(HI,xnγ)

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

Additional information 1.

Experimental articles:

1981La24: ^{148}Sm(^{14}N,3nγ) at 68 MeV, γγ(θ) with an array of 5 Ge and 6 NaI(Tl) detectors. Report 22 negative-parity levels to 49/2$^-$. See 1984La11 by same first author.

1983Ho10: ^{141}Pr(^{22}Ne,4nγ) at 120 MeV, γγ(θ) with an array of 4 Ge and 6 NaI(Tl) detectors. Report 28 negative-parity and 11 positive-parity levels.

1983LaZP: ^{148}Sm(^{14}N,3nγ) at 68 MeV and ^{141}Pr(^{22}Ne,4nγ) at 113 MeV, γγ(θ) with an array of 7 Ge and 2 NaI(Tl) detectors. Lab report, see 1984La11 by same first author.

1984La11: ^{148}Sm(^{14}N,3nγ) and ^{141}Pr(^{22}Ne,4nγ), γγ(θ) with an array of 7 Ge and 2 NaI(Tl) detectors. Report 28 negative-parity and 19 positive-parity levels.

1985An09: ^{150}Sm(^{14}N,5nγ) at 86 MeV, γγ(t) with 3 Ge detectors. Report 20 negative-parity and 12 positive-parity levels.

1985Ho04: ^{141}Pr(^{22}Ne,4nγ) at 110-120 MeV, γγ(θ) with 4 Ge and 1 NaI(Tl) detectors. Same first author as 1983Ho10 and report same negative-parity levels as 1983Ho10.

1987Ga09: ^{128}Te(^{35}Cl,4nγ) at 150 MeV, level lifetimes by recoil-distance method. Report 33 lifetimes and 2 limits.

1989RaZW: ^{126}Te(^{37}Cl,4nγ) at 160 MeV, γγ measured in 8π array. Lab progress report, no results.

Level structure near the ground state is from 1985An09, which differs from placements in earlier references. At higher energies, the structure is from 1983Ho10 for the negative-parity levels and 1984La11 for the positive-parity levels.

^{159}Tm Levels

E(level)†	Jπ‡	$T_{1/2}$#	Comments
0@	5/2(+)		
52.9& 7	7/2(+)		E(level): From energies of 166 and 113 γ's (1985An09).
166.3b	7/2(−)	37 ns 5	$T_{1/2}$: From (HI,xnγ) by γγ(t) measurement (1985An09); see ^{159}Tm Adopted Levels for all measurements.
182.7c	9/2(−)		
232.5b	11/2(−)		E(level): 1985Ho04 and 1984La11 place the 166.3 γ depopulating this 11/2$^-$ level. However, 1985An09 conclude from their γγ coincidence and γ(t) results that the yrast band is based on the 7/2$^-$ level at 166 keV which the 166-keV γ depopulates. The evaluator has adopted this latter assignment. E(level): Energy determined by 1985An09 from the energy of the γ between the 25/2$^+$ level at 2374 keV and the 23/2$^-$ level at 1583 keV and the energies of the γ's depopulating the latter level.
246.3a	9/2(+)		
456.7&	11/2(+)	7.7 ps 23	
463.6c	13/2(−)	14.8 ps 11	
563.4b	15/2(−)	10.5 ps 5	
691.3a	13/2(+)	3 ps 3	
908.8c	17/2(−)	1.2 ps 4	
946.3&	15/2(+)	3.5 ps 7	
1025.1b	19/2(−)	2.6 ps 2	
1217.5a	17/2(+)	<3.5 ps	
1458.2c	21/2(−)	1.5 ps 3	
1507.0&	19/2(+)	0.7 ps 3	
1583.3b	23/2(−)	1.25 ps 14	
1800.8a	21/2(+)	0.6 ps 5	
2076.4c	25/2(−)	0.6 ps 5	
2110.0&	23/2(+)	0.76 ps 21	

Continued on next page (footnotes at end of table)

(HI,xnγ) (continued)

^{159}Tm Levels (continued)

E(level)[†]	Jπ[‡]	$T_{1/2}$[#]	E(level)[†]	Jπ[‡]	$T_{1/2}$[#]	E(level)[†]	Jπ[‡]	$T_{1/2}$[#]
2176.0	$23/2^{(+)}$		3158.7[a]	$33/2^{(+)}$	1.1 ps *5*	4742?[&]	$43/2^{(+)}$	
2212.8[b]	$27/2^{(-)}$	0.55 ps *21*	3348.6[b]	$35/2^{(-)}$	1.18 ps *21*	4778.7[c]	$45/2^{(-)}$	0.28 ps *14*
2374.4[a]	$25/2^{(+)}$	0.3 ps *3*	3402.4[&]	$35/2^{(+)}$	1.2 ps *3*	5144.0[b]	$47/2^{(-)}$	0.35 ps *14*
2422.9	$25/2^{(+)}$		3582.7[c]	$37/2^{(-)}$	1.1 ps *3*	5503.7[c]	$49/2^{(-)}$	0.2 ps *2*
2549.2[&]	$27/2^{(+)}$	9 ps *4*	3733.6[a]	$37/2^{(+)}$	0.35 ps *14*	5906.9[b]	$51/2^{(-)}$	
2703.5[a]	$29/2^{(+)}$	4.4 ps *17*	3859.2[b]	$39/2^{(-)}$	1.32 ps *21*	6302.7[c]	$53/2^{(-)}$	
2709.6[c]	$29/2^{(-)}$	0.4 ps *4*	4019.4[&]	$39/2^{(+)}$	0.42 ps *14*	6740.5[b]	$55/2^{(-)}$	
2862.3[b]	$31/2^{(-)}$	0.62 ps *21*	4135.2[c]	$41/2^{(-)}$	0.35 ps *14*	7172.2[c]	$57/2^{(-)}$	
2911.1[&]	$31/2^{(+)}$	5.1 ps *8*	4404.6[a]	$41/2^{(+)}$	<1.0 ps	7649.5[b]	$59/2^{(-)}$	
3139.9[c]	$33/2^{(-)}$	0.83 ps *21*	4458.8[b]	$43/2^{(-)}$	0.48 ps *14*	8132.2[c]	$61/2^{(-)}$	

[†] Since the γ transitions from the lowest levels do not have uncertainties on their energies, no uncertainties are calculated for the levels.
[‡] Assignments are those of the authors and are based on γγ(θ) measurements and the expected band structure.
[#] From 1987Ga09 by recoil-distance method, unless otherwise noted.
[@] Band(A): π5/2[402] bandhead.
[&] Band(B): π7/2[404] band, signature=−1/2 branch.
[a] Band(C): π7/2[404] band, signature=+1/2 branch.
[b] Band(D): π7/2[523] band, signature=−1/2 branch.
[c] Band(E): π7/2[523] band, signature=+1/2 branch.

(HI,xnγ) (continued)

γ(^{159}Tm)

E_i(level)	J_i^π	E_γ[†]	I_γ[‡]	E_f	J_f^π	Mult.[@]	δ[&]	α[a]	$I_{(\gamma+ce)}$[b]	Comments
166.3	7/2$^{(-)}$	113.4		52.9	7/2$^{(+)}$					E_γ: From 1985An09.
		166.31 *3*		0	5/2$^{(+)}$				79 *10*	
232.5	11/2$^{(-)}$	50.2		182.7	9/2$^{(-)}$					E_γ: γ observed and placed by 1985An09.
		66.2		166.3	7/2$^{(-)}$					E_γ: Eγ deduced from 232 and 166 level energies.
246.3	9/2$^{(+)}$	193.7		52.9	7/2$^{(+)}$	E2+M1				
456.7	11/2$^{(+)}$	210.3	25 *2*	246.3	9/2$^{(+)}$	E2+M1		0.30 *8*		
		403.9	65 *2*	52.9	7/2$^{(+)}$	E2		0.0302		
463.6	13/2$^{(-)}$	230.93 *3*	64 *1*	232.5	11/2$^{(-)}$	E2+M1	0.32 *2*	0.282 *5*	75 *6*	
		280.9 *2*	16.8 *10*	182.7	9/2$^{(-)}$	E2		0.0873	22.5 *17*	
563.4	15/2$^{(-)}$	99.9 *3*	10.5 *9*	463.6	13/2$^{(-)}$	E2+M1	<0.40	3.11 *6*	72 *15*	
		330.80 *3*	58 *4*	232.5	11/2$^{(-)}$	E2		0.0534	100	
691.3	13/2$^{(+)}$	234.2	12 *8*	456.7	11/2$^{(+)}$	E2+M1		0.22 *7*		
		445.2	83 *10*	246.3	9/2$^{(+)}$	E2		0.0232		
908.8	17/2$^{(-)}$	345.35 *4*	53 *3*	563.4	15/2$^{(-)}$	E2+M1	0.36 *3*	0.0935 *16*	31.6 *25*	
		445.15 *3*	41 *3*	463.6	13/2$^{(-)}$	E2		0.0232	40.6 *21*	I_γ: Includes contribution from ^{158}Er.
946.3	15/2$^{(+)}$	255.1	14 *2*	691.3	13/2$^{(+)}$	E2+M1		0.17 *6*		
		489.6	82 *2*	456.7	11/2$^{(+)}$	E2		0.0181		
1025.1	19/2$^{(-)}$	116.4 *2*	6.0 *8*	908.8	17/2$^{(-)}$	E2+M1	0.35 *25*	1.98 *6*	20 *5*	
		461.69 *3*	80.3 *24*	563.4	15/2$^{(-)}$	E2		0.0211	119.7 *22*	
1217.5	17/2$^{(+)}$	271.1	10 *4*	946.3	15/2$^{(+)}$	E2+M1		0.145		
		526.2	88 *5*	691.3	13/2$^{(+)}$	E2		0.01505		
1458.2	21/2$^{(-)}$	433.22 *5*	43 *2*	1025.1	19/2$^{(-)}$	E2+M1	0.23 *2*	0.0533	18.3 *18*	I_γ: Doublet, but only one placement given.
		549.43 *3*	54 *2*	908.8	17/2$^{(-)}$	E2		0.01351	23.3 *15*	
1507.0	19/2$^{(+)}$	289.5	37 *1*	1217.5	17/2$^{(+)}$	E2+M1		0.12 *4*		
		560.5	58 *1*	946.3	15/2$^{(+)}$	E2		0.01286		
1583.3	23/2$^{(-)}$	125.0[d] *1*	3.0 *17*	1458.2	21/2$^{(-)}$	E2+M1	<0.10	1.637 *24*	<15	
		558.26 *3*	91 *5*	1025.1	19/2$^{(-)}$	E2		0.01299	120 *7*	
1800.8	21/2$^{(+)}$	293.7	8.1 *18*	1507.0	19/2$^{(+)}$	E2+M1		0.11 *4*		
		583.5	90 *2*	1217.5	17/2$^{(+)}$	E2		0.01166		
2076.4	25/2$^{(-)}$	493.3 *2*	42 *4*	1583.3	23/2$^{(-)}$	E2+M1	0.34 *7*	0.0369 *10*	21.5 *24*	
		618.2 *1*	55 *4*	1458.2	21/2$^{(-)}$	E2		0.01015	27 *4*	
2110.0	23/2$^{(+)}$	309.2	11 *2*	1800.8	21/2$^{(+)}$	E2+M1		0.10 *4*		
		603.1	87 *2*	1507.0	19/2$^{(+)}$	E2		0.01077		
2176.0	23/2$^{(+)}$	717.4		1458.2	21/2$^{(-)}$					
2212.8	27/2$^{(-)}$	136.3	3.0 *8*	2076.4	25/2$^{(-)}$	[M1+E2]		1.13 *16*	<5	E_γ: From 1983Ho10, where placement is questionable, but also reported by 1984La11 and 1985An09 with this placement. I_γ: Not seen by 1985Ho04, but intensity limit given.
		629.44 *3*	92.7 *17*	1583.3	23/2$^{(-)}$	E2		0.00973	90 *6*	

$^{159}_{69}Tm_{90}$-3

(HI,xnγ) (continued)

γ(^{159}Tm) (continued)

E_i(level)	J_i^π	E_γ [†]	I_γ [‡]	E_f	J_f^π	Mult. [@]	δ [&]	α [a]	$I_{(\gamma+ce)}$ [b]	Comments
2374.4	25/2(+)	198.3	13 *7*	2176.0	23/2(+)	[M1+E2]		0.36 *9*		
		264.3	23 *13*	2110.0	23/2(+)	E2+M1		0.15 *5*		
		573.5	21 *10*	1800.8	21/2(+)	E2		0.01216		
		791.0	34 *20*	1583.3	23/2(−)	[E1]		0.00224		
2422.9	25/2(+)	313.0		2110.0	23/2(+)	E2+M1				
		622.1		1800.8	21/2(+)	E2				
		839.7		1583.3	23/2(−)					
2549.2	27/2(+)	125.9		2422.9	25/2(+)	E2+M1		1.45 *16*		
		174.7	26 *11*	2374.4	25/2(+)	E2+M1		0.52 *12*		
		373.0	32 *15*	2176.0	23/2(+)	E2		0.0377		
		439.5	27 *15*	2110.0	23/2(+)	E2		0.0240		
2703.5	29/2(+)	154.3		2549.2	27/2(+)	E2+M1		0.77 *14*		
		280.5		2422.9	25/2(+)	E2		0.0877		
		329.2	36 *10*	2374.4	25/2(+)	E2				
2709.6	29/2(−)	496.9 *1*	31 *4*	2212.8	27/2(−)	E2+M1	0.25 *8*	0.0372 *10*	10.2 *16*	δ: Quoted in 1987Ga09 from other references. Other: < 0.20 (1985Ho04).
		633.3 *1*	68 *4*	2076.4	25/2(−)	E2		0.00959	20 *3*	
2862.3	31/2(−)	152.71 *6*	7.2 *30*	2709.6	29/2(−)	E2+M1	<0.20	0.924 *14*	49 *12*	I_γ: Doublet, but only one placement given.
		649.51 *3*	85 *6*	2212.8	27/2(−)	E2		0.00904	58 *3*	
2911.1	31/2(+)	206.5	52 *11*	2703.5	29/2(+)	E2+M1		0.32 *9*		
		361.0	31 *14*	2549.2	27/2(+)	E2		0.0414		
3139.9	33/2(−)	277.5 *1*	64 *4*	2862.3	31/2(−)	E2+M1	<0.10	0.178 *3*	48 *6*	
		430.3 *1*	24 *5*	2709.6	29/2(−)	E2		0.0254	10.6 *15*	I_γ: Includes contribution from ^{158}Tm.
3158.7	33/2(+)	247.6	39 *3*	2911.1	31/2(+)	E2+M1		0.19 *6*		
		454.3	53 *4*	2703.5	29/2(+)	E2		0.0220		
3348.6	35/2(−)	208.78 *5*	40 *3*	3139.9	33/2(−)	E2+M1	0.13 *2*	0.386	62 *10*	I_γ: Includes contribution from ^{159}Er.
		486.32 *4*	43 *4*	2862.3	31/2(−)	E2		0.0184	25.3 *14*	
3402.4	35/2(+)	243.9	36 *3*	3158.7	33/2(+)	E2+M1		0.19 *6*		
		491.3	56 *3*	2911.1	31/2(+)	E2		0.0179		
3582.7	37/2(−)	234.2 *1*	56 *3*	3348.6	35/2(−)	E2+M1	0.08 *2*	0.283	46 *6*	
		442.82 *5*	28 *3*	3139.9	33/2(−)	E2		0.0235	15.1 *25*	I_γ: Includes contribution from ^{158}Er.
3733.6	37/2(+)	331	42 *9*	3402.4	35/2(+)	E2+M1		0.08 *3*		
		575	54 *10*	3158.7	33/2(+)	E2		0.01208		
3859.2	39/2(−)	276.1 [c] *2*	35 [c] *7*	3582.7	37/2(−)	E2+M1		0.14 *5*	15 *5*	
		510.6 *3*	59 *8*	3348.6	35/2(−)	E2		0.01624	22 *3*	I_γ: Includes contribution from ^{158}Er.
4019.4	39/2(+)	285 [d]		3733.6	37/2(+)					
		616.0	69 *30*	3402.4	35/2(+)	E2		0.01024		
4135.2	41/2(−)	276.1 [c] *2*	32 [c] *7*	3859.2	39/2(−)	E2+M1	<0.10	0.181	15 *5*	
		552.5 *1*	61 *8*	3582.7	37/2(−)	E2		0.01333	24.6 *24*	

$^{159}_{69}Tm_{90}$-4

(HI,xnγ) (continued)

γ(^{159}Tm) (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[‡]	E_f	J_f^π	Mult.[@]	δ[&]	α[a]	$I_{(\gamma+ce)}$[b]	Comments
4404.6	41/2$^{(+)}$	385[d]		4019.4	39/2$^{(+)}$					
		671	69 *30*	3733.6	37/2$^{(+)}$	E2		0.00838		
4458.8	43/2$^{(-)}$	323.7 *1*	45 *3*	4135.2	41/2$^{(-)}$	E2+M1	<0.20	0.1170 *21*	14 *4*	δ: Other: 0.025 *25* (quoted in 1987Ga09).
		599.5 *1*	49 *4*	3859.2	39/2$^{(-)}$	E2		0.01093	19.7 *16*	
4742?	43/2$^{(+)}$	722[d]		4019.4	39/2$^{(+)}$					
4778.7	45/2$^{(-)}$	319.8 *2*	35 *2*	4458.8	43/2$^{(-)}$	E2+M1	0.08 *4*	0.1217 *18*	9 *4*	δ: Other: 0.025 *35* (quoted in 1987Ga09).
		643.6 *2*	61 *2*	4135.2	41/2$^{(-)}$	E2		0.00924	13.8 *18*	
5144.0	47/2$^{(-)}$	365.3 *2*	38 *3*	4778.7	45/2$^{(-)}$	E2+M1	<0.20	0.0849	10.7 *24*	δ: Other: 0.025 *25* (quoted in 1987Ga09).
		685.3 *1*	58 *3*	4458.8	43/2$^{(-)}$	E2		0.00799	6.5 *10*	
5503.7	49/2$^{(-)}$	359.9 *3*	29 *3*	5144.0	47/2$^{(-)}$	E2+M1	0.2 *1*	0.0874 *25*	6.0 *21*	
		724.6 *3*	68 *3*	4778.7	45/2$^{(-)}$	E2		0.00704	15.2 *20*	
5906.9	51/2$^{(-)}$	403.2 *3*	51[#] *13*	5503.7	49/2$^{(-)}$	E2+M1	0.17 *7*	0.0651 *14*	7.4 *20*	
		763.2 *5*	49[#] *7*	5144.0	47/2$^{(-)}$	E2		0.00627	6.7 *10*	
6302.7	53/2$^{(-)}$	395.9 *4*	28[#] *15*	5906.9	51/2$^{(-)}$	E2+M1	<0.20	0.0687 *13*	3.0 *16*	
		799.0 *3*	72[#] *20*	5503.7	49/2$^{(-)}$	E2		0.00567	7.3 *20*	
6740.5	55/2$^{(-)}$	438 *1*	46[#] *17*	6302.7	53/2$^{(-)}$	E2+M1		0.039 *15*	4.6 *15*	
		833.5 *6*	54[#] *21*	5906.9	51/2$^{(-)}$	E2		0.00517	5.1 *20*	
7172.2	57/2$^{(-)}$	432 *1*	<39[#]	6740.5	55/2$^{(-)}$	E2+M1		0.040 *15*	<2	I_γ: Doublet, but only one placement given.
		869.4 *5*	>61[#]	6302.7	53/2$^{(-)}$	E2		0.00473	3.1 *15*	
7649.5	59/2$^{(-)}$	909[d] *1*	100	6740.5	55/2$^{(-)}$	E2			<3	
8132.2	61/2$^{(-)}$	960 *1*	100	7172.2	57/2$^{(-)}$	E2			3.3 *15*	

[†] From 1983Ho10 for the γ′s from the negative-parity levels, except as noted, and from a combination of 1984La11, 1985An09, and 1987Ga09 from the positive-parity levels. The values of 1983Ho10 are repeated in 1985Ho04 and some of those in 1987Ga09 are the same as those in 1984La11. The values in 1983Ho10 have uncertainties; the others do not. Other: 1981La24.

[‡] Relative photon branching (in photons per 100 decays of the decaying level) from 1987Ga09. Unless noted otherwise, these values have been deduced by the evaluator from the branching ratios given by 1987Ga09, which include the contribution from internal conversion. For most levels in the negative-parity band, the values of 1987Ga09 result from averaging previous data, including those of 1985Ho04, as well as some unpublished results.

[#] Computed by the evaluator from the I(γ+ce) values of 1985Ho04 and the listed α values.

[@] Assigned by evaluator from general statements of 1984La11 based on γ(θ) and γγ(θ) measurements and A_2, A_4 values from γ(θ) of 1985Ho04. The evaluator has assumed that all D+Q mixtures are M1+E2 mixtures and all Q represent E2′s rather than M2′s.

[&] From 1985Ho04.

[a] Values are listed for those transitions where this information was needed to extract photon intensities from the reported transition (i.e., Iγ+Ice) intensities.

[b] From 1985Ho04 for ^{141}Pr(^{22}Ne,4nγ) at 120 MeV. In some instances, the relative branching (after removal of the effect of internal conversion) from individual levels implied by these data differs somewhat from those of 1987Ga09.

$^{159}_{69}Tm_{90}$-5

(HI,xnγ) (continued)

$\gamma(^{159}\mathrm{Tm})$ (continued)

[c] Multiply placed with undivided intensity.
[d] Placement of transition in the level scheme is uncertain.

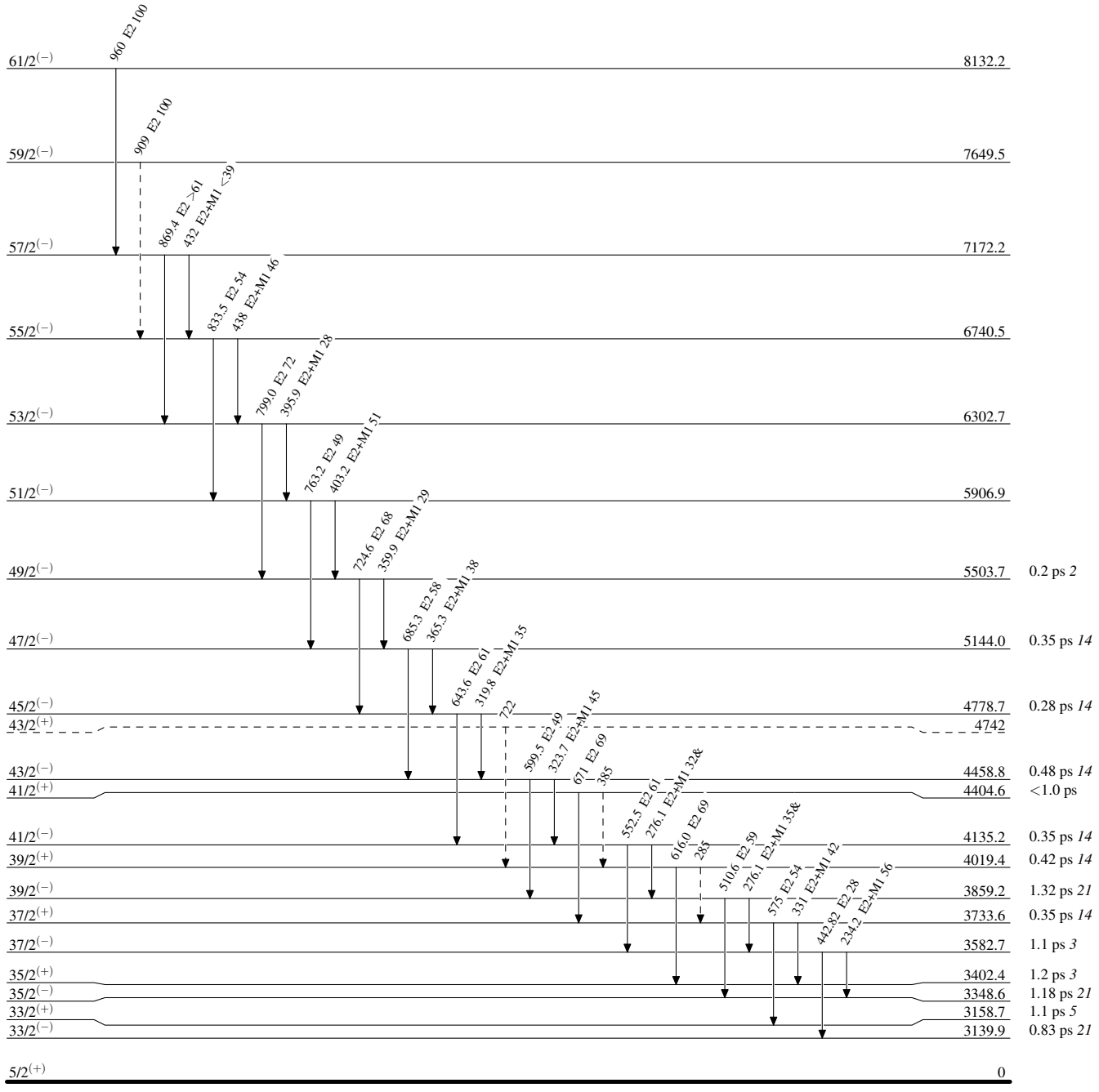
(HI,xnγ)

Legend

Level Scheme

Intensities: % photon branching from each level
& Multiply placed: undivided intensity given

- - - - - - ► γ Decay (Uncertain)

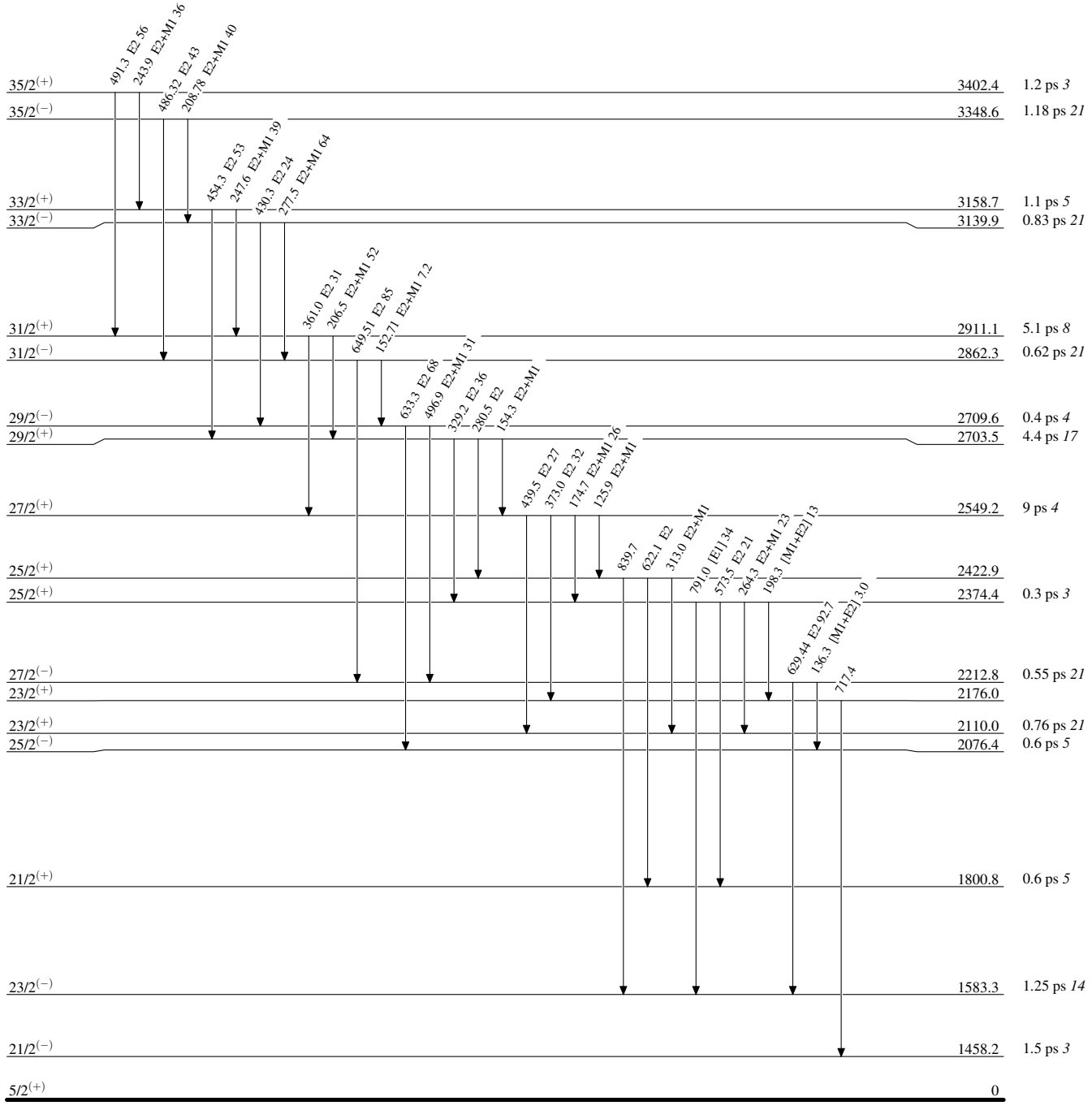


$^{159}_{69}Tm_{90}$

(HI,xnγ)

Level Scheme (continued)

Intensities: % photon branching from each level
& Multiply placed: undivided intensity given



$^{159}_{69}Tm_{90}$

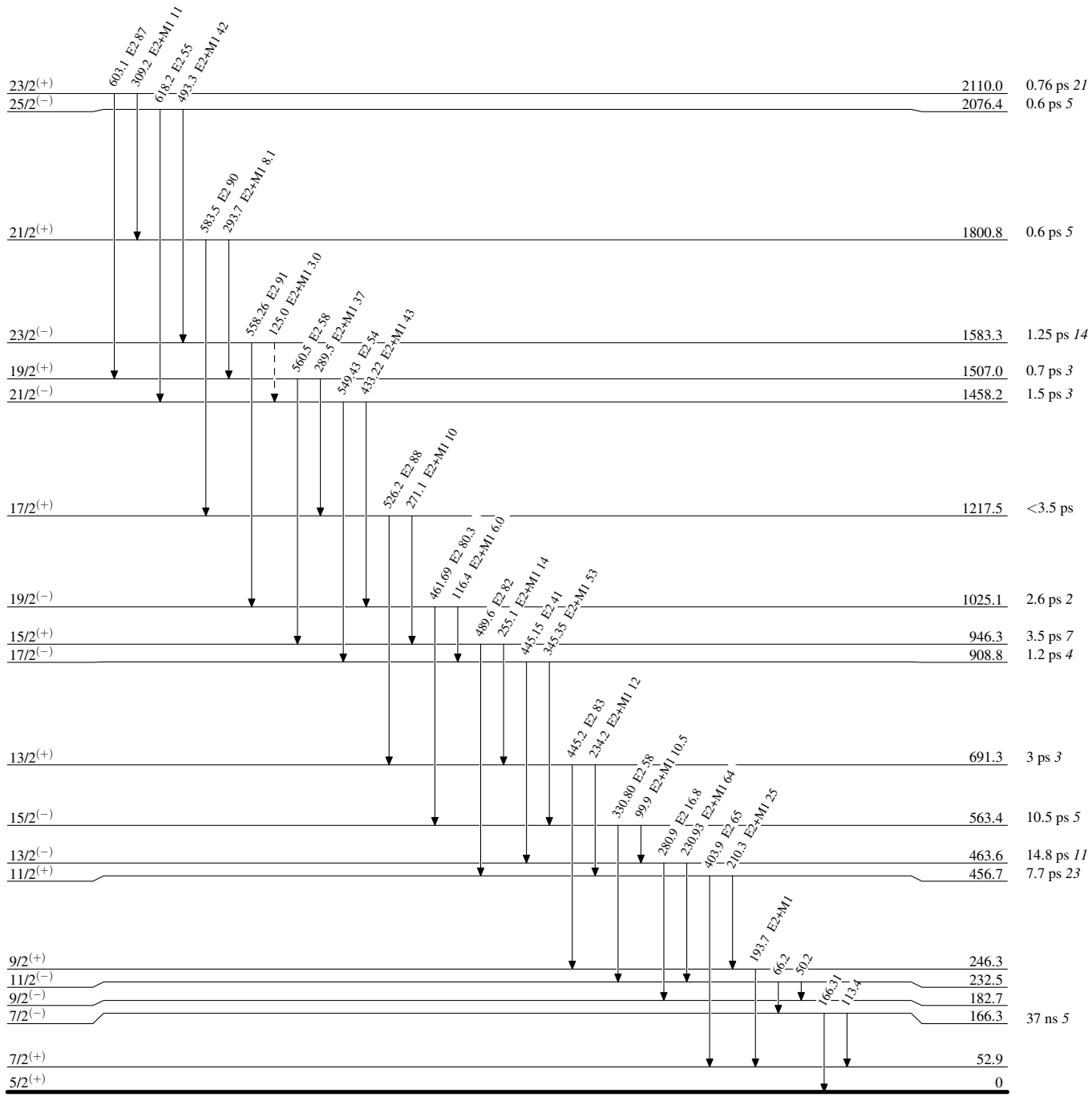
(HI,xnγ)

Legend

Level Scheme (continued)

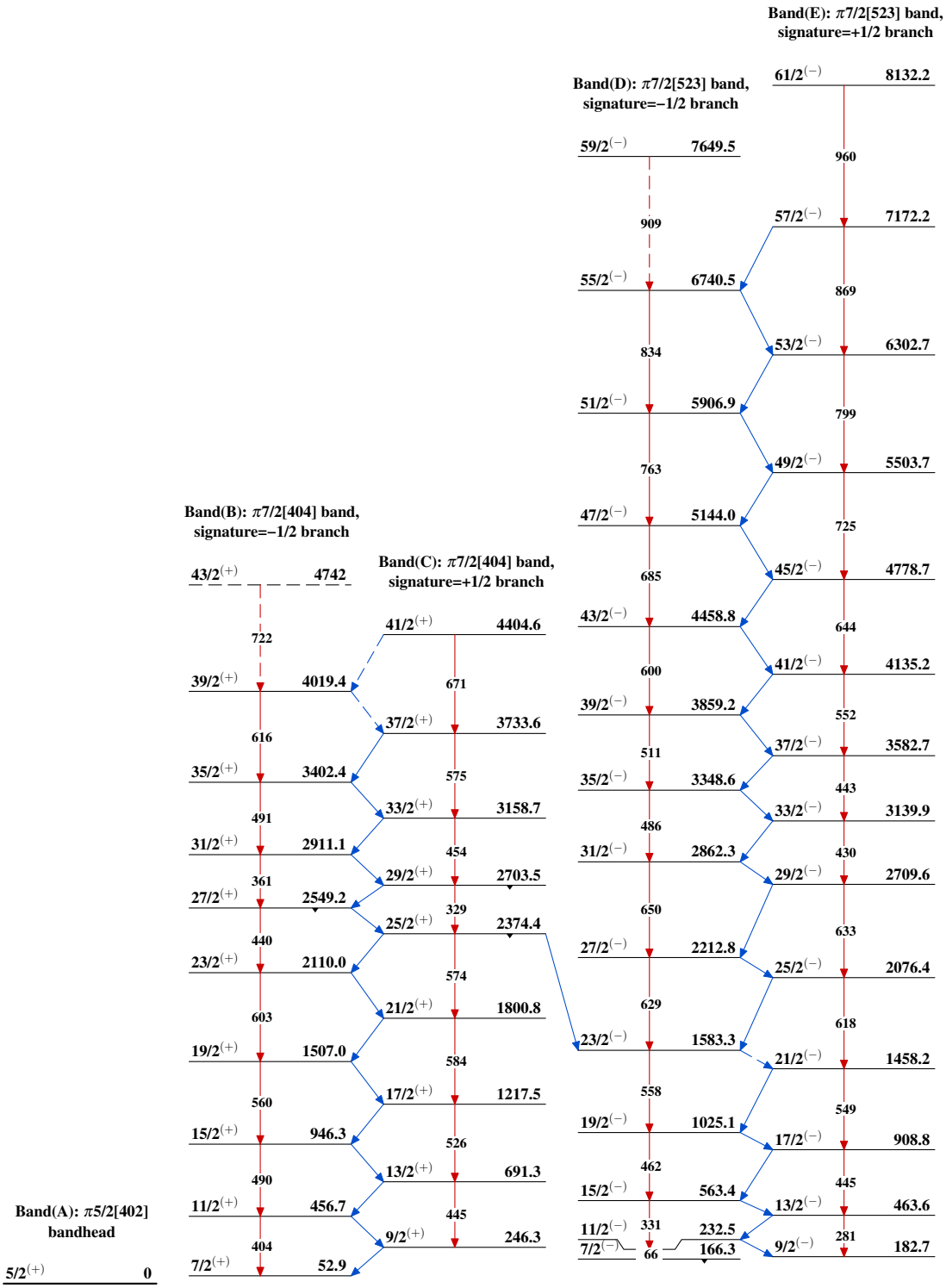
Intensities: % photon branching from each level
& Multiply placed: undivided intensity given

– – – – – – ► γ Decay (Uncertain)



$^{159}_{69}Tm_{90}$

(HI,xnγ)



$^{159}_{69}Tm_{90}$