^{237}Np α decay (2.144×10^6 y) 2002Wo03,2000Sc04,1979Go12

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	B. Singh, J. K. Tuli, E. Browne	NDS 170,499 (2020)	8-Oct-2020

Parent: ^{237}Np: E=0.0; J$^\pi$=5/2$^+$; $T_{1/2}$=2.144×10^6 y *7*; Q(α)=4957.3 *7*; %α decay=100

^{237}Np-J$^\pi$,$T_{1/2}$: Values are from ^{237}Np Adopted Levels in the ENSDF database (March 2006), and are still valid.

^{237}Np-Q(α): From 2017Wa10.

^{237}Np-%α decay: %α=100. The SF and cluster decay modes are insignificant.

Following points should be noted:

1. The directly measured %α feedings (adopted here from 2002Wo03) and those deduced from the gamma-ray intensity balances in the decay scheme (given under comments) are not always in good agreement.
2. Below 115 keV the photon spectrum is mainly dominated by many (complex) peaks from Pa x-rays (from ^{237}Np α decay) and U x-rays (from ^{233}Pa β decay), which makes it difficult to extract accurate intensities of γ rays in this energy region.

2000Sc04, 2002Wo03 (also 2000Wo01,2000Si02): measured α, γ, $\alpha\gamma$, $\beta\gamma$, x-rays using Ge(Li), two HPGe and Si(Li) detectors at PTB. Survey of previous measurements. The photon intensities in 2002Wo03 were originally listed in 2000Sc04 together with detailed information about the origin of a radiation. The α results given in 2002Wo03 were originally listed in 2000Si02. 2000Wo01 give absolute intensities of only 10 prominent γ rays.

2004Sh07: measured x-ray and γ-ray emission probabilities for ^{237}Np decay in equilibrium with ^{233}Pa decay. Euromet project.

2002Lu01, 2000Lu01: measured emission probabilities of x-rays and γ rays for ^{237}Np-^{233}Pa source in equilibrium. The results are also listed in 2002Wo03. Euromet project.

1992Lo03: measured half-life of decay of ^{237}Np.

1990Pe16: ce.

1990Lo04: α, γ.

1990Bo44: Eα, Iα.

1988Wo01: ce, α, $\gamma\gamma$-coin.

1984Va27: photon emission probabilities of five x-ray lines and ten γ rays.

1981Ba68: relative and absolute γ-ray intensities of 40 γ rays.

1979Go12: measured α, γ, $\gamma\gamma$- and $\alpha\gamma$-coin, x rays, γ(x ray)-coin; 51 γ rays assigned to the decay of ^{237}Np; absolute intensities of 31 γ rays measured.

1976Sk01: energies and relative intensities of 42 γ rays.

1975PeZI: Eγ, Iγ, $\gamma\gamma$- and $\alpha\gamma$-coin.

1974HeYW (also 1971Cl01): measured Eγ, Iγ of 31 γ rays.

1969Br12 (also 1968Br25,1969BrZV): Eγ, Iγ, ce, α, $\gamma\gamma$-, $\alpha\gamma$- and α(ce)-coin. Data from 1969Br12 are cited in 1971El11 evaluation of A=137 nuclides.

1960Br12: measured half-life of decay of ^{237}Np.

1949Ma01: measured half-life of decay of ^{237}Np.

Others:

First identification of ^{237}Np isotope: 1948Wa04, 1948Ma16.

Additional information 1.

γ measurements: 1975IoZZ, 1974ChXY, 1969Va06, 1969HoZY, 1961Ba44, 1955St04, 1955Ma67.

α: 1976BaZZ, 1969Va06, 1968Ba25, 1961Ba44, 1956Ko56, 1955Ma67.

$\gamma\gamma$-coin: 1969HoZY.

$\alpha\gamma(\theta)$: 1967Hu03.

α(θ,temp) from oriented ^{237}Np: 1961Ha34, 1974Go08.

$\alpha\gamma$(t), α(ce)(t) measurements: 1972Mc12, 1972Mc29, 1972Wi11, 1971Ga16, 1968Ob02, 1961Ma10, 1955St88, 1954En11.

^{233}Pa Levels

(α)(140γ,200γ)(t): $T_{1/2}$<2 ns (1955St88).

(α)(Eγ>100)(t): $T_{1/2}\le$1.02 ns (1968Ob02).

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^{237}Np α decay (2.144×10^{6} y) 2002Wo03,2000Sc04,1979Go12 (continued)

^{233}Pa Levels (continued)

E(level)†	Jπ‡	$T_{1/2}$	Comments
0.0#	3/2−	26.975 d *13*	$T_{1/2}$: From the Adopted Levels.
6.658# *17*	1/2−		
57.112# *10*	7/2−		
70.526# *20*	5/2−		
86.482@ *8*	5/2+	36.5 ns *4*	$T_{1/2}$: from α(86.5γ)(t), unless otherwise stated. Weighted average of 35.7 ns *4* (1972Mc12), 36.4 ns *5* (1972Mc29), 35.7 ns *5* (1972Wi11), 35.4 ns *8* (α(29.6γ)(t),1972Wi11), 37.4 ns *4* (α(65-105 α)(t),1971Ga16), 36.8 ns *16* (α(70-90 γ)(t),1968Ob02), 36.9 ns *5* (1961Ma10), 36.9 ns *4* (α(ce, <100 keV)(t),1954En11).
94.651@ *12*	3/2+		
103.651@ *18*	7/2+		
109.05@ *3*	9/2+		
133.25@ *20*	(11/2+)		
163.32# *5*	(11/2−)		
169.160& *17*	1/2+		
179.59# *10*	(9/2−)		
201.619& *14*	3/2+		
212.346& *13*	5/2+		
218? *3*			E(level): level not included in the Adopted dataset.
237.904a *11*	5/2+		
257.129b *24*	5/2−		
279.719& *22*	(7/2+)		
283? *3*			E(level): level not included in the Adopted Levels.
300.483a *25*	7/2+		
303.51& *6*	(9/2+)		
306.09b *7*	(7/2−)		
365.96a *7*	9/2+		

† From least-squares fit to Eγ values, assuming 0.2 keV uncertainty when not given.
‡ From the Adopted Levels.
# Band(A): π1/2[530].
@ Band(B): π3/2[651].
& Band(C): π1/2[660].
a Band(D): π5/2[642].
b Band(E): π5/2[523].

α radiations

Eα†	E(level)	Iα‡d	HF#	Comments
≈4386		0.02&	46265	
4550.5@ *22*		0.011 *3*	8.4×10^{4} *24*	
4515.1 *19*	365.96	0.035 *4*	59 *7*	Eα: other: 4513.7 (1990Bo44). Iα: others: 0.041 *4* (1990Bo44); 0.066 *7* (from decay scheme).
4567ae	306.09	0.010 *4*		Iα: from decay scheme.
4573 *3*	303.51	0.048& *23*	127 *61*	Iα: possibly includes Iα to 306.05 level. Iα: other: 0.059 *9* (from decay scheme).
4578.6 *14*	300.483	0.369 *23*	17.3 *11*	Eα: other: 4577.5 (1990Bo44). Iα: others: 0.41 *2* (1990Bo44); 0.7 *4* (from decay scheme).

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^{237}Np α decay (2.144×10^6 y) 2002Wo03,2000Sc04,1979Go12 (continued)

α radiations (continued)

Eα[†]	E(level)	Iα[‡d]	HF[#]	Comments
4680.5[@] *18*		0.020 *4*	4.6×10^4 *10*	
4825[@] *4*		0.014 *11*	6.6×10^4 *52*	
4849[@] *5*		0.006 *4*	1.5×10^5 *11*	
4594.9[e] *20*	283?	0.085[&]	101	Eα: not reported in 2002Wo03 and 1990Bo44.
4599.1 *18*	279.719	0.371 *9*	24.5 *7*	Eα: other: 4598.5 (1990Bo44). Iα: others: 0.39 *2* (1990Bo44); 0.36 *3* (from decay scheme).
4619.7 *21*	257.129	0.032 *8*	4.2×10^2 *11*	Eα: other: 4619, uncertain α (1990Bo44).
4640.0 *10*	237.904	6.43 *3*	2.86 *3*	Eα: other: 4839.5 (1990Bo44). Iα: others: 6.45 *4* (1990Bo44); 6.0 *7* (from decay scheme).
4659.1[e] *20*	218?	≤0.57[&]	≥45	Eα: α not in 2002Wo03 and 1990Bo44.
4665.0 *9*	212.346	3.478 *24*	8.1 *8*	Eα: other: 4664.6 (1990Bo44). Iα: others: 3.43 *4* (1990Bo44), 2.76 *20* (from decay scheme).
4698.2 *8*	179.59	0.535 *10*	90 *2*	Eα,Iα: other: 4698.0, 0.54 *4* (1990Bo44).
4708.3[bc] *20*	169.160	≤1.174[c]	≥48	Iα: other: 0.24 *4* (from decay scheme).
4712.3[bc] *20*	163.32	≤1.174[c]	≥53	Iα: other: 0.484 *13* (from decay scheme).
4741.3[b] *20*	133.25	0.019[&]	5395	Eα: not in 2002Wo03; Eα=4748? (1990Bo44).
4766.5 *8*	109.05	9.3 *3*	16.3 *6*	Eα,Iα: other: 4766.4, 9.7 *3* (1990Bo44).
4771.4 *8*	103.651	23.2 *3*	7.1 *1*	Eα,Iα: other: 4771.4, 22.7 *4* (1990Bo44).
4788.0 *9*	86.482	47.64 *6*	4.55 *3*	Eα: 4788.1 (1990Bo44). Iα: others: 47.75 *20* (1990Bo44); 82 *2* (to 86+95+104+109 levels) (from decay scheme).
4803.5 *10*	70.526	2.014 *17*	139 *2*	Eα: other: 4803.6 (1990Bo44). Iα: from 1961Ba44. Others: 2.06 *5* (1990Bo44), ≈3% (1969Br12), 1.4 *3* (from decay scheme).
4816.8 *10*	57.112	2.430 *17*	142 *2*	Eα: 4817.0 (1990Bo44). Iα: others: 2.47 *2* (1990Bo44), 4.1 *21* (from decay scheme).
4866.4 *14*	6.658	0.53 *4*	1.43×10^3 *11*	Eα: other: 4866.4 (1990Bo44). Iα: others: 0.49 *3* (1990Bo44), 0.24 (1961Ba44), ≥0.3 *1* (1969Br12); 3.5 *17* (to g.s. +6.66 level) (from decay scheme).
4872.7 *14*	0.0	2.39 *4*	353 *7*	Eα: others: 4873.0 (1990Bo44), 4871 *3* (1961Ba44). Iα: others: 2.43 *3* (1990Bo44), 2.6 *2* (1969Br12), 0.925 (1961Ba44); 3.5 *17* (to g.s. +6.66 level) (from decay scheme).

[†] From 2002Wo03 (also 2000Si02). In an earlier evaluation (1990Ak02), the adopted values were from 1961Ba44, 1968Ba25, 1976BaZZ. Others: 1979Go12 (semi), 1969Br12 (semi), 1969Va06 (semi), 1956Ko56 (s), 1955Ma67.

[‡] From 2002Wo03 (also 2000Si02). Values from 1990Bo44 are given under comments. Earlier measurements: 1969Br12 (also 1968Br25), 1956Ko56. Measurements of 1961Ba44 and 1979Go12 do not agree well with the intensities given by 2002Wo03.

[#] The nuclear radius parameter r_0(^{233}Pa)=1.51670 *40* is deduced from interpolation (or unweighted average) of radius parameters of the adjacent even-even nuclides (2020Si16).

[@] Transition seen by 2002Wo03 (also 2000Si02).

[&] Reported by 1961Ba44 only, treated as uncertain.

[a] From level scheme. This possible α was observed only by 1979Go12 in αγ-coin spectrum (indicated by 1979Go12 in their table for αγ-coin results).

[b] From 1961Ba44, 1968Ba25 and 1976BaZZ.

[c] Combined to 163.25+169.1 levels: Eα=4710.8 *7*, Iα=1.174% *13* (2002Wo03); Eα=4710.6, Iα=1.20% *5* (1990Bo44).

[d] Absolute intensity per 100 decays.

[e] Existence of this branch is questionable.

γ(^{233}Pa)

$\gamma\gamma$-coin from 1988Wo01 and 1976Sk01; $\gamma\gamma$- and $\alpha\gamma$-coin from 1979Go12; $\alpha\gamma$-coin and α(ce)-coin from 1969Br12.

Pa x-ray intensities

E(x ray) 2000Sc04 2002Wo03	Radiation	I(x ray) (%) 2004Sh07	I(x ray) (%) 2000Sc04 2002Wo03
3.15	M (?)		4.8 *25*
11.37	L_1	1.31 *20*	1.55 *8*
13.27	L_α	23.3 *24*	26 *3*
14.95	L_η	0.50 *4*	0.64 *6*
15.4(b)	$L_{\beta6}$		<0.66 *5*
16.0	$L_{\beta2,15;\beta4}$	6.3 *6*	7.9 *3*
16.6(b)	$L_{\beta1,\beta5,\beta3}$		<27.4 *11*
17.2(b)	$L_{L1-M4,5}$		<11.5 *5*
18.9(a)	L_{L1-N1}	0.126 *12*	
19.50	$L_{\gamma1}$		4.65 *17*
20.16(b)	$L_{\gamma2,\gamma3,\gamma6}$		<3.49 *13*
20.7 (b)	$L_{L1-O2,4}$	1.22 *11*	
92.29(c)	$K_{\alpha2,\alpha3}$	1.80 *3*	1.82 *5*
95.87(c)	$K_{\alpha1}$	2.89 *4*	2.98 *7*
107.60(c)	$K_{\beta3}$	0.330 *24*	0.249 *8*
108.43(c)	K_{b1}	0.69 *3*	0.864 *19*(d)
109.1(a)	K_{b5}	0.0252 *12*	
111.50(c)	$K_{\beta2}$	0.269 *13*	(b)
111.9(a)	$K_{\beta4}$	0.0078 *4*	
112.5(a)	K_{OP}	0.099 *15*	

K x-ray intensities are in agreement with those from 2002Lu01 and 1984Va27
(a) From 2004Sh07
(b) Combined with U x-rays from ^{233}Pa β^- decay
(c) From 1979Go12 and 1984Va27
(d) For 108.43+109.1

E_γ[†]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	α[k]	Comments
(5.18[df])	109.05	9/2$^+$	103.651	7/2$^+$			E_γ: from 1990Lo04, Iγ=0.222 *5* listed which may be transition intensity.
(6.68[h] 5)	6.658	1/2$^-$	0.0	3/2$^-$	(M1)	3.04×10^3 *8*	α(M)=2.25×10^3 *6*

γ(^{233}Pa) (continued)

E$_\gamma$[†]	I$_\gamma$[‡j]	E$_i$(level)	J$^\pi_i$	E$_f$	J$^\pi_f$	Mult.[#]	α[k]	I$_{(\gamma+ce)}$[j]	Comments
									α(N)=610 *17*; α(O)=146 *4*; α(P)=28.0 *8*; α(Q)=2.33 *7* E$_\gamma$,Mult.: from the Adopted Gammas.
8.22 *5*	≈0.0055	94.651	3/2$^+$	86.482	5/2$^+$	(M1)	1.64×10^3 *4*	≈9	α(M)=1.22×10^3 *3*; α(N)=329 *8*; α(O)=78.9 *19*; α(P)=15.1 *4*; α(Q)=1.25 *3* E$_\gamma$: from ^{233}Th β^- decay. Other: 8.03 (1990Lo04) with Iγ=0.034 *11*. Total I(ce)(8.22γ)/Iγ(88.0γ)≈62, as deduced in ^{233}Th β^- decay, yields total Ice(8.22γ)≈9. Mult.: from Adopted Gammas.
(9.0[d])		103.651	7/2$^+$	94.651	3/2$^+$	[E2]	4.2×10^5		Eγ=9.78, Iγ=0.36 (1990Lo04) may partly belong to ^{237}Np decay.
(10.7[g])		212.346	5/2$^+$	201.619	3/2$^+$				
(17.40[h] *5*)		103.651	7/2$^+$	86.482	5/2$^+$	[M1+E2]	8.0×10^3 *78*		E$_\gamma$: 17.78 in 1990Lo04.
^{x}21.5[e]	0.356 *13*								I$_\gamma$: 0.65 *5* (2004Sh07).
(22.6[d])		109.05	9/2$^+$	86.482	5/2$^+$				
24.14[bm] *10*		133.25	(11/2$^+$)	109.05	9/2$^+$				
^{x}27.7[e]	0.84 *7*								
29.374 *10*	14.5 *4*	86.482	5/2$^+$	57.112	7/2$^-$	E1	3.07		α(M1)exp<0.0078 *5*; α(M2)exp=0.059 *8*; α(M3)exp=0.054 *7*; α(M4)exp=0.012 *3* (1988Wo01) α(M5)exp=0.009 *2*; α(N+...)exp=0.048 *2* (1988Wo01) α(L)=2.29 *4*; α(M)=0.585 *9* α(N)=0.1527 *22*; α(O)=0.0331 *5*; α(P)=0.00487 *7*; α(Q)=0.0001509 *22* E$_\gamma$: weighted average of 29.374 *20* (1979Go12), 29.373 *10* (1976Sk01), 29.375 *20* (1974HeYW). 1990Pe16: Ice(L1)=1.4% *2*, Ice(L2)=1.6% *2*, Ice(L3)=2.6% *2*. I$_\gamma$: unweighted average of 13.2 *4* (2004Sh07), 13.51 *16* (2002Lu01), 14.12 *15* (2000Sc04), 13.9 *1* (1990Lo04), 15.0 *4* (1984Va27), 15.6 *2* (1981Ba68), 16.3 *9* (1976Sk01). Weighted average is 14.2 *3*, but reduced χ^2=14. Others: 19.3 *9* (1988Wo01), 9.8 *10* (1979Go12), both seem discrepant. Mult.: ce data of 1988Wo01 indicate that this transition may be an anomalous E1, as is the 86.477γ. Measured I(ce) are: M1:M2:M3:M4:M5=<8:61 *8*:55 *7*:12 *3*:9.0 *18*; the theoretical ratios for E1 are: 36:41.1:(55):14.1:16.9 (normalized at M3 line). The deduced M conversion coefficients are smaller than the theoretical ones, in contrast to the 86.477γ. However, as 1988Wo01 pointed out, the detector efficiency was not completely reliable

$^{233}_{91}$Pa$_{142}$-5

γ(^{233}Pa) (continued)

E_γ[†]	I_γ[‡j]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	δ[&]	α[k]	Comments
									for E(ce)<50 keV. The theoretical conversion coefficients are given here for that reason, rather than the deduced ones from measured I(ce)/Iγ ratios. α(29γ)(θ): A_2=+0.28 *17* (1967Hu03).
(29.6[g])		133.25	(11/2$^+$)	103.651	7/2$^+$				
(32.46[d])		201.619	3/2$^+$	169.160	1/2$^+$				
36.32[cf] *2*	0.005[c] *1*	237.904	5/2$^+$	201.619	3/2$^+$	M1+E2	0.31 *9*	2.1×10^2 *8*	α(L)=1.57×10^2 *56*; α(M)=41 *16* α(N)=11.1 *41*; α(O)=2.56 *93*; α(P)=0.44 *15*; α(Q)=0.0144 *5* L1:L2:L3=1.1 *4*:1.3 *5*:1.0 *3* (1990Pe16). I_γ: from 1990Lo04.
(43.2[g])		212.346	5/2$^+$	169.160	1/2$^+$				
46.53 *4*	0.109 *3*	103.651	7/2$^+$	57.112	7/2$^-$	[E1]		0.914	α(L)=0.687 *10*; α(M)=0.1707 *25* α(N)=0.0448 *7*; α(O)=0.01000 *15*; α(P)=0.001587 *23*; α(Q)=5.98×10^{-5} *9* E_γ: weighted average of 46.53 *6* (1979Go12), 46.534 *40* (1976Sk01). I_γ: unweighted average of 0.100 *13* (2004Sh07), 0.103 *2* (2002Wo03), 0.104 *4* (2000Sc04), 0.113 *1* (1990Lo04), 0.121 *10* (1988Wo01), 0.110 *10* (1984Va27), 0.119 *4* (1981Ba68), 0.100 *10* (1979Go12). Weighted average is 0.111 *2* with reduced χ^2=4.5. Other: 0.163 *5* (2002Lu01) seems discrepant.
48.96[cfm] *10*	[c]	306.09	(7/2$^-$)	257.129	5/2$^-$	[M1+E2]		2.0×10^2 *17*	
54.40[b] *10*		163.32	(11/2$^-$)	109.05	9/2$^+$				
57.113 *20*	0.362 *4*	57.112	7/2$^-$	0.0	3/2$^-$	E2		175.6	α(M2)exp=23 *1*; α(M3)exp=19 *1*; α(N+...)exp=11 *1*; α(M1)exp<1.2 *3* (1988Wo01) α(M4)exp=1.2 *3*; α(M5)exp<1.2 *3* (1988Wo01) α(L)exp=122 *18*; L12:L3:M:N=26:18:16:5.6 (1969Br12) α(L)=128.2 *18*; α(M)=35.3 *5* α(N)=9.51 *14*; α(O)=2.15 *3*; α(P)=0.345 *5*; α(Q)=0.000911 *13* E_γ: weighted average of 57.104 *20* (1979Go12), 57.15 *4* (1976Sk01), 57.112 *20* (1974HeYW). I_γ: weighted average of 0.356 *16* (2004Sh07), 0.366 *3* (2002Lu01), 0.360 *5* (2002Wo03), 0.354 *8* (2000Sc04), 0.34 *1* (1988Wo01), 0.38 *4* (1979Go12). Others: 0.39 *1* (1984Va27), 0.42 *2* (1981Ba68), 0.43 *3* (1976Sk01). Mult.: L1, L2, L3 ce lines used for normalization (1988Wo01). E_γ: admixture of ^{233}Pa decay.

γ(^{233}Pa) (continued)

E_γ [†]	I_γ [‡ j]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [#]	α [k]	Comments
62.59 [f] *10*	0.006 *2*	300.483	7/2$^+$	237.904	5/2$^+$	[M1+E2]	65 *49*	α(L)=47 *35*; α(M)=12.9 *99* α(N)=3.5 *27*; α(O)=0.79 *60*; α(P)=0.130 *93*; α(Q)=0.0018 *13* I_γ: from 1981Ba68. Other: ≈0.012 (1976Sk01). α(M1)=17.5, α(E2)=115.3.
63.90 [f] *10*	0.0108 *4*	70.526	5/2$^-$	6.658	1/2$^-$	(E2)	102.3	α(L)=74.7 *12*; α(M)=20.6 *4* α(N)=5.55 *9*; α(O)=1.252 *20*; α(P)=0.202 *4*; α(Q)=0.000565 *9* I_γ: from 1981Ba68. Mult.: from Adopted Gammas.
70.49 [f] *10*	0.0108 *4*	70.526	5/2$^-$	0.0	3/2$^-$	[M1+E2]	38 *27*	α(L)=28 *19*; α(M)=7.5 *54* α(N)=2.0 *15*; α(O)=0.46 *33*; α(P)=0.076 *51*; α(Q)=0.00126 *89* I_γ: from Iγ(63.9)/Iγ(70.75)=1.0 (1975IoZZ).
74.54 [f] *10*	0.012 *3*	169.160	1/2$^+$	94.651	3/2$^+$	[M1+E2]	29 *20*	α(L)=7.43 *11*; α(M)=1.79 *3* α(N)=0.481 *7*; α(O)=0.1153 *17*; α(P)=0.0220 *4*; α(Q)=0.00183 *3* I_γ: from 1981Ba68.
86.484 *10*	12.2 *3*	86.482	5/2$^+$	0.0	3/2$^-$	E1	1.43 *8*	α(L)exp=1.13 *5*; α(M)exp=0.22 *6*; α(N)exp=0.08 *1*; α(L1)exp=0.54 *3* (1988Wo01) α(L2)exp=0.55 *3*; α(L3)exp=0.035 *7*; α(M1)exp=(0.03 *3*); α(M2)exp=(0.09 *1*) (1988Wo01) α(M3)exp<0.056 *3*; α(M4)exp<0.017 *1*; α(M5)exp=0.024 *3*; α(N+...)exp=0.08 *1* (1988Wo01) α(L)exp=1.0 *1*; L12:L3:M:N=133:8:40:13 (1969Br12) E_γ: weighted average of 86.477 *10* (1979Go12), 86.503 *20* (1976Sk01), 86.486 *10* (1974HeYW). I_γ: unweighted average of 12.86 *21* (2000Wo01), 11.40 *24* (2002Lu01), 12.44 *33* (1984Va27), 11.5 *3* (1981Ba68), 12.6 *13* (1969Br12). Weighted average is 12.1 *3*, but reduced χ^2=6.7. Others: Iγ(86.48+86.8 from ^{233}Pa decay)=13.6 *5* (2004Sh07), 14.1 *3* (2000Sc04,2002Wo03), 14.0 *4* (2002Lu01). The M and N+ regions of the ce spectra are highly complex. α: from I(ce)/Iγ measured by 1988Wo01. Other: 1.49 *18*, analyzed by 2008Go10 from data for measured conversion L-shell conversion coefficients for anomalous E1 transition. The total conversion coefficient is much enhanced as compared to the theoretical value of 0.177. Mult.: anomalous E1. See 1960As02 for discussions. Others: 1969Br12, 2008Go10. α(87γ)(θ): A_2=+0.12 *4* (1967Hu03).
87.99 [f] *3*	0.148 *10*	94.651	3/2$^+$	6.658	1/2$^-$	[E1]	0.1694	α(L)=0.1277 *18*; α(M)=0.0312 *5* α(N)=0.00824 *12*; α(O)=0.00189 *3*; α(P)=0.000321 *5*; α(Q)=1.539×10^{-5} *22* I_γ: unweighted average of 0.134 *13* (2004Sh07), 0.167 *4* (2002Lu01), 0.143 *1* (1990Lo04). Weighted average is 0.146 *6* with reduced χ^2=16.
94.65 *5*	0.591 *20*	94.651	3/2$^+$	0.0	3/2$^-$	E1	0.1398	α(L)=0.1054 *15*; α(M)=0.0257 *4*

γ(^{233}Pa) (continued)

E_γ[†]	I_γ[‡j]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	δ[&]	α[k]	Comments
									α(N)=0.00680 10; α(O)=0.001561 22; α(P)=0.000267 4; α(Q)=1.312×10^{-5} 19 E_γ: weighted average of 94.64 5 (1979Go12), 94.66 5 (1976Sk01). Mult.: from Adopted Gammas. I_γ: weighted average of 0.575 19 (2004Sh07) and 0.615 23 (2002Lu01).
106.12[f] 5	0.048 1	163.32	(11/2$^-$)	57.112	7/2$^-$	[E2]		9.30	α(L)=6.78 10; α(M)=1.87 3 α(N)=0.505 8; α(O)=0.1143 17; α(P)=0.0186 3; α(Q)=7.89×10^{-5} 12 E_γ: from 1976Sk01. Other: 106.15 25 (1979Go12). I_γ: weighted average of 0.051 3 (2004Sh07), 0.049 1 (2002Lu01), 0.048 1 (1990Lo04), 0.042 3 (1988Wo01).
108.7	0.071 3	212.346	5/2$^+$	103.651	7/2$^+$	M1(+E2)	<0.9	4.4 12	α(L)=3.3 8; α(M)=0.84 25 α(N)=0.226 66; α(O)=0.053 15; α(P)=0.0094 21; α(Q)=0.00049 12 α(L1)exp+α(L2)exp=2.7 6 (1969Br12) E_γ: from level-energy difference. Eγ=108.0 was given by 1969Br12 from E(ceL12) and E(ceM) measured in coincidence with α. I_γ: weighted average of 0.072 4 (2004Sh07) and 0.070 3 (2002Lu01). Other: 0.068 15 from Iγ(108γ):Iγ(117γ):Iγ(155γ):Iγ(212γ)= 23 4:56 6:31 2:55 4, measured by 1969Br12 in αγ-coin spectrum. Iγ(108.2+108.7+109.1)+x−ray=0.864 19 (2000Sc04). L12:L3:M=62:<3:17 (1969Br12).
109.10[cm] 10	[c]	179.59	(9/2$^-$)	70.526	5/2$^-$				E_γ: overlap with Pa $K_{\beta5}$-x rays.
115.44 20	0.0026 8	201.619	3/2$^+$	86.482	5/2$^+$	[M1+E2]		10.0 35	α(K)=5.4 52; α(L)=3.3 13; α(M)=0.89 39 α(N)=0.24 11; α(O)=0.055 23; α(P)=0.0094 32; α(Q)=2.9×10^{-4} 23 E_γ: weighted average of 115.40 35 (1979Go12), 115.45 20 (1976Sk01). I_γ: from 1976Sk01. Others: 0.32 (1979Go12) is in disagreement, probably includes sum peak; 0.332 10 for sum peak (2000Sc04). E_γ: admixture with U K x-rays.
117.705 20	0.170 4	212.346	5/2$^+$	94.651	3/2$^+$	M1+E2	0.46 +22−13	11.5 10	α(K)=8.4 14; α(L)=2.4 4; α(M)=0.60 10 α(N)=0.16 3; α(O)=0.038 6; α(P)=0.0068 8; α(Q)=0.00041 7 α(L)exp=1.8 3 (1969Br12)

From ENSDF

$^{233}_{91}$Pa$_{142}$-8

γ(^{233}Pa) (continued)

E_γ[†]	I_γ[‡j]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	δ[&]	α[k]	Comments
									E_γ: weighted average of 117.702 *20* (1979Go12), 117.681 *30* (1976Sk01), 117.718 *20* (1974HeYW). I_γ: weighted average of 0.169 *17* (2004Sh07), 0.184 *12* (2002Lu01), 0.169 *4* (2000Sc04) and 0.15 *2* (1988Wo01). L12:L3:M:N=90:8:51:≈8 (1969Br12).
131.093 *20*	0.0849 *31*	201.619	3/2$^+$	70.526	5/2$^-$	E1[@]		0.262	α(K)=0.202 *3*; α(L)=0.0451 *7*; α(M)=0.01095 *16* α(N)=0.00290 *4*; α(O)=0.000672 *10*; α(P)=0.0001179 *17*; α(Q)=6.40×10^{-6} *9* α(L1)exp<0.06 (1969Br12) E_γ: weighted average of 131.101 *25* (1979Go12), 131.043 *30* (1976Sk01), 131.11 *2* (1974HeYW). I_γ: weighted average of 0.075 *5* (2004Sh07), 0.0857 *22* (2000Sc04), and 0.091 *5* (1988Wo01).
134.276 *20*	0.072 *3*	237.904	5/2$^+$	103.651	7/2$^+$	[M1+E2]	≈0.4[a]	≈8.04	α(K)=6.05 *9*; α(L)=1.484 *21*; α(M)=0.369 *6* α(N)=0.0991 *14*; α(O)=0.0235 *4*; α(P)=0.00433 *6*; α(Q)=0.000291 *4* E_γ: weighted average of 134.285 *20* (1979Go12), 134.23 *4* (1976Sk01), 134.28 *3* (1974HeYW). I_γ: unweighted average of 0.073 *6* (2004Sh07), 0.075 *3* (2002Lu01), 0.067 *3* (2000Sc04), 0.0640 *9* (1990Lo04) and 0.080 *5* (1988Wo01). Weighted average is 0.066 *3* with reduced χ^2=5.8.
139.9[fm] *1*	0.0046 *4*	303.51	(9/2$^+$)	163.32	(11/2$^-$)	[E1]		0.225	α(K)=0.1742 *25*; α(L)=0.0381 *6*; α(M)=0.00925 *13* α(N)=0.00245 *4*; α(O)=0.000569 *8*; α(P)=0.0001002 *15*; α(Q)=5.55×10^{-6} *8* I_γ: from 1981Ba68. Iγ=0.019 *5* (1976Sk01) is in disagreement. Not reported in any other study.
141.74[b] *10*		212.346	5/2$^+$	70.526	5/2$^-$				
143.248 *10*	0.416 *11*	237.904	5/2$^+$	94.651	3/2$^+$	M1+E2	0.69 *19*	5.8 *6*	α(K)exp=3.1 *4*; α(L1)exp=1.5 *2*; α(L2)exp=0.3 *1*; α(M1)exp=0.3 *1* (1988Wo01) α(L1)exp+α(L2)exp=0.9 *1* (1969Br12) α(K)=4.0 *7*; α(L)=1.32 *8*; α(M)=0.34 *3* α(N)=0.091 *7*; α(O)=0.0212 *15*; α(P)=0.00379 *18*; α(Q)=0.00020 *3* E_γ: weighted average of 143.249 *20* (1979Go12), 143.208 *25* (1976Sk01), 143.254 *10* (1974HeYW). I_γ: unweighted average of 0.394 *24* (2004Sh07), 0.428 *3* (2002Lu01), 0.443 *8*, 0.387 *2* (1990Lo04) and 0.43 *1* (1988Wo01). Weighted average is 0.410 *11* with reduced χ^2=17. α(N+)exp<0.76 *3* (1988Wo01).

γ(^{233}Pa) (continued)

E_γ[†]	I_γ[‡j]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	δ[&]	α[k]	Comments
									α(L3)exp=α(M2)exp=α(M3)exp=α(M4)exp=α(M5)exp<0.44 *2* (1988Wo01). From their ce data, 1988Wo01 give %E2=9 *7* or δ(E2/M1)=0.31 *+13−17*. K:L12:L3:M:N=250:69:<5:15:6 (1969Br12).
151.408 *15*	0.244 *3*	237.904	5/2$^+$	86.482	5/2$^+$	M1+E2	0.28 *12*	5.9 *3*	α(K)exp=5.3 *7*; α(L1)exp=1.2 *2*; α(L2)exp=0.6 *2*; α(N+...)exp<1.12 *6*; α(L3)exp<0.78 *4* (1988Wo01) α(L1)exp+α(L2)exp=1.0 *2* (1969Br12) α(K)=4.6 *4*; α(L)=0.99 *3*; α(M)=0.242 *10* α(N)=0.065 *3*; α(O)=0.0155 *6*; α(P)=0.00291 *7*; α(Q)=0.000220 *14* E_γ: weighted average of 151.414 *20* (1979Go12), 151.375 *35* (1976Sk01), 151.410 *15* (1974HeYW). I_γ: weighted average of 0.223 *14* (2004Sh07), 0.244 *3* (2002Lu01), 0.232 *24* (2000Sc04) and 0.248 *7* (1988Wo01). Measured conversion electron intensities for this transition do not agree well: Ice(K)/Ice(L1+L2)=2.0 *6* (1988Wo01), ≈6.5 (1968Br12). Ice(L1)/Ice(L2)=15.8 *26*:8.3 *21* measured by 1988Wo01 is used to determine the M1+E2 admixture. Other: 1969Br12. α(M1)exp=α(M2)exp=α(M3)exp=α(M4)exp=α(M5)exp<0.71 *4* (1988Wo01). K:L12:L3:M=≈220:34:2:8 (1969Br12). δ: deduced by evaluators considering experimental ce data for K, L1 and L2 shells from 1988Wo01, and K:L12:L3:M ratio data (with 25% uncertainty) from 1969Br12. Using data from 1988Wo01 only, evaluators obtain δ<0.5, whereas 1988Wo01 give %E2=33 *9* or δ(E2/M1)=0.70 *16*, which the evaluators cannot reproduce.
153.37[lf] *10*	[i]	257.129	5/2$^-$	103.651	7/2$^+$				
153.37[lf] *10*	0.0061 *11*	365.96	9/2$^+$	212.346	5/2$^+$	[E2]		1.96	α(K)=0.226 *4*; α(L)=1.268 *19*; α(M)=0.349 *5* α(N)=0.0942 *14*; α(O)=0.0214 *3*; α(P)=0.00350 *5*; α(Q)=2.42×10^{-5} *4* I_γ: average of 1976Sk01 and 1981Ba68.
155.242 *20*	0.0887 *18*	212.346	5/2$^+$	57.112	7/2$^-$	E1[@]		0.1755	α(K)=0.1368 *20*; α(L)=0.0292 *4*; α(M)=0.00708 *10* α(N)=0.00188 *3*; α(O)=0.000437 *7*; α(P)=7.74×10^{-5} *11*; α(Q)=4.41×10^{-6} *7* α(L1)exp+α(L2)exp<0.09 (1969Br12) E_γ: weighted average of 155.239 *20* (1979Go12), 155.22 *4* (1976Sk01), 155.25 *2* (1974HeYW). I_γ: weighted average of 0.087 *6* (2004Sh07), 0.091 *6* (2002Lu01), 0.0889 *18* (2000Sc04) and 0.086 *6* (1988Wo01).
162.51[l] *3*	0.0326 *12*	169.160	1/2$^+$	6.658	1/2$^-$	(E1)		0.1574	α(K)=0.1230 *18*; α(L)=0.0260 *4*; α(M)=0.00629 *9* α(N)=0.001670 *24*; α(O)=0.000389 *6*; α(P)=6.91×10^{-5} *10*; α(Q)=3.99×10^{-6} *6* Mult.: from Adopted Gammas.

γ(^{233}Pa) (continued)

Eγ[†]	Iγ[‡j]	Ei(level)	J^{π}_{i}	Ef	J^{π}_{f}	Mult.[#]	δ[&]	α[k]	Comments
									Eγ: weighted average of 162.41 *8* (1979Go12), 162.50 *6* (1976Sk01), 162.52 *3* (1974HeYW). Iγ: weighted average of 0.0327 *12* (2000Sc04) and 0.032 *4* (1988Wo01).
162.51[l] *3*	[i]	257.129	5/2$^-$	94.651	3/2$^+$				
169.156 *20*	0.0621 *24*	169.160	1/2$^+$	0.0	3/2$^-$	[E1]		0.1431	α(K)=0.1120 *16*; α(L)=0.0235 *4*; α(M)=0.00568 *8* α(N)=0.001508 *22*; α(O)=0.000352 *5*; α(P)=6.26×10^{-5} *9*; α(Q)=3.65×10^{-6} *6* Iγ: weighted average of 0.0633 *19* (2000Sc04) and 0.057 *4* (1988Wo01).
170.62[l] *5*	[i]	257.129	5/2$^-$	86.482	5/2$^+$				
170.62[l] *5*	0.020 *4*	279.719	(7/2$^+$)	109.05	9/2$^+$	[M1+E2]	≈0.4[a]	≈4.0	α(K)≈3.09; α(L)≈0.698; α(M)≈0.1720 α(N)≈0.0462; α(O)≈0.01097; α(P)≈0.00205; α(Q)≈0.0001466 Eγ: weighted average of 170.59 *6* (1979Go12), 170.63 *8* (1976Sk01), 170.64 *5* (1974HeYW). Iγ: weighted average of 1976Sk01 and 1979Go12.
176.09 *5*	0.016 *4*	279.719	(7/2$^+$)	103.651	7/2$^+$	[M1+E2]	≈0.4[a]	≈3.67	α(K)≈2.82; α(L)≈0.633; α(M)≈0.1559 α(N)≈0.0418; α(O)≈0.00995; α(P)≈0.00186; α(Q)≈0.0001340 Eγ: weighted average of 176.12 *6* (1979Go12), 176.09 *7* (1976Sk01), 176.06 *5* (1974HeYW). Iγ: weighted average of 0.012 *4* (2000Sc04) and 0.020 *4* (1988Wo01).
180.79 *5*	0.0156 *10*	237.904	5/2$^+$	57.112	7/2$^-$	[E1]		0.1223	α(K)=0.0960 *14*; α(L)=0.0199 *3*; α(M)=0.00480 *7* α(N)=0.001275 *18*; α(O)=0.000298 *5*; α(P)=5.32×10^{-5} *8*; α(Q)=3.15×10^{-6} *5* Eγ: weighted average of 180.81 *10* (1979Go12), 180.80 *8* (1976Sk01), 180.78 *5* (1974HeYW). Iγ: weighted average of 0.0158 *10* and 0.015 *2* (1988Wo01).
186.86[lf] *35*	[i]	257.129	5/2$^-$	70.526	5/2$^-$	M1+E2	0.8 *3*	2.5 *5*	Mult.,δ: from the Adopted Gammas.
186.86[lf] *35*	0.003 *3*	365.96	9/2$^+$	179.59	(9/2$^-$)	[E1]		0.1131	α(K)=0.0889 *13*; α(L)=0.0183 *3*; α(M)=0.00442 *7* α(N)=0.001173 *18*; α(O)=0.000274 *4*; α(P)=4.91×10^{-5} *8*; α(Q)=2.93×10^{-6} *5* Iγ: from 1976Sk01. Others: Iγ=0.0069 *14* (1969Br12), 0.0013 *8* (1981Ba68).
191.43 *3*	0.0187 *13*	300.483	7/2$^+$	109.05	9/2$^+$	[M1+E2]		2.0 *12*	α(K)=1.4 *12*; α(L)=0.487 *10*; α(M)=0.125 *7* α(N)=0.0337 *19*; α(O)=0.00786 *25*; α(P)=0.00140 *7*; α(Q)=6.7×10^{-5} *54* Eγ: weighted average of 191.46 *5* (1979Go12), 191.45 *6*

$^{233}_{91}$Pa$_{142}$-11

γ(^{233}Pa) (continued)

E_γ[†]	I_γ[‡j]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	δ[&]	α[k]	Comments
									(1976Sk01), 191.42 *3* (1974HeYW). I_γ: weighted average of 0.023 *5* (2004Sh07), 0.015 *4* (2002Lu01), 0.0192 *15* (2000Sc04) and 0.014 *5* (1988Wo01).
193.24 *3*	0.0437 *18*	279.719	(7/2$^+$)	86.482	5/2$^+$	[M1+E2]	≈0.4[a]	≈2.8	α(K)≈2.18; α(L)≈0.477; α(M)≈0.1172 α(N)≈0.0314; α(O)≈0.00748; α(P)≈0.001403; α(Q)≈0.0001030 E_γ: weighted average of 193.26 *5* (1979Go12), 193.26 *4* (1976Sk01), 193.22 *3* (1974HeYW). I_γ: weighted average of 0.041 *8* (2004Sh07), 0.030 *5* (2002Lu01), 0.0437 *10* (2000Sc04), 0.049 *3* (1988Wo01). Reduced χ^2=3.6.
194.67 *20*	0.033 *8*	303.51	(9/2$^+$)	109.05	9/2$^+$	[M1+E2]		1.9 *12*	E_γ: from 1976Sk01. I_γ: from 2002Lu01. Others: 0.03 *1* (2004Sh07), 0.051 *15* (1976Sk01). Alaga rule suggests Iγ≤0.013 if Iγ(199.95γ) deexciting the 303.6 level is <0.004.
194.96 *2*	0.182 *5*	201.619	3/2$^+$	6.658	1/2$^-$	E1[@]		0.1024	α(K)=0.0806 *12*; α(L)=0.01644 *23*; α(M)=0.00397 *6* α(N)=0.001055 *15*; α(O)=0.000247 *4*; α(P)=4.43×10^{-5} *7*; α(Q)=2.68×10^{-6} *4* α(L1)exp+α(L2)exp<0.05 (1969Br12) E_γ: weighted average of 194.95 *3* (1979Go12), 194.97 *2* (1974HeYW). Other: 195.096 *20* (1976Sk01). I_γ: weighted average of 0.16 *3* (2004Sh07), 0.177 *5* (2000Sc04), 0.191 *6* (1988Wo01).
196.85 *5*	0.0209 *12*	300.483	7/2$^+$	103.651	7/2$^+$	[M1+E2]	≈0.4[a]	≈2.67	α(K)≈2.07; α(L)≈0.451; α(M)≈0.1108 α(N)≈0.0297; α(O)≈0.00708; α(P)≈0.001327; α(Q)≈9.77×10^{-5} E_γ: weighted average of 196.86 *5* (1979Go12), 196.84 *6* (1976Sk01), 196.8 *1* (1974HeYW). I_γ: weighted average of 0.020 *4* (2004Sh07), 0.024 *5* (2002Lu01), 0.0208 *12* (2000Sc04) and 0.021 *2* (1988Wo01). Other: 0.156 *2* (1990Lo04) seems discrepant.
199.95[f] *6*	0.0053 *8*	303.51	(9/2$^+$)	103.651	7/2$^+$	[M1+E2]		1.8 *11*	I_γ: from 1981Ba68.
201.670 *25*	0.0394 *9*	201.619	3/2$^+$	0.0	3/2$^-$	E1[@]		0.0946	α(K)=0.0746 *11*; α(L)=0.01512 *22*; α(M)=0.00365 *6* α(N)=0.000970 *14*; α(O)=0.000227 *4*; α(P)=4.08×10^{-5} *6*; α(Q)=2.49×10^{-6} *4* α(L1)exp+α(L2)exp<0.05 (1969Br12) E_γ: weighted average of 201.62 *5* (1979Go12), 201.72 *5* (1976Sk01), 201.670 *25* (1974HeYW). I_γ: weighted average of 0.0393 *9* (2000Sc04) and 0.041 *4* (1988Wo01).
202.9 *2*	0.0048 *19*	365.96	9/2$^+$	163.32	(11/2$^-$)	[E1]		0.0932	α(K)=0.0735 *11*; α(L)=0.01489 *22*; α(M)=0.00360 *6* α(N)=0.000955 *14*; α(O)=0.000223 *4*; α(P)=4.02×10^{-5} *6*; α(Q)=2.45×10^{-6} *4* E_γ: from 1976Sk01. I_γ: other: Iγ(201.6+202.9)=0.0393 *9* (2000Sc04).

$^{233}_{91}$Pa$_{142}$-12

^{237}Np α decay (2.144×10^{6} y) 2002Wo03,2000Sc04,1979Go12 (continued)

γ(^{233}Pa) (continued)

E_γ[†]	I_γ[‡j]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	δ[&]	α[k]	Comments
209.20 *3*	0.0142 *9*	279.719	(7/2$^+$)	70.526	5/2$^-$	[E1]		0.0868	α(K)=0.0685 *10*; α(L)=0.01381 *20*; α(M)=0.00333 *5* α(N)=0.000886 *13*; α(O)=0.000207 *3*; α(P)=3.73×10^{-5} *6*; α(Q)=2.30×10^{-6} *4* E_γ: weighted average of 209.19 *5* (1979Go12), 209.25 *5* (1976Sk01), 209.18 *3* (1974HeYW). I_γ: from 2000Sc04. Others: <0.02 (2004Sh07), 0.019 *2* (2002Lu01), 0.010 *2* (1988Wo01).
212.32 *2*	0.152 *3*	212.346	5/2$^+$	0.0	3/2$^-$	E1[@]		0.0839	α(K)=0.0663 *10*; α(L)=0.01331 *19*; α(M)=0.00321 *5* α(N)=0.000854 *12*; α(O)=0.000200 *3*; α(P)=3.60×10^{-5} *5*; α(Q)=2.22×10^{-6} *4* α(L1)exp+α(L2)exp<0.013 (1969Br12) E_γ: weighted average of 212.29 *5* (1979Go12), 212.33 *2* (1974HeYW). Other: 212.415 *25* (1976Sk01), I_γ: weighted average of 0.150 *4* (2002Lu01), 0.151 *3* (2000Sc04) and 0.156 *4* (1988Wo01). Other: 0.209 *7* for 212.4+214.1 (2004Sh07).
214.01 *4*	0.0357 *10*	300.483	7/2$^+$	86.482	5/2$^+$	[M1+E2]	≈0.4	≈2.1	α(K)≈1.637; α(L)≈0.351; α(M)≈0.0860 α(N)≈0.0231; α(O)≈0.00550; α(P)≈0.001034; α(Q)≈7.72×10^{-5} E_γ: weighted average of 214.01 *5* (1979Go12), 214.09 *5* (1976Sk01), 213.96 *4* (1974HeYW). I_γ: weighted average of 0.039 *2* (2002Lu01), 0.0362 *8* (2000Sc04), and 0.034 *1* (1988Wo01). Others: 0.209 *7* for 212.4+214.0 (2004Sh07), 0.132 *2* (1990Lo04). α: for assumed δ≈0.4.
219.8[bm]		306.09	(7/2$^-$)	86.482	5/2$^+$	[E1]		0.0774	
222.6[f] *2*	0.0020 *10*	279.719	(7/2$^+$)	57.112	7/2$^-$	[E1]		0.075	I_γ: average of 1976Sk01 and 1981Ba68.
229.94[f] *5*	0.011 *3*	300.483	7/2$^+$	70.526	5/2$^-$	[E1]		0.0697	α(K)=0.0552 *8*; α(L)=0.01095 *16*; α(M)=0.00264 *4* α(N)=0.000702 *10*; α(O)=0.0001646 *23*; α(P)=2.98×10^{-5} *5*; α(Q)=1.87×10^{-6} *3* I_γ: average of 1981Ba68, 1976Sk01 and 1969Br12.
237.884 *24*	0.0572 *9*	237.904	5/2$^+$	0.0	3/2$^-$	[E1]		0.0645	α(K)=0.0511 *8*; α(L)=0.01008 *15*; α(M)=0.00243 *4* α(N)=0.000646 *9*; α(O)=0.0001516 *22*; α(P)=2.75×10^{-5} *4*; α(Q)=1.740×10^{-6} *25* E_γ: weighted average of 237.86 *2* (1979Go12), 237.908 *20* (1974HeYW). Other: 238.04 *4* (1976Sk01). I_γ: weighted average of 0.067 *4* (2004Sh07), 0.056 *3* (2002Lu01), 0.0569 *6* (2000Sc04) and 0.059 *3* (1988Wo01).
248.93 *10*	0.0050 *14*	306.09	(7/2$^-$)	57.112	7/2$^-$	[M1+E2]		0.93 *61*	α(K)=0.67 *57*; α(L)=0.20 *4*; α(M)=0.050 *7* α(N)=0.0135 *18*; α(O)=0.0032 *5*; α(P)=0.00057 *13*; α(Q)=3.2×10^{-5} *26*

γ(^{233}Pa) (continued)

E_γ[†]	I_γ[‡,j]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	δ[&]	α[k]	Comments
									E_γ: weighted average of 248.95 *10* (1979Go12), 248.90 *10* (1976Sk01). I_γ: others: 0.006 *3* (2002Lu01); for 248.5 (from ^{233}Pa decay)+248.9: 0.0618 *11* (2000Sc04), 0.10 *5* (2004Sh07).
250.58[b]	[i]	257.129	5/2$^-$	6.658	1/2$^-$				
257.09[l,f] *20*	[i]	257.129	5/2$^-$	0.0	3/2$^-$	M1+E2	1.1 *2*	0.80 *12*	Mult.,δ: from the Adopted Gammas.
257.09[l,f] *20*	0.0064 *14*	365.96	9/2$^+$	109.05	9/2$^+$	[M1+E2]		0.9 *6*	I_γ: average of 1981Ba68, 1971Cl03 and 1969Br12. Others: 0.019 *6* (1979Go12) for 257.1+258.2 (from ^{233}Pa decay): <0.05 (2004Sh07), 0.036 *5* (2002Lu01).
262.44 *15*	0.00471 *18*	365.96	9/2$^+$	103.651	7/2$^+$	[M1+E2]		0.8 *6*	E_γ: from 1976Sk01. Value is the same in 1979Go12, with uncertainty of 0.20. I_γ: from 2000Sc04.
279.65 *20*	0.0109 *4*	365.96	9/2$^+$	86.482	5/2$^+$	[E2]		0.222	α(K)=0.0847 *12*; α(L)=0.1005 *15*; α(M)=0.0272 *4* α(N)=0.00733 *11*; α(O)=0.001676 *24*; α(P)=0.000282 *4*; α(Q)=5.02×10^{-6} *7* I_γ: from 2000Sc04. Others: 0.0017 *17* (1976Sk01), 0.011 *4* (1979Go12), 0.0023 (1971Cl03).
[x]288.3[e]	0.0164 *5*								

[†] From weighted averages of 1979Go12, 1976Sk01 and 1974HeYW for several transitions, unless otherwise stated. Energies measured by 1988Wo01, 1975IoZZ, 1969Br12 and 1969HoZY are in good agreement. Others: 1975PeZI, 1974ChXY, 1969Va06, 1961Ba44, 1955Ma67, 1955St04.

[‡] Weighted or unweighted averages from 2004Sc04, 2002Lu01 (also 2000Lu01), 2000Sc04 (also 2002Wo03,2000Wo01), 1990Lo04, 1988Wo01, and others, as stated with each γ ray. Minimum uncertainty of 1% was used in the averaging procedure, as well as in the final result. Other measurements: 1984Va27, 1981Ba68, 1979Go12, 1976Sk01, 1975IoZZ, 1975PeZI, 1971Cl03, 1969Br12, 1969Va06, 1969HoZY.

[#] From ce data of 1988Wo01 and 1969Br12. See also 1969HoZY and ^{233}Th β^- decay. Assumed mixing ratios are from analogous transitions. Experimental conversion data quoted here are from 1988Wo01, unless otherwise stated. Assignment are the same in the Adopted Gammas.

[@] E1 from upper limit of α(L1+L2)exp deduced from α(ce)-coin (1969Br12).

[&] From BrIccMixing code when ce data are available.

[a] δ(E2/M1) assumed as ≈0.4 from analogous transitions as in 1990Ak02 evaluation of A=233 nuclei.

[b] Seen only by 1979Go12.

[c] From 1990Pe16.

[d] Not observed; existence has been inferred by coincidence data. Energy from level scheme.

[e] From 2000Sc04, isotopic assignment is uncertain.

[f] From 1981Ba68, 1976Sk01 or 1969Br12. Transition is not reported by 2000Sc04, or in any other recent experiments.

[g] Expected interband transition has not been observed. This transition is not listed in the Adopted dataset.

[h] From ^{233}Th β^- decay; not seen in ^{237}Np α decay.

[i] Photon intensities of transitions deexciting the 257.3 level are assumed very small in comparison to their doublets, since the α transition feeding the level is uncertain

γ(^{233}Pa) (continued)

or very weak.

[j] Absolute intensity per 100 decays.

[k] Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on γ-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.

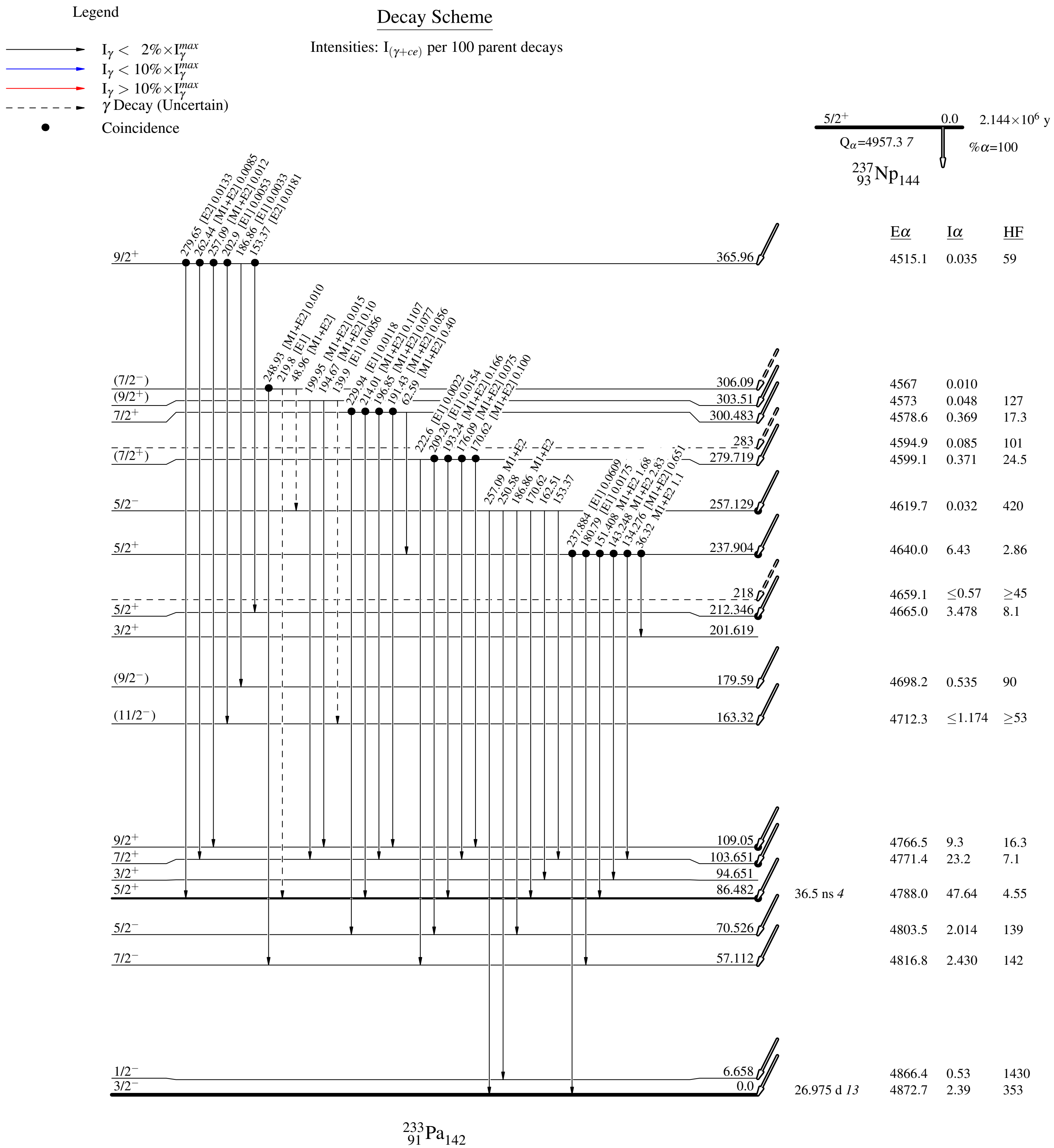
[l] Multiply placed.

[m] Placement of transition in the level scheme is uncertain.

[x] γ ray not placed in level scheme.

$^{233}_{91}$Pa$_{142}$-15

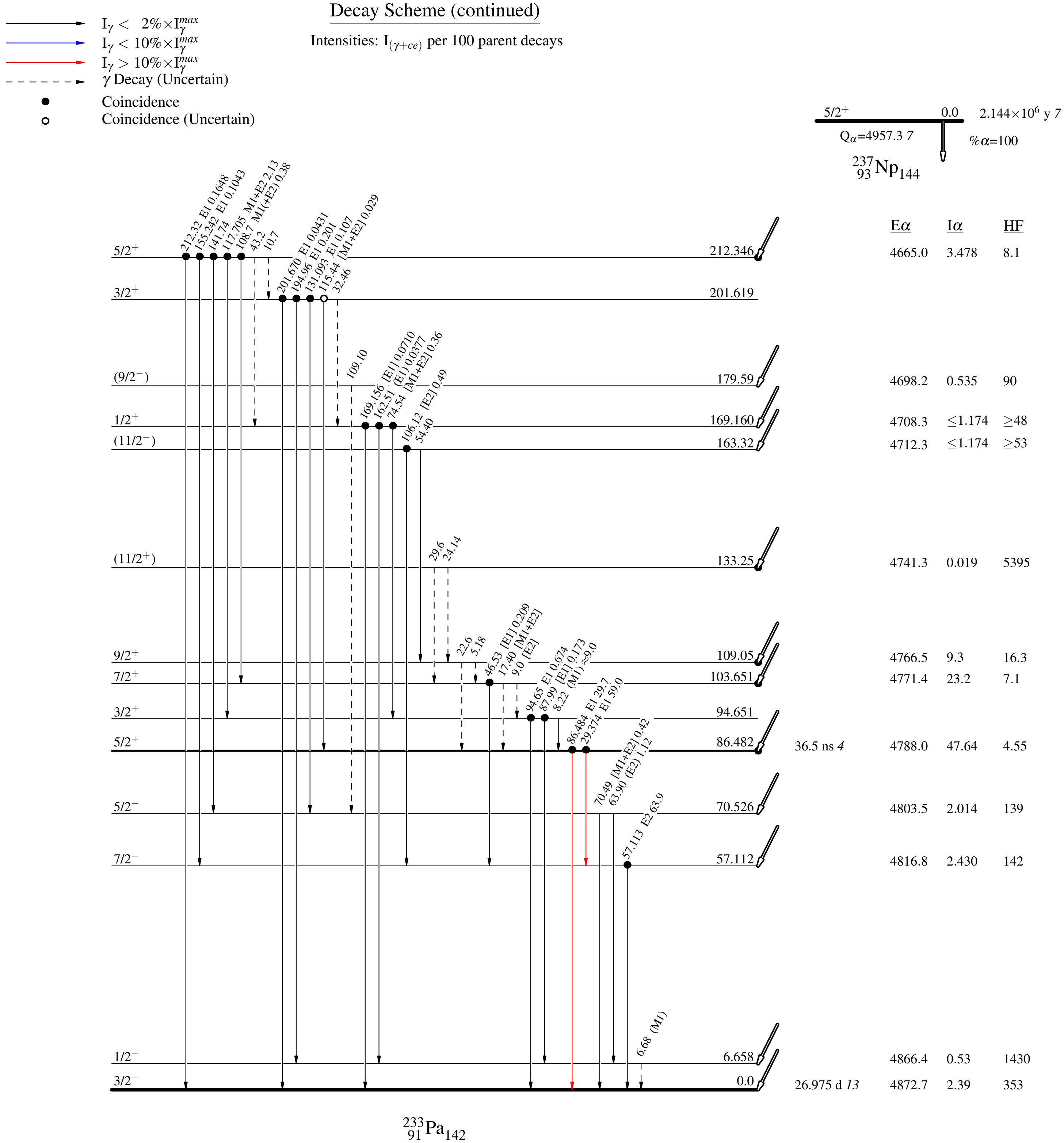
^{237}Np α decay (2.144×10^{6} y) 2002Wo03,2000Sc04,1979Go12

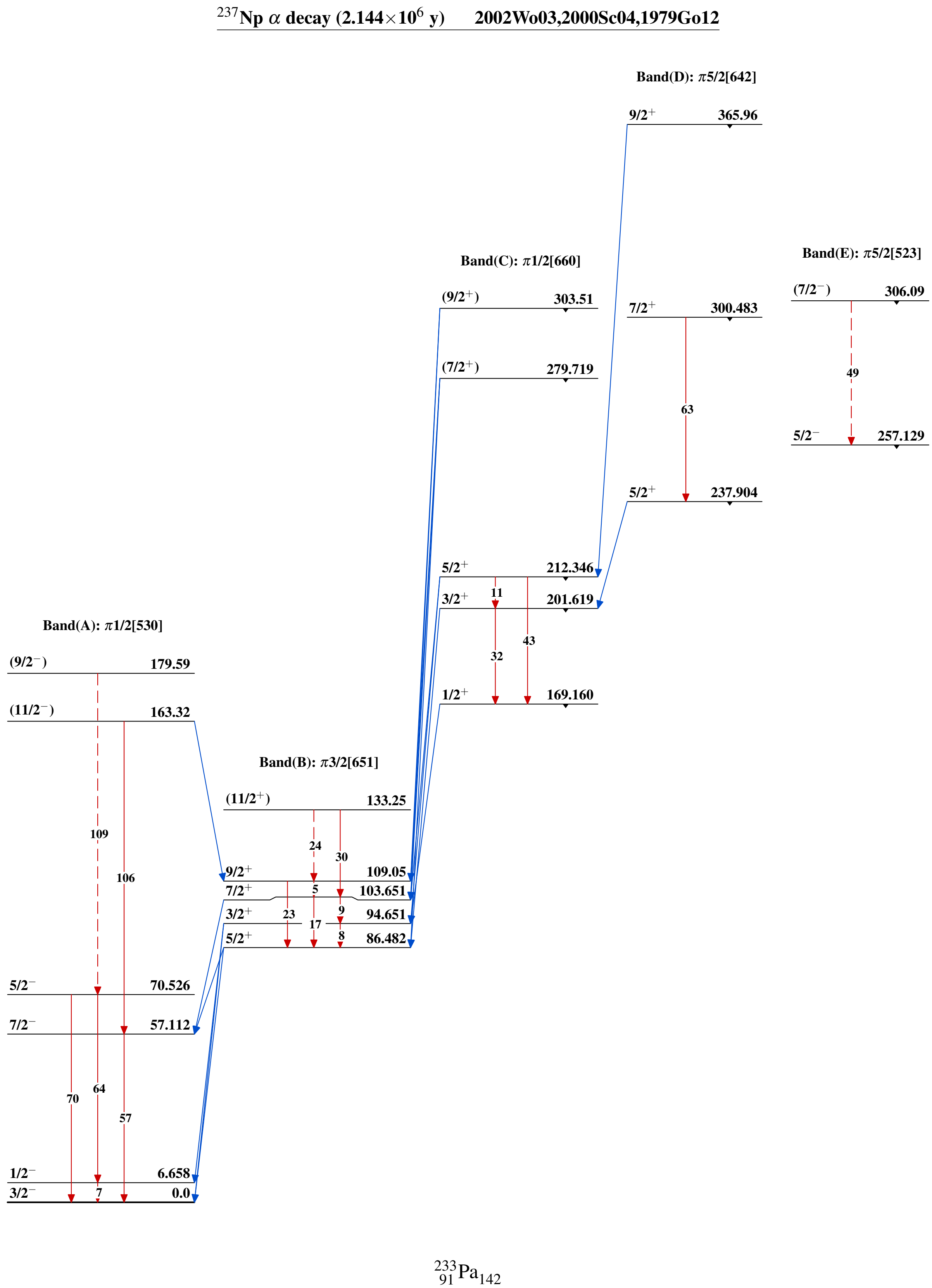


^{237}Np α decay (2.144×10^{6} y) 2002Wo03,2000Sc04,1979Go12

Decay Scheme (continued)

Intensities: $I_{(\gamma+ce)}$ per 100 parent decays




^{237}Np α decay (2.144×10^6 y) 2002Wo03,2000Sc04,1979Go12
Band(D): π5/2[642]
9/2+ 365.96
Band(C): π1/2[660]
Band(E): π5/2[523]
(9/2+) 303.51
7/2+ 300.483
(7/2−) 306.09
(7/2+) 279.719
49
63
5/2− 257.129
5/2+ 237.904
5/2+ 212.346
11
3/2+ 201.619
43
32
1/2+ 169.160
Band(A): π1/2[530]
(9/2−) 179.59
(11/2−) 163.32
Band(B): π3/2[651]
(11/2+) 133.25
109
106
24
30
9/2+ 109.05
7/2+ 103.651
5
3/2+ 94.651
23
9
17
5/2+ 86.482
8
5/2− 70.526
7/2− 57.112
70
64
57
1/2− 6.658
3/2− 0.0
7
$^{233}_{91}Pa_{142}$