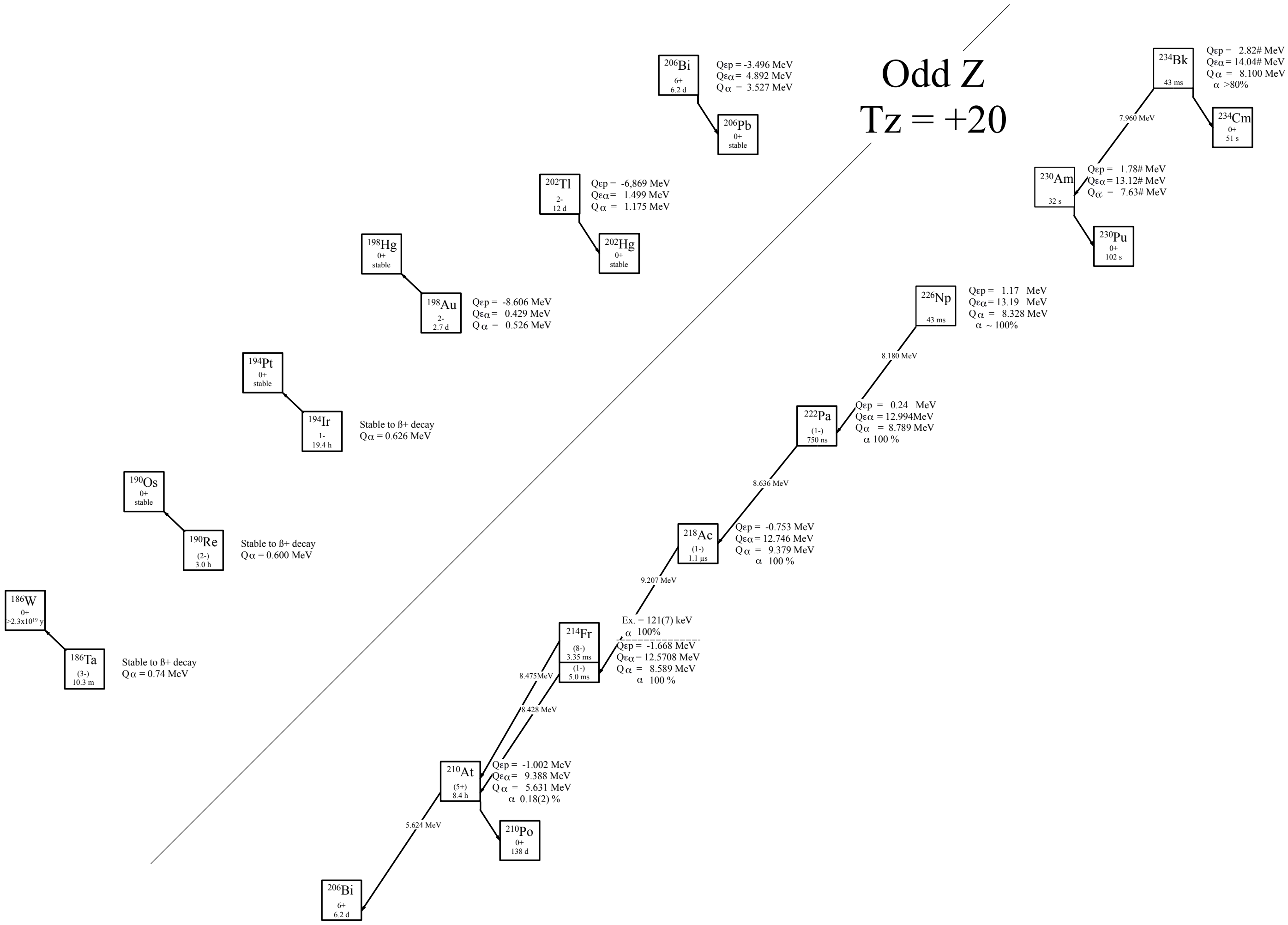

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +20 nuclei.

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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_f^{π} @	$E_{daughter}$(^{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^{π}_{f} @@	$E_{daughter}$(^{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^{π}_{f} @@	$E_{daughter}$(^{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^{π}_{f} @@	$E_{daughter}$(^{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 = $\approx$ 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)	$\approx$ 3
8.236(20)	8.090(20)	***	***		0.091(28)		1.516(42)	$\approx$ 5
8.327(20)	8.180(20)	***	***		0.0@@	—	1.516(42)	$\approx$ 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 $\approx$ 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 $\approx$ 5 counts each.
@ Transition is assumed to feed the ground state.

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