^{138}Ba(γ,γ'),(pol γ,γ') 1977Sw03,2006Vo11,2002Pi02

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Jun Chen	NDS 146, 1 (2017)	30-Sep-2017

1977Sw03 and 1978Me18: (γ,γ') E=5 MeV photon beam was produced by bremsstrahlung of electrons from the Bartol Van de Graaff accelerator. Target was 116.5 g $BaCO_3$ powder of normal isotopic abundance. γ rays were detected with a 55 cm^3 Ge(Li) detector at 96° and a 45 cm^3 detector at 126°. Measured Eγ, σ(Eγ), intensity ratio, linear polarization. Deduced levels, J, π, widths, transition strengths. Comparisons with available data and theoretical calculations. Report levels from 1436 to 4857.

2006Vo11: (γ,γ') E=9.2 MeV photon beam was produced from the low-energy bremsstrahlung facility of the superconducting linear electron accelerator S-DALINAC at TU Darmstadt. Targets was 3 g 99.5% enriched $BaCO_3$. γ rays were detected with two HPGe detectors at 90° and 130°, respectively. Measured Eγ, σ(Eγ), intensity ratio. Deduced levels, J, widths, transition strengths. Comparisons with available data and QPM calculations. Report levels from 4026 to 8433.

2002Pi02: (pol γ,γ') E=5.5-6 MeV polarized photon beams were produced from the High Intensity γ-ray Source (HIγS) at the Duke Free Electron Laser Laboratory (DFELL). Target was 2.14 g/cm^2 $^{nat}BaNO_3$. γ rays were detected with four coaxial Ge detectors. Measured Eγ, $\gamma\gamma$-coin, γ scattering asymmetry. Deduced levels, J, π, γ-ray multipolarities. Report levels from 5511 to 6434.

1999He31: (γ,γ') E=6.7 MeV beam was produced at the S-DALINAC facility at TU Darmstadt. Target was 3 g 99.4% enriched ^{138}Ba. γ rays were detected with two Cluster detectors of seven large volume Ge crystals. Measured Eγ, $\gamma\gamma$-coin, γ scattering asymmetry, σ(Eγ). Deduced levels, J, π, transition strengths, γ-ray multipolarities. Comparisons with QPM calculations. Report levels from 4025 to 6434.

1995He25: (γ,γ') E=4.1 MeV beam was produced at the bremsstrahlung facility at Stuttgart Dynamitron. Target was 1043 mg 99% enriched $BaCO_3$. γ rays were detected with three HPGe detectors. Measured Eγ, σ(Eγ). Deduced levels, widths, transition strengths, half-lives.

2011To17,2010To01: (pol γ,γ') E=5.4, 7.2, 8.5 MeV. Measured Eγ, I$\gamma(\theta)$ using HPGe with nuclear resonance fluorescence at the HIγS facility. Deduced σ, M1, E1 asymmetry, GDR, PDR photoabsorption.

Others: 2009SaZW, 2007Kl05, 2004Zi01, 2003Ha33, 2002OhZZ, 2002Zi05, 2000Zi04.

^{138}Ba Levels

E(level)[†]	J$^\pi$[‡]	$T_{1/2}$[#]	$\Gamma^2_{\gamma0}/\Gamma$ (eV)[@]	Comments
0.0	0^+	stable		$T_{1/2}$: from Adopted Levels.
1435.50 *25*	2	0.193 ps *+15−13*	0.00237 *17*	J$^\pi$: 2^+ in Adopted Levels. $\Gamma^2_{\gamma0}/\Gamma$: weighted average of 2.33 meV *17* (1977Sw03) and 2.48 meV *27* (1995He25).
2218.0 *10*	2	0.114 ps *+14−12*	0.0038 *4*	J$^\pi$: 2^+ in Adopted Levels. $T_{1/2}$: using $\Gamma_{\gamma0}/\Gamma$=0.976 *2* deduced from Iγ in Adopted Gammas. $\Gamma^2_{\gamma0}/\Gamma$: weighted average of 4.02 meV *41* (1977Sw03) and 3.51 meV *41* (1995He25). Γ_0/Γ= 0.97 *7* (1995Bo05).
2639.7 *10*	(2)	0.26 ps *+10−5*	0.0013 *3*	J$^\pi$: 2^+ in Adopted Levels. $T_{1/2}$: using $\Gamma_{\gamma0}/\Gamma$=0.869 *12* deduced from Iγ in Adopted Gammas. $\Gamma^2_{\gamma0}/\Gamma$: weighted average of 2.9 meV *11* (1977Sw03), 1.1 meV *3* (1978Me18) and 1.52 meV *44* (1995He25).
3338.4 *15*	2	31 fs *9*	0.0101 *14*	J$^\pi$: 2^+ in Adopted Levels. $T_{1/2}$: using $\Gamma_{\gamma0}/\Gamma$=0.82 *+5−7* deduced from Iγ in Adopted Gammas. $\Gamma^2_{\gamma0}/\Gamma$: weighted average of 12.3 meV *14* (1977Sw03), 9.4 meV *15* (1978Me18) and 8.4 meV *14* (1995He25).
3365.4 *15*	2	29 fs *+21−13*	0.0107 *23*	J$^\pi$: 2^+ in Adopted Levels. $T_{1/2}$: using $\Gamma_{\gamma0}/\Gamma$=0.82 *+13−14* deduced from Iγ in

Continued on next page (footnotes at end of table)

^{138}Ba(γ,γ′),(pol γ,γ′) 1977Sw03,2006Vo11,2002Pi02 (continued)

^{138}Ba Levels (continued)

E(level)[†]	Jπ[‡]	$T_{1/2}$[#]	$\Gamma^2_{\gamma 0}/\Gamma$ (eV)[@]	Comments
				Adopted Gammas. $\Gamma^2_{\gamma 0}/\Gamma$: unweighted average of 14.5 meV *15* (1977Sw03), 6.5 meV *12* (1978Me18) and 11.0 meV *12* (1995He25).
3642.7 *15*	2	≤15 fs	0.0080 *12*	Jπ: 2^+ in Adopted Levels. $T_{1/2}$: using $\Gamma_{\gamma 0}/\Gamma \leq 0.47$ deduced from Iγ in Adopted Gammas. $\Gamma^2_{\gamma 0}/\Gamma$: weighted average of 7.5 meV *8* (1977Sw03) and 10.8 meV *19* (1995He25).
4025.6 *5*	1^-	2.11 fs *+17−15*	0.216 *16*	Jπ: spin from intensity ratio in 1977Sw03 and 2006Vo11; parity from γ(lin pol) in 1977Sw03. $\Gamma^2_{\gamma 0}/\Gamma$: weighted average of 208 meV *10* (1977Sw03), 270 meV *30* (1978Me18) and 297 meV *63* (1995He25), 394 meV *60* (2006Vo11). $T_{1/2}$: deduced assuming $\Gamma_{\gamma 0}/\Gamma=1$.
4323.0 *7*	$1^{(-)}$	3.6 fs *+19−12*	0.101 *18*	Jπ: 1^- in Adopted Levels. $T_{1/2}$: using $\Gamma_{\gamma 0}/\Gamma=0.89$ *+11−10* deduced from Iγ in Adopted Gammas. $\Gamma^2_{\gamma 0}/\Gamma$: from 2006Vo11. Other: 14.4 meV *25* (1977Sw03).
4448 *2*	(1)	10.4 fs *+20−14*	0.044 *7*	E(level),Jπ: observed by 1977Sw03 only. $J^\pi=1^-$ in Adopted Levels. $\Gamma^2_{\gamma 0}/\Gamma$ from 1977Sw03.
4535.1 *6*	1	2.5 fs *+5−4*	0.18 *3*	E(level),Jπ: observed by 1977Sw03 and 2006Vo11. $J^\pi=1^-$ in Adopted Levels. $\Gamma^2_{\gamma 0}/\Gamma$ from 2006Vo11.
4705.6 *9*	1	7.5 fs *+22−14*	0.061 *14*	$\Gamma^2_{\gamma 0}/\Gamma$ from 2006Vo11. $J^\pi=1^-$ in Adopted Levels.
4854.7 *14*	$1^{(-)}$	0.28 fs *+39−16*	0.52 *8*	$T_{1/2}$: using $\Gamma_{\gamma 0}/\Gamma=0.56$ *+24−17* deduced from Iγ in Adopted Gammas. $\Gamma^2_{\gamma 0}/\Gamma$ from 2006Vo11. Other: 196 meV *20* (1977Sw03).
5145.4 *6*	1	0.85 fs *+17−12*	0.54 *9*	
5283.9 *7*	1	1.6 fs *+4−3*	0.28 *5*	
5390.7 *6*	$1^{(-)}$	0.69 fs *+16−11*	0.66 *12*	
5475.7 *6*	1	1.43 fs *+27−19*	0.32 *5*	
5511.3 *10*	1^-	0.23 fs *+5−3*	1.9 *3*	$T_{1/2}$: deduced by evaluator using $\Gamma^2_{\gamma 0}/\Gamma$ from 2006Vo11 and Iγ(4076)/Iγ(5511) from 1999He31.
5582.1 *7*	1^-	1.38 fs *+31−21*	0.33 *6*	
5644.6 *5*	1^-	0.29 fs *+6−4*	1.53 *24*	$T_{1/2}$: deduced by evaluator using $\Gamma^2_{\gamma 0}/\Gamma$ from 2006Vo11 and Iγ(4209)/Iγ(5645) from 1999He31.
5655.3 *7*	1^-	0.85 fs *+22−14*	0.54 *11*	
5694.5 *7*	1^-	1.30 fs *+27−19*	0.35 *6*	
5742.9 *7*	1^-	0.88 fs *+19−14*	0.43 *7*	$T_{1/2}$: deduced by evaluator using $\Gamma^2_{\gamma 0}/\Gamma$ from 2006Vo11 and Iγ(4307)/Iγ(5743) from 1999He31.
5752.4 *8*	1	2.1 fs *+5−3*	0.22 *4*	E(level),Jπ: observed by 2006Vo11 only.
5766.3 *6*	1^-	0.79 fs *+15−11*	0.58 *9*	
5815.0 *7*	1^-	1.09 fs *+22−16*	0.42 *7*	
5873.6 *6*	1^-	0.44 fs *+8−6*	1.04 *16*	
5963.5 *6*	1^-	0.56 fs *+11−8*	0.82 *13*	
6102.2 *7*	1^-	0.42 fs *+50−15*	1.1 *6*	
6114.5 *9*	1^-	0.72 fs *+31−17*	0.63 *19*	
6192.9 *5*	1^-	0.25 fs *+5−4*	1.8 *3*	
6244.6 *8*	1^-	0.82 fs *+16−11*	0.56 *9*	
6347.9 *8*	1^-	0.42 fs *+24−25*	0.81 *13*	$T_{1/2}$: deduced by evaluator using $\Gamma^2_{\gamma 0}/\Gamma$ from 2006Vo11 and Iγ(4912)/Iγ(6348) from 1999He31.

Continued on next page (footnotes at end of table)

^{138}Ba(γ,γ′),(pol γ,γ′) 1977Sw03,2006Vo11,2002Pi02 (continued)

^{138}Ba Levels (continued)

E(level)[†]	Jπ[‡]	$T_{1/2}$[#]	$\Gamma^2_{\gamma 0}/\Gamma$ (eV)[@]
6361.6 *6*	1⁻	0.35 fs *+6−5*	1.31 *20*
6410.1 *6*	1⁻	0.19 fs *+4−3*	2.4 *4*
6434.3 *6*	1⁻	0.20 fs *+4−3*	2.3 *4*
6465.8 *7*	1	0.76 fs *+15−11*	0.60 *10*
6486.3 *9*	1	1.8 fs *+5−3*	0.25 *5*
6552.6 *8*	1	0.75 fs *+17−12*	0.61 *11*
6575.3 *8*	1	0.66 fs *+14−10*	0.69 *12*
6612.7 *6*	1	0.16 fs *+3−2*	2.8 *4*
6635.1 *8*	1	0.95 fs *+22−15*	0.48 *9*
6663.7 *7*	1	0.63 fs *+12−9*	0.73 *12*
6678.6 *5*	1	0.18 fs *+3−2*	2.6 *4*
6693.4 *5*	1	0.17 fs *+3−2*	2.7 *4*
6703.5 *6*	1	0.43 fs *+8−6*	1.06 *17*
6801.9 *8*	1	0.74 fs *13*	0.62 *11*
6813.4 *6*	1	0.21 fs *+5−3*	2.2 *4*
6821.6 *11*	1	0.99 fs *+28−18*	0.46 *10*
6839.1 *8*	1	0.65 fs *+14−10*	0.70 *12*
6848.3 *7*	1	0.33 fs *+7−5*	1.37 *22*
6862.0 *6*	1	0.25 fs *+5−4*	1.8 *3*
6870.4 *7*	1	0.40 fs *+8−6*	1.15 *19*
6894.8 *6*	1	0.16 fs *+3−2*	2.8 *4*
6922.1 *8*	1	0.42 fs *+8−6*	1.10 *18*
6956.8 *12*	1	0.63 fs *+16−11*	0.73 *15*
6980.9 *8*	1	0.74 fs *+16−11*	0.62 *11*
7040.1 *9*	1	0.80 fs *+19−13*	0.57 *11*
7105.9 *15*	1	0.76 fs *+17−12*	0.60 *11*
7143.8 *9*	1	0.97 fs *+26−17*	0.47 *10*
7211.6 *8*	1	0.27 fs *+6−4*	1.7 *3*
7275.8 *10*	1	0.18 fs *+4−3*	2.5 *4*
7334.1 *10*	1	0.51 fs *+11−8*	0.89 *16*
7376.6 *9*	1	0.44 fs *+9−7*	1.03 *18*
7546.7 *22*	1	0.75 fs *+22−14*	0.61 *14*
7705.6 *12*	1	0.38 fs *+8−6*	1.21 *22*
7774.0 *7*	1	0.20 fs *+4−3*	2.3 *4*
7805.3 *8*	1	0.33 fs *+7−5*	1.37 *24*
7819.7 *8*	1	0.30 fs *+8−5*	1.5 *3*
7871.1 *10*	1	0.33 fs *+9−6*	1.4 *3*
8075.6 *8*	1	0.15 fs *+3−2*	3.0 *5*
8433.2 *14*	1⁻	0.52 fs *+19−11*	0.87 *23*

[†] From Eγ values with uncertainties in 1977Sw03 up to 3643 level and from 2006Vo11 above that, unless otherwise noted.

[‡] From 2006Vo11 for E(level)>6434 based on intensity ratios, from 2002Pi02 for E(level)>5476 and from 1999He31 for E(level)>3643 based on scattering asymmetries, and from 1977Sw03 for the rest based on intensity ratios, unless otherwise noted. The same assignments are adopted in Adopted Levels when this dataset is the only source; if different, the assignment from Adopted Levels is given under comments.

[#] Deduced from $\Gamma^2_{\gamma 0}/\Gamma$ quoted here and $\Gamma_{\gamma 0}/\Gamma$ values from branching ratios in Adopted Gammas, unless otherwise noted.

[@] From 2006Vo11 for levels above 4855 level, unless otherwise noted.

^{138}Ba(γ,γ'),(pol γ,γ') 1977Sw03,2006Vo11,2002Pi02 (continued)

$\gamma(^{138}Ba)$

E_γ [†]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡]	Comments
1435.50 *25*	1435.50	2	0.0	0^+		
2218.0 *10*	2218.0	2	0.0	0^+		
2591[#]	4025.6	1^-	1435.50	2		E_γ,I_γ: proposed by not observed by 1995He25, Iγ<5.
2639.7 *10*	2639.7	(2)	0.0	0^+		
3338.4 *15*	3338.4	2	0.0	0^+		
3365.4 *15*	3365.4	2	0.0	0^+		
3642.7 *15*	3642.7	2	0.0	0^+		
4025.6 *5*	4025.6	1^-	0.0	0^+	E1	E_γ: 4027.0 *15* from 1977Sw03. Mult.: from γ(lin pol) in 1977Sw03.
4076	5511.3	1^-	1435.50	2		Iγ(4076)/Iγ(5510.7)=0.031 *3* (1999He31).
4209	5644.6	1^-	1435.50	2		Iγ(4209)/Iγ(5645)=0.025 *3* (1999He31).
4307	5742.9	1^-	1435.50	2		Iγ(4307)/Iγ(5742.9)=0.10 *1* (1999He31).
4323.0 *7*	4323.0	$1^{(-)}$	0.0	0^+		E_γ: 4362 *2* from 1977Sw03.
4448 *2*	4448	(1)	0.0	0^+		E_γ: from 1977Sw03 only.
4535.1 *6*	4535.1	1	0.0	0^+		E_γ: 4538 *2* from 1977Sw03.
4705.6 *9*	4705.6	1	0.0	0^+		
4854.7 *14*	4854.7	$1^{(-)}$	0.0	0^+		E_γ: 4857 *2* from 1977Sw03.
4912	6347.9	1^-	1435.50	2		Iγ(4912)/Iγ(6348)=0.16 *+54−15* (1999He31).
5145.4 *6*	5145.4	1	0.0	0^+		
5283.9 *7*	5283.9	1	0.0	0^+		
5390.7 *6*	5390.7	$1^{(-)}$	0.0	0^+		
5475.7 *6*	5475.7	1	0.0	0^+		
5511.3 *10*	5511.3	1^-	0.0	0^+	E1	Iγ(4076)/Iγ(5510.7)=0.031 *3* (1999He31).
5582.1 *7*	5582.1	1^-	0.0	0^+	E1	
5644.6 *5*	5644.6	1^-	0.0	0^+	E1	Iγ(4209)/Iγ(5645)=0.025 *3* (1999He31).
5655.3 *7*	5655.3	1^-	0.0	0^+	E1	
5694.5 *7*	5694.5	1^-	0.0	0^+	E1	
5742.9 *7*	5742.9	1^-	0.0	0^+	E1	Iγ(4307)/Iγ(5742.9)=0.10 *1* (1999He31).
5752.4 *8*	5752.4	1	0.0	0^+		
5766.3 *6*	5766.3	1^-	0.0	0^+	E1	
5815.0 *7*	5815.0	1^-	0.0	0^+	E1	
5873.6 *6*	5873.6	1^-	0.0	0^+	E1	
5963.5 *6*	5963.5	1^-	0.0	0^+	E1	
6102.2 *7*	6102.2	1^-	0.0	0^+	E1	
6114.5 *9*	6114.5	1^-	0.0	0^+	E1	
6192.9 *5*	6192.9	1^-	0.0	0^+	E1	
6244.6 *8*	6244.6	1^-	0.0	0^+	E1	
6347.9 *8*	6347.9	1^-	0.0	0^+	E1	E_γ: 6345.6 from 1999He31. Iγ(4912)/Iγ(6348)=0.16 *+54−15* (1999He31).
6361.6 *6*	6361.6	1^-	0.0	0^+	E1	
6410.1 *6*	6410.1	1^-	0.0	0^+	E1	
6434.3 *6*	6434.3	1^-	0.0	0^+	E1	
6465.8 *7*	6465.8	1	0.0	0^+		
6486.3 *9*	6486.3	1	0.0	0^+		
6552.6 *8*	6552.6	1	0.0	0^+		
6575.3 *8*	6575.3	1	0.0	0^+		
6612.7 *6*	6612.7	1	0.0	0^+		
6635.1 *8*	6635.1	1	0.0	0^+		
6663.7 *7*	6663.7	1	0.0	0^+		
6678.6 *5*	6678.6	1	0.0	0^+		
6693.4 *5*	6693.4	1	0.0	0^+		
6703.5 *6*	6703.5	1	0.0	0^+		
6801.9 *8*	6801.9	1	0.0	0^+		
6813.4 *6*	6813.4	1	0.0	0^+		
6821.6 *11*	6821.6	1	0.0	0^+		

Continued on next page (footnotes at end of table)

^{138}Ba(γ,γ'),(pol γ,γ') 1977Sw03,2006Vo11,2002Pi02 (continued)

$\gamma(^{138}Ba)$ (continued)

E_γ †	E_i(level)	J_i^π	E_f	J_f^π	E_γ †	E_i(level)	J_i^π	E_f	J_f^π	E_γ †	E_i(level)	J_i^π	E_f	J_f^π
6839.1 *8*	6839.1	1	0.0	0^+	7040.1 *9*	7040.1	1	0.0	0^+	7705.6 *12*	7705.6	1	0.0	0^+
6848.3 *7*	6848.3	1	0.0	0^+	7105.9 *15*	7105.9	1	0.0	0^+	7774.0 *7*	7774.0	1	0.0	0^+
6862.0 *6*	6862.0	1	0.0	0^+	7143.8 *9*	7143.8	1	0.0	0^+	7805.3 *8*	7805.3	1	0.0	0^+
6870.4 *7*	6870.4	1	0.0	0^+	7211.6 *8*	7211.6	1	0.0	0^+	7819.7 *8*	7819.7	1	0.0	0^+
6894.8 *6*	6894.8	1	0.0	0^+	7275.8 *10*	7275.8	1	0.0	0^+	7871.1 *10*	7871.1	1	0.0	0^+
6922.1 *8*	6922.1	1	0.0	0^+	7334.1 *10*	7334.1	1	0.0	0^+	8075.6 *8*	8075.6	1	0.0	0^+
6956.8 *12*	6956.8	1	0.0	0^+	7376.6 *9*	7376.6	1	0.0	0^+	8433.2 *14*	8433.2	1^-	0.0	0^+
6980.9 *8*	6980.9	1	0.0	0^+	7546.7 *22*	7546.7	1	0.0	0^+					

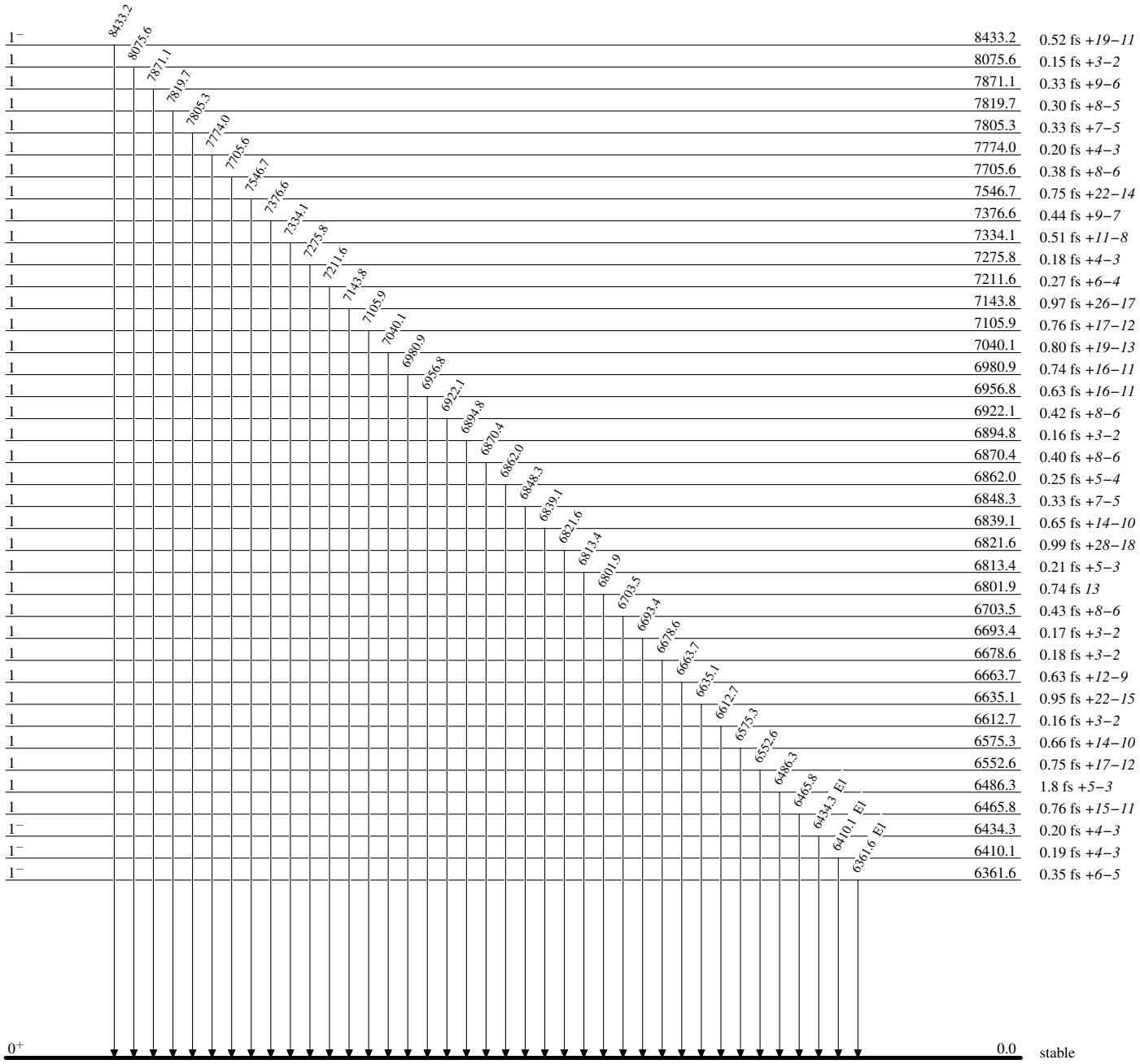
† From 1977Sw03 up to 3643 level and from 2006Vo11 above that, unless otherwise noted. Quoted values from 2006Vo11 are taken from level energies, since only g.s. transitions are observed from those levels.

‡ From 2002Pi02 deduced from measured scattering asymmetries, unless otherwise noted.

Placement of transition in the level scheme is uncertain.

^{138}Ba(γ,γ'),(pol γ,γ') 1977Sw03,2006Vo11,2002Pi02

Level Scheme



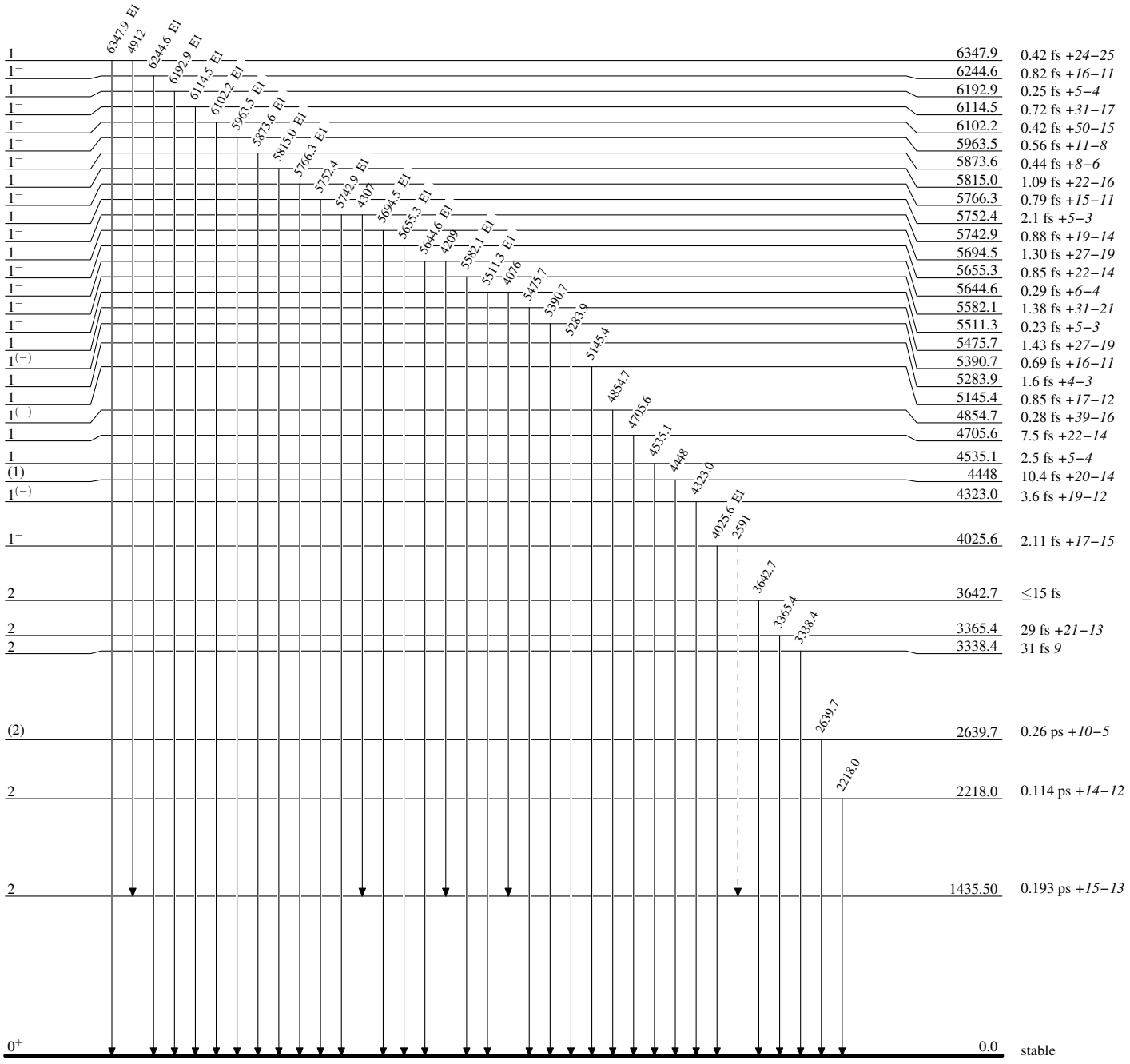
$^{138}_{56}Ba_{82}$

^{138}Ba(γ,γ'),(pol γ,γ') 1977Sw03,2006Vo11,2002Pi02

Legend

γ Decay (Uncertain)

Level Scheme (continued)



$^{138}_{56}Ba_{82}$