^{154}Sm(γ,γ′),(e,e′) 1993Zi05,1977Be05,1976Me17

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	N. Nica	NDS 200,2 (2025)	22-Aug-2022

Additional information 1.

Measurements have observed $J^\pi=1^-$ levels (1976Me17, 1977Be05) and 1^+ levels (1984Bo43, 1990Zi06, 1991Ri02). Other measurements have been done to deduce the nuclear radius, isomer shift, and deformation parameters (1970Wh02,1976Co08,1987MeZR).

Articles on theory of 1^+ states include: 1986Fa01, 1986No07, 1986Va28, 1987Ca28, 1987Ca31, 1987Ci04, 1987Ha19, 1987Ha38, 1987Ra30, 1988No05, 1989Ra01, 1990Fa09, 1990Li07, 1990Ri02, 1990Vl01, 1991De20, 1991Ma08, 1991Ra03, 1994Sa08, 1995No07, 1996No05, 1999So15, and 2000Ku24.

Experimental methods:

1993Zi05: enriched (98.6%) target with bremsstrahlung photons of 2 to 10 MeV from injector of the S-DALINAC accelerator. Scattered γ′s measured at 90° and 127° with Ge detectors.

1990Zi06: (γ,γ′). Identifies six 1^+ levels in a spectrum. Level energies estimated by evaluator from spectrum.

1984Bo43: (e,e′) on enriched (98.7%) target with E(e)=25, 29, 41, and 48 MeV, FWHM=21-35 keV. Report 3200 keV 1^+ level.

1977Be05: natural Sm target with capture γ′s from the V(n,γ) reaction to excite a 6465, 1^- level. Measured γ(θ) and linear polarization for some γ′s and level width. Methods described in 1979Mo19.

1977HoZF: (e,e′) with E(e-) from 80 to 300 MeV. The elastic and inelastic cross sections were measured.

1976Me17: natural Sm target with 1.2-3.8 MeV bremsstrahlung. γ′s were measured by two Ge detectors at 96° and 126°. γ(θ) and linear polarization measured and width deduced for the 921, 1^- level.

1976Co08: (e,e′) with E(e-)=35 to 110 MeV on enriched (99.5%) target. Scattered electrons measured at 92.5°, 110°, 127.5° and 145° in a double-focusing spectrometer and an array of 20 Si(Li) detectors in the focal plane.

^{154}Sm Levels

E(level)[†]	Jπ[‡#]	$T_{1/2}$	$\Gamma_{\gamma 0}$ (meV)[b]	Comments
0	0^+			RMS charge radius=5.154 *17* fm (1977HoZF). Other: 5.126 fm (1976Co08) (e,e′).
82	2^+			B(E2)↑=4.40 *9* B(E2)↑: From 1976Co08. Other: 4.45 *39* (1977HoZF, preliminary result).
267	4^+			B(E4)↑=0.221 *10* B(E4)↑: From 1976Co08. Other: 0.23 *8* (1977HoZF, preliminary result).
544	6^+			B(E6)↑=0.007 *5* B(E6)↑: From 1977HoZF, preliminary result.
921[@]	1^-	24 fs *3*		Jπ: From γ(θ) and linear polarization measurements, the γ connecting this level and the ground state is E1 (1976Me17). $T_{1/2}$: Calculated from the level width of 19.0 meV *25*. This value was obtained from $\Gamma\gamma_0^2/\Gamma$=3.1 meV *4* (measured, 1976Me17, relative to $\Gamma\gamma_0^2/\Gamma$=3.18 meV *28* for the 963, 1^- level in ^{152}Sm) and the adopted γ branching.
1099[&]	0^+			
1178[&]	2^+			
1202[&]	0^+			
1440[&]	2^+			
1756[&]	(3^-)			
1900[a] *10*				
1922[&]	2^+			
1972.6 *5*	$1^-,2^+$		4.4[c] *9*	Jπ: 1993Zi05 give $J^\pi=1^+$, from the reported excitation of this level via M1 radiation. However, this would require M2 for the 961.3 γ to the 3^- level at 1012. [This γ is not reported by 1993Zi05, but it is seen in the ^{154}Pm β^- decay (1.73 m).] From the reported $\Gamma\gamma_0$ and the relative γ intensities, this

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^{154}Sm(γ,γ′),(e,e′) 1993Zi05,1977Be05,1976Me17 (continued)

^{154}Sm Levels (continued)

E(level)[†]	Jπ[‡#]	$T_{1/2}$	$\Gamma_{\gamma 0}$ (meV)[b]	Comments
				M2 transition would have a transition probability ≈ 2000 times greater than that allowed by RUL. For the $J^\pi=1^-$ assignment, the 961.3 γ (now E2) would have B(E2)(W.u.)=23. For a 2^+ assignment, B(E2)(W.u.)=3.7 for the γ deexciting this level to the ground state and, thus, B(E2)(W.u.)=18 for its excitation from the ground state. In the first instance ($J^\pi=1^-$), the implied B(E2)(W.u.) for the 961.3 γ is large, but perhaps not impossibly so. In the second case ($J^\pi=2^+$), the implied B(E2)(W.u.) for excitation is of such a magnitude that the state probably should have been seen in Coulomb excitation.
1986[&]	3^-			
2443.5 *5*	1^+		10.0[c] *25*	B(M1)↑=0.18 *4*
2486?[&] *3*				
2555.7 *5*	1^-		30[c] *3*	B(E1)↑=5.2×10^{-5} *5*
2616.8 *5*	1^-		36[c] *4*	B(E1)↑=5.7×10^{-5} *6*
2743.7 *5*	1^-		30[c] *4*	B(E1)↑=4.1×10^{-5} *4*
2778.4 *5*	1		6.7 *11*	
2825.3 *5*	1^-		15[c] *4*	B(E1)↑=1.9×10^{-5} *5*
2842.1 *5*	1^-		25[c] *3*	B(E1)↑=3.1×10^{-4} *4*
2882.0 *5*	1^-		12[c] *4*	B(E1)↑=1.4×10^{-5} *5*
2907.3 *5*	1^+		17[c] *4*	B(M1)↑=0.18 *4*
3091.5 *5*	1^+		52[c] *5*	B(M1)↑=0.45 *4*
3117.0 *5*	1^+		36[c] *4*	B(M1)↑=0.31 *4*
3193.4 *5*	1^+		101[c] *7*	B(M1)↑=0.81 *6* B(M1)↑: 1984Bo43 report B(M1)=0.8 *2*.
3339.5 *5*	1		13.8 *24*	
3365.9 *5*	1		14.9 *21*	
3371.1 *5*	1^+		21[c] *5*	B(M1)↑=0.14 *4*
3426.4 *5*	1		16.4[c] *22*	
3492.4 *5*	1^+		16[c] *6*	B(M1)↑=0.10 *4*
3621.7 *5*	1^+		36[c] *11*	B(M1)↑=0.19 *6*
3745.8 *5*	1		32 *4*	
3759.8 *5*	1		19 *4*	
3801.3 *5*	1		40 *9*	
3826.7 *5*	1^-		48[c] *10*	B(E1)↑=2.5×10^{-5} *4*
3836.7 *5*	1		14 *6*	
3844.0 *5*	1		15 *7*	
4020[a] *10*				
4240[a] *10*				
4300[a] *10*				
6465	1^-	4.3 fs *21*	25 *13*	E(level): Level reported by 1977Be05. Jπ: E1 excitation in (γ,γ′) (1977Be05). $T_{1/2}$: Calculated from Γ=0.105 eV *50* (1977Be05). Γγ0 reported by 1977Be05.

[†] Below 1 MeV, the listed values are nominal ones, as given in the various studies. Above 1 MeV, the values are from 1993Zi05, unless noted otherwise. These authors list no uncertainties, but they state that the uncertainties in the Eγ are 0.5 keV; this value is used here.

[‡] From Adopted Levels.

[#] Using the Alaga rules, 1993Zi05 distinguish transitions having ΔK=0 from those having ΔK=1. γ transitions having ΔK=0 are considered to be E1, while those having ΔK=1 are generally taken to be M1.

[@] From 1976Me17.

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^{154}Sm(γ,γ'),(e,e') 1993Zi05,1977Be05,1976Me17 (continued)

^{154}Sm Levels (continued)

[&] Observed by 1977Be05 as a final state only. The deexciting γ's were not reported.
[a] Evaluators' estimate from spectral plot of 1991Ri02. Evaluators have assigned an uncertainty of 10 keV to these energies.
[b] Values are from 1993Zi05, unless noted otherwise.
[c] The listed B(E1)↑ and B(M1)↑ values have been derived from the $\Gamma\gamma_0$ data of 1993Zi05.

$\gamma(^{154}Sm)$

E_i(level)	J_i^π	E_γ[†]	I_γ[‡]	E_f	J_f^π	Mult.[#]
921	1^-	921		0	0^+	E1
1900		1820		82	2^+	
		1900		0	0^+	
1972.6	$1^-,2^+$	1890.6 *5*	48 *24*	82	2^+	
		1972.6 *5*	100	0	0^+	
2443.5	1^+	2361.5 *5*	38 *24*	82	2^+	
		2443.5 *5*	100	0	0^+	M1
2555.7	1^-	2473.7 *5*	207 *24*	82	2^+	
		2555.7 *5*	100	0	0^+	E1
2616.8	1^-	2534.8 *5*	149 *27*	82	2^+	
		2616.8 *5*	100	0	0^+	E1
2743.7	1^-	2661.7 *5*	171 *23*	82	2^+	
		2743.7 *5*	100	0	0^+	E1
2778.4	1	(2696.4 *5*)	≤17	82	2^+	
		2778.4 *5*	100	0	0^+	D
2825.3	1^-	2743.3 *5*	100	82	2^+	
		2825.3 *5*	53 *14*	0	0^+	E1
2842.1	1^-	2760.1 *5*	140 *20*	82	2^+	
		2842.1 *5*	100	0	0^+	E1
2882.0	1^-	2800.0 *5*	100	82	2^+	
		2882.0 *5*	79 *26*	0	0^+	E1
2907.3	1^+	2825.3 *5*	52 *13*	82	2^+	
		2907.3 *5*	100	0	0^+	M1[a]
3091.5	1^+	3009.5 *5*	49 *5*	82	2^+	
		3091.5 *5*	100	0	0^+	M1[a]
3117.0	1^+	3035.0 *5*	53 *6*	82	2^+	
		3117.0 *5*	100	0	0^+	M1[a]
3193.4	1^+	3111.4 *5*	57 *4*	82	2^+	
		3193.4 *5*	100	0	0^+	M1[a]
3339.5	1	(3257.5 *5*)	≤21	82	2^+	
		3339.5 *5*	100	0	0^+	D
3365.9	1	(3283.9 *5*)	≤21	82	2^+	
		3365.9 *5*	100	0	0^+	D
3371.1	1^+	3289.1 *5*	67 *20*	82	2^+	
		3371.1 *5*	100	0	0^+	M1[a]
3426.4	1	(3344.4 *5*)	≤21	82	2^+	
		3426.4 *5*	100	0	0^+	D
3492.4	1^+	3410.4 *5*	42 *20*	82	2^+	
		3492.4 *5*	100	0	0^+	M1
3621.7	1^+	3539.7 *5*	49 *14*	82	2^+	
		3621.7 *5*	100	0	0^+	M1
3745.8	1	(3663.8 *5*)	≤17	82	2^+	
		3745.8 *5*	100	0	0^+	D
3759.8	1	(3677.8 *5*)	≤28	82	2^+	
		3759.8 *5*	100	0	0^+	D
3801.3	1	3719.3 *5*	93 *23*	82	2^+	
		3801.3 *5*	100	0	0^+	D

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^{154}Sm(γ,γ′),(e,e′) 1993Zi05,1977Be05,1976Me17 (continued)

γ(^{154}Sm) (continued)

E_i(level)	J_i^π	E_γ [†]	I_γ [‡]	E_f	J_f^π	Mult.[#]	δ	Comments
3826.7	1⁻	3744.7 *5*	100	82	2⁺			
		3826.7 *5*	41 *6*	0	0⁺	E1		
3836.7	1	3754.7 *5*	85 *30*	82	2⁺			
		3836.7 *5*	100	0	0⁺	D		
3844.0	1	3762.0 *5*	112 *40*	82	2⁺			
		3844.0 *5*	100	0	0⁺	D		
4020		3940		82	2⁺			
		4020		0	0⁺			
4240		4160		82	2⁺			
		4240		0	0⁺			
4300		4220		82	2⁺			
		4300		0	0⁺			
6465	1⁻	3979[@b] *3*	10[@] *2*	2486?				
		4479[@] *3*	0.3[@]	1986	3⁻			I_γ: Value shown on the level scheme of 1977Be05. In their table, Iγ < 1.
		4543[@] *3*	10[@] *2*	1922	2⁺			
		4709[@] *3*	4[@] *3*	1756	(3⁻)			
		5025[@] *3*	5[@] *3*	1440	2⁺			
		5263[@] *3*	7[@] *1*	1202	0⁺	E1[&]		
		5287[@] *3*	8[@] *2*	1178	2⁺	E1[&]		
		5366[@] *3*	45[@] *1*	1099	0⁺	E1[&]		
		5544[@] *3*	8[@] *2*	921	1⁻	[&]		I_γ: From the table of Iγ values given by 1977Be05. On their scheme, Iγ = 7 is given. Mult.: E1 multipolarity is not consistent with $J^{\pi\prime}$s of 1⁻ to 1⁻.
		6383[@] *3*	67[@] *1*	82	2⁺	E1+M2[&]	0.081 *18*	δ: From 1977Be05, γ(θ).
		6465 *3*	100	0	0⁺	E1[&]		Mult.: From γ(θ), this transition is dipole. Linear polarization (1977Be05) indicates that mult=E1.

[†] Unless otherwise noted, the values are those deduced by the evaluator from the level energies reported by 1993Zi05. These authors do not list their measured Eγ values, but state that the uncertainties are 0.5 keV. The γ′s for levels reported by other authors (except for the 6465 level) were deduced from the differences in the level energies.

[‡] From 1993Zi05, unless noted otherwise.

[#] Unless noted otherwise, the multipolarities are from 1993Zi05. From their γ-intensity data, measured at 90° and 127°, these authors establish that the γ′s deexciting the excited states are dipole.

[@] From 1977Be05.

[&] From γ(θ) (1977Be05) and known J^π values.

[a] M1 multipolarity, inferred from (γ,γ′), is supported by (e,e′) data at backward angles, where M1 transitions are selectively excited. These data are mentioned in 1993Zi05 as "to be published".

[b] Placement of transition in the level scheme is uncertain.

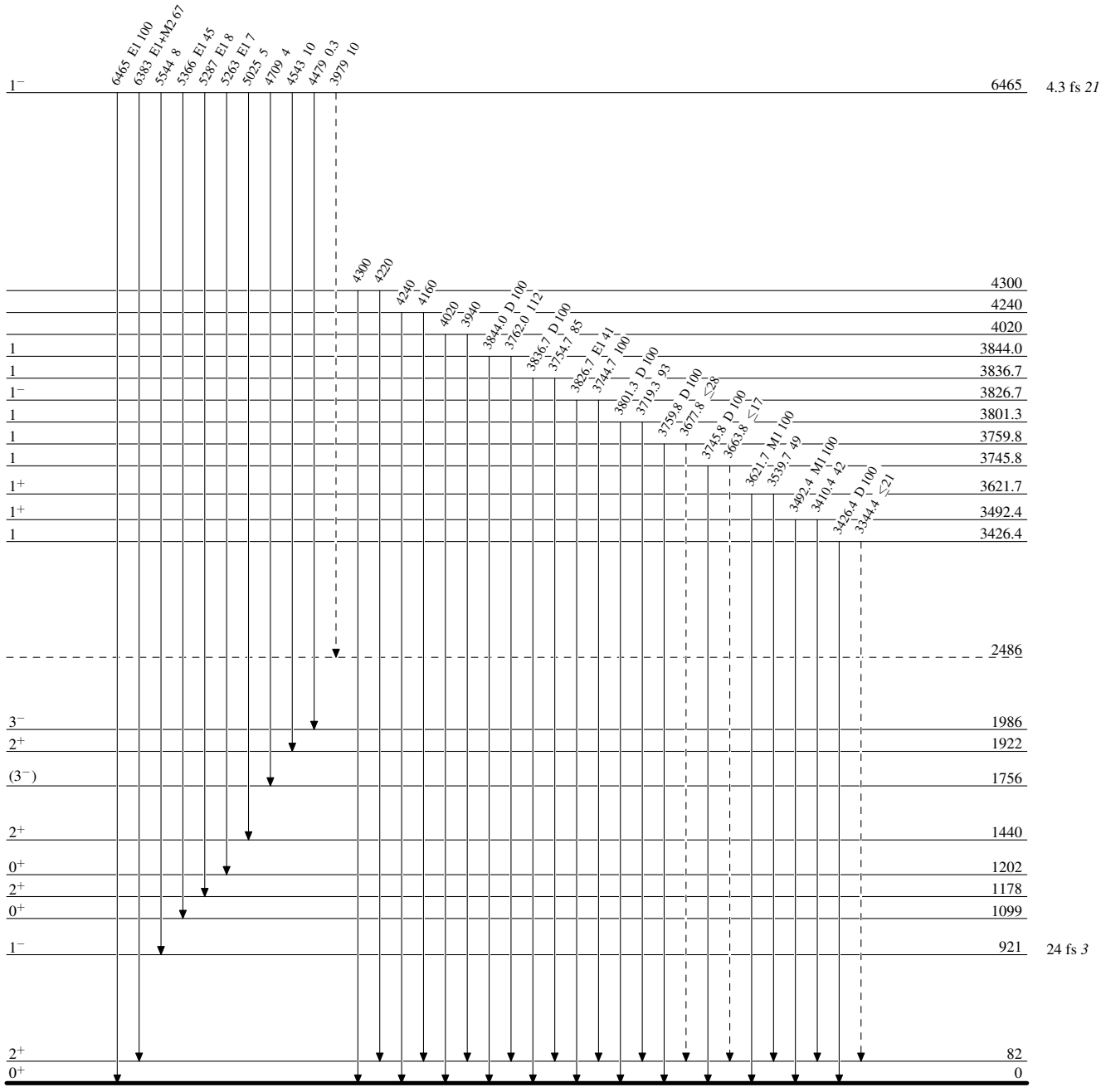
^{154}Sm(γ,γ′),(e,e′) 1993Zi05,1977Be05,1976Me17

Legend

Level Scheme

Intensities: Relative photon branching from each level

γ Decay (Uncertain)



$^{154}_{62}Sm_{92}$

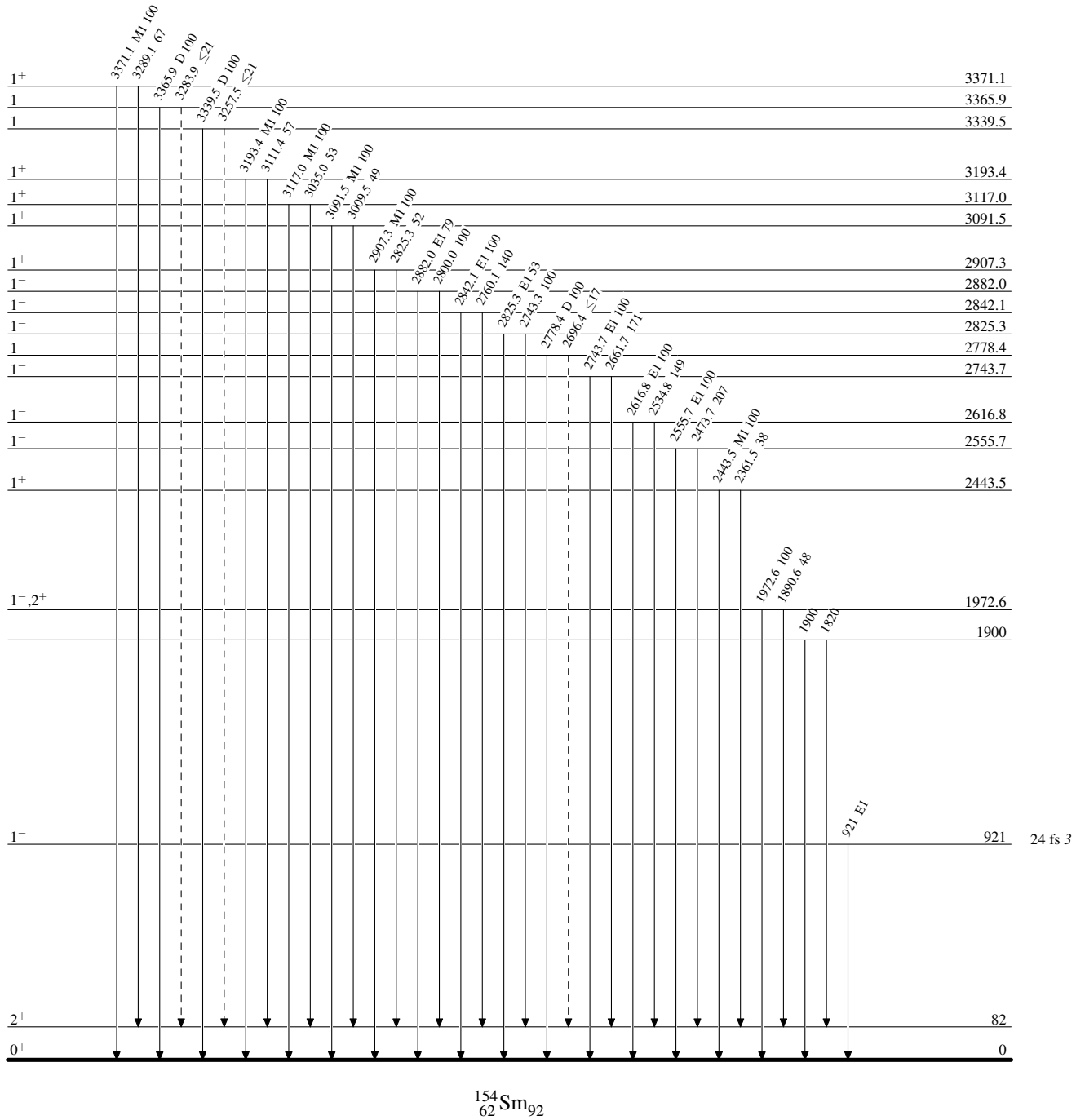
^{154}Sm(γ,γ'),(e,e′) 1993Zi05,1977Be05,1976Me17

Legend

Level Scheme (continued)

Intensities: Relative photon branching from each level

γ Decay (Uncertain)



$^{154}_{62}Sm_{92}$