

$^{91}\text{Zr}(^{12}\text{C},3n\gamma)$ 1981Pi02

Type	Author	History	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh and Jun Chen		NDS 172, 1 (2021)	31-Jan-2021

1981Pi02: E=63 and 56 MeV ^{12}C beams were produced from the Brookhaven Tandem Van de Graaff Facility. γ rays were detected with Ge(Li) detectors. Measured $E\gamma$, $I\gamma$, $\gamma\gamma$ -coin, $\gamma(t)$, $\gamma(\theta)$, $\gamma(\text{lin pol})$, $\gamma(\text{DCO})$, excitation functions. Deduced levels, J, π , γ -ray multiplicities. Comparisons with theoretical calculations. See also [1976StYS](#) and [1973Sc14](#) from the same group. [1981Pi02](#) also report two states at 2017 and 2547 from the $^{96}\text{Ru}(^{16}\text{O},^{12}\text{C})$ reaction at E=70 MeV from an earlier study ([1978ThZY](#)).

Others: [1982An17](#) and [1982An09](#), $T_{1/2}$ measurement by $\gamma\gamma(t)$; [1974SmZV](#).

Several modifications to the level scheme of [1981Pi02](#) are proposed in other reactions. The level scheme given here is from

[1981Pi02](#) with appropriate comments noted from the Adopted Levels, Gammas.

The 876-1071-1035-940-809-805 cascade from 7839 level given in [1981Pi02](#) is reordered as 1071-940-1035-805-809-876 in the Adopted Levels, Gammas based on several recent studies: [1997Ta02](#), [2000ApZY](#), [2001Pe05](#) and [2001Zh26](#).

 ^{100}Pd Levels

E(level) [†]	J^π [@]	$T_{1/2}$	Comments
0.0 ^{&}	0 ⁺		
665.32 ^{& 12}	2 ⁺		
1415.80 ^{& 17}	4 ⁺		
2017? [#]			
2188.86 ^{& 21}	6 ⁺		
2504.9 ^{a 4}	5 ⁻		
2547? [#]			
2987.46 ^{& 25}	8 ⁺		
3177.1 4	8 ⁺	0.9 ns 2	J^π : from the Adopted Levels, based on $\gamma(\theta)$ and $\gamma(\text{lin pol})$ measurements of 2001Pe05 . 1981Pi02 proposed 8 ⁻ based on M2 from for 988.6 $\gamma(\text{lin pol})$. $T_{1/2}$: $\gamma\gamma(t)$ (1982An17).
3230.7 ^{a 6}	7 ⁻		
3868.8 ^{& 3}	10 ⁺		
3982.6? ^{‡b 4}			J^π : (10 ⁻) in 1981Pi02 , but 10 ⁺ from $\Delta J=2$ E2 γ to 8 ⁺ .
4092.8 ^{a 6}	(9 ⁻)		
4146.1 5	(10 ⁺)		
4760.7 ^{& 4}	12 ⁺		
4791.9? ^{‡b 5}			J^π : 12 ⁻ in 1981Pi02 , but 12 ⁺ from $\Delta J=2$, E2 γ cascade to 8 ⁺ .
5452.3? 6			
5706.2 ^{& 6}	14 ⁺		
5732.1? ^{‡b 6}	14 ⁻		E(level): reverse ordering of 1036-940 cascade in the Adopted Levels, Gammas gives a different level energy.
5919.7? 8			
6185.8? ^{‡ 6}			
6768.0? ^{‡b 6}	16 ⁻		
7839.0? ^{‡b 8}	18 ⁻		
8714.5? ^{‡ 9}	(19)		

[†] From least-squares fit to $E\gamma$ data.

[‡] Level not supported in other recent high-spin studies ([2001Pe05](#), [2001Zh26](#), [2000ApZY](#), [1997Ta02](#)). The deexciting γ ray is placed differently in several other reactions and in the Adopted Levels, Gammas. The 876-1071-1035-940-809-805 cascade from 7839 level given in [1981Pi02](#) is reordered as 1071-940-1035-806-809-876 in the Adopted Levels, Gammas based on recent studies

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$^{91}\text{Zr}(^{12}\text{C},3n\gamma)$ **1981Pi02 (continued)** ^{100}Pd Levels (continued)

quoted above.

1981Pi02 report two levels from the $^{96}\text{Ru}(^{16}\text{O},^{12}\text{C})$ reaction from an earlier study (**1978ThZY**) but do not give any deexciting transitions. This level is not included in the Adopted Levels.

@ From **1981Pi02** based on $\gamma(\theta)$, $\gamma(\text{lin pol})$ and $\gamma\gamma(\theta)$ data. The assignments in the Adopted Levels are mostly the same but several are placed in parentheses there, and also some level energies differ due to reordering of the $\gamma\gamma$ cascades.

& Band(A): g.s. band.

^a Band(B): 5^- band.

^b Band(C): 10^- band.

 $\gamma(^{100}\text{Pd})$

All data are from **1981Pi02**, obtained at $E(^{12}\text{C})=63$ MeV, unless otherwise noted. Some of the A_2 and A_4 coefficients from $\gamma(\theta)$ are at $E=56$ MeV, especially when a second set of these coefficients is listed.

POL values range from +1 for stretched pure electric transitions to -1 for stretched pure magnetic transitions; DCO values are for gates on stretched quadrupole transitions (**1981Pi02**).

E_γ^\dagger	I_γ^\dagger	$E_i(\text{level})$	J_i^π	E_f	J_f^π	Mult.&	δ	Comments
189.6 3	7.3 [#] 9	3177.1	8 ⁺	2987.46	8 ⁺	D(+Q)	≤ 0.1	$A_2=+0.216$ 8; $A_4=-0.010$ 12; DCO=1.6 5 I_γ : other: <17 (1981Pi02 at 56 MeV). Mult., δ : from $\gamma(\theta)$ and DCO, consistent with $\Delta J=0$, dipole. $A_2=+0.306$ 22, $A_4=-0.005$ 32.
277.3 5	5.6 [#] 9	4146.1	(10 ⁺)	3868.8	10 ⁺			DCO=0.75 24 $A_2=+0.41$ 6; $A_4=-0.10$ 9 I_γ : other: 6.4 4 (1981Pi02 at 56 MeV). Mult.: $\gamma(\theta)$ and DCO consistent with $\Delta J=0$, dipole.
467.4 [‡] 5	4.0 [#] 10	5919.7?		5452.3?				DCO=2.9 +20-9 $A_2=+0.20$ 9; $A_4=-0.13$ 13 I_γ : other: <17 (1981Pi02 at 56 MeV).
479.6 ^{‡@b} 3	2.8 3	6185.8?		5706.2	14 ⁺	D		$A_2=-0.32$ 9; $A_4=+0.10$ 12; DCO=1.4 8; pol=-0.75 25 $A_2=+0.03$ 9, $A_4=-0.09$ 13. E_γ : placement from a 6939, (16) ⁺ level in the Adopted Levels, Gammas.
665.32 12	100.0 21	665.32	2 ⁺	0.0	0 ⁺	E2		I_γ : other: 3.7 3 (1981Pi02 at 56 MeV). $A_2=+0.269$ 5; $A_4=-0.089$ 7; pol=+0.53 4 I_γ : other: 100.0 17 (1981Pi02 at 56 MeV). $A_2=+0.277$ 13, $A_4=-0.062$ 18.
691.5 [‡] 4	4.7 12	5452.3?		4760.7	12 ⁺	D		$A_2=-0.108$ 20; $A_4=-0.003$ 29; DCO=1.8 +8-4 $A_2=-0.08$ 8, $A_4=+0.08$ 12. I_γ : other: 5.7 6 (1981Pi02 at 56 MeV).
725.8 4	12.0 [#] 17	3230.7	7 ⁻	2504.9	5 ⁻	(E2) ^a		$A_2=+0.172$ 17; $A_4=-0.080$ 24; DCO=1.2 4; pol=+0.26 10 $A_2=+0.23$ 3, $A_4=-0.03$ 4. I_γ : other: <20 (1981Pi02 at 56 MeV).
750.48 12	87.2 15	1415.80	4 ⁺	665.32	2 ⁺	E2		$A_2=+0.269$ 12; $A_4=-0.083$ 18; DCO=1.13 8; pol=+0.37 4 E_γ : doublet in the Adopted Gammas. The second component is placed from a 6457 level. I_γ : other: <99 (1981Pi02 at 56 MeV). $A_2=+0.290$ 10, $A_4=-0.068$ 15.

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$^{91}\text{Zr}(^{12}\text{C},3n\gamma)$ **1981Pi02 (continued)** $\gamma(^{100}\text{Pd})$ (continued)

E_γ †	I_γ †	$E_i(\text{level})$	J_i^π	E_f	J_f^π	Mult. &	Comments
773.05 12	82.9 19	2188.86	6 ⁺	1415.80	4 ⁺	E2	$A_2=+0.298$ 7; $A_4=-0.078$ 9; DCO=0.97 6; pol=+0.48 4 I_γ : other: 71.5 10 (1981Pi02 at 56 MeV). $A_2=+0.317$ 13, $A_4=-0.078$ 18.
798.58 14	53.2 17	2987.46	8 ⁺	2188.86	6 ⁺	E2	$A_2=+0.322$ 9; $A_4=-0.119$ 12; DCO=0.90 6; pol=+0.45 6 I_γ : other: 50.7 11 (1981Pi02 at 56 MeV). $A_2=+0.307$ 12, $A_4=-0.062$ 17.
805.43 @b 18	15.8# 10	3982.6?		3177.1	8 ⁺	a	$A_2=+0.312$ 7; $A_4=-0.121$ 10; DCO=0.93 12; pol=+0.42 7 $A_2=+0.31$ 3, $A_4=-0.04$ 4. E_γ : placement from a 5669, 13 ⁻ level in the Adopted Levels, Gammas. I_γ : other: 6.6, corrected for 31% contribution from a transition in ^{101}Pd (1981Pi02 at 56 MeV). Mult.: $\gamma(\theta, \text{pol})$ and $\gamma\gamma(\text{DCO})$ from 1981Pi02 consistent with E2.
809.39 @b 14	14.1 11	4791.9?		3982.6?		E2	$A_2=+0.309$ 25; $A_4=-0.16$ 4; DCO=1.01 10; pol=+0.37 12 $A_2=+0.34$ 4, $A_4=-0.06$ 6. E_γ : placement from a 4864, 11 ⁻ level in the Adopted Levels, Gammas. I_γ : other: 12.4 4 (1981Pi02 at 56 MeV).
862.1 3	7.1# 11	4092.8	(9 ⁻)	3230.7	7 ⁻	Q ^a	DCO=1.7 +7-4 $A_2=+0.19$ 3; $A_4=-0.10$ 4 I_γ : other: 11, corrected for 50% contribution from a ^{99}Rh transition (1981Pi02 at 56 MeV).
875.5 @b 6	7.0# 8	8714.5?	(19)	7839.0?	18 ⁻		DCO=2.2 7 $A_2=+0.090$ 23; $A_4=0.00$ 4 E_γ : placement from a 4054, 9 ⁻ level in the Adopted Levels, Gammas. I_γ : other: <28 (1981Pi02 at 56 MeV).
881.33 18	34.9# 13	3868.8	10 ⁺	2987.46	8 ⁺	E2	$A_2=+0.309$ 18; $A_4=-0.120$ 25; DCO=1.18 9; pol=+0.54 5 $A_2=+0.288$ 18, $A_4=-0.116$ 26. I_γ : other: 41.8 18, corrected for 10% contribution from a ^{99}Pd transition (1981Pi02 at 56 MeV).
891.95 16	24.3# 11	4760.7	12 ⁺	3868.8	10 ⁺	(E2) ^a	$A_2=+0.332$ 19; $A_4=-0.09$ 3; DCO=1.08 10; pol=+0.48 9 $A_2=+0.358$ 17, $A_4=-0.102$ 25. I_γ : other: 20.7, corrected for 15% contribution from a ^{99}Rh and 10% from ^{101}Pd transitions (1981Pi02 at 56 MeV).
940.2 @b 3	10.5# 9	5732.1?	14 ⁻	4791.9?		a	$A_2=+0.279$ 19; $A_4=-0.12$ 3; DCO=0.93 11; pol=+0.34 11 $A_2=+0.29$ 5, $A_4=-0.15$ 7. E_γ : placement from a 7645, (17) ⁻ level in the Adopted Levels, Gammas. I_γ : other: 3.8 8 (1981Pi02 at 56 MeV). Mult.: $\gamma(\theta, \text{pol})$ and $\gamma\gamma(\text{DCO})$ from 1981Pi02 consistent with (E2).
945.4 4	11.1# 9	5706.2	14 ⁺	4760.7	12 ⁺	(E2) ^a	$A_2=+0.262$ 15; $A_4=-0.115$ 12; DCO=0.96 15; pol=+0.53 13 $A_2=+0.34$ 6, $A_4=-0.11$ 9. I_γ : other: 9.5 15 (1981Pi02 at 56 MeV).
969.1 ^b 6	4.1 3	4146.1	(10 ⁺)	3177.1	8 ⁺	(Q)	$A_2=+0.51$ 16; $A_4=-0.16$ 23; DCO=1.2 6 $A_2=+0.46$ 8, $A_4=-0.15$ 12.

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$^{91}\text{Zr}(^{12}\text{C},3n\gamma)$ **1981Pi02 (continued)** $\gamma(^{100}\text{Pd})$ (continued)

E_γ^\dagger	I_γ^\dagger	$E_i(\text{level})$	J_i^\ddagger	E_f	J_f^\ddagger	Mult.&	Comments
988.6 6	5.2 3	3177.1	8 ⁺	2188.86	6 ⁺	Q	<p>E_γ: this transition is uncertain since not reported in other studies.</p> <p>I_γ: other: 4.70 23, corrected for 7% contribution from a ^{103}Pd transition (1981Pi02 at 56 MeV).</p> <p>$A_2=+0.35$ 3; $A_4=-0.09$ 4; DCO=1.0 3; pol=-0.3 4</p> <p>$A_2=+0.33$ 6; $A_4=-0.03$ 9</p> <p>I_γ: other: 5.25 21, corrected for 4% contribution from a ^{103}Pd transition (1981Pi02 at 56 MeV).</p> <p>Mult.: M2 is proposed by 1981Pi02 from Pol=-0.33 37, but E2 is proposed in $^{50}\text{Cr}(^{58}\text{Ni},4p\alpha\gamma)$, $^{70}\text{Zn}(^{36}\text{S},6n\gamma)$ (2001Pe05) from POL=+1.1 7.</p>
1035.87 ^{@b} 21	11.7 [#] 9	6768.0?	16 ⁻	5732.1?	14 ⁻	E2	<p>$A_2=+0.25$ 6; $A_4=-0.16$ 8; DCO=1.10 13; pol=+0.70 18</p> <p>$A_2=+0.29$ 7; $A_4=-0.02$ 10.</p> <p>E_γ: placement from a 6705, 15⁻ level in the Adopted Levels, Gammas.</p> <p>I_γ: other: 8.0 4 (1981Pi02 at 56 MeV).</p>
1071.0 ^{@b} 5	6.4 [#] 10	7839.0?	18 ⁻	6768.0?	16 ⁻	E2	<p>$A_2=+0.15$ 9; $A_4=-0.19$ 13; DCO=1.3 3; pol=+0.49 20</p> <p>E_γ: Placement from a 8716, (19)⁻ level in the Adopted Levels, Gammas.</p> <p>I_γ: other: <4 (1981Pi02 at 56 MeV).</p>
1089.1 3	14.4 5	2504.9	5 ⁻	1415.80	4 ⁺	E1	<p>$A_2=-0.231$ 25; $A_4=-0.01$ 4; DCO=3.6 +15-8; pol=+0.42 20</p> <p>I_γ: other: 14.6 4 (1981Pi02 at 56 MeV).</p> <p>$A_2=-0.27$ 4; $A_4=+0.02$ 6.</p>

[†] From data obtained at $E(^{12}\text{C})=63$ MeV in 1981Pi02. Data for I_γ and $\gamma(\theta)$ at $E=56$ MeV are also available in 1981Pi02 and given under comments.

[‡] γ ray definitely assigned to ^{100}Pd on the basis of $\gamma\gamma$ data, but the placement is uncertain in view of the tentative nature of the final level.

[#] Unresolved peak, intensity derived from $\gamma\gamma$ data.

[@] Different placement is adopted in the Adopted Levels, Gammas.

[&] From $\gamma(\theta)$ and $\gamma(\text{lin pol})$ data in 1981Pi02. For unresolved transitions, the assignments are given in parentheses since the quoted values of $\gamma(\theta)$ coefficients and $\gamma(\text{pol})$ are for the composite structures.

^a The polarization value may be perturbed by unresolved transitions (1981Pi02).

^b Placement of transition in the level scheme is uncertain.

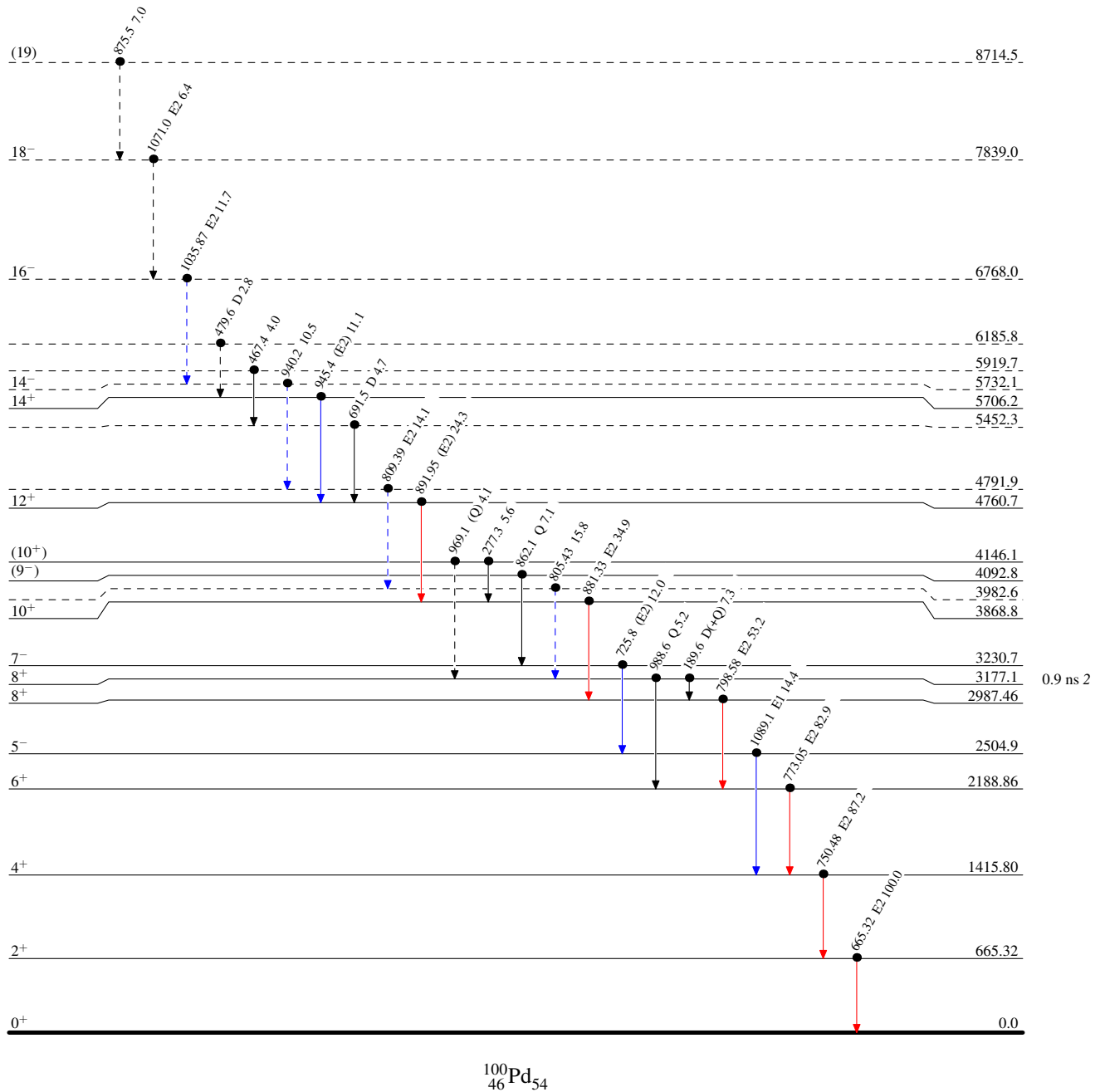
$^{91}\text{Zr}(^{12}\text{C},3n\gamma)$ 1981Pi02

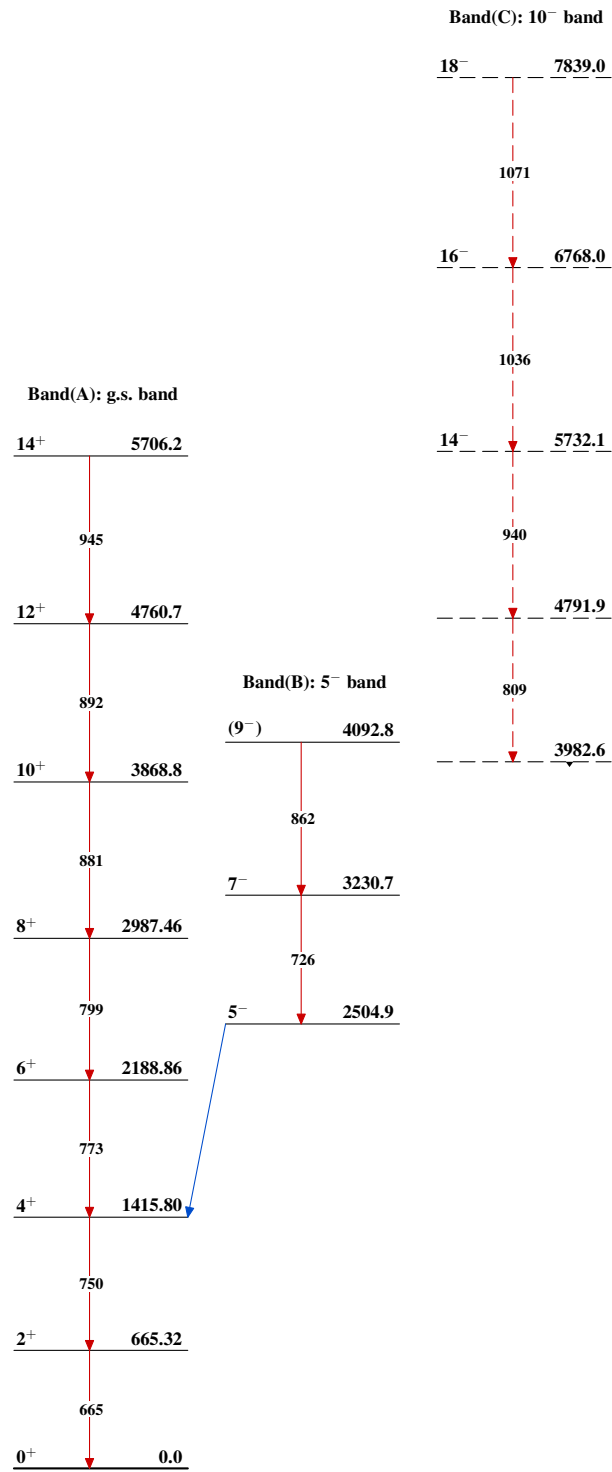
Level Scheme

Intensities: Relative I_γ

Legend

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

 $^{100}_{46}\text{Pd}_{54}$

$^{91}\text{Zr}(^{12}\text{C},3n\gamma)$ 1981Pi02 $^{100}_{46}\text{Pd}_{54}$