^{229}Th α decay

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	A. K. Jain (a), R. Raut (b), J. K. Tuli	NDS 110, 1409 (2009)	1-Dec-2008

Parent: ^{229}Th: E=0.0; J^π=5/2$^+$; $T_{1/2}$=7340 y *160*; Q(α)=5168.1 *12*; %α decay=100.0

2000Ga52: Studied α decay of ^{229}Th populating the levels of ^{225}Ra. It improves upon the results of same experiment reported earlier in 1998Ga48. Two HPGe detectors were used. Normalization of intensities is again relative to I(193γ). The earlier work of 1987He28 has been supplemented and improved.

^{225}Ra Levels

E(level)	J^π[†]	$T_{1/2}$
0.0	1/2$^+$	14.8 d *2*
25.41 *2*	5/2$^+$	0.88 ns *4*
31.56 *3*	3/2$^-$	2.1 ns *5*
42.77 *3*	3/2$^+$	<3 ns
55.16 *6*	(1/2$^-$)	
69.36 *6*	(7/2$^-$)	
100.50 *6*	9/2$^+$	
101.72	(3/2$^+$)	
111.60 *5*	7/2$^+$	
120.36 *6*	5/2$^-$	
149.96 *6*	3/2$^+$	
151.59		
179.75 *2*	5/2$^+$	
203.47	(9/2$^-$)	
216.28?		
220.55 *7*	(7/2$^+$,9/2$^+$)	
225.08		
226.9 *3*	(11/2$^+$)	
236.25 *2*	5/2$^+$	
243.56 *4*	7/2$^+$	
248.63		
≈260.18	(5/2)$^-$	
267.92 *5*	7/2$^+$	
272.15 *15*		
284.49 *5*	7/2$^+$	
292.72		
321.76 *8*	(9/2$^+$)	
327.71		
335.40		
349.43		
390.21	(11/2$^+$)	
394.24		
394.45	(5/2)$^+$	
394.72 *13*	(3/2,5/2,7/2)$^+$	
399.54?		
403.50?		
416.77		
446.45		
478.10		
486.82	(5/2$^+$)	
487.22 *3*	(13/2$^+$)	
535.25	(5/2$^+$)	
592.79		
604.51		
608.93		
663.23	(5/2$^+$,7/2$^+$)	

[†] Based on transition multipolarities and 5/2$^+$ assignment for the 236.25-keV level (unhindered α transition from ^{229}Th).

α radiations

Eα[†]	E(level)	Iα[‡&]	HF[#]	Comments
4478[@] *3*	608.93	≈0.005	≈44	
4484 *2*	604.51	0.03 *2*	8.1	Iα: measured intensities do not agree well: 0.050 *7* (1987He28), ≈0.009 (1970Ba20).
4599 *3*	487.22	0.02 *1*	83	Iα: measured intensities do not agree well: 0.029 *5* (1987He28), ≈0.007 (1970Ba20).
4608[a] *2*	478.10	0.050 *8*	39	This α was not reported by 1970Ba20.
≈4667[@a]	416.77	≈0.001	≈5170	
4690 *2*	394.72	0.23 *8*	32	
4694 *2*	390.21	0.12 *2*	65	
≈4737[@a]	349.43	≈0.01	≈1560	
≈4748[@a]	335.40	≈0.005	≈3760	
≈4754[@]	327.71	≈0.05	≈420	
4761 *2*	321.76	1.0 *4*	23	

Continued on next page (footnotes at end of table)

^{229}Th α decay (continued)

α radiations (continued)

Eα[†]	E(level)	Iα[‡&]	HF[#]	Comments
4797.8 *12*	284.49	1.5 *2*	27	
≈4809[@]	272.15	≈0.22	≈225	
4814.6 *12*	267.92	9.30 *8*	5.7	
≈4833[@a]	248.63	≈0.29	≈244	
4838 *2*	243.56	5.0 *2*	15.3	
4845.3 *12*	236.25	56.2 *2*	1.5	
≈4852[@a]	226.9	≈0.03	≈3.3×10^{3}	
4861 *2*	220.55	0.28 *10*	386	
≈4865[@a]	216.28?	≈0.03	≈3.9×10^{3}	
≈4878[@a]	203.47	≈0.03	≈4.6×10^{3}	
4901.0 *12*	179.75	10.20 *8*	19.4	
4930 *2*	149.96	0.16 *5*	1925	
4967.5 *12*	111.60	5.97 *6*	90	
4978.5 *12*	100.50	3.17 *4*	200	
5009 *2*	69.36	0.09 *1*	1.10×10^{4}	This α was not reported by 1970Ba20.
5023 *2*	55.16	0.009 *3*	1.3×10^{5}	This α was not reported by 1970Ba20.
5036 *2*	42.77	0.24 *2*	6024	
5047[a] *2*	31.56	<0.2	>3.4×10^{3}	Eα: from Eα(g.s.)=5078 *2* and E(level)=32.5. An α group at Eα≈5050 was inferred by 1970Ba20; the 5053 and 5050 α′s were not resolved, but the lineshape is distorted indicating that it may include more than one α group. No α with Eα≈5050 was observed by 1987He28. However, as noted by 1987He28, their resolution was 5.0 keV, and it was 2.2 keV in 1970Ba20′s spectrum. Iα: from 1985Is03. Iα(5050α)=5.2 was given by 1970Ba20.
5053 *2*	25.41	6.6 *1*	280	Iα: measured intensities disagree: 6.6 *1* (1987He28), 1.6 (1970Ba20).
5078 *2*	0.0	0.05	5.3×10^{4}	Iα: measured intensities do not agree well: 0.05 *1* (1987He28), 0.01 (1970Ba20).

[†] From 1970Ba20, 1976BaZZ and 1987He28 except where otherwise noted. Energies measured by 1970Ba20 have been increased by 0.5 keV, as recommended by 1979Ry03, because of change in calibration energy. Energies given by 1987He28 were calibrated with the strongest ^{229}Th α group: Eα=4845 *2*, given by 1970Ba20 as Eα=4844.7 *12*. Other measurements: 1959Go87, 1960En09, 1961Ko11.

[‡] From 1970Ba20, 1976BaZZ and 1987He28, unless otherwise noted. Other measurements: 1959Go87, 1960En09, 1961Ko11.

[#] $r_0(^{225}Ra)$=1.5326 is used in calculations.

[@] α was not observed by 1987He28.

[&] Absolute intensity per 100 decays.

[a] Existence of this branch is questionable.

γ(^{225}Ra)

ce intensities quoted here are from 1970Tr04; they have been renormalized such that α(K)exp(193γ)=2.033 (a multiplication factor of 1.028 is used for Ice′s listed by 1970Tr04).

```
αγ:   1970Tr04, 1987He28.
γγ,   γce,  (ce)(ce): 1970Tr04, 1987He28.
αγ(t):
(5054α)(35-keV  ce)(t): T1/2(31.6    level)=2.1 ns 5    (1985Is03),
(4845α)(15-25  keV ce)(t): T1/2(25.4    level)=0.88 ns 4    (1985Is03).

X rays (intensities relative to Iγ(193γ)=4.3):
I(K x rays)=49.3 20    (1987He28)
I(K x rays)=38.9 32    (1983Ra01)
I(L x rays)=90.0 24    (1983Ra01).
```

E_γ [†]	I_γ [‡&]	E_i(level)	J^π_i	E_f	J^π_f	Mult. [#]	α [a]	$I_{(\gamma+ce)}$ [&]	Comments
11.1 *1*	12 *2*	111.60	7/2$^+$	100.50	9/2$^+$			8 *3*	$I_{(\gamma+ce)}$: deduced by 1987He28 from γγ coincidence data where 11.1γ is an unobserved intermediate transition. ce line assigned as ce(L1 25γ) by 1970Tr04 could be ce(M1 11.1γ) (1987He28).
11.79 *20*	≈0.0005	604.51		592.79					
17.36 *3*	0.18 *9*	42.77	3/2$^+$	25.41	5/2$^+$	(M1)	140.6		α(L)=2.99; α(M)=103.5 I_γ: calculated from Ice(M1)=16.5 and α(M1)=91.7.
^{x}19.08 *20*	0.22 *3*								
^{x}21.58 *2*	0.007 *10*								
23.6[d]	0.0012 *1*	55.16	(1/2$^-$)	31.56	3/2$^-$	(M1+E2)	241 *33*		α(L)=182 *9*; α(M)=43.9 *24* α: from intensity balance at the 55.11-keV level. This value corresponds to δ=0.034 *34*.
25.39 *2*	0.008 *4*	25.41	5/2$^+$	0.0	1/2$^+$	(E2)	7377		α(L)=5442; α(M)=1455 I_γ: calculated from Ice(L3)=22.6 and α(L3)=2727 for E2.
^{x}27.50 *2*	0.034 *17*								
28.68[@] *10*	0.10 *3*	272.15		243.56	7/2$^+$				
29.9[c] *1*	≈0.002[c]	149.96	3/2$^+$	120.36	5/2$^-$				
29.9[c] *1*	0.11[c] *2*	179.75	5/2$^+$	149.96	3/2$^+$	(M1+E2)	≈223		α(L)≈167; α(M)≈42 Iγ=0.038 *13* was measured for the doublet. α: for δ≈0.2 in analogy to 28.37γ in ^{233}U.
31.10 *5*	0.82 *8*	100.50	9/2$^+$	69.36	(7/2$^-$)	[E1]	2.52		α(L)=1.90; α(M)=0.472
31.50 *5*	1.16 *4*	31.56	3/2$^-$	0.0	1/2$^+$	E1	2.44		α(L)=1.83; α(M)=0.456
31.57 *9*	0.066 *10*	267.92	7/2$^+$	236.25	5/2$^+$	[M1]	96.5		α(L)=0.480; α(M)=17.5 Intensity balance at the 267.92-keV level suggests that any E2 admixture is negligible.
33.04 *20*	≈0.01	292.72		≈260.18	(5/2)$^-$				
^{x}34.02 *20*	≈0.01								

γ(^{225}Ra) (continued)

E_γ[†]	I_γ[‡&]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	δ	α[a]	$I_{(\gamma+ce)}$[&]	Comments
37.8 *1*	0.0032 *16*	69.36	(7/2$^-$)	31.56	3/2$^-$	(E2)		1040		α(L)=766; α(M)=206 I_γ: calculated from Ice(L3)=1.2, α(L3)=370.
42.3 *1*	0.080 *8*	111.60	7/2$^+$	69.36	(7/2$^-$)	[E1]		1.113		α(L)=0.839; α(M)=0.206
42.82 *5*	0.16 *1*	42.77	3/2$^+$	0.0	1/2$^+$	(M1+E2)	0.28 *7*	77 *20*		α(L)=58 *14*; α(M)=15 *4*
43.990 *10*	0.64 *3*	69.36	(7/2$^-$)	25.41	5/2$^+$	E1		1.002		α(L)=0.756; α(M)=0.185 Mult.: determined by 1983Ny01 in ^{225}Fr β^- decay by γγ coincidences.
^{x}46.52 *4*	0.020 *2*									
46.52 *4*	0.020 *2*	267.92	7/2$^+$	220.55	(7/2$^+$,9/2$^+$)					
49.75 *8*	0.021 *2*	321.76	(9/2$^+$)	272.15		[M1]		25.2		α(L)=19.1; α(M)=4.57
50.99 *4*	0.017 *4*	120.36	5/2$^-$	69.36	(7/2$^-$)	[M1]		23.5		α(L)=17.7; α(M)=4.25; α(N+..)=1.52 Intensity balance at the 120-keV level yields α≈21.5. α(M1)=23.5, α(E2)=242.
^{x}53.2 *1*										
53.75 *20*	0.011 *3*	321.76	(9/2$^+$)	267.92	7/2$^+$	[M1]		20.1		α(L)=15.2; α(M)=3.64; α(N+..)=1.30 Intensity balance at the 321.76-keV level suggests that E2 admixture should be negligible.
55.11 *3*	0.0026 *4*	55.16	(1/2$^-$)	0.0	1/2$^+$	[E1]		0.549		α(L)=0.414; α(M)=0.1008; α(N+..)=0.0339
56.518 *5*	0.28 *2*	236.25	5/2$^+$	179.75	5/2$^+$	M1(+E2)	0.11 *11*	18.9 *16*		α(L)=14.3 *12*; α(M)=3.5 *4*; α(N+..)=1.23 *12*
59.33 *10*	0.012 *2*	179.75	5/2$^+$	120.36	5/2$^-$					
63.7 *2*	0.005 *2*	284.49	7/2$^+$	220.55	(7/2$^+$,9/2$^+$)				0.11 *22*	$I_{(\gamma+ce)}$: from intensity balance at the 284.49-keV level. This value corresponds to α(63.7γ)=21 *+44−21*. The 63.7γ might be M1+E2, if α≈21: α(M1)=12.2, α(E2)=82.7, α(E1)=0.372.
64.96 *10*	0.085 *11*	120.36	5/2$^-$	55.16	(1/2$^-$)					
65.91 *10*	0.157 *17*	292.72		226.9	(11/2$^+$)					
68.09 *4*	0.067 *10*	179.75	5/2$^+$	111.60	7/2$^+$	M1+E2	0.32 *16*	15 *5*		α(L)=11 *4*; α(M)=2.8 *10*; α(N+..)=1.0 *4*
68.80 *10*	≈0.04	220.55	(7/2$^+$,9/2$^+$)	151.59						
68.8[cd] *10*	≈0.09[c]	248.63		179.75	5/2$^+$					
68.8[@d]		272.15		203.47	(9/2$^-$)					
68.83 *3*	0.133 *13*	111.60	7/2$^+$	42.77	3/2$^+$	E2		57.0		α(L)=41.7; α(M)=11.3; α(N+..)=4.05
72.739 *10*	0.14 *2*	394.72	(3/2,5/2,7/2)$^+$	321.76	(9/2$^+$)					
75.10 *10*	0.59 *13*	100.50	9/2$^+$	25.41	5/2$^+$	E2		37.6		α(L)=27.5; α(M)=7.46; α(N+..)=2.68
75.19[c] *10*	0.002[c] *1*	225.08		149.96	3/2$^+$					
^{x}75.3 *1*										

γ(^{225}Ra) (continued)

E_γ [†]	I_γ [‡&]	E_i(level)	J^π_i	E_f	J^π_f	Mult. [#]	δ	α [a]	Comments
[x]76.67 *20*	0.035 *8*								
77.63 *5*	0.044 *6*	120.36	5/2⁻	42.77	3/2⁺	[E1]		0.220	α(L)=0.1659; α(M)=0.0401; α(N+..)=0.01362
78.3[d] *2*	0.008 *2*	321.76	(9/2⁺)	243.56	7/2⁺	[M1]		6.70	α(L)=5.06; α(M)=1.21; α(N+..)=0.430
86.25 *4*	1.3 *1*	111.60	7/2⁺	25.41	5/2⁺	M1+E2	0.27 *9*	6.0 *7*	α(L)=4.5 *5*; α(M)=1.1114; α(N+..)=0.40 *5*
86.40 *5*	2.5 *1*	236.25	5/2⁺	149.96	3/2⁺	M1		5.03	α(L)=3.80; α(M)=0.908; α(N+..)=0.324
[x]88.43 *8*	0.026 *6*								
89.09[b] *20*	≈0.14[b]	120.36	5/2⁻	31.56	3/2⁻				
89.09[c] *20*	≈0.01[c]	349.43		≈260.18	(5/2)⁻				
89.09[c] *20*	≈0.005[c]	416.77		327.71					
94.70[c] *10*	0.027[c] *10*	321.76	(9/2⁺)	226.9	(11/2⁺)				
94.73[c] *2*	0.26[c] *2*	149.96	3/2⁺	55.16	(1/2⁻)	[E1]		0.1292	α(L)=0.0977; α(M)=0.0235; α(N+..)=0.00807
94.92 *8*	0.013 *3*	120.36	5/2⁻	25.41	5/2⁺	[E1]		0.1286	α(L)=0.0971; α(M)=0.0234; α(N+..)=0.00803
97.01 *12*	0.011 *3*	487.22	(13/2⁺)	390.21	(11/2⁺)				
98.86 *10*	0.117 *15*	248.63		149.96	3/2⁺				
101.1[d] *2*	0.018 *3*	321.76	(9/2⁺)	220.55	(7/2⁺,9/2⁺)			≈3.2	α(E1)=0.109, α(M1)=3.19, α(E2)=9.25.
101.58[b] *10*	0.048[b] *7*	101.72	(3/2⁺)	0.0	1/2⁺				
101.58[b] *10*	0.048[b] *7*	394.72	(3/2,5/2,7/2)⁺	292.72					
102.54 *2*	0.156 *19*	327.71		225.08					
104.6[d] *2*	0.009 *3*	284.49	7/2⁺	179.75	5/2⁺	[M1+E2]		5.4 *25*	
107.108 *8*	0.79 *4*	149.96	3/2⁺	42.77	3/2⁺	M1(+E2)	0.3 *3*	13.1 *6*	α(K)=10.1 *9*; α(L)=2.3 *3*; α(M)=0.56 *7*; α(N+..)=0.20 *3*
109.2	0.043 *8*	220.55	(7/2⁺,9/2⁺)	111.60	7/2⁺	[M1]		12.9	α(K)=10.3; α(L)=1.93; α(M)=0.462; α(N+..)=0.165
110.3[c] *5*	0.009[c] *2*	≈260.18	(5/2)⁻	149.96	3/2⁺				
110.332[c] *8*	0.121[c] *12*	179.75	5/2⁺	69.36	(7/2⁻)	[E1]		0.385	α(K)=0.299; α(L)=0.0653; α(M)=0.01567; α(N+..)=0.00541
114.75 *10*	0.0147 *22*	592.79		478.10					
115.85[c] *10*	≈0.010[c]	216.28?		100.50	9/2⁺				
115.85[c] *10*	≈0.010[c]	236.25	5/2⁺	120.36	5/2⁻	[E1]		0.341	α(K)=0.265; α(L)=0.0572; α(M)=0.01373; α(N+..)=0.00474
118.10[c] *10*	0.007[c] *3*	149.96	3/2⁺	31.56	3/2⁻				
118.10[c] *10*	0.013[c] *4*	267.92	7/2⁺	149.96	3/2⁺	[E2]		4.83	α(K)=0.313; α(L)=3.30; α(M)=0.896; α(N+..)=0.325
119.98 *2*	0.05 *2*	220.55	(7/2⁺,9/2⁺)	100.50	9/2⁺	[M1]		9.84	α(K)=7.89; α(L)=1.47; α(M)=0.352; α(N+..)=0.126
123.193 *13*	0.147 *7*	243.56	7/2⁺	120.36	5/2⁻	[E1]		0.294	α(K)=0.2295; α(L)=0.0489; α(M)=0.01171; α(N+..)=0.00405
124.55 *5*	0.67 *6*	149.96	3/2⁺	25.41	5/2⁺	(M1)		8.84	α(K)=7.09; α(L)=1.322; α(M)=0.316; α(N+..)=0.1131
124.65 *5*	0.72 *6*	236.25	5/2⁺	111.60	7/2⁺	(M1)		8.82	α(K)=7.07; α(L)=1.32; α(M)=0.315; α(N+..)=0.113
126.48[c] *10*	0.014[c] *4*	226.9	(11/2⁺)	100.50	9/2⁺	[M1,E2]		6.0 *25*	α(K)=3.6 *33*; α(L)=1.8 *6*; α(M)=0.48 *18*; α(N+..)=0.17 *7* Intensity balance at the 226.9-keV level yields α(126.4γ)=5.5 *41*, suggesting M1,E2 multipolarity: α(M1)=8.47, α(E2)=3.61.

$^{225}_{88}Ra_{137}$-5

^{229}Th α decay (continued)

γ(^{225}Ra) (continued)

E_γ[†]	I_γ[‡&]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	δ	α[a]	Comments
126.48[c] 10	0.009[c] 4	394.72	(3/2,5/2,7/2)$^+$	267.92	7/2$^+$	[M1,E2]		6.0 24	α(K)=3.5 32; α(L)=1.8 6; α(M)=0.48 18; α(N+..)=0.17 6
^{x}129.04 3	0.016 10								
131.926 5	0.327 12	243.56	7/2$^+$	111.60	7/2$^+$	M1		7.49	α(K)=6.01; α(L)=1.12; α(M)=0.268; α(N+..)=0.0957
^{x}132.6 1									
134.19[c] 10	0.0092[c] 15	203.47	(9/2$^-$)	69.36	(7/2$^-$)	(M1)		7.14	Iγ=0.012 3 was measured. Iγ of 134.2γ level is deduced by the evaluator from measured I(cek)=0.10 3 for deexciting the 284.49-keV.
134.19[c] 10	0.006[c] 3	284.49	7/2$^+$	149.96	3/2$^+$	[E2]			α(K)=0.301; α(L)=1.83; α(M)=0.497; α(N+..)=0.180
134.19[c] 10	0.0014[c] 7	394.72	(3/2,5/2,7/2)$^+$	≈260.18	(5/2)$^-$				
^{x}135.71 7									
136.990 4	1.15 3	179.75	5/2$^+$	42.77	3/2$^+$	M1		6.91	α(K)=5.40; α(L)=1.01; α(M)=0.241; α(N+..)=0.086 δ<0.24, if there is any E2 admixture.
137.0 1	0.04 1	248.63		111.60	7/2$^+$				
139.8 1	0.0045 10	≈260.18	(5/2)$^-$	120.36	5/2$^-$				
142.0 1	0.011 3	321.76	(9/2$^+$)	179.75	5/2$^+$	[E2]		2.23	α(K)=0.285; α(L)=1.421; α(M)=0.385; α(N+..)=0.1396
142.962 5	0.394 12	243.56	7/2$^+$	100.50	9/2$^+$	M1		5.97	α(K)=4.79; α(L)=0.890; α(M)=0.213; α(N+..)=0.0759
^{x}146.8	0.016 8								
147.64 5	0.20 2	267.92	7/2$^+$	120.36	5/2$^-$	E1		0.1893	α(K)=0.1490; α(L)=0.0305; α(M)=0.00729; α(N+..)=0.00252
148.15 4	0.86 6	179.75	5/2$^+$	31.56	3/2$^-$	E1		0.1877	α(K)=0.1478; α(L)=0.0302; α(M)=0.00722; α(N+..)=0.00250
150.04 3	<0.06	149.96	3/2$^+$	0.0	1/2$^+$	(M1+E2)	0.4 4	4.7 5	α(K)=3.6 6; α(L)=0.82 5; α(M)=0.201 16; α(N+..)=0.072 6
151.6[b] 3	≈0.025[b]	151.59		0.0	1/2$^+$				
151.6[d] 3	≈0.025	394.72	(3/2,5/2,7/2)$^+$	243.56	7/2$^+$	[M1]		5.05	α(K)=4.05; α(L)=0.753; α(M)=0.180; α(N+..)=0.0641 I_γ: calculated from measured Ice(K)=0.1 and α(K)=4.05, assuming M1 multipolarity. An E2 multipolarity would yield Iγ=0.39 in which case, its photon would have been observed.
154.336 10	0.75 2	179.75	5/2$^+$	25.41	5/2$^+$	M1+E2	0.4 4	4.4 4	α(K)=3.4 5; α(L)=0.75 4; α(M)=0.184 13; α(N+..)=0.066 5
156.409 9	1.16 3	267.92	7/2$^+$	111.60	7/2$^+$	M1		4.62	α(K)=3.71; α(L)=0.688; α(M)=0.165; α(N+..)=0.0586
158.42 12	0.047 5	394.72	(3/2,5/2,7/2)$^+$	236.25	5/2$^+$	M1(+E2)	<0.9	4.5 14	α(K)=3.6 15; α(L)=0.66 10; α(M)=0.16 4; α(N+..)=0.056 13
160.6		272.15		111.60	7/2$^+$				
^{x}161.6 3									
163.34 17	0.020 7	390.21	(11/2$^+$)	226.9	(11/2$^+$)	[M1]		4.08	α(K)=3.28; α(L)=0.608; α(M)=0.146; α(N+..)=0.0517
^{x}165.7 3									
166.976 7	0.200 10	236.25	5/2$^+$	69.36	(7/2$^-$)	[E1]		0.141	α(K)=0.1115; α(L)=0.222; α(M)=0.00530; α(N+..)=0.00183
167.45 5	0.05 1	267.92	7/2$^+$	100.50	9/2$^+$	[M1]		3.80	α(K)=3.05; α(L)=0.567; α(M)=0.136; α(N+..)=0.0482
169.2[c] 3	0.0010[c] 5	225.08		55.16	(1/2$^-$)				

$^{225}_{88}Ra_{137}$-6

^{229}Th α decay (continued)

γ(^{225}Ra) (continued)

E_γ[†]	I_γ[‡&]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	α[a]	Comments
169.2[c] 3	0.0039[c] 14	390.21	(11/2$^+$)	220.55	(7/2$^+$,9/2$^+$)			
169.2[c] 3	0.0029[c] 14	394.24		225.08				
[x]171.5 2	0.18 5							
171.76 5	0.039 4	272.15		100.50	9/2$^+$			
172.926 18	0.11 1	284.49	7/2$^+$	111.60	7/2$^+$	M1	3.47	α(K)=2.79; α(L)=0.518; α(M)=0.124; α(N+..)=0.0439
174.05[c] 11	<0.002[c]	243.56	7/2$^+$	69.36	(7/2$^-$)	[E1]	0.126	α(K)=0.100; α(L)=0.0197; α(M)=0.00471; α(N+..)=0.00163
174.05[c] 11	0.0069[c] 18	390.21	(11/2$^+$)	216.28?				
174.05[c] 11	0.0065[c@] 18	394.72	(3/2,5/2,7/2)$^+$	220.55	(7/2$^+$,9/2$^+$)			
174.7 2	0.030 3	446.45		272.15				
179.757 7	0.192 15	179.75	5/2$^+$	0.0	1/2$^+$	E2	0.884	α(K)=0.2000; α(L)=0.500; α(M)=0.1353; α(N+..)=0.0487
182.12 10	0.0054 11	225.08		42.77	3/2$^+$			
183.0 1	0.0069 12	403.50?		220.55	(7/2$^+$,9/2$^+$)			
183.928 8	0.138 7	284.49	7/2$^+$	100.50	9/2$^+$	M1(+E2)	2.92	α(K)=2.35; α(L)=0.435; α(M)=0.104; α(N+..)=0.0368
185.6[c]	<0.002[c]	335.40		149.96	3/2$^+$			
185.6[c] 1	<0.002[c]	478.10		292.72				
186.1 1	0.013 5	446.45		≈260.18	(5/2)$^-$			
189.25 6	0.0101 21	592.79		403.50?				
190.63 20	0.0098 20	≈260.18	(5/2)$^-$	69.36	(7/2$^-$)			
193.52[c] 5	0.0007[c] 3	225.08		31.56	3/2$^-$			
193.52[c] 5	4.3[c]	236.25	5/2$^+$	42.77	3/2$^+$	M1	2.53	α(K)=2.03; α(L)=0.377; α(M)=0.0900; α(N+..)=0.0319
194.3 3	0.03 2	220.55	(7/2$^+$,9/2$^+$)	25.41	5/2$^+$	[M1,E2]	1.6 10	α(K)=1.1 9; α(L)=0.365 8; α(M)=0.093 4; α(N+..)=0.033 2
200.807 16	0.067 3	243.56	7/2$^+$	42.77	3/2$^+$	[E2]	0.588	α(K)=0.163; α(L)=0.311; α(M)=0.0830; α(N+..)=0.0301
204.690 5	0.58 3	236.25	5/2$^+$	31.56	3/2$^-$	(E1)	0.0861	α(K)=0.0687; α(L)=0.0132; α(M)=0.00316; α(N+..)=0.00109
210.15 8	0.19 4	321.76	(9/2$^+$)	111.60	7/2$^+$	[M1]	2.01	α(K)=1.61; α(L)=0.299; α(M)=0.0713; α(N+..)=0.0252
210.853 3	2.7 3	236.25	5/2$^+$	25.41	5/2$^+$	M1	1.98	α(K)=1.60; α(L)=0.296; α(M)=0.0706; α(N+..)=0.0250
[x]211.47 10	0.044 12							
213.48 5	0.0085 16	535.25	(5/2$^+$)	321.76	(9/2$^+$)			
215.100 10	0.134 10	284.49	7/2$^+$	69.36	(7/2$^-$)	[E1]	0.0766	α(K)=0.0611; α(L)=0.0117; α(M)=0.00279; α(N+..)=0.00097
[x]215.4								
216.0 1	0.052 6	327.71		111.60	7/2$^+$			
217.41 10	0.0063 11	≈260.18	(5/2)$^-$	42.77	3/2$^+$			
218.154 17	0.18 2	243.56	7/2$^+$	25.41	5/2$^+$	M1	1.81	α(K)=1.45; α(L)=0.269; α(M)=0.0642; α(N+..)=0.0227
219.8[c] 1	0.0033[c] 8	399.54?		179.75	5/2$^+$			
219.8[c] 1	<0.0008[c]	446.45		226.9	(11/2$^+$)			
221.22 5	0.022 6	321.76	(9/2$^+$)	100.50	9/2$^+$	[M1]	1.739	α(K)=1.396; α(L)=0.259; α(M)=0.0617; α(N+..)=0.0218
225.26[c] 10	0.003[c] 1	225.08		0.0	1/2$^+$			
225.26[c] 10	0.061[c] 6	267.92	7/2$^+$	42.77	3/2$^+$	[E2]	0.393	α(K)=0.130; α(L)=0.192; α(M)=0.0517; α(N+..)=0.0185
228.6 1	0.0006 2	≈260.18	(5/2)$^-$	31.56	3/2$^-$			
234.8[c] 1	0.0008[c] 2	≈260.18	(5/2)$^-$	25.41	5/2$^+$			
234.8[c] 1	0.00082[c]	478.10		243.56	7/2$^+$			
236.249 8	0.170 9	236.25	5/2$^+$	0.0	1/2$^+$	E2	0.333	α(K)=0.118; α(L)=0.158; α(M)=0.0423; α(N+..)=0.0151
242.6 2	0.081 8	267.92	7/2$^+$	25.41	5/2$^+$	M1	1.35	α(K)=1.08; α(L)=0.201; α(M)=0.0478; α(N+..)=0.0169

γ(^{225}Ra) (continued)

E_γ[†]	I_γ[‡&]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	α[a]	Comments
[x]243.5 3								
244.4 1	0.0013 3	394.24		149.96	3/2$^+$			
250.1 1	0.00033 16	292.72		42.77	3/2$^+$			
252.43 3	0.093 12	321.76	(9/2$^+$)	69.36	(7/2$^-$)	[E1]	0.0526	α(K)=0.0422; α(L)=0.00788; α(M)=0.00188; α(N+..)=0.00065
259.08 4	0.033 5	284.49	7/2$^+$	25.41	5/2$^+$	[M1]	1.12	α(K)=0.901; α(L)=0.166; α(M)=0.0397; α(N+..)=0.0140
[x]261.0 5								
267.4 1	0.0008 3	292.72		25.41	5/2$^+$			
274.1 1	0.0007 2	394.72	(3/2,5/2,7/2)$^+$	120.36	5/2$^-$			
276.85 10	0.0041 10	604.51		327.71				
[x]277.48 5								
278.65 5	0.0066 8	390.21	(11/2$^+$)	111.60	7/2$^+$			
281.27 10	0.007 1	608.93		327.71				
282.6 1	0.0037 7	394.72	(3/2,5/2,7/2)$^+$	111.60	7/2$^+$			
289.62 5	0.0146 17	390.21	(11/2$^+$)	100.50	9/2$^+$			
[x]292.27 5								
[x]292.91 12								
293.78 10	0.0064 8	394.72	(3/2,5/2,7/2)$^+$	100.50	9/2$^+$			
296.21 10	0.0161 17	321.76	(9/2$^+$)	25.41	5/2$^+$	[E2]	0.1606	α(K)=0.0734; α(L)=0.0640; α(M)=0.01705; α(N+..)=0.00610
298.72 12	0.0068 8	478.10		179.75	5/2$^+$			
303.75 10	0.0017 3	335.40		31.56	3/2$^-$			
307.3 1	0.006 3	486.82	(5/2$^+$)	179.75	5/2$^+$			
310.1 1	0.0020 3	335.40		25.41	5/2$^+$			
313.3 1	0.00036 11	663.23	(5/2$^+$,7/2$^+$)	349.43				
317.8 1	0.00053 14	349.43		31.56	3/2$^-$			
320.8 1	0.00016 7	592.79		272.15				
324.6 1	0.00042 13	394.24		69.36	(7/2$^-$)			
327.9[c] 1	0.016[c] 3	327.71		0.0	1/2$^+$			
327.9[c] 1	<0.003[c]	663.23	(5/2$^+$,7/2$^+$)	335.40				
328.2 1	0.0020 8	478.10		149.96	3/2$^+$			
329.9 2	0.0006 2	399.54?		69.36	(7/2$^-$)			
334.74 10	0.00042 11	446.45		111.60	7/2$^+$			
336.7[c] 1	<0.0001[c]	486.82	(5/2$^+$)	149.96	3/2$^+$			
336.7[c] 1	0.0080[c] 1	604.51		267.92	7/2$^+$			
341.1 1	0.0008 2	663.23	(5/2$^+$,7/2$^+$)	321.76	(9/2$^+$)			
344.3[b] 1	<0.0001[b]	399.54?		55.16	(1/2$^-$)			
347.4 1	0.0006 1	416.77		69.36	(7/2$^-$)			
349.4[c] 1	0.0004[c] 1	349.43		0.0	1/2$^+$			
349.4[c] 1	<0.0001[c]	592.79		243.56	7/2$^+$			
351.7 1	0.0005 1	394.45	(5/2)$^+$	42.77	3/2$^+$			
358.0 1	0.006 1	478.10		120.36	5/2$^-$			
361.0 1	0.0006 1	604.51		243.56	7/2$^+$			
366.5[c] 1	0.0004[c] 1	478.10		111.60	7/2$^+$			

^{229}Th α decay (continued)

$\gamma(^{225}Ra)$ (continued)

E_γ[†]	I_γ[‡&]	E_i(level)	J^π_i	E_f	J^π_f
366.5[c] 1	<0.0001[c]	486.82	$(5/2^+)$	120.36	$5/2^-$
368.1 1	0.0019 3	604.51		236.25	$5/2^+$
368.9 1	0.0019 3	394.24		25.41	$5/2^+$
375.1 1	0.0003 1	486.82	$(5/2^+)$	111.60	$7/2^+$
377.4 1	0.0028 3	478.10		100.50	$9/2^+$
379.4 1	0.0013 2	604.51		225.08	
386.4 1	0.0008 2	486.82	$(5/2^+)$	100.50	$9/2^+$
395.3 2	0.0008 1	394.45	$(5/2)^+$	0.0	$1/2^+$
399.9 2	0.00014 6	399.54?		0.0	$1/2^+$
403.3 1	0.0018 2	403.50?		0.0	$1/2^+$
408.5 1	0.0010 1	478.10		69.36	$(7/2^-)$
414.61 10	0.0003 1	535.25	$(5/2^+)$	120.36	$5/2^-$
417.4 1	0.0014 2	486.82	$(5/2^+)$	69.36	$(7/2^-)$
419.9 2	0.0006 1	663.23	$(5/2^+,7/2^+)$	243.56	$7/2^+$
[x]422.8 1	0.0005 1				
424.8 1	0.0032 3	604.51		179.75	$5/2^+$
435.3 1	0.0031 4	478.10		42.77	$3/2^+$
444.1 1	0.0005 1	486.82	$(5/2^+)$	42.77	$3/2^+$
452.6 1	0.0017 2	478.10		25.41	$5/2^+$
454.76 10	0.0102 11	604.51		149.96	$3/2^+$
[x]455.85 10	0.0114 14				
459.1 3	≈0.001	608.93		149.96	$3/2^+$

E_γ[†]	I_γ[‡&]	E_i(level)	J^π_i	E_f	J^π_f
465 1	≈0.0001	535.25	$(5/2^+)$	69.36	$(7/2^-)$
478.0 1	0.0036 4	478.10		0.0	$1/2^+$
478.0 1	0.0036 4	486.82	$(5/2^+)$		
483.7 1	0.0018 2	663.23	$(5/2^+,7/2^+)$	179.75	$5/2^+$
487.3 2	0.0004 1	486.82	$(5/2^+)$	0.0	$1/2^+$
492.9 1	0.00148 16	604.51		111.60	$7/2^+$
503.6[c] 1	0.00012[c] 5	535.25	$(5/2^+)$	31.56	$3/2^-$
503.6[c] 1	<0.00005[c]	604.51		100.50	$9/2^+$
513.5 2	0.0007 2	663.23	$(5/2^+,7/2^+)$	149.96	$3/2^+$
523.5 1	0.0005 1	592.79		69.36	$(7/2^-)$
535.1[c] 1	0.0013[c] 2	535.25	$(5/2^+)$	0.0	$1/2^+$
535.1[c] 1	<0.0002[c]	604.51		69.36	$(7/2^-)$
543.0 3	≈0.0001	663.23	$(5/2^+,7/2^+)$	120.36	$5/2^-$
549.8 5	≈0.0001	592.79		42.77	$3/2^+$
551.7 2	0.00011 4	663.23	$(5/2^+,7/2^+)$	111.60	$7/2^+$
561.8 1	0.0019 2	604.51		42.77	$3/2^+$
565.7 3	0.0009 1	608.93		42.77	$3/2^+$
573.0 1	0.0027 3	604.51		31.56	$3/2^-$
579.2 2	0.0006 1	604.51		25.41	$5/2^+$
592.5 1	0.0003 1	592.79		0.0	$1/2^+$
594.4 3	≈0.0001	663.23	$(5/2^+,7/2^+)$	69.36	$(7/2^-)$
[x]603.6 2	0.0009 2				

[†] From 1970Tr04, 1987He28 and 2000Ga52. Other measurements: 1955St04, 1959Go87, 1960En09, 1981Di14, 1983Ra01.

[‡] Relative photon intensity, measured by 2000Ga52 and 1987He28. Other measurements: 1970Tr04, 1981Di14, 1983Ra01.

[#] From ce data of 1970Tr04 and from Iγ, (α)(ce) data of 1987He28 and 2000Ga52. Multipolarities in brackets are from level scheme; they were not determined experimentally.

[@] Multiply placed, intensities not divided.

[&] For absolute intensity per 100 decays, multiply by 1.026 14.

[a] 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.

[b] Multiply placed with undivided intensity.

[c] Multiply placed with intensity suitably divided.

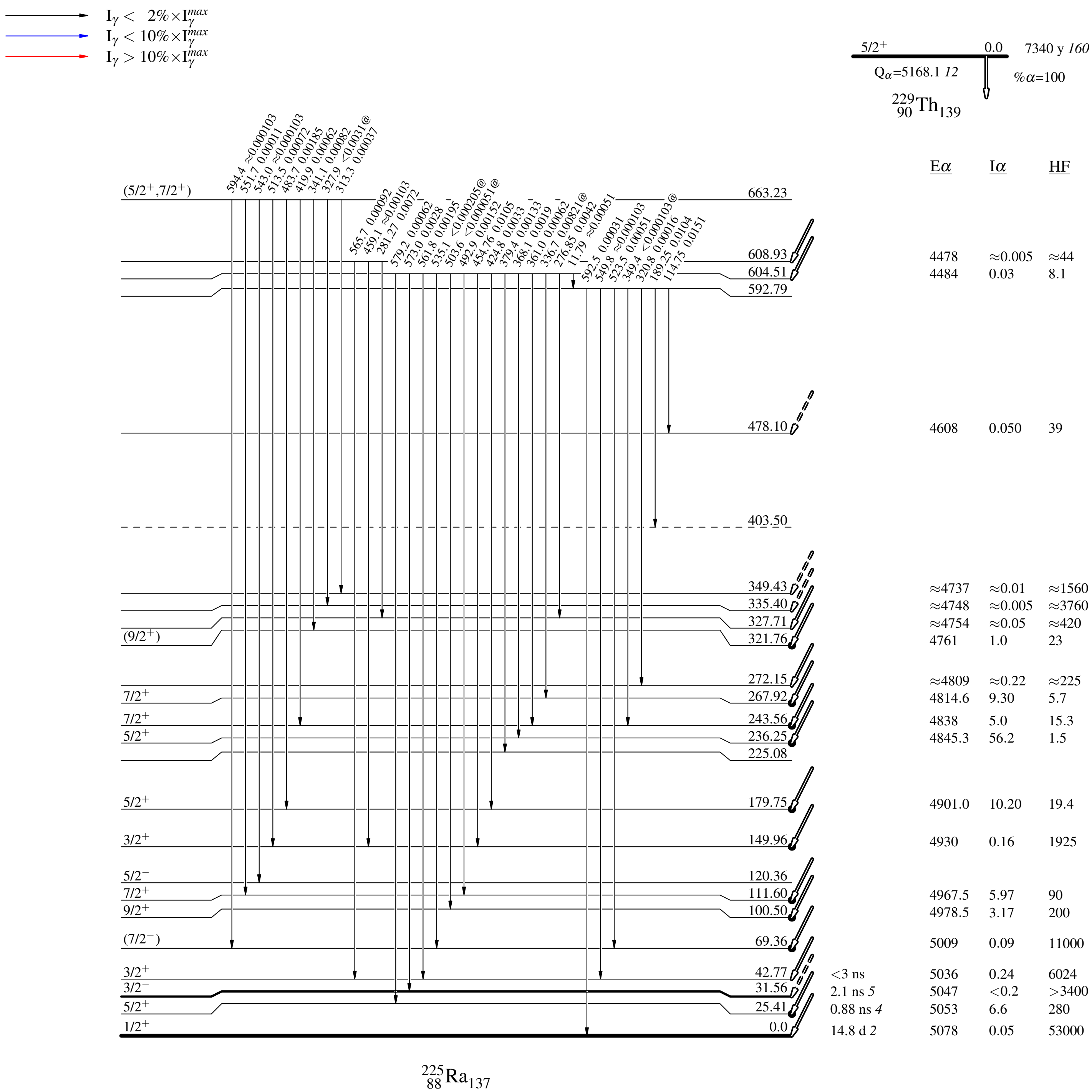
[d] Placement of transition in the level scheme is uncertain.

[x] γ ray not placed in level scheme.

^{229}Th α decay

Decay Scheme

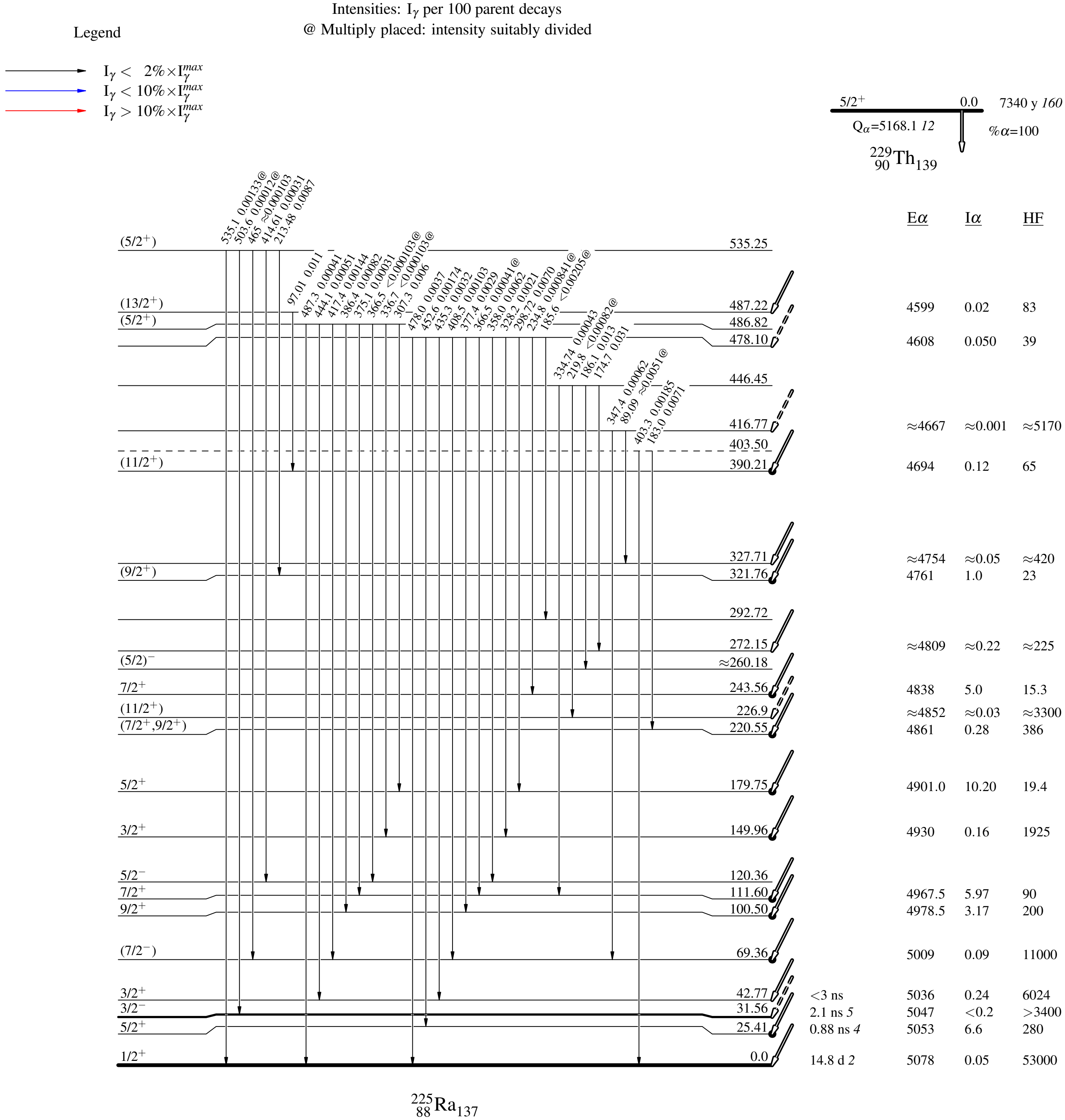
Intensities: I_γ per 100 parent decays
@ Multiply placed: intensity suitably divided



^{229}Th α decay

Decay Scheme (continued)

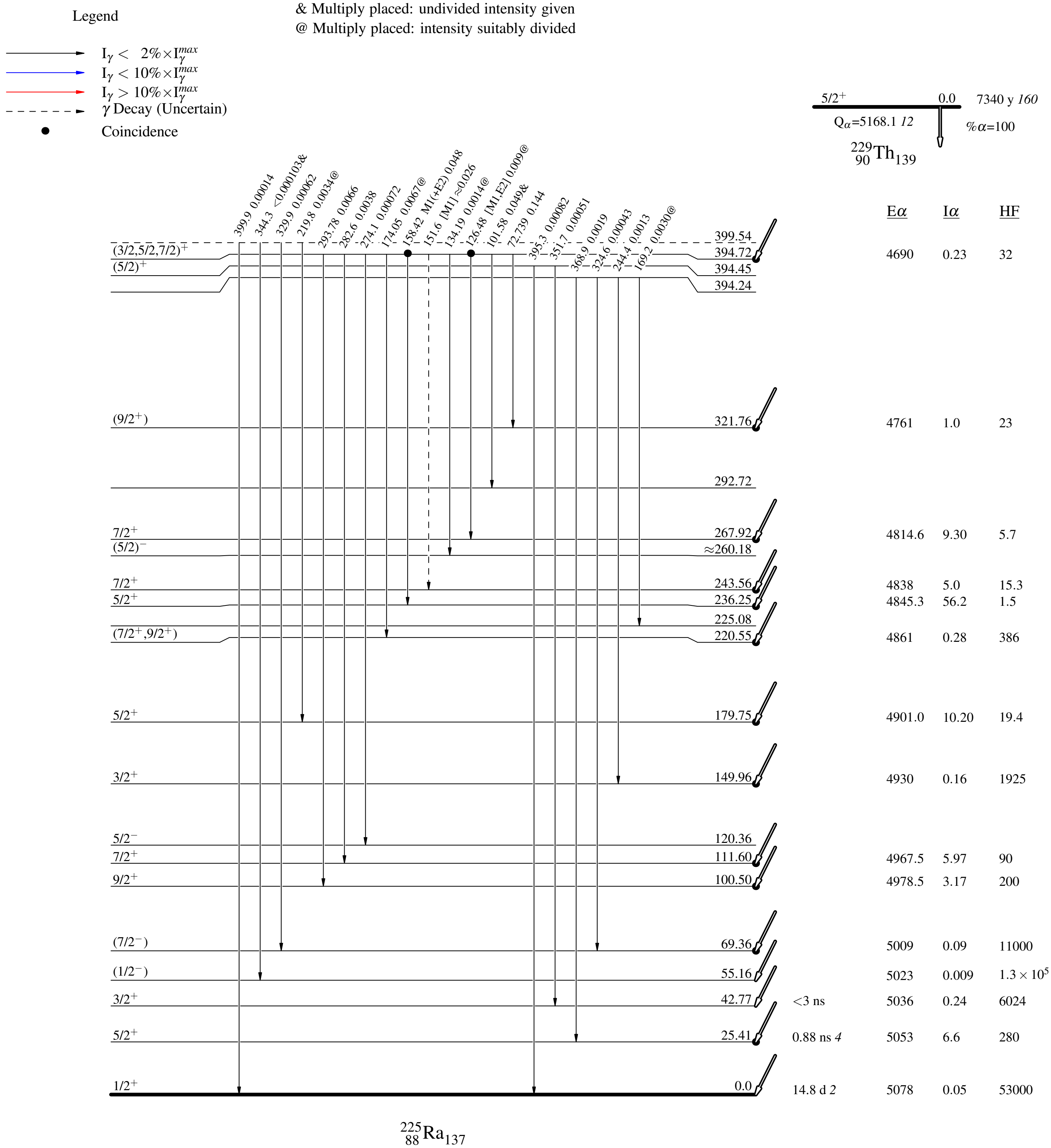
Intensities: I_γ per 100 parent decays
@ Multiply placed: intensity suitably divided



^{229}Th α decay

Decay Scheme (continued)

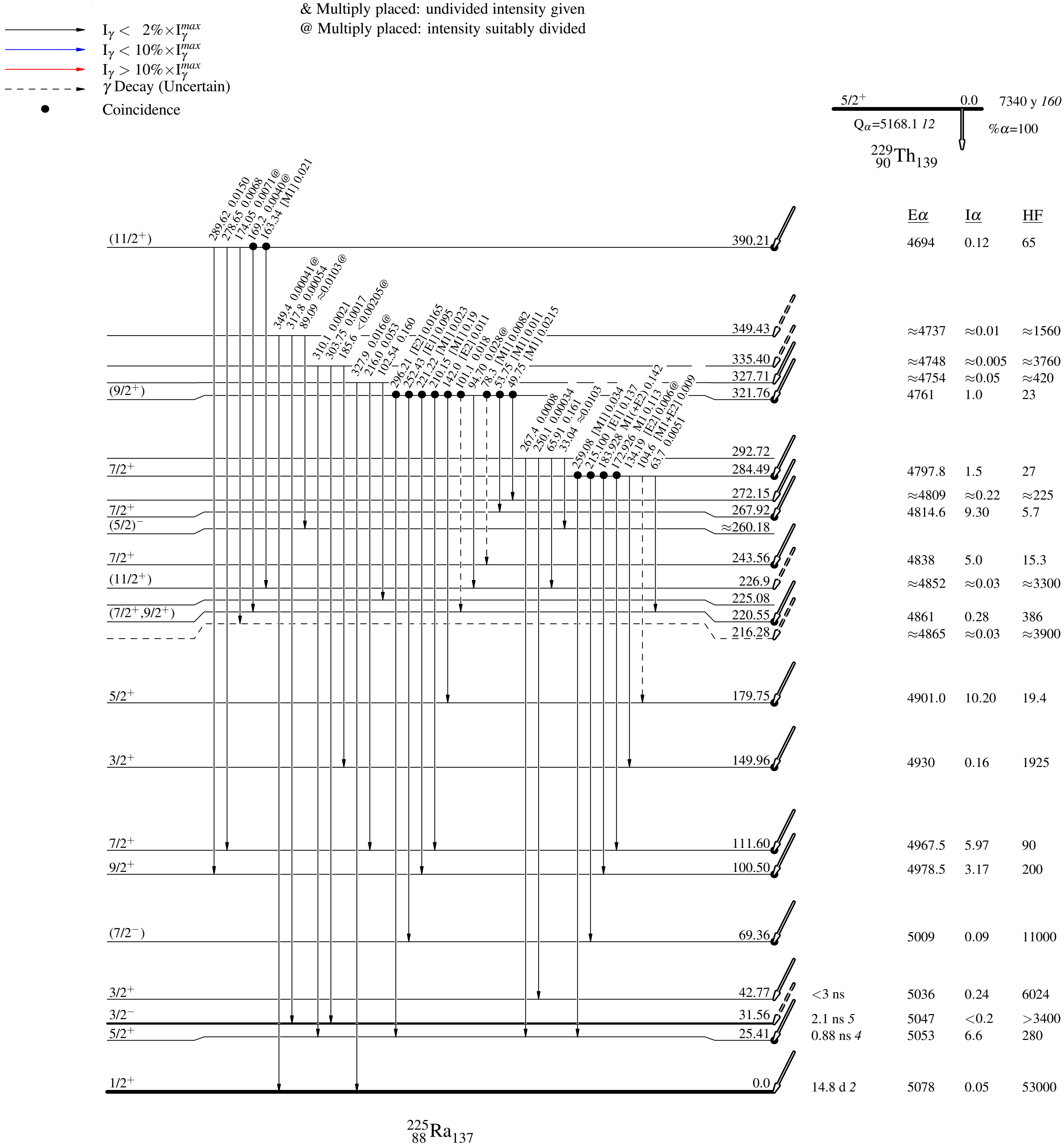
Intensities: I_γ per 100 parent decays
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided



^{229}Th α decay

Decay Scheme (continued)

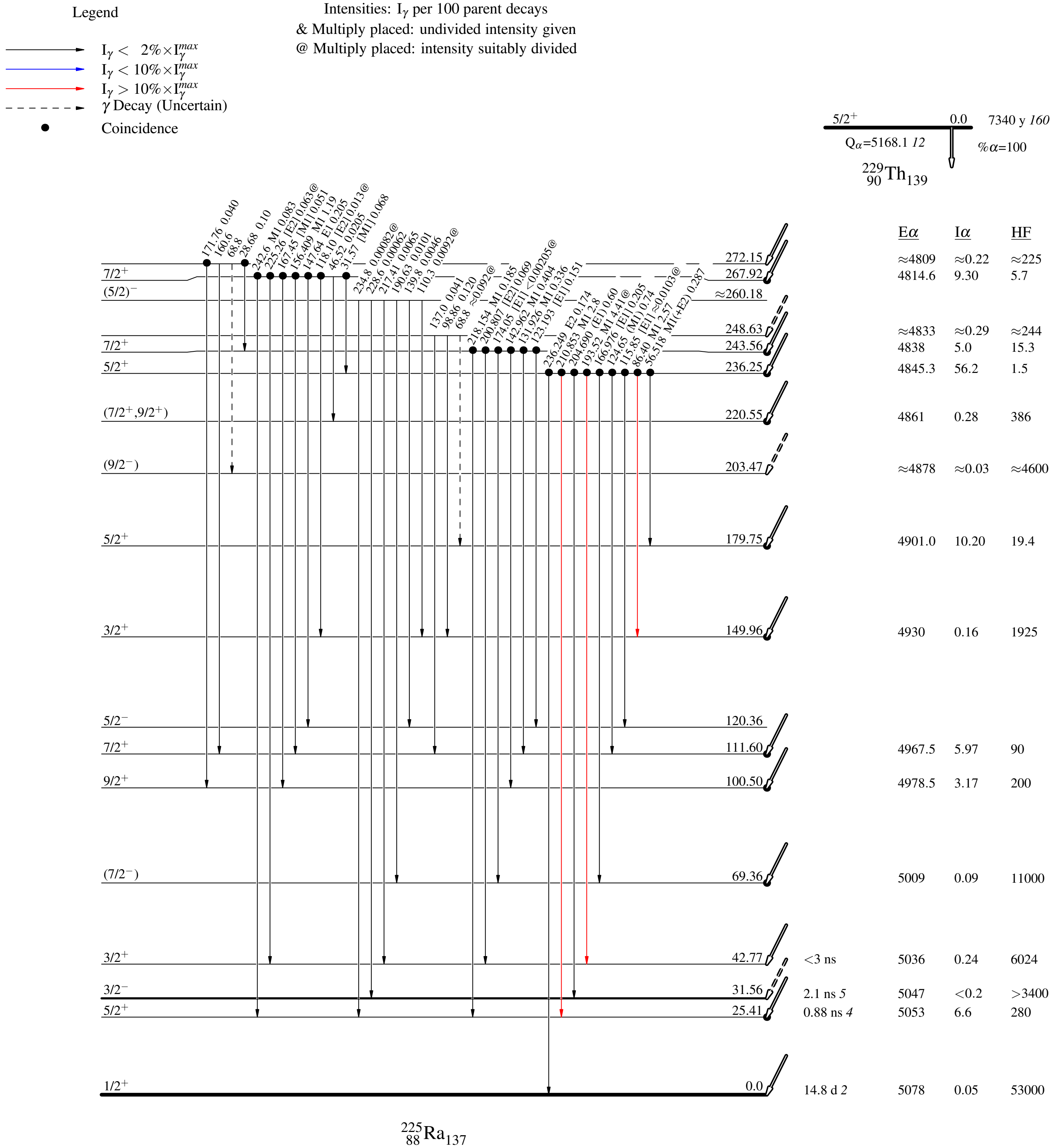
Intensities: I_γ per 100 parent decays
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided



^{229}Th α decay

Decay Scheme (continued)

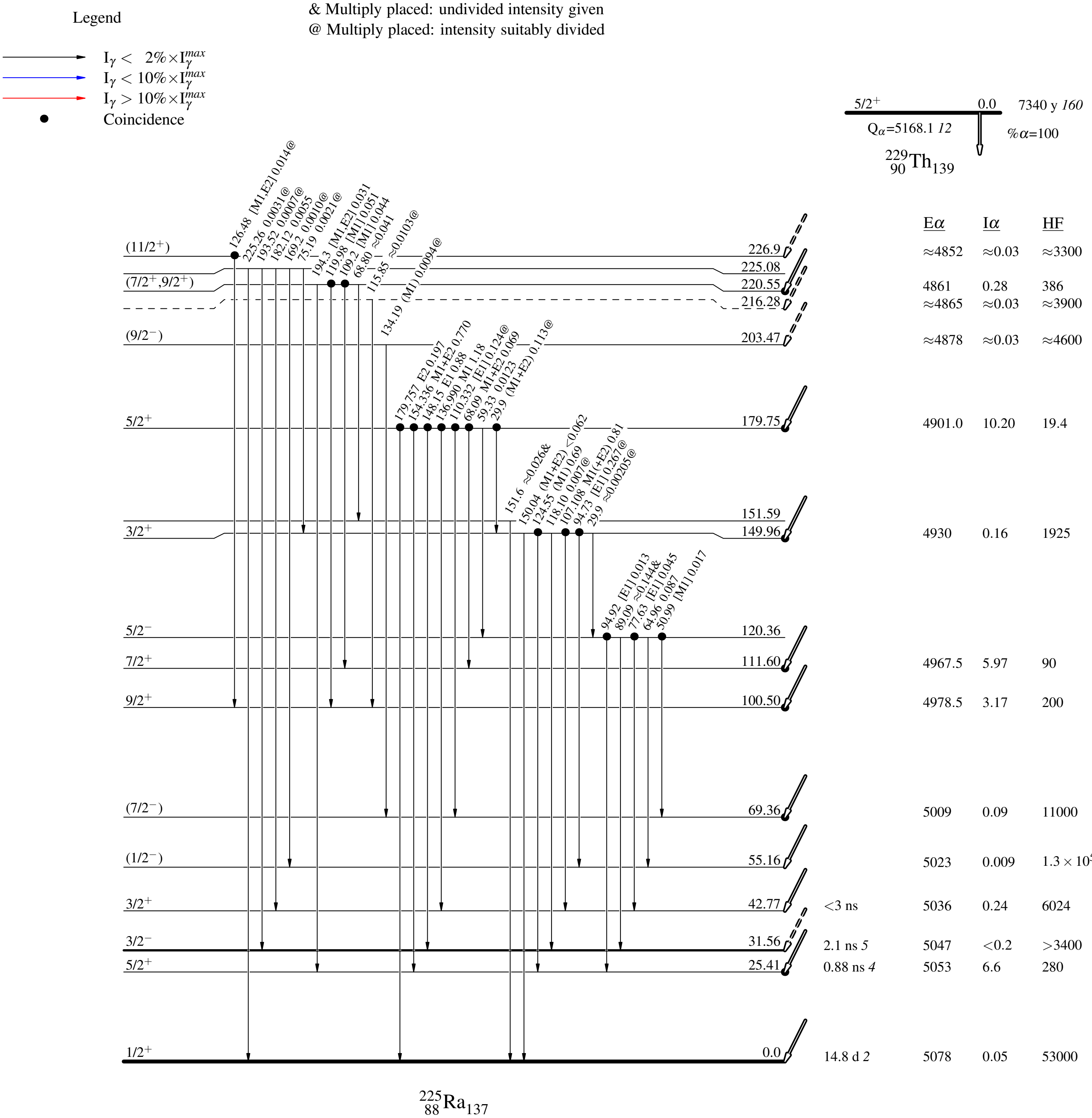
Intensities: I_γ per 100 parent decays
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided



^{229}Th α decay

Decay Scheme (continued)

Intensities: I_γ per 100 parent decays
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided



^{229}Th α decay

Decay Scheme (continued)