^{142}Nd(^{52}Cr,p2nγ) 2004Ni06

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	M. S. Basunia	NDS 195,368 (2024)	1-Dec-2023

Slightly edited the updated dataset by B. Singh (McMaster) for ENSDF, dated 29-Feb-2016.

See also ^{109}Ag(^{86}Kr,4nγ) (2015Ny02) from the same group where level scheme and band structures have been revised, improved and extended by $\gamma\gamma$-coin data.

2004Ni06 (also 2003NiZZ, 2001Ni04): Reaction ^{142}Nd(^{52}Cr,p2n), E(lab)=235 MeV. Separated fusion evaporation residues using the RITU gas-filled mass separator. Used 27 Compton-suppressed Ge detectors, of various types, to observe prompt γ rays at the target position. The mass-separated recoils were implanted into a position-sensitive Si strip detector at the focal plane of the separator. An upstream multiwire proportional gas counter was used to discriminate between recoil fragments and α-decay signals. Delayed, isomeric, γ rays were observed with five Ge detectors surrounding the Si detector. Used recoil-decay tagging techniques to process the events. Measured E(γ), I(γ), $\gamma\gamma$ and γ-recoil coincidences. Improved high-spin data are reported by the same group in 2015Ny02 using ^{109}Ag(^{86}Kr,4nγ) reaction; see a separate dataset for this reaction.

1999NiZY: Production by ^{159}Tb(^{36}Ar,4n), E=175 MeV. Measured prompt γ-ray energy at the target position using the SARI detector array, Fusion-evaporation residues implanted in Si detector at the focal-plane of the RITU gas-filled recoil separator. Decay of isomeric states studied with four TESSA array detectors for delayed γ rays. Analysis of events using the recoil-decay tagging technique.

^{191}Bi Levels

Level scheme, γ-ray energies and intensities, J^π assignments are from 2004Ni06, unless noted otherwise. However, several revisions have been made in the placement of transitions with improved $\gamma\gamma$-coin data in 2015Ny02, thus revising some level energies.

From recoil-decay tagging (RDT) analysis a collective band, on the $(1/2^+)$ isomeric state at 240 keV, is observed (2001Ni04). It was found that the on top of the expected $(13/2^+)$ state decays to the $(9/2^-)$ ground state via an (M2) 429-keV γ ray, with a half-life of 533 ns *7* (2001Ni04). A sequence of γ rays can be arranged into a band-like structure above the $(13/2^+)$ state. These comprise a cascade of (M1) γ rays, with several (E2) crossover transitions (2001Ni04,2003NiZZ). Another band identified for this nucleus is a negative parity band linked to the $(9/2^-)$ ground state.

E(level)[†‡]	J^π	$T_{1/2}$	Comments
0.0[@]	$9/2^-$	12.4 s *3*	$T_{1/2}$: from Adopted Levels.
149.0 *5*	$7/2^-$	<10 ns	J^π: from the multipolarity of the γ-ray to the $(9/2^-)$ g.s., possible values are $(7/2^-,9/2^-,11/2^-)$. The absence of any γ transition connecting to the 429.7-keV $13/2^+$ level, indicates $7/2^-$ as the most probable value for this level. Supporting evidence is provided by the low hindrance factor of the 7075-keV α decay from the $7/2^-$ level in ^{195}At to this level (2003Ke04). $T_{1/2}$: From Adopted Levels.
242[&] *4*	$1/2^+$	125 ms *8*	Additional information 1. E(level),$T_{1/2}$: from Adopted Levels. J^π: from systematics for $1/2^+$ intruder states in all Bi isotopes from the N=104 neutron mid shell to N=126 (1985Co06,2001Ni04). Confirming evidence is provided by the hindrance factors of both the α decay feeding this level (E(α)=6953 keV, HF=0.92) from the $1/2^+$ ^{195}At g.s., and deexciting it (E(α)=6870 keV, HF=1.5) to the $1/2^+$ ^{187}Tl ground state (2003Ke04).
343.7? *9*			
422.9[&] *7*	$(5/2^+)$		
429.7[#] *5*	$13/2^+$	562 ns *10*	J^π: from systematics of $(13/2^+)$ levels in neighboring Bi nuclei and (M2) multipolarity of the γ ray to the $(9/2^-)$ g.s. $T_{1/2}$: from recoil-γ(t) (2004Ni06). Earlier value from the same group was 533 ns *7* (2001Ni04).
486.0[@] *5*	$(11/2^-)$		

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^{142}Nd(^{52}Cr,p2nγ) 2004Ni06 (continued)

^{191}Bi Levels (continued)

E(level)[†][‡]	J$^\pi$	T$_{1/2}$	Comments
693.1[@] *6*	(13/2$^-$)		
747.1[&] *10*	(9/2$^+$)		This state (9/2$^+$) is discarded in the adopted dataset since the 324.2γ from this level is reassigned in 2015Ny02 from a 933,(9/2$^+$) level. A comparable level energy 747 keV of J$^\pi$=(15/2$^+$) is present in the adopted dataset.
748.0[#] *7*	15/2$^+$		
1017.8[@] *8*	(15/2$^-$)		
1026.7[#] *7*	17/2$^+$		
1144.7[&] *13*	(13/2$^+$)		This level is discarded in the Adopted dataset since the 397.6γ from this level is reassigned by 2015Ny02 from a 1332, (13/2$^+$) level.
1257.0 *12*			
1271.1[@] *9*	(17/2$^-$)		This level is discarded in the Adopted dataset since the 578.0γ from this level is reassigned in 2015Ny02 from an 1825, (21/2$^-$) level.
(1271.1+x)		400 ns *40*	Additional information 2. E(level): the existence of this unknown level is inferred from the half-life observed for the 578-keV γ ray deexciting the 1271-keV level (2004Ni06,2003NiZZ). Due to the reassignment of 578.0γ from an 1825, (21/2$^-$) level, this level is listed in the Adopted dataset with energy 1825+x.
1351.5[#] *8*	19/2$^+$		
1599.6[#] *9*	21/2$^+$		
1616.9?[@] *10*	(19/2$^-$)		
1626.7[&] *16*	(17/2$^+$)		This level is discarded in the Adopted dataset since the 482γ from this level is reassigned in 2015Ny02 from an 1815 (1813 in adopted), (17/2$^+$) level.
1736.6 *10*	(21/2$^+$)		This level is discarded in the Adopted dataset since the 385γ from this level is reassigned in 2015Ny02 from a 1982, (23/2$^+$) level; and 710γ from this level is not reported in 2015Ny02.

[†] From least-squares fit to Eγ values.
[‡] As of Fig. 12 in 2004Ni06.
[#] Band(A): Band based on 13/2$^+$ isomeric state. This band is built based on intensity arguments and recoil-gated $\gamma\gamma$ coincidences (2004Ni06).
[@] Band(B): Negative-parity band based on 9/2$^-$ g.s.
[&] Band(C): Positive parity band based on 1/2$^+$ intruder state. This band is proposed to consist of a cascade of stretched E2 transitions (2004Ni06), built on the basis of intensity arguments and weak $\gamma\gamma$ coincidences.

γ(^{191}Bi)

Angular distribution coefficients in 2004Ni06 are defined as the ratio R(exp)=I(134°,158°)/I(79°,101°), where the angles are those of four of the detectors in the Jurosphere array at the target position.

E$_\gamma$[†]	I$_\gamma$[†]	E$_i$(level)	J$_i^\pi$	E$_f$	J$_f^\pi$	Mult.[‡]	α[@]	Comments
149.0 *5*	22 *3*	149.0	7/2$^-$	0.0	9/2$^-$	(M1)	3.27 *6*	α(K)=2.66 *5*; α(L)=0.465 *8*; α(M)=0.1094 *19* α(N)=0.0280 *5*; α(O)=0.00572 *10*; α(P)=0.000681 *12* Mult.: From Adopted Gammas.
180.9 *7*	17 *3*	422.9	(5/2$^+$)	242	1/2$^+$	(E2)	0.642 *13*	α(K)=0.2093 *34*; α(L)=0.322 *7*; α(M)=0.0847 *19* α(N)=0.0216 *5*; α(O)=0.00401 *9*; α(P)=0.000324 *7* R(exp)=0.9 *2*. Mult.: suggested in 2004Ni06 as having stretched E2 character.

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^{142}Nd(^{52}Cr,p2nγ) 2004Ni06 (continued)

$\gamma(^{191}Bi)$ (continued)

E_γ[†]	I_γ[†]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡]	α[@]	Comments
[x]187.0[#] *7*	6 *2*							Placement: from 609, $(5/2^+)$ level (2015Ny02).
194.7 *7*	18 *5*	343.7?		149.0	$7/2^-$	D		R(exp)=0.8 *2*.
207.1 *7*	7 *4*	693.1	$(13/2^-)$	486.0	$(11/2^-)$			
248.2 *7*	17 *5*	1599.6	$21/2^+$	1351.5	$19/2^+$	(M1)	0.782 *13*	α(K)=0.637 *10*; α(L)=0.1105 *18*; α(M)=0.0260 *4* α(N)=0.00664 *11*; α(O)=0.001357 *22*; α(P)=0.0001616 *26* R(exp)=0.8 *2*. Mult.: Suggested as most probable multipolarity in 2004Ni06.
278.6 *5*	50 *5*	1026.7	$17/2^+$	748.0	$15/2^+$	(M1)	0.568 *8*	α(K)=0.463 *7*; α(L)=0.0802 *12*; α(M)=0.01884 *28* α(N)=0.00482 *7*; α(O)=0.000985 *15*; α(P)=0.0001173 *17* R(exp)=0.76 *8*. Mult.: Suggested as most probable multipolarity in 2004Ni06.
[x]297.2[#] *7*	3 *1*							Placement: from 719, $(7/2^+)$ level (2015Ny02).
318.3 *5*	100 *10*	748.0	$15/2^+$	429.7	$13/2^+$	(M1)	0.395 *6*	α(K)=0.322 *5*; α(L)=0.0556 *8*; α(M)=0.01305 *19* α(N)=0.00334 *5*; α(O)=0.0006820 *99*; α(P)=8.12×10^{-5} *12* R(exp)=0.78 *7*. This γ ray placed to feed directly the 430-keV $13/2^+$ band head, based on intensity arguments, and from systematics of similar transitions in heavier Bi isotopes. Mult.: Suggested as most probable multipolarity in 2004Ni06.
324.2 *7*	11 *3*	747.1	$(9/2^+)$	422.9	$(5/2^+)$	[E2]	0.0960 *15*	α(K)=0.0553 *8*; α(L)=0.0305 *5*; α(M)=0.00784 *13* α(N)=0.001998 *32*; α(O)=0.000380 *6*; α(P)=3.40×10^{-5} *5* Placement not adopted: this γ is placed from a 933, $(9/2^+)$ level in 2015Ny02. Mult.: Suggested in 2004Ni06 as having stretched E2 character.
324.6 *7*	17 *9*	1017.8	$(15/2^-)$	693.1	$(13/2^-)$			
324.8 *5*	19 *7*	1351.5	$19/2^+$	1026.7	$17/2^+$	(M1)	0.374 *5*	α(K)=0.305 *4*; α(L)=0.0526 *8*; α(M)=0.01234 *18* α(N)=0.00316 *5*; α(O)=0.000645 *9*; α(P)=7.68×10^{-5} *11* R(exp)=0.81 *8*. Mult.: Suggested as most probable multipolarity in 2004Ni06.
[x]344.0[#] *7*	3 *1*							Placement: from 824, $(7/2^+)$ level (2015Ny02).
[x]368.6[#] *7*	5 *2*							Placement: from 609, $(5/2^+)$ level (2015Ny02).
385 *1*	10 *5*	1736.6	$(21/2^+)$	1351.5	$19/2^+$	D		The 385γ is placed from a 1982, $(23/2^+)$ level in 2015Ny02. R(exp)=0.92 *9*.

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^{142}Nd(^{52}Cr,p2nγ) 2004Ni06 (continued)

$\gamma(^{191}Bi)$ (continued)

E_γ[†]	I_γ[†]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡]	α[@]	Comments
397.6 *7*	9 *3*	1144.7	(13/2$^+$)	747.1	(9/2$^+$)	[E2]	0.0546 *8*	α(K)=0.0350 *5*; α(L)=0.01472 *22*; α(M)=0.00374 *6* α(N)=0.000953 *15*; α(O)=0.0001830 *28*; α(P)=1.714×10^{-5} *26* The 397.6γ is placed from a 1332, (13/2$^+$) level in 2015Ny02. Mult.: Suggested in 2004Ni06 as having stretched E2 character.
429.7 *5*		429.7	13/2$^+$	0.0	9/2$^-$	M2	0.542 *8*	B(M2)(W.u.)=0.0757 *22* α(K)=0.418 *6*; α(L)=0.0938 *14*; α(M)=0.02288 *33* α(N)=0.00589 *9*; α(O)=0.001197 *17*; α(P)=0.0001391 *20* Observed in spectra tagged with the 9/2$^-$ ^{191}Bi g.s. α decay. Additional information 3. Mult.: proposed on the basis of the K X ray intensity and in analogy with heavier Bi isotopes (1999NiZY). The relative intensities of K X rays and γ rays yield an estimate of α_K=0.61 *10*, in reasonable agreement with an M2 assignment (2004Ni06).
[x]459[#] *1*	3 *1*							Placement: from 880, (9/2$^+$) level (2015Ny02).
482 *1*	6 *2*	1626.7	(17/2$^+$)	1144.7	(13/2$^+$)	[E2]	0.0335 *5*	α(K)=0.02316 *34*; α(L)=0.00781 *12*; α(M)=0.001958 *30* α(N)=0.000499 *8*; α(O)=9.68×10^{-5} *15*; α(P)=9.47×10^{-6} *14* The 482γ is placed from an 1815 (1813 in adopted), (17/2$^+$) level in 2015Ny02. Mult.: Suggested in 2004Ni06 as having stretched E2 character.
486.0 *5*	39 *6*	486.0	(11/2$^-$)	0.0	9/2$^-$	D		R(exp)=0.7 *2*.
509 *1*	14 *7*	1257.0		748.0	15/2$^+$			
[x]527[#] *1*	3 *1*							Placement: from 2341 level (2015Ny02).
532 *1*	20 *6*	1017.8	(15/2$^-$)	486.0	(11/2$^-$)			
[x]544[#] *1*	3 *1*							An unplaced 542.5 *5* γ ray seen in 2015Ny02 is probably the same as 544 in 2004Ni06.
[x]553[#] *1*	3 *1*							Placement: from 2367, (21/2$^+$) level (2015Ny02).
572.8 *7*	38 *11*	1599.6	21/2$^+$	1026.7	17/2$^+$	(E2)	0.02235 *32*	α(K)=0.01622 *23*; α(L)=0.00463 *7*; α(M)=0.001146 *17* α(N)=0.000292 *4*; α(O)=5.72×10^{-5} *8*; α(P)=5.81×10^{-6} *8* R(exp)=1.1 *2*. Mult.: Suggested as most probable multipolarity in 2004Ni06.
578.0 *7*	29 *5*	1271.1	(17/2$^-$)	693.1	(13/2$^-$)	(E2)	0.02190 *31*	α(K)=0.01593 *23*; α(L)=0.00451 *7*; α(M)=0.001116 *16* α(N)=0.000285 *4*; α(O)=5.57×10^{-5} *8*; α(P)=5.67×10^{-6} *8*

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^{142}Nd(^{52}Cr,p2nγ) 2004Ni06 (continued)

$\gamma(^{191}Bi)$ (continued)

E_γ †	I_γ †	E_i(level)	J_i^π	E_f	J_f^π	Mult. ‡	α @	Comments
								The 578.0γ is placed from an 1825, (21/2$^-$) level in 2015Ny02. R(exp)=1.9 *4*. This γ ray allows one to deduce the existence of an unknown precursor level, from the half-life of 400 ns *40* which can be extracted form the observed time differences (2004Ni06,2003NiZZ) between recoil implantation and the detection of the 578-keV γ ray. No more precise information regarding the precursor state could be obtained in the experiments (2004Ni06). Mult.: Multipolarity suggested by evaluator, based on the measured R(exp)=1.9 *4* value, and the assumed spin difference between connected states.
597.0 *7*	63 *10*	1026.7	17/2$^+$	429.7	13/2$^+$	[E2]	0.02036 *29*	α(K)=0.01493 *21*; α(L)=0.00411 *6*; α(M)=0.001014 *15* α(N)=0.000259 *4*; α(O)=5.07×10^{-5} *7*; α(P)=5.19×10^{-6} *7* Mult.: Suggested as most probable multipolarity in 2004Ni06.
599.1& *7*	8 *4*	1616.9?	(19/2$^-$)	1017.8	(15/2$^-$)			
603.7 *7*	20 *6*	1351.5	19/2$^+$	748.0	15/2$^+$	[E2]	0.01986 *28*	α(K)=0.01460 *21*; α(L)=0.00398 *6*; α(M)=0.000982 *14* α(N)=0.000250 *4*; α(O)=4.91×10^{-5} *7*; α(P)=5.04×10^{-6} *7* Mult.: Suggested as most probable multipolarity in 2004Ni06.
693.1 *7*	55 *8*	693.1	(13/2$^-$)	0.0	9/2$^-$	Q		R(exp)=1.1 *2*.
710 *1*	17 *8*	1736.6	(21/2$^+$)	1026.7	17/2$^+$			E_γ: γ not reported in 2015Ny02.

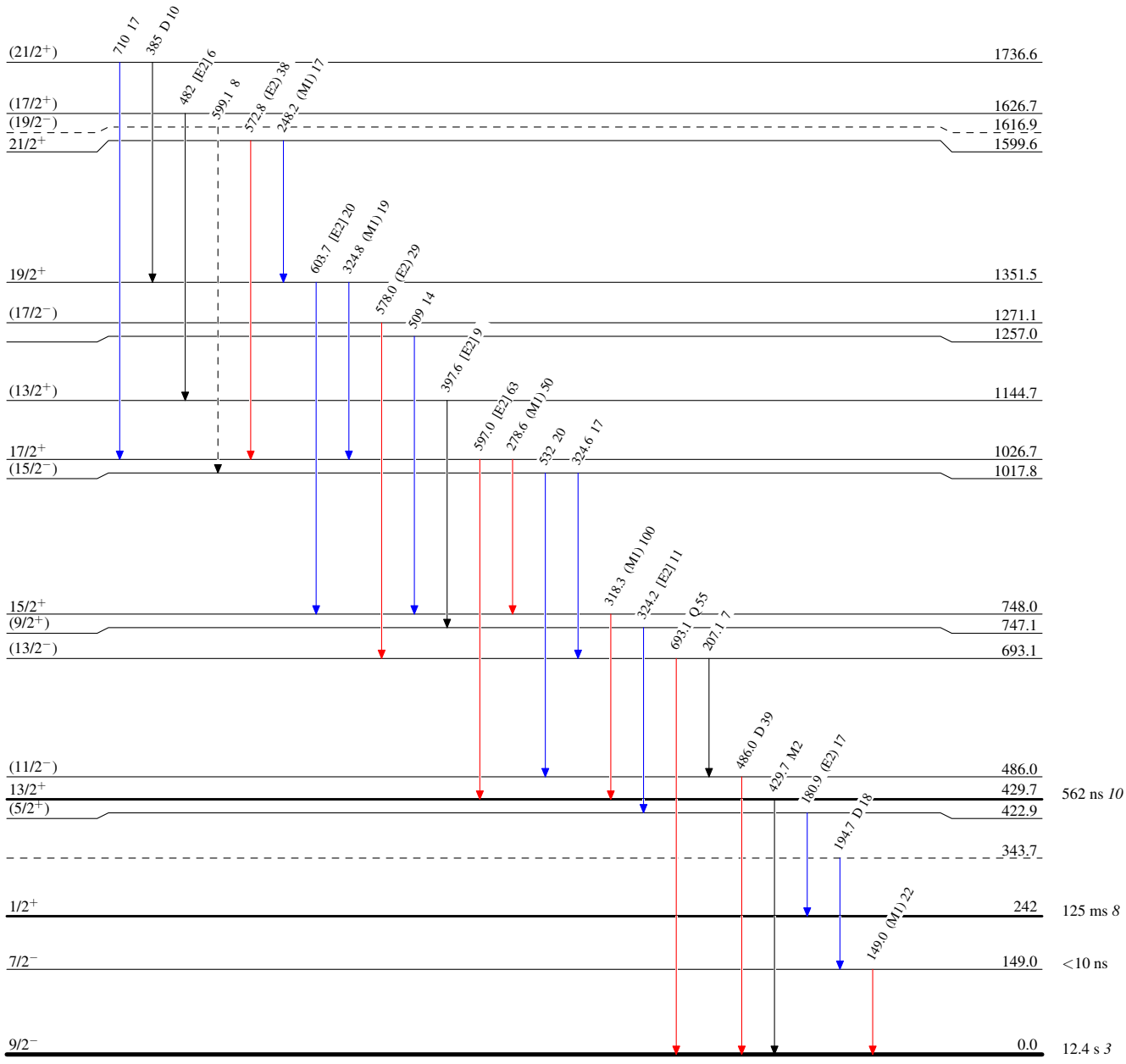
† From 2004Ni06. Relative intensities as percentage of the most intense γ-ray (318.3 keV).
‡ Multipole character deduced on the basis of the measured angular distribution coefficients (2004Ni06), except where noted otherwise.
# The γ ray seen in singles spectra gated by recoils and gated by the 6870-keV α decay from the (1/2$^+$) intruder state. The placement of these transitions could not be resolved (2004Ni06). Proposed placement in 2015Ny02 is given under comments.
@ Additional information 4.
& Placement of transition in the level scheme is uncertain.
x γ ray not placed in level scheme.

^{142}Nd(^{52}Cr,p2nγ) 2004Ni06

Level Scheme

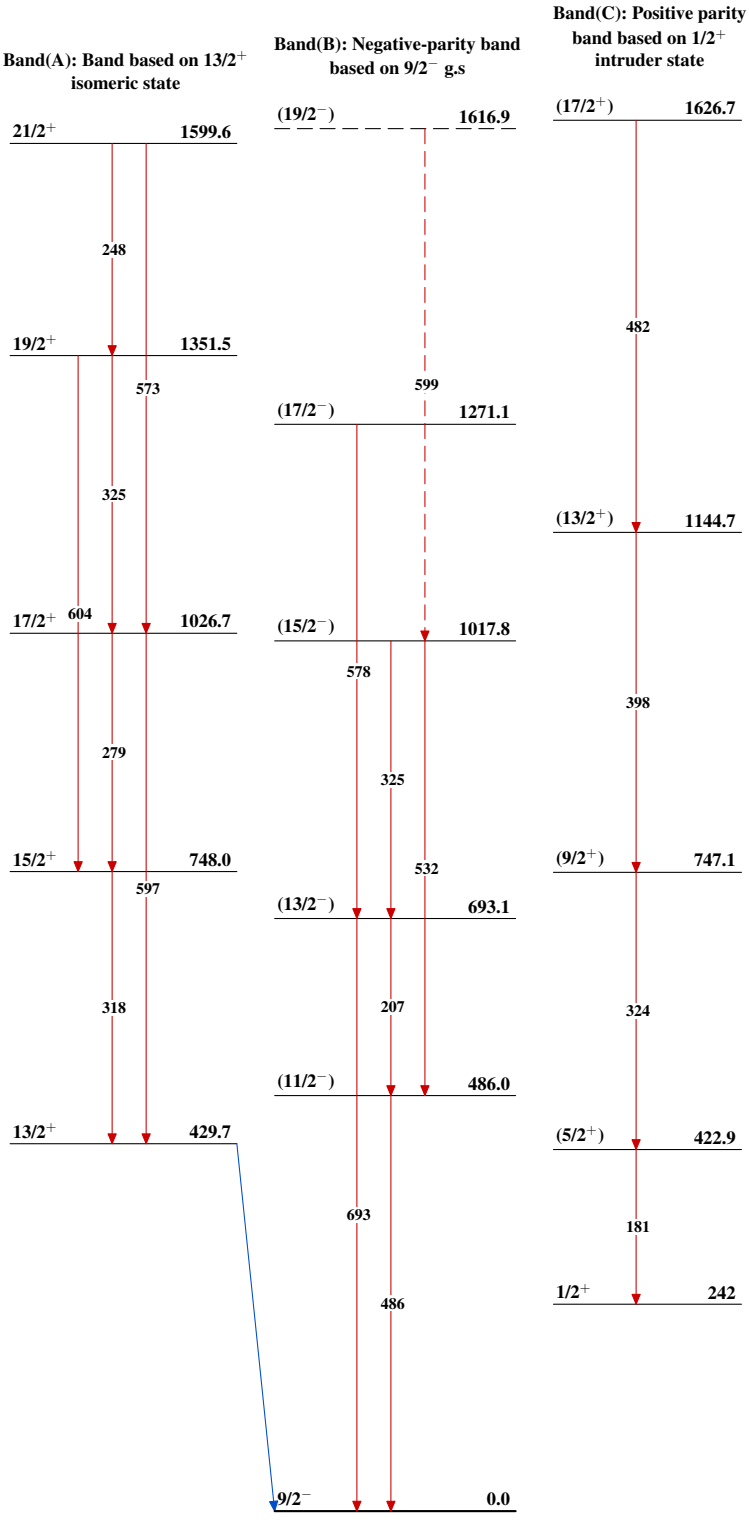
Intensities: Relative I_γ

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)



$^{191}_{83}Bi_{108}$

^{142}Nd(^{52}Cr,p2nγ) 2004Ni06



$^{191}_{83}Bi_{108}$