(HI,xnγ) 2008Su08,1989An08,1986Dr06

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

Additional information 1.
Inludes the reactions: ^{128}Te(^{37}Cl,5nγ), ^{130}Re(^{35}Cl,5nγ), ^{146}Nd(^{19}F,5nγ), ^{152}Sm(^{14}N,6nγ).
XUNDL compilations: 2008Su08 and 2008Te07, compiled by S. Geraedts and B. Singh (McMaster); 2005La32 compiled by B. Singh (McMaster).
2008Su08, 2008Lu17: ^{146}Nd(^{19}F,5nγ), E(^{19}F)=102 MeV; beam provided by the HI-13 tandem accelerator at CIAE. Measured Eγ, Iγ, γγ-coin, DCO ratios using twelve HPGe detectors.
2008Te07: ^{128}Te(^{37}Cl,5nγ), E(^{37}Cl)=170 MeV beam provided by ATLAS facility at Argonne. Measured Eγ, Iγ, γγ using GAMMASPHERE array. Comparisons with cranked-shell model calculations.
2005La32: ^{130}Re(^{35}Cl,5nγ) E(^{35}Cl)=170 MeV. Measured Eγ, Iγ, γγ using Euroball detector array and an inner BGO ball.
1990TeZX: ^{128}Te(^{37}Cl,5n), E(^{37}Cl)=170 MeV. Unbacked targets were used. γ-ray coincidences were recorded using the TESSA 3 array of 16 escape-suppressed Ge detectors and the 50-element BGO inner ball. The four previously identified band sequences were extended to higher spins.
1989An08: ^{128}Te(^{37}Cl,5n), E(^{37}Cl)=167 MeV. Enriched (98% ^{128}Te) Pb-backed metallic target. Four coaxial Ge detectors and a multiplicity filter of 12 NaI(Tl) detectors. Measured Eγ, γγ, γγ(t), γ(θ).
1986Dr06: ^{152}Sm(^{14}N,6n), E(^{14}N)=80,96,107,120 MeV. Enriched (98% ^{152}Sm) targets. A variety of Ge and Ge(Li) detectors was used. Measured Eγ, γγ, γ(t), γγ(t), γ(θ) at θ=18,35,55,70,90°. From A_2 and A_4 values (measured but not given), authors identify stretched E2 and dipole (plus quadrupole) transitions.
2001Kv02 discuss signature inversion in ^{160}Tm and ^{162}Tm using a two-quasiparticle-phonon model. For a discussion of the systematic features of signature inversion in the (π $h_{11/2}$)(ν $i_{13/2}$) bands in nuclides in the mass region A≈160, see 2001Ri19. For other discussions, including theoretical calculations, see 1995Li40, 1997Zh13, 2000Xu01, 2001Zh16 and 2003Ya19.
The level scheme is from 2008Su08 and 2008Te07 (same group) who connected the first six bands to the g.s. (which in the previous papers were not connected − so called hanging bands).

^{160}Tm Levels

E(level)[d]	Jπ[†]	$T_{1/2}$[e]	Comments
0.0	1⁻	9.4 min *3*	Jπ: adopted value.
42.0 *10*	(2⁻)		
70.9 *15*	(5)	74.5 s *15*	
124.4 *16*	(6)		
150.8 *16*	(6)		
157.2 *16*	(6)		
169.2 *16*	(6)		
244.6[&] *19*	(7⁺)		A level previously adopted by 2005Re18 (from 1989An08) of energy 76.0+Y (with Y undetermined), with J=7⁺, and decaying by a 76.0γ could tentatively be associated with this level, which is also decaying by a close-lying 76.0γ.
245.3 *16*	(7)		
262.1 *16*	(7)		
342.4[@] *20*	(8⁺)		A level previously adopted by 2005Re18 (from 1989An08) of energy 98.2+X (with X undetermined), with J=(8), $T_{1/2}$ ≈ 200 ns (from γγ(t) in 1986Dr06)), and decaying by a 98.2γ could tentatively be associated with this level, which is also decaying by a close-lying 97.9γ (however the feeding patterns of 98.2+X and this level are different).
390.9 *16*	(8⁻)		
444.4[#] *17*	(9⁻)		
484.5[&] *21*	(9⁺)		
523.6[‡] *17*	(10⁻)		
606.9[#] *18*	(11⁻)		
655.0[@] *21*	(10⁺)		
783.6[‡] *18*	(12⁻)		

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(HI,xnγ) 2008Su08,1989An08,1986Dr06 (continued)

^{160}Tm Levels (continued)

E(level)[d]	Jπ[†]
865.3[&] *21*	(11+)
936.5[#] *19*	(13−)
1094.1[@] *21*	(12+)
1182.2[‡] *19*	(14−)
1358.6[&] *21*	(13+)
1406.1[#] *19*	(15−)
1632.0[@] *21*	(14+)
1696.2[‡] *20*	(16−)
1796.5 *23*	(14+)
1938.4[&] *21*	(15+)
1985.6[#] *20*	(17−)
2054.8 *23*	(15+)
2242.7[@] *21*	(16+)
2302.8[‡] *20*	(18−)
2320.5 *22*	(16+)
2499.0[b] *21*	(18−)
2570.4[&] *21*	(17+)
2616.6 *22*	(17+)
2647.2[#] *20*	(19−)
2689.7[a] *21*	(19−)
2814.1[@] *22*	(18+)
2909.4[b] *20*	(20−)
2909.7 *21*	(18+)
2977.4[‡] *21*	(20−)
3051.5[&] *22*	(19+)
3160.8[a] *20*	(21−)
3314.1[@] *23*	(20+)
3358.2[#] *21*	(21−)
3413.8[b] *21*	(22−)
3596.8[&] *23*	(21+)
3688.4[‡] *22*	(22−)
3723.2[a] *21*	(23−)
3911.2[@] *24*	(22+)
4029.0[b] *22*	(24−)
4081.6[#] *22*	(23−)
4249.5[&] *24*	(23+)
4382.3[a] *22*	(25−)
4411.3[‡] *23*	(24−)
4610.5[@] *25*	(24+)
4749.9[b] *23*	(26−)
4812.5[#] *23*	(25−)
4824.5 *25*	(25−)
5006[&] *3*	(25+)
5138.2[a] *25*	(27−)
5155.4[‡] *24*	(26−)
5410[@] *3*	(26+)

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(HI,xnγ) 2008Su08,1989An08,1986Dr06 (continued)

^{160}Tm Levels (continued)

E(level)[d]	Jπ[†]	Comments
5581.5[#] *24*	(27⁻)	
5848[&] *3*	(27⁺)	
5946.5[‡] *25*	(28⁻)	
6410[#] *3*	(29⁻)	
6798[‡] *3*	(30⁻)	
7303[#] *3*	(31⁻)	
x[c]	(8⁺)	Additional information 2.
234.4+x[c] *10*	(10⁺)	
599.0+x[c] *15*	(12⁺)	
1067.8+x[c] *18*	(14⁺)	
1624.4+x[c] *20*	(16⁺)	
2268.7+x[c] *23*	(18⁺)	
2973.4+x[c] *25*	(20⁺)	

[†] Above 400 keV J^π values for bands A,a and B,b were deduced mainly by 1989An08 from considerations of band structure, alignments and crossing frequencies, and model-dependent arguments, and taken over by 2008Lu17 and 2008Su08. Below 400 keV, J^π values are from 2008Lu17 (and 2008Su08) that mention also the extra use of multipolarities based on DCO-ratio measurements (with no given values as evidence). J^π values for bands C and c are from 2008Lu17 while J^π values for band D are from 2008Su08.

[‡] Band(A): Yrast band, signature=0. Configuration=(π 7/2[523] + ν 5/2[642]). By analogy with the situation in ^{162}Tm, this is the most likely Nilsson-orbital composition. At higher spins, the classification according to spherical shell-model structure, namely $\pi h_{11/2}\otimes\nu i_{13/2}$, as given by the authors, might be more appropriate.

[#] Band(a): Yrast band, signature=1. Configuration=(π 7/2[523] + ν 5/2[642]). See comment on the signature-0 portion of this band.

[@] Band(B): Side band 1, signature=0. Configuration=(π 7/2[523] + ν 3/2[521]). In the spherical shell-model notation, the band can be described as $\pi h_{11/2}\otimes\nu h_{9/2}$.

[&] Band(b): Side band 1, signature=1. Configuration=(π 7/2[523] + ν 3/2[521]). See comment on the signature-0 portion of this band.

[a] Band(c): Side band 2, signature=1. $\pi g_{7/2}\otimes\nu h_{9/2}\otimes\nu i^2_{13/2}$, assigned to ^{160}Tm by 2008Lu17.

[b] Band(C): Side band 2, signature=0. $\pi g_{7/2}\otimes\nu h_{9/2}\otimes\nu i^2_{13/2}$, assigned to ^{160}Tm by 2008Lu17.

[c] Band(D): $\pi d_{3/2}\otimes\nu i_{13/2}$, α=0. Assigned to ^{160}Tm by 2008Su08 based on population intensity, the decoupled feature, highly alignment properties, delayed band crossing frequency, and systematic analyses. 10% of the intensity of band A.

[d] From least-squares fit to Eγ′s, assuming an uncertainty of 1.0 keV.

[e] From Adopted Levels.

γ(^{160}Tm)

Eγ	Ei(level)	J^π_i	Ef	J^π_f	Comments
28.85[†]	70.9	(5)	42.0	(2⁻)	Eγ: value given with two decimals but with no unc by 2008Lu17 and 2008Su08. Because of missing information it is not clear how this transition was measured, reason for which its existence is questioned by evaluator.
42.02	42.0	(2⁻)	0.0	1⁻	
53.7	124.4	(6)	70.9	(5)	
53.7	444.4	(9⁻)	390.9	(8⁻)	
75.6	244.6	(7⁺)	169.2	(6)	
79.3	523.6	(10⁻)	444.4	(9⁻)	
79.8	150.8	(6)	70.9	(5)	

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(HI,xnγ) 2008Su08,1989An08,1986Dr06 (continued)

γ(^{160}Tm) (continued)

E_γ	E_i(level)	J_i^π	E_f	J_f^π	Mult.	Comments
83.3	606.9	(11$^-$)	523.6	(10$^-$)		
86.3	157.2	(6)	70.9	(5)	(D)	Mult.: ΔJ=1, D transition quoted by 2008Su08 as obtained from DCO ratio value around 0.5.
97.8	169.2	(6)	70.9	(5)	(D)	Mult.: ΔJ=1, D transition quoted by 2008Su08 as obtained from DCO ratio value around 0.5.
97.9	342.4	(8$^+$)	244.6	(7$^+$)		
110.8	262.1	(7)	150.8	(6)		
128.9	390.9	(8$^-$)	262.1	(7)	(D)	Mult.: ΔJ=1, D transition quoted by 2008Su08 as obtained by DCO (with no evidence).
132.4	523.6	(10$^-$)	390.9	(8$^-$)		
142.0	484.5	(9$^+$)	342.4	(8$^+$)		
145.5	390.9	(8$^-$)	245.3	(7)		
152.6	936.5	(13$^-$)	783.6	(12$^-$)		
162.7	606.9	(11$^-$)	444.4	(9$^-$)		
170.6	655.0	(10$^+$)	484.5	(9$^+$)		
174.3	245.3	(7)	70.9	(5)		
176.6	783.6	(12$^-$)	606.9	(11$^-$)		
191.8	262.1	(7)	70.9	(5)	(Q)	Mult.: ΔJ=2, Q transition quoted by 2008Su08 as obtained by DCO (with no evidence).
197.4	2814.1	(18$^+$)	2616.6	(17$^+$)		
210.3	865.3	(11$^+$)	655.0	(10$^+$)		
220.0	2909.4	(20$^-$)	2689.7	(19$^-$)		
221.1	390.9	(8$^-$)	169.2	(6)	(Q)	Mult.: ΔJ=2, Q transition quoted by 2008Su08 as obtained from DCO ratio value around 1.0.
223.8	1406.1	(15$^-$)	1182.2	(14$^-$)		
228.6	1094.1	(12$^+$)	865.3	(11$^+$)		
233.7	390.9	(8$^-$)	157.2	(6)	(Q)	Mult.: ΔJ=2, Q transition quoted by 2008Su08 as obtained from DCO ratio value around 1.0.
234.4	234.4+x	(10$^+$)	x	(8$^+$)		
237.7	3051.5	(19$^+$)	2814.1	(18$^+$)		
240.5	390.9	(8$^-$)	150.8	(6)		
243.6	2814.1	(18$^+$)	2570.4	(17$^+$)		
245.7	1182.2	(14$^-$)	936.5	(13$^-$)		
251.2	3160.8	(21$^-$)	2909.4	(20$^-$)		
253.2	3413.8	(22$^-$)	3160.8	(21$^-$)		
259.6	783.6	(12$^-$)	523.6	(10$^-$)	(Q)	Mult.: ΔJ=2, Q transition quoted by 2008Su08 as obtained by DCO (with no evidence).
262.9	3314.1	(20$^+$)	3051.5	(19$^+$)		
263.3	2909.4	(20$^-$)	2647.2	(19$^-$)		
264.3	1358.6	(13$^+$)	1094.1	(12$^+$)		
266.6	390.9	(8$^-$)	124.4	(6)		
273.2	1632.0	(14$^+$)	1358.6	(13$^+$)		
282.7	3596.8	(21$^+$)	3314.1	(20$^+$)		
289.8	1696.2	(16$^-$)	1406.1	(15$^-$)		
289.8	1985.6	(17$^-$)	1696.2	(16$^-$)		
304.6	2242.7	(16$^+$)	1938.4	(15$^+$)		
305.9	4029.0	(24$^-$)	3723.2	(23$^-$)		
306.3	1938.4	(15$^+$)	1632.0	(14$^+$)		
309.3	3723.2	(23$^-$)	3413.8	(22$^-$)		
312.8	655.0	(10$^+$)	342.4	(8$^+$)		
314.4	3911.2	(22$^+$)	3596.8	(21$^+$)		
316.8	2302.8	(18$^-$)	1985.6	(17$^-$)		
327.7	2570.4	(17$^+$)	2242.7	(16$^+$)		
329.7	4411.3	(24$^-$)	4081.6	(23$^-$)		
329.8	2977.4	(20$^-$)	2647.2	(19$^-$)		
330.0	936.5	(13$^-$)	606.9	(11$^-$)		

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(HI,xnγ) 2008Su08,1989An08,1986Dr06 (continued)

γ(^{160}Tm) (continued)

E_γ	E_i(level)	J_i^π	E_f	J_f^π	Comments
330.1	3688.4	(22$^-$)	3358.2	(21$^-$)	
338.5	4249.5	(23$^+$)	3911.2	(22$^+$)	
339.2	2909.7	(18$^+$)	2570.4	(17$^+$)	
342.5	5155.4	(26$^-$)	4812.5	(25$^-$)	
344.3	2647.2	(19$^-$)	2302.8	(18$^-$)	
353.5	4382.3	(25$^-$)	4029.0	(24$^-$)	
361.3	4610.5	(24$^+$)	4249.5	(23$^+$)	
364.4	5946.5	(28$^-$)	5581.5	(27$^-$)	
364.6	599.0+x	(12$^+$)	234.4+x	(10$^+$)	
367.4	4749.9	(26$^-$)	4382.3	(25$^-$)	
380.6	3358.2	(21$^-$)	2977.4	(20$^-$)	
380.8	865.3	(11$^+$)	484.5	(9$^+$)	
393.5	4081.6	(23$^-$)	3688.4	(22$^-$)	
398.4	1182.2	(14$^-$)	783.6	(12$^-$)	
401.0	4812.5	(25$^-$)	4411.3	(24$^-$)	
409.4	2909.4	(20$^-$)	2499.0	(18$^-$)	
425.0	5581.5	(27$^-$)	5155.4	(26$^-$)	E_γ: Eγ deviates by >3σ from the fit giving reduced χ^2=1.8, compared to critical χ^2=1.6. Uncertainty of 1 keV is assigned which gives χ^2=1.3.
435.3	3051.5	(19$^+$)	2616.6	(17$^+$)	E_γ: 453.3 in figure 1 of 2008Su08 seems a type error.
437.9	1796.5	(14$^+$)	1358.6	(13$^+$)	
439.2	1094.1	(12$^+$)	655.0	(10$^+$)	
468.8	1067.8+x	(14$^+$)	599.0+x	(12$^+$)	
469.6	1406.1	(15$^-$)	936.5	(13$^-$)	
471.3	3160.8	(21$^-$)	2689.7	(19$^-$)	
480.6	3051.5	(19$^+$)	2570.4	(17$^+$)	
493.5	1358.6	(13$^+$)	865.3	(11$^+$)	
499.6	3314.1	(20$^+$)	2814.1	(18$^+$)	
504.2	3413.8	(22$^-$)	2909.4	(20$^-$)	
513.5	3160.8	(21$^-$)	2647.2	(19$^-$)	
513.9	1696.2	(16$^-$)	1182.2	(14$^-$)	
538.1	1632.0	(14$^+$)	1094.1	(12$^+$)	
545.4	3596.8	(21$^+$)	3051.5	(19$^+$)	
556.6	1624.4+x	(16$^+$)	1067.8+x	(14$^+$)	
562.4	3723.2	(23$^-$)	3160.8	(21$^-$)	
571.7	2814.1	(18$^+$)	2242.7	(16$^+$)	
579.8	1985.6	(17$^-$)	1406.1	(15$^-$)	
579.9	1938.4	(15$^+$)	1358.6	(13$^+$)	
589.3	2909.7	(18$^+$)	2320.5	(16$^+$)	
597.1	3911.2	(22$^+$)	3314.1	(20$^+$)	
606.1	2909.4	(20$^-$)	2302.8	(18$^-$)	
606.7	2302.8	(18$^-$)	1696.2	(16$^-$)	
610.7	2242.7	(16$^+$)	1632.0	(14$^+$)	
615.4	4029.0	(24$^-$)	3413.8	(22$^-$)	
631.4	2570.4	(17$^+$)	1938.4	(15$^+$)	
644.3	2268.7+x	(18$^+$)	1624.4+x	(16$^+$)	
652.8	4249.5	(23$^+$)	3596.8	(21$^+$)	
658.8	4382.3	(25$^-$)	3723.2	(23$^-$)	
662.2	2647.2	(19$^-$)	1985.6	(17$^-$)	
667.2	2909.7	(18$^+$)	2242.7	(16$^+$)	
675.0	2977.4	(20$^-$)	2302.8	(18$^-$)	
678.5	2616.6	(17$^+$)	1938.4	(15$^+$)	
688.5	2320.5	(16$^+$)	1632.0	(14$^+$)	
696.2	2054.8	(15$^+$)	1358.6	(13$^+$)	
699.0	4610.5	(24$^+$)	3911.2	(22$^+$)	
704.5	2689.7	(19$^-$)	1985.6	(17$^-$)	
704.7	2973.4+x	(20$^+$)	2268.7+x	(18$^+$)	

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(HI,xnγ) 2008Su08,1989An08,1986Dr06 (continued)

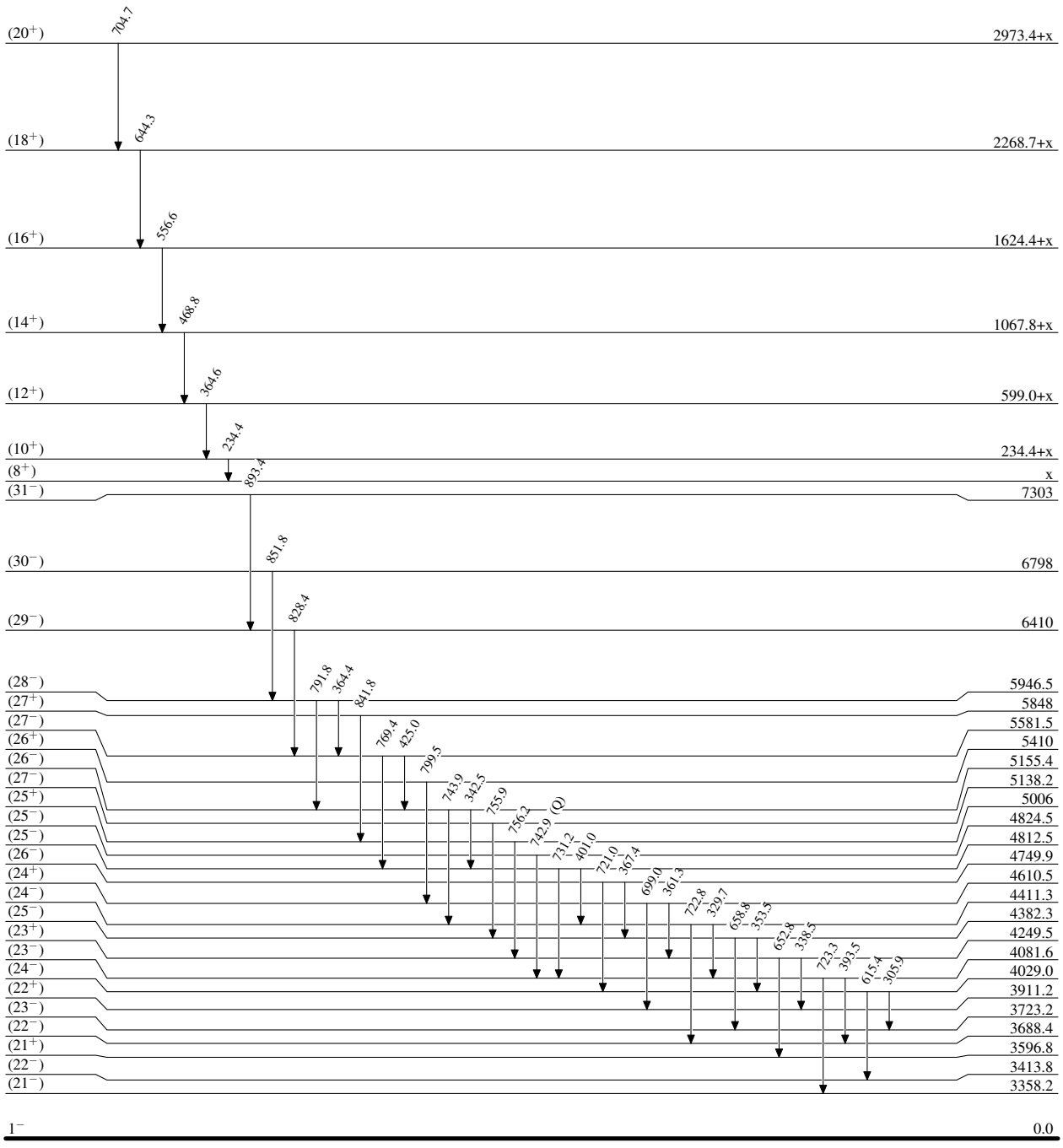
$\gamma(^{160}Tm)$ (continued)

E_γ	E_i(level)	J_i^π	E_f	J_f^π	Mult.	Comments
711.0	3358.2	(21^-)	2647.2	(19^-)		
711.2	3688.4	(22^-)	2977.4	(20^-)		
721.0	4749.9	(26^-)	4029.0	(24^-)		
722.8	4411.3	(24^-)	3688.4	(22^-)		
723.3	4081.6	(23^-)	3358.2	(21^-)		
731.2	4812.5	(25^-)	4081.6	(23^-)		
742.9	4824.5	(25^-)	4081.6	(23^-)	(Q)	Mult.: $\Delta J=2$, Q transition quoted by 2008Su08 as obtained by DCO (with no evidence) and intensity balance ratio.
743.9	5155.4	(26^-)	4411.3	(24^-)		
755.9	5138.2	(27^-)	4382.3	(25^-)		
756.2	5006	(25^+)	4249.5	(23^+)		
769.4	5581.5	(27^-)	4812.5	(25^-)		
791.8	5946.5	(28^-)	5155.4	(26^-)		
799.5	5410	(26^+)	4610.5	(24^+)		
801.9	2499.0	(18^-)	1696.2	(16^-)		
828.4	6410	(29^-)	5581.5	(27^-)		
841.8	5848	(27^+)	5006	(25^+)		
851.8	6798	(30^-)	5946.5	(28^-)		
893.4	7303	(31^-)	6410	(29^-)		

† Placement of transition in the level scheme is uncertain.

(HI,xnγ) 2008Su08,1989An08,1986Dr06

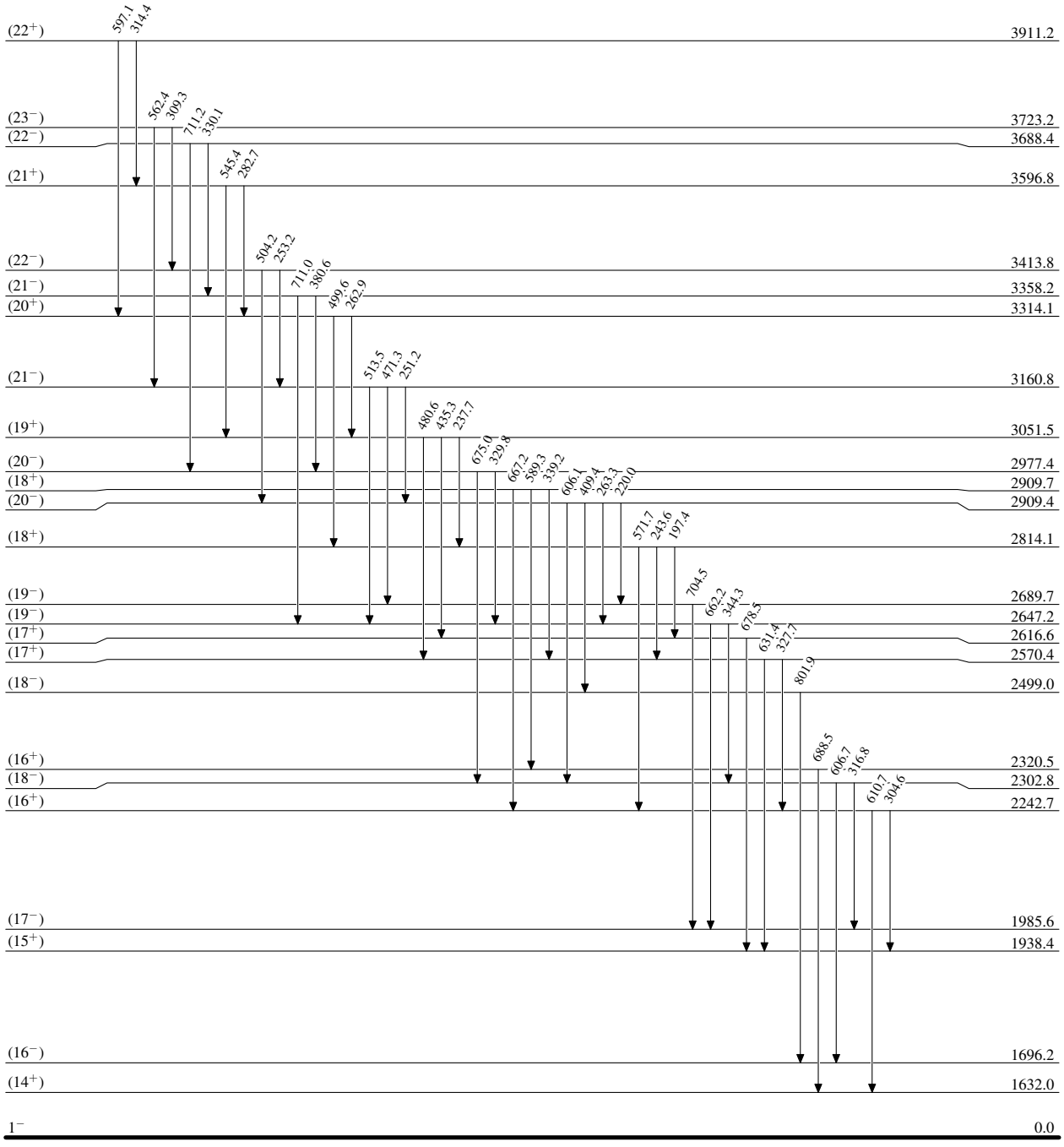
Level Scheme



$^{160}_{69}Tm_{91}$

(HI,xnγ) 2008Su08,1989An08,1986Dr06

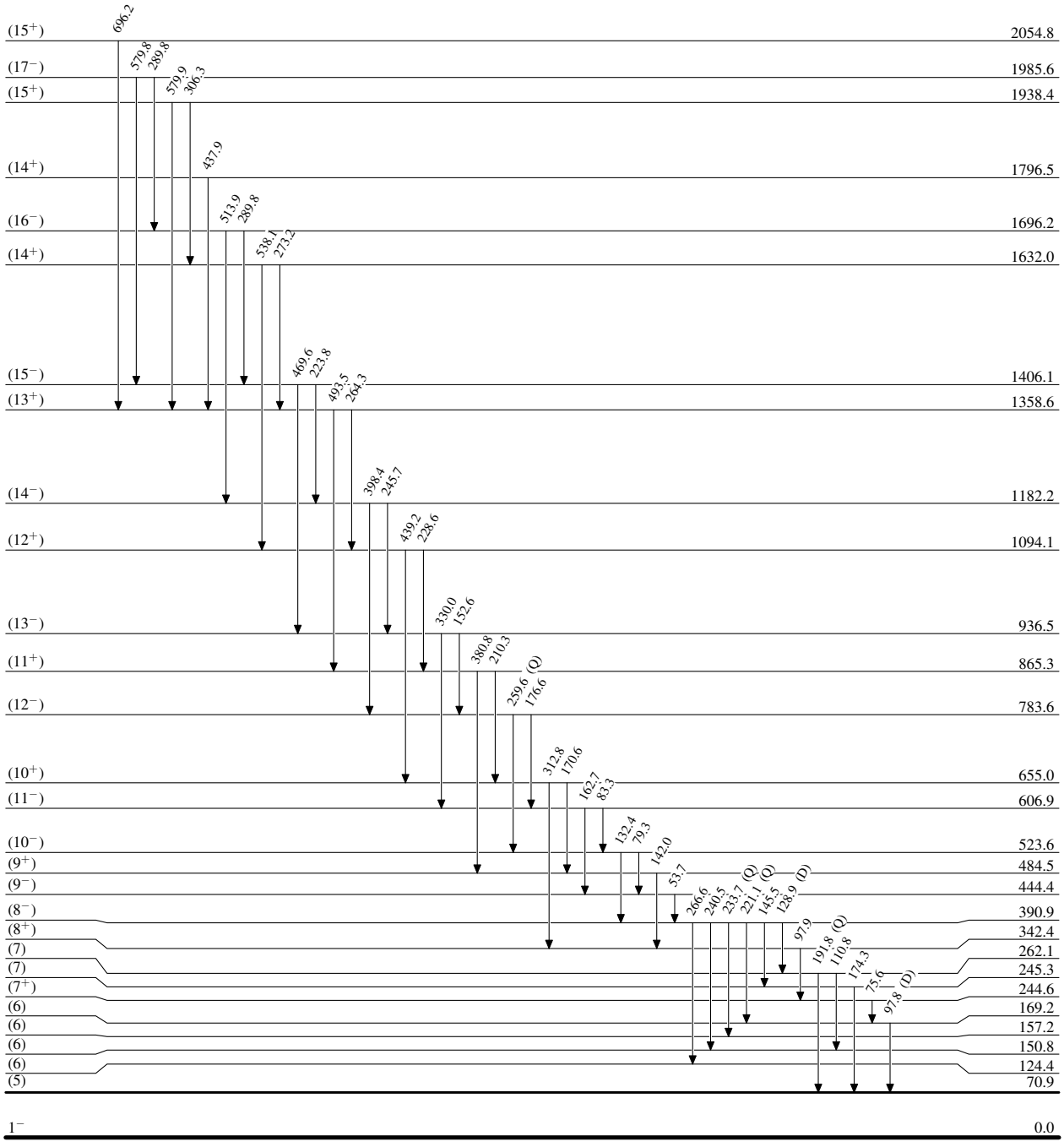
Level Scheme (continued)



$^{160}_{69}Tm_{91}$

(HI,xnγ) 2008Su08,1989An08,1986Dr06

Level Scheme (continued)



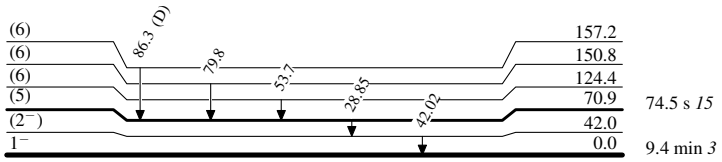
$^{160}_{69}Tm_{91}$

(HI,xnγ) 2008Su08,1989An08,1986Dr06

Legend

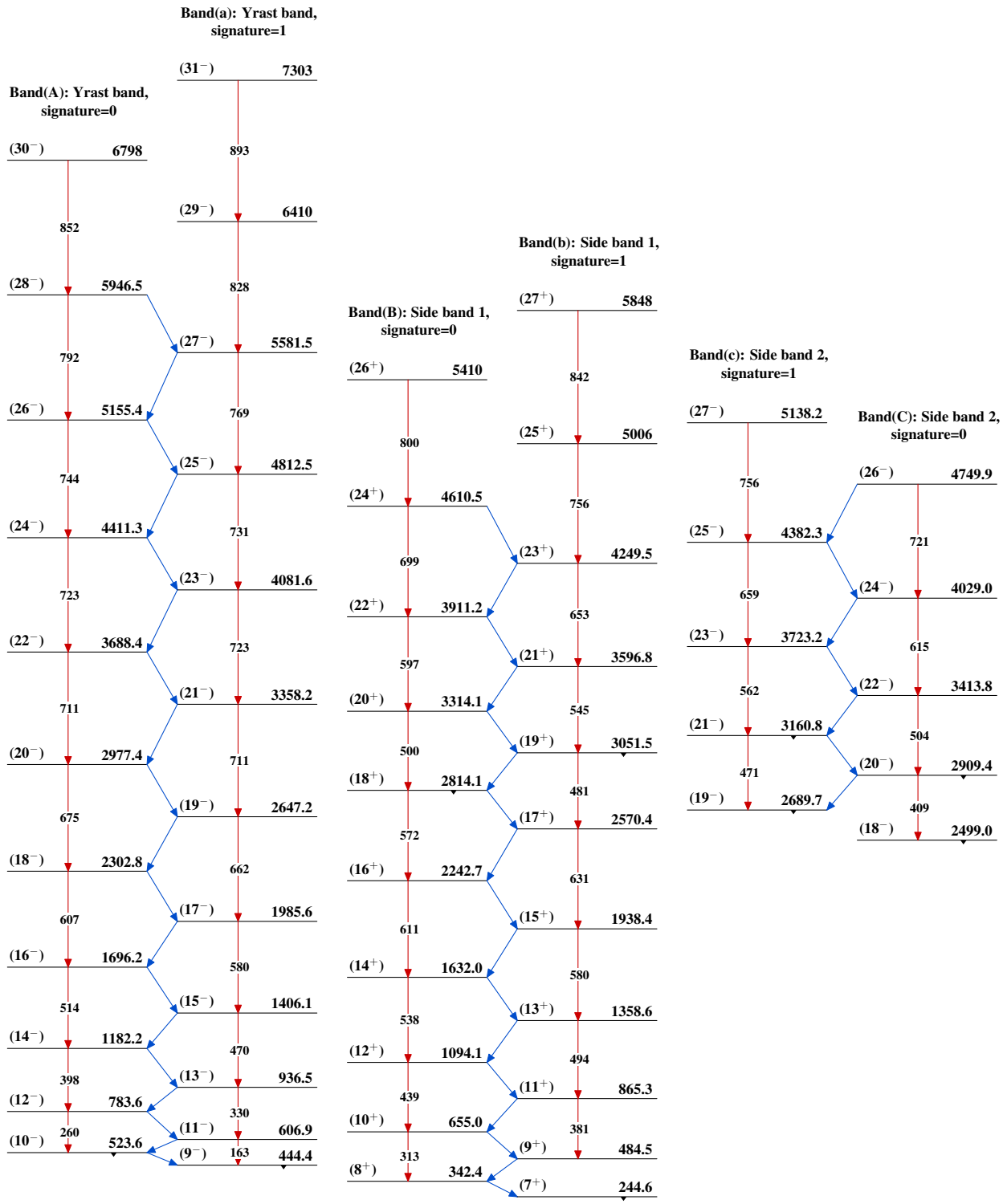
Level Scheme (continued)

- - - - - - ► γ Decay (Uncertain)



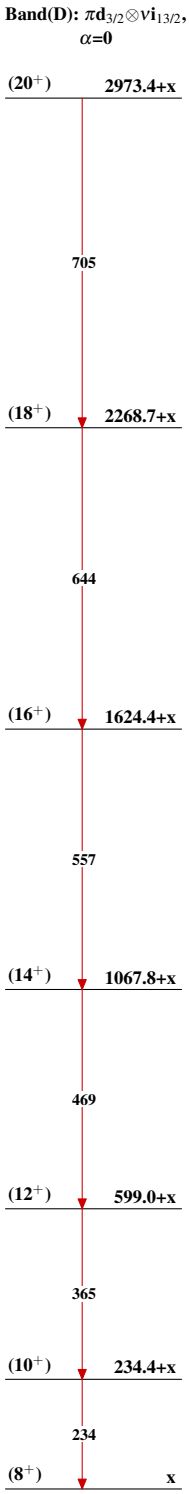
$^{160}_{69}Tm_{91}$

(HI,xnγ) 2008Su08,1989An08,1986Dr06



$^{160}_{69}Tm_{91}$

(HI,xnγ) 2008Su08,1989An08,1986Dr06 (continued)



$^{160}_{69}Tm_{91}$