^{222}Fr β^- decay (14.2 min) 1992Ru01

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh, M. S. Basunia, Jun Chen et al. ,	NDS 192,315 (2023)	25-Sep-2023

Parent: ^{222}Fr: E=0.0; J$^\pi$=2$^-$; $T_{1/2}$=14.2 min *3*; Q(β^-)=2058 *9*; %β^- decay=100
^{222}Fr-J$^\pi$,$T_{1/2}$: From ^{222}Fr Adopted Levels.
^{222}Fr-Q(β^-): From 2021Wa16.
Dataset by Balraj Singh, Jun Chen, and IAEA-ICTP-workshop participants: S. Leblond and V. Vallet.
BetaShape code (2019Mo35) used for log *ft* values and Eβ(average).
1992Ru01: ^{222}Fr source was produced in a spallation reaction by bombarding thorium carbide powder with a 280 MeV ^{3}He beam from the IPN synchro-cyclotron in Orsay. Fragments were separated by the ISOCELE II on-line mass separator. β particles were detected with a 4π plastic detector and γ rays were detected with two Ge(Li) detectors (planar and coaxial). Measured Eγ, Iγ, $\beta\gamma$-coin, $\beta\gamma\gamma$-coin. Deduced levels, J, π, β-decay branching ratios, log *ft*.
1985Go05: ^{222}Fr source was produced by separating a francium fraction. γ rays were detected with Ge(Li) detectors. Measured Eγ, Iγ. Deduced levels, J, π, β-decay branching ratios, log *ft*.
The ^{222}Fr β^- decay scheme is presented as constructed by 1992Ru01 based on their β-gated $\gamma\gamma$-coincidence measurements. The decay scheme was built upon the previously known levels which were established up to the 1170-keV level.

^{222}Ra Levels

E(level)†	J$^\pi$‡	$T_{1/2}$‡	E(level)†	J$^\pi$‡
0.0	0$^+$	33.6 s *4*	1360.83 *9*	(1$^-$,2,3)
111.117 *8*	2$^+$	0.52 ns *4*	1375.72 *8*	(1,2,3$^-$)
242.109 *8*	1$^-$	9.5 ps *+21−16*	1402.541 *25*	(2$^+$,3$^-$)
301.381 *18*	4$^+$	135 ps *+17−14*	1432.70 *5*	(1,2,3$^-$)
317.283 *14*	(3)$^-$	4.7 ps *+26−14*	1439.883 *28*	(3$^-$)
473.751 *26*	(5$^-$)	24 ps *+5−9*	1499.45 *5*	(1$^-$,2,3$^-$)
1024.861 *18*	(2$^+$)		1555.94 *7*	(2$^+$)
1170.886 *32*	(3$^-$,4$^+$)		1619.58 *9*	(1,2,3$^-$)
1171.53 *4*	(1,2$^+$)		1644.823 *34*	(2$^+$,3$^-$)
1225.21 *5*	(1,2$^+$)		1754.33 *5*	(3$^-$)
1264.99 *4*	(2$^+$,3)		1821.52 *20*	(1,2,3$^-$)
1310.19 *8*	(0$^+$,1,2,3$^-$)		1841.14 *5*	(1,2,3$^-$)

† From a least-squares fit to γ-ray energies. Nine Eγ values fit poorly, as detailed in comments for relevant γ rays.
‡ From the Adopted Levels.

β^- radiations

See 1975We23 for singles β spectrum measurements. The spectrum shows a flat tail of low intensity and extended to much higher energy than the main portion of the data. After subtraction of this tail (which was assumed due to α particles from ^{222}Ra), an F-K analysis gives Eβ(max)=1780 *20* for the endpoint which does not agree with the Eβ^- (to 111.12 level).
E(average β energies) from BetaShape code (2019Mo35, 2015Mo10).

E(decay)	E(level)	Iβ^-†#	Log *ft*‡	Comments
(217 *9*)	1841.14	0.10 *5*	6.09 *+37−25*	av Eβ=58.5 *26*
(237 *9*)	1821.52	0.016 *4*	7.0 *+19−16*	av Eβ=64.0 *26*
(304 *9*)	1754.33	0.101 *15*	6.55 *12*	av Eβ=84.3 *27*
(413 *9*)	1644.823	0.12 *6*	6.91 *+34−22*	av Eβ=118.3 *29*
(438 *9*)	1619.58	0.049 *8*	7.38 *12*	av Eβ=126.3 *29*
(502 *9*)	1555.94	0.068 *10*	7.43 *10*	av Eβ=147.2 *30*
(559 *9*)	1499.45	0.120 *16*	7.34 *9*	av Eβ=166.2 *30*
(618 *9*)	1439.883	0.33 *5*	7.05 *10*	av Eβ=186.3 *31*

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^{222}Fr β^- decay (14.2 min) 1992Ru01 (continued)

β^- radiations (continued)

E(decay)	E(level)	$I\beta^-$[†#]	Log ft[‡]	Comments
(625 *9*)	1432.70	0.144 *19*	7.42 *9*	av Eβ=188.7 *31*
(656 *9*)	1402.541	0.64 *9*	6.84 *9*	av Eβ=199.0 *31*
(682 *9*)	1375.72	0.036 *6*	8.15 *11*	av Eβ=208.4 *31*
(697 *9*)	1360.83	0.051 *8*	8.03 *10*	av Eβ=213.7 *32*
(748 *9*)	1310.19	0.021 *5*	8.52 *13*	av Eβ=231.7 *32*
(793 *9*)	1264.99	0.34 *5*	7.40 *9*	av Eβ=247.8 *32*
(833 *9*)	1225.21	0.086 *14*	8.07 *10*	av Eβ=262.2 *33*
(887 *9*)	1171.53	0.76 *10*	7.22 *9*	av Eβ=281.6 *33*
(887 *9*)	1170.886	0.07 *4*	8.25 *+39−22*	av Eβ=281.9 *33*
(1033 *9*)	1024.861	0.83 *11*	7.41 *8*	av Eβ=336.3 *34*
(1741 *9*)	317.283	53 *8*	6.43 *9*	av Eβ=614.9 *37*
(1757 *9*)	301.381	0.35 *7*	9.54^{1u} *11*	av Eβ=583.8 *34*
(1816 *9*)	242.109	1.7 *3*	7.99 *10*	av Eβ=645.5 *37*
(1947 *9*)	111.117	36 *12*	6.78 *+19−14*	av Eβ=699.2 *37*
(2058[@] *9*)	0.0	3 *3*	≥8.7^{1u}	av Eβ=699.2 *35*

† From intensity balance at each level.
‡ From BetaShape code (2019Mo35, 2015Mo10).
\# Absolute intensity per 100 decays.
@ Existence of this branch is questionable.

γ(^{222}Ra)

Iγ normalization: Relative photon intensities were normalized by 1992Ru01 to Iγ(324.2γ in ^{218}Rn)=2.77 *8* per 100 ^{222}Ra α decays. This value was measured absolutely by 1969Pe17, and it has been adopted by the evaluators. 1992Ru01 did not explicitly provide their measured Iγ(324γ) relative to the Iγ values given here but gave γ+ce total intensities in the decay scheme in Fig. 4, where %Iγ(206γ+ce)=53.4, after correction of the internal conversion coefficient=0.841 (estimated by the evaluators using BrIcc) from 1978Ro21 used by 1992Ru01, gives %Iγ(206γ)=49.3% and thus the normalization factor=0.493 *54*, with the total uncertainty from that in relative Iγ(206γ)=100 *10*, an estimation of 5% uncertainty for the determination of the total conversion coefficient in 1978Ro21, and uncertainty in Iγ(324.2γ)=2.77 *8*. Others: an assumption of any β feeding to the g.s. to be negligible yields Iγ normalization=0.51 *6*; by requiring that the log $f^{1u}t$ for a β feeding to the g.s. is >8.5, Iβ is deduced as <7%. Iβ(g.s.)=3% *3* yields Iγ normalization=0.50 *6*; Iγ(324γ)/Iγ(206γ)=5.7 *6*/100 from 1985Go05, %Iγ(324γ)=2.77 *8* from 1969Pe17 and relative Iγ(206)=100 *10* from 1992Ru01, yield Iγ normalization=0.486 *72*.
Measured Ra x-ray intensities:
E(Kα x ray): 88.5, I(x ray)/I(206γ)=0.143 *20* (1985Go05).
E(Kβ x ray): 100.0, I(x ray)/I(206γ)=0.0275 *35* (1985Go05).

E_γ[‡]	I_γ[‡@]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	α[&]	Comments
^{x}50.14 *2*	0.030 *5*							%Iγ=0.0148 *30*
75.13 *2*	0.017 *4*	317.283	(3)$^-$	242.109	1$^-$	[E2]	36.8 *5*	α(L)=27.0 *4*; α(M)=7.35 *10* α(N)=1.940 *27*; α(O)=0.412 *6*; α(P)=0.0593 *8*; α(Q)=0.0001583 *22* %Iγ=0.0084 *22*
111.11 *1*	26.2 *26*	111.117	2$^+$	0.0	0$^+$	E2	6.13 *9*	α(K)=0.293 *4*; α(L)=4.29 *6*; α(M)=1.168 *16* α(N)=0.308 *4*; α(O)=0.0656 *9*; α(P)=0.00952 *13*; α(Q)=3.90×10^{-5} *5* %Iγ=12.9 *19* Other: Eγ=111.09 *5*, Iγ=24.5 *25* (1985Go05).
130.98 *1*	1.25 *12*	242.109	1$^-$	111.117	2$^+$	(E1)	0.2502 *35*	α(K)=0.1959 *27*; α(L)=0.0412 *6*; α(M)=0.00990 *14*

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$^{222}Fr\ \beta^-$ decay (14.2 min) 1992Ru01 (continued)

$\gamma(^{222}Ra)$ (continued)

E_γ [‡]	I_γ [‡@]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [#]	α [&]	Comments
								α(N)=0.00258 4; α(O)=0.000566 8; α(P)=9.03×10^{-5} 13; α(Q)=4.85×10^{-6} 7 %Iγ=0.62 9 Other: Eγ=131.0 4, Iγ=1.3 2 (1985Go05).
172.37 2	0.12 1	473.751	(5$^-$)	301.381	4$^+$	[E1]	0.1288 18	α(K)=0.1021 14; α(L)=0.02026 28; α(M)=0.00486 7 α(N)=0.001267 18; α(O)=0.000280 4; α(P)=4.55×10^{-5} 6; α(Q)=2.62×10^{-6} 4 %Iγ=0.059 8
190.24 2	1.19 5	301.381	4$^+$	111.117	2$^+$	E2	0.702 10	α(K)=0.1778 25; α(L)=0.386 5; α(M)=0.1043 15 α(N)=0.0275 4; α(O)=0.00590 8; α(P)=0.000872 12; α(Q)=8.46×10^{-6} 12 %Iγ=0.59 7 Other: Eγ=190.3 4, Iγ=1.00 15 (1985Go05).
196.31 4	0.08 1	1841.14	(1,2,3$^-$)	1644.823	(2$^+$,3$^-$)	[D,E2]	1.3 12	%Iγ=0.039 7
206.18 2	100 10	317.283	(3)$^-$	111.117	2$^+$	E1	0.0839 12	α(K)=0.0669 9; α(L)=0.01289 18; α(M)=0.00308 4 α(N)=0.000805 11; α(O)=0.0001788 25; α(P)=2.93×10^{-5} 4; α(Q)=1.758×10^{-6} 25 %Iγ=49.3 54 Other: Eγ=206.10 4, Iγ=100 (1985Go05).
^{x}218.66 4	0.12 1							%Iγ=0.059 8
^{x}221.36 2	0.52 5							%Iγ=0.256 37
^{x}224.10 2	0.19 2							%Iγ=0.094 14
231.67 4	0.076 8	1402.541	(2$^+$,3$^-$)	1170.886	(3$^-$,4$^+$)	[D,E2]	0.8 7	%Iγ=0.038 6
242.11 1	3.93 40	242.109	1$^-$	0.0	0$^+$	E1	0.0575 8	α(K)=0.0461 6; α(L)=0.00866 12; α(M)=0.002069 29 α(N)=0.000541 8; α(O)=0.0001205 17; α(P)=1.991×10^{-5} 28; α(Q)=1.236×10^{-6} 17 %Iγ=1.94 29 Other: Eγ=241.8 5, Iγ=3.7 4 (1985Go05).
268.99 4	0.040 8	1439.883	(3$^-$)	1170.886	(3$^-$,4$^+$)	[D,E2]	0.53 48	%Iγ=0.0197 45
351.75 4	0.037 8	1754.33	(3$^-$)	1402.541	(2$^+$,3$^-$)	[D,E2]	0.25 22	%Iγ=0.0182 44
377.64 4	0.12 1	1402.541	(2$^+$,3$^-$)	1024.861	(2$^+$)	[D,E2]	0.020 18	%Iγ=0.059 8
415.05 4	0.032 6	1439.883	(3$^-$)	1024.861	(2$^+$)	[E1]	0.01732 24	α(K)=0.01407 20; α(L)=0.002471 35; α(M)=0.000586 8 α(N)=0.0001535 21; α(O)=3.45×10^{-5} 5; α(P)=5.83×10^{-6} 8; α(Q)=3.99×10^{-7} 6 %Iγ=0.0158 34
^{x}455.37 7	0.018 4							%Iγ=0.0089 22
474.45 9	0.079 8	1499.45	(1$^-$,2,3$^-$)	1024.861	(2$^+$)	[D,E2]	0.11 10	%Iγ=0.039 6
619.95 4	0.072 8	1644.823	(2$^+$,3$^-$)	1024.861	(2$^+$)	[D,E2]	0.054 46	%Iγ=0.036 6

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^{222}Fr β^- decay (14.2 min) 1992Ru01 (continued)

γ(^{222}Ra) (continued)

E_γ [‡]	I_γ [‡@]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	α[&]	Comments
696.88[†] *5*	0.046 *8*	1170.886	(3$^-$,4$^+$)	473.751	(5$^-$)	[D,E2]	0.040 *33*	%Iγ=0.0227 *47* E_γ: uncertainty multiplied by a factor of 2 in the fitting; level-energy difference=697.13.
707.54 *3*	0.89 *4*	1024.861	(2$^+$)	317.283	(3)$^-$	[E1]	0.00599 *8*	α(K)=0.00492 *7*; α(L)=0.000817 *11*; α(M)=0.0001926 *27* α(N)=5.05×10^{-5} *7*; α(O)=1.143×10^{-5} *16*; α(P)=1.960×10^{-6} *27*; α(Q)=1.446×10^{-7} *20* %Iγ=0.439 *52* Other: Eγ=706.4 *10*, Iγ=0.71 *20* (1985Go05).
723.45 *4*	0.030 *4*	1024.861	(2$^+$)	301.381	4$^+$	[E2]	0.01711 *24*	α(K)=0.01253 *18*; α(L)=0.00344 *5*; α(M)=0.000859 *12* α(N)=0.0002266 *32*; α(O)=5.04×10^{-5} *7*; α(P)=8.29×10^{-6} *12*; α(Q)=4.39×10^{-7} *6* %Iγ=0.0148 *26*
782.77 *3*	0.87 *8*	1024.861	(2$^+$)	242.109	1$^-$	[E1]	0.00497 *7*	α(K)=0.00408 *6*; α(L)=0.000672 *9*; α(M)=0.0001582 *22* α(N)=4.15×10^{-5} *6*; α(O)=9.40×10^{-6} *13*; α(P)=1.616×10^{-6} *23*; α(Q)=1.206×10^{-7} *17* %Iγ=0.43 *6* Other: Eγ=780.7 *10*, Iγ=0.40 *15* (1985Go05).
^{x}831.58 *5*	0.036 *5*							%Iγ=0.0178 *32*
^{x}846.72 *8*	0.070 *14*							%Iγ=0.035 *8*
853.78 *8*	0.16 *1*	1170.886	(3$^-$,4$^+$)	317.283	(3)$^-$			%Iγ=0.079 *10*
869.6 *2*	0.13 *4*	1170.886	(3$^-$,4$^+$)	301.381	4$^+$			%Iγ=0.064 *21*
913.69 *5*	0.15 *2*	1024.861	(2$^+$)	111.117	2$^+$			%Iγ=0.074 *13*
929.47 *8*	0.14 *2*	1171.53	(1,2$^+$)	242.109	1$^-$			%Iγ=0.069 *13*
963.61 *6*	0.14 *2*	1264.99	(2$^+$,3)	301.381	4$^+$			%Iγ=0.069 *13*
966.24 *9*	0.070 *14*	1439.883	(3$^-$)	473.751	(5$^-$)			%Iγ=0.035 *8*
982.90 *8*	0.072 *14*	1225.21	(1,2$^+$)	242.109	1$^-$			%Iγ=0.036 *8*
1025.02 *8*	0.060 *10*	1024.861	(2$^+$)	0.0	0$^+$			%Iγ=0.030 *6*
1043.60 *9*	0.065 *8*	1360.83	(1$^-$,2,3)	317.283	(3)$^-$			%Iγ=0.0321 *53*
1060.33 *5*	0.92 *7*	1171.53	(1,2$^+$)	111.117	2$^+$			%Iγ=0.45 *6* Other: Eγ=1059.2 *15*, Iγ=0.63 *20* (1985Go05).
1068.08 *8*	0.043 *8*	1310.19	(0$^+$,1,2,3$^-$)	242.109	1$^-$			%Iγ=0.0212 *46*
1085.20 *5*	0.46 *6*	1402.541	(2$^+$,3$^-$)	317.283	(3)$^-$			%Iγ=0.227 *39*
1101.09 *5*	0.50 *5*	1402.541	(2$^+$,3$^-$)	301.381	4$^+$			%Iγ=0.247 *37*
1114.26 *8*	0.074 *14*	1225.21	(1,2$^+$)	111.117	2$^+$			%Iγ=0.037 *8*
1122.41 *9*	0.12 *2*	1439.883	(3$^-$)	317.283	(3)$^-$			%Iγ=0.059 *12*
1133.61 *8*	0.074 *8*	1375.72	(1,2,3$^-$)	242.109	1$^-$			%Iγ=0.037 *6*
1138.47 *5*	0.30 *3*	1439.883	(3$^-$)	301.381	4$^+$			%Iγ=0.148 *22*
1153.87 *5*	0.54 *5*	1264.99	(2$^+$,3)	111.117	2$^+$			%Iγ=0.266 *38*
^{x}1156.75 *9*	0.044 *9*							%Iγ=0.0217 *50*
1160.52 *8*	0.072 *7*	1402.541	(2$^+$,3$^-$)	242.109	1$^-$			%Iγ=0.0355 *52*
1171.69 *8*	0.49 *5*	1171.53	(1,2$^+$)	0.0	0$^+$			%Iγ=0.242 *36* Other: Eγ=1168, Iγ=0.3 (1985Go05).

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^{222}Fr β^- decay (14.2 min) 1992Ru01 (continued)

γ(^{222}Ra) (continued)

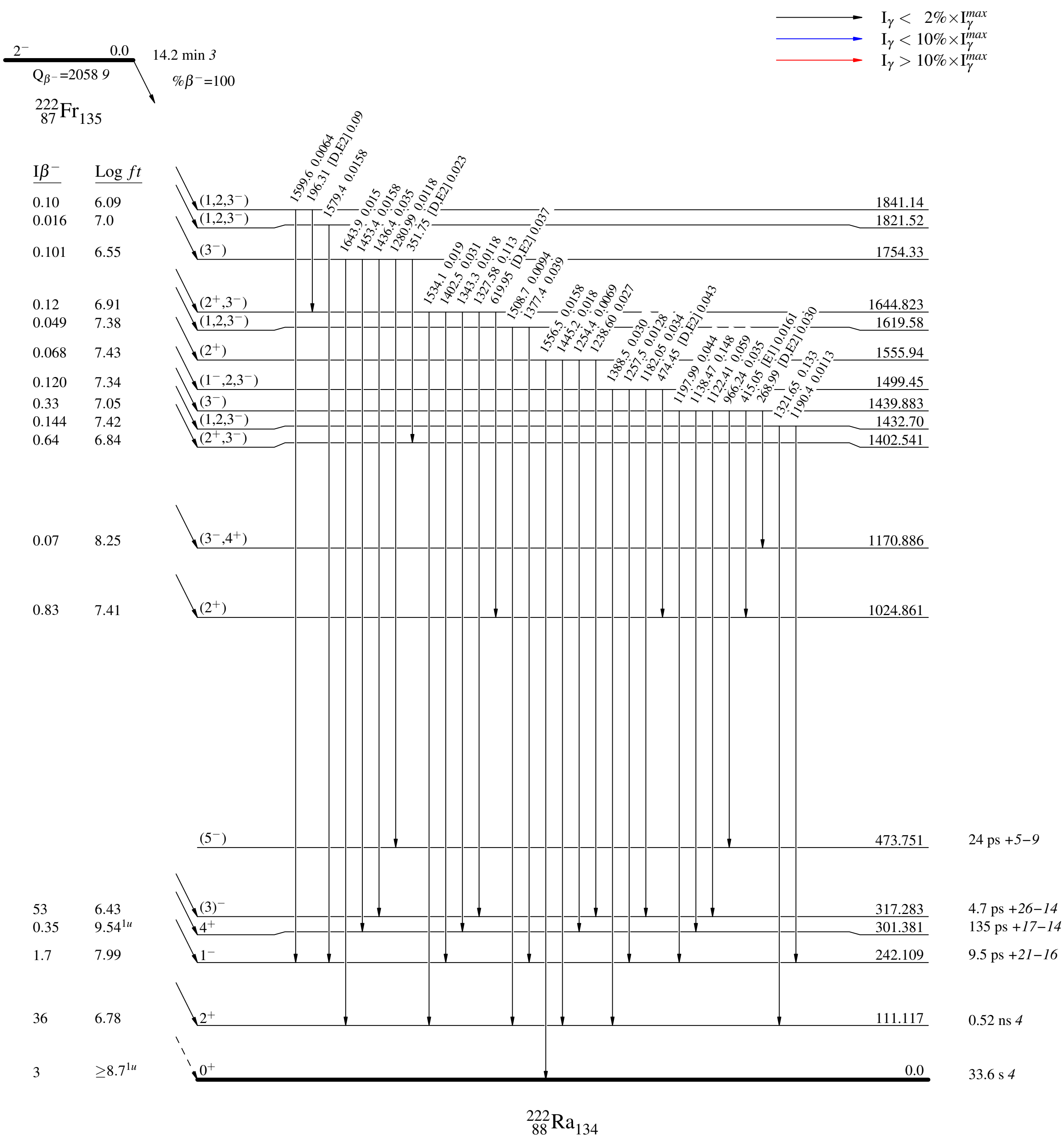
E_γ[‡]	I_γ[‡@]	E_i(level)	J^π_i	E_f	J^π_f	Comments
1182.05 *8*	0.069 *8*	1499.45	(1⁻,2,3⁻)	317.283	(3)⁻	%Iγ=0.0340 *54*
1190.4 *1*	0.023 *4*	1432.70	(1,2,3⁻)	242.109	1⁻	%Iγ=0.0113 *23*
1197.99[†] *8*	0.089 *15*	1439.883	(3⁻)	242.109	1⁻	%Iγ=0.044 *9* E_γ: uncertainty multiplied by a factor of 2 in the fitting; level-energy difference=1197.771.
1225.24 *8*	0.028 *5*	1225.21	(1,2⁺)	0.0	0⁺	%Iγ=0.0138 *29*
1238.60 *8*	0.054 *7*	1555.94	(2⁺)	317.283	(3)⁻	%Iγ=0.0266 *45*
1249.1[†] *1*	0.039 *7*	1360.83	(1⁻,2,3)	111.117	2⁺	%Iγ=0.0192 *41* E_γ: uncertainty multiplied by a factor of 3 in the fitting; level-energy difference=1249.71.
1254.4 *2*	0.014 *3*	1555.94	(2⁺)	301.381	4⁺	%Iγ=0.0069 *17*
1257.5 *1*	0.026 *5*	1499.45	(1⁻,2,3⁻)	242.109	1⁻	%Iγ=0.0128 *28*
1280.99[†] *9*	0.024 *5*	1754.33	(3⁻)	473.751	(5⁻)	%Iγ=0.0118 *28* E_γ: uncertainty multiplied by a factor of 2 in the fitting; level-energy difference=1280.57.
1291.61 *8*	0.048 *8*	1402.541	(2⁺,3⁻)	111.117	2⁺	%Iγ=0.0237 *47*
[x]1295.6 *1*	0.028 *5*					%Iγ=0.0138 *29*
1321.65 *6*	0.27 *2*	1432.70	(1,2,3⁻)	111.117	2⁺	%Iγ=0.133 *18*
1327.58 *6*	0.23 *2*	1644.823	(2⁺,3⁻)	317.283	(3)⁻	%Iγ=0.113 *16*
1343.3 *1*	0.024 *4*	1644.823	(2⁺,3⁻)	301.381	4⁺	%Iγ=0.0118 *24*
1377.4 *1*	0.080 *9*	1619.58	(1,2,3⁻)	242.109	1⁻	%Iγ=0.039 *6*
1388.5 *1*	0.060 *8*	1499.45	(1⁻,2,3⁻)	111.117	2⁺	%Iγ=0.0296 *51*
1402.5 *2*	0.062 *7*	1644.823	(2⁺,3⁻)	242.109	1⁻	%Iγ=0.0306 *48*
1436.4[†] *1*	0.071 *7*	1754.33	(3⁻)	317.283	(3)⁻	%Iγ=0.0350 *52* E_γ: uncertainty multiplied by a factor of 3 in the fitting; level-energy difference=1437.04.
1445.2 *2*	0.037 *6*	1555.94	(2⁺)	111.117	2⁺	%Iγ=0.0182 *36*
1453.4[†] *1*	0.032 *6*	1754.33	(3⁻)	301.381	4⁺	%Iγ=0.0158 *34* E_γ: uncertainty multiplied by a factor of 2 in the fitting; level-energy difference=1452.94.
[x]1502.3 *1*	0.050 *9*					%Iγ=0.0247 *52*
1508.7 *2*	0.019 *4*	1619.58	(1,2,3⁻)	111.117	2⁺	%Iγ=0.0094 *22*
1534.1 *2*	0.039 *7*	1644.823	(2⁺,3⁻)	111.117	2⁺	%Iγ=0.0192 *41*
1556.5[†] *2*	0.032 *6*	1555.94	(2⁺)	0.0	0⁺	%Iγ=0.0158 *34* E_γ: uncertainty multiplied by a factor of 2 in the fitting; level-energy difference=1555.94.
1579.4 *2*	0.032 *6*	1821.52	(1,2,3⁻)	242.109	1⁻	%Iγ=0.0158 *34*
1599.6[†] *2*	0.013 *4*	1841.14	(1,2,3⁻)	242.109	1⁻	%Iγ=0.0064 *21* E_γ: uncertainty multiplied by a factor of 2 in the fitting; level-energy difference=1599.02.
1643.9[†] *2*	0.031 *8*	1754.33	(3⁻)	111.117	2⁺	%Iγ=0.0153 *43* E_γ: uncertainty multiplied by a factor of 2 in the fitting; level-energy difference=1643.20.

[†] Poor fit; uncertainty multiplied by a factor in the fitting.
[‡] From 1992Ru01. Quoted Iγ values are relative photon intensities.
[#] From the Adopted Gammas.
[@] For absolute intensity per 100 decays, multiply by 0.493 *54*.
[&] 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.
[x] γ ray not placed in level scheme.

^{222}Fr β^- decay (14.2 min) 1992Ru01

Decay Scheme

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



^{222}Fr β^- decay (14.2 min) 1992Ru01

Decay Scheme (continued)

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