^{165}Ho(^{28}Si,4nγ) 1991Po15,2007Ch41

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	T. D. Johnson, Balraj Singh	NDS 142, 1 (2017)	15-Apr-2017

1991Po15: E=130-145 MeV. Target=600 μg/cm^2 and 1.7 mg/cm^2 on Au backing. "Chateau de Cristal" array consisting of 12 Compton-suppressed detectors and 38 BaF_2 counters acting as an inner ball. Measured Eγ, Iγ, $\gamma\gamma$, $\gamma(\theta)$, $\gamma\gamma(\theta)$(DCO) and $\gamma\gamma(\theta$,pol). Deduced high-spin levels, J^π, multipolarity.
Additional information 1.
2007Ch41: E=138 MeV. Measured Eγ, lifetimes by recoil-distance method using array of 12 Compton-suppressed HPGe detectors at NSC facility in New Delhi. Target was about 1 mg/cm^2 self-supporting ^{165}Ho. Stopper foil was about 10 mg/cm^2 gold. Target-stopper distance ranged from 14 to 10000 μm in 24 unequal steps. The partial level scheme and J^π assignments were taken from 1991Po15.
2015Ho14: ^{106}Pd(^{86}Kr,p2nγ),E(^{86}Kr)=355 MeV. Experiment was performed at the K130 cyclotron facility in Jyvaskyla. The recoiling nuclei were transported through the RITU separator, followed by detection of events using the GREAT spectrometer consisting of a multiwire proportional counter (MWPC), two double-sided silicon strip detectors (DSSDs), three Clover Ge detectors, and a planar Ge detector. The goal of this experiment was the measurement of new levels in ^{189}Pb, however, angular intensity ratios R(θ) were obtained for four transitions forming a dipole cascade in ^{189}Tl. They are given in the comments for the relevant γ transitions. Based on the measured R(θ) for transitions of known multipolarity in ^{189}Tl, 2015Ho14 establish average R(θ)=0.54 *4* for stretched dipole, and 1.07 *3* for stretched quadrupole transition.

^{189}Tl Levels

Q_t=transition quadrupole moment (2007Ch41) extracted from lifetime measurements.

E(level)[†]	J$^\pi$[‡]	$T_{1/2}$[#]	Comments
281[@&] *7*	9/2$^-$	1.4 min *1*	%ε+%β^+=98 *2*; %IT<4 Additional information 2. E(level),$T_{1/2}$: from Adopted Levels based on α decay studies.
667.01[@&] *16*	11/2$^-$	37.8 ps *35*	
980.99[@&] *16*	13/2$^-$	1.9 ps *6*	Q_t=2.3 *3* (2007Ch41).
1146.82[@b] *24*	13/2$^+$	209 ps *12*	
1324.6 *4*	13/2$^-$		
1408.2[@&] *3*	15/2$^-$		
1545.4[@b] *3*	15/2$^+$		
1645.18[@&] *25*	17/2$^-$	1.80 ps *42*	Q_t=2.7 *3* (2007Ch41).
1745.0 *4*			
1828.6[@b] *4*	17/2$^+$	9.0 ps *11*	Q_t=1.1 *1* (2007Ch41).
1994.5[@a] *5*	(17/2$^+$)		
2062.0 *7*			
2147.1[@&] *6*	21/2$^-$	7.1 ps *14*	Q_t=2.5 *3* (2007Ch41) with assumed E2 for 502.0γ. J$^\pi$: proposed as (21/2$^-$) in 1991Po15 and 2007Ch41. In 1996RiZZ and 1995Re18, it is proposed as (19/2$^-$) from stretched dipole character of 502γ.
2162.9[&] *6*	(19/2$^-$)		
2236.0[@a] *5*	21/2$^+$	8.6 ps *12*	Q_t=3.8 *3* (2007Ch41).
2236.1 *6*	(17/2)		
2307.0? *6*			
2307.2[@b] *6*	(19/2$^+$)		
2631.2[@a] *6*	25/2$^+$	2.08 ps *28*	Q_t=7.8 *5* (2007Ch41).
2649.0[@&] *8*	25/2$^-$	<6.1 ps	Q_t>2.8 (2007Ch41). J$^\pi$: (23/2$^-$) in Adopted Levels.
2788.5[@&] *9*	27/2$^-$		J$^\pi$: (25/2$^-$) in Adopted Levels.

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^{165}Ho(^{28}Si,4nγ) 1991Po15,2007Ch41 (continued)

^{189}Tl Levels (continued)

E(level)[†]	Jπ[‡]	$T_{1/2}$[#]	Comments
3025.4[@&] *10*	29/2⁻		Jπ: (27/2⁻) in Adopted Levels.
3093.7[@a] *6*	29/2⁺	0.90 ps *14*	Q_t=8.6 *8* (2007Ch41).
3277.6[@&] *10*	31/2⁻		Jπ: (29/2⁻) in Adopted Levels.
3441.7 *8*			
3627.3[@&] *11*	33/2⁻		Jπ: from 2007Ch41. J=(33/2,35/2) in 1991Po15. *J*π=(31/2⁻) in Adopted Levels.
3628.1[@a] *8*	33/2⁺	<0.7 ps	Q_t>8.8 (2007Ch41).
4231.2[@a] *10*	(37/2⁺)		
4895.2[a] *14*			

† From a least-square fit to Eγ data using 281-keV level as fixed. Uncertainty of 7 keV in this energy is not reflected in the uncertainties of other level energies.
‡ As proposed in 1991Po15, unless otherwise stated.
# From recoil-distance Doppler-shift method (2007Ch41) for levels above the 281-keV isomer.
@ Level shown populated in 2007Ch41 (Figure 1 in the paper).
& Band(A): $\pi h_{9/2}$ oblate.
a Band(B): $\pi i_{13/2}$ prolate.
b Band(C): $\pi i_{13/2}$ oblate.

γ(^{189}Tl)

DCO ratios, A_2 and A_4 coefficients and POL values are from 1991Po15.

Eγ[†]	Iγ	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	α[@]	$I_{(\gamma+ce)}$[‡]	Comments
139.5 *5*	5	2788.5	27/2⁻	2649.0	25/2⁻	D		20	A_2=−0.3 *1* Mult.: most likely M1, α(theory)=3.32. R(θ)=0.56 *6* (2015Ho14).
165.9 *5*		1146.82	13/2⁺	980.99	13/2⁻				
199.6 *5*		1745.0		1545.4	15/2⁺				
236.9[b] *5*	b	1645.18	17/2⁻	1408.2	15/2⁻				
236.9[b] *5*	b	3025.4	29/2⁻	2788.5	27/2⁻	D		22	DCO=0.3 *1*; A_2=−0.25 *12*
241.6 *5*		2236.0	21/2⁺	1994.5	(17/2⁺)				
252.2 *3*		3277.6	31/2⁻	3025.4	29/2⁻	D		11	DCO=0.3 *1*; A_2=−0.31 *14*
283.3 *5*		1828.6	17/2⁺	1545.4	15/2⁺	D		7	DCO=0.3 *1*; A_2=−0.28 *5*
314.0 *2*	22	980.99	13/2⁻	667.01	11/2⁻	M1	0.346	30	DCO=0.20 *5*; A_2=−0.32 *5* Pol=−0.08 *4*. R(θ)=0.51 *5* (2015Ho14).
317.0 *5*		2062.0		1745.0					
336.7 *5*		1745.0		1408.2	15/2⁻				
348.0 *5*		3441.7		3093.7	29/2⁺				
349.7 *5*		3627.3	33/2⁻	3277.6	31/2⁻				
386.0 *2*	62	667.01	11/2⁻	281	9/2⁻	M1+E2	0.13 *8*	70	α(K)=0.10 *7*; α(L)=0.021 *7*; α(M)=0.0051 *16*; α(N+..)=0.0016 *5* DCO=0.15 *5*; A_2=−0.68 *7* Pol=+0.05 *5*.
395.2 *3*	15	2631.2	25/2⁺	2236.0	21/2⁺	E2	0.0510	16	α(K)=0.0340; α(L)=0.0132; α(M)=0.00331; α(N+..)=0.00106 DCO=1.0 *2*; A_2=+0.31 *14* Pol=+0.09 *5*.

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^{165}Ho(^{28}Si,4nγ) 1991Po15,2007Ch41 (continued)

γ(^{189}Tl) (continued)

E_γ[†]	I_γ	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	α[@]	$I_{(\gamma+ce)}$[‡]	Comments
398.6 *2*	18	1545.4	15/2$^+$	1146.82	13/2$^+$	M1+E2	0.12 *7*	20	DCO=0.2 *1*; A_2=−0.68 *9* Pol=+0.06 *6*.
407.3 *3*	14	2236.0	21/2$^+$	1828.6	17/2$^+$	E2	0.0471	15	DCO=1.0 *2*; A_2=+0.20 *14* Pol=+0.11 *5*.
427.3 *5*	4	1408.2	15/2$^-$	980.99	13/2$^-$	M1	0.1503	5	DCO=0.3 *1* Pol=−0.06 *3*.
449.2 *5*		1994.5	(17/2$^+$)	1545.4	15/2$^+$				
462.5 *3*	12	3093.7	29/2$^+$	2631.2	25/2$^+$	E2	0.0341	12	DCO=1.1 *2* Pol=+0.15 *5*.
479[&] *1*		2307.2	(19/2$^+$)	1828.6	17/2$^+$			10	
479.8 *2*	40	1146.82	13/2$^+$	667.01	11/2$^-$	E1	0.0101	40	DCO=0.40 *11*; A_2=−0.19 *5* Pol=+0.25 *7*.
489.2 *5*		3277.6	31/2$^-$	2788.5	27/2$^-$				
501.9[b] *5*	30[b]	2147.1	21/2$^-$	1645.18	17/2$^-$			30	Mult.: E2 proposed in 1991Po15 but ΔJ=1, dipole in 1995Re18 based on DCO ratios for the 303 and 199 cascade of transitions in parallel to the 502γ.
501.9[b] *5*	19[b]	2649.0	25/2$^-$	2147.1	21/2$^-$	E2	0.0279	20	DCO=1.3 *3*; A_2=+0.15 *4* Pol=+0.29 *8* for 501.9+502.2. R(θ)=1.08 *3* (2015Ho14).
534.4 *5*	8	3628.1	33/2$^+$	3093.7	29/2$^+$	E2	0.0240	8	DCO=1.0 *3* Pol=+0.13 *5*.
562.0[a] *5*		2307.0?		1745.0					
603.1 *5*		4231.2	(37/2$^+$)	3628.1	33/2$^+$				
657.6 *3*	10	1324.6	13/2$^-$	667.01	11/2$^-$	M1	0.0485	10	A_2=−0.17 *8* E_γ: A 657γ placed from a different level in 1996RiZZ which requires it to be E2 from ΔJ^π, but negative value of POL suggests M1. This γ may be a doublet. Pol=−0.18 *6*.
662[a] *1*		2307.0?		1645.18	17/2$^-$				
664 *1*		4895.2		4231.2	(37/2$^+$)				
664.2 *2*	34	1645.18	17/2$^-$	980.99	13/2$^-$	E2	0.0147	35	DCO=0.9 *2*; A_2=+0.26 *3* Pol=+0.17 *5*.
681.8 *3*	15	1828.6	17/2$^+$	1146.82	13/2$^+$	E2	0.0139	15	DCO=1.0 *3*; A_2=+0.41 *17* Pol=+0.13 *5*.
690.7[a] *5*		2236.1	(17/2)	1545.4	15/2$^+$				
700.0 *2*	30	980.99	13/2$^-$	281	9/2$^-$	E2	0.0131	30	DCO=1.0 *2*; A_2=+0.26 *9* Pol=+0.27 *11*. R(θ)=1.04 *5* (2015Ho14).
741.1 *5*	7	1408.2	15/2$^-$	667.01	11/2$^-$			7	DCO=0.9 *3*
754.7 *5*		2162.9	(19/2$^-$)	1408.2	15/2$^-$				
761.7[&] *5*	10	2307.2	(19/2$^+$)	1545.4	15/2$^+$				

[†] From 1991Po15, Δ(Eγ)=0.2 keV for Iγ≥20, 0.3 keV for Iγ=10-20, 0.5 keV for Iγ<10 and doublets or when Iγ is unlisted, and 1 keV when Eγ stated to nearest keV, based on a general statement in 1991Po15 that these are 0.2-0.5 keV.

[‡] From 1991Po15, uncertainty=30% for Iγ<30, 20% for 30<Iγ<60, and 10% for Iγ>60, based on a general statement in 1991Po15 that these are 10-30%. The evaluators estimate Iγ values from expected multipolarities and corresponding conversion coefficients.

[#] From DCO values and γ(lin pol) (1991Po15), except as noted. For mult=M1 or D, small E2 or quadrupole admixture is expected in ΔJ=1 transitions. Mult=D here is assigned M1(+E2) in 1991Po15.

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^{165}Ho(^{28}Si,4nγ) 1991Po15,2007Ch41 (continued)

$\gamma(^{189}Tl)$ (continued)

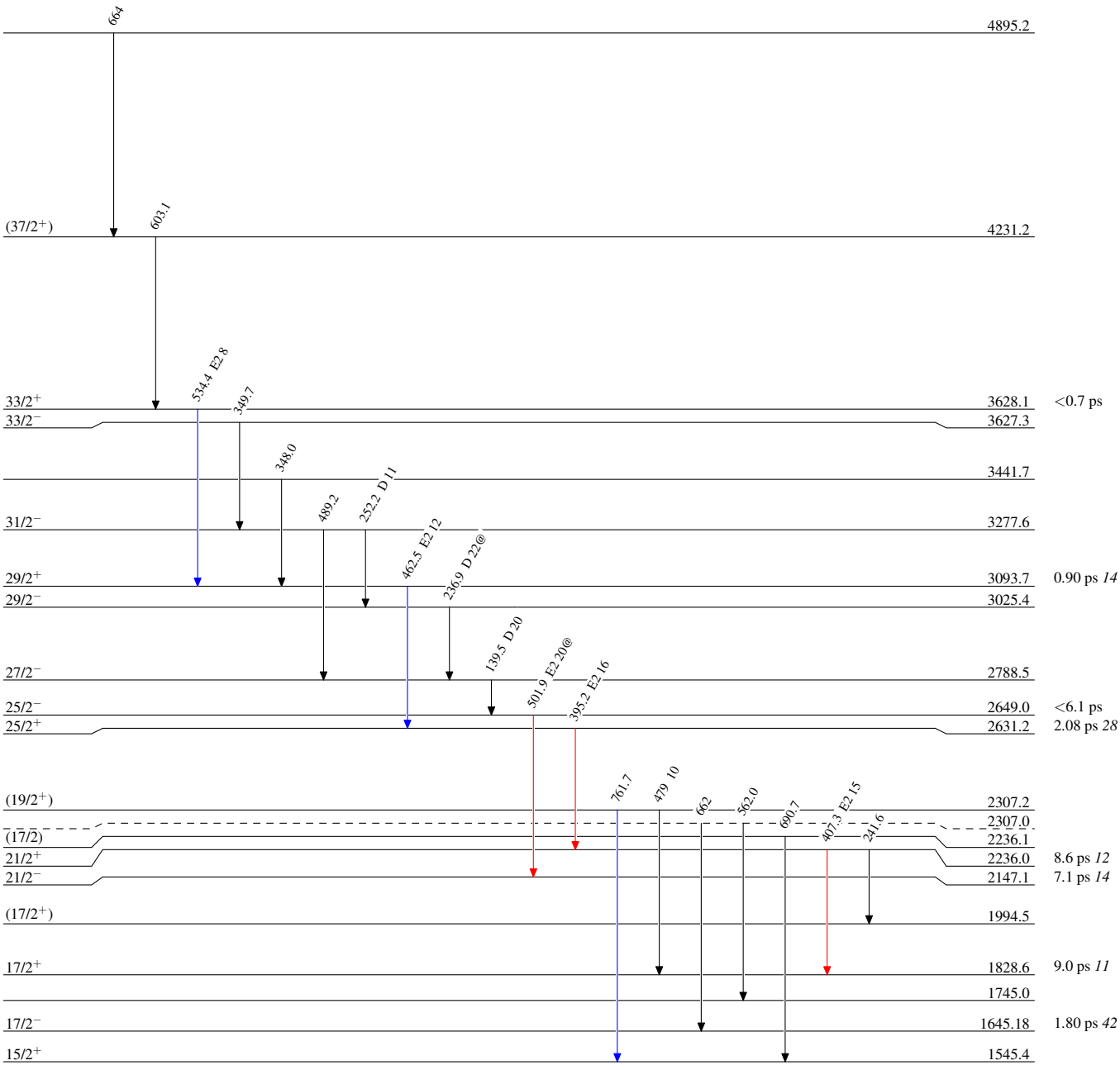
@ From BrIcc code (2008Ki07) with "Frozen Orbitals" approximation.
& This γ not reported in 1996RiZZ but present in 2007Ch41.
a This γ not shown in the level scheme of 1996RiZZ.
b Multiply placed with intensity suitably divided.

^{165}Ho(^{28}Si,4nγ) 1991Po15,2007Ch41

Level Scheme

Intensities: Relative $I_{(\gamma+ce)}$
@ Multiply placed: intensity suitably divided

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



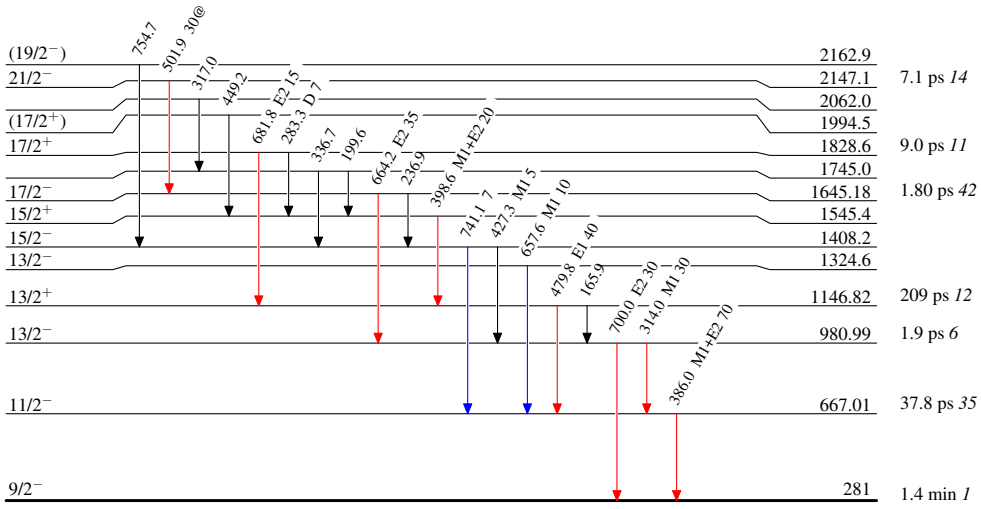
$^{189}_{81}Tl_{108}$

^{165}Ho(^{28}Si,4nγ) 1991Po15,2007Ch41

Level Scheme (continued)

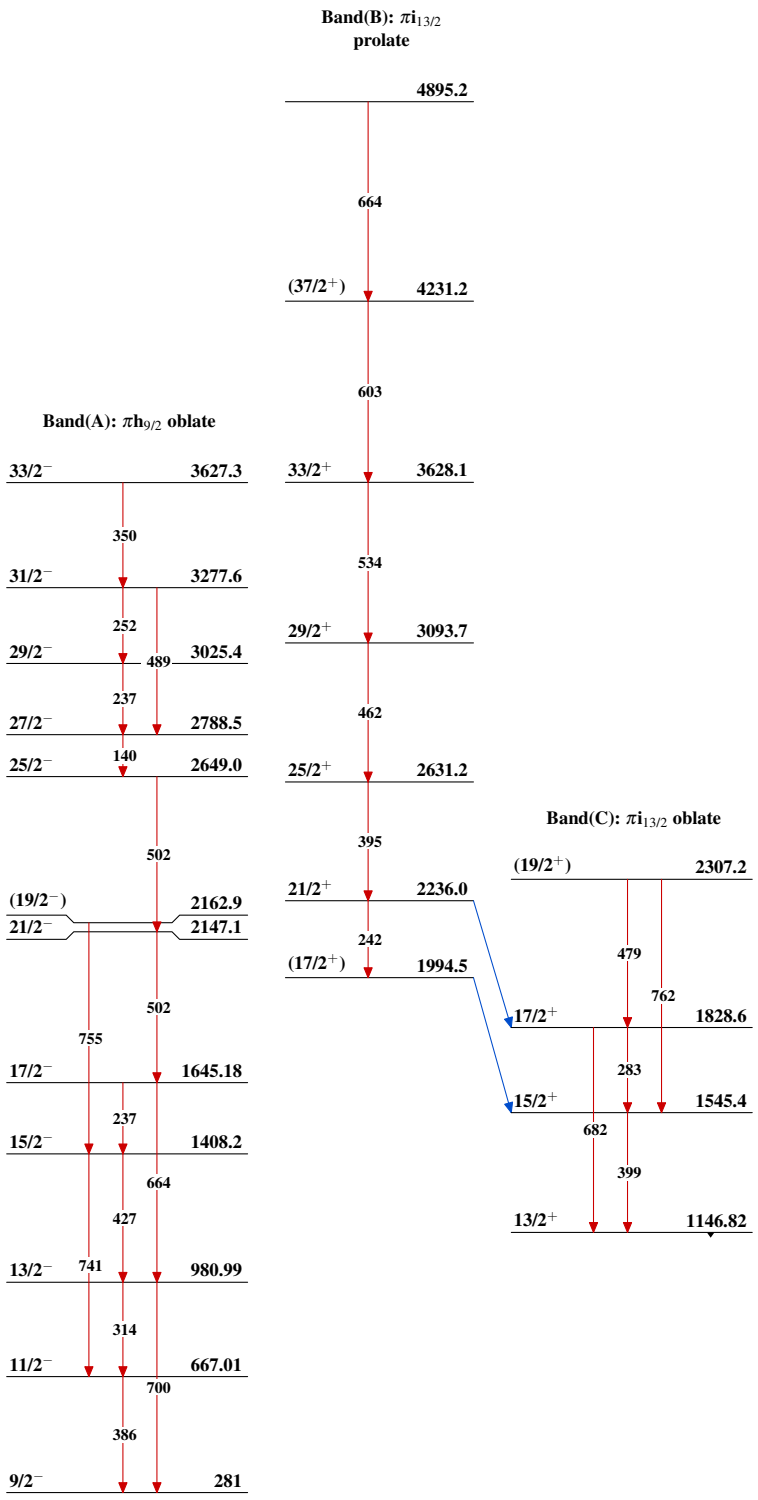
Intensities: Relative $I_{(\gamma+ce)}$
@ Multiply placed: intensity suitably divided

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



$^{189}_{81}Tl_{108}$

^{165}Ho(^{28}Si,4nγ) 1991Po15,2007Ch41



$^{189}_{81}Tl_{108}$