^{110}Pd(^{56}Fe,5nγ) 2014Ma91

History

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

Includes ^{118}Sn(^{48}Ti,5nγ) reaction at E(^{48}Ti)=240 MeV.

Two reactions were used to study the high-spin structure and isomerism in ^{161}Hf at University of Jyvaskyla accelerator facility: ^{110}Pd(^{56}Fe,5nγ),E(^{56}Fe)=270 MeV and ^{118}Sn(^{48}Ti,5nγ) at E(^{48}Ti)=240 MeV. Targets=^{118}Sn and ^{110}Pd with total thicknesses of ≈1.2 mg/cm^2 each. Recoiling products were separated using the RITU gas-filled separator and transported to the focal plane, and implanted into the double-sided silicon strip (DSSDs) of the GREAT spectrometer. Identification of recoils was made through energy-loss and time-of-flight measurements in GREAT spectrometer. Prompt gamma rays were detected using JUROGAM-II array consisting of 24 Compton-suppressed Clover and 13 tapered HPGe detectors surrounding the target chamber. The gamma rays emitted after implantation at the focal plane were detected with three clover HPGe detectors and a planar HPGe detector of GREAT spectrometer. Measured Eγ, Iγ, $\gamma\gamma$-coin, $\gamma(\theta)$, conversion coefficients, level lifetime by $\gamma\gamma$(t). Deduced high-spin levels, J, π, bands, isomer, multipolarity, configurations, alignments. Comparison with Woods-Saxon cranked shell-model calculations.

^{161}Hf Levels

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

E(level)†	J$^\pi$‡	T$_{1/2}$	Comments
0.0	(7/2$^-$)		E(level): probable assignment of ground state is based on systematics of neighboring nuclides (2014Ma91) with configuration=$\nu f_{7/2}$.
126.8 *3*	(9/2$^-$)		Probable configuration=$\nu h_{9/2}$.
329.0# *5*	(13/2$^+$)	4.8 μs *2*	%IT=100 Probable configuration=$\nu i_{13/2}$. 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$^+$)		
1137.8# *8*	(21/2$^+$)		
1418.9 *10*	(17/2$^-$)		
1698.0# *10*	(25/2$^+$)		
1968.9 *11*	(21/2$^-$)		
1982.2 *10*			
2324.4# *11*	(29/2$^+$)		
2399.1@ *10*	(25/2$^-$)		
2466.3 *14*			
2745.8 *21*			
2871.6@ *11*	(29/2$^-$)		
3002.0# *11*	(33/2$^+$)		
3095.5& *11*	(31/2$^-$)		
3359.1@ *12*	(33/2$^-$)		
3645.1& *12*	(35/2$^-$)		
3730.4# *12*	(37/2$^+$)		
3924.7@ *13*	(37/2$^-$)		

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$^{110}Pd(^{56}Fe,5n\gamma)$ 2014Ma91 (continued)

^{161}Hf Levels (continued)

E(level)†	Jπ‡	E(level)†	Jπ‡	E(level)†	Jπ‡	E(level)†	Jπ‡
4277.9& 14	(39/2−)	5791.9& 22	(47/2−)	7488& 4	(55/2−)	9531# 4	(65/2+)
4518.9# 13	(41/2+)	6006.9# 16	(49/2+)	7639.1# 22	(57/2+)	10294@ 4	(69/2−)
4571.9@ 14	(41/2−)	6082.3@ 18	(49/2−)	7681.5@ 24	(57/2−)	10546# 4	(69/2+)
4981.9& 17	(43/2−)	6655& 4	(51/2−)	8480@ 3	(61/2−)	11599?# 5	(73/2+)
5273.6# 15	(45/2+)	6790.2# 18	(53/2+)	8553# 3	(61/2+)		
5280.6@ 16	(45/2−)	6921.1@ 20	(53/2−)	9361@ 3	(65/2−)		

† 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$_p$.
@ Band(B): Band based on (25/2−),α=+1/2. This band is most likely a 3-qp band, undergoing crossing at $\hbar\omega\approx0.4$ MeV due to pair of $h_{11/2}$ protons. Configuration=EAB ->EABA$_p$B$_p$.
& Band(b): Band based on (31/2−),α=−1/2. This band is most likely a 3-qp band, undergoing crossing at $\hbar\omega\approx0.4$ MeV due to pair of $h_{11/2}$ protons. Configuration=FAB ->FABA$_p$B$_p$.

γ(^{161}Hf)

Experimental K-conversion coefficients determined from a comparison of intensities of γ rays and K-x rays in the delayed spectrum.
For the purpose of γ-ray energy and relative intensity determination, data from the two reactions were added together, according to e-mail reply of Nov 22, 2014 from J. Simpson.

Eγ	Iγ†	Ei(level)	Jπi	Ef	Jπf	Mult.‡	α@	Comments
126.8 3	100 2	126.8	(9/2−)	0.0	(7/2−)	M1#	2.03	α(K)exp=1.7 2 (2014Ma91) α(K)=1.692 25; α(L)=0.263 4; α(M)=0.0595 9; α(N)=0.01413 21 Delayed γ.
202.2 4	56 3	329.0	(13/2+)	126.8	(9/2−)	M2#	2.86 5	α(K)exp=2.8 4 (2014Ma91) 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 (2014Ma91) Iγ: delayed γ normalized to 100 for 126.8γ.
263.7 10	3 1	3359.1	(33/2−)	3095.5	(31/2−)			
279.6 14	2 1	3924.7	(37/2−)	3645.1	(35/2−)			
333.3 4	100 1	662.3	(17/2+)	329.0	(13/2+)			
349.8 22	2 2	3095.5	(31/2−)	2745.8				
405.5 14	2 1	2871.6	(29/2−)	2466.3				
416.7 8	5 1	2399.1	(25/2−)	1982.2				
430.2 7	5 1	2399.1	(25/2−)	1968.9	(21/2−)	(Q)		
472.4 7	10 3	2871.6	(29/2−)	2399.1	(25/2−)	(Q)		γ(θ)for 476+472 consistent with stretched quadrupole.
475.5 5	91 3	1137.8	(21/2+)	662.3	(17/2+)	(Q)		γ(θ) for 476+472 is consistent with stretched quadrupole.
487.4 5	10 1	3359.1	(33/2−)	2871.6	(29/2−)	(Q)		
549.4 7	9 1	3645.1	(35/2−)	3095.5	(31/2−)	(Q)		γ(θ)for 549.9+549.4 consistent with stretched quadrupole.

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^{110}Pd(^{56}Fe,5nγ) 2014Ma91 (continued)

γ(^{161}Hf) (continued)

E_γ	I_γ †	E_i(level)	J_i^π	E_f	J_f^π	Mult. ‡	Comments
549.9 *9*	6 *1*	1968.9	(21/2⁻)	1418.9	(17/2⁻)	(Q)	$\gamma(\theta)$ for 549.9+549.4 is consistent with stretched quadrupole.
560.3 *5*	75 *2*	1698.0	(25/2⁺)	1137.8	(21/2⁺)	(Q)	
563.3 *12*	2 *1*	1982.2		1418.9	(17/2⁻)		
565.7 *6*	14 *1*	3924.7	(37/2⁻)	3359.1	(33/2⁻)	(Q)	
626.4 *5*	62 *2*	2324.4	(29/2⁺)	1698.0	(25/2⁺)	(Q)	
632.8 *8*	8 *1*	4277.9	(39/2⁻)	3645.1	(35/2⁻)		
643.3 *9*	4 *1*	3645.1	(35/2⁻)	3002.0	(33/2⁺)		
647.2 *6*	12 *1*	4571.9	(41/2⁻)	3924.7	(37/2⁻)		
677.7 *5*	36 *2*	3002.0	(33/2⁺)	2324.4	(29/2⁺)	(Q)	
704.0 *9*	8 *1*	4981.9	(43/2⁻)	4277.9	(39/2⁻)		
708.7 *7*	9 *1*	5280.6	(45/2⁻)	4571.9	(41/2⁻)		
728.4 *5*	25 *1*	3730.4	(37/2⁺)	3002.0	(33/2⁺)		
733.3 *6*	10 *1*	6006.9	(49/2⁺)	5273.6	(45/2⁺)		
754.7 *6*	12 *2*	5273.6	(45/2⁺)	4518.9	(41/2⁺)		
756.5 *10*	10 *2*	1418.9	(17/2⁻)	662.3	(17/2⁺)		
760.4 *13*	3 *1*	7681.5	(57/2⁻)	6921.1	(53/2⁻)		
768.5 *13*	4 *1*	2466.3		1698.0	(25/2⁺)		
771.1 *7*	13 *1*	3095.5	(31/2⁻)	2324.4	(29/2⁺)	(D)	
783.3 *8*	8 *1*	6790.2	(53/2⁺)	6006.9	(49/2⁺)		
788.5 *5*	20 *1*	4518.9	(41/2⁺)	3730.4	(37/2⁺)		
798.5 *14*	2 *1*	8480	(61/2⁻)	7681.5	(57/2⁻)		
801.6 *8*	7 *1*	6082.3	(49/2⁻)	5280.6	(45/2⁻)		
810.0 *14*	4 *1*	5791.9	(47/2⁻)	4981.9	(43/2⁻)		
831.1 *15*	2 *1*	1968.9	(21/2⁻)	1137.8	(21/2⁺)		
833.0 *13*	1 *1*	7488	(55/2⁻)	6655	(51/2⁻)		
838.8 *9*	5 *1*	6921.1	(53/2⁻)	6082.3	(49/2⁻)		
844.4 *6*	4 *1*	1982.2		1137.8	(21/2⁺)		
848.9 *12*	4 *1*	7639.1	(57/2⁺)	6790.2	(53/2⁺)		
863 *3*	2 *1*	6655	(51/2⁻)	5791.9	(47/2⁻)		
881.4 *12*	1 *1*	9361	(65/2⁻)	8480	(61/2⁻)		
914.3 *20*	2 *1*	8553	(61/2⁺)	7639.1	(57/2⁺)		
933 *2*	1 *1*	10294	(69/2⁻)	9361	(65/2⁻)		
978 *2*	1 *1*	9531	(65/2⁺)	8553	(61/2⁺)		
1015 *2*	1 *1*	10546	(69/2⁺)	9531	(65/2⁺)		
1048 *3*	4 *1*	2745.8		1698.0	(25/2⁺)		
1053& *2*	1 *1*	11599?	(73/2⁺)	10546	(69/2⁺)		E_γ: 1054 in level-scheme figure 2 of 2014Ma91.

† Prompt γ rays above the (13/2⁺) isomer normalized to 100 for 333.3γ. The two delayed γ rays of 126.8 and 202.2 keV are normalized separately to 100 for 126.8γ.

‡ From $\gamma(\theta)$ data. Mult=Q indicates stretched quadrupole, most likely E2 transition, and mult=D, stretched dipole. Angular distribution coefficients are not listed by 2014Ma91, but figure 5 in the paper shows $\gamma(\theta)$ plots for 430γ, 487γ, 560γ and 771γ with comparison to theoretical distributions for stretched quadrupole and stretched dipole transitions.

From measured K-conversion coefficient.

@ From BrIcc code.

& Placement of transition in the level scheme is uncertain.

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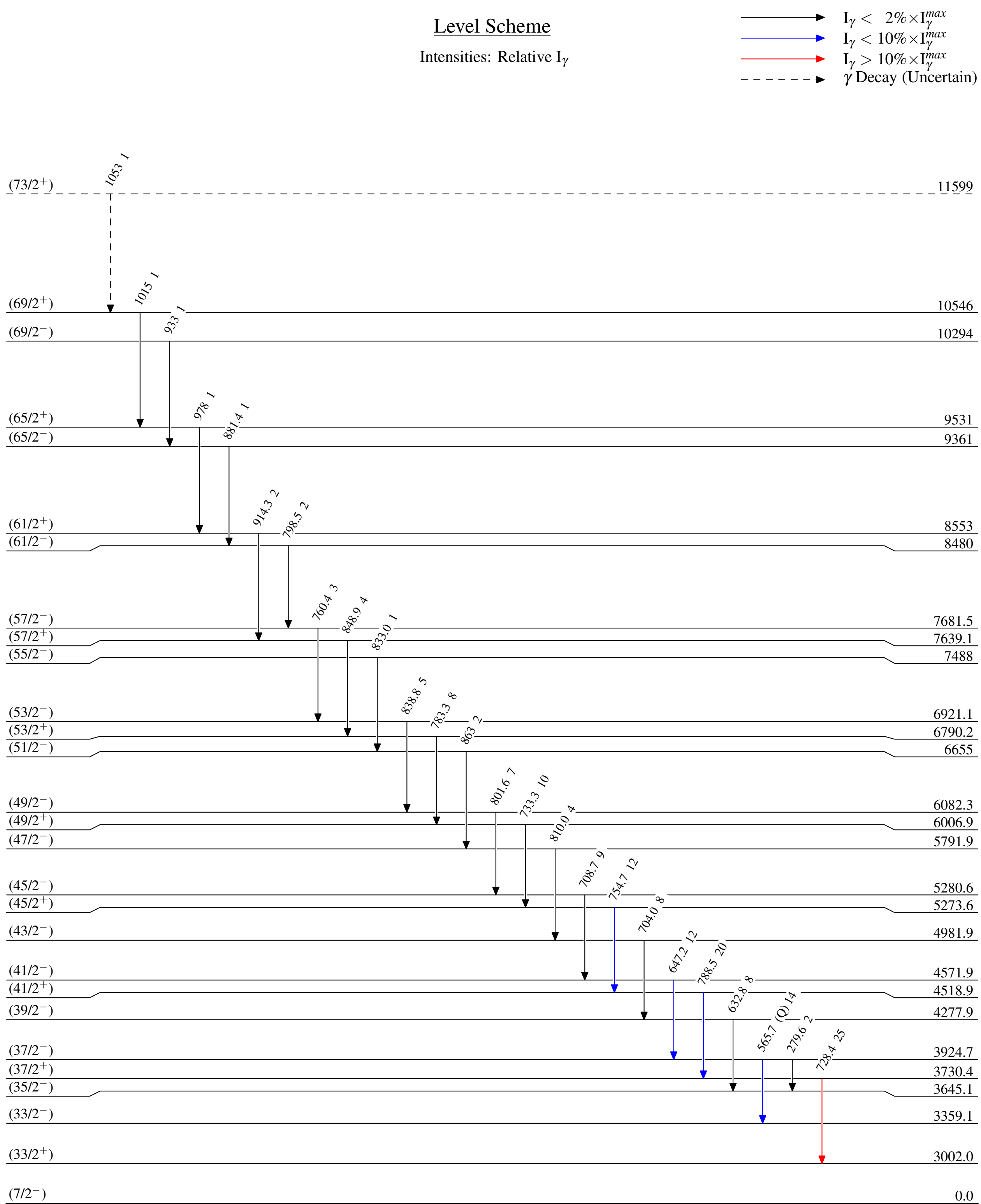
Level Scheme

Intensities: Relative I_γ



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

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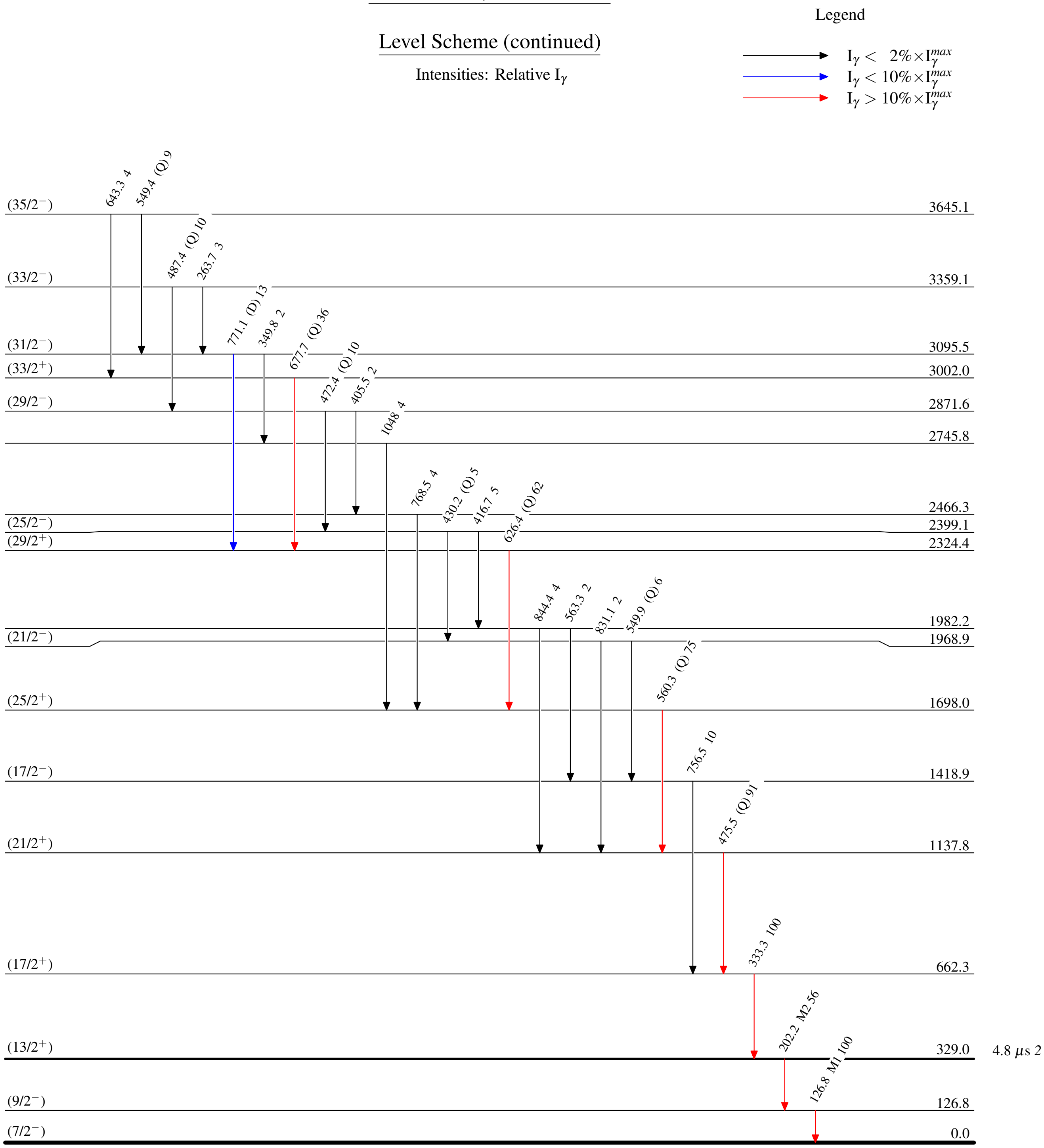
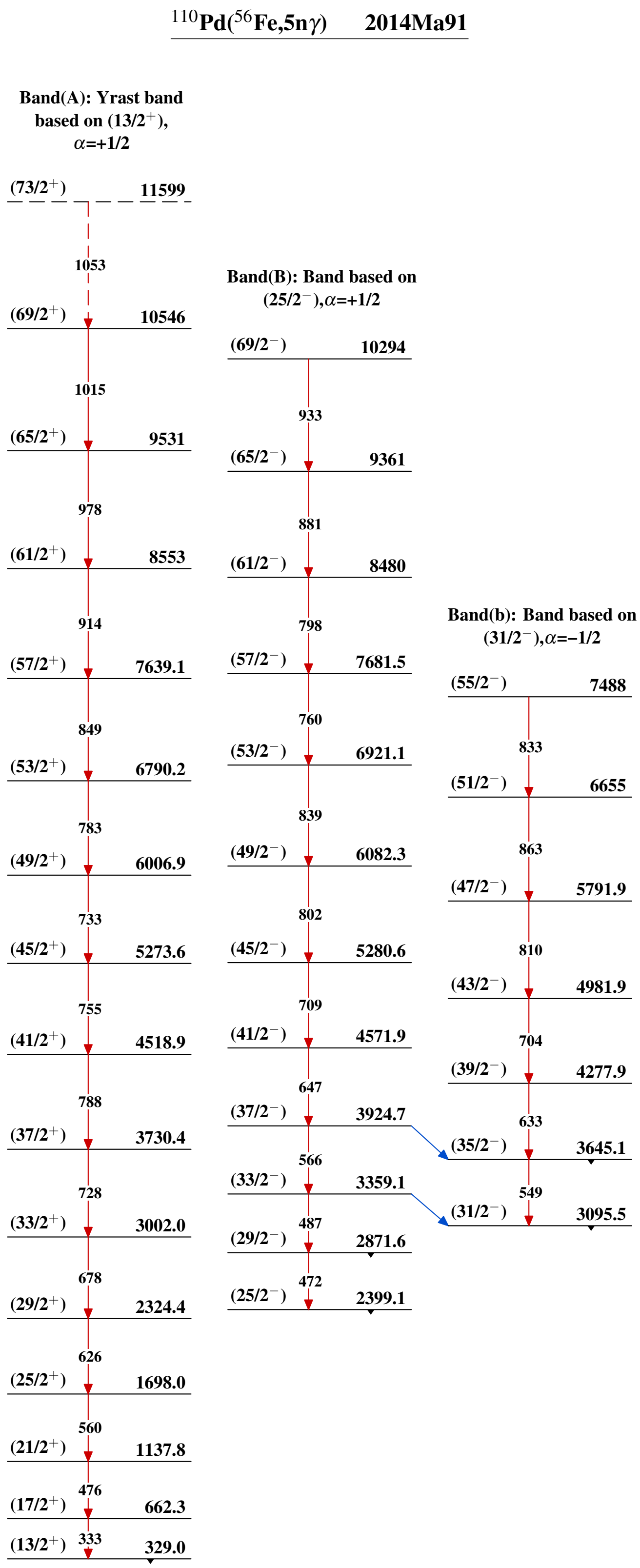
Level Scheme (continued)

Intensities: Relative I_γ



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


^{110}Pd(^{56}Fe,5nγ) 2014Ma91
Band(A): Yrast band based on (13/2+), α=+1/2
(73/2+) 11599
1053
(69/2+) 10546
1015
(65/2+) 9531
978
(61/2+) 8553
914
(57/2+) 7639.1
849
(53/2+) 6790.2
783
(49/2+) 6006.9
733
(45/2+) 5273.6
755
(41/2+) 4518.9
788
(37/2+) 3730.4
728
(33/2+) 3002.0
678
(29/2+) 2324.4
626
(25/2+) 1698.0
560
(21/2+) 1137.8
476
(17/2+) 662.3
333
(13/2+) 329.0
Band(B): Band based on (25/2−),α=+1/2
(69/2−) 10294
933
(65/2−) 9361
881
(61/2−) 8480
798
(57/2−) 7681.5
760
(53/2−) 6921.1
839
(49/2−) 6082.3
802
(45/2−) 5280.6
709
(41/2−) 4571.9
647
(37/2−) 3924.7
566
(33/2−) 3359.1
487
(29/2−) 2871.6
472
(25/2−) 2399.1
Band(b): Band based on (31/2−),α=−1/2
(55/2−) 7488
833
(51/2−) 6655
863
(47/2−) 5791.9
810
(43/2−) 4981.9
704
(39/2−) 4277.9
633
(35/2−) 3645.1
549
(31/2−) 3095.5

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