^{168}Ta ε decay 2007Mc08,1989Hi04,1976Le14

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Coral M. Baglin	NDS 111, 1807 (2010)	15-Jun-2010

Parent: ^{168}Ta: E=0.0; J$^\pi$=(2$^-$,3$^+$); T$_{1/2}$=2.0 min *1*; Q(ε)=6970 *40*; %ε+%β^+ decay=100.0

Additional information 1.

2007Mc08: ^{168}Ta produced in reaction ^{159}Tb(^{16}O,7n) using a 130 MeV beam provided by the Yale ESTU accelerator; Yrast Ball array (eight Compton-suppressed Clover HPGe detectors); measured Eγ, Iγ, $\gamma\gamma$ coin, $\gamma\gamma(\theta)$; comparisons with geometric collective models. Significant contributions from ^{168}Lu ε decay to ^{168}Yb and ^{166}Lu ε decay to ^{166}Yb were also present in γ spectra.

1989Hi04: sources from ^{133}Cs(^{40}Ar,5n) (E(^{40}Ar)=205 MeV, helium-jet transport); measured Eγ, Iγ, $\gamma\gamma$ coin.

1976Le14: sources from ^{159}Tb(^{16}O,7n) (E(^{16}O)=130 MeV, Tb foil, thermalization and transport of recoil products); measured Eγ, Iγ (Ge(Li)), 2-parameter $\gamma\gamma$ coin.

The decay scheme is from 2007Mc08.

^{168}Hf Levels

E(level)†	J$^\pi$‡	T$_{1/2}$	Comments
0.0#	0$^+$	25.95 min *20*	T$_{1/2}$: from Adopted Levels.
124.10# *5*	2$^+$		
385.92# *6*	4$^+$		
757.27# *7*	6$^+$		
875.94@ *6*	2$^+$		J=2 from (752γ)-(124γ)(θ) (2007Mc08).
942.09& *8*	0$^+$		J$^\pi$: 818γ-124γ(θ) indicates a 0-2-0 cascade establishing J=0 for 942 level and J=2 for 124 level.
1030.93@ *6*	3$^+$		J=3 from (907γ)-(124γ)(θ) and 645γ-262γ(θ) (2007Mc08).
1058.62& *6*	2$^+$		J=2 from 935γ-124γ(θ) (2007Mc08).
1160.72@ *9*	4$^{(+)}$		J=4 from 775γ-262γ(θ) (2007Mc08).
1284.64& *9*	(4$^+$)		
1373.11 *8*	(2)		
1386.37 *9*	(4$^+$,5,6$^+$)		
1401.54 *7*			
1408.30 *11*	(4)		
1411.82 *7*	(≤4)		
1497.22 *9*	(4$^-$)		
1551.38 *8*	(6$^+$)		
1568.50 *8*	(3)		
1618.00 *7*	(≤4)		
1644.21? *11*	(≤4)		
1671.41 *8*	(1$^+$,2$^+$)		
1734.02 *7*	(2$^+$,3,4$^+$)		
1797.22 *15*	(4)		
1799.52 *15*	(2$^+$,3,4$^+$)		
1966.63? *12*			
2047.92? *14*			
2108.70 *11*	(2$^+$,3,4$^+$)		
2353.04 *9*			

† From least-squares fit to Eγ.
‡ From Adopted Levels.
\# Band(A): K$^\pi$=0$^+$ g.s. band.
@ Band(B): K$^\pi$=(2$^+$) γ-vibration band.
& Band(C): K$^\pi$=(0$^+$) β^-vibration band.

^{168}Ta ε decay 2007Mc08,1989Hi04,1976Le14 (continued)

ε,$β^+$ radiations

E(decay)	E(level)	Iβ+ #	Iε#	Log ft‡	I(ε+β+)†#	Comments
(4.62×10^3 *4*)	2353.04	0.22 *3*	0.19 *3*	7.3	0.41 *6*	av Eβ=1629 *19*; εK=0.382 *7*; εL=0.0607 *11*; εM+=0.0185 *4* Additional information 2.
(4.86×10^3 *4*)	2108.70	0.40 *7*	0.28 *5*	7.2	0.68 *12*	av Eβ=1741 *19*; εK=0.343 *7*; εL=0.0545 *10*; εM+=0.0166 *3* Additional information 3.
(4.92×10^3@ *4*)	2047.92?	0.049 *11*	0.033 *8*	8.2	0.082 *19*	av Eβ=1769 *19*; εK=0.334 *6*; εL=0.0530 *10*; εM+=0.0161 *3* Additional information 4.
(5.00×10^3@ *4*)	1966.63?	0.21 *3*	0.13 *2*	7.6	0.34 *5*	av Eβ=1807 *19*; εK=0.322 *6*; εL=0.0511 *10*; εM+=0.0156 *3* Additional information 5.
(5.17×10^3 *4*)	1799.52	1.1 *2*	0.61 *11*	6.9	1.7 *3*	av Eβ=1884 *19*; εK=0.299 *6*; εL=0.0474 *9*; εM+=0.0144 *3* Additional information 6.
(5.17×10^3 *4*)	1797.22	0.39 *8*	0.22 *5*	7.4	0.61 *13*	av Eβ=1885 *19*; εK=0.298 *6*; εL=0.0473 *9*; εM+=0.0144 *3* Additional information 7.
(5.24×10^3 *4*)	1734.02	0.94 *10*	0.51 *6*	7.0	1.45 *16*	av Eβ=1915 *19*; εK=0.290 *6*; εL=0.0460 *9*; εM+=0.0140 *3* Additional information 8.
(5.30×10^3 *4*)	1671.41	0.78 *5*	0.40 *3*	7.1	1.18 *8*	av Eβ=1944 *19*; εK=0.282 *5*; εL=0.0448 *8*; εM+=0.01363 *25*
(5.33×10^3@ *4*)	1644.21?	0.69 *8*	0.35 *4*	7.2	1.04 *12*	av Eβ=1956 *19*; εK=0.279 *5*; εL=0.0442 *8*; εM+=0.01346 *25* Additional information 9.
(5.35×10^3 *4*)	1618.00	1.58 *11*	0.78 *6*	6.9	2.36 *16*	av Eβ=1969 *19*; εK=0.276 *5*; εL=0.0437 *8*; εM+=0.01331 *24* Additional information 10.
(5.40×10^3 *4*)	1568.50	2.00 *14*	0.97 *7*	6.8	2.97 *21*	av Eβ=1992 *19*; εK=0.270 *5*; εL=0.0427 *8*; εM+=0.01301 *24* Additional information 11.
(5.42×10^3 *4*)	1551.38	1.17 *13*	0.56 *6*	7.0	1.73 *19*	av Eβ=1999 *19*; εK=0.268 *5*; εL=0.0424 *8*; εM+=0.01291 *24* Additional information 12. No feeding expected to 6^+.
(5.47×10^3 *4*)	1497.22	0.64 *6*	0.30 *3*	7.3	0.94 *9*	av Eβ=2025 *19*; εK=0.261 *5*; εL=0.0414 *8*; εM+=0.01261 *23* Additional information 13.
(5.56×10^3 *4*)	1411.82	3.4 *3*	1.5 *1*	6.6	4.9 *4*	av Eβ=2064 *19*; εK=0.252 *5*; εL=0.0399 *8*; εM+=0.01213 *22* Additional information 14.
(5.56×10^3 *4*)	1408.30	1.7 *2*	0.76 *9*	6.9	2.5 *3*	av Eβ=2066 *19*; εK=0.251 *5*; εL=0.0398 *8*; εM+=0.01212 *22* Additional information 15.
(5.57×10^3 *4*)	1401.54	1.36 *11*	0.59 *5*	7.0	1.95 *15*	av Eβ=2069 *19*; εK=0.250 *5*; εL=0.0397 *8*; εM+=0.01208 *22* Additional information 16.
(5.58×10^3 *4*)	1386.37	0.59 *6*	0.26 *2*	7.4	0.85 *8*	av Eβ=2076 *19*; εK=0.249 *5*; εL=0.0394 *7*; εM+=0.01200 *22* Additional information 17.
(5.60×10^3 *4*)	1373.11	3.5 *3*	1.5 *1*	6.6	5.0 *4*	av Eβ=2082 *19*; εK=0.247 *5*; εL=0.0392 *7*; εM+=0.01193 *22* Additional information 18.
(5.69×10^3 *4*)	1284.64	1.8 *2*	0.72 *9*	7.0	2.5 *3*	av Eβ=2124 *19*; εK=0.238 *5*; εL=0.0377 *7*;

Continued on next page (footnotes at end of table)

^{168}Ta ε decay 2007Mc08,1989Hi04,1976Le14 (continued)

ε,β$^+$ radiations (continued)

E(decay)	E(level)	Iβ$^+$ #	Iε#	Log *ft*‡	I(ε+β$^+$)†#	Comments
						εM+=0.01147 *21* Additional information 19.
(5.81×10^3 *4*)	1160.72	2.4 *3*	0.90 *11*	6.87 *6*	3.3 *4*	av Eβ=2182 *19*; εK=0.225 *4*; εL=0.0357 *7*; εM+=0.01086 *20* Additional information 20.
(5.91×10^3 *4*)	1058.62	6.2 *4*	2.2 *1*	6.5	8.4 *5*	av Eβ=2229 *19*; εK=0.216 *4*; εL=0.0341 *6*; εM+=0.01038 *19*
(5.94×10^3 *4*)	1030.93	3.7 *4*	1.3 *2*	6.7	5.0 *6*	av Eβ=2242 *19*; εK=0.213 *4*; εL=0.0337 *6*; εM+=0.01026 *18*
(6.03×10^3 *4*)	942.09	1.6 *2*	0.52 *7*	7.1	2.1 *3*	av Eβ=2284 *19*; εK=0.205 *4*; εL=0.0324 *6*; εM+=0.00987 *18* log $f^{1u}t$=9.0 if J$^\pi$(parent)=2$^-$. No feeding is expected if J$^\pi$(parent)=3$^+$.
(6.09×10^3 *4*)	875.94	6.2 *6*	2.0 *2*	6.6	8.2 *8*	av Eβ=2315 *19*; εK=0.199 *4*; εL=0.0315 *6*; εM+=0.00959 *17*
(6.21×10^3@ *4*)	757.27	0.55 *13*	0.16 *4*	7.7	0.71 *17*	av Eβ=2371 *19*; εK=0.189 *4*; εL=0.0299 *6*; εM+=0.00912 *16* I(ε+β$^+$): no feeding is expected if J$^\pi$(parent)=2$^-$ or 3$^+$.
(6.58×10^3 *4*)	385.92	6.5 *8*	1.6 *2*	6.7	8.1 *10*	av Eβ=2545 *19*; εK=0.162 *3*; εL=0.0256 *5*; εM+=0.00779 *13* if J$^\pi$(^{168}Ta)=2$^-$, log $f^{1u}t$=8.7.
(6.85×10^3 *4*)	124.10	26 *3*	5.4 *7*	6.2	31 *4*	av Eβ=2669 *19*; εK=0.1458 *24*; εL=0.0230 *4*; εM+=0.00700 *12*
(6.97×10^3@ *4*)	0.0				9 *8*	

† ε feedings are from intensity imbalance at each level and assume negligible g.s. feeding. Values should probably be considered as upper limits since a large difference of 4.5 MeV exists between the Q value and highest known level at 2353 and this leaves the possibility of missed γ rays from possible levels above 2353.

‡ Deduced by evaluator. Values should probably be considered as lower limits.

Absolute intensity per 100 decays.

@ Existence of this branch is questionable.

$\gamma(^{168}$Hf)

Iγ normalization: if J$^{\pi}$(parent)=3^{+}, negligible ε+β^{+} feeding to g.s. is expected (ΔJ=3, $\Delta\pi$=No), and Iγ normalization=0.358 *12* based on Σ (I(γ+ce) to g.s.)=100. If J$^{\pi}$(parent)=2^{-}, <17% Eβ+β^{+} feeding to g.s. is expected based on log $f^{1u}t\geq$8.5 (ΔJ=2, $\Delta\pi$=yes) and this implies Iγ normalization=0.33 *3*.

E$_{\gamma}$[†]	I$_{\gamma}$[†a]	E$_i$(level)	J$^{\pi}_i$	E$_f$	J$^{\pi}_f$	Mult.[‡]	δ[‡]	α[b]	Comments
117[c]	<0.20	1058.62	2^{+}	942.09	0^{+}				
124.10 *5*	100 *3*	124.10	2^{+}	0.0	0^{+}	E2[@]		1.548	α(K)=0.591 *9*; α(L)=0.728 *11*; α(M)=0.181 *3*; α(N+..)=0.0474 *7* α(N)=0.0420 *6*; α(O)=0.00536 *8*; α(P)=3.59×10^{-5} *5* %Iγ=33 *3* assuming recommended normalization.
130[c]	<0.25	1160.72	4$^{(+)}$	1030.93	3^{+}				
183[c]	<0.10	1058.62	2^{+}	875.94	2^{+}				
226[c]	<0.40	1284.64	(4^{+})	1058.62	2^{+}				
261.85 *5*	63.2 *18*	385.92	4^{+}	124.10	2^{+}	E2[@]		0.1201	α(K)=0.0794 *12*; α(L)=0.0312 *5*; α(M)=0.00756 *11*; α(N+..)=0.00201 *3* α(N)=0.001764 *25*; α(O)=0.000237 *4*; α(P)=5.52×10^{-6} *8* Mult.: (262γ)(124γ)(θ): A$_2$=+0.104 *10*, A$_4$=+0.006 *14* (2007Mc08).
285[c]	<0.2	1160.72	4$^{(+)}$	875.94	2^{+}				
370.62 *8*	1.9 *2*	1401.54		1030.93	3^{+}				
371.36 *6*	4.0 *4*	757.27	6^{+}	385.92	4^{+}	E2[@]		0.0426	α(K)=0.0313 *5*; α(L)=0.00872 *13*; α(M)=0.00208 *3*; α(N+..)=0.000556 *8* α(N)=0.000486 *7*; α(O)=6.75×10^{-5} *10*; α(P)=2.32×10^{-6} *4* other Eγ (Iγ): 370.0 *7* (11.7 *9*) (1989Hi04).
380.88 *8*	1.7 *2*	1411.82	($\leq$4)	1030.93	3^{+}				
390.65 *10*	0.33 *3*	1551.38	(6^{+})	1160.72	4$^{(+)}$				
403[c]	<0.1	1160.72	4$^{(+)}$	757.27	6^{+}				
409[c]	<0.10	1284.64	(4^{+})	875.94	2^{+}				
490[c]	<0.10	875.94	2^{+}	385.92	4^{+}				
520.5 *1*	1.5 *3*	1551.38	(6^{+})	1030.93	3^{+}				
525.6 *1*	0.86 *12*	1401.54		875.94	2^{+}				
527.4 *1*	0.88 *11*	1284.64	(4^{+})	757.27	6^{+}				
535.88 *7*	7.8 *6*	1411.82	($\leq$4)	875.94	2^{+}				
559.4 *1*	0.68 *8*	1618.00	($\leq$4)	1058.62	2^{+}				
612.8 *1*	0.95 *9*	1671.41	(1^{+},2^{+})	1058.62	2^{+}				
629.1 *9*	0.47 *6*	1386.37	(4^{+},5,6^{+})	757.27	6^{+}				
640.5 *1*	0.90 *10*	1671.41	(1^{+},2^{+})	1030.93	3^{+}				
645.05 *10*	2.6 *3*	1030.93	3^{+}	385.92	4^{+}	E2+M1	>10	0.01056 *17*	α(K)=0.00846 *14*; α(L)=0.001624 *24*; α(M)=0.000375 *6*; α(N+..)=0.0001021 *15* α(N)=8.85×10^{-5} *13*; α(O)=1.293×10^{-5} *20*; α(P)=6.57×10^{-7} *11* Mult.,δ: (645γ)(262γ)(θ): A$_2$=−0.02 *4*, A$_4$=−0.22 *4* (2007Mc08) δ >+10 or <−20 from $\gamma\gamma(\theta)$.

γ(^{168}Hf) (continued)

E_γ [†]	I_γ [†a]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [‡]	δ [‡]	α [b]	Comments
672.75 *8*	7.2 *6*	1058.62	2^+	385.92	4^+	(E2)		0.00953 *14*	α(K)=0.00766 *11*; α(L)=0.001444 *21*; α(M)=0.000333 *5*; α(N+..)=9.07×10^{-5} *13* α(N)=7.86×10^{-5} *11*; α(O)=1.152×10^{-5} *17*; α(P)=5.96×10^{-7} *9* Mult.: (673γ)(262γ)(θ): A_2=+0.19 *2*, A_4=+0.05 *3* (2007Mc08).
729.3 *1*	0.69 *9*	1671.41	$(1^+,2^+)$	942.09	0^+				
739.98 *11*	0.83 *10*	1497.22	(4^-)	757.27	6^+				
742.0 *1*	1.9 *2*	1618.00	(≤4)	875.94	2^+				
751.81 *8*	23.0 *18*	875.94	2^+	124.10	2^+	E2+M1	−10 *+3−9*	0.00754 *15*	α(K)=0.00612 *12*; α(L)=0.001095 *19*; α(M)=0.000251 *5*; α(N+..)=6.86×10^{-5} *12* α(N)=5.93×10^{-5} *10*; α(O)=8.76×10^{-6} *15*; α(P)=4.78×10^{-7} *10* other Iγ: 20.6 *16* (1989Hi04). Mult.: (752γ)(124γ)(θ): A_2=−0.004 *32*, A_4=+0.29 *4* (2007Mc08).
774.80 *9*	9.7 *9*	1160.72	$4^{(+)}$	385.92	4^+	(M1+E2)	+0.8 *+6−4*	0.0123 *24*	α(K)=0.0103 *21*; α(L)=0.0016 *3*; α(M)=0.00036 *6*; α(N+..)=9.9×10^{-5} *16* α(N)=8.5×10^{-5} *14*; α(O)=1.30×10^{-5} *22*; α(P)=8.4×10^{-7} *18* Mult.: (775γ)(262γ)(θ): A_2=−0.078 *20*, A_4=+0.046 *20* (2007Mc08).
795.4 *2*	0.76 *9*	1671.41	$(1^+,2^+)$	875.94	2^+				
817.98 *7*	6.4 *7*	942.09	0^+	124.10	2^+	(E2) [@]		0.00620 *9*	α(K)=0.00507 *7*; α(L)=0.000880 *13*; α(M)=0.000201 *3*; α(N+..)=5.50×10^{-5} *8* α(N)=4.76×10^{-5} *7*; α(O)=7.06×10^{-6} *10*; α(P)=3.96×10^{-7} *6* Mult.: (818γ)(124γ)(θ): A_2=+0.33 *3*, A_4=+1.08 *5* (2007Mc08).
[x]831.1 *10*	7.6 *19*								not coincident with 262γ (2007Mc08).
[x]838.6 [#] *10*	3.8 [#] *13*								
858.03 *8*	1.1 *1*	1734.02	$(2^+,3,4^+)$	875.94	2^+				
875.95 *9*	12.8 *5*	875.94	2^+	0.0	0^+				
887.2 [c] *1*	0.23 *5*	2047.92?		1160.72	$4^{(+)}$				
898.8 *2*	0.42 *8*	1284.64	(4^+)	385.92	4^+				
906.81 *7*	17.7 *14*	1030.93	3^+	124.10	2^+	E2+M1	+11 *+13−4*	0.00504 *10*	α(K)=0.00415 *9*; α(L)=0.000693 *13*; α(M)=0.000158 *3*; α(N+..)=4.33×10^{-5} *8* α(N)=3.74×10^{-5} *7*; α(O)=5.58×10^{-6} *10*; α(P)=3.24×10^{-7} *7* other Iγ: 14.0 *19* (1989Hi04). Additional information 21.

$^{168}_{72}$Hf$_{96}$-5

γ(^{168}Hf) (continued)

E_γ [†]	I_γ [†a]	E_i(level)	J^π_i	E_f	J^π_f	Mult. [‡]	δ [‡]	α [b]	Comments
									Mult.: (907γ)(124γ)(θ): A_2=−0.14 *3*, A_4=−0.12 *3* (2007Mc08).
934.51 *10*	6.0 *6*	1058.62	2^+	124.10	2^+	E2+M1	−8 *+4−10*	0.00477 *24*	α(K)=0.00393 *20*; α(L)=0.00065 *3*; α(M)=0.000148 *6*; α(N+..)=4.06×10^{-5} *17* α(N)=3.50×10^{-5} *15*; α(O)=5.24×10^{-6} *23*; α(P)=3.08×10^{-7} *17* other Iγ: 4.7 *13* (1989Hi04). Mult.: (935γ)(124γ)(θ): A_2=+0.02 *4*, A_4=+0.27 *7* (2007Mc08).
987.21 *9*	8.4 *7*	1373.11	(2)	385.92	4^+				
1000.46 *9*	1.9 *2*	1386.37	(4^+,5,6^+)	385.92	4^+				
1037 [c]	<0.30	1160.72	$4^{(+)}$	124.10	2^+				
1058.60 *10*	11.8 *8*	1058.62	2^+	0.0	0^+				
[x]1063.0 [#] *12*	5.7 [#] *3*								
1111.29 *8*	1.8 *2*	1497.22	(4^-)	385.92	4^+				
1160.5 *1*	5.6 *7*	1284.64	(4^+)	124.10	2^+				
1165.4 *1*	3.0 *4*	1551.38	(6^+)	385.92	4^+				
1182.57 *8*	4.0 *3*	1568.50	(3)	385.92	4^+				Additional information 23.
1248.98 *10*	5.7 *6*	1373.11	(2)	124.10	2^+				
1277.4 *1*	2.7 *3*	1401.54		124.10	2^+				
1284.2 *1*	7.1 *8*	1408.30	(4)	124.10	2^+				
1287.7 *2*	4.1 *5*	1411.82	(≤4)	124.10	2^+				Additional information 22.
1322.0 *1*	0.42 *8*	2353.04		1030.93	3^+				
1348.1 *1*	0.56 *7*	1734.02	(2^+,3,4^+)	385.92	4^+				
1411.4 [&] *2*	1.0 *3*	1797.22	(4)	385.92	4^+				Additional information 24.
1413.5 [&] *2*	1.8 *4*	1799.52	(2^+,3,4^+)	385.92	4^+				
[x]1440.5 [#c] *13*	2.4 [#] *8*								
1444.42 *10*	4.3 *4*	1568.50	(3)	124.10	2^+				
1477.2 *1*	0.72 *13*	2353.04		875.94	2^+				
1493.92 *8*	4.0 *3*	1618.00	(≤4)	124.10	2^+				
1520.1 [c] *1*	2.9 *3*	1644.21?	(≤4)	124.10	2^+				
1580.7 [c] *1*	0.95 *12*	1966.63?		385.92	4^+				
1610.0 *1*	2.4 *4*	1734.02	(2^+,3,4^+)	124.10	2^+				
1673.0 [&] *2*	0.7 *2*	1797.22	(4)	124.10	2^+				
1675.5 [&] *2*	3.0 *7*	1799.52	(2^+,3,4^+)	124.10	2^+				
1722.8 *1*	0.5 *1*	2108.70	(2^+,3,4^+)	385.92	4^+				
1984.5 *2*	1.4 *3*	2108.70	(2^+,3,4^+)	124.10	2^+				

[†] From 2007Mc08.

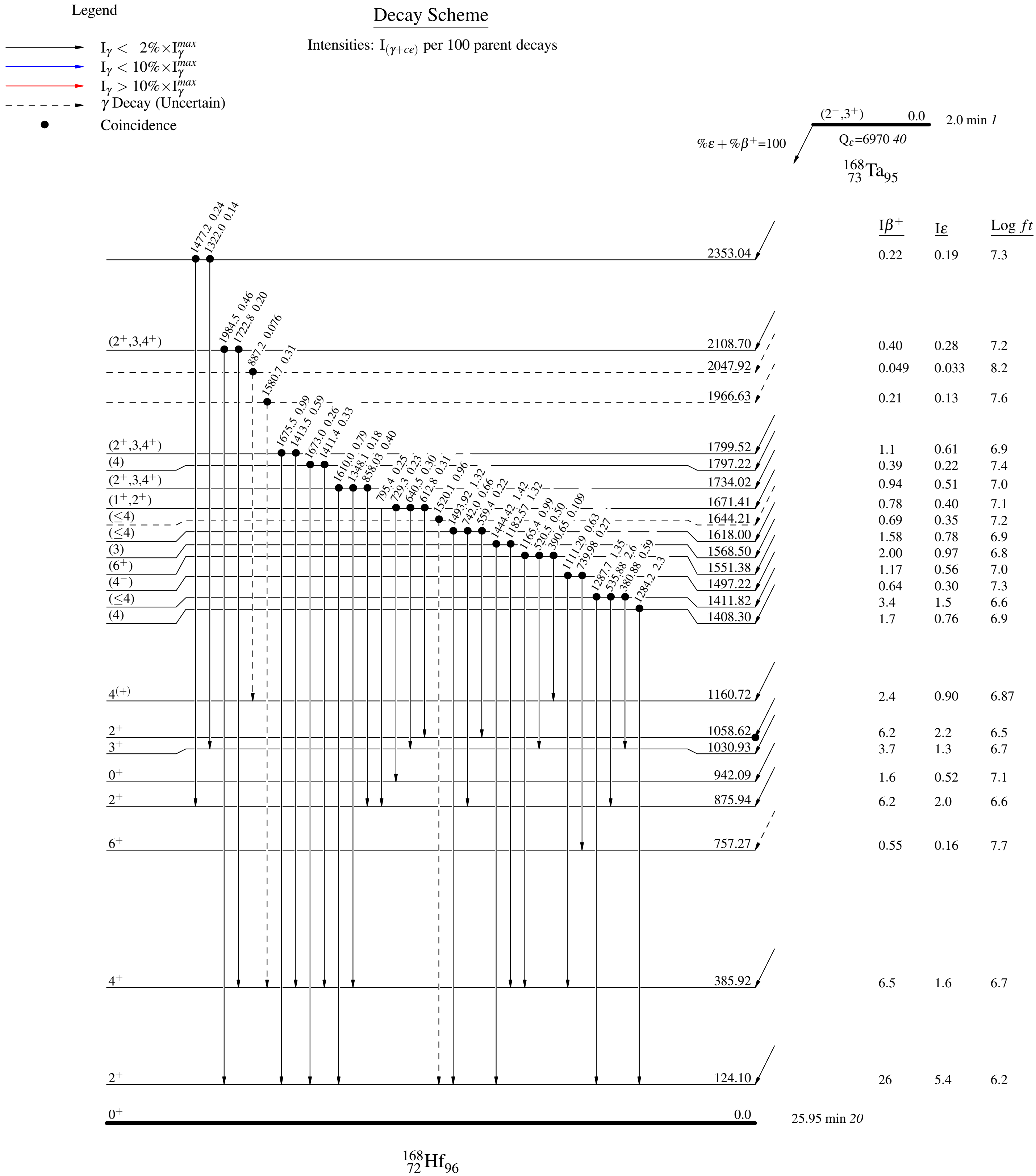
From ENSDF

$^{168}_{72}$Hf$_{96}$-6

γ(^{168}Hf) (continued)

‡ From $\gamma\gamma(\theta)$ (2007Mc08), except As noted.
# From 1989Hi04. not observed by 2007Mc08.
@ From Adopted Gammas.
& 1411.4γ+1413.5γ and 1673.0γ+1675.5γ form doublets. Each γ-ray intensity may contain an unresolved contribution from its second component.
[a] For absolute intensity per 100 decays, multiply by 0.33 *3*.
[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.
[x] γ ray not placed in level scheme.

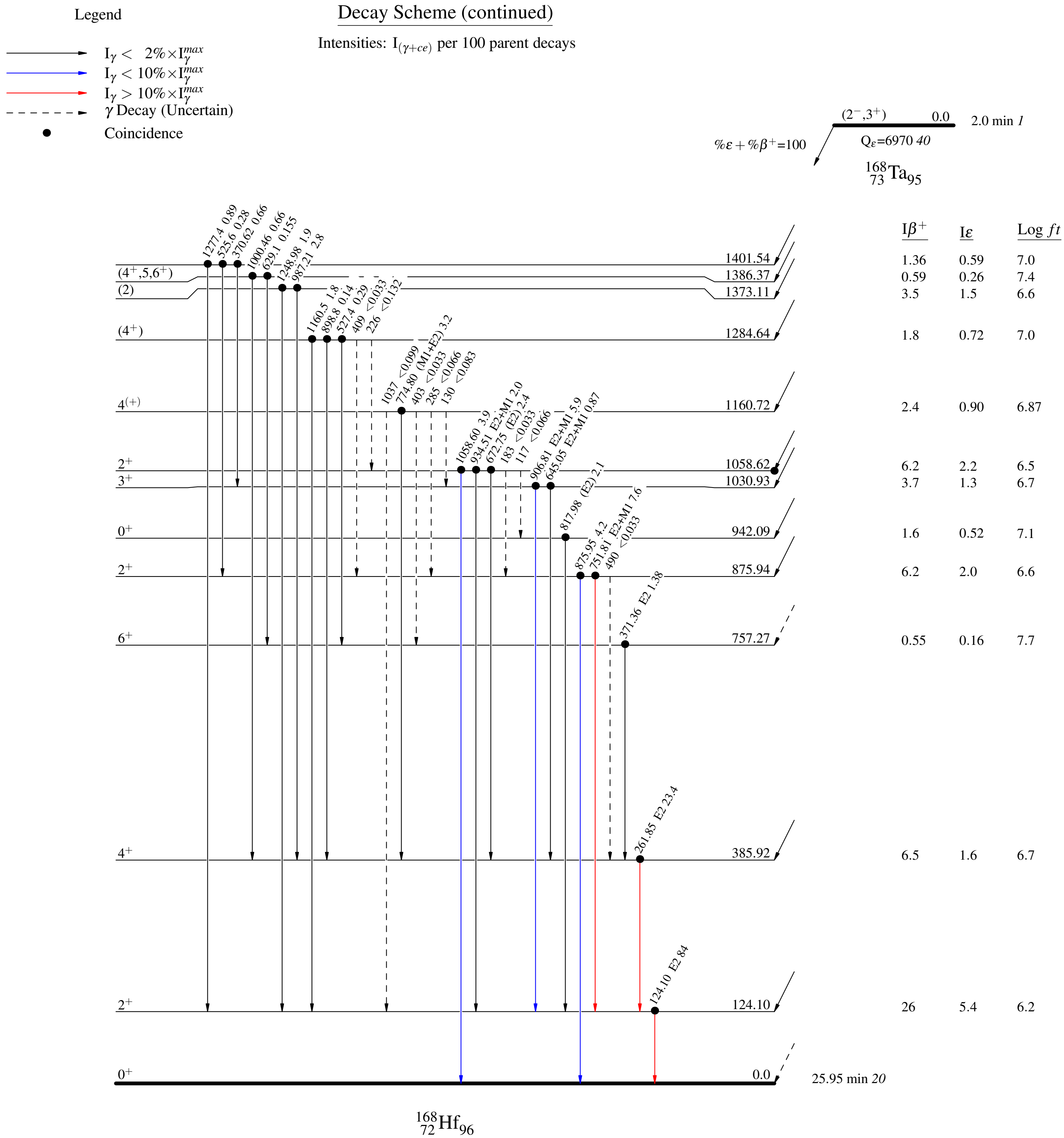
^{168}Ta ε decay 2007Mc08,1989Hi04,1976Le14



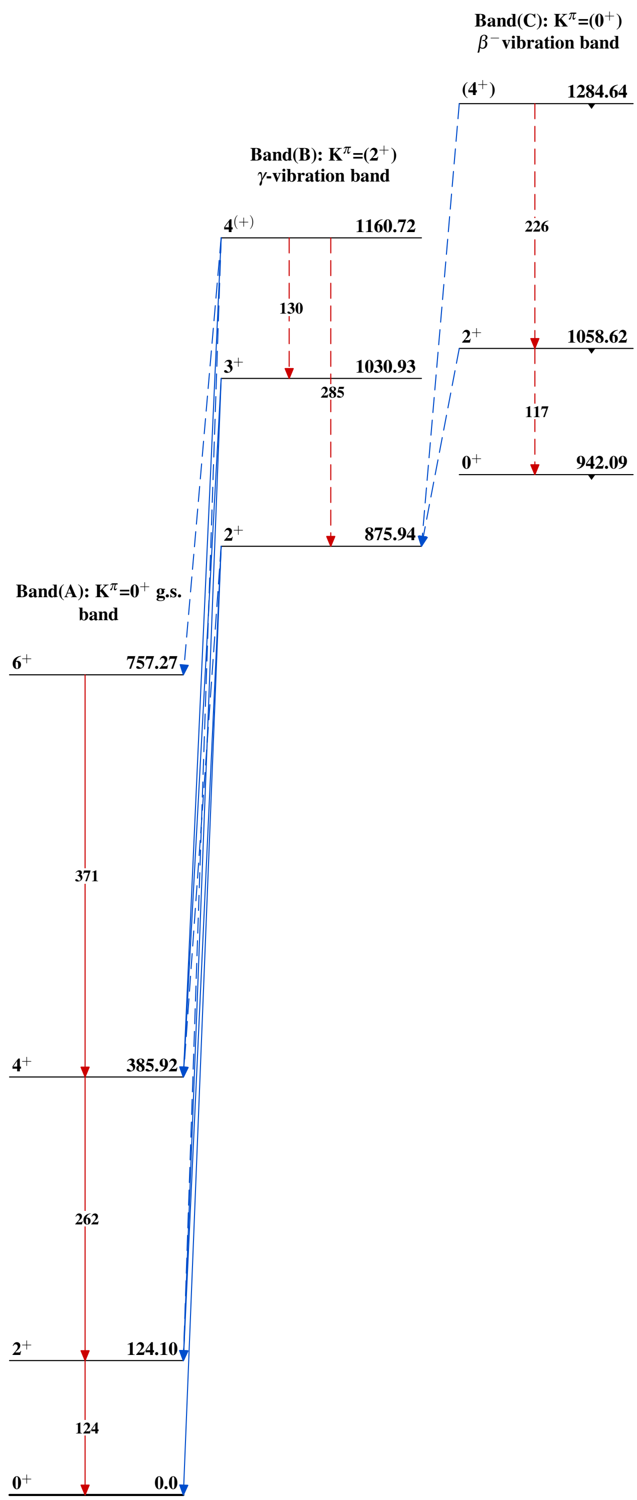
^{168}Ta ε decay 2007Mc08,1989Hi04,1976Le14

Decay Scheme (continued)

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



^{168}Ta ε decay 2007Mc08,1989Hi04,1976Le14



$^{168}_{72}Hf_{96}$