Adopted Levels, Gammas

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	S. -c. Wu	NDS 108,1057 (2007)	1-Mar-2007

Q(β^-)=−7.50×10^3 *6*; S(n)=8694 *15*; S(p)=3021 *18*; Q(α)=8072 *5* 2012Wa38
Note: Current evaluation has used the following Q record −7.50E3 7 *8694* 30 *2996* 25 *8071* 6 2003Au03.
Calculations, compilations, systematics:
Cluster model for α decay, Geiger-Nuttall plot: 1991Bu05, 1986Ir01.
n-p interaction energy: 1990Mo11.
Quasi-bands in even-even nuclei: 1984Sa37.
Spontaneous emission of heavy ions: 1986Po06.
Super- and hyperdeformed configurations: 1995We02.

^{216}Th Levels

Cross Reference (XREF) Flags

A (HI,xnγ)

E(level)†	J$^\pi$	T$_{1/2}$†	XREF	Comments
0.0	0$^+$	26.0 ms *2*	A	%α=100; %ε+%β^+≈0.01 syst %ε: from gross β-decay strength function (1973Ta30). 1968Va18 report %ε<0.6. log *ft*>3.6 gives %ε+%β^+<0.2 for any single ε+β^+ group. Eα=7921 keV *3*, weighted average of Eα=7923 keV *5* from 2005Ku31; 7919 keV *6* from 2001Ha46 and 7911 keV *8* from 1968Va18. 7922 keV *10* from 2000He17 is superseded by the value from 2005Ku31. T$_{1/2}$: weighted average of values measured in α-decay: 26.0 ms *2* from 2005Ku31, 25.4 ms *8* from 2001Ha46 and 28 ms *2* from 1968Va18. OThers: 27.0 ms *3* and 30 ms *3* from 2000H317 are superseded by data from 2005Ku31.
1478.2 *1*	2$^+$		A	J$^\pi$: stretched E2 to 0$^+$.
1687.7 *2*	3$^-$		A	J$^\pi$: E1 to 2$^+$, E1 from 4$^+$.
1813.8 *2*	4$^+$		A	J$^\pi$: stretched E2 to 2$^+$.
2013.7 *2*	6$^+$		A	J$^\pi$: stretched E2 to 4$^+$.
2040 *9*	8$^+$	134 μs *4*		%α=2.8 *9* %α from 2005Ku31. Other: 5 *+5−3* from 2001Ha46. %IT=97 *1* calculated by 1983Hi08 from the observed isomer ratio and comparison with that for ^{217}Pa(29/2 level). Configuration=h$_{9/2}$f$_{7/2}$. Eα=9923 keV *8*, weighted average of Eα=9930 keV *10* from 2005Ku31; 9915 keV *15* from 2001Ha46 and 9912 keV *20* from 1983Hi08. 9933 keV *15* from 2000He17 is superseded by the value from 2005Ku31. E(level): from the energy difference for the α-decay from this level and and the ground state to the ^{212}Ra ground state, corrected for recoil. J$^\pi$: suggested by 1983Hi08 on the basis of systematics of N=126 nuclei (^{210}Po,^{212}Rn,^{214}Ra). Current systematics of Z=90 nuclei (N=132,130,128) and Z=88 nuclei (N=130,128,126,124) confirm the expectation of an 8$^+$ level at ≈2 MeV. T$_{1/2}$: weighted average of values measured in α-decay: 0.135 ms *4* from 2005Ku31; 0.128 ms *8* from 2001Ha46 and 0.18 ms *4* from 1983Hi08. Other: 0.140 ms *5* from 2000He17 is superseded by data from 2005Ku31.
2130.5 *2*	(8$^+$)		A	Configuration=h$^2_{9/2}$.
2646.8 *1*	11$^-$	0.58 μs *3*	A	Configuration=h$_{9/2}$i$_{11/2}$. J$^\pi$: suggested by 1983Hi08 on the basis of systematics is an 11$^-$ level. Extrapolation from ^{210}Po (2849 keV), ^{212}Rn (2760 keV) and ^{214}Ra (2683 keV) puts the 11$^-$ level in ^{216}Th at ≈2.6 MeV. This extrapolation is again supported by the behavior

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Adopted Levels, Gammas (continued)

^{216}Th Levels (continued)

E(level)†	J$^\pi$	T$_{1/2}$†	XREF	Comments
				of the 11$^-$ level in Z=88 nuclei (^{218}Ra to ^{212}Ra).
3530.2 *4*	(12$^+$)		A	
3681.4 *7*	(14$^+$)	0.74 μs *7*	A	

† From (HI,xnγ), except as noted.

γ(^{216}Th)

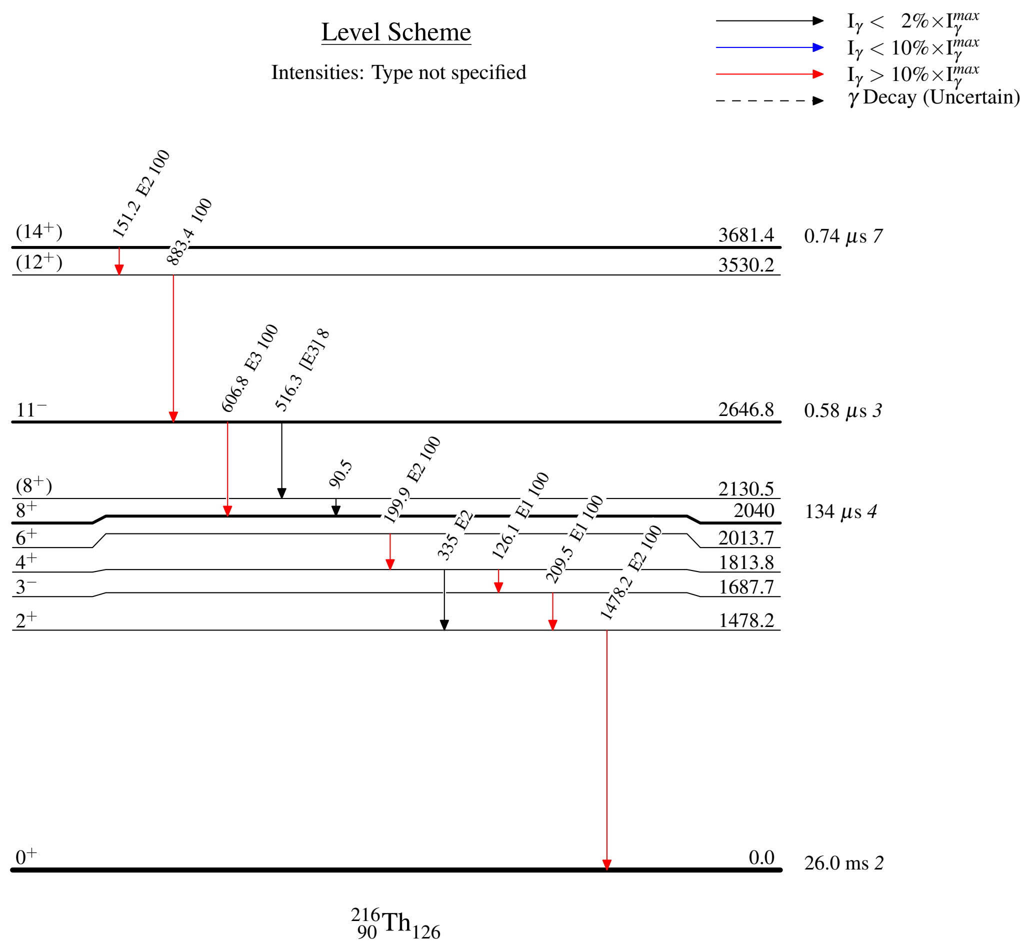
E$_i$(level)	J$^\pi_i$	E$_\gamma$	I$_\gamma$	E$_f$	J$^\pi_f$	Mult.	α†	Comments
1478.2	2$^+$	1478.2 *1*	100	0.0	0$^+$	E2	0.00487	
1687.7	3$^-$	209.5 *1*	100	1478.2	2$^+$	E1	0.0846	
1813.8	4$^+$	126.1 *1*	100	1687.7	3$^-$	E1	0.283	
		335		1478.2	2$^+$	E2	0.1216	
2013.7	6$^+$	199.9 *1*	100	1813.8	4$^+$	E2	0.660	
2130.5	(8$^+$)	(90.5 *3*)		2040	8$^+$			
2646.8	11$^-$	516.3 *2*	8 *2*	2130.5	(8$^+$)	[E3]	0.1428	B(E3)(W.u.)=5.0 *15*
		606.8 *1*	100 *4*	2040	8$^+$	E3	0.0876	B(E3)(W.u.)=21 *2*
3530.2	(12$^+$)	883.4 *3*	100	2646.8	11$^-$			
3681.4	(14$^+$)	151.2 *6*	100	3530.2	(12$^+$)	E2	1.94 *5*	B(E2)(W.u.)=0.053 *8*

† 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.

Adopted Levels, Gammas

Level Scheme

Intensities: Type not specified



Adopted Levels, Gammas

History			
Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh	ENSDF	10-Jun-2021

Q(β^-)=−6283 *21*; S(n)=7910 *15*; S(p)=3625 *15*; Q(α)=9849 *9* 2021Wa16
Q(ε)=1520 *60*, S(2n)=14074 *15*, S(2p)=5503 *13* (2021Wa16).
Additional information 1.
^{218}Th identified by 1973Hi06 in ^{209}Bi(^{14}N,5n) reaction and by 1973Ha32 in ^{206}Pb(^{16}O,4n), the two independent studies, 1973Hi06 published July 23, 1973, and 1973Ha32 on July 30, 1973.
Search for long-lived isomers: 2008La14 (no evidence found), 2007Ma57 (claimed evidence of presence of isomers).
Theory references: consult NSR database (www.nndc.bnl.gov/nsr/) for 64 primary references for calculations of half-lives of radioactive decays, and 23 for nuclear structure.

^{218}Th Levels

Cross Reference (XREF) Flags

A	^{222}U α decay (4.7 μs)
B	^{174}Yb(^{48}Ca,4nγ)
C	^{206}Pb(^{16}O,4nγ),^{209}Bi(^{14}N,5nγ)

E(level)[†]	J$^\pi$[‡]	T$_{1/2}$	XREF	Comments
0.0[#]	0$^+$	122 ns *5*	ABC	%α=100 Only the α decay has been observed. Theoretical partial T$_{1/2}$>100 s for ^{218}Th $\varepsilon+\beta^+$ decay (2019Mo01) gives %ε+%β^+<1.2×10^{-7}. T$_{1/2}$: from decay curve for g.s. to g.s. 9666α. Weighted average (NRM) of 122 ns *8* (1973Ha32); 96 ns *7* (1973No09,1973Hi06); 125 ns *5* (1982Ch29); 0.16 μs *4* (2015Kh09); and 169 ns *+73−40* (2018Br13). Regular weighted average is 117 ns *7*, with reduced χ^2 of 3.7 as compared to critical χ^2=2.4. Weighted average is 125 ns *5* if the lowest value of 96 ns from 1973Hi06 is omitted. Configuration=$\pi(h^6_{9/2}f^2_{7/2})\otimes\nu g^2_{9/2}$ with 14% probability (2020Od01).
689.0[#] *3*	2$^+$		BC	J$^\pi$: E2 γ to 0$^+$. Configuration=$\pi(h^6_{9/2}f^2_{7/2})\otimes\nu g^2_{9/2}$ with 25% probability (2020Od01).
1078.0 *6*	(3$^-$)		BC	XREF: C(?). J$^\pi$: ΔJ=(1) γ to 2$^+$. Configuration=$\pi h^8_{9/2}\otimes\nu(g^1_{9/2}j^1_{15/2})$ with 26% probability (2020Od01).
1192.3[#] *5*	4$^+$		BC	J$^\pi$: E2 γ to 2$^+$. Configuration=$\pi(h^6_{9/2}f^2_{7/2})\otimes\nu g^2_{9/2}$ with 28% probability (2020Od01).
1560.8[#] *6*	6$^+$		BC	J$^\pi$: E2 γ to 4$^+$, yrast band member. Configuration=$\pi(h^6_{9/2}f^2_{7/2})\otimes\nu g^2_{9/2}$ with 28% probability (2020Od01).
1761.7[#] *7*	8$^+$	1.2 ns *2*	BC	T$_{1/2}$: from ce(t) in ^{209}Bi(^{14}N,5nγ). J$^\pi$: E2 γ to 6$^+$, yrast band member. Configuration=$\pi(h^6_{9/2}f^2_{7/2})\otimes\nu g^2_{9/2}$ with 28% probability (2020Od01).
2099.5[#] *9*	10$^+$	0.25 ns *15*	BC	T$_{1/2}$: from ce(t) in ^{209}Bi(^{14}N,5nγ). J$^\pi$: E2 γ to 8$^+$, yrast band member. Configuration=$\pi(h^6_{9/2}f^2_{7/2})\otimes\nu(i^1_{11/2}g^1_{9/2})$ with 26% probability (2020Od01).
2272.6[@] *10*	(11$^-$)		BC	XREF: C(?). J$^\pi$: ΔJ=(1), (E1) γ to 10$^+$; shell-model prediction (2020Od01). Configuration=$\pi h^8_{9/2}\otimes\nu(g^1_{9/2}j^1_{15/2})$ with 32% probability (2020Od01).
2686.3[@] *10*	(13$^-$)		BC	XREF: C(?). J$^\pi$: ΔJ=(2) γ to (11$^-$); band member; shell-model prediction (2020Od01). Configuration=$\pi(h^6_{9/2}i^2_{13/2})\otimes\nu(g^1_{9/2}j^1_{15/2})$ with 31% probability (2020Od01).

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Adopted Levels, Gammas (continued)

^{218}Th Levels (continued)

E(level)†	Jπ‡	XREF	Comments
3160.0@ *12*	(15⁻)	B	Jπ: ΔJ=(2) γ to (13⁻); band member; shell-model prediction (2020Od01). Configuration=$\pi(h^6_{9/2}i^2_{13/2})\otimes\nu(g^1_{9/2}j^1_{15/2})$ with 37% probability (2020Od01).
3306.7 *13*	(16⁺)	B	Jπ: ΔJ=1, (E1) transition to (15⁻); shell-model prediction (2020Od01). Configuration=$\pi(h^7_{9/2}f^1_{7/2})\otimes\nu g^2_{9/2}$ with 42% probability (2020Od01).

† From Eγ data.
‡ In addition to the arguments given, the assignments are supported from shell-model calculations in 2020Od01.
# Band(A): Yrast (g.s.) band.
@ Band(B): Band based on (11⁻).

γ(^{218}Th)

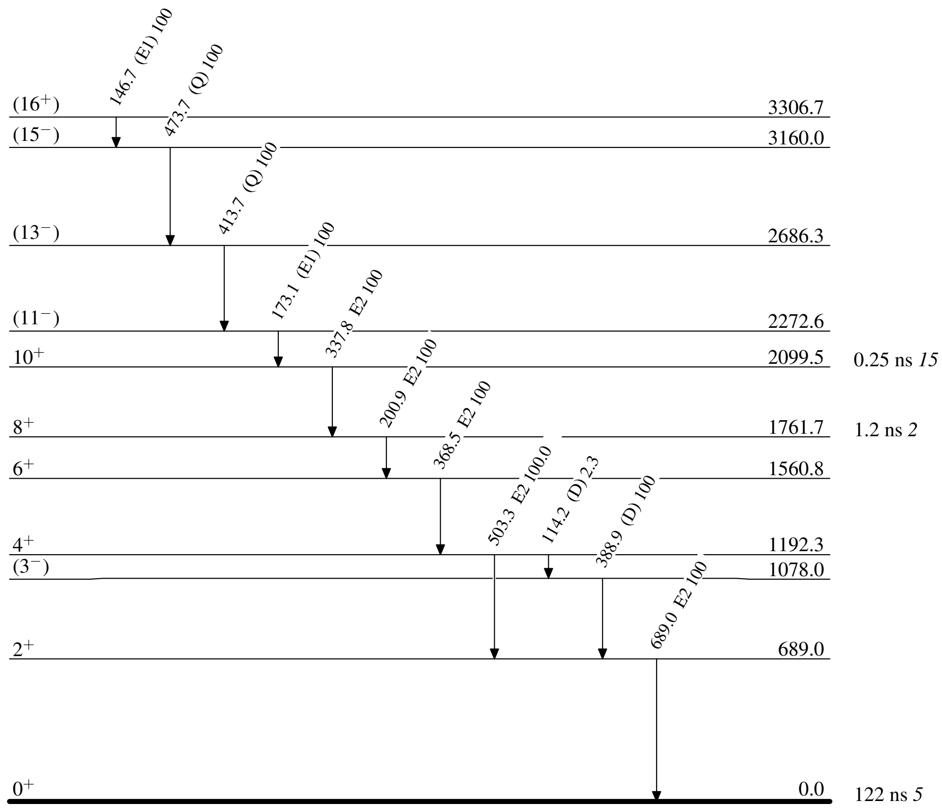
E_i(level)	J^π_i	Eγ†	Iγ	E_f	J^π_f	Mult.	α&	Comments
689.0	2⁺	689.0 *3*	100	0.0	0⁺	E2‡	0.0209	Eγ: 689.6 *6* in (^{16}O,4nγ).
1078.0	(3⁻)	388.9 *6*	100	689.0	2⁺	(D)#		Eγ: 390.5 *10* in (^{16}O,4nγ).
1192.3	4⁺	114.2 *7*	2.3 *2*	1078.0	(3⁻)	(D)#		Eγ: from (^{48}Ca,4nγ) only.
		503.3 *3*	100.0 *17*	689.0	2⁺	E2‡	0.0420	Eγ: 504.6 *6* in (^{16}O,4nγ).
1560.8	6⁺	368.5 *3*	100	1192.3	4⁺	E2‡	0.093	Eγ: 369.7 *6* in (^{16}O,4nγ).
1761.7	8⁺	200.9 *4*	100	1560.8	6⁺	E2‡	0.648 *11*	B(E2)(W.u.)=11 *2* Eγ: 201.9 *6* in (^{16}O,4nγ).
2099.5	10⁺	337.8 *5*	100	1761.7	8⁺	E2‡	0.1187	B(E2)(W.u.)=6 *+9−2* Eγ: 338.2 *6* in (^{16}O,4nγ).
2272.6	(11⁻)	173.1 *4*	100	2099.5	10⁺	(E1)@	0.133 *2*	Eγ: 173.3 *6* in (^{16}O,4nγ).
2686.3	(13⁻)	413.7 *4*	100	2272.6	(11⁻)	(Q)#		Eγ: 414.5 *10* in (^{16}O,4nγ).
3160.0	(15⁻)	473.7 *5*	100	2686.3	(13⁻)	(Q)#		Eγ: from (^{48}Ca,nγ) only.
3306.7	(16⁺)	146.7 *5*	100	3160.0	(15⁻)	(E1)@	0.197 *4*	Eγ: from (^{48}Ca,nγ). An unplaced 146.9 *6* γ was seen in (^{16}O,4nγ).

† From ^{174}Yb(^{48}Ca,4nγ). Values in ^{206}Pb(^{16}O,4nγ), ^{209}Bi(^{14}N,5nγ), listed under comments, seem consistently higher by about a keV.
‡ From K/L ratios in ce data in ^{209}Bi(^{14}N,5nγ), supplemented by ΔJ=2, quadrupole from γ-ray angular distributions in ^{174}Yb(^{48}Ca,4nγ), and by RUL for E2 and M2, when level half-lives are known.
# From γ-ray angular distributions in ^{174}Yb(^{48}Ca,4nγ), with mult=(Q) and (D), most likely (E2) and (E1), respectively.
@ From γ-ray angular distribution in ^{174}Yb(^{48}Ca,4nγ), and intensity balance arguments.
& 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.

Adopted Levels, Gammas

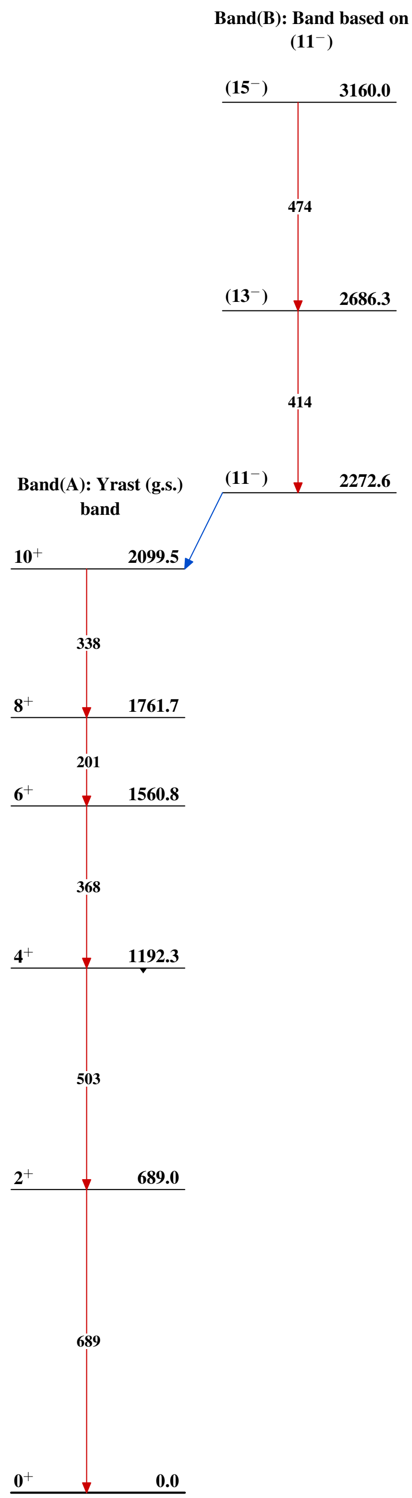
Level Scheme

Intensities: Relative photon branching from each level



$^{218}_{90}Th_{128}$

Adopted Levels, Gammas



$^{218}_{90}Th_{128}$

Adopted Levels, Gammas

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh, M. S. Basunia, Jun Chen et al. ,	NDS 192,315 (2023)	25-Sep-2023

Q(β^-)=−4860 *90*; S(n)=7808 *13*; S(p)=4620 *60*; Q(α)=8132.6 *29* 2021Wa16
Q(ε)=581 *11*, S(2n)=13629 *17*, S(2p)=7647 *13* (2021Wa16).

1970To07: ^{222}Th produced and identified in ^{208}Pb(^{16}O,2n), E(^{16}O)=10.6 MeV/nucleon at the Yale accelerator facility; measured α-decay and half-life.

1970Va13: ^{222}Th produced and identified in ^{208}Pb(^{18}O,4n); ^{208}Pb(^{20}Ne,α2n); ^{208}Pb(^{22}Ne,α4n); ^{209}Bi(^{19}F,α2n); E=10.3 MeV/nucleon from Berkeley HILAC facility; measured α-decay and half-life.

Later studies of ^{222}Th decay: 1991AnZZ, 1999Ho28, 2000He17, 2001Ku07, 2005Li17, 2016Pa28, 2018Mi11.

Theoretical nuclear structure calculations:

2022Ja07: calculated fragmentation potentials and preformation probabilities as functions of mass and charge distributions, fission σ(E) using dynamical cluster-decay model (DCM), including quadrupole β_2 and octupole β_3 deformations of fission fragments.

2020Ca18: calculated deformation parameters β_2, β_3, octupole deformation energies, proton moments Q_{20} and Q_{30} for octupole-deformed nuclei using Skyrme energy density functionals, and covariant energy density functionals.

2020No13: calculated potential energy surface in (β_2,β_3) plane, energies of yrast positive-parity and negative-parity states, energy splitting between positive- and negative-parity yrast bands, B(E1), B(E2), B(E3), transition quadrupole and octupole moments using interacting boson model (IBM).

2018Ah03: calculated levels, J^π, bands using IBM-1, Bohr-Mottelson, and IVBM models.

2018Ry04: calculated deformation energy relative to (β_{20},β_{30}) plane, quadrupole and octupole deformation of the mean-field minimum, excitation energies of rotational states using cranked HFB approach; deduced sudden change in configuration and shape of the observed yrast states from large octupole deformation at low spin to small octupole deformation at high spin.

2017Xi15: calculated levels, J^π, B(E1), B(E2), B(E3), electric dipole moments, deformation energy surface in (β_2,β_3) plane, states of reflection-asymmetric nuclei using microscopic quadrupole-octupole collective Hamiltonian (QOCH) based on relativistic PC-PK1 energy density functionals.

2017Ne02: calculated potential energy surface, deformation, g.s. and superdeformed quadrupole moments using Fourier shape parameterization.

2013No07: calculated levels, J^π, bands, potential energy surfaces, B(E2), B(E1) using microscopic framework based on nuclear density functional theory.

2008Fr03: calculated energy differences between positive and negative parity yrast sequences, and energies of aligned octupole multiphonon bands for heart-shaped nuclei.

2005Bo18: calculated g.s. and vibrational bands, level energies, B(E1), B(E2), shape transitions using analytic quadrupole octupole axially symmetric model.

2000Bo34: calculated octupole bands transition energies, beat patterns using algebraic models.

1995Jo11: calculated alternating-parity ground state bands level energies, octupole correlations, rotational spectra.

1989Eg02: calculated octupole barrier energies, pairing energy, deformations using microscopic model.

1987Na10: calculated levels, J^π, routhians, rotational bands, shapes, B(E1)/B(E2) ratios using the cranking model.

1986Le05: calculated B(E1)/B(E2) branching ratio, shell effects on collective E1 excitations, adiabatic isovector and isoscalar deformations.

1984Fr06: calculated quasiparticle routhians for pear-shaped rotating nuclei, octupole-quadrupole deformed axial Woods-Saxon potential.

1984Na08: calculated β_2, β_3 deformation parameters using Woods-Saxon-Bogolyubov cranking theory.

Other theoretical calculations: 73 primary references for structure, and 75 for decay modes (α, ^{14}C and clusters, SF) retrieved from the NSR database are listed as ‘document’ records in this dataset.

Additional information 1.

Adopted Levels, Gammas (continued)

^{222}Th Levels

The $K^{\pi}=0^+$ g.s. band and the $K^{\pi}=0^-$ band at 246 keV have been interpreted as octupole parity-doublet bands.

Additional high-spin levels, decaying by a single transition each, with no J^{π} assignments, are proposed only by 1988ScZF at 1477.2, 1502.4, 1541.4, 1593.3, 1612.6, 1774.6, 1906.2, 1926.2, 1935.2, 2035.8, 2304.8, 2312.6 and 2404.0 keV. These are not listed in this dataset, as evaluators consider these as unconfirmed, but can be found in the ^{208}Pb(^{18}O,4nγ) dataset.

Cross Reference (XREF) Flags

A	^{226}U α decay (268 ms)
B	^{208}Pb(^{18}O,4nγ)

E(level)[†]	J^{π}[‡]	$T_{1/2}$[#]	XREF	Comments
0.0[@]	0^+	1.964 ms *2*	AB	%α=100 %ε<1.3×10^{-8}, estimated by evaluators from a possible ε branch to ^{222}Ac g.s., with log *ft*>5.9. Theoretical partial $T_{1/2}$>100 s for ^{222}Th ε decay (2019Mo01) gives %ε<0.002, and theoretical partial $T_{1/2}\approx 8\times 10^{+4}$ s of 1973Ta30 gives %$\varepsilon\approx 3\times 10^{-6}$. $T_{1/2}$: from 2016Pa28 (recoil-α decay, authors used the RITU separator and measured $\alpha\gamma$-coin and Eα). Others: 2.3 ms +*8*−*5* (2018Mi11); 2.4 ms *3* (2005Li17), 2.237 ms *13* (2001Ku07, recoil-α decay curve), 2.0 ms *1* (2000He17), 4.2 ms *5* (1999Ho28), 2.2 ms *2* (1991AnZZ), 2.8 ms *3* (1970Va13), 4 ms *1* (1970To07). Precise values from 2001Ku07 (conference report), and 1999Ho28 are in severe disagreement with that from 2016Pa28, the former differing by ≈20 standard deviations, and the latter larger by a factor of two. The three measurements (2016Pa28, 2001Ku07, 1999Ho28) are from the same laboratory, with several of the same authors. For this reason, values from 2001Ku07 and 1999Ho28 are not considered in the averaging procedure. Other values agree with the adopted value within about two σ, but are too imprecise to be considered in the averaging procedure.
182.9[@] *2*	2^+	240 ps *20*	AB	
246[&] *20*	(1^-)		A	E(level): from Eα and Q(α). J^{π}: proposed by 2000He17, based on systematics of 1^- states in neighboring nuclei.
439.2[@] *3*	4^+	46 ps *6*	B	
466.6[&] *6*	(3^-)		B	
650.4[&] *4*	5^-		B	
749.3[@] *4*	6^+	<51 ps	B	$T_{1/2}$: <45 ps *6* (1985Bo32). B(E1)/B(E2)=0.00016 *3* (1983Wa20), 0.00011 *2* (1985Bo32).
922.6[&] *4*	7^-		B	B(E1)/B(E2)=0.00018 *7* (1983Wa20), 0.00011 *3* (1985Bo32).
1092.8[@] *5*	8^+		B	B(E1)/B(E2)=0.00015 *3* (1983Wa20), 0.00025 *5* (1985Bo32).
1254.2[&] *5*	9^-		B	B(E1)/B(E2)=0.00014 *3* (1983Wa20), 0.00014 *3* (1985Bo32).
1460.8[@] *5*	10^+		B	B(E1)/B(E2)=0.00029 *16* (1983Wa20), 0.00026 *6* (1985Bo32).
1622.0[&] *5*	11^-		B	B(E1)/B(E2)=0.00021 *6* (1983Wa20), 0.00026 *7* (1985Bo32).
1850.6[@] *5*	12^+		B	B(E1)/B(E2)=0.00022 *11* (1983Wa20), 0.00019 *3* (1985Bo32).
2015.1[&] *6*	13^-		B	B(E1)/B(E2)=0.00019 *5* (1983Wa20), 0.00026 *5* (1985Bo32).
2259.7[@] *6*	14^+		B	B(E1)/B(E2)=0.00009 *3* (1983Wa20), 0.00022 *4* (1985Bo32).
2431.7[&] *6*	15^-		B	B(E1)/B(E2)=0.00020 *6* (1983Wa20), 0.00034 *8* (1985Bo32).
2688.0[@] *6*	16^+		B	B(E1)/B(E2)=0.00008 *3* (1983Wa20).
2873.1[&] *6*	17^-		B	B(E1)/B(E2)=0.00022 *8* (1983Wa20).
3133.9[@] *6*	18^+		B	
3340.9[&] *7*	19^-		B	

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Adopted Levels, Gammas (continued)

^{222}Th Levels (continued)

E(level)†	Jπ‡	XREF	E(level)†	Jπ‡	XREF
3596.8@ *7*	20+	B	4348.5& *7*	23−	B
3836.0& *7*	21−	B	4579.2@ *7*	24+	B
4078.6@ *7*	22+	B	4882.1?& *8*	(25−)	B
			5099.2?@ *9*	(26+)	B

† From ^{208}Pb(^{18}O,4nγ), based on least-squares fit to Eγ data. Exceptions are noted.

‡ From transition multipolarities measured in ^{208}Pb(^{18}O,4nγ) from conversion electron measurements and $\gamma(\theta)$ for selected γ rays, and g.s. yrast band, and octupole rotational band, as assigned in 1995Sm06 and 1988ScZF.

\# For excited states, values are from measurement in ^{208}Pb(^{18}O,4nγ) (1985Bo32) using recoil-shadow method for conversion electrons.

@ Band(A): K^π=0$^+$ g.s. band.

& Band(B): K^π=0$^-$ octupole-vibrational band.

γ(^{222}Th)

E$_i$(level)	J$^\pi_i$	E$_\gamma$†	I$_\gamma$†	E$_f$	J$^\pi_f$	Mult.‡	α#	Comments
182.9	2+	182.9 *2*	100	0.0	0+	E2	0.920 *14*	B(E2)(W.u.)=75 *6*
439.2	4+	256.3 *2*	100	182.9	2+	E2	0.278 *4*	B(E2)(W.u.)=109 *15*
466.6	(3−)	283.7	100	182.9	2+	[E1]	0.0421 *7*	
650.4	5−	211.1 *3*	100	439.2	4+	E1	0.0831 *12*	
749.3	6+	98.7 *3*	80 *7*	650.4	5−	(E1)	0.1215 *20*	B(E1)(W.u.)>0.0013
		310.2 *3*	100 *10*	439.2	4+	E2	0.1524 *22*	B(E2)(W.u.)>22
922.6	7−	173.1 *3*	100 *10*	749.3	6+	E1	0.1329 *19*	
		272.4 *3*	1.4 *4*	650.4	5−	(E2)	0.2280 *33*	
1092.8	8+	170.1 *3*	100 *10*	922.6	7−	E1	0.1385 *20*	
		343.6 *3*	18 *6*	749.3	6+	E2	0.1131 *16*	
1254.2	9−	161.2 *3*	100 *11*	1092.8	8+	E1	0.1575 *23*	
		331.6 *3*	23 *7*	922.6	7−	E2	0.1252 *18*	
1460.8	10+	206.4 *3*	100 *10*	1254.2	9−	E1	0.0876 *13*	
		368.1 *3*	15 *5*	1092.8	8+	E2	0.0932 *13*	
1622.0	11−	161.1 *3*	100 *20*	1460.8	10+	E1	0.1577 *23*	
		367.8 *3*	54 *17*	1254.2	9−	E2	0.0934 *13*	
1850.6	12+	228.5 *3*	100 *20*	1622.0	11−	E1	0.0691 *10*	
		389.8 *3*	13 *4*	1460.8	10+	(E2)	0.0798 *11*	
2015.1	13−	164.4 *3*	100 *21*	1850.6	12+	(E1)	0.1503 *22*	
		393.2 *3*	45 *15*	1622.0	11−	(E2)	0.0780 *11*	
2259.7	14+	244.6 *3*	100 *19*	2015.1	13−	E1	0.0590 *8*	
		409.2 *3*	10 *4*	1850.6	12+	(E2)	0.0702 *10*	
2431.7	15−	171.7 *3*	100 *21*	2259.7	14+	[E1]	0.1355 *20*	
		416.6 *3*	47 *16*	2015.1	13−	(E2)	0.0670 *9*	
2688.0	16+	256.2 *3*	100 *28*	2431.7	15−	[E1]	0.0531 *8*	
		428.5 *3*	26 *8*	2259.7	14+	(E2)	0.0624 *9*	
2873.1	17−	185.1 *3*	100 *21*	2688.0	16+	(E1)	0.1133 *16*	
		441.3 *3*	35 *11*	2431.7	15−	(E2)	0.0579 *8*	
3133.9	18+	260.6 *3*	100 *21*	2873.1	17−	(E1)	0.0511 *7*	
		446.0 *3*	40 *12*	2688.0	16+	[E2]	0.0564 *8*	
3340.9	19−	206.9 *3*	100 *19*	3133.9	18+	[E1]	0.0871 *13*	
		468.0 *3*	41 *12*	2873.1	17−	(E2)	0.0500 *7*	
3596.8	20+	256.0 *3*	100 *28*	3340.9	19−	[E1]	0.0532 *8*	
		462.8 *3*	37 *11*	3133.9	18+	(E2)	0.0514 *7*	
3836.0	21−	239.2 *3*	100 *30*	3596.8	20+	[E1]	0.0622 *9*	

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Adopted Levels, Gammas (continued)

$\gamma(^{222}Th)$ (continued)

E_i(level)	J_i^π	E_γ [†]	I_γ [†]	E_f	J_f^π	Mult. [‡]	α [#]
3836.0	21⁻	494.9 *3*	29 *9*	3340.9	19⁻	(E2)	0.0437 *6*
4078.6	22⁺	242.3 *3*	100 *29*	3836.0	21⁻	[E1]	0.0603 *9*
		482.0 *3*	21 *7*	3596.8	20⁺	(E2)	0.0466 *7*
4348.5	23⁻	269.8 *3*	100 *29*	4078.6	22⁺	[E1]	0.0472 *7*
		512.6 *3*	60 *19*	3836.0	21⁻	[E2]	0.0402 *6*
4579.2	24⁺	230.7 *3*	100 *30*	4348.5	23⁻	[E1]	0.0676 *10*
		500.7 *3*	34 *11*	4078.6	22⁺	(E2)	0.0425 *6*
4882.1?	(25⁻)	304 [@]		4579.2	24⁺		
		533.3	100	4348.5	23⁻	[E2]	0.0367 *5*
5099.2?	(26⁺)	217 [@]		4882.1?	(25⁻)		
		520.0	100	4579.2	24⁺	[E2]	0.0389 *6*

† From $^{208}Pb(^{18}O,4n\gamma)$.

‡ From ce and $\gamma(\theta)$ data in $^{208}Pb(^{18}O,4n\gamma)$.

\# 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.

@ Placement of transition in the level scheme is uncertain.

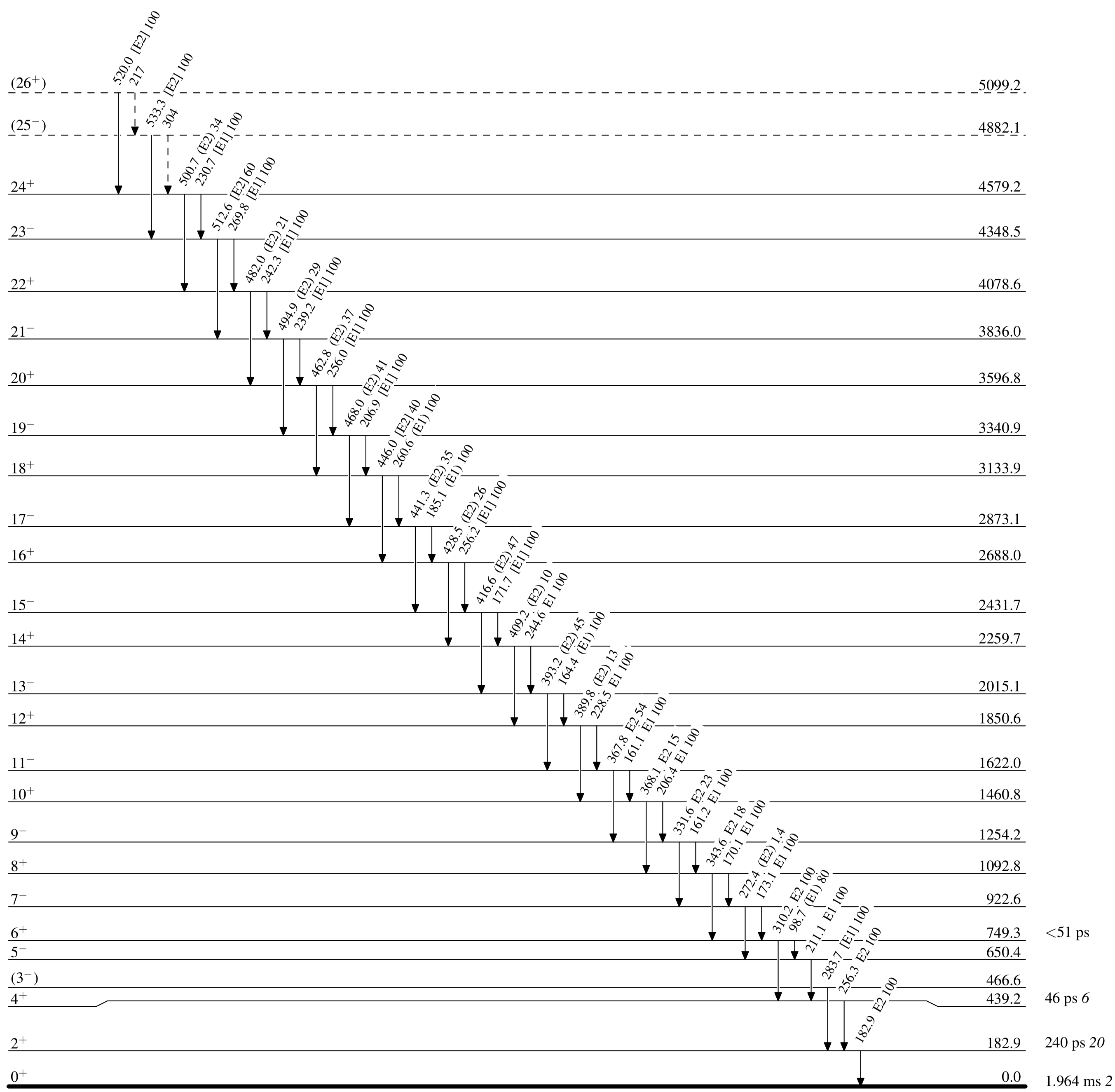
Adopted Levels, Gammas

Legend

Level Scheme

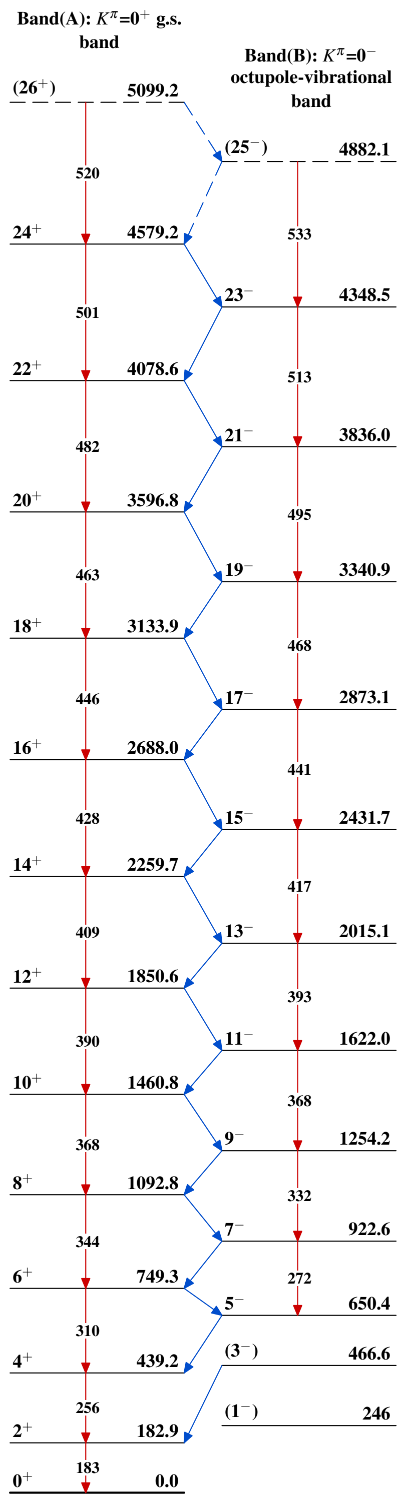
Intensities: Relative photon branching from each level

γ Decay (Uncertain)



$^{222}_{90}Th_{132}$

Adopted Levels, Gammas



$^{222}_{90}Th_{132}$

Adopted Levels, Gammas

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh, Sukhjeet Singh	ENSDF	08-Mar-2022

History

$Q(\beta^-)$=−3867 *12*; S(n)=7461 *12*; S(p)=5118 *12*; $Q(\alpha)$=7299 *6* 2021Wa16
S(2n)=13350 *14*, S(2p)=8903 *10* (2021Wa16).

^{224}Th isotope identified and produced by 1949Me54 in Th(α,X) at E(α)=100-120 MeV, with an estimated half-life of ≈1 s. Later studies of ^{224}Th decay: 1958To25, 1961Ru06, 1970Va13, 1978IbZZ, 1989An13, 2000He17.

2020Cs01: theoretical structure calculations for levels, J^π, low-lying bandheads using pseudo- and proxy-SU(3) semimicroscopic algebraic quartet model (SAQM).

Theoretical calculations: 109 references extracted from the NSR database are listed in document records.
Additional information 1.

^{224}Th Levels

D_0/Q_0=electric dipole moment to electric quadrupole moment ratio deduced by 1993Ac02 from B(E1)/B(E2) ratios determined in (α,6nγ) reaction.

Cross Reference (XREF) Flags

A	^{228}U α decay (9.1 min)
B	^{208}Pb(^{16}O,Fγ):GDR
C	^{208}Pb(^{18}O,2nγ)
D	^{226}Ra(α,6nγ)

E(level)[†]	J^{π}[#]	$T_{1/2}$	XREF	Comments
0.0[@]	0^+	1.04 s *2*	A CD	%α=100 $T_{1/2}$: weighted average of 0.812 s *99* (2000He17 from α decay), 1.05 s *2* (1978IbZZ), 1.03 s *5* (1970Va13, from α decay curve), 1.05 s *5* (1958To25, detection of integral α particles with pulsed beam).
98.1[@] *3*	2^+	0.590 ns *40*	A CD	J^π: E2 γ to 0^+. $T_{1/2}$: (186 ce(L2))(98 ce(L2))(t) in ^{226}Ra(α,6nγ) (1986Sc18).
251.0?[&] *3*	(1^-)		A D	XREF: D(?). J^π: possible member of $K^\pi=0^-$ band.
284.1[@] *5*	4^+		A CD	J^π: stretched E2 γ to 2^+.
305.3[&] *5*	(3^-)		CD	
464.5[&] *5*	(5^-)		CD	
534.7[@] *5*	6^+		CD	$D_0/Q_0=7.3\times10^{-4}$ fm^{-1} *11*.
699.5[&] *5*	(7^-)		CD	
833.9[@] *6*	8^+		CD	$D_0/Q_0=6.7\times10^{-4}$ fm^{-1} *7*.
997.7[&] *6*	(9^-)		CD	
1173.8[@] *6*	10^+		CD	$D_0/Q_0=7.3\times10^{-4}$ fm^{-1} *4*.
1347.3[&] *6*	(11^-)		CD	XREF: C(?). $D_0/Q_0=8.8\times10^{-4}$ fm^{-1} *6*.
1549.8[@] *6*	12^+		D	$D_0/Q_0=8.4\times10^{-4}$ fm^{-1} *4*.
1738.7[&] *6*	(13^-)		D	$D_0/Q_0=8.0\times10^{-4}$ fm^{-1} *4*.
1958.9[@] *7*	14^+		D	$D_0/Q_0=9.3\times10^{-4}$ fm^{-1} *5*.
2164.7[&] *7*	(15^-)		D	$D_0/Q_0=8.9\times10^{-4}$ fm^{-1} *6*.
2398.0[@] *7*	16^+		D	

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Adopted Levels, Gammas (continued)

^{224}Th Levels (continued)

E(level)[†]	J^{π}[#]	$T_{1/2}$	XREF	Comments
2620.2?[&] 7	(17$^-$)		D	$D_0/Q_0=10.0\times10^{-4}$ fm^{-1} 13.
2864?[@]	18$^+$		D	
10.8×10^3[‡] 3		4.4 MeV 6	B	
14.1×10^3[‡] 6		5.9 MeV 10	B	

[†] From least squares fit to Eγ data.
[‡] GDR.
[#] Based on multipolarities for selected transitions in in-beam γ-ray studies, band structures and systematics of neighboring nuclides, unless specific arguments are given.
[@] Band(A): $K^{\pi}=0^+$ g.s. band.
[&] Band(B): $K^{\pi}=0^-$ band.

γ(^{224}Th)

E_i(level)	J^{π}_i	E_{γ}[†]	I_{γ}[†]	E_f	J^{π}_f	Mult.[‡]	α[@]	Comments
98.1	2$^+$	98.1 3	100	0.0	0$^+$	E2[#]	12.33 25	B(E2)(W.u.)=96 7
251.0?	(1$^-$)	152.9 3	50 13	98.1	2$^+$	[E1]	0.179	I_{γ}: from ^{228}U α decay.
		246 3	100 25	0.0	0$^+$	[E1]	0.059	E_{γ},I_{γ}: γ seen in ^{228}U α decay only.
284.1	4$^+$	186.0 3	100	98.1	2$^+$	E2[#]	0.863	
305.3	(3$^-$)	207.2 3	100	98.1	2$^+$	(E1)	0.0868	
464.5	(5$^-$)	180.4 3	100	284.1	4$^+$	(E1)	0.1204	
534.7	6$^+$	70.2 3	85 25	464.5	(5$^-$)	[E1]	0.299 6	
		250.6 3	100	284.1	4$^+$	(E2)	0.299	
699.5	(7$^-$)	164.8 3		534.7	6$^+$	(E1)	0.151	
		235.0 3		464.5	(5$^-$)			
833.9	8$^+$	134.4 3	100	699.5	(7$^-$)	(E1)	0.243	
		299.2 3	50 10	534.7	6$^+$	[E2]	0.170	
997.7	(9$^-$)	163.8 3		833.9	8$^+$			
		298.2 3		699.5	(7$^-$)			
1173.8	10$^+$	176.1 3	100	997.7	(9$^-$)	(E1)	0.1276	
		339.9 3	36 4	833.9	8$^+$	[E2]	0.1166	
1347.3	(11$^-$)	173.4 3	100	1173.8	10$^+$	(E1)	0.1323	
		349.6 3	30 4	997.7	(9$^-$)	[E2]	0.1076	
1549.8	12$^+$	202.5 3	100	1347.3	(11$^-$)	[E1]	0.0916	
		376.0 3	29 3	1173.8	10$^+$	[E2]	0.0880	
1738.7	(13$^-$)	188.9 3	100	1549.8	12$^+$	[E1]	0.1080	
		391.4 3	50 5	1347.3	(11$^-$)	[E2]	0.0790	
1958.9	14$^+$	220.2 3	100	1738.7	(13$^-$)	[E1]	0.0753	
		409.0 3	29 3	1549.8	12$^+$	[E2]	0.0703	
2164.7	(15$^-$)	205.8 3	100	1958.9	14$^+$	[E1]	0.0882	
		426.1 3	45 6	1738.7	(13$^-$)	[E2]	0.0633	
2398.0	16$^+$	233.3 3		2164.7	(15$^-$)			
		439.1 3		1958.9	14$^+$			
2620.2?	(17$^-$)	222.3[&]	100	2398.0	16$^+$	[E1]	0.0737	
		455.4[&] 3	42 11	2164.7	(15$^-$)	[E2]	0.0535	
2864?	18$^+$	466[&]		2398.0	16$^+$			

[†] From ^{226}Ra(α,6nγ), where data are more extensive and generally given with uncertainties. The Eγ and γ branching ratios

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

$\gamma(^{224}Th)$ (continued)

available from $^{208}Pb(^{18}O,2n\gamma)$ are in agreement with those from $(\alpha,6n\gamma)$ reaction but are less complete. The only exception is 251,(1^-) level, where energy of one γ ray and intensities are taken from α decay.

‡ From $\gamma(\theta)$ data in $(^{18}O,2n\gamma)$, unless otherwise stated.

Intensities of L1, and L2+L3 peaks in $(^{18}O,2n\gamma)$ displayed in spectral figure 1 of 1986Sc12 are consistent with E2.

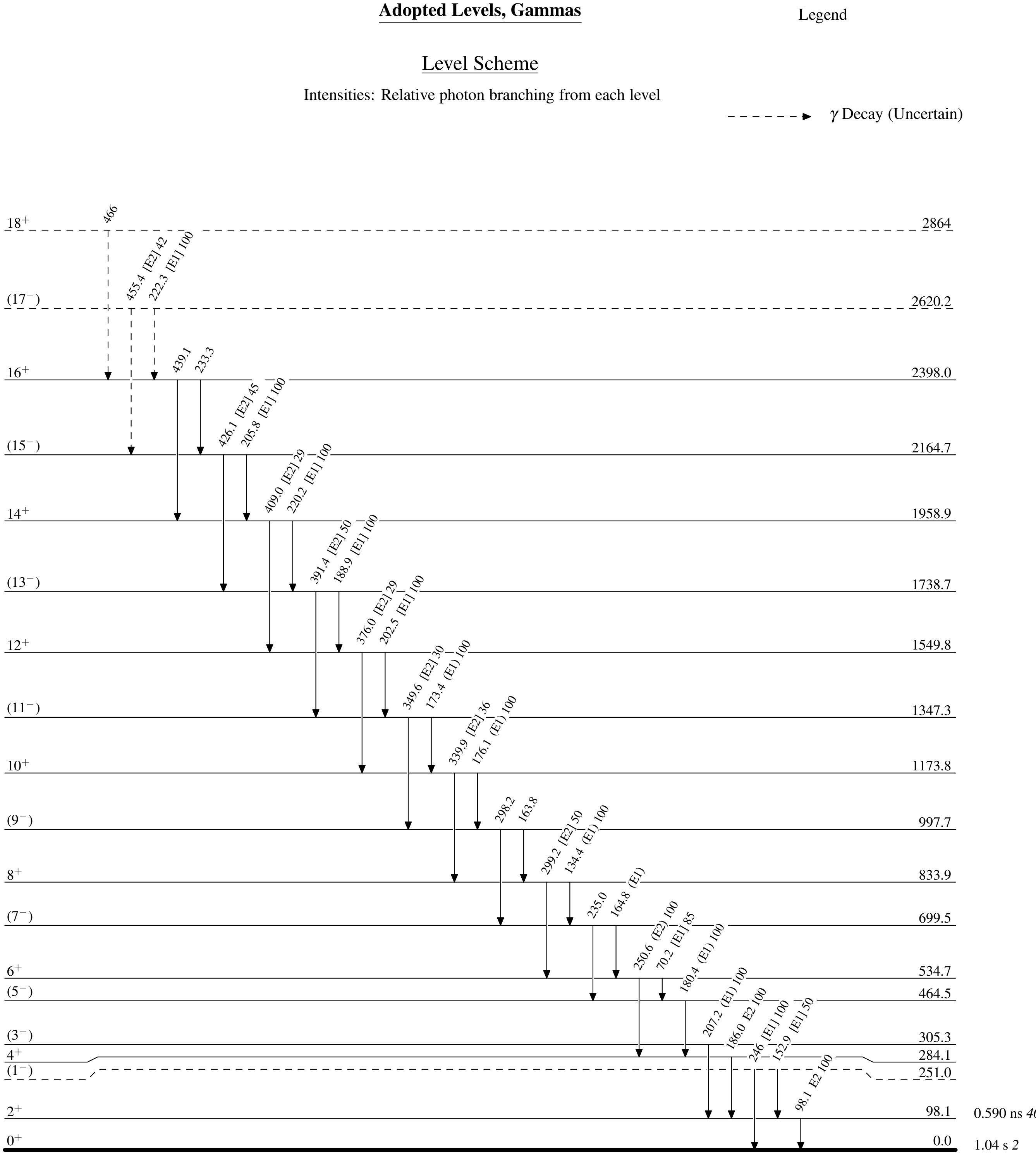
@ Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on γ-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.

& Placement of transition in the level scheme is uncertain.

Adopted Levels, Gammas

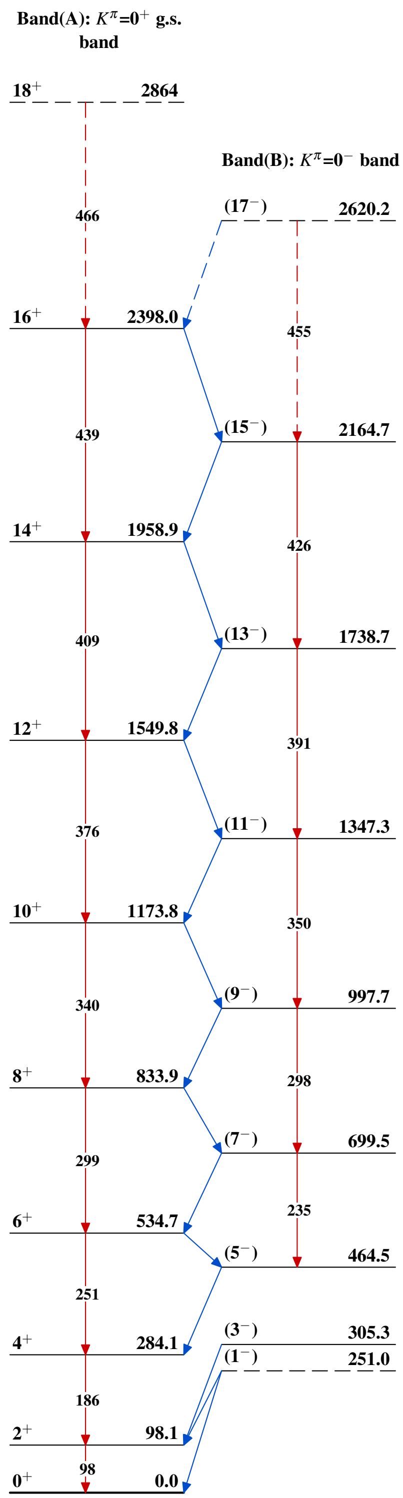
Level Scheme

Intensities: Relative photon branching from each level



$^{224}_{90}Th_{134}$

Adopted Levels, Gammas



$^{224}_{90}Th_{134}$

Adopted Levels, Gammas

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Y. A. Akovali	NDS 77,433 (1996)	1-Feb-1996

Q(β^-)=−2836 *13*; S(n)=7185 *7*; S(p)=5730 *7*; Q(α)=6450.9 *23* 2012Wa38

Note: Current evaluation has used the following Q record −2834 13 *7187* 8 *5733* 9 *6451.2 10* 1995Au04.

Wave functions and energies of K=0$^-$,2$^+$,2$^-$,3$^-$ and second 0$^-$ octupole-vibrational states were calculated by 1975Iv03. See 1985Bo43, 1983Pi04, 1983Da28 for calculations of K=0$^-$, 0$^+$ vibrational states energies for various nuclear potentials; see 1970Ne08 for calculated energies of K=0$^-$,1$^-$,2$^-$ and 3$^-$ bands. See 1972Va20 for a noncollective description of a low-lying 0$^+$ state and its calculated energy.

See 1995De13 and 1995La01 for calculations of the 0$^+$ and 0$^-$ rotational band energies.

For calculations of equilibrium deformation parameters see, for example, 1970Ga12, 1975Iv03, 1981Gy03, 1982Du16, 1982Le19, 1983Ro14, 1984Na22 and 1985Na07.

For calculations of electric quadrupole and hexadecapole moments see, for example, 1970Ga12, 1975Iv03 and 1983Ro14.

See 1970Ne08 and 1985Bo43 for calculated B(E3; 0$^+$ to 3$^-$); 1977Ba45 for calculated B(E3; 0$^+$ to 3$^-$) and B(E1; 0$^+$ to 1$^-$) values for K=0$^-$ band; 1995La01 for transition matrix elements for 1$^-$ to 0$^+$, 2$^+$ to 0$^+$, 3$^-$ to 1$^-$ and 3$^-$ to 0$^+$ γ transitions.

The fermion dynamic symmetry model was used by 1992Ch20 to calculate the properties of the predicted superdeformed state. See 1992Ch20 for the calculated potential well, level energies and deformations.

^{226}Th Levels

Cross Reference (XREF) Flags

A ^{230}U α decay
B ^{226}Ac β^- decay
C (HI,xnγ)

E(level)	J$^\pi$ @	T$_{1/2}$	XREF	Comments
0.0†	0$^+$	30.57 min *10*	ABC	%α=100 T$_{1/2}$: measured by 1987Mi10. Other measurement: 30.9 min (1948St42).
72.20† *4*	2$^+$	0.395 ns *20*	ABC	J$^\pi$: 72.20γ to 0$^+$ is E2. T$_{1/2}$: by (α)(ce 72γ)(t) in ^{230}U α decay (1960Be25).
226.43† *5*	4$^+$		ABC	J$^\pi$: intensity balance at 226.43-keV level suggests that 154.23γ to 2$^+$ level is E2; α hindrance factor is consistent with J^π=4$^+$ of the g.s. band.
230.37‡ *5*	1$^-$		ABC	J$^\pi$: 230.37γ to 0$^+$ g.s. is E1.
307.5‡ *2*	3$^-$		ABC	J$^\pi$: intensity balance at the 307.5 level in ^{230}U α decay suggests that 81.0 and 235.3 γ's to 4$^+$ and 2$^+$ levels are E1.
351 *2*			A	
362 *3*			A	
447.3† *2*	6$^+$		A C	J$^\pi$: 220.9γ to 4$^+$ level of g.s. band; energy fit to the rotational band.
450.5‡ *2*	5$^-$		A C	J$^\pi$: γ to 4$^+$ state; energy fit to the K=0$^-$ band.
657.9‡ *2*	7$^-$		C	
721.9† *2*	8$^+$		C	
805.2# *4*	(0$^+$)		AB	J$^\pi$: in analogy to 831.7-keV, 0$^+$ level in ^{228}Th, 1976Ku08 proposed J^π=0$^+$. γ transition to 1$^-$ state, hindrance factor ≈8 for the α transition from ^{230}U and log *ft*=8.9 *1* for the β^- decay J=(1) ^{226}Ac are consistent with this assignment.
847.8# *4*	(2$^+$)		AB	J$^\pi$: log *ft* for β^- decay from J=(1) ^{226}Ac and γ to 3$^-$ level limit J^π to 1$^-$, 2$^+$. Intensity ratio of photons deexciting 847.8-keV level is in agreement with the Alaga rule for K=0, J=2.
923.1‡ *3*	9$^-$		C	
1040.3† *3*	10$^+$		C	

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Adopted Levels, Gammas (continued)

^{226}Th Levels (continued)

E(level)	J^{π}@	XREF	E(level)	J^{π}@	XREF	E(level)	J^{π}@	XREF
1238.4‡ *4*	11⁻	C	1781.5† *5*	14⁺	C	2412.8‡ *6*	17⁻	C
1395.2† *4*	12⁺	C	1989.4‡ *5*	15⁻	C	2635.1† *7*	18⁺	C
1596.0‡ *5*	13⁻	C	2195.8† *6*	16⁺	C	2861.1‡ *7*	19⁻	C
						3097.1† *8*	20⁺	C

† Band(A): $K^{\pi}=0^+$ ground-state band.
‡ Band(B): $K^{\pi}=0^-$ octupole-vibrational band.
# Band(C): $K^{\pi}=0^+$ β-vibrational band.
@ Assignments for J≥8 and J≥7 members of the g.s. and the octupole-vibrational bands, respectively, are based on (HI,xnγ) data.

γ(^{226}Th)

E_i(level)	J_i^{π}	E_{γ}†	I_{γ}#	E_f	J_f^{π}	Mult.‡	α&	Comments
72.20	2⁺	72.20 *4*	100@	0.0	0⁺	E2	53.5	B(E2)(W.u.)=164 *10*
226.43	4⁺	154.23 *3*	100@	72.20	2⁺	(E2)	1.83	
230.37	1⁻	158.18 *3*	60 *5*	72.20	2⁺	E1	0.167	
		230.37 *5*	100 *5*	0.0	0⁺	E1	0.0683	
307.5	3⁻	81.0 *5*	4.1 *10*	226.43	4⁺			
		235.3 *1*	100 *7*	72.20	2⁺			
447.3	6⁺	220.9 *1*	100@	226.43	4⁺	[E2]	0.461	
450.5	5⁻	224.1 *2*	100@	226.43	4⁺	[E1]	0.0723	
657.9	7⁻	207.4 *1*		450.5	5⁻			
		210.7 *1*		447.3	6⁺			
721.9	8⁺	63.9 *1*	0.13 *5*	657.9	7⁻			
		274.6 *1*	1.0	447.3	6⁺			
805.2	(0⁺)	574.8 *3*		230.37	1⁻			
847.8	(2⁺)	540.4 *3*	100 *20*	307.5	3⁻			
		617.4 *4*	90 *20*	230.37	1⁻			
923.1	9⁻	201.3 *1*	400 *40*	721.9	8⁺			
		265.2 *1*	100	657.9	7⁻			
1040.3	10⁺	116.9 *2*	27.6 *21*	923.1	9⁻			
		318.4 *2*	100	721.9	8⁺			
1238.4	11⁻	198.2 *2*	161 *12*	1040.3	10⁺			
		315.2 *2*	100	923.1	9⁻			
1395.2	12⁺	156.7 *2*	42 *3*	1238.4	11⁻			
		354.9 *2*	100	1040.3	10⁺			
1596.0	13⁻	200.9 *2*		1395.2	12⁺			
		357.6 *2*		1238.4	11⁻			
1781.5	14⁺	185.5 *2*	40 *4*	1596.0	13⁻			
		386.3 *2*	100	1395.2	12⁺			
1989.4	15⁻	208.0 *2*	61 *10*	1781.5	14⁺			
		393.4 *2*	100	1596.0	13⁻			
2195.8	16⁺	206.3 *3*		1989.4	15⁻			
		414.3 *3*		1781.5	14⁺			
2412.8	17⁻	216.9 *3*	43 *7*	2195.8	16⁺			
		423.5 *3*	100	1989.4	15⁻			
2635.1	18⁺	439.3 *3*		2195.8	16⁺			
2861.1	19⁻	226.0 *3*	42 *10*	2635.1	18⁺			
		448.3 *3*	100	2412.8	17⁻			
3097.1	20⁺	462.0 *3*		2635.1	18⁺			

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Adopted Levels, Gammas (continued)

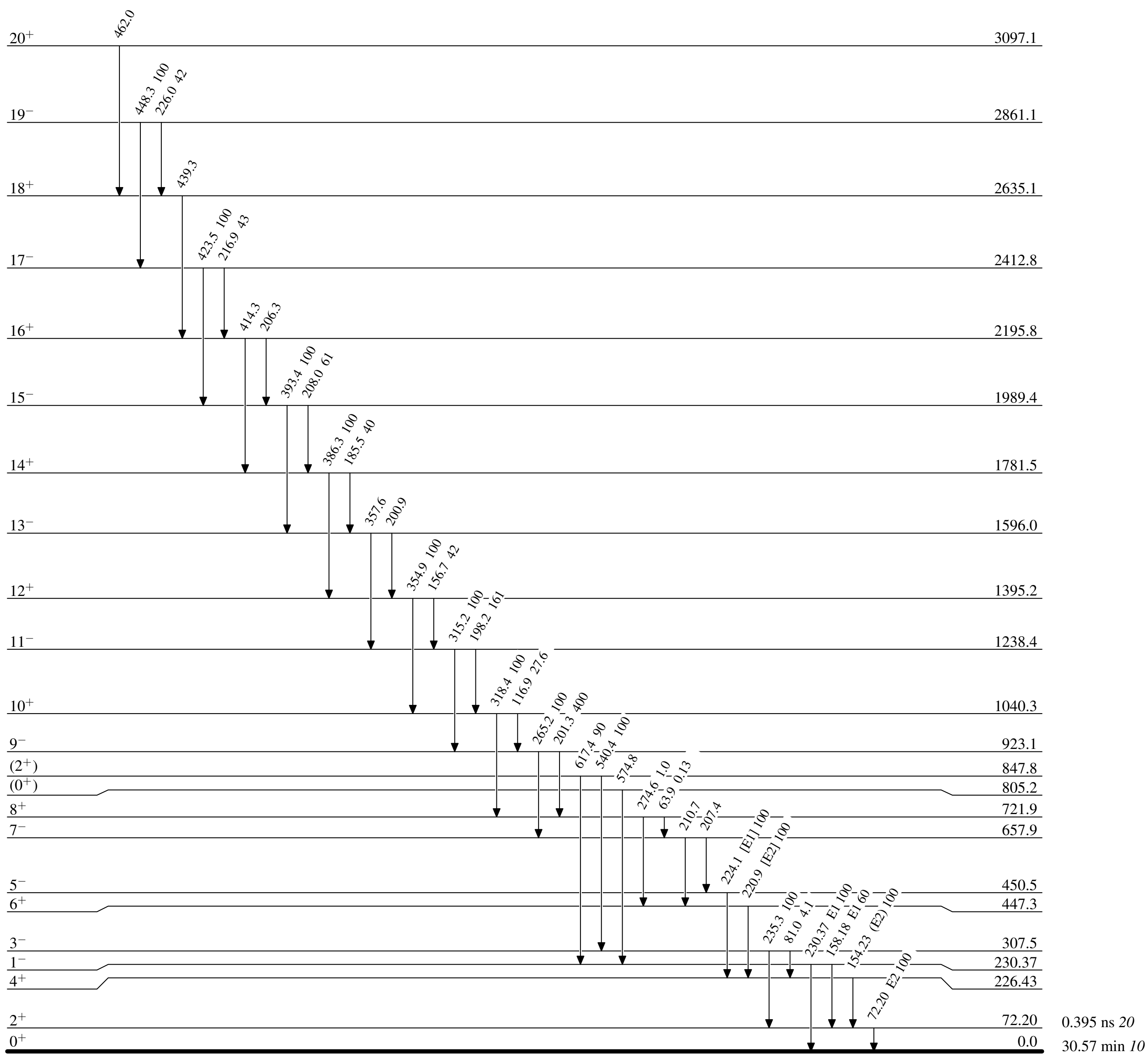
$\gamma(^{226}Th)$ (continued)

† From ^{230}U α decay and ^{226}Ac β^- decay.
‡ From ce measurements in ^{226}Ac β^- decay.
# Relative photon intensity from each level.
@ Set to 100 (β. Singh).
& 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.

Adopted Levels, Gammas

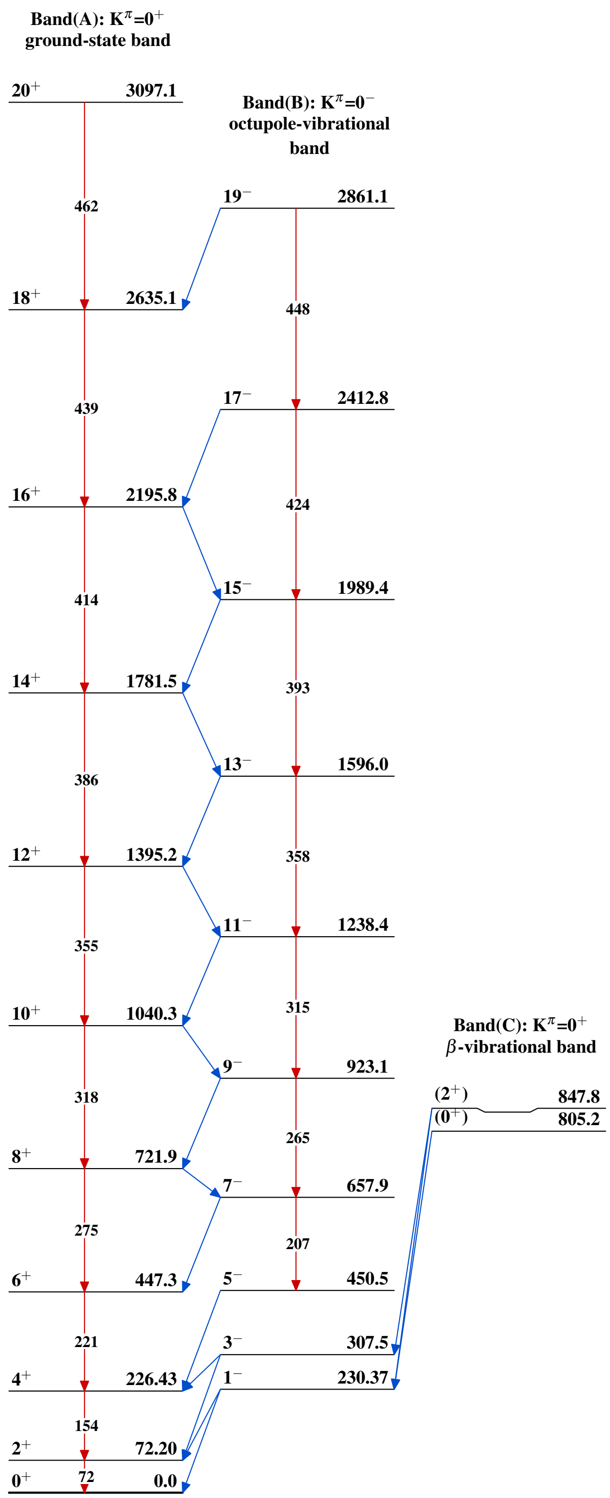
Level Scheme

Intensities: Relative photon branching from each level



$^{226}_{90}Th_{136}$

Adopted Levels, Gammas



$^{226}_{90}Th_{136}$

Adopted Levels, Gammas

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Khalifeh Abusaleem	NDS 116, 163 (2014)	31-Dec-2012

Q(β^-)=−2152 *4*; S(n)=7105.3 *22*; S(p)=6367.7 *21*; Q(α)=5520.08 *22* 2012Wa38

Calculations, compilations, systematics:
α decay width and half-life: 1996De19, 2011Qi06, 2011Sh13, 2011Si14 2011Zh36, 2010Wa31, 2009De32, 2009Ni06, 2009Qi07, 2009Wa01, 2008Bh05.
Binding energies, deformation role: 1986Ch23.
B(E1) from octupole states: 1989De11, 1986Le05, 1981Le15, 2010Ch35.
Cluster model for α decay; Geiger-Nuttall plot: 1991Bu05, 1986Da03.
Equilibrium deformation: 1988So08, 1984Na22, 1981Gy03.
Heavy cluster spontaneous emission: 1996Bu05, 1994Bu07, 1993Go18, 1992Sa30, 1986Po15, 1986Po06.
Levels, shapes, B(λ): 1996Li18, 1995De13, 1995La01, 1989Hu05, 1989Sh35, 1988Ri07, 1986An10, 1986Go07, 1984Ba59, 1984Ba63, 2011Ra05.
Octupole shapes and shape changes: 1987Na10.
p-n interaction energy: 1990Mo11.
Rotational bands in even-even nuclei: 1992So10, 1988Ab07.
Quasi-bands in even-even nuclei: 1984Sa37.
Super- and hyper-deformed configurations: 1995We02.
Octupole and quadrupole deformation: 2008Bi03.
Yrast band parity splitting: 1994Jo02, 1993Jo12.
Production cross section: 2012Er03, 2011Ch57.
β^- decay: 2009So02.
For a discussion of the level scheme and the rotational bands see 1995Ba42, 1987Da28.

^{228}Th Levels

Cross Reference (XREF) Flags

A	^{228}Ac β^- decay	E	^{232}Th(n,5nγ)
B	^{228}Pa ε decay	F	^{226}Ra(α,2nγ)
C	^{232}U α decay	G	^{230}Th(p,t)
D	^{232}Th(^{136}Xe,Xγ)	H	^{230}Th(α,α'2nγ)

E(level)†	J$^\pi$	T$_{1/2}$	XREF	Comments
0.0‡	0$^+$	1.9116 y *16*	ABCD FGH	%α=100 %^{20}O=1.13×10^{-11} *22* (1993Bo20). T$_{1/2}$: value (698.2 d *6*) recommended by 1991BaZS; based on measurements from 1971Jo14, 1962Ma57, 1956Ki16 (tropical year (365.24220 days) used in conversion). Others: 1.912 y *2* (recommended value, 1990Ho28), 1.906 y (1918Me01). Isotope shift: Δ<r^2>=−0.413 *5* relative to ^{232}Th (1989Ka29).
57.773‡ *3*	2$^+$	0.406 ns *7*	ABCDEFGH	J$^\pi$: L(p,t)=2 for even-even nucleus; E2 γ to 0$^+$ g.s. T$_{1/2}$: from ^{232}U α decay.
186.838‡ *3*	4$^+$	0.164 ns *4*	ABCDEFGH	J$^\pi$: L(p,t)=4 for even-even nucleus;E2 γ to 2$^+$ level; member of g.s. rotational band. T$_{1/2}$: from ^{232}U α decay.

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Adopted Levels, Gammas (continued)

^{228}Th Levels (continued)

E(level)[†]	J^π	$T_{1/2}$	XREF	Comments
328.019[#] 3	1^-		ABCD FGH	J^π: L(p,t)=1 for even-even nucleus; E1 γ to 0^+ g.s.
378.195[‡] 12	6^+		ABCDEFGH	J^π: L(p,t)=6 for even-even nucleus; E2 γ to 4^+ level: member of g.s. rotational band.
396.094[#] 4	3^-		ABCD FGH	J^π: L(p,t)=3 for even-even nucleus; E1 γ's to 4^+ and 2^+ levels.
519.208[#] 5	5^-		ABCD FGH	J^π: L(p,t)=(5) for even-even nucleus; E1 γ's to 4^+ and 6^+ levels.
622.5[‡] 3	8^+		DEFGH	J^π: L(p,t)=(8) for even-even nucleus. J^π: E2 γ to 6^+ level; member of g.s. rotational band.
695.45[#] 15	7^-		B D FGH	J^π: L(p,t)=(7) for even-even nucleus. J^π: γ to 6^+ level; member of $K^\pi=0^-$ octupole band.
831.842[@] 10	0^+		ABC FG	J^π: L(p,t)=0 for even-even nucleus.
874.535[@] 16	2^+		ABC FG	J^π: L(p,t)=2 for even-even nucleus.
911.8[‡] 3	(10^+)		D FGH	J^π: γ to 8^+ level; member of g.s. band.
920.77[#] 22	9^-		D FGH	J^π: γ to 7^- and 8^+ levels; member of $K^\pi=0^-$ octupole band.
938.61[&] 7	0^+		AB G	J^π: L(p,t)=0 for even-even nucleus.
944.205[b] 12	1^-		AB E G	J^π: L(p,t)=1 for even-even nucleus.
968.381[b] 22	2^-		AB	J^π: γ's to 1^-, band member.
968.451[@] 24	4^+		B F	J^π: γ to 3^- and 5^- levels; $K^\pi=0^+$ band member.
968.984[c] 4	2^+		AB FG	J^π: L(p,t)=2 for even-even nucleus.
979.522[&] 13	2^+		AB G	J^π: γ's to 0^+ g.s. and 4^+ level.
1016.386[b] 16	3^-		AB G	J^π: L(p,t)=3 for even-even nucleus.
1022.542[c] 6	$(3)^+$		AB FG	J^π: E2 γ to 4^+ and E2+M1 to 2^+ levels; E1 γ from 4^- level; member of $K^\pi=2^+$ band.
1059.928[b] 22	4^-		AB	J^π: γ's to 3^- and 5^- levels; $J^\pi=3^-,4^+,5^-$ ruled out by $\gamma(\theta$,H,T) (^{228}Pa decay).
1074.80[&] 6	4^+		B G	J^π: L(p,t)=4 for even-even nucleus.
1091.048[c] 11	4^+		AB FG	J^π: L(p,t)=4 for even-even nucleus.
1105.38[@] 15	6^+		FG	J^π: L(p,t)=6 for even-even nucleus.
1119.7[a] 10	0^+		B G	J^π: L(p,t)=0. Probably bandhead of third $K^\pi=0^+$.
1122.959[d] 5	2^-		AB	J^π: E1 γ to 2^+ level, E2+M1 γ to 1^- level, (E1+M2) γ to $(3)^+$ level; member of $K^\pi=2^-$ band.
1143.16[b] 10	5^-		B G	J^π: L(p,t)=5 for even-even nucleus.
1153.487[e] 9	2^+	0.29 ns 2	AB G	J^π: γ to 2^+ has E0 component. $T_{1/2}$: from ^{228}Ac β^- decay.
1160 5			G	
1168.389[d] 6	3^-		AB G	J^π: L(p,t)=3 for even-even nucleus.
1174.515[c] 18	(5^+)		AB F	J^π: γ to 4^+ level; member of $K^\pi=2^+$ band.
1175.41[a] 4	2^+		AB G	J^π: L(p,t)=2 for even-even nucleus.
1189.8[#] 3	11^-		D F H	J^π: γ's to 9^- and (10^+) levels; band structure.
1200.60[e] 3	$3^{(+)}$		B G	J^π: L(p,t)=3 for even-even nucleus.
1226.580[d] 7	4^-		AB G	E(level): L(p,t)=4, may not be the same level.
1239.3[‡] 4	(12^+)		D F H	J^π: γ to 10^+ level; member of g.s. band.
1261.57[e] 8	4^+		B G	J^π: L(p,t)=4 for even-even nucleus.
1270.08[c] 18	6^+		B FG	J^π: L(p,t)=6 for even-even nucleus.
1280.41[@] 22	8^+		F	J^π: γ's to 6^+, 7^-, and 9^-; member of a rotational band.
1290.07[a] 8	4^+		B G	J^π: L(p,t)=4 for even-even nucleus.
1297.435[d] 10	(5^-)		AB G	J^π: L(p,t)=(5) for even-even nucleus.
1319.2 4	(2^+)		G	J^π: L(p,t)=(2) for even-even nucleus.
1344.142[f] 20	3^-		AB G	J^π: L(p,t)=3 for even-even nucleus.
1379.5[c] 3	7^+		F	J^π: γ's to 8^+ and 6^+; member of a rotational band.

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Adopted Levels, Gammas (continued)

^{228}Th Levels (continued)

E(level)[†]	J^π	L	S	XREF	Comments
1393.31 7	(1+,2,3−)			B	J^π: γ's 1+, 2+ and 3−; probable 1+ (band head of K^π=1+) from DCO ratio.
1416.10 6	(3−)			AB G	J^π: L(p,t)=3 for even-even nucleus.
1420? 2				G	
1423.8 5	(2+)	(2)	0.03	G	J^π: L(p,t)=2 for even-even nucleus.
1431.994 5	4+			AB G	J^π: L(p,t)=4 for even-even nucleus.
1448.92 7	3,4−			B	J^π: Multiple γ to (2+), 3−, and 4.
1450.402 10	4−			AB	J^π: M1+E2 γ's to 3− (5)− levels.
1453.5 3	(3−)			G	J^π: L(p,t)=(3) for even-even nucleus.
1467? 2				G	
1470.0 5	(6+)			G	J^π: L(p,t)=(6) for even-even nucleus.
1490.2[@] 3	10+			F	J^π: γ's to 11−, 9−, and 8+; member of a rotational band.
1497.0[#] 4	(13−)			D F H	E(level): Tentative in (α,2nγ), but σ's to 11− and 12+ are consistent with data. J^π: γ's to 11− and 12+ levels; band structure.
1497.2[c] 4	8+			F	J^π: γ's to 6+ and 8+; member of a rotational band.
1497.70 8	(5−)			B G	J^π: L(p,t)=(5) for even-even nucleus.
1511.1 3	0+			G	J^π: L(p,t)=0 for even-even nucleus.
1531.490 5	0+&3+			AB G	J^π: L(p,t)=0,3 for even-even nucleus; E2+M1 γ to 2+, M1 γ to 4+.
1539.21 8	2+			AB G	XREF: G(1544). J^π: L(p,t)=2 for even-even nucleus.
1580.92 6	(2−)			B	J^π: (M1+E2) γ's to 3− and 1− levels.
1586.9 4	2+			G	
1588.347 14	(4−)			B	
1599.4[‡] 5	(14+)			D F H	XREF: H(1595.9). E(level): Shown tentative in (α,2nγ), which deexcites by Eγ=357.2 keV to 12+ state. J^π: γ to (12+); member of g.s. band.
1617.80 7	4+			AB	J^π: γ's to 4+ and 2+ levels.
1618.3 5	4+			G	J^π: L(p,t)=4 for even-even nucleus.
1627.8[c] 4	(9+)			F	J^π: γ to (10+) and 8+; member of rotational band.
1627.9 3	0+			G	J^π: L(p,t)=0 for even-even nucleus.
1638.284 9	2+			AB G	J^π: L(p,t)=2 for even-even nucleus.
1643.131 14	(2−,3−)			AB G	J^π: (M1) γ's to 2− and 3− levels.
1643.82[g] 7	4+			B G	J^π: L(p,t)=4 for even-even nucleus.
1646.003 11	3+			AB	J^π: E2 γ's to 2+ and 4+ levels, γ's to 2− and 4− levels.
1651.4 3	(3−)			G	J^π: L(p,t)=(3) for even-even nucleus.
1667.38 15	2+			B G	J^π: L(p,t)=2 for even-even nucleus.
1672.3 5	2+			G	J^π: L(p,t)=2 for even-even nucleus.
1678.42 7	2+			B G	J^π: L(p,t)=2 for even-even nucleus.
1682.81 3	(2+,3+,4+)			AB	J^π: (E2) γ to 4+ level, γ to 2+ level.
1683.80 4	(4−)			AB	J^π: (M1+E2) γ's to 3− and 5− levels.
1688.408 10	2+,3+			AB	J^π: γ's to 2+ and 4+ levels; J^π≠3−,4+ excluded in γ(θ,H,T) (^{228}Pa decay).
1691.4 4	0+			G	J^π: L(p,t)=0 in 230Th(p,t); even-even nucleus.
1707.29 16	(2,3−)			B	J^π: γ to 1− and 3−.
1710.7 6	0+			G	J^π: L(p,t)=0 for even-even nucleus.
1724.299 5	2+			AB G	J^π: L(p,t)=2 for even-even nucleus.
1733.1 3	12+			F	J^π: γ's to 13−, 11−, and (10+).
1735.49 4	4+			AB G	XREF: G(1733.8). J^π: L(p,t)=4 for even-even nucleus.
1743.902 18	4+			AB G	XREF: G(1742.8). J^π: L(p,t)=4 for even-even nucleus. J^π: (E2) γ to 2+; (E2+M1) γ to 4+; γ's to 1−, 3−, 4−, and 6+.
1750.7 3	0+			G	J^π: L(p,t)=0 for even-even nucleus.
1758.06 20	2+			B G	J^π: L(p,t)=2 for even-even nucleus. J^π: γ's to 1−, (2+), and 3−.

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Adopted Levels, Gammas (continued)

^{228}Th Levels (continued)

E(level)[†]	J^π	L	XREF	Comments
1758.26 *12*	$2^+,3,4^+$		A	J^π: γ's to 2^+ and 4^+ levels.
1760.209 *21*	$2^{(+)},3^{(+)}$		AB	J^π: (E2) γ to 4^+ level, γ to 2^+ level; $\gamma(\theta$,H,T) excludes $J^\pi=4^+$ ^{228}Pa decay; log *ft*=8.13.
1762.6[c] *4*	10^+		F	J^π: γ to 8^+ and 10^+; member of a rotational band.
1795.92 *10*	4^+		A G	J^π: L(p,t)=4 for even-even nucleus.
1796.44 *8*	4^+		B G	J^π: L(p,t)= for even-even nucleus.
1797.67 *8*	2^+		A	J^π: γ's to 0^+ g.s. and 3^- level; log $f^{1u}t$=8.4 for β^- decay from 3^+ ^{228}Ac.
1802.86 *15*	2^+	2	B G	J^π: L(p,t)=2 for even-even nucleus.
1804.672 *18*	4^+		B G	J^π: M1+E2 γ to 3^+ level, M1+E2 γ to 4^+ level, γ to 6^+ level.
1811.56 *15*	$(1^-,2,3^-)$		B	J^π: γ's to 1^- and 3^- levels.
1812.7[g] *4*	(6^+)		G	J^π: L(p,t)=(6^+) for even-even nucleus.
1817.435 *20*	4^-		B	J^π: multiple γ's to 4^-, 2^-, and 5; (E2)+M1 γ to 3^- level; $\gamma(\theta$,H,T) excludes $J^\pi=3^-,5^-$ (log *ft*=7.57 6 1998Wi13).
1823.47 *16*	(4^+)		B G	XREF: G(1826). J^π: L(p,t)=(4) for even-even nucleus.
1838.1[#] *5*	(15^-)		D F	J^π: γ to (13^-) level; band structure.
1842.23 *11*	(2,3)		B G	J^π: γ's to 4^+, $(3)^+$, 2^+, 1^- levels; log *ft*=8.38 for ε decay from 3^+ ^{228}Pa.
1858.6 *5*	(6^+)		G	J^π: L(p,t)=(6^+) for even-even nucleus.
1864.95 *5*	(2^+)		B G	XREF: G(1863.9). J^π: L(p,t)=(2) for even-even nucleus.
1876.46 *22*	$(3^-,4,5^-)$		B	J^π: γ's to 5^- and 3^- levels.
1879.1 *3*	(3^-)		B G	J^π: L(p,t)=(3) for even-even nucleus.
1893.003 *15*	3^+		AB	J^π: E2+M1 γ to 2^+ level, M1+E2 γ to 4^+ level, log *ft*=7.52.
1899.955 *20*	(2^+)	(2)	AB G	J^π: L(p,t)=(2^+) for even-even nucleus.
1901.92[h] *7*	(6^+)	(6)	B G	J^π: L(p,t)=(6) for even-even nucleus.
1906.65 *10*	(2^+)		A	J^π: γ to 0^+ g.s., γ to $2^+,3^-$ level; log *ft*=7.98 from 3^+ ^{228}Ac.
1908.39 *8*	0^+		B G	J^π: L(p,t)=0 for even-even nucleus.
1924.16 *6*	$(2^-,3,4)$		B	J^π: γ to 3^- level; log *ft*=7.90 from 3^+ ^{228}Pa.
1924.64 *9*	$4^+,5^-$		B G	J^π: L(p,t)=4,5 for even-even nucleus.
1925.21 *4*	$3^+,4^+$		B	J^π: M1+E2 γ to 4^+ level, γ to 3^- level; $\gamma(\theta$,H,T) excludes $J^\pi=2^+,3^-$.
1928.49 *5*	3^+		AB	J^π: γ's to 2^+ and 4^+ levels; $\gamma(\theta$,H,T) excludes $J^\pi=2^+,3^-,4^+$.
1937.18 *9*	$2^+,3,4^+$		A	J^π: γ's to 2^+ and 4^+ levels.
1939.07 *9*	(4^+)		B G	J^π: L(p,t)=(4) for even-even nucleus.
1944.904 *11*	3^+		AB	J^π: E2+M1 γ's to 2^+ and 4^+ levels; M1 to 2^+ level.
1945.74 *9*	$4^+,5^-$		B	J^π: γ's to 5^-, 3^-, and 6^+ levels.
1949.73 *10*	(2^+)		B G	XREF: G(1947.8). J^π: L(p,t)=(2) for even-even nucleus.
1958.35 *16*	(2^+)		AB G	J^π: L(p,t)=(2) for even-even nucleus.
1965.05 *8*	(2^+)		B	J^π: γ to 2^+ and 4^+ levels; multiple placed γ to 0^+ g.s., would limit J^π to 2^+.
1974.19 *11*	$(2^+,3^-)$		B G	XREF: G(1971.7). J^π: L(p,t)=(2,3) for even-even nucleus.
1981.90 *5*	(3^-)		B G	J^π: L(p,t)=(3) for even-even nucleus.
1987.47 *10*	4^+		A	J^π: γ's to 2^+ and 6^+ levels.
1987.9[‡] *6*	(16^+)		D F	J^π: γ to (14^+) level; member of g.s. band.
1993.9 *5*	(3^-)		G	J^π: L(p,t)=(3) for even-even nucleus.
2010.15 *5*	(2^+)		AB G	J^π: L(p,t)=(2) for even-even nucleus.
2013.6 *3*	$2^+,3,4^+$		A	J^π: γ's to 2^+ and 4^+ levels.
2016.75 *9*	$(4^+,5^-)$		B	J^π: (M1+E2) γ to 3^-.
2022.82 *8*	(2^+)		AB	J^π: Multiple γ to 2^+ level, and γ's to 0^+, $(3)^+$ levels.
2030.40 *11*	2^+		A G	J^π: L(p,t)=2 for even-even nucleus.
2037.01 *17*	$2^+,3,4^+$		A	J^π: γ's to 2^+ and 4^+ levels.
2044.7 *5*	0^+		G	J^π: L(p,t)=0 for even-even nucleus.
2052.1 *4*	(6^+)		G	J^π: L(p,t)=(6) for even-even nucleus.
2069.6 *5*	2^+		G	J^π: L(p,t)=2 for even-even nucleus.
2079.9 *5*	0^+		G	J^π: L(p,t)=0 for even-even nucleus.

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Adopted Levels, Gammas (continued)

^{228}Th Levels (continued)

E(level)[†]	J^π	XREF	Comments
2091.2 *7*	(6^+)	G	J^π: L(p,t)=(6) for even-even nucleus.
2111.6 *5*	(2^+)	G	J^π: L(p,t)=(2) for even-even nucleus.
2123.1 *3*	(2^+)	A	E(level): the level may be questionable, Q(β^-)(^{228}Ac)=2127 *3*. J^π: γ's to 4^+ and 1^- levels; log *ft*=4.9 *5* indicates an allowed transition.
2131.3 *6*	0^+	G	J^π: L(p,t)=0 for even-even nucleus.
2152.8 *4*	(4^+)	G	J^π: L(p,t)=(4) for even-even nucleus.
2159.4 *5*	0^+	G	J^π: L(p,t)=0 for even-even nucleus.
2170.3 *4*	(2^+)	G	J^π: L(p,t)=(2) for even-even nucleus.
2198.2 *4*	2^+	G	J^π: L(p,t)=2 for even-even nucleus.
2209.5[#] *6*	(17^-)	D F	J^π: γ to (15^-) level; band structure.
2215.9 *4*	(4^+)	G	J^π: L(p,t)=(4) for even-even nucleus.
2235.2 *7*	(4^+)	G	J^π: L(p,t)=(4) for even-even nucleus.
2290.0 *7*	0^+	G	J^π: L(p,t)=0 for even-even nucleus.
2302.9 *5*	(4^+)	G	J^π: L(p,t)=(4) for even-even nucleus.
2323.2 *5*	2^+	G	J^π: L(p,t)=2 for even-even nucleus.
2335.9	(4^+,0^+)	G	J^π: L(p,t)=(4,0) for even-even nucleus.
2344.2 *5*	(3^-)	G	J^π: L(p,t)=(3) for even-even nucleus.
2356.2 *5*	(2^+)	G	J^π: L(p,t)=(2) for even-even nucleus.
2375.5 *8*	(2^+)	G	J^π: L(p,t)=(2) for even-even nucleus.
2398.3 *9*	(3^-)	G	J^π: L(p,t)=(3) for even-even nucleus.
2400.5[‡] *8*	(18^+)	D	J^π: γ to (16^+); member of g.s. band. E(level): 2407.9 in (α,2nγ) with Eγ=419.9 to (16^+).
2408.8 *9*	(4^+)	G	J^π: L(p,t)=(4) for even-even nucleus.
2441.7 *5*	(2^+)	G	J^π: L(p,t)=(2) for even-even nucleus.
2456.8 *5*	0^+	G	J^π: L(p,t)=0 for even-even nucleus.
2476.8 *5*	(2^+)	G	J^π: L(p,t)=(2) for even-even nucleus.
2494.1 *5*	(2^+)	G	J^π: L(p,t)=(2) for even-even nucleus.
2513.5 *7*		G	
2531.5 *7*		G	
2536.8 *9*		G	
2542.4 *9*		G	
2554.5 *5*		G	
2566.3 *6*		G	
2595.4 *5*		G	
2606.1 *5*		G	
2608.4?[#]	(19^-)	D	J^π: γ to (17^-); member of a rotational band.
2615.1 *9*		G	
2634.8 *5*		G	
2644.0 *3*		G	
2657.1 *4*		G	
2660.1 *5*		G	
2667.1 *5*		G	
2676.0 *6*		G	
2688.4 *4*		G	
2695.6 *7*		G	
2705.5 *5*		G	
2718.4 *5*		G	
2742.3 *4*		G	
2763.7 *4*		G	
2781.4 *5*		G	
2798.6 *8*		G	
2805.6 *7*		G	
2821.0 *5*		G	
2834.4?[‡]	(20^+)	D	J^π: γ to (18^+); member of a rotational band.
2839.3 *6*		G	

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

^{228}Th Levels (continued)

E(level)†	Jπ	XREF	Comments
2853.7 *5*		G	
2868.1 *5*		G	
2877.5 *8*		G	
2883.7 *9*		G	
2918.8 *6*		G	
2927.4 *5*		G	
2936.8 *9*		G	
2945.3 *9*		G	
2955.1 *8*		G	
2993.1 *12*		G	
2999.5 *10*		G	
3014.3 *11*		G	
3035.6 *9*		G	
3046.4 *6*		G	
3059.2 *5*		G	
3075.2 *5*		G	
3085.2 *8*		G	
3097.0 *6*		G	
3104.7 *6*		G	
3112.7 *11*		G	
3119.9 *9*		G	
3128.2 *10*		G	
3158.8 *8*		G	
3165.7 *6*		G	
3186.0 *6*		G	
3195.2 *6*		G	
3209.6 *12*		G	
3214.8 *9*		G	
3225.0 *20*		G	
3232.9 *13*		G	
3239.9 *8*		G	
3283.4?‡	(22^+)	D	J^π: γ to (20^+); member of a rotational band.

† From least squares fit to Eγ.
‡ Band(A): g.s. rotational band.
# Band(B): $K^\pi=0^-$ octupole-vibrational band.
@ Band(C): first $K^\pi=0^+$ band.
& Band(D): second $K^\pi=0^+$ band.
[a] Band(E): third $K^\pi=0^+$ band.
[b] Band(F): $K^\pi=1^-$ octupole-vibrational.
[c] Band(G): first $K^\pi=2^+$ band.
[d] Band(H): $K^\pi=2^-$ octupole-vibrational band.
[e] Band(I): second $K^\pi=2^+$ band.
[f] Band(J): $K^\pi=3^-$ octupole-vibrational band head.
[g] Band(K): $K^\pi=4^+$ band.
[h] Band(L): $K^\pi=6^+$ band.

$\gamma(^{228}Th)$

E_i(level)	J^π_i	E_γ[†]	I_γ[†]	E_f	J^π_f	Mult.[‡]	δ[‡]	α[h]	$I_{(\gamma+ce)}$	Comments
57.773	2^+	57.766[a] *5*	100	0.0	0^+	E2		153 *2*		B(E2)(W.u.)=167 *6* Mult.: also from ^{232}U α decay.
186.838	4^+	129.065[a] *1*	100	57.773	2^+	E2		3.74 *6*		B(E2)(W.u.)=242 *9* Mult.: also from (α,α'2nγ).
328.019	1^-	270.245[a] *2*	100.0[&] *16*	57.773	2^+	E1		0.0470 *7*		
		328.022[a] *3*	88.3[&] *7*	0.0	0^+	E1		0.0305 *5*		
378.195	6^+	191.349[a] *17*	100 *8*	186.838	4^+	E2		0.776 *11*		Mult.: also from (α,α'2nγ).
396.094	3^-	68.08	≤0.05	328.019	1^-	[E2]				
		209.253[a] *6*	34.2 *6*	186.838	4^+	E1		0.0848 *12*		
		338.320[a] *3*	100.0 *17*	57.773	2^+	E1		0.0285 *4*		
519.208	5^-	141.01 *2*	9.90 *6*	378.195	6^+	E1		0.217 *3*		
		332.370[a] *4*	100 *5*	186.838	4^+	E1		0.0297 *5*		
622.5	8^+	244.3 *10*	100	378.195	6^+	E2		0.326 *5*		Mult.: from (α,α'2nγ).
695.45	7^-	317.2[@] *2*	[@]	378.195	6^+	[E1]				
831.842	0^+	503.823 *13*	100 *5*	328.019	1^-	(E1)		0.0124 *2*		
		774.05 *14*	32 *5*	57.773	2^+					
		831	<0.5	0.0	0^+	E0			0.04 *2*	E_γ,Mult.,$I_{(\gamma+ce)}$: from ^{232}U α decay.
874.535	2^+	478.40 *6*	100 *5*	396.094	3^-	E1		0.0138 *2*		
		546.45 *2*	90 *4*	328.019	1^-	[E1]				
		688.10[id] *5*	25[i] *8*	186.838	4^+	[E2]				
		816.62 *10*	12.3 *20*	57.773	2^+	[M1+E2]				
		874.45 *6*	23 *3*	0.0	0^+	[E2]				
911.8	(10^+)	289.3[b] *2*	100	622.5	8^+					
920.77	9^-	225.23[b] *26*	24.6[b] *15*	695.45	7^-					
		298.3[b] *26*	100[b] *7*	622.5	8^+					
938.61	0^+	610.65 *9*	100 *22*	328.019	1^-	[E1]				
		880.76[a] *10*	27[a] *8*	57.773	2^+	[E2]				
944.205	1^-	547.8[@] *2*	15[@] *4*	396.094	3^-					
		616.21 *2*	100[@] *8*	328.019	1^-	(M1+E2)	+1.5 *5*	0.055 *18*		
		886.44[@]	≤3.7[@]	57.773	2^+					
		944.196 *14*	100[@] *8*	0.0	0^+					
968.381	2^-	572.23 *8*	100 *11*	396.094	3^-					
		640.34 *3*	39 *8*	328.019	1^-	[E2]				
		910.6[@] *1*	98[@] *9*	57.773	2^+					
968.451	4^+	449.23[@] *3*	58[@] *6*	519.208	5^-					
		572.3[@] *1*	100[@] *10*	396.094	3^-					
		590.1[@] *3*	1.5[@] *5*	378.195	6^+					
		781.9[@] *3*	13[@] *3*	186.838	4^+					

$^{228}_{90}Th_{138}$-7

γ(^{228}Th) (continued)

E_i(level)	J^π_i	E_γ[†]	I_γ[†]	E_f	J^π_f	Mult.[‡]	δ[‡]	α[h]	Comments
968.451	4^+	910.7[@] *1*	46[@] *8*	57.773	2^+				
968.984	2^+	782.140 *5*	1.84 *11*	186.838	4^+	[E2]			
		911.204 *4*	100 *2*	57.773	2^+	E2+M1	+24 *8*	0.0120 *2*	
		968.974 *17*	61.3 *10*	0.0	0^+	E2		0.0106 *2*	
979.522	2^+	583.41 *5*	100[ga] *8*	396.094	3^-	[E1]			
		651.48 *5*	81[ga] *7*	328.019	1^-	[E1]			
		792.74	≈73[a]	186.838	4^+	[E2]			
		921.94[c] *11*	13.2[a] *19*	57.773	2^+	[M1,E2]			Doubly placed γ with undivided intensity (Iγ=16.3 *23*) in ^{228}Ac decay.
		979.46[a] *10*	23[a] *3*	0.0	0^+				
1016.386	3^-	497.0[@#]	36[@] *8*	519.208	5^-				
		620.33 *6*	28.4 *13*	396.094	3^-				
		688.11[i] *4*	24.0[i] *15*	328.019	1^-				
		829.55[#@]	≤28[@]	186.838	4^+				
		958.62 *4*	100 *12*	57.773	2^+				
		1016.44[ia] *15*	6.8[ia] *11*	0.0	0^+				
1022.542	$(3)^+$	835.701 *15*	33.1 *10*	186.838	4^+	E2		0.0142 *2*	Mult.: δ≤−9 (^{228}Pa decay).
		964.777[a] *11*	100.0 *18*	57.773	2^+	E2+M1	−7.2 *10*	0.0112 *2*	
1059.928	4^-	540.68 *5*	58 *10*	519.208	5^-	[M1,E2]			
		663.88 *6*	87 *7*	396.094	3^-	(M1+E2)		0.06 *4*	
		873.11 *12*	100 *10*	186.838	4^+	[E1]			
1074.80	4^+	555.5[@] *1*	100[@] *11*	519.208	5^-				
		678.6[@] *2*	90[@] *11*	396.094	3^-				
		697.1[@] *4*	16[@] *4*	378.195	6^+				
		887.9[@] *3*	26[@] *5*	186.838	4^+				
		1017.0[@] *3*	37[@] *5*	57.773	2^+				
1091.048	4^+	571.8[#@] *2*	2.3[@] *8*	519.208	5^-				
		694.8[#@] *2*	2.9[@] *4*	396.094	3^-				
		713.1[#@] *3*	1.8[@] *4*	378.195	6^+				
		904.19 *3*	100 *4*	186.838	4^+	E2		0.0121 *2*	δ: ≥+3.7 (^{228}Pa decay).
		1033.25[b] *9*	26.9[b] *7*	57.773	2^+	E2		0.0094 *1*	
1105.38	6^+	409.9[b] *2*	89[b] *11*	695.45	7^-				
		586.4[b] *2*	100[b] *44*	519.208	5^-				
		918.1[b] *3*	83[b] *11*	186.838	4^+				
1119.7	0^+	1062.4[@k] *1*	100[@]	57.773	2^+				
1122.959	2^-	100.41[a] *3*	2.2[a] *3*	1022.542	$(3)^+$	(E1+M2)	≈0.23	≈3.10	
		153.962[a] *9*	16.8 *4*	968.984	2^+	E1		0.1757 *25*	
		178.7[@] *2*	2.0[@] *9*	944.205	1^-				

$^{228}_{90}Th_{138}$-8

γ(^{228}Th) (continued)

E_i(level)	J^π_i	E_γ†	I_γ†	E_f	J^π_f	Mult.‡	δ‡	α[h]	Comments
1122.959	2⁻	726.864[a] 5	13.6 17	396.094	3⁻	(E2)		0.0187 3	
		794.948[a] 5	100.0 17	328.019	1⁻	E2+M1	−4.4 10	0.0179 14	
		1065.19 4	3.04 15	57.773	2⁺				
1143.16	5⁻	624.0[@] 2	47[@] 13	519.208	5⁻				
		747.0[@] 4	30[@] 10	396.094	3⁻				
		764.5[@] 3	17[@] 7	378.195	6⁺				
		956.6[@] 2	100[@] 33	186.838	4⁺				
1153.487	2⁺	173.964 13	15.5 22	979.522	2⁺	M1+E2	1.2 +11−6	2.2 9	B(M1)(W.u.)=4.E−5 +6−4; B(E2)(W.u.)=0.6 +7−6
		184.54[a] 2	31[a] 4	968.984	2⁺	E0+M1		63 8	B(M1)(W.u.)=1.2×10⁻⁴ 3 α(K)exp, L1/L2, L1/L3 indicate E0+5.4%M1 transition (^{228}Ac β^- decay).
		214.9 2		938.61	0⁺				I_γ: Unresolved doublet in ^{228}Ac β^- decay.
		278.70[j] 10	71[j] 9	874.535	2⁺	(M1+E2)		0.6 5	
		321.646[a] 8	100 5	831.842	0⁺	[E2]		0.137 2	B(E2)(W.u.)=0.29 5
		1095.679[a] 20	55 4	57.773	2⁺	[M1,E2]		0.017 9	
		1153.52 4	61 4	0.0	0⁺	[E2]			B(E2)(W.u.)=0.00030 6
1168.389	3⁻	77.34[a] 3	1.70 24	1091.048	4⁺				
		145.84[a] 1	10.4 4	1022.542	(3)⁺	E1		0.200 3	
		199.41[a] 1	20.83[a] 28	968.984	2⁺	E1		0.0950 14	
		199.8[#@] 2	0.7[@] 2	968.451	4⁺				
		224.0[#@] 2	6.8[@] 24	944.205	1⁻				
		649.03[i] 13	2.35[i] 23	519.208	5⁻				
		772.29[a] 1	100.0 19	396.094	3⁻	E2+M1	−3.4 +8−27	0.021 3	
		840.38[a] 1	62.0 20	328.019	1⁻	E2		0.0140 2	
		981.5[@#] 2	3.0[@] 4	186.838	4⁺				
		1110.61[ja] 1	18.9[j] 12	57.773	2⁺	E1		0.00288 4	
1174.515	(5⁺)	796.2 1	48 9	378.195	6⁺				
		987.70 7	100 12	186.838	4⁺				
1175.41	2⁺	231.42[a] 10	≤2[@]	944.205	1⁻				
		779.5[#@] 6	6[@] 3	396.094	3⁻				
		847.1[#@] 4	5[@] 2	328.019	1⁻				
		988.45 9	100 10	186.838	4⁺				
		1117.56 13	44[@] 5	57.773	2⁺				
		1175.33 9	23[@] 5	0.0	0⁺				
1189.8	11⁻	268.9[b] 3	67[b] 5	920.77	9⁻				
		278.2[b] 3	100[b]	911.8	(10⁺)				
1200.60	3⁽⁺⁾	178.14[@] 7	≤8[@]	1022.542	(3)⁺	(E0)			
		231.50[@] 5	36[@] 2	968.984	2⁺	[M1+E2]			

$^{228}_{90}$Th$_{138}$-9

γ(^{228}Th) (continued)

E_i(level)	J^π_i	E_γ[†]	I_γ[†]	E_f	J^π_f	Mult.[‡]	δ[‡]	α[h]	Comments
1200.60	$3^{(+)}$	326.1 3	100 24	874.535	2^+				
		1013.54[i@] 13	11[i@] 2	186.838	4^+	[M1+E2]			
		1142.78[@]	4.0[@] 12	57.773	2^+	[M1+E2]			
1226.580	4^-	135.51 2	3.4 5	1091.048	4^+	E1		0.238 4	
		204.031[a] 10	21 3	1022.542	$(3)^+$	E1		0.0900 13	
		258.1[j#@] 2	4.1[j@] 2	968.451	4^+				
		258.1[j#@] 2	4.1[j@] 2	968.381	2^-				
		282.37[#@k]		944.205	1^-				
		707.40 3	27.5 13	519.208	5^-	(E2)		0.0198 3	
		830.486[a] 8	100 4	396.094	3^-	E2(+M1)	−7.7 9	0.0150 3	
		1039.84 8	10.0 5	186.838	4^+				
1239.3	(12^+)	327.3[b] 4	100	911.8	(10^+)				
1261.57	4^+	170.6[@] 2	36[@] 7	1091.048	4^+				
		239.1[@] 3	54[@] 14	1022.542	$(3)^+$				
		292.5[@]	≤36[@]	968.984	2^+				
		293.1[@] 2	46[@] 11	968.451	4^+				
		387.0[@] 3	32[@] 11	874.535	2^+				
		883.4[@] 3	39[@] 11	378.195	6^+				
		1074.7[@] 3	100[@] 18	186.838	4^+				
		1204.1[@] 3	82[@] 11	57.773	2^+				
1270.08	6^+	891.8 2	100 8	378.195	6^+				
		1083.2		186.838	4^+				I_γ: Weak γ-ray.
1280.41	8^+	359.6[b] 2	30[b] 10	920.77	9^-				
		585.0[b] 2	100[b] 30	695.45	7^-				
		902.3[b]	[b]	378.195	6^+				I_γ: γ-ray peak is masked.
1290.07	4^+	911.7[@] 1	100[@] 50	378.195	6^+				
		1103.4[@] 1	55[@] 5	186.838	4^+				
1297.435	(5^-)	206.3[#@] 1	100[@] 14	1091.048	4^+				
		602.0[i#@k]	≤40[i@]	695.45	7^-				
		778.1[@] 2	54[@] 6	519.208	5^-				
		901.26 13	45[@] 12	396.094	3^-				
		1110.61[j] 1	48[j@] 4	186.838	4^+	E1		0.00288 4	
1344.142	3^-	168.62 9	10 3	1175.41	2^+				
		824.94 2	48 5	519.208	5^-				
		947.98[a] 11	100[a] 8	396.094	3^-				
		1016.44[ia] 15	18[ia] 3	328.019	1^-				
		1157.14[a] 15	6.6[a] 12	186.838	4^+				

γ(^{228}Th) (continued)

E_i(level)	J^π_i	E_γ[†]	I_γ[†]	E_f	J^π_f	Mult.[‡]	δ[‡]	α[h]
1344.142	3⁻	1286.27[a] *20*	47[a] *9*	57.773	2⁺			
1379.5	7⁺	756.9[b] *3*	50[b] *19*	622.5	8⁺			
		1001.3[b] *3*	100[b] *13*	378.195	6⁺			
1393.31	(1⁺,2,3⁻)	425.0[@] *2*	64[@] *12*	968.451	4⁺			
		449.2[@] *1*	100[@] *31*	944.205	1⁻			
		1065.4[@] *4*	44[@] *16*	328.019	1⁻			
1416.10	(3⁻)	399.8[#@] *2*	90[@] *10*	1016.386	3⁻			
		447.8[#@] *2*	33[@] *3*	968.451	4⁺			
		471.77[a] *12*	100[a] *9*	944.205	1⁻			
		1019.86[a] *10*	64[a] *12*	396.094	3⁻			
		1088.18[a] *15*	18[a] *4*	328.019	1⁻			
		1229.40[a] *15*	90[a] *10*	186.838	4⁺			
		1358.3[#@]	87[@] *13*	57.773	2⁺			
1431.994	4⁺	134.9[#@] *2*	0.89[@] *4*	1297.435	(5⁻)			
		161.6[#@] *4*	0.36[@] *13*	1270.08	6⁺			
		231.4[#@] *1*	3.7[@] *2*	1200.60	3$^{(+)}$			
		257.49[@] *2*	0.64 *3*	1174.515	(5⁺)	(M1)		1.285 *18*
		263.62[@] *2*	0.96 *4*	1168.389	3⁻	E1		0.0497 *7*
		278.70[j] *10*	0.71[j] *7*	1153.487	2⁺			
		340.98[@] *2*	8.8 *4*	1091.048	4⁺	E2+M1	−5.2 *18*	0.133 *21*
		357.1[#@] *2*	1.65[@] *18*	1074.80	4⁺			
		372.2[#@] *2*	0.4[@] *1*	1059.928	4⁻			
		409.461 *6*	43.7 *8*	1022.542	(3)⁺	E2+M1	−5.4 *8*	0.080 *4*
		415.6[#@] *1*	2.1[@] *2*	1016.386	3⁻			
		452.51 *5*	0.45 *4*	979.522	2⁺			
		463.005 *6*	100.0[a] *16*	968.984	2⁺	E2		0.0514 *8*
		463.3[#@] *1*	7.1[@] *18*	968.451	4⁺			
		557.4[#@] *1*	2.5[@] *3*	874.535	2⁺			
		1053.8[#@] *1*	≈0.002[@]	378.195	6⁺			
		1103.41[ca] *10*	0.34[a] *11*	328.019	1⁻			
		1245.16 *6*	2.21 *12*	186.838	4⁺			
		1374.24 *6*	0.32[a] *9*	57.773	2⁺			
1448.92	3,4⁻	389.1[@] *1*	100[@]	1059.928	4⁻			
		432.5[@] *3*	≤75[@]	1016.386	3⁻			
		480.6[@] *2*	≤75[@]	968.451	4⁺			
		1052.7[@@] *2*	≤75[@@]	396.094	3⁻			
		1261.7 *4*	≤38	186.838	4⁺			

$^{228}_{90}Th_{138}$-11

γ(^{228}Th) (continued)

E_i(level)	J^π_i	E_γ[†]	I_γ[†]	E_f	J^π_f	Mult.[‡]	δ[‡]	α[h]	Comments
1450.402	4⁻	18.4	11.9[@] *16*	1431.994	4⁺	[E1]		6.47 *9*	E_γ: deduced from E(level).
		153.02[@#] *2*	3.58[@] *19*	1297.435	(5⁻)	M1+E2	+0.60 *8*	4.56 *21*	
		223.80[@] *2*	43.4 *20*	1226.580	4⁻	M1+E2	−0.18 *5*	1.85 *4*	
		275.85[@] *4*	2.6[@] *13*	1174.515	(5⁺)				
		282.01 *2*	60.0[a] *16*	1168.389	3⁻	M1+E2	−0.51 *12*	0.83 *7*	
		327.45[@] *4*	100 *10*	1122.959	2⁻				
		359.36[@#] *3*	4.19[@] *23*	1091.048	4⁺				
		390.45[@#] *5*	3.58[@] *19*	1059.928	4⁻				
		427.90[@#] *3*	4.0[@] *3*	1022.542	(3)⁺				
		434.01[@#@] *3*	5.6[@] *3*	1016.386	3⁻				
		481.5 *6*	6.0 *13*	968.381	2⁻				E_γ: Unweighted avg. Weighted avg.= 481.97 *26* with chi-squared=28.
		931.0 *1*	11.0 *13*	519.208	5⁻				
		1054.22 *5*	10.9 *10*	396.094	3⁻				
1490.2	10⁺	300.6[b] *3*	33[b] *13*	1189.8	11⁻				
		569.5[b] *2*	100[b] *13*	920.77	9⁻				
		867.1[b] *5*	14[b] *4*	622.5	8⁺				
1497.0	(13⁻)	257.6[b] *3*	52[b] *4*	1239.3	(12⁺)				
		307.2[b] *3*	100[b]	1189.8	11⁻				
1497.2	8⁺	874.7[b] *3*	100[b] *15*	622.5	8⁺				
		1119.1[b]	[b]	378.195	6⁺				I_γ: Weak γ-ray.
1497.70	(5⁻)	354.5[@] *2*	≈21[@]	1143.16	5⁻				
		481.4[@] *2*	69[@] *19*	1016.386	3⁻				
		529.0[@] *2*	10[@] *4*	968.984	2⁺				
		978.3[@] *3*	33[@] *12*	519.208	5⁻				
		1119.5[@] *3*	21[@] *8*	378.195	6⁺				
		1310.8[@] *1*	100[@] *10*	186.838	4⁺				
1531.490	0⁺&3⁺	99.509[a] *6*	100 *6*	1431.994	4⁺	M1		4.09	
		356.94[a] *10*	1.35[a] *14*	1174.515	(5⁺)				
		377.99[a] *10*	2.00[a] *18*	1153.487	2⁺				
		440.44[a] *5*	9.6[a] *6*	1091.048	4⁺	M1		0.295 *5*	
		508.97 *4*	40 *10*	1022.542	(3)⁺	E2(+M1)	>1.1	0.08 *4*	
		562.500[a] *4*	71 *4*	968.984	2⁺	E2+M1	+1.6 *6*	0.07 *3*	
		1135.24[a] *15*	0.8[a] *1*	396.094	3⁻				
		1344.59[a] *15*	0.7[a] *1*	186.838	4⁺				
1539.21	2⁺	416.30[a] *20*	100[a] *16*	1122.959	2⁻				
		1142.85[a] *15*	7.8[a] *16*	396.094	3⁻				

$^{228}_{90}$Th$_{138}$-12

γ(²²⁸Th) (continued)

E_i(level)	J^π_i	E_γ[†]	I_γ[†]	E_f	J^π_f	Mult.[‡]	δ[‡]	α[h]	Comments
1580.92	(2⁻)	354.2[i@] 2	43[i@] 7	1226.580	4⁻				
		601.7[i@] 3	44[i@] 7	979.522	2⁺				
		1184.71[@] 9	69[@] 6	396.094	3⁻	(M1+E2)	1.29	0.014 7	
		1252.98[@] 10	100[@] 9	328.019	1⁻	(M1+E2)	1.115	0.012 6	
		1523.4[i@] 2	88[i@] 9	57.773	2⁺				
1588.347	(4⁻)	56.86[@] 3	8.8[@] 4	1531.490	0⁺&3⁺	E1		0.524 8	
		137.95[@] 2	55[@] 2	1450.402	4⁻	M1		7.44 11	
		156.34[@] 2	11.3[@] 22	1431.994	4⁺	E1		0.169 2	
		420.03[@] 8	5.7[@] 4	1168.389	3⁻				
		465.4[@] 1	100[@] 17	1122.959	2⁻				
		528.5[@] 2	7.5[@] 17	1059.928	4⁻				
1599.4	(14⁺)	360.1[b] 3		1239.3	(12⁺)				
1617.80	4⁺	649.03[i] 13	100[i] 9	968.984	2⁺				
		1430.95[a] 10	72 13	186.838	4⁺				
		1559.78 14	38[a] 6	57.773	2⁺				
1627.8	(9⁺)	715.9[b] 3	38[b] 8	911.8	(10⁺)				
		1005.4[b] 3	100[b] 15	622.5	8⁺				
1638.284	2⁺	470.20 19	2.3 5	1168.389	3⁻				
		515.12 7	10 4	1122.959	2⁻				
		1309.71[a] 20	3.2[a] 9	328.019	1⁻				
		1451.40[a] 15	1.80 28	186.838	4⁺				
		1580.53 3	100 6	57.773	2⁺	(M1,E2)			
		1638.28[a] 1	85 7	0.0	0⁺	(E2)			
1643.131	(2⁻,3⁻)	299.0[#@] 2	16[@] 8	1344.142	3⁻				
		416.5[#@] 1	≤33[@]	1226.580	4⁻				
		474.75[a] 10	4.6[a] 10	1168.389	3⁻				
		520.152[a] 16	12.5 10	1122.959	2⁻	(M1)		0.189 3	
		583.2[#@]	15[@] 4	1059.928	4⁻				
		626.81 21	2.8 4	1016.386	3⁻				
		674.16[fa]	≤21[a@]	968.984	2⁺				E_γ: from level energies.
		674.7[f] 2	7.7[@] 11	968.381	2⁻				E_γ: from level energies.
		698.96 8	7.5 7	944.205	1⁻				
		1247.08 3	100 5	396.094	3⁻	(M1)		0.0187 3	
		1315.31 9	2.46 19	328.019	1⁻				
1643.82	4⁺	442.9[@] 3	4[@] 2	1200.60	3⁽⁺⁾				
		490.4[@] 2	32.8[@] 16	1153.487	2⁺				
		552.9[@] 2	7.2[@] 16	1091.048	4⁺				

$^{228}_{90}Th_{138}$-13

Adopted Levels, Gammas (continued)

γ(^{228}Th) (continued)

E_i(level)	J^π_i	E_γ[†]	I_γ[†]	E_f	J^π_f	Mult.[‡]	δ[‡]	α[h]	Comments
1643.82	4+	621.4[@] *1*	37[@] *4*	1022.542	(3)+				
		674.7[@] *1*	100[@] *12*	968.984	2+				
1646.003	3+	114.54 *6*	0.28 *4*	1531.490	0+&3+				
		229.9[#@] *4*	4.3[@] *18*	1416.10	(3−)				
		419.40 *9*	0.65 *10*	1226.580	4−				
		444.9[#@] *3*	2.7[@] *13*	1200.60	3(+)				
		470.6[#@k] *2*	3.2[@] *13*	1175.41	2+				
		477.5[#@] *1*	9.1[@] *13*	1168.389	3−				
		492.30 *7*	0.74 *5*	1153.487	2+				
		523.132[ca] *16*	3.5 *3*	1122.959	2−				
		555.10 *16*	1.40 *14*	1091.048	4+				
		571.1[#@] *1*	15[@]	1074.80	4+				
		586.2[#@] *2*	3.2[@] *8*	1059.928	4−				
		623.48 *22*	0.45 *25*	1022.542	(3)+				
		629.40[c] *5*	1.24 *20*	1016.386	3−				
		666.47[j] *4*	1.77[j] *16*	979.522	2+				
		677.07 *9*	1.99 *16*	968.984	2+				
		1249.97 *14*	1.93 *17*	396.094	3−				
		1459.14 *2*	23.7 *12*	186.838	4+	E2			
		1588.19 *3*	100.0 *25*	57.773	2+	E2			
1667.38	2+	1148.2[@] *2*	42[@] *24*	519.208	5−				
		1480.5[@] *2*	100[@] *28*	186.838	4+				
1678.42	2+	503.0[@k] *2*	1.3[@] *4*	1175.41	2+				
		803.8[@] *2*	1.7[@] *9*	874.535	2+				
		1282.6[@] *4*	2.0[@] *6*	396.094	3−				
		1620.67[@] *10*	100[@] *4*	57.773	2+				
1682.81	(2+,3+,4+)	660.1[a] *3*	≈0.58[a]	1022.542	(3)+				
		1286.3[#@]	91[@] *29*	396.094	3−				
		1496.03[c] *12*	100 *5*	186.838	4+	(E2)			E_γ: Unweighted avg. Weighted avg.=1495.93 *7* with chi-squared=14.4.
		1625.06[c] *5*	29.1 *19*	57.773	2+				
1683.80	(4−)	457.35 *7*	19.1 *19*	1226.580	4−				
		515.1[#@] *2*	23[@] *4*	1168.389	3−				
		623.7[@#] *2*	23[@] *4*	1059.928	4−				γ not resolved from the 623.27γ from 1645 level in ^{228}Pa decay, I(doublet)=23 *3*. Not reported in ^{228}Ac decay.
		667.5[#@] *3*	103[@] *32*	1016.386	3−				
		1164.55 *4*	83 *5*	519.208	5−	(M1+E2)	1.09	0.015 *8*	

Adopted Levels, Gammas (continued)

$\gamma(^{228}Th)$ (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[‡]	δ[‡]	α[h]
1683.80	(4⁻)	1287.77 *8*	100 *7*	396.094	3⁻	(M1+E2)	0.91	0.012 *6*
1688.408	2⁺,3⁺	42.46[a] *5*	0.61 *15*	1646.003	3⁺			
		672.00[a] *15*	1.7[a] *5*	1016.386	3⁻			
		813.77[a] *15*	0.46 *11*	874.535	2⁺			
		1501.57[a] *5*	29.4 *15*	186.838	4⁺			
		1630.627[a] *10*	100.0[a] *26*	57.773	2⁺	(M1,E2)		0.007 *3*
1707.29	(2,3⁻)	1311.6[@] *4*	26[@] *10*	396.094	3⁻			
		1379.2[@] *2*	100[@] *48*	328.019	1⁻			
1724.299	2⁺	308.2[@#] *2*	23[@]	1416.10	(3⁻)			
		497.49[a] *15*	[a]	1226.580	4⁻			
		523.5[#@] *1*	26[@] *5*	1200.60	3⁽⁺⁾			
		548.74 *9*	2.20 *21*	1175.41	2⁺			
		570.88 *4*	17.2 *8*	1153.487	2⁺	(M1)		0.147 *2*
		701.744 *14*	18.1 *9*	1022.542	(3)⁺	(M1)		0.0850 *1*
		755.315[a] *4*	100 *3*	968.984	2⁺	M1		0.070 *1*
		780.2[a#@] *3*	5.1[@] *13*	944.205	1⁻			
		849.5[#@] *2*	5.1[@] *20*	874.535	2⁺			
		1537.87[c] *10*	4.2 *5*	186.838	4⁺			
		1666.522 *6*	17.3 *7*	57.773	2⁺	M1		0.0090 *1*
		1724.20 *4*	2.75 *3*	0.0	0⁺			
1733.1	12⁺	236.0[b] *3*	25[b] *8*	1497.0	(13⁻)			
		543.3[b] *2*	100[b] *17*	1189.8	11⁻			
		821.6[b] *4*	15[b] *11*	911.8	(10⁺)			
1735.49	4⁺	1217.03[cak] *10*	39[a] *6*	519.208	5⁻			
		1357.78[cak] *15*	37[a] *7*	378.195	6⁺			
		1548.65 *4*	68 *7*	186.838	4⁺			
		1677.7 *6*	100 *8*	57.773	2⁺			
1743.902	4⁺	399.84[e] *15*	16.3 *17*	1344.142	3⁻			
		590.40[@] *11*	9.40 *11*	1153.487	2⁺			
		683.97[@] *3*	10.6 *3*	1059.928	4⁻			
		727.2[@#] *3*	16[@] *5*	1016.386	3⁻			
		764.3[@#] *3*	27[@] *11*	979.522	2⁺			
		1347.52[a] *16*	8.4 *17*	396.094	3⁻			
		1365.71 *2*	9.0 *4*	378.195	6⁺			
		1415.69 *10*	19 *5*	328.019	1⁻			
		1557.09 *4*	100.0 *17*	186.838	4⁺	(E2+M1)	+1.2 *2*	0.007 *1*
		1686.12 *7*	54 *3*	57.773	2⁺	(E2)		0.0039 *1*
1758.06	2⁺	741.9[@] *3*	74[@] *26*	1016.386	3⁻			

$^{228}_{90}Th_{138}$-15

γ(^{228}Th) (continued)

E$_i$(level)	J$^\pi_i$	E$_\gamma$[†]	I$_\gamma$[†]	E$_f$	J$^\pi_f$	Mult.[‡]	δ[‡]	α[h]	Comments
1758.06	2+	1361.4[@] 5	63[@] 26	396.094	3−				
		1430.0[@] 3	100[@] 37	328.019	1−				
1758.26	2+,3,4+	326.04[a] 20	100[a] 15	1431.994	4+				
		1571.52[a] 20	17[a] 5	186.838	4+				
		1700.59[a] 20	31[a] 7	57.773	2+				
1760.209	2(+),3(+)	416.15[@#]	22.3[@] 23	1344.142	3−				
		585.03[i#@]	10[i@] 3	1175.41	2+				
		668.9[#@] 2	100[@] 12	1091.048	4+				
		737.72 5	49 21	1022.542	(3)+				
		791.44[j] 9	11[j] 4	968.984	2+				
		1573.26 5	39 15	186.838	4+	(E2)		0.0044 1	
		1702.43 3	62 19	57.773	2+				
1762.6	10+	850.8[b] 3	100[b] 50	911.8	(10+)				
		1140.2[b]	[b]	622.5	8+				I$_\gamma$: Weak γ-ray.
1795.92	4+	1276.69[a] 10	78[a] 17	519.208	5−				
		1738.22[a] 25	100[a] 22	57.773	2+				
1796.44	4+	621.9[@] 2	17[@] 5	1174.515	(5+)				
		705.3[@] 2	65[@] 22	1091.048	4+				
		1609.6[@] 1	100[@] 8	186.838	4+				
1797.67	2+	1401.49[a] 10	60[a] 15	396.094	3−				
		1469.71[a] 15	100[a] 20	328.019	1−				
		1740.4[a] 3	55[a] 15	57.773	2+				
		1797.5[a] 5	10[a] 4	0.0	0+				
1802.86	2+	1406.8[@] 2	100[@] 25	396.094	3−				
		1474.8[@] 2	28[@] 16	328.019	1−				
1804.672	4+	116.26[@] 5	1.45[@] 18	1688.408	2+,3+				
		121.18[@ck] 7	1.7[@] 3	1683.80	(4−)				
		121.87[@] 3	3.0[@] 3	1682.81	(2+,3+,4+)				
		158.74[@] 3	11.4[@] 6	1646.003	3+	M1+E2	0.55 15	4.2 2	
		216.3[@] 1	100[@] 27	1588.347	(4−)				
		354.21[i@]	2.6[i@] 5	1450.402	4−				
		372.60[@c] 3	14.3[@] 7	1431.994	4+				
		651.5[@] 2	3.1[@] 5	1153.487	2+				
		713.6[@] 2	9.1[@] 5	1091.048	4+				
		781.8[@c] 1	62[@] 8	1022.542	(3)+				
		835.63[@]	[@]	968.984	2+				
		1286.0[@] 3	13[@] 4	519.208	5−				

$^{228}_{90}$Th$_{138}$-16

$\gamma(^{228}$Th) (continued)

E_i(level)	J^π_i	E_γ†	I_γ†	E_f	J^π_f	Mult.‡	δ‡	α[h]	Comments
1804.672	4$^+$	1426.43@	4.4@ *5*	378.195	6$^+$				
		1618.0@ *1*	8.2@ *5*	186.838	4$^+$	(M1,E2)		0.007 *3*	
		1746.84@	≤27@	57.773	2$^+$				
1811.56	(1$^-$,2,3$^-$)	1415.5@ *2*	100@ *7*	396.094	3$^-$				
		1483.5@ *2*	58@ *18*	328.019	1$^-$				
1817.435	4$^-$	229.3@ *2*	49@ *29*	1588.347	(4$^-$)				
		367.04@ *2*	41.5@ *20*	1450.402	4$^-$	M1(+E2)		0.484 *7*	
		590.7@ *1*	56@ *12*	1226.580	4$^-$				
		642.7@ *2*	48@ *14*	1174.515	(5$^+$)				
		649.0@ *1*	100@ *14*	1168.389	3$^-$				
		674.6@ *3*	≤34@	1143.16	5$^-$				
		694.5@ *1*	85@ *17*	1122.959	2$^-$				
		726.3@ *2*	31@ *10*	1091.048	4$^+$				
		757.4@ *2*	32@ *8*	1059.928	4$^-$				
		801.1@ *1*	78@ *8*	1016.386	3$^-$				
		1298.3@ *2*	7.6@ *8*	519.208	5$^-$	(M1+E2)	0.77		δ: +0.27≤δ≤+5 from $\gamma(\theta$,H,T) in ^{228}Pa decay.
		1421.1@ *2*	23.7@ *12*	396.094	3$^-$	E2+M1	+2.0 *5*	0.007 *1*	
1823.47	(4$^+$)	596.8@ *2*	100@ *27*	1226.580	4$^-$				
		732.9@ *4*	47@ *20*	1091.048	4$^+$				
		1304.2@ *3*	47@ *20*	519.208	5$^-$				
1838.1	(15$^-$)	238.6 *5*		1599.4	(14$^+$)				
		341.2[b] *3*		1497.0	(13$^-$)				
1842.23	(2,3)	751.1@ *2*	29@ *1*	1091.048	4$^+$				
		819.9@ *2*	27@ *8*	1022.542	(3)$^+$				
		862.8@ *3*	18@ *6*	979.522	2$^+$				
		1513.4@ *5*	10@ *3*	328.019	1$^-$				
		1784.4@ *2*	100@ *8*	57.773	2$^+$				
1864.95	(2$^+$)	696.5@ *2*	17@ *4*	1168.389	3$^-$				
		741.8@ *2*	28@ *4*	1122.959	2$^-$				
		895.9@ *1*	100@ *5*	968.984	2$^+$				
		990.3@ *2*	16@ *4*	874.535	2$^+$				
		1468.8@ *3*	20@ *5*	396.094	3$^-$				
		1536.8@ *3*	10@ *4*	328.019	1$^-$				
		1807.2@ *1*	43@ *3*	57.773	2$^+$				
		1865.1@ *1*	57@ *3*	0.0	0$^+$				

$^{228}_{90}$Th$_{138}$-17

$\gamma(^{228}Th)$ (continued)

E_i(level)	J^π_i	E_γ [†]	I_γ [†]	E_f	J^π_f	Mult. [‡]	δ [‡]	α [h]	Comments
1876.46	$(3^-,4,5^-)$	1357.2$^{@}$ *3*	100$^{@}$ *33*	519.208	5^-				
		1480.4$^{@}$ *3*	87$^{@}$ *48*	396.094	3^-				
1879.1	(3^-)	1359.9$^{@}$ *3*	65$^{@}$ *25*	519.208	5^-				
		1482.9$^{@}$ *23*	100$^{@}$ *30*	396.094	3^-				
1893.003	3^+	157.5$^{@\#}$ *2*	11$^{@}$ *3*	1735.49	4^+				
		214.6$^{@\#}$ *1*	≤6$^{@}$	1678.42	2^+				
		255.2$^{@\#}$ *3*	3.8$^{@}$ *13*	1638.284	2^+				
		444.0$^{@\#}$ *2*	31$^{@}$ *11*	1448.92	$3,4^-$				
		477.1$^{@\#e}$ *3*	4.4$^{@}$ *13*	1416.10	(3^-)				
		666.47^{j} *4*	1.31$^{j@}$ *9*	1226.580	4^-				
		692.47$^{@}$ *7*	12.6$^{@}$ *9*	1200.60	$3^{(+)}$	(M1+E2+E0)		0.24 *3*	α: from α(K)exp in ^{228}Pa decay.
		718.0$^{@\#}$ *2*	10$^{@}$ *4*	1175.41	2^+				
		724.5$^{i@\#}$ *1*	4.8$^{i@}$ *6*	1168.389	3^-				
		739.2$^{@\#}$ *2*	3.6$^{@}$ *6*	1153.487	2^+				
		770.2$^{@}$ *2*	14.2$^{@}$ *9*	1122.959	2^-				
		801.7$^{@\#}$ *3*	7$^{@}$ *3*	1091.048	4^+				
		870.45 *2*	99 *5*	1022.542	$(3)^+$	M1			δ: −0.1 *1* (^{228}Pa decay).
		876.7$^{@\#}$ *2*	13$^{@}$ *5*	1016.386	3^-				
		913.0$^{@c\#}$ *1*	24$^{@}$ *8*	979.522	2^+				
		924.0$^{@\#}$ *1*	100$^{@}$ *13*	968.984	2^+				E_γ: ^{228}Ac decay reports unresolved doublets around 924.03 keV without uncertainty. ^{228}Pa decay resolves the doublets to 924.0 *1*, 924.5 *1*, and 924.6 *1*. There is also disagreement in the reported relative intensities. Since level decay in ^{228}Pa is more complete than ^{228}Ac decay, the evaluator adopts the γ-rays reported in ^{228}Pa decay with their relative intensities.
		924.5$^{@\#}$ *1*	62$^{@}$ *19*	968.451	4^+				E_γ,I_γ: See note on 924.0 *1*.
		924.6$^{@\#}$ *1*	31$^{@}$ *6*	968.381	2^-				E_γ,I_γ: See note on 924.0 *1*.
		1018.5$^{@\#}$ *1*	81$^{@}$ *19*	874.535	2^+				
		1706.17 *7*	18.0 *8*	186.838	4^+	M1+E2	+0.42 *4*	0.0078 *2*	
		1835.29 *5*	64 *8*	57.773	2^+	E2+M1	+2.9 *3*	0.0038 *1*	
1899.955	(2^+)	253.9$^{@\#}$ *5*	22$^{@}$ *9*	1646.003	3^+				
		261.6$^{@\#}$ *2*	48$^{@}$ *18*	1638.284	2^+				
		506.5$^{@\#}$ *2*	≤87$^{@}$	1393.31	$(1^+,2,3^-)$				
		724.7$^{@c\#k}$ *3*	44$^{@}$ *22*	1175.41	2^+				

$\gamma(^{228}Th)$ (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[‡]	δ[‡]	α[h]	Comments
1899.955	(2+)	780.3[@#]	83[@] 9	1119.7	0+				
		877.39 7	40.6 33	1022.542	(3)+				
		883.53[@#] 3	6.6[@] 18	1016.386	3−				
		920.46[@#] 3	17[@] 4	979.522	2+				
		930.99 7	35 11	968.984	2+				
		1503.7[@#] 2	31.4[@] 26	396.094	3−				
		1572.0[@#] 1	176[@] 44	328.019	1−				I_γ: Seems larger than expected because it is considered as unresolved doublet.
		1713.47[a] 20	12.9[a] 24	186.838	4+				
		1842.14 8	100 5	57.773	2+	M1+E2	−0.86 14	0.0055 4	
		1900.14 17	9 3	0.0	0+				
1901.92	(6+)	255.9[@] 2	56[@] 24	1646.003	3+				
		640.3[@] 2	48[@] 20	1261.57	4+				
		810.7[@] 2	48[@] 16	1091.048	4+				
		826.6[@k] 3	80[@] 40	1074.80	4+				
		933.1[@] 3	100[@] 40	968.984	2+				
		1383.2[@] 2	22[@] 2	519.208	5−				
		1505.9[@] 2	22[@] 2	396.094	3−				
		1523.4[i@] 2	24.0[i@] 24	378.195	6+				
		1715.06[@] 10	20.0[@] 12	186.838	4+				
1906.65	(2+)	490.33[a] 15	93[a] 19	1416.10	(3−)				
		1074.71[a] 15	84[a] 25	831.842	0+				
		1907.18[a] 20	100[a] 8	0.0	0+				
1908.39	0+	785.2[@] 2	67[@] 28	1122.959	2−				
		817.4[@] 3	33[@] 10	1091.048	4+				
		848.6[@] 2	27[@] 10	1059.928	4−				
		885.7[@] 2	63[@] 13	1022.542	(3)+				
		891.9[@] 2	63[@] 13	1016.386	3−				
		939.9[@] 2	77[@] 17	968.451	4+				
		964.3[@] 3	100[@] 43	944.205	1−				
		1512.9[@] 3	47[@] 17	396.094	3−				
1924.16	(2−,3,4)	697.6[@] 1	80[@] 13	1226.580	4−				
		723.6[@] 1	100[@] 17	1200.60	3(+)				
		755.7[@] 1	70[@] 17	1168.389	3−				
1924.64	4+,5−	750.10[@] 10	100[@] 12	1174.515	(5+)				
		902.1[@] 5	45[@] 15	1022.542	(3)+				

$^{228}_{90}Th_{138}$-19

γ(^{228}Th) (continued)

E$_i$(level)	J$^\pi_i$	E$_\gamma$[†]	I$_\gamma$[†]	E$_f$	J$^\pi_f$	Mult.[‡]	α[h]	Comments
1924.64	4$^+$,5$^-$	1405.5[@] 2	48[@] 12	519.208	5$^-$			
1925.21	3$^+$,4$^+$	476.7[@] 2	4[@] 2	1448.92	3,4$^-$			
		663.5[@] 2	11[@] 2	1261.57	4$^+$			
		724.42[i@] 11	3.0[i@] 4	1200.60	3$^{(+)}$			
		771.72[@]	≤4[@]	1153.487	2$^+$			
		834.1[@] 1	100[@] 16	1091.048	4$^+$			
		850.5[@] 2	13[@] 6	1074.80	4$^+$			
		865.2[@] 2	2.0[@] 3	1059.928	4$^-$			
		908.7[@] 3	12[@] 4	1016.386	3$^-$			
		956.8[@] 2	88[@] 20	968.381	2$^-$			
		1529.02[@] 6	10.4[@] 5	396.094	3$^-$			
		1547.0[@] 2	18[@] 5	378.195	6$^+$			
		1738.48[@] 5	38[@] 2	186.838	4$^+$	M1+E2	0.006 2	
1928.49	3$^+$	168.65[@c] 10	2.0[@] 4	1760.209	2$^{(+)}$,3$^{(+)}$			
		389.12[@] 15	6.9[@] 11	1539.21	2$^+$			
		584.4[i#@e] 3	4.9[i@] 16	1344.142	3$^-$			
		774.86[@#]	≤22[@]	1153.487	2$^+$			
		837.0[@c#] 1	100[@] 22	1091.048	4$^+$			
		906.0[@#] 6	38[@] 13	1022.542	(3)$^+$			
		1741.72 18	9.3[@] 18	186.838	4$^+$			
		1870.81 9	16.2[@] 9	57.773	2$^+$	(M1+E2)	0.0051 18	Iγ: Largest in ^{228}Ac decay, since the γ-ray set seems more in ^{228}Pa, the evaluator adopts Iγ reported in ^{228}Pa decay.
1937.18	2$^+$,3,4$^+$	397.94[a] 10	100[a] 11	1539.21	2$^+$			
		1062.55[a] 15	37[a] 11	874.535	2$^+$			
		1750.54[a] 20	30[a] 3	186.838	4$^+$			
		1879.6[a] 3	4.8[a] 18	57.773	2$^+$			
1939.07	(4$^+$)	677.8[@] 2	30[@] 11	1261.57	4$^+$			
		764.0[@] 3	49[@] 27	1175.41	2$^+$			
		847.8[@] 3	14[@] 5	1091.048	4$^+$			
		879.1[@] 3	16[@] 5	1059.928	4$^-$			
		916.6[@] 3	46[@] 14	1022.542	(3)$^+$			
		1419.8[@] 2	54[@] 24	519.208	5$^-$			
		1542.8[@] 2	76[@] 14	396.094	3$^-$			
		1752.1[@] 2	100[@] 11	186.838	4$^+$			
1944.904	3$^+$	148.4[@#] 2	12[@] 4	1796.44	4$^+$			

$^{228}_{90}$Th$_{138}$-20

Adopted Levels, Gammas (continued)

$\gamma(^{228}Th)$ (continued)

E_i(level)	J^π_i	E_γ[†]	I_γ[†]	E_f	J^π_f	Mult.[‡]	δ[‡]	α[h]	Comments
1944.904	3^+	184.61[@#] *5*	1.7[@] *2*	1760.209	$2^{(+)},3^{(+)}$	(M1)		3.26 *5*	
		220.61[@#] *2*	5.2[@] *3*	1724.299	2^+	(M1)		1.98 *3*	
		237.7[@#] *3*	8[@] *3*	1707.29	$(2,3^-)$				
		299.10[@#] *10*	1.79[@] *21*	1646.003	3^+	M1		0.849 *12*	
		306.61[@#] *2*	8.3[@] *4*	1638.284	2^+	M1		0.793 *12*	
		512.79[@#] *11*	5.5[@] *6*	1431.994	4^+				
		551.79[@#] *11*	≤8[@]	1393.31	$(1^+,2,3^-)$				
		683.4[@#] *2*	4.2[@] *17*	1261.57	4^+				
		718.31 *2*	26.2 *17*	1226.580	4^-	(E1)			
		744.2[@#] *1*	15[@] *4*	1200.60	$3^{(+)}$				
		769.6[@#] *1*	17[@] *8*	1175.41	2^+				
		776.52 *4*	32 *3*	1168.389	3^-				
		791.44[j] *9*	14.4[ja] *3*	1153.487	2^+	(M1)		0.0618 *9*	
		853.7 *4*	3.4 *3*	1091.048	4^+				
		922.08 *21*	9.7 *14*	1022.542	$(3)^+$				
		928.4[@#] *2*	3.7[@] *3*	1016.386	3^-				
		965.3[@#] *2*	50[@] *8*	979.522	2^+				
		975.98 *5*	56 *3*	968.984	2^+	M1		0.0356 *5*	
		976.5[@#] *1*	25[@] *8*	968.381	2^-				
		976.5[@#] *1*	29[@] *12*	968.451	4^+				
		1000.69[a] *15*	5.6[a]	944.205	1^-				
		1070.40[@#] *7*	5.0[@] *3*	874.535	2^+				
		1548.8[@#] *2*	5.0[@] *8*	396.094	3^-				
		1758.11 *5*	37.7 *20*	186.838	4^+	E2+M1	−9 *1*		
		1887.12 *5*	100 *5*	57.773	2^+	E2+M1	−9.1 *9*		
1945.74	$4^+,5^-$	1426.6[@] *1*	40[@] *5*	519.208	5^-				
		1549.3[@] *2*	100[@] *17*	396.094	3^-				
		1567.6[@] *3*	19[@] *9*	378.195	6^+				
1949.73	(2^+)	827.1[@] *3*	89[@] *29*	1122.959	2^-				
		927.2[@] *2*	100[@] *18*	1022.542	$(3)^+$				
		980.7[@] *2*	54[@] *18*	968.984	2^+				
		1005.5[@] *2*	43[@] *14*	944.205	1^-				
		1075.1[@] *2*	50[@] *14*	874.535	2^+				
1958.35	(2^+)	935.2[@#]	90[@] *17*	1022.542	$(3)^+$				
		1561.7[@#] *4*	34[@] *14*	396.094	3^-				
		1772.2[a] *3*	83 *28*	186.838	4^+				γ not reported in ^{228}Pa decay.

Adopted Levels, Gammas (continued)

γ(^{228}Th) (continued)

E_i(level)	J^π_i	E_γ[†]	I_γ[†]	E_f	J^π_f	Comments
						I_γ: Adopted as a ratio between I_γ(1958.2) (^{228Pa}/^{228Ac}) since I_γ(1772.2) is largest in ^{228}Ac and it is not reported in ^{228}Pa decay.
1958.35	(2$^+$)	1958.2 2	100 10	0.0	0$^+$	
1965.05	(2$^+$)	321.75[@k]	[@]	1643.131	(2$^-$,3$^-$)	
		548.9[i@k] 11	41[i@] 5	1416.10	(3$^-$)	Multiply placed γ in ^{228}Pa decay with Iγ(doublet)=41 5.
		1778.0[@] 6	6.1[@] 20	186.838	4$^+$	
		1907.13[@] 11	100[@] 5	57.773	2$^+$	
		1965.22[i@] 12	43[i@] 4	0.0	0$^+$	
1974.19	(2$^+$,3$^-$)	1455.0[@] 2	61[@] 4	519.208	5$^-$	
		1578.2[@] 2	70[@] 7	396.094	3$^-$	
		1595.8[@] 3	100[@] 42	378.195	6$^+$	
		1787.2[@] 2	19.5[@] 21	186.838	4$^+$	
		1916.6[@] 3	7.9[@] 16	57.773	2$^+$	
1981.90	(3$^-$)	684.6[@] 3	12[@] 5	1297.435	(5$^-$)	
		890.6[@] 3	8[@] 2	1091.048	4$^+$	
		959.1[@] 1	50[@] 7	1022.542	(3)$^+$	
		1013.44[@]	≤1.6[@]	968.381	2$^-$	
		1013.54[@] 13	25[@] 8	968.451	4$^+$	
		1585.5[@] 2	27[@] 8	396.094	3$^-$	
		1795.15[@] 6	100[@] 6	186.838	4$^+$	
		1924.2[@] 2	15.1[@] 17	57.773	2$^+$	
1987.47	4$^+$	1017.92[a] 20	29[a] 7	968.984	2$^+$	
		1609.41[a] 15	39[a] 8	378.195	6$^+$	
		1800.86[a] 20	22[a] 4	186.838	4$^+$	
		1929.78[a] 20	100[a] 11	57.773	2$^+$	
1987.9	(16$^+$)	388.5[b] 3	100	1599.4	(14$^+$)	
2010.15	(2$^+$)	214.85[ak] 10	49[a] 7	1795.92	4$^+$	γ not reported in ^{228}Pa decay.
		372.57[ac] 20	11[a] 3	1638.284	2$^+$	
		887.33 10	43 5	1122.959	2$^-$	
		919.0[a] 1	46[a] 5	1091.048	4$^+$	Mult.: possible E0 component (^{228}Ac β^- decay).
		1040.91 15	76 14	968.984	2$^+$	
		1823.21 10	65 4	186.838	4$^+$	
		1952.37 10	100 7	57.773	2$^+$	
2013.6	2$^+$,3,4$^+$	1826.7[a] 3	100[a] 38	186.838	4$^+$	
		1955.9[a] 5	38[a] 14	57.773	2$^+$	
2016.75	(4$^+$,5$^-$)	1048.2[@] 3	43[@] 17	968.451	4$^+$	
		1497.5[@] 2	100[@] 7	519.208	5$^-$	

Adopted Levels, Gammas (continued)

γ(^{228}Th) (continued)

E$_i$(level)	J$^\pi_i$	E$_\gamma$[†]	I$_\gamma$[†]	E$_f$	J$^\pi_f$	Mult.[‡]	Comments
2016.75	(4$^+$,5$^-$)	1620.67[@] *10*	97[@] *27*	396.094	3$^-$	(M1+E2)	
		1638.5[@] *3*	30[@] *13*	378.195	6$^+$		
2022.82	(2$^+$)	384.63[a] *20*	33[a] *7*	1638.284	2$^+$		
		1000.4[@#] *3*	16[@] *7*	1022.542	(3)$^+$		
		1053.23[c] *28*	36 *17*	968.984	2$^+$		Possibly part of a doublet in ^{228}Pa decay.
		1148.16 *14*	22 *8*	874.535	2$^+$		
		1190.81[a] *21*	30[a] *8*	831.842	0$^+$		
		1965.23[i] *12*	100[ia] *9*	57.773	2$^+$		
2030.40	2$^+$	939.87[ac] *15*	100[a] *33*	1091.048	4$^+$		
		1013.58[a] *20*	55[a] *14*	1016.386	3$^-$		
		1971.9[a] *3*	40[a] *9*	57.773	2$^+$		
		2029.4[a] *5*	20[a] *6*	0.0	0$^+$		
2037.01	2$^+$,3,4$^+$	1850.13[a] *20*	100[a] *18*	186.838	4$^+$		
		1979.3[a] *3*	41[a] *11*	57.773	2$^+$		
2123.1	(2$^+$)	1795.1[a] *5*	100[a] *38*	328.019	1$^-$		
		1936.3[a] *3*	100[a] *24*	186.838	4$^+$		
2209.5	(17$^-$)	371.4[b] *3*	[b]	1838.1	(15$^-$)	[E2]	
2400.5	(18$^+$)	412.6 *5*	100	1987.9	(16$^+$)		
2608.4?	(19$^-$)	399[k] *1*		2209.5	(17$^-$)		
2834.4?	(20$^+$)	434[k] *1*		2400.5	(18$^+$)		
3283.4?	(22$^+$)	449[k] *1*		2834.4?	(20$^+$)		

† Weighted average of measurements in ^{228}Ac and ^{228}Pa decays, unless otherwise noted.
‡ From ^{228}Ac β^- decay and/or ^{228}Pa ε decay.
# γ-ray not reported in ^{228}Ac β^- decay.
@ From ^{228}Pa ε decay.
& From ^{232}U α decay.
a From ^{228}Ac β^- decay.
b From (α,2nγ) data set.
c Energy fit poor. Not included in E(level) calculation.
d Doublet, energy not included in E(level) calculation.
e A γ of this energy was seen in ^{228}Pa decay and placed here in level scheme; however, the γ's deexciting the final level of this γ were not seen in ^{228}Pa decay.
f γ's of approximately same energy and intensity seen in both ^{228}Ac and ^{228}Pa decays. On the basis of coin with 911γ, it is suggested in ^{228}Ac decay, that the γ feeds the 2$^+$ 968.968 level. In ^{228}Pa decay, the γ is placed feeding the 3$^-$ 968.368 level. The energy fit is much better feeding the 3$^-$ level. Possibly the γ seen is a doublet feeding both the 968 and 969 levels. Iγ(doublet)=24 *6*, E(doublet)=674.65 *5*.
g There is a disagreement in the ratio Iγ(583γ)/Iγ(651γ) between ^{228}Ac decay (1.23 *15*) and ^{228}Pa decay (2.26 *24*).

$^{228}_{90}$Th$_{138}$-23

γ(^{228}Th) (continued)

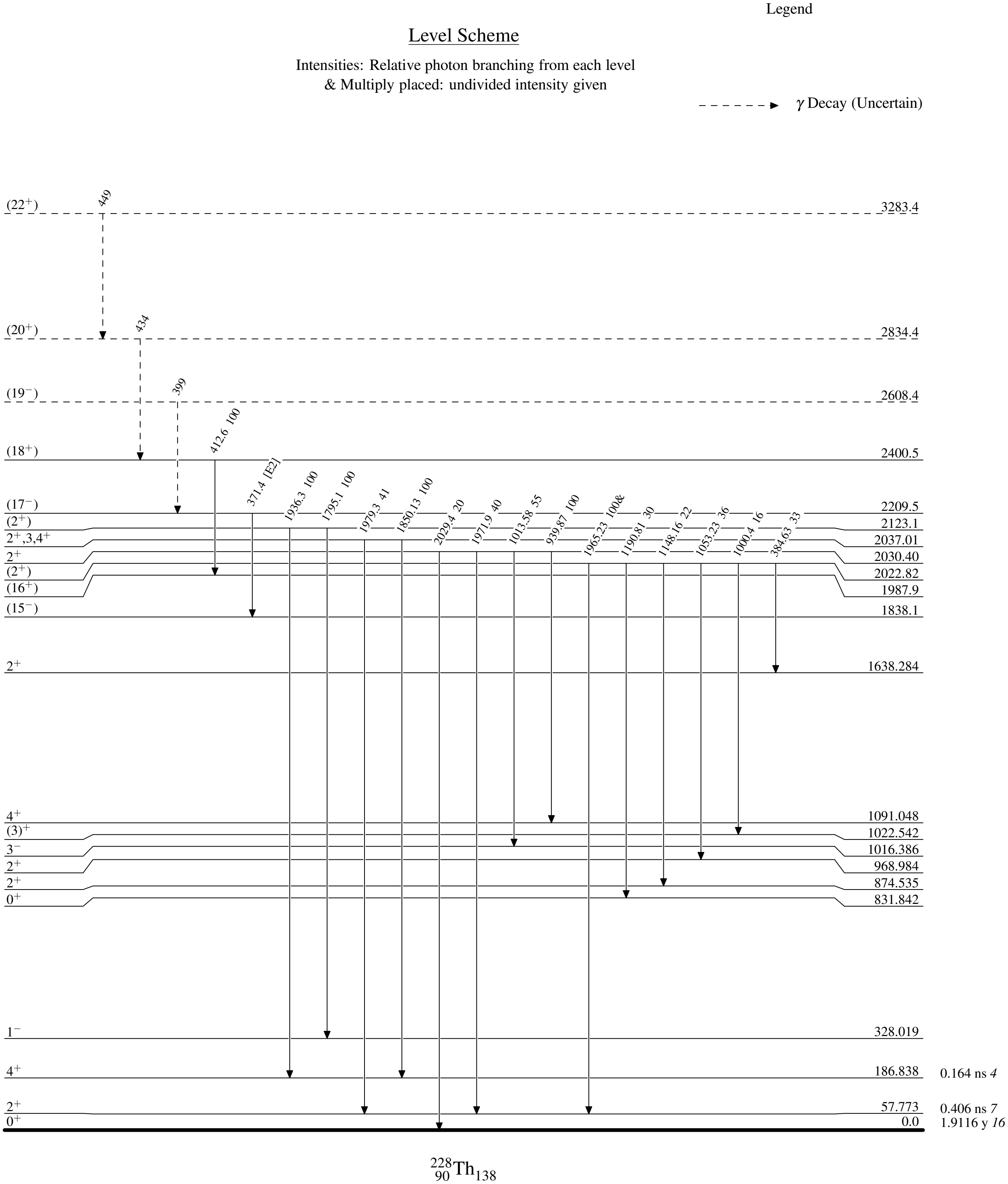
[h] Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on γ-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.
[i] Multiply placed with undivided intensity.
[j] Multiply placed with intensity suitably divided.
[k] Placement of transition in the level scheme is uncertain.

$^{228}_{90}$Th$_{138}$-24

Adopted Levels, Gammas

Level Scheme

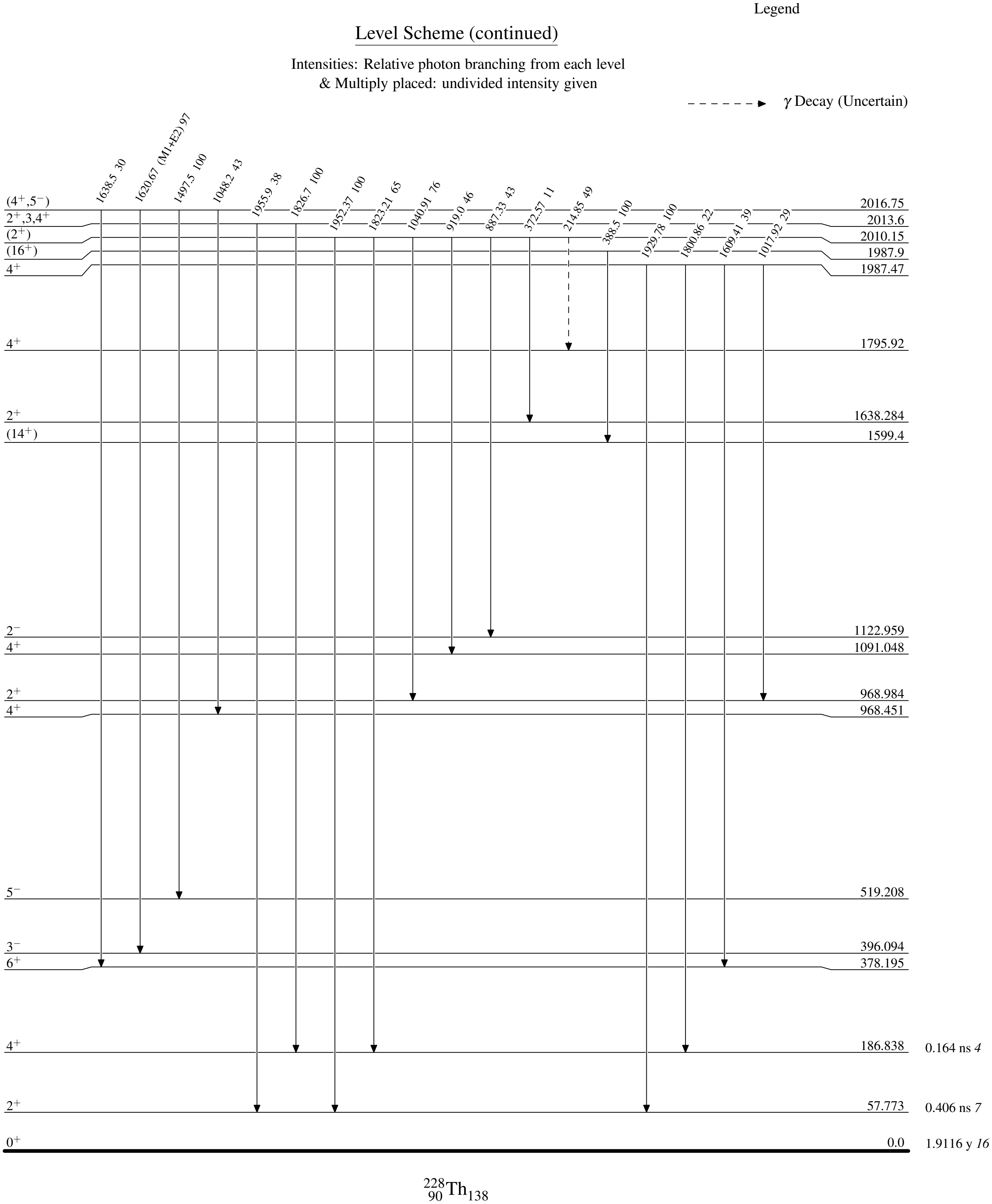
Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given



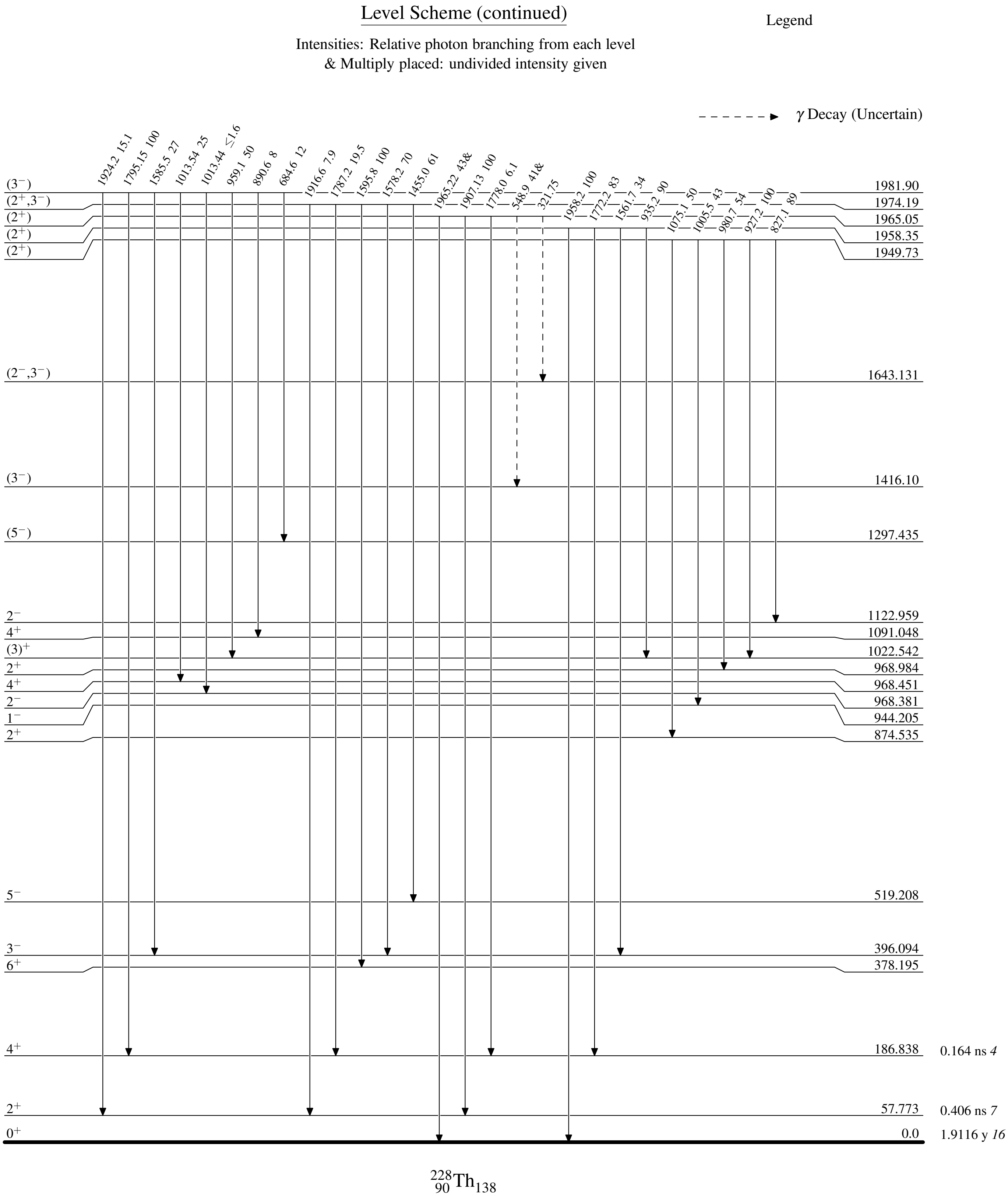
Adopted Levels, Gammas

Level Scheme (continued)

Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given



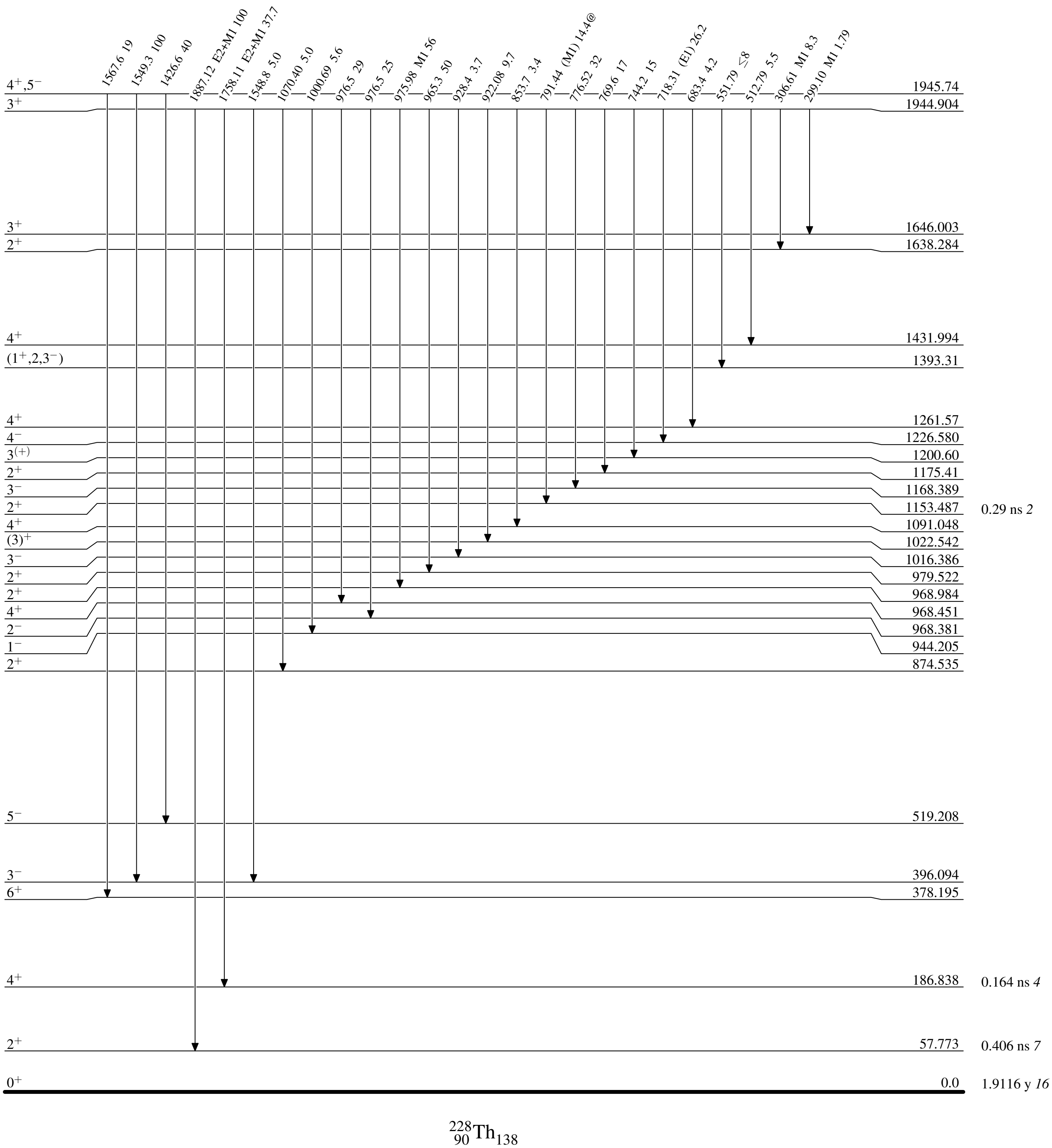
Adopted Levels, Gammas



Adopted Levels, Gammas

Level Scheme (continued)

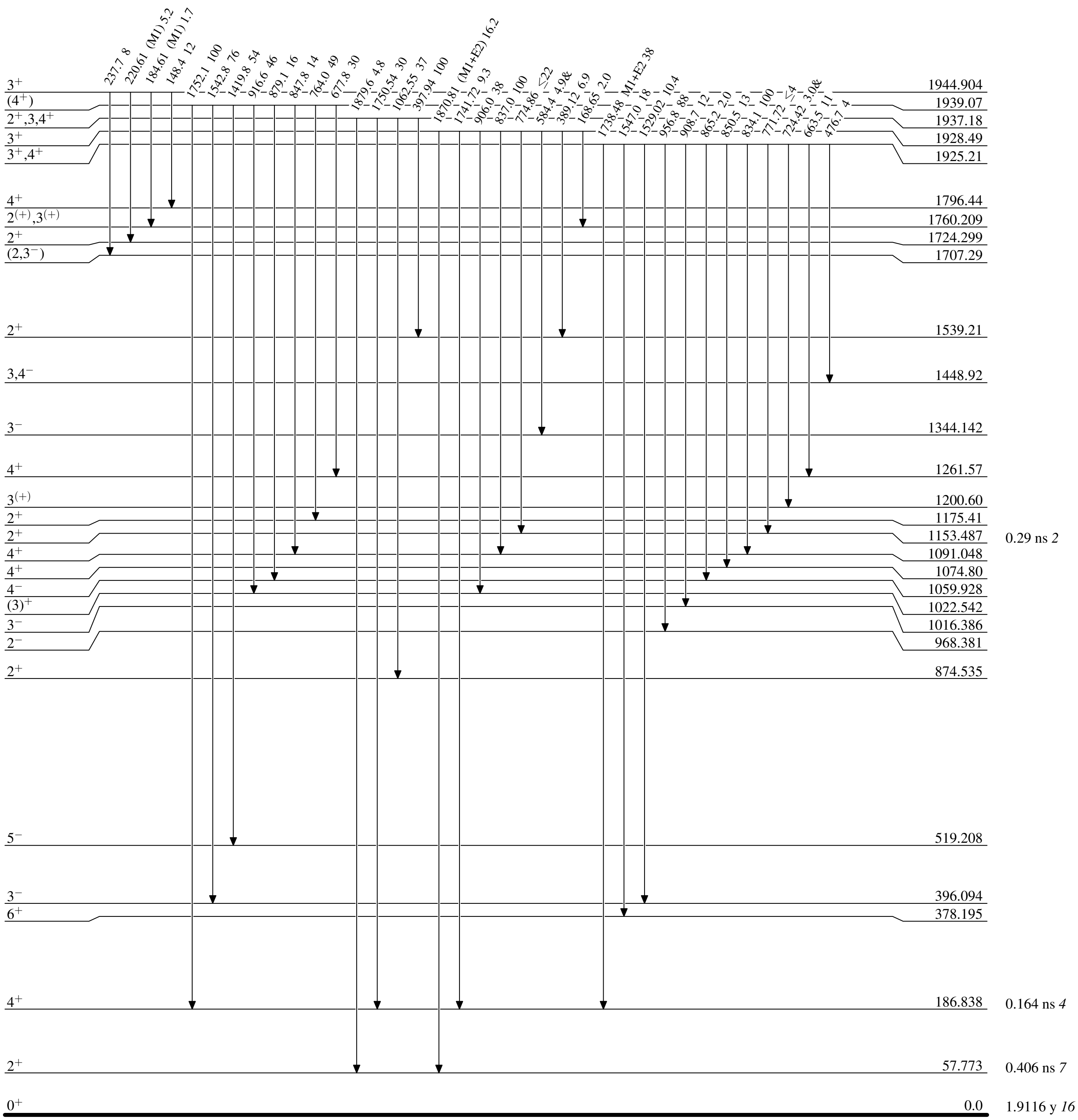
Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided



Adopted Levels, Gammas

Level Scheme (continued)

Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided

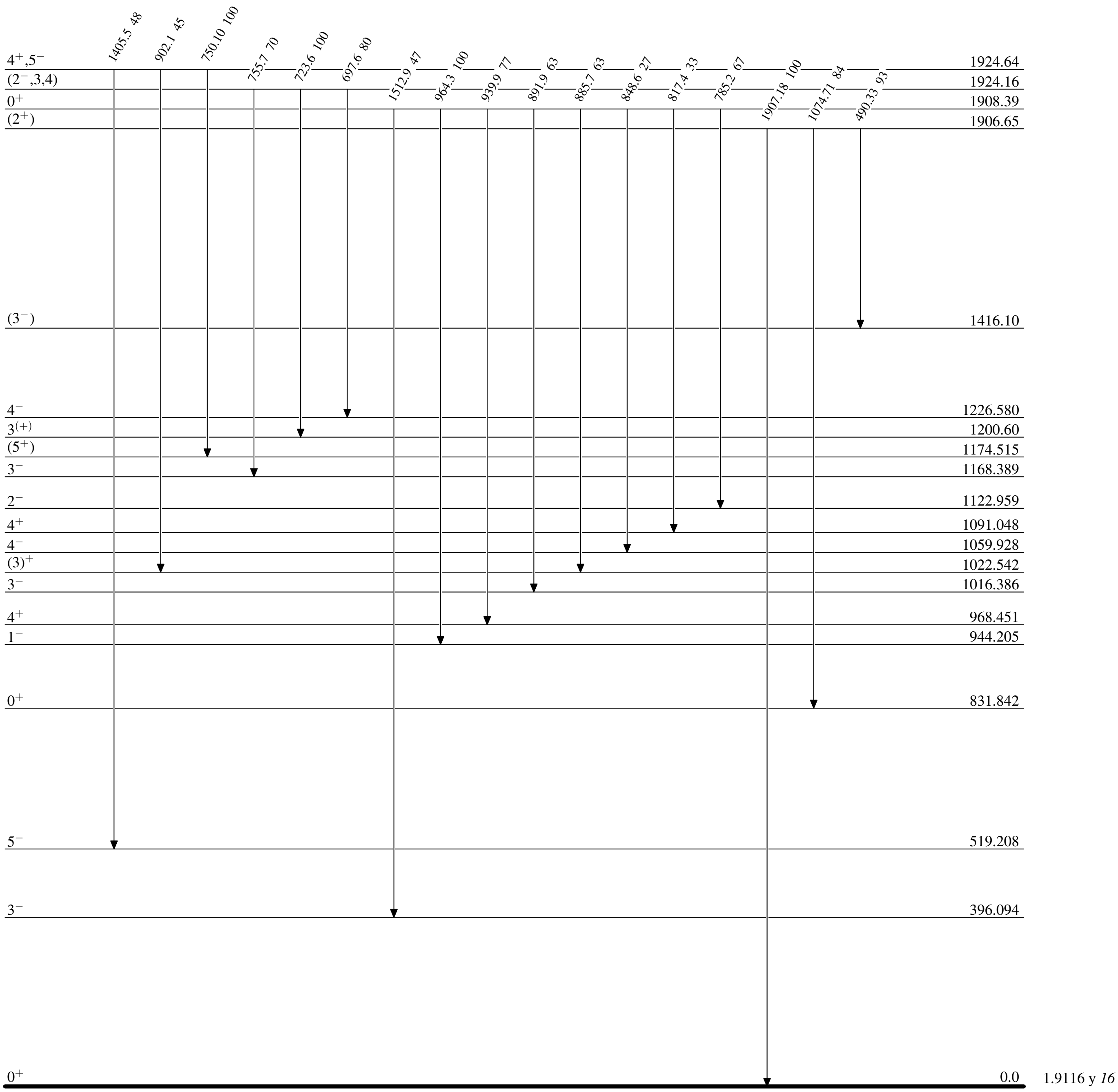


$^{228}_{90}Th_{138}$

Adopted Levels, Gammas

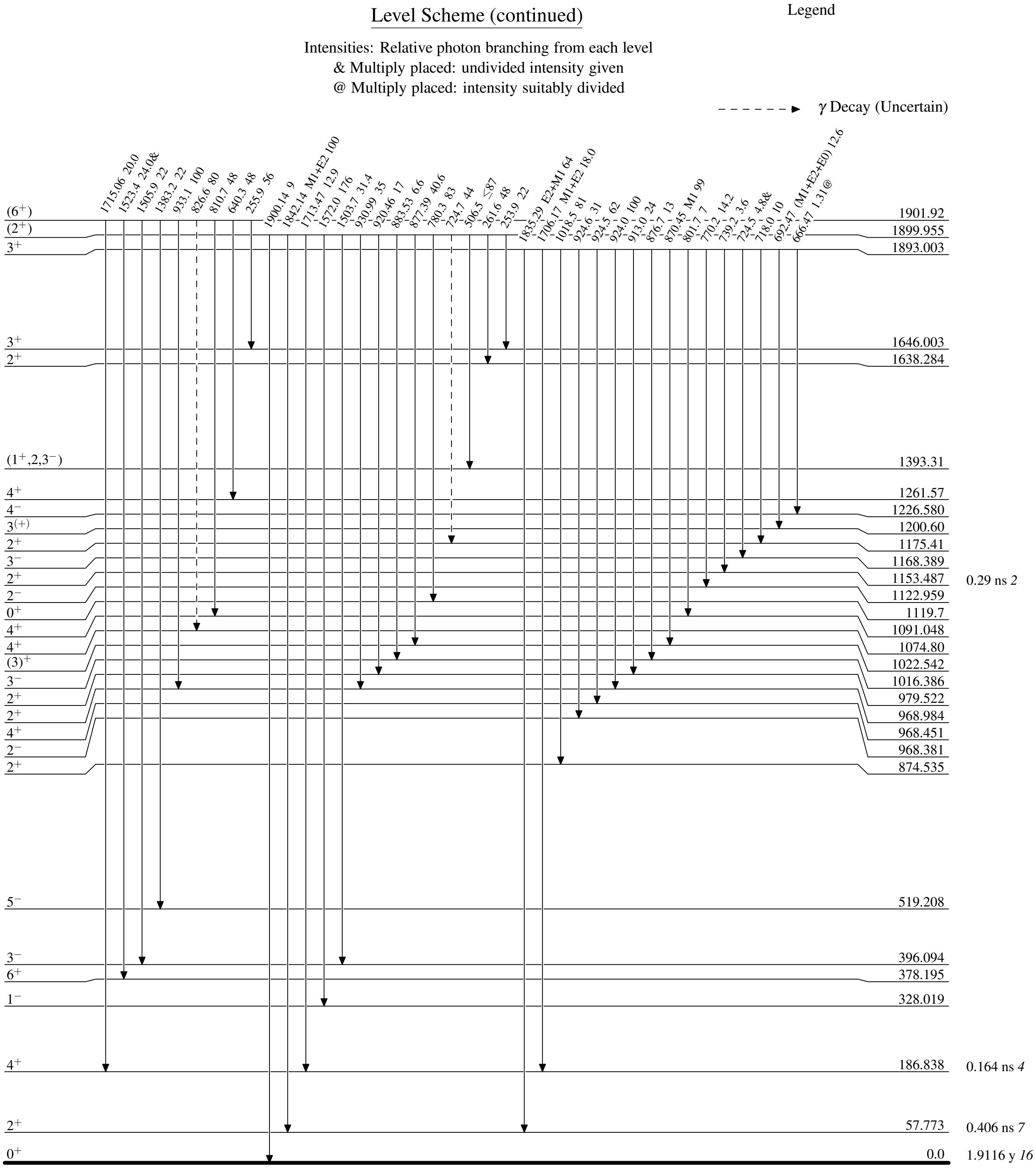
Level Scheme (continued)

Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided



$^{228}_{90}Th_{138}$

Adopted Levels, Gammas

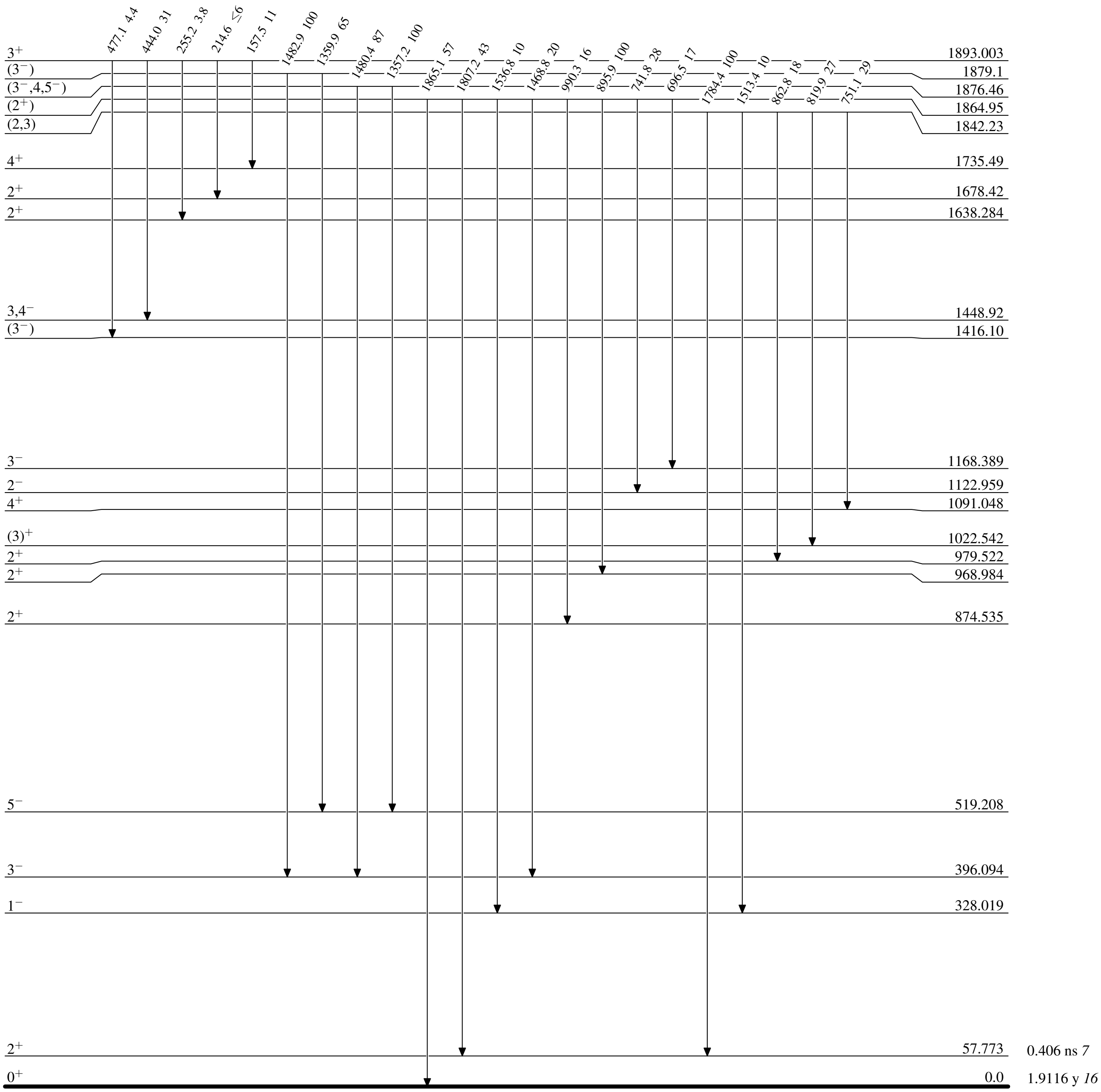


$^{228}_{90}Th_{138}$

Adopted Levels, Gammas

Level Scheme (continued)

Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided



$^{228}_{90}Th_{138}$

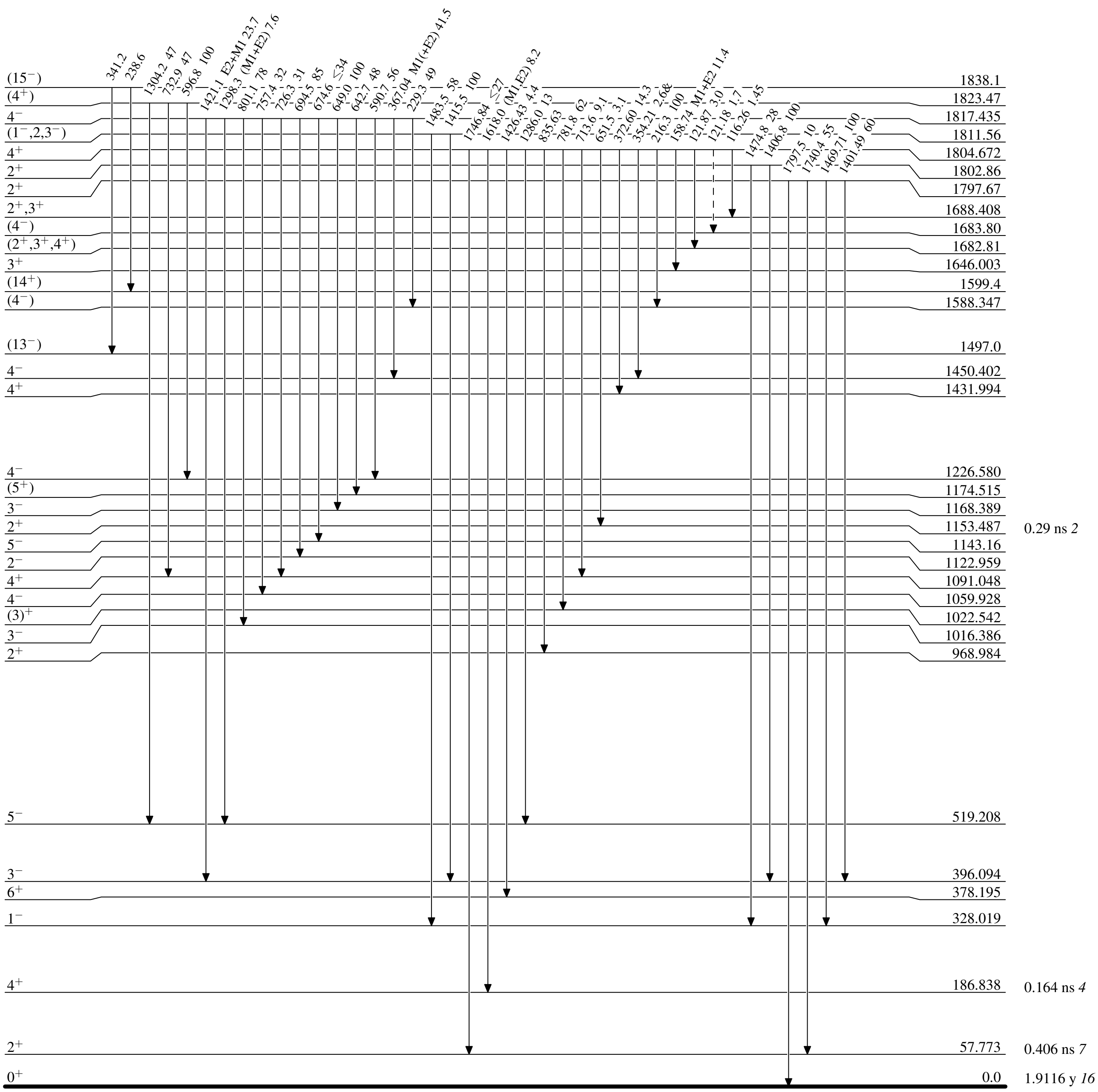
Adopted Levels, Gammas

Level Scheme (continued)

Legend

Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided

γ Decay (Uncertain)

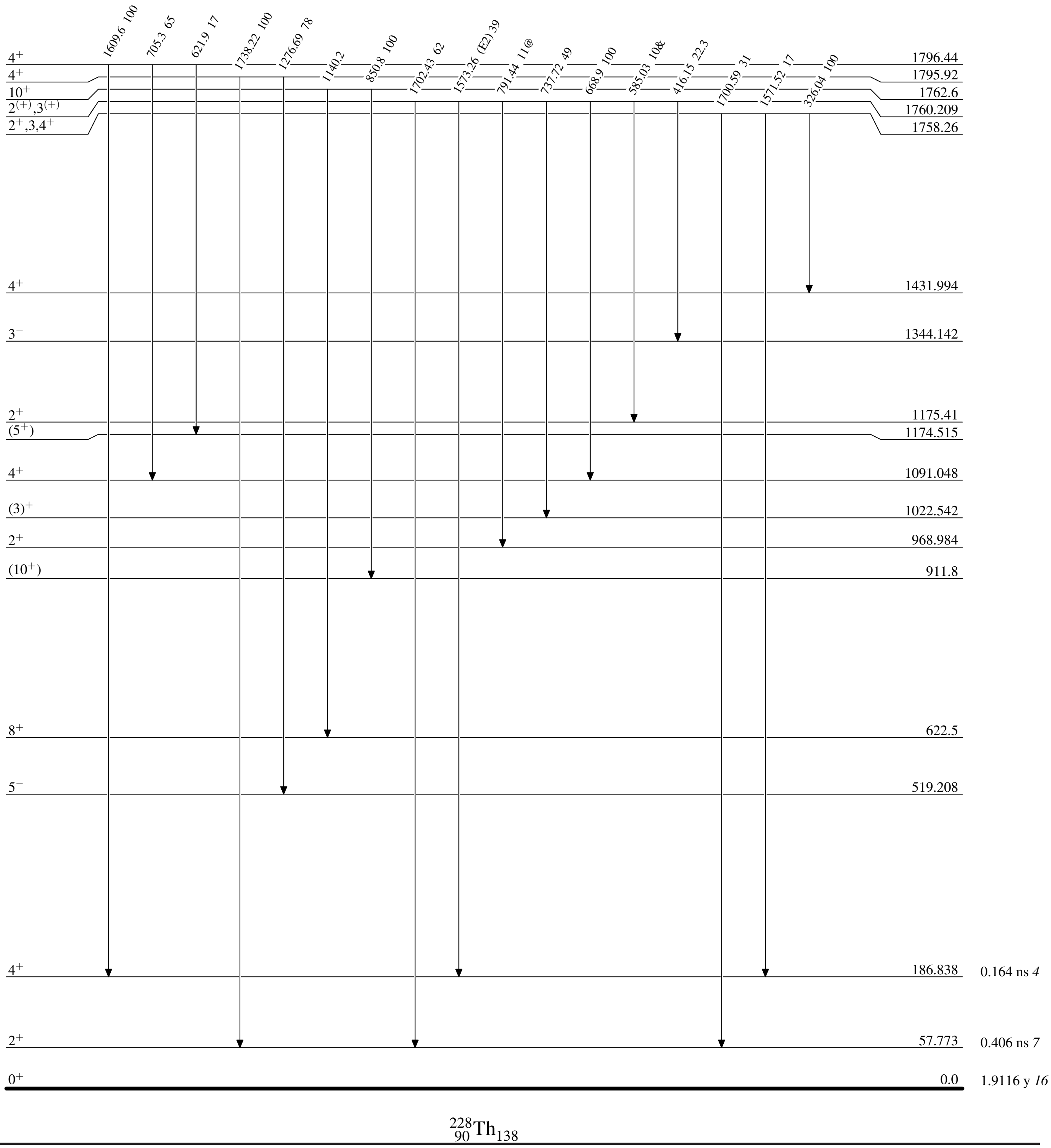


$^{228}_{90}Th_{138}$

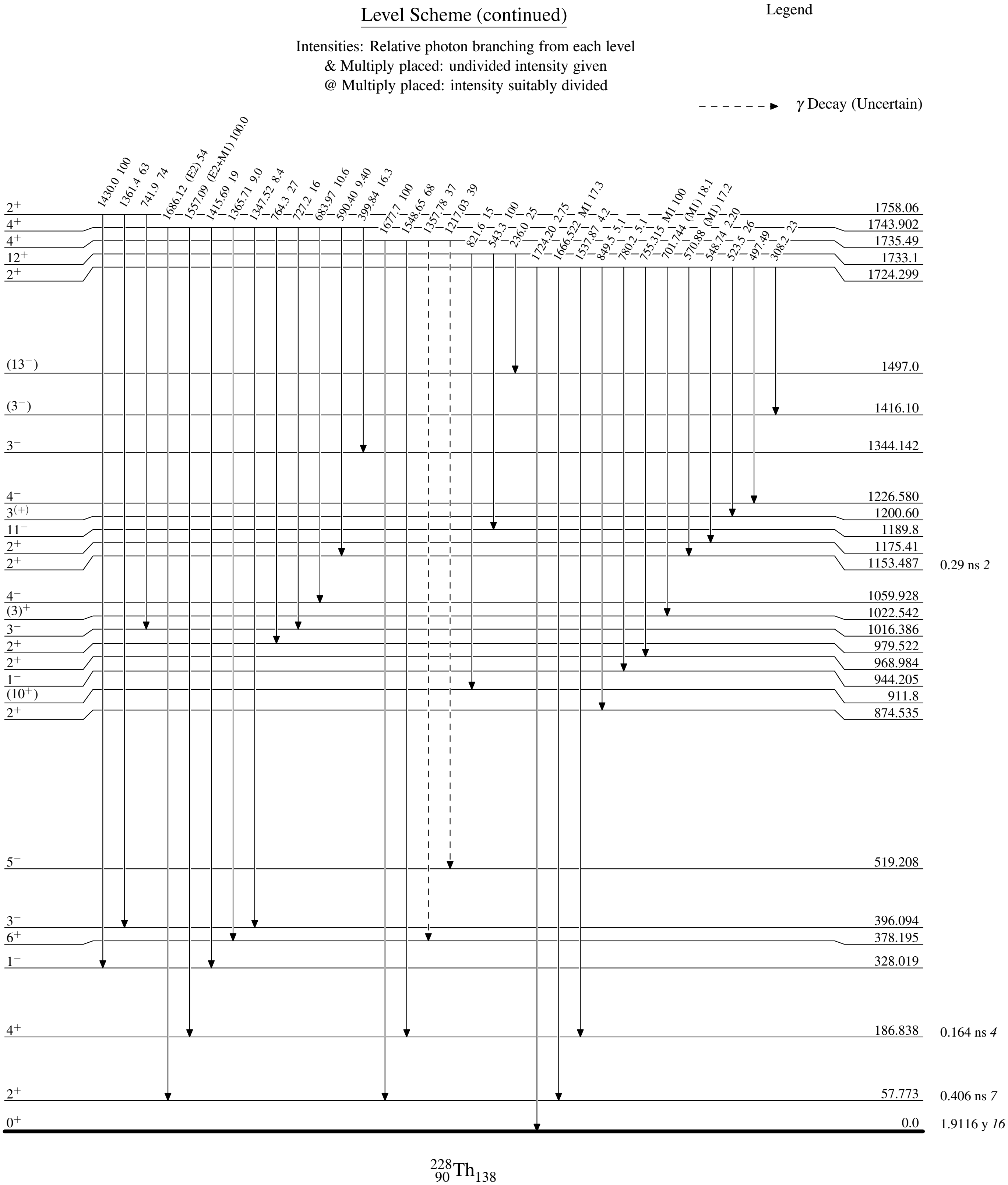
Adopted Levels, Gammas

Level Scheme (continued)

Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided



Adopted Levels, Gammas



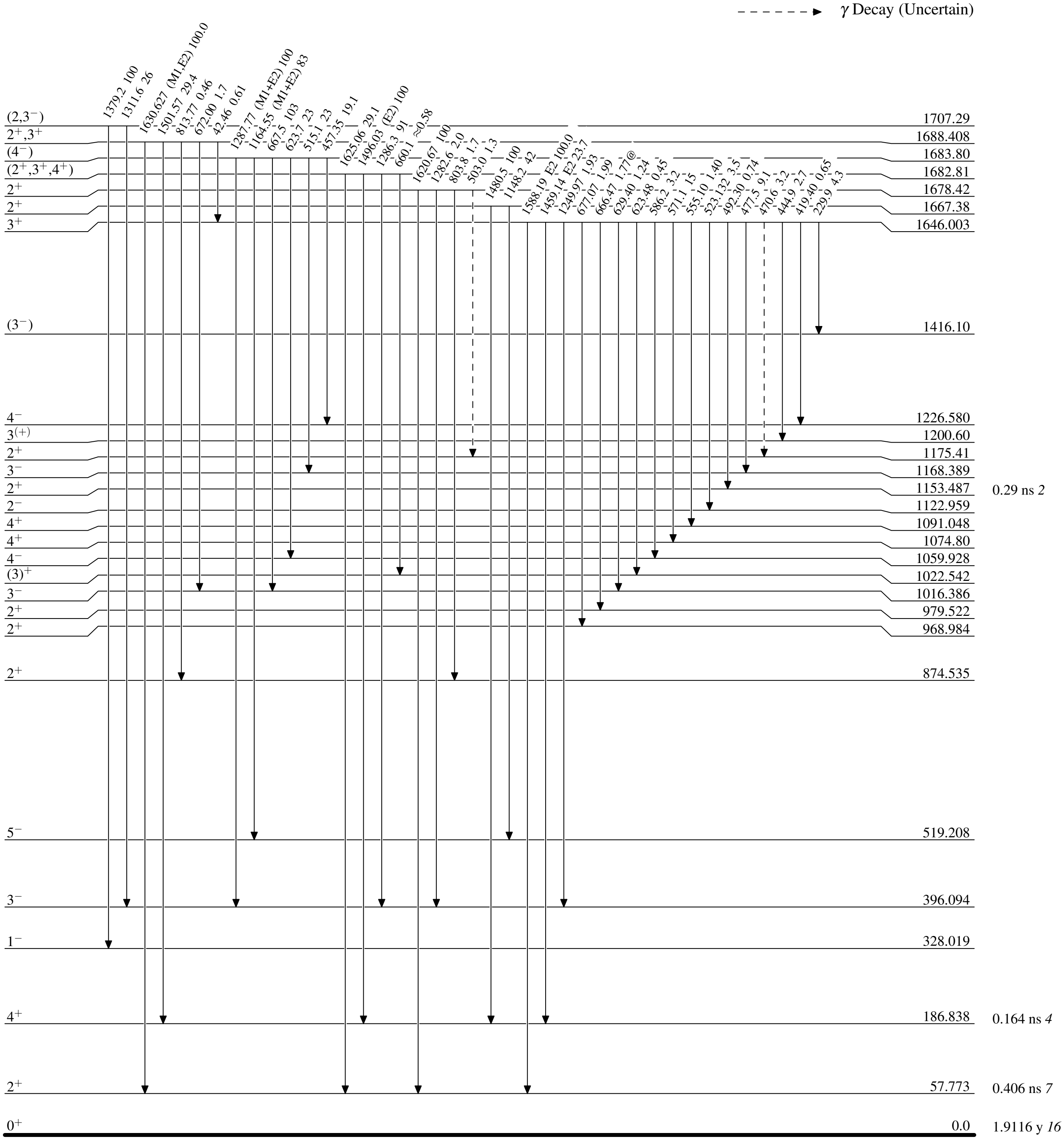
Adopted Levels, Gammas

Level Scheme (continued)

Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided

Legend

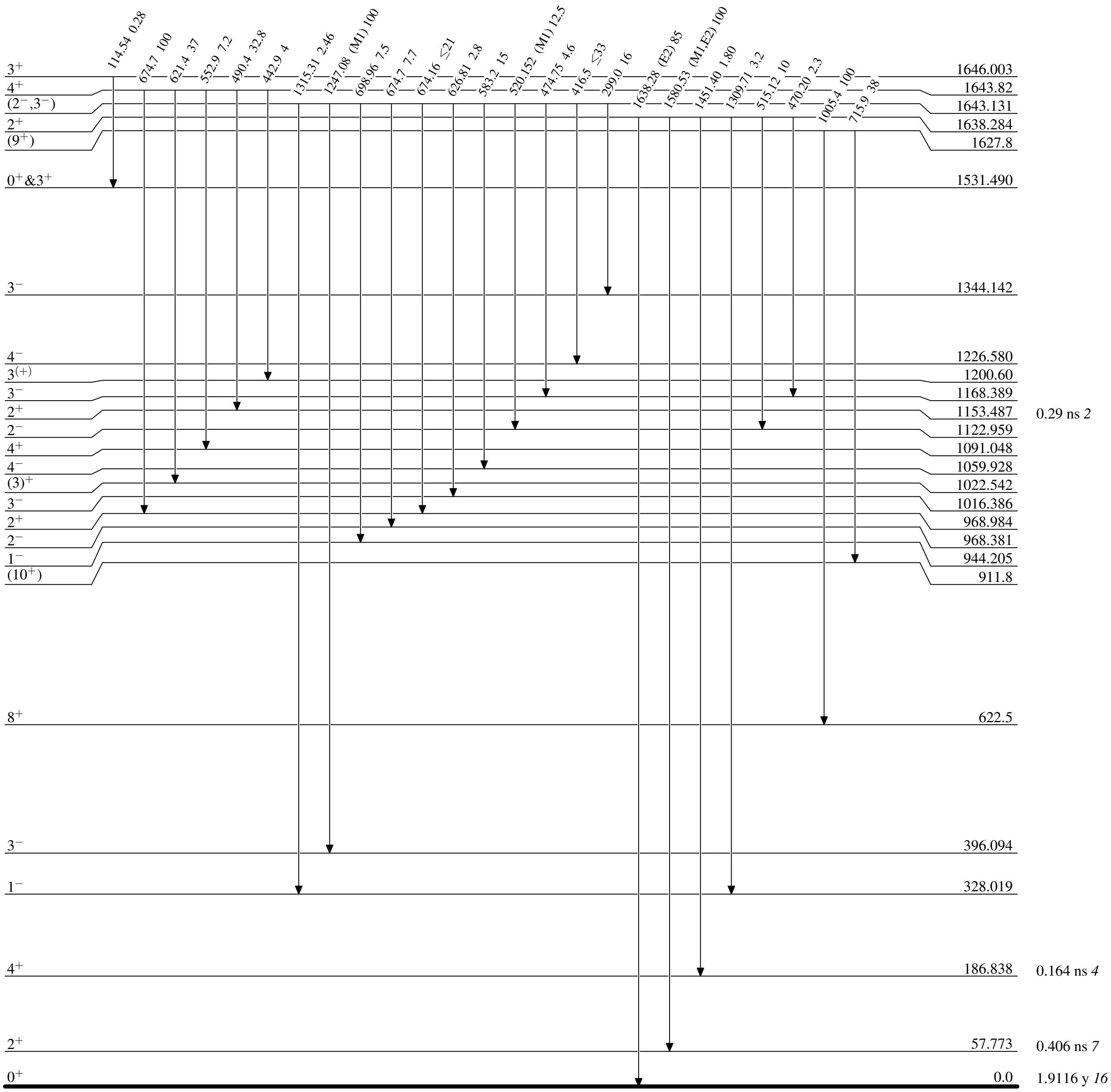
γ Decay (Uncertain)



Adopted Levels, Gammas

Level Scheme (continued)

Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided

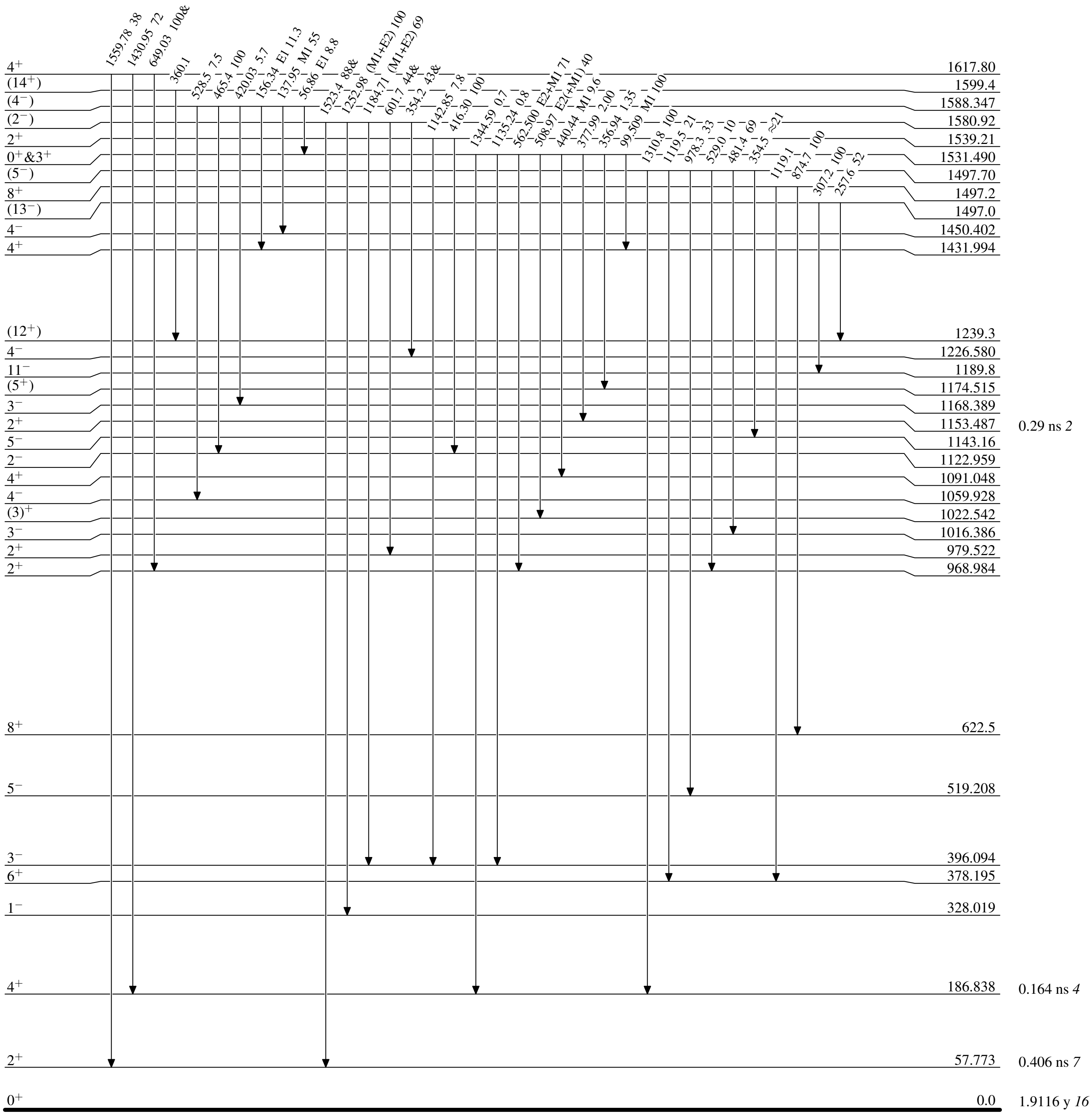


$^{228}_{90}Th_{138}$

Adopted Levels, Gammas

Level Scheme (continued)

Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided

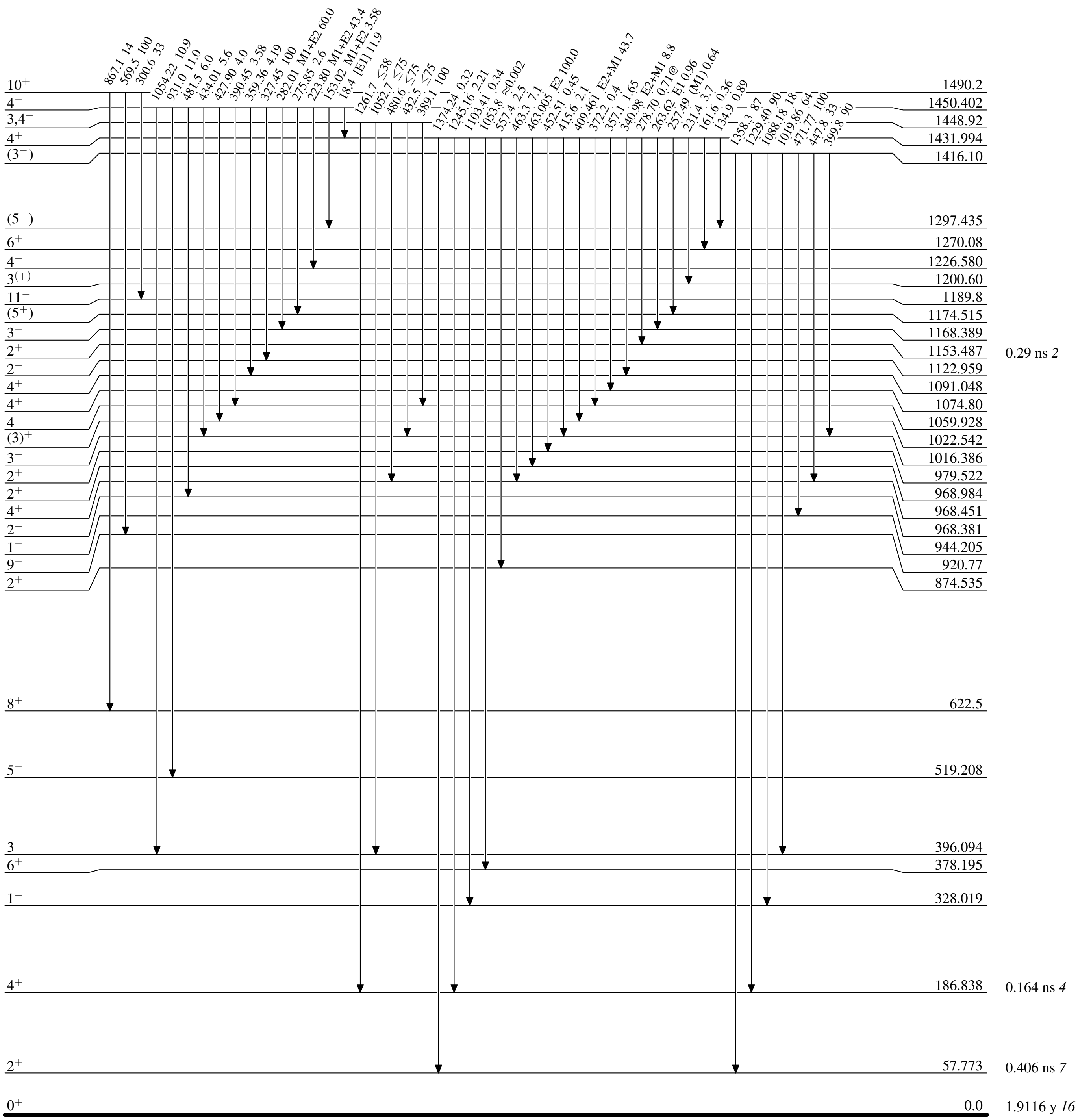


$^{228}_{90}Th_{138}$

Adopted Levels, Gammas

Level Scheme (continued)

Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided



$^{228}_{90}Th_{138}$

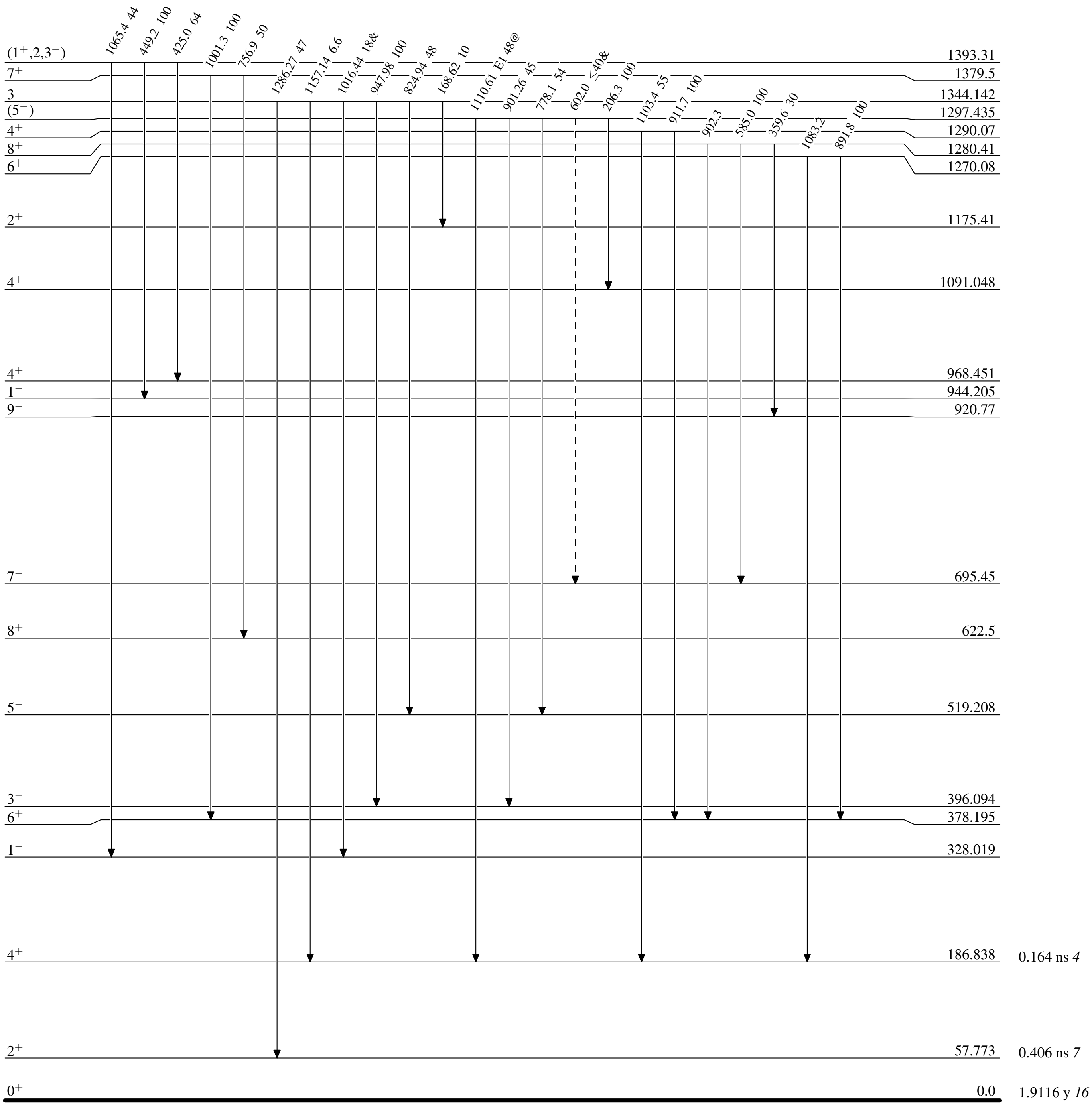
Adopted Levels, Gammas

Level Scheme (continued)

Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided

Legend

γ Decay (Uncertain)



$^{228}_{90}Th_{138}$

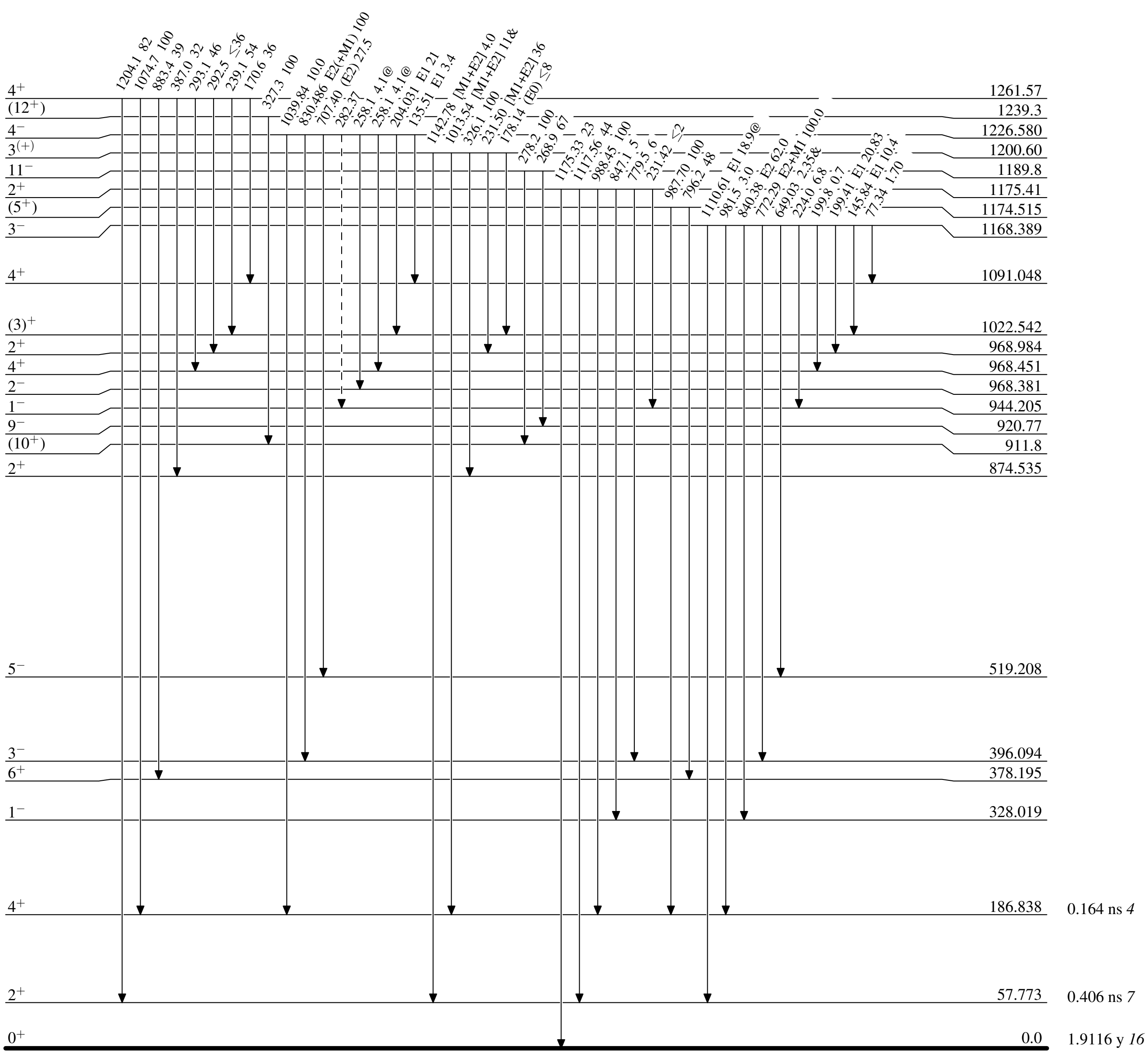
Adopted Levels, Gammas

Level Scheme (continued)

Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided

Legend

- - - - - -► γ Decay (Uncertain)

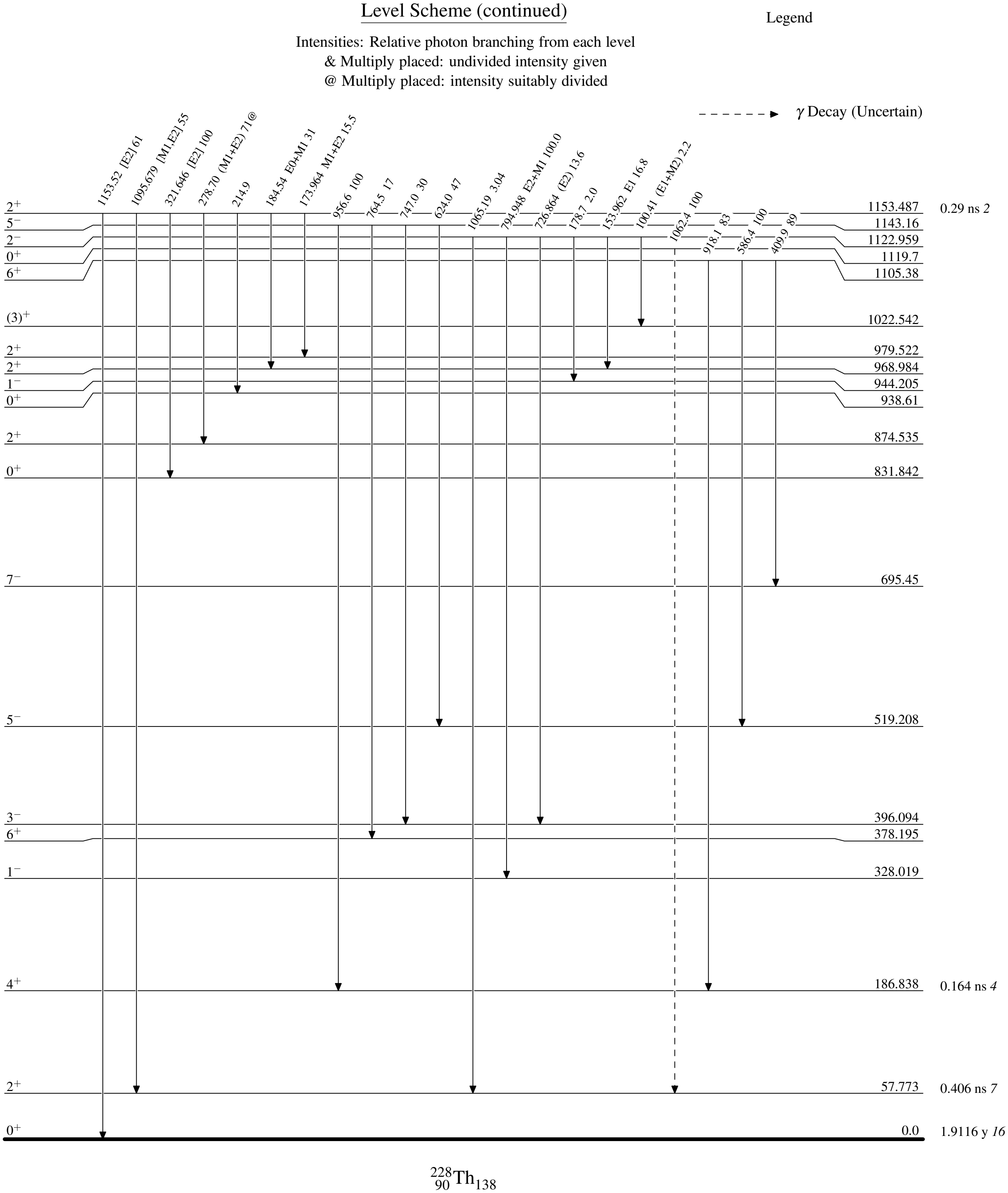


$^{228}_{90}$Th$_{138}$

Adopted Levels, Gammas

Level Scheme (continued)

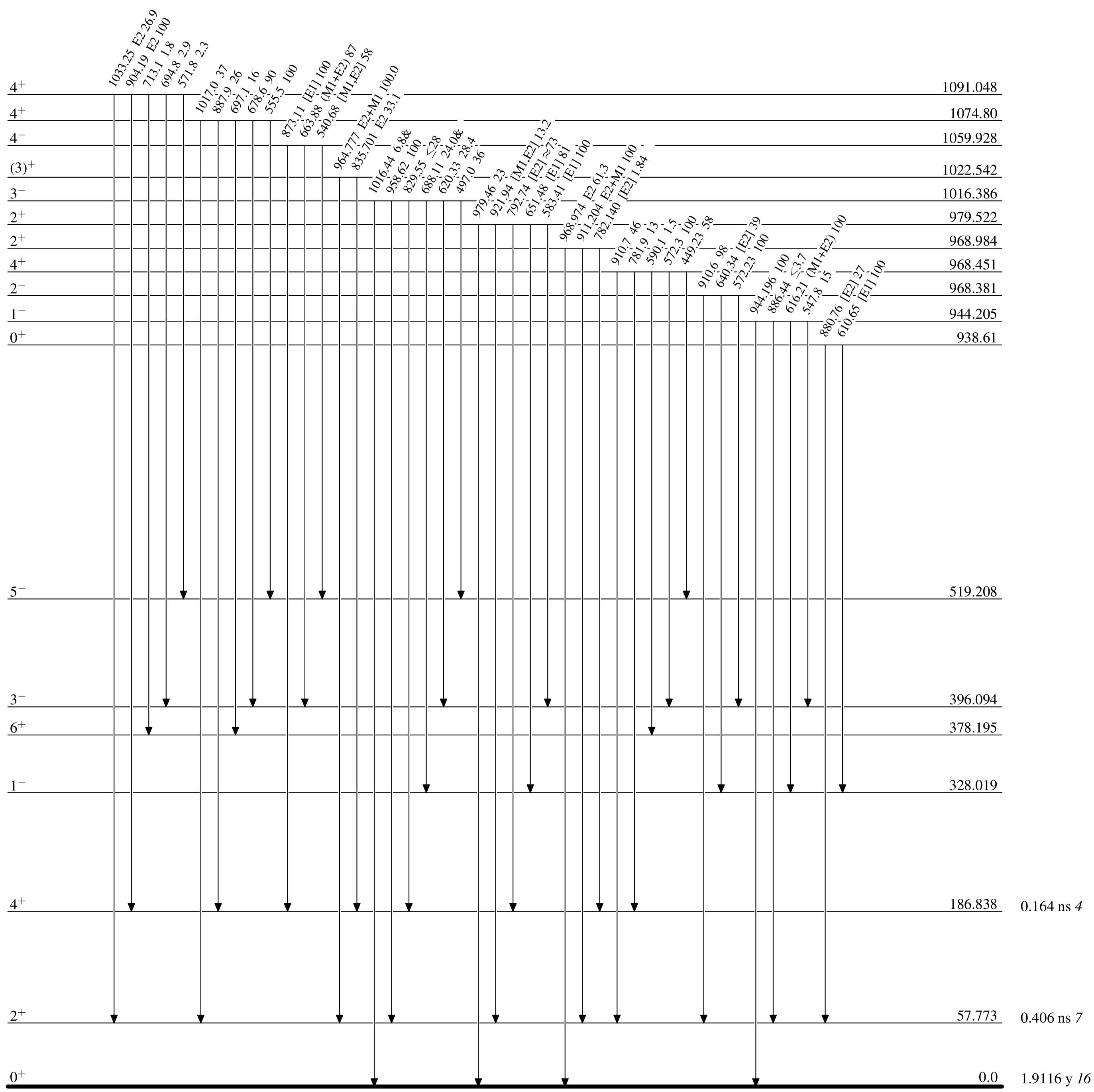
Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided



Adopted Levels, Gammas

Level Scheme (continued)

Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided

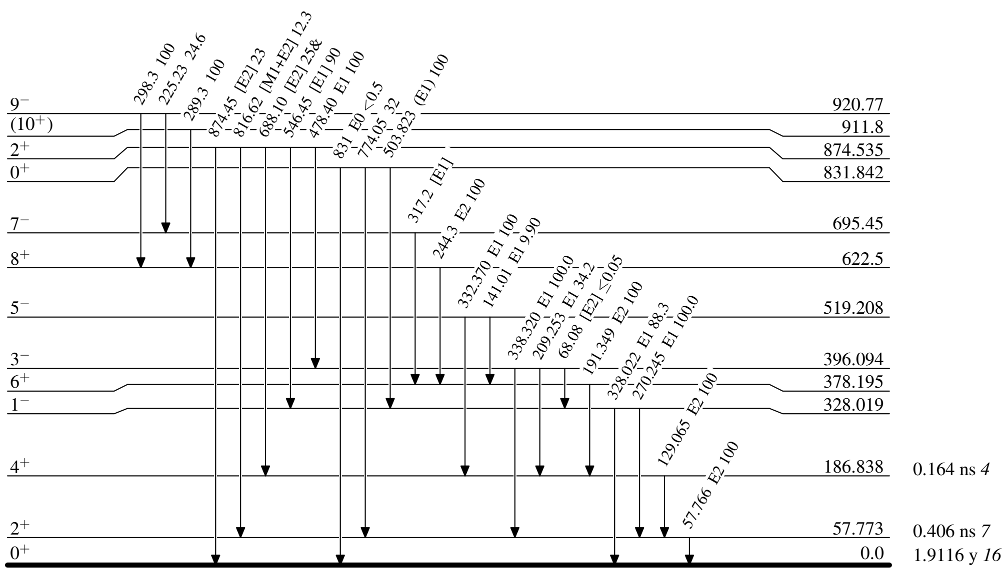


$^{228}_{90}Th_{138}$

Adopted Levels, Gammas

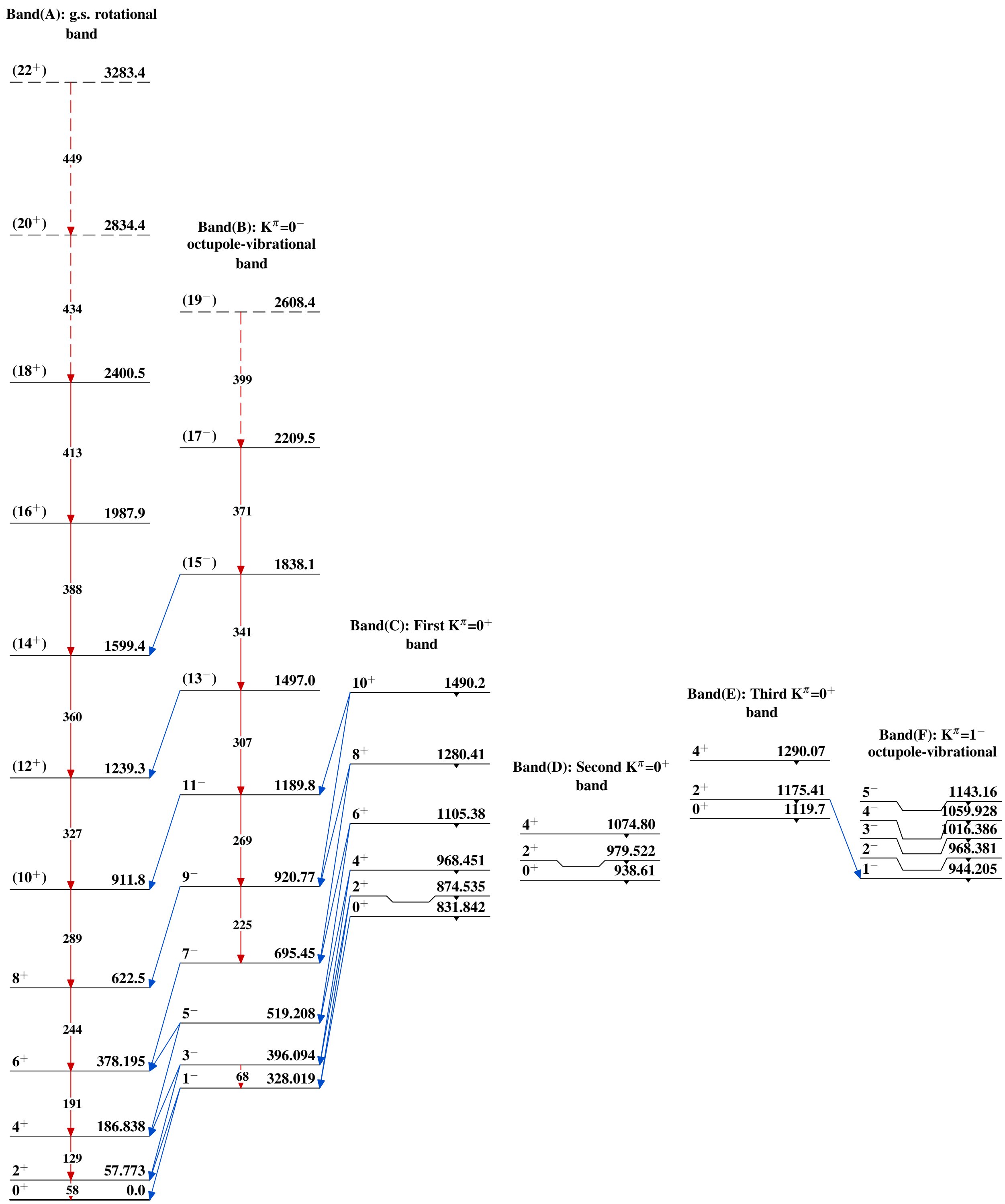
Level Scheme (continued)

Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided



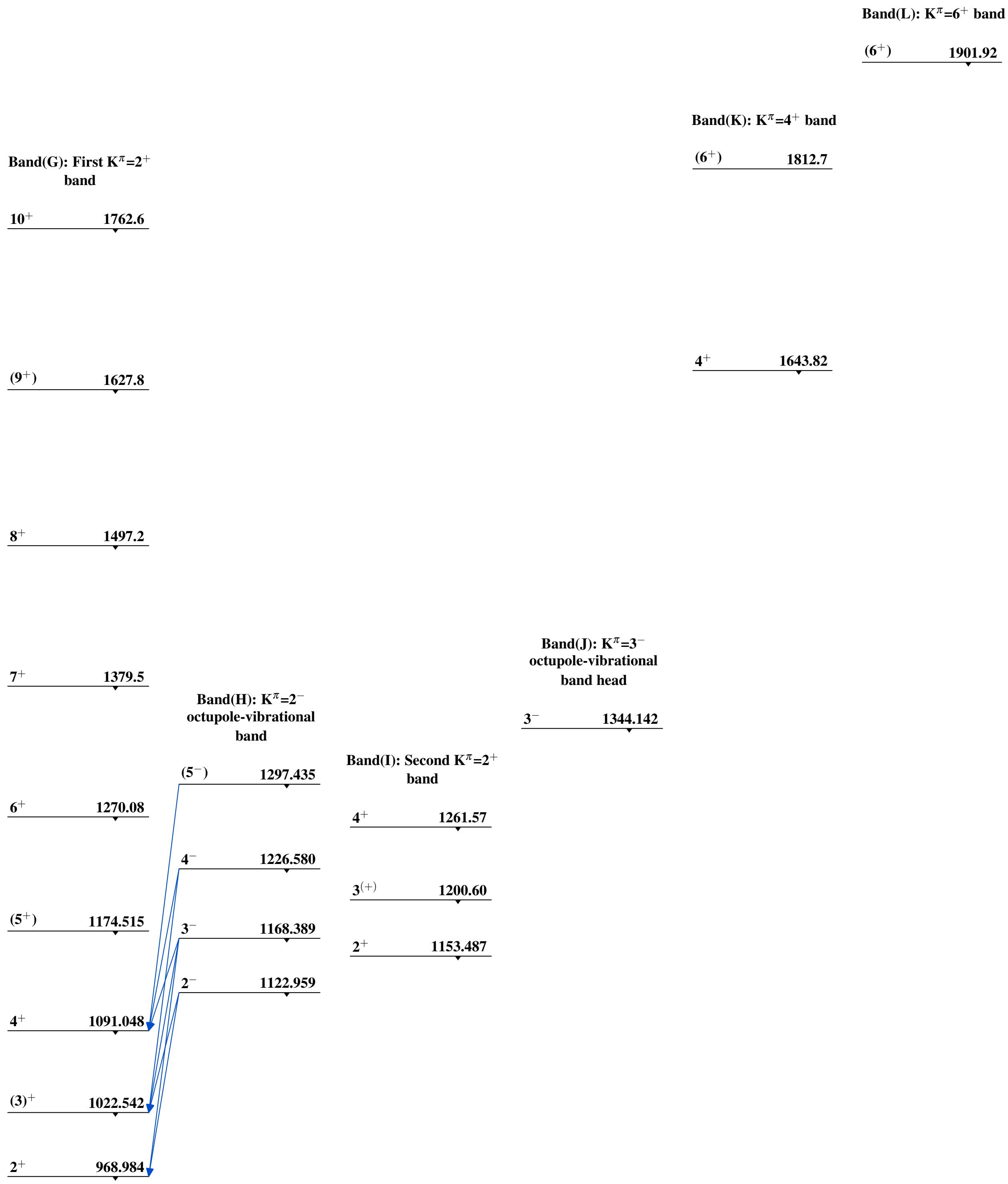
$^{228}_{90}Th_{138}$

Adopted Levels, Gammas



$^{228}_{90}Th_{138}$

Adopted Levels, Gammas (continued)



$^{228}_{90}Th_{138}$

Adopted Levels, Gammas

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	E. Browne, J. K. Tuli	NDS 113,2113 (2012)	1-May-2012

Q(β^-)=−1311 *3*; S(n)=6793.9 *23*; S(p)=7123 *12*; Q(α)=4769.8 *16* 2012Wa38

Note: Current evaluation has used the following Q record −1310.5 28 *6795.6* *23* 7175 324769.8 *15* 2011AuZZ.

Additional information 1.

Wave functions and energies for the K=2$^+$ γ vibrational, K=0$^-$, 1$^-$, 2$^-$, 3$^-$ octupole vibrational states were calculated by 1964So02 and 1975Iv03. See also 1969Bl13, 1970Ne08, 1974Be69, 1976Iv01, 1988Ot02 for calculated energies of these collective states. 1964So02 calculated also two-quasiparticle state energies. K=2 γ- and K=0 β-band energies were calculated by 1978To13, 1984Ba59; and K=0$^-$, K=0$^+$ band energies by 1990TrZY. See 1989Eg02 for calculated level energies and systematics of 1$^-$ states. For calculations of two-phonon state energy, see 1981So05, 1988Le14. For calculated positive parity, K=0 and K=2 band spectra and comparison with experiments, see 1989Br21.

The B(E2) and B(E3) values for excitation of the 2$^+$ and 3$^-$ members of quadrupole and octupole band, respectively, were calculated by 1975Iv03, 1970Ne08, 1988Ot02. B(E2) was also calculated by 1981So11, 1982Gu05 and 1990TrZY. The B(E3) and B(E1) values for the excitation of 3$^-$, 1$^-$ levels of K=0, K=1 bands, respectively, were calculated by 1977Ba45. See also 1984Ba59 and 1989Ch07 for calculated B(E3) values.

For calculations and discussions on reduced transition probabilities of gammas deexciting the octupole vibrational states, see for example, 1965So04, 1971Ku25, 1972Va24, 1987Na05, 1987Na27, 1989Eg02, 1990TrZY, 1990Na30. For calculated reduced E2 transition probabilities of gammas from the β and the γ vibrational band to the g.s. band, see 1965Be40, 1986Go07, 1989Br21.

In order to explain the observed (p,t) cross section to the 0$^+$ state at 635 keV, various formalisms were applied; (t,p) and (p,t) strengths, E0 and E2 reduced transition probabilities were calculated by 1972Va20, 1973Im02, 1976Ra12. Hindrance factor of α transition to this 0$^+$ state was calculated by 1969Cr05, 1972Ci02.

For proposed structures of low-lying 0$^+$ states and for discussions, see for example, 1969Cr05, 1972Ci02, 1972Ma15, 1972Va20, 1973Im02, 1976Ra12, 1976Iv04, 1990TrZY.

For calculated equilibrium quadrupole and hexadecapole deformation parameters, see 1970Ga12, 1974Br36, 1982Du16, 1982Le19, 1982Li01, 1983Ro14, 1984Eg01, 1984Na22, for example.

For deformation parameters deduced from Coulomb excitation, see 1973Be44 and 1977Mi11. For deformation parameter deduced from the ratio of (p,t) spectroscopic factors for g.s. and the first 0$^+$ state, see 1979Ab10.

1985Na07 studied the influence of octupole deformation on high-spin properties of nuclear spectra. See also 1986Sc18 for discussions on stable octupole deformations in neighboring thorium isotopes that may be deduced from displacement energy of the positive- and the negative-parity bands, and from enhanced E1 transitions connecting those bands.

Changes in nuclear shapes were studied by 1984Va24 as dependence on spin.

For systematics of the proton- and neutron-pairing interaction strengths estimated from empirical odd-even mass differences, see 1989Pi03.

For calculations of nuclear potential at large deformation, see for example, 1971Pa20, 1971Oh07, 1972Ma11, 1987Be42. For calculations of fission-barrier energies, see 1972Ma11, 1979Sh01, 1980Ku14. For experimentally deduced energies, see 1988Bl03 (triple-humped fission barrier) and 1974Ba28 (double-humped barrier). Nuclear properties (energy, ε (2,3,4,5,6), moment of inertia) at the third minimum were studied by 1987Be42.

Level energies of the shape isomers in two wells were deduced by 1988Bl03 from fission probability measurements in ^{229}Th(d,pF) reaction. Level energy of the shape isomer in first well was calculated by 1972Ma11.

Deformations, quadrupole and hexadecapole moments, moment of inertia of the expected first shape isomer were calculated by 1973So01, 1974Br36, 1978Po01.

Other references:

Calculated level energies, J^π: 2012Cu01, 2011Bo12, 2011No04, 2011Ra05, 2011Ri05, 2010Ab21, 2010Bo25, 2010Ch35, 2008Bi03, 2008Bu11, 2008Ch15, 2008Fr03, 2007Bo46.

Calculate alpha decay half-lives: 2012Qi01, 2011Qi01, 2011Sh13, 2011Zh36, 2009De32, 2009Qi07, 2007Pe30.

Calculated fission barriers and half-lives: 2012Lu02, 2010Ab23, 2010Sa09, 2009Dr05, 2008Xu06.

Cluster decay: 2011Ko36, 2010Ni13, 2010Si12, 2010Zh51, 2009Ar11, 2009Ni06, 2009Ro16, 2008Ku21, 2008Ro08.

Nuclear Structure: 2010Ko36, 2009Pa46, 2009So02, 2009Wa01, 2009Zh28, 2008Al13, 2008Bh05.

Calculated Q(α): 2010Wa23, 2008Zh12.

Calculated nuclear moments: 2010Vr01.

Calculated B(E2) ratios: 2011In03.

Nuclear reactions: 2011Ch57, 2011Si14.

Adopted Levels, Gammas (continued)

^{230}Th Levels

Cross Reference (XREF) Flags

A	^{234}U α decay	E	^{230}Pa ε decay	I	^{230}Th(d,pnγ)
B	^{230}Ac β^- decay	F	^{232}Th(p,t)	J	^{232}Th(^{136}Xe,Xγ)
C	Coulomb excitation	G	^{232}Th(^{206}Pb,^{208}Pbγ)		
D	^{230}Th(d,d′)	H	^{232}Th(α,α'2nγ) E=56 MeV		

E(level)[†]	J$^\pi$[‡]	T$_{1/2}$	XREF	Comments
0.0[#]	0$^+$	7.54×10^4 y *3*	ABCDEFGHIJ	%α=100; %^{24}Ne=5.8×10^{-11} *13*; %SF≤4×10^{-12} %^{24}Ne from T$_{1/2}$(^{24}Ne)=1.3×10^{17} y *3* (1996Bu05). %SF from T$_{1/2}$(SF)>2×10^{18} y (1985TrZY). Value recommended in 2000Ho27. Relative probability of cluster and α emission was measured by 1986Tr10; clusters were identified as neon ions from their residual ionic paths, and assigned to ^{24}Ne from comparison of experimental path distribution with calculations and from its decay energies. For theoretical predictions of various cluster decay modes (mostly ^{24}Ne) calculations of their partial half-lives, relative branchings, and decay energies, see 1984Po22, 1985Po10, 1986Po15, 1986Ka46, 1986Pi11, 1986Ir01, 1987Po08, 1987Sh04, 1988Bl11, 1989Ci03, 1989Ma43, 1989Sh37, 1990Sh01, 1990Ba20, 1990Ka15, 1990Bu09, 1990Bu13, 1991Bu01, 1991Ro03, 1996Bu05, 1997MiZP, 1997Ro24, 1997Tr17, 1998Bu18, 1998Ro11, 1999De51, 2000Bu32, 2000Bu02, 2002Du16, 2002Ba80, 2003Sh02, 2003Mi18, 2003Ad34, 2003Ad32, 2004Re22, 2004He16, 2004Ba64, 2005Ku32, 2005Ku04, 2005Bu38, 2005Bh02, 2006Xu15. T$_{1/2}$: measurement of 1980Me10 (specific activity). Other measured values: 8.23×10^4 y *25* (1930Cu02, from ^{222}Rn growth), 7.3×10^4 y *4* (1931So01, from ^{226}Ra growth), 8.0×10^4 y *3* (1949Hy03, specific activity), 7.61×10^4 y *14* (1962At01, calorimetry). See 1980Me10 and 1990Ho28 for earlier measurements and for recalculated half-lives. Other value: >1.5×10^{17} y (1952Se67). T$_{1/2}$(SF)≥1.5×10^{17} y (1952Se67) yields %SF≤5×10^{-11}. See 1979Po23 and 2004Ro01 for theoretical half-life values. Isotope shift relative to ^{232}Th was measured by 1989Ka29 by LASER spectroscopy: IS=15360 *30* MHz [IS=ν(^{230}Th)-ν(^{232}Th)]. For calculated charge radii, theoretical quadrupole and hexadecapole moments at g.s., and comparison with the values deduced from Coulomb excitation, see 1974Br36, 1982Li01, 1983Ro14.
53.227[#] *11*	2$^+$	0.354 ns *9*	ABCDEFGHIJ	J$^\pi$: 53.20γ to 0$^+$ is E2. T$_{1/2}$: From (α)(ce)(t) in ^{234}U decay (1965Ne03). Other values: T$_{1/2}$=0.37 ns *2* from γce(t) in ^{230}Pa decay (1960Be25), T$_{1/2}$=0.352 ns *5* calculated by the evaluator from B(E2) of 8.06 *11*.
174.111[#] *17*	4$^+$	0.166 ns *5*	ABCDEFGHIJ	B(E4)↑=1.19 *32* J$^\pi$: 120.90γ E2 to 2$^+$; hindrance factor from ^{234}U alpha decay. T$_{1/2}$: from (α)(ce)(t) in ^{234}U decay (1965Ne03).
356.47[#] *14*	6$^+$		CD FGHIJ	
508.150[@] *13*	1$^-$		ABCDEF IJ	J$^\pi$: 508.2γ E1 to 0$^+$.
571.756[@] *15*	3$^-$		BCDEF IJ	B(E3)↑=0.64 *6* J$^\pi$: 518.5γ E1 and 397.7γ E1 to 2$^+$ and 4$^+$ levels.
593.79[#] *20*	8$^+$		CD FGHIJ	
634.919[&] *18*	0$^+$		ABCDEF I	J$^\pi$: 634.9-keV E0 transition to 0$^+$.

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

^{230}Th Levels (continued)

E(level)[†]	Jπ[‡]	$T_{1/2}$	XREF	Comments
677.515[&] *18*	2^+	15 ps *2*	ABC EF I	B(E2)↑=0.046 *6* $T_{1/2}$: calculated by the evaluator from B(E2). See Coulomb excitation. Jπ: 624.3γ E0+M1+E2 to 2^+.
686.6[@] *3*	(5^-)		CD F IJ	Jπ: 114.9γ to 3^-, 330.1γ to 6^+.
769.6 *6*	(4^+)		C	Jπ: γ rays to 2^+ and 6^+ states.
775.5[&] *3*	(4^+)		F I	
781.375[a] *13*	2^+	3.3 ps *5*	BCDEF I	B(E2)↑=0.123 *13* Jπ: 781.35γ E2 to 0^+. $T_{1/2}$: calculated by the evaluator from B(E2). See Coulomb excitation.
825.664[a] *21*	3^+		BC EF I	Jπ: 772.4γ E2 to 2^+; γ ray to 4^+, and γ ray from 2^-; ratio of reduced transition rates agrees with theory (Alaga rule): B(E2,772.4γ)/B(E2,651.6γ)=0.39 *17* observed, 0.40 theory.
852.14[@] *21*	(7^-)		CD F IJ	
879.3[#] *3*	(10^+)		C FGHIJ	
883.6[a] *6*	4^+		CD F I	Jπ: γ rays to 2^+, 4^+, 6^+ states.
922.95[&] *20*	(6^+)		F I	
951.898[b] *14*	1^-		BCDEF	Jπ: 951.95γ E1 to 0^+.
955.04[a] *23*	(5^+)		I	
971.726[b] *17*	2^-		BC EF	Jπ: 463.6γ M1+E2 to 1^-, 399.95γ M1+E2 to 3^-.
1009.601[c] *14*	2^+	≥0.8 ps	BC EF I	B(E2)↑≤0.097 XREF: F(1011.6). $T_{1/2}$: Calculated by evaluators from B(E2). See Coulomb excitation. Jπ: 1009.6γ E2 to 0^+.
1012.46[b] *3*	3^-		BCDEF	B(E3)↑≤0.57 XREF: F(1011.6). Jπ: 959.2γ E1 to 2^+; 838.4γ to 4^+.
1022 *2*			F	
1039.45[a] *23*	(6^+)		C F I	
1052.14[c] *10*	(3^+)		C EF I	
1065.3[@] *4*	(9^-)		C F IJ	
1079.216[d] *15*	$(2)^-$		BC EF	Jπ: 1026γ E1 to 2^+; 253.6γ to 3^+ state; no γ ray to 4^+; ratio of reduced transition rates is in fair agreement with theory (Alaga rule): B(E2,571γ)/B(E2,508γ)=2.7 *14* observed, 4.0 theory.
1089 *2*			F	
1108.2[c] *7*	(4^+)		C F I	
1108.9[b] *7*	(5^-)		CD	Jπ: γ-ray transitions to 4^+, 3^- states of the K=0^+ g.s. and K=0^- octupole-vibrational bands, but no γ rays to 0^+, 2^+ and 1^- states of these bands.
1117.4[&] *3*	(8^+)		I	
1125.6 *5*	(1^-),(0^+)		F	
1127.789[d] *15*	3^-		CDE	Jπ: 1074.68γ E1 to 2^+; 954γ to 4^+ state.
1134.2[a] *3*	(7^+)		I	
1144 *2*			F	
1148.0 *9*			F	
1176.0[c] *3*	(5^+)		C I	
1184.8 *9*			F	
1196.8[d] *10*	(4^-)		C	Jπ: 1022.7γ to 4^+ state, but no γ rays to the 0^+, 2^+ states of the g.s. band.
1206.6[#] *5*	(12^+)		C GHIJ	
1241.2 *9*			F	
1243.0[a] *3*	(8^+)		I	

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Adopted Levels, Gammas (continued)

^{230}Th Levels (continued)

E(level)[†]	J^{π}[‡]	XREF	Comments
1251.2 *8*	(8$^+$)	C	
1255.4[c] *4*	(6$^+$)	F I	
1259.2 *6*	(3$^-$)	F	
1283.6 *6*	(5$^-$)	F	
1297.14 *8*	0$^+$	B F	
1322.0[@] *5*	(11$^-$)	C IJ	
1322.3 *5*	(3$^-$)	F	
1337.2 *5*	4$^+$	F	
1349.0[c] *4*	(7$^+$)	I	
1358.4[a] *4*	(9$^+$)	I	
1359.5 *7*	(2$^+$)	F	
1375.28 *6*	(1,2$^+$)	B F	J$^\pi$: γ ray to 0$^+$ level.
1400.89 *5*	(2$^+$)	B F	J$^\pi$: γ rays to 0$^+$ and 4$^+$ levels.
1401.5 *5*	2$^+$	F	
1420.4 *5*	(3$^+$)	F	
1440.4 *8*	(3$^+$)	F	
1447.9 *5*	0$^+$	F	
1448.4[c] *5*	(8$^+$)	I	
1485.62 *8*	(4$^+$)	B	
1496.0 *10*		F	
1507.4 *5*	4$^+$	F	
1520.1[a] *8*	(10$^+$)	C	
1524.8 *5*	2$^+$	F	
1566.2 *6*	(1$^-$)	F	
1571.8[#] *7*	(14$^+$)	C J	
1573.51 *20*	1$^{(-)}$,2$^+$	B D F	J$^\pi$: 1573.5γ to 0$^+$; populated in (d,d′).
1584.7 *6*	(4$^-$,5$^+$)	F	
1589.8 *3*	0$^+$	B D F	J$^\pi$: L=0 in ^{232}Th(p,t) reaction.
1594.7 *8*	(1$^-$)	F	
1601.2 *11*	(3$^-$)	F	
1612.1 *10*	(4$^-$,5$^+$)	F	
1616.0[@] *6*	(13$^-$)	C J	
1618.7 *9*	(4$^-$,5$^+$)	F	
1628 *2*		D F	
1630.1 *7*	2$^+$	F	
1638.45 *9*	(0$^+$)	B F	J$^\pi$: γ rays to 2$^+$ states; log *ft*=7.1 from (1$^+$) ^{230}Ac β^- decay. J^π=2$^+$, K=0 was suggested by 1972Ma15 from energy difference of the 1638.5- and 1589.8-keV levels.
1653.2 *11*	(6$^+$)	F	
1663 *3*		D	
1668.2 *7*	(4$^+$)	F	
1679.1 *7*	(2$^+$)	F	
1683.3 *7*	(4$^-$)	F	
1694.9 *7*	(4$^+$)	F	
1695.71 *9*	1$^{(-)}$,2$^+$	B D	J$^\pi$: 1695.7γ to 0$^+$ level. Populated in (d,d′).
1708.8 *8*	2$^+$	F	
1718 *3*		D	
1723.5 *7*	(4$^+$)	F	
1745.3 *8*	(0$^+$)	B F	
1750.7 *8*	(3$^-$)	F	
1762.3 *8*	(4$^+$)	F	
1769.6 *8*	(4$^+$)	F	
1770.73 *10*	(1,2$^+$)	B	J$^\pi$: 1770.5γ to 0$^+$ level.
1775.22 *7*	(1,2$^+$)	B F	J$^\pi$: 1775.3γ to 0$^+$ level.

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Adopted Levels, Gammas (continued)

^{230}Th Levels (continued)

E(level)†	Jπ‡	XREF	Comments
1789.4 *5*	$1^{(-)},2^+$	B D	Jπ: 1789.4γ to 0^+ level. Populated in (d,d′).
1793.1 *6*	(5^-)	F	
1802.5 *6*	0^+	F	
1810.74 *6*	$(1,2^+)$	B	Jπ: 1810.7γ to 0^+ level.
1812.0 *8*	4^+	F	
1824.9 *7*	(6^+)	F	
1839.61 *20*	$1^{(-)},2^+$	B D F	Jπ: 1839.6γ to 0^+ level. Populated in (d,d′).
1849.54 *9*	(2^+)	B	Jπ: γ rays to 4^+, 2^+, and 2^- levels; log *ft*=6.9 from (1^+) ^{230}Ac β- decay.
1851.4 *7*	(3^-)	F	
1858.2 *5*	(3^-)	B D F	
1868.9 *7*	(0^+)&(6^+)	F	
1887.0 *9*	(2^+)	F	
1902.70 *9*	$(1,2^+)$	B	Jπ: 1902.7γ to 0^+ level.
1910.0 *9*	(6^+)	F	
1914.7 *9*	(1^-)	F	
1926.0 *7*	4^+	F	
1931.1 *8*	(1^-)	F	
1939.8 *11*	(1)	F	
1947.0 *6*	4^+	F	
1947.1@ *7*	(15^-)	C J	
1949.87 *7*	$(1,2^+)$	B	Jπ: 1949.8γ to 0^+ level.
1956.4 *6*	2^+	F	
1967.00 *10*	$(1,2^+)$	B F	Jπ: 1966.7γ to 0^+ level.
1969.5# *8*	(16^+)	C J	
1973.44 *10*	$(1^+,2^+)$	B F	Jπ: 1973.5γ to 0^+ level, and possible 1147.9γ to 3^+ state.
1985.4 *8*	(5^-)	F	
2000.91 *10*	$(1,2^+)$	B	Jπ: 2000.9γ to 0^+ level.
2001.6 *8*	(3^-)	F	
2010.13 *9*	$(1,2^+)$	B F	Jπ: 2010.1γ to 0^+ level.
2017.3 *7*	(3^-)	F	
2024.67 *13*	$(1^+,2^+)$	B F	Jπ: γ rays to 0^+ and 3^+ levels.
2032.8 *7*	4^+	F	
2039.1 *7*	4^+	F	
2048.7 *7*	(4^+)	F	
2060.9 *12*	(3^-)	F	
2073.2 *8*	(8^+)	F	
2074.9 *8*	(4^+)	F	
2078.25? *10*		B	
2085.9 *8*	(4^+)	F	
2093.9 *7*	0^+	F	
2102.0 *7*	4^+	F	
2118.4 *6*	4^+	F	
2122.77 *9*	$(1,2^+)$	B	Jπ: 2122.8γ to 0^+ level.
2130.7 *7*	2^+	F	
2133.14? *12*		B F	
2137.9 *7*	2^+	F	
2150.5 *6*	0^+	F	
2151.81 *10*	$(1,2^+)$	B	Jπ: 2152.0γ to 0^+ level.
2168.8 *7*	(4^+)	F	
2175.1 *6*	0^+	F	
2181.7 *7*	(4^+)	F	
2187.1 *6*	2^+	F	
2194.8 *8*	(6^+)	F	
2205.4 *10*	2^+	F	
2207.8 *8*	(4^+)	F	

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

^{230}Th Levels (continued)

E(level)†	J$^{\pi}$‡	XREF	Comments
2216.0 *7*	(4$^+$)	F	
2226.0 *6*	2$^+$	F	
2241.0 *7*	2$^+$	F	
2249.9 *7*	(6$^+$)	F	
2255.3 *7*	4$^+$	F	
2268.9 *6*	0$^+$	F	
2276.0 *8*	(4$^+$)	F	
2282.98 *16*	1,2$^+$	B F	J$^{\pi}$: 2282.5γ to 0$^+$ level.
2295.9 *8*	4$^+$	F	
2298.6 *3*	(1,2$^+$)	B	J$^{\pi}$: 2298.6γ to 0$^+$ level.
2305.4 *7*	2$^+$	F	
2310.5@ *8*	(17$^-$)	C J	
2311.2 *8*	(4$^+$)	F	
2314.27? *15*	(1,2$^+$)	B	J$^{\pi}$: 2314.0γ to 0$^+$ level.
2317.7 *7*	4$^+$	F	
2329.6 *7*	2$^+$	F	
2337.1 *8*	(5$^-$)	F	
2354.8 *10*	(6$^+$)	F	
2368.91 *17*	(0$^+$)	B F	
2383.8 *8*	(4$^+$)	F	
2388.4 *10*		F	
2395.2 *7*	0$^+$	F	
2396.3# *9*	(18$^+$)	C J	
2402.0 *8*	(6$^+$)	F	
2411.6 *7*	2$^+$	F	
2422.7 *7*	2$^+$	F	
2426.4 *9*	(0$^+$)	F	
2436.6 *9*	2$^+$	F	
2442.5 *8*	2$^+$	F	
2449.2 *2*	(3$^-$)	F	
2461.0 *7*	2$^+$	F	
2467.2 *7*	2$^+$	F	
2474.3 *8*	2$^+$	F	
2478.5 *8*	4$^+$	F	
2481.3 *12*	(6$^+$)	F	
2493.8 *7*	0$^+$	F	
2501.1 *7*	4$^+$	F	
2508.3 *7*		F	
2519.3 *7*	(6$^+$)	F	
2528.1 *7*	0$^+$	F	
2536.9 *7*	4$^+$	F	
2549.8 *11*	0$^+$	F	
2556.2 *8*	(4$^+$)	F	
2562.9 *9*	(4$^+$)	F	
2573.2 *7*	(6$^+$)	F	
2589.1 *7*	2$^+$	F	
2596.4 *8*	(0$^+$)	F	
2601.3 *7*	(4$^+$)	F	
2616.0 *7*	2$^+$	F	
2625.9 *7*	2$^+$	F	
2640.0 *8*	4$^+$	F	
2660.9 *7*	4$^+$	F	
2666.4 *7*	(2$^+$)	F	
2671.6 *7*	4$^+$	F	
2679.2 *8*	2$^+$	F	

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

^{230}Th Levels (continued)

E(level)[†]	J^{π}[‡]	XREF
2694.9 *7*	2^+	F
2703.7[@] *9*	(19^-)	C J
2706.5 *7*	2^+	F
2712.9 *5*	(6^+)	F
2726.6 *7*	2^+	F
2740.6 *7*	2^+	F
2746.2 *7*	4^+	F
2754.2 *10*	(6^+)	F
2764.9 *7*	2^+	F
2777.3 *7*	2^+	F
2791.5 *7*	4^+	F
2799.7 *8*	2^+	F
2808.1 *7*	0^+	F
2824.4 *10*	4^+	F
2834.0 *10*	2^+	F
2841.3 *7*	(2^+)	F
2848.6[#] *11*	(20^+)	C J
2855.9 *7*	2^+	F
2862.9 *7*	2^+	F
2870.6 *10*	(3^-)	F
2879.7 *7*	2^+	F
2886.1 *10*	(1^-)	F
2896.1 *7*	2^+	F
2906.4 *8*	(3^-)	F
2913.6 *15*	(4^+)	F
2923.7 *9*	2^+	F
2930.6 *7*	2^+	F
2940.6 *7*	2^+	F
2950.5 *8*	(6^+)	F
2987.9 *10*	(6^+)	F
2999.0 *7*	2^+	F
3009.9 *8*	2^+	F
3020.6 *8*	2^+	F
3030.3 *9*	2^+	F
3043.0 *7*	2^+	F
3052.4 *9*	(3^+)	F
3064.3 *15*	(2^+)	F
3072.6 *8*	(6^+)	F
3083.8 *7*	2^+	F
3100.9 *7*	2^+	F
3113.9 *12*	(≤ 4)	F
3124.7 *8*	(4^+)	F
3125[@]	(21^-)	C J
3135.9 *10*	(≤ 4)	F
3147.4 *8*	(≤ 4)	F
3162.0 *7*	2^+	F
3173.6 *8*	2^+	F
3186.1 *7*	(6^+)	F
3198.4 *7*	2^+	F
3212.2 *7*	2^+	F
3223.1 *7*	2^+	F
3234.0 *7*		F
3248.6 *7*	2^+	F
3258.8 *8*		F
3269.9 *12*	(2^+)	F

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

^{230}Th Levels (continued)

E(level)[†]	J^{π}[‡]	XREF	Comments
3324.0[#] *12*	(22^+)	C J	
3572.5?[@]	(23^-)	J	
3819?[#]	(24^+)	C J	
50×10^2 *4*		F	Group of levels containing deep-hole states (1982Na06).

[†] Deduced by evaluators from a least squares fit to adopted γ-ray energies, unless otherwise specified.

[‡] Spin/parity assignments are based on rotational and band structures, on γ-ray multipolarities, on log *ft* values from ^{230}Ac β^- decay and ^{230}Pa ε decay, and on hindrance factors from ^{234}U alpha decay. For levels populated only in ^{234}Th(p,t), spin/parity assignments are based on angular distribution of scattered tritons. Some additional specific arguments are given for individual levels.

[#] Band(A): $K^{\pi}=0^+$ g.s. rotational band. Assignments for levels with $J^{\pi}\geq6^+$ are from inband γ rays observed in Coulomb excitation. For g.s. band level-energy calculations, see 1989Hu05 (by using Harris expansion) and 1989Xu04 (by least square, four parameter fitting to rotational-band formula). For theoretical calculations of moment of inertia, see 1974Br36, 1980Du07, 1987Mi26, for example.

[@] Band(B): $K^{\pi}=0^-$ octupole-vibrational band. Assignments for levels with $J^{\pi}\geq5^-$ are from γ rays to lower members of the K=0$^-$ octupole-vibrational band and to the g.s. rotational band. See 1989Ku23 for a discussion on alignments.

[&] Band(C): $K^{\pi}=0^+$ β-vibrational band.

[a] Band(D): $K^{\pi}=2^+$ γ-vibrational band. Assignments for levels with $J^{\pi}\geq6^+$ are from γ ray decays to the g.s. rotational band, and from fit to the K=2 γ- vibrational band.

[b] Band(E): $K^{\pi}=1^-$ octupole-vibrational band. Distorted by Coriolis interaction. For discussions see 1971Ku25, 1973ChZH, 1989Ku23, for example.

[c] Band(F): $K^{\pi}=2^+$ band. Assignments for levels with $J^{\pi}\geq3^+$ are from γ decays to the g.s. band observed in Coulomb excitation.

[d] Band(G): $K^{\pi}=2^-$ octupole-vibrational band.

Adopted Levels, Gammas (continued)

$\gamma(^{230}Th)$

E_i(level)	J^π_i	E_γ[‡]	I_γ[‡]	E_f	J^π_f	Mult.[#]	α[†]	$I_{(\gamma+ce)}$	Comments
53.227	2^+	53.20 *2*	100	0.0	0^+	E2	228		α(L)=166.8 *24*; α(M)=45.7 *7*; α(N+..)=15.39 *22* α(N)=12.22 *18*; α(O)=2.72 *4*; α(P)=0.448 *7*; α(Q)=0.001240 *18* B(E2)(W.u.)=196 *6* E_γ: From ^{234}U alpha decay.
174.111	4^+	120.90 *2*	100	53.227	2^+	E2	4.94		α(K)=0.257 *4*; α(L)=3.42 *5*; α(M)=0.940 *14*; α(N+..)=0.318 *5* α(N)=0.252 *4*; α(O)=0.0562 *8*; α(P)=0.00936 *14*; α(Q)=5.21×10^{-5} *8* B(E2)(W.u.)=265 *9* E_γ: From ^{234}U alpha decay.
356.47	6^+	182.5 *2*	100	174.111	4^+				E_γ: From ^{232}Th(^{136}Xe,Xγ).
508.150	1^-	454.92 *2*	100 *3*	53.227	2^+	E1	0.01528		α(K)=0.01237 *18*; α(L)=0.00220 *3*; α(M)=0.000525 *8*; α(N+..)=0.0001782 *25* α(N)=0.0001391 *20*; α(O)=3.25×10^{-5} *5*; α(P)=6.15×10^{-6} *9*; α(Q)=5.10×10^{-7} *8*
		508.15 *2*	60 *3*	0.0	0^+	E1	0.01222		α(K)=0.00992 *14*; α(L)=0.001743 *25*; α(M)=0.000415 *6*; α(N+..)=0.0001410 *20* α(N)=0.0001099 *16*; α(O)=2.57×10^{-5} *4*; α(P)=4.88×10^{-6} *7*; α(Q)=4.13×10^{-7} *6*
571.756	3^-	63.5 *2*		508.150	1^-				E_γ: From ^{230}Th(d,pnγ).
		397.62 *2*	87 *4*	174.111	4^+	E1	0.0202		α(K)=0.01630 *23*; α(L)=0.00295 *5*; α(M)=0.000704 *10*; α(N+..)=0.000239 *4* α(N)=0.000187 *3*; α(O)=4.36×10^{-5} *6*; α(P)=8.20×10^{-6} *12*; α(Q)=6.65×10^{-7} *10*
		518.54 *2*	100 *5*	53.227	2^+	E1	0.01174		α(K)=0.00953 *14*; α(L)=0.001671 *24*; α(M)=0.000398 *6*; α(N+..)=0.0001351 *19* α(N)=0.0001054 *15*; α(O)=2.47×10^{-5} *4*; α(P)=4.68×10^{-6} *7*; α(Q)=3.97×10^{-7} *6*
593.79	8^+	237.4 *2*	100	356.47	6^+				E_γ: From ^{232}Th(^{136}Xe,Xγ).
634.919	0^+	581.65 *10*	100	53.227	2^+	E2	0.0302		α(K)=0.0203 *3*; α(L)=0.00735 *11*; α(M)=0.00188 *3*; α(N+..)=0.000641 *9* α(N)=0.000503 *7*; α(O)=0.0001158 *17*; α(P)=2.09×10^{-5} *3*; α(Q)=1.089×10^{-6} *16*
		634.9 *2*		0.0	0^+	E0		120 *25*	
677.515	2^+	503.55[f] *10*	86[f@] *13*	174.111	4^+	E2	0.0420		B(E2)(W.u.)=10 *4* α(K)=0.0266 *4*; α(L)=0.01141 *16*; α(M)=0.00296 *5*; α(N+..)=0.001007 *15* α(N)=0.000792 *11*; α(O)=0.000181 *3*; α(P)=3.24×10^{-5} *5*; α(Q)=1.463×10^{-6} *21*
		624.33 *7*	88 *5*	53.227	2^+	E0+M1+E2	0.07 *5*		α(K)=0.06 *4*; α(L)=0.012 *6*; α(M)=0.0028 *13*; α(N+..)=0.0010 *5*

From ENSDF

Adopted Levels, Gammas (continued)

$\gamma(^{230}Th)$ (continued)

E_i(level)	J^π_i	E_γ[‡]	I_γ[‡]	E_f	J^π_f	Mult.[#]	α[†]	Comments
								α(N)=0.0008 4; α(O)=0.00018 9; α(P)=3.4×10^{-5} 17; α(Q)=2.9×10^{-6} 20
								α: Experimental value.
677.515	2^+	677.53 6	100 9	0.0	0^+	E2	0.0217	B(E2)(W.u.)=2.7 9
								α(K)=0.01533 22; α(L)=0.00475 7; α(M)=0.001204 17; α(N+..)=0.000410 6
								α(N)=0.000322 5; α(O)=7.43×10^{-5} 11; α(P)=1.359×10^{-5} 19; α(Q)=8.03×10^{-7} 12
686.6	(5^-)	114.9[a]	19[a] 6	571.756	3^-			
		330.1[a]	55[a] 4	356.47	6^+			
		512.6[a]	100[a] 6	174.111	4^+			
769.6	(4^+)	413.0[a]	≤45[a]	356.47	6^+			
		595.5[a]	82[a] 55	174.111	4^+			
		716.4[a]	100[a] 37	53.227	2^+			
775.5	(4^+)	419.7[b] 5	16[b] 4	356.47	6^+			
		601.1[b] 3	100[b] 10	174.111	4^+			
781.375	2^+	607.41 8	2.7 12	174.111	4^+	[E2]	0.0274	α(K)=0.0187 3; α(L)=0.00647 9; α(M)=0.001654 24; α(N+..)=0.000563 8
								α(N)=0.000442 7; α(O)=0.0001018 15; α(P)=1.85×10^{-5} 3; α(Q)=9.98×10^{-7} 14
								B(E2)(W.u.)=0.37 14
		728.13 2	100 5	53.227	2^+	E2	0.0187	α(K)=0.01345 19; α(L)=0.00391 6; α(M)=0.000985 14; α(N+..)=0.000336 5
								α(N)=0.000263 4; α(O)=6.09×10^{-5} 9; α(P)=1.120×10^{-5} 16; α(Q)=6.97×10^{-7} 10
								B(E2)(W.u.)=5.5 18
		781.39 2	75 4	0.0	0^+	E2	0.01618	α(K)=0.01184 17; α(L)=0.00325 5; α(M)=0.000815 12; α(N+..)=0.000278 4
								α(N)=0.000217 3; α(O)=5.04×10^{-5} 7; α(P)=9.32×10^{-6} 13; α(Q)=6.08×10^{-7} 9
								B(E2)(W.u.)=2.9 9
825.664	3^+	651.61 6	27 4	174.111	4^+	M1+E2	0.06 4	α(K)=0.05 4; α(L)=0.010 5; α(M)=0.0025 12; α(N+..)=0.0009 4
								α(N)=0.0007 4; α(O)=0.00016 8; α(P)=3.0×10^{-5} 15; α(Q)=2.6×10^{-6} 18
		772.41 6	100 7	53.227	2^+	M1+E2	0.041 25	α(K)=0.033 21; α(L)=0.007 4; α(M)=0.0016 8; α(N+..)=0.0005 3
								α(N)=0.00042 20; α(O)=0.00010 5; α(P)=1.9×10^{-5} 10; α(Q)=1.7×10^{-6} 11
852.14	(7^-)	165.5 2	6 5	686.6	(5^-)			Eγ from ^{230}Th(d,pnγ); Iγ from Coulomb Excitation.
		258.2 2	30 3	593.79	8^+			Eγ from ^{230}Th(d,pnγ); Iγ from Coulomb Excitation.
		495.8 2	100 5	356.47	6^+			Eγ from ^{230}Th(d,pnγ); Iγ from Coulomb Excitation.
879.3	(10^+)	285.6 2	100	593.79	8^+			
883.6	4^+	205.9[ag]	6.0[a] 30	677.515	2^+			
		527.0[a]	6.3[a] 15	356.47	6^+			
		709.5[a]	100[a] 5	174.111	4^+			
		830.4[a]	36.2[a] 30	53.227	2^+			
922.95	(6^+)	566.5 2	34 4	356.47	6^+			Eγ from ^{230}Th(d,pnγ); Iγ from Coulomb Excitation.
		748.8 3	100 7	174.111	4^+			Eγ from ^{230}Th(d,pnγ); Iγ from Coulomb Excitation.

$^{230}_{90}Th_{140}$-10

Adopted Levels, Gammas (continued)

γ(^{230}Th) (continued)

E_i(level)	J^{π}_i	E_γ[‡]	I_γ[‡]	E_f	J^{π}_f	Mult.[#]	δ	α[†]	Comments
951.898	1^-	170.53 *5*	≤0.02[&]	781.375	2^+	E1		0.1377	α(K)=0.1083 *16*; α(L)=0.0223 *4*; α(M)=0.00537 *8*; α(N+..)=0.00181 *3* α(N)=0.001417 *20*; α(O)=0.000326 *5*; α(P)=5.94×10^{-5} *9*; α(Q)=4.00×10^{-6} *6*
		274.38 *2*	0.25 *2*	677.515	2^+	E1		0.0454	α(K)=0.0363 *5*; α(L)=0.00690 *10*; α(M)=0.001656 *24*; α(N+..)=0.000560 *8* α(N)=0.000438 *7*; α(O)=0.0001017 *15*; α(P)=1.89×10^{-5} *3*; α(Q)=1.426×10^{-6} *20*
		316.99 *2*	0.57 *4*	634.919	0^+				
		380.12 *2*	1.12 *6*	571.756	3^-	E2		0.0854	α(K)=0.0457 *7*; α(L)=0.0293 *5*; α(M)=0.00776 *11*; α(N+..)=0.00263 *4* α(N)=0.00208 *3*; α(O)=0.000472 *7*; α(P)=8.26×10^{-5} *12*; α(Q)=2.67×10^{-6} *4*
		443.74 *2*	19.6 *10*	508.150	1^-	M1+E2	0.6 *6*	0.23 *8*	α(K)=0.18 *7*; α(L)=0.036 *9*; α(M)=0.0088 *20*; α(N+..)=0.0030 *7* α(N)=0.0024 *6*; α(O)=0.00056 *13*; α(P)=0.00011 *3*; α(Q)=9.E−6 *4*
		898.66 *2*	19.6 *12*	53.227	2^+	E1		0.00418 *6*	α(K)=0.00343 *5*; α(L)=0.000570 *8*; α(M)=0.0001347 *19*; α(N+..)=4.59×10^{-5} *7* α(N)=3.57×10^{-5} *5*; α(O)=8.41×10^{-6} *12*; α(P)=1.617×10^{-6} *23*; α(Q)=1.471×10^{-7} *21*
		951.95 *6*	100 *5*	0.0	0^+	E1		0.00377 *6*	α(K)=0.00310 *5*; α(L)=0.000513 *8*; α(M)=0.0001211 *17*; α(N+..)=4.13×10^{-5} *6* α(N)=3.21×10^{-5} *5*; α(O)=7.57×10^{-6} *11*; α(P)=1.455×10^{-6} *21*; α(Q)=1.332×10^{-7} *19*
955.04	(5^+)	598.6[b] *3*	48[b] *4*	356.47	6^+				
		780.9[b] *3*	100[b] *5*	174.111	4^+				
971.726	2^-	294.23 *2*	0.65 *9*	677.515	2^+	E1		0.0388	α(K)=0.0311 *5*; α(L)=0.00585 *9*; α(M)=0.001403 *20*; α(N+..)=0.000475 *7* α(N)=0.000371 *6*; α(O)=8.63×10^{-5} *12*; α(P)=1.609×10^{-5} *23*; α(Q)=1.231×10^{-6} *18*
		399.95 *2*	7.8 *5*	571.756	3^-	M1+E2	1.4 *6*	0.18 *9*	α(K)=0.13 *8*; α(L)=0.036 *9*; α(M)=0.0089 *20*; α(N+..)=0.0031 *7* α(N)=0.0024 *6*; α(O)=0.00056 *13*; α(P)=0.00010 *3*; α(Q)=7.E−6 *4*
		463.59 *6*	10.3 *7*	508.150	1^-	M1+E2	−0.28 *3*	0.242 *5*	α(K)=0.194 *4*; α(L)=0.0368 *7*; α(M)=0.00884 *15*; α(N+..)=0.00303 *5* α(N)=0.00236 *4*; α(O)=0.000557 *10*; α(P)=0.0001079 *19*; α(Q)=1.008×10^{-5} *20*
		918.50 *2*	100 *5*	53.227	2^+	E1		0.00402 *6*	α(K)=0.00330 *5*; α(L)=0.000548 *8*; α(M)=0.0001294 *19*; α(N+..)=4.41×10^{-5} *7* α(N)=3.43×10^{-5} *5*; α(O)=8.08×10^{-6} *12*; α(P)=1.553×10^{-6} *22*; α(Q)=1.417×10^{-7} *20*
1009.601	2^+	183.90 *11*	0.20[&] *7*	825.664	3^+	M1+E2		2.1 *12*	α(K)=1.4 *13*; α(L)=0.513 *15*; α(M)=0.132 *12*; α(N+..)=0.045 *4* α(N)=0.035 *4*; α(O)=0.0081 *6*; α(P)=0.001462 *24*; α(Q)=8.E−5 *7*

$^{230}_{90}Th_{140}$-11

$\gamma(^{230}Th)$ (continued)

E_i(level)	J_i^π	E_γ‡	I_γ‡	E_f	J_f^π	Mult.#	δ	α†	$I_{(\gamma+ce)}$	Comments
1009.601	2^+	228.23 *5*	0.41 *7*	781.375	2^+	E0+E2+M1		1.1 *7*	27 *8*	B(M1)(W.u.)<0.051 ce(K)/(γ+ce)=0.37 *20*; ce(L)/(γ+ce)=0.11 *4*; ce(M)/(γ+ce)=0.029 *10*; ce(N+)/(γ+ce)=0.010 *4* ce(N)/(γ+ce)=0.008 *3*; ce(O)/(γ+ce)=0.0018 *7*; ce(P)/(γ+ce)=0.00033 *12*; ce(Q)/(γ+ce)=2.0×10^{-5} *18*
		332.07 *5*	2.96 *7*	677.515	2^+	[E2]		0.1247		α(K)=0.0596 *9*; α(L)=0.0479 *7*; α(M)=0.01279 *18*; α(N+..)=0.00434 *6* α(N)=0.00343 *5*; α(O)=0.000776 *11*; α(P)=0.0001345 *19*; α(Q)=3.61×10^{-6} *5* B(E2)(W.u.)<27 Although an admixture of M1 multipolarity is possible, the 332.0-keV γ ray is assumed to be E2, since a $J^\pi=2^+$,K=2 to 2^+,0 M1 transition is K forbidden and since the relative photon intensities of 332.0γ and 374.7γ agree with the Alaga rule (see ^{230}Ac β^- decay) when 332.0γ is taken as E2.
		374.67[e] *2*		634.919	0^+	(E2)		0.0888		α(K)=0.0470 *7*; α(L)=0.0309 *5*; α(M)=0.00818 *12*; α(N+..)=0.00278 *4* α(N)=0.00219 *3*; α(O)=0.000497 *7*; α(P)=8.69×10^{-5} *13*; α(Q)=2.75×10^{-6} *4*
		835.59 *8*	3.7 *4*	174.111	4^+	E2		0.01415		B(E2)(W.u.)<0.38 α(N)=0.000182 *3*; α(O)=4.24×10^{-5} *6*; α(P)=7.86×10^{-6} *11*; α(Q)=5.35×10^{-7} *8*
		956.38 *2*	100 *8*	53.227	2^+	M1+E2	6.1 *4*	0.01157 *19*		B(E2)(W.u.)<5.2 α(K)=0.00883 *15*; α(L)=0.00206 *4*; α(M)=0.000509 *8*; α(N+..)=0.000174 *3* α(N)=0.0001357 *21*; α(O)=3.17×10^{-5} *5*; α(P)=5.94×10^{-6} *10*; α(Q)=4.43×10^{-7} *8* δ: From ^{230}Pa ε Decay.
		1009.59 *2*	68 *4*	0.0	0^+	E2		0.00980 *14*		B(E2)(W.u.)<2.7 α(K)=0.00750 *11*; α(L)=0.001734 *25*; α(M)=0.000427 *6*; α(N+..)=0.0001458 α(N)=0.0001139 *16*; α(O)=2.66×10^{-5} *4*; α(P)=4.99×10^{-6} *7*; α(Q)=3.74×10^{-7} *6*
1012.46	3^-	440.78 *10*	20 *4*	571.756	3^-	M1+E2		0.18 *12*		α(K)=0.14 *11*; α(L)=0.031 *14*; α(M)=0.008 *3*; α(N+..)=0.0026 *11* α(N)=0.0020 *8*; α(O)=0.00047 *20*; α(P)=9.E−5 *4*; α(Q)=7.E−6 *6*
		503.55[f] *10*	≤3[f@]	508.150	1^-					
		838.45 *5*	7.0 *25*	174.111	4^+	E1		0.00473 *7*		α(K)=0.00388 *6*; α(L)=0.000649 *9*; α(M)=0.0001534 *22*;

Adopted Levels, Gammas (continued)

$\gamma(^{230}Th)$ (continued)

E_i(level)	J^π_i	E_γ[‡]	I_γ[‡]	E_f	J^π_f	Mult.[#]	δ	α[†]	Comments
									α(N+..)=5.22×10^{-5} 8 α(N)=4.07×10^{-5} 6; α(O)=9.57×10^{-6} 14; α(P)=1.84×10^{-6} 3; α(Q)=1.659×10^{-7} 24
1012.46	3$^-$	959.28 4	100 13	53.227	2$^+$	E1		0.00372 6	α(K)=0.00305 5; α(L)=0.000506 7; α(M)=0.0001194 17; α(N+..)=4.07×10^{-5} 6 α(N)=3.17×10^{-5} 5; α(O)=7.46×10^{-6} 11; α(P)=1.435×10^{-6} 20; α(Q)=1.315×10^{-7} 19
1039.45	(6$^+$)	683.0[b] 2	100[b] 6	356.47	6$^+$				
		865.2[b] 5	34[b] 5	174.111	4$^+$				
1052.14	(3$^+$)	374.67[eg] 2		677.515	2$^+$				
		878.02 10	57 7	174.111	4$^+$				I_γ: Iγ=129 48 from Coulomb Excitation may have a contribution from other γ-ray transition.
		999.4 10	100 7	53.227	2$^+$				
1065.3	(9$^-$)	213.2 2	50 10	852.14	(7$^-$)				Eγ from ^{230}Th(d,pnγ), Iγ from Coulomb Excitation.
		471.4 2	100 10	593.79	8$^+$				Eγ from ^{230}Th(d,pnγ), Iγ from Coulomb Excitation.
1079.216	(2)$^-$	253.55 2	1.4 1	825.664	3$^+$	E1		0.0544	α(K)=0.0433 6; α(L)=0.00834 12; α(M)=0.00200 3; α(N+..)=0.000677 10 α(N)=0.000530 8; α(O)=0.0001228 18; α(P)=2.28×10^{-5} 4; α(Q)=1.687×10^{-6} 24
		297.86 2	6.0 4	781.375	2$^+$	E1		0.0378	α(K)=0.0303 5; α(L)=0.00569 8; α(M)=0.001363 19; α(N+..)=0.000462 7 α(N)=0.000361 5; α(O)=8.39×10^{-5} 12; α(P)=1.564×10^{-5} 22; α(Q)=1.200×10^{-6} 17
		401.62 10	1.2 2	677.515	2$^+$	E1		0.0198	α(K)=0.01596 23; α(L)=0.00289 4; α(M)=0.000689 10; α(N+..)=0.000234 4 α(N)=0.000182 3; α(O)=4.26×10^{-5} 6; α(P)=8.03×10^{-6} 12; α(Q)=6.52×10^{-7} 10
		571.08 2	76 4	508.150	1$^-$	M1+E2	0.11 2	0.1457	α(K)=0.1169 17; α(L)=0.0217 4; α(M)=0.00521 8; α(N+..)=0.00179 3 α(N)=0.001389 20; α(O)=0.000329 5; α(P)=6.38×10^{-5} 10; α(Q)=6.05×10^{-6} 9
		1025.96 2	100 5	53.227	2$^+$	E1		0.00330 5	α(K)=0.00272 4; α(L)=0.000448 7; α(M)=0.0001056 15; α(N+..)=3.60×10^{-5} 5 α(N)=2.80×10^{-5} 4; α(O)=6.60×10^{-6} 10; α(P)=1.272×10^{-6} 18; α(Q)=1.173×10^{-7} 17
1108.2	(4$^+$)	934.0[a]	59[a] 28	174.111	4$^+$				
		1055.0[a]	100[a] 25	53.227	2$^+$				
1108.9	(5$^-$)	537.0		571.756	3$^-$				E_γ: From Coulomb Excitation.
		935.0		174.111	4$^+$				E_γ: From Coulomb Excitation.

$^{230}_{90}Th_{140}$-13

Adopted Levels, Gammas (continued)

γ(^{230}Th) (continued)

E_i(level)	J^{π}_i	E_γ[‡]	I_γ[‡]	E_f	J^{π}_f	Mult.[#]	α[†]	Comments
1117.4	(8^+)	524.1[b] 5	20[b] 5	593.79	8^+			α(K)exp=2.9 12.
		760.7[b] 3	100[b] 10	356.47	6^+			
1127.789	3^-	175.84 5	0.7[&] 2	951.898	1^-			I_γ: From ^{230}Pa ε Decay.
		302.16 4	1.6 2	825.664	3^+	E1	0.0366	α(K)=0.0293 5; α(L)=0.00550 8; α(M)=0.001318 19; α(N+..)=0.000446 7 α(N)=0.000349 5; α(O)=8.11×10^{-5} 12; α(P)=1.514×10^{-5} 22; α(Q)=1.164×10^{-6} 17
		346.39 3	1.69 15	781.375	2^+	E1	0.0271	α(K)=0.0218 3; α(L)=0.00402 6; α(M)=0.000961 14; α(N+..)=0.000326 5 α(N)=0.000254 4; α(O)=5.93×10^{-5} 9; α(P)=1.111×10^{-5} 16; α(Q)=8.78×10^{-7} 13
		450.22[g] 2	≈1.5	677.515	2^+			The 450-keV γ from $J^{\pi}=3^-$ of K=2 band to the $J^{\pi}=2^+$ state of the K=0 band is a K-forbidden [E1] transition.
		556.06 2	26.9 15	571.756	3^-	M1+E2	0.10 7	α(K)=0.07 6; α(L)=0.016 8; α(M)=0.0039 18; α(N+..)=0.0013 6 α(N)=0.0010 5; α(O)=0.00024 12; α(P)=4.7×10^{-5} 23; α(Q)=4.E−6 3 M1 part of the 556.0γ from the 3^- state of the K=2 band to the 3^- state of the K=0 octupole band is K-forbidden.
		619.66 2	24 2	508.150	1^-	E2	0.0263	α(K)=0.0181 3; α(L)=0.00611 9; α(M)=0.001559 22; α(N+..)=0.000531 8 α(N)=0.000417 6; α(O)=9.60×10^{-5} 14; α(P)=1.744×10^{-5} 25; α(Q)=9.59×10^{-7} 14
		954 1	23 5	174.111	4^+			
		1074.52 2	100 5	53.227	2^+	E1	0.00305 5	α(K)=0.00251 4; α(L)=0.000412 6; α(M)=9.71×10^{-5} 14; α(N+..)=3.31×10^{-5} 5 α(N)=2.58×10^{-5} 4; α(O)=6.08×10^{-6} 9; α(P)=1.171×10^{-6} 17; α(Q)=1.084×10^{-7} 16
1134.2	(7^+)	540.3[b] 3	34[b] 4	593.79	8^+			
		777.8[b] 3	100[b] 7	356.47	6^+			
1176.0	(5^+)	819.5[b] 3	65[b] 6	356.47	6^+			
		1001.9[b] 4	100[b] 7	174.111	4^+			
1196.8	(4^-)	1022.7	100	174.111	4^+			E_γ: From Coulomb Excitation.
1206.6	(12^+)	327.9 5	100	879.3	(10^+)			
1243.0	(8^+)	365.3[bg]	≤20[b]	879.3	(10^+)			
		649.4[b] 3	100[b] 10	593.79	8^+			
		886.1[b] 4	35[b] 7	356.47	6^+			
1251.2	(8^+)	657.3[a]	100[a] 38	593.79	8^+			
		894.8[a]	62[a] 44	356.47	6^+			
1255.4	(6^+)	661.4[bg]	≤12[b]	593.79	8^+			
		898.9[b] 3	100[b] 8	356.47	6^+			
		1081.4[bg]	≤30[b]	174.111	4^+			

$^{230}_{90}Th_{140}$-14

γ(^{230}Th) (continued)

E_i(level)	J^π_i	E_γ‡	I_γ‡	E_f	J^π_f	Comments
1297.14	0^+	789.0[c] 1	15.2[c] 8	508.150	1^-	
		1243.9[c] 1	100[c] 3	53.227	2^+	
1322.0	(11^-)	256.6[d] 5		1065.3	(9^-)	
		442.2[d] 5		879.3	(10^+)	
1349.0	(7^+)	755.6[b] 5	86[b] 11	593.79	8^+	
		992.2[b] 5	100[b] 12	356.47	6^+	
1358.4	(9^+)	479.7[b] 6	39[b] 8	879.3	(10^+)	
		764.5[b] 3	100[b] 12	593.79	8^+	
1375.28	$(1,2^+)$	423.2[c] 1	7.4[c] 14	951.898	1^-	
		867.1[c] 3	38.5[c] 21	508.150	1^-	
		1322.1[c] 1	58[c] 4	53.227	2^+	
		1375.4[c] 1	100[c] 4	0.0	0^+	
1400.89	(2^+)	448.9[c] 1	7.9[c] 16	951.898	1^-	
		892.7[c] 1	43.9[c] 21	508.150	1^-	
		1226.7[c] 1	61[c] 4	174.111	4^+	
		1347.7[c] 1	100[c] 3	53.227	2^+	
		1401.0[c] 1	20.9[c] 21	0.0	0^+	
1448.4	(8^+)	569.0[bg]	≤25[b]	879.3	(10^+)	
		854.6[b] 4	100[b] 14	593.79	8^+	
		1092.1[bg]	≤25[b]	356.47	6^+	
1485.62	(4^+)	913.7[c] 2	50[c] 13	571.756	3^-	
		977.6[c] 2	29[c] 13	508.150	1^-	
		1432.4[c] 1	100[c] 9	53.227	2^+	
1520.1	(10^+)	313.0[ag]	44[a] 15	1206.6	(12^+)	
		640.7[a]	33[a] 19	879.3	(10^+)	
		926.3[a]	100[a] 41	593.79	8^+	
1571.8	(14^+)	365.3[d] 5	100	1206.6	(12^+)	
1573.51	$1^{(-)},2^+$	1573.5[c] 2	100[c]	0.0	0^+	E_γ: From ^{230}Ac β^- decay.
1589.8	0^+	1536.6[c] 3	100[c]	53.227	2^+	E_γ: From ^{230}Ac β^- decay.
1616.0	(13^-)	293.4[d] 5		1322.0	(11^-)	
		409.8[d] 5		1206.6	(12^+)	
1638.45	(0^+)	628.8[c] 1	100[c] 11	1009.601	2^+	
		1585.4[c] 2	72[c] 7	53.227	2^+	
1695.71	$1^{(-)},2^+$	1187.5[c] 3	45[c] 11	508.150	1^-	
		1642.5[c] 2	38[c] 7	53.227	2^+	
		1695.7[c] 1	100[c] 11	0.0	0^+	

$^{230}_{90}Th_{140}$-15

Adopted Levels, Gammas (continued)

$\gamma(^{230}Th)$ (continued)

E_i(level)	J^π_i	E_γ[‡]	I_γ[‡]	E_f	J^π_f
1745.3	(0^+)	735.1[c] *2*	16[c] *4*	1009.601	2^+
		1691.7[c] *1*	100[c] *6*	53.227	2^+
1770.73	$(1,2^+)$	1717.5[c] *1*	100[c] *6*	53.227	2^+
		1770.5[c] *10*	15[c] *4*	0.0	0^+
1775.22	$(1,2^+)$	1267.1[c] *2*	37[c] *4*	508.150	1^-
		1721.9[c] *1*	59[c] *3*	53.227	2^+
		1775.3[c] *1*	100[c] *4*	0.0	0^+
1789.4	$1^{(-)},2^+$	1789.4[c] *5*	100[c]	0.0	0^+
1810.74	$(1,2^+)$	1302.6[c] *1*	62[c] *3*	508.150	1^-
		1757.5[c] *1*	100[c] *3*	53.227	2^+
		1810.7[c] *1*	19.8[c] *19*	0.0	0^+
1839.61	$1^{(-)},2^+$	1839.6[c] *2*	100[c]	0.0	0^+
1849.54	(2^+)	363.9[c] *3*	23[c] *9*	1485.62	(4^+)
		839.9[c] *1*	100[c] *9*	1009.601	2^+
		878.0[c] *2*	45[c] *5*	971.726	2^-
		1675.4[c] *3*	45[c] *10*	174.111	4^+
1858.2	(3^-)	1805.0[c] *5*	100[c]	53.227	2^+
1902.70	$(1,2^+)$	1394.5[c] *2*	22[c] *6*	508.150	1^-
		1902.7[c] *1*	100[c] *4*	0.0	0^+
1947.1	(15^-)	331.0[d] *5*		1616.0	(13^-)
		375.5[d] *5*		1571.8	(14^+)
1949.87	$(1,2^+)$	1896.7[c] *1*	42[c] *2*	53.227	2^+
		1949.8[c] *1*	100[c] *2*	0.0	0^+
1967.00	$(1,2^+)$	1913.8[c] *1*	100[c] *5*	53.227	2^+
		1966.7[c] *3*	15[c] *3*	0.0	0^+
1969.5	(16^+)	397.7[d] *5*		1571.8	(14^+)
1973.44	$(1^+,2^+)$	1147.9[cg] *1*	92[c] *6*	825.664	3^+
		1920.2[c] *1*	100[c] *4*	53.227	2^+
		1973.5[c] *5*	10[c] *4*	0.0	0^+
2000.91	$(1,2^+)$	991.2[cg] *1*	27[c] *7*	1009.601	2^+
		2000.9[c] *1*	100[c] *10*	0.0	0^+
2010.13	$(1,2^+)$	1956.9[c] *1*	100[c] *6*	53.227	2^+
		2010.1[c] *2*	17[c] *4*	0.0	0^+
2024.67	$(1^+,2^+)$	1053.1[c] *2*	100[c] *23*	971.726	2^-
2024.67	$(1^+,2^+)$	1198.9[c] *2*	100[c] *23*	825.664	3^+
		1971.3[c] *5*	28[c] *12*	53.227	2^+
		2024.6[c] *3*	33[c] *12*	0.0	0^+
2078.25?		999.1[c] *1*	100[c] *19*	1079.216	$(2)^-$
		1068.1[c] *3*	30[c] *12*	1009.601	2^+
		1252.5 *3*	30 *8*	825.664	3^+
2122.77	$(1,2^+)$	1043.2[c] *3*	14[c] *5*	1079.216	$(2)^-$
		2069.5[c] *2*	51[c] *5*	53.227	2^+
		2122.8[c] *1*	100[c] *5*	0.0	0^+
2133.14?		388.3[c] *1*	67[c] *6*	1745.3	(0^+)
		1455.5[c] *2*	100[c] *28*	677.515	2^+
		1625.1[cg] *3*	≤78[c]	508.150	1^-
2151.81	$(1,2^+)$	750.7[c] *3*	28[c] *5*	1400.89	(2^+)
		2098.6[c] *1*	100[c] *5*	53.227	2^+
		2152.0 *10*	6.3 *16*	0.0	0^+
2282.98	$1,2^+$	1311.5[c] *2*	100[c] *23*	971.726	2^-
		2229.5[c] *5*	61[c] *12*	53.227	2^+
		2282.5[c] *3*	78[c] *6*	0.0	0^+
2298.6	$(1,2^+)$	2245.4[c] *10*	57[c] *29*	53.227	2^+
		2298.6[c] *3*	100[c] *15*	0.0	0^+
2310.5	(17^-)	341[d] *1*		1969.5	(16^+)
		363.4[d] *5*		1947.1	(15^-)
2314.27?	$(1,2^+)$	503.5[c] *2*	[c]	1810.74	$(1,2^+)$
		1636.8[c] *2*	100[c] *22*	677.515	2^+
		2314.0[c] *10*	26[c] *6*	0.0	0^+
2368.91	(0^+)	968.0[c] *2*	100[c] *42*	1400.89	(2^+)
		1797.2[c] *3*	83[c] *17*	571.756	3^-
2396.3	(18^+)	426.8[d] *5*		1969.5	(16^+)
2703.7	(19^-)	393.2[d] *5*		2310.5	(17^-)
2848.6	(20^+)	452.3[d] *5*		2396.3	(18^+)
3125	(21^-)	421.6[dg] *5*		2703.7	(19^-)
3324.0	(22^+)	475.4[d] *5*		2848.6	(20^+)
3572.5?	(23^-)	446.9[dg] *5*		3125	(21^-)
3819?	(24^+)	495[dg] *1*		3324.0	(22^+)

† Additional information 2.
‡ From ^{230}Pa ε decay, unless otherwise specified.

$\gamma(^{230}Th)$ (continued)

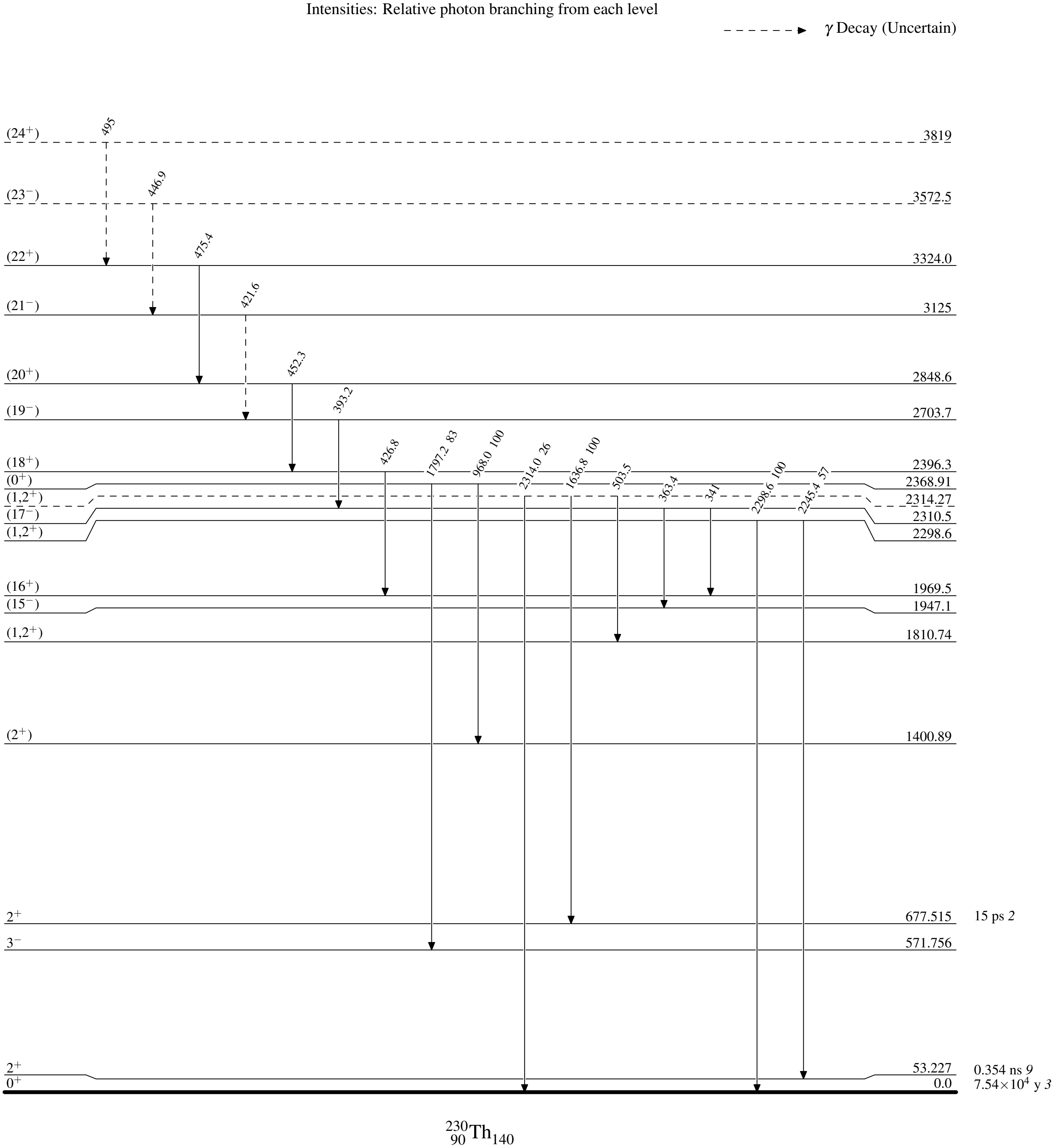
[#] From ce measurements in ^{230}Pa ε decay. Multipolarities in square brackets are from level scheme; they are included for transition-rate calculations when needed.
[@] Doublet. Individual intensities were determined from coincidence data in ^{230}Pa ε decay.
[&] Weak γ ray; seen only in $\gamma\gamma$- coincidence spectra in ^{230}Pa ε decay.
[a] From Coulomb Excitation.
[b] From ^{230}Th(d,pnγ).
[c] From ^{230}Ac β^- decay.
[d] From ^{232}Th(^{136}Xe,Xγ).
[e] Multiply placed.
[f] Multiply placed with intensity suitably divided.
[g] Placement of transition in the level scheme is uncertain.

$^{230}_{90}Th_{140}$-17

Adopted Levels, Gammas

Level Scheme

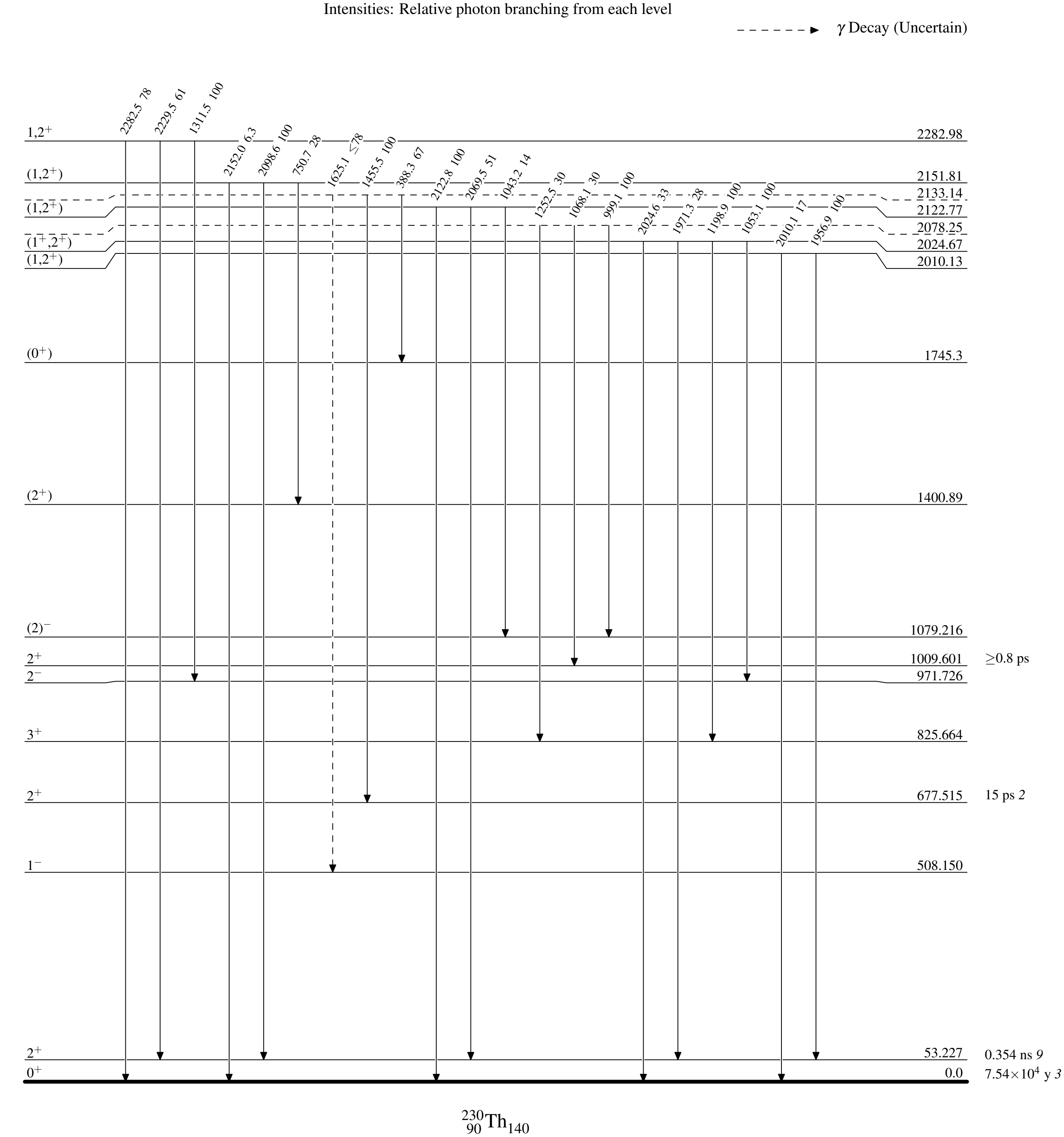
Intensities: Relative photon branching from each level



Adopted Levels, Gammas

Level Scheme (continued)

Intensities: Relative photon branching from each level



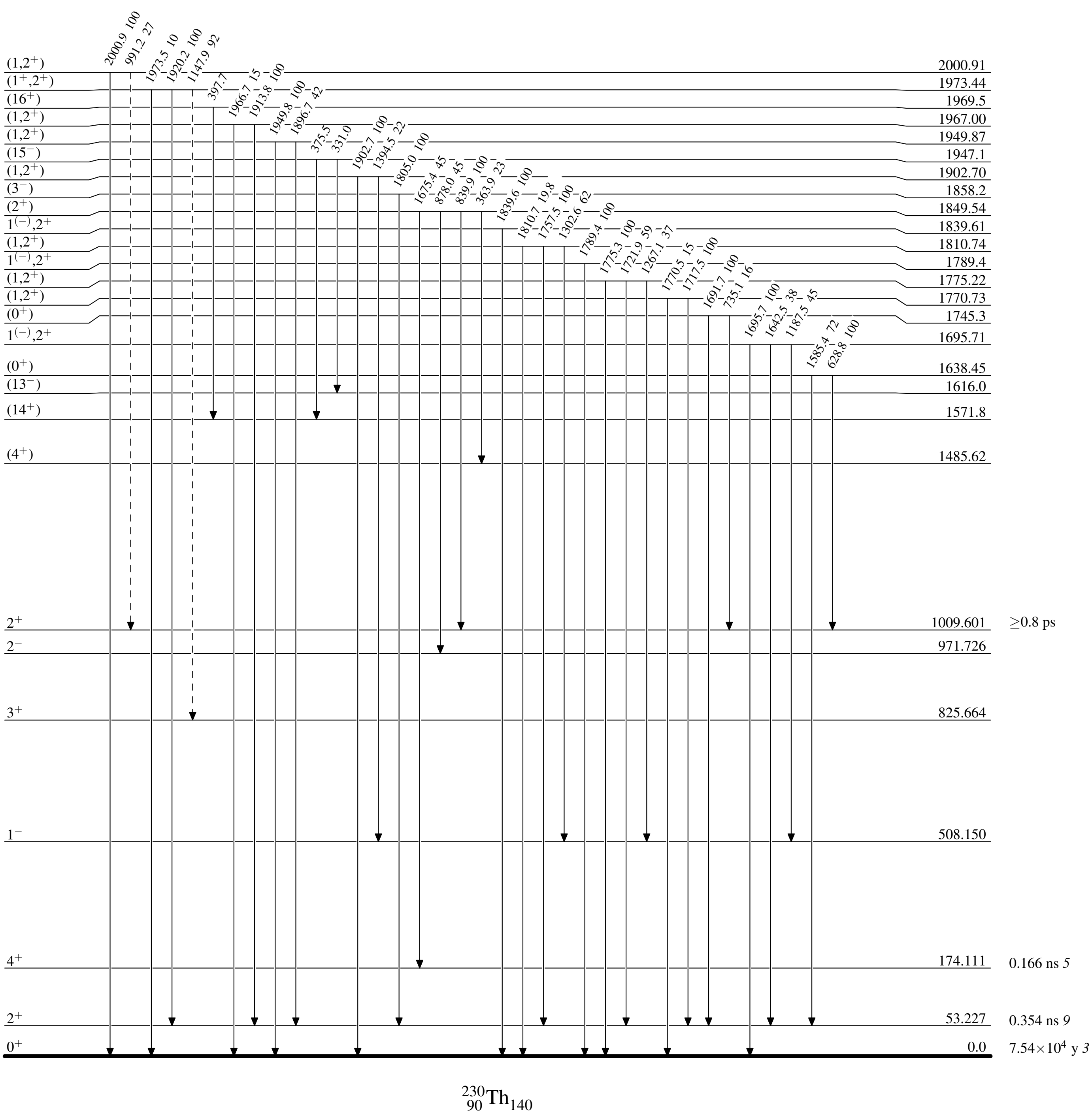
Adopted Levels, Gammas

Legend

Level Scheme (continued)

Intensities: Relative photon branching from each level

γ Decay (Uncertain)

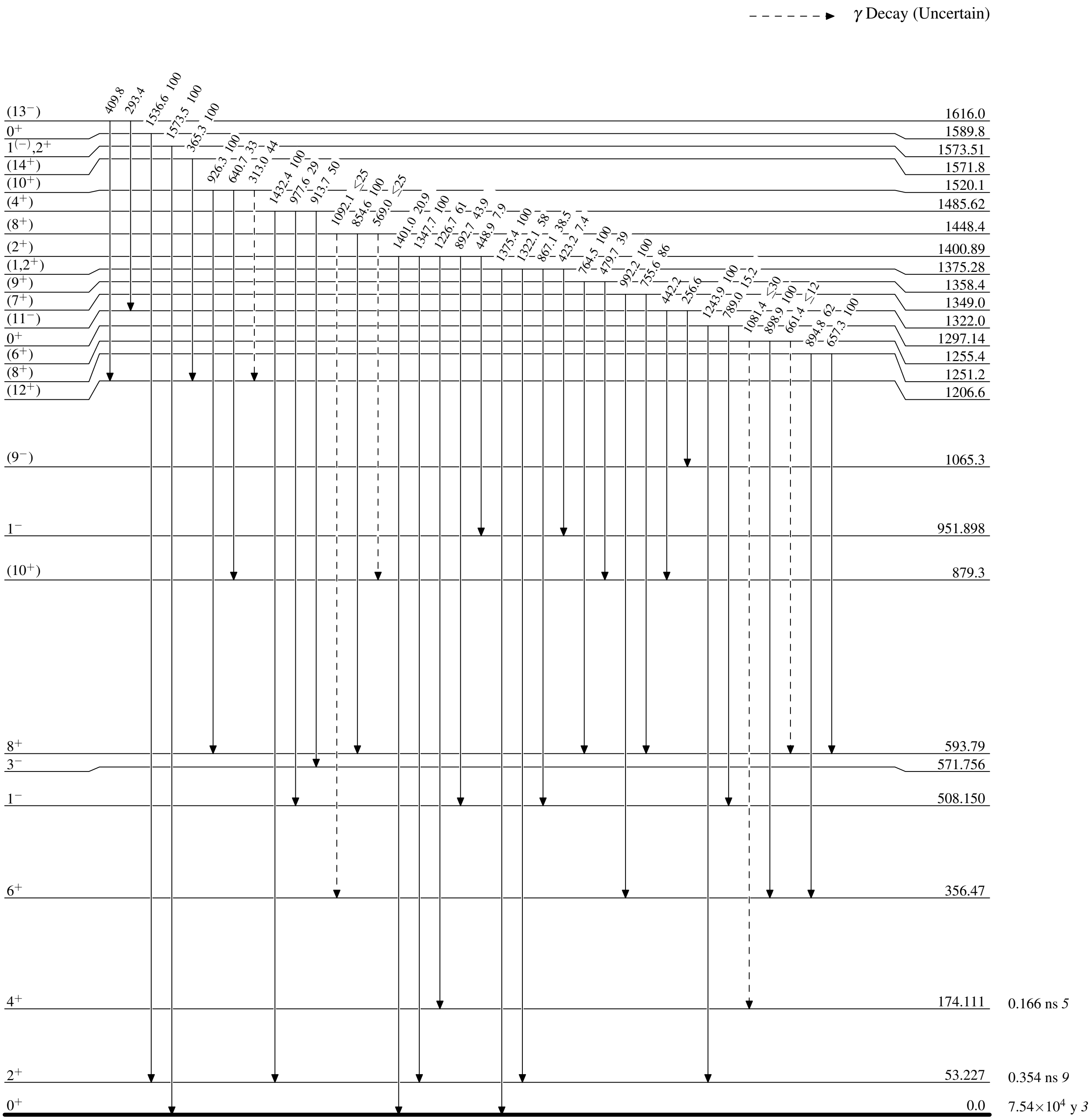


Adopted Levels, Gammas

Legend

Level Scheme (continued)

Intensities: Relative photon branching from each level



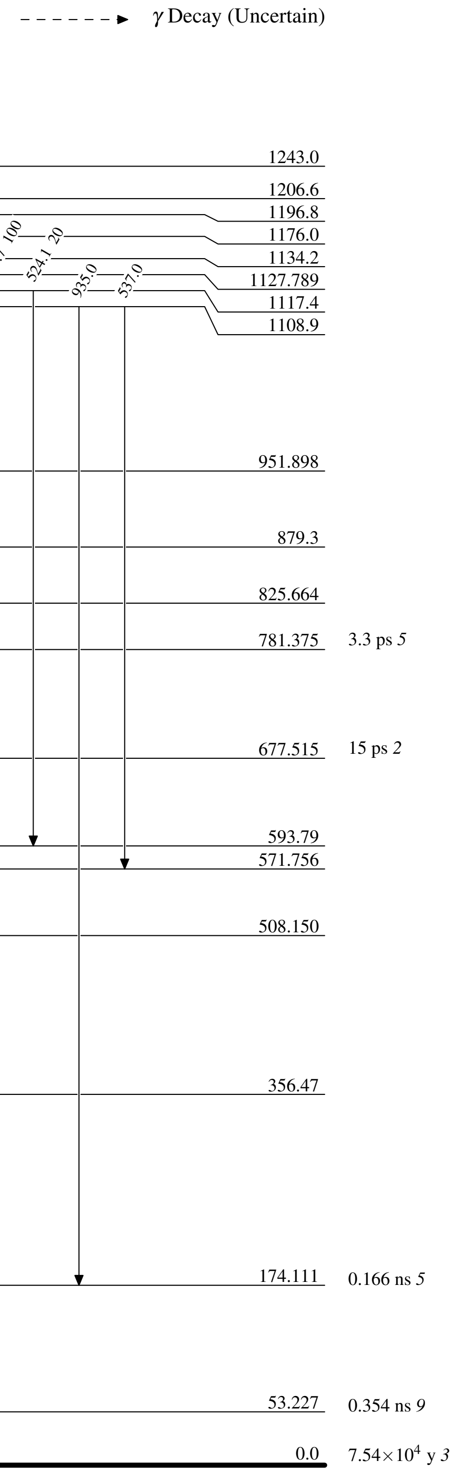
$^{230}_{90}Th_{140}$

Adopted Levels, Gammas

Level Scheme (continued)

Intensities: Relative photon branching from each level

Legend



$^{230}_{90}Th_{140}$

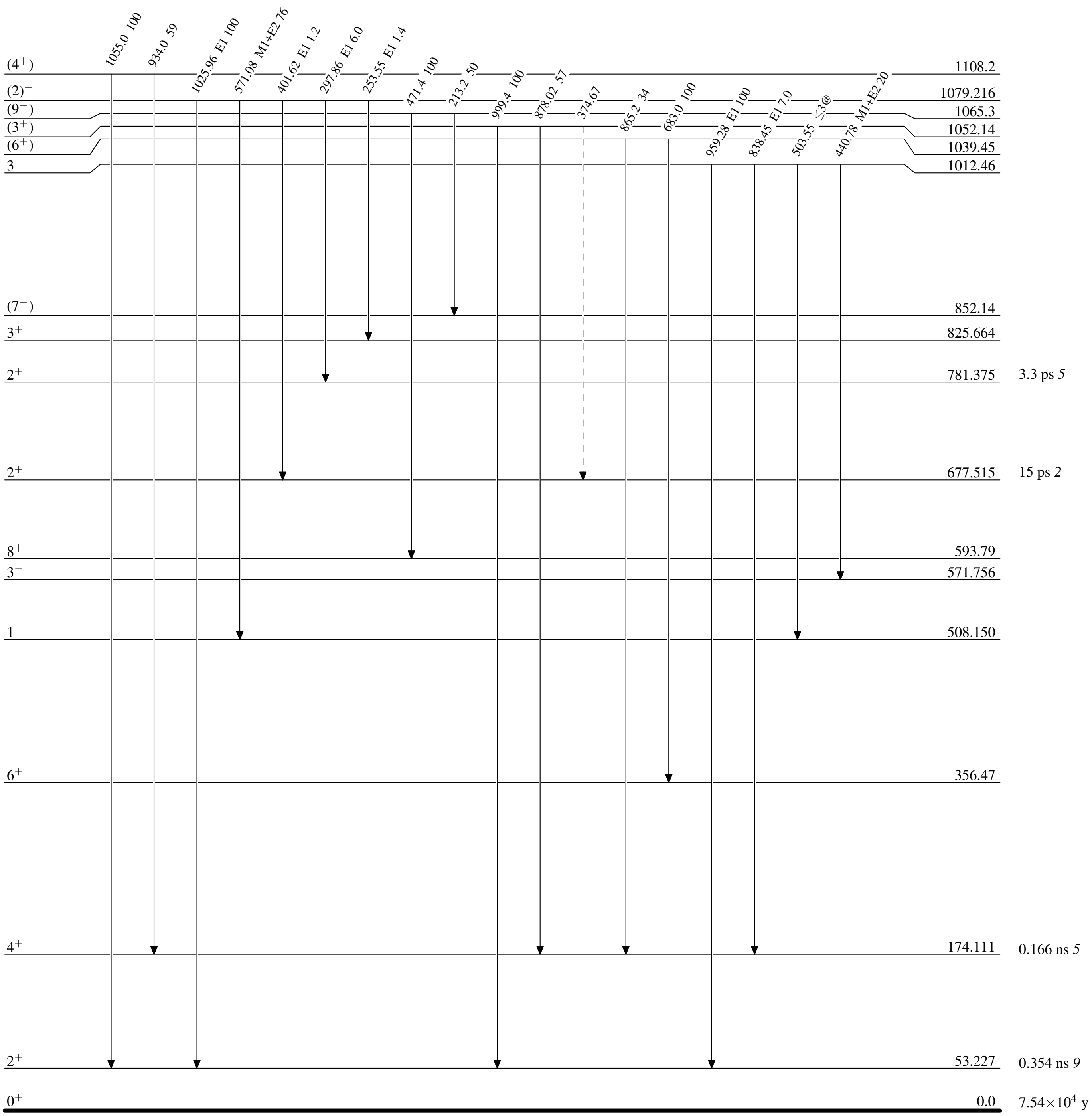
Adopted Levels, Gammas

Level Scheme (continued)

Intensities: Relative photon branching from each level
@ Multiply placed: intensity suitably divided

Legend

γ Decay (Uncertain)



$^{230}_{90}Th_{140}$

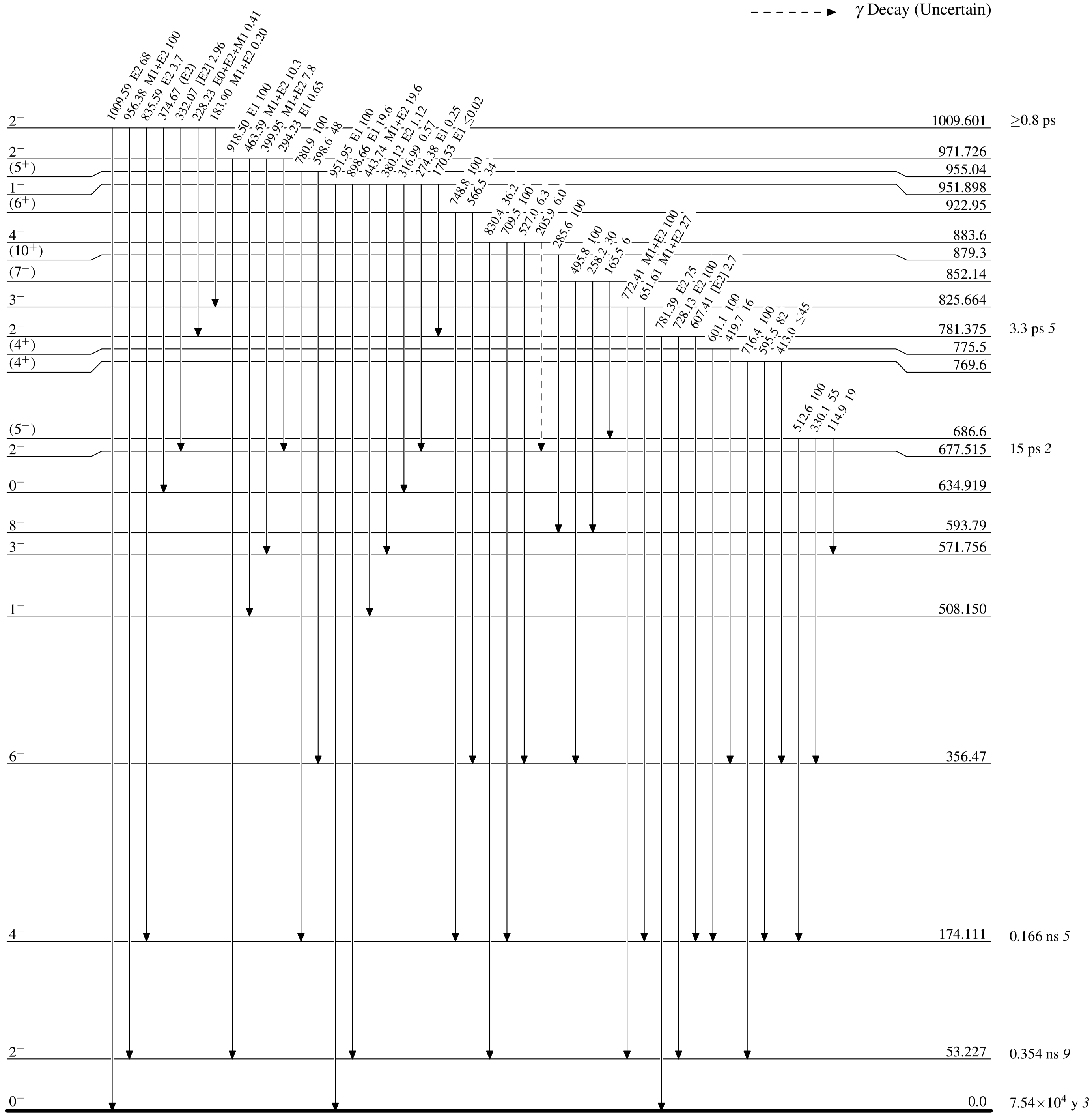
Adopted Levels, Gammas

Legend

Level Scheme (continued)

Intensities: Relative photon branching from each level
@ Multiply placed: intensity suitably divided

- - - - - -► γ Decay (Uncertain)

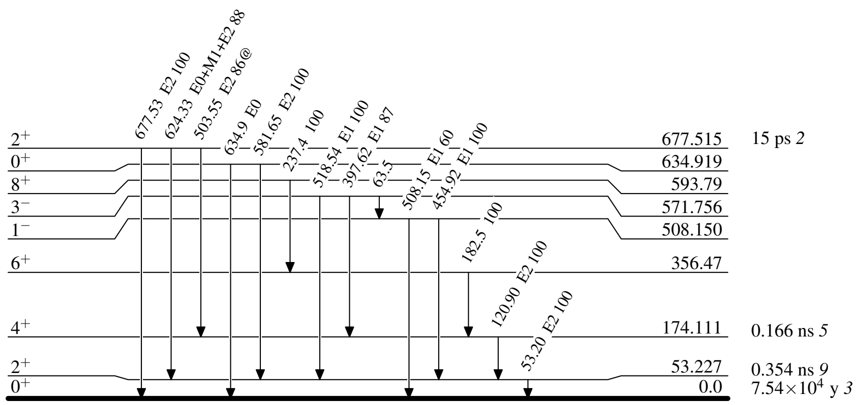


$^{230}_{90}Th_{140}$

Adopted Levels, Gammas

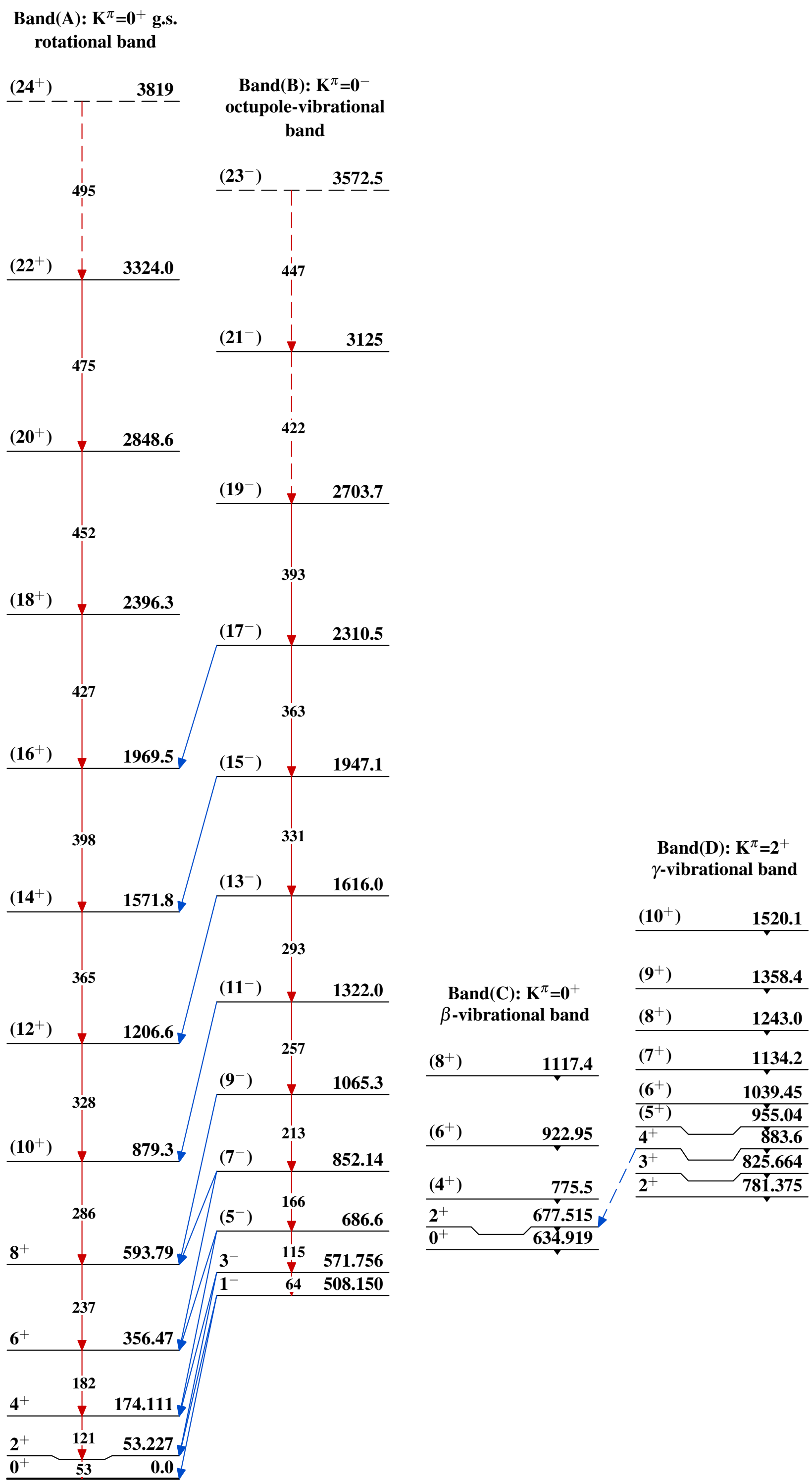
Level Scheme (continued)

Intensities: Relative photon branching from each level
@ Multiply placed: intensity suitably divided



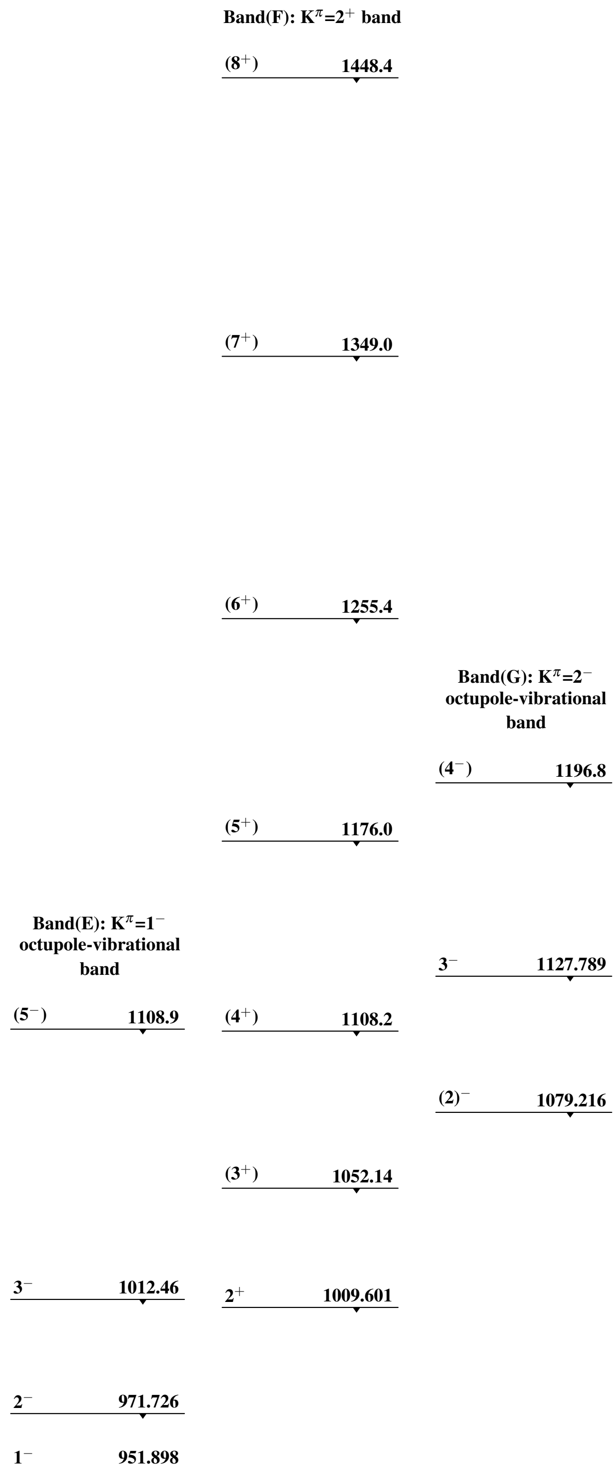
$^{230}_{90}Th_{140}$

Adopted Levels, Gammas



$^{230}_{90}Th_{140}$

Adopted Levels, Gammas (continued)



$^{230}_{90}Th_{140}$

Adopted Levels, Gammas

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	E. Browne	NDS 107,2579 (2006)	1-Nov-2004

Q(β^-)=−499 *8*; S(n)=6440.1 *11*; S(p)=7603 *14*; Q(α)=4081.6 *14* 2012Wa38
Note: Current evaluation has used the following Q record −500 8 *6440.3 11* 776E1 10 *4081.6 14* 2003Au03.
Other reactions:
^{232}Th(n,Fission): E=1 eV- 20 keV, measured cross-section (1991Na03); E<20 MeV, calculated fission cross-section (2004Ma84).
^{232}Th(γ,Fission): E=68-264 MeV (2000Sa09); E=40-100 MeV (1996Ka16); E=4.75-6.5 MeV (1996Se07); E=6.44-13.15 MeV, deduced height of fission barrier (1993Pi05); E=250-1200 MeV, measured fission cross-section (1993Bi16); E=6.73-9.72 MeV, measured γ rays (1992Ge01).
^{232}Th(γ,f) Eγ=4-7 MeV bremsstrahlung, quadrupole component in photofission deduced (1979Zh01). Others: 1978Zh03, 1978Zh04, 1977Zh06. ^{232}Th(γ,f), isomer at ≈3 MeV in third minimum decaying primarily by γ emission suggested (1978As02).
^{232}Th(pol γ,Fission): E=52 meV (1991Ta15); E=69 MeV (1991Ma22).
232Th(e,Fission), E=4.54-6.64 MeV, measured cross-sections of fission fragments (1994EnZZ).
^{232}Th(e,e′f) E(e)=20-120 MeV. Possible E2 component deduced (1977Sh15) E(e)=10-40 MeV, possible E2 component at 22 MeV (1976Kn01).
Fission following ^{232}Th(α,α') studied at E(α)=120 MeV. Small fission probability found in the region of the giant-quadrupole resonance (1980Va14). Fission mass asymmetry studied in ^{232}Th(γ,fission) for bremsstrahlung of 15-55 MeV (1980Gu12).
Three-humped fission barrier proposed. Branching=2.5×10^{-4} *15* for isomeric fission; E=2.4 MeV *2* for excitation energy of the fission shape isomer are deduced from ^{232}Th(γ,f). Eγ(bremsstrahlung)=3.25-5.75 MeV (1978Bo07,1979Be33).
^{232}Th(γ,n), (γ,2n), (γ,f) studied for Eγ=5-18.3 MeV. Deduced β(2)=0.290, Q=9.8 *4* from giant-dipole resonance parameters (1980Ca08).
^{232}Th(p,p): 2002Ig01, 2000De61.
^{232}Th(pol p,p): 1998Do16.
^{232}Th(p-bar,x): anti-proton absorption (1993Ja09,1993Wy05,1998Lu05,2001Tr19,2001Tr23).
Additional information 1.
^{232}Th(^{40}Ar,^{40}Ar), E=200 MeV (1993Ad01). Other: 1991An16.
^{232}Th(^{12}C,^{12}C) (1992An12).
Optical-model parameters deduced from (d,d) (1974Ch27).
Cluster radioactivity:
^{232}Th ^{26}Ne decay (1997Tr17,1997MiZP,1995Si05,1975ChZj,2002Sa55).
^{232}Th ^{24}Ne decay (1993Si26).
^{232}Th Double beta decay with emission of two neutrinos (2004Ra13,2002Tr04). Other: 2002Hi06.
Isotope shifts measured by LASER spectroscopy, mean square charge radii of Th isotopes determined (1989Ka29).
Deduced mean square charge radii of U and Pu isotopes from muonic x-rays relative to 232Th (1990Na22).
g-factors for g.s. band up to J^π=22$^+$ studied by 1982Ha03.

^{232}Th Levels

Additional information 2.
Band(ayz) K=0$^+$ g.s. rotational band.

Cross Reference (XREF) Flags

A	^{232}Ac β^- decay	F	^{232}Th(d,pnγ)	K	^{232}Th(n,n′γ)
B	^{232}Pa ε decay	G	Coulomb excitation: HI	L	^{232}Th(d,d′)
C	^{236}U α decay	H	Coulomb excitation: Li	M	^{232}Th(α,α'),(γ,X) E=resonance
D	^{230}Th(t,p)	I	Inelastic scattering		
E	^{232}Th(γ,γ'), ^{232}Th(e,e′)	J	Muonic atom		

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Adopted Levels, Gammas (continued)

^{232}Th Levels (continued)

E(level)[†]	J^{π}	$T_{1/2}$	XREF	Comments
0	0^+	1.40×10^{10} y *1*	ABCDEFGHI KL	%α=100; %SF=1.1×10^{-09} *4* Deformation β_4=0.050 *5* from (p,p′) (1972BrZK). Additional information 3. Q(0), giant-dipole resonance studied (1973Ve01). $T_{1/2}$: Evaluated and recommended in 1990Ho28. Weighted average of: 1.39×10^{10} y *3* (1938Ko01, 1956Pi42), 1.42×10^{10} y *7* (1956Se17), 1.45×10^{10} y *5* (1956Ma43), 1.41×10^{10} y *14* (1960Fa07), and 1.40×10^{10} y *7* (1963Le21). %SF: From $T_{1/2}$(SF)=1.2×10^{21} y *4*, evaluated and recommended in 2000Ho27, from: >0.0014×10^{21} y (1952Se67), >0.1×10^{21} y (1955Po45), >1×10^{21} y (1958Fl44), >1.0×10^{21} y *3* (1967Sp12), >0.7×10^{21} y (1975Em03), and 1.22 y *43* (1995Bo18). Others: 1997Ro12, 2004Ro01. $T_{1/2}$: $T_{1/2}$ ^{12}C,^{16}O emissions >3×10^{18} y (1975ChZJ). $T_{1/2}$: Measured $T_{1/2}$ ^{24}Ne-^{26}Ne emissions >5.06×10^{21} y (1995Bo18). Others: 1996Bo18, 1975ChZJ.
49.369 *9*	2^+[‡]	345 ps *15*	ABCDEFGHI KL	J^{π}: 49.4γ E2 to 0^+. $T_{1/2}$: Delayed coincidence (1960Be25). Other values: 320 ps *24* Mossbauer (1973Ca29), 345 ps *15* delayed coincidence (1960Be25), 315 ps *3* from B(E2)=9.21 *9* (1973Be44) and α=332 (reducing α by 1.5% *7* as recommended by 1987Ra01 would give $T_{1/2}$=320 ps *4*).
162.12 *2*	4^+[‡]	164 ps *13*	A CD FGHI KL	B(E4)↑=1.16 *5* (1976Co08) $T_{1/2}$: Doppler-shift recoil distance (1982Ow01). J^{π}: 112.7γ E2 to 2^+. $T_{1/2}$: The effect of charge-state of recoils on $T_{1/2}$ is probably <20%. μ: Studied for 4^+,6^+ levels by γ,γ precession in Fe (1971MuZN).
333.26 *8*	6^+[‡]	62 ps *4*	C FGHI KL	$T_{1/2}$: Weighted average of 58.4 ps *42* (1976Gu12) and 66.2 ps *51* (1975Jo07), Doppler-shift recoil distance. J^{π}: 171.2γ E2 to 4^+.
556.9 *1*	8^+[‡]	24 ps *1*	FGHI L	$T_{1/2}$: Weighted average of 23.8 ps *13* (Doppler-shift recoil distance, 1976Gu12), 25.1 ps *23* (Doppler-shift recoil distance, 1975Jo07), and 20 ps *3* (From B(E2)=4.0 *2*, 1982Ow01). J^{π}: 226.3γ E2 to 6^+.
714.42[&] *9*	1^-[‡]		A EFGHI KL	J^{π}: 714.4γ (E1) to 0^+, 665.0γ (E1) to 2^+. σ in ^{232}Th(d,d′).
730.6[a] *2*	0^+[‡]		GH KL	J^{π}: 730.0γ E0 to 0^+.
774.15[a] *14*	2^+[‡]	6 ps *2*	A de GH KL	J^{π}: 724.7γ E0+E2 to 2^+. $T_{1/2}$: From B(E2)=0.086 *14* (1993Mc07).
774.43[&] *7*	3^-[‡]		A deFGHI KL	J^{π}: 612.3γ (E1) to 4^+, 724.7γ (E1) to 2^+. σ in ^{232}Th(d,d′).
785.25[b] *8*	2^+[‡]	2.3 ps *3*	A E GH KL	J^{π}: 785.3γ E2 to 0^+. $T_{1/2}$: From B(E2)=0.145 *15* (1993Ko42).
826.8 *1*	10^+[‡]	10.3 ps *6*	FGHI	J^{π}: Weighted average of 10.4 ps *6* (Doppler-shift recoil distance, 1976Gu12), 11.2 ps *17* (Doppler-shift recoil distance, 1975Jo07), and 9.5 ps *11* (from B(E2)=3.9 *2*, 1982Ow01). J^{π}: 269.8γ E2 to 8^+.
829.6[b] *2*	(3^+)[‡]		GH K	J^{π}: 780.2γ to 2^+, 667.5γ to 4^+.
873.0[a] *3*	4^+[‡]		GH K	J^{π}: 823.6γ E2 to 2^+, possible 539.9γ to 6^+.
883.8[&] *1*	5^-[‡]		FGHI KL	J^{π}: 550.4γ (E1) to 6^+. σ in ^{232}Th(d,d′).
890.1[b] *2*	4^+[‡]		GH K	J^{π}: 840.5γ E2 to 2^+, 558.1γ E2 to 6^+.
960.24[b] *15*	(5^+)[‡]		G K	J^{π}: 627.2γ to 6^+, 797.9γ to 4^+.
1023.3[a] *1*	6^+[‡]		GH	J^{π}: 861.2γ E2 to 4^+, 466.7γ E2 to 8^+.

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Adopted Levels, Gammas (continued)

^{232}Th Levels (continued)

E(level)[†]	J^π	$T_{1/2}$	XREF	Comments
1042.9[&] *1*	7^-[‡]		FGHI	J^π: 159.2γ E2 to 5^-, 486.0γ to 8^+.
1050.9[b] *1*	6^+[‡]		GH	J^π: 492.3γ E2 to 8^+, 888.4γ E2 to 4^+.
1053.9 *1*	(2^+)		GH KL	J^π: 891.9γ (E2) to 4^+, 1054.0γ (E2) to 0^+.
1072.4 *3*	(2^+)[@]		A H K	Additional information 4.
1077.9 *2*	(1^-)[@]		A d GH Kl	J^π: Possible $K^\pi=1^-$ bandhead.
1078.6 *1*	(0^+)		A dE H Kl	J^π: From γ-ray deexcitation.
1094.4 *2*	$(2)^+$[@]		E H K	Additional information 5.
1105.7 *1*	3^-		A GH KL	B(E3)↑=0.26 *5* J^π: 1056γ E1 to 2^+, 943γ E1 4^+.
1121.68 *8*	2^+		A GH K	J^π: 1122.0γ E2 to 0^+.
1137.1 *5*	12^+[‡]	5.5 ps *4*	FG I	$T_{1/2}$: Weighted average of 5.5 ps *4* (Doppler-shift recoil distance, 1976Gu12), and 5.8 ps *7* (From B(E2)=3.6 *2*, 1982Ow01). J^π: 310.2γ E2 to 10^+.
1143.3 *2*	(4^-)		K	J^π: 981.2γ to 4^+, rotational band structure (possibly $K^\pi=2^-$).
1146.3? *15*	(7^+)		G	J^π: 812.7γ to 6^+.
1148.3 *2*	(4^+)		g KL	J^π: 815.0γ to 6^+, 986.3γ to 4^+, rotational band structure, (possibly $K^\pi=0^+$).
1182.6 *2*	3^-		GH KL	J^π: 1020.5γ E1 to 4^+, 1133.2γ E1 to 2^+, (possibly $K^\pi=3^-$ band).
1208.8 *1*	(5^-)		GH KL	J^π: 434.3γ to 3^-, 875.6γ to 6^+, rotational band structure, (possibly $K^\pi=2^-$).
1218.1 *3*			K	
1222.1[a] *1*	(8^+)[‡]		GH	J^π: 888.8γ to 6^+, possible 395γ to 10^+.
1249.6[&] *1*	9^-[‡]		FGHI	J^π: 206.8γ E2 to 7^-, 422.7γ to 10^+. Additional information 6.
1258.7?[b] *10*	(8^+)[‡]		G	J^π: From Coulomb excitation cross-section.
1293.0 *3*	(5^-)[@]		GH L	J^π: 959.7γ to 6^+.
1303.2 *6*			K	
1322.3 *3*	2^+		G	B(E2)↑=0.00220 *22* J^π: 1322.3γ E2 to 0^+.
1327.4 *2*	2^+		GH KL	B(E2)↑=0.00113 *13* J^π: 1327.7γ E2 to 0^+.
1352.2 *1*			H	
≈1370[b]	(9^+)[‡]		G	J^π: From Coulomb excitation cross-section.
1387.1 *1*	2^+	0.4 ps *1*	H K	J^π: 1387.2γ E2 to 0^+. $T_{1/2}$: From B(E2)=0.0105 *8* (1993Mc07) and adopted Branching(1387γ)=0.075 *23*.
1413.8[c] *2*	4^+[‡]	2.2 ps *5*	GH	$T_{1/2}$: From Coulomb Excitation: HI (1995Ko15). Additional information 7. J^π: 584.2γ M1+E2 to 3^+, 524γ M1+E2 to 4^+, 628.5 E2 to 2^+.
1419? *2*			L	E(level): From ^{232}Th(d,d′). Seen only at one angle.
1450.3 *2*			K	
1466.4 *1*	4^+		H	J^π: 691.9γ to 3^-, 1133.5γ to 6^+.
≈1469.3?[a]	(10^+)[‡]		G	J^π: 912.5γ to 8^+.
1477.0 *2*	2^+		H	J^π: 1477.0γ E2 to 0^+.
1480.1 *2*			G K	
1482.2 *6*	14^+[‡]	3.1 ps *2*	G I	$T_{1/2}$: Doppler-shift recoil distance (1976Gu12). Other value: 3.1 ps *3* (From B(E2)=3.8 *2*, 1982Ow01). J^π: 345.2γ E2 to 12^+.
1484.9 *2*	(5^+)		G KL	J^π: 1323γ to 4^+, 524γ to (5^+); σ in 232Th(d,d′).
1489.4 *4*	$(1,2^+)$		K	J^π: 1489γ to 0^+, 1440γ to 2^+.
≈1490[c]	(5^+)[‡]		G	J^π: From Coulomb excitation cross-section.
1498.7[&] *5*	11^-[‡]		FG I	J^π: 249.2γ E2 to 9^-, 361.6γ to 12^+.

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Adopted Levels, Gammas (continued)

^{232}Th Levels (continued)

E(level)[†]	J^π	$T_{1/2}$	XREF	Comments
				Additional information 8.
≈1511.9[b]	(10^+)[‡]		G	J^π: From Coulomb excitation cross-section.
1519.8 *2*			K	
1553.8 *1*	2^+	110 fs *10*	E H K	$T_{1/2}$: From B(E2)=0.0279 *20* (1993Mc07) and branching(1554γ) from Coulomb Excitation: Li. J^π: 1554.0γ E2 to 0^+. $T_{1/2}$: from B(E2).
1561.4 *5*	$(1,2^+)$		KL	J^π: 1561.4γ to 0^+.
1573.0 *15*	$(1,2^+)$		K	J^π: 1572.8γ to 0^+, 1523.8γ to 2^+.
1573.7[c] *7*	(6^+)[‡]		G	J^π: 614γ M1+E2 to (5^+), 683γ (E2) to 4^+, 550γ to 6^+.
1578.5 *4*	(2^+)		K	J^π: 1578.3γ to 0^+, 1527.4γ to 2^+, 1417.0γ to 4^+.
1609.1 *5*			K	
1618.0 *7*			KL	
≈1640?[b]	(11^+)[‡]		g	J^π: From Coulomb excitation cross-section.
1647.6 *8*			K	
1690.9 *10*			KL	
1727.6 *7*			K	
1738.1 *10*	$(1,2^+)$		KL	J^π: 1738γ to 0^+.
≈1755[a]	(12^+)[‡]		G	J^π: From Coulomb excitation cross-section.
1783[c] *1*	$(8)^+$[‡]		G	J^π: 760γ E2 to 6^+, 637γ to (7^+).
1784.7[&] *6*	13^-[‡]		G I	J^π: 286.0γ E2 to 11^-, 302.5γ to 14^+.
1791 *2*			L	E(level): From ^{232}Th(d,d′). ΔE estimated by evaluator.
≈1801[b]	(12^+)[‡]		G	J^π: From Coulomb excitation cross-section.
1858.5 *7*	16^+[‡]	2.3 ps *2*	G I	$T_{1/2}$: Weighted average of 2.2 ps *2* (Doppler-shift recoil distance, 1976Gu12), and 2.7 ps *6* (From B(E2)=3.5 *2*, 1982Ow01). J^π: 376.3γ E2 to 14^+.
2043.2 *15*	1^+[#]	6.1 fs *4*	E	$T_{1/2}$: From B(M1)=1.48 *9* and branching(2043γ)=0.650 *8* in ^{232}Th(γ,γ') (1988He02).
≈2080[a]	(14^+)[‡]		G	J^π: From Coulomb excitation cross-section.
2101.6[&] *7*	15^-[‡]		G I	J^π: 316.9γ E2 to 13^-, 243.1γ to 16^+.
≈2117[b]	(14^+)[‡]		G	J^π: From Coulomb excitation cross-section.
2248.2 *15*	1^+[#]	13 fs *2*	E	B(M1)↑=0.55 *7* $T_{1/2}$: From B(M1)=0.55 *7* and branching(2248γ)=0.70 *12* in ^{232}Th(γ,γ') (1988He02).
2262.4 *9*	18^+[‡]	1.4 ps *2*	G I	$T_{1/2}$: Weighted average of 1.3 ps *2* (Doppler-shift recoil distance, 1976Gu12), and 1.6 ps *4* (From B(E2)=3.7 *6*, 1980Ow01). J^π: 403.9γ E2 to 16^+.
2274 *4*	1^+[#]	25 fs *6*	E	B(M1)↑=0.25 *3* $T_{1/2}$: From B(M1)=0.25 *3* and branching(2274γ)=0.62 *12* in ^{232}Th(γ,γ') (1988He02).
2296 *4*	1^+[#]	19 fs *9*	E	B(M1)↑=0.32 *6* $T_{1/2}$: From B(M1)=0.31 *6* and branching(2296γ)=0.59 *25* in ^{232}Th(γ,γ') (1988He02).
≈2441[a]	(16^+)[‡]		G	J^π: From Coulomb excitation cross-section.
2445.3[&] *9*	17^-[‡]		G I	J^π: 343.7γ E2 to 15^-.
2445.7[b]	(16^+)[‡]		G	J^π: From Coulomb excitation cross-section.
≈2446[b]	(16^+)[‡]		G	
2691 *1*	20^+[‡]	1.2 ps *2*	G I	J^π: From B(E2)=3.4 *4* (1982Ow01). J^π: 428.9γ E2 to 18^+.
≈2767[b]	(18^+)[‡]		G	

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Adopted Levels, Gammas (continued)

^{232}Th Levels (continued)

E(level)[†]	J^{π}	$T_{1/2}$	XREF	Comments
2813[&] *1*	19^{-}[‡]		G I	J^{π}: 367.8γ E2 to 17^{-}.
≈2832[a]	(18^{+})[‡]		G	J^{π}: From Coulomb excitation cross-section.
3144 *1*	22^{+}[‡]	0.8 ps *1*	G I	J^{π}: From B(E2)=3.9 *6* (1982Ow01). J^{π}: 452.7γ E2 to 20^{+}.
3204[&] *2*	21^{-}[‡]		G I	J^{π}: 390.6γ E2 to 19^{-}.
≈3249[a]	(20^{+})[‡]		G	J^{π}: From Coulomb excitation cross-section.
3616[&] *2*	23^{-}[‡]		G I	J^{π}: 412.6γ E2 to 21^{-}.
3620.0 *15*	24^{+}[‡]	1.1 ps *3*	G	J^{π}: From B(E2)=2.1 *7* (1982Ow01). J^{π}: 476γ E2 to 22^{+}.
4050[&] *2*	25^{-}[‡]		G I	J^{π}: 433.8γ E2 to 23^{-}.
4117 *2*	26^{+}[‡]	0.6 ps *2*	G I	J^{π}: From B(E2)=3.3 *13* (1982Ow01). J^{π}: 497γ E2 to 24^{+}.
4506[&] *3*	27^{-}[‡]		G I	J^{π}: 456γ E2 to 25^{-}.
4633 *2*	(28^{+})[‡]	≈0.2 ps	G I	J^{π}: From B(E2)≈7 (1982Ow01). J^{π}: 516γ (E2) to 26^{+}.
5164 *3*	(30^{+})[‡]		G I	J^{π}: 530.5γ (E2) to (28^{+}).

[†] Deduced by evaluator from a least-squares fit to γ-ray energies, unless given otherwise.
[‡] From rotational band structure. Additional arguments are given with individual levels.
[#] From M1 excitation in ^{232}Th(γ,γ') and ^{232}Th(e,e′).
[@] Coulomb excited by light ions, $\gamma(\theta)$, and ratios of γ-ray reduced transition probabilities (1993Mc07).
[&] Band(A): $K^{\pi}=0^{-}$ Octupole vibrational band.
[a] Band(B): $K^{\pi}=0^{+}$ Beta vibrational band.
[b] Band(C): $K^{\pi}=2^{+}$ Gamma vibrational band.
[c] Band(D): $K^{\pi}=4^{+}$ Two-phonon gamma vibrational band.

Adopted Levels, Gammas (continued)

$\gamma(^{232}Th)$

E_i(level)	J_i^π	E_γ	I_γ	E_f	J_f^π	Mult.[a]	δ	α[b]	Comments
49.369	2^+	49.369[&] 9	100[&]	0	0^+	E2[&]		332	α(L)=244; α(M)=66.4 B(E2)(W.u.)=198 11 E_γ: From ^{232}Ac β^- decay.
162.12	4^+	112.75[†] 2	100[†]	49.369	2^+	E2[†]		6.82	α(K)=0.234; α(L)=4.78; α(M)=1.31; α(N+..)=0.490 B(E2)(W.u.)=286 24
333.26	6^+	171.2[‡] 1	100[‡]	162.12	4^+	E2[‡]		1.21	α(K)=0.208; α(L)=0.729; α(M)=0.199; α(N+..)=0.0738 B(E2)(W.u.)=326 22
556.9	8^+	223.6[‡] 1	100[‡]	333.26	6^+	E2[‡]		0.450	α(K)=0.131; α(L)=0.233; α(M)=0.0633; α(N+..)=0.0234 B(E2)(W.u.)=344 15
714.42	1^-	665.0[†] 2	100[†] 2	49.369	2^+	(E1)[†]		0.00729	α(K)=0.00594; α(L)=0.00102
		714.4[†] 2	16[†] 2	0	0^+	(E1)[†]		0.00637	α(K)=0.00520; α(L)=0.00088
730.6	0^+	681.1[‡] 3	100[‡]	49.369	2^+				
		≈730.4[#]		0	0^+	E0			
774.15	2^+	612.0[&] 3	≈43[&]	162.12	4^+	[E2][&]		0.0273	α(K)=0.0187; α(L)=0.00646 B(E2)(W.u.)≈3.3
		724.7[&] 2	≈1.8[&]	49.369	2^+	E0+E2[&]			B(E2)(W.u.)≈0.52 Additional information 9.
		774.1[&] 4	100[&]	0	0^+	E2[&]		0.0167	α(K)=0.0122; α(L)=0.00339 B(E2)(W.u.)=2.8 12
774.43	3^-	612.3[&] 1	100[&]	162.12	4^+	(E1)[&]		0.0085	α(K)=0.00694; α(L)=0.00120
		724.7[&] 5	≈9[&]	49.369	2^+	(E1)[&]		0.00620	α(K)=0.00506; α(L)=0.00086 Additional information 10.
785.25	2^+	623.1[‡] 1	≈0.8[‡]	162.12	4^+	(E2)[‡]		0.0262	α(K)=0.0181; α(L)=0.00613 B(E2)(W.u.)≈0.13
		735.9[‡] 2	100[‡] 4	49.369	2^+	E2+M1[‡]	23 10	0.0186 3	α(K)=0.0134 2; α(L)=0.00389 4 B(M1)(W.u.)=2.4×10^{-5} 22; B(E2)(W.u.)=7.2 7
		785.3[‡] 2	56[‡] 5	0	0^+	E2[‡]		0.0162	α(K)=0.0118; α(L)=0.00327 B(E2)(W.u.)=2.9 4 Additional information 11.
826.8	10^+	269.8[‡] 1	100[‡]	556.9	8^+	E2[‡]		0.240	α(K)=0.091; α(L)=0.109; α(M)=0.0293; α(N+..)=0.0108 B(E2)(W.u.)=363 21
829.6	(3^+)	667.5[#] 4	25[#] 6	162.12	4^+				
		780.2[#] 2	100[#] 6	49.369	2^+				
873.0	4^+	539.9[†c] 10	100[†]	333.26	6^+	[†]			Not seen in ^{232}Th(n,n′γ).
		823.6[‡] 3		49.369	2^+	E2		0.0147	α(K)=0.0109; α(L)=0.00289
883.8	5^-	550.4[†] 5		333.26	6^+	(E1)		0.0105	α(K)=0.0085; α(L)=0.00149

γ(^{232}Th) (continued)

E_i(level)	J^π_i	E_γ	I_γ	E_f	J^π_f	Mult.[a]	δ	α[b]	Comments
883.8	5^-	≈722[†c]		162.12	4^+	(E1)		0.00625	α(K)=0.00510; α(L)=0.00087
890.1	4^+	558.1[†c] *10*	5.0[†] *16*	333.26	6^+	E2[†]		0.0335	α(K)=0.0222; α(L)=0.0085 Not seen in ^{232}Th(n,n′γ).
		728.0[†] *2*	100[†] *4*	162.12	4^+	[†]			
		840.5[†] *4*	18[†] *4*	49.369	2^+	E2[†]		0.0141	α(K)=0.0105; α(L)=0.00275
960.24	(5^+)	627.2[#] *2*	52[#] *5*	333.26	6^+	[#]			
		797.9[#] *2*	100[#] *5*	162.12	4^+	[#]			
1023.3	6^+	466.7[‡] *2*	2.0[‡] *3*	556.9	8^+	E2[‡]		0.0512	α(K)=0.0311; α(L)=0.0148; α(M)=0.00386; α(N+..)=0.00142
		690.0[‡] *1*	30[‡] *5*	333.26	6^+				
		861.2[‡] *10*	100[‡] *17*	162.12	4^+	E2[‡]		0.0135	α(K)=0.0100; α(L)=0.00258
1042.9	7^-	159.2[‡] *1*	100[‡] *14*	883.8	5^-	E2[‡]		1.61	α(K)=0.230; α(L)=1.01; α(M)=0.275; α(N+..)=0.102
		486.0[‡] *1*	65[‡] *10*	556.9	8^+				
		≈710[c]	0.6 *6*	333.26	6^+				
1050.9	6^+	492.3[†] *10*		556.9	8^+	E2		0.0450	α(K)=0.0281; α(L)=0.0125; α(M)=0.00324; α(N+..)=0.00119
		717.7[‡] *1*	100[‡] *15*	333.26	6^+				
		888.4[‡] *5*	25[‡] *4*	162.12	4^+	E2[‡]		0.0127	α(K)=0.0095; α(L)=0.00239
1053.9	(2^+)	268.4[‡]	<33[‡]	785.25	2^+				
		279.5[‡] *3*	81[‡] *29*	774.15	2^+				
		323.2[‡] *2*	100[‡] *14*	730.6	0^+				
		891.9[‡] *3*		162.12	4^+	(E2)		0.0126	α(K)=0.0094; α(L)=0.00237
		1004.6[‡] *3*		49.369	2^+	(M1+E2)	2.6 *4*	0.0133 *11*	α(K)=0.0103 *9*; α(L)=0.00222 *15*
		1054.0[‡] *3*		0	0^+	(E2)		0.0091	α(K)=0.00702; α(L)=0.00159
1072.4	(2^+)	1023.0[‡] *3*	100[‡]	49.369	2^+	[‡]			
1077.9	(1^-)	1028.5[‡] *3*		49.369	2^+				
		1078.0[‡] *3*		0	0^+				
1078.6	(0^+)	364.2[‡] *1*		714.42	1^-				
		1029.2[‡]		49.369	2^+				
1094.4	$(2)^+$	932.3[‡] *3*		162.12	4^+				
		1045.0[‡] *3*	[‡]	49.369	2^+	M1+E2[‡]	−3.7 *+34−17*	0.011 *20*	α(K)=0.008 *16*; α(L)=0.002 *3*
1105.7	3^-	331.3[‡] *1*	38[‡] *6*	774.43	3^-				
		391.3[‡] *3*	5[‡] *1*	714.42	1^-				
		943.5[‡] *1*	100[‡] *15*	162.12	4^+	E1[‡]		0.00384	α(K)=0.00315; α(L)=0.00052
		1056.4[‡] *3*		49.369	2^+	E1		0.00315	α(K)=0.00258; α(L)=0.00043

$^{232}_{90}Th_{142}$-7

Adopted Levels, Gammas (continued)

γ(^{232}Th) (continued)

E_i(level)	J^π_i	E_γ	I_γ	E_f	J^π_f	Mult.[a]	δ	α[b]	Comments
1121.68	2^+	347.2‡ *1*	30‡ *5*	774.43	3^-	E1‡		0.0272	α(K)=0.0219; α(L)=0.00402; α(M)=0.00096; α(N+..)=0.00034
		407.3‡ *1*	37‡ *6*	714.42	1^-				
		959.3‡ *2*	100‡ *15*	162.12	4^+	E2‡		0.0109	α(K)=0.00829; α(L)=0.00199
		1072.6‡ *3*		49.369	2^+	M1+E2	1.45 *16*	0.0156 *11*	α(K)=0.0123 *9*; α(L)=0.00245 *16*
		1122.0‡ *3*		0	0^+	E2		0.00812	α(K)=0.00629; α(L)=0.00138
1137.1	12^+	310.2† *5*	100†	826.8	10^+	E2†		0.155	α(K)=0.0691; α(L)=0.0631; α(M)=0.0169; α(N+..)=0.00625 B(E2)(W.u.)=3.7×10^2 *3*
1143.3	(4^-)	981.2# *2*	100#	162.12	4^+				
1146.3?	(7^+)	812.7†c *10*		333.26	6^+				
1148.3	(4^+)	815.0# *2*	47# *18*	333.26	6^+				
		986.3# *2*	100# *18*	162.12	4^+				
1182.6	3^-	408.2‡ *3*		774.15	2^+	E1		0.0192	α(K)=0.0155; α(L)=0.00280; α(M)=0.00067; α(N+..)=0.00024
		1020.5‡ *3*		162.12	4^+	E1		0.00335	α(K)=0.00274; α(L)=0.00045
		1133.2‡ *3*		49.369	2^+	E1		0.00279	α(K)=0.00229; α(L)=0.00038
1208.8	(5^-)	325.0‡ *1*	9.6‡ *15*	883.8	5^-				
		434.3‡ *2*	3.4‡ *11*	774.43	3^-				
		875.6‡ *2*	1.9‡ *6*	333.26	6^+				
		1046.7‡ *1*	100‡ *15*	162.12	4^+				
1218.1		884.8# *3*	100#	333.26	6^+				
1222.1	(8^+)	≈395.3†		826.8	10^+				
		888.8† *10*		333.26	6^+				
1249.6	9^-	206.8‡ *1*	71‡ *12*	1042.9	7^-	E2‡		0.595	α(K)=0.151; α(L)=0.323; α(M)=0.088; α(N+..)=0.0325
		422.7‡ *1*	100‡ *15*	826.8	10^+				
1293.0	(5^-)	959.7‡ *3*	100‡	333.26	6^+				
1303.2		1303.2# *6*	100#	0	0^+				
1322.3	2^+	1322.3# *3*	100#	0	0^+	E2		0.00598	α(K)=0.00470; α(L)=0.00096
1327.4	2^+	1165.1‡ *3*		162.12	4^+	E2		0.00757	α(K)=0.00588; α(L)=0.00127
		1277.8‡ *3*		49.369	2^+	(M1+E2)		0.013 *7*	α(K)=0.010 *6*; α(L)=0.0019 *9*
		1327.7‡ *3*		0	0^+	E2		0.00594	α(K)=0.00467; α(L)=0.00096
1352.2		637.8‡ *1*	100‡	714.42	1^-				
1387.1	2^+	612.7‡ *3*	100‡ *21*	774.43	3^-				
		656.7‡c *11*		730.6	0^+	E2		0.0234	α(K)=0.0164; α(L)=0.00528
		672.6‡ *1*	55‡ *8*	714.42	1^-	E1‡		0.00713	α(K)=0.00581; α(L)=0.00099 B(E1)(W.u.)=0.00011 *3*

γ(^{232}Th) (continued)

E_i(level)	J^π_i	E_γ	I_γ	E_f	J^π_f	Mult.[a]	δ	α[b]	Comments
1387.1	2^+	1225.1[‡] 3	64[‡] 19	162.12	4^+	E2[‡]		0.00689	α(K)=0.00538; α(L)=0.00114 B(E2)(W.u.)=0.51 18
		1337.8[‡] 3	40 8	49.369	2^+	M1+E2	−1.5 5	0.0092 21	α(K)=0.0073 18; α(L)=0.0014 3 I_γ: From ^{232}Th(n,n′γ).
		1387.2[‡] 3	21 6	0	0^+	E2		0.00548	α(K)=0.00432; α(L)=0.00087 I_γ: From ^{232}Th(n,n′γ).
1413.8	4^+	≈524[†]		890.1	4^+	M1+E2	1.4	≈0.092	α(K)=0.0699; α(L)=0.0168
		584.2[†] 2	29[†] 5	829.6	(3^+)	M1+E2[†]	<5	0.09 6	α(K)=0.07 5; α(L)=0.015 7 B(M1)(W.u.)>0.00028; B(E2)(W.u.)<12
		628.5[†] 2	100[†] 15	785.25	2^+	E2[†]		0.0257	α(K)=0.0178; α(L)=0.00598 B(E2)(W.u.)=23 7
1450.3		1400.9 2		49.369	2^+				
1466.4	4^+	582.6[‡] 1	87 13	883.8	5^-				
		691.9[‡] 2	34 5	774.43	3^-				
		1133.5[‡] 2	100 19	333.26	6^+				
		1304.3[‡c]	<85	162.12	4^+				
≈1469.3?	(10^+)	≈912.5[†c]	100[†]	556.9	8^+				
1477.0	2^+	702.6[‡] 3		774.15	2^+	M1+E2	2.0 5	0.034 8	α(K)=0.026 7; α(L)=0.0062 10
		1427.6[‡] 3		49.369	2^+				
		1477.0[‡] 3		0	0^+	E2		0.00488	α(K)=0.00387; α(L)=0.00076
1480.1		1430.7[#] 2	100[#]	49.369	2^+				
1482.2	14^+	345.2[†] 5	100[†]	1137.1	12^+	E2[†]		0.114	α(K)=0.0559; α(L)=0.0423; α(M)=0.0113; α(N+..)=0.00417 B(E2)(W.u.)=3.9×10^2 3
1484.9	(5^+)	523.8[#] 10		960.24	(5^+)				
		≈1150.9[†]		333.26	6^+				
		1322.8[#] 2	100[#]	162.12	4^+				
1489.4	$(1,2^+)$	530.3[#] 16		960.24	(5^+)				
		1440.0[#] 5	100[#] 13	49.369	2^+				
		1489.3[#] 5	89[#] 13	0	0^+				
1498.7	11^-	249.2[†] 5		1249.6	9^-	E2		0.311	α(K)=0.106; α(L)=0.149; α(M)=0.0404; α(N+..)=0.0149
		361.6[†] 5		1137.1	12^+				
1519.8		1470.4[#] 2	100[#]	49.369	2^+				
1553.8	2^+	681.0[‡c] 3		873.0	4^+	E2		0.0217	α(K)=0.0153; α(L)=0.00478
		768.5[‡c] 3		785.25	2^+	M1+E2	≈6	≈0.0184	α(K)=0.0135; α(L)=0.00365
		779.6[‡] 3		774.15	2^+	M1+E2	2.5 5	0.024 4	α(K)=0.018 3; α(L)=0.0043 5

$\gamma(^{232}Th)$ (continued)

E_i(level)	J^π_i	E_γ	I_γ	E_f	J^π_f	Mult.[a]	δ	α[b]	Comments
1553.8	2+	823.5[‡c] *3*		730.6	0+	E2		0.0147	α(K)=0.0109; α(L)=0.00289
		839.4[‡] *1*		714.42	1−	E1		0.00474	α(K)=0.00387; α(L)=0.00065
		1391.9[‡c] *3*		162.12	4+	E2		0.00544	α(K)=0.00429; α(L)=0.00086
		1504.6[‡c] *3*		49.369	2+	M1+E2	−2.7 *+26−12*	0.004 *6*	α(K)=0.004 *6*
		1554.0[‡c] *3*		0	0+	E2		0.00354	α(K)=0.00354
1561.4	(1,2+)	1561.4[#] *5*	100[#]	0	0+				
1573.0	(1,2+)	1523.8[#] *2*	45[#] *17*	49.369	2+				
		1572.8[#] *2*	100[#] *17*	0	0+				
1573.7	(6+)	550[†]	32	1023.3	6+				
		614[†]	100[†]	960.24	(5+)	M1+E2[†]	<6	0.08 *5*	α(K)=0.06 *5*; α(L)=0.013 *7*
		≈683[†]	37[†]	890.1	4+	(E2)[†]		≈0.0216	α(K)=0.0153; α(L)=0.00474
1578.5	(2+)	1417.0[#] *5*	100[#] *17*	162.12	4+				
		1527.4[#] *8*	86[#] *17*	49.369	2+				
		1578.3[#] *14*	92[#] *17*	0	0+				
1609.1		1447.0[#] *5*	100[#]	162.12	4+				
1618.0		1568.6[#] *7*	100[#]	49.369	2+				
1647.6		1485.5[#] *8*	100[#]	162.12	4+				
1690.9		1641.5[#] *10*	100[#]	49.369	2+				
1727.6		1679.1[#] *15*	100[#]	49.369	2+				
		1727.3[#] *8*	61[#] *20*	0	0+				
1738.1	(1,2+)	1738.1[#] *10*	100[#]	0	0+				
1783	(8)+	637[†]	100[†]	1146.3?	(7+)				
		760[†]	59[†]	1023.3	6+	E2[†]		0.0173	α(K)=0.0126; α(L)=0.00356
1784.7	13−	286.0[†] *5*		1498.7	11−	E2		0.199	α(K)=0.0812; α(L)=0.086; α(M)=0.0232; α(N+..)=0.0086
		302.5[†] *5*		1482.2	14+				
1858.5	16+	376.3[†] *5*	100[†]	1482.2	14+	E2[†]		0.089	α(K)=0.0472; α(L)=0.0310; α(M)=0.00819; α(N+..)=0.00303 B(E2)(W.u.)=3.9×10^2 *4*
2043.2	1+	1994[@] *2*	53[@] *2*	49.369	2+				
		2043[@] *2*	100[@]	0	0+	M1[#@]			B(M1)(W.u.)=0.2849 *9*
2101.6	15−	243.1[†] *5*		1858.5	16+				
		316.9[†] *5*		1784.7	13−	E2		0.146	α(K)=0.0662; α(L)=0.0582; α(M)=0.0156; α(N+..)=0.00576
2248.2	1+	2199[@] *2*	42[@] *7*	49.369	2+				
		2248[@] *2*	100[@]	0	0+	M1[#@]			B(M1)(W.u.)=0.1107 *3*

$^{232}_{90}Th_{142}$-10

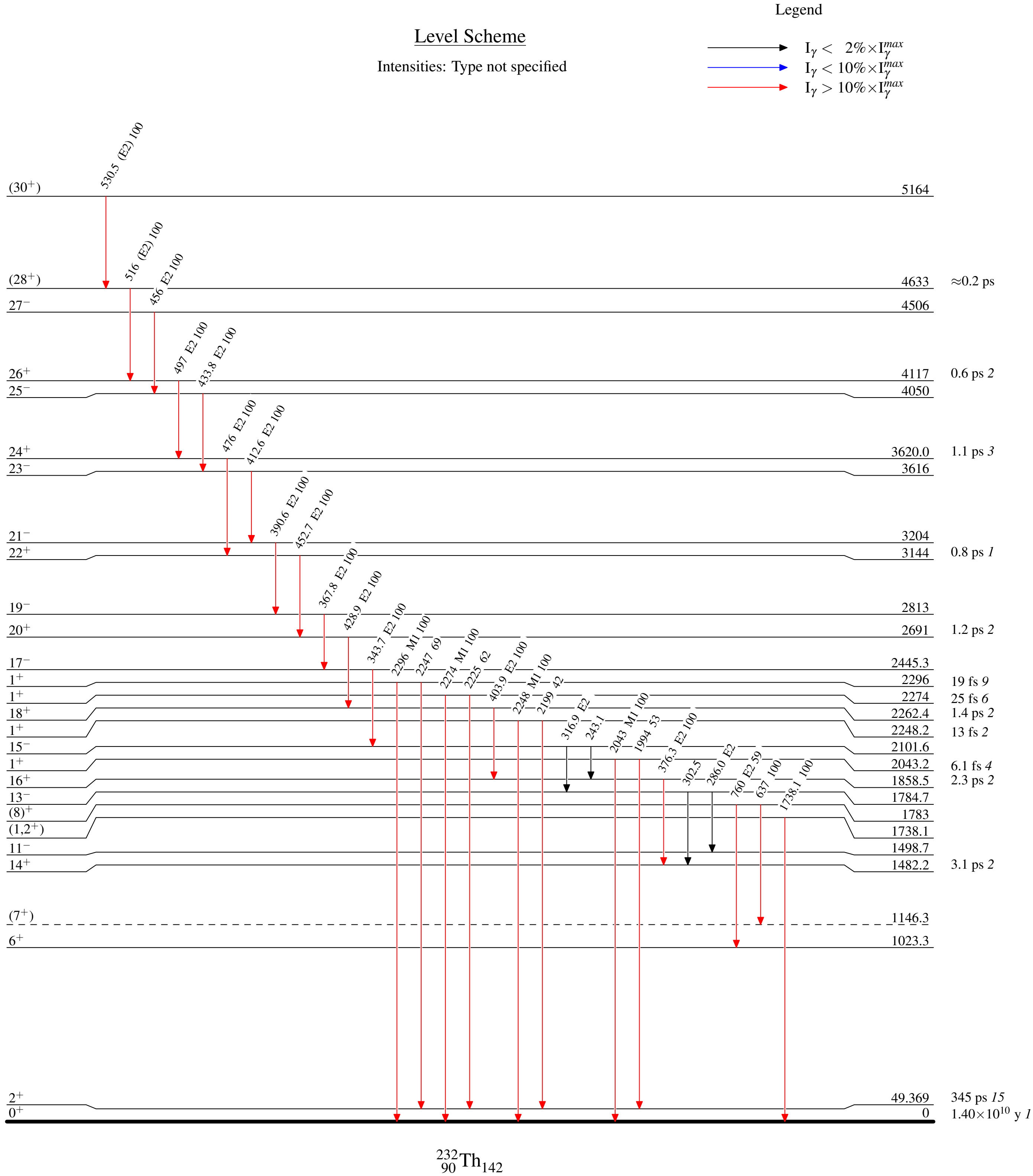
$\gamma(^{232}$Th) (continued)

E_i(level)	J^π_i	E_γ	I_γ	E_f	J^π_f	Mult.[a]	α[b]	Comments
2262.4	18^+	403.9[†] *5*	100[†]	1858.5	16^+	E2[†]	0.0739	α(K)=0.0411; α(L)=0.0241; α(M)=0.00635; α(N+..)=0.00235 B(E2)(W.u.)=4.5×10^2 *7*
2274	1^+	2225[@] *5*	62[@] *13*	49.369	2^+			
		2274[@] *5*	100[@]	0	0^+	M1[#@]		B(M1)(W.u.)=0.0431 *3*
2296	1^+	2247[@] *5*	69[@] *29*	49.369	2^+			
		2296[@] *5*	100[@]	0	0^+	M1[#@]		B(M1)(W.u.)=0.0590 *4*
2445.3	17^-	343.7[†] *5*	100[†]	2101.6	15^-	E2[†]	0.115	α(K)=0.0564; α(L)=0.0430; α(M)=0.0114; α(N+..)=0.00423
2691	20^+	428.9[†] *5*	100[†]	2262.4	18^+	E2[†]	0.0633	α(K)=0.0366; α(L)=0.0197; α(M)=0.00515; α(N+..)=0.00190 B(E2)(W.u.)=3.6×10^2 *6*
2813	19^-	367.8[†] *10*	100[†]	2445.3	17^-	E2[†]	0.095	α(K)=0.0493; α(L)=0.0336; α(M)=0.0089; α(N+..)=0.00329
3144	22^+	452.7[†] *5*	100[†]	2691	20^+	E2[†]	0.0552	α(K)=0.0330; α(L)=0.0164; α(M)=0.00428; α(N+..)=0.00158 B(E2)(W.u.)=4.2×10^2 *11*
3204	21^-	390.6[†] *10*	100[†]	2813	19^-	E2[†]	0.0808	α(K)=0.0438; α(L)=0.0271; α(M)=0.00716; α(N+..)=0.00265
3616	23^-	412.6[†] *10*	100[†]	3204	21^-	E2[†]	0.0699	α(K)=0.0394; α(L)=0.0224; α(M)=0.00589; α(N+..)=0.00218
3620.0	24^+	476[†] *1*	100[†]	3144	22^+	E2[†]	0.0488	α(K)=0.0300; α(L)=0.0139; α(M)=0.00362; α(N+..)=0.00133 B(E2)(W.u.)=2.4×10^2 *7*
4050	25^-	433.8[†] *10*	100[†]	3616	23^-	E2[†]	0.0615	α(K)=0.0358; α(L)=0.0189; α(M)=0.00495; α(N+..)=0.00183
4117	26^+	497[†] *1*	100[†]	3620.0	24^+	E2[†]	0.0440	α(K)=0.0276; α(L)=0.0121; α(M)=0.00314; α(N+..)=0.00115 B(E2)(W.u.)=3.5×10^2 *12*
4506	27^-	456[†] *2*	100[†]	4050	25^-	E2[†]	0.0543	α(K)=0.0325; α(L)=0.0160; α(M)=0.00418; α(N+..)=0.00154
4633	(28^+)	516[†] *1*	100[†]	4117	26^+	(E2)[†]	0.0401	α(K)=0.0257; α(L)=0.0108 B(E2)(W.u.)≈7.0×10^2
5164	(30^+)	530.5[†] *20*	100[†]	4633	(28^+)	(E2)[†]	0.0376	α(K)=0.0244; α(L)=0.0099

[†] From Coulomb Excitation: HI.
[‡] From Coulomb Excitation: Li.
[#] From ^{232}Th(n,n′γ).
[@] From ^{232}Th(γ,γ').
[&] From ^{232}Ac β^- decay.
[a] From $\gamma(\theta)$ and $\gamma\gamma(\theta)$ in light-ion and heavy-ion Coul. ex., unless otherwise specified.
[b] 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.
[c] Placement of transition in the level scheme is uncertain.

$^{232}_{90}$Th$_{142}$-11

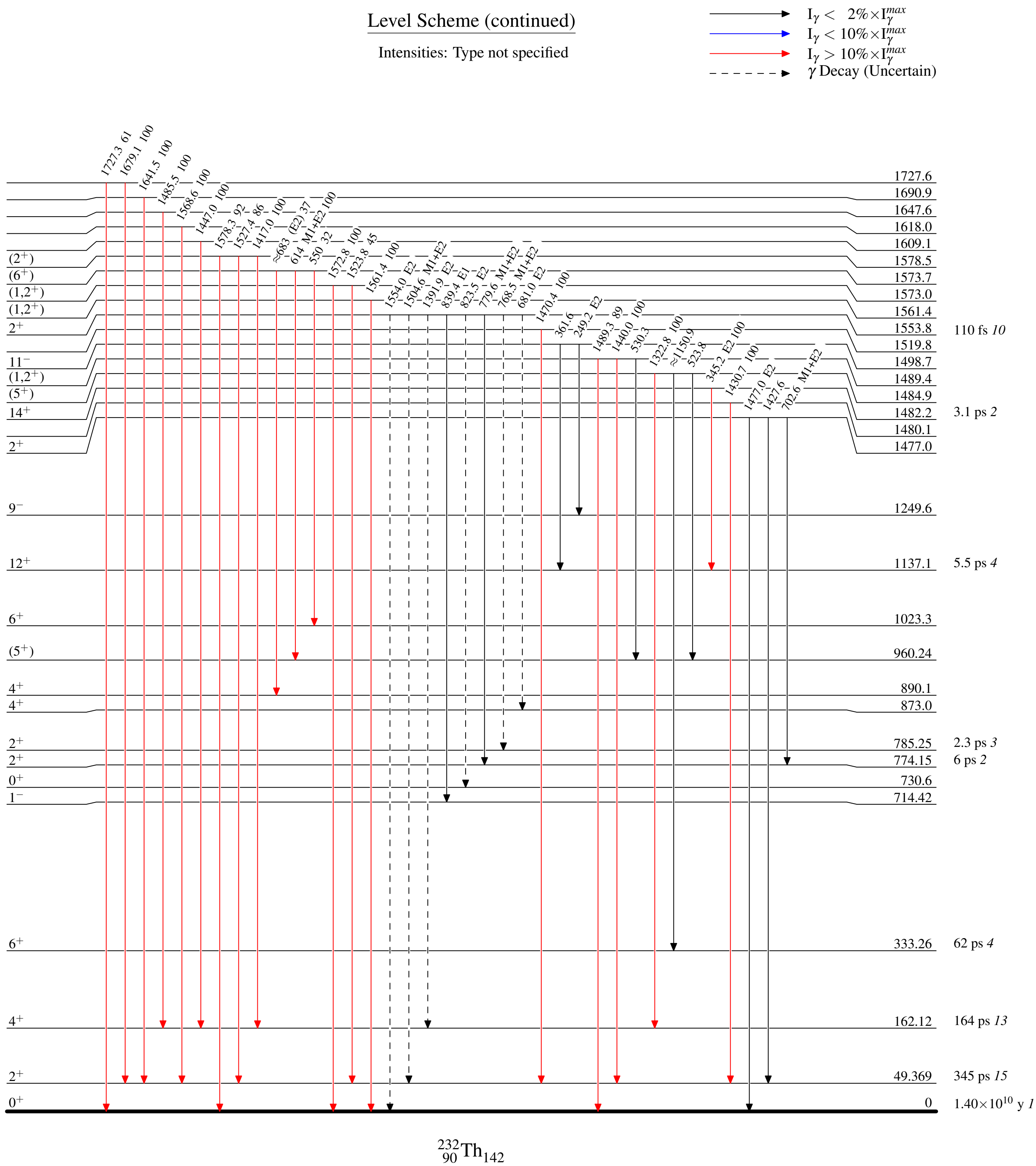
Adopted Levels, Gammas



Adopted Levels, Gammas

Level Scheme (continued)

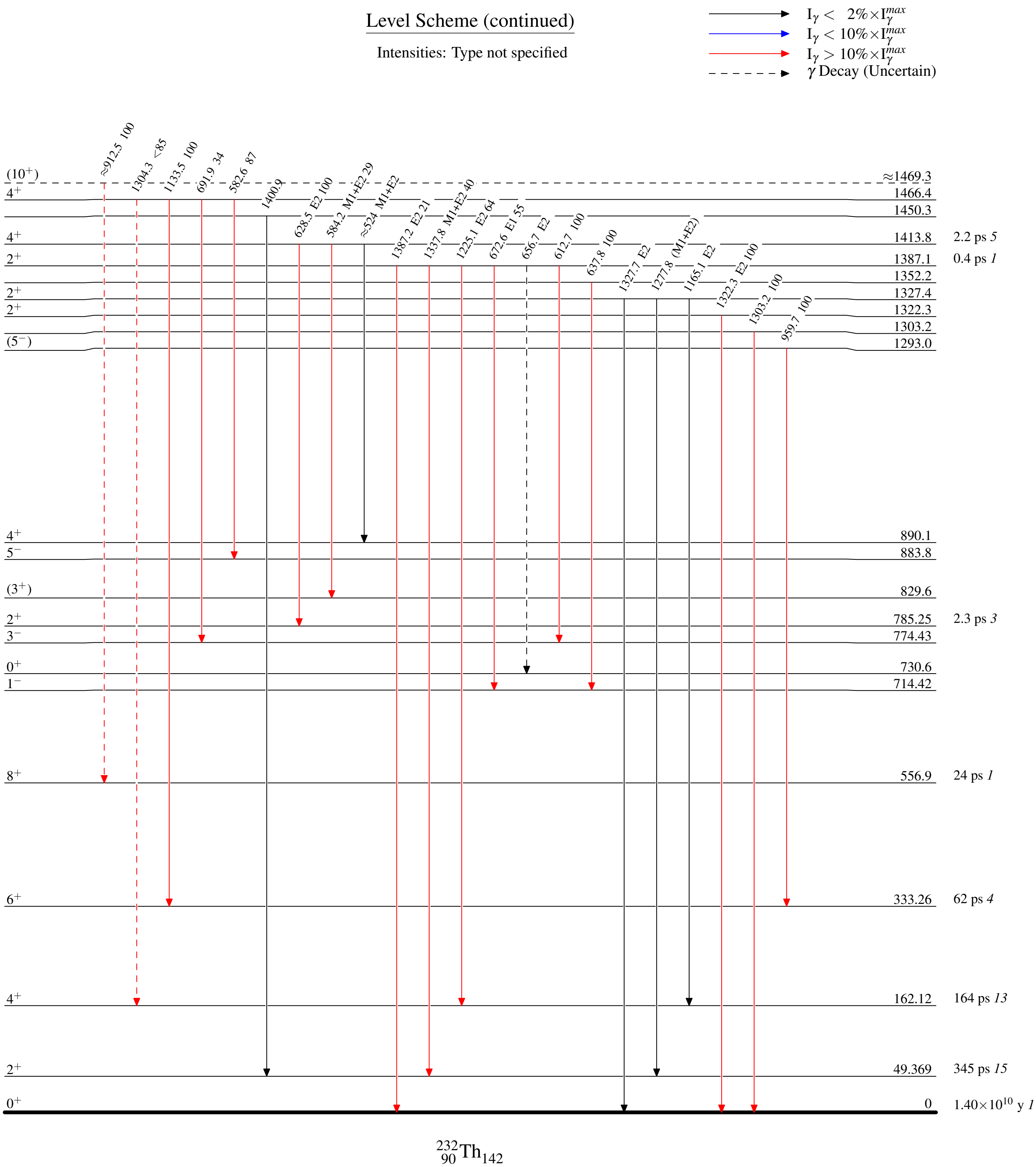
Intensities: Type not specified



Adopted Levels, Gammas

Level Scheme (continued)

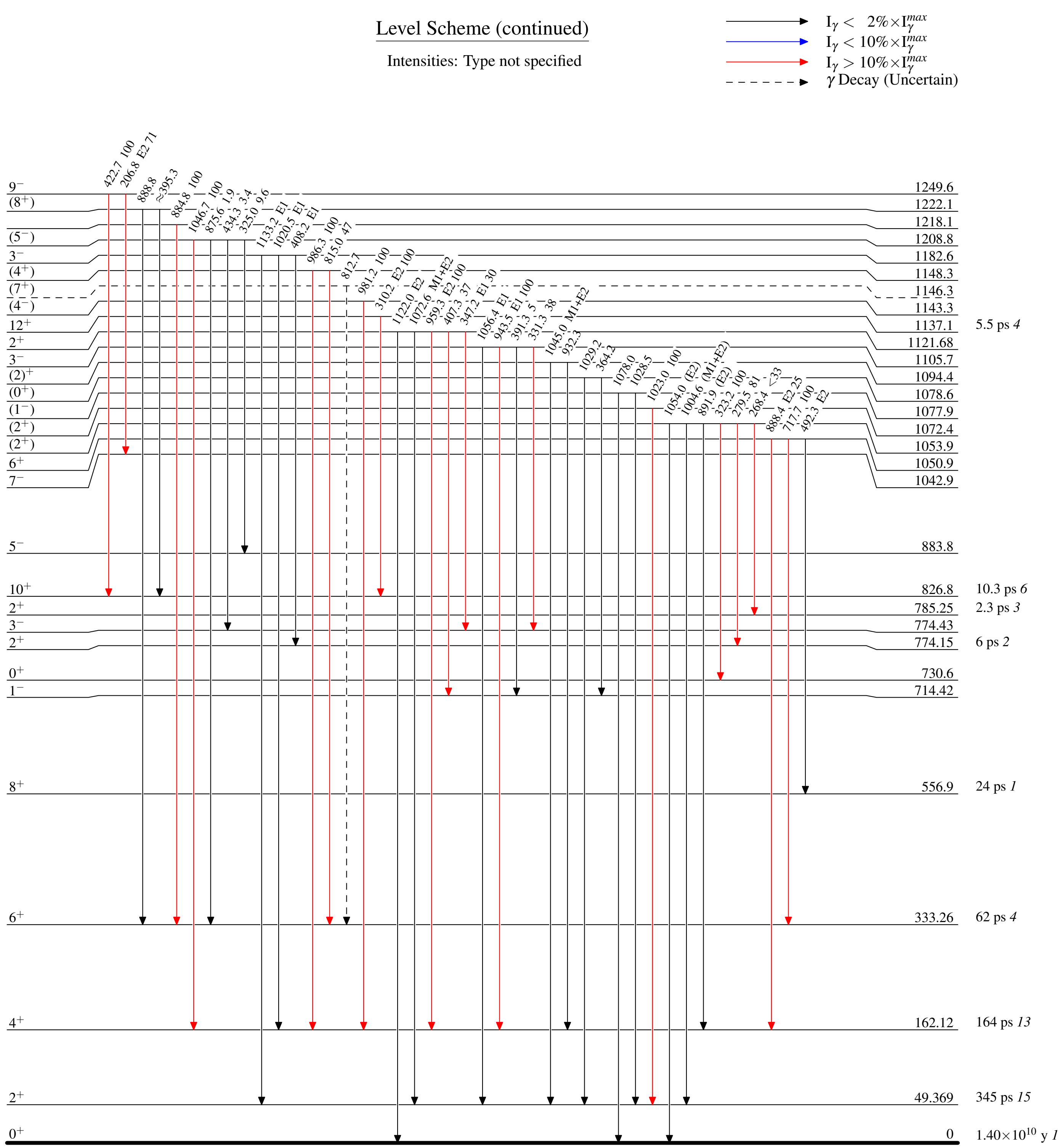
Intensities: Type not specified



Adopted Levels, Gammas

Level Scheme (continued)

Intensities: Type not specified



$^{232}_{90}Th_{142}$

Adopted Levels, Gammas

Level Scheme (continued)

Intensities: Type not specified

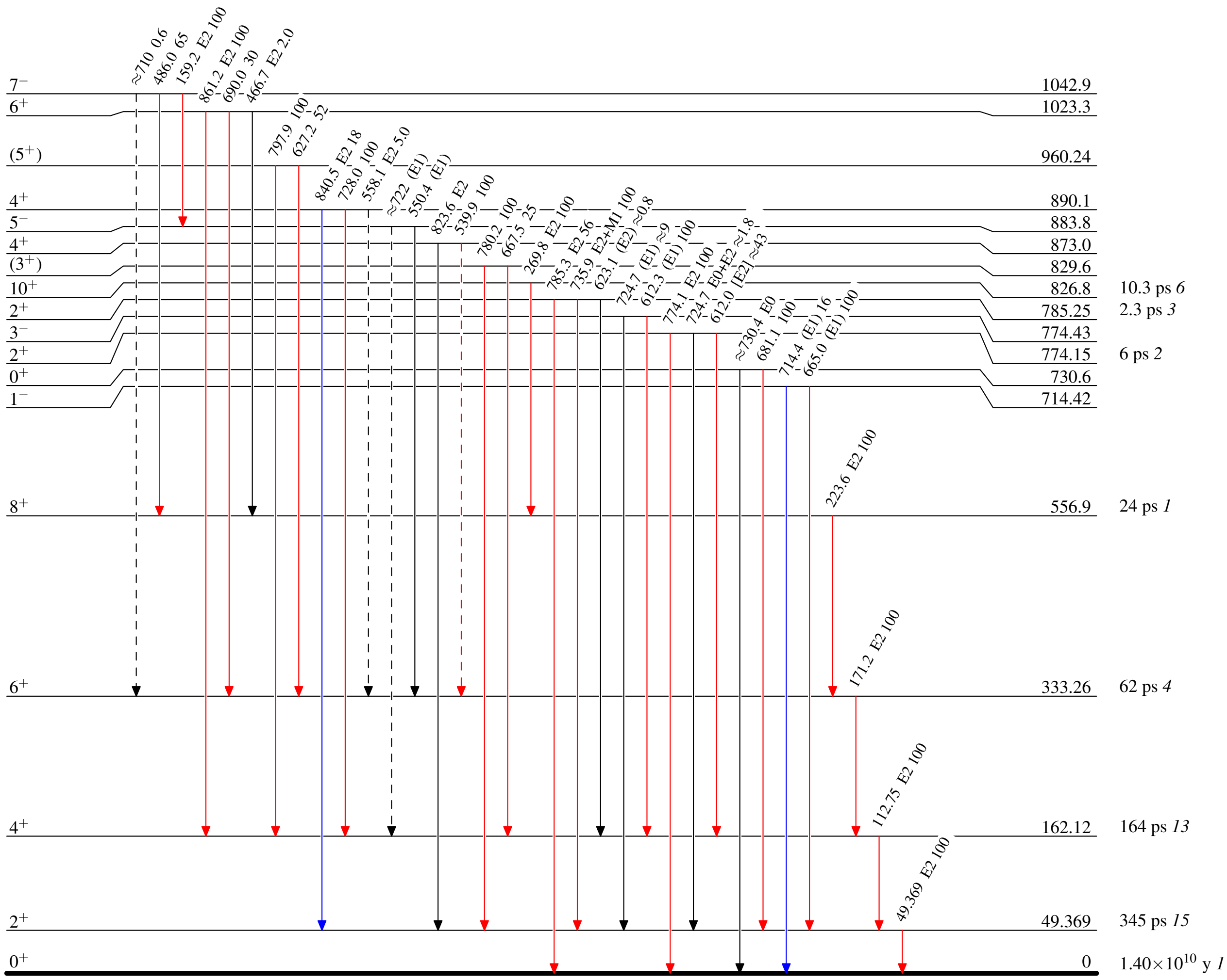
Legend

$I_\gamma < 2\% \times I_\gamma^{max}$

$I_\gamma < 10\% \times I_\gamma^{max}$

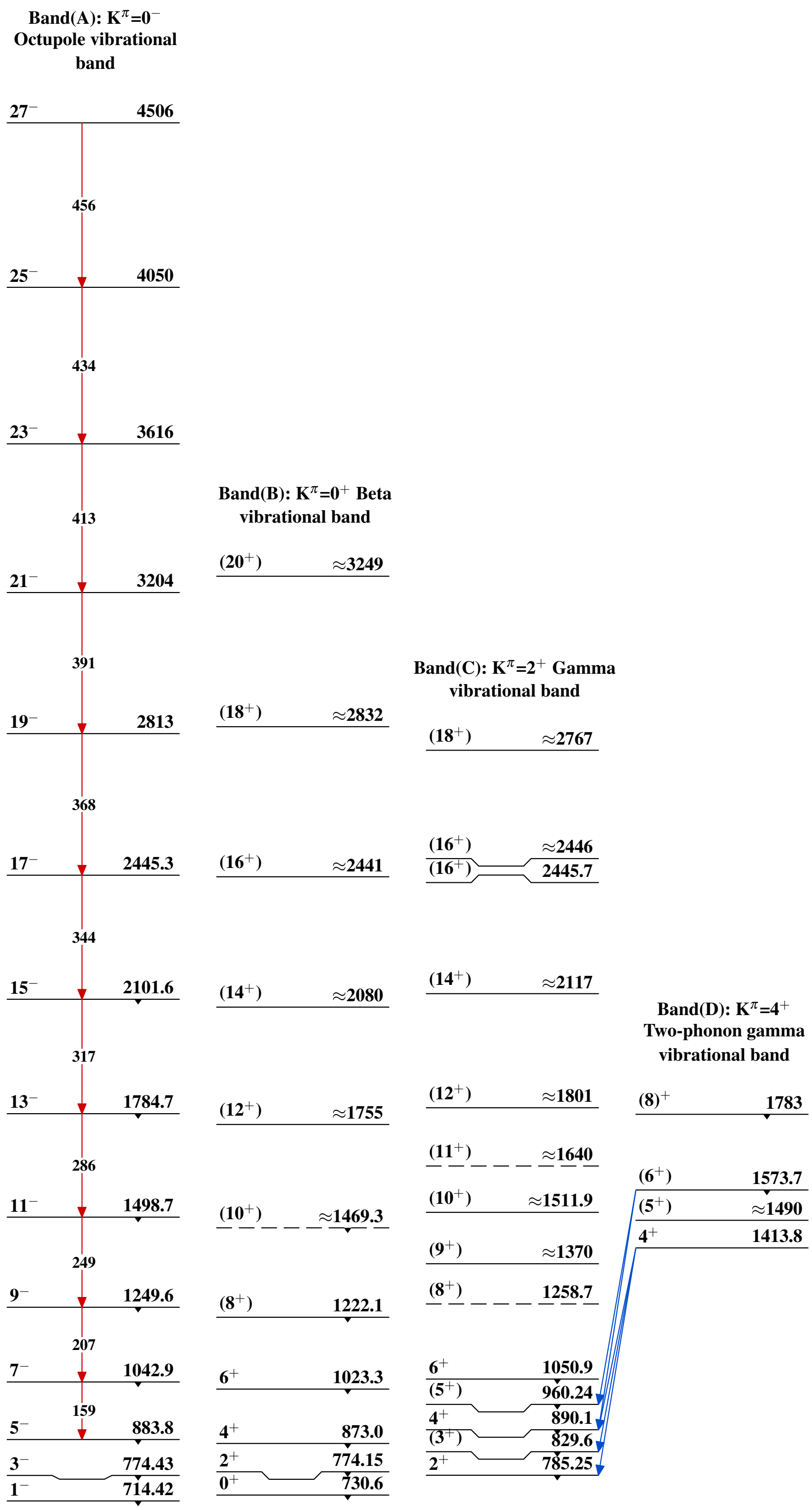
$I_\gamma > 10\% \times I_\gamma^{max}$

γ Decay (Uncertain)



$^{232}_{90}Th_{142}$

Adopted Levels, Gammas



$^{232}_{90}Th_{142}$