^{156}Pm β^- decay (26.70 s) 1990He11

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	C. W. Reich	NDS 113, 2537 (2012)	1-Mar-2012

Parent: ^{156}Pm: E=0; $J^\pi=4^{(+)}$; $T_{1/2}$=26.70 s *10*; $Q(\beta^-)$=5150 *33*; $\%\beta^-$ decay=100.0

^{156}Pm-J^π: Additional information 1.

^{156}Pm-$T_{1/2}$: Additional information 2.

^{156}Pm-$Q(\beta^-)$: Additional information 3.

Additional information 4.

^{156}Pm has been produced by thermal-neutron induced fission of ^{235}U (1986Ma12,1986Ok01,1990He11) and spontaneous fission of ^{252}Cf (1987Gr12), all with isotope separation. All data reported here are from 1990He11 or computed by the evaluator. For shorter lists of γ's, see 1986Ma12, 1986Ok01, and 1987Gr12.

1990He11: ^{156}Sm, from thermal-neutron fission of ^{235}U followed by isotope separation. Source material collected on a movable tape and transported to a counting station. Measured multiscaled γ singles using a large-volume coaxial Ge detector and a LEPS detector. Measured simultaneously low-energy γ's and ce's using the LEPS and an ion-implanted Si detector. System geometry was calibrated using γ's of known multipolarities from the ^{124}In decay. Measured $\gamma\gamma$ and $\beta\gamma$(t) coincidences using a small plastic detector and various Ge detectors. Report Eγ, Iγ, $Q(\beta^-)$, $T_{1/2}$ values for two excited states. The ce data are not reported in 1990He11, but some of the deduced multipolarities are given there.

^{156}Sm Levels

The level energies are from a least-squares fit to the γ energies. There are several cases in which the deduced level-energy difference differs from the corresponding γ energy by more than 2 or 3 times the quoted uncertainty. It is thus reasonable to assume, for specific γ lines, that there are doublets and/or that the uncertainties are underestimated, possibly due to difficulties in the spectral analysis.

E(level)	J^π[#]	$T_{1/2}$	Comments
0[@]	0^+		
75.89[@] *5*	2^+		
249.71[@] *7*	4^+		
517.07[@] *8*	6^+		
803.69[&] *22*	(1^-)		
875.69[&] *11*	(3^-)		
1009.79[&] *9*	(2^-)		
1020.62[&] *10*	(5^-)		
1110.11[a] *11*	(3^-)		J^π: 1990He11 report J^π=(3).
1144.07[&] *9*	(4^-)		
1256.1 *5*			
1397.55[b] *9*	5^-	185 ns *7*	$T_{1/2}$: From 1990He11. Note that 1974ClZX report a half-life of 160 ns *40*, but were not able to identify the associated level.
1509.22[d] *9*	4^+		1990He11 propose the two-proton quasiparticle excitation π5/2[413]+π3/2[411] as the conf of this state (note that the one shown by them apparently has a misprint), presumably by analogy with the 1510.5, 4^+, state in ^{156}Gd. However, the location of the Fermi surface for protons in ^{156}Sm is different from that in ^{156}Gd. The evaluator has proposed a different conf for this state (see the Adopted Levels data set).
1515.04[c] *9*	5^-	4.5 ns *2*	$T_{1/2}$: From 1990He11.
1610.30 *12*			
1738.35 *13*			
2033.8 *3*			
2199.91 *11*			
2265.52 *11*			

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^{156}Pm β^- decay (26.70 s) 1990He11 (continued)

^{156}Sm Levels (continued)

E(level)	E(level)	J$^{\pi}$#	E(level)	J$^{\pi}$#
2341.92 *12*	2519.04† *11*	3	2609.7† *3*	(4)
2482.6 *3*	2526.22‡ *9*	3	2616.51‡ *21*	(4)
			2699.7 *5*	

† Suggested member of a band by 1990He11. From log *ft* considerations, these authors suggest that π for the J=3 level is most likely the same as that of the ^{156}Pm g.s., which these authors propose to be negative. 2011So05, however, indicate that this log *ft* argument may not be a strong one in this case. Based on the expected nucleonic configurations, the evaluator prefers π=+ for the ^{156}Pm g.s. The sole decay mode of the 2609 level is to a 4$^+$ level, consistent with J$^{\pi}$=4$^-$, which is the value listed by 1990He11. In that case this and the J=3 level would not be members of the same band.
‡ Suggested member of a band by 1990He11. From log *ft* considerations, these authors indicate that π for the J=3 level is most likely the same as that of the ^{156}Pm g.s., which they propose to be negative. However, the evaluator has preferred π=+ for the ^{156}Pm g.s. The sole decay mode of the 2616 level is to a 4$^+$ level, consistent with J$^{\pi}$=4$^-$, which is the value listed by 1990He11. In that case this and the J=3 level would not be members of the same band.
# From the adopted values. These are generally those proposed by 1990He11. Where there are differences, these are noted.
@ Band(A): K$^{\pi}$=0$^+$ ground-state band.
& Band(B): Probable K$^{\pi}$=1$^-$ octupole band. This band likely contains a significant component of ν5/2[642]-ν3/2[521].
[a] Band(C): Possible 3$^-$ member of the K$^{\pi}$=0$^-$ octupole band. This suggestion is supported by the observation that the γ branching from this level to the 2$^+$ and 4$^+$ members of the g.s. band agrees well with the Alaga-rule expectations for ΔK=0 dipole transitions.
[b] Band(D): K$^{\pi}$=5$^-$ bandhead, conf=ν5/2[642]+ν5/2[523]. This is the dominant conf. See the discussion regarding the 5$^-$ state at 1515 keV regarding possible configuration mixing between these two 5$^-$ states.
[c] Band(E): K$^{\pi}$=5$^-$ bandhead, conf=π5/2[532]+π5/2[413]. The preferential β^- feeding of this state relative to the 1397, 5$^-$, state suggests that it is predominantly two-proton, rather than two-neutron, in character. These two 5$^-$ states are, however, most likely mixed to some extent. Evidence for such mixing, which is frequently observed between two-proton and two-neutron bands with the same K$^{\pi}$ values, is evidenced by the existence (albeit with a sizeable hindrance factor) of the 117-keV M1 transition connecting them and the possible, but much weaker, β^- feeding of this level.
[d] Band(F): Probable K$^{\pi}$=4$^+$ bandhead.

β^- radiations

The Iβ^- values have all been computed from the γ-transition intensity balances and therefore are accurate only insofar as this decay scheme is correct and complete. There are 3 unplaced γ rays with intensities of ≈0.6% and, since the weakest reported γ's have intensities of 0.3%, it is reasonable to expect that there are unobserved γ rays with intensites of 0.2% and less. With a Q value of 5150 keV and the high spin (J=4) of the parent, it is expected that many levels above that at 2699 keV will be populated, albeit weakly. Therefore, a minimum uncertainty of 0.4% has been assigned to each Iβ^- by the evaluator.
1995Gr19, using total-absorption γ spectroscopy, deduce that the β branching to the ground and first excited states is 1.8% 17. These authors point out that their data do not provide evidence for a nonzero β- branch to the first excited state.
The Iβ^- to the 803 and 1009 levels have been set to zero because the adopted J^{π} requires that these transitions be negligibly weak. The values deduced from the intensity balance are 2.0% *3* and 2.1% *8*, respectively.

E(decay)	E(level)	Iβ^-†	Log *ft*	Comments
(2.45×10^3 *3*)	2699.7	0.4 *4*	7.0 *5*	av Eβ=968 *15*
(2.53×10^3 *3*)	2616.51	0.8 *4*	6.76 *22*	av Eβ=1006 *15*
(2.54×10^3 *3*)	2609.7	1.0 *4*	6.67 *18*	av Eβ=1009 *15*
(2.62×10^3 *3*)	2526.22	16.5 *6*	5.51 *3*	av Eβ=1047 *15*
(2.63×10^3 *3*)	2519.04	8.2 *5*	5.82 *4*	av Eβ=1050 *15*

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^{156}Pm β^- decay (26.70 s) 1990He11 (continued)

β^- radiations (continued)

E(decay)	E(level)	I$\beta^{-\dagger}$	Log *ft*	Comments
(2.67×10^3 *3*)	2482.6	1.0 *4*	6.75 *18*	av Eβ=1067 *15*
(2.81×10^3 *3*)	2341.92	1.8 *4*	6.59 *10*	av Eβ=1131 *15*
(2.88×10^3 *3*)	2265.52	4.2 *4*	6.27 *5*	av Eβ=1165 *15*
(2.95×10^3 *3*)	2199.91	7.7 *4*	6.05 *3*	av Eβ=1195 *15*
(3.12×10^3 *3*)	2033.8	1.9 *4*	6.75 *10*	av Eβ=1271 *16*
(3.41×10^3 *3*)	1738.35	1.0 *4*	7.20 *18*	av Eβ=1407 *16*
(3.54×10^3 *3*)	1610.30	1.8 *4*	7.01 *10*	av Eβ=1466 *16*
(3.63×10^3 *3*)	1515.04	23.0 *15*	5.95 *4*	av Eβ=1510 *16*
(3.64×10^3 *3*)	1509.22	11.4 *9*	6.26 *4*	av Eβ=1513 *16*
(3.75×10^3 *3*)	1397.55	3.1 *16*	6.88 *23*	av Eβ=1564 *16*
(3.89×10^3 *3*)	1256.1	0.6 *4*	7.7 *3*	av Eβ=1629 *16*
(4.04×10^3 *3*)	1110.11	2.5 *4*	7.11 *8*	av Eβ=1697 *16*
(4.13×10^3 *3*)	1020.62	1.7 *4*	7.32 *11*	av Eβ=1738 *16*
(4.27×10^3 *3*)	875.69	3.6 *5*	7.05 *7*	av Eβ=1805 *16*
(4.63×10^3 *3*)	517.07	3.4 *10*	8.96^{1u} *13*	av Eβ=1947 *16*

† Absolute intensity per 100 decays.

γ(^{156}Sm)

Iγ normalization: calculated to give average γ feeding of levels at 0 and 75 keV as 100%; these feedings are 96% *6* and 102% *3*, respectively.

E$_\gamma$†	I$_\gamma$$^{\dagger\#}$	E$_i$(level)	J$^\pi_i$	E$_f$	J$^\pi_f$	Mult.‡	$\alpha$$^@$	Comments
75.88 *5*	12.5 *7*	75.89	2$^+$	0	0$^+$	E2	6.51	α(K)=2.38 *4*; α(L)=3.20 *5*; α(M)=0.745 *11*; α(N+..)=0.183 *3* α(N)=0.1629 *24*; α(O)=0.0202 *3*; α(P)=9.97×10^{-5} *14*
117.42 *5*	13.8 *7*	1515.04	5$^-$	1397.55	5$^-$	M1	1.068	α(K)=0.906 *13*; α(L)=0.1281 *18*; α(M)=0.0275 *4*; α(N+..)=0.00723 *11* α(N)=0.00624 *9*; α(O)=0.000935 *14*; α(P)=5.78×10^{-5} *9* Mult.: As assigned by 1990He11. The ce data are also consistent with mult=E1+M2, with %M2 between 8 and 9. However, from RUL, δ(M2/E1)≤0.01. Thus, there is no parity change involved in the 117.42 transition.
173.75 *5*	52.0 *20*	249.71	4$^+$	75.89	2$^+$	E2	0.336	α(K)=0.232 *4*; α(L)=0.0809 *12*; α(M)=0.0184 *3*; α(N+..)=0.00461 *7* α(N)=0.00407 *6*; α(O)=0.000533 *8*; α(P)=1.112×10^{-5} *16*
223.31 *10*	1.0 *1*	1738.35		1515.04	5$^-$			
267.32 *5*	13.3 *7*	517.07	6$^+$	249.71	4$^+$	E2	0.0808	α(K)=0.0618 *9*; α(L)=0.01483 *21*; α(M)=0.00332 *5*; α(N+..)=0.000841 *12* α(N)=0.000738 *11*; α(O)=0.0001005 *14*; α(P)=3.25×10^{-6} *5*
370.94 *10*	0.6 *1*	1515.04	5$^-$	1144.07	(4$^-$)	[M1,E2]	0.038 *9*	α(K)=0.032 *8*; α(L)=0.0050 *4*; α(M)=0.00109 *7*; α(N+..)=0.000284 *22* α(N)=0.000246 *18*; α(O)=3.6×10^{-5} *4*; α(P)=1.9×10^{-6} *6*

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^{156}Pm β^- decay (26.70 s) 1990He11 (continued)

$\gamma(^{156}Sm)$ (continued)

E_γ [†]	I_γ [†#]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [‡]	α [@]	Comments
376.75 *10*	0.9 *1*	1397.55	5^-	1020.62	(5^-)	[M1,E2]	0.036 *9*	α(K)=0.030 *8*; α(L)=0.0048 *4*; α(M)=0.00104 *8*; α(N+..)=0.000271 *23* α(N)=0.000235 *18*; α(O)=3.4×10^{-5} *4*; α(P)=1.8×10^{-6} *6*
380.4 *4*	0.6 *1*	1256.1		875.69	(3^-)			
494.4 *4*	0.3 *1*	1515.04	5^-	1020.62	(5^-)	[M1,E2]	0.018 *5*	α(K)=0.015 *4*; α(L)=0.0022 *4*; α(M)=0.00048 *8*; α(N+..)=0.000125 *20* α(N)=0.000108 *17*; α(O)=1.6×10^{-5} *3*; α(P)=9.E−7 *3*
503.37 *20*	0.3 *1*	1020.62	(5^-)	517.07	6^+			
518.4 *4*	0.9 *1*	2033.8		1515.04	5^-			
524.9 *4*	1.0 *1*	2033.8		1509.22	4^+			
^{x}625.27 *20*	0.6 *1*							
626.37 *20*	0.6 *1*	875.69	(3^-)	249.71	4^+			
684.65 *10*	2.1 *1*	2199.91		1515.04	5^-			
690.90 *10*	5.6 *3*	2199.91		1509.22	4^+			
727.6 *3*	0.9 *2*	803.69	(1^-)	75.89	2^+			
750.26 *10*	2.1 *2*	2265.52		1515.04	5^-			
756.51 *10*	2.1 *2*	2265.52		1509.22	4^+			
770.77 *10*	2.6 *3*	1020.62	(5^-)	249.71	4^+			
799.70 *10*	3.6 *4*	875.69	(3^-)	75.89	2^+			
803.9 *3*	1.1 *2*	803.69	(1^-)	0	0^+			
827.03 *10*	0.6 *1*	2341.92		1515.04	5^-			
832.08 *20*	1.2 *2*	2341.92		1509.22	4^+			
860.26 *20*	1.1 *1*	1110.11	(3^-)	249.71	4^+			
880.39 *10*	10.4 *5*	1397.55	5^-	517.07	6^+			
894.35 *10*	8.4 *4*	1144.07	(4^-)	249.71	4^+			
934.00 *10*	12.3 *6*	1009.79	(2^-)	75.89	2^+			
992.0 *10*	0.3 *1*	1509.22	4^+	517.07	6^+			
1034.25 *10*	1.4 *1*	1110.11	(3^-)	75.89	2^+			
1147.84 *10*	20.5 *10*	1397.55	5^-	249.71	4^+			I_γ: 1990He11 report this uncertainty as 0.1. However, this seems unusually small. The evaluator has assumed that it is a misprint.
1259.44 *10*	12.6 *6*	1509.22	4^+	249.71	4^+			
1360.56 *10*	1.8 *2*	1610.30		249.71	4^+			
1374.91 *10*	2.3 *2*	2519.04	3	1144.07	(4^-)			
1382.24 *10*	5.7 *3*	2526.22	3	1144.07	(4^-)			
^{x}1416.6 *5*	0.6 *1*							
1433.70 *10*	8.4 *4*	1509.22	4^+	75.89	2^+			
^{x}1473.6 *4*	0.5 *1*							
1509.12 *20*	2.8 *3*	2519.04	3	1009.79	(2^-)			
1516.56 *10*	7.4 *4*	2526.22	3	1009.79	(2^-)			
1555.6 *5*	0.4 *1*	2699.7		1144.07	(4^-)			
2269.9 *4*	0.7 *1*	2519.04	3	249.71	4^+			
2276.18 *20*	0.7 *1*	2526.22	3	249.71	4^+			
2360.0 *3*	1.0 *1*	2609.7	(4)	249.71	4^+			
2366.78 *20*	0.8 *1*	2616.51	(4)	249.71	4^+			
2406.7 *3*	1.0 *1*	2482.6		75.89	2^+			
2443.34 *20*	2.4 *2*	2519.04	3	75.89	2^+			
2450.17 *10*	2.7 *3*	2526.22	3	75.89	2^+			

† From 1990He11. Others: 1986Ok01, 1987Gr12.
‡ Based on Iγ and Ice data normalized using transitions of known multipolarity in the ^{124}In decay. Multipolarities deduced from

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^{156}Pm β^- decay (26.70 s) 1990He11 (continued)

$\gamma(^{156}Sm)$ (continued)

the J^π assignments are omitted if α<0.01.

[#] For absolute intensity per 100 decays, multiply by 1.00 *5*.

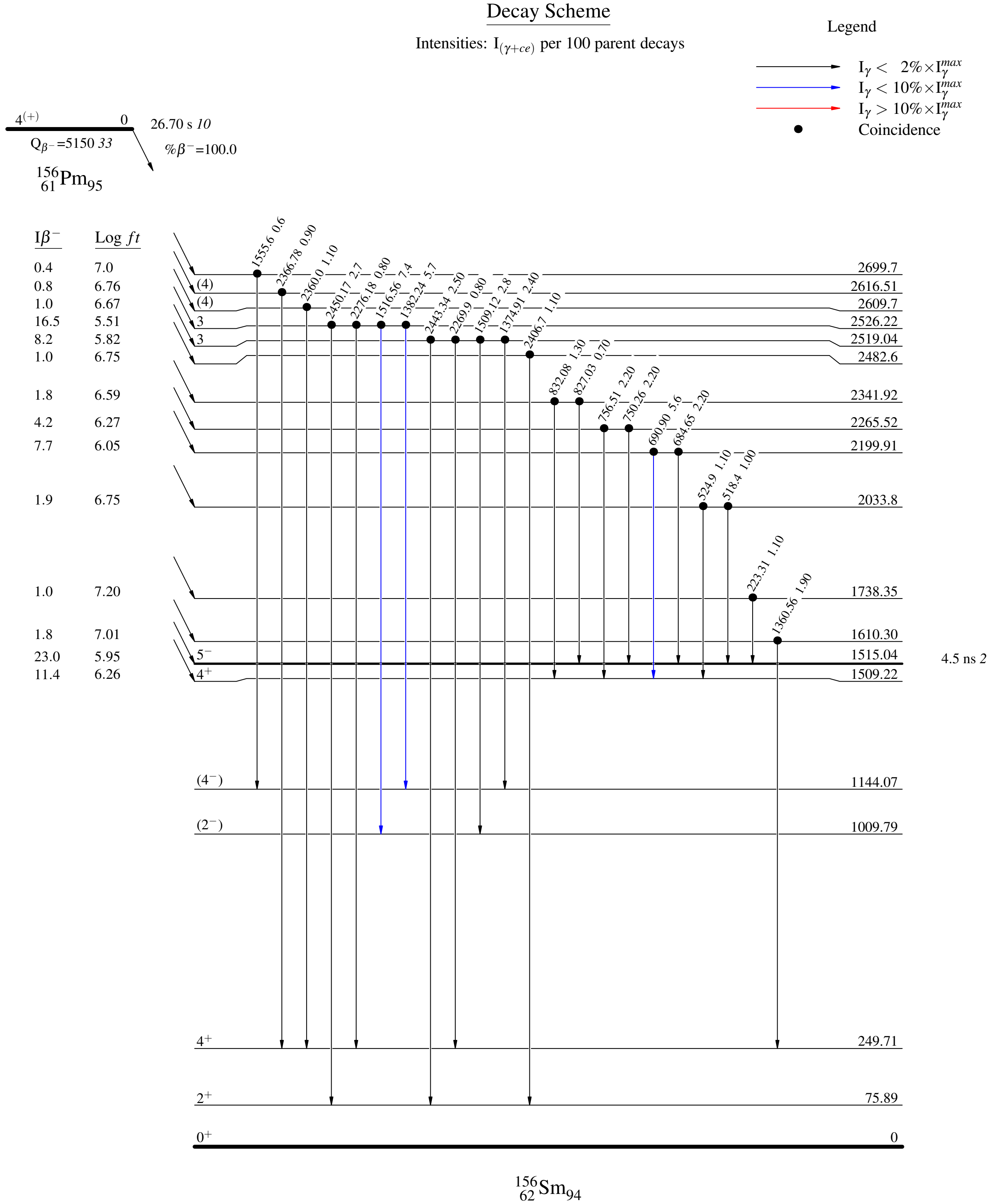
[@] Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on γ-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.

[x] γ ray not placed in level scheme.

^{156}Pm β^- decay (26.70 s) 1990He11

Decay Scheme

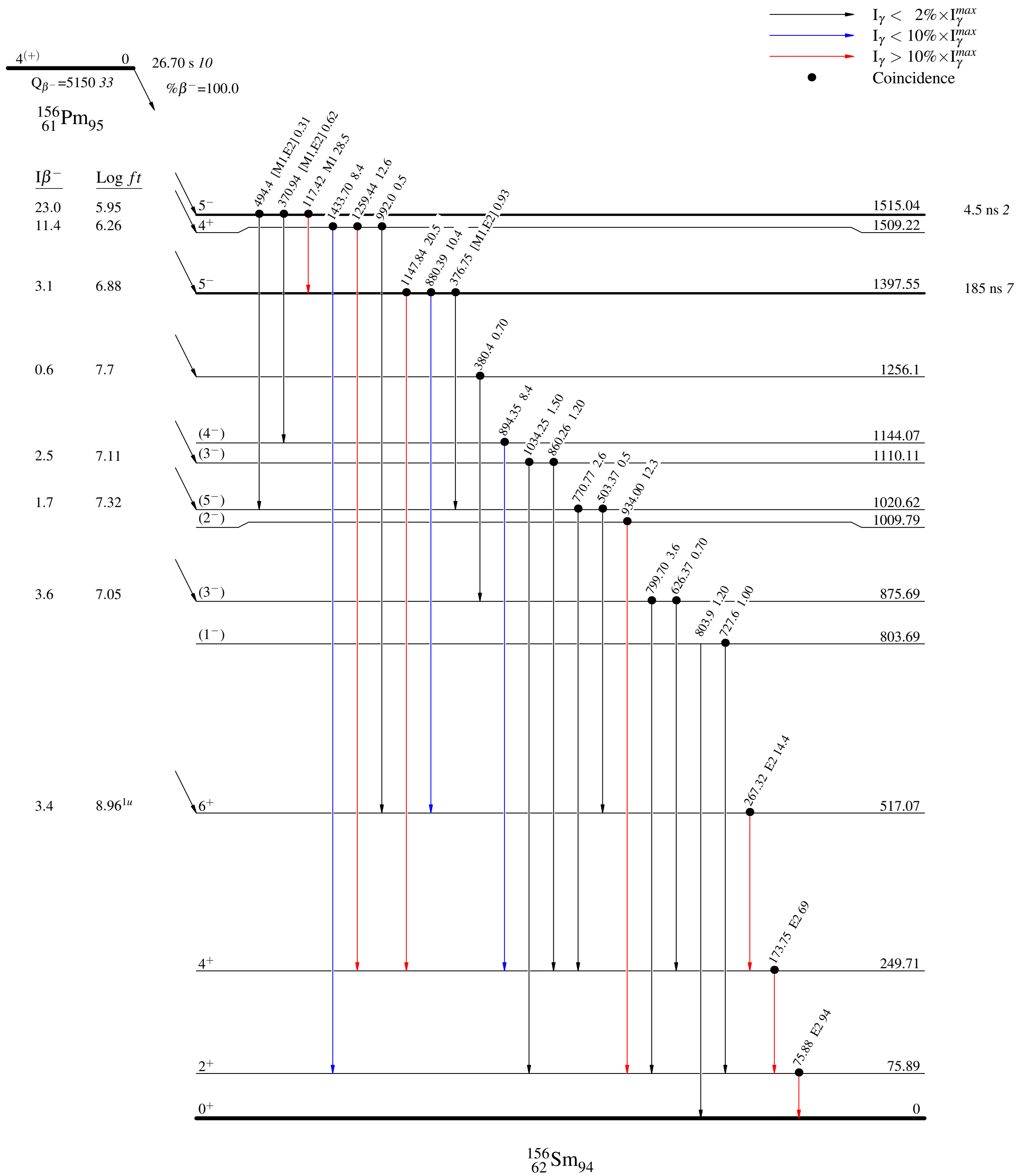
Intensities: $I_{(\gamma+ce)}$ per 100 parent decays



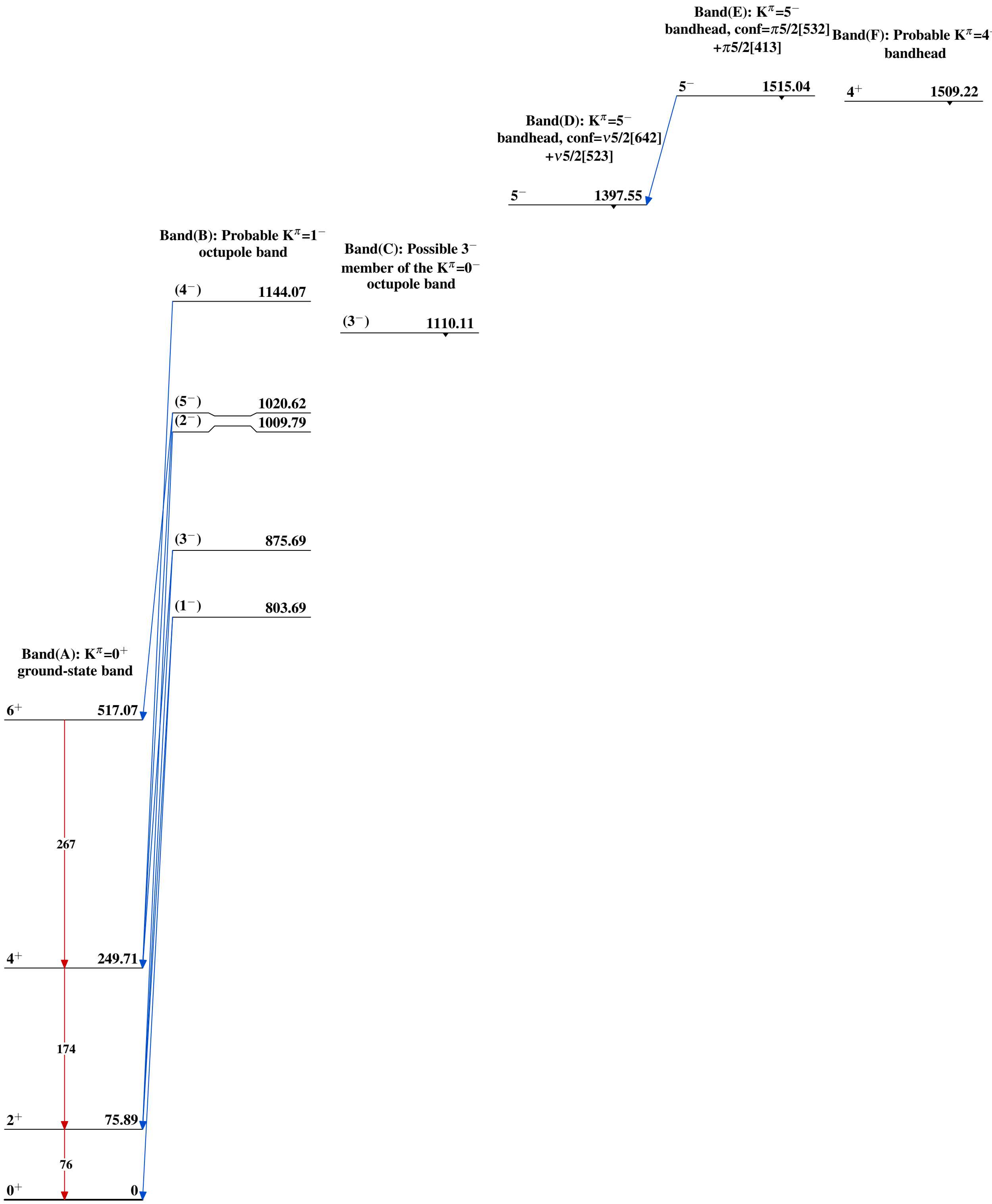
^{156}Pm β^- decay (26.70 s) 1990He11

Decay Scheme (continued)

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



^{156}Pm β^- decay (26.70 s) 1990He11



$^{156}_{62}Sm_{94}$