^{158}Gd(n,γ) E=thermal 2004Gr26,1971Gr42

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	C. W. Reich	NDS 113, 157 (2012)	31-Dec-2010

Additional information 1.

2004Gr26: γ′s measured using the curved-crystal spectrometers GAMS2/3 and the ultrahigh-resolution double-flat-crystal spectrometer GAMS4 at the high-flux reactor at the ILL, Grenoble. Enriched (98.0% ^{158}Gd) 55-mg Gd_2O_3 target wrapped in Al foil, irradiated for several days to “burn out” the isotopes ^{155}Gd and ^{157}Gd with very large n-capture cross sections. Measured Eγ, Iγ for γ′s from≈95 keV to≈1.2 MeV. Report results of theoretical calculations of makeup of levels using quasiparticle-phonon and quasiparticle-rotor models for a strongly deformed nucleus.

1971Gr42: ^{158}Gd, enriched to 83.8%, irradiated with thermal neutrons from a reactor. Measured primary γ′s with Ge detector, FWHM=10 keV at 6 MeV.

In the entry for this reaction in the XUNDL data file (compiled by J. Roediger and B. Singh, McMaster Univ., August 19, 2004), a number of private communications from the first author (C. Granja) of 2004Gr26 are referenced. These are included, as relevant, in the present evaluation.

^{159}Gd Levels

Conf assignments are the dominant ones deduced from other studies. For more details for specific bands, see the Adopted Levels data set.

E(level)	J$^{\pi}$‡	Comments
0.0#	3/2⁻	
50.624# 7	5/2⁻	
67.890@ 18	5/2⁺	
118.75@ 3	7/2⁺	
121.85# 3	7/2⁻	
146.324& 7	5/2⁻	
227.438& 21	7/2⁻	
330.477& 10	9/2⁻	
466?		E(level): Based solely on a reported primary γ transition (1971Gr42). level not included in the Adopted Levels.
507.739a 16	1/2⁻	
558.213a 10	3/2⁻	
588.478a 25	5/2⁻	
601.976f 7	3/2⁺	E(level): Evaluator assumes that this is the same level as the 598 level reported (1971Gr42) to be fed by a primary γ transition.
633.63b 5	7/2⁺	J$^{\pi}$: Interpreted by 2004Gr26 as the bandhead of ν7/2[633].
637?		E(level): Based solely on a reported primary γ transition (1971Gr42). level not included in the Adopted Levels.
646.637f 20	5/2⁺	
675?		E(level): Based solely on a reported primary γ transition (1971Gr42). level not included in the Adopted Levels.
684?		E(level): Based solely on a reported primary γ transition (1971Gr42). probably not the same level as the 684.2, 11/2⁻ level seen in (d,p). level not included in the Adopted Levels.
710.29f 5	7/2⁺	
732.93 6		
744.386c 17	3/2⁺	
781.573d 18	1/2⁺	
800.45c 4	5/2⁺	
818.981d 21	5/2⁺	

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^{158}Gd(n,γ) E=thermal 2004Gr26,1971Gr42 (continued)

^{159}Gd Levels (continued)

E(level)	Jπ‡	Comments
858.57[d] 3	3/2+	
872.66[e] 3	5/2−	
881.01 5	1/2+,3/2+,5/2+	
915.828 11		
960		E(level): Level fed by a primary γ transition (1971Gr42).
974.366[i] 18	1/2+	
1001.65[i] 16	3/2+	
1044?		E(level): Based solely on a reported primary γ transition (1971Gr42). level not included in the Adopted Levels.
1061.63 11	1/2−	
1079.36 6	1/2−	
1082.54	3/2−	Jπ: Value proposed by 2004Gr26 but no basis given for it. IT has not been ADOPTED.
1110.17[g] 10	3/2−	
1129.07 8	3/2+	E(level): E=1129.19 in the γ-decay summary table (Table V) of 2004Gr26. Jπ: 2004Gr26 list 1/2+.
1139.85[h] 3	1/2−	
1145.61[h] 3	3/2−	
1160.52 7	5/2+	
1284†		
1337†		
1390†		
1432†		
1559†		
1609†		
1638†		
1722†		
1841†		
1898†		
1981†		
1992†		
2158†		
2197†		
2296†		
(5943.21 8)	1/2+	E(level): n-capture "state". E=S(n), from 2009AuZZ. 1971Gr42 report 5942 1. Jπ: s-wave n capture by the g.s. of ^{158}Gd, Jπ=0+.

† Levels above 1160 keV are not reported by 2004Gr26. The values listed here are from 1971Gr42 and simply represent the values computed from the measured primary γ energies and the neutron separation energy, without correction for nuclear recoil. Some of these levels are supported by other studies. Some are possible doublets and some are not confirmed by other studies. See the Adopted Levels data set for more details.

‡ From the Adopted Levels.

\# Band(A): ν3/2[521] band.

@ Band(B): ν5/2[642] band.

& Band(C): ν5/2[523] band.

[a] Band(D): ν1/2[521] band .

[b] Band(E): proposed ν7/2[633] bandhead.

[c] Band(F): ν3/2[402] band.

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^{158}Gd(n,γ) E=thermal 2004Gr26,1971Gr42 (continued)

^{159}Gd Levels (continued)

[d] Band(G): ν1/2[660] band, with mixture of ν1/2[400].
[e] Band(H): ν5/2[512] bandhead.
[f] Band(I): ν3/2[651] band.
[g] Band(J): ν3/2[532] bandhead.
[h] Band(K): ν1/2[530] band.
[i] Band(L): ν1/2[400] band.

γ(^{159}Gd)

$E_γ$[&]	$I_γ$[bc]	E_i(level)	$J^π_i$	E_f	$J^π_f$	Comments
95.685 *5*	2.6 *4*	146.324	5/2−	50.624	5/2−	
[x]138.996 *6*	0.46 *10*					
146.324 *7*	1.44 *17*	146.324	5/2−	0.0	3/2−	
159.547 *10*	0.34 *7*	227.438	7/2−	67.890	5/2+	
172.368 *15*	0.27 *6*	818.981	5/2+	646.637	5/2+	
[x]181.84 *9*	0.39 *6*					
184.163 *7*	0.41 *7*	330.477	9/2−	146.324	5/2−	
273.856 *21*	0.17 *8*	781.573	1/2+	507.739	1/2−	
313.851 *8*	0.23 *3*	915.828		601.976	3/2+	
[x]326.873 *18*	0.15 *3*					
358.26 *3*	0.17 *2*	1139.85	1/2−	781.573	1/2+	
364.029 *20*	0.26 *3*	1145.61	3/2−	781.573	1/2+	
416.09 *5*	0.23 *4*	974.366	1/2+	558.213	3/2−	
466.618[e] *11*	1.43[e] *14*	588.478	5/2−	121.85	7/2−	
466.618[e] *11*	1.43[e] *14*	974.366	1/2+	507.739	1/2−	
507.639[‡] *20*	3.7 *3*	558.213	3/2−	50.624	5/2−	
507.727[‡] *20*	5.2 *4*	507.739	1/2−	0.0	3/2−	
524.77 *7*	0.95 *8*	646.637	5/2+	121.85	7/2−	
534.12 *6*	0.28 *4*	601.976	3/2+	67.890	5/2+	
537.86 *4*	1.38 *15*	588.478	5/2−	50.624	5/2−	
551.385 *17*	2.08 *11*	601.976	3/2+	50.624	5/2−	
558.195 *10*	2.7 *3*	558.213	3/2−	0.0	3/2−	
581.71 *9*	0.11 *3*	1139.85	1/2−	558.213	3/2−	
582.85 *6*	0.23 *3*	633.63	7/2+	50.624	5/2−	
588.54[f] *4*	0.15[f] *5*	588.478	5/2−	0.0	3/2−	$I_γ$: From Iγ=0.23 *5*, after subtracting Iγ=0.084 *15* for the other placement.
588.54[f] *4*	0.084[f] *19*	710.29	7/2+	121.85	7/2−	$I_γ$: From Iγ(588γ)/Iγ(659γ) in Eu β- decay and Iγ(659γ).
596.066 *24*	0.79 *3*	646.637	5/2+	50.624	5/2−	
601.969 *7*	4.30 *14*	601.976	3/2+	0.0	3/2−	
633.78[d] *6*	0.36 *4*	633.63	7/2+	0.0	3/2−	$E_γ$: In different tables (Tables I and V), 2004Gr26 give different placements for this γ.
633.78[d] *6*	0.36 *4*	818.981	5/2+			$E_γ$: In different tables (Tables I and V), 2004Gr26 give different placements for this γ.
646.75 *9*	1.33 *9*	646.637	5/2+	0.0	3/2−	
659.26 *8*	0.29 *4*	710.29	7/2+	50.624	5/2−	$E_γ$: Poor energy fit. Level-energy difference is 659.67.
665.04 *5*	0.20 *3*	732.93		67.890	5/2+	
676.512 *24*	1.71 *8*	744.386	3/2+	67.890	5/2+	
678.53 *6*	0.25 *4*	800.45	5/2+	121.85	7/2−	
681.71 *6*	0.73 *5*	800.45	5/2+	118.75	7/2+	
693.73 *6*	0.49 *6*	744.386	3/2+	50.624	5/2−	
700.163 *25*	1.00 *19*	818.981	5/2+	118.75	7/2+	
713.649 *19*	0.97 *6*	781.573	1/2+	67.890	5/2+	
726.47 *8*	0.12 *2*	872.66	5/2−	146.324	5/2−	

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^{158}Gd(n,γ) E=thermal 2004Gr26,1971Gr42 (continued)

γ(^{159}Gd) (continued)

E_γ[&]	I_γ[bc]	E_i(level)	J^π_i	E_f	J^π_f
732.68 *8*	0.15 *4*	800.45	5/2+	67.890	5/2+
739.843 *17*	0.74 *12*	858.57	3/2+	118.75	7/2+
744.375 *20*	0.60 *14*	744.386	3/2+	0.0	3/2−
751.23 *5*	0.48 *4*	818.981	5/2+	67.890	5/2+
754.03 *9*	0.29 *5*	872.66	5/2−	118.75	7/2+
768.15 *6*	0.28 *3*	818.981	5/2+	50.624	5/2−
781.56 *5*	0.97 *6*	781.573	1/2+	0.0	3/2−
[x]784.35 *25*	0.20 *3*				
790.90 *16*	1.52 *19*	858.57	3/2+	67.890	5/2+
800.39 *14*	0.23 *4*	800.45	5/2+	0.0	3/2−
804.739 *26*	0.73 *4*	872.66	5/2−	67.890	5/2+
807.60 *11*	0.43 *4*	858.57	3/2+	50.624	5/2−
813.12 *4*	0.15 *7*	881.01	1/2+,3/2+,5/2+	67.890	5/2+
[x]834.85 *14*	0.23 *4*				
858.39 *5*	0.75 *17*	858.57	3/2+	0.0	3/2−
933.08[e] *6*	1.2[e] *3*	1079.36	1/2−	146.324	5/2−
933.08[ea] *6*	1.2[e] *3*	1160.52	5/2+	227.438	7/2−
951.1 *3*	0.29 *9*	1001.65	3/2+	50.624	5/2−
963.85[ea] *10*	1.20[e] *11*	1082.54	3/2−	118.75	7/2+
963.85[ea] *10*	1.20[e] *11*	1110.17	3/2−	146.324	5/2−
974.72 *6*	0.45 *28*	974.366	1/2+	0.0	3/2−
[x]1000.51 *11*	0.82 *11*				
1001.61 *19*	0.66 *10*	1001.65	3/2+	0.0	3/2−
1015.02[a] *14*	0.65 *8*	1082.54	3/2−	67.890	5/2+
1028.62 *11*	1.13 *9*	1079.36	1/2−	50.624	5/2−
1061.63 *11*	1.64 *9*	1061.63	1/2−	0.0	3/2−
1078.57 *8*	1.00 *15*	1129.07	3/2+	50.624	5/2−
1082.37[a] *15*	0.49 *8*	1082.54	3/2−	0.0	3/2−
1095.18 *8*	0.84 *14*	1145.61	3/2−	50.624	5/2−
[x]1121.4 *5*	0.45 *9*				
1128.47 *17*	1.16 *6*	1129.07	3/2+	0.0	3/2−
1139.90 *8*	1.93 *15*	1139.85	1/2−	0.0	3/2−
3647[†]	0.18[@]	(5943.21)	1/2+	2296	
3746[†]	0.17[@]	(5943.21)	1/2+	2197	
3785[†]	0.22[@]	(5943.21)	1/2+	2158	
3951[†]	0.20[@]	(5943.21)	1/2+	1992	
3962[†]	0.11[@]	(5943.21)	1/2+	1981	
4045[†]	0.49[@]	(5943.21)	1/2+	1898	
4102[†]	0.27[@]	(5943.21)	1/2+	1841	
4221[†]	0.21[@]	(5943.21)	1/2+	1722	
4305[†]	0.23[@]	(5943.21)	1/2+	1638	
4334[†]	0.15[@]	(5943.21)	1/2+	1609	
4384[†]	0.20[@]	(5943.21)	1/2+	1559	
4511[†]	0.07[@]	(5943.21)	1/2+	1432	
4553[†]	0.09[@]	(5943.21)	1/2+	1390	
4606[†#g]	0.12[@]	(5943.21)	1/2+	1337	
4659[†]	0.17[@]	(5943.21)	1/2+	1284	
4802[†]	1.2[@]	(5943.21)	1/2+	1139.85	1/2−
4815[†]	0.26[@]	(5943.21)	1/2+	1129.07	3/2+
4834[†]	0.19[@]	(5943.21)	1/2+	1110.17	3/2−

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^{158}Gd(n,γ) E=thermal 2004Gr26,1971Gr42 (continued)

γ(^{159}Gd) (continued)

E_γ[&]	I_γ[bc]	E_i(level)	J_i^π	E_f	J_f^π	E_γ[&]	I_γ[bc]	E_i(level)	J_i^π	E_f	J_f^π
4865[†]	0.53[@]	(5943.21)	1/2+	1079.36	1/2−	5268[†#g]	<0.23[@]	(5943.21)	1/2+	675?	
4899[†#g]	0.10[@]	(5943.21)	1/2+	1044?		5306[†#g]	0.19[@]	(5943.21)	1/2+	637?	
4968[†]	0.14[@]	(5943.21)	1/2+	974.366	1/2+	5345[†]	0.30[@]	(5943.21)	1/2+	601.976	3/2+
4983[†#]	0.21[@]	(5943.21)	1/2+	960		5385[†]	0.86[@]	(5943.21)	1/2+	558.213	3/2−
5161[†]	0.16[@]	(5943.21)	1/2+	781.573	1/2+	5434[†]	1.6[@]	(5943.21)	1/2+	507.739	1/2−
5199[†]	0.24[@]	(5943.21)	1/2+	744.386	3/2+	5477[†#g]	0.20[@]	(5943.21)	1/2+	466?	
5259[†#g]	0.13[@]	(5943.21)	1/2+	684?		5942[†]	4.5[@]	(5943.21)	1/2+	0.0	3/2−

[†] From a general statement in 1971Gr42, the uncertainties are 1 keV for γ's with Iγ > 0.2 and 2 keV otherwise.
[‡] Doublet structure resolved using the ultrahigh-resolution double-flat-crystal spectrometer GAMS4.
[#] The final state implied by this placement is not observed in any of the other studies. The evaluator has thus assumed that this transition/placement is questionable.
[@] Iγ values in photons per 100 n-captures given by 1971Gr42, but taken from other sources.
[&] Energy calibration was carried out using several precisely known E_γ values from the ^{155}Gd(n,γ) reaction measured using the ultrahigh-resolution double-flat-crystal spectrometer GAMS4 (1993Kl03).
[a] There exist discrepancies in some aspects of the listing of this γ in the table of secondary γ's from (n,γ) (the authors' Table I) and the authors' summary of the γ-decay properties of the ^{159}Gd levels (their Table V). These discrepancies have been resolved by means of private communications between the first author of 2004Gr26 and the evaluator of the XUNDL data set. The information given here incorporates this resolution.
[b] Values corrected for absorption in the target material and internal conversion. Intensity scale normalized to the absolute intensity, previously measured in n-capture in isolated resonances (2000Po07), of the 601.969γ.
[c] Intensity per 100 neutron captures.
[d] Multiply placed.
[e] Multiply placed with undivided intensity.
[f] Multiply placed with intensity suitably divided.
[g] Placement of transition in the level scheme is uncertain.
[x] γ ray not placed in level scheme.

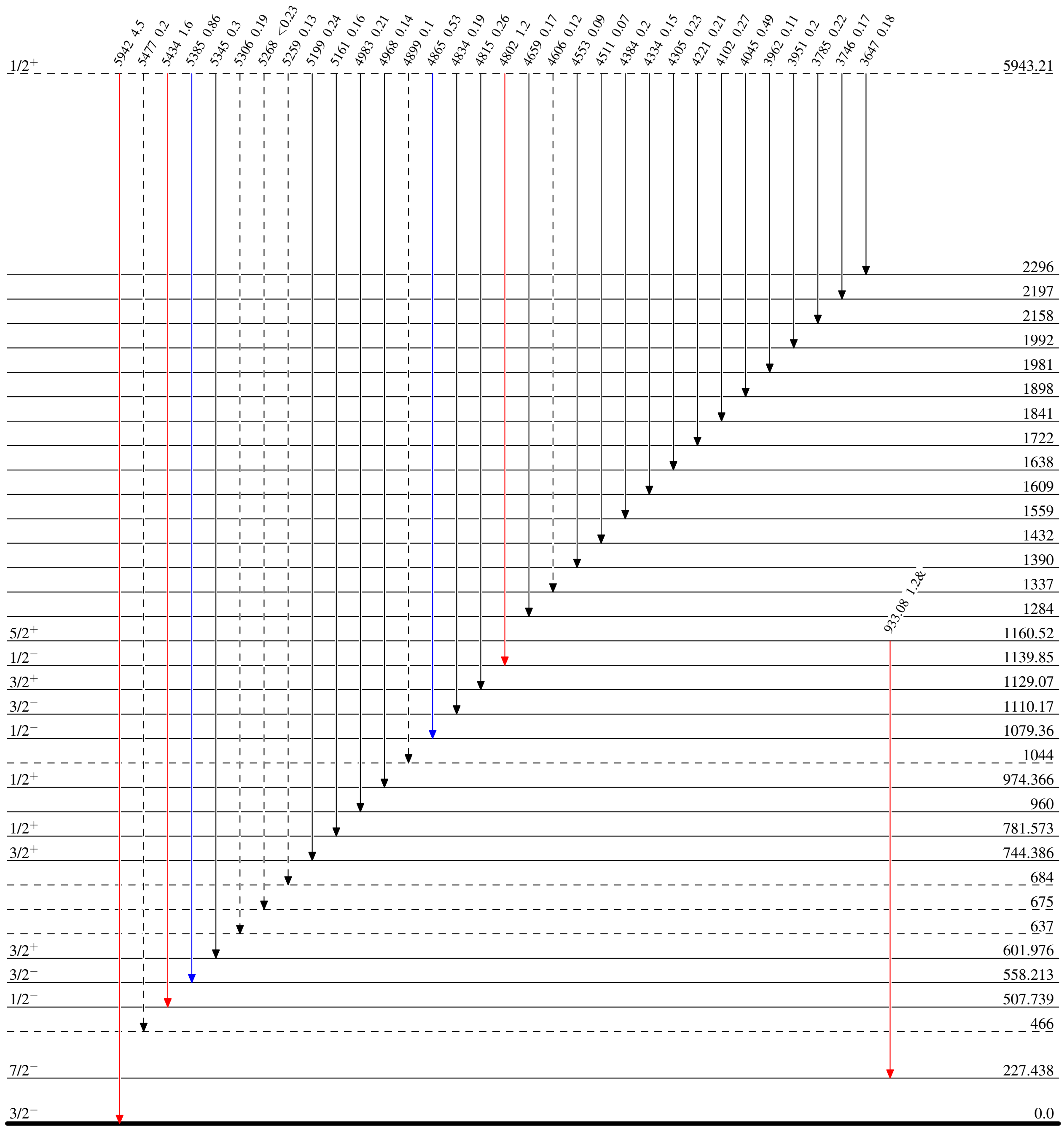
$^{158}Gd(n,\gamma)$ E=thermal 2004Gr26,1971Gr42

Legend

Level Scheme

Intensities: Photons per 100 n-captures.
& Multiply placed: undivided intensity given

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

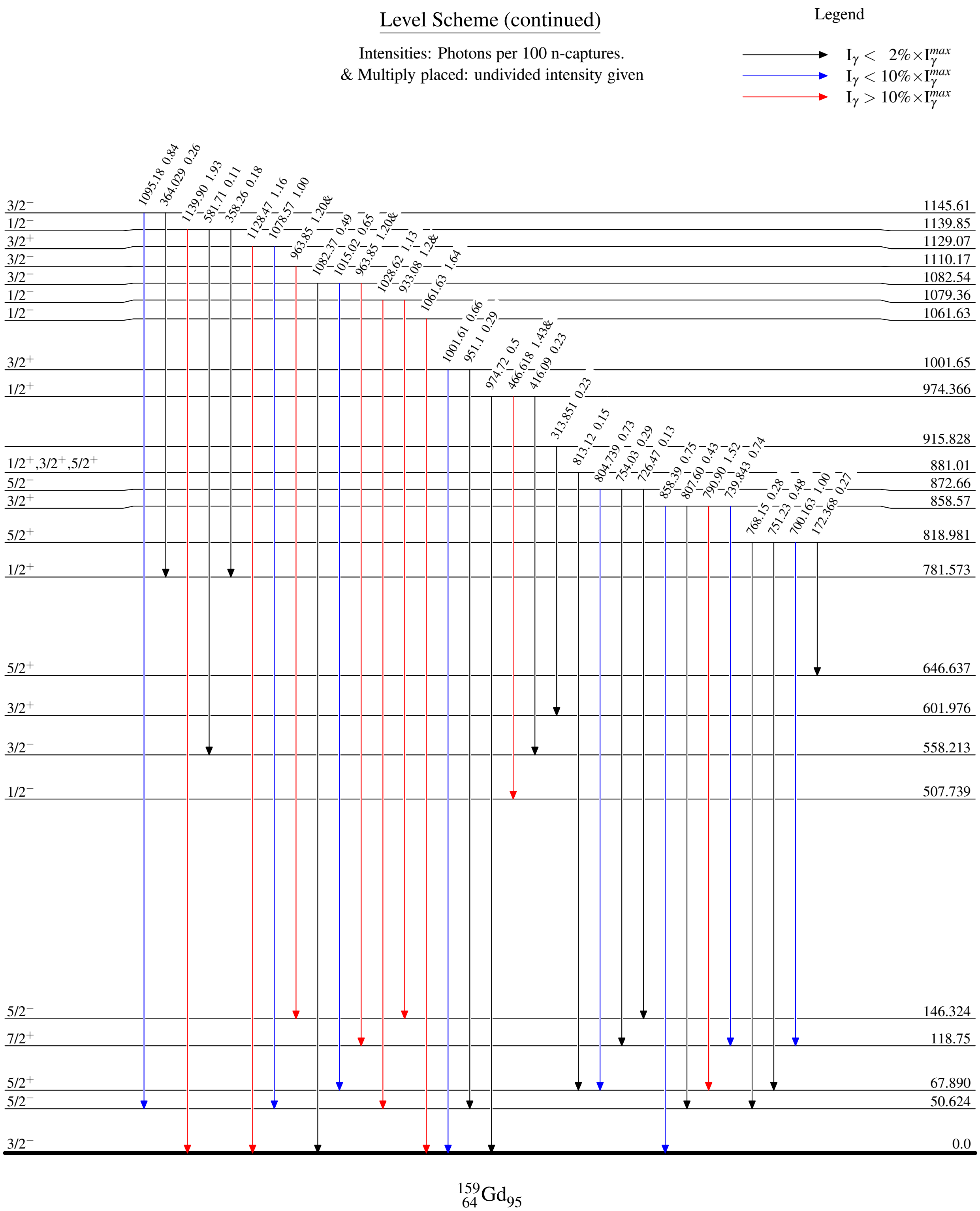


$^{159}_{64}Gd_{95}$

^{158}Gd(n,γ) E=thermal 2004Gr26,1971Gr42

Level Scheme (continued)

Intensities: Photons per 100 n-captures.
& Multiply placed: undivided intensity given



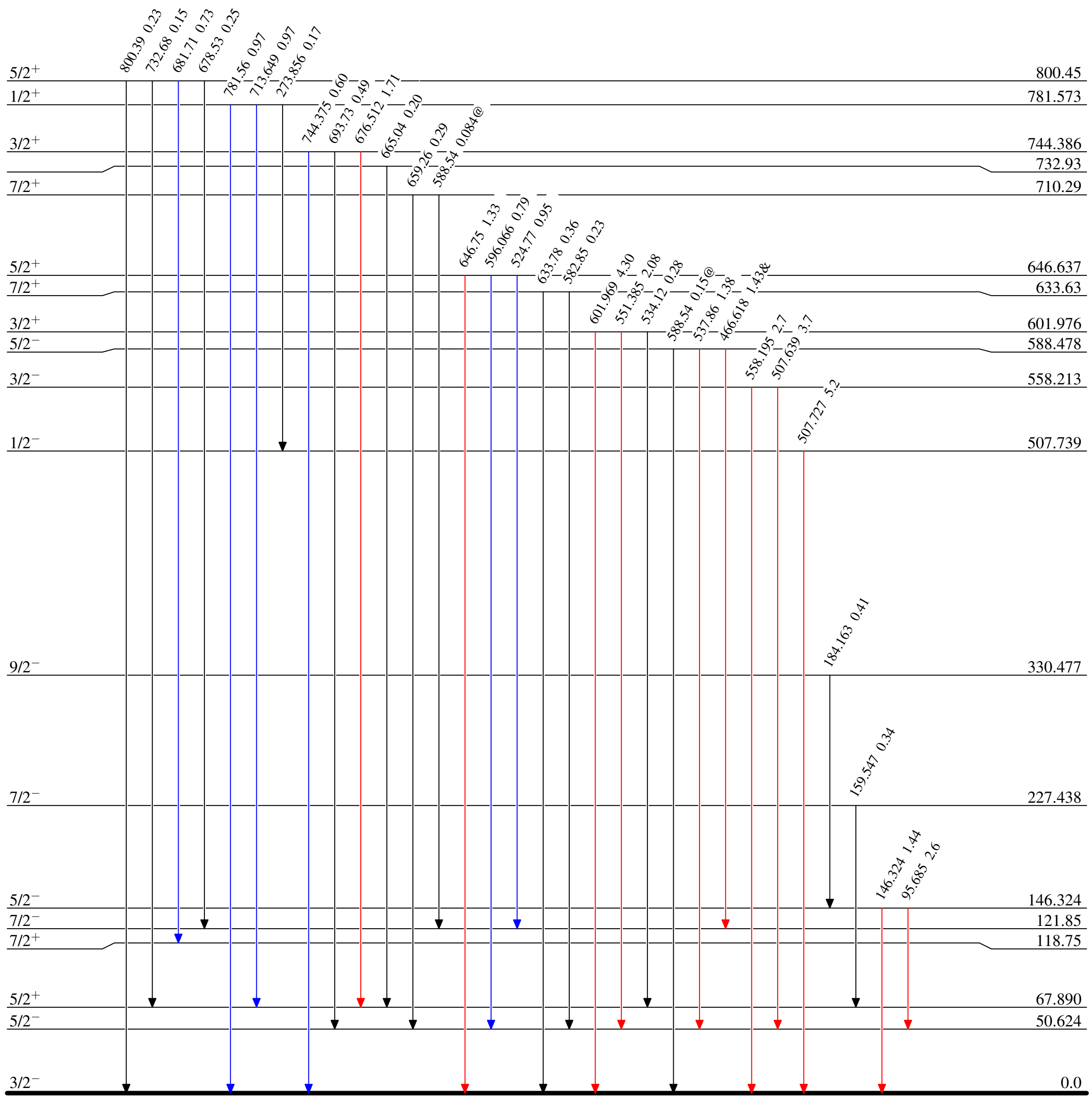
^{158}Gd(n,γ) E=thermal 2004Gr26,1971Gr42

Level Scheme (continued)

Intensities: Photons per 100 n-captures.
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided

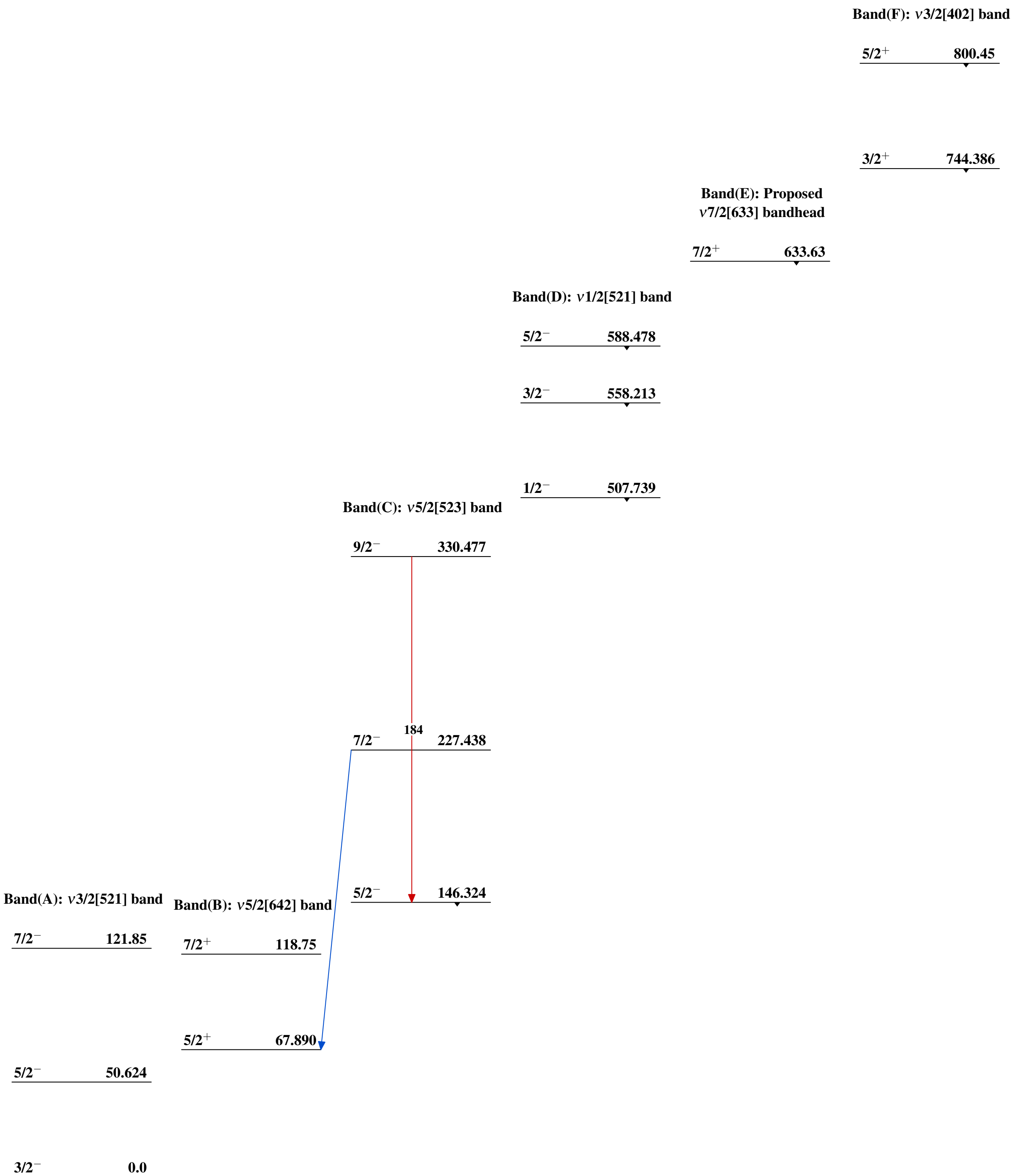
Legend

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



$^{159}_{64}Gd_{95}$

^{158}Gd(n,γ) E=thermal 2004Gr26,1971Gr42



$^{159}_{64}Gd_{95}$

^{158}Gd(n,γ) E=thermal 2004Gr26,1971Gr42 (continued)