

¹⁶⁵Lu ε+β⁺ decay (10.74 min) 1980AdZP,1982Ra19

Type	Author	History	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh and Jun Chen		NDS 194,460 (2024)	31-Oct-2022

Parent: ¹⁶⁵Lu: E=0; J^π=1/2⁺; T_{1/2}=10.74 min 10; Q(ε)=3850 40; %ε+%β⁺ decay=100

¹⁶⁵Lu-J^π,T_{1/2}: From ¹⁶⁵Lu Adopted Levels.

¹⁶⁵Lu-Q(ε): From 2021Wa16.

1980AdZP (also 1980AdZO): measured E_γ, I_γ, γγ-coin, γ(ce)-coin, γγ(x-ray)-coin, conversion electrons measured by iron-free beta spectrometer at JINR-Dubna.

1982Ra19: measured E_γ, I_γ, γγ-coin, γ(x ray)-coin, γ(β⁺)-coin, positrons detected using an HPGe detector. ¹⁶⁵Lu activity produced in ¹⁵⁵Gd(¹⁴N,4n),E=9.6 MeV/nucleon at the Manchester University Heavy-Ion Linear Accelerator.

1981By04: measured E_β, I_β, β strength function, mass-separated sources, total absorption (NaI(Tl)) gamma-ray spectrometer.

1979AlYZ: measured γ(ce)-coin, T_{1/2} using iron-free toroidal spectrometer for electrons and a Ge(Li) detector for γ rays.

1978Bu13: measured E_γ, I_γ, γγ-coin, T_{1/2} of ¹⁶⁵Lu decay. ¹⁶⁵Lu source prepared by irradiation of enriched ¹⁵³Eu target with ≈105-MeV ¹⁶O beam from the Yale heavy ion accelerator. A total of 13 γ rays reported from 87.4 keV to 686.0 keV.

1975Gr44: measured γ spectra, T_{1/2} of ¹⁶⁵Lu decay. Source produced.

1973Me25: measured E_γ, I_γ, T_{1/2} of ¹⁶⁵Lu decay using a Ge(Li) and a Compton-suppressed Ge(Li) detector. Source of ¹⁶⁵Lu prepared by irradiating thulium foil with 50-, 60-, 70- and 80-MeV ³He ions from IKO synchrocyclotron. A total of 54 γ rays reported from 39.30 keV to 2005.06 keV. No decay scheme was proposed.

¹⁶⁵Yb Levels

Levels at 252.2, 425.9, 455.2, 613.2 and 642.5 keV proposed in 1978Bu13 have been discarded as the γ rays shown from these levels have been placed elsewhere based on γγ-coin data in 1982Ra19 and 1980AdZP.

E(level) [†]	J ^π [‡]	T _{1/2} [#]	Comments
0.0	5/2 ⁻		
87.51 6	7/2 ⁻	0.80 ns 10	
120.60 6	3/2 ⁻	0.30 ns 4	J ^π : 5/2,7/2,(9/2 ⁻) in 1982Ra19.
126.74 10	9/2 ⁺	300 ns 30	%IT=100
132.49 6	7/2 ⁺	2.8 ns 5	J ^π : 5/2 ⁺ ,7/2 ⁺ in 1980AdZP.
174.23 6	(5/2) ⁻	0.23 ns 4	J ^π : 3/2 ⁻ ,5/2 ⁻ in 1980AdZP; 5/2,(7/2 ⁺) in 1982Ra19.
254.64 10	(5/2)		J ^π : 3/2,5/2,7/2 in 1980AdZP.
324.44 11	(1/2) ⁻		J ^π : 1/2 ⁻ in 1980AdZP.
391.69 15	(3/2) ⁻		J ^π : 1/2 ⁺ ,3/2 ⁻ in 1980AdZP.
400.83 12	(5/2) ⁻		J ^π : 3/2 ⁻ ,5/2 ⁻ in 1980AdZP.
427.6 2	(3/2) ⁻		J ^π : 3/2 ⁻ ,5/2 ⁻ in 1980AdZP.
483.67 15			J ^π : 5/2 ⁺ ,11/2 ⁺ in 1980AdZP.
493.57 15	(3/2,5/2) ⁺		J ^π : 1/2,3/2,5/2 ⁺ in 1980AdZP.
533.16 15	(⁺)		J ^π : 1/2,3/2,5/2 ⁺ in 1980AdZP.
591.30 17			
664.98 20			
669.81 21			
726.36 20			
762.33 15			
783.26 15			Placement of 458.77γ from this level is not supported by γγ-coin data in 1982Ra19. See comment for this γ from 591 level.
807.3 2			
874.2 15			
944.5 2			Level proposed by 1982Ra19 based on γγ-coin data.
948.2 2			
1013.08 2			
1361.4 2			Level proposed by 1982Ra19 based on γγ-coin data.
1559.6 2			Level proposed by 1982Ra19 based on γγ-coin data.
1692.9? 3			Tentative level proposed by 1982Ra19.

Continued on next page (footnotes at end of table)

^{165}Lu $\varepsilon+\beta^+$ decay (10.74 min) 1980AdZP,1982Ra19 (continued) ^{165}Yb Levels (continued)

E(level) [†]	J^π [‡]	Comments
1718.8 8		J^π : 1/2,3/2 in 1980AdZP.
1734.13 20	(3/2 ⁺)	J^π : 1/2,3/2 in 1980AdZP.
1931.0 4		Level proposed by 1982Ra19 based on $\gamma\gamma$ -coin data.
1983.1 3		Level proposed by 1982Ra19 based on $\gamma\gamma$ -coin data.
2007.8 4		Level proposed by 1982Ra19 based on $\gamma\gamma$ -coin data.
2012.0? 4		Tentative level proposed by 1982Ra19.
2125.86 23	(3/2)	J^π : 1/2,3/2 in 1980AdZP.
2800 [@]		
3200 [@]		
3600 [@]		

[†] From a least-squares fit to E_γ data, unless otherwise noted.

[‡] From Adopted Levels.

From $\gamma\gamma(t)$ (1980AdZO).

[@] Pseudo-level indicated by measurement of total absorption γ spectrum and deduction of β strength function in 1981By04.

 ε,β^+ radiations

E(decay)	E(level)	$I\beta^+$ [‡]	$I\varepsilon$ [‡]	Log ft	$I(\varepsilon+\beta^+)$ ^{†‡}	Comments
(2.5×10^2 4)	3600				0.6	
(6.5×10^2 4)	3200				3	
(1.05×10^3 4)	2800				12	
(1.72×10^3 4)	2125.86				48	$I(\varepsilon+\beta^+)$: for 2060 excitation energy (1981By04), levels at 2008 and 2012 are probably included in this feeding.
(2.12×10^3 4)	1734.13				22	$I(\varepsilon+\beta^+)$: for 1700 excitation energy (1981By04), levels at 1692 and 1719 are probably included in this feeding.
(2.49×10^3 4)	1361.4				9	$I(\varepsilon+\beta^+)$: for 1300 excitation energy (1981By04).
(2.84×10^3 4)	1013.08				6	$I(\varepsilon+\beta^+)$: for 1000 excitation energy (1981By04), level at 948 is probably included in this feeding.
(3.85×10^3 [#] 4)	0.0	<0.6	<2.4	>8.5 ^{1u}	<3.0	av $E\beta=1267$ 18; $\varepsilon K=0.667$ 6; $\varepsilon L=0.1071$ 11; $\varepsilon M+=0.0324$ 4 $I(\varepsilon+\beta^+)$: <3.0% for $\log ft>8.5$ for first-forbidden unique transition.

[†] From β strength measurement of 1981By04. This study indicates that most of the β feedings populate levels in the energy range 1.5 to 2.5 MeV excitation energy, and that feeding to low-lying levels (below 1 MeV) and to levels above 3.5 MeV is weak.

[‡] Absolute intensity per 100 decays.

Existence of this branch is questionable.

¹⁶⁵Lu ε+β⁺ decay (10.74 min) 1980AdZP,1982Ra19 (continued)

γ(¹⁶⁵Yb)

I_γ normalization: sufficient data are lacking to deduce normalization factor for converting relative photon intensities to per 100 decays of the parent.

Experimental conversion coefficients given in this dataset are deduced by evaluators from I(ce) values given in 1980AdZP, and normalized to

α(K)(120.6γ,M1+E2,δ=0.16 +8-5)=1.63 4. α(K)=1.56 was used for δ≤0.18 by 1980AdZP.

Sufficient data are lacking to deduce γ-normalization factor for converting relative photon intensities to per 100 decays of the parent, as the direct ε+β⁺ feeding to the ground state is unknown, although, as a first-forbidden unique transition it is expected to be weak. Other unknowns are that multiplicities of many fairly low-energy γ-ray transitions are unknown, about 58 γ rays remain unassigned in the level scheme, which may or may not account for possible missing transitions from unobserved levels in a gap of 1.7 MeV between the highest observed level at E=2126 keV and Q-value=3850 keV.

<u>E_γ[†]</u>	<u>I_γ[†]</u>	<u>E_i(level)</u>	<u>J_i^π</u>	<u>E_f</u>	<u>J_f^π</u>	<u>Mult.[‡]</u>	<u>δ[‡]</u>	<u>α[#]</u>	<u>I_(γ+ce)</u>	<u>Comments</u>
(5.72)		132.49	7/2 ⁺	126.74	9/2 ⁺	[M1]		582 8	≈116	α(M)=458 6 α(N)=107.7 15; α(O)=15.32 21; α(P)=0.810 11 I(γ+ce)(5.72γ) is comparable to I(γ+ce)(132γ) (1982Ra19).
39.23 8	35.7 30	126.74	9/2 ⁺	87.51	7/2 ⁻	E1		0.802 12		L1:M1=6 1:2 1 (1980AdZP) α(L)=0.624 9; α(M)=0.1414 21 α(N)=0.0319 5; α(O)=0.00381 6; α(P)=0.0001145 17 E _γ =38.94 19, I _γ =54.6 76 (1982Ra19). E _γ =39.30 10, I _γ =31 5 (1973Me25). α(L) _{exp} =2.6 5 α(L)=2.65 5; α(M)=0.593 10 α(N)=0.1392 24; α(O)=0.01987 34; α(P)=0.001055 18 E _γ ,I _γ : from 1982Ra19; γ not listed in 1980AdZP, although, observed as an L-shell conversion line. Ice(L)=15 3 (1980AdZP). α(K)=5.2 35; α(L)=6 5; α(M)=1.5 12 α(N)=0.34 27; α(O)=0.039 29; α(P)=3.2×10 ⁻⁴ 22 E _γ : from 1979AIYZ only. Transition observed only in ce spectra in 1980AdZP, ce(K)=13.6 if Ice(K)(120.6γ)=156.
53.66 18	6.1 7	174.23	(5/2) ⁻	120.60	3/2 ⁻	(M1)		3.40 6		K:L1=20 4:3.0 15 (1980AdZP) α(K)=4.25 6; α(L)=0.652 9; α(M)=0.1461 21 α(N)=0.0343 5; α(O)=0.00490 7; α(P)=0.000261 4 E _γ =86.76 17, I _γ =5.5 5 (1982Ra19). α(K)=2.59 11; α(L)=1.99 9; α(M)=0.485 23 α(N)=0.111 6; α(O)=0.0131 6; α(P)=0.000147 7 E _γ =87.57 17, I _γ =24.8 25 (1982Ra19). E _γ =87.4 2, I _γ =11.4 16 (1978Bu13).
67.4 ^a		391.69	(3/2) ⁻	324.44	(1/2) ⁻	[M1,E2]		13.1 26		
80.4 3		254.64	(5/2)	174.23	(5/2) ⁻					
86.71 6	5.4 6	174.23	(5/2) ⁻	87.51	7/2 ⁻	M1		5.09 7		
87.54 6	23.0 16	87.51	7/2 ⁻	0.0	5/2 ⁻	E2+M1	1.10 +8-7	5.19 8		

¹⁶⁵Lu ε+β⁺ decay (10.74 min) **1980AdZP,1982Ra19 (continued)**

γ(¹⁶⁵Yb) (continued)

<u>E_γ[†]</u>	<u>I_γ[†]</u>	<u>E_i(level)</u>	<u>J_i^π</u>	<u>E_f</u>	<u>J_f^π</u>	<u>Mult.[‡]</u>	<u>δ[‡]</u>	<u>α[#]</u>	<u>Comments</u>
									K:L1:L2:L3:M2:M3=30 6:3.0 15:30 6:30 2:7 2:7 2 (1980AdZP). Mult.,δ: from the Adopted Levels, Gammas dataset. Others: δ(E2/M1)≥2.8 from data for K, L1, L2, L3, M2 and M3 shells, and using BrIccMixing code; ≤15% M1, or δ(E2/M1)≥2.4 (1980AdZP). I _γ : 1980AdZP list 14.3 relative to I _γ (120.6)=1000, evaluators assume the value as 14 3. E _γ ,I _γ : γ from 1982Ra19 only, I _γ from γγ-coin data. α(K)=1.7 8; α(L)=0.9 5; α(M)=0.22 13 α(N)=0.050 29; α(O)=0.0060 31; α(P)=1.0×10 ⁻⁴ 6 E _γ ,I _γ : γ from 1982Ra19 only, I _γ from γγ-coin data. α(K)=1.63 4; α(L)=0.264 14; α(M)=0.059 4 α(N)=0.0139 8; α(O)=0.00196 9; α(P)=9.9×10 ⁻⁵ 3 E _γ =120.68 15, I _γ =100 (1982Ra19). E _γ =120.58 5, I _γ =100 (1973Me25). E _γ =120.2 2, I _γ =100 7 (1978Bu13). Ice(K)=156 31 and 158 32 (1980AdZP). K:L1:L2:L3:M1=156 31:22 5:3.0 15:0.9 5:5.0 25 (1980AdZP). δ(E2/M1)=0.7 +4-2 using data for K, L1, L2, L3 and M1 shells, but reduced χ ² is large. Using only the data for L1, L2 and L3 shells, δ(E2/M1)=0.16 +8-5, closer to the values of ≤0.18 listed by 1980AdZP. α(K)(120.6γ,M1(+E2),δ≤0.18)=1.56 were used for normalization of α(K)exp values in 1980AdZP. Here evaluators use α(K)(120.6γ)=1.63 4 for δ(E2/M1)(120.6)=0.16 +8-5.
^x 93.33 8	1.4 3								
97.43 17	2.3 3	591.30		493.57	(3/2,5/2) ⁺				
103.73 17	12.6 25	427.6	(3/2) ⁻	324.44	(1/2) ⁻	[M1,E2]		2.91 13	
120.60 6	100 6	120.60	3/2 ⁻	0.0	5/2 ⁻	M1+E2	0.16 +8-5	1.97 3	
121.92 10	4.2 7	254.64	(5/2)	132.49	7/2 ⁺				
127.52 ^a 20	6 1	254.64	(5/2)	126.74	9/2 ⁺				
132.49 6	100 6	132.49	7/2 ⁺	0.0	5/2 ⁻	E1		0.1629 23	E _γ ,I _γ : unplaced γ from 1973Me25 only, γ not reported in 1980AdZP and 1982Ra19. Tentative placement suggested in 1987Pe01 evaluation based on level-energy difference. α(K)exp=0.13 3 α(K)=0.1354 19; α(L)=0.02141 30; α(M)=0.00479 7 α(N)=0.001105 16; α(O)=0.0001477 21; α(P)=6.22×10 ⁻⁶ 9 E _γ =132.50 10, I _γ =84 9 (1982Ra19). E _γ =132.43 10, I _γ =92 5 (1973Me25). E _γ =132.0 2, I _γ =84.9 64 (1978Bu13), placed from a 252 level). Ice(K)=12 3 and 10 2 (1980AdZP). Additional information 1.
134.10 16	4.6 10	254.64	(5/2)	120.60	3/2 ⁻				
167.07 10	2.5 4	254.64	(5/2)	87.51	7/2 ⁻				

¹⁶⁵Lu ε+β⁺ decay (10.74 min) **1980AdZP,1982Ra19** (continued)

γ(¹⁶⁵Yb) (continued)

E_γ †	I_γ †	$E_i(\text{level})$	J_i^π	E_f	J_f^π	Mult. ‡	δ^\ddagger	$\alpha^\#$	Comments
172.86 8	6.5 7	427.6	(3/2) ⁻	254.64	(5/2)				$\alpha(\text{K})_{\text{exp}}=0.38$ (1980AdZP)
174.25 6	47.0 25	174.23	(5/2) ⁻	0.0	5/2 ⁻	M1+E2	0.32 +45-21	0.67 8	K:L1:L2=22 5:2.5 12:0.50 25; K:L=22 5:3.6 18 (1980AdZP) $\alpha(\text{K})=0.55$ 10; $\alpha(\text{L})=0.094$ 15; $\alpha(\text{M})=0.021$ 4 $\alpha(\text{N})=0.0050$ 9; $\alpha(\text{O})=0.00069$ 8; $\alpha(\text{P})=3.3 \times 10^{-5}$ 7 $E_\gamma=174.30$ 30, $I_\gamma=40$ 8 (1982Ra19). $E_\gamma=174.22$ 10, $I_\gamma=50$ 5 (1973Me25). $E_\gamma=173.7$ 2, $I_\gamma=38.4$ 59 (1978Bu13, placed from a 426 level). $\delta(\text{E2/M1})$ from K, L, L1 and L2 electron data. 1980AdZP give $\leq 15\%$ E2 or $\delta(\text{E2/M1}) \leq 0.42$.
203.68 6	38.0 25	324.44	(1/2) ⁻	120.60	3/2 ⁻	M1		0.453 6	K:L1:L2=18 4:2 1:0.30 15 (1980AdZP) $\alpha(\text{K})=0.379$ 5; $\alpha(\text{L})=0.0574$ 8; $\alpha(\text{M})=0.01284$ 18 $\alpha(\text{N})=0.00301$ 4; $\alpha(\text{O})=0.000431$ 6; $\alpha(\text{P})=2.303 \times 10^{-5}$ 32 $E_\gamma=203.61$ 10, $I_\gamma=28.2$ 33 (1982Ra19). $E_\gamma=203.58$ 5, $I_\gamma=42$ 5 (1973Me25). $E_\gamma=203.0$ 2, $I_\gamma=51.5$ 37 (1978Bu13, unplaced).
217.43 6	20.0 15	391.69	(3/2) ⁻	174.23	(5/2) ⁻	M1(+E2)		0.29 9	$\alpha(\text{K})_{\text{exp}}=0.31$ 6 $\alpha(\text{K})=0.22$ 9; $\alpha(\text{L})=0.052$ 4; $\alpha(\text{M})=0.0122$ 15 $\alpha(\text{N})=0.00282$ 31; $\alpha(\text{O})=0.000370$ 11; $\alpha(\text{P})=1.3 \times 10^{-5}$ 7 $E_\gamma=217.33$ 10, $I_\gamma=16.1$ 17 (1982Ra19). $E_\gamma=217.40$ 5, $I_\gamma=19$ 2 (1973Me25). $E_\gamma=216.6$ 2, $I_\gamma=26.7$ 22 (1978Bu13, placed from a 643 level). $\text{Ice}(\text{K}) \geq 2$ and 5.9 12 (1980AdZP). $\delta(\text{E2/M1}) < 0.75$ from $\alpha(\text{K})_{\text{exp}}$.
253.43 7	16.2 15	427.6	(3/2) ⁻	174.23	(5/2) ⁻	M1,E2		0.19 6	$\alpha(\text{K})_{\text{exp}}=0.09$ 5 (1980AdZP); $\alpha(\text{K})_{\text{exp}}=0.32$ 16 (1980AdZP) $\alpha(\text{K})=0.15$ 6; $\alpha(\text{L})=0.0311$ 5; $\alpha(\text{M})=0.00719$ 21 $\alpha(\text{N})=0.001672$ 35; $\alpha(\text{O})=0.000223$ 13; $\alpha(\text{P})=8.E-6$ 4 $E_\gamma=253.61$ 15, $I_\gamma=16.8$ 25 (1982Ra19). $E_\gamma=253.44$ 10, $I_\gamma=16$ 2 (1973Me25). $E_\gamma=252.2$ 2, $I_\gamma=15.3$ 13 (1978Bu13, placed from a 252 level). $\text{Ice}(\text{K})=1.5$ 7 and 5.0 25 (1980AdZP). $\alpha(\text{K})_{\text{exp}}$ values overlap M1 and E2.
254.89 11	4.0 7	254.64	(5/2)	0.0	5/2 ⁻				$E_\gamma=268.57$ 10, $I_\gamma=5.2$ 6 (1982Ra19).
268.72 11	6.0 7	762.33		493.57	(3/2,5/2) ⁺				$E_\gamma=268.67$ 12, $I_\gamma=6.0$ 10 (1973Me25).
271.15 10	19.8 10	391.69	(3/2) ⁻	120.60	3/2 ⁻	M1(+E2)		0.15 5	$\alpha(\text{K})_{\text{exp}}=0.24$ 12 $\alpha(\text{K})=0.12$ 5; $\alpha(\text{L})=0.0249$ 12; $\alpha(\text{M})=0.00575$ 11 $\alpha(\text{N})=0.00134$ 4; $\alpha(\text{O})=0.000179$ 17; $\alpha(\text{P})=7.0 \times 10^{-6}$ 35 $\delta(\text{E2/M1}) < 0.75$. $E_\gamma=270.73$ 15, $I_\gamma=19.7$ 17 (1982Ra19). $E_\gamma=271.03$ 6, $I_\gamma=20.5$ 15 (1973Me25). $E_\gamma=270.4$ 2, $I_\gamma=18.4$ 13 (1978Bu13, unplaced).

¹⁶⁵Lu ε+β⁺ decay (10.74 min) [1980AdZP](#),[1982Ra19](#) (continued)

γ(¹⁶⁵Yb) (continued)

E_γ †	I_γ †	E_i (level)	J_i^π	E_f	J_f^π	Mult. ‡	$\alpha^\#$	Comments
279.82 10	3.5 6	400.83	(5/2) ⁻	120.60	3/2 ⁻	M1(+E2)	0.14 5	Ice(K)≥1.2 and 4.5 22 (1980AdZP). δ(E2/M1)<1.0 from α(K)exp. α(K)exp=0.24 12 (1980AdZP) α(K)=0.11 5; α(L)=0.0225 14; α(M)=0.00519 17 α(N)=0.00121 5; α(O)=0.000162 18; α(P)=6.4×10 ⁻⁶ 32 Ice(K)=0.8 4 (1980AdZP). δ(E2/M1)<0.9 from α(K)exp. Eγ=312.93 5, Iγ=2.4 3 (1973Me25). Eγ=319.50 30, Iγ=5.5 5 (1982Ra19). Eγ=319.51 20, Iγ=4.5 10 (1973Me25). α(K)exp=0.06 3 α(K)=0.0426 6; α(L)=0.01226 17; α(M)=0.00290 4 α(N)=0.000669 9; α(O)=8.48×10 ⁻⁵ 12; α(P)=2.206×10 ⁻⁶ 31 Eγ=324.03 34, Iγ=6.1 10 (1982Ra19). Eγ=324.70 20, Iγ=5.0 5 (1973Me25). Ice(K)=0.2 1 and 0.50 25 (1980AdZP).
313.78 12	3.0 5	400.83	(5/2) ⁻	87.51	7/2 ⁻			
319.46 10	4.2 6	493.57	(3/2,5/2) ⁺	174.23	(5/2) ⁻			
324.54 11	3.4 6	324.44	(1/2) ⁻	0.0	5/2 ⁻	E2	0.0585 8	
340.10 25	1.8 4	427.6	(3/2) ⁻	87.51	7/2 ⁻			
345.37 18	1.7 4	669.81		324.44	(1/2) ⁻			
356.93& 10	8& 2	483.67		126.74	9/2 ⁺			α(K)exp=0.035 17 (1980AdZP) The Eγ, Iγ values from 1982Ra19 , 1973Me25 and 19878Bu13 for this γ are listed from 484 level. Ice(K)=0.6 3 and 0.8 4 (1980AdZP).
356.93& 10	12& 2	948.2		591.30		(E2)	0.0444 6	α(K)exp=0.036 18 α(K)=0.0330 5; α(L)=0.00877 12; α(M)=0.002063 29 α(N)=0.000477 7; α(O)=6.11×10 ⁻⁵ 9; α(P)=1.737×10 ⁻⁶ 24 Total Iγ=19.9 8 for the doublet (1980AdZP). Eγ=356.83 10, Iγ=21 3 (1982Ra19 , combined Iγ for double placement, 15 3 from 948 level, 10 4 from 484 level). Eγ=356.52 10, Iγ=20.8 15 (1973Me25 , combined Iγ for double placement, other placement from 484 level). Eγ=356.2 2, Iγ=16.9 14 (1978Bu13). Ice(K)=0.6 3 and 0.8 4 (1980AdZP). δ(E2/M1)>1.5 from α(K)exp.
361.07 10	29.3 12	493.57	(3/2,5/2) ⁺	132.49	7/2 ⁺	M1,E2	0.069 27	α(K)exp=0.057 28 α(K)=0.056 24; α(L)=0.0102 18; α(M)=0.00233 35 α(N)=0.00054 9; α(O)=7.5×10 ⁻⁵ 16; α(P)=3.3×10 ⁻⁶ 16 Eγ=361.05 14, Iγ=32 3 (1982Ra19). Eγ=360.51 10, Iγ=32.7 20 (1973Me25). Eγ=361.0 2, Iγ=28.8 11 (1978Bu13 , placed from a 613 level). Ice(K)=1.5 7 and 1.7 8 (1980AdZP). α(K)exp values overlap M1 and E2.

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¹⁶⁵Lu ε+β⁺ decay (10.74 min) **1980AdZP,1982Ra19** (continued)

γ(¹⁶⁵Yb) (continued)

<u>E_γ[†]</u>	<u>I_γ[†]</u>	<u>E_i(level)</u>	<u>J_i^π</u>	<u>E_f</u>	<u>J_f^π</u>	<u>Mult.[‡]</u>	<u>α[#]</u>	<u>Comments</u>
372.97 10	12.8 6	493.57	(3/2,5/2) ⁺	120.60	3/2 ⁻	E1	0.01181 17	α(K)exp=0.017 8 α(K)=0.00995 14; α(L)=0.001446 20; α(M)=0.000322 5 α(N)=7.49×10 ⁻⁵ 11; α(O)=1.045×10 ⁻⁵ 15; α(P)=5.14×10 ⁻⁷ 7 Eγ=373.01 14, Iγ=15.1 25 (1982Ra19). Eγ=372.45 10, Iγ=13.4 15 (1973Me25). Eγ=372.0 2, Iγ=12.7 52 (1978Bu13, unplaced). Ice(K)=0.2 1 (1980AdZP). Placement from 1982Ra19. Unplaced in 1980AdZP. Eγ=391.45 17, Iγ=7.2 13 (1982Ra19).
391.76 10	3.5 5	391.69	(3/2) ⁻	0.0	5/2 ⁻			
^x 398.06 24	2.1 4							
400.55 10	20.0 8	533.16	(⁺)	132.49	7/2 ⁺	(E2)	0.0321 4	α(K)exp=0.026 13 α(K)=0.02440 34; α(L)=0.00594 8; α(M)=0.001389 19 α(N)=0.000322 5; α(O)=4.17×10 ⁻⁵ 6; α(P)=1.306×10 ⁻⁶ 18 Eγ=400.56 25, Iγ=25 3 (1982Ra19). Ice(K)=0.50 25 (1980AdZP). Weak γγ-coin evidence in 1982Ra19 in their Table 2.
412.70 21	1.7 3	533.16	(⁺)	120.60	3/2 ⁻			
415.80 17	1.7 4	807.3		391.69	(3/2) ⁻			
^x 426.23 18	1.6 3							
^x 431.93 25	1.0 2							
^x 443.00 30	1.5 5							Eγ,Iγ: γ from 1973Me25 only, could correspond to 444.79γ in 1980AdZP.
^x 444.79 16	1.3 2							
455.31 16	2.5 3	948.2		493.57	(3/2,5/2) ⁺			Eγ=454.97 15, Iγ=2.2 10 (1982Ra19). Eγ=454.70 30, Iγ=3.0 6 (1973Me25). Eγ=455.2 2, Iγ=10.2 7 (1978Bu13). Eγ=458.56 10, Iγ=15.0 21 (1982Ra19, placed from 591 level only based on γγ-coin data). 1980AdZP placed this γ from 783 level, which is not consistent with γγ-coin data in 1982Ra19. Evaluators prefer assignment of 458.77γ from 591 level. Eγ=458.12 12, Iγ=12.4 10 (1973Me25).
458.77 12	12.4 6	591.30		132.49	7/2 ⁺			
472.04 17	2.5 4	726.36		254.64	(5/2)			
^x 479.20 16	1.6 4							
^x 485.10 27	0.9 3							
^x 494.68 18	1.6 2							
519.51 15	5.7 5	1013.08		493.57	(3/2,5/2) ⁺			Eγ=519.55 20, Iγ=5.0 4 (1982Ra19). Eγ=519.36 15, Iγ=7.2 10 (1973Me25).
^x 525.46 25	1.8 4							
532.82 15	4.3 4	664.98		132.49	7/2 ⁺			Eγ=532.82 38, Iγ=6.7 2 (1982Ra19, uncertainty for Iγ seems too low in comparison to those for other Iγ values). Eγ=532.69 20, Iγ=4.6 10 (1973Me25). Eγ=544.50 17, Iγ=4.8 17 (1982Ra19). Eγ=544.04 25, Iγ=3.8 10 (1973Me25).
543.95 15	3.2 3	664.98		120.60	3/2 ⁻			

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¹⁶⁵Lu ε+β⁺ decay (10.74 min) **1980AdZP,1982Ra19** (continued)

γ(¹⁶⁵Yb) (continued)

E_γ †	I_γ †	E_i (level)	E_f	J_f^π	Comments
549.80 20	4.3 7	874.2	324.44	(1/2) ⁻	Eγ=552.01 17, Iγ=8.6 21 (1982Ra19). Eγ=552.35 15, Iγ=8.2 10 (1973Me25).
552.07 12	9.8 8	726.36	174.23	(5/2) ⁻	
^x 566.91 12	2.5 2				
^x 578.66 15	2.1 3				
605.79 14	4.0 4	726.36	120.60	3/2 ⁻	Eγ=605.8 6, Iγ=3.9 8 (1982Ra19). Eγ=605.96 20, Iγ=4.8 10 (1973Me25).
608.98 10	8.6 5	783.26	174.23	(5/2) ⁻	Eγ=609.3 6, Iγ=5.9 12 (1982Ra19). Eγ=609.11 15, Iγ=8.2 10 (1973Me25).
^x 613.66 33	1.0 3				
623.38 23	1.3 3	948.2	324.44	(1/2) ⁻	Eγ=629.7 4, Iγ=7.6 17 (1982Ra19). Eγ=629.75 20, Iγ=5.6 10 (1973Me25).
629.89 10	6.9 4	762.33	132.49	7/2 ⁺	
638.50 16	2.9 3	726.36	87.51	7/2 ⁻	
^x 655.78 28	0.8 3				Eγ=655.87 20, Iγ=5.0 10 (1973Me25).
^x 659.54 15	4.4 6				Eγ=659.65 25, Iγ=6.0 10 (1973Me25).
662.72 11	6.6 4	783.26	120.60	3/2 ⁻	Eγ=662.8 2, Iγ=5.9 8 (1982Ra19). Eγ=662.63 20, Iγ=6.6 10 (1973Me25).
^x 671.07 10	10.7 5				
686.54 10	10.3 5	807.3	120.60	3/2 ⁻	Eγ=687.3 1, Iγ=11.7 25 (1982Ra19, placed from 874 level). Eγ=686.60 15, Iγ=10.2 10 (1973Me25). Eγ=686.0 2, Iγ=14.7 12 (1978Bu13, unplaced). Eγ=727.03 30, Iγ=4.4 10 (1973Me25).
^x 726.87 11	3.9 3				
753.55 11	7.0 5	874.2	120.60	3/2 ⁻	Eγ=753.66 15, Iγ=5.7 8 (1982Ra19). Eγ=753.48 15, Iγ=8.8 8 (1973Me25).
770.33 ^{@a} 14	4.0 [@] 5	944.5	174.23	(5/2) ⁻	This γ placed from 1719 level in 1980AdZP. Eγ=770.8 5, Iγ=5.9 17 (1982Ra19, tentative placement). Eγ=770.68 40, Iγ=3.7 7 (1973Me25).
770.33 [@] 14	4.0 [@] 5	1718.8	948.2		Tentative placement by 1982Ra19 from 944 level only, while 1980AdZP place this γ from 1719 level only. For Eγ, Iγ data for this γ in 1982Ra19 and 1973Me25, see the listing of γ-ray data for 944 level. Evaluators place this γ from both the levels.
811.8 3	2.8 11	944.5	132.49	7/2 ⁺	Eγ, Iγ: γ from 1982Ra19 only, Iγ from γγ-coin data.
815.31 14	5.5 4	948.2	132.49	7/2 ⁺	Eγ=815.2 3, Iγ=2.8 11 (1982Ra19). Eγ=815.32 30, Iγ=4.7 10 (1973Me25).
824.06 15	4.4 4	944.5	120.60	3/2 ⁻	γ unplaced in 1980AdZP. Eγ=823.9 2, Iγ=5.5 8 (1982Ra19).
827.61 25	2.3 3	948.2	120.60	3/2 ⁻	
860.6 30	1.7 3	948.2	87.51	7/2 ⁻	
^x 875.19 15	3.8 3				
^x 891.31 27	1.0 2				
^x 896.20 17	2.1 3				

¹⁶⁵Lu ε+β⁺ decay (10.74 min) **1980AdZP,1982Ra19** (continued)

γ(¹⁶⁵Yb) (continued)

E_γ †	I_γ †	E_i (level)	J_i^π	E_f	J_f^π	Comments
^x 930.67 25	2.0 4					
^x 943.54 15	3.6 4					
^x 963.19 19	2.7 4					
^x 978.73 26	2.3 5					
^x 1029.93 25	6.5 15					E _γ ,I _γ : γ from 1973Me25 only.
^x 1050.59 17	4.7 5					E _γ =1050.13 30, I _γ =5.4 10 (1973Me25).
^x 1073.35 25	7.5 15					E _γ ,I _γ : γ from 1973Me25 only.
^x 1114.60 33	1.7 5					
1127.81 52	0.8 3	1718.8		591.30		
^x 1131.30 43	1.6 3					
^x 1144.70 18	3.1 3					
^x 1182.02 23	3.4 4					E _γ =1181.90 50, I _γ =2.8 10 (1973Me25).
^x 1187.93 20	2.7 3					
1240.82 16	4.7 4	1361.4		120.60	3/2 ⁻	This γ is placed from 1734 level only in 1980AdZP , whereas 1982Ra19 place this γ from 1361 level only, based on its observation in coincidence with 120γ. Evaluators prefer the assignment in 1982Ra19 . E _γ =1240.58 18, I _γ =4.7 13 (1982Ra19). E _γ =1240.57 35, I _γ =6.2 10 (1973Me25).
^x 1248.76 21	2.1 3					
^x 1265.36 40	1.8 6					
^x 1268.27 43	1.7 6					
^x 1281.12 17	5.6 4					E _γ =1280.89 25, I _γ =5.9 10 (1973Me25).
^x 1288.72 40	3.5 12					
1291.16 74	1.8 8	1718.8		427.6	(3/2) ⁻	E _γ =1290.14 40, I _γ =4.0 10 (1973Me25).
1306.52 18	5.7 4	1734.13	(3/2 ⁺)	427.6	(3/2) ⁻	
^x 1329.75 21	2.9 6					E _γ =1329.09 35, I _γ =6.2 10 (1973Me25).
^x 1334.99 28	2.3 4					
1342.41 ^a 31	2.0 4	1734.13	(3/2 ⁺)	391.69	(3/2) ⁻	Tentative placement suggested in 1987Pe01 evaluation based on level-energy difference; unplaced in 1980AdZP .
^x 1368.12 21	3.1 4					
^x 1391.97 23	2.7 4					
1427.09 17	4.4 4	1559.6		132.49	7/2 ⁺	This γ is unplaced in 1980AdZP . E _γ =1426.6 6, I _γ =4.8 9 (1982Ra19). E _γ =1438.65 70, I _γ =2.3 7 (1973Me25).
^x 1438.66 37	1.3 4					
^x 1454.10 23	2.1 3					
1461.12 33	2.0 4	2125.86	(3/2)	664.98		
1478.88 ^a 22	2.3 3	2012.0?		533.16	(⁺)	This γ is unplaced in 1980AdZP . E _γ =1478.6 2, I _γ =1.0 3 (1982Ra19). E _γ =1479.02 45, I _γ =2.6 8 (1973Me25).
^x 1519.16 21	2.3 3					
^x 1539.08 22	1.7 2					

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¹⁶⁵Lu ε+β⁺ decay (10.74 min) **1980AdZP,1982Ra19** (continued)

γ(¹⁶⁵Yb) (continued)

<u>E_γ[†]</u>	<u>I_γ[†]</u>	<u>E_i(level)</u>	<u>J_i^π</u>	<u>E_f</u>	<u>J_f^π</u>	<u>Comments</u>
1559.86 15	7.2 4	1734.13	(3/2 ⁺)	174.23	(5/2) ⁻	E _γ =1560.24 18, I _γ =5.0 10 (1982Ra19). E _γ =1560.02 30, I _γ =7.7 10 (1973Me25).
1572.29 ^a 18	2.7 3	1692.9?		120.60	3/2 ⁻	This γ is unplaced in 1980AdZP. E _γ =1571.8 4, I _γ =2.9 10 (1982Ra19, tentative placement). E _γ =1572.33 55, I _γ =2.5 7 (1973Me25).
1601.43 13	16.4 7	1734.13	(3/2 ⁺)	132.49	7/2 ⁺	E _γ =1601.58 13, I _γ =9.6 15 (1982Ra19).
1606.57 28	2.3 3	1931.0		324.44	(1/2) ⁻	E _γ =1601.56 20, I _γ =16.0 15 (1973Me25). This γ is unplaced in 1980AdZP.
1613.46 13	15.1 7	1734.13	(3/2 ⁺)	120.60	3/2 ⁻	E _γ =1606.0 10, I _γ =1.3 4 (1982Ra19). E _γ =1613.42 10, I _γ =10.4 15 (1982Ra19).
1632.21 21	2.7 3	2125.86	(3/2)	493.57	(3/2,5/2) ⁺	E _γ =1613.51 20, I _γ =16.0 15 (1973Me25).
^x 1672.21 23	4.8 6					
1734.13 16	11.6 8	2125.86	(3/2)	391.69	(3/2) ⁻	E _γ =1734.28 19, I _γ =9.7 13 (1982Ra19). E _γ =1734.40 30, I _γ =9.0 15 (1973Me25).
^x 1746.22 27	2.2 3					
^x 1779.36 34	1.3 3					
^x 1790.12 27	1.8 3					
1801.34 20	6.9 6	2125.86	(3/2)	324.44	(1/2) ⁻	E _γ =1801.2 3, I _γ =4.0 8 (1982Ra19). E _γ =1801.90 35, I _γ =7.6 15 (1973Me25).
^x 1807.98 24	3.6 4					E _γ =1808.08 50, I _γ =4.4 15 (1973Me25).
^x 1833.06 25	2.1 2					
1862.45 25	3.5 4	1983.1		120.60	3/2 ⁻	This γ is unplaced in 1980AdZP. E _γ =1861.0 4, I _γ =2.8 4 (1982Ra19). E _γ =1862.27 45, I _γ =4.6 15 (1973Me25).
1887.21 28	3.8 4	2007.8		120.60	3/2 ⁻	This γ is unplaced in 1980AdZP. E _γ =1886.9 8, I _γ =1.8 3 (1982Ra19). E _γ =1887.05 45, I _γ =4.3 15 (1973Me25).
^x 1907.97 47	1.0 2					
^x 1922.55 30	2.6 3					
^x 1943.70 37	1.3 2					
1951.88 36	1.4 2	2125.86	(3/2)	174.23	(5/2) ⁻	
^x 1980.57 38	1.7 3					
^x 1988.70 48	1.0 2					
2005.25 32	5.2 6	2125.86	(3/2)	120.60	3/2 ⁻	E _γ =2004.9 3, I _γ =3.2 4 (1982Ra19). E _γ =2005.06 50, I _γ =4.4 15 (1973Me25).
^x 2032.64 38	2.6 4					
^x 2154.49 50	1.8 3					

[†] From 1980AdZP, except where noted otherwise. Available values from 1982Ra19 and 1973Me25 are listed for comparison. However, evaluators prefer to adopt data

$\gamma(^{165}\text{Yb})$ (continued)

from 1980AdZP as these are the most extensive as well as generally better in precision. It should be noted that relative γ -ray intensities are in general agreement with those in 1973Me25, but not with those in 1982Ra19.

‡ From subshell ratios, and $\alpha(\text{K})_{\text{exp}}$ or $\alpha(\text{L})_{\text{exp}}$, the latter normalized to $\alpha(\text{K})(120.6)=1.63$ for M1+E2, $\delta=0.16$ +8-5 deduced by evaluators using BrIccMixing code. In 1980AdZP, $\alpha(\text{K})(120.6)=1.56$ was used for normalization based on $\delta\leq 0.18$. Uncertainties for electron intensities in 1980AdZP are stated as $\leq 20\%$ for $I(e)>5$, and ≈ 50 for $I(e)\leq 5$. Evaluators assign 20% for $I(e)>5$. The same mult and δ assignments are given in the Adopted dataset for transitions from levels populated in this decay, except for the 87.54-keV g.s. transition for which $\delta(\text{E2/M1})$ is from the Adopted Levels, Gammas dataset. Two sets of $I(\text{ce})$ values are listed in 1980AdZP, as given under comments.

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

@ Multiply placed with undivided intensity.

& Multiply placed with intensity suitably divided.

^a Placement of transition in the level scheme is uncertain.

^x γ ray not placed in level scheme.

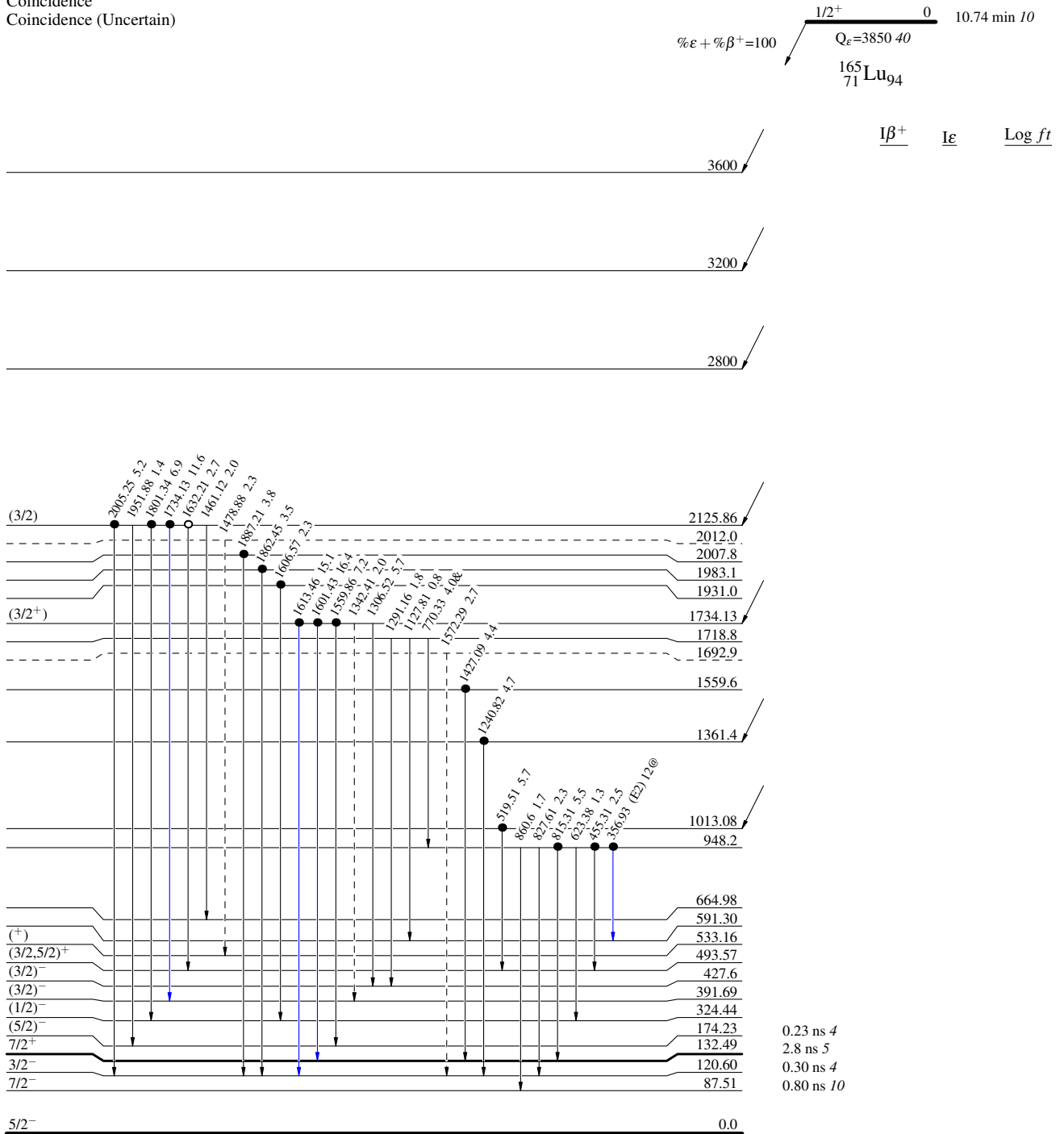
^{165}Lu ϵ decay (10.74 min) 1980AdZP,1982Ra19

Legend

- $I_\gamma < 2\% \times I_\gamma^{\text{max}}$
- $I_\gamma < 10\% \times I_\gamma^{\text{max}}$
- $I_\gamma > 10\% \times I_\gamma^{\text{max}}$
- - - - γ Decay (Uncertain)
- Coincidence
- Coincidence (Uncertain)

Decay Scheme

Intensities: Relative I_γ
 & Multiply placed: undivided intensity given
 @ Multiply placed: intensity suitably divided



^{165}Lu ϵ decay (10.74 min) 1980AdZP,1982Ra19

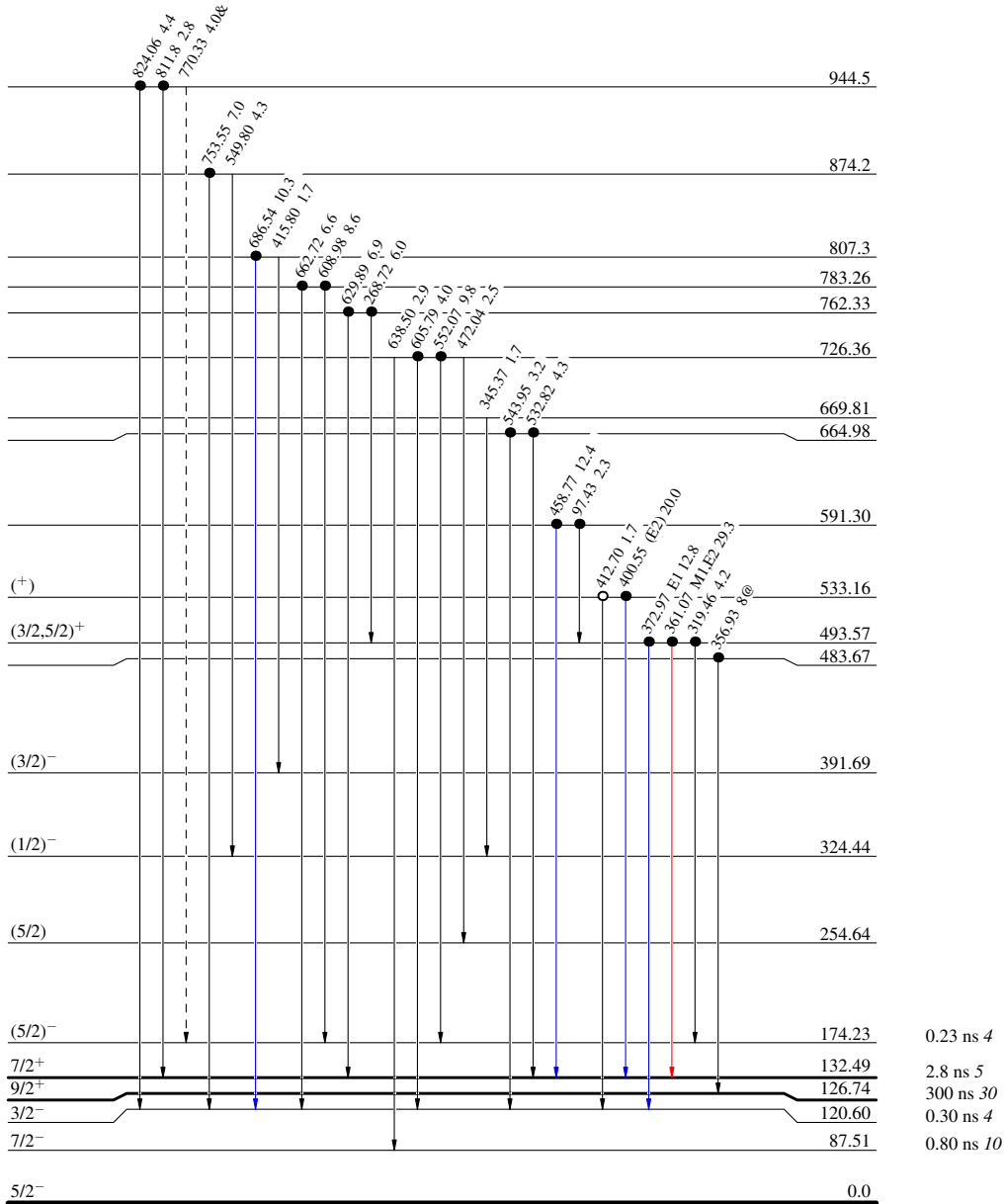
Decay Scheme (continued)

Legend

- $I_\gamma < 2\% \times I_\gamma^{max}$
- $I_\gamma < 10\% \times I_\gamma^{max}$
- $I_\gamma > 10\% \times I_\gamma^{max}$
- - -→ γ Decay (Uncertain)
- Coincidence
- Coincidence (Uncertain)

Intensities: Relative I_γ
 & Multiply placed: undivided intensity given
 @ Multiply placed: intensity suitably divided

$^{165}_{71}\text{Lu}_{94}$ $1/2^+$ 0 10.74 min 10
 $Q_\epsilon = 3850.40$
 $\% \epsilon + \% \beta^+ = 100$



$^{165}_{70}\text{Yb}_{95}$

¹⁶⁵Lu ε decay (10.74 min) 1980AdZP,1982Ra19

Decay Scheme (continued)

Legend

- I_γ < 2% × I_γ^{max}
- I_γ < 10% × I_γ^{max}
- I_γ > 10% × I_γ^{max}
- - - - - γ Decay (Uncertain)
- Coincidence
- Coincidence (Uncertain)

Intensities: Relative I_γ
 & Multiply placed: undivided intensity given
 @ Multiply placed: intensity suitably divided

1/2⁺ 0 10.74 min 10
 Q_ε=3850 40
¹⁶⁵Lu₉₄

