

<sup>165</sup>Ho( $\alpha$ ,4n $\gamma$ )    **1972Gi12,1975Fo14**

Type	Author	History	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh and Jun Chen		NDS 194,460 (2024)	31-Oct-2022

Includes <sup>166</sup>Er(p,2n $\gamma$ ).

**1972Gi12:** <sup>165</sup>Ho( $\alpha$ ,4n $\gamma$ ),E( $\alpha$ )=38, 50 MeV. Measured E $\gamma$ , I $\gamma$ ,  $\gamma\gamma$ -coin, excitation functions at the Grenoble cyclotron facility.

Also, <sup>166</sup>Er(p,2n $\gamma$ ),E(p)=30 MeV; measure I $\gamma$ ( $\alpha$ ,4n $\gamma$ )/I $\gamma$ (p,2n $\gamma$ ) ratios.

**1975Fo14:** <sup>165</sup>Ho( $\alpha$ ,4n $\gamma$ ),E( $\alpha$ )=53 MeV. Measured E $\gamma$ , I $\gamma$ ,  $\gamma\gamma$ -coin, excitation functions,  $\gamma(\theta)$  at the Grenoble cyclotron facility.

Only a level scheme with E $\gamma$  values and band structures is given in this reference. This work is by the same experimental group as **1972Gi12**.

Others:

**1976Sv01:** <sup>166</sup>Er(p,2n $\gamma$ ),E(p)=8-12 MeV. Measured E $\gamma$ ,  $\gamma\gamma$ -coin, ce,  $\gamma\gamma(t)$  using 94.9% enriched target at the 6 MV EN Tandem van de Graaff generator in Uppsala.

**1974PoZR:** <sup>165</sup>Ho( $\alpha$ ,4n $\gamma$ ). Measured E $\gamma$ , I $\gamma$ , level lifetimes by  $\gamma(t)$ .

**1967Co26:** <sup>166</sup>Er(p,2n $\gamma$ ),E(p)=5-17.5 MeV. Measured lifetime of the 81-keV level by (x ray) $\gamma(t)$  and pulsed beam at the Princeton FM cyclotron facility.

The level scheme and bands originally reported by **1972Gi12** have been significantly modified by **1975Fo14**, whose level scheme is adopted in this dataset. Many gamma rays from **1972Gi12** have been reassigned in the level scheme by **1975Fo14**.

<sup>165</sup>Tm Levels

E(level) <sup>†</sup>	J $\pi$ #	T <sub>1/2</sub>	Comments
0.0 <sup>c</sup>	1/2 <sup>+</sup>		
11.93 <sup>d</sup> 21	3/2 <sup>+</sup>		
81.00 <sup>b</sup> 23	7/2 <sup>+</sup>	80 $\mu$ s 3	%IT=100 T <sub>1/2</sub> : (x ray) $\gamma(t)$ in (p,2n $\gamma$ ) ( <b>1967Co26</b> ).
130.20 <sup>c</sup> 10	5/2 <sup>+</sup>		
159.26 <sup>d</sup> 22	7/2 <sup>+</sup>	322 ps 20	T <sub>1/2</sub> : from $\gamma\gamma(t)$ in (p,2n $\gamma$ ) ( <b>1976Sv01</b> ).
161.30 <sup>&amp;</sup> 25	7/2 <sup>-</sup>	9 $\mu$ s	%IT=100 T <sub>1/2</sub> : from ( $\alpha$ ,4n $\gamma$ ) ( <b>1974PoZR</b> ), authors claim that 80.3 $\gamma$ has a component with T <sub>1/2</sub> =80 $\mu$ s, but it is not accounted for in the level scheme.
182.12 <sup>e</sup> 25	5/2 <sup>-</sup>		
211.19 <sup>a</sup> 24	9/2 <sup>+</sup>		
253.3 <sup>@</sup> 3	9/2 <sup>-</sup>		
293.91 <sup>e</sup> 23	9/2 <sup>-</sup>		
362.68 <sup>c</sup> 21	9/2 <sup>+</sup>		
366.74 <sup>b</sup> 25	11/2 <sup>+</sup>		
370.0 <sup>&amp;</sup> 3	11/2 <sup>-</sup>		
414.23 <sup>d</sup> 22	11/2 <sup>+</sup>		
498.37 <sup>e</sup> 23	13/2 <sup>-</sup>		
512.5 <sup>@</sup> 3	13/2 <sup>-</sup>		
545.9 <sup>a</sup> 3	13/2 <sup>+</sup>		
676.6 <sup>&amp;</sup> 3	15/2 <sup>-</sup>		
690.1 <sup>c</sup> 3	13/2 <sup>+</sup>		
747.1 <sup>b</sup> 3	15/2 <sup>+</sup>		
769.44 <sup>d</sup> 25	15/2 <sup>+</sup>		
796.89 <sup>e</sup> 25	17/2 <sup>-</sup>		
867.7 <sup>@</sup> 3	17/2 <sup>-</sup>		
969.0 <sup>a</sup> 4	17/2 <sup>+</sup>		
1074.2 <sup>&amp;</sup> 4	19/2 <sup>-</sup>		
1103.7 <sup>c</sup> 4	17/2 <sup>+</sup>		

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$^{165}\text{Ho}(\alpha,4n\gamma)$  **1972Gi12,1975Fo14** (continued)

$^{165}\text{Tm}$  Levels (continued)

E(level) <sup>†</sup>	J <sup>π</sup> #	E(level) <sup>†</sup>	J <sup>π</sup> #	E(level) <sup>†</sup>	J <sup>π</sup> #	E(level) <sup>†</sup>	J <sup>π</sup> #
1186.5 <sup>e</sup> 3	21/2 <sup>-</sup>	1661.1 <sup>e</sup> 5	25/2 <sup>-</sup>	2213.0 <sup>e</sup> 7	29/2 <sup>-</sup>	2831.7 <sup>e</sup> 9	33/2 <sup>-</sup>
1206.8 <sup>b</sup> 4	19/2 <sup>+</sup>	1730.6 <sup>b</sup> 5	23/2 <sup>+</sup>	2308.5 <sup>b</sup> 6	27/2 <sup>+</sup>	2862.1 <sup>b</sup> 8	31/2 <sup>+</sup>
1217.1 <sup>d</sup> 4	19/2 <sup>+</sup>	1747.3 <sup>d</sup> 6	23/2 <sup>+</sup>	2332.3 <sup>d</sup> 7	27/2 <sup>+</sup>	3019.0 <sup>@</sup> 8	33/2 <sup>-</sup>
1310.8 <sup>@</sup> 4	21/2 <sup>-</sup>	1830.0 <sup>@</sup> 5	25/2 <sup>-</sup>	2411.5 <sup>@</sup> 6	29/2 <sup>-</sup>	3156.3 <sup>‡a</sup> 11	33/2 <sup>+</sup>
1467.9 <sup>a</sup> 5	21/2 <sup>+</sup>	2029.7 <sup>a</sup> 9	25/2 <sup>+</sup>	2624.6 <sup>a</sup> 10	29/2 <sup>+</sup>	3270.7 <sup>&amp;</sup> 8	35/2 <sup>-</sup>
1552.3 <sup>&amp;</sup> 4	23/2 <sup>-</sup>	2099.0 <sup>&amp;</sup> 5	27/2 <sup>-</sup>	2666.3 <sup>c</sup> 9	29/2 <sup>+</sup>	3506.7 <sup>e</sup> 13	37/2 <sup>-</sup>
1591.8 <sup>c</sup> 5	21/2 <sup>+</sup>	2138.4 <sup>c</sup> 8	25/2 <sup>+</sup>	2698.0 <sup>&amp;</sup> 7	31/2 <sup>-</sup>		

<sup>†</sup> From least-squares fit to E<sub>γ</sub> data, assuming Δ(E<sub>γ</sub>)=0.5 or 1 keV when not stated.

<sup>‡</sup> This level is not reported by 2001Je09, instead a 531.5<sub>γ</sub> is assigned in the same band higher up from a 39/2<sup>+</sup> level at 3905. Thus this level is not listed in the Adopted Levels.

# As proposed by 1972Gi12 and 1975Fo14, based on γ(θ) and γ-decay patterns of the members of rotational bands. All assignments are consistent with those in the Adopted Levels, except that some are in parentheses there due to lack of strong supporting arguments.

@ Band(A): π7/2[523],α=+1/2.

& Band(a): π7/2[523],α=-1/2.

<sup>a</sup> Band(B): π7/2[404],α=+1/2.

<sup>b</sup> Band(b): π7/2[404],α=-1/2.

<sup>c</sup> Band(C): π1/2[411],α=+1/2.

<sup>d</sup> Band(c): π1/2[411],α=-1/2.

<sup>e</sup> Band(D): π1/2[541],α=+1/2.

γ( $^{165}\text{Tm}$ )

E <sub>γ</sub> <sup>†</sup>	I <sub>γ</sub> <sup>†</sup>	E <sub>i</sub> (level)	J <sub>i</sub> <sup>π</sup>	E <sub>f</sub>	J <sub>f</sub> <sup>π</sup>	E <sub>γ</sub> <sup>†</sup>	I <sub>γ</sub> <sup>†</sup>	E <sub>i</sub> (level)	J <sub>i</sub> <sup>π</sup>	E <sub>f</sub>	J <sub>f</sub> <sup>π</sup>
<sup>x</sup> 35.4 3	47 15					134.6 1	292 15	293.91	9/2 <sup>-</sup>	159.26	7/2 <sup>+</sup>
<sup>x</sup> 40.9 3	56 20					<sup>x</sup> 139.8 3	12 6				
<sup>x</sup> 41.7 3	59 20					<sup>x</sup> 141.1 3	10 5				
<sup>x</sup> 62.6 1	36 4					142.5 1	185 13	512.5	13/2 <sup>-</sup>	370.0	11/2 <sup>-</sup>
69.1 <sup>@</sup> 1	41 4	81.00	7/2 <sup>+</sup>	11.93	3/2 <sup>+</sup>	147.3 12	19 15	159.26	7/2 <sup>+</sup>	11.93	3/2 <sup>+</sup>
<sup>x</sup> 73.0 1	11 2					155.6 1	70 7	366.74	11/2 <sup>+</sup>	211.19	9/2 <sup>+</sup>
80.3 11	92 10	161.30	7/2 <sup>-</sup>	81.00	7/2 <sup>+</sup>	<sup>x</sup> 160.9 3	10 3				
<sup>x</sup> 81.6 3	7 3					164.2 1	167 20	676.6	15/2 <sup>-</sup>	512.5	13/2 <sup>-</sup>
84.2 1	30 3	498.37	13/2 <sup>-</sup>	414.23	11/2 <sup>+</sup>	<sup>x</sup> 168.6 3	23 5				
<sup>x</sup> 85.3 3	6 2					170.2 2	79 10	182.12	5/2 <sup>-</sup>	11.93	3/2 <sup>+</sup>
92.0 1	100 5	253.3	9/2 <sup>-</sup>	161.30	7/2 <sup>-</sup>	<sup>x</sup> 176.4 3	12 2				
<sup>x</sup> 96.0 3	6 2					179.2 2	36 5	545.9	13/2 <sup>+</sup>	366.74	11/2 <sup>+</sup>
<sup>x</sup> 98.4 2	14 2					<sup>x</sup> 187.8 3	22 4				
<sup>x</sup> 100.0 3	6 2					191.1 1	137 15	867.7	17/2 <sup>-</sup>	676.6	15/2 <sup>-</sup>
<sup>x</sup> 110.1 2	4 1					<sup>x</sup> 197.4 2	27 5				
111.8 2	17 3	293.91	9/2 <sup>-</sup>	182.12	5/2 <sup>-</sup>	201.2 3	25 5	747.1	15/2 <sup>+</sup>	545.9	13/2 <sup>+</sup>
116.7 1	175 22	370.0	11/2 <sup>-</sup>	253.3	9/2 <sup>-</sup>	203.2 4	52 15	362.68	9/2 <sup>+</sup>	159.26	7/2 <sup>+</sup>
118.3 2	89 12	130.20	5/2 <sup>+</sup>	11.93	3/2 <sup>+</sup>	204.4 1	205 25	498.37	13/2 <sup>-</sup>	293.91	9/2 <sup>-</sup>
120.4 2	39 5	414.23	11/2 <sup>+</sup>	293.91	9/2 <sup>-</sup>	206.4 2	115 17	1074.2	19/2 <sup>-</sup>	867.7	17/2 <sup>-</sup>
<sup>x</sup> 122.0 3	16 4					<sup>x</sup> 207.8 3	34 9				
<sup>x</sup> 128.7 2	10 3					208.8 3	28 9	370.0	11/2 <sup>-</sup>	161.30	7/2 <sup>-</sup>
130.2 <sup>&amp;</sup> 1	100 <sup>&amp;</sup> 10	130.20	5/2 <sup>+</sup>	0.0	1/2 <sup>+</sup>	<sup>x</sup> 212.3 3	10 3				
130.2 <sup>&amp;</sup> 1	100 <sup>&amp;</sup> 10	211.19	9/2 <sup>+</sup>	81.00	7/2 <sup>+</sup>	<sup>x</sup> 215.6 3	11 3				

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$^{165}\text{Ho}(\alpha,4n\gamma)$  **1972Gi12,1975Fo14** (continued)

$\gamma(^{165}\text{Tm})$  (continued)

$E_\gamma^\dagger$	$I_\gamma^\dagger$	$E_i(\text{level})$	$J_i^\pi$	$E_f$	$J_f^\pi$
$^{x}217.5\ 3$	8 3				
$^{x}219.1\ 3$	17 4				
$^{x}221.8\ 3$	18 5	969.0	17/2 <sup>+</sup>	747.1	15/2 <sup>+</sup>
$^{x}229.9\ 3$	16 3				
232.5 2	34 5	362.68	9/2 <sup>+</sup>	130.20	5/2 <sup>+</sup>
236.6 2	95 12	1310.8	21/2 <sup>-</sup>	1074.2	19/2 <sup>-</sup>
238 $\frac{3}{2}^{\ddagger}$		1206.8	19/2 <sup>+</sup>	969.0	17/2 <sup>+</sup>
$^{x}239.8\ 3$	10 3				
241.5 2	52 10	1552.3	23/2 <sup>-</sup>	1310.8	21/2 <sup>-</sup>
$^{x}242.8\ 3$	37 7				
251.6 3	17 2	3270.7	35/2 <sup>-</sup>	3019.0	33/2 <sup>-</sup>
255.0 1	133 10	414.23	11/2 <sup>+</sup>	159.26	7/2 <sup>+</sup>
259.1 2	36 5	512.5	13/2 <sup>-</sup>	253.3	9/2 <sup>-</sup>
261.6 5	7 3	1467.9	21/2 <sup>+</sup>	1206.8	19/2 <sup>+</sup>
269.0 2	33 7	2099.0	27/2 <sup>-</sup>	1830.0	25/2 <sup>-</sup>
271.1 2	46 9	769.44	15/2 <sup>+</sup>	498.37	13/2 <sup>-</sup>
275.8 3	48 12	690.1	13/2 <sup>+</sup>	414.23	11/2 <sup>+</sup>
277.7 3	39 10	1830.0	25/2 <sup>-</sup>	1552.3	23/2 <sup>-</sup>
285.8 2	63 10	366.74	11/2 <sup>+</sup>	81.00	7/2 <sup>+</sup>
286.8 5	9 5	2698.0	31/2 <sup>-</sup>	2411.5	29/2 <sup>-</sup>
$^{x}292.6\ 4$	15 3				
$^{x}296.8\ 4$	13 6				
298.5 1	224 18	796.89	17/2 <sup>-</sup>	498.37	13/2 <sup>-</sup>
$^{x}299.6\ 3$	52 8				
306.6 2	93 12	676.6	15/2 <sup>-</sup>	370.0	11/2 <sup>-</sup>
312.2 $\frac{3}{2}^{\ddagger}$		2411.5	29/2 <sup>-</sup>	2099.0	27/2 <sup>-</sup>
$^{x}315.4\ 4$	38 8				
$^{x}317.2\ 5$	17 6				
321.1 5	18 4	3019.0	33/2 <sup>-</sup>	2698.0	31/2 <sup>-</sup>
327.4 3	46 9	690.1	13/2 <sup>+</sup>	362.68	9/2 <sup>+</sup>
334.4 $\&$ 3	113 $\&$ 16	545.9	13/2 <sup>+</sup>	211.19	9/2 <sup>+</sup>
334.4 $\&$ 3	113 $\&$ 16	1103.7	17/2 <sup>+</sup>	769.44	15/2 <sup>+</sup>
$^{x}336.5\ 5$	15 6				
355.2 $\&$ 2	191 $\&$ 16	769.44	15/2 <sup>+</sup>	414.23	11/2 <sup>+</sup>
355.2 $\&$ 2	191 $\&$ 16	867.7	17/2 <sup>-</sup>	512.5	13/2 <sup>-</sup>
$^{x}358.7\ 4$	30 6				
374.7 $\frac{3}{2}^{\ddagger}$		1591.8	21/2 <sup>+</sup>	1217.1	19/2 <sup>+</sup>
$^{x}380.3\ 3$	83 13				
380.3 3	83 13	747.1	15/2 <sup>+</sup>	366.74	11/2 <sup>+</sup>
389.7 2	174 16	1186.5	21/2 <sup>-</sup>	796.89	17/2 <sup>-</sup>
397.6 3	127 19	1074.2	19/2 <sup>-</sup>	676.6	15/2 <sup>-</sup>
403.7 5	25 10	769.44	15/2 <sup>+</sup>	366.74	11/2 <sup>+</sup>
$^{x}409.0\ 5$	28 6				
409.0 5	28 6	1206.8	19/2 <sup>+</sup>	796.89	17/2 <sup>-</sup>
413.2 4	52 13	1103.7	17/2 <sup>+</sup>	690.1	13/2 <sup>+</sup>
420.1 6	29 9	1217.1	19/2 <sup>+</sup>	796.89	17/2 <sup>-</sup>
423.0 4	89 18	969.0	17/2 <sup>+</sup>	545.9	13/2 <sup>+</sup>
438.5 5	48 10	1206.8	19/2 <sup>+</sup>	769.44	15/2 <sup>+</sup>
442.9 4	89 18	1310.8	21/2 <sup>-</sup>	867.7	17/2 <sup>-</sup>
447.4 4	54 11	1217.1	19/2 <sup>+</sup>	769.44	15/2 <sup>+</sup>
459.8 4	79 16	1206.8	19/2 <sup>+</sup>	747.1	15/2 <sup>+</sup>
470.2 7	34 9	1217.1	19/2 <sup>+</sup>	747.1	15/2 <sup>+</sup>

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$^{165}\text{Ho}(\alpha,4n\gamma)$  **1972Gi12,1975Fo14 (continued)** $\gamma(^{165}\text{Tm})$  (continued)

$E_\gamma$ †	$I_\gamma$ †	$E_i(\text{level})$	$J_i^\pi$	$E_f$	$J_f^\pi$
474.7 4	121 20	1661.1	25/2 <sup>-</sup>	1186.5	21/2 <sup>-</sup>
478.3 4	87 17	1552.3	23/2 <sup>-</sup>	1074.2	19/2 <sup>-</sup>
488.1 7	39 10	1591.8	21/2 <sup>+</sup>	1103.7	17/2 <sup>+</sup>
498.6 4	106 20	1467.9	21/2 <sup>+</sup>	969.0	17/2 <sup>+</sup>
519.1 10	65 13	1830.0	25/2 <sup>-</sup>	1310.8	21/2 <sup>-</sup>
523.7 5	45 9	1730.6	23/2 <sup>+</sup>	1206.8	19/2 <sup>+</sup>
527.9 ‡		2666.3	29/2 <sup>+</sup>	2138.4	25/2 <sup>+</sup>
529.3 7	39 12	1747.3	23/2 <sup>+</sup>	1217.1	19/2 <sup>+</sup>
531.7 ‡		3156.3	33/2 <sup>+</sup>	2624.6	29/2 <sup>+</sup>
544 ‡		1730.6	23/2 <sup>+</sup>	1186.5	21/2 <sup>-</sup>
546.6 & 5	77 & 15	2099.0	27/2 <sup>-</sup>	1552.3	23/2 <sup>-</sup>
546.6 &	77 & 15	2138.4	25/2 <sup>+</sup>	1591.8	21/2 <sup>+</sup>
551.9 5	44 10	2213.0	29/2 <sup>-</sup>	1661.1	25/2 <sup>-</sup>
553.6 ‡		2862.1	31/2 <sup>+</sup>	2308.5	27/2 <sup>+</sup>
561.8 & 7	41 & 10	1747.3	23/2 <sup>+</sup>	1186.5	21/2 <sup>-</sup>
561.8 & 7	41 & 10	2029.7	25/2 <sup>+</sup>	1467.9	21/2 <sup>+</sup>
572.8 ‡		3270.7	35/2 <sup>-</sup>	2698.0	31/2 <sup>-</sup>
577.7 ‡		2308.5	27/2 <sup>+</sup>	1730.6	23/2 <sup>+</sup>
581.9 ‡		2411.5	29/2 <sup>-</sup>	1830.0	25/2 <sup>-</sup>
585.1 ‡		2332.3	27/2 <sup>+</sup>	1747.3	23/2 <sup>+</sup>
594.9 ‡ #	48 12	2624.6	29/2 <sup>+</sup>	2029.7	25/2 <sup>+</sup>
598.8 10	50 12	2698.0	31/2 <sup>-</sup>	2099.0	27/2 <sup>-</sup>
606.5 10	28 7	3019.0	33/2 <sup>-</sup>	2411.5	29/2 <sup>-</sup>
<sup>x</sup> 616.1 10	12 3				
618.7 ‡	20 5	2831.7	33/2 <sup>-</sup>	2213.0	29/2 <sup>-</sup>
647.6 ‡		2308.5	27/2 <sup>+</sup>	1661.1	25/2 <sup>-</sup>
671 ‡		2332.3	27/2 <sup>+</sup>	1661.1	25/2 <sup>-</sup>
675 ‡		3506.7	37/2 <sup>-</sup>	2831.7	33/2 <sup>-</sup>

† From 1972Gi12, unless otherwise stated.

‡ This  $\gamma$  reported only by 1975Fo14.

# 631 in level-scheme Fig. 4 of 1972Gi12.

@ Mult=E1 suggested by 1967Co26 from  $\alpha(K)\text{exp}=0.95$  from  $I(x\text{ ray})/I(69\gamma)$ ; but the band assignments suggest E2.

& Multiply placed with undivided intensity.

<sup>x</sup>  $\gamma$  ray not placed in level scheme.

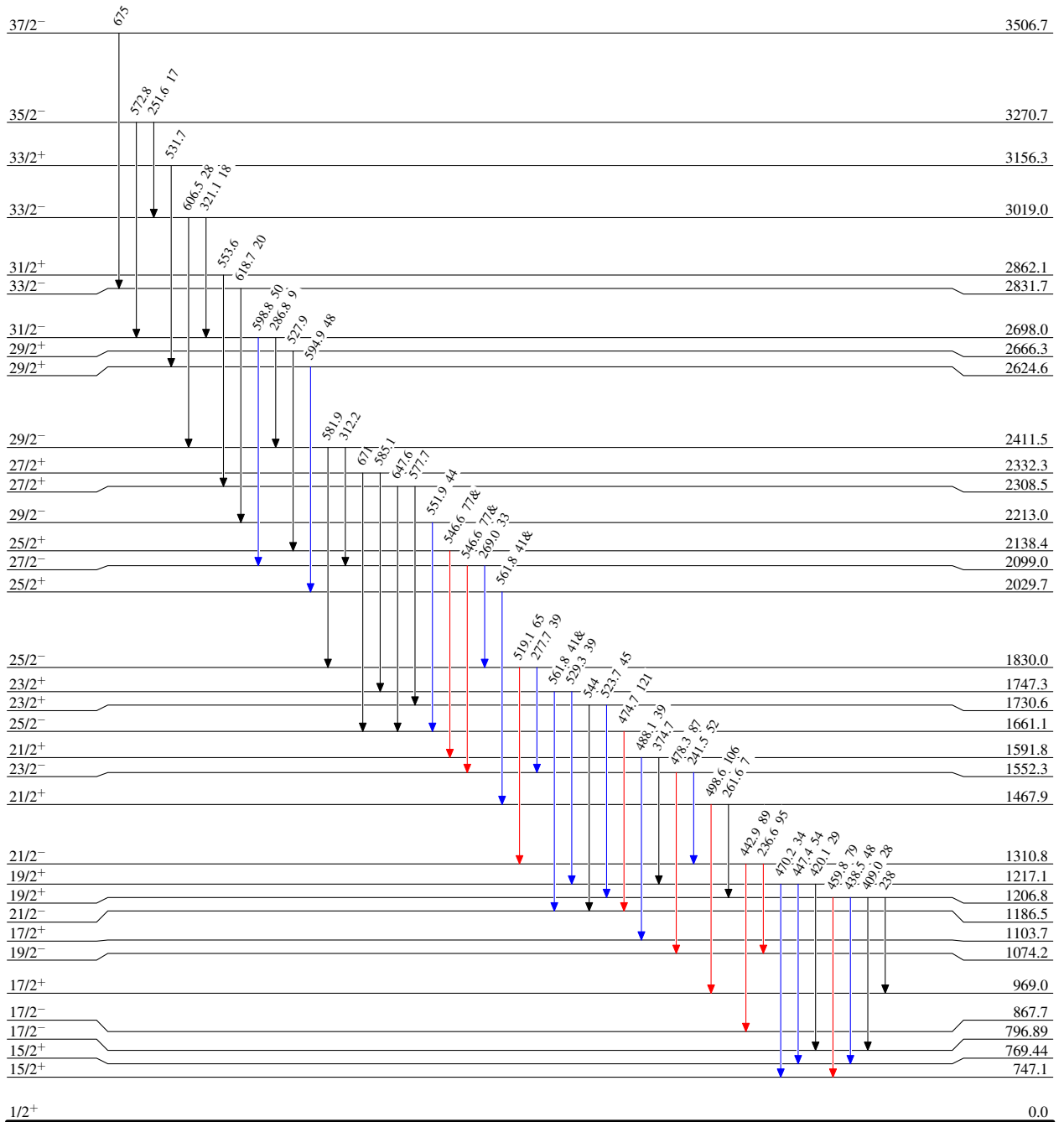
$^{165}\text{Ho}(\alpha,4n\gamma)$  1972Gi12,1975Fo14

Level Scheme

Intensities: Relative  $I_\gamma$   
& Multiply placed: undivided intensity given

Legend

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



$^{165}_{69}\text{Tm}_{96}$

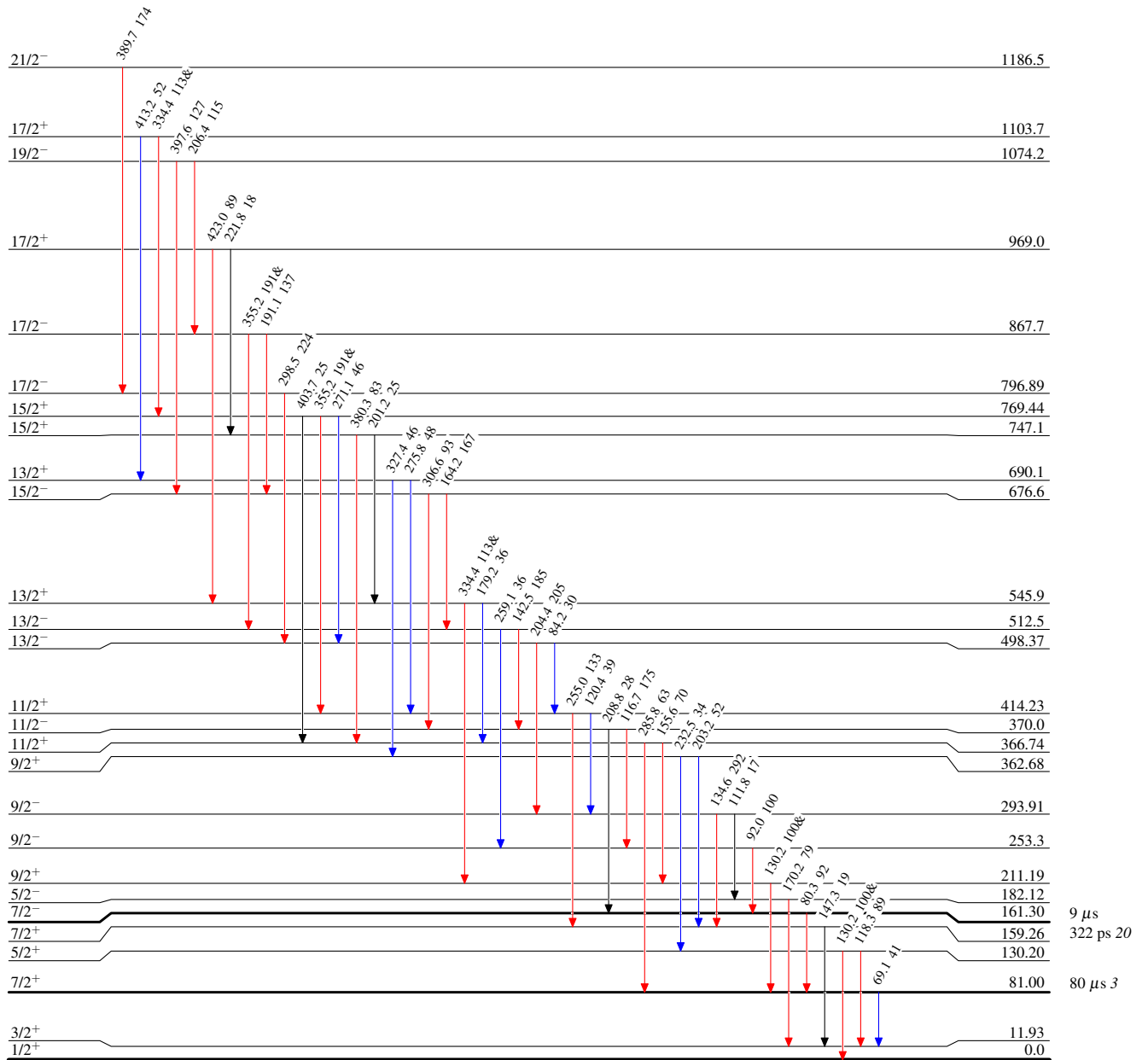
$^{165}\text{Ho}(\alpha,4n\gamma)$  1972Gi12,1975Fo14

Level Scheme (continued)

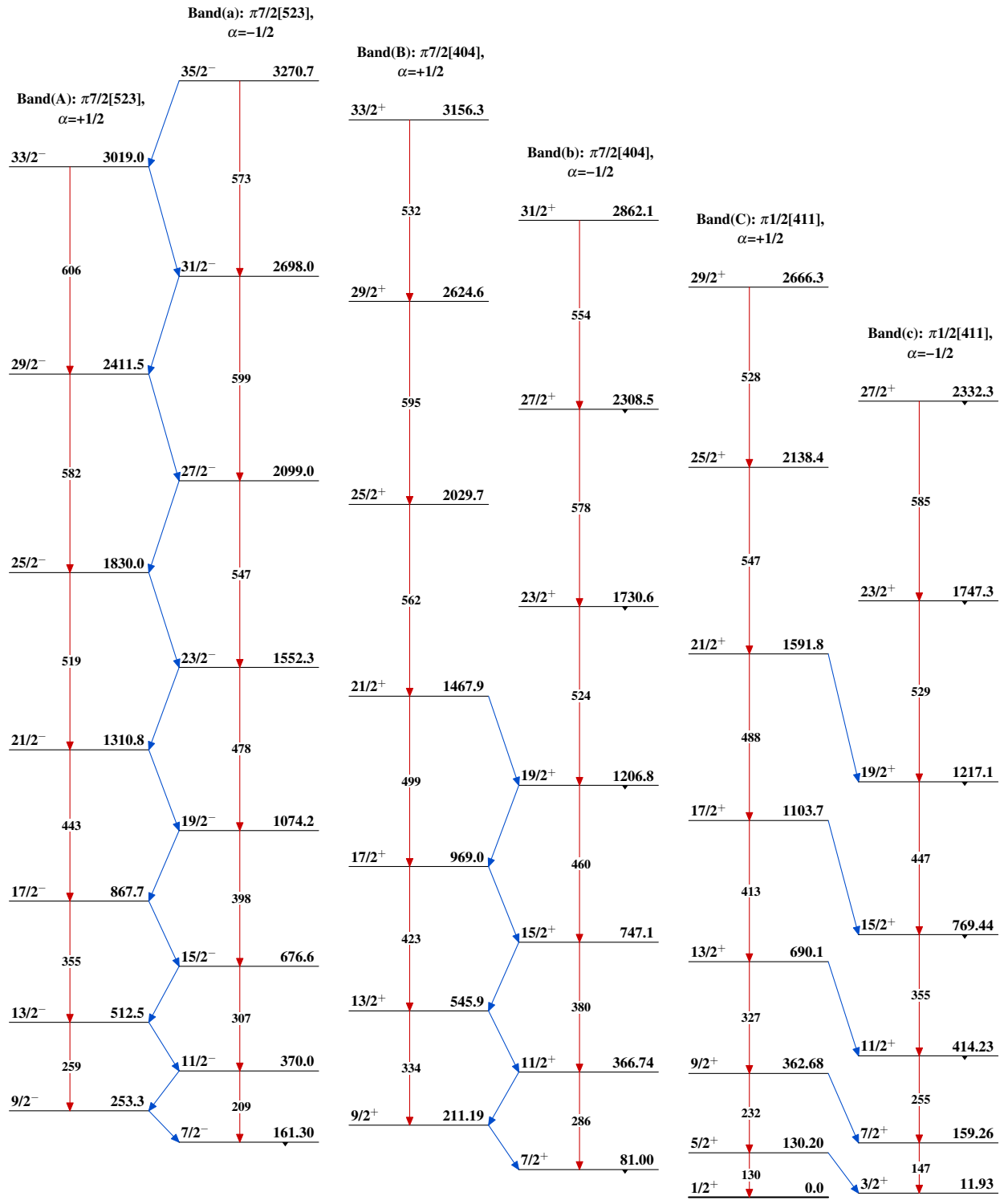
Intensities: Relative  $I_\gamma$   
& Multiply placed: undivided intensity given

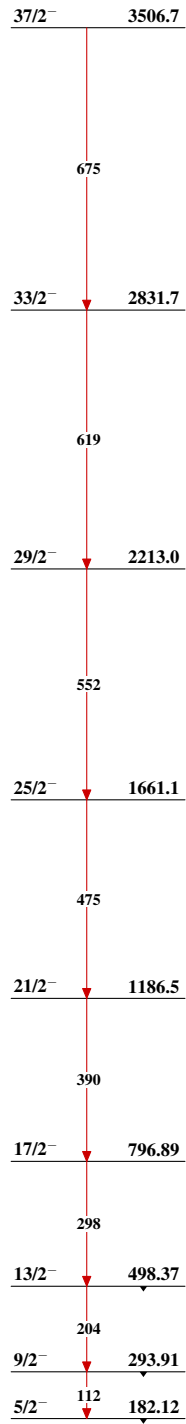
Legend

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



$^{165}\text{Tm}_{96}$

$^{165}\text{Ho}(\alpha,4n\gamma)$  1972Gi12,1975Fo14 $^{165}\text{Tm}_{96}$

$^{165}\text{Ho}(\alpha,4n\gamma)$  1972Gi12,1975Fo14 (continued)Band(D):  $\pi 1/2[541]$ ,  
 $\alpha = +1/2$  $^{165}_{69}\text{Tm}_{96}$