^{160}Gd(n,n′γ) 2009Go33,2015Le05,2017Le04

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	N. Nica	NDS 176, 1 (2021)	1-May-2021

XUNDL compilations: 2009Go33 compiled by J. Choquette, B. Karamy and B. Singh (McMaster); 2015Le05 compiled by B. Singh (McMaster).

2009Go33: E=fast reactor neutrons from Ir-8 rector of Kurchatov Institute of Atomic Energy. Measured Eγ, Iγ, γ(θ) using a Ge detector of 20% efficiency. Comparisons with quasiparticle-phonon model.

2012Gr22 (single author): produces an extra $K^\pi=2^-$ band and adds new rotational states to other bands seemingly by reanalyzing the 2009Go33 data.

2015Le05, 2017Le04 (same group): E=1.5-2.8 MeV in steps of 0.08 or 0.1 MeV and using enriched 98.12% $^{160}Gd_2O_3$ target. Measured Eγ, Iγ, excitation functions, angular distributions, level lifetimes via DSAM and γ(θ) technique at the University of Kentucky van de Graaff accelerator facility. Deduced B(E2), B(E1). 2015Le05 studied the existence of $K^\pi=0^+$ stated at 1379.7 and 1558.3 keV; 2017Le04 extended the determination of 28 excited level $T_{1/2}$′s in low-lying $K^\pi=0^-$, 1^-, and 2^- bands of which are the negative-parity levels attributed to octupole vibrations.

1989Be48 (also 1983Be72 and 1985Be44): Enriched (98.6% ^{160}Gd, according to 1985Be44) target, (fast) neutron beam from nuclear reactor, Ge(Li) detector with 2-keV resolution at 1.3 MeV. γ radiation measured at 90° with respect to the beam.

1989Be48 report that they have measured Eγ values that differ from those of 1983Be72 for a number of the γ rays (at least in the region below 1.3 MeV). However, they do not give a complete list of these values, showing only those for the gammas that they have placed between levels that have been assigned as members of rotational bands. Also, they appear to use the Iγ values reported by 1983Be72. Unless otherwise indicated, the level energies and the Eγ values of the γ rays that are placed in the level scheme are those of 1989Be48, while the Eγ values of the unplaced gammas are those of 1983Be72. There may thus be some inconsistencies in the two sets of γ-ray energies.

Other: 1988BeYP, 1987BeYU, 1983BeZB, 1974El06.

Data before 2009 were replaced by 2009Go33 (who confirmed or rejected older data), that were further used by 2015Le05 and 2017Le04. The most complete dataset is that of 2009Go33 giving the level scheme which was slightly added by 2012Gr22 and completed by 2015Le05 and 2017Le04 mostly with $T_{1/2}$ measurements.

^{160}Gd Levels

2015Le05 confirm 0^+ assignments for here 1379.5 and 1558.4 levels but not for the 1325.73 and 2236 levels (from ^{158}Gd(t,p) dataset).

2009Go33 propose excluding following levels reported in other studies: 1325.73, 1331.1, 1388.7.

E(level)[†]	J^π[‡]	$T_{1/2}$[#]	Comments
0.0[&]	0^+		
75.276[&] *14*	2^+		
248.514[&] *20*	4^+		
514.86[&] *4*	6^+		
868.06[&] *10*	8^+		
988.555[a] *16*	2^+	>1248 fs	
1057.438[a] *22*	3^+	>1525 fs	
1070.434[b] *24*	4^+		
1147.985[a] *23*	4^+	0.75 ps *+51−22*	
1173.10[b] *4*	5^+		
1224.244[c] *22*	1^-	14.2 fs *14*	$T_{1/2}$: mean value of 14.5 fs *14* (2015Le05) and 13.9 fs *14* (2017Le04). This value agrees with 13.8 fs *66* calculated by evaluator from $\Gamma^2_{\gamma 0}/\Gamma$=4.5 meV 12 and $\Gamma_{\gamma 0}$=12.2 *34* meV in (γ,γ′) (1989Pi05). This agreement was used as a test case for the half-lives of higher levels.
1260.99[a] *4*	5^+	243 fs *+83−55*	
1289.77[c] *3*	3^-	23.6 fs *21*	

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^{160}Gd(n,n′γ) 2009Go33,2015Le05,2017Le04 (continued)

^{160}Gd Levels (continued)

E(level)[†]	Jπ[‡]	$T_{1/2}$[#]	Comments
1295.22[b] 5	6+		
1300.7[&j]	10+[j]		
1325.7 10	2+		Jπ: previous (0+) assignment by 1989Be48 is rejected by 2015Le05 from anisotropic pattern of 1250γ(θ) (Fig. 3 in 2015Le05); but note that 1250γ is doubly placed, other (main) placement in 2015Le05 from 1498 level.
1351.199[f] 22	1−	125 fs 14	
1376.74[f] 4	2−	>381 fs	
1379.55[d] 5	0+	>936[@] fs	Jπ: spin 0+ confirmed by isotropic pattern of 1304γ(θ) (Fig. 4 in 2015Le05) and angular distribution coefficients of 2009Go33.
1393.05[a] 9	6+		
1427.41[c] 5	5−	35 fs 7	
1436.28[d] 4	2+	>236[@] fs	
1437.2[bj]	7+[j]		
1463.86[f] 4	3−	5.0 fs 35	
1498.86[f] 5	4−	>277 fs	Jπ: 0+ suggested by 1989Be48 is not confirmed by 2009Go33 nor by 2015Le05 due to anisotropic pattern of 1250γ(θ), based on which 2009Go33 assigned 4−.
1531.95[h] 8	3−		
1548.27[a] 9	7+		
1558.36[e] 9	0+	>409[@] fs	
1561.50[d] 5	4+	>222[@] fs	Jπ: from Alaga rules for γ-ray branching ratios, 2015Le05 conclude that this level is not a member of band built on the first excited 0+ state which however is sustained by 2012Gr22.
1568.68[g] 4	1+	0.7 ps +13−3	
1583.60 14			
1586.57[g] 4	2+	>347 fs	
1597.3[bj] 10	8+[j]		
1598.82[e] 5	2+	0.56 ps +51−21	$T_{1/2}$: >208 fs (2015Le05).
1621.38[i] 7	2−	0.2 ps +25−1	$T_{1/2}$: the value given by 2017Le04 is 166 fs +2495−97.
1644.45[c] 13	7−		
1647.96 8	4+	0.21 ps +18−7	
1653.28[f] 8	5−	42 fs +14−10	
1661.77 5		0.6 ps +11−3	$T_{1/2}$: the value given by 2017Le04 is 610 fs +1109−250.
1665.10[g] 5	3+		
1668.4[fj] 10	6−[j]		
1691.36[i] 6	3−	0.15 ps +24−7	
1692.8?[gj] 6	4+[j]		E(level): very close lying to well defined 1691 level; according to 2012Gr22 both these levels are deexcited by 1442.95γ and 1443.0γ (possibly of same intensities).
1717[aj]	8+[j]		
1720.49 9			Jπ: 2−,3,4 ruled out by γ(θ) (2009Go33).
1731.94 7	NOT 1		Jπ: 1 is ruled out by A_2 value in γ(θ) (2009Go33).
1748.55[dj]	6+[j]		
1782.49[ij] 7	4−[j]		E(level): given by 2012Gr22 and confirmed by 2017Le04.
1804.98 7	2+	>208 fs	
1806.3[&j]	12+[j]		
1884.0[ij] 4	5−[j]		E(level): given by 2012Gr22 but not confirmed by 2017Le04.
1910.8[fj] 4	7−[j]		
1931.87 10	2+	0.5 ps +12−2	$T_{1/2}$: the value given by 2017Le04 is 527 fs +1248−229.
1941[cj]	9−[j]		
1966.54 10	1−	26 fs +6−5	
1969.67 13	2+		

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^{160}Gd(n,n′γ) 2009Go33,2015Le05,2017Le04 (continued)

^{160}Gd Levels (continued)

E(level)†	Jπ‡	$T_{1/2}$#	E(level)†	Jπ‡
1996.27 *15*	2^+		2347.4 *4*	1^+
2030.62 *13*	(2^+)		2361.90 *15*	
2059.64 *10*	(3^-)	159 fs *+62−35*	2377.3&*j*	14^+*j*
2109.33 *9*	1^+	229 fs *+83−49*	2383.6 *6*	
2118*aj*	10^+*j*		2444.8 *3*	
2118.90 *18*	2^+		2456.0 *3*	
2135.73 *10*		0.29 ps *+61−13*	2470.5? *5*	1^-
2162.70 *12*	1		2547.0 *5*	
2282.67 *23*	1		2582*aj*	12^+*j*
2301.54 *16*	2^+		3008.1&*j*	16^+*j*
2313.4*cj* *13*	11^-*j*			

† From least-squares fit to the Eγ′s.
‡ Set of assigned values by 2009Go33, confirmed and/or slightly extended by 2012Gr22, 2015Le05, and 2017Le04. See Adopted Levels, Gammas dataset for evaluated J^π values.
# Unless noted otherwise, from γ(θ) and DSAM of 2017Le04.
@ From γ(θ) and DSAM of 2015Le05.
& Band(A): $K^\pi=0^+$ ground-state rotational band. A=12.60 keV, B=−8.6 eV (from 0^+, 2^+, and 4^+ levels).
a Band(B): $K^\pi=2^+$ γ-vibrational band. A=11.54 keV, B=−7.9 eV, and A_4=−0.89 eV (from 2^+, 3^+, 4^+, and 5^+ levels).
b Band(C): $K^\pi=4^+$ band. possible hexadecapole-vibrational band. A=11.85 keV (from 4^+ and 6^+ levels). A significant odd-even shift in the level energies renders extraction of additional band parameters from only two energy differences ambiguous. The quasiparticle-phonon model calculations of 1996So19 and 1997So26 indicate that this band is predominantly hexadecapole-vibrational in makeup.
c Band(D): $K^\pi=0^-$ octupole-vibrational band. A=6.58 keV (from 1^- and 3^- levels). Small A-value and relatively large, positive, implied B-value probably reflects strong Coriolis mixing with other octupole bands.
d Band(E): first excited $K^\pi=0^+$ band.
e Band(F): second excited $K^\pi=0^+$ band.
f Band(G): first $K^\pi=1^-$ band.
g Band(H): first $K^\pi=1^+$ band.
h Band(a): first $K^\pi=3^-$ band ?
i Band(b): first $K^\pi=2^-$ band. 1621 bandhead and unique level assigned to $K^\pi=4^+$ by 2003Go33 was reassigned as $K^\pi=2^-$ bandhead (plus extra higher band levels) by 2012Gr22. The new $K^\pi=2^-$ assignment is confirmed by 2017Le04.
j Added by 2012Gr22 by reanalyzing 2009Go33 data. Not all these levels are given with decaying γ transitions.

γ(^{160}Gd)

Unless noted otherwise the unplaced γ′s and angular distribution coefficients A_2, A_4 are from 2009Go33.
According to 2017Le04 the following doublets from 2009Go33 were deleted by the evaluator: 632.82γ doublet from 1147.9, 1215.42γ doublet from 1463.85, and 1350.98γ doublet from 1598.82.

Eγ†	Iγ†	Ei(level)	J_i^π	E_f	J_f^π	Mult.‡	Comments
75.28 *2*	38 *8*	75.276	2^+	0.0	0^+		
x102.43 *20*	1.8 *4*						
173.24 *3*	100	248.514	4^+	75.276	2^+	E2	A_2=+0.195 *16*; A_4=−0.006 *22*
x191.9 *3*	0.31 *5*						
x197.07 *25*	0.79 *16*						
203.2 *4*	0.20 *6*	1260.99	5^+	1057.438	3^+		

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^{160}Gd(n,n′γ) 2009Go33,2015Le05,2017Le04 (continued)

γ(^{160}Gd) (continued)

E_γ[†]	I_γ[†]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡]	δ[‡]	Comments
217.4[&] *3*	0.13[&] *4*	1568.68	1^+	1351.199	1^-	E1[#]		
217.4[&] *3*	0.13[&] *4*	1644.45	7^-	1427.41	5^-			
224.96 *12*	0.92 *7*	1295.22	6^+	1070.434	4^+			
[x]229.4 *5*	0.14 *4*							
[x]247.4 *5*	0.14 *4*							
[x]253.13 *20*	0.34 *5*							
[x]264.1 *4*	0.68 *14*							
266.31 *4*	17.3 *5*	514.86	6^+	248.514	4^+	E2		A_2=+0.233 *19*; A_4=−0.05 *3*
[x]283.51 *20*	0.61 *6*							
288.21[&] *25*	0.41[&] *6*	1436.28	2^+	1147.985	4^+			
288.21[&] *25*	0.41[&] *6*	1665.10	3^+	1376.74	2^-			I_γ: upper limit in 2012Gr22.
293.76 *17*	0.57 *6*	1583.60		1289.77	3^-			
[x]302.1 *5*	0.23 *4*							
302.1		1597.3	8^+	1295.22	6^+			E_γ: from 2012Gr22.
309.0 *5*	0.29 *5*	1598.82	2^+	1289.77	3^-	E1[#]		
319.2 *6*	0.10 *4*	1376.74	2^-	1057.438	3^+	E1		
353.19 *9*	1.46 *9*	868.06	8^+	514.86	6^+			
[x]355.93 *13*	0.75 *6*							
[x]363.16 *15*	0.84 *9*							
[x]365.56 *24*	0.46 *8*							
[x]367.24 *13*	1.33 *10*							
374.6 *4*	0.27 *4*	1598.82	2^+	1224.244	1^-	E1[#]		
384.02 *10*	1.17 *7*	1531.95	3^-	1147.985	4^+	E1+M2	−0.14 *5*	A_2=+0.07 *4*; A_4=−0.01 *6*
397.10 *17*	0.64 *6*	1621.38	2^-	1224.244	1^-			E_γ: from 2012Gr22 (unplaced γ in 2009Go33).
[x]402.8 *5*	0.10 *4*							
[x]408.55 *13*	0.86 *6*							
412.66 *7*	2.15 *4*	1996.27	2^+	1583.60				A_2=−0.27 *4*; A_4=−0.08 *6*
[x]427.5 *6*	0.20 *4*							
[x]432.82 *9*	1.52 *8*							A_2=−0.06 *3*; A_4=+0.09 *4*
[x]437.91 *20*	0.31 *5*							
441.51 *22*	0.27 *4*	1498.86	4^-	1057.438	3^+			
[x]444.9 *4*	0.12 *4*							
[x]453.9 *4*	0.09 *3*							
466.95 *12*	0.49 *5*	1691.36	3^-	1224.244	1^-			E_γ: from 2012Gr22 (unplaced γ in 2009Go33).
[x]476.8 *3*	0.29 *5*							
521.44 *17*	0.25 *4*	1782.49	4^-	1260.99	5^+			E_γ: from 2012Gr22 (unplaced γ in 2009Go33) and confirmed by 2017Le04.
[x]523.9 *7*	0.08 *4*							
541.40 *12*	0.60 *6*	1598.82	2^+	1057.438	3^+	M1		A_2=+0.02 *6*; A_4=+0.12 *9* δ: −0.06 *10* or −4.3 *+13−29* (2009Go33); −0.01 *9* or −5.6 *+19−50* (2017Le04).
543.37[&] *11*	0.73[&] *6*	1531.95	3^-	988.555	2^+			A_2=−0.10 *6*; A_4=+0.01 *8*
543.37[&] *11*	0.73[&] *6*	1691.36	3^-	1147.985	4^+	E1[#]		A_2=−0.10 *6*; A_4=+0.01 *9*
555.6 *5*	0.14 *4*	1070.434	4^+	514.86	6^+			
560.0 *7*	0.10 *4*	1996.27	2^+	1436.28	2^+			
563.99 *15*	0.96 *14*	1621.38	2^-	1057.438	3^+	E1[#]		A_2=+0.10 *4*; A_4=−0.01 *6* Mult.,δ: M1+E2 with δ=+0.25 *+4−3* (2009Go33).
[x]566.3 *5*	0.12 *4*							
580.11 *7*	1.17 *7*	1568.68	1^+	988.555	2^+	M1+E2	+0.28[#] *+25−18*	A_2=−0.10 *4*; A_4=−0.04 *5*

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^{160}Gd(n,n′γ) 2009Go33,2015Le05,2017Le04 (continued)

γ(^{160}Gd) (continued)

E_γ[†]	I_γ[†]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡]	δ[‡]	Comments
								δ: +0.45 +*50*−*24* or +2<δ < −11 (2009Go33).
[x]601.8 *7*	0.15 *3*							
[x]608.06 *20*	0.35 *7*							
[x]610.0 *3*	0.40 *5*							
[x]618.44 *23*	0.43 *4*							
622.3 *8*	0.08 *4*	1884.0	5−	1260.99	5+			E_γ: from 2012Gr22 (unplaced γ in 2009Go33).
632.82 *8*	3.90 *24*	1621.38	2−	988.555	2+	E1[#]		
634.18[&] *20*	1.29[&] *13*	1691.36	3−	1057.438	3+	E1[#]		
634.18[&] *20*	<1.29[&]	1782.49	4−	1147.985	4+	E1[#]		E_γ: from 2012Gr22 who tacitly imply this transition as doublet.
[x]636.1 *6*	0.10 *4*							
[x]640.8 *3*	0.20 *4*							
658.20 *12*	0.59 *6*	1173.10	5+	514.86	6+			
[x]660.5 *5*	0.15 *4*							
663.4 *6*	0.08 *4*	1720.49		1057.438	3+			
[x]668.7 *3*	0.20 *4*							
702.82 *8*	1.31 *8*	1691.36	3−	988.555	2+	E1+M2	+0.06 *4*	A_2=−0.12 *4*; A_4=+0.03 *5* Mult.: E1 (2017Le04).
[x]706.87 *24*	0.31 *5*							
[x]709.06 *12*	0.53 *6*							
725.12 *8*	0.89 *6*	1782.49	4−	1057.438	3+			E_γ: from 2012Gr22 (unplaced γ in 2009Go33) and confirmed by 2017Le04.
[x]727.0 *4*	0.15 *5*							
[x]729.8 *8*	0.08 *4*							
729.8[a]		1597.3	8+	868.06	8+			E_γ: from 2012Gr22 where is unclear if this placement or that at 1437.2 level is valid (the latter would populate an inexiting level).
731.93 *9*	0.86 *6*	1720.49		988.555	2+			A_2=−0.17 *6*; A_4=−0.03 *8* δ: −0.67 +*15*−*24* or −6 +*3*−*11* for J(1720)=2.
734.50 *13*	0.42 *5*	1804.98	2+	1070.434	4+	E2	[#]	
736.2 *4*	0.17 *4*	1884.0	5−	1147.985	4+			E_γ: from 2012Gr22 (unplaced γ in 2009Go33).
739.96[a] *10*	0.99 *8*	988.555	2+	248.514	4+	E2		A_2=+0.18 *5*; A_4=−0.11 *7*
743.39 *7*	1.57 *9*	1731.94	NOT 1	988.555	2+			A_2=+0.25 *4*; A_4=−0.01 *5*
746.21 *8*	0.95 *7*	1260.99	5+	514.86	6+	M1+E2	+8[#] +*13*−*4*	A_2=−0.14 *5*; A_4=+0.05 *7* δ: +0.03 *3* or −22 +*11*−*800* (2009Go33); 2017Le04 also gives 0.24 *10* (higher χ^2).
747.8 *3*	0.25 *4*	1804.98	2+	1057.438	3+			
[x]769.18 *22*	0.25 *4*							
[x]777.0 *8*	0.10 *4*							
780.66 *13*	0.61 *6*	1295.22	6+	514.86	6+			
[x]789.0 *11*	0.08 *4*							
[x]794.00 *23*	0.18 *4*							
[x]806.0 *5*	0.15 *4*							
808.94 *3*	5.20 *21*	1057.438	3+	248.514	4+	M1+E2	−11.7 +*16*−*23*	A_2=−0.101 *11*; A_4=+0.024 *16* δ: 0.11 *3* (2017Le04).
816.43 *7*	0.99 *7*	1804.98	2+	988.555	2+	M1+E2	−1.8 +*9*−*8*	A_2=−0.27 *4*; A_4=+0.02 *6* δ: −0.76 +*10*−*13* or −3.90 +*97*−*134* (2017Le04).

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^{160}Gd(n,n′γ) 2009Go33,2015Le05,2017Le04 (continued)

γ(^{160}Gd) (continued)

E_γ[†]	I_γ[†]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡]	δ[‡]	Comments
821.92 *2*	11.9 *4*	1070.434	4^+	248.514	4^+	M1+E2	−0.71 *3*	A_2=−0.069 *7*; A_4=−0.022 *10*
[x]838.3 *7*	0.11 *4*							
[x]841.96 *14*	0.55 *6*							
[x]854.9 *7*	0.13 *4*							
[x]858.9 *7*	0.12 *4*							
[x]865.7 *3*	0.35 *5*							
874.4 *3*	0.33 *4*	1931.87	2^+	1057.438	3^+	M1+E2[#]		
878.17 *8*	1.21 *7*	1393.05	6^+	514.86	6^+	M1(+E2)	+14 *16*	A_2=−0.26 *4*; A_4=−0.25 *6* δ: +30<δ < −1.5.
[x]883.85 *8*	1.28 *7*							A_2=+0.27 *4*; A_4=+0.06 *5*
899.47 *2*	8.33 *25*	1147.985	4^+	248.514	4^+	M1+E2	+21 *+21−7*	A_2=−0.147 *8*; A_4=−0.090 *12*
[x]906.7 *3*	0.26 *4*							
[x]908.04 *10*	0.60 *5*							
913.27 *2*	21.0 *5*	988.555	2^+	75.276	2^+	M1+E2	−0.45[#] *+4−5*	A_2=−0.058 *6*; A_4=−0.018 *8* δ: < −37 and −72 *+35−∞* (2009Go33).
924.59 *3*	4.72 *16*	1173.10	5^+	248.514	4^+	M1+E2	+40 *+23−11*	A_2=+0.033 *12*; A_4=+0.108 *18*
[x]932.55 *17*	0.46 *4*							
[x]939.7 *3*	0.19 *4*							
[x]943.76 *12*	0.32 *5*							
[x]945.3 *4*	0.15 *4*							
[x]952.03 *6*	1.08 *6*							A_2=+0.17 *4*; A_4=+0.03 *6*
[x]959.38 *22*	0.40 *5*							
[x]964.2 *7*	0.10 *4*							
[x]968.10 *15*	0.48 *4*							
973.4 *3*	0.29 *4*	2030.62	(2^+)	1057.438	3^+			
[x]976.81 *16*	0.39 *5*							
982.16 *2*	21.4 *5*	1057.438	3^+	75.276	2^+	M1+E2	+47 *+18−10*	A_2=+0.089 *6*; A_4=+0.093 *9*
988.56 *2*	18.7 *5*	988.555	2^+	0.0	0^+	E2		A_2=+0.230 *5*; A_4=−0.048 *7*
995.16 *3*	7.06 *21*	1070.434	4^+	75.276	2^+	E2+M3		A_2=+0.079 *22*; A_4=−0.015 *18* δ: mixing ratio not given.
[x]997.77 *14*	0.50 *5*							
[x]1001.27 *19*	0.38 *4*							
1007.86 *24*	0.24 *4*	1996.27	2^+	988.555	2^+			
1012.46 *3*	4.49 *15*	1260.99	5^+	248.514	4^+	M1+E2	+15[#] *+17−6*	A_2=+0.027 *11*; A_4=+0.175 *16* δ: +49 *+34−14* (2009Go33).
[x]1017.7 *4*	0.16 *3*							
[x]1025.88 *14*	0.43 *4*							
[x]1028.0 *5*	0.09 *4*							
1033.40 *8*	0.48 *5*	1548.27	7^+	514.86	6^+			
1041.27 *3*	4.58 *15*	1289.77	3^-	248.514	4^+	E1+M2	+0.10 *2*	A_2=−0.169 *9*; A_4=−0.025 *16* Mult.: E1 (2017Le04).
1046.62[&] *5*	1.72[&] *7*	1295.22	6^+	248.514	4^+			A_2=+0.123 *24*; A_4=−0.13 *4*
1046.62[&] *5*	1.72[&] *7*	1561.50	4^+	514.86	6^+			A_2=+0.123 *24*; A_4=−0.13 *4*
1051.72 *20*	0.25 *4*	2109.33	1^+	1057.438	3^+	E2[#]		
1057.9 *7*	0.10 *3*	2282.67	1	1224.244	1^-			
[x]1059.46 *21*	0.20 *4*							
1072.74 *3*	4.85 *15*	1147.985	4^+	75.276	2^+	E2		A_2=+0.285 *13*; A_4=−0.056 *19*
[x]1087.3 *3*	0.12 *3*							
[x]1105.8 *3*	0.26 *4*							
[x]1112.9 *6*	0.09 *3*							
[x]1116.42 *24*	0.18 *4*							
1120.52 *21*	0.24 *4*	2109.33	1^+	988.555	2^+	M1+E2[#]		
1129.51 *13*	0.37 *4*	1644.45	7^-	514.86	6^+			
1132.7 *8*	0.052 *20*	1647.96	4^+	514.86	6^+			
1138.44 *16*	0.70 *5*	1653.28	5^-	514.86	6^+	E1+M2	−0.06 *5*	A_2=−0.08 *6*; A_4=−0.06 *9*

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^{160}Gd(n,n′γ) 2009Go33,2015Le05,2017Le04 (continued)

γ(^{160}Gd) (continued)

E_γ[†]	I_γ[†]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡]	δ[‡]	Comments
[x]1141.8 *5*	0.37 *8*							
1144.63 *25*	0.70 *5*	1393.05	6^+	248.514	4^+	E2		A_2=+0.36 *5*; A_4=+0.06 *7*
1148.98 *3*	9.9 *3*	1224.244	1^-	75.276	2^+	E1		A_2=−0.012; A_4=0
1153.5 *4*	0.28 *4*	2301.54	2^+	1147.985	4^+			
1153.54	0.28	1668.4	6^-	514.86	6^+			E_γ,I_γ: from 2012Gr22.
[x]1170.0 *4*	0.101 *25*							
1178.90 *4*	2.09 *8*	1427.41	5^-	248.514	4^+	E1+M2	−0.03 *2*	A_2=−0.254 *19*; A_4=−0.01 *3* Mult.: E1 (2017Le04).
[x]1184.8 *7*	0.60 *17*							
1187.76 *4*	4.9 *3*	1436.28	2^+	248.514	4^+	E2		A_2=+0.054 *10*; A_4=−0.015 *14*
[x]1197.01 *20*	0.40 *5*							
[x]1208.9 *4*	0.14 *3*							
1214.43 *5*	6.8 *5*	1289.77	3^-	75.276	2^+	E1[#]		
[x]1217.27 *20*	0.49 *5*							
[x]1222.37 *14*	0.46 *4*							
1224.21 *3*	7.15 *21*	1224.244	1^-	0.0	0^+	E1		A_2=−0.125 *10*; A_4=−0.012 *15*
[x]1233.72 *20*	0.51 *4*							
1250.34 *4*	3.45 *12*	1498.86	4^-	248.514	4^+	E1(+M2)	+0.05 *6*	A_2=+0.298 *15*; A_4=+0.008 *21* A2=+0.48 10 (2015Le05). Mult.: E1 (2017Le04).
1250.42		1325.7	2^+	75.276	2^+			A_2=+0.48 *10* (2015Le05) 1989Be48 and 2015Le05 confirmed the placement of this γ to 1326 level, which however is not confirmed by 2009Go33.
[x]1256.91 *22*	0.17 *3*							
[x]1260.41 *21*	0.20 *4*							
[x]1270.6 *3*	0.16 *3*							
1275.90 *2*	7.73 *23*	1351.199	1^-	75.276	2^+	E1+M2	+0.14 *5*	A_2=−0.039 *8*; A_4=−0.010 *12* Mult.: E1 (2017Le04).
1283.1 *3*	0.07 *3*	1531.95	3^-	248.514	4^+			
[x]1287.6 *9*	0.06 *3*							
[x]1298.5 *3*	0.18 *3*							
1301.46 *3*	9.1 *3*	1376.74	2^-	75.276	2^+	E1+M2	−0.08 *+5−4*	A_2=+0.132 *7*; A_4=−0.015 *10* Mult.: E1 (2017Le04).
1304.27 *4*	3.17 *14*	1379.55	0^+	75.276	2^+	E2		A_2=+0.000 *14*; A_4=−0.009 *21*
1312.99 *7*	1.09 *5*	1561.50	4^+	248.514	4^+	M1+E2	+0.28 *+34−12*	A_2=+0.35 *4*; A_4=−0.04 *5* δ: from 2017Le04; +0.57 *+17−44* (2009Go33).
[x]1323.02 *11*	0.33 *4*							
[x]1327.30 *18*	0.29 *3*							
[x]1338.8 *3*	0.16 *3*							
[x]1344.1 *4*	0.10 *3*							
1351.30 *5*	1.29	1351.199	1^-	0.0	0^+	E1[#]		A_2=−0.075 *19*; A_4=−0.03 *3* E_γ: from 2017Le04. Doublet 1350.98 *4* from 2009Go33 gives poor fit in level scheme, level-energy difference=1351.17 (2009Go33). Second 1350.98γ placed by 2009Go33 at 1599 level is not confirmed by 2017Le04.
1361.06 *5*	1.80 *7*	1436.28	2^+	75.276	2^+	M1+E2		A_2=+0.202 *22*; A_4=+0.01 *3* δ: −0.02 *4* or +2.46 *+30−25* (2009Go33); 0.00 *8* or +2.4 *+6−4* (2017Le04).
1388.56 *4*	2.70 *8*	1463.86	3^-	75.276	2^+	E1+M2	−0.050 *20*	A_2=−0.235 *16*; A_4=+0.012 *24* Mult.: E1 (2017Le04).

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^{160}Gd(n,n′γ) 2009Go33,2015Le05,2017Le04 (continued)

γ(^{160}Gd) (continued)

E_γ †	I_γ †	E_i(level)	J_i^π	E_f	J_f^π	Mult.‡	δ‡	Comments
x1395.9 *4*	0.11 *3*							
1395.9 *4*	0.11 *3*	1910.8	7^-	514.86	6^+			E_γ,I_γ: from 2012Gr22 (unplaced γ in 2009Go33).
1399.4 *4*	0.10 *3*	1647.96	4^+	248.514	4^+			
1404.75 *8*	0.70 *4*	1653.28	5^-	248.514	4^+	E1+M2	−0.08 *4*	A_2=−0.31 *5*; A_4=0.00 *7*
x1410.0 *9*	0.08 *3*							
1412.95 *25*	0.24 *4*	1661.77		248.514	4^+			
1416.66 *6*	0.95 *6*	1665.10	3^+	248.514	4^+	M1+E2	+1.5 *10*	A_2=−0.50 *4*; A_4=+0.04 *6*
x1420.32 *20*	0.24 *4*							
1436.16 *7*	0.94 *5*	1436.28	2^+	0.0	0^+	E2		A_2=+0.32 *3*; A_4=−0.08 *5*
1442.95[a]	<0.12	1692.8?	4^+	248.514	4^+			E_γ,I_γ: almost identical with 1443.0γ from 1691 level.
1443.0 *3*	0.120 *25*	1691.36	3^-	248.514	4^+	E1#		
1471.9 *3*	0.072 *25*	1720.49		248.514	4^+			
x1474.93 *25*	0.19 *3*							
1483.08 *8*	1.00 *5*	1558.36	0^+	75.276	2^+	E2#		A_2=−0.01 *4*; A_4=−0.03 *5* A_2=+0.053 38 (2015Le05).
1493.39 *7*	1.18 *6*	1568.68	1^+	75.276	2^+	M1+E2	+1.34# *+16−6*	A_2=−0.09 *4*; A_4=+0.04 *5* δ: +12.5 *122* and +0.3<δ<+24.6 (2009Go33).
1511.40 *7*	1.08 *5*	1586.57	2^+	75.276	2^+	M1+E2	−0.24 *5*	A_2=+0.05 *3*; A_4=−0.02 *5* δ: −0.24 *5* or +5.8 *+24−13*.
1523.54 *6*	1.44 *7*	1598.82	2^+	75.276	2^+	M1+E2	−1.0# *+2−21*	A_2=−0.22 *3*; A_4=−0.04 *4* δ: −0.83 *+10−15* or −3.4 *+8−11* (2009Go33).
x1539.8 *10*	0.10 *3*							
x1543.4 *3*	0.29 *4*							
1568.70 *7*	1.47 *7*	1568.68	1^+	0.0	0^+	M1		A_2=−0.11 *3*; A_4=−0.02 *4*
1572.68 *8*	1.33 *7*	1647.96	4^+	75.276	2^+	E2		A_2=+0.25 *3*; A_4=−0.03 *4*
x1581.6 *3*	0.13 *3*							
1586.50& *5*	3.27& *12*	1586.57	2^+	0.0	0^+			A_2=+0.100 *16*; A_4=−0.039 *23* I_γ: upper limit in 2012Gr22.
1586.50& *5*	3.27& *12*	1661.77		75.276	2^+			
1589.69 *8*	0.93 *5*	1665.10	3^+	75.276	2^+	M1+E2	−0.9 *5*	A_2=−0.59 *4*; A_4=+0.02 *6*
1598.81 *7*	1.21 *6*	1598.82	2^+	0.0	0^+	E2		A_2=+0.26 *3*; A_4=−0.13 *5*
1617.5 *6*	0.14 *3*	1692.8?	4^+	75.276	2^+			from 2012Gr22 (unplaced γ in 2009Go33).
1656.4 *4*	0.20 *3*	1731.94	NOT 1	75.276	2^+			
1683.22 *21*	0.26 *3*	1931.87	2^+	248.514	4^+	E2#		
x1697.6 *4*	0.14 *3*							
x1716.94 *21*	0.30 *3*							
1721.2 *9*	0.07 *3*	1969.67	2^+	248.514	4^+			
1729.2 *4*	0.20 *4*	1804.98	2^+	75.276	2^+			
x1734.9 *5*	0.15 *3*							
x1768.0 *6*	0.11 *3*							
1782.1 *4*	0.17 *3*	2030.62	(2^+)	248.514	4^+			
1805.51[a] *25*	0.33 *4*	1804.98	2^+	0.0	0^+	E2		A_2=+0.18 *11*; A_4=+0.12 *15*
1811.11 *9*	1.00 *6*	2059.64	(3^-)	248.514	4^+	E1+M2	+0.07 *6*	A_2=−0.10 *4*; A_4=+0.07 *6*
1856.63 *13*	0.63 *5*	1931.87	2^+	75.276	2^+	M1+E2	+0.92 *+41−64*	A_2=+0.30 *7*; A_4=−0.03 *9* δ: +0.16 *+18−13* or +1.5 *5* (2009Go33); +0.92 *+41−64* or +0.50 *+87−24* (2017Le04).
x1860.31 *16*	0.40 *4*							A_2=+0.15 *9*; A_4=−0.02 *14*
x1879.5 *3*	0.19 *3*							

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^{160}Gd(n,n′γ) 2009Go33,2015Le05,2017Le04 (continued)

γ(^{160}Gd) (continued)

E_γ †	I_γ †	E_i(level)	J_i^π	E_f	J_f^π	Mult.‡	δ‡	Comments
1891.26 *12*	0.85 *6*	1966.54	1^-	75.276	2^+	E1(+M2)	−0.03 *+25−31*	A_2=−0.02 *4*; A_4=−0.02 *6* Mult.: E1 (2017Le04).
1894.39 *16*	0.54 *5*	1969.67	2^+	75.276	2^+	M1+E2		A_2=0.00 *7*; A_4=−0.04 *10* δ: >+5 or −0.33 *+11−13*.
x1913.3@ *4*	0.19 *3*							
1931.9 *3*	0.26 *4*	1931.87	2^+	0.0	0^+	E2	#	
x1940.72 *20*	0.32 *4*							
x1951.0 *6*	0.12 *3*							
1955.28 *14*	0.65 *5*	2030.62	(2^+)	75.276	2^+	M1+E2		A_2=+0.19 *7*; A_4=+0.02 *10* δ: −0.03 *+12−11* or +2.4 *+11−6*.
x1958.19 *25*	0.31 *4*							
1966.52 *15*	0.49 *5*	1966.54	1^-	0.0	0^+	E1#		
1969.65 *20*	0.55 *5*	1969.67	2^+	0.0	0^+			
x1972.4 *6*	0.14 *4*							
x1977.4 *3*	0.18 *4*							
x1980.5 *6*	0.09 *4*							
x1983.68@ *16*	0.58 *5*							Additional information 1.
x2006.88@ *21*	0.46 *4*							
2034.17@ *12*	0.72 *5*	2109.33	1^+	75.276	2^+	M1+E2#		A_2=+0.07 *6*; A_4=−0.01 *9*
2043.6 *3*	0.13 *3*	2118.90	2^+	75.276	2^+			
x2052.88 *24*	0.16 *3*							
2060.44@ *10*	0.66 *5*	2135.73		75.276	2^+			A_2=−0.11 *5*; A_4=+0.02 *8*
x2079.6 *3*	0.25 *3*							
2087.45 *14*	0.44 *4*	2162.70	1	75.276	2^+			A_2=−0.19 *10*; A_4=−0.18 *14*
2109.36 *17*	0.36 *4*	2109.33	1^+	0.0	0^+	M1		A_2=−0.13 *10*; A_4=+0.02 *14*
2113.40 *16*	0.41 *4*	2361.90		248.514	4^+			A_2=+0.06 *9*; A_4=+0.06 *13*
2118.89 *21*	0.37 *4*	2118.90	2^+	0.0	0^+	E2		A_2=+0.31 *11*; A_4=+0.06 *14*
x2129.15 *24*	0.33 *4*							
x2131.1 *3*	0.45 *4*							
2135.7& *3*	0.31& *4*	2135.73		0.0	0^+			
2135.7&a *3*	0.31& *4*	2383.6		248.514	4^+			
x2154.4 *6*	0.10 *3*							
x2157.3 *3*	0.27 *4*							
2162.58 *22*	0.39 *4*	2162.70	1	0.0	0^+			A_2=−0.09 *10*; A_4=−0.09 *15* According to 2015Le05 this γ ray cannot be assigned to a 2236, (0^+) reported previously in (t,p) work (1986Lo15) since γ(θ) is anisotropic, and the excitation function threshold of 2.16 MeV is too low.
x2162.74								
x2170.6@ *5*	0.17 *4*							
x2178.2 *4*	0.26 *4*							
x2181.1 *5*	0.15 *3*							
x2191.4 *4*	0.15 *3*							
2196.0 *6*	0.14 *3*	2444.8		248.514	4^+			
x2200.99 *24*	0.23 *4*							
x2204.5 *4*	0.15 *4*							
2207.5& *3*	0.27& *4*	2282.67	1	75.276	2^+			
2207.5& *3*	0.27& *4*	2456.0		248.514	4^+			
x2227.73 *17*	0.41 *4*							
x2242.29 *16*	0.48 *4*							
x2261.13 *24*	0.25 *4*							

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^{160}Gd(n,n′γ) 2009Go33,2015Le05,2017Le04 (continued)

γ(^{160}Gd) (continued)

E_γ[†]	I_γ[†]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡]	Comments
[x]2269.8 *9*	0.10 *3*						
2272.5 *7*	0.15 *3*	2347.4	1^+	75.276	2^+		
[x]2277.4 *4*	0.28 *4*						
2282.6 *4*	0.26 *4*	2282.67	1	0.0	0^+		
2286.5 *3*	0.35 *4*	2361.90		75.276	2^+		
2301.53[@] *17*	0.66 *5*	2301.54	2^+	0.0	0^+	E2	A_2=+0.19 *7*; A_4=−0.03 *10*
2308.3[@] *6*	0.16 *4*	2383.6		75.276	2^+		
[x]2317.7 *4*	0.12 *3*						
[x]2332.76 *17*	0.35 *4*						
2347.3 *4*	0.24 *3*	2347.4	1^+	0.0	0^+		
2369.6 *3*	0.23 *3*	2444.8		75.276	2^+		
[x]2373.9 *4*	0.20 *3*						
2380.3 *8*	0.11 *3*	2456.0		75.276	2^+		
2395.2[@] *5*	0.15 *3*	2470.5?	1^-	75.276	2^+		
[x]2464.5[@] *5*	0.14 *3*						
2471.8[&a] *4*	0.26[&] *4*	2470.5?	1^-	0.0	0^+		
2471.8[&a] *4*	0.26[&] *4*	2547.0		75.276	2^+		
[x]2481.6 *6*	0.120 *24*						
[x]2514.1 *7*	0.20 *3*						
[x]2519.4 *9*	0.09 *3*						
[x]2522.4 *5*	0.16 *3*						
[x]2537.6 *4*	0.29 *3*						
2547.0 *5*	0.120 *24*	2547.0		0.0	0^+		

[†] Unless noted otherwise, from 2009Go33 (energies measured at 90° and intensities at 125°). 2009Go33, 2015Le05 and 2017Le04 list very precise E_γ values which are in general good agreement (the uncertainties of all three references seem underestimated). For I_γ 2009Go33 list relative intensities (to 173.24γ) while 2017Le04 and 2015Le05 give branching ratios at each level. Many more γ transitions were found and placed in the level scheme by 2009Go33 (136) than by 2017Le04 (73) and 2015Le05 (23), reason for which the E_γ and I_γ values of 2009Go33 were adopted here. However since the method of 2017Le04 and 2015Le05 is more selective their more precise branching ratios are adopted in the Adopted Levels, Gammas dataset.

[‡] Unless noted otherwise, from 2009Go33 based on angular distribution measurements combined with multiplet analysis and intensity arguments. Based on these arguments they assigned E2 for ΔJ=2 transitions, and used the values of measured ΔJ=2 mixing ratios of the D+Q transitions to distinguish between M1 and E1 character (high mixing ratio values implying M1 rather than E1).

[#] From 2017Le04 based primarily on angular distribution measurements (coefficients not provided) combined with level scheme arguments leading to E2 assignment for ΔJ=2 transitions and claiming to distinguish E1 and M1 for ΔJ=1 transitions. For weak transitions data from literature were combined (mostly from 2009Go33).

[@] Doublet or multiplet (2009Go33).

[&] Multiply placed with undivided intensity.

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

[x] γ ray not placed in level scheme.

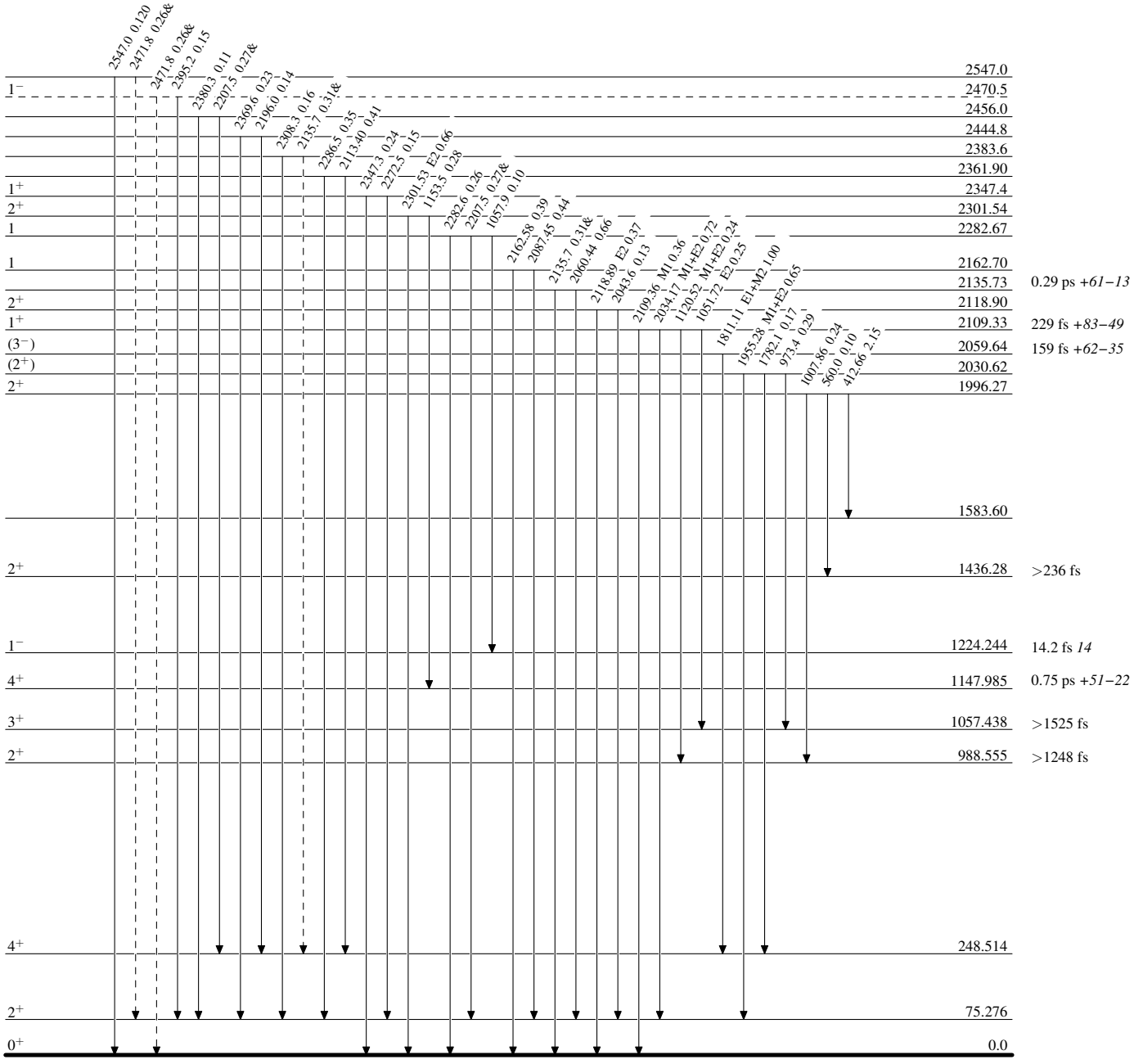
^{160}Gd(n,n′γ) 2009Go33,2015Le05,2017Le04

Legend

$I_\gamma < 2\% \times I_\gamma^{max}$
$I_\gamma < 10\% \times I_\gamma^{max}$
$I_\gamma > 10\% \times I_\gamma^{max}$
γ Decay (Uncertain)

Level Scheme

Intensities: Relative I_γ
& Multiply placed: undivided intensity given



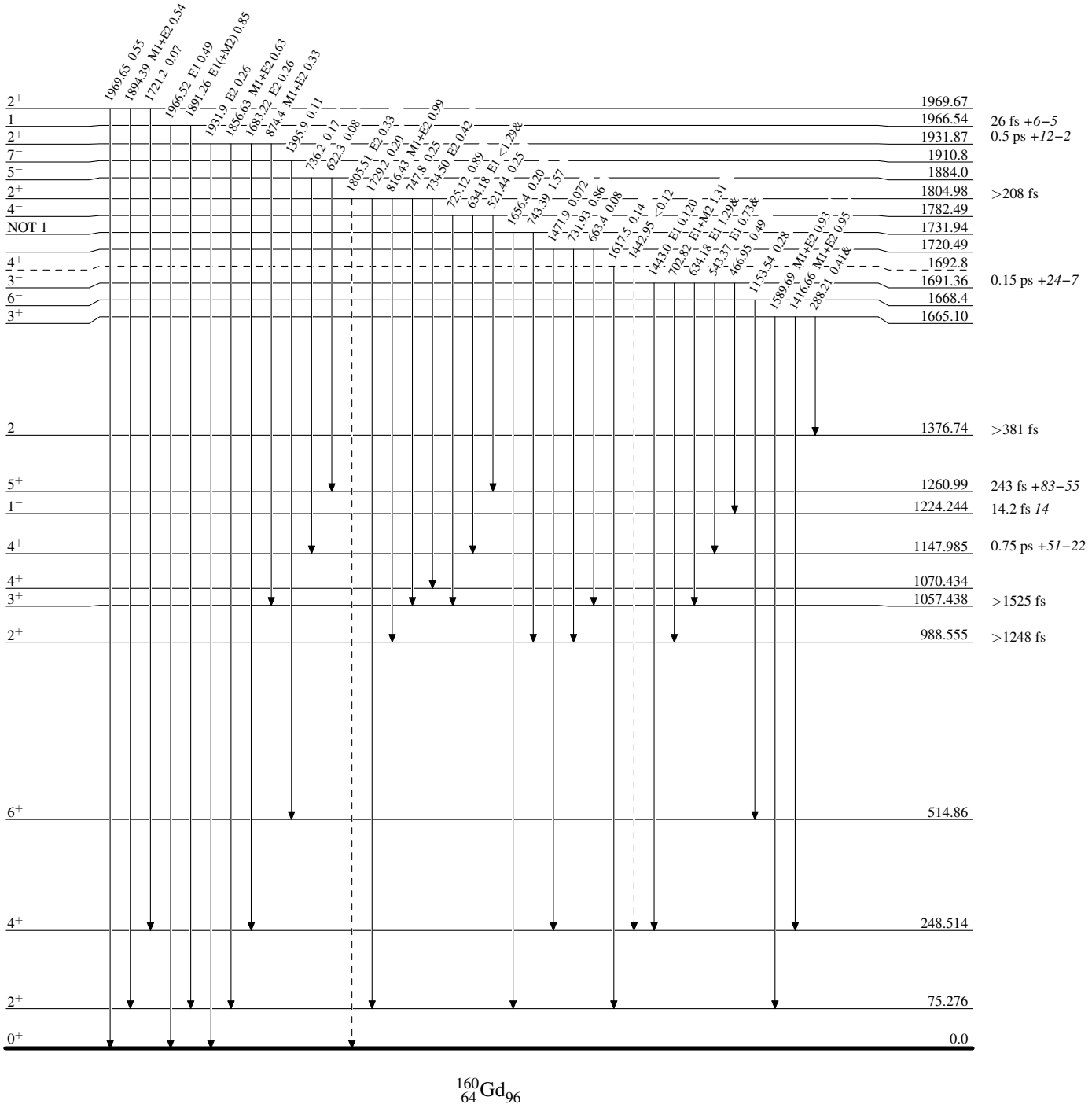
$^{160}_{64}Gd_{96}$

^{160}Gd(n,n′γ) 2009Go33,2015Le05,2017Le04

Level Scheme (continued)

Intensities: Relative I_γ
& Multiply placed: undivided intensity given

Legend
$I_\gamma < 2\% \times I_\gamma^{max}$
$I_\gamma < 10\% \times I_\gamma^{max}$
$I_\gamma > 10\% \times I_\gamma^{max}$
γ Decay (Uncertain)



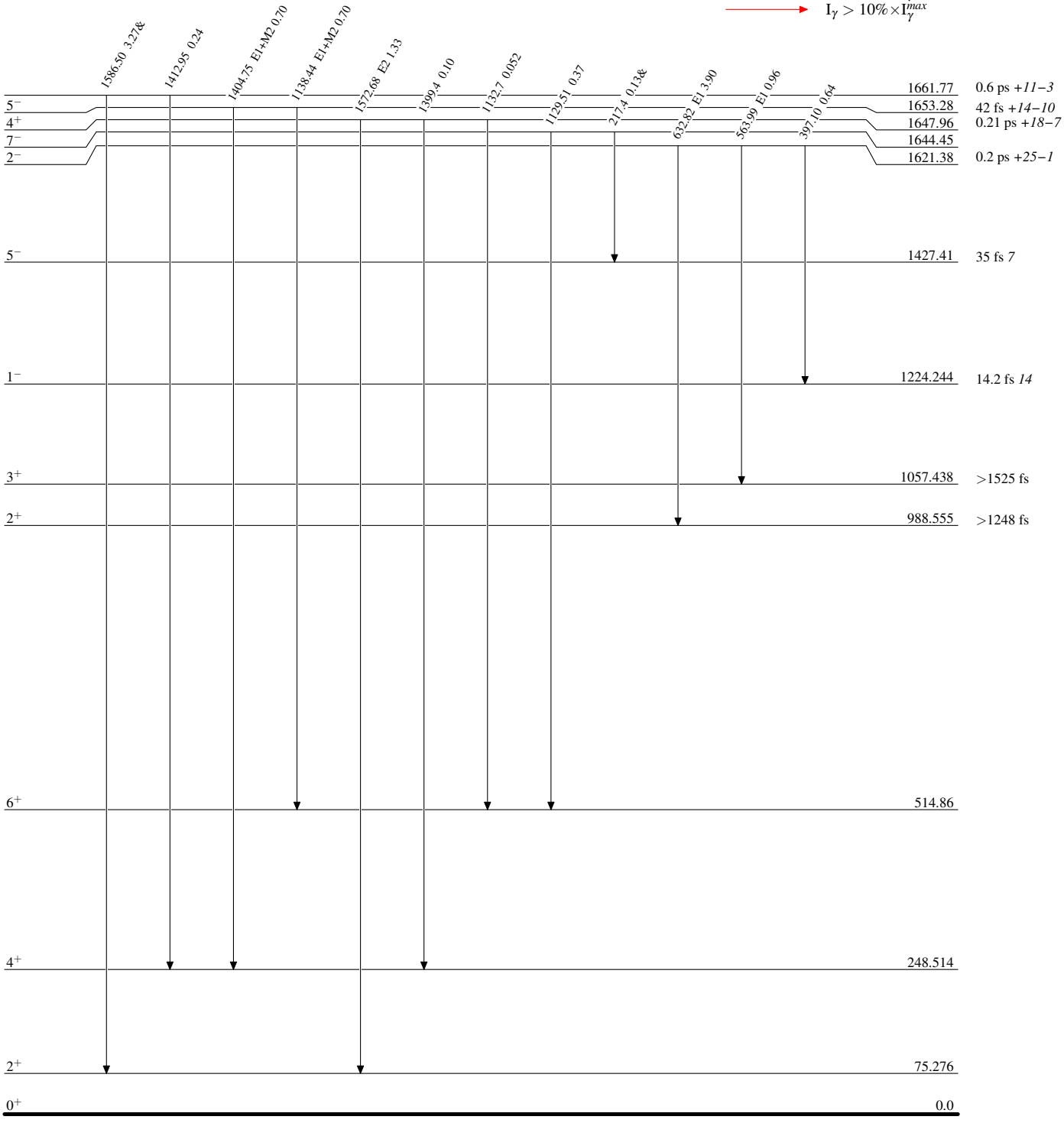
$^{160}_{64}Gd_{96}$

^{160}Gd(n,n′γ) 2009Go33,2015Le05,2017Le04

Level Scheme (continued)

Intensities: Relative I_γ
& Multiply placed: undivided intensity given

Legend
$I_\gamma < 2\% \times I_\gamma^{max}$
$I_\gamma < 10\% \times I_\gamma^{max}$
$I_\gamma > 10\% \times I_\gamma^{max}$



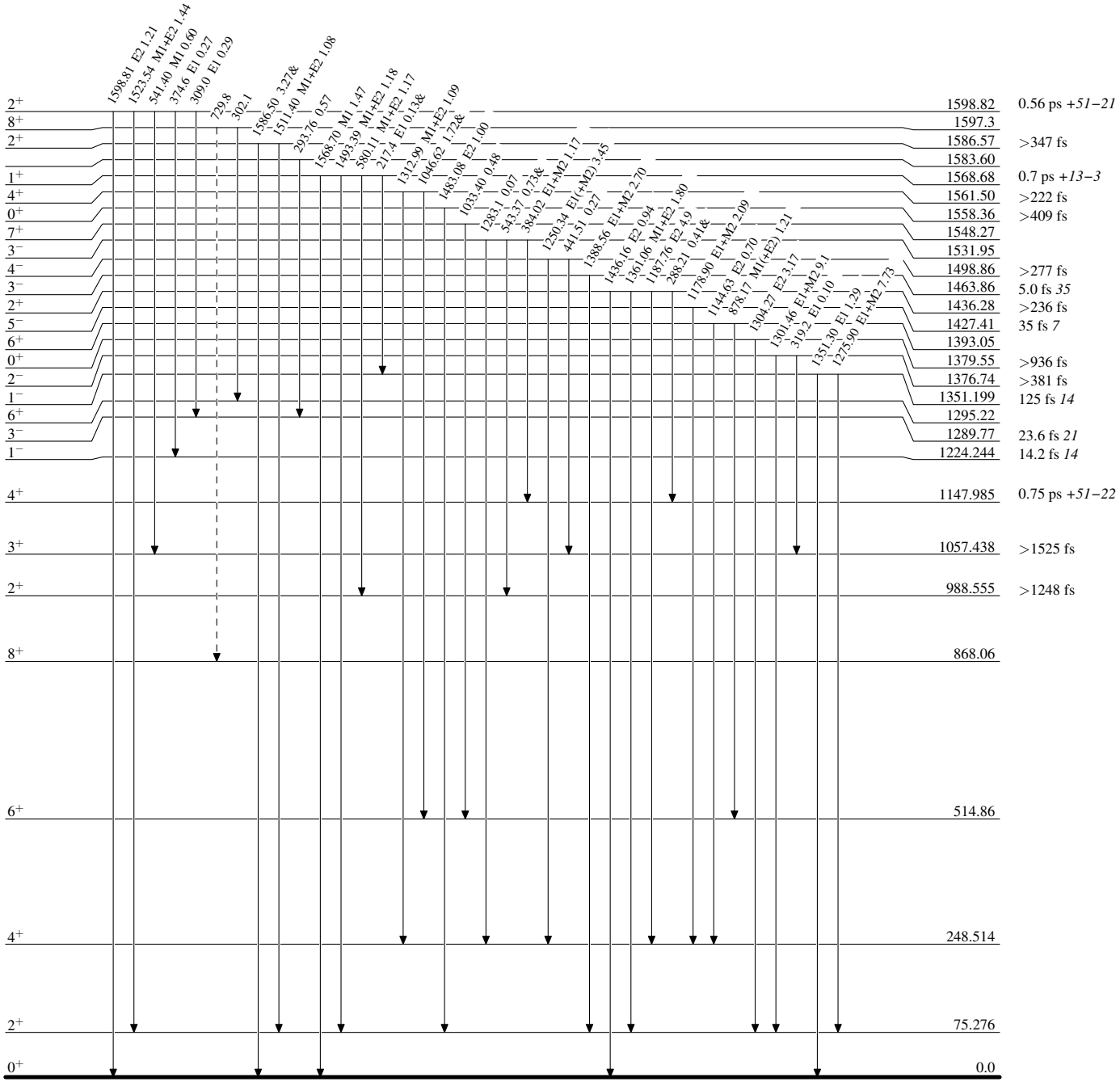
$^{160}_{64}Gd_{96}$

^{160}Gd(n,n′γ) 2009Go33,2015Le05,2017Le04

Level Scheme (continued)

Intensities: Relative I_γ
& Multiply placed: undivided intensity given

Legend
$I_\gamma < 2\% \times I_\gamma^{max}$
$I_\gamma < 10\% \times I_\gamma^{max}$
$I_\gamma > 10\% \times I_\gamma^{max}$
γ Decay (Uncertain)



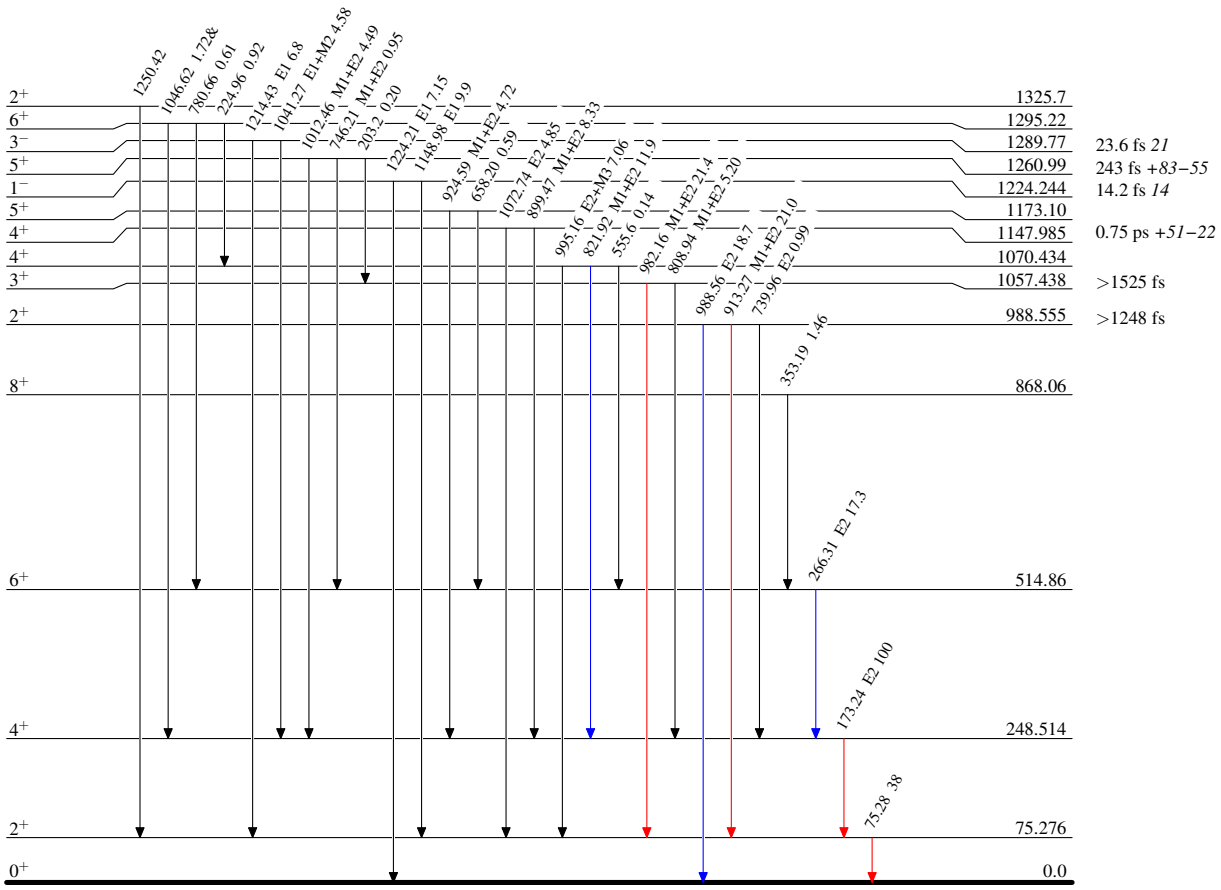
$^{160}_{64}Gd_{96}$

^{160}Gd(n,n′γ) 2009Go33,2015Le05,2017Le04

Level Scheme (continued)

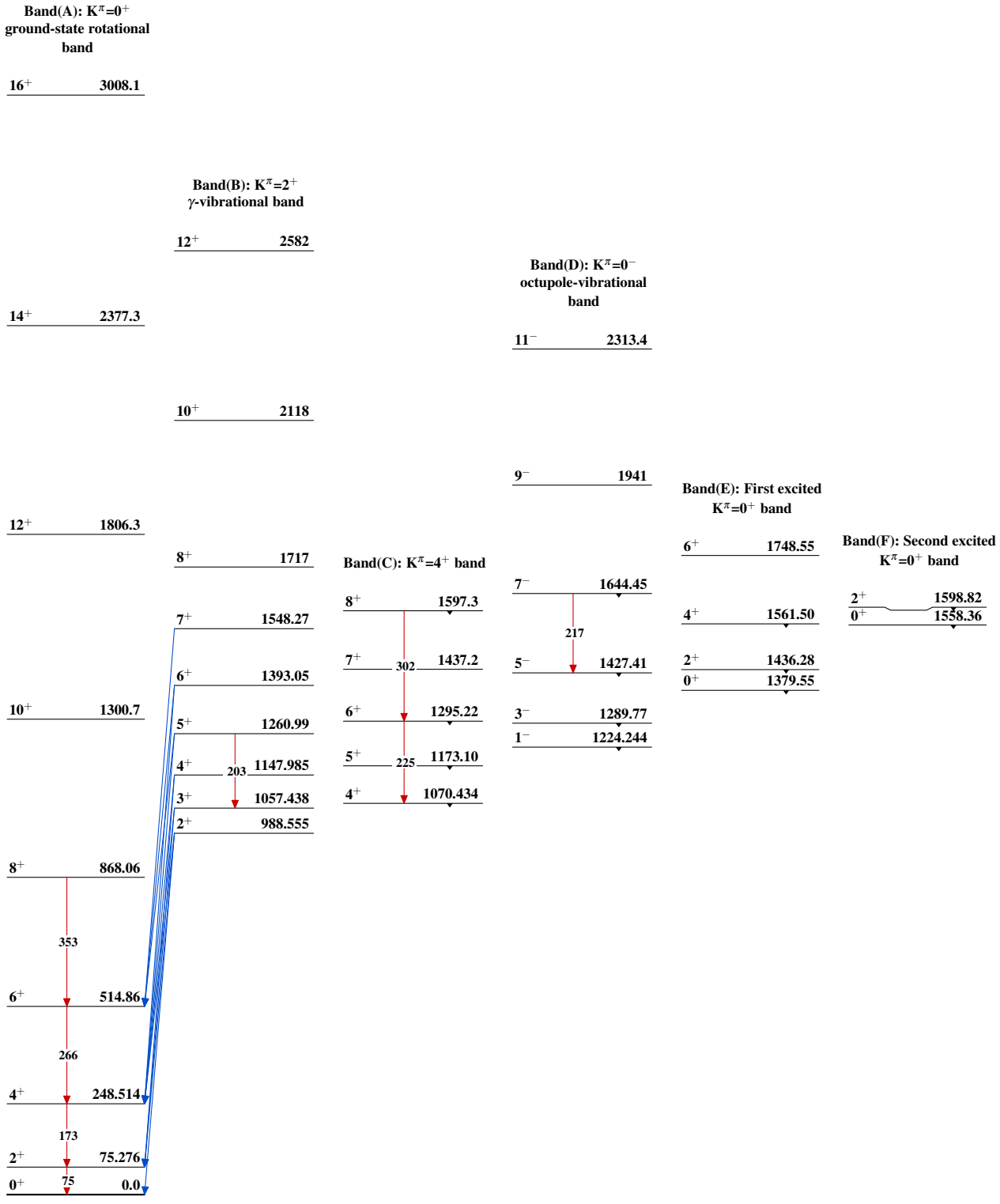
Intensities: Relative I_γ
& Multiply placed: undivided intensity given

Legend
$I_\gamma < 2\% \times I_\gamma^{max}$
$I_\gamma < 10\% \times I_\gamma^{max}$
$I_\gamma > 10\% \times I_\gamma^{max}$



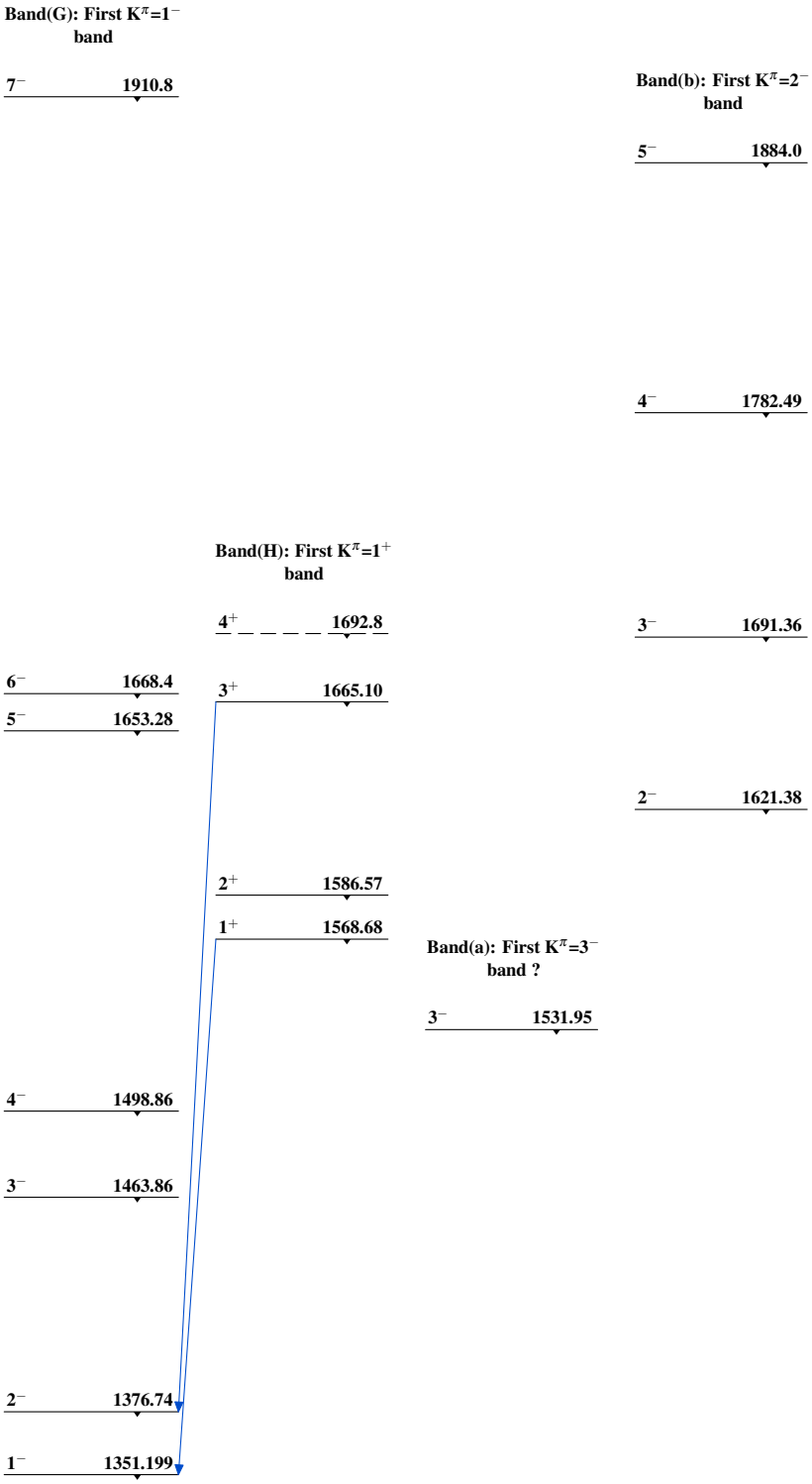
$^{160}_{64}Gd_{96}$

^{160}Gd(n,n′γ) 2009Go33,2015Le05,2017Le04



$^{160}_{64}Gd_{96}$

^{160}Gd(n,n′γ) 2009Go33,2015Le05,2017Le04 (continued)



$^{160}_{64}Gd_{96}$