^{180}Hf(n,n′γ) 1983Gr30,1991Gr19,1979Bo43

History			
Type	Author	Citation	Literature Cutoff Date
Full Evaluation	E. A. Mccutchan	NDS 126, 151 (2015)	1-Feb-2015

1991Gr19, 1983Gr30, 1979Bo43: E(n)=fast. Measured Eγ, Iγ, γ(θ) at 90°, 110°, 125°, 135°, and 140° using a Ge(Li) detector.
All three papers are by similar authors, thus, the evaluator considers the results of 1991Gr19 to supercede those given in 1983Gr30 and 1979Bo43.
Others: 1969Hi03, 1978Si13, 1981Ko32, 1991GrZW, 1991GrZX, 2004Sh37, 2011Se12.
Additional information 1.

^{180}Hf Levels

The levels at 1107.2, 1164.2, 1192.6, and 1381.6 keV proposed in (n,γ), E=thermal were not observed by 1983Gr30. They place limits on the depopulating transition intensities of 1107-keV level: 1014γ, Iγ<7; 1164-keV level: 1071γ, Iγ<3; 1193-keV level: 552γ, Iγ<1, 885γ, Iγ<1.5; 1382-keV level: 1073γ, Iγ<3.

E(level)†	Jπ‡	Comments
0.0	0^+	
93.41 *10*	2^+	
308.67 *18*	4^+	
640.92 *25*	6^+	
1084.0 *4*	8^+	
1102.0 *5*	0^+	Jπ: from isotropic γ(θ) for 1009γ.
1183.1 *4*	2^+	
1199.83 *24*	2^+	
1291.77 *25*	3^+	
1300.3 *4*	(1^-)	Jπ: from 1991Gr19 based on γ(θ) decomposed for the 1299γ, 1300γ, 1301γ triplet. $J^\pi=2^+$ from 1983Gr30 based on γ(θ) for single 1301γ.
1315.8 *5*	0^+	Jπ: from isotropic γ(θ) for 1222γ.
1354.1 *5*	(2^-)	Jπ: γ(θ) would also allow $J^\pi=2^+$. See comment on 1260.7γ.
1369.5 *4*	4^+	
1373.7 *3*	(3^-)	Jπ: from γ(θ) in 1983Gr30. $J^\pi=4^-$ from γ(θ) in 1991Gr19 is inconsistent with 1281.5γ to 2^+.
1409.4 *4*	4^+	
1409.4 *4*	2^+	
1430.7 *6*	3^-	
1482.4 *10*	3^-	
1484.4 *10*	4^+	
1510.0? *5*		
1540.1 *6*	$(3^-,4^+)$	
1557.5 *4*	5^+	
1597.7? *10*	4^+	
1608.13 *25*	4^+	
1608.9 *3*	3^-	Jπ: from γ(θ) in 1983Gr30. $J^\pi=5^-$ from γ(θ) in 1991Gr19 is inconsistent with 410γ to 2^+.
1611.8 *4*	4^-	
1633.7 *3*	(3^+)	Jπ: γ(θ) gives J≥2; no observed γ-rays to the ground state band suggests J=3.
1637.2 *8*	2^+	
1687.0 *8*		
1700.3? *7*	6^+	
1724.7 *4*	2^+	
1725.4 *4*	6^+	
1742.8? *10*	5^+	
1743.0? *10*	2^+	
1820.0 *3*	3^-	
1861.8 *9*	(5^+)	Jπ: from rotational band assignment for levels built on the $J^\pi=(3^+)$ 1633-keV level.
1904.2 *6*		

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^{180}Hf(n,n′γ) 1983Gr30,1991Gr19,1979Bo43 (continued)

^{180}Hf Levels (continued)

E(level)[†]
1926.4 *8*
1948.6 *8*
2075.4 *8*
2082.7? *10*
2389.0 *6*

[†] From a least-squares fit to Eγ by evaluator.
[‡] From γ(θ), γ-ray decay pattern and assumed rotational structure as proposed in 1991Gr19 and 1983Gr30. Specific arguments, when given by the authors, are included in the comments.

γ(^{180}Hf)

E_γ[†]	I_γ[†]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡]	δ[‡]	Comments
93.4 *1*	2.0×10^3 *5*	93.41	2$^+$	0.0	0$^+$			
x204.5 *3*	22 *10*							
208.5 *3*	15 *6*	1820.0	3$^-$	1611.8	4$^-$			
215.3 *2*	1.40×10^3 *15*	308.67	4$^+$	93.41	2$^+$	E2		
224.1 *8*	9 *4*	1633.7	(3$^+$)	1409.4	4$^+$			
235.0 *2*	59 *8*	1608.9	3$^-$	1373.7	(3$^-$)	M1+E2		δ: −0.4 *1* or >25 (1983Gr30); +0.09 *3* or −15 *+10−5* (1991Gr19).
238.7 *4*	6 *2*	1611.8	4$^-$	1373.7	(3$^-$)			
x243.2 *7*	3 *2*							
266.1 *7*	1.7 *8*	1557.5	5$^+$	1291.77	3$^+$			
x292.5 *4*	7 *4*							
x304.0 *4*	25 *5*							
316.6 *3*	25 *5*	1608.13	4$^+$	1291.77	3$^+$			
332.0 *2*	140 *15*	640.92	6$^+$	308.67	4$^+$	E2		
342.3 *3*	20 *5*	1633.7	(3$^+$)	1291.77	3$^+$			
x344.9 *3*	27 *5*							
346 *1*	10 *5*	1637.2	2$^+$	1291.77	3$^+$			
x352.7 *4*	6 *2*							
x357.5 *7*	6 *2*							
x366.4 *4*	4 *2*							
408.0 *2*	54 *8*	1608.13	4$^+$	1199.83	2$^+$	E2		
410.2 *5*	5 *2*	1608.9	3$^-$	1199.83	2$^+$			
x421.1 *3*	15 *5*							
433.7& *2*	45& *10*	1633.7	(3$^+$)	1199.83	2$^+$	M1+E2	+0.4 *3*	
433.7& *2*	45& *10*	1725.4	6$^+$	1291.77	3$^+$	M1+E2		
443.1 *3*	13 *5*	1084.0	8$^+$	640.92	6$^+$			E_γ: 433.1 *3* in Table 1 of 1983Gr30 is likely a typo.
446.8 *3*	20 *5*	1820.0	3$^-$	1373.7	(3$^-$)			
451&*b*	<2&	1742.8?	5$^+$	1291.77	3$^+$			
451&	<2&	1820.0	3$^-$	1369.5	4$^+$			
x458.0 *8*	3 *1*							
x465.1 *4*	5 *2*							
x477.0 *5*	12 *5*							
x482.0 *5*	6 *2*							
x487.4 *3*	20 *5*							
x498.9 *3*	16 *5*							
x500.7	<5							
527.0 *3*	15 *4*	1820.0	3$^-$	1291.77	3$^+$			

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^{180}Hf(n,n′γ) 1983Gr30,1991Gr19,1979Bo43 (continued)

γ(^{180}Hf) (continued)

E_γ[†]	I_γ[†]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡]	δ[‡]	Comments
x534.5 4	15 6							
x555.4 4	5 2							
617[b]	<3	1700.3?	6+	1084.0	8+			
621.3 5	18 5	1820.0	3−	1199.83	2+			
x634.0 5	4 2							
x643.9 5	4 2							
x656.7 5	3 1							
x725.3 5	4 1							
728.1 7	2 1	1369.5	4+	640.92	6+			
x739.9 5	6 2							
x743.6 5	2 1							
x763.1 5	4 2							
768.3 8	2 1	1409.4	4+	640.92	6+			
x778.3 5	3 1							
x786.1 8	2.5 15							
874.3 5	20 5	1183.1	2+	308.67	4+			
890.5 5	2.5 15	1199.83	2+	308.67	4+			
916.3 5	6 2	1557.5	5+	640.92	6+			
x918.2 6	2.5 15							
x969.1 5	7 3							
x972.8 8	3 1							
982.2 5	33 5	1291.77	3+	308.67	4+	M1+E2	−5.0 +20−15	
1008.6 5	65 6	1102.0	0+	93.41	2+	E2		
1060.9 5	50 10	1369.5	4+	308.67	4+			
1065.9 5	250 20	1373.7	(3−)	308.67	4+	E1(+M2)	−0.12 30	
1082.8 5	3 2	1724.7	2+	640.92	6+			
1089.7 5	120 10	1183.1	2+	93.41	2+	M1(+E2)	−0.3 4	
1100.7[a] 5	42[a#] 21	1409.4	4+	308.67	4+	M1+E2		δ: <−0.4 or >2 (1983Gr30).
1100.7[a] 5	68[a#] 34	1409.4	2+	308.67	4+	(E2)		
1106.2 5	150 15	1199.83	2+	93.41	2+	M1+E2		δ: −2.2 13 (1991Gr19); −0.45 25 or <−10 (1983Gr30).
1122.0 7	6 2	1430.7	3−	308.67	4+			
x1164	<1.5							
x1167	<1.5							
1183.2 8	4 1	1183.1	2+	0.0	0+			
1197.7 8	165 15	1291.77	3+	93.41	2+	M1+E2		δ: <−10 or 0.18 5 (1991Gr19); >3 (1983Gr30).
1200.3 7	110 15	1199.83	2+	0.0	0+	(E2)		
x1206.7 5	53 20					(E1)		
1222.4 5	40 5	1315.8	0+	93.41	2+	E2		
1231.7 7	4 1	1540.1	(3−,4+)	308.67	4+			
1249.0 6	25 5	1557.5	5+	308.67	4+			
1260.7[@] 5	100	1354.1	(2−)	93.41	2+	(E1)		Eγ: placement from 1991Gr19. 1983Gr30 place the γ as a single depopulating transition from a 2+ level at 1260.7 keV. 1991Gr19 argue that such a decay pattern would be unusual for a low-lying state in a deformed nucleus.
1276.8 8	3 1	1369.5	4+	93.41	2+			
1281.5 8	9 3	1373.7	(3−)	93.41	2+			
1289[b] 1	3.0 15	1597.7?	4+	308.67	4+			
1300.3[&] 4	160[&] 20	1300.3	(1−)	0.0	0+	(E1)		
1300.3[&] 4	160[&] 20	1608.13	4+	308.67	4+	(E2)		

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^{180}Hf(n,n′γ) 1983Gr30,1991Gr19,1979Bo43 (continued)

γ(^{180}Hf) (continued)

E_γ[†]	I_γ[†]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡]	Comments
1300.3[a] 4	160[a] 20	1608.9	3⁻	308.67	4⁺	(E1)	
x1315 1	10 5						
1316.1[a] 8	35[a#] 16	1409.4	4⁺	93.41	2⁺	(E2)	
1316.1[a] 8	20[a#] 10	1409.4	2⁺	93.41	2⁺		
1328 1	2 1	1637.2	2⁺	308.67	4⁺		
1337.3 8	3 2	1430.7	3⁻	93.41	2⁺		
1389	<2	1482.4	3⁻	93.41	2⁺		
1391[&b]	<2[&]	1484.4	4⁺	93.41	2⁺		
1391[&b]	<2[&]	1700.3?	6⁺	308.67	4⁺		
x1393.5 7	4 1						
1409.3 7	8 2	1409.4	2⁺	0.0	0⁺		E_γ: unplaced in 1983Gr30.
1416.6[& 4]	3[& 1]	1510.0?		93.41	2⁺		
1416.6[& 4]	3[& 1]	1724.7	2⁺	308.67	4⁺		
x1434.5 8	8 2						
1446	<2	1540.1	(3⁻,4⁺)	93.41	2⁺		
1514.4[& 8]	4[& 2]	1608.13	4⁺	93.41	2⁺		
1514.4[& 8]	4[& 2]	1608.9	3⁻	93.41	2⁺		
1553.1 8	4 2	1861.8	(5⁺)	308.67	4⁺		
x1575.4 8	3 1						
1593.6 8	3 1	1687.0		93.41	2⁺		
x1601.0 8	2 1						
1631 1	<2	1725.4	6⁺	93.41	2⁺		
x1662.5 8	9 3						
1743[b]	<2	1743.0?	2⁺	0.0	0⁺		
x1767.8 8	14 6						
1774[b]	<2	2082.7?		308.67	4⁺		
1810.9 8	7 3	1904.2		93.41	2⁺		
x1834.3 8	6 2						
x1840	<3						
x1861.4 5	5 2						
x1885.9 8	10 3						
x1895	<2						
1904.1 8	4 2	1904.2		0.0	0⁺		
1926.4 8	7 3	1926.4		0.0	0⁺		
1948.6 8	8 3	1948.6		0.0	0⁺		
x1961.2 8	10 4						
1982.0 8	5 2	2075.4		93.41	2⁺		
x1990.9 8	5 2						
x1996.7 8	3 2						
x2006.5 8	5 2						
x2024.0 8	5 2						
x2035.1 8	5 2						
x2051.1 8	4 2						
x2093.4 8	4 2						
x2109.0 8	4 2						
x2168.4 8	3 2						
x2278.9 8	3 2						
2295.2 8	3 2	2389.0		93.41	2⁺		
x2323.4 8	3 2						
2389.4 8	3 2	2389.0		0.0	0⁺		

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^{180}Hf(n,n′γ) 1983Gr30,1991Gr19,1979Bo43 (continued)

γ(^{180}Hf) (continued)

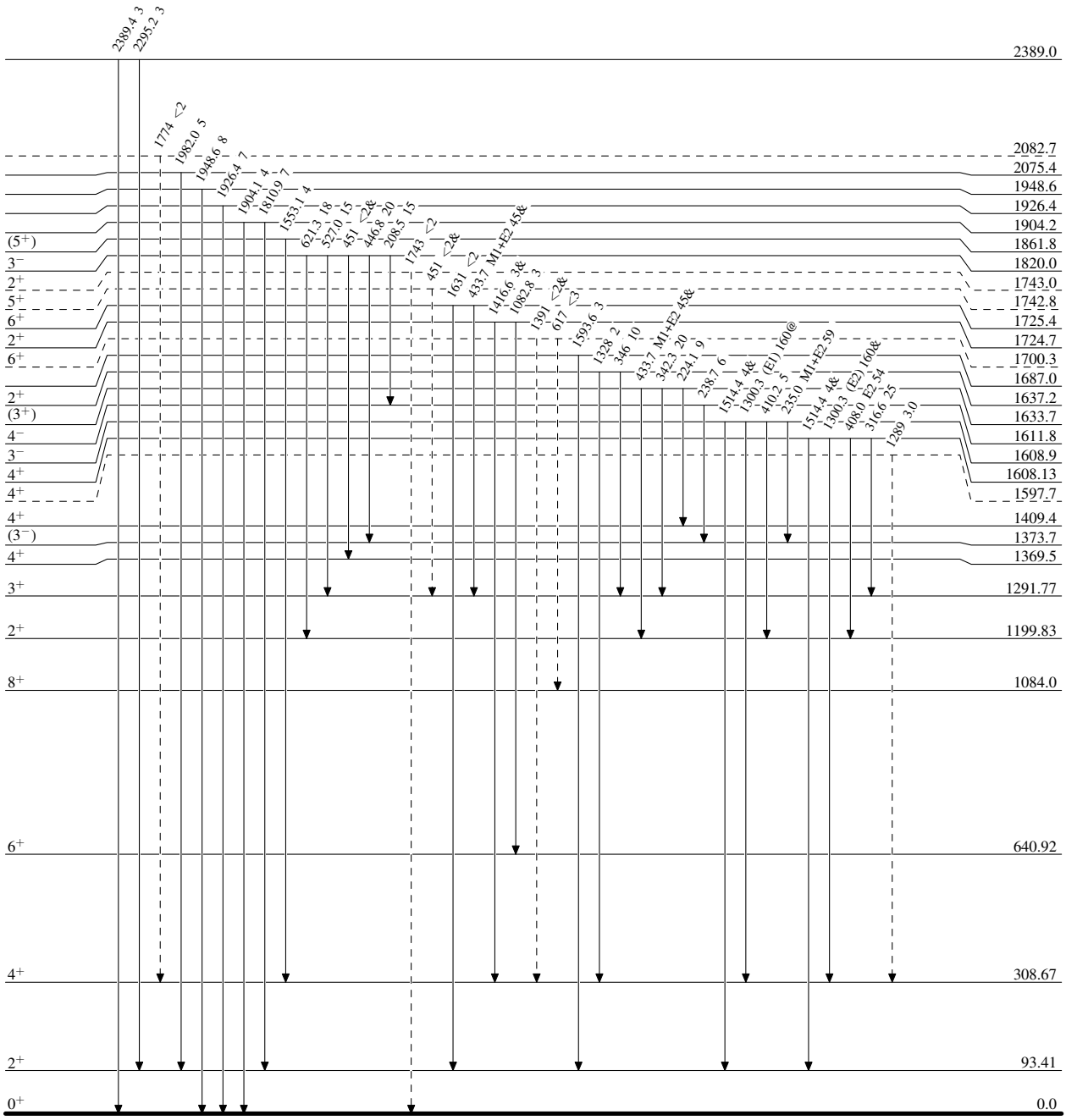
† From 1983Gr30, except where noted.
‡ From γ(θ) in 1983Gr30 and 1991Gr19. Quadrupole transitions are assumed to be E2, and transitions with mixed multipolarities, M1+E2.
# From 1991Gr19.
@ Possible doublet.
& Multiply placed with undivided intensity.
a Multiply placed with intensity suitably divided.
b Placement of transition in the level scheme is uncertain.
x γ ray not placed in level scheme.

^{180}Hf(n,n′γ) 1983Gr30,1991Gr19,1979Bo43

Level Scheme

Intensities: Relative I_γ
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided

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)



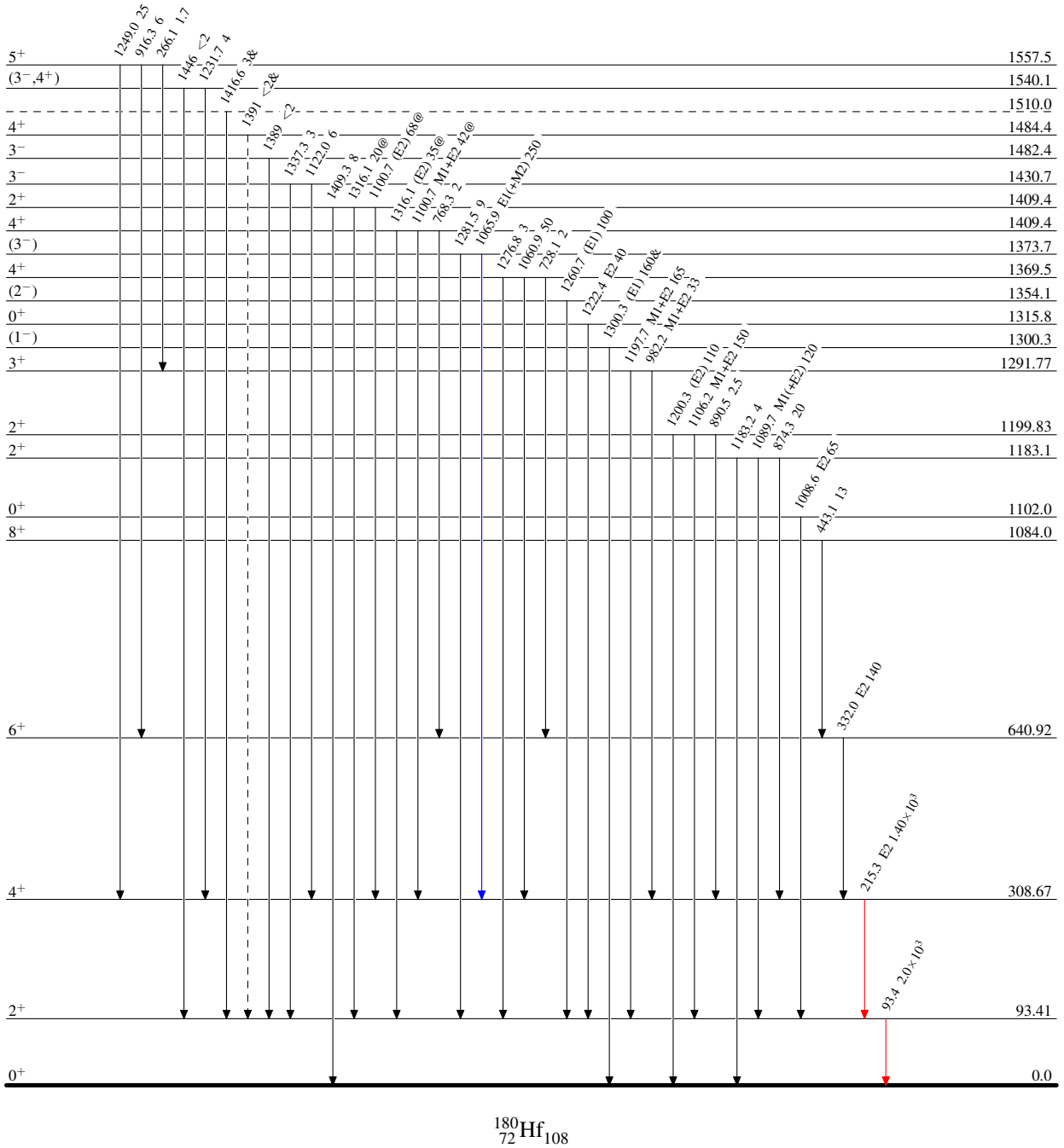
$^{180}_{72}Hf_{108}$

^{180}Hf(n,n′γ) 1983Gr30,1991Gr19,1979Bo43

Level Scheme (continued)

Intensities: Relative I_γ
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided

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)



$^{180}_{72}Hf_{108}$