^{146}Cs β^- decay 2016Mi02,1980Sc16

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Yu. Khazov, A. Rodionov and G. Shulyak	NDS 136, 163 (2016)	14-Jul-2016

Parent: ^{146}Cs: E=0.0; $J^\pi=1^-$; $T_{1/2}$=0.3220 s *13*; Q(β^-)=9370 *40*; %β^- decay=100.0

^{146}Cs-$T_{1/2}$ from 'Adopted Levels'.

Note: edited by Balraj Singh, Feb 25, 2021, in consultation with A. Rodionov, one of the evaluators of 2016 update: removed quoted experimental total conversion coefficients for 181.038 and 332.37 γ rays, taken from 1978BlZY, as the listed values in the latter are theoretical total conversion coefficients. In general comment for multipolarity assignment, removed comment about conversion coefficient.

1980Sc16,1979Sc24: ^{146}Cs β^- decay (fission product of ^{235}U); measured Eγ, Iγ, $\gamma\gamma$, $\gamma\gamma(\theta)$. ^{146}Ba; deduced levels, J^π, δ. Mass-separator OSTIS, tape transport system, Ge(Li) detectors.

1980MoZA,1979MoZU,1978BlZY (the same group): ^{146}Cs β^- decay; measured Eγ, Iγ, $\gamma\gamma$, Ice. ^{146}Ba; deduced levels, J^π. Mass-separator OSTIS.

1986Gr11,1982Pa24: ^{146}Cs β^- decay; measured Eβ, Iβ, $\beta\gamma$ coin, β-endpoint energies; deduced Q(β). Mass-separator OSTIS, plastic and Ge(Li) detectors.

2016Mi02: ^{146}Cs source from the CAlifornium Rare Ion Breeder Upgrade (CARIBU) facility at Argonne National Laboratory. Spontaneous fission fragments were extracted from a 1.7-Ci ^{252}Cf source, thermalized in a He gas catcher and separated with an isobar separator. Fragments implanted into aluminum foil. Measured Eγ, Iγ, Eβ, $\gamma\gamma$, $\beta\gamma$, and $\beta\gamma\gamma$ coincidences using the SATURN (Scintillator and Tape Using Radioactive Nuclei) system composed of four symmetrically arranged plastic scintillator paddles and the X-Array composed of five HPGe Clover detectors. Deduced levels, J, π, branching. Comparison to interacting boson approximation (IBA) model calculations.

The ^{146}Ba level scheme is constructed on the basis of data of 1980Sc16, 1980MoZA, and 2016Mi02. Iγ's may be different up to two times in different papers.

^{146}Ba Levels

E(level)[†]	J^π[#]	$T_{1/2}$[@]	Comments
0.0	0^+	2.21 s *6*	$T_{1/2}$: weighted average from γ(t) of 2.22 s *7* (1985Ch16), 2.2 s *3* (1979En02), 2.18 s *11* (1978Wo09).
181.06 *5*	2^+	0.859 ns *29*	g=0.28 *7* (PAC method, H=22.4 kG, 1983Wo05).
513.55 *6*	4^+	18 ps *15*	
738.79 *8*	1^-	160 ps *10*	
820.98 *7*	3^-	237 ps *8*	
1052.38 *17*	0^+	<26 ps	
1115.22 *9*	$(1,2^+)$		
1157.69?[‡] *17*			Introduced by 1980MoZA, supported by 1980Sc16, coin with 181γ not supported in 2016Mi02. Evaluators treat this level as doubtful.
1256.26 *10*	(1,2)		
1309.25 *13*	3^+		
1341.97 *11*	0^+		
1398.65 *19*	2^+		
1410.62 *20*			
1511.06 *12*	1^-		
1527.70 *13*	3		
1566.34 *11*	(2^+)		
1600.21? *20*			Introduced by 1978BlZY, not supported by 1980Sc16, 2016Mi02. Evaluators treat this level as doubtful.
1632.3 *3*			
1637.72[‡] *16*			
1656.34[‡] *24*	$(1,2^+)$		
1668.87? *20*			
1682.86[‡] *16*			
1715.29[‡] *9*	$(1,2^+)$		

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^{146}Cs β^- decay 2016Mi02,1980Sc16 (continued)

^{146}Ba Levels (continued)

E(level)[†]	Jπ[#]	Comments
1780.0 *3*		
1932.9 *4*		
1968.51 *15*	(1,2$^+$)	
1979.9 *4*		
1983.16? *20*		Introduced by 1978BlZY, γ's not supported by others. Evaluators treat this level as doubtful.
1996.25[‡] *23*	(1,2$^+$)	
2037.6 *4*		
2060.1 *4*		
2134.9 *4*		
2162.1 *5*		
2171.4 *5*		
2195.59? *22*		Introduced by 1978BlZY based on a single transition. Evaluators treat this level as doubtful.
2209.0 *4*		
2343.9[‡] *5*	(1,2$^+$)	
2444? *5*		Introduced by 1978BlZY based on a single transition to g.s. Evaluators treat this level as doubtful.
2567? *5*		Introduced by 1978BlZY based on a single transition to g.s. Evaluators treat this level as doubtful.

[†] From a least-squares fit to Eγ's; χ^2_{norm}=1.79.
[‡] The level introduced by 1980MoZA.
[#] From 'Adopted Levels'.
[@] From βγγ(t) 1990Ma25, except as noted.

β^- radiations

β-endpoints measured by 1986Gr11: Eβ$^-$=9045 *160*, 8460 *205*, 8405 *205*, 8175 *200*, 7715 *195*, 7335 *205*, 6875 *165*; deduced Q(β$^-$)=9290 *75*. Others: 1981Ke07, 1981De25, 1982Pa24, 1988GrZX.

E(decay)	E(level)	Iβ$^-$[†‡]	Log *ft*	Comments
(7.16×10^3 *4*)	2209.0	<0.6	>6.8	av Eβ=3179 *19*
(7.20×10^3 *4*)	2171.4	<0.5	>6.9	av Eβ=3197 *19*
(7.21×10^3 *4*)	2162.1	<1.3	>6.5	av Eβ=3201 *19*
(7.24×10^3 *4*)	2134.9	<0.6	>6.8	av Eβ=3214 *19*
(7.31×10^3 *4*)	2060.1	<0.5	>6.9	av Eβ=3249 *19*
(7.33×10^3 *4*)	2037.6	<1.2	>6.5	av Eβ=3260 *19*
(7.37×10^3 *4*)	1996.25	<1.9	>6.4	av Eβ=3279 *19*
(7.39×10^3 *4*)	1979.9	<0.4	>7.0	av Eβ=3287 *19*
(7.40×10^3 *4*)	1968.51	<4.4	>6.0	av Eβ=3292 *19*
(7.44×10^3 *4*)	1932.9	<0.4	>7.1	av Eβ=3309 *19*
(7.59×10^3 *4*)	1780.0	<1.7	>6.5	av Eβ=3380 *19*
(7.65×10^3 *4*)	1715.29	<3.5	>6.2	av Eβ=3410 *19*
(7.69×10^3 *4*)	1682.86	<1.8	>6.5	av Eβ=3425 *19*
(7.70×10^3 *4*)	1668.87?	<1.4	>6.6	av Eβ=3432 *19*
(7.71×10^3 *4*)	1656.34	<2.5	>6.3	av Eβ=3437 *19*
(7.73×10^3 *4*)	1637.72	<2.3	>6.4	av Eβ=3446 *19*
(7.74×10^3 *4*)	1632.3	<1.3	>6.6	av Eβ=3449 *19*
(7.80×10^3 *4*)	1566.34	<4.4	>6.1	av Eβ=3480 *19*
(7.84×10^3 *4*)	1527.70	<1.1	>6.7	av Eβ=3498 *19*
(7.86×10^3 *4*)	1511.06	<3.7	>6.2	av Eβ=3506 *19*
(7.96×10^3 *4*)	1410.62	<0.3	>7.3	av Eβ=3553 *19*

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^{146}Cs β^- decay 2016Mi02,1980Sc16 (continued)

β^- radiations (continued)

E(decay)	E(level)	Iβ^-[†‡]	Log *ft*	Comments
(7.97×10^3 *4*)	1398.65	<2.5	>6.4	av Eβ=3559 *19*
(8.03×10^3 *4*)	1341.97	<1.4	>6.7	av Eβ=3585 *19*
(8.06×10^3 *4*)	1309.25	<2.3	>6.4	av Eβ=3600 *19*
(8.11×10^3 *4*)	1256.26	<3.2	>6.3	av Eβ=3625 *19*
(8.25×10^3 *4*)	1115.22	<3.8	>6.3	av Eβ=3691 *19*
(8.32×10^3 *4*)	1052.38	<1.7	>6.6	av Eβ=3720 *19*
(8.55×10^3 *4*)	820.98	<2.9	>6.5	av Eβ=3828 *19*
(8.63×10^3 *4*)	738.79	<7	>6.1	av Eβ=3866 *19*
(8.86×10^3 *4*)	513.55	<3	>6.5	av Eβ=3971 *19*
(9.19×10^3 *4*)	181.06	<19	>5.8	av Eβ=4125 *19*
(9.37×10^3 *4*)	0.0	<27	>5.7	av Eβ=4210 *19*

† As given in 2016Mi02. Authors provide upper limits on Iβ^- since the observed population of 4^+ and 3^- states at the few percent level from a 1^- parent indicates missing γ-ray strength.

‡ Absolute intensity per 100 decays.

^{146}Cs β^- decay 2016Mi02,1980Sc16 (continued)

$\gamma(^{146}Ba)$

Iγ normalization: From 2016Mi02; determined by comparison of Iγ(181γ) to the Iγ(141γ) in the decay of ^{146}Ba. Calculation used the absolutely intensity of Iγ(141γ)=20.2 % *30* and accounted for the β-delayed neutron branch of ^{146}Cs taking %β^-n=14.2.
A_2, A_4 from 1980Sc16, except as noted.

E_γ[†]	I_γ[‡c]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[@]	δ[&]	α[b]	Comments
82.2 *2*	0.11 *4*	820.98	3⁻	738.79	1⁻	E2		3.89 *7*	α(K)=2.16 *4*; α(L)=1.357 *25*; α(M)=0.298 *6* α(N)=0.0617 *11*; α(O)=0.00807 *15*; α(P)=9.61×10^{-5} *15* E_γ,I_γ,Mult.: from 1990Ma25.
181.03 *5*	100 *1*	181.06	2⁺	0.0	0⁺	E2		0.242	α(exp)=0.244 (1978BlZY) α(K)=0.184 *3*; α(L)=0.0454 *7*; α(M)=0.00973 *14* α(N)=0.00204 *3*; α(O)=0.000282 *4*; α(P)=9.58×10^{-6} *14* 1979Bo26: Eγ=180.894 *6*, curved cryst.
307.30 *6*	4.8 *1*	820.98	3⁻	513.55	4⁺	(E1+M2)	+0.12 *6*	0.013 *4*	α(K)=0.011 *3*; α(L)=0.0015 *5*; α(M)=0.00031 *9* α(N)=6.8×10^{-5} *19*; α(O)=1.0×10^{-5} *3*; α(P)=7.0×10^{-7} *20* A_2=−0.236 *47*, A_4=−0.035 *88*.
332.37 *5*	11.3 *2*	513.55	4⁺	181.06	2⁺	E2		0.0327	α(exp)=0.0329 (1978BlZY) α(K)=0.0269 *4*; α(L)=0.00466 *7*; α(M)=0.000980 *14* α(N)=0.000208 *3*; α(O)=3.01×10^{-5} *5*; α(P)=1.546×10^{-6} *22* A_2=0.015 *42*, A_4=0.009 *74*.
557.70 *17*	16.1 *2*	738.79	1⁻	181.06	2⁺	(E1+M2)	−0.024 *21*	0.00256 *6*	α(K)=0.00221 *5*; α(L)=0.000277 *7*; α(M)=5.66×10^{-5} *13* α(N)=1.22×10^{-5} *3*; α(O)=1.86×10^{-6} *5*; α(P)=1.33×10^{-7} *3* A_2=−0.222 *24*, A_4=−0.021 *44*.
640.06 *11*	5.1 *1*	820.98	3⁻	181.06	2⁺	(E1+M2)	+0.19 *13*	0.0025 *11*	α(K)=0.0022 *10*; α(L)=0.00028 *14*; α(M)=6.E−5 *3* α(N)=1.2×10^{-5} *6*; α(O)=1.9×10^{-6} *9*; α(P)=1.4×10^{-7} *7* A_2=0.071 *86*, A_4=0.11 *16*.
738.86 *12*	5.3 *1*	738.79	1⁻	0.0	0⁺				
745.30 *17*	1.0 *1*	1566.34	(2⁺)	820.98	3⁻				
772.14 *12*	5.2 *6*	1511.06	1⁻	738.79	1⁻				Observed by 1978BlZY with Iγ=1.4, placed by 2016Mi02.
788.9 *1*	0.5[a] *1*	1527.70	3	738.79	1⁻				
795.55 *14*	2.0 *7*	1309.25	3⁺	513.55	4⁺				Observed by 1978BlZY with Iγ=1.2, placed by 2016Mi02.
[x]808.8[#] *2*	1.0[#]								
816.78 *19*	1.2 *5*	1637.72		820.98	3⁻				I_γ: from 2016Mi02; observed by 1978BlZY with Iγ=1.7.
821.1[#] *2*	1.2[#]	820.98	3⁻	0.0	0⁺				
827.80 *26*	1.6 *1*	1566.34	(2⁺)	738.79	1⁻				
[x]847.3[#] *2*	0.7[#]								
861.6[#] *2*	0.5[#]	1600.21?		738.79	1⁻				
867.9[#] *2*	1.3[#]	1983.16?		1115.22	(1,2⁺)				
871.49 *17*	2.7 *1*	1052.38	0⁺	181.06	2⁺	E2		0.00245	α(K)=0.00210 *3*; α(L)=0.000281 *4*; α(M)=5.79×10^{-5} *9* α(N)=1.244×10^{-5} *18*; α(O)=1.89×10^{-6} *3*; α(P)=1.299×10^{-7} *19* A_2=0.57 *13*, A_4=1.18 *26*; A_2=0.355 *14*, A_4=1.08 *16* (1983Wo05).

$^{146}_{56}Ba_{90}$-4

^{146}Cs β^- decay 2016Mi02,1980Sc16 (continued)

$\gamma(^{146}Ba)$ (continued)

E_γ [†]	I_γ [‡c]	E_i(level)	J_i^π	E_f	J_f^π	Comments
893.41 *31*	2.4[a] *1*	1632.3		738.79	1^-	Observed by 1980Sc16 with Iγ=2.4 *1*, placed by 2016Mi02.
894.1 *1*	0.21[a] *4*	1715.29	$(1,2^+)$	820.98	3^-	
917.51 *26*	2.0 *1*	1656.34	$(1,2^+)$	738.79	1^-	
934.07 *16*	3.1 *1*	1115.22	$(1,2^+)$	181.06	2^+	
943.6 *2*	1.1 *1*	1682.86		738.79	1^-	
944.1[#] *2*	1.45[#]	1996.25	$(1,2^+)$	1052.38	0^+	
976.63 *16*	1.1 *1*	1157.69?		181.06	2^+	possible placement of this γ: from 1714.9 keV level (2016Mi02).
976.7 *1*	2.6 *8*	1715.29	$(1,2^+)$	738.79	1^-	
1052.6[#] *2*	0.8[#]	1566.34	(2^+)	513.55	4^+	
1075.31 *13*	1.1 *1*	1256.26	(1,2)	181.06	2^+	
1115.24 *10*	2.4 *2*	1115.22	$(1,2^+)$	0.0	0^+	
1128.58 *24*	2.7[a] *2*	1309.25	3^+	181.06	2^+	Observed by 1980Sc16 with Iγ=1.8 *2*, placed by 2016Mi02.
[x]1158.7[#] *2*	2.3[#]					
1160.9 *1*	1.2[a] *1*	1341.97	0^+	181.06	2^+	
1217.8 *2*	0.6 *5*	1398.65	2^+	181.06	2^+	Observed by 1978BlZY with Iγ=0.9, placed by 2016Mi02.
1229.5 *2*	0.6[a] *1*	1410.62		181.06	2^+	
1256.12 *14*	1.9 *2*	1256.26	(1,2)	0.0	0^+	
1299 *1*	0.8 *4*	2037.6		738.79	1^-	
[x]1300.3[#] *2*	0.9[#]					
1310 *1*	<0.19	1309.25	3^+	0.0	0^+	
1330.4 *2*	1.6 *5*	1511.06	1^-	181.06	2^+	
1342 *2*	<0.19	1341.97	0^+	0.0	0^+	
1348.9 *3*	1.6 *5*	1527.70	3	181.06	2^+	Final level record added Feb 25, 2021 by B. Singh. E_γ: level energy difference gives 1346.64 keV; this γ was not used for least-square fitting.
1385.32 *21*	2.4 *2*	1566.34	(2^+)	181.06	2^+	
1397.8 *4*	1.1 *6*	1398.65	2^+	0.0	0^+	
1412 *1*	<0.20	1410.62		0.0	0^+	
1451.6 *25*	0.8[a] *1*	1632.3		181.06	2^+	Observed by 1980Sc16 with Iγ=1.1 *1*, placed by 2016Mi02.
1456.58 *23*	1.4 *2*	1637.72		181.06	2^+	Iγ from 1980Sc16. Observed by 1978BlZY with Iγ=3.4, placed by 2016Mi02 with Iγ=3.3 *7*.
1456.8 *2*	3.4	2195.59?		738.79	1^-	Other placement: from 1637.7 keV level (1980Sc16, 2016Mi02).
1487.8 *2*	2 *1*	1668.87?		181.06	2^+	Observed by 1978BlZY, placed by 2016Mi02.
1502.31 *22*	2.3 *2*	1682.86		181.06	2^+	other: Iγ=2.8 *2* (coin, 2016Mi02).
1510 *1*	0.9 *5*	1511.06	1^-	0.0	0^+	
1529 *1*	<0.21	1527.70	3	0.0	0^+	
1533.8 *6*	1.0 *2*	1715.29	$(1,2^+)$	181.06	2^+	
[x]1546.2[#] *5*	0.3[#]					
1566.8[#] *5*	2.8[#]	1566.34	(2^+)	0.0	0^+	
1598.9 *3*	2.3 *6*	1780.0		181.06	2^+	Observed by 1978BlZY with Eγ=1599.1, Iγ=1.4 and placed from the 1600 keV level; placement from the 1780.0 keV level is from 2016Mi02, supported by coin in 1980Sc16.
1599.1[#] *5*	1.4[#]	1600.21?		0.0	0^+	E_γ: other: 1597.80 *38* Iγ=4.00 *34* in coin with 181γ (1980Sc16); supported by 1598.7 *4* Iγ=2.3 *6* from 1780 keV level (2016Mi02).

$\gamma(^{146}Ba)$ (continued)

E_γ [†]	I_γ [‡c]	E_i(level)	J_i^π	E_f	J_f^π	Comments
1633 *1*	<0.23	1632.3		0.0	0^+	
1638 *1*	<0.23	1637.72		0.0	0^+	
1656.5# *5*	3.2#	1656.34	$(1,2^+)$	0.0	0^+	
1669 *1*	<0.23	1668.87?		0.0	0^+	
1684 *1*	<0.23	1682.86		0.0	0^+	
1715.8# *5*	2.7# *6*	1715.29	$(1,2^+)$	0.0	0^+	
1751.7 *4*	0.8[a] *1*	1932.9		181.06	2^+	
1780.2 *8*	0.9 *6*	1780.0		0.0	0^+	
1787.2 *3*	2.3 *6*	1968.51	$(1,2^+)$	181.06	2^+	I_γ: from 2016Mi02; other: 1.2 (1980MoZA).
1798.3 *4*	0.8[a] *2*	1979.9		181.06	2^+	
1813.5 *7*	1.4 *2*	1996.25	$(1,2^+)$	181.06	2^+	I_γ: other: 3.1 (1978BlZY, 1980MoZA).
1856.6 *4*	1.5 *2*	2037.6		181.06	2^+	
1878.9 *4*	1.0[a] *2*	2060.1		181.06	2^+	
1934 *1*	<0.28	1932.9		0.0	0^+	
1953.7 *4*	1.1 *2*	2134.9		181.06	2^+	
1968.56 *16*	7 *1*	1968.51	$(1,2^+)$	0.0	0^+	I_γ: from 2016Mi02; other: 4.1 (1980MoZA).
1980.8 *5*	<0.28	1979.9		0.0	0^+	Observed by 1978BlZY with Iγ=1.4, placed by 2016Mi02. Part of Iγ may belong to the transition from 2162.1 keV level.
1981.0 *5*	2.2 *9*	2162.1		181.06	2^+	Observed by 1978BlZY with Iγ=1.4, placed by 2016Mi02. Part of Iγ may belong to the transition from 1979.9 keV level.
1983.4# *5*	0.9#	1983.16?		0.0	0^+	
1990.2 *5*	1.0[a] *2*	2171.4		181.06	2^+	
1995.6# *5*	0.5#	1996.25	$(1,2^+)$	0.0	0^+	
2027.8 *4*	1.3 *2*	2209.0		181.06	2^+	Observed by 1978BlZY with Iγ=0.8, placed by 2016Mi02.
2037 *1*	<0.29	2037.6		0.0	0^+	
2061 *1*	<0.30	2060.1		0.0	0^+	
2136 *1*	<0.31	2134.9		0.0	0^+	
2162 *1*	<0.32	2162.1		0.0	0^+	
2162.8# *5*	0.9#	2343.9	$(1,2^+)$	181.06	2^+	
2172 *1*	<0.32	2171.4		0.0	0^+	
[x]2188# *5*	0.6#					
2210 *1*	<0.33	2209.0		0.0	0^+	
2344# *5*	2.4#	2343.9	$(1,2^+)$	0.0	0^+	
2444# *5*	1.3#	2444?		0.0	0^+	
2567# *5*	0.8#	2567?		0.0	0^+	

[†] Weighted average of 1980Sc16, 1978BlZY and 2016Mi02 except as noted.
[‡] From 1980Sc16, except as noted.

$^{146}_{56}Ba_{90}$-6

^{146}Cs β^- decay 2016Mi02,1980Sc16 (continued)

$\gamma(^{146}Ba)$ (continued)

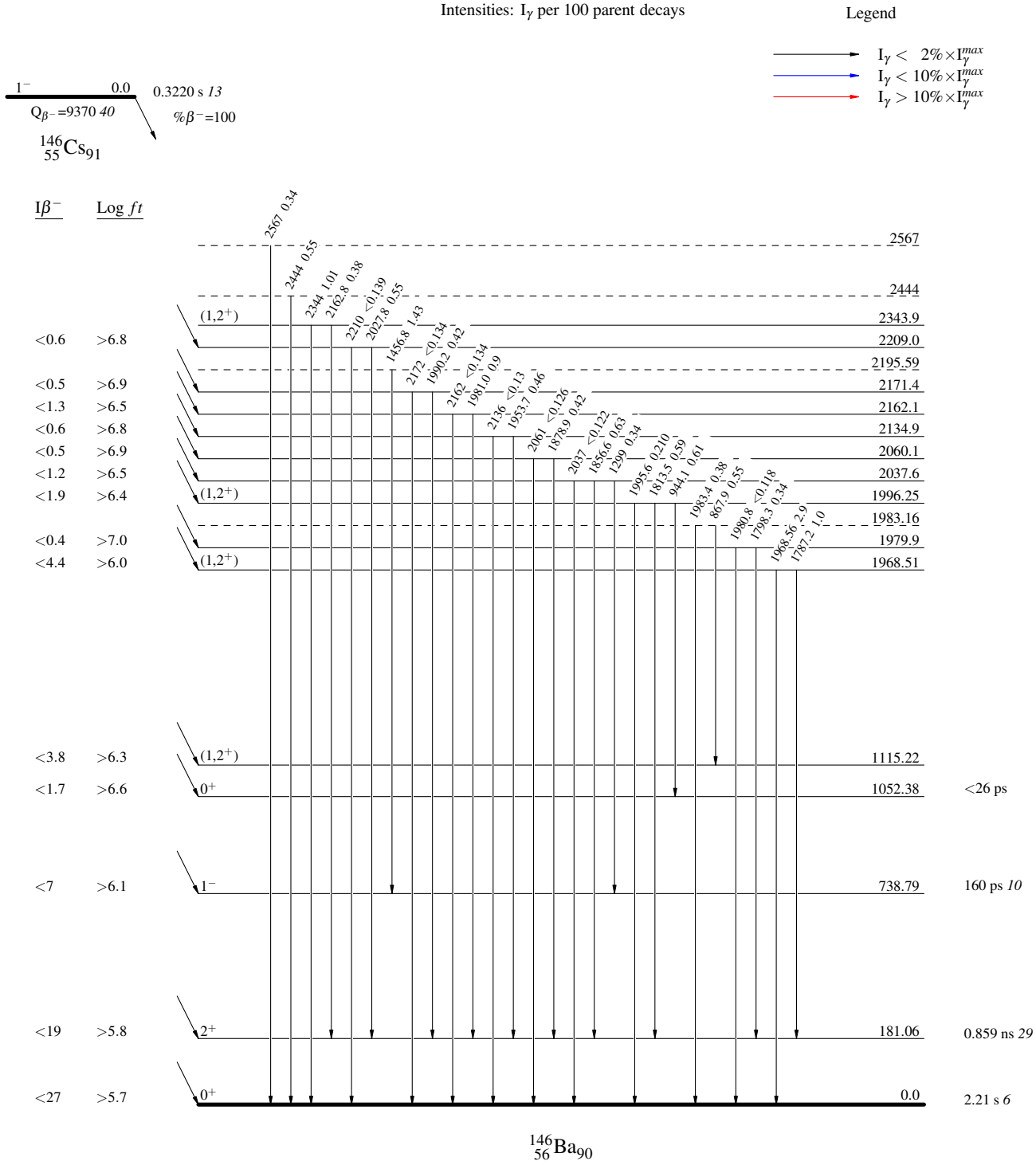
[#] From 1978BlZY, 1980MoZA.
[@] From $\gamma\gamma(\theta)$ and the level scheme (1980Sc16).
[&] From $\gamma\gamma(\theta)$ (1980Sc16).
[a] From coincidence data (2016Mi02).
[b] Additional information 1.
[c] For absolute intensity per 100 decays, multiply by 0.42 *5*.
[x] γ ray not placed in level scheme.

$^{146}_{56}Ba_{90}$-7

^{146}Cs β^- decay 2016Mi02,1980Sc16

Decay Scheme

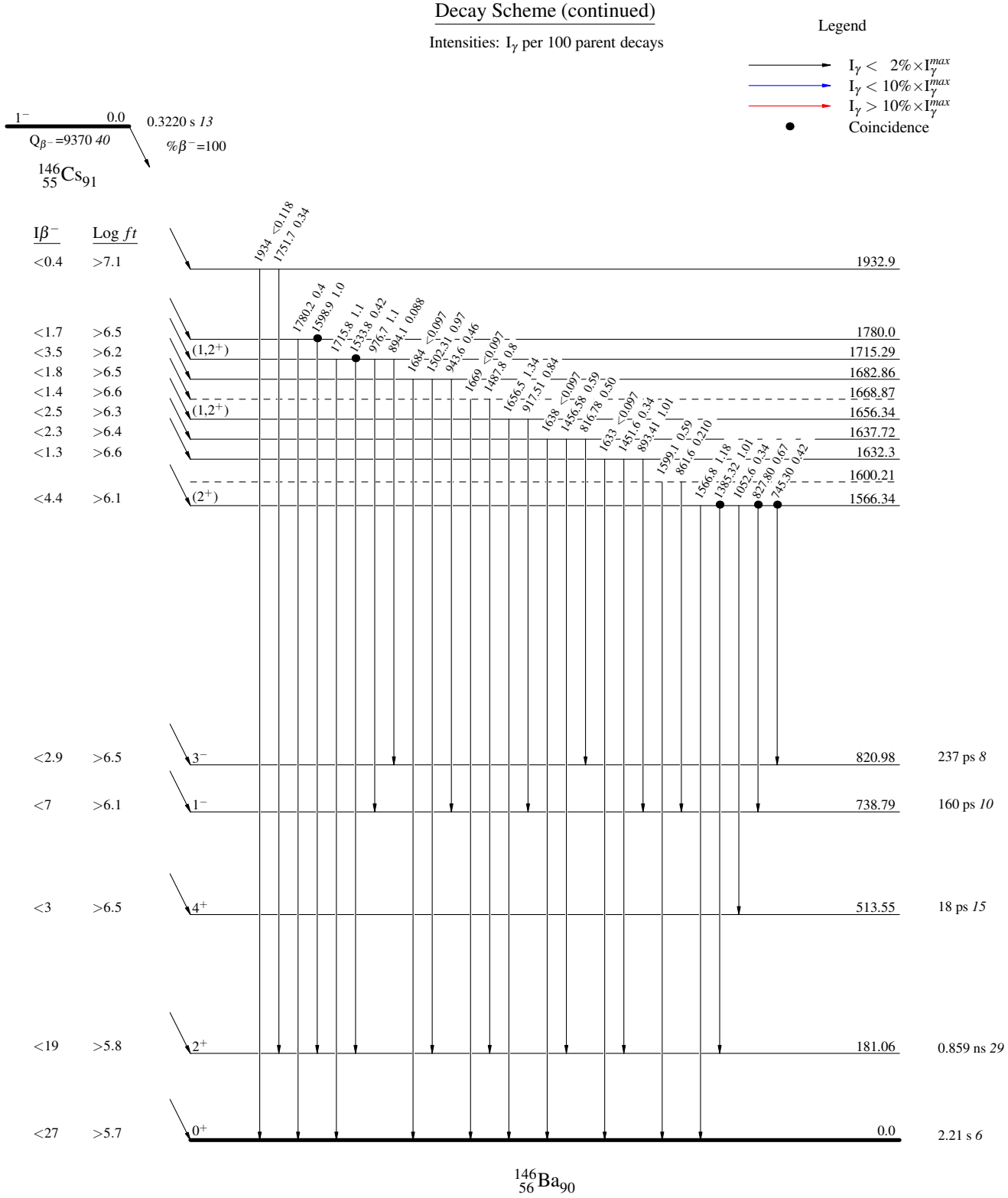
Intensities: I_γ per 100 parent decays



^{146}Cs β^- decay 2016Mi02,1980Sc16

Decay Scheme (continued)

Intensities: I_γ per 100 parent decays



^{146}Cs β^- decay 2016Mi02,1980Sc16

Decay Scheme (continued)

Intensities: I_γ per 100 parent decays