Adopted Levels, Gammas

	History		
Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

Q(β^-)=−17770 *10*; S(n)=20063.9 *10*; S(p)=1943.49 *27*; Q(α)=−9495.9 *9* 2021Wa16
S_{2n}=35163 *5*; S_{2p}=17900.17 *27* (2021Wa16).

The ^{13}N nucleus was first identified by its characteristic β-decay lifetime property observed in the α bombardment of a boron sample (1934Cu01, 2012Th01).

Nuclear moments:
Measurements:
1961Po09: μ=0.321 *3*.
1964Be24: μ=(−) 0.32212 nm *35*, sign is assumed.
Tabulations: 1989Ra17, 2019StZV: μ=0.3219 *4*.
Calculations: 1966El08, 1968Pe16, 1969Sc33, 1969Sc34, 1974Ha27, 1976Br26, 1978Le03, 1988Va03, 1990Iw02, 1991Bo02, 1999Ki27, 1999Ga57, 2003Su04, 2016Me17.

Theory:
Shell model: 1965Co25, 1971Ja13, 1973Sa30, 1976Br26, 1996Du21, 2000Ko23, 2013Ho14.
Other model analyses: 1963Ba43, 1963Fa03, 1973Le06, 1974Va24, 1975Me24, 1983Sh38, 1993Po11, 1996Ki24, 1997Po12, 2000Zh42, 2002Zh37, 2003Ch33, 2005Du03, 2008Ch34, 2008Sh16, 2013Ci04, 2013Ma60, 2017De19, 2022Sa37.

Mirrors and analog states: 1963Se19, 1966Ce02, 1972Gu05, 1973Sa25, 1974Ch46, 1993Zh17, 1996Ki27, 2005Ch02, 2005Ti07, 2005Ti14, 2006Sh10, 2013Fo22, 2015Fr05, 2018Fo04, 2019Mu05, 2022Va06, 2022Zo01, 2023Se01.

Other related studies: 2003Ar33, 2008Pe13, 2008Se10, 2010Ti04, 2011Ti09, 2015Mo10, 2015To02, 2018Ge07.

Unplaced experimental results:
1962Wa31: ^{12}C(p,d) E=18 to 19.8 MeV. No resonant structures are observed.
1975Na15, 1976Na09: ^{16}O(^{14}N,^{17}O) E=155 MeV. Compared Coulomb effects in (^{14}N,^{17}O) and (^{14}N,^{17}F) reactions.
1976Mo03: ^{16}O(^{14}N,^{17}O) E=79 MeV. Reported angular distributions.
1998Di14: The $^{13}N_{g.s.}$ structure was studied via the ^{11}B(^{13}N,^{12}C)^{12}C transfer reaction at E(^{13}N)=29.5 and 45 MeV.
2001Na02: Si(p,^{13}N). Calculated spallation yields.
2002Ar07, 2002Ar09:^{9}Be,^{181}Ta(^{18}O,^{13}N) E=35 MeV/nucleon. Measured isotope production yields at forward angles.
2005Ba40: Measured ^{13}N production in p+^{16}O spallation at 3.2 GeV.
2007Na31: Measured ^{13}N production in p+^{136}Xe spallation at 1 GeV.
2007No13: ^{9}Be(^{40}Ar, ^{13}N) E=100 MeV/nucleon. Measured isotope production σ.
2010Mi08: ^{181}Ta(^{18}O,^{13}N) E=35 MeV/nucleon. Calculated isotope production yields at forward angles. Compared with measurements of (2002Ar07).
2012Fl02: Studied 1-proton removal from ^{14}O at ≈53 MeV/nucleon.
2019Ch50: Excited states in ^{14}O are observed to 1p decay to ^{13}N+p and to decay sequentially via $^{13}N^{*}$(2.36, 3.50, 3.55).
2020Na24: Measured isotope yields in ^{93}Nb(^{12}C,X),(^{13}C,X) at E=65 MeV.
2022Bo01: Measured ^{13}N production yields from ^{12}C(X,^{13}N): X=^{14,15,20}O, ^{14}N at E_{beam}≈450 MeV/nucleon.

Adopted Levels, Gammas (continued)

^{13}N Levels

Cross Reference (XREF) Flags

A	^{13}O ε decay	U	^{12}C(d,n)	AN	^{13}C(^{14}N,^{14}C)
B	^{1}H(^{13}N,p)	V	^{12}C(^{3}He,d)	AO	^{14}N(γ,n)
C	^{1}H(^{14}O,^{13}N)	W	^{12}C(α,t)	AP	^{14}N(π^+,π^+n),(π^+,p)
D	^{2}H(^{14}O,^{3}He)	X	^{12}C(^{7}Li,^{6}He)	AQ	^{14}N(n,2n)
E	^{9}Be(^{10}C,^{13}N)	Y	^{12}C(^{10}B,^{9}Be)	AR	^{14}N(p,d)
F	^{9}Be(^{13}N,X)	Z	^{12}C(^{11}B,^{10}Be)	AS	^{14}N(d,t)
G	^{10}B(^{3}He,n),(^{3}He,X):res	Others:		AT	^{14}N(^{3}He,α)
H	^{10}B(^{3}He,p):res	AA	^{12}C(^{12}C,^{11}B)	AU	^{14}N(^{6}Li,^{7}Li)
I	^{10}B(^{3}He,d):res	AB	^{12}C(^{13}C,^{12}B)	AV	^{14}N(^{10}B,^{11}B)
J	^{10}B(^{3}He,^{3}He):res	AC	^{12}C(^{13}N,^{13}N),^{13}C(^{13}N,^{13}N)	AW	^{14}N(^{14}N,^{13}N)
K	^{10}B(^{3}He,α):res	AD	^{12}C(^{14}N,^{13}C)	AX	^{15}N(p,t)
L	^{10}B(α,n)	AE	^{12}C(^{16}O,^{15}N),(^{16}O,^{13}N)	AY	^{16}O(n,^{13}N)
M	^{10}B(^{6}Li,t)	AF	^{13}C(γ,π^-)	AZ	^{16}O(p,pt)
N	^{10}B(^{9}Be,^{6}He)	AG	^{13}C(ν,μ^-),(ν,e)	BA	^{16}O(p,α)
O	^{11}B(^{3}He,n),^{11}B(^{3}He,nγ)	AH	^{13}C(π^+,π^0)	BB	^{16}O(^{3}He,^{6}Li)
P	^{12}C(p,γ)	AI	^{13}C(π^+,γ)	BC	^{17}Ne $\beta^+\alpha$ decay
Q	^{12}C(p,π^0)	AJ	^{13}C(p,n)	BD	^{208}Pb(^{13}N,^{13}N): coulex
R	^{12}C(p,n):res	AK	^{13}C(^{3}He,t)	BE	^{232}Th(^{22}Ne,^{13}N),^{154}Sm(^{16}O,^{13}N)
S	^{12}C(p,p):res	AL	^{13}C(^{6}Li,^{6}He)		
T	^{12}C(p,α):res	AM	^{13}C(^{13}N,^{13}C)		

E(level)	J$^\pi$	T$_{1/2}$ or Γ	XREF	Comments
0.0	1/2$^-$	9.9584 min *36*	ABCD F LMNOPQ UVWXYZ	XREF: Others: AA, AB, AC, AD, AE, AF, AG, AH, AI, AJ, AK, AL, AM, AN, AO, AP, AQ, AR, AS, AT, AU, AV, AW, AX, AY, AZ, BA, BB, BC, BD, BE %ε+%β^+=100 T=1/2; μ=0.3219 *4* (2019StZV,1964Be24) J$^\pi$: From L=0 ^{15}N(p,t) (1968Fl03). T$_{1/2}$: From the average of T$_{1/2}$=9.9502 min *32* (2022Lo14), 9.962 min *20* (1989KaYR), 9.967 min *10* (1980An40), 9.965 min *10* (1977Az01), 10.0 min *5* (1973SiYS), 9.963 min *9* (1968Ri15), 10.05 min *5* (1965Bo42), 9.96 min *2* (1965Eb01), 9.965 min *5* (1960Ja12), 9.93 min *5* (1960Ki02), 9.96 min *3* (1958Ar15), 9.96 min *3* (1957Da08, 1958Da09), 10.02 min *10* (1957De22), 10.07 min *6* (1957No17), 10.08 min *4* (1955Wi43), 10.05 min *3* (1953Ch34), 10.05 min *10* (1950Ho01), 10.2 min *1* (1948Co24) 10.13 min *10* (Siegbahn, Arkiv. f. Ast. Math-Fys. 32A No. 9 (1945)) 9.93 min *3* (1939Wa09). T$_{1/2}$: See also 12.3 min ±5.4% (1961Ra06), 9.9670 min *37* (DDEP) and 9.9647 min *39* (2008Se10). T$_{1/2}$: In (1935Ru01), Rutherford discusses β decay.
2367.8 *8*	1/2$^+$	34.5 keV *3*	LM OP S UV XY	XREF: Others: AB, AD, AE, AF, AJ, AK, AL, AR, AS, AT, AU, AX, AZ, BA, BC, BD Γ$_\gamma$=0.49 eV *2* Decay Modes: γ, p. E(level): From the average of E$_x$=2367.6 keV *9* from references in ^{12}C(p,γ), 2369 keV *3* from (1953Ja04) in ^{12}C(p,p):res and 2368.2 keV *28* from (1974Bl06)

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Adopted Levels, Gammas (continued)

^{13}N Levels (continued)

E(level)	J^{π}	$T_{1/2}$ or Γ	XREF	Comments
				$^{12}C(^{3}He,d)$. J^{π}: From L=0 $^{12}C(p,p)$:res (1951Ja21). Γ: From the average (external errors) of Γ=36.15 keV *54* (1973Cl04) $^{12}C(d,n)$, 36.1 keV *28* (1974Bl06) $^{12}C(^{3}He,d)$, 34.5 keV *9* (1953Hu18,1973Cl04) $^{12}C(p,\gamma)$, 33.7 keV *20* (1968Bl17) $^{12}C(p,\gamma)$ 31.4 keV *9* (1968Ri16) $^{12}C(p,\gamma)$, 33.3 keV *18* (1974Bl06) $^{12}C(p,\gamma)$, 36 keV *2* (1974Ro29) $^{12}C(p,\gamma)$, 34.9 keV *2* (2023Sk02) $^{12}C(p,\gamma)$ 35.2 keV *5* (2023Cs01) $^{12}C(p,\gamma)$ and 34.0 keV *2* (2023Ke11: includes 2008Bu19) $^{12}C(p,\gamma)$. Note: uncertainty surrounds some Γ values related to assigning the values as lab or c.m. frame values. Table 1 of (1992Hi14) is helpful for resolving some issues. Γ: In (1991Aj01) Γ=31.7 keV *8* was determined by averaging only (1974Bl06) and (1968Ri16) values from $^{12}C(p,\gamma)$.
3500.4 *8*	$3/2^{-}$	55.0 keV *6*	A CD LMNOP S UV XYZ	XREF: Others: AF, AH, AJ, AK, AL, AM, AR, AS, AT, AV, AX, AZ, BA, BB, BC $\Gamma_{\gamma 0}$=0.49 eV *3*; $\Gamma_{\gamma 1}$=0.043 eV $\Gamma_{\gamma}\approx$0.533 eV XREF: AJ(3464)AK(3.53E3)AS(3.51E3)AV(3.51E3). Decay Modes: γ, p. E(level): From E_x=3499 keV *6* (1966Ar03) $^{12}C(p,p)$:res and 3500.4 keV *8* from references in $^{12}C(p,\gamma)$. J^{π}: From L=0,2 $^{11}B(^{3}He,n)$ (1971Hs03). Γ: From the average of Γ=60 keV *3* (1974Ro29) $^{12}C(p,\gamma)$, 61.9 keV *40* (1968Bl17) $^{12}C(p,\gamma)$, 55.2 keV *3* (2023Ke11) $^{12}C(p,\gamma)$, 53.2 keV *7* (2023Cs01) $^{12}C(p,\gamma)$, and 63 keV *4* (2005Kn02) ^{13}O β-p. $\Gamma_{\gamma 0}$: From the R-matrix analysis in (2023Ke11) as detailed above. In (1991Aj01) the analysis of (1952Se01, 1963Yo06) data given in (1980Ba54) was accepted. $\Gamma_{\gamma 1}$: From $\Gamma_{\gamma 0}$, I(γ0)=92% *1* and I(γ1)=8% *1* from (1974Ro29).
3544.5 *5*	$5/2^{+}$	49.0 keV *5*	LM O S UV XYZA	XREF: Others: AB, AD, AE, AF, AH, AJ, AK, AR, AT, BA, BC XREF: AE(3.5E3)AF(3.51E3)AH(3.5E3)AJ(3.5E3). Decay Mode: p. E(level): From the average of E_x=3544.4 keV *5* from the (2023Ke11) analysis of (1976Me22) $^{12}C(p,p)$:res and 3549.1 keV *50* (1974Bl06) $^{12}C(^{3}He,d)$. J^{π}: From phase-shift analysis of $^{12}C(p,p)$ (1951Ja21). Γ: From the (2023Ke11) R-matrix analysis of (1976Me22) $^{12}C(p,p)$:res. See also 47 keV *7* from (1974Bl06).
6368 *9*	$5/2^{+}$	11 keV	MNO S V	XREF: Others: AF, AJ, AK, AR, AT, AX, BA, BB XREF: AJ(6.3E3). Decay Mode: p. E(level): From the weighted average (external errors) of E_x=6378 keV *8* (1956Re39) $^{12}C(p,p)$:res, 6353 keV *9* (1971Hs03) $^{11}B(^{3}He,n)$ and 6380 keV *30* (1968Fl03) $^{15}N(p,t)$. J^{π},Γ: From phase-shift analysis (1956Re39) $^{12}C(p,p)$:res.

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Adopted Levels, Gammas (continued)

^{13}N Levels (continued)

E(level)	J$^{\pi}$	T$_{1/2}$ or Γ	XREF	Comments
6886 *5*	3/2^{+}	115 keV *5*	M O S V YZ	XREF: Others: AD, AK, AT Γ_{p0}=51 keV; Γ_{p1}=63 keV (1963Ba36) Decay Mode: p. E(level): From the average of E_x=6890 keV *6* from values in ^{12}C(p,p):res and 6875 keV *10* (1971Hs03) in ^{11}B(^{3}He,n). J$^{\pi}$: From phase-shift analysis of angular distributions and σ(E) in (1956Re39) ^{12}C(p,p),(p,p$_1$γ(θ)). Γ: From the average of Γ=115 keV *5* (1963Ni05) ^{12}C(p,p):res, 110 keV *15* (1962Cl12) ^{14}N(^{3}He,α) and 120 keV *30* (1974Ho06) ^{10}B(^{6}Li,t).
7156 *5*	7/2^{+}	9.0 keV *5*	MNO S V YZA	XREF: Others: AB, AJ, AK, AT XREF: O(7145)AJ(7.2E3). Decay Mode: p. E(level): From the average of E_x=7145 keV *9* (1971Hs03) ^{11}B(^{3}He,n), 7155 keV *9* (1963Ba36) ^{12}C(p,p):res and 7166 keV *8* (1962Cl12) ^{14}N(^{3}He,α). J$^{\pi}$: From phase-shift analysis in (1963Ba36, 1963Ni05) ^{12}C(p,p):res. Γ: From (1963Ni05) ^{12}C(p,p):res.
7377 *6*	5/2^{-}	66 keV *9*	A M O S V Y A	XREF: Others: AH, AK, AL, AR, AS, AT, AV, AX, BA, BB Γ_{p0}/Γ=0.10 (1963Ni05) XREF: O(7363)AL(7.4E3). Decay Mode: p. E(level): From the average of E_x=7363 keV *8* (1971Hs03) ^{11}B(^{3}He,n), 7.38 MeV *1* (1963Ba36) ^{12}C(p,p), 7380 keV *20* (1968Fl03) ^{15}N(p,t) and 7388 keV *8* (1962Cl12) ^{14}N(^{3}He,α). J$^{\pi}$: From phase-shift analysis of ^{12}C(pol. p,p) (1968Be31). L=2 ^{15}N(p,t) (1968Fl03). Γ: From the average (external errors) of Γ=69 keV *5* (1963Ni05) ^{12}C(p,p):res, 104 keV *20* (2005Kn02) ^{13}O β-p and 45 keV *10* (1962Cl12) ^{14}N(^{3}He,α). Γ: In (1970Aj04) the value Γ=75 keV *5* from (1963Ni05) is listed, but this value, given in the abstract of (1963Ni05) was Γ_{lab}.
8×10^{3}	3/2^{+}	≈1.5 MeV	O S V Z	XREF: Others: AB XREF: AB(7.9E3). Decay Mode: p. E(level),Γ: From (1962Sh22, 1966Ba35) ^{12}C(p,p):res. See also E_x=8200 keV *22* from (1971Hs03) ^{11}B(^{3}He,n), but note that data supporting this value is not shown in the article. J$^{\pi}$: From phase-shift analysis of ^{12}C(p,p) (1962Sh22).
8918 *11*	1/2^{-}	278 keV *16*	A M O S V Y	XREF: Others: AB, AJ, AK, AR, AS, AT, AX, BA Γ_{p0}/Γ≈0.541; Γ_{p1}/Γ≈0.459 (2005Kn02) XREF: AB(8.5E3)AJ(8.8E3)AS(8.93E3). Decay Mode: p. E(level): From (1971Hs03) ^{11}B(^{3}He,n). J$^{\pi}$: From L=0 ^{15}N(p,t) (1968Fl03) and phase-shift

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Adopted Levels, Gammas (continued)

^{13}N Levels (continued)

E(level)	J^π	$T_{1/2}$ or Γ	XREF	Comments
				analysis of ^{12}C(p,p) (1962Sh22). Γ: From (2005Kn02) ^{13}O β-p. See also 230 keV from ^{12}C(p,p):res.
9×10^3 †	$9/2^+$	280 keV *30*	MN V Z	XREF: Others: AA, AK E(level),Γ: From (1974Ho06) ^{10}B(^{6}Li,t). J^π: In (1974Ho06) comparison of angular distributions in ^{10}B(^{6}Li,^{3}He) and ^{10}B(^{6}Li,t) indicates the state is the analog of $^{13}C^*$(9.5 MeV), which is presently identified as $9/2^+$. See also L=4 in ^{12}C(^{3}He,d) (1980Pe13). Γ: See also 0.40 MeV *5* in ^{12}C(^{3}He,d) (1969Fo02).
9476 *8*	$3/2^-$	30 keV	A M O S V	XREF: Others: AJ, AK, AS, BA Γ_{p0}/Γ=0.72 (1972Be15) XREF: M(9.52E3)BA(9.52E3). Decay Mode: p. E(level): From (1971Hs03) ^{11}B(^{3}He,n). See also E_x=9520 keV *20* from (1966Ch18) ^{11}B(^{3}He,n). J^π: From L=0,2 ^{11}B(^{3}He,n) (1971Hs03) and phase-shift analysis of ^{12}C(p,p) (1962Sh22). Γ: From (1962Sh22) ^{12}C(p,p):res. See also Γ=143 keV *18* (2005Kn02) ^{13}O β-p, but note the fit in this region is rather poor.
10.26×10^3 *14*	$(1/2^+,3/2^+)$	260 keV *90*	P	$\Gamma_{\gamma0}$>0.6 eV (1973Me12) Decay Modes: γ, p. E(level),Γ: From (1973Me12) ^{12}C(p,γ). For $J^\pi=3/2^+$, Γ_{lab}=280 keV *100* and for $J^\pi=1/2^+$, Γ_{lab}=300 keV *100*. J^π: From ^{12}C(p,γ_0) (1973Me12) where θ_γ=90° and γ_0 to $^{13}N_{g.s.}$($J^\pi=1/2^-$) is observed.
10.36×10^3	$5/2^-$	30 keV	e mnO S V	XREF: Others: AK, BA Γ_{p0}/Γ=0.26 (1968Be31) XREF: m(10.35E3)O(10381). Decay Mode: p. E(level),Γ: From (1968Be31) ^{12}C(p,p):res where the $5/2^-$ and $7/2^-$ doublet partners are both analyzed. In (1968Be31) the authors find the level energies do not differ by more than 2 keV. See also E_x=10381 keV *8* (1971Hs03) ^{11}B(^{3}He,n) and 10350 keV *20* (1966Ch18) ^{11}B(^{3}He,n). J^π: From phase-shift analysis of ^{12}C(pol. p,p) (1968Be31).
10.36×10^3	$7/2^-$	76 keV	e mn S V	XREF: Others: AK, BA Γ_{p0}/Γ=0.81 (1968Be31) XREF: m(10.35E3). Decay Mode: p.

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Adopted Levels, Gammas (continued)

^{13}N Levels (continued)

E(level)	J^π	$T_{1/2}$ or Γ	XREF	Comments
				E(level),Γ: From (1968Be31) ^{12}C(p,p):res. See above comment. J^π: From phase-shift analysis of ^{12}C(pol. p,p) (1968Be31).
10833[†] *9*	1/2$^-$	75 keV *15*	E M O V	XREF: Others: AJ, AK, AX XREF: M(10.78E3)V(10.78E3)AX(10780). E(level): From (1971Hs03) ^{11}B(^{3}He,n). J^π: From L=0 ^{15}N(p,t) (1968Fl03). Γ: From (1980Pe13) ^{12}C(^{3}He,d).
11.3×10^3?[‡] *1*	[3/2$^-$][‡]	<200 keV	A	Decay Modes: p, α. E(level),J^π,Γ: Deduced in (2024Bi01) ^{13}O β^++ε; if decay from this state is visible in the delayed proton spectrum of (2005Kn02), then (2024Bi01) suggest Γ<40 keV. Suggested to decay via α_0+^{9}B$_{g.s.}$, p+^{12}C$_{g.s.}$ and p+^{12}C(7654.7 MeV).
11530 *12*	5/2$^+$	430 keV *35*	E O S	XREF: Others: BA Γ_{p0}/Γ=0.70 *5* (1973Me03) XREF: BA(11.5E3). Decay Mode: p. E(level): From (1971Hs03) ^{11}B(^{3}He,n). See also E_x=11490 keV *50* (1973Me03) ^{12}C(p,p):res. J^π: From phase-shift analysis of ^{12}C(pol.p, p),(pol. p,p′) (1973Me03). Γ: From (1973Me03) ^{12}C(p,p):res.
11700 *30*	5/2$^-$	115 keV *30*	A M S V	XREF: Others: AB Γ_{p0}/Γ=0.60 *4* (1973Me03) XREF: M(11.65E3)V(11.1E3)AB(11.3E3). Decay Mode: p. E(level),J^π,Γ: From (1973Me03) ^{12}C(p,p):res. J^π: From phase-shift analysis of ^{12}C(pol.p, p),(pol. p,p′) (1973Me03).
11740 *40*	3/2$^+$	250 keV *30*	P S	$\Gamma_{\gamma0}$≈4.2 eV (1973Me12) Γ_{p0}/Γ=0.30 *5* (1973Me03) Decay Modes: γ, p. E(level),Γ: From (1973Me03) ^{12}C(p,p):res where the 3/2$^+$ and 3/2$^-$ doublet partners are both analyzed. J^π: From phase-shift analysis of ^{12}C(pol.p, p),(pol. p,p′) (1973Me03).
11740 *50*	3/2$^-$	530 keV *80*	O S	XREF: Others: AJ, AK, AR, AS, AX Γ_{p0}/Γ=0.55 *5* (1973Me03) XREF: O(11878)AK(11850)ar(11.86E3)AS(11.9E3)AX(11880). Decay Mode: p. E(level),Γ: From (1973Me03) ^{12}C(p,p):res. Other results associated with J^π=3/2$^-$ but reported with energies near the next highest level are E_x=11878 keV *12* (1971Hs03) ^{11}B(^{3}He,n), 11850 keV *40* (1969Ba06) ^{13}C(^{3}He,t) and 11880 keV *40* (1968Fl03) ^{15}N(p,t); these likely correspond to unresolved

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Adopted Levels, Gammas (continued)

^{13}N Levels (continued)

E(level)	J^π	$T_{1/2}$ or Γ	XREF	Comments
				$3/2^-$&$1/2^+$ states. Γ: See also 98 keV (2004Fu12) ^{13}C(^{3}He,t). ^{13}C(^{3}He,t). J^π: From phase-shift analysis of ^{12}C(pol.p, p),(pol. p,p′) (1973Me03).
11860 *40*	$1/2^+$	380 keV *50*	S	XREF: Others: AR, AT, AV Γ_{p0}/Γ=0.35 *5* (1973Me03) XREF: ar(11.86E3). Decay Mode: p. E(level),Γ: From (1973Me03) ^{12}C(p,p):res. J^π: From phase-shift analysis of ^{12}C(pol. p,p) (1973Me03); see also $J^\pi=3/2^-$ from L=0,2 ^{11}B(^{3}He,n) (1971Hs03).
12130 *50*	$7/2^-$	250 keV *30*	S V	XREF: Others: AB, BA Γ_{p0}/Γ=0.30 *5* (1973Me03) XREF: V(12.08E3)AB(12.6E3). Decay Mode: p. E(level),Γ: From (1973Me03) ^{12}C(p,p):res. See also E_x=12130 keV *60* (1972Ma72) ^{16}O(p,α). J^π: From phase-shift analysis of ^{12}C(pol.p, p),(pol. p,p′) (1973Me03).
12.4×10^3?‡ *1*	[$3/2^-$]‡		A	Decay Modes: p, α. E(level),J^π: Deduced in (2024Bi01) ^{13}O β^++ε. Suggested to decay via α_0+^{9}B$_{g.s.}$, α_1+^{9}B(1.8 MeV) and p+^{12}C(7654.7 MeV).
12558† *23*		>400 keV	O Z	XREF: Others: AL, BA XREF: ba(12.75E3). E(level),Γ: From (1971Hs03) ^{11}B(^{3}He,n).
12937 *24*		>400 keV	A O	XREF: Others: BA XREF: ba(12.75E3). E(level),Γ: From (1971Hs03) ^{11}B(^{3}He,n). Decay Mode: p. E(level): See nearby E_x=13260 keV *100* with $\Gamma\approx$520 keV reported in (2005Kn02) ^{13}O β-p.
13.1×10^3?‡ *1*	[$1/2^-$,$5/2^-$]‡		A	Decay Modes: p, α. E(level),J^π: Deduced in (2024Bi01) ^{13}O β^++ε. J^π: $1/2^-$ for α_4 decay through ^{9}B(2.78:$1/2^-$) is preferred. Suggested to decay via α_1+^{9}B(1.8 MeV), α_0+^{9}B(2.75 MeV) or α_0+^{9}B(2.78 MeV) and p+^{12}C$_{g.s.}$.
13.50×10^3 *20*	$3/2^+$	≈6.5 MeV	P	XREF: Others: AH $\Gamma_{\gamma0}$>1.1 keV (1973Me12) XREF: AH(12.8E3). Decay Modes: γ, p.

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Adopted Levels, Gammas (continued)

^{13}N Levels (continued)

E(level)	J^π	$T_{1/2}$ or Γ	XREF	Comments
				E(level),Γ: From (1973Me12) ^{12}C(p,γ). J^π: From ^{12}C(p,γ_0) (1973Me12) where detector(θ)=90° and γ_0 to $^{13}N_{g.s.}$(J^π=1/2$^-$) is observed; also strong interference with J^π=3/2$^+$ states at ^{13}N*(11.74, 14.05); assumed component of GDR. Γ: See also Γ≈7.9 MeV (1994Ha41) ^{13}C(π^+,π^0).
13650? *10*		<300 keV	E S	XREF: Others: BA XREF: S(13.5E3)BA(13.48E3). Decay Mode: p. E(level),Γ: From (2009Ch38) ^{9}Be(^{10}C,^{13}N). Γ: See also Γ≈500 keV (1961Na02) ^{12}C(p,p):res. and Γ≈ few hundred keV (1972Ma21) ^{16}O(p,α).
13.7×10^3?‡ *1*	[3/2$^-$]‡		A	Decay Modes: p, α. E(level),J^π: Deduced in (2024Bi01) ^{13}O β^++ε. Suggested to decay via α_0+$^9B_{g.s.}$, α_1+^{9}B(1.8 MeV), α_0+^{9}B(2.75 MeV) and p+^{12}C(7.6547 MeV).
14050 *20*	3/2$^+$	162 keV *16*	P ST	XREF: Others: AR T=1/2 (1976Me18) $\Gamma_{\gamma0}$=3.7 eV *10* (1973Me12) Γ_{p0}/Γ=0.29 *7* (1976Me18) XREF: T(13962)AR(14.0E3). Decay Modes: γ, p, α. E(level): From (1976Me18) ^{12}C(p,p):res. See also E_x=14050 keV *80*. J^π: From phase-shift analysis of ^{12}C(pol. p,p) (1976Me18). Γ: From the average of Γ=157 keV *18* (1973Me12) ^{12}C(p,γ) and 180 keV *35* (1976Me18) ^{12}C(p,p):res.
15064.56 *40*	3/2$^-$	0.932 keV *28*	A C OP ST	XREF: Others: AJ, AK, AX T=3/2 (1969Ad02) $\Gamma_{\gamma0}$=24.5 eV *15* (1975Ma21,1973Ad02) $\Gamma_{\gamma1}$≤2.82 eV (1975Ma21) Γ_{p0}/Γ=0.236 *12*; Γ_{p0}=220 eV *13* Γ_{p1}/Γ=0.150 *10*; Γ_{p1}=140 eV *10* Γ_{p2}/Γ=0.053 *15*; Γ_{p2}=49 eV *14* $\Gamma_{\alpha0}$/Γ=0.049 *27*; $\Gamma_{\alpha0}$=46 eV *25* $\Gamma_{\alpha1}$/Γ=0.039 *39*; $\Gamma_{\alpha1}$=36 eV *36* $\Gamma_{\alpha2}$/Γ=0.072 *45*; $\Gamma_{\alpha2}$=67 eV *42* Γ_γ=44.1 eV *35* Γ_p=651 eV *40* Γα=149 eV *61* XREF: AJ(15.1E3). Decay Modes: γ, p, α. E(level),Γ: From (1973Hu07) ^{12}C(p,p):res. E(level): See also E_x=15064 keV *4* (1969Le18) and 15068 keV *8* (1969Ad02).

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Adopted Levels, Gammas (continued)

^{13}N Levels (continued)

E(level)	J^π	$T_{1/2}$ or Γ	XREF	Comments
				Γ: See also Γ=1.10 keV *9* (1975Hi07) ^{12}C(p,α). Beginning in (1981Aj01) the value Γ=0.86 keV *12* was given in the evaluations. This value is derived in (1977Ma16) using their measured $\Gamma_{p0}\Gamma_{\gamma0}/\Gamma$=5.79 eV *20* value. J^π: From L=0 ^{11}B(^{3}He,n) (1971Hs03) and phase-shift analysis of (1969Le18). Γ_p,Γα: Branching ratios for p- and α-decay branches are from (1973Ad02); partial widths are deduced using these and Γ=0.932 keV *28*. Γ_p: See also Γ_p(→^{12}C(9.6 MeV))/Γ=0.096 *14* and Γ_p(→^{12}C(10.8 MeV))/Γ=0.164 *36* 1967AdZY; these imply Γ_p (→^{12}C(9.6 MeV))=89.5 eV *5* and Γ_p(→10.8 MeV)=153 eV *34*. Hence Γ_p=651 eV *40* for all proton branches. $\Gamma_{\gamma0}$: $\Gamma\gamma_0$=24.5 eV *15* is obtained by combining Γ_{p0}/Γ=0.236 *12* (1973Ad02) with $\Gamma_{p0}\Gamma\gamma0/\Gamma$=5.79 eV *20* (1975Ma21). Γ_γ: Γγ=44.1 eV *35* from $\Gamma\gamma_0$=24.5 eV *15* $\Gamma\gamma_1$≤2.82 eV *30* and $\Gamma\gamma_{(2+3)}$=19.6 eV *14* (1975Ma21,1973Ad02).
15.30×10^3 *20*	(3/2$^+$)	0.35 MeV *14*	A P	$\Gamma_{\gamma0}$≥0.5 eV (1973Me12) Γ_{p0}/Γ≈1.0 (2005Kn02) XREF: A(?). Decay Modes: γ, p. E(level),Γ: From (1973Me12) ^{12}C(p,γ). J^π: From ^{12}C(p,γ_0) (1973Me12) θ_γ=90° and γ_0 to $^{13}N_{g.s.}$(J^π=1/2$^-$) is observed. See also (3/2$^-$) in (2005Kn02) ^{13}O β-p; but note the reported %Iβ=0.004 *3* intensity corresponds to perhaps three counts in a region where no background contribution is considered.
16000 *30*	7/2$^+$	135 keV *90*	ST	XREF: Others: AK T=1/2 (1967Ku02,1976Me18) Γ_{p0}/Γ=0.05 *4* (1976Me18) XREF: AK(15980). Decay Modes: p, α. E(level): From the average of E_x=16010 keV *40* (1973Me12) ^{12}C(p,p):res and E_x=15980 keV *50* (1969Ba06) ^{13}C(^{3}He,t). See also E_x=16 MeV and Γ=500 keV (1964Da03) ^{12}C(p,p):res. J^π: From phase-shift analysis of ^{12}C(pol. p,p) (1976Me18). Γ: From (1973Me12). See also Γ≈100 keV (1969Le18) ^{12}C(p,α) and ≈163 keV (2004Fu12) ^{13}C(^{3}He,t).
16.6×10^3 *1*		<350 keV	E	Decay Mode: α. E(level),Γ: From (2009Ch38). Decays to α+^{9}B(2.345).
17.4×10^3			S	Decay Mode: p. E(level): From (1976Be28) ^{12}C(p,pγ(12.71 MeV)).

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Adopted Levels, Gammas (continued)

^{13}N Levels (continued)

E(level)	J$^{\pi}$	T$_{1/2}$ or Γ	XREF	Comments
17680 *30*		1212 keV *74*	P	XREF: Others: AB, AK, AL XREF: P(18.1E3)AB(16.2E3)AL(17.5E3). E(level),Γ: From (2004Fu12) ^{13}C(^{3}He,t). Decay Modes: γ, p. E(level),J$^{\pi}$: (1988Vo08) ^{12}C(^{13}C,^{12}B) suggests a broad (5/2^{+}) GDR component near E$_{x}$=16.2 MeV.
18130 *17*	3/2^{+}	287 keV *36*	S	XREF: Others: AK T=1/2 (1967Ku02,1976Me18) Γ$_{p0}$/Γ=0.08 *2* (1976Me18) Decay Mode: p. E(level): From the average of E$_{x}$=18150 keV *30* (1976Me18) ^{12}C(p,p):res and 18120 keV *20* (2004Fu12) ^{13}C(^{3}He,t). J$^{\pi}$: From phase-shift analysis of ^{12}C(pol. p,p) (1976Me18). Γ: From the average of Γ=322 keV *75* (1976Me18) and 276 keV *41* (2004Fu12).
18170 *20*	1/2^{-}	225 keV *50*	ST	T=1/2 (1976Me18) Γ$_{p0}$/Γ=0.24 *6* (1976Me18) XREF: T(18232). Decay Modes: p, α. E(level),Γ: From (1976Me18) ^{12}C(p,p):res. See also E$_{x}$=18232 keV and Γ=300 keV in (1969Le18) ^{12}C(p,α). J$^{\pi}$: From phase-shift analysis of ^{12}C(pol. p,p) (1976Me18).
18405 *5*	3/2^{+}	66 keV *8*	O ST	XREF: Others: AK T=3/2 (1967Ku02,1969Ad02) Γ$_{p0}$/Γ=0.25 (1969Le18) XREF: O(18.44E3)T(18352). Decay Modes: p, α. E(level),Γ: See comments in ^{12}C(p,p):res. Values are apparently from (1968Sn03) and a private communication reported in (1970Aj04). See also E$_{x}$=18370 keV *10* (2004Fu12) ^{13}C(^{3}He,t) and 18440 keV *40* (1969Ad02) ^{11}B(^{3}He,n). J$^{\pi}$: From phase-shift analysis of ^{12}C(p,p) (1969Le18).
18963 *8*	(3/2^{-},7/2^{+})	23 keV *5*	O ST	T=3/2 (1967Ku02,1969Ad02) Γ$_{p0}$/Γ=0.017 (1969Le18) XREF: O(18.98E3). Decay Modes: p, α. E(level): From the average of E$_{x}$=18960 *9* see comments in ^{12}C(p,p):res and 18980 keV *20* (1969Ad02) ^{11}B(^{3}He,n). J$^{\pi}$: From phase-shift analysis in (1969Le18) ^{12}C(p,p). Γ: See discussion in ^{12}C(p,p):res related to (1968Sn03). See also Γ=40 keV *20* (1969Ad02).
19110† *10*		183 keV *41*		XREF: Others: AK E(level),Γ: From (2004Fu12) ^{13}C(^{3}He,t).

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Adopted Levels, Gammas (continued)

^{13}N Levels (continued)

E(level)	J$^\pi$	T$_{1/2}$ or Γ	XREF	Comments
19830 *20*	5/2$^-$	1542 keV *84*	T	XREF: Others: AK T=1/2 (1969Le18) Γ_{p0}/Γ=0.18 (1969Le18) Decay Modes: p, α. E(level),Γ: From (2004Fu12) ^{13}C(^{3}He,t). J$^\pi$: From phase-shift analysis of ^{12}C(p,p) (1969Le18).
19880	7/2$^+$	750 keV	ST	T=1/2 (1969Le18) Γ_{p0}/Γ=0.40 (1969Le18) XREF: T(19.88E3). Decay Modes: p, α. E(level): From (1969Le18) ^{12}C(p,p),(p,α). J$^\pi$: From (1979Ga13) analysis of $\sigma(\theta)$ and A$_y(\theta)$ from ^{12}C(pol. p,p),(pol. p′) See also 3/2$^+$ in phase-shift analysis (1969Le18). Γ: From (1979Ga13) ^{12}C(p,p):res. See also Γ=520 keV (1969Le18).
20.2×10^3	5/2$^-$	1 MeV	S	E(level),Γ: From (1979Ga13) ^{12}C(p,p):res. Decay Mode: p. J$^\pi$: From (1979Ga13) analysis of $\sigma(\theta)$ and A$_y(\theta)$ from ^{12}C(pol. p,p),(pol. p′).
20.90×10^3 *30*	1/2$^+$	1.2 MeV	P RS	$\Gamma_{\gamma0}$>0 eV (1976Be28) Γ_{p0}/Γ≈0.1 (1973Me12) XREF: P(20.5E3). Decay Modes: γ, p, (n). E(level): From (1973Me12) ^{12}C(p,p):res. E(level): In ^{12}C(p,γ) broad Γ≈1.2-4.0 MeV groups are reported with E$_x$ ranging from 20.0 MeV to 20.8 MeV. J$^\pi$: From (1979Ga13) analysis of $\sigma(\theta)$ and A$_y(\theta)$ from ^{12}C(pol. p,p),(pol. p′). Γ: From (1979Ga13) ^{12}C(p,p):res.
21200 *10*	5/2$^-$	581 keV *44*	S	XREF: Others: AK XREF: S(21.4E3). Decay Mode: p. E(level),Γ: From (2004Fu12) ^{13}C(^{3}He,t). The previous evaluation accepted a state at E$_x$=21.4 MeV with Γ=750 keV (1979Ga13) ^{12}C(p,p):res; the evaluator assumes (2004Fu12) observed the same level. J$^\pi$: From (1979Ga13) analysis of $\sigma(\theta)$ and A$_y(\theta)$ from ^{12}C(pol. p,p),(pol. p′).
21.7×10^3	(3/2$^+$)		S	Decay Mode: p. E(level): From ^{12}C(p,p):res. See for discussion on (1964Ta15) analysis of (1963Di16) data and see (1979Ga13). J$^\pi$: From (1979Ga13) analysis of $\sigma(\theta)$ and A$_y(\theta)$ from ^{12}C(pol. p,p),(pol. p′) and (1964Ta15).
22140 *10*	1/2$^+$	1706 keV *82*	P S	XREF: Others: AB, AK Γ_{p0}/Γ≈0.1 (1973Me12) XREF: S(22.4E3)AB(22.5E3). Decay Modes: γ, p.

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Adopted Levels, Gammas (continued)

^{13}N Levels (continued)

E(level)	J^{π}	$T_{1/2}$ or Γ	XREF	Comments
				E(level),Γ: From (2004Fu12) $^{13}C(^{3}He,t)$. The previous evaluation accepted a state at E_x=22.4 MeV *5* with Γ≈1 MeV (1973Me12, 1979Ga13) $^{12}C(p,p)$:res; the evaluator assumes (2004Fu12) observed the same level. J^{π}: From (1979Ga13) analysis of $\sigma(\theta)$ and $A_y(\theta)$ from ^{12}C(pol. p,p),(pol. p′). E(level),J^{π}: (1988Vo08) $^{12}C(^{13}C,^{12}B)$ suggests a broad $(3/2^{+})$ GDR component near E_x=22.5 MeV.
23.3×10^{3}†		10.4 MeV		XREF: Others: AH T=3/2 (1994Ha41) E(level),Γ: From (1994Ha41). Represents the T=3/2 giant resonance built on $^{13}C_{g.s.}$
23.3×10^{3}	$3/2^{-}$	500 keV	H J P	XREF: P(23.2E3). Decay Modes: γ, p, ^{3}He. E(level): From E_x=23.2 MeV (1976Be28) $^{12}C(p,\gamma)$, 23.25 MeV (1987Ba34) $^{10}B(^{3}He,^{3}He)$ and 23.3 MeV (1966Pa10) $^{10}B(^{3}He,p_0)$. In the prior evaluation the (p,γ) resonance was listed separately with E_x=23 MeV. J^{π}: From L=1 and R-matrix analysis in (1987Ba34) $^{10}B(^{3}He,^{3}He)$. Γ: From Γ=500 keV (1987Ba34) $^{10}B(^{3}He,^{3}He)$ and Γ=500 keV (1966Pa10) $^{10}B(^{3}He,p_0)$. See also Γ≈1 MeV (1976Be28) $^{12}C(p,\gamma)$.
23830 *40*	$3/2^{-}$	346 keV *38*	H J	XREF: J(23.87E3). Decay Modes: p, ^{3}He. E(level): From (1964Ku09) $^{10}B(^{3}He,p)$. J^{π}: From L=1 and R-matrix analysis in (1987Ba34) $^{10}B(^{3}He,^{3}He)$. Γ: From (1956Sc01) $^{10}B(^{3}He,p)$.
23.93×10^{3}	$13/2^{-}$	20 keV	J	Decay Mode: ^{3}He. E(level),Γ: From (1987Ba34) $^{10}B(^{3}He,^{3}He)$. J^{π}: From L=3 and R-matrix analysis in (1987Ba34) $^{10}B(^{3}He,^{3}He)$.
24.1×10^{3}	$7/2^{-}$	≈500 keV	H JK RS	XREF: H(24.5E3)J(24.40E3)R(24E3). Decay Modes: (p), n, ^{3}He, α. E(level),Γ: From (1966Lo16) $^{12}C(p,p)$:res. In the previous evaluation, Γ=700 keV from (1987Ba34) was listed, but this resonance was not covered in the energy range of that study; inclusion of the resonance did improve the fit in that study, but the value is not accepted here. Other reported widths are Γ=750 keV (1970Gi04) $^{10}B(^{3}He,\alpha)$, ≤500 keV (1966Lo16) $^{12}C(p,p)$:res. J^{π}: From Legendre polynomial analysis of $^{10}B(^{3}He,\alpha)$ in (1987Ba34) and scattered proton polarization results from $^{12}C(p,p)$ (1966Lo16).
24500 *40*		2.46 MeV *22*	P	XREF: Others: AK $\Gamma_{\gamma0}$>0 eV (1976Be28) Decay Modes: γ, p, ^{3}He.

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Adopted Levels, Gammas (continued)

^{13}N Levels (continued)

E(level)	J^π	$T_{1/2}$ or Γ	XREF	Comments
				E(level): From (2004Fu12) $^{13}C(^3He,t)$. See also E_x=24.5 MeV (1963Fi07,1991Co07) $^{12}C(p,\gamma)$. Γ: From (2004Fu12) $^{13}C(^3He,t)$. See also Γ=3.5 MeV (1991Co07).
24.8×10^3		120 keV	H	Decay Modes: p, ^{3}He. E(level),Γ: From (1956Sc01) $^{10}B(^3He,p)$.
25.64×10^3 *10*	(3/2)$^-$	184 keV *60*	H S	Decay Modes: p, ^{3}He. E(level),Γ: From (1964Ku09). J^π: From (1967Sc11) where L=1 waves in the entrance and exit channels are found in $^{12}C(p,p')^{12}C(15.11\ MeV:\ 1^+)$,
25900		1.0 MeV	GHI K	XREF: H(26.1E3)K(26.1E3). Decay Modes: γ, p, (n), d, ^{3}He, α. E(level),Γ: From discussion in (1972Be56) finding $^{10}B(^3He,X)$ where X=α_0, d_0, $p_{0,2,3}$ γ_0 and (n). J^π: 7/2$^-$ is found by (1970Gi04), where both Legendre polynomial analysis of $^{10}B(^3He,\alpha)$ and analyzing power data in ^{12}C(pol. p,p) are discussed. However, the level is found to γ decay to $^{13}C_{g.s.}$ so this is unlikely. See also J≤3/2 (1966Pa10) $^{10}B(^3He,p)$ and see discussion in (1972Be56).
26.90×10^3 *90*		4.38 MeV *47*	RS	XREF: Others: AK Decay Modes: p, (n). E(level),Γ: From (2004Fu12) $^{13}C(^3He,t)$. See also E_x=26.87 MeV (1964Ta15) analysis of (1963Di16) and 26.84 (1966Cr04) in ^{12}C(p,p):res.
28000			GH K	Decay Modes: (γ), p, ^{3}He, (α). E(level): From discussion in (1972Be56) finding $^{10}B(^3He,X)$ where X=α_0, p_0 and γ_0, and (1966Pa10) $^{10}B(^3He,p)$. J^π: 9/2$^+$ is found by (1970Gi04), where both Legendre polynomial analysis of $^{10}B(^3He,\alpha)$ and analyzing power data in ^{12}C(pol. p,p) are discussed. However, the level is found to γ decay to $^{13}C_{g.s.}$ so this is unlikely. See also J≤7/2 (1966Pa10) $^{10}B(^3He,p)$ and see discussion in (1972Be56).
31.7×10^3?			P S	XREF: P(31.9E3). Decay Modes: γ, p. E(level): From the average of E_x=31.4 MeV (1976Fe11) $^{12}C(p,p'\gamma(4.44))$ and 31.9 MeV from the average of (1963Fi07, 1976Fe11, 1991Co07) values in $^{12}C(p,\gamma)$. In earlier evaluations this level is listed with E_x=31 MeV. The level appears distinct from the E_x=32 MeV level, since it is not populated in $^{10}B(^3He,p)$ reactions.
32000		≈2000 keV	G I K	$\Gamma_{\gamma0}$>0 eV (1976Be28) Decay Modes: γ, d, ^{3}He, α. E(level),Γ: From discussion in

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Adopted Levels, Gammas (continued)

^{13}N Levels (continued)

E(level)	J^{π}	$T_{1/2}$ or Γ	XREF	Comments
				(1972Be56) finding $^{10}B(^{3}He,X)$ where X=α_0, $d_{4,5}$ and γ_0.

† Decay mode not specified.

‡ Four new states are suggested at $^{13}N^{*}$(11.3, 12.4, 13.1 and 13.7 MeV) in ^{13}O $\beta^{+}p$ (2023Bi03, 2024Bi01). The authors indicate an independent branching-ratio measurement is not reliable, and no intensity is assigned in the present evaluation. Assuming these are allowed decays, J^{π} arguments are given based on the various particle emission decay modes.

Adopted Levels, Gammas (continued)

$\gamma(^{13}N)$

Additional information 1.

E_i(level)	J^π_i	E_γ‡	I_γ	E_f	J^π_f	Mult.	δ#	α†	Comments
2367.8	$1/2^+$	≈2367.7	100	0.0	$1/2^-$	[E1]		2.67×10^{-5} *4*	α(K)≈4.38×10^{-7}; α(L)≈2.153×10^{-8} α(IPF)≈0.000888 α(K)=1.365×10^{-6} *19*; α(L)=6.72×10^{-8} *9* α(IPF)=2.525×10^{-5} *35* Γ_γ=0.49 eV *2* B(E1)(W.u.)=0.0989 *47* Γ_γ: From Γ_γ=0.52 eV *4* (2002SeZY) ^{208}Pb(^{13}N,^{12}C+p), and the ^{12}C(p,γ) values 0.45 eV *5* (1968Ri16), 0.53 eV *5* (1992Hi14), 0.49 eV *3* (2023Sk02), 0.48 eV *3* (2023Ke11: includes 2008Bu19).
3500.4	$3/2^-$	1135.6	8.4	2367.8	$1/2^+$	[E1]			Γ_γ≈0.043 eV (2023Ke11,1974Ro29) B(E1)(W.u.)=0.079
		3500.3	100	0.0	$1/2^-$	[M1+E2]	−0.09 *2*	8.45×10^{-4} *12*	α(K)=3.41×10^{-7} *5*; α(L)=1.677×10^{-8} *23* α(IPF)=0.000845 *12* Γ_γ≈0.49 eV (2023Ke11) B(M1)(W.u.)≈0.55; B(E2)(W.u.)≈5 Mult.,δ: From angular distribution and a_2=−0.64 *4* in (1974Ro29) ^{12}C(p,γ) . See also δ=−0.092 (1963Yo06).
10.26×10^3	$(1/2^+,3/2^+)$	≈10256		0.0	$1/2^-$				Γ_γ>0.6 eV
11740	$3/2^+$	11734		0.0	$1/2^-$	[E1]			Γ_γ≈4.2 eV B(E1)(W.u.)≈0.007
13.50×10^3	$3/2^+$	≈13492		0.0	$1/2^-$				Γ_γ≥1.1 keV
14050	$3/2^+$	14042		0.0	$1/2^-$	[E1]			Γ_γ=3.7 eV *10* B(E1)(W.u.)=3.6×10^{-3} *10*
15064.56	$3/2^-$	11558		3500.4	$3/2^-$	[M1]			B(M1)(W.u.)≤0.61 $\Gamma\gamma_{(2+3)}$=19.6 eV *14*.
		12693	<2.82	2367.8	$1/2^+$	[E1]			Γ_γ≤2.82 eV B(E1)(W.u.)<3.7×10^{-3}
		15055	100	0.0	$1/2^-$	[E2+M1]	−0.115 *21*		Γ_γ=24.5 eV *15* B(M1)(W.u.)=0.325 *18*; B(E2)(W.u.)=0.27 *10* Mult.,δ: From $\Gamma\gamma0$(M1)=24.2 eV *15* and $\Gamma\gamma0$(E2)=0.32 eV *12*; δ^2=0.013 *5* deduced from ^{12}C(p,γ_0) angular distributions in (1975Ma21, 1977Ma16). See also δ^2=0.095 7 (1968Di04).
15.30×10^3	$(3/2^+)$	≈15290		0.0	$1/2^-$				Γ_γ≥0.5 eV
17680		17667		0.0	$1/2^-$				

Adopted Levels, Gammas (continued)

$\gamma(^{13}N)$ (continued)

E_i(level)	J^π_i	E_γ‡	E_f	J^π_f	Comments
20.90×10^3	$1/2^+$	20.90×10^3	0.0	$1/2^-$	
22140	$1/2^+$	19756	2367.8	$1/2^+$	From (1976Be28) $^{12}C(p,\gamma_1)$.
23.3×10^3	$3/2^-$	23.3×10^3	0.0	$1/2^-$	
24500		21.0×10^3	3500.4	$3/2^-$	
25900		25872	0.0	$1/2^-$	From (1972Be56) $^{10}B(^3He,\gamma_0)$.
28000		27967	0.0	$1/2^-$	From (1972Be56) $^{10}B(^3He,\gamma_0)$.
$31.7\times10^{3?}$		28.2×10^3	3500.4	$3/2^-$	
		31.7×10^3	0.0	$1/2^-$	
32000		31958	0.0	$1/2^-$	From (1972Be56) $^{10}B(^3He,\gamma_0)$.

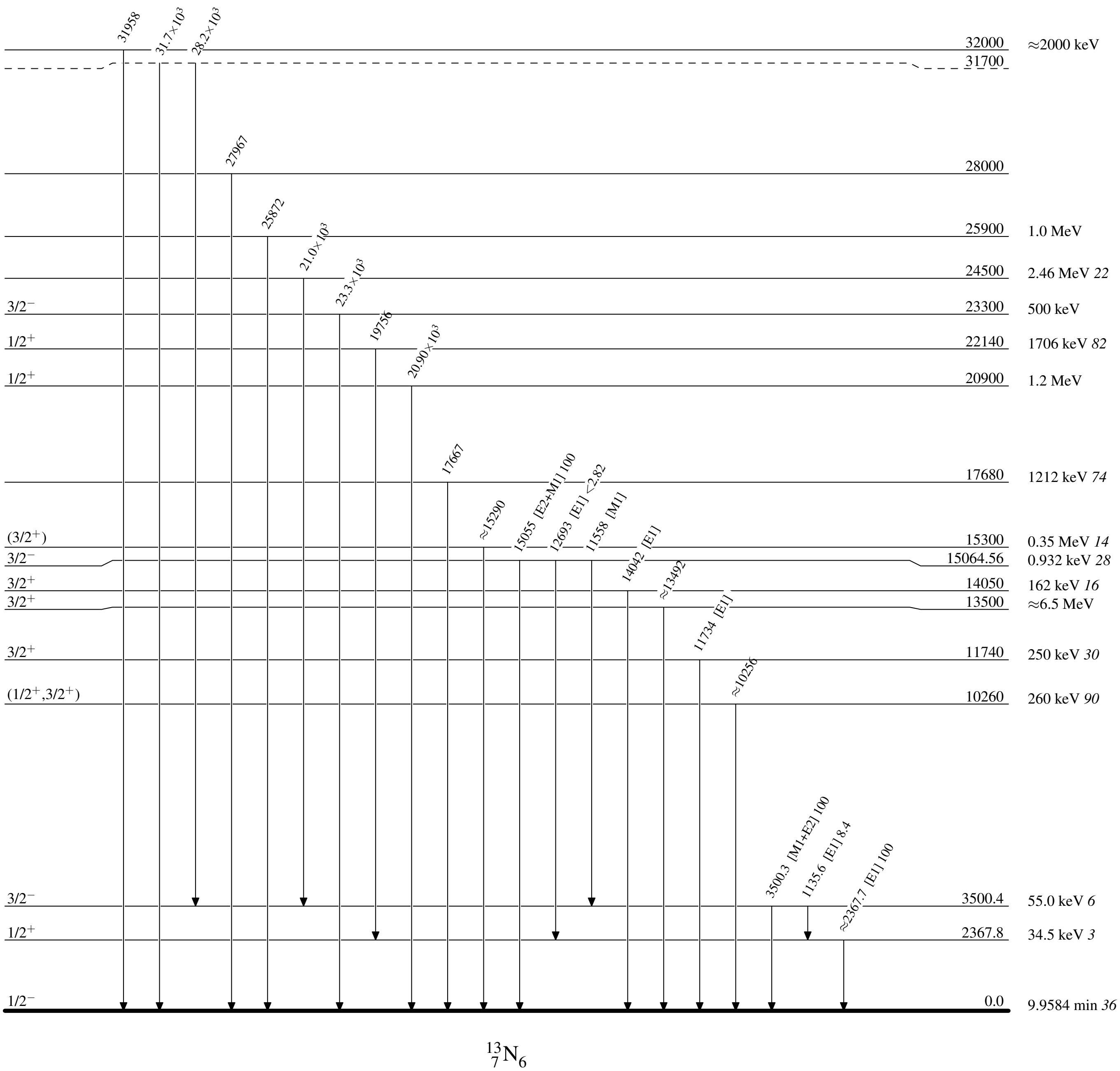
† Additional information 2.
‡ From level-energy difference.
\# The sign has been changed, where necessary, from that given in (1991Aj01) in order to conform to the convention used in the nuclear data sheets.

$^{13}_{7}N_{6}$-16

Adopted Levels, Gammas

Level Scheme

Intensities: Relative photon branching from each level



^{13}O $\varepsilon+\beta^+$ decay 2005Kn02

History			
Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

Parent: ^{13}O: E=0; J$^{\pi}$=3/2$^-$; T$_{1/2}$=8.58 ms *5*; Q(ε)=17770 *10*; %ε+%β^+ decay=100

All daughter levels deexcite mainly by proton decay, except the ground state. The 3501 keV level has a small %Iγ=0.0011 branch compared to it's main %p≈100 decay. Consequently, there is no observable γ emission following ^{13}O β^+ decay.

1965Mc09: ^{13}O(β+p), [from ^{14}N(p,2n)], measured delayed p spectrum; analyzed proton groups at E$_p$=6.06 and 6.65 MeV; deduced E$_x$=8.77 *4* and 9.49 *4* MeV.

1970Es03: ^{13}O(β+p), [from ^{14}N(p,2n)], measured delayed p spectrum, analyzed E$_p$ groups; deduced I$_p$, E$_p$, I$_p$, I$_\beta$ and Log ft. (*Expected but not observed).

E$_{c.m.}$=1.565 MeV from ^{13}N*(3.509) with I$_{rel}$=100;

E$_{c.m.}$=1.01(*) MeV and 5.48 MeV *5* from ^{13}N*(7.387) with I$_{rel}$=0.33 *10*;

E$_{c.m.}$=2.56 MeV *5* and 6.98 MeV from ^{13}N*(8.92) with I$_{rel}$=1.5 *3* and 3.5 *3*, resp.;

E$_{c.m.}$=3.12 MeV *5* and 7.58 MeV from ^{13}N*(9.52) with I$_{rel}$=0.43 *15* and 0.8 *1*, resp.;

and E$_{c.m.}$=3.97 *5* and 8.41(*) MeV from ^{13}N*(10.35) with I$_{rel}$=0.13 *7*.

1990As01: ^{13}O(β+p) [from ^{14}N(p,2n)], measured β delayed I$_p$, E$_p$, I$_p$, I$_\beta$.

E$_{c.m.}$=1.568 MeV from ^{13}N*(3.511) with I$_{p_rel}$=100;

E$_{c.m.}$=0.994 MeV and 5.433 MeV ^{13}N*(7.387) with I$_{p_rel}$=1.7 *8* and 0.17 *7*, resp.;

E$_{c.m.}$=2.536 MeV and 6.975 MeV from ^{13}N*(8.918) with I$_{p_rel}$=1.44 *25* and 4.83 *51*, resp.;

E$_{c.m.}$=3.094 MeV and 7.533 MeV from ^{13}N*(9.476) with I$_{p_rel}$=0.61 *15* and 0.98 *14*, resp.;

E$_{c.m.}$=3.97 MeV *5* and 8.42 MeV from ^{13}N*(10.36) with I$_{p_rel}$=0.12 *8* and 0.05 *3*. resp. Analyzed total Iβ along with I$_p$ from ^{13}N*(3.51) to obtain an absolute I$_p$(3.51)=Iβ(3.51)=9.8% *20*; this implies Iβ(g.s.)=89.2% *22*.

2005Kn02: ^{13}O ions were produced at the IGISOL facility via the ^{14}N(p,2n)reaction by impinging an E$_p$=45 MeV beam on a 1 mg/cm^2 target. The ^{13}O ions recoiled out of the target and were collected in a helium carrier gas which delivered them to the mass separator. The ions were then implanted into a 30 μg/cm^2 carbon foil. The implantation target was surrounded by three position sensitive ΔE-E Si detector telescopes, which triggered the DAQ; the ISOLDE Si ball was not included in the trigger due to a high sensitivity to β particles.

The delayed-proton energy spectrum was analyzed using Breit-Wigner shapes, the analysis deduced relative Ip and I$_\beta$ values, which were normalized to I$_p$(3.51)=Iβ(3.51)=9.8% *20* from (1990As01).

The (2005Kn02) data set has the highest statistical relevance and covers a broader energy range than other measurements (1965Mc09, 1970Es03, 1990As01). Furthermore, the discussion on the line-shape analysis suggests the results of (2005Kn02) should be adopted. Noteworthy differences between other measurements are for decay from ^{13}N*(8.918); (2005Kn02) observe a stronger p$_1$ branch than earlier measurements. Second, no evidence is seen for decay of ^{13}N*(10.360); the difference is attributed to the more sophisticated line-shape analysis in (2005Kn02).

A subtle note to understanding the (2005Kn02) manuscript: in Table 2 for %Iβ for ^{13}N*(15.065), the value includes unobserved contributions from γ decay, proton decay and α decay.

2023Bi03,2024Bi01: A 15.1 MeV ^{13}O beam from the Texas A&M MARS facility was implanted into the TexAT TPC. The β-delayed charged-particle emission events producing 3αp events were analyzed. A total of 149 events (%β3αp≈0.078 *6*) mainly included decay via ^{13}N*→p+[^{12}C*(7.65 MeV)→α+^{8}Be$_{g.s.}$] and ^{13}N*→α+[^{9}B*→p+^{8}Be$_{g.s.}$]; three low-lying ^{9}B states appear to be involved.

From the 149 3αp events, 102 events were fully reconstructed. The remaining 47 events were incomplete, for example, because they involved high energy α-particles that could not be fully characterized by the active volume of the TexAT TPC, for example, feeding to high-lying states that decay to ^{9}B$_{g.s.}$+α. In general, the decay energy was deduced using momentum conservation and the excitation energies of related ^{8}Be, ^{9}B, and ^{12}C were obtained from an invariant mass analysis.

The authors found evidence for population of ^{13}N* states at 11.3, 11.8, 12.4, 13.1, and 13.7 MeV; only the 11.8 MeV state was previously reported. These states show significant clustering. The evaluator notes that for 1.9×10^5 decays, 17 events should have proceeded through the ^{13}N*(15.1 MeV) IAS state and resulted in 3αp events.

In Table I, (2024Bi01) clarifies the deduced decay modes. Some interpretation of the (2005Kn02) ^{13}O β-p$_0$ results are included in the present analysis. A state at 11.3 MeV mainly decays to ^{9}B$_{g.s.}$; the authors suggest this new state may have been overlooked by

^{13}O $\varepsilon+\beta^+$ decay 2005Kn02 (continued)

(2005Kn02) where a narrow peak is visible at E_p=8.64 MeV that was attributed to the peak corresponding to p_2 decay from $^{13}N^*$(15.1 MeV) at E_p=8.68 MeV; this new state also has a component to ^{12}C(7.65 MeV). Authors suggest the E_x=11.8 MeV group corresponds to the known J^π=3/2$^-$ E_x=11.74 state; it is mainly seen in the p_2 channel and the present analysis associates the (2005Kn02) $E_p\approx$9.78 MeV counts with this state. A new state at E_x=12.4 MeV is found to decay mainly to ^{9}B via α_0 and α_1 with a small component to ^{12}C(7.65 MeV). Authors suggest a strong ^{9}B(1/2$^+$)$\otimes\alpha$ configuration. A state at E_x=13.1 MeV appears to decay mainly via α_3 emission; in such a case a ^{9}B(5/2$^+$)$\otimes\alpha$ configuration would be likely; however involvement of ^{9}B(2.78 MeV: 1/2$^-$) cannot be rulled out which would suggest J=1/2$^-$. Authors suggest possible evidence of a peak at E_p=6.20 MeV in (2005Kn02) that could correspond to p_0 decay to this level. This state is associated with a state previously reported at 13.26 MeV. Lastly, a state at E_x=13.7 is reported to decay via p_2, and α0,1,3; J^π=3/2$^-$ or 5/2$^-$ are permitted, but L=3 would be required for p_2 decay so 3/2$^-$ is preferred.

Theory:
1993Ch06: Shell model analysis of β-decay.
2003Sm02: Analysis of B(GT) rates.
2012Sa50: Global analysis of isospin-breaking corrections in superallowed decays.

Studies relevant to ^{13}O properties include: (1996Ma37, 1996Ma38, 1999Ma46).

^{13}N Levels

E(level)†	Jπ†	Γ†‡	Comments
0	1/2$^-$	9.9584 min *36*	
3500.4 *8*	3/2$^-$	55.0 keV *6*	Γ: See 63 keV *4* in (2005Kn02). %Iβ-p0=9.8 *20*; this implies %p_0=100.
7377 *6*	5/2$^-$	66 keV *9*	Γ: See 104 keV *20* in (2005Kn02). %Iβ-p0=0.009 *4* and %Iβ-p1=0.235 *29*; this implies %p_0=3.6 and %p_1=96.4.
8918 *11*	1/2$^-$	278 keV *16*	Γ: From (2005Kn02). %Iβ-p0=0.519 *40* and %Iβ-p1=0.441 *29*; this implies %p_0=54.1 and %p_1=45.9.
9476 *8*	3/2$^-$	30 keV	Γ: See 143 keV *18* in (2005Kn02). %Iβ-p0=0.137 *12* and %Iβ-p1=0.104 *11*; this implies %p_0=56.9 and %p_1=43.1.
11.3×10^3# *1*	[3/2$^-$]#	<200 keV	Γ: Deduced in (2024Bi01); if this state is observed in (2005Kn02) (2024Bi01) suggest Γ<40 keV. Suggested to decay via α_0+$^9B_{g.s.}$, p+$^{12}C_{g.s.}$ and p+^{12}C(7654.7 MeV).
11700 *30*	5/2$^-$	115 keV *30*	Γ: See 315 keV *112* (2005Kn02). Jπ: In (2024Bi01), decay to p+^{12}C(7654.7 MeV) is reported for a state in this energy region; they suggest the J^π=3/2$^-$ state near E_x=11.8 MeV was involved. Iβ-p0=0.015 *4* and %$p_1\le$0.002; this implies %p_0=100. A small branch via p_2 decay is reported in (2024Bi01).
12.4×10^3# *1*	[3/2$^-$]#		Suggested to decay via α_0+$^9B_{g.s.}$, α_1+^{9}B(1.8 MeV) and p+^{12}C(7.6547 MeV).
12937 *24*		>400 keV	E(level): See 13.26 MeV *10* deduced from E_p in (2005Kn02). Γ: See 521 keV *210* (2005Kn02). Jπ: See (−) in (2005Kn02). %Iβ-p0=0.011 *3*; this implies %p_0=100.
13.1×10^3# *1*	[1/2$^-$,5/2$^-$]#		Jπ: 1/2$^-$ for α_4 decay through ^{9}B(2.78:1/2$^-$) is preferred. Suggested to decay via α_1+^{9}B(1.8 MeV), α_0+^{9}B(2.75 MeV) or α_0+^{9}B(2.78 MeV) and p+$^{12}C_{g.s.}$.
13.7×10^3# *1*	[3/2$^-$]#		Suggested to decay via α_0+$^9B_{g.s.}$, α_1+^{9}B(1.8 MeV), α_0+^{9}B(2.75 MeV) and p+^{12}C(7654.7 MeV).
15064.56 *40*	3/2$^-$	0.932 keV *28*	%Iβ-p0=0.0048 *7*, %Iβ-p1=0.0029 *5* and %Iβ-p2=0.0011 *2*; when γ and α

Continued on next page (footnotes at end of table)

^{13}O ε+β^+ decay 2005Kn02 (continued)

^{13}N Levels (continued)

E(level)†	Jπ†	Γ†‡	Comments
			decay are considered, this implies %γ=4.9%, %α=53.4, %p_0=22.8, %p_1=14.0 and %p_2=4.9.
15.30×10^3 *20*	(3/2$^+$)	0.35 MeV *14*	E(level): deduced from E_p. J^π: If populated in this (2005Kn02), the transition is allowed and π=−; however the evaluator expresses reservations upon consideration of the background near where perhaps three or four counts attributed to this broad state are identified. The evaluator discounts the merit of any J^π constraints based on the suggestion this is an allowed transition. %Iβ-p0=0.004 *3* and %p_1≤0.0004; this implies %p_0=100.

† From Adopted Levels, except where noted.
‡ From fit to β-p spectrum from ^{13}O β^+ decay (2005Kn02).
# Four new states are suggested at ^{13}N*(11.3, 12.4, 13.1 and 13.7 MeV) (2023Bi03, 2024Bi01). The authors indicate an independent branching-ratio measurement from the number of implants is not reliable due to sizeable noise in some detectors; using their reported count rates the evaluator could suggest %Iβ on the order of 0.01-0.02% for each state. No intensity is assigned in the present evaluation. Assuming these are allowed decays, J^π arguments are given based on the various decay modes.

ε,β^+ radiations

εK, εL, εM, εN: Additional information 1.
av Eβ: Additional information 2.

E(decay)	E(level)	Iβ^+ †‡	Iε‡	Log *ft*	I(ε+β^+)‡	Comments
(2.47×10^3 *20*)	15300	0.004 *3*	7×10^{-6} *7*	3.56 *45*	0.004 *3*	av Eβ=6.0×10^2 *9*; εK=0.0016 *9*; εL=1.2×10^{-4} *7* The deduced Iβ differs slightly from (2005Kn02) Iβ=0.004 *2*.
(2705 *10*)	15064.56	0.019 *4*	2.07×10^{-5} *44*	3.16 *9*	0.019 *4*	av Eβ=710.9 *46*; εK=0.001011 *35*; εL=7.79×10^{-5} *27*
(4833 *26*)	12937	0.011 *3*	1.06×10^{-6} *29*	4.96 *12*	0.011 *3*	av Eβ=1718 *13*; εK=8.95×10^{-5} *33*; εL=6.90×10^{-6} *26* The $I_{p\_rel}(p_0)$=0.11 *9* and $I_{p\_rel}(p_1)$≤0.09 given in (2005Kn02) are incompatible with %Iβ=0.011 *3* given in their table II; after considering Fig. 2, the evaluator takes $I_{p\_rel}(p_0)$=0.11 *3* rather than $I_{p\_rel}(p_0)$=0.11 *9*, and uncertainty from p_1 is neglected.
(6070 *32*)	11700	0.015 *4*	6.4×10^{-7} *17*	5.38 *12*	0.015 *4*	av Eβ=2319 *16*; εK=3.93×10^{-5} *14*; εL=3.03×10^{-6} *11* The deduced Iβ differs slightly from (2005Kn02) Iβ=0.015 *8*.
(8294 *13*)	9476	0.24 *2*	3.53×10^{-6} *30*	4.919 *36*	0.24 *2*	av Eβ=3407 *6*; εK=1.366×10^{-5} *29*; εL=1.053×10^{-6} *23*
(8852 *15*)	8918	0.96 *5*	1.14×10^{-5} *6*	4.469 *23*	0.96 *5*	av Eβ=3681 *7*; εK=1.105×10^{-5} *24*; εL=8.52×10^{-7} *19* The deduced Iβ differs slightly from (2005Kn02) Iβ=0.96 *4*.
(10393 *12*)	7377	0.24 *3*	1.71×10^{-6} *22*	5.44 *5*	0.24 *3*	av Eβ=4440 *6*; εK=6.62×10^{-6} *13*; εL=5.11×10^{-7} *11* The deduced Iβ differs slightly from (2005Kn02) Iβ=0.24 *2*.

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^{13}O $\varepsilon+\beta^+$ decay 2005Kn02 (continued)

ϵ,β^+ radiations (continued)

E(decay)	E(level)	Iβ^+ †‡	Iε‡	Log *ft*	I$(\varepsilon+\beta^+)$‡	Comments
(14270 *10*)	3500.4	9.8 *20*	2.7×10^{-5} *5*	4.55 *9*	9.8 *20*	av Eβ=6353.1 *49*; εK=2.524×10^{-6} *47*; εL=1.946×10^{-7} *38*
(17770 *10*)	0	88.7 *20*	1.287×10^{-4} *37*	4.088 *10*	88.7 *20*	av Eβ=8083.0 *49*; εK=1.347×10^{-6} *24*; εL=1.038×10^{-7} *20* Iβ^+: From 100%-Σ(decay to excited states).

† Normalized to absolute I_p(3.51)=Iβ(3.51)=9.8% *20* from (1990As01).

‡ Absolute intensity per 100 decays.

^{17}Ne $\beta^+\alpha$ decay 2002Mo19

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

Parent: ^{17}Ne: E=0; J$^\pi$=1/2$^-$; T$_{1/2}$=109.2 ms *6*; Q($\beta^+\alpha$)=8730.1 *4*; %$\beta^+\alpha$ decay=2.77 *19*

^{17}Ne-T$_{1/2}$: Weighted mean from (1971Ha05,1988Bo39).

^{17}Ne-Q($\beta^+\alpha$): From (2021Wa16).

^{17}Ne-%$\beta^+\alpha$ decay: From (2002Mo19).

1988Bo39: A beam of ^{17}Ne ions was produced at the CERN/ISOLDE facility, using proton spallation reactions on a MgO target. Neon ions from the target were collected, post-accelerated to 60 keV and magnetically separated to obtain the ^{17}Ne beam, which was implanted in a 50 μg/cm^2 carbon foil. An annular plastic scintillator detector was placed on the upstream side of the target (w.r.t. beam) while a series of different ΔE Si surface-barrier detectors (covering $\approx$0.2% of 4π) were separately placed on the downstream side of the target. The Si detectors had thicknesses of 10, 15, 27 and 1000 μm and were used to characterize the proton and α groups of the delayed particle spectrum. Twenty-eight different groups of β-delayed protons and αs were identified. The lifetime was measured by collecting ^{17}Ne ions for 0.2 s and counting for 1.0 s. The value T=109.3 ms *6* was obtained. See other results on decay to ^{17}F in (1993Bo36,1993RiZY).

1997Ki19,1998Ch05,2002Ch61,2002Mo19: A series of experiments on ^{17}Ne decay were carried out at the TRIUMF/TISOL facility. The aim of the measurements was to exploit the ^{17}Ne(βp) reaction as a means to populate astrophysically important states in ^{16}O. Proton spallation of a MgO target resulted in ^{17}Ne ions that were implanted on a collection tape that was positioned at the center of various counting station configurations.

1998Ch05: A set of four ΔE-E telescopes were used to study the decay ^{17}Ne(β)^{17}F*(11193 keV)$\rightarrow$p+^{16}O*(9590) and ^{17}Ne(β)^{17}F*(11193 keV)$\rightarrow\alpha$+^{13}N*(2365,3502+3547); a total of 11 decay branches were observed for the decay of ^{17}F*(11193 keV).

2002Ch61: The configuration of (1998Ch05) was improved by implementing double-sided Si strip detectors into parts of the counting station; this lowered the pile-up and random coincidence rates. It is noted that the reported branching ratios show a significant systematic dependence on the detector configuration.

2002Mo19: ^{17}Ne β delayed particle emission was studied using four different experimental techniques: proton-γ coincidences, proton-γ angular correlations, ToF spectra for the proton and α particle spectra, and a ratio cut for a clean α spectrum. Proton-γ coincidences were determined using a beam of ^{17}Ne ions at the TISOL facility at TRIUMF. The beam traveled through a four-sector annular silicon detector and was implanted onto a collection tape directly in front of a plastic scintillator and a HPGe detector that was not in the vacuum system. Counting rates were very high so only γ-ray events with energy above 4 MeV were accepted. A particle-β coincidence spectrum was also recorded by the Silicon detector.

Proton-γ angular correlations were studied using two HPGe γ-ray detectors and four ion-implanted Silicon detctors surrounding a carbon collector foil. Angular correlations between emitted protons and ^{16}O γ rays were measured. Using this method, J^π was determined for states in ^{17}F.

ToF spectra were determined for proton and α particle emissions. A beam of ^{17}Ne ions passed through a carbon collector foil that was positioned at an angle and centered between to scintillation paddles, the beam then passed into a SSB detector. Time and pulse-height information were recorded. A clean α spectrum was not able to be produced because β-proton coincidences at low energies were very strong and obscured the weaker α decay peaks. Therefore, the ratio cut technique was used to obtain a cleaner spectrum.

A thin SSB detector was placed on the opposite side of a collector foil and a PIPS detector. Each detector had a thicker detector behind it in order to reject background events due to electrons and high energy protons. The PIPS detector recorded particle recoil and the SSB detector recorded coincident α particles. Additional background events were removed using the ratio-cut technique.

Using these methods, relative proton and α branching ratios were determined along with branching ratios for the β decay of ^{17}Ne. Using these branching ratios, reduced Gamow-Teller matrix elements were determined. β-delayed proton decay to α-unbound states in ^{16}O was also examined because of its relevance to astrophysics (helium-burning stage of stellar evolution).

The values %βp=95.4 *46* and %$\beta\alpha$=2.77 *19* are deduced from the tables given in (2002Mo19).

^{17}Ne $\beta^{+}\alpha$ decay 2002Mo19 (continued)

^{13}N Levels

E(level)†	J$^{\pi}$‡
0.0	1/2^{-}
2365	1/2^{+}
3502	3/2^{-}
3547	5/2^{+}

† From (2002Mo19).
‡ From Adopted Levels.

γ(^{13}N)

E$_{\gamma}$†	E$_{i}$(level)	J$^{\pi}_{i}$	E$_{f}$	J$^{\pi}_{f}$
1137	3502	3/2^{-}	2365	1/2^{+}
2365	2365	1/2^{+}	0.0	1/2^{-}
3502	3502	3/2^{-}	0.0	1/2^{-}

† From level-energy differences.

Delayed Alphas (^{13}N)

E(α)†	E(^{13}N)	I(α)†‡#	E(^{17}F)	E(α)†	E(^{13}N)	I(α)†‡#	E(^{17}F)
1397	3547	0.0016 *9*	11193	2301	2365	0.0682 *69*	11193
1432	3502	0.0016 *9*	11193	2776	0.0	0.0570 *58*	9450
1725	0.0	2.09 *18*	8075	3219	0.0	0.0499 *49*	10030
1821	0.0	0.215 *22*	8200	3701	0.0	0.00066 *58*	10660
2001	0.0	0.092 *9*	8436	3892	0.0	0.0115 *16*	10910
2299	0.0	0.178 *17*	8825	4110	0.0	0.0024 *7*	11193

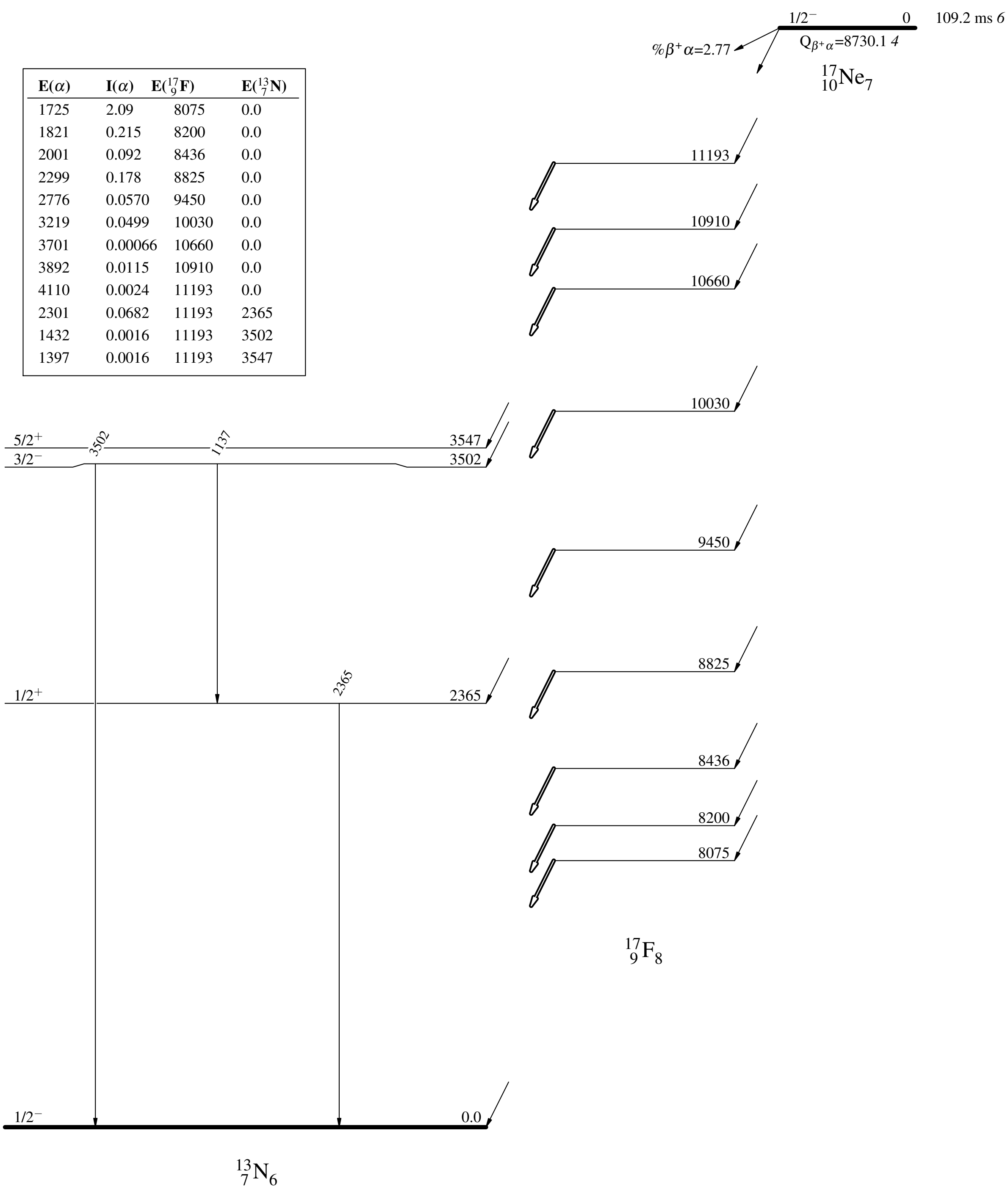
† From (2002Mo19).
‡ The feeding to the particle unbound states is determined by normalizing the %β^{+} strength to the relative Iβ^{+}-p and Iβ^{+}-α branching ratios using the measured β^{+}p, β^{+}pγ, $\beta^{+}\alpha$, $\beta^{+}\alpha\gamma$ observations and by assuming I$\beta^{+}_{g.s.}$<0.55% (1997Mi08) and Iβ^{+}(495 keV)=1.59% *17* (1993Bo36,1998Oz01: and including a correction for the γ-ray feeding from the 11193 keV isobaric analog state).
# Absolute intensity per 100 decays.

^{17}Ne $\beta^{+}\alpha$ decay 2002Mo19

Decay Scheme

I(α) Intensities: I(α) per 100 parent decays

E(α)	I(α)	E($^{17}_{9}$F)	E($^{13}_{7}$N)
1725	2.09	8075	0.0
1821	0.215	8200	0.0
2001	0.092	8436	0.0
2299	0.178	8825	0.0
2776	0.0570	9450	0.0
3219	0.0499	10030	0.0
3701	0.00066	10660	0.0
3892	0.0115	10910	0.0
4110	0.0024	11193	0.0
2301	0.0682	11193	2365
1432	0.0016	11193	3502
1397	0.0016	11193	3547



^{1}H(^{13}N,p)

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1992De19: ^{1}H(^{13}N,p) E≈8.2 MeV; analyzed ^{14}O resonance.
2004Be16: ^{13}N(pol. p,p); calculated observables at E_p=500, 547, 800 MeV.
2007Te09: ^{1}H(^{13}N,p) E=0.4-3.3 MeV; measured $\sigma(E_p,\theta_p)$ for $\theta=-5°$ to 5° and 10° to 22°. Analyzed ^{14}O resonances via thick-target inverse kinematics study (TTIK).
2008Wa09, 2009Wa25, 2010Wa18: ^{1}H(^{13}N,p) $E_{c.m.}$=0.5-3.0 MeV. TTIK study of ^{14}O.
2015Be12: ^{13}N(p,p′) E<200 MeV. Cluster model analysis of proton scattering.

^{13}N Levels

E(level)
0

$^{1}H(^{14}O,^{13}N)$ 2015KaZU

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

2015KaZU: $^{1}H(^{14}O,^{13}N)$ E≈250 MeV/nucleon at the RIKEN/SHARAQ facility. Measured the $^{14}O(p,2p)$ reaction in inverse kinematics; $^{13}N^{*}(0, 3.5, 15)$ were populated.

See also (2015KaZY, 2018Go21, 2018At01, 2019Ph04).

2023Po05: $^{1}H(^{14}O,^{13}N)$ E=94 MeV/nucleon at RIKEN/RIBF; also studied $^{1}H(^{14}O,^{13}O)$. Measured the parallel momentum distributions and reaction cross sections. Analyzed quasifree knockout and other mechanisms. Deduced S=1.58 for the ground state in DWIA analysis.

^{13}N Levels

E(level)	J^{π}†	C^2S†	Comments
0	$1/2^-$	1.51 *8*	σ=251 μb *14*.
3.5×10^3	$3/2^-$	2.02 *14*	σ=326 μb *22*.
15×10^3	$3/2^-$	0.65 *19*	T=3/2 σ=63 μb *18*.

† From DWIA analysis of spectroscopic factors using the THREEDEE code (2015KaZU).

$^{2}H(^{14}O,^{3}He)$ 2013Fl01

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

2013Fl01: XUNDL dataset compiled by TUNL (2013).

The $^{2}H(^{14}O,^{14}O)$ elastic scattering, and $^{14}O(d,^{3}He)$ and $^{14}O(d,t)$ single nucleon transfer reactions were measured in inverse kinematics and spectroscopic factors, $C^2 2S$, were deduced.

A 18.1 MeV/nucleon ^{14}O beam was produced at the GANIL/SPIRAL facility. The beam impinged on a 1.5 mg/cm^2 CD_2 target (elastic scattering) or a 0.5 mg/cm^2 target $(d,^{3}He)$ and the light recoil nuclei were detected in one of six MUST2 array telescopes: four covered $\theta_{cm}\approx15°-70°$ for the nucleon transfer reactions while the other two telescopes were near $\theta_{lab}\approx90°$ and were used to extend the elastic measurements.

The angular distributions were analyzed using the FRESCO code. Spectroscopic factors are deduced using both phenomenological and microscopic overlap functions and compared with literature results for $^{16}O(d,^{3}He)$, (d,t) and $^{18}O(d,^{3}He)$.

See further analysis in (2018Fl03).

^{13}N Levels

J,C^2S: From FRESCO coupled-reactions channel analysis of spectroscopic factors in (2013Fl01).

E(level)	J^π	Comments
0.0	$1/2^-$	C^2S(phenomenological)=1.14 *16*(exp.) *15*(analysis), also see C^2S(microscopic)=1.58 *22*(exp.) *2*(analysis).
3.5×10^3	$3/2^-$	C^2S(phenomenological)=0.94 *19*(exp.) *7*(analysis), also see C^2S(microscopic)=1.00 *20*(exp.) *1*(analysis).

^{9}Be(^{13}N,X) 1996Oz01

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1996Oz01, 2001Oz04: ^{9}Be, C, ^{27}Al(^{13}N,^{13}N) E≈730 MeV; measured interaction cross sections. Deduced proton, charge, neutron and matter radii of 2.32 fm *4*, 2.45 fm *4*, 2.30 fm *4* and 2.31 fm *4*, respectively.

2001Oz04: Glauber analysis of available breakup data.

2002Me12: Calculated charge changing σ on carbon, radius.

2017Ah08: Glauber model analysis of nuclear radii.

^{13}N Levels

E(level)	Comments
0	$<r_p^2>^{1/2}$=2.32 fm, $<r_n^2>^{1/2}$=2.45 fm and $<r_m^2>^{1/2}$=2.30 rm.

^{9}Be(^{10}C,^{13}N) 2009Ch38

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

2009Ch38: XUNDL dataset compiled by TUNL (2009).

^{9}Be(^{10}C,^{13}N→p+3α) and ^{12}C(^{10}C,^{13}N→p+3α) at E(^{10}C)=10.7 MeV/nucleon at the Texas A&M MARS facility.

A set of four HiRA detectors covering θ=1.3° to 7.7° were used to measure resonance decay of particle-unbound ^{13}N states. The analysis identified states that p- and α-decay to ^{12}C and ^{9}B excited states.

^{13}N Levels

E(level)	J$^{\pi}$	T$_{1/2}$	Comments
10.36×10^{3} †			E(level): A doublet is identified at this energy in the Adopted Levels.
10.83×10^{3} †	(1/2^{-},1/2^{+},3/2^{-})		J$^{\pi}$: Suggested from systematics.
11.53×10^{3} †		<300 keV	
13.65×10^{3} ‡# *1*		<300 keV	Approximate branching ratios (p+^{12}C(9.65))=48% and (α+^{9}B$_{g.s.}$)=52%.
16.6×10^{3} @ *1*		<350 keV	

† Decays to p+^{12}C(7.65).
‡ Decays to p+^{12}C(9.64).
# Decays to α+^{9}B$_{g.s.}$
@ Decays to α+^{9}B(2.345).

^{10}B(^{3}He,n),(^{3}He,X):res

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1955Bi26: ^{10}B(^{3}He,X) E=900 keV; measured particle spectra.
1957Aj71: ^{10}B(^{3}He,n) E=2.54 and 3.60 MeV; analyzed ^{12}N yields.
1963Pe10: ^{10}B(^{3}He,n) E=2-6.3 MeV; measured excitation function.
1972Be05: ^{10}B(^{3}He,p), ^{10}B(^{3}He,γ) E=4-14 MeV; measured $\sigma(E_{3He},E_{\gamma})$; reported no resonances.
1972Be56: ^{10}B(^{3}He,n), (^{3}He,p), (^{3}He,d), (^{3}He,α) E=11-19 MeV; measured $\sigma(E,E_n)$, $\sigma(E,E_p,\theta)$, $\sigma(E,E_d,\theta)$, for θ=90° and 150° and $\sigma(E,E_\alpha,\theta)$ for θ=30° to 150°. Analyzed existing data and deduced resonances at E_{res}= 5.6 MeV (α_0, d_0, $p_{0,2,3}$, pγ(12.71,15.11), n, γ_0), 8.5 MeV (α_0, p_0, pγ(12.71,15.11), γ_0), and 13.5 MeV ($\alpha_{1,2}$, $d_{4,5}$, γ_0).

See also:
1966Za01: ^{10}B(^{3}He,n) E=2.6, 3.0, 4.0, 5.8 MeV; measured $\sigma(E_n,\theta)$. Deduced reaction Q-value.
1968Ad03: ^{10}B(^{3}He,n) E=3 MeV; measured $\sigma(E_n)$. Deduced Q-value.
1970Bo39: ^{10}B(^{3}He,n) E=6.2 MeV, ^{10}B(^{3}He,n/p) E=10, 11 MeV, measured $\sigma(E_n,\theta)$, $\sigma(E_p,\theta)$.
1970Si16: ^{10}B(^{3}He,n) E=6.9-30.6 MeV; measured σ(E).
1974Fu11: ^{10}B(^{3}He,n) E=10.5-13 MeV; measured $\sigma(E_n,\theta)$.

^{13}N Levels

E(level)	Γ	$E_{^3He}$(res) (MeV)	Comments
25.9×10^{3}	1000 keV	5.6	(1972Be56) indicate a state near 26 MeV that decays via α_0, d_0,$p_{0,2,3}$,γ_0, (n).
$28.\times10^{3}$		8.5	(1972Be56) indicate a state near 28 MeV that decays via α_0,p_0,γ_0.
$32.\times10^{3}$	≈2 MeV	13.5	(1972Be56) indicate a state near 32 MeV that decays via α_1,$d_{4\&5}$,γ_0.

^{10}B(^{3}He,p):res

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

History

1956Sc01: ^{10}B(^{3}He,p) E=1-5 MeV; measured $\sigma(\theta)$ for θ=0° and 90°. Deduced resonances at $E_{^3He}$(res)= 2.0, 3.7, 4.1, 4.6 MeV (E_x=23.2, 24.5, 24.8, 25.2 MeV) with Γ=0.5 MeV, 0.7 MeV, 120 keV and 150 keV, respectively.
1961Al27: ^{10}B(^{3}He,p_2)^{12}C*(7.65 MeV) E=2.2 MeV; measured p$\gamma\gamma$-coincidence.
1964Ku09: ^{10}B(^{3}He,p)^{12}C*(15.11 MeV) E(^{3}He)=1.8-5.5 MeV; measured σ(E) excitation function for E_γ=15.1 MeV. Deduced resonances at $E_{^3He}$(res)=2.85 and 5.2 MeV.
1966Ba01: ^{10}B(^{3}He,p)^{12}C*(15.11 MeV) E(^{3}He)=4.5-9 MeV; measured σ(E) excition function for E_γ=15.1 MeV across $E_x\approx$ 26 MeV region. No evidence of resonances.
1966Pa10: ^{10}B(^{3}He,p) E(^{3}He)=1.2-12 MeV; deduced resonances to ^{12}C(0,4.44,7.65,9.64 MeV) at $E_{^3He}$(res)=2.2, 3.7, 5.8 and 8.2 MeV, $E_x\approx$23.3, 24.5, 26.1, 28.0 MeV.
1972Be56: ^{10}B(^{3}He,n), (^{3}He,p), (^{3}He,d), (^{3}He,α) E=11-19 MeV; measured σ(E,E_n), σ(E,E_p,θ), σ(E,$E_d\theta$), for θ=90° and 150° and σ(E,E_α,θ) for θ=30° to 150°. Analyzed existing data and deduced resonances at $E_{^3He}$(res)=5.6, 8.5, 13.5 MeV.

See also:
1972Al03: ^{10}B(^{3}He,p)^{12}C*(15.11 MeV) E=2.2 MeV; measured σ(E_p,E_γ).
1983Ch08: ^{10}B(^{3}He,p) E=15.75 MeV; measured σ(E_p), deduced Q-value.
1996Mc09: ^{10}B(^{3}He,p) E=2-4 MeV; measured σ(E_p,θ) for θ=90° and 135°.

^{13}N Levels

E(level)	J^π †	Γ	$E_{^3He}$(res) (MeV)	Comments
23.3×10^3		500 keV	2.2	$E_{^3He}$(res) (MeV): From (1966Pa10): (^{3}He,p_0). Γ: From (1956Sc01): $E_{^3He}$(res)=2.0 MeV.
23.83×10^3 *4*		346 keV *38*	2.85 *5*	$E_{^3He}$(res) (MeV),Γ: From (1964Ku09): (^{3}He,p) resonance to ^{12}C(15.1 MeV).
24.5×10^3		0.7 MeV	3.7	$E_{^3He}$(res) (MeV): From (1966Pa10): (^{3}He,$p_{0,1}$). Γ: From (1956Sc01): $E_{^3He}$(res)=3.7 MeV.
24.8×10^3		120 keV	4.1	$E_{^3He}$(res) (MeV),Γ: From (1956Sc01).
25.2×10^3?		150 keV	4.6	$E_{^3He}$(res) (MeV),Γ: From (1956Sc01).
25.64×10^3 *8*		184 keV *60*	5.2	$E_{^3He}$(res) (MeV),Γ: From (1964Ku09): (^{3}He,p) resonance to ^{12}C(15.1 MeV). (1966Ba01) suggest no evidence of a GDR at $E_x\approx$ 26 MeV.
26.1×10^3	≥3/2		5.8	$E_{^3He}$(res) (MeV): From (1966Pa10): (^{3}He,p) resonance to ^{12}C(0,4.44,9.6 MeV). See also (1972Be56) where $E_{^3He}$(res)=5.6 is reported for $p_{0,2,3}$.
28.0×10^3	≥7/2		8.2	$E_{^3He}$(res) (MeV): From (1966Pa10): (^{3}He,p_0) resonance. See also (1972Be56) where $E_{^3He}$(res)=5.5 is reported for p_0.

† From analysis of angular distributions in (1966Pa10).

^{10}B(^{3}He,d):res

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1965Pa10: ^{10}B(^{3}He,d) E=3.5-10 MeV; measured $\sigma(\theta)$ for at E(^{3}He)=3.7, 5.8, 7.5, 9.8 MeV. Mainly focused on the prominent E_{res}=5.8 MeV state.

1972Be56: ^{10}B(^{3}He,n), (^{3}He,p), (^{3}He,d), (^{3}He,α) E=11-19 MeV; measured $\sigma(E,E_n)$, $\sigma(E,E_p,\theta)$, $\sigma(E,E_d,\theta)$, for θ=90° and 150° and $\sigma(E,E_\alpha,\theta)$ for θ=30° to 150°. Analyzed existing data and deduced resonances at E_{res}=5.6, 8.5, 13.5 MeV.

See also:
1967Ha20: ^{10}B(^{3}He,d) and ^{11}B(^{3}He,t) E=6-18 MeV, measured thick target yields; deduced σ(E). Discussed reaction mechanism.
1970Bo07: ^{10}B(^{3}He,d), ^{10}B(^{3}He,np) E=8, 10, 11 MeV; measured $\sigma(\theta(n+p))$, $\sigma(E_n,E_p)$. Deduced singlet deuteron emission.
1976Ga27: ^{10}B(^{3}He,d) E=1.5-4.6 MeV; measured σ(E).

^{13}N Levels

E(level)	$T_{1/2}$	$E_{^3He}$(res) (MeV)†	Comments
25.9×10^{3}		5.6	Γ: Broad. $E_{^3He}$(res) (MeV): From (1972Be56) for d_0. See also (1965Pa10) where $E_{^3He}$(res)=5.8 is reported.
32×10^{3}	≈2 MeV	13.5	$E_{^3He}$(res) (MeV): From (1972Be56) for $d_{4\&5}$.

† From (1972Be56).

$^{10}B(^{3}He,^{3}He)$:res

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1987Ba34: $^{10}B(^{3}He,^{3}He)$ E=1.5-3.3 MeV; measured $\sigma(\theta)$ for θ=75.1°, 107.5° and 143.3°. R-matrix analysis. Deduced levels, level parameters.

See also:
1964Os02: $^{10}Be(^{3}He,t)$ E=5-10.5 MeV; measured excitation function.
1970Du07: $^{10}B(^{3}He,^{3}He)$ E=4-18 MeV; measured $\sigma(E,\theta)$ for θ=15° to 160°; deduced optical model parameters.
1970Nu02: $^{10}B(^{3}He,^{3}He)$, $(^{3}He,t)$ E=14 MeV; measured $\sigma(\theta)$ for θ=5° to 140°; deduced optical model parameters.
1972Bu30: $^{10}B(^{3}He,^{3}He)$ E=13-27 MeV; measured $\sigma(\theta)$ for θ=8° to 150°; deduced optical model parameters.
1979Go07: $^{10}B(^{3}He,^{3}He)$ E=46.1 MeV; measured $\sigma(\theta)$ for θ=10° to 160°; deduced optical model parameters.
1980Tr02: $^{10}B(^{3}He,^{3}He)$ E=41 MeV; measured $\sigma(\theta)$ for θ=20° to 85°; deduced optical model parameters.

^{13}N Levels

E(level)‡	J^{π}†	Γ†	L	$E_{^3He}$(res) (MeV)†	Comments
23.25×10^{3}	3/2⁻	500 keV	1	2.10	Γ: Γ_{3He}=0.25 MeV (1987Ba34).
23.87×10^{3}	3/2⁻	400 keV	1	2.90	Γ: Γ_{3He}=0.12 MeV (1987Ba34).
23.93×10^{3}	$(11/2,13/2)^{-}$	20 keV	3	2.975	Γ: Γ_{3He}=0.020 MeV (1987Ba34).
24.40×10^{3}	$(5/2,7/2)^{+}$	700 keV	0	3.60	Γ: Γ_{3He}=0.35 MeV (1987Ba34). E(level): The upper energy covered in (1987Ba34) was $E(^{3}He)$=3.3 MeV. The authors found an improved fit by including this resonance. Fit values should be considered tentative.

† From R-matrix analysis in (1987Ba34).
‡ Level energies are deduced using $E_{res}(^{3}He)$ and ^{10}B, ^{3}He and ^{13}C masses from (2021Wa16: AME-2020). $E_x=S(^{3}He)+E_{c.m.}$(relativistic).

^{10}B(^{3}He,α):res

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1963Ea03: ^{10}B(^{3}He,α) E(^{3}He)=3-10.5 MeV; measured excitation function.
1965Pa05: ^{10}B(^{3}He,$\alpha_{0,1}$) E(^{3}He)=2-10 MeV; measured $\sigma(\theta=30°, 90°, 150°)$, focused on broad E_{res}=5.8 MeV group in α_0.
1970Gi04: ^{10}B(^{3}He,α) E(^{3}He)=1-10 MeV. Analysis included measurements on ^{12}C(pol. p,p). Measured $\sigma(E,\theta)$; Legendre polynomial analysis; deduced resonances at E_{res}=3, 5.8, and 8 MeV with Γ= 0.75 *25*, 1.35 *15* and 2.25 *25* MeV and J^π=7/2$^-$, 7/2$^-$ and 9/2$^+$, respectively.
1972Be56: ^{10}B(^{3}He,n), (^{3}He,p), (^{3}He,d), (^{3}He,α) E=11-19 MeV; measured $\sigma(E,E_n)$, $\sigma(E,E_p,\theta)$, $\sigma(E,E_d,\theta)$, for θ=90° and 150° and $\sigma(E,E_\alpha,\theta)$ for θ=30° to 150°. Analyzed existing data and deduced resonances at E_{res}=5.6, 8.5, 13.5 MeV.

See also:
1955Al57: ^{10}B(^{3}He,α) E=900 keV; measured E_α. First author is Bigham; details are given in (1959Al96).
1968Kr02: ^{10}B(^{3}He,α) E=2.49, 3.24, 3.74 MeV; measured $\sigma(E_\alpha,\theta)$ for θ=30° to 140°.
1971Sq03: ^{10}B(^{3}He,α) E=33.7 MeV; measured $\sigma(E_\alpha,\theta)$ for θ=10° to 120°.
1986Ar14, 1988Ar05: ^{10}B(^{3}He,α) E=2.3, 5 MeV; measured $\alpha\alpha$-coin, $\sigma(\theta_{\alpha1},\theta_{\alpha2})$.

^{13}N Levels

E(level)	J^π	Γ	$E_{^3He}$(res) (MeV)	Comments
24×10^3	7/2$^-$	0.75 MeV *25*	3	$E_{^3He}$(res) (MeV),J^π,Γ: From R-matrix analysis in (1970Gi04). Γ from Γ=0.5-1.0 MeV.
26.1×10^3	7/2$^-$	1.35 MeV *15*	5.8	$E_{^3He}$(res) (MeV): From (1965Pa05, 1970Gi04). J^π,Γ: From R-matrix analysis in (1970Gi04). Γ from 1.2-1.5 MeV. Γ: Broad (1965Pa05). See also (1972Be56) where $E_{^3He}$(res)=5.6 is reported for α_0.
28×10^3	9/2$^+$	2.25 MeV *25*	8	$E_{^3He}$(res) (MeV),J^π,Γ: From R-matrix analysis in (1970Gi04). Γ from 2.0-2.5 MeV. See also (1972Be56) where $E_{^3He}$(res)=8.5 is reported for α_0.
32×10^3		≈2 MeV	13.5	$E_{^3He}$(res) (MeV): From (1972Be56) for α_1.

^{10}B(α,n) 1973Va25

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1935Ru01: ^{10}B(α,n). Measured ^{13}N $T_{1/2}$≈14 minutes.
1956Qu04: ^{10}B(α,n) E=8.0 MeV; measured states at $^{13}N^{*}$(2.4 MeV *3*, 3.6 *3*, (4.3 *3*), 5.0 *3*).
1973Va25: ^{10}B(α,n) E=1.0-5.0 MeV; studied excitation functions and deduced ^{14}N levels and level parameters.
1975Wi04: ^{10}B(α,n) E=2-10 MeV; studied excitation functions and deduced ^{14}N levels and level parameters.
1976Du08: ^{10}B(α,$n_{0,1}$) E=18-20 MeV; measured σ(E,θ).
1977Li19: ^{10}B(α,n); analyzed σ(E<7 MeV).
1979Ba48: ^{10}B(α,n) E=3-7.5 MeV; measured neutron yield, deduced σ(E).
1979Gi09: ^{10}B(α,n) E=4-14 MeV; measured σ(E) via activation technique.
1983Ro26: ^{10}B(α,n) E=3.2-14 MeV; measured yield.
2019Li42: ^{10}B(α,n_0) E=2.2-4.9 MeV; measured σ(E,θ), analyzed available data.
2020Li08: ^{10}B(α,n_0) E=575-2522 keV. Measured σ(θ), analyzed available data. Discussed astrophysical relevance.
2021Wi02: ^{10}B(α,n): Analyzed available σ($E_α$,θ) data for astrophysically relevant reactions.
2023Gu04: ^{10}B(α,n),(α,X) E=0.21-1.4 MeV; R-matrix analysis of available data.

^{13}N Levels

E(level)†	$T_{1/2}$	Comments
0	≈14 min	$T_{1/2}$: From (1935Ru01).
2366		
3.51×10^3		
3.55×10^3		

† From (1973Va25).

^{10}B(^{6}Li,t)

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1966Mc05: ^{10}B(^{6}Li,t): $E_{c.m.}$=3.05 MeV; measured angular distributions and σ to $^{13}N^{*}$(0,2.36, 3.51+3.56,6.38) $\theta\approx10°$ to 150°.
1974Ho06: ^{10}B(^{6}Li,t) E=18 MeV; measured $\sigma(E_t,\theta)$, Deduced E, Γ, J,π. Analyzed ^{13}C analog pairs from comparison with (^{6}Li,^{3}He). They associate $^{13}N^{*}$(7.17,9.00,9.52,10.35+10.36) with $^{13}C^{*}$(7.49,9.50,9.90,10.81+10.75), respectively.

^{13}N Levels

E(level)†	$T_{1/2}$†	Comments
0‡		$\sigma_{tot.}$=0.47 (1966Mc05).
2.36×10^{3}‡		$\sigma_{tot.}$=0.30 (1966Mc05).
3.51×10^{3}‡		$\sigma_{tot.}$(3.51+3.56)=2.02 (1966Mc05).
3.56×10^{3}‡		
6.38×10^{3}‡		$\sigma_{tot.}$=1.21 (1966Mc05).
6.90×10^{3}	120 keV *30*	
7.17×10^{3}		
7.38×10^{3}	70 keV *30*	
8.92×10^{3}?		E(level): The authors suggest this level may not be strongly populated in this reaction since its $^{13}C^{*}$(8.86) analog is weakly populated in (^{6}Li,^{3}He). This level cannot be resolved from $^{13}N^{*}$(9.00).
9.00×10^{3}	280 keV *30*	
9.52×10^{3}		
10.35×10^{3}		
10.35×10^{3}		
10.78×10^{3}		
11.65×10^{3}		

† From (1974Ho06).
‡ Reported in (1966Mc05).

$^{10}B(^{9}Be,^{6}He)$

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1992Co05: $^{10}B(^{9}Be,^{6}He)$ E=40 MeV; measured $\sigma(\theta)$ for θ=10° to 30°.

^{13}N Levels

E(level)†
0
3.5×10^{3}
6.38×10^{3}
7.16×10^{3}
9.00×10^{3}
10.36×10^{3}

† From (1992Co05).

^{11}B(^{3}He,n),^{11}B(^{3}He,nγ)

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1966Di04: ^{11}B(^{3}He,n_0) E=1.5-5.5 MeV; measured $\sigma(E,\theta)$ for $\theta\approx0°$ to 170°.
1966Ch18: ^{11}B(^{3}He,nγ) E=1.23-2.00 MeV; measured n-p, n-γ coincidences. Explained erronious identification of $^{13}C^*$(6.27,5.56) states.
1968Co27: ^{11}B(^{3}He,nγ) E=7.3 MeV; measured decay modes of $^{13}N^*$(15.07 MeV). Analyzed E_γ, I_γ, pγ-, nγ-coincidences. Deduced level energy, γ, IAS γ decay. Deduced $\Gamma_{\gamma0}/\Gamma_{p0}$=0.12 *2* from; when combined with $\Gamma_p\Gamma_{\gamma0}/\Gamma$ from (1968Di04) and Γ_{p0}/Γ from (1967AdZY) this gives $\Gamma_{\gamma0}/\Gamma$=0.024 *5* and Γ=1.13 keV *3*. Reviewed other IAS decay branches.
1969Ad01,1969Ad02: ^{11}B(^{3}He,n) E=7-13.5 MeV, measured $\sigma(E_n,\theta)$. Deduced level energies, T, Γ, J, π, L, discussed T=3/2 states (1969Ad02). Found Γ_{p0}/Γ=0.202 *20* and Γ_{p1}/Γ=0.121 *15* (1969Ad01). When combined with results from (1968Di04, 1969Le18,1968Co27) this implies Γ=1.17 keV *12*, $\Gamma_{\gamma0}$=27 keV *5*, Γ_{p0}=0.24 keV *5* and Γ_{p1}=0.14 keV *3*.
1971Hs03: ^{11}B(^{3}He,n) E=4.7, 6.1, 6.49 MeV; measured $\sigma(E,E_n,\theta)$ for θ=0° to 150°. Deduced Q-value to levels, level energies, L, J, Γ.
1973Ad02: ^{11}B(^{3}He,n) E=7.0 MeV; detected neutrons and decay protons from $^{13}N^*$(15.07) to ^{12}C(0,4.4,7.65). Deduced Γ_p/Γ and Γ_α/Γ branching ratios and partial widths. Referenced E_x=15.066 MeV *4* from the (1968Ce01) review.
1975Ma21: ^{11}B(^{3}He,nγ); measured pγ-, nγ-coincidences with θ_γ=125° and θ_n=0°. For $^{13}N^*$(15.07) deduced $\Gamma_p\Gamma_{\gamma0}/\Gamma$=5.79 eV *20* from ^{12}C(p,γ) measurements. They combine results with (1973Ad02) to obtain $\Gamma_{\gamma0}$=24.5 eV *15*. Using the E2/M1 intensity ratio they measured (=0.013 *5*) they found Γγ0(M1)=24.2 eV *15* and Γγ0(E2)=0.32 eV *12*. They determined relative transition strengths for γ_0, γ_1 and γ_2. Lastly, they discussed ^{13}C/^{13}N isotensor asymmetries.
1977Da18: ^{11}B(^{3}He,n_0) E=5-12 MeV; measured $\sigma(E,E_n,\theta)$.
1977Ma16: ^{11}B(^{3}He,nγ) E=7.0 MeV; measured nγ-coincidence. θ_γ=125°. Deduced $\Gamma_{\gamma0}/\Gamma_{p0}$=0.121 *11*. Combined their results with others to find Γ=0.86 keV *12*.
1977Os08: ^{11}B(^{3}He,n) E=1.7, 1.9 MeV; analyzed 2-p stripping reactions and spectroscopic factors.
1979Os10: ^{11}B(^{3}He,n_0) E=0.9-1.9 MeV; measured σ(θ). deduced S using different models.

^{13}N Levels

E(level)†	Jπ†	Γ	L†	Comments
0	1/2⁻		2	
2358 *10*	1/2⁺		1	
3502 *10*	3/2⁻		0+2	
3550 *18*				
6353 *9*	5/2⁺		1+3	
6875 *10*	3/2⁺		1+3	
7145 *9*	7/2⁺		3+5	
7363 *8*	5/2⁻		2+4	
8200 *22*				
8918 *11*				
9476 *8*	3/2⁻		0+2	E(level): See also E_x=9.52 MeV 2 (1966Ch18).
10381 *8*	5/2⁻		2+4	E(level): See also E_x=10.35 MeV 2 (1966Ch18).
10833 *9*				
11530 *12*				
11878 *12*	3/2⁻		0+2	
12558 *23*		>400 keV		Γ: From (1971Hs03).
12937 *24*		>400 keV		Γ: From (1971Hs03).
15068 *8*	3/2⁻	<15 keV	0	T=3/2 E(level),Γ,Jπ,L: and T from (1969Ad02). (1968Co27): $\Gamma_{\gamma0}/\Gamma_{p0}$=0.12 *2*. (1969Ad02): Γ<15 keV; Γ_{p0}/Γ=0.202 *20* and Γ_{p1}/Γ=0.121 *15* from (1969Ad01). (1973Ad02) Measured Branching ratios to ^{12}C and ^{9}B states. Assuming Γ=0.82 keV *20* from (1973Ad02,1968Co27,1968Di04), ^{12}C(0)=23.6% *12* and Γ_{p0}=0.19 keV *5*, ^{12}C(4.44)=15.0% *10* and Γ_{p1}=0.12 keV *3*, ^{12}C(7.65)=5.3% *15* and Γ_{p2}=0.043 keV *16*, ^{9}B(0)=4.9% *27* and $\Gamma_{\alpha0}$=0.040 keV *24*, ^{9}B(1.6)=3.9% *39* and $\Gamma_{\alpha1}$=0.032 keV

Continued on next page (footnotes at end of table)

$^{11}B(^{3}He,n),^{11}B(^{3}He,n\gamma)$ (continued)

^{13}N Levels (continued)

E(level)†	Γ	Comments
		32, ^{9}B(2.36)=7.2% *45* and $\Gamma_{\alpha 2}$=0.059 keV *40*, $\Gamma_{\gamma 0}$=23.3 eV *36*. (1975Ma21):$\Gamma_p\Gamma_{\gamma 0}/\Gamma$=5.79 eV *20* and 0.013 *5* for the E2/M1 intensity ratio from $^{12}C(p,\gamma)$. In (1975Ma21) $\Gamma_{\gamma 0}$=24.5 eV *15* and reduced M1 and E2 transition strengths are deduced after making several assumptions. Using relative intensities measured via $^{11}B(^{3}He,n\gamma)$ and with θ_γ=125° and θ_n=0°, they obtained Γγ0(M1)=24.2 eV *15*, Γγ0(E2)=0.32 eV *12*, Γγ1(E1)≤2.18 eV *30* and Γγ2(M1)=19.6 eV *14*. (1977Ma16): $\Gamma_{\gamma 0}/\Gamma_{p0}$=0.121 *11*.
18.44×10^3 *4*		T=3/2 E(level),T: and T from (1969Ad02).
18.98×10^3 *2*	40 keV *20*	T=3/2 E(level),Γ,T: and T from (1969Ad02).

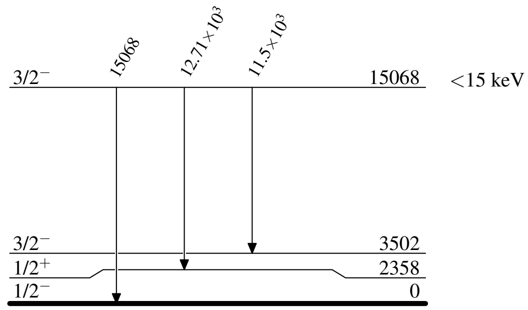
† From DWBA analysis in (1971Hs03), except where noted.

$\gamma(^{13}N)$

E_γ	E_i(level)	J^π_i	E_f	J^π_f	Comments
11.5×10^3	15068	3/2$^-$	3502	3/2$^-$	(1975Ma21: with $^{12}C(p,\gamma)$ data): Γ_γ(M1)=19.6 eV *14* and B(M1)W=0.613 *44*.
12.71×10^3	15068	3/2$^-$	2358	1/2$^+$	(1975Ma21: with $^{12}C(p,\gamma)$ data): Γ_γ(E1) ≤ 2.82 eV *30* and B(E1)W ≤ 03.69E-3 *39*.
15068	15068	3/2$^-$	0	1/2$^-$	(1973Ad02): Combined their Γ_{p0}/Γ=0.236 *12* value with $\Gamma_{p0}\Gamma_{\gamma 0}/\Gamma$=5.5 eV *8* from (1968Di04) and obtained $\Gamma^{M1}_{\gamma 0}$=23.0 eV *36* and $\Gamma_{\gamma 0}$=23.3 eV *36*. (1975Ma21: with $^{12}C(p,\gamma)$ data $\Gamma_{p0}\Gamma_{\gamma 0}/\Gamma$=5.79 eV *20* and the Γ_{p0}/Γ value from (1973Ad02)): Γ_γ(M1)=24.2 eV *15*, Γ_γ(E2)=0.32 eV *12* and B(M1)W=0.342 *21* and B(E2)W=0.28 *11*; I(E2/M1)=0.013 *5* See discussion in (1975Ku21).

$^{11}B(^{3}He,n),^{11}B(^{3}He,n\gamma)$

Level Scheme



$^{13}_{7}N_{6}$

^{12}C(p,γ)

	History		
Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1949Fo18: ^{12}C(p,γ) E≈456 keV; measured resonance γ-ray production. Deduced E_p=456.0 keV *20*, $\omega\gamma$=0.63 and Γ=35 keV.
1950Ba89: E=128-202 keV; measured activation σ.
1950Ha78: E=88-128 keV; measured activation σ.
1951Se67: E<2.5 MeV; measured thick target activation yield. Deduced resonances at 0.45 MeV and 1698 keV *5*; the later resonance has Γ_{lab}=70 keV *10*.
1952Se01: ^{12}C(p,γ) E=0.4-2.7 MeV; measured Eγ, Iγ. Deduced E_{res}=0.45 and 1.70 MeV with Γ_{lab}=35 and 70 keV, and $\omega\gamma$=0.67 and 1.39 eV, resp.
1953Ch34: ^{12}C(p,γ) measured $T_{1/2}$=602.9 s *19*.
1953Hu18: ^{12}C(p,γ) E≈450 keV; measured γ rays with a Geiger-Muller counter. Deduced E_{res}=456.8 keV *5* with $\Gamma_{lab.}$=39.5 keV *10*.
1954Wo09: ^{12}C(p,γ) E=1-3 MeV; measured E_γ, I_γ with a NaI(Tl) counter at θ=0° and 90°. Deduced resonance at $E_{res.}$=1.7 MeV; also found $\Gamma_{\gamma 1}$=0.04 eV and compared with $\Gamma_{\gamma 0}$=0.7 eV from (1952Se01).
1955Co57: E=5, 11 MeV; measured activation σ.
1957La15: E=85-130 keV; measured σ(E) for capture γ ray.
1957De22: ^{12}C(p,γ) and (d,n); measured activation cross sections in the few hundred keV range. Deduced $T_{1/2}$=10.02 min *10*.
1958Ar15: ^{12}C(p,γ); measured ^{13}N decay. Deduced $T_{1/2}$=597.6 s *18*.
1963Fi07: ^{12}C(p,$\gamma_{0,2}$) E=10-48.5 MeV; measured $\sigma(\theta)$ for θ=90°. Identified peaks in γ_0 associated with T=1/2 states at E_x=13, 20, (24), and 32.5 MeV; in addition γ_2 capture to the ^{13}N*(3.5 MeV) indicated a resonance at E_x=24.5 MeV.
1960He14, 1963VoZZ: ^{12}C(p,γ) E<700 keV, measured σ(E). Deduced first excited state at E_p=462 keV with θ^2_p=0.567 and $\omega\Gamma_\gamma$=0.63 eV (see 1992Hi14) and Γ_{lab}=35 keV.
1963Yo06: ^{12}C(p,γ) E=1.5-2.0 MeV; measured E_γ, I_γ at θ=0° to 135°. Deduced no participation of ^{13}N*(3.56: 5/2$^+$). Upper limit is σ=0.16 μb ($\omega\gamma$<0.006 eV) vs. σ=37 μb ($\omega\gamma$=1.06 eV) for ^{13}N*(3.51: 3/2$^-$). Analyzed angular distributions.
1968Bl17: ^{12}C(p,γ) E<5 MeV; measured σ(E,E_γ) using Ge(Li) detectors. Reported resonance energies of E_{res}=459 keV and 1.697 MeV and $\Gamma_{c.m.}$=33.7 keV *20* and 61.9 keV *40* for ^{13}N*(2365,3502). (Uncertainty given in (1970Aj04) from (1968Bl18)).
1968Di04: ^{12}C(p,γ) E_x ≈ 15.07 MeV; measured decay γ rays with Li(Ge). For ^{13}N*(15.07) deduced $\Gamma_p\Gamma_\gamma/\Gamma$=5.5 eV *8*, J^π=3/2$^-$, T=3/2 and amplitude ratio E2/M1=−0.095 *7*. Branching ratios $\Gamma_{\gamma 1}/\Gamma_{\gamma 0}$<0.14 and ($\Gamma_{\gamma 2}$+$\Gamma_{\gamma 3}$)/$\Gamma_{\gamma 0}$=0.84 *8*.
1968Ri16: ^{12}C(p,γ) E≈0.459 MeV; measured Γ_γ(2.37 MeV)=0.45 eV *5* and Γ_{lab}=34 keV *1* via DSAM, which implies τ=1.47 fsec *15*. A private communication in (1973Cl04) establishes this Γ is a lab value. Analysis given in (1992Hi14) indicates Γ_γ is a c.m. value.
1970Di09: ^{12}C(p,γ) E=14.2 MeV, characterized detector array with decay from 15.07 MeV level.
1972Ha32: ^{12}C(p,γ_0) E=8.6-16.3 MeV; measured σ(E). Deduced destructive interference, Deduced resonances, widths. States are reported at E_{res}=9.01, 10.62, 13.12 and 14.50 MeV (E_x=10.25, 11.74, 14.04 and 15.31 MeV) with Γ=280 keV *100*, 220 keV *50*, 170 keV *20* and 380 keV *150* (assumed lab in 1981Aj01), and with $\Gamma_{p0}\Gamma_{\gamma 0}$=0.17 keV^2 *9*, 0.28 keV^2 *10*, 0.47 keV^2 *12* and 0.21 keV^2 *8*, respectively.
1973Cl14: ^{12}C(p,γ) E=480, 600, 1750 keV; measured σ(E_p,E_γ).
1973Me12: ^{12}C(p,γ) E=9-24 MeV; measured σ(Eγ). Deduced low-energy states as in (1972Ha32). Reported at E_{res}=9.01 MeV *15*, 10.62 MeV *12*, 12.5 MeV *2*, 13.12 MeV *9* and 14.5 MeV *2* (E_x=10.25, 11.74, 13.5, 14.04 and 15.31). The Γ and $\Gamma_{p0}\Gamma_{\gamma 0}$ are also given along with $\Gamma_{\gamma 0}$≥0.6 eV, ≈4.2 eV, 3.7 eV *10* and ≥0.5 eV, respectively. Various assumptions are described in finding $\Gamma_{\gamma 0}$. Also analyzed ^{12}C(p,p′$\gamma_{12.71,15.11}$) yield curves where resonances at E_p=15.27, 19.35, 20.55 and 22.2 MeV were found (see ^{12}C(p,p′)).
1974Al16: ^{12}C(p,γ) E=1.65 GeV, Measured σ(E_γ).
1974Bl06: ^{12}C(p,γ) E=600 keV; measured I_γ, E_γ. Deduced ^{13}N*(2364) resonance width $\Gamma_{c.m.}$=33.3 keV *18*.
1974Ro29: ^{12}C(p,γ) E=150-3000 keV, Measured σ(E), E_γ, I_γ, for θ=0° and 90°. Deduced levels at E_p=457 keV *1* and 1699 keV *2* with Γ=39 keV *2* and 65 keV *3*, respectively. Also C^2S(0,2366,3512,3547)=0.49 *15*(*l*=1), 1.02 *15*(*l*=0), <0.5(*l*=1) and ≤1.0(*l*=2), respectively, and δ_R(E2/M1)(3.5 MeV)=−0.09 *2*. Lastly, the branching ratio I_γ(3512→2366)=8% *1* was obtained. An associated lab report (1975FoZD) indicates $\Gamma_{\gamma 0}$=0.64 eV *7* but insufficient details can be understood; see also (1978BaXY).
1975Ma21: ^{12}C(p,γ) E=14.2-14.3 MeV; measured resonance γ0 yield from ^{13}N*(15.07). Deduced $\Gamma_{p0}\Gamma_{\gamma 0}/\Gamma$=5.79 eV; deduced E2/M1 intensity ratio of 0.013 *5*. In (1975Ma21) Γ_γ and reduced transition strengths are deduced from ^{11}B(^{3}He,nγ) data after making several assumptions.

^{12}C(p,γ) (continued)

1976Be28: ^{12}C(p,γ) E=9-24 MeV; measured $\sigma(E_p,\theta)$ for $\theta\approx45°$ to 135°. Deduced resonances structures in γ_0 capture at E_p=9.01 MeV *15* with $\Gamma\approx$300 keV, E_p=17.5 MeV with $\Gamma\approx$1 MeV, E_x=20.8 MeV with $\Gamma\approx$4 MeV and E_p=23 MeV with $\Gamma\approx$1 MeV. The discussion was sometimes ambiguous when listing E_p vs. E_x. See additional reference to E_x=11.74. Their results for capture to excited states are complicated by high backgrounds. For γ_1 capture they find a resonance at $E_p\approx$21.8 MeV, which gives $E_x\approx$22 MeV; (1981Aj01) gave $E_x\approx$20 MeV for this peak, but Fig. 10 and related discussion clarify the issue. Further, in (1981Aj01) an E_p=23 MeV group is connected to E_x=23 MeV (accepted in the Adopted Levels), but this corresponds better to the E_x=23.3 MeV state. The authors report no strong resonances in γ_{2+3} They discuss other relevant measurements.

1976Fe11: ^{12}C(p,p′γ(4.44,12.7,15.1)), ^{12}C(p,$\gamma_{0,2,3}$) E=16-40 MeV; measured σ(E). Observed resonances at E_p=20, 27, 32 MeV ($E_x\approx$20.4, 26.8, 31.5 MeV). The 20 MeV resonance is seen in all channels, while the 27 MeV state is not seen in capture reactions. The 32 MeV resonance is seen in ^{12}C(p,p′γ(4.44)) and in the capture reactions.

1977Fr20: ^{12}C(p,γ) E=150-350 keV; measured yield, deduced Q=1943.31 keV *32*, calibrated accelerator.

1977He26: ^{12}C(p,γ) E$\approx$774 keV; measured γ-ray spectrum, deduced Q=1944.01 keV *22*.

1977Ma16: ^{12}C(p,γ) E$\approx$14.25 MeV; measured thick target yield at θ=125°. Combined results with ^{11}B(^{3}He,n). Deduced $\Gamma_{p0}\Gamma_{\gamma0}/\Gamma$=5.79 eV *20*. Also determined E2/M1 intensity ratio of 0.013 *5*. Matches (1975Ma21) analysis. Significant discussion of ^{13}N parameters when additional observables are considered.

1979Ko05: ^{12}C(p,γ) E=40 MeV; measured E_γ, I_γ. Deduced unconfirmed evidence for excited states around E_x=8.1, 12, 16.1 MeV.

1980An40: ^{12}C(p,γ) E=0.8-2 MeV; measured thick target yield via activation technique. Deduced τ_m=862.76 sec *88*.

1980He04: ^{12}C(vec p,γ_0) E=10-17 MeV; measured $\sigma(E_p,\theta(\gamma))$ for θ=43° to 137°, deduced asymmetry. Deduced (E1/E2) ratios in σ(E) in energy region below the GDR.

1980Sn01: ^{12}C(vec p,γ) E=5-30 MeV; measured σ(E) Deduced GDR, T=3/2 M1(E2) interference.

1984Bl10: ^{12}C(p.$\gamma_{0,2,3}$), (vec p,γ) E=24-80 MeV; measured $\sigma(\theta)$, analyzing power vs θ for θ=30° to 150°. Deduced reaction mechanism.

1984Po13: ^{12}C(p,γ) E=1.5-2 MeV; measured $\sigma(E_\gamma$,E). Deduced coherent energy width effect.

1985Br06: ^{12}C(vec p,γ) E=1.6-1.8 MeV; measured A(E,θ), γ-ray yield vs E. R-Matrix analysis in region of $^{13}N^*$(3.5 MeV).

1985Ki07: ^{12}C(p,γ) E=2.4-4.2 MeV; measured thick target yields.

1985Wa12: ^{12}C(p,γ) E=14.26 MeV; measured E_γ, I_γ, analyzed NaI response function to high-energy γ rays.

1986Ai04: ^{12}C(p,γ) E<14.7 MeV; measured σ via activation technique.

1987La11: ^{12}C(p,γ) E=40, 65, 85 MeV; measured E_γ, I_γ; deduced σ(E).

1987Po09: ^{12}C(p,γ) E=400-2500 keV; measured E_γ, I_γ $\sigma(E_\gamma,\theta$=90°). Observed decay radiations from $^{13}N^*$(2316, 3512) from thick target study. Found a deviation from expected γ-ray energies from E_x=3512 level. E_γ=1123 and 3500 keV *2* were observed while E_γ=1146 and 3512 keV were expected. Continued with a 15 μg/cm^2 target and measured E_γ at θ=0° and 90°. Found Doppler shifted E_γ(0°)=3517 keV *2* and E_γ(90°)=3500 keV *2*; A more detailed study is given in (1991Po18).

1987Re11: ^{12}C(p,γ) E=140 MeV; measured $\sigma(E_\gamma,\theta)$.

1987Se13: ^{12}C(p,γ) E=220-340 keV; measured γ-ray yields.

1988Ha04: ^{12}C(vec p,γ) E=20-100 MeV; measured $E_{\gamma0}$, I_γ, σ(E,θ), $A_y(\theta)$ for θ=30° to 150°. Deduced GDR at E_x=20.40 MeV with Γ=3.5 MeV.

1989Ki21: ^{12}C(p,γ) E=1.5-1.9 MeV; measured E_γ, I_γ, γ yield vs E. Deduced E_{res}=1688.7 keV *7* with E_γ=3501.5 keV, and Γ=65.6 keV *18* for a thick target measurement. E_{res}=1689 keV *2* was deduced for a thin target measurement.

1990Co34: ^{12}C(p,$\gamma_{0,2+3}$) E=27 MeV; measured E_γ.

1991Ca25: ^{12}C(p,γ) E=14.24 MeV; measured γ-ray spectrum.

1991Co07: ^{12}C(p,γ) E_x=19.6-47 MeV; measured σ(E,θ), deduced dipole resonances for γ_0 at E_x=14.0, 20.6, 32.0 MeV with Γ=12.0, 1.2, 10.0 MeV, respectively; for γ_{2+3} at E_x=24.5 and 35.0 with Γ=3.5, 14.0 MeV, respectively.

1991Po18: ^{12}C(p,γ) E=1.69-1.75 MeV; study of the $E_x\approx$3500 keV region where E_p, E_γ and I_γ were measured for θ=0° to 90°. The aim is to resolve discrepancies between identification of the $E_x\approx$3500 keV state at E_{res}=1688 keV (1987Po09,1989Ki21) vs other studies that found E_{res}=1699 keV (see 1986Aj01). Target thicknesses varying from 20-50 μg/cm^2 along with a thick 2mm thick plate of carbon were used to measure the excitation function and produced γ rays. Similarly, on the thick target, the Doppler shifted spectrum was measured over θ=0° to 140°. Considering all measurement, E_{res}=1686 keV *1* was found. Widths of Γ=63.6 keV *15* and Γ=62.2 keV *15* were deduced for the different measurements (referenced as half-width in E_p spectrum so assumed as lab frame). Additionally, an anomolous slope was observed in the Doppler function.

1991Zh31: ^{12}C(p,γ) E=0.6-0.9 MeV; measured E_γ, I_γ analyzed suitability for PIGE analysis.

1992Hi14: ^{12}C(p,γ) E=400-480 keV; measured σ(E) at Canberra. Deduced resonance at $E_p\approx$424 with $\Gamma_{c.m.}\approx$36.4 and Γ_γ=0.53 eV *5*. Compared with prior works and discussed astrophysical reaction rates.

1994Zu05: ^{12}C(p,γ) E=40-54 MeV; measured σ(E,θ) for θ=30° to 148°. Observed capture to states up to 11 MeV, i.e. E_x=0,

^{12}C(p,γ) (continued)

2.37. 3.50+3.55, 6.36, 7.38, 7.90, 9.0, 10.36 MeV. Analyzed reaction mechanism.

1997Br19: ^{12}C(p,γ_{0-3}) E=98, 176 MeV; measured $\sigma(\theta)$ for $\theta\approx40°-100°$: γ_{3+4} unresolved. Analyzed reaction mechanism.

1997Ko24: ^{12}C(p,γ) E=72,140 MeV; measured $\sigma(E_\gamma,\theta)$. Analyzed γ emission.

2023Sk01, 2023Sk02, 2023SkZZ: ^{12}C(p,γ) E=320-620 keV; measured σ(E) at Dresden. Deduced $E_{c.m.}$=426.1 keV *4*, Γ_p=35.6 keV *2* and Γ_γ=0.48 eV *3* from an R-matrix analysis.

2023Cs01: ^{12}C(p,γ) E≈460 keV and 1.69 MeV; measured $\sigma(E,\theta(\gamma))$ for θ=0°, 90° and 112° at Atomki in Hungary. Analyzed excitation with a Breit-Wigner shape and deduced resonances at E_p=459.8 keV *8* and 1685.1 keV *7* with Γ_{lab}=38.2 keV *5* and 57.6 keV *8*, respectively.

2023Ke11: ^{12}C(p,γ). Measured $\sigma(E,\theta(\gamma))$ for E=1-2.5 and θ=0° to ≈130° at Notre Dame using a thin-target approach and measured σ(E) using thick-target activation methods. At Bochum they measured $\sigma(E,\theta(\gamma))$ around the E_p≈460 keV resonance. The analysis is a continuation of (2010Az01), where (p,γ) data (1974Ro29,1963VoZZ) and (pol. p,p) data of (1976Me22) were reanalyzed using the AZURE R-matrix code; in (2023Ke11) additional (p,γ) data from (1992Hi14,1963Yo06,2008Bu19) have been added along with the new (2023Ke11) data. The data of (1974Ro29) were not considered. A global R-matrix analysis using AZURE found resonance parameters of E_p=460.3 keV *5* with $J^\pi=1/2^+$, Γ=34.0 keV *2* and Γ_γ=0.48 eV *3*, E_p=1688.8 keV *8* with $J^\pi=3/2^-$, Γ=55.2 keV *3*, Γ_γ(M1)=0.49 eV *3* and Γ_γ(E2)=7.2×10-4 *11*, and E_p=1735.5 keV *5* with $J^\pi=5/2^+$, and Γ=49.0 keV *5*.

2023Gy02: ^{12}C(p,γ) E=0.3-1.9 MeV; measured σ(E) using activation techniques at ATOMKI. Discussed astrophysical rate.

Theoretical analysis:

1977Ba29: ^{12}C(p,γ) E=low. Theoretical analysis of direct capture to ^{13}N*(2366).

1980Ba54: ^{12}C(p,γ). Shell model analysis of E=100-800 keV capture.

1982Ph01: ^{12}C(p,γ). Single-particle model of capture to continuum states.

1984Se16: ^{12}C(vec p,$\gamma_{0,3}$); analyzed $\sigma(\theta)$, A_y and b_2 coefficients to determine *j* sensitivity.

1990Lo20: ^{12}C(p,γ) E=40 MeV; calculated $A_y(\theta)$.

1992Lo01: Theory: E=40 MeV; analyzed angular distributions.

1993Ho06: Theory: Analyzed giant resonance region.

1997Du09: Theory: GCM analysis of cluster effects in the ^{12}C+p system.

2000Li06: ^{12}C(p,γ) E=98, 176 MeV; calculated $\sigma(\theta)$, analyzed reaction mechanism.

2010Hu11: ^{12}C(p,γ). Theoretical analysis of reaction mechanism.

2015Ti03: ^{12}C(p,γ). Shell model analysis of ^{13}N*(3.5: $3/2^-$) proton resonance.

2018Ti06: Potential model analysis of direct capture reaction.

2020Br14: R-matrix analysis of ^{12}C(p,γ).

Astrophysically relevant:

1937Be10, 1939Be01: Early review of energy production in stars.

1979Ro12: Analyzed astrophysical reaction rates.

1980Ba27: ^{12}C(p,γ) 100-800 keV; calculated σ(E).

1984Ma36: ^{12}C(p,γ) E≤1 MeV; analyzed data from (1974Ro29) with input from (1980Ba54) and obtained spectroscopic factor $S_{g.s.}$=0.88 *11*. Analysed astrophysical reaction rates.

1985La06: ^{12}C(p,γ) E=90-600 keV; calculated σ(E).

1994Ka02: Theory: Analyzed vacuum polarization corrections in solar fusion rates.

1996Gi11: ^{1}H(^{12}C,γ), E(^{12}C)=11 MeV; measured $\sigma(\theta)$, nonresonant capture.

1998Ad12: Review of solar-fusion cross sections; includes analysis of the ^{12}C(p,γ) reaction at astrophysical energies.

1999An35: ^{12}C(p,γ) E≈100 keV-2.5 MeV; analyzed astrophysical S-factor.

2000Ic01: ^{12}C(p,γ). Calculated electron screening effects.

2001Ge10: ^{12}C(p,γ). Analysis of CNO rates in dense stellar plasma.

2000Li13: Calculated screening effects for astrophysical energies.

2001Ne15: ^{12}C(p,γ) E≤160 keV; analyzed S-factor shape.

2004Ue05: Calcluated astrophysical reaction rate.

2008Bu19: ^{12}C(p,γ) E=354, 390, 460, 463, 565, 750, 1061 keV; measured E_γ, I_γ, σ, $\sigma(\theta)$. Deduced astrophysical S-factors, Analyzed Γ_p and Γ_γ for various resonances. Deduced Γ_p=35.0 keV *10* and Γ_γ=0.65 eV *7* for $E_{c.m.}$=421 keV; Γ_p=62 keV for $E_{c.m.}$=1.7 MeV. To fit their data, the tail of the $E_{c.m.}$=8.2 MeV state was included in their R-matrix analysis; using Γ_p=280 keV from (1973Me12); they suggest Γ_γ=6 keV, but it is important that the E_p≈9 MeV region is not included in their measurement.

2010Az01: ^{12}C(p,γ). AZURE R-matrix analysis of astrophysically relevant data.

2011Ad03: ^{12}C(p,γ). Broad analysis of CNO reactions.

^{12}C(p,γ) (continued)

2012Du10: ^{12}C(p,γ). Broad analysis of astrophysically relevant reactions.
2012Mi24: ^{12}C(p,γ). Broad analysis of astrophysically relevant reactions.
2017Mu06: Potential model analysis of $^{13}N^{*}$(2.37 MeV) radiative width and related ANC.
2018Ti06: Potential model analysis of capture reactions for E_p<1.2 MeV.
2021An01: Folding model analysis of ^{12}C(p,γ) at low energies.
2021An05: Mean-field analysis of ^{12}C(p,γ) and other astrophysical CNO cycle reactions.
2021An13: Potential model analysis of capture reactions for E_p<800 keV.
2022An15: Analyzed capture cross section for E≤600 keV.
2023Ch57: Discussed the role of ^{12}C(p,γ) on X-ray burst phenomena.
2023Sk04: Compared proton capture on ^{12,13}C and discussed stellar abundances.

^{13}N Levels

E(level)[†‡]	J^π	Γ	E_p(res.) (MeV)[@]	Comments
0	1/2⁻[#]	598.02 s *61*		J^π: From Adopted Levels. $T_{1/2}$: $T_{1/2}$ from (1980An40). (1953Ch34): $T_{1/2}$=602.9 s *19*. (1957De22): $T_{1/2}$=10.02 min *10*. (1958Ar15): $T_{1/2}$= 597.6 s *18*. (1980An40): $T_{1/2}$=598.02 s *61* from τ_m=862.76 s *88*. (1974Ro29): C^2S=0.49 *15* L=1.
2367.6 *9*	1/2⁺	34.7 keV *3*	459.7 *9*	$\Gamma_{\gamma0}$=0.51 eV *3* E(level): E_p=459.7 keV *9* from the average (external errors) of E_{res}=456.0 keV *20* (1949Fo18), E_p=456.8 keV *5* (1953Hu18) E_{res}=457 keV *1* (1974Ro29), $E_{c.m.}$=426.1 keV *4* (E_p=461.9 *4*) (2023Sk02) E_p=460.3 keV *5* (2023Cs01) and E_p=459.8 keV *8* (2023Ke11: includes global analysis of data). Γ: From weighted average (external errors) of Γ_{lab}=37.4 keV *10* (1953Hu18, 1973Cl04), $\Gamma_{c.m.}$=33.7 keV *20* (1968Bl17), Γ_{lab}=34 keV *1* (1968Ri16), $\Gamma_{c.m.}$=33.3 keV *18* (1974Bl06), $\Gamma_{(lab)}$=39 keV *2* (1974Ro29), $\Gamma_{c.m.}$=34.9 keV *2* (2023Sk02), Γ_{lab}=38.2 keV *5* (2023Cs01) and $\Gamma_{c.m.}$=34.0 keV *2* (2023Ke11: includes 2008Bu19). See also Γ_p=33.5 keV *10* obtained from a global analysis in (2022Ar03). Note: some inconsistencies exist in the literature related to assigning the values as lab or c.m. frame values. Table 1 of (1992Hi14) is helpful for resolving some issues. $\Gamma_{\gamma0}$: Weighted average (external errors) of Γ_γ=0.45 eV *5* (1968Ri16-c.m. value), Γ_γ=0.53 eV *5* (1992Hi14-c.m. value), Γ_γ=0.49 eV *3* (2023Sk02-c.m. value); Γ_γ=0.48 ev *2* (2023Ke11-c.m. value: includes 2008Bu19); see also $\Gamma_{\gamma0}$=0.63 eV (1949Fo18-lab value). As with Γ, there are some inconsistencies with determining the reference frame of the widths. J^π: From R-matrix analysis in (2023Ke11). C^2S=1.02 *15* (1974Ro29). (1949Fo18): Eres=456.0 keV *20*, Γ=35 keV and $\omega\gamma$=0.63 eV. (1951Se67,1952Se01): E_p=0.45 MeV, Γ_{lab}=35 keV and $\omega\gamma$=0.67 eV (implies $\Gamma_{\gamma0}$=0.67 eV). (1953Hu18): E_p=456.8 keV *5* and Γ_{lab}=39.5 keV *10* (analysis in (1973Cl04) deduced Γ_{lab}=37.4 keV *13* after correcting for target thickness effects). (1968Bl17): E_p=459 keV and $\Gamma_{c.m.}$=33.7 keV *20* (Uncertainty given in (1970Aj04) from (1968Bl18), see also (1973Cl04) where γ uncertainty of 2 keV is given). (1968Ri16): Γ_{lab}=34 keV *1*, τ=1.47 fs *15* and Γ_γ=0.45 eV *5*. A private communication in (1973Cl04) establishes this Γ is a lab

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^{12}C(p,γ) (continued)

^{13}N Levels (continued)

E(level)[†‡]	J$^{\pi}$	Γ	E$_p$(res.) (MeV)[@]	Comments
				value. (1974Bl06): $\Gamma_{c.m.}$=33.3 keV *18* (assumed lab in (1976Aj04)). (see for discussion on Γ variation in prior measurements). (1974Ro29): E_{res}=457 keV *1*, $\Gamma_{(lab)}$=39 keV *2*, L=0, C^2S=1.02 *15*, θ^2(l=0)≈0.81 A lab report (1975FoZD) indicates $\Gamma_{\gamma0}$=0.64 eV *7*. (1992Hi14): E_p≈424, $\Gamma_{c.m.}$≈36.4 and Γ_γ=0.53 eV *5*. (2008Bu19): Γ_p=35.0 keV *10* and Γ_γ=0.65 eV *7* (assumed c.m.). (2023Sk02): $E_{c.m.}$=426.1 keV *4*, $\Gamma_{c.m.}$=34.9 keV *2* and Γ_γ=0.49 eV *3*. (2023Cs01): E_p=459.8 keV *8* and Γ_{lab}=38.2 keV *5*. (2023Ke11): E_p=460.3 keV *5*, Γ_p=34.0 keV *2* and Γ_γ=0.48 eV *3*. See additional discussion in (2017Mu06).
3500.4 *8*	3/2$^-$	55.0 keV *3*	1.6878 *8*	$\Gamma_{\gamma0}$=0.49 eV *3*; $\Gamma_{\gamma1}$=0.043 eV E(level): From E_p=1687.8 keV *8* the weighted average of E_p=1687 keV *1* (1991Po18), E_p=1688.7 keV *7* (1989Ki21: thick target), E_p=1689 keV *2* (1989Ki21: thin target), E_p=1685.1 keV *7* (2023Cs01) and E_p=1688.8 keV *5* (2023Ke11). Γ: From $\Gamma_{c.m.}$=61.9 keV *40* (1968Bl17), Γ_{lab}=65 keV *3* (1974Ro29), Γ_{lab}=57.6 keV *8* (2023Cs01) and $\Gamma_{c.m.}$=55.2 keV *3* (2023Ke11). See also Γ=65.6 keV *18* (1989Ki21: thick target − taken as lab), see also Γ=74 keV *9* (1949Va03), Γ_{lab}=70 keV *10* (1951Se67,1952Se01) and Γ=62.2 keV *15* (1991Po18-reference frame is unclear). J$^\pi$: From phase-shift analysis in (1974Ro29). $\Gamma_{\gamma0}$: From the R-matrix analysis in (2023Ke11) as detailed above. In (1991Aj01) the analysis of (1952Se01, 1963Yo06) cross sections given in (1980Ba54) was accepted; see discussion in (1991Aj01). See also $\Gamma_{\gamma0}$=0.70 eV from $\omega\gamma$=1.39 eV (1951Se67,1952Se01) as quoted in (1954Wo09), and see $\omega\gamma$=1.06 and Γ_γ=0.53 eV in (1963Yo06). $\Gamma_{\gamma1}$: From $\Gamma_{\gamma0}$ and Iγ1=8% *1* from (1974Ro29). 1949Va03: E_{res}=1697 keV *12*, Γ=74 keV *9*, ratio of yield from E_{res}=1697 keV *12* and E_{res}=456 keV is R=1.3 *2*, which is used to deduce Γγ=1.3 eV *2* (this may be a typo). (1951Se67,1952Se01): E_p=1.698 MeV *5* and Γ_{lab}=70 keV *10* and $\omega\gamma$=1.39 eV (implies $\Gamma_{\gamma0}$=0.70 eV). (1954Wo09): $\Gamma_{\gamma1}$=0.04 eV. (1963Yo06): σ=37 μb, $\omega\gamma$=1.06 eV, Γ_γ=0.53 eV (no participation of $^{13}N^*$(3.56: 5/2$^+$); σ≤0.16 μb ;$\omega\gamma$<0.006 eV); δ(M2/E1)=−0.092 from A_2/A_0=−0.65. (1968Bl17): E_p=1697 keV and $\Gamma_{c.m.}$=61.9 keV *40* (Uncertainty given in (1970Aj04) from (1968Bl18)). (1974Ro29): E_{res}=1699 keV *2*, Γ_{lab}=65 keV *3*, L=1, C^2S<0.5 and δ_R(M2/E1)=−0.09 *2* from a2=−0.64 *4*. (1989Ki21: thick target): E_p=1688.7 keV *7* and Γ=65.6 keV *18*. (1989Ki21: thin target):E_p=1689 keV *2*; in this work the energy shift is attributed to the thick target measurement methodology. (1991Po18: see important discussion): E_p=1687 keV *1*. Γ_{lab}=63.6 keV *16* and Γ_{lab}=62.2 keV *15* were deduced from separate configurations. (2008Bu19): Γ_p=62 keV (2008Bu19) (assumed c.m.). (2023Cs01): E_p=1685.1 keV *7* and Γ_{lab}=57.6 keV *8*. (2023Ke11): E_p=1688.8 keV *5*, $\Gamma_{c.m.}$=55.2 keV *3*, Γ_γ(M1)=0.49 eV *3* and Γ_γ(E2)=7.2E−4 eV *11*.

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^{12}C(p,γ) (continued)

^{13}N Levels (continued)

E(level)[†‡]	J$^\pi$	Γ	Comments
10.26×10^3 *14*	(1/2$^+$,3/2$^+$)	0.26 MeV *9*	$\Gamma_{\gamma0}$>0.6 eV E(level): E_{res}=9.01 MeV *15* from E_{res}=9.01 MeV *15* (1972Ha32,1973Me12) and E_p=9.01 MeV *15* (1976Be28). Γ: From Γ_{lab}=0.28 MeV *10* (1972Ha32,1973Me12). $\Gamma_{\gamma0}$: From (1973Me12); see other discussion in (2008Bu19). (1972Ha32,1973Me12): E_{res}=9.01 MeV *15*, Γ_{lab}=0.28 MeV *10*, detector θ=90° gives π=+, J^π=(1/2$^+$,3/2$^+$) and $\Gamma_{p0}\Gamma_{\gamma0}$=0.17 keV^2 *9*. (1973Me12): $\Gamma_{\gamma0}\geq$0.6 eV. (1976Be28): E_p=9.01 MeV *15* and Γ≈300 keV. (2008Bu19): $E_{c.m.}$=8.371 MeV accounting for the tail of this resonance in the $E_p\leq$2 MeV region suggests Γ_γ=6 keV (assumed lab).
11.74×10^3 *11*	3/2$^+$	202 keV *46*	$\Gamma_{\gamma0}\approx$4.2 eV E(level),Γ: From (1972Ha32,1973Me12). $\Gamma_{\gamma0}$: From (1973Me12). (1972Ha32,1973Me12): E_{res}=10.62 MeV *12*, Γ_{lab}=220 keV *50*, J^π=3/2$^+$ and $\Gamma_{p0}\Gamma_{\gamma0}$=0.28 keV^2 *10*. (1973Me12): $\Gamma_{\gamma0}\approx$4.2 eV. (1976Be28): See discussion on J^π assignments of $^{13}N^*$(11.74, 14.05) and other nearby levels.
13.5×10^3 *2*	(3/2$^+$)	6500 keV	$\Gamma_{\gamma0}$>1.1 keV E(level),Γ: From (1973Me12). J$^\pi$: From (1973Me12) ^{12}C(p,γ_0); L=0,2, strong interference with J^π=3/2$^+$ states at $^{13}N^*$(11.74, 14.04), assumed component of GDR. $\Gamma_{\gamma0}$: From (1973Me12). (1973Me12): E_p=12.5 MeV *2*, Γ=7 MeV, $\Gamma_{\gamma0}\geq$ 1.1 keV. (1963Fi07): E_x=13 MeV. (1991Co07): E_x=14.0 MeV, Γ=12 MeV ^{12}C(p,γ_0).
14.05×10^3 *8*	3/2$^+$	157 keV *18*	$\Gamma_{\gamma0}$=3.7 eV *10* E(level),Γ: From (1972Ha32,1973Me12). $\Gamma_{\gamma0}$: From (1973Me12). (1972Ha32,1973Me12): E_{res}=13.12 MeV *9*, Γ_{lab}=170 keV *20* J^π=3/2$^+$ and $\Gamma_{p0}\Gamma_{\gamma0}$=0.47 keV^2 *12*. (1973Me12): $\Gamma_{\gamma0}$=3.7 eV *10*; associated with the J^π=3/2$^+$ state from (1969Le18) (p,p) phase-shift analysis. (1976Be28): See discussion on J^π assignments of $^{13}N^*$(11.74, 14.05) and other nearby levels.
15.07×10^3	3/2$^-$		T=3/2 (1968Di04): $\Gamma_p\Gamma\gamma/\Gamma$=5.5 eV *8*, J^π=3/2$^-$ from $\gamma(\theta)$, T=3/2 I(E2/M1)=−0.095 *7*, $\Gamma_{\gamma1}/\Gamma_{\gamma0}$<0.14, $(\Gamma_{\gamma2}+\Gamma_{\gamma3})/\Gamma_{\gamma0}$=0.84 *8*. (1975Ma21,1977Ma16) $\Gamma_p\Gamma\gamma/\Gamma$=5.79 eV *20*, I(E2/M1)=0.013 *5*. Using Γ_{p0}/Γ=0.236 *12* from (1973Ad02) they deduced $\Gamma_{\gamma0}$(M1)=24.2 eV *15*, $\Gamma_{\gamma0}$(E2)=0.32 eV *12*, B(M1)W=0.342 *21* and B(E2)W=0.28 *11* for the ground state transition. They also measured ^{11}B(^{3}He,nγ) and determined relative transition strengths for γ_0, γ_1 and γ_2.
15.3×10^3 *2*	(3/2$^+$)	0.35 MeV *14*	$\Gamma_{\gamma0}$>0.5 eV E(level),J$^\pi$,Γ: From (1972Ha32,1973Me12). $\Gamma_{\gamma0}$: From (1973Me12). (1972Ha32,1973Me12): E_{res}=14.5 MeV *2*, Γ_{lab}=0.38 MeV *15*, $\Gamma_{p0}\Gamma_{\gamma0}$=0.21 keV^2 *8*. Possible doublet. (1973Me12): $\Gamma_{\gamma0}\geq$0.5 eV.
18.1×10^3		≈1 MeV	E(level),Γ: From (1976Be28). (1976Be28): $E_p\approx$17.5 MeV and Γ≈1 MeV.
20.5×10^3		≈3.7 MeV	E(level): From average of measured values listed below.

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^{12}C(p,γ) (continued)

^{13}N Levels (continued)

E(level)†‡	Γ	Comments
		E(level): In (1981Aj01) an additional level at $E_p\approx$20 MeV was deduced based a peak seen in Figure 11 of (1976Be28). However, those authors indicated, "at lower energies the γ_{2+3} pulses are completely submerged in the sea of inelastic γ rays"; therefore there seems to be evidence for only one level in this region. (1963Fi07): E_x=20 MeV ^{12}C(p,γ_0). (1976Fe11): E_p=20 MeV ^{12}C(p,$\gamma_{0,2+3}$). (1976Be28): $E_x\approx$20.8 MeV and Γ≈4 MeV. (1988Ha04): $E_x\approx$20.40 MeV and Γ≈3.5 MeV (GDR). (1991Co07): E_x=20.6 MeV with Γ=1.2 MeV.
22.0×10^3		E(level): From (1976Be28). (1976Be28): E_p=21.8 MeV ^{12}C(p,γ_1).
23.2×10^3	≈1 MeV	E(level),Γ: From (1976Be28). (1976Be28): $E_p\approx$23 MeV and Γ≈1 MeV (1976Be28).
24.5×10^3	3.5 MeV	E(level): From (1963Fi07, 1991Co07). Γ: From (1991Co07). (1963Fi07): E_x=24.5 MeV (γ_2) and uncertain E_x=24 MeV (γ_0). (1991Co07): E_x=24.5 MeV with Γ=3.5 MeV ^{12}C(p,γ_{2+3}).
31.9×10^3		Γ: Γ=broad. E(level): From average (1963Fi07, 1976Fe11). (1963Fi07): E_x=32.5 MeV ^{12}C(p,γ_0). (1976Fe11): E_p=32 MeV ^{12}C(p,$\gamma_{0,2+3}$). (1991Co07): E_x=32.0 MeV, Γ=10 MeV ^{12}C(p,γ_0) and E_x=35.0 MeV, Γ=14 MeV ^{12}C(p,γ_{2+3}).

† Level energies are deduced using E_p(res) and ^{12}C, p and ^{13}C masses from (2021Wa16: AME-2020). E_x=S_p+$E_{c.m.}$(relativistic).

‡ In (1994Zu05), the continuum region was populated and capture γ rays to ^{13}N states at E_x=0, 2.37. 3.50+3.55, 6.36, 7.38, 7.90, 9.0, 10.36 MeV were observed. See also (1979Ko05).

From Adopted Levels.

@ Authors symbols are used in the discussion; for reference E_p=E_{res}=laboratory proton energy; $E_{c.m.}$=center of mass energy and E_x=$E_{c.m.}$+S_p.

γ(^{13}N)

E_i(level)	J^π_i	E_γ†	I_γ	E_f	J^π_f	Mult.	δ	Comments
2367.6	1/2$^+$	2367.4	100	0	1/2$^-$	E1		
3500.4	3/2$^-$	1135	8	2367.6	1/2$^+$	E1		E_γ: From (1987Po09). I_γ: From (1974Ro29). Mult.: From angular distributions measured in (1974Ro29).
		3498 *2*	92	0	1/2$^-$	M1+E2	−0.09 *2*	Mult.: From angular distributions and a_2=−0.64 measured in (1974Ro29). I_γ: In (1954Wo09), the partial widths $\Gamma_{\gamma1}$=0.04 eV and $\Gamma_{\gamma0}$=0.7 eV are given (5%:95%); $\Gamma_{\gamma0}$=0.7 eV is from $\omega\gamma$=1.39 eV in (1952Se01). Later, (1963Yo06) claim agreement and show Iγ=5% and 95%, respectively. In (1974Ro29) uncertainties of 1% are added to the branching ratios of (1954Wo09); however (1974Ro29) reported Iγ=8% *1* for γ_1. In (1991Aj01) $\Gamma_{\gamma1}$=0.06 eV and $\Gamma_{\gamma0}$=0.64 eV (8.5%:91.5%) were adopted based on an analysis of (1952Se01,1963Yo06) given in

Continued on next page (footnotes at end of table)

^{12}C(p,γ) (continued)

γ(^{13}N) (continued)

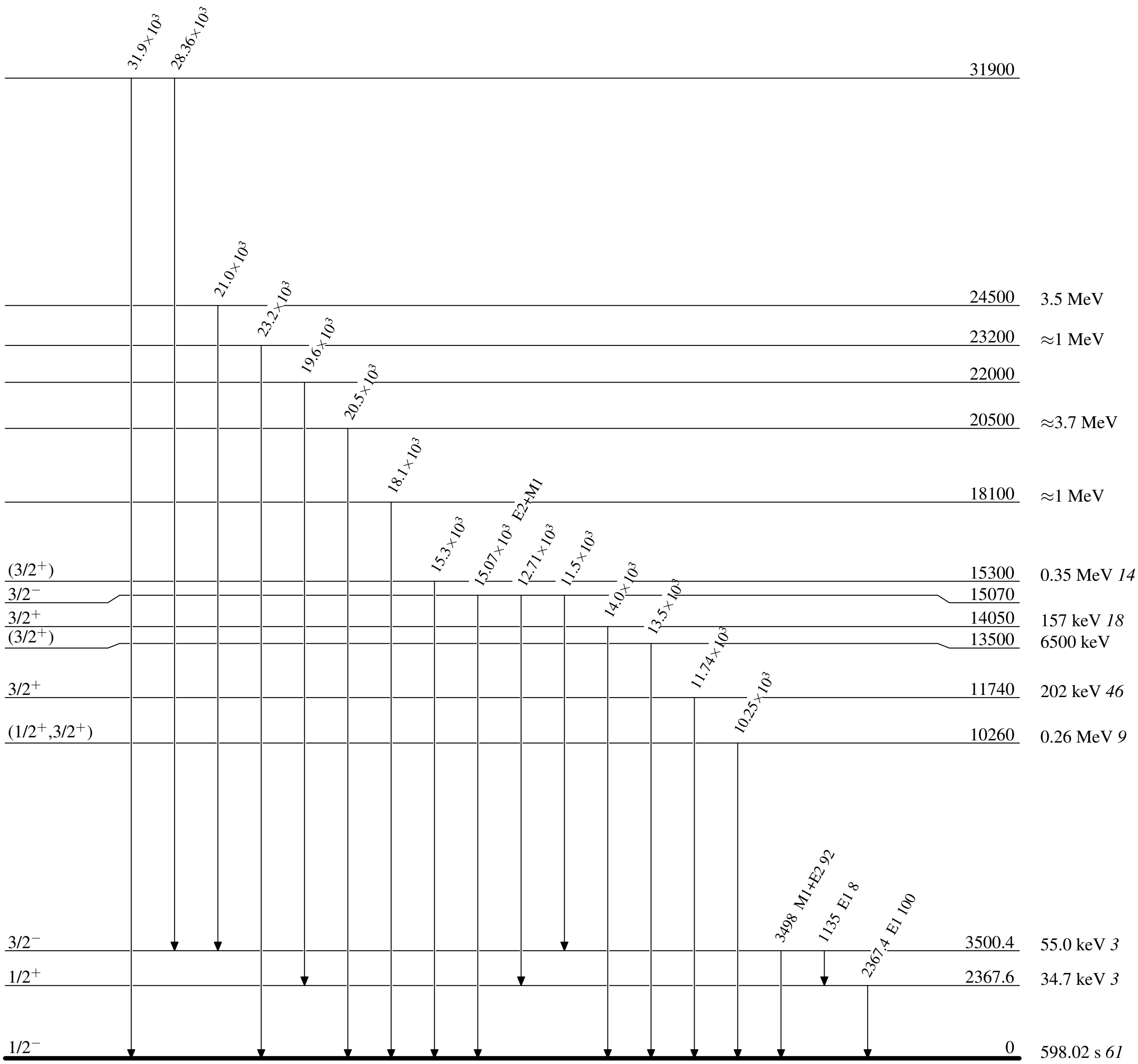
E_i(level)	J^{π}_{i}	E_{γ} †	E_f	J^{π}_{f}	Mult.	δ	Comments
							(1980Ba54) and using the $I_{\gamma1}$=8% *1*, which is the only related value that is reported with an uncertainty. We accept the branching ratio given in (1974Ro29); however we accept the partial $\Gamma_{\gamma0}$ width from the R-matrix analysis in (2023Ke11) as detailed above where $\Gamma_{\gamma0}$=0.49 eV *3* (δ=0.038 *6*: $\Gamma_{\gamma0}$(M1)=0.49 eV *3* and $\Gamma_{\gamma0}$(E2)=0.49 eV *3*). See also δ(E2/M1)=−0.09 *2* (1974Ro29) from *a2*=−0.64 4 compared with δ(E2/M1)=−0.092 from *a2*=−0.65 reported in (1963Yo06). E_{γ}: From (1987Po09); see also 3501.5 keV (1989Ki21).
10.26×10^{3}	(1/2^{+},3/2^{+})	10.25×10^{3}	0	1/2^{-}			$\Gamma_{\gamma0}\approx$6 eV
11.74×10^{3}	3/2^{+}	11.74×10^{3}	0	1/2^{-}			$\Gamma_{\gamma0}\approx$4.2 eV (1973Me12)
13.5×10^{3}	(3/2^{+})	13.5×10^{3}	0	1/2^{-}			
14.05×10^{3}	3/2^{+}	14.0×10^{3}	0	1/2^{-}			$\Gamma_{\gamma0}$=3.7 eV *10* (1973Me12)
15.07×10^{3}	3/2^{-}	11.5×10^{3}	3500.4	3/2^{-}			(1968Di04):$\Gamma_{\gamma(3.5+3.56)}$=23 eV *5*.
		12.71×10^{3}	2367.6	1/2^{+}			Γ_{γ}<4.5 eV (1968Di04)
		15.07×10^{3}	0	1/2^{-}	E2+M1	−0.115 *21*	Mult.: From angular distributions measured in (1975Ma21). (1968Di04): $\Gamma_{p0}\Gamma_{\gamma0}/\Gamma$=5.5 eV *8*, I(E2/M1)=−0.095 *7*. Then, $\Gamma_{\gamma0}$=27 eV *5* assuming Γ_{p0}/Γ=0.200 eV *25* (1967AdZY). (1975Ma21, 1977Ma16): $\Gamma_{p}\Gamma_{\gamma}/\Gamma$=5.79 eV *20*, I(E2/M1)=−0.013 *5* and $\Gamma_{\gamma0}/\Gamma_{p0}$=0.121 *11*. Assuming Γ_{p0}/Γ=0.236 *12* from (1973Ad02) gives Γ_{γ}(M1)=24.2 eV *15*, Γ_{γ}(E2)=0.32 eV *12*, and B(M1)W=0.342 *21* and B(E2)W=0.28 *11*; I(E2/M1)=0.013 5. See discussion in (1975Ku21). Also see (1975Ma21, 1977Ma16) where ^{11}B(^{3}He,nγ) data are used to deduce γ-ray partial widths $\Gamma_{\gamma(2+3)}$=19.6 eV *14*, $\Gamma_{\gamma1}\leq$2.82 eV *30*, $\Gamma_{\gamma0(M1)}$=24.2 eV *15*, $\Gamma_{\gamma0(E2)}$=0.32 eV *12*, and Γ=0.86 keV *12*.
15.3×10^{3}	(3/2^{+})	15.3×10^{3}	0	1/2^{-}			$\Gamma_{\gamma0}\geq$0.5 eV (1973Me12)
18.1×10^{3}		18.1×10^{3}	0	1/2^{-}			
20.5×10^{3}		20.5×10^{3}	0	1/2^{-}			
22.0×10^{3}		19.6×10^{3}	2367.6	1/2^{+}			
23.2×10^{3}		23.2×10^{3}	0	1/2^{-}			
24.5×10^{3}		21.0×10^{3}	3500.4	3/2^{-}			
31.9×10^{3}		28.36×10^{3}	3500.4	3/2^{-}			
		31.9×10^{3}	0	1/2^{-}			

† From level-energy difference, except where noted.

$^{12}C(p,\gamma)$

Level Scheme

Intensities: % photon branching from each level



$^{13}_{7}N_{6}$

^{12}C(p,π^0)

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1987Ho21: ^{12}C(p,p^0) E=186 MeV; measured $\sigma(\theta)$ for θ=30° to 180°.
1992Ho03: ^{12}C(p,p^0) E=153-204 MeV; measured $\sigma(\theta)$ for θ=0° to 180°. Compared with ^{12}C(p,π^+) and analyzed isospin invariance.
1993Pi14: ^{12}C(pol. p,p^0) E=146.9 MeV; measured A_y, $\sigma(\theta)$.
1993Na17: ^{12}C(pol. p,p^0) E=330 MeV; measured $\sigma(\theta)$.

^{13}N Levels

E(level)
0

^{12}C(p,n):res

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1968Ri01: ^{12}C(p,n) E=18.9-50 MeV; measured $\sigma(E_p)$.
1984Na06: ^{12}C(p,n) E=30 MeV; measured E_n, thick target yields.
1984Sa12: ^{12}C(p,n) E=65 MeV; measured spin-transfer coefficient.

^{13}N Levels

E(level)†	Comments
21×10^3	
24×10^3	
27×10^3?	Γ: Broad.

† From (1968Ri01).

^{12}C(p,p):res

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1951Ja21: ^{12}C(p,p) E_p=0.32-4.0 MeV; analyzed (1951Go50) data via partial wave analysis and deduced a $S_{1/2}$ level at E_x=2379, $P_{3/2}$ at 3501 and $D_{5/2}$ at 3549 keV with Γ=33, 42 and 40 keV, respectively.

1952Ja21, 1953Ja03, 1953Ja04: ^{12}C(p,p) E=0.32-4 MeV; deduced E_p 0.461, 1.698, 1.748, with Γ_{cm}=31, 55, 61 keV, and J^π= $1/2^+$, $3/2^-$ and $5/2^+$, respectively. See further discussion on reduced widths.

1954Mi05: ^{12}C(p,p) E=300-550 keV; measured σ(θ) for θ=30° to 160°. Deduced E_{res}=462 keV *4* with $\Gamma_{c.m.}$=32 keV.

1954Wo09: ^{12}C(p,pγ) E=1-3 MeV; observed influences of $^{13}N^*$(2.37,3.51,3.58 MeV) states. Observed (p,γ) capture to $^{13}N^*$(2.37) followed by proton emission. They note the higher $5/2^+$ state is suppressed in the capture reaction.

1956Br27: ^{12}C(p,p′) E_p=1.5-5.5 MeV; measured scattered proton yield. Deduced state at E_{res}=5.891 MeV with Γ_{lab}=55 keV.

1956Re39: ^{12}C(p,p′)1.5-5.5 MeV; deduced resonances at E_p=4.808 MeV *8* and 5.37 MeV with $J^\pi=5/2^+$ and $3/2^+$, and with Γ_{lab}=12 keV and 125 keV, respectively. J^π(5.37) from angular distribution of ^{12}C(p,p′$\gamma_{4.4}$). See further discussion on reduced widths.

1956Sc29: ^{12}C(p,p),(p,p′) E=4.7-7 MeV; measured σ(E) for θ=40° to 160°. Deduced levels at E_{res}=5.05, 5.30, 5.85, 6.65 MeV ^{13}N((6.61), 6.84, 7.35, (8.1)) with L:J^π=0:$1/2^+$, 2:$3/2^+$, 1:$3/2^-$, 2:$3/2^+$ and with Γ=75, 50, 50 and 350 keV, respectively. These states are not all accepted.

1960Ev02: ^{12}C(p,p_0) E=2.3-4.3 MeV; measured induced polarization at θ=60°.

1960St09: ^{12}C(p,p_0) E=9.4 MeV; measured induced polarization for θ=34° to 140°.

1960To09: ^{12}C(p,p_0) E=3-5 MeV; measured induced polarization for θ=50° to 160°.

1960Ya07: ^{12}C(p,p) E=14,16 MeV; measured induced polarization for θ=45°.

1960Yo05: ^{12}C(p,p′γ) E=5.3-6.1 MeV; measured excitation function for γ(^{12}C=4.4 MeV). Deduced resonances at E_{res}=5.37, 5.69 and 5.93 MeV (E_x=6.91, 7.17 and 7.42 MeV); analyzed angular correlation (θ≈35° to 140°) of γ-p for E_x=7.42 MeV.

1961Ad04: ^{12}C(p,p′γ(4.44)) E=5-12 MeV; measured yield at θ=90°. Deduced resonances E_{res}=5.36, 5.89, 7.55, 8.17, 9.12, 10.51, 10.74 and 10.99 MeV and widths for $^{13}N^*$(6.89, 7.38, 8.91, 9.48, 10.36, 11.64, 11.85, 12.09) with Γ_{lab}=140, 70, 255, 38, 70, 85, 140, 150 keV, respectively.

1961Ba25, 1961Mc11: ^{12}C(p,p) E=5-11.5 MeV; measured angular distributions (θ=10° to 170°) and excitation functions with resonances at E_p≈5.4, 5.9, 6.65, 7.6, 8.2, 9.2 and 10.5 MeV including new states at E_x≈8.9, 9.5, 10.4 and 11.6 MeV.

1961Mc16: ^{12}C(p,p′) E=5-11.5 MeV measured angular distributions (θ=25° to 170°) and excitation functions with resonances at E_p≈7.6, 8.2, 9.2, 10.3, 10.5 and 11.0 MeV.

1961Na02: ^{12}C(p,$p_{0,1}$) E=6.5-16 MeV; measured angular distributions for θ=21.8° to 166.2°. Deduced resonances at E_p=(6.65), 9.1, 10.5, 12.5, 13.2, 13.7 and 15.1 MeV for $^{13}N^*$(8.08, 10.4, 11.6. 13.5, 14.2, 14.6, 15.9 MeV) Widths of Γ=150, 700, 500, 500, 500 keV are deduced for $^{13}N^*$(10.4, 11.6. 13.5, 14.2, 14.6), respectively.

1962Sh22: ^{12}C(p,p) E=5-11.5 MeV; measured σ(E) for θ=30° to 170°. Deduced levels at E_{res}=5.38, 5.90, 6.6, 7.53, 8.17, 9.14 MeV with J^π=$3/2^+$, $5/2^+$, $3/2^+$, $1/2^-$, $3/2^-$, $7/2^-$, with Γ=115, 80, 1400, 225, 30 and 73 keV. Reduced widths of θ^2=0.01, 0.01, 0.14, 0.02, 0.001 and 0.01 are also given. Phase-shift analysis.

1962Wa31: ^{12}C(p,γ), (p,p′γ(4.44,12.7, 15.1)),(p,d) E=14-20 MeV and θ(γ)=90°. Yields for (p,γ) and (p,d) reactions were reported as relatively structureless. For (p,p′γ(15.1)) resonances corresponding at E_p=17.5, 18.05 and 19.3 MeV $^{13}N^*$(18.1, 18.65, 19.8 MeV) are reported. The width of the 18.1 MeV level is $\Gamma_{c.m.}$=330 keV *100*, while the other two levels have $\Gamma_{c.m.}$≤200 keV.

1963Ba36: ^{12}C(p,$p_{0,1}$) E=5.2-6.6 MeV; measured σ(θ) for θ≈30° to 150° (table provided). Also measured angular distribution of Eγ=4.44 MeV. Deduce E_{res}=5.35 MeV *1*, 5.65 MeV *1* and 5.89 MeV *1* for $^{13}N^*$(6.88, 7.16, 7.38 MeV) with $\Gamma_{c.m.}$=114, 7.7 and 61 keV, J^π=$3/2^+$, $7/2^+$ and ($5/2^-$,$7,2^-$), respectively. J^π(7.38)=$7/2^-$ is preferred, but $5/2^-$ is accepted in the Adopted Levels giving Γ_{p0}=51, 0.03 and 5.0 keV and Γ_{p1}=63, 7.4 and 56 keV, respectively for the states.

1963Ba43: Theoretical analysis of E_x≈7 MeV state spins. Find $^{13}N^*$(7.42) should be J^π=$5/2^-$.

1963Di16: ^{12}C(p,p′γ) E=18-30 MeV; measured σ(E_p,θ) for θ=14° to 153° (tables provided).

1963Me04: ^{12}C(p,p′γ) E≤50 MeV; measured excitation function for proton scattering to $^{12}C^*$(12.7,15.11). Deduced some evidence for a resonance at E_p=20 MeV and give discussion on a possible width 0.27 MeV<Γ_p<3.7 MeV. They give additional discussion suggesting as many as 4 resonances in the region.

1963Ni05: ^{12}C(p,p$\gamma_{4.4}$) E=5-6 MeV; measured σ(Eγ,θ) for θ≈5° to 150°. Deduced resonances at E_p=5.38, 5.68 and 5.90 MeV indicating $^{13}N^*$(6.91, 7.19, 7.40 MeV) with $\Gamma_{c.m.}$=115 keV *5*, 9.0 keV *5* and 69 keV *5*, respectively. The J^π values of $3/2^+$, $7/2^+$ and $5/2^-$ and c.m. elastic proton widths Γ_p=46 keV, 0.36 keV and 6.9 keV, respectively, are also deduced.

^{12}C(p,p):res (continued)

1964Bo18: ^{12}C(p,p$_0$) E_p=4.5 MeV; measured induced polarization for θ=50° to 128°.
1964Da03: ^{12}C(p,p$_{0,1}$) E_p=13.6-19.6 MeV; measured $\sigma(\theta)$ for θ=15° to 160°. Suggest fluctuations at Ep= 13.9, 14.4, 14.9, 15.3, 15.6, 16.5, 17.9, 18.2, 18.8 MeV with ΔE≈50-100 keV. They indicate higher resolution is necessary for meaningful results.
1964Dr04: ^{12}C(p,p$_0$) E_p=4.5-5.2 MeV; measured induced polarization at 48°.
1964Ta15: optical model analysis of the (1963Di16) data. Deduced resonances at $E_{c.m.}$=19.75 (3/2$^+$), 20.05 (5/2$^+$), 24.93 MeV with $\Gamma_{c.m.}$=2.49, 1.46 and 2.17 MeV, respectively.
1965Be12: ^{12}C(p,p′γ) E=5.37 MeV (E_x=6.91 MeV); measured triple correlation for θ_p=40° to 150° and θ_γ=0° and 150°. Compared with phase-shift analysis of (1956Re39). Data is well represented with a 3/2$^-$ state interfering with a small mixture of a 1/2$^-$ state. This is in disagreement with accepted interpretation.
1965Ma26: ^{12}C(p,p) E=16-28 MeV; measured total reaction cross sections; estimated elastic and inelastic cross sections. Deduced resonances at $E_{c.m.}$=19.8, 20.01 and 24.9 MeV ^{13}N*(21.7, 21.94, 26.8 MeV).
1965Mo15: ^{12}C(p,p) E=4.7-11.3 MeV; measured induced proton polarization for θ=20° to 140°.
1966Ar03: ^{12}C(p,p) E=1.48-2.02 MeV; measured $\sigma(\theta)$ for θ=25° to 125.5°. Deduced resonances at E_p=1686 keV *6* and 1734 keV *6* with J$^\pi$=3/2$^-$ and 5/3$^+$, with reduced widths θ^2=0.036 *2* and 0.25 *2* and with Γ=63 keV and 74 keV, respectively. The level energy difference is 48 keV *2*. Cross-sections table given.
1966Ba35: ^{12}C(p,p) E=2.4-11.6 MeV, ^{12}C(p,p′) E=6.6-11.6 MeV, ^{12}C(p,α) E=11.6 MeV; measured σ(E,θ). Deduced resonances at E_p=4.80, 5.30, 5.88, 6.35, 7.53, 8.16, 9.13 MeV for ^{13}N*(6.37, 6.83, 7.37, 7.79, 8.89, 9.47, 10.37) with J^π=5/2$^+$, 3/2$^+$, 5/2$^-$, 3/2$^+$, 1/2$^-$, 3/2$^-$, 7/2$^-$ and with Γ_{lab}=12, 74, 70, 1720, 250, 30 and 84 keV, respectively.
1966Cr04,1966Cr14: ^{12}C(pol. p,p),(pol. p,p′) E=20-28 MeV; measured polarization observables for θ=20° to 160°. Compared with earlier predictions of (1964Ta15).
1966Lo16: ^{12}C(p,p) E=20-28 MeV; measured $\sigma(\theta)$ for θ=15° to 160°. Deduced three states at $E_{c.m.}$=19.0, 20.8, ≈22.2 MeV with J^π=(5/2,9/2), (5/2,9/2) and 7/2 with Γ=1.5, 1.0, 0.5 MeV, respectively.
1966Sh10: ^{12}C(p,p′γ) E=5.9 MeV; measured $\sigma(E_p,\theta_p,\theta_{\gamma4.44})$ for θ_p=30° to 145°. Analyzed in-plane p-γ correlations with the aim of resolving the ^{13}N*(7.4 MeV) J^π spin assignment. 5/2$^-$ is favored, but not fully adopted.
1966Sw04: ^{12}C(p,p) E=4.7-12.8 MeV, ^{12}C(p,p′) E=6.0-12.8 MeV, measured σ(E,θ) for θ=25.4°−159.5°. Deduced new level at E_x=10.38 MeV.
1967Ba84: Theory, phase-shift analysis of E_x≈6.5 MeV region. Deduce the E_p=4.808 and ≈5.3 MeV features are due to the 0.461 keV *s*-wave resonance.
1967Du12: ^{12}C(p,p) E=5.179-5.480 MeV and θ=30° to 150°. Phase-shift analysis. Deduce resonance energy E_0=5374 keV *20*; discuss earlier results including some discussion on the complex process for determining the total width.
1967Cl04: ^{12}C(pol. p,p),(pol. p,p′) E=4-12 MeV; measured polarization observables for θ=17° to 60°.
1967Fa06: ^{12}C(pol. p,p),(pol. p,p′) E=49.5 MeV Measured $\sigma(\theta)$ for θ=11° to 147°.
1967Ku02: ^{12}C(p,p) E=13-19 MeV; measured σ(E,θ) for $\theta_{c.m.}$= 90° and 166.5°. Deduced T=3/2 resonances at E_x=18.43 MeV *2* and 18.98 MeV *2*. For 18.43, Γ≈30 keV is aparent, but if these are analogs of ^{13}N*(3.68,3.71) the width is unclear. For 19.89, Γ<10 keV and *l*=1 is likely from comparison with E_x=15.07; J=1/2$^-$ is suggested . They suggest population of T=1/2 states at E_p=14.4, 15.2 (broad), and 17.6 MeV.
1967Pa25: ^{12}C(p,p) E=1 BeV; measured $\sigma(\theta)$ for θ=6° to 18°.
1967Sc11: ^{12}C(p,p′γ(15.11)) E=20.5-30.3 MeV; measured excitation function. Deduced levels at ^{13}N*(20.9, 22.5, 25.5) with J^π=5/2$^+$, 5/2$^-$ and 3/2$^-$, respectively. See further discussion on L-values.
1967Sw02: ^{12}C(p,p) E=8.20 and 9.10-9.26 MeV: measured $\sigma(\theta)$ for θ=20° to 160°. phase-shift analysis. Deduced resonances at E_p= 9145 and 9152 keV with J^π=5/2$^-$ and 7/2$^-$ and with Γ_{lab}=12 and 90 keV, respectively.
1967Tr08: ^{12}C(pol. p,p) E=1.5-3 MeV; measured polarization observables for θ=30° to 140°. Phase-shift analysis in the region around E_x=3.5 MeV.
1968An25: ^{12}C(p,p),(p,p′) E=6 MeV; measured $\sigma(E_p,\theta)$.
1968Be31: ^{12}C(pol. p,p) analyzed the data of (1968Te05). For the E_{res}=5.38 and 5.88 MeV levels, they deduce J^π=3/2$^+$ and 5/2$^-$, respectively. For 5.88 MeV, Γ_{lab}=70 keV and Γ_{p0}/Γ=0.08 are deduced. The resonance at 9.13 MeV is identified as two overlapping states whose energies differ by less than 2 keV. The states have J^π=5/2$^-$ with Γ_{lab}=33 keV and Γ_{p0}/Γ=0.26 and J^π=7/2$^-$ with Γ_{lab}=82 keV and Γ_{p0}/Γ=0.81.
1968Sl01: ^{12}C(pol. p,p) E=1-3 MeV; measured induced proton polarization.
1968Te05: ^{12}C(pol. p,p) E=4.6 to 7.2 MeV; measured polarization observables for θ≈40° to 165°. Data is analyzed in (1968Be31).
1969Fa04: ^{12}C(p,p),(p,p′) E=11-22.7 MeV; measured polarization observables at θ=55°.
1969Fu07: ^{12}C(p,p) E=61.4 MeV; measured $\sigma(\theta)$ for θ=15° to 110°. For a broad collection of targets they deduced OM potential parameters.

^{12}C(p,p):res (continued)

1969Gu02: ^{12}C(p,p) E=7 MeV; measured $\sigma(\theta)$ and polarization observables for θ=20° to 160°. Deduced OM parameters.
1969Ko07: ^{12}C(p,p′) E=9-20 MeV; measured $\sigma(\theta)$ for θ=30° to 160°. Deduced spin-flip probabilities.
1969Le18: ^{12}C(p,p) E≈9.4-21.5 MeV. Measured σ(E,θ) for θ=25° to 165°. Deduced resonances in $\alpha_{0,1}$ and $p_{0,1}$. In (1970Aj04) the full collection of states given in Table 1 of (1969Le18) are associated with the (p,α) reaction; but this seems arbitrary given their θ=60° data shown in Fig 7. Isospin values are discussed. The results shown in Table 1 include ^{13}N states from E_x=13.96 to 19.88 MeV that were studied via phase-shift analysis. The complex of states around E_p=10.5 to 11 MeV were analyzed, but no results could be obtained.
1970Bl03: ^{12}C(pol. p, p),(pol. p, p′) E=20.3 MeV; measured polarization observables for θ≈40° to 160°.
1970Di08: ^{12}C(p,p) E=9.9-19.5 MeV; measured attenuation. Deduced broad levels near E_p≈10.4 and 13.8 MeV.
1970Gi04: ^{12}C(pol. p,p) E=20-30 MeV; measured σ(E,θ) for θ=20° to 150°. Results are combined with ^{10}B(^{3}He,α) at E(^{3}He)=1-10 MeV; deduced resonances at E_{res}(^{3}He)=3, 5.8, and 8 MeV (^{13}N*(24, 26.1, 28 MeV)) with Γ= 0.75 *25*, 1.35 *15* and 2.25 *25* MeV and J^π=7/2$^-$, 7/2$^-$ and 9/2$^+$, respectively. See ^{10}B(^{3}He,α).
1970Ko15: ^{12}C(p,p′γ(4.44)) E=12-14 MeV; measured $\sigma(\theta)$ for θ=30° to 160°; analyzed spin-flip probability. Focused on the region around E_{res}=13.1 MeV.
1970Ts03: ^{12}C(p,p) E=41-50 MeV; measured polarization observables.
1971Na29: ^{12}C(p,p) E≈4.81 MeV; measured polarization observables around the E_p=4.81 MeV resonance at θ=50° and 137.5°.
1972Ba14: ^{12}C(p,p) E=14.2 MeV; measured σ(E) for θ=165° near the E_x=15.07 MeV T=3/2 resonance. Deduced change in resonance shape attributed to molecular ion beams.
1972Be15: ^{12}C(p,pγ) E≈8.2 MeV; measured elastic, inelastic and spin-flip cross sections for θ≈30° to 160°. Analyzed resonance and found E_{res}=8.18 MeV, Γ_{lab}≈28 keV and Γ_{p1}/Γ=0.72. Deduced resonance is a proton coupled to ^{12}C*(4.44 MeV).
1972Dz05: ^{12}C(p,p) E≈14.23 MeV; measured $\sigma(\theta)$ at θ=40°, 140° and 165°. Used the observed width, FWHM=1.6 keV, and previously reported width, Γ=1.22 keV to estimated their systems′s resolution function.
1972Gr02: ^{12}C(pol. p, p),(pol. p, p′) E=30.4 MeV; measured $\sigma(\theta)$ and polarization observables for θ=20° to 170°. Deduced effective interactions.
1972Ja07: ^{12}C(p,p) E=144 MeV; measured $\sigma(\theta)$. Deduced scattering amplitudes and OM parameters.
1972Vo20: ^{12}C(p,p) E=1 GeV; measured induced proton polarization for θ<13°.
1972Wi24: ^{12}C(p,p) E=46 MeV measured $\sigma(\theta)$. Deduced OM parameters.
1972Wi26: ^{12}C(pol p,p) E=9.95-10.90 MeV; measured $\sigma(\theta)$, $A_y(\theta)$ for θ=50° to 150°. Deduced phase shifts, resonances. Tabular data. Resonances at E_{res}=10.25 MeV *10*, 10.51 MeV *2*, 10.54 MeV *5* and 10.70 MeV *5* (^{13}N*(11.40, 11.64, 11.67, 11.82 MeV)), with J^π=5/2$^+$, 5/2$^-$, 3/2$^-$, 3/2$^+$, and with Γ=0.45 MeV *10*, 120 keV *30*, 230 keV *50*, 250 keV *50*, and with Γ_{p0}/Γ= 0.65 *15*, 0.55 *5*, 0.45 *10* and 0.62 *10*, respectively.
1973Be29: ^{12}C(p,p), (p,p′) E=1.04 GeV; measured $\sigma(\theta)$ for θ≈4° to 35°.
1973Be37: ^{12}C(p,p), (p,p′) E=7-8 MeV; measured σ(E). As in (1972Be15), measured elastic, inelastic and spin-flip cross sections for θ≈45° to 165°. Analyzed resonance and found E_{res}=7.575 (assumed) with Γ=0.25 MeV. They find the decay is dominated by *f*-wave proton emission.
1973Ha59: 12C(p,p) E=2.0-4.5 MeV; measured A_y.
1973Hu07,1974Hu15: 12C(p,p) E≈14.2 MeV; measured σ(E). Find T=3/2 resonance at E_p=14230.75 keV *20*.
1973Me03: ^{12}C(pol. p,p), (pol. p,p′) E=9.5-11.5 MeV, measured $\sigma(\theta)$, $A_y(\theta)$ for θ=20° to 160°. Phase-shift analysis. Deduced resonances with E_{res}=10.35 MeV *5*, 10.58 MeV *3*, 10.62 MeV *4*, 10.62 MeV *5*, 10.75 MeV *4* and 11.05 MeV *5* (^{13}N*(11.49, 11.71, 11.75, 11.75, 11.86, 12.14 MeV)), with J^π=5/2$^+$, 5/2$^-$, 3/2$^+$, 3/2$^-$, 1/2$^+$ and 7/2$^-$, with $\Gamma_{c.m.}$= 430 keV *35*, 115 keV *30*, 250 keV *30*, 530 keV *80*, 380 keV *50* and 250 keV *30*, and with Γ_p/Γ=0.70 *5*, 0.60 *4*, 0.30 *5*, 0.55 *5*, 0.35 *5* and 0.30 *5*. See further discussion on reduced widths.
1973Me12: ^{12}C(p,p′γ) E=9-24 MeV; measured E_γ, I_γ excitation function capture γs and ^{12}C*(12.7, 15.11 MeV) de-excitation. A high background has resulted in multiple solutions for deduced widths in the γ_0 capture analysis; the preferred option is listed. For ^{12}C(p,γ_0) resonances at E_p=9.01 MeV *15*, 10.62 MeV *12*, 12.5 MeV *2*, 13.12 MeV *9* 14.5 MeV *2* for ^{13}N*(10.25, 11.74, 13.0, 14.04, 15.3 MeV), with J^π=3/2$^+$, (3/2$^+$,1/2$^+$), 3/2$^+$, 3/2$^+$, (3/2$^+$), and with Γ=0.28 MeV *10*, 220 keV *50*, 7 MeV, 170 keV *20* and 0.38 MeV *15*, and with $\Gamma_{\gamma0}$ ≥0.6 eV, 4.2 eV, ≥1.1 keV, 76 eV *28* and ≥0.5 eV. See further discussion in text. Levels in ^{12}C(p,p′γ) are found at E_p=15.27 MeV *3* (E_x=16.02) with Γ=130 keV *30*, Γ_{p0}≈7.5 keV, $\Gamma_{p12.71}$≈30 keV; E_p=19.35 MeV *20* (E_x=19.77) with J^π=(5/2$^+$), Γ=800 keV, Γ_{p0}≈80 keV, $\Gamma_{p15.11}$≈300 keV (*Not accepted*); E_p=20.55 MeV *30* (E_x=20.87) with J^π=(5/2$^+$), Γ=1.1 MeV, Γ_{p0}≈110 keV, $\Gamma_{p15.11}$≈400 keV; E_p=22.2 MeV *5* (E_x=22.7) with J^π=(7/2$^+$), Γ=2 MeV, Γ_{p0}≈200 keV, $\Gamma_{p15.11}$≈450 keV. Significant comparison with literature values.
1974Ae01: ^{12}C(p,p) E=399-576 MeV; measured $A_y(\theta)$ for θ=4° to 10°.
1974Al31: ^{12}C(p,p), (pol. p,p) E=4.6-6 MeV; measured $\sigma(\theta)$ and $A_y(\theta)$.

^{12}C(p,p):res (continued)

1974Co09: ^{12}C(p,p) E=156 MeV; measured $\sigma(\theta)$ for θ=5° to 65°. Deduced OM parameters.
1974Fe08: ^{12}C(p,p), (p,p′) E=24 MeV; measured $\sigma(\theta)$.
1974Gu04: ^{12}C(p,p) E=5.8-6.3 MeV; measured induced proton polarization.
1974Ja25: ^{12}C(p,p) E=10-20 MeV; measured $\sigma(\theta)$ for θ=15° to 70°.
1974Lo19: ^{12}C(p,p) E≈4.8 MeV; measured $\sigma(E_p)$. Analyzed E_{res}=4.8 MeV level properties.
1974Ro42: ^{12}C(pol. p,p) E=6.2 MeV; measured $A_y(\theta)$.
1975Cr06: ^{12}C(p,p) E=1770, 1900 keV; measured $\sigma(E_\gamma)$. Analyzed proton induced bremsstrahlung spectrum for near-resonance energies.
1975De26: ^{12}C(p,p), (p,p′) E=6 MeV; measured $\sigma(E_{p'},\theta)$.
1975De32: ^{12}C(p,p′γ) E=15.9-37.6 MeV; measured $\sigma(E_{p'},\theta)$. for θ=40° to 170°. Observed resonances at E_p=20 and 29 MeV. Suggest E1 and E2, respectively.
1975Ge15: ^{12}C(p,p′γ) E=22.5-45 MeV; measured $\sigma(E_{p'},\theta)$. for θ=20° to 160°.
1975Go03: ^{12}C(p,p) E=14.22-14.24 MeV; measured σ(E) around the T=3/2 resonance using a broad range spectrometer to determine the proton energy. Various thin targets from 10-20 μg/cm^2 were utilized. Deduced E_{res}=14232.5 keV *22* from phase-shift analysis. The value Γ_p/Γ≈0.18 was used in their fit.
1975Hi07: ^{12}C(p,p),(p,p′),(p,α) E=14.222-14.242 MeV; measured σ(E) at θ=175°. Analyzed ^{13}N*(15.07) mainly from (p,p) analysis. They deduced Γ=1.10 keV *9*, Γ_p=210 eV *11* and Γ_p/Γ=0.191 *17*. Analyzed other level decay properties such as partial widths, but they used branching ratios from (1973Ad02) with their Γ and Γ_p.
1975Sl02: ^{12}C(p,p) E=20-44 MeV; measured total σ(E). Observed structures at E_p=23.8 and 25.9 MeV.
1976Be28: ^{12}C(p,pγ(12.71,15.11)) E≤24 MeV; measured σ(E) for θ=90° and 55°. States at E_p=17.87, 18.46, 19.5 MeV and 20.5 MeV are observed in E_γ(15.11) excitation spectrum (seems shifted). E_x=18.456 MeV *15* for the E_p=17.87 state. For E_γ(12.71), structures are seen at E_p=15.27, 16.8, 20.5 MeV. They suggest the 20.5 could be (3/2$^+$), but express uncertainty.
1976Cu08: ^{12}C(p,p) E=1.5-4.0 MeV; measured $\sigma(E,\theta)$ for θ=5° to 41°. Deduced OM parameters.
1976Fe11: ^{12}C(p,p′γ(4.44,12.7,15.1)), ^{12}C(p,$\gamma_{0,2,3}$) E=16-40 MeV; measured σ(E). Observed resonances at E_p=20, 27, 32 MeV (E_x≈20.4, 26.8, 31.5 MeV). The 20 MeV resonance is seen in all channels, while the 27 MeV state is not seen in capture reactions. The 32 MeV resonance is seen in ^{12}C(p,p′γ(4.44)).
1976Ma06,1976Ma55: ^{12}C(p,p) E=1.765, 1.795, 1.895 MeV; analyzed proton induced bremsstrahlung spectrum for near-resonance energies.
1976Me18: ^{12}C(pol. p,p) E=11.5-18.1 MeV; measured $\sigma(\theta)$, $A_y(\theta)$ for θ≈20° to 160°. Phase-shift analysis. Deduced resonances at E_p=13.13 MeV *2*, 15.24 MeV *4*, 17.58 MeV *3* and 17.60 MeV *2* (^{13}N*(14.06, 16.00, 18.16, 18.18 MeV)) with J^π=3/2$^+$, 7/2$^+$, 3/2$^+$, 1/2$^-$, and with $\Gamma_{c.m.}$=180 keV *35*, 135 keV *90*, 322 keV *75*, 225 keV *50*, and with Γ_p/Γ=0.29 *7*, 0.05 *4*, 0.08 *2* and 0.24 *6*. See further discussion on reduced widths and other fitting parameters. They suggest systematic errors in (1969Le18) that require ≤70 keV energy shifts.
1976Me22: ^{12}C(p,p) E=0.3-2.0 MeV; measured $\sigma(\theta)$ for θ=89.1°, 118.7° and 146.9°. R-Matrix analysis deduced levels at $E_{c.m.}$= 424 , 1558, 1604 keV with $\Gamma_{c.m.}$=33, 55, 50 keV. These data were included in a reanalysis given in (2023Ke11); see discussion in ^{12}C(p,γ). Of particular relevance was the description of the E_p=1735.5 keV *5* resonance with J^π=5/2$^+$, and Γ=49.0 keV *5*.
1976So02: ^{12}C(p,p) E=8.0-8.3 MeV, 8.909.4 MeV; measured $\sigma(\theta)$ for θ=87.4°. Analyzed the region around the E_{res}=9.14 MeV doublet by analyzing cross sections and spin-flip probability.
1977Bl09: ^{12}C(p,p) E=0.8 GeV; measured $\sigma(\theta)$ and $A_y(\theta)$ for θ≈1° to 30°.
1977Ma16: ^{12}C(p,p) E=14.23 MeV, ^{13}N*(15.066 MeV T=3/2). Observed p decay to ^{12}C(0,4.4, 7.65, 9.65) and associated γ rays.
1978Cu04: ^{12}C(p,p) E=3.0, 49.48 MeV; measured $\sigma(\theta)$ for θ= 3° to 90°. Deduced OM parameters.
1978Fr12,1978Ho05: ^{12}C(pol. p,p) E=800 MeV; measured $\sigma(\theta)$ and A(θ) for θ=2° to 30°.
1979Al26: ^{12}C(p,p) E=1 GeV; measured $\sigma(\theta)$ for θ=5° to 25°. Analyzed nuclear density. Discussed quadrupole moments.
1979Be44: ^{12}C(pol. p,p) E=300-560 MeV; measured A(θ) for θ=5° to 20°.
1979Bo03: ^{12}C(p,p) E=3-61.4 MeV; measured and analyzed literature $\sigma(\theta)$. Deduced α-cluster structure in ^{12}C.
1979Ga13: ^{12}C(pol. p,p),(pol. p,p′) E=19.15-23.34 MeV; measured $\sigma(\theta)$ and $A_y(\theta)$ for θ=20° to 160° and for protons to ^{12}C(0, 4.4, 12.7 MeV). Deduced resonances at E_x= (≥19.5 MeV), 19.9 MeV, 20.2, 20.9, 21.4 and 22.4 MeV with J^π=1/2$^+$, 7/2$^+$, 5/2$^-$, 1/2$^+$, 5/2$^-$,1/2$^+$, and with Γ=(≥1.0), 0.75, 1.0, 1.2, 0.75 and (1.0) MeV. Evidence for additional states around 21.7 with J^π=3/2$^+$ and above 22.7 with 3/2$^+$ was discussed. They give an overview comparison of their results for this region with those of (1966Lo16, 1964Ta15, 1967Sc11, 1969Le18).
1979Kr18: ^{12}C(pol. p,p) E=450-600 keV; measured A(θ) for θ=90° and 120°. Deduced evidence for Mott-Schwinger interaction.
1979Pr04: ^{12}C(p,p), (p,p′) E=6.9 MeV; measured $\sigma(\theta)$. Analyzed spin-flip probability. Deduced reaction mechanism.
1980Al09: ^{12}C(p,p) E=1 GeV; measured polarization observables for θ=3° to 19° Deduced spin-orbit amplitude parameters.

^{12}C(p,p):res (continued)

1980Co05: ^{12}C(p,p), (p,p′) E=122 MeV; measured $\sigma(E_P,\theta)$ for θ=10° to 60°. DWIA analysis. Analyzed spin-orbit tensor effective interaction.
1980Fa07: ^{12}C(p,p), (p,p′) E=35.2 MeV; measured $\sigma(\theta)$ for θ= 30° to 170°. Deduced OM parameters.
1980Ka02: ^{12}C(p,p) E=40-75 MeV; measured $\sigma(\theta)$ and polarization observables forθ=47.5°. Presented measurements for θ=15° to 115° at E_p=65 MeV.
1980Th05: ^{12}C(pol p,p) E=14.226-14.236 MeV; measured $\sigma(\theta)$, $A_y(\theta)$ for θ=60° to 160°. For $^{13}N^*$(15.07) deduced Γ_{lab}=1010 eV *30* and Γ_{p-lab}=285 eV *15* with a beam energy resolution of 850 eV; analyzed atomic excitation effects for the E_p=14230.75 keV state.
1980Tr03: ^{12}C(p,p) E≈1.7 MeV; measured σ(E). Analyzed interaction of proton induced bremsstrahlung with resonance.
1981Dy03: ^{12}C(p,p′γ(4.44)) E≈5-23 MeV; measured σ(E).
1981Me02, 1981Me11: ^{12}C(pol. p,p) E=200 MeV; measured $\sigma(\theta)$ and $A_y(\theta)$ for θ=6° to 115°.
1982Al18: ^{12}C(p,p) E=1 GeV; measured induced proton polarization, deduced spin-orbit parameters.
1981Fu12: ^{12}C(pol p,p′γ) E=22-29 MeV; measured polarization observables θ=45° to 150°.
1982Le03: ^{12}C(p,p) E=591, 696, 796 keV; analyzed interaction of proton induced bremsstrahlung with resonance.
1982Ta09,1982Ta11: ^{12}C(p,p) E≈1.7 MeV; measured σ(E). Analyzed interaction of proton induced bremsstrahlung with resonance.
1983Ba57: ^{12}C(p,p′), (p,p) E=135 MeV; measured $\sigma(\theta)$ for θ=10° to 70°. Deduced OM parameters.
1983Me02: ^{12}C(pol. p,p) E=122, 160 MeV; measured $\sigma(\theta)$, A(θ) for θ=5° to 154°. Deduced OM parameters.
1983Ta12: ^{12}C(pol. p,p′(4.44)) E=159.4 MeV; measured $\sigma(\theta)$ and $A_y(\theta)$ for θ=7.5° to 45° DWBA/DWIA analyses.
1985Al16: ^{12}C(p,p) E=1 GeV; measured $\sigma(\theta)$ for θ=5° to 26°. Deduced OM parameters, analyzed density distribution.
1986Er06,1987Er01,1990Er02: ^{12}C(p,p) E ≈1.7 MeV; measured σ(E). Analyzed interaction of proton induced bremsstrahlung with resonances. Deduced reaction duration time and discussed $T_{1/2}$ for ^{13}N*(3.5 MeV) doublet.
1986Ho26: ^{12}C(p,p) E=350-550 keV; measured σ(E) for θ=95°, 124° and 152°.
1986Vu02: ^{12}C(pol. p,p) E=4-8 MeV; measured $A_y(\theta)$ for θ=20° to 165°.
1988Me02: ^{12}C(pol. p,p) E=200-300 MeV; measured $\sigma(\theta)$, $A_y(\theta)$ for θ=5° to 100°. Deduced OM parameters.
1989Vo05: ^{12}C(pol. p,p) E=72 MeV; measured $\sigma(\theta)$, $A_y(\theta)$ for θ≈15° to 160°. Deduced OM parameters.
1990Ev01: ^{12}C(pol. p,p) E=71.2 MeV; measured $A_y(\theta)$ for θ=40° to 48°.
1990Ho06: ^{12}C(pol. p,p) E=494 MeV; measured $\sigma(\theta)$, polarization observables for θ=5° to 37°.
1991Ba45: ^{12}C(pol. p,p) E=500 MeV; measured $A_y(\theta)$ and spin-rotation depolarization parameters for θ=10°, 15° and 20°.
1991Ka12: ^{12}C(p,p), (p,p′) E≈11-13 MeV; measured $\sigma(\theta$, E) Deduced levels and level parameters *Not accesible*.
1991Ya10: ^{12}C(p,p) E=2.5-3.6 MeV; measured $\sigma(\theta$=170°).
1992Ba30: ^{12}C(pol. p,p) E=1-2.1 MeV; measured analyzing powers $A_y(\theta)$ for θ=40° to 160°. Phase-shift analysis. Deduced E_{res}=1685 keV *6* and 1736 keV *8* for $^{13}N^*$(3.499,3.546).
1992Wi01: ^{12}C(pol. p,p) E=189 MeV; measured $A_y(\theta)$ for θ=16.3°, 17.3° and 18.3°.
1992Wi13: ^{12}C(pol. p,p), E ≈14.231 MeV; reported $\sigma(\theta)$, $A_y(\theta)$ as in (1980Th05). See also (1983Wi04).
1993Ba37: ^{12}C(pol. p,p), (pol. p,p′) E=318 MeV; measured $\sigma(\theta)$ and polarization observables. RPA, DWIA analyses.
1993Da16: ^{12}C(p,p) E=1.5-1.8 MeV; measured σ(E). Analyzed interaction of proton induced bremsstrahlung with resonances. Discussed total collision duration.
1993Sy01: ^{12}C(pol. p,p) E=3.5-7.5 MeV; measured $\sigma(\theta)$, $A_y(\theta)$ and polarization observables for θ=30° to 145°.
1994Ai04: ^{12}C(p,p) E≈16.5-20 MeV; measured $\sigma(\theta)$.
1994Fa05: ^{12}C(p,p) E=1.80, 1.83 MeV; measured $\sigma(\theta)$, Analyzed interaction of proton induced bremsstrahlung with resonances.
1996Ho08: ^{12}C(pol. p,p) E=500 MeV; measured polarization transfer parameter.
1999Ta22: ^{12}C(pol. p,p) E=392 MeV; measured polarization observables for θ=0°.
2001Op01: ^{12}C(pol. p,p′) E=198 MeV; measured polarization observables for θ=7° to 22°.
2003Ha12: ^{12}C(pol. p,p) E=150 MeV; measured polarization observables for θ≈5° to 30°.
2006Ca19: ^{12}C(p,p) E=3-7 MeV; measured $\sigma(\theta)$ for θ=150°.
2007Be47: ^{12}C(p,p′γ) E=5-25 MeV; measured E_γ, I_γ, $\sigma(\theta)$ for θ=45° to 157.5°.
2010To03: ^{12}C(p,p) E=4.9-6.1 MeV; measured scattered protons. Deduced yields, stopping σ, sharp backscattering resonance at E_p=4808 keV.
2011Ab05: ^{12}C(p,p) E=2.7-7 MeV; measured backscattered protons for θ=140° to 170°. Analyzed utility for elastic spectroscopy.
2011Gu31: ^{12}C(p,p) E=1-2, 8 MeV measured $\sigma(\theta)$ for 30° to 170°.

theoretical analysis:
1971Au02: Computed partial proton width for E_x=15.07 MeV T=3/2 state.

^{12}C(p,p):res (continued)

1973An07: ^{12}C(p,p) E=1.5-3 MeV; analyzed E≈3.5 MeV resonances.
1977Al25: ^{12}C(p,p) E=1 GeV; analyzed induced proton polarization.
1981Pe06: ^{12}C(p,p) E_p≈1.7 MeV; calculated $\sigma(\theta)$.
1983Ol04: ^{12}C(p,p) E<4.5 MeV; calculated σ(E). S-matrix formalism.
1984Ko37: ^{12}C(vec p,p_0); analyzed data for states up to E_x=7.8 MeV.
1984Ph02: ^{12}C(pol. p,p) E=800 MeV; analyzed LANL $\sigma(\theta)$ and $A_y(\theta)$ data to obtain OM parameters. See also (1985Bl22).
1993By02: ^{12}C(p,p) E=64.9, 72, 83.4 MeV; calculated $\sigma(\theta)$ for θ=20°−80°. Analyzed N-N interaction.
2019Ma89: ^{12}C(p,p′γ) E=8-22 MeV; measured $\sigma(\theta)$ for θ=50° to 140°.
2005Pi16: ^{12}C(p,p) E≈1-7 MeV. Calculated $\sigma(\theta)$ and predicted level energies.
2015Be12: ^{12}C(p,p) E < 200 MeV. Cluster model analysis of proton scattering.

^{13}N Levels

E(level)[†]	J^π	Γ	L	Comments
2369 *3*	1/2$^+$	31 keV	0	E(level),J^π,Γ: From E_{res}=461 keV *3* (1953Ja04). θ^2=0.54 (1953Ja04 × 0.66). (1951Ja21): E_x=2379 keV, Γ=33 keV. (1953Ja04): E_{res}=461 keV *3*, J^π=1/2$^+$ and Γ=31 keV from phase-shift analysis. (1954Mi05): E_{res}=462 keV *4* and $\Gamma_{c.m.}$=32 keV. (1976Me22): $E_{c.m.}$=424 keV with $\Gamma_{c.m.}$=33 keV (1976Me22).
3499 *6*	3/2$^-$	63 keV	1	θ^2=0.031 (1953Ja04 value × 0.66). E(level),J^π,Γ: From E_p=1686 keV *6* (1966Ar03). (1951Ja21): E_x=3501 keV, Γ=42 keV. (1953Ja04) E_{res}=1698 keV, J^π=3/2$^-$ and Γ=55 keV. (1966Ar03): E_p=1686 keV *6*, J^π=3/2$^-$ and Γ=63 keV. They also report ΔE(3/2$^-$,5/2$^+$)=48 keV *2* and reduced width values. (1976Me22): $E_{c.m.}$=1558 keV with $\Gamma_{c.m.}$=55 keV. (1992Ba30): E_{res}=1685 keV *6* J=3/2$^-$ from phase-shift analysis.
3544.4 *5*	5/2$^+$	49.0 keV *5*	2	E(level): E_{res}=1735.5 keV *5* from the average of E_p=1734 keV *6* (1966Ar03), E_p=1736 keV *8* (1992Ba30) and E_p=1735.5 keV *5* from the (2023Ke11) analysis of (1976Me22). J^π,Γ: From the (2023Ke11) R-matrix analysis of (1976Me22). θ^2=0.21 (1953Ja04 value × 0.66). (1951Ja21): E_x=3549 keV, Γ=40 keV (1951Ja21). (1953Ja04) E_{res}=1748 keV, J^π=5/2$^+$ and Γ=61 keV, (1966Ar03): E_p=1734 keV *6*, J^π=5/2$^+$ and Γ=74 keV. They also report ΔE(3/2$^-$,5/2$^+$)=48 keV *2* and reduced width values. (1976Me22): $E_{c.m.}$=1604 keV with $\Gamma_{c.m.}$=50 keV. A subsequent reanalysis in (2023Ke11) resulted in E_p=1735.5 keV *5* with J^π=5/2$^+$, and Γ=49.0 keV *5*. (1992Ba30): E_{res}=1736 keV *8* J=5/2$^+$ from phase-shift analysis.
6378 *8*	5/2$^+$	11 keV	2	E(level),J^π,Γ: From E_{res}=4808 keV *8* (1956Re39). θ^2=0.0031 (1956Re39). (1956Re39): E_{res}=4808 keV *8*, J^π=5/2$^+$, Γ_{lab}=12 keV and θ^2=0.0031 from phase-shift analysis. (1966Ba35): E_{res}=4.80 MeV, J^π=5/2$^+$ and Γ_{lab}=12 keV. See also (1967Ba84).
6890 *6*	3/2$^+$	115 keV *5*	2	Γ_{p0}=51 keV (1963Ba36); Γ_{p1}=63 keV (1963Ba36) θ^2=0.13 (1963Ba36). E(level): From E_{res}=5363 keV *6* from the average of E_{res}=5370 keV *8* (1956Re39), E_{res}=5.35 MeV *1* (1963Ba36) and E_p=5374 keV *20* (1967Du12). J^π: From phase-shift analysis of angular distributions and σ(E) in (1956Re39) ^{12}C(p,p),(p,$p_1\gamma(\theta)$). See also (1965Be12). Γ: From (1963Ni05). Γ_{p0}: See also Γ_{p0}=46 keV (1963Ni05).

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^{12}C(p,p):res (continued)

^{13}N Levels (continued)

E(level)†	J^{π}	Γ	L	Comments
				(1956Re39): E_{res}=5370 keV *8*, J^{π}=3/2^{+} and Γ_{lab}=125 keV. (1956Sc29): E_{res}=5.30 keV, L:J^{π}=2:3/2^{+}, Γ=50 keV. See unpublished results in (1959Aj76). (1960Yo05): E_{res}=5.37 MeV. (1961Ad04): E_{res}=5.63 MeV and Γ_{lab}=140 keV. (1962Sh22): E_{res}=5.38 MeV, J^{π}=3/2^{+}, Γ=115 keV and θ^2=0.01 from phase-shift analysis. (1961Ba25, 1961Mc11): E_{res}=5.4 MeV. (1963Ba36): E_{res}=5.35 MeV *1*, J^{π}=3/2^{+}, $\Gamma_{c.m.}$=114 keV Γ_{p0}=51 keV, Γ_{p1}=63 keV. (1963Ni05): E_p=5.38 MeV, J^{π}=3/2^{+}, $\Gamma_{c.m.}$=115 keV *5* and Γ_{p0}=46 keV (1963Ni05). (1966Ba35): E_{res}=5.30 MeV, J^{π}=3/2^{+} and Γ_{lab}=74 keV. (1967Du12): E_p=5374 keV *20*. (1968Be31): E_{res}=5.38 MeV, J^{π}=3/2^{+}.
7155 *9*	7/2^{+}	9.0 keV *5*	4	Γ_{p0}=0.36 keV; Γ_{p1}=8.64 keV *50* E(level),J^{π}: From E_{res}=5.65 MeV *1* (1963Ba36). Γ,Γ_{p1}: From (1963Ni05). θ^2=0.016 (1963Ba36). (1960Yo05): E_{res}=5.69 MeV (1960Yo05). (1963Ba36): E_{res}=5.65 MeV *1*, J^{π}=7/2^{+}, $\Gamma_{c.m.}$=7.7 keV Γ_{p0}=0.03 keV, Γ_{p1}=7.4 keV. Γ_{p0}=0.03 keV may be a typo since the value Γ_{p0}=0.3 keV gives the better accounting. Phase-shift and interference analysis. (1963Ni05) E_p=5.68 MeV, J^{π}=(7/2^{+}), $\Gamma_{c.m.}$=9.0 keV *5* and Γ_{p0}=0.36 keV. Phase-shift analysis.
7.38×10^{3} *1*	5/2^{-}	69 keV *5*	3	Γ_{p0}=6.9 keV E(level): From (1963Ba36). J^{π}: From polarization data in (1968Be31). See discussion in (1966Sh10). Γ,Γ_{p0}: From (1963Ni05). See also $\Gamma_{c.m.}$=61 keV, Γ_{p0}=5.0 keV, Γ_{p1}=56 keV (1963Ba36) and Γ_{lab}=70 keV and Γ_{p0}/Γ=0.08 (1968Be31). θ^2=0.069 (1963Ba36). (1956Br27) E_{res}=5891 keV, Γ_{lab}= 55 keV. (1956Sc29): E_{res}=5.85 keV, L:J^{π}=1:3/2^{-}, Γ=50 keV. See unpublished results in (1959Aj76). (1960Yo05): E_{res}=5.93 MeV. (1961Ad04): E_{res}=5.89 MeV, Γ_{lab}=70 keV. (1961Ba25,1961Mc11): E_{res}=5.9 MeV. (1962Sh22): E_{res}=5.90 MeV, J^{π}=5/2^{+}, Γ=80 keV and θ^2=0.01 from phase-shift analysis. (1963Ba36): E_{res}=5.89 MeV *1*, J^{π}=(5/2^{-},7/2^{-}), $\Gamma_{c.m.}$=61 keV, Γ_{p0}=5.0 keV, Γ_{p1}=56 keV. (1963Ni05): E_p=5.90 MeV, J^{π}=5/2^{-}, $\Gamma_{c.m.}$=69 keV *5* and Γ_{p0}=6.9 keV. (note:Γ_{lab}=75 keV *5* is listed in the abstract as $\Gamma_{c.m.}$. The issue is clear in the conclusions paragraph). (1966Ba35): E_{res}=5.88 MeV, J^{π}=5/2^{-} and Γ_{lab}=70 keV. (1968Be31): E_{res}=5.88 MeV, J^{π}=5/2^{-}, Γ_{lab}=70 keV and Γ_{p0}/Γ=0.08.
8.0×10^{3}	3/2^{+}	≈1.5 MeV	2	E(level): E_{res}≈6530 from average of E_{res}=6.65, 6.6, 6.35 MeV. J^{π}: From (1962Sh22,1966Ba35). Γ: From average of Γ=1400 keV (1962Sh22) and Γ_{lab}=1.72 MeV (1966Ba35). See also Γ=350 keV (1956Sc29). θ^2=0.14 (1962Sh22). (1956Sc29): E_{res}=6.65 keV, L:J^{π}=2:3/2^{+}, Γ=350 keV. (1961Ba25, 1961Mc11): E_{res}=6.65 MeV. (1961Na02): E_{res}=(6.65) MeV.

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^{12}C(p,p):res (continued)

^{13}N Levels (continued)

E(level)[†]	J^{π}	Γ	L	Comments
				(1962Sh22): E_{res}=6.6 MeV, J^{π}=3/2^{+}, Γ=1400 keV and θ^2=0.14 from phase-shift analysis. (1966Ba35): E_{res}=6.35 MeV, J^{π}=3/2^{+} and Γ_{lab}=1.72 MeV.
8.90×10^3	1/2$^-$	230 keV	1	E(level),Γ: From E_{res}≈7540 keV, Γ from Γ_{lab}≈250 keV. θ^2=0.02 (1962Sh22). (1961Ad04): E_{res}=7.55 MeV, Γ_{lab}=255 keV. (1961Ba25, 1961Mc11, 1961Mc16): E_{res}=7.6 MeV. (1962Sh22): E_{res}=7.53 MeV, J^{π}=1/2$^-$, Γ=225 keV and θ^2=0.02 from phase-shift analysis. (1966Ba35): E_{res}=7.53 MeV, J^{π}=1/2$^-$ and Γ_{lab}=250 keV. (1973Be37): $E_{res.}$=7575 keV and Γ=0.25 MeV.
9.48×10^3	3/2$^-$	30 keV	1	E(level): From E_{res}=8170 keV. θ^2=0.001 (1962Sh22). Γ_{p1}/Γ=0.72 (1972Be15). (1961Ad04): E_{res}=8.17 MeV, Γ_{lab}=38 keV. (1961Ba25, 1961Mc11, 1961Mc16): E_{res}=8.2 MeV. (1962Sh22): E_{res}=8.17 MeV, J^{π}=3/2$^-$, Γ=30 keV and θ^2=0.001 from phase-shift analysis. (1966Ba35): E_{res}=8.16 MeV, J^{π}=3/2$^-$ and Γ_{lab}=30 keV. (1972Be15): E_{res}=8.18, Γ_{lab}≈28 keV and Γ_{p1}/Γ=0.72.
10.37×10^3	5/2$^-$	30 keV	3	Γ_{p0}/Γ=0.26 (1968Be31). E(level),J^{π},Γ: From E_{res}≈9130 keV (1968Be31). E(level): In (1966Sw04) a doublet was identified around E_{res}=9.12 MeV. Previously, only the J^{π}=7/2$^-$ state had been identified. Later, (1967Sw02) identified the doublet members at E_p= 9145 and 9152 keV via phase-shift analysis with J^{π}=5/2$^-$ and 7/2$^-$ and with Γ_{lab}=12 and 90 keV, respectively. E(level): In (1968Be31) E_{res}=9.13 MeV, J^{π}=5/2$^-$ from polarization data , Γ_{lab}=33 keV and Γ_{p0}/Γ=0.26. The level energies of the doublet states differ by less than 2 keV. (1961Ad04): E_{res}=9.12 MeV, Γ_{lab}=70 keV. (1961Ba25, 1961Mc11, 1961Mc16): E_{res}=9.2 MeV. (1961Na02): E_{res}=9.1 MeV, Γ=150 keV.
10.37×10^3	7/2$^-$	76 keV	3	Γ_{p0}/Γ=0.81 (1968Be31). E(level),J^{π},Γ: From E_{res}≈9130 keV (1968Be31). E(level): In (1966Sw04) a doublet was identified around E_{res}=9.12 MeV. Previously, only the J^{π}=7/2$^-$ state had been identified. Later, (1967Sw02) identified the doublet members at E_p=9145 and 9152 keV via phase-shift analysis with J^{π}=5/2$^-$ and 7/2$^-$ and with Γ_{lab}=12 and 90 keV, respectively. E(level): In (1968Be31) E_{res}=9.13 MeV, J^{π}=7/2$^-$ from polarization data, Γ_{lab}=82 keV and Γ_{p0}/Γ=0.81. (1961Ad04): E_{res}=9.12 MeV, Γ_{lab}=70 keV. (1961Ba25, 1961Mc11, 1961Mc16): E_{res}=9.2 MeV. (1961Na02): E_{res}=9.1 MeV, Γ=150 keV. (1962Sh22): E_{res}=9.14 MeV, J^{π}=7/2$^-$, Γ=73 keV and θ^2=0.01 from phase-shift analysis. (1966Ba35): E_{res}=9.13 MeV, J^{π}=7/2$^-$ and Γ_{lab}=84 keV.
11.49×10^3 *5*	5/2$^+$	430 keV *35*	2	Γ_{p0}/Γ=0.70 *5* (1973Me03) E(level),J^{π},Γ: From E_{res}=10.35 MeV *5* (1973Me03). In (1976Aj04) values from the E_p=9.5-11.5 MeV phase-shift analysis of (1973Me03) were accepted; we continue this acceptance and note that averaging with other values would have little impact. (1961Mc16): E_{res}=10.3 MeV. (1961Na02): E_{res}=10.5 MeV, Γ=700 keV. (1972Wi26): E_{res}=10.25 MeV *10*, J^{π}=5/2$^+$, Γ=0.45 MeV *10* and Γ_{p0}/Γ=0.65 *15*.

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^{12}C(p,p):res (continued)

^{13}N Levels (continued)

E(level)[†]	J^π	Γ	L	Comments
				(1973Me03): E_{res}=10.35 MeV *5*, J^π=5/2$^+$, $\Gamma_{c.m.}$=430 keV *35* and Γ_{p0}/Γ=0.70 *5*.
11.70×10^3 *3*	5/2$^-$	115 keV *30*	3	Γ_{p0}/Γ=0.60 *4* (1973Me03) E(level),J^π,Γ: E_{res}=10.58 MeV *3* (1973Me03). The E_p=9.5-11.5 MeV phase-shift analysis of (1973Me03) is accepted. See comment on E_x=10.49 MeV. (1961Ad04): E_{res}=10.51 MeV, Γ_{lab}=85 keV. (1961Ba25, 1961Mc11, 1961Mc16): E_{res}=10.5 MeV. (1972Wi26): E_{res}=10.51 MeV *2*, J^π=5/2$^-$, Γ=120 keV *30* and Γ_{p0}/Γ=0.55 *5*. (1973Me03): E_{res}=10.58 MeV *3*, J^π=5/2$^-$, $\Gamma_{c.m.}$=115 keV *30* and Γ_{p0}/Γ=0.60 *4*.
11.74×10^3 *4*	3/2$^+$	250 keV *30*	2	Γ_{p0}/Γ=0.30 *5* (1973Me03) E(level),J^π,Γ: E_{res}=10.62 MeV *4*, J^π=3/2$^+$, $\Gamma_{c.m.}$=250 keV *30* and Γ_{p0}/Γ=0.30 *5* from the E_p=9.5-11.5 MeV phase-shift analysis of (1973Me03) are acccepted. See comment on E_x=10.49 MeV. See also E_{res}=10.70 MeV *5*, J^π=3/2$^+$, Γ=250 keV *50* and Γ_{p0}/Γ=0.62 *10* (1972Wi26).
11.74×10^3 *5*	3/2$^-$	530 keV *80*	1	Γ_{p0}/Γ=0.55 *5* (1973Me03) E(level),J^π,Γ: E_{res}=10.62 MeV *5*, J^π=3/2$^-$, $\Gamma_{c.m.}$=530 keV *80* and Γ_{p0}/Γ=0.55 *5* from the E_p=9.5-11.5 MeV phase-shift analysis of (1973Me03) are acccepted. See comment on E_x=10.49 MeV. See also E_{res}=10.54 MeV *50*, J^π=3/2$^-$, Γ=230 keV *50* and Γ_{p0}/Γ=0.45 *10* (1972Wi26).
11.86×10^3 *4*	1/2$^+$	380 keV *50*	0	Γ_{p0}/Γ=0.35 *5* (1973Me03) E(level),J^π,Γ: E_{res}=10.75 MeV *4*, J^π=1/2$^+$, $\Gamma_{c.m.}$=380 keV *50* and Γ_{p0}/Γ=0.35 *5* from the E_p=9.5-11.5 MeV phase-shift analysis of (1973Me03) are acccepted. See comment on E_x=10.49 MeV. See also E_{res}=10.74 MeV, Γ_{lab}=140 keV (1961Ad04).
12.13×10^3 *5*	7/2$^-$	250 keV *30*	3	Γ_{p0}/Γ=0.30 *5* (1973Me03) E(level): From E_{res}=11.05 MeV *5* (1973Me03). The E_p=9.5-11.5 MeV phase-shift analysis of (1973Me03) is acccepted. See comment on E_x=10.49 MeV. (1961Ad04): E_{res}=10.99 MeV, Γ_{lab}= 150 keV. (1961Mc16) E_{res}=11.0 MeV. (1973Me03): E_{res}=11.05 MeV *5*, J^π=7/2$^-$, $\Gamma_{c.m.}$=250 keV *30* and Γ_{p0}/Γ=0.30 *5*.
13.5×10^3		≈500 keV		E(level),Γ: From E_p=12.5 and Γ=500 keV (1961Na02).
14.05×10^3 *2*	3/2$^+$	180 keV *35*	2	T=1/2; Γ_{p0}/Γ=0.29 *7* E(level),J^π,Γ: From E_{res}=13.13 MeV *2*, J^π=3/2$^+$, $\Gamma_{c.m.}$=180 keV *35* and Γ_{p0}/Γ=0.29 *7* phase-shift analysis (1976Me18). The authors suggest a ≤70 keV systematic error in (1969Le18). See also E_{res}=13.2 MeV, Γ=500 keV (1961Na02).
14.7×10^3?		≈500 keV		E(level): See E_{res}=13.7 MeV, Γ=500 keV (1961Na02). This resonance does not appear in the (1981Aj01) evaluation or later.
15064.56 *40*	3/2$^-$	0.932 keV *28*	1	T=3/2 Γ_p=263 eV *14* (1980Th05) E(level),T: From E_p=14230.75 keV *20* and T=3/2 (1973Hu07). E(level): See also E_p=14232.5 keV *22* (1975Go03); Γ_p/Γ=0.18 was used in the fit. Γ: From Γ=1010 eV *30* and Γ_p=285 eV *15* (both lab frame) (1980Th05). Atomic excitations were taken into account, See also (1983Wi04,1992Wi13). Γ: See also $\Gamma_{c.m.}$=1.10 keV *9*, Γ_p=210 eV *11* and Γ_p/Γ=0.191 *17* (1975Hi07). J^π: From phase-shift analysis in (1969Le18). p decay to ^{12}C(0,4.4, 7.65, 9.65) is observed in (1977Ma16).

Continued on next page (footnotes at end of table)

^{12}C(p,p):res (continued)

^{13}N Levels (continued)

E(level)[†]	J^π	Γ	L	Comments
16.01×10^3 *4*	7/2$^+$	135 keV *90*	4	T=1/2; Γ_{p0}/Γ=0.05 *4* E(level): From average of E_{res}=15.27 MeV *3* (1973Me12) and E_{res}=15.24 MeV *4* (1976Me18). J^π: From phase-shift analysis in (1969Le18). Γ: From (1973Me12). See also (1976Me18). E(level): A second state near E_x=16 MeV with Γ≈500 keV had previously been adopted, apparently based on (1964Da03) and (1961Na02); however this seems unwarranted. In (1964Da03) the authors indicate improved data are necessary, and in (1961Na02,1967Ku02,1976Be28) the associated peaks are rather narrow. (1973Me12): E_{res}=15.27 MeV *3*, $\Gamma_{c.m.}$=130 keV *30* and Γ_p(12.71)=30 keV. (1976Me18): E_{res}=15.24 MeV *4*, J^π=7/2$^+$, $\Gamma_{c.m.}$=135 keV *90* and Γ_{p0}/Γ=0.05 *4*. (1961Na02): E_{res}=15.1 MeV (1961Na02). (1967Ku02): E_p=15.2 MeV and T=(1/2) (1967Ku02). (1976Be28) E_p=15.27 MeV (1976Be28).
17.4×10^3				E(level): From E_p=16.8 MeV (1976Be28).
18.15×10^3 *3*	3/2$^+$	322 keV *75*	2	T=1/2; Γ_{p0}/Γ=0.08 *2* E(level),J^π,Γ: From E_{res}=17.58 MeV *3* phase-shift analysis in (1976Me18). (1962Wa31): E_p=17.5 MeV and $\Gamma_{c.m.}$=0.33 MeV *10*. (1976Me18): E_{res}=17.58 MeV *3*, J^π=3/2$^+$, $\Gamma_{c.m.}$=322 keV *75* and Γ_{p0}/Γ=0.08 *2*. See also table 13.25 of (1970Aj04) where Ep=17.27 MeV *5* and $\Gamma_{c.m.}$≈400 keV from (1968Sn03) and a 1968 Private Communication with Snover are referenced.
18.17×10^3 *2*	1/2$^-$	225 keV *50*	1	T=1/2; Γ_{p0}/Γ=0.24 *6* E(level),J^π,Γ: From E_{res}=17.60 MeV *2*, J^π=1/2$^-$, $\Gamma_{c.m.}$=225 keV *50* and Γ_{p0}/Γ=0.24 *6* phase-shift analysis in (1976Me18). E(level): See also E_p=17.6 MeV and T=(1/2) (1967Ku02).
18405 *5*	3/2$^+$	66 keV *8*	2	T=3/2 E(level),Γ: From E_p=17.857 MeV in (1970Aj04) Table 13.25. E(level): In (1970Aj04), E_p=17857 keV *5* and Γ=66 keV *8* are given in Table 13.25; the values appear connected with (1968Sn03) a 1968 Private Communication with Snover. J^π: From phase-shift analysis in (1969Le18). (1967Ku02): E_x=18.43 MeV *2*, Γ≈30 and T=3/2. (1962Wa31): E_p=18.05 MeV and $\Gamma_{c.m.}$≤200 keV. (1976Be28): E_p=17.87 MeV.
18960 *9*	3/2$^-$ or 7/2$^+$	23 keV *5*		T=3/2 E(level),Γ: From E_p=18.460 MeV in (1970Aj04) Table 13.25. E(level): In (1970Aj04), E_p=18460 keV *10* and Γ=23 keV *5* are given in Table 13.25; the values appear connected with (1968Sn03) and a 1968 Private Communication with Snover. J^π: From phase-shift analysis in (1969Le18). (1967Ku02): E_x=18.98 MeV *2*, Γ≈10 keV, L=(1) and T=3/2. (1976Be28): E_p=18.46 MeV.
19.9×10^3	7/2$^+$	750 keV	4	T=1/2 E(level),J^π,Γ: From E_x=19.9 MeV, J^π=7/2$^+$, Γ=0.75 MeV polarization data in (1979Ga13); see also E_p=19.3 MeV and $\Gamma_{c.m.}$≤200 keV (1962Wa31). E(level): Several earlier Ajzenberg-Selove evaluations associate this state with resonances observed near $E_{c.m.}$=19.8 MeV; see (1965Ma26,1966Lo16,1967Sc11), but these appear to be misplaced.

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^{12}C(p,p):res (continued)

^{13}N Levels (continued)

E(level)†	J^π	Γ	Comments
20.2×10^3	$5/2^-$	1000 keV	E(level),J^π,Γ: From E_x=20.2 MeV, $J^\pi=5/2^-$, Γ=1.0 MeV polarization data in (1979Ga13). E(level): See also (1963Me04) who suggested resonances near E_p=20 MeV based on their analysis of ^{12}C(p,p′γ(12.7,15.1)).
20.90×10^3 *30*	$1/2^+$	1.2 MeV	E(level): From E_p=20.5 MeV *30* (1973Me12). J^π,Γ: From E_x=20.9 MeV polarization data in (1979Ga13). (1966Lo16): $E_{c.m.}$=19.0 MeV, J^π=(5/2,9/2) and Γ=1.5 MeV. (1967Sc11) find E_x=20.9 MeV, $J^\pi=5/2^+$, L=2,0. (1973Me12): E_p=20.55 MeV *30*, $J^\pi=(5/2^+)$, Γ=1.1 MeV, $\Gamma_{p0}\approx$110 keV, $\Gamma_{p15.11}\approx$400 keV. (1976Fe11): E_p=20 MeV. (1976Be28): E_p=20.5 MeV, $J^\pi=(3/2^+)$. (1979Ga13): E_x=20.9 MeV, $J^\pi=1/2^+$, Γ=1.2 MeV. See (1963Me04) who suggested a resonance near E_p=20 MeV Based on their analysis of ^{12}C(p,p′γ(12.7,15.1)).
21.4×10^3	$5/2^-$	750 keV	E(level),J^π,Γ: From E_x=21.4 MeV, $J^\pi=5/2^-$, Γ=0.75 MeV polarization data in (1979Ga13).
21.7×10^3	$(3/2^+)$		E(level): From (1964Ta15) analysis of (1963Di16) $E_{c.m.}$=19.75 MeV, $J^\pi=(3/2^+)$ and $\Gamma_{c.m.}$=2.49 MeV are deduced. (1965Ma26):See $E_{c.m.}$=19.8 MeV. (1979Ga13): polarization data suggest a state around 21.7 MeV with $J^\pi=3/2^+$.
22.4×10^3 *5*	$1/2^+$	≈1 MeV	E(level): From E_p=22.2 MeV *5* (1973Me12). J^π,Γ: From E_x=22.4 MeV polarization data in (1979Ga13). E(level): Resonances at several energies around E_x=22 MeV have been reported in (1963Di16, 1964Ta15, 1965Ma26, 1967Sc11). In (1970Aj04) Table 13.25 proton resonances were listed at E_x=21.99 and 22.6 MeV. However, guided by the discussion and analysis of (1979Ga13, 1981Aj01), we accept only the E_x=22.4 MeV $J^\pi=1/2^+$ state. Along with the accepted states reported in (1979Ga13), their analysis indicated additional states around 21.7 with $J^\pi=3/2^+$ and above 22.7 with $3/2^+$. (1964Ta15) analysis of (1963Di16): $E_{c.m.}$=20.05 MeV, $J^\pi=(5/2^+)$ and $\Gamma_{c.m.}$=1.46 MeV. (1965Ma26): $E_{c.m.}$=20.01 MeV. (1967Sc11): E_x=22.5 MeV, $J^\pi=5/2^-$, L=1. (1966Lo16): $E_{c.m.}$=20.8 MeV, J^π=(5/2,9/2) and Γ=0.5 MeV. (1973Me12): E_p=22.2 MeV *5*, $J^\pi=(5/2^-)$, Γ≈2 MeV, $\Gamma_{p0}\approx$200 keV, $\Gamma_{p15.11}\approx$450 keV. (1979Ga13): E_x=22.4 MeV, $J^\pi=1/2^+$, Γ≈1.0 MeV.
24.1×10^3	7/2	<500 keV	E(level),J^π,Γ: From $E_{c.m.}$=22.2 MeV, J^π=7/2 and Γ=0.5 MeV polarization data in (1966Lo16). E(level): See also E_p=23.8 MeV (1975Sl02).
25.6×10^3	$(3/2^-)$		E(level): From average of E_x=25.5 MeV (1967Sc11) and E_p=25.9 MeV (1975Sl02). J^π: From E_x=25.5 MeV, $J^\pi=3/2^-$, L=1 Legendre polynomial angular correlation analysis in (1967Sc11).
26.87×10^3			E(level): From (1964Ta15) analysis of (1963Di16) where $E_{c.m.}$=24.93 MeV and $\Gamma_{c.m.}$=2.17 MeV are deduced. (1965Ma26): $E_{c.m.}$=24.9 MeV (1965Ma26). (1976Fe11): E_p=27 MeV.
31.4×10^3			E(level): From E_p=32 MeV (1976Fe11); seen only in ^{12}C(p,p′γ(4.44)).

† Level energies are deduced using E_p(res) and ^{12}C, p and ^{13}C masses from (2021Wa16: AME-2020). $E_x=S_p+E_{c.m.}$(relativistic).

^{12}C(p,α):res

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1969Le18: ^{12}C(p,α) E=9.4-21.5 MeV; measured σ(E,θ) for θ=25° to 165°. Deduced resonance in $\alpha_{0,1}$ at E_p=14.231 MeV *4* with Γ=1.22 keV and Γ_{p0}=0.25 keV. The analysis is coupled with their associated (p,p) data. In (1970Aj04) the full collection of states given in Table 1 of (1969Le18) are associated with the (p,α) reaction; but this seems arbitrary given their θ=60° data shown in Fig 7. Isospin values are discussed. The results shown in Table 1 include ^{13}N states from E_x=13.96 to 19.88 MeV that were studied via phase-shift analysis. The complex of states around E_p=10.5 to 11 MeV were analyzed, but no results could be obtained.

1975Hi07: ^{12}C(p,α), ^{12}C(p,p) E=14.222-14.242 MeV; measured σ(E) at θ=175°. Analyzed ^{13}N*(14.07) mainly from (p,p). They deduced Γ=1.10 keV *9*, Γ_p=210 eV *11* and Γ_p/Γ=0.191 *17*. Analyzed other level decay properties such as partial widths, but they used branching ratios from (1973Ad02) with their Γ and Γ_p.

See also.
1964Ba29: ^{12}C(p,α) E=12.7-18.3 MeV; studied ^{9}B states.
1965Is05: ^{12}C(p,α), (p,p′) E=13 MeV; measured $\sigma(E_\alpha,\theta)$, $\sigma(E_p,\theta)$.
1967Ac01: ^{12}C(p,α) E=38 MeV; measured $\sigma(E_\alpha,\theta)$.
1967Cr05: ^{12}C(p,α) E=30.5-45.1 MeV, measured $\sigma(E_\alpha,\theta)$ for $\theta\approx$20° to 173°.
1969Ga03: ^{12}C(p,α) E=38 MeV; measured $\sigma(E_\alpha,\theta)$ for $\theta\approx$20° to 180°. PWBA analysis.
1970Gu06, 1971Gu23: ^{12}C(p,α_0) E=25-45 MeV; measured σ(E,θ) θ=20° to 170°. Discussed reaction mechanism.
1970Ko25: ^{12}C(p,α) E=665 MeV; measured σ(E).
1972Ma21: ^{12}C(p,α) E=54.1 MeV; measured $\sigma(E_\alpha,\theta)$ for θ=10° to 60°.
1980Da07: ^{12}C(p,α) E=45.2 MeV; measured $\sigma(E_\alpha,\theta)$ for θ=20° to 50°. Analyzed data via finite range DWBA.
1981Do13: 12C(pol. p,α_0) E=72 MeV; measured $\sigma(\theta)$, $A_y(\theta)$ for θ=20° to 150°. Deduced reaction mechanism.
1983Pe07: ^{12}C(p,α) E=42.77 MeV; measured $\sigma(E_\alpha,\theta)$ for θ=15° to 75°. Deduced optical model parameters.
1989Gu05: ^{12}C(p,α) E=50 MeV; measured $\sigma(\theta)$.

^{13}N Levels

E(level)†‡	J^π‡	Γ‡	E_{res} (keV)	Comments
13962?	3/2$^+$	140 keV	13035	Γ_{p0}=126 keV (1969Le18)
15064 *4*	3/2$^-$	1.10 keV *9*	14231 *4*	Γ_{p0}=210 eV *11* T=3/2 Γ,Γ_{p0}: From (1975Hi07) analysis (p,p) and (p,α) data. E(level): From (1969Le18); see also Γ=1.22 keV and Γ_p=0.24 keV from their analysis of (p,p) and (p,α) data.
15975?	7/2$^+$	100 keV	15220	Γ_{p0}=7.5 keV (1969Le18)
18232	1/2$^-$	300 keV	17670	Γ_{p0}=120 keV (1969Le18)
18352	3/2$^+$	100 keV	17800	Γ_{p0}=25 keV (1969Le18)
18960	(3/2$^-$,7/2$^+$)	15 keV	18459	$\Gamma_{p0}\approx$0.30 keV (1969Le18)
19.83×10^3	5/2$^-$	1 MeV	19.4×10^3	Γ_{p0}=175 keV (1969Le18)
19.88×10^3	3/2$^+$	520 keV	19.46×10^3	Γ_{p0}=208 keV (1969Le18)

† Level energies are deduced using E_p(res) and ^{12}C, p and ^{13}C masses from (2021Wa16: AME-2020). $E_x=S_p+E_{c.m.}$(relativistic).
‡ From phase-shift analysis in (1969Le18).

^{12}C(d,n)

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1948Co24: ^{12}C(d,n) E=12 MeV at the Indiana University cyclotron. Measured β end point and deduced $T_{1/2}$=10.2 min *1*.
1949Gr29: ^{12}C(d,n). Reported states at E_x=2.29 MeV *12*, 3.48 MeV *12* and 3.74 MeV *5*.
1950Ho01: ^{12}C(d,n). Measured β spectrum and end-point energy; deduced $T_{1/2}$=10.05 min *10*.
1953Mi10: ^{12}C(d,n) E=8 MeV; measured $\sigma(\theta)$ for θ=0° to 60°. Deduced ^{13}N*(0,2.38 MeV *5*,3.53 MeV *5*) with L=1, 0 and 2(doublet), respectively.
1955Ma76: ^{12}C(d,n) E≈ 3 MeV; investigated threshold region. Deduced E_x=2.37 MeV *2*.
1955Wi43: ^{12}C(d,n) E≤20 MeV; measured activation cross section. Deduced $T_{1/2}$=10.08 min *4* from analysis of the 14.1 MeV data.
1959El44: ^{12}C(d,n) E=1.45-2.95 MeV; measured $\sigma(\theta)$ for θ=0° to165°.
1957Ca02: ^{12}C(d,$n_{0,1,2+3}$) E=1.45-2.95 MeV; measured $\sigma(\theta)$ for θ<60°. Deduced level energies, L, J^π, $\sigma(\theta=0)$, reduced widths.
1957Da08, 1959Da09: ^{12}C(d,n) E=7 MeV; measured β spectrum. Deduced Fierz coefficient, b=0.14% *237* and $T_{1/2}$=9.96 min *3*.
1957De22: ^{12}C(p,γ) and (d,n); measured activation cross sections in the few hundred keV range. Deduced $T_{1/2}$=10.02 min *10*.
1960Bu15: ^{12}C(d,n) E=12.9 MeV; measured polarization of neutrons to various states for θ=15°.
1960Ja12: ^{12}C(d,n) measured $T_{1/2}$ of superallowed β emitters. Summarize $T_{1/2}$ early measurements on ^{13}N made between 1939 and 1958. Their work gives $T_{1/2}$=597.9 sec *3*. Measurement carries a significant weight. (German/Heidelberg text).
1961Ja08: ^{12}C(d,n_0) E=0.7-1.3 MeV at the Cambridge accelerator. Measured $\sigma(\theta)$ for θ=0° to 150°.
1963Bu24: ^{12}C(d,n) E=12.8 MeV; measured $\sigma(\theta)$ for θ=0° to 150°. Deduced optical model parameters.
1963Ko24: ^{12}C(d,n) measured $\sigma(\theta)$.
1965Ke10: ^{12}C(d,n) E=4,5,6,7,7.5 MeV; measured polarization obserables for θ=20° to 80°.
1966La18: ^{12}C(d,pn) E=5.39 MeV; measured $\sigma(E_p, \theta_n, \theta_p)$ deduced τ≈0.7E−20 sec for states in the region of ^{13}N*(3.5 MeV).
1966Gu04: ^{12}C(d,n_0) E_d=2.7-3.2 MeV. Studied ^{14}N resonances.
1966Ho11: ^{12}C(d,$n_{0,1}$) E_d=3.8-5.0 MeV; measured yield curves for θ=5° to 150°.
1966Sa05: ^{12}C(d,n_0) E_d=2.8-4.2 MeV; measured $\sigma(\theta)$ and polarization observables for θ=10° to 130°.
1967Fu03: ^{12}C(d,n_0) E_d=3.8-4.2 MeV; measured σ(E).
1967Wo07: ^{12}C(d,n) E=0.4-3.0 MeV; measured σ(E).
1968Do09: ^{12}C(d,n) E=5.2-6.2 MeV; measured polarization observables to ^{13}N*(0, 2.37 MeV) for θ=10° to 130°.
1968Ri15: ^{12}C(d,n) E=3.0 MeV; measured $T_{1/2}$=9.963 min *9*.
1969Ch04: ^{12}C(d,n) E=0.5-0.8 MeV; measured $\sigma(\theta)$ for θ=5° to 160°. Deduced optical model parameters.
1970Ga07: ^{12}C(d,n_0) E=12, 15 and 17 MeV; measured $\sigma(\theta)$ for θ=30° to 150°; list tabular data. Deduced optical model parameters and spectroscopic factors. Ground state S(12 MeV)=1.35; S(15 MeV)=1.29; S(17 MeV)=0.78.
1970Ba63: ^{12}C(d,n) E=6.4 MeV; measured neutron polarization.
1971Hi09: ^{12}C(d,n_0) E=8.5 MeV. Measured neutron polarization for θ=2.5° to 70°.
1971Ja17: ^{12}C(d,n) E=2.17, 2.96 MeV; measured polarization observables at θ=20°.
1971Mu18: ^{12}C(d,$n_{0,1,2+3}$) E=11.8 MeV; measured $\sigma(E,\theta)$ for θ=20° to 170°. Deduced level energies and spectroscopic factors. Tabular data provided.
1973Cl04: ^{12}C(d,n) E=3.3,3.4 MeV; measured $\sigma(E_n)$, deduced Γ(^{13}N*(2366))=36.15 keV *54*. Discussed all previous data on Γ(2366); analyzed width dependence on reaction.
1975Ka26:^{12}C(d,n) E=1.86 MeV; measured polarization observables at θ=5°.
1975Az02: ^{12}C(d,$n_{0,1,2+3}$) 15.25 MeV; measured $\sigma(E,\theta)$ for θ=0.3° to 99°.
1975Bo32,1975Bo35: ^{12}C(d,$n_{0,1,2+3}$) E=6.3 MeV; measured $\sigma(E,\theta)$ for θ=0° to 82.5°. Analyzed shape of the ^{13}N*(2364) state.
1976Te03: ^{12}C(d,$n_{0,1}$) E=5.7-9.7 MeV; measured $\sigma(E,\theta)$ and polarization observables over θ=5° to 35°.
1981Li23: ^{12}C(vec d,$n_{0,1}$) E=6-14 MeV; measured θ=0° polarization transfer.
1981Sh22: ^{12}C(d,n_0) E=7-10 MeV; measured $\sigma(E,\theta=0°)$: thick target yield.
1984Sc04: ^{12}C(d,$n_{0,1,2+3}$) E=7-13 MeV; measured $\sigma(E,\theta)$ for θ=5° to 160°; deduced optical model parameters and S=0.34 and 0.28 for ^{13}N*(0, 2.36), respectively.
1987Ie02: ^{12}C(d,n_0) E=25 MeV; measured polarization observables for θ=10° to 90°.
1987KaZL, 1988Ka30: ^{12}C(d,$n_{0,1}$) E=18 MeV; analyzed Γ(2.36)=54 keV.
1990Mi11: ^{12}C(d,n) E=0.5-6 MeV; measured σ(E) via activation technique.
1991Fi05, 1991Fi11: ^{12}C(d,n) E=1-23 MeV; measured σ(E), thick target.

^{12}C(d,n) (continued)

2020Ge10: ^{12}C(d,n) E=1-12 MeV; measured thick target yields.
2021Su11: ^{12}C(d,n) E≈200 MeV; analyzed neutron energy spectrum.
Theory:
1958Mc63: Analyzed ^{13}C and ^{13}N ground state reduced widths. Found consistency; see additional references within.
1968Ba47: ^{12}C(d,n) E=3-12 MeV; calculated polarization observables.
1972Pe11: Analyzed spectroscopic factors between 4 and 20 MeV.
1974Bo52, 1974Bo53: ^{12}C(d,n); calculated $\sigma(\theta)$.
1978Ba21: ^{12}C(d,n$_{0,1}$) E=6.3 MeV; analyzed resonant and non-resonant σ(E,θ).
1983Mu13: ^{12}C(d,n), (^{3}He,d); analyzed data.
1984Bl21: ^{12}C(d,n); calculated $\sigma(\theta)$.
2015De38: ^{12}C(d,n) 3-body model analysis of (d,n) and (d,p) reactions.
2016Na23, 2016NaZT: ^{12}C(d,n); calculated σ(E), deduced spectroscopic factors.
2016No14: ^{12}C(d,n); calculated σ(E) using TALYS.
2017De20: ^{12}C(d,n); analyzed $\sigma(\theta)$ for E=7, 12, 18 and 25 MeV.
2024Ol01: ^{12}C(d,n); calculated σ(E) for E≤200 MeV and σ(E,θ) for E≤100 MeV and θ=15°, 30°, 45° and 60°. Compared PHITS reaction code with experimantal results.

^{13}N Levels

E(level)†	J$^{\pi}$†	T$_{1/2}$	L†	S†	Comments
0	1/2^{-}	9.963 min *9*	1	0.74	T$_{1/2}$: From T$_{1/2}$=597.9 s *3* (1960Ja12), T$_{1/2}$=9.963 min *9* (1968Ri15). S: From (1971Mu18). See also S=0.34 (1984Sc04).
2.36×10^{3} *2*	1/2^{+}	36.15 keV *54*		1.02	E(level): From (1955Ma76). T$_{1/2}$: Γ$_{c.m.}$ from 1973Cl04. S: From (1971Mu18). See also S=0.25 (1984Sc04).
3.51×10^{3}	(3/2^{-})			0.13	E(level): Doublet (1966La18).
3.55×10^{3}	(5/2^{+})			0.87	E(level): Doublet (1966La18).

† From DWBA analysis of spectroscopic factors in (1971Mu18).

^{12}C(^{3}He,d)

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1960Hi07: ^{12}C(^{3}He,d$_0$) E=5.98-10.14 MeV; measured angular distributions and excitation function; θ=10° to 125°.
1960Pr12: ^{12}C(^{3}He,d$_0$) E=13.9 MeV; measured $\sigma(\theta)$ for θ=10° to 150°.
1960We04: ^{12}C(^{3}He,d) E=21,25 MeV; measured angular distributions of ^{13}N*(0, 2.36, 3.50, 3.54) for θ=5° to 170°. Deduced L.
1967Ha21: ^{12}C(^{3}He,d) E=24.8 MeV; measured $\sigma(\theta)$ for recoil ^{13}N nuclei, θ=10° to 40°.
1969Fo02: ^{12}C(^{3}He,d0,1,2+3,4,5,6,7) E=12−19 MeV; measured σ(E,E$_d$,θ) for θ=10° to 170°. Deduced level energies, J^π, Γ, θ^2_p.
1970Si15: ^{12}C(^{3}He,d) E=6.5-30.6 MeV; measured σ(E), failed to observe significant structure in the excitation function.
1971St21: ^{12}C(^{3}He,d$_{0,2+3}$) E=40 MeV; measured $\sigma(\theta)$ for θ=5° to 40°.
1974Bl06: ^{12}C(^{3}He,d) E=12-15 MeV; measured σ(E,E$_d$,θ) for θ=60°, 90° and 120°. Deduced resonance widths.
1976Ka23: ^{12}C(vec ^{3}He,d) E=33.3 MeV; measured $\sigma(\theta)$, A(θ). for θ=10° to 90°. Deduced ground state deduced S=0.68.
1976Ko36: ^{13}C(^{3}He,d$_{0,1,2+3}$) E=81.4 MeV; measured σ(E$_d$,θ) for θ=5° to 70°. Deduced levels, optical model parameters.
1977Bo30: ^{12}C(^{3}He,d) E=8.8-14 MeV; analyzed $\sigma(\theta)$, deduced ground state S.
1978Ma42: ^{12}C(^{3}He,d) E=70 and 90 MeV; measured σ(E$_d$,θ=13°).
1979Fu03: ^{12}C(^{3}He,d) E=36.0 MeV; measured σ(E$_d$,θ) for θ=7° to 20°, deduced reaction mechanism, level energies.
1979Se07: ^{12}C(^{3}He,d) E≈25.4 MeV analyzed $\sigma(\theta)$ for θ=0° to 50°. Deduced S for lowest four states.
1980Pe13: ^{12}C(^{3}He,d) E=43.6 MeV; measured σ(E$_d$,θ). for θ=0° to 80°. Deduced reaction mechanism, J, π, S. 2-step DWBA model analysis.
1982Co20: ^{12}C(^{3}He,d) E=36 MeV, calculated σ(E$_d$), DWBA.
1983Ca07: ^{12}C(^{3}He,d) E=13 MeV; measured σ(E$_d$,θ) for θ=4.8 to 12°. Analyzed continuum region.
1983Mu13: ^{12}C(d,n), (^{3}He,d) analyzed data.
1984Ca06: ^{12}C(^{3}He,d) E=13 MeV; measured $\sigma(\theta)$ for θ=10° to 170° deduced levels, S. DWBA analysis.
1989Li06: ^{12}C(^{3}He,d) E=0.4-14 MeV; measured σ(E), activation.
1995Da08, 1995Da21: ^{12}C(^{3}He,d) E=90, 98 MeV; measured $\sigma(\theta)$ for θ≈20°−60°. Analyzed nuclear-rainbow effects.
1996Ar07: ^{12}C(^{3}He,d) E=22.3-34 MeV; measured σ(E$_d$,θ). at forward angles. DWBA analysis; deduced S, reaction mechanism.
1997Ya06: ^{12}C(^{3}He,d) E=34 MeV; analyzed 3-body Coulomb effects in proton transfer. Deduced nuclear vertex constant.
2002Ar22: ^{12}C(^{3}He,d) E=22.3 MeV; measured $\sigma(\theta)$. Analyzed 3-particle Coulomb effects. Deduced nuclear vertex constants.
2022Ko25: ^{12}C(^{3}He,d) E=81.4 MeV; calculated σ(E$_d$,θ) using eikonal approximation and folding model. Compared results with (1976Ko36).

^{13}N Levels

E(level)[†]	J^π[†]	Γ	L	S[†]	Comments
0[#@]	1/2$^-$[@]		1[‡]	0.48	S: See also S=0.81 (1979Se07) and S=0.76-1.13 (1984Ca06).
2368.2[#@] *28*	1/2$^+$[@]	36.1 keV *28*	0[‡]	0.14	E(level),Γ: From (1974Bl06). S: See also S=0.23 (1979Se07) and S=0.28-0.66 (1984Ca06).
3507.8[#] *76*	3/2$^-$	55 keV *12*			E(level),Γ: From (1974Bl06). S: See S=(0.69) (1979Se07) and S=0.05-0.08 (1984Ca06).
3549.1[#@] *50*	5/2$^+$[@]	46.5 keV *71*		0.53	E(level),Γ: From (1974Bl06). S: See also S=(1.76) (1979Se07) and S=0.34-0.58 (1984Ca06).
6.36×10^3[#&]	5/2$^+$			0.007	
6.89×10^3[#&]	3/2$^+$			0.015	
7.16×10^3[#&]	7/2$^+$			<0.009	J^π: See J^π=1/2$^+$ in (1969Fo02).
7.38×10^3[#&]	5/2$^-$			0.024	
8.0×10^3[@]	3/2$^+$[@]			0.13	E(level): Not seen in (1969Fo02).
8.92×10^3[#]	1/2$^-$			<0.005	
9.0×10^3	9/2$^+$	400 keV *50*		<0.005	Γ: From (1969Fo02).
9.48×10^3	3/2$^-$			<0.002	

Continued on next page (footnotes at end of table)

$^{12}C(^{3}He,d)$ (continued)

^{13}N Levels (continued)

E(level)[†]	J^{π}[†]	Γ	S[†]	Comments
10.36×10^{3}[@]	$(5/2^-,7/2^-)$[@]		<0.001	
10.78×10^{3}	$1/2^-$	75 keV *15*	0.064	Γ: From (1980Pe13).
11.1×10^{3}[@]	$(5/2^-)$[@]			
12.08×10^{3}[@]	$(7/2^-)$[@]			

[†] From DWBA analysis of spectroscopic factors in (1980Pe13) unless indicated otherwise.
[‡] From (1960We04).
[#] Reported in (1969Fo02).
[@] Reported in (1976Ko36).
[&] Reported in (1979Fu03).

^{12}C(α,t) 1972Ha08

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1969Ga11: ^{12}C(α,t) E=56 MeV; measured $\sigma(\theta,E_{t0})$ for θ=10° to 60°.
1972Ha08: ^{12}C(α,t) E=104 MeV; measured $\sigma(\theta,E_{t0})$ for θ=10° to 70°. Compared with (α,^{3}He) cross sections. Deduced absolute S=1.48.
1990Go05: ^{12}C(α,t) E=160 MeV; measured $\sigma(E_{t0},\theta=20.7°)$.
1994Da32: ^{12}C(α,t) E=90 MeV; measured $\sigma(\theta,E_{t0})$ for $\theta\approx20°-80°$; analyzed nuclear rainbow effects.

^{13}N Levels

E(level)	J$^{\pi}$	L	S	Comments
0	1/2^{-}	1	1.82	J$^{\pi}$,L,S: From DWBA analysis in (1972Ha08).

^{12}C(^{7}Li,^{6}He)

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1973Sc26: ^{12}C(^{7}Li,^{6}He) E=36 MeV; measured σ(E(^{6}He),θ) for θ=15° to 60°. Deduced L, Spectroscopic factors.
1979Ze01: ^{12}C(^{7}Li,^{6}He) E=48 MeV; measured σ(E(^{6}He),θ) for θ=5° to 40°. Deduced S.
1986Co02: ^{12}C(^{7}Li,^{6}He) E=34 MeV; measured σ(E(^{6}He),θ). for θ=15° to 100°. Deduced S.
2002Ke04: ^{12}C(pol. ^{7}Li,^{6}He) E=34 MeV; measured σ(E(^{6}He),θ) and polarization observables for $\theta\approx$15°−70° to ^{13}N*(0, 3.51+3.55).
2010Li38: ^{12}C(^{7}Li,^{6}He) E=44 MeV; measured σ(E(^{6}He),θ) for θ=10° to 35°. Deduced ANC and ^{12}C(p,γ) astrophysical S-factor.

^{13}N Levels

E(level)†	J$^{\pi}$	L	S	Comments
0	1/2^{-}	1,2	0.613	J$^{\pi}$,L,S: From finite-range DWBA (1973Sc26:E=36 MeV); see also S=0.72 from (1979Ze01:E=48 MeV) and S=0.38 *5* from (1986Co02:E=34 MeV).
2367				
3.51×10^{3}				
3.55×10^{3}				

† Values listed in (1973Sc26).

^{12}C(^{10}B,^{9}Be)

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1965Sa07: ^{12}C(^{10}B,^{9}Be) E=105 MeV; populated ground state and unresolved states at E_x=3.5 MeV.
1974Na20: ^{12}C(^{10}B,^{9}Be) E=100 MeV. Measured $\sigma(\theta)$ for θ=10° to 40°, deduced level energies. Considered model dependencies for S.
2022Ar03: ^{12}C(^{10}B,^{9}Be) E=41.3 MeV; measured $\sigma(\theta)$ for θ=7° to 51°. Analyzed data using a modified DWBA; deduced p+^{12}C→^{13}N ANC and analyzed astrophysical reaction rates. The study included a reanalysis of the collection of low-energy (p,γ) data resulting in Γ_p=33.5 keV *10*, 46.0 keV *34* and 280 keV *50* and Γ_γ=0.63 eV *7*, 0.35 eV *8* and 2200 eV *500* for ^{13}N*(2.36, 3.50, 10.26), respectively. Note: the tail of the 10.26 MeV state is fit using data below the E_x=2 MeV region.
1975Ra13: DWBA analysis of (1974Na20) data.
1976Ku06: DWBA analysis of ^{13}N*(2.37 MeV) data from (1974Na20).
2000Fe08: ^{12}C(^{10}B,^{9}Be) E=100 MeV; analyzed ANC method.

^{13}N Levels

E(level)†
0
2.37×10^3
3.51×10^3‡
3.55×10^3‡
6.9×10^3‡
7.17×10^3‡
7.39×10^3‡
8.82×10^3

† From (1974Na20).
‡ Unresolved.

^{12}C(^{11}B,^{10}Be)

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1965Sa07, 1967Po13: ^{12}C(^{11}B,^{10}Be) E=116 MeV; populated ground state and unresolved states at E_x=3.5 MeV.

1974An36: E=114 MeV; measured σ. Analyzed the reaction mechanism, which was found to be mostly direct. Developed a dynamical nuclear reaction theory and compared with DWBA in this review article. Analysis includes ^{11}B(^{12}C,^{10}Be), ^{11}B(^{11}B,^{9}Li), ^{12}C(^{11}B,^{10}Be), ^{12}C(^{12}C,^{11}B), ^{12}C(^{14}N,^{13}C).

^{13}N Levels

E(level)	J^{π}†	L†	S†	Comments
0‡#@&a	1/2$^-$	2	1.2	
3.51×10^3‡#@	3/2$^-$	0+2		S: S(L=0)=0.334; S(L=2)=0.211.
3.56×10^3‡#@&a	5/2$^+$	1+3		S: S(L=1)=0.40; S(L=3)=0.669.
6.9×10^3#@&a	3/2$^+$	1+3		S: S(L=1)=0.302; S(L=1)=0.354.
7.17×10^3#@	7/2$^+$	3	0.488	
7.9×10^3‡#@	3/2$^+$	1+3		S: S(L=1)=0.288; S(L=3)=0.462.
9.0×10^3#@	(9/2$^+$)	3	0.507	
12.5×10^3‡				

† From DWBA analysis of spectroscopic factors in (1974An36).
‡ Reported in ^{12}C(^{11}B,^{10}Be).
# Reported in ^{11}B(^{12}C,^{10}Be).
@ Reported in ^{11}B(^{11}B,^{9}Li).
& Reported in ^{12}C(^{12}C,^{11}B).
a Reported in ^{12}C(^{14}N,^{13}C).

^{12}C(^{12}C,^{11}B)

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1979Fu04: ^{12}C(^{12}C,^{11}B) E=93.8 MeV; measured $\sigma(\theta)$ for ^{13}N*(0,3.5 MeV) and θ=10° to 60°. DWBA analysis; deduced g.s. spectroscopic factor.
1992Ja10: ^{12}C(^{12}C,^{11}B) E=344.5 MeV; analyzed $\sigma(\theta)$, for θ=5° to 25°; deduced S.
1999Sz01: ^{12}C(^{12}C,^{11}B) $E_{c.m.}$=30-60 MeV; analyzed σ(E).

Related measurements on quasifree nucleon scattering are reported in (2019Pa61) and (1988Ki05); see also (2022Li09,2023Be20).

^{13}N Levels

E(level)†	J^{π}‡	S†
0	1/2$^-$	0.60
3.55×10^3	5/2$^+$	0.48
7.16×10^3	7/2$^+$	0.050
7.37×10^3	5/2$^-$	0.096
9.00×10^3	9/2$^+$	0.054

† From DWBA analysis in (1992Ja10).
‡ From Adopted Levels.

$^{12}C(^{13}C,^{12}B)$

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1987Ad07: $^{12}C(^{13}C,^{12}B)$ E=30 MeV/nucleon; measured $\sigma(\theta)$ for θ=1.8° to 5.6°. Observed low-lying states along with E_x=16.3 and 22.1 MeV, which are suggested as the J^{π}=5/2^{+} and 3/2^{+} GDR components. The same data are discussed in (1988Vo08).
1988Vo08: $^{12}C(^{13}C,^{12}B)$ E=30 MeV/nucleon; measured $\sigma(\theta)$ for θ=4° to 10°. Deduced L and S values via DWBA.
1990Br25: $^{12}C(^{13}C,^{12}B)$ E=50 MeV/nucleon; measured $\sigma(\theta)$ for θ=0° to 6°. Discussed spectroscopic factors.

^{13}N Levels

E(level)†‡	J^{π}†	$T_{1/2}$	L†	S†	Comments
0	1/2^{-}		1	0.48	
2.36×10^{3}	1/2^{+}		0	0.14	
3.55×10^{3}	5/2^{+}		2	0.53	
7.1×10^{3}	7/2^{+}		4		
7.9×10^{3}	3/2^{+}		2	0.14	
8.5×10^{3}	(1/2^{-})		1	0.02	
11.3×10^{3}	(5/2^{-})		3	0.03	
12.6×10^{3}	(7/2^{-})		3	0.03	
16.2×10^{3}	(5/2^{+})	4.8 MeV	2	0.52	
22.5×10^{3}	(3/2^{+})	4.2 MeV	2	0.43	J^{π},L: The discussion of (1987Ad07) and (1988Vo08) associates this state with the J^{π}=3/2^{+} GDR at E_x=21.7 MeV; however Table 6 of (1988Vo08) shows J;L=5/2^{+};2, which appears to be a typo.

† Reported in DWBA analysis of spectroscopic factors of (1988Vo08).
‡ (1990Br25) report poorly resolved groups at E_x=0, 2.34, 3.55, 5.4, 6.6, 7.6, 8.5, 10.5, 11.8, 13.2, 17.5, 24.0 MeV.

$^{12}C(^{14}N,^{13}C)$

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1969Vo01, 1970Vo02: $^{12}C(^{14}N,^{13}C)$ E=78 MeV; measured $\sigma(\theta)$ for θ=5° to 40°. Compared population of $^{13}N/^{13}C$ IAS states. Higher-lying ^{13}N states are unresolved.
1974An36: E=114 MeV; measured σ; compared different transfer reactions.
1974De03: $^{12}C(^{14}N,^{13}C)$ E=100 MeV; measured $\sigma(\theta)$ for θ=10° to 30°.
1975Go14: E=78 MeV; analyzed σ.
1975Na15, 1975Vo05: E=155 MeV; measured $\sigma(\theta)$ for θ=15° to 50°. Analyzed S.
1997Zi05: $^{12}C(^{14}N,^{13}C)$ E=116 MeV; measured $\sigma(\theta)$ for θ=10°−60°. Coupled channels analysis of various transfer reactions.
Theory:
1973De02, 1973De35: $^{12}C(^{14}N,^{13}C)$ calculated impact of recoil effects on angular distributions.
1975Re04: $^{12}C(^{14}N,^{13}C)$ calculated impact of recoil effects on angular distributions.
1976Ku06: DWBA analysis of the reaction to $^{13}N^{*}$(2.37 MeV).
1976Na09: comparison of $^{12}C(^{14}N,^{13}N)$ and $^{12}C(^{14}N,^{13}C)$ reactions at E=155 MeV.

^{13}N Levels

E(level)†	J$^{\pi}$	L	S‡	Comments
0	1/2^{-}	0,1	0.62	L,S: From DWBA analysis in (1975Na15).
2.37×10^{3}				
3.56×10^{3}				
6.90×10^{3}				

† From (1974An36).
‡ $C_2^2S_2$.

$^{12}C(^{16}O,^{15}N),(^{16}O,^{13}N)$

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1979Pr07: $^{12}C(^{16}O,^{15}N)$ E=128 MeV; measured $\sigma(E,\theta)$ for θ=15° to 30°. Deduced S via DWBA.
2023Me12: $^{12}C(^{16}O,^{13}N)$: Measured production yields of 240 MeV/nucleon $^{12,14}C$, $^{14,16}N$ and ^{16}O projectiles on a carbon target at the Lanzhou RIBLL2 facility. Deduced cross sections for ^{13}N production using a ^{16}O beam.

^{13}N Levels

E(level)	J^{π} †	S†
0	$1/2^-$	0.29
2.37×10^3	$1/2^+$	0.04
3.5×10^3	$5/2^+$	0.15

† From DWBA analysis of spectroscopic factors in (1975Na15).

$^{12}C(^{13}N,^{13}N),^{13}C(^{13}N,^{13}N)$

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1995Li10, 1995Li23: $^{12}C(^{13}N,^{13}N)$, $^{13}C(^{13}N,^{13}N)$ E=16.3-29.5 MeV; measured elastic $\sigma(\theta)$ for $\theta_{cm}\approx15°-145°$. Compared with $^{12}C(^{13}C,^{13}C)$.

2021Do04: Coupled-channels analysis of $^{12}C(^{13}N,^{13}N)$.

^{13}N Levels

E(level)
0

$^{13}C(\gamma,\pi^-)$

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1982Le06: $^{13}C(\gamma,\pi^-)$ E=17, 29, 42 MeV; measured anomalously low $\sigma(E_\pi)$ to $^{13}N_{g.s.}$.
1984Du16: $^{13}C(\gamma,\pi^-)$ E=267 MeV; discussed π detection capabilities at NIKHEF-K.
1984St16: $^{13}C(\gamma,\pi^-)$ E=193 MeV; measured $\sigma(\theta)$ for θ=60° to 130°. Analyzed reactions to $^{13}N^*$(0,3.51). Deduced form factor.
1986Sh13: $^{13}C(\gamma,\pi^-)^{13}N_{g.s.}$ E=165 MeV; measured $\sigma(\theta)$ for θ=50° to 150°; analyzed E0 and M1 contributions.
1987Du08: $^{13}C(\gamma,\pi^-)$; measured $\sigma(\theta)$ in the Δ-resonance region.
1994Ch03: $^{13}C(\gamma,\pi^-)$ E=170, 300 MeV; analyzed polarization observables for the ground state reaction.
1995Va13: $^{13}C(\gamma,\pi^-)$ E=184 MeV; measured $\sigma(\theta)$ for θ=45°−100° and for $^{13}N^*$(0, 3.5 MeV).

Theory:

1973Na14: Calculated $T_<$ and $T_>$ giant resonance contributions.
1983Ma40: $^{13}C(\gamma,\pi^-)$ E=197 MeV; calculated $\sigma(\theta)$.
1984Ti02: $^{13}C(\gamma,\pi^-)$ E=200-400 MeV; calculated $\sigma(\theta)$ in the Δ resonance region.
1985Sa06: $^{13}C(\gamma,\pi^-)$ E=200-400 MeV; calculated $\sigma(\theta)$, form factors.
1986Dy02: $^{13}C(\gamma,\pi^-)$; calculated $\sigma(\theta)$ analyzed in medium effects.
1987Or01: $^{13}C(\gamma,\pi^-)$; calculated $\sigma(\theta)$.
1990Be12, 1990Be45: $^{13}C(\gamma,\pi^-)$ E=160-320 MeV; calculated $\sigma(\theta)$.
1990Er03: $^{13}C(\gamma,\pi^-)$ E=170-320 MeV; calculated $\sigma(\theta)$.
1990Ko19: $^{13}C(\gamma,\pi^-)$ E=193,223 MeV; calculated $\sigma(\theta)$.
1991Od04: $^{13}C(\gamma,\pi^-)$ E=163, 190 MeV; calculated $\sigma(\theta)$.
1993Ch26: $^{13}C(\gamma,\pi^-)$ E=170 MeV, calculated polarization observables.

^{13}N Levels

E(level)†
0
2.4×10^3
3.51×10^3
6.4×10^3

† See (1984Du16).

^{13}C(π^+,γ)

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1984Ma45: ^{13}C(π,γ) E_π=115.5 MeV; measured $\sigma(E_\gamma)$ for θ=37° to 85°.
1986Si13, 1986Si22: ^{13}C(π,γ_0) E_π=49, 115.5 MeV; calculated $\sigma(\theta)$.
1990Ko19, 1990Be45: ^{13}C(π,γ_0) E_π=115 MeV; calculated $\sigma(\theta)$.

^{13}N Levels

E(level)
0

$^{13}C(\pi^+,\pi^0)$

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1976Sh01: $^{13}C(\pi^+,\pi^0)$ E_{π^+}=70-250 MeV; measured activation σ(E).
1980Ba27: $^{13}C(\pi^+,\pi^0)$ E_{π^+}=98 MeV; measured σ_{ave}=0.43 mb/sr *6* for θ=0° to 16°.
1980Bo03: $^{13}C(\pi^+,\pi^0)$ E_{π^+}=200 MeV; measured $\sigma(\theta)$ for θ=0° to 50°. Overview of LAMPF facility.
1982Do02: $^{13}C(\pi^+,\pi^0)$ E_{π^+}=70-180 MeV; measured $\sigma(\theta)$ for θ=0° and 7° for $^{13}N_{g.s.}$. Listed σ(E, θ) table.
1982Do10: $^{13}C(\pi^+,\pi^0)$ E_{π^+}=164 MeV; measured $\sigma(\theta)$ for θ=0° to 60° for $^{13}N_{g.s.}$. Listed $\sigma(\theta)$ table.
1988Us01: $^{13}C(\pi^+,\pi^0)$ E_{π^+}=50-340 MeV; measured σ(E) for $^{13}N_{g.s.}$. Listed σ(E) table.
1990Go36,1991Go14: $^{13}C(\pi^+,\pi^0)$ E_{π^+}=163 MeV; polarized ^{13}C target. Measured $\sigma(\theta)$ $A_y(\theta)$ for θ=20° to 60°. Analyzed $^{13}N_{g.s.}$ and unresolved $^{13}N^*$(3.5 MeV:3/2$^-$&5/2$^+$) doublet.
1994Ha41: $^{13}C(\pi^+,\pi_0)$ E=165; measured $\sigma(\theta, E_\pi)$ for θ=0° to 50° at LAMPF using the π^0 spectrometer to measure the decay γ-γ photons. Analyzed π_0 to $^{13}N^*$(0,12.8 MeV) T=1/2 states and $^{13}N^*$(23.3 MeV) T=3/2 state.

Theory:
Calculated σ(E) or $\sigma(\theta)$: 1970Bj01: E_{π^+}=180 MeV; 1971Ka62: E_{π^+}=180 MeV; 1973Ch20: E_{π^+}=180 MeV; 1973Au06: E_{π^+}=30-90 MeV; 1974Ka07: E_{π^+}=30-200 MeV; 1976Ga06: E_{π^+}=30-200 MeV; 1976Ga21: analyzed σ(E) in $\Delta_{(3,3)}$ resonance region; 1976Gi01: E_{π^+}=20-240 MeV; 1976Li04: E_{π^+}=30-230 MeV; 1976Ni05: E_{π^+}=40-200 MeV; 1976Os06: E_{π^+}=150-250 MeV; 1977Au01: E_{π^+}=80-200 MeV; 1977Fu10; 1977Lo19: E_{π^+}=100-300 MeV; 1977Wa02, 1978Wa02: E_{π^+}=80-200 MeV; 1979La22: E_{π^+}=30-250 MeV; 1979Sa21: E_{π^+}=100-200 MeV; 1980Ch08: E_{π^+}=120-226 MeV; 1980Ei01: E_{π^+}=100-200 MeV; 1980Ga12: E_{π^+}=0-300 MeV; 1980Le02: E_{π^+}=80-240 MeV; 1980Sa04: E_{π^+}=100-200 MeV; 1981Hi06: E_{π^+}=70-230 MeV; 1981Li02: E_{π^+}=30-260 MeV; 1981Os04: E_{π^+}=130-250 MeV; 1981Po10: E_{π^+}=162 MeV; 1983Ka19: E_{π^+}=40-240 MeV; 1990Gl09: E_{π^+}=163 MeV; 1991Ka18: E_{π^+}=130-250 MeV; 1996No03: E_{π^+}=163; 1999Ta33: E_{π^+}=165.

^{13}N Levels

E(level)	Γ	Comments
0		
3.5×10^3 †		
7.4×10^3 †		
12.8×10^3 ‡	7.9 ‡ MeV	T=1/2
23.3×10^3 ‡	10.4 ‡ MeV	T=3/2

† From (1991Go14).
‡ From (1994Ha41).

^{13}C(ν,μ^-),(ν,e)

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

2008Ei01: ^{13}C(ν,e$^-$) $E_\nu \leq 52.8$ MeV; measured flux-averaged σ for neutrinos from π^+ and μ^+ at KArlsruhe Rutherford Medium Energy Neutrino (KARMEN). $<\sigma>=10.2\times10^{-42}$ cm^2 *4*(stat.) *8*(sys.).

Theory:

1985Mi21: Calculated σ for E<260 MeV.
1990Fu03: Calculated σ for E<20 MeV.
1990Po04: Calculated σ for E<280 MeV.
2000Mi14: Calculated σ for E<300 MeV.
2012Su15, 2012Su29: Shell model calculation of σ(E=threshold−100 MeV).
2013Su17: Shell Model analysis of low-lying excitations.
2018Su20: See for related information on ^{16}O(ν,X).

^{13}N Levels

E(level)
0

^{13}C(p,n)

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1960Da05, 1961Da09: ^{13}C(p,n) E≤13 MeV; measured σ(E(n),θ) for θ=15° to 170°. Deduced participation of low-lying ^{13}N states. Q=3.2372 MeV *16*.
1961Al07: ^{13}C(p,n_0) E=3.1 to 5.3 MeV; measured $\sigma(\theta)$.
1961Be13: ^{13}C(p,n); deduced E_{thres}=3.2353 MeV *15*; later revised to 3.2371 MeV *16* in (1964Bo10).
1961Wo03: ^{13}C(p,n) E=6.5-12.2 MeV; measured $\sigma(\theta_{n0})$ for θ=0° to 150°. Observed contributions from ^{13}N*(0,2.37, 3.51+3.56).
1964An15: ^{13}C(p,n_0) E=18.5 MeV; measured $\sigma(\theta)$ for θ≈5° to 130°.
1965Va23: ^{13}C(p,n) E=155 MeV; measured σ=1.9 mb *2*.
1966Bo20: ^{13}C(p,n) E=3.2 to 9.5 MeV; measured Yield(E), deduced E_{thres}=3.2354 MeV *24*.
1966Di03: ^{13}C(p,n) E=3.27 to 3.85 MeV; measured $\sigma(\theta)$ near the reaction threshold for θ=0° to 150°.
1966Ma60: Analyzed literature data; recommend E_{thres}=3.2357 MeV *7*.
1966Ri09: ^{13}C(p,n) E=3.2-9.5 MeV; measured σ. Deduced Q($^{13}N_{g.s.}$)=3004 keV *10* and E_x=3464 keV *10* to the 3/2$^-$ state.
1969Kr21: ^{13}C(p,n) E=thresh−40 MeV; measured activation σ.
1969Mo32: ^{13}C(p,n) E≈3 MeV; discussed method for correlating reaction threshold with beam energy.
1970Cl01: ^{13}C(p,n) E=30, 50 MeV; measured σ.
1974Sh06: ^{13}C(p,n) E≈3 MeV; deduced E_{thresh}=3235.7 keV *7*.
1975Li11: ^{13}C(p,n) E=16.3, 22.8 MeV; compared cross sections determined via direct and activation techniques.
1976Li08: ^{13}C(pol. p,n_0) E=7-15 MeV; measured polarization transfer coefficients along θ=0°.
1977Az01: ^{13}C(p,n) E=10-13 MeV (also ^{16}O(p,α)). Measured $T_{1/2}$=597.9 s *6*.
1980Go07: ^{13}C(p,n) E=120 MeV; analyzed relation between $\sigma(\theta$=0°:(p,n)) and G-T matrix element values for the g.s. transition.
1981Ba22: ^{13}C(p,n) E=4-12 MeV; measured σ(E); results are tabulated.
1981By01: ^{13}C(p,$n_{0,1,2+3}$) E=10.1-16.75 MeV; measured σ(E,θ) for θ=0° to 150°. Potential model analysis.
1982Ta03: ^{13}C(p,n) E=60-200 MeV; measured $\sigma(\theta$=0°) deduced G-T transition strengths.
1983Pe14: ^{13}C(p,n) E=26.1 MeV; compared analog states populated via (p,p) and (p,n) reactions.
1984Ta07: ^{13}C(p,n) E=160 MeV; measured $D_{NN}(\theta$=0°) spin-transfer coefficients.
1984He20: ^{13}C(pol. p,n_0) E=5.5 MeV; measured neutron polarization at θ=40°.
1985Go02: ^{13}C(p,$n_{0,2}$) E=160 MeV; measured $\sigma(\theta)$. Analyzed relation between $\sigma(\theta$≈0°) and *B*(GT).
1985Wa24: ^{13}C(p,$n_{0,2}$) E=135 MeV; measured $\sigma(\theta)$. Analyzed relation between $\sigma(\theta$≈0°) and *B*(GT).
1986Ki12: ^{13}C(p,n) E=800 MeV; measured $\sigma(\theta)$. Analyzed Fermi and G-T strength intensities.
1986Oh03: ^{13}C(p,n) E=35 MeV; compared low-lying analog states populated via (p,p) and (p,n) reactions.
1987Ta22: ^{13}C(pol. p,n_0) E=60-200 MeV; measured $D_{NN}(\theta$=0°) spin-transfer coefficient.
1987Ra15, 1987Ra32: ^{13}C(p,n) E=160 MeV; measured $\sigma(\theta,E_n)$ for θ=0° to 50°. Analyzed G-T strength for ^{13}N*(0, 3.51, 15.1).
1987Or01: ^{13}C(p,n) E=35 MeV; measured $\sigma(\theta,E_n)$ for θ=0° to 150°. Analyzed ΔJ=0$^-$ component to ^{13}N*(2.37).
1987Li29: ^{13}C(p,n) E=800 MeV; measured $\sigma(E_n)$. Overview of LAMPF capabilities for charge-exchange reactions.
1988Ka30: ^{13}C(p,$n_{0,1}$) E=18.6 MeV; measured $\sigma(\theta)$.
1989Ra09: ^{13}C(pol. p,pol. n_0) E=492,590 MeV; measured $\sigma(E_n,\theta$=0°). Deduced B(GT) values for ^{13}N*(0,3.51 MeV).
1989Wa16: ^{13}C(p,n) E=5-30 MeV; measured activation yields.
1990Dr10: ^{13}C(p,n) $E_{c.m.}$<13 MeV and θ≈0°. Analyzed monoenergetic neutron beam production.
1991Mi03: ^{13}C(p,n) E=200 MeV; measured $\sigma(\theta$=0°) for ^{13}N*(8.92, 9.48, 10.83, 11.88, 15.06 MeV).
1991Fi11, 1991Fi05: ^{13}C(p,n) E=1-33 MeV; measured σ(E), thick target.
1993Go15: ^{13}C(p,n) E=2.5-10.5, analyzed utility to produce ^{13}N beams.
1994Ra23: ^{13}C(pol. p,n) E=186 MeV; measured $\sigma(E_n,\theta$=0°−50°), multipole decomposition analysis in giant resonance region.
1994Sa36: ^{13}C(pol. p,n) E=50, 80 MeV; measured polarization transfer coefficients, $D_{NN}(\theta$=0°).
1994Wa22: ^{13}C(pol. p,n) E=186 MeV; measured $\sigma(E_n,\theta$=0°−50°), analyzing powers. Analyzed quasifree scattering.
1995Ya12: ^{13}C(p,n) E=186 MeV; measured $\sigma(E_n,\theta$=0°−50°), multipole decomposition analysis to determine ΔL=1 strength. Significant strength around E_x=18-24 MeV.
1995Wa16: ^{13}C(pol. p,n) E=295 MeV; measured $\sigma(E_n,\theta$=0°−10°) for ^{13}N*(0,3.51); deduced polarization transfer coefficients D_{NN}(0°).
1994Wa05: ^{13}C(p,n) E=160 MeV; measured $\sigma(E_n,\theta$=0°−20°); analyzed J^π=1/2$^-$→1/2$^+$ transition to ^{13}N*(2.46).
1996Yu02: ^{13}C(p,n_0) E=200 MeV; measured $\sigma(\theta)$; analyzed large angle scattering.

^{13}C(p,n) (continued)

1999Ha24: ^{13}C(p,n),(^{3}He,t),(π^{+},π^{0}). Analyzed giant resonance features.
2000Jo17: ^{13}C(p,n$_0$) E=35 MeV; measured $\sigma(\theta)$ for $\theta\approx5°-140°$. DWBA analysis.
2001Go25: ^{13}C(p,n) E=120, 160 MeV; analyzed relation between $\sigma(\theta=0°)$ and Gamow-Teller strength.
2001Wa05: ^{13}C(pol. p,n$_0$) E=197 MeV; measured $\sigma(\theta=0°)$; analyzed reaction mechanism; deduced GT and Fermi contributions.
2001Wa18: ^{13}C(pol. p,n$_0$) E=135 MeV; measured $\sigma(\theta=0°)$; analyzed reaction mechanism and $\sigma(\theta=0°)$ relation to B(GT). Deduced GT and Fermi contributions.
2002Ra51, 2002Wa23: ^{13}C(pol. p,n$_0$) E=197 MeV; measured $\sigma(\theta)$ for $\theta\approx0°-33°$; analyzed polarization observables.
2009De03: ^{13}C(p,n$_0$) E=35 MeV; analyzed $\sigma(\theta)$.
2009Os01: DWBA analysis of ^{13}C(p,n$_0$) investigating the density dependence of the N-nucleus potential.
2009Sa06: ^{13}C(p,n); analyzed Fermi and GT transitions across a broad range of targets at E=198, 297 MeV; deduced unit cross sections to connects $\sigma(\theta=0)$ with strengths.
2016Ta07: ^{1}H(^{13}C,^{13}N) and ^{12}C(^{13}C,^{13}N) at E≈950 MeV/nucleon; measured charge changing cross sections. Compared with GT strength.

Theory:

1969Ra36: Surveyed available data for various targets.
1970Li01: ^{13}C(p,n) E=18.5 MeV, calculated $\sigma(\theta)$.
1971Ge12: ^{13}C(p,n) E=12.2,13.3 MeV, DWBA analysis of $\sigma(\theta)$.
1982Ba14: ^{13}C(p,n) E=6 MeV Calculated $\sigma(\theta)$.
1983Kr10: ^{13}C(p,n) E=150, 160, 200 MeV; calculated $\sigma(\theta)$.
1989Am02: analysis of M1 quenching.
1989Ra15: ^{13}C(pol. p,pol. n$_0$) E=500 MeV; calculated polarization tranfer coefficient.
1990Mi14: Analyzed spin-flip and nonflip reactions at $\theta=0°$.

^{13}N Levels

E(level)‡	Jπ#	Comments
0	1/2−	Spin transfer coefficient $D_{NN}(0°)\approx0.05$ *6* (1984Ta07).
2.3×10^3 *1*		
3464† *10*	(3/2−)	Spin transfer coefficient for $J^{\pi}=3/2^{-}$ state $D_{NN}(0°)=-0.33$ *5* (1984Ta07). E(level): From (1966Ri09). See also 3.5 MeV *1* (1970Cl01).
3.5×10^3† *1*		
4.6×10^3?@ *1*		E(level): This state is not observed in other studies.
6.3×10^3 *1*		
7.2×10^3 *2*		
8.8×10^3 *2*	1/2−	$\sigma(\theta=0°)$=1.30 mb/sr *8* for E_x=8.92 MeV (1991Mi03).
9.48×10^3	3/2−	E(level): From (1991Mi03); $\sigma(\theta=0°)$=0.78 mb/sr *5*.
10.83×10^3	1/2−	E(level): From (1991Mi03); $\sigma(\theta=0°)$=1.07 mb/sr *6*.
11.6×10^3 *2*	(3/2−)	$\sigma(\theta=0°)$=3.27 mb/sr *20* for E_x=11.88 MeV (1991Mi03).
13.3×10^3@ *2*		
15.1×10^3	(3/2−)	E(level): From (1984Ta07). Spin transfer coefficient $D_{NN}(0°)=-0.36$ *8* (1984Ta07). $\sigma(\theta=0°)$=1.85 mb/sr *11* for known T=3/2 state at E_x=15.06 MeV.

† Unresolved in (1970Cl01).
‡ From (1970Cl01).
# From L=0,2 transfer states populated in GT trnasitions along $\theta=0°$ (1991Mi03).
@ Some states are not associated with Adopted Levels because inadequate details for association are given in the literature.

$^{13}C(^{3}He,t)$

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1969Ba06: $^{13}C(^{3}He,t)$ E=40-50 MeV; measured $\sigma(E(t),\theta)$ for θ=20° to 75°. Deduced optical model parameters, level energies, L, J. Discussed shell configurations.
1970Nu02: $^{13}C(^{3}He,t)$ E=14 MeV; measured $\sigma(\theta)$ for $\theta\approx$10° 10 150°. Deduced optical model parameters for $^{13}N^{*}$(0,2.36 MeV).
1981Pe08: $^{13}C(^{3}He,t)$ E=43.6 MeV; measured $\sigma(E(^{3}He),\theta)$, $\sigma(E_t,\theta)$ for θ=5° to 60°. Deduced $^{13}N/^{13}C$ isoscalar, isovector transition amplitude ratio, β_L deformation parameters.
1987Be25: $^{13}C(^{3}He,t)$ E=0.6-2.3 GeV; measured $\sigma(E_t,\theta)$ for θ=0° to 4°. Deduced isovector strength ratio.
1990De31: $^{13}C(^{3}He,t)$ E=39.6 MeV; analyzed $\sigma(E,\theta)$ for θ=10° to 100°. Deduced optical model parameters.
1991Ja04: $^{13}C(^{3}He,t)$ E=200 MeV; measured $\sigma(E_t,\theta=0°)$. See also (1993JaZZ).
1994Ak02: $^{13}C(^{3}He,t)$ E=450 MeV; measured $\sigma(E_t,\theta=0°)$.
1996Fu06: $^{13}C(^{3}He,t+p)$ E=450 MeV; measured proton decay from $^{13}N^{*}$ relevant to states populated in $^{13}C+\nu$ interactions. Populated $^{13}N^{*}$(0, 3.51, 8.92, 10.83, 11.88, 15.06) plus SDRs at 18 and 21.5 MeV. Qualitative discussion on proton decay branches.
1996BuZZ: $^{13}C(^{3}He,t)$ E=60 MeV; measured $\sigma(\theta=0°)$ for θ=10°−100°. Analyzed diffraction effects.
2003Bu01: $^{13}C(^{3}He,t)$ E=60 MeV; measured $\sigma(E_t,\theta)$ for θ=10°−120°. DWBA analysis for $^{13}N^{*}$(0, 2.36, 3.51+3.55). Discussed refractive properties.
2004Fu12: $^{13}C(^{3}He,t)$ E=150 MeV/nucleon; measured $\sigma(E_t,\theta)$ for θ=0°−17°. Analyzed GT strengths. Measured protons from $^{13}N^{*}$ decay in coincidence with θ=0° tritons; deduced branching ratios. XUNDL dataset by McMaster (2004).
2007Ze06 , 2008Ze01: $^{13}C(^{3}He,t)$ E=420 MeV; measured $\sigma(E_t,\theta\approx0°)$. Analyzed relation between B(GT) and σ. In (2008Ze01), the B(GT) unit cross section is normalized using the σ to $^{13}N^{*}(15.1{:}3/2^{-})$ and B(GT)=1.37 *7* is deduced for $^{13}N^{*}(3.50{:}3/2^{-})$.
2011Pe12: $^{13}C(^{3}He,t)$ E=420 MeV; analyzed relation between B(GT) and $\sigma(\theta=0°)$. Global analysis of unit cross section.
2016De39, 2017De38: $^{13}C(^{3}He,t)$; analyzed $^{13}N^{*}$(2.37) wavefunction. Deduced formation of a proton halo. Developed method to determine nuclear radii of excited states. See also (2023De29).
2019Li48: $^{13}C(^{3}He,t)$; Eikonal approach analysis of $\sigma(\theta)$.
2023He16: $^{13}C(^{3}He,t)$; initial plans for development of a semicylindrical TPC chamber for charge exchange reactions.

^{13}N Levels

E(level)[†&]	J^{π}[#]	L[#&]	Comments
0	$1/2^{-}$	0[@]	β_0=0.061 (1981Pe08).
2.36×10^{3}	$1/2^{+}$	1	β_1=0.035 (1981Pe08)
3.53×10^{3}		2	E(level): Doublet reported at 3.53 MeV *3* in (1969Ba06). %p_0 ($^{12}C_{g.s.}$) =71 *17* (2004Fu12).
3.55×10^{3}		3	E(level): Unresolved.
6.36×10^{3}	$5/2^{+}$	3	β_3=0.041 (1981Pe08)
6.89×10^{3}	$3/2^{+}$	1	β_1=0.025 (1981Pe08)
7.16×10^{3}	$7/2^{+}$	3	β_3=0.060 (1981Pe08)
7.38×10^{3}	$5/2^{-}$	2[@]	β_2=0.056 (1981Pe08)
8920 *40*	$1/2^{-}$	0[@]	J^{π}: From (1969Ba06). %p_0 ($^{12}C_{g.s.}$)=60 *9*, %p_1(^{12}C(4.44))=30 *5* (2004Fu12).
9.0×10^{3}[‡]	$9/2^{+}$	5	β_5=0.083 (1981Pe08)
9.48×10^{3}[‡]	$3/2^{-}$	2	%p_0=58 *11*, %p_1=43 *9* (2004Fu12).
10.36×10^{3}[‡]	$(5/2^{-},7/2^{-})$	2	β_2=0.019 (1981Pe08) E(level): Known doublet.
10780 *40*	$(3/2,5/2)^{-}$	2	β_2=0.037 (1981Pe08) E(level): Reported as 10.833 MeV in (1981Pe08). J^{π}: (1981Pe08) indicate L=2, which implies $(3/2,5/2)^{-}$, but this disagrees with the $J^{\pi}=1/2^{-}$ from their $^{12}C(^{3}He,d)$ result in (1980Pe13). %p_0=5 *1*, %p_1=54 *9*, %p_2=43 *16* (2004Fu12).

Continued on next page (footnotes at end of table)

^{13}C(^{3}He,t) (continued)

^{13}N Levels (continued)

E(level)[†&]	Jπ[#]	Γ[b]	L[#&]	Comments
11850 *40*	(3/2⁻)	98 keV	2	β_2=0.20 (1981Pe08) %p_0=8 *1*, %p_1=35 *5*, %p_2=10 *2* (2004Fu12).
15.07×10³	3/2⁻		2[@]	T=3/2 β_2=0.065 (1981Pe08) %p_0=16 *2*, %p_1=13 *2*, %p_2=3 *1* (2004Fu12). E(level): (2004Fu12) report this state has a considerable amount of the isospin violation component in the wave function, surpassing the weak γ-ray decay rates, as the 15060, T=3/2 state in ^{13}N decays to the forbidden T=0 states in ^{12}C.
15980 *50*	7/2⁺	163 keV	3	β_3=0.094 (1981Pe08)
17.68×10³ *3*		1212 keV *74*	1	
18.12×10³ *2*		276 keV *41*		
18.37×10³ *1*		23 keV		
19.11×10³ *1*		183 keV *41*		
19.83×10³ *2*		1542 keV *84*	[a]	
21.20×10³ *1*		581 keV *44*	2	
22.14×10³ *1*		1706 keV *82*	[a]	
24.50×10³ *4*		2.46 MeV *22*	[a]	
26.9×10³ *9*		4.38 MeV *47*		

† From (1969Ba06) unless otherwise indicated.
‡ Observed in (1981Pe08).
\# From DWBA comparison of ^{13}C and ^{13}N analog states in ^{13}C(^{3}He,^{3}He), (^{3}He,t) and ^{13}C(α,α) reactions (1981Pe08).
@ From (1969Ba06).
& Above E_x=17 MeV from (2004Fu12).
a Assumed ΔL=1 spin-dipole resonances.
b From (2004Fu12).

^{13}C(^{6}Li,^{6}He)

	History		
Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1970Ch19: ^{13}C(^{6}Li,^{6}He) E=30.8 MeV; measured $\sigma(\theta$, E(^{6}He)) for θ=18° and 36°. Deduced levels.
1981Vi03: ^{13}C(^{6}Li,^{6}He) E=93 MeV; measured $\sigma(\theta$=12°, E(^{6}He)) deduced levels. See further discussion in (2010Ga19).
1984Gl06: ^{13}C(^{6}Li,^{6}He) E=93 MeV, ^{13}C(^{7}Li,^{6}He) E=78 MeV; measured $\sigma(\theta$, E(^{6,7}He)).
1989De34: ^{13}C(^{6}Li,^{6}He) E=93 MeV; measured $\sigma(\theta$, E(^{6}He)) for θ=20° to 60°; analyzed ^{13}N*(0, 3.5) peaks.
1994La10: ^{13}C(^{6}Li,^{6}He) E=100 MeV/nucleon; measured $\sigma(\theta\approx0°$, E(^{6}He)).
1999Ue03, 1999UeZY: ^{13}C(^{6}Li,^{6}He) E=100 MeV/nucleon; measured $\sigma(\theta\approx0°$, E(^{6}He)) for $\theta_{c.m.}\leq7$ mrad. Compared yields with B(GT) from β decay.

^{13}N Levels

E(level)	J$^{\pi}$	Comments
0[†‡#@&]		
2.37×10^{3}[†&]		
3.5×10^{3}[†‡#@&]	(3/2^{-})	J$^{\pi}$: From (1970Ch19). Population of 3/2^{-} is preferred.
7.4×10^{3}[‡#@]		
9.2×10^{3}[‡@a]		
12.5×10^{3}[‡@]		
17.5×10^{3}[‡]		
21×10^{3}[‡a]		

[†] Observed in (1970Ch19).
[‡] Observed in (1981Vi03).
[#] Observed in (1984Gl06).
[@] Observed in (1994La10).
[&] Observed in (1999Ue03).
[a] Some states are not associated with Adopted Levels because inadequate details for association are given in the literature.

$^{13}C(^{14}N,^{14}C)$

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1971Ga05: $^{13}C(^{14}N,^{14}C)$ E=12.5-20.5 MeV; measured neutron transfer reaction σ via activation technique.
1973To05: $^{13}C(^{14}N,^{14}C)$; DWBA analysis of $\sigma(\theta)$.
1978Os06: $^{13}C(^{14}N,^{14}C)$ E=12,15 MeV; calculated σ.

^{13}N Levels

E(level)
0

^{13}C(^{13}N,^{13}C)

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1996St05: ^{13}C(^{13}N,^{13}C) E=57,105 MeV; measured $\sigma(\theta=0°)$. Populated $J^{\pi}=1/2^{-}$ ground states along with single and double excitation of the ≈3.5 MeV ^{13}N and ^{13}C $3/2^{-}$ states. Analyzed GT/Fermi strengths. See also (1997Sh11).

Theory:

1993Kr01: ^{13}C(^{13}N,^{13}C) $E_{c.m.}$=7.5-10 MeV; calculated $\sigma(\theta)$ analyzed effective n-p interaction.

1997Be33: E=105 MeV/nucleon; analyzed heavy-ion charge-exchange reactions.

2020Li51: Eikonal model analysis of $\sigma(\theta)$ at E=105 MeV/nucleon.

^{13}N Levels

E(level)	J^{π} †
0	$1/2^{-}$
3.50×10^{3}	$3/2^{-}$

† From Adopted Levels.

^{14}N(γ,n)

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1960Ki02: ^{14}N(γ,n) $E_{\beta rem}$=25 MeV; measured excitation function. Deduced $T_{1/2}$=9.93 min *5*.
1962Ko23: ^{14}N(γ,n) $E_{\beta rem}$=90 MeV; measured excitation function.
1963Fu06: ^{14}N(γ,n) $E_{\beta rem}$=30.5 MeV; measured excitation function.
1970Sh06: ^{14}N(γ,nX) $E_{\beta rem}$=15 MeV and $E_{\beta rem}$=30 MeV; analyzed neutron spectrum.
1971An08: ^{14}N(γ,n) 150<E<950 MeV; calculated meson effects.
1971Fr11: ^{14}N(γ,n) E=100-800 MeV; measured σ(E); searched for meson effects.
1972Ge11: ^{14}N(γ,n) E=15.5-29.5 MeV; measured $\sigma(E,E_n)$.
1972Go23: ^{14}N(γ,n) E<30 MeV; calculated σ.
1978Di12: ^{14}N(γ,n); analyzed reaction dynamics.
1980Ju02: ^{14}N(γ,n_0) E=17-26 MeV; measured σ(E).
1999Ab39, 1999Ab40: ^{14}N(γ,n) $E_{\beta rem}$=20 MeV; measured yields.

^{13}N Levels

E(level)
0

^{14}N(π^+,π^+n),(π^+,p)

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1973Ka19: ^{14}N(π^+,π^+n) 190 MeV; measured σ via activation at the NASA Space Radiation Effects Laboratory (SREL).
1985La20: ^{14}N(π^+,p) 170 MeV; measured yields.
1981Gi15: ^{14}N(π^+,p) 114 MeV; calculated σ.

^{13}N Levels

E(level)
0

^{14}N(n,2n)

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1949Kn25: ^{14}N(n,2n) $E_n \approx 90$ MeV; measured activation σ.
1951Co50: ^{14}N(n,2n) $E_n \approx 0.4$-18 MeV white source; measured activation.
1961Ra06: ^{14}N(n,2n) $E_n \approx 14.4$ MeV; measured activation cross section and lifetime $T_{1/2}$=12.3 min±5.4% at Argonne.
1965Bo42: ^{14}N(n,2n) E_n=12.6-18.8 MeV; measured activation cross section and lifetime $T_{1/2}$=10.05 min *5*.
1965Eb01: ^{14}N(n,2n) $E_n \approx 14.7$ MeV; measured ^{13}N decay and deduced $T_{1/2}$=9.96 min *2*; compared with prior values.
1965Go18: ^{14}N(n,2n) $E_n \approx 14.1$ MeV; measured cross section.
1965Gr41: ^{14}N(n,2n) $E_n \approx 14.8$ MeV; measured cross section.
1967Cs02: ^{14}N(n,2n) $E_n \approx 14.7$ MeV; measured cross section.
1967Pa27: ^{14}N(n,2n) $E_n \approx 14.7$ MeV; measured cross section.
1973Ro29: ^{14}N(n,2n) $E_n \approx 14.8$ MeV; measured cross section.
1978Ry02: ^{14}N(n,2n) E_n=14.7-19.0 MeV; measured cross section via activation technique.
1989KaYR: ^{14}N(n,2n); counted 511 annihilation γ ray. Measured $T_{1/2}$=9.962 min *20*.
2001Sa27: ^{14}N(n,2n) E_n=13.4-14.9 MeV; measured cross section via activation techniques.
2011Ha04: ^{14}N(n,2n) E_n=13.4-14.9 MeV; global analysis of reaction systematics.
2023Te01: ^{14}N(n,2n) E_n=14-15 MeV; developed imperical formalism for σ in the 14≤A≤241 region.

^{13}N Levels

E(level)	$T_{1/2}$	Comments
0	9.962 min *20*	$T_{1/2}$: From (1989KaYR). See also (1961Ra06, 1965Bo42, 1965Eb01).

^{14}N(p,d) 1966Ba44,1975Ro27

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

History

1960ChZZ, 1961Ma02: ^{14}N(p,pn) E=0.4-6.2 GeV; measured activation σ.
1961Po09: ^{14}N(p,^{13}N) E=18 MeV; analyzed decay and hyperfine structure. Deduced J=1/2 and μ=0.321 *3* (μ assumed negative).
1961Be12: ^{14}N(p,d) E=16.5-18.5 MeV; measured angular distributions for $\theta\approx10°-60°$. Observed states with $E_x\leq3.5$ MeV.
1966Ba44: ^{14}N(p,d) E=155.6 MeV; measured $\sigma(\theta)$ for θ=5° to 30°. Deduced level energies; discussed S factors.
1967Ko08: ^{14}N(p,d) E=30.3 MeV; measured $\sigma(\theta)$ for θ=10° to 160°. Deduced levels, J$^\pi$, S. ^{13}N*(0,3.51,7.38,8.93,11.80).
1971Cu01: ^{14}N(p,d) E=14.5 MeV; measured $\sigma(\theta)$ for θ=10° to 80°. Deduced $^{13}N_{g.s.}$ S=0.83-1.3.
1973Fa10: ^{14}N(p,d) E=185 MeV; measured $\sigma(E_d,\theta)$ analyzed deep-lying hole states around E_x= 50 MeV.
1974Mu17: ^{14}N(p,pn) E=11-18 MeV; measured σ(E).
1975Ro27: ^{14}N(p,d) E=65 MeV; measured $\sigma(E_d,\theta)$ for θ=10° to 60°. Deduced levels, optical model parameters, S.
1977Gu14: ^{14}N(p,d_0) E=16.2, 17.7, measured $\sigma(\theta)$.
1982Ao05: ^{14}N(pol. p,d_0) E=21 MeV; measured $\sigma(\theta)$ for θ=20° to 140°.
1987Va28: ^{14}N(pol. p,d_0) E=18.6 MeV; measured $\sigma(\theta)$.
1991Ab04: ^{14}N(p,d) E=30.3 MeV; measured $\sigma(\theta)$ for $\theta\approx$20° to 160°. Discussed configurations.
2003Ko72: ^{14}N(p,d) E≈ 6-19 MeV; measured thick target yields.
2023Ro01: ^{14}N(p,pn) E≈ threshold-200 MeV; measured activation σ motivated by determining dose in proton therapy treatment.

Theory:
1969Do08: calculated $\sigma(\theta)$ at E_p=19,30,156 MeV.
1971Mc15: calculated $\sigma(\theta)$ at E=30 MeV.
1976Wa15: ^{14}N(p,d_0); analyzed d_0 angular distribution. Deduced S=0.504.
1977Bo42: ^{14}N(p,d) E=30.3 MeV, calculated $\sigma(\theta)$.
1978Ma34: ^{14}N(p,d) E=17.7 MeV; calculated $\sigma(\theta)$.

^{13}N Levels

E(level)	J$^{\pi}$ @	S @	Comments
0 †‡	1/2$^-$	0.8 *2*	μ=0.321 *3* (1961Po09) S: See also S=0.45 (1975Ro27).
2.36×10^3	(1/2$^+$)		
3.50×10^3 †‡	(3/2$^-$)	0.25 *5*	E(level): Observed in (1966Ba44: E_x=3.6 MeV *1* likely unresolved states). S: See also S=0.21 (1975Ro27).
3.55×10^3 †#			
6.38×10^3	(5/2$^+$)		
7.38×10^3 †‡#	(5/2$^-$)	1.5 *3*	E(level): Observed in (1966Ba44: E_x=7.4 MeV *1*). S: See also S=1.92 (1975Ro27).
8.92×10^3 †‡#	(1/2$^-$)	0.30 *6*	E(level): Observed in (1966Ba44: E_x=9.0 MeV *2*). S: See also S=0.68 (1975Ro27).
11.86×10^3 ‡#	(3/2$^-$)	0.65 *2*	E(level): Observed in (1966Ba44: E_x=11.9 MeV *2*, likely unresolved states). S: See also S=1.29 (1975Ro27).
14.0×10^3			E(level): Observed in (1966Ba44: E_x=14.0 MeV *3*, likely unresolved states).

† Observed in (1966Ba44), see discussion on spectroscopic factors.
‡ Observed in (1975Ro27), see discussion on spectroscopic factors.
# Reported in (1991Ab04).
@ From (1967Ko08): J From theory, S from DWBA.

^{14}N(d,t)

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1957Wa01: ^{14}N(d,t) E=14.8 MeV; measured yields to $^{13}N^{*}$(0, 2.37, 3.5 MeV (doublet)).
1968Ga13: ^{14}N(d,t) E=28 MeV; measured $\sigma(\theta)$ for θ=10° to 70°, DWBA analysis of (d,t) and (d,^{3}He) cross sections. Deduced C^2S=0.9 to $^{13}N_{g.s.}$ vs 0.88 to $^{13}C_{g.s.}$
1968Hi01: ^{14}N(d,t) E=52 MeV; measured $\sigma(E_t,\theta)$ for θ=12° to 60°. Deduced level energies, J^{π}. Discussed S.
1971Bo50: Theoretical analysis of spectroscopic factors.
1973Da26,1975DaYO: ^{14}N(pol. d,t) E=15 MeV; measured analyzing power A(θ) for θ=30° to 90°.
1974Lu06: ^{14}N(pol. d, t_0) E=15 MeV; measured $\sigma(E_t,\theta)$, A(θ). for θ=20° to 100°. DWBA analysis.
1985Sa35: ^{14}N(d,t), ^{15}N(p,d); measured thick target yields.
1995Gu22: ^{14}N(d,t) E=8-50 MeV; analyzed $\sigma(\theta)$.
1998Sz01: ^{14}N(d,t) E=3.8-12.3 MeV; measured σ(E) for ^{13}N production as background radiation produced along with $^{14}N(d,n)^{15}O$.

^{13}N Levels

E(level)†	J^{π}†	S†	Comments
0	1/2$^-$	0.6	S: See also S=0.9 from (1968Ga13).
2.37×10^3			E(level): From (1975DaYO).
3.51×10^3	3/2$^-$	0.25	
7.38×10^3	5/2$^-$	1.3	
8.93×10^3‡	1/2$^-$		
9.5×10^3‡	3/2$^-$		
11.9×10^3	3/2$^-$	1.25	

† From DWBA analysis of spectroscopic factors in (1968Hi01).
‡ Unresolved, S(8.9+9.5 MeV)=0.7.

^{14}N(^{3}He,α)

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1960Ta12: ^{14}N(^{3}He,α) E=5.2 MeV; measured $\sigma(\theta)$ for θ=10° to 100°. Deduced Q, levels, L, peak σ. Discussed reaction mechanism.
1962Cl12: ^{14}N(^{3}He,α) E=2763 MeV; measured $\sigma(\theta)$ for θ=90° and 150°. Deduced levels, Γ.
1962Se13: ^{14}N(^{3}He,α) E=29 MeV; measured $\sigma(\theta)$.
1965Ar07: ^{14}N(^{3}He,α) E=17.4-36.6 MeV; measured σ to $\alpha_{0,1,2+3,5+6,}$ and to ^{13}N*(11.4 MeV).
1967Ha20: ^{14}N(^{3}He,α) E=6-18 MeV; measured activation σ.
1968Ar12: ^{14}N(^{3}He,α) E=19-37 MeV; measured $\sigma(E_{\alpha},\theta)$. Deduced level energies, L, S.
1968Lu03: ^{14}N(^{3}He,$\alpha_{0,1,2+3,4,6+7}$) E=13.9 MeV; measured $\sigma(\theta)$.
1969Ho13: ^{14}N(^{3}He,α) E=8 MeV.
1970Kn01: ^{14}N(^{3}He,α) E=2.5-8.5 MeV; measured $\sigma(E,E_{\alpha},\theta)$ for θ=5° to 155°. Deduced S.
1971Gu22: ^{14}N(^{3}He,$\alpha_{0,1,2+3}$) E=3.75-10.75 MeV; measured $\sigma(E,\theta)$ for θ=10° to 169°.
1972Mo39: ^{14}N(^{3}He,α) E=3.5-7.0 MeV; measured $\sigma(\theta,E_{\alpha})$ for θ=60° to 150°.
1992Ad06: ^{14}N(^{3}He,α) E=50, 60 MeV; measured $\sigma(\theta)$. Deduced optical model parameters.
1994Te04: ^{14}N(^{3}He,α) E=1.6-2.8 MeV; measured $\sigma(E,\theta)$. Evaluated utility for depth profiling.

^{13}N Levels

E(level)	J^{π}	Γ	L	S	Comments
0‡	1/2^{-}		1	0.83	S: From DWBA analysis in (1970Kn01). E(level): Q=10.029 MeV *16*, σ_{max}=1.07 mb/sr (1960Ta12).
2358‡ *10*					
3502‡#					
3547‡#					
6364#					
6886#		110 keV *15*			Γ: From (1962Cl12).
7166 *8*					E(level): From (1962Cl12).
7388† *8*		45 keV *10*			E(level),Γ: From (1962Cl12).
8.93×10^{3}†					
11.65×10^{3}†					E(level): This state is not associated with any Adopted Level because inadequate detail for association is given in the literature.
11.88×10^{3}†					

† Reported in (1969Ho13).
‡ From (1960Ta12).
# Unresolved in most studies.

^{14}N(^{6}Li,^{7}Li) 1971Gr44

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1971Gr44: ^{14}N(^{6}Li,^{7}Li) E=32 MeV; measured $\sigma(\theta)$ for θ=10° to 60°.

^{13}N Levels

E(level)
0
2.36×10^{3}

^{14}N(^{10}B,^{11}B) **1975Na15**

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1975Na15: ^{14}N(^{10}B,^{11}B) E=97 MeV; measured σ(E,θ) for θ=10° to 40°. Analyzed spectroscopic factors.
1976Na09: E=97 MeV; compared ^{14}N(^{10}B,^{11}B) neutron transfer σ with the ^{14}N(^{10}B,^{11}C) proton transfer σ.

^{13}N Levels

E(level)†	J$^{\pi}$†	C^2S^2†
0	(1/2$^-$)	0.72
3.51×10^3	(3/2$^-$)	0.19
7.4×10^3		
11.9×10^3		

† From DWBA analysis of spectroscopic factors in (1975Na15).

^{14}N(^{14}N,^{13}N)

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1961To01, 1961To07: ^{14}N(^{14}N,^{13}N) E=19-28 MeV, measured $\sigma(\theta)$ for $\theta\approx6°$ to 60°.
1965Hi13: ^{14}N(^{14}N,^{13}N) E= 12.3, 14, 16 and 18 MeV; measured $\sigma(\theta)$ for $\theta\approx10°$ to 100°.
1969Ka42: DWBA analysis of data from (1965Hi13) at E=12.3, 14, 16 and 18 MeV,
See also (1988Da12).

^{13}N Levels

E(level)
0

^{15}N(p,t) 1968Fl03

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1960ChZZ: ^{15}N(p,p2n) E=0.4-6.2 GeV; measured activation σ.
1966Ce02: ^{15}N(p,t) E=43.7 MeV; measured $\sigma(\theta)$ for θ=10° to 90° at the 88 inch. Observed $^{13}N^*$(0, 3.51, 7.73 and 15.07 MeV). Deduced E_x=15065 keV *37*; compared IAS states.
1968Fl03: ^{15}N(p,t) E=43.7 MeV; measured $\sigma(\theta)$ for θ=10° to 90°. Deduced level energies for $E_x \leq 16$ MeV, L, J. Deduced integrated σ.
1970Ha23: ^{15}N(pol. p,t) E=44 MeV; measured $\sigma(\theta)$, A(θ) for θ=10° to 80°. Deduced L for $^{13}N^*$(3.51, 7.38 MeV).
1971Ka04: ^{15}N(p,t); analyzed angular distributions of L=0&2 transfer reactions.
1974Ma12: ^{15}N(p,t) E=43.8 MeV; measured $\sigma(E_t,\theta)$, A(θ). for θ=10° to 60°. Analyzed distributions for $^{13}N^*$(0,3.51, 7.39, 15.07 MeV). Deduced level energies, L.
1974Pi05: ^{15}N(p,t) E=20-45 MeV; measured $\sigma(E_t,\theta)$ for θ=12° to 126°. Deduced OM parameters. Deduced $^{13}N^*$(0, 3.51, 7.38 MeV) levels, L, J, π.
1985Sa35: ^{14}N(d,t), ^{15}N(p,d); measured thick target yields.

^{13}N Levels

E(level)†	J$^{\pi}$†	L†	Comments
0	1/2$^-$	0	
2360 *30*	1/2$^+$		
3.51×10^3	3/2$^-$	2	
6380 *30*	5/2$^+$		
7380 *20*	5/2$^-$	2	
8930 *50*	1/2$^-$	0	
10780 *60*	1/2$^-$	0	
11880 *40*	3/2$^-$	2	
15070 *20*	3/2$^-$	2	T=3/2 E(level): See also E_x=15065 keV *37* (1966Ce02).

† From DWBA analysis of (p,^{3}He) and (p,t) mirror partners and comparison of related differential cross sections (1968Fl08).

^{16}O(p,pt)

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1975Gr40: ^{16}O(p,pt) E=75 MeV; deduced reaction mechanism.
1977Gr04: ^{16}O(p,pt) E=75 MeV; deduced levels. Spectroscopic factors from Table VI S(0,3.51)=1.64, 2.57, respectively.
1982Sa24: ^{16}O(p,pt) E=101.3 MeV, ^{16}O(α,αt) E=139.2 MeV deduced L, S.
1983Ka37: ^{16}O(p,pt) E=670 MeV; calculated knockout reaction cross sections.
1983Go10: ^{16}O(p,pt); calculated reaction form factors.

^{13}N Levels

E(level)†	J^{π}†	S†
0	1/2$^-$	1.64
2360		
3.51×10^3	3/2$^-$	2.57

† From DWIA analysis of spectroscopic factors in (1975Gr40,1977Gr04).

^{16}O(p,α)

	History		
Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1960Wh03: ^{16}O(p,α) E=8.59 MeV; measured reaction Q-value=−5206 keV *10*.
1960Pa14: ^{16}O(p,α) E=362 MeV; studied ^{13}N production.
1961Ma15: ^{16}O(p,α) E=13.5-18.1 MeV at the Princeton cyclotron; measured $\sigma(\theta)$ for θ=15° to 170°. Deduced E(J^π)=0(1/2$^-$), 2.37 MeV(1/2$^+$), 3.51 MeV (3/2$^-$) and 3.56 MeV (5/2$^+$).
1964Da02: ^{16}O(p,α_0) E=7.9 to 10.2 MeV; measured $\sigma(\theta)$ for θ=33° to 166°.
1967Ac01: ^{16}O(p,α) E=38 MeV; measured $\sigma(\theta)$.
1967Ch41: E=13 MeV; measured σ to ^{13}N*(0,2.36, 3.51+3.56 MeV).
1969Ga03: ^{16}O(p,α_0) E_p=38 MeV; measured $\sigma(\theta)$ for θ=15° to 170°. Deduced integrated σ=760 μb *30*. PWBA analysis.
1970Gu06: ^{16}O(p,α_0) E=25-38 MeV; measured $\sigma(\theta)$ for θ=20° to 170°.
1970Ko25: ^{16}O(p,α) E=665 MeV; measured $\sigma(E_\alpha)$.
1971Bu05: ^{16}O(p,α) E=21.3-38.5 MeV from the UCLA sector-focused cyclotron; measured $\sigma(\theta)$ for θ=70°.
1971Gu23: ^{16}O(p,α) E=19-45 MeV; measured σ(E,θ). Deduced reaction mechanism. $\alpha_{0,1,2+3,4}$.
1972Ma21: ^{16}O(p,α) E=54, 43.7, 50.5 MeV; measured $\sigma(E_\alpha,\theta)$ for $\theta\approx$15° to 80°. Deduced level energies, L, J^π.
1973Mc12: ^{16}O(p,α) E=threshold=−7.7 MeV; measured σ(E) via activation technique.
1973Ne12: ^{16}O(p,α_0) E(c.m.)=5.4-9.9 MeV; measured σ(E). Deduced table of σ(E) values, and deduced astrophysical rates.
1974Sk02: ^{16}O(p,α) E=9.0-20.4 MeV; measured σ(E,θ) for θ=25° to 165°. Deduced ^{17}F levels.
1976Hi09: ^{16}O(p,$\alpha_{0,1}$) E=11.2-14.6 MeV; deduced ^{17}F states.
1977Gr17: ^{16}O(p,α) E=6.7-9.2 MeV; measured σ(E) via activation technique. Deduced astrophysical reaction rates.
1985Ku13: ^{16}O(p,α) E=9.1 MeV; measured thick target γ-ray yields.
1985Va14: ^{16}O(p,α) E=21 MeV; measured thick target yields.
1986Ai04: ^{16}O(p,α) E<14.7 MeV; measured residual yields.
1986Sa33: ^{16}O(p,α) E=6.5-16.5 MeV; measured thick target yields. deduced σ(E).
1989Wa16: ^{16}O(p,α) E=15-30 MeV; measured thick target yields via activation techniques. Evaluated radiopharmaceutical production.
1972Ga10: Develop pre-equilibrium emission model to explain the energy dependence of excitation functions.
1972Wo05: Computed astrophysically important reaction rates.
1999Ch50: ^{16}O(p,α) E$\leq$250 MeV; calculated σ(E), compared with data.
2003Ta17: ^{16}O(p,α) E$\approx$6.5-19 MeV. IAEA report on ^{13}N production cross sections. Deduced σ(E).
2021He14: ^{16}O(p,α). IAEA analysis of cross sections for PET/SPECT isotopes.

^{13}N Levels

E(level)†	J^π†	$T_{1/2}$†	L†	Comments
0	1/2$^-$		1	
2.36×10^3	1/2$^+$			E(level): (1967Ch41).
3.50×10^3	(3/2$^-$)			E(level): Doublet (1967Ch41).
6.38×10^3	5/2$^+$			E(level): From (1971Gu23).
7.39×10^3	5/2$^-$		3	
8.92×10^3	1/2$^-$			
9.52×10^3	3/2$^-$			
10.35×10^3	(5/2$^-$,7/2$^-$)			
11.5×10^3				
12.13×10^3 *6*	7/2$^-$	≈300 keV	3	
12.75×10^3? *6*				E(level): Probably unresolved 12.6+12.9 MeV states.
13.48×10^3?				Γ: Broad: few hundred keV.

† From (1972Ma21), where a J dependence is found in the angular distributions, except where noted.

$^{16}O(^{3}He,^{6}Li)$ 1966Ce02

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

$^{16}O(^{3}He,^{6}Li)$.

1966Ce02: $^{16}O(^{3}He,^{6}Li)$ E=65.3 MeV; measured $\sigma(\theta)$ for θ=12°.

1972Oh01: $^{16}O(^{3}He,^{6}Li)$ E=30 and 40.7 MeV; measured $\sigma(\theta)$ for θ=20° to 100°. Compared $(^{3}He,^{6}Li)$ angular distributions measured on a variety of targets.

$^{16}O(\alpha,^{7}Li)$.

1972Ru03: $^{16}O(\alpha,^{7}Li)$ E=42 MeV; measured angular distribution to $^{13}N_{g.s.}$ for $\theta\approx$20° to 90°.

^{13}N Levels

E(level)[†]
0
3.5×10^{3}
6.4×10^{3}
7.4×10^{3}

[†] From (1966Ce02).

^{16}O(n,^{13}N)

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1949Kn25: ^{16}O(n,^{13}N) E_n≈90 MeV; measured activation products.

^{13}N Levels

E(level)
0

^{208}Pb(^{13}N,^{13}N): coulex

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

2002SeZY: ^{208}Pb(^{13}N,^{12}C+p) E=76 MeV/nucleon; measured Coulomb excitation via ^{13}N*(2.37 MeV), deduced radiative width $\Gamma_{rad.}$=0.52 eV *4*. (Preliminary RIKEN lab report).

^{13}N Levels

E(level)	Comments
0	
2.37×10^{3}	Γ_{γ}=0.52 eV *4*

^{232}Th(^{22}Ne,^{13}N),^{154}Sm(^{16}O,^{13}N)

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1977Ar06: ^{232}Th(^{22}Ne,^{13}N): The transfer reaction products resulting from E(^{22}Ne)=172 MeV bombardment of a 2.5 mg/cm^2 metallic ^{232}Th foil were measured at Dubna. The reaction products were momentum analyzed in a magnetic spectrometer, positioned at either θ=12° or 40°, and then focused on a ΔE-E Si detector telescope, which provided particle identification. ^{13}N was identified.

2022Ro09: ^{154}Sm(^{16}O,^{13}N) E=85 MeV; measured reaction products using a ΔE-E telescope at the Bhabha Atomic Research Centre in Mumbai. Obtained differential cross sections for $\theta_{c.m.}$≈55° to 75°. Discussed multi-nucleon transfer reaction mechanism.

^{13}N Levels

E(level)
0