^{224}Fr β^- decay (3.33 min) 1981Ku02,1980KuZL,1979Va20

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh, Sukhjeet Singh	ENSDF	08-Mar-2022

Parent: ^{224}Fr: E=0; J$^\pi$=1$^{(-)}$; $T_{1/2}$=3.33 min *10*; Q(β^-)=2923 *11*; %β^- decay=100.0

^{224}Fr-J$^\pi$,$T_{1/2}$: From ^{224}Fr Adopted Levels.

^{224}Fr-Q(β^-): From 2021Wa16.

1981Ku02, 1980KuZL: measured Eγ, Iγ, $\gamma\gamma$-coin, ^{224}Fr half-life; deduced levels, J, π. A total of 120 γ rays were assigned to ^{224}Fr decay, with only 20 γ rays out of these not assigned in the decay scheme.

1979Va20 (1973AfZY): measured Eγ, Iγ, ce, (ce)γ-coin; deduced 11 excited states incorporating 26 γ rays, J, π. Another 17 γ rays were unplaced, some of which are now assigned in level scheme by 1981Ku02.

1975We23: measured Eβ, $\beta\gamma$-coin; deduced Q value.

The decay scheme is that of 1981Ku02, 1980KuZL. It is consistent with, but more extensive than that of 1979Va20 (also 1973AfZY).

^{224}Ra Levels

E(level)†	J$^\pi$‡	$T_{1/2}$‡	E(level)†	J$^\pi$‡
0#	0$^+$	3.6319 d *23*	1614.41 *17*	(1$^-$,2)
84.373# *3*	2$^+$		1652.42 *6*	2$^+$
215.985@ *4*	1$^-$		1658.52 *9*	1$^{(-)}$,2$^+$
250.783# *5*	4$^+$		1736.3 *2*	1,2$^+$
290.36@ *4*	3$^-$		1754.84 *9*	0$^+$,1,2
433.07@ *10*	(5)$^-$		1789.61 *7*	1,2$^+$
916.34 *7*	0$^+$		1796.75 *9*	(1$^-$,2)
965.51 *6*	2$^+$		1818.1 *2*	(1$^-$,2)
992.65 *6*	(2$^+$)		1838.49 *10*	0,1,2
1052.95 *3*	1$^-$		1896.3 *3*	(1$^-$,2)
1089.98 *6*	(2,3)$^-$		1969.92 *10*	(0,1,2)
1187.1 *4*	0$^+$,1,2		2000.2 *2*	(1$^-$,2)
1216.9 *2*	(1$^-$,2)		2043.2 *5*	0,1,2
1348.22 *9*	2$^+$,3$^+$		2052.3 *4*	2$^+$
1378.35 *5*	1$^-$		2077.3 *4*	0$^+$,1,2
1378.93 *7*	(1$^+$,2$^+$)		2117.4 *4*	1,2$^+$
1389.71 *9*	(0$^+$,1,2)		2135.3 *5*	0,1,2
1425.03 *5*	(0,1,2)$^-$		2229.4 *4*	(1$^-$,2)
1435.47 *4*	1$^-$		2246.5 *3*	1,2$^+$
1437.08 *6*	2$^+$		2368.7 *4*	1,2$^+$
1553.7 *2*	1,2$^+$			

† From least-squares fit to Eγ data.

‡ From Adopted Levels.

Band(A): K^π=0$^+$ g.s. band.

@ Band(B): K^π=0$^-$ band.

^{224}Fr β^- decay (3.33 min) 1981Ku02,1980KuZL,1979Va20 (continued)

β^- radiations

There is unexpected apparent β feeding of 1.2% to 433, (5)$^-$ level, whereas none is expected from $J^\pi=1^{(-)}$ of the parent. Note that several γ rays are still unplaced, although, none is strong enough to counterbalance 1.2% β feeding.

E(decay)	E(level)	Iβ^-†	Log *ft*	Comments
(554 *11*)	2368.7	0.050 *9*	7.0 *1*	av Eβ=165.2 *38*
(677 *11*)	2246.5	0.27 *5*	6.5 *1*	av Eβ=207.1 *39*
(694 *11*)	2229.4	0.050 *9*	7.3 *1*	av Eβ=213.1 *39*
(788 *11*)	2135.3	0.045 *9*	7.5 *1*	av Eβ=246.5 *40*
(806 *11*)	2117.4	0.10 *2*	7.2 *1*	av Eβ=252.9 *40*
(846 *11*)	2077.3	0.12 *2*	7.2 *1*	av Eβ=267.4 *40*
(871 *11*)	2052.3	0.08 *2*	7.4 *1*	av Eβ=276.5 *41*
(880 *11*)	2043.2	0.10 *2*	7.4 *1*	av Eβ=279.9 *41*
(923 *11*)	2000.2	0.13 *2*	7.31 *7*	av Eβ=295.7 *41*
(953 *11*)	1969.92	0.10 *2*	7.5 *1*	av Eβ=306.8 *41*
(1027 *11*)	1896.3	0.073 *13*	7.7 *1*	av Eβ=334.3 *42*
(1085 *11*)	1838.49	0.20 *4*	7.4 *1*	av Eβ=356.2 *42*
(1105 *11*)	1818.1	0.059 *10*	7.9 *1*	av Eβ=363.9 *42*
(1126 *11*)	1796.75	0.49 *8*	7.0 *1*	av Eβ=372.0 *42*
(1133 *11*)	1789.61	0.98 *14*	6.74 *7*	av Eβ=374.7 *42*
(1168 *11*)	1754.84	0.30 *6*	7.3 *1*	av Eβ=388.0 *43*
(1187 *11*)	1736.3	0.20 *4*	7.5 *1*	av Eβ=395.1 *43*
(1264 *11*)	1658.52	0.36 *7*	7.4 *1*	av Eβ=425.2 *43*
(1271 *11*)	1652.42	1.8 *3*	6.7 *1*	av Eβ=427.6 *43*
(1309 *11*)	1614.41	0.12 *2*	7.9 *1*	av Eβ=442.3 *43*
(1369 *11*)	1553.7	0.22 *3*	7.69 *7*	av Eβ=466.1 *44*
(1486 *11*)	1437.08	1.9 *3*	6.88 *7*	av Eβ=512.2 *44*
(1488 *11*)	1435.47	2.8 *4*	6.71 *7*	av Eβ=512.8 *44*
(1498 *11*)	1425.03	7.2 *9*	6.32 *6*	av Eβ=517.0 *44*
(1533 *11*)	1389.71	0.33 *6*	7.7 *1*	av Eβ=531.0 *44*
(1544 *11*)	1378.93	1.9 *3*	6.94 *7*	av Eβ=535.3 *44*
(1545 *11*)	1378.35	5.6 *7*	6.47 *6*	av Eβ=535.6 *44*
(1575 *11*)	1348.22	0.27 *6*	7.8 *1*	av Eβ=547.6 *44*
(1706 *11*)	1216.9	0.16 *3*	8.2 *1*	av Eβ=600.4 *45*
(1736 *11*)	1187.1	0.14 *3*	8.3 *1*	av Eβ=612.4 *45*
(1833‡ *11*)	1089.98	<0.09	>8.5	av Eβ=651.9 *45*
(1870 *11*)	1052.95	10.3 *14*	6.52 *7*	av Eβ=667.0 *45* E(decay): 1780 *50* (1975We23, $\beta\gamma$-coin).
(1957 *11*)	965.51	0.37 *10*	8.0 *1*	av Eβ=702.7 *46*
(2007‡ *11*)	916.34	<0.04	>9.0	av Eβ=722.9 *46*
(2707 *11*)	215.985	43 *6*	6.51 *7*	av Eβ=1014.4 *47* E(decay): 2580 *80* (1975We23, singles β).
(2839 *11*)	84.373	14 *8*	7.1 *3*	av Eβ=1069.8 *47*
(2923‡ *11*)	0	10 *10*	7.3 *5*	av Eβ=1105.3 *47* Iβ^-: 7 *13* from decay scheme.

† Absolute intensity per 100 decays.
‡ Existence of this branch is questionable.

γ(^{224}Ra)

Iγ normalization: Iγ(216γ)=34% *4* (adjustment of 33% *4* measured in 1979Va20 for revised absolute Iγ(240γ)=4.10% *5* recommended in 1991BaZS evaluation).
Value in 1979Va20 was deduced from measured ratio of Iγ(216γ) and Iγ(240γ) in ^{224}Ra α decay, using absolute γ(240γ)=3.95% *13*.

E$_\gamma$[†]	I$_\gamma$[†c]	E$_i$(level)	J$^\pi_i$	E$_f$	J$^\pi_f$	Mult.[a]	α[d]	Comments
74.4[#] *5*	0.16[#] *3*	290.36	3$^-$	215.985	1$^-$	[E2]	38.5 *14*	α(L)=28.3 *10*; α(M)=7.7 *3* α(N)=2.03 *8*; α(O)=0.431 *16*; α(P)=0.0621 *22*; α(Q)=0.000164 *5*
84.373[‡] *3*	12.8[&] *18*	84.373	2$^+$	0	0$^+$	E2[b]	21.2	α(L1)exp+α(L2)exp=10.4 *28*; α(L3)exp=7.8 *18*; α(M)exp=4.7 *11*; α(N)exp=1.6 *5* α(L)=15.57 *22*; α(M)=4.24 *6* α(N)=1.119 *16*; α(O)=0.238 *4*; α(P)=0.0343 *5*; α(Q)=0.0001015 *15* Ice(L1+L2)=131 *28*, Ice(L3)=98 *15*, Ice(M)=60 *10*, Ice(N)=21 *5*. Eγ=84.38 *3*, Iγ=14.6 *12* (1979Va20). Iγ=11.0 *11* (1980KuZL).
[x]110.34 *5*	0.84 *6*							Eγ=110.79 *8*, Iγ=0.7 (1979Va20, unidentified γ).
131.613[‡] *4*	100[@] *4*	215.985	1$^-$	84.373	2$^+$	E1[b]	0.247	α(L1)exp+α(L2)exp=0.033 *11* α(K)=0.194 *3*; α(L)=0.0406 *6*; α(M)=0.00977 *14* α(N)=0.00254 *4*; α(O)=0.000559 *8*; α(P)=8.92×10^{-5} *13*; α(Q)=4.80×10^{-6} *7* Ice(L1+L2)=3.2 *10*. Eγ=131.618 *16*, Iγ=100 *4* (1979Va20). Iγ=100 *5* (1980KuZL).
142.0 *10*	1.04 *27*	433.07	(5)$^-$	290.36	3$^-$	[E2]	2.18 *7*	α(K)=0.280 *5*; α(L)=1.40 *5*; α(M)=0.380 *14* α(N)=0.100 *4*; α(O)=0.0214 *8*; α(P)=0.00313 *11*; α(Q)=1.86×10^{-5} *5* I$_\gamma$: from Iγ/Iγ(182γ)=0.56 *13* from Adopted Gammas. 1980KuZL report Iγ<0.8 and do not place this transition.
166.410[‡] *4*	2.35[@] *11*	250.783	4$^+$	84.373	2$^+$	E2[b]	1.164	α(L1)exp+α(L2)exp=0.82 *33* α(K)=0.225 *4*; α(L)=0.691 *10*; α(M)=0.187 *3* α(N)=0.0495 *7*; α(O)=0.01056 *15*; α(P)=0.001553 *22*; α(Q)=1.200×10^{-5} *17* Mult.: α(L1)exp+α(L2)exp agrees with M1 or E2; E2 in Adopted Gammas. Ice(L1+L2)=1.9 *7*. Eγ=166.304 *30*, Iγ=2.4 *2* (1979Va20). Iγ=2.33 *11* (1980KuZL).
182.30 *10*	1.86 *22*	433.07	(5)$^-$	250.783	4$^+$	[E1]	0.1126	α(K)=0.0894 *13*; α(L)=0.01757 *25*; α(M)=0.00421 *6* α(N)=0.001098 *16*; α(O)=0.000243 *4*; α(P)=3.96×10^{-5} *6*; α(Q)=2.31×10^{-6} *4*
205.942[@] *35*	13.9[@] *7*	290.36	3$^-$	84.373	2$^+$	E1	0.0841	α(K)=0.0671 *10*; α(L)=0.01292 *19*; α(M)=0.00309 *5* α(N)=0.000807 *12*; α(O)=0.000179 *3*; α(P)=2.94×10^{-5} *5*; α(Q)=1.763×10^{-6} *25* Eγ=205.948 *35*, Iγ=13.9 *7* (1979Va20). Eγ=205.93 *5*, Iγ=14.0 *10* (1980KuZL).
215.983[‡] *5*	195[@] *9*	215.985	1$^-$	0	0$^+$	E1[b]	0.0752	α(K)=0.0600 *9*; α(L)=0.01148 *16*; α(M)=0.00274 *4* α(N)=0.000717 *10*; α(O)=0.0001593 *23*; α(P)=2.62×10^{-5} *4*; α(Q)=1.587×10^{-6} *23* Ice(K)=11.5 *10*, Ice(L1+L2)=2.6 *6*.

γ(^{224}Ra) (continued)

E_γ[†]	I_γ[†c]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[a]	δ	α[d]	Comments
									Eγ=215.969 *16*, Iγ=189 *9* (1979Va20). Iγ=203 *10* (1980KuZL).
325.348[@] *19*	5.86[@] *28*	1378.35	1^-	1052.95	1^-	M1(+E2)	<0.3	0.549 *20*	α(K)exp=0.57 *14* α(K)=0.441 *18*; α(L)=0.0821 *20*; α(M)=0.0196 *5* α(N)=0.00518 *12*; α(O)=0.00118 *3*; α(P)=0.000205 *6*; α(Q)=1.58×10^{-5} *7* Ice(K)=3.3 *7*. Eγ=325.352 *19*, Iγ=6.0 *4* (1979Va20). Eγ=325.32 *5*, Iγ=5.79 *28* (1980KuZL).
335.056[@] *19*	6.17[@] *25*	1425.03	$(0,1,2)^-$	1089.98	$(2,3)^-$	M1(+E2)	<0.5	0.48 *5*	α(K)exp=0.48 *13* α(K)=0.39 *4*; α(L)=0.073 *4*; α(M)=0.0176 *9* α(N)=0.00465 *22*; α(O)=0.00106 *6*; α(P)=0.000183 *11*; α(Q)=1.39×10^{-5} *14* Ice(K)=2.9 *7*. Eγ=335.058 *19*, Iγ=6.2 *4* (1979Va20). Eγ=335.04 *5*, Iγ=6.16 *25* (1980KuZL).
372.08[@] *4*	3.89[@] *19*	1425.03	$(0,1,2)^-$	1052.95	1^-	M1(+E2)	<1.1	0.31 *9*	α(K)exp=0.31 *14* α(K)=0.24 *8*; α(L)=0.049 *9*; α(M)=0.0120 *19* α(N)=0.0032 *5*; α(O)=0.00072 *12*; α(P)=0.000123 *23*; α(Q)=9.E−6 *3* Ice(K)=1.2 *5*. Eγ=372.10 *4*, Iγ=4.0 *3* (1979Va20). Eγ=372.06 *5*, Iγ=3.84 *19* (1980KuZL).
382.511[@] *25*	2.89[@] *14*	1435.47	1^-	1052.95	1^-	M1(+E2)	<0.7	0.32 *5*	α(K)exp=0.46 *25* α(K)=0.25 *5*; α(L)=0.049 *5*; α(M)=0.0118 *11* α(N)=0.0031 *3*; α(O)=0.00070 *7*; α(P)=0.000122 *13*; α(Q)=9.1×10^{-6} *15* Ice(K)=1.3 *7*. Eγ=382.514 *25*, Iγ=3.0 *2* (1979Va20). Eγ=382.50 *5*, Iγ=2.84 *14* (1980KuZL).
386.4 *10*	1.23 *10*	1378.93	$(1^+,2^+)$	992.65	(2^+)	[M1,E2]		0.21 *14*	α(K)=0.16 *13*; α(L)=0.038 *15*; α(M)=0.009 *4* α(N)=0.0025 *9*; α(O)=0.00055 *20*; α(P)=9.E−5 *4*; α(Q)=6.E−6 *5*
[x]396.65 *10*	0.48 *6*								Eγ=396.57 *13*, Iγ=0.46 *9* (1979Va20, unidentified).
413.398[@] *25*	4.13[@] *25*	1378.93	$(1^+,2^+)$	965.51	2^+	M1(+E2)	<0.5	0.272 *24*	α(K)exp≈0.30 α(K)=0.218 *21*; α(L)=0.041 *3*; α(M)=0.0098 *6* α(N)=0.00259 *15*; α(O)=0.00059 *4*; α(P)=0.000102 *7*; α(Q)=7.8×10^{-6} *8* Mult.: assuming 30% uncertainty in α(K)exp. Ice(K)≈1.2. Eγ=413.398 *25*, Iγ=4.5 *3* (1979Va20). Eγ=413.40 *5*, Iγ=3.96 *20* (1980KuZL).
442.78 *8*	1.50 *20*	1435.47	1^-	992.65	(2^+)	[E1]		0.01513	α(K)=0.01231 *18*; α(L)=0.00215 *3*; α(M)=0.000508 *8*

$\gamma(^{224}Ra)$ (continued)

E_γ[†]	I_γ[†c]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[a]	δ	α[d]	Comments
									α(N)=0.0001332 *19*; α(O)=3.00×10^{-5} *5*; α(P)=5.07×10^{-6} *8*; α(Q)=3.51×10^{-7} *5*
461.98 *8*	1.86 *10*	1378.35	1^-	916.34	0^+	[E1]		0.01386	α(K)=0.01128 *16*; α(L)=0.00196 *3*; α(M)=0.000464 *7* α(N)=0.0001215 *17*; α(O)=2.73×10^{-5} *4*; α(P)=4.63×10^{-6} *7*; α(Q)=3.23×10^{-7} *5*
[x]478.30 *10*	0.48 *7*								
519.5 *2*	0.50 *4*	1435.47	1^-	916.34	0^+	[E1]		0.01092	α(K)=0.00891 *13*; α(L)=0.001526 *22*; α(M)=0.000361 *5* α(N)=9.46×10^{-5} *14*; α(O)=2.13×10^{-5} *3*; α(P)=3.63×10^{-6} *5*; α(Q)=2.57×10^{-7} *4*
659.64 *10*	0.70 *13*	1652.42	2^+	992.65	(2^+)	[M1,E2]		0.05 *4*	α(K)=0.04 *3*; α(L)=0.008 *4*; α(M)=0.0020 *10* α(N)=0.00053 *25*; α(O)=0.00012 *6*; α(P)=2.1×10^{-5} *11*; α(Q)=1.5×10^{-6} *10*
702.0 *2*	0.50 *16*	1754.84	0^+,1,2	1052.95	1^-				
741.8[#] *2*	1.40[#] *30*	992.65	(2^+)	250.783	4^+	[E2]		0.01625	α(K)=0.01196 *17*; α(L)=0.00322 *5*; α(M)=0.000803 *12* α(N)=0.000212 *3*; α(O)=4.71×10^{-5} *7*; α(P)=7.77×10^{-6} *11*; α(Q)=4.18×10^{-7} *6*
762.63[@] *4*	13.9[@] *7*	1052.95	1^-	290.36	3^-	(E2)		0.01536	α(K)=0.01137 *16*; α(L)=0.00300 *5*; α(M)=0.000745 *11* α(N)=0.000197 *3*; α(O)=4.38×10^{-5} *7*; α(P)=7.23×10^{-6} *11*; α(Q)=3.96×10^{-7} *6* α(K)exp<0.015 Mult.: α(K)exp agrees with M1, E2 or E1, but ΔJ^π requires E2. Ice(K)<0.2. Mult.: E1,E2 from α(K)exp<0.016; but E1 is inconsistent with ΔJ^π. Eγ=762.649 *23*, Iγ=14.1 *7* (1979Va20). Eγ=762.53 *6*, Iγ=13.7 *7* (1980KuZL).
799.705[@] *37*	5.98[@] *38*	1089.98	$(2,3)^-$	290.36	3^-	M1(+E2)	<1.9	0.037 *15*	α(K)exp=0.051 *34* α(K)=0.029 *13*; α(L)=0.0055 *19*; α(M)=0.0013 *5* α(N)=0.00035 *12*; α(O)=8.E−5 *3*; α(P)=1.4×10^{-5} *5*; α(Q)=1.0×10^{-6} *5* Ice(K)=0.3 *2*. Eγ=799.718 *25*, Iγ=5.5 *4* (1979Va20). Eγ=799.60 *7*, Iγ=6.29 *32* (1980KuZL).
832.01[@] *8*	2.34[@] *20*	916.34	0^+	84.373	2^+	[E2]		0.01289	α(K)=0.00970 *14*; α(L)=0.00240 *4*; α(M)=0.000594 *9* α(N)=0.0001565 *22*; α(O)=3.50×10^{-5} *5*; α(P)=5.81×10^{-6} *9*; α(Q)=3.35×10^{-7} *5* Eγ=832.02 *8*, Iγ=2.4 *2* (1979Va20). Eγ=832.00 *10*, Iγ=2.20 *30* (1980KuZL).
837.03[@] *7*	59.5[@] *30*	1052.95	1^-	215.985	1^-	M1+E2	1.6 *+16−6*	0.022 *8*	α(K)exp=0.017 *5* α(K)=0.017 *6*; α(L)=0.0035 *10*; α(M)=0.00086 *22*

From ENSDF

γ(^{224}Ra) (continued)

E_γ[†]	I_γ[†c]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[a]	α[d]	Comments
								α(N)=0.00023 *6*; α(O)=5.1×10^{-5} *13*; α(P)=8.7×10^{-6} *24*; α(Q)=6.0×10^{-7} *21* Ice(K)=1.0 *3*. Eγ=837.062 *19*, Iγ=59 *3* (1979Va20). Eγ=836.90 *7*, Iγ=60.0 *30* (1980KuZL).
874.10[@] *7*	2.34[@] *18*	1089.98	(2,3)$^-$	215.985	1$^-$	[M1,E2]	0.026 *15*	α(K)=0.021 *12*; α(L)=0.0040 *19*; α(M)=0.0010 *5* α(N)=0.00025 *12*; α(O)=6.E−5 *3*; α(P)=1.0×10^{-5} *5*; α(Q)=7.E−7 *5* Eγ=874.10 *7*, Iγ=2.1 *2* (1979Va20). Eγ=874.0 *10*, Iγ=2.48 *15* (1980KuZL).
881.32[@] *7*	4.51[@] *27*	965.51	2$^+$	84.373	2$^+$	[M1,E2]	0.026 *14*	α(K)=0.020 *12*; α(L)=0.0039 *19*; α(M)=0.0009 *5* α(N)=0.00025 *12*; α(O)=6.E−5 *3*; α(P)=1.0×10^{-5} *5*; α(Q)=7.E−7 *5* Eγ=881.35 *4*, Iγ=4.5 *3* (1979Va20). Eγ=881.14 *10*, Iγ=4.52 *27* (1980KuZL).
908.10 *10*	1.60 *13*	992.65	(2$^+$)	84.373	2$^+$	[M1,E2]	0.024 *13*	α(K)=0.019 *11*; α(L)=0.0036 *17*; α(M)=0.0009 *4* α(N)=0.00023 *11*; α(O)=5.2×10^{-5} *24*; α(P)=9.E−6 *5*; α(Q)=7.E−7 *4*
926.5 *2*	0.55 *13*	1216.9	(1$^-$,2)	290.36	3$^-$			
[x]943.8 *2*	1.10 *13*							
947.2 *2*	0.43 *5*	2000.2	(1$^-$,2)	1052.95	1$^-$			
965.56[@] *10*	2.74[@] *27*	965.51	2$^+$	0	0$^+$	[E2]	0.00963	α(K)=0.00741 *11*; α(L)=0.001674 *24*; α(M)=0.000410 *6* α(N)=0.0001080 *16*; α(O)=2.42×10^{-5} *4*; α(P)=4.07×10^{-6} *6*; α(Q)=2.52×10^{-7} *4* Eγ=965.62 *6*, Iγ=2.8 *3* (1979Va20). Eγ=965.40 *10*, Iγ=2.70 *27* (1980KuZL).
968.62[@] *13*	2.01[@] *20*	1052.95	1$^-$	84.373	2$^+$			Eγ=968.77 *11*, Iγ=2.0 *4* (1979Va20, Iγ includes a sum peak). Eγ=968.50 *10*, Iγ=2.02 *20* (1980KuZL).
970.9 *5*	0.38 *4*	1187.1	0$^+$,1,2	215.985	1$^-$			
992.9[e] *10*	≈1.4	992.65	(2$^+$)	0	0$^+$			E$_\gamma$: reported earlier by 1977Ku15 in their study of ^{228}Th α decay, Iγ/Iγ(742γ)≈1. Not listed in 1980KuZL or 1981Ku02, although a 992.1γ is labeled in spectrum figure 1 in 1981Ku02.
1001.1 *5*	0.39 *5*	1216.9	(1$^-$,2)	215.985	1$^-$			
1005.5 *5*	0.33 *4*	1089.98	(2,3)$^-$	84.373	2$^+$			
1053.01[@] *8*	1.30[@] *20*	1052.95	1$^-$	0	0$^+$			Eγ=1053.09 *12*, Iγ≈2 (1979Va20). Eγ=1052.96 *10* (1980KuZL).
1097.6 *2*	0.84 *23*	1348.22	2$^+$,3$^+$	250.783	4$^+$	[M1,E2]	0.015 *8*	α(K)=0.012 *6*; α(L)=0.0022 *10*; α(M)=0.00053 *23* α(N)=0.00014 *6*; α(O)=3.2×10^{-5} *14*; α(P)=5.5×10^{-6} *25*; α(Q)=4.2×10^{-7} *22*
1103.0 *5*	0.44 *12*	1187.1	0$^+$,1,2	84.373	2$^+$			
[x]1127.7 *2*	0.86 *10*							
[x]1133.8 *2*	0.86 *10*							
1163.09[@] *5*	4.41[@] *30*	1378.93	(1$^+$,2$^+$)	215.985	1$^-$			Eγ=1163.10 *5*, Iγ=4.3 *3* (1979Va20). Eγ=1163.04 *10*, Iγ=4.57 *37* (1980KuZL).

$^{224}_{88}Ra_{136}$-6

$\gamma(^{224}Ra)$ (continued)

E_γ[†]	I_γ[†c]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[a]	α[d]	Comments
1173.89[@] *23*	1.30[@] *20*	1389.71	(0$^+$,1,2)	215.985	1$^-$			Eγ=1174.12 *12*, Iγ=1.2 *2* (1979Va20). Eγ=1173.66 *10*, Iγ=1.40 *20* (1980KuZL).
1186.35[@] *10*	1.68[@] *17*	1437.08	2$^+$	250.783	4$^+$			Eγ=1186.44 *11*, Iγ=1.6 *3* (1979Va20). Eγ=1186.27 *10*, Iγ=1.70 *17* (1980KuZL).
1209.2[@] *2*	0.40[@] *4*	1425.03	(0,1,2)$^-$	215.985	1$^-$	[M1,E2]	0.012 *6*	α(K)=0.009 *5*; α(L)=0.0017 *8*; α(M)=0.00042 *18* α(N)=0.00011 *5*; α(O)=2.5×10^{-5} *11*; α(P)=4.3×10^{-6} *19*; α(Q)=3.3×10^{-7} *17*; α(IPF)=7.E−6 *3* Eγ=1209.17 *15*, Iγ=0.5 (1979Va20). Eγ=1209.2 *2*, Iγ=0.40 *4* (1980KuZL).
1219.46[@] *10*	1.31[@] *15*	1435.47	1$^-$	215.985	1$^-$	[M1,E2]	0.012 *6*	α(K)=0.009 *5*; α(L)=0.0017 *8*; α(M)=0.00041 *17* α(N)=0.00011 *5*; α(O)=2.4×10^{-5} *11*; α(P)=4.2×10^{-6} *19*; α(Q)=3.2×10^{-7} *16*; α(IPF)=8.E−6 *3* Eγ=1219.53 *14*, Iγ=1.2 *2* (1979Va20). Eγ=1219.42 *10*, Iγ=1.37 *15* (1980KuZL).
[x]1239.1 *2*	0.30 *6*							
1263.80 *10*	0.68 *9*	1348.22	2$^+$,3$^+$	84.373	2$^+$	[M1,E2]	0.011 *5*	α(K)=0.009 *4*; α(L)=0.0016 *7*; α(M)=0.00037 *16* α(N)=0.00010 *4*; α(O)=2.2×10^{-5} *10*; α(P)=3.9×10^{-6} *17*; α(Q)=3.0×10^{-7} *15*; α(IPF)=1.5×10^{-5} *6*
[x]1274.50 *10*	1.22 *16*							
1294.21[@] *6*	4.7[@] *5*	1378.35	1$^-$	84.373	2$^+$			Eγ=1294.21 *6*, Iγ=4.6 *5* (1979Va20). Eγ=1294.20 *10*, Iγ=4.82 *50* (1980KuZL).
1305.6 *2*	0.62 *9*	1389.71	(0$^+$,1,2)	84.373	2$^+$			
1323.9 *3*	0.20 *3*	1614.41	(1$^-$,2)	290.36	3$^-$			
1338.0[#] *5*	≈0.5[#]	1553.7	1,2$^+$	215.985	1$^-$			
1340.800[@] *25*	27.0[@] *20*	1425.03	(0,1,2)$^-$	84.373	2$^+$			Eγ=1340.806 *25*, Iγ=26 *2* (1979Va20). Eγ=1340.70 *10*, Iγ=29.4 *30* (1980KuZL).
1351.14[@] *14*	2.4[@&] *7*	1435.47	1$^-$	84.373	2$^+$			Eγ=1351.23 *12*, Iγ=3.1 *5* (1979Va20). Eγ=1350.9 *2*, Iγ=1.69 *25* (1980KuZL).
1352.60 *10*	4.2 *6*	1437.08	2$^+$	84.373	2$^+$			
1368.1 *2*	0.68 *16*	1658.52	1$^{(-)}$,2$^+$	290.36	3$^-$			
1378.45 *10*	16.8 *10*	1378.35	1$^-$	0	0$^+$			Eγ=1378.44 *22*, Iγ=16.3 *10* (1979Va20). Eγ=1378.45 *10*, Iγ=18.3 *18* (1980KuZL).
1398.5 *2*	0.48 *6*	1614.41	(1$^-$,2)	215.985	1$^-$			
1401.6 *2*	0.43 *6*	1652.42	2$^+$	250.783	4$^+$			
1435.60 *10*	6.3 *6*	1435.47	1$^-$	0	0$^+$			Eγ=1436.35, Iγ=10.3 *10* (1979Va20, marked as weak).
1437.20 *10*	4.9 *5*	1437.08	2$^+$	0	0$^+$			
1442.3 *2*	0.40 *5*	1658.52	1$^{(-)}$,2$^+$	215.985	1$^-$			
1469.4 *2*	0.50 *6*	1553.7	1,2$^+$	84.373	2$^+$			
1506.4 *2*	0.66 *9*	1796.75	(1$^-$,2)	290.36	3$^-$			
1520.6 *2*	0.21 *3*	1736.3	1,2$^+$	215.985	1$^-$			
1527.7 *2*	0.16 *3*	1818.1	(1$^-$,2)	290.36	3$^-$			

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$\gamma(^{224}$Ra) (continued)

E_γ [†]	I_γ [†c]	E_i(level)	J_i^π	E_f	J_f^π	Comments
1538.4 *2*	0.22 *3*	1754.84	0^+,1,2	215.985	1^-	
1553.5 *2*	0.24 *3*	1553.7	1,2^+	0	0^+	
1568.18[@] *6*	3.36[@] *40*	1652.42	2^+	84.373	2^+	Eγ=1568.19 *6*, Iγ=3.3 *5* (1979Va20). Eγ=1568.15 *10*, Iγ=3.4 *4* (1980KuZL).
1573.73[@] *8*	2.49[@] *30*	1789.61	1,2^+	215.985	1^-	Eγ=1573.69 *8*, Iγ=2.3 *4* (1979Va20). Eγ=1573.80 *10*, Iγ=2.60 *30* (1980KuZL).
1580.8 *2*	0.60 *10*	1796.75	(1^-,2)	215.985	1^-	Eγ=1580.9 (1979Va20, questionable).
1602.1 *5*	0.18 *3*	1818.1	(1^-,2)	215.985	1^-	
1607.1 *5*	0.18 *3*	1896.3	(1^-,2)	290.36	3^-	
1622.54[@] *10*	1.13[@] *15*	1838.49	0,1,2	215.985	1^-	Eγ=1622.74 *23*, Iγ=1.8 (1979Va20). Eγ=1622.50 *10* (1980KuZL).
1652.47 *5*	6.1 *7*	1652.42	2^+	0	0^+	Eγ=1652.47 *5*, Iγ=5.7 *7* (1979Va20). Eγ=1652.45 *10*, Iγ=6.7 *8* (1980KuZL).
1658.54[@] *10*	1.00[@] *20*	1658.52	$1^{(-)}$,2^+	0	0^+	Eγ=1658.40 *20*, Iγ=0.8 *2* (1979Va20). Eγ=1658.58 *10*, Iγ=1.20 *20* (1980KuZL).
1670.53[@] *10*	0.98[@] *16*	1754.84	0^+,1,2	84.373	2^+	Eγ=1670.48 *24*, Iγ=0.8 *2* (1979Va20). Eγ=1670.54 *10*, Iγ=1.10 *16* (1980KuZL).
1679.5 *5*	0.11 *3*	1896.3	(1^-,2)	215.985	1^-	
1705.12[@] *10*	1.22[@] *21*	1789.61	1,2^+	84.373	2^+	Eγ=1705.16 *12*, Iγ=1.1 *3* (1979Va20). Eγ=1705.09 *10*, Iγ=1.28 *21* (1980KuZL).
1712.30[@] *10*	1.55[@] *26*	1796.75	(1^-,2)	84.373	2^+	Eγ=1712.24 *10*, Iγ=1.4 *4* (1979Va20). Eγ=1712.36 *10*, Iγ=1.61 *26* (1980KuZL).
1736.19[@] *25*	0.95[@] *16*	1736.3	1,2^+	0	0^+	Eγ=1736.40 *17*, Iγ=0.9 *2* (1979Va20). Eγ=1735.9 *2*, Iγ=0.99 *16* (1980KuZL).
1753.93 *10*	0.59 *10*	1969.92	(0,1,2)	215.985	1^-	
[x]1779.1 *5*	0.12 *3*					
1784.3 *3*	0.30 *5*	2000.2	(1^-,2)	215.985	1^-	
1789.4 *2*	1.90 *30*	1789.61	1,2^+	0	0^+	
[x]1798.4 *5*	0.18 *3*					
1801.3 *5*	0.27 *5*	2052.3	2^+	250.783	4^+	
1811.6 *5*	0.13 *3*	1896.3	(1^-,2)	84.373	2^+	
[x]1816.2 *5*	0.11 *2*					
1827.05[@] *27*	0.56[@] *10*	2043.2	0,1,2	215.985	1^-	Eγ=1827.01 *27*, Iγ=0.43 *15* (1979Va20). Eγ=1827.2 *5*, Iγ=0.61 *10* (1980KuZL).
1836.5 *5*	0.17 *5*	2052.3	2^+	215.985	1^-	
[x]1847.1 *5*	0.40 *7*					
1862.0 *5*	0.22 *4*	2077.3	0^+,1,2	215.985	1^-	
1919.3 *5*	0.26 *4*	2135.3	0,1,2	215.985	1^-	
1938.3 *10*	0.08 *2*	2229.4	(1^-,2)	290.36	3^-	
[x]1944.8 *5*	0.12 *2*					
[x]1950.1 *5*	0.12 *2*					
[x]1973.9 *5*	0.10 *2*					

From ENSDF

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$\gamma(^{224}$Ra) (continued)

E_γ[†]	I_γ[†c]	E_i(level)	J_i^π	E_f	J_f^π	Comments
1992.4[@] *4*	0.47[@] *8*	2077.3	0^+,1,2	84.373	2^+	Eγ=1992.6 *4*, Iγ=0.50 *17* (1979Va20). Eγ=1992.2 *5*, Iγ=0.46 *8* (1980KuZL).
2013.4 *5*	0.10 *2*	2229.4	$(1^-,2)$	215.985	1^-	
2030.5 *5*	0.74 *12*	2246.5	$1,2^+$	215.985	1^-	Eγ=2029.80 *31* (1979Va20).
2033.2 *5*	0.22 *4*	2117.4	$1,2^+$	84.373	2^+	
2117.3 *5*	0.34 *5*	2117.4	$1,2^+$	0	0^+	
[x]2123.2 *5*	0.17 *3*					
2145.2 *5*	0.11 *2*	2229.4	$(1^-,2)$	84.373	2^+	
2152.5 *5*	0.19 *3*	2368.7	$1,2^+$	215.985	1^-	
2162.0 *5*	0.69 *11*	2246.5	$1,2^+$	84.373	2^+	Eγ=2164.4 (1979Va20) may correspond to 2162.0 and 2169.7 γ rays in 1980KuZL.
[x]2169.7 *5*	0.29 *5*					
[x]2214.8 *5*	0.22 *4*					
2246.6 *5*	0.10 *2*	2246.5	$1,2^+$	0	0^+	
2368.8 *5*	0.10 *2*	2368.7	$1,2^+$	0	0^+	
[x]2372.6 *5*	0.20 *2*					
[x]2388.0 *5*	0.11 *3*					

[†] From 1980KuZL unless otherwise stated.
[‡] From 1977Ku25 (^{228}Th α decay) and adopted by 1981Ku02.
[#] From $\gamma\gamma$ coin spectra.
[@] Weighted average of values from 1980KuZL and 1979Va20.
[&] Unweighted average of values from 1980KuZL and 1979Va20.
[a] From α(K)exp=Ice(1979Va20)/Iγ(listed here), normalized to α(K)(216γ, E1)=0.0600.
[b] From Adopted Gammas.
[c] For absolute intensity per 100 decays, multiply by 0.174 *20*.
[d] 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.
[e] Placement of transition in the level scheme is uncertain.
[x] γ ray not placed in level scheme.

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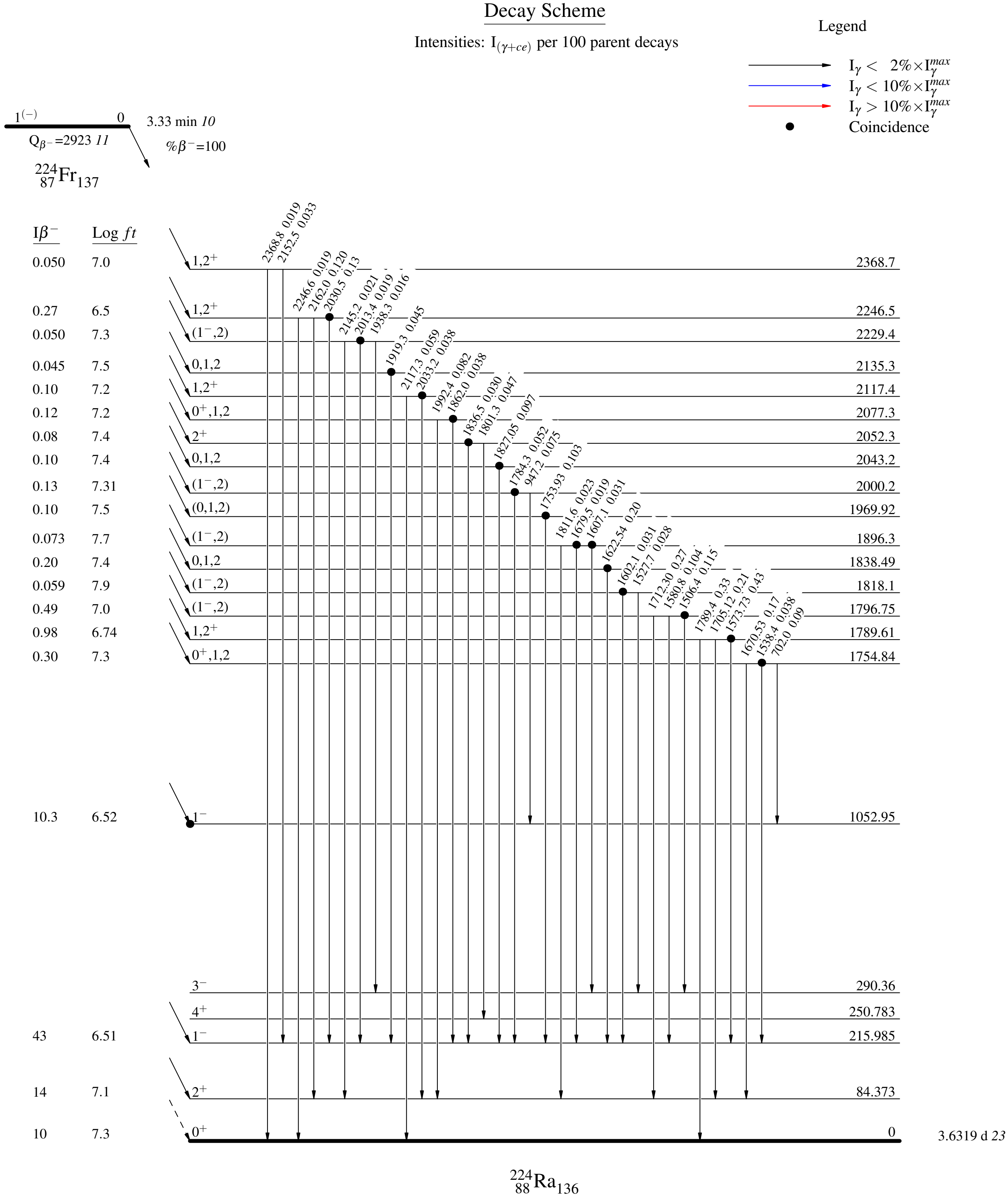
$^{224}Fr\ \beta^-$ decay (3.33 min) 1981Ku02,1980KuZL,1979Va20

Decay Scheme

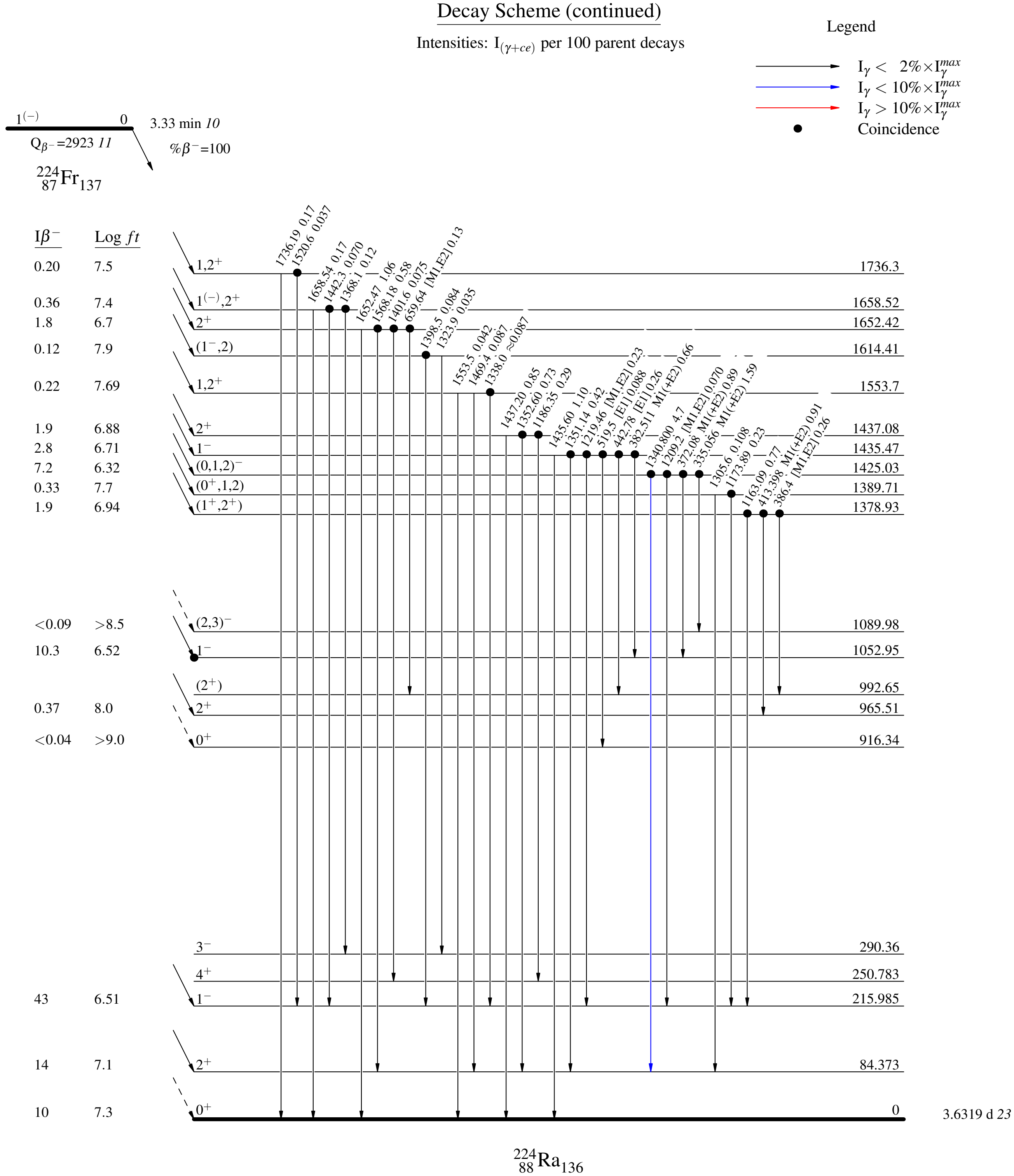
Intensities: $I_{(\gamma+ce)}$ per 100 parent decays



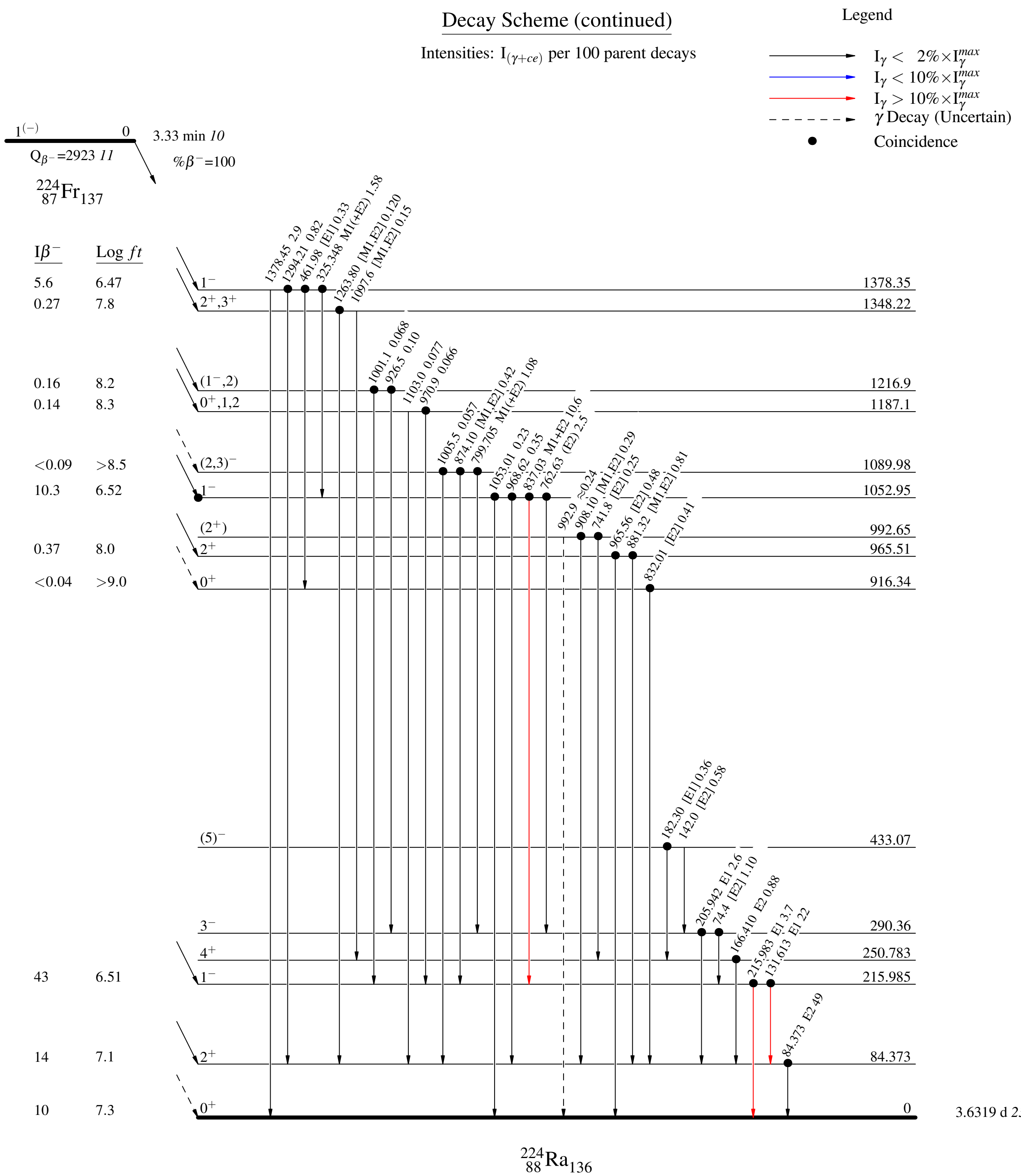
^{224}Fr β^- decay (3.33 min) 1981Ku02,1980KuZL,1979Va20

Decay Scheme (continued)

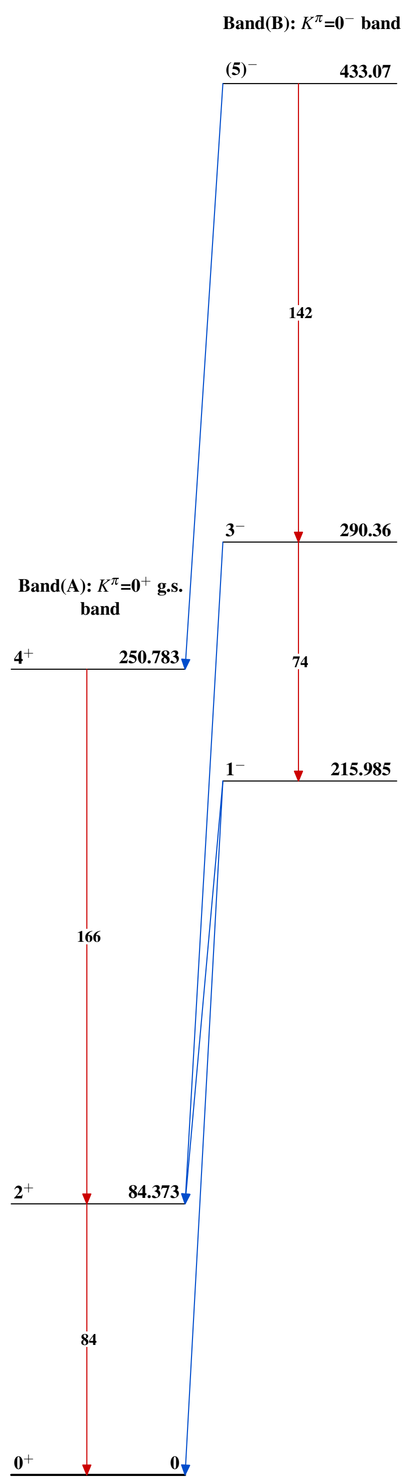
Intensities: $I_{(\gamma+ce)}$ per 100 parent decays



^{224}Fr β^- decay (3.33 min) 1981Ku02,1980KuZL,1979Va20



^{224}Fr β^- decay (3.33 min) 1981Ku02,1980KuZL,1979Va20



$^{224}_{88}Ra_{136}$