^{12}C(^{28}Si,αpγ) 2007Ks01,2013Bi10,2020Ra14

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Lijie Sun and Jun Chen	NDS 211,1 (2026)	30-Sep-2025

2007Ks01: two different experiments: one with E=70 MeV ^{28}Si beam at BARC-TIFR facility and the second with E=88 MeV ^{28}Si beam at NSC facility, both using a target of about 50 μg/cm^2 ^{12}C on a ≈10.5−mg/cm^2 gold backing. γ rays were detected with almost identical (INGA) arrays of eight Compton-suppressed Clover HPGe detectors. Measured Eγ, Iγ, $\gamma\gamma$-coin, $\gamma\gamma(\theta)$(DCO), $\gamma\gamma$(lin pol), Doppler-shift attenuations. Deduced levels, J, π, $T_{1/2}$, γ-ray multipolarities and mixing ratios. Comparisons with available data and large-scale shell-model calculations.

2013Bi10: E=110 MeV ^{28}Si beam was produced from the IUAC-New Delhi accelerator facility. Target was 50 μg/cm^2 thick ^{12}C on 18 mg/cm^2 Au backing. γ rays were detected with the INGA array of thirteen Compton-suppressed Clover detectors. Measured Eγ, Iγ, $\gamma\gamma$-coin, $\gamma\gamma(\theta)$(DCO), Doppler-shift attenuations. Deduced levels, J, π, $T_{1/2}$, evidence for an SD band, γ-ray multipolarities. Comparison with large-scale shell-model calculations, two-level mixing calculation, and with structure of SD states in ^{36}Ar.

2020Ra14: E=110 MeV ^{28}Si beam was produced from the 15UD Pelletron accelerator at the Inter-University Accelerator Centre (IUAC), New Delhi. Target was 50 μg/cm^2 ^{12}C evaporated onto 18 mg/cm^2 Au backing. γ rays were detected with a multi-detector array (Indian National Gamma Array) consisting of 13 Compton-suppressed clovers. Measured Eγ, Iγ, $\gamma\gamma$-coin, $\gamma\gamma$(DCO), $\gamma\gamma$(ADO), $\gamma\gamma$(IPDCO). Deduced levels, J, π, γ-ray multipolarities. Comparisons with theoretical calculations.

Other reactions:

1982Le04: ^{28}Si(^{12}C,Xγ) ^{12}C (E_{cm}=23-35 MeV) beam produced from the University of Washington FN Tandem Van de Graaff. A target of 100 μg/cm^2 ^{28}Si on a thick tantalum backing. A Ge(Li) detector. Measured σ(E), Eγ.

1985Kr21: ^{27}Al(^{12}C,X) E=85 MeV/nucleon. Measured particle-particle angular correlations.

^{35}Cl Levels

E(level)[†‡]	J$^\pi$[#]	$T_{1/2}$[@]	Comments
0.0	3/2$^+$		
1763.0 *6*	5/2$^+$		
2645.8 *6*	7/2$^+$	<0.90 ps	
3003.1 *8*	5/2$^+$		
3163.1 *6*	7/2$^-$		
3942.0 *7*	9/2$^+$	<0.35 ps	
4347.8 *6*	9/2$^-$	0.91 ps *+21−16*	
5407.4 *8*	11/2$^-$	<0.76 ps	
5927.1 *7*	(11/2)$^-$	<0.28 ps	
6087.6 *8*	13/2$^-$		
6119.5? *13*	(11/2$^-$)		
6660.2 *8*	(11/2$^-$)		
7873.3 *8*	13/2$^+$		
8319.4[b] *9*	15/2$^-$	12.5[a] fs *7*	Tentative 8324, (13/2$^-$) level in 2007Ks01 is considered the same level here by the evaluators. $T_{1/2}$: other: <70 fs (2007Ks01). Q(transition)=0.65 *2*, β_2=0.30 (2013Bi10).
8487.8 *10*	15/2$^-$	<0.07 ps	Tentative 8481, (15/2$^-$) level in 2007Ks01 is considered the same level here by the evaluators.
8558.2? *13*	(13/2$^-$)	<0.14 ps	
8787.3? *13*	(15/2$^+$)	<0.28 ps	
8845.1[&] *9*	17/2$^+$		
10181.1[b] *10*	19/2$^-$	42.3[a] fs *28*	Tentative 10181, (19/2$^+$) level in 2007Ks01 is considered the same level here by the evaluators. $T_{1/2}$: other: <0.14 ps (2007Ks01). Q(transition)=0.82 *6*, β_2=0.37 (2013Bi10).
10223.2? *14*	(17/2$^-$)	<0.28 ps	
10862.2? *14*	19/2$^+$	<0.28 ps	

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$^{12}C(^{28}Si,\alpha p\gamma)$ 2007Ks01,2013Bi10,2020Ra14 (continued)

^{35}Cl Levels (continued)

E(level)[†][‡]	Jπ[#]	$T_{1/2}$[@]	Comments
11459.2[&] *12*	$21/2^+$	43.0[a] fs *21*	Q(transition)=0.56 *2*, β_2=0.27 (2013Bi10).
12572.2[b] *12*	$23/2^-$	33[a] fs *4*	Q(transition)=0.71 *5*, β_2=0.32 (2013Bi10).
16306.4[b] *16*	$(27/2^-)$	<9.0[a] fs	Q(transition)>0.5, β_2=0.24 (2013Bi10).

† Additional information 1.
‡ From a least-squares fit to γ-ray energies, assuming ΔEγ=1 keV in the fitting procedure.
# From the Adopted Levels, unless otherwise noted. Assignments for tentative levels not adopted in Adopted Levels are proposed by 2007Ks01.
@ From DSAM in 2007Ks01, unless otherwise noted.
& Existence of $17/2^+$ and $21/2^+$ levels provides indirect evidence in favor of SD band interpretation and parity-doublet cluster structure (2013Bi10).
[a] From DSAM in 2013Bi10.
[b] Band(A): SD band. Proposed configuration=3p−3h, $(sd)^{16}(pf)^3$. Negative-parity partner of SD band in ^{36}Ar (2013Bi10).

γ(^{35}Cl)

Δ_{IPDCO} corresponds to integrated polarization asymmetry measurement at E=70 MeV at TIFR facility (2007Ks01). The values are from e-mail reply of Dec 1, 2006 from one of the authors (M. Saha Sarkar) of 2007Ks01 to the previous evaluator B. Singh.

Δ_{IPDCO} and DCO under comments are from 2007Ks01, unless otherwise noted. Positive value of Δ_{IPDCO} indicates electric character and negative value indicates magnetic character. Expected value of DCO is ≈1.0 for a stretched transition gated by a transition of same multipolarity, ≈2.0 for dipole when gated by a stretched quadrupole (DCO(Q)) and ≈0.5 for stretched quadrupole when gated by a stretched dipole (DCO(D)) (2007Ks01). Values deviating from above values indicate a mixed transition. DCO values are also available in 2020Ra14, but expected values are opposite to those in 2007Ks01 for stretched dipole and quadrupole transitions when gated by a transition of different multipolarity, that is DCO(Q)≈0.5 for stretched dipole and DCO(D)≈2.0 for stretched quadrupole (2020Ra14).

For ADO ratios under comments from 2020Ra14, expected values are 0.6 for pure dipole transitions and 1.6 for pure quadrupole transitions or ΔJ=0 transitions (2020Ra14).

E_γ[†]	I_γ[‡]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	δ[#]	Comments
160[@]	1.1 *3*	3163.1	$7/2^-$	3003.1	$5/2^+$			I_γ: other: 0.6 *2* at E=70 MeV.
518	9.2 *5*	3163.1	$7/2^-$	2645.8	$7/2^+$	D		I_γ: other: 10.0 *2* at E=70 MeV. DCO(Q)=0.8 *1*. DCO(D)=1.5 *2*, R_{ADO}=1.6 *4* (2020Ra14).
526		8845.1	$17/2^+$	8319.4	$15/2^-$			
680	32 *1*	6087.6	$13/2^-$	5407.4	$11/2^-$	M1(+E2)	+0.1 *1*	I_γ: other: 8.6 *2* at E=70 MeV. DCO(Q)=1.3 *1* at E=70 MeV. Δ_{IPDCO}=−0.09 *2*.
712[@&]	<1	6119.5?	$(11/2^-)$	5407.4	$11/2^-$			
779[@&]	<1	3942.0	$9/2^+$	3163.1	$7/2^-$			
883	3.2 *2*	2645.8	$7/2^+$	1763.0	$5/2^+$			Iγ=4.6 *2* at E=70 MeV. Δ_{IPDCO}=+0.01 *5*.
914[&]	2.4 *5*	8787.3?	$(15/2^+)$	7873.3	$13/2^+$	D(+Q)	−0.2 *2*	DCO(Q)=2.2 *6* at E=88 MeV.
972	33 *1*	8845.1	$17/2^+$	7873.3	$13/2^+$	E2		I_γ: other: 2.0 *1* at E=70 MeV. DCO(Q)=1.0 *2* at E=70 MeV, 0.9 *1* at E=88 MeV. Δ_{IPDCO}=+0.08 *4*. DCO(D)=1.8 *2*, DCO(Q)=0.9 *1*, R_{ADO}=1.6 *2* (2020Ra14).

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^{12}C(^{28}Si,αpγ) 2007Ks01,2013Bi10,2020Ra14 (continued)

γ(^{35}Cl) (continued)

E_γ[†]	I_γ[‡]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	δ[#]	Comments
1060	7.3 *7*	5407.4	11/2$^-$	4347.8	9/2$^-$	M1+E2	+0.2 *1*	I_γ: other: 6.9 *3* at E=70 MeV. DCO(D)=0.9 *1*. Δ_{IPDCO}=−0.10 *4*.
1113		12572.2	23/2$^-$	11459.2	21/2$^+$			
1185	25 *1*	4347.8	9/2$^-$	3163.1	7/2$^-$	M1+E2	−0.3 *1*	I_γ: other: 25 *1* at E=70 MeV. DCO(Q)=2.0 *2* at E=70 MeV, 2.8 *3* at E=88 MeV. Δ_{IPDCO}=−0.08 *3*.
1213		7873.3	13/2$^+$	6660.2	(11/2$^-$)			
1296	0.4 *2*	3942.0	9/2$^+$	2645.8	7/2$^+$			I_γ: other: 0.2 *1* at E=70 MeV.
1336	6 *1*	10181.1	19/2$^-$	8845.1	17/2$^+$	D(+Q)	−0.2 *2*	DCO(Q)=2.0 *4* at E=88 MeV.
1378[@&]	2 *1*	10223.2?	(17/2$^-$)	8845.1	17/2$^+$			
1400	<1	3163.1	7/2$^-$	1763.0	5/2$^+$			
1579	18 *2*	5927.1	(11/2)$^-$	4347.8	9/2$^-$	(M1+E2)	−0.2 *1*	I_γ: other: 12 *1* at E=70 MeV. DCO(D)=0.9 *1* at E=70 MeV, 1.0 *1* at E=88 MeV. Δ_{IPDCO}=+0.02 *3*.
1693		10181.1	19/2$^-$	8487.8	15/2$^-$			
1702	11.4 *6*	4347.8	9/2$^-$	2645.8	7/2$^+$	E1+M2	+0.5 *+5−3*	I_γ: other: 10.8 *5* at E=70 MeV. DCO(Q)=1.0 *2* from 2007Ks01 indicating ΔJ=2 or 0 seems inconsistent with ΔJ=1 from level scheme. Δ_{IPDCO}=+0.04 *4*. DCO(Q)=0.49 *6*, R_{ADO}=0.60 *6* (2020Ra14).
1740	2.0 *2*	6087.6	13/2$^-$	4347.8	9/2$^-$	E2		I_γ: other: 2.3 *2* at E=70 MeV. Δ_{IPDCO}=+0.12 *7*.
1763	>9.7	1763.0	5/2$^+$	0.0	3/2$^+$	E2+M1		I_γ: other: >15.7 at E=70 MeV. Δ_{IPDCO}=+0.13 *5*.
1786	1.8 *4*	7873.3	13/2$^+$	6087.6	13/2$^-$	D(+Q)	−0.6 *6*	I_γ: other: 0.1 *1* at E=70 MeV. DCO(Q)=1.2 *3* at E=88 MeV.
1862		10181.1	19/2$^-$	8319.4	15/2$^-$			
1946	10 *1*	7873.3	13/2$^+$	5927.1	(11/2)$^-$	E1+M2	+0.2 *1*	I_γ: other: 0.5 *1* at E=70 MeV. DCO(Q)=1.3 *2* at E=88 MeV. Δ_{IPDCO}=+0.11 *6*. DCO(Q)=0.45 *8*, R_{ADO}=0.59 *8* (2020Ra14).
1985[@]	2.0 *4*	5927.1	(11/2)$^-$	3942.0	9/2$^+$			I_γ: other: 1.6 *6* at E=70 MeV.
2017[@&]	7 *1*	10862.2?	19/2$^+$	8845.1	17/2$^+$			
2179	6.5 *7*	3942.0	9/2$^+$	1763.0	5/2$^+$	E2		I_γ: other: 11.1 *6* at E=70 MeV. Δ_{IPDCO}=+0.07 *5*.
2232		8319.4	15/2$^-$	6087.6	13/2$^-$			E_γ: from 2013Bi10 only.
2244	61 *2*	5407.4	11/2$^-$	3163.1	7/2$^-$	E2		I_γ: other: 50 *3* at E=70 MeV. DCO(Q)=1.0 *1* at E=70 MeV, 1.2 *1* at E=88 MeV. Δ_{IPDCO}=+0.04 *2*.
2312		6660.2	(11/2$^-$)	4347.8	9/2$^-$			
2391		12572.2	23/2$^-$	10181.1	19/2$^-$			
2400	<1	8487.8	15/2$^-$	6087.6	13/2$^-$	D(+Q)	+0.2 *+3−2*	E_γ: other: 2394 (2007Ks01). DCO(Q)=1.4 *4* at E=88 MeV.
2466	22 *2*	7873.3	13/2$^+$	5407.4	11/2$^-$	E1+M2	−0.25 *10*	I_γ: other: 1.2 *1* at E=70 MeV. DCO(Q)=2.4 *3*. Δ_{IPDCO}=+0.21 *6*. DCO(Q)=0.51 *8*, R_{ADO}=0.65 *9* (2020Ra14).

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^{12}C(^{28}Si,αpγ) 2007Ks01,2013Bi10,2020Ra14 (continued)

γ(^{35}Cl) (continued)

E_γ [†]	I_γ [‡]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	δ[#]	Comments
2614		11459.2	21/2$^+$	8845.1	17/2$^+$			
2631[@&]	<1	8558.2?	(13/2$^-$)	5927.1	(11/2)$^-$	D(+Q)	−0.2 *+2−3*	DCO(Q)=2.4 *7* at E=88 MeV.
2646	37 *2*	2645.8	7/2$^+$	0.0	3/2$^+$	E2		I_γ: other: 47 *2* at E=70 MeV. Δ_{IPDCO}=+0.08 *5*. DCO(D)=1.7 *2*, R_{ADO}=1.6 *2* (2020Ra14).
2757		8845.1	17/2$^+$	6087.6	13/2$^-$			
2764		5927.1	(11/2)$^-$	3163.1	7/2$^-$			E_γ: from 2013Bi10 only.
2912	<1	8319.4	15/2$^-$	5407.4	11/2$^-$			E_γ: other: 2917 (2007Ks01, tentative). Mult.,δ: D(+Q) with δ=−0.1 *+3−2* if J(8319)=13/2 in 2007Ks01. DCO(Q)=1.9 *6* at E=88 MeV.
3003[@]	>1.1	3003.1	5/2$^+$	0.0	3/2$^+$			I_γ: other: >0.6 at E=70 MeV.
3080	<1	8487.8	15/2$^-$	5407.4	11/2$^-$			E_γ: other: 3074 (2007Ks01).
3163	100 *5*	3163.1	7/2$^-$	0.0	3/2$^+$	M2+E3	+0.16 *1*	I_γ: other: 100 *2* at E=70 MeV. DCO(Q)=0.9 *1* at E=70 MeV, 0.7 *1* at 88 MeV. Δ_{IPDCO}=−0.06 *2*.
3497		6660.2	(11/2$^-$)	3163.1	7/2$^-$			
3734		16306.4	(27/2$^-$)	12572.2	23/2$^-$			
4347[@]	<1	4347.8	9/2$^-$	0.0	3/2$^+$			I_γ: other: <1 at E=70 MeV.

[†] From 2013Bi10, unless otherwise noted.
[‡] From 2007Ks01, measured at E(^{28}Si)=88 MeV at the NSC. Values are also available from E=70 MeV data of 2007Ks01 at TIFR facility, but less complete and are given under comments where available.
[#] Q and D+Q with δ(Q/D) are from $\gamma\gamma(\theta)$(DCO) in 2007Ks01 and magnetic/electric characters are from $\gamma\gamma$(lin pol) in 2007Ks01 where available and/or RUL where level $T_{1/2}$ is measured, unless otherwise noted.
[@] From 2007Ks01 only.
[&] Placement of transition in the level scheme is uncertain.

$^{12}C(^{28}Si,\alpha p\gamma)$ 2007Ks01,2013Bi10,2020Ra14

Level Scheme

Intensities: Relative I_γ

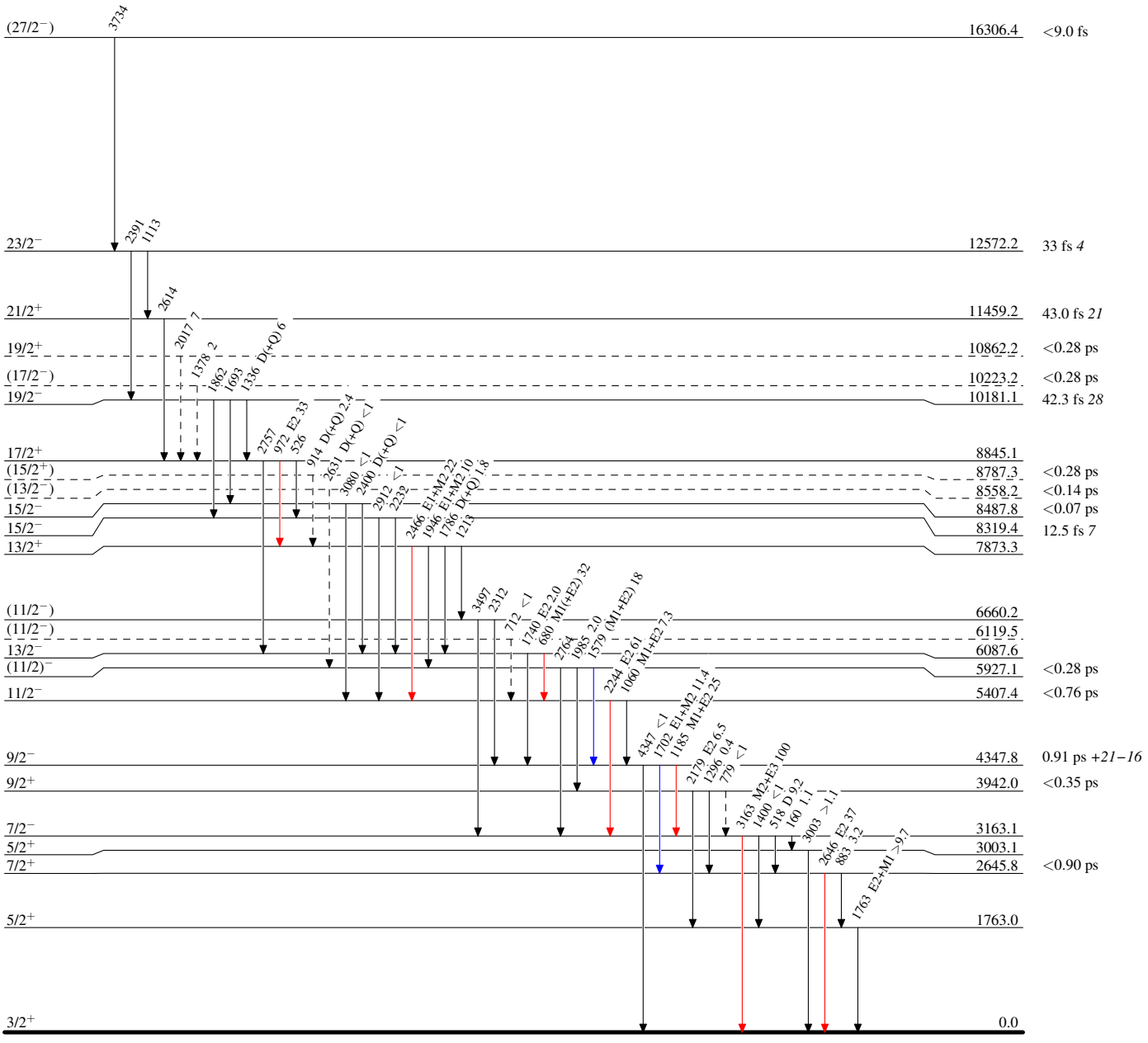
Legend

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

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

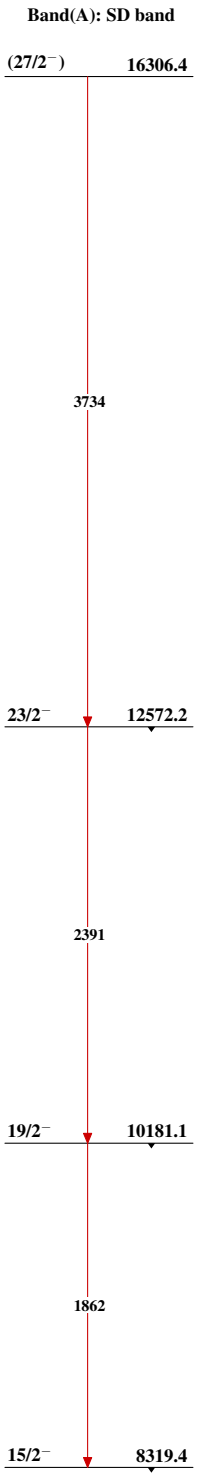
$I_\gamma > 10\% \times I_\gamma^{max}$

γ Decay (Uncertain)



$^{35}_{17}Cl_{18}$

$^{12}C(^{28}Si,\alpha p\gamma)$ 2007Ks01,2013Bi10,2020Ra14



$^{35}_{17}Cl_{18}$