14)	$1.8^{+1.9}_{-0.7}\times10^4$
6.483(5)	6.348(5)	2.5(2)%	0.23(7)%	7^+	0.035(30)		1.608(14)	$1.0^{+0.6}_{-0.4}\times10^4$

* All values from [1991Va04], except where noted.
** [2017Au03].
*** Weighted average of 39.6(4) s [1988Hu03], 40.6(9) s [1991Va04].
@ Interpolated between 1.4923(55) fm ^{190}Pb and 1.724(13) fm ^{194}Po.

Table 6
direct α emission from ^{196}At*, J_i^π = (3^+), $T_{1/2}$ = 371(5) ms, BR_α = 97.5(3)%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{192}Bi)	coincident γ-rays	R_0 (fm)**	HF
6.782(8)	6.644(8)	0.14(3)%	0.14(3)%		0.409(8)	0.200, 0.221	1.743(13)	$5.5^{+2.3}_{-1.7}\times10^3$
6.887(5)	6.746(5)	1.84(6)%	1.79(6)%		0.316	0.116, 0.200, 0.316	1.743(13)	940^{+270}_{-5210}
6.997(6)	6.854(6)	0.27(3)%	0.26(3)%		0.200	0.200	1.743(13)	$1.7^{+0.5}_{-0.4}\times10^4$
7.200(5)	7.053(5)	100.0(1)%	97.5(3)%	(3^+)	0.0	—–	1.743(13)	220^{+60}_{-50}

* All values from [2016Tr07].
** Interpolated between 1.724(13) fm ^{194}Po and 1.7622(23) fm ^{198}Rn.

Table 7
direct α emission from ^{200}Fr*, J_i^π = (3^+), $T_{1/2}$ = 48(4) ms**, BR_α = $\approx$ 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{196}At)	coincident γ-rays	R_0 (fm)***	HF
7.622(5)	7.470(5)	$\approx$ 100%	(3^+)	0.0	—–	1.778(23)	250^{+140}_{-90}

* All values from [2014Ka23], except where noted.
** Weighted average of 46(4) ms [2014Ka23] and 49(4) ms [2005De01].
*** Interpolated between 1.7622(23) fm ^{198}Rn and 1.794(23) fm ^{202}Ra.

Table 8
direct α emission from ^{204}Ac*, $T_{1/2}$ = 75^{+23}_{-15} ms, BR_α = >97.5%.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}$(^{200}Fr)	coincident γ-rays	R_0 (fm)	HF
8107(15)	7.948(15)	≈ 100%	0.0	—		

* All values from [2014Ka23].

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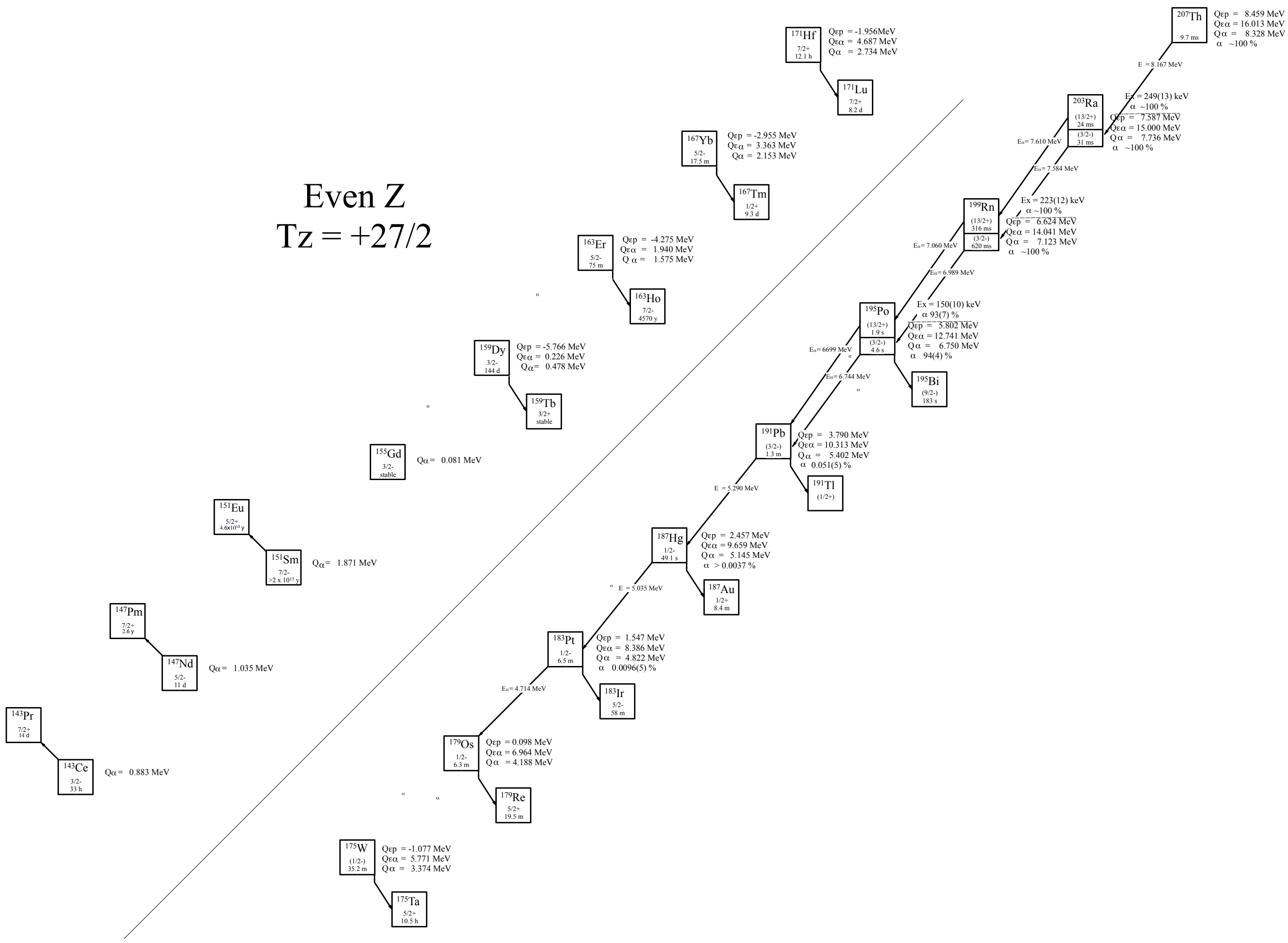

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +27/2 nuclei.

Last updated 7/19/2023

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +27/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J$^{\pi}$ values for ^{143}Ce, ^{147}Nd, ^{151}Sm, ^{155}Gd, ^{159}Dy, ^{163}Er, ^{167}Yb, ^{171}Hf, ^{175}W, ^{179}Os ^{183}Pt and ^{187}Hg are taken from ENSDF

Nuclide	Ex	J^{π}	$T_{1/2}$	Qε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{143}Ce*		3/2$^-$	33.039(6) h	-3.435(8)	—–	—–	[**1989Ab18**]
^{147}Nd*		5/2$^-$	11.03(3) d	-2.703(16)	—–	—–	[**2019Br01**]
^{151}Sm*		5/2$^-$	90(6) y**	-1.190(4)	—–	—–	[**1968Re04, 1965Fl02**]
^{155}Gd		3/2$^-$	stable	stable	—–	—–	
^{159}Dy		3/2$^-$	144.4(2) d	0.365(1)	-5.766(1)	0.226(2)	[**1959Ke28**]
^{163}Er		5/2$^-$	75.1(4) m	1.211(5)	-4.275(5)	1.940(5)	[**1963Pe16**]
^{167}Yb		5/2$^-$	17.5(2) m***	1.953(4)	-2.955(4)	3.363(4)	[**1964Wa04, 1960Wi15**]
^{171}Hf		7/2$^+$	12.1(4) h	2.397(29)	-1.956(29)	4.687(29)	[**1970Ch17**]
^{175}W		(1/2$^-$)	35.2(6) m	2.780(40)	-1.077(28)	5.771(28)	[**1984Sz07**]
^{179}Os		1/2$^-$	6.3(3) m	3.564(29)	0.098(22)	6.964(32)	[**1976Be62**]
^{183}Pt		1/2$^-$	6.5(10) m	4.429(28)	1.547(26)	8.386(28)	[**1963Gr08**]
^{187}Hg		3/2$^-$	2.2(3) m	4.910(26)	2.457(25)	9.659(28)	[**1970Ha18**]
^{191}Pb		(3/2$^-$)	1.3(3) m	5.992(10)	3.790(17)	10.313(23)	[**1974Le02**]
^{195}Po		(3/2$^-$)	4.64(9) s	6.909(8)	5.802(18)	12.741(10)	[**1993Wa04**]
^{195m}Po	0.150(10)	(13/2$^+$)	1.92(2) s	7.059(13)	5.952(21)	12.891(14)	[**2017Al34, 1993Wa04**
^{199}Rn		(3/2$^-$)	620(25) ms$^{@}$	7.264(9)	6.624(19)	14.041(9)	[**1984Ca32, 1999Ti03**]
^{199m}Rn	0.223(12)	(13/2$^+$)	316(16) ms$^{@@}$	7.487(15)	6.847(22)	14.264(15)	[**1984Ca32, 1999Ti03**]
^{203}Ra		(3/2$^-$)	31^{+17}_{-9} ms	7.725(12)	7.587(20)	15.000(11)	[**2005Uu02**]
^{203m}Ra	0.249(13)	(13/2$^+$)	24^{+6}_{-4} ms	7.975(18)	7.837(24)	15.250(17)	[**2005Uu02**]
^{207}Th			$9.7^{+46.6}_{-4.4}$ ms	8.164(65)$^{@@@}$	8.459(31)$^{@@@}$	16.013(26)$^{@@@}$	[**2022Ya15**]

* 100% β^- emitter.
** Weighted average of 93(8) y [1968Re04] and 87(9) y [1965Fl02].
*** Weighted average of 17.7(2) m [1960Wi15] and 17.3(2) m [1964Wa04].
$^{@}$ Weighted average of 620(25) ms [1984Ca32] and 570(30) ms [1999Ti03].
$^{@@}$ Weighted average of 325(25) ms [1984Ca32] and 310(20) ms [1999Ti03].
$^{@@@}$ Deduced from our mass excess (19314(25) keV) for ^{207}Th and daughter mass excesses from [2021Wa16].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the even-Z, T_z = +27/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{143}Ce	8.871(6)	16.452(6)	0.883(2)		
^{147}Nd	8.762(34)	15.658(34)	1.035(2)		
^{151}Sm	8.268(20)	14.779(2)	1.145(1)		
^{155}Gd	7.621(1)	14.088(1)	0.081(1)		
^{159}Dy	6.985(1)	12.921(1)	0.478(1)		
^{163}Er	6.416(6)	11.690(5)	1.575(5)		
^{167}Yb	5.992(12)	10.646(4)	2.153(6)		
^{171}Hf	5.414(33)	9.634(29)	2.734(29)		
^{175}W	5.181(40)	8.799(40)	3.374(40)		
^{179}Os	4.656(32)	7.896(32)	4.188(32)		
^{183}Pt	4.010(25)	6.801(29)	4.822(9)	$9.6(5)\times10^{-3}$%	[**1995Bi01**, 1993BiZY, 1966Si08, 1963Gr08]
^{187}Hg	3.693(25)	6.008(20)	5.145(20)*	$>3.7\times10^{-3}$%	[**1970Ha18**, 1969NaZT, 1969NaZU]
^{191}Pb	3.214(10)	5.243(32)	5.402(14)	0.051(5)%	[**2010Co13, 1974Ho26, 1974Le02**, 1974JoZU]
^{195}Po	2.383(8)	3.465(12)	6.750(3)	94(4)%	[**2010Co13**, 2017Al34, 2005Uu01, 2002Va13, 1993Wa04, 1982LeZN, 1967Si09, 1967Tr04, 1967Tr06]
^{195m}Po	2.233(13)	3.315(16)	6.900(10)	93(7)%	[**2010Co13, 2017Al34, 1993Wa04**, 2005Uu01, 2002Va13, 1982LeZN, 1967Si09, 1967Tr04, 1967Tr06]
^{199}Rn	2.140(9)	2.745(12)	7.132(4)	≈ 100%**	[**2005Uu02**, 2014Ka23, 1999Ta03, 1993Wa04, 1984Ca32, 1982Hi14, 1982HiZR, 1981En02, 1980Di07]
^{199m}Rn	1.917(15)	2.522(17)	7.355(13)	≈ 100%**	[**2005Uu02**, 2014Ka23, 1999Ta03, 1993Wa04, 1984Ca32, 1982Hi14, 1982HiZR, 1980Di07]
^{203}Ra	1.789(11)	1.869(14)	7.736(6)	≈ 100%**	[**2014Ka23, 2005Uu02**, 1996Le02]
^{203m}Ra	1.539(17)	1.8619(14)	7.986(19)	≈ 100%**	[**2014Ka23, 2005Uu02**, 1996Le02]
^{207}Th	1.455(74)@	1.068(34)@	8.328(21)***	≈ 100%**	[**2022Ya15**]

* Deduced from α energy, 5.230(14) in [2021Wa16].
** Not measured, based on short half-life.
*** Deduced from α energy, assuming it feeds the ground state of ^{203}Ra, giving a mass excess for ^{207}Th of 19314(25) keV.
@ Deduced from our mass excess (19314(25) keV) for ^{207}Th and daughter mass excesses from [2021Wa16].

Table 3
direct α emission from ^{183}Pt*, J_i^π = 1/2$^-$, $T_{1/2}$ = 6.5(10) m**, BR_α = $9.6(5)\times10^{-3}$%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{179}Os)	coincident γ-rays	R_0 (fm)	HF
4.819(10)	4.714(10)	$9.6(5)\times10^{-3}$%	1/2$^-$	0.0	—	1.548(17)	$1.5^{+0.7}_{-0.5}$

* All values from [1995Bi01], except where noted.
** [1963Gr08].

Table 4
direct α emission from ^{187}Hg*, J_i^π = 3/2$^-$, $T_{1/2}$ = 2.2(3) m, BR_α = $>3.7\times10^{-3}$%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{183}Pt)	coincident γ-rays	R_0 (fm)	HF
4.976(20)	4.870(20)	32(5)%	$>1.2\times10^{-3}$%		0.169(28)		1.490(16)	<1.3
5.145(20)	5.035(20)	100%	$>2.5\times10^{-3}$%	1/2$^-$	0.0	—	1.490(16)	<3.5

* All values from [1970Ha18].

Table 5
direct α emission from ^{191}Pb*, J_i^π = (3/2$^-$), $T_{1/2}$ = 1.3(3) m, BR_α = 0.051(5)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{187}Hg)	coincident γ-rays	R_0 (fm)	HF
5.403(20)	5.290(20)	0.051(5)%**	3/2$^-$	0.0	—	1.4964(71)	$1.4^{+1.4}_{-0.7}$

* All values from [1974Le02], except where noted.
** [2010Co13].

Table 6
direct α emission from ^{195}Po*, J_i^π = (3/2$^-$), $T_{1/2}$ = 4.64(9) s**, BR_α = 94(4)%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{191}Pb)	coincident γ-rays	R_0 (fm)	HF
6.110(10)	5.985(10)	0.036(3)%	0.034(3)%	(3/2$^-$)	0.642	0.2148, 0.427	1.5120(34)	11.5(14)
6.153(5)	6.027 5(5)	0.34(3)%	0.32(3)%	(3/2$^-$)	0.5972	0.2148, 0.383, 0.5972	1.5120(34)	1.91(24)
6.533(10)	6.399(10)	0.054(12)%	0.051(12)%	(5/2$^-$)	0.20148	0.2148	1.5120(34)	450^{+150}_{-100}
6.744(5)	6.606(5)	100.00(2)%	94(4)%	(3/2$^-$)	0.0	—	1.5120(34)	1.64(16)

* All values from [2010Co13], except where noted.
** [1993Wa04].

Table 7
direct α emission from ^{195m}Po*, Ex. = 150(10) keV, J_i^π = (13/2$^+$), $T_{1/2}$ = 1.92(2) s***, BR_α = 93(7)%***.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{191}Pb)	coincident γ-rays	R_0 (fm)	HF
6.174(5)	6.047(5)	0.17(1)%	0.16(2)%	(13/2$^+$)	0.725(12)	0.6697	1.5120(34)	1.99(24)
6.839(5)	6.699(5)	100.00(1)%	93(7)%	(13/2$^+$)	0.55(12)		1.5120(34)	1.54(17)

* All values from [2010Co13], except where noted.
** [2017Al34].
*** [1993Wa04].

Table 8
direct α emission from ^{199}Rn*, J_i^π = (3/2$^-$), $T_{1/2}$ = 620(25) ms**, BR_α = ≈ 100%***.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{195}Po)	coincident γ-rays	R_0 (fm)	HF
7.132(6)	6.989(6)	≈ 100%	(3/2$^-$)	0.0	—	1.5330(60)	≈1.4

* All values from [2005Uu02], except where noted.
** Weighted average of 620(25) ms [1984Ca32] and 570(30) ms [1999Ti03].
*** Not measured, based on short half-life.

Table 9
direct α emission from ^{199m}Rn*, Ex. = 223(12) keV, J_i^π = (13/2$^+$), $T_{1/2}$ = 316(16) ms**, BR_α = ≈ 100%***.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{195}Po)	coincident γ-rays	R_0 (fm)	HF
7.205(6)	7.060(6)	≈ 100%	(13/2$^+$)	0.150(10)		1.5330(60)	≈1.3

* All values from [2005Uu02], except where noted.
** Weighted average of 325(25) ms [1984Ca32] and 310(20) ms [1999Ti03].
*** Not measured, based on short half-life.

Table 10
direct α emission from ^{203}Ra, J_i^π = (3/2$^-$), $T_{1/2}$ = 31^{+17}_{-9} ms*, BR_α = ≈ 100%***.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{199}Rn)	coincident γ-rays	R_0 (fm)	HF
7.736(8)	7.584(8)**	≈ 100%	(3/2$^-$)	0.0	—	1.549(15)	1.9(12)

* [2005Uu02].
** Weighted average of 7.575(10) MeV [2014Ka23] and 7.589(8) MeV [2005Uu02].
*** Not measured, based on short half-life.

Table 11
direct α emission from ^{203m}Ra, Ex. = 250(13) keV, J_i^π = (13/2$^+$), $T_{1/2}$ = 24^{+6}_{-4} ms*, BR_α = ≈ 100%***.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{199}Rn)	coincident γ-rays	R_0 (fm)	HF
7.763(6)	7.610(6)**	≈ 100%	(13/2$^+$)	0.223(12)		1.5330(60)	1.8(8)

* [2005Uu02].
** Weighted average of 7.575(10) MeV [2014Ka23] and 7.589(8) MeV [2005Uu02].
*** Not measured, based on short half-life.

Table 12
direct α emission from ^{207}Th*, $T_{1/2}$ = $9.7^{+46.6}_{-4.4}$ ms, BR_α = ≈ 100%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{203}Ra)	coincident γ-rays	R_0 (fm)	HF
8.328(21)	8.167(21)	≈ 100%		0.0***	—		

* All values from [2022Ya15].
** Not measured, based on short half-life.
*** Transition assumed to feed the ground state.

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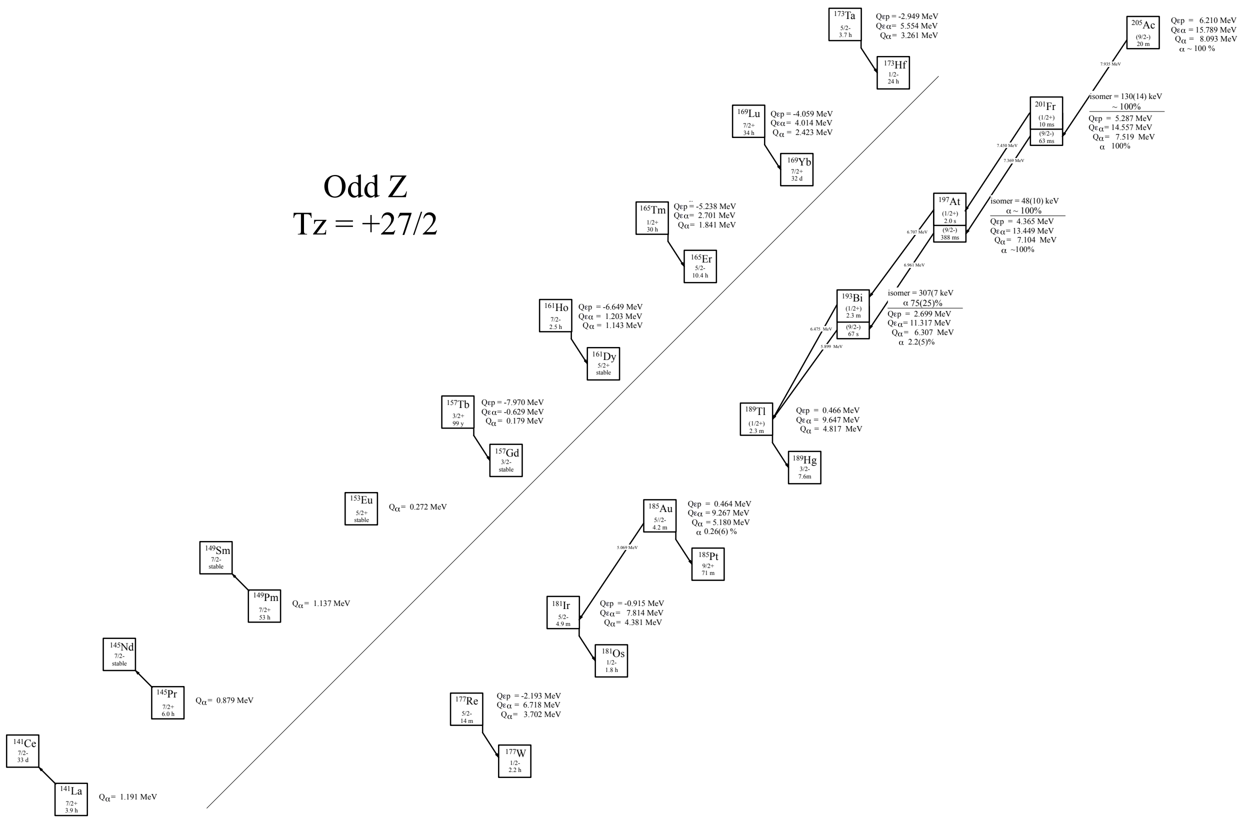

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +27/2 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +27/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{141}La*		7/2$^+$	3.92(3) h	-3.197(7)	—	—	[**1981Ge04**]
^{145}Pr*		7/2$^+$	5.984(10) h	-2.560(30)	—	—	[**1980Ge11**]
^{149}Pm*		7/2$^+$	53.09(9) h	-1.689(3)	—	—	[**1960Bu06**]
^{153}Eu		5/2$^+$	stable	stable	—	—	
^{157}Tb		3/2$^+$	99(10) y	0.060	-7.970(3)	-0.629(1)	[**1983Be42**]
^{161}Ho		7/2$^-$	2.48(5) h	0.859(2)	-6.649(2)	1.203(2)	[**1965Ab04**]
^{165}Tm		1/2$^+$	30.06(5) h	1.591(2)	-5.238(2)	2.701(2)	[**1970Ka23**]
^{169}Lu		7/2$^+$	34.06(5) h	2.293(3)	-4.059(3)	4.014(3)	[**1970Ka23**]
^{173}Ta		5/2$^-$	3.65(5) h	3.020(40)	-2.949(28)	5.554(28)	[**1963Sa14**]
^{177}Re		5/2$^-$	14(1) m	3.430(40)	-2.193(42)	6.718(40)	[**1970Go20**]
^{181}Ir		5/2$^-$	4.90(15) m	4.087(26)	-0.915(22)	7.814(28)	[**1978La04**]
^{185}Au		5/2$^-$	4.2(1) m	4.830(26)	0.464(28)	9.267(25)	[**1995Bi01**]
^{189}Tl		(1/2$^+$)	2.3(2) m	5.010(30)	0.466(9)	9.647(27)	[**1976Ha25**]
^{193}Bi		(9/2$^-$)	67(3) s**	6.345(13)	2.699(33)	11.317(32)	[**1985Co06, 1972Ga27**]
^{193m}Bi	0.307(7)	(1/2$^+$)	3.4(2) s***	6.652(15)	3.006(34)	11.624(33)	[**1985Co06, 1972Ga27**]
^{197}At		(9/2$^-$)	388(6) ms	7.038(13)	4.365(26)	13.449(13)	[**1999Sm07**]
^{197m}At	0.048(10)	(1/2$^+$)	2.0(2) s	7.086(16)	4.413(28)	13.497(16)	[**1999Sm07**]
^{201}Fr		(9/2$^-$)	63(3) ms$^@$	7.696(14)	5.287(26)	14.557(13)	[**2014Ka23, 2005De01, 2005Uu02**]
^{201m}Fr	0.130(14)	(1/2$^+$)	10^{+12}_{-3} ms$^{@@}$	7.826(20)	5.417(30)	14.687(19)	[**2014Ka23, 2005Uu02**]
^{205}Ac		(9/2$^-$)	20^{+97}_{-9} ms	8.300(60)	6.210(64)	15.789(60)	[**2014Zh03**]

* 100% β^- emitter.
** Weighted average of 67(3) s [1985Co06] and 62.2(36) s [1972Ga27].
*** Weighted average of 3.2(2) s [1985Co06] and3.48(18) s [1972Ga27].
@ Weighted average of 64(3) ms [2014Ka23], 67(3) ms [2005De01] and 53(4) ms [2005Uu02].
@@ Weighted average of 8^{+12}_{-3} ms [2014Ka23],and 19^{+19}_{-6} ms [2005Uu02].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +27/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{141}La	6.951(9)	16.807(5)	1.191(4)		
^{145}Pr	6.483(7)	16.032(10)	0.879(8)		
^{149}Pm	5.945(2)	15.198(16)	1.137(7)		
^{153}Eu	5.893(1)	14.559(5)	0.272(2)		
^{157}Tb	5.517(0)	13.523(1)	0.179(1)		
^{161}Ho	4.813(2)	12.242(2)	1.143(2)		
^{165}Tm	4.276(1)	11.130(2)	1.841(3)		
^{169}Lu	3.792(3)	10.117(3)	2.423(3)		
^{173}Ta	3.283(37)	9.146(28)	3.261(28)		
^{177}Re	2.917(40)	8.438(40)	3.702(40)		
^{181}Ir	2.396(17)	7.457(25)	4.381(28)		
^{185}Au	1.815(15)	6.234(25)	5.180(5)	0.26(6)%	[**1995Bi01**, 1993BiZY, 1991Bi04, 1970Ha18, 1968De01, 1968Si01, 1965Si07]
^{189}Tl	1.707(11)	6.165(24)	4.817(9)		
^{193}Bi	0.622(9)	4.180(11)	6.307(5)	2.2(5)%	[**2005De01, 1985Co06, 1972Ga27**, 2004DeZV, 1993An19, 1990AnZR, 1989AnZF, 1984Co13, 1982LeZN, 1978Va21, 1974Le02, 1970Ta14, 1967Tr06]
^{193m}Bi	0.315(11)	3.873(13)	6.614(9)	75(25)%	[**1993An19, 1985Co06, 1972Ga27**, 2005De01, 2004DeZV 1984Co13, 1982LeZN, 1978Va21, 1974Le02, 1970Ta14, 1967Tr06]
^{197}At	0.175(10)	2.908(10)	7.104(3)	≈ 100%*	[**2014Ka23, 2005De01, 2005Uu02, 1999Sm07, 1996En01**, 2015We13, 2004DeZV, 1986Co12, 1985HuZY, 1967Tr04, 1967Tr06]
^{197m}At	0.127(14)	2.860(14)	7.152(10)	≈ 100%*	[**2014Ka23, 2005De01, 1999Sm07**, 2004DeZV, 1986Co12, 1985HuZY]
^{201}Fr	-0.300(11)	2.166(11)	7.519(4)	≈ 100%*	[**2014Ka23, 2005De01, 2005Uu02, 1996En01**, 2004DeZV,] 1980Ew03, 1979Ca16]
^{201m}Fr	-0.430(17)	2.036(18)	7.649(14)	100%*	[**2014Ka23, 2005Uu02**]
^{205}Ac	-0.757(60)	1.348(60)	8.093(59)	≈ 100%*	[**2014Zh03**]

* Based on short half-life.

Table 3
direct α emission from ^{185}Au*, J_i^π = 5/2$^-$, $T_{1/2}$ = 4.2(1) m, BR_α = 0.26(6)%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{181}Ir)	coincident γ-rays**	R_0 (fm)	HF
4.680(10)	4.579(10)	0.03(1)%	7.8(32)$\times10^{-5}$%		0.501		1.521(22)	$3.0^{+2.8}_{-1.4}$
4.933(10)	4.826(10)	0.15(1)%	3.9(9)$\times10^{-4}$%	(3/2$^-$, 5//2$^-$)	0.243	0.112, 0.131, 0.243	1.521(22)	20^{+14}_{-9}
5.181(5)	5.069 5(5)	100(1)%	0.26(6)%	(5/2$^-$)	0.0	—	1.521(22)	0.7^{+4}_{-3}

* All values from 1005Bi01], except where noted.
** [2005Wu07].

Table 4
direct α emission from ^{193}Bi, J_i^π = (9/2$^-$), $T_{1/2}$ = 67(3) s*, BR_α = 2.2(5)%**.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{189}Tl)	coincident γ-rays	R_0 (fm)	HF
6.024(5)	5.899(5)***	100%	0.021(5)%	(9/2$^-$)	0.281(7)		1.5059(63)	$2.9^{+1.1}_{-0.8}$
6.305(5)	6.174(5)***	4.4(5)%	9.3(2)$\times10^{-4}$%	(1/2$^+$)	0.0	—	1.5059(63)	1000^{+500}_{-300}

* Weighted average of 67(3) s [1985Co06] and 62.2(36) s [1972Ga27].
** [2005De01].
*** [1985Co06].

Table 5
direct α emission from ^{193m}Bi, Ex = 307(7) keV, J_i^π = (1/2$^+$), $T_{1/2}$ = 3.4(2) s*, BR_α = 75(25)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{189}Tl)	coincident γ-rays	R_0 (fm)	HF
6.612(5)	6.475(5)***	75(25)%**	(1/2$^+$)	0.0	—	1.5059(63)	$1.0^{+0.6}_{-0.3}$

* Weighted average of 3.2(2) s [1985Co06] and3.48(18) s [1972Ga27].
** [1993An19].
*** [1985Co06].

Table 6
direct α emission from ^{197}At, J_i^π = (9/2$^-$), $T_{1/2}$ =388(6) ms*, BR_α = $\approx$ 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{193}Bi)	coincident γ-rays	R_0 (fm)	HF
7.105(3)	6.961(3)**	$\approx$ 100%	(9/2$^-$)	0.0	—	1.5291(28)	1.53(10)

* [1999Sm07].
** Weighted average of 6.963(5) MeV [2014Ka23], 6.963(4) MeV [2005De01], 6.959(6) MeV [2005Uu02], 6.960(5) [1999Sm07] and 6.956(5) MeV [1996En01].

Table 7
direct α emission from ^{197m}At*, Ex = 48(10) keV, J_i^π = (1/2$^+$), $T_{1/2}$ = 2.0(2) s, BR_α = $\approx$ 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{193}Bi)	coincident γ-rays	R_0 (fm)	HF
6.846(5)	6.707(5)**	$\approx$ 100%	(1/2$^+$)	0.307(7)		1.5291(28)	0.93(12)

* All values from [1999Sm07].

Table 8
direct α emission from ^{201}Fr, J_i^π = (9/2$^-$), $T_{1/2}$ =63(3) ms*, BR_α = $\approx$ 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{197}At)	coincident γ-rays	R_0 (fm)	HF
7.519(5)	7.369(5)**	$\approx$ 100%	(9/2$^-$)	0.0	—	1.547(12)	$1.7^{+0.5}_{-0.4}$

* Weighted average of 64(3) ms [2014Ka23], 67(3) ms [2005De01] and 53(4) ms [2005Uu02].
** Weighted average of 7.369(5) MeV [2014Ka23], 7.379(7) MeV [2005De01], 7.369(8) MeV [2005Uu02], and 7.361(7) MeV [1996En01].

Table 9
direct α emission from ^{201m}Fr, Ex = 130(14) keV, J_i^π = (1/2$^+$), $T_{1/2}$ = 10^{+12}_{-3} ms*, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{197}At)	coincident γ-rays	R$_0$ (fm)	HF
7.601(8)	7.450(8)**	100%	(1/2$^+$)	0.048(10)		1.547(12)	$0.5^{+0.5}_{-0.2}$

* Weighted average of 8^{+12}_{-3} ms [2014Ka23],and 19^{+19}_{-6} ms [2005Uu02].
** Weighted average of 7.445(8) MeV [2014Ka23], and 7.454(8) MeV [2005Uu02].

Table 10
direct α emission from ^{205}Ac*, J_i^π = (9/2$^-$), $T_{1/2}$ = 20^{+97}_{-9} ms, BR_α = ≈ 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{201}Fr)	coincident γ-rays	R$_0$ (fm)	HF
8.093(30)	7.935(30)	≈ 100%	(9/2$^-$)	0.0	——	1.541(17)	6^{+6}_{-3}

* All values from [2014Zh03].

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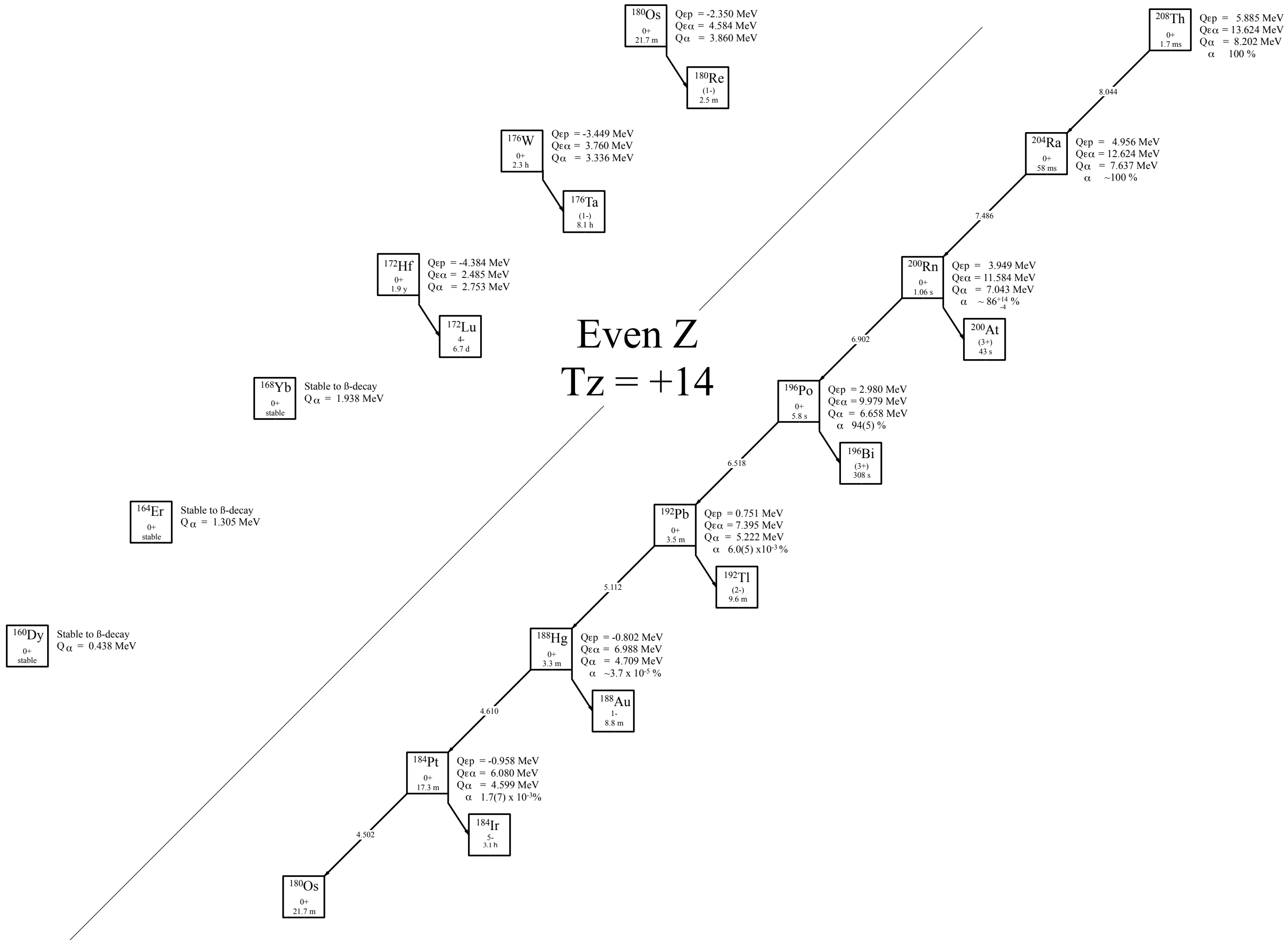

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +14 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the even-Z, $T_z = +14$ nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{160}Dy	0^+	stable	—	—	—	
^{164}Er	0^+	stable	—	—	—	
^{168}Yb	0^+	stable	—	—	—	
^{172}Hf	0^+	1.86(3) y	0.334(25)	-4.384(24)	2.485(24)	[**1971Ch57**]
^{176}W	0^+	2.3(1) h	0.720(40)	-3.449(28)	3.670(28)	[**1963Va20**]
^{180}Os	0^+	21.7(6) m	1.481(27)	-2.350(21)	4.584(35)	[**1966Ho16**]
^{184}Pt	0^+	17.3(2) m	2.280(30)	-0.958(52)	6.080(26)	[**1972Fi12**]
^{188}Hg	0^+	3.25(15) m	2.173(7)	-0.802(25)	6.988(29)	[**1972Fi12**]
^{192}Pb	0^+	3.5(1) m	3.320(30)	0.751(23)	7.395(6)	[**1979To06**]
^{196}Po	0^+	5.8(2) s	4.540(25)	2.980(7)	9.979(32)	[**1985Va03**]
^{200}Rn	0^+	1.06(2) s	4.987(25)	3.949(8)	11.584(25)	[**1984Ca32**]
^{204}Ra	0^+	58^{+10}_{-7} ms*	5.454(26)	4.956(11)	12.624(26)	[**2005Uu02, 1996Le09**]
^{208}Th	0^+	$1.7^{+1.7}_{-0.6}$ ms	5.930(70)	5.885(66)	13.656(40)	[**2010He25**]

* Weighted average of 54^{+19}_{-11} ms [2005Uu02] and 59^{+12}_{-9} ms [1996Le09].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the even-Z, $T_z = +14$ nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{160}Dy	7.429(1)	13.560(1)	0.438(1)		
^{164}Er	6.854(0)	12.339	1.305(0)		
^{168}Yb	6.326(1)	11.234	1.938(1)		
^{172}Hf	5.863(24)	10.216(24)	2.753(24)		
^{176}W	5.522(40)	9.375(28)	3.336(37)		
^{180}Os	5.061(29)	8.527(22)	3.860(32)		
^{184}Pt	4.419(29)	7.301(26)	4.599(8)	$1.7(7)\times10^{-3}$%	[**1995Bi01**, 1993BiZY, 1966Si08, 1963Gr08]
^{188}Hg	4.459(24)	6.912(23)	4.709(15)	$\approx3.7\times10^{-5}$%	[**1979Ha10**, 1993ToZY]
^{192}Pb	3.558(9)	5.759(17)	5.222(5)	$6.0(5)\times10^{-3}$%*	[**1992Wa14, 1979To06**, 1992WaZV, 1984To09, 1974Ho16, 1974Le02]
^{196}Po	2.732(8)	3.839(18)	6.658(2)	94(5)%	[**1996Ta18, 1993Wa04, 1985Va03**, 2016Tr07, 1993WaZO, 1992WaZV, 1967Si09, 1967Tr06, 1965Si22]
^{200}Rn	2.466(8)	3.105(18)	7.043(2)	86^{+14}_{-4}%	[**1995Bi17, 1993Wa04, 1984Ca32**, 2015We15, 2005Uu02 1995BiZY, 1992WaZV, 1971Ho01]
^{204}Ra	2.104(11)	2.242(20)	7.637(7)	$\approx$ 100%**	[**2005Uu02, 1996Le09, 1995Le04**, 1995Le15, 1995LeZY]
^{208}Th	1.747(65)	1.456(37)	8.202(31)	100%	[**2010He25**]

* Weighted average of $6.2(6)\times10^{-3}$% [1992Wa14] and $5.7(10)\times10^{-3}$% [1979To06].
** Based on short half-life.

Table 3
direct α emission from ^{184}Pt*, $J_i^\pi = 0^+$, $T_{1/2}$ = 17.3(2) m**, $BR_\alpha = 1.7(7)\times10^{-3}$%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{180}Os)	coincident γ-rays	R_0 (fm)	HF
4.602(10)	4.502(10)	$1.7(7)\times10^{-3}$%	0^+	0.0	—	1.542(27)	$1.0^{+0.7}_{-0.3}$

* All values from [1995Bi01], except where noted.
** [1972Fi12].

Table 4
direct α emission from ^{188}Hg*, $J_i^\pi = 0^+$, $T_{1/2}$ = 3.25(15) m**, $BR_\alpha = \approx3.7\times10^{-5}$%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{184}Pt)	coincident γ-rays	R_0 (fm)	HF
4.710(20)	4.610(20)	$1.7(7)\times10^{-3}$%	0^+	0.0	—	1.480(15)	1.01

* All values from [1979Ha10], except where noted.
** [1972Fi12].

Table 5
direct α emission from ^{192}Pb*, $J_i^\pi = 0^+$, $T_{1/2}$ = 3.5(1) m, $BR_\alpha = 6.0(5)\times10^{-3}$%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{188}Hg)	coincident γ-rays	R_0 (fm)	HF
5.221(5)	5.112(5)	$6.0(5)\times10^{-3}$%**	0^+	0.0	—	1.5126(28)	0.98(9)

* All values from [1979To06], except where noted.
** Weighted average of $6.2(6)\times10^{-3}$% [1992Wa14] and $5.7(10)\times10^{-3}$% [1979To06].

Table 6
direct α emission from ^{196}Po, $J_i^\pi = 0^+$, $T_{1/2}$ = 5.8(2) s*, BR_α = 94(5)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{192}Pb)	coincident γ-rays	R_0 (fm)	HF
6.654(1)	6.518(1)***	94(5)%**	0^+	0.0	—	1.5005(86)	1.00(6)

Table 7
direct α emission from ^{200}Rn, $J_i^\pi = 0^+$, $T_{1/2}$ = 1.06(2) s*, $BR_\alpha = 86^{+14}_{-4}$%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	I_α(abs)	J_f^π	$E_{daughter}$(^{196}Po)	coincident γ-rays	R_0 (fm)	HF
6.485(6)	6.355(6)	$6(2)\times10^{-3}$%	$5.2^{+10}_{-5}\times10^{-3}$%	0^+	0.558(7)		1.5205(93)	140^{+90}_{-40}
6.586(4)	6.454(4)	$8.1(7)\times10^{-3}$%	$7.0^{+14}_{-9}\times10^{-3}$%	2^+	0.4631(1)@	0.4631(1)@	1.5205(93)	242^{+60}_{-24}
7.0433(25)	6.9024(25)	100%	86^{+14}_{-4}%	0^+	0.0	—	1.5205(93)	1.3^{+4}_{-1}

* [1984Ca32].
** [1993Wa04].
*** [1996Tr18].
@ [2007Hu13].

Table 8
direct α emission from ^{204}Ra, $J_i^\pi = 0^+$, $T_{1/2} = 58^{+10}_{-7}$ ms*, $BR_\alpha = \approx$ 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{200}Rn)	coincident γ-rays	R_0 (fm)	HF
7.636(6)	7.486(6)**	≈ 100%	0^+	0.0	—	1.525(14)	1.07(19)

* Weighted average of 54^{+19}_{-11} ms [2005Uu02] and 59^{+12}_{-9} ms [1996Le09].
** Weighted average of 7.486(8) MeV [2005Uu02], 7.484(10) MeV [1996Le09], and 7.488(12) MeV [1995Le04].

Table 9
direct α emission from ^{208}Th*, $J_i^\pi = 0^+$, $T_{1/2} = 1.7^{+1.7}_{-0.6}$ ms, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{204}Ra)	coincident γ-rays	R_0 (fm)	HF
8.202(30)	8.044(30)	100%	0^+	0.0	—	1.555(18)	$0.66^{+0.66}_{-0.24}$

* All values from [2010He25].

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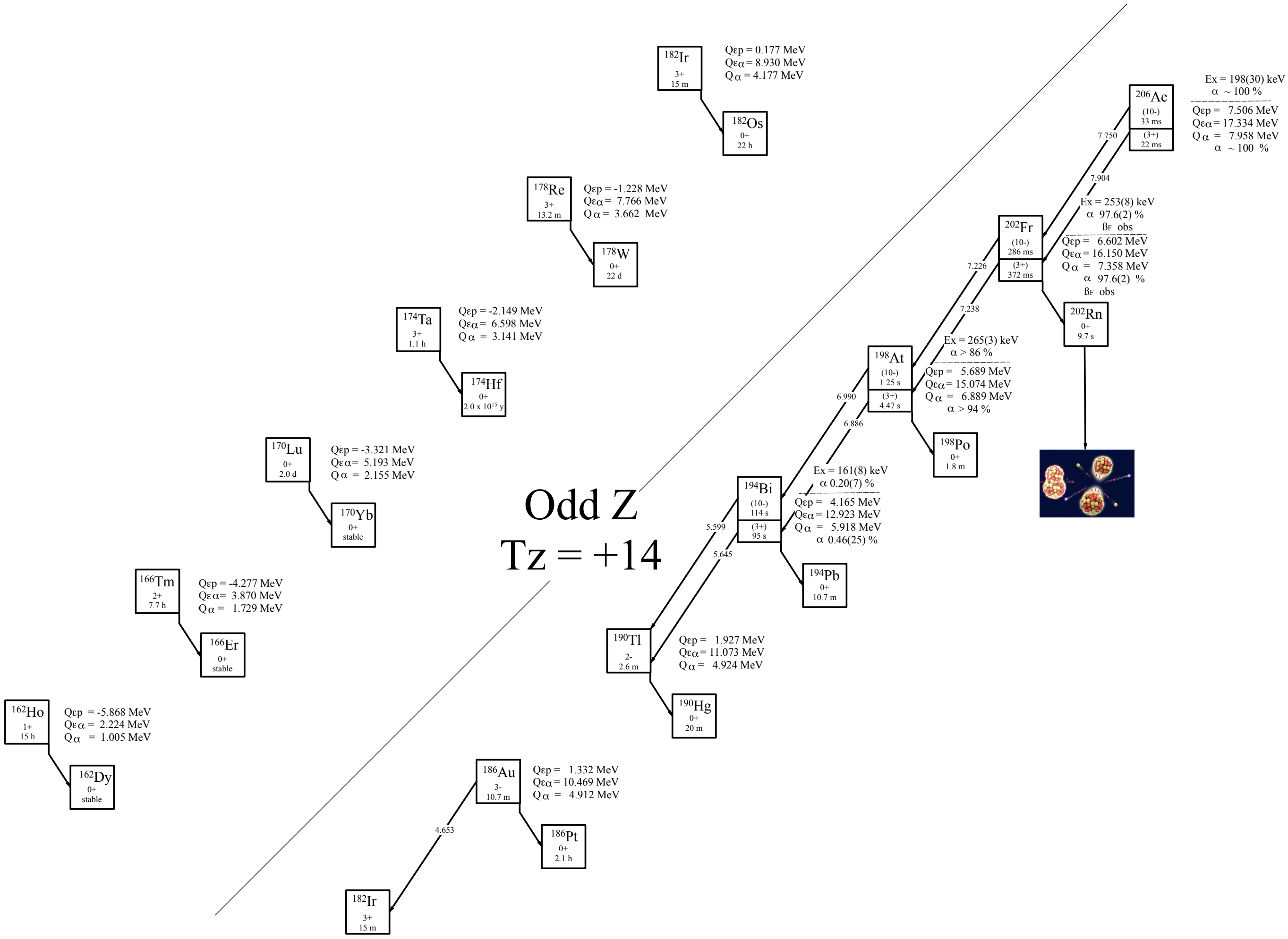

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +14 nuclei.

Last updated 8/1/2023

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +14 nuclei. J$^\pi$ values for ^{162}Ho, ^{1466}Tm, ^{170}Lu, ^{174}Ta, ^{178}Re, ^{182}Ir, and ^{190}Tl are taken from ENSDF. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex	J^π	$T_{1/2}$	Q$_\varepsilon$	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	BR$_F$	Experimental
^{162}Ho		1^+	15.0(10) h	0.294(3)	-5.868(3)	2.224(3)		[**1965St08**]
^{166}Tm		2^+	7.70(4) h*	3.038(12)	-4.277(12)	3.870(12)		**1960Wi12, 1960Gr15**]
^{170}Lu		0^+	2.03(3) d**	3.458(17)	-3.321(17)	5.193(17)		[**1970Ka23, 1960Wi14**]
^{174}Ta		3^+	1.06(4) h	4.104(28)	-2.149(28)	6.598(28)		[**1985Sz03**]
^{178}Re		3^+	13.2(2) m	4.750(30)	-1.228(28)	7.766(28)		[**1970Go20**]
^{182}Ir		3^+	15(1) m	5.560(30)	0.177(24)	8.930(26)		[**1972Ak03**]
^{186}Au		3^-	10.7(5) m	6.150(30)	1.332(35)	10.469(30)		[**1970Jo02**]
^{190}Tl		2^-	2.6(3) m	7.004(17)	1.927(21)	11.073(23)		[**1976Bi09**]
^{194}Bi		(3^+)	95(3) s	8.185(18)	4.165(9)	12.923(17)		[**1991Va04**]
^{194m}Bi	0.161(8)	(10^-)	114(4) s	8.346(20)	4.326(12)	13.084(19)		[**2019Gi11, 1991Va04**]
^{198}At		(3^+)	4.47(5) s	8.765(18)	5.689(10)	15.074(18)		[**2019Gi11**]
^{198m}At	0.265(3)	(10^-)	1.25(5) s***	9.028(18)	5.954(10)	15.339(18)		[**2019Gi11, 2014Ka23**]
^{202}Fr		(3^+)	372(10) ms	9.376(19)	6.602(10)	16.150(18)	obs	[**2014Ka23, 2014Gh09**]
^{202m}Fr	0.253(8)	(10^-)	286(13) ms	9.629(21)	6.855(13)	16.403(20)	obs	[**2014Ka23, 2014Gh09**]
^{206}Ac		(3^+)	22^{+9}_{-5} ms	9.920(70)	7.506(66)	17.334(67)		[**1998Es02**]
^{206m}Ac	0.198(30)	(10^-)	33^{+22}_{-9} ms	10.118(76)	7.704(72)	17.532(73)		[**1998Es02**]

* Weighted average of 7.69(5) h [1960Wi12] and 7.74(8) h [1960Gr15].
** Weighted average of 2.02 d [1970Ka23] and 2.05(5) h [1960Wi14].
*** Weighted average of 1.28(10) s [2019Gh11] and 1.24(6) s [2014Ka23].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +14 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_p$	S$_{2p}$	Q$_\alpha$	BR$_\alpha$	Experimental
^{162}Ho	5.274(3)	12.782(3)	1.005(3)		
^{166}Tm	4.654(12)	11.484(12)	1.729(12)		
^{170}Lu	4.220(17)	10.572(17)	2.155(20)		
^{174}Ta	3.618(40)	9.583(28)	3.141(33)		
^{178}Re	3.241(40)	8.866(42)	3.662(40)		
^{182}Ir	2.791(33)	7.792(30)	4.177(35)		
^{186}Au	2.316(33)	6.682(35)	4.912(14)	8(2)$\times10^{-4}$%	[**1990Ak04**, 1995Bi01, 1993BiZY, 1992BiZZ]
^{190}Tl	2.029(32)	6.573(8)	4.924(22)		
^{194}Bi	1.083(12)	4.729(32)	5.918(5)	0.46(25)%	[**1991Va04**, 1988Hu03, 1985HuZY]
^{194m}Bi	0.922(14)	4.568(33)	6.079(9)	0.20(7)%	[**1991Va04**, 1988Hu03, 1985HuZY, 1974Le02, 1970Ta14]
^{198}At	0.605(11)	3.278(25)	6.889(2)	>94%	[**2019Gi11, 2014Ka23, 1995BiZZ**, 2015We13, 2005Uu02, 2005Uu03, 1999Ta03, 1998Bo14, 1992Hu04, 1980Ew03, 1967Tr04, 1967Tr06
^{198m}At	0.340(11)	3.013(25)	7.154(4)	>86%	[**2019Gi11, 2014Ka23, 1995BiZZ**, 2005Uu02, 2005Uu03, 1999Ta03, 1998Bo14, 1996En01, 1992Hu04, 1980Ew03, 1967Tr04, 1967Tr06
^{202}Fr	0.080(12)	2.489(25)	7.385(4)	97.6(2)%*	[**2019Gh11**, 2014Ka23, 2014Ly01, 2005Uu02, 1996En01, 1995BiZZ, 1992Hu04, 1980Ew03, 1976HaYQ, 1976HoZD]
^{202m}Fr	-0.173(14)	2.236(26)	7.638(9)	97.6(2)%*	[**2019Gh11**, 2014Ka23, 2014Ly01, 1996En01, 1995BiZZ, 1992Hu04]
^{206}Ac	-0.392(69)	1.700(70)	7.958(65)	≈ 100%**	[**2014Zh03, 1998Es02**, 1998LuZV]
^{206m}Ac	-0.590(75)	1.502(76)	8.156(71)	≈ 100%**	[**1998Es02**]

* [2019Gh11] estimate a β-branching ratio for a combination of the ground state and isomer of 2.4(2)%.
** Based on short half-life.

Table 3
direct α emission from ^{186}Au*, J_i^π = 3$^-$, $T_{1/2}$ = 10.7(5) m**, BR_α = 8(2)×10^{-4}%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{182}Ir)	coincident γ-rays	R$_0$ (fm)***	HF
4.755(15)	4.653(15)	8(2)×10^{-4}%	0$^+$	0.0	—	1.519(23)***	$2.2^{+1.7}_{-1.1}$

* All values from [1990Ak04], except where noted.
** [1970Jo02].
*** Interpolated between 1.542(27) fm (^{184}Pt) and 1.480(15) fm (^{188}Hg).

Table 4
direct α emission from ^{194}Bi*, J_i^π = (3$^+$), $T_{1/2}$ = 95(3) s, BR_α = 0.46(25)%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{190}Tl)	coincident γ-rays	R$_0$ (fm)**	HF
5.764(5)	5.645(5)	100%	4.6(25)×10^{-3}%	(3$^+$)	0.1513	0.1513	1.5066(90)	$1.4^{+1.8}_{-0.6}$
5.921(5)	5.799(5)	0.59(7)%	2.7(15)×10^{-3}%	(2$^-$)	0.0	—	1.5066(90)	1200^{+1600}_{-500}

* All values from [1991Va04], except where noted.
** Interpolated between 1.5126(28) fm (^{192}Pb) and 1.5005(86) fm (^{196}Po).

Table 5
direct α emission from ^{194m}Bi*, Ex. = 161(8) keV, J_i^π = (10$^-$), $T_{1/2}$ = 114(4) s, BR_α =0.20(7)%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{190}Tl)	coincident γ-rays	R$_0$ (fm)	HF
5.447(5)	5.335(5)	0.16(3)%	2.9(12)×10^{-6}%	(11$^-$)	0.572	0.069, 0.2724	1.5066(90)	60^{+50}_{-20}
5.717(5)	5.599(5)	100%	1.8(6)×10^{-3}%	(10$^-$)	0.300	0.069	1.5066(90)	$2.3^{+1.5}_{-0.8}$
5.779(5)	5.660(5)	2.2(2)%	4.0(15)×10^{-5}%	(9$^-$)	0.236		1.5066(90)	210^{+140}_{-70}
5.903(5)	5.781(5)	3.0(2)%	5.5(20)×10^{-5}%	(6$^+$, 7$^+$)	0.1122	0.1122	1.5066(90)	600^{+400}_{-200}
6.016(5)	5.892(5)	3.9(2)%	7.1(25)×10^{-5}%	7$^+$	0.0	—	1.5066(90)	$1.4^{+0.9}_{-0.5}\times10^{+3}$

* All values from [1991Va04], except where noted.
** Interpolated between 1.5126(28) fm (^{192}Pb) and 1.5005(86) fm (^{196}Po).

Table 6
direct α emission from ^{198}At*, J_i^π = (3$^+$), $T_{1/2}$ = 4.47(5) s, BR_α = >94%**.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{194}Bi)	coincident γ-rays	R$_0$ (fm)$^@$	HF
6.404(8)	6.275(8)	0.08(1)%	>0.075%		0.486	0.103, 0.218, 0.267, 0.382, 0.486	1.511(13)	<36
6.489(8)	6.358(8)	0.11(1)%	>0.10%		0.400	0.181, 0.218, 0.400	1.511(13)	<59
6.492(9)	6.361(9)	0.008(2)%	>0.0075%		0.382	0.382	1.511(13)	<1000
6.670(8)	6.535(8)	0.020(3)%	>0.019%		0.218	0.218	1.511(13)	<1700
6.886(5)	6.747(5)***	100 %	>94%	(3$^+$)	0.0	—	1.511(13)	<2.2

* All values from [2019Gh11], except where noted.
** [1995BiZZ].
*** [2014Ka23].
$^@$ Interpolated between 1.5005(86) fm (^{196}Po) and 1.5205(93) fm (^{200}Rn).

Table 7
direct α emission from ^{198m}At*, Ex.=265(3) keVJ_i^{π} = (10$^-$), $T_{1/2}$ = 1.25(5) s**, BR_{α} = >86%***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{194}Bi)	coincident γ-rays	R_0 (fm)$^{@@}$	HF
6.452(12)	6.322(12)	0.005(3)%	>0.0043%		0.699(8)	0.538	1.511(13)	<340
6.469(8)	6.338(8)	0.09-0.13%	>0.08-0.11%		0.686(8)	0.525	1.511(13)	<15-20
6.892(8)	6.753(8)	0.05-0.34%	>0.04-0.29%		0.266(8)	0.105	1.511(13)	< 230-1700
6.990(5)	6.849(5)$^{@}$	100%	>86%	(10$^-$)	0.161(8)		1.511(13)	<1.5

* All values from [2019Gh11], except where noted.
** Weighted average of 1.28(10) s [2019Gh11] and 1.24(6) s [2014Ka23].
*** [1995BiZZ].
$^{@}$ [2014Ka23].
$^{@@}$ Interpolated between 1.5005(86) fm (^{196}Po) and 1.5205(93) fm (^{200}Rn).

Table 8
direct α emission from ^{202}Fr*, J_i^{π} = (3$^+$), $T_{1/2}$ = 372(10) ms**, BR_{α} = 97.6(2)%***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{198}At)	coincident γ-rays	R_0 (fm)$^{@}$	HF
7.229(8)	7.086(8)	0.03-0.11%	0.03-0.11%		0.154	0.154	1.523(17)	620-2300
7.249(8)	7.105(8)	0.09(2)%	0.09(2)%		0.130	0.130	1.523(17)	900^{+500}_{300}
7.384(5)	7.238(5)**	100%	97.6(2)%	(3$^+$)	0.0	—	1.523(17)	$2.4^{+1.0}_{-0.7}$

* All values from [2019Gh11], except where noted.
** [2014Ka23].
*** [2019Gh11] estimate a β-branching ratio for a combination of the ground state and isomer of 2.4(2)%.
$^{@}$ Interpolated between 1.5205(93) fm (^{200}Rn) and 1.525(14) fm (^{204}Ra).

Table 9
direct α emission from ^{202m}Fr*, Ex. = 253(8) keV, J_i^{π} = (10$^-$), $T_{1/2}$ = 286(13) ms**, BR_{α} = 97.6(2)%***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{198}At)	coincident γ-rays	R_0 (fm)$^{@}$	HF
6.860(8)	6.724(8)	0.06(1)%	0.06(1)%	(8$^-$)	0.792(3)	0.130, 0.151, 0.511(3), 0.527	1.523(17)	34^{+18}_{-13}
7.253(8)	7.109(8)	0.28-0.53%	0.27-0.52%	(8$^-$, 9$^-$)	0.391(3)	0.126	1.523(17)	110-220
7.311(8)	7.166(8)	0.06(1)%	0.06(1)%		0.334(7)	0.053(7), 0.130, 0.151	1.523(17)	$1.5^{+0.8}_{-0.6}\times10^3$
7.363(8)	7.217(8)	0.23(5)%	0.22(5)%	(6$^-$)	0.281	0.130, 0.151	1.523(17)	600^{+400}_{-300}
7.372(5)	7.226(5)**	100%	97.6(2)%	(10$^-$)	0.265(3)		1.523(17)	$1.6^{+0.7}_{-0.5}$
7.530(26)	7.381(26)	0.014(6)%	0.014(6)%	(5$^+$)	0.130	0.130	1.523(17)	$3.2^{+3.0}_{-1.4}\times10^3$
7.635(32)	7.484(32)	<0.008	<0.008	(3$^+$)	0.0	—	1.523(17)	$>1.5\times10^5$

* All values from [2019Gh11], except where noted.
** [2014Ka23].
*** [2019Gh11] estimate a β-branching ratio for a combination of the ground state and isomer of 2.4(2)%.
$^{@}$ Interpolated between 1.5205(93) fm (^{200}Rn) and 1.525(14) fm (^{204}Ra).

Table 10
direct α emission from ^{206}Ac*, J_i^{π} = (3$^+$), $T_{1/2}$ = 22^{+9}_{-5} ms , BR_{α} = ≈ 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{202}Fr)	coincident γ-rays	R_0 (fm)***	HF
7.958(21)	7.804(21)**	100%	(3$^+$)	0.0	—	1.540(23)	$2.6^{+2.0}_{-1.5}$

* All values from [1998Es02], except where noted.
** Weighted average of 7.817(30) MeV [2014Zh03] and 7.790(30) MeV [1998Es02].
*** Interpolated between 1.555(18) fm (^{208}Th) and 1.525(14) fm (^{204}Ra).

Table 11
direct α emission from ^{206m}Ac*, Ex. = 198(30) keV, J_i^π = (10^-), $T_{1/2}$ = 33^{+22}_{-9} ms , BR_α = ≈ 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{202}Fr)	coincident γ-rays	R_0 (fm)**	HF
7.903(20)	7.750(20)	100%	(10^-)	0.253(8)		1.540(23)	$2.6^{+2.4}_{-2.0}$

* All values from [1998Es02].
** Interpolated between 1.555(18) fm (^{208}Th) and 1.525(14) fm (^{204}Ra).

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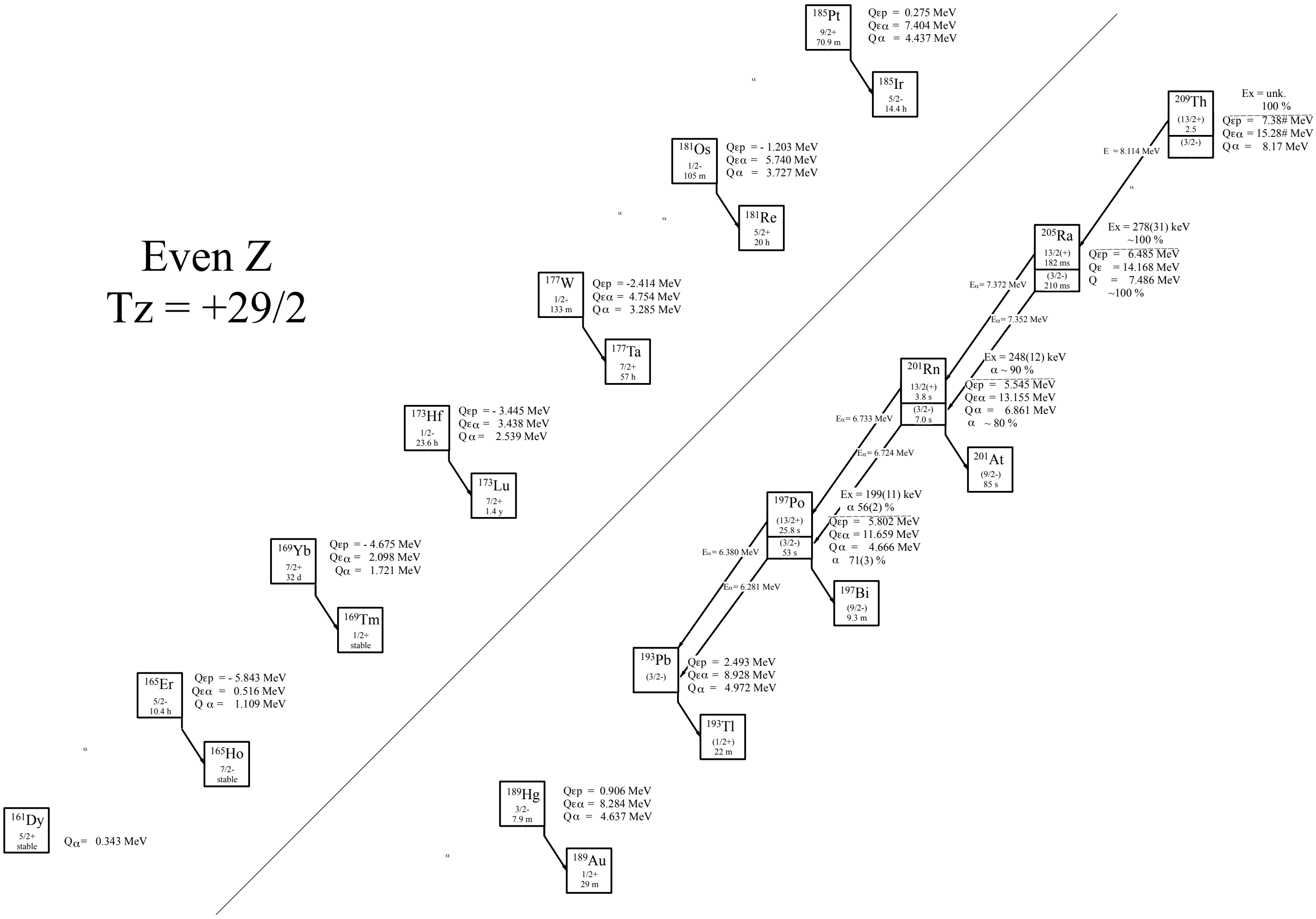

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +29/2 nuclei.

Last updated 8/7/2023

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +29/2 nuclei. J$^{\pi}$ values for ^{161}Dy, ^{14}Er, ^{169}Yb, ^{173}hf, ^{177}W, ^{181}Os, and ^{185}Pt are taken from ENSDF. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex	J^{π}	$T_{1/2}$	Qε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{161}Dy		5/2^{+}	stable	—–	—–	—–	
^{165}Er		5/2^{-}	10.36(4) h*	0.377(1)	-5.843(1)	0.516(2)	[**1963Zy01, 1963Ry01, 1963Ra15**]
^{169}Yb		7/2^{+}	32.1047(93) d	0.899(0.8)	-4.675(0)	2.098(1)	[**2002Un02**]
^{173}Hf		1/2^{-}	23.6(1) h	1.469(28)	-3.445(28)	3.438(28)	[**1951Wi08**]
^{177}W		1/2^{-}	133(3) m**	2.013(28)	-2.414(28)	4.754(28)	[**1963Sa14, 1950Wi67**]
^{181}Os		1/2^{-}	105(3) m	2.967(28)	-1.203(25)	5.740(26)	[**1966Ho16**]
^{185}Pt		9/2^{+}	70.9(24) m	3.650(40)	0.275(26)	7.404(29)	[**1970FiZZ**]
^{189}Hg		3/2^{-}	7.9(2) m***	3.960(40)	0.906(32)	8.284(42)	[**1975Be17, 1970ErZX, 1950Wi67**]
^{193}Pb		(3/2^{-})		5.248(12)	2.493(19)	8.928(23)	
^{197}Po		(3/2^{-})	53(1) s	6.294(13)	4.666(13)	11.659(12)	[**1993Wa04**]
^{197m}Po	0.199(11)	(13/2^{+})	25.8(1) s	6.493(17)	4.865(17)	11.858(16)	[**2017Al34, 1993Wa04**]
^{201}Rn		(3/2^{-})	7.0(4) s	6.682(13)	5.545(13)	13.155(13)	[**1971Ho01**]
^{201m}Rn	0.248(12)	13/2$^{(+)}$	3.8(4) s	6.930(18)	5.793(18)	13.403(18)	[**2017Al34, 1971Ho01**]
^{205}Ra		(3/2^{-})	210^{+41}_{-26} ms$^{@}$	7.114(24)	6.485(24)	14.168(24)	[**1996Le09, 1995Le15**]
^{205m}Ra	0.278(31)	13/2$^{(+)}$	182^{+38}_{-24} ms$^{@@}$	7.392(39)	6.763(39)	14.446(39)	[**2017Al34, 1996Le09, 1995Le15**]
^{209}Th	x	(3/2^{-})		7.55(12)#	7.38(10)#	15.28(10)#	
^{209m}Th	x	(13/2^{+})	$2.5^{+1.7}_{-0.7}$ ms	7.55(12)#+x	7.38(10)#+x	15.28(10)#+x	[**2010He25**]

* Weighted average of 10.39(7) h [1963Zy01], 10.34(5) h [1963Ry01] and 10.4(1) h [1963Ra15].
** Weighted average of 135(3) m [1963Sa14] and 130(3) m [1950Wi67].
*** Weighted average of 7.5(2) m [1975Be17], 7.7(2) m [1970ErZX] and 130(3) m [1950Wi67].
$^{@}$ Weighted average of 210^{+60}_{-40} ms [1996Le09] and 210^{+55}_{-35} ms [1995Le15].
$^{@@}$ Weighted average of 170^{+60}_{-40} ms [1996Le09] and 190^{+50}_{-30} ms [1995Le15].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the even-Z, T_z = +29/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_p$	S$_{2p}$	Q$_\alpha$	BR$_\alpha$	Experimental
^{161}Dy	7.508(1)	14.072(1)	0.343(1)		
^{165}Er	6.830(1)	12.718(1)	1.109(1)		
^{169}Yb	6.352(2)	11.664(1)	1.721(1)		
^{173}Hf	5.965(28)	10.683(28)	2.539(28)		
^{177}W	5.625(42)	9.798(28)	3.285(40)		
^{181}Os	5.002(33)	8.833(29)	3.727(38)		
^{185}Pt	4.366(38)	7.602(56)	4.437(10)		
^{189}Hg	4.544(32)	7.519(40)	4.637(41)	$<3\times10^{-7}$%	[**1963Ka17**]
^{193}Pb	3.646(33)	6.215(25)	4.972(33)		
^{197}Po	2.673(26)	4.233(11)	6.411(3)	71(3)%*	[**1996Ta18, 1993Wa04, 1981Sc01**, 1987Wo04, 1971Ho01, 1970HoZT, 1967Le21, 1967Si09, 1965Br17, 1965Si22]
^{197m}Po	2.474(28)	4.034(16)	6.610(11)	56(2)%**	[**2002Va13, 1996Ta18, 1993Wa04, 1981Sc01**, 1987Wo04, 1973BoXL, 1971Ho01, 1970HoZT, 1967Le21, 1967Si09, 1965Br17, 1965Si22]
^{201}Rn	2.408(26)	3.447(11)	6.861(2)	≈ 80 %	[**1996Ta18, 1993Wa04, 1971Ho01**, 1987He10, 1967Va17 1965Nu04]
^{201m}Rn	2.160(29)	3.199(16)	7.109(12)	≈ 90 %	[**1996Ta18, 1993Wa04, 1971Ho01**, 1987He10, 1967Va17 1965Nu04]
^{205}Ra	2.092(34)	2.590(24)	7.486(20)	≈ 100%***	[**1996Le09, 1995Le04, 1995Le15**, 1987He10]
^{205m}Ra	1.814(46)	2.312(39)	7.764(37)	≈ 100%***	[**1996Le09, 1995Le15**]
^{209}Th	1.66(12)	1.70(12)	8.17(11)		
^{209m}Th	1.66(12)-x	1.70(12)-x	8.17(11)+x	100%	[**2010He25, 1996Ik01**, 1996IkZY]

* Weighted average of 76(3)% [1993Wa04] and 44(7)% [1981Sc01].
** Weighted average of 55(2)% [1993Wa04] and 84(9)% [1981Sc01].
*** Based on short half-life.

Table 3
direct α emission from ^{197}Po, J_i^π = (3$^-$), $T_{1/2}$ = 53(1) s*, BR_α = 71(3)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{193}Pb)	coincident γ-rays	R$_0$ (fm)$^@$	HF
6.411(2)	6.281(2)***	71(3)%**	(3$^-$)	0.0	—	1.5044(24)	1.19(8)

* [1993Wa04].
** Weighted average of 76(3)% [1993Wa04] and 44(7)% [1981Sc01].
*** [1996Ta18].

Table 4
direct α emission from ^{197m}Po, Ex. = 199(11) keV*, J_i^π = (13/2$^+$), $T_{1/2}$ = 25.8(1) s**, BR_α = 56(2)%***.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{193}Pb)	coincident γ-rays	R$_0$ (fm)$^@$	HF
5.739(25)	5.622(25)$^{@@}$	≥0.05(3)%	≥0.03(2)%	(13/2$^+$)	0.757(1)	0.757(1)	1.5044(24)	$1.9^{+2.9}_{-0.7}$
6.512(1)	6.380(1)$^@$	100%	56(2)%	(13/2$^+$)	0.0	—	1.5044(24)	1.86(12)

* [2017Al34].
** [1993Wa04].
*** Weighted average of 55(2)% [1993Wa04] and 84(9)% [1981Sc01].
$^@$ [1996Ta18].
$^{@@}$ [2002Va13].

Table 5
direct α emission from ^{201}Rn, J_i^π = (3$^-$), $T_{1/2}$ = 7.0(4) s*, BR_α = ≈ 80 %*.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{197}Po)	coincident γ-rays	R$_0$ (fm)$^@$	HF
6.861(2)	6.724(2)**	≈ 80 %*	(3$^-$)	0.0	—	1.5156(71)	≈ 1.6

* [1971Ho01].
** Weighted average of 6.725(2) MeV [1996Ta18] and 6.7237(25) MeV [1993Wa04].

Table 6
direct α emission from ^{201m}Rn, Ex. = 248(12) keV*, J_i^π = 13/2$^{(+)}$, $T_{1/2}$ = 3.8(4) s**, BR_α = ≈ 90 %**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{197}Po)	coincident γ-rays	R$_0$ (fm)$^@$	HF
6.910(2)	6.733(2)***	≈ 90 %**	13/2$^{(+)}$	0.199(11)	—	1.5156(71)	≈ 1.16

* [2017Al34].
** [1971Ho01].
*** Weighted average of 6.773(2) MeV [1996Ta18] and 6.7721(25) MeV [1993Wa04].

Table 7
direct α emission from ^{205}Ra, J_i^π = (3$^-$), $T_{1/2}$ = 210^{+41}_{-26} ms*, BR_α = ≈ 100 %.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{201}Rn)	coincident γ-rays	R$_0$ (fm)$^@$	HF
7.498(8)	7.352(8)**	≈ 100 %	(3$^-$)	0.0	—	1.5269(91)	$1.5^{+0.5}_{-0.3}$

* Weighted average of 210^{+60}_{-40} ms [1996Le09] and 210^{+55}_{-35} ms [1995Le15].
** Weighted average of 7.340(20) MeV [1996Le09], 7.350(25) MeV [1995Le15], and 7.340(20) MeV [1995Le04]. In addition [1987He10] report one peak from ^{205}Ra at 7.360(20) MeV which may an unresolved combination of the two isomers.

Table 8
direct α emission from ^{205m}Ra, Ex. = 278(31) keV, J_i^π = 13/2$^{(+)}$, $T_{1/2}$ = 182^{+38}_{-24} ms*, BR_α = ≈ 100 %.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{201}Rn)	coincident γ-rays	R_0 (fm)$^@$	HF
7.519(16)	7.372(16)**	≈ 100 %	13/2$^{(+)}$	0.248(12)	—	1.5269(91)	$1.5^{+0.5}_{-0.4}$

* Weighted average of 210^{+60}_{-40} ms [1996Le09] and 210^{+55}_{-35} ms [1995Le15].
** Weighted average of 7.370(20) MeV [1996Le09], and 7.375(25) MeV [1995Le15].

Table 9
direct α emission from ^{209m}Th*, Ex. = unk, J_i^π = (13/2$^+$), $T_{1/2}$ = $2.5^{+1.7}_{-0.7}$ ms**, BR_α = 100 %.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{205}Ra)	coincident γ-rays	R_0 (fm)$^@$	HF
8.272(25)	8.114(25)***	100 %	(13/2$^+$)	0.278(31)	—	1.531(14)	$1.0^{+0.8}_{-0.4}$

* All values from [2010He25], except where noted.
** From [2010He25], obtained from their 4 events and the 2 events from [1996Ik01].
** Weighted average of 8.123(25) MeV [2010He25], and 8.080(50) MeV [1996Ik01].

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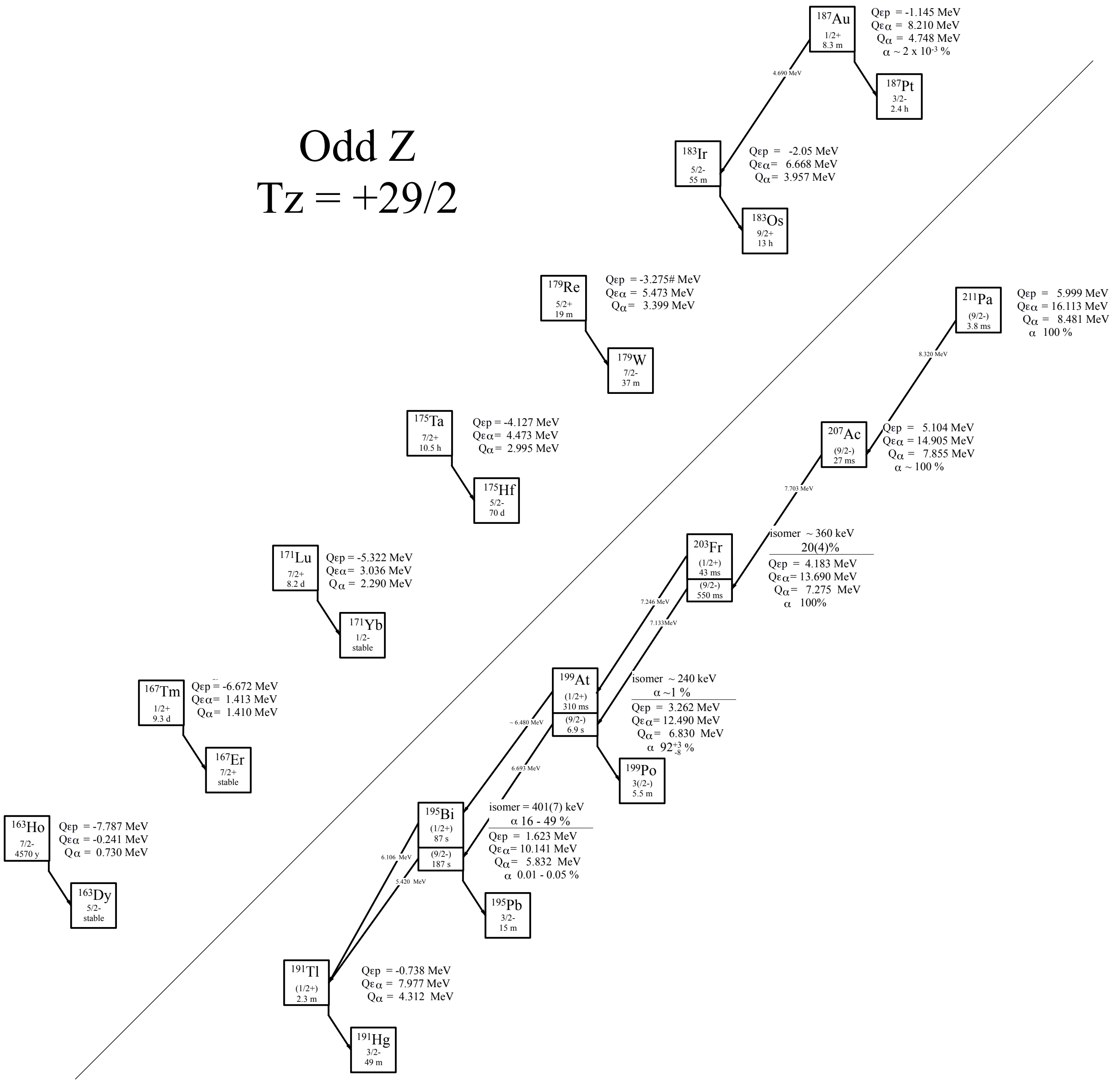

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +29/2 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +29/2 nuclei. J$^\pi$ values for ^{163}Ho, ^{167}Tm, ^{171}Lu, ^{175}Ta, ^{179}Re, ^{183}Ir, and ^{191}Tl are taken from ENSDF. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex	J^π	$T_{1/2}$	Qε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{163}Ho		7/2$^-$	4570(50) y	0.003	-7.787(2)	-0.241(1)	[**1983Ba32**]
^{167}Tm		1/2$^+$	9.25(2) d	0.746(1)	-6.762(1)	1.413(1)	[**1970Ka23**]
^{171}Lu		7/2$^+$	8.22(3) d	1.478(2)	-5.322(2)	3.036(2)	[**1970Ka23**]
^{175}Ta		7/2$^+$	10.5(2) h	2.073(28)	-4.127(28)	4.473(28)	[**1963Sa14**]
^{179}Re		5/2$^+$	19.5(1) m	2.711(27)	-3.275(58)#	5.473(25)	[**1975Me20**]
^{183}Ir		5/2$^-$	55(7) m	3.460(50)	-2.05(11)	6.668(29)	[**1961Di04**]
^{187}Au		1/2$^+$	8.3(3) m*	3.657(27)	-1.145(28)	8.210(55)	[**1983Ga01, 1979Be51**]
^{191}Tl		(1/2$^+$)		4.309(23)	-0.738(8)	7.977(25)	
^{195}Bi		(9/2$^-$)	187(5) s	5.712(7)	1.623(15)	10.141(23)	[**1985Co06**]
^{195m}Bi	0.401(7)	(1/2$^+$)	87(1) s	6.113(10)	2.024(17)	10.542(24)	[**1985Co06**]
^{199}At		(9/2$^-$)	6.92(13) s	6.415(8)	3.262(28)	12.490(7)	[**2013Ja06**]
^{199m}At	$\approx$ 0.240	(1/2$^+$)	0.31(8) s	$\approx$6.655(8)	$\approx$3.502(28)	$\approx$12.710(7)	[**2013Ja06**]
^{203}Fr		(9/2$^-$)	550(7) ms**	7.060(9)	4.183(28)	13.690(8)	[**2013Ja06, 2005De01, 2005Uu02, 1980Ew03**]
^{203m}Fr	$\approx$ 0.360	(1/2$^+$)	43(4) ms	$\approx$7.420(9)	$\approx$4.543(28)	$\approx$14.050(8)	[**2013Ja06**]
^{207}Ac		(9/2$^-$)	27^{+11}_{-6} ms	7.630(80)	5.104(63)	14.905(57)	[**1998Es02**]
^{211}Pa		(9/2$^-$)	$3.8^{+4.6}_{-1.4}$ ms	8.18(11)	5.999(93)	16.113(91)	[**2020Au04**]

* Weighted average of 8.4(3) m [1983Ga01] and 8.0(4) m [1979Be51].
** Weighted average of 550(10) ms [2013Ja06], 560(15) ms [2005De01], 530(20) ms [2005Uu02], and 550(20) ms [1980Ew03].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +29/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_p$	S$_{2p}$	Q$_\alpha$	BR$_\alpha$	Experimental
^{163}Ho	5.486	13.494(1)	0.730(1)		
^{167}Tm	4.908(1)	12.223(1)	1.410(1)		
^{171}Lu	4.354(2)	11.132(2)	2.290(2)		
^{175}Ta	3.853(28)	10.106(28)	2.995(28)		
^{179}Re	3.466(29)	9.448(25)	3.399(37)		
^{183}Ir	2.882(33)	8.263(28)	3.957(35)		
^{187}Au	2.453(31)	7.271(36)	4.748(30)	$\approx 2\times10^{-3}$%*	[**1968Si01**]
^{191}Tl	2.201(18)	7.279(21)	4.321(24)		
^{195}Bi	1.107(18)	5.126(9)	5.832(5)	0.01 - 0.05%	[**1985Co06**, 1993An19, 1990AnZR, 1989AnZF, 1978Va21, 1974Le02, 1973LiYK, 1972Ga27, 1970Ta14, 1967Es05]
^{195m}Bi	0.706(19)	4.725(11)	6.233(9)	16 - 49%	[**1985Co06**, 1993An19, 1978Va21, 1974Le02, 1973LiYK, 1972Ga27, 1970Ta14, 1967Es05]
^{199}At	0.639(18)	3.714(10)	6.830(1)***	92^{+3}_{-8}%	[**2013Ja06, 1996Ta18, 1980Ew03**, 2015We13, 2015We16, 1986Wo03, 1975BaYJ, 1967Tr04, 1967Tr06]
^{199m}At	$\approx$0.399(18)	$\approx$3.474(10)	$\approx$7.017(1)	$\approx$ 1%	[**2013Ja06**]
^{203}Fr	0.138(19)	2.912(10)	7.275(4)	$\approx$ 100%**	[**2013Ja06, 2005De01, 2005Uu02, 1980Ew03, 1967Va20** 2015We13, 2004DeZV, 1994Le05]
^{203m}Fr	$\approx$-0.222(19)	$\approx$2.552(10)	$\approx$7.635(4)	20(4) %	[**2013Ja06**, 2005Uu02]
^{207}Ac	-0.292(59)#	2.122(57)#	7.855(18)$^@$	$\approx$ 100%	[**1998Es02, 1994Le05**, 1998LuZV]
^{211}Pa	-0.704(72)	1.371(89)	8.481(41)	100 %	[**2020Au04**, 2006Ku07]

* Value estimated by setting HF =1 (see table 3).
** Based on short half-life.
*** Deduced from α energy, 6.777(1) in [2021Wa16].
@ Deduced from α energy, 7.845(56)# in [2021Wa16].

Table 3
direct α emission from ^{187}Au*, J$^\pi_i$ = 1/2$^+$, T$_{1/2}$ = 8.3(3)s**, $BR_\alpha = \approx 2\times10^{-3}$%***.

E_α(c.m.)	E_α(lab)	I_α(abs)	J$^\pi_f$	$E_{daughter}$(^{183}Ir)	coincident γ-rays	R$_0$ (fm)	HF
4.793(20)	4.690(20)	$\approx 2\times10^{-3}$%***	(1/2$^+$)				

* All values from [1968Si08], except where noted.
** weighted average of 8.4(3) m [1983Ga01] and 8.0(4) m [1979Be51].
*** Value estimated by setting HF =1.

Table 4
direct α emission from ^{195}Bi*, J_i^π = (9/2$^-$), $T_{1/2}$ = 187(5) s, BR_α = 0.01 - 0.05%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{191}Tl)	coincident γ-rays	R_0 (fm)	HF
5.534(5)	5.420(5)	100%	0.9 - 4.5 $\times10^{-4}$%	(9/2$^-$)	0.299		1.475(14)	1.0 - 5.2
5.833(5)	5.713(5)	10(1)%	0.9 - 4.5 $\times10^{-5}$%	(1/2$^+$)	0.0	—	1.475(14)	290 - 1400

* All values from [1985Co06].

Table 5
direct α emission from ^{195m}Bi*, Ex. = 401(7) keV, J_i^π = (1/2$^+$), $T_{1/2}$ = 87(1) s, BR_α = 16 - 49%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{191}Tl)	coincident γ-rays	R_0 (fm)	HF
5.893(5)	5.772(5)	0.16(2)%	0.036 - 0.078 %	(9/2$^-$)	0.341	0.341	1.475(14)	15 - 45
6.234(5)	6.106(5)	100%	16 -49 %	(1/2$^+$)	0.0	—	1.475(14)	0.73 - 2.2

* All values from [1985Co06].

Table 6
direct α emission from ^{199}At, J_i^π = (9/2$^-$), $T_{1/2}$ = 6.92(13) s*, BR_α = 92^{+3}_{-8}%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{195}Bi)	coincident γ-rays	R_0 (fm)	HF
6.830(1)	6.693(1)***	92^{+3}_{-8}%**	(9/2$^-$)	0.0	—	1.5084(56)	2.2(3)

* [2013Ja06].
** [1980Ew03].
*** [1996Ta18].

Table 7
direct α emission from ^{199m}At*, Ex. = $\approx$ 240 keV, J_i^π = (1/2$^+$), $T_{1/2}$ = 0.31(8) s, BR_α = $\approx$ 1%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{195}Bi)	coincident γ-rays	R_0 (fm)	HF
$\approx$ 6.613	$\approx$ 6.480	$\approx$ 1%	(1/2$^+$)	0.401(7)		1.5084(56)	$\approx$ 1.6

* All values from [2013Ja06].

Table 8
direct α emission from ^{203}Fr, J_i^π = (9/2$^-$), $T_{1/2}$ = 550(7) ms*, BR_α = $\approx$ 100 %.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{199}At)	coincident γ-rays	R_0 (fm)	HF
7.274(3)	7.133(3)**	$\approx$ 100%	(9/2$^-$)	0.0	—	1.5178(95)	$1.3^{+0.3}_{-0.2}$

* Weighted average of 550(10) ms [2013Ja06], 560(15) ms [2005De01], 530(20) ms [2005Uu02], and 550(20) ms [1980Ew03].
** Weighted average of 7.130(6) MeV [2013Ja06], 7.132(5) MeV [2005De01], 7.130(6) MeV [2005Uu02], and 7.130(5) MeV [1967Va20].

Table 9
direct α emission from ^{203m}Fr*, Ex. = $\approx$ 360 keV, J_i^π = (1/2$^+$), $T_{1/2}$ = 43(4) ms, BR_α = 20(4) %.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{199}At)	coincident γ-rays	R_0 (fm)	HF
7.395(5)	7.246(5)	20(4) %	(1/2$^+$)	$\approx$ 0.240		1.5178(95)	$1.3^{+0.6}_{-0.4}$

* All values from [2013Ja06].

Table 10
direct α emission from ^{207}Ac, J_i^π = (9/2$^-$), $T_{1/2}$ = 27^{+11}_{-6} ms*, BR_α = ≈ 100 %.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{203}Fr)	coincident γ-rays	R_0 (fm)	HF
7.855(18)	7.703(18)**	≈ 100%	(9/2$^-$)	0.0	—	1.542(11)	$1.7^{+0.8}_{-0.6}$

* [1998Es02].
** Weighted average of 7.693(25) MeV [1998Es02] and 7.712(25) meV [1994Le05].

Table 11
direct α emission from ^{211}Pa*, J_i^π = (9/2$^-$), $T_{1/2}$ = $3.8^{+4.6}_{-1.4}$ ms, BR_α = 100 %.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{207}Ac)	coincident γ-rays	R_0 (fm)	HF
8.481(40)	8.320(40)	100%	(9/2$^-$)	0.0	—	1.508(27)	$1.7^{+2.3}_{-1.2}$

* All values from [2020Au04].

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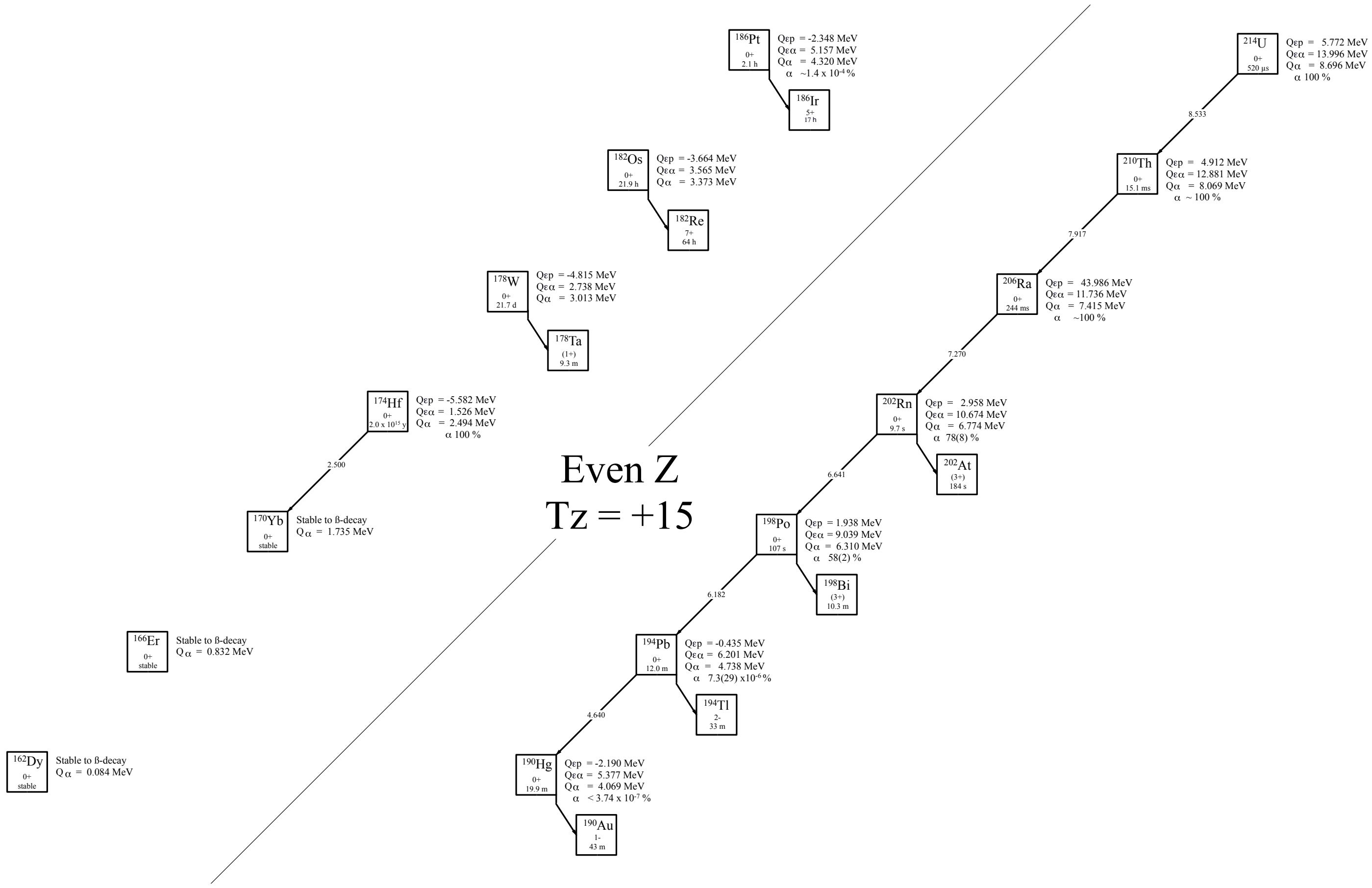

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +15 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the even-Z, $T_z = +15$ nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{162}Dy	0^+	stable	-2.302(2)	—	—	
^{166}Er	0^+	stable	-1.853(1)	—	—	
^{170}Yb	0^+	stable	-0.969(1)	—	—	
^{174}Hf	0^+	2.0(4) × 10^{15} y	-0.274(2)	—	—	[**1961Ma05**]
^{178}W	0^+	21.7(4) d*	0.190(50)#	-4.815(15)	2.738(15)#	[**1964Sa16, 1963Ra14**]
^{182}Os	0^+	21.9(1) h	0.840(100)	-3.664(22)	3.565(57)	[**1958Fo47**]
^{186}Pt	0^+	2.10(5) h	1.308(27)	-2.348(22)	5.157(104)	[**1991Be25**]
^{190}Hg	0^+	19.9(4) m**	1.463(16)	-2.190(19)	5.377(23)	[**1964Ja05, 1961An02**]
^{194}Pb	0^+	12.0(5) m	2.730(22)	-0.435(23)	6.201(18)	[**1987El09**]
^{198}Po	0^+	107(2) s***	3.900(30)	1.983(18)	9.039(22)	[**1994Wa13, 1971Ho01, 1967Si09**
^{202}Rn	0^+	9.7(2) s$^@$	4.320(30)	2.958(18)	10.674(33)	[**1992Wa29, 1971Ho01**]
^{206}Ra	0^+	244(13) ms$^{@@}$	4.810(30)	3.986(19)	11.736(33)	[**2021Ni08, 1987He10**]
^{210}Th	0^+	15.1(27) ms$^{@@@}$	5.300(70)	4.912(20)	12.881(34)	[**2023Ch23, 2010He25**]
^{214}U	0^+	520^{+950}_{-210} μs	5.721(84)^a	5.772(28)^a	13.996(65)^a	[**2021Zh22**]

* Weighted average of 21.4(5) d [1964Sa16] and 22.0(5) d [1963Ra14].
** Weighted average of 20.0(5) m [1964Ja05] and 19.8(6) m [1961An02].
*** Weighted average of 105(3) s [1994Wa13], 107(3) s [1971Ho01] and 1.80(5) s [1967Si09].
@ Weighted average of 9.5(2) s [1992Wa29], and 9.7(2) s [1971Ho01].
@@ Weighted average of 248(18) ms [2021Ni08], and 240(20) ms [1987He10].
@@@ Weighted average of 14(4) ms [2023Ch24], and 16.0(36) ms [2010He25].
^{a} From Q_α of ^{214}U and daughter values from [2021Wa16].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the even-Z, $T_z = +15$ nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{162}Dy	8.008(1)	14.817(1)	0.084(1)		
^{166}Er	7.315(1)	13.534(1)	0.832(1)		
^{170}Yb	6.778(1)	12.353	1.735(0)		
^{174}Hf	6.253(2)	11.167(2)	2.494(2)	100%	[**1961Ma05, 2020Ca15**, 2021Br09, 1960Ma29, 1959Ri34]
^{178}W	5.981(15)	10.409(15)#	3.013(15)		
^{182}Os	5.381(25)	9.551(22)	3.373(27)		
^{186}Pt	4.818(35)	8.190(22)	4.320(18)	≈ 1.4 × 10^{-4}%	[**1963Gr08**]
^{190}Hg	5.078(26)	8.128(17)	4.069(27)	< 3.4 × 10^{-7}%	
^{194}Pb	4.020(19)	6.774(23)	4.738(17)	7.3(29) × 10^{-6}%	[**1987El09**]
^{198}Po	3.075(19)	4.703(19)	6.310(1)	58(2)%*	[**1998Bo14, 1996Ta18, 1994Wa03, 1993Wa04, 1971Ho01, 1967Si09**, 2022We04, 2015We13, 2015We16, 2014Ma66, 1993WaZO, 1989De18, 1984Da14, 1982Bo04, 1967Le21, 1967Tr04, 1967Tr06, 1965Br17, 1965Si22, 1964Br23]
^{202}Rn	2.774(19)	3.911(19)	6.774(2)	78(8)%	[**2000Va34, 1992Wa29, 1987He10**, 2015We16, 1996Ta18, 1993Wa04, 1992WaZV, 1991Wa29, 1971Ho01, 1969Ha03, 1967Va07, 1967Va17, 1965Nu04]
^{206}Ra	2.414(20)	3.042(19)	7.415(4)	≈ 100%**	[**1996Le09, 1987He10, 1967Va22**, 2021Ni08, 2021NiZW, 1995Le41, 1968Lo15]
^{210}Th	2.074(59)	2.246(21)	8.069(6)	≈ 100%**	[**2023Ch23, 2010He25**, 1995Le15, 1995Le41, 1995Uu01]
^{214}U	1.758(65)***	1.508(28)***	8.696(18)***	100 %	[**2021Zh22**]

* Weighted average of 59(3)% [1998Bo04] and 57(2)% [1994Wa13, 1993Wa04].
** Based on short half-life.
*** From Q_α of ^{214}U and daughter values from [2021Wa16].

Table 3
direct α emission from ^{174}Hf*, $J_i^\pi = 0^+$, $T_{1/2} = 2.0(4) \times 10^{15}$ y, BR_α = 100 %.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{170}Yb)	coincident γ-rays	R_0 (fm)	HF
2.559(30)	2.500(30)	100 %	0^+	0.0	—	1.4833(91)	0.23(5)**

* All values from [1961Ma05].
** This unphysically low value may indicate that the actual half-life is longer than reported in [1961Ma05]. Using a value of 9×10^{15} y gives a HF = 1.0.

Table 4
direct α emission from ^{186}Pt*, $J_i^\pi = 0^+$, $T_{1/2}$ = 2.10(5) h**, $BR_\alpha = \approx 1.4 \times 10^{-4}$%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{182}Os)	coincident γ-rays	R_0 (fm)	HF
4.323(20)	4.230(20)	$\approx 1.4 \times 10^{-4}$%	0^+	0.0	—	1.536(30)	≈ 1.3

* All values from [1963Gr08], except where noted.
** [1991Be25].

Table 5
direct α emission from ^{194}Pb*, $J_i^\pi = 0^+$, $T_{1/2}$ = 12.0(5) m, $BR_\alpha = 7.3(29) \times 10^{-6}$%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{190}Hg)	coincident γ-rays	R_0 (fm)	HF
4.738(20)	4.640(20)	$7.3(29) \times 10^{-6}$%	0^+	0.0	—	1.437(24)	$1.1^{+0.8}_{-0.4}$

* All values from [1987El09].

Table 6
direct α emission from ^{198}Po, $J_i^\pi = 0^+$, $T_{1/2}$ = 107(2) s*, BR_α = 58(2)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{194}Pb)	coincident γ-rays	R_0 (fm)	HF
6.309(1)	6.182(1)	58(2)%**	0^+	0.0	—	1.4962(19)	0.99(4)

* Weighted average of 105(3) s [1994Wa13], 107(3) s [1971Ho01] and 1.80(5) s [1967Si09].
** Weighted average of 59(3)% [1998Bo04] and 57(2)% [1994Wa13, 1993Wa04].

Table 7
direct α emission from ^{202}Rn, $J_i^\pi = 0^+$, $T_{1/2}$ = 9.7(2) s*, BR_α = 78(8)%**.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{198}Po)	coincident γ-rays	R_0 (fm)	HF
5.954(5)	5.836(5)***	$1.8(6) \times 10^{-3}$%***	$1.4(5) \times 10^{-3}$%	0^+	0.816	0.211, 0.605	1.5106(49)	21^{+12}_{-6}
6.775(1)	6.641(1)@	100%	78(8)%**	0^+	0.0	—	1.5106(49)	1.0(1)

* Weighted average of 9.5(2) s [1992Wa29], and 9.7(2) s [1971Ho01].
** [1987He10].
*** [1992Wa29].
@ [2000Va34].

Table 8
direct α emission from ^{206}Ra, $J_i^\pi = 0^+$, $T_{1/2}$ = 244(13) ms*, BR_α = ≈ 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{202}Rn)	coincident γ-rays	R_0 (fm)	HF
7.414(4)	7.270(4)**	≈ 100%	0^+	0.0	—	1.5287(42)	1.00(5)

* Weighted average of 248(18) ms [2021Ni08], and 240(20) ms [1987He10].
** Weighted average of 7.268(10) MeV [1996Le09], 7.270(10) MeV [1987He10] and 7.270(5) MeV [1967Va22].

Table 9
direct α emission from ^{210}Th, $J_i^\pi = 0^+$, $T_{1/2}$ = 15.1(27) ms*, $BR_\alpha = \approx 100\%$.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{206}Ra)	coincident γ-rays	R_0 (fm)	HF
8.071(6)	7.917(6)	≈ 100%	0^+	0.0	—	1.507(11)	0.97(17)

* Weighted average of 14(4) ms [2023Ch24], and 16.0(36) ms [2010He25].
* [2010He25].

Table 10
direct α emission from ^{214}U*, $J_i^\pi = 0^+$, $T_{1/2} = 520^{+950}_{-210}$ μs, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{210}Th)	coincident γ-rays	R_0 (fm)	HF
8.696(18)	8.533(18)	≈ 100%	0^+	0.0	—		

* All values from [2021Zh22].

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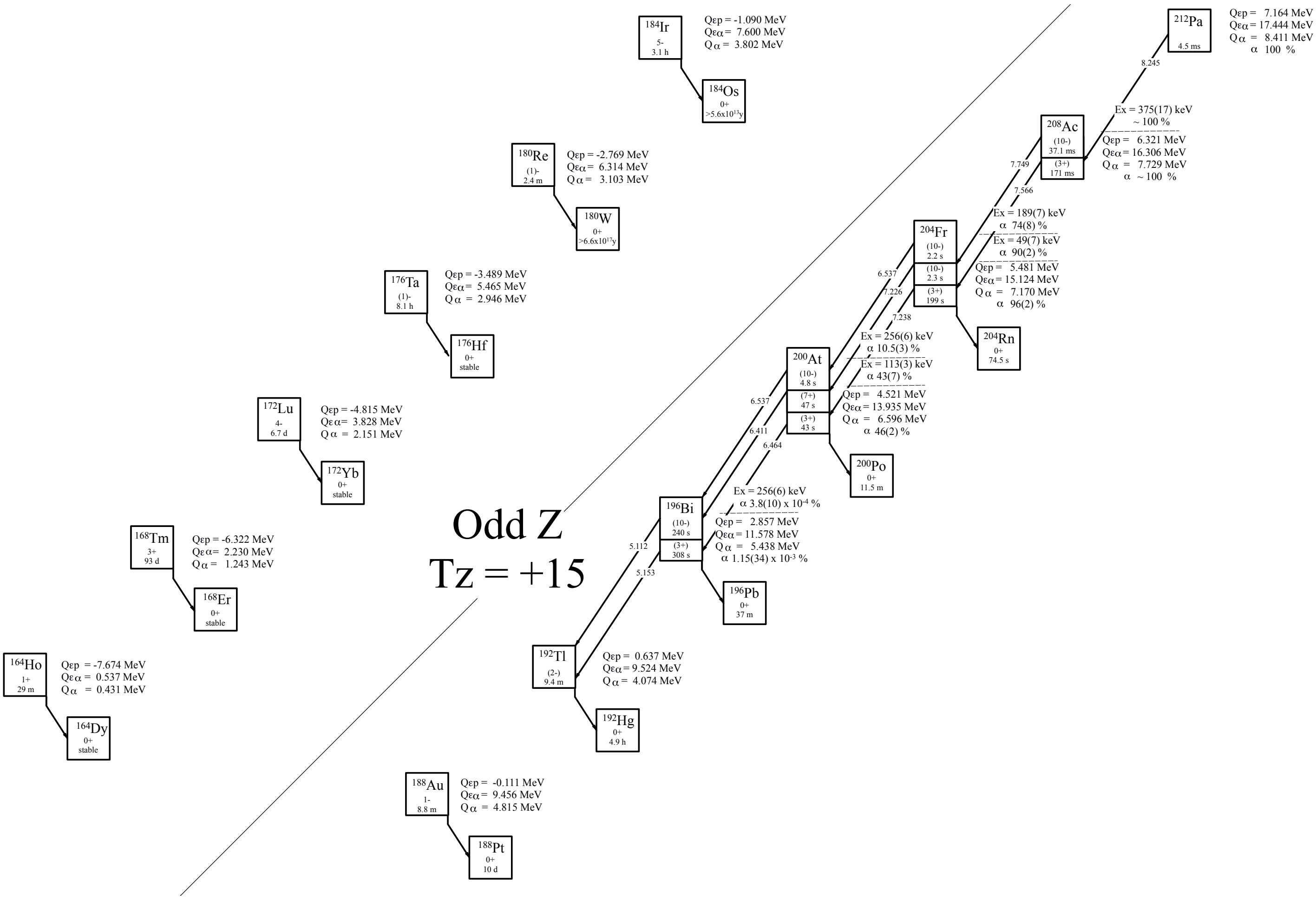

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +15 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +15 nuclei. J^π values for ^{164}Ho, ^{168}Tm, ^{172}Lu, ^{176}Ta, ^{180}Re, ^{184}Ir, ^{188}Au, and ^{192}Tl are taken from ENSDF. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{164}Ho		1^+	29.0(5) m	0.987(1)	-7.674(4)	0.537(2)	[**1972Ka19**]
^{168}Tm		3^+	93.1(1) d	1.6772(2)	-6.322(6)	2.230(2)	[**1968Ne02**]
^{172}Lu		4^-	6.70(4) d	2.519(2)	-4.815(3)	3.828(2)	[**1960Wi11**]
^{176}Ta		$(1)^-$	8.08(7) h	3.210(30)	-3.489(31)	5.465(31)	[**1969Bo23**]
^{180}Re		$(1)^-$	2.42(7) m	3.799(21)	-2.769(21)	6.314(21)	[**1955Fi30**]
^{184}Ir		5^-	3.14(2) h	4.642(28)	-1.090(29)	7.600(28)	[**1982Al34**]
^{188}Au		1^-	8.84(60 m	5.450(6)	-0.111(28)	9.456(3)	[**1972Fi12**]
^{192}Tl		(2^-)	9.4(2) m	6.140(40)	0.637(32)	9.524(32)	[**1979To06**]
^{196}Bi		(3^+)	308(12) s	7.339(26)	2.857(27)	11.578(29)	[**1991Va04, 1992Hu04**]
^{196m}Bi	0.256(6)*	(10^-)	240(3) s	7.595(27)	3.113(28)	11.834(30)	[**1991Va04, 1992Hu04**]
^{200}At		(3^+)	43(1) s	7.954(26)	4.521(27)	13.935(26)	[**1992Hu04**]
^{200m1}At	0.113(3)	(7^+)	47(1) s	8.008(26)	4.688(27)	14.048(26)	[**1992Hu04**]
^{200m2}At	0.256(6)	(10^-)	4.8(3) s**	9.067(26)	4.777(28)	14.191(27)	[**1996Ta18, 1967Tr06**]
^{204}Fr		(3^+)	1.99(12) s	8.577(26)	5.481(27)	15.124(26)	[**2022Ya27**]
^{204m1}Fr	0.049(7)	(7^+)	2.3(3) s***	8.626(27)	5.530(28)	15.173(27)	[**2005Uu02, 1992Hu04**]
^{204m2}Fr	0.189(7)	(10^-)	2.19(41) s	8.766(27)	5.4670(28)	15.313(27)	[**2022Ya27**]
^{208}Ac		(3^+)	171(13) ms	9.030(70)	6.321(67)	16.306(65)	[**2022Ya27**]
^{208m}Ac	0.375(17)	(10^-)	37.1(37) ms	9.405(72)	6.696(69)	16.681(67)	[**2022Ya27**]
^{212}Pa			$4.5^{+2.7}_{-1.3}$ ms	9.490(90)	7.164(103)	17.444(88)	[**2020Au04**]

* Deduced from the ^{200}At α decay energies.
** Weighted average of 6.3(5) s [1996Ta18] and 4.3(3) s [1967Tr06].
*** Weighted average of $1.6^{+0.5}_{-0.3}$ s [2005Uu02], and 2.6(3) s [1992Hu04].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +15 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{164}Ho	5.889(1)	13.679(2)	0.431(2)		
^{168}Tm	5.312(2)	12.820(2)	1.243(2)		
^{172}Lu	4.718(2)	11.519(2)	2.151(3)		
^{176}Ta	4.173(31)	10.373(31)	2.946(31)		
^{180}Re	3.831(26)	9.817(56)	3.103(37)		
^{184}Ir	3.236(57)	8.74(11)	3.802(35)		
^{188}Au	2.975(24)	7.777(17)	4.815(28)		
^{192}Tl	2.569(39)	7.617(32)	4.074(32)		
^{196}Bi	1.560(25)	5.649(28)	5.438(40)	$1.15(34) \times 10^{-3}$ %	[**1991Va04, 1992Hu04**]
^{196m}Bi	1.304(26)	5.393(29)	5.694(41)	$3.8(10) \times 10^{-4}$ %	[**1991Va04, 1992Hu04**]
^{200}At	1.038(25)	4.192(37)	6.596(1)	46(2)%*	[**1998Bo14, 1996Ta18, 1992Hu04**, 2005Uu02, 1995BiZZ, 1975BaYJ, 1967Tr04, 1967Tr06]
^{200m1}At	0.925(25)	4.079(37)	6.709(2)	43(7)%	[**1992Hu04**, 2015We13, 2005Uu02, 1995BiZZ, 1975BaYJ, 1967Tr04, 1967Tr06]
^{200m2}At	0.782(26)	3.936(38)	6.852(6)	10.5(3)%	[**2005Uu02, 1996Ta18, 1992Hu04, 1967Tr06**, 1995BiZZ, 1975BaYJ, 1967Tr04]
^{204}Fr	0.498(25)	3.376(37)	7.170(2)	96(2)%	[**2014Ly01, 1995BiZZ, 1992Hu04**, 2005Uu02, 1974Ho27, 1964Gr04]
^{204m1}Fr	0.449(26)	3.327(38)	7.219(7)	90(2)%	[**2014Ly01, 1995BiZZ, 1992Hu04**, 2005Uu02]
^{204m2}Fr	0.4309(26)	3.187(38)	7.359(7)	74(8)%	[**2014Ly01, 1995BiZZ, 1992Hu04**, 2005Uu02]
^{208}Ac	0.042(87)	2.570(70)	7.714(10)***	≈100%**	[**2022Ya27, 1994Le15**, 2014Ya19, 1998LuZV, 1996Ik01]
^{208m}Ac	-0.333(89)	2.195(72)	8.089(20)	≈100%**	[**2022Ya27, 1994Le15**, 1998LuZV, 1996Ik01]
^{212}Pa	-0.431(123)	1.75(11)	8.411(59)	100%**	[**2020Au04, 2014Ya19, 1997Mi03**, 1997MiZX]

* Weighted average of 49(4)% [1998Bo14], 44(2)% [1996Ta18] and 57(6)% [1992Hu04].
** Based on short half-life.
*** Deduced from α energy, 7.729(60) in [2021Wa16].

Table 3
direct α emission from ^{196}Bi*, J_i^π = (3$^+$), $T_{1/2}$ = 308(12) s, BR_α = 1.15(34) × 10^{-3} %.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{192}Tl)	coincident γ-rays	R_0 (fm)***	HF
5.260(10)	5.153(10)	1.15(34) × 10^{-3} %	(3$^+$)	0.178(40)**		1.467(24)	$2.2^{+1.9}_{-1.1}$

* All values from [1991Va04, 1992Hu04], except where noted.
** [2012Ba36].
*** Interpolated between 1.437(24) fm (^{194}Pb) and 1.4962(19) fm (^{198}Po).

Table 4
direct α emission from ^{196m}Bi*, Ex. = 256(6) keV, J_i^π = (10$^-$), $T_{1/2}$ = 240(3) s, BR_α = 3.8(10) × 10^{-4} %.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{192}Tl)	coincident γ-rays	R_0 (fm)***	HF
5.219(10)	5.112(10)	3.8(10) × 10^{-4} %	(10$^-$)	0.3204 + x**		1.467(24)	$3.1^{+2.5}_{-1.5}$

* All values from [1991Va04, 1992Hu04], except where noted.
** [2012Ba36].
*** Interpolated between 1.437(24) fm (^{194}Pb) and 1.4962(19) fm (^{198}Po).

Table 5
direct α emission from ^{200}At, J_i^π = (3$^+$), $T_{1/2}$ = 43(1) s*, BR_α = 46(2)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{196}Bi)	coincident γ-rays	R_0 (fm)@	HF
6.596(1)	6.464(1)*	46(2)%**	(3$^+$)	0.0	—	1.5034(53)	3.3(4)

* [1992Hu04].
** Weighted average of 49(4)% [1998Bo14], 44(2)% [1996Ta18] and 57(6)% [1992Hu04].
*** [1996Ta18].
@ Interpolated between 1.4962(19) fm (^{198}Po) and 1.5106(49) (^{202}Rn).

Table 6
direct α emission from ^{200m1}At*, Ex. = 113(3) keV, J_i^π = (7$^+$), $T_{1/2}$ = 47(1) s, BR_α = 43(7)%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{196}Bi)	coincident γ-rays	R_0 (fm)**	HF
6.435(5)	6.306(5)	0.17(4)%	0.073(15)%	(10$^-$)	0.256(6)		1.5034(53)	1300^{+500}_{-300}
6.542(2)	6.411(2)	100(16)%	43(7)%	(7$^+$)	0.054(2)		1.5034(53)	$6.6^{+1.7}_{-1.3}$
6.709(3)	6.575(3)	0.84(20)%	0.36(6)%	(3$^+$)	0.0	—	1.5034(53)	1300^{+600}_{-300}

* All values from [1992Hu04], except where noted.
** Interpolated between 1.4962(19) fm (^{198}Po) and 1.5106(49) (^{202}Rn.

Table 7
direct α emission from ^{200m2}At, Ex. = 256(6) keV, J_i^π = (10$^-$), $T_{1/2}$ = 4.8(3) s*, BR_α = 10.5(3)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{196}Bi)	coincident γ-rays	R_0 (fm)@	HF
6.670(2)	6.537(2)***	10.5(3)%**	(10$^-$)	0.256(6)		1.5034(53)	3.1(4)

* Weighted average of 6.3(5) s [1996Ta18] and 4.3(3) s [1967Tr06].
** [1992Hu04].
*** Weighted average of 6.534(6) MeV [2005Uu02], 6.538(3) MeV [1992Hu04] and 6.536(5) MeV [1996Ta18]. [1996Ta12] report 6.528(1) MeV, which is not consistent with the other measured values.
@ Interpolated between 1.4962(19) fm (^{198}Po) and 1.5106(49) (^{202}Rn.

Table 8
direct α emission from ^{204}Fr, J_i^π = (3$^+$), $T_{1/2}$ = 1.99(12) s, BR_α = 96(2)%**.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{200}At)	coincident γ-rays	R_0 (fm)@	HF
7.054(8)	6.916(8)***	≤0.6%	≤0.6%		0.113(3)		1.5197(65)	≥18
7.172(5)	7.031(5)***	100%	95(2)%	(3$^+$)	0.0	—	1.5197(65)	2.4(4)

* [2022Ya27].
** [1995BiZZ].
*** [1992Hu04].
@ Interpolated between 1.5106(49) fm (^{202}Rn) and 1.5287(42) fm (^{206}Ra).

Table 9
direct α emission from ^{204m1}Fr*, Ex. = 49(7) keV, J_i^π = (7$^+$), $T_{1/2}$ = 2.3(3) s*, BR_α = 90(2)%**.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{200}At)	coincident γ-rays	R_0 (fm)**	HF
7.108(5)	6.969(5)***	100%	89(2)%	(7$^+$)	0.113(3)		1.5197(65)	≥250
7.219(8)	7.077(8)	≤0.7%	≤0.6%	(3$^+$)	0.0	—	1.5197(65)	4.4(9)

Weighted average of $1.6^{+0.5}_{-0.3}$ s [2005Uu02] and 2.63) s [1992Hu04].
** [1995BiZZ].
*** [1992Hu04].
@ Interpolated between 1.5106(49) fm (^{202}Rn) and 1.5287(42) fm (^{206}Ra).

Table 10
direct α emission from ^{204m2}Fr, Ex. = 189(7) keV, J_i^π = (10$^-$), $T_{1/2}$ = 0.8(2) s*, BR_α = 74(8)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{200}At)	coincident γ-rays	R_0 (fm)@	HF
7.155(4)	7.015(4)***	10.5(3)%**	(10$^-$)	0.256(6)		1.5197(65)	2.0(3)

* [2005Uu02].
** [1995BiZZ].
*** Weighted average of 7.017(6) MeV [2005Uu02] and 7.013(5) MeV [1992Hu04].
@ Interpolated between 1.4962(19) fm (^{198}Po) and 1.5106(49) (^{202}Rn.

Table 11
direct α emission from ^{208}Ac, J_i^π = (3$^+$), $T_{1/2}$ = 171(13) ms*, BR_α = ≈100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{204}Fr)	coincident γ-rays	R_0 (fm)***	HF
7.630(15)	7.483(15)*	>5%	>5%	(2$^+$, 4$^+$)	0.079(21)		1.518(12)	<26
7.714(10)	7.566(10)**	100%	<95%	(3$^+$)	0.0	—	1.518(12)	2.5(8)

* [2022Ya27].
** Weighted average of 7.483(15) MeV [2022Ya27] and 7.572(15) MeV [1994Le02].
*** Interpolated between 1.5287(42) (^{206}Ra) and 1.507(11) (^{210}Th).

Table 12
direct α emission from ^{208m}Ac, Ex. = 375(17) keV, J_i^π = (10$^-$), $T_{1/2}$ = 37.1(37) ms*, BR_α = ≈100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{204}Fr)	coincident γ-rays	R_0 (fm)***	HF
7.901(12)	7.749(12)**	100%	(10$^-$)	0.189(7)		1.518(12)	$2.0^{+0.7}_{-0.5}$

* [2022Ya27].
** Weighted average of 7.745(14) MeV [2022Ya27] and 7.758(20) MeV [1994Le02].
*** Interpolated between 1.5287(42) (^{206}Ra) and 1.507(11) (^{210}Th).

Table 13
direct α emission from ^{212}Pa, J_i^π = , $T_{1/2} = 4.5^{+2.7}_{-1.3}$ ms*, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{208}Ac)	coincident γ-rays	R_0 (fm)	HF
8.404(14)	8.245(14)**	100%					

* [2020Au04].
** Weighted average of 8.240(20) MeV [2020Au04] and 8.250(20) MeV [2014Ya19].

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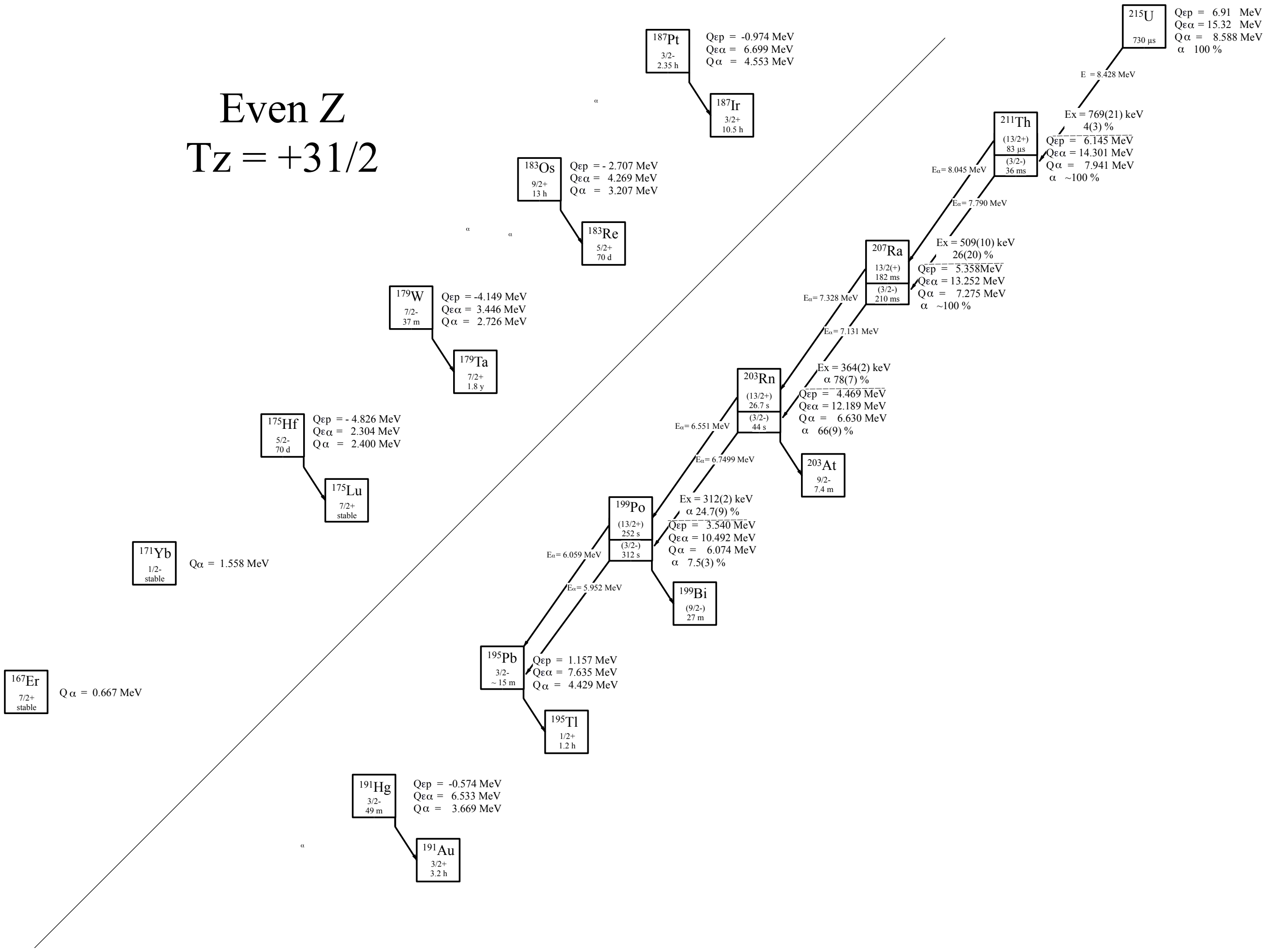

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +31/2 nuclei.

Last updated 9/26/2023

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +31/2 nuclei. J$^\pi$ values for ^{167}Er, ^{171}Yb, ^{175}Hf, ^{179}W, ^{183}Os, ^{187}Pt, ^{191}Hg and ^{195}Pb are taken from ENSDF. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex	J^π	$T_{1/2}$	Qε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{167}Er		7/2$^+$	stable	-1.010(5)	—	—	
^{171}Yb		1/2$^-$	stable	-0.097(1)	—	—	
^{175}Hf		5/2$^-$	70(2) d	0.684(2)	-4.826(2)	2.304(2)	[**1963Ra14**]
^{179}W		7/2$^-$	37.00(17) m	1.062(15)	-4.149(15)	3.446(15)	[**1969Bi10**]
^{183}Os		9/2$^+$	13.0(5) h	2.150(50)	-2.707(50)	4.269(50)	[**1960Ne03**]
^{187}Pt		3/2$^-$	2.35(3) h	2.860(40)	-0.974(24)	6.699(25)	[**1973Se13**]
^{191}Hg		3/2$^-$	49(10) m	3.206(23)	-0.574(22)	6.533(36)	[**1974Va19**]
^{195}Pb		3/2$^-$	$\approx$ 15 m	4.417(12)	1.157(6)	7.635(7)	[**1982Hi04**]
^{199}Po		(3/2$^-$)	312(6) s	5.559(12)	3.540(10)	10.492(12)	[**1993Wa04**]
^{199m}Po	0.312(2)	(13/2$^+$)	252(6) s	5.871(12)	3.852(10)	10.804(12)	[**1993Wa04**]
^{203}Rn		(3/2$^-$)	44(2) s*	5.979(12)	4.469(10)	12.189(12)	[**1996Ta18, 1971Ho01**]
^{203m}Rn	0.364(2)	(13/2$^+$)	26.7(5) s	6.343(12)	4.833(10)	12.553(12)	[**1996Ta18**]
^{207}Ra		(3/2$^-$)	1.2(2) s	6.360(60)	5.358(59)	13.252(59)	[**1996Ta18, 1971Ho01**]
^{207m}Ra	0.509(10)	(13/2$^+$)	55(7) ms**	6.869(61)	5.867(60)	13.761(60)	[**2021Ni08, 1987He10**]
^{211}Th		(3/2$^-$)	36^{+13}_{-6} ms***	6.73(10)	6.145(87)	14.301(88)	[**2023Ch24, 1995Uu01**]
^{211m}Th	0.769(21)	(13/2$^+$)	83(8) μs	7.50(23)	6.914(89)	15.070(90)	[**2021Au03**]
^{215}U			$0.73^{+1.33}_{-0.29}$ ms	7.08(13)	6.91(11)	15.32(12)	[**2015Ya13**]

* Weighted average of 42(3) s [1996Ta18] and 45(2) s [1971Ho01].
** Weighted average of 55(9) ms [2021Ni08] and 55(10) ms [1987He10].
*** Weighted average of 36^{+15}_{-8} ms [2023Ch24] and 37^{+28}_{-11} ms [1995Uu01].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the even-Z, T_z = +31/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_p$	S$_{2p}$	Q$_\alpha$	BR$_\alpha$	Experimental
^{167}Er	7.508(1)	14.255(1)	0.667(1)		
^{171}Yb	6.800(1)	12.964	1.558		
^{175}Hf	6.200(2)	11.508(2)	2.400(2)		
^{179}W	5.986(54)	10.992(15)	2.762(15)		
^{183}Os	5.51(11)	10.01(51)	3.207(52)		
^{187}Pt	4.802(29)	8.457(24)	4.553(55)		
^{191}Hg	5.047(23)	8.700(24)	3.669(33)	$< 5\times10^{-6}$%	[**1963Ka17**]
^{195}Pb	4.090(15)	7.254(16)	4.429(23)		
^{199}Po	3.154(28)	5.071(7)	6.074(2)	7.5(3)%	[**1996Ta18, 1993Wa04, 1971Ho01, 1968Go12**, 1991Gr12 1985St02, 1984Co13, 1967Le08, 1967Si04, 1967Ti04, 1967Tr04, 1967Tr06, 1965Br17, 1965Br27, 1965Si22, 1965Ti03, 1964Br23]
^{199m}Po	2.842(28)	4.759(7)	6.386(3)	24.7(9)%*	[**1996Ta18, 1993Wa04, 1967Le08**, 2015We13, 2016We13, 2014Ma66, 1991Gr12, 1985St02, 1984Co13, 1973BoXL, 1971Ho01, 1968Go12, 1967Si09, 1967Ti04, 1967Tr06, 1965Br17, 1965Br27, 1965Si22, 1965Ti03, 1964Br23, 1962Be26, 1961Be25]
^{203}Rn	2.878(28)	4.241(8)	6.630(2)	66(9)%	[**1996Ta18, 1993Wa04, 1978HoZZ**, 1971Ho01, 1967Va07, 1967Va17, 1965Nu04]
^{203m}Rn	2.514(28)	3.877(8)	6.994(3)	78(7)%	[**1998Bo14, 1996Ta18, 1995Le04, 1993Wa04, 1967Va17**, 2015We13, 1995Le09, 1987He10, 1971Ho01, 1967Va07, 1965Nu04]
^{207}Ra	2.528(65)	3.354(59)	7.272(5)***	obs$^@$	[**1967Va22**, 2021Au03, 2021Ni08, 2021NiZW, 1995Uu01, 1987He10]
^{207m}Ra	2.019(66)	2.845(60)	7.781(11)	26(20)%	[**2021Ni08, 1996Le09, 1987He10**, 2021Au03 2021NiZW]
^{211}Th	2.18(11)	2.560(86)	7.941(10)$^{@@}$	$\approx$ 100%$^@$	[**2023Ch24, 1995Uu01**, 2015Ya13, 2009LaZV, 1995Le15, 1995LeZY]
^{211m}Th	1.41(11)	1.791(89)	8.706(66)	4(3)%	[**2021Au03**]
^{215}U	1.86(13)	1.81(10)	8.588(30)$^{@@@}$	100%	[**2015Ya13**, 2016Zh33, 2015WaZT, 2014WaZU]

* Weighted average of 24(1)% [1993Wa04] and 27.5(20)% [1967Le08].
** Weighted average of 80(10)% [1998Bo14] and 75(10)% [1987He10].
*** Deduced from α energy, 7.273(58) in [2021Wa16].
$^@$ Not measured, but estimated to be close to 100% based on half-life.

@@ Deduced from α energy, 7.937(63) in [2021Wa16].
@@@ Deduced from α energy, 8.588(59) in [2021Wa16].

Table 3
direct α emission from ^{199}Po, J_i^π = (3/2$^-$), $T_{1/2}$ = 312(6) s*, BR_α = 7.5(3)%*.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{195}Pb)	coincident γ-rays	R_0 (fm)	HF
6.074(2)	5.952(2)**	7.5(3)%*	(3/2$^-$)	0.0	—	1.4883(18)	1.96(12)

* [1993Wa04].
** Weighted average of 5.953(2) MeV [1996Ta18], 5.952(2) MeV [1993Wa04] and 5.952(2) MeV [1968Go12].

Table 4
direct α emission from ^{199m}Po, Ex. = 312(2) MeV, J_i^π = (13/2$^+$), $T_{1/2}$ = 252(6) s*, BR_α = 24.7(9)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{195}Pb)	coincident γ-rays	R_0 (fm)	HF
6.183(1)	6.059(1)***	7.5(3)%*	(13/2$^+$)	0.2029(7)@		1.4883(18)	1.43(8)

* [1993Wa04].
** Weighted average of 24(1)% [1993Wa04] and 27.5(20)% [1967Le08].
*** [1996Ta16].
@ [2014Hu18].

Table 5
direct α emission from ^{203}Rn, J_i^π = (3/2$^-$), $T_{1/2}$ = 44(2) s*, BR_α = 66(9)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{199}Po)	coincident γ-rays	R_0 (fm)	HF
6.630(2)	6.499(2)***	66(9)%**	(3/2$^-$)	0.0	—	1.45066(31)	1.4(3)

* Weighted average of 4293) [1996Ta18] and 45(2) s [1971Ho01].
** [19789HoZZ].
*** Weighted average of 6.499(2) MeV [1996Ta18] and 6.4993(25) MeV [1993Wa04].

Table 6
direct α emission from ^{203m}Rn, Ex. = 364(2) MeV, J_i^π = (13/2$^+$), $T_{1/2}$ = 26.7(5) s*, BR_α = 78(7)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{199}Po)	coincident γ-rays	R_0 (fm)	HF
6.682(1)	6.551(1)*	78(7)%**	(13/2$^+$)	0.312(2)		1.4883(18)	1.18(14)

* [1996Ta18].
** Weighted average of 80(10)% [1998Bo14] and 75(10)% [1987He10].

Table 7
direct α emission from ^{207}Ra*, J_i^π = (3/2$^-$), $T_{1/2}$ = 1.2(2) s, BR_α = obs**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{203}Rn)	coincident γ-rays	R_0 (fm)	HF
7.272(5)	7.131(5)	obs**	(3/2$^-$)	0.0	—	1.5158(39)	1.28(25)***

* All values taken from [1967Va22].
** Not measured, but estimated to be close to 100% based on half-life.
*** Result obtained using a BR of 100%

Table 8
direct α emission from ^{207m}Ra, Ex. = 509(10) MeV, J_i^π = (13/2$^+$), $T_{1/2}$ = 55(7) ms*, BR_α = 26(20)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{203}Rn)	coincident γ-rays	R_0 (fm)	HF
7.467(8)	7.323(8)**	26(20)%**	(13/2$^+$)	0.364(2)		1.5158(39)	$1.1^{+4.1}_{-0.6}$

* Weighted average of 55(9) ms [2021Ni08] and 55(10) ms [1987He10].

** [2021Ni08].
*** Weighted average of 7.331(15) MeV [1996Le09] and 7.320(10) MeV [1987He10].

Table 9
direct α emission from ^{211}Th, J_i^π = (3/2$^-$), $T_{1/2}$ = 36^{+13}_{-6} ms*, BR_α = ≈ 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{207}Ra)	coincident γ-rays	R$_0$ (fm)	HF
7.941(10)	7.790(10)**	≈ 100%	(3/2$^-$)	0.0	—	1.5064(68)	$1.0^{+0.4}_{-0.2}$

* Weighted average of 36^{+15}_{-8} ms [2023Ch24] and 37^{+28}_{-11} ms [1995Uu01].
** Weighted average of 7.788(14) MeV [2023Ch24] and 7.792(14) MeV [1995Uu01].

Table 10
direct α emission from ^{211m}Th*, Ex. = 769(21) MeV, J_i^π = (13/2$^+$), $T_{1/2}$ = 83(8) μs, BR_α = 4(3)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{207}Ra)	coincident γ-rays	R$_0$ (fm)	HF
8.200(15)	8.045(15)	4(3)%	(13/2$^+$)	0.364(2)		1.5158(39)	$0.3^{+1.1}_{-0.2}$**

* All values taken from [2021Au03].
** The low HF value suggests that the BR is towards the lower value of the uncertainty. A value of 1.4% for the BR gives a HF = 1.0.

Table 11
direct α emission from ^{215}U*, J_i^π = , $T_{1/2}$ = $0.73^{+1.33}_{-0.29}$ ms, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{211}Th)	coincident γ-rays	R$_0$ (fm)	HF
8.588(30)	8.428(30)	100%					

* All values taken from [2015Ya13].

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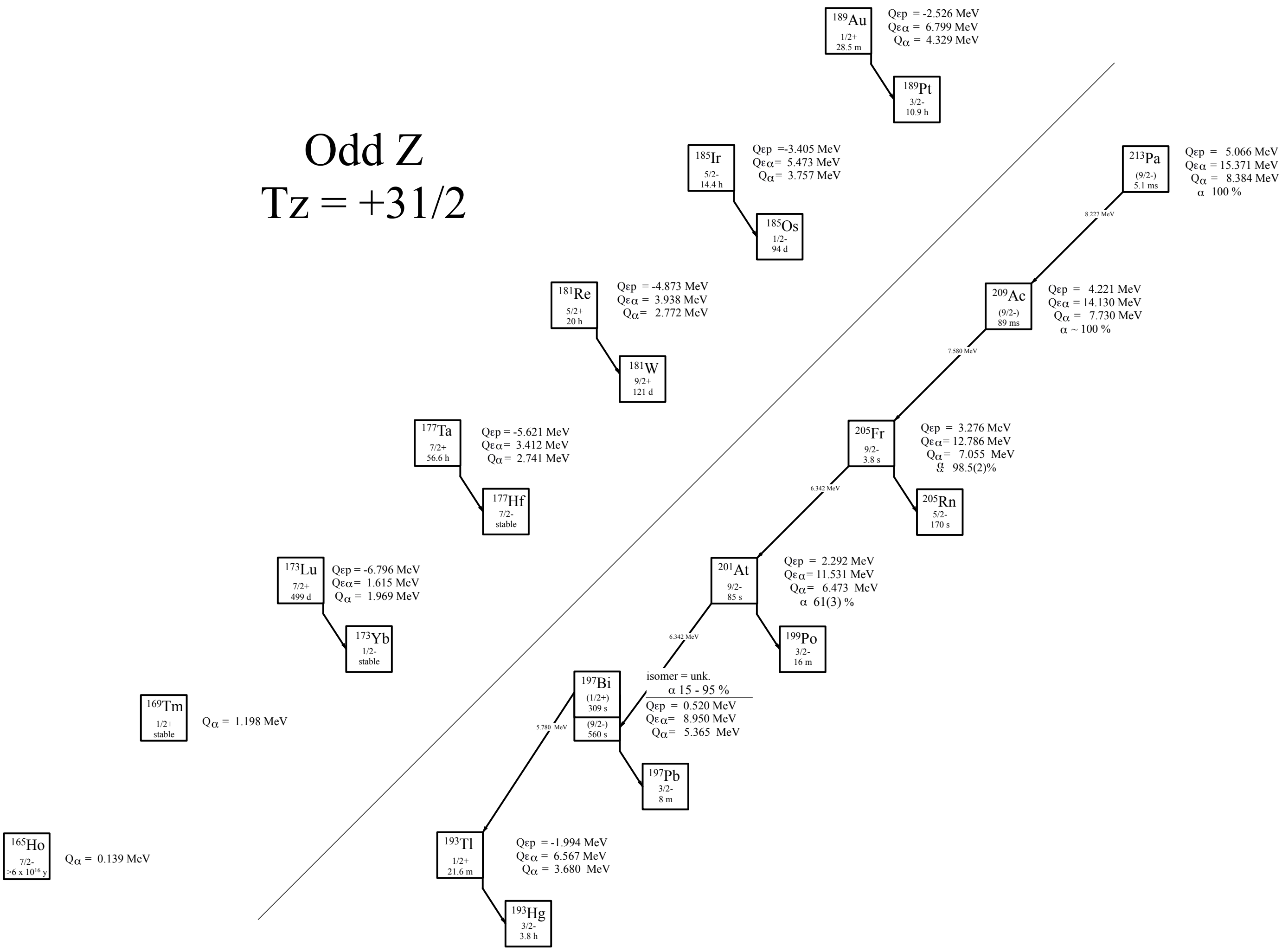

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +31/2 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +31/2 nuclei. J$^\pi$ values for ^{165}Ho, ^{169}Tm, ^{173}Lu, ^{177}Ta, ^{181}Re, ^{185}Ir, ^{189}Au, and ^{193}Tl are taken from ENSDF. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex	J^π	$T_{1/2}$	Q$_\varepsilon$	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{165}Ho		7/2$^-$	>6 × 10^{16} y	-1.286(1)	—–	—–	[**1956Po16**]
^{169}Tm		1/2$^+$	stable	-0.354(1)	—–	—–	
^{173}Lu		7/2$^+$	499(5) d	0.670(2)	-6.796(6)	1.615(2)	[**1962Bo12**]
^{177}Ta		7/2$^+$	56.56(6) h	1.166(3)	-5.621(3)	3.412(3)	[**1961We11**]
^{181}Re		5/2$^+$	19.9(7) h	1.717(13)	-4.873(13)	3.938(13)	[**1968Sc27**]
^{185}Ir		5/2$^-$	14.4(1) h	2.470(28)	-3.405(28)	5.473(28)	[**1982Al34**]
^{189}Au		1/2$^+$	28.5(3) m*	2.887(22)	-2.526(22)	6.799(20)	[**1970Fi16, 1966Fo13**]
^{193}Tl		1/2$^+$	21.6(6) m**	3.585(17)	-1.994(17)	6.567(12)	[**1961An03, 1974Va23**]
^{197}Bi		(9/2$^-$)	560(30) s	5.058(10)	0.520(15)	8.950(18)	[**1991Va09**]
^{197m}Bi	x	(1/2$^+$)	309(33) s	5.058(10)+x	0.520(15)+x	8.950(18)+x	[**1985Co06**]
^{201}At		9/2$^-$	85(2) s***	5.732(10)	2.292(24)	11.531(9)	[**1996Ta18, 1975BaYJ, 1974Ho27**]
^{205}Fr		9/2$^-$	3.80(3) s	6.400(9)	3.276(24)	12.786(9)	[**2005De01**]
^{209}Ac		(9/2$^-$)	89^{+12}_{-9} ms$^@$	6.990(60)	4.221(57)	14.130(56)	[**1996Ta18, 1975BaYJ, 1974Ho27**]
^{213}Pa		(9/2$^-$)	$5.1^{+3.3}_{-1.2}$ ms$^{@@}$	7.530(60)	5.066(61)	15.371(57)	[**2020Au04, 1995Ni05**]

* Weighted average of 28.3(5) m [1970Fi16] and 28.7(4) m [1966Fo13].
** Weighted average of 22.6(10) m [1961An03] and 21.0(8) m [1974Va23].
*** Weighted average of 83(2) s [1996Ta18], 87(3) s [1975BaYJ] and 88(5) s [1974Ho27].
$^@$ Weighted average of 98(20) ms [2014Ya19], 82^{+18}_{-13} ms [1996Ik01] and 91^{+21}_{-14} ms [1996Ik01].
$^{@@}$ Weighted average of $4.9^{+5.9}_{-1.8}$ ms [2020Au04] and $5.3^{+4.0}_{-1.6}$ ms [1995Ni05].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +31/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_p$	S$_{2p}$	Q$_\alpha$	BR$_\alpha$	Experimental
^{165}Ho	6.219(1)	14.880(4)	0.139(1)		
^{169}Tm	5.574(1)	13.573(5)	1.198(1)		
^{173}Lu	4.915(2)	12.249(2)	1.969(2)		
^{177}Ta	4.427(3)#	11.127(3)	2.741(3)		
^{181}Re	4.170(13)	10.738(13)	2.772(13)		
^{185}Ir	3.372(28)	9.104(29)	3.757(31)		
^{189}Au	3.050(21)	8.611(34)	4.329(34)	$< 3 \times 10^{-5}$%	
^{193}Tl	2.755(17)	8.257(8)	3.680(21)		
^{197}Bi	1.628(11)	6.110(14)	5.365(11)		
^{197m}Bi	1.628(11)-x	6.110(14)-x	5.365(11)+x	15-95 %	[**1985Co06**, 1984Co13, 1974Le02, 1972Ga27, 1970Ta14]
^{201}At	1.137(11)	4.570(13)	6.473(2)	61(3)%*	[**1998Bo14, 1996Ta18, 1974Ho27**, 2015We13, 2005De01 2004DeZV, 1986Wo03, 1975BaYJ, 1970DaZM, 1970HoZT, 1967Tr06]
^{205}Fr	0.629(11)	3.725(13)	7.055(2)	98.5(2)%	[**2010De04, 2005De01, 1981Ri04, 1967Va20**, 2015Ma63, 2012Ja01, 2004DeZV, 1974Ho27, 1964Gr02, 1961Gr42]
^{209}Ac	0.172(57)	2.884(59)	7.730(55)	≈ 100%**	[**2000He17, 1994Le05, 1968Va04**, 2014Ya19, 1996Ik01]
^{213}Pa	-0.254(58)	2.067(78)	8.384(12)	100%**	[**2020Au04, 1995Ni05**, 2000He17, 1996An21, 1995NiZR, 1995NiZS]

* Weighted average of 59(3)% [1998Bo14] and 71(7)% [1974Ho27].
** Based on short half-life.

Table 3
direct α emission from ^{197m}Bi*, Ex. = unk., J$_i^\pi$ = (1/2$^+$), T$_{1/2}$ = 309(33) s, BR_α = 15-95 %.

E_α(c.m.)	E_α(lab)	I_α(abs)	J$_f^\pi$	$E_{daughter}$(^{193}Tl)	coincident γ-rays	R$_0$ (fm)	HF
5.900(5)	5.780(5)	15-95 %	(1/2$^+$)	0.0	—–	1.4900(31)	0.071-0.45

* All values taken from [2015Ya13].

Table 4
direct α emission from ^{201}At, J_i^π = 9/2$^-$, $T_{1/2}$ = 85(2) s*, BR_α = 61(3)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{197}Bi)	coincident γ-rays	R_0 (fm)	HF
6.471(1)	6.342(1)***	61(3)%**	(9/2$^-$)	0.0	—–	1.4955(33)	1.39(13)

* Weighted average of 83(2) s [1996Ta18], 87(3) s [1975BaYJ] and 88(5) s [1974Ho27].
** Weighted average of 59(3)% [1998Bo14] and 71(7)% [1974Ho27].
*** [1996Ta18].

Table 5
direct α emission from ^{205}Fr, J_i^π = 9/2$^-$, $T_{1/2}$ = 3.80(3) s*, BR_α = 98.5(2)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{201}At)	coincident γ-rays	R_0 (fm)	HF
7.054(3)	6.342(3)***	98.5(2)%**	(9/2$^-$)	0.0	—–	1.5157(28)	1.64(11)

* [2005De01].
** [2010De04].
*** Weighted average of 6.916(5) MeV [2005De01], 6.917(5) MeV [1981Ri04] and 6.917(5) MeV [1967Va20].

Table 6
direct α emission from ^{209}Ac, J_i^π = (9/2$^-$), $T_{1/2}$ = 89^{+12}_{-9} ms*, BR_α = ≈ 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{205}Fr)	coincident γ-rays	R_0 (fm)	HF
7.728(7)	7.580(7)**	≈ 100%	(9/2$^-$)	0.0	—–	1.5050(73)	1.1(3)

* Weighted average of 98(20) ms [2014Ya19], 82^{+18}_{-13} ms [1996Ik01] and 91^{+21}_{-14} ms [1996Ik01].
** Weighted average of 7.577(10) MeV [2000He17], 7.581(15) MeV [1994Le05] and 7.585(15) MeV [1968Va04],

Table 7
direct α emission from ^{213}Pa, J_i^π = (9/2$^-$), $T_{1/2}$ = $5.1^{+3.3}_{-1.2}$ ms*, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{209}Ac)	coincident γ-rays	R_0 (fm)	HF
8.384(15)	8.227(15)**	100%	(9/2$^-$)	0.0	—–	1.516(14)	$1.6^{+1.2}_{-0.7}$

* Weighted average of $4.9^{+5.9}_{-1.8}$ ms [2020Au04] and $5.3^{+4.0}_{-1.6}$ ms [1995Ni05].
** Weighted average of 8.210(20) MeV [2020Au04] and 8.236(15) MeV [1995Ni05],

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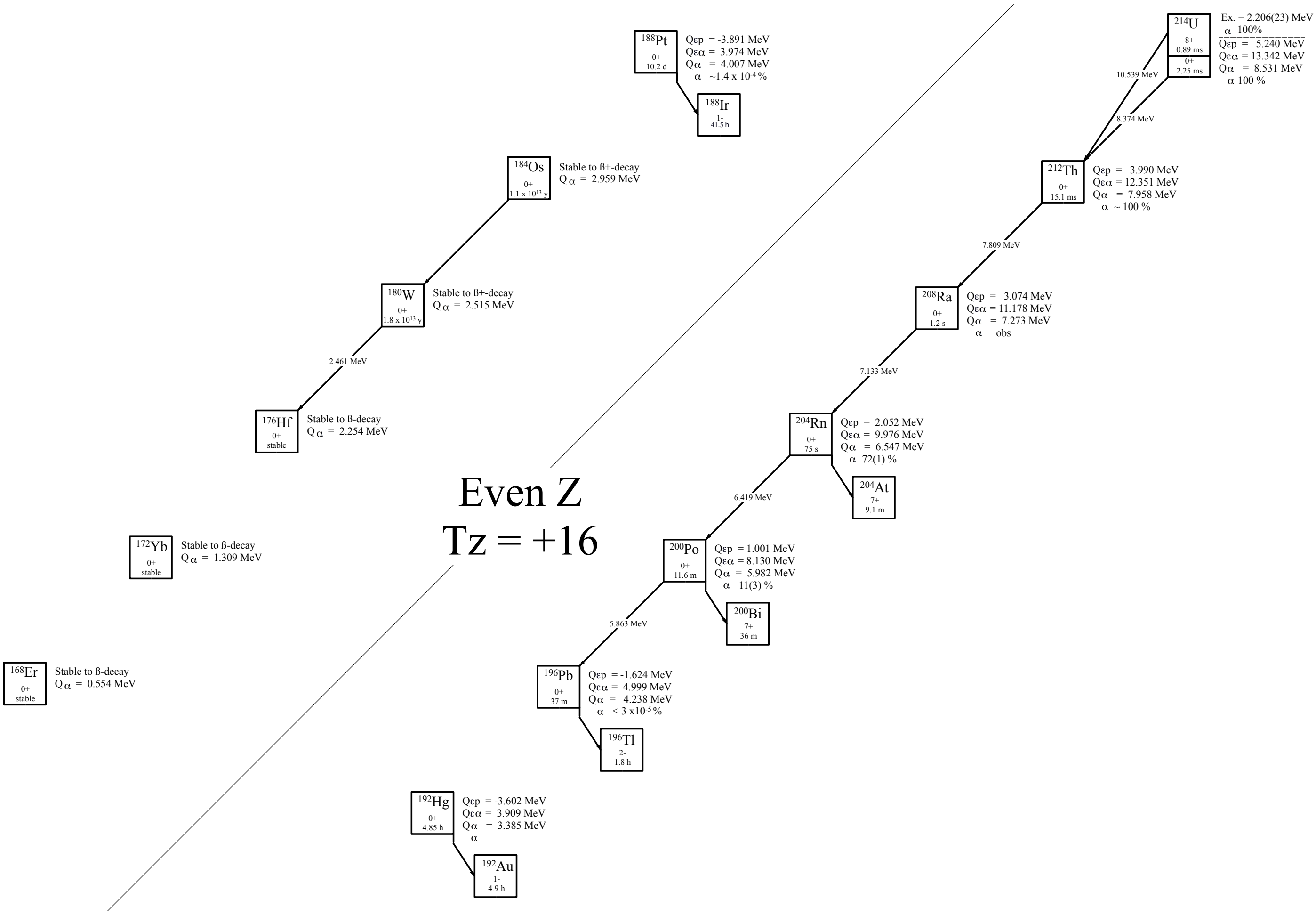

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +16 nuclei.

Last updated 10/12/2023

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +16 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{168}Er		0^+	stable	-2.930(30)	—	—	
^{172}Yb		0^+	stable	-1.882(5)	—	—	
^{176}Hf		0^+	stable	-1.194(1)	—	—	
^{180}W		0^+	1.8(2) $\times 10^{18}$ y	-0.703(2)	—	—	[**2004Co26**]
^{184}Os		0^+	1.12(23) $\times$ 10^{13} y	-0.033(4)	—	—	[**2014Pe22**]
^{188}Pt		0^+	10.2(3) d	0.524(9)	-3.891(5)	3.974(7)	[**1963Gr08**]
^{192}Hg		0^+	4.85(20) h	0.761(22)	-3.602(16)	3.909(18)	[**1961Ja10**]
^{196}Pb		0^+	37(3) m	2.148(14)	-1.624(24)	4.999(18)	[**1961Su01**]
^{200}Po		0^+	11.6(1) m	3.429(24)	1.001(10)	8.130(14)	[**1970Ra14**]
^{204}Rn		0^+	75(1) s*	3.905(24)	2.052(9)	9.976(24)	[**1971Ho01, 1967Va17**]
^{208}Ra		0^+	1.2(2) s	4.393(15)	3.074(10)	11.178(24)	[**1967Va22**]
^{212}Th		0^+	31.7(13) ms	4.811(24)	3.990(11)	12.351(15)	[**2010He25**]
^{216}U		0^+	$2.25^{+0.63}_{0.40}$ ms	5.240(40)	4.856(29)	13.342(36)	[**2021Zh22**]
^{216m}U	2.206(23)	8^+	$0.89^{+0.27}_{0.17}$ ms	7.446(46)	7.062(37)	15.548(43)	[**2021Zh22**]

* Weighted average of 74(2) s [1971Ho01] and 75(2) s [1967Va17].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the even-Z, T_z = +16 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{168}Er	7.999(5)	14.983(1)	0.554(1)		
^{172}Yb	7.334(1)	13.726(1)	1.309(0)		
^{176}Hf	6.700(1)	12.210(1)	2.254(1)		
^{180}W	6.568(1)	11.779(0)	2.515(1)	100%	[**2004Co26**, 2005Zd04, 2004CoZY, 2003Ce01, 2003Da05, 2002Bi16, 2002BiZZ, 2002DaZT]
^{184}Os	5.732(8)	10.584(1)	2.959(2)	100%	[**2014Pe22**, 1976Sp04]
^{188}Pt	5.561(28)	9.399(5)	4.007(5)		
^{192}Hg	5.503(16)	9.283(16)	3.385(16)		
^{196}Pb	4.482(14)	7.742(8)	4.238(17)	$\leq 3 \times 10^{-5}$%	[**1963Ka17**]
^{200}Po	3.433(13)	5.452(12)	5.982(2)	11.3(3)%*	[**1996Ta18, 1993Wa04, 1967Le08**, 1992WaZV, 1970DaZM 1970Ra14, 1971Ho01, 1970Jo26, 1969Ha03, 1967Le08, 1967Le21, 1967Si09, 1967Tr04, 1967Tr06, 1965Br17, 1965Br27, 1965Si22, 1965Ti03, 1964Br23, 1962Be26, 1961Be25, 1961Fo05, 1954Ro39]
^{204}Rn	3.096(13)	4.606(11)	6.547(2)	72(1)%**	[**1996Ta18, 1993Wa04, 1971Ho01, 1967Va17**, 2022Zh45, 2014WaZU, 1992WaZV, 1967Va07, 1965Nu04]
^{208}Ra	2.712(20)	3.717(12)	7.273(5)	obs	[**1967Va22**, 2022Zh45, 2015Ma37, 2015Ma63, 2014WaZU, 1968Lo15]
^{212}Th	2.322(55)	2.910(14)	7.958(5)	$\approx$ 100%	[**2010He25**, 2022Zh45, 2015De22, 2015Ma37, 1996Ik01, 1980Ve01]
^{216}U	2.027(87)	2.206(30)	8.531(26)	100%	[**2021Zh22**, 2022Zh45, 2015De22, 2015WaZT, 2014WaZU]
^{216m}U	0.021(90)	0.000(38)	10.737(35)	100%	[**2022Zh45**, 2021Zh22, 2016Zh33]

* Weighted average of 11.1(3)% [1993Wa04] and 12.2(6)% [1967Le08].
** Weighted average of 73(1)% [1993Wa04] and 70(2)% [1971Ho01].
*** Based on short half-life

Table 3
direct α emission from ^{180}W*, $J_i^\pi = 0^+$, $T_{1/2}$ = 1.8(2) $\times 10^{18}$ y, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{176}Hf)	coincident γ-rays	R_0 (fm)	HF
2.5164(16)	2.4605(16)	100%	0^+	0.0	—	1.4631(61)	1.59(18)

* All values taken from [2004Co26].

Table 4
direct α emission from ^{200}Po, $J_i^\pi = 0^+$, $T_{1/2}$ = 11.6(1) m*, BR_α = 11.3(3)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{196}Pb)	coincident γ-rays	R_0 (fm)	HF
5.983(2)	5.863(2)***	11.3(3)%**	0^+	0.0	—–	1.4803(16)	1.007(28)

* [1970Ra14].
** Weighted average of 11.1(3)% [1993Wa04] and 12.2(6)% [1967Le08].
*** [1996Ta18].

Table 5
direct α emission from ^{204}Rn, $J_i^\pi = 0^+$, $T_{1/2}$ = 75(1) s*, BR_α = 72(1)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{200}Po)	coincident γ-rays	R_0 (fm)	HF
6.5472(14)	6.4188(14)***	72(1)%**	0^+	0.0	—–	1.5026(16)	1.014(20)

* Weighted average of 74(2) s [1971Ho01] and 75(2) s [1967Va17].
** Weighted average of 73(1)% [1993Wa04] and 70(2)% [1971Ho01].
*** Weighted average of 6.420(2) MeV [1996Ta18], 6.4189(25) MeV [1993Wa04] and 6.416(3) MeV [1967Va17].

Table 6
direct α emission from ^{208}Ra*, $J_i^\pi = 0^+$, $T_{1/2}$ = 1.2(2) s, BR_α = obs**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{204}Rn)	coincident γ-rays	R_0 (fm)	HF
7.273(5)	7.133(5)***	≈ 100%**	0^+	0.0	—–	1.5029(36)	1.03(17)

* All values from [1967Va22].
** Not observed, estimated to be ≈ 100% based on half-life.

Table 7
direct α emission from ^{212}Th*, $J_i^\pi = 0^+$, $T_{1/2}$ = 31.7(13) ms, BR_α = ≈ 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{208}Ra)	coincident γ-rays	R_0 (fm)	HF
7.959(5)	7.809(5)	≈ 100%	0^+	0.0	—–	1.5058(26)	1.15(5)

* All values from [2010He25].

Table 8
direct α emission from ^{216}U*, $J_i^\pi = 0^+$, $T_{1/2} = 2.25^{+0.63}_{0.40}$ ms, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{212}Th)	coincident γ-rays	R_0 (fm)	HF
8.532(17)	8.374(17)	100%	0^+	0.0	—–	1.486(33)	$0.48^{+0.14}_{-0.09}$

* All values from [2021Zh22].

Table 9
direct α emission from ^{216m}U*, Ex. = 2.206(23) MeV, $J_i^\pi = 8^+$, $T_{1/2} = 0.89^{+0.27}_{0.17}$ ms, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{212}Th)	coincident γ-rays	R_0 (fm)	HF
10.355(27)	10.163(27)	≈5%**	≈5%	(2^+)	0.383(31)		1.486(33)	$\approx 1 \times 10^5$
10.738(16)	10.539(16)	100%**	≈95%	0^+	0.0	—–	1.486(33)	$\approx 3.1(9) \times 10^4$

* All values from [2022Zh45].
** One α was observed for this transition compared to 19 for the transition to the ground state.

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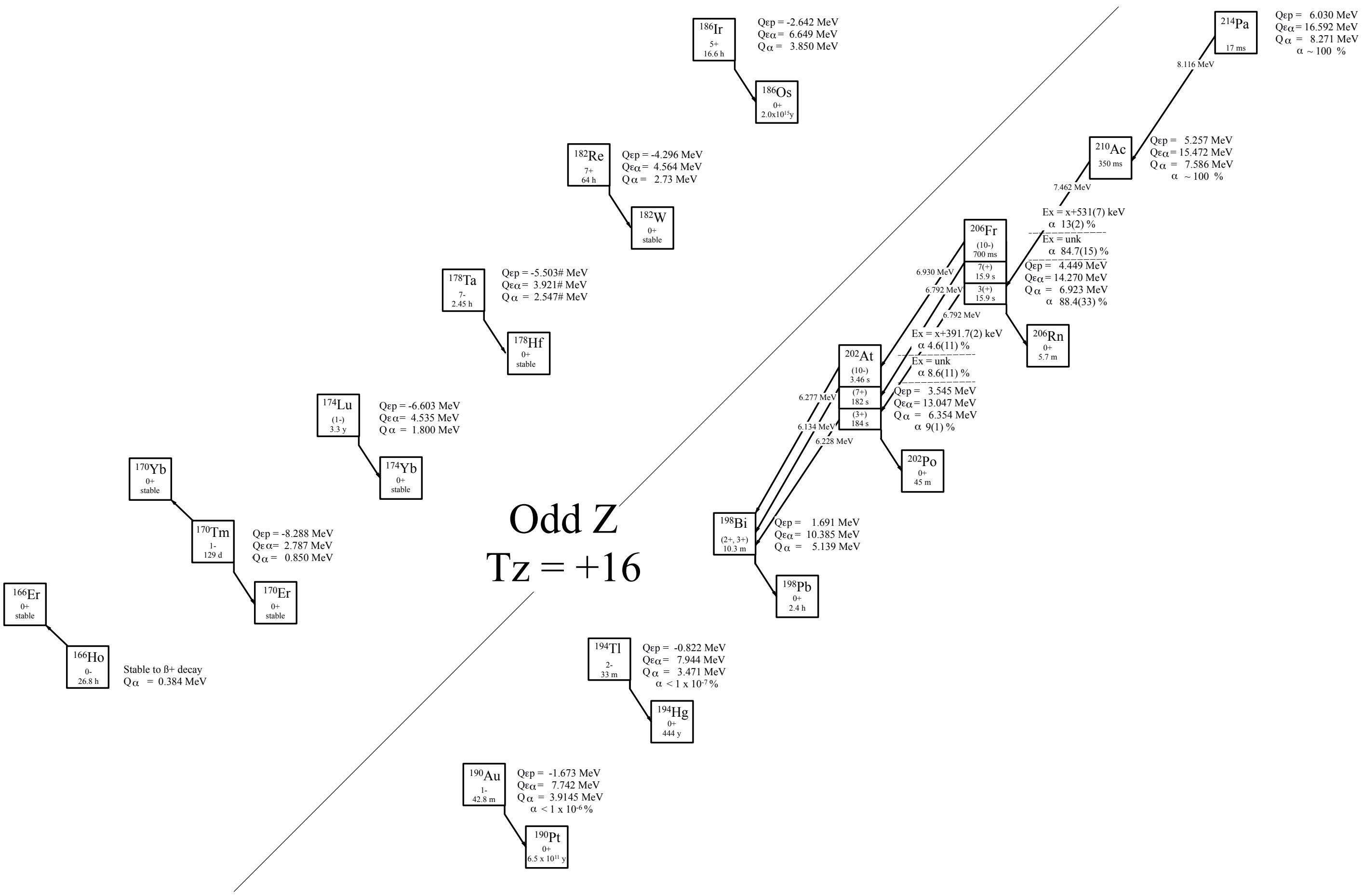

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +16 nuclei.

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +16 nuclei. J$^{\pi}$ values for ^{166}Ho, ^{170}Tm, ^{174}Lu, ^{178}Ta, ^{182}Re, ^{186}Ir, ^{190}Au, ^{194}Tl and ^{198}Bi are taken from ENSDF. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex	J^{π}	$T_{1/2}$	Qε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{166}Ho*		0^-	26.827(5) h	-1.854(1)	—–	—–	[**1989Ab05**]
^{170}Tm**		1^-	128.6(3) d	0.312(2)	-8.288(20)	2.787(1)	[**1968Re04**]
^{174}Lu		(1^-)	3.6(4) y	1.374(2)	-6.603(5)	4.535(2)	[**1962Bo12**]
^{178}Ta		7^-	2.45(5) h	1.840(50)#	-5.503(52)#	3.921(52)#	[**1975Wa24**]
^{182}Re		7^+	64.3(5) h	2.800(100)	-4.296(102)	4.564(102)	[**2011Bo01**]
^{186}Ir		5^+	16.64(3) h	3.828(17)	-2.642(17)	6.649(17)	[**1982Al34**]
^{190}Au		1^-	42.8(10) m	4.473(4)	-1.673(13)	7.742(4)	[**1973Jo11**]
^{194}Tl		2^-	33.0(5) m	5.246(14)	-0.822(16)	7.944(14)	[**2003Su30**]
^{198}Bi		$(2^+, 3^+)$	10.3(3) m	6.694(29)	1.691(31)	10.385(28)	[**1982Hu04**]
^{202}At		(3^+)	184(1) s	7.346(29)	3.545(30)	13.047(29)	[**1992Hu04**]
^{202m1}At	x	(7^+)	182(2) s	7.346(29)+x	3.545(30)+x	13.047(29)+x	[**1992Hu04**]
^{202m2}At	0.3917(2) + x	(10^-)	3.46(5) s	7.738(29)+x	3.937(30)+x	13.439(29)+x	[**1992Hu04**]
^{206}Fr		$3^{(+)}$	15.9(3) s***	7.886(29)	4.449(30)	14.270(29)	[**1981Ri04**]
^{206m1}Fr	x	$7^{(+)}$	15.9(3) s***	7.886(29)+x	4.449(30)+x	14.270(29)+x	[**1981Ri04**]
^{206m2}Fr	x + 0.531(7)	$10^{(-)}$	0.7(1) s	8.417(30)+x	4.980(31)+x	14.801(30)+x	[**2016Ly01, 1981Ri04**]
^{210}Ac			350(50) ms	8.320(60)	5.257(63)	15.472(63)	[**1968Va04**]
^{214}Pa			17(3) ms	8.760(80)	6.030(82)	16.592(82)	[**2000He17, 1995Ni05, 1996An21**]

* 100% β^- emitter.
** 99.869(10)% β^-, 0.131(10)% ε emitter [2018Ba41].
*** Combination of T$_{1/2}$ from ^{206gs}Fr and ^{206m1}Fr [1981Ri04].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +16 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_p$	S$_{2p}$	Q$_\alpha$	BR$_\alpha$	Experimental
^{166}Ho	6.747(1)	15.543(2)	0.384(2)		
^{170}Tm	6.163(1)	14.314(30)	0.850(1)		
^{174}Lu	5.308(2)	12.775(6)	1.800(2)		
^{178}Ta	5.007(52)#	11.794(52)#	2.547(52)#		
^{182}Re	4.50(10)	11.09(10)	2.73(12)#		
^{186}Ir	3.655(17)	9.530(17)	3.850(10)		
^{190}Au	3.653(11)	9.067(10)	3.914(17)	$< 1 \times 10^{-6}$%	[**1963Ka17**]
^{194}Tl	3.164(21)	8.743(21)	3.471(14)	$< 1 \times 10^{-7}$%	[**1963Ka17**]
^{198}Bi	1.917(28)	6.455(30)	5.139(31)		
^{202}At	1.363(28)	4.802(36)	6.354(1)	9(1)%	[**1992Hu04, 1975BaYJ, 1974Ho27**, 2016Ly01, 1996Ta18, 1970DaZM, 1967Tr04, 1967Tr06, 1963Ho18, 1961Fo04, 1961La02]
^{202m1}At	1.363(28)	4.802(36)	6.354(1)	8.6(11)%*	[**2016Ly01, 1996Ta18, 1992Hu04, 1975BaYJ**, 1974Ho27, 1970DaZM, 1967Tr04, 1967Tr06, 1963Ho18, 1961Fo04, 1961La02]
^{202m2}At	1.363(28)	4.802(36)	6.354(1)	4.6(11)%	[**2016Ly01, 1992Hu04**]
^{206}Fr	0.826(28)	3.950(36)	6.923(3)	88.4(33)%	[**2016Ly01, 1992Hu04, 1981Ri04**, 2015Ma63, 2012Ly01 1974Ho27, 1967Va20, 1964Gr04, 1961Gr42]
^{206m1}Fr	0.826(28)-x	3.950(36)-x	6.923(3)+x	84.7(15)%	[**2016Ly01, 1992Hu04, 1981Ri04**, 2015Ma63, 2012Ly01 1974Ho27, 1967Va20, 1964Gr04, 1961Gr42]
^{206m2}Fr	0.295(29)-x	3.419(37)-x	7.436(8)+x	13(2)%	[**2016Ly01, 1992Hu04, 1981Ri04**, 2012Ly01]
^{210}Ac	0.383(62)	3.149(63)	7.586(57)	≈ 100%**	[**2000He17, 1968Va04**, 2014Ya19, 1967Tr03]
^{214}Pa	-0.051(82)	2.418(84)	8.271(52)	≈ 100%**	[**2000He17, 1995Ni05, 1996An21**, 1995NiZR, 1995NiZS]

* Weighted average of 8.5(15)% [2016Ly01] and 8.7(15)% [1992Hu04].
** Based on short half-life.

Table 3
direct α emission from ^{202}At, J$_i^{\pi}$ = (3$^+$), T$_{1/2}$ = 184(1) s*, BR_α = 9(1)%**.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J$_f^{\pi}$	$E_{daughter}$(^{198}Bi)	coincident γ-rays	R$_0$ (fm)$^@$	HF
6.049(10)	5.929(10)*	≈0.04%	≈0.004%		0.425(10)		1.4915(23)	≈ 220
6.193(10)	6.070(10)*	≈0.2%	≈0.02%		0.161(10)		1.4915(23)	≈ 670
6.354(2)	6.228(2)***	100%	9(1)%	(3$^+$)	0.0	—–	1.4915(23)	$6.5^{+0.9}_{-0.8}$

* [1992Hu04].
** [1974Ho27].
***[1975BaYJ].
** Interpolated between 1.4803(16) fm (^{200}Po) and 1.5026(16) fm (^{204}Rn).

Table 4
direct α emission from ^{202m1}At, Ex = unk., J_i^π = (7$^+$), $T_{1/2}$ = 182(2) s*, BR_α = 8.6(11)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{198}Bi)	coincident γ-rays	R$_0$ (fm)$^@$	HF
6.258(2)	6.134(2)***	8.6(11)%**	(7$^+$)	x		1.4915(23)	$2.7^{+0.5}_{-0.4}$

* [1992Hu04].
** Weighted average of 8.5(15)% [2016Ly01] and 8.7(15)% [1992Hu04].
*** Weighted average of 6.133(3) MeV [1996Ta18] and 6.135(2) MeV [1975BaYJ].
** Interpolated between 1.4803(16) fm (^{200}Po) and 1.5026(16) fm (^{204}Rn).

Table 5
direct α emission from ^{202m2}At*, Ex = 391.7 keV + x, J_i^π = (10$^-$), $T_{1/2}$ = 3.46(5) s, BR_α = 4.6(11)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{198}Bi)	coincident γ-rays	R$_0$ (fm)**	HF
6.404(5)	6.277(5)	4.6(11)%	(10$^-$)	0.249 + x		1.4915(23)	$0.39^{+0.13}_{-0.08}$

* All values from [1992Hu04].
** Interpolated between 1.4803(16) fm (^{200}Po) and 1.5026(16) fm (^{204}Rn).

Table 6
direct α emission from ^{206}Fr, J_i^π = 3($^+$), $T_{1/2}$ = 15.9(3) s*, BR_α = 88.4(33)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{202}At)	coincident γ-rays	R$_0$ (fm)$^@$	HF
6.926(5)	6.792(5)***	88.4(33)%**	(3$^+$)	0.0	—–	1.5028(38)	$2.05^{+0.22}_{-0.20}$

* Combination of $T_{1/2}$ from ^{206gs}Fr and ^{206m1}Fr [1981Ri04].
** [2016Ly01].
*** Unresolved doublet de-exciting the 3($^+$) and 7($^+$) isomers in ^{206}Fr [1992Hu04].
@ Interpolated between 1.5026(16) fm (^{204}Rn) and 1.5029(36) fm (^{208}Ra).

Table 7
direct α emission from ^{206m1}Fr, Ex = unk., J_i^π = 7($^+$), $T_{1/2}$ = 15.9(3) s* , BR_α = 84.7(15)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{202}At)	coincident γ-rays	R$_0$ (fm)$^@$	HF
6.926(5)	6.792(5)***	84.7(15)%**	(7$^+$)	x		1.5028(38)	$2.16^{+0.22}_{-0.20}$

* Combination of $T_{1/2}$ from ^{206gs}Fr and ^{206m1}Fr [1981Ri04].
** [2016Ly01].
*** Unresolved doublet de-exciting the 3($^+$) and 7($^+$) isomers in ^{206}Fr [1992Hu04].
@ Interpolated between 1.5026(16) fm (^{204}Rn) and 1.5029(36) fm (^{208}Ra).

Table 8
direct α emission from ^{206m2}Fr, Ex = 531(7) keV + x, J_i^π = 10($^-$), $T_{1/2}$ = 0.7(1) s*, BR_α = 13(2)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{202}At)	coincident γ-rays	R$_0$ (fm)$^@$	HF
7.067(5)	6.930(5)	13(2)%**	(10$^-$)	0.531(7) + x	0.531	1.5028(38)	$2.0^{+0.8}_{-0.6}$

* [1981Ri04].
** [2016Ly01].
*** [1992Hu04].
@ Interpolated between 1.5026(16) fm (^{204}Rn) and 1.5029(36) fm (^{208}Ra).

Table 9
direct α emission from ^{210}Ac*, $T_{1/2}$ = 350(50) ms, BR_α = ≈ 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{206}Fr)	coincident γ-rays	R_0 (fm)@	HF
7.607(8)	7.462(8)	≈ 100%			—	1.5044(44)	1.81(33)

* All Values from [1968Va04].
** Interpolated between 1.5029(36) fm (^{208}Ra) and 1.5058(26) fm (^{212}Th).

Table 10
direct α emission from ^{214}Pa*, $T_{1/2}$ = 17(3) ms, BR_α = ≈ 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{210}Ac)	coincident γ-rays	R_0 (fm)@	HF
8.271(15)	8.116(15)	≈ 100%			—	1.496(33)	$1.4^{+1.5}_{-0.8}$

* All values from [2000He17, 1996An21, 1995Ni02].
** Interpolated between 1.5058(26) fm (^{212}Th) and 1.486(33) fm (^{216}U).

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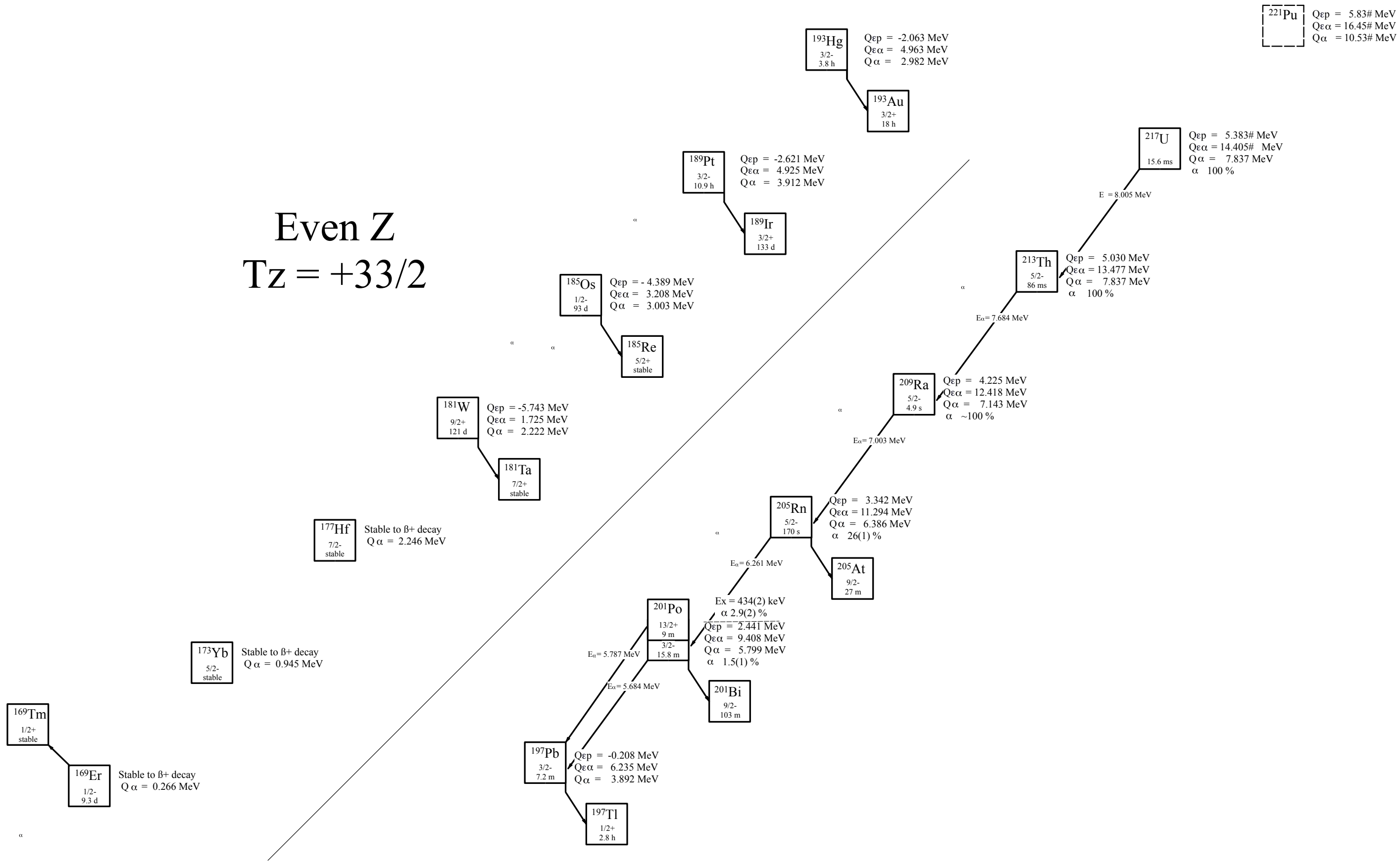

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +33/2 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +33/2 nuclei. J^π values for ^{169}Er, ^{173}Yb, ^{177}Hf, ^{181}W, ^{185}Os, ^{189}Pt, ^{193}Hg, ^{197}Pb and ^{201}Po are taken from ENSDF. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{169}Er*		1/2$^-$	9.36(4) d	-2.125(20)	—	—	[**2004Sc04**]
^{173}Yb		5/2$^-$	stable	-1.295(4)	—	—	
^{177}Hf		7/2$^-$	stable**	-0.497(1)	—	—	
^{181}W		9/2$^+$	120.95(2) d	0.205(2)	-5.743	1.725(2)	[**1973My02**]
^{185}Os		1/2$^-$	92.95(9) d	1.013(1)	-4.389(1)	3.208(2)	[**2012Kr05**]
^{189}Pt		3/2$^-$	10.87(12) h	1.980(14)	-2.621(10)	4.925(10)	[**1964Le07**]
^{193}Hg		3/2$^-$	3.80(15) h	2.343(14)	-2.063(16)	4.963(20)	[**1974ViZS**]
^{197}Pb		3/2$^-$	7.2(10) m***	3.609(14)	-0.208(6)	6.235(10)	[**1980Hi04, 1979Ra04**]
^{201}Po		3/2$^-$	15.8(3) m	4.908(13)	2.441(11)	9.408(14)	[**1965Br17, 1967Le21**]
^{201m}Po	0.4234(2)$^@$	13/2$^+$	9(2) m	5.331(13)	2.864(11)	9.831(14)	[**1965Br17, 1967Le21**]
^{205}Rn		5/2$^-$	170(4) s	5.275(13)	3.342(11)	11.294(13)	[**1971Ho01**]
^{209}Ra		5/2$^-$	4.9(2) s$^{@@}$	5.640(13)	4.225(12)	12.418(13)	[**2008Ha12, 1967Va22**]
^{213}Th		5/2$^-$	86(10) ms$^{@@@}$	5.979(15)	5.030(14)	13.477(15)	[**1980Ve01, 1968Va18**]
^{217}U			$15.6^{+21.3}_{-5.7}$ ms	5.920(80)#	5.383(81)#	14.405(81)#	[**2000Ma65**]
^{221}Pu				6.02(36)#	5.63(32)#	16.45(30)#	

* 100% β^- emitter.
** T$_{1/2}$ reported as $\geq 7.5 \times 10^{16}$ y [2020Ca15], due to non observation of α decays from this nucleus.
*** Weighted average of 10(2) m [1979Ra04] and 6.2(12) m [1980Hi04].
$^@$ [2023Ko01].
$^{@@}$ Weighted average of 5.1(2) s [2008Ha12] and 4.7(2) s [1967Va22].
$^{@@@}$ Weighted average of 80(10) ms [1980Ve01] and 125(25) ms [1968Va18].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the even-Z, T_z = +33/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{169}Er	8.151(30)	15.588(4)	0.266(1)		
^{173}Yb	7.467(5)	14.411(1)	0.945		
^{177}Hf	6.787(1)	12.763(1)	2.246(1)		
^{181}W	6.589(2)	12.349	2.222		
^{185}Os	5.875(4)	11.018(1)	3.003(2)		
^{189}Pt	5.413(14)	9.828(10)	3.912(10)		
^{193}Hg	5.579(22)	9.942(16)	2.982(18)		
^{197}Pb	4.538(13)	8.310(24)	3.892(16)		
^{201}Po	3.440(23)	5.867(8)	5.799(2)	1.15(1)%	[**1965Br17, 1967Le21, 1968Go12**, 1993Wa04, 1986Br28, 1970DaZM, 1970Jo26, 1970Ra14, 1967Le08, 1967Ti04, 1967Tr04, 1967Tr06, 1963Ho18, 1962Be26, 1961Be25, 1961Fo05, 1954Ro39]
^{201m}Po	3.440(23)	5.867(8)	5.799(2)	2.9(2)%	[**1965Br17, 1967Le21, 1968Go12**, 2015We13, 1993Wa04, 1986Br28, 1970Jo26, 1970Ra14, 1967Le08]
^{205}Rn	3.123(23)	4.977(7)	6.386(2)	26(1)%*	[**1993Wa04, 1971Ho01, 1967Va17**, 1971Jo19, 1967Va07, 1965Nu04]
^{209}Ra	2.766(13)	4.085(7)	7.143(3)	≈ 100%**	[**2003He06**, 2008Ha12, 2001HeZY, 1997Mi03, 1968Lo15, 1967Va22]
^{213}Th	2.468(24)	3.290(10)	7.837(7)	100%**	[**1980Ve01, 1968Va18**, 2000Ma65]
^{217}U	2.142(84)	2.529(81)	8.426(80)	100%**	[**2000Ma65**, 2022Zh45, 2012WaZX, 2005Le42]
^{221}Pu	1.83(30)#	1.94(30)#	10.53(31)#		

* Weighted average of 25(1)% [1993Wa04] and 35(3)% [1971Ho01].
** Based on half-life.

Table 3
direct α emission from ^{201}Po, J_i^π = (3$^-$), T$_{1/2}$ = 15.8(3) m*, BR_α =1.15(1)%*.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{210}Ac)	coincident γ-rays	R$_0$ (fm)	HF
5.799(2)	5.684(2)	1.15(1)%*	(3$^-$)	0.0	—	1.4762(18)	1.82(9)

* [1965Br17, 1967Le21]

** [1968Go12].

Table 4
direct α emission from ^{201m}Po, Ex. = 423.4(2) keV*, J_i^π = (13$^+$), $T_{1/2}$ = 9(2) m**, BR_α = 2.9(2)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{197}Pb)	coincident γ-rays	R_0 (fm)	HF
5.905(2)	5.787(2)	1.15(1)%*	(13$^+$)	0.3193(1)$^@$	0.085, 0.234$^@$	1.4762(18)	1.29(31)

* [2023Ko01].
** [1965Br17, 1967Le21]
*** [1968Go12].
$^@$ [2005Hu03].

Table 5
direct α emission from ^{205}Rn, J_i^π = (5$^-$), $T_{1/2}$ = 170(4) s*, BR_α = 26(1)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{201}Po)	coincident γ-rays	R_0 (fm)	HF
6.3855(25)	6.2609(25)	26(1)%*	(5$^-$)	0.00561(13)$^@$	0.0056	1.4972(20)	1.23(8)

* [1971Ho01].
** Weighted average of 25(1)% [1993Wa04] and 35(3)% [1971Ho01].
*** [1993Wa04].
$^@$ α-transition assumed to decay to the favored 5/2$^-$ state in the ^{201}Po daughter. Energy from [2023Ko01].

Table 6
direct α emission from ^{209}Ra, J_i^π = (5$^-$), $T_{1/2}$ = 4.9(2) s*, BR_α = ≈ 100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{205}Rn)	coincident γ-rays	R_0 (fm)	HF	
6.500(5)	6.376(5)**	0.2%	≈ 0.2%			0.6337(11)	0.6337(11)	1.4945(33)	≈ 2.2
6.754(5))	6.625(5)**	0.5%	≈0.5%			0.3870(5)	0.3870(5)	1.4945(33)	≈ 8.8
7.140(10)	7.003(10)**	100%	≈ 99.3%	(5$^-$)		0.0	——	1.4945(33)	≈ 1.25

* Weighted average of 5.1(2) s [2008Ha12] and 4.7(2) s [1967Va22].
** [2003He06].

Table 7
direct α emission from ^{213}Th, J_i^π = (5$^-$), $T_{1/2}$ = 86(10) ms*, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{209}Ra)	coincident γ-rays	R_0 (fm)	HF
7.824(10)	7.684(10)	100%	(5$^-$)	0.0	——	1.5022(41)	0.99(16)

* Weighted average of 80(10) ms [1980Ve01] and 125(25) ms [1968Va18].
** Weighted average of 7.690(10) MeV [1968Va18] and 7.677(10) MeV [1980Ve01].

Table 8
direct α emission from ^{217}U*, J_i^π = (5$^-$), $T_{1/2}$ = $15.6^{+21.3}_{-5.7}$ ms, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{213}Th)	coincident γ-rays	R_0 (fm)	HF
8.155(20)	8.005(20)	100%	(5$^-$)	0.0	——	1.499(24)	$0.37^{+0.53}_{-0.21}$**

* All values from [2000Ma65].
** The unphysically low HF value may suggest that the half-life is longer than reported. A $T_{1/2}$ of 42 ms at this energy gives a HF of 1.0.

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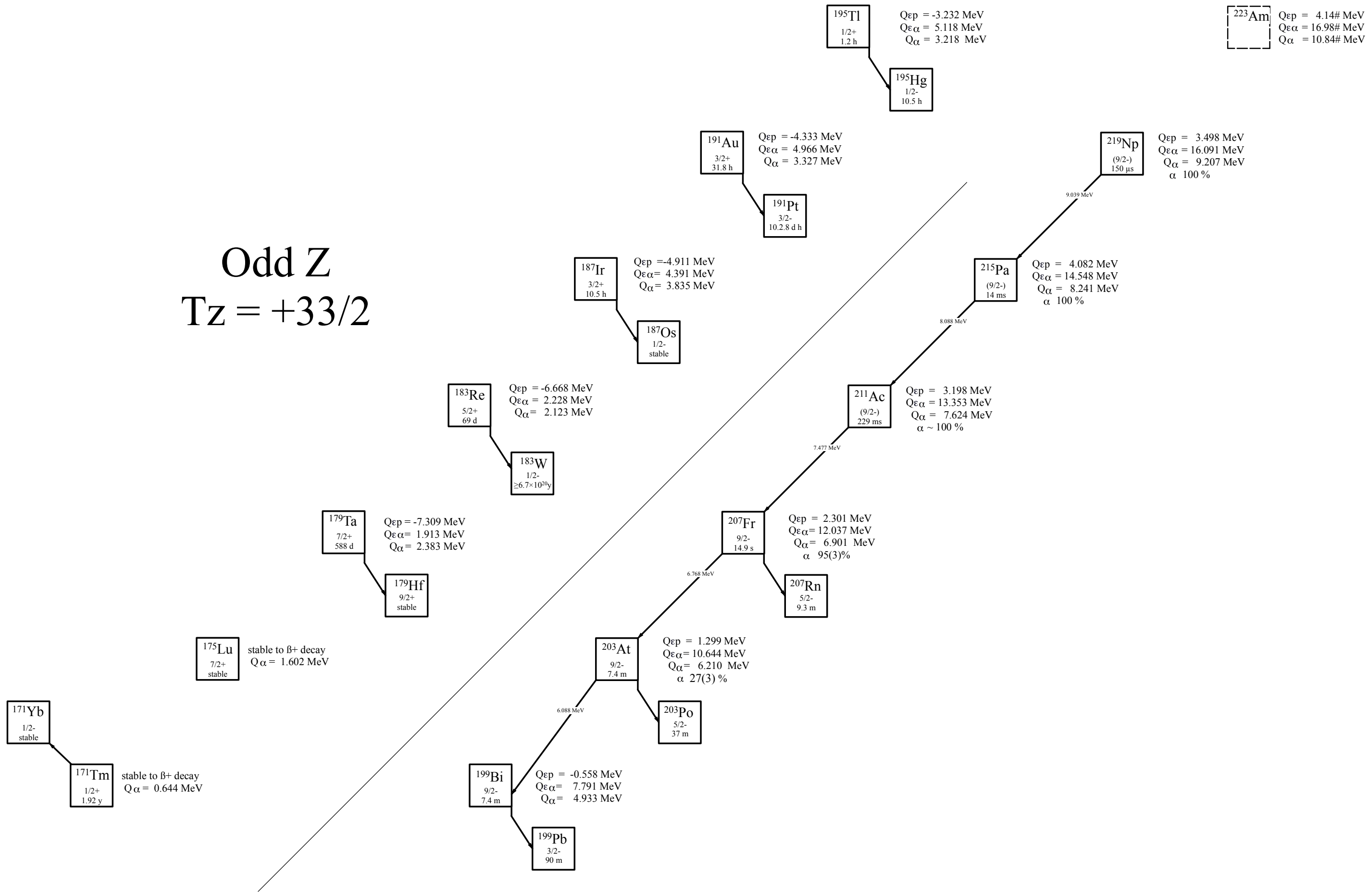

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +33/2 nuclei.

Last updated 10/20/2023

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +33/2 nuclei. J$^\pi$ values for ^{171}Tm, ^{175}Lu, ^{179}Ta, ^{183}Re, ^{187}Ir, ^{191}Au, ^{195}Tl and ^{199}Bi are taken from ENSDF. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q$_\varepsilon$	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{171}Tm*	1/2$^+$	1.92(1) y	-1.492(1)	——	——	[**1965Fl02**]
^{175}Lu	7/2$^+$	stable	-0.470(1)	——	——	
^{179}Ta	7/2$^+$	588(10) d	0.106(1)	-7.309(2)	1.913(1)	[**1974Ch53**]
^{183}Re	5/2$^+$	69.0(19) d**	0.556(8)	-6.668(8)	2.228(8)	[**1958Fo47, 1958Ga17**]
^{187}Ir	3/2$^+$	10.5(3) h	1.670(28)	-4.911(28)	4.391(28)	[**1963Em02**]
^{191}Au	3/2$^+$	31.8(8) h	1.900(6)	-4.333(5)	4.996(5)	[**1967Jo06**]
^{195}Tl	1/2$^+$	1.16(5) h	2.858(26)	-3.232(11)	5.118(12)	[**1961Ju06**]
^{199}Bi	9/2$^-$	27(1) m	4.434(13)	-0.558(13)	7.791(25)	[**1964Si11**]
^{203}At	9/2$^-$	7.4(3) m	5.148(12)	1.299(18)	10.644(13)	[**1961La02**]
^{207}Fr	9/2$^-$	14.9(1) s	5.786(18)	2.301(22)	12.037(18)	[**1981Ri04**]
^{211}Ac	(9/2$^-$)	229(25) ms***	6.310(50)	3.198(55)	13.353(54)	[**2000He17, 1968Va04**]
^{215}Pa	(9/2$^-$)	14(2) ms	6.880(80)	4.082(84)	14.548(83)	[**2000He17**]
^{219}Np	(9/2$^-$)	150^{+720}_{-70} μs	6.140(90)	3.498(94)	16.091(92)	[**2018Ya01**]
^{223}Am		$5.2^{+12.0}_{-4.4}$ms	6.58(42)#	4.14(30)#	16.98(30)#	[**2105De22**]

* 100% β^- emitter.
** Weighted average of 67.6(25) d [1958Fo47] and 71(3) d [1958Ga17].
*** Weighted average of 200(29) ms [2000He17], and 250(25) ms [1968Va04].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +33/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_p$	S$_{2p}$	Q$_\alpha$	BR$_\alpha$	Experimental
^{171}Tm	6.392(1)	14.992(20)	0.644(5)		
^{175}Lu	5.510(1)	13.488(5)	1.620(2)		
^{179}Ta	5.211(0)	12.551(1)	2.383(1)		
^{183}Re	4.852(8)	11.949(8)	2.123(8)		
^{187}Ir	3.838(28)	10.308(28)	3.835(29)		
^{191}Au	3.780(5)	9.926(14)	3.327(28)		
^{195}Tl	3.260(11)	9.328(14)	3.218(12)		
^{199}Bi	2.019(14)	7.021(17)	4.933(7)		
^{203}At	1.510(14)	5.312(16)	6.210(1)	27(3)%*	[**1998Bo14, 1996Ta18, 1975BaYJ, 1974Ho27, 1968Go12, 1967Tr06, 1963Ho18**, 1986Wo03, 1983SeZQ, 1970DaZM, 1967Tr04, 1961Fo04, 1956Bu12, 1951Ba04]
^{207}Fr	1.005(20)	4.442(21)	6.901(3)**	95(3)%***	[**1981Ri04, 1974Ho27, 1967Va20**, 1964Gr04, 1961Gr42]
^{211}Ac	0.588(55)	3.652(55)	7.624(6)$^@$	≈ 100%$^{@@}$	[**2000He17, 1968Va04**, 2014Ya19]
^{215}Pa	0.180(80)	2.910(80)	8.241(7)$^{@@@}$	100%	[**2000He17, 1996An21, 1979Sc09**, 2018Ya01, 1997Mi03,] 1995NiZS]
^{219}Np	-0.253(93)	2.196(93)	9.207(41)	100%	[**2018Ya01**, 2015De22]
^{223}Am	-0.35(42)#	1.79(36)#	10.84(31)#		[**2015De22**]

* Weighted average of 22(3)% [1998Bo14] and 31(3)% [1974Ho27].
** Deduced from α energy, 6.889(20) MeV in [2021Wa16].
*** Weighted average of 97^{+2}_{-3}% [1981Ri04] and 93(3)% [1974Ho27].
$^@$ Deduced from α energy, 7.568(52) MeV in [2021Wa16].
$^{@@}$ Based on half-life.
$^{@@@}$ Deduced from α energy, 8.240(60) MeV in [2021Wa16].

Table 3
direct α emission from ^{203}At, J$_i^\pi$ = (9/2$^-$), T$_{1/2}$ = 7.4(3) m*, BR_α = 27(3)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J$_f^\pi$	$E_{daughter}$(^{199}Bi)	coincident γ-rays	R$_0$ (fm)$^@$	HF
6.210(1)	6.088(1)***	27(3)%**	(9/2$^-$)	0.0	——	1.4873(17)	$1.24^{+0.22}_{-0.18}$

* [1961La02].
** Weighted average of 22(3)% [1998Bo14] and 31(3)% [1974Ho27].
*** Weighted average of 6.088(2) MeV [1996Ta18], 6.089(3) MeV [1975BaYJ], 6.087(2) MeV [1968Go128], 6.086(3) MeV [19Tr06], and 6.085(1) MeV [1963Ho18] (adjusted to 6.088(1) in [1991Ry01].

Table 4
direct α emission from ^{207}Fr, J_i^π = 9/2$^-$, $T_{1/2}$ = 14.9(1) s*, BR_α = 95(3)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{203}At)	coincident γ-rays	R$_0$ (fm)$^@$	HF
6.901(3)	6.768(3)***	95(3)%**	9/2$^-$	0.0	—	1.4973(32)	1.36(11)

* [1981Ri04].
** Weighted average of 97^{+2}_{-3}% [1981Ri04] and 93(3)% [1974Ho27].
*** Weighted average of 6.773(5) MeV [1967Va20] (adjusted to 6.774(5) in [1991Ry01], 6.761(5) MeV [1967Va20] (adjusted to 6.762(5) in [1991Ry01], and 6.766(5) MeV [1967Va20] (adjusted to 6.767(5) in [1991Ry01],

Table 5
direct α emission from ^{211}Ac, J_i^π = (9/2$^-$), $T_{1/2}$ = 229(25) ms*, BR_α = ≈ 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{207}Fr)	coincident γ-rays	R$_0$ (fm)$^@$	HF
7.624(6)	7.477(6)**	≈ 100%	(9/2$^-$)	0.0	—	1.4960(28)	1.18(16)

* Weighted average of 200(29) ms [2000He17], and 250(25) ms [1968Va04].
** Weighted average of 7.472(10) MeV [2000He17] and 7.480(8) MeV [1968Va04].

Table 6
direct α emission from ^{215}Pa, J_i^π = (9/2$^-$), $T_{1/2}$ = 14(2) ms*, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{211}Ac)	coincident γ-rays	R$_0$ (fm)$^@$	HF
8.241(7)	8.088(7)**	27(3)%**	(9/2$^-$)	0.0	—	1.557(16)	$1.1^{+0.6}_{-0.4}$

* [2000He17].
** Weighted average of 8.091(15) MeV [2000He17], 8.088(10) MeV [1996An21], and 8.085(15) MeV [1979Sc09].

Table 7
direct α emission from ^{219}Np*, J_i^π = (9/2$^-$), $T_{1/2}$ = 150^{+720}_{-70} μs, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{215}Pa)	coincident γ-rays	R$_0$ (fm)$^@$	HF
9.207(40)	9.039(40)	100%	(9/2$^-$)	0.0	—	1.492(19)	$4.9^{+23.1}_{-2.9}$

* All values from [2018Ya01].

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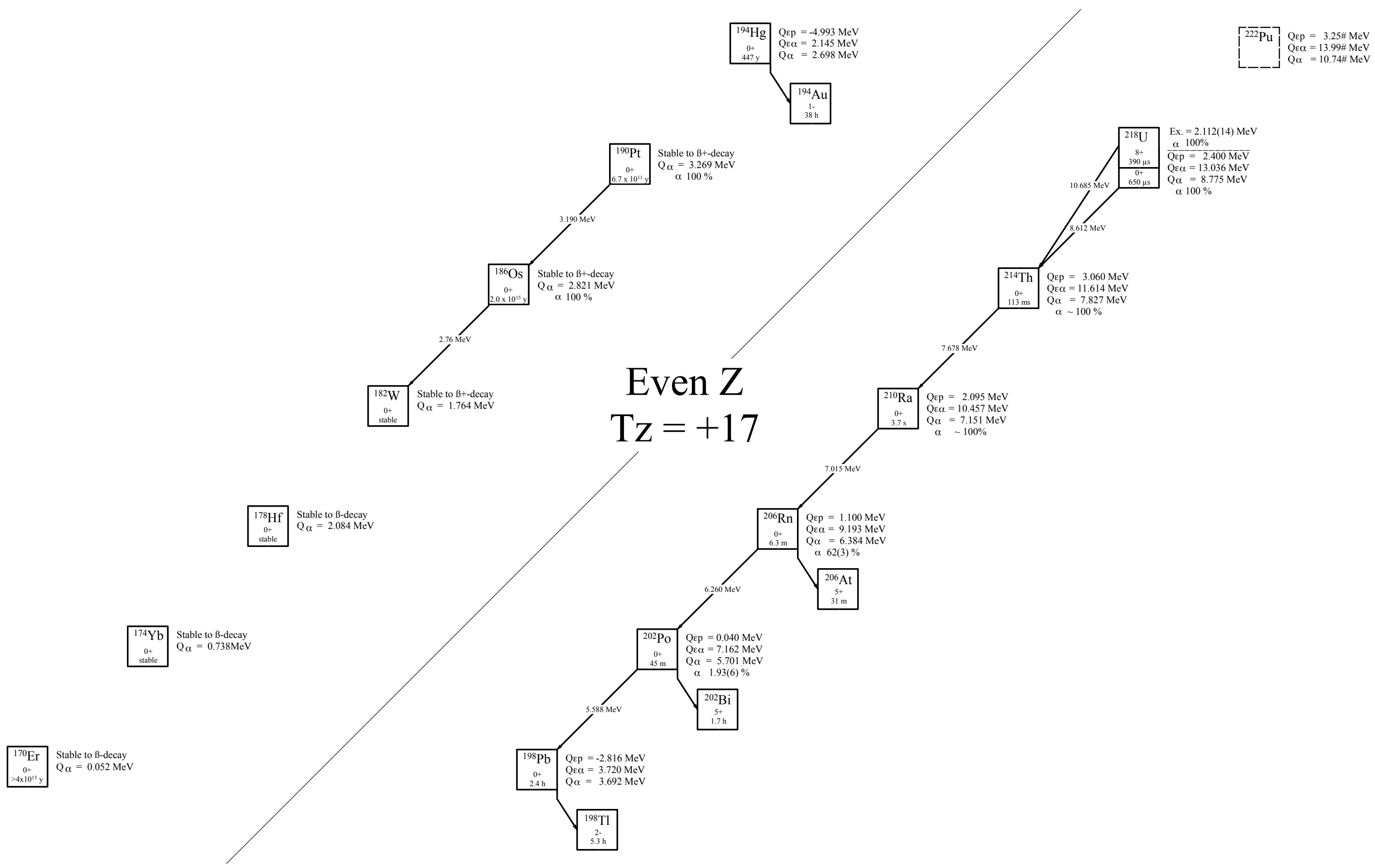

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +17 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +17 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	Ex.	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{170}Er		0^+	$\geq 4.1 \times 10^{+15}$ y	-3.870(50)	—	—	[**2018Be25**]
^{174}Yb		0^+	stable	-3.080(40)	—	—	
^{178}Hf		0^+	stable	-2.098(2)	—	—	
^{182}W		0^+	stable	-1.816(2)	—	—	
^{186}Os		0^+	$2.0(11) \times 10^{+15}$ y	-1.073(1)	—	—	[**1975Vi01**]
^{190}Pt		0^+	$6.65(28) \times 10^{11}$ y	-0.553(1)	—	—	[**2011Be08**]
^{194}Hg		0^+	447(28) y	0.028(4)	-4.993(3)	2.145(3)	[**2015Do01**]
^{198}Pb		0^+	2.4(1) h	1.461(12)	-2.816(9)	3.720(9)	[**1959Ju39**]
^{202}Po		0^+	45.4(2) m	2.809(16)	0.040(16)	7.162(11)	[**1970Ra14**]
^{206}Rn		0^+	6.29(10) m*	3.306(16)	1.100(13)	9.193(16)	[**1969Ha03, 1967Va17**]
^{210}Ra		0^+	3.7(2) s**	3.786(16)	2.095(14)	10.457(16)	[**1968Lo15, 1967Va22**]
^{214}Th		0^+	113^{+11}_{-9} ms	4.262(17)	3.060(14)	11.614(17)	[**2022Zh45**]
^{218}U		0^+	650^{+80}_{-70} μs	3.245(23)	2.400(17)	13.036(19)	[**2022Zh45**]
^{218m}U	2.112(14)	8^+	390^{+60}_{-50} μs	5.357(27)	4.512(22)	15.148(24)	[**2022Zh45**]
^{222}Pu		0^+		3.79(30)#	3.25(31)#	13.99(30)#	

* Weighted average of 5.67(17) m [1969Ha03] and 6.5(1) m [1967Va17].
* Weighted average of 3.8(2) s [1967Va22] and 3.6(2) s [1968Lo15].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the even-Z, T_z = +17 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{170}Er	8.600(20)	16.13(14)	0.052(2)		
^{174}Yb	7.977(4)	15.040(4)	0.738(1)		
^{178}Hf	7.340(1)	13.522(1)	2.084(1)		
^{182}W	7.096(2)	13.045(2)	1.764(2)		
^{186}Os	6.470(1)	11.873(1)	2.821(1)	100%	[**1975Vi01**, 2020Be23, 1973ViZL]
^{190}Pt	6.146(13)	10.747(1)	3.269(1)	100%	[**2011Be08, 1987Al28**, 2017Br04, 1997Ta33, 1986AlZT, 1966Ka23, 1961Ma05, 1963Gr08, 1961Gr37, 1961Ma05, 1961Pe23, 1956Po16, 1954Po24, 1953Po01]
^{194}Hg	6.068(9)	10.473(4)	2.698(3)		
^{198}Pb	5.002(16)	8.819(9)	3.692(9)		
^{202}Po	3.802(15)	6.269(13)	5.701(2)	1.93(6)%*	[**1993Wa04, 1970Jo26, 1970Ra14, 1968Go12, 1967Le08, 1967Ti10, 1967Tr06**, 1992WaZV, 1971Ho01, 1969Ha03, 1967Le21, 1967Tr04, 1965Br17, 1965Br27, 1964Br23, 1963Ho10, 1962Ax02, 1961Ax02, 1961Be25, 1961Fo05, 1954Ro39, 1951Ka14]
^{206}Rn	3.437(15)	5.370(13)	6.384(2)	62(3)%	[**1993Wa04, 1971Go35, 1971Ho01, 1969Ha03, 1967Va17**, 2014Ma66, 1992WaZV, 1967Va07, 1965Nu04, 1957St10, 1954Bu67]
^{210}Ra	3.064(15)	4.480(14)	7.151(3)	≈ 100%**	[**2003He06, 1967Va22**, 2015Ma37, 2001HeZY, 1997Mi03, 1968Lo15]
^{214}Th	2.735(16)	3.684(15)	7.827(5)	100%	[**2022Zh45, 1980Ve01, 1968Va18**, 2005Li17, 1984Sc13, 1968Va10]
^{218}U	2.449(19)	2.982(18)	8.775(9)	100%	[**2022Zh45, 2021Zh22, 2005Le42**, 2015Ma37, 2007Le14, 2006LeZR, 1994AnZY, 1994Ye08]
^{218m}U	0.337(23)	0.870(24)	10.887(17)	100%	[**2022Zh45, 2005Le42**, 2021Zh22, 2015Ma37, 2007Le14, 2006LeZR]
^{222}Pu	2.14(36)#	2.53(32)#	10.74(30)#		

* Weighted average of 1.92(7)% [1993Wa04] and 2.00(15)% [1967Le08].
** Based half-life.

Table 3
direct α emission from ^{186}Os*, $J_i^\pi = 0^+$, $T_{1/2} = 2.0(11) \times 10^{+15}$ y, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{182}W)	coincident γ-rays	R$_0$ (fm)]	HF
≈2.82	≈2.76	100%	0^+	0.0	—	1.486(29)	1.0(5)

* All values taken from [1975Vi01].

Table 4
direct α emission from ^{190}Pt, $J_i^\pi = 0^+$, $T_{1/2} = 6.5(3) \times 10^{11}$ y*, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{186}Os)	coincident γ-rays	R$_0$ (fm)]	HF
3.122	3.053**	0.25(10)%	0.25(10)%**	2^+	0.137	0.137	1.486(29)	13^{+8}_{-4}
3.258	3.190(10)	100%	99.75(10)%**	0^+	0.0	—	1.486(29)	1.04(4)

* [2017Br04].
** α was not observed, the decay branch was determined through the observation of 137-keV γ ray from ^{190}Pt decay [2011Be08].

Table 5
direct α emission from ^{202}Po, $J_i^\pi = 0^+$, $T_{1/2}$ = 45.4(2) m*, BR_α = 1.93(6)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{198}Pb)	coincident γ-rays	R$_0$ (fm)]	HF
5.701(1)	5.588(1)***	100%	0^+	0.0	—	1.4720(20)	1.013(32)

* [1970Ra14].
** Weighted average of 1.92(7)% [1993Wa04] and 2.00(15)% [1967Le08].
*** Weighted average of 5.589(3) MeV [1970Ra14] (adjusted to 5.588(3) MeV in [1991Ry01]), 5.590(5) MeV [1970Jo26], 5.588(2) MeV [1968Go12], 5.587(5) MeV [1967Ti10] and 5.578(3) MeV [1970Ra14] (adjusted to 5.579(5) MeV in [1991Ry01]).

Table 6
direct α emission from ^{206}Rn, $J_i^\pi = 0^+$, $T_{1/2}$ = 6.29(10) m*, BR_α = 62(3)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{202}Po)	coincident γ-rays	R$_0$ (fm)]	HF
6.3836(16)	6.2597(16)***	100%	0^+	0.0	—	1.4917(27)	1.11(6)

* Weighted average of 5.67(17) m [1969Ha03] and 6.5(1) m [1967Va17].
** [1971Ho01].
*** Weighted average of 6.2606(25) MeV [1993Wa04], 6.260(3) MeV [1971Go35] and 6.258(3) MeV [1967Va17].

Table 7
direct α emission from ^{210}Ra, $J_i^\pi = 0^+$, $T_{1/2}$ = 3.7(2) s*, $BR_\alpha = \approx 100\%$.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{206}Rn)	coincident γ-rays	R$_0$ (fm)]	HF
7.151(5)	7.015(5)**	100%	0^+	0.0	—	1.4861(29)	0.90(5)

* Weighted average of 3.8(2) s [1967Va22] and 3.6(2) s [1968Lo15].
** Weighted average of 7.003(10) MeV [2003He06] and 7.018(5) MeV [1967Va22].

Table 8
direct α emission from ^{214}Th, $J_i^\pi = 0^+$, $T_{1/2} = 113^{+11}_{-9}$ ms*, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{210}Ra)	coincident γ-rays	R$_0$ (fm)]	HF
7.824(6)	7.678(6)**	100%	0^+	0.0	—	1.4986(56)	1.26(12)

* [2022Zh45].
** Weighted average of 7.674(14) MeV [2022Zh45], 7.677(10) MeV [1980Ve01] and 7.680(10) MeV [1968Va18].

Table 9
direct α emission from ^{218}U, $J_i^\pi = 0^+$, $T_{1/2} = 650^{+80}_{-70}$ μs*, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{214}Th)	coincident γ-rays	R$_0$ (fm)]	HF
8.773(8)	8.612(8)**	100%	0^+	0.0	—	1.512(14)	1.26(16)

* [2022Zh45].
** Weighted average of 8.612(14) MeV [2022Zh45] and 8.612(9) MeV [2005Le42].

Table 10
direct α emission from ^{218m}U, ex. = 2.112(14) MeV, $J_i^\pi = 8^+$, $T_{1/2} = 390^{+60}_{-50}$ μs*, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{214}Th)	coincident γ-rays	R$_0$ (fm)]	HF
10.261(16)	10.073(16)*	28(5)%*	22(5)%*		0.629		1.512(14)	$1.2^{+0.6}_{-0.4} \times 10^4$
10.885(11)	10.685(11)**	100(5)%*	78(5)%*	0^+	0.0	—	1.512(14)	$5.8(10) \times 10^4$

* [2022Zh45].
** Weighted average of 20.690(14) MeV [2022Zh45] and 10.678(17) MeV [2005Le42].

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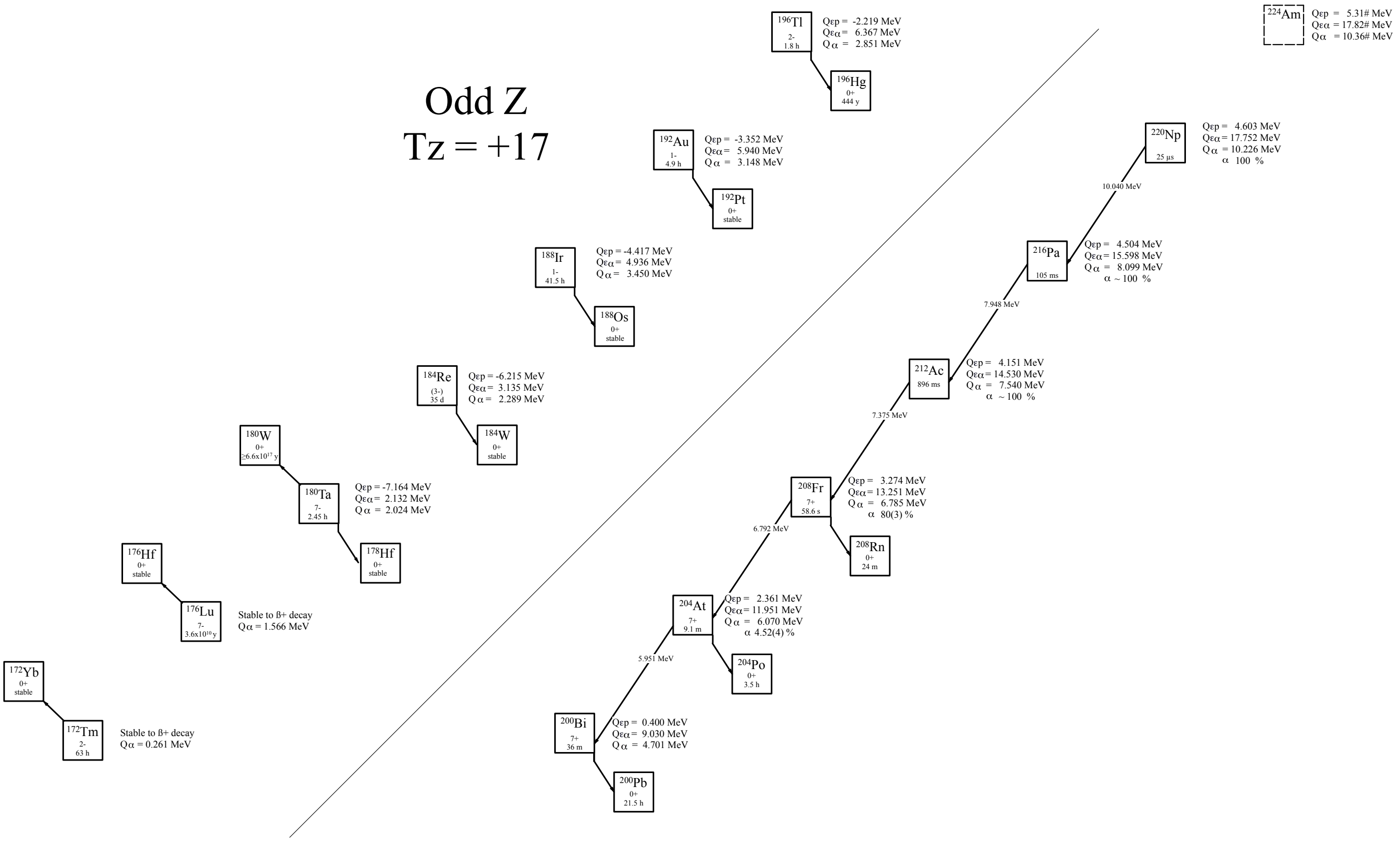

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +17 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +17 nuclei. J^π values for ^{172}Tm, ^{176}Lu, ^{180}Ta, ^{184}Re, ^{188}Ir, ^{192}Au, ^{196}Tl and ^{200}Bi are taken from ENSDF. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{172}Tm*	2^-	63.6(3) h	-0.891(5)	—	—	[**1956Ne08**]
^{176}Lu*	7^-	3.640(35) × 10^{10} y	0.109(1)	-8.361(50)	0.676(4)	[**2013Ko20**]
^{180}Ta**	1^+	8.152(6) h	0.846(2)	-7.164(5)	2.132(2)	[**1980Ry01**]
^{184}Re	(3^-)	35.43(16) d	1.486(4)	-6.215(4)	3.135(4)	[**2022La12**]
^{188}Ir	1^-	41.5(5) h	2.792(9)	-4.417(9)	4.936(9)	[**1950Ch11**]
^{192}Au	1^-	4.94(10) h***	3.516(16)	-3.352(16)	5.940(16)	[**1966Ny01, 1962Ma18**]
^{196}Tl	2^-	1.84(3) h	4.329(12)	-2.219(12)	6.367(12)	[**1960Ju01**]
^{200}Bi	7^+	36.4(5) m	5.880(25)	0.400(36)	9.030(23)	[**1970DaZM**]
^{204}At	7^+	9.1(1) m@	6.466(25)	2.361(26)	11.951(25)	[**1963Ho18, 1970DaZM, 1964Th07**]
^{208}Fr	7^+	58.6(3) s@@	6.990(15)	3.274(17)	13.251(15)	[**1974Ho27, 1981Ri04**]
^{212}Ac	(7^+)	896(35) ms@@@	7.498(24)	4.151(25)	14.530(24)	[**1968Va04, 2014Ya19**]
^{216}Pa		105(12) ms	7.525(27)	4.504(28)	15.598(27)	[**1996An21**]
^{220}Np		25^{+14}_{-7} μs	7.46(11)#	4.603(76)	17.752(33)#	[**2019Zh23**]
^{224}Am			7.98(50)#	5.31(41)#	17.82(41)#	

* 100% β^- emitter.
** Decays by 22.1(14)% β^+, 77.9(14)% β^- emitter [2013Ko20].
*** Weighted average of 4.85(10) h [1966Ny01] and 5.03(10) h [1962Ma18].
@ Weighted average of 9.3(2) m [1963Ho18], 9.1(2) m [1970DaZM], and 8.9(2) m [1964Th07].
@@ Weighted average of 58.0(3) s [1974Ho27] and 59.1(3) s [1981Ri04].
@@@ Weighted average of 880(35) ms [2014Ya19] and 930(50) ms [1968Va04].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +17 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{172}Tm	6.945(5)	15.714(50)	0.261(30)		
^{176}Lu	5.976(1)	14.096(45)	1.566(6)		
^{180}Ta	5.760(2)	13.174(3)	2.024(2)		
^{184}Re	5.143(4)	12.367(4)	2.289(5)		
^{188}Ir	4.415(9)	10.996(9)	3.450(10)		
^{192}Au	4.363(16)	10.597(16)	3.148(18)		
^{196}Tl	3.772(26)	9.863(12)	2.851(20)		
^{200}Bi	2.428(24)	7.420(24)	4.701(26)		
^{204}At	1.853(23)	5.702(27)	6.070(1)	4.52(4)%	[**1981Va27, 1968Go12, 1967Tr06, 1963Ho18, 1961La02**, 2014Ma66, 1981Va29, 1981VaZT, 1975BaYJ, 1974Ho27, 1970DaZM, 1967Tr04, 1964Th07]
^{208}Fr	1.319(13)	4.803(18)	6.785(25)	80(3)%*	[**1981Ri04, 1974Ho27, 1967Va20**, 2019Zh23, 2003At01, 1971ReZE, 1964Gr04, 1961Gr42]
^{212}Ac	0.821(22)	3.935(26)	7.540(24)	≈ 100%**	[**2014Ya19, 2000He17,1968Va04**, 2019Zh23, 2015Ma63]
^{216}Pa	0.387(25)	3.187(28)	8.099(11)	≈ 100%**	[**2000He17**, 2019Zh23, 1998Ik01, 1998MiZW, 1996An21, 1979Sc09, 1971Su14]
^{220}Np	0.110(33)	2.752(36)	10.226(18)	100%	[**2019Zh23**]
^{224}Am	0.15(50)#	2.59(40)#	10.36(40)#		

* Weighted average of 90(4)% [1981Ri04] and 74(3)% [1974Ho27].
** Not measured, based on half-life.

Table 3
direct α emission from ^{204}At, J_i^π = 7^+, $T_{1/2}$ = 9.1(1) m*, BR_α = 4.52(4)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{200}Bi)	coincident γ-rays	R$_0$ (fm)]	HF
6.070(1)	5.951(1)***	4.52(4)%**	7^+	0.0	—	1.4809(34)$^@$	2.02(16)

* Weighted average of 9.3(2) m [1963Ho18], 9.1(2) m [1970DaZM], and 8.9(2) m [1964Th07].
** [1961La02].
*** Weighted average of 5.952(2) MeV [1968Go12], 5.948(3) MeV (adjusted to 5.951(3) MeV in [1991Ry01]) [1963Ho18], 5.947(3) MeV [1967Tr06] and 5.953(3) MeV [1981Va27].
$^@$ Interpolated between 1.4720(20) fm (^{202}Po) and 1.4917(27) fm (^{206}Rn).

Table 4
direct α emission from ^{208}Fr, J_i^π = (7^+), $T_{1/2}$ = 58.6(3) s*, BR_α = 80(3)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{204}At)	coincident γ-rays	R$_0$ (fm)]	HF
6.771(5)	6.641(5)***	80(3)%**	7^+	0.0	—	1.4889(40)$^@$	$1.78^{+0.20}_{-0.18}$

* Weighted average of 9.3(2) m [1963Ho18], 9.1(2) m [1970DaZM], 9.3(2) m [19631La02] and 8.9(2) m [1964Th07].
** Weighted average of 90(4)% [1981Ri04] and 74(3)% [1974Ho27].
*** Weighted average of 6.647(5) MeV (adjusted to 6.647(5) MeV in [1991Ry01]) [1967Va20], 6.636(5) MeV (adjusted to 6.637(5) MeV in [1991Ry01]) [1974Ho27] and 6.636(5) MeV (adjusted to 6.637(5) MeV in [1991Ry01]) [1981Ri04].
$^@$ Interpolated between 1.4917(27) fm (^{206}Rn) and 1.4861(29) fm (^{210}Ra).

Table 5
direct α emission from ^{212}Ac, J_i^π = (7^+), $T_{1/2}$ = 896(35) ms*, BR_α = $\approx$ 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{208}Fr)	coincident γ-rays	R$_0$ (fm)]	HF
7.517(6)	7.375(6)**	100%	(7^+)	0.0	—	1.4924(63)***	$1.98^{+0.32}_{-0.28}$

* Weighted average of 880(35) ms [2014Ya19] and 930(50) ms [1968Va04].
** Weighted average of 7.373(10) MeV [2000He17] and 7.377(8) MeV [1968Va04].
*** Interpolated between 1.4861(29) fm (^{210}Ra) and 1.4986(56) fm (^{214}Th).

Table 6
direct α emission from ^{216}Pa*, $T_{1/2}$ = 105(12) ms**, BR_α = $\approx$ 100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{212}Ac)	coincident γ-rays	R$_0$ (fm)]	HF
7.940(15)	7.793(15)	8(2)%	4(1)%		0.158	0.158	1.505(15)***	35^{+22}_{-14}
7.962(15)	7.815(15)	88(12)%	45(5)%		0.1336(3)	0.1336(3)	1.505(15)***	$3.7^{+1.8}_{-1.4}$
8.098(15)	7.948(15)	100(8)%	51(4)%	(7^+)	0.0	—	1.505(15)***	9^{+4}_{-3}

* All values from [2000He25], except where noted.
** [1996An21].
*** Interpolated between 1.4986(56) fm (^{214}Th) and 1.512(14) fm(^{218}U).

Table 7
direct α emission from ^{220}Np*, $T_{1/2}$ = 25^{+14}_{-7} μs, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{216}Pa)	coincident γ-rays	R$_0$ (fm)]	HF
10.226(18)	10.040(18)	100%		0.0**	—	1.512(39)***	80^{+100}_{-50}

* All values from [219Zh23].
** α is assumed to feed the ground state of ^{216}Pa.
*** Interpolated between 1.512(14) fm (^{218}U) and 1.511(36) fm (^{222}Pu).

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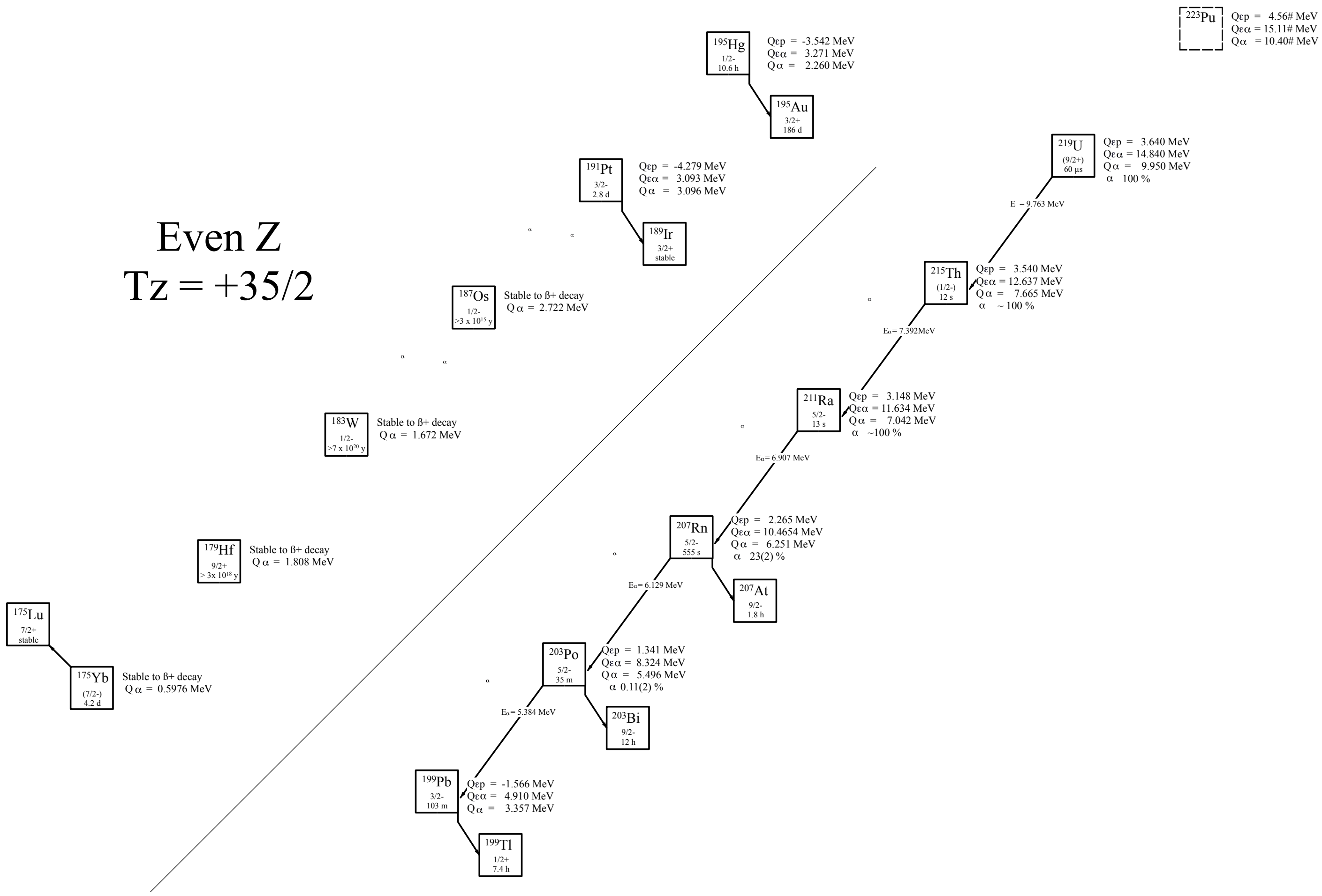

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +35/2 nuclei.

Last updated 12/8/23

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +35/2 nuclei. J^π values for ^{171}Tm, ^{175}Lu, ^{179}Ta, ^{183}Re, ^{187}Ir, ^{191}Au, ^{195}Tl ^{199}Bi and ^{211}Ra are taken from ENSDF. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{175}Yb*	(7/2$^-$)	4.185(1) d	-2.390(50)	—	—	[**1989Ab05**]
^{179}Hf	9/2$^+$	$\geq$2.7 × 10^{18} y	-1.404(5)	—	—	[**2021Br09**]
^{183}W	1/2$^-$	$\geq$6.7 × 10^{20} y	-1.072(2)	—	—	[**2011Be39**]
^{187}Os	1/2$^-$	$\geq$3.2 × 10^{15} y	-0.002	—	—	[**2020Be23**]
^{191}Pt	3/2$^-$	2.817(4) d**	1.010(4)	-4.279(4)	3.093(4)	[**2000Mo05, 1994Pa16**]
^{195}Hg	1/2$^-$	10.69(3) h***	1.554(23)	-3.542(23)	3.271(23)	[**2015Do01, 2001Li17**]
^{199}Pb	3/2$^-$	103.0(14) m	2.828(29)	-1.566(7)	4.910(7)	[**2014Pa07**]
^{203}Po	5/2$^-$	34.8(5) m$^@$	4.214(14)	1.341(6)	8.324(28)	[**1970DaZM, 1970Jo26, 1967Le21**]
^{207}Rn	5/2$^-$	555(10) s	4.593(13)	2.265(6)	10.465(14)	[**1971Ho01**]
^{211}Ra	5/2$^-$	13(2) s$^{@@}$	4.972(13)	3.148(7)	11.634(13)	[**2019Zh54, 1968Lo15, 1967Va22**]
^{215}Th	(1/2$^-$)	12(2) s	4.891(14)	3.540(8)	12.637(14)	[**1968Va18**]
^{219}U	(9/2$^+$)	60(7) μs	4.710(70)	3.640(17)	14.840(18)	[**2019Zh54**]
^{223}Pu			5.46(31)#	4.56(30)#	15.11(31)#	

* 100% β^- emitter.
** Weighted average of 2.862(7) d [2000Mo05] and 2.802(4) d [1994Pa16].
*** Weighted average of 10.84(3) h [2015Do01] and 10.53(3) h [2001Li17].
$^@$ Weighted average of 36.7(5) m [1970DaZM], 33(1) m [1970Jo26] and 29(1) m [1967Le21].
$^{@@}$ Weighted average of 10(3) s [2019Zh54], 1592) s [1968Lo15] and 12(2) s [1967Va22].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the even-Z, T_z = +35/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{175}Yb	8.120(45)	15.62(20)	0.597(1)		
^{179}Hf	7.414(2)	14.055(1)	1.808(1)		
^{183}W	7.224(2)	13.541(2)	1.672(2)		
^{187}Os	6.581(1)	12.409(1)	2.722(1)		
^{191}Pt	6.234(4)	11.289(4)	3.096(4)		
^{195}Hg	6.090(23)	11.112(23)	2.260(24)		
^{199}Pb	4.992(10)	9.269(8)	3.357(24)		
^{203}Po	3.849(15)	6.618(15)	5.496(5)	0.11(2)%	[**1970Ra14, 1968Go12, 1967Le21**, 1970DaZM, 1967Ti04, 1963Be28, 1962Be26, 1961Be25, 1961Fo05, 1959AtXX, 1951Ka03]
^{207}Rn	3.484(14)	5.691(11)	6.251(2)	23(2)%	[**1993Wa04, 1971Go35, 1971Ho01**, 1971Jo19, 1967Va07, 1967Va17, 1967Va20, 1957St10, 1954Bu67]
^{211}Ra	3.114(14)	4.805(11)	7.042(3)	≈ 100%*	[**2003He06**, 2019Zh54, 2007Le14, 1968Lo15, 1967Va22]
^{215}Th	2.801(15)	4.002(12)	7.665(4)	≈ 100%*	[**2005Ku31**, 2007Le14, 2000He17, 1989He03, 1968Va18, 1968Va10]
^{219}U	2.643(22)	3.488(17)	9.950(12)	100%*	[**2019Zh54**, 2007Le14, 2006LeZR, 2005Le42, 1994AnZY, 1994Ye08, 1993An07]
^{223}Pu	2.44(30)#	2.98(31)#	10.40(30)#		

* Not measured. Based on half-life.

Table 3
direct α emission from ^{203}Po, J_i^π = 5/2$^-$, $T_{1/2}$ = 34.8(5) m*, BR_α = 0.11(2)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{199}Pb)	coincident γ-rays	R$_0$ (fm)]	HF
5.492(3)	5.384(3)***	0.11(2)%**		0.0	—	1.4673(21)	$1.15^{+0.29}_{-0.20}$

* Weighted average of 36.7(5) m [1970DaZM], 33(1) m [1970Jo26] and 29(1) m [1967Le21].
** [1967Le21].
*** [1970Ra14, 1968Go12].

Table 4
direct α emission from ^{207}Rn, J_i^π = 5/2$^-$, $T_{1/2}$ = 555(10) s*, BR_α = 23(2)%*.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{203}Po)	coincident γ-rays	R_0 (fm)]	HF
6.113(4)	5.995(4)	0.10(3)%	0.023(7)%	(1/2$^-$)	0.137		1.4836(40)	260^{+130}_{-70}
6.188(3)	6.068(3)	0.66(2)%	0.15(1)%	(3/2$^-$)	0.063	0.063	1.4836(40)	84(11)
6.2502(25)	6.1294(25)**	100%	23(2)%	5/2$^-$	0.0	—	1.4836(40)	1.05(13)

* [1971Ho01].
** [1993Wa04]

Table 5
direct α emission from ^{211}Ra*, J_i^π = 5/2$^-$, $T_{1/2}$ = 13(2) s**, BR_α = ≈ 100%.

E_α(c.m.)	E_α(lab)	I_α(rel)***	I_α(abs)***	J_f^π	$E_{daughter}$(^{207}Rn)	coincident γ-rays	R_0 (fm)]	HF
6.376(5)	6.255(5)	0.06%	≈0.06%	(9/2$^-$)	0.6650(1)	0.6650(1)	1.4790(30)	4.3
6.437(10)	6.315(10)	0.04%	≈0.04%		0.6016(3)	0.6016(3)	1.4790(30)	12
6.442(10)	6.32(10)	7 × 10^{-5}%	≈7 × 10^{-5}%		0.5691(3)	0.5691(3)	1.4790(30)	90
6.755(5)	6.627(5)	0.08%	≈0.08%(1/2$^-$, 3/2$^-$)		0.2830(1)	0.1200, 0.1629, 0.2830(1)	1.4790(30)	120
6.919(5)	6.788(5)	1%	≈1%	3/2$^-$	0.1200(1)	0.1200(1)	1.4790(30)	40
7.040(5)	6.907(5)	100%	≈99%	5/2$^-$	0.0	—	1.4790(30)	1.14(20)

* All values from [2003He06], except where noted.
** Weighted average of 10(3) s [2019Zh54], 1592) s [1968Lo15] and 12(2) s [1967Va22].
*** No uncertainties are given in [2003He06].

Table 6
direct α emission from ^{215}Th*, J_i^π = (1/2$^-$), $T_{1/2}$ = 1.2(2) s**, BR_α = ≈ 100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{211}Ra)	coincident γ-rays	R_0 (fm)]	HF
7.373(7)	7.236(7)	1.9(8)%	1.0(4)%	(3/2$^-$)	0.2951(3)	0.2951(3)	1.4841(35)	31^{+30}_{-13}
7.474(5)	7.335(5)	15.4%	8%***	(3/2$^-$)	0.1945(1)	0.0609(3), 0.1945(1)	1.4841(35)	9
7.532(4)	7.392(4)	100%	52%***	(1/2$^-$)	0.1339(1)	0.1339(1)	1.4841(35)	2.2
7.666(5)	7.523(5)	76.9%	40%***	5/2($^-$)	0.0	—	1.4841(35)	8

* All values from [2005Ku31], except where noted.
** [1968Va18].
*** No uncertainties are given in [2003He06].

Table 7
direct α emission from ^{219}U*, J_i^π = (9/2$^+$), $T_{1/2}$ = 60(7) μs, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{215}Th)	coincident γ-rays	R_0 (fm)]	HF
9.142(17)	8.975(17)	$7.3^{+4.2}_{-3.0}$%	$6.5^{+3.7}_{-2.6}$%	(3/2$^-$)	0.807(23)		1.516(14)	19^{+31}_{-9}
9.418(17)	9.246(17)	$4.8^{+4.4}_{-2.4}$%	$4.3^{+3.9}_{-2.1}$%	(5/2$^-$)	0.527(23)		1.516(14)	$1.1^{+6.9}_{-0.7} \times 10^3$
9.945(15)	9.763(15)	100(11)%	89.2(9.8)	(1/2$^-$)	0.0	—	1.516(14)	110^{+50}_{-40}

* All values from [2019Zh45].

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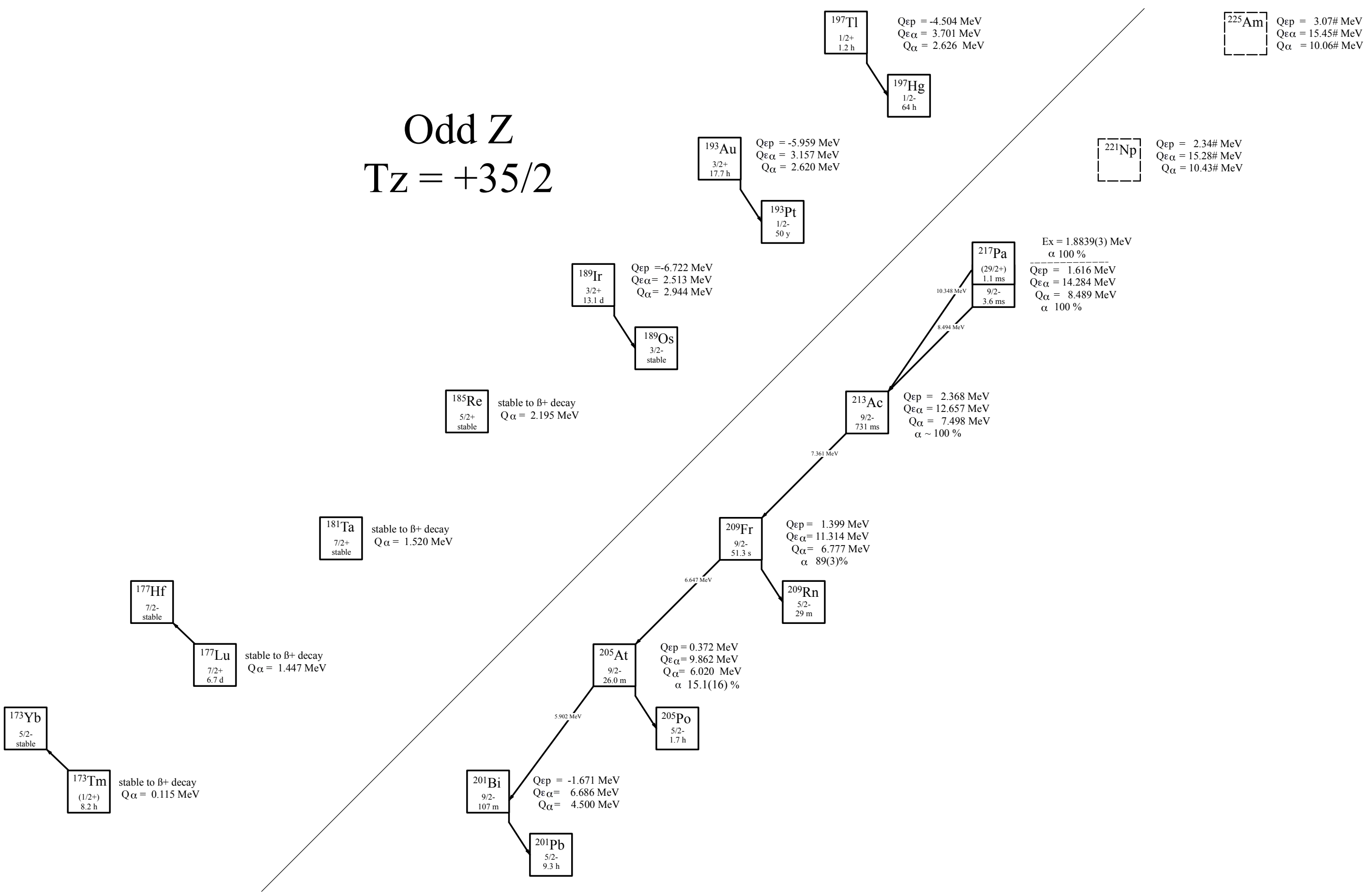

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +35/2 nuclei.

Last updated 12/5/23

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +35/2 nuclei. J$^\pi$ values for ^{173}Tm, ^{177}Lu, ^{181}Ta, ^{185}Re, ^{189}Ir, ^{193}Au, ^{197}Tl and ^{201}Bi are taken from ENSDF. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex.	J^π	$T_{1/2}$	Qε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{173}Tm*		(1/2$^+$)	8.24(8) h	-2.60(20)#	—	—	[**1963Or01**]
^{177}Lu*		7/2$^+$	6.7479(7) d	-1.398(1)	—	—	[**1990Ab02**]
^{181}Ta		7/2$^+$	stable	-1.036(2)	—	—	
^{185}Re		5/2$^+$	stable	-0.431(1)	—	—	
^{189}Ir		3/2$^+$	13.1(1) d**	0.537(13)	-6.722(13)	2.513(13)	[**1975Ba35, 1964Le07, 1963Gr22**]
^{193}Au		3/2$^+$	17.65(15) h	1.075(9)	-5.858(9)	3.157(9)	[**1968Sv01**]
^{197}Tl		1/2$^+$	2.84(4) h	2.186(14)	-4.504(14)	3.701(14)	[**1961Ju05**]
^{201}Bi		9/2$^-$	107.4(21) m***	3.842(18)	-1.671(13)	6.686(13)	[**1970DaZM, 1956St05**]
^{205}At		9/2$^-$	26.0(5) m$^@$	4.537(16)	0.372(15)	9.862(18)	[**1970DaZM, 1968Go12, 1961La02**]
^{209}Fr		9/2$^-$	51.3(8) s	5.159(15)	1.399(15)	11.314(15)	[**1996Xu02**]
^{213}Ac		9/2$^-$	731(17) ms	5.795(15)	2.368(15)	12.657(15)	[**2000He17**]
^{217}Pa		9/2$^-$	3.6(2) ms$^{@@}$	4.849(16)	1.616(16)	14.284(16)	[**2002He29, 1996An21**]
^{217m}Pa	1.8839(3)	29/2$^+$	1.08(3) ms	6.733(16)	3.500(16)	16.168(16)	[**2002He29**]
^{221}Np				5.39(21)#	2.34(20)#	15.28(20)#	
^{225}Am				6.09(50)#	3.07(40)#	15.45(41)#	

* 100% β^- emitter.
** Weighted average of 13.1(1) d [1975Ba35], 13.3(1) d [1964Le07] and 13.2(2) d [1963Gr22].
*** Weighted average of 106.2(24) m [1970DaZM] and 111(4) m [1956St05].
$^@$ Weighted average of 27.2(6) m [1970DaZM], 25.0(5) m [1968Go12] and 26.2(5) m [1961La02].
$^{@@}$ Weighted average of 3.8(2) ms [2002He29] and 3.4(2) ms [1996An21].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +35/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_p$	S$_{2p}$	Q$_\alpha$	BR$_\alpha$	Experimental
^{173}Tm	7.062(6)	16.32(60)#	0.115(21)		
^{177}Lu	6.182(1)	14.651(50)	1.447(5)		
^{181}Ta	5.949(2)	13.958(5)	1.520(2)		
^{185}Re	5.403(1)	13.103(2)	2.195(2)		
^{189}Ir	4.601(13)	11.811(138)	2.944(13)		
^{193}Au	4.405(9)	11.274(9)	2.620(15)		
^{197}Tl	3.817(14)	10.365(14)	2.626(16)		
^{201}Bi	2.467(16)	7.948(30)	4.500(6)		
^{205}At	1.932(16)	6.038(18)	6.020(2)	15.1(16)%*	[**1974Ho27, 1968Go12, 1961La02**, 1970DaZM, 1963Ho18, 1963Uh01, 1961Fo04, 1954Bu67, 1951Ba14]
^{209}Fr	1.416(15)	5.133(17)	6.777(4)	89(3)%	[**1974Ho27, 1967Va20**, 1964Gr04, 1964Gr04]
^{213}Ac	0.949(16)	4.297(17)	7.498(4)	≈ 100%	[**200He17, 1968Va04**, 1961Gr42]
^{217}Pa	0.533(17)	3.554(18)	8.489(4)	100%	[**2002He29**, 2008DoZZ, 2002HeZV, 1998Ik01, 1998MiZW, 1996An21, 1996AnZY, 1995NiZS, 1978ReZZ, 1977ScZC, 1968Va18]
^{217m}Pa	-1.351(17)	1.670(18)	10.373(4)	100%	[**2002He29**, 2008DoZZ, 2002HeZV, 1998Ik01, 1998MiZW, 1996An21, 1996AnZY, 1995NiZS, 1978ReZZ]
^{221}Np	0.39(22)#	3.25(21)#	10.43(20)#		
^{225}Am	0.18(50)#	2.85(41)#	10.06(45)#		

* Weighted average of 10(2)% [1974Ho27] and 18.4(16)% [1961La02].
** Not measured, inferred from half-life.

Table 3
direct α emission from ^{205}At, J$_i^\pi$ = 9/2$^-$, T$_{1/2}$ = 26.0(5) m*, BR_α = 15.1(16)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J$_f^\pi$	$E_{daughter}$(^{201}Bi)	coincident γ-rays	R$_0$ (fm)]	HF
6.019(2)	5.902(2)***	15.1(16)%$^@$	9/2$^-$	0.0	—	1.4771(25)	$0.98^{+0.15}_{-0.13}$

* Weighted average of 27.2(6) m [1970DaZM], 25.0(5) m [1968Go12] and 26.2(5) m [1961La02].
** Weighted average of 10(2)% [1974Ho27] and 18.4(16)% [1961La02].
*** Weighted average of 5.901(5) MeV [1974Ho27], 5.903(2) MeV [1968Go12] and 5.896(4) MeV (adjusted to 5.899(4) MeV in [1991Ry01])[1974Ho27].
$^@$ Weighted average of 10(2)% [1974Ho27] and 18.4(16)% [1961La02].

Table 4
direct α emission from ^{209}Fr*, J_i^π = 9/2$^-$, $T_{1/2}$ = 51.3(8) s**, BR_α = 89(3)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{205}At)	coincident γ-rays	R$_0$ (fm)]	HF
6.777(5)	6.647(5)***	89(3)%$^@$	9/2$^-$	0.0	—–	1.4808(14)	1.30(14)

* All values from [1974Ho27], except where noted.
** [1996Xu02].
*** 6.646(5) MeV in [1974Ho27], modified to 6.647(5) MeV in [1991Ry01].

Table 5
direct α emission from ^{213}Ac*, J_i^π = 9/2$^-$, $T_{1/2}$ = 731(17) ms, BR_α = $\approx$ 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{209}Fr)	coincident γ-rays	R$_0$ (fm)]	HF
7.502(8)	7.361(8)**	$\approx$ 100%	9/2$^-$	0.0	—–	1.4852(44)	1.29(15)

* All values from [2000He17], except where noted.

Table 6
direct α emission from ^{217}Pa*, J_i^π = (9/2$^-$), $T_{1/2}$ = 3.6(2) ms**, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{213}Ac)	coincident γ-rays	R$_0$ (fm)]	HF
7.855(5)	7.710(5)	0.3(2)%	0.3(2)%	(13/2$^-$)	0.6343	0.6343(1)	1.4908(17)	7^{+15}_{-3}
7.873(5)	7.728(5)	0.3(2)%	0.3(2)%	(13/2$^-$)	0.6130	0.6125(8)	1.4908(17)	8^{+18}_{-4}
8.021(5)	7.873(5)	0.4(2)%	0.4(2)%		0.4665	0.4661(20)	1.4908(17)	17^{+20}_{-7}
8.494(5)	8.337(5)	100 (1)%	99(1)%	(9/2$^-$)	0.0	—–	1.4908(17)	$1.67^{+0.32}_{-0.28}$

* All values from [2002He29], except where noted.
** Weighted average of 3.8(2) ms [2002He29] and 3.4(2) ms [1996An21].

Table 7
direct α emission from ^{217m}Pa*, Ex. = 1.8839(3) MeV, J_i^π = (29/2$^+$), $T_{1/2}$ = 1.08(3) ms, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{213}Ac)	coincident γ-rays	R$_0$ (fm)]	HF
8.462(5)	8.306(5)	15.3(29)% %	11(2)%	(21/2$^-$)	1.8842	0.450, 0.613, 0.821	1.4908(17)	$3.7^{+1.2}_{-0.9}$
9.712(5)	9.533(5)	8.3(15)%	6(1)%	(13/2$^-$)	0.6343	0.634	1.4908(17)	$1.00^{+0.29}_{-0.23}\times10^4$
9.731(5)	9.552(5)	12.5(15)%	9(1)%	(13/2$^-$)	0.613	0.613	1.4908(17)	$7.5^{+1.8}_{-1.5}\times10^3$
9.879(5)	9.697(5)	2.8(14)%	2(1)%		0.4665	0.466	1.4908(17)	$7^{+8}_{-3}\times10^4$
10.348(5)	10.157(5)	100(8)%	72(4)%	(9/2$^-$)	0.0	—–	1.4908(17)	$1.9^{+0.4}_{-0.3}\times10^4$

* All values from [2002He29], except where noted.

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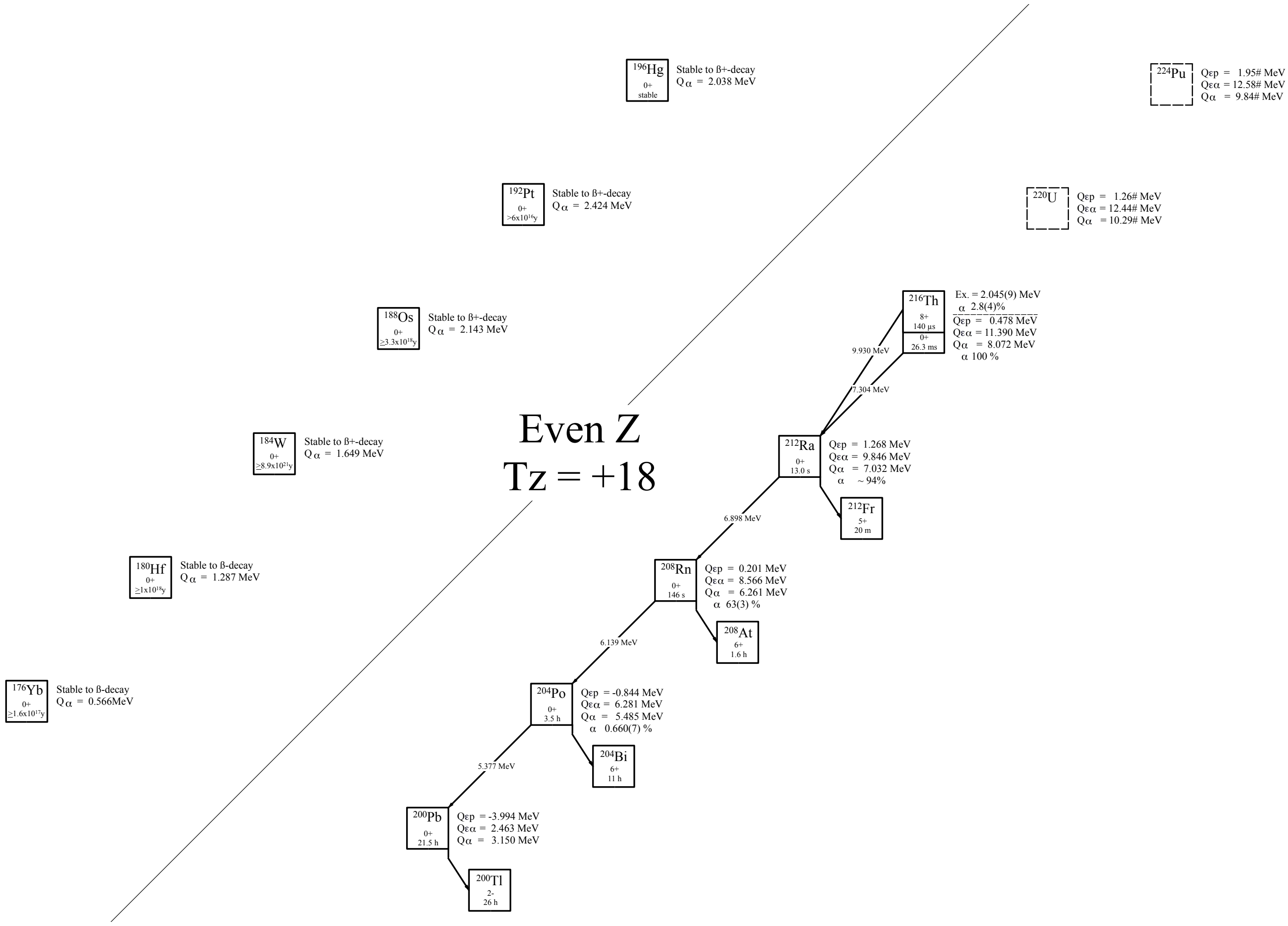

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +18 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +18 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex.	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{176}Yb		0^+	$\geq 1.6 \times 10^{17}$ y	-4.12(10)	—	—	[**1996De60**]
^{180}Hf		0^+	$\geq 1 \times 10^{18}$ y	-3.100(70)	—	—	[**2020Da04**]
^{184}W		0^+	$\geq 8.9 \times 10^{21}$ y	-2.866(26)	—	—	[**2004Co26**]
^{188}Os		0^+	$\geq 3.3 \times 10^{18}$ y	-2.120	—	—	[**2020Be23**]
^{192}Pt		0^+	$>6 \times 10^{16}$ y	-1.453(2)	—	—	[**2011Be08**]
^{196}Hg		0^+	stable	-0.697(3)	—	—	
^{200}Pb		0^+	21.5(4) h	0.796(12)	-3.994(10)	2.463(10)	[**1955Be12**]
^{204}Po		0^+	3.52(1) h*	2.305(14)	-0.844(12)	6.281(12)	[**1970Ra14, 1965AnZZ, 1961La02**]
^{208}Rn		0^+	1461(8) s	2.815(14)	0.201(12)	8.566(14)	[**1971Ho01**]
^{212}Ra		0^+	13.0(2) s	3.317(13)	1.268(12)	9.846(14)	[**1974Ho27**]
^{216}Th		0^+	26.3(2) ms**	2.149(14)	0.478(13)	11.390(14)	[**2019Zh45, 2005Ku31, 2000He17**]
^{216m}Th	2.045(9)	8^+	140(5) μs***	4.194(17)	2.523(16)	13.435(17)	[**2019Zh45, 2005Ku31, 2000He17**]
^{220}U				2.74(10)#	1.26(12)#	12.44(10)#	
^{224}Pu				3.25(30)#	1.946(31)#	12.58(30)#	

* Weighted average of 3.57(2) h [1970Ra14], 3.50(1) h [1965AnZZ] and 3.53(3) h [1961La02].
** Weighted average of 26.3(5) ms [2019Zh45], 26.0(2) ms [2005Ku31] and 27.0(3) ms [2000He17].
*** Weighted average of 135(4) μs [2005Ku31] and 140(5) μs [2000He17].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the even-Z, T_z = +18 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{176}Yb	8.470(50)	16.12(30)#	0.566(4)		
^{180}Hf	8.009(5)	14.680(7)	1.287(1)		
^{184}W	7.701(2)	14.234(6)	1.649(2)		
^{188}Os	7.210(0)	13.207(1)	2.143(1)		
^{192}Pt	6.869(2)	12.159(2)	2.424(3)		
^{196}Hg	6.548(3)	11.644(3)	2.038(4)		
^{200}Pb	5.480(30)	9.874(10)	3.150(10)		
^{204}Po	4.105(16)	6.978(11)	5.485(1)	0.660(7)%	[**1970Ra14, 1970DaZM, 1967Ti04, 1965AnZZ**, 1971Go35, 1970Jo26, 1969Go23, 1967Le08, 1967Le21, 1967Ti04, 1963Be28, 1961Fo05, 1961La02, 1955Mo68, 1954Ro39, 1951Ka03, 1951Ka37]
^{208}Rn	3.717(16)	6.045(11)	6.261(2)	63(3)%*	[**1971Go35, 1971Ho01**, 1993Wa04, 1957St10, 1955Mo68, 1955Mo69, 1953AsZZ]
^{212}Ra	3.347(16)	5.172(11)	7.032(2)	≈ 94%**	[**2003He06**, 2001HeZY, 1982Bo04, 1974Ho27, 1973BoXL, 1968Lo15, 1967Va22, 1961Gr42]
^{216}Th	3.021(17)	4.372(12)	8.072(4)	100%	[**2005Ku31, 2000He17**, 2019Zh45, 2014Ya19, 2005KuZZ, 2005Li17, 2001Ha46, 1968Va10, 1968Va18]
^{216m}Th	0.976(19)	2.327(15)	10.117(10)	2.8(4)%	[**2005Ku31**, 2019Zh45, 2005KuZZ, 2001Ha46, 2000He17, 1983Hi08]
^{220}U	2.86(12)#	3.93(10)#	10.29(10)#		
^{224}Pu	2.67(31)#	3.57(30)#	9.84(32)#		

* Weighted average of 67(3)% [1971Go35] and52(5)% [1971Ho01].
** Deduced by setting the HF of the α decay of ^{212}Ra to the ground state of ^{208}Rn equal to 1.0.

Table 3
direct α emission from ^{204}Po, $J_i^{\pi} = 0^+$, $T_{1/2}$ = 3.52(1) h*, BR_{α} = 0.660(7)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{200}Pb)	coincident γ-rays	R$_0$ (fm)]	HF
5.485(2)	5.377(2)***	0.660(7)%**	0^+	0.0	—–	1.4625(22)	1.017(11)

* Weighted average of 3.57(2) h [1970Ra14], 3.50(1) h [1965AnZZ] and 3.53(3) h [1961La02].
** [1965AnZZ].
*** Weighted average of 5.379(3) MeV (adjusted to 5.378(3) MeV in [1991Ry01]) [1970Ra14], 5.375(5) MeV (adjusted to 5.374(5) MeV in [1991Ry01]) [1970DaZM] and 5.379(5) MeV [1967Ti04].

Table 4
direct α emission from ^{208}Rn, $J_i^{\pi} = 0^+$, $T_{1/2}$ = 31461(8) s*, BR_{α} = 63(3)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{204}Po)	coincident γ-rays	R$_0$ (fm)]	HF
5.577(4)	5.470(4)***	4.7(4) × 10^{-3}%***	3.0(10) × 10^{-3}%	2^+	0.684	0.684	1.4755(52)	12.1(12)
6.259(3)	6.139(3)***	100%***	63(3)%**	0^+	0.0	—–	1.4755(52)	0.97(5)

* [1971Ho01].
** Weighted average of 67(3)% [1971Go35] and 52(5)% [1971Ho01].
*** [1971Go35].

Table 5
direct α emission from ^{212}Ra*, $J_i^{\pi} = 0^+$, $T_{1/2}$ = 13.0(2) s**, BR_{α} = ≈ 94%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{208}Rn)	coincident γ-rays	R$_0$ (fm)]	HF
6.390(5)	6.269(5))	≈ 0.05%	≈ 0.047%	2^+	0.635	0.635	1.4718(31)	≈ 6.0
7.031(5)	6.898(5)	100%	≈ 94%	0^+	0.0	—–	1.4718(31)	1.0***

* All values from [2003He06] unless otherwise stated.
** [1974Ho27].
*** An even-even g.s to g.s. α decay should have a HF =1.0. Setting the BR_{α} = 94% gives this value. Using a BR_{α} = 100% results in a HF of 0.935(14).

Table 6
direct α emission from ^{216}Th, $J_i^{\pi} = 0^+$, $T_{1/2}$ = 26.3(2) ms*, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{212}Ra)	coincident γ-rays	R$_0$ (fm)]	HF
7.442(4)	7.304(4)**	100.0(4)%	99.46(40)%***	2^+	0.6293(1)	0.6293(1)	1.4695(14)	1.73(12)
8.072(5)	7.923(5)**	0.0054(3)%	0.54(3)%***	0^+	0.0	—–	1.4695(14)	1.013(9)

* Weighted average of 26.3(5) ms [2019Zh45], 26.0(2) ms [2005Ku31] and 27.0(3) ms [2000He17].
** [2005Ku31].
*** [2000He17].

Table 7
direct α emission from ^{216m}Th, Ex. = 2.045(9) MeV, $J_i^{\pi} = 8^+$, $T_{1/2}$ = 140(5) μs*, BR_{α} = 2.8(9)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{212}Ra)	coincident γ-rays	R$_0$ (fm)]	HF
8.150(10)	7.999(10)	18(3)%	13(2)%	8^+	1.967(13)		1.4695(14)	$2.6^{+1.6}_{-0.8}$
9.488(12)	9.312(12)	18(4)%	13(3)%	2^+	0.6293(1)	0.6293(1)	1.4695(14)	$9^{+6}_{-3} \times 10^3$
10.117(10)	9.930(10)	100(5)%	74(4)%	0^+	0.0	—–	1.4695(14)	$3.7^{+2.0}_{-1.0} \times 10^4$

* All values from [2005Ku31], except where noted.
** Weighted average of 135(4) μs [2005Ku31] and 140(5) μs [2000He17].

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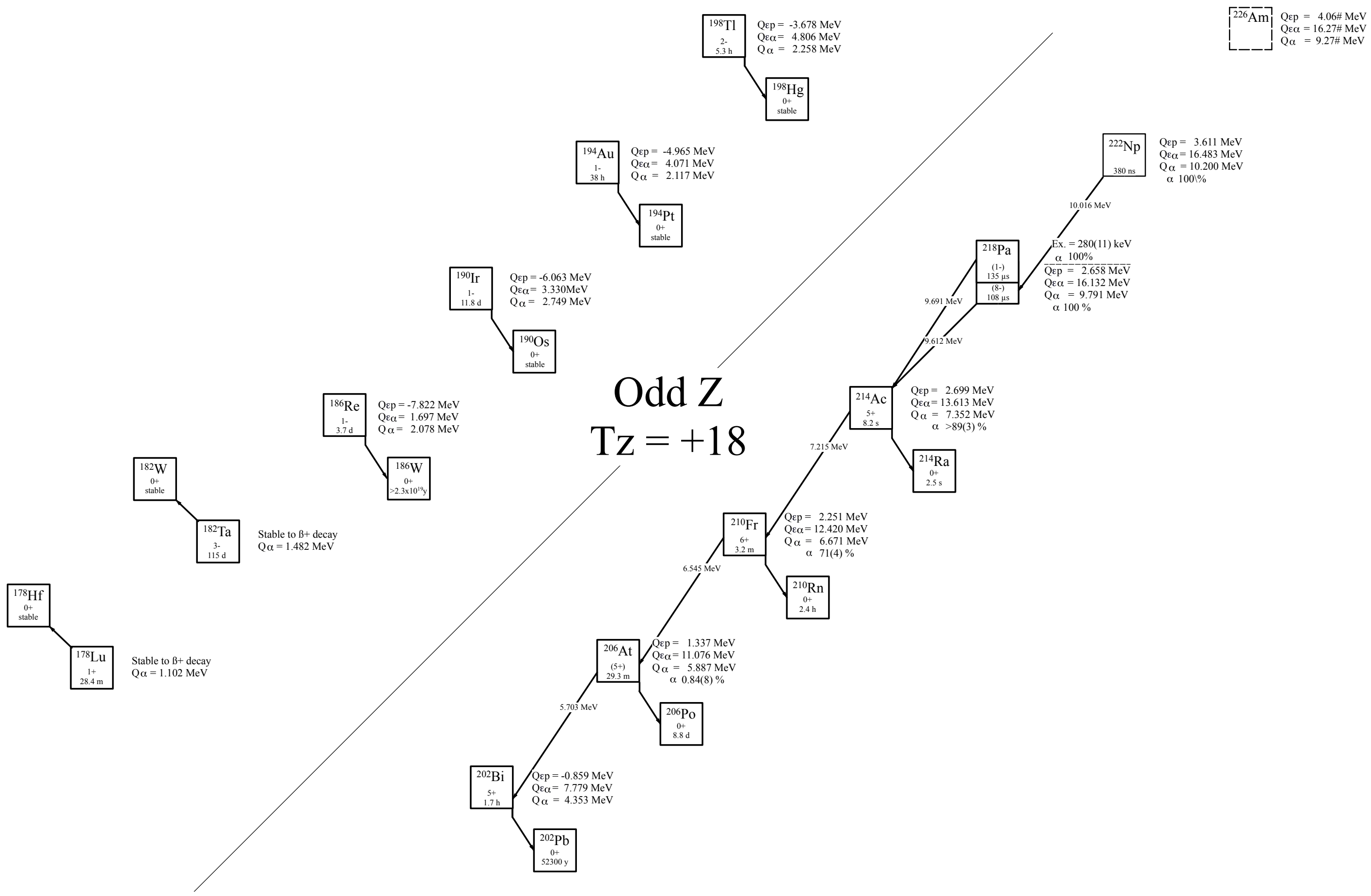

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +18nuclei.

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Table 1

Observed and predicted β-delayed particle emission from the odd-Z, T_z = +18 nuclei. J^π values for ^{178}Lu, ^{182}Ta, ^{186}Re, ^{190}Ir, ^{194}Au, ^{198}Tl and ^{202}Bi are taken from ENSDF. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	Ex.	$T_{1/2}$	Qε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{178}Lu*		$1^{(+)}$	28.4(2) m	-0.661(7)	—	—	[**1973Or03**]
^{182}Ta*		3^-	114.740(24) d	-0.381(6)	—	—	[**1973Vi13**]
^{186}Re		1^-	3.7186(5) d	0.581(1)	-7.822(14)	1.697(6)	[**2004Sc04**]
^{190}Ir		4^-	11.78(10) d	1.954(1)	-6.063(8)	3.330(2)	[**1975Ba35**]
^{194}Au		1^-	38.02(10) h	2.548(2)	-4.965(2)	4.071(2)	[**1992Si02**]
^{198}Tl		2^-	5.3(5) h	3.426(8)	-3.678(8)	4.806(8)	[**1954Mi16**]
^{202}Bi		5^+	1.71(2) h***	5.190(15)	-0.859(20)	7.779(14)	[**1970DaZM, 1966KaZY**]
^{206}At		(5^+)	29.3(4) m	5.749(14)	1.337(14)	11.076(14)	[**1977Li16**]
^{210}Fr		6^+	3.18(6) m	6.261(14)	2.251(14)	12.420(14)	[**2005Ku06**]
^{214}Ac		5^+	8.2(2) s	6.341(15)	2.699(14)	13.613(14)	[**1968Va04**]
^{218}Pa		(8^-)	108(5) μs$^@$	6.283(21)	2.658(21)	16.132(19)	[**2020Zh01, 2000He17**]
^{218m}Pa	0.080(11)	(1^-)	135^{+62}_{-32} μs	6.363(24)	2.738(24)	16.212(22)	[**2020Zh01**]
^{222}Np			380^{+260}_{-110} ns	7.000(60)	3.611(71)	16.483(39)	[**2020Ma27**
^{226}Am				7.34(36)#	4.06(31)#	16.27(30)#	

* 100 β^- emitter.
** 92.5(1)% β^-, 7.5(1)% ε emitter.
*** Weighted average of 1.67(2) h [1966KaZY] and 1.79(3) h [1970DaZM].
@ Weighted average of 107(5) μs [2020Zh01] and 113(10) μs [2000He17].

Table 2

Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +18 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{178}Lu	6.640(2)	15.55(10)	1.102(45)		
^{182}Ta	6.317(2)	14.332(71)	1.482(3)		
^{186}Re	5.828(1)	13.666(26)	2.078(2)		
^{190}Ir	5.056(1)	12.315(1)	2.749(1)		
^{194}Au	5.021(2)	11.954(2)	2.117(2)		
^{198}Tl	4.277(8)	10.968(8)	2.258(8)		
^{202}Bi	2.769(20)	8.282(15)	4.353(16)		
^{206}At	2.207(17)	6.371(16)	5.887(5)	0.87(8)%*	[**1981Va27, 1981Va29, 1977VaZT, 1961La02**, 1970DaZM, 1969Ba69, 1969BaZM, 1968Go12, 1964Th07, 1963Ho18, 1961Fo04]
^{210}Fr	1.691(17)	5.452(16)	6.671(5)	71(4)%	[**2005Ku06**, 2022Ha06, 2014Ma66, 2000RuZZ, 1972KeYY, 1971ReZE, 1967Va20, 1964Gr04, 1961Gr42]
^{214}Ac	1.201(17)	4.629(16)	7.352(2)	89(3)%	[**2004Ku24, 1968Va04**, 2000He17, 1961Gr42]
^{218}Pa	0.845(21)	4.078(20)	9.791(12)	100%	[**2020Zh01, 2000He17, 1996An21, 1979Sc09**, 1995AnZY, 1995NiZS, 1978ReZZ]
^{218m}Pa	0.765(24)	3.998(23)	9.871(16)	100%	[**2020Zh01**]
^{222}Np	0.534(82)	3.582(41)	10.200(34)	100%	[**2020Ma27**
^{226}Am	0.62(42)#	3.64(30)#	9.27(30)#		

* A value of 0.88(8)% was reported in [1961La02]. This value was deduced using an α branching ratio of 5(1)% [1955Mo08] for the decay of ^{206}Po. [1981Va27] report a value of 0.70(14)% for the α branching of ^{206}At, using using an α branching ratio of 5.2(4)% [1971Go35] for the decay of ^{206}Po. Adjusting the value of [1961La02] using the ^{206}Po α branching ratio of [1971Go35] results in a value of 0.92(8)%. The weighted average of 0.70(14)% and 0.92(8)% is adopted here. In addition, note that [1967Le08] list an α branching ratio of 5.45% for ^{206}Po with no uncertainty reported.

Table 3
direct α emission from ^{206}At, Ex. = 2.045(9) MeV, J_i^π = (5$^+$), $T_{1/2}$ = 29.3(4) m**, BR_α = 0.87(8)%***.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	$J_f^{\pi @}$	$E_{daughter}$(^{202}Bi)	coincident γ-rays$^@$	R_0 (fm)$^{@@}$	HF
5.816(2)	5.703(2)	100%	0.83(8)%	(5$^+$)	0.072(4)		1.4690(56)	2.0^{+4}_{-3}
5.848(3)	5.734(3)	1.2(3)%	9.6(28) × 10^{-3}%	(4$^+$)	0.041(5)	.041	1.4690(56)	240^{+110}_{-70}
5.881(3)	5.767(3)	2.4(4)%	0.020(4)%	(7$^+$)	0.007(5)		1.4690(56)	170^{+50}_{-40}
5.888(4)	5.774(4)	0.9(3)%	7.8(27) × 10^{-3}%	5$^+$	0.0	——	1.4690(56)	460^{+260}_{-140}

* All values from [1981Va27], except where noted.
** [1977Li16].
*** A value of 0.88(8)% was reported in [1961La02]. This value was deduced using an α branching ratio of 5(1)% [1955Mo08] for the decay of ^{206}Po. [1981Va27] report a value of 0.70(14)% for the α branching of ^{206}At, using using an α branching ratio of 5.2(4)% [1971Go35] for the decay of ^{206}Po. Adjusting the value of [1961La02] using the ^{206}Po α branching ratio of [1971Go35] results in a value of 0.92(8)%. The weighted average of 0.70(14)% and 0.92(8)% is adopted here. In addition, note that [1967Le08] list an α branching ratio of 5.45% for ^{206}Po with no uncertainty reported.
$^@$ [2008Zh05].
$^{@@}$ Interpolated between 1.4625(22) fm (^{204}Po) and 1.4755(52) fm (^{208}Rn).

Table 4
direct α emission from ^{210}Fr, J_i^π = 6$^+$, $T_{1/2}$ = 3.18(6) m*, BR_α = 71(4)%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{206}Ra)	coincident γ-rays	R_0 (fm)***	HF
6.015(5)**	5.900(5)**	>0.010(5)%	>0.0071(36)%		0.6573(2)**	0.6263(3)**, 0.6515(3)**	1.4737(61)	$<32^{+34}_{-12}$
6.231(7)	6.112(7)	>0.0017(9)%	>0.0012(6)%		0.4442(5)	0.442(5)	1.4737(61)	$<1.8(3) \times 10^3$
6.333(4)	6.212(4)	>0.022(3)%	>0.016(2)%		0.3404(1)	0.3404(1)	1.4737(61)	$<380^{+100}_{-80}$
6.348(5)**	6.227(5)**	>0.010(2)%	>0.0071(15)%		0.3223(1)**	0.3223(1)**	1.4737(61)	$<1.0^{+0.3}_{-0.2} \times 10^3$
6.471(5)**	6.348(5)**	>0.0041(13)%	>0.0029(9)%		0.2009(5)**	0.1953(2)**	1.4737(61)	$<1.1^{+0.6}_{-0.3} \times 10^4$
6.524(4)	6.400(4)	>0.034(7)%	>0.024(5)%		0.1480(1)	0.1169(3)**, 0.1480(1)	1.4737(61)	$<1.6^{+0.5}_{-0.4} \times 10^3$
6.533(4)**	6.409(4)**	>0.014(4)%	>0.010(3)%		0.1376(3)**	0.1065(2)**, 0.1376(3)**	1.4737(61)	$<4.3^{+2.0}_{-1.2} \times 10^3$
6.545(4)	6.420(4)	>0.030(5)%	>0.021(4)%		0.1263(1)	0.1207(3)**, 0.1263(1)	1.4737(61)	$<2.2^{+0.6}_{-0.5} \times 10^3$
6.672(5)	6.545(5)	100%	70.9(40)%	(5$^+$)	0.0	——	1.4737(61)	$2.13^{+0.35}_{-0.31}$

* All values from [2005Ku06].
** Tentatively assigned.
*** Interpolated between 1.4755(52) fm (^{208}Rn) and 1.4718(31) fm (^{212}Ra).

Table 5
direct α emission from ^{214}Ac*, J_i^π = 5$^+$, $T_{1/2}$ = 8.2(2) s**, BR_α = 89(3)%**.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{210}Fr)	coincident γ-rays	R_0 (fm)$^@$	HF
6.601(15)	6.478(15)	> 0.0043(15)%	>0.0020(7)%		0.7537(7)	0.7537(7)	1.4707(34)	$<270^{+1460}_{-80}$
6.639(15)	6.515(15)	> 0.0041(15)%	>0.0020(7)%		0.7134(7)	0.7134(7)	1.4707(34)	$<390^{+230}_{-110}$
6.732(7)	6.606(7)	>0.0122(24)%	>0.0059(12)%		0.6225(2)	0.6225(2)	1.4707(34)	$<310^{+90}_{-60}$
6.752(7)	6.626(7)	>0.0087(22)%	>0.0042(11)%		0.6014(2)	0.6014(2)	1.4707(34)	$<530^{+210}_{-130}$
6.829(5)	6.701(5)	0.26(4)%	0.125(18)%		0.5259(1)	0.2814(1), 0.3166(2), 0.3301(1), 0.3867(2), 0.4630(2), 0.5259(1)	1.4707(34)	35^{+8}_{-6}
6.912(7)	6.783(7)	>0.028(8)%	>0.013(4)%		0.4442(2)	0.4442(2)	1.4707(34)	$<680^{+280}_{-170}$
6.992(6)	6.861(6)	>0.167(4)%	>0.080(18)%		0.3639(2)	0.1546(1), 0.2247(1), 0.3639(2)	1.4707(34)	$<230^{+80}_{-50}$
7.009(5)	6.878(5)	>0.24(9)%	>0.116(18)%		0.3464(1)	0.3464(1)	1.4707(34)	$<180^{+40}_{-30}$
7.010(6)	6.879(6)	>0.057(15)%	>0.027(7)%		0.3395(1)	0.3395(1)	1.4707(34)	$<810^{+310}_{-190}$
7.020(6)	6.889(6)	>0.100(19)%	>0.048(9)%		0.3330(1)	0.3330(1)	1.4707(34)	$<500^{+140}_{-100}$
7.111(5)	6.978(5)	2.04(56)%	0.98(27)%		0.2442(1)	0.1814(1), 0.2442(1)	1.4707(34)	52^{+22}_{-13}
7131(7)***	6998(7)***	>0.074(37)%***	>0.036(18)%		0.2551(2)***	0.1625(1)***, 0.2551(2)***	1.4707(34)	$<1.7^{+1.8}_{-0.6} \times 10^3$
7.145(5)	7.011(5)	>0.81(8)%	>0.39(4)%		0.2090(1)	0.14640(1), 0.2090(1)	1.4707(34)	$<176^{+29}_{-24}$
7.157(5)	7.023(5)	>0.65(10)%	>0.312(5)%		0.1955(1)	0.1331(1), 0.1955(1)	1.4707(34)	$<250^{+60}_{-40}$
7.216(4)	7.081(4)	77.8(45)%	37.4(22)%		0.1390(1)	0.0763(1), 0.1390(1)	1.4707(34)	3.3(4)
7.289(6)	7.153(6)	?	?		0.0626(1)	0.0626(1)	1.4707(34)	
7.352(3)	7.215(3)	100(5)%	48(2)%		0.0	——	1.4707(34)	7.9(8)

* All values from [2004Ku24], except where noted.
** [1968Va04], the I_α value is reported as a lower limit.
*** Tentatively assigned.
$^@$ Interpolated between 1.4718(31) fm (^{2128}Ra) and 1.4695(14) ^{216}Th

Table 6
direct α emission from ^{218}Pa, J_i^{π} = (8$^-$), $T_{1/2}$ = 108(5) μs*, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{214}Ac)	coincident γ-rays	R_0 (fm)$^@$	HF
9.712(8)	9.534(8)**	40(3)%**	29(2)%	(4$^+$)	0.092	0.092	1.495(21)	220^{+130}_{-80}
9.792(8)	9.612(8)***	100%	71(4)%	(5$^+$)	0.0	—	1.495(21)	150^{+180}_{-50}

* Weighted average of 107(5) μs [2020Zh01] and 113(10) μs [2000He17].
** Weighted average of 9.524(16) MeV; 26(2)% [2020Zh01], 9.544(15) MeV; 35(5)% [2000He17], 9.530(15) MeV; 31(4)% [1996An21] and 9.535(15) MeV; 35(10)% [1979Sc09].
*** Weighted average of 9.610(14) MeV; 74(5)% [2020Zh01], 9.616(15) MeV; 65(7)% [2000He17], 9.610(15) MeV; 69(4)% [1996An21] and 9.614(15) MeV; 365(10)% [1979Sc09].
$^@$ Interpolated between 1.4695(14) fm ^{216}Th and 1.521(15) fm ^{220}U.

Table 7
direct α emission from ^{218m}Pa*, Ex. = 80(11) keV, J_i^{π} = (1$^-$), $T_{1/2}$ = 135^{+62}_{-32} μs, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{214}Ac)	coincident γ-rays	R_0 (fm)***	HF
9.775(21)	9.596(21)**			(4$^+$)	0.092	0.092	1.495(21)	
9.872(15)	9.691(15)***	100%	≈100%	(5$^+$)	0.0	—	1.495(21)	200^{+140}_{-120}

* All values from [2020Zh01].
** Tentatively assigned.
*** Interpolated between 1.4695(14) fm ^{216}Th and 1.521(15) fm ^{220}U.

Table 8
direct α emission from ^{222}Np*, $T_{1/2}$ = 380^{+260}_{-110} ns, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{218}Pa)	coincident γ-rays	R_0 (fm)**	HF	
10.200(33)	10.016(33)	100%	29(2)%	(8$^-$)	0.0	—	1.503(50)	$0.9^{+1.8}_{-0.7}$

* All values from [2020Ma27].
** Interpolated between 1.521(15) fm ^{220}U and 1.484(48) fm ^{224}Pu,

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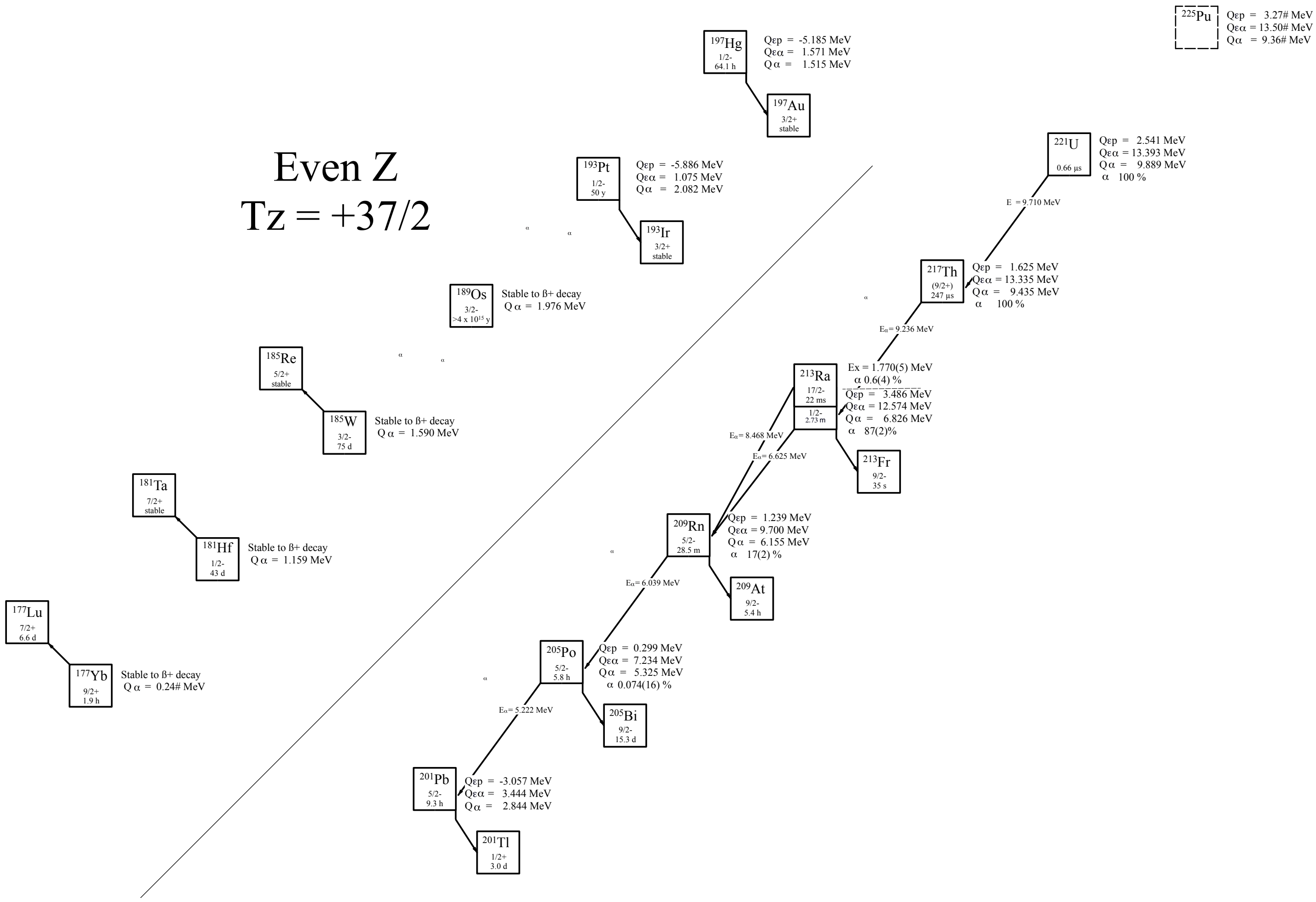

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +37/2 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +37/2 nuclei. J$^\pi$ values for ^{177}Yb, ^{181}Hf, ^{185}W, ^{189}Os, ^{193}Pt, ^{197}Hg, and ^{201}Pb are taken from ENSDF. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	Ex.	$T_{1/2}$	Qε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{177}Yb*		9/2$^+$	1.911(3) h	-3.42(20)#	—	—	[**1989Ab18**]
^{181}Hf*		1/2$^-$	43.39(8) d**	-2.61(13)	—	—	[**1966Br20, 1960Li14**
^{185}W*		3/2$^-$	75.1(3) d	-1.994(14)	—	—	[**1972Em01**
^{189}Os		3/2$^-$	$\geq$3.5 $\times$ 10^{15} y	-1.008(8)	—	—	[**2020Be23**
^{193}Pt		1/2$^-$	50(9) y	0.0566(3)	-5.886(2)	1.075(8)	[**1971Ra18**
^{197}Hg		1/2$^-$	64.14(5) h	0.600(3)	-5.185(3)	1.571(3)	[**1966El09**
^{201}Pb		5/2$^-$	9.33(3) h	1.910(19)	-3.057(14)	3.444(14)	[**1981An11**
^{205}Po		5/2$^-$	5.79(2) h	3.544(11)	0.299(10)	7.234(17)	[**1983He09**]
^{209}Rn		5/2$^-$	28.5(10) m	3.943(11)	1.239(10)	9.700(11)	[**1971Go35**]
^{213}Ra		1/2$^-$	2.73(5) m	3.900(11)	1.716(10)	10.804(11)	[**2017Lo13**]
^{213m}Ra	1.770(5)	17/2$^-$	2.20(5) ms	5.670(12)	3.486(11)	12.574(12)	[**2006Ku26**]
^{217}Th		(9/2$^+$)	247(2) μs***	3.503(15)	1.625(13)	13.335(12)	[**2005Ku31, 2002He29, 2009QiZZ**]
^{221}U			0.66(14) μs	4.150(0)	2.541(73)	13.393(73)	[**2015Kh09**]
^{225}Pu				4.68(31)#	3.27(30)#	13.50(31)#	

* 100 β^- emitter
** Weighted average of 42.29(10) d [1966Br20] and 42.45(8) d [1960Li14].
*** Weighted average of 257(2) μs [2005Ku31], 237(2) μs [2002He29] and 247(3) μs [2009QiZZ].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the even-Z, T_z = +37/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_p$	S$_{2p}$	Q$_\alpha$	BR$_\alpha$	Experimental
^{177}Yb	8.90(10)	16.91(40)#	0.24(20)#		
^{181}Hf	8.015(71)	15.34(20)#	1.159(1)		
^{185}W	7.837(26)	14.682(30)	1.590(2)		
^{189}Os	7.259	13.661(1)	1.976(1)		
^{193}Pt	6.933	12.662(1)	2.082(1)		
^{197}Hg	6.690(3)	12.324(3)	1.515(3)		
^{201}Pb	5.513(15)	10.303(14)	2.844(14)		
^{205}Po	4.164(14)	7.313(12)	5.325(10)	0.074(16)%	[**1970Jo26, 1967Ti01, 1951Ha83**, 1970DaZM, 1951Ka37]
^{209}Rn	3.760(13)	6.373(12)	6.155(2)	17(2)%	[**1971Go35**, 2017Lo13, 1993Wa04, 1971Jo19, 1955Mo68, 1955Mo69, 1952Mo23]
^{213}Ra	3.427(13)	5.477(12)	6.862(2)	87(2)%	[**2017Lo13, 2006Ku26**, 2005KuZV, 1976Ra37, 1970TaZS, 1968Lo15, 1967Va22, 1961Gr42, 1955Mo68]
^{213m}Ra	1.657(14)	3.707(13)	8.632(5)	0.6(4)%	[**2006Ku26**, 1976Ra37]
^{217}Th	3.233(14)	4.904(13)	9.435(4)	100%	[**2005Ku31, 2002He29**, 2019Zh54, 2009QiZZ, 2005Li17, 2005YeZZ, 2000He17, 2000Ni02, 2000NiZY, 1973HaZO, 1969MaZT, 1968Va10, 1968Va18]
^{221}U	3.047(74)	4.521(92)	9.889(71)	100%	[**2015Kh09**
^{225}Pu	3.02(30)#	4.32(31)#	9.36(31)#		

Table 3
direct α emission from ^{205}Po, J$_i^\pi$ = 5/2$^-$, T$_{1/2}$ = 5.79(2) h*, BR_α = 0.074(16)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J$_f^\pi$	$E_{daughter}$(^{201}Pb)	coincident γ-rays	R$_0$ (fm)]	HF
5.326(7)	5.222(7)***	0.074(16)%**	5/2$^-$	0.0	—	1.4586(16)	$2.1^{+0.6}_{-0.4}$

* [1983He09].
** [1951Ha83].
*** Weighted average of 5.224(10) MeV [1970Jo26] and 5.220(10) MeV [1967Ti04].

Table 4
direct α emission from ^{209}Rn*, J_i^{π} = 5/2$^-$, $T_{1/2}$ = 28.5(10) m, BR_{α} = 17(2)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{205}Po)**	coincident γ-rays**	R$_0$ (fm)]	HF
5.770(3)	5.660(3)	0.024(2)%	0.0041(6)%		0.384	0.154, 0.230, 0.384	1.4662(37)	87^{+20}_{-15}
6.002(3)	5.887(3)	0.22(2)%	0.037(6)%		0.154	0.154	1.4662(37)	117^{+27}_{-21}
6.013(3)	5.898(3)	0.14(2)%	0.024(4)%		0.143	0.143	1.4662(37)	210^{+60}_{-40}
6.157(3)	6.039(3)	100	16.9(20)%		0.0	—–	1.4662(37)	$1.3^{+0.3}_{-0.2}$

* All values from [1971Go35], except where noted.
** [2020Ko17].

Table 5
direct α emission from ^{213}Ra, J_i^{π} = 1/2$^-$, $T_{1/2}$ = 2.83(5) m*, BR_{α} = 89(2)%*.

E_{α}(c.m.)	E_{α}(lab)**	I_{α}(rel)*	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{209}Rn)	coincident γ-rays	R$_0$ (fm)]	HF
6.349(6)	6.230(6)	0.7(3)%	0.44(17)%	(5/2$^-$)	0.5113	0.1106(2), 0.1830(2), 0.2152(2), 0.2181(2), 0.2964(2), 0.3283(1), 0.5113(3)	1.4638(22)	$4.5^{+3.2}_{-1.4}$
6.536(4)	6.413(4)	0.7(3)%	0.44(17)%	3/2$^-$	0.3283	0.1106(2), 0.2181(2), 0.3283(1)	1.4638(22)	27^{+19}_{-8}
6.647(3)	6.522(3)	13.9(22)%	8.3(13)%	3/2$^-$	0.2149	0.106(1), 0.1106(2), 0.2152(2)	1.4638(22)	$4.1^{+0.9}_{-0.7}$
6.752(3)	6.625(3)	100(4)%	59.6(22)%	1/2$^-$	0.1103	0.1103	1.4638(22)	1.49(10)
6.862(3)	6.733(3)	30.7(31)%	18.3(18)%	5/2$^-$	0.0	—–	1.4638(22)	13.0(15)

* [2017Lo13].
** [2006Ku26].

Table 6
direct α emission from ^{213m}Ra, Ex. = 1.770(5) MeV, J_i^{π} = 17/2$^-$, $T_{1/2}$ = 2.20(5) ms*, BR_{α} = 0.6(4)%*.

E_{α}(c.m.)	E_{α}(lab)**	I_{α}(rel)*	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{209}Rn)	coincident γ-rays	R$_0$ (fm)]	HF
8.426(9)	8.268(9)**	5.2(21)%**	0.021(16)%	3/2$^-$	0.2149	0.106(1), 0.1106(2), 0.2152(2)	1.4638(22)	$1.7^{+6.2}_{-0.8} \times 10^4$
8.517(7)	8.357(7)***	43(29)%***	0.17(12)%	1/2$^-$	0.1103	0.1103	1.4638(22)	$4^{+10}_{-2} \times 10^3$
8.630(4)	8.468(4)$^@$	100%	0.41(27)%	5/2$^-$	0.0	—–	1.4638(22)	$3^{+7}_{-2} \times 10^3$

* [2006Ku26].
** Weighted average of 8.270(20) MeV; 4(2)% [2006Ku26] and 8.266(10) MeV (adjusted to 8.267(10) in [1991Ry01]); 3(2)% [2006Ku26].
*** Weighted average of 8.355(9) MeV; 33(13)% [2006Ku26] and 8.358(10) MeV (adjusted to 8.359(10) in [1991Ry01]); 28(6)% [2006Ku26].
$^@$ Weighted average of 8.469(6)(6) MeV; 63(13)% [2006Ku26] and 8.467(5) MeV (adjusted to 8.468(5) in [1991Ry01]); 69(7)% [2006Ku26].

Table 7
direct α emission from ^{217}Th, J_i^{π} = (9/2+), $T_{1/2}$ = 247(2) μs*, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{213}Ra)	coincident γ-rays	R$_0$ (fm)]	HF
8.616(5)	8.457(5)**	3.8(2)%**	3.5(1)%	(3/2$^-$)	0.8221	0.8221(1)	1.5091(22)	24.3(14)
8.890(5)	8.726(5)***	1.7(1)%***	1.6(1)%	(5/2$^-$)	0.5461	0.5461(1)	1.5091(22)	286(23)
9.437(5)	9.263(5)$^@$	100%	95.0(3)%	1/2$^-$	0.0	—–	1.5091(22)	106(6)

*** Weighted average of 257(2) μs [2005Ku31], 237(2) μs [2002He29] and 247(3) μs [2009QiZZ].
** Weighted average of 8.460(7) MeV, I_{α}(rel) = 3.1(2)% [2005Ku31] and 8.455(5) MeV, I_{α}(rel) = 3.9(1)% [2002He29].
*** Weighted average of 8.727(8) MeV, I_{α}(rel) = 1.6(1)% [2005Ku31] and 8.725(5) MeV, I_{α}(rel) = 1.9(1)% [2002He29].
$^@$ Weighted average of 9.269(9) MeV, [2005Ku31] and 9.261(5) MeV [2002He29].

Table 8
direct α emission from ^{221}U*, $T_{1/2}$ = 0.66(14) μs, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{217}Th)	coincident γ-rays	R$_0$ (fm)]	HF
9.889(50)	9.710(50)	100%	(9/2$^+$)	0.0	—-	1.525(15)	$1.1^{+0.5}_{-0.4}$

* All values from [2015Kh09].

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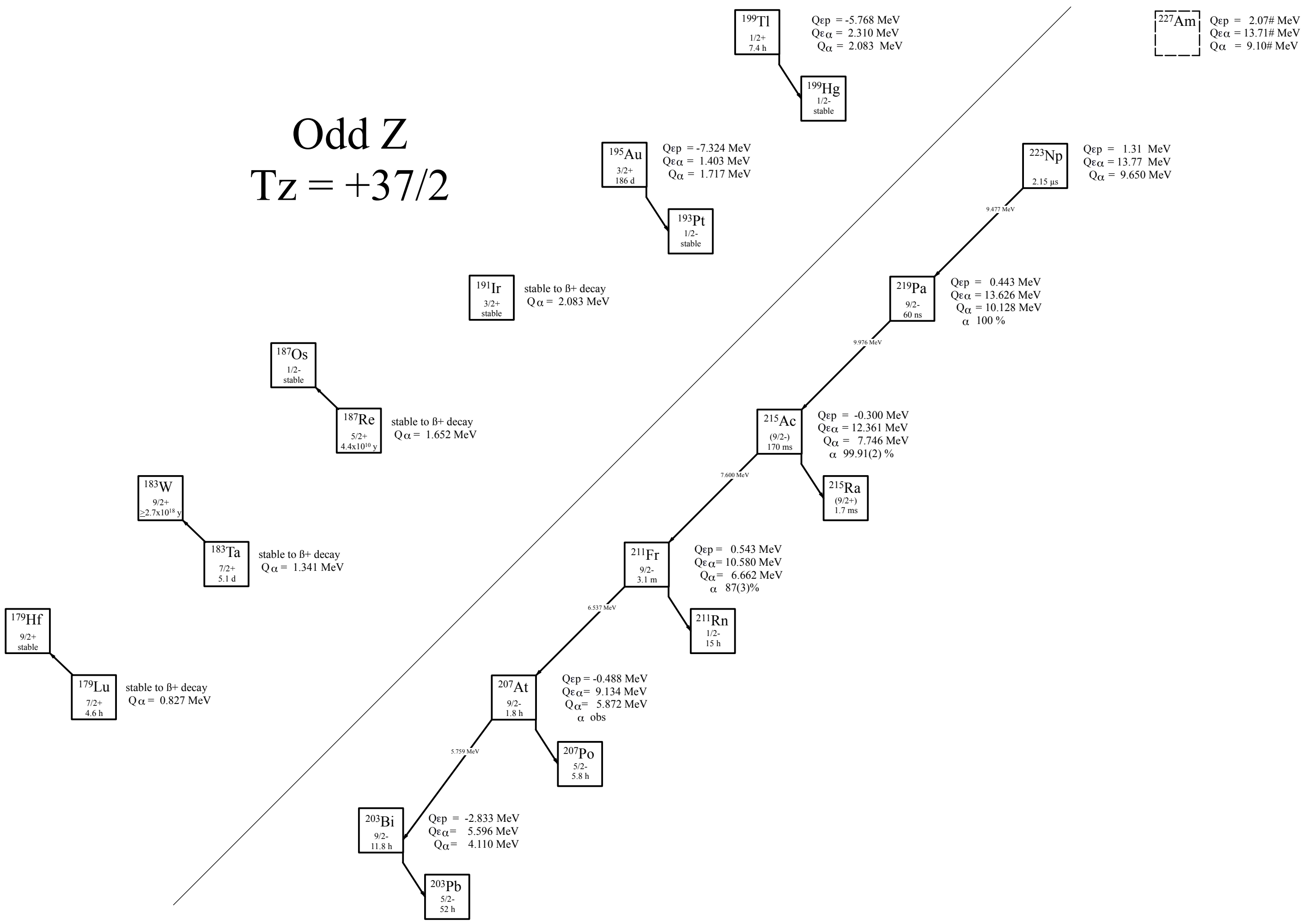

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +37/2 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +37/2 nuclei. J^π values for ^{179}Lu, ^{183}Ta, ^{187}Re, ^{187}Ir, ^{195}Au, ^{199}Tl and ^{203}Bi are taken from ENSDF. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{179}Lu*	7/2$^+$	4.59(6) h	-2.42(20)#	——	—–	[**1963St08**]
^{183}Ta*	7/2$^+$	5.1(1) d**	-2.010(30)	——	—–	[**1953Du20, 1955Po26**]
^{187}Re*	5/2$^+$	4.12(13) × 10^{10} y	-1.313(1)	——	—–	[**2001Ga01**]
^{191}Ir	3/2$^+$	stable	-0.314(1)	——	—–	
^{195}Au	3/2$^+$	186.01(6) d	0.227(1)	-7.324(2)	1.403(1)	[**2012Fu06**]
^{199}Tl	1/2$^+$	7.42(8) h	1.487(28)	-5.768(28)	2.310(28)	[**1960Ju03**]
^{203}Bi	9/2$^-$	11.76(5) h	3.262(14)	-2.833(13)	5.596(13)	[**1960St01**]
^{207}At	9/2$^-$	1.80(3) h**	3.918(14)	-0.488(15)	9.134(14)	[**1962Th08, 1969Ba69, 1968GuZX**]
^{211}Fr	9/2$^-$	3.10(2) m	4.615(14)	0.543(14)	10.580(14)	[**1971ReZE**]
^{215}Ac	(9/2$^-$)	170(10) ms	3.499(14)	-0.300(15)	12.361(14)	[**1968Va04**]
^{219}Pa	(9/2$^-$)	60^{+28}_{-15} ns	4.120(90)	0.443(90)	13.626(70)	[**2017Su18**]
^{223}Np		$2.15^{+1.00}_{-0.52}$ μs	4.61(10)	1.31(12)	13.77(10)	[**2017Su18**]
^{227}Am			5.41(22)#	2.07(23)#	13.71(21)#	

* 100 β^- emitter
** Weighted average of 1.80(5) h [1962Th08], 1.82(4) h [1969Ba69] and 1.77(5) h [1968GuZX].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +37/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{179}Lu	6.671(8)	16.07(20)#	0.827(50)		
^{183}Ta	6.533(6)	15.07(13)	1.341(5)		
^{187}Re	5.997(1)	14.400(14)	1.652(2)		
^{191}Ir	5.290(1)	13.308(8)	2.083(1)		
^{195}Au	5.096(1)	12.609(2)	1.717(2)		
^{199}Tl	4.394(28)	11.498(28)	2.083(28)		
^{203}Bi	2.873(13)	8.922(19)	4.110(31)		
^{207}At	2.328(13)	6.740(13)	5.872(3)	obs*	[**1969Go23, 1951Ba14**]
^{211}Fr	1.825(13)	5.834(13)	6.662(3)	87(3)%	[**2005Ku06**, 2022Ha06, 1971ReZE, 1969Gr04, 1967Va20, 1961Gr42]
^{215}Ac	1.351(13)	4.993(13)	7.746(3)	99.91(2)%	[**2004Ku24, 1968Va04**, 2017Su18, 2003KuZX, 2000He17]
^{219}Pa	1.072(70)	4.697(71)	10.128(69)	100%	[**2017Su18**, 1987FaZS]
^{223}Np	0.903(98)	4.29(10)	9.650(45)	100%	[**2017Su18**]
^{227}Am	0.74(28)#	4.02(22)#	9.10(22)#		

* [1951Ba14] reports the branching ratio as ≈ 10%.

Table 3
direct α emission from ^{207}At, J^π = 9/2$^-$, $T_{1/2}$ = 1.80(3) h*, BR_α = obs**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{203}Bi)	coincident γ-rays	R_0 (fm)]	HF
5.872(3)	5.759(3)***	obs**	9/2$^-$	0.0	—–	1.4651(131)	≈1.10

* Weighted average of 1.80(5) h [1962Th08], 1.82(4) h [1969Ba69] and 1.77(5) h [1968GuZX].
** "No serious attempt has been made to determine the degree of alpha-branching of At^{207}. The best estimate from the alpha-particles of At^{207} and the yield of Po^{207} is 10 percent alpha-branching." [1951Ba14]. ≈ 10% is used for the branching ratio in determining the HF value.
*** [1969GoZX].

Table 4
direct α emission from ^{211}Fr*, J^π = 9/2$^-$, $T_{1/2}$ = 3.10(2) m**, BR_α = 87(3)%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{207}At)	coincident γ-rays	R_0 (fm)]	HF
5.979(6)	5.866 (6)	>0.009(5)%	>0.0078(44)%	(13/2−)	0.6867(6)	0.6867(6)	1.4643(27)	<16
6.019(7)	5.905(7)	>0.006(4)%	>0.0052(35)%	(11/2−)	0.6439(5)	0.6439(5)	1.4643(27)	<40
6.319(5)	6.199 (5)	>0.041(13)%	>0.036(11)%	(7/2−)	0.3445(2)	0.3445(2)	1.4643(27)	<120
6.663(4)	6.537 (4)	100%	>87(3)%	(9/2−)	0.0	—	1.4643(27)	1.33(10)

* All values from [2005Ku06], except where noted.
** [1971ReZE].

Table 5
direct α emission from ^{215}Ac*, J^π = (9/2$^-$), $T_{1/2}$ = 170(10) ms**, BR_α = 99.91(2)%**.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{211}Fr)	coincident γ-rays	R_0 (fm)]	HF
7.007(7)	6.877(7)	0.026(4)%	0.026(4)%	(7/2$^-$)	0.7392(4)	0.3426(5), 0.7392(4)	1.4626(13)	$13.2^{+3.4}_{-2.5}$
7.091(5)	6.959(5)	0.07(1)%	0.07(1)%	(13/2$^-$)	0.6526(2)	0.6526(2)	1.4626(13)	$10.3^{+2.54}_{-1.9}$
7.111(6)	6.979(6)	0.007(4)%	0.007(4)%	(5/2$^-$)	0.6331(2)	0.2372(4), 0.6331(2)	1.4626(13)	120^{+180}_{-50}
7.162(5)	7.029(5)	0.12(1)%	0.12(1)%	(11/2$^-$)	0.5832(1)	0.5832(1)	1.4626(13)	10.8(12)
7.243(7)	7.108(7)	0.007(4)%	0.007(4)%	(5/2$^-$)	0.5059(2)	0.1101(4), 0.5059(2)	1.4626(13)	400^{+500}_{-200}
7.348(5)	7.211(5)	0.20(2)%	0.20(2)%	(7/2$^-$)	0.3958(1)	0.3958(1))	1.4626(13)	130^{+6}_{-5}
7.744(4)	7.600(4)	100%	99.48(7)%	(9/2$^-$)	0.0	—	1.4626(13)	1.26(9)

* All values from [2004Ku24], except where noted.
** [1968Va04].
*** Tentative assignment [2004Ku24].

Table 6
direct α emission from ^{219}Pa*, J^π = (9/2$^-$), $T_{1/2}$ = 60^{+28}_{-15} ns, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{215}Ac)	coincident γ-rays	R_0 (fm)]	HF
10.162(37)	9.976(37)	100%	(9/2$^-$)	0.0	—	1.5346(88)	$0.9^{+0.5}_{-0.3}$

* All values from [2017Su18].

Table 7
direct α emission from ^{223}Np*, $T_{1/2}$ = $2.15^{+1.00}_{-0.52}$ μs, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{219}Pa)	coincident γ-rays	R_0 (fm)]	HF
9.650(44)	9.477(44)	100%	(9/2$^-$)	0.0	—	1.507(32)	$0.3^{+0.4}_{-0.2}$

* All values from [2017Su18].

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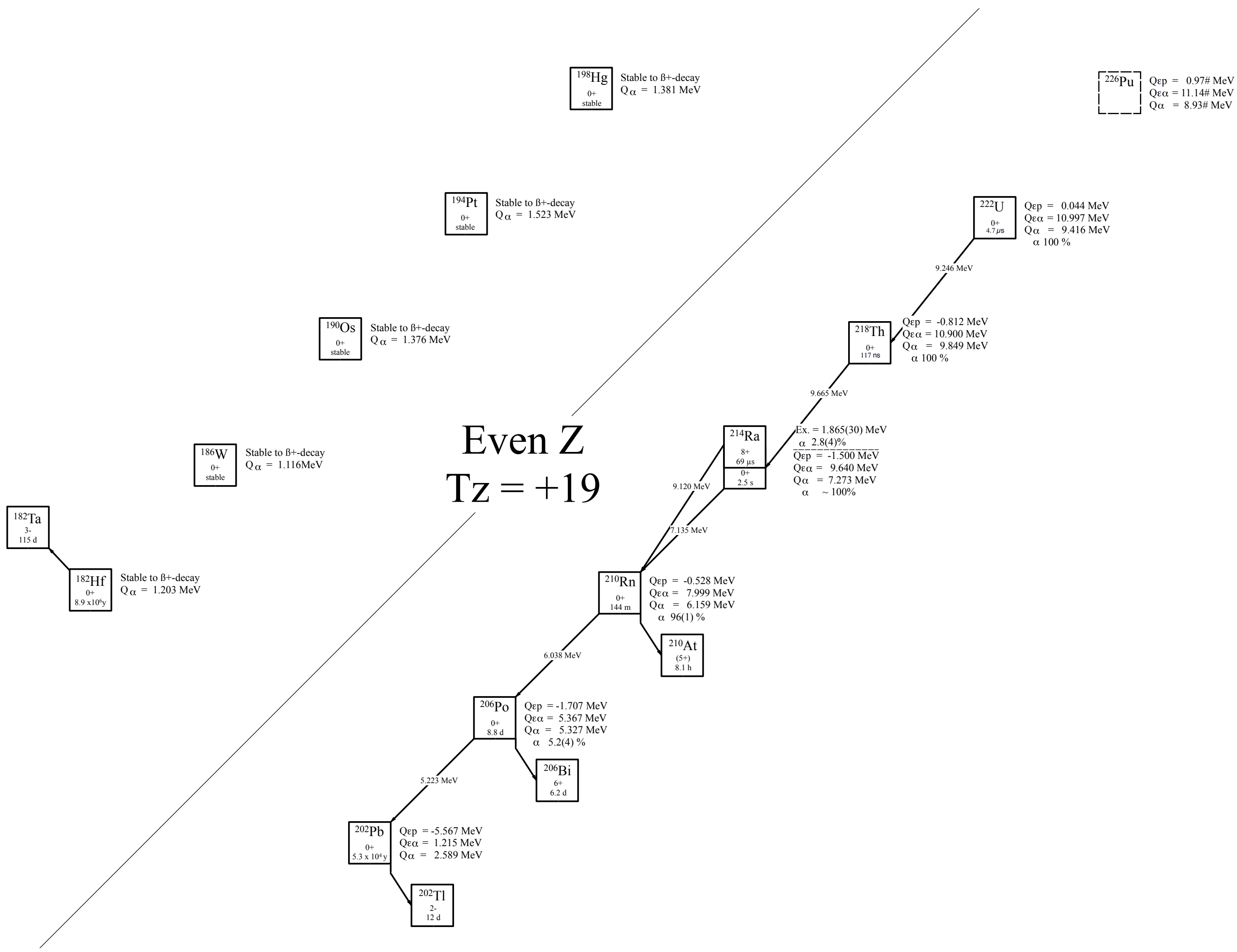

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +19 nuclei.

Last updated 1/13/23

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +19 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex.	J^{π}	$T_{1/2}$	Q_{ε}	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{182}Hf*		0^+	8.90(9) × 10^6 y	-4.28(20)#	—	—	[**2004Vo16**]
^{186}W		0^+	stable	-3.900(60)	—	—	
^{190}Os		0^+	stable	-3.125(5)	—	—	
^{194}Pt		0^+	stable	-2.228(1)	—	—	
^{198}Hg		0^+	stable	-1.374(1)	—	—	
^{202}Pb		0^+	5.25(28) × 10^4 y	0.040(4)	-5.567(4)	1.215(4)	[**1981Na15**]
^{206}Po		0^+	8.8(1) d	1.840(9)	-1.707(4)	5.367(4)	[**1956Jo34**]
^{210}Rn		0^+	144(6) m	2.367(9)	-0.528(5)	7.999(9)	[**1971Go35**]
^{214}Ra		0^+	2.47(2) s**	1.051(10)	-1.500(6)	9.640(9)	[**2009MuZV, 2006Ku26**]
^{214m}Ra	1.865(30)	8^+	68.6(20) μs	2.916(10)	0.365(6)	11.505(9)	[**2006Ku26**]
^{218}Th		0^+	117(5) ns***	1.520(60)	-0.812(13)	10.900(14)	[**1982Ch29, 1973Ha32, 1973No09**]
^{222}U		0^+	4.7(7) μs	2.21(10)	0.044(53)	10.997(78)	[**2015Kh09**]
^{226}Pu		0^+		2.81(23)#	0.97(20)#	11.14(22)#	

* 100% β^- emitter.
** Weighted average of 2.485(25) s [2009MuZV] and 2.46(3) s [2006Ku26].
*** Weighted average of 125(5) ns [1982Ch29], 122(8) ns [1973Ha32] and 96(7) ns [1973No09].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the even-Z, T_z = +19 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_{α}	BR_{α}	Experimental
^{182}Hf	8.54(13)	15.91(30)#	1.203(9)		
^{186}W	8.403(14)	15.587(40)	1.116(6)		
^{190}Os	8.018(8)	14.618(3)	1.376(1)		
^{194}Pt	7.513(1)	13.456(2)	1.523(0)		
^{198}Hg	7.104(0)	12.888(1)	1.381(1)		
^{202}Pb	6.049(15)	11.015(4)	2.589(4)		
^{206}Po	4.412(6)	7.657(4)	5.327(1)	5.2(4)%	[**1971Go35, 1970Ra14, 1968Go11**, 1970AfZZ, 1967Le08, 1967Ti04, 1961Fo05, 1956Bu12, 1955Mo68, 1951Ka37, 1947Te01]
^{210}Rn	4.010(7)	6.713(4)	6.159(2)	96(1)%	[**1971Go35, 1955Mo68**, 1955Mo69, 1952Mo23]
^{214}Ra	3.642(7)	5.826(6)	7.273(3)	≈100%	[**2006Ku26**, 2015Kh09. 2009MuZV, 2000He17, 1974Ho27, 1968Lo15, 1961Gr42]
^{214m}Ra	1.777(7)	3.961(6)	9.138(3)	0.09(7)%	[**2006Ku26**]
^{218}Th	3.625(15)	5.503(13)	9.849(9)	100%	[**1973No09**, 2018Br13, 2015Kh09, 1982Ch29, 1973Ha32, 1973Hi06]
^{222}U	3.391(79)	4.995(54)	9.416(8)*	100%	[**2023Lu04, 2015Kh09**, 1983Hi12]
^{226}Pu	3.28(22)#	4.69(20)#	8.93(22)#		

* From α decay of ^{222}U. 9.481(51) MeV in [2021Wa16].

Table 3
direct α emission from ^{206}Po, $J^{\pi} = 0^+$, $T_{1/2}$ = 8.8(1) d*, BR_{α} = 5.2(4)%***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_f	$E_{daughter}$(^{202}Pb)	coincident γ-rays	R_0 (fm)]	HF
5.327(2)	5.223(2)**	5.2(4)%***	0^+	0.0	—	1.4547(10)	1.05(8)

* [1956Jo14].
** Weighted average of 5.224(2) MeV [1968Go11] and 5.222(3) MeV [1970Ra14].
*** From [1971Go35]. [1967Le08] reports 5.45% with no error bar.

Table 4
direct α emission from ^{210}Rn, $J^{\pi} = 0^{+}$, $T_{1/2}$ = 144(6) m*, BR_{α} = 96(1)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{206}Po)	coincident γ-rays	R_0 (fm)]	HF
5.455(3)	5.351(3)*	5.6(3) $\times 10^{-3}$%*	5.4(3) $\times 10^{-3}$%	0^{+}	0.700(4)	0.700	1.4568(22)	6.7(4)
6.155(3)	6.038(3)	100%	96(1)%	0^{+}	0.0	—	1.4568(22)	0.97(2)

* [1971Go35].
** [1955Mo68].

Table 5
direct α emission from ^{214}Ra*, $J^{\pi} = 0^{+}$, $T_{1/2}$ = 2.47(2) s**, BR_{α} = ≈ 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{210}Rn	coincident γ-rays	R_0 (fm)]	HF
6.629(5)	6.505(5)	0.16(3)%	0.16(3)%	2^{+}	0.6439	0.6439	1.4557(12)	$2.6^{+0.6}_{-0.4}$
7.271(4)	7.135(4)	100%	99.84(3)%	0^{+}	0.0	—	1.4557(12)	0.997(8)

* All values from [2006Ku26], except where noted.
** Weighted average of 2.485(25) s [2009MuZV] and 2.46(3) s [2006Ku26].

Table 6
direct α emission from ^{214m}Ra*, Ex. = 1.865.2 keV, $J^{\pi} = 8^{+}$, $T_{1/2}$ = 68.6(20) μs, BR_{α} = 0.09(7)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{210}Rn	coincident γ-rays	R_0 (fm)]	HF
7.429(30)	7.290(30)	6.6(33)%	5.4(46) $\times 10^{-3}$%	8^{+}	1.710(30)	0.2031, 0.6439, 0.8178	1.4557(12)	14(12)
≈8.509	≈8.350**	0.18(3)%	0.16(3)%	2^{+}	0.6439	0.6439	1.4557(12)	$>6 \times 10^{3}$
9.120(30)	8.950(30)	100%	91(6)%	0^{+}	0.0	—	1.4557(12)	$8^{+30}_{-4} \times 10^{3}$

* All values from [2006Ku26], except where noted.
** tentatively assigned [2006Ku26].

Table 7
direct α emission from ^{218}Th, $J^{\pi} = 0^{+}$, $T_{1/2}$ = 117(5) ns*, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{214}Ra)	coincident γ-rays	R_0 (fm)]	HF
9.846(10)	9.665(10)**	100%	0^{+}	0.0	—	1.5487(30)	0.95(4)

* Weighted average of 125(5) ns [1982Ch29], 122(8) ns [1973Ha32] and 96(7) ns [1973No09].
** [1973No09].

Table 8
direct α emission from ^{222}U, $J^{\pi} = 0^{+}$, $T_{1/2}$ = 4.7(7) μs*, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{218}Th)	coincident γ-rays	R_0 (fm)]	HF
9.416(8)	9.246(8)**	100%	0^{+}	0.0	—	1.529(15)	0.70(10)

* [2015Kh09].
** [2023Lu04].

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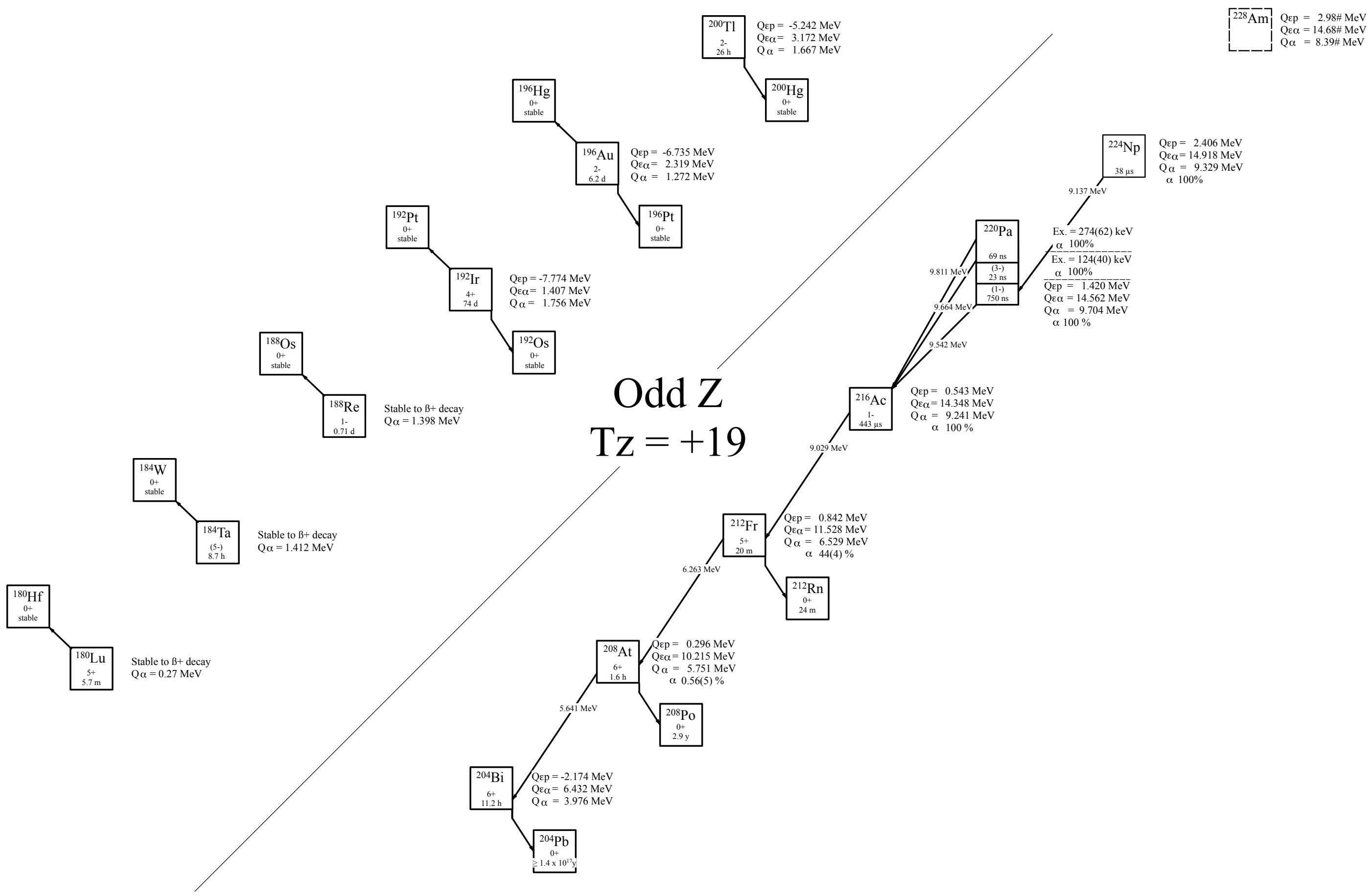

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +19 nuclei.

Last updated 1/13/24

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +19 nuclei. J$^\pi$ values for ^{180}Lu, ^{184}Ta, ^{188}Re, ^{192}Ir, ^{196}Au, ^{200}Tl and ^{204}Bi are taken from ENSDF. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	Ex.	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{180}Lu*		5^+	5.7(1) m	-1.96(31)#	—	—	[**1973KaYQ**]
^{184}Ta*		(5^-)	8.7(1) h	-1.340(3)	—	—	[**1955Bu80**]
^{188}Re*		1^-	0.70846(14) d	-0.349(3)	—	—	[**2004Sc04**]
^{192}Ir**		4^+	73.831(8) d	1.047(2)	-7.774(10)	1.407(3)	[**1980Ho17**]
^{196}Au***		2^-	6.1669(6) d	0.687(3)	-6.735(3)	2.319(4)	[**2001Li17**]
^{200}Tl		2^-	26.1(1) h	2.456(6)	-5.242(6)	3.172(6)	[**1962Ja10**]
^{204}Bi		6^+	11.22(10) h	4.464(9)	-2.174(9)	6.432(9)	[**1960St21**]
^{208}At		6^+	1.63(3) h	4.999(9)	0.296(9)	10.215(9)	[**1964Th07**]
^{212}Fr		5^+	20.3(3) m$^{@}$	5.143(9)	0.842(9)	11.528(9)	[**1973GoZX, 1950Hy27**]
^{216}Ac		1^-	443(7) μs	4.858(12)	0.543(12)	14.384(10)	[**2000He17**]
^{220}Pa		(1^-)	0.75(4) μs$^{@@}$	5.589(20)	1.420(54)	14.562(17)	[**2023Lu04, 2021Ma66, 2020Ma27, 2019Ya04, 2017Hu08**]
^{220m1}Pa	0.124(40)	(3^-)	233^{+108}_{-56} ns	5.589(20)	1.544(67)	14.686(43)	[**2021Ma66**]
^{220m2}Pa	0.274(62)		69^{+330}_{-30} ns	5.589(20)	1.694(82)	14.836(75)	[**2018Hu13**]
^{224}Np			38^{+26}_{-11} μs	6.290(30)	2.406(81)	14.918(32)	[**2018Hu13**]
^{228}Am				6.74(20)#	2.98(22)#	14.68(20)#	

* 100% β^- emitter.
** 92.24(4)% β^-, 4.76(4)% ε emitter [2012Ba36].
*** 97.0(3)% β^-, 93(3)% ε emitter [2007Hu13].
@ Weighted average of 20.6(3) m [1973GoZX] and 19.3(5) m [1950Hy27].
@@ Weighted average of 0.83(7) μs [2023Lu04], 0.75(8) μs [2021Ma66], 0.73(11) μs [2020Ma27], 0.91(10) μs [2019Ya04] and 0.90(13) μs [2017Hu08].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +19 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{180}Lu	7.33(21)#	17.04(31)#	0.27(12)		
^{184}Ta	6.845(40)	15.65(20)	1.412(75)		
^{188}Re	6.402(1)	14.987(60)	1.398(26)		
^{192}Ir	5.729(1)	13.831(5)	1.756(1)		
^{196}Au	5.634(3)	13.185(3)	1.272(3)		
^{200}Tl	4.790(6)	12.044(6)	1.667(6)		
^{204}Bi	3.148(11)	9.243(9)	3.976(11)		
^{208}At	2.613(11)	7.020(12)	5.751(2)	0.56(5)%	[**1981Va27, 1981Va29, 1970GoZZ, 1950Hy27**, 1981VaZM, 1981VaZN, 1981VaZO, 1980VaZT, 1963Uh01]
^{212}Fr	2.050(11)	6.122(12)	6.529(2)	44(4)%*	[**2005Ku06, 1981Va27, 1981Va29, 1950Hy27**, 1980VaZT, 1974Ho27, 1973GoZX, 1971ReZE, 1966Va21, 1955Mo69, 1953AsZZ]
^{216}Ac	1.671(12)	5.470(13)	9.241(3)	100%	[**2004Ku24**, 2021Ma66, 2018Hu13, 2017Hu08, 2005Li17, 2000He17, 1970To18, 1969MaZT, 1968Va18, 1966Ro12]
^{220}Pa	1.473(58)	5.150(59)	9.704(11)	100%	[**2023Lu04**, 2021Ma66, 2020Ma27, 2019Ya04, 2019Zh54, 2017Hu08, 1987FaZS]
^{220m1}Pa	1.349(70)	5.026(71)	9.828(41)	100%	[**2021Ma66**]
^{220m2}Pa	1.199(85)	4.876(86)	9.976(63)	100%	[**2018Hu13**]
^{224}Np	1.302(66)	4.610(91)	9.329(30)	100%	[**2018Hu13**]
^{228}Am	1.21(22)#	4.55(23)$	8.39(20)#		

* based on the K-xray/α ratio of 1.3(1)% [1950Hy01].

Table 3

direct α emission from ^{208}At, J^{π} = 6^{+}, $T_{1/2}$ = 1.63(3) h*, BR_{α} = 0.56(6)%**.

E_{α}(c.m.)	E_{α}(lab)***	I_{α}(rel)***	I_{α}(abs)	J_f^{π} @	$E_{daughter}$(^{204}Bi)@	coincident γ-rays@	R_0 (fm)@@@	HF
≈5.615	≈5.507@@	≈0.2@@%	≈1.1 × 10^{-3}%		0.137		1.4558(24)	420
5.696(2)	5.586(2)	0.9(1)%	4.9(8) × 10^{-3}%	7^{+}	0.0534(2)	0.0534(2)	1.4558(24)	250^{+50}_{-40}
5.736(4)	5.626(4)	2.2(2)%	1.2(2) × 10^{-2}%	4^{+}	0.0151(1)		1.4558(24)	160^{+40}_{-30}
5.752(3)	5.641(3)	100(3)%	0.54(6)%	6^{+}	0.000		1.4558(24)	$4.2^{+0.7}_{-0.5}$

* [1964Th07].
** Based on the ratio of K x-ray/α from ^{208}At [1950Hy27].
*** [1981Va27, 1981Va29], except where noted.
@ [2010Ch02].
@@ From [1970GoZZ]. Not observed in [1981Va27, 1981Va29], but may have been below statistical threshold.
@@@ Interpolated between 1.4547(10) fm (^{206}Po) and 1.4568(22) fm (^{210}Rn).

Table 4

direct α emission from ^{212}Fr, J^{π} = 5^{+}, $T_{1/2}$ = 20.3(3) m*, BR_{α} = 44(4)%**.

E_{α}(c.m.)	E_{α}(lab)***	I_{α}(rel)***	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{208}At)@@@	coincident γ-rays@@@	R_0 (fm)@	HF
5.848(6)	5.738(6)@@@	≈0.005%@@@	≈0.002%		0.6817	0.6871	1.4563(25)	≈200
5.940(6)	5.828(6)	0.13(8)%	0.022(13)%		0.5879	0.0235, 0.0401, 0.0503, 0.5879 0.1245, 0.1479, 0.1635, 0.1699, 0.2037, 0.2199, 0.2272, 0.2601, 0.2835, 0.3047, 0.3613, 0.4406, 0.5242, 0.5879	1.4563(25)	22^{+35}_{-9}
6.098(4)	5.983(4)@@	0.19(3)%	0.031(5)%		0.4295	0.0235, 0.0401, 0.0719, 0.1245 0.1479, 0.1635, 0.2023, 0.2037, 0.2272, 0.2816, 0.3577, 0.4058	1.4563(25)	90^{+40}_{-20}
6.194(3)	6.077(3)	2.5(3)%	0.40(6)%		0.3347	0.0235, 0.0401, 0.2170, 0.3112, 0.3347	1.4563(25)	$17.9^{+3.5}_{-2.7}$
6.245(3)	6.127(3)	3.4(3)%	0.57(7)%		0.2835	0.0235, 0.0401, 0.0503, 0.1699, 0.2199 0.2601, 0.2835	1.4563(25)	21.0(23)
6.292(4)	6.173(4)@@	3.4(3)%	0.57(7)%		0.2372	0.0235, 0.0401, 0.1736, 0.2137	1.4563(25)	34^{+6}_{-5}
6.303(3)	6.184(3)	4.2(4)%	0.69(8)%		0.2272	0.0235, 0.0401, 0.1635, 0.2037, 0.2272	1.4563(25)	30^{+5}_{-4}
6.383(3)	6.263(3)	100(5)%	16.5(16)%	5^{+}	0.1479	0.0235, 0.1245, 0.1479	1.4563(25)	2.79(31)
6.458(3)	6.336(3)@@	27(2)%@@	4.4(5)%	(3^{+})	0.1139	0.0235, 0.0401, 0.0503	1.4563(25)	14(2)
6.464(3)	6.342(3)	8.0(6)%	1.32(15)%	7^{+}	0.0719	0.0719	1.4563(25)	73^{+11}_{-9}
6.507(3)	6.384(3)	64(3)%	10.6(10)%	(5^{+})	0.0235	0.0235	1.4563(25)	14.4(6)
6.528(3)	6.405(3)	59(3)%	9.7(9)%	6^{+}	0.0	—	1.4563(25)	19.6(23)

* Weighted average of 20.6(3) m [1973GoZX] and 19.3(5) m [1950Hy27].
** based on the K-xray/α ratio of 1.3(1)% [1950Hy01].
*** Weighted average of values from [2005Ku06] and [1981Va27, 1981Va29].
@ Interpolated between 1.4568(22) fm (^{210}Rn) and 1.4557(12) fm (^{214}Ra).
@@ [1981Va27, 1981Va29].
@@@ [2005Ku06].

Table 5
direct α emission from ^{216}Ac*, J^{π} = 1^{-}, $T_{1/2}$ = 443(7) μs**, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)***	I_{α}(rel)***	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{212}Fr)	coincident γ-rays	R_0 (fm)***	HF
7.904(6)	7.758(6)	0.023(6)%	0.011(3)%		1.3753(3)	0.0826(1), 0.4368(6), 0.8558(7), 0.9382(1), 1.2931(4), 1.3753(3)	1.5022(32)	230^{+100}_{-60}
7.923(15)	7.776(15)	> 0.0020(8)%	>0.0010(4)%		1.356(2)	1.356(2)	1.5022(32)	$<1.6 \times 10^3$
7.994(15)	7.846(15)	0.033(6)%	0.016(3)%		1.2871(8)	1.2871(8)	1.5022(32)	<300
8.041(10)	7.892(10))	0.043(4)%	0.021(2)%		1.2399(4)	1.2399(4)	1.5022(32)	<310
8.074(15)	7.924(15)	0.0027(4)%	0.0013(2)%		1.2095(5)	1.2095(5)	1.5022(32)	$<6.3 \times 10^3$
8.152(15)	8.001(15)	> 0.0049(33)%	>0.0024(16)%		1.1299(5)	0.0826(1), 1.0475(9), 1.1299(5)	1.5022(32)	$<5.8 \times 10^3$
8.267(9)	8.114(9)	>0.0041(6)%	>0.002 0(3)%		1.0087(4)	1.0087(4)	1.5022(32)	$<1.6 \times 10^4$
8.341(5)	8.187(5)	1.5(1)%	0.74(2)%		0.9382(1)	0.0826(1), 0.8558(7),0.9382(1)	1.5022(32)	68(6)
8.426(5)	8.270(5)	2.9(2)%	1.40(7)%		0.8537(1)	0.0826(1), 0.3529(2), 0.4183(1), 0.5007(1), 0.7713(1), 0.8537(1)	1.5022(32)	69(7)
8.503(7)	8.346(7)	>0.21%	<0.1%		0.7773(2)	0.0826(1), 0.2766(2), 0.4183(1), 0.5007(1), 0.6948(1), 0.7773(1)	1.5022(32)	>140
8.670(7)	8.509(7)	>0.035(2)%	>0.017(1)%		0.6106(2)	0.6106(2)	1.5022(32)	$<2.3 \times 10^4$
8.675(6)	8.514(6)	> 0.23(4)%	>0.11(2)%		0.6062(1)	0.0826(1), 0.1058(2), 0.4183(1), 0.5007(1), 0.5237(1), 0.6062(1)	1.5022(32)	$<3.7 \times 10^3$
8.697(15)	8.536(15)	> 0.25(4)%	>0.12(2)%		0.5750(4)	0.0826(1), 0.4924(1), 0.5750(4)	1.5022(32)	$<4.1 \times 10^3$
8.738(6)	8.576(6)	> 0.94(10)%	>0.46(5)%	$(7)^{+}$	0.542(1)	0.542(1)	1.5022(32)	$<1.3 \times 10^3$
8.743(6)	8.581(6)	> 1.05(12)%	>0.51(6)%		0.5363(1)	0.0826(1), 0.4539(1), 0.5363(1)	1.5022(32)	$<1.2 \times 10^3$
8.779(6)	8.616(6)	0.47(10)%	0.23(5)%		0.5007(1)	0.0826(1), 0.4183(1), 0.5007(1)	1.5022(32)	$3.4^{+1.1}_{-0.7} \times 10^3$
9.199(7)	9.029(7)	100(3)%	48.8(10)%	(4^{+})	0.0826(1)	0.0826(1)	1.5022(32)	177(15)
9.277(7)	9.105(7)	97(2)%	47.5(5)%	5^{+}	0.0	——	1.5022(32)	288(25)

* All values from [2004Ku24], except where noted. Previous works [2000He17, 1970To18, 1968Va18] had assigned α's as decaying from both a 1^{-} ground state and a 9^{-} isomer. [2004Ku24] demonstrated that all α's could be accounted for using HF and coincident γ-rays.
** [2000He17].
*** Interpolated between 1.4557(12) fm (^{214}Ra) and 1.5487(30) ^{218}Th

Table 6
direct α emission from ^{220}Pa, J^{π} = (1^{-}), $T_{1/2}$ = 0.75(4) μs*, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)**	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{216}Ac)	coincident γ-rays	R_0 (fm)***	HF
9.719(6)	9.542(6)	100%	1^{-}	0.0	——	1.539(15)	$1.4^{+0.5}_{-0.4}$

* Weighted average of 0.83(7) μs [2023Lu04], 0.75(8) μs [2021Ma66], 0.73(11) μs [2020Ma27], 0.91(10) μs [2019Ya04] and 0.90(13) μs [2017Hu08].
** [2023Lu04].
*** Interpolated between 1.5487(30) fm ^{218}Th and 1.529(15) fm ^{222}U.

Table 7
direct α emission from ^{220m2}Pa*, Ex. = 124(40) keV, J^{π} = (3^{-}), $T_{1/2}$ = 233^{+108}_{-56} ns, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{216}Ac)	coincident γ-rays	R_0 (fm)**	HF
9.843(40)	9.664(40)	100%	1^{-}	0.0	——	1.539(15)	0.8(5)

* All values from [2021Ma66]. They assign a J^{π} = (3^{-}). However the HF indicates a unhindered decay, suggesting 1^{-} as a more likely value.
** Interpolated between 1.5487(30) fm ^{218}Th and 1.529(15) fm ^{222}U.

Table 8
direct α emission from ^{220m2}Pa*, Ex. = 274(62) keV, $T_{1/2}$ = 69^{+330}_{-30} ns, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{216}Ac)	coincident γ-rays	R_0 (fm)**	HF
9.993(62)	9.811(62)	100%	1^{-}	0.0	——	1.539(15)	$0.5^{+2.4}_{-0.3}$

* All values from [2021Ma66]. They assign a J^{π} = (3^{-}). However the HF indicates a unhindered decay, suggesting 1^{-} as a more likely value.
** Interpolated between 1.5487(30) fm ^{218}Th and 1.529(15) fm ^{222}U.

Table 9
direct α emission from ^{224}Np*, $T_{1/2} = 38^{+26}_{-11}$ μs, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{220}Pa)	coincident γ-rays	R_0 (fm)**	HF
9.029(62)	8.868(62)	≈20%	0.17(17)%		0.274(62)		1.503(50)	$0.3^{+8.5}_{-0.2}$
9.303(20)	9.137(20)	100%	83(51)%	0.0	—-	1.503(50)	$0.3^{+1.0}_{-0.2}$	

* All values form [2018Hu13].
** Interpolated between 1.521(15) fm (^{220}U) and 1.484(48) fm (^{224}Pu).

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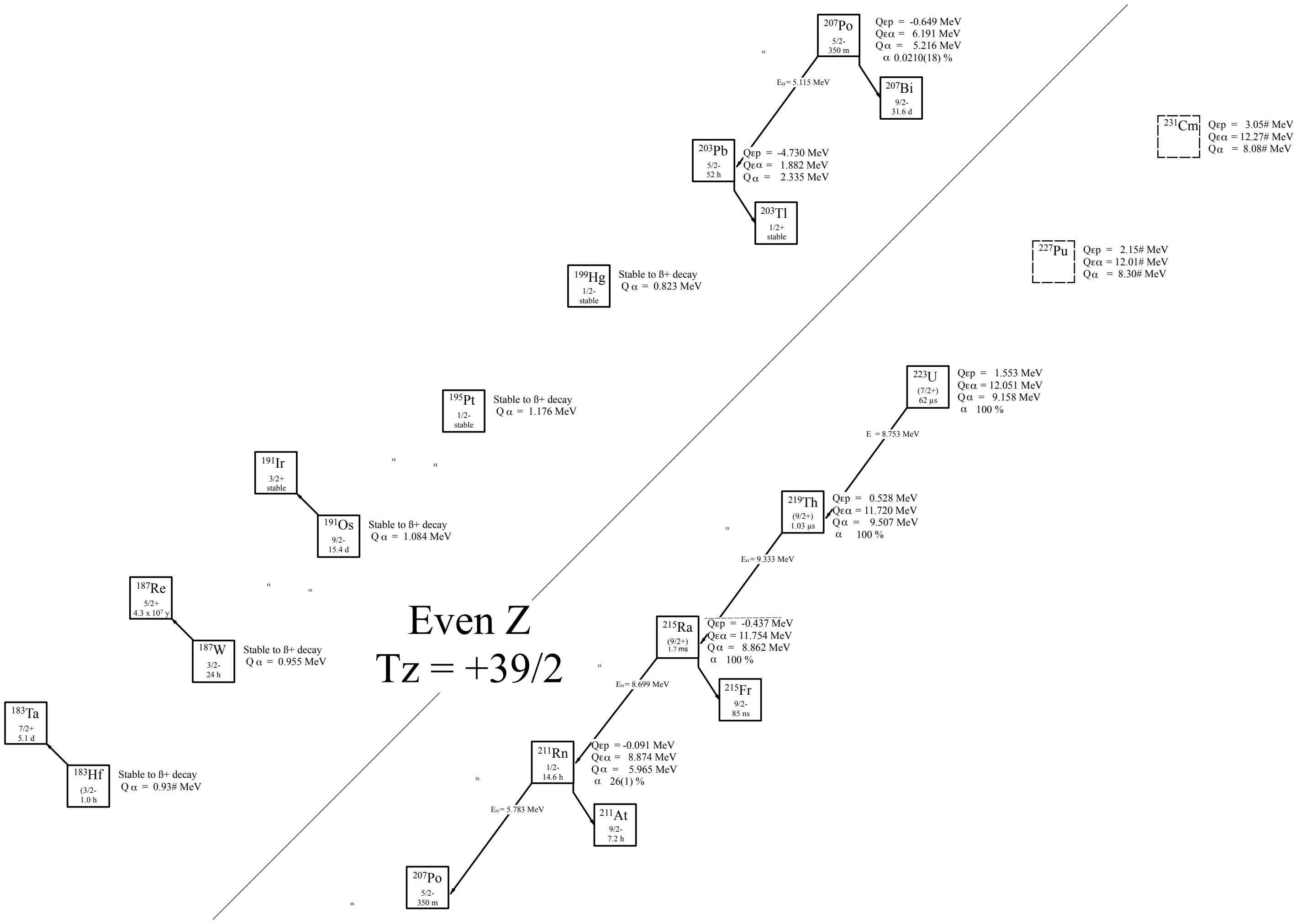

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +39/2 nuclei.

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +39/2 nuclei. J^π values for ^{183}Hf, ^{187}W, ^{191}Os, ^{195}Pt, ^{199}Hg, and ^{203}Pb are taken from ENSDF. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{183}Hf*	(3/2$^-$)	1.018(2) h	-3.570(90)	—–	—–	[**2006Vo12**]
^{187}W*	3/2$^-$	23.80(3) h	-3.010(60)	—–	—–	[**2019Kr02**]
^{191}Os*	9/2$^-$	15.4(1) d	-2.045(10)	—–	—–	[**1967Ag07**]
^{195}Pt	1/2$^-$	stable	-1.102(1)	—–	—–	
^{199}Hg	1/2$^-$	stable	-0.452(1)	—–	—–	
^{203}Pb	5/2$^-$	51.95(1) h	0.975(6)	-4.730(7)	1.882(7)	[**2001Li17**]
^{207}Po	5/2$^-$	350.3(41) m	2.909(7)	-0.649(7)	6.191(7)	[**1974Pa05**]
^{211}Rn	1/2$^-$	14.6(2) h	2.892(7)	-0.091(7)	8.874(7)	[**1972As11**]
^{215}Ra	(9/2$^+$)	1.67(1) ms	2.214(10)	-0.437(12)	11.754(8)	[**2000He17**]
^{219}Th	(9/2$^+$)	1.03(3) μs**	2.890(80)	0.528(57)	11.720(57)	[**2017Su18, 2015Kh09, 1973Ha32**]
^{223}U	(7/2$^+$)	62^{+14}_{-10} μs	3.71(10)	1.553(60)	12.051(78)	[**2020Su02**]
^{227}Pu			4.19(13)#	2.15(10)#	12.01(13)#	
^{231}Cm			4.86(42)#	3.05(30)#	12.27(31)#	

* 100% β^- emitter.
** Weighted average of 1.09(8) μs [2017Su18], 0.97(4) μs [2015Kh09] and 1.05(3) μs [1973Ha32].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the even-Z, T_z = +39/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{183}Hf	8.80(20)	16.77(30)	0.93(20)#		
^{187}W	8.585(60)	16.162(64)	0.955(30)		
^{191}Os	8.101(5)	15.16(20)	1.084(1)		
^{195}Pt	7.551(1)	13.977(2)	1.176(1)		
^{199}Hg	7.254(1)	13.704(1)	0.823(1)		
^{203}Pb	6.095(7)	11.702(7)	2.335(7)		
^{207}Po	4.406(10)	7.953(7)	5.216(3)	0.0210(18)%	[**1974Pa05, 1970AfZZ**, 1971Go35, 1967Ti04, 1955Mo68, 1951Ka37, 1947Ho06, 1947Te01]
^{211}Rn	4.072(10)	6.967(7)	5.965(1)	26(1)%	[**1971Go35**, 1970AfZZ, 1955Mo68, 1955Mo69, 1952Mo23]
^{215}Ra	3.799(11)	6.350(8)	8.862(2)	100%	[**1970To18, 1968Va18**, 2020Su02, 2015Kh09, 2005Li17, 2000He17, 1970TaZS, 1969MaZT, 1961Gr43]
^{219}Th	3.677(81)	6.005(57)	9.507(11)*	100%	[**2020Ma27, 2017Su18, 1973Ha32**, 2020Su02, 2020Wa16, 2015Kh09, 1973HaVQ, 1973HaWU]
^{223}U	3.308(105)	5.473(60)	9.158(17)	100%	[**2020Su02**, 1994AnZY, 1993AnZS, 1991An10, 1991An13]
^{227}Pu	3.34(14)#	5.18(10)#	8.30(12)#		
^{231}Cm	2.89(33)#	4.70(31)#	8.08(31)#		

* Deduced from α energy, 9.506(56) in [2021Wa16].

Table 3
direct α emission from ^{207}Po, J^π = 5/2$^-$, $T_{1/2}$ = 350.3(41) m*, BR_α = 0.0210(18)%*.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{203}Pb)	coincident γ-rays	R_0 (fm)	HF
5.2158(25)	5.1150(25)**	0.0210(18)%*	5/2$^-$	0.0	—–	1.44219(87)	1.41(13)

* [1974Pa05].
** [1970AfZZ].

Table 4
direct α emission from ^{211}Rn, J^{π} = 1/2^{-}, $T_{1/2}$ = 14.6(2) h**, BR_{α} = 26(1)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}***	$E_{daughter}$(^{207}Po)***	coincident γ-rays***	R_0 (fm)	HF
5.153(4)	5.055(4)	1.0(3) × 10^{-3}%	1.6(5) × 10^{-4}%	9/2^{-}	0.8144	0.8144	1.4456(24)	22^{+12}_{-6}
5.279(3)	5.179(3)	4.1(3) × 10^{-3}%	6.7(6) × 10^{-4}%	5/2^{-}	0.6858	0.0686, 0.0973, 0.1679, 0.2365, 0.2928, 0.3244, 0.3929, 0.4491,0.6172	1.4456(24)	27.6(28)
5.378(3)	5.276(3)	0.024(2)%	0.39(3)× 10^{-3}%	7/2^{-}	0.5883	0.5883	1.4456(24)	16.7(16)
5.572(3)	5.466(3)	0.022(2)%	0.36(3)× 10^{-3}%	3/2^{-}	0.3930	0.0686, 0.1565, 0.1679, 0.2365, 0.3244, 0.3929	1.4456(24)	196(19)
5.725(3)	5.616(3)	4.3(3)%	0.70(6)%	3/2^{-}	0.2365	0.0686, 0.1679, 0.2365	1.4456(24)	6.3(6)
5.895(2)	5.783(2)	100(2)%	16.4(7)%	1/2^{-}	0.0686	0.0686	1.4456(24)	1.78(12)
5.963(2)	5.850(2)	54(2)2%	8.8(4)%	5/2^{-}	0.0	—	1.4456(24)	6.9(5)

* All values from [1971Go35], except where noted.
** [1972As11].
*** [2011Ko].

Table 5
direct α emission from ^{215}Ra, J^{π} = (9/2^{+}), $T_{1/2}$ = 1.67(1) ms*, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)**	I_{α}(rel)***	I_{α}(abs)***	J^{π}_{f} @	$E_{daughter}$(^{211}Rn)@	coincident γ-rays@	R_0 (fm)	HF
8.031(6)	7.882(6)	3.1(5)%	3.0(5)%	(3/2^{-})	0.8335(2)	0.8335(2)	1.4995(24)	17^{+4}_{-3}
8.326(6)	8.171(6)	1.4(5)%	1.3(5)%	5/2^{-}	0.5399(2)	0.5399(2)	1.4995(24)	280^{+180}_{-80}
8.864(4)	8.699(4)	100(1)%	95.7(10)%	1/2^{-}	0.0	—	1.4995(24)	105(6)

* [2000He17].
** Weighted average of values from [1970To18] and [1968Va18], adjusted as recommended by [1991Ry01].
*** [1968Va18].
@ [2013Si17].

Table 6
direct α emission from ^{219}Th, J^{π} = (9/2^{+}), $T_{1/2}$ = 1.03(3) μs*, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)**	I_{α}(abs)***	J^{π}_{f}	$E_{daughter}$(^{215}Ra)	coincident γ-rays	R_0 (fm)	HF
9.507(11)	9.333(11)	100%	(9/2^{+})	0.0	—	1.5769(37)	2.7(3)

* Weighted average of 1.09(8) μs [2017Su18], 0.97(4) μs [2015Kh09] and 1.05(3) μs [1973Ha32].
** Weighted average of 9.338(24) MeV [2020Ma27], 9.327(15) MeV [2017Su189] and 9.340(20) MeV [1973Ha32].

Table 7
direct α emission from ^{223}U*, J^{π} = (7/2^{+}), $T_{1/2}$ = 62^{+14}_{-10} μs, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{219}Th)	coincident γ-rays	R_0 (fm)	HF
8.913(16)	8.753(16)	100(31)%	65(20)%	(7/2^{+})	0.244(23)		1.5402(90)	$1.0^{+0.9}_{-0.5}$
9.157(17)	8.993(17)	54(26)%	35(13)%	(9/2^{+})	0.0	—	1.5402(90)	8^{+8}_{-4}

* All values from [2020Su02].

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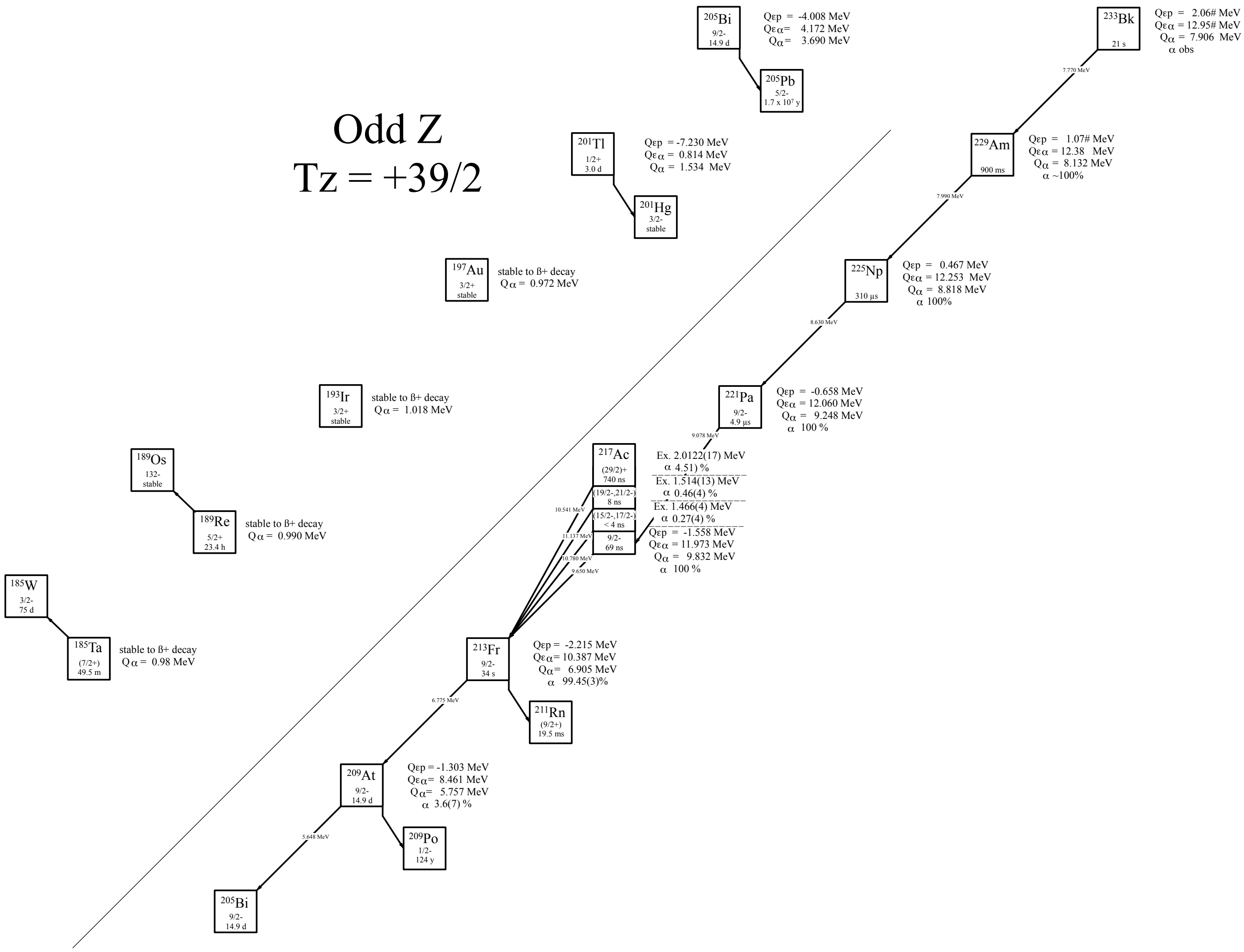

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +39/2 nuclei.

Last updated 1/21/24

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +39/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex.	J^{π}	$T_{1/2}$	Q_{ε}	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{185}Ta*		(7/2$^+$)	49.5(15) m	-3.070(7)	—–	—–	[**1955Po26**]
^{189}Re*		5/2$^+$	23.4(4) h	-2.17(20)#	—–	—–	[**1965Bl06**]
^{193}Ir		3/2$^+$	stable	-1.142(2)	—–	—–	
^{197}Au		3/2$^+$	stable	-0.720(1)	—–	—–	
^{201}Tl		1/2$^+$	3.0380(17) d	0.482(14)	-7.230(30)	0.814(14)	[**2004De02**]
^{205}Bi		9/2$^-$	14.91(7) d	2.705(5)	-4.008(5)	4.172(5)	[**2004Ku33**]
^{209}At		9/2$^-$	5.41(5) h	3.482(5)	-1.303(5)	8.461(5)	[**1968GuZX**]
^{213}Fr		9/2$^-$	34.14(6) s	2.142(6)	-2.215(5)	10.387(5)	[**2013Fi08**]
^{217}Ac		9/2$^-$	69(4) ns	2.813(13)	-1.558(12)	11.973(12)	[**1985De14**]
^{217m1}Ac	1.1466(4)**	(15/2$^-$, 17/2$^-$)	<4 ns	3.960(13)	-0.411(12)	13.120(12)	[**1985De14, 1982GoZU**]
^{217m2}Ac	1.514(30)***	(19/2$^-$, 21/2$^-$)	8(2) ns	4.327(33)	-0.044(32)	13.487(32)	[**1985De14, 1973No02**]
^{217m3}Ac	2.0122(7)	(29/2)$^+$	740(40) ns	4.825(13)	-0.454(12)	13.985(12)	[**1985De14**]
^{221}Pa		9/2$^-$	4.9(8) μs	3.440(60)	-0.658(60)	12.060(60)	[**1995AnZY**]
^{225}Np			$0.31^{+0.75}_{-13}$ ms	4.250(90)	0.467(92)	12.253(92)	[**2019Mi08, 2015De22**]
^{229}Am			$0.9^{+2.1}_{-0.7}$ s	4.79(12)	1.07(15)#	12.38(11)	[**2015De22**]
^{233}Bk			21^{+48}_{-17} s	5.48(25)#	2.06(38)#	12.95(24)#	[**2015De22**]

* 100% β^- emitter.

** [1985De14] report the energy of this α-emitting level as either 1.150 MeV (15/2$^-$) or 1.147 (17/2$^-$). The value of 1.1466(4) is from [2018Si] based on the γ cascade form the (29/2$^+$) isomer.

*** [1985De14] report the energy of this α-emitting level as either 1.498 MeV (19/2$^-$) or 1.529 (21/2$^-$).

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +39/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{185}Ta	7.184(42)	16.256(81)	0.98(13)		
^{189}Re	6.600(9)	15.661(56)#	0.990(16)		
^{193}Ir	5.943(2)	14.764(10)	1.018(8)		
^{197}Au	5.784(1)	14.025(1)	0.972(1)		
^{201}Tl	4.966(14)	12.665(14)	1.534(14)		
^{205}Bi	3.245(5)	9.882(4)	3.690(15)		
^{209}At	2.704(5)	7.407(5)	5.757(2)	3.6(7)%	[**2017Lo13, 1969Go23, 1968GuZX**, 1963Uh01, 1956HuXX, 1955Mo68, 1951Ba14]
^{213}Fr	2.184(6)	6.485(5)	6.905(1)	99.45(3)%	[**2016Pr08, 2005Ku06**, 2019Mi08, 2017Lo13, 2013Fi08, 2012Mo08, 1982Bo04, 1976RaZG, 1974Ho27, 1973BoXL, 1971ReZG, 1967Va20, 1964Gr04, 1961Gr42]
^{217}Ac	1.878(14)	6.194(13)	9.832(10)	100%	[**1985De14**, 2019Mi08, 1982GoZU, 1982SaZO, 1981MaYW, 1977BaYU, 1973No02, 1973No09, 1972No06]
^{217m1}Ac	0.731(14)	5.047(13)	10.979(10)	0.27(4)%	[**1985De14**, 1982GoZU, 1982SaZO, 1972No06]
^{217m2}Ac	0.364(33)	4.680(33)	11.346(32)	0.46(13)%	[**1985De14**, 1982GoZU, 1973No02]
^{217m3}Ac	-0.134(14)	4.182(13)	11.844(10)	4.51(17)%	[**1985De14**, 1982GoZU, 1982SaZO, 1981MaYW, 1973No02, 1972No06]
^{221}Pa	1.604(61)	5.773(79)	9.248(58)	100%	[**1995AnZY, 1989Mi17**, 2019Mi08, 1989MiZK, 1989MiZZ, 1987MiZO, 1983Hi12]
^{225}Np	1.414(93)	5.30(12)	8.818(70)	100%	[**2015De22, 1994Ye08**, 2019Mi08, 1994AnZY, 1993AnZS, 1993AnZY
^{229}Am	1.222(30)*	4.716(82)*	8.132(20)*	≈100%	[**2015De22**]
^{233}Bk	0.586(31)**	4.212(38)#	7.906(20)**	obs	[**2015De22**]

* Deduced from α energy. S_p = 1.22(11)# MeV, S_{2p} = 4.98(13)# MeV, Q_α = 8.137(54# MeV) in [2021Wa16].

** Deduced from α energy. S_p = 0.85(31)# MeV, Q_α = 8.17(21)# MeV) in [2021Wa16].

Table 3
direct α emission from ^{209}At, J^{π} = 9/2^{-}, $T_{1/2}$ = 5.41(5) h*, BR_{α} = 3.6(7)%**.

E_{α}(c.m.)	E_{α}(lab)***	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{205}Bi)	coincident γ-rays	R_0 (fm)	HF
5.216(2)	5.116(2)$^{@}$	0.10(5)%$^{@}$	0.0036(9)		0.542(4)		1.4432915)	$2.5^{+3.0}_{-0.9}$
5.758(4)	5.648(4)	100%	3.697)%	9/2^{-}	0.0	—–	1.4432915)	$1.8^{+0.5}_{-0.3}$

* [1968GuZX].
** [2017Lo13].
*** [1969Go23].
@ Only reported in [1969Go23].

Table 4
direct α emission from ^{213}Fr, J^{π} = 9/2^{-}, $T_{1/2}$ = 34.14(6) s*, BR_{α} = 99.45(3)%**.

E_{α}(c.m.)***	E_{α}(lab)	I_{α}(rel)***	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{209}At)	coincident γ-rays	R_0 (fm)	HF
4.083(2)	4.007(2)	weak	weak	(5/2,7/2)	2.8206(10)	0.4083(5), 0.6894(5), 0.8554(5), 0.8675(5)		
5.806(2)	5.697(2)	0.010(5)%	0.010(5)%	(7/2)$^{-}$	1.0977(7)	0.4083(5), 0.6894(5)	1.4450(19)	$0.25^{+0.25}_{-0.9}$ @@@
5.823(2)	5.713(2)	0.020(3)%	0.020(3)%	(5/2,7/2)$^{-}$	1.0812(7)	0.4083(5), 0.6729(5)	1.4450(19)	$0.15^{+0.3}_{-0.2}$ @@@
6.115(2)	6.000(2)	0.020(10)%	0.020(10)%	(9/2)$^{-}$	0.7890(7)	0.3807(5), 0.4083(5)	1.4450(19)	4^{+4}_{-1}
6.158(2)	6.043(2)	0.040(6)%	0.040(6)%	7/2^{-}	0.7457(5)	0.7457(5)	1.4450(19)	$2.8^{+0.5}_{-0.4}$
6.327(2)	6.208(2)$^{@}$	0.070(11)%	0.070(11)%	11/2^{-}	0.5770(5)	0.5770(5)	1.4450(19)	$8.9^{+1.7}_{-1.3}$
6.496(2)	6.374(2)$^{@}$	0.12(2)%	0.12(2)%	7/2^{-}	0.4083(5)	0.4083(5)	1.4450(19)	27^{+6}_{-4}
6.904(2)	6.775(2)$^{@@}$	100%	99.23(3)%	9/2^{-}	0.0	—–	1.4450(19)	1.31(6)

* [2013Fi08].
** [2005Ku06].
*** Deduced from table 2 and figure 8 in [2016Pr08]. The authors list γ-ray intensities and energies following the α decay of ^{213}Fr. Note that α's are not directly measured in this work, and are deduced assuming a Q_{α} of 6.9040(18) MeV for ^{213}Fr.
@ α also observed in [2005Ku06].
@@ Weighted average of 6.775(4) MeV [2005Ku06] and 6.775(2) MeV [1982Bo04].
@@@ Unphysically low HF indicate that the apparent β branching reported in [2016Pr08] for these levels is too high, likely due to the levels being fed from above (*i.e.* pandemonium).

Table 5
direct α emission from ^{217}Ac, J^{π} = 9/2^{-}, $T_{1/2}$ = 69(4) ns*, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{213}Fr)	coincident γ-rays	R_0 (fm)	HF
9.831(10)	9.650(10)**	100%	9/2^{-}	0.0	—–	1.5460(33)	0.98(10)

* From [1985De14]. [1973No09] reported a half-life of 111(7) ns, which results in a HF equal to 1.58(17). The g.s. to g.s. α-decay is expected to be unhindered. Therefore, the value from [1985De14] is adopted.
** [1973No09].

Table 6
direct α emission from ^{217m1}Ac, Ex. = 1.1466(4)**, J^{π} = (15/2^{-}, 17/2^{-}), $T_{1/2}$ = <4 ns***, BR_{α} = 0.27(4)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{213}Fr)	coincident γ-rays	R_0 (fm)	HF
10.982(15)	10.780(15)	100%	9/2^{-}	0.0	—–	1.5460(33)	>3.8 × 10^{3}

* All values from [1985De14], except where noted.
*** [1985De14] report the energy of this α-emitting level as either 1.150 MeV (15/2^{-}) or 1.147 (17/2^{-}). The value of 1.1466(4) is from [2018Si] based on the γ cascade form the (29/2^{+}) isomer.
*** [1982GoZU].

Table 7
direct α emission from ^{217m2}Ac*, Ex. = 1.514(30)**, J^{π} = (19/2$^-$, 21/2$^-$), $T_{1/2}$ = 8(2) ns***, BR_α = 0.46(13)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{213}Fr)	coincident γ-rays	R_0 (fm)	HF
11.346(15)	11.137(15)	0.46(13)%	9/2$^-$	0.0	—	1.5460(33)	$1.9^{+1.4}_{-0.8}\times 10^4$

* All values from [1985De14], except where noted.
** [1985De14] report the energy of this α-emitting level as either 1.498 MeV (19/2$^-$) or 1.529 (21/2$^-$).
*** [1973No02].

Table 8
direct α emission from ^{217m3}Ac*, Ex. = 2.0122(7), J^{π} = (29/2$^-$), $T_{1/2}$ = 740(40) ns, BR_α = 4.51(17)%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{213}Fr)	coincident γ-rays	R_0 (fm)	HF
10.739(10)	10.541(10))	100(4)%	4.07(16)%	13/2$^+$	1.105	1.105	1.5460(33)	$1.7^{+1.1}_{-0.5}\times 10^5$
11.346(15)	11.137(15)	11.3(32)%	0.46(13)%	7/2$^-$	0.498	0.498	1.5460(33)	$1.8^{+1.1}_{-0.5}\times 10^7$
11.843(15)	11.625(15)	2.95(50)%	0.12(2)%	9/2$^-$	0.0	—	1.5460(33)	$4.3^{+2.6}_{-1.3}\times 10^8$

* All values from [1985De14], except where noted.

Table 9
direct α emission from ^{221}Pa, J^{π} = 9/2$^-$, $T_{1/2}$ = 4.9(8) μs*, BR_α = 100%.

E_α(c.m.)	E_α(lab)**	I_α(abs)	J^π_f	$E_{daughter}$(^{217}Ac)	coincident γ-rays	R_0 (fm)	HF
9.245(21)	9.078(21)	100%	9/2$^-$	0.0	—	1.5671(97)	1.3(4)

* [1995AnZY].
** Weighted average of 9.075(30) MeV [1995AnZY] and 9.080(30) MeV [1989Mi17].[

Table 10
direct α emission from ^{225}Np, $T_{1/2}$ = $0.31^{+0.75}_{-13}$ ms*, BR_α = 100%.

E_α(c.m.)	E_α(lab)**	I_α(abs)	J^π_f	$E_{daughter}$(^{221}Pa)	coincident γ-rays	R_0 (fm)	HF
8.786(20)	8.630(20)	100%	9/2$^-$	0.0	—	1.534(15)	$0.7^{+1.6}_{-0.3}$

* From [2019Mi08]. Using this half-life gives a HF equal to $0.7^{+1.6}_{-0.3}$, indicating an unhindered transition. [2015De22] report a value of $3.8^{+7.6}_{-2.7}$ ms which gives a HF of 8^{+3}_{-1}.
** [1994Ye08].

Table 11
direct α emission from ^{229}Am*, $T_{1/2}$ = $0.9^{+2.1}_{-0.7}$ s, BR_α = ≈100%**.

E_α(c.m.)	E_α(lab)**	I_α(abs)	J^π_f	$E_{daughter}$(^{225}Np)	coincident γ-rays	R_0 (fm)	HF
8.132(20)	7.990(20)	100%		0.0	—	1.534(15)	$1.0^{+2.9}_{-0.9}$

* All values from [2015De22].
** Only α decay observed.

Table 12
direct α emission from ^{233}Bk*, $T_{1/2}$ = 21^{+48}_{-17} s, BR_α = obs.

E_α(c.m.)	E_α(lab)**	I_α(abs)	J^π_f	$E_{daughter}$(^{229}Am)	coincident γ-rays	R_0 (fm)	HF
7.906(20)	7.770(20)	obs		0.0	—	1.525(46)	***

* All values from [2015De22].
** Only α decay observed.
*** Using a BR of 100%, a HF of 4^{+10}_{-4} is obtained.

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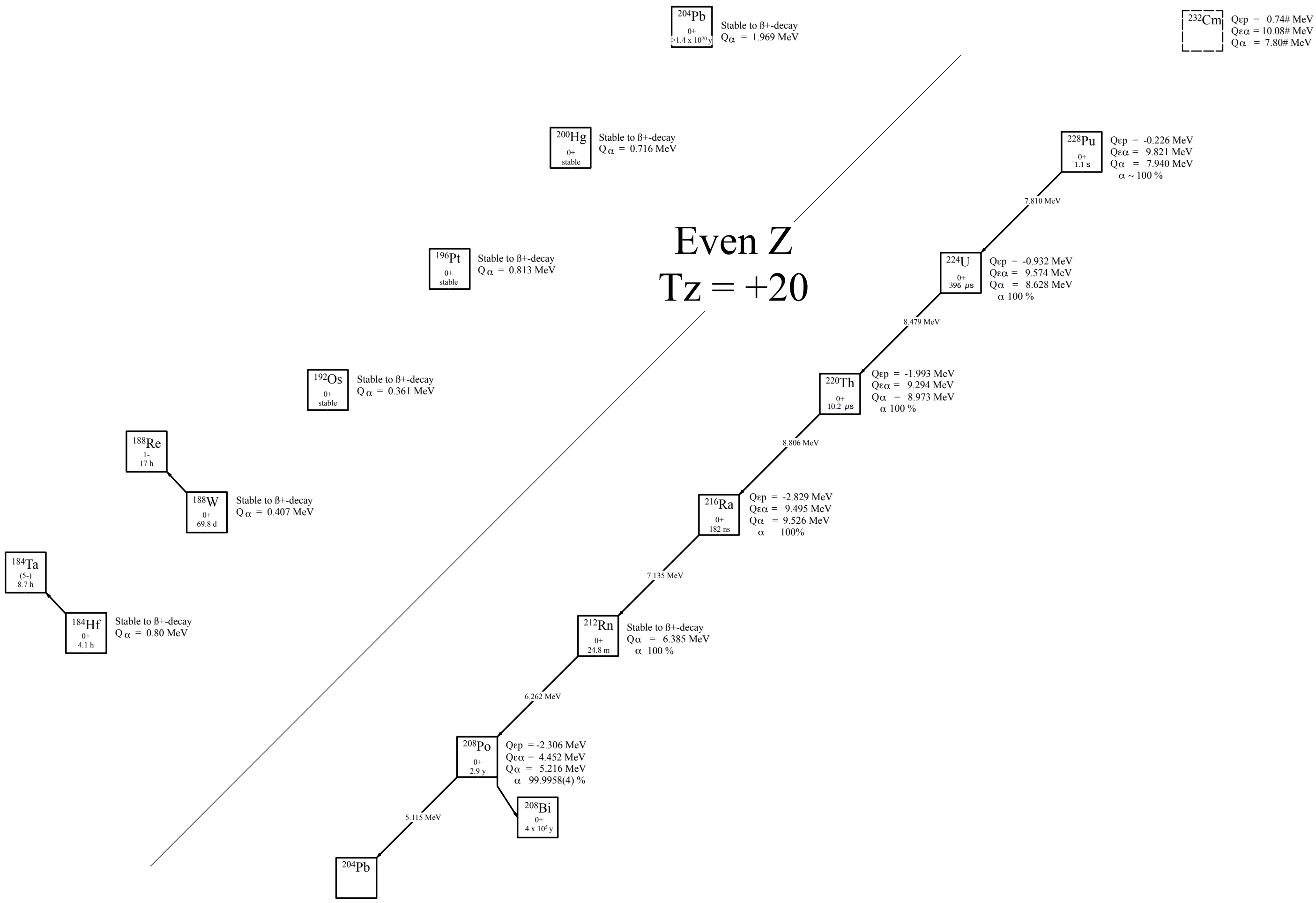

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +20 nuclei.

Last updated 2/20/24

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +20 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{184}Hf*	0^+	4.12(5) h	-5.20(20#	—	—	[**1973Wa18**]
^{188}W*	0^+	69.78(12) d	-4.76(20)#	—	—	[**2014Un01**]
^{192}Os	0^+	stable	-4.290(70)	—	—	
^{196}Pt	0^+	stable	-3.210(40)	—	—	
^{200}Hg	0^+	stable	-2.463(27)	—	—	
^{204}Pb	0^+	>1.4 × 10^{20} y	-0.7638(2)	—	—	[**2013Be16**]
^{208}Po	0^+	2.888 y	1.401(2)	-2.306(1)	4.452(2)	[**1966Ha29**]
^{212}Rn	0^+	24.8(5) m**	-0.031(4)	—	—	[**1971Go35, 1968Cr02**]
^{216}Ra	0^+	182(10) ns	0.320(9)	-2.829(10)	9.495(8)	[**1973No09**]
^{220}Th	0^+	10.2(4) μs***	0.946(15)	-1.993(15)	9.294(14)	[**2019Pa45, 1973Ha32**]
^{224}U	0^+	396(17) μs	1.880(17)	-0.932(17)	9.574(16)	[**2014Lo10**]
^{228}Pu	0^+	$1.1^{+2.0}_{-0.5}$ s	2.28(10)#	-0.226(25)	9.821(25)#	[**2003Ni10**]
^{232}Cm	0^+		2.91(36)#	0.74(20)#	10.08(23)#	

* 100% β^- emitter
** Weighted average of 22.0(10) m [1971Go35] and 25.5(5) m [1968Cr02].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the even-Z, T_z = +20 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{184}Hf	9.072(89)	17.18(40)#	0.80(30)#		
^{188}W	9.061(56)#	16.822(51)#	0.407(40)		
^{192}Os	8.821(10)	16.091(35)	0.361(4)		
^{196}Pt	8.241(1)	14.787(2)	0.813(2)		
^{200}Hg	7.698(1)	14.177(2)	0.716(1)		
^{204}Pb	6.6375(3)	12.342(1)	1.969(1)		
^{208}Po	4.704(2)	8.262(1)	5.216(1)	99.9958(4)%	[**1993Sa14, 1970Ra14, 1969Go23, 1967Ti04, 1966Ha29**, 1955Mo68, 1953AsZZ, 1951Ka03, 1951Ka37, 1947Te01]
^{212}Rn	4.301(4)	7.284(3)	6.385(3)	100%	[**1971Go35**, 2003Ni10, 2003NiZV, 1970AfZZ, 1970TaZS, 1968Cr02, 1963Uh01, 1959Ka15, 1955Mo68, 1952Mo23, 1950Hy27]
^{216}Ra	4.316(11)	6.967(12)	9.526(7)	100%	[**1973No09**, 2017Su18, 1975No09, 1972No06, 1961Gr43]
^{220}Th	4.169(53)	6.534(17)	8.973(11)	100%	[**2019Pa45, 1973Ha32**, 1991AnZZ, 1973HaWU]
^{224}U	3.884(77)	6.038(18)	8.628(7)	100%	[**2014Lo10**, 2003Ni10, 2003NiZV, 1994AnZY, 1994Ye08, 1993AnZS, 1993ToZW, 1992To02, 1992ToZV, 1991An10, 1991An13, 1990AnZU]
^{228}Pu	3.760(80)	5.799(26)	7.940(18)	≈ 100%*	[**1994An02, 1994Ye08**, 2004NiZZ, 2003Ni10, 2003NiZV, 2001NiZY, 1994AnZX, 1994AnZY]
^{232}Cm	3.37(36)#	5.18(20)#	7.80(20)#		

* Based on short half-life.

Table 3
direct α emission from ^{208}Po*, $J^\pi = 0^+$, $T_{1/2}$ = 2.888 y, BR_α = 99.9958(4)%**

E_α(c.m.)	E_α(lab)***	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{204}Pb)	coincident γ-rays	R_0 (fm)	HF
4.303(15)	4.220(15)	2.4(7) × 10^{-4}%	2.4(7) × 10^{-4}%	2^+	0.899@	0.899@	1.42967(74)	$0.54^{+0.22}_{-0.12}$@@
5.215(2)	5.115(2)***	100%	99.9958(4)%**	0^+	0.0	—	1.42967(74)	0.98(2)

* All values from [1966Ha29], except where noted.
** [1993Sa14] report a BR_ε equal to 0.0042(4)%.
*** Weighted average from [1991Ry01] based on 5.114(3) MeV [1970Ra14] (modified to 5.113(3) MeV), 5.116(2) MeV [1969Go23], 5.118(5) MeV [1967Ti04] (modified to 5.120(3) MeV), 5.110(5) MeV [1966Ha29] and 5.108(3) MeV [1953AsZZ] (modified to 5.114(3) MeV).
@ [2010Ch02].
@@ This unphysicaly low HF value may indicate that the branching ratio is too high or that the reported transition is incorrect.

Table 4
direct α emission from ^{212}Rn*, J^{π} = 0^{+}, T$_{1/2}$ = 24.8(5) m**, BR_{α} = 100%**

E_{α}(c.m.)	E_{α}(lab)***	I_{α}(rel)	I_{α}(abs)	J$^{\pi}_{f}$	$E_{daughter}$(^{208}Po)	coincident γ-rays	R$_0$ (fm)	HF
5.996(3)	5.883(3)	0.050(5)%	0.050(5)%	2^{+}	0.687	0.687	1.4343(25)	$1.43^{+0.19}_{-0.16}$
6.382(3)	6.262(3)	100%	99.95(5)%	0^{+}	0.0	—–	1.4343(25)	1.01(2)

* All values from [1971Go35], except where noted.
** Weighted average of 22.0(10) m [1971Go35] and 25.5(5) m [1968Cr02].
*** This low HF value may indicate that the branching ratio is too high or that the reported transition is incorrect.

Table 5
direct α emission from ^{216}Ra*, J^{π} = 0^{+}, T$_{1/2}$ = 182(10) ns, BR_{α} = 100%

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J$^{\pi}_{f}$	$E_{daughter}$(^{212}Rn)	coincident γ-rays	R$_0$ (fm)	HF
9.525(8)	9.349(8)	100%	0^{+}	0.0	—–	1.5433(36)	1.05(6)

* All values from [1973No09].

Table 6
direct α emission from ^{220}Th, J^{π} = 0^{+}, T$_{1/2}$ = 10.2(4) μs*, BR_{α} = 100%

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J$^{\pi}_{f}$	$E_{daughter}$(^{216}Ra)	coincident γ-rays	R$_0$ (fm)	HF
8.969(13)	8.806(13)**	100%	0^{+}	0.0	—–	1.6051(43)	2.53(10)***

* Weighted average of 10.4(4) μs [2019Pa45] and 9.7(6) μs [1973Ha32].
** Weighted average of 8.813(13) MeV [2019Pa45] and 8.790(20) MeV [1973Ha32].
*** Expect this transition to be an unhindered $0^{+} \to 0^{+}$. The reason for the larger HF is unknown.

Table 7
direct α emission from ^{224}U*, J^{π} = 0^{+}, T$_{1/2}$ = 396(17) μs, BR_{α} = 100%

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J$^{\pi}_{f}$	$E_{daughter}$(^{220}Th)	coincident γ-rays	R$_0$ (fm)	HF
8.242(18)	8.095(11)	3.5(8)%	3.4(8)%	2^{+}	0.387(2)	0.387(2)	1.5514(30)	$2.2^{+0.7}_{-0.5}$
8.633(8)	8.479(8)	100%	96.6(8)%	0^{+}	0.0	—–	1.5514(30)	1.009(10)

* All values from [2014Lo10].

Table 8
direct α emission from ^{228}Pu, J^{π} = 0^{+}, T$_{1/2}$ = $1.1^{+2.0}_{-0.5}$ s*, BR_{α} = ≈100%

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J$^{\pi}_{f}$	$E_{daughter}$(^{224}U)	coincident γ-rays	R$_0$ (fm)	HF
7.949(20)	7.810(20)**	≈100%	0^{+}	0.0	—–	1.480(42)	$1.1^{+2.0}_{-0.5}$

* [2003Ni10].
* [1994An02, 1994Ye08].

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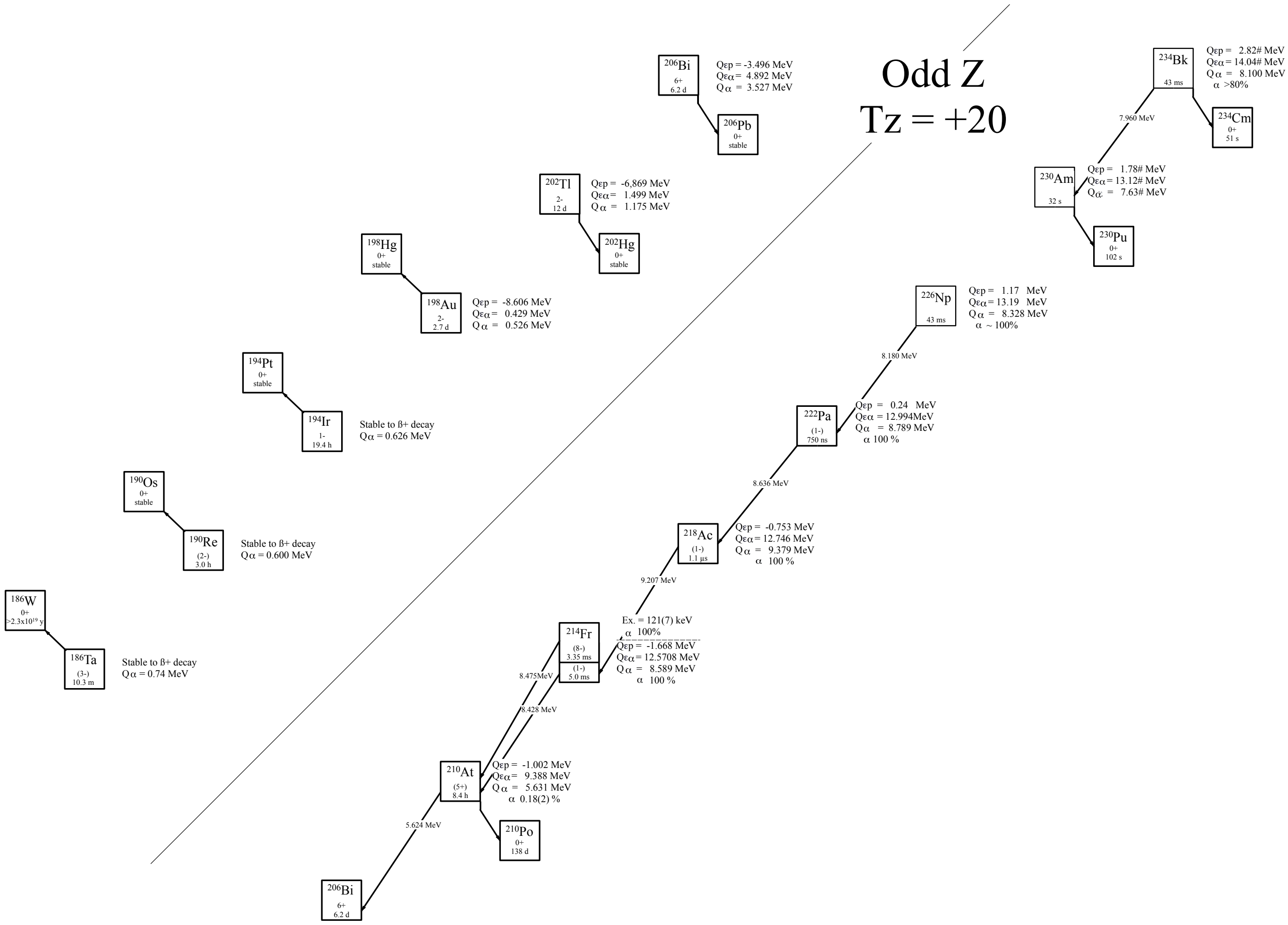

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +20 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +20 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex.	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	$BR_{\varepsilon F}$	Experimental
^{186}Ta*		(3$^-$)	10.390(27) m	-2.180(80)	—	—		[**1995ItZY**]
^{190}Re*		(2)$^-$	2.96(1) h	-1.210(40)	—	—		[**1973DeWI**]
^{194}Ir*		1$^-$	19.37(1) h	-0.097(2)	—	—		[**2016Kr06, 1972Em01**]
^{198}Au*		2$^-$	2.6971(20) d	0.323(2)	-8.606(20)	0.429(2)		[**2008Ku09**]
^{202}Tl		2$^-$	12.23(2) d	1.365(1.8)	-6.869(4)	1.499(3)		[**1995Co19**]
^{206}Bi		6$^+$	6.243(3) d	3.757(8)	-3.496(8)	4.892(8)		[**1961Br19**]
^{210}At		(5$^+$)	8.440(79) h	3.981(8)	-1.002(8)	9.388(8)		[**2003HaZT**]
^{214}Fr		(1$^-$)	5.0(2) ms	3.361(12)	-1.668(10)	12.570(9)		[**1968To10**]
^{214m}Fr	0.121(7)	(8$^-$)	3.35(5) ms	3.486(14)	-1.547(12)	12.691(11)		[**1968To10**]
^{218}Ac		(1$^-$)	1.12(3) μs**	4.210(60)	-0.753(58)	12.746(58)		[**2021Hu18, 2019Mi08, 2019Ya04, 2017Su18, 2015Kh09, 1989De06, 1989Mi17, 1983Sc23**]
^{222}Pa			$2.76^{+0.43}_{-0.33}$ ms	4.860(90)	0.24(10)	12.994(87)		[**2021Hu18**]
^{226}Np			43(5) ms***	5.49(10)	1.17(13)	13.19(10)		[**2019Mi08, 1990Ni05**]
^{230}Am			32^{+22}_{-9} s	5.94(14)#	1.78(18)#	13.12(14)#	>30%	[**2017Wi13, 2016Ka13**, 2010KaZV]
^{234}Bk			19^{+6}_{-4} s	6.67(15)#	2.82(19)#	14.04(15)#		[**2016Ka13**]

* 100% β^- emitter.

** Weighted average of $0.87^{+0.18}_{-0.07}$ μs [2021Hu18], 1.8(1) μs [2019Mi08], 1.04(12) μs [2019Ya04], 0.98(12) μs [2017Su18], 0.96(5) μs [2015Kh09], 1.31(12) μs [1989De06], 1.06(9) μs [1989Mi17] and 1.21(18) μs [1983Sc23].

*** Weighted average of 43(5) ms [2019Mi08] and 31(8) ms [1990Ni05].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +20 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{186}Ta	7.577(88)	16.89(21)	0.74(21)		
^{190}Re	7.06(20)	16.25(20)	0.600(60)		
^{194}Ir	6.426(2)	15.521(71)	0.626(5)		
^{198}Au	6.450(1)	14.723(38)	0.526(1)		
^{202}Tl	5.607(2)	13.318(27)	1.175(2)		
^{206}Bi	3.547(8)	10.260(8)	3.527(8)		
^{210}At	2.895(8)	7.680(8)	5.631(1)	0.18(2)%	[**1981Va27, 1981Va29, 1977VaZT, 1969Go23**, 2003HaZT, 1975Ja09, 1975JaZF, 1968GuZX, 1955Mo68, 1953AsZZ]
^{214}Fr	2.551(9)	6.908(9)	8.589(4)	100%	[**1970To18**, 2021Hu18, 2019Mi08, 2016Fa11, 2015Kh09, 2005Ku06, 2005Li17, 1989AnZL, 1968To10, 1968Va18]
^{214m}Fr	2.430(11)	6787(11)	8.710(8)	100%	[**1970To18**, 2016Fa11, 2005Ku06, 1966Ro12]
^{218}Ac	2.328(58)	6.698(58)	9.379(10)*	100%	[**2021Hu18, 2017Su18, 1970Bo13, 2021Hu19, 2019Mi17,** 2019Ya04, 2015Kh09, 1989De06, 1989Mi17, 1989MiZK, 1989MiZZ, 1988MiZJ, 1983Sc23, 1970Bo13, 1970VaZZ]
^{222}Pa	2.165(87)	6.257(87)	8.789(65)	100%	[**2021Hu18**, 2019Mi08, 1995AnZY, 1979Sc09, 1970Bo13, 1970VaZZ]
^{226}Np	1.84(10)	5.62(10)	8.328(54)	≈ 100%	[**2019Mi08**, 1994AnZY, 1994Ye08, 1993AnZS, 1990Ni05]
^{230}Am	1.81(16)#	5.53(18)#	7.63(10)#		
^{234}Bk	1.19(17)#	4.60(34)#	8.100(50)	>80%	[**2016Ka13, 2003MoZT**, 2010KaZV, 2003MoZX]

* Deduced from α energy, 9.384(57) MeV in [2021Wa16].

Table 3
direct α emission from ^{210}At*, J^π = (5$^+$), $T_{1/2}$ = 8.440(79) h**, BR_α = 0.18(2)%***

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	$J^{\pi\,@}_f$	$E_{daughter}$(^{206}Bi)	coincident γ-rays$^@$	R_0 (fm)$^{@@}$	HF
5.275(4)	5.175(4)	0.7(2)%	3.8(12) × 10^{-4} %	(3,4)$^+$	0.356	0.338	1.4320(26)	66^{+30}_{-17}
5.344(3)	5.242(3)	2.8(4)%	1.6(3) × 10^{-3} %	(4$^+$, 5$^+$)	0.288		1.4320(26)	36^{+8}_{-6}
5.4640(13)	5.3599(13)	91(5)%	0.050(7)%	5$^+$	0.167	0.106, 0.167	1.4320(26)	$5.3^{+0.9}_{-0.7}$
5.492(2)	5.387(2)	15.0(10)%	8.3(11) × 10^{-3} %	7$^+$	0.140	0.141	1.4320(26)	44^{+8}_{-6}
5.5485(15)	5.4428(15)	93(5)%	0.051(6)%	(5$^+$)	0.083	0.083	1.4320(26)	$14.1^{+2.3}_{-1.9}$
5.562(2)	5.456(2)	1.3(2)%	7.2(13) × 10^{-4} %	(3$^+$)	0.069		1.4320(26)	$1.2^{+0.4}_{-0.3} \times 10^3$
5.5714(15)	5.4653(15)	23.6(10)%	0.013(2)%	4$^+$	0.060		1.4320(26)	73^{+12}_{-10}

Table 3
direct α emission from ^{210}At*, J^{π} = (5^{+}), T$_{1/2}$ = 8.440(79) h**, BR_{α} = 0.18(2)%***

5.6314(13)	5.5241(13)	100(3)%	0.055(6)%	6^{+}	0.0	—	1.4320(26)	35^{+5}_{-4}

* All values from [1977VaZT, 1981Va27, 1981Va29], except where noted.
** [2003HaZT].
*** [1969Go23].
@ [2008Ko21].
@@ Interpolated between 1.42967(74) fm (^{208}Po) and 1.4343(25) fm (^{212}Rn).

Table 4
direct α emission from ^{214}Fr*, J^{π} = (1^{-}), T$_{1/2}$ = 5.0(2) ms**, BR_{α} = 100%

E_{α}(c.m.)	E_{α}(lab)***	I_{α}(rel)	I_{α}(abs)	J_f^{π}@@	$E_{daughter}$(^{210}At)@@	coincident γ-rays@@	R$_0$ (fm)@@@	HF
7.549(5)	7.408(5)	≈ 0.3%	≈ 0.3%	(3^{+})	1.0367	0.073, 0.424, 0.496, 0.540, 0.946	1.4888(44)	≈ 31
7.752(8)	7.607(8)	≈1%	≈1%		0.8378		1.4888(44)	≈ 40
8.090(8)	7.939(8)	≈1%	≈1%	(4^{+})	0.4962(1)		1.4888(44)	≈420
8.519(5)	8.360(5)	5.2(2)%	4.8(2)%@	(4^{+})	0.073(1)	0.073	1.4888(44)	1.33(15) × 10^{3}
8.588(5)	8.428(5)	100.(5)%	93.0(5)%@	(5^{+})	0.0	—	1.4888(44)	107(11)

* All values from [1970To18], except where noted.
** [1968To10].
*** Adjusted by +2.3 keV in [1991Ry01].
@ [2016Fa11].
@@ [2014Ba41].
@@@ Interpolated between 1.4343(25) fm (^{212}Rn) and 1.5433(36) fm (^{216}Ra).

Table 5
direct α emission from ^{214m}Fr*, Ex. = 121(7) keV, J^{π} = (8^{-}), T$_{1/2}$ = 3.35(5) ms, BR_{α} = 100%

E_{α}(c.m.)	E_{α}(lab)**	I_{α}(rel)	I_{α}(abs)	J_f^{π}@@	$E_{daughter}$(^{210}At)@@	coincident γ-rays@@@	R$_0$ (fm)^{b}	HF
7.481(5)	7.341(5)	0.1%	0.05%		1.228(7)^{a}		1.4888(44)	75
7.739(5)	7.594(5)	1.0%	0.5%		0.966(2)	0.966(2)	1.4888(44)	51
7.859(5)	7.712(5)***	2.2%	1.1%		0.8469(3)	0.0728(2), 0.7747(4), 0.8469(3)	1.4888(44)	54
8.104(6)	7.953(6)				0.6035(5)	0.0728(2), 0.5307(4)	1.4888(44)	
8.131(5)	7.979(5)	1.4%	0.7%	(7^{+})	0.5767(3)	0.5767(3)	1.4888(44)	540
8.177(6)	8.024(6)@			(3^{+})	0.5311(4)	0.0728(2), 0.4583(3)	1.4888(44)	
8.199(5)	8.046(5)	1.8%	0.9%	(6^{+})	0.5074(2)	0.0728(2), 0.4231(6), 0.5074(2)	1.4888(44)	660
8.211(5)	8.058(6)@			(4^{+})	0.4966(6)	0.0728(2), 0.4231(6), 0.4966(6)	1.4888(44)	
8.636(5)	8.475(5)***	100%	50.9%	(4^{+})	0.0728(2)	0.0728(2)	1.4888(44)	180
8.709(5)	8.546(5)***	90.4%	46.0%	(5^{+})	0.0	—	1.4888(44)	300

* All values from [1968To10], except where noted. Uncertainties for I_{α} are not given.
** Energy values from [1968To10] are adjusted by +0.8 keV in [1991Ry01].
*** Weighted average of values from [1968To10] and [2005Ku06].
@ α not observed. Deduced in [2005Ku06] from α-γ coincidences.
@@ [2014Ba41].
@@@ [2005Ku06].
^{a} Deduced from α energies [1968To10].
^{b} Interpolated between 1.4343(25) fm (^{212}Rn) and 1.5433(36) fm (^{216}Ra).

Table 6
direct α emission from ^{218}Ac, J^{π} = (1^{-}), T$_{1/2}$ = 1.12(3) μs*, BR_{α} = 100%

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J_f^{π}@@	$E_{daughter}$(^{214}Fr)@@	coincident γ-rays@@	R$_0$ (fm)@@@	HF
9.379(10)	9.207(10)	100%	(1^{-})	0.0	—	1.5742(56)	2.9(4)

* Weighted average of $0.87^{+0.18}_{-0.07}$ μs [2021Hu18], 1.8(1) μs [2019Mi08], 1.04(12) μs [2019Ya04], 0.98(12) μs [2017Su18], 0.96(5) μs [2015Kh09], 1.31(12) μs [1989De06], 1.06(9) μs [1989Mi17] and 1.21(18) μs [1983Sc23].
** Weighted average of 9.917(15) MeV [2021Hu18], 9.919(15) MeV [2017Su18] and 9.205(15) MeV [1970Bo13].
*** Interpolated between 1.5433(36) fm (^{216}Ra) and 1.6051(43) fm (^{220}Th).

Table 7
direct α emission from ^{222}Pa*, $T_{1/2}$ = $2.76^{+0.43}_{-0.33}$ ms, BR_α = 100%

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)**	J^π_f	$E_{daughter}$(^{218}Ac)	coincident γ-rays	R_0 (fm)***	HF
8.206(18)	8.058(18)	23%	5.7%		0.589		1.5783(52)	27
8.401(16)	8.250(16)	77%	19.2%		0.393		1.5783(52)	30
8.491(16)	8.338(16)	58%	14.4%		0.303		1.5783(52)	72
8.592(16)	8.437(16)	80%	19.9%		0.203		1.5783(532)	100
8.681(16)	8.525(16)	64%	15.9%		0.113		1.5783(52)	220
8.794(15)	8.636(15)	100%	24.9%	(1^-)	0.0	—	1.5783(52)	280

* All values from [2021Hu18], except where noted.
** No uncertainties were reported [2021Hu18].
*** Interpolated between 1.6051(43) fm (^{220}Th) and 1.5514(30) fm (^{224}U).

Table 8
direct α emission from ^{226}Np*, $T_{1/2}$ = 43(5) ms**, BR_α = ≈ 100%

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{222}Pa)	coincident γ-rays	R_0 (fm)[@]	HF
8.134(20)	7.990(20)	***	***		0.193(28)		1.516(42)	≈ 3
8.236(20)	8.090(20)	***	***		0.091(28)		1.516(42)	≈ 5
8.327(20)	8.180(20)	***	***		0.0[@@]	—	1.516(42)	≈ 10

* All values from [2019Mi08], except where noted.
** Weighted average of 43(5) ms [2019Mi08] and 31(8) ms [1990Ni05].
*** Text from [2019Mi08]: "For ^{226}Np, the α1 events (Fig. 4 top right energy panel) show a broad energy distribution E=(7.9 – 8.4) MeV, however with the signature for three different α-decay transitions with comparable intensities at 7.98(2), 8.09(2) and 8.18(2) MeV. This could correspond to either single α decay activities or to α-decay+conversion electron summing." In the aforementioned Fig. 4, there are ≈ 6 counts in each peak.
[@] Interpolated between 1.5514(30) fm (^{224}U) and 1.480(42) (^{228}Pu).
[@@] Transition is assumed to feed the ground state.

Table 9
direct α emission from ^{234}Bk*, $T_{1/2}$ =19^{+6}_{-4} s, BR_α = > 80%**

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{230}Am)	coincident γ-rays	R_0 (fm)	HF
7.753(20)	7.620(20)	***	***		0.345(28)			
7.895(20)	7.760(20)	***	***		0.203(28)			
7.997(20)	7.860(20)	***	***		0.101(28)			
8.098(20)	7.960(20)	***	***		0.0[@]	—		

* All values from [2016Ka13], except where noted.
** [2003MoZT].
*** Fig. 2a in [2016Ka13] shows the α spectrum of ^{234}Bk. The four peaks present each have ≈ 5 counts each.
[@] Transition is assumed to feed the ground state.

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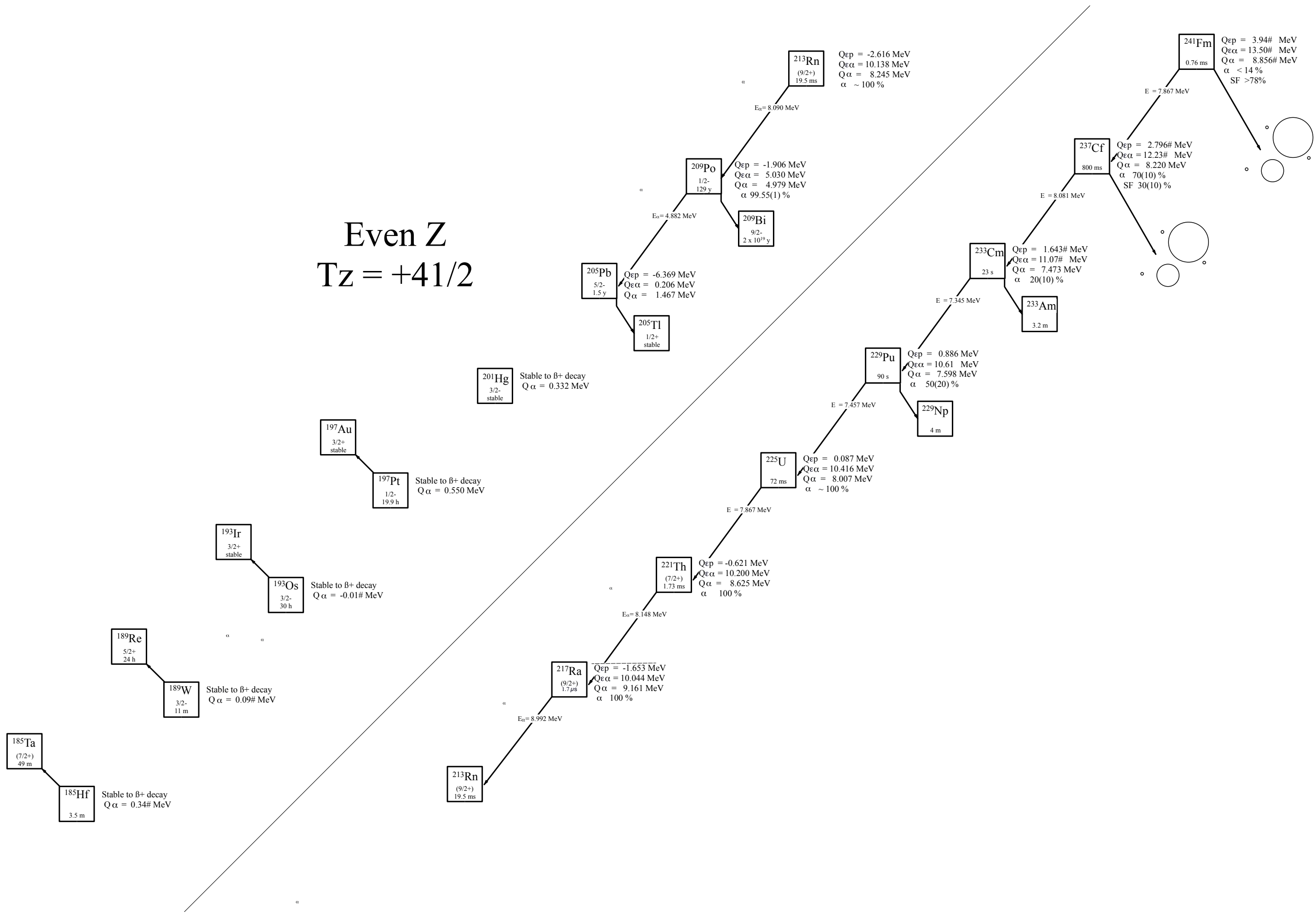

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_Z= +41/2 nuclei.

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Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +41/2 nuclei. J^π values for ^{185}Hf, ^{189}W, ^{193}Os, ^{197}Pt, ^{201}Hg, and ^{205}Pb are taken from ENSDF. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{185}Hf*		3.5(6) m	-4.36(31)#	—	—	[**1993Yu01**]
^{189}W*	(3/2$^-$)	11.7(5) m	-3.85(28)#	—	—	[**1997Ya03**]
^{193}Os*	3/2$^-$	29.830(18) h	-3.160(40)	—	—	[**2012Kr05**]
^{197}Pt*	1/2$^-$	19.8915(19) h	-2.156(20)	—	—	[**1992An13**]
^{201}Hg	3/2$^-$	stable	-1.262(3)	—	—	
^{205}Pb	5/2$^-$	1.51(4) y	0.051(1)	-6.369(1)	0.206(3)	[**1978Pe08**]
^{209}Po	1/2$^-$	128.7(3) y	1.893(2)	-1.906(1)	5.030(2)	[**2007Co07**, 2015Po03, 2014Co16]
^{213}Rn	(9/2$^+$)	19.5(1) ms	0.884(6)	-2.616(3)	10.138(4)	[**2000He17**]
^{217}Ra	(9/2$^+$)	1.7(1) μs**	1.575(9)	-1.653(9)	10.044(9)	[**2019Ya04, 2019Mi08, 1990AnZU, 1970Va13**]
^{221}Th	(7/2$^+$)	1.73(3) ms***	2.410(60)	-0.621(11)	10.200(10)	[**2001Ku07, 1993AnZS, 1970To07**]
^{225}U		72(4) ms$^@$	3.020(80)	0.087(14)	10.416(58)	[**2019Mi08, 2001Ku07, 2000He17**]
^{229}Pu		90(10) s	3.59(12)	0.886(62)	10.61(10)	[**2002CaZU**]
^{233}Cm		23^{+13}_{-6} s	4.01(14)#	1.643(83)#	11.07(13)#	[**2010Kh06**]
^{237}Cf		0.8(2) s	4.73(25)#	2.796(99)#	12.23(15)#	[**2010Kh06**]
^{241}Fm		0.73(6) ms	5.33(38)#	3.94(30)#	13.50(38)#	[**2008Kh10**]

* 100% β^- emitter.
** Weighted average of 1.4(4) μs [2019Ya04], 2.5(2) μs [2019Mi08], 1.7(1) μs [1990AnZU] and 1.6(2) μs [1970Va13].
*** Weighted average of 1.73(3) ms [2001Ku07], 1.9(1) ms [1993AnZS] and 1.68(6) ms [1970To07].
$^@$ Weighted average of 63(7) ms [2019Mi08], 84(4) ms [2001Ku07] and 59^{+5}_{-2} ms [2000He17].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the even-Z, T_z = +41/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	BR_{SF}	Experimental
^{185}Hf	9.31(21)#	17.90(41)#	0.34(31)#			
^{189}W	9.19(28)#	17.39(28)#	0.09(21)#			
^{193}Os	9.095(71)	16.796(42)	-0.01(20)#			
^{197}Pt	8.273(38)	15.486(56)	0.550(2)			
^{201}Hg	7.711(27)	14.852(2)	0.332(1)			
^{205}Pb	6.713	13.079(1)	1.467(1)			
^{209}Po	4.785(2)	8.492(1)	4.979(1)	99.55(1)%		[**1996Sc24, 1989Ma05, 1966Ha29**, 1969Go23, 1953AsZZ, 1951Ka03, 1951Ka37]
^{213}Rn	4.357(4)	7.841(3)	8.245(3)	≈ 100%		[**2001Ku07, 2000He17**, 2021Hu19, 2019Mi08, 2005Li17, 1970TaZS, 1970Va13, 1970VaZZ, 1966Ro12, 1961Gr43]
^{217}Ra	4.370(8)	7.519(9)	9.161(6)	100%		[**1970To07, 1970Va13**, 2021Hu19, 2019Ya04, 2019Mi08, 1970VaZZ,1969ToXX, 1961Gr43]
^{221}Th	4.093(10)	7.032(10)	8.625(4)	100%		[**2020Pa44, 2021Hu19**, 2019Mi08, 2019Ya04, 2015Li17, 2014Lo10, 2003Ni10, 2001Ku07, 2000He17, 1993AnZS, 1990An19, 1990AnZQ, 1990AnZU, 1970To07, 1970Va13, 1970VaZZ, 1969MaZT]
^{225}U	3.779(12)	6.591(13)	8.007(6)	≈ 100%		[**2001Ku07, 2000He17**, 2019Mi08, 2003Ni10, 1994AnZY, 1994Ye08, 1993AnZS, 1992To02, 1992ToZV, 1990YeZY, 1989An13, 1989HeZK, 1989HeZZ, 1988AnZS]
^{229}Pu	3.72(12)#	6.228(61)	7.590(20)**	50(20)%	<7%*	[**2010Kh06**, 2002CaZU, 2002CaZZ, 1994An02, 1994AnZX, 1994AnZY, 1994Ye08]
^{233}Cm	3.42(31)#	5.593(84)#	7.473(20)***	20(10)%		[**2010Kh06**, 2002CaCU, 2002CaZZ]
^{237}Cf	2.89(37)#	4.65(14)#	8.220(54)	70(10)%	30(10)%	[**2010Kh06**]
^{241}Fm	2.29(47)#	3.56(32)#	8.856(32)#	<14%*	>78%	[**2008Kh10**]

* Not observed.
** Deduced from α decay. 7.598(60) MeV in [2021Wa16].
*** Deduced from α decay. 7.473(54) MeV in [2021Wa16].

Table 3
direct α emission from ^{209}Po, J^{π} = 1/2^{-},$T_{1/2}$ = 128.7(3) y*, BR_{α} = 99.55(1)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}@@	$E_{daughter}$(^{205}Pb)@@	coincident γ-rays@@	R_0 (fm)	HF
4.190(15)	4.110(15)	5.7(42) × 10^{-4}%***	5.6(42) × 10^{-4}%		0.787(15)		1.41923(39)	$1.1^{+3.3}_{-0.6}$
4.394(15)	4.310(15)	1.5(4) × 10^{-4}%***	1.5(4) × 10^{-4}%	3/2^{-}	0.576(4)@@	0.2605, 0.2628 , 0.3134, 0.5739, 0.5763	1.41923(39)	160^{+60}_{-40}
4.707(5)	4.617(5)	0.56(1)%	0.551(6)%**	3/2^{-}	0.263@@	0.2605, 0.2628	1.41923(39)	6.33(9)
4.977(2)	4.882(2)@	100%	98.56 (1)%**	5/2^{-}, 1/2^{-}	0.0, 0.0023@@		1.41923(39)	1.536(21)

* [2007Co07].
** [1996Sc24].
*** [1966Ha29].
@ α energy is a weighted average of 4.877(5) MeV [1966Ha29] and 4.883(2) MeV [1989Ma05]. This peak is an unresolved transition that feeds both the 5/2^{-} ground state and a low-lying state 1/2^{-} at 2.3 keV [1996Sc24]. Due to the change in respective spins and the low HF (treating it as one transition), it appears that the majority of the α transitions frred the 2.3 keV state.
@@ [2020Ko17].

Table 4
direct α emission from ^{213}Rn, J^{π} = (9/2^{+}),$T_{1/2}$ = 19.5(1) ms*, BR_{α} = ≈ 100%.

E_{α}(c.m.)	E_{α}(lab)**	I_{α}(rel)*	I_{α}(abs)	J^{π}_{f}***	$E_{daughter}$(^{209}Po)***	coincident γ-rays***	R_0 (fm)	HF
7.393(4)	7.254(4)	1.1(1)%	1.1(1)%	3/2^{-}	0.854	0.854	1.4842(25)	22(2)
7.700(4)	7.555(4)	0.68(7)%	0.67(7)%	5/2^{-}	0.545	0.545	1.4842(25)	350^{+50}_{-40}
8.245(3)	8.090(3)	100%	98.2(2)%	1/2^{-}	0.0	—–	1.4842(25)	96(5)

* [2000He17].
** [2001Ku07].
*** [2015Ch30].

Table 5
direct α emission from ^{217}Ra, J^{π} = (9/2^{+}), $T_{1/2}$ = 1.7(1) μs*, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{213}Rn)	coincident γ-rays	R_0 (fm)	HF
9.161(6)	8.992(6)**	100%	(9/2^{+})	0.0	—–	1.5544(25)	1.86(16)

* Weighted average of 1.4(4) μs [2019Ya04], 2.5(2) μs [2019Mi08], 1.7(1) μs [1990AnZU] and 1.6(2) μs [1970Va13].
** Weighted average of 8.990(8) MeV [1970To07] and 8.995(10) MeV [1970Va13].

Table 6
direct α emission from ^{221}Th*, J^{π} = (7/2^{+}),$T_{1/2}$ = 1.73(3) ms**, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{217}Ra)	coincident γ-rays	R_0 (fm)	HF
7.878(3)	7.735(3)	7.8(3)%	4.7(2)%	(7/2^{+})	0.753	0.177, 0.227, 0.331, 0.526, 0.576, 0.753	1.5811(30)	4.9(4)
8.098(8)	7.951(8)	0.23(5)%	0.14(3)%	(13/2^{+})	0.540	0.540	1.5811(30)	740^{+230}_{-160}
8.298(3)	8.148(3)	100(1)%	60.3(7)%	(11/2^{+})	0.331	0.177, 0.331	1.5811(30)	7.1(5)
8.399(3)	8.247(3)	2.5(2)%	1.5(1)%	(7/2,9/2)$^{-}$	0.227	0.227	1.5811(30)	560(60)
8.564(16)***	8.409(16)***	12%***		0.063			1.5811(30)	370
8.627(3)	8.471(3)	55.4(9)%	33.4(4)%	(9/2^{+})	0.0	—–	1.5811(30)	106(7)

* All values from [2020Pa44], except where noted.
** Weighted average of 1.73(3) ms [2001Ku07], 1.9(1) ms [1993AnZS] and 1.68(6) ms [1970To07].
*** Tentatively assigned by [2021Hu19], with the comment "the small peak at 8409 keV may stem from the internal conversion effect." In addition, [1990An19] reports peaks at 8.265(10) MeV (I_{α} = 4) and 8.375(10) MeV (I_{α} = 11), with no spectra are shown in this work. No levels at 63, 98, or 210 keV have been observed in ^{208}Pb(^{13}C,4nγ) [1983Lo16] or ^{208}Pb(^{12}C,3nγ) [1991Dr08, 1984Ro20, 1984Su10] reactions (as detailed in [2018Ko01]).

Table 7
direct α emission from ^{225}U, $T_{1/2}$ = 72(4) ms*, BR_α = ≈ 100%.

E_α(c.m.)	E_α(lab)**	I_α(rel)***	I_α(abs)	J_f^π	$E_{daughter}$(^{221}Th)	coincident γ-rays	R_0 (fm)	HF
7.762(12)	7.624(12)	9(4)%	5(2)%	(11/2$^+$)$^@$	0.2509(3)$^@$	0.2509$^@$	1.5454(32)	8^{+6}_{-3}
7.970(12)	7.828(12)	64(5)%	37(5)%		0.040(21)		1.5454(32)	$4.9^{+1.4}_{-1.2}$
8.010(6)	7.867(6)	100(7)%	58(4)%	(7/2$^+$)	0.0	—	1.5454(32)	4.2(5)

* Weighted average of 63(7) ms [2019Mi08], 84(4) ms [2001Ku07] and 59^{+5}_{-2} ms [2000He17].
** Weighted average of values from [2001Ku07] and [2000He17].
*** [2000He17].
@ [2007Ja05].

Table 8
direct α emission from ^{229}Pu*, $T_{1/2}$ = 90(10) s**, BR_α = 50(20)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{225}U)	coincident γ-rays	R_0 (fm)	HF
7.590(20)	7.457(20)	50(20)%		0.0	—	1.509(24)	22^{+25}_{-13}

* All values from [2010Kh06], except where noted.
** [2002CaZU].

Table 9
direct α emission from ^{233}Cm*, $T_{1/2}$ = 23^{+13}_{-6} s, BR_α = 20(10)%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{229}Pu)	coincident γ-rays	R_0 (fm)	HF
7.381(20)	7.254(20)	43^{+47}_{-34}%	6^{+7}_{-5}%		0.092(28)		1.502(33)	1^{+9}_{-1}
7.473(20)	7.345(20)	100(43)%	14(9)%		0.0	—	1.502(33)	1^{+5}_{-1}

* All values from [2010Kh06].

Table 10
direct α emission from ^{237}Cf*, $T_{1/2}$ = 0.8(2) s, BR_α = 70(10)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{233}Cm)	coincident γ-rays	R_0 (fm)	HF
8.220(20)	8.081(20)	70(10)%		0.0	—	1.471(55)	$0.3^{+0.8}_{-0.3}$

* All values from [2010Kh06].

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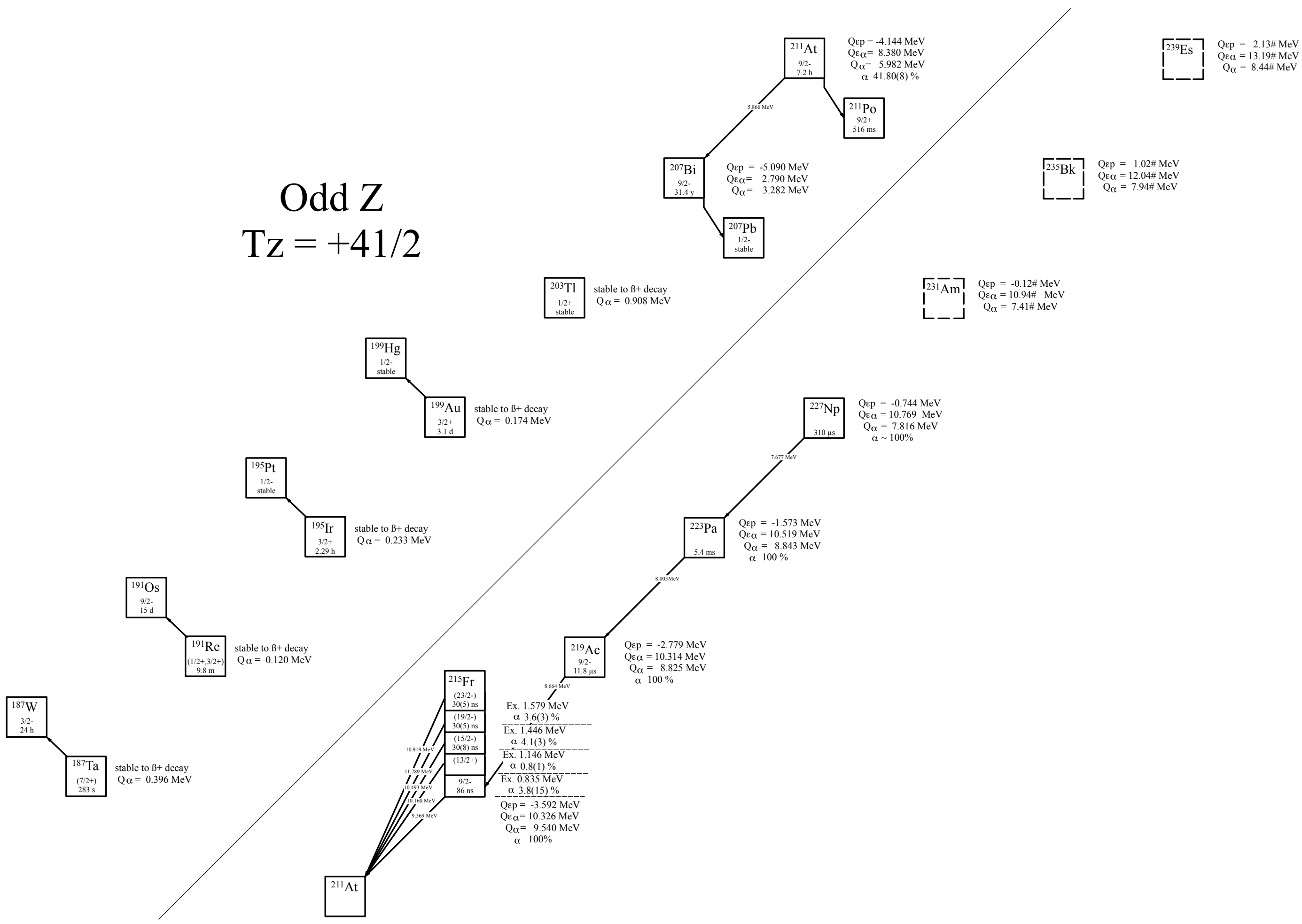

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +41/2 nuclei.

Last updated 3/5/2024

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +41/2 nuclei. J^π values for ^{187}Ta, ^{191}Re, ^{195}Ir, ^{199}Au, ^{203}Tl and ^{207}Bi and taken from ENSDF. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex.	J^π	$T_{1/2}$	Q$_\varepsilon$	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{187}Ta		(7/2$^+$)	283(10) s	-3.90(21)#	—	—	[**2022Mu10**]
^{191}Re		(1/2$^+$, 3/2$^+$)	9.8(5) m	-3.170(40)	—	—	[**1953At24**]
^{195}Ir		3/2$^+$	2.29(17) h	-2.180(60)	—	—	[**2013Bi14**]
^{199}Au		3/2$^+$	3.129(11) d	-1.705(2)	—	—	[**1969La34**]
^{203}Tl		1/2$^+$	stable	-0.492(1)	—	—	
^{207}Bi		9/2$^-$	31.35(4) y	2.397(2.1)	-5.090(2)	2.790(3)	[**2002Un02**]
^{211}At		9/2$^-$	7.214(7) h	0.785(2.5)	-4.144(2)	8.380(3)	[**1961Ap01**]
^{215}Fr		9/2$^-$	86(5) ns	1.487(9)	-3.592(8)	10.326(7)	[**1984De16**]
^{215m1}Fr	0.835	(13/2$^+$)		2.322(9)	-2.727(8)	11.161(7)	[**1984Sc25**]
^{215m2}Fr	1.146	(15/2$^-$)	30(8) ns	2.633(9)	-2.446(8)	11.472(7)	[**1984De16**]
^{215m3}Fr	1.446	(19/2$^-$)	30(5) ns	2.933(9)	-2.146(8)	11.772(7)	[**1984De16**]
^{215m4}Fr	1.579	(23/2$^-$)	30(5) ns	3.066(9)	-2.013(8)	11.905(7)	[**1982GoZU**]
^{219}Ac		9/2$^-$	11.8(15) μs	2.180(50)	-2.779(52)	10.314(52)	[**1989Mi17**]
^{223}Pa			5.4(4) ms*	2.950(80)	-1.573(76)	10.519(76)	[**2019Mi08, 1999Ho28, 1995AnZY, 1970Bo13**]
^{227}Np			510(60) ms	3.530(80)	-0.744(78)	10.769(77)	[**1990Ni05**]
^{231}Am				4.10(30)#	-0.12(31)#	10.94(30)#	
^{235}Bk				4.76(41)#	1.02(43)#	12.04(40)#	
^{239}Es				5.43(32)#	2.13(39)#	13.19(33)#	

* Weighted average of 7(1) ms [2019Mi08], 4.9(5) ms [1999Ho28], 5(1) ms [1995AnZY] and 6.5(10) ms [1970Bo13].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +41/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_p$	S$_{2p}$	Q$_\alpha$	BR$_\alpha$	Experimental
^{187}Ta	7.760(76)	17.51(31)#	0.396(98)		
^{191}Re	7.271(37)	16.97(20)#	0.120(57)		
^{195}Ir	6.546(2)	16.039(39)	0.233(10)		
^{199}Au	6.479(2)	15.408(20)	0.174(1)		
^{203}Tl	5.705(1)	13.939(3)	0.908(1)		
^{207}Bi	3.558(2)	10.812(2)	3.282(2)		
^{211}At	2.983(2)	7.967(2)	5.982(1)	41.80(8)%*	[**1985La17, 1978Ya04, 1975Ja04, 1969Go23**, 2009Vi09, 2003HaZT, 2001Ch66, 2000ChZU, 2000OgZU, 1977YaZG, 1970AfZZ, 1968GuZX, 1963Uh01, 1961Ap01, 1955Mo68, 1953AsZZ, 1953Ho49, 1953Hy83, 1951Ne02, 1940Co01, 1940Co02]
^{215}Fr	2.651(11)	7.680(8)	9.540(7)	100%	[**1984Sc25, 1984De16**, 2019Mi08, 1982GoZU, 1982SaZO, 1974Ni02, 1973HaVQ, 1973HaZO, 1973HiYZ, 1972No06, 1971HyZX, 1970VaZZ]
^{215m1}Fr	1.816(11)	6.845(8)	10.375(7)	3.8(15)%	[**1984Sc25**]
^{215m2}Fr	1.505(11)	6.534(8)	10.686(7)	0.8(1)%	[**1984Sc25, 1984De16**]
^{215m3}Fr	1.205(11)	6.234(8)	10.986(7)	4.1(3)%	[**1984Sc25, 1984De16**, 1982GoZU]
^{215m4}Fr	1.072(11)	6.101(8)	11.119(7)	3.6(3)%	[**1984Sc25, 1984De16**, 1982GoZU, 1982SaZO]
^{219}Ac	2.365(52)	7.323(52)	8.825(10)**	100%	[**1989Mi17**, 2019Mi08, 1989MiZK, 1989MiZZ, 1988MiZJ, 1970Bo13, 1970VaZZ]
^{223}Pa	2.154(76)	6.771(94)	8.343(8)***	100%	[**1995AnZY, 1970Bo13**, 2019Mi08, 1999Ho28, 1993AnZS, 1970VaZZ]
^{227}Np	2.039(78)	6.36(11)	7.816(14)	≈ 100%[@]	[**1990Ni05**, 1994AnZY, 1994Ye08, 1993AnZS, 1990An19, 1990AnZQ, 1990YeZY]
^{231}Am	1.81(30)#	5.97(32)#	7.41(31)#		
^{235}Bk	1.24(40)#	5.09(42)#	7.94(50)#		
^{239}Es	0.94(42)#	4.16(38)#	8.44(50)#		

* Weighted average of 41.94(16)% [1985La17], 41.74(10)% [1978Ya04] and 41.8(2)% [1969Go23].
** Deduced from α decay. 8.826(51) MeV in [2021Wa16].
*** Deduced from α decay. 8.343(55) MeV in [2021Wa16].
[@] No other decay observed.

Table 3
direct α emission from ^{211}At, J^π = (9/2$^-$), $T_{1/2}$ = 7.214(7) h*, BR_α = 41.80(8)%**.

E_α(c.m.)	E_α(lab)***	I_α(rel)	I_α(abs)	$J_f^{\pi\,@}$	$E_{daughter}$(^{207}Bi)$^@$	coincident γ-rays$^@$	R_0 (fm)	HF
5.240(2)	5.141(2)	0.0023(8)%	0.00097(33)%	7/2$^-$	0.7247(1)	0.7427	1.4216(13)	33^{+17}_{-8}
5.311(2)	5.210(2)	0.0086(19)%	0.0036(8)%	11/2$^-$	0.6698(1)	0.6698	1.4216(13)	18^{+5}_{-3}
5.979(2)	5.866(2)	100%	41.80(8)%**	9/2$^-$	0.0	—–	1.4216(13)	1.52(6)

* [1961Ap01].
** Weighted average of 41.94(16)% [1985La17], 41.74(10)% [1978Ya04] and 41.8(2)% [1969Go23].
*** [1969Go23].
@ [1975Ja04].

Table 4
direct α emission from ^{215}Fr*, J^π = (9/2$^-$), $T_{1/2}$ = 86(5) ns, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{211}At)	coincident γ-rays	R_0 (fm)	HF
9.547(10)	9.369(10)	100%	9/2$^-$	0.0	—–	1.5387(31)	1.03(10)

* All values from [1984De16].

Table 5
direct α emission from ^{215m1}Fr*, Ex. = 0.835 MeV, J^π = (13/2$^+$), $T_{1/2}$ = , BR_α = 3.8(15)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{211}At)	coincident γ-rays	R_0 (fm)	HF
10.353(30)	10.160(30)	100%	9/2$^-$	0.0	—–	1.5387(31)	

* All values from [1984Sc25].

Table 6
direct α emission from ^{215m2}Fr*, Ex. = 1.146 MeV*, J^π = (15/2$^-$), $T_{1/2}$ = 30(8) ns*, BR_α = 0.8(1)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{211}At)	coincident γ-rays	R_0 (fm)	HF
10.692(20)	10.493(20)	100%	9/2$^-$	0.0	—–	1.5387(31)	$9^{+4}_{-3} \times 10^3$

* [1984De16].
** [1984Sc25].

Table 7
direct α emission from ^{215m3}Fr, Ex. = 1.446 MeV*, J^π = (19/2$^-$), $T_{1/2}$ = 30(5) ns, BR_α = 4.1(3)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{211}At)	coincident γ-rays	R_0 (fm)	HF
10.994(15)	10.789(15)	100%	9/2$^-$	0.0	—–	1.5387(31)	$5.8(12) \times 10^3$

* [1984De16].
** [1984Sc25].

Table 8
direct α emission from ^{215m4}Fr, Ex. = 1.579 MeV*, J^π = (23/2$^-$), $T_{1/2}$ = 30(5), BR_α = 3.6(3)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{211}At)	coincident γ-rays	R_0 (fm)	HF
11.126(15	10.919(15)	100%	9/2$^-$	0.0	—–	1.5387(31)	$1.12(23) \times 10^4$

* [1984De16].
** [1984Sc25].

Table 9
direct α emission from ^{219}Ac*, J^{π} = (9/2^{-}), $T_{1/2}$ = 11.8(15) μs, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{215}Fr)	coincident γ-rays	R_0 (fm)	HF
8.825(10)	8.664(10)**	100%	9/2^{-}	0.0	—–	1.5853(28)	1.79(27)

* All values from [1989Mi17], except where noted.
** From [1989Mi17], which has the highest statistics. [1970Bo13] report one peak at 8.665(10) MeV. [2019Mi17] report 2 peaks at 8.520(40) and 9.160(40) MeV. However, no spectra is shown, or relative ratios where reported.

Table 10
direct α emission from ^{223}Pa, $T_{1/2}$ = 5.4(4) ms*, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{219}Ac)	coincident γ-rays	R_0 (fm)	HF
8.149(8)	8.003(8)**	100(5)%	57(3)%$^{@}$		0.194(11)		1.5543(24)	2.3(3)
8.343(8)	8.193(8)***	75(7)%	43(3)%$^{@}$	9/2^{-}	0.0	—–	1.5543(24)	11.3(14)

* Weighted average of 7(1) ms [2019Mi08], 4.9(5) ms [1999Ho28], 5(1) ms [1995AnZY] and 6.5(10) ms [1970Bo13].
** Weighted average of 8.000(15) MeV [1995AnZY] and 8.005(10) MeV [1970Bo13].
*** Weighted average of 8.190(15) MeV [1995AnZY] and 8.195(10) MeV [1970Bo13].
$^{@}$ [1995AnZY].

Table 11
direct α emission from ^{227}Np*, $T_{1/2}$ = 510(60) ms, BR_{α} = ≈ 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{223}Pa)	coincident γ-rays	R_0 (fm)	HF
7.787(20)	7.650(20)	≈33%	≈25%**		0.028(20)		1.510(23)	≈2.7
7.815(20)	7.677(20)	100%	≈75%**		0.0	—–	1.510(23)	≈1.1

* All values from [1990Ni05].
** Estimated by evaluator based on Fig. 2 in [1990Ni05].

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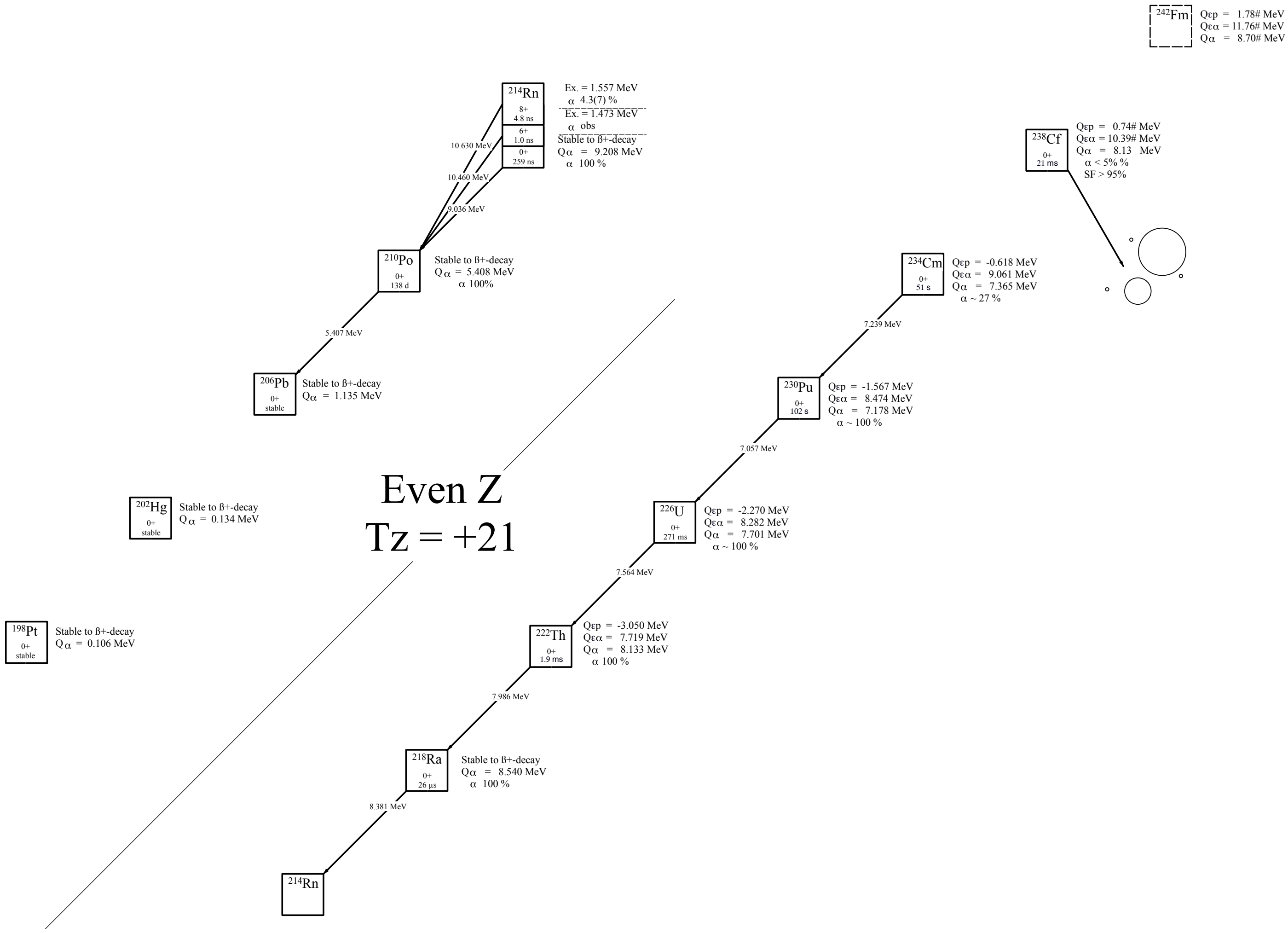

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +21 nuclei.

Last updated 3/18/2024

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +21 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex.	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{198}Pt		0^+	stable	-4.19(20)#	——	——	
^{202}Hg		0^+	stable	-2.992(23)	——	——	
^{206}Pb		0^+	stable	-1.532(1)	——	——	
^{210}Po		0^+	138.3787(16) d*	-1.161(1)	——	——	[**1964EiZZ, 1954Ei20**, 1953Cu46]
^{214}Rn		0^+	259(3) ns	-0.941(10)	——	——	[**2019Pa45**]
^{214m1}Rn	1.473	6^+	1.0(3) ns	0.532(10)	-3.482(10)	9.520(9)	[**1983Dr08, 1981Go06**]
^{214m2}Rn	1.557	8^+	4.8(3) ns	0.616(10)	-3.398(10)	9.604(9)	[**1983Dr08,1981Go06**]
^{218}Ra		0^+	25.99(10) μs	-0.414(11)	——	——	[**2019Pa45**]
^{222}Th		0^+	1.964(2) ms	0.581(11)	-3.050(11)	7.719(11)	[**2016Pa28**]
^{226}U		0^+	271(6) ms*	1.295(16)	-2.270(12)	8.282(12)	[**2018Mi11, 2002CaZU, 2001Ku07, 2000He17**]
^{230}Pu		0^+	102(10) s	1.700(60)	-1.567(16)	8.474(18)	[**2002CaZU**]
^{234}Cm		0^+	51(12) s	2.26(16)#	-0.618(57)	9.061(58)#	[**2002CaZU**]
^{238}Cf		0^+	21(2) ms	3.06(39)#	0.74(31)#	10.39(34)#	[**1995La09**]
^{242}Fm		0^+	< 4 μs	3.60(48)#	1.78(43)#	11.76(48)#	[**2008Kh10**]

* Weighted average of 138.3763(17) d [1964EiZZ] and 138.4005(51) d [1954Ei20].
** Weighted average of 270(10) ms [2018Mi11], 258(13) ms [2002CaZU], 260(20) ms [2001Ku07] and 281(9) ms [2000He17].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the even-Z, T_z = +21 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	BF_{SF}	Experimental
^{198}Pt	8.929(20)	16.205(40)	0.106(3)			
^{202}Hg	8.234(3)	15.324(20)	0.134(2)			
^{206}Pb	7.254(1)	13.673(1)	1.135(1)			
^{210}Po	4.983(1)	8.782	5.408	100%		[**2023Av04, 2018Sh12, 1973Go39, 1960Fe04**, 2015Zh41, 2014Po01, 2012Do08, 2001Gi12, 1999Oh02, 1997Ka59, 1987Er06, 1961Be13, 1961Ry05, 1960Ry01, 1958Ba45, 1958Si78, 1958Wh09, 1957Ag15, 1955Mo68, 1954Br07, 1952Ba20, 1951Ka03, 1951Ka37, 1949Me54, 1934Le01, 1933Ro03, 1902Ma02, 1898Cu02]
^{214}Rn	5.029(10)	8.528(9)	9.208(9)	100%		[**1970To07, 1970Va13**, 2019Pa45, 2018Mi11, 1986Ki13, 1981Go06, 1970TaZS, 1970VaZZ]
^{214}Rn	3.556(10)	7.055(9)	10.681(9)	obs		[**1981Go06**]
^{214}Rn	3.472(10)	6.971(9)	10.765	4.3(7)%		[**1981Go06**]
^{218}Ra	4.958(12)	8.186(11)	8.540(3)	100%		[**2019Pa45**, 2018Mi11, 1986Ki13, 1986To02, 1970To07, 1970Va13, 1970VaZZ]
^{222}Th	4.617(58)	7.647(13)	8.133(3)	100%		[**2016Pa28**, 2018Mi11, 2005Li17, 2002CaZU, 2002CaZZ, 2000He17, 1991AnZZ, 1990AnZT, 1990AnZU, 1970To07, 1970Va13, 1970VaZZ]
^{226}U	4.317(83)	7.245(15)	7.701(4)	$\approx$ 100%		[**2002CaZU, 2001Ku07, 2000He17, 1999Gr28**, 2018Mi11 2003MoZT, 2002CaZZ, 1998Gr19, 1994AnZY, 1994Ye08, 1991An10, 1990An22, 1990AnZT, 1989An13, 1988AnZS, 1973Vi10, 1972MiZK, 1972MiZL, 1972MiZN, 1972ViZQ]
^{230}Pu	4.16(10)	6.866(20)	7.178(9)	$\approx$ 100%		[**2002CaZU**, 2007KhZQ, 2003MoZT, 1999Gr28, 1999GrZY, 1994AnZY, 1994Ye08, 1993AnZS, 1990An22, 1990AnZT, 1990YeZY]
^{234}Cm	3.85(12)#	6.216(24)	7.365(9)	$\approx$ 27%	$\approx$ 2%	[**2010Kh06,2002CaZU**, 2002CaZZ]
^{238}Cf	3.22(38)#	5.15(30)#	8.13(30)	$<$ 5%*	>95%	[**2010Kh06**, 2001Og08, 1995La09]
^{242}Fm	2.78(46)#	4.17(40)#	8.697(50)#		**	

* Not observed.
** SF reported by [1975Te01] with a $T_{1/2}$ = 0.8(2) ms. However, this was not observed in [2008Kh10], leading to the conclusion that the $T_{1/2}$ was less than $<$ 4 μs. The events observed in [1975Te01] were likely from the SF decay of ^{241}Fm ($T_{1/2}$ = 0.73(6) ms [2008Kh10]).

Table 3
direct α emission from ^{210}Po, J^{π} = 0^{+}, $T_{1/2}$ = 138.3787(16) d*, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J_f^{π}@@	$E_{daughter}$(^{206}Pb)@@	coincident γ-rays@@	R_0 (fm)	HF
4.613(5)	4.525(5)**	0.00122(3)%	0.00122(3)%***	2^{+}	0.803	0.803	1.40879(38)	1.34(11)
5.40733(7)	5.30433(7)@	100%	99.99878(3)%	0^{+}	0.0	—	1.40879(38)	0.997929(12)

* Weighted average of 138.3763(17) d [1964EiZZ] and 138.4005(51) d [1954Ei20].
** [1960Fe04].
*** [2018Sh12].
@ Reported as 5.30451(7) MeV in [1973Go39], modified to 5.30433(7) meV in [1999Ry01].
@@ [2008Ko21].

Table 4
direct α emission from ^{214}Rn, J^{π} = 0^{+}, $T_{1/2}$ = 259(3) ns*, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{210}Po)	coincident γ-rays	R_0 (fm)	HF
9.208(9)	9.036(9)**	100%	0^{+}	0.0	—	1.5340(25)	0.999(12)

* [2019Pa45].
** Weighted average of 9.040(20) MeV [1970To07] and 9.035(10) MeV [1970Va13].

Table 5
direct α emission from ^{214m1}Rn, J^{π} = (6^{+}), Ex. = 1.473 MeV*, $T_{1/2}$ = 1.0(3) ns**, BR_{α} = obs***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{210}Po)	coincident γ-rays@@	R_0 (fm)	HF
10.659(30)	10.460(30)***		0^{+}	0.0	—	1.5340(25)	

* [2014Ba41].
** [1987Dr08].
*** [1981Go06].

Table 6
direct α emission from ^{214m2}Rn, J^{π} = (8^{+}), Ex. = 1.557 MeV*, $T_{1/2}$ = 4.8(3) ns**, BR_{α} = 4.3(7)%***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{210}Po)	coincident γ-rays@@	R_0 (fm)	HF
10.832(30)	10.630(30)**	4.3(7)%***	0^{+}	0.0	—	1.5340(25)	790^{+210}_{-150}

* [2014Ba41].
** [1987Dr08].
*** [1981Go06].

Table 7
direct α emission from ^{218}Ra*, J^{π} = 0^{+}, $T_{1/2}$ = 25.99(10) μs, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J_f^{π}**	$E_{daughter}$(^{206}Pb)**	coincident γ-rays**	R_0 (fm)	HF
7.859(40)	7.715(40)	0.123(11)%	0.123(11)%	2^{+}	0.695(1)	0.695(1)	1.5655(13)	6.3(8)
8.537(4)	8.381(4)	100%	99.88(6)%	0^{+}	0.0	—	1.5655(13)	0.998(4)

* All values from [2019Pa45], except where noted.
** [2021Zh35].

Table 8
direct α emission from ^{222}Th*, J^{π} = 0$^+$, T$_{1/2}$ = 1.964(2) ms, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{218}Ra)	coincident γ-rays	R$_0$ (fm)	HF
7.274(4)	7.143(4)	0.014(4)%	0.014(4)%	(1$^-$)	0.858(5)	0.858(5)	1.5571(17)	12^{+5}_{-3}
7.337(4)	7.205(4)	0.018(3)%	0.018(3)%	3$^-$	0.7932(2)**	0.3522(1), 0.3889(1)**	1.5571(17)	$15.7^{+3.2}_{-2.3}$
7.743(3)	7.603(3)	1.84(1)%	1.81(1)%	2$^+$	0.3889(1)**	0.3889(1)**	1.5571(17)	3.551(20)
8.133(3)	7.986(3)	100%	98.16(5)%	0$^+$	0.0	—	1.5571(17)	1.0430(12)

* All values from [2019Pa45], except where noted.
** [2019Si39].

Table 9
direct α emission from ^{226}U, J^{π} = 0$^+$, T$_{1/2}$ = 271(6) ms*, BR_α = ≈ 100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)**	J^π_f	$E_{daughter}$(^{222}Th)	coincident γ-rays	R$_0$ (fm)	HF
7.455(20)	7.323(20)**	3.7(12)%	3(1)%	(1$^-$)	0.245(20)		1.5394(34)	$4.2^{+2.3}_{-1.3}$
7.516(4)	7.383(4)***	18.3(38)%	15(3)%	2$^+$	0.1829(2)$^{@@}$	0.1829(2)$^{@@}$	1.5394(34)	$1.4^{+0.4}_{-0.3}$
7.700(3)	7.564(3)$^{@}$	100%	82(5)%	0$^+$	0.0	—	1.5394(34)	1.05(8)

* Weighted average of 270(10) ms [2018Mi11], 258(13) ms [2002CaZU], 260(20) ms [2001Ku07] and 281(9) ms [2000He17].
** [2000He17].
*** Weighted average of 7.384(7) MeV [2001Ku07], 7.374(10) MeV [2000He17], and 7.385(5) MeV [1999Gr28].
$^{@}$ Weighted average of 7.560(10) MeV [2002CaZU], 7.566(4) MeV [2001Ku07], 7.555(10) MeV [2000He17], and 7.565(5) MeV [1999Gr28].
$^{@@}$ [2023Si22].

Table 10
direct α emission from ^{230}Pu*, J^{π} = 0$^+$, T$_{1/2}$ = 102(10) s, BR_α = ≈ 100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{226}U)	coincident γ-rays	R$_0$ (fm)	HF
7.123(15)	6.999(15)	23(5)%	19(4)%	2$^+$	0.059(18)		1.5375(56)	$2.6^{+1.1}_{-0.8}$
7.182(10)	7.057(10)	100(5)%	81(4)%	0$^+$	0.0	—	1.5375(56)	1.01(11)

* All values from [2002CaZU], except where noted.

Table 11
direct α emission from ^{234}Cm*, J^{π} = 0$^+$, T$_{1/2}$ = 51(12) s, BR_α = ≈ 27%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{230}Pu)	coincident γ-rays	R$_0$ (fm)	HF
7.365(10)	7.239(10)	≈ 27%	0$^+$	0.0	—	1.491(25)	≈ 0.49**

* All values from [2010Kh06, 2002CaZU].
** The unphysically low HF may indicate that the value of ≈ 27% is too high (a value of 13% gives a HF = 1).

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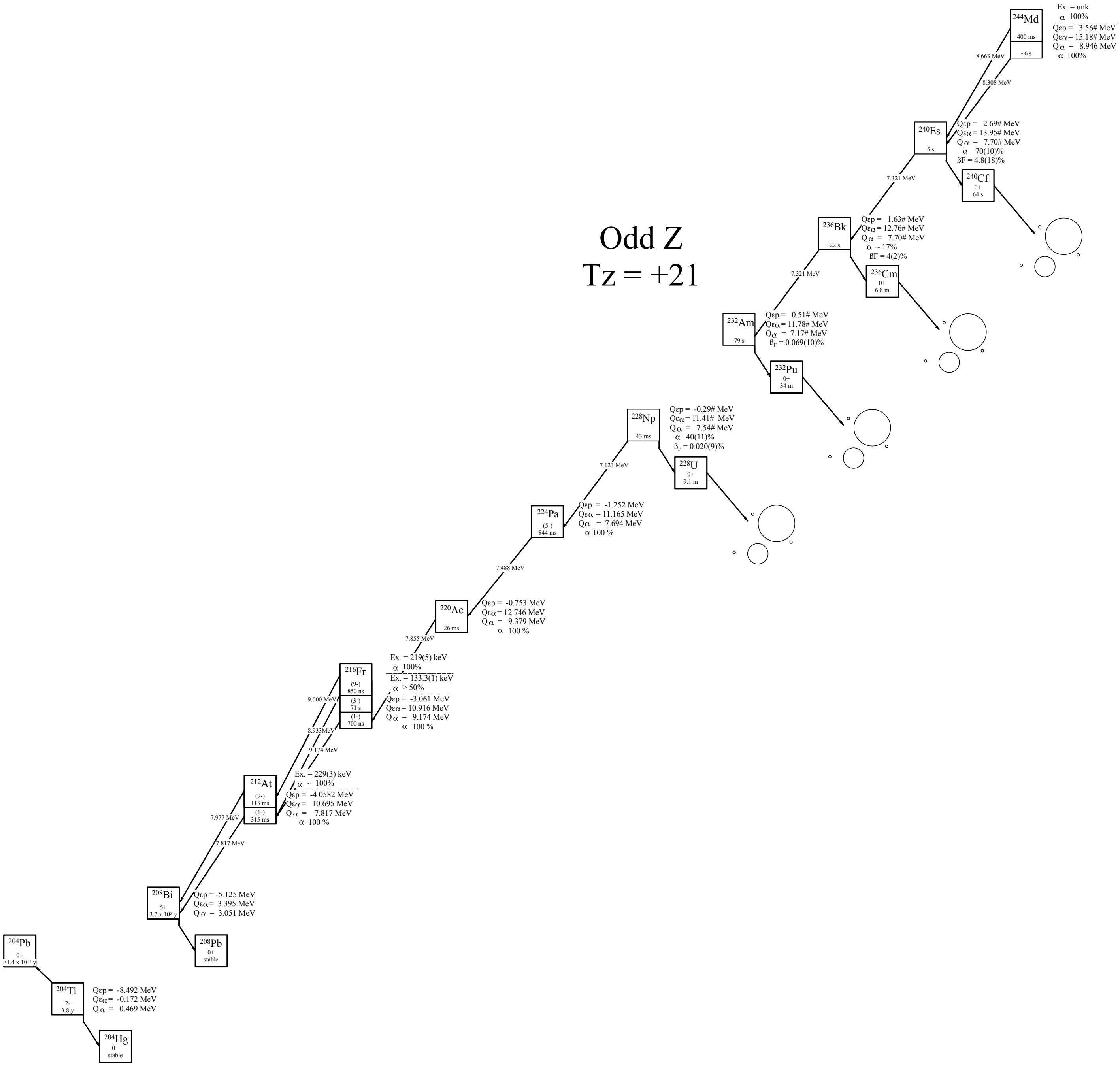

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +1/2 nuclei.

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +21 nuclei. J^π values for ^{204}Tl and ^{208}Bi are taken from ENSDF. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex.	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	BR_{β_F}	Experimental
^{204}Tl*		2$^-$	3.794(2) y**	0.344(1)	-8.492(3)	-0.172(20)		[**1970Ha32, 1969Bo24, 1968Ho07, 1965An07**]
^{208}Bi		5$^+$	3.68(4) × 10^5 y	2.878(2)	-5.125(6)	3.395(2)		[**1964Ha07**]
^{212}At		(1$^-$)	314.5(21) ms***	1.741(2)	-4.058(6)	10.695(3)		[**1976FrZO, 1970Re02**]
^{212m}At	0.229(3)	(9$^-$)	112.6(9) ms$^@$	1.970(4)	-3.829(7)	10.924(4)		[**1976FrZO, 1970Re02**]
^{216}Fr		(1$^-$)	0.7(2) μs	2.718(7)	-3.061(8)	10.916(4)		[**1970Bo13**]
^{216m1}Fr	0.1333(1)	(3$^-$)	71(5) ns	2.851(7)	-2.928(8)	11.049(4)		[**1971EpZY**]
^{216m2}Fr	0.219(5)	(9$^-$)	850(30) ns	2.937(9)	-2.842(9)	11.135(6)		[**2007Ku30**]
^{220}Ac			26.4(2) ms	3.472(10)	-2.162(9)	11.066(8)		[**1990An19**]
^{224}Pa		(5$^-$)	844(19) ms$^{@@}$	3.867(12)	-1.252(10)	11.165(11)		[**1996Li05, 1997Wi15**]
^{228}Np			61.4(15) s	4.61(10)#	-0.29(10)#	11.41(10)#	0.020(9)%	[**1994Kr13**, 1978SoZZ, 1976SoZT]
^{232}Am			79(2) s	5.06(30)#	0.51(30)#	11.78(30)#	0.069(10)%	[**1990Ha28**, 1989HaZO, 1978Ha05]
^{236}Bk			22^{+13}_{-6} s	5.69(36)#	1.63(36)#	12.76(36)#	4(2)%	[**2017Ko02**]
^{240}Es			5(2) s	6.24(37)#	2.69(42)#	13.95(37)#	4.8(18)%	[**2017Ko02**]
^{244}Md			≈ 6 s	6.63(43)#	3.56(43)#	15.18(38)#		[**2020Po07**]
^{244m}Md	x		$0.4^{+0.4}_{-0.1}$ s	6.63(43)#+x	3.56(43)#+x	15.18(38)#+x		[**2020Po07**]

* Decays by 97.08(7)% β^- and 2.92(7)% β^+ [1990Sc08].
** Weighted average of 3.793(5) y [1970Ha32], 3.774(5) y [1969Bo24], 3.825(3) y [1968Ho07] and 3.754(4) y [1965An07].
*** Weighted average of 314(3) ms [1976FrZO] and 315(3) ms [1970Re02].
$^@$ Weighted average of 115(2) ms [1976FrZO] and 112(1) ms [1970Re02].
$^{@@}$ Weighted average of 790(60) ms [1996Li05] and 850(20) ms [1997Wi15].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +21 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{204}Tl	6.366(1)	14.571(23)	0.469(27)		
^{208}Bi	3.707(2)	11.195(2)	3.051(2)		
^{212}At	3.485(2)	8.414(2)	7.817(1)	100%	[**1976FrZO, 1970Re02**, 2009Vi09, 2007Ku30, 1999Ho28, 1996Li37, 1975FrZR, 1968Va18, 1963Jo09, 1961Gr43]
^{212m}At	3.256(4)	8.185(4)	8.046(3)	≈ 100%	[**1976FrZO, 1970Re02**, 2009Vi09, 2007Ku30, 1999Ho28, 1996Li37, 1975FrZR, 1968Va18, 1963Jo09, 1961Gr43]
^{216}Fr	3.149(7)	8.228(5)	9.174(3)	100%	[**2007Ku30, 1970Bo13**, 2003Ni10, 1996Li37, 1970VaZZ]
^{216m1}Fr	3.016(7)	8.095(5)	9.307(3)	>50%	[**1996Li37, 1971EpZY**]
^{216m2}Fr	2.930(9)	8.0098(7)	9.393(6)	100%	[**2007Ku30**]
^{220}Ac	2.939(9)	7.894(7)	8.348(4)	≈ 100%	[**1997Sh09**, 2007Ku30, 2003Ni10, 1971EpZY, 1971HyZX, 1970Bo13]
^{224}Pa	2.812(11)	7.337(9)	7.694(4)	≈ 100%	[**1996Li05**, 2003Ni10, 1997Sh09, 1997Wi15, 1993AnZS, 1990An19, 1990AnZQ, 1989AnZL, 1987FaZT, 1970Bo13]
^{228}Np	2.51(10)#	6.79(10)#	7.54(10)#	40(11)%	[**2003Ni10**, 2004NiZZ, 2003NiZV, 1994Kr13]
^{232}Am	2.18(30)#	6.40(31)#	7.17(32)#		
^{236}Bk	1.76(38)#	5.50(39)#	7.70(20)#	≈ 17%	[**2020Po07**, 2017Ko02]
^{240}Es	1.27(39)#	4.57(45)#	8.259(63)	70(10)%	[**2017Ko02**, 2020Kh08, 2020Po07]
^{244}Md	1.01(40)#	3.78(45)#	8.947(79)	≈100%	[**2020Po07, 2020Kh08**]
^{244m}Md	1.01(40)#-x	3.78(45)#-x	8.947(79)+x	≈100%	[**2020Po07**]

Table 3
direct α emission from ^{212}At*, J^π = 1$^-$, $T_{1/2}$ = 314.5(21) ms**, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{208}Bi)$^@$	coincident γ-rays$^@$	R_0 (fm)$^{@@}$	HF
6.7488(8)	6.6215(8)	0.162(7)%	0.135(6)%	3$^+$	1.0691(1)	0.0630, 0.4357, 0.4674, 0.0630, 0.4357, 0.4674, 0.5384, 0.5701, 0.6015, 1.0062, 1.0693	1.4714(45)	$28.9^{+3.3}_{-3.0}$
6.796(1)	6.668(1)***	0.06(2)%	0.05(2)%	4$^+$	1.020(1)		1.4714(45)	120^{+80}_{-40}
6.859(5)	6.730(5)	0.07(2)%	0.06(2)%	4$^+$	0.9590(1)	0.0630, 0.3257, 0.5701, 0.6015, 0.8960, 0.9590	1.4714(45)	170^{+90}_{-50}
6.884(2)	6.754(2)***	0.14(4)%	0.12(3)%	3$^+$	0.9363(1)	0.063, 0.873, 0.936	1.4714(45)	100^{+40}_{-20}

Table 3
direct α emission from ^{212}At*, J^{π} = 1^{-}, $T_{1/2}$ = 314.5(21) ms**, BR_{α} = 100%.

6.8878(12)	6.7578(12)	0.08(2)%	0.07(2)%	2^{+}	0.9249(1)	0.063, 0.2918, 0.5701, 0.8618	1.4714(45)	190^{+80}_{-50}
6.929(2)	6.798(2)	0.058(6)%	0.048(5)%	5^{+}	0.8864(1)	0.063, 0.8233, 0.8864	1.4714(45)	390^{+60}_{-50}
7.1844(4)	7.0488(4)	0.48(2)%	0.40(2)%	3^{+}	0.6331(1)	0.063, 0.5701	1.4714(45)	360(40)
7.2156(3)	7.0795(3)	0.71(1)%	0.59(1)%	4^{+}	0.6015(1)	0.063, 0.5384, 0.6015	1.4714(45)	316^{+33}_{-30}
7.3057(5)	7.1679(5)	0.180(9)%	0.150(7)%	6^{+}	0.5103(1)	0.5103	1.4714(45)	210(24)
7.7539(2)	7.6076(2)	18.5(7)%	15.4(6)%	4^{+}	0.0630(1)	0.063	1.4714(45)	650(70)
7.8165(2)	7.6690(2)	100.0(7)%	83.2(6)%	5^{+}	0.0	——	1.4714(45)	186(19)

* All values from [1976FrZO], except where noted.
** Weighted average of 314(3) ms [1976FrZO] and 315(3) ms [1970Re02].
*** [1970Re02].
@ [2007Ma45]. Only those transition > 10% are listed.
@@ Interpolated between 1.40879(38) fm (^{210}Po) and 1.5340(25) fm (^{214}Rn).

Table 4
direct α emission from ^{212}At*, Ex. = 229(3) keV, J^{π} = 9^{-}, $T_{1/2}$ = 112.6(9) ms**, BR_{α} = ≈ 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{208}Bi)***	coincident γ-rays***	R_0 (fm)@	HF
6.9436(8)	6.8126(8)	0.53(6)%	0.36(4)%	6^{+}	1.0951(1)	0.063, 0.2078, 0.8233, 0.8864	1.4714(45)	21^{+4}_{-3}
7.0807(15)	6.9471(15)	0.077(10)%	0.052(7)%	4^{+}	0.9590(1)	0.0630, 0.3257, 0.5701, 0.6015, 0.8960, 0.9590	1.4714(45)	440^{+90}_{-70}
7.1570(2)	7.022(2)	0.19(3)%	0.13(2)%	5^{+}	0.8864(1)	0.063, 0.8233, 0.8864	1.4714(45)	310^{+70}_{-50}
7.3902(9)	7.2508(9)	0.56(12)%	0.38(8)%	7^{+}	0.6506(1)	0.1401, 0.5103, 0.6506	1.4714(45)	670^{+200}_{-140}
7.1844(4)	7.0488(4)	0.48(2)%	0.40(2)%	3^{+}	0.6331(1)	0.063, 0.5701	1.4714(45)	720(80)
7.4116(7)	7.2718(7)	0.53(12)%	0.36(8)%	5^{+}	0.6283(1)	0.063, 0.5262	1.4714(45)	830^{+260}_{-180}
7.4388(15)	7.2984(15)	0.10(1)%	0.07(1)%	4^{+}	0.6015(1)	0.063, 0.5384, 0.6015	1.4714(45)	$5.2^{+1.1}_{-0.9} \times 10^3$
7.5298(6)	7.3877(6)	0.52(3)%	0.35(2)%	6^{+}	0.5103(1)	0.5103	1.4714(45)	$2.1(2) \times 10^3$
7.9769(2)	7.8264(2)	100.0(9)%	67.6(6)%	4^{+}	0.0630(1)	0.063	1.4714(45)	242^{+24}_{-22}
8.0394(2)	7.8877(2)	45.4(8)%	30.7(5)%	5^{+}	0.0	——	1.4714(45)	810(80)

* All values from [1976FrZO], except where noted.
** Weighted average of 115(2) ms [1976FrZO] and 122(1) ms [1970Re02].
*** [2007Ma45]. Only those transition > 10% are listed.
@ Interpolated between 1.40879(38) fm (^{210}Po) and 1.5340(25) fm (^{214}Rn).

Table 5
direct α emission from ^{216}Fr*, J^{π} = (1^{-}), $T_{1/2}$ = 0.7(2) μs**, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{212}At)***	coincident γ-rays***	R_0 (fm)@	HF
8.977(15)	8.811(15)	≈ 0.2%	≈ 0.2%	(3^{-})	0.2053	0.045, 0.1603	1.5498(28)	≈ 250
9.028(15)	8.861(15)	0.5(2)%	0.5(2)%	(2^{-})	0.1603	0.1603	1.5498(28)	130^{+150}_{-60}
9.174(5)	9.004(5)	100%	99.3(10)%	(1^{-})	0.0	——	1.5498(28)	1.6(5)

* All values from [1996Li37], except where noted.
** [1970Bo13].
*** [2020Au03].
@ Interpolated between 1.5340(25) fm (^{214}Rn) and 1.5655(13) fm (^{218}Ra.

Table 6
direct α emission from ^{216m1}Fr*, Ex. = 133.3(1) keV, J^{π} = (3^{-}), $T_{1/2}$ = 71(5) ns**, BR_{α} = ≈ 50%***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{212}At)@	coincident γ-rays@	R_0 (fm)@@	HF
9.102(8)	8.933(8)	≈ 50%***	(3^{-})	0.2053	0.045, 0.1603	1.5498(28)	≈0.21@@@

* All values from [1996Li37], except where noted.
** [1971EpZY].
*** [2007Wu02].
@ [2020Au03].

@@ Interpolated between 1.5340(25) fm (^{214}Rn) and 1.5655(13) fm (^{218}Ra.
@@@ The reason for the unphysically low HF value is unknown.

Table 7
direct α emission from ^{216m1}Fr*, Ex. = 219(8) keV, J^{π} = (9^-), $T_{1/2}$ =850(30) ns, BR_{α} = 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{212}At)	coincident γ-rays	R_0 (fm)**	HF
9.169(5)	9.000(5)	100%	(9^-)	0.2239		1.5498(28)	1.85(13)

* All values from [2007Ku30], except where noted.
** Interpolated between 1.5340(25) fm (^{214}Rn) and 1.5655(13) fm (^{218}Ra.

Table 8
direct α emission from ^{220}Ac*, $T_{1/2}$ = 26.4(2) ms**, BR_{α} = ≈ 100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{216}Fr)	coincident γ-rays	R_0 (fm)***	HF
7.763	7.622	15%	4%	(3)	0.5814	0.0374, 0.0579, 0.0786, 0.1210, 0.1333, 0.1210, 0.1333, 0.1600, 0.1722, 0.3270, 0.3902, 0.4484	1.5613(21)	61
7.776	7.635	15%	4%	(4,5^-)	0.5867	0.0349, 0.0579, 0.1333, 0.3427, 0.3780	1.5613(21)	50
7.794	7.652	35%	9%	$(3)^-$	0.5507	0.0374, 0.0536, 0.0643, 0.0786, 0.349, 0.579, 0.1333, 0.2067, 0.2544, 0.2964, 0.3014	1.5613(21)	34
7.806	7.664	15%	4%	(3,4,5^-)	0.5394	0.0349, 0.0579, 0.0928, 0.1333, 0.3129	1.5613(21)	83
7.812	7.670	31%	8%	(3,4,5)	0.5320	0.0349, 0.0374, 0.0579, 0.0786, 0.0928, 0.1233, 0.1333, 0.1373, 0.1600, 0.1878, 0.1828, 0.2437, 0.2678	1.5613(21)	44
7.852	7.709	42%	11%	(3,4,5^-)	0.4934	0.0349, 0.0374, 0.0579, 0.0643, 0.0786, 0.1333, 0.1490, 0.1531, 0.2036, 0.2437, 0.2678	1.5613(21)	42
7.936	7.792	38%	10%	(2,3,4,5^-)	0.4093	0.0374, 0.0786, 0.1333, 0.1600	1.5613(21)	84
7.995	7.850	19%	5%	(2,3,4)	0.3492	0.0786, 0.1333, 0.1373		
8.000	7.855	100%	26%	(4,5^-)	0.3442	0.0374, 0.0579, 0.0786, 0.0928, 0.0948, 0.1182, 0.1333, 0.1531	1.5613(21)	51
8.091	7.944	≈8%	≈2%	(2)	0.2544	0.1210, 0.1333	1.5613(21)	1.22×10^3
8.119	7.971	15%	4%	$(4)^-$	0.2261	0.0349, 0.0579, 0.1333	1.5613(21)	740
8.154	8.006	12%	3%	$(5)^-$	0.1912	0.0579, 0.1333	1.5613(21)	1.25×10^3
8.204	8.055	15%	4%	$(0)^-$	0.1416	0.1416	1.5613(21)	1.31×10^3
8.212	8.063	8%	2%	(3^-)	0.1333	0.1333	1.5613(21)	2.8×10^3
8.346	8.194	15%	4%	(1^-)	0.0	—	1.5613(21)	3.3×10^3

* All values from [1997Sh09], except where noted. No uncertainties were reported in [1997Sh09].
** [1990An19].
*** Interpolated between 1.5655(13) fm (^{218}Ra and 1.5571(17) fm (^{222}Th).

Table 9
direct α emission from ^{224}Pa*, $T_{1/2}$ = 844(19) ms**, BR_{α} = ≈ 100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{220}Ac)	coincident γ-rays	R_0 (fm)***	HF
7.281	7.151	<0.1%	<0.05%		0.4120	0.0138, 0.3980, 0.4120	1.5483(38)	>530
7.336	7.205	0.3%	0.2%		0.3561	0.0280, 0.0407, 0.0678, 0.2476, 0.2874, 0.3158	1.5483(38)	210
7.357	7.226	0.1%	0.1%		0.3354	0.0138, 0.0407, 0.1510, 0.1705, 0. 1820, 0.1842, 0.2947, 0.3350	1.5483(38)	500
7.381	7.249	0.1%	0.1%		0.3120	0.0138, 0.2982	1.5483(38)	600
7.430	7.297	2.9%	2%	(4^+)	0.2632	0.0280, 0.0407, 0.0678, 0.1095, 0.1131, 0.1547, 0.1945	1.5483(38)	45
7.459	7.326	2.1%	1.5%	(5^+)	0.2339	0.0280, 0.0407, 0.1651	1.5483(38)	75
7.509	7.375	3.6%	2.5%	(3^-)	0.1842	0.0138, 0.1705, 0.1842	1.5483(38)	67
7.540	7.405	17.1%	12%	(2^-)	0.1530	0.0138, 0.1392, 0.1530	1.5483(38)	18
7.543	7.408	5.7%	4%	(4^-)	0.1502	0.0407, 0.1095	1.5483(38)	55

Table 9
direct α emission from ^{224}Pa*, $T_{1/2}$ = 844(19) ms**, BR_α = ≈ 100%.

7.579	7.444	3.6%	2.5%	(1^-)	0.1133	0.1133	1.5483(38)	116
7.584	7.449	5.7%	4%	(3^-)	0.1085	0.0407, 0.0678,	1.5483(38)	76
7.624	7.488	100%	70%	(5^-)	0.0687	0.0280, 0.0407	1.5483(38)	5.9

* All values from [1996Li05], except where noted. No uncertainties were reported in [1996Li05].
** Weighted average of 790(60) ms [1996Li05] and 850(20) ms [1997Wi15].
*** Interpolated between 1.5571(17) fm (^{222}Th) and 1.5394(34) fm (^{226}U).

Table 10
direct α emission from ^{228}Np*, $T_{1/2}$ = 61.4(14) s*, BR_α = 40(11)%*.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{224}Pa)	coincident γ-rays	R_0 (fm)***	HF
7.250	7.123**	40(11)%				1.5385(66)	$6.8^{+3.0}_{-1.8}$

* [1994Kr13].
** Average of 5 events identified by α-α chains [2003Ni10, 2004NiZZ, 2003NiZV] (See Fig. 1f in [2003Ni10]). This is likely several unresolved peaks.
*** Interpolated between 1.5394(34) fm (^{226}U) and 1.5375(56) (^{230}Pu).

Table 11
direct α emission from ^{236}Bk, $T_{1/2}$ = 22^{+13}_{-6} s*, BR_α = ≈ 17 %*.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{232}Am)	coincident γ-rays	R_0 (fm)***	HF
7.447(14)	7.321(14)**	≈ 17%*				1.515(26)	≈ 0.5

* [2017Ko02].
** [2020Po07].
*** Interpolated between 1.5375(56) (^{230}Pu) and 1.491(25) fm (^{234}Cm).

Table 12
direct α emission from ^{240}Es, $T_{1/2}$ = 5(2) s, BR_α = 70(10) %.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{236}Bk)	coincident γ-rays	R_0 (fm)	HF
8.227(30)	8.090(30)	≈ 25%	≈14%					
8.329(30)	8.190(30)	100%	≈56%					

* All values from [2017Ko02].

Table 13
direct α emission from ^{244}Md, $T_{1/2}$ = ≈ 6 s, BR_α = ≈ 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{240}Es)	coincident γ-rays	R_0 (fm)	HF
8.446(19)	8.308(19)	≈ 100%					

* All values from [2020Po07].

Table 14
direct α emission from ^{244m}Md, Ex. = unk., $T_{1/2}$ =$0.4^{+0.4}_{-0.1}$ s, BR_α = ≈ 100%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{240}Es)	coincident γ-rays	R_0 (fm)	HF
8.807(23)	8.663(23)	≈ 100%					

* All values from [2020Po07].

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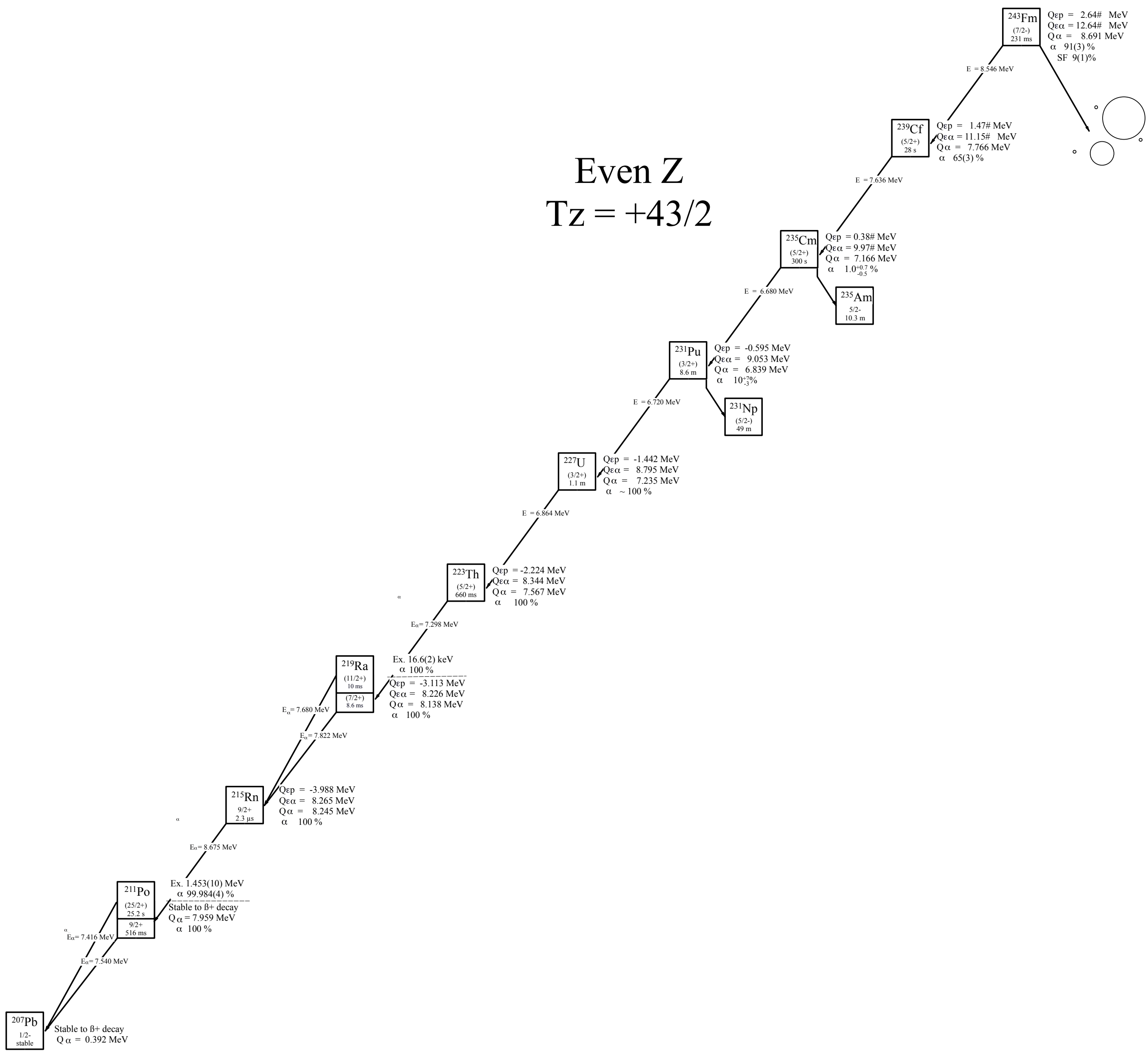

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +43/2 nuclei.

Last updated 4/4/2024

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +43/2 nuclei. J^π values for ^{204}Tl and ^{208}Bi are taken from ENSDF. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide		J^π	Ex.	$T_{1/2}$	Q$_\varepsilon$	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	BR$_{\beta_F}$	Experimental
^{207}Pb		1/2$^-$	stable	-1.418(5)	—–	—–			
^{211}Po		9/2$^+$	516(3) ms	-0.573(5)	—–	—–	[**1974Ba29**]		
^{211m}Po	1.453(10)	(25/2$^+$)	25.2(5) s	0.880(11)	-3.540(10)	7.630(12)	[**1974Ba29**]		
^{215}Rn		9/2$^+$	2.3(1) μs	0.088(9)	-3.988(6)	8.265(8)	[**1970Va13**]		
^{219}Ra		(7/2)$^+$	8.6(17) ms*	0.777(10)	-3.113(7)	8.226(10)	[**2018Sa45**]		
^{219m}Ra	0.0166(2)**	(11/2)$^+$	10(3) ms	0.793(10)	-3.096(7)	8.243(10)	[**2018Sa45**]		
^{223}Th		(5/2$^+$)	660(10) ms	1.560(10)	-2.224(9)	8.344(11)	[**1970Va13**]		
^{227}U		(3/2$^+$)	1.1(1) m	2.215(11)	-1.442(10)	8.795(11)	[**1969Ha32**]		
^{231}Pu		(3/2$^+$)	8.6(5) m	2.680(60)	-0.595(22)	9.053(23)	[**1999La14**]		
^{235}Cm		(5/2$^+$)	300^{+250}_{-100} s	3.39(12)#	0.38(10)#	9.97(12)#	[**2020Kh10**]		
^{239}Cf		(5/2$^+$)	28(2) s	3.95(24)#	1.47(12)#	11.15(13)#	[**2020Kh10**]		
^{243}Fm		(7/2$^-$)	231(9) ms	4.57(25)#	2.64(13)#	12.64(24)#	[**2020Kh10**		

* Weighted average of 10(3) ms and 8(2) ms [2018Sa45].
** [2021Si21].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the even-Z, T_z = +43/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_p$	S$_{2p}$	Q$_\alpha$	BR$_\alpha$	BR$_{SF}$	Experimental
^{207}Pb	7.488(1)	14.742(4)	0.392(1)			
^{211}Po	4.930(1)	9.396(1)	7.595(1)	100%		[**2001Ch66, 1969Go23**, 2000ChZU, 2000ChZX, 2000OgZR, 1989Ku08, 1989KuZE, 1988KuZR, 1985La17, 1982Bo14, 1978Ya04, 1975Ja04, 1974Ba29, 1970Va13, 1969Ha32, 1968GuZX, 1963Uh01, 1962Pe15, 1958To25, 1955Mo68, 1954Je11, 1954Sp32, 1954Wi26, 1953AsZZ, 1952Me13]
^{211m}Po	3.477(10)	7.943(10)	9.048(10)	99.984(4)%		[**1989Ku08, 1962Pe15**, 1989KuZE, 1988KuZR, 1982Bo14, 1974Ba29, 1954Je11, 1954Sp32]
^{215}Rn	5.079(7)	9.093(7)	8.839(6)	100%		[**1970Va13**, 2018Sa45, 1970VaZZ, 1969Ha32, 1952Me13]
^{219}Ra	. 4.955(8)	8.843(8)	8.138(3)	100%		[**1994Sh02**, 2018Sa45, 1993AnZS, 1989An13, 1987El02, 1970Va13, 1970VaZZ, 1969Ha32, 1952Me13
^{219m}Ra	4.937(8)	8.826(8)	8.155(3)	100%		[**2018Sa45**]
^{223}Th	4.525(9)	8.156(9)	7.567(4)	100%		[**1992Li09**, 1990An19, 1990AnZQ, 1989An13, 1989AnZL, 1988AnZS, 1987El02, 1970Va13, 1970VaZZ, 1969Ha32, 1952Me13]
^{227}U	4.278(14)	7.843(10)	7.235(3)	≈ 100%		[**2015Ka24**, 1991Ho05, 1990JoZU, 1986BuZP, 1970Va13, 1969Ha32, 1952Me13]
^{231}Pu	4.217(59)	7.480(23)	6.839(20)	10^{+7}_{-3}%		[**1999La14**, 2007KhZQ]
^{235}Cm	3.74(19)#	6.62(12)#	7.116(14)*	$1.0^{+0.7}_{-0.5}$%		[**2020Kh10, 2007KhZQ**
^{239}Cf	3.30(28)#	5.62(14)#	7.766(8)**	65(3)%		[**2020Kh10**, 1981Mu12]
^{243}Fm	2.77(29)#	4.59(21)#	8.691(8)***	91(3)%	9(1)%	[**2020Kh10**, 2008Kh10, 1981Mu12]

* Deduced from α energy, 7.28(10)# in [2021Wa16].
** Deduced from α energy, 7.763(63) in [2021Wa16].
*** Deduced from α energy, 8.689(51) in [2021Wa16].

Table 3
direct α emission from ^{211}Po, J^{π} = 9/2^{+}, T$_{1/2}$ = 516(3) ms*, BR_{α} = ≈ 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)$^{@}$	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{207}Pb)$^{@@}$	coincident γ-rays$^{@@}$	R$_0$ (fm)	HF
5.961	5.848**	8.1(10) × 10^{-4}%	8.1(10) × 10^{-4}%**	13/2^{+}	1.6333	0.5697, 1.0637	1.46528(11)	$10.3^{+1.6}_{-1.3}$
6.6970(25)	6.5700(25)***	0.59(1)%	0.58(1)%	3/2^{-}	0.8978	0.8978	1.46528(11)	16.10(34)
7.0250(25)	6.8920(25)***	0.61(1)%	0.60(1)%	5/2^{-}	0.5697	0.5697	1.46528(11)	244(5)
7.594(3)	7.450(3)***	100	98.82(1)%	1/2^{-}	0.0	—–	1.46528(11)	112(3)

* [1974Ba29].
** [2001Ch66].
*** [1969Go23].
@ [1978Ya04].
@@ [2011Ko04].

Table 4
direct α emission from ^{211m}Po, Ex. = 1.453(10) MeV, J^{π} = (25/2^{+}), T$_{1/2}$ = 25.2(5) s*, BR_{α} =99.984(4)%**.

E_{α}(c.m.)	E_{α}(lab)***	I_{α}(rel)$^{@}$	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{207}Pb)$^{@@}$	coincident γ-rays$^{@@}$	R$_0$ (fm)	HF
7.416(15)	7.275(15)	100%	91%	13/2^{+}	1.6333	0.5697, 1.0637	1.46528(11)	1.60(16) × 10^{3}
8.149(15)	7.995(15)	1.82(3)%	1.66(3)%	3/2^{-}	0.8978	0.8978	1.46528(11)	1.36(4) × 10^{7}
8.465(15)	8.305(15)	0.27(2)%	0.25(2)%	5/2^{-}	0.5697	0.5697	1.46528(11)	6.8(6) × 10^{8}
9.046(10)	8.875(10)	7.74(15)%	7.04(14)%	1/2^{-}	0.0	—–	1.46528(11)	6.1(4) × 10^{8}

* [1974Ba29].
** [1989Ku08].
*** Values taken from [1962Pe15], adjusted by +5 keV in [1991Ry01].
@ [1962Pe15].
@@ [2011Ko04].

Table 5
direct α emission from ^{215}Rn*, J^{π} = 9/2^{+}, T$_{1/2}$ = 2.3(1) μs, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{211}Po)	coincident γ-rays	R$_0$ (fm)	HF
8.839(8)	8.675(8)	100%	9/2^{+}	0.0	—–	1.5499(42)	1.69(18)

* Al values from [1970Va13], unless noted otherwise.

Table 6
direct α emission from ^{219}Ra, J^{π} = (7/2)$^{+}$, T$_{1/2}$ = 8.6(17) ms**, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{215}Rn)	coincident γ-rays	R$_0$ (fm)	HF
7.330(5)	7.196(5)	3.2%	2.0%	7/2^{+}	0.806	0.2140, 0.3160, 0.490, 0.5920, 0.8052	1.5597(35)	3.5
7.822(3)	7.679(3)	100%	62%	11/2^{+}	0.316	0.316	1.5597(35)	4.4
7.846(10)	7.703(10)	2.3%	1.4%	(11/2)$^{-}$	0.2906	0.2906	1.5597(35)	230
7.925(10)	7.780(10)	≈0.8%	≈0.5%		0.2140	0.2140	1.5597(35)	≈1.1 × 10^{3}
8.138(3)	7.989(3)	55%	34%	9/2^{+}	0.0	—–	1.5597(35)	70

* All values from [1994Sh02], except where noted.
** Weighted average of 10(3) ms and 8(2) ms [2018Sa45].

Table 7
direct α emission from ^{219}Ra*, Ex. = 0.0166(2)**, J^{π} = (11/2)$^{+}$, T$_{1/2}$ = 10(3) ms, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{215}Rn)	coincident γ-rays	R$_0$ (fm)	HF
7.823(20)	7.680(20)	100%	11/2^{+}	0.316	0.316	1.5597(35)	3.6(11)

* All values from [2018Sa45], except where noted.
** [2021Si21].

Table 8

direct α emission from ^{223}Th*, J^{π} = $(5/2)^{+}$, $T_{1/2}$ = 660(10) ms**, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}(^{219}Ra)$	coincident γ-rays	R_0 (fm)	HF
7.052	6.928	0.7%	0.4%		0.5155(10)	0.0972(1), 0.1138(1), 0.4017(10)	1.5478(22)	18
7.098	6.973	1.1%	0.6%		0.4707(7)	0.0382(3), 0.0972(1), 0.1138(1), 0.3188(7), 0.3569(7)	1.5478(22)	18
7.124	6.998	2.7%	1.5%		0.4450(5)	0.0382(3), 0.088, 0.0972(1), 0.2930(5), 0.3050(5), 0.3313(5)	1.5478(22)	8.9
7.146	7.020	0.5%	0.3%		0.4217(12)	0.4217(12)	1.5478(22)	54
7.163	7.037	3.4%	1.9%		0.4047(2)	0.0382(3), 0.088, 0.0972(1), 0.1520(1), 0.2528(2), 0.2647(2), 0.353	1.5478(22)	9.9
7.245	7.117	1.3%	0.7%		0.3206(7)	0.0382(3), 0.0972(1), 0.1520(1), 0.1688(5), 0.2680(10), 0.3206(8)	1.5478(22)	54
7.417	7.286	47.7%	26.4%	$(7/2^{+})$	0.1520(3)	0.0382(3), 0.0972(1), 0.1520(1)	1.5478(22)	5.6
7.429	7.298	100%	55.3%	$(9/2^{+})$	0.1400(3)	0.0520(3), 0.088, 0.1400(3)	1.5478(22)	2.9
7.454	7.323	23.9%	13.2%	$(5/2^{+})$	0.1138(1)	0.1138(1)	1.5478(22)	35
7.565	7.432	1.8%	≈1%	$7/2^{+}$	0.0	—	1.5478(22)	≈480

* All values from [1992Li09], except where noted. Uncertainties were not given for α energies and intensities.
** [1970Va13].

Table 9

direct α emission from ^{227}U*, J^{π} = $(3/2)^{+}$, $T_{1/2}$ = 1.1(1) m**, BR_{α} = ≈ 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)[@]	I_{α}(abs)	J^{π}_{f}	$E_{daughter}(^{223}Th)$	coincident γ-rays	R_0 (fm)	HF
6.746(7)	6.627(7)	2(2)%	1(1)%	$(3/2^{+}, 5/2^{+}, 7/2^{+})$	0.4888(6)	0.0513, 0.4374, 0.4888	1.5316(43)	5^{+54}_{-3}
6.839(8)	6.718(8)	12(3)%	5(1)%	$(1/2^{+}, 3/2^{+}, 5/2^{+})$	0.3955(7)	0.0513, 0.0850, 0.1492, 0.2471, 0.2589, 0.3104, 0.3955	1.5316(43)	$2.6^{+1.0}_{-0.7}$
6.864(4)	6.743(4)	14(3)%	6(1)%	$(1/2^{+}, 9/2^{+})$	0.3702(3)	0.3702	1.5316(43)	$2.7^{+0.9}_{-0.7}$
6.924(4)	6.802(4)	40(10)%	17(3)%	$(5/2^{+})$	0.3104(3)	0.0513, 0.2589, 0.3104	1.5316(43)	$1.7^{+0.6}_{-0.4}$
6.987(3)	6.864(3)	100(17)%	42(7)%	$(3/2^{+})$	0.2471(3)	0.2471	1.5316(43)	$1.2^{+0.4}_{-0.3}$
7.026(5)	6.902(5)	48(12)%	20(4)%	$(7/2^{+})$	0.2089(5)	0.0513, 0.1574, 0.2089	1.5316(43)	$3.5^{+1.3}_{-0.9}$
7.183(3)	7.056(3)	10(10)%	4(4)%	$(7/2^{+})$	0.0515(4)	0.0513	1.5316(43)	69(9)
7.234(3)	7.107(3)	14(10)%	6(4)%	$(5/2^{+})$	0.0	—	1.5316(43)	70^{+160}_{-30}

* All values from [2015Ka24], except where noted.
** [1969Ha32].

Table 10

direct α emission from ^{231}Pu*, J^{π} = $(3/2)^{+}$, $T_{1/2}$ = 8.6(5) m, BR_{α} = 10^{+7}_{-3}%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}(^{227}U)$	coincident γ-rays	R_0 (fm)	HF
6.838(30)	6.720(30)	10^{+7}_{-3}%	$(3/2^{+})$	0.0	—	1.512(28)	$1.1^{+2.9}_{-0.6}$

* All values from [1999La14].

Table 11

direct α emission from ^{235}Cm, J^{π} = $(5/2)^{+}$*, $T_{1/2}$ = 300^{+250}_{-100} s*, BR_{α} = $1.0^{+0.7}_{-0.5}$%*.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}(^{231}Pu)$	coincident γ-rays	R_0 (fm)	HF
6.796(14)	6.680(14)**	100%	≈0.7%*	$(5/2^{+})$	0.320(20)		1.505(16)	≈0.8
7.116(14)	6.995(14)***	≈ 40%	≈0.3%*	$(3/2^{+})$	0.0	—	1.505(16)	≈40

* [2020Kh10].
** Weighted average of 6.690(20) MeV [2020Kh10] and 6.670(20) MeV [2007KhZQ].
*** Weighted average of 7.010(20) MeV [2020Kh10] and 6.980(20) MeV [2007KhZQ].

Table 12
direct α emission from ^{239}Cf*, J^{π} = (5/2)$^{+}$, $T_{1/2}$ = 28(2) s, BR_{α} = 65(3)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{235}Cm)	coincident γ-rays	R_0 (fm)	HF
7.766(8)	7.636(8)	65(3)%	(5/2)$^{+}$	0.0	—	1.504(21)	$0.8^{+0.5}_{-0.3}$

* All values taken from [2020Kh10].

Table 13
direct α emission from ^{243}Fm*, J^{π} = (7/2)$^{-}$, $T_{1/2}$ = 231(9) ms, BR_{α} = 91(3)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{239}Cf)	coincident γ-rays	R_0 (fm)	HF
8.691(8)	8.546(8)	65(3)%	(5/2)$^{+}$	0.0	—	1.511(39)	$1.1^{+1.7}_{-0.37}$

* All values taken from [2020Kh10], except where noted.

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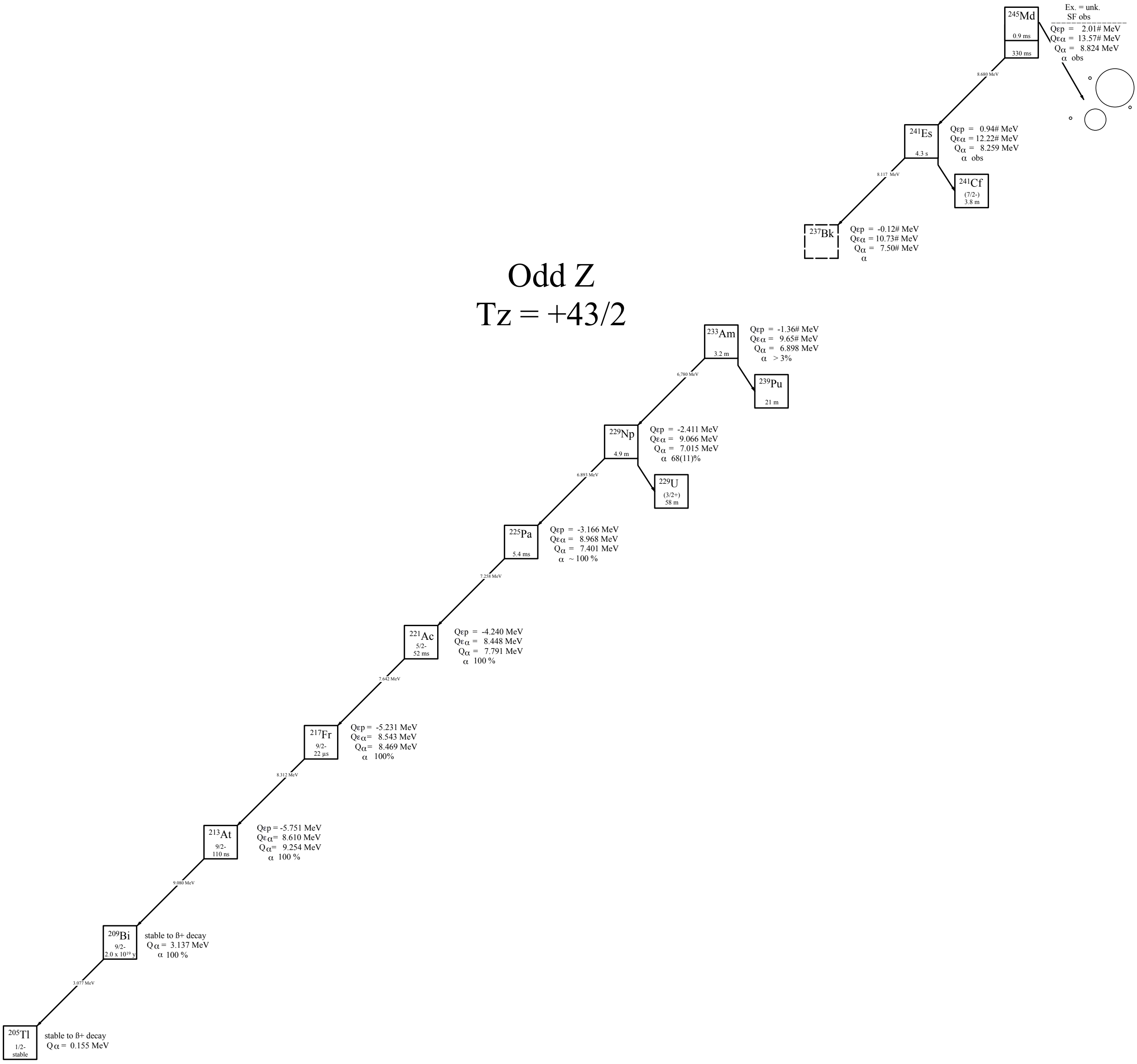

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +43/2 nuclei.

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +43/2 nuclei. zThe J^π value for ^{205}Tl are taken from ENSDF. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex.	J^π	$T_{1/2}$	Q$_\varepsilon$	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{205}Tl		1/2$^-$	stable	-1.533(4)	—	—	
^{209}Bi		9/2$^-$	2.01(8) × 10^{19} y	-0.644(1)	—	—	[**2012Be06**]
^{213}At		9/2$^-$	110(20) ns	0.074(5)	-5.751(5)	8.610(5)	[**1970Bo13**]
^{217}Fr		9/2$^-$	22(5) μs	0.656(8)	-5.231(7)	8.543(7)	[**1970Bo13**]
^{221}Ac		5/2$^-$	52(2) ms	1.570(60)	-4.240(57)	8.448(57)	[**1970Bo13**]
^{225}Pa		5/2$^-$	1.8(3) s	2.050(50)	-3.166(82)	8.968(82)	[**1970Bo13**]
^{229}Np			4.0(2) m	2.59(10)	-2.411(101)	9.066(101)	[**1968Ha14**]
^{233}Am			3.2(8) m	3.23(13)#	-1.36(15)#	9.65(12)#	[**2000Sa52**]
^{237}Bk				3.96(24)#	-0.12(26)#	10.73(24)#	
^{241}Es			$4.3^{+2.4}_{-1.2}s$	4.57(29)#	0.94(28)#	12.22(24)#	[**2020Kh09**]
^{245}Md			330^{+150}_{-80} ms	5.13(33)#	2.01(32)#	13.57(31)#	[**2020Kh09**]
^{245m}Md	x	(1/2$^-$)	$0.9^{+0.6}_{-0.3}$ ms	5.13(33)#	2.01(32)#	13.57(31)#	[**1996Ni09**]

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +43/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S$_p$	S$_{2p}$	Q$_\alpha$	BR$_\alpha$	BR$_{SF}$	Experimental
^{205}Tl	6.420(1)	15.255(3)	0.155(3)			
^{209}Bi	3.799(1)	11.802(5)	3.137(1)	100%		[**2012Be06, 2003De11**, 1952RiXX, 1951Fa10]
^{213}At	3.499(5)	9.298(7)	9.254(5)	100%		[**1988Hu08, 1970Ha14**, 2022Pa09, 2009Vi09, 1970VaZZ, 1968Ha14, 1951Ke53]
^{217}Fr	3.228(9)	9.007(9)	8.469(4)	100%		[**1970Bo13, 1988Hu08**, 2022Pa09, 1990An19, 1990AnZL, 1990AnZQ, 1990AnZU, 1989AnZL, 1970VaZZ, 1968Ha14, 1951Ke53]
^{221}Ac	3.030(57)	8.664(57)	7.791(57)	100%		[**2023Re08, 2022Pa09, 1993AnZS**, 1989AnZL, 1988Hu08, 1978IbZZ, 1970Bo13, 1970VaZZ, 1968Ha14, 1951Ke53]
^{225}Pa	2.928(82)	8.046(82)	7.401(59)	≈ 100%		[**2023Re08**, 2022Pa09, 2000Sa52, 1988Hu08, 1987HuZV, 1978IbZZ, 1970Bo13, 1970VaZZ, 1968Ha14, 1951Ke53]
^{229}Np	2.71(10)	7.61(10)	7.015(23)*	68(11)%		[**2004Sa05**, 2000Sa52, 1968Ha14]
^{233}Am	2.37(12)#	6.92(13)#	6.898(17)**	>3%		[**2000Sa52**, 2004Sa05, 2003Na10, 2002AsZX, 2000TsZX]
^{237}Bk	1.93(23)#	5.99(24)#	7.50(20)#			
^{241}Es	1.38(23)#	4.93(31)#	8.259(17)	obs		[**2020Kh08, 1996Ni09**, 1994HoZW, 1985HiZU]
^{245}Md	0.93(33)#	4.00(33)#	8.824(20)***	obs		[**2020Kh08, 1996Ni09**, 1994HoZW]
^{245m}Md	0.93(33)#-x	4.00(33)#-x	9.01(12)#+x		obs	[**1996Ni09**, 2020Kh08]

* Deduced from α energy, 7.020(59) MeV in [2021Wa16].
** Deduced from α energy, 7.059(53)# MeV in [2021Wa16].
** Deduced from α energy, 9.01(12)# MeV in [2021Wa16].

Table 3
direct α emission from ^{209}Bi, J^π = 9/2$^-$, T$_{1/2}$ = 2.01(8) × 10^{19} y*, BR_α = 100 %.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J$^\pi_f$	$E_{daughter}$(^{205}Tl)	coincident γ-rays	R$_0$ (fm)	HF
2.933	2.877**	12(3)%	12(3)%	3/2$^+$	0.2037@	0.2037@	1.485(11)	280^{+140}_{-90}
3.137(2)***	3.077(2)	100%	98.8(3)%	1/2$^+$	0.0	—	1.485(11)	$1.3^{0.4}_{-0.3} \times 10^3$

* [2012Be06].
** α branch from calorimetric studies [2012Be06].
*** [2003De11].
@ [2020Ko17].

Table 4
direct α emission from ^{213}At, J^{π} = 9/2^{-}, $T_{1/2}$ = 110(20) ns*, BR_{α} = 100 %.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{209}Bi)	coincident γ-rays	R$_0$ (fm)	HF
9.254(5)	9.080(5)**	100%	9/2^{-}	0.0	—	1.5279(14)	0.99(18)

* [1970Bo13].
** [1988Hu08].

Table 5
direct α emission from ^{217}Fr, J^{π} = 9/2^{-}, $T_{1/2}$ = 22(5) μs*, BR_{α} = 100 %.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{213}At)	coincident γ-rays	R$_0$ (fm)	HF
8.468(5)	8.312(5)**	100%	9/2^{-}	0.0	—	1.5657(36)	1.21(29)

* [1970Bo13].
** [1988Hu08].

Table 6
direct α emission from ^{221}Ac*, J^{π} = 5/2^{-}, $T_{1/2}$ = 52(2) ms*, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)***	J^{π}_{f}	$E_{daughter}$(^{217}Fr)	coincident γ-rays	R$_0$ (fm)	HF
7.208(15)	7.078(15)				0.5790	0.0878, 0.2094, 0.2830, 0.4918, 0.5790	1.5555(37)	
7.299(9)	7.167(9)				0.4918	0.2094, 0.2830, 0.4918	1.5555(37)	
7.421(6)	7.287(6)				0.3647	0.1556, 0.2094, 0.3647	1.5555(37)	
7.509(4)	7.373(4)	13(3)%	9(2)%	(7/2^{-})	0.2757	0.0443, 0.2314, 0.2757	1.5555(37)	$7.3^{+3.0}_{-2.0}$
7.555(4)	7.418(4)				0.2314	0.2314	1.5555(37)	
7.575(4)	7.438(4)	28(3)%	20(2)%	(5/2^{-})	0.2094	0.2094	1.5555(37)	$5.4^{+1.3}_{-1.1}$
7.686(4)	7.547(4)				0.0988	0.0988	1.5555(37)	
7.783(4)	7.642(4)	100(8)%	71(4)%	9/2^{-}	0.0	—	1.5555(37)	7.2(10)

* All values from [2023Re08], except where noted.
** [1970Bo13].
*** Taken from [2022Pa09], no I_{α} were reported in [2023Re08].

Table 7
direct α emission from ^{225}Pa*, J^{π} = 5/2^{-}, $T_{1/2}$ = 1.8(3) s*, BR_{α} = $\approx$ 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{217}Fr)	coincident γ-rays	R$_0$ (fm)	HF
7.164(5)	7.037(5)	3.2(19)%	1.7(1)%	7/2^{+}	0.2237	0.0195, 0.0274, 0.0571, 0.0641, 0.0724, 0.0754, 0.0915, 0.1218, 0.1293, 0.1323, 0.1497, 0.1966, 0.02237	1.5390(31)	10.8(21)
7.206(2)	7.078(2)	5.7(6)%	3.0(3)%	5/2^{+}	0.1800	0.0195, 0.0274, 0.0641, 0.0724, 0.0887, 0.0915, 0.1526, 0.1607, 0.1800	1.5390(31)	$8.8^{+2.7}_{-2.2}$
7.238(6)	7.109(6)	8.7(10)%	4.6(5)%	5/2^{+}	0.1497	0.0195, 0.0274, 0.0571, 0.0641, 0.0724, 0.0915, 0.1218, 0.1293, 0.1497	1.5390(31)	$7.4^{+2.4}_{-1.9}$
7.298(2)	7.168(2)	20.9(9)%	11.1(4)%	5/2^{-}	0.0915	0.0195, 0.0274, 0.0641, 0.0724, 0.0915	1.5390(31)	5.0(9)
7.360(2)	7.229(2)	50.2(16)%	26.6(7)%	7/2^{-}	0.0274	0.0274	1.5390(31)	3.5(7)
7.389(2)	7.258(2)	100(3)%	53.0(10)%	5/2^{-}	0.0	—	1.5390(31)	2.2(4)

* All values from [2023Re08], except where noted.
** [1970Bo13].

Table 8
direct α emission from ^{229}Np*, $T_{1/2}$ = 4.0(2) m**, BR_α = 68(11)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{225}Pa)	coincident γ-rays	R_0 (fm)	HF
7.015(23)	6.893(23)	68(11)%	5/2$^-$	0.0***	—	1.5306(54)	$1.4^{+0.5}_{0.4}$

* All values from [2004Sa05], except where noted.
** [1968Ha14].
*** Assumed to decay to the ground state.

Table 9
direct α emission from ^{233}Am*, $T_{1/2}$ = 3.2(8) m, BR_α = > 3%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{229}Np)	coincident γ-rays	R_0 (fm)	HF
6.898(17)	6.780(17)	> 3%		0.0**	—	1.489(37)	<0.5

* All values from [2000Sa52].
** Assumed to decay to the ground state.

Table 10
direct α emission from ^{241}Es, $T_{1/2}$ = $4.3^{+2.4}_{-1.2}$*, BR_α = obs.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{237}Bk)	coincident γ-rays	R_0 (fm)	HF
8.253(14)	8.117(14)**			0.0***	—		

* [2020Kh08].
** Weighted average of 8.120(20) MeV [2020Kh08] and 8.113(20) MeV [1996Ni09].
*** Assumed to decay to the ground state.

Table 11
direct α emission from ^{245}Md*, J^π = 5/2$^-$, $T_{1/2}$ = 330^{+150}_{-80} ms**, BR_α = obs.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J_f^π	$E_{daughter}$(^{241}Es)	coincident γ-rays	R_0 (fm)	HF
8.778(20)	8.635(20)				0.046(28)			
8.824(20)	8.680(20)				0.0***	—		

* All values taken from [1996Ni09], except where noted.
** [2020Kh08].
*** Assumed to decay to the ground state.

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