Adopted Levels, Gammas

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	C. D. Nesaraja	NDS 146, 387 (2017)	31-Aug-2017

Q(β^-)=−2262 *14*; S(n)=6801.4 *10*; S(p)=6012.1 *14*; Q(α)=5901.60 *5* 2017Wa10

Identification:
1950Re55: Produced by neutron irradiation on ^{241}Am. Curium was chemically separated and its isotopic composition determined with a 60° focusing mass spectrograph.

Systematic studies/Compilation/Evaluation:
2017He08: Review of properties of spontaneous fission.
2017Pr04: Systematics of B(E2) revisited using elemental data fit parameters.
2016Pr01: Compilation, evaluation for B(E2), $T_{1/2}$ and deformation parameter.

Theoretical studies, calculations:
2017Vi02, 2017Ad03: Calculated cluster decay half-life.
2016Sa53, 2015Ba24, 2014De43, 2014Is03, 2013Ra05, 2013Se17, 2013Is13, 2012Is08, 2011Qi06, 2009De32, 2009Ni06, 2007Pe30, 2010Sa09, 2008Xu06, 2005Sh42, 2005Re16, 2005Xu01, 2004Ro01, 1990Bh02, 1989St20, 1978Po09, 1976Ra02, 1976Re09, 1972We09: Calculated spontaneous fission half-lives.
2017Zh03, 2017Ph01, 2016Sa16, 2016Su09, 2006De05, 2005Sh42, Calculated α decay half-life.
2016Sa20, 2014De43: Calculated energy levels, J, π, deformation parameters, B(E2).
2013De12, 1995Mo29, 1984Eg01, 1983Bo15, 1982Du16, 1982Eg01, 1978Po01, 1977Mi11, 1976Iv04: Calculated deformation parameters.
1998Bu18: Calculated B(E2 down; 2^+ to 0^+), B(E3 up; 0^+ to 3^-) and B(E4 up; 0^+ to 4^+) for ^{244}Cm as a ^{32}Si+ ^{212}Pb cluster system. The calculated B(E2 down; 2^+ to 0^+), B(E3 up; 0^+ to 3^-) agree with experiments. However, calculated B(E4 up; 0^+ to 4^+) does not agree with the measured value. The authors strongly recommend confirmation of the B(E4) experimental results.
2013De12: Calculated deformation parameters, and predicted α transitions J^π= 2^+, 4^+, 6^+ states.
2013Li30: Calculated two-quasiparticle high K-state with $\nu5/2^+[622]\otimes\nu7/2^-[624]$ configuration. Predicted the octupole deformed high K-isomeric state at 0.976 MeV.
2010Wa31: Calculated relative intensities of α decay to the rotational states in the framework of the generalized liquid drop model (GLDM) and improved Royer's formula.
2010Wa23: Calculated branching ratios of α-decay to the ground-state rotational bands as well as the high-lying excited states within the framework of the generalized liquid drop model (GLDM) and an improved Royer's formula.
2002Pr01: Calculated excitation energies of quadrupole-vibrational states, calculated B(E2)(0^+ gs to 2^+).
2002Re31: Calculated g.s properties based on the deformed relativistic (RMF) mean-field theory.
1990Co26: Systematic behavior of the first 3^- octupole-vibrational state was studied, and fragmentation and its dependence on β_2 were analyzed.
1989Pi03: The pairing interaction strength for protons and neutrons was deduced from empirical odd-even mass differences.
1984Eg01: Analysis of yrast states, and alignment.
1982Li01, 1978Po01: Calculated electric quadrupole and hexadecapole moments.
1976Iv04: Low-lying two-quasi particle neutron states and single phonon states were studied and excitation energies were calculated using a semi-microscopic method.
1983Bo15: Calculated equilibrium deformations and static electric moment.
1993Sa05, 1988Ri07: Calculated B(E2)(0^+ gs to 2^+).
1988Bh04: Calculated B(E2)(2^+ to 0^+ gs).
1978Po01: Calculated moment of inertia and collective gyromagnetic ratio of the ground state.
1982Eg01, 1980Du07: Calculated moment of inertia.
1991Pi05: Studied nuclear stretching.
1974Ma17, 1975Vo06, 1981Be59: Calculated density of states.
1974No17: Calculated gamma width of highly excited nuclei.
1979Po23: Half-life for alpha decay was calculated by considering this decay mode as a form of fission.
1997Mo25: Calculated the α half-life based on the finite-range droplet model and folded-Yukawa single-particle potential.

Adopted Levels, Gammas (continued)

1977VaYN: Review of properties of spontaneously fissioning isomers.

2014Ji14, 2014Lu01, 2014Ro09, 2009Mo18, 2012Ja08, 2011Zh36, 1993OH03 1995Ra07, 1992Bh03, 1990Bh02, 1981Re06, 1980Ku14, 1977Pr10, 1976Re09, 1974Ju02, 1973Br04, 1973Al08, 1972Ma11, 1972Mo27, 1971Pa33, 1971Br39 : Calculated fission barriers heights.

1980Bj02: Review, evaluation and recommended parameters for fission barriers.

1972Go19: Influence of axially asymmetric deformation on fission barriers.

2000Du06: Influence of triaxial shape on the ground-state binding energy and on the fission barriers.

1978Po01: Calculated quadrupole and hexadecapole deformations, electric moments, and gyromagnetic ratio for the fission isomeric state.

1976Ma42: Calculated giant octupole resonances and γ strength.

1977Ky01: Studied semi-microscopic description for giant quadrupole resonances and calculated E2 strengths for various deformed nuclei.

Experiments involving fission:

1999Pa55, 1983Ca02, 1973Go46, 1973Da34, 1972Fl13: Measured fission yields.

1989Sa03: Fragment-fragment coincidence data following ^{232}Th(8.4-MeV ^{12}C,X) reaction were interpreted as being from decay of the excited compound nucleus ^{244}Cm.

1989Au01: Coincidence spectra of α particles and fission fragments measured following ^{232}Th(85-MeV ^{12}C,X) reaction;

1990Li26: Angular distribution of fission fragments following ^{232}Th(78-MeV ^{12}C,X) reaction were measured; saddle point effective moment of inertia was deduced.

1993Oh03: Proton-induced fission data, ^{243}Am(p,F); deduced fission parameters; competition of fission to neutron emission.

1995Da18: Angular distributions of fission products in ^{237}Np(α,F).

1986Ca14, 1972Al07, 1974Al26: Measured prompt neutrons as a function of fragment kinetic energy 1983Sc07: Coincidences between prompt neutron and fission fragments.

^{244}Cm Levels

Cross Reference (XREF) Flags

A	^{248}Cf α decay	D	Coulomb excitation
B	^{244}Am β^- decay (10.1 h)	E	^{244}Bk ε decay
C	^{244}Am β^- decay (26 min)		

E(level)[&]	J$^\pi$	T$_{1/2}$	XREF	Comments
0.0[†]	0$^+$	18.11 y *3*	ABCDE	%α=100; %SF=1.37×10^{-4} *2* %SF is deduced from the adopted total and partial half-lives. The measured α/SF activity ratios are α/SF=743×10^3 *1* (1965Me02), 742.0×10^3 *35* (1972Ha80); 697.7×10^3 *14* (1993Pa29). T$_{1/2}$: Weighted average of 17.9 y *5* (1954Fr19; α activity relative to ^{242}Cm (this half-life will not change when the adopted T$_{1/2}$ ^{242}Cm= 162.88 d *8* from email reply by M. Martin on 12 July 2017 is used), 18.099 y *32* (1968Be26; 2π α counting; uncertainty was revised by 1989Ho24), 18.13 y *4* (1972Ke29; calorimetry), 18.24 y *25* (1982Po14; specific activity; revised by 1984Ho24). Other T$_{1/2}$ measurements that were not included in the weighted average due to their large contribution to the chi-square: 19.2 y *6* (1954St33; activity relative to ^{242}Cm), 17.59 y *6* (1961Ca01; specific activity). T$_{1/2}$(SF)=1.32×10^7 y *2* as recommended by 2000Ho27 is the weighted average of 1.4×10^7 y *2* (1952Gh27; revised by 2000Ho27), 1.46×10^7 y *6* (1963Ma56; gas scintillator), 1.346×10^7 y *6* (1965Me02; from α/SF counts), 1.33×10^7 y *3* (1967Ar09; LiI scintillator), 1.250×10^7 y *7* (1970Ba11), low geometry fission counter), 1.343×10^7 y *6* (1972Ha80; from α/SF counts), 1.263×10^7 y *25* (1993Pa29; from α/SF counts).
42.957[†] *9*	2$^+$	97 ps *5*	ABCDE	B(E2)↑=14.58 *19* (1973Be44)

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Adopted Levels, Gammas (continued)

^{244}Cm Levels (continued)

E(level)[&]	J^π	$T_{1/2}$	XREF	Comments
				$T_{1/2}$: Measured by 1962Ch19 in the 10.1-h ^{244}Am beta decay using the delayed coincidence technique between γ rays and conversion electron lines. $T_{1/2}$= 126.1 ps *17* is calculated by the evaluator from B(E2)=14.58 *19* measured in Coulomb excitation. J^π: 42.965γ to gs is E2.
142.340[†] *10*	4^+		AB DE	B(E4)↑=0.0 +*25*−*00* (1973Be44)
296.204[†] *10*	6^+		B	
501.779[†] *11*	8^+		B	
933.8? *3*	(3,4)		E	J^π: 891.0γ to 2^+ at 42.965 level, 217.3γ with stronger intensity from (4) at 1150.98 level.
963.6? *3*	(2,3)		E	J^π: 920.8γ to 2^+ at 42.957 level, 187.4γ with weaker intensity from (4) at 1150.98 level.
970[#] *4*	$(2^+,3^-)$[@]		D	
984.914 *15*	0^+		C	J^π: 984.919γ to 0^+ gs is E0.
1020.756? *22*	(2^+)		C	This level is tentatively assigned. An alternate placement of the 977.796-keV transition would be to de excite a 977.8-keV 0^+ level to the ground state (1984Ho02). J^π: 977.796γ to 2^+ state is E0(+M1+E2). 1984Ho02 proposed this level to be 2^+ member of a K=0 band based on 984.9-keV level.
1038[#] *6*	$(2^+,3^-)$[@]		D	
1040.181 *11*	6^+	34 ms *2*	B	%IT=100 E(level): Probable Nilsson assignment is 6^+,(ν 5/2[622]+ ν 7/2[624]). In this case, the beta branch from 10.1-hour ^{244}Am would involve a transformation of the ν $5/2^+$[622] state to the π $5/2^-$[523] state, as also suggested by 1962Va08. J^π: 897.848γ to 4^+ level is E2, 538.400γ decay to 8^+ level is (E2) J=6 was also confirmed by the angular correlation measurement in the 10.1-h ^{244}Am β decay by 1963Ha29. $T_{1/2}$: Measured by 1963Ha29 in 10.1-h ^{244}Am beta decay by delayed coincidence between β particles and conversion electrons. $T_{1/2}$(SF)>140 y (1964Va04). The authors attributed their observed SF activities to the ^{244}Cm ground state SF decay.
1084.199?[‡] *12*	$(1,2^+)$		C	J^π: 1084.181γ to 0^+ g.s.
1105.909?[‡] *20*	(1,2)		C	J^π: Gamma transitions to 0^+ and 2^+ states. See ^{244}Am β- decay (26-min) data set for comments on the multipolarities of these transitions.
1150.98? *24*	(4)		E	J^π: Expected largest direct feeding by ε-decay from ^{244}Bk with $J^\pi=(4^-)$.
1187[#] *4*	$(2^+,3^-)$[@]		D	
1220.16? *10*			E	
1295.59? *25*	(3,4)		E	J^π: From 1153.4γ to the 4^+ 143 level.
1327.7? *3*			E	
1654.3? *5*			E	
1785.37? *21*			E	
0+x		>500 ns		%SF≤100 Additional information 1. $T_{1/2}$: $T_{1/2}$(SF)>500 ns (1969MeZX). Only SF decay observed (1969MeZX). From fit to the experimental excitation function for ^{242}Pu(α,2n) reaction, 1971Br39 calculated E(level)=3.7 MeV *3* with $T_{1/2}$SF>100 ns. In a later evaluation, 1973Br38 calculated the level energy as 3.0 MeV *4* which is believed to be an excited state at the shape isomeric deformation. No

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Adopted Levels, Gammas (continued)

^{244}Cm Levels (continued)

E(level)[&]	$T_{1/2}$	XREF	Comments
			recommended level energy was given in the review work by 1980Bj02. No resonance structure was observed by 1973Ba55 nor 1974Ba28 for ^{244}Cm in the ^{243}Am(^{3}He,dF) reaction. Estimate for the fission barrier was made from theoretical model fit to their measured fission probabilities as a function of excitation energy. 1976GA11 deduced fission barrier heights and widths for neutron/fission from their ^{243}Am(^{3}He,dF) data.
(0+y)	≤5 ps		Additional information 2. $T_{1/2}$: No short lived fission activity was observed by 1976Sl01 following the ^{242}Pu(α,2n) reaction; an upper limit for half-life was set from their lower limit on the ratio of isomer to prompt fission. From the correlation between isomers′ half-lives and the fission barriers, the authors predicted 1 − 50 ps half-lives for the second fission isomer in the even-even curium isotopes. For a systematics of fission isomer half-lives see 1975Me28.

† Band(A): K=0 Ground-state band. J^{π} assignments for levels with J>2 are based on E2 transitions within the band, and energy fit to the rotational band.
‡ Tentative levels proposed by 1984Ho02.
\# See Coulomb excitation for extracted B(E2),B(E3) values.
@ From Coulomb excitation.
& From least-squares fit to Eγ data by the evaluator.

γ(^{244}Cm)

E_i(level)	J^π_i	E_γ†	I_γ#	E_f	J^π_f	Mult.‡	δ‡	α@	Comments
42.957	2^+	42.965 *10*	100	0.0	0^+	E2		1050	α(L)=760 *11*; α(M)=214 *3* α(N)=59.5 *9*; α(O)=14.38 *21*; α(P)=2.35 *4*; α(Q)=0.00578 *9* B(E2)(W.u.)=419 *23*
142.340	4^+	99.383 *4*	100	42.957	2^+	E2		19.3	α(L)=13.93 *20*; α(M)=3.94 *6* α(N)=1.095 *16*; α(O)=0.265 *4*; α(P)=0.0441 *7*; α(Q)=0.000180 *3*
296.204	6^+	153.863 *2*	100	142.340	4^+	E2		2.81	α(K)=0.1741 *25*; α(L)=1.90 *3*; α(M)=0.536 *8* α(N)=0.1492 *21*; α(O)=0.0362 *5*; α(P)=0.00610 *9*; α(Q)=3.92×10^{-5} *6*
501.779	8^+	205.575 *4*	100	296.204	6^+	(E2)		0.887	α(K)=0.1409 *20*; α(L)=0.541 *8*; α(M)=0.1514 *22* α(N)=0.0421 *6*; α(O)=0.01025 *15*; α(P)=0.001746 *25*; α(Q)=1.644×10^{-5} *23*
933.8?	(3,4)	891.0 *4*	100	42.957	2^+				
963.6?	(2,3)	(≈30)		933.8?	(3,4)				E_γ: Assumed by 2014So17 based on the coincidence between 187.4γ and the 891.0γ.
		920.8 *5*		42.957	2^+				
984.914	0^+	941.949 *18*		42.957	2^+				
		984.919 *20*		0.0	0^+	E0			
1020.756?	(2^+)	977.796 *20*		42.957	2^+	E0(+M1+E2)		0.036 *22*	α(K)=0.028 *18*; α(L)=0.0060 *32*; α(M)=0.00148 *75* α(N)=4.1×10^{-4} *21*; α(O)=1.03×10^{-4} *53*; α(P)=2.0×10^{-5} *11*; α(Q)=1.34×10^{-6} *84*
1040.181	6^+	538.400 *16*	1.0 *2*	501.779	8^+	(E2)		0.0495	α(K)=0.0292 *4*; α(L)=0.01492 *21*; α(M)=0.00396 *6* α(N)=0.001096 *16*; α(O)=0.000271 *4*; α(P)=4.93×10^{-5} *7*; α(Q)=1.637×10^{-6} *23* B(E2)(W.u.)=2.7×10^{-11} *8*
		743.971 *5*	100 *27*	296.204	6^+	M1+E2	−0.92 *8*	0.077 *5*	α(K)=0.059 *4*; α(L)=0.0130 *7*; α(M)=0.00321 *15* α(N)=0.00088 *4*; α(O)=0.000223 *11*; α(P)=4.34×10^{-5} *21*; α(Q)=2.86×10^{-6} *17* B(M1)(W.u.)=5.6×10^{-13} *20*; B(E2)(W.u.)=2.4×10^{-10} *9*
		897.848 *7*	42 *12*	142.340	4^+	E2		0.01697	α(K)=0.01215 *17*; α(L)=0.00358 *5*; α(M)=0.000912 *13* α(N)=0.000251 *4*; α(O)=6.29×10^{-5} *9*; α(P)=1.186×10^{-5} *17*; α(Q)=5.93×10^{-7} *9* B(E2)(W.u.)=9.E−11 *4*
1084.199?	$(1,2^+)$	1041.278 *22*	53 *18*	42.957	2^+				
		1084.181 *14*	100 *32*	0.0	0^+				
1105.909?	(1,2)	1062.953 *18*	100 *31*	42.957	2^+				
		1105.43 *19*	15 *8*	0.0	0^+				
1150.98?	(4)	187.4 *3*	16.5 *5*	963.6?	(2,3)				
		217.3 *3*	100	933.8?	(3,4)				
		1107.6 *5*	2.4 *1*	42.957	2^+				
1220.16?		1177.2 *1*	100	42.957	2^+				

From ENSDF

$\gamma(^{244}Cm)$ (continued)

E_i(level)	J^{π}_i	E_{γ}[†]	I_{γ}[#]	E_f	J^{π}_f	E_i(level)	J^{π}_i	E_{γ}[†]	I_{γ}[#]	E_f	J^{π}_f
1295.59?	(3,4)	144.6 *2*		1150.98?	(4)	1654.3?		690.7 *3*	100	963.6?	(2,3)
		1153.4 *6*	100 *3*	142.340	4^+	1785.37?		489.8 *4*	100 *4*	1295.59?	(3,4)
		1252.5 *7*	27 *1*	42.957	2^+			565.2 *2*	12.9 *21*	1220.16?	
1327.7?		176.7 *2*	100	1150.98?	(4)						

† From ^{244}Am beta decays, measured by 1984Ho02.

‡ From conversion electron and $(\gamma)(\gamma)(\theta)$ data measured in ^{244}Am beta decay.

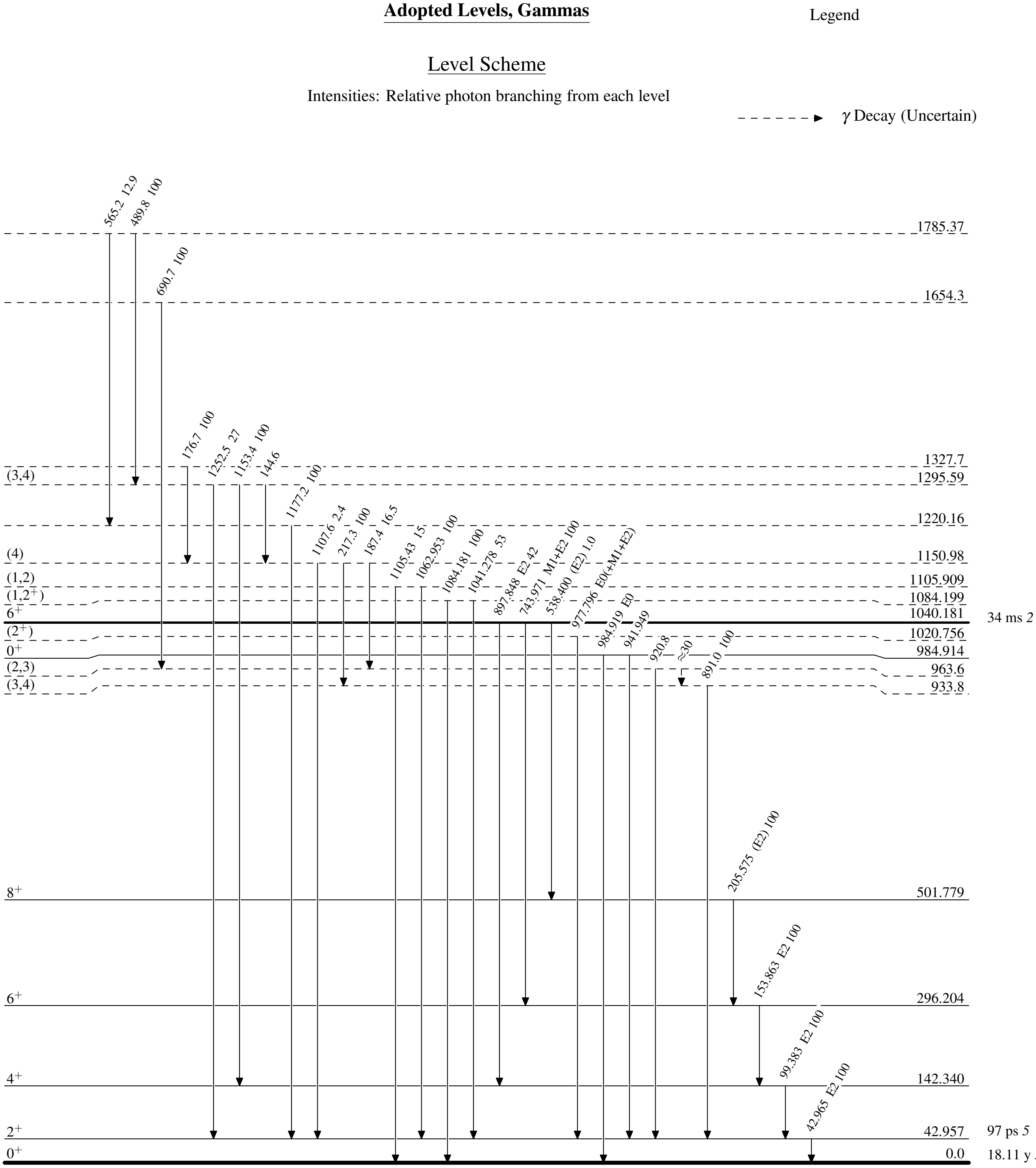
\# Relative photon intensity normalized to 100 at the strongest photon deexciting each level. For levels with multiple gamma transitions, the $I\gamma'$s were taken from the decay datasets: γ's from 1040 level (^{244}Am β- decay (10.1 h)), γ's from 1084 and 1106 levels (^{244}Am β- decay (26 m)), γ's from 1151, 1296 and 1786 levels (^{244}Bk ε decay).

@ Additional information 3.

Adopted Levels, Gammas

Level Scheme

Intensities: Relative photon branching from each level



$^{244}_{96}Cm_{148}$

Adopted Levels, Gammas