

^{232}Pa β^- decay 1963Bj01

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	E. Browne	NDS 107, 2579 (2006)	1-Nov-2004

Parent: ^{232}Pa : $E=0$; $J^\pi=(2^-)$; $T_{1/2}=1.31$ d 2; $Q(\beta^-)=1337$ 7; $\% \beta^-$ decay=100.0

Singles γ -ray measurements, $\gamma\gamma$, $\beta\gamma$, $\text{ce}\gamma$ coincidences (1963Bj01,1970Va01,1971Ka42).

 ^{232}U Levels

E(level)	J^π	$T_{1/2}$	Comments
0 [†]	0 ⁺		
47.58 [†] 1	2 ⁺		
156.57 [†] 1	4 ⁺		
321.6 [†] 10	6 ⁺		
563.20 [‡] 7	1 ⁻		
628.97 [‡] 1	3 ⁻		
691.9 [#] 2	0 ⁺		
734.4 [#] 2	2 ⁺		
832.5 [#] 7	4 ⁺		
866.79 [@] 1	2 ⁺		
911.49 [@] 4	3 ⁺		
970.7 [@] 1	(4 ⁺)		
1016.86 1	2 ⁻	<50 ps	$T_{1/2}$: From $\beta\gamma(t)$ (1963Bj01).
1050.90 1	3 ⁻	<50 ps	$T_{1/2}$: From $\beta\gamma(t)$ (1963Bj01).
1132.9 3	(2 ⁺)		
1173.0 2	(2 ⁻)		
1211.3 3	3 ⁻		

[†] Band(A): $K^\pi=0^+$ g.s. rotational band.

[‡] Band(B): $K^\pi=0^-$ Octupole vibrational band.

[#] Band(C): $K^\pi=0^+$ Beta vibrational band.

[@] Band(D): $K^\pi=2^+$ Gamma vibrational band.

 β^- radiations

E(decay)	E(level)	$I\beta^{-\dagger@}$	Log ft	Comments
(126 7)	1211.3	0.086 5	7.54 9	av $E\beta=32.9$ 20
(164 7)	1173.0	0.210 10	7.51 7	av $E\beta=43.6$ 20
(204 7)	1132.9	0.034 4	8.60 7	av $E\beta=55.0$ 21
294 11	1050.90	24.5 4	6.20 4	av $E\beta=79.1$ 21
314 8	1016.86	73 1	5.89 4	av $E\beta=89.4$ 22
(366 ^{&} 7)	970.7	<0.04 [#]	>9.2 ^{1u}	av $E\beta=109.8$ 22
(426 ^{&} 7)	911.49	0.2 1	8.85 22	av $E\beta=122.3$ 23
(470 ^{&} 7)	866.79	<0.75 [#]	>8.4	av $E\beta=136.6$ 23
(505 ^{&} 7)	832.5	0.008 2	10.50 ^{1u} 12	av $E\beta=152.1$ 22
(603 ^{&} 7)	734.4	<0.03 [#]	>10.2	av $E\beta=180.5$ 24
(645 ^{&} 7)	691.9	\approx 0.03	\approx 10.4 ^{1u}	av $E\beta=196.0$ 23
(708 ^{&} 7)	628.97	0.4 3	9.3 4	av $E\beta=216.7$ 25
(774 ^{&} 7)	563.20	<0.6 [#]	>9.2	av $E\beta=239.7$ 25

Continued on next page (footnotes at end of table)

^{232}Pa β^- decay 1963Bj01 (continued) β^- radiations (continued)

<u>E(decay)</u>	<u>E(level)</u>	<u>$I\beta^{-\dagger@}$</u>	<u>Log ft</u>	<u>Comments</u>
(1015& 7)	321.6	0.074 13	10.55 8	av $E\beta=327$ 3
1190‡ 20	156.57	0.8‡	10.4 ^{1u}	av $E\beta=374.7$ 25
1295‡ 20	47.58	0.7‡	9.9	av $E\beta=430$ 3

† From decay scheme γ -ray transition intensity balance and $I\beta=1.5\%$ to the $J^\pi=2^+$ and 4^+ members of the g.s. rotational band (1963Bj01).

‡ Experimental value from a beta spectrum (1963Bj01).

Upper limit at 90% confidence level (deduced by evaluator).

@ Absolute intensity per 100 decays.

& Existence of this branch is questionable.

γ(²³²U)

I_γ normalization: Deduced by evaluator from γ-ray transition intensity balance and I_β=1.5% to the J^π=2⁺ and 4⁺ members of the g.s. rotational band (**1963Bj01**).

E _γ	I _γ ^{‡@}	E _i (level)	J _i ^π	E _f	J _f ^π	Mult.	δ	α&	Comments
34 ^a 47.64 5	0.24 4	866.79 47.58	2 ⁺ 2 ⁺	832.5 0	4 ⁺ 0 ⁺	E2		464	α(L)= 339; α(M)= 93.6 E _γ : Weighted average of 47.6 keV 1 (1963Bj03) and 47.65 keV 5 (1971Ka42). Other value: 47.6 keV (1970Va01). I _γ : From 1971Ka42 . Mult.: (ce(L1) + ce(L2))/ce(L3)=1.2 (1963bJ01). α(L)= 0.1695; α(M)= 0.0415; α(N+..)=0.01447 E _γ : Weighted average of 80.27 keV 10 (1971Ka42) and 80.20 keV 10 (1963Bj01). Other value: 80.0 keV (1970Va01). I _γ : From 1971Ka42 .
80.23 10	0.20 3	1050.90	3 ⁻	970.7	(4 ⁺)	[E1]		0.2255	α(L)= 0.0829; α(M)=0.02017; α(N+..)=0.00712 E _γ : From 1963Bj01 . Other measurement: 105.4 keV (1970Va01). Mult.: From (ce(L1)+ce(L2))/ce(L3) mentioned in 1963Bj01 . E _γ : From 1970Va01 . Other measurement: 109.0 keV 1 (1963Bj01). α(K)=4.3 30; α(L)=2.2 5; α(M)=0.55 15; α(N+..)=0.21 7 E _γ : From 1963Bj01 . Other value: 132.2 keV (1970Va01). Mult.: (ce(L1)+ce(L2))/ce(L3)=1.9 (1963Bj01). α(K)= 0.1796; α(L)= 0.0400; α(M)=0.00973; α(N+..)=0.00344 E _γ : From 1963Bj01 . Other measurement: 139.2 keV (1970Va01). α(K)= 0.1520; α(L)= 0.0332; α(M)=0.00808; α(N+..)=0.00286 E _γ : Other value: 150.1 keV 1 (1970Va01 , 1963Bj01). Mult.: (ce(L1)+ce(L2))/ce(L3)=3.4, ce(K)/ce(L)=3.4 (1963Bj01). α(K)= 0.2054; α(L)= 1.015; α(M)= 0.281; α(N+..)= 0.1044 E _γ : From 1970Va01 . α(K)= 0.1914; α(L)= 0.781; α(M)= 0.2155; α(N+..)= 0.0801 E _γ : From 1963Bj01 . Other value: 175.4 (1970Va01). α(K)=2.8 9; α(L)=0.73 2; α(M)=0.19 2; α(N+..)=0.07 1 E _γ : From 1970Va01 . Other value: 178 keV (1963Bj01). α(K)= 0.0945; α(L)=0.01983; α(M)=0.00480; α(N+..)=0.00170 E _γ : Other values: 183.9 keV (1970Va01), 183.9 keV 1 (1963Bj01). E _γ : From 1970Va01 , 1963Bj01 . α(K)= 0.0359; α(L)=0.00702; α(M)=0.00169; α(N+..)=0.00060 E _γ : From 1970Va01 . α(K)= 0.064 5; α(L)= 0.0348 6; α(M)=0.00920 12; α(N+..)=0.00341 5 E _γ : Other values: 387.9 keV 1 (1970Va01), 388.0 keV 2 (1963Bj01).
105.4 1	1.54 5	1016.86	2 ⁻	911.49	3 ⁺	[E1]		0.1102	
109.0 1	2.63 6	156.57	4 ⁺	47.58	2 ⁺	E2		9.15	
132.5 2	0.010 5	866.79	2 ⁺	734.4	2 ⁺	M1,E2		7 3	
139.2 1	0.57 5	1050.90	3 ⁻	911.49	3 ⁺	[E1]		0.2327	
150.059 [†] 3	11.0 5	1016.86	2 ⁻	866.79	2 ⁺	E1		0.1962	
165.0	0.030 5	321.6	6 ⁺	156.57	4 ⁺	E2		1.605	
174.9 2	0.010 2	866.79	2 ⁺	691.9	0 ⁺	[E2]		1.268	
176.3	0.004 2	911.49	3 ⁺	734.4	2 ⁺	[M1,E2]		3.0 17	
184.101 [†] 9	0.98 6	1050.90	3 ⁻	866.79	2 ⁺	[E1]		0.1208	
219	<0.005	1050.90	3 ⁻	832.5	4 ⁺			0.08	
282.2	0.010 5	1016.86	2 ⁻	734.4	2 ⁺	[E1]		0.0452	
387.884 [†] 4	6.91 15	1016.86	2 ⁻	628.97	3 ⁻	E2+M1	4.6 5	0.111 5	

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²³²Pa β⁻ decay **1963Bj01** (continued)

γ(²³²U) (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>I_(γ+ce)[@]</u>	<u>Comments</u>
										Mult.: α(K)exp=0.068 (1970Va01), (ce(L1)+ce(L2))/ce(L3)=4.0, ce(K)/ce(L)=2.1 (1963Bj01). α(K)exp=0.064 5.
421.932 [†] 7	2.44 7	1050.90	3 ⁻	628.97	3 ⁻	E2+M1	1.96 15	0.145 10		α(K)= 0.101 8; α(L)= 0.0326 11; α(M)=0.00834 25; α(N+..)=0.00307 9 E _γ : Other values: 421.7 keV 1 (1970Va01), 422.0 keV 2 (1963Bj01).
453.655 [†] 5	8.78 24	1016.86	2 ⁻	563.20	1 ⁻	E2+M1	2.8 3	0.093 7		Mult.: α(K)exp=0.11 (1970Va01). α(K)= 0.062 6; α(L)= 0.0229 9; α(M)=0.00591 20; α(N+..)=0.00217 7 E _γ : Other values: 453.6 keV 1 (1970Va01), 454.2 keV 2 (1963Bj01).
472.390 [†] 6	4.27 11	628.97	3 ⁻	156.57	4 ⁺	[E1]		0.01516		Mult.: α(K)exp=0.068 (1970Va01). α(K)exp=0.061 5. α(K)=0.01222; α(L)=0.00222; α(M)=0.00053; α(N+..)=0.00019 E _γ : Other values: 472.4 keV 1 (1970Va01),472.8 keV 3 (1963Bj01).
515.607 [†] 9	5.72 14	563.20	1 ⁻	47.58	2 ⁺	E1		0.01274		α(K)=0.01028; α(L)=0.00185 E _γ : Other values: 516.1 keV (1963Bj01), 515.6 keV 1 (1970Va01).
563.197 [†] 7	3.96 9	563.20	1 ⁻	0	0 ⁺	E1		0.01074		Mult.: ce(K)/ce(L)=2.4 (1963Bj01). α(K)=0.00868; α(L)=0.00155 E _γ : Other values: 564 keV (1963Bj01), 563.2 keV 1 (1970Va01).
581.398 [†] 8	6.52 15	628.97	3 ⁻	47.58	2 ⁺	E1		0.01010		Mult.: ce(K)/ce(L) (563γ + 581γ)=6 (1963Bj01). α(K)=0.00817; α(L)=0.00145 E _γ : Other values: 584 keV (1963Bj01), 581.4 keV 1 (1970Va01).
^x 590.3 645.0 ^α	<0.02	691.9	0 ⁺	47.58	2 ⁺	[E2]		0.027		Mult.: α(K)exp=0.0078 (1970Va01), ce(K)/ce(L) (563γ + 581γ)=6 (1963Bj01). E _γ ,I _γ : From 1970Va01. α(K)=0.018; α(L)=0.007 E _γ : From 1970Va01, 1963Bj01.
676.5		832.5	4 ⁺	156.57	4 ⁺	E0			0.011 [#] 2	E _γ : From 1970Va01. Other value: 676 keV (1963Bj01).
687.0		734.4	2 ⁺	47.58	2 ⁺	E0			0.050 [#] 4	E _γ : From 1970Va01, 1963Bj01.
691.3		691.9	0 ⁺	0	0 ⁺	E0			0.025 [#] 2	E _γ : From 1970Va01. Other value: 693 keV (1963Bj01).
710.1 3	0.22 1	866.79	2 ⁺	156.57	4 ⁺	E2		0.02206		α(K)=0.01548; α(L)=0.00495 E _γ : From 1970Va01. Other value: 712 keV (1963Bj01).
(735) 754.8		734.4 911.49	2 ⁺ 3 ⁺	0 156.57	0 ⁺ 4 ⁺	 E2			0.01950	Mult.: α(K)exp=0.017 (1970Va01). I(γ+ce)<0.03%. α(K)=0.01391; α(L)=0.00420

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γ(²³²U) (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>
814.2	0.10 3	970.7	(4 ⁺)	156.57	4 ⁺			E _γ : From 1970Va01. Other value: 757 keV (1963Bj01). Mult.: α(K)exp=0.016 (1970Va01), ce(K)/ce(L)=3 (1963Bj01).
819.187 [†] 13	7.74 8	866.79	2 ⁺	47.58	2 ⁺	E2	0.017	E _γ : From 1970Va01. α(K)=0.01205; α(L)=0.00340
863.89 [†] 4	1.99 7	911.49	3 ⁺	47.58	2 ⁺	E2	0.01494	E _γ : Other values: 819.1 keV 1 (1970Va01), 820 (1963Bj01). Mult.: α(K)exp=0.0127 (1970Va01), ce(K)/ce(L)=3.3 (1963Bj01).
866.760 [†] 19	5.95 15	866.79	2 ⁺	0	0 ⁺	E2	0.01484	α(K)=0.01098; α(L)=0.00297 E _γ : Other values: 865 keV (1963Bj01), 863.8 keV 1 (1970Va01). Mult.: α(K)exp=0.0156 (1970Va01).
894.351 [†] 12	20.7 3	1050.90	3 ⁻	156.57	4 ⁺	E1	0.00457	α(K)=0.01092; α(L)=0.00295 E _γ : Other values: 868 keV (1963Bj01), 866.7 keV 1 (1970Va01). Mult.: α(K)exp=0.0116 (1970Va01), ce(K)/ce(L)=3.5 (1963Bj01).
911.4 ^a	0.012 1	911.49	3 ⁺	0	0 ⁺	[M3]	0.2282	α(K)=0.00373; α(L)=0.00064 E _γ : Other values: 895 keV (1963Bj01), 894.3 keV 1 (1970Va01). Mult.: α(K)exp=0.0038 (1970Va01), ce(K)/ce(L)=5.3 (1963Bj01).
923.1	0.045 3	970.7	(4 ⁺)	47.58	2 ⁺			α(K)= 0.1671; α(L)= 0.0460 E _γ : From 1970Va01.
969.315 [†] 11	44.6 5	1016.86	2 ⁻	47.58	2 ⁺	E1	0.00397	E _γ : From 1970Va01. α(K)=0.00324; α(L)=0.00055 E _γ : Other values: 971 keV (1963Bj01), 969.2 keV 1 (1970Va01). Mult.: α(K)exp=0.0031 (1970Va01), ce(K)/ce(L)=5.4 (1963Bj01).
1003.28 [†] 4	0.166 8	1050.90	3 ⁻	47.58	2 ⁺	E1	0.00373	α(K)=0.00305; α(L)=0.00052 E _γ : Other values: 1003.3 keV (1970Va01), 1003.3 keV 2 (1971Ka42). I _γ : Weighted average of 0.163 8 (1970Va01) and 0.17 1 (1971Ka42). Mult.: α(L)exp=0.00075 27, ce(K)/ce(L)<11 (1971Ka42).
1016.4 4	0.0136 20	1016.86	2 ⁻	0	0 ⁺	M2	0.0915	α(K)= 0.0710; α(L)=0.01543 E _γ : From 1971Ka42. Other value: 1016.9 keV (1970Va01). I _γ : Weighted average of 0.013 2 (1970Va01) and 0.016 4 (1971Ka42). Mult.: α(K)exp=0.059 19, ce(K)/ce(L)=5.5 (1971Ka42).
1051.4 1	0.018 2	1050.90	3 ⁻	0	0 ⁺			E _γ : From 1971Ka42. Other value: 1050.9 keV (1970Va01). I _γ : Weighted average of 0.018 2 (1970Va01) and 0.017 5 (1971Ka42). Mult.: α(L)exp<0.013 (1971Ka42).
1054.5 3	0.073 4	1211.3	3 ⁻	156.57	4 ⁺	E1	0.00342	α(K)=0.00279; α(L)=0.00047 E _γ : From 1971Ka42. Other value: 1055.4 keV (1970Va01). I _γ : Weighted average of 0.070 4 (1970Va01) and 0.076 4 (1971Ka42). Mult.: α(K)exp<0.013 (1971Ka42).
1085.4 3	0.026 2	1132.9	(2 ⁺)	47.58	2 ⁺	(E2)		E _γ : From 1971Ka42. Other value: 1085.2 keV (1970Va01). I _γ : Weighted average of 0.026 2 (1970Va01) and 0.024 4 (1971Ka42). Mult.: E1 or E2 from α(K)exp<0.065. Decay scheme requires E2 (1971Ka42).
1125.48 [†] 17	0.22 1	1173.0	(2 ⁻)	47.58	2 ⁺	E1	0.00306	α(K)=0.00250; α(L)=0.00042 E _γ : Other values: 1125.0 keV (1970Va01), 1125.1 keV 2 (1971Ka42). I _γ : Weighted average of 0.223 10 (1970Va01) and 0.22 1 (1971Ka42). Mult.: α(K)exp=0.0026 4, ce(K)/ce(L)=11 (1971Ka42).

²³²Pa β⁻ decay **1963Bj01** (continued)

γ(²³²U) (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>
1132.7 7	0.010 3	1132.9	(2 ⁺)	0	0 ⁺	(E2)		E _γ : From 1971Ka42. Other value: 1132.2 keV (1970Va01). I _γ : Weighted average of 0.008 3 (1970Va01) and 0.014 4 (1971Ka42). Mult.: E1 or E2 from α(K)exp<0.02. Decay scheme requires E2 (1971Ka42).
1164.5 5	0.017 3	1211.3	3 ⁻	47.58	2 ⁺	E1	0.00289	α(K)=0.00236; α(L)=0.00040 E _γ : From 1971Ka42. Other value: 1162 keV (1970Va01). I _γ : From 1971Ka42. Other value: ≤0.005 (1970Va01). Mult.: α(K)exp=0.003 2 (1971Ka42).
1171 ^x 1193	<0.005	1173.0	(2) ⁻	0	0 ⁺			E _γ : From 1970Va01. E _γ , I _γ : From 1970Va01.

[†] From 1979Bo30 cryst. ΔE does not include a calibration uncertainty of 0.002%.

[‡] From 1970Va01, unless otherwise specified. Others: 1963Bj01, 1970Va01, 1971Ka42.

[#] Deduced from ce data assuming pure E0 (1970Va01).

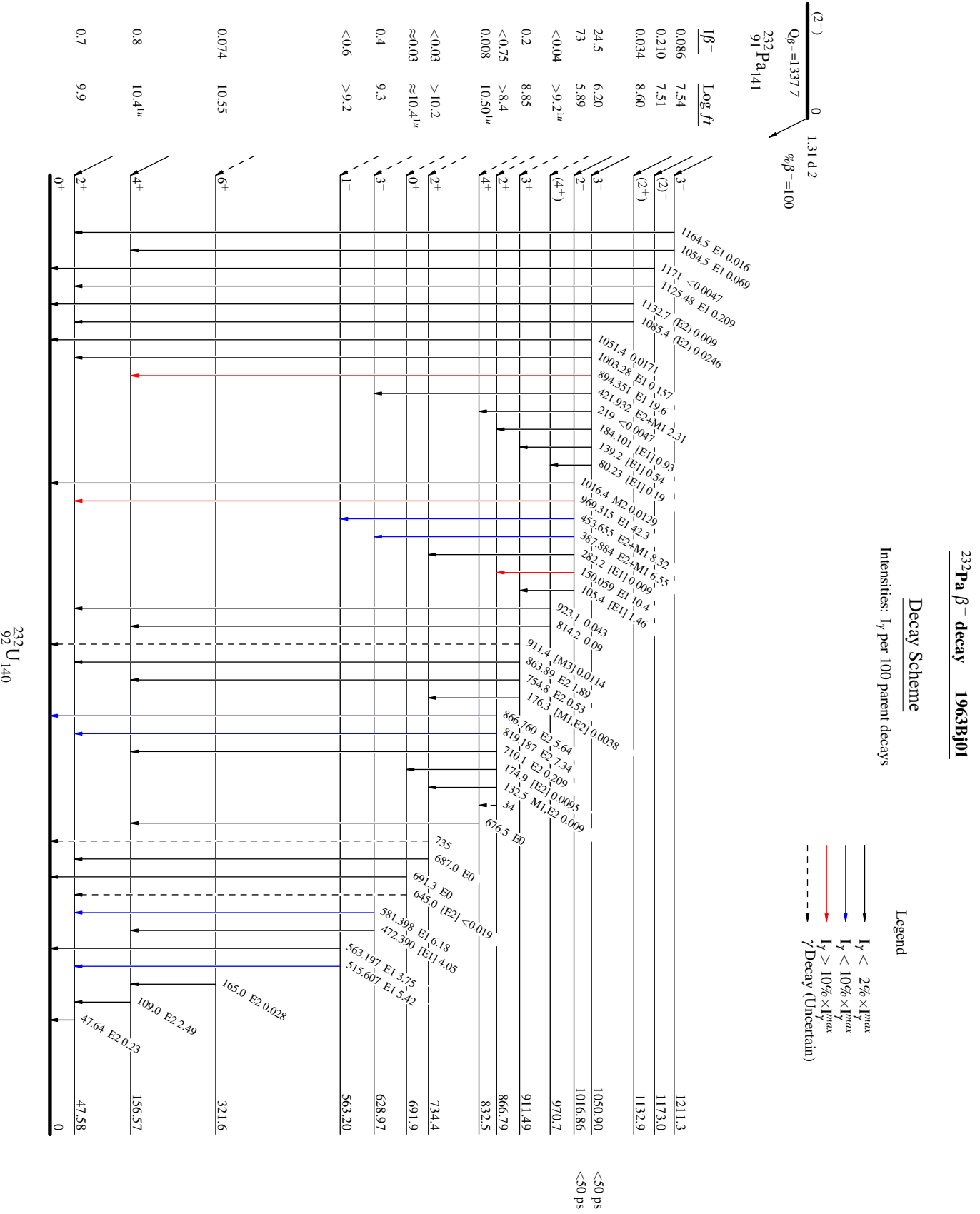
[@] For absolute intensity per 100 decays, multiply by 0.948 8.

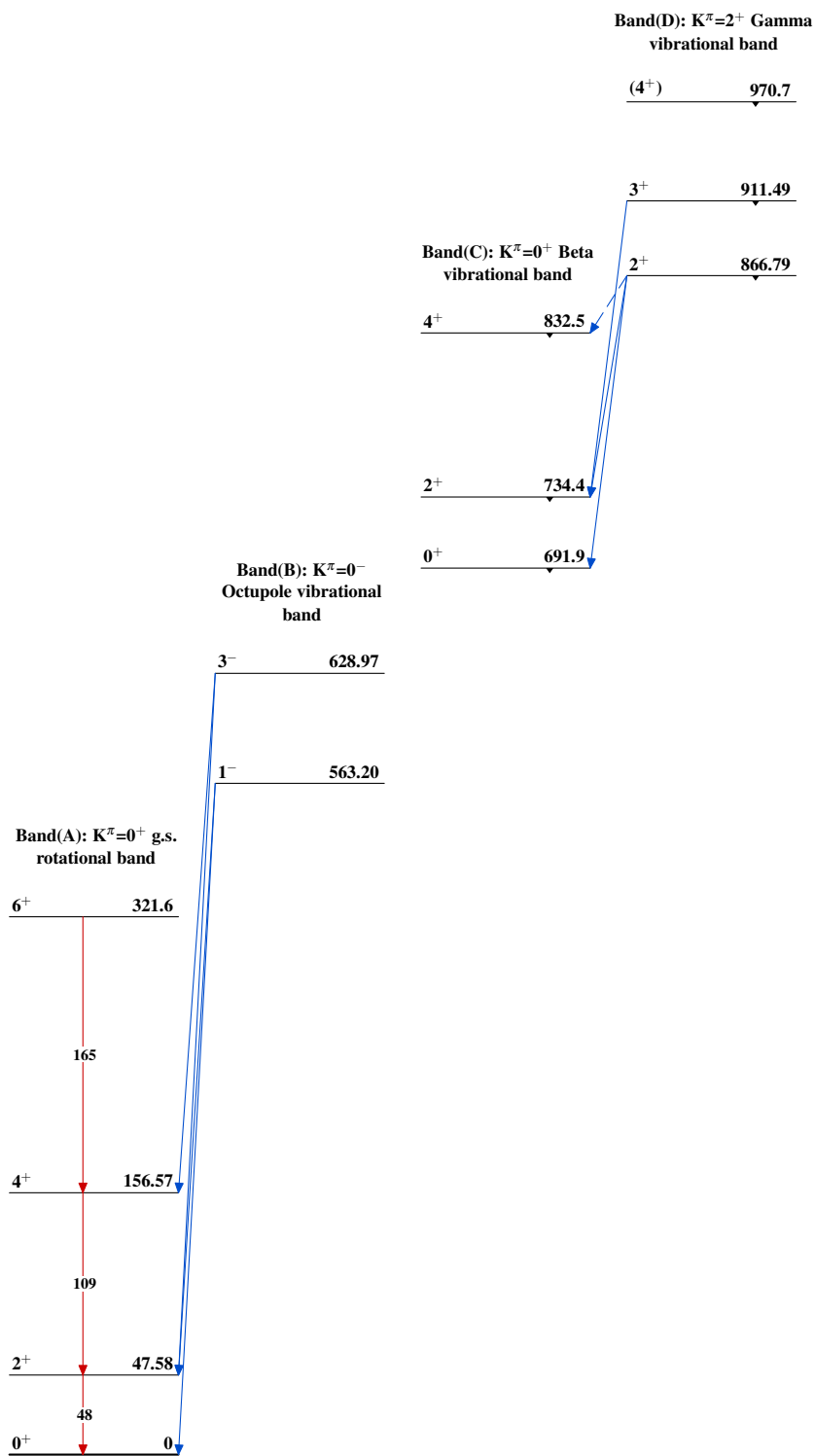
[&] Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on γ-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.

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

^x γ ray not placed in level scheme.

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${}^{232}\text{Pa}$ β^- decay 1963Bj01 ${}^{232}_{92}\text{U}_{140}$