Comments Dataset for ^{213} *

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Abstract: Evaluated spectroscopic data and level schemes from radioactive decay and nuclear reaction studies are presented for all nuclei with mass number A=213. This evaluation for A=213 supersedes the earlier one by Y. A. Akovali (1992Ak01), published in Nuclear Data Sheets 66, 237 (1992).

Cutoff Date: All data received prior to November 1, 2006, have been considered.

General Policies and Organization of Material: See the January issue of the *Nuclear Data Sheets* or http://www.nndc.bnl.gov/nds/NDSPolicies.pdf.

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From NNDC(BNL)
program ENSDAT

$^{213}_{82}Pb_{131}$–1

Adopted Levels

Q(β⁻)=2046 *9*; S(n)=3708 *8*; S(p)=8800 *SY*; Q(α)=2740 *SY* 2003Au03.
ΔS(p)=300(syst), ΔQ(α)=200(syst) 2003Au03.
Assignment: descendant of ^{221}Rn, parent of ^{213}Bi (1964Bu05).
Nuclear charge radius was calculated by 1987Za02 using the HFB method. The calculations were done including a separable four–body interaction and also a three–body contact force in the procedure. Their calculations, which were carried out also for other lead nuclei as well as for mercury isotopes in the region and for tin isotopes, by using an effective interaction, reproduced the odd–even staggering. These calculations were compared with experiments.
See also 1984He17 for calculated lead radii relative to ^{208}Pb radius.
Isotope shifts of lead nuclei were calculated by 1987Sa51 by including perturbations due to giant monopole and giant quadrupole resonances.
Isotope shifts and nuclear charge radii were calculated by 1990Du03 for lead isotopes by using an enlarged superfluid model.

^{213}Pb Levels

Cross Reference (XREF) Flags

A ^{217}Po α Decay

E(level)	Jπ	XREF	$T_{1/2}$	Comments
0.0	(9/2+)	A	10.2 min *3*	%β⁻=100. $T_{1/2}$: From 1964Bu05: measured from growth of ^{213}Bi. Jπ: favored α decay (HF=1.3) strongly suggest a $g_{9/2}$ to $g_{9/2}$ transition between ^{217}Po and ^{213}Pb ground states (2004Li28). Also from analogy to ^{215}Po and ^{217}Rn isotones. Suggested configuration=(ν $g_{9/2}$).

^{217}Po α Decay 2004Li28,1997Li23,1977Vy02

Parent ^{217}Po: E=0.0; Jπ=(9/2+); $T_{1/2}$=1.46 s *5*; Q(g.s.)=6660 *4*; %α decay>95.0.
2004Li28: Parent: ^{221}Rn; studied ^{217}Po level structure and g.s. of ^{213}Pb through α decay; measured $T_{1/2}$ of ^{217}Po, α–γ coin.
1997Li23: Parent: ^{221}Rn; studied ^{217}Po level structure and g.s. of ^{213}Pb through α decay, α–γ coin.
1977Vy02: Parent: ^{221}Rn; studied ^{217}Po, ^{213}Pb, and ^{213}Po level structure, Eα, Eγ, Iγ. ^{213}Pb through α decay.

^{213}Pb Levels

E(level)	Jπ	Comments
0.0	(9/2+)	Jπ: From adopted levels.

α radiations

Eα	E(level)	Iα‡	HF†	Comments
6537 *4*	0.0	100	1.30 *6*	Eα: measurement of 1977Vy02 (s). Original α energy of 1977Vy02 is decreased by 2 keV, as recommended by 1991Ry01, because of a change in calibration energy. Other measurement: 1956Mo15. Iα: no other α groups were observed; if they exist, Iα≤5% of the Iα(6537α) (1977Vy02).

† Using $r_0(^{213}Pb)$=1.5393 *11*; average of $r_0(^{212}Pb)$=1.5408 *9* and $r_0(^{214}Pb)$=1.5379 *7* (1998Ak04), 95<%α≤100.
‡ For α intensity per 100 decays, multiply by >0.95.

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From NNDC(BNL)
program ENSDAT

$^{213}_{83}Bi_{130}$−1

Adopted Levels, Gammas

Q(β⁻)=1423 *5*; S(n)=5185 *5*; S(p)=4972 *5*; Q(α)=5982 *6* 2003Au03.

^{213}Bi Levels

Cross Reference (XREF) Flags

A ^{217}At α Decay

E(level)†	Jπ	XREF	$T_{1/2}$	Comments
0.0	9/2−	A	45.59 min *6*	Jπ: Favored α decay (HF=1.16) from 9/2− g.s. of ^{217}At. μ=+3.717 *13*. μ: Weighted average of +3.716 *7* (from laser spectroscopy (2000Pe30,1997Ki15)) and +3.89 *9* (from γ(θ,t) (1992Li25)). Q=−0.60 *5*. Q: Laser spectroscopy (2000Pe30, 1997Ki15). %α=2.20 *10*; %β⁻=97.80 *10*. %β⁻ from 1997Ch53. %α=2.20 *10* by the evaluator. %α=2.16 *11* was deduced in 1964Gr11. Others: 1947En03, 1950Ha52. $T_{1/2}$: From 1973Po16. Others: 46 min (1947En03), 47 min *1* (1950Ha52), 46 min *1* (1964Gr11).
257.87 *11*	7/2−	A		Jπ: 257.9γ M1+E2 to 9/2− state. Unfavored α decay (HF=404).
593.18 *13*	(5/2,7/2,9/2)−	A		Jπ: 593.1γ to 9/2− state, 335.3γ to 7/2− state.
758.90 *10*	(5/2−,13/2−)	A		Jπ: 758.9γ to 9/2− state.
1050		A		E(level): From 6037α feeding from ^{217}At.

† From a least squares fit to the γ−ray energies.

γ(^{213}Bi)

E(level)	Eγ†	Iγ†	Mult.	δ	α	Comments
257.87	257.90 *12*	100	M1+E2	0.64 *8*	0.555 *19*	α(K)=0.434 *17*; α(L)=0.0918 *16*; α(M)=0.0221 *4*; α(N+..)=0.00691 *11*. α(N)=0.00565 *9*; α(O)=0.001132 *19*; α(P)=0.000126 *3*. Mult.: M1+E2 from α(K)exp=0.45 *4* in ^{217}At α decay (1997Ch19). M1 in 1969LeZW from (α)(K x ray)/(α)(γ) coincidence. δ: Deduced by the evaluator from α(K)exp=0.45 *4*.
593.18	335.33 *10*	54 *3*				
	593.1 *2*	100 *4*				
758.90	758.9 *1*	100				

† From ^{217}At α decay.

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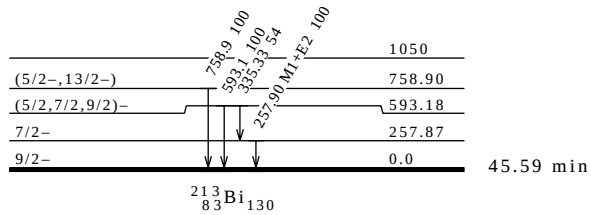
From NNDC(BNL)
program ENSDAT

$^{213}_{83}Bi_{130}$–2

Adopted Levels, Gammas (continued)

Level Scheme

Intensities: relative photon branching from each level



^{217}At α Decay 1997Ch19,1997Ch53,1967Dz02

Parent ^{217}At: E=0.0; Jπ=9/2−; $T_{1/2}$=32.3 ms *4*; Q(g.s.)=7201.3 *12*; %α decay=?

Others: 1969LeZW (αγ,semi), 1964Va20 (αγ,scin), 1962Wa28, 1960Vo05, 1955St04.

1997Ch19: Source: Separated ^{225}Ac from ^{229}Th; Detector: Si(Au) α–detector, HPGe γ–detector; Measured: Eα, Iα, Eγ, Iγ, α–γ coin.

1997Ch53: Source: Separated ^{225}Ac from ^{229}Th; Detector: Si(Au)–α–detector, Measured: Eα.

^{213}Bi Levels

E(level)†	Jπ‡	$T_{1/2}$	Comments
0.0	9/2−	45.59 min *6*	$T_{1/2}$: From adopted levels.
257.87 *11*	7/2−		
593.18 *13*	(5/2,7/2,9/2)−		
758.90 *10*	(5/2−,13/2−)		
1050			E(level): From 1997Ch53.

† From a least squares fit to the γ–ray energies. The 465–keV level in ^{213}Bi, reported earlier in 1969Dz02 feeding through 6609–keV α from ^{217}At, is not confirmed by 1997Ch53, instead the 6609α is assigned to ^{221}Ra (1997Ch53).

‡ From adopted levels.

α radiations

Eα†	E(level)	Iα‡	HF§	Comments
6037	1050	<0.002		Eα: From 1997Ch53. In 1968Le07 and 1967Dz02, the 6037α is shown from ^{221}Fr.
6322.0 *16*	758.90	0.005 *1*	36 *8*	
6484.7 *16*	593.18	0.021 *2*	39 *4*	Eα: 6483 *5* (adjusted value in 1991Ry01). Iα: Weighted average of 0.02 *1* (1969LeZW) and 0.021 *2* (1997Ch19).
6813.8 *16*	257.87	0.036 *3*	404 *36*	Eα: 6812 *5* (adjusted value in 1991Ry01). Iα: 0.06 *2* (1969LeZW).
7066.9 *16*	0.0	99.9 *1*	1.16 *4*	Eα: 7066.9 *15* (adjusted value in 1991Ry01), 7062 *5* (1977Vy02), 7071 *2* (1982Bo04). Iα: From 1969LeZW. Iα=99.9 (1997Ch19).

† From 1997Ch19. α's 6849–, 6772–, 6541–, and 6422–keV reported in 1967Dz02 were not confirmed in 1997Ch19,1997Ch53, and 1969LeZW. These α's are assumed to be due to contaminants and they are not listed here.

‡ From 1997Ch19, except otherwise noted. In 1997Ch19, Iα per 100 ^{217}At decays is reported, assuming the absence of γ–feeding from higher–lying unknown levels.

§ $r_0(^{213}Bi)$=1.550 *8*, average of $r_0(^{212}Pb)$=1.5408 *9* and $r_0(^{214}Po)$=1.559 *8* (1998Ak04).

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From NNDC(BNL)
program ENSDAT

$^{213}_{83}Bi_{130}$–3

^{217}At α Decay 1997Ch19,1997Ch53,1967Dz02 (continued)

γ(^{213}Bi)

Iγ normalization: from 1997Ch19.

Eγ†	E(level)	Iγ‡§	Mult.	δ	α	Comments
x165.8		<0.0002				Eγ: Reported both in 1997Ch19 and 1964Va20.
257.90 *12*	257.87	0.0287 *7*	M1+E2	0.64 *8*	0.555 *19*	α(K)=0.434 *17*; α(L)=0.0918 *16*; α(M)=0.0221 *4*; α(N+..)=0.00691 *11*. α(N)=0.00565 *9*; α(O)=0.001132 *19*; α(P)=0.000126 *3*. Eγ: Weighted average of 257.88 *4* (1997Ch19) and 258.5 *2* (1981Di14). Iγ: 0.056 *20*, multiplying Iγ=0.239 *20* (relative) in 1980Di14 with a normalizing factor of 0.236 *6*, deduced comparing 218γ Iγ=49 (1981Di14) of ^{221}Fr to 11.57% *15* (absolute) (1986He06). 218γ Iγ is deduced to be of 11.2% *2* (absolute) in 1997Ch19. Mult.: M1+E2 from α(K)exp=0.45 *4* (1997Ch19). M1 from (α)(K x ray)/(α)(γ) coincidence (1969LeZW). δ: Deduced by the evaluator from α(K)exp=0.45 *4* (deduced in 1997Ch19).
335.33 *10*	593.18	0.0062 *3*				Eγ: 334 in 1969LeZW.
x501.0		<0.0002				
593.1 *2*	593.18	0.0115 *5*				Iγ: 0.018 *6*, multiplying Iγ=0.0507 *25* (relative) in 1980Di14 with a normalizing factor of 0.236 *6*, deduced comparing 218γ Iγ=49 (1981Di14) of ^{221}Fr to 11.57% *15* (absolute) (1986He06). 218γ Iγ is deduced to be of 11.2% *2* (absolute) in 1997Ch19.
758.9 *1*	758.90	0.0049 *4*				

† From 1997Ch19. γ's 140–, 375–, and 455–keV, not placed in the level scheme, are reported in 1964Va20. These are not confirmed by 1997Ch19 and 1969LeZW. The reported 218γ in 1969LeZW is not also confirmed by 1997Ch19. These γ could arise due to summing effect or remnant of random coincidence peaks (1997Ch19). These γ are not listed here.

‡ From 1997Ch19, absolute photon intensity per 100 ^{217}At decays.

§ Absolute intensity per 100 decays.

x γ ray not placed in level scheme.

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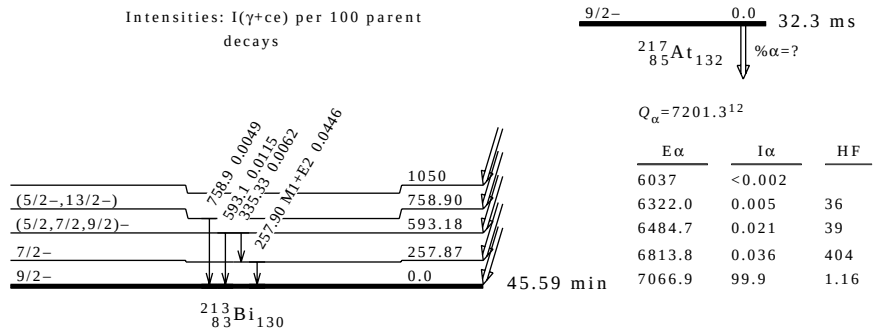
From NNDC(BNL)
program ENSDAT

$^{213}_{83}Bi_{130}$−4

^{217}At α Decay 1997Ch19,1997Ch53,1967Dz02 (continued)

Decay Scheme

Intensities: I(γ+ce) per 100 parent decays



Q_α=7201.3[12]

Eα	Iα	HF
6037	<0.002	
6322.0	0.005	36
6484.7	0.021	39
6813.8	0.036	404
7066.9	99.9	1.16

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From NNDC(BNL)
program ENSDAT

$^{213}_{84}Po_{129}$−1

Adopted Levels, Gammas

Q(β⁻)=−74 *5*; S(n)=4355 *3*; S(p)=5825 *3*; Q(α)=8536 *3* 2003Au03.

^{213}Po Levels

Cross Reference (XREF) Flags

A ^{213}Bi β⁻ Decay
B ^{217}Rn α Decay

E(level)†	Jπ‡	XREF	$T_{1/2}$	Comments
0.0	9/2+	AB	3.72 μs *2*	%α=100. Jπ: favored α decay to ^{209}Pb g.s. $T_{1/2}$: Weighted average of 3.65 μs *4* (1998Wa25), 3.75 μs *4* (1997Wa27), 3.70 μs *3* (1997VaZV), and 3.74 μs *2* (1995WaZQ). Unweighted average 3.71 μs *2*. Others: 4.2 μs *8* (1948Je05), and 3.65 μs (2002Mo46).
292.800 *11*	(11/2+)	A	78 ps *14*	Jπ: 292.78γ (M1+E2) to 9/2+ state. $T_{1/2}$: From delayed γγ–coin in ^{213}Bi β⁻ decay (1997Wa27).
440.450 *9*	7/2+	A	93 ps *14*	%α=0.001. %α from 1997Wa27. Jπ: 440γ M1 to 9/2+ state. log *ft*=6.1 in 9/2− ^{213}Bi β⁻ decay. HF≥70 estimated in 1997Wa27. $T_{1/2}$: From β–γ coincidences in ^{213}Bi β⁻ decay (1997Wa27).
600.73? *22*	(5/2+)	A		
867.98 *3*	(13/2+)	A		
1003.553 *10*	(9/2+)	A		
1045.67 *9*	(9/2+,11/2+)	A		
1100.167 *12*	(7/2,9/2,11/2)	A		
1119.291 *10*	(7/2,9/2,11/2)	A		
1328.2 *3*	(7/2,9/2,11/2)	A		

† Deduced by evaluator from a least square fit to the γ–ray energies.
‡ From 1998Ar03 (^{213}Bi β⁻ decay). In 1998Ar03, semiempirical shell–model calculation results were compared as a guide for parity and spin assignments. Additional arguments are given as comments.

γ(^{213}Po)

E(level)	Eγ†	Iγ†	Mult.†	δ†	α	Comments
292.800	292.78 *2*	100	(M1+E2)	1.0	0.338	B(M1)↓(W.u.)=(0.0042 *8*); B(E2)↓(W.u.)=(17 *3*). α(K)=0.255 *4*; α(L)=0.0626 *9*; α(M)=0.01534 *22*; α(N+..)=0.00484 *7*. α(N)=0.00394 *6*; α(O)=0.000802 *12*; α(P)=9.43×10⁻⁵ *14*. Mult.,δ: Mult: from α(K)exp=0.0010 *3* (1998MaZO). δ=1.0 from 1998MaZO.
440.450	147.66 *2*	0.057 *4*	(E2)		1.454	B(E2)↓(W.u.)=0.55 *10*. α(K)=0.307 *5*; α(L)=0.850 *12*; α(M)=0.226 *4*; α(N+..)=0.0701 *10*. α(N)=0.0580 *9*; α(O)=0.01109 *16*; α(P)=0.001015 *15*. Mult.: B(E2)=0.0031 *6* (1997Wa27) is close to the B(E2, 2+ to 0+) values of the neighboring nuclei.
	440.46 *1*	100 *1*	M1		0.179	B(M1)↓(W.u.)=0.0023 *4*. α(K)=0.1456 *21*; α(L)=0.0252 *4*; α(M)=0.00593 *9*; α(N+..)=0.00189 *3*. α(N)=0.001527 *22*; α(O)=0.000320 *5*; α(P)=4.13×10⁻⁵ *6*.
600.73?	600.7 *3*	100				
867.98	574.8 *3*	23 *9*	[M1+E2]		0.06 *4*	α(K)=0.04 *3*; α(L)=0.009 *4*; α(M)=0.0021 *9*; α(N+..)=0.0007 *3*. α(N)=0.00053 *22*; α(O)=0.00011 *5*; α(P)=1.4×10⁻⁵ *7*.
	867.98 *3*	100 *10*				
1003.553	402.8 *3*	0.19 *5*	[E2]		0.0551	α(K)=0.0349 *5*; α(L)=0.01515 *22*; α(M)=0.00387 *6*; α(N+..)=0.001209 *18*. α(N)=0.000993 *15*; α(O)=0.000196 *3*; α(P)=2.07×10⁻⁵ *3*. α(N)=0.0015 *5*; α(O)=0.00030 *11*; α(P)=3.7×10⁻⁵ *16*.

Continued on next page (footnotes at end of table)

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From NNDC(BNL)
program ENSDAT

$^{213}_{84}Po_{129}$−2

Adopted Levels, Gammas (continued)

γ(^{213}Po) (continued)

E(level)	Eγ†	Iγ†	Mult.†	α	Comments
1003.553	710.81 *21*	20.9 *13*	[M1+E2]	0.033 *18*	α(K)=0.026 *16*; α(L)=0.0049 *22*; α(M)=0.0012 *5*; α(N+..)=0.00037 *16*. α(N)=0.00030 *13*; α(O)=6.×10^{-5} *3*; α(P)=8.×10^{-6} *4*.
	1003.55 *1*	100 *4*			
1045.67	604.9 *3*	13 *3*			
	1045.70 *9*	100 *17*			
1100.167	659.77 *2*	12.4 *7*			
	807.36 *1*	100 *4*			
	1100.13 *2*	87 *5*			
1119.291	826.47 *3*	13.7 *19*			
	1119.29 *1*	100 *4*			
1328.2	886.66‡ *14*	100 *19*			
	1328.2 *3*	40 *10*			

† From ^{213}Bi β$^-$ decay.

‡ Placement of transition in the level scheme is uncertain.

CITATION:
Nuclear Data Sheets (2007)

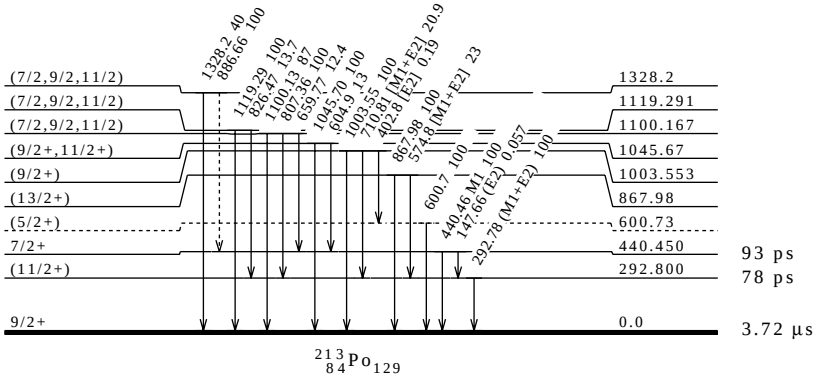
From NNDC(BNL)
program ENSDAT

$^{213}_{84}Po_{129}$–3

Adopted Levels, Gammas (continued)

Level Scheme

Intensities: relative photon branching from each level



^{213}Bi β⁻ Decay 1998Ar03,1997Wa27,1994Ar23

Parent ^{213}Bi: E=0.0; Jπ=9/2−; $T_{1/2}$=45.59 min *6*; Q(g.s.)=1423 *5*; %β⁻ decay=97.80 *10*.

Others: 1989Ko26, 2000Gr35, 2002Mo46, 1986He06, 1981Di14, 1977Vy02, 1955Ma61.

1998Ar03,1994Ar23: Source: Chemically separated ^{213}Bi; Detector: p–type coaxial HPGe and planar HPGe; Measured: Eγ, Iγ, γγ coin.

1997Wa27: Source: ^{213}Bi was accumulated on an Al foil from the recoil of ^{217}At decay; Measured: $T_{1/2}$ by the method of delayed coincidences in ^{213}Bi β⁻ decay.

1989Ko26: Source: Chemically separated ^{213}Bi; Detector: HPGe and LEPS (Low Energy Photon Spectrometer); Eγ, Iγ, γγ coin.

^{213}Po Levels

E(level)†	Jπ‡	$T_{1/2}$	Comments
0.0	9/2+	3.72 µs *2*	Jπ,$T_{1/2}$: From adopted levels.
292.798 *9*	(11/2+)	78 ps *14*	Jπ: 292.78γ (M1+E2) to (9/2+) state. $T_{1/2}$: From delayed γγ–coin in ^{213}Bi β⁻ decay (1997Wa27).
440.445 *9*	7/2+	93 ps *14*	%α=0.001. %α from 1997Wa27. Jπ: 440γ M1 to 9/2+ state. log *ft*=6.1 in 9/2− ^{213}Bi β⁻ decay. HF≥70 estimated in 1997Wa27. $T_{1/2}$: From β–γ coincidences in ^{213}Bi β⁻ decay (1997Wa27).
600.86? *15*	(5/2+)		
867.98 *3*	(13/2+)		
1003.553 *10*	(9/2+)		
1045.65 *9*	(9/2+,11/2+)		
1100.161 *11*	(7/2,9/2,11/2)		
1119.294 *10*	(7/2,9/2,11/2)		
1328.2 *3*	(7/2,9/2,11/2)		

† Deduced by evaluator from a least square fit to the γ–ray energies.

‡ From 1998Ar03, except otherwise noted. In 1998Ar03, semiempirical shell–model calculation results were compared as a guide for parity and spin assignments.

β⁻ radiations

Continued on next page (footnotes at end of table)

From NNDC(BNL)
program ENSDAT

$^{213}_{84}Po_{129}$–4

^{213}Bi β⁻ Decay 1998Ar03,1997Wa27,1994Ar23 (continued)

β⁻ radiations (continued)

Eβ⁻†	E(level)	Iβ⁻‡§	Log *ft*	Comments
(95 *5*)	1328.2	0.00040 *10*	7.67 *13*	av Eβ=24.6 *14*.
(304 *5*)	1119.294	0.059 *2*	7.08 *3*	av Eβ=84.9 *16*.
(323 *5*)	1100.161	0.587 *21*	6.17 *3*	av Eβ=90.8 *16*.
(377 *5*)	1045.65	0.020 *3*	7.85 *7*	av Eβ=107.9 *16*.
(419 *5*)	1003.553	0.064 *2*	7.499 *22*	av Eβ=121.4 *17*.
(555 *5*)	867.98	0.0137 *16*	8.57 *6*	av Eβ=166.4 *17*.
(822 *5*)	600.86?	0.0041 *8*	9.67 *9*	av Eβ=260.8 *19*.
(983 *5*)	440.445	30.79 *24*	6.070 *9*	av Eβ=320.4 *19*. Iβ⁻: 35% *3* of ^{213}Bi β⁻ decay was measured by 1968Va17, and 32% by 1952Wa24, 1955Ma61.
(1130 *5*)	292.798	0.229 *17*	8.41 *4*	av Eβ=376.8 *20*.
1420 *10*	0.0	65.9 *4*	6.318 *7*	av Eβ=492.2 *20*. Iβ⁻: 65% *3* of ^{213}Bi β⁻ decay was measured by 1968Va17.

† E(β⁻ to g.s.) is measurement of 1968Va17 (s). Other measurements: 1952Wa24, 1955Ma61. E(β⁻)'s to excited states are from Q(β⁻) and level energies.

‡ From intensity balance at each level.

§ Absolute intensity per 100 decays.

γ(^{213}Po)

x–rays (Po): 1972Dz14
I(Kα$_1$ x ray)=1.6%
I(Kα$_2$ x ray)=0.93%
I(Kβ$_1$ x ray)=0.35%
I(Kβ$_2$ x ray)=0.12%
these x–ray intensities were measured by 1972Dz14 in γ spectrum of ^{225}Ac and its daughters in equilibrium with it; intensities were normalized to ^{225}Ac γ's, given per 100 decays of ^{225}Ac. The uncertainties were assigned as 10–15%.
The expected total x–ray intensity from level scheme is 4.00% *5*.

Eγ†	E(level)	Iγ†a	Mult.&	δ	α	Comments
147.66 *2*	440.445	0.0150 *12*	(E2)		1.454	α(K)=0.307 *5*; α(L)=0.850 *12*; α(M)=0.226 *4*; α(N+..)=0.0701 *10*. α(N)=0.0580 *9*; α(O)=0.01109 *16*; α(P)=0.001015 *15*. Iγ: Weighted average of 0.0148 *12* (1998Ar03) and 0.022 *8* (2000Gr35). Mult.: B(E2)=0.0031 *6* (1997Wa27) is close to the B(E2, 2+ to 0+) values of the neighboring nuclei.
292.80 *1*	292.798	0.429 *7*	(M1+E2)	1.0	0.338	α(K)=0.255 *4*; α(L)=0.0626 *9*; α(M)=0.01534 *22*; α(N+..)=0.00484 *7*. α(N)=0.00394 *6*; α(O)=0.000802 *12*; α(P)=9.43×10^{-5} *14*. Eγ: Weighted average of 292.76 *5* (1998Ar03), 292.76 *1* (1994Ar05), and 292.81 *1* (2000Gr35). Iγ: Others: 0.40 *1* (2000Gr35), and 0.31 *4* (2002Mo46). Mult.,δ: Mult from α(K)exp=0.0010 *3* (1998MaZO). δ=1.0 was deduced by the evaluator from data in 1998MaZO.
402.8 *3*	1003.553	0.00010 *3*	[E2]		0.0551	α(K)=0.0349 *5*; α(L)=0.01515 *22*; α(M)=0.00387 *6*; α(N+..)=0.001209 *18*. α(N)=0.000993 *15*; α(O)=0.000196 *3*; α(P)=2.07×10^{-5} *3*. α(N)=0.0015 *5*; α(O)=0.00030 *11*; α(P)=3.7×10^{-5} *16*.
440.45 *1*	440.445	25.94 *15*	M1		0.179	α(K)=0.1456 *21*; α(L)=0.0252 *4*; α(M)=0.00593 *9*; α(N+..)=0.00189 *3*. α(N)=0.001527 *22*; α(O)=0.000320 *5*; α(P)=4.14×10^{-5} *6*. Eγ: Weighted average of 440.46 *1* (1998Ar03) and 440.44 *1* (2000Gr35). Iγ: Weighted average of 26.1 *3* (1998Ar03), 25.4 *3* (2000Gr35), and 26.1 *2* (2002Mo46).

Continued on next page (footnotes at end of table)

From NNDC(BNL)
program ENSDAT

$^{213}_{84}Po_{129}$−5

^{213}Bi β⁻ Decay 1998Ar03,1997Wa27,1994Ar23 (continued)

γ(^{213}Po) (continued)

Eγ[†]	E(level)	Iγ[†a]	Mult.[&]	α	Comments
574.9 *3*	867.98	0.0025 *10*	[M1+E2]	0.06 *4*	α(K)=0.04 *3*; α(L)=0.009 *4*; α(M)=0.0021 *9*; α(N+..)=0.0007 *3*. α(N)=0.00053 *22*; α(O)=0.00011 *5*; α(P)=1.4×10^{-5} *7*. Eγ: Weighted average of 574.8 *3* (1998Ar03), and 575.2 *5* (2000Gr35). Iγ: From 2000Gr35. Other: 0.00063 *17* (1998Ar03).
600.90 *17*	600.86?	0.0042 *8*			Eγ: Weighted average of 600.7 *3* (1998Ar03) and 601.0 *2* (2000Gr35). Iγ: From 2000Gr35. Other: 0.00070 *22* (1998Ar03).
604.94 *21*	1045.65	0.0023 *6*			Eγ,Iγ: From 2000Gr35. Other: Eγ=604.9 *3* and Iγ=0.00050 *18* (1998Ar03).
[x]646.03 *9*		0.00231 *22*			
659.75 *2*	1100.161	0.0361 *20*			Eγ: Weighted average of 659.77 *2* (1994Ar23) and 659.74 *2* (2000Gr35). Iγ: Others: 0.035 *11* (2002Mo46) and 0.044 *3* (2000Gr35).
710.81 *21*	1003.553	0.0111 *7*	[M1+E2]	0.033 *18*	α(K)=0.026 *16*; α(L)=0.0049 *22*; α(M)=0.0012 *5*; α(N+..)=0.00037 *16*. α(N)=0.00030 *13*; α(O)=6.×10^{-5} *3*; α(P)=8.×10^{-6} *4*. Iγ: Weighted average of 0.0102 *11* (1998Ar03), 0.0119 *10* (2000Gr35), and 0.015 *8* (2002Mo46).
807.36[§] *1*	1100.161	0.292[@] *12*			Iγ: Others: 0.283 *18* (2000Gr35) and 0.27 *2* (2002Mo46).
826.52 *6*	1119.294	0.0071 *10*			Eγ: Weighted average of 826.47 *4* (1994Ar23) and 826.59 *5* (2000Gr35). Iγ: Weighted average of 0.0062 *15* (1994Ar23) and 0.0077 *13* (2000Gr35).
867.98 *3*	867.98	0.0111 *11*			Iγ: Weighted average of 0.0111 *11* (1998Ar03) and 0.0123 *11* (2000Gr35); Other: 0.023 *13* (2002Mo46).
[x]880.91 *1*		0.0040 *4*			Eγ: From 2000Gr35. Other: 880.2 *3* (1998Ar03). Iγ: Weighted average of 0.0029 *10* (1998Ar03) and 0.0042 *4* (2000Gr35).
[x]884.6 *3*		0.00029 *10*			
886.66[b] *14*	1328.2	0.00102 *19*			
[x]897.0 *3*		0.00031 *9*			
1003.55[#] *1*	1003.553	0.053 *2*			Iγ: Weighted average of 0.050 *5* (1998Ar03), 0.054 *5* (1994Ar23), and 0.053 *3* (2000Gr35).
1045.70 *9*	1045.65	0.018 *3*			Iγ: Other: 0.034 *19* (2000Gr35).
1100.13[‡] *2*	1100.161	0.259 *16*			
1119.29[#] *1*	1119.294	0.052 *2*			Iγ: Weighted average of 0.054 *3* (1994Ar23) and 0.050 *3* (1998Ar03).
1328.2 *3*	1328.2	0.00040 *10*			Iγ: Weighted average of 0.00042 *15* (1994Ar23) and 0.00039 *14* (1998Ar03).

[†] From 1998Ar03, except otherwise noted.
[‡] Weighted average of 1994Ar23 and 1989Ko26.
[§] From 1989Ko26.
[#] From 1994Ar23.
[@] From 1986He06. The absolute photon intensities were measured from the decay of ^{229}Th and its daughters in equilibrium.
[&] From ce measurements of 1955Ma61 and 1969DzZZ, except otherwise noted.
[a] For absolute intensity per 100 decays, multiply by 1.0000 *11*.
[b] Placement of transition in the level scheme is uncertain.
[x] γ ray not placed in level scheme.

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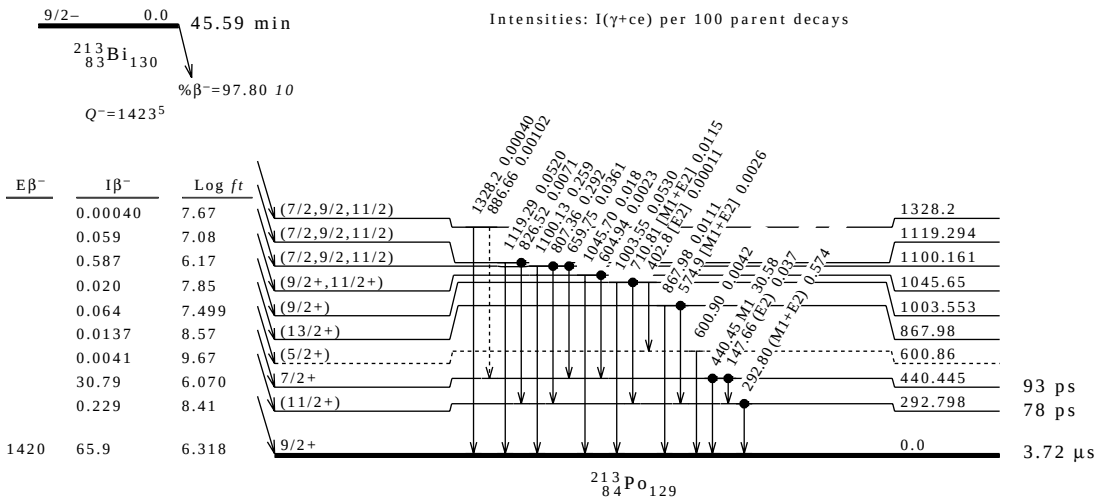
From NNDC(BNL)
program ENSDAT

$^{213}_{84}Po_{129}$–6

^{213}Bi β⁻ Decay 1998Ar03,1997Wa27,1994Ar23 (continued)

Decay Scheme

Intensities: I(γ+ce) per 100 parent decays



^{217}Rn α Decay

Parent ^{217}Rn: E=0.0; Jπ=9/2+; $T_{1/2}$=0.54 ms *5*; Q(g.s.)=7887 *3*; %α decay=100.

αγ: no (7735α)(γ,L x ray) (1961Ru06).

Another α peak at 7.50 MeV with an intensity of 0.1% was observed by 1961Ru06. The energy difference from the 7741–keV α, including the recoils, yields 243 keV for the level energy, if the 7500–keV α is from ^{217}Rn decay. The first excited state in ^{213}Po has been observed at 293 keV in ^{213}Bi decay. The observed α peak at 7.50 MeV may be due to an impurity; no positive identification could be made by 1961Ru06.

^{213}Po Levels

E(level)	Jπ	$T_{1/2}$	Comments
0.0	9/2+	3.72 μs *2*	Jπ,$T_{1/2}$: From adopted levels.

α radiations

Eα	E(level)	Iα‡	HF†	Comments
7741 *2*	0.0	100	1.49 *15*	Eα: From 1982Bo04. Original energy of 1982Bo04 is increased by 2 keV, as recommended by 1991Ry01, because of a change in calibration energy. Other measured value: Eα=7735 *4* (1961Ru06).

† Using $r_0(^{213}Po)$=1.562 *8*, average of $r_0(^{212}Po)$=1.5649 *8* and $r_0(^{214}Po)$=1.559 *8* (1998Ak04).

‡ Absolute intensity per 100 decays.

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From NNDC(BNL)
program ENSDAT

$^{213}_{85}At_{128}$–1

Adopted Levels, Gammas

Q(β⁻)=–881 *7*; S(n)=6030 *8*; S(p)=3499 *5*; Q(α)=9254 *5* 2003Au03.

Assignment: daughter of ^{229}Np, ^{225}Pa, ^{221}Ac, and ^{217}Fr (1968Ha14,1970Bo13).

Induced fission data from ^{209}Bi(α,f) reaction were taken, and fission barrier parameters were deduced by 1982Gr21, 1982Gr24, 1983Gr17, 1984Gr06, 1984Gr13, 1984Ig01, 1984It01, 1985It01, 1986Be20, 1986It01, 1987It03, and 1988Gr16.

See 1972Mo10, 1973Ba19, 1974Ba87, 1977Ha41, 1977Pr10, 1979Ad07, 1979Ig04, 1980Ig02, 1983Br06, 1983Br15, 1984Ni09, and 1984Ro23 for calculations of fission barriers and probabilities for decay by fission. Effective moment of inertia was calculated by 1982Ad01.

^{213}At Levels

Cross Reference (XREF) Flags

A ^{217}Fr α Decay
B ^{208}Pb(^{7}Li,2nγ),^{209}Bi(^{18}O,^{14}Cγ)
C ^{209}Bi(^{7}Li,p2nγ),^{209}Bi(^{8}He,4nγ)

E(level)†	Jπ‡	XREF	$T_{1/2}$	Comments
0.0	9/2–	ABC	125 ns *6*	%α=100. Possible ε decay to ^{213}Po g.s. is expected to be <2.5×10^{-12}% from log *ft*>5.1. Jπ: favored α decay to ^{209}Bi g.s. $T_{1/2}$: from 1981Bo29. Other measurements: <2 s (1968Ha14), 110 ns (1975LiZH), 110 ns *20* (1970Bo13). Probability for decay by ^{8}Be emission relative to α emission was calculated by 1986Pi11. See 1973Ma52 for theoretical calculations of α–decay probabilities. See also 1976De25 for absolute reduced Γ(α) obtained by analyzing ^{209}Bi(α) reaction cross sections. α clustering effects were studied by 1982Ka37.
340.5 *3*	(7/2–,9/2–)	B	≤5.5 ns@	Jπ: 340.5γ (M1+E2) to 9/2– state. Calculation for level energy indicates a $(\pi h_{9/2})^2(\pi f_{7/2})(\nu g_{9/2})^2$; 7/2– orbital configuration in addition to the $(\pi h_{9/2})^3(\nu g_{9/2})^2$ structure (1980Sj01).
724.6 *3*	(13/2–)	BC	≤5.5 ns@	Jπ: 724.6γ (E2) to 9/2– state.
1111.3 *5*	(15/2–)	BC	≤5.5 ns@	Jπ: 386.7γ (M1+E2) to (13/2–) state.
1129.7 *5*	(17/2–)	BC	≤5.5 ns@	Jπ: 405γ (E2) to (13/2–) state.
1318.1 *6*	(19/2–)	BC	≤5.5 ns@	Jπ: 188.4γ (M1+E2) to (17/2–) state.
1318.1+x		B	110 ns *17*	$T_{1/2}$: from (386.7γ)(t) in ^{208}Pb(^{7}Li,2nγ) (1980Sj01).
1319+y	(27/2–)§	C	85 ns#	
1682+y	(29/2+)§	C		
1838+y	(33/2+)§	C	82 ns#	
2194+y	(35/2–)§	C		
2570+y	(37/2–)§	C		
2620+y	(43/2–)	C	34.7 ns#	Jπ: from possible configuration: $\pi(h_{9/2})^2f_{7/2}\nu(g_{9/2}i_{11/2})$ and theoretical level energy calculation in 2003LaZZ. $T_{1/2}$: a 50–keV unobserved γ is introduced to understand the isomer (2003LaZZ).
2926+y	(49/2+)	C	45 μs *4*	Jπ: From possible configuration: $\pi(h_{9/2})^2i_{13/2}\nu(g_{9/2}i_{11/2})$ and theoretical level energy calculation (2003LaZZ). 306γ (E3) to 43/2– state. $T_{1/2}$: From a time spectrum of 306γ.

† Deduced by the evaluator from a least square fit to the γ–ray energies. Energy levels at 1319+y keV and above are from ^{209}Bi(^{7}Li,p2nγ). These level energies are about 235 keV less than the level energy presented in 2003LaZZ. Evaluator labeled these levels with '+y', because placement of some highly converted low energy γ–lines between (27/2–) and 19/2– states are not clear and the evaluator placed those gammas as unplaced in the ^{209}Bi(^{7}Li,p2nγ),^{209}Bi(^{8}He,4nγ) dataset.

‡ From γ–ray angular distribution in ^{208}Pb(^{7}Li,2nγ), except otherwise noted. Most low level energies are well produced from a $(\pi h_{9/2})^3(\nu g_{9/2})^2$ structure calculation, except the 340 keV level in ^{208}Pb(^{7}Li,2nγ) (1980Sj01).

§ From ^{208}Pb(^{7}Li,2nγ) (2003LaZZ), detailed arguments are not available.

From intermediate time spectra between different parts of γ–ray transitions in ^{209}Bi(^{7}Li,p2nγ) (2003LaZZ).

@ From ^{208}Pb(^{7}Li,2nγ),^{209}Bi(^{18}O,^{14}Cγ) (1980Sj01).

γ(^{213}At)

E(level)	Eγ†	Iγ	Mult.‡	α	Comments
340.5	340.5 *3*	100	(M1+E2)	0.24 *15*	α(K)=0.18 *14*; α(L)=0.043 *14*; α(M)=0.010 *3*; α(N+..)=0.0033 *9*. α(N)=0.0027 *8*; α(O)=0.00057 *17*; α(P)=7.×10^{-5} *3*.
724.6	724.6 *3*	100	(E2)	0.01473	α(K)=0.01106 *16*; α(L)=0.00278 *4*; α(M)=0.000683 *10*; α(N+..)=0.000218 *3*. α(N)=0.0001766 *25*; α(O)=3.67×10^{-5} *6*; α(P)=4.64×10^{-6} *7*.

Continued on next page (footnotes at end of table)

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From NNDC(BNL)
program ENSDAT

$^{213}_{85}At_{128}$−2

Adopted Levels, Gammas (continued)

γ(^{213}At) (continued)

E(level)	Eγ†	Iγ	Mult.‡	α	Comments
1111.3	386.7 *3*	100	(M1+E2)	0.17 *11*	α(K)=0.13 *10*; α(L)=0.029 *11*; α(M)=0.0071 *23*; α(N+..)=0.0023 *8*. α(N)=0.0018 *6*; α(O)=0.00038 *14*; α(P)=5.0×10^{-5} *22*.
1129.7	(18.4)				Transition was not observed. Its existence is inferred from the observed (188.4)(386.7γ) coincidences. Intensity balance at 1111.3 level yields I(γ+ce)(18.4)/Iγ(405.1γ)<1.2 *4*.
	405.1 *3*	100	(E2)	0.0568	α(K)=0.0354 *5*; α(L)=0.01600 *23*; α(M)=0.00410 *6*; α(N+..)=0.001302 *19*. α(N)=0.001061 *16*; α(O)=0.000215 *3*; α(P)=2.49×10^{-5} *4*.
1318.1	188.4 *3*	100	(M1+E2)	1.3 *7*	α(K)=0.9 *8*; α(L)=0.303 *15*; α(M)=0.076 *8*; α(N+..)=0.0243 *23*. α(N)=0.0197 *21*; α(O)=0.0041 *3*; α(P)=0.00049 *4*.
1682+y	363	100			
1838+y	156				
	520				
2194+y	356	100			
2570+y	376	100			
2620+y	(50)				Eγ: The 50−keV unobserved γ−ray is introduced to understand the isomer in ^{209}Bi(^{7}Li,p2nγ) (2003LaZZ).
2926+y	306	100	(E3)	0.707	B(E3)↓(W.u.)=40 *4*. α(K)=0.1715 *24*; α(L)=0.393 *6*; α(M)=0.1075 *15*; α(N+..)=0.0342 *5*. α(N)=0.0280 *4*; α(O)=0.00558 *8*; α(P)=0.000600 *9*. Mult.: From ^{209}Bi(^{7}Li,p2nγ) 2003LaZZ. Deduced E3 strength is 23 (2) W.u., compared to 26(1) W.u. in ^{212}At.

† From ^{208}Pb(^{7}Li,2nγ), except otherwise noted.
‡ From ^{208}Pb(^{7}Li,2nγ) (1980Sj01), based on γ(θ), except otherwise noted.

CITATION:
Nuclear Data Sheets (2007)

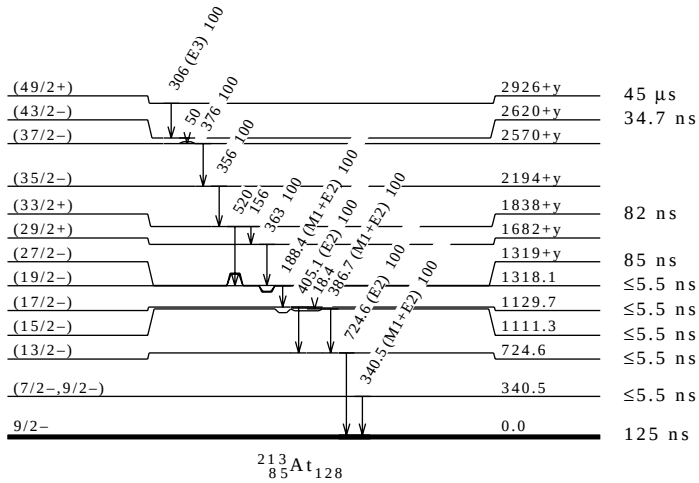
From NNDC(BNL)
program ENSDAT

$^{213}_{85}At_{128}$–3

Adopted Levels, Gammas (continued)

Level Scheme

Intensities: relative photon branching from each level



^{217}Fr α Decay

Parent ^{217}Fr: E=0.0; Jπ=9/2–; $T_{1/2}$=19 µs *3*; Q(g.s.)=8469 *4*; %α decay=100.

^{213}At Levels

E(level)	Jπ	$T_{1/2}$	Comments
0.0	9/2–	125 ns *6*	Jπ,$T_{1/2}$: From adopted levels.

α radiations

Eα	E(level)	Iα‡	HF†	Comments
8315 *8*	0.0	100	1.01 *16*	Eα: measurement of 1970Bo13 (semi); other measured value: 8310 *20* (1968Ha14, semi).

† Using $r_0(^{213}Po)$=1.564 *4*, average of $r_0(^{212}Po)$=1.5649 *8* and $r_0(^{214}Rn)$=1.563 *4* (1998Ak04).
‡ Absolute intensity per 100 decays.

^{208}Pb(^{7}Li,2nγ),^{209}Bi(^{18}O,^{14}Cγ) 1980Sj01,1981Bo29

1980Sj01: ^{208}Pb(^{7}Li,2nγ) E=30–34 MeV, (pulsed beam); measured: Eγ, Iγ, Eα, αγ, γγ, γ(θ).
1981Bo29: ^{209}Bi(^{18}O,^{14}Cγ) E=79 MeV (pulsed beam); measured: Eα, Eγ, $T_{1/2}$. Level scheme not presented.
Other: 1980Me05: ^{208}Pb(^{16}O,^{11}B) E=140–312 MeV; population of continuum states was analyzed.

^{213}At Levels

E(level)†	Jπ‡	$T_{1/2}$	Comments
0.0	9/2–	125 ns *6*	$T_{1/2}$: From α decay (1981Bo29).
340.5 *3*	(7/2–,9/2–)	≤5.5 ns§	Jπ: 340γ (M1+E2) to 9/2– state. Calculation for level energy indicates a $(\pi h_{9/2})^2(\pi f_{7/2})(\nu g_{9/2})^2$; 7/2– orbital configuration in addition to the $(\pi h_{9/2})^3(\nu g_{9/2})^2$ structure (1980Sj01).

Continued on next page (footnotes at end of table)

From NNDC(BNL)
program ENSDAT

$^{213}_{85}At_{128}$–4

$^{208}Pb(^{7}Li,2n\gamma),^{209}Bi(^{18}O,^{14}C\gamma)$ 1980Sj01,1981Bo29 (continued)

^{213}At Levels (continued)

E(level)†	Jπ‡	$T_{1/2}$	Comments
724.6 *3*	13/2−	≤5.5 ns§	Jπ: 725γ (E2) to 9/2− state.
1111.3 *5*	15/2−	≤5.5 ns§	Jπ: 387γ (M1+E2) to 13/2− state.
1129.7 *5*	(17/2−)	≤5.5 ns§	
1318.1 *6*	(19/2−)	≤5.5 ns§	
1318.1+x		110 ns *17*	E(level): all gammas, except the 340.5–keV γ, had delayed components. The 386.7–, 405.1– and 724.6–keV gammas also showed prompt peak in their time spectra; however, existence of any prompt component in 188.4–keV γ could not be excluded (1980Sj01). The 110–ns state, therefore, is at or above 1318.1 keV. $T_{1/2}$: from (386.7γ)(t) (1980Sj01). The authors also measured (405γ)(t) and obtained $T_{1/2}$=113 ns *10* for its ^{213}At component and $T_{1/2}$=17 ns *7* for ^{212}Po component.

† Deduced by evaluator from a least square fit to the γ–ray energies.

‡ Assignments are from 1980Sj01, based on γ–ray multipolarity deduced from γ(θ). Most low level energies are well produced from a $(\pi h_{9/2})^3(\nu g_{9/2})^2$ structure calculation, except the 340 keV level (1980Sj01).

§ From 1980Sj01.

γ(^{213}At)

Eγ†	E(level)	Iγ‡	Mult.§	α	Comments
(18.4)	1129.7				Transition was not observed. Its existence is inferred from the observed (188.4)(386.7γ) coincidences.
188.4 *3*	1318.1	13 *2*	(M1+E2)	1.3 *7*	α(K)=0.9 *8*; α(L)=0.303 *15*; α(M)=0.076 *8*; α(N+..)=0.0243 *23*. α(N)=0.0197 *21*; α(O)=0.0041 *3*; α(P)=0.00049 *4*. A_2=−0.21 *7*.
340.5 *3*	340.5	40 *4*	(M1+E2)	0.24 *15*	α(K)=0.18 *14*; α(L)=0.043 *14*; α(M)=0.010 *3*; α(N+..)=0.0033 *9*. α(N)=0.0027 *8*; α(O)=0.00057 *17*; α(P)=7.×10^{-5} *3*. Other: Eγ=340.6 (1981Bo29). A_2=+0.14 *4*.
386.7 *3*	1111.3	27 *3*	(M1+E2)	0.17 *11*	α(K)=0.13 *10*; α(L)=0.029 *11*; α(M)=0.0071 *23*; α(N+..)=0.0023 *8*. α(N)=0.0018 *6*; α(O)=0.00038 *14*; α(P)=5.0×10^{-5} *22*. Other: Eγ=388.8 (1981Bo29). A_2=−0.35 *6*.
405.1 *3*	1129.7	33 *9*	(E2)	0.0568	α(K)=0.0354 *5*; α(L)=0.01600 *23*; α(M)=0.00410 *6*; α(N+..)=0.001302 *19*. α(N)=0.001061 *16*; α(O)=0.000215 *3*; α(P)=2.49×10^{-5} *4*. Iγ: γ overlaped with 405–keV transition in ^{212}Po, and Iγ=58 was measured for the total peak. The ^{213}At and ^{212}Po components were deduced by 1980Sj01 from γγ–coincidence measurements. Other: Eγ=405.1 was measured by 1981Bo29. A_2=+0.21 *5* doublet.
724.6 *3*	724.6	100 *10*	(E2)	0.01473	α(K)=0.01106 *16*; α(L)=0.00278 *4*; α(M)=0.000683 *10*; α(N+..)=0.000218 *3*. α(N)=0.0001766 *25*; α(O)=3.67×10^{-5} *6*; α(P)=4.64×10^{-6} *7*. Other: Eγ=725.2 (1981Bo29). A_2=+0.28 *5*.

† From 1980Sj01. Assignments to ^{213}At were made from the observed (9.08–MeV α from ^{213}At g.s.)(γ) and γγ–coincidences.

‡ Relative photon intensity, from 1980Sj01, normalized to Iγ=100 for 724.6γ.

§ From 1980Sj01 based on γ–ray angular distributions by assuming that the states were aligned and that the dominant γ rays proceed via yrast levels by stretched transitions. Lifetime information was considered to eliminate higher multipolarities. (M1,E2) multipolarities in 1980Sj01 are presented as (M1+E2) here.

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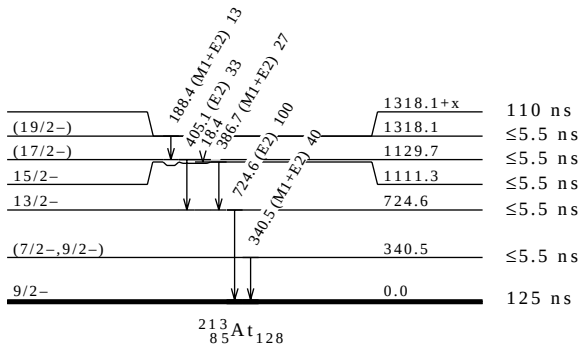
From NNDC(BNL)
program ENSDAT

$^{213}_{85}At_{128}$–5

$^{208}Pb(^{7}Li,2n\gamma),^{209}Bi(^{18}O,^{14}C\gamma)$ 1980Sj01,1981Bo29 (continued)

Level Scheme

Intensities: relative Iγ



$^{209}Bi(^{7}Li,p2n\gamma),^{209}Bi(^{8}He,4n\gamma)$ 2003LaZZ,2005Ga46

2003LaZZ: $^{209}Bi(^{7}Li,p2n\gamma)$ E=48 MeV; Detector: CAESAR array, consisting of six Compton–suppressed HPGe detector and two LEPS detectors, an ADC clock; measured: Eγ, γ–γ coin, $T_{1/2}$.

2005Ga46: $^{209}Bi(^{8}He,4n\gamma)$ E=28 MeV; Detector: EXOGAM array, composed of four Compton suppressed Ge Clover detectors; Measured: Eγ. Level scheme not given.

^{213}At Levels

E(level)†	Jπ‡	$T_{1/2}$	Comments
0.0	9/2–	125 ns *6*	$T_{1/2}$: From adopted levels.
724.6 *3*	13/2–		
1112 *5*	15/2–		
1130	17/2–		
1319	19/2–		
1319+x	(27/2–)§	85 ns#	E(level): In 2003LaZZ, this level energy is presented as (1554) keV, can be obtained combining γ–rays, presented as unplaced in this dataset, and 1319 keV level as 1319+92+105+(38)=1554 or 1319+92+55+51=1556.
1682+x	(29/2+)§		E(level): (1917) keV in 2003LaZZ.
1838+x	(33/2+)§	82 ns#	E(level): (2073) keV in 2003LaZZ.
2194+x	(35/2–)§		E(level): (2429) keV in 2003LaZZ.
2570+x	(37/2–)§		E(level): (2805) keV in 2003LaZZ.
2620+x	(43/2–)	34.7 ns#	E(level): (2855) keV in 2003LaZZ. Jπ: from possible configuration: $\pi(h_{9/2})^2f_{7/2}\nu(g_{9/2}i_{11/2})$ and theoretical level energy calculation in 2003LaZZ. $T_{1/2}$: a 50–keV unobserved γ is introduced to understand the isomer.
2926+x	(49/2+)	45 μs *4*	E(level): (3161) keV in 2003LaZZ. Jπ: From possible configuration: $\pi(h_{9/2})^2i_{13/2}\nu(g_{9/2}i_{11/2})$ and theoretical level energy calculation (2003LaZZ). 306γ E3 to 43/2– state. $T_{1/2}$: From a time spectrum of 306γ.

† Deduced by evaluator from a least square fit to the γ–ray energies, assuming ΔE=1 keV. Levels above 19/2– state, 1319 keV, are labeled adding '+x' by the evaluator due to premature placements of highly converted low energy γ–lines between (27/2–) and 19/2– states. Those low energy γ–lines are presented as unplaced here in the dataset.

‡ From adopted levels, except otherwise noted.

§ From 2003LaZZ, detailed arguments are not available.

From intermediate time spectra between different parts of γ–ray transitions in 2003LaZZ.

CITATION:
Nuclear Data Sheets (2007)

From NNDC(BNL)
program ENSDAT

$^{213}_{85}At_{128}$–6

$^{209}Bi(^{7}Li,p2n\gamma),^{209}Bi(^{8}He,4n\gamma)$ 2003LaZZ,2005Ga46 (continued)

$\gamma(^{213}At)$

Eγ†	E(level)	Mult.	α	Comments
(17)	1130			
([x]38‡)				
(50)	2620+x			Eγ: The 50–keV unobserved γ–ray is introduced to understand the isomer (2003LaZZ).
[x]51‡				
[x]55‡				
[x]88‡				
[x]92‡				
[x]105‡				
156	1838+x			
189§	1319			
306	2926+x	E3	0.707	α(K)=0.1715 *24*; α(L)=0.393 *6*; α(M)=0.1075 *15*; α(N+..)=0.0342 *5*. α(N)=0.0280 *4*; α(O)=0.00558 *8*; α(P)=0.000600 *9*. Mult.: Deduced E3 strength is 23 (2) W.u., compared to 26(1) W.u. in ^{212}At.
356	2194+x			
363§	1682+x			
376§	2570+x			
387§	1112			
405§	1130			
520	1838+x			
725§	724.6			

† From 2003LaZZ, except otherwise noted.

‡ In 2003LaZZ shown between the (27/2–) and 19/2– states, in coincidence with 725 keV by 30–850 ns. The evaluator presents these γ–rays as unplaced due to unclear level scheme between (27/2–) and 19/2– states.

§ This γ–ray is also present in figure of the γ–ray spectrum in 2005Ga46.

[x] γ ray not placed in level scheme.

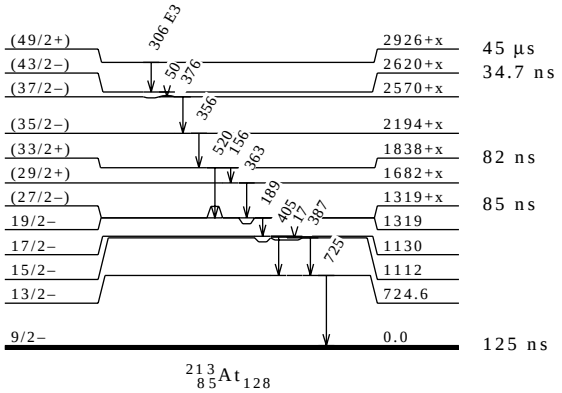
CITATION:
Nuclear Data Sheets (2007)

From NNDC(BNL)
program ENSDAT

$^{213}_{85}At_{128}$–7

$^{209}Bi(^{7}Li,p2n\gamma)$,$^{209}Bi(^{8}He,4n\gamma)$ 2003LaZZ,2005Ga46 (continued)

Level Scheme



CITATION:
Nuclear Data Sheets (2007)

From NNDC(BNL)
program ENSDAT

$^{213}_{86}Rn_{127}$–1

Adopted Levels, Gammas

Q(β⁻)=–2148 *9*; S(n)=5110 *6*; S(p)=4366 *9*; Q(α)=8243 *5* 2003Au03.

^{213}Rn Levels

ll levels, gammas and their properties are from (HI,xnγ).

ee 1989Lo02 for calculations of level energies by using the deformed Woods–Saxon potential, and for inferred deformations.

ee 1988St10 and 1990St14 for shell–model level energies calculated by using empirical interaction energies derived from neighboring nuclei. See 1988St10 and 1990St14 also for calculations of g–factors and comparison with their experiment.

E(level)†	Jπ‡	$T_{1/2}$§	Comments
0.0	(9/2+)	19.5 ms *1*	%α=100. Only α decay observed. Possible ε decay to ^{213}At g.s. is expected to be <5.8×10^{-4}% from log *ft*>5.1. Jπ: analogy to ^{209}Pb and ^{211}Po isotones. Configuration=(ν $g_{9/2}$). $T_{1/2}$: From 2000He17 (using 8088α–t); Others: 18.0 ms *4* (7550α–t) and 19.0 ms *5* (7552α–t) (2000He17); 25.0 ms *2* (8088α–t) (1970Va13); 20.5 ms *10* (1970TaZS); 21 ms *4* (8064α–t) (2005Li17); 31 ms (8024α–t), 15 ms (7976α–t), 8.1 ms (8074α–t), 4.3 ms (8177α–t) – all four values from 2003Ni10, and 19 ms (1962Gr20).
705.0 *8*	(11/2+)		Jπ: 705.0γ M1 to (9/2+) state.
896.1 *8*	(15/2–)	26 ns *1*	Jπ: 191.1γ M2 to (11/2+) state, 896.1γ E3 to (9/2+) state.
1259.6 *9*	(13/2+)		Jπ: 1259.6γ to (9/2+) state.
1529.0 *9*	(17/2+)		Jπ: 269.4γ E2 to (13/2+) state, 632.9γ E1 to (15/2–) state.
1574.1 *13*			
1612.4?			
1664.0 *10*	(21/2+)	29 ns *2*	μ=4.73 *11* (1988St10,1989Ra17). Jπ: 135.0γ E2 to (17/2+) state, 767.9γ (E3) to (15/2–) state.
1664.0+x	(25/2+)	1.00 μs *21*	μ=7.63 *25* (1988St10).
1703.5? *13*			
1745.9 *11*			
1788.7 *12*			
1856.6+x *7*	(25/2+)		Jπ: 192.6γ (M1) to (25/2+) state.
1879.4 *13*			
1936.9 *13*			
2007.4 *11*			
2072.8 *11*			
2121.6+x *8*	(27/2)		
2184.3 *14*			
2186.7+x *6*	(31/2–)	1.36 μs *7*	μ=9.90 *8* (1988St10,1989Ra17). Jπ: 330.1γ (E3) to (25/2+) state, 522.7γ E3 to (25/2+) state.
2201.5+x *8*	(27/2–)		Jπ: 344.9γ (E1) to (25/2+) state, 537.5γ (E1) to (25/2+) state.
2227.5 *14*			
2257.5 *15*			
2327.1 *16*			
2610.7 *17*			
2640.8+x *10*			
2662.0+x *13*			
2677.0+x *7*	(29/2+)		Jπ: 490.2γ D+Q to (31/2–) state, 1013.0γ Q to (25/2+).
2684.5+x *13*			
2739.8+x *9*	(31/2–)		Jπ: 553.1γ M1 to (31/2–) state.
2786.7+x *9*	(29/2+)		Jπ: 930.1γ to (25/2+) state.
2915.8+x *8*	(33/2)+		Jπ: 729.1γ E1 to (31/2–) state.
2984.0+x *8*	(33/2+)		Jπ: 68.2γ M1 to (33/2+) state, 244.2γ (E1) to (31/2–) state, 797.3γ E1 to (31/2–) state.
3029.3+x *10*	(37/2+)	26 ns *1*	μ=13.67 *13* (1988St10,1989Ra17). Jπ: 45.3γ E2 to (33/2+) state, 113.5γ E2 to (33/2+).
3181.8+x *9*	(35/2–)		Jπ: 995.1γ (E2) to (31/2–) state.
3301.3+x *12*			
3441.1+x *11*	(39/2–)		Jπ: 411.8γ E1 to (37/2+) state.
3495.4+x *15*	(43/2–)	28 ns *1*	μ=15.59 *15* (1988St10,1989Ra17). Jπ: 54.3γ E2 to (39/2–) state.
3604.8+x *14*			
3623.8+x *18*			
3922.9+x *17*	(43/2–)		Jπ: 427.5γ M1 to (43/2–) state.
3927.3+x *18*			

Continued on next page (footnotes at end of table)

CITATION:
Nuclear Data Sheets (2007)

From NNDC(BNL)
program ENSDAT

$^{213}_{86}Rn_{127}$–2

Adopted Levels, Gammas (continued)

^{213}Rn Levels (continued)

E(level)†	Jπ‡	$T_{1/2}$§	Comments
4047.9+x *16*	(45/2−)		Jπ: 552.5γ M1 to (43/2−) state.
4050.3+x *17*			
4343.1+x *20*			
4505.5+x *17*	(49/2+)	12 ns *1*	μ=19.87 *29* (1988St10,1989Ra17). Jπ: 1010.1γ E3 to (43/2−) state.
4532.7+x *20*			
4581.3+x *22*			
4723.0+x *20*			
4875.6+x *19*	(49/2+)		Jπ: 370.1γ (M1) to (49/2+) state.
5225.6+x *18*	(51/2+)		Jπ: 350.0γ (M1) to (49/2+) state, 720.1γ (M1) to (49/2+).
5763.7+x *18*	(53/2,55/2)		Jπ: 1258.1γ (M2,E3) to (49/2+) state.
5928.9+x *19*	(53/2,55/2)		Jπ: 165.2 M1 to (53/2,55/2) state.
5929+y	(55/2+)	164 ns *11*	μ=16.61 *14* (1988St10,1989Ra17).
6744.00+y *20*		59 ns	
7926.5+y *3*			
8831.9+y *3*			

† Deduced by the evaluator from a least−square fit to the γ−ray energies, assuming ΔE=1 keV for all γ−rays.
‡ Proposed in (HI,xnγ) from γ multipolarities obtained by ce and γ(θ) measurements. Monotonically increasing spins are assumed. See 1988St10, 1989Lo02, and 1990St14 for configuration assignments.
§ From 1988St10 in (HI,xnγ).

γ(^{213}Rn)

ee 1988St10 for B(E3) values calculated using the empirical−shell model, and comparison with experiments. See 1989Dr02 and 1985Be05 for systematics of E3 strengths of 15/2− to 9/2+ transitions in the region.

E(level)	Eγ†	Iγ	Mult.†	α	Comments
705.0	705.0	100	M1	0.0604	α(K)=0.0491 *7*; α(L)=0.00860 *12*; α(M)=0.00204 *3*; α(N+..)=0.000663 *10*. α(N)=0.000530 *8*; α(O)=0.0001160 *17*; α(P)=1.697×10^{-5} *24*.
896.1	191.1	0.44 *8*	M2	9.96	B(M2)↓(W.u.)=0.54 *11*. α(K)=6.95 *10*; α(L)=2.24 *4*; α(M)=0.575 *8*; α(N+..)=0.189 *3*. α(N)=0.1518 *22*; α(O)=0.0329 *5*; α(P)=0.00464 *7*.
	896.1	100	E3	0.0250	B(E3)↓(W.u.)=34.7 *14*. α(K)=0.01723 *25*; α(L)=0.00582 *9*; α(M)=0.001476 *21*; α(N+..)=0.000478 *7*. α(N)=0.000386 *6*; α(O)=8.19×10^{-5} *12*; α(P)=1.091×10^{-5} *16*.
1259.6	1259.6	100			
1529.0	269.4	1.6 *1*	E2	0.192	α(K)=0.0870 *13*; α(L)=0.0780 *11*; α(M)=0.0206 *3*; α(N+..)=0.00659 *10*. α(N)=0.00536 *8*; α(O)=0.001100 *16*; α(P)=0.0001304 *19*.
	632.9	100 *10*	E1	0.00688	α(K)=0.00566 *8*; α(L)=0.000930 *13*; α(M)=0.000218 *3*; α(N+..)=7.05×10^{-5} *10*. α(N)=5.65×10^{-5} *8*; α(O)=1.225×10^{-5} *18*; α(P)=1.745×10^{-6} *25*.
1574.1	314.5	100			
1612.4?	352.8§	36 *14*			
	907.4§	100 *20*			
1664.0	135.0	100 *2*	E2	2.35	B(E2)↓(W.u.)=1.68 *16*. α(K)=0.326 *5*; α(L)=1.495 *21*; α(M)=0.402 *6*; α(N+..)=0.1283 *18*. α(N)=0.1047 *15*; α(O)=0.0212 *3*; α(P)=0.00238 *4*.
	767.9	3.6 *4*	(E3)	0.0365	B(E3)↓(W.u.)=1.04 *14*. α(K)=0.0237 *4*; α(L)=0.00961 *14*; α(M)=0.00247 *4*; α(N+..)=0.000799 *12*. α(N)=0.000645 *9*; α(O)=0.0001362 *19*; α(P)=1.781×10^{-5} *25*.
1703.5?	(39.5‡)				
1745.9	(81.9‡)				
	216.9	100			
1788.7	259.7	100			
1856.6+x	192.6	100	(M1)	2.05	α(K)=1.653 *24*; α(L)=0.298 *5*; α(M)=0.0708 *10*; α(N+..)=0.0231 *4*. α(N)=0.0185 *3*; α(O)=0.00404 *6*; α(P)=0.000590 *9*.

Continued on next page (footnotes at end of table)

CITATION:
Nuclear Data Sheets (2007)

From NNDC(BNL)
program ENSDAT

$^{213}_{86}Rn_{127}$–3

Adopted Levels, Gammas (continued)

γ(^{213}Rn) (continued)

E(level)	Eγ†	Iγ	Mult.†	α	Comments
1879.4	1174.4	100			
1936.9	233.4	100 *12*			
	272.9	19 *6*			
2007.4	218.7	≈12			
	261.5	≈12			
	343.4	100 *25*			
2072.8	543.7	12 *6*			
	1176.8	100 *19*			
2121.6+x	457.6#	100			
2184.3	520.3	100			
2186.7+x	(65.1‡)				I(γ+ce)(65.1γ)<7 from intensity balance at 2121.6+x level.
	330.1	1.9 *2*	(E3)	0.552	B(E3)↓(W.u.)=12.6 *16*. α(K)=0.1470 *21*; α(L)=0.298 *5*; α(M)=0.0815 *12*; α(N+..)=0.0263 *4*. α(N)=0.0214 *3*; α(O)=0.00439 *7*; α(P)=0.000519 *8*.
	522.7	100 *2*	E3	0.1073	B(E3)↓(W.u.)=26.6 *18*. α(K)=0.0536 *8*; α(L)=0.0398 *6*; α(M)=0.01055 *15*; α(N+..)=0.00341 *5*. α(N)=0.00276 *4*; α(O)=0.000575 *8*; α(P)=7.16×10^{-5} *10*.
2201.5+x	344.9	100 *4*	(E1)	0.0243	α(K)=0.0198 *3*; α(L)=0.00346 *5*; α(M)=0.000817 *12*; α(N+..)=0.000263 *4*. α(N)=0.000211 *3*; α(O)=4.54×10^{-5} *7*; α(P)=6.30×10^{-6} *9*.
	537.5	33 *4*	(E1)	0.00951	α(K)=0.00780 *11*; α(L)=0.001301 *19*; α(M)=0.000306 *5*; α(N+..)=9.88×10^{-5} *14*. α(N)=7.92×10^{-5} *11*; α(O)=1.713×10^{-5} *24*; α(P)=2.42×10^{-6} *4*.
2227.5	563.5	100			
2257.5	184.7	100			
2327.1	390.2	100			
2610.7	383.2	100			
2640.8+x	454.1	100			
2662.0+x	460.5	100			
2677.0+x	490.2	100 *8*	D+Q	0.0115	
	1013.0	85 *31*	Q	0.00802	
2684.5+x	483.0	100			
2739.8+x	(99.0‡)				
	553.1		M1	0.1147	α(K)=0.0931 *13*; α(L)=0.01641 *23*; α(M)=0.00389 *6*; α(N+..)=0.001266 *18*. α(N)=0.001012 *15*; α(O)=0.000222 *4*; α(P)=3.24×10^{-5} *5*.
2786.7+x	930.1	100			
2915.8+x	238.8	1.0 *8*			
	729.1	100 *5*	E1	0.00525	α(K)=0.00433 *6*; α(L)=0.000703 *10*; α(M)=0.0001645 *23*; α(N+..)=5.32×10^{-5} *8*. α(N)=4.26×10^{-5} *6*; α(O)=9.26×10^{-6} *13*; α(P)=1.324×10^{-6} *19*.
2984.0+x	68.2	3.0 *3*	M1	7.78	α(L)=5.91 *9*; α(M)=1.405 *20*; α(N+..)=0.458 *7*. α(N)=0.366 *6*; α(O)=0.0802 *12*; α(P)=0.01171 *17*.
	197.3	2.3 *3*			
	244.2	7.8 *20*	(E1)	0.0535	α(K)=0.0432 *6*; α(L)=0.00788 *11*; α(M)=0.00187 *3*; α(N+..)=0.000600 *9*. α(N)=0.000483 *7*; α(O)=0.0001029 *15*; α(P)=1.403×10^{-5} *20*.
	307.0	2.0 *12*			
	797.3	100 *2*	E1	0.00444	α(K)=0.00367 *6*; α(L)=0.000591 *9*; α(M)=0.0001383 *20*; α(N+..)=4.47×10^{-5} *7*. α(N)=3.58×10^{-5} *5*; α(O)=7.79×10^{-6} *11*; α(P)=1.117×10^{-6} *16*.
3029.3+x	45.3	33 *17*	E2	359	B(E2)↓(W.u.)=4 *3*. α(L)=265 *4*; α(M)=71.1 *10*; α(N+..)=22.6 *4*. α(N)=18.5 *3*; α(O)=3.71 *6*; α(P)=0.405 *6*.
	113.5	100 *34*	E2	4.85	B(E2)↓(W.u.)=0.12 *7*. α(K)=0.365 *6*; α(L)=3.31 *5*; α(M)=0.891 *13*; α(N+..)=0.284 *4*. α(N)=0.232 *4*; α(O)=0.0468 *7*; α(P)=0.00521 *8*.
	842.6§	167 *34*	[E3]	0.0290	B(E3)↓(W.u.)=(0.7 *4*). α(K)=0.0195 *3*; α(L)=0.00707 *10*; α(M)=0.00180 *3*; α(N+..)=0.000584 *9*. α(N)=0.000471 *7*; α(O)=9.98×10^{-5} *14*; α(P)=1.321×10^{-5} *19*.

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CITATION:
Nuclear Data Sheets (2007)

From NNDC(BNL)
program ENSDAT

$^{213}_{86}Rn_{127}$–4

Adopted Levels, Gammas (continued)

γ(^{213}Rn) (continued)

E(level)	Eγ†	Iγ	Mult.†	α	Comments
3181.8+x	266.0	≈8			
	995.1	100 *12*	(E2)	0.00821	α(K)=0.00641 *9*; α(L)=0.001361 *19*; α(M)=0.000330 *5*; α(N+..)=0.0001068 *15*. α(N)=8.58×10^{-5} *12*; α(O)=1.85×10^{-5} *3*; α(P)=2.57×10^{-6} *4*.
3301.3+x	272.0	100			
3441.1+x	139.8	0.88 *16*			
	259.4	≈0.77			
	411.8	100.0 *19*	E1	0.01652	α(K)=0.01348 *19*; α(L)=0.00231 *4*; α(M)=0.000545 *8*; α(N+..)=0.0001758 *25*. α(N)=0.0001411 *20*; α(O)=3.04×10^{-5} *5*; α(P)=4.26×10^{-6} *6*.
3495.4+x	54.3	100	E2	148.8	B(E2)↓(W.u.)=3.7 *4*. α(L)=109.9 *16*; α(M)=29.5 *5*; α(N+..)=9.37 *14*. α(N)=7.66 *11*; α(O)=1.541 *22*; α(P)=0.1685 *24*.
3604.8+x	575.5	100			
3623.8+x	128.4	100			
3922.9+x	427.5	100	M1	0.228	α(K)=0.185 *3*; α(L)=0.0328 *5*; α(M)=0.00778 *11*; α(N+..)=0.00254 *4*. α(N)=0.00203 *3*; α(O)=0.000444 *7*; α(P)=6.49×10^{-5} *9*.
3927.3+x	431.9	100			
4047.9+x	(125.0‡)	<2			
	552.5	100 *9*	M1	0.1150	α(K)=0.0934 *13*; α(L)=0.01646 *23*; α(M)=0.00390 *6*; α(N+..)=0.001270 *18*. α(N)=0.001015 *15*; α(O)=0.000222 *4*; α(P)=3.25×10^{-5} *5*.
4050.3+x	445.5	100			
4343.1+x	420.2	100			
4505.5+x	457.6#	<6		0.579	B(M2)↓(W.u.)=0.10 *11*.
	1010.1	100 *8*	E3	0.0189	B(E3)↓(W.u.)=33 *5*. α(K)=0.01351 *19*; α(L)=0.00405 *6*; α(M)=0.001016 *15*; α(N+..)=0.000329 *5*. α(N)=0.000265 *4*; α(O)=5.66×10^{-5} *8*; α(P)=7.64×10^{-6} *11*.
4532.7+x	609.8	100			
4581.3+x	(48.6‡)				
	533.4§				
4723.0+x	217.5	100			
4875.6+x	370.1	100	(M1)	0.337	α(K)=0.273 *4*; α(L)=0.0486 *7*; α(M)=0.01153 *17*; α(N+..)=0.00376 *6*. α(N)=0.00300 *5*; α(O)=0.000657 *10*; α(P)=9.60×10^{-5} *14*.
5225.6+x	350.0		(M1)	0.392	α(K)=0.318 *5*; α(L)=0.0566 *8*; α(M)=0.01343 *19*; α(N+..)=0.00438 *7*. α(N)=0.00350 *5*; α(O)=0.000766 *11*; α(P)=0.0001119 *16*.
	720.1	100 *30*	(M1)	0.0572	α(K)=0.0465 *7*; α(L)=0.00813 *12*; α(M)=0.00192 *3*; α(N+..)=0.000627 *9*. α(N)=0.000501 *7*; α(O)=0.0001097 *16*; α(P)=1.605×10^{-5} *23*.
5763.7+x	538.1	62 *7*			
	1258.1	100 *19*	(M2,E3)	0.022 *10*	α(K)=0.017 *9*; α(L)=0.0035 *13*; α(M)=0.0008 *3*; α(N+..)=0.00028 *10*. α(N)=0.00022 *8*; α(O)=4.8×10^{-5} *18*; α(P)=7.×10^{-6} *3*; α(IPF)=4.0×10^{-6} *8*.
5928.9+x	165.2	100 *25*	M1	3.15	α(K)=2.55 *4*; α(L)=0.461 *7*; α(M)=0.1094 *16*; α(N+..)=0.0357 *5*. α(N)=0.0285 *4*; α(O)=0.00624 *9*; α(P)=0.000911 *13*.
	1053.3	75 *25*			
	1423.3	75 *25*			
6744.00+y	815.0 *2*	100			
7926.5+y	1182.5 *2*	100			
8831.9+y	905.4 *2*	100			

† From (HI,xnγ).
‡ Transition was not observed; existence deduced from coincidence data; energy from level scheme.
§ Placement of transition in the level scheme is uncertain.
# Multiply placed.

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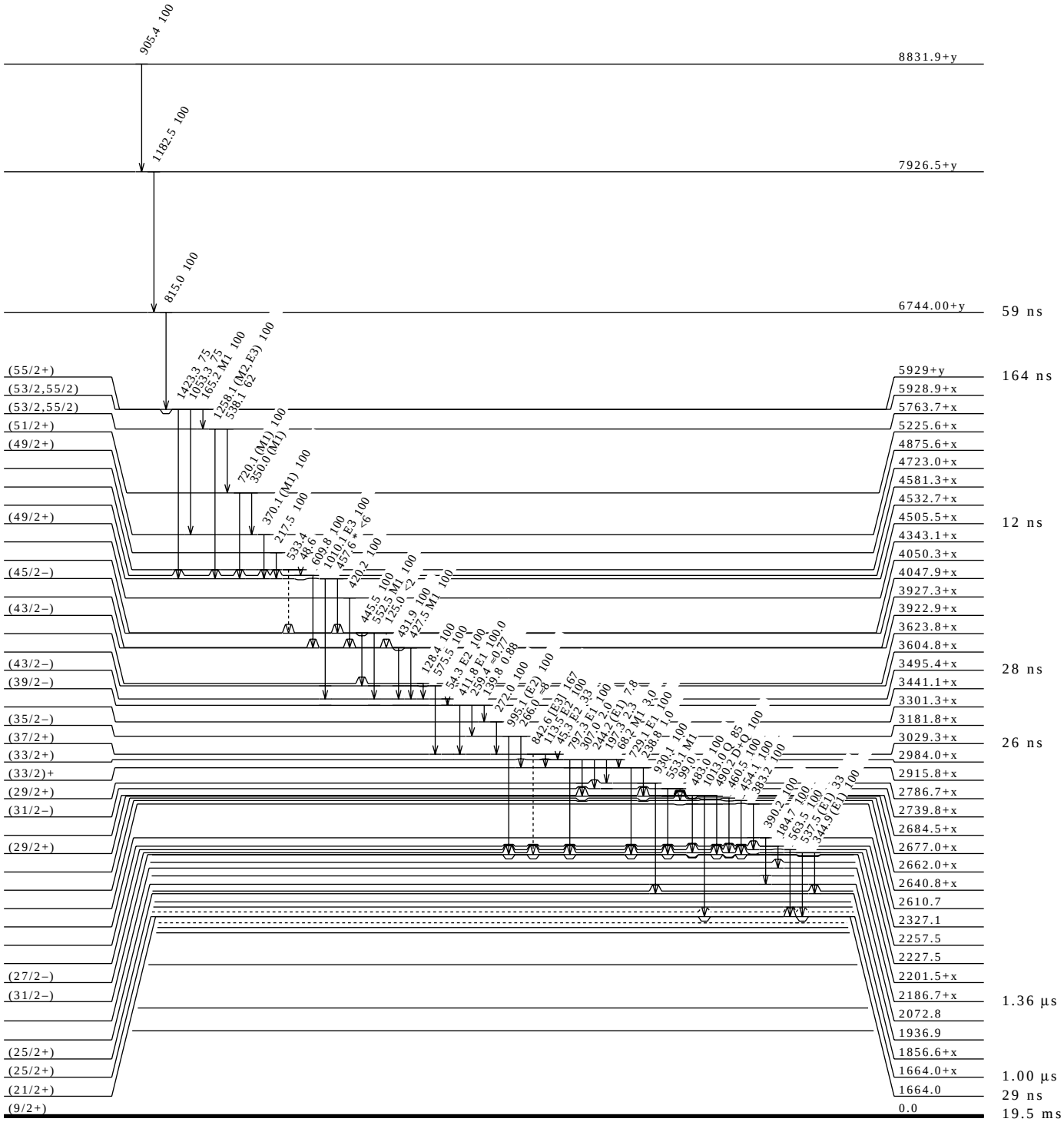
From NNDC(BNL)
program ENSDAT

$^{213}_{86}Rn_{127}$–5

Adopted Levels, Gammas (continued)

Level Scheme

Intensities: relative photon branching from each level
* Multiply placed



$^{213}_{86}Rn_{127}$

CITATION:
Nuclear Data Sheets (2007)

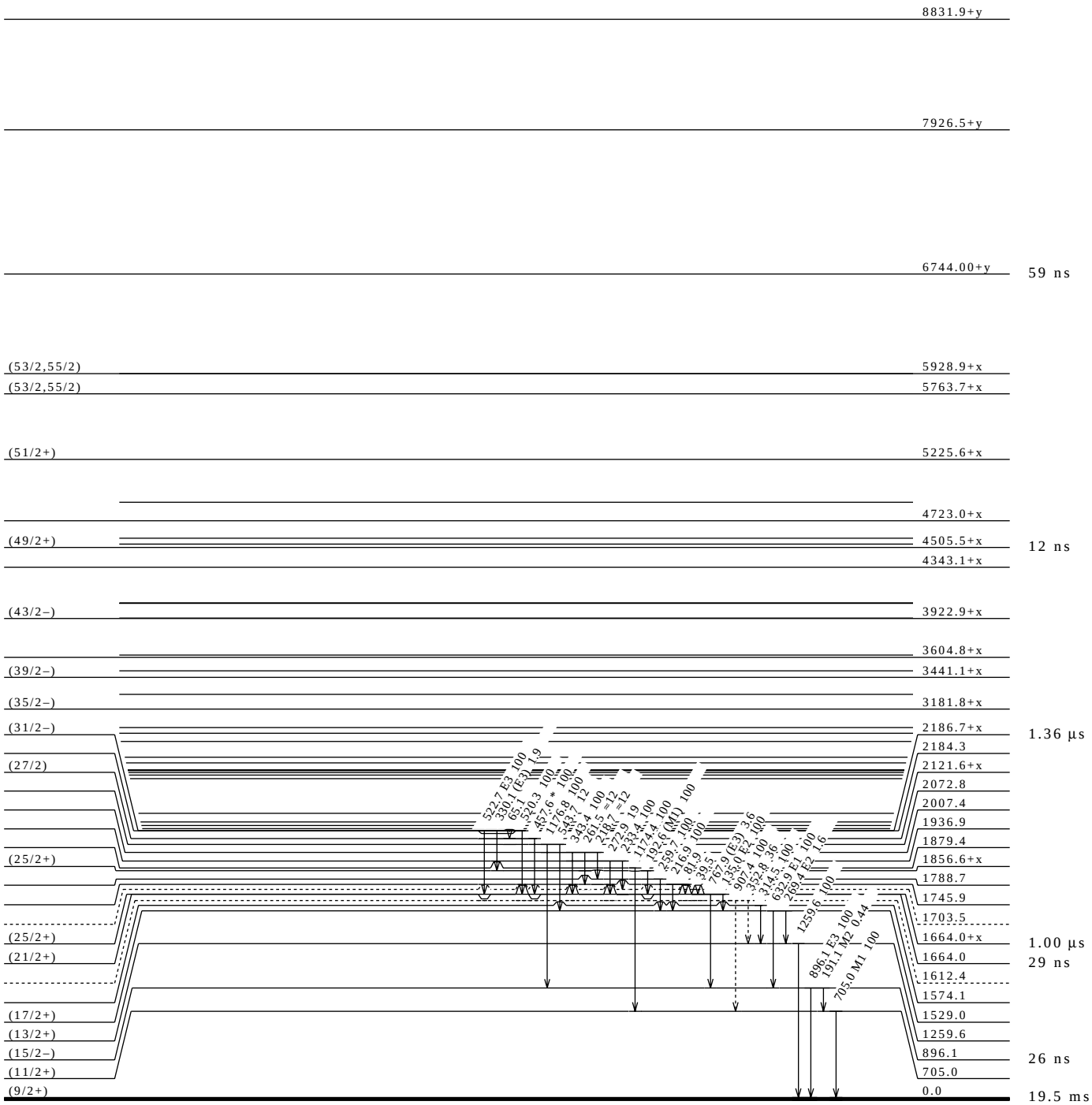
From NNDC(BNL)
program ENSDAT

$^{213}_{86}Rn_{127}$–6

Adopted Levels, Gammas (continued)

Level Scheme (continued)

Intensities: relative photon branching from each level
* Multiply placed



$^{213}_{86}Rn_{127}$

CITATION:
Nuclear Data Sheets (2007)

From NNDC(BNL)
program ENSDAT

$^{213}_{86}Rn_{127}$–7

^{213}Fr ε Decay

Parent ^{213}Fr: E=0.0; Jπ=9/2–; $T_{1/2}$=34.6 s *3*; Q(g.s.)=2148 *9*; %ε+%$β^+$ decay=0.55 *3*.
The ^{213}Fr ε decay scheme has not been studied. 0.55% *3* ε decay branching was obtained from comparison of ^{213}Fr and ^{213}Rn α activities (1964Gr04,1967Va20,1974Ho27).

^{217}Ra α Decay

Parent ^{217}Ra: E=0.0; Jπ=(9/2+); $T_{1/2}$=1.6 μs *2*; Q(g.s.)=9161 *6*; %α decay=100.

^{213}Rn Levels

E(level)	Jπ	$T_{1/2}$	Comments
0.0	(9/2+)	19.5 ms *1*	Jπ,$T_{1/2}$: From adopted levels.

α radiations

Eα	E(level)	Iα‡	HF†	Comments
8992 *8*	0.0	100	1.67 *22*	Eα: unweighted average of 8990 *8* (1970To07, semi), 8995 *10* (1970Va13, semi).

† Using r_0(^{213}Rn)=1.552 *6*, average of r_0(^{212}Rn)=1.541 *5* and r_0(^{214}Rn)=1.563 *4* (1998Ak04).
‡ Absolute intensity per 100 decays.

(HI,xnγ)

^{204}Hg(^{14}C,5nγ) E=80–94 MeV (1989Lo02).
^{208}Pb(^{9}Be,4nγ) E=45–60 MeV (1988St10).
^{204}Hg(^{13}C,4nγ) E=72–75 MeV (1988St10).
^{208}Pb(^{9}Be,4nγ) E=31–57 MeV (1988Fu10).
^{206}Pb(^{12}C,αnγ) E=63–75 MeV (1988Fu10).
^{208}Pb(^{14}C,α5nγ) E=75–95 MeV (1983Lo16).
1989Lo02 measured: Eγ, Iγ, γ(θ), γγ, γγ(t), ce, pulsed beam–γ(t).
1988St10 measured: Eγ, Iγ, γ(θ), γγ, γγ(t), γ(θ,H,t), ce, pulsed beam–γ(t).
1988Fu10 measured: Eγ, Iγ, γ(θ), γγ, γγ(t), γ(linear polarization), pulsed beam–γ(t).
1983Lo16 measured: Eγ, Iγ, γ(θ), γγ, γγ(t), pulsed beam–γ(t).
Half–life measurements:

E(level)	$T_{1/2}$ 1988Fu10	$T_{1/2}$ 1988St10	$T_{1/2}$ 1989Lo02
896.1	25 ns *3*	26 ns *1*	28 ns
1664.0		29 ns *2*	16 ns
1664.0+x		1005 ns *210*	680 ns
2186.7+x		1358 ns *70*	1400 ns
3029.3+x		26 ns *1*	24 ns
3495.4+x		28 ns *1*	26 ns
4505.5+x		12 ns *1*	14 ns
5929+y		164 ns *11*	157 ns
6744+y			59 ns

Results from γ(θ,H,t) measurements:

E(level)	Jπ	deduced g factor 1988St10
1664.0	21/2+	0.45 *1*
1664.0+x	25/2+	0.61 *2*
2186.7+x	31/2–	0.639 *5*
3029.3+x	37/2+	0.739 *7*
3495.4+x	43/2–	0.725 *7*
4505.5+x	49/2+	0.811 *12*
5928.8+x	(55/2+)	0.604 *5*

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Nuclear Data Sheets (2007)

From NNDC(BNL)
program ENSDAT

$^{213}_{86}Rn_{127}$–8

(HI,xnγ) (continued)

The level scheme constructed by 1988St10, except where noted otherwise, is presented here. There are a number of differences between the level schemes of 1988St10 and 1989Lo02, especially at high energy levels and their deexcitation. The γs associated with the three highest energy levels of this dataset, proposed by 1989Lo02, are adopted without the proposed M assignments for consistency.

^{213}Rn Levels

E(level)†	Jπ‡	$T_{1/2}$#	Comments
0.0	(9/2+)	19.5 ms *1*	Jπ,$T_{1/2}$: From adopted levels.
705.0 *8*	11/2+		
896.1 *8*	15/2−	26 ns *1*	
1259.6 *9*	13/2+		
1529.0 *9*	17/2+		
1574.1 *13*			
1612.4?			
1664.0 *10*	21/2+	29 ns *2*	
1664.0+x	25/2+	1.00 μs *21*	
1703.5? *13*			
1745.9 *11*			
1788.7 *12*			
1856.6+x *7*	25/2+		
1879.4 *13*			
1936.9 *13*			
2007.4 *11*			
2072.8 *11*			
2121.6+x *8*	(27/2)		
2184.3 *14*			
2186.7+x *6*	31/2−	1.36 ns *7*	
2201.5+x *8*	(27/2−)		
2227.5 *14*			
2257.5 *15*			
2327.1 *16*			
2610.7 *17*			
2640.8+x *10*			
2662.0+x *13*			
2677.0+x *7*	29/2+		
2684.5+x *13*			
2739.8+x *9*	31/2−		
2786.7+x *9*	29/2+		
2915.8+x *8*	33/2+		
2984.0+x *8*	33/2+		
3029.3+x *10*	37/2+	26 ns *1*	
3181.8+x *9*	(35/2−)		
3301.3+x *12*			
3441.2+x *11*	39/2−		
3495.5+x *15*	43/2−	28 ns *1*	
3604.8+x *14*			
3623.9+x *18*			
3923.0+x *17*	(43/2−)		
3927.4+x *18*			
4048.0+x *16*	(45/2−)		
4050.3+x *17*			
4343.2+x *20*			
4505.6+x *17*	49/2+§	12 ns *1*	
4532.8+x *20*			
4581.4+x *22*			
4723.1+x *20*			
4875.6+x *18*	(49/2+)		
5225.6+x *18*	(51/2+)§		
5763.7+x *18*	(53/2,55/2)		
5928.9+x *18*	(53/2,55/2)		
5929+y	(55/2+)	164 ns *11*	
6744.00+y *20*		59 ns	Level proposed by 1989Lo02. Jπ,$T_{1/2}$: Jπ=(61/2+), both from 1989Lo02.
7926.5+y *3*			Level proposed by 1989Lo02. Jπ: (65/2,67/2) in 1989Lo02.

Continued on next page (footnotes at end of table)

From NNDC(BNL)
program ENSDAT

$^{213}_{86}Rn_{127}$–9

(HI,xnγ) (continued)

^{213}Rn Levels (continued)

E(level)†	Jπ‡	$T_{1/2}$#	Comments
8831.9+y *3*			Level proposed by 1989Lo02. Jπ: (71/2,73/2) in 1989Lo02.

† Deduced by the evaluator from a least square fit to the γ–ray energies assuming ΔE=1 keV.
‡ Proposed by 1988St10 from γ multipolarities based on ce and γ(θ) data.
§ Spins deduced by 1989Lo02 are two units less than those given here because of the 54.3–keV transition, not seen by 1989Lo02.
# From 1988St10, except noted otherwise. Meanlife reported (1988St10), determined from γγ coin, γX coin, pulsed beam, and time differential perturbed angular distribution (TDPAD) g–factor measurements. Others: Please see the Table above.

γ(^{213}Rn)

Eγ†#	E(level)	Iγ@	Mult.a	α	Comments
(39.5‡)	1703.5?				
45.3§	3029.3+x	≈1	E2	359	α(L)=265 *4*; α(M)=71.1 *10*; α(N+..)=22.6 *4*. α(N)=18.5 *3*; α(O)=3.71 *6*; α(P)=0.405 *6*. Mult.: α(exp)=~380 (1988St10).
(48.6‡)	4581.4+x				
(≤50‡)	5929+y				Transition not observed, expected by 1988St10 from the observation that the 165.2γ deexciting the 5928.8+x–keV level had a prompt component, suggesting that the 164–ns level is above the 5928.8+x level.
54.3§	3495.5+x	≈1&	E2	148.8	α(L)=109.9 *16*; α(M)=29.5 *5*; α(N+..)=9.37 *14*. α(N)=7.66 *11*; α(O)=1.541 *22*; α(P)=0.1685 *24*. Mult.: α(exp)=160 *70* (1988St10).
(65.1‡)	2186.7+x				
68.2§	2984.0+x	7.6& *7*	M1	7.78	α(L)=5.91 *9*; α(M)=1.405 *20*; α(N+..)=0.458 *7*. α(N)=0.366 *6*; α(O)=0.0802 *12*; α(P)=0.01171 *17*. Mult.: α(exp)=9.8 *11* (1988St10).
(81.9‡)	1745.9				
(99.0‡)	2739.8+x				
113.5§	3029.3+x	3 *1*	E2	4.85	α(K)=0.365 *6*; α(L)=3.31 *5*; α(M)=0.891 *13*; α(N+..)=0.284 *4*. α(N)=0.232 *4*; α(O)=0.0468 *7*; α(P)=0.00521 *8*. A_2/A_0=0.15 *10* (1988St10). Mult.: α(exp)=5.9 *16* (1988St10).
(125.0‡)	4048.0+x	<1			
128.4§	3623.9+x	3.4& *4*			
135.0	1664.0	274 *5*	E2	2.35	α(K)=0.326 *5*; α(L)=1.495 *21*; α(M)=0.402 *6*; α(N+..)=0.1283 *18*. α(N)=0.1047 *15*; α(O)=0.0212 *3*; α(P)=0.00238 *4*. Eγ: others: 135.3 *2* (1989Lo02), 135.1 (1988Fu10). A_2/A_0=0.07 *1* (1988St10). Mult.: α(exp)=2.46 *4* (1988St10).
139.8§	3441.2+x	2.3& *4*			
165.2	5928.9+x	4 *1*	M1	3.15	α(K)=2.55 *4*; α(L)=0.461 *7*; α(M)=0.1094 *16*; α(N+..)=0.0357 *5*. α(N)=0.0285 *4*; α(O)=0.00624 *9*; α(P)=0.000911 *13*. Mult.: α(exp)=3 *1* (1988St10). Eγ: other: 165.7 *2* (1989Lo02).
184.7§	2257.5	2.0 *5*			
191.1§	896.1	4.4 *8*	M2	9.96	α(K)=6.95 *10*; α(L)=2.24 *4*; α(M)=0.575 *8*; α(N+..)=0.189 *3*. α(N)=0.1518 *22*; α(O)=0.0329 *5*; α(P)=0.00464 *7*. A_2/A_0=−0.06 *28* (1988St10). Mult.: α(exp)=9.9 *13* (1988St10).
192.6§	1856.6+x	29 *1*	(M1)	2.05	α(K)=1.653 *24*; α(L)=0.298 *5*; α(M)=0.0708 *10*; α(N+..)=0.0231 *4*. α(N)=0.0185 *3*; α(O)=0.00404 *6*; α(P)=0.000590 *9*. A_2/A_0=0.40 *6* (1988St10). Mult.: α(exp)=2.5 *3* (1988St10).
197.3§	2984.0+x	6.0& *7*			
216.9§	1745.9	8.2& *12*			
217.5§	4723.1+x	13& *2*			
218.7§	2007.4	≈1			

Continued on next page (footnotes at end of table)

From NNDC(BNL)
program ENSDAT

$^{213}_{86}Rn_{127}$–10

(HI,xnγ) (continued)

γ(^{213}Rn) (continued)

Eγ[†#]	E(level)	Iγ[@]	Mult.[a]	α	Comments
233.4[§]	1936.9	9 *1*			
238.8[§]	2915.8+x	1.5 *12*			
244.2[§]	2984.0+x	20 *5*	(E1)	0.0535	α(K)=0.0432 *6*; α(L)=0.00788 *11*; α(M)=0.00187 *3*; α(N+..)=0.000600 *9*. α(N)=0.000483 *7*; α(O)=0.0001029 *15*; α(P)=1.403×10^{-5} *20*. A_2/A_0=−0.15 *4* (1988St10). Mult.: α(exp)=0.0 *3* (1988St10).
259.4[§]	3441.2+x	≈2[&]			
259.7[§]	1788.7	≈1[&]			
261.5[§]	2007.4	≈1[&]			
266.0[§]	3181.8+x	≈3[&]			
269.4[§]	1529.0	15 *1*	E2	0.192	α(K)=0.0870 *13*; α(L)=0.0780 *11*; α(M)=0.0206 *3*; α(N+..)=0.00659 *10*. α(N)=0.00536 *8*; α(O)=0.001100 *16*; α(P)=0.0001304 *19*. A_2/A_0=0.01 *6* (1988St10). Mult.: α(exp)=0.18 *16*, deduced from intensity balance (1988St10).
272.0[§]	3301.3+x	5 *1*			A_2/A_0=−0.26 *15* (1988St10).
272.9[§]	1936.9	1.7 *5*			
307.0[§]	2984.0+x	5 *3*			
314.5[§]	1574.1	6 *1*			
330.1[§]	2186.7+x	9 *1*	(E3)	0.552	α(K)=0.1470 *21*; α(L)=0.298 *5*; α(M)=0.0815 *12*; α(N+..)=0.0263 *4*. α(N)=0.0214 *3*; α(O)=0.00439 *7*; α(P)=0.000519 *8*. Mult.: α(exp)=0.2 *3* (1988St10).
343.4[§]	2007.4	8 *2*			A_2/A_0=0.34 *13* (1988St10).
344.9[§]	2201.5+x	54 *2*	(E1)	0.0243	α(K)=0.0198 *3*; α(L)=0.00346 *5*; α(M)=0.000817 *12*; α(N+..)=0.000263 *4*. α(N)=0.000211 *3*; α(O)=4.54×10^{-5} *7*; α(P)=6.30×10^{-6} *9*. A_2/A_0=−0.28 *3* (1988St10). Mult.: α(exp)<0.17 (1988St10).
350.0	5225.6+x	9 *2*	(M1)	0.392	α(K)=0.318 *5*; α(L)=0.0566 *8*; α(M)=0.01343 *19*; α(N+..)=0.00438 *7*. α(N)=0.00350 *5*; α(O)=0.000766 *11*; α(P)=0.0001119 *16*. A_2/A_0=−0.39 *14* (1988St10). Mult.: α(K)exp=0.23 *4*, and α(L)exp<0.09 (1988St10). There is disagreement between the multipolarity assignments of 1988St10 and 1989Lo02. α(K)exp=0.23 *4* was deduced, and M1 was suggested by 1988St10; from a weak K line, 1989Lo02 deduced E1 multipolarity. However, since the 720.1γ (parallel to the cascading 350.0 and 370.1 gammas) and the 370.1γ are (M1), the 350.0γ probably is not E1.
352.8[b]	1612.4?	1.8 *7*			
370.1	4875.6+x	8 *2*	(M1)	0.337	α(K)=0.273 *4*; α(L)=0.0486 *7*; α(M)=0.01153 *17*; α(N+..)=0.00376 *6*. α(N)=0.00300 *5*; α(O)=0.000657 *10*; α(P)=9.60×10^{-5} *14*. Eγ: other measurement: 369.4 (1989Lo02). A_2/A_0=0.33 *5* (1988St10). Mult.: α(K)exp=0.22 *4*, α(L)exp=0.12 *1* (1988St10). Intensities measured by 1989Lo02 suggest that the 350.0γ is stronger, and therefore, should be below the 370.1γ. However, if the above placement between the above γ switched, then placement of 1053.3γ from 5928.8+x keV level to this level (1988St10) do not fit the level energy difference. So, 1988St10 level structure is followed by the evaluator. 1053.3γ is not reported in 1989Lo02.
383.2[§]	2610.7	<1			
390.2[§]	2327.1	5 *1*			

Continued on next page (footnotes at end of table)

From NNDC(BNL)
program ENSDAT

$^{213}_{86}Rn_{127}$–11

(HI,xnγ) (continued)

γ(^{213}Rn) (continued)

Eγ[†#]	E(level)	Iγ[@]	Mult.[a]	α	Comments
411.8	3441.2+x	260 *5*	E1	0.01652	α(K)=0.01348 *19*; α(L)=0.00231 *4*; α(M)=0.000545 *8*; α(N+..)=0.0001758 *25*. α(N)=0.0001411 *20*; α(O)=3.04×10^{-5} *5*; α(P)=4.26×10^{-6} *6*. Eγ: others: 412.2 *2* (1989Lo02), 411.8 (1988Fu10). A_2/A_0=−0.18 *1* (1988St10). Mult.: α(K)exp=0.035 *4*, and α(L)exp=0.005 *1* (1988St10).
420.2[§]	4343.2+x	<1			
427.5[§]	3923.0+x	16 *3*	M1	0.228	α(K)=0.185 *3*; α(L)=0.0328 *5*; α(M)=0.00778 *11*; α(N+..)=0.00254 *4*. α(N)=0.00203 *3*; α(O)=0.000444 *7*; α(P)=6.49×10^{-5} *9*. A_2/A_0=0.26 *7* (1988St10). Mult.: α(K)exp=0.19 *3*, and α(L)exp=0.08 *2* (1988St10).
431.9[§]	3927.4+x	13 *1*			
445.5[§]	4050.3+x	≈1[&]			
454.1[§]	2640.8+x	13 *2*			A_2/A_0=0.0 *1* (1988St10).
457.6[c]	2121.6+x	30 *5*			
	4505.6+x	<3			Iγ: determined by 1988St10 from coincidence spectra. Eγ: other: 456.9 *2* (1989Lo02). This transition was placed on the level scheme only once by 1989Lo02.
460.5[§]	2662.0+x	4 *1*			
483.0[§]	2684.5+x	5 *1*			
490.2[§]	2677.0+x	13 *1*	D+Q		Mult.: Assigned by the evaluator from A_2/A_0 value and level structure. A_2/A_0=−0.15 *8* (1988St10).
520.3[§]	2184.3	8[&] *2*			
522.7	2186.7+x	480 *10*	E3	0.1073	α(K)=0.0536 *8*; α(L)=0.0398 *6*; α(M)=0.01055 *15*; α(N+..)=0.00341 *5*. α(N)=0.00276 *4*; α(O)=0.000575 *8*; α(P)=7.16×10^{-5} *10*. Eγ: others: 521.7 *2* (1989Lo02) and 522.7 (1988Fu10), 521.7 (1983Lo16). A_2/A_0=0.130 *6* (1988St10). Mult.: α(K)exp=0.060 *2*, α(L)exp=0.036 *2*, and α(M)exp=0.013 *1* (1988St10). Polarization amplitude=−0.01 *4* (1988Fu10).
533.4[§b]	4581.4+x				From decay scheme of 1988St10; this transition was not listed by the authors.
537.5	2201.5+x	18 *2*	(E1)	0.00951	α(K)=0.00780 *11*; α(L)=0.001301 *19*; α(M)=0.000306 *5*; α(N+..)=9.88×10^{-5} *14*. α(N)=7.92×10^{-5} *11*; α(O)=1.713×10^{-5} *24*; α(P)=2.42×10^{-6} *4*. Eγ: other: 536.7 *2* (1989Lo02).
538.1	5763.7+x	10[&] *1*			Eγ: other: 536.7 *2* (1989Lo02).
543.7[§]	2072.8	2[&] *1*			
552.5	4048.0+x	47 *4*	M1	0.1150	α(K)=0.0934 *13*; α(L)=0.01646 *23*; α(M)=0.00390 *6*; α(N+..)=0.001270 *18*. α(N)=0.001015 *15*; α(O)=0.000222 *4*; α(P)=3.25×10^{-5} *5*. Eγ: Other: 551.8 *2* (1989Lo02). Mult.: α(K)exp=0.12 *2* (1988St10). The α(K)exp value is presented for 553γ with a multipolarity M1 in Table 3 (1988St10). Evaluator presents the same α(K)exp value and M1 multipolarity for both the 552.5γ and 553.1γ from (45/2−) state at 4048.0+x and 31/2− state at 2737.4+x levels, respectively.
553.1[§]	2739.8+x	26 *4*	M1	0.1147	α(K)=0.0931 *13*; α(L)=0.01641 *23*; α(M)=0.00389 *6*; α(N+..)=0.001266 *18*. α(N)=0.001012 *15*; α(O)=0.000222 *4*; α(P)=3.24×10^{-5} *5*. Mult.: α(K)exp=0.12 *2* (1988St10). The α(K)exp value is presented for 553γ with a multipolarity M1 in Table 3 (1988St10). Evaluator presents the same α(K)exp value and M1 multipolarity for both the 552.5γ and 553.1γ from (45/2−) state at 4048.0+x and 31/2− state at 2737.4+x levels, respectively.
563.5[§]	2227.5	28 *1*			A_2/A_0=−0.11 *7* (1988St10).
575.5[§]	3604.8+x	12 *3*			A_2/A_0=−0.05 *10* (1988St10).

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From NNDC(BNL)
program ENSDAT

$^{213}_{86}Rn_{127}$–12

(HI,xnγ) (continued)

γ(^{213}Rn) (continued)

Eγ[†#]	E(level)	Iγ[@]	Mult.[a]	α	Comments
609.8[§]	4532.8+x	7 *3*			A_2/A_0=−0.19 *6* (1988St10).
632.9	1529.0	950 *100*	E1	0.00688	α(K)=0.00566 *8*; α(L)=0.000930 *13*; α(M)=0.000218 *3*; α(N+..)=7.05×10^{-5} *10*. α(N)=5.65×10^{-5} *8*; α(O)=1.225×10^{-5} *18*; α(P)=1.745×10^{-6} *25*. Eγ: others: 631.7 *2* (1989Lo02), 632.7 (1988Fu10), 631.7 (1983Lo16). A_2/A_0=−0.112 *24* (1988St10). Mult.: α(K)exp=0.008 *1*, α(L)exp=0.0014 *2*, and α(M)exp<0.0009 (1988St10). Polarization amplitude=−0.01 *2* (1988Fu10).
705.0[§]	705.0	770 *5*	M1	0.0604	α(K)=0.0491 *7*; α(L)=0.00860 *12*; α(M)=0.00204 *3*; α(N+..)=0.000663 *10*. α(N)=0.000530 *8*; α(O)=0.0001160 *17*; α(P)=1.697×10^{-5} *24*. A_2/A_0=−0.03 *2* (1988St10). Mult.: α(K)exp=0.040 *3* and α(L)exp=0.013 *2* (1988St10).
720.1	5225.6+x	10 *3*	(M1)	0.0572	α(K)=0.0465 *7*; α(L)=0.00813 *12*; α(M)=0.00192 *3*; α(N+..)=0.000627 *9*. α(N)=0.000501 *7*; α(O)=0.0001097 *16*; α(P)=1.605×10^{-5} *23*. Eγ: other: 718.9 *2* (1989Lo02). Mult.: α(K)exp=0.041 *4* (1988St10).
729.1	2915.8+x	115 *6*	E1	0.00525	α(K)=0.00433 *6*; α(L)=0.000703 *10*; α(M)=0.0001645 *23*; α(N+..)=5.32×10^{-5} *8*. α(N)=4.26×10^{-5} *6*; α(O)=9.26×10^{-6} *13*; α(P)=1.324×10^{-6} *19*. Eγ: others: 727.8 *2* (1989Lo02) and 728.7 (1988Fu10). Mult.: there are disagreements between the experimental Ice's and the angular distributions measured by 1988St10 and by 1989Lo02: α(K)exp<0.0065, α(L)exp=0.004 *1* (1988St10), α(K)exp=0.019 (1989Lo02); angular distribution: A_2/A_0=−0.22 *2* (1988St10), −0.02 *4* (1989Lo02).
767.9	1664.0	10 *1*	(E3)	0.0365	α(K)=0.0237 *4*; α(L)=0.00961 *14*; α(M)=0.00247 *4*; α(N+..)=0.000799 *12*. α(N)=0.000645 *9*; α(O)=0.0001362 *19*; α(P)=1.781×10^{-5} *25*. Eγ: other: 767.6 (1988Fu10). A_2/A_0=0.4 *1* (1988St10). Mult.: E3 is expected from the level scheme; angular distribution is consistent with this multipolarity; no conversion electron line was observed.
797.3	2984.0+x	256 *5*	E1	0.00444	α(K)=0.00367 *6*; α(L)=0.000591 *9*; α(M)=0.0001383 *20*; α(N+..)=4.47×10^{-5} *7*. α(N)=3.58×10^{-5} *5*; α(O)=7.79×10^{-6} *11*; α(P)=1.117×10^{-6} *16*. Eγ: others: 795.8 *2* (1989Lo02), 797.2 (1988Fu10), 795.5 (1983Lo16). A_2/A_0=−0.168 *8* (1988St10). Mult.: α(K)exp=0.0048 *4* and α(L)exp=0.0013 *3* (1988St10).
815.0 *2*	6744.00+y	≈100[#]			Eγ: From 1989Lo02. Mult.: E3 from A_2/A_0=0.29 *5*, A_4/A_0=0.28 *4*; εK(exp)=0.027 (1989Lo02). α(K)=0.0209 *3*; α(L)=0.00788 *11*; α(M)=0.00202 *3*; α(N+..)=0.000653 *10*. α(N)=0.000527 *8*; α(O)=0.0001114 *16*; α(P)=1.468×10^{-5} *21*.
842.6[§b]	3029.3+x	5[&] *1*			Placement of 842.6γ between the 37/2+ state at 3029.3+x and the 31/2− state at 2186.7+x keV requires the 842.6γ to be an E3 transition, with B(E3)(W.u.)=0.7 *4*.
896.1	896.1	1000	E3	0.0250	α(K)=0.01723 *25*; α(L)=0.00582 *9*; α(M)=0.001476 *21*; α(N+..)=0.000478 *7*. α(N)=0.000386 *6*; α(O)=8.19×10^{-5} *12*; α(P)=1.091×10^{-5} *16*. Eγ: others: 894.5 *2* (1989Lo02), 896.0 (1988Fu10), 894.5 (1983Lo16). A_2/A_0=0.098 *9* (1988St10). Mult.: α(K)exp=0.016 *1*, α(L)exp=0.0059 *4*, and α(M)exp=0.0016 *2* (1988St10). Polarization amplitude=−0.04 *2* (1988Fu10).

Continued on next page (footnotes at end of table)

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From NNDC(BNL)
program ENSDAT

$^{213}_{86}Rn_{127}$–13

(HI,xnγ) (continued)

γ(^{213}Rn) (continued)

Eγ[†#]	E(level)	Iγ[@]	Mult.[a]	α	Comments
905.4 *2*	8831.9+y	60[#] *18*			Eγ: From 1989Lo02. Mult.: (E3) from A_2/A_0=0.34 *7*, A_4/A_0=0.41 *10*; εK(exp)≤0.024 (1989Lo02).
907.4[b]	1612.4?	5 *1*			Eγ: other: 905.4 (1989Lo02). This transition was placed by 1989Lo02 to deexcite a level at 8769+d keV.
930.1[§]	2786.7+x	12 *1*			A_2/A_0=0.0 *1* (1988St10).
995.1[§]	3181.8+x	35 *4*	(E2)	0.00821	α(K)=0.00641 *9*; α(L)=0.001361 *19*; α(M)=0.000330 *5*; α(N+..)=0.0001068 *15*. α(N)=8.58×10^{-5} *12*; α(O)=1.85×10^{-5} *3*; α(P)=2.57×10^{-6} *4*. A_2/A_0=0.13 *5* (1988St10).
1010.1	4505.6+x	51 *4*	E3	0.0189	α(K)=0.01351 *19*; α(L)=0.00405 *6*; α(M)=0.001016 *15*; α(N+..)=0.000329 *5*. α(N)=0.000265 *4*; α(O)=5.66×10^{-5} *8*; α(P)=7.64×10^{-6} *11*. Eγ: other: 1008.1 *2* (1989Lo02). A_2/A_0=0.47 *2* (1988St10). Mult.: α(K)exp=0.0155 *12*, α(L)exp=0.0049 *5*, and α(M)exp=0.0014 *3* (1988St10).
1013.0[§]	2677.0+x	11 *4*	Q		Mult.: Assigned by the evaluator from A_2/A_0 value and level structure. A_2/A_0=0.10 *9* (1988St10).
1053.3[§]	5928.9+x	3[&] *1*			
1174.4[§]	1879.4	17 *3*			
1176.8[§]	2072.8	16 *3*			A_2/A_0=0.14 *10* (1988St10).
1182.5 *2*	7926.5+y	≈80[#]			Eγ: From 1989Lo02. Mult.: (E3) from A_2/A_0=0.36 *2*, A_4/A_0=0.02 *3*; εK(exp)≤0.025 (1989Lo02). α(K)=0.00986 *14*; α(L)=0.00258 *4*; α(M)=0.000641 *9*; α(N+..)=0.000209 *3*. α(N)=0.0001672 *24*; α(O)=3.58×10^{-5} *5*; α(P)=4.92×10^{-6} *7*; α(IPF)=7.24×10^{-7} *11*.
1258.1	5763.7+x	16 *3*	(M2,E3)	0.022 *10*	α(K)=0.017 *9*; α(L)=0.0035 *13*; α(M)=0.0008 *3*; α(N+..)=0.00028 *10*. α(N)=0.00022 *8*; α(O)=4.8×10^{-5} *18*; α(P)=7.×10^{-6} *3*; α(IPF)=4.0×10^{-6} *8*. Eγ: other: 1255.9 *2* (1989Lo02).
1259.6[§]	1259.6	24 *3*			
1423.3[§]	5928.9+x	3[&] *1*			

† From 1988St10, unless noted otherwise.
‡ Transition not observed; existence was deduced from coincidence data.
§ Transition was not seen by others.
# From 1989Lo02.
@ Relative singles intensity measured in ^{208}Pb(57–MeV ^{9}Be,4n) by 1988St10 and normalized to Iγ(896)=1000.
& From coincidence data (1988St10).
a From ce measurements of 1989Lo02 and 1988St10, angular distribution measurements of 1989Lo02, 1988St10, 1988Fu10, and 1983Lo16.
b Placement of transition in the level scheme is uncertain.
c Multiply placed.

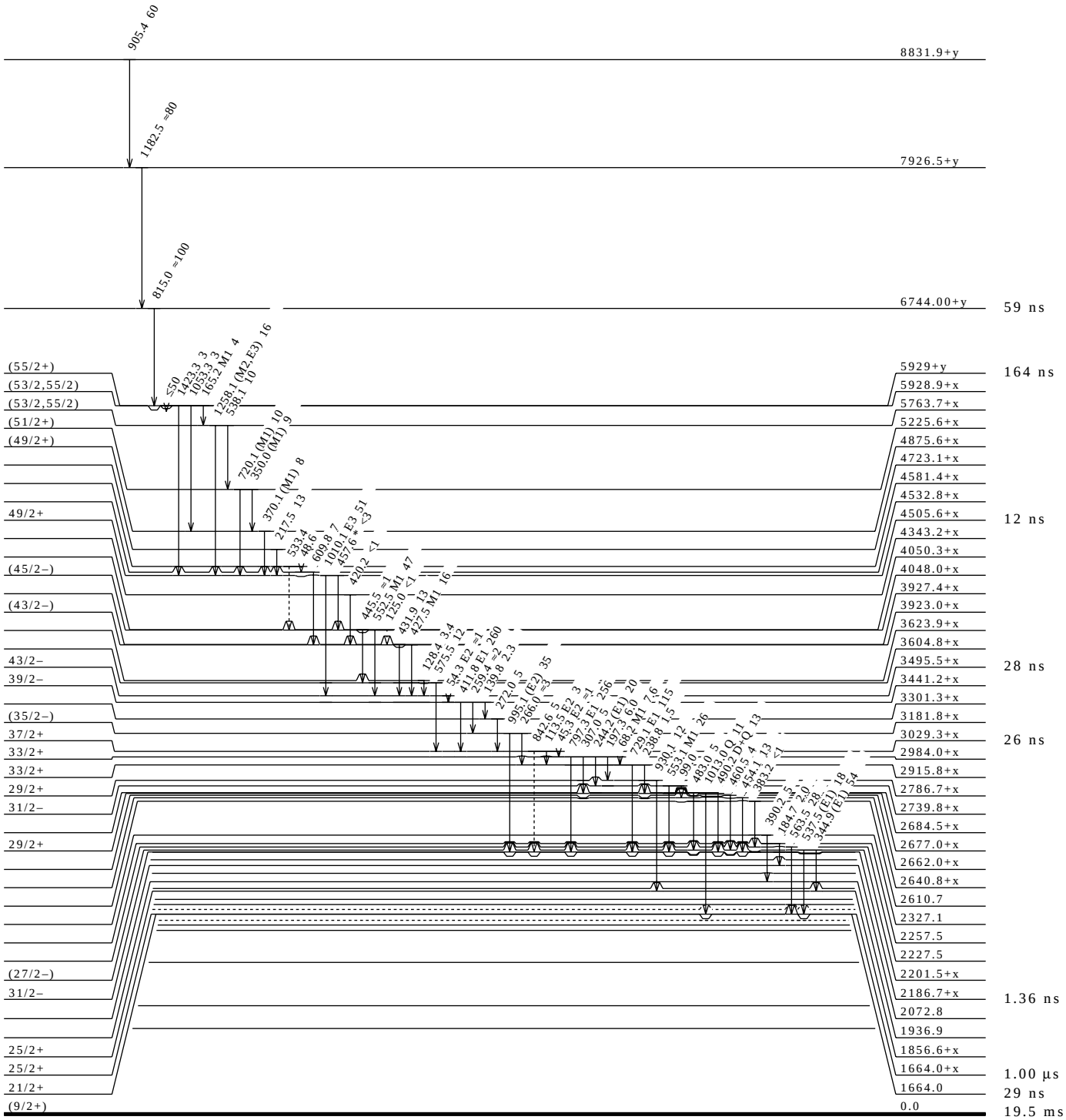
From NNDC(BNL)
program ENSDAT

$^{213}_{86}Rn_{127}$–14

(HI,xnγ) (continued)

Level Scheme

Intensities: relative Iγ
* Multiply placed



$^{213}_{86}Rn_{127}$

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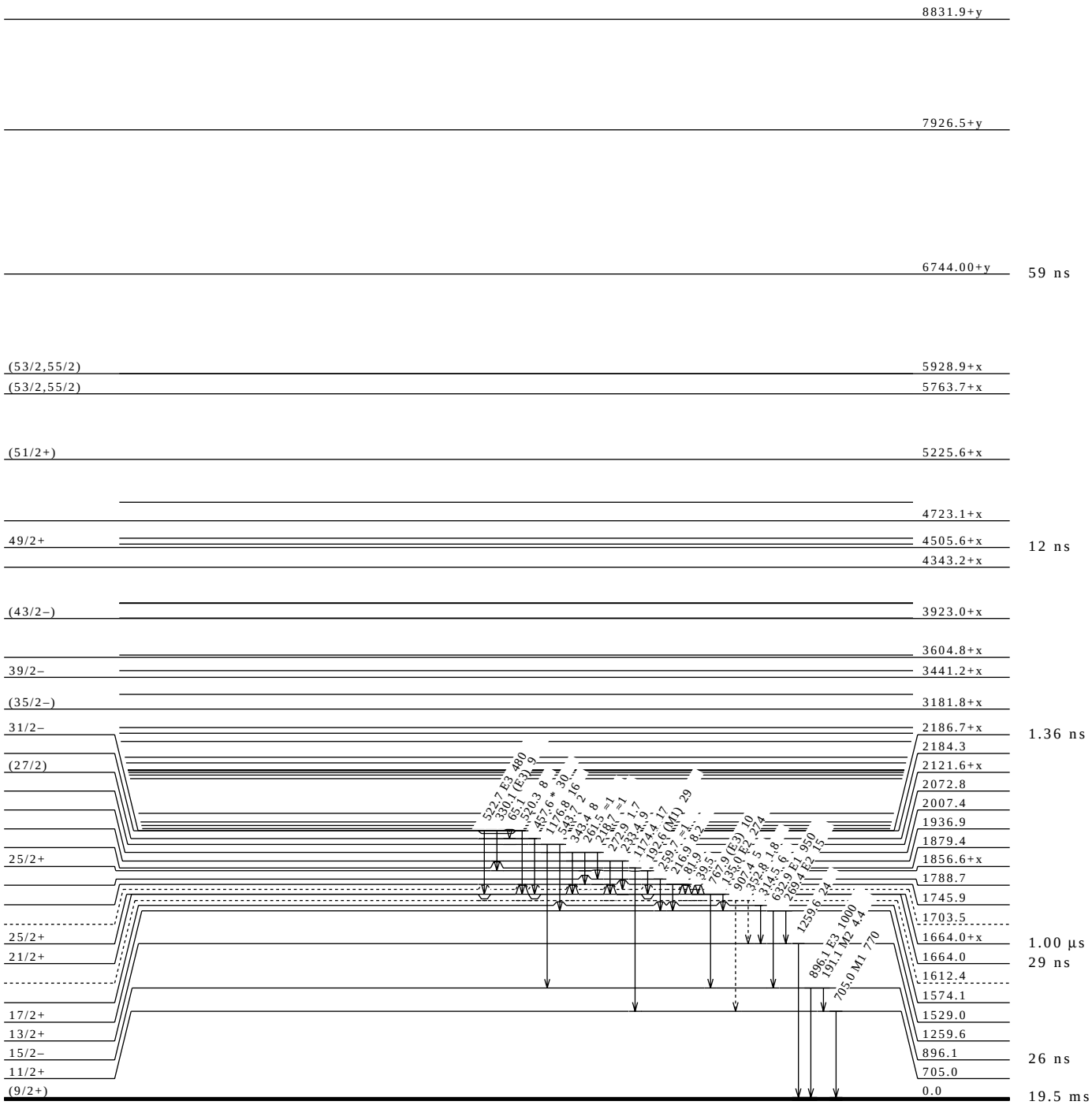
From NNDC(BNL)
program ENSDAT

$^{213}_{86}Rn_{127}$–15

(HI,xnγ) (continued)

Level Scheme (continued)

Intensities: relative Iγ
* Multiply placed



$^{213}_{86}Rn_{127}$

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From NNDC(BNL)
program ENSDAT

$^{213}_{87}Fr_{126}$−1

Adopted Levels, Gammas

Q(β⁻)=−3908 *22*; S(n)=8080 *30*; S(p)=2179 *8*; Q(α)=6904.9 *18* 2003Au03.

^{213}Fr Levels

Cross Reference (XREF) Flags

A ^{217}Ac α Decay (69 ns)
B ^{217}Ac α Decay (740 ns)
C ^{217}Ac α Decay: E=1.15 MeV
D ^{217}Ac α Decay: E=1.5 MeV
E (HI,xnγ)

E(level)†	Jπ‡	XREF	$T_{1/2}$§	Comments
0.0	9/2−	ABCDE	34.82 s *14*	Jπ: Measured by Atomic Beam Magnetic Resonance (ABMR) technique (1978Ek02); configuration=(π $h_{9/2}$)^5 from μ and shell model. $T_{1/2}$: Weighted average of 34.6 s *3* (1974Ho27), 34.7 s *3* (1967Va20), 33.7 s *15* (1964Gr04), and 35.0 s *2* (1982Bo04). %α=99.44 *5*; %ε+%β⁺=0.56 *5*. Using the Limitation of Relative Statistical Weight Method (LWM) (1985ZiZY) of %α=99.48 *3*, %(ε+β⁺)=0.52 *3* (1964Gr04), %α=99.43 *3*, %(ε+β⁺)=0.57 *3* (1967Va20), and %α=99.1 *1*, %(ε+β⁺)=0.9 *1* (1974Ho27) values. ε branching was deduced from comparison of ^{213}Fr and ^{213}Rn α's in by 1964Gr04, 1967Va20, and 1974Ho27. ^{213}Fr ε decay scheme has not been studied. An ε branch to ^{213}Rn g.s. would have a log *ft* value of ≥6.1. μ=+4.02 *8*; Q=−0.14 *2* (1989Ra17). Dipole−magnetic moment was obtained by LASER induced optical pumping by 1985Co24 and 1986Ek02. Isomeric shift=−1641 *2* MHz (1985Co24).
498.0 *10*	(7/2−)	B		Jπ: α decay from 29/2+ isomeric state in ^{217}At and from shell model, 1985De14 suggest π f7/2 configuration.
1105.0 *10*	(13/2)+	B		Jπ: 1105γ M2 to 9/2− g.s. From similar α reduced widths for (^{216}Ra 10+ to ^{212}Rn 0+) and for (^{217}At 29/2+ to ^{213}Fr 13/2+) α's, 1984De14 suggest i13/2 configuration.
1188.81 *10*	13/2−	E	<2.1 ns	Jπ: 1188.8γ E2 to 9/2− state. Configuration=(π $h_{9/2}$)^5.
1411.01 *15*	17/2−	E	18 ns *1*	μ=7.5 *14* (1986By01,1989Ra17). Jπ: 222.2γ E2 to 13/2− state. g=0.88 *16* by γ(H,θ,t) in (HI,xnγ) (1986By01). Configuration=(π $h_{9/2}$)^5.
1590.41 *18*	21/2−	E	505 ns *14*	μ=9.32 *3* (1989Ra17). Jπ: 179.4γ E2 to 17/2− state. Measurements: g=0.888 *3* (1977Be56, 1976Ha37); 0.888 *4* (1979Ho06); 0.89 *2* (1986By01) by γ(H,θ,t) in (HI,xnγ). Configuration=(π $h_{9/2}$)^5.
1856.31 *20*	23/2−	E	<1.4 ns	Jπ: 265.9γ M1+E2 to 21/2− state. Configuration=((π $h_{9/2}$)^4(π $f_{7/2}$)).
2537.62 *23*	29/2+	E	238 ns *6*	Jπ: 681.3γ E3 to 23/2− state. Main configuration=((π $h_{9/2}$)^4(π $i_{13/2}$)). $T_{1/2}$: Other: 243 ns *21* (1986By01). μ=15.22 *3* (1989Ra17); Q=−70 *7* (1991Ha02). μ is from the measurements of (by γ(H,θ,t), corrected for Knight shift): g=1.055 *5* (1989By01), 1.049 *2* (1979Ho06), 1.0494 *18* (1977Be56,1976Ha37), and 1.04 *2* (1974Re09). Q=81 *4* was obtained by 1990Ha30 by level mixing spectroscopy. Q=−70 *7* was deduced by 1990By03 by using B(E2) for the 8+ to 6+ transition in ^{212}Rn and an effective charge of 1.5e. See also 1991Ha02 for calculations.
2740.2 *3*	27/2−	E	<7 ns	Jπ: 884γ E2 to 23/2− state. Configuration=((π $h_{9/2}$)^4(π $f_{7/2}$)).
2950.6 *3*	31/2−	E	<2.1 ns	Jπ: 413.0γ E1 to 29/2+ state, 210.4γ (E2) to 27/2− state. Configuration=((π $h_{9/2}$)^4(π $f_{7/2}$)).
3427.35 *24*	33/2+	E	<2.1 ns	Jπ: 476.9γ E1 to 31/2− state, 889.7γ E2 to 29/2+ state. Configuration=((π $h_{9/2}$)^4(π $i_{13/2}$)).
3489.3 *4*	(33/2)	E		Jπ: 538.7γ (D) to 31/2− state.
3655.5 *4*	37/2+	E	2.4 ns *7*	Jπ: 228.1γ E2 to 33/2+ state. Configuration=((π $h_{9/2}$)^4(π $i_{13/2}$)).
4029.3 *5*		E		
4082.9 *4*	39/2+	E	<1.4 ns	Jπ: 427.5γ M1+E2 to 37/2+ state.
4653.6? *11*		E		
4675.5 *4*		E	<2.1 ns	Two cascading gammas combining the level with 47/2−, three cascading gammas from 49/2+ state, and probable M1 character of the 592.5γ to 39/2+ suggest (41/2+).
4695.9 *4*	39/2−	E	<2.1 ns	Jπ: 1040.3γ E1 to 37/2+ state.

Continued on next page (footnotes at end of table)

From NNDC(BNL)
program ENSDAT

$^{213}_{87}Fr_{126}$–2

Adopted Levels, Gammas (continued)

^{213}Fr Levels (continued)

E(level)†	Jπ‡	XREF	$T_{1/2}$§	Comments
4898.5 *4*	41/2–	E	<2.8 ns	Jπ: 815.6γ E1 to 39/2+ state.
4982.0 *6*		E		If 306.5γ to 4675.4–keV level is E1, as implied by intensity balance at 4675.4–keV level, and if Jπ(4675.4–keV level) is (41/2+), Jπ(4982.0–keV level)=(43/2–) is consistent with being populated from 49/2+ state through three cascading γ transitions.
4992.7 *4*	45/2–	E	13 ns *2*	μ=22.3 *6*. μ value was recommended by 1989Ra17. Jπ: 909.8γ E3 to 39/2+ state, 94.4γ E2 to 41/2– state. Measurements: g=0.990 *25* (1979Ho06); 1.03 *3* (1986By01) by γ(H,θ,t) in (HI,xnγ).
5002.0 *5*		E		784.0γ from 47/2– state and two cascading γ transitions to 39/2+ state (326.3γ (D) and 592.5γ (D)) suggest Jπ=(43/2–).
5220.2 *5*		E		
5506.3 *4*	43/2–	E	<2.1 ns	Jπ: 810.2γ E2 to 39/2– state.
5785.9 *4*	47/2–	E	<1.4 ns	Jπ: 793.2γ M1 to 45/2– state. 279.6γ E2 to 43/2– state.
5814.8 *5*	(45/2+)	E		Jπ: 308.3γ (E1) to 43/2– state.
5951.5 *5*		E		
6102.7 *6*	(49/2–)	E		Jπ: 316.8γ (M1+E2) to 47/2– state.
6334.1 *5*		E		
6572.9 *4*	49/2+	E	<2.1 ns	Jπ: 786.9γ E1 to 47/2– state.
6715.3 *5*	53/2+	E	6.2 ns *14*	Jπ: 142.3γ E2 to 49/2+ state, 929.5γ E3 to 47/2– state.
6724.5 *6*	(55/2+)	E		Jπ: 621.8γ to (49/2–) state presumably an E3, since of the cascading 621.8γ and 316.8γ (from 49/2– state) later one is (M1+E2).
6802.9 *7*	(55/2)	E		Jπ: the 738.8γ from the 7541 level is probably dipole; no γ from (59/2+).
6812.9 *6*		E		
7135.2 *7*		E		
7247.4 *7*		E		
7288.0 *7*	(57/2+)	E	<2.1 ns	Jπ: 563.3γ M1 to (55/2+) state.
7374.3 *7*	(57/2,59/2)	E		Jπ: 349.5γ from (59/2+) state at 7723 keV is probably dipole; possible γ to (57/2+); level decays through six cascading gammas to 45/2– level. If 349.5γ is E1, then π=(–).
7541.7 *6*	(57/2)	E		Jπ: 182.0γ from (59/2+) state at 7723 keV is dipole; 817.7γ to (55/2+) state. If 182.0γ is M1, as suggested by the intensity balance at the 7723.3 level, then Jπ=(57/2+).
7723.6 *6*	(59/2+)	E		Jπ: 182γ d to (57/2), 349.5γ d to (57/2,59/2).
7983.5 *7*	(61/2–)	E	<3.5 ns	Jπ: 1259γ E3 to (55/2+),.
8094.8 *7*	(65/2–)	E	3.1 μs *2*	Jπ: 371.2γ (E3) to (59/2+) state. μ=22.6 *3*; Q=–219 *53*. Q is from 1991Ha02, if Q(29/2+ state)=–70 *7*. μ was obtained by 1989By01 from time–differential perturbed angular distribution for 1259γ. Q=251 *51* was obtained (1990Ha30) by level mixing spectroscopy; g–factor of 0.695 *7* was used.

† Deduced by the evaluator from a least squares fit to the γ–ray energies.

‡ All spins and parities for levels above 1188 keV were deduced from (HI,xnγ) data. They were based on γ angular distribution, linear polarization, conversion electron measurements, and transition strength results.

§ All excited states' half–lives are from (HI,xnγ) data.

γ(^{213}Fr)

ll γ properties are from (HI,xnγ) data.

E(level)	Eγ	Iγ	Mult.	δ	α	Comments
498.0	498	100				
1105.0	1105	100	M2		0.0479	α(K)=0.0380 *6*; α(L)=0.00747 *11*; α(M)=0.00180 *3*; α(N+..)=0.000596 *9*. α(N)=0.000473 *7*; α(O)=0.0001056 *15*; α(P)=1.688×10^{-5} *24*; α(Q)=9.26×10^{-7} *13*; α(IPF)=5.71×10^{-8}. Mult.: from ce in ^{217}Ac α decay (740 ns) (1985De14).

Continued on next page (footnotes at end of table)

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From NNDC(BNL)
program ENSDAT

$^{213}_{87}Fr_{126}$–3

Adopted Levels, Gammas (continued)

γ(^{213}Fr) (continued)

E(level)	Eγ	Iγ	Mult.	δ	α	Comments
1188.81	1188.8 *1*	100	E2		0.00616	B(E2)↓(W.u.)=0.0014928 *7*. α(K)=0.00487 *7*; α(L)=0.000976 *14*; α(M)=0.000235 *4*; α(N+..)=8.01×10^{-5} *12*. α(N)=6.16×10^{-5} *9*; α(O)=1.360×10^{-5} *19*; α(P)=2.12×10^{-6} *3*; α(Q)=1.025×10^{-7} *15*; α(IPF)=2.65×10^{-6} *4*.
1411.01	222.2 *1*	100	E2		0.382	B(E2)↓(W.u.)=0.55 *4*. α(K)=0.1318 *19*; α(L)=0.185 *3*; α(M)=0.0494 *7*; α(N+..)=0.01603 *23*. α(N)=0.01295 *19*; α(O)=0.00271 *4*; α(P)=0.000362 *6*; α(Q)=3.43×10^{-6} *5*.
1590.41	179.4 *1*	100	E2		0.823	B(E2)↓(W.u.)=0.0439 *20*. α(K)=0.201 *3*; α(L)=0.458 *7*; α(M)=0.1234 *18*; α(N+..)=0.0400 *6*. α(N)=0.0324 *5*; α(O)=0.00675 *10*; α(P)=0.000890 *13*; α(Q)=5.84×10^{-6} *9*.
1856.31	265.9 *1*	100	M1+E2	0.9 *+11−9*	0.6 *4*	B(M1)↓(W.u.)=0.0003 *+4−3*; B(E2)↓(W.u.)=1.1 *+16−11*. α(K)=0.4 *3*; α(L)=0.113 *20*; α(M)=0.028 *4*; α(N+..)=0.0092 *13*. α(N)=0.0074 *10*; α(O)=0.00161 *25*; α(P)=0.00024 *6*; α(Q)=1.0×10^{-5} *7*.
2537.62	681.3 *1*	100	E3		0.0529	B(E3)↓(W.u.)=25.8 *23*. α(K)=0.0317 *5*; α(L)=0.01579 *23*; α(M)=0.00412 *6*; α(N+..)=0.001354 *19*. α(N)=0.001086 *16*; α(O)=0.000234 *4*; α(P)=3.38×10^{-5} *5*; α(Q)=9.27×10^{-7} *13*.
2740.2	202.8‡ *4*					
	884.0 *3*	100 *16*	E2		0.01087	B(E2)↓(W.u.)=0.001960 *4*. α(K)=0.00831 *12*; α(L)=0.00193 *3*; α(M)=0.000473 *7*; α(N+..)=0.0001553 *22*. α(N)=0.0001238 *18*; α(O)=2.71×10^{-5} *4*; α(P)=4.14×10^{-6} *6*; α(Q)=1.79×10^{-7} *3*.
2950.6	210.4 *3*	<33	(E2)		0.462	B(E2)↓(W.u.)=1.133 *14*. α(K)=0.1474 *21*; α(L)=0.232 *4*; α(M)=0.0622 *10*; α(N+..)=0.0202 *3*. α(N)=0.01631 *25*; α(O)=0.00341 *6*; α(P)=0.000454 *7*; α(Q)=3.92×10^{-6} *6*.
	413.0 *2*	100 *3*	E1		0.01695	B(E1)↓(W.u.)=1.0179×10^{-6} *16*. α(K)=0.01381 *20*; α(L)=0.00240 *4*; α(M)=0.000567 *8*; α(N+..)=0.000185 *3*. α(N)=0.0001475 *21*; α(O)=3.25×10^{-5} *5*; α(P)=5.03×10^{-6} *7*; α(Q)=2.47×10^{-7} *4*.
3427.35	476.9 *2*	45.7 *20*	E1		0.01255	B(E1)↓(W.u.)=2.582×10^{-7} *4*. α(K)=0.01025 *15*; α(L)=0.001751 *25*; α(M)=0.000413 *6*; α(N+..)=0.0001353 *19*. α(N)=0.0001077 *16*; α(O)=2.38×10^{-5} *4*; α(P)=3.70×10^{-6} *6*; α(Q)=1.86×10^{-7} *3*.
	889.7 *1*	100 *4*	E2		0.01073	B(E2)↓(W.u.)=0.004341 *3*. α(K)=0.00822 *12*; α(L)=0.00190 *3*; α(M)=0.000465 *7*; α(N+..)=0.0001528 *22*. α(N)=0.0001219 *17*; α(O)=2.67×10^{-5} *4*; α(P)=4.08×10^{-6} *6*; α(Q)=1.765×10^{-7} *25*.
3489.3	538.7 *3*	100	(D)			
3655.5	228.1 *2*	100	E2		0.349	B(E2)↓(W.u.)=3.7 *11*. α(K)=0.1248 *18*; α(L)=0.1655 *24*; α(M)=0.0443 *7*; α(N+..)=0.01437 *21*. α(N)=0.01161 *17*; α(O)=0.00243 *4*; α(P)=0.000325 *5*; α(Q)=3.22×10^{-6} *5*.
4029.3	540.0 *3*	100				

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CITATION:
Nuclear Data Sheets (2007)

From NNDC(BNL)
program ENSDAT

$^{213}_{87}Fr_{126}$−4

Adopted Levels, Gammas (continued)

γ(^{213}Fr) (continued)

E(level)	Eγ	Iγ	Mult.	δ	α	Comments
4082.9	427.5 *1*	100	M1+E2	0.10 *3*	0.246	B(M1)↓(W.u.)=0.0001580 *14*; B(E2)↓(W.u.)=0.0029 *18*. α(K)=0.199 *3*; α(L)=0.0359 *6*; α(M)=0.00854 *13*; α(N+..)=0.00282 *4*. α(N)=0.00224 *4*; α(O)=0.000500 *8*; α(P)=8.02×10^{-5} *12*; α(Q)=4.47×10^{-6} *7*.
4653.6?	624.2‡ *5*	100				
4675.5	592.5 *3*	100 *7*	(D)			
4695.9	(42.3†)					
	665‡					
	1040.3 *3*	100 *10*	E1		0.00286	B(E1)↓(W.u.)=7.999×10^{-8} *7*. α(K)=0.00236 *4*; α(L)=0.000377 *6*; α(M)=8.83×10^{-5} *13*; α(N+..)=2.90×10^{-5} *4*. α(N)=2.30×10^{-5} *4*; α(O)=5.13×10^{-6} *8*; α(P)=8.15×10^{-7} *12*; α(Q)=4.46×10^{-8} *7*. Other probable gammas from the level are ignored.
4898.5	815.6 *2*	100	E1		0.00443	B(E1)↓(W.u.)=1.2430×10^{-7} *10*. α(K)=0.00365 *6*; α(L)=0.000593 *9*; α(M)=0.0001392 *20*; α(N+..)=4.57×10^{-5} *7*. α(N)=3.63×10^{-5} *5*; α(O)=8.06×10^{-6} *12*; α(P)=1.274×10^{-6} *18*; α(Q)=6.82×10^{-8} *10*.
4982.0	306.5 *4*	100				
4992.7	94.4 *3*	3.4 *9*	E2		11.49 *24*	B(E2)↓(W.u.)=2.5 *8*. α(L)=8.46 *18*; α(M)=2.29 *5*; α(N+..)=0.741 *16*. α(N)=0.601 *13*; α(O)=0.124 *3*; α(P)=0.0160 *4*; α(Q)=3.84×10^{-5} *7*.
	909.8 *2*	100 *8*	E3		0.0255	B(E3)↓(W.u.)=63 *12*. α(K)=0.01750 *25*; α(L)=0.00601 *9*; α(M)=0.001530 *22*; α(N+..)=0.000503 *7*. α(N)=0.000402 *6*; α(O)=8.75×10^{-5} *13*; α(P)=1.303×10^{-5} *19*; α(Q)=4.59×10^{-7} *7*.
5002.0	326.3 *4*	100	D			
5220.2	(227.5†)					
	238					
	545.1 *5*	100				
5506.3	810.2 *3*	100	E2		0.01293	B(E2)↓(W.u.)=0.010084 *19*. α(K)=0.00975 *14*; α(L)=0.00239 *4*; α(M)=0.000590 *9*; α(N+..)=0.000194 *3*. α(N)=0.0001545 *22*; α(O)=3.38×10^{-5} *5*; α(P)=5.12×10^{-6} *8*; α(Q)=2.11×10^{-7} *3*.
5785.9	279.6 *2*	46 *5*	E2		0.180	B(E2)↓(W.u.)=0.903 *6*. α(K)=0.0812 *12*; α(L)=0.0729 *11*; α(M)=0.0193 *3*; α(N+..)=0.00628 *9*. α(N)=0.00507 *8*; α(O)=0.001068 *16*; α(P)=0.0001452 *21*; α(Q)=1.99×10^{-6} *3*.
	784.0 *4*	0.024 *8*				
	793.2 *3*	100 *16*	M1		0.0481	B(M1)↓(W.u.)=1.976×10^{-5} *4*. α(K)=0.0391 *6*; α(L)=0.00690 *10*; α(M)=0.001638 *23*; α(N+..)=0.000541 *8*. α(N)=0.000429 *6*; α(O)=9.60×10^{-5} *14*; α(P)=1.541×10^{-5} *22*; α(Q)=8.66×10^{-7} *13*.
5814.8	308.3 *3*	60 *20*	(E1)		0.0322	α(K)=0.0260 *4*; α(L)=0.00467 *7*; α(M)=0.001109 *16*; α(N+..)=0.000362 *6*. α(N)=0.000288 *4*; α(O)=6.32×10^{-5} *9*; α(P)=9.66×10^{-6} *14*; α(Q)=4.53×10^{-7} *7*.
	594.7 *4*	100 *20*				
5951.5	949.4 *3*	91 *37*				
	959.0 *3*	100 *28*				
6102.7	316.8 *4*	100	(M1+E2)		0.34 *22*	α(K)=0.26 *20*; α(L)=0.064 *19*; α(M)=0.016 *4*; α(N+..)=0.0052 *13*. α(N)=0.0041 *10*; α(O)=0.00090 *25*; α(P)=0.00014 *5*; α(Q)=6.×10^{-6} *5*.

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CITATION:
Nuclear Data Sheets (2007)

From NNDC(BNL)
program ENSDAT

$^{213}_{87}Fr_{126}$–5

Adopted Levels, Gammas (continued)

γ(^{213}Fr) (continued)

E(level)	Eγ	Iγ	Mult.	δ	α	Comments
6334.1	382.7 *3*	100	M1+E2	1.4 *+25−6*	0.16 *8*	α(K)=0.12 *7*; α(L)=0.031 *8*; α(M)=0.0078 *16*; α(N+..)=0.0026 *6*. α(N)=0.0021 *5*; α(O)=0.00045 *10*; α(P)=6.7×10^{-5} *18*; α(Q)=2.7×10^{-6} *15*.
6572.9	239.0 *4*	8.9 *5*				
	469.7‡ *4*					
	758.0 *4*	16 *4*				
	786.9 *1*	100 *10*	E1		0.00473	B(E1)↓(W.u.)=1.4784×10^{-7} *6*. α(K)=0.00390 *6*; α(L)=0.000635 *9*; α(M)=0.0001491 *21*; α(N+..)=4.89×10^{-5} *7*. α(N)=3.89×10^{-5} *6*; α(O)=8.63×10^{-6} *12*; α(P)=1.363×10^{-6} *19*; α(Q)=7.27×10^{-8} *11*.
6715.3	142.3 *3*	70 *9*	E2		2.03 *4*	B(E2)↓(W.u.)=4.6 *13*. α(K)=0.292 *5*; α(L)=1.278 *22*; α(M)=0.345 *6*; α(N+..)=0.1119 *19*. α(N)=0.0906 *16*; α(O)=0.0188 *4*; α(P)=0.00245 *5*; α(Q)=1.083×10^{-5} *17*.
	929.5 *3*	100 *20*	E3		0.0243	B(E3)↓(W.u.)=38 *13*. α(K)=0.01676 *24*; α(L)=0.00563 *8*; α(M)=0.001429 *20*; α(N+..)=0.000470 *7*. α(N)=0.000376 *6*; α(O)=8.18×10^{-5} *12*; α(P)=1.221×10^{-5} *18*; α(Q)=4.37×10^{-7} *7*.
6724.5	(9.2†)					
	621.8 *3*	100 *34*	[E3]		0.0681	α(K)=0.0384 *6*; α(L)=0.0221 *4*; α(M)=0.00580 *9*; α(N+..)=0.00190 *3*. α(N)=0.001528 *22*; α(O)=0.000328 *5*; α(P)=4.70×10^{-5} *7*; α(Q)=1.171×10^{-6} *17*.
6802.9	(78.4†)	100				
6812.9	478.7 *3*	100				
7135.2	322.2 *5*	100				
7247.4	(112.2†)	100				
7288.0	563.3 *3*	100	M1		0.1187	B(M1)↓(W.u.)=5.212×10^{-5} *20*. α(K)=0.0961 *14*; α(L)=0.01716 *25*; α(M)=0.00408 *6*; α(N+..)=0.001347 *19*. α(N)=0.001068 *15*; α(O)=0.000239 *4*; α(P)=3.83×10^{-5} *6*; α(Q)=2.15×10^{-6} *3*.
7374.3	(86.3†)					
	127.2 *4*	100 *19*				
7541.7	253.6 *4*	100 *7*				
	294.1 *3*	13 *3*				
	738.8 *3*	12.8 *16*	D			
	817.7 *3*	15 *5*				
7723.6	182.0 *3*	56 *11*	D			
	349.5 *3*	100 *6*	D			
	435.6 *4*	11 *3*				
	998.9 *3*	16 *6*				
7983.5	695					
	1259.1 *3*	100 *5*	E3		0.01229	B(E3)↓(W.u.)=25.35 *5*. α(K)=0.00916 *13*; α(L)=0.00235 *4*; α(M)=0.000583 *9*; α(N+..)=0.000196 *3*. α(N)=0.0001532 *22*; α(O)=3.36×10^{-5} *5*; α(P)=5.15×10^{-6} *8*; α(Q)=2.20×10^{-7} *3*; α(IPF)=3.31×10^{-6} *5*.
8094.8	111.3 *2*	64.0 *20*	[E2]		5.66 *9*	B(E2)↓(W.u.)=0.045 *4*. α(K)=0.329 *5*; α(L)=3.92 *7*; α(M)=1.063 *18*; α(N+..)=0.344 *6*. α(N)=0.279 *5*; α(O)=0.0578 *10*; α(P)=0.00747 *13*; α(Q)=2.24×10^{-5} *4*. B(E2)(W.u.)=0.0158 *14*.

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From NNDC(BNL)
program ENSDAT

$^{213}_{87}Fr_{126}$−6

Adopted Levels, Gammas (continued)

γ(^{213}Fr) (continued)

E(level)	Eγ	Iγ	Mult.	α	Comments
8094.8	371.2 *2*	100 *8*	(E3)	0.372	B(E3)↓(W.u.)=74 *9*. α(K)=0.1160 *17*; α(L)=0.188 *3*; α(M)=0.0513 *8*; α(N+..)=0.01682 *24*. α(N)=0.01356 *20*; α(O)=0.00286 *4*; α(P)=0.000392 *6*; α(Q)=4.99×10^{-6} *7*.

† Transition expected, but not observed.

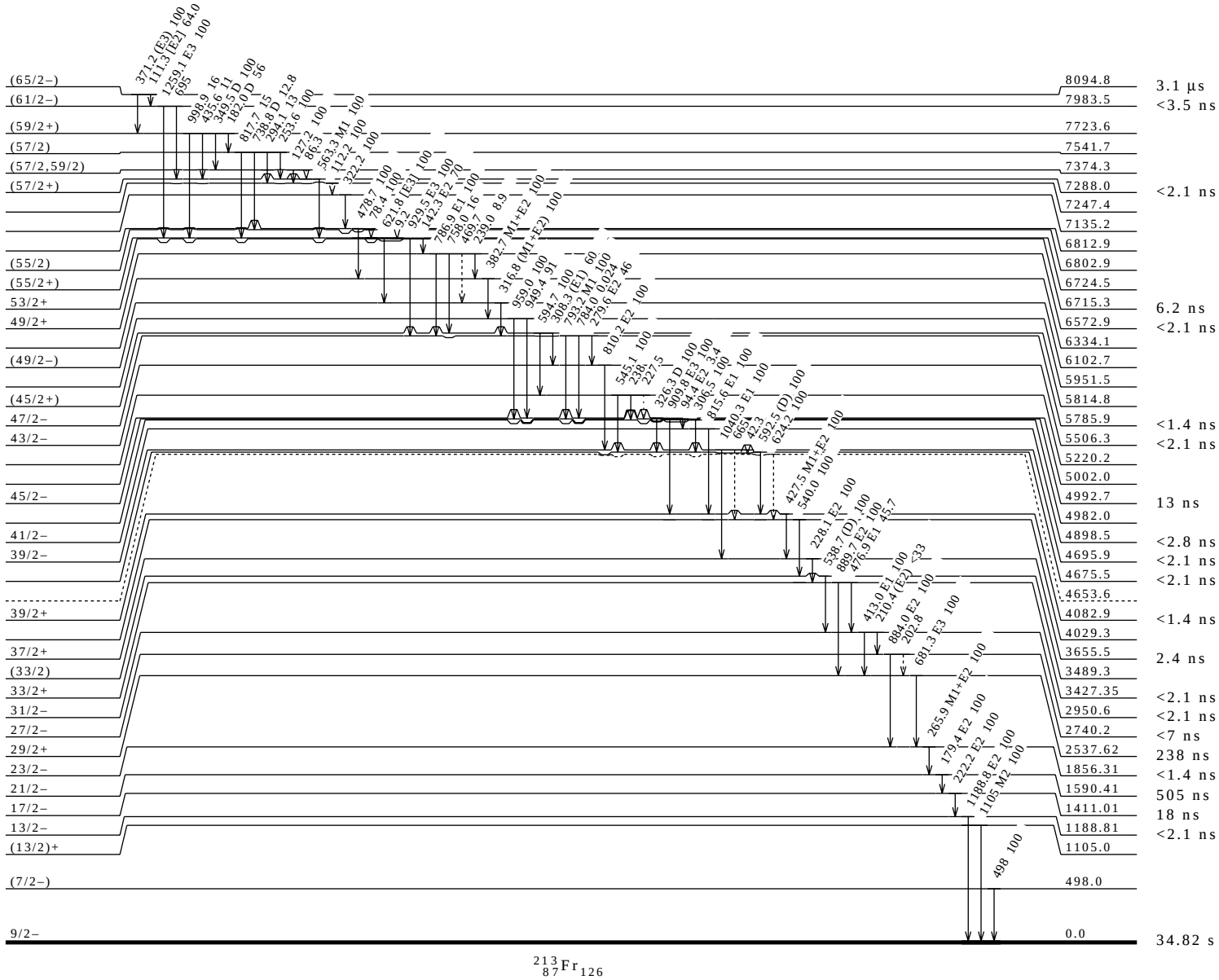
‡ Placement of transition in the level scheme is uncertain.

CITATION:
Nuclear Data Sheets (2007)

From NNDC(BNL)
program ENSDAT

Level Scheme

Intensities: relative photon branching from each level



$^{213}_{87}Fr_{126}$

$^{213}_{87}Fr_{126}$ −7

$^{213}_{87}Fr_{126}$–8

^{217}Ac α Decay (69 ns)

Parent ^{217}Ac: E=0.0; Jπ=9/2–; $T_{1/2}$=69 ns *4*; Q(g.s.)=9832 *10*; %α decay=100.

^{213}Fr Levels

E(level)	Jπ	$T_{1/2}$	Comments
0.0	9/2–	34.82 s *14*	Jπ,$T_{1/2}$: From adopted levels.

α radiations

o strong γ transitions belonging to ^{213}Fr were observed by 1973No09. The observed 9650–keV α has been assigned as the transition to the ^{213}Fr g.s. by considering the Q(α) systematics and the known levels in ^{213}Fr.

a angular distribution was measured by 1973No09 following production of ^{217}Ac in the ^{207}Pb(^{14}N,4n) reaction where nuclear alignment is expected to be preserved during its short (69 ns) half–life. The angular distribution was found to be isotropic within 2%, indicating that the 9650α has mainly L=0 component.

Eα	E(level)	Iα‡	HF†	Comments
9650 *10*	0.0	100	1.00 *7*	Eα: from 1973No09 (semi).

† Using r_0(^{213}Fr)=1.547 *10*, average of r_0(^{212}Rn)=1.541 *5* and r_0(^{214}Ra)=1.554 *9* (1998Ak04).
‡ Absolute intensity per 100 decays.

^{217}Ac α Decay: E=1.15 MeV

Parent ^{217}Ac: E=1150; Jπ=15/2–; $T_{1/2}$<10 ns; Q(g.s.)=9832 *10*; %α decay≤1.70.

^{213}Fr Levels

E(level)	Jπ	$T_{1/2}$	Comments
0.0	9/2–	34.82 s *14*	Jπ,$T_{1/2}$: From adopted levels.

α radiations

Eα	E(level)	Iα‡	HF†	Comments
10780 *15*	0.0	100	<6077	Eα: measured by 1985De14. The 9.65 and 10.54 MeV α's from the g.s. and 740–ns isomer of ^{217}Ac were used as calibration energies. Iα: α intensity per 100 α decays from the level.

† Using r_0(^{213}Fr)=1.547 *10*, average of r_0(^{212}Rn)=1.541 *5* and r_0(^{214}Ra)=1.554 *9* (1998Ak04).
‡ For α intensity per 100 decays, multiply by ≤0.017.

^{217}Ac α Decay: E=1.5 MeV

Parent ^{217}Ac: E≈1500; Jπ=19/2–; $T_{1/2}$=8 ns; Q(g.s.)=9832 *10*; %α decay≤0.980.

^{213}Fr Levels

E(level)	Jπ	$T_{1/2}$	Comments
0.0	9/2–	34.82 s *14*	Jπ,$T_{1/2}$: From adopted levels.

α radiations

Continued on next page (footnotes at end of table)

From NNDC(BNL)
program ENSDAT

$^{213}_{87}Fr_{126}$–9

^{217}Ac α Decay: E=1.5 MeV (continued)

α radiations (continued)

Eα	E(level)	Iα‡	HF†	Comments
11137	0.0	100	≈17027	Eα: 11130 (1973No09), 11137 *15* (1985De14; peaks at 9.65 and 10.54 MeV, measured by 1973No09 were used as calibration points). Iα: α intensity per 100 α decays from the level.

† Using $r_0(^{213}Fr)$=1.547 *10*, average of $r_0(^{212}Rn)$=1.541 *5* and $r_0(^{214}Ra)$=1.554 *9* (1998Ak04).
‡ For α intensity per 100 decays, multiply by ≤0.0098.

^{217}Ac α Decay (740 ns)

Parent ^{217}Ac: E=2013 *10*; Jπ=(29/2)+; $T_{1/2}$=740 ns *40*; Q(g.s.)=9832 *10*; %α decay=4.3 *10*.

^{213}Fr Levels

E(level)	Jπ	$T_{1/2}$	Comments
0.0	9/2−	34.82 s *14*	Jπ,$T_{1/2}$: From adopted levels.
498	(7/2−)		Jπ: from α decay from 29/2+ isomeric state in ^{217}At and from shell model, 1985De14 suggest π f7/2 configuration.
1105	(13/2)+		Jπ: 1105γ to 9/2− g.s. is M2. From similar α reduced widths for (^{216}Ra 10+ to ^{212}Rn 0+) and for (^{217}At 29/2+ to ^{213}Fr 13/2+) α's, 1984De14 suggest i13/2 configuration.

α radiations

a(θ): 1985De14, 1973No09.
α)(γ): 1985De14.

Eα	E(level)	Iα§@	HF#
10540†	1105	90 *6*	1.80×10^4 *45*
11137‡ *15*	498	7.1 *21*	2.7×10^6 *11*
11625‡ *17*	0.0	2.7 *5*	4.5×10^7 *14*

† Measurement of 1973No09.
‡ Measurement of 1985De14. Eα=9.650 MeV and Eα=10.54 MeV lines were used as calibration energies.
§ From 1985De14.
# Using $r_0(^{213}Fr)$=1.547 *10*, average of $r_0(^{212}Rn)$=1.541 *5* and $r_0(^{214}Ra)$=1.554 *9* (1998Ak04).
@ For α intensity per 100 decays, multiply by 0.043 *10*.

γ(^{213}Fr)

Eγ†	E(level)	Mult.	α	Comments
498	498			
1105	1105	M2	0.0479	α(K)=0.0380 *6*; α(L)=0.00747 *11*; α(M)=0.00180 *3*; α(N+..)=0.000596 *9*. α(N)=0.000473 *7*; α(O)=0.0001056 *15*; α(P)=1.688×10^{-5} *24*; α(Q)=9.26×10^{-7} *13*; α(IPF)=5.71×10^{-8}. Mult.: from ce (1985De14).

† From 1985De14.

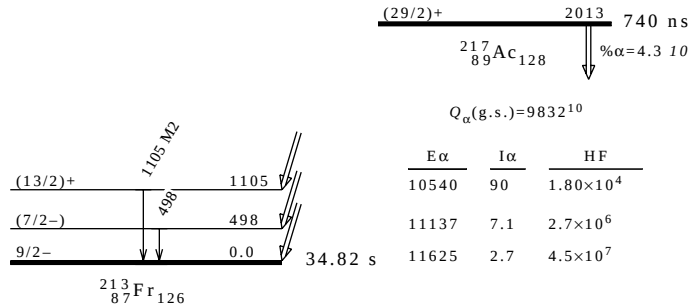
CITATION:
Nuclear Data Sheets (2007)

From NNDC(BNL)
program ENSDAT

$^{213}_{87}Fr_{126}$–10

^{217}Ac α Decay (740 ns) (continued)

Decay Scheme



Eα	Iα	HF
10540	90	1.80×10^4
11137	7.1	2.7×10^6
11625	2.7	4.5×10^7

(HI,xnγ)

^{204}Hg(^{14}N,5nγ)	E=94 MeV, pulsed beam	1974Re09
^{205}Tl(^{12}C,4nγ)	E=71– to 80–MeV pulsed beams	1976Ha37
^{205}Tl(^{13}C,5nγ)	E=72– to 86–MeV pulsed beams	1979Ho06
^{205}Tl(^{12}C,4nγ), ^{205}Tl(^{13}C,5nγ)	E=77–96 MeV; and	
^{198}Pt(^{19}F,5nγ)	E=102 MeV, pulsed beam	1986By01
^{205}Tl(^{13}C,5nγ)	E=90 MeV, pulsed beam	1989By01
^{238}U fragmentation at E/A=900 MeV		2006Po01
	Other:	1971MaXH.

The decay scheme of levels below E≤2538 keV was constructed by 1971MaXH from their γγ coincidence data, and it was confirmed by 1976Ha37. The main cascade of strongly populated levels above 2538 keV and up to 6573 keV was added by 1979Ho06 from their coincidence data; the levels above the 6573–keV level and the weakly populated side cascades were built by 1986By01 and 1989By01. Delayed and out–of–beam coincidences were also taken by 1989By01, designed to study the high energy isomeric state. The placements of 1259.1 and 563.3 gammas to feed the 6725–keV level were based on the coincidences observed with the 621.8–keV γ (1991ByZZ). The level scheme shown in 1989By01 is presented here.

^{213}Fr Levels

E(level)†	Jπ‡	$T_{1/2}$§	Comments
0.0	9/2−	34.82 s *14*	$T_{1/2}$: From adopted levels.
1188.81 *10*	13/2−	<2.1 ns	
1411.01 *15*	17/2−	18 ns *1*	$T_{1/2}$≤60 ns was measured by 1976Ha37 by delayed coincidence method. g(1411 level)=0.88 *16* (1986By01).
1590.41 *18*	21/2−	499 ns *21*	$T_{1/2}$: Weighted average of 499 ns *21* (1986By01) and 510 ns *20* (1976Ha37). Other: ≈1 μs (1971MaXH). g(1590 level)=0.888 *3* (1977Be56,1976Ha37); 0.888 *4* (1979Ho06); 0.89 *2* (1986By01).
1856.31 *20*	23/2−	<1.4 ns	
2537.62 *23*	29/2+	238 ns *6*	$T_{1/2}$: From 1976Ha37. Others: 243 ns *21* (1986By01) and ≈0.5 μs (1971MaXH). g(2537 level)=1.0494 *18* (1977Be56,1976Ha37); 1.04 *2* (1974Re09), 1.055 *5* (1989By01) by γ(H,θ,t).
2740.2 *3*	27/2−	<7 ns	
2950.6 *3*	31/2−	<2.1 ns	
3427.35 *24*	33/2+	<2.1 ns	
3489.3 *4*	33/2		
3655.5 *4*	37/2+	2.4 ns *7*	$T_{1/2}$=4.1 ns was measured by 1979Ho06.
4029.3 *5*			
4082.9 *4*	39/2+	<1.4 ns	
4653.6? *11*			
4675.5 *4*		<2.1 ns	
4695.9 *4*	39/2−	<2.1 ns	
4898.5 *4*	41/2−	<2.8 ns	
4982.0 *6*			
4992.7 *4*	45/2−	13 ns *2*	$T_{1/2}$=13.5 ns was measured by 1979Ho06. Jπ: 909.8γ E3 to 39/2+ state, 94.4γ E2 to 41/2− state. g(4993 level)=0.990 *25* (1979Ho06), 1.03 *3* (1986By01) by γ(H,θ,t).

Continued on next page (footnotes at end of table)

From NNDC(BNL)
program ENSDAT

$^{213}_{87}Fr_{126}$–11

(HI,xnγ) (continued)

^{213}Fr Levels (continued)

E(level)†	Jπ‡	$T_{1/2}$§	Comments
5002.0 *5*			
5220.2 *5*			
5506.3 *4*	43/2−	<2.1 ns	
5785.9 *4*	47/2−	<1.4 ns	
5814.8 *5*	(45/2+)		
5951.5 *5*			
6102.7 *6*	49/2−		
6334.1 *5*			
6572.9 *4*	49/2+	<2.1 ns	$T_{1/2}$=7 ns was measured by 1979Ho06.
6715.3 *5*	53/2+	6.2 ns *14*	
6724.5 *6*	55/2+		Jπ: Assignment based on 9.2γ M1 to 53/2+ state (1989By01). Possible configuration=$\pi(h^3_{9/2}i^2_{13/2})+\nu(p_{1/2}{}^{-1}g_{9/2})$. $T_{1/2}$: the half–life was determined by 1989By01 from the 142– and 929–keV γ's deexciting the 6715–keV level. Since the 621.8γ was observed in coincidence with the 1259.1 and 563.3 γ's, $T_{1/2}$(6724–keV level) is short. The same half–life of 6.2 ns *14* was assigned to both 6715– and 6724–keV levels.
6802.9 *7*			
6812.9 *6*			
7135.2 *7*			
7247.4 *7*			
7288.0 *7*	57/2+	<2.1 ns	
7374.3 *7*			
7541.7 *6*			
7723.6 *6*	59/2+		
7983.5 *7*	61/2−	<3.5 ns	Jπ: 1259γ E3 to 55/2+ state. Possible configuration=$\pi(h^3_{9/2}i^2_{13/2})+\nu(p_{1/2}{}^{-1}g_{15/2})$. $T_{1/2}$: From 1989By01.
8094.8 *7*	65/2−	3.1 μs *2*	

† Deduced by the evaluator from a least square fit to the γ–ray energies.

‡ From 1989By01. The assignments were based on their γ angular distribution and conversion electron data, on linear polarization measurements of 1979Ho06, transition strengths, and on shell states in neighboring nuclei.

§ Obtained by 1986By01 from pulsed–beam, chopped–beam, γγ(t) and n,γ(t) measurements, unless otherwise noted.

γ(^{213}Fr)

Eγ†	E(level)	Iγ§	Mult.‡	δ	α	Comments
(9.2#)	6724.5		M1		778	α(M)=584 *9*; α(N+..)=194 *3*. α(N)=153.5 *22*; α(O)=34.3 *5*; α(P)=5.50 *8*; α(Q)=0.309 *5*. Mult.: α(exp)(M1)=828.1. Other multipolarities were ruled out by 1989By01 by considering the transition strength limits deduced from the measured $T_{1/2}$=6.2 ns which was assigned also to the 6724–keV level. 0.21 *4*<Iγ<0.51 *6* from intensity balances at the 6724–keV and 6715–keV levels, assuming that the 9.2–keV transition is M1 and the 621.8γ is an E3 transition. An assumption of E1 multipolarity and the intensity balances would yield 10<Iγ<24 and 0.002<B(E1)(W.u.)<0.005.
(42.3#)	4695.9					
x60.3@ *3*						
(78.4#)	6802.9					
(86.3#)	7374.3					
94.4 *3*	4992.7	4 *1*	E2		11.49 *24*	α(L)=8.46 *18*; α(M)=2.29 *5*; α(N+..)=0.741 *16*. α(N)=0.601 *13*; α(O)=0.124 *3*; α(P)=0.0160 *4*; α(Q)=3.84×10^{-5} *7*. Iγ: from Iγ(94.4γ)/Iγ(909.7γ)=4 *1*/117 *2*, measured by 1986By01. Iγ(94.4γ) was not listed by 1991ByZZ.

Continued on next page (footnotes at end of table)

From NNDC(BNL)
program ENSDAT

$^{213}_{87}Fr_{126}$–12

(HI,xnγ) (continued)

γ(^{213}Fr) (continued)

Eγ[†]	E(level)	Iγ[§]	Mult.[‡]	δ	α	Comments
111.3 *2*	8094.8	80.0 *24*	E2		5.66 *9*	α(K)=0.329 *5*; α(L)=3.92 *7*; α(M)=1.063 *18*; α(N+..)=0.344 *6*. α(N)=0.279 *5*; α(O)=0.0578 *10*; α(P)=0.00747 *13*; α(Q)=2.24×10^{-5} *4*. Mult.: From α(exp)=6.2 *3*, determined from the delayed intensity data (1989By01).
(112.2[#])	7247.4					
127.2 *4*	7374.3	11.6 *22*				
142.3 *3*	6715.3	93 *12*	E2		2.03 *4*	α(K)=0.292 *5*; α(L)=1.278 *22*; α(M)=0.345 *6*; α(N+..)=0.1119 *19*. α(N)=0.0906 *16*; α(O)=0.0188 *4*; α(P)=0.00245 *5*; α(Q)=1.083×10^{-5} *17*. Mult.: From total α<40, from intensity balance in 1986By01.
179.4 *1*	1590.41	538 *24*	E2		0.823	α(K)=0.201 *3*; α(L)=0.458 *7*; α(M)=0.1234 *18*; α(N+..)=0.0400 *6*. α(N)=0.0324 *5*; α(O)=0.00675 *10*; α(P)=0.000890 *13*; α(Q)=5.84×10^{-6} *9*. Mult.: From total α=0.83 *18*, deduced from delayed intensity measurement (1986By01).
182.0 *3*	7723.6	42 *8*	D			The angular distribution suggests a dipole character for the 182.5γ. α(E1)=0.1108, α(M1)=2.732.
202.8[a] *4*	2740.2					
210.4 *3*	2950.6	<43	(E2)		0.462	α(K)=0.1474 *21*; α(L)=0.232 *4*; α(M)=0.0622 *10*; α(N+..)=0.0202 *3*. α(N)=0.01631 *25*; α(O)=0.00341 *6*; α(P)=0.000454 *7*; α(Q)=3.92×10^{-6} *6*. Iγ<38 *5* (1991ByZZ).
222.2 *1*	1411.01	694 *30*	E2		0.382	α(K)=0.1318 *19*; α(L)=0.185 *3*; α(M)=0.0494 *7*; α(N+..)=0.01603 *23*. α(N)=0.01295 *19*; α(O)=0.00271 *4*; α(P)=0.000362 *6*; α(Q)=3.43×10^{-6} *5*. Mult.: From α(L)exp=0.16 *6*, α(M)exp=0.048 *20* (1986By01).
(227.5[#])	5220.2					
228.1 *2*	3655.5	425 *26*	E2		0.349	α(K)=0.1248 *18*; α(L)=0.1655 *24*; α(M)=0.0443 *7*; α(N+..)=0.01437 *21*. α(N)=0.01161 *17*; α(O)=0.00243 *4*; α(P)=0.000325 *5*; α(Q)=3.22×10^{-6} *5*. Mult.: From α(L)exp=0.12 *5*, α(M)exp=0.067 *23* (1986By01). A_2=0.293 *14*, A_4=−0.091 *19* (1979Ho06).
238[&]	5220.2					
239.0 *4*	6572.9	19 *9*				
253.6 *4*	7541.7	131 *9*				
265.9 *1*	1856.31	283 *13*	M1+E2	0.9 *+11−9*	0.6 *4*	α(K)=0.4 *3*; α(L)=0.113 *20*; α(M)=0.028 *4*; α(N+..)=0.0092 *13*. α(N)=0.0074 *10*; α(O)=0.00161 *25*; α(P)=0.00024 *6*; α(Q)=1.0×10^{-5} *7*. Mult.: From total α=0.76 *18* (1986By01).
279.6 *2*	5785.9	117 *11*	E2		0.180	α(K)=0.0812 *12*; α(L)=0.0729 *11*; α(M)=0.0193 *3*; α(N+..)=0.00628 *9*. α(N)=0.00507 *8*; α(O)=0.001068 *16*; α(P)=0.0001452 *21*; α(Q)=1.99×10^{-6} *3*. Mult.: From α(K)exp=0.06 *4* (1986By01).
294.1 *3*	7541.7	17 *4*				
306.5 *4*	4982.0	15.4 *24*				α(E1)=0.0329, α(M1)=0.647, α(E2)=0.138.
308.3 *3*	5814.8	18 *6*	(E1)		0.0322	α(K)=0.0260 *4*; α(L)=0.00467 *7*; α(M)=0.001109 *16*; α(N+..)=0.000362 *6*. α(N)=0.000288 *4*; α(O)=6.32×10^{-5} *9*; α(P)=9.66×10^{-6} *14*; α(Q)=4.53×10^{-7} *7*.

Continued on next page (footnotes at end of table)

From NNDC(BNL)
program ENSDAT

$^{213}_{87}Fr_{126}$–13

(HI,xnγ) (continued)

γ(^{213}Fr) (continued)

Eγ†	E(level)	Iγ§	Mult.‡	δ	α	Comments
316.8 *4*	6102.7	24 *4*	(M1+E2)		0.34 *22*	α(K)=0.26 *20*; α(L)=0.064 *19*; α(M)=0.016 *4*; α(N+..)=0.0052 *13*. α(N)=0.0041 *10*; α(O)=0.00090 *25*; α(P)=0.00014 *5*; α(Q)=6.×10^{-6} *5*. Mult.: the measured large A_2 value indicated some quadrupole admixture. Authors' earlier assignment of E1 (1986By01) from conversion electron measurement has been withdrawn (1991ByZZ). Since the ce(K 317γ) line was contaminated by the ce(M 222γ), the angular distribution measurements were more reliable for determination of its multipolarity. E1+M2 with any significant amount of M2 admixture is ruled out because of short half–life of the 6102–keV level.
322.2 *5*	7135.2	13 *4*				
326.3 *4*	5002.0	16 *5*	(D)		0.0285	α: for E1, as implied by the intensity balance at the 4675–keV level. α(M1)=0.543. The angular distribution is consistent with a dipole transition.
349.5 *3*	7723.6	75 *4*				No ce line was listed for this transition. It is assumed that ce lines were weak, suggesting E1 or E2 multipolarity. The angular distribution coefficient listed is in agreement with a dipole character. α(E1)=0.0245.
371.2 *2*	8094.8	125 *10*	E3		0.372	α(K)=0.1160 *17*; α(L)=0.188 *3*; α(M)=0.0513 *8*; α(N+..)=0.01682 *24*. α(N)=0.01356 *20*; α(O)=0.00286 *4*; α(P)=0.000392 *6*; α(Q)=4.99×10^{-6} *7*. Mult.: α(exp)=0.35 *7*, deduced by 1989By01 (method was not discussed), and E3 multipolarity was assigned. Although α(exp) is also consistent with an M1 transition [α(M1)=0.3835], if its placement is correct, $T_{1/2}$(8094 level) suggests E3 multipolarity.
382.7 *3*	6334.1	27 *3*	M1+E2	1.4 *+25–6*	0.16 *8*	α(K)=0.12 *7*; α(L)=0.031 *8*; α(M)=0.0078 *16*; α(N+..)=0.0026 *6*. α(N)=0.0021 *5*; α(O)=0.00045 *10*; α(P)=6.7×10^{-5} *18*; α(Q)=2.7×10^{-6} *15*. Mult.: From α(K)exp=0.20 *7*.
413.0 *2*	2950.6	129 *3*	E1		0.01695	α(K)=0.01381 *20*; α(L)=0.00240 *4*; α(M)=0.000567 *8*; α(N+..)=0.000185 *3*. α(N)=0.0001475 *21*; α(O)=3.25×10^{-5} *5*; α(P)=5.03×10^{-6} *7*; α(Q)=2.47×10^{-7} *4*. Mult.: From α(K)exp=0.047 *24* (1986By01). A_2=–0.222 *24*, A_4=0.034 *34* (1979Ho06).
427.5 *1*	4082.9	255 *11*	M1+E2	0.10 *3*	0.246	α(K)=0.199 *3*; α(L)=0.0359 *6*; α(M)=0.00854 *13*; α(N+..)=0.00282 *4*. α(N)=0.00224 *4*; α(O)=0.000500 *8*; α(P)=8.02×10^{-5} *12*; α(Q)=4.47×10^{-6} *7*. Mult.: From α(K)exp=0.28 *7*, α(L)exp=0.051 *15*, α(M)exp=0.018 (5) (1986By01); A_2=–0.424 *13*, A_4=0.023 *19* (1979Ho06).
435.6 *4*	7723.6	8.4 *20*				
469.7[a] *4*	6572.9					Eγ: from 1986By01; transition was not listed by 1991ByZZ.
476.9 *2*	3427.35	137 *6*	E1		0.01255	α(K)=0.01025 *15*; α(L)=0.001751 *25*; α(M)=0.000413 *6*; α(N+..)=0.0001353 *19*. α(N)=0.0001077 *16*; α(O)=2.38×10^{-5} *4*; α(P)=3.70×10^{-6} *6*; α(Q)=1.86×10^{-7} *3*. Mult.: α(K)exp<0.047 (1986By01); A_2=–0.257 *20*, A_4=0.059 *29* (1979Ho06).

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From NNDC(BNL)
program ENSDAT

$^{213}_{87}Fr_{126}$–14

(HI,xnγ) (continued)

γ(^{213}Fr) (continued)

Eγ†	E(level)	Iγ§	Mult.‡	α	Comments
478.7 *3*	6812.9	25 *4*			
538.7 *3*	3489.3	27.8 *10*	(D)		α(E1)=0.00984, α(M1)=0.1409, α(E2)=0.0311.
540.0 *3*	4029.3	17.2 *10*			
545.1 *5*	5220.2	<76			
563.3 *3*	7288.0	136 *6*	M1	0.1187	α(K)=0.0961 *14*; α(L)=0.01716 *25*; α(M)=0.00408 *6*; α(N+..)=0.001347 *19*. α(N)=0.001068 *15*; α(O)=0.000239 *4*; α(P)=3.83×10^{-5} *6*; α(Q)=2.15×10^{-6} *3*.
592.5 *3*	4675.5	33 *7*	(D)		The angular distribution is consistent with a dipole transition; the intensity balance at the 4675–keV level is worse if it is an E1 transition. α(E1)=0.00817, α(M1)=0.110.
594.7 *4*	5814.8	30 *6*			
621.8 *3*	6724.5	18 *6*	[E3]	0.0681	α(K)=0.0384 *6*; α(L)=0.0221 *4*; α(M)=0.00580 *9*; α(N+..)=0.00190 *3*. α(N)=0.001528 *22*; α(O)=0.000328 *5*; α(P)=4.70×10^{-5} *7*; α(Q)=1.171×10^{-6} *17*.
624.2@a *5*	4653.6?				
665&a	4695.9				
681.3 *1*	2537.62	439 *15*	E3	0.0529	α(K)=0.0317 *5*; α(L)=0.01579 *23*; α(M)=0.00412 *6*; α(N+..)=0.001354 *19*. α(N)=0.001086 *16*; α(O)=0.000234 *4*; α(P)=3.38×10^{-5} *5*; α(Q)=9.27×10^{-7} *13*. Mult.: α(K)exp=0.046 *5*, α(L)exp=0.018 *2*, and α(M)exp=0.007 *1* (1986By01).
695&	7983.5				
738.8 *3*	7541.7	16.8 *20*			The angular distribution is consistent with dipole character for this transition. α(E1)=0.00534, α(M1)=0.0614.
758.0 *4*	6572.9	34 *7*			
784.0 *4*	5785.9	6 *2*			
786.9 *1*	6572.9	214 *20*	E1	0.00473	α(K)=0.00390 *6*; α(L)=0.000635 *9*; α(M)=0.0001491 *21*; α(N+..)=4.89×10^{-5} *7*. α(N)=3.89×10^{-5} *6*; α(O)=8.63×10^{-6} *12*; α(P)=1.363×10^{-6} *19*; α(Q)=7.27×10^{-8} *11*. Mult.: From α(K)exp=0.007 *2* (1986By01). A_2=–0.292 *53*, A_4=0.020 *82* (1979Ho06).
793.2 *3*	5785.9	254 *40*	M1	0.0481	α(K)=0.0391 *6*; α(L)=0.00690 *10*; α(M)=0.001638 *23*; α(N+..)=0.000541 *8*. α(N)=0.000429 *6*; α(O)=9.60×10^{-5} *14*; α(P)=1.541×10^{-5} *22*; α(Q)=8.66×10^{-7} *13*. Mult.: α(K)exp=0.041 *7*, α(L)exp=0.0097 *10* (1986By01); A_2=–0.212 *78*, A_4=0.048 *120* (1979Ho06).
810.2 *3*	5506.3	144 *8*	E2	0.01293	α(K)=0.00975 *14*; α(L)=0.00239 *4*; α(M)=0.000590 *9*; α(N+..)=0.000194 *3*. α(N)=0.0001545 *22*; α(O)=3.38×10^{-5} *5*; α(P)=5.12×10^{-6} *8*; α(Q)=2.11×10^{-7} *3*. Mult.: α(K)exp=0.0065 *35* (1986By01).
815.6 *2*	4898.5	157 *9*	E1	0.00443	α(K)=0.00365 *6*; α(L)=0.000593 *9*; α(M)=0.0001392 *20*; α(N+..)=4.57×10^{-5} *7*. α(N)=3.63×10^{-5} *5*; α(O)=8.06×10^{-6} *12*; α(P)=1.274×10^{-6} *18*; α(Q)=6.82×10^{-8} *10*. Mult.: From α(K)exp=0.006 *3* (1986By01); A_2=–0.229 *18*, A_4=0.002 *26* (1979Ho06).
817.7 *3*	7541.7	20 *6*			
884.0 *3*	2740.2	31 *5*	E2	0.01087	α(K)=0.00831 *12*; α(L)=0.00193 *3*; α(M)=0.000473 *7*; α(N+..)=0.0001553 *22*. α(N)=0.0001238 *18*; α(O)=2.71×10^{-5} *4*; α(P)=4.14×10^{-6} *6*; α(Q)=1.79×10^{-7} *3*. Mult.: From α(K)exp=0.015 *6* (1986By01).

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From NNDC(BNL)
program ENSDAT

$^{213}_{87}Fr_{126}$–15

(HI,xnγ) (continued)

γ(^{213}Fr) (continued)

Eγ†	E(level)	Iγ§	Mult.‡	α	Comments
889.7 *1*	3427.35	300 *12*	E2	0.01073	α(K)=0.00822 *12*; α(L)=0.00190 *3*; α(M)=0.000465 *7*; α(N+..)=0.0001528 *22*. α(N)=0.0001219 *17*; α(O)=2.67×10^{-5} *4*; α(P)=4.08×10^{-6} *6*; α(Q)=1.765×10^{-7} *25*. Mult.: From α(K)exp=0.011 *2*, α(L)exp=0.002 *1* (1986by01); A_2=0.311 *18*, A_4=–0.085 *29* (1979Ho06).
909.8 *2*	4992.7	116 *9*	E3	0.0255	α(K)=0.01750 *25*; α(L)=0.00601 *9*; α(M)=0.001530 *22*; α(N+..)=0.000503 *7*. α(N)=0.000402 *6*; α(O)=8.75×10^{-5} *13*; α(P)=1.303×10^{-5} *19*; α(Q)=4.59×10^{-7} *7*. Mult.: From α(K)exp=0.023 *3*, α(L)exp=0.006 *1* (1986By01); A_2=0.538 *37*, A_4=0.038 *51* (1979Ho06).
929.5 *3*	6715.3	132 *26*	E3	0.0243	α(K)=0.01676 *24*; α(L)=0.00563 *8*; α(M)=0.001429 *20*; α(N+..)=0.000470 *7*. α(N)=0.000376 *6*; α(O)=8.18×10^{-5} *12*; α(P)=1.221×10^{-5} *18*; α(Q)=4.37×10^{-7} *7*. Mult.: From α(K)exp=0.014 *8*, α(L)exp=0.0045 *15* (1986By01).
949.4 *3*	5951.5	10 *4*			
959.0 *3*	5951.5	11 *3*			
[x]963.4[@] *5*					
998.9 *3*	7723.6	12 *4*			
1040.3 *3*	4695.9	111 *11*	E1	0.00286	α(K)=0.00236 *4*; α(L)=0.000377 *6*; α(M)=8.83×10^{-5} *13*; α(N+..)=2.90×10^{-5} *4*. α(N)=2.30×10^{-5} *4*; α(O)=5.13×10^{-6} *8*; α(P)=8.15×10^{-7} *12*; α(Q)=4.46×10^{-8} *7*. Mult.: From α(K)exp=0.0017 *6* (1986By01).
1188.8 *1*	1188.81	1000 *40*	E2	0.00616	α(K)=0.00487 *7*; α(L)=0.000976 *14*; α(M)=0.000235 *4*; α(N+..)=8.01×10^{-5} *12*. α(N)=6.16×10^{-5} *9*; α(O)=1.360×10^{-5} *19*; α(P)=2.12×10^{-6} *3*; α(Q)=1.025×10^{-7} *15*; α(IPF)=2.65×10^{-6} *4*. Mult.: From α(K)exp=0.0053 *6*, α(L)exp=0.00097 *10* (1986By01).
1259.1 *3*	7983.5	254 *12*	E3	0.01229	α(K)=0.00916 *13*; α(L)=0.00235 *4*; α(M)=0.000583 *9*; α(N+..)=0.000196 *3*. α(N)=0.0001532 *22*; α(O)=3.36×10^{-5} *5*; α(P)=5.15×10^{-6} *8*; α(Q)=2.20×10^{-7} *3*; α(IPF)=3.31×10^{-6} *5*. Mult.: From α(K)exp=0.010 *2* (1986By01).

† From 1991ByZZ. See also 1989By01, 1986By01, 1976Ha37, 1977Be56. Other measurements: 1971MaXH, 1974Re09.

‡ From conversion electron measurements and angular distribution of the γ–ray (1986By01), except otherwise noted.

§ Relative photon intensities, measured by 1991ByZZ in a time window 2–9 microseconds after the beam burst. Therefore, these Iγ's represent relative feedings through the 4.5–μs isomer at 8095 keV. See also 1986By01.

Transition was not observed; energy from decay scheme.

@ From 1986By01, not listed by 1991ByZZ.

& From level scheme shown in 1989By01; transition was not listed by 1991ByZZ and 1986By01.

a Placement of transition in the level scheme is uncertain.

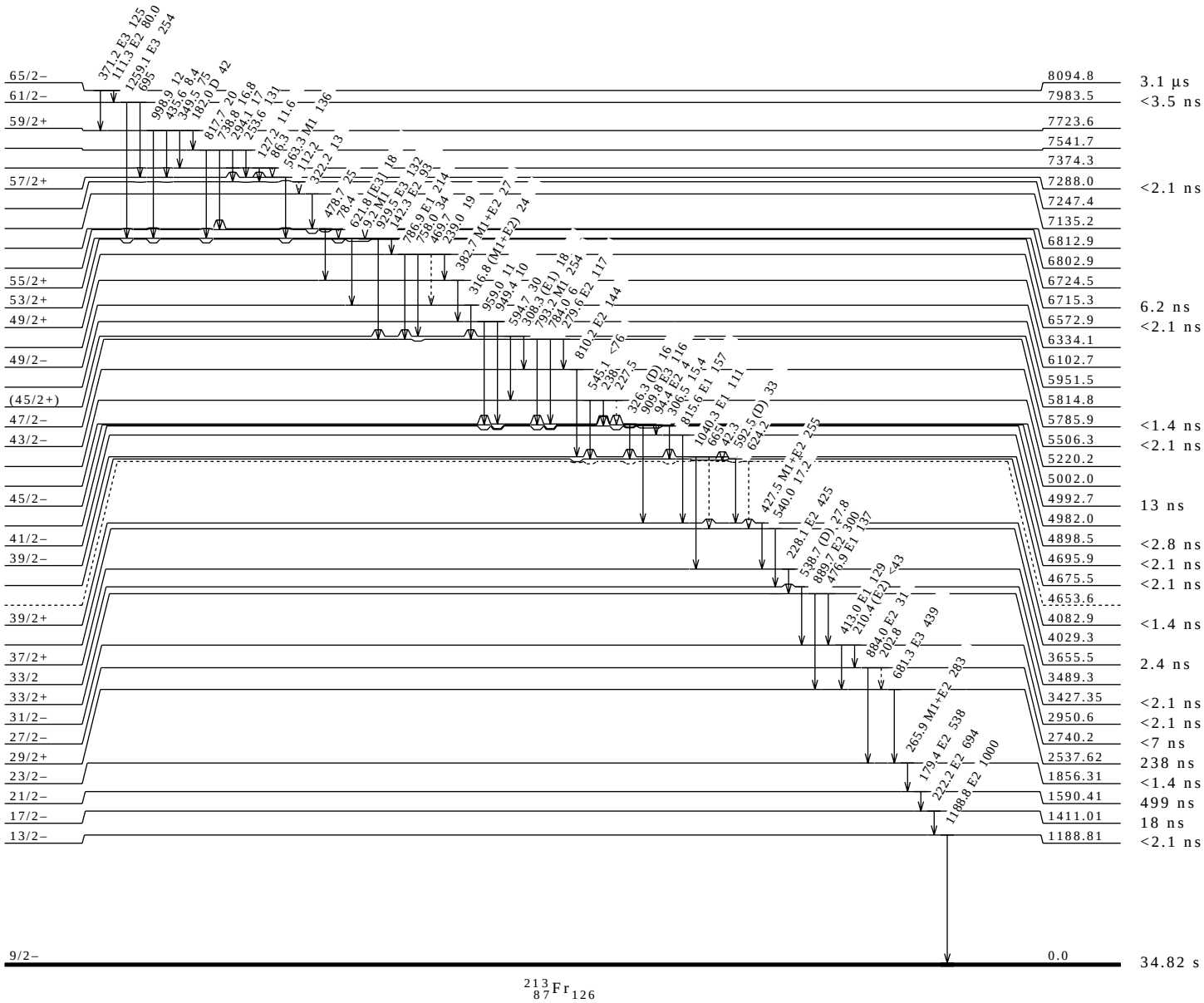
x γ ray not placed in level scheme.

From NNDC(BNL)
program ENSDAT

(HI,xnγ) (continued)

Level Scheme

Intensities: relative Iγ



CITATION:
Nuclear Data Sheets (2007)

From NNDC(BNL)
program ENSDAT

$^{213}_{87}Fr_{126}$–16

$^{213}_{88}Ra_{125}$–1

Adopted Levels, Gammas

Q(β⁻)=–5800 *60*; S(n)=7522 *23*; S(p)=3390 *30*; Q(α)=6861 *4* 2003Au03.

^{213}Ra Levels

Cross Reference (XREF) Flags

A ^{217}Th α Decay
B ^{213}Ra IT Decay (2.15 ms)

E(level)†	Jπ	XREF	$T_{1/2}$	Comments
0.0	1/2–	AB	2.73 min *5*	μ=+0.6133 *18* (1989Ra17). μ: Larmor precession, optical pumping by LASER (1987Ar20). Others: 1983Ah03, 1987We03. %α=80 *5*; %ε+%β⁺=20 *5* (1967Va22). $T_{1/2}$: Weighted average of 2.74 min *6* (1968Lo15), 2.75 min *15* (1967Va22), 2.7 min *3* (1955Mo68), and 2.54 min +0.21 –0.18 (9247α–t) (2000Ni02). Others: 2.7 min +2.1–0.8 (8713α–t) (2000Ni02), 2.5 min +1.2 –0.6 (8429α–t) (2000Ni02), and 2.72 min (1961Gr42). Jπ: spin measured (hyperfine structure by LASER spectroscopy, 1983Ah03). Configuration=(ν 3p1/2 –1) from measured μ. See 1983Ah03, 1985Dz04, 1985He03, 1987We03 and 1990Ne11 for magnetic moment calculations by using various models.
546.35 *5*	(5/2–)	AB		Jπ: 546.35γ (E2) to 1/2– g.s. From systematics of shell states, probable configuration=(ν $f_{5/2}$).
818	(3/2–)	A		E(level): Level energy calculated by the evaluator using Q(α) (^{217}Th) and Eα feeding this level. Jπ: Comparatively favored α–decay to this state than (5/2–) state. Also from comparison to ^{215}Ra α–decay to (3/2–) state at 833 keV of ^{211}Rn.
1608.9 *3*	(9/2–)	B		Jπ: 1062.5γ (E2) to 5/2– state. Systematics of 9/2– levels in nuclei with 125 neutrons (see 1976Ra37).
1769.7 *3*	(13/2–)	B		Jπ: 160.87γ to (9/2–) state is predominantly E2; no γ to the (5/2–) state. Please see ^{213}Ra IT decay (2.15 ms) dataset.
1770 *7*	(17/2–)	B	2.15 ms *7*	%α≈1; %IT≈99 (1976Ra37). Jπ: Measured g=0.87 *5* (1994Ne01) value supports the configuration $[(\pi 1h^6{}_{9/2})_{8+}\otimes(\nu 3p^{-1}{}_{1/2})]_{17/2-}$ for which the calculated magnetic moment, 7.672 *33*, is in good agreement with the measured g value (1994Ne01). $T_{1/2}$: Weighted average of 2.1 ms *1* (1976Ra37) and 2.2 ms *1* (545.4γ) (2004He25). 2004He25 also provides two more values of 2.1 ms *1* (1061.2γ) and 2.1 ms *1* (160.4γ). The three values determined by 2004He25 from the decrease of γ–ray intensities within the 14.6 ms pause between two consecutive beam bursts.

† Deduced by the evaluator from a least square fit to the γ–ray energies, except otherwise noted.

γ(^{213}Ra)

E(level)	Eγ†	Iγ†	Mult.†	α	Comments
546.35	546.35 *5*	100	(E2)	0.0315	α(K)=0.0212 *3*; α(L)=0.00763 *11*; α(M)=0.00195 *3*; α(N+..)=0.000645 *9*. α(N)=0.000513 *8*; α(O)=0.0001131 *16*; α(P)=1.82×10⁻⁵ *3*; α(Q)=7.70×10⁻⁷ *11*.
1608.9	1062.5 *2*	100	(E2)	0.00802	α(K)=0.00624 *9*; α(L)=0.001342 *19*; α(M)=0.000327 *5*; α(N+..)=0.0001089 *16*. α(N)=8.61×10⁻⁵ *12*; α(O)=1.94×10⁻⁵ *3*; α(P)=3.27×10⁻⁶ *5*; α(Q)=2.11×10⁻⁷ *3*.
1769.7	160.87 *5*	100	E2	1.328	α(K)=0.237 *4*; α(L)=0.802 *12*; α(M)=0.217 *3*; α(N+..)=0.0715 *10*. α(N)=0.0575 *8*; α(O)=0.01227 *18*; α(P)=0.00180 *3*; α(Q)=1.314×10⁻⁵ *19*.
1770	(161 *7*)				Eγ: from level scheme. Transition was not observed. Another transition from this isomeric level to 1769.72 keV level is expected in 1976Ra37.

† From 2.12–ms ^{213}Ra IT decay.

CITATION:
Nuclear Data Sheets (2007)

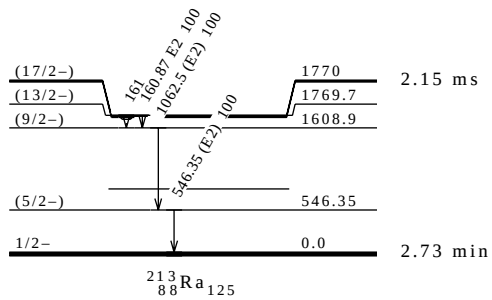
From NNDC(BNL)
program ENSDAT

$^{213}_{88}Ra_{125}$–2

Adopted Levels, Gammas (continued)

Level Scheme

Intensities: relative photon branching from each level



^{213}Ra IT Decay (2.15 ms) 1976Ra37,1994Ne01

Parent ^{213}Ra: E=1770 *8*; Jπ=(17/2–); $T_{1/2}$=2.15 ms *7*; %IT decay≈99.0.
Others: 2004He25, 1993Ne04.
1976Ra37: The decay scheme is given as constructed by 1976Ra37. Measured γγ coin.
I994ne01: Measured g factor for the 17/2– isomeric state using an indirect method that is the ratio of Korringa constant for two isomers is proportional to the inverse ratio of the respective g factors.
1993Ne04: Determined the static–quadrupole–interaction frequency of the 17/2– isomeric state using level–mixing–spectroscopy (LEMS).
2004He25: Measured $T_{1/2}$ for the 17/2– isomeric state.

x–rays: 1976Ra37

E(x ray)	Iγ(relative)	
85.4	4.2 *3*	$K\alpha_2$ x ray
88.5	6.2 *4*	$K\alpha_1$ x ray
100.0	2.1 *3*	$K\beta_1'$ x ray
103.0	0.7 *2*	$K\beta_2'$ x ray

^{213}Ra Levels

E(level)†	Jπ	$T_{1/2}$	Comments
0.0	1/2–	2.73 min *5*	Jπ,$T_{1/2}$: From adopted levels.
546.35 *5*	(5/2–)		Jπ: 546.35γ (E2) to 1/2– state.
1608.85 *21*	(9/2–)		Jπ: 1062.5γ (E2) to (5/2–) state.
1769.72 *22*	(13/2–)		Jπ: 160.8γ E2 to (9/2–) state requires (13/2–), in 1976Ra37 Jπ is given as (13/2–,11/2–).
1770 *7*	(17/2–)	2.15 ms *7*	E(level): 1769 *7*, considering Eα=8467 *5* and Eα=6731 *5* (1976Ra37) from the isomeric level and g.s. feeding to the g.s. of ^{209}Rn. Jπ: Measured g=0.87 *5* (1994Ne01) value supports the configuration $[(\pi 1h^{6}{}_{9/2})_{8+}\otimes(\nu 3p^{-1}{}_{1/2})]_{17/2-}$ for which the calculated magnetic moment, 7.672 *33*, is in good agreement with the measured g value (1994Ne01). $T_{1/2}$: Weighted average of 2.1 ms *1* (1976Ra37) and 2.2 ms *1* (545.4γ) (2004He25). Others: 2.1 ms *1* (160.4γ) and 2.1 ms *1* (1061.2γ) also from (2004He25). The three values determined by 2004He25 from the decrease of γ–ray intensities within the 14.6 ms pause between two consecutive beam bursts.

† Deduced by evaluator from a least square fit to the γ–ray energies.

CITATION:
Nuclear Data Sheets (2007)

From NNDC(BNL)
program ENSDAT

$^{213}_{88}Ra_{125}$−3

^{213}Ra IT Decay (2.15 ms) 1976Ra37,1994Ne01 (continued)

γ(^{213}Ra)

Iγ normalization: Relative transition intensities of 546.35, 1062.5, and 160.87 cascading: γ's are 107 *4*, 101 *4*, and 108 *5*, respectively. The normalization factor of 0.96 *5* is obtained by the evaluator by equating relative transition intensity of 104 *5* to 100 IT decays.

Eγ†	E(level)	Iγ‡#	Mult.§	α	Comments
160.87 *5*	1769.72	46 *2*	E2	1.328	α(K)=0.237 *4*; α(L)=0.802 *12*; α(M)=0.217 *3*; α(N+..)=0.0715 *10*. α(N)=0.0575 *8*; α(O)=0.01227 *18*; α(P)=0.00180 *3*; α(Q)=1.314×10^{-5} *19*.
(161 *7*)	1770				Eγ: from level scheme. Transition was not observed. Another transition from the isomeric level to 1769.72 keV level is expected in 1976Ra37.
546.35 *5*	546.35	104 *3*	(E2)	0.0315	α(K)=0.0212 *3*; α(L)=0.00763 *11*; α(M)=0.00195 *3*; α(N+..)=0.000645 *9*. α(N)=0.000513 *8*; α(O)=0.0001131 *16*; α(P)=1.82×10^{-5} *3*; α(Q)=7.70×10^{-7} *11*.
1062.5 *2*	1608.85	100 *3*	(E2)	0.00802	α(K)=0.00624 *9*; α(L)=0.001342 *19*; α(M)=0.000327 *5*; α(N+..)=0.0001089 *16*. α(N)=8.61×10^{-5} *12*; α(O)=1.94×10^{-5} *3*; α(P)=3.27×10^{-6} *5*; α(Q)=2.11×10^{-7} *3*.

† Measurements of 1976Ra37 (semi).
‡ Relative photon intensity, measured by 1976Ra37.
§ Deduced by 1976Ra37 from (γ)(K x ray) coincidence intensities.
# For absolute intensity per 100 decays, multiply by ≈0.95 *5*.

CITATION:
Nuclear Data Sheets (2007)

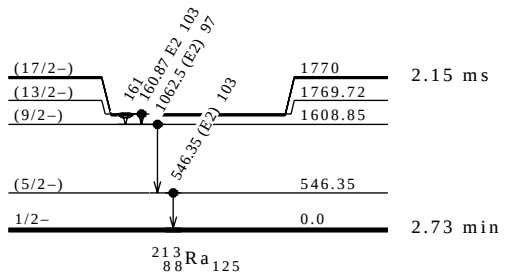
From NNDC(BNL)
program ENSDAT

$^{213}_{88}Ra_{125}$–4

^{213}Ra IT Decay (2.15 ms) 1976Ra37,1994Ne01 (continued)

Decay Scheme

Intensities: I(γ+ce) per 100 decays by this branch
%IT≈99



^{217}Th α Decay 2005Ku31,2002He29,2000Ni02

Parent ^{217}Th: E=0.0; Jπ=(9/2+); $T_{1/2}$=0.251 ms *5*; Q(g.s.)=9433 *4*; %α decay=100.

Others: 2005Li17, 2000He17, 1968Va18, and 2005YeZZ.

2005Ku31: ^{217}Th produced through ^{170}Er(^{50}Ti,3n)^{217}Th; E=4.35 A.MeV; Detector: 16–strip PIPS–detector, Ge–Clover detector of 4 crystals; Measured: Eα, Iα, investigated by Evaporation Residues (ER)–γ–α– coincidences.

2002He29: ^{217}Th produced through ^{181}Ta(^{40}Ar,p3n)^{217}Th, Target: 99.988% natural tantalum; E=182 MeV; Detector: 16–strip PIPS–detector, Ge–Clover detector of 4 crystals; Measured: Eα, Iα, α–γ coincidences.

2000Ni02: ^{217}Th produced through ^{198}Pt(^{28}Si,α5n)^{217}Th; E=140–180 MeV; Detector: Double sided strip detector, TOF signal; Measured: Eα, Iα, t, deduced Jπ of 818 state.

2000He17: ^{217}Th produced through ^{170}Er(^{50}Ti,3n)^{217}Th; E=215–235 MeV; Detector: 16–strip PIPS–detector, a HPGe detector; Measured: Eα, Iα.

2005Li17: Isotope produced by fragment separator of 1 GeV/u ^{238}U beam; Measured: Eα.

1968Va18: ^{217}Th produced through ^{206}Pb(^{16}O,5n)^{217}Th; E=166 MeV; 97.22% ^{206}Pb isotopes in the target; Detector: Semi; Measured: Eα, $T_{1/2}$.

2005YeZZ: ^{217}Th from ^{181}Ta(^{40}Ar,p3n)^{217}Th; Detector: array of silicon strip, 7 HPGe, time–of–flight detectors; Measured Eα; no γ event was attributed to the decay of ^{217}Pa isomer.

^{213}Ra Levels

E(level)	Jπ†	$T_{1/2}$†	Comments
0.0	(1/2–)	2.74 min *4*	
546.35 *5*	(5/2–)		
818	(3/2–)		E(level): Calculated by the evaluator using Q(α) (^{217}Th) and Eα feeding this level. Jπ: Comparatively favored α–decay to this state than (5/2–) state. Also from comparison to ^{215}Ra α–decay to (3/2–) state at 833 keV of ^{211}Rn.

† From adopted levels, except noted otherwise.

α radiations

Eα	E(level)	Iα‡	HF†	Comments
8456 *4*	818	3.67 *14*	23.1 *13*	Eα: Weighted average of 8460 *7* (2005Ku31), 8455 *5* (2002He29), 8459 *15* (2000He17), and 8429 *32* (2000Ni02). Iα: Using the Limitation of Relative Statistical Weight Method (LWM) (1985ZiZY) of 3.0 *2* (2005Ku31), 3.7 *1* (2002He29), 3.8 *1* (2000He17), and 5.1 *20* (Actual: 5.1 +2.0–1.6 in 2000Ni02). Weighted average 3.67 *7*.
8726 *4*	546.35	1.64 *6*	282 *15*	Eα: Weighted average of 8727 *8* (2005Ku31), 8725 *5* (2002He29), 8731 *15* (2000He17), and 8713 *32* (2000Ni02). Iα: Weighted average of 1.5 *1* (2005Ku31), 1.8 *1* (2002He29), 1.6 *1* (2000He17), and 2.6 *16* (Actual: 2.6 +1.6–1.1 in 2000Ni02).

Continued on next page (footnotes at end of table)

From NNDC(BNL)
program ENSDAT

$^{213}_{88}Ra_{125}$–5

^{217}Th α Decay 2005Ku31,2002He29,2000Ni02 (continued)

α radiations (continued)

Eα	E(level)	Iα‡	HF†	Comments
9261 *4*	0.0	94.7 *8*	108 *5*	Eα: Weighted average of 9250 *10* (1968Va18), 9269 *9* (2005Ku31), 9250 *47* (2005Li17), 9261 *5* (2002He29), 9268 *15* (2000He17), and 9247 *15* (2000Ni02). Iα: Using the Limitation of Relative Statistical Weight Method (LWM) (1985ZiZY) of 95.5 *3* (2005Ku31), 94.5 *5* (2002He29), 94.6 *6* (2000He17), and 92.3 *6* (2000Ni02). Weighted average 94.7 *2*.

† Using $r_0(^{213}Ra)$=1.51 *1*, average of $r_0(^{212}Ra)$=1.466 *6* and $r_0(^{214}Ra)$=1.554 *9* (1998Ak04).

‡ Absolute intensity per 100 decays.

CITATION:
Nuclear Data Sheets (2007)

From NNDC(BNL)
program ENSDAT

$^{213}_{89}Ac_{124}-1$

Adopted Levels, Gammas

Q(β⁻)=–5960 *90*; S(n)=9190 *90*; S(p)=940 *50*; Q(α)=7500 *50* 2003Au03.
Assignment: ^{209}Bi(^{12}C,8n) excit (1961Gr42,1968Va04); ^{197}Au(^{20}Ne,4n) excit (1968Va04); ^{203}Tl(^{16}O,6n) excit (1968Va04); ^{205}Tl(^{16}O,8n) excit (1968Va04); parent of ^{209}Fr (1968Va04).

^{213}Ac Levels

Cross Reference (XREF) Flags

A ^{217}Pa α Decay (3.6 ms)
B ^{217}Pa α Decay (1.2 ms)

E(level)†	XREF	$T_{1/2}$	Comments
0.0	AB	738 ms *16*	%α≤100. Only α decay was observed. Possible ε decays to 1608.9 (9/2–) and 546.35 (5/2–) levels are expected to be <25% and <0.05%, if log *ft*>3.6 and log f^1t>8.5, respectively. β gross theory calculations by 1973Ta30 give $T_{1/2}(\beta^+)$≈50 s, which suggests %(ε+β⁺)≈1.6. Jπ: In 2002He29, Jπ=(9/2–) is presented in the tentative partial decay scheme of ^{213}Ac. If Eα=7364 *8* is the ^{213}Ac g.s. to ^{209}Fr g.s. transition, that has a HF≈1.2 (1991Ma16), would be a good support for the assignment. $T_{1/2}$: Weighted average of 731 ms *17* (2000He17) and 800 ms *50* (1968Va04). Unweighted average 765 ms *3*. Other: ≈1 s (1961Gr42).
468	AB		
616	AB		
634	AB		Jπ: In 2002He29, Jπ=(13/2–) is presented for this level in the tentative partial decay scheme of ^{213}Ac.
(1066.4)	B		
1884	B		Jπ: In 2002He29, Jπ=(21/2–) is presented for this level in the tentative partial decay scheme of ^{213}Ac.

† Deduced by the evaluator from Eα and Q(α) values from 3.6–ms g.s. and 1.2–ms isomeric state ^{217}Pa α decay.

γ(^{213}Ac)

E(level)	Eγ†	Iγ
468	(468)	100
616	(616)	100
634	(634)	100
(1066.4)	(450.4)	100
1884	(817.6)	100

† From level energy difference, expected in 2002He29.

CITATION:
Nuclear Data Sheets (2007)

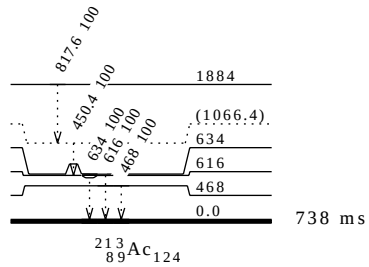
From NNDC(BNL)
program ENSDAT

$^{213}_{89}Ac_{124}$–2

Adopted Levels, Gammas (continued)

Level Scheme

Intensities: relative photon branching from each level



^{217}Pa α Decay (3.6 ms) 2002He29,2000He17,1968Va18

Parent ^{217}Pa: E=0.0; Jπ=?; $T_{1/2}$=3.6 ms *8*; Q(g.s.)=8489 *4*; %α decay=100.

^{217}Pa–J: In 2002He29, Jπ=(9/2–) is presented in the tentative partial decay of ^{217}Pa, not adopted in 2003Ak06.

Others: 1998Ik01, 1996An21, 1979Sc09, and 2005YeZZ.

2002He29: ^{217}Pa produced through ^{181}Ta(^{40}Ar,4n)^{217}Th, Target: 99.988% natural tantalum; E=182 MeV; Detector: 16–strip PIPS–detector, Ge–Clover detector of 4 crystals; Measured: Eα, Iα, α–α coincidences.

2000He17: ^{217}Pa produced through ^{170}Er(^{51}V,4n)^{217}Th; E=214–286 MeV; Detector: 16–strip PIPS–detector, a HPGe detector; Measured: Eα, Iα.

1968Va18: ^{217}Pa produced through ^{206}Pb(^{20}Ne,p8n)^{217}Pa and ^{208}Tl(^{20}Ne,11n)^{217}Pa; Detector: Semi; Measured: Eα.

1998Ik01: ^{217}Pa produced through ^{194}Pt(^{28}Si,p4n)^{217}Pa; E=163–MeV and 175–MeV; Detector: double sided position sensitive strip detector; Measured: Eα, $T_{1/2}$.

1996An21: ^{217}Pa from ^{170}Er(^{51}V,4n)^{217}Pa; E=28–87 MeV; Detector: ER are separated in flight, 16–strip PIPS detector, a HPGe detector; Measured: Eα, $T_{1/2}$.

1979Sc09: 181Ta(^{40}Ar,4n)^{217}Pa; E=165–202 MeV; Measured: Eα, $T_{1/2}$.

2005YeZZ: ^{217}Pa from ^{181}Ta(^{40}Ar,4n)^{217}Pa; Detector: array of silicon strip, 7 HPGe, time–of–flight detectors; Measured Eα.

^{213}Ac Levels

E(level)†	Comments
0.0	Jπ: In 2002He29, Jπ=(9/2–) is presented for this level in the tentative partial decay scheme of ^{213}Ac.
468	
616	
634	Jπ: In 2002He29, Jπ=(13/2–) is presented for this level in the tentative partial decay scheme of ^{213}Ac.

† Deduced by the evaluator using the Eα and Q(α) values.

α radiations

Eα	E(level)	Iα‡§	HF†	Comments
7710 *5*	634	0.3 *2*	4 *4*	Eα: From 2002He29.
7728 *5*	616	0.3 *2*	5 *4*	Eα: From 2002He29.
7873 *5*	468	0.4 *2*	10 *7*	Eα: From 2002He29.
8336 *4*	0.0	99 *1*	1.0 *4*	Eα: Weighted average of 8337 *5* (2002He29), 8334 *15* (2000He17), 8330 *50* (1998Ik01), 8330 *10* (1996An21), 8334 *15* (1979Sc09), and 8340 *10* (1968Va18).

† Using r_0(^{213}Ac)=1.47 *9*, average of r_0(^{212}Ra)=1.466 *6* and r_0(^{214}Th)=1.46 *+4–9* (considered 0.09 uncertainty in averaging by the evaluator) (1998Ak04).

‡ From 2002He29.

§ Absolute intensity per 100 decays.

CITATION:
Nuclear Data Sheets (2007)

From NNDC(BNL)
program ENSDAT

$^{213}_{89}Ac_{124}$–3

^{217}Pa α Decay (3.6 ms) 2002He29,2000He17,1968Va18 (continued)

γ(^{213}Ac)

Eγ†	E(level)
(468)	468
(616)	616
(634)	634

† From level energy difference, expected in 2002He29.

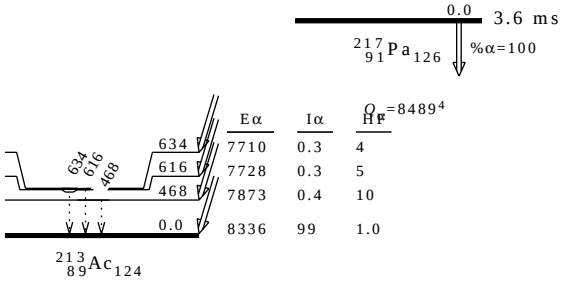
CITATION:
Nuclear Data Sheets (2007)

From NNDC(BNL)
program ENSDAT

$^{213}_{89}Ac_{124}$–4

^{217}Pa α Decay (3.6 ms) 2002He29,2000He17,1968Va18 (continued)

Decay Scheme



^{217}Pa α Decay (1.2 ms) 2002He29,2000He17,1998Ik01

Parent ^{217}Pa: E=1857.0 *12*; Jπ=?; $T_{1/2}$=1.2 ms *2*; Q(g.s.)=8489 *4*; %α decay=75.3.

^{217}Pa–E: An average value, deduced using all the Eα from this level of ^{217}Pa to the different energy levels of ^{213}Ac and Q(α) (^{217}Pa) by the evaluator.

^{217}Pa–J: In 2002He29, Jπ=(29/2–) is presented in the tentative partial ^{217}Pa isomeric decay, not adopted in 2003Ak06.

Others: 1996An21, 1979Sc09.

2002He29: ^{217}Pa produced through ^{181}Ta(^{40}Ar,4n)^{217}Th, Target: 99.988% natural tantalum; E=182 MeV; Detector: 16–strip PIPS–detector, Ge–Clover detector of 4 crystals; Measured: Eα, Iα, α–α coincidences.

2000He17: ^{217}Pa produced through ^{170}Er(^{51}V,4n)^{217}Th; E=214–286 MeV; Detector: 16–strip PIPS–detector, a HPGe detector; Measured: Eα, Iα.

1998Ik01: ^{217}Pa produced through ^{194}Pt(^{28}Si,p4n)^{217}Pa; E=163–MeV and 175–MeV; Detector: double sided position sensitive strip detector; Measured: Eα, $T_{1/2}$.

1996An21: ^{217}Pa from ^{170}Er(^{51}V,4n)^{217}Pa; E=28–87 MeV; Detector: ER are separated in flight, 16–strip PIPS detector, a HPGe detector; Measured: Eα, $T_{1/2}$.

1979Sc09: 181Ta(^{40}Ar,4n)^{217}Pa; E=165–202 MeV; Measured: Eα, $T_{1/2}$.

^{213}Ac Levels

E(level)†	Comments
0.0	Jπ: In 2002He29, Jπ=(9/2–) is presented for this level in the tentative partial decay scheme of ^{213}Ac.
468	
616	
634	Jπ: In 2002He29, Jπ=(13/2–) is presented for this level in the tentative partial decay scheme of ^{213}Ac.
(1066.4)	E(level): From 450.4γ feeding the 616 keV level.
1884	E(level): Deduced from the Eα, Q(α), and 1857–keV isomeric ^{217}Pa α decay. Jπ: In 2002He29, Jπ=(21/2–) is presented for this level in the tentative partial decay scheme of ^{213}Ac.

† From adopted levels, except noted otherwise.

α radiations

Eα‡	E(level)	Iα§#	HF†	Comments
8306 *5*	1884	0.15 *3*	260 *100*	Iα: From 2002He29.
9533 *5*	634	0.08 *1*	7.1×10^5 *27*	Eα: Other: 9540 *50* (1998Ik01). Iα: From 2002He29.
9552 *5*	616	0.15 *4*	4.3×10^5 *19*	Eα: Other: 9648 *15* (2000He17).
9697 *5*	468	0.033 *9*	3.7×10^6 *16*	Eα: Other: 9694 *20* (2000He17).
10157 *5*	0.0	99.6 *5*	1.32×10^4 *45*	Eα: Others: 10155 *15* (2000He17), 10140 *50* (1998Ik01), 10155 *15* (1996An21), and 10160 *20* (1979Sc09).

† Using r_0(^{213}Ac)=1.47 *9*, average of r_0(^{212}Ra)=1.466 *6* and r_0(^{214}Th)=1.46 *+4–9* (considered 0.09 uncertainty in averaging by the evaluator) (1998Ak04).

‡ From 2002He29.

§ Weighted average of values from 2002He29 and 2000He17, except otherwise noted.

For α intensity per 100 decays, multiply by 0.753.

CITATION:
Nuclear Data Sheets (2007)

From NNDC(BNL)
program ENSDAT

$^{213}_{89}Ac_{124}$–5

^{217}Pa α Decay (1.2 ms) 2002He29,2000He17,1998Ik01 (continued)

γ(^{213}Ac)

Eγ†	E(level)	Comments
(450.4)	(1066.4)	
(468)	468	
(616)	616	
(634)	634	
(817.6)	1884	Eγ: 820.8 keV in 2002He29.

† From level energy difference, expected in 2002He29.

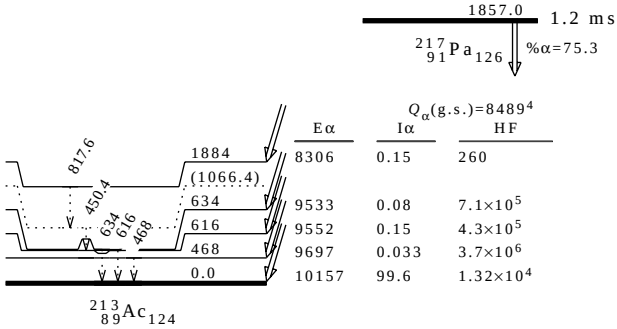
CITATION:
Nuclear Data Sheets (2007)

From NNDC(BNL)
program ENSDAT

$^{213}_{89}Ac_{124}$–6

^{217}Pa α Decay (1.2 ms) 2002He29,2000He17,1998Ik01 (continued)

Decay Scheme



CITATION:
Nuclear Data Sheets (2007)

From NNDC(BNL)
program ENSDAT

$^{213}_{90}Th_{123}$−1

Adopted Levels

Q(β⁻)=−7.54×10³ *10*; S(n)=8040 *70*; S(p)=2450 *100*; Q(α)=7840 *50* 2003Au03.
Assignment: ^{206}Pb(^{16}O,9n) excit (1968Va18), ^{177}Hf(^{40}Ar,4n) excit (1980Ve01).

^{213}Th Levels

Cross Reference (XREF) Flags

A ^{217}U α Decay

E(level)	XREF	$T_{1/2}$	Comments
0.0	A	144 ms *21*	%α≤100. Only α decay is reported. Branching for a possible (ε+β⁺) decay to ^{213}Ac is estimated by the evaluator as ≈1.4% from $T_{1/2}$(ε+β⁺)≈10 second, calculated by 1973Ta30 using β gross theory. $T_{1/2}$: Weighted average of 150 ms *25* (1968Va18) and 130 ms *+50−30* (1980Ve01), considering uncertainty ±40 for the later value. Unweighted average 140 ms *10*.

^{217}U α Decay 2000Ma65,2005Le42

Parent ^{217}U: E=0.0; Jπ=?; $T_{1/2}$=16 ms *+21−6*; Q(g.s.)=8160 *50*; %α decay=100.
^{217}U−$T_{1/2}$: Adopted value in 2003Ak06. 15.6 ms +21.3−5.7 (2000Ma65) and 0.19 ms +1.13−0.10 (2005Le42).
^{217}U−J: In 2005Le42, Jπ=(1/2−) is presented.
2000Ma65: ^{217}U was produced through ^{182}W(^{40}Ar,5n)^{217}U; Target 92% enriched; E=193 MeV; multi−strip silicon detector; Eα, $T_{1/2}$ measured.
2005Le42: ^{217}U was produced through ^{182}W(^{40}Ar,5n)^{217}U; E=186 MeV, double−sided silicon detector; Eα, $T_{1/2}$ measured.

^{213}Th Levels

E(level)
0.0

α radiations

Eα	E(level)	Iα‡	HF†	Comments
8018 *11*	0.0	100	0.16 *22*	Eα: Weighted average of 8005 *20* (2000Ma65), 8024 *14* (2005Le42).

† Using r_0(^{213}Th)=1.46 *9*, from r_0(^{214}Th)=1.46 *+4−9* (1998Ak04) r_0(^{212}Th)=not exist in 1998Ak04.
‡ Absolute intensity per 100 decays.

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$^{213}_{91}Pa_{122}-1$

Adopted Levels

S(n)=10020 *100*; S(p)=−280 *70*; Q(α)=8390 *50* 2003Au03.
^{150}Er(^{51}V,X), E=5.2−5.6 Mev/nucleon; measured a, αα (1995Ni05,1997Au04).

^{213}Pa Levels

E(level)	$T_{1/2}$	Comments
0.0	5.3 ms *+40−16*	%α=100. $T_{1/2}$: from 1995Ni05. 2000He17 and 1996An21 present also the same value.

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KEYNUMBERS

1947En03
1948Je05
1950Ha52
1952Wa24
1955Ma61
1955Mo68
1955St04
1956Mo15
1960Vo05
1961Gr42
1961Ru06
1962Gr20
1962Wa28
1964Bu05
1964Gr04
1964Gr11
1964Va20
1967Dz02
1967Va20
1967Va22
1968Ha14
1968Le07
1968Lo15
1968Va04
1968Va17
1968Va18
1969Dz02
1969DzZZ
1969LeZW
1970Bo13
1970TaZS
1970To07
1970Va13
1971MaXH
1972Dz14
1972Mo10
1973Ba19
1973Ma52
1973No09
1973Po16
1973Ta30
1974Ba87
1974Ho27
1974Re09
1975LiZH
1976De25
1976Ha37
1976Ra37
1977Be56
1977Ha41
1977Pr10
1977Vy02
1978Ek02
1979Ad07
1979Ho06
1979Ig04
1979Sc09
1980Di14
1980Ig02
1980Me05
1980Sj01
1980Ve01
1981Bo29
1981Di14
1982Ad01
1982Bo04
1982Gr21
1982Gr24
1982Ka37
1983Ah03
1983Br06
1983Br15
1983Gr17
1983Lo16
1984De14
1984Gr06
1984Gr13
1984He17
1984Ig01
1984It01
1984Ni09
1984Ro23
1985Be05
1985Co24
1985De14
1985Dz04
1985He03
1985It01
1985ZiZY
1986Be20
1986By01
1986Ek02
1986He06
1986It01
1986Pi11
1987Ar20
1987It03
1987Sa51
1987We03
1987Za02
1988Fu10
1988Gr16
1988St10
1989By01
1989Dr02
1989Ko26
1989Lo02
1989Ra17
1990By03
1990Du03
1990Ha30
1990Ne11
1990St14
1991ByZZ
1991Ha02
1991Ma16
1991Ry01
1992Ak01
1992Li25
1993Ne04
1994Ar05
1994Ar23
1994Ne01
1995Ni05
1995WaZQ
1996An21
1997Au04
1997Ch19
1997Ch53
1997Ki15
1997Li23
1997VaZV
1997Wa27
1998Ak04
1998Ar03
1998Ik01
1998MaZO
1998Wa25
2000Gr35
2000He17
2000Ma65
2000Ni02
2000Pe30
2002He29
2002Mo46
2003Ak06
2003Au03
2003LaZZ
2003Ni10
2004He25
2004Li28
2005Ga46
2005Ku31
2005Le42
2005Li17
2005YeZZ
2006Po01

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