Adopted Levels, Gammas

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh	ENSDF	31-Dec-2014

Q(β^-)=−7610 *30*; S(n)=8455 *25*; S(p)=3330 *60*; Q(α)=4685 *24* 2012Wa38
S(2n)=19605 *28*, S(2p)=5055 *29*, Q(εp)=4561 *28* (2012Wa38).
^{161}Hf produced and identified by 1973To02 in ^{144,147}Sm(^{20}Ne,xn),E=80-153 MeV reaction; measured Eα, $T_{1/2}$. Later studies of ^{161}Hf decay: 1989Br19, 1992Ha10, 1995Hi12.

^{161}Hf Levels

Quasiparticle labels:
A: $\nu i_{13/2}$, (π,α)=(+,+1/2)$_1$.
B: $\nu i_{13/2}$, (π,α)=(+,−1/2)$_1$.
C: $\nu i_{13/2}$, (π,α)=(+,+1/2)$_2$.
E: ν($h_{9/2}$,$f_{7/2}$), (π,α)=(-,+1/2)$_1$.
F: ν($h_{9/2}$,$f_{7/2}$), (π,α)=(-,−1/2)$_1$.
A_p: $\pi h_{11/2}$, (π,α)=(-,−1/2)$_1$.
B_p: $\pi h_{11/2}$, (π,α)=(-,+1/2)$_1$.

Cross Reference (XREF) Flags

A ^{165}W α decay (5.1 s)
B ^{110}Pd(^{56}Fe,5nγ)
C ^{126}Te(^{40}Ca,5nγ)

E(level)[†]	J$^\pi$[‡]	$T_{1/2}$	XREF	Comments
0.0	(7/2$^-$)	18.4 s *4*	AB	%ε+%β^+>99.87; %α<0.13 E(level): the evaluator assumes that this half-life is associated with the decay of the ^{161}Hf g.s. J$^\pi$: M2-M1 γ cascade from (13/2$^+$); systematics of neighboring nuclides (2014Ma91) with configuration=$\nu f_{7/2}$. $T_{1/2}$: from weighted average of 17 s *2* (1973To02, α decay); 20 s *3* (1989Br19, 136γ decay); 16.8 s *8* (1992Ha10, α decay); 18.7 s *5* (1995Hi12, α decay); 18.7 s *5* (1995Hi12, 135.6γ, uncertainty increased from 0.1 s to 0.5 s so that its weight in averaging procedure does not exceed 50%). Half-lives measured in 1995Hi12 from other γ rays are consistent with that from 135.6γ but much less precise: 17.6 s *12* for 91.2γ, 18.7 s *1* for 135.6γ, 16.7 s *19* for 199.6γ, 18.0 s *16* for 209.2γ, 20.3 s *37* for 217.6γ, and 18.5 s *12* for 275.9γ. %α: deduced by the evaluator by requiring that the hindrance factor of the α transition be greater than unity. From their Iα/Iγ data, 1995Hi12 infer that %α=0.30 *5*. These authors, however, assume that the total ε+β^+ decay intensity is given by the sum of the intensities of the 135, 209 and 276 γ rays from this decay branch. If this is not the case, then the actual α branching fraction will be smaller than this. Also from Iα/Iγ, 1992Ha10 report %α=0.29 *5*, assuming that the ε+β^+ intensity is given by the intensity of the 136 decay γ. Hence, the evaluator's estimated value of %α is consistent with the present experimental knowledge.
126.8 *3*	(9/2$^-$)		B	J$^\pi$: M2 γ from (13/2$^+$); probable configuration=$\nu h_{9/2}$.
329.0[#] *5*	(13/2$^+$)	4.8 μs *2*	BC	%IT=100 Probable configuration=$\nu i_{13/2}$ from systematics. $T_{1/2}$: from exponential fit to the decay curve from the time differences between ^{161}Hf implantations and 127- and 202−γ rays (2014Ma91).
662.3[#] *7*	(17/2$^+$)		BC	

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Adopted Levels, Gammas (continued)

^{161}Hf Levels (continued)

E(level)[†]	Jπ[‡]	XREF	Comments
1137.8[#] *8*	(21/2$^+$)	BC	
1418.9 *10*	(17/2$^-$)	B	
1698.0[#] *10*	(25/2$^+$)	BC	
1968.8 *11*	(21/2$^-$)	B	
1982.2 *10*		B	
2324.4[#] *11*	(29/2$^+$)	BC	
2399.1[@] *10*	(25/2$^-$)	B	
2466.3 *14*		B	
2745.2 *13*	(27/2$^-$)	BC	J$^\pi$: ΔJ=1, dipole γ to (25/2$^+$).
2871.6[@] *11*	(29/2$^-$)	B	
3002.0[#] *11*	(33/2$^+$)	BC	
3095.5[&] *11*	(31/2$^-$)	BC	
3359.0[@] *12*	(33/2$^-$)	B	
3645.1[&] *12*	(35/2$^-$)	BC	
3730.4[#] *12*	(37/2$^+$)	BC	
3924.7[@] *13*	(37/2$^-$)	B	
4277.9[&] *14*	(39/2$^-$)	BC	
4518.9[#] *13*	(41/2$^+$)	BC	
4571.9[@] *14*	(41/2$^-$)	B	
4981.9[&] *17*	(43/2$^-$)	BC	
5273.6[#] *15*	(45/2$^+$)	BC	
5280.6[@] *16*	(45/2$^-$)	B	
5791.9[&] *22*	(47/2$^-$)	B	
6006.9[#] *16*	(49/2$^+$)	BC	
6082.2[@] *18*	(49/2$^-$)	B	
6655[&] *4*	(51/2$^-$)	B	
6790.2[#] *18*	(53/2$^+$)	B	
6921.0[@] *20*	(53/2$^-$)	B	
7488[&] *4*	(55/2$^-$)	B	
7639.1[#] *22*	(57/2$^+$)	B	
7681.4[@] *24*	(57/2$^-$)	B	
8480[@] *3*	(61/2$^-$)	B	
8553[#] *3*	(61/2$^+$)	B	
9361[@] *3*	(65/2$^-$)	B	
9531[#] *4*	(65/2$^+$)	B	
10294[@] *4*	(69/2$^-$)	B	
10546[#] *4*	(69/2$^+$)	B	
11599?[#] *5*	(73/2$^+$)	B	

[†] From least-squares fit to Eγ data.

[‡] As proposed by 2014Ma91 based on angular distribution data for selected gamma rays, band structures and previous assignments.

[#] Band(A): Yrast band based on (13/2$^+$),α=+1/2. This band undergoes two crossings, first due to pair of $i_{13/2}$ neutrons or pair of $i_{13/2}$ neutrons and a pair of ($f_{7/2}/h_{9/2}$) neutrons, second due to pair of $h_{11/2}$ protons. Configuration=A ->ABC ->ABCA$_p$B$_p$ or A ->ABCEF ->ABCEFA$_p$B$_p$.

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Adopted Levels, Gammas (continued)

^{161}Hf Levels (continued)

@ Band(B): Band based on (25/2$^-$),α=+1/2. This band is most likely a 3-qp band, undergoing crossing at $\hbar\omega\approx$0.4 MeV due to pair of $h_{11/2}$ protons. Configuration=EAB ->$EABA_pB_p$.

& Band(b): Band based on (31/2$^-$),α=−1/2. This band is most likely a 3-qp band, undergoing crossing at $\hbar\omega\approx$0.4 MeV due to pair of $h_{11/2}$ protons. Configuration=FAB ->$FABA_pB_p$.

γ(^{161}Hf)

E_i(level)	J^π_i	E_γ†	I_γ†	E_f	J^π_f	Mult.‡	α@	Comments
126.8	(9/2$^-$)	126.8 *3*	100	0.0	(7/2$^-$)	M1#	2.03	α(K)=1.692 *25*; α(L)=0.263 *4*; α(M)=0.0595 *9*; α(N)=0.01413 *21* Delayed γ.
329.0	(13/2$^+$)	202.2 *4*	100	126.8	(9/2$^-$)	M2#	2.86 *5*	α(K)=2.20 *4*; α(L)=0.507 *8*; α(M)=0.1204 *20*; α(N)=0.0288 *5* B(M2)(W.u.)=0.17 *1*
662.3	(17/2$^+$)	333.3 *4*	100	329.0	(13/2$^+$)	Q		Additional information 1.
1137.8	(21/2$^+$)	475.5 *5*	100	662.3	(17/2$^+$)	Q		Additional information 2.
1418.9	(17/2$^-$)	756.5 *10*	100	662.3	(17/2$^+$)			
1698.0	(25/2$^+$)	560.3 *5*	100	1137.8	(21/2$^+$)	Q		Additional information 3.
1968.8	(21/2$^-$)	549.9 *9*	100 *17*	1418.9	(17/2$^-$)	(Q)		$\gamma(\theta)$for 549.9+549.4 consistent with stretched quadrupole.
		831.1 *15*	33 *17*	1137.8	(21/2$^+$)			
1982.2		563.3 *12*	50 *25*	1418.9	(17/2$^-$)			
		844.4 *6*	100 *25*	1137.8	(21/2$^+$)			
2324.4	(29/2$^+$)	626.4 *5*	100	1698.0	(25/2$^+$)	Q		Additional information 4.
2399.1	(25/2$^-$)	416.7 *8*	100 *20*	1982.2				Additional information 5.
		430.2 *7*	100 *20*	1968.8	(21/2$^-$)	(Q)		Additional information 6.
2466.3		768.5 *13*	100	1698.0	(25/2$^+$)			
2745.2	(27/2$^-$)	1047.1 *10*	100	1698.0	(25/2$^+$)	D		E_γ,Mult.: from ^{126}Te(^{40}Ca,5nγ). Other Eγ=1048 *3* (2014Ma91).
2871.6	(29/2$^-$)	405.5 *14*	20 *10*	2466.3				
		472.4 *7*	100 *20*	2399.1	(25/2$^-$)	(Q)		Additional information 7. $\gamma(\theta)$for 476+472 consistent with stretched quadrupole.
3002.0	(33/2$^+$)	677.7 *5*	100	2324.4	(29/2$^+$)	Q		Additional information 8.
3095.5	(31/2$^-$)	349.8 *22*	15 *15*	2745.2	(27/2$^-$)			
		771.1 *7*	100 *8*	2324.4	(29/2$^+$)	D		Additional information 9.
3359.0	(33/2$^-$)	263.7 *10*	30 *10*	3095.5	(31/2$^-$)			
		487.4 *5*	100 *10*	2871.6	(29/2$^-$)	(Q)		Additional information 10.
3645.1	(35/2$^-$)	549.4 *7*	100 *11*	3095.5	(31/2$^-$)	(Q)		Additional information 11. $\gamma(\theta)$for 549.9+549.4 consistent with stretched quadrupole.
		643.3 *9*	44 *11*	3002.0	(33/2$^+$)			
3730.4	(37/2$^+$)	728.4 *5*	100	3002.0	(33/2$^+$)	Q		Additional information 12.
3924.7	(37/2$^-$)	279.6 *14*	14 *7*	3645.1	(35/2$^-$)			
		565.7 *6*	100 *7*	3359.0	(33/2$^-$)	(Q)		Additional information 13.
4277.9	(39/2$^-$)	632.8 *8*	100	3645.1	(35/2$^-$)	Q		Additional information 14.
4518.9	(41/2$^+$)	788.5 *5*	100	3730.4	(37/2$^+$)	Q		Additional information 15.
4571.9	(41/2$^-$)	647.2 *6*	100	3924.7	(37/2$^-$)			Additional information 16.
4981.9	(43/2$^-$)	704.0 *9*	100	4277.9	(39/2$^-$)			Additional information 17.
5273.6	(45/2$^+$)	754.7 *6*	100	4518.9	(41/2$^+$)	(Q)		Additional information 18.
5280.6	(45/2$^-$)	708.7 *7*	100	4571.9	(41/2$^-$)			Additional information 19.
5791.9	(47/2$^-$)	810.0 *14*	100	4981.9	(43/2$^-$)			
6006.9	(49/2$^+$)	733.3 *6*	100	5273.6	(45/2$^+$)	Q		Additional information 20.
6082.2	(49/2$^-$)	801.6 *8*	100	5280.6	(45/2$^-$)			Additional information 21.
6655	(51/2$^-$)	863 *3*	100	5791.9	(47/2$^-$)			

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Adopted Levels, Gammas (continued)

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

E_i(level)	J_i^π	E_γ†	I_γ†	E_f	J_f^π	Comments
6790.2	(53/2+)	783.3 *8*	100	6006.9	(49/2+)	Additional information 22.
6921.0	(53/2−)	838.8 *9*	100	6082.2	(49/2−)	
7488	(55/2−)	833.0 *13*	100	6655	(51/2−)	
7639.1	(57/2+)	848.9 *12*	100	6790.2	(53/2+)	
7681.4	(57/2−)	760.4 *13*	100	6921.0	(53/2−)	
8480	(61/2−)	798.5 *14*	100	7681.4	(57/2−)	
8553	(61/2+)	914.3 *20*	100	7639.1	(57/2+)	
9361	(65/2−)	881.4 *12*	100	8480	(61/2−)	
9531	(65/2+)	978 *2*	100	8553	(61/2+)	
10294	(69/2−)	933 *2*	100	9361	(65/2−)	
10546	(69/2+)	1015 *2*	100	9531	(65/2+)	
11599?	(73/2+)	1053& *2*	100	10546	(69/2+)	

† From $^{110}Pd(^{56}Fe,5n\gamma)$ (2014Ma91). Some of the $E\gamma$ values in $^{126}Te(^{40}Ca,5n\gamma)$ (1988Hu05) are more precisely listed as shown in document comments on γ records, however, all data for excited states are adopted here from 2014Ma91 for internal consistency since these authors present a much more extensive level scheme than in 1988Hu05.

‡ From angular anisotropy ratios in both the high-spin reactions (1988Hu05,2014Ma91), mult=Q in dictates $\Delta J=2$, quadrupole (most likely E2) transition and mult=D indicates $\Delta J=1$, dipole.

From ce data in $^{110}Pd(^{56}Fe,5n\gamma)$ (2014Ma91).

@ Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on γ-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.

& Placement of transition in the level scheme is uncertain.

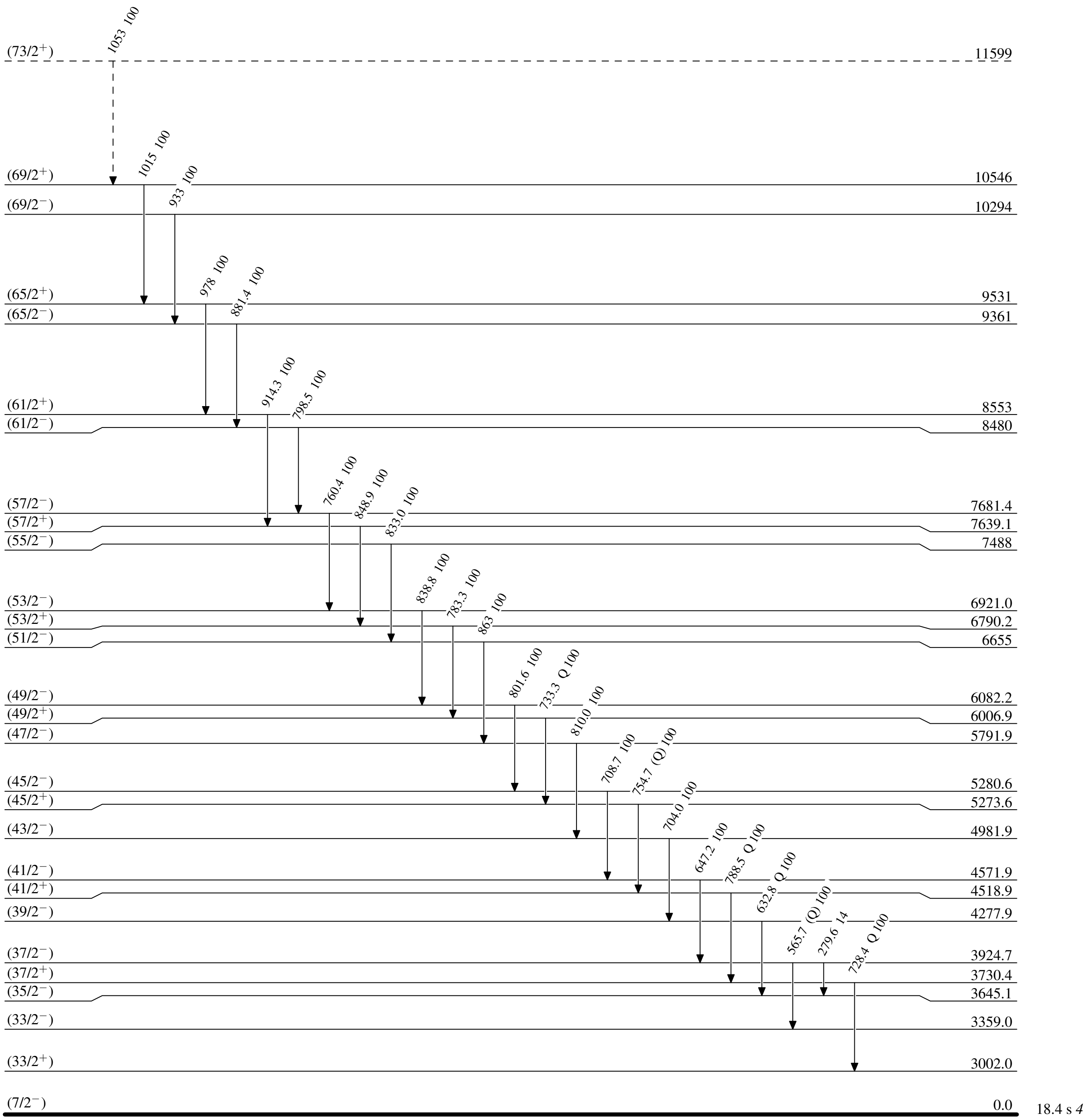
Adopted Levels, Gammas

Legend

Level Scheme

Intensities: Relative photon branching from each level

γ Decay (Uncertain)

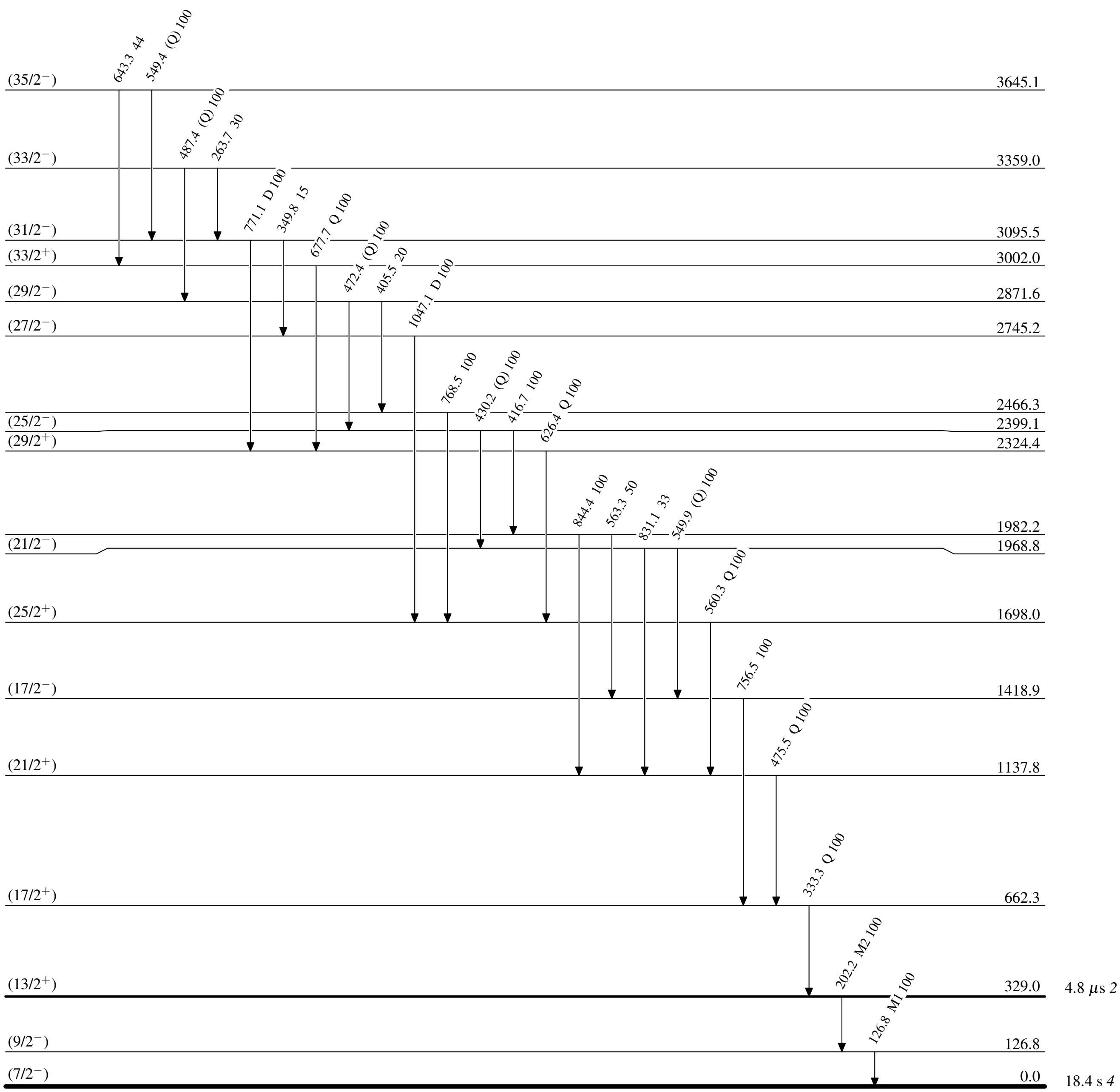


$^{161}_{72}\mathrm{Hf}_{89}$

Adopted Levels, Gammas

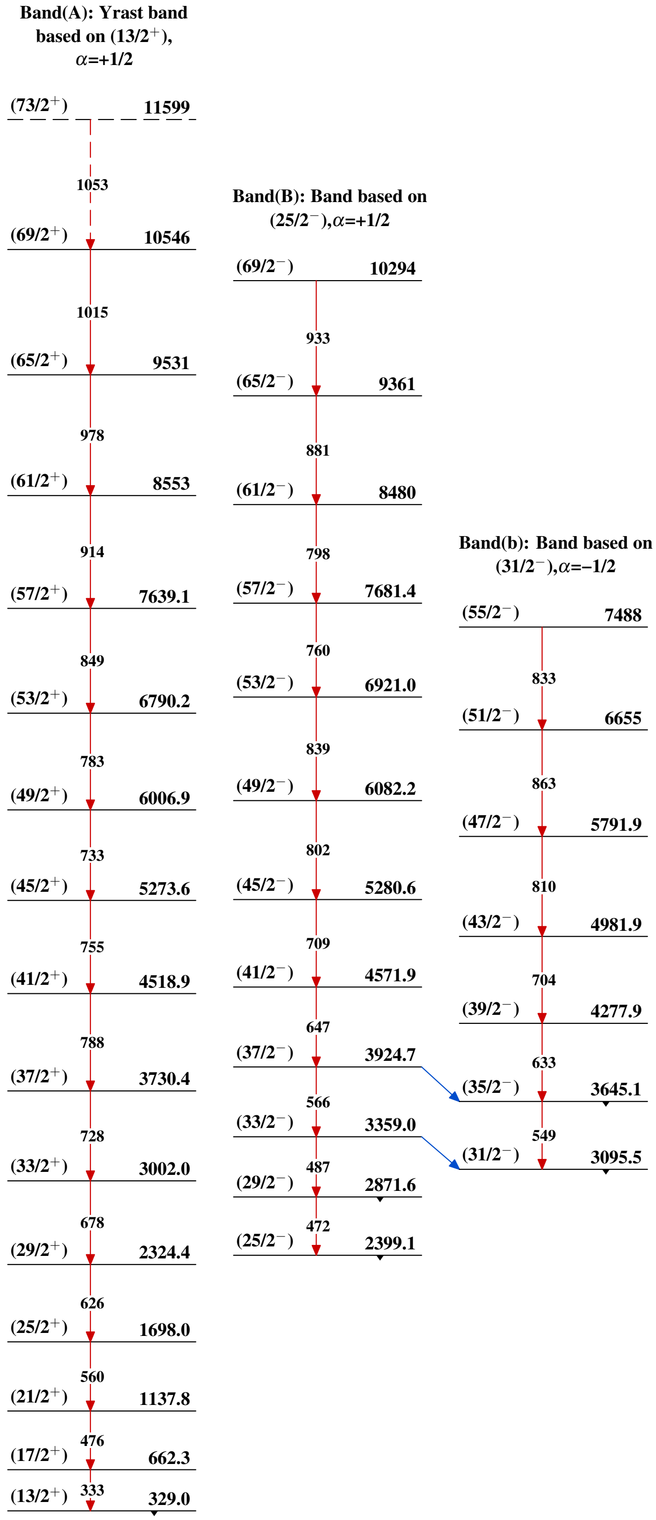
Level Scheme (continued)

Intensities: Relative photon branching from each level



$^{161}_{72}Hf_{89}$

Adopted Levels, Gammas



$^{161}_{72}Hf_{89}$