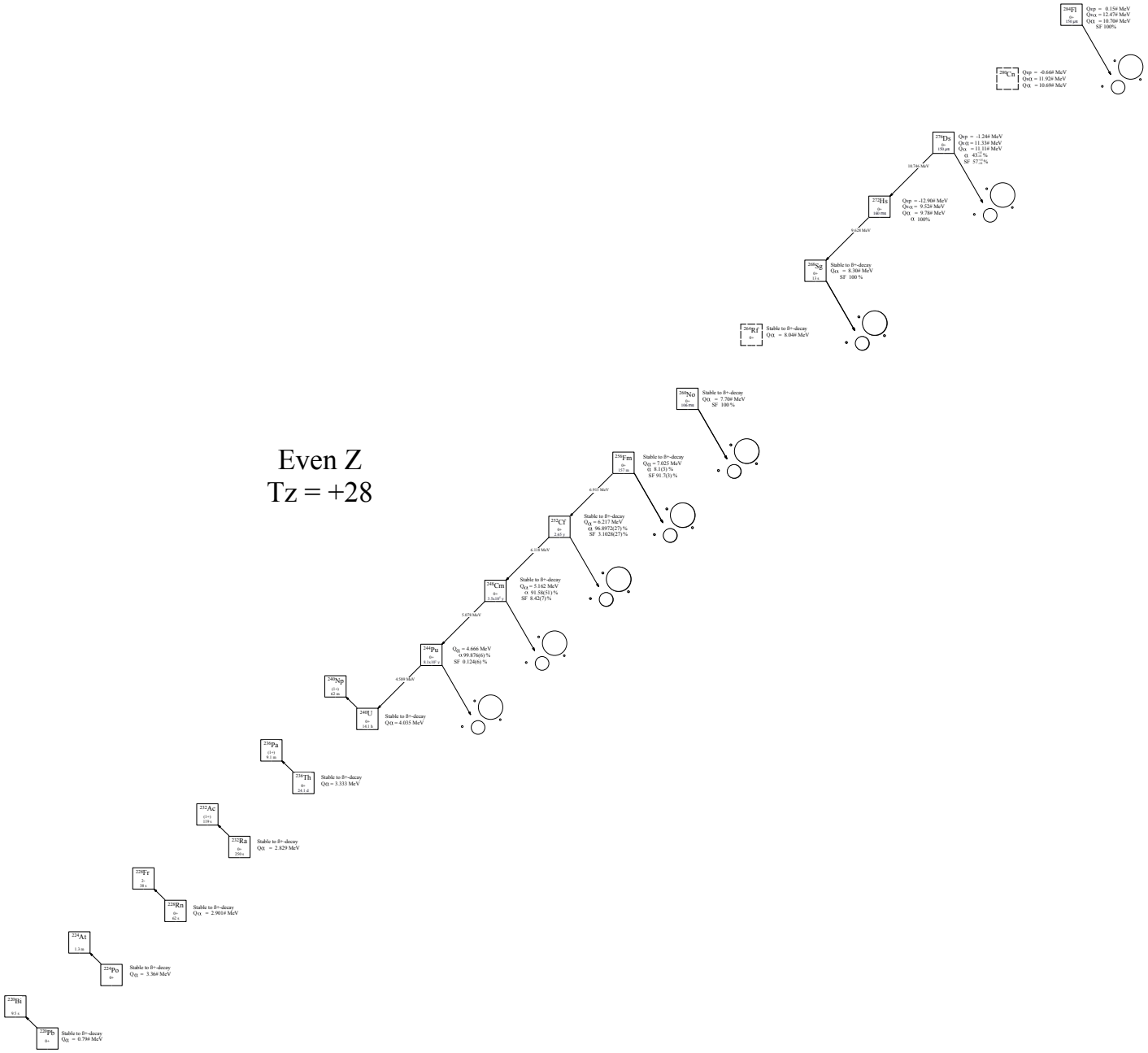

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +28 nuclei.

Last updated 4/23/25

Table 1
Observed and predicted β-delayed particle emission from the even-Z, T_z = +28 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$_\beta$-	Q$_{\beta\text{-}\,\alpha}$	Experimental
^{220}Pb	0^+	obs		3.170(50)#	7.02(50)#	[**2010Al24**]
^{224}Po	0^+	obs	-7.16(45)#	2.20(20)#	6.71(36)#	[**2010Al24**]
^{228}Rn	0^+	62(3) s	-6.64(40)#	1.859(19)	5.287(28)	[**1989Bo11**]
^{232}Ra	0^+	250(50) s	-5.576(17)	1.343(16)	4.868(11)	[**1986Gi08**]
^{236}Th	0^+	37.5(25) m	-4.970(40)	0.921(0)	4.856(19)	[**1973Or06**]
^{240}U	0^+	14.1(1) h	-4.30(20)#	0.399(17)	5.137(14)	[**1981Hs02**]
				$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	
^{244}Pu	0^+	8.12(3)$\times10^7$ y	-3.43(10)#	—	—	[**2006Ag15**]
^{248}Cm	0^+	3.487(20)$\times10^5$ y*	-3.17(20)#	—	—	[**1971Mc19, 1971Ma32, 1969Me01**]
^{252}Cf	0^+	2.6483(10) y	-2.50(20)#	—	—	[**2022Th06**]
^{256}Fm	0^+	157(2) m	-1.70(10)#)	—	—	[**1968Ho13**]
^{260}No	0^+	106(8) ms**	-0.94(37)#	—	—	[**1985So03**]
^{264}Rf			-0.30(57)#	—	—	
^{268}Sg	0^+	13^{+17}_{-4} s	-0.26(71)#	-3.93(74)#	8.00(64)#	[**2023Og03**]
^{272}Hs	0^+	160^{+190}_{-60} ms	0.220(74)#	-2.90(78)#	9.52(74)#	[**2023Og03**]
^{276}Ds	0^+	150^{+100}_{-40} μs	1.23(76)#	-1.24(81)#	11.33(76)#	[**2023Og03**]
^{280}Cn			1.77(79)#	-0.66(84)#	11.92(79)#	
^{284}Fl	0^+	$2.5^{+1.8}_{-0.8}$ ms	2.19(85)#	0.15(90)#	12.47(85)#	[**2015Ut02**]

* Deduced from weighted average of $t_{1/2}(\alpha)$ = 3.703(32)$\times10^5$ y and $t_{1/2}$(SF = 4.115(34)$\times10^6$ y [1971Mc19], $t_{1/2}(\alpha)$ = 3.94(4)$\times10^5$ y and $t_{1/2}$(SF = 4.20(5)$\times10^6$ y [1971Ma32] and $t_{1/2}(\alpha)$ = 3.84(4)$\times10^5$ y and $t_{1/2}$(SF = 4.22(12)$\times10^6$ y [1969Me01].

** Tenatively assigned as ^{260}No by [1985So03], who remarked "a 100-ms half-life for ^{260}No would be surprisingly long, based on an extrapolation of the known nobelium half-lives in Fig. 8 and a known half-life of only 1 ms for ^{258}No. Thus, an assignment to No is supported by our cross bombardments but would be surprising in view of the nobelium half-life systematics.

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the even-Z, T_z = +28 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	Q_α	BR_α	BR_{SF}	Experimental
^{220}Pb		0.79(57)#			
^{224}Po	9.62(45)#	3.36(45)#			
^{228}Rn	9.48(30)#	2.901(20)#			
^{232}Ra	8.873(12)	2.829(20)			
^{236}Th	8.391(20)	3.333(17)			
^{240}U	7.91(20)#	4.035(14)			
^{244}Pu	7.289(32)#	4.666(1)	99.876(6)%	0.124(6)%	[**1983Mo02, 1969Be06**, 2006Ag15, 1998Se17, 1997SeZW, 1994Ve03, 1989Wa29, 1983Th02, 1982Al13, 1971Or03,1968HaZX, 1966Fi07, 1956Bu92, 1956Di09, 1954St98]
^{248}Cm	7.05(10)#	5.1618(3)	91.58(51)%*	8.42(7)%*	[**1977Ba69, 1971Mc19, 1971Ma32, 1969Me01**, 2010TeZZ, 2008Ve05, 2005VoZX, 1997Fo11, 1993Be52, 1991Ba66, 1973Go20, 1973Go46, 1973St04, 1973StZQ, 1972Pr19, 1971Or03, 1967Sc32, 1964Hy02, 1963Br35, 1962Br45]
^{252}Cf	6.482(11)	6.217	96.8972(27)%	3.1028(27)%	[**2018Be29, 1986Ry04, 1970Ba18**, 2025De08, 2024Cz03, 2024Ma21, 2023WaZX, 2023Gj01, 2023Py01, 2022Th06, 2020Al22, 2018Be29, 2018Ch44, 2017Bl07, 2017Py01, 2016Wa03, 2014Go28, 2014Ha25, 2013Vo03, 2012VoZW, 2011KaZY, 2011Ze04, 2010TeZZ, 2010Ve03, 2010ZeZZ, 2008Mu24, 2006Da21, 2006Fo10, 2005Je04, 2004Da13, 2003Ko78, 2002Ha24, 2001Ra20, 2000Hw01, 2000MuZY, 1999Hw04, 1999Ko01, 1999Po36, 1997DaZS, 1997Fo11, 1997Go36, 1997Sa72, 1996InZY, 1994Va24, 1993DlZZ, 1993Pa29, 1989Gl05, 1988Af01, 1988Bu24, 1988Me12, 1987Sc13, 1986Bo11, 1985Az02, 1984Di11, 1984GrZK, 1984SmZV, 1983BlZT, 1983BoZS, 1983Li17, 1983Sc07, 1982Al33, 1982La25, 1981Cu05,1979Ba53, 1979Za04, 1978Ye02, 1977Ma40, 1977Wa01, 1975Fl04, 1975Pr07, 1974Ga23, 1974Sh15, 1974Sp02, 1973Ad03, 1973Fl01, 1973Me01, 1973Mi05, 1973PlZV, 1973Za10, 1972Ch31, 1972Gr40, 1972Ra19, 1971Ha29, 1970Al23, 1970BaZX, 1970Ga08, 1970Pl02, 1969Ba57, 1969De23, 1968Er01, 1967Me20, 1967Wh05, 1965Me02, 1964Fr10, 1958As64, 1964Ho32, 1963Le17, 1961Wa22, 1960Ne20, 1960Te02, 1957Ea01, 1957Sm81, 1956Sm98, 1955As42, 1955Gl42, 1955Hi67, 1954Ma98]
^{256}Fm	5.893(11)	7.025(2)	8.1(3)%	91.7(3)%	[**2019Ah04, 1970Fi12, 1968Ho13**, 2019De11, 1991So16, 1990SoZY, 1989So15, 1987Po22, 1985Wi10, 1974UnZU, 1974UnZV, 1974UnZX, 1972Da11, 1972Fl04, 1972FlZS, 1965Si14, 1958Ph40, 1955Ch30]
^{260}No	5.24(22)#	7.70(20)#		obs**	[**1985So03**]
^{264}Rf	4.88(42)#	8.04(30)#			
^{268}Sg	4.50(60)#	8.30(30)#		100%	[**2023Og03**]
^{272}Hs	4.14(64)#	9.78(20)#	100%		[**2023Og03**]
^{276}Ds	3.52(67)#	11.11(20)#	43^{+15}_{-18}%	57^{+15}_{-18}%	[**2023Og03**]
^{280}Cn	3.36(72)#	10.69(20)#			
^{284}Fl	3.07(79)#	10.70(30)#		100%	[**2015Ut02**]

* Deduced from weighted average of $t_{1/2}(\alpha)$ = 3.703(32)×10^5 y and $t_{1/2}$(SF = 4.115(34)×10^6 y [1971Mc19], $t_{1/2}(\alpha)$ = 3.94(4)×10^5 y and $t_{1/2}$(SF = 4.20(5)×10^6 y [1971Ma32] and $t_{1/2}(\alpha)$ = 3.84(4)×10^5 y and $t_{1/2}$(SF = 4.22(12)×10^6 y [1969Me01].

** Tenatively assigned as ^{260}No by [1985So03], who remarked "a ≈ 100-ms half-life for ^{260}No would be surprisingly long, based on an extrapolation of the known nobelium half-lives in Fig. 8 and a known half-life of only 1 ms for ^{258}No. Thus, an assignment to No is supported by our cross bombardments but would be surprising in view of the nobelium half-life systematics."

Table 3
direct α emission from ^{244}Pu*, $J^\pi = 0^+$, $T_{1/2}$ = 8.12(3)×10^7 y**, BR_α = 99.876(6)%**.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{240}U)	coincident γ-rays (keV)	R_0 (fm)	HF
4.622(1)	4.546(1)	24.1(10)%	19.4(8)%	2^+	0.043(1)	43	1.50549(82)	1.95(8)
4.665(1)	4.589(1)	100%	80.6(8)%	0^+	0.0	——	1.50549(82)	0.989(11)

* All values from [1969Be06], except where noted. E_α values are adjusted by +2.0 keV as recommended by [1991Ry01].
** Deduced from partial half-life of SF = 6.56(30)×10^{10} y [1983Mo02].

Table 4
direct α emission from ^{248}Cm*, $J^{\pi} = 0^+$, $T_{1/2} = 3.487(20)\times10^5$ y**, $BR_{\alpha} = 91.58(51)\%$**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J_f^{π}***	$E_{daughter}$(^{244}Pu)	coincident γ-rays (keV)	R_0 (fm)	HF
4.8541(15)	4.7758(15)	$\leq$0.01%	$\leq$0.009%	6^+	0.3130***	163.1***	1.49627(74)	>58
5.01181(50)	4.93097(50)	0.093(15)%	0.070(1)%	4^+	0.1499		1.49627(74)	107^{+21}_{-15}
5.11743(25)	5.03489(25)	22.02(26)%	16.51(20)%	2^+	0.0442		1.49627(74)	2.326(31)
5.16166(25)	5.07841(25)	100.00	74.99(56)%		0.00	——	1.49627(74)	1.000(10)

* All values from [1977Ba69], except where noted. E_{α} values are adjusted by -0.17 keV as recommended by [1991Ry01].
* Deduced from weighted average of $t_{1/2}(\alpha) = 3.703(32)\times10^5$ y and $t_{1/2}$(SF = $4.115(34)\times10^6$ y [1971Mc19], $t_{1/2}(\alpha) = 3.94(4)\times10^5$ y and $t_{1/2}$(SF = $4.20(5)\times10^6$ y [1971Ma32] and $t_{1/2}(\alpha) = 3.84(4)\times10^5$ y and $t_{1/2}$(SF = $4.22(12)\times10^6$ y [1969Me01].
*** [2017Ne10]
@ The much lower than expected HF makes this branch reported by [1977Ba69] questionable.

Table 5
direct α emission from ^{252}Cf, $J^{\pi} = 0^+$, $T_{1/2} = 2.6483(10)$ y*, $BR_{\alpha} = 96.8972(27)\%$**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J_f^{π}@@	$E_{daughter}$(^{248}Cm)@@	coincident γ-rays (keV)@@	R_0 (fm)	HF
5.707	5.616***	$\approx7\times10^{-5}$%	$\approx6\times10^{-5}$%	8^+	0.5064	207.4	1.50113(23)	$\approx2.8\times10^3$
5.9202	5.8262***	2×10^{-3}%	2×10^{-3}%	6^+	0.2989	155.1	1.50113(23)	1.3×10^3
6.0729	5.9765***	0.24%	0.2%	4^+	0.1438	100.4	1.50113(23)	78
6.17362(11)	6.07563(11)	18.4(6)%	15.0(5)%@@@	2^+	0.0434	43.4	1.50113(23)	3.28(11)
6.21678(4)	6.11810(4)	100.0(4)%	81.7(4)%@@@	0^+	0.0	——	1.50113(23)	0.997(4)

* Value from evaluated data [2022Th06].
** [2018Be29].
*** [1970Ba18]. E_{α} values adjusted by +1.5 keV due to calibration changes.
@ [1986Ry04]. E_{α} values adjusted by -0.14 keV as recommended in [1991Ry01].
@@ [2014Ma86].

Table 6
direct α emission from ^{256}Fm*, $J^{\pi} = 0^+$, $T_{1/2} = 157(2)$ m*, $BR_{\alpha} = 8.1(3)\%$*.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J_f^{π}***	$E_{daughter}$(^{244}Pu)	coincident γ-rays (keV)	R_0 (fm)	HF
6.983	6.874**	16.3(24)%@	1.1(2)%	2^+	0.0457@@	45.7@@	$3.8^{+0.7}_{-0.5}$	
7.0248(20)	6.915(20)***	100%@	7.0(3)%	0^+	0.0	——	1.4989(35)	0.97(5)

* [1968Ho13].
** Deduced from the level energy. Original value from [1970Fi12] = 6.868 MeV.
*** [2019Ah04].
@ [1970Fi12].
@@ [2021Ma19].

Table 7
direct α emission from ^{272}Hs*, $J^{\pi} = 0^+$, $T_{1/2} = 160^{+190}_{-60}$ ms, $BR_{\alpha} = 100\%$.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{268}Sg)	coincident γ-rays (keV)	R_0 (fm)	HF
9.772(21)	9.628(21)	100%	0^+	0.0	——	1.484(72)	$2.5^{+3.0}_{-1.0}$

* All values from [2023Og03].

Table 8
direct α emission from ^{276}Ds*, $J^{\pi} = 0^+$, $T_{1/2} = 150^{+100}_{-40}$ μs, $BR_{\alpha} = 43^{+15}_{-18}\%$.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J_f^{π}	$E_{daughter}$(^{268}Sg)	coincident γ-rays (keV)	R_0 (fm)	HF
10.904(28)	10.746(28)	$43^{+15}_{-18}\%$	0^+	0.0	——		

* All values from [2023Og03].

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