Adopted Levels, Gammas

History

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

Q(β^-)=−1032 *7*; S(n)=7197 *7*; S(p)=3755 *6*; Q(α)=1600 *24* 2012Wa38

Produced and identified by 1957Go78, 1957Go72. Spallation of Ta under bombardment with 660 MeV protons.

The ^{146}Eu level scheme is built on the basis of ε decay and reaction measurements. There was stated the cascade of coincident transitions 70→433→464→136 keV in (HI,xnγ). However, the evaluators changed the sequence 433 and 464 transitions according to (α,p4nγ) results and intensity balance at the corresponding levels.

^{146}Eu Levels

Cross Reference (XREF) Flags

A	^{146}Gd ε decay	D	^{144}Sm(^{3}He,p)
B	^{150}Tb α decay	E	^{147}Sm(α,p4nγ)
C	^{147}Sm(p,2nγ)	F	(HI,xnγ)

E(level)[†‡]	J$^{\pi}$[#]	T$_{1/2}$	XREF	Comments
0.0[&]	4$^-$	4.61 d *3*	A CDEF	%ε+%β^+=100 μ=+1.422 *6*; Q=−0.179 *5* J$^{\pi}$: from atomic beam magnetic resonance technique (1972Ek05); parity: decay pattern (1968Pa13), single particle model analysis (1972Ho51). μ: weighted average of +1.425 *11* (1985Ah02) and +1.421 *8* (1993HuZU) (collinear-laser-ion-beam spectroscopy). Others: +1.3 *2* (1985Va21), +1.7 *3* (1983Kr19). Q: from (collinear-laser-ion-beam spectroscopy) Q/Q(^{153}Eu)=−0.0743 *20* (1993HuZU), Q(^{153}Eu)=2.412 *21* (1984Ta04). Other: −0.18 *6* (1985Ah02). T$_{1/2}$: weighted average of 4.59 d *3* (1964Ta11) and 4.65 d *4* (1970Ch09) Other: 4.95 d (2000La10).
14.51[&] *9*	5$^-$[i]		C EF	J$^{\pi}$: 14.49γ (M1) to 4$^-$, 358.2γ M1 from 6$^-$, 274.8γ M1 from 6$^-$.
114.713 *20*	3$^-$	3.7 ps *16*	A CD	J$^{\pi}$: 114.7γ M1+E2 to 4$^-$, 115.5γ M1+E2 from 2$^-$, 576.0γ M1 from 2$^-$. T$_{1/2}$: from $\beta\gamma$(t) using mirror symmetric centroid (MSCD) analysis (2013Bh07). Others: 0.8 ns *3* (1970Ko16), <0.160 ns (1972Ho51), <0.3 ns (1976Se02), ≈0.23 ns (1958Be72).
230.23 *3*	2$^-$	5.8 ps *15*	A CD	J$^{\pi}$: log $f^{1u}t$=8.22 in ε decay g.s., 0$^+$ of ^{146}Gd; 230.5γ to 4$^-$. T$_{1/2}$: from $\beta\gamma$(t) using mirror symmetric centroid (MSCD) analysis (2013Bh07). Others: <0.165 ns (1972Ho51), <0.3 ns (1976Se02).
289.29[&] *10*	6$^-$[i]		CDEF	
316.44[a] *10*	5$^-$		C EF	J$^{\pi}$: 316.5γ M1 (ΔJ=1) to 4$^-$, 56.3γ from 6$^-$.
331.06 *22*			C	
372.64[a] *10*	6$^-$[i]		C EF	
384.80 *4*	1$^-$		A CD	J$^{\pi}$: log *ft*=7.24 in ε decay g.s., 0$^+$ of ^{146}Gd; 154.6γ M1+(E2) to 2$^-$.
421.59 *7*	(3,4)$^-$		A	J$^{\pi}$: 421.6γ M1 to 4$^-$, 76.5γ from (1,2)$^-$.
436			D	
498.13 *7*	(1,2)$^-$		A CD	J$^{\pi}$: log $f^{1u}t$=9.52 in ε decay g.s., 0$^+$ of ^{146}Gd; 267γ (M1,E2) to 2$^-$, 383.5γ to 3$^-$.
647.53[a] *11*	7$^-$		CDEF	J$^{\pi}$: 274.9γ M1 (ΔJ=1) to 6$^-$, 358.2γ M1 to 6$^-$, significant feeding from 9$^+$ by 18.8γ (M2).
666.33[b] *11*	9$^+$[i]	235 μs *3*	C EF	%IT=100 T$_{1/2}$: weighted average of 230 μs *10* (1980LeZN), 235 μs *25* (1980Er04), 240 μs *10* (1962Re04), 235 μs *3* (1971HaXM).
690.71 *20*	2$^-$		A D	XREF: D(683). J$^{\pi}$: log $f^{1u}t$=9.66 from J=0$^+$ in ε decay g.s. 0$^+$ of ^{146}Gd; 576.0γ M1 to 3$^-$.
752.80 *20*			CD	XREF: D(746).

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Adopted Levels, Gammas (continued)

^{146}Eu Levels (continued)

E(level)[†‡]	J$^{\pi}$[#]	$T_{1/2}$	XREF	Comments
802.36[d] *15*	8+[j]		DEF	XREF: D(796).
805.97 *22*			C	
839.56 *24*			CD	XREF: D(836).
878			D	
914.2 *4*			C	
936			D	
1201			D	
1235.27[d] *17*	9+[j]		E	
1698.71[e] *18*	10+[j]		EF	
1768.70[c] *17*	11−	4.5 ns *7*	EF	J$^{\pi}$: 70.0γ E1 (ΔJ=1) to 10$^+$, 966.2γ (E3) to 8$^+$. $T_{1/2}$: from ^{147}Sm(p,2n) of 1988Er02.
1882.83[c] *21*	9−		E	J$^{\pi}$: 1080γ E1 (stretched ΔJ=1) to 8$^+$, 1216.1γ E1 to 9$^+$ multiplet assignment.
1978.06[c] *22*	10−		E	J$^{\pi}$: 209.4γ M1 (stretched ΔJ=1) to 11$^-$, 95.2γ to 9$^-$.
2026.98[c] *19*	12−		EF	J$^{\pi}$: 258.3γ M1 (stretched ΔJ=1) to 11$^-$, 1275γ from (14) multiplet assignment.
2105.42[f] *19*	11+		EF	J$^{\pi}$: 1439.1γ E2 (stretched ΔJ=2) to 9$^+$.
2540.06[g] *22*	(12+)		EF	J$^{\pi}$: 434.8γ D+Q(M1+E2, ΔJ=1) to 11$^+$, 513.0γ to 12$^-$.
2665.88[g] *23*	(13+)		EF	J$^{\pi}$: 125.8γ M1 (stretched ΔJ=1) to (12$^+$), 843γ from (14).
2951.23[g] *25*	(14+)		EF	J$^{\pi}$: 285.5γ D+Q(M1+E2) (ΔJ=1) to 13$^+$, 518.5γ from (15$^+$).
3200			E	
3302.1 *3*	(14)		F	
3400			E	
3469.8[g] *4*	(15+)		EF	J$^{\pi}$: 518.5γ D+Q(M1+E2)(ΔJ=1) to (14$^+$), 442γ from (16).
3509.1 *3*	(14)		F	
3619.2 *3*	(15)		F	
3714.2 *4*	(15)		F	
3745.8 *4*	(16)		F	
3782.0 *4*	(15)		F	
3911.2 *4*	(16)		F	
4120.0 *5*	(16)		F	
4130			E	
4160.3 *4*	(17)		F	
4170.8 *4*	(16)		F	
4614.7 *4*	(18)		F	
5022.5 *4*	(19)		F	
5058.0 *4*	(18)		F	
5169.3 *4*	(18)		F	
5184.3 *5*	(20)		F	
5372.3 *5*	(19)		F	
5486.0 *5*	(18)		F	
5525.6 *4*	(18)		F	
5830.4 *4*	(19)		F	
5905.4 *4*	(20)		F	
6185.1 *4*	(21)		F	
6345.3 *6*	(22)		F	
6350.7 *5*	(20)		F	
6689.1 *5*	(21)		F	
6832.7 *6*	(21)		F	
6980.9 *5*	(22)		F	
7535.9 *6*	(23)		F	
8128.9 *6*	(24)		F	
8138.9 *6*	(24)		F	
8207.9 *6*	(25)		F	
8445.9 *7*	(26)		F	
8649.9[h] *7*	(27)	10.0[@] ns *6*	F	

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Adopted Levels, Gammas (continued)

^{146}Eu Levels (continued)

E(level)[†‡]	Jπ[#]	XREF
9166.9 *8*	(28)	F
10365.9 *9*	(29)	F

[†] If $\Delta E\gamma$ not given, ±0.30 keV assumed for least-squares fitting.
[‡] From a least-squares fit to $E\gamma$, normalized χ^2=1.07.
[#] Spin assignment for the levels higher than 3300 keV was made on the basis of angular distribution analysis in 1999Id01.
[@] from $\gamma\gamma$(t) with pulsed beam (1999Id01).
[&] Possible configuration=$\pi d^{-1}_{5/2}\times\nu f_{7/2}$ (1988Er02).
[a] Possible configuration=$\pi g^{-1}_{7/2}\times\nu f_{7/2}$ (1988Er02).
[b] Possible configuration=$\pi h_{11/2}\times\nu f_{7/2}$ (1988Er02).
[c] possible configuration=$\pi h_{11/2}\times\nu f_{7/2}\times 3^-$ (1988Er02), or $\pi h_{11/2}\times\nu i_{13/2}$ for the level at 2027 keV, 12$^-$, (1988La18, (α,d) reaction).
[d] Possible configuration=$\pi d^{-1}_{5/2}\times\nu i^{*}_{13/2}$ (1988Er02).
[e] Possible configuration= $\pi g^{-1}_{7/2}\times\nu i^{*}_{13/2}$ (1988Er02).
[f] Possible configuration=$9^+\times(\pi^{-2})_{2+}$ (1988Er02).
[g] Possible configuration= $9^+\times(\pi d^{-1}_{5/2}\times g^{-1}_{7/2})_{6^+}$ (1988Er02).
[h] Possible configuration= $[\nu(f_{7/2}h_{11/2}i_{13/2})\times\pi(d^{-1}_{5/2}h^2_{11/2})]_{27^+}$ (1999Id01), see systematics of high spin isomers (2005Od03,2002Go06).
[i] Cascades of 377(E3)→275(M1)→14.5(M1) and 294(E3)→358(M1)→14.5(M1) γ's from the 666 level to the 4$^-$ g.s. (no γ's from 289 and 373 levels to 4$^-$ g.s.) establish J^π(666)=9$^+$, J^π(373)=6$^-$, J^π(289)=6$^-$, and J^π(14.4)=5$^-$.
[j] Cascade of 463(M1,ΔJ=1)→433(M1,ΔJ=1)→136(M1,ΔJ=1) and cross-over 1032(M1,ΔJ=1) g's to 9$^+$ level establish J^π(1698)=10$^+$, J^π(1235)=9$^+$, and J^π(802)=8$^+$.

γ(^{146}Eu)

E_i(level)	J^π_i	E_γ[†]	I_γ[@]	E_f	J^π_f	Mult.	δ[d]	α[c]	$I_{(\gamma+ce)}$	Comments
14.51	5⁻	14.49 *9*	100	0.0	4⁻	(M1)		84.1 *20*		
114.713	3⁻	114.71 *2*	100	0.0	4⁻	M1+(E2)	<0.04	1.247		B(M1)(W.u.)>0.040 δ: from 1973Ga26. δ<0.01 (1963Bo44).
230.23	2⁻	115.51 *2*	100[a] *1*	114.713	3⁻	M1+(E2)	<0.022	1.223		B(M1)(W.u.)>0.039 δ: from 1973Ga26. δ<0.01 (1963Bo44).
		230.51 *20*	0.20[a] *11*	0.0	4⁻	[E2]		0.1347		B(E2)(W.u.)>0.10
289.29	6⁻	274.77 *5*	100	14.51	5⁻	M1		0.1112		
316.44	5⁻	316.46 *11*	100	0.0	4⁻	M1		0.0763		
331.06		216.3		114.713	3⁻					
		331.1		0.0	4⁻					
372.64	6⁻	56.26 *17*	0.64 *8*	316.44	5⁻					
		83.41 *23*	≤0.56	289.29	6⁻					
		358.18 *9*	100 *50*	14.51	5⁻	M1		0.0551		
384.80	1⁻	154.57 *2*	100	230.23	2⁻	M1(+E2)	<0.071	0.537		δ: from 1973Ga26. −0.041<δ<−0.018 (1963Bo44).
421.59	(3,4)⁻	421.6 *1*	100	0.0	4⁻	M1		0.0361		
498.13	(1,2)⁻	76.54 *1*	50[a] *20*	421.59	(3,4)⁻	[M1,E2]		5.3 *13*		
		267.74 *17*	80[a] *40*	230.23	2⁻	(M1,E2)		0.101 *18*		
		383.5 *1*	100[a] *40*	114.713	3⁻					
647.53	7⁻	274.90 *7*	43[&] *20*	372.64	6⁻	M1		0.1110		
		358.20 *9*	100[&] *24*	289.29	6⁻	M1		0.0551		
666.33	9⁺	(18.8)	0.0158 *34*	647.53	7⁻	(M2)		7.27×10³	115 *25*	B(M2)(W.u.)=0.14 *4* $I_{(\gamma+ce)}$: from balance of I(γ+ce) at 666 and 647.5 levels.
		293.72 *9*	3.9 *2*	372.64	6⁻	E3		0.254		B(E3)(W.u.)=0.37 *3*
		377.00 *9*	100 *15*	289.29	6⁻	E3		0.0994		B(E3)(W.u.)=1.64 *19* I_γ: normalized line in ^{147}Sm(α,p4nγ) dataset, ΔIγ=15 adopted by the evaluators based on experimental data.
690.71	2⁻	576.0 *2*	100 *2*	114.713	3⁻	M1		0.01634		
752.80		368.1		384.80	1⁻					
		522.6		230.23	2⁻					
802.36	8⁺	136.00 *10*	100	666.33	9⁺	M1		0.770		
805.97		421.2		384.80	1⁻					
		575.7		230.23	2⁻					
839.56		86.9		752.80						
		609.2		230.23	2⁻					
914.2		624.9	100	289.29	6⁻					
1235.27	9⁺	432.91 *10*	100	802.36	8⁺	M1		0.0337		See general comment for the level scheme.
1698.71	10⁺	463.46 *18*	100 *11*	1235.27	9⁺	M1		0.0283		See general comment for the level scheme.
		1032.5 *3*	57 *6*	666.33	9⁺	M1		0.00393		
1768.70	11⁻	70.00 *10*	83 *10*	1698.71	10⁺	E1		0.739		B(E1)(W.u.)=5.0×10⁻⁵ *11*

γ(^{146}Eu) (continued)

E_i(level)	J^π_i	E_γ[†]	I_γ[@]	E_f	J^π_f	Mult.	α[c]	Comments
1768.70	11^-	966.21 *17*	20 *3*	802.36	8^+	(E3)[b]	0.00610	
		1102.5 *3*	100 *10*	666.33	9^+	(E3+M2)[b]	0.0063 *19*	
1882.83	9^-	1080.5 *2*	100 *8*	802.36	8^+	E1	9.38×10^{-4}	
		1216.1 *5*	76 *11*	666.33	9^+	E1	7.90×10^{-4}	
1978.06	10^-	95.2 *2*	100 *8*	1882.83	9^-			
		209.4 *2*	35[&] *3*	1768.70	11^-	M1	0.232	
2026.98	12^-	258.27 *10*		1768.70	11^-	M1	0.1313	
2105.42	11^+	1439.14 *17*	100	666.33	9^+	E2	1.31×10^{-3}	
2540.06	(12^+)	434.75 *25*	100 *15*	2105.42	11^+	D+Q		
		513.0	26 *9*	2026.98	12^-			
2665.88	(13^+)	125.82 *10*	100 *10*	2540.06	(12^+)	M1	0.959	
		639.0	24 *12*	2026.98	12^-			
2951.23	(14^+)	285.45 *15*	100	2665.88	(13^+)	D+Q		
3302.1	(14)	1275	100	2026.98	12^-			
3469.8	(15^+)	518.5 *7*	100	2951.23	(14^+)	D+Q		
3509.1	(14)	558	100[&] *11*	2951.23	(14^+)			
		843	50[&] *6*	2665.88	(13^+)			
		1482	59[&] *7*	2026.98	12^-			
3619.2	(15)	110	28[&] *4*	3509.1	(14)			
		149	52[&] *6*	3469.8	(15^+)			
		317		3302.1	(14)			
		668	100[&] *10*	2951.23	(14^+)			
3714.2	(15)	763	100	2951.23	(14^+)			
3745.8	(16)	126	100	3619.2	(15)			
3782.0	(15)	831	100	2951.23	(14^+)			
3911.2	(16)	197		3714.2	(15)			
		292	100[&] *10*	3619.2	(15)			
		442	68[&] *8*	3469.8	(15^+)			
4120.0	(16)	338	100	3782.0	(15)			
4160.3	(17)	249	60[&] *6*	3911.2	(16)			
		414	100[&] *10*	3745.8	(16)			
4170.8	(16)	389	88[&] *10*	3782.0	(15)			
		701	100[&] *10*	3469.8	(15^+)			
4614.7	(18)	444	100[&] *10*	4170.8	(16)			
		454	54[&] *5*	4160.3	(17)			
		704	69[&] *7*	3911.2	(16)			
5022.5	(19)	408	100	4614.7	(18)			
5058.0	(18)	896[‡]	100[&] *11*	4160.3	(17)			E_γ: poor fit, the energy level difference is equal to 897.69 *22*.

$^{146}_{63}Eu_{83}$-5

γ(^{146}Eu) (continued)

E_i(level)	J_i^π	E_γ †	I_γ @	E_f	J_f^π	Mult.	Comments
5058.0	(18)	1312	85& *11*	3745.8	(16)		
5169.3	(18)	1009	100	4160.3	(17)		
5184.3	(20)	162	100	5022.5	(19)		
5372.3	(19)	1212	100	4160.3	(17)		
5486.0	(18)	1326	100	4160.3	(17)		
5525.6	(18)	468	74& *11*	5058.0	(18)		
		1365	100& *11*	4160.3	(17)		
5830.4	(19)	305	100& *11*	5525.6	(18)		
		772	33& *4*	5058.0	(18)		
5905.4	(20)	75	44& *10*	5830.4	(19)		
		736	78& *7*	5169.3	(18)		
		846‡	66& *7*	5058.0	(18)		E_γ: poor fit, the energy level difference is equal to 847.39 *22*.
		883	100& *10*	5022.5	(19)		
		1745	34& *5*	4160.3	(17)		
6185.1	(21)	280	100& *10*	5905.4	(20)		
		1001	44& *3*	5184.3	(20)		
		1127	44& *3*	5058.0	(18)		
6345.3	(22)	1161	100	5184.3	(20)		
6350.7	(20)	520	100& *11*	5830.4	(19)		
		865	49& *4*	5486.0	(18)		
6689.1	(21)	784	100	5905.4	(20)		
6832.7	(21)	482	100	6350.7	(20)		
6980.9	(22)	292	100& *10*	6689.1	(21)		
		796	94& *10*	6185.1	(21)		
		1075	59& *6*	5905.4	(20)		
7535.9	(23)	555	100	6980.9	(22)		
8128.9	(24)	593	100	7535.9	(23)		
8138.9	(24)	603	100	7535.9	(23)		
8207.9	(25)	69#	31& *10*	8138.9	(24)		
		79#	33& *7*	8128.9	(24)		
		672	100& *15*	7535.9	(23)		
8445.9	(26)	238	100	8207.9	(25)		
8649.9	(27)	204	100	8445.9	(26)	D,E2	Mult.: from RUL.
9166.9	(28)	517	100	8649.9	(27)		
10365.9	(29)	1199	100	9166.9	(28)		

$^{146}_{63}Eu_{83}$-6

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

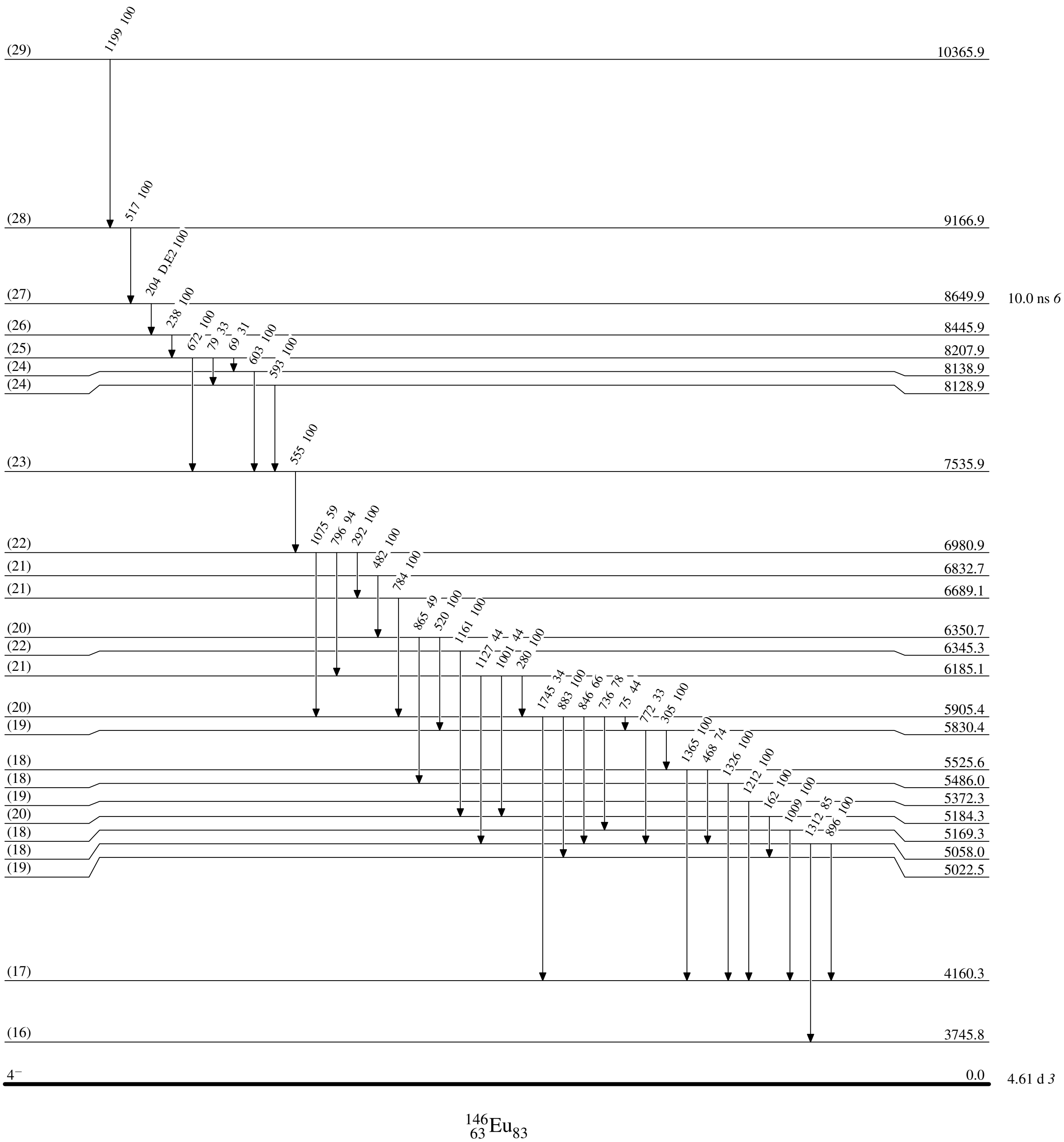
† Weighted average of ε decay, (p,2nγ), (α,p4nγ) and (HI,xnγ) data, except as noted. If ΔEγ not given the evaluators have assumed ΔEγ=0.3.
‡ Energy of γ ray were not used for least-squares fit.
# In fig. 1 of 1999Id01 this energy is given in figure brackets, the evaluators believe that it is calculated by the authors.
@ From ^{147}Sm(α,p4nγ), except as noted.
& Assuming multipolarities for the transitions according to the level pattern, calculated by the evaluators from I(γ+ce) in (HI,xnγ) dataset which obtained from fig. 1 of 1999Id01.
a From ^{146}Gd $\varepsilon+\beta^+$ decay.
b From RUL.
c Additional information 1.
d If No value given it was assumed δ=1.00 for E2/M1, δ=1.00 for E3/M2 and δ=0.10 for the other multipolarities.

$^{146}_{63}Eu_{83}$-7

Adopted Levels, Gammas

Level Scheme

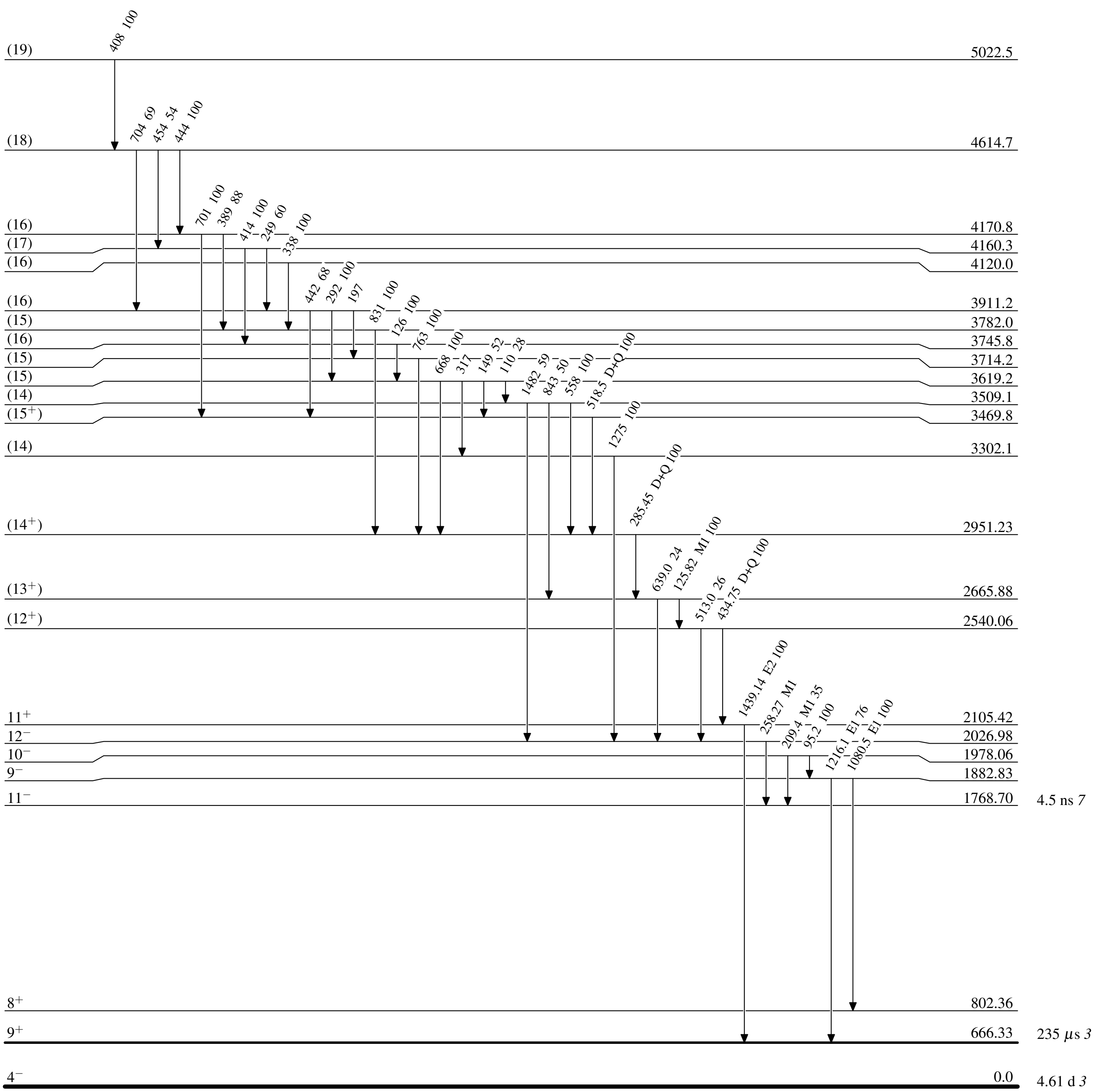
Intensities: Relative photon branching from each level



Adopted Levels, Gammas

Level Scheme (continued)

Intensities: Relative photon branching from each level



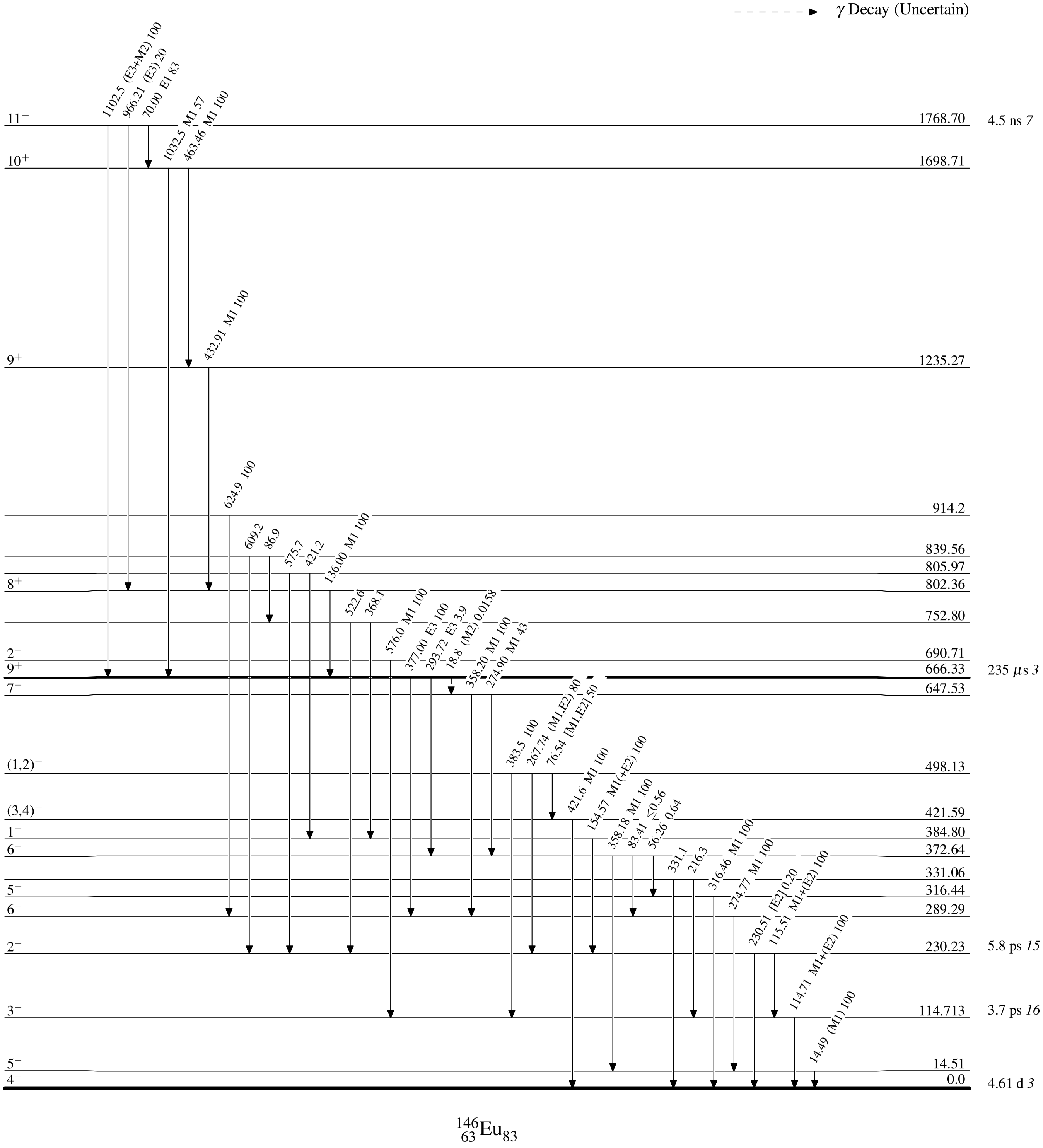
$^{146}_{63}Eu_{83}$

Adopted Levels, Gammas

Legend

Level Scheme (continued)

Intensities: Relative photon branching from each level



$^{146}_{63}Eu_{83}$