^{152}Sm(^{14}N,5nγ),^{165}Ho(^{4}He,^{8}Nγ) 1984Fo04

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	C. W. Reich	NDS 112,2497 (2011)	1-Jun-2011

Additional information 1.

1984Fo04: ^{152}Sm(^{14}N,5nγ), E(^{14}N)=65-98 MeV. Enriched (98.3% ^{152}Sm) self-supporting metallic target of thickness 3 mg/cm^2. γ radiation was measured using high-resolution 6 cm^3 and 50 cm^3 Ge(Li) detectors (FWHM=0.67 and 1.01 keV, respectively, at 100 keV). A planar high-resolution Ge(Li) detector was used to study the low-energy level scheme. Measured excitation functions, Eγ, γ singles, $\gamma\gamma$, $\gamma(\theta)$ (at five angles from 90° to 162°). ^{165}Ho(^{4}He,^{8}Nγ), E(^{4}He)=86.5, 97, 106 MeV. Metallic Ho foil, 10mγ/cm^2 thick. γ radiation studied using a Compton suppression spectrometer. Measured $\gamma\gamma$(t) using detectors having volumes of 50 cm^3 (true coaxial) and 75 cm^3.

^{161}Tm Levels

E(level)[†]	J$^\pi$[‡]	T$_{1/2}$	Comments
0.0[#]	7/2$^+$	30.2 min *8*	T$_{1/2}$: from adopted values.
7.2[&] *6*	1/2$^+$		Note that this level may well have a half-life of the order of minutes or so. Thus, it would be expected to decay by both isomeric-transition (M3) and $\varepsilon+\beta^+$ decay. Neither of these potential decay modes has yet been observed. See the comment on this level in the Adopted Levels data set.
18.90[a] *12*	5/2$^+$		
22.62[&] *21*	3/2$^+$		
78.1[b] *1*	7/2$^-$	108 ns *4*	T$_{1/2}$: weighted average of 111 ns *6* (^{4}He-induced reaction) and 106 ns *5* (^{14}N-induced reaction), from $\gamma\gamma$(t) (1984Fo04).
149.10[c] *13*	9/2$^-$		
159.04[a] *15*	7/2$^+$		
161.81[@] *8*	9/2$^+$		
167.12[&] *23*	5/2$^+$		
210.91[&] *20*	7/2$^+$		
254.70[b] *13*	11/2$^-$		
326.62[a] *16*	9/2$^+$		
347.89[#] *8*	11/2$^+$		
367.2[d] *6*	1/2$^-$		
376.36[d] *18*	5/2$^-$		
417.40[c] *14*	13/2$^-$		
515.69[a] *17*	11/2$^+$		
516.36[d] *18*	9/2$^-$		
531.30[&] *17*	11/2$^+$		
557.34[@] *10*	13/2$^+$		
577.30[b] *15*	15/2$^-$		
756.25[d] *17*	13/2$^-$		
788.50[#] *12*	15/2$^+$		
815.50[c] *15*	17/2$^-$		
989.10[&] *20*	15/2$^+$		
1008.30[b] *16*	19/2$^-$		
1036.73[@] *12*	17/2$^+$		
1080.0[d] *3*	17/2$^-$		
1305.03[#] *14*	19/2$^+$		
1310.00[c] *17*	21/2$^-$		
1496.0[d] *3*	21/2$^-$		

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^{152}Sm(^{14}N,5nγ),^{165}Ho(^{4}He,^{8}Nγ) 1984Fo04 (continued)

^{161}Tm Levels (continued)

E(level)†	Jπ‡	E(level)†	Jπ‡	E(level)†	Jπ‡	E(level)†	Jπ‡
1525.43[b] *18*	23/2−	2108.85[b] *19*	27/2−	2736.48[b] *24*	31/2−	3476.7[c] *3*	37/2−
1581.66[@] *15*	21/2+	2172.25[@] *25*	25/2+	3050.79[c] *24*	33/2−	3739.6[b] *3*	39/2−
1873.87[c] *19*	25/2−	2478.0[#] *3*	27/2+	3206.3[d] *5*	33/2−	4012.6[c] *3*	41/2−
1876.73[#] *25*	23/2+	2480.85[c] *22*	29/2−	3255.24[b] *25*	35/2−	4330.3[b] *3*	43/2−
1996.1[d] *4*	25/2−	2570.2[d] *4*	29/2−	3380.8 *4*	35/2−		

† From a least-squares fit to the γ energies.
‡ From adopted values. For the present in-beam data, the Jπ assignments rely largely on considerations of the expected rotational band structure, supplemented with information on γ multipolarities.
# Band(A): 7/2[404] band; α=−1/2 branch.
@ Band(a): 7/2[404] band; α=+1/2 branch.
& Band(B): 1/2[411] band.
a Band(C): 5/2[402] band.
b Band(D): 7/2[523] band; α=−1/2 branch.
c Band(E): 7/2[523] band; α=+1/2 branch.
d Band(F): 1/2[541] band; α=+1/2 branch. Only the α=+1/2 portion is observed.

γ(^{161}Tm)

Extensive $\gamma\gamma$ coincidence results (1984Fo04) are included in their level-scheme drawing. These support the placements of most of the γ's, but, with the long decay sequences that occur, they may not be unique for the order within a sequence.

Eγ	Iγ†	Ei(level)	Jiπ	Ef	Jfπ	Mult.‡	Comments
(7.4)		7.2	1/2+	0.0	7/2+		
(15.4)		22.62	3/2+	7.2	1/2+		
(18.90 *12*)		18.90	5/2+	0.0	7/2+	M1	Eγ,Mult.: from ^{161}Yb ε decay (1981Ad02).
71.0 *1*	267	149.10	9/2−	78.1	7/2−		A2=−0.07 *9*; A4=−0.03 *14*.
78.1 *1*	1400	78.1	7/2−	0.0	7/2+		
105.6 *1*	526	254.70	11/2−	149.10	9/2−		
[x]133.4 *1*	115					D	A2=−0.42 *5*; A4=−0.23 *6*.
139.9 *1*	<115	516.36	9/2−	376.36	5/2−		A2=−0.13 *7*; A4=0.00 *9*. (Values for both the 139.9 and 140.2 γ's.) Iγ: peak contains two γ's. The listed Iγ value is for the pair.
140.2 *1*	<115	159.04	7/2+	18.90	5/2+		A2=−0.13 *7*; A4=0.00 *9*. (Values for both the 139.9 and 140.2 γ's.) Iγ: peak contains two γ's. The listed Iγ value is for the pair.
144.5 *1*	30	167.12	5/2+	22.62	3/2+		
159.9 *1*	576	577.30	15/2−	417.40	13/2−		
161.8 *1*	261	161.81	9/2+	0.0	7/2+	*a*	A2=0.25 *8*; A4=0.20 *13*.
162.7 *1*	780	417.40	13/2−	254.70	11/2−	D	A2=−0.07 *4*; A4=−0.02 *6*.
[x]164.3 *1*	73						
167.6 *1*	148	326.62	9/2+	159.04	7/2+	D	A2=−0.21 *10*; A4=0.01 *16*.
176.6 *1*	<220[@]	254.70	11/2−	78.1	7/2−		
186.1 *1*	117	347.89	11/2+	161.81	9/2+	*a*	A2=0.27 *7*; A4=0.06 *12*.
188.3 *1*	139	210.91	7/2+	22.62	3/2+		A2=0.02 *4*; A4=−0.08 *6*. (Values for both the 188.3 and 189.0 γ's.) Mult.: ce data suggest E1 or E2.

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^{152}Sm(^{14}N,5nγ),^{165}Ho(^{4}He,^{8}Nγ) 1984Fo04 (continued)

γ(^{161}Tm) (continued)

E_γ	I_γ[†]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡]	Comments
189.0 *1*	80	515.69	11/2$^+$	326.62	9/2$^+$		A_2=0.02 *4*; A_4=−0.08 *6*. (Values for both the 188.3 and 189.0 γ's.).
192.8 *1*	370	1008.30	19/2$^-$	815.50	17/2$^-$	D	A_2=−0.11 *4*; A_4=−0.01 *4*.
204.5 *1*	225	3255.24	35/2$^-$	3050.79	33/2$^-$	D	A_2=−0.20 *7*; A_4=0.09 *8*.
204.8 *1*	62	531.30	11/2$^+$	326.62	9/2$^+$		
209.5 *1*	74	557.34	13/2$^+$	347.89	11/2$^+$		A_2=−0.05 *7*; A_4=0.26 *10*.
215.4 *1*	166	1525.43	23/2$^-$	1310.00	21/2$^-$		A_2=−0.06 *12*; A_4=−0.06 *16*.
221.4 *1*	179	3476.7	37/2$^-$	3255.24	35/2$^-$	D	A_2=−0.22 *6*; A_4=0.04 *8*.
225.0 *1*	84	756.25	13/2$^-$	531.30	11/2$^+$		A_2=0.01 *15*; A_4=−0.06 *16*.
x230.3 *1*	49						A_2=−0.03 *21*; A_4=0.14 *30*.
231.2	26[@]	788.50	15/2$^+$	557.34	13/2$^+$		A_2=−0.04 *8*; A_4=0.15 *12*.
235.0 *1*	84	2108.85	27/2$^-$	1873.87	25/2$^-$		
238.2 *1*	494	815.50	17/2$^-$	577.30	15/2$^-$		A_2=0.07 *4*; A_4=0.04 *8*.
239.8 *1*	101	756.25	13/2$^-$	516.36	9/2$^-$	Q	A_2=0.19 *6*; A_4=−0.15 *11*.
240.6 *1*	64	756.25	13/2$^-$	515.69	11/2$^+$		A_2=0.03 *15*; A_4=0.01 *23*.
248.2 *1*	68	1036.73	17/2$^+$	788.50	15/2$^+$		A_2=0.20 *21*; A_4=−0.04 *30*.
255.6 *2*	70	2736.48	31/2$^-$	2480.85	29/2$^-$		
263.0 *2*	51	3739.6	39/2$^-$	3476.7	37/2$^-$		A_2=−0.06 *20*; A_4=0.27 *30*.
268.3[b] *1*	234[b]	417.40	13/2$^-$	149.10	9/2$^-$		A_2=0.21 *5*; A_4=0.00 *8*. Note: γ is doubly placed.
268.3[b] *1*	234[b]	1305.03	19/2$^+$	1036.73	17/2$^+$		A_2=0.21 *5*; A_4=0.00 *8*. Note: γ is doubly placed.
x270.6 *1*	46[#]						
273.1 *1*	54	4012.6	41/2$^-$	3739.6	39/2$^-$		
276.7 *2*	19	1581.66	21/2$^+$	1305.03	19/2$^+$		
x278.0 *1*	73[#]						
x282.7 *1*	46						
x294.1 *2*	≈25						
x296.7 *2*	≈24						
301.7 *1*	278	1310.00	21/2$^-$	1008.30	19/2$^-$		A_2=0.05 *6*; A_4=0.13 *10*.
305.5 *2*	[&]	516.36	9/2$^-$	210.91	7/2$^+$		
307.8 *2*	[&]	326.62	9/2$^+$	18.90	5/2$^+$		
314.4 *1*	≈69	3050.79	33/2$^-$	2736.48	31/2$^-$	D	A_2=−0.27 *15*; A_4=0.00 *15*.
317.7 *1*	47	4330.3	43/2$^-$	4012.6	41/2$^-$		A_2=0.05 *13*; A_4=−0.12 *15*.
x319.6 *1*	134					D	A_2=−0.31 *25*; A_4=−0.23 *30*.
320.4 *2*	105	531.30	11/2$^+$	210.91	7/2$^+$		A_2=0.20 *20*; A_4=0.28 *30*.
322.6 *1*	450	577.30	15/2$^-$	254.70	11/2$^-$	Q	A_2=0.24 *8*; A_4=−0.07 *10*.
323.7 *2*	199	1080.0	17/2$^-$	756.25	13/2$^-$	Q	A_2=0.24 *8*; A_4=−0.21 *12*.
x326.0 *2*	70						
x329.5[c] *2*							E_γ: 1984Fo04 place this γ from a 45/2$^-$ level at 4660.0. However, 1995Sm02, in ^{128}Te(^{37}Cl,4nγ), place the 45/2$^-$ level 3 keV lower and show different γ's deexciting it.
344.4	32	367.2	1/2$^-$	22.62	3/2$^+$		
347.9 *1*	185	347.89	11/2$^+$	0.0	7/2$^+$		
348.4 *2*	187	1873.87	25/2$^-$	1525.43	23/2$^-$		
353.7 *2*	56	376.36	5/2$^-$	22.62	3/2$^+$		
357.1[b] *2*	67[b#]	376.36	5/2$^-$	18.90	5/2$^+$		
357.1[b] *2*	67[b#]	515.69	11/2$^+$	159.04	7/2$^+$		
358		3739.6	39/2$^-$	3380.8	35/2$^-$		From 1995Sm02. 1984Fo04 report a 357.1 γ, but indicate that it is contaminated by a γ from ^{162}Tm.
359.9 *2*	[&]	367.2	1/2$^-$	7.2	1/2$^+$		
x368.8 *2*	52						
x369.6 *2*	40						
372.0[b] *2*	154[b]	531.30	11/2$^+$	159.04	7/2$^+$		A_2=−0.04 *2*; A_4=−0.05 *4*. Note: γ is doubly placed.

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^{152}Sm(^{14}N,5nγ),^{165}Ho(^{4}He,^{8}Nγ) 1984Fo04 (continued)

γ(^{161}Tm) (continued)

E_γ	I_γ[†]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡]	Comments
372.0[b] *2*	154[b]	2480.85	29/2$^-$	2108.85	27/2$^-$		A_2=−0.04 *2*; A_4=−0.05 *4*. Note: γ is doubly placed.
395.5 *1*	214	557.34	13/2$^+$	161.81	9/2$^+$	Q	A_2=0.22 *4*; A_4=−0.29 *6*.
398.1 *1*	373	815.50	17/2$^-$	417.40	13/2$^-$	Q	A_2=0.26 *6*; A_4=−0.03 *8*.
416.0 *1*	132	1496.0	21/2$^-$	1080.0	17/2$^-$	Q	A_2=0.28 *6*; A_4=−0.01 *7*.
425.9 *1*	94	3476.7	37/2$^-$	3050.79	33/2$^-$	Q	A_2=0.32 *4*; A_4=−0.26 *8*.
431.0 *1*	597	1008.30	19/2$^-$	577.30	15/2$^-$	Q	A_2=0.24 *7*; A_4=−0.02 *10*.
440.6 *1*	254	788.50	15/2$^+$	347.89	11/2$^+$	Q	A_2=0.17 *4*; A_4=−0.12 *6*.
457.8 *1*	61	989.10	15/2$^+$	531.30	11/2$^+$		
479.4 *1*	327	1036.73	17/2$^+$	557.34	13/2$^+$	Q	A_2=0.28 *8*; A_4=−0.11 *7*.
484.3 *1*	100	3739.6	39/2$^-$	3255.24	35/2$^-$	Q	A_2=0.23 *5*; A_4=−0.01 *8*.
[x]490.2 *2*	79						
494.5 *1*	342	1310.00	21/2$^-$	815.50	17/2$^-$	Q	A_2=0.27 *5*; A_4=−0.10 *8*.
[x]496.4 *3*	26						
500.1 *2*	100	1996.1	25/2$^-$	1496.0	21/2$^-$	Q	A_2=0.27 *15*; A_4=−0.16 *28*.
[x]502.4 *2*	69						
[x]515.6 *2*	154						
516.6 *2*	<540	1305.03	19/2$^+$	788.50	15/2$^+$	(Q)	A_2=0.26 *2*; A_4=−0.12 *2*. (Values are for both the 516.6 and 517.1 γ's.). I_γ: peak contains two γ's. The listed Iγ value is for the pair.
517.1 *2*	<540	1525.43	23/2$^-$	1008.30	19/2$^-$	(Q)	A_2=0.26 *2*; A_4=−0.12 *2*. (Values are for both the 516.6 and 517.1 γ's.). I_γ: peak contains two γ's. The listed Iγ value is for the pair.
518.4 *2*	74	3255.24	35/2$^-$	2736.48	31/2$^-$		
536.2	78	4012.6	41/2$^-$	3476.7	37/2$^-$		
544.9 *1*	289	1581.66	21/2$^+$	1036.73	17/2$^+$	Q	A_2=0.21 *6*; A_4=−0.09 *5*.
[x]555.0 *2*	60						
[x]558.6 *1*	115[@]						
563.9 *1*	320	1873.87	25/2$^-$	1310.00	21/2$^-$	Q	A_2=0.23 *9*; A_4=−0.08 *9*.
[x]565.4 *2*	76						
570.0 *2*	188	3050.79	33/2$^-$	2480.85	29/2$^-$	Q	A_2=0.21 *5*; A_4=−0.18 *9*.
571.7 *2*	212	1876.73	23/2$^+$	1305.03	19/2$^+$	Q	A_2=0.23 *1*; A_4=−0.18 *1*.
574.1 *2*	103	2570.2	29/2$^-$	1996.1	25/2$^-$	(Q)	A_2=0.12 *8*; A_4=−0.04 *12*.
583.4 *1*	390	2108.85	27/2$^-$	1525.43	23/2$^-$	Q	A_2=0.30 *6*; A_4=0.01 *8*.
590.6[b] *2*	250[b]	2172.25	25/2$^+$	1581.66	21/2$^+$	(Q)	A_2=0.27 *10*; A_4=−0.10 *17*. Note: γ is doubly placed.
590.6[b] *2*	250[b]	4330.3	43/2$^-$	3739.6	39/2$^-$	(Q)	A_2=0.27 *10*; A_4=−0.10 *17*. Note: γ is doubly placed.
[x]595.0 *3*	104						
[x]599.9 *3*	48						
601.3 *2*	167	2478.0	27/2$^+$	1876.73	23/2$^+$	Q	A_2=0.12 *9*; A_4=−0.01 *14*.
607.0 *2*	257	2480.85	29/2$^-$	1873.87	25/2$^-$		A_2=0.25 *20*; A_4=−0.10 *30*.
627.6 *2*	245	2736.48	31/2$^-$	2108.85	27/2$^-$	Q	A_2=0.33 *8*; A_4=−0.10 *14*.
[x]630.8 *2*	103						A_2=0.17 *6*; A_4=0.04 *10*.
636.1[c] *3*	≈90	3206.3	33/2$^-$	2570.2	29/2$^-$		A_2=0.06 *3*; A_4=0.00 *4*.
644.2 *3*	≈70	3380.8	35/2$^-$	2736.48	31/2$^-$	(Q)	A_2=0.14 *9*; A_4=−0.15 *15*.
[x]647.3[c] *3*	≈50						E_γ: 1984Fo04 place this γ from a 45/2$^-$ level at 4660.0. However, 1995Sm02, in ^{128}Te(^{37}Cl,4nγ), place the 45/2$^-$ level 3 keV lower and show different γ's deexciting it.
[x]692.1 *3*	[&]						

[†] The listed values are for θ=90° and E(^{14}N)=82 MeV. (See 1984Fo04 for values from the ^{165}Ho(^{4}He,^{8}Nγ) reaction at 90° and

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^{152}Sm(^{14}N,5nγ),^{165}Ho(^{4}He,^{8}Nγ) 1984Fo04 (continued)

$\gamma(^{161}Tm)$ (continued)

E(^{4}He)=97 MEV.) Their uncertainties are stated to vary from 10% to 30%, depending on the line strength.

‡ Primarily from $\gamma(\theta)$ (1984Fo04), although the deduced multipolarities are not explicitly given there. The evaluator has assigned Q to the γ's with A_2>0.20 and A_4=small, and D(=dipole) to those with A_2<0.

Value may include contribution from γ from ^{162}Tm.

@ Value may include contribution from γ from ^{160}Tm.

& Observed only in the ^{165}Ho(α,8nγ) reaction.

a $\gamma(\theta)$ (1984Fo04) suggests stretched Q, but placement has $\Delta J=1$.

b Multiply placed with undivided intensity.

c Placement of transition in the level scheme is uncertain.

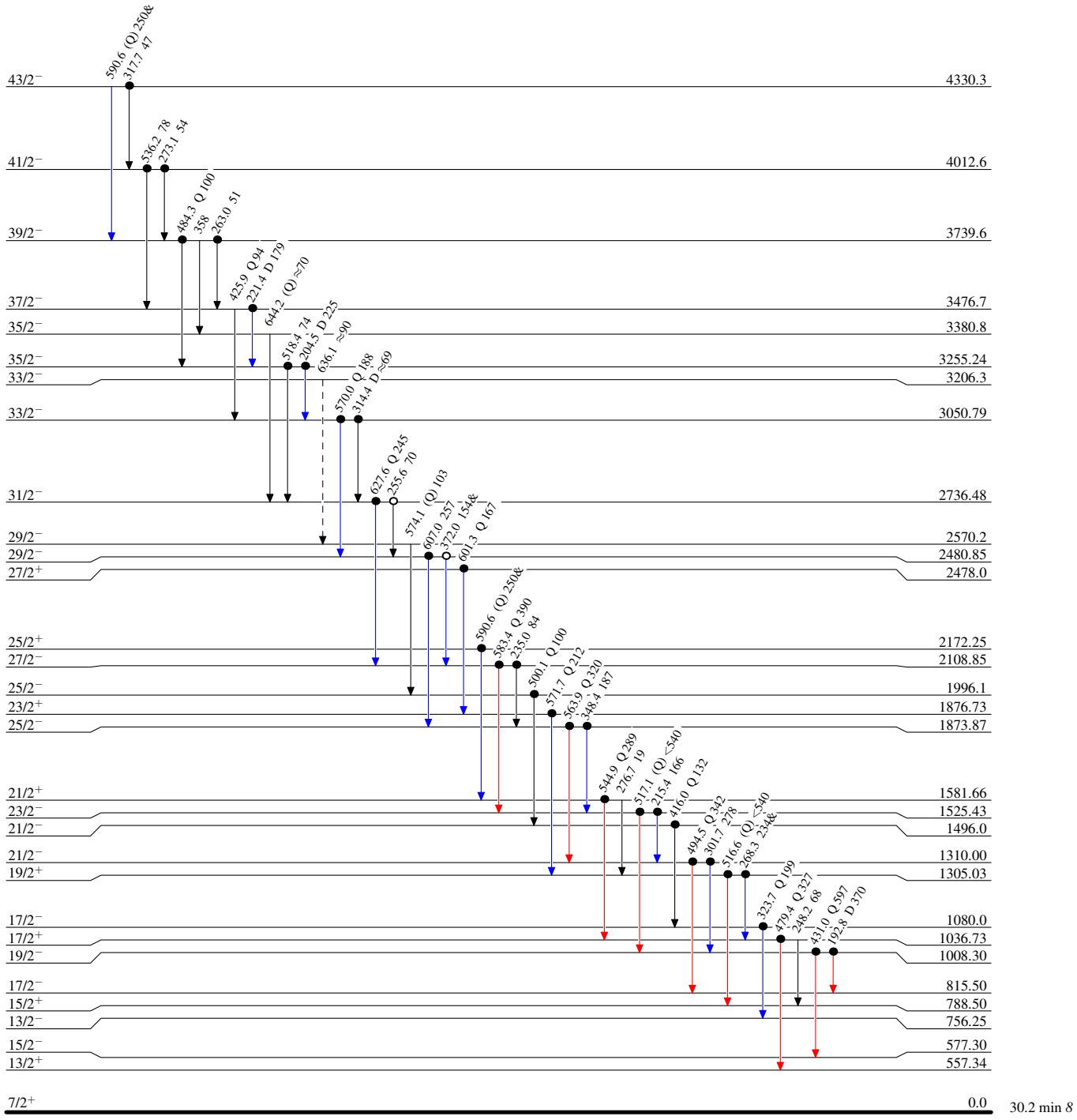
x γ ray not placed in level scheme.

^{152}Sm(^{14}N,5nγ),^{165}Ho(^{4}He,^{8}Nγ) 1984Fo04

Level Scheme

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)
Coincidence
Coincidence (Uncertain)



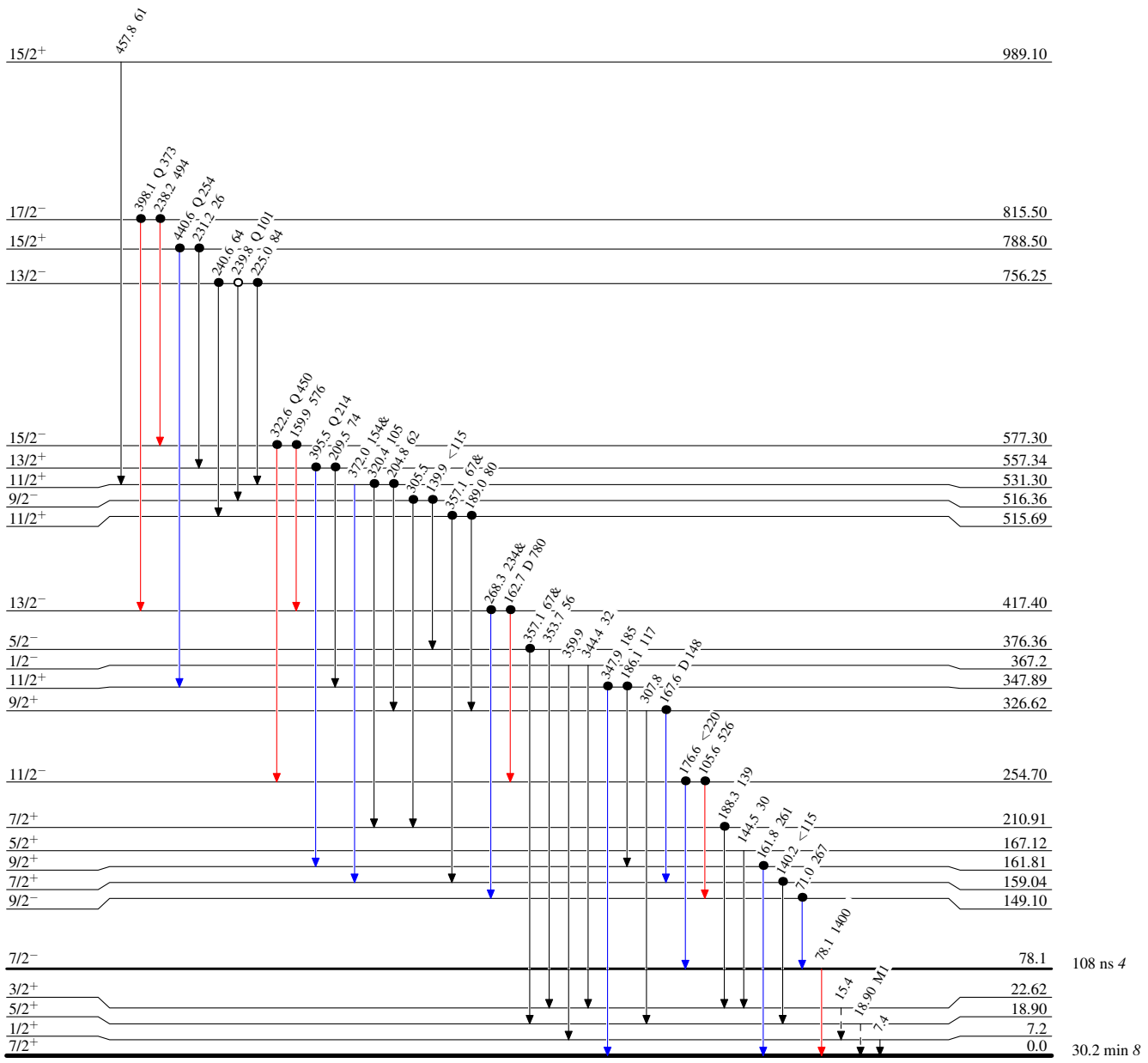
$^{161}_{69}Tm_{92}$

^{152}Sm(^{14}N,5nγ),^{165}Ho(^{4}He,^{8}Nγ) 1984Fo04

Level Scheme (continued)

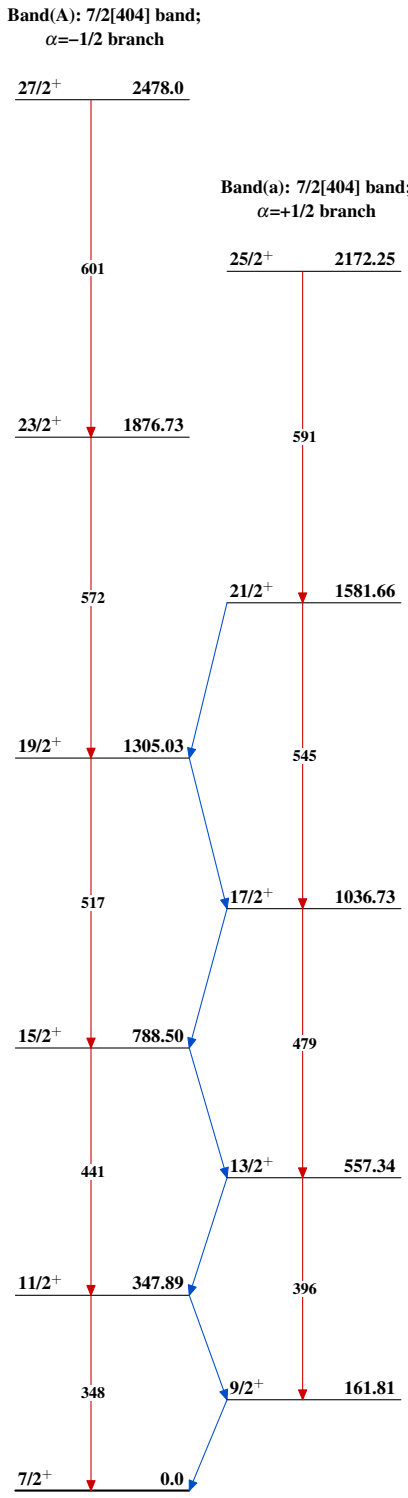
Intensities: Relative I_γ
& Multiply placed: undivided intensity given

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)
- Coincidence
- Coincidence (Uncertain)



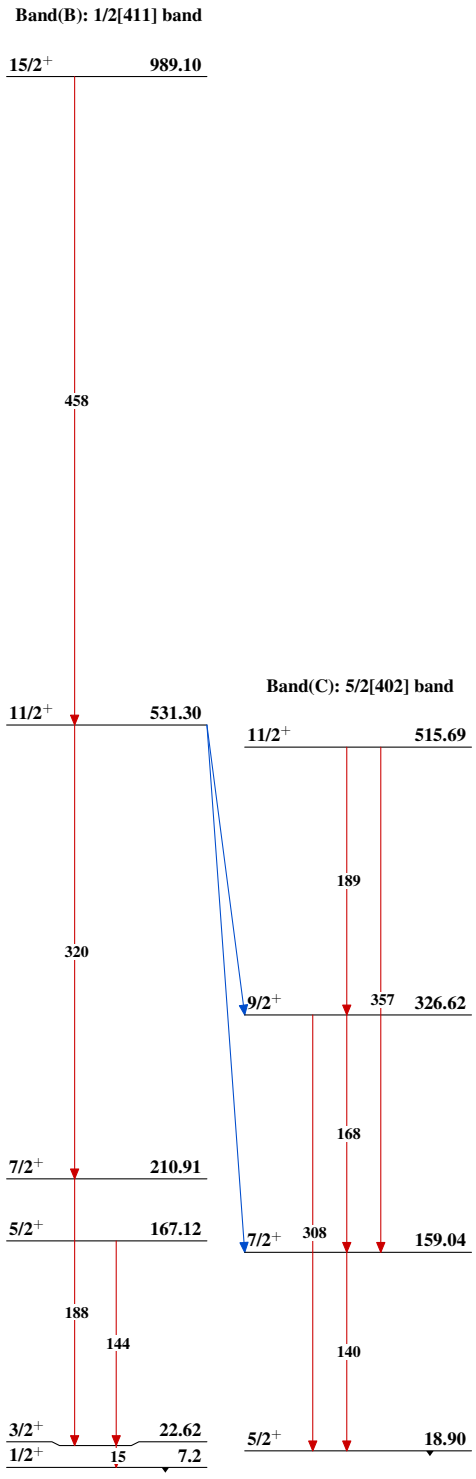
$^{161}_{69}Tm_{92}$

^{152}Sm(^{14}N,5nγ),^{165}Ho(^{4}He,^{8}Nγ) 1984Fo04



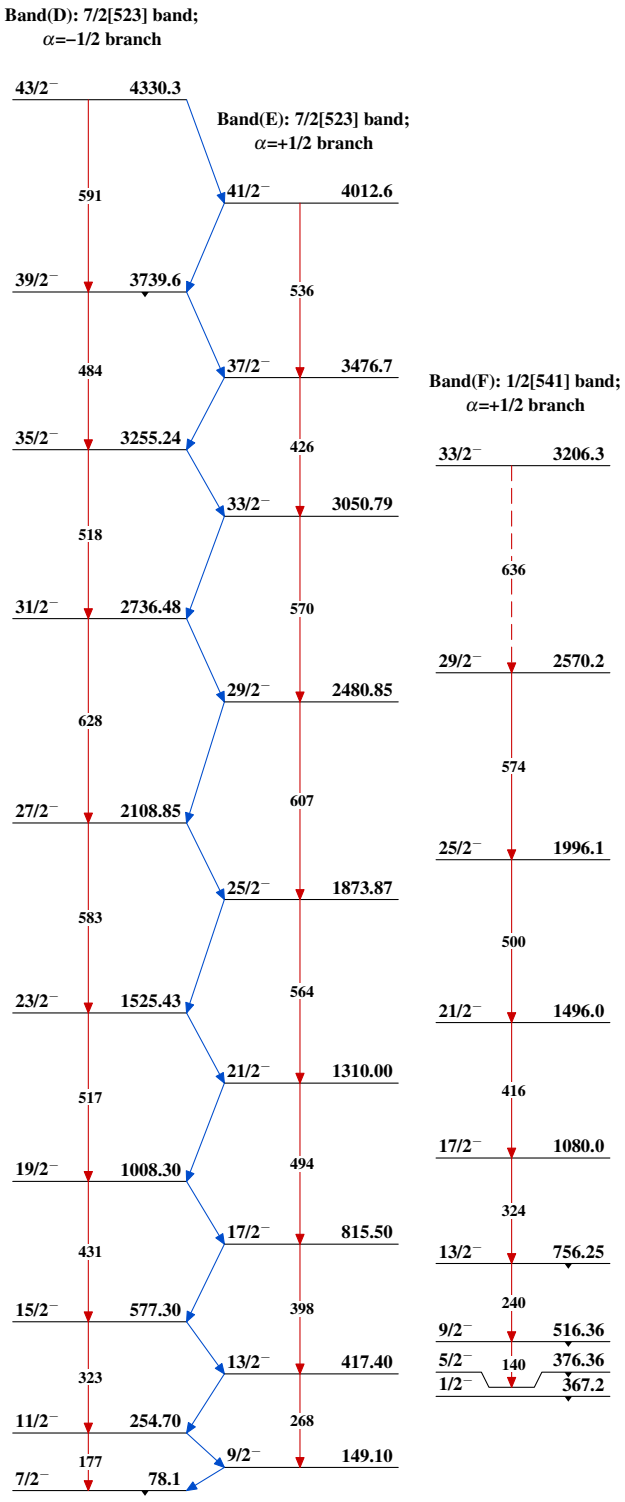
$^{161}_{69}Tm_{92}$

^{152}Sm(^{14}N,5nγ),^{165}Ho(^{4}He,^{8}Nγ) 1984Fo04 (continued)



$^{161}_{69}Tm_{92}$

^{152}Sm(^{14}N,5nγ),^{165}Ho(^{4}He,^{8}Nγ) 1984Fo04 (continued)



$^{161}_{69}Tm_{92}$