

Odd Z
 $T_z = +19/2$

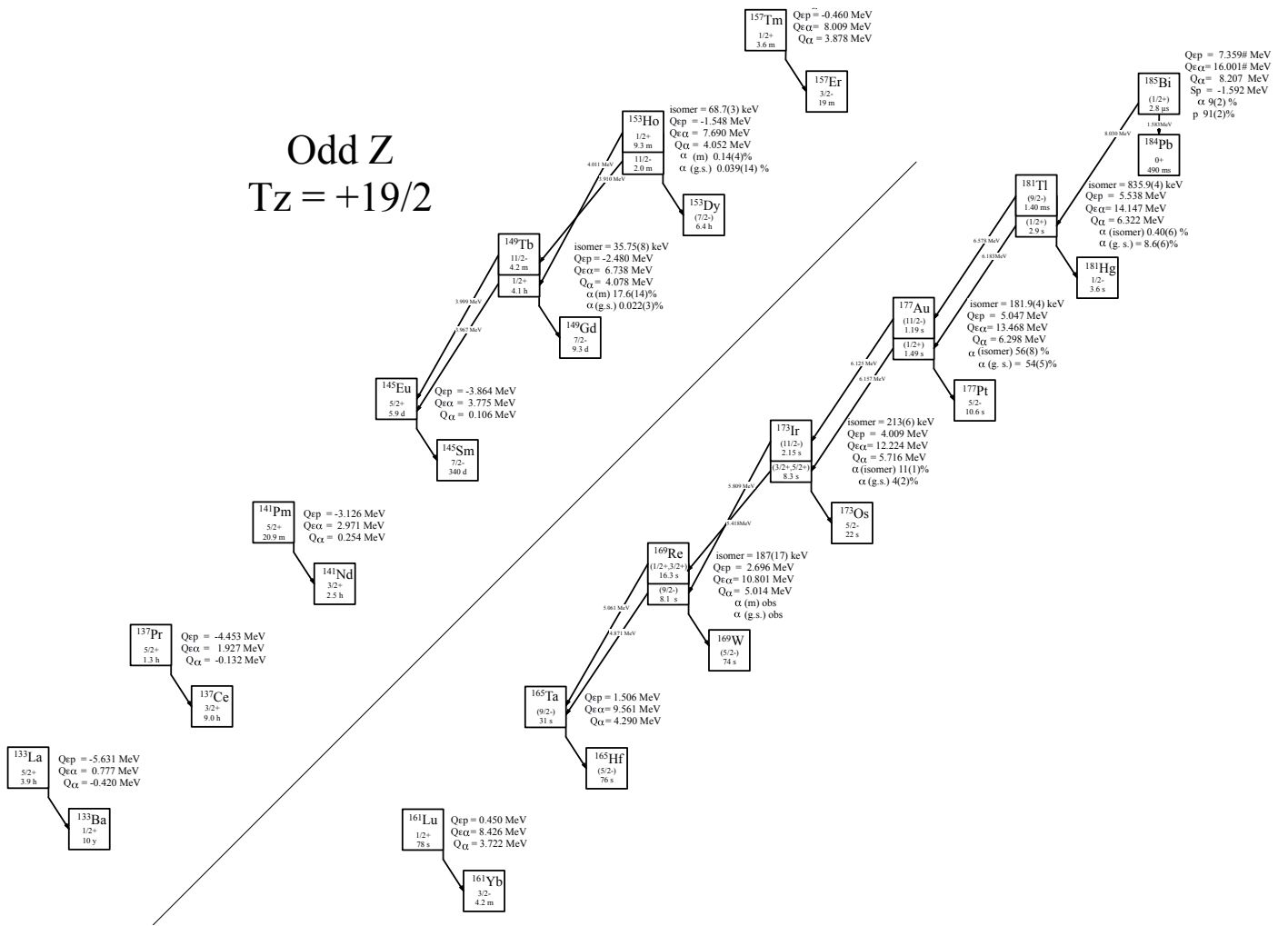


Fig. 1: Known experimental values for heavy particle emission of the odd-Z $T_z = +19/2$ nuclei.

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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	$Q_{\epsilon p}$	$Q_{\epsilon\alpha}$	$\text{BR}_{\beta F}$	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)		[1967Bi27]
^{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]
$^{181m}\text{Tl}^e$	0.8359(4)	$(9/2^-)$	1.40(3) ms	7.862(18)	5.538(10)	14.983(18)		[2009An14]
^{185}Bi		$(1/2^+)$	$2.8_{-10}^{+23} \mu\text{s}$	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, 1992BiZW, 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)% [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 $Q_\alpha = 8.138(81)\#$ 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 3direct α emission from ^{149}Tb , $J^\pi = 1/2^+$, $T_{1/2} = 4.13(5)$ h*, $BR_\alpha = 17.6(14)\%^{**}$.

E_α (c.m.)	E_α (lab)	I_α (rel)	I_α (abs)	J_f^π	$E_{daughter}(^{145}\text{Eu})$	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 , $E_x = 35.75(8)$ keV, $J^\pi = 11/2^-$, $T_{1/2} = 4.16(4)$ m**, $BR_\alpha = 0.022(3)\%^{***}$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{145}\text{Eu})$	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 , $J^\pi = 11/2^-$, $T_{1/2} = 2.02(3)$ m*, $BR_\alpha = 0.039(14)\%^{**}$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{149m}\text{Tb})$	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 6direct α emission from ^{153m}Ho , $E_x = 68.7(3)$ keV*, $J^\pi = 1/2^+$, $T_{1/2} = 9.3(5)$ m**, $BR_\alpha = 0.14(4)\%^{***}$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{149}\text{Tb})$	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 $^{169}\text{Re}^*$, $J^\pi = (9/2^-)$, $T_{1/2} = 8.1(3)$ s, $BR_\alpha = \text{obs}$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{165}\text{Ta})$	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 8direct α emission from $^{169m}\text{Re}^*$, $E_x = 187(7)$ keV, $J^\pi = (1/2^+, 3/2^+)$, $T_{1/2} = 16.3(8)$ s, $BR_\alpha = \text{obs.}$

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{149}\text{Tb})$	coincident γ -rays	R_0 (fm)	HF
5.184(10)	5.061(10)			x		1.571(21)	

* All values taken from [1992Me10].

Table 9direct α emission from ^{173}Ir , $J^\pi = (3/2^+, 5/2^+)$, $T_{1/2} = 8.3(3)$ s*, $BR_\alpha = 4(2)\%^{**}$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{169}\text{Re})$	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 10direct α emission from $^{173m}\text{Ir}^*$, $E_x = 213(16)$ keV, $J^\pi = (11/2^-)$, $T_{1/2} = 2.150(47)$ s**, $BR_\alpha = 11(1)\%^{***}$.

E_α (c.m.)	E_α (lab)	I_α (rel)	I_α (abs)	J_f^π	$E_{daughter}(^{169}\text{Re})$	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 11direct α emission from ^{177}Au , $J^\pi = (1/2^+)$, $T_{1/2} = 1.486(20)$ s*, $BR_\alpha = 54(5)\%^{**}$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{173}\text{Ir})$	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 12direct α emission from $^{177m}\text{Au}^*$, $E_x = 181.9(4)$ keV, $J^\pi = (11/2^-)$, $T_{1/2} = 1.186(12)$ s**, $BR_\alpha = 56(8)\%$.

E_α (c.m.)	E_α (lab)	I_α (rel)	I_α (abs)	J_f^π	$E_{daughter}(^{173}\text{Ir})$	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 13direct α emission from $^{181}\text{Tl}^*$, $J^\pi = (1/2^+)$, $T_{1/2} = 2.9(1)$ s, $BR_\alpha = 8.6(6)\%$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{177}\text{Au})$	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 14direct α emission from $^{181m}\text{Tl}^*$, Ex. = 836.9(4) keV, $J^\pi = (9/2^-)$, $T_{1/2} = 1.40(3)$ ms, $BR_\alpha = 0.40(6)\%$.

E_α (c.m.)	E_α (lab)	I_α (rel)	I_α (abs)	J_f^π	$E_{daughter}$ (^{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} $\times 10^3$

* All values from [2009An14], except where noted.

Table 15direct p emission from ^{185}Bi , $J^\pi = (1/2^+)$, $T_{1/2} = 2.8^{+23}_{-10}$ μs^* , $BR_p = 91(2)\%^{**}$.

E_p (c.m.)	E_p (lab)	I_p (abs)	J_f^π	$E_{daughter}$ (^{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 16direct α emission from ^{185}Bi , $J^\pi = (1/2^+)$, $T_{1/2} = 2.8^{+23}_{-10}$ μs^* , $BR_\alpha = 9(2)\%^{**}$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}$ (^{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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