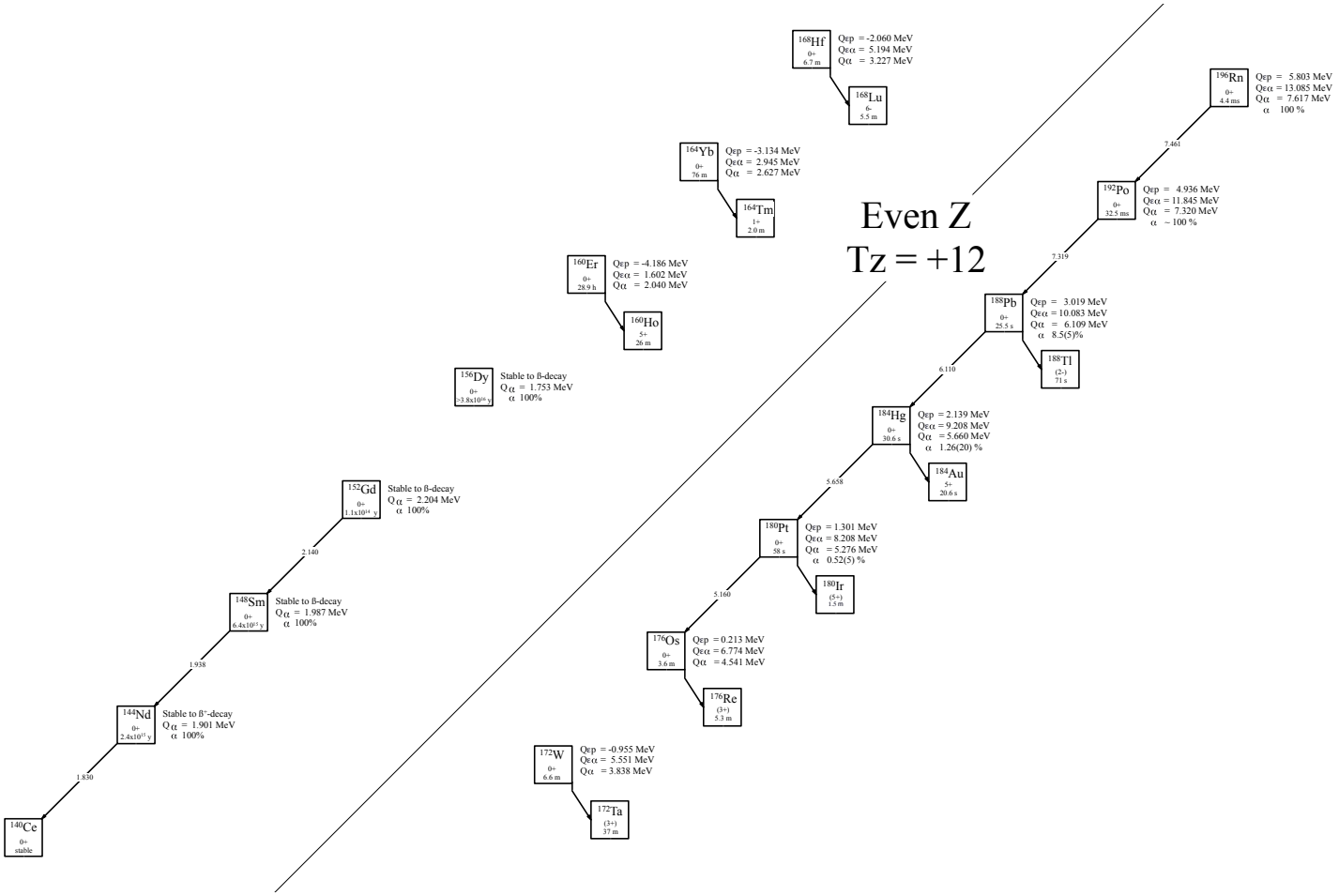

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +12 nuclei.

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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_ε	$Q_{\varepsilon p}$	$Q_{\varepsilon \alpha}$	Experimental
^{144}Nd	0^+	2.4(2)×10^{15} y*	-2.997(1)	——	——	[**1961Ma05, 1987Al28, 1965Is01**]
^{148}Sm	0^+	$6.4^{+1.2}_{-1.3}$×10^{15} y	-2.470(6)	——	——	[**2016Ca43**]
^{152}Gd	0^+	1.08(8)×10^{14} y	-1.819(1)	——	——	[**1961Ma05**]
^{156}Dy	0^+	$\geq$3.8×10^{16} y	-0.438(4)	——	——	[**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_α	BR_α	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_f^π	$E_{daughter}$(^{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_f^π	$E_{daughter}$(^{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_f^π	$E_{daughter}$(^{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_f^π	$E_{daughter}$(^{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_f^π	$E_{daughter}$(^{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*, $J^\pi = 0^+$, $T_{1/2}$= 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, $J^\pi = 0^+$, $T_{1/2}$= 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*, $J^\pi = 0^+$, $T_{1/2}$= $4.4^{+1.3}_{-0.9}$ 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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