

Adopted Levels, Gammas

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

$Q(\beta^-) = -2152.4$; $S(n) = 7105.3$ 22; $S(p) = 6367.7$ 21; $Q(\alpha) = 5520.08$ 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 LevelsCross Reference (XREF) Flags

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

E(level) [†]	J ^π	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: $\Delta\langle r^2 \rangle = -0.413$ 5 relative to ^{232}Th (1989Ka29).
57.773 [‡] 3	2 ⁺	0.406 ns 7	ABCDEFGH	J ^π : 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 ^π : 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.

Continued on next page (footnotes at end of table)

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 ^π =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 ^π =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 ^π =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 ^π =2 ⁺ band.
1059.928 ^b 22	4 ⁻		AB	J ^π : γ's to 3 ⁻ and 5 ⁻ levels; J ^π =3 ⁻ ,4 ⁺ ,5 ⁻ ruled out by γ(θ,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 ^π =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 ^π =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 ^π =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)

²²⁸Th 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.
1750.7 3	0 ⁺			G	J ^π : (E2) γ to 2 ⁺ ; (E2+M1) γ to 4 ⁺ ; γ's to 1 ⁻ , 3 ⁻ , 4 ⁻ , and 6 ⁺ .
1758.06 20	2 ⁺			B G	J ^π : L(p,t)=0 for even-even nucleus. 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)

²²⁸Th 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; γ(θ,H,T) excludes J ^π =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; γ(θ,H,T) excludes J ^π =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; γ(θ,H,T) excludes J ^π =2 ⁺ ,3 ⁻ .
1928.49 5	3 ⁺		AB	J ^π : γ's to 2 ⁺ and 4 ⁺ levels; γ(θ,H,T) excludes J ^π =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 [#] 7	(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 [‡] 7	(20 ⁺)	D	J ^π : γ to (18 ⁺); member of a rotational band.
2839.3 6		G	

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Adopted Levels, Gammas (continued) ^{228}Th Levels (continued)

E(level) [†]	J ^π	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^π=0⁻ octupole-vibrational band.

@ Band(C): first K^π=0⁺ band.

& Band(D): second K^π=0⁺ band.

^a Band(E): third K^π=0⁺ band.

^b Band(F): K^π=1⁻ octupole-vibrational.

^c Band(G): first K^π=2⁺ band.

^d Band(H): K^π=2⁻ octupole-vibrational band.

^e Band(I): second K^π=2⁺ band.

^f Band(J): K^π=3⁻ octupole-vibrational band head.

^g Band(K): K^π=4⁺ band.

^h Band(L): K^π=6⁺ band.

Adopted Levels, Gammas (continued)

$\gamma(^{228}\text{Th})$										
$E_i(\text{level})$	J_i^π	E_γ^\dagger	I_γ^\dagger	E_f	J_f^π	Mult. [‡]	δ^\ddagger	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 ($\alpha, \alpha' 2n\gamma$).
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 ($\alpha, \alpha' 2n\gamma$).
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 ($\alpha, \alpha' 2n\gamma$).
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	$E_\gamma, \text{Mult.}, I_{(\gamma+ce)}$: 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 ⁺					

Adopted Levels, Gammas (continued)

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

$E_i(\text{level})$	J_i^π	E_γ †	I_γ †	E_f	J_f^π	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 ($I_\gamma=16.3$ 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.: $\delta \leq -9$ (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 : $\geq +3.7$ (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 ⁻				

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Adopted Levels, Gammas (continued)

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

$E_i(\text{level})$	J_i^π	E_γ^\dagger	I_γ^\dagger	E_f	J_f^π	Mult. [‡]	δ^\ddagger	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 $\alpha(\text{K})_{\text{exp}}$, L1/L2, L1/L3 indicate E0+5.4%M1 transition (²²⁸ Ac β^- decay). I_γ : Unresolved doublet in ²²⁸ Ac β^- decay.
1168.389	3 ⁻	214.9 2		938.61	0 ⁺				
		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
		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 ⁻				
1174.515	(5 ⁺)	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	
		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 ⁻		
1175.41	2 ⁺	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]			

Adopted Levels, Gammas (continued)

$\gamma(^{228}\text{Th})$ (continued)									
$E_i(\text{level})$	J_i^π	E_γ^\dagger	I_γ^\dagger	E_f	J_f^π	Mult. [‡]	δ^\ddagger	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 ⁺				I_γ : Weak γ -ray.
		1083.2		186.838	4 ⁺				
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 ⁺				

Adopted Levels, Gammas (continued)

E _i (level)	J ^π _i	E _γ [†]	I _γ [†]	E _f	J ^π _f	<u>γ(²²⁸Th) (continued)</u>		
						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 ⁺			

Adopted Levels, Gammas (continued)

$\gamma(^{228}\text{Th})$ (continued)											
$E_i(\text{level})$	J_i^π	E_γ^\dagger	I_γ^\dagger	E_f	J_f^π	Mult. [‡]	δ^\ddagger	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 ⁻						
				931.0 1	11.0 13	519.208	5 ⁻				E _γ : Unweighted avg. Weighted avg.= 481.97 26 with chi-squared=28.
				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 ⁻						

Adopted Levels, Gammas (continued)

$E_i(\text{level})$	J_i^π	$\gamma(^{228}\text{Th})$ (continued)							Comments
		E_γ^\dagger	I_γ^\dagger	E_f	J_f^π	Mult. [‡]	δ^\ddagger	α^h	
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 ⁺				
		674.7 ^f 2	7.7 [@] 11	968.381	2 ⁻				
		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 ⁺				

E_γ : from level energies.

E_γ : from level energies.

Adopted Levels, Gammas (continued)

γ(²²⁸Th) (continued)

E _i (level)	J _i ^π	E _γ [†]	I _γ [†]	E _f	J _f ^π	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)

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

$E_i(\text{level})$	J_i^π	E_γ^\dagger	I_γ^\dagger	E_f	J_f^π	Mult. [‡]	δ^\ddagger	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 ⁻			

Adopted Levels, Gammas (continued)

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

$E_i(\text{level})$	J_i^π	E_γ^\dagger	I_γ^\dagger	E_f	J_f^π	Mult. [‡]	δ^\ddagger	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 _{γ} : 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 ⁻				

Adopted Levels, Gammas (continued)

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

$E_i(\text{level})$	J_i^π	E_γ †	I_γ †	E_f	J_f^π	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		$\delta: +0.27 \leq \delta \leq +5$ from $\gamma(\theta, H, T)$ in ²²⁸ Pa decay.
1823.47	(4 ⁺)	1421.1 @ 2	23.7 @ 12	396.094	3 ⁻	E2+M1	+2.0 5	0.007 1	
		596.8 @ 2	100 @ 27	1226.580	4 ⁻				
		732.9 @ 4	47 @ 20	1091.048	4 ⁺				
1838.1	(15 ⁻)	1304.2 @ 3	47 @ 20	519.208	5 ⁻				
		238.6 5		1599.4	(14 ⁺)				
1842.23	(2,3)	341.2 ^b 3		1497.0	(13 ⁻)				
		751.1 @ 2	29 @ 1	1091.048	4 ⁺				
		819.9 @ 2	27 @ 8	1022.542	(3) ⁺				
		862.8 @ 3	18 @ 6	979.522	2 ⁺				
1864.95	(2 ⁺)	1513.4 @ 5	10 @ 3	328.019	1 ⁻				
		1784.4 @ 2	100 @ 8	57.773	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 ⁺						

Adopted Levels, Gammas (continued)

$\gamma(^{228}\text{Th})$ (continued)									
$E_i(\text{level})$	J_i^π	E_γ^\dagger	I_γ^\dagger	E_f	J_f^π	Mult. [‡]	δ^\ddagger	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 ⁻)				
		666.47j 4	1.31j@ 9	1226.580	4 ⁻				
		692.47@ 7	12.6@ 9	1200.60	3 ⁽⁺⁾	(M1+E2+E0)	0.24 3		α : from $\alpha(\text{K})\text{exp}$ in ^{228}Pa decay.
		718.0@# 2	10@ 4	1175.41	2 ⁺				
		724.5i@# 1	4.8i@ 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 ⁺				

Adopted Levels, Gammas (continued)

$E_i(\text{level})$	J_i^π	$\gamma(^{228}\text{Th})$ (continued)							Comments
		E_γ^\dagger	I_γ^\dagger	E_f	J_f^π	Mult. [‡]	δ^\ddagger	α^h	
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 ⁻				
		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 ⁺				
1906.65	(2 ⁺)	1715.06@ 10	20.0@ 12	186.838	4 ⁺				
		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) ⁺				

I_γ : Seems larger than expected because it is considered as unresolved doublet.

Adopted Levels, Gammas (continued)

$E_i(\text{level})$	J_i^π	$\gamma(^{228}\text{Th})$ (continued)						Comments
		E_γ^\dagger	I_γ^\dagger	E_f	J_f^π	Mult. [‡]	α^h	
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	I_γ : Largest in ²²⁸ Ac decay, since the γ -ray set seems more in ²²⁸ Pa, the evaluator adopts I_γ 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 ⁺			

Adopted Levels, Gammas (continued)

E _i (level)	J _i ^π	<u>γ(²²⁸Th) (continued)</u>							Comments	
		E _γ [†]	I _γ [†]	E _f	J _f ^π	Mult. [‡]	δ [‡]	α ^h		
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 ⁻					
1958.35	(2 ⁺)	1075.1@ 2	50@ 14	874.535	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 ²²⁸Pa decay.

Adopted Levels, Gammas (continued)

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

<u>E_i(level)</u>	<u>J_i^{π}</u>	<u>E_{γ}[†]</u>	<u>I_{γ}[†]</u>	<u>E_f</u>	<u>J_f^{π}</u>	<u>Comments</u>
						I _{γ} : Adopted as a ratio between I _{γ} (1958.2) (²²⁸ Pa/ ²²⁸ Ac) 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 I _{γ} (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)

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

$E_i(\text{level})$	J_i^π	E_γ^\dagger	I_γ^\dagger	E_f	J_f^π	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 ²²⁸Ac and ²²⁸Pa decays, unless otherwise noted.

[‡] From ²²⁸Ac β^- decay and/or ²²⁸Pa ϵ decay.

γ -ray not reported in ²²⁸Ac β^- decay.

@ From ²²⁸Pa ϵ decay.

& From ²³²U α decay.

^a From ²²⁸Ac β^- decay.

^b From ($\alpha,2n\gamma$) 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 ²²⁸Pa decay and placed here in level scheme; however, the γ 's deexciting the final level of this γ were not seen in ²²⁸Pa decay.

^f γ 's of approximately same energy and intensity seen in both ²²⁸Ac and ²²⁸Pa decays. On the basis of coin with 911 γ , it is suggested in ²²⁸Ac decay, that the γ feeds the 2⁺ 968.968 level. In ²²⁸Pa 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. I γ (doublet)=24 6, E(doublet)=674.65 5.

^g There is a disagreement in the ratio I γ (583 γ)/I γ (651 γ) between ²²⁸Ac decay (1.23 15) and ²²⁸Pa decay (2.26 24).

Adopted Levels, Gammas (continued)

$\gamma(^{228}\text{Th})$ (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.

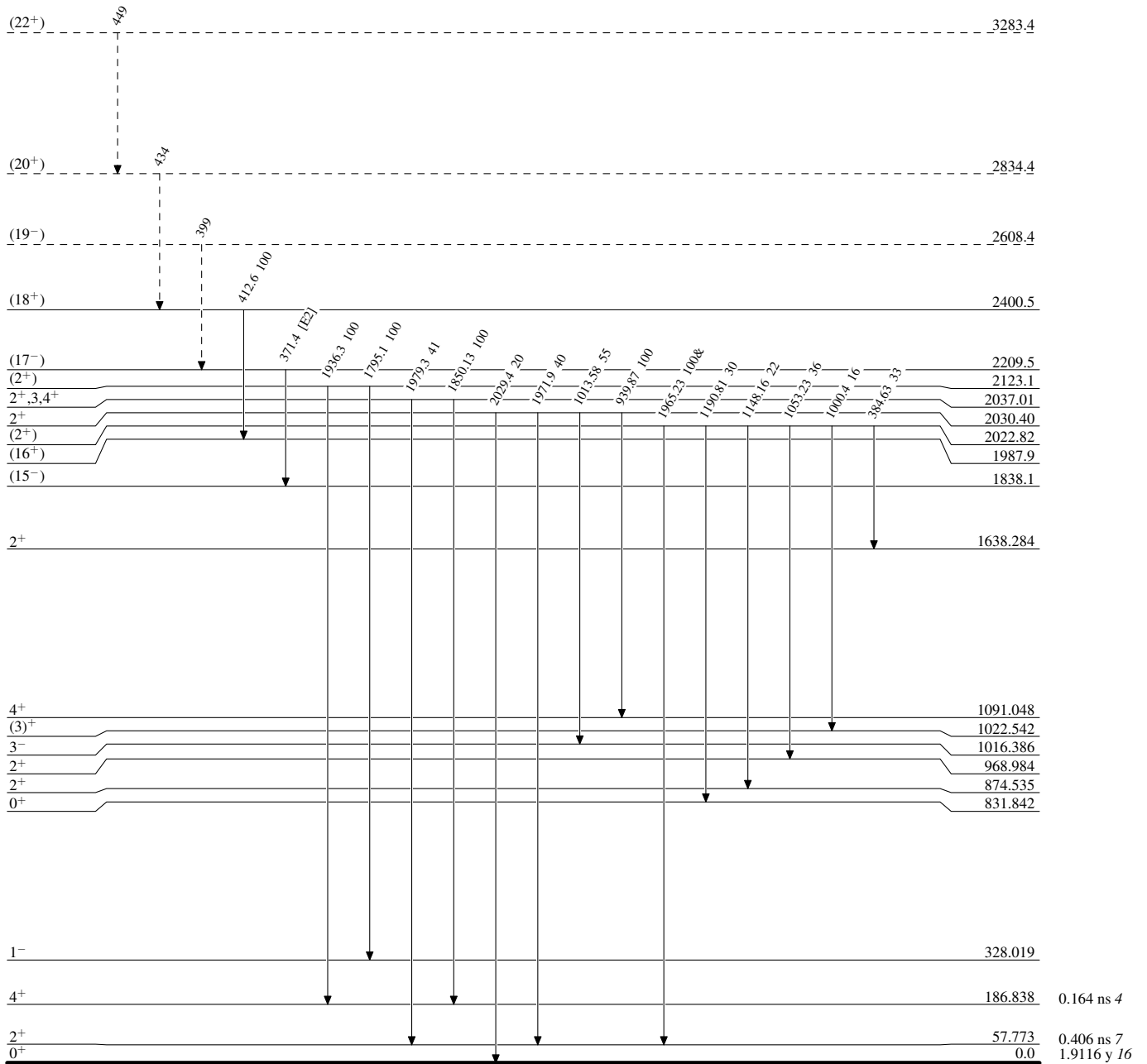
Adopted Levels, Gammas

Legend

Level Scheme

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

-----▶ γ Decay (Uncertain)

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

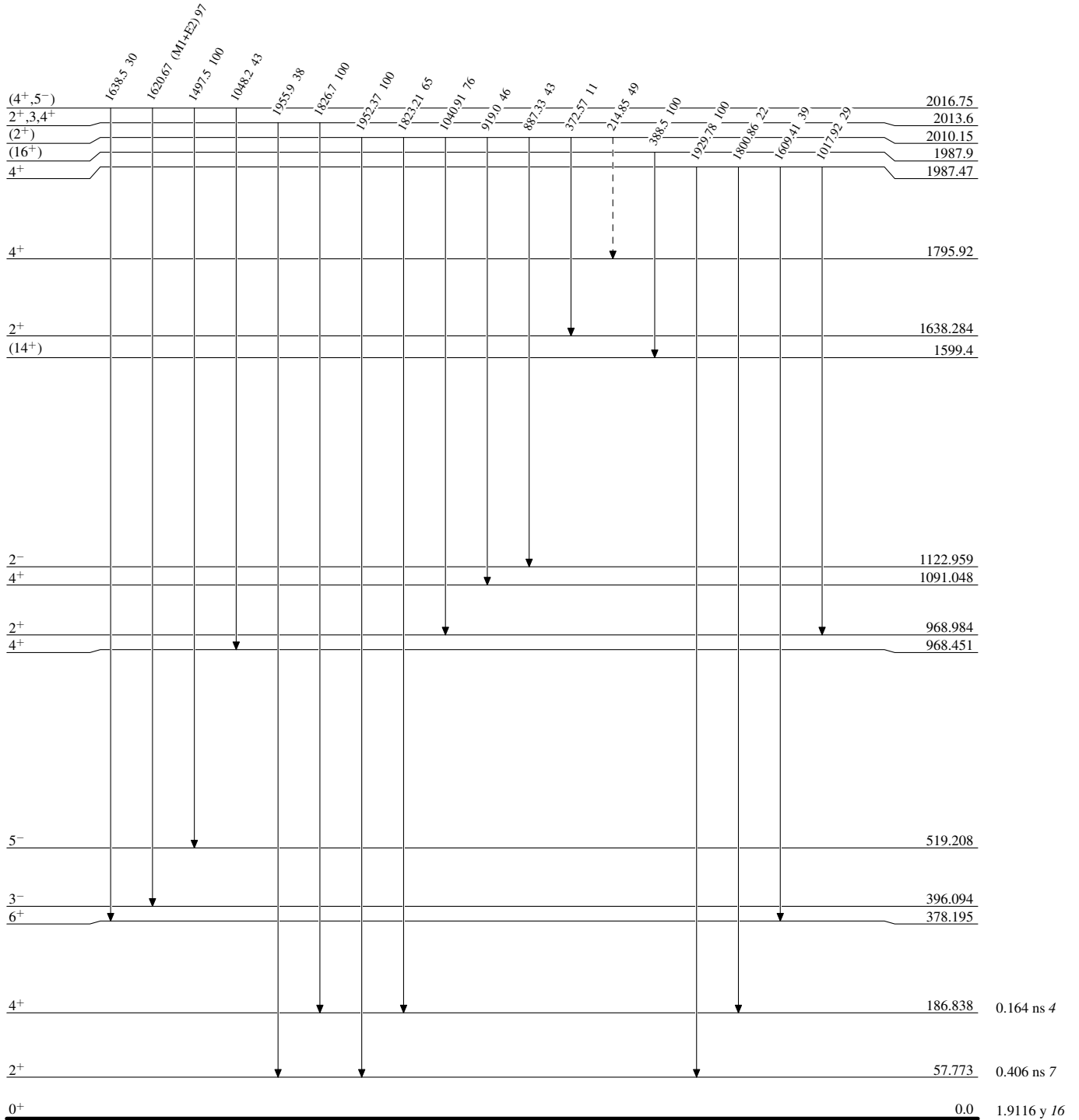
Adopted Levels, Gammas

Legend

Level Scheme (continued)

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

-----> γ Decay (Uncertain)

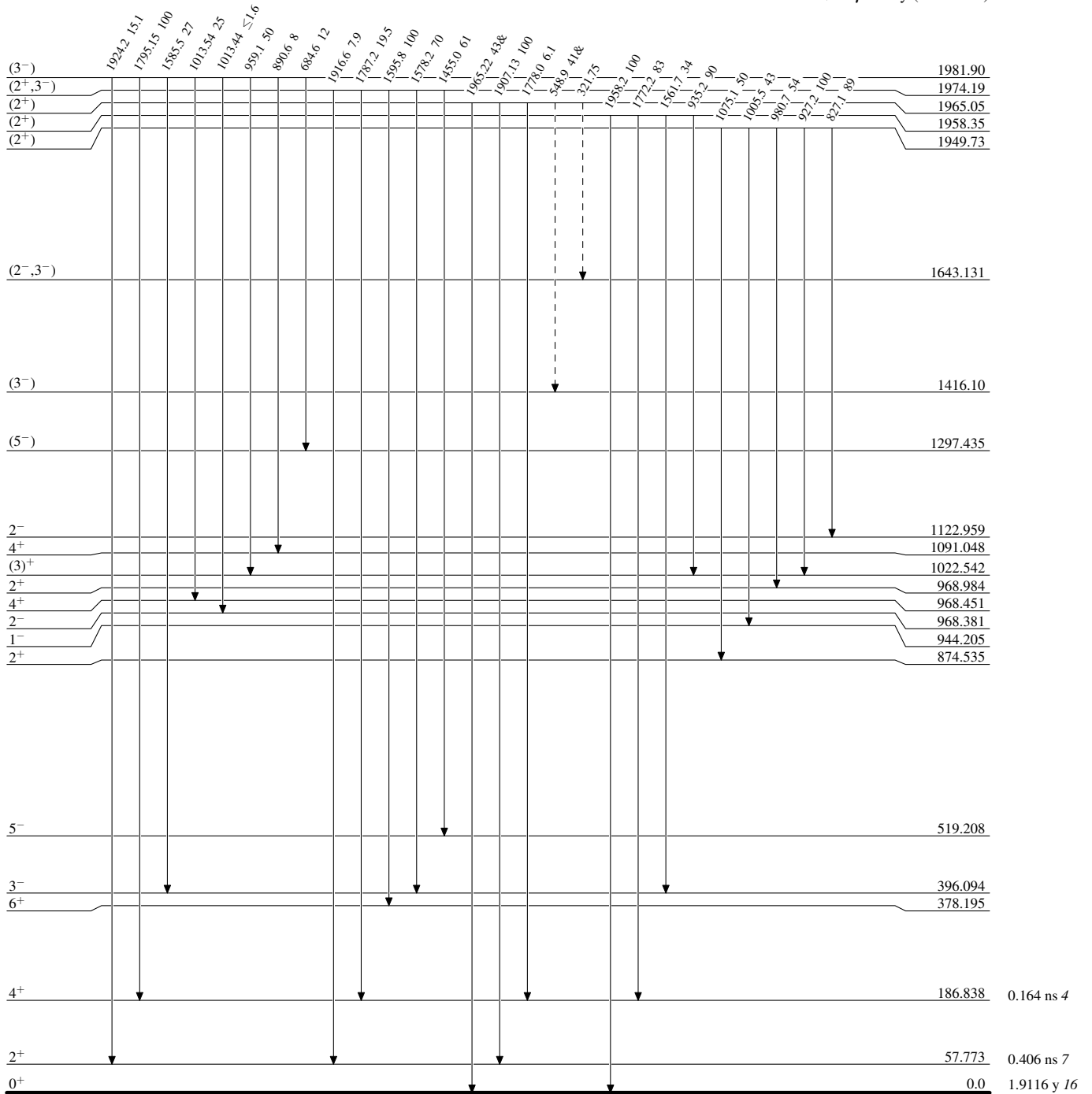


$^{228}_{90}\text{Th}_{138}$

Adopted Levels, GammasLevel Scheme (continued)

Legend

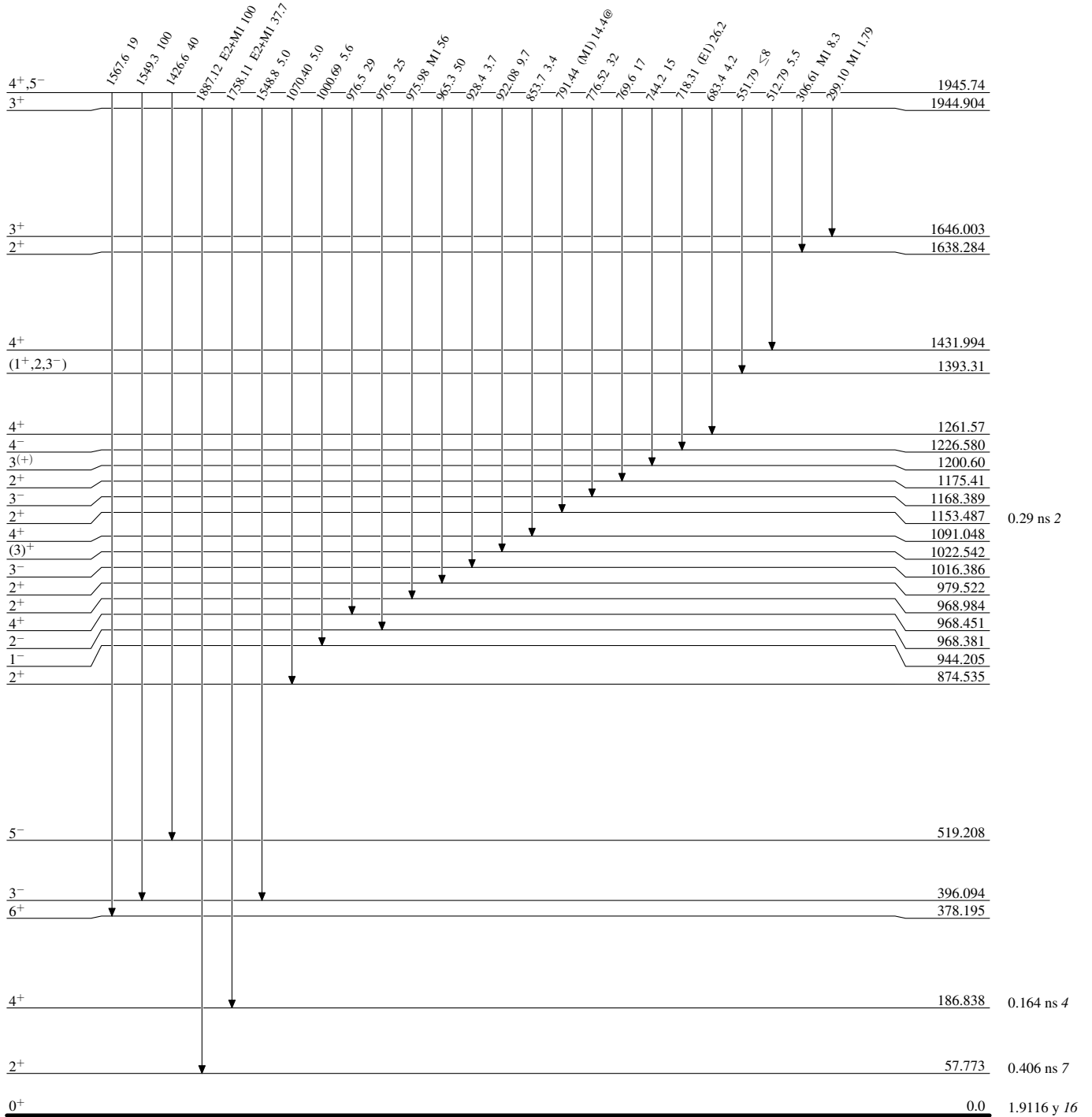
Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given

-----> γ Decay (Uncertain) $^{228}\text{Th}_{90}$

Adopted Levels, Gammas

Level Scheme (continued)

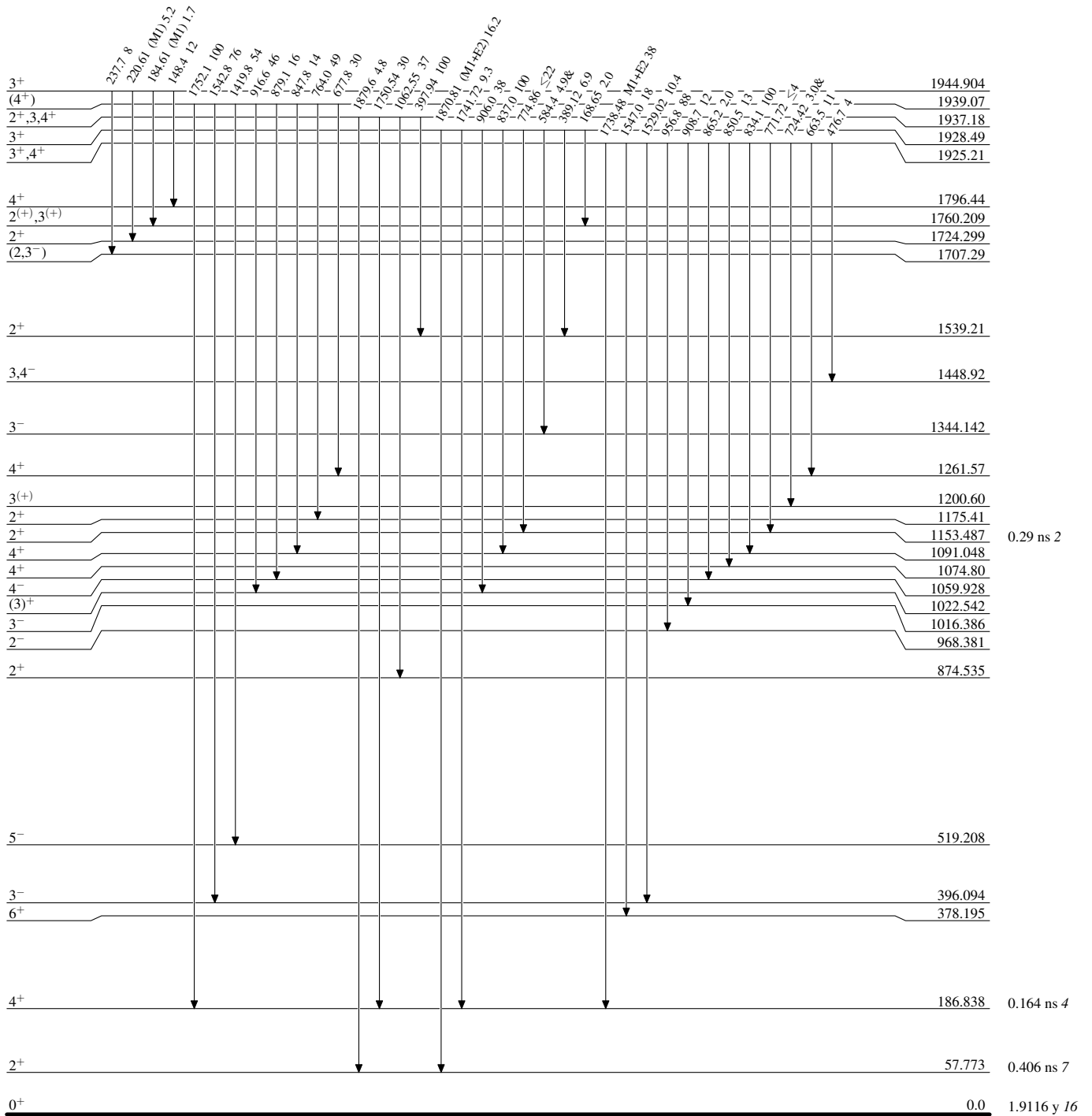
Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided



Adopted Levels, Gammas

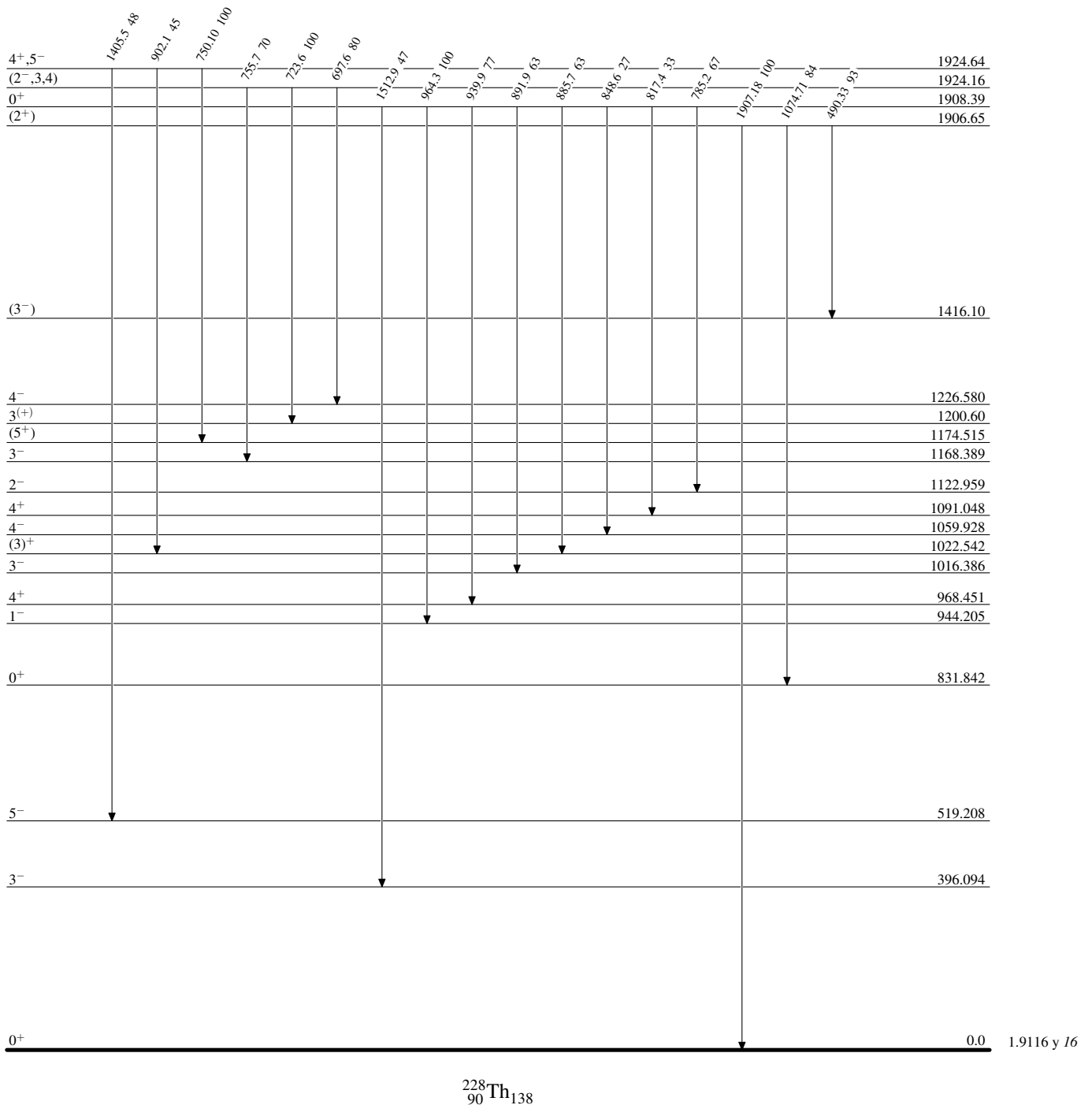
Level Scheme (continued)

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



Adopted Levels, GammasLevel Scheme (continued)

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



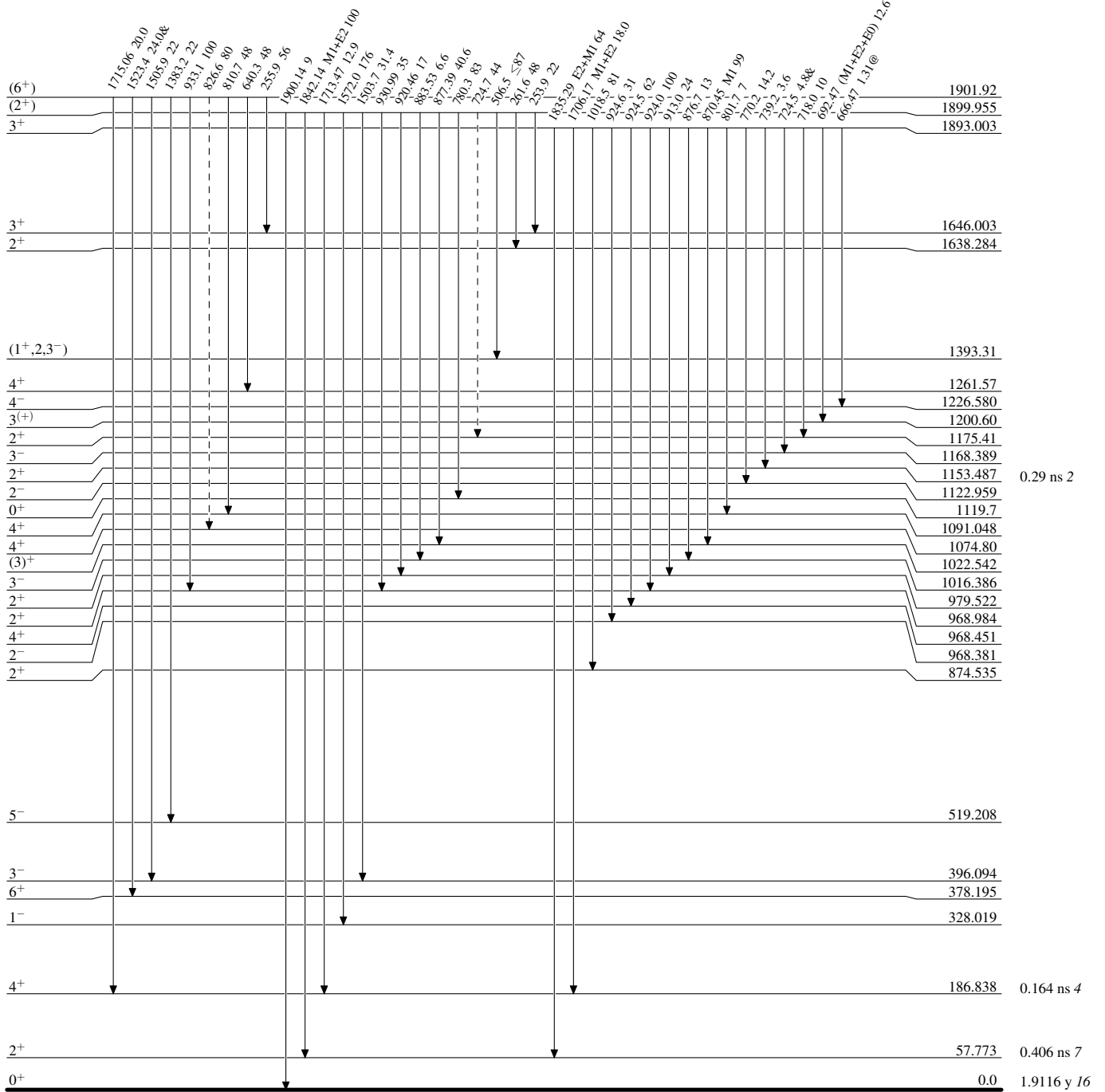
Adopted Levels, Gammas

Level Scheme (continued)

Legend

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

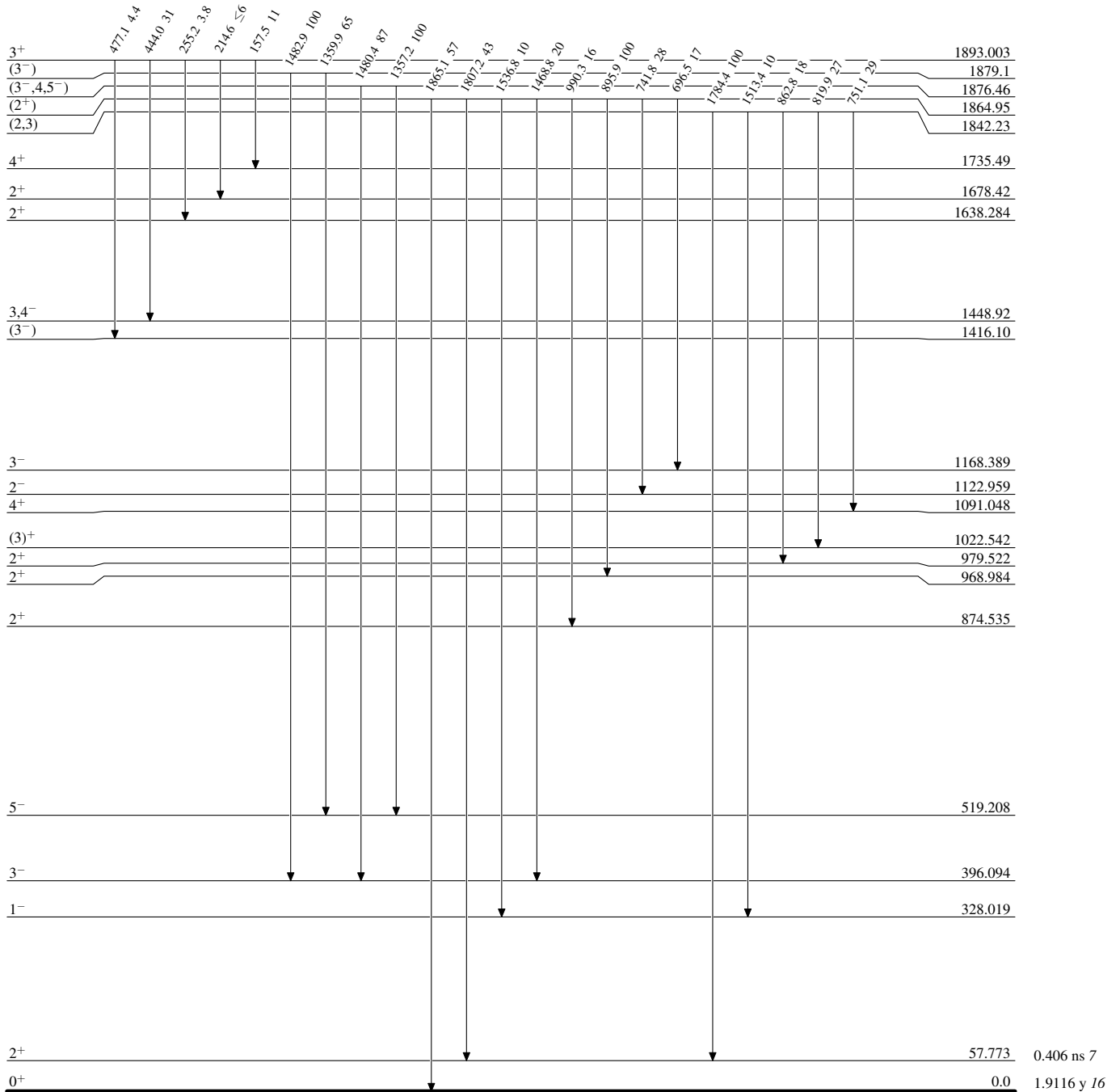
-----> γ Decay (Uncertain)



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

Adopted Levels, Gammas**Level Scheme (continued)**

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

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

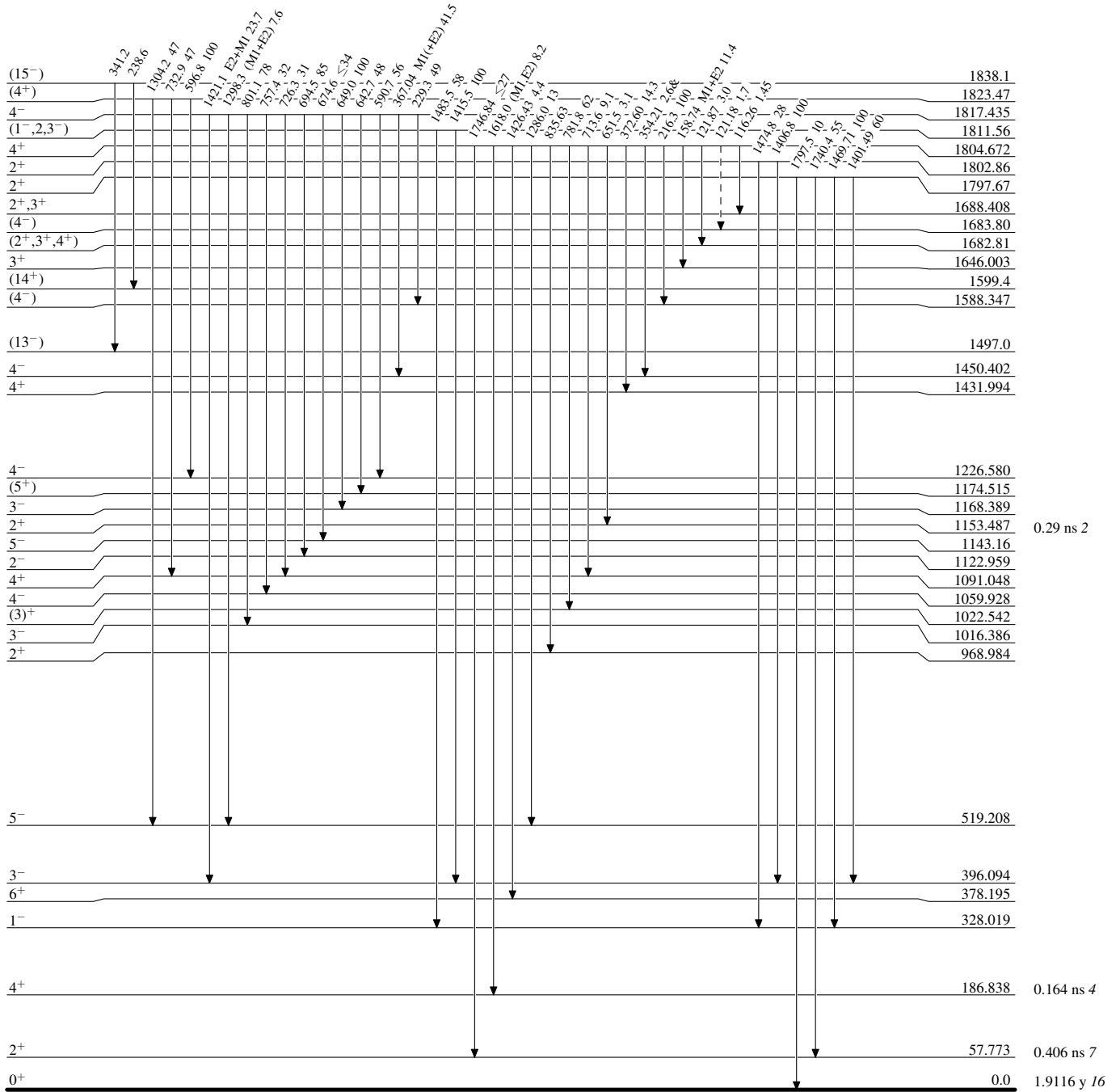
Adopted Levels, Gammas

Level Scheme (continued)

Legend

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

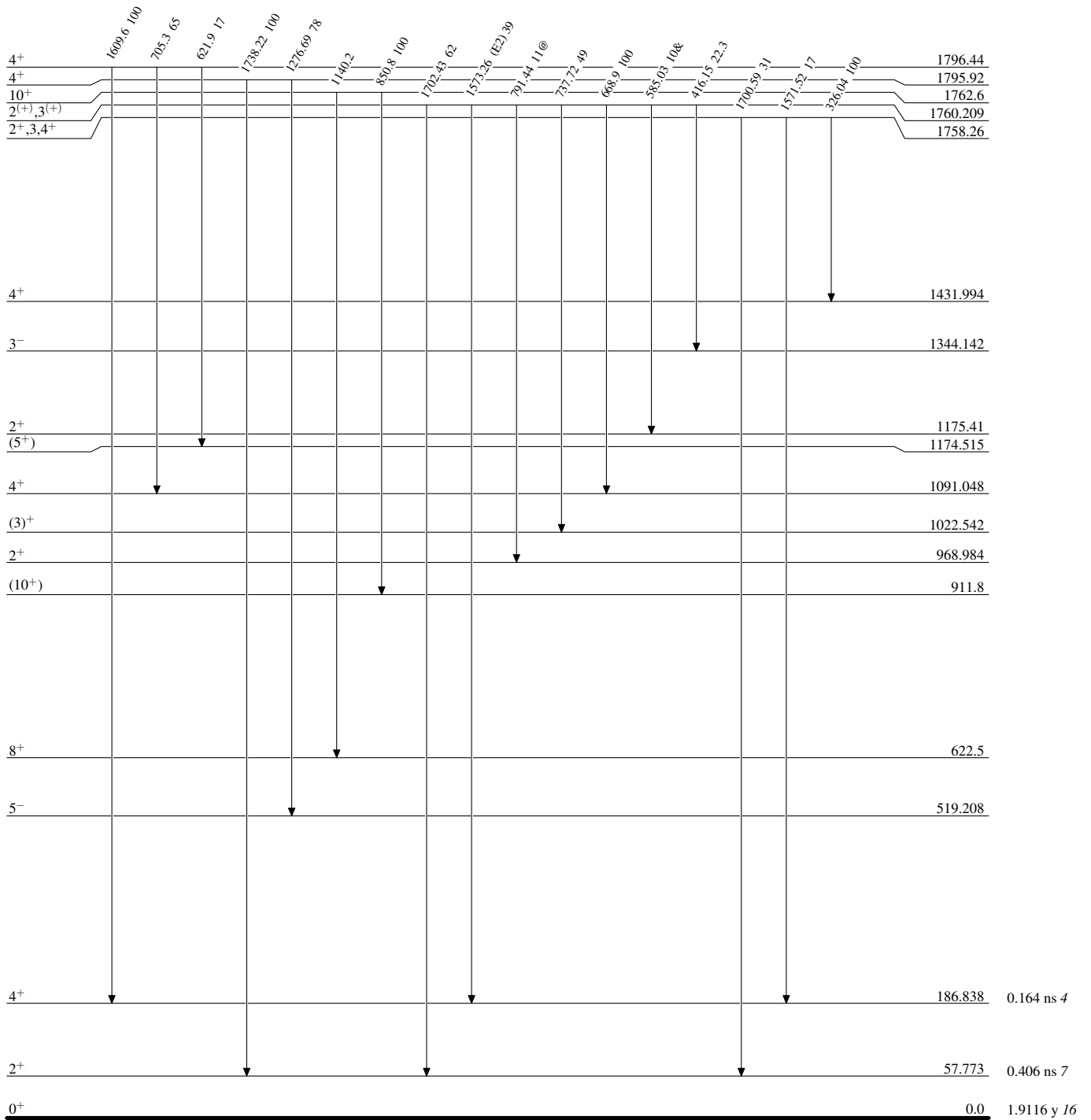
-----> γ Decay (Uncertain)



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

Adopted Levels, Gammas**Level Scheme (continued)**

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



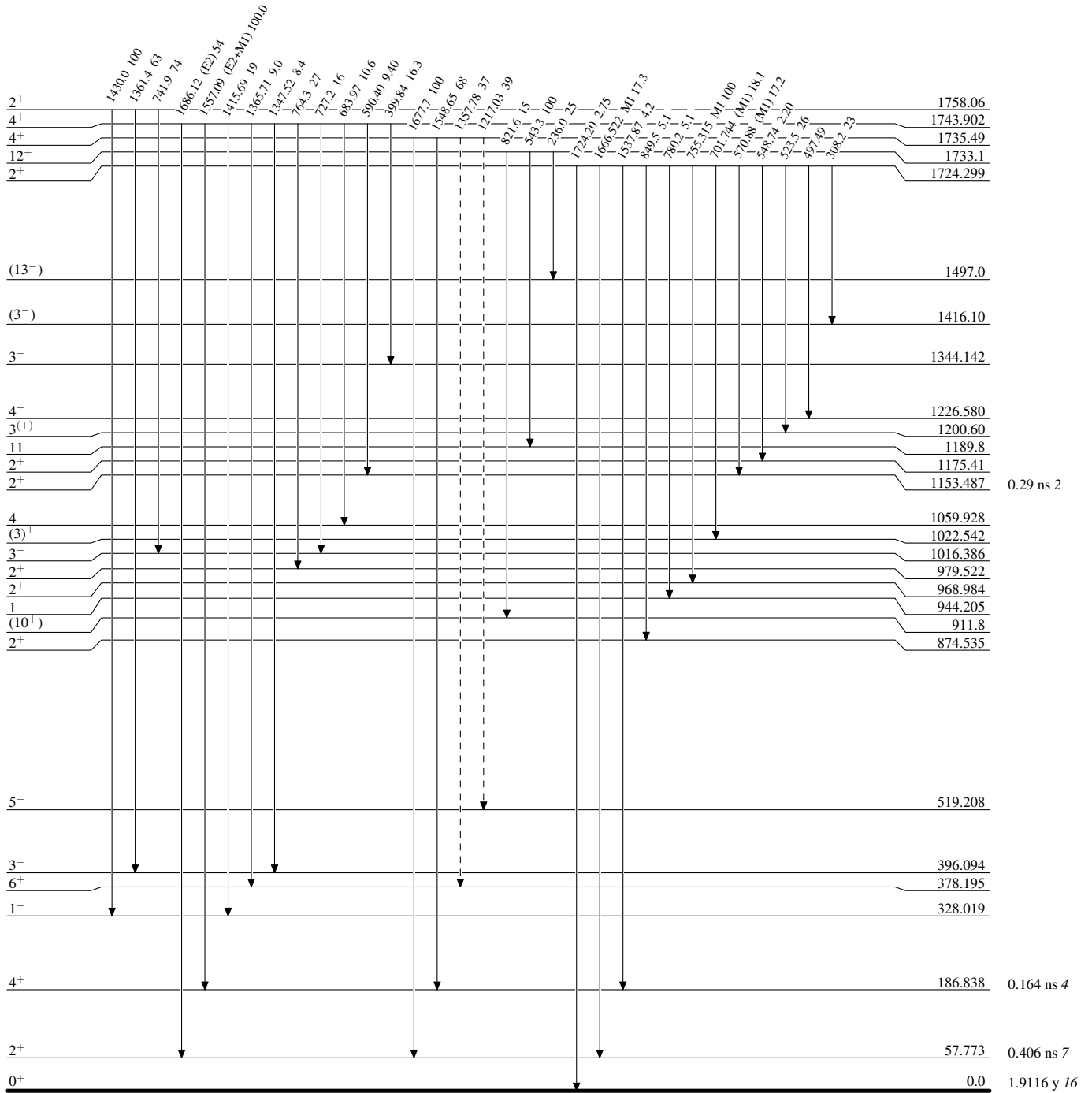
Adopted Levels, Gammas

Level Scheme (continued)

Legend

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

-----▶ γ Decay (Uncertain)



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

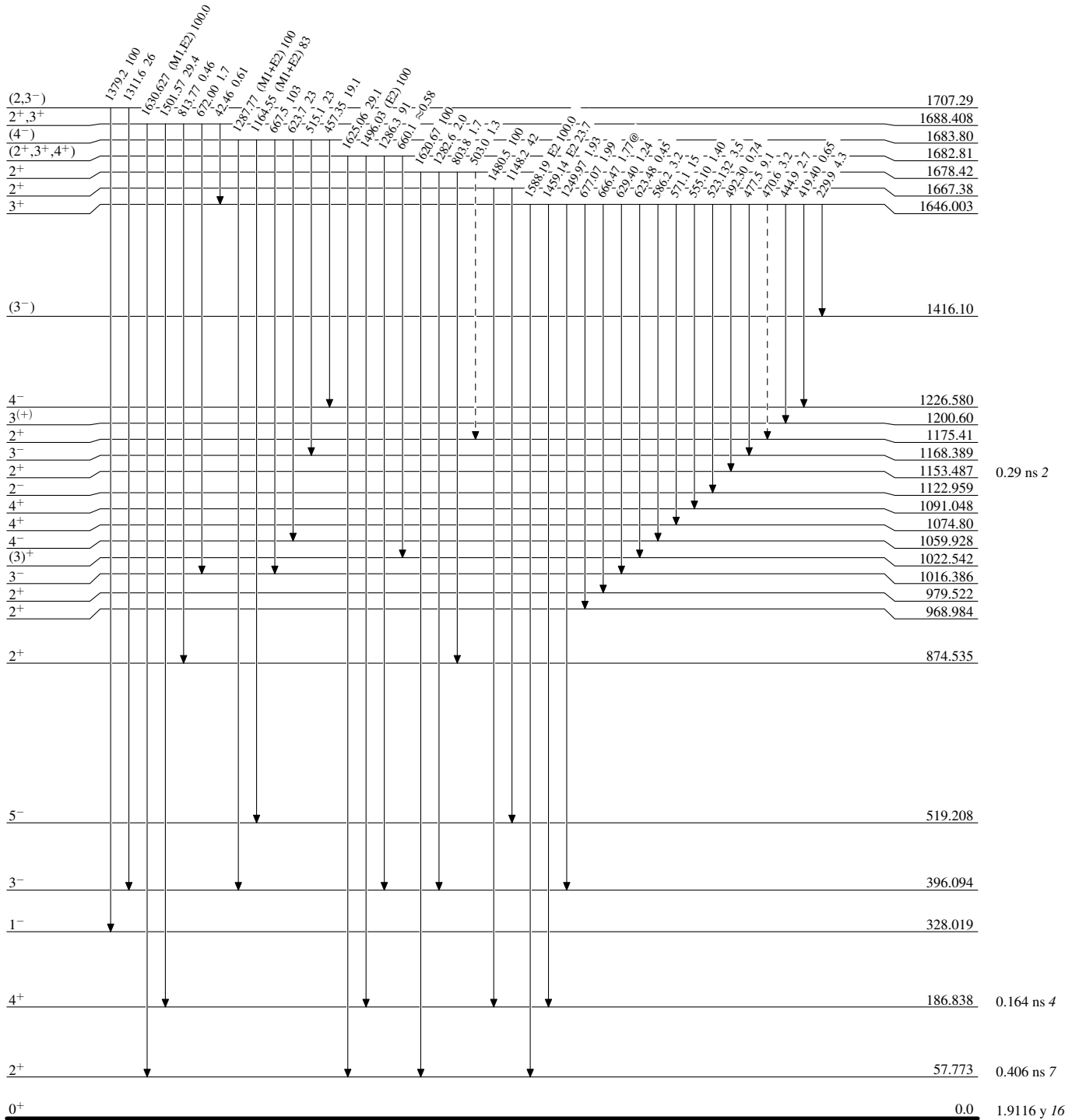
Adopted Levels, Gammas

Level Scheme (continued)

Legend

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

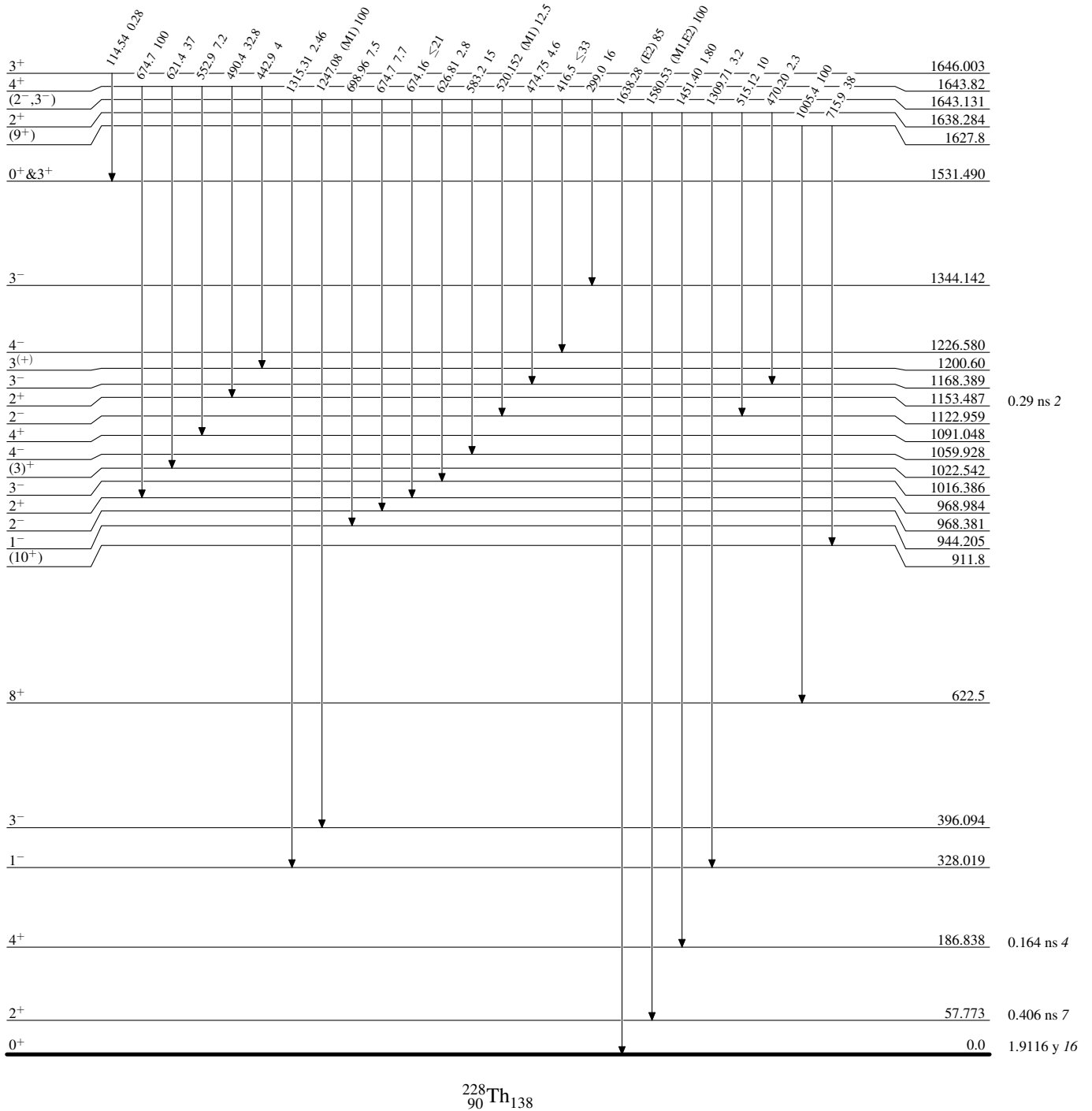
-----> γ Decay (Uncertain)



Adopted Levels, Gammas

Level Scheme (continued)

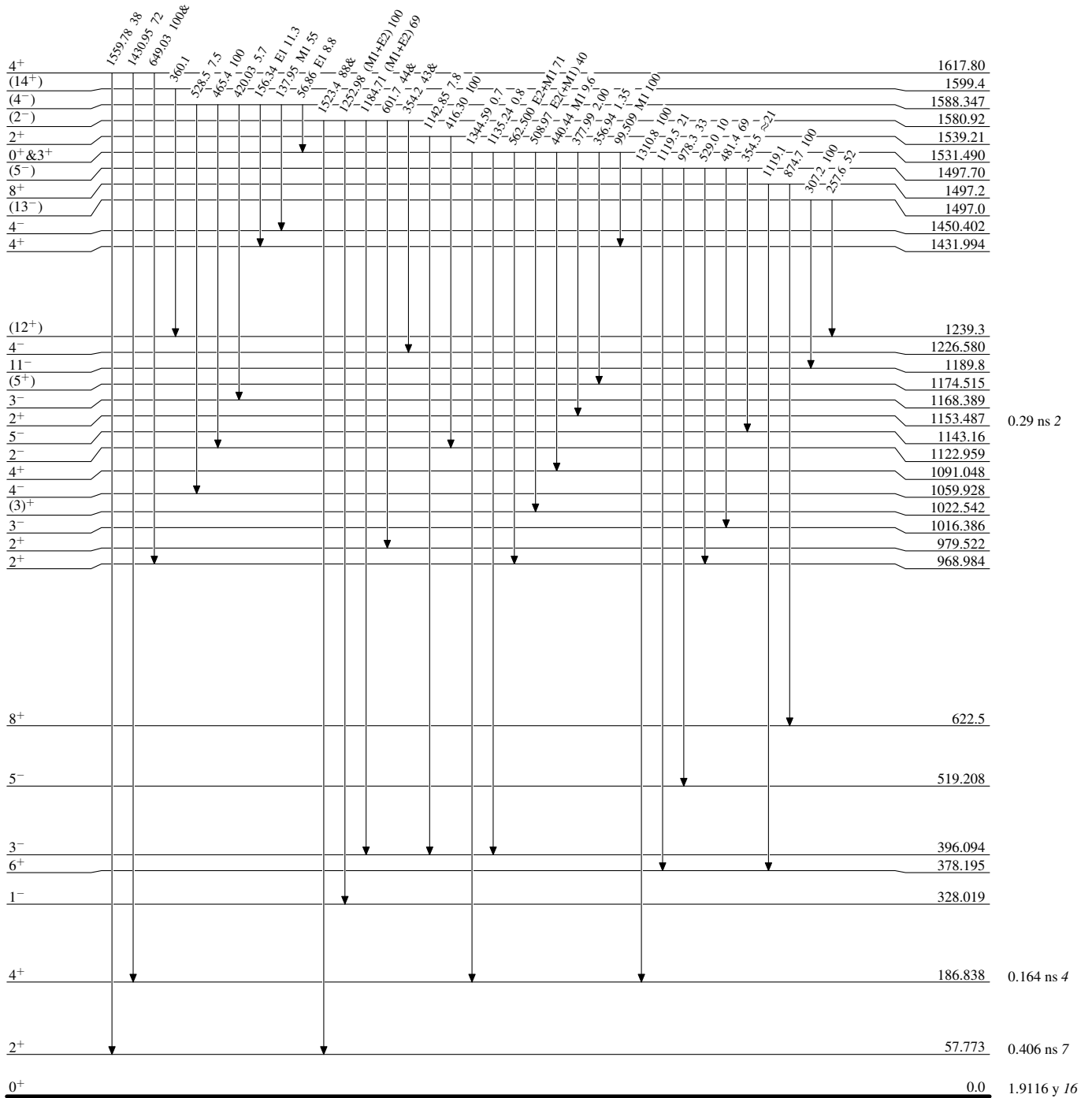
Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided



Adopted Levels, Gammas

Level Scheme (continued)

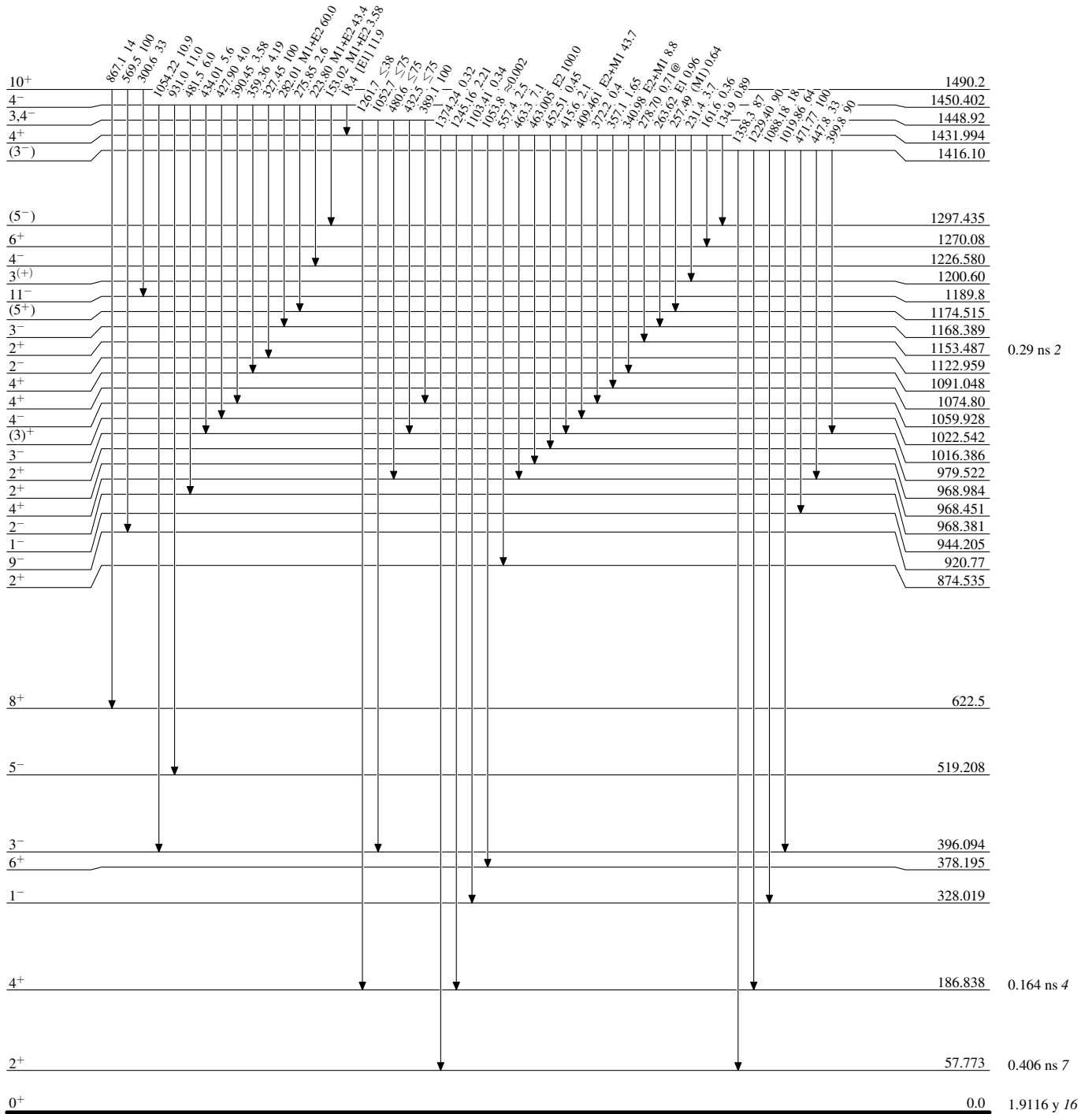
Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided



Adopted Levels, Gammas

Level Scheme (continued)

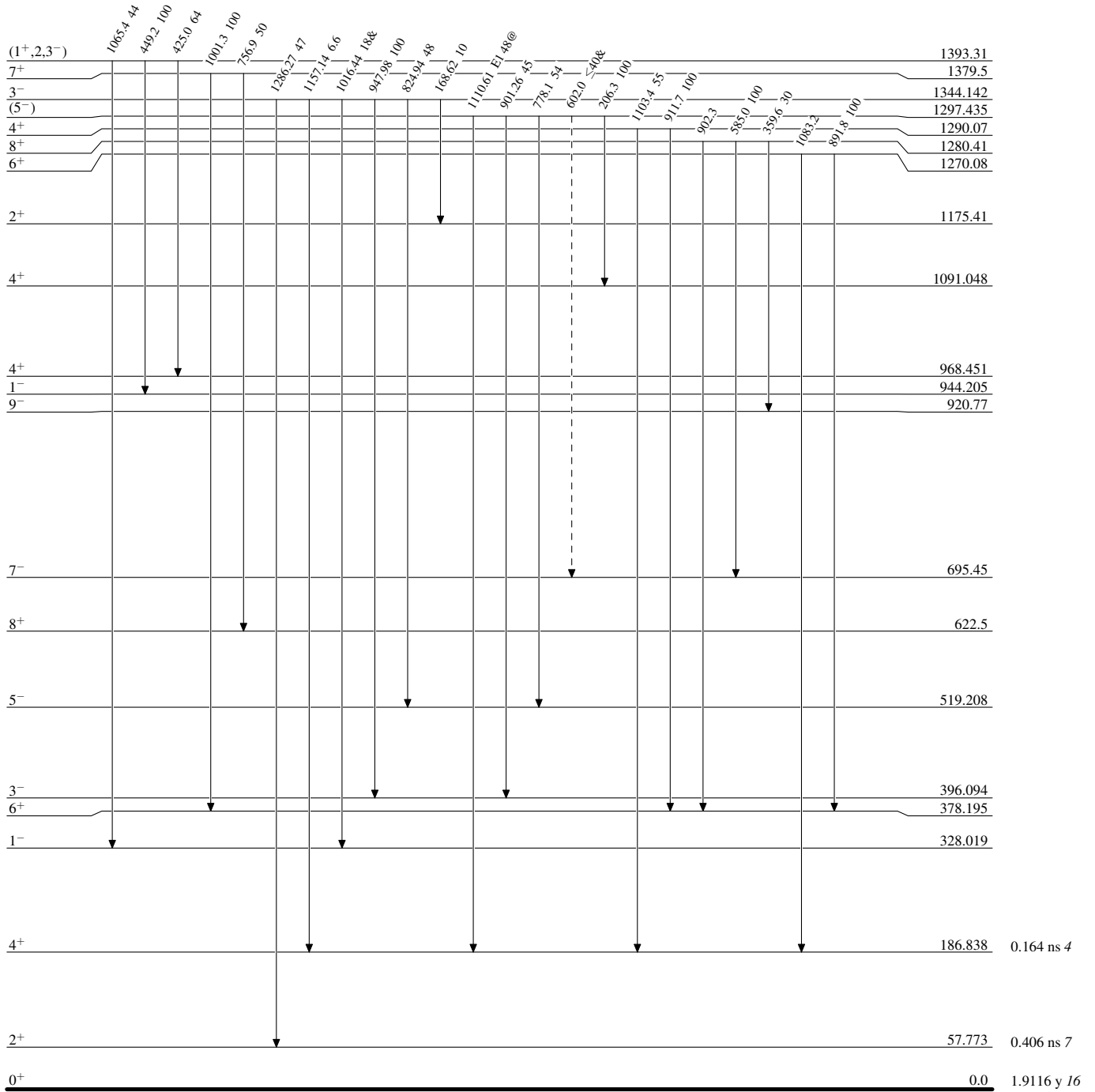
Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided



Adopted Levels, GammasLevel Scheme (continued)

Legend

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

-----► γ Decay (Uncertain) $^{228}\text{Th}_{138}$

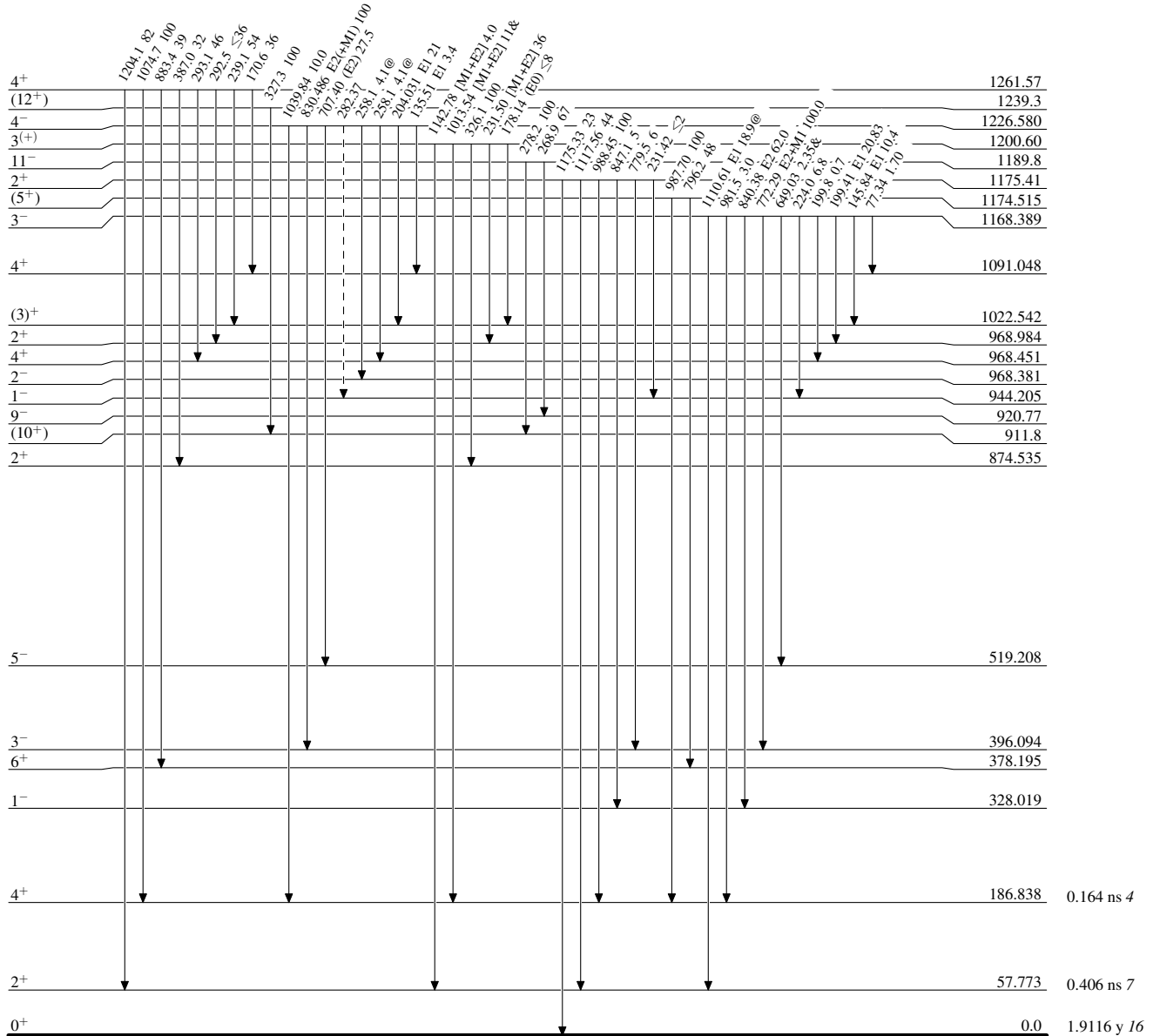
Adopted Levels, Gammas

Level Scheme (continued)

Legend

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

-----▶ γ Decay (Uncertain)



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

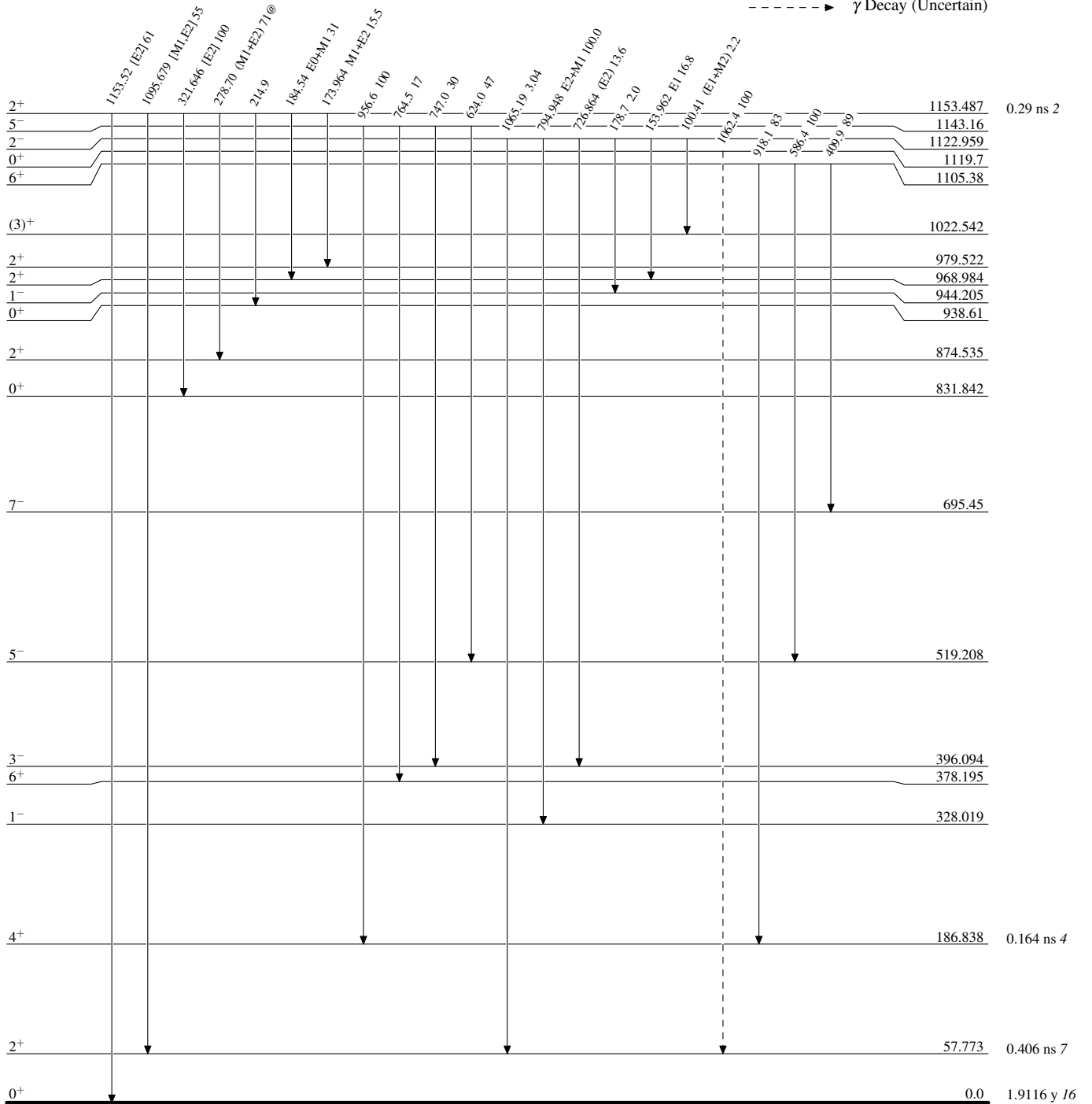
Adopted Levels, Gammas

Level Scheme (continued)

Legend

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

-----> γ Decay (Uncertain)

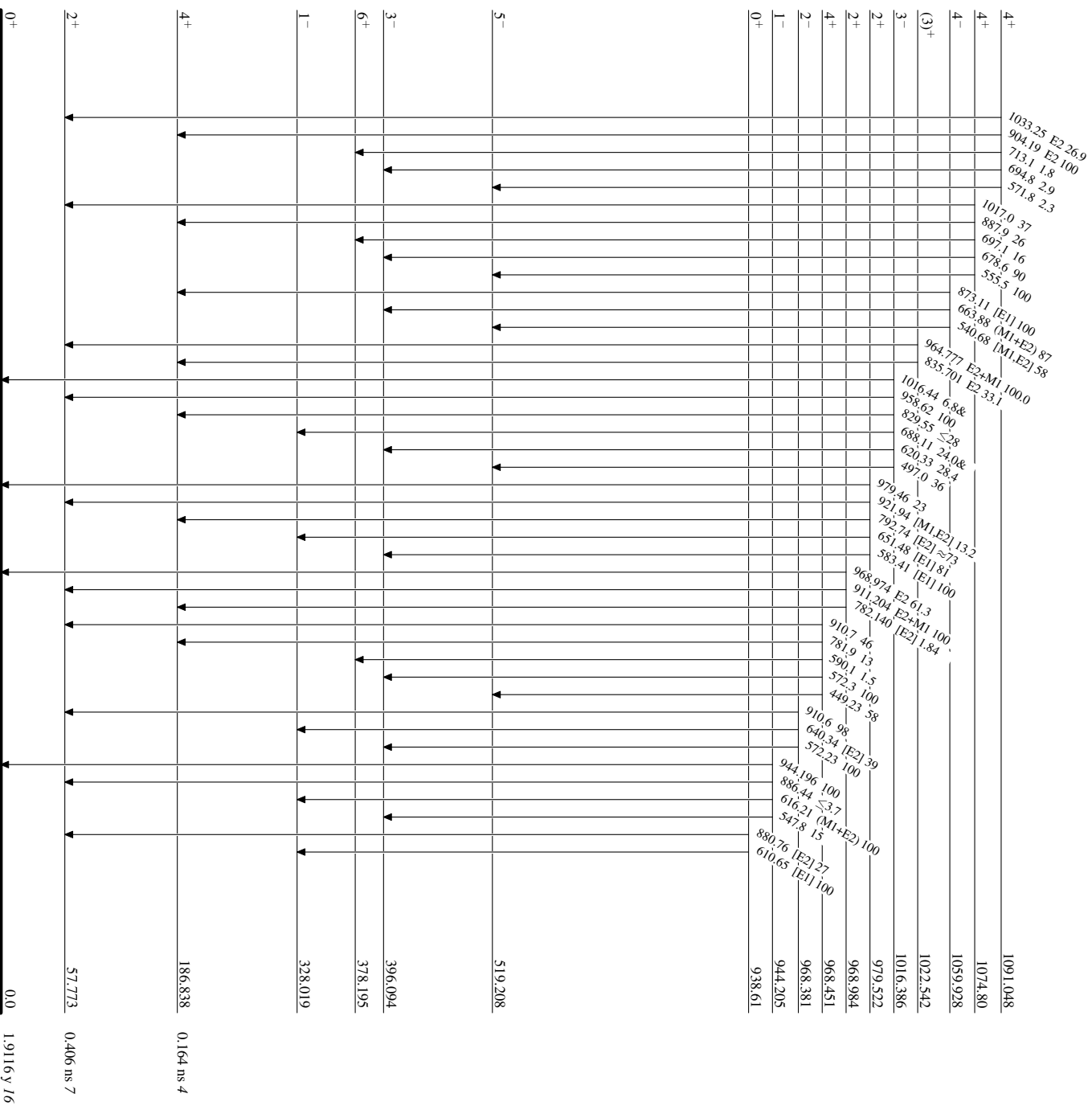


$^{228}_{90}\text{Th}_{138}$

Adopted Levels, Gammas

Level Scheme (continued)

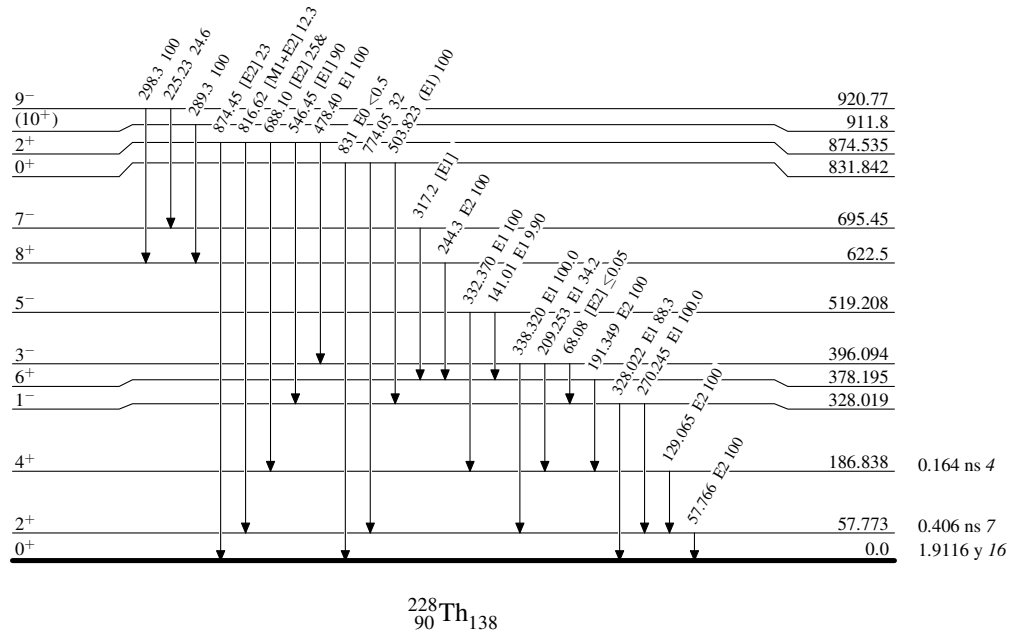
Intensities: Relative photon branching from each level
 & Multiply placed: undivided intensity given
 @ Multiply placed: intensity suitably divided

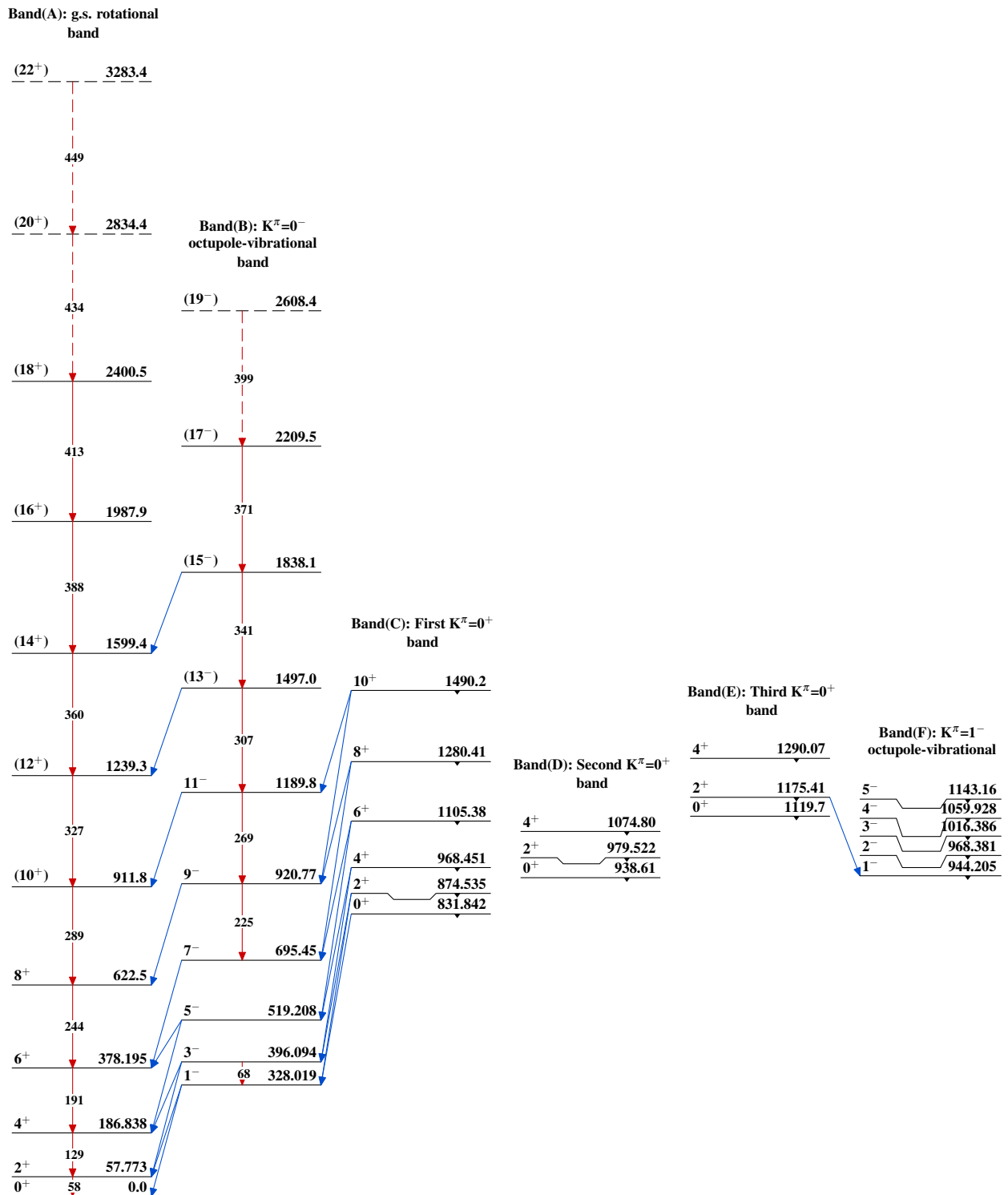


²²⁸Th₁₃₈

Adopted Levels, GammasLevel 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 (continued)