^{173}Hf ε decay 1974Fu01,1975Br15

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	V. S. Shirley	NDS 75,377 (1995)	1-Oct-1993

Parent: ^{173}Hf: E=0.0; J$^{\pi}$=1/2$^-$; $T_{1/2}$=23.6 h *1*; Q(ε)=1600 *SY*; %ε+%β^+ decay=100.0

The decay scheme is based mainly on data from two papers: 1974Fu01 (sources from ^{172}Yb(α,3n) (Eα=37 MeV, enriched ^{172}Yb target (91.5%)); measured Eγ, Iγ (coaxial Ge(Li) with FWHM=2.2 keV at 1332 keV, planar Ge(Li), Si(Li)), E(ce), Ice (Si(Li) with FWHM=1.5 keV at 234 keV and 2.5 keV at 836 keV), prompt and delayed $\gamma\gamma$ and γce coin) and 1975Br15 (sources from ^{172}Yb(α,3n) and ^{173}Yb(α,4n)) (enriched Yb oxide targets (97.2% for ^{172}Yb, 95.0% for ^{173}Yb); measured Eγ, Iγ (Ge(Li) with FWHM≈2.2 keV at 1332 keV, planar Ge(Li) detector, anti-Compton spect), $\gamma\gamma$ coin).

Reference citations are given with data from other sources. Others: 1954Wa02, 1959Ba10, 1961Br29, 1961Br39, 1963Ra14, 1971Na28, 1972Lo22.

^{173}Lu Levels

Band structure: see Adopted Levels.

E(level)	J$^{\pi}$	$T_{1/2}$‡	Comments
0.0	7/2$^+$	1.37 y *1*	
117.18 *3*	(9/2$^+$)		
123.675 *15*	5/2$^-$	74.2† μs *10*	
128.345 *21*	1/2$^-$	5.2 ns *5*	
263.310 *21*	3/2$^-$	≤0.16 ns	
356.999 *22*	5/2$^+$	383 ps *19*	
425.320 *23*	1/2$^+$	0.84† ns *20*	
434.914 *21*	3/2$^+$	0.38† ns *10*	
552.10 *3*	(5/2)$^+$		
721.54 *11*	(1/2$^+$)		
734.71 *8*	(7/2$^-$)		
889.23 *3*	(3/2)$^-$		
957.78? *13*	(5/2$^-$)		
975.153 *24*	3/2$^+$		
981.81 *3*	1/2$^+$		
1003.402 *25*	3/2$^+$		
1097.40 *7*	(1/2,3/2)		
1129.66 *4*	(1/2$^-$,3/2)		
1162.435 *24*	3/2$^-$		
1192.67 *8*	(1/2$^-$)		
1246.52 *4*	1/2$^+$		
1334.05 *3*	3/2$^-$		
1359.27 *10*	(3/2$^+$)		
1408.75 *14*	(1/2$^+$)		
1579.1? *6*	(1/2$^+$)		If ε decay proceeds to this level Q(^{173}Hf) will be≥1580.

† Adopted values.
‡ $\gamma\gamma$(t), γce(t) (1974Fu01), except where noted. Other: 1967WiZY.

^{173}Hf ε decay 1974Fu01,1975Br15 (continued)

ε,β$^+$ radiations

ε+β$^+$ feedings are from intensity imbalance at each level (g.s. feeding not expected (ΔJ=3)).

E(decay)	E(level)	Iβ$^+$ †	Iε†	Log *ft*	I(ε+β$^+$)†	Comments
(20‡ *SY*)	1579.1?		≈0.003	6.1	≈0.003	εL= 0.50; εM+= 0.50
(191 *SY*)	1408.75		0.0109 *18*	8.4	0.0109 *18*	εK= 0.7; εL= 0.22; εM+= 0.07
(240 *SY*)	1359.27		0.0071 *13*	8.8	0.0071 *13*	εK= 0.7; εL= 0.19; εM+= 0.06
(265 *SY*)	1334.05		0.497 *14*	7.1	0.497 *14*	εK= 0.8; εL= 0.18; εM+= 0.06
(353 *SY*)	1246.52		0.065 *3*	8.3	0.065 *3*	εK= 0.8; εL= 0.17; εM+= 0.05
(407 *SY*)	1192.67		0.0101 *10*	9.2	0.0101 *10*	εK= 0.8; εL= 0.16; εM+= 0.051
(437 *SY*)	1162.435		1.75 *5*	7.0	1.75 *5*	εK= 0.8; εL= 0.16; εM+= 0.050
(470 *SY*)	1129.66		0.0303 *22*	8.9	0.0303 *22*	εK= 0.8; εL= 0.16; εM+= 0.049
(502 *SY*)	1097.40		0.0119 *11*	9.3	0.0119 *11*	εK= 0.8; εL= 0.15; εM+= 0.048
(596 *SY*)	1003.402		0.679 *17*	7.8	0.679 *17*	εK= 0.8; εL= 0.15; εM+= 0.046
(618 *SY*)	981.81		0.658 *16*	7.8	0.658 *16*	εK= 0.8; εL= 0.15; εM+= 0.046
(624 *SY*)	975.153		0.929 *17*	7.7	0.929 *17*	εK= 0.8; εL= 0.15; εM+= 0.046
(710 *SY*)	889.23		0.110 *3*	8.7	0.110 *3*	εK= 0.8; εL= 0.15; εM+= 0.045
(878 *SY*)	721.54		0.0099 *23*	10.0	0.0099 *23*	εK= 0.8; εL= 0.14; εM+= 0.044
(1047 *SY*)	552.10		0.15 *4*	9.5^{1u}	0.15 *4*	εK= 0.8; εL= 0.15; εM+= 0.048
(1165 *SY*)	434.914		21.3 *6*	6.9	21.3 *6*	εK= 0.8; εL= 0.14; εM+= 0.042
(1174 *SY*)	425.320		37.4 *9*	6.6	37.4 *9*	εK= 0.8; εL= 0.14; εM+= 0.042
(1336 *SY*)	263.310	≈0.007	32.0 *9*	6.8	32.0 *9*	av Eβ= 158; εK= 0.8; εL= 0.14; εM+= 0.042
(1471 *SY*)	128.345	≈0.005	≈5.0	≈7.7	≈5.0	av Eβ= 2.2×10^{02}; εK= 0.8; εL= 0.14; εM+= 0.041

† Absolute intensity per 100 decays.

‡ Existence of this branch is questionable.

γ(^{173}Lu)

Iγ normalization: from total I(γ+ce) to g.s.=100%.
Iγ(Lu K x ray)=1140 *200* (relative to Iγ=1000 for 123.7γ) (1962Va06).
The high energies of several unplaced γ's tentatively attributed to ^{173}Hf decay are not consistent with Q+=1605 (1993Au05).

E_γ[†]	I_γ[‡b]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	δ[#]	α[c]	$I_{(\gamma+ce)}$[b]	Comments
4.670 *15*	3.19×10^{-4} *22*	128.345	1/2$^-$	123.675	5/2$^-$	E2		2.18×10^6	696 *47*	α(M)= 1.64×10^{06} $I_{(\gamma+ce)}$: deduced from intensity balance at 123.7 level. I_γ: from I(γ+ce) and α. Mult.: from M2/M3≈0.6 (1962Va06). M/M+N+=0.75 (theory).
9.594 *17*	0.31 *4*	434.914	3/2$^+$	425.320	1/2$^+$	[M1]		149		α(L)= 2.84; α(M)= 112 I_γ: deduced from assumed multipolarity and I(γ+ce)=46 *6*, as obtained by comparing Iγ(540.2γ) in singles spectrum with Iγ measured in coincidence with 297.0γ.
77.92 *3*	0.633 *20*	434.914	3/2$^+$	356.999	5/2$^+$	M1+E2	≈3.6	9.0 *2*		α(K)= 1.8; α(L)= 5.5; α(M)= 1.37; α(N+..)= 0.38
117.18[e] *3*	0.024[e] *10*	117.18	(9/2$^+$)	0.0	7/2$^+$	[M1,E2]		2.1 *3*		α(K)= 1.4 *7*; α(L)= 0.6 *3*; α(M)= 0.14 *7*; α(N+..)= 0.041 *20*
117.18[e] *3*	0.75[e] *15*	552.10	(5/2)$^+$	434.914	3/2$^+$	[M1,E2]		2.1 *3*		α(K)= 1.4 *7*; α(L)= 0.6 *3*; α(M)= 0.14 *7*; α(N+..)= 0.041 *20*
123.675 *15*	1000 *38*	123.675	5/2$^-$	0.0	7/2$^+$	E1		0.202		α(K)= 0.167; α(L)= 0.0271; α(M)= 0.00604; α(N+..)= 0.00163 %Iγ=83.0 *4*. Mult.: L-subshell ratios (1959Ha09,1962Va06) confirm E1, as determined from α(K)exp.
134.965 *14*	57.1 *15*	263.310	3/2$^-$	128.345	1/2$^-$	M1+E2[&]	1.7[&] *1*	1.23		α(K)= 0.708; α(L)= 0.40; α(M)= 0.0971; α(N+..)= 0.0262
139.635 *15*	153 *4*	263.310	3/2$^-$	123.675	5/2$^-$	M1+E2[&]	0.41[&] *4*	1.38		α(K)= 1.10; α(L)= 0.218; α(M)= 0.0501; α(N+..)= 0.0137
162.010 *16*	77.8 *20*	425.320	1/2$^+$	263.310	3/2$^-$	E1		0.099		α(K)= 0.0828; α(L)= 0.0130; α(M)= 0.00290; α(N+..)= 0.000765 Mult.: L-subshell ratios (1962Va06) confirm E1, as determined from α(K)exp.
171.604 *17*	2.04 *10*	434.914	3/2$^+$	263.310	3/2$^-$	E1		0.086		α(K)= 0.0714; α(L)= 0.01109; α(M)= 0.00248; α(N+..)= 0.000662

$^{173}_{71}$Lu$_{102}$-3

$\gamma(^{173}$Lu) (continued)

E_γ[†]	I_γ[‡b]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	δ[#]	α[c]	$I_{(\gamma+ce)}$[b]	Comments
229.61 *11*	0.030 *10*	1359.27	(3/2$^+$)	1129.66	(1/2$^-$,3/2)					
239.82 *4*	0.072 *29*	356.999	5/2$^+$	117.18	(9/2$^+$)	[E2]		0.155		α(K)= 0.101; α(L)= 0.0414; α(M)= 0.00996; α(N+..)= 0.00293
288.79 *3*	0.336 *20*	552.10	(5/2)$^+$	263.310	3/2$^-$	[E1]		0.0228		α(K)= 0.0191; α(L)= 0.00285; α(M)= 0.000634; α(N+..)= 0.000208
296.974 *16*	408 *8*	425.320	1/2$^+$	128.345	1/2$^-$	E1		0.0213		α(K)= 0.0178; α(L)= 0.00265; α(M)= 0.000591; α(N+..)= 0.000196 Mult.: from α(K)exp=0.013 *5*, determined from Iγ and Ice (relative) compared with ^{137}Cs counterparts (used as standard) (1962Va06); α(K)exp=0.013 was also determined with the internal-external conversion technique (1962Va06). α(K)(E1 theory)=0.0178.
306.568 *15*	77.4 *17*	434.914	3/2$^+$	128.345	1/2$^-$	E1		0.0197		α(K)= 0.0165; α(L)= 0.00245; α(M)= 0.000546; α(N+..)= 0.000182
311.239 *15*	129.5 *24*	434.914	3/2$^+$	123.675	5/2$^-$	E1		0.0190		α(K)= 0.0159; α(L)= 0.00236; α(M)= 0.000526; α(N+..)= 0.000176
356.998 *22*	5.61 *23*	356.999	5/2$^+$	0.0	7/2$^+$	M1		0.110		α(K)= 0.092; α(L)= 0.0139; α(M)= 0.00312; α(N+..)= 0.00106
377.71 *9*	≈0.010	734.71	(7/2$^-$)	356.999	5/2$^+$					
423.06 *3*	0.76 *3*	975.153	3/2$^+$	552.10	(5/2)$^+$	M1		0.0704		α(K)= 0.0590; α(L)= 0.00885; α(M)= 0.00198; α(N+..)= 0.000644
426.94 *13*	0.119 *20*	1408.75	(1/2$^+$)	981.81	1/2$^+$	[M1]		0.0687		α(K)= 0.0576; α(L)= 0.00864; α(M)= 0.00194; α(N+..)= 0.000626
428.42 *3*	0.146 *19*	552.10	(5/2)$^+$	123.675	5/2$^-$	[E1]		0.0089		α(K)= 0.00752; α(L)= 0.00109; α(M)= 0.000243; α(N+..)= 0.0000783
429.71 *4*	0.107 *22*	981.81	1/2$^+$	552.10	(5/2)$^+$	[E2]		0.0277		α(K)= 0.0211; α(L)= 0.00507; α(M)= 0.001186; α(N+..)= 0.000363
444.82 *3*	0.052 *14*	1334.05	3/2$^-$	889.23	(3/2)$^-$	M1		0.0617		α(K)= 0.0517; α(L)= 0.00775; α(M)= 0.00174; α(N+..)= 0.000549
451.30 *3*	0.107 *14*	1003.402	3/2$^+$	552.10	(5/2)$^+$	M1+E2	1.4 +*82*−*7*	0.036 *12*		α(K)= 0.029 *10*; α(L)= 0.0054 *15*; α(M)= 0.0012 *4*; α(N+..)= 0.00038 *7*
458.23 *11*	0.040 *20*	721.54	(1/2$^+$)	263.310	3/2$^-$					
^{x}492.4 *3*	0.015 *7*									
540.238 *16*	4.45 *12*	975.153	3/2$^+$	434.914	3/2$^+$	M1		0.0375		α(K)= 0.0313; α(L)= 0.00466
546.895 *23*	0.366 *17*	981.81	1/2$^+$	434.914	3/2$^+$	M1		0.0364		α(K)= 0.0304; α(L)= 0.00452
549.832 *18*	5.27 *15*	975.153	3/2$^+$	425.320	1/2$^+$	M1		0.0359		α(K)= 0.0300; α(L)= 0.00445
556.489 *23*	0.148 *15*	981.81	1/2$^+$	425.320	1/2$^+$	E0+M1		0.41[a] *15*	0.209[@] *32*	α(K)exp=0.35 *4*.

From ENSDF

γ(^{173}Lu) (continued)

E_γ[†]	I_γ[‡b]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	α[c]	$I_{(\gamma+ce)}$[b]	Comments
568.487 *22*	0.100 *12*	1003.402	$3/2^+$	434.914	$3/2^+$	E0+(M1+E2)	0.42[a] *6*	0.142[@] *18*	α(K)exp=0.36 *5*.
578.081 *22*	0.283 *15*	1003.402	$3/2^+$	425.320	$1/2^+$	M1	0.0316		α(K)= 0.0264; α(L)= 0.00391
593.20 *11*	0.079 *20*	721.54	$(1/2^+)$	128.345	$1/2^-$				
596[f] *1*	<0.02	1579.1?	$(1/2^+)$	981.81	$1/2^+$	(E0+M1)			α(K)exp>0.15 (α(K)(M1 theory)=0.0244).
618.15 *3*	0.290 *15*	975.153	$3/2^+$	356.999	$5/2^+$	(M1)	0.0266		α(K)= 0.0222; α(L)= 0.00329
625.917 *23*	0.361 *15*	889.23	$(3/2)^-$	263.310	$3/2^-$	M1	0.0258		α(K)= 0.0216; α(L)= 0.00319
694.46[d] *13*	<0.15[d]	957.78?	$(5/2^-)$	263.310	$3/2^-$				
694.46[d] *13*	<0.15[d]	1246.52	$1/2^+$	552.10	$(5/2)^+$				
718.499 *20*	3.53 *12*	981.81	$1/2^+$	263.310	$3/2^-$	E1			
734.71 *8*	0.061 *10*	734.71	$(7/2^-)$	0.0	$7/2^+$				
740.090 *21*	0.28 *3*	1003.402	$3/2^+$	263.310	$3/2^-$				
760.881 *21*	0.81 *3*	889.23	$(3/2)^-$	128.345	$1/2^-$	M1	0.0158		α(K)= 0.0132; α(L)= 0.00194
765.551 *24*	0.181 *9*	889.23	$(3/2)^-$	123.675	$5/2^-$	(M1)	0.0155		α(K)= 0.0130; α(L)= 0.00191
781.95 *4*	0.050 *9*	1334.05	$3/2^-$	552.10	$(5/2)^+$				
807.17 *11*	0.015 *7*	1359.27	$(3/2^+)$	552.10	$(5/2)^+$				
811.61 *4*	0.199 *18*	1246.52	$1/2^+$	434.914	$3/2^+$				
821.20 *4*	0.047 *9*	1246.52	$1/2^+$	425.320	$1/2^+$	E0+M1	≈0.064[a]	0.050[@] *10*	α(K)exp=0.049 *13*.
[x]828.39 *25*	≈0.04								
834.10[d] *13*	<0.077[d]	957.78?	$(5/2^-)$	123.675	$5/2^-$				
834.10[d] *13*	<0.077[d]	1097.40	(1/2,3/2)	263.310	$3/2^-$				
[x]845.4 *4*	0.015 *7*								
853.463 *20*	3.87 *15*	981.81	$1/2^+$	128.345	$1/2^-$	E1			
[x]857.4 *10*	<0.02					E0+M1+(E2)			α(K)exp>0.10 (α(K)(M1 theory)=0.00978, α(K)(E2 theory)= 0.00442).
866.35 *4*	0.010 *5*	1129.66	$(1/2^-,3/2)$	263.310	$3/2^-$				
875.054 *20*	2.74 *10*	1003.402	$3/2^+$	128.345	$1/2^-$	E1			
879.724 *20*	4.64 *18*	1003.402	$3/2^+$	123.675	$5/2^-$	E1			
889.52 *5*	0.043 *9*	1246.52	$1/2^+$	356.999	$5/2^+$				
899.123[e] *18*	11.9[e] *5*	1162.435	$3/2^-$	263.310	$3/2^-$	M1	0.0104		α(K)= 0.0087; α(L)= 0.00127
899.123[e] *18*	0.13[e] *3*	1334.05	$3/2^-$	434.914	$3/2^+$				
[x]905.81 *20*	0.022 *6*								
929.36 *8*	0.061 *7*	1192.67	$(1/2^-)$	263.310	$3/2^-$				
933.94 *10*	0.015 *7*	1359.27	$(3/2^+)$	425.320	$1/2^+$				
969.05 *6*	0.066 *13*	1097.40	(1/2,3/2)	128.345	$1/2^-$				
977.05 *4*	0.117 *15*	1334.05	$3/2^-$	356.999	$5/2^+$				
983.21 *4*	0.048 *9*	1246.52	$1/2^+$	263.310	$3/2^-$				
[x]990.0 *3*	≈0.010								
[x]991.8 *10*	≈0.010								
1001.31 *4*	0.137 *15*	1129.66	$(1/2^-,3/2)$	128.345	$1/2^-$				
1005.98 *4*	0.248 *18*	1129.66	$(1/2^-,3/2)$	123.675	$5/2^-$				
1034.087 *18*	5.07 *20*	1162.435	$3/2^-$	128.345	$1/2^-$	M1			

$^{173}_{71}$Lu$_{102}$-5

γ(^{173}Lu) (continued)

E_γ[†]	I_γ[‡b]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]
1038.757 *19*	3.89 *15*	1162.435	3/2⁻	123.675	5/2⁻	M1
1064.32 *8*	0.061 *9*	1192.67	(1/2⁻)	128.345	1/2⁻	
1070.74 *3*	0.95 *4*	1334.05	3/2⁻	263.310	3/2⁻	M1
[x]1085.8 *3*	≈0.004					
1095.95 *10*	0.015 *7*	1359.27	(3/2⁺)	263.310	3/2⁻	
[x]1100.0 *3*	0.006 *2*					
1118.17 *4*	0.301 *20*	1246.52	1/2⁺	128.345	1/2⁻	
1145.43 *13*	0.0020 *10*	1408.75	(1/2⁺)	263.310	3/2⁻	
1205.70 *3*	3.59 *15*	1334.05	3/2⁻	128.345	1/2⁻	M1
1210.37 *3*	1.07 *4*	1334.05	3/2⁻	123.675	5/2⁻	M1
1230.92 *10*	0.0089 *20*	1359.27	(3/2⁺)	128.345	1/2⁻	
1235.59 *10*	0.0020 *10*	1359.27	(3/2⁺)	123.675	5/2⁻	
[x]1274.6[f] *5*	≈0.002					

E_γ[†]	I_γ[‡b]	E_i(level)	J_i^π	E_f	J_f^π
1280.40 *13*	0.0020 *10*	1408.75	(1/2⁺)	128.345	1/2⁻
[x]1286.6 *2*	0.009 *2*				
1316.0[f] *3*	0.007 *2*	1579.1?	(1/2⁺)	263.310	3/2⁻
[x]1332.87 *20*	≈0.002				
[x]1363.9 *5*	≈0.001				
[x]1428.6[f] *4*	0.003 *1*				
1450[f] *1*	≈0.005	1579.1?	(1/2⁺)	128.345	1/2⁻
[x]1488.9 *3*	0.004 *1*				
[x]1512.5[f] *4*	≈0.002				
[x]1778.4[f] *7*	≈0.008				
[x]2043[f] *1*	0.003 *1*				
[x]2127.7[f] *10*	≈0.002				
[x]2613.1[f] *14*	≈0.002				

[†] Weighted average from 1962Va06, 1972Gn01, 1974Fu01, 1975Br15, and 1978Gu18, except where noted.

[‡] From combined analysis of Iγ values from 1972Gn01, 1974Fu01, 1975Br15, and 1978Gu18, except where noted.

[#] From α(K)exp except where noted (Iγ from 1974Fu01, Ice from 1959Ha09, 1962Va06, and 1974Fu01); the photon and ce intensity scales were normalized through α(K)=0.0178 (E1 theory) for 297.0γ.

[@] Deduced from α(K)exp, Iγ, and K/L ratios for E0 transitions (1969Ha61).

[&] From ce subshell ratios (1962Va06).

[a] Experimental value.

[b] For absolute intensity per 100 decays, multiply by 0.083 *3*.

[c] 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.

[d] Multiply placed with undivided intensity.

[e] Multiply placed with intensity suitably divided.

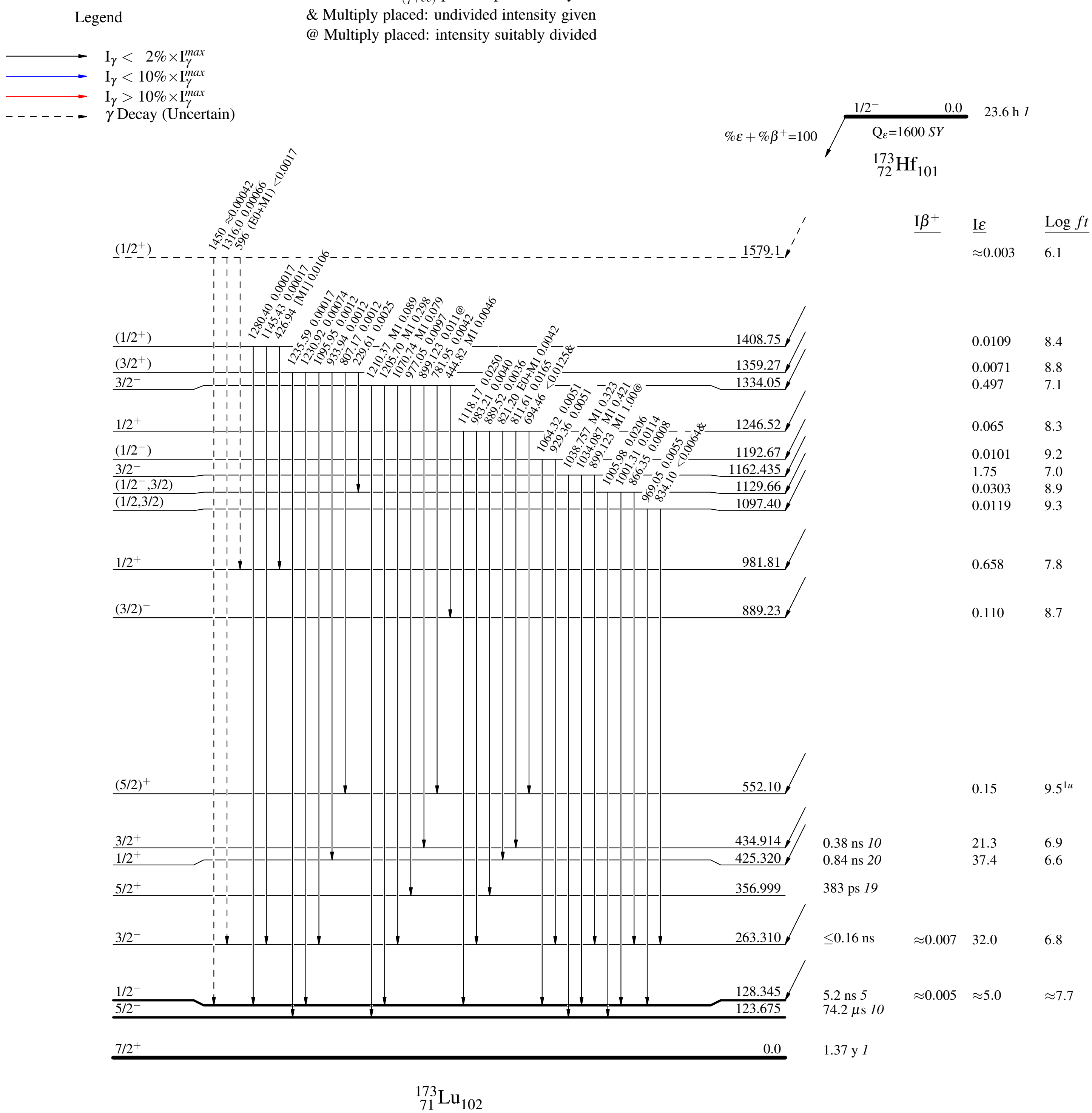
[f] Placement of transition in the level scheme is uncertain.

[x] γ ray not placed in level scheme.

^{173}Hf ε decay 1974Fu01,1975Br15

Decay Scheme

Intensities: $I_{(\gamma+ce)}$ per 100 parent decays
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided



^{173}Hf ε decay 1974Fu01,1975Br15

Decay Scheme (continued)

Intensities: $I_{(\gamma+ce)}$ per 100 parent decays
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided