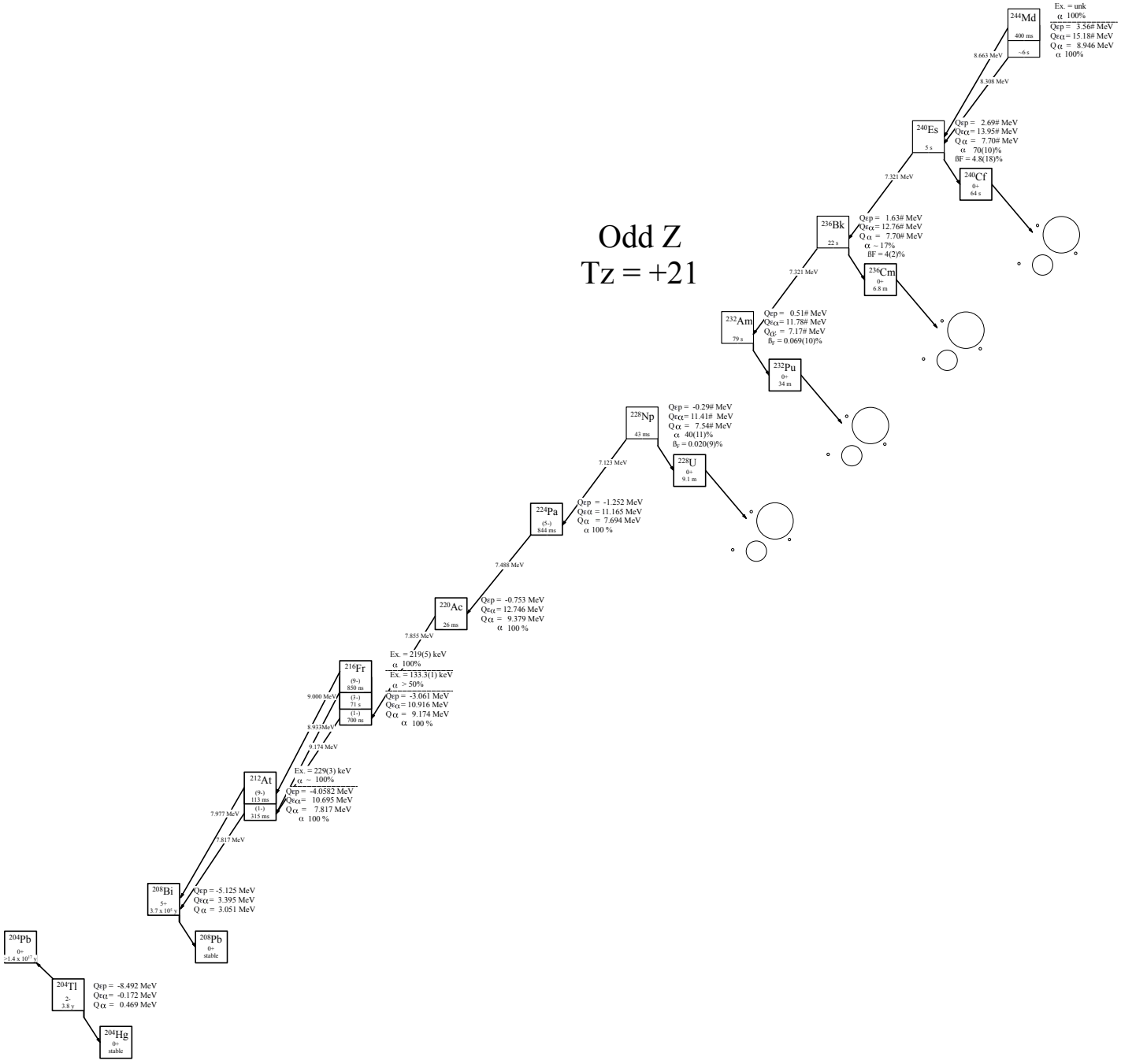

Fig. 1: Known experimental values for heavy particle emission of the even-Z T_z= +1/2 nuclei.

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_{ε_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^+	$3.68(4) \times 10^5$ 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			$\approx$ 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)	$\approx$ 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)	$\approx$ 100%	[**1997Sh09**, 2007Ku30, 2003Ni10, 1971EpZY, 1971HyZX, 1970Bo13]
^{224}Pa	2.812(11)	7.337(9)	7.694(4)	$\approx$ 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)#	$\approx$ 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)	$\approx$100%	[**2020Po07, 2020Kh08**]
^{244m}Md	1.01(40)#-x	3.78(45)#-x	8.947(79)+x	$\approx$100%	[**2020Po07**]

Table 3
direct α emission from ^{212}At*, $J^\pi = 1^-$, $T_{1/2}$ = 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*, $J^{\pi} = 1^{-}$, $T_{1/2}$ = 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, $J^{\pi} = 9^{-}$, $T_{1/2}$ = 112.6(9) ms**, $BR_{\alpha} = \approx 100\%$.

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*, $J^{\pi} = (1^{-})$, $T_{1/2}$ = 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)	$\approx 0.2\%$	$\approx 0.2\%$	(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, $J^{\pi} = (3^{-})$, $T_{1/2}$ = 71(5) ns**, $BR_{\alpha} = \approx 50\%$***.

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)	$\approx 50\%$***	(3^{-})	0.2053	0.045, 0.1603	1.5498(28)	$\approx 0.21^{@@@}$

* 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} = $\approx$ 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	$\approx$8%	$\approx$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} = $\approx$ 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**, $BR_\alpha = \approx 100\%$.

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_f^π	$E_{daughter}$(^{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*, $BR_\alpha = \approx 17$ %*.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{232}Am)	coincident γ-rays	R_0 (fm)***	HF
7.447(14)	7.321(14)**	$\approx$ 17%*				1.515(26)	$\approx$ 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_f^π	$E_{daughter}$(^{236}Bk)	coincident γ-rays	R_0 (fm)	HF
8.227(30)	8.090(30)	$\approx$ 25%	$\approx$14%					
8.329(30)	8.190(30)	100%	$\approx$56%					

* All values from [2017Ko02].

Table 13
direct α emission from ^{244}Md, $T_{1/2} = \approx 6$ s, $BR_\alpha = \approx 100\%$.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{240}Es)	coincident γ-rays	R_0 (fm)	HF
8.446(19)	8.308(19)	$\approx$ 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, $BR_\alpha = \approx 100\%$.

E_α(c.m.)	E_α(lab)	I_α(abs)	J_f^π	$E_{daughter}$(^{240}Es)	coincident γ-rays	R_0 (fm)	HF
8.807(23)	8.663(23)	$\approx$ 100%					

* All values from [2020Po07].

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