

¹⁴¹Pr(¹⁶O,3nγ) 2013Mo35,1994Ch50

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	N. Nica	NDS 200,2 (2025)	22-Aug-2022

2013Mo35 compiled for XUNDL database by C.D. Nesaraja (ORNL) and B. Singh (McMaster).

1994Ch50: E(¹⁶O)=67, 70, 73, 75 and 77 MeV on natural Pr target. Measured γ's with Tsukuba "ball" of six Compton-suppressed Ge detectors and determined excitation functions and DCO ratios, defined as I_γ(0°)/I_γ(117°). Only the E_γ and γ placements are reported.

2013Mo35: E(¹⁶O)=75 MeV beam from 12UD pelletron accelerator at University of Tsukuba, self supporting natural Pr target 2.7-mg/cm² thick. Measured E_γ, I_γ, γγ-coin, γγ(θ)(DCO) using the 11 HPGe detector array with BGO anti-Compton shields and low energy photon spectrometer (LEPS).

2013Mo35 and 1994Ch50 are related (same lab and common authors) which are in very good agreement. Data and level scheme are from 2013Mo35.

¹⁵⁴Ho Levels

E(level) [†] f	J ^π g	T _{1/2} [#]	Comments
0+x	8 ⁺	3.10 min 14	%ε+%β ⁺ =100 Additional information 1.
18.8+x 4			
20.9+x 3			
58.7+x 3	(7)		
213.3+x 3			
285.0+x @ 2	9 ⁺		
339.3+x & 2	10 ⁺		
521.7+x b 4	11 ⁻		
701.7+x 5			
814.2+x a 5	12 ⁻		
854.1+x @ 4	11 ⁺		
890.4+x & 4	12 ⁺		
1097.0+x b 5	13 ⁻		
1198.4+x 5			
1376.2+x a 5	14 ⁻		
1453.8+x @ 5	13 ⁺		
1475.6+x & 5	14 ⁺		
1687.0+x b 5	15 ⁻		
1728.4+x 5			
1868.5+x 5	(14 ⁺)		
1973.4+x a 5	16 ⁻		
2187.0+x 5	(16 ⁻)		
2229.9+x & 6	16 ⁺		
2270.4+x @ 6	15 ⁺		
2302.3+x b 5	17 ⁻		
2385.4+x c 5	18 ⁻		
2439.3+x 5			
2446.2+x 6	(16 ⁺)		
2641.7+x a 5	18 ⁻		
2741.6+x d 6	19 ⁻		
3058.3+x & 6	18 ⁺		
3072.4+x b 6	19 ⁻		
3169.9+x 6	(18 ⁺)		
3217.4+x c 6	20 ⁻		

Continued on next page (footnotes at end of table)

$^{141}\text{Pr}(^{16}\text{O},3\text{n}\gamma)$ **2013Mo35,1994Ch50 (continued)** ^{154}Ho Levels (continued)

E(level) ^{†f}	J^{π} ^{‡g}	Comments
3396.6+x ^a 6	20 ⁻	
3454.8+x 7	(20 ⁺)	
3458.0+x 6	20 ⁻	
3638.4+x ^d 6	21 ⁻	
3640.4+x 7	(21 ⁺)	
3849.8+x ^b 6	21 ⁻	
3997.1+x ^c 6	22 ⁻	
4070.8+x 8	(22 ⁺)	
4299.8+x 6	22 ⁻	
4414.1+x ^d 7	23 ⁻	
4552.8+x 8	(23 ⁺)	
4632.4+x ^b 7	23 ⁻	
4760.3+x ^c 7	24 ⁻	
4930.0+x 8	(24 ⁺)	
5171.6+x ^d 7	25 ⁻	
5212.8+x 8	(24 ⁺)	
5215.9+x 7	25 ⁻	
5349.0+x 8	(25 ⁺)	
5436.7+x ^e 7	27 ⁻	
5859.7+x 8	(26 ⁺)	
5998.6+x ^e 8	28	
6351.9+x 9	(27)	J ^π : from level-scheme figure 2 in 2013Mo35 , not listed in authors' table II.
6454.8+x 8		
6677.0+x 8	27 ⁻	
6882.3+x ^e 8	30	
7453.9+x ^e 9	32	

[†] From least-squares fit to E γ data (18.8 and 20.9 keV unobserved γ rays not used by fitting procedure).

[‡] Adopted by [2013Mo35](#) (can be different from Adopted Levels J^{π} 's) based on DCO multipolarity measurements, assigned configurations and systematic behaviors of neighboring isotopes and isotones, as well as the fact that spin values are generally increasing with excitation energy for heavy-ion induced reactions. According to [2013Mo35](#) J^{π} 's for the bandheads of the first four bands are consistent with those for the similar collective bands observed in heavier odd-odd isotopes and odd-odd ^{152}Tb . Specific arguments were made explicit by evaluator.

From Adopted Levels of ^{154}Ho as quoted by [2013Mo35](#).

@ Band(A): $\pi h_{11/2} \otimes \nu f_{7/2}$ band.

& Band(B): $\pi h_{11/2} \otimes \nu h_{9/2}$ band.

^a Band(C): $\pi h_{11/2} \otimes \nu i_{13/2}$ band, $\alpha=0$.

^b Band(c): $\pi h_{11/2} \otimes \nu i_{13/2}$ band, $\alpha=1$.

^c Band(D): Band based on 18⁻.

^d Band(E): Band based on 19⁻.

^e Seq.(F): γ cascade based on 27⁻.

^f g.s. is not populated in this reaction.

^g from Adopted Levels of ^{154}Ho in ENSDF database.

$^{141}\text{Pr}(^{16}\text{O},3n\gamma)$ **2013Mo35,1994Ch50 (continued)**

$\gamma(^{154}\text{Ho})$

DCO ratios for 37° (or 143°) and 79° (or 101°) geometry with gates set only on stretched quadrupole transitions. Expected DCO ratios: ≈ 1 for $\Delta J=2$, stretched quadrupole transitions; ≈ 0.6 for $\Delta J=1$, stretched dipole transition, and ≈ 0.5 -2.5 for $\Delta J=1$, mixed dipole-quadrupole transition, depending on value of mixing ratio δ : 0.5 for $\delta=-1.0$ and 2.5 for $\delta=1.0$ (with no explicit δ values extracted).

E_γ [†]	I_γ [‡]	$E_i(\text{level})$	J_i^π	E_f	J_f^π	Mult. [#]	Comments
(18.8)		18.8+x		0+x	8 ⁺		
(20.9)		20.9+x		0+x	8 ⁺		
54.3 3	8@ 2	339.3+x	10 ⁺	285.0+x	9 ⁺	D(+Q)	DCO=0.66 5
58.7 3		58.7+x	(7)	0+x	8 ⁺		
71.7 3	1.0@ 3	285.0+x	9 ⁺	213.3+x			
83.1 3	<0.5	2385.4+x	18 ⁻	2302.3+x	17 ⁻		
101.4 3		1198.4+x		1097.0+x	13 ⁻		
136.2 3	<0.5	5349.0+x	(25 ⁺)	5212.8+x	(24 ⁺)		
154.6 3	7@ 2	213.3+x		58.7+x	(7)		
180.0 3		701.7+x		521.7+x	11 ⁻		
182.4 3	100 15	521.7+x	11 ⁻	339.3+x	10 ⁺	D(+Q)	DCO=0.71 1
185.6 3	5 2	3640.4+x	(21 ⁺)	3454.8+x	(20 ⁺)	D(+Q)	DCO=0.53 3
192.4 3	22@ 2	213.3+x		20.9+x		D+Q	DCO=0.70 5
198.4 3	<0.5	2385.4+x	18 ⁻	2187.0+x	(16 ⁻)		DCO=0.56 10 Mult.: D(+Q) based on DCO value; 2013Mo35 adopted Q.
216.3 3	<0.5	2446.2+x	(16 ⁺)	2229.9+x	16 ⁺		
220.8 3	<0.5	5436.7+x	27 ⁻	5215.9+x	25 ⁻	E2	DCO=1.14 8
252.3 3	<0.5	2439.3+x		2187.0+x	(16 ⁻)	(M1+E2)	DCO=0.85 8
264.1 3	10@ 3	285.0+x	9 ⁺	20.9+x		D(+Q)	DCO=0.71 10
265.1 3	1.5 5	5436.7+x	27 ⁻	5171.6+x	25 ⁻	E2	DCO=0.96 12
266.2 3	44@ 4	285.0+x	9 ⁺	18.8+x		D+Q	DCO=0.69 2
279.2 3	18 3	1376.2+x	14 ⁻	1097.0+x	13 ⁻	D	DCO=0.66 3
282.8 3	<0.5	5212.8+x	(24 ⁺)	4930.0+x	(24 ⁺)		
285.0 3	9 2	285.0+x	9 ⁺	0+x	8 ⁺		
286.4 3	21 3	1973.4+x	16 ⁻	1687.0+x	15 ⁻	D(+Q)	DCO=0.68 2
292.5 3	14 2	814.2+x	12 ⁻	521.7+x	11 ⁻	D(+Q)	DCO=0.70 6
318.4 3	100@ 10	339.3+x	10 ⁺	20.9+x		D	DCO=0.63 2
324.2 3	0.10 3	3396.6+x	20 ⁻	3072.4+x	19 ⁻	D(+Q)	DCO=0.74 15
339.3 3	16@ 2	339.3+x	10 ⁺	0+x	8 ⁺	(E2)	DCO=0.80 5
339.4 3	2.0 6	2641.7+x	18 ⁻	2302.3+x	17 ⁻	D	DCO=0.61 6
346.2 3	1.0 3	4760.3+x	24 ⁻	4414.1+x	23 ⁻	D(+Q)	DCO=0.56 20
356.2 3	24 4	2741.6+x	19 ⁻	2385.4+x	18 ⁻	D(+Q)	DCO=0.69 2
358.7 3	1.0 3	3997.1+x	22 ⁻	3638.4+x	21 ⁻	D(+Q)	DCO=0.55 25
377.2 3	1.0 3	4930.0+x	(24 ⁺)	4552.8+x	(23 ⁺)	(M1+E2)	DCO=0.76 8
384.2 3	0.6 2	1198.4+x		814.2+x	12 ⁻		
392.9 3	1.0 3	1868.5+x	(14 ⁺)	1475.6+x	14 ⁺	E2	DCO=1.03 10
412.0 3	38 6	2385.4+x	18 ⁻	1973.4+x	16 ⁻	E2	DCO=0.99 1
430.4 3	1.8 5	4070.8+x	(22 ⁺)	3640.4+x	(21 ⁺)	D(+Q)	DCO=0.56 7
455.6 3	0.8 2	5215.9+x	25 ⁻	4760.3+x	24 ⁻	(M1+E2)	DCO=0.70 25
458.6 3	1.0 3	2187.0+x	(16 ⁻)	1728.4+x			
465.9 3	<0.5	2439.3+x		1973.4+x	16 ⁻		E_γ : from level-energy difference. $E_\gamma=456.9$ listed in table II of 2013Mo35 seems a misprint.
475.8 3	<0.5	3217.4+x	20 ⁻	2741.6+x	19 ⁻	(M1+E2)	DCO=0.73 8
492.2 3	<0.5	6351.9+x	(27)	5859.7+x	(26 ⁺)		
496.7 3		1198.4+x		701.7+x			
500.0 3	3 1	2187.0+x	(16 ⁻)	1687.0+x	15 ⁻	(M1+E2)	DCO=0.78 7

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¹⁴¹Pr(¹⁶O,3n γ) **2013Mo35,1994Ch50** (continued)

$\gamma(^{154}\text{Ho})$ (continued)

E_γ †	I_γ ‡	$E_i(\text{level})$	J_i^π	E_f	J_f^π	Mult. #	Comments
510.7 3	<0.5	5859.7+x	(26 ⁺)	5349.0+x	(25 ⁺)	(M1+E2)	DCO=0.78 10
530.0 3		1728.4+x		1198.4+x			E_γ : from level-scheme figure 2, not listed in authors' table II.
551.1 3	11 2	890.4+x	12 ⁺	339.3+x	10 ⁺	E2	DCO=1.06 5
561.9 3	<0.5	5998.6+x	28	5436.7+x	27 ⁻	D(+Q)	DCO=0.64 10
562.0 3	10 3	1376.2+x	14 ⁻	814.2+x	12 ⁻	E2	DCO=1.00 3
569.1 3	5 2	854.1+x	11 ⁺	285.0+x	9 ⁺	(E2)	DCO=0.83 10
571.6 3	<0.5	7453.9+x	32	6882.3+x	30	E2	DCO=1.03 15
575.3 3	77 12	1097.0+x	13 ⁻	521.7+x	11 ⁻	E2	DCO=1.01 1
585.2 3	6 2	1475.6+x	14 ⁺	890.4+x	12 ⁺	E2	DCO=0.99 3
							Initial level $J^\pi=14^-$ listed in table II of 2013Mo35 is a misprint.
590.0 3	48 7	1687.0+x	15 ⁻	1097.0+x	13 ⁻	E2	DCO=1.02 1
597.2 3	17 3	1973.4+x	16 ⁻	1376.2+x	14 ⁻	E2	DCO=1.01 2
599.7 3	5 2	1453.8+x	13 ⁺	854.1+x	11 ⁺	E2	DCO=1.01 5
615.3 3	11 2	2302.3+x	17 ⁻	1687.0+x	15 ⁻	(E2)	DCO=0.98 2
646.9 3	<0.5	5859.7+x	(26 ⁺)	5212.8+x	(24 ⁺)	(E2)	DCO=0.8 3
660.0 3	<0.5	5212.8+x	(24 ⁺)	4552.8+x	(23 ⁺)	(M1+E2)	DCO=0.75 21
668.3 3	2.0 6	2641.7+x	18 ⁻	1973.4+x	16 ⁻	(E2)	DCO=0.98 12
676.7 3	1.0 3	1198.4+x		521.7+x	11 ⁻		
687.0 3	<0.5	3072.4+x	19 ⁻	2385.4+x	18 ⁻	D(+Q)	DCO=0.6 4
713.2 3	11 2	3454.8+x	(20 ⁺)	2741.6+x	19 ⁻	(E1)	DCO=0.54 2
							Mult.: D interpreted by 2013Mo35 as (E1) from comparison with 279.2 γ , 286.4 γ , and 356.2 γ known (M1(+E2)) transitions with DCO=0.65–0.69 (2013Mo35).
754.3 3	2.0 6	2229.9+x	16 ⁺	1475.6+x	14 ⁺	E2	DCO=1.01 10
754.9 3	1.0 3	3396.6+x	20 ⁻	2641.7+x	18 ⁻	(E2)	DCO=0.88 9
757.5 3	3 1	5171.6+x	25 ⁻	4414.1+x	23 ⁻	(E2)	DCO=0.91 7
763.2 3	0.6 2	4760.3+x	24 ⁻	3997.1+x	22 ⁻	(E2)	DCO=1.0 3
770.1 3	2.0 6	3072.4+x	19 ⁻	2302.3+x	17 ⁻	(E2)	DCO=0.92 7
775.7 3	5 2	4414.1+x	23 ⁻	3638.4+x	21 ⁻	(E2)	DCO=0.88 5
777.4 3	1.0 3	3849.8+x	21 ⁻	3072.4+x	19 ⁻	(E2)	DCO=0.88 5
779.7 3	1.0 3	3997.1+x	22 ⁻	3217.4+x	20 ⁻	(E2)	DCO=0.87 10
782.6 3	1.0 3	4632.4+x	23 ⁻	3849.8+x	21 ⁻	(E2)	DCO=0.89 12
796.2 3	0.5 2	5349.0+x	(25 ⁺)	4552.8+x	(23 ⁺)	E2	DCO=1.2 4
810.8 3	2.0 6	2187.0+x	(16 ⁻)	1376.2+x	14 ⁻	E2	DCO=1.07 8
816.2 3	1.0 3	3458.0+x	20 ⁻	2641.7+x	18 ⁻	(E2)	DCO=0.85 7
816.6 3	<0.5	2270.4+x	15 ⁺	1453.8+x	13 ⁺	(E2)	DCO=1.2 4
828.4 3	2.0 6	3058.3+x	18 ⁺	2229.9+x	16 ⁺	E2	DCO=1.02 7
832.0 3	0.3 1	3217.4+x	20 ⁻	2385.4+x	18 ⁻		
841.8 3	2.0 6	4299.8+x	22 ⁻	3458.0+x	20 ⁻	E2	DCO=1.01 8
859.2 3	0.3 1	4930.0+x	(24 ⁺)	4070.8+x	(22 ⁺)	E2	DCO=1.0 4
883.7 3	<0.5	6882.3+x	30	5998.6+x	28	(E2)	DCO=1.20 15
896.8 3	9 3	3638.4+x	21 ⁻	2741.6+x	19 ⁻	(E2)	DCO=0.93 3
912.4 3	2.7 8	4552.8+x	(23 ⁺)	3640.4+x	(21 ⁺)	(E2)	DCO=1.15 7
940.0 3	<0.5	3169.9+x	(18 ⁺)	2229.9+x	16 ⁺	(E2)	DCO=1.1 4
970.6 3	<0.5	2446.2+x	(16 ⁺)	1475.6+x	14 ⁺	(E2)	DCO=1.1 4
978.1 3		1868.5+x	(14 ⁺)	890.4+x	12 ⁺	(E2)	DCO=0.88 26
1018.1 3	<0.5	6454.8+x		5436.7+x	27 ⁻		
1072.6 3	2.0 6	3458.0+x	20 ⁻	2385.4+x	18 ⁻	E2	DCO=0.93 6
1240.3 3	<0.5	6677.0+x	27 ⁻	5436.7+x	27 ⁻	(E2)	DCO=0.92 20

† Uniform uncertainty of 0.3 keV is assigned by **2013Mo35** for all reported γ -ray energies.

 ${}^{141}\text{Pr}({}^{16}\text{O},3n\gamma)$ [2013Mo35,1994Ch50](#) (continued) $\gamma({}^{154}\text{Ho})$ (continued)

‡ Values are normalized to 100 for 182.4-keV γ ray, unless otherwise stated. According to [2013Mo35](#) uncertainties are <15% for transitions with $I_\gamma > 10$, and <30% for weaker ones (authors' Table II), and respectively <10% and <25% (authors' Table I), quantified by evaluator as 10% or 15% for $I_\gamma > 10$, and 25% or 30% for weaker transitions.

Adopted by evaluator based on the DCO results from [2013Mo35](#). For Q (quadrupole) transitions the E2 character was adopted, while for D (dipole) transitions no definite (E1) or (M1) character is adopted unless extra arguments are given by authors. Mixed D+Q transitions are assigned the tentative (M1+E2) character ((E1+M2) being less likely). Unless mentioned otherwise transitions are stretched.

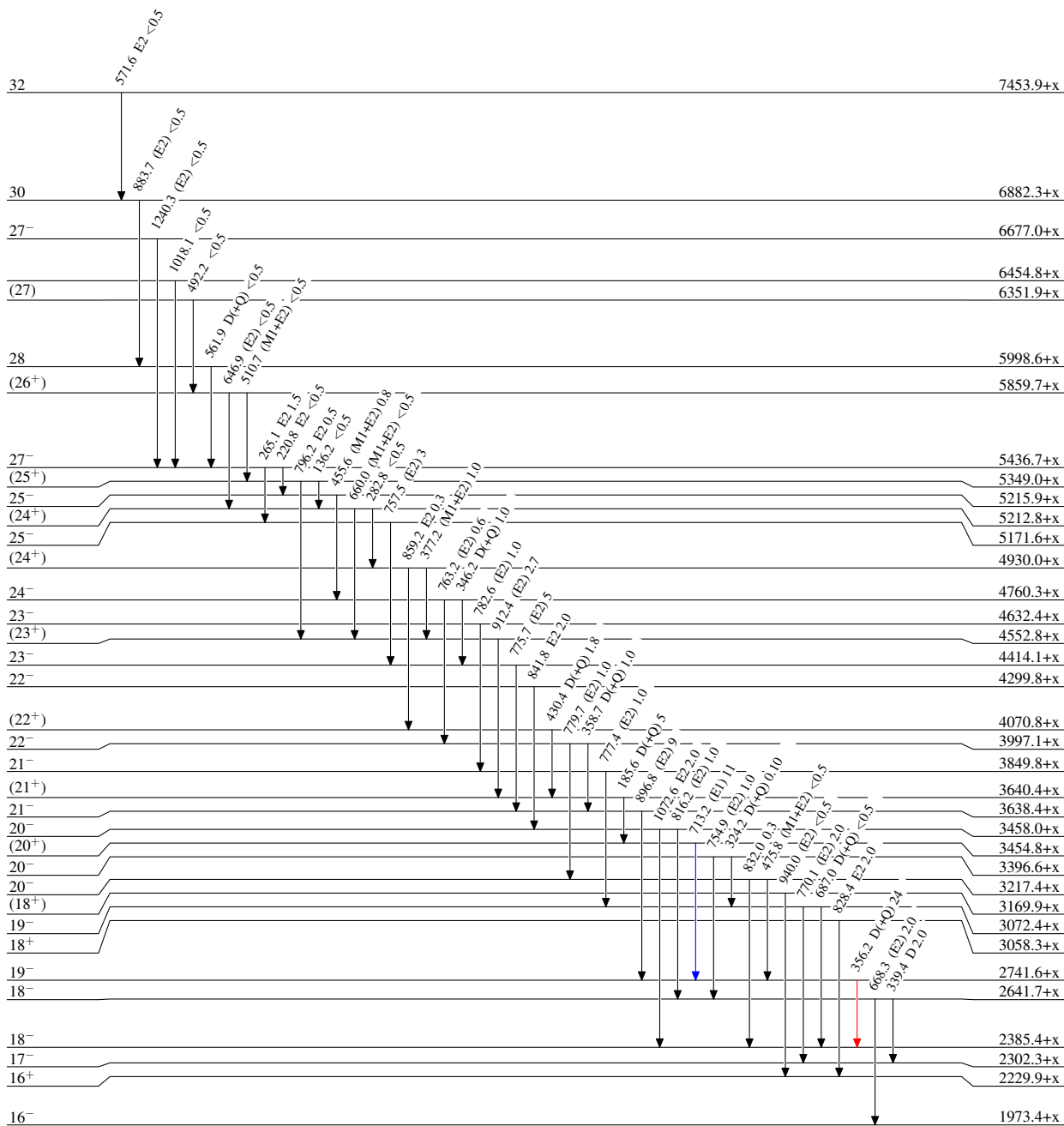
@ Values are normalized to 100 for 318.4-keV γ ray.

$^{141}\text{Pr}(^{16}\text{O},3n\gamma)$ 2013Mo35,1994Ch50

Level Scheme
Intensities: Relative I_γ

Legend

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



$^{154}_{67}\text{Ho}_{87}$

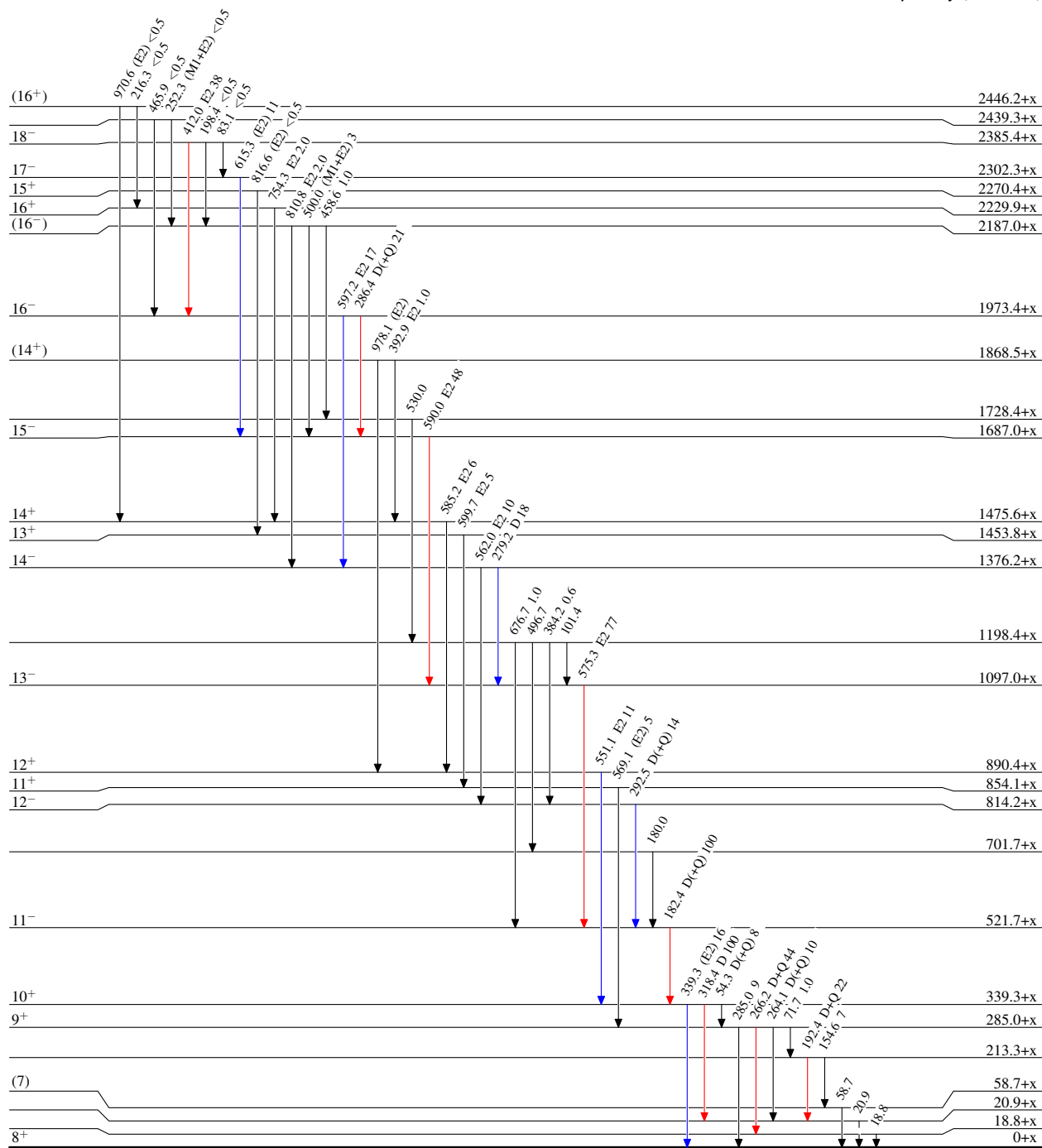
$^{141}\text{Pr}(^{16}\text{O},3n\gamma)$ 2013Mo35,1994Ch50

Legend

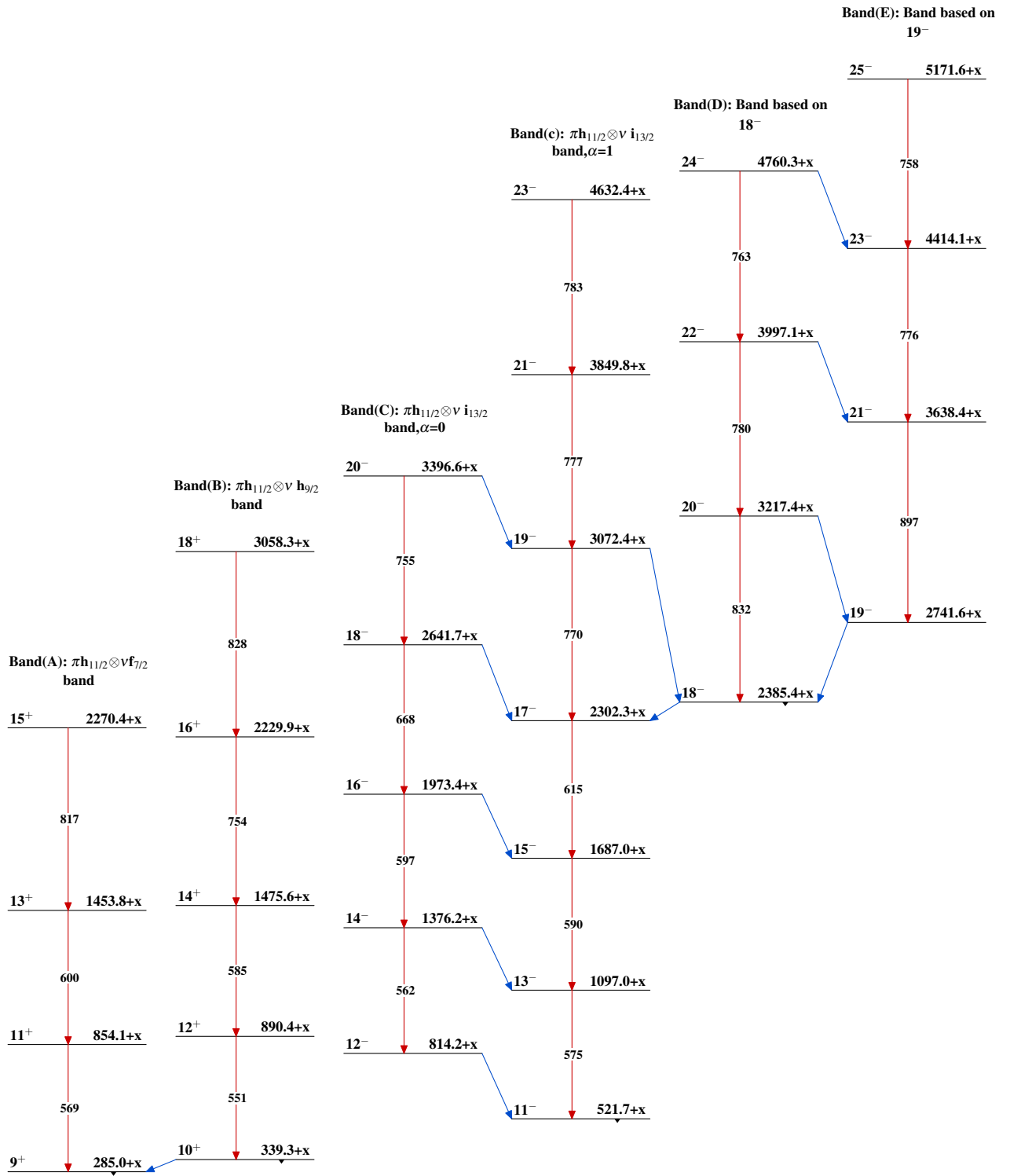
Level Scheme (continued)

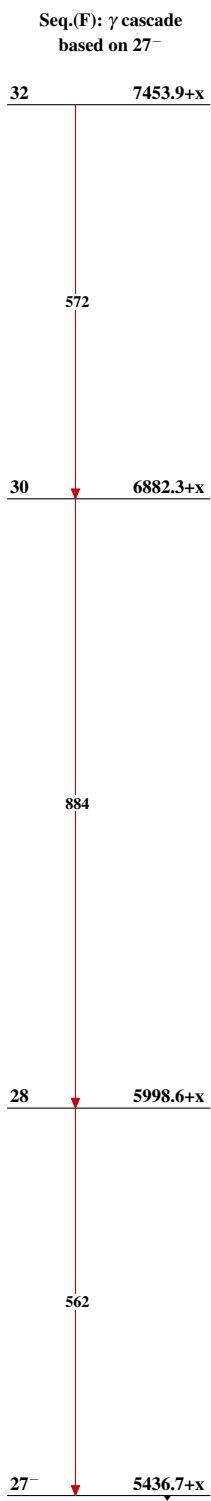
Intensities: Relative I_γ

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



3.10 min 14

$^{141}\text{Pr}(^{16}\text{O},3n\gamma)$ 2013Mo35,1994Ch50 $^{154}_{67}\text{Ho}_{87}$

$^{141}\text{Pr}(^{16}\text{O},3n\gamma)$ 2013Mo35,1994Ch50 (continued) $^{154}_{67}\text{Ho}_{87}$