Energy Levels of Light Nuclei
$A = 12$

F. Ajzenberg-Selove [a] and T. Lauritsen [b]

[a] *University of Pennsylvania, Philadelphia, Pennsylvania 19104-6396*
[b] *California Institute of Technology, Pasadena, California*

Abstract: An evaluation of $A = 11$–12 was published in *Nuclear Physics A*114 (1968), p. 1. This version of $A = 12$ differs from the published version in that we have corrected some errors discovered after the article went to press. Figures and introductory tables have been omitted from this manuscript. Reference key numbers have been changed to the NNDC/TUNL format.

(References closed December 15, 1967)

Table of Contents for $A = 12$

Below is a list of links for items found within the PDF document. Figures from this evaluation have been scanned in and are available on this website or via the link below.

A. Nuclides: ^{12}Be, ^{12}B, ^{12}C, ^{12}N, ^{12}O

B. Tables of Recommended Level Energies:

C. References

D. Figures: ^{12}B, ^{12}C, ^{12}N, Isobar diagram

E. Erratum to this Publication: PS or PDF

^{12}Be

(Fig. 8)

An activity of $\tau_{1/2} = 11.4 \pm 0.5$ msec, ascribed to ^{12}Be, is observed in the GeV proton irradiation of ^{15}N, ^{16}O, ^{18}O, ^{19}F, ^{23}Na and ^{27}Al targets (1965PO03). A peak in the particle-identifier spectrum from 5.3 GeV protons on U confirms the existence of ^{12}Be, but the assignment of the 11.4 msec half-life is rendered uncertain by the discovery of ^{11}Li (1966PO09). A calculation by Kurath (see ref [8] in (1965PO03)) suggests $\log ft = 3.5$ for the ground state; E_{β^-}(max) is then ≈ 11.7 MeV for the above $\tau_{1/2}$. $(M - A)$ for ^{12}Be is then ≈ 25.1 MeV, which would mean that ^{12}Be is bound with respect to ^{11}Be $+$ n by ≈ 3.2 MeV. See also (1960GO1B, 1960ZE03, 1961BA1C, 1967AU1B).

^{12}B

(Figs. 5 and 8)

GENERAL:

See (1956KU1A, 1959FL41, 1960TA1C, 1963RE1C, 1963RU1C, 1964MA2A, 1964NA1G, 1964ST1B, 1965UB1C, 1966MA1P, 1967HA10, 1967KE1K, 1967KE1L, 1967MO1R, 1968HI1C).

$$\mu = +1.003 \pm 0.001 \text{ nm (1967SU03)}.$$

1. ^{12}B$(\beta^-)^{12}$C $\qquad\qquad\qquad Q_m = 13.370$
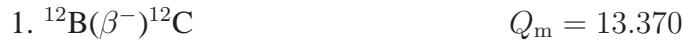
Measured values of the half-life are displayed in Table 12.2. The decay is complex; ^{12}B decays to the ground state of ^{12}C and to several excited states: see ^{12}C. The transition to ^{12}C$_{\text{g.s.}}$ and (4.4) are allowed: hence $J(^{12}\text{B}) = 1^+$.

2. ^{6}Li$(^7$Li, p$)^{12}$B $\qquad\qquad\qquad Q_m = 8.337$

At $E(^7\text{Li}) = 2$ MeV, eleven groups of protons are reported to known states of ^{12}B (1959MO12). At $E(^7\text{Li}) = 2.6$ MeV, a 1.67 MeV γ-ray is reported by (1962BE24). Angular distributions of protons have been determined by (1967GA06: $E(^6\text{Li}) = 3.5$ MeV; p_0, p_1, p_2, p_3) and by (1967KI03: $E(^7\text{Li}) = 3.78$ to 5.95 MeV; p_0, p_1, p_2, p_{3+4}, p_5). Except for p_2, the distributions are nearly isotropic. See also (1957NO14, 1962BE16).

Table 12.1: Energy levels of ^{12}B

E_x in ^{12}B (MeV ± keV)	J^π	τ or Γ (keV)	Decay	Reactions
g.s.	1^+	$\tau_{1/2} = 20.41 \pm 0.06$ msec	β^-	1, 2, 3, 5, 6, 7, 8, 9, 12, 15, 17, 22, 24
0.95314 ± 0.60	2^+	$\tau_m = 300 \pm 33$ fsec	γ	2, 3, 6, 8, 12
1.67365 ± 0.60	2^-	< 50 fsec	γ	2, 3, 6, 8, 12
2.6208 ± 1.2	1^-	< 70 fsec	γ	2, 3, 6, 8, 12
2.723 ± 11	$(\leq 3^+)$		γ	2, 3, 8, 12
3.388 ± 7	$(\leq 3^+)$	< 1.5	n, γ	2, 6, 8, 9, 12
3.756 ± 7	2^+	37 ± 4	n, γ	2, 6, 8, 9, 10, 12
4.303 ± 7	$(1)^-$	9 ± 4	n, γ	2, 6, 8, 9, 10
4.540 ± 20	3^-	110 ± 20	n, γ	2, 6, 8, 9, 10, 12
5.00 ± 20	$1^{(+)}$	60 ± 20	n, γ	2, 6, 8, 9, 10
5.610 ± 20	2	110 ± 20	n	2, 6, 8, 10
5.730 ± 20	3	60 ± 15	n	6, 8, 10
6.6	> 0	140	n	6, 10
(6.76)		65	n	6, 10
7.54	> 3	≤ 14	n	6, 10
(7.66)	> 0	45	n	10
7.77	> 0	90	n	6, 10
(7.96)	> 0	27	n	6, 10
8.23	> 1	65	n	10
8.40		110	n	6, 10
8.49	> 1	75	n	10
9.03	> 1	120	n	6, 10
9.95	> 0	100	n	10
10.53	> 2	65	n	10
12.27	> 2	120	n	10
a				

[a] And thirteen resonances in ^{9}Be(t, n)^{11}B.

Table 12.2: Half-life of ^{12}B [a]

$\tau_{1/2}$ (msec)	Ref.
20.6 ± 0.2	(1958VE20)
$18^{+1.5}_{-1.3}$	(1957CO57)
20.7 ± 0.3	(1958BU1E)
20.4 ± 0.4	(1959FA03)
18.87 ± 0.50	(1959KR1B)
20.31 ± 0.20	(1961SC09)
20.15 ± 0.2	(1962PO02) [b]
20.80 ± 0.15	(1962NE14)
20.3 ± 0.1	(1963FI05)
20.2 ± 0.2	(1963PE10)
20.41 ± 0.06	Weighted average [c]

[a] See also (1955AJ61).
[b] See also (1962MA19).
[c] Excluding (1957CO57, 1959KR1B).

3. ^{7}Li(^{7}Li, d)^{12}B $\qquad\qquad Q_m = 3.309$

The gamma decay of the first four excited states has been studied by (1963CA09): besides the 0.95 MeV state, the states at 1.67 and 2.72 MeV decay primarily to the ground state ($> 98\%$ and $> 80\%$, respectively), while the 2.62 MeV state decays primarily via cascades through the 0.95 or 1.67 MeV states ($> 80\%$). $\tau_m(^{12}\text{B}^*(0.95)) = 295 \pm 40$ fsec; $\tau_m(^{12}\text{B}^*(1.67)) < 50$ fsec (1967THZX). See also ^{11}B(d, p)^{12}B. See also (1962BE24, 1967WY1B) and ^{14}C in (1970AJ04).

4. ^{9}Be(t, n)^{11}B $\qquad\qquad Q_m = 9.561 \qquad\qquad E_b = 12.930$
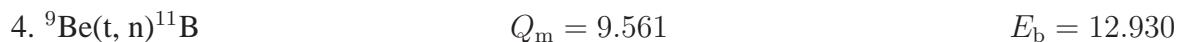
Reported resonances in the yield of neutrons at $\theta = 0°$ are listed in Table 12.3 (1961VA1C). See also (1962SE1A).

5. ^{9}Be(α, p)^{12}B $\qquad\qquad Q_m = -6.884$

See (1951MC57, 1955RA41, 1962WE1C).

Table 12.3: Resonances in ^{9}Be(t, n)^{11}B (1961VA1C)

E_t (MeV)	E_x in ^{12}B (MeV)	Γ_{cm} (keV)	E_t (MeV)	E_x in ^{12}B (MeV)	Γ_{cm} (keV)
1.00	13.679	100	1.880	14.339	45
1.130	13.777		1.932	14.378	40
1.350	13.942	60	2.045	14.462	70
1.405	13.983	50	2.130	14.526	75
1.505	14.058	70	2.210	14.586	60
1.585	14.118	65	2.325	14.672	50
1.765	14.253	110			

6. ^{9}Be(^{7}Li, α)^{12}B $Q_m = 10.463$

At $E(^7$Li$) = 3.5$ MeV, α-groups are seen to the ground state of ^{12}B and to levels at 0.90, 1.61, 2.58, 3.27, 3.60, 4.22, 4.39, 4.90, 5.60, 5.80, 6.61, 7.00, 7.42, 7.77, 8.05, 8.34 and 9.06 MeV. Angular distributions have been obtained for the first five states for $E(^7$Li$) = 3.3$, 3.5 and 3.75 MeV. The total cross sections range from 1.1 to 2.3 mb. All angular distributions are characterized by backward maxima (1961HO19). See also (1966RO1E).

7. ^{9}Be(^{11}B, 2α)^{12}B $Q_m = 1.799$

See (1963HO1E).

8. ^{10}B(t, p)^{12}B $Q_m = 6.343$

Eleven excited states of ^{12}B have been observed by (1960JA17) at $E_t = 5.5$ MeV and by (1964MI04) at $E_t = 10$ MeV. Widths and J^π values derived from angular distribution analyses (1964MI04) are displayed in Table 12.4. See also (1963HO19) and (1965SH1E, 1966SH1F, 1967BA1E; theor.).

9. ^{11}B(n, γ)^{12}B $Q_m = 3.369$

The thermal neutron capture cross section is 5 ± 3 mb (1962IM01). The excitation function of β^- particles (from ^{12}B decay) shows a resonance at $E_n = 20$ keV, with $\omega\Gamma_\gamma \approx 0.4$ eV, $\Gamma < 10$ keV (1964MO07). In the range 140 to 2325 keV, resonances are observed at $E_n = 0.43$, 1.03, 1.28 and 1.78 MeV, with radiation widths of 0.3, 0.3, 0.2 and 0.9 eV, respectively ($\pm 50\%$) (1962IM01).

Table 12.4: Parameters of ^{12}B states from ^{10}B(t, p)^{12}B

E_x in ^{12}B (MeV)	Γ (keV)		L [a]	J^π [a]
(1960JA17) [b]	(1964MI04)	(1960JA17)		
g.s.				
0.955			0	3^+
1.673				
2.627			0	3^+
2.73			(0)	(3^+)
3.393			0	3^+
3.754	42 ± 5	45	1	$2^-, 3^-, 4^-$
4.297	≤ 15			
4.514	100 ± 15	50	1	$2^-, 3^-, 4^-$
5.00	130 ± 40	≈ 40		
5.612	120 ± 20	145	0	3^+
5.724	70 ± 20		0	3^+

[a] (1964MI04).

[b] ± 8 keV, except for the 2.73 and 5.00 MeV states.

10. ^{11}B(n, n)^{11}B $\hspace{3cm} E_b = 3.369$

The thermal (bound) scattering cross section for B is 4.4 ± 0.2 b (1958HU18, 1961WI1A). The scattering amplitude (bound) is $a = 6.6 \pm 0.3$ fm (1965DO14), 6.53 ± 0.35 fm (1966DO11). Parameters of observed resonances in σ_{tot} are listed in Table 12.5. The resonance at $E_n = 20$ keV (1966MO09) is also observed in ^{11}B(n, γ)^{12}B (1964MO07). Angular distributions near the $E_n = 0.43$ MeV resonance $(J = 2)$ show $\cos\theta$ terms, indicating interference with s-wave potential scattering. The best fit to the data is obtained with $l = 1$ formation of the resonance, either all channel spin 1 or all channel spin 2 (1955WI25). Polarization results can be explained by interference of s- and p-wave neutrons at this resonance (1962EL01). The $E_n = 1.28$ MeV resonance can be fitted with $J = 3$, $l = 2$ with the partial width in channel spin 2 equal to 10 times that in channel spin 1. Potential scattering at $E_n = 1.5$ MeV is nearly all s-wave, $\delta_0 = -90°$ (1955WI25). A resonance not seen in earlier work is reported by (1962IM01) at $E_n = 1.027$ MeV. The observed cross section is consistent with s-wave formation, $J^\pi = (1)^-$. Polarization and differential cross section measurements have been carried out at 70 neutron energies from 0.075 to 2.25 MeV. Large polarizations are observed from the resonance at $E_n = 1.28$ MeV up to 2.25 MeV. Resonance behavior of the interference terms indicates that the parities of ^{12}B*(4.54) and (5.00) must be opposite (1967LA1N).

Total cross sections from $E_n = 3.4$ to 15.5 MeV have been studied by (1961FO07): see Table 12.5. There is no evidence of sharp structure in the range $9.7 < E_x < 17.3$ MeV. Limitations of statistical accuracy exclude observation of $J = 0$ levels above $E_n = 4$ MeV, and of $J = 1$ levels above $E_n = 12$ MeV in this work. Total cross sections from $E_n = 14.1$ to 18.0 MeV are reported by (1954CO16).

See also (1963BA1F, 1963KU1F, 1963NE1H, 1965MO1J, 1967MA1K) and (1963LU10, 1966AG1A; theor.) and (1959AJ76).

11. (a) ^{11}B(n, d)^{10}Be $Q_m = -9.004$ $E_b = 3.369$

   (b) ^{11}B(n, t)^{9}Be $Q_m = -9.561$

   (c) ^{11}B(n, α)^{8}Li $Q_m = -6.632$

   (d) ^{11}B(n, p)^{11}Be $Q_m = -10.731$

Reaction (a) has not been reported. At $E_n = 14.1$ MeV, the cross section for reaction (b) is 15 ± 5 mb (1958WY67). The cross section for reaction (c) decreases from 27 mb at $E_n = 12.6$ MeV to 16 mb at $E_n = 20.0$ MeV (1956AR21). At $E_n = 14.1$ MeV, the cross section is 35 ± 7 mb (1959SA04; see also (1962KA37, 1963CH20, 1966MO09)). The cross section for reaction (d) has been measured for $E_n = 14.7$ to 16.9 MeV (1962KA37, 1966ST17). See also (1959AL83, 1964ST25).

12. ^{11}B(d, p)^{12}B $Q_m = 1.144$

Observed proton groups and gamma rays are displayed in Table 12.6. Angular distributions of protons leading to the ground and 0.95 MeV states are of special interest because of the low Q-value: see studies by (1953HO48, 1961GO27, 1961GO28, 1961PU1B, 1962GO24, 1963RO22, 1963SE1F, 1963SE1G, 1964FI1D, 1964TI03, 1965BE1V, 1965FI05, 1965GA02, 1965LO02, 1965SA15, 1966GA09, 1966HA10, 1967BO17, 1967MO1Q, 1967SC29). Spectroscopic factors are listed by (1965GA02, 1966GA09, 1967MO1Q, 1967SC29). Polarization of the recoil ^{12}B is reported by (1959CH1D, 1967SU03).

The 0.95 MeV level is formed by p-wave capture, $J^\pi = 0^+$, 1^+, 2^+ or 3^+. The observed anisotropy of the γ-radiation (1960KO03, 1963WA20, 1965BE1V) excludes $J = 0$. The mean life of the state is 0.30 ± 0.033 psec (1968OL01). So short of a life excludes pure E2 radiation and hence $J \neq 3$, and limits $\delta^2 \equiv$ E2/M1 intensity ratio to < 0.02 for $J = 1$ or 2 (1963WA20). The observed polarization of the γ-ray also excludes $J = 3$ (1965BE1V). Gamma-γ correlations in the cascade $1.67 \rightarrow 0.95 \rightarrow$ g.s. fix $J = 2$; the amplitude mixing ratio $\delta \equiv$ E2/M1 for γ (0.95) is in the range $-0.124 \rightarrow 0.00$ (1968CH05). The energy of the level is 953.14 ± 0.60 keV (1966WI01). The observed $\Gamma_\gamma = 2.2 \pm 0.25$ meV and the mixing rates E2/M1 are in satisfactory agreement with IPM predictions (1968OL01). See also (1961GO27, 1961GO28, 1966BE31, 1967BO17).

Table 12.5: Resonances in ^{11}B(n, n)^{11}B [a]

E_n (MeV $\pm$ keV)	Γ_r (lab) (keV)	^{12}B* (MeV)	l [b]	θ_n^2 [c]	J^π
0.02 [d]	< 1.5	3.387			
0.43 $\pm$ 10 [e]	40 $\pm$ 5	3.76	1	0.036	2^+ [h]
1.027 $\pm$ 11 [f]	10 $\pm$ 4	4.310	0		$(1)^-$
1.28 $\pm$ 20 [e]	140 $\pm$ 20	4.54	2	0.28	3^- [h]
1.78 $\pm$ 20 [e]	65 $\pm$ 20	5.00	1	0.012	1 [c,i]
			(2)	0.056	
2.45 $\pm$ 20 [e]	120 $\pm$ 40	5.61	1	0.017	2 [c]
			2	0.053	
2.58 $\pm$ 20 [e]	60 $\pm$ 20	5.73	1	0.008	3 [c]
			2	0.025	
3.5 [g]	140 (c.m.)	6.6			> 0
(3.70)	65 (c.m.)	(6.76)			$\geq$ 0
4.55	$\leq$ 14 (c.m.)	7.54			> 3
(4.68)	45 (c.m.)	(7.66)			> 0
4.80	90 (c.m.)	7.77			> 0
(5.01)	27 (c.m.)	(7.96)			> 0
5.31	65 (c.m.)	8.23			> 1
5.49	110 (c.m.)	8.40			
5.59	75 (c.m.)	8.49			> 1
6.18	120 (c.m.)	9.03			> 1
7.18	100 (c.m.)	9.95			> 0
7.82	65 (c.m.)	10.53			> 2
9.72	120 (c.m.)	12.27			> 2

[a] (1964ST25). [b] (1951BO45, 1955WI25, 1964ST25).

[c] (1951BO45); $R = 4.5$ fm.

[d] (1964MO07, 1966MO09).

[e] (1951BO45, 1958HU18, 1964ST25).

[f] (1962IM01).

[g] This resonance and all the higher energy ones have been observed by (1961FO07).

[h] (1955WI25, 1966MO09).

[i] The parity appears to be even: see (1967LA1N).

Table 12.6: ^{12}B levels from ^{11}B(d, p)^{12}B

^{12}B* (MeV ± keV)	l_n [f]	J^π [g]	Gamma decay [d] (%)	τ_m [d] (fsec)
0	1	1^+	−	
0.95314 ± 0.60 [a]	1	2^+	to g.s.	300 ± 33
0.947 ± 5 [b]				
0.952 ± 3 [c]				
1.67365 ± 0.60 [a]	0	2^-	$(3.2 \pm 0.4) \rightarrow 0.95$	< 50
1.674 ± 11 [b]			$(96.8 \pm 0.4) \rightarrow$ g.s.	
2.6185 ± 3.5 [a]	0	1^-	$(14 \pm 3) \rightarrow 1.67$	
2.6208 ± 1.2 [d]			$(80 \pm 3) \rightarrow 0.95$	< 70
2.618 ± 11 [b]			$(6 \pm 1) \rightarrow$ g.s.	
2.723 ± 11 [b]	(1)	$(\leq 3^+)$	$(> 85\%) \rightarrow$ g.s.	
3.383 ± 9 [b]	1	$(\leq 3^+)$	$\Gamma_\gamma < 0.1\,\Gamma$ [g]	
3.76 [e]				
4.53 [e]	2			

[a] (1966WI01).
[b] (1950BU1A, 1953EL12).
[c] (1961JA23).
[d] (1968OL01).
[e] (1953HO48).
[f] (1953HO48, 1961GO27, 1961GO28, 1962GO24, 1965GA02, 1966GA09).
[g] See (1965GA02, 1968CH05).

The 1.67 MeV state is formed by s-wave capture, $J^\pi = 1^-$ or 2^-. The gamma decay is mainly direct, with a $(3.2 \pm 0.5)\%$ (1968OL01), $3.0 \pm 0.6\%$ (1968CH05) branch via ^{12}B*(0.95): $\tau_m < 50$ fsec (1968OL01). See also (1964CH04, 1963WA20, 1965GA02). Gamma-γ correlations lead to an assignment $J^\pi = 2^-$ (1964CH04, 1965GA02, 1968CH05). The energy of the level is 1673.65 ± 0.60 keV (1966WI01).

The 2.62 MeV level is formed by s-wave capture, $J^\pi = 1^-$ or 2^- (1962GO24, 1965GA02). The level decays mainly via ^{12}B*(0.95) $(80 \pm 3)\%$. The ground-state branch is $(6 \pm 1)\%$ (1968OL01): $\tau_m < 70$ fsec (1968OL01). See also (1963WA20, 1965GA02). Gamma-γ correlations lead to $J^\pi = 1^-$. $E_x = 2620.8 \pm 1.2$ keV (1968OL01), 2618.5 ± 3.5 keV (1964CH04, 1966WI01). See also (1965GA02).

The 2.72 MeV level is only weakly excited; most probably $l_n = 1$, $J^\pi \leq 3^+$, although $l_n = 0, 2$ are not excluded (1965GA02). The decay is mainly, if not entirely, ($> 85\%$) to the g.s. (1968OL01): see also ^{7}Li(^{7}Li, d)^{12}B.

The 3.39 MeV state is formed by $l_n = 1$ (1953HO48); $\Gamma_\gamma/\Gamma < 0.1$ (1965GA02). See also (1963BR16, 1966BE1E, 1966GO1L, 1966SC23, 1967CH19).

13. ^{11}B(t, d)^{12}B $Q_m = -2.888$

Not reported.

14. ^{11}B(α, ^{3}He)^{12}B $Q_m = -17.209$

Not reported.

15. ^{12}C(n, p)^{12}B $Q_m = -12.588$

See (1948JE03, 1959AL83, 1967ME11) and ^{13}C in (1970AJ04).

16. ^{12}C(t, ^{3}He)^{12}B $Q_m = -13.352$

Not reported.

17. ^{13}C(γ, p)^{12}B $Q_m = -17.535$

See (1963NE02) and ^{13}C in (1970AJ04).

18. ^{13}C(d, ^{3}He)^{12}B $Q_m = -12.041$

Not reported.

19. ^{13}C(t, α)^{12}B $Q_m = 2.280$

Not reported.

20. ^{14}C(n, t)^{12}B $\qquad\qquad$ $Q_m = -17.229$

Not reported.

21. ^{14}C(p, ^{3}He)^{12}B $\qquad\qquad$ $Q_m = -17.993$

Not reported.

22. ^{14}C(d, α)^{12}B $\qquad\qquad$ $Q_m = 0.361$

See (1950HU72, 1956DO41).

23. ^{14}N(n, ^{3}He)^{12}B $\qquad\qquad$ $Q_m = -17.366$

Not reported.

24. ^{15}N(n, α)^{12}B $\qquad\qquad$ $Q_m = -7.623$

See (1948JE03).

<div align="center">

¹²C

(Figs. 6 and 8)

</div>

GENERAL:

Shell model : (1956KU1A, 1956PE1A, 1957KU58, 1960ME1C, 1960TA1C, 1960WE1C, 1961BA1E, 1961TR1B, 1963NA04, 1963VI1A, 1964AM1D, 1964CL1A, 1964GI1B, 1964GI1C, 1964NE1E, 1965BA2E, 1965CO25, 1965FA1C, 1965NE1C, 1966GI1A, 1966HA18, 1966VA1D, 1966YO1B, 1967CO32, 1967EV1C, 1967KU1N, 1968HI1H).

Collective model : (1959BA1F, 1959BR1E, 1961CL10, 1962CL13, 1962GO1R, 1962WA17, 1963GO1Q, 1964BR1H, 1964VO1B, 1965ST22, 1965UB1B, 1965UB1A, 1965VO1A, 1966BO1X, 1966DA1F, 1966DR1F, 1966KR02, 1967BA2N, 1967BO1G, 1967BO04, 1967BR1E, 1967KR1C, 1967LA09, 1967LA1G, 1967PA10, 1967RI1B, 1967RO1G, 1967SA1K, 1967SO1A, 1967SO07, 1967BA1K, 1967BA12, 1967BA2D, 1968MI1E, 1968SO1B).

Cluster model : (1956GL1B, 1956PE1A, 1959PI1B, 1960BI1E, 1960IN1B, 1960SH1A, 1966HE1C, 1962MA1H, 1963MA1D, 1963MA1E, 1964GR1M, 1964MA1G, 1965BA2D, 1965BE1H, 1965FA1C, 1965IN1A, 1965KU1E, 1965NE1B, 1965SH11, 1966DA1J, 1966DU1D, 1966HA1R, 1966HE1C, 1966KA1A, 1966BR1U, 1967NO1C, 1967TA1C, 1967UI01, 1968GO01).

Special levels : (1959BA1D, 1960BA38, 1960WE1C, 1960ZE1B, 1961YO1A, 1962BA1C, 1963DU1C, 1963SE17, 1964LI1B, 1964NA1G, 1964PA1H, 1966BR2E, 1966ME05, 1966MO08, 1967RO1L).

*E*1 *giant resonance* : (1960SA1F, 1962NI1D, 1962VI01, 1963MI1B, 1963PE04, 1964GI1C, 1964MI1E, 1966DR1F, 1966LE1J, 1967BA2N, 1967DA1H, 1967DR1D, 1967KE1L, 1967ME1G, 1967MU1F, 1967YO04, 1968KA1M).

Special reactions : (1961BE1E, 1961JA1H, 1964AF1A, 1964DU1D, 1964PA1H, 1964RE1B, 1965KR1A, 1965MA1X, 1966DE1G, 1966DU1D, 1966PH1C, 1967AU1B, 1967KA1C, 1967ZI1A).

Transition probabilities : (1956EL1C, 1957KU58, 1962KU1D, 1962WA17, 1963BO1D, 1963KI1D, 1963KU03, 1963MA1E, 1964CL1D, 1965GR1H, 1965ST22, 1967HS1A, 1967KU1N).

Muon capture : (1965FO1F, 1965UB1A, 1966FR1J, 1967BA78, 1968BA2G).

Other topics : (1959CA1B, 1964RA1A, 1966BA42, 1966BO1P, 1966WI1E, 1966YO1C, 1967BL1D, 1967EL1E, 1967NE1G).

1. (a) ^{6}Li(^{6}Li, α)^{8}Be $Q_\mathrm{m} = 20.808$ $E_\mathrm{b} = 28.177$

   (b) ^{6}Li(^{6}Li, n)^{11}C $Q_\mathrm{m} = 9.457$

   (c) ^{6}Li(^{6}Li, p)^{11}B $Q_\mathrm{m} = 12.220$

<div align="center">

13

</div>

(d) ^{6}Li(^{6}Li, d)^{10}B $Q_m = 2.989$

(e) ^{6}Li(^{6}Li, nα)^{7}Be $Q_m = 1.912$

(f) ^{6}Li(^{6}Li, pα)^{7}Li $Q_m = 3.556$

(g) ^{6}Li(^{6}Li, ^{6}Li)^{6}Li

Table 12.7: Energy levels of ^{12}C

E_x in ^{12}C (MeV $\pm$ keV)	$J^\pi; T$	Γ (keV)	Decay	Reactions
0	$0^+; 0$	–	stable	3, 4, 6, 15, 16, 17, 18, 19, 23, 24, 25, 26, 27, 28, 29, 36, 38, 39, 40, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 72, 73, 74, 75, 76, 77, 78
4.4392 ± 0.3	$2^+; 0$	11.7 ± 0.5 meV	γ	6, 15, 16, 17, 19, 23, 24, 25, 28, 29, 36, 38, 39, 40, 43, 44, 47, 48, 49, 51, 53, 54, 55, 60, 61, 63, 65, 66, 68
7.653 ± 3	$0^+; 0$	9.7 ± 3.3 eV	γ, π, α	6, 15, 17, 23, 24, 28, 36, 38, 39, 40, 43, 44, 51, 54, 55, 61, 65
9.638 ± 5	$3^-; 0$	34 ± 5 keV	γ, α	6, 15, 17, 19, 23, 24, 36, 38, 39, 40, 44, 47, 55, 61, 65
10.3 ± 300	$(0^+); 0$	3000 ± 700	α	6, 24, 28, 38, 51
10.844 ± 16	$1^-; 0$	320 ± 20	α	6, 15, 23, 24, 38, 39, 55, 61, 65
11.828 ± 16	$2^-; 0$	274 ± 20	α	15, 17, 23, 24, 38, 39, 44
12.713 ± 6	$1^+; 0$		$\gamma_0, \gamma_1, \alpha$	15, 17, 23, 24, 39, 44, 51, 53, 61
13.352 ± 17	$(2^-); 0$	400 ± 50	α	15, 23, 24, 61
14.083 ± 15	$(4^+); 0$	258 ± 15	α	15, 23, 39, 44, 47, 61,
14.71 ± 10		< 15		24
15.109 ± 4	$1^+; 1$	39.4 ± 1.5 eV	γ_0, γ_1	2, 6, 15, 17, 23, 30, 36, 39, 51, 53, 55, 61
16.106 ± 1	$2^+; 1$	6 ± 0.6 keV	$\gamma_0, \gamma_1, \gamma_3, \alpha_0, \alpha_1, \mathrm{p}$	15, 19, 23, 29, 36, 39, 61
16.577 ± 20	$2^-; (1)$	300	$\gamma_1, \alpha_1, \mathrm{p}$	15, 19, 21, 30, 53
17.23	$1^-; 1$	1150	$\gamma_0, \gamma_1, \alpha_0, \alpha_1, \mathrm{p}$	19, 21, 23, 29
17.77	$0^+; (1)$	100	$\alpha_0, \alpha_1, \mathrm{p}$	19, 21
(18.1)	(1^-)	500	$\gamma_0, \alpha, \mathrm{p}$	34, 36, 39
18.36	$(3^-; 0)$	310	$\gamma_1, \alpha_0, \alpha_1, \mathrm{p}$	19, 21

14

Table 12.7: Energy levels of ^{12}C (continued)

E_x in ^{12}C (MeV ± keV)	$J^\pi; T$	$\Gamma_{\text{c.m.}}$ (keV)	Decay	Reactions
18.39	0^-	42	p	21
18.71	(; 1)	100	α_0, p	19
18.84	$2^+; 1$	100	γ_1, p, n	19, 20, 21
19.2	$(1^-; 1)$	1100	γ_0, γ_1, α_0, α_1, p, n	19, 20, 21, 30, 36
19.2	$(2^-; 1)$	500		36, 39
19.39	$(2^+; 0)$	(1100)	γ_1, α_0, α_1, p	19, 21
(19.42)		45	p	21
(19.69)		180	p, n	20
19.88		90	p	21
20.24		150	p, n	20, 21
20.47		180	γ_1, α_1, p	19, 39
20.64	$(3^-; 1)$	200	γ_1, α_0, p, n	15, 19, 20, 21
20.99		270	p, n	20, 39
21.49		430	γ_0, p, n	19, 20, 39
22.1			γ_0, γ_1, α_0, p, n	19, 20, 30, 39
22.6	$(1^-; 1)$	3200	γ_0, p	19, 29, 30, 31, 36, 39
22.64		330	p, n	20
23.04		60	p, n	20
23.52		350	p, n	20, 30, 39
23.6			γ_0, γ_1, α_0, p, n	19, 20
23.89		170	p, n	20
(24.2)			p, n	20
24.44		80	p, n	15, 20
24.93		900	p, n	20
25.25	(; 2)	115	γ_1, p, n	19, 20
25.4	$(1^-; 1)$	≈ 6500	γ_0, γ_1	19, 29, 30
25.96		400	p, n, d, α	9, 12, 20, 39
26.9		270	γ_1, p, n	19, 20
27.45			γ_0, p, n, d	10, 19, 30
28.0		350	γ_0, p_1, p, n, ^{3}He	5, 19
28.45			γ_1, p	19
28.9			γ_0, p, α, n	19, 29, 30, 34

Table 12.7: Energy levels of ^{12}C (continued)

E_x in ^{12}C (MeV $\pm$ keV)	$J^\pi; T$	$\Gamma_{\text{c.m.}}$ (keV)	Decay	Reactions
32.4			γ_0, n	31
34.4	$(1^-; 1)$	≈ 4000	γ_0, γ_1, p	19, 30, 36

Elastic scattering, studied for $E(^6\text{Li}) = 3.2$ to 7.0 MeV follows the Mott formula at low energies, but deviates at energies $\gtrsim 4.0$ MeV. Angular distributions can be accounted for by the Blair cut-off model, but the parameters are not sharply defined (1966PI02).

For $E(^6\text{Li}) = 1.2$ to 2.8 MeV, population ratios of ^{7}Be*(0.43), ^{7}Li*(0.48) and ^{10}B*(0.72) remain approximately constant. Simple tunneling or compound nucleus models are not compatible with the data and a direct interaction through long-range tails is suggested (1962MC12). Absolute reaction cross sections at $E(^6\text{Li}) = 2.1$ MeV are in reasonable agreement with estimates based on barrier penetration. A strong preference for α-emission suggests that the favored mechanism involves interacting clusters (1963HU02). A conspicuous feature of the α-spectrum involves a transition through highly excited states of ^{8}Be, possibly those at $E_x = 22.2$ and 22.9 MeV with large ^{6}Li + d parentage (1963KA20, 1964MA26). Angular distributions of α_0 and α_1 indicate stripping (1964MA26: 2.0 to 4.4 MeV). Noticeable fluctuations of protons angular distributions and of 0° α-yields in the range $E(^6\text{Li}) = 2.4$ to 9.0 MeV (1966KI09), and 2.2 to 14.5 MeV (1967AL1F), indicate compound nucleus effects. See also (1962DE1F, 1963BA1Q, 1963CO35, 1963LE19, 1964CA1G, 1964GA1E, 1965NO1A), ^{8}Be and ^{10}B in (1966LA04), and ^{11}B and ^{11}C here.

2. ^{6}Li(^{7}Li, n)^{12}C $Q_m = 20.924$

At $E(^7\text{Li}) = 2.6$ MeV, population of the ^{12}C states at 15.11 and 4.44 MeV is reported (1962BE24). See also (1957NO17, 1963KA1E).

3. ^{6}Li(^{11}B, αn)^{12}C $Q_m = 12.260$

See (1963HO1E).

4. ^{7}Li(^{7}Li, 2n)^{12}C $Q_m = 13.672$
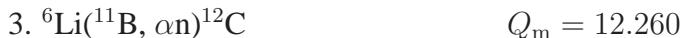
See (1962BE16, 1962BE24).

5. (a) ^{9}Be(^{3}He, γ)^{12}C $\qquad\qquad Q_m = 26.282 \qquad\qquad\qquad E_b = 26.282$

   (b) ^{9}Be(^{3}He, n)^{11}C $\qquad\qquad Q_m = 7.562$

   (c) ^{9}Be(^{3}He, p)^{11}B $\qquad\qquad Q_m = 10.325$

   (d) ^{9}Be(^{3}He, d)^{10}B $\qquad\qquad Q_m = 1.094$

   (e) ^{9}Be(^{3}He, t)^{9}B $\qquad\qquad Q_m = -1.087$

   (f) ^{9}Be(^{3}He, α)^{8}Be $\qquad\qquad Q_m = 18.913$

   (g) ^{9}Be(^{3}He, ^{3}He)^{9}Be

The yield of capture γ-rays to the ground and 4.4 MeV states (reaction (a)) has been measured for $E(^3$He$) = 2$ to 4.5 MeV. The cross section increases monotonically; at 4.5 MeV, $\sigma(\gamma_0)$ is ≈ 4 μb. A strong 17.6 MeV γ-ray is ascribed to reaction (f) (1964BL12). Evidence for decays via higher states of ^{12}C is not conclusive (1963BL05, 1964BL12).

Excitation functions for neutrons (reaction (b)) have been determined by (1963DU12: 1.2 to 2.7 MeV; n_0, n_1, n_2, n_3, n_{4+5}; $\theta = 0°$ and 81.5°), (1965DI06: 1.3 to 4.9 MeV; n_0, n_1; $\theta = 0°$, 90° and 160°), (1965TO06: 3.5 to 5.8 MeV; n_0, n_1, n_{2+3}, n_{4+5}, n_6, n_7, n_8; $\theta = 5°$ and 90°) and (1968OK1D: 3.5 to 9.9 MeV; n_0, n_1). See also (1959MA1D, 1962SE1A, 1966MA1R, 1967HA20). No sharp structure is observed but there is some suggestion from angular distribution data and excitation functions at forward angles for a broad structure ($\Gamma \approx 350$ keV) at $E(^3$He$) \approx 2$ MeV: $E_x = 27.8$ MeV (1963DU12, 1965DI06). Comparison with (^{3}He, p) shows reasonable similarity at low energies, but strong differences for $E(^3$He$) > 2.5$ MeV (1965DI06, 1965TO06). For $E(^3$He$) = 3.5$ to 5.8 MeV the reaction proceeds predominantly by direct interaction (1965TO06). The total cross section for ^{11}C production shows a broad maximum, $\sigma = 113$ mb, at $E(^3$He$) = 4.3$ MeV (1966HA21: 3.2 to 10 MeV). See also (1965BR42, 1967HA20). Angular distributions of the polarization of neutrons to ^{11}C*(0, 2.0, $4.3 + 4.8$) have been measured at nine ^{3}He energies from 2.1 to 3.9 MeV by (1967TH1H). See also ^{11}C.

Excitation functions and angular distributions for protons (reaction (c)) have been measured for $E(^3$He$) = 1.0$ to 2 MeV (1967CO03: 90°; p_2 to p_9), 1.8 to 4.9 MeV (1959WO53: total and differential cross sections; p_0 and p_1), 3 to 5 MeV (1959WO53: p_2 and p_3) and 5.7 to 10.2 MeV (1960HI08: 10°, p_0 to p_9; 90°, p_0, p_1). From $E(^3$He$) = 5.7$ to 10 MeV the majority of angular distributions are essentially independent of energy, showing pronounced forward peaking, consistent with a predominantly direct process. The excitation curves show only a slow and smooth increase (1960HI08). See also ^{11}B.

Excitation functions for ground-state tritons (reaction (e)) for $E(^3$He$) = 2.4$ to 4.1 MeV ($\theta = 20°$, 40°, 55° and 90°) show a smooth rise with energy in the region explored (1960TA04). At $\theta = 20°$ the cross section then shows a broad maximum at $E(^3$He$) \approx 4.5$ MeV. Following this maximum, the cross section decreases to $E(^3$He$) \approx 7.5$ MeV and then rises slowly to 9 MeV. Angular distributions of ground-state tritons have been measured at 1 MeV intervals between $E(^3$He$) = 5.0$ and 9.0 MeV (1967EA01). Near $E(^3$He$) = 10$ MeV, excitation functions for tritons and deuterons show no detailed structure; angular distributions show characteristic direct interaction features. DWBA fits for tritons are less satisfactory than those for deuterons (1967CR04). See also (1960HI08).

The elastic scattering excitation function (reaction (g)) has been measured at $45°$ for $E(^3\text{He}) = 4.0$ to 9.0 MeV: it decreases monotonically over this energy region (1967EA01). For reaction (f), see (1964BL12) and ^{8}Be in (1966LA04).

6. ^{9}Be$(\alpha, \text{n})^{12}$C $\qquad\qquad\qquad\qquad Q_\text{m} = 5.704$

Neutron groups corresponding to ^{12}C levels at 0, 4.4, 7.7, 9.6, (10.1) and (10.8) MeV are reported: see (1960AJ04, 1962NI02). Observation of the γ-decay of the 15.1 MeV level is reported by (1954RA35, 1957WA04, 1957WA1F). Angular distributions have been studied by (1959SM98: 1.9 to 2.7 MeV; n_0, n_1), (1960RE02: 2 to 5.6 MeV; n_0, n_1, n_2), (1960GA14: 3.35 and 5.10 MeV; n_1), (1963ME11: 5.3 MeV; n_1), (1960AJ04: 5.6 and 5.8 MeV; n_0, n_1, n_2), (1961GA03: 5.5, 5.8 and 6.0 MeV; n_0, n_1, n_2), (1967VE1D: 6 to 10 MeV; n_0, n_1, n_2), (1962KJ02, 1962KJ04, 1962NI02: 9.8 to 14.2 MeV; n_0, n_1, n_2, n_{3+4}), (1962DE1G, 1963DE27, 1965DE1F: 12.9 to 23 MeV; n_0, n_1) and (1963KO03: 17.5 to 22.1 MeV; n_0, n_1, n_3).

Doppler shift measurements on the transition ^{12}C*(4.4 $\rightarrow$ g.s.) yield a mean life $\tau_\text{m} = 50 \pm 6$ fsec (1961DE38); 57^{+23}_{-17} fsec, $\Gamma_\gamma = (11.5^{+5}_{-3.2})$ meV (1966WA10); $\leq 48\pm10$ fsec (1967CA02): see Table 12.8. The internal pair conversion coefficient indicates an E2 transition (1954MI68): the pair angular correlation permits M1 or E2 and favors the latter (1954HA07, 1956GO1K, 1956GO73, 1958AR1B). Angular distributions of n_1 and $n_1 - \gamma$ correlations strongly indicate a direct interaction mechanism even at $E_\alpha = 3.3$ and 5.5 MeV (1960GA14, 1962KJ01). Gamma ray angular distributions have been studied by (1955TA28, 1959SM98, 1963SE04). See also ^{13}C.

The 7.65 MeV state decays predominantly into ^{8}Be$+\alpha$ (see reactions 15 and 28). The 7.7 MeV nuclear pairs have been observed: $\Gamma_\pi/\Gamma = (6.6\pm2.2) \times 10^{-6}$ (1959AL97, 1960AJ04, 1960AL04, 1961GA03). See also (1959AJ76) for a survey of the earlier work.

See also (1959HE1B, 1959LI1D, 1959NA1B, 1961DE08, 1961EL1A, 1962BR14, 1962EL1C, 1962GO1J, 1962HU1D, 1962ST12, 1963AN1B, 1964SA1J, 1965CL1B, 1967EL1D, 1967VA1J).

7. ^{9}Be$(^7\text{Li}, ^4\text{H})^{12}$C

Not observed: see (1964CA05).

8. ^{10}B$(\text{d}, \gamma)^{12}$C $\qquad\qquad\qquad\qquad Q_\text{m} = 25.188$

At $E_\text{d} = 0.95$ MeV, the upper limit to the capture cross section is $0.1\ \mu$b (1955SA1B).

9. ^{10}B$(\text{d}, \text{n})^{11}$C $\qquad\qquad Q_\text{m} = 6.468 \qquad\qquad\qquad E_\text{b} = 25.188$
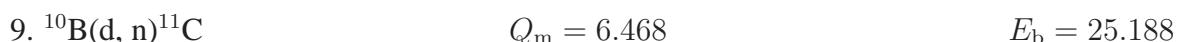
The thin-target excitation function in the forward direction in the range $E_\text{d} = 0.3$ to 4.6 MeV

Table 12.8: Electromagnetic decay of ^{12}C levels [a]

Level	Width	Reaction	Refs.
4.44	$\Gamma_\gamma = 12.5 \pm 2.5$ meV	^{12}C(e, e)	(1956HE83)
	11.2 ± 1.2	^{12}C(e, e)	(1964CR11)
	10.6 ± 1.1	^{12}C(e, e)	(1967CR01)
	12.2 ± 0.8	^{12}C(e, e)	(1967AR1A)
	13 ± 1.5	^{9}Be(α, n)	(1961DE38)
	$11.5^{+5}_{-3.2}$	^{9}Be(α, n)	(1966WA10)
	10.1 ± 2	^{12}C(γ, γ)	(1958RA14)
	11.7 ± 0.5 meV		mean
7.65	$\Gamma_\pi = 55 \pm 30$ μeV	^{12}C(e, e)	(1956FR27)
	65 ± 7	^{12}C(e, e)	(1964CR11)
	73 ± 13	^{12}C(e, e)	(1965GU04)
	62 ± 6	^{12}C(e, e)	(1967CR01)
	64 ± 4 μeV		mean
	$\Gamma_\pi/\Gamma = (6.6 \pm 2.2) \times 10^{-6}$	^{9}Be(α, n)	(1960AJ04, 1960AL04)
	$\Gamma_\gamma/\Gamma = (3.3 \pm 0.9) \times 10^{-4}$	^{10}B(^{3}He, p)	(1961AL23)
	(3.5 ± 1.2)	^{10}B(^{3}He, p)	(1964HA23)
	(2.8 ± 0.3)	^{14}N(d, α)	(1963SE23)
	$(2.9 \pm 0.3) \times 10^{-4}$		mean
	$\Gamma = \Gamma_\pi/(\Gamma_\pi/\Gamma) = (9.7 \pm 3.3)$ eV		
	$\Gamma_\gamma = \Gamma(\Gamma_\gamma/\Gamma) = (2.8 \pm 1.0)$ meV		
9.64	$\Gamma_\gamma = 0.36 \pm 0.04$ meV	^{12}C(e, e)	(1964CR11)
	0.31 ± 0.04	^{12}C(e, e)	(1967CR01)
	0.34 ± 0.03 meV		mean
12.71	$\Gamma_\gamma/\Gamma_\alpha = 0.025 \pm 0.007$	^{10}B(^{3}He, p)	(1958MO99, 1959AL96)
	$\Gamma_\gamma/\Gamma = 0.027 \pm 0.007$	^{12}C(p, p)	(1962WA31)
15.11 [b]	$\Gamma_{\gamma 0} = 54.5 \pm 9.3$ eV	^{12}C(γ, γ)	(1957HA13)
	59.2 ± 9.7	^{12}C(γ, γ)	(1959GA09)

Table 12.8: Electromagnetic decay of ^{12}C levels [a] (continued)

Level	Width	Reaction	Refs.
	40.2 ± 5.2	^{12}C(γ, γ)	(1963SC21)
	54 ± 6	^{12}C(γ, γ)	(1961BU1E)
	50.5 ± 7.1	^{12}C(γ, γ)	(1960HA1H)
	37 ± 5	^{12}C(γ, γ)	(1967KU11)
	40^{+8}_{-6}	^{12}C(e, e)	(1959BA36, 1960BA47)
	39 ± 4	^{12}C(e, e)	(1962ED02)
	34.4 ± 3	^{12}C(e, e)	(1964GU05)
	36.0 ± 3	^{12}C(e, e)	(1967PE07)
	39.4 ± 1.5 eV		mean
	$\Gamma_\alpha/\Gamma < 0.05$	^{10}B(^{3}He, p)	(1965AL1B)
	$\Gamma_\gamma/\Gamma = 1.15 \pm 0.3$	^{12}C(p, p)	(1962WA31)

[a] See also ^{11}B(p, γ)^{12}C and ^{12}C + γ.

[b] See also Table 12.15.

shows some indication of a broad resonance near $E_d = 0.9$ MeV. Above $E_d = 2.4$ MeV, the cross section increases rapidly to 210 mb/sr at 3.8 MeV, and then remains constant to 4.6 MeV (1954BU06, 1955MA76). The $0°$ excitation function for ground state neutrons shows no structure for $E_d = 3.2$ to 9.0 MeV. The angular distributions all show a sharp peak around $20°$ and a smaller contribution in the background direction. DWBA produces a satisfactory fit to these distributions, but the parameters vary with energy (1967DI01). Cross-section ratios have been obtained at $E_d = 1$ to 5 MeV for the neutrons and protons to the second, third, fourth, and fifth excited states of the ^{11}B and ^{11}C mirror nuclei (1967SC1K). Polarization measurements have been carried out for $E_d = 2.5$ to 4.0 MeV (1967ME1N). See also (1955SA1B) and ^{11}C.

10. ^{10}B(d, p)^{11}B $Q_m = 9.231$ $E_b = 25.188$

Absolute yields and angular distributions are reported for various proton groups by (1952EN19, 1954BU06, 1954PA28, 1956MA69, 1956VA17, 1959CR1A, 1960CR1A, 1960HA08, 1964BR1A, 1965LE1B, 1967PO01) for $E_d = 0.14$ to 12 MeV. Although the excitation functions show several broad peaks, no clear resonances can be identified, and it is assumed that many overlapping resonances are involved (1956MA69) except possibly at $E_d = 2.3$ MeV ($E_x = 27.1$ MeV) where the effect of a broad resonance influences the cross section of the p_1 and p_3 groups (to ^{11}B*(2.14, 5.03)) (1964BR1A). Studies of plane wave, distorted wave and Coulomb wave Born approximation angular distributions are reported by (1967PO01: see also (1966MO1H, 1967MO1N). There

are no significant fluctuations in the yield of protons for $E_d = 5$ to 12 MeV (1965LE1B: $\theta = 50°$ and $150°$). See also (1965BA31). Yields of gamma rays have been measured by (1955SA1B). Cross section ratios for the (d, n) and (d, p) reactions to mirror states have been measured by (1967SC1K) [see reaction 9].

Polarization measurements have been made by (1959HI1E: 6.9 MeV; p_0), (1964BE08: 10 MeV; p_0, p_1, $p_2 + p_3$), (1962TA13, 1964PA1E: 11 to 13.8 MeV; p_0), (1960TA27: 11.4 MeV; p_0), (1963BO1J: 21 MeV; p_0). The circular polarization of 2.12 and 4.44 MeV γ-rays has been investigated at $E_d = 0.45$ MeV (1960ER1A, 1961ZI02, 1962ZI01, 1963ER1A). See also ^{11}B.

11. ^{10}B(d, d)^{10}B $E_b = 25.188$

See ^{10}B and (1965LE1B, 1967DI01, 1967PO01).

12. ^{10}B(d, α)^{8}Be $Q_m = 17.819$ $E_b = 25.188$
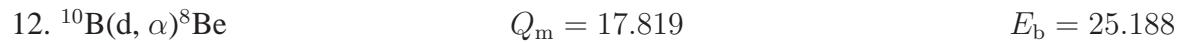
Excitation curves and angular distributions are reported for α_0 and α_1 groups (to ^{8}Be*(0, 2.9)) by (1956MA69, 1960BE15, 1961LE10, 1963PU02, 1964AL1Q, 1964BR1A, 1966LO18, 1967LO1J) for $E_d = 0.4$ to 3.3 MeV. Broad maxima are observed in both excitation curves above $E_d = 1$ MeV. Preliminary data at $E_d = 0.98$ MeV indicate the formation of a level in ^{12}C at 26.00 ± 0.01 MeV which decays via ^{8}Be*(2.9) and ^{8}Be$_{g.s.}$ (1967PE1B).

13. ^{10}B(d, ^{6}Li)^{6}Li $Q_m = -2.989$

This reaction has been studied for $E_d = 8$ to 13.5 MeV. A DWBA calculation with $L = 2$ α-transfer gives a qualitative account of the angular distribution (1964GE10).

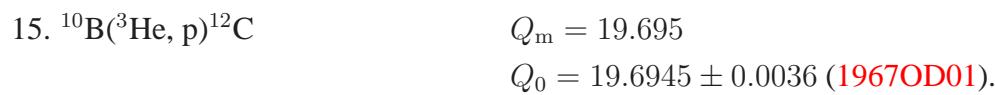14. ^{10}B(t, n)^{12}C $Q_m = 18.931$

Not reported.

15. ^{10}B(^{3}He, p)^{12}C $Q_m = 19.695$
                                                $Q_0 = 19.6945 \pm 0.0036$ (1967OD01).

Table 12.9: ^{12}C states from ^{10}B(^{3}He, p)^{12}C

E_x [a] (MeV ± keV)	Γ (keV)	Γ_γ/Γ	Gamma branching to ^{12}C$_{g.s.}$	^{12}C*(4.43)	Alpha decay [c] to ^{8}Be$_{g.s.}$	^{8}Be*(2.9)	Parity [c,g]	$J^\pi; T$
4.43								
7.655 ± 6		3×10^{-4} [d]			yes		natural	0^+
9.645 ± 6	36 ± 6 [b]				yes		natural	
10.849 ± 25	320 ± 30 [b]				strong	no	natural	
11.841 ± 25	245 ± 30 [b]				no	yes	unnatural	
12.713 ± 6		0.025 ± 0.01		0.20 ± 0.07 [f]	no	yes	unnatural	1^+
13.29 ± 30	430 ± 100 [b]				no	yes	unnatural	≥ 1 [c]
	290 ± 70 [c]							
14.083 ± 15	252 ± 15 [b]				yes	yes	natural	(2^-) [c]
	320 ± 50 [c]							
15.108 ± 6		> 0.95 [g]	0.97 [e]	0.034 ± 0.005 [e,f]	($\Gamma_\alpha/\Gamma < 0.05$) [g]			$1^+; 1$
16.108 ± 6					weak	strong	natural	(2^-)
16.57					yes	yes	natural	
≈ 20.6	≈ 200							
≈ 24.5	≈ 50							

[a] (1962BR10): excitation energies based on $Q_0 = 19.693$ MeV and Po $\alpha = 5.3056$ MeV: see also (1958MO99, 1959AL96, 1967CO1F).
[b] (1962BR10).
[c] (1966WA16).
[d] (1961AL23): the cascade decay (via 4.44) is $(3.3 \pm 0.9) \times 10^{-4}$ of the total decay. This is 50 times stronger than the direct g.s. decay (via pairs). $\Gamma_{rad}/\Gamma = (3.5 \pm 1.2) \times 10^{-4}$ (1964HA23): see Table 12.8.
[e] (1959AL96).
[f] (1960AL14).
[g] (1965AL1B).

Proton groups observed by (1958MO99, 1959AL96, 1962BR10, 1967CO1F) are displayed in Table 12.9. Angular distributions of many of these groups have been measured for $E(^3$He$) = 2.0$ to 3.0 MeV (1965BH1A), 3.7 MeV (1962BR10), 10.1 MeV (1962AL01) and 14 MeV (1967CO1F). The following comments on individual levels derive largely from the ^{10}B(^{3}He, p)^{4}He^{4}He^{4}He studies of (1964ET02, 1965AL1B, 1966WA16): see Table 12.9.

^{12}C*(7.65, 9.6) are observed to decay to ^{8}Be$_{g.s.}$, confirming natural parity $\pi = (-1)^J$ for both states (1966WA16). Pair emission from ^{12}C*(7.66) has been measured: $\Gamma_\pi/\Gamma = (6.6 \pm 2.2) \times 10^{-6}$ [see Table 12.8] as has the cascade through ^{12}C*(4.4): $\Gamma_\gamma/\Gamma = (3.3 \pm 0.9) \times 10^{-4}$ (1961AL23). By observation of ^{12}C recoils, a value $\Gamma_{rad}/\Gamma = (3.5 \pm 1.2) \times 10^{-4}$ is found by (1964HA23): compare to ^{14}N(d, α)^{12}C.

^{12}C*(10.8) decays to both ^{8}Be*(0, 2.9), indicating natural parity. (1966WA1C) searched for ^{12}C*(10.1) with inconclusive results: see also (1962BR10).

^{12}C*(11.83, 12.71, 13.35) decay to ^{8}Be*(2.9) but not to the g.s., indicating unnatural parity: this result is inconsistant with the assignment (1^-) to ^{12}C*(11.83): see (1964BR25). For ^{12}C*(12.71) $\Gamma_\gamma/\Gamma_\alpha = (3 \pm 1)$% (1958MO99), (2 ± 1)% (1959AL96): the cascade through ^{12}C*(4.4) is (20 ± 7)% relative to the ground-state transition (1960AL14): see Table 12.9. The alpha breakup of ^{12}C*(12.71) shows a triple-peaked α-particle spectrum, characteristic of the breakup of a $J^\pi = 1^+$ state (1967BH1B).

^{12}C*(14.08) decays both to ^{8}Be*(0, 2.9); the branching ratio $\Gamma(\alpha_0)/\Gamma$ is 0.1–0.4. Proton α-correlations require $J \geq 2$ (1966WA16).

^{12}C*(15.11: $J^\pi = 1^+$; $T = 1$) decays by γ-emission to ^{12}C$_{\text{g.s.}}$ 97% and to ^{12}C*(4.4) (3.1 ± 0.6)% (1959AL96), (4 ± 1)% (1960AL14); $\Gamma_\alpha/\Gamma < 0.2$ (1960MI1E), < 0.05 (1965AL1B), < 0.10 (1966WA16), respectively. The strong inhibition of the transition to ^{8}Be*(2.9) is cited as evidence for a high isospin purity (1965AL1B): see, however, (1958KA31).

^{12}C*(16.11, 16.57) show decay to both ^{8}Be*(0, 2.9). The consequent assignment of natural parity is consistent with $J^\pi = 2^+$ for the former but not with the accepted $J^\pi = 2^-$ for the latter [see reaction 19]. For ^{12}C*(16.11) observed values of Γ_{α_0}/Γ are $0.05 - 0.12$; the decay to 3α occurs rarely, if at all (1966WA16: see, however, ^{11}B(p, α)^{8}Be: (1965DE1R)).

The giant resonance excitation region has been searched for levels with a resolution of ≈ 20 keV at $E(^3\text{He}) = 14$ MeV. Two peaks have been observed corresponding to ^{12}C* ≈ 20.6 and 24.5 MeV, with $\Gamma \approx 200$ and 50 keV, respectively. Angular distributions show forward maxima. peaks which could be associated with structure seen in photodisintigration experiments are not observed (1967CO1F). See also (1959JO1E, 1961AL10, 1961WO08, 1962KU02, 1965SI05, 1966BA01) and ^{13}N.

16. ^{10}B(α, d)^{12}C $Q_m = 1.341$
                                            $Q_0 = 1.3406 \pm 0.0015$ (1965BR28).

At $E_\alpha = 21.2$, 23.0 and 25.0 MeV angular distributions of the deuterons corresponding to ^{12}C*(0, 4.4) have been measured (1967AL16).

See also (1959HE1C, 1960ON01, 1965JA03, 1965NI1B) and ^{14}N.

17. ^{10}B(^{6}Li, α)^{12}C $Q_m = 23.716$

At $E(^6\text{Li})_{\text{c.m.}} = 3.05$ MeV, angular distributions have been obtained for α_0, α_1, α_2 and α_3. The α-particles to ^{12}C*(11.83) and (12.71) have also been observed (1966MC05). At $E(^6\text{Li}) = 3.8$ MeV, the population of the $T = 15.11$ MeV state is about 3 ± 2% of the $T = 0$ state at 12.71 MeV. It is pointed out that in this reaction the distance of closest approach is 15 fm and the dominant potential would be the Coulomb potential. It is therefore not neccessary to invoke a large $T = 0$ mixing in the 15.11 MeV state to explain the observation of the 15 MeV γ rays (1964CA18).

See also (1963MI02, 1963MO1B, 1965GA1H, 1966BR1G, 1967SE08).

Table 12.10: Resonances in ^{11}B(p, γ)^{12}C and ^{11}B(p, α)^{8}Be

Peak number	E_p (MeV)	$\Gamma_\mathrm{c.m.}$ (keV)	$\sigma(\gamma_0)$ (μb)	$\sigma(\gamma_1)$ (μb)	$\sigma(\alpha_0)$ (mb)	$\sigma(\alpha_1)$ (mb)	Γ_{γ_0} (eV)	Γ_{γ_1} (eV)
1	0.163 [a]	6.4 [a]	5.5	152	res.	res.	0.22 ± 0.09 [b]	6.8 ± 1.1
2	0.675	300	non-res.	48 [f]	non-res.	600 [f]	< 0.4	8.0
3	1.388	1150	[27] [c]	3	3.3	≈ 180	44	5
4	1.98	100	non-res.	non-res.	9.0	(25)	< 0.5	< 0.5
5	2.62	310	weak?	res.	32.4 ± 4.8	270 ± 40	< 1.5	3.2
6	2.66	42	non-res.	non-res.	non-res.	non-res.	< 0.5	< 0.5
7	3.01	100	non-res.	non-res.	3.4			
8	3.12	100	weak	[20] [c]	non-res.	non-res.	(0.4)	2.0
9	3.5	1100	[20] [c]	res.	5.2	res.	25	10
10	3.75	(1100)	non-res.	res.	7.4 ± 1.1	300 ± 40	< 3	3
11	4.93	180	non-res.	res.	non-res.	170 ± 40		
12	5.11	275	non-res.	[35] [c]	6.0 ± 0.9	non-res.		
13	6.0		res.	non-res.				
14	6.7		res.	[35] [c]	res.			
15	7.2	3200	120	non-res.		(res.)	≥ 2500 [e]	
16	8.3		res.	res.	res.			
17	10.15	115	non-res.	res.				
18	10.3	≈ 6500	[60] [c]	83				
19	11.76		non-res.	45 [d]	res.			
20	12.55		21 [d]	non-res.				
21	13.09		19 [d]	38 [d]				
22	[13.6]		non-res.	25 [d]				
23	14.19		16 [d]	non-res.				
24	20.1	≈ 4000	≈ 9	≈ 20				

Table 12.10: Resonances in ^{11}B(p, γ)^{12}C and ^{11}B(p, α)^{8}Be (continued)

Peak number	Γ_{α_0} (keV)	Γ_{α_1} (keV)	Γ_p (keV)	^{12}C* (MeV)	J^π; T	Refs.
1	0.290 ± 0.045	6.3 ± 0.5	0.069 ± 0.015	16.11	2^+; 1	(1953HU29, 1961SE10)
2	< 0.27	150	150	16.58	2^-; (1)	(1953BE61, 1953HU29, 1965SE06)
3	10	140	1000	17.23	1^-; 1	(1953HU29, 1963SY01, 1965SE06)
4	4.6	11.4	76	17.77	0^+; (1)	(1955HO48, 1963SY01, 1965SE06)
5	65	177	68	18.36	$(3^-$; 0)	(1955BA22, 1963SY01, 1965SE06)
6	< 1	< 5	33	18.39	0^-	(1965SE06)
7			< 10	18.71	n.π. ^{g}; (1)	(1965SE06)
8	< 0.2	< 1.5	97	18.82	2^+; (1)	(1955BA22, 1965SE06)
9	50	200	300	19.2	$(1^-$; 1)	(1955BA22, 1965SE06)
10	20	450	450	19.40	$(2^+$; 0)	(1963SY01, 1965SE06)
11				20.47		(1955BA22, 1963SY01, 1964AL20)
12				20.64	$(3^-$; 1)	(1955BA22, 1963SY01, 1964AL20, 1964BL1D)
13				21.5		(1964AL20)
14				22.1		(1963BE18, 1964AL20)
15				22.6	$(1^-$; 1)	(1961GO13, 1963BE18, 1964AL20, 1964BL1D)
16				23.6		(1963BE18, 1964AL20, 1964BL1D)
17				25.26	$(T = 2)$	(1964AL20)
18				25.5		(1961GO13, 1963BE18, 1964AL20, 1967FE04)
19				26.9		(1963BE18, 1964AL20, 1964BL1D, 1967FE04)

Table 12.10: Resonances in ^{11}B(p, γ)^{12}C and ^{11}B(p, α)^{8}Be (continued)

Peak number	Γ_{α_0} (keV)	Γ_{α_1} (keV)	Γ_{p} (keV)	^{12}C* (MeV)	$J^\pi; T$	Refs.
20				27.45		(1967FE04)
21				28.0		(1964AL20, 1967FE04)
22				28.45		(1967FE04)
23				28.9		(1967FE04)
24				34.4	$(1^-; 1)$	(1963RE09)

[a] 163.1 ± 0.2 keV, $\Gamma = 6.0 \pm 0.6$ keV: see text.

[b] 1% branch to ^{12}C*(9.63) (1961CA13).

[c] Estimated from graph (1964AL20).

[d] $4\pi \times \sigma(90°)$.

[e] Assuming a single resonance (1961GO13).

[f] (1953BE61, 1953HU29).

[g] n.π. = natural parity.

18. ^{10}B(^{7}Li, αn)^{12}C $Q_\mathrm{m} = 16.463$

See (1964CA18).

19. (a) ^{11}B(p, γ)^{12}C $Q_\mathrm{m} = 15.957$
    (b) ^{11}B(p, α)^{8}Be $Q_\mathrm{m} = 8.588$ $E_\mathrm{b} = 15.957$

In the range $E_\mathrm{p} = 0$ to 25 MeV, twenty-three resonances are reported. Their characteristics are displayed in Table 12.10. Cross sections of astrophysical interest are discussed by (1967FO1B).

The $E_\mathrm{p} = 0.16$ MeV resonance (^{12}C* = 16.11 MeV) is well established as the $J^\pi = 2^+$; $T = 1$ analogue of the first excited states of ^{12}B and ^{12}N: see (1959AJ76). The resonant energy is 163.1 ± 0.2 keV; $\Gamma_\mathrm{lab} = 6.5 \pm 0.6$ keV [see (1955AJ61)]. The gamma decay of the 16.11 MeV state takes place to ^{12}C*(0, 4.4, 9.6): see (1959AJ76, 1961CA13, 1961SE10). The decay to ^{12}C*(9.6) is via a 6.45 ± 0.05 MeV γ-ray whose angular distribution, together with the known α-decay properties of ^{12}C*(9.6), leads to $J^\pi = 3^-$. The intensity of the transition is 1% of the γ_1 decay (1961CA13). See also (1961GR07, 1965CV1A, 1966SO1B).

The character of the α-decay at the $E_\mathrm{p} = 0.16$ MeV resonance has been studied with coincidence techniques by (1961DE31, 1962DE1H, 1964DE1J, 1965DE1R). Immediately below and above the resonance, a Dalitz plot indicates sequential decay via ^{8}Be*(0, 2.9): in this region, the behavior is ascribed to tails of the $E_\mathrm{p} = 0.675$ and 1.4 MeV resonances. At $E_\mathrm{p} = 0.163$ MeV, the

Dalitz plot shows a striking increase in population near the center, indicative of direct 3α breakup. Some part of the reaction also goes through ${}^8\text{Be}_{\text{g.s.}}$, and there is evidence for a final-state two-body interaction with $l = 2$ (1964DE1J): see, however, (1965MA1X, 1965PH1A, 1966CH1L, 1966WA16). See also (1959KA12, 1959KA13, 1960BO26, 1962BE21, 1964DE1H, 1964LO05, 1964LO1E, 1965KR1A, 1965KR1B, 1967KA09, 1967LO1H). Similar studies at $E_\text{p} = 0.675$, 1.388 (1965KA1G), 2.0, 2.65, 3.25, 3.73, 4.00, 5.08, and 5.64 MeV (1964PH1A, 1965BR18, 1965PH1A) indicate that sequential decays through ${}^8\text{Be}^*(0, 2.9)$ dominate; direct 3α decay is $< 5\%$. The latter work shows evidence for "order-of-emission" interference in the shapes of α-groups: see also (1965DU1C, 1965SW1B). See also (1958FO1D, 1966AD1E, 1966SO1B, 1967LO1H, 1968CH1L).

The $E_\text{p} = 0.67$ MeV state (${}^{12}\text{C}^* = 16.58$ MeV) has a proton width $\Gamma_\text{p} \approx 150$ keV. Such a width indicates s-wave protons and therefore $J^\pi = 1^-$ or 2^-. These assignments are supported by the near isotropy of the two resonant exit channels, α_1 and γ_1. The size of the α_1 cross section indicates $2J + 1 \geq 5$; therefore $J^\pi = 2^-$. The reduced width $\theta^2(\alpha_1) \approx 0.05$ and the γ_1 E1 transition has $|M|^2 \approx 0.01$ Weisskopf units, suggesting $T = 1$ (1957DE11, 1965SE06). See also (1959AJ76). (1962BL10) report a γ-branch to the 12.71 MeV state, $\approx 6\%$ of the intensity of the 4.4 MeV transition. Such a branch may also be present at ${}^{12}\text{C}^*(17.23)$.

For the $E_\text{p} = 1.4$ MeV state (${}^{12}\text{C}^* = 17.23$ MeV), $(2J + 1)\,\Gamma_{\gamma_0} \geq 115$ eV. This indicates $J^\pi = 1^-$, with $T = 1$ most probable (1965SE06). $J^\pi = 1^-$ is also required to account for the interference at lower energies in α_0 and γ_0: see (1957DE11); see also (1959AJ76). Two solutions for Γ_p are possible; the larger (chosen for Table 12.10) is favored by elastic scattering data (1965SE06). (1963SY01) find no evidence for resonance in α_0 or α_1 at this energy.

$J^\pi = 0^+$; $T = 1$ is consistent with all data for the $E_\text{p} = 2.0$ MeV resonance (${}^{12}\text{C}^* = 17.77$ MeV) which decays via the α_0 and α_1 channels (1965SE06). The resonance in the yield of α_0 requires natural parity, and the small α-widths suggest $T = 1$. For $J^\pi = 1^-$ or 3^- the small γ-widths would be surprising; $J^\pi = 2^+$ would lead to a larger elastic anomaly than is observed (1965SE06: see also (1963SY01)).

At $E_\text{p} = 2.62$ MeV ($E_\text{x} = 18.36$ MeV), the resonance for α_0 again demands natural parity; the presence of a large P_4 term in the angular distribution requires $J \geq 2$ and $l_\text{p} \geq 2$. The assignment $J^\pi = 3^-$; $T = 0$ is consistent with the resonance data and with the angular distribution of α_0 at the $E_\text{p} = 1.98$ MeV resonance (1965SE06: see also (1955GO10, 1963SY01, 1967FL1F, 1968CH1L)).

The $E_\text{p} = 2.66$ MeV resonance, distinguished from that at $E_\text{p} = 2.62$ MeV by its width, is not seen here: see ${}^{11}\text{B}(\text{p, p})$.

The $E_\text{p} = 3.01$ MeV resonance appears only in the angular distributions for α_0: the small α-widths suggest $T = 1$ (1965SE06).

At $E_\text{p} = 3.12$ MeV ($E_\text{x} = 18.82$ MeV), the angular distribution of γ_0 indicate E2 radiation, $J^\pi = 2^+$. This assignment is supported by the angular correlation in the cascade γ_1 and by the behavior of $\sigma(\alpha_0)$; $T = 1$ is suggested by the small Γ_α (1965SE06).

The structure near $E_\text{p} = 3.5 - 3.7$ MeV ($E_\text{x} = 19.2$ and 19.4 MeV) seems to require at least two levels. The large Γ_{γ_0} requires that one be $J^\pi = 1^-$; $T = 1$ and interference terms in $\sigma(\alpha_0)$ require the other to have even spin and even parity: $J^\pi = 2^+$; $T = 0$ is favored (1963SY01,
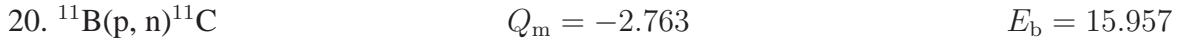
1965SE06).

Levels at $E_p = 4.93$ and 5.11 MeV, seen in $\sigma(\gamma_1)$ (1955BA22) also appear in $\sigma(\alpha_1)$, but not in $\sigma(\alpha_0)$. Angular distributions suggest $J^\pi = 2^+$ or 3^- for the latter ($E_x = 20.64$ MeV); the strength of γ_1 and absence of γ_0 favors $J^\pi = 3^-$; $T = 1$ (1963SY01).

In the range $4 < E_p < 14.5$ MeV, $\sigma(\gamma_0)$ is dominated by the giant dipole resonance at $E_p = 7.2$ MeV ($E_x = 22.6$ MeV), $\Gamma_{cm} = 3.2$ MeV: $\int \sigma dE = 630$ eV $\cdot$ b. $\sigma(\gamma_1)$ likewise shows a giant resonance centered at about 10.3 MeV ($E_x = 25.4$ MeV), $\Gamma_{cm} \approx 6.5$ MeV, $\int \sigma dE = 850$ eV $\cdot$ b. Both excitation functions show significant fine structure (Table 12.10): see (1964AL20, 1967FE04).

From $E_p = 4$ to 14 MeV the angular distributions of γ_0 are given by $W(\theta) = 1 + a_1 P_1(\cos\theta) + a_2 P_2(\cos\theta)$ with the coefficient a_2 almost constant at -0.6, in approximate agreement with the expectation from particle-hole calculations of $J^\pi = 1^-$; $T = 1$ states by (1962VI01). The a_1 term exhibits fluctuations for $E_p = 4$ to 5.5 MeV in the region of narrow resonances; from 5.5 to 14 MeV it rises smoothly from $+0.03$ to $+0.3$. A sharp resonance in $\sigma(\gamma_1)$ at $E_p = 10.15$ MeV, $\int \sigma dE = 4$ eV $\cdot$ b, may have $T = 2$ (1964AL20). See also (1959GE33, 1959GO89, 1961GO13, 1963BE18, 1964AL1J, 1964BL1D, 1964TA05, 1965TA1E, 1966HA1M, 1966ME1H, 1966UB01, 1967KA05, 1967KE1K, 1967MA11).

For $15 < E_p < 25$ MeV, a resonance is found at $E_x = 34.4 \pm 0.5$ MeV, $\Gamma \approx 4$ MeV, $\int \sigma(\gamma_0) dE = 38$ eV $\cdot$ b (1963RE09: see, however, (1968BR1M)). The resonance is ascribed to a component of the E1 giant resonance, but the cross section is an order of magnitude less than predicted (1963RE09). (1968BR1M) report no pronounced structure for $E_p = 13$ to 22 MeV.

See also (1961BL09, 1963FE03, 1963VA1C, 1966AR1D, 1966SU1F, 1967TA1D).

20. ^{11}B(p, n)^{11}C $\qquad\qquad Q_m = -2.763 \qquad\qquad E_b = 15.957$

Excitation functions are reported by (1955BA22: $E_p = 2$ to 5 MeV, long counter), (1959GI47: $E_p = 2.6$ to 5.5 MeV, 4π graphite sphere), (1964BA16: $E_p = 4$ to 14 MeV, 4π graphite sphere), (1961LE11: $E_p = 4.9$ to 11.4 MeV, ^{11}C activity), (1965SE06: $E_p = 3$ to 4 MeV, ^{11}C activity), and (1965OV01: $E_p = 4$ to 11.5 MeV: time-of-flight resolved groups). The excitation functions are characterized by numerous peaks (see Table 12.11) whose positions appear to correspond with ^{11}B(p, α)^{12}C and with some of the (γ, n) and (γ, p) structure, suggesting that resonances, and not fluctuations, are involved. Angular distributions do not change as rapidly as might be expected from the pronounced structure in the excitation function (1965OV01). The strength of the pronounced peak at $E_p = 6.03$ MeV ($E_x = 21.49$ MeV) appears to demand $J \geq 4$ (1961LE11). See also (1959GO89, 1960FU1A, 1961GO13).

Polarization measurements have been made for $E_p = 7$ to 11 MeV (1965WA04). See also (1962AL18, 1963VA1C, 1965VA23, 1966CA1J, 1966SK03, 1967CA1T) and (1959AJ76).

21. (a) ^{11}B(p, p)^{11}B $\qquad\qquad\qquad\qquad\qquad\qquad E_b = 15.957$

(b) ^{11}B(p, p′)^{11}B*

Table 12.11: Maxima in yields of ^{11}B(p, n)^{11}C and ^{11}B(p, p′)^{11}B*

Peak number	(1955BA22, 1964BA16)[d]		(1959GI47)[d]	(1961LE11)[d]			(1965OV01)[c,d]	
	E_p (MeV)	Γ_{lab} (keV)	E_p (MeV)	E_p (MeV)	Γ_{lab} (keV)	σ (mb)	E_p (MeV)	res. in group(s)
1								
2								
3	3.17	100	3.18 [a]					
4	3.65	500	3.67 [a]					
5								
6	4.05	200					4.10	n_0
7								
8	4.70	150	4.70				4.62	n_0
9	5.10	150	5.10	5.065	210	335	5.07	n_0
10	5.5			5.48	300	308	5.50	n_0
11	6.05	500		6.03	610	430	6.01	n_0, n_1
12							6.4	n_0
13	7.30	300		7.28	420	365	7.3	n_0, n_1
14	7.75	60		7.73	70	322	7.73	n_0, n_1
15	8.26	350		8.25	410	363	8.25	n_0, n_1
16	(8.30)	(≤ 50)						
17	8.67 [b]	140		8.64	230	370	8.6	n_0, n_2
18	9.0							
19	9.26	80		9.24	140	320	9.25	n_0, n_2
20	9.7			9.79	1000	295	9.79	n_0, n_1
21	10.16 [b]	200		10.13	150	310	10.1	n_0, n_2
22	10.92 [b]	400		10.91	480	282	10.9	n_0
23	11.88 [b]	300						

Peak number	(1955BA22)[e]		(1963AN12)[f]		(1965SE06)[g]		E_x (MeV)
	E_p (MeV)	Γ_{lab} (keV)	E_p (MeV)	Γ_{lab} (keV)	E_p (MeV)	Γ_{lab} (keV)	
1			2.0		1.98 [f]		17.77
2	2.664	48	2.63	≈ 300	2.66 [e,f]	46	18.40
3	3.15	100	3.15	≈ 90	3.15 [e,f]	100	18.86
4	3.4	500			3.5 [e]	broad	19.3
5	3.78	50					19.42

Table 12.11: Maxima in yields of ^{11}B(p, n)^{11}C and ^{11}B(p, p′)^{11}B* (continued)

Peak number	(1955BA22) [e]		(1963AN12) [f]		(1965SE06) [g]		
	E_p (MeV)	Γ_{lab} (keV)	E_p (MeV)	Γ_{lab} (keV)	E_p (MeV)	Γ_{lab} (keV)	E_x (MeV)
6							19.69
7	4.28	100					19.88
8	4.68	200					20.24
9	5.13	200					20.60
10							20.99
11							21.49
12							21.8
13							22.64
14							23.04
15							23.52
16							(23.56)
17							23.89
18							24.2
19							24.44
20							24.93
21							25.26
22							25.96
23							26.84

[a] (1965SE06): $E_p = 3.12$ and ≈ 3.65 MeV.

[b] See also (1960FU1A).

[c] Widths ≈ 200 keV, except $E_p = 6.4$ and ≥ 9.25 which are wider.

[d] (p, n).

[e] (p, p′).

[f] (p, p).

[g] See also Table 12.10.

A pronounced anomaly in the elastic scattering is observed near $E_p = 0.67$ MeV at all angles; the level is therefore formed by s-waves. The 0.3 to 1.0 MeV results are well accounted for by two resonances: $E_p = 0.67$ MeV, s-wave, $J^\pi = 2^-$, $\Gamma = 0.33$ MeV. $\Gamma_p/\Gamma = 0.5$, and $E_p = 1.4$ MeV, $J^\pi = 1^-$ (1957DE11). Higher energy structure in the yields of reactions (a) and (b) are displayed in Table 12.11 (1955BA22, 1963AN12, 1965SE06). See also (1960SA28) and Table 12.10.

22. ^{11}B(p, d)^{10}B $Q_m = -9.231$ $E_b = 15.957$

See ^{10}B.

23. ^{11}B(d, n)^{12}C $Q_m = 13.732$

Reported neutron groups are listed in Table 12.12. Angular distributions of the neutrons to many of the ^{12}C states up to $E_x = 17.23$ MeV have been reported for energies in the range $E_d = 0.5$ to 10 MeV: see (1957AM48, 1958AM13: 0.5 to 1.15 MeV), (1955WA30: 0.6 MeV), (1955IH1B: 0.69 MeV), (1954GR53: 0.85 MeV), (1957BI78: 0.92 MeV), (1962SA09: 1.0 to 2.0 MeV), (1963KI02: 1.6 to 2.7 MeV), (1961ZD02: 1.1 to 2.8 MeV), (1965SI12: 1.1 to 3.2 MeV), (1965CL02: 1.5 to 4.7 MeV), (1961GA04: 2.7 and 5.4 MeV), (1966HU1H, 1967WI1J: 3.0 to 5.5 MeV), (1965AL17: 2.4 to 9.7 MeV), (1964RO1F, 1966RO1X, 1966WE1B: 6.3 MeV), (1953GI05: 8.1 MeV), (1956MA83: 9 MeV), and (1958ZE01: 10 MeV). See also (1959AJ76) and (1960WA1G, 1961HO1D, 1962LE1A, 1963LA1E, 1964NA02, 1965SI13, 1967DI01).

For E_d less than 6 to 7 MeV, angular distributions of n_0 and n_1 are characterized by both forward and backward peaks, with broad minima near $90°$. Detailed shapes are strongly dependent on bombarding energy. The general behavior in the lower-energy range is ascribed to heavy-particle stripping by (1957OW03, 1958AN32, 1961ZD02), but others (1961GA04, 1965AL17, 1966ST1L, 1967WI1J), find reasonable agreement with DWBA, possibly also with compound nucleus effects (1963KI02, 1965CL02). For $E_d > 7$ MeV, DWBA gives a quite satisfactory account of n_0 and n_1 distributions, except for a single example (n_1 at 8.8 MeV: (1965AL17)). See also (1968YA1G).

Angular correlations of neutrons and 4.4 MeV γ-rays have been studied by (1963HU05: 0.7 and 1 MeV), (1963RI03, 1964RI1D: 1 and 1.2 MeV), (1961ZD02: 1.1 MeV), (1961GA04: 2.65 and 5.35 MeV), (1966RO1X, 1966WE1B: 6.3 MeV). Angular correlations have also been determined for neutrons and 15.1 MeV γ-rays: see (1963KI14: 2.3 and 2.6 MeV), (1960FE01, 1960FE13: 5 and 8 MeV), (1964RO1F: $E_d = 6.3$ MeV). The formation of the 15.11 MeV state involves $l_p = 1$ with a 12 : 1 ratio between channel spins 2 and 1. The reduced proton width is approximately equal to the single-particle width (1960FE01, 1960FE13).

In the range $E_d = 1.0$ to 5.5 MeV, two slow neutron thresholds are observed at 1.627 ± 0.004 MeV ($E_x = 15.109 \pm 0.005$ MeV) and near 4.1 MeV (broad; $E_x = 17.2$ MeV) (1955MA76). At the lower threshold, 15.1 MeV γ-rays are observed: $E_d = 1.633 \pm 0.003$ MeV, width less than 2 keV (1958KA31) [$E_x = 15.110 \pm 0.003$ MeV].

A study of the angular distributions and energy spectra of α-particles from the decay of ^{12}C states shows that the 12.71 and 11.83 MeV states decay sequentially via ^{8}Be; the former via ^{8}Be*(2.9), the latter 90% via ^{8}Be*(2.9) and 10% via ^{8}Be(0). There is some evidence that the 10.84 MeV state decays primarily to ^{8}Be(0). $J^\pi = 3^-$ for the 9.64 MeV state is favored on the basis of the angular distribution of the α-particles to ^{8}Be(0). There is no evidence for direct 3α decay of ^{12}C levels in the range $E_x = 9$ to 13 MeV, nor does ^{12}C*(10.3) appear to participate in this reaction (1965OL01).

Table 12.12: Neutron groups from ^{11}B(d,n)^{12}C

E_{x} (MeV $\pm$ keV) [a]	l_{p}	θ^2 [c]
0	1 [c]	0.11
4.38 ± 70	1 [c,d]	0.03
7.57 ± 110	[e]	
9.6 ± 100	2 [c,d,f]	0.02
10.8 ± 100	0 [f]	
11.1 ± 100		
11.74 ± 80	0 [f]	
12.76 ± 80	1 [f,g]	
13.21 ± 50 [b]		
13.36 ± 50 [b]		
(14.16 ± 50)		
15.09 ± 30 [i]	1 [h]	
(15.52 ± 30)		
16.07 ± 30	1 [h]	
17.23	> 1 [h]	

[a] (1952JO10, 1954GR53, 1957BI78, 1964RO1F).

[b] May represent a single level at 13.3 MeV (1952JO10).

[c] (1956MA83): $E_{\mathrm{d}} = 9$ MeV.

[d] (1954GR53).

[e] Non-stripping distribution: see (1962SA09).

[f] (1962SA09).

[g] $J^{\pi} = 1^+$ (1965OL01).

[h] (1964RO1F).

[i] 15.110 ± 0.003 MeV.

Table 12.13: Deuteron groups from ^{11}B(^{3}He, d)^{12}C

^{12}C* [a] (MeV ± keV)	Γ [b] (keV)	l	J^π	$(2J+1)\theta_p^2$ [b]	$(2J+1)S_{\rm rel}$ [e]
0		1 [c,e]	$0 \to 3^+$		1.00
4.44		1 [c,e]	$0 \to 3^+$		0.61
7.66		1 [c,e]	$0 \to 3^+$		0.035
9.629 ± 10 [d]		2 [b,c,e]	$0 \to 4^-$	0.048	0.30
(10.1)					
10.84 ± 20 [b]	320 ± 30	0 [b]	$1^-, 2^-$	0.040	
11.82 ± 20 [b]	300 ± 30	0 [b]	$1^-, 2^-$	0.073	
12.70 ± 10 [b]		1 [b,e]	$0 \to 3^+$	0.13	0.26
13.38 ± 20 [b]	700 ± 100				
14.71 ± 10 [b]	< 15				

[a] Levels listed without errors were observed by (1960FO01) or (1961HI08) but the level energies were not determined.

[b] (1961HI08); $E(^3$He$) = 9.84$ MeV.

[c] (1960FO01); $E(^3$He$) = 5.1$ MeV.

[d] Based on 7656 ± 7 keV for next lower level (1960FO01).

[e] (1967CR04); DWBA; $E(^3$He$) = 10$ MeV.

See also ^{13}C, (1959AJ76) and (1958ED1B, 1962KU02, 1962NA04, 1962RO1L, 1963RO1K, 1965MA1K, 1966ST1L).

24. ^{11}B(^{3}He, d)^{12}C $Q_m = 10.463$

$Q_0 = 10.4697 \pm 0.0057$ (1967OD01).

Observed deuteron groups are displayed in Table 12.13 (1960FO01, 1961HI08). Excitation functions near 10 MeV show no structure; angular distributions exhibit characteristic direct inter-action features (1967CR04). See also (1959HO01, 1959WO1B, 1961HO1F) and (1967AD1F).

25. ^{11}B(α, t)^{12}C $Q_m = -3.858$

Differential cross sections have been obtained for the ground-state tritons and for the tritons to ^{12}C*(4.4), in the forward direction at $E_\alpha = 43$ MeV: single-proton transfer seems to be the

dominant reaction mode (1967DE1K). The angular distributions appear to be affected by final state spin (1967SI1A).

26. ^{11}B(^{14}N, ^{13}C)^{12}C $\qquad\qquad\qquad$ $Q_m = 8.407$

See (1962NE01).

27. ^{11}B(^{16}O, ^{15}N)^{12}C $\qquad\qquad\qquad$ $Q_m = 3.831$

See (1965BO14, 1968KA1L).

28. ^{12}B(β^-)^{12}C $\qquad\qquad\qquad$ $Q_m = 13.370$

The decay is mainly to the ground state of ^{12}C; branching ratios to other states are listed in Table 12.14. The half-life is 20.41 ± 0.06 msec (Table 12.2). Since transitions to ^{12}C(0^+) and (2^+) are allowed, J^π of ^{12}B is 1^+.

Since the decays of ^{12}B and ^{12}N are mirror transitions, comparison of the ft values has some interest. According to (1964KA08), $ft(^{12}$B$) = 11.800 \pm 70$ sec, $ft(^{12}$N$) = 13.060 \pm 90$ sec; the ratio ^{12}N$/^{12}$B is 1.11 ± 0.01: see also (1963FI05, 1963PE10, 1964FI02, 1964NA1C, 1964WU01, 1966BA1A). Possible explanations of the difference are discussed by (1963HU10, 1964EI1C, 1965BL1F, 1966MA2R, 1966OK1B).

Comparison of shape factors for the ground-state β-transitions for ^{12}B–^{12}N provides a test of the conserved vector current theory. The correction to the simple Fermi shape should have the form $1 + AE$ for ^{12}B and $1 - AE$ for ^{12}N where A is determined mainly by the (experimental) M1 width of the ^{12}C*(15.1) $T = 1$ level: A(theor.)$ = 0.52 \pm 0.12\%$ MeV^{-1} (1958GE1C, 1959GE1D, 1963KI1D, 1964WU01): see also (1959FL41, 1959MO27, 1960WE1C, 1961MO1C, 1967HU10). The experimental values of (1964WU01) are $A = 0.55 \pm 0.10$ and 0.52 ± 0.06 for ^{12}B and ^{12}N, respectively: see also (1961MA16, 1962LI05, 1962MA22, 1962MC14, 1963GL04, 1963LE05, 1965WU1A).

Transitions to ^{12}C*(4.4), $J^\pi = 2^+$, are allowed. According to (1963PE10) the ratio $ft(^{12}$N$)/ft(^{12}$B$) = 0.92 \pm 0.06$. The level energy is 4438.91 ± 0.31 keV (1967CH19).

The level at $E_x = 7.6$ MeV has special interest for helium burning processes in stars (1963SE17, 1963SE23, 1967FO1B). Observation of the α-spectrum yields $Q(^{12}$C*–^{8}Be–^{4}He$) = 278 \pm 4$ keV (1957CO59). With $Q(^8$Be–2^{4}He$) = 92.12 \pm 0.05$ keV (1966BE05), $Q(^{12}$C*–3^{4}He$) = 370 \pm 4$ keV. Using (1965MA54) masses for ^{8}Be and ^{4}He, ^{12}C* $= 7647.0 \pm 4.1$ keV. Although the level decays mainly by α-emission, both the gamma branch to ^{12}C*(4.4) and pair emission to ^{12}C$_{g.s.}$ have been observed in various reactions. The relevant parameters are given in Table 12.8 (see (1963AL15, 1963SE23)). The fact that the β-decay is allowed indicates $J^\pi = 0^+$, 1^+ or 2^+ for

Table 12.14: Branching in ^{12}B$(\beta^-)^{12}$C

Decay to ^{12}C*	Branch (%)	$\log ft$ [a]	Ref.
g.s. [b]	97.1	4.075 ± 0.002	
4.43891 ± 0.00031 [c]	1.4 ± 0.4		(1958KA31)
	1.7 ± 0.4		(1956TA07)
	1.3 ± 0.1		(1963PE10)
	1.33 ± 0.09	5.10 ± 0.03	mean
7.647 ± 0.004	1.3 ± 0.4		(1957CO59)
	1.7 ± 0.5		(1963AL15)
	1.5 ± 0.3	4.14 ± 0.10	mean
10.3 ± 0.3 [d]	0.13 ± 0.04		(1958CO66)
	0.07 ± 0.02		(1963WI05)
	0.08 ± 0.02	4.2 ± 0.2	mean

[a] Based on Q_m and $\tau_{1/2} = 20.41$ msec: see (1966BA1A).
[b] $E_{\beta^-}(\text{max}) = 13.381 \pm 0.041$ (1962MA22).
[c] (1967CH19).
[d] $\Gamma = 3.0 \pm 0.7$ MeV, $\theta_\alpha^2 = 1.5$ (1966SC23).

Table 12.15: Parameters of the 15.1 MeV ^{12}C level from ^{12}C$(\gamma, \gamma)^{12}$C

	(1957HA13)	(1959GA09)	(1960HA1H)	(1961BU1E)	(1963SC21)	(1967KU11)
Γ(total) (eV)	79 ± 16	64.5 ± 10.4		60 ± 8	44.7 ± 10.3	39 ± 5
$\Gamma_\gamma(15 \to \text{g.s.})$ (eV) [b]	54.5 ± 9.3	59.2 ± 9.7	50.5 ± 7.1 [a]	54 ± 6	40.2 ± 5.2	37 ± 5
$\Gamma_\gamma(15 \to 4.4)$ (eV)	< 5.5	3.2 ± 2.5		6.5 ± 3		
Γ_α (eV)	$(19 - 25) \pm 8$	2.1 ± 3.2				

[a] Measured $\Gamma_{\gamma_0}(\Gamma_{\gamma_0}/\Gamma)^{1/2} = 47.0 \pm 6.0$ eV.
[b] See also Tables 12.8 and 12.20.

^{12}C*(7.6); observation of the α particles eliminates $J^\pi = 1^+$, and the large Γ_α requires $J^\pi = 0^+$ (1957CO59).

The 10.3 MeV level is observed in both ^{12}B and ^{12}N decays. The excitation energy given by (1966SC23) is 10.3 ± 0.3 MeV, $\Gamma = 3.0\pm0.7$ MeV. The decay is to ^{8}Be$_{\text{g.s.}}$. With $R = 5.2$ fm, $\theta_\alpha^2 = 1.5$ and 7.5 for $J^\pi = 0^+$ and 2^+, respectively (1958CO66). It is suggested by (1966MO08) that this level is a highly deformed rotational state with $J^\pi = 2^+$, related to ^{12}C*(7.66). Some fraction of the observed α-spectrum is presumed to result from a "ghost" of the lower level (1962BA1C, 1963WI05, 1964BL12).

In ^{12}N, allowed transitions are observed to ^{12}C*(12.7) and (15.1) (1966SC23, 1967AL03: see also (1963GL04, 1963WI05)). The 12.7 MeV level decays primarily to ^{8}Be*(2.9; $J^\pi = 2^+$); the absence of decay to ^{8}Be$_{\text{g.s.}}$ is in agreement with the assignment $J^\pi = 1^+$ (1966SC23). The ft values for both β-transitions (see Table 12.25) agree well with shell model calculations of (1965CO25). In particular, the agreement strongly suggests a close relation between ^{12}C*(12.71; $J^\pi = 1^+$; $T = 0$) and ^{12}C*(15.11; $J^\pi = 1^+$; $T = 1$). A search for the transition from ^{12}B to ^{12}C*(12.71) was unsuccessful (1967AL03). See also (1959JA1B, 1960FA02, 1964SH1J, 1966DU1E).

29. ^{12}C$(\gamma, \gamma)^{12}$C

The lifetime of the 4.4 MeV state has been determined by resonance scattering and absorption as $\tau_{\text{m}} = 65 \pm 12$ fsec (1958RA14). See Table 12.8.

Resonance scattering and absorption by the 15.1 MeV level have been studied by (1957HA13, 1959GA09, 1960BU14, 1960HA1H, 1961BU1E, 1963SC21, 1967KU11): partial widths are displayed in Table 12.15. The scattering angular distribution is $W(\theta) = 1 + \cos^2\theta$, indicating dipole radiation (1959GA09); the azimuthal distribution of scattered polarized radiation indicates M1 (1960JA01) and the large $\Gamma(\text{M1})$ indicates $T = 1$.

The ground-state γ-width of ^{12}C*(16.11) is reported as $\Gamma_\gamma = 7.5 \pm 1.9$ eV (1959KE19: see, however, (1961SE10)). For ^{12}C*(17.22), the scattering cross section is 1.0 ± 1.0 μb, consistent with Γ_γ given by ^{11}B(p, γ) (1963SC21). See also (1960WE1C).

At higher energies, elastic scattering studies show the giant resonance peak at ≈ 24 MeV (see ^{12}C$(\gamma, n)^{11}$C), $d\sigma/d\Omega(135°) = 4$ μb/sr. A considerable tail is visible, extending to > 40 MeV (1959PE32). See also (1958WO53, 1961DE22, 1961WI1G, 1962SE02, 1967LO1B).

30. ^{12}C$(\gamma, n)^{11}$C $\hspace{3cm} Q_{\text{m}} = -18.720$

Recent review papers dealing with this reaction are: (1963HA1E, 1965DA1D, 1965SH1G, 1966BA2Y, 1966FU1C, 1966ME1H).

The total absorption, mainly $(\gamma, p) + (\gamma, n)$, in the range $E_\gamma = 13$ to 30 MeV is dominated by the giant resonance peak at 23.2 MeV, $\Gamma = 3.2$ MeV $\quad [E_{\text{x}} = 22.6$ MeV from ^{11}B$(p, \gamma)^{12}$C$]$. This

Table 12.16: Integrated cross sections, ^{12}C $+ \gamma$

Range in E_γ (MeV)	$\int \sigma \mathrm{d}E$ (MeV · mb)	Reaction	Refs.
$10 - 27$	120	σ(tot)	(1959KO55)
$11 - 32$	200 ± 35	σ(tot)	(1960TA15)
$0 - 30$	130 ± 20	σ(tot)	(1960ZI01)
$0 - 27$	84 ± 10 [a]	σ(tot)	(1963BU1G)
$0 - 35$	144.0	σ(tot)	(1965WY02)
$13 - 80$	377 ± 60	σ(tot)	(1960WY1A) [b]
$0 - 24$	22	(γ, n)	(1961RO1C)
$0 - 25$	29	(γ, n)	(1953MO1B)
$0 - 25$	27 ± 5	(γ, n)	(1954NA02)
$0 - 25$	32 ± 3	(γ, n)	(1955BA63)
$0 - 25$	34	(γ, n)	(1957CO57)
$0 - 26$	29.4 ± 3	(γ, n)	(1966MI04)
$0 - 28$	39.2	(γ, n)	(1965MI03)
$20 - 27$	36	(γ, n)	(1966LO04)
$20.5 - 26.5$	40.5	(γ, n)	(1966CO09)
$0 - 38$	56 ± 3	(γ, n)	(1955BA63)
$0 - 37$	46.2 ± 4	(γ, n)	(1966FU02)
$0 - 38$	59 ± 5	(γ, n)	(1966CO09)
$35 - 70$	30 ± 5	(γ, n)	(1966FO06)
$0 - 65$	77 ± 6	(γ, n)	(1966CO09)
$0 - 250$	80 ± 10	(γ, n)	(1955BA63)
$0 - 300$	90 ± 22	(γ, n)	(1951ST89)
$0 - 24$	46 [c]	(γ, p)	(1956CO59)
$20 - 26$	43	(p, γ)	(1961GO13)
$20 - 26$	[58]	(p, γ)	(1964AL20)
$20 - 29$	50 ± 8	(γ, p)	(1962DO1A)
$0 - 24$	41 ± 9	(γ, p)	(1961VA10)
$0 - 37$	102	(γ, p)	(1964TA1G)
$0 - 40$	77 ± 18	(γ, p)	(1961VA10)
$0 - 40$	55 ± 13	(p, γ)	(1963RE09)
$0 - 170$	122 ± 5	(γ, p)	(1964TA1G)

^a See, however, (1965WY02; p. 591).

^b See also (1965WY02).

^c As corrected by (1961VA10).

single peak accounts for 64% of the total strength below 27 MeV. The total integrated cross section to 35 MeV is 144 MeV · mb, about 80% of the classical sum rule, 60 NZ/A MeV · mb: see Table 12.16. Other resonant structure is reported at $E_\gamma = (16.5)$, 17.5, (19.1), 26 and 29 MeV: see Table 12.17 (1960ZI01, 1963BU1G, 1965WY02). See also (1958MO1F, 1958WO53, 1958ZI1B, 1959BU1H, 1959KO55, 1959KU84, 1959PE21, 1960CA09, 1960TA15, 1960WY1A, 1962DE03, 1962MI07, 1963BU18, 1963CO1D, 1965MA1N, 1967BR1P, 1967DR1E).

Shell-model calculations on the structure of the giant resonance ascribe the main effect to four $J^\pi = 1^-$; $T = 1$ levels formed from the particle-hole configurations $p_{\frac{3}{2}}^{-1}s_{\frac{1}{2}}$, $p_{\frac{3}{2}}^{-1}d_{\frac{5}{2}}$, $p_{\frac{3}{2}}^{-1}d_{\frac{3}{2}}$ and $s_{\frac{1}{2}}^{-1}p_{\frac{1}{2}}$, of which the second contributes most of the E1 strength. The computed energies are 19.6, 23.3, 25.0 and 35.8 MeV [the most probable identifications are $E_x = 19.2$, 22.6, 25.4 and 34.4 MeV (Table 12.7)] ((1964LE1D), and references therein). Calculations with a deformed potential suggest a somewhat more complicated structure (1962NI1D). See also (1961BA1D, 1962VI01, 1963BO21, 1963MI1B, 1964GI1C, 1964MI1E, 1965DA1D, 1966FU02, 1966LO04, 1966UB01, 1967LE1H, 1967MA1P).

Observations of $\sigma(\gamma, n)$ show a giant resonance centered at about 22.5 MeV, $\sigma(\text{peak}) \approx 8$ mb, $\Gamma \approx 3$ MeV, with a long tail slopping off to about 40 MeV. The integrated cross section to 40 MeV is about 60 MeV · mb; integrated to 250 MeV, it is about 80 MeV · mb (Table 12.16). In the giant resonance region, the angular distribution of ground-state neutrons is $W(\theta) = 1 + 1.5 \sin^2 \theta$, consistent with $l_n = 2$ ejection (1960EM02, 1964AL33, 1965VE03: see, however, (1967HA1P)). For $E_\gamma = 28$ to 145 MeV, comparison with (e, e′n) indicates mainly E1 processes, with $\lesssim 8\%$ E2 (1958BA60: see also (1961RO1H)).

The giant resonance appears to have a fine structure (Table 12.18): at least two major components are identified at $E_x = 22.0$ and 23.5 MeV (1966FU02, 1966LO04: see also (1966CO09, 1967FI1E)). A satellite at $E_x = 25.5$ MeV is also well established: a large fraction of the decay of this level (6 MeV · mb) involves excited states of ^{11}B and ^{11}C (1966MA1T: see also (1966CO09, 1966FU02)). Up to 28 MeV, about 83% of the neutrons leave ^{11}C in the ground state (1966FU02). Several broad levels are indicated in the range $E_x = 27$ to 35 MeV (1966CO09, 1966FI1D, 1966FU02, 1967FI1E). A possible level near 52 MeV is reported by (1966FO06). See also (1962BO1H, 1966BI1B, 1966CO09). Considerable fine structure in the range $E_x = 19$ to 23 MeV is reported by (1959SA06, 1960GE06, 1961TH03, 1966CO09): see also (1959CO62, 1959VA1D, 1960EM02, 1962FU11, 1965MI03).

Polarization of neutrons has been studied by (1964BE1E, 1964HA1F, 1966RA1E, 1967HA1N, 1967HA1P).

See also (1959OC07, 1961BR28, 1961PR07, 1961RO1C, 1962MI07, 1963FU05, 1965BI1G, 1966KA1C, 1966ME1H, 1967AN11, 1967AU1F, 1967FE05, 1967GL1B, 1967SM1A).

31. ^{12}C(γ, p)^{11}B $\qquad\qquad\qquad Q_m = -15.957$

Table 12.17: Resonance structure in ^{12}C $+ \gamma$ (total absorption) [a]

E_x (MeV)	Γ (MeV)	σ (peak) (mb)	$\int \sigma \mathrm{d}E$ (MeV $\cdot$ mb)	Ref.
16.5	0.25		(3%)	(1963BU1G)
17.6	0.4		(6%)	(1963BU1G)
[17.5] [b]		[2]		(1965WY02)
19.1	0.65		(6.5%)	(1963BU1G)
23	4.6	[24]		(1959KO55)
22.5		18		(1960ZI01)
23.0	3.2	16 [c]	54 (64%)	(1963BU1G)
23.2		19.8		(1965WY02)
25.6	≈ 2	8	17 (20%)	(1963BU1G)
[26]		[11]		(1965WY02)
29		[12]		(1960ZI01)
[30]		[7]		(1965WY02)

[a] See also Table 12.18.

[b] Numbers read from graph.

[c] Corrected to 22 mb, see (1965WY02).

The photoproton cross section exhibits a single broad giant resonance peak centering at $E_\gamma = 22.5$ MeV, (Table 12.19). There appears to be a significant difference from $\sigma(\gamma, \mathrm{n})$ both in shape and peak cross section (1963HA1E, 1966FU1C, 1966ME1H): such a difference could result from a comparatively small isospin mixing (1957BA1K). Some fine structure is suggested by the work of (1956CO59, 1962DO1A, 1963MU08, 1963WA18, 1964SH24, 1964TA1G): compare ^{11}B(p, $\gamma)^{12}$C. The angular distributions near the giant resonance are consistent with $W(\theta) = 1 + 1.5 \sin^2 \theta$ expected on the IPM (1962DO1A). For higher energies, an appreciable $\cos\theta$ term makes its appearance (1959PE22, 1961VA10, 1963WA18). See also (1965DA1D, 1967FR1E). The azimuthal distribution observed with polarized γ-rays at $E_\gamma = 21.3 - 21.6$ MeV is not inconsistent with E1 (1966KE06). Evidence for involvement of excited states of ^{11}B for $E_\gamma > 30$ MeV is reported by (1959PE22). See also (1960BA1P, 1963BU1G, 1963FI1B, 1966MA1T, 1966RA1E, 1967LE1H).

At high energies, $E_\gamma \gtrsim 150$ MeV, the cross section for photoproton production remains relatively large (≈ 100 μb) and the angular distributions show forward peaking. The high internal momenta thus implies may be understood on a quasi-deuteron picture, in which the interaction involves neutron-proton pairs in close proximity within the target nucleus (1951LE1B). This picture is strongly supported by the observation that most, if not all, high energy photoprotons are accompanied by neutrons with the proper kinematical relation (1954MY1A, 1958BA1C, 1958WH35); see, however, (1965RE1B).

Table 12.18: Resonance structure in $^{12}C(\gamma, n)^{11}C$ [a]

E_x [b] (MeV)	Γ (MeV)	σ (peak) (mb)	$\int \sigma dE$ (MeV · mb)	Refs.
[22] [c]				(1965VE03)
22.0	1.0	[8]	8.7	(1965BA2G, 1966BA34)
22.0	1.5	4.50	10.6	(1966FU02)
22.1				(1962FI1C, 1966FI1D) [d]
22.1				(1966CO09)
22.2		[7.7]		(1966LO04)
22.2				(1965MI03)
[22.2]		[6]		(1966MI04)
22.5		8.3		(1955BA63)
22.75				(1966CO09)
23.0		[7.7]		(1966LO04)
23.1				(1962FI1C, 1966FI1D)
23.2	2.0	5.75	18.1	(1966FU02)
[23.4]		[7.5]		(1966MI04)
23.5	0.8	[11]	10.9	(1965BA2G, 1966BA34)
[23.5]				(1965VE03)
23.5				(1965MI03)
23.6				(1966CO09)
23.7				(1966LO04)
23.8				(1962FI1C, 1966FI1D)
(24.0)				(1966FU02)
(24.9)				(1966LO04)
25.0	0.7	[9]	5.8	(1965BA2G, 1966BA34)
[25.1]				(1965VE03)
25.4				(1966CO09)
25.5	2.0	2.50	7.9	(1966FU02)
25.5				(1965MI03)
25.6		[5.7]		(1966LO04)
(26)				(1966MI04)
26.0				(1966CO09)

Table 12.18: Resonance structure in ^{12}C(γ, n)^{11}C [a] (continued)

E_x [b] (MeV)	Γ (MeV)	σ (peak) (mb)	$\int \sigma \mathrm{d}E$ (MeV · mb)	Refs.
(26.0)				(1966LO04)
(26.5)				(1966LO04)
27.1	1.5	1.50	3.5	(1966FU02)
27.5				(1962FI1C, 1966FI1D)
27.6				(1966CO09)
28.3	1.5	1.50	3.5	(1966FU02)
29.5				(1966CO09)
30.0				(1962FI1C, 1966FI1D)
30.5	2.0	1.95	6.1	(1966FU02)
32.2				(1962FI1C, 1966FI1D)
32.7				(1966CO09)
35.2	≈ 3.5	≈ 1.0	≈ 5.5	(1966FU02)
36.4				(1966CO09)
35.0			5 ± 1	(1966FO06)
≈ 52				(1966FO06)

[a] See Table 12.16 for integrated cross section: see also (1957CO57).
[b] For structure in the range 19 to 22 MeV, see (1962FI1C, 1965BA2G, 1966BA34, 1966CO09, 1966FI1D, 1966FI1E, 1966LO04, 1966MI04).
[c] [ ] = read from figure.
[d] See also (1966FI1E).

Experimentally derived momentum distributions are reported by (1961CE1B, 1963KI03, 1963KI1C). See also (1958MA1A, 1959CH25, 1961MA36, 1961SH1C, 1962CH26, 1962PA08, 1964JI1A). Polarization of the photoprotons has been studied by (1962LI13).

See also (1959PE21, 1962FE12, 1963BO21, 1963FU1D, 1964MO02, 1964SE09, 1966RA1G, 1967MA1P), ^{11}B(p, γ)^{12}C and ^{12}C(e, ep)^{11}B.

32. ^{12}C(γ, d)^{10}B $Q_m = -25.188$

For $E_{\mathrm{brems}} = 90$ MeV, the ratio of yields of deuterons to protons is $\approx 2\%$, for particle energies 15 to 30 MeV. For higher particle energies, the ratio decreases. Angular distributions are similar for

Table 12.19: Giant resonance in ^{12}C$(\gamma, p)^{11}$B [a]

E_{x} (MeV)	Γ (MeV)	$\sigma_{\max}$ [b] (mb)	Refs.
22.1	3.6	8.1 ± 2.4	(1959PE22)
22.4		13.2 ± 1.6	(1964SH24)
22.4	3.1	9.6	(1962DO1A)
22.5		12.7 ± 2.5	(1961VA10)
22.5	3.1	12	(1961GO13) [f]
[22.5] [c]			(1962HE10)
22.55		19 ± 4 [d]	(1959GE33) [f]
22.6		14.7 [e]	(1956CO59)
22.6	3.2	[11]	(1964AL20) [f]

[a] Compare with ^{11}B$(p, \gamma)^{12}$C.

[b] See Table 12.16 for integrated cross sections.

[c] [   ] = read from figure.

[d] As corrected by (1962DO1A).

[e] As corrected by (1961VA10).

[f] From ^{11}B$(p, \gamma)^{12}$C.

(γ, d) and (γ, p), with strong forward peaking. These observations are consistent either with a quasi-deuteron mechanism or with a two-stage pickup process (1962CH26: see (1962MA1F, 1964SH1B)). According to (1964SH1B) the high apparent threshold for (γ, d) reflects the presence of continuum states of ^{10}B with a high parentage in ^{12}C. See also (1959CH25, 1960SH1D, 1963BA1K, 1964KI1D, 1965KI04, 1967SM1A).

33. ^{12}C$(\gamma, t)^9$B $Q_{\mathrm{m}} = -27.369$

See (1968BU1D).

34. ^{12}C$(\gamma, 3\alpha)$ $Q_{\mathrm{m}} = -7.274$

The cross section exhibits broad peaks at about 18 MeV and ≈ 29 MeV; a pronounced minimum occurs at 20.5 MeV: to what extent the peaks have fine structure is not clear (1953GO13, 1955CA19, 1955GO59, 1955JO1C, 1964TO1A).

For $E_\gamma < 22$ MeV, transitions are mainly to ${}^8\text{Be}_{\text{g.s.}}$ and ${}^8\text{Be}^*(2.9)$ with the g.s. transition dominating for $E_\gamma \lesssim 14$ MeV. For $E_\gamma > 26.4$ MeV, ${}^8\text{Be}$ $(T = 1)$ levels near 17 MeV are strongly excited (1955GO59). Integrated cross sections are 0.82 ± 0.03 MeV $\cdot$ mb (1964TO1A: to 20.5 MeV), 1.21 ± 0.16 MeV $\cdot$ mb (1953GO13: to 20.5 MeV), 2.8 ± 0.4 MeV $\cdot$ mb (1953GO13: 20.5 to 42 MeV) and < 0.2 MeV $\cdot$ mb (1953GO13: 42 to 60 MeV). Alpha energy distributions show surprisingly strong E1 contributions below $E_\gamma \approx 17$ MeV (1955GO59, 1964TO1A). See also (1958MA1A, 1960GA16, 1961SE13, 1964WA1J, 1965RO1J), and (1959YO1B, 1964LE1C, 1965DZ1A, 1965DZ1B).

35. (a) ${}^{12}\text{C}(\gamma, \text{p}\alpha){}^7\text{Li}$ $\qquad\qquad Q_{\text{m}} = -24.621$

    (b) ${}^{12}\text{C}(\gamma, \text{n}\alpha){}^7\text{Be}$ $\qquad\qquad Q_{\text{m}} = -26.265$

Reported integrated cross sections for reaction (a) are for 25 to 40 MeV: 1.61 MeV $\cdot$ mb (1962MO16), 1.35 MeV $\cdot$ mb (1956LI05), 3.85 MeV $\cdot$ mb (1958MA1A); for 25 to 120 MeV: 1.9 ± 0.4 MeV $\cdot$ mb (1962MO16). For production of ${}^7\text{Be}$ (reaction (b)), the integrated cross section to 57 MeV is 6.0 ± 0.4 MeV $\cdot$ mb (1966AR01).

36. ${}^{12}\text{C}(\text{e}, \text{e}){}^{12}\text{C}$

Elastic scattering has been studied up to 800 MeV: momentum transfers $q^2 \leq 11.5$ fm^{-2} (1959ME24, 1964CR11, 1966CR07). The form factor is well accounted for by a harmonic-well model with $R(\text{r.m.s.}) = 2.40 \pm 0.02$ fm. Only one diffraction minimum is observed (1966CR07). $R = 2.42 \pm 0.04$ fm (1967EN1C), $R = 2.58$ fm (1967EL1B), $R = 2.35 \pm 0.1$ fm (1966AF1A: see also (1967AF02, 1967AF04, 1968AF1A)). See also (1960IN1A, 1963GO04, 1965MU1B, 1965RA1F, 1967BE1P, 1967BO1X, 1967EL1B, 1967FR1D, 1968BR1N).

Sharp inelastic peaks are reported corresponding to ${}^{12}\text{C}^*(4.4, 7.7, 9.6, 15.1$ and 16.1 MeV) (1956FR27, 1956HE83, 1959BA36, 1959EH1A, 1960BA47, 1961BO32, 1961DU09, 1962ED02, 1963BO36, 1963GO1P, 1964BR1N, 1964CR11, 1964GO14, 1965GU04, 1966CR07, 1967AR1A, 1967CR01, 1967PE07). Observed widths are reported in Table 12.20. Additional structure in the range $E_{\text{x}} = 16.6$ to 25.5 MeV is reported by (1963BO36, 1966PR1C). The variation of the form factor $F(q^2)$ with momentum transfer yields unambiguous assignments of $J^\pi = 2^+, 0^+$ and 3^- for the first three levels (1960BA38, 1964CR11, 1967HA1U). There is some evidence of a diffraction structure in $F({}^{12}\text{C}^*(4,4))$ at high momentum transfer (1966CR07). Transverse and longitudinal scattering form factors from ${}^{12}\text{C}^*(4,4)$ have been measured by (1967BE43).

The 15.1 MeV transition is a strong M1: $J^\pi = 1^+$; $T = 1$: the indicated Γ_γ is somewhat lower than the mean from ${}^{12}\text{C}(\gamma, \gamma)$ (1964GO15, 1964GU05, 1965FO1F). The theoretical value is sensitive to the spin-orbit coupling parameter, but a pure $\text{p}_{\frac{3}{2}}^4$ ground state seems to be excluded (1964BI1H, 1964KU1G). The 16.1 MeV level corresponds to that observed in ${}^{11}\text{B}(\text{p}, \gamma){}^{12}\text{C}$. $\Gamma_{\gamma_0} = 0.184 \pm 0.045$ eV is obtained from the electron data, and $T = 1$ is confirmed (1961DU09,

Table 12.20: Widths of ^{12}C states from ^{12}C(e, e)^{12}C [a]

^{12}C*	$J^\pi; T$	Γ_{γ_0} (eV)	Refs.
4.44	$2^+; 0$	$(12.5 \pm 2.5) \times 10^{-3}$	(1956HE83)
		$(11.2 \pm 1.2) \times 10^{-3}$	(1964CR11)
		$(10.6 \pm 1.1) \times 10^{-3}$	(1967CR01)
		$(12.2 \pm 0.8) \times 10^{-3}$	(1967AR1A)
7.65 [b]	$0^+; 0$	$(5.5 \pm 3) \times 10^{-5}$	(1956FR27) [d]
		$(6.5 \pm 0.7) \times 10^{-5}$	(1964CR11)
		$(7.3 \pm 1.3) \times 10^{-5}$	(1965GU04)
		$(6.2 \pm 0.6) \times 10^{-5}$	(1967CR01)
9.64	$3^-; 0$	$(3.6 \pm 0.4) \times 10^{-4}$	(1964CR11)
		$(3.1 \pm 0.4) \times 10^{-4}$	(1967CR01)
15.11 [c]	$1^+; 1$	40^{+8}_{-6}	(1959BA36, 1960BA47)
		39 ± 4	(1962ED02)
		34.4 ± 3	(1964GU05)
		36 ± 3	(1967PE07)
16.1	$2^+; 1$	$(184 \pm 45) \times 10^{-3}$	(1963BO36, 1965BI1B)
18.1			(1964GO14)
19.2	$(2^-; 1)$		(1963BO36, 1965DE1C, 1966BE1Q, 1967BI1K, 1967DR1C)
19.5	$(1^-; 1)$		(1963BO36, 1964GO14, 1967BI1K, 1967CR02)
≈ 24			(1964GO14)
≈ 34			(1964GO14)

[a] See also Tables 12.8 and 12.15.

[b] Partial width for g.s. decay via pairs.

[c] M1; see (1964GO15), Table 12.15.

[d] See (1967CR01).

1964BI1H, 1965BI1B, 1966PR1C). See also (1960IN1A, 1962KU1C, 1963BO36, 1964GI1A, 1965IN1A, 1965SE1D, 1967SH1L).

Inelastic excitation of the giant resonance has been studied by (1959BA36, 1960BA47, 1961BO32, 1963BO36, 1963GO1P, 1963LE1H, 1964GO14, 1966PR1C). There appears to be evidence for structure at 18.1 ± 0.05, 19.5 ± 0.05 ($\Gamma = 0.5 \pm 0.1$), ≈ 24 and ≈ 34 MeV (1964GO14: see also (1967CR02)). The variation of $F(q^2)$ with q^2 in the range $0 - 0.6$ fm^{-2} shows good agreement with the calculations of (1964LE1D) which assumes four 1^- particle-hole states at $E_x = 19.6$, 23.3, 25.0 and 35.8 MeV (see also (1967CR02)). See also (1960FA1E, 1965LE1D, 1966FR1H, 1966UB01, 1967BI1K). Reported integrated cross sections are 75 MeV $\cdot$ mb (1960BA47), 50 MeV$\cdot$mb (1963GO1P). See also ^{12}C(γ, n)^{11}C. The behavior of the 19.2 MeV level suggests ascription to the expected giant magnetic quadrupole state $J^\pi = 2^-$; this state is not likely to have been seen in ^{11}B(p, γ)^{12}C (1965DE1C, 1965DE1K, 1966BE1Q, 1967BI1K, 1967CR02, 1967DR1C). A positive parity state with a large longitudinal matrix element may also be present (1967BI1K).

See (1962BA1D, 1964BA1R, 1966DE1K, 1966GO1C, 1967WA1E, 1967WA1F) for general discussions.

See also (1960DE1A, 1963PO1B, 1964ZI1A, 1966BO1N, 1966BO1P, 1966GI1A, 1966KA1C, 1966PE1E, 1966SI1E, 1967CZ1B, 1967IS1A).

37. (a) ^{12}C(e, e$'$p)^{11}B $Q_m = -15.957$

     (b) ^{12}C(e, e$'$n)^{11}C $Q_m = -18.720$

Electron spectra in the region of large energy loss show a broad peak which is ascribed to quasi-elastic processes involving ejection of single nucleons from bound shells: see (1961BO32, 1963CZ1A, 1966DE1K). A study of e$'$-p coincidences for incident energies around $550 - 600$ MeV reveals peaks corresponding to ejection of 1p and 1s protons: the results are consistent with observations in (p, 2p) (1961JA1L, 1964AM1C, 1967AM1E). Angular distributions for the two groups are analyzed by (1967AM03) in terms of proton momenta.

See also ^{12}C(γ, n)^{11}C, ^{12}C(γ, p)^{11}B and (1961GO1R, 1961RO1H, 1961VA10, 1962DO1A, 1962PA08, 1963BO36, 1964SU1B, 1966RA1C, 1967DE1P, 1968AM1A).

38. (a) ^{12}C(n, n)^{12}C

     (b) ^{12}C(n, n$'$)^{12}C*

     (c) ^{12}C(n, n$'$)^{4}He^{4}He^{4}He $Q_m = -7.274$

Elastic and inelastic scattering have been studied at many energies up to 350 MeV. The data are summarized by (1963GO1M, 1964ST25); some later references are listed in Table 12.21. At $E_n = 14$ MeV, the elastic angular distribution shows a forward-peaked diffraction structure indicating direct interaction. Optical model fits in the forward hemisphere are satisfactory but fail at back angles (1963LU10, 1964CL05). A strong-coupling calculation has been made by (1965BL09).

Table 12.21: Summary of ^{12}C(n, n)^{12}C angular distribution studies [a]

E_n (MeV)	^{12}C states	Refs.
$0.05 - 2.30$	g.s.	(1961LA1A)
0.5, 0.8	g.s.	(1965KO1E)
$1.0 - 10$	g.s.	(1966FI1C)
6.0	g.s., 4.4	(1965WI17)
6.0, 7.5	4.4	(1966DR1E)
7.6	g.s., 4.4	(1967PE1E)
14	g.s.	(1966FR18)
14	4.4	(1960BE24, 1961BO28, 1964ST30)
14	g.s., 4.4, 7.7, 9.6	(1963BO15, 1963BO1M, 1964SZ1A)
14	g.s., 4.4, 9.6	(1964CL05)
14	4.4, 7.7, 9.6, 10.1	(1963RO1L)
14	4.4, 7.7, 9.6	(1963JO1G, 1964JO1E, 1966GR1L, 1966JO1B)
14.6	9.6, 10.8, 11.8	(1967TU02)
14.8	4.4, 7.6	(1962RE1B)
96	g.s.	(1960SA25)

[a] See also (1963GO1M, 1964ST25).

polarization studies at $E_n = 24$ MeV are in fair agreement with optical model predictions and yield a sign for the spin-orbit coupling in agreement with shell model predictions (1962WO08: see also (1960SA1E, 1965BR1E)). See also (1959GL57, 1959KE1A, 1959WI1C, 1960HO14, 1960RO24, 1964CR1B).

At 14 MeV the cross sections for n_0, n_1 (4.4) and n_2 (9.6) are about 800, 220 and 100 mb, respectively: see (1963BO15, 1964ST25, 1966GR1L, 1967GR1P). Angular distributions at $E_n = 14$ MeV of neutrons corresponding to ^{12}C*(4.4) show direct interaction, but DWBA optical model fits are unsatisfactory (1964CL05: see also (1959GL57, 1960PE02, 1960RO24)). (1967GR1P) find that coupled channel calculations, with ^{12}C*(0, 4.44, 9.64, 10.84) taken as collective states yield fair agreement with the experimental angular distributions at $E_n = 14$ MeV. See also (1962BA15, 1962BA25, 1962CO1E, 1963HO08, 1964JO1E). The angular correlation (n', $\gamma_{4.4}$) has forward neutron angles the distributions are similar to (p, p'γ) while a strong difference is apparent at $\theta_n = 135°$ (1963BE31, 1966BE1R). See also (1961AS1B, 1963MO04, 1964MO1D, 1965LA1D). See also (1958AN32, 1958NA09, 1959GA1D, 1959HA06, 1959SI79, 1960DE10, 1960HE10, 1960PE1A, 1961BR08, 1961JA19, 1961ST22, BL62C, 1962BO06, 1962BR11, 1962ST18, 1962TE05, 1963ED1B, 1963GA1G, 1963KO1C, 1963MC1B, 1963OP1A, 1963SE1P, 1964AD1B, 1964EN1B,

Table 12.22: ^{12}C(p, p)^{12}C angular distribution and correlation studies [a]

(a) Angular distribution of protons

E_p (MeV)	Angular distribution of ^{12}C*	Refs.
$2.4 - 13$	g.s., 4.4, 7.7	(1966BA35, 1966SW04)
$2.5 - 3.0$	g.s.	(1965BE1L)
$4.7 - 8.7$	g.s. (and 4.4 at 8.7 MeV)	(1965MO15)
$4.7 - 11.0$	g.s., 4.4	(1960DE1C)
$5 - 20$	g.s., 4.4	(1962RO14)
$6.5 - 16$	g.s., 4.4	(1961NA02)
6.9	4.4	(1961GO13)
$9.4 - 9.6$	g.s.	(1953BU72, 1957GI14, 1957GR53, 1959GR1C)
9	g.s.	(1961HO09)
9.2, 10	4.4	(1961MC16)
12	4.4	(1957CO53)
$13.6 - 19.6$	g.s., 4.4, 7.7, 9.6	(1964DA03)
$14 - 19.4$	g.s., 4.4	(1957PE14)
14.5	g.s., 4.4	(1962ST11)
14.5, 20, 31.5	g.s.	(1955KI43, 1956KI54)
17	g.s.	(1956DA03)
$17.5 - 20$	12.7	(1962WA31)
19.5	15.1	(1962WA31)
17.8	g.s., 4.4	(1965BA54)
18.9	9.6	(1961BR08)
$18 - 30$	g.s., 4.4, 7.7, 9.6, 12.7	(1963DI04, 1963DI16)
29	g.s., 4.4	(1966CR14)
30.3	g.s.	(1964RI07)
30.6	g.s., 4.4, 9.6	(1952BR52)
31.1	g.s., 4.4, 7.7, 9.6, 12.7, 14.0, 15.1, 16.1	(1963DI04)
40	4.4, 7.7, 9.6	(1964ST15)
40	g.s., 4.4, 7.7, 9.6	(1963HW01, 1966BL19)
40	g.s.	(1967FR20)
40	4.4	(1959CH1B, 1966FR1G)
46	4.4, 7.7, 9.6, 10.8, 11.8, 12.7, 14.0, 15.1, 16.1	(1967PE05, 1967SA13)
48	g.s., 4.4, 7.7, 9.6, 18.4	(1965WI1H)
49	g.s., 4.4	(1966CR14)
49.5	g.s., 4.4, 7.7	(1967FA06)
57	g.s., 4.4	(1962NO08, 1962YA04)
68	g.s., 4.4	(1963PO06)
95, 135	4.4	(1957DI28)
96	g.s.	(1957GE08)

Table 12.22: ^{12}C(p, p)^{12}C angular distribution and correlation studies [a] (continued)

E_p (MeV)	Angular distribution of ^{12}C*	Refs.
96	g.s., 4.4, 9.6, 20.8	(1956ST65)
100	g.s., 4.4, 7.7, 9.6	(1966MA38)
142	g.s.	(1961TA06)
143	g.s.	(1964ST16)
145	g.s., 4.4, 9.6, 14, 18.5	(1966EM01, 1966JA03, 1966JA07)
150	15.1	(1961DE16)
155	g.s., 4.4, 7.7, 9.6, 15.1	(1957AL39, 1964JA03)
180	g.s.	(1961JO18)
185	4.4, 7.7, 9.6, 12.7, 15.1, 16.1, 18.2, 19.3	(1964HA34, 1965HA17)
185	13.9	(1967JO1F)
660	g.s.	(1963AZ01, 1963AZ1B, 1963AZ1C)
725	g.s.	(1965MC04)
1000	g.s., 4.4, 7.6 + 9.6	(1967FR10, 1967PA25)

(b) Angular correlation of protons and gamma rays

E_p (MeV)	States involved	Refs.
6.5	4.4	(1960HA21, 1961AD04)
8.5	4.4	(1964BA14)
$9.9 - 14.6$	4.4	(1963NA1D)
$10 - 10.8$	4.4	(1959BR1J, 1964SC07)
$12 - 15$	4.4	(1966SC1L)
39	4.4	(1960AD1A, 1964AD1A)
147	4.4	(1964RO23)
150	4.4, 15.1	(1961DE16, 1962SA05)

[a] See also ^{13}N.

1964OL1B, 1964PE20, 1966BR1D, 1966CI1A, 1966FE1C, 1966JO1B, 1966KA1E, 1966KO1D, 1966LI1F, 1966MO1C, 1967BR23, 1967CH1R, 1967LE1G) and ^{13}C.

At $E_n = 14.2$ MeV, reaction (c) proceeds about 50% through ^{12}C states which then decay via ^{8}Be$_{g.s.}$ and ^{8}Be*(2.9). Most of the remainder of the observed events take place through ^{12}C(n, $\alpha)^9$Be* $\rightarrow$ n + ^{8}Be* and ^{12}C(n, $\alpha)^9$Be* (α) ^{5}He* (n) α. The reaction ^{12}C(n, ^{5}He*)^{8}Be* cannot be excluded. Four-body break-up is not necessary to explain the results. The α-decay of the 10.8 and 11.8 MeV states, together with stripping results, suggest $J^\pi = 1^-$ and 2^- for these states (1964BR25: see also (1966MO05)). See also (1959TS1A, 1960VA10, 1962BA15, 1962BA25, 1964SA1E, 1965GR1V, 1965GR1W, 1966CI1A, 1966FE1C, 1966GR1M).

39. (a) ^{12}C(p, p)^{12}C

(b) ^{12}C(p, pn)^{11}C $Q_\mathrm{m} = -18.720$

(c) ^{12}C(p, 2p)^{11}B $Q_\mathrm{m} = -15.957$

(d) ^{12}C(p, pd)^{10}B $Q_\mathrm{m} = -25.188$

(e) ^{12}C(p, pα)^{8}Be $Q_\mathrm{m} = -7.369$

Up to $E_\mathrm{p} \approx 12$ MeV, the elastic scattering exhibits resonance structure: see ^{13}N. References to elastic and inelastic studies at higher energies are listed in Table 12.22. Excitation functions for both (p, p) and (p, p$_1$(4.43)) exhibit pronounced resonance-like structure for $E_\mathrm{p} = 14$ to 20 MeV (1957PE14, 1961NA02, 1964DA03). An optical model analysis gives a good account of the data, but the parameters vary strongly with energy (1962NO03: see also (1962RO14)). Between 18 and 30 MeV the elastic scattering and polarization angular distributions show strong energy dependence, while those for inelastic groups are much smoother (1963DI04, 1963DI16, 1966CR04). An optical model analysis with resonances is discussed by (1964TA1E); see also (1965BA1M). At 40 MeV an 11-parameter optical model fit is satisfactory for elastic differential cross sections, but unsatisfactory for polarization data (1966BL19, 1967FR20: see also (1965BA54 , 1965FR17)). The same problem arises with the data at 46 MeV (1967SA13) and 49 MeV (1966CR14). For analysis of the 140 MeV small angle results, see (1966JA08). See also (1958BE1B, 1959WI1C, 1962RO1F, 1964CR1B, 1967BE1Q, 1967TA1B). At 1 MeV, the differential elastic scattering cross section exhibits diffraction-like structure associated with the multiple scattering of protons by nucleons inside the nucleus (1967PA25).

At $E_\mathrm{p} = 40$ MeV, angular distributions of inelastic protons corresponding to ^{12}C*(4.4, 7.7, 9.6) confirm the assigned parities even, even, odd, respectively. Comparison of deformation parameters for ^{12}C*(4.4) determined by (p, p$'$), (α, α') and (e, e$'$) show considerable differences (1964ST15): see, however, (1966BA2K, 1967SA13). Angular distribution measurements at $E_\mathrm{p} = 46$ MeV (1967PE05) have been analyzed by (1967SA13): a large quadrupole deformation was found ($\beta_2 \approx 0.6$); the inelastic scattering agrees best with deformation of both the real and imaginary parts of the optical potential; the angular distribution for ^{12}C*(7.6) is best described by double quadrupole excitation via ^{12}C*(4.4). ^{12}C*(14) is interpreted as the 4^+ rotational state. The similarities of distributions corresponding to ^{12}C*(10.8, 11.8) suggest that they have the same spin (1967SA13). Asymmetries observed with 40 MeV polarized protons on ^{12}C*(4.4) disagree with DWBA predictions (1966FR1G: see also (1967SA13)). See also (1960BA38, 1963DI16, 1964DA03, 1965FR17, 1966BL19, 1967FA06, 1967LE13, 1967LE1G, 1967PA1L, 1967SA1L, 1968GA1H, 1968TA1P).

A number of inelastic groups have been studied at $E_\mathrm{p} = 155$ to 185 MeV: see Table 12.23. When treated in the impulse approximation, the cross sections and angular distributions are closely related to the electric transition moments. Comparison of (p, p$'$) and (e, e$'$) form factors yield the transition multipolarities indicated in Table 12.23 (1964JA03: see also (1960NI02, 1961BR08, 1961PI04, 1962BR11, 1962RO1F, 1962SA1G, 1963HO1D, 1963NI02, 1964HA1L, 1965HA17, 1965HA28, 1966HA51, 1967HA1U, 1967JO1F). The broad levels reported in the range $E_\mathrm{x} = 20$ to 24 MeV are associated with the giant E1 resonance (1961SA1E, 1962SA1G, 1963DE35, 1965HA17).

Table 12.23: ^{12}C levels from ^{12}C(p, p')^{12}C*

^{12}C* [a,b] (MeV ± keV)	Multipolarity [c]	Γ [a] (keV)
4.43 ± 100 [d,e]	E2	
7.65 ± 100		
9.7 ± 150	E3	
10.6 ± 400		
11.1 ± 400		
12.7 ± 200	(M1)	[h]
13.9 ± 100 [f]		
15.15 ± 100	M1	[h]
16.1 ± 200		
18.2 ± 300		500 − 800
19.3 ± 200	M2 [g]	500 − 800
(20.4 ± 400)		500 − 800
21.4 ± 300		500 − 800
22.1 ± 300	E1	500 − 800
23.4 ± 400		500 − 800

[a] (1965HA17: 185 MeV).

[b] (1963DE35, 1964ST15). See also (1956ST65, 1959AJ76, 1960GA10, 1960LA03, 1962NO08, 1963ME04, 1966EM01).

[c] (1964JA03).

[d] $E_x = 4437 \pm 7$ keV (1962BR10).

[e] $E_x = 4440.0 \pm 0.5$ keV (1967KO14).

[f] (1967JO1F): $J^\pi = (4^+)$.

[g] See also (1960RI1C).

[h] (1962WA31): $\Gamma_\gamma/\Gamma = 0.027 \pm 0.007$ for ^{12}C*(12.7), 1.15 ± 0.3 for ^{12}C*(15.1).

The energy of the first excited state is 4440.0 ± 0.5 keV, from the γ-ray. The character of the Doppler broadening indicates rather little spin-flip contribution to the inelastic scattering (1967KO14: $E_p = 23$ MeV). Proton γ-angular correlations provide a sensitive measure of the spin-flip: for $E_p = 10$ to 15 MeV a considerable contribution is observed (1964SC07, 1966SC1L: see also (1961AD04, 1961CL1D, 1961GI1C, 1961GO13, 1962NO04, 1964BA14, 1964RO23, 1967GI1D, 1967KO1N) and Table 12.21).

The following is a list of other recent theoretical and review papers dealing with this reaction: (1959GL57, 1959HO95, 1959MC63, 1959PU1A, 1960BE31, 1960LU1B, 1960MA43, 1960MI1C, 1960SA1C, 1960SA1E, 1960SA1G, 1961DO1C, 1961GI1D, 1961MC1C, 1961SA1B, 1962KA1E, 1962MA1P, 1962NI1C, 1963BU1E, 1963LO1A, 1963VI1A, 1964DA07, 1964HO1C, 1964SA1L, 1965CL1E, 1966BO1P, 1966GI1A, 1966LI1F, 1966SA1D, 1967CH1R, 1967VA1K) and (1959AJ76).

See also (1960WA15, 1961CL09, 1961RA1B, 1964SC1F, 1965DE14, 1965JA1A, 1966YA04).

Reaction (b) is widely used to monitor high-energy proton beams: see (1963CU05, 1963CU1B). For studies of recoil spectra, see (1962SI09, 1965BE1U). Possible emission of singlet deuterons is discussed by (1966NO1A). See also (1967HO1M).

In the summed proton spectrum of reaction (c), peaks are observed corresponding to the ejection of p- and s-shell protons: see ^{11}B. Absolute cross sections are reported by (1965GI1F). See also (1962AU1A, 1962ST1F, 1964LI1D, 1964LI1E, 1965MC1F, 1965RI1A, 1966BE1B, 1966KO1F, 1966JA1A, 1967CO1V, 1967EL1C, 1967GO01, 1967JA1C, 1967RI08, 1968JA1G, 1968YU1B). At $E_p = 57$ MeV the reaction involves an excited state at 20.3 MeV (1967EP1B, 1968RO1L).

For reaction (d) see (1963SH1A, 1965BA11, 1967SU1C, FR68A). See also (1962AU1A, 1964BA1P).

Reaction (e) has been studied up to $E_p = 660$ MeV. Various states in ^{12}C appear to be involved. At $E_p = 57$ MeV, the sequential process dominates; α-decay to ^{8}Be$_{g.s.}$ is observed via ^{12}C*(21.1, 22.2, 26); comparison with other reactions suggests $(J^\pi; T) = (1^+, 3^+; 0), (1^-; 0 + 1); (\pi =$ natural; significant $T = 0$ component) (1967EP1B). See also (1966RO1D, 1968RO1L). See also (1959VA15, 1960VA10, 1961VA17, 1962VA1A, 1962ZH1B, 1963JA07, 1963VA04, 1963ZH1A, 1964BA29, 1964KE1F, 1964SY02, 1964YU1A, 1965IS05, 1965KU14, 1965SA1K, 1965YU1C, 1965ZH1A, 1966JA1B, 1966ZE1A, 1967GA01) and (1959AJ76).

Total proton reaction cross sections are reported by (1959BU97, 1959GO90, 1964GI05, 1964GR1M, 1967CA1K).

40. (a) ^{12}C(d, d)^{12}C

   (b) ^{12}C(d, pn)^{12}C $Q_m = -2.224$

The angular distribution of elastically scattered deuterons has been studied at a number of energies from $E_d = 2.8$ to 650 MeV: see (1954FR24, 1960BU25, 1960CA24, 1961IG02, 1961IS02, 1961LO01, 1962SL02, 1963BU24, 1963CA1E, 1963FR1F, 1963VA23, 1965DI1C, 1965DU01, 1966CO24, 1966DO1B, 1966DU08, 1966GA09, 1966GE03, 1966NG01, 1967AU05, 1967DU1E,

1967FI07, 1967NE09 , 1967PL1B, 1967WA1M). Inelastic groups corresponding to levels at 4.4 and 9.6 MeV are reported by (1961JA02, 1962SL02, 1966NG01: see also (1951KE02, 1954FR24, 1956GR37, 1956HA90)). The angular distributions of inelastically scattered deuterons to these two states and to ^{12}C*(7.7) have been measured at $E_\mathrm{d} = 25.9$ MeV (1963VA23). A systematic optical model analysis yields a set of smoothly varying parameters which give a good account of the elastic angular distributions from $E_\mathrm{d} = 3$ to 34 MeV. For the inelastic scattering, $Q = -4.4$, deformation of the potential corresponding to $\beta = 0.4 - 0.6$ was required (1966SA1C). See also (1961CI08, GO61I, 1963CA1J, 1963SA1G, 1968HI1H), (1958MA52, 1960EL09, 1960FA05, 1960LU1B, 1961RO1G, 1962SA1J, 1963ST1A, 1963ZA1B, 1964HE1H, 1964HO1C, 1964RU1A, 1964SA1K, 1965CA1F, 1965TJ1A, 1966BA2W, 1966JA1J, 1966MA2Q, 1967RE1E, 1967RU1A; theor.) and (1959AJ76).

For reaction (b), see (1963PH1A, 1965LA08, 1965LA1F, 1967MA1N, 1967NO1A) and ^{13}N.

41. ^{12}C(d, ^{6}Li)^{8}Be $\qquad\qquad Q_\mathrm{m} = -5.897$

Differential cross sections measured for $E_\mathrm{d} = 14.7$ MeV are analyzed by DWBA to yield S_α, a measure of the composition ^{8}Be $+ \alpha$ in the wave function of ^{12}C$_\mathrm{g.s.}$. Subject to an uncertain normalization, S_α is found to be close to unity (1964DA1B, 1966DA1C, 1966DE09).

42. ^{12}C(t, t)^{12}C

Angular distributions of elastically scattered tritons have been determined at $E_\mathrm{t} = 1.0$ to 1.75 MeV (1962GU01: see also (1968HE1N)), at 6.4, 6.8 and 7.2 MeV (1964PU01) and at 12 MeV (1965GL04: optical model analysis; see also (1966GL1B)).

43. (a) ^{12}C(^{3}He, ^{3}He)^{12}C
    (b) ^{12}C(^{3}He, pd)^{12}C $\qquad\qquad Q_\mathrm{m} = -5.494$
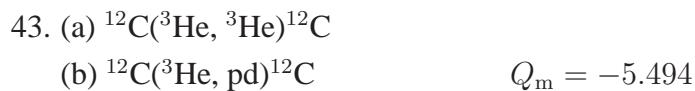
Angular distributions of elastically scattered ^{3}He particles have been determined for $E(^{3}\mathrm{He}) = 2$ to 6 MeV (1966SC12), 5.5 MeV (1961PA04), 8.5 and 10 MeV (1966SC22), 12 MeV (1965YO1B), 12.0 to 18.6 MeV (1967FO1F), 20.1 MeV (1967MA1G: also ^{12}C*(4.4)), 24.5, 25.3 and 26.8 MeV (1964SE05), 25.7 MeV (1966DA1H: also ^{12}C*(4.4, 7.7)), 26.1 to 32.6 MeV (1963PA15: also ^{12}C*(4.4)) and $29 - 30$ MeV (1961AG1A, 1961CA18, 1962AG01, 1962CA29, 1962GA17, 1965BU1H, 1967BA2P, 1967BR1N). See also (1961FO02, 1962WE1C, 1967AR17, 1967AS1B) and (1961HO1J, 1964GO1J, 1965FR1E, 1967GR1N, 1967PA1U; theor.). For reaction (b) see (1965DO1H).

44. (a) $^{12}C(\alpha, \alpha)^{12}C$

    (b) $^{12}C(\alpha, \alpha n)^{11}C$ $Q_m = -18.720$

    (c) $^{12}C(\alpha, 4\alpha)$ $Q_m = -7.274$

Angular distributions of elastic and inelastic α-particles and of 4.43 MeV γ-rays have been measured at a number of energies: see Table 12.24. DWBA fits to differential cross sections observed at 40.5 MeV for $Q = -4.4$ yield $B(E2)\downarrow = 13\ e^2 \cdot fm^4$; for $Q = -9.6$, $B(E3)\downarrow = 50 - 70\ e^2 \cdot fm^6$ (1966HA19). Except for the broad 10.1 MeV state all known levels of ^{12}C with $E_x < 14$ MeV have been observed by (1966HA19). Angular distributions of α-particles and 4.4 MeV γ-rays have been studied at $E_\alpha = 22.5$ (1964EI01) and at 43 MeV (1959SH62, 1962MC11). The studies of (1962MC11, 1964EI01) yield information on the polarization of the $^{12}C^*(4.4)$ as produced in inelastic scattering. The derived polarizations show strong dependence on scattering angle and are not explained by simple PWBA or adiabatic reaction mechanisms: DWBA gives qualitative agreement. Similar studies involving $^{12}C^*(9.6)$ confirm that $J^\pi = 3^-$ (1963LA07). See also (1959CA14, 1962BR14, 1964BU1F, 1964LA07, 1967VE1C) and (1959BL31, 1959GL57, 1960RO1E, 1961EI1A, 1962RE1C, 1963DA1B, 1963HO1J, 1964DA1D, 1964GR1L, 1965JA1D, 1966JO1A, 1967BO1W, 1967JA1G, 1967LA1K; theor.) and (1959AJ76). The 9.6 MeV state decays predominantly through $^8Be_{g.s.}$ (1966BO28).

The angular distribution of alphas corresponding to $^{12}C^*(12.7;\ J^\pi = 1^+)$ at $E_\alpha = 28.5$ MeV is not accounted for in DWBA. A spin-orbit interaction leading to spin flip appears to be involved (1967NA06).

For reaction (b) see (1953LI28). Angular correlations in $^{12}C(\alpha, 2\alpha)$ (reaction (c)) observed at $E_\alpha = 915$ MeV give evidence for strong α-clustering in ^{12}C (1961GO1T). See also (1961VA38, 1962BR14, 1962VA25, 1965YA02).

45. (a) $^{12}C(^6Li, {}^6Li)^{12}C$

    (b) $^{12}C(^7Li, {}^7Li)^{12}C$

See (1964OL1A); see also (1963BE1R, 1966DE09, 1967SI1C).

46. (a) $^{12}C(^{10}B, {}^{10}B)^{12}C$

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

See (1964OL1A). See also (1963SH1E) for reaction (a) and (1963SA1E) for reaction (b).

47. $^{12}C(^{12}C, {}^{12}C)^{12}C$

Table 12.24: Summary of ^{12}C$(\alpha, \alpha)^{12}$C angular distribution data

E_α (MeV)	^{12}C states	Refs.
2.5 – 4.8	g.s.	(1962JO09)
7.9 – 8.1	4.4	(1964MI12)
7.9 – 19	4.4	(1964MI08)
8.8 – 10.1	g.s.	(1967BR1F)
11 – 19	g.s.	(1964CA07)
14	g.s., 4.4	(1963JO1F)
18	g.s., 4.4, 7.7, 9.6	(1959CO70)
18.5	7.7	(1964MI08)
18.7	g.s.	(1962WO02)
20	g.s., 4.4, 7.7, 9.6	(1959FU62)
20.3, 21.9	g.s., 4.4, 7.7, 9.6	(1964JO14)
21.2 – 22.7	g.s.	(1962JO14)
22	g.s., 4.4	(1959HU14)
22.5	g.s., 4.4	(1964EI01)
24	g.s.	(1967AG1A)
24.7	g.s.	(1964BU1E)
25	9.6	(1966BO28)
27.2	g.s.	(1966NE1D, 1967NE1F)
27 – 36	g.s., 4.4, 7.7, 9.6, 12.7	(1960MI03, 1960MI10)
28.5	g.s.	(1962AG01)
28.5	g.s., 4.4, 7.7, 9.6, 11.8, 12.7, 14.1	(1967NA06)
31.5	g.s., 4.4, 7.7	(1956WA29)
33.4	g.s., 4.4	(1967AR17)
38 [a]	g.s., 4.4, 7.7, 9.6	(1960AG01, 1960VA03)
40	g.s., 4.4, 7.7, 9.6	(1956IG02, 1957IG03, 1959YA01)
40.5	g.s., 4.4, 7.7, 9.6	(1966HA19)
42	g.s., 4.4	(1959EC13, 1962MC11)
51	g.s.	(1966VI1A)
56	g.s.	(1967SY1A)

[a] (1960VA03) report $E_x = 4.38 \pm 0.04, 7.59 \pm 0.04, 9.67 \pm 0.06$ MeV.

At $E(^{12}C) = 126$ MeV, strong inelastic peaks corresponding to $^{12}C^*(0, 4.4, 14.0 \pm 0.5)$ have been observed. Groups with $Q = -9$ and -19 MeV are also seen. Their interpretation is less clear. Angular distributions suggest that the 14 MeV state has $J^\pi = 4^+$; the large intensity indicates close association with $^{12}C_{g.s.}$ (1962WA24, 1963GA05, 1966BA2K); deformation parameters are listed by (1966BA2K); see also (1962GA02, 1962WI09). The elastic scattering has also been studied for $E_{c.m.} = 3$ to 13.4 MeV (1961BR15) and at $E_{c.m.} = 56.7$ MeV (1962SM02). See also (1965GR1F), (1959AL1H, 1962BE43, 1962SE1G, 1963WI1G) and (1962BU1B, 1963BA1Y).

48. $^{12}C(^{14}N, \, ^{14}N)^{12}C$

Differential cross sections have been determined for the $^{12}C_{g.s.}$ transition at $E(^{14}N) = 21.5$ to 27.3 MeV (1960HA16) and at $E_{c.m.}(^{14}N) = 62.5$ MeV (1962SM02); those to the 4.4 MeV state have been measured at $E(^{14}N) = 27.3$ MeV (1961HA04). See also (1961KU1D, 1961NE04, 1962WI09) and (1963KU1L).

49. $^{12}C(^{16}O, \, ^{16}O)^{12}C$

Differential cross sections have been determined for the $^{12}C_{g.s.}$ transition at $E_{c.m.}(^{16}O) = 8$ to 13.7 MeV (1963KU12) and at $E(^{16}O) = 35$ (1967GO1A, 1968VO1D), 42 (1964NE01), 67 (1959MC1D) and 168 MeV (1964HI09): those to the 4.4 MeV state have been measured at $E(^{16}O) = 42$ and 168 MeV (1964HI09, 1964NE01).

A DWBA analysis of the 168 MeV data is given by (1966BA2K). See also (1963KU1L, 1967AB1D).

50. (a) $^{12}C(^{17}O, \, ^{17}O)^{12}C$
(b) $^{12}C(^{18}O, \, ^{18}O)^{12}C$

The elastic scattering angular distributions in both (a) and (b) have been measured at $E = 35$ MeV (1967GO1A).

51. $^{12}N(\beta^+)^{12}C$ $Q_m = 17.342$

The decay is mainly to the ground state via an allowed transition. Branching fractions to other states of ^{12}C are listed in Table 12.25. The half-life is 10.97 ± 0.04 msec; see Table 12.28. Since transitions to $^{12}C_{g.s.}$ and $^{12}C^*(4.4)$ are allowed, $J^\pi(^{12}N) = 1^+$. See discussion of $^{12}B(\beta^-)$ and (1965WU1A). See also (1962PO02, 1966DU1E, 1967HU10).

Table 12.25: Branching in ^{12}N$(\beta^+)^{12}$C

Decay to ^{12}C*	Branch (%)	$\log ft$ [f]	Refs.
g.s. [a]	94.25	4.117 ± 0.002	
4.44	2.4 ± 0.2		(1963PE10)
	2.2 ± 0.25 [b]		(1963WI05)
	2.3 ± 0.2	5.06 ± 0.04	mean
7.65 [c]	2.2 ± 0.6		(1963GL04)
	3.0 ± 0.5		(1962MA22)
	2.7 ± 0.4	4.34 ± 0.06	mean
10.3 [d]	0.85 ± 0.6		(1963GL04)
	0.44 ± 0.15		(1963WI05)
	0.46 ± 0.15	4.36 ± 0.17	mean
12.71 [e]	0.29 ± 0.13	3.55 ± 0.16	(1967AL03)
15.11	$(4.4 \pm 1.5) \times 10^{-3}$	3.30 ± 0.13	(1967AL03)

[a] $E_\beta(\mathrm{max}) = 16.384 \pm 0.015$ MeV (1963GL04, 1963PE10).

[b] 1.72 times ^{12}B value.

[c] See also (1963WI05).

[d] (1966SC23).

[e] See also (1963GL04, 1963WI05, 1966SC23).

[f] Based on $\tau_{1/2} = 10.97 \pm 0.04$ msec and on Q_m: see (1966BA1A).

52. ^{13}C$(\gamma, \mathrm{n})^{12}$C $\qquad\qquad Q_\mathrm{m} = -4.947$

See ^{13}C.

53. ^{13}C$(\mathrm{p, d})^{12}$C $\qquad\qquad Q_\mathrm{m} = -2.722$

Angular distributions of deuterons to ^{12}C*(0, 4.4) have been measured by (1966GL01: 8 and 12 MeV) and by (1961BE12: 17 MeV). For the ground state, $\theta^2 = 0.036$ at $E_\mathrm{p} = 8$ MeV and 0.058 at 12 MeV; for the 4.4 MeV state $\theta^2 = 0.051$ at 12 MeV (1966GL01: PWBA). See also (1960NE1C, 1964TE1G). At $E_\mathrm{p} = 54.9$ MeV, strong deuteron groups are observed to ^{12}C*(0, 4.4, 12.7, 15.1, 16.1) and partial angular distributions of these groups have been observed. Spectroscopic factors (from DWBA) indicate that the summed transition strengths to the four excited states are approximately equal to the P$_{\frac{3}{2}}$ neutron pickup strength in ^{12}C(p, d) (1968TA1V).

54. ^{13}C(d, t)^{12}C $\qquad\qquad Q_m = 1.311$
$$Q_0 = 1.311 \pm 0.006 \; (1961\text{TE}02, \; 1964\text{MA}57);$$
$$Q_0 = 1.3109 \pm 0.0007 \; (1967\text{OD}01).$$

Angular distributions of tritons have been obtained by (1954HO48: 2.2 and 3.3 MeV; t_0), (1966GL01: 8 and 12 MeV; t_0 and t_1), (1960MA10: 14.8 MeV; t_0, t_1, t_2). The relative θ^2 for the ground and first two excited states are 1 : 0.76 : 0.039 (1960MA10, 1966GL01: PWBA). Assuming $\theta^2 = 0.031$ for ^{12}C$_{g.s.}$, $\theta^2 = 0.024$ for ^{12}C*(4.4) and 0.0012 for ^{12}C*(7.7) (1960MA32). See also (1959KU1C, 1963OG1A, 1965DE26, 1967DE1J).

55. ^{13}C(^{3}He, α)^{12}C $\qquad\qquad Q_m = 15.631$

Angular distributions have been determined at many energies: see (1962CH02: 1.6 to 3.3 MeV; α_0, α_1, α_2), (1968MI1H: 1.66 to 3.12 MeV; α_0, α_1, α_2), (1957HO63: 2 MeV; α_0, α_1), (1960BA25: 1.8 MeV; α_0), (1957HO62: 4.5 MeV; α_0, α_1), (1964DE1E, 1965DE26: 8.8, 9.4, 10.3 MeV; α_0, α_1; DWBA), (1966KE08: 12, 15, 18 MeV; α_0, α_1, α_2, α_3, α_5, α_6, α_7, α_8; DWBA), (1967BA2G: $40 - 45$ MeV). (1966KE08) find $l = 1$ or 0 for all the groups except α_3 (to ^{12}C*(9.6)) for which $l = 2$. Angular correlations of α-particles and 4.4 MeV γ-rays have been studied at $E(^3$He$) = 4.5$ MeV (1962HO13). See also (1968NO1E). The 15.1 MeV γ-ray has been observed: see (1957BR18, 1959AL96, 1959BR79). See also (1959OW1A, 1961HO1F, 1964EL1B, 1965NE1B, 1967BH1B).

56. ^{14}C(p, t)^{12}C $\qquad\qquad Q_m = -4.641$

At $E_p = 18.5$ MeV, the angular distribution of the tritons to the ground state has been determined: $l = 0$ (1961LE1A, 1963LE03).

57. ^{14}N(γ, d)^{12}C $\qquad\qquad Q_m = -10.272$

Not reported.

58. ^{14}N(n, t)^{12}C $\qquad\qquad Q_m = -4.015$

At $E_n = 14 - 15$ MeV, the angular distribution of the tritons to the ground state has been fitted with $L = 2$ (1967AN08, 1967FE06, 1967LI06, 1967RE01). See also (1959GA14, 1967BA1E, 1967MO21).

59. ^{14}N(p, pd)^{12}C $\qquad\qquad\qquad\qquad Q_{\mathrm{m}} = -10.272$

See (1964BA1C, 1967FU1A).

60. ^{14}N(p, ^{3}He)^{12}C $\qquad\qquad\qquad\qquad Q_{\mathrm{m}} = -4.779$
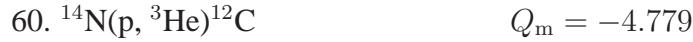
At $E_{\mathrm{p}} = 40$ MeV, angular distributions of the ^{3}He to ^{12}C*(0, 4.4) have been determined. They show strong forward peaking (1966BR1X, 1966HO1F). See also (1961CL09, 1962MA1L, 1967HO1N).

61. ^{14}N(d, α)^{12}C $\qquad\qquad\qquad\qquad Q_{\mathrm{m}} = 13.575$

$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\quad Q_0 = 13.579 \pm 0.006$ (1964MA57: see also (1962TE02)).

Alpha groups have been observed corresponding to all ^{12}C states up to ^{12}C*(16.11), with the exception of ^{12}C*(10.3) and ^{12}C*(14.7) (see (1965BR08)). See Table 12.26 for a listing of energy parameters measurements. Angular distributions have been obtained at many energies: see (1966EU01: 0.5 to 2.2 MeV; α_0), (1961SJ1B: 0.6 to 0.8 MeV; α_0), (1965WI11; 0.8 to 1.9 MeV; α_0, α_1), (1965ST02: 0.9 to 1.2 MeV; α_0, α_1), (1960KA1H: 1.4 to 2.9 MeV; α_0), (1961IS03: 1.5 to 3 MeV; α_0), (1965SC12: 4 MeV; α_0, α_1, α_2, α_3, α_5, α_6, α_7; 7.2 MeV; α_7, α_8, α_9, α_{11}), (1965BR08: 5.9 and 7.2 MeV; α_7, α_{11}, α_{12}), (1964CH1C: 4, 6, 8 and 10 MeV; α_0, α_1, α_2), (1962WI05: 10 MeV; α_0, α_1), (1960HU10: 10.3 to 11.4 MeV: α_0, α_1), (1966DR04: 11.3 and 12.6 MeV; α_0, α_1), (1961YA08: 14.7 MeV; α_0, α_1), (1959BO40, 1959HE1C: 20.0 MeV; α_0), (1959FI30: 20.9 MeV; α_0, α_1, α_3), (1965PE17: 24 MeV; α_0, α_1, α_2, α_3), (1966VI1A: 28.5 MeV; α_1). Integrated cross sections for eight alpha groups have been obtained at $E_{\mathrm{d}} = 11.8$ MeV (1966JA05). At $E_{\mathrm{d}} = 24$ MeV, α_1 is strongly favored over α_0, and α_3 is favored over α_4. For α_0, α_1 $L = 2$ is preferred (1965PE17). Angular distributions at $E_{\mathrm{d}} = 4$ MeV are nearly symmetric about $90°$, suggesting a compound nucleus process involving many overlapping levels (1965SC12).

In a test of isospin conservation, (1965BR08) find, at $E_{\mathrm{d}} = 7.2$ MeV, the cross section for excitation of ^{12}C*(15.11, $J^\pi = 1^+$; $T = 1$) $= 31\%$ of that for ^{12}C*(12.71, $J^\pi = 1^+$; $T = 0$); $\sigma(16.11)/\sigma(12.71) = 4\%$. Violation of this order can be understood as being due to coulomb mixing in the compound nucleus.

Comparison of angular distributions of ^{14}N(d, α)^{12}C at $E_{\mathrm{d}} = 20$ MeV and ^{12}C(α, d)^{14}N at $E_{\mathrm{d}} = 41.7$ MeV suggest an upper limit of 3% for the time reversal non-conserving fraction of the Hamiltonian (1959BO40, 1959HE1C, 1965PE17). See also (1962AL09, 1966ME1E).

At $E_{\mathrm{d}} = 1.8$ MeV, the alpha particles to the 7.65 MeV state were observed in coincidence with recoiling ^{12}C$_{\mathrm{g.s.}}$ nuclei. If $\Gamma_{\mathrm{rad}} \equiv (\Gamma_\gamma + \Gamma_\pi)$, the ratio $\Gamma_{\mathrm{rad}}/\Gamma = (2.8 \pm 0.3) \times 10^{-4}$: see ^{12}B($\beta^-$)^{12}C (1963SE23). See also (1967UI01).

Table 12.26: Alpha groups from ^{14}N(d, α)^{12}C

E_x (MeV $\pm$ keV)	Γ (keV)	Ref.
4.438 $\pm$ 6 [a]		(1951MA08)
4.430 $\pm$ 30		(1965PE17)
4.447 $\pm$ 10		(1961JA23)
7.665 $\pm$ 15		(1955PA50)
7.663 $\pm$ 13		(1956AH32)
7.669 $\pm$ 10		(1961JA23)
7.66 $\pm$ 50		(1965PE17)
9.642 $\pm$ 14	30 $\pm$ 8	(1956DO41)
9.616 $\pm$ 15		(1961JA23)
9.620 $\pm$ 3 [b]		(1951MA08)
9.64 $\pm$ 50		(1965PE17)
10.85 [c]		(1965SC12)
11 [c]		(1965SC12)
12.7 $\pm$ 70		(1965PE17)
13.29 [c]	355 $\pm$ 50	(1965SC12)
14.08 [c]		(1965SC12)
15.11		(1965BR08)
16.11		(1965BR08)

[a] Based on Q_m.

[b] (1956DO41) suggest that a systematic error exists in (1951MA08)'s value for this state.

[c] Nominal value; E_x not determined in this experiment.

62. ^{14}N(^{3}He, pα)^{12}C $Q_m = 8.081$

See (1962BL1E) and ^{16}O.

63. ^{14}N(α, ^{6}Li)^{12}C $Q_m = -8.800$

At $E_\alpha = 42$ MeV, angular distributions of ^{6}Li ions corresponding to the ground and first excited states of ^{12}C have been measured (1964ZA1A). See also (1964BR1L).

64. ^{14}N(^{10}B, 3α)^{12}C $Q_m = 7.642$

See (1965SH1A).

65. ^{15}N(p, α)^{12}C $Q_m = 4.965$
                                    $Q_0 = 4.954 \pm 0.008$ (1961LO10).
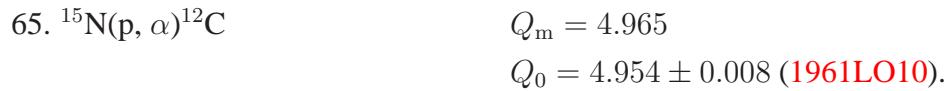
Searches for double dipole de-excitation of the 4.4 MeV state have been unsuccessful $\Gamma_{E1E1}/\Gamma_{E2}$ $\leq 0.5 \times 10^{-4}$ (1964AL18), $\leq 1.7 \times 10^{-4}$ (1960MC03). A theoretical estimate of 10^{-8} is cited by (1960MC03).

Angular distributions of α-particles leading to the ground and 4.4 MeV states have been determined for E_p up to 18.6 MeV: (see (1963MI1H, 1963RO01, 1964EC03, 1965WA1N, 1967NO02)). At the higher energies the ground-state alpha particles show marked backward peaking, in agreement with the inverse reaction ^{12}C(α, p)^{15}N (1964EC03). See also (1963NA1C, 1964HO1D, 1966EV1B).

66. ^{15}N(α, ^{7}Li)^{12}C $Q_m = -12.382$

Angular distributions of the ^{7}Li ions to the ground and 4.4 MeV states have been determined at $E_\alpha = 42$ MeV (1966MI1M).

67. (a) ^{16}O(γ, α)^{12}C $Q_m = -7.161$
    (b) ^{16}O(γ, 4α) $Q_m = -14.436$

There is evidence for the involvement of many ^{12}C states: see (1965RO05, 1967CA1C).

68. (a) ^{16}O(n, nα)^{12}C $\qquad\qquad\qquad$ $Q_m = -7.161$

$\quad$ (b) ^{16}O(p, pα)^{12}C $\qquad\qquad\qquad$ $Q_m = -7.161$

$\quad$ (c) ^{16}O(α, 2α)^{12}C $\qquad\qquad\qquad$ $Q_m = -7.161$

$\qquad$ For reaction (a), see (1963MO04, 1964MO1D). In reaction (b), 4.4 MeV γ-rays are observed at $E_p = 146$ (1962FO03) and 150 MeV (1962RO25). See also (1957CH1A, 1964BA1C, 1965ZH1A, 1967CH04, 1967FU1A). In reaction (c), the angular distributions of ^{8}Be nuclei (identified through the α-decay) leading to the ground and 4.4 MeV states of ^{12}C have been determined for $E_\alpha = 35.5$ to 41.9 MeV. The angular distributions and integrated cross sections vary strongly with energy (1965BR13). See also (1962DO1B, 1962ZU01, 1965KU1B, 1965ZE1B, 1967PA1T, 1967TA1C, 1968YA1C).

69. ^{16}O(d, ^{6}Li)^{12}C $\qquad\qquad\qquad$ $Q_m = -5.689$

$\qquad$ At $E_d = 14.6$ MeV, the ground state angular distribution suggests that direct interaction predominates (1964DA1B). Qualitative agreement with DWBA is reported (1966DA1C). See also (1963DR1B, 1964BL1C, 1965SL1C).

70. ^{16}O(^{3}He, ^{7}Be)^{12}C $\qquad\qquad\qquad$ $Q_m = -5.574$

$\qquad$ See (1967ZA1B).

71. ^{16}O(^{10}B, ^{14}N)^{4}He^{4}He^{4}He $\qquad\qquad$ $Q_m = -2.822$

$\qquad$ See (1965SH10, 1966SH1B).

72. ^{16}O(^{14}N, ^{18}F)^{12}C $\qquad\qquad\qquad$ $Q_m = -2.745$

$\qquad$ See (1966GA10).

73. ^{17}O(d, ^{7}Li)^{12}C $\qquad\qquad\qquad$ $Q_m = -2.579$

$\qquad$ See (1967DE03).

74. ^{18}O(d, ^{8}Li)^{12}C $\qquad\qquad Q_m = -8.593$

See (1963DE02).

75. ^{19}F(p, 2α)^{12}C $\qquad\qquad Q_m = 0.953$

See (1962FO03).

76. ^{19}F(d, ^{9}Be)^{12}C $\qquad\qquad Q_m = 0.299$

Ground-state angular distributions have been measured at $E_d = 9$ to 14.5 MeV (1964DA1B, 1967DE03, 1967DE14).

77. ^{19}F(^{3}He, ^{10}B)^{12}C $\qquad\qquad Q_m = 1.393$

See (1967DE14).

78. ^{20}Ne(α, ^{12}C)^{12}C $\qquad\qquad Q_m = -4.617$

The α-induced fission of ^{20}Ne has been studied by (1962LA03, 1962LA05, 1962LA15). See also (1963HO1H, 1963TA1B).

GENERAL: See (1964NA1G, 1964SH1J, 1964ST1B, 1966KE16, 1967KE1L).

Mass of ^{12}N: From a weighted average of the Q_0 values for ^{10}B(^{3}He, n)^{12}N and ^{12}C(p, n)^{12}N (see reactions 2 and 3), $M - A$ for ^{12}N = 17.342 ± 0.005 MeV.

1. ^{12}N(β^+)^{12}C $\qquad\qquad\qquad\qquad Q_m = 17.342$

Measured values of the half-life are displayed in Table 12.28. The decay is complex; ^{12}N decays to the ground state of ^{12}C and to several excited states: see ^{12}C.

2. ^{10}B(^{3}He, n)^{12}N $\qquad\qquad\qquad Q_m = 1.570$

$\qquad\qquad\qquad\qquad\qquad\qquad Q_0 = 1.561 \pm 0.009$ (1964KA08);

$\qquad\qquad\qquad\qquad\qquad\qquad Q_0 = 1.568 \pm 0.020$ (1966ZA01);

$\qquad\qquad\qquad\qquad\qquad\qquad Q_0 = 1.570 \pm 0.025$ (1964FI02);

$\qquad\qquad\qquad\qquad\qquad\qquad Q_0 = 1.574 \pm 0.007$ (1967AD1E);

$\qquad\qquad\qquad\qquad\qquad\qquad Q_0 = 1.569 \pm 0.005$ (mean).

Observed neutron groups are displayed in Table 12.29 (1957AJ71, 1964KA08, 1966ZA01, 1967AD1E). Angular distributions have been studied at $E(^3$He$) = 2.5$ and 3.6 MeV (1957AJ71) at $E(^3$He$) = 2.4$, 2.75 and 2.94 MeV (1967AD1E), and at $E(^3$He$) = 4.0$ and 5.8 MeV (1966ZA01). See also (1964BR13, 1966SC23, 1967AL03) and (1965SH1E, 1966SH1F; theor.).

3. ^{12}C(p, n)^{12}N $\qquad\qquad\qquad Q_m = -18.124$

$\qquad\qquad\qquad\qquad\qquad\qquad Q_0 = -18.122 \pm 0.009$ (1966BR17).

At $E_p = 138$ MeV, $\theta = 3°$, neutron structure corresponding to the ground state (and possibly to the unresolved first two energy levels of ^{12}N) is observed in addition to structure corresponding to ^{12}N*($E_x \approx 6$ MeV). At large angles (to $\theta = 16°$), the latter structure becomes relatively more prominent. It is suggested that it corresponds to the ^{12}N equivalent of the $T = 1$ giant dipole state at $E_x \approx 20$ MeV in ^{12}C (1963LA1F; see also (1962BO33)). See also (1949AL05, 1960TA1K, 1963BA1X, 1963EL1C).

Table 12.27: Energy levels of ^{12}N

E_{x} (MeV $\pm$ keV)	$J^{\pi}; T$	$\tau_{1/2}$ or Γ (keV)	Decay	Reactions
g.s.	$1^{+}; 1$	$\tau_{1/2} = 10.97 \pm 0.04$ msec	β^{+}	1, 2, 3, 4
0.969 ± 7		< 50		2, 4, 6
1.198 ± 9		140 ± 40		2
1.65 ± 80				2
(2.0 ± 100)				2
2.35 ± 80				2
3.15 ± 80		280 ± 80		2
3.55 ± 80		270 ± 80		2
(≈ 6)	$(1^{-}; 1)$			3

Table 12.28: Half-life of ^{12}N

$\tau_{1/2}$ (msec)	Ref.
12.5 ± 1	(1949AL05) [a]
11.2 ± 0.4	(1959FA03)
11.1 ± 0.2	(1962PO02)
10.95 ± 0.05	(1963FI05)
11.0 ± 0.1	(1963PE10)
10.97 ± 0.04	Weighted mean

[a] This value is excluded from the weighted average.

Table 12.29: Neutron groups from ^{10}B(^{3}He, n)^{12}N

E_{x} (MeV $\pm$ keV)				Γ_{cm} (keV)
(1957AJ71)	(1964KA08)	(1966ZA01)	(1967AD1E)	(1966ZA01)
g.s.	g.s.	g.s.	g.s.	sharp
	0.994 ± 20	0.959 ± 20	0.969 ± 10	< 50
1.06 ± 80				
	1.22 ± 30	1.24 ± 30	1.191 ± 10	140 ± 40
1.56 ± 80		a		c
(1.97 ± 100)		b		
2.35 ± 80		2.4 ± 100		c
3.18 ± 150		3.14 ± 80		280 ± 80
3.46 ± 150		3.57 ± 80		270 ± 80

[a] There is some evidence for ^{12}N* at 1.72 ± 0.08 MeV.

[b] The evidence on this state is inconclusive.

[c] These groups are very weak at $E(^3$He$) = 5.8$ MeV, typically two orders of magnitude less than the first two excited states.

4. ^{12}C(^{3}He, t)^{12}N $\qquad\qquad Q_{\mathrm{m}} = -17.361$
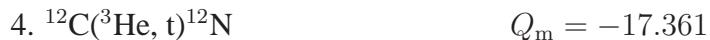
At $E(^3$He$) = 44.6$ MeV, triton groups are observed to the ground state of ^{12}N and to the first excited state: $E_{\mathrm{x}} = 0.957 \pm 0.020$ MeV (1969BA06). See also (1965RI1C).

5. ^{14}N(γ, 2n)^{12}N $\qquad\qquad Q_{\mathrm{m}} = -30.621$

See ^{14}N.

6. ^{14}N(p, t)^{12}N $\qquad\qquad Q_{\mathrm{m}} = -22.139$

At $E_{\mathrm{p}} = 43.7$ MeV, triton groups are observed to ^{12}N(0) and to the first excited state: $E_{\mathrm{x}} = 0.963 \pm 0.030$ MeV (1967CE1B).

^{12}O
(Not illustrated)

See (1960GO1B, 1965GO1D, 1966GO1B, 1966KE16).

References

(Closed 15 December 1967)

References are arranged and designated by the year of publication followed by the first two letters of the first-mentioned author's name and then by two additional characters. Most of the references appear in the National Nuclear Data Center files (Nuclear Science References Database) and have NNDC key numbers. Otherwise, TUNL key numbers were assigned with the last two characters of the form 1A, 1B, etc. In response to many requests for more informative citations, we have, when possible, included up to ten authors per paper and added the authors' initials.

1948JE03   J.V. Jelley and E.B. Paul, Proc. Cambridge Phil. Soc. 44 (1948) 133

1949AL05   L.W. Alvarez, Phys. Rev. 75 (1949) 1815

1950BU1A   Buechner, van Patter, Strait and Sperduto, Phys. Rev. 70 (1950) 262

1950HU72   E.L. Hudspeth, C.P. Swann and N.P. Heydenburg, Phys. Rev. 80 (1950) 643

1951BO45   C.K. Bockelman, D.W. Miller, R.K. Adair and H.H. Barschall, Phys. Rev. 84 (1951) 69

1951KE02   K.K. Keller, J.B. Niedner, C.F. Wang and F.B. Shull, Phys. Rev. 81 (1951) 481

1951LE1B   Levinger, Phys. Rev. 84 (1951) 43

1951MA08   R. Malm and W.W. Buechner, Phys. Rev. 81 (1951) 519

1951MC57   W.O. McMinn, M.B. Sampson and V.K. Rasmussen, Phys. Rev. 84 (1951) 963

1951ST89   K. Strauch, Phys. Rev. 81 (1951) 973

1952BR52   R. Britten, Phys. Rev. 88 (1952) 283

1952EN19   P.M. Endt, C.H. Paris, H.M. Jongerius and F.P.G. Valckx, Physica 18 (1952) 423

1952JO10   V.R. Johnson, Phys. Rev. 86 (1952) 302

1953BE61   O. Beckman, T. Huus and C. Zupancic, Phys. Rev. 91 (1953) 606.

1953BU72   W.E. Burcham, W.M. Gibson, A. Hossain and J. Rotblat, Phys. Rev. 92 (1953) 1266

1953EL12   M.M. Elkind, Phys. Rev. 92 (1953) 127

1953GI05   W.M. Gibson, Phil. Mag. 44 (1953) 297

1953GO13   F.K. Goward and J.J. Wilkins, Proc. Roy. Soc. A217 (1953) 357

1953HO48   J.R. Holt and T.N. Marsham, Prog. Phys. Soc. A66 (1953) 1032

1953HU29   T. Huus and R.B. Day, Phys. Rev. 91 (1953) 599

1953LI28   M. Lindner and R.N. Osborne, Phys. Rev. 91 (1953) 1501

1953MO1B   Montalbetti, Katz and Goldemberg, Phys. Rev. 91 (1953) 659

1954BU06   W.H. Burke, J.R. Risser and G.C. Phillips, Phys. Rev. 93 (1954) 188

1954CO16   C.F. Cook and T.W. Bonner, Phys. Rev. 94 (1954) 651

1954FR24   R.G. Freemantle, W.M. Gibson and J. Rotblat, Phil. Mag. 45 (1954) 1200

1954GR53   A. Graue, Phil. Mag. 45 (1954) 1205

1954HA07   G. Harries, Proc. Phys. Soc. (London) A67 (1954) 153

1954HO48   H.D. Holmgren, J.M. Blair, B.E. Simmons, T.F. Stratton and R.V. Stuart, Phys. Rev. 95 (1954) 1544

1954MI68   W.R. Mills and R.J. Mackin, Phys. Rev. 95 (1954) 1206

1954MY1A   Myers, Odian, Stein and Wattenberg, Phys. Rev. 95 (1954) 576

1954NA02   R. Nathans and J. Halpern, Phys. Rev. 93 (1954) 437

1954PA28   C.H. Paris, F.P.G. Valckx and P.M. Endt, Physica 20 (1954) 573

1954RA35   V.K. Rasmussen, J.R. Rees, M.B. Sampson and N.S. Wall, Phys. Rev. 96 (1954) 812

1955AJ61   F. Ajzenberg and T. Lauritsen, Rev. Mod. Phys. 27 (1955) 77

1955BA22   J.K. Bair, J.D. Kington and H.B. Willard, Phys. Rev. 100 (1955) 21.

1955BA63   W.C. Barber, W.D. George and D.D. Reagan, Phys. Rev. 98 (1955) 73

1955CA19   J.H. Carver, H.J. Hay and E.W. Titterton, Phil. Mag. 46 (1955) 841

1955GO10   H.E. Gove and E.B. Paul, Phys. Rev. 97 (1955) 104

1955GO59   F.K. Goward and J.J. Wilkins, Proc. Roy. Soc. 228 (1955) 376

1955HO48   R.E. Holland, D.R. Inglis, R.E. Malm and F.P. Mooring, Phys. Rev. 99 (1955) 92

1955IH1B   Ihsan, Proc. Phys. Soc. (London) A68 (1955) 393

1955JO1C   Jones, Proc. Glasgow Conf. (Pergamon Press, 1955)

1955KI43   B.B. Kinsey, Phys. Rev. 99 (1955) 332

1955MA76   J.B. Marion, T.W. Bonner and C.F. Cook, Phys. Rev. 100 (1955) 847.

1955PA50   R.T. Pauli, Ark. Fys. 9 (1955) 571

1955RA41   V.K. Rasmussen, D.W. Miller, M.B. Sampson and U.C. Gupta, Phys. Rev. 100 (1955) 851

1955SA1B   Sample, Neilson, Chadwick and Warren, Can. J. Phys. 33 (1955) 828

1955TA28   N.W. Tanner, Proc. Phys. Soc. (London) A68 (1955) 1195

1955WA30   A. Ward and P.J. Grant, Proc. Phys. Soc. (London) A68 (1955) 637

1955WI25   H.B. Willard, J.K. Bair and J.D. Kington, Phys. Rev. 98 (1955) 669

1956AH32   K. Ahnlund, Ark. Fys. 10 (1956) 369

1956AR21   A.H. Armstrong and G.M. Frye Jr., Phys. Rev. 103 (1956) 335

1956CO59   L. Cohen, A.K. Mann, B.J. Patton, K. Reibel, W.E. Stephens and E.J. Winhold, Phys. Rev. 104 (1956) 108

1956DA03   I.E. Dayton and G. Schrank, Phys. Rev. 101 (1956) 1358

1956DO41   R.A. Douglas, J.W. Broer, R. Chiba, D.F. Herring and E.A. Silverstein, Phys. Rev. 104 (1956) 1059

1956EL1C   Elliott, Phys. Rev. 101 (1956) 1212

1956FR27   J.H. Fregeau, Phys. Rev. 104 (1956) 225

1956GL1B   Glassgold and Galonsky, Phys. Rev. 103 (1956) 701

1956GO1K   Gorodetzky, Armbruster, Chevallier and Gallmann, J. Phys. Rad. 17 (1956) 548

1956GO73   S. Gorodetzky, R. Armbruster, P. Chevallier and A. Gallman, Compt. Rend. 242 (1956) 898

1956GR37   T.S. Green and R. Middleton, Proc. Phys. Soc. (London) A69 (1956) 28

1956HA90   J.W. Haffner, Phys. Rev. 103 (1956) 1398

1956HE83   R.H. Helm, Phys. Rev. 104 (1956) 1466

1956IG02   G. Igo, H.E. Wegner and R.M. Eisberg, Phys. Rev. 101 (1956) 1508

1956KI54   B.B. Kinsey and T. Stone, Phys. Rev. 103 (1956) 975

1956KU1A   Kurath, Phys. Rev. 101 (1956) 216

1956LI05   D.L. Livesey, Can. J. Phys. 34 (1956) 216

1956MA69   J.B. Marion and G. Weber, Phys. Rev. 103 (1956) 1408.

1956MA83   E.E. Maslin, J.M. Calvert and A.A. Jaffe, Proc. Phys. Soc. (London) A69 (1956) 754

1956PE1A   Perring and Skyrme, Proc. Phys. Soc. (London) A69 (1956) 600

1956ST65   K. Strauch and F. Titus, Phys. Rev. 103 (1956) 200

1956TA07   N.W. Tanner, Phil, Mag. 1 (1956) 47

1956VA17   F.P.G. Valckx, Ph.D. Thesis, Univ. of Utrecht (1956)

1956WA29   H.J. Watters, Phys. Rev. 103 (1956) 1763

1957AJ71   F. Ajzenberg-Selove, M.L. Bullock and E. Almqvist, Phys. Rev. 108 (1957) 1284

1957AL39   R. Alphonce, A. Johansson and G. Tibell, Nucl. Phys. 4 (1957) 672

1957AM48   O. Ames, G.E. Owen and C.D. Swartz, Phys. Rev. 106 (1957) 775

1957BA1K   Barker and Mann, Phil. Mag. 2 (1957) 5

1957BI78   J.R. Bird and R.H. Spear, Aust. J. Phys. 10 (1957) 268

1957BR18   D.A. Bromley, E. Almqvist, H.E. Gove, A.E. Litherland, E.B. Paul and A.J. Ferguson, Phys. Rev. 105 (1957) 957

1957CH1A   Chlebowska, Bull. Acad. Polon. Sci. 5 (1957) 883; Phys. Abs. 645 (1959)

1957CO53   H.E. Conzett, Phys. Rev. 105 (1957) 1324

1957CO57   B.C. Cook, Phys. Rev. 106 (1957) 300

1957CO59   C.W. Cook, W.A. Fowler, C.C. Lauritsen and T. Lauritsen, Phys. Rev. 107 (1957) 508

1957DE11 G. Dearnaley, G.A. Dissanaike, A.P. French and G.L. Jones, Phys. Rev. 108 (1957) 743

1957DI28 J.M. Dickson and D.C. Salter, Nuovo Cim. 6 (1957) 235

1957GE08 G. Gerstein, J. Niederer and K. Strauch, Phys. Rev. 108 (1957) 427

1957GI14 W.M. Gibson, D.J. Prowse and J. Rotblat, Proc. Roy. Soc. A243 (1957) 237

1957GR53 G.W. Greenlees, I.G. Kuo and M. Petravic, Proc. Roy. Soc. A243 (1957) 206

1957HA13 E. Hayward and E.G. Fuller, Phys. Rev. 106 (1957) 991

1957HO62 H.D. Holmgren, E.H. Geer, R.L. Johnston and E.A. Wolicki, Phys. Rev. 106 (1957) 102

1957HO63 H.D. Holmgren, Phys. Rev. 106 (1957) 100

1957IG03 G. Igo and R.M. Thaler, Phys. Rev. 106 (1957) 126

1957KU58 D. Kurath, Phys. Rev. 106 (1957) 975

1957NO14 E. Norbeck Jr., Phys. Rev. 105 (1957) 204

1957NO17 E. Norbeck Jr. and C.S. Littlejohn, Phys. Rev. 108 (1957) 754

1957OW03 G.E. Owen and L. Madansky, Phys. Rev. 105 (1957) 1766; Erratum Phys. Rev. 108 (1957) 1647

1957PE14 R.W. Peelle, Phys. Rev. 105 (1957) 1311

1957WA04 C.N. Waddell, H.E. Adelson, B.J. Moyer and H.C. Shaw, Bull. Amer. Phys. Soc. 2 (1957) 181, E10

1957WA1F Waddell, Thesis, Univ. of California (1957); UCRL-3901 (1957)

1958AM13 O. Ames and G.E. Owen, Phys. Rev. 109 (1958) 1639

1958AN32 J.D. Anderson, C.C. Gardner, J.W. McClure, M.P. Nakada and C. Wong, Phys. Rev. 111 (1958) 572

1958AR1B Armbuster, Ann. Phys. (France) 3 (1958) 88

1958BA1C Barton and Smith, Phys. Rev. 110 (1958) 1143

1958BA60 W.C. Barber, Phys. Rev. 111 (1958) 1642

1958BE1B Bethe, Ann. Phys. 3 (1958) 190

1958BU1E Burgman et al., Phys. Rev. Lett. 1 (1958) 469

1958CO66 C.W. Cook, W.A. Fowler, C.C. Lauritsen and T. Lauritsen, Phys. Rev. 111 (1958) 567

1958ED1B Edwards, NYO 2054 (1958)

1958FO1D Fodor and Keszthelyi, Repts. Central Research Inst. Phys., Hung. Acad. Sci. 6 (1958) 454

1958GE1C M. Gell-Mann, Phys. Rev. 111 (1958) 362

1958HU18   D.J. Hughes and R.B. Schwartz, BNL-325, 2nd Ed. (1958); BNL-325, 2nd Ed., Suppl. I (1960)

1958KA31   R.W. Kavanagh and C.A. Barnes, Phys. Rev. 112 (1958) 503

1958MA1A   Maikov, Zh. Eksp. Teor. Fiz. 34 (1958) 1406; JETP (Sov. Phys.) 7 (1958) 973

1958MA52   V.I. Mamasakhlisov and T.I. Kopaleishvili, Zh. Eksp. Teor. Fiz. 34 (1958) 1169; JETP (Sov. Phys.) 7 (1958) 809

1958MO1F   Moffatt, Thresher, Weeks and Wilson, Proc. Roy. Soc. 244 (1958) 245

1958MO99   C.D. Moak, A. Galonsky, R.L. Traughber and C.M. Jones, Phys. Rev. 110 (1958) 1369

1958NA09   M.P. Nakada, J.D. Anderson, C.C. Gardner and C. Wong, Phys. Rev. 110 (1958) 1439

1958RA14   V.K. Rasmussen, F.R. Metzger and C.P. Swann, Phys. Rev. 110 (1958) 154

1958VE20   J.F. Vedder, Thesis, Univ. of California (1958); UCRL-8324 (1958)

1958WH35   C. Whitehead, W.R. Mcmurray, M.J. Aitken, N. Middlemas and C.H. Collie, Phys. Rev. 110 (1958) 941

1958WO53   M.M. Wolff and W.E. Stephens, Phys. Rev. 112 (1958) 890

1958WY67   M.E. Wyman, E.M. Fryer and M.M. Thorpe, Phys. Rev. 112 (1958) 1264

1958ZE01   B. Zeidman and J.M. Fowler, Phys. Rev. 112 (1958) 2020

1958ZI1B   Ziegler, Z. Phys. 152 (1958) 566

1959AJ76   F. Ajzenberg and T. Lauritsen, Nucl. Phys. 11 (1959) 1

1959AL1H   Alkhazov et al., Izv. Akad. Nauk SSSR Ser. Fiz. 23 (1959) 1466

1959AL83   D.E. Alburger, A. Elwyn, A. Gallmann, J.V. Kane, S. Ofer and R.E. Pixley, Phys. Rev. Lett. 2 (1959) 110

1959AL96   E. Almqvist, D. A. Bromley, A. J. Ferguson, H. E. Gove, and A. E. Litherland, Phys. Rev. 114 (1959) 1040

1959AL97   D.E. Alburger, Phys. Rev. Lett. 3 (1959) 280

1959BA1D   Baz, Adv. Phys. 8 (1959) 349

1959BA1F   Balashov and Tulinov, Zh. Eksp. Teor. Fiz. 36 (1959) 615; JETP (Sov. Phys.) 9 (1959) 426

1959BA36   W.C. Barber and F.E. Gudden, Phys. Rev. Lett. 3 (1959) 219

1959BL31   J.S. Blair, Phys. Rev. 115 (1959) 928

1959BO40   D. Bodansky, S.F. Eccles, G.W. Farwell, M.E. Rickey and P.C. Robinson, Phys. Rev. Lett. 2 (1959) 101

1959BR1E   Brink and Kerman, Nucl. Phys. 12 (1959) 314

1959BR1J   Braid and Yntema, Bull. Amer. Phys. Soc. 4 (1959) 17

1959BR79   D.A. Bromley, J.A. Kuehner and E. Almqvist, Nucl. Phys. 13 (1959) 1

1959BU1H   Burgov et al., JETP (Sov. Phys.) 10 (1959) 1278

1959BU97   E.J. Burge, Nucl. Phys. 13 (1959) 511

1959CA14   J. Catala, L. Miralles and J. Aguilar, An. Real. Soc. Espan. Fis. y Quim. A55 (1959) 241

1959CA1B   Cameron, Astrophys. J. 130 (1959) 452

1959CH1B   Chen and Hintz, Congres Int. de Phys. Nucl., Paris, 1958 (Dunod, Paris, 1959) 387

1959CH1D   Chase and Igo, Phys. Rev. 116 (1959) 170

1959CH25   V.P. Chizhov and L.A. Kulchitskii, Zh. Eksp. Teor. Fiz. 36 (1959) 345; JETP (Sov. Phys.) 9 (1959) 239

1959CO62   L.D. Cohen and W.E. Stephens, Phys. Rev. Lett. 2 (1959) 263

1959CO70   J.C. Corelli, E. Bleuler and D.J. Tendam, Phys. Rev. 116 (1959) 1184

1959CR1A   Croissiaux, Thesis, Univ. of Starsbourg (1959)

1959EC13   S.F. Eccles and D. Bodansky, Phys. Rev. 113 (1959) 608

1959EH1A   Ehpenberg et al., Phys. Rev. 113 (1959) 666

1959FA03   B.J. Farmer and C.M. Class, Bull. Amer. Phys. Soc. 4 (1959) 278, U5

1959FI30   G.E. Fischer and V.K. Fischer, Phys. Rev. 114 (1959) 533

1959FL41   G. Flamand and K.W. Ford, Phys. Rev. 116 (1959) 1591

1959FU62   H.W. Fulbright, N.O. Lassen and N.O.R. Poulsen, Kgl. Dan. Vid. Selsk. Mat. Fys. Medd. 31, No. 10 (1959)

1959GA09   E.L. Garwin, Phys. Rev. 114 (1959) 143

1959GA14   F. Gabbard, H. Bischel and T.W. Bonner, Nucl. Phys. 14 (1959) 277

1959GA1D   Garg and Torki, Congres. Int. de Phys. Nucl., 1958 (Dunod, Paris, 1959) 419

1959GE1D   Gell-Mann and Berman, Phys. Rev. Lett. 3 (1959) 99

1959GE33   D.S. Gemmell, A.H. Morton and E.W. Titterton, Nucl. Phys. 10 (1959) 33

1959GI47   J.H. Gibbons and R.L. Macklin, Phys. Rev. 114 (1959) 571

1959GL57   N.K. Glendenning, Phys. Rev. 114 (1959) 1297

1959GO89   H.E. Gove, A.E. Litherland and R. Batchelor, Phys. Rev. Lett. 3 (1959) 177

1959GO90   T.J. Gooding, Nucl. Phys. 12 (1959) 241

1959GR1C   Greenlees, Kuo and Petravic, Congres Int. de Phys. Nucl., 1958 (Dunod, Paris, 1959) 438

1959HA06   E. Haddad and D.D. Phillips, Bull. Amer. Phys. Soc. 4 (1959) 358, J2

1959HE1B   Hess, Ann. Phys. 6 (1959) 115

1959HE1C Henley and Jacobsohn, Phys. Rev. 113 (1959) 225

1959HI1E Hird, Cookson and Bokhari, Congres Int. de. Phys. Nucl., 1958 (Dunod, Paris, 1959) 470

1959HO01 H.D. Holmgren, E.A. Wolicki and R.L. Johnston, Phys. Rev. 114 (1959) 1281

1959HO95 D.J. Hooton and G.R. Allcock, Proc. Phys. Soc. (London) A73 (1959) 881

1959HU14 C.Hu, S. Kato, Y. Oda and M. Takeda, J. Phys. Soc. Jpn. 14 (1959) 549

1959JA1B Jancovici, Ann. Phys. 4 (1959) 689

1959JO1E Johnston, Holmgren and Wolicki, Bull. Amer. Phys. Soc. 4 (1959) 233

1959KA12 D. Kamke, Z. Phys. 156 (1959) 603

1959KA13 D. Kamke, Z. Phys. 156 (1959) 621

1959KE19 L. Keszthelyi and I. Fodor, Nucl. Phys. 10 (1959) 564

1959KE1A Kerman, McManus and Thaler, Ann. Phys. 8 (1959) 551

1959KO55 J. Kockum and N. Starfelt, Nucl. Instrum. Meth. 5 (1959) 37

1959KR1B Kreger and Kern, Phys. Rev. 113 (1959) 890

1959KU1C Kurepin and Neudachin, Zh. Eksp. Teor. Fiz. 36 (1959) 1725; JETP (Sov. Phys.) 9 (1959) 1229

1959KU84 L.A. Kulchitsky and V. Presperin, Zh. Eksp. Teor. Fiz. 37 (1959) 1524; JETP (Sov. Phys.) 10 (1960) 1082

1959LI1D Litherland, Almqvist, Batchelor and Gove, Phys. Rev. Lett. 2 (1959) 104

1959MA1D Markowitz and Hall, Bull. Amer. Phys. Soc. 4 (1959) 8

1959MC1D McIntyre, Baker and Watts, Phys. Rev. 116 (1959) 1212

1959MC63 G.P. McCauley, Proc. Phys. Soc. (London) A73 (1959) 309

1959ME24 U. Meyer-Berkhout, K.W. Ford and A.E.S. Green, Ann. Phys. (N.Y.) 8 (1959) 119

1959MO12 G.C. Morrison and J.A. Galey, Phys. Rev. 116 (1959) 1583

1959MO27 M. Morita, Phys. Rev. 113 (1959) 1584

1959NA1B Nagarajana and Banerjee, Congres Int. de Phys. Nucl., 1958 (Dunod, Paris, 1959) 506

1959OC07 J. O'Connell, P. Dyal and J. Goldemberg, Phys. Rev. 116 (1959) 173

1959OW1A Owen, Madansky and Edwards, Phys. Rev. 113 (1959) 1575

1959PE21 A.S. Penfold and E.L. Garwin, Phys. Rev. 114 (1959) 1324

1959PE22 S. Penner and J.E. Leiss, Phys. Rev. 114 (1959) 1101

1959PE32 A.S. Penfold and E.L. Garwin, Phys. Rev. 116 (1959) 120

1959PI1B Picou, Compt. Rend. 248 (1959) 3272

1959PU1A Pujara and Gatha, Indian J. Phys. 33 (1959) 243

1959SA04   M. Sakisaka, J. Phys. Soc. Jpn. 14 (1959) 554

1959SA06   D. Sadeh, Compt. Rend. 249 (1959) 531

1959SH62   G.B. Shook, Phys. Rev. 114 (1959) 310

1959SI79   J.B. Singletary and D.E. Wood, Phys. Rev. 114 (1959) 1595

1959SM98   R.V. Smith, R.H. Abramson and L.F. Chase Jr., Bull. Amer. Phys. Soc. 4 (1959) 286, X3

1959TS1A   Tsuneoka, J. Phys. Soc. Jpn. 14 (1959) 869

1959VA15   S.S. Vasilev, V.V. Komarov, G.V. Koshelyaev and A.M. Popova, Zh. Eksp. Teor. Fiz. 37 (1959) 1460; JETP (Sov. Phys.) 10 (1960) 1034

1959VA1D   Vakselj, Congres Int. de Phys. Nucl., 1958 (Dunod, Paris, 1959) 665

1959WI1C   Wilson, Phys. Rev. 114 (1959) 260

1959WO1B   Wolicki et al., Bull. Amer. Phys. Soc. 4 (1959) 232

1959WO53   E.A. Wolicki, H.D. Holmgren, R.L. Holmgren, R.L. Johnston and E.G. Illsley, Phys. Rev. 116 (1959) 1585

1959YA01   A.I. Yavin and G.W. Farwell, Nucl. Phys. 12 (1959) 1

1959YO1B   Yoccoz, Compt. Rend. 248 (1959) 952

1960AD1A   Adams and Hintz, Nucl. Forces and the Few Nucleon Problem (Pergamon, 1960) 679

1960AG01   J. Aguilar, W.E. Burcham, J. Catala, J.B.A. England, J.S.C. McKee and J. Rotblat, Proc. Roy. Soc. A254 (1960) 395

1960AJ04   F. Ajzenberg-Selove and P.H. Stelson, Phys. Rev. 120 (1960) 500

1960AL04   D.E. Alburger, Phys. Rev. 118 (1960) 235

1960AL14   D.E. Alburger and R.E. Pixley, Phys. Rev. 119 (1960) 1970

1960BA1P   Bazhanov, Zh. Eksp. Teor. Fiz. 38 (1960) 267; JETP (Sov. Phys.) 11 (1960) 193

1960BA25   R. Barjon, M. Lambert and J. Schmouker, J. Phys. Rad. 21 (1960) 356

1960BA38   F.C. Barker, E. Bradford and L.J. Tassie, Nucl. Phys. 19 (1960) 101

1960BA47   W.C. Barber, F. Berthold, G. Fricke and F.E. Gudden, Phys. Rev. 120 (1960) 2081

1960BE15   R.L. Becker, Phys. Rev. 119 (1960) 1076

1960BE24   J. Benveniste, A.C. Mitchell, C.D. Schrader and J.H. Zenger, Nucl. Phys. 19 (1960) 448

1960BE31   P. Benoist-Gueutal, Proc. Int. Conf. on Nucl. Struct., Kingston, Canada; Eds. D.A. Bromley and E.W. Vogt (Univ. of Toronto Press, 1960) 743

1960BI1E   Bifl, Butcher and McNamee, Nucl. Forces and the Few Nucleon Problem (Pergamon, 1960) 641

1960BO26   R. Bouchez, H. Beaumevielle, J. Fleury, P. Perrin, R. De Swiniarski and M. Chabre, J. Phys. Rad. 21 (1960) 819

1960BU14   A. Bussiere de Nercy and M. Langevin, J. Phys. Rad. 21 (1960) 293

1960BU25   J. Button and R. Mermod, Phys. Rev. 118 (1960) 1333

1960CA09   E.E. Carroll Jr. and W.E. Stephens, Phys. Rev. 118 (1960) 1256

1960CA24   J. Catala, E. Villar, A. Garcia, F. Senent and J. Aguilar, An. Real. Soc. Espan. Fis. y Quim. A56 (1960) 293

1960CR1A   Croissiaux, Ann. Phys. 5 (1960) 409

1960DE10   W.M. Deuchars and D. Dandy, Proc. Phys. Soc. (London) A75 (1960) 855

1960DE1A   Deshpande and Kelkar, Current Sci. (India) 29 (1960) 385

1960DE1C   Dearnaley and Whitehead, Proc. Int. Conf. on Nucl. Struct., Kingston (1960)

1960EL09   M. El-Nadi and M. Wafik, Proc. Phys. Soc. (London) 76 (1960) 185

1960EM02   V. Emma, C. Milone and A. Rubbino, Phys. Rev. 118 (1960) 1297

1960ER1A   Ero, Pocs, Szentpetery and Zimanyi, Rept. Central Research Inst. Phys. Hung. Acad. Sci 8 (1960) 263

1960FA02   B.J. Farmer, J.G. Cramer Jr. and C.M. Class, Bull. Amer. Phys. Soc. 5 (1960) 101, C1

1960FA05   W.M. Fairbairn, Nucl. Phys. 15 (1960) 678

1960FA1E   Fallieros, Ferrell and Pal, Nucl. Phys. 15 (1960) 363

1960FE01   A.J. Ferguson, H.E. Gove, A.E. Litherland and R. Batchelor, Bull. Amer. Phys. Soc. 5 (1960) 45, MA7

1960FE13   A.J. Ferguson, H.E. Gove, A.E. Litherland and R. Batchelor, Proc. Int. Conf. on Nucl. Struct., Kingston, Canada; Eds. D.A. Bromley and E.W. Vogt (Univ. of Toronto Press, 1960) 364

1960FO01   P.D. Forsyth, F. de S. Barros, A.A. Jaffe, I.J. Taylor and S. Ramavataram, Proc. Phys. Soc. (London) A75 (1960) 291

1960FU1A   Furukama et al., J. Phys. Soc. Jpn. 15 (1960) 2167

1960GA10   J.P. Garron, J.C. Jacmart, L. Massonnet, M. Riou and C. Ruhla, J. Phys. Rad. 21 (1960) 317

1960GA14   M.B. Garg, J.M. Calvert and N.H. Gale, Nucl. Phys. 19 (1960) 264

1960GA16   M. Garnier, H. Gauvin and W. Sebaoun, J. Phys. Rad. 21 (1960) 893

1960GE06   K.N. Geller, J. Halpern and E.G. Muirhead, Phys. Rev. 119 (1960) 716

1960GO1B   Goldansky, Nucl. Phys. 19 (1960) 482

1960HA08   G.R. Harrison, G.D. Schmidt and C.D. Curtis, Phys. Rev. 117 (1960) 532

1960HA16   M.L. Halbert, C.E. Hunting and A. Zucker, Phys. Rev. 117 (1960) 1545

1960HA1H Hanna and Segel, Proc. Roy. Soc. A259 (1960) 267

1960HA21 H.J. Hausman, G.F. Dell and H.F. Bowsher, Phys. Rev. 118 (1960) 1237

1960HE10 M. Heyman, H. Jeremie, J. Kahane and R. Sene, J. Phys. Rad. 21 (1960) 380

1960HI08 S. Hinds and R. Middleton, Proc. Phys. Soc. (London) 75 (1960) 754

1960HO14 P.E. Hodgson, Nucl. Phys. 21 (1960) 21

1960HU10 C. Hu, J. Phys. Soc. Jpn. 15 (1960) 1741

1960IN1A Inopin and Tishchenko, Zh. Eksp. Teor. Fiz. 38 (1960) 1150; JETP (Sov. Phys.) 11 (1960) 840

1960IN1B Inopin, Ukr. Fiz. Zh. (USSR) 5 (1960) 744; Phys. Abs. 8011 (1962)

1960JA01 D. Jamnik and P. Axel, Phys. Rev. 117 (1960) 194

1960JA17 A.A. Jaffe, F. de S. Barros, P.D. Forsyth, J. Muto, I.J. Taylor and S. Ramavataram, Prog. Phys. Soc. 76 (1960) 914

1960KA1H Kaway, J. Phys. Soc. Jpn. 15 (1960) 930

1960KO03 E. Kondaiah and C. Badrinathan, Nucl. Phys. 15 (1960) 254

1960LA03 H. Langevin-Joliot, N. Marty and M.X. de Bouard, J. Phys. Rad. 21 (1960) 320

1960LU1B Lubitz, Bull. Amer. Phys. Soc. 5 (1960) 18

1960MA10 S. Mayo and A.I. Hamburger, Phys. Rev. 117 (1960) 832

1960MA32 R.D. Macfarlane and J.B. French, Rev. Mod. Phys. 32 (1960) 567

1960MA43 K. Matsuda, Proc. Int. Conf. on Nucl. Struct., Kingston, Canada; Eds. D.A. Bromley and E.W. Vogt (Univ. of Toronto Press, 1960) 228

1960MC03 G.J. McCallum, D.A. Bromley and J.A. Kuehner, Nucl. Phys. 20 (1960) 382

1960ME1C Meshkov, Nucl. Forces and the Few Nucleon Problem (Pergamon, 1960) 653

1960MI03 T. Mikumo, H. Yamaguchi, I. Nonaka, M. Odera, Y. Hashimoto, M. Kondo and T. Maki, J. Phys. Soc. Jpn. 15 (1960) 1158

1960MI10 T. Mikumo, H. Yamaguchi, I. Nonaka, S. Hitaka, T. Maki, M. Mukae and T. Nakajima, Proc. Int. Conf. on Nucl. Struct., Kingston, Canada; Eds. D.A. Bromley and E.W. Vogt (Univ. Of Toronto Press, 1960) 391

1960MI1C Mitra and Banerjee, Bull. Amer. Phys. Soc. 5 (1960) 29

1960MI1E G.L. Miller, R.E. Pixley, R.E. Segel, Proc. Roy. Soc. A259 (1960) 275.

1960NE1C Neudachin, Teplov and Tulinov, JETP (Sov. Phys.) 10 (1960) 387

1960NI02 K. Nishimura, Phys. Rev. 118 (1960) 1350

1960ON01 K. Ono and K. Kuroda, Phys. Rev. 117 (1960) 214

1960PE02 F.G.J. Perey and P. Lorrain, Bull. Amer. Phys. Soc. 5 (1960) 18, E6

1960PE1A   Perey, Proc. Int. Conf. on Nucl. Struct., Kingston (1960)

1960RE02   T. Retz-Schmidt, T.W. Bonner, G.U. Din and J.L. Weil, Bull. Amer. Phys. Soc. 5 (1960) 110, N3

1960RI1C   Riou, Garron, Jacmart and Ruhla, Proc. Int. Conf. on Nucl. Struct., Kingston (1960)

1960RO1E   Rost and Austern, Phys. Rev. 120 (1960) 1375

1960RO24   B.A. Robson and D. Robson, Proc. Phys. Soc. (London) 76 (1960) 611

1960SA1C   Sakamoto, Prog. Theor. Phys. 23 (1960) 183

1960SA1E   Sakamoto, Prog. Theor. Phys. 23 (1960) 382

1960SA1F   Sakamoto, Prog. Theor. Phys. 24 (1960) 81

1960SA1G   Sakamoto, Prog. Theor. Phys. 23 (1960) 1205

1960SA25   G.L. Salmon, Nucl. Phys. 21 (1960) 15

1960SA28   Y. Sakamoto and T. Takemiya, Prog. Theor. Phys. 23 (1960) 172

1960SH1A   Sheline and Wildermuth, Nucl. Phys. 21 (1960) 196

1960SH1D   Shklyarevskii, Zh. Eksp. Teor. Fiz. 39 (1960) 1031; JETP (Sov. Phys.) 12 (1961) 717

1960TA04   M. Tatcher, E. Bogart, S. Devons and L.J. Lidofsky, Bull. Amer. Phys. Soc. 5 (1960) 230, C8

1960TA15   G. Tamas, J. Miller, C.G. Schuhl and C. Tzara, J. Phys. Rad. 21 (1960) 532

1960TA1C   Talmi and Unna, Ann. Rev. Nucl. Sci. 10 (1960) 353

1960TA1K   Takemiya and Sakamoto, Prog. Theor. Phys. 24 (1960) 1123

1960TA27   M. Takeda, S. Kato, C. Hu and N. Takahashi, Proc. Int. Conf. on Nucl. Struct., Kingston, Canada; Eds. D.A. Bromley and E.W. Vogt (Univ. of Toronto Press, 1960) 400

1960VA03   I.J. Van Heerden and D.J. Prowse, Nucl. Phys. 15 (1960) 356

1960VA10   S.S. Vasilev, V.V. Komarov and A.M. Popova, Izv. Akad. Nauk SSSR Ser. Fiz. 24 (1960) 1149; Bull. Acad. Sci. Phys. 24 (1960) 1151

1960WA15   T. Wakatsuki, Y. Hirao, E. Okada, I. Miura, K. Sugimoto and A. Mizobuchi, J. Phys. Soc. Jpn. 15 (1960) 1141

1960WA1G   Warburton and Chase, Phys. Rev. 120 (1960) 2095

1960WE1C   Weidenmuller, Nucl. Phys. 21 (1960) 397

1960WY1A   Wyckoff and Koch, Phys. Rev. 117 (1960) 1261

1960ZE03   Ya.B. Zeldovich, Zh. Eksp. Teor. Fiz. 38 (1960) 1123; JETP (Sov. Phys.) 11 (1960) 812

1960ZE1B   Zeldovich, Zh. Eksp. Teor. Fiz. 38 (1960) 278; JETP (Sov. Phys.) 11 (1960) 202

1960ZI01   B. Ziegler, Nucl. Phys. 17 (1960) 238

1961AD04 H.S. Adams, J.D. Fox, N.P. Heydenburg and G.M. Temmer, Phys. Rev. 124 (1961) 1899

1961AG1A Aguilar and Garcia, An. Real. Soc. Espan. Fis. y Quim. A57 (1961) 29; Phys. Abs. 3611 (1962)

1961AL10 D.E. Alburger and D.H. Wilkinson, Phys. Rev. 122 (1961) 1508

1961AL23 D.E. Alburger, Phys. Rev. 124 (1961) 193

1961AS1B Ashe, McGrary, Morgan and Prud'Homme, Bull. Amer. Phys. Soc. 6 (1961) 61

1961BA1C Baz, Goldanskii and Zeldovich, Sov. Phys. Uspekhi 3 (1961) 729

1961BA1D Badalyan and Baz, Zh. Eksp. Teor. Fiz. 40 (1961) 549; JETP (Sov. Phys.) 13 (1961) 383

1961BA1E Balashov, Neudachin and Smirnov, Izv. Akad. Nauk SSSR Ser. Fiz. 25 (1961) 170; Bull. Acad. Sci. USSR Phys. 25 (1961) 165

1961BE12 E.F. Bennett, Phys. Rev. 122 (1961) 595

1961BE1E Beckner, Jones and Philips, Phys. Rev. 123 (1961) 255

1961BL09 H.R. Blieden, G.M. Temmer and K.L. Warsh, Bull. Amer. Phys. Soc. 6 (1961) 415, B3

1961BO28 V.V. Bobyr, L.Ya. Grona and V.I. Strizhak, Zh. Eksp. Teor. Fiz. 41 (1961) 24; JETP (Sov. Phys.) 14 (1962) 18

1961BO32 P. Bounin and G.R. Bishop, J. Phys. Rad. 22 (1961) 555

1961BR08 E. Bradford and B.A. Robson, Phys. Rev. Lett. 6 (1961) 550; Erratum Phys. Rev. Lett. 6 (1961) 711

1961BR15 D.A. Bromley, J.A. Kuehner and E. Almqvist, Phys. Rev. 123 (1961) 878

1961BR28 P. Brix, H. Fuchs, K.H. Lindenberger and C. Salander, Z. Phys. 165 (1961) 485

1961BU1E Bussiere de Nercy, Ann. Phys. 6 (1961) 1379

1961CA13 R.R. Carlson, Nucl. Phys. 28 (1961) 443

1961CA18 J. Catala, J. Aguilar, A. Garcia, G. Pardo and A. Lleo, An. Real. Soc. Espan. Fis. y Quim. (Madrid) A57 (1961) 249

1961CE1B Cence and Moyer, Phys. Rev. 122 (1961) 1634

1961CI08 S.D. Cirilov, Proc. Rutherford Jub. Int. Conf., Manchester, England; Ed. J.B. Birks (Academic Press Inc., New York, 1961) 781

1961CL09 A.B. Clegg, K.J. Foley, G.L. Salmon and R.E. Segel, Proc. Phys. Soc. (London) 78 (1961) 681

1961CL10 A.B. Clegg, Phil. Mag. 6 (1961) 1207

1961CL1D Clegg and Satchler, NUcl. Phys. 27 (1961) 431

1961DE08   V.W. Deshpande, J.K. Verba and H.W. Fulbright, Bull. Amer. Phys. Soc. 6 (1961) 368, S6

1961DE16   X. Debouard, H. Langevin-Joliot, N. Marty and B. Tatischeff, Nucl. Phys. 28 (1961) 293

1961DE22   A.B. De Nercy, J. Phys. Rad. 22 (1961) 535

1961DE31   D. Dehnhard, D. Kamke and P. Kramer, Z. Naturforsch. A16 (1961) 1245

1961DE38   S. Devons, Proc. Conf. Electromagnetic Lifetimes and Properties of Nucl. States, Gatlinburg, Tennessee (Oct. 1961); NAS-974 (1962) p. 86

1961DO1C   Do Dang, J. Phys. Rad. 22 (1961) 633

1961DU09   B. Dudelzak and R.E. Taylor, J. Phys. Rad. 22 (1961) 544

1961EI1A   Eisberg and Porter, Rev. Mod. Phys. 33 (1961) 190

1961EL1A   El Nadi and Sherif, Nucl. Phys. 28 (1961) 331

1961FO02   P.D. Forsyth and G.S. Mani, Bull. Amer. Phys. Soc. 6 (1961) 227, AA12

1961FO07   D.B. Fossan, R.L. Walter, W.E. Wilson and H.H. Barschall, Phys. Rev. 123 (1961) 209

1961GA03   N.H. Gale and J.B. Garg, Nuovo Cim. 19 (1961) 742

1961GA04   J.B. Garg, N.H. Gale and J.M. Calvert, Nucl. Phys. 23 (1961) 630

1961GI1C   Gilbert, Proc. Phys. Soc. (London) 77 (1961) 362

1961GI1D   Giu and Marty, Proc. Rutherford Jub. Int. Conf. (1961) 179

1961GO13   H.E. Gove, A.E. Litherland and R. Batchelor, Nucl. Phys. 26 (1961) 480

1961GO1R   Gomonai, Krivskii and Shkoda-Ul-Yanov, Sov. J. At. Energy 7 (1961) 944

1961GO1T   Gooding and Igo, Phys. Rev. Lett. 7 (1961) 28

1961GO27   S. Gorodetzky, A. Gallmann, P. Fintz and G. Bassompierre, J. Phys. Rad. 22 (1961) 573

1961GO28   S. Gorodetzky, A. Gallmann, P. Fintz and G. Bassompierre, J. Phys. Rad. 22 (1961) 575

1961GR07   A.G. Gregory, Nucl. Phys. 23 (1961) 518

1961HA04   M.L. Halbert and A. Zucker, Phys. Rev. 121 (1961) 236

1961HI08   J. Hinds and R. Middleton, Proc. Phys. Soc. (London) 78 (1961) 81

1961HO09   D. Hoare, A.B. Robbins and G.W. Greenlees, Proc. Phys. Soc. (London) 77 (1961) 830

1961HO19   R.K. Hobbie, C.W. Lewis and J.M. Blair, Phys. Rev. 124 (1961) 1506

1961HO1D   Honda and Ui, Prog. Theor. Phys. 25 (1961) 635

1961HO1F Holmgren and Wolicki, Proc. Rutherford Jub. Int. Conf., Manchester, England; Ed. J.B. Birks (Academic Press Inc., New York, 1961) 541

1961HO1J Hodgson, Proc. Phys. Soc. (London) 77 (1961) 997

1961IG02 G. Igo, W. Lorenz and U. Schmidt-Rohr, Phys. Rev. 124 (1961) 832

1961IS02 Y. Ishizaki, J. Phys. Soc. Jpn. 16 (1961) 1056

1961IS03 T. Ishimatsu, J. Phys. Soc. Jpn. 16 (1961) 1529

1961JA02 R. Jahr, K.D. Muller, W. Oswald and H. Schmidt-Rohr, Z. Phys. 161 (1961) 509

1961JA19 von L. Jarczyk, J. Lang, R. Muller and W. Wolfli, Helv. Phys. Acta 34 (1961) 483

1961JA1H Jacobson and Ryndin, Nucl. Phys. 24 (1961) 505

1961JA1L Jacob and Maris, Proc. Rutherford Jub. Int. Conf., Manchester, England; Ed. J.B. Birks (Academic Press Inc., New York, 1961) 153

1961JA23 A. Jaidar, G. Lopez, M. Mazari and R. Dominguez, Rev. Mex. Fisica 10 (1961) 247

1961JO18 A. Johansson, U. Svanberg and P.E. Hodgson, Ark. Fys. 19 (1961) 541

1961KU1D Kuehner and Almqvist, Bull. Amer. Phys. Soc. 6 (1961) 48

1961LA1A Lane, Langsdorf, Monahan and Elwyn, Ann. Phys. 12 (1961) 135

1961LE10 G.J.F. Legge, Nucl. Phys. 26 (1961) 608

1961LE11 G.J.F. Legge, Nucl. Phys. 26 (1961) 616.

1961LE1A Legg, Unpublished Thesis, Princeton Univ. (1961)

1961LO01 C.A. Low Jr. and K.S. Quisenberry, Bull. Amer. Phys. Soc. 6 (1961) 249, GA7

1961LO10 G. Lopez and O. Almen, Rev. Mex. Fis. 10 (1961) 239

1961MA16 T. Mayer-Kuckuk and F.C. Michel, Phys. Rev. Lett. 7 (1961) 167

1961MA36 V.I. Mamasakhlisov and R.I. Jibuti, Zh. Eksp. Teor. Fiz. 41 (1961) 1493; JETP (Sov. Phys.) 14 (1962) 1066

1961MC16 V.R. McKenna and G.G. Shute, Aust. J. Phys. 14 (1961) 432

1961MC1C McCarthy and Pursey, Phys. Rev. 122 (1961) 578

1961MO1C Morita, Bull. Amer. Phys. Soc. 6 (1961) 514

1961NA02 Y. Nagahara, J. Phys. Soc. Jpn. 16 (1961) 133

1961NE04 E. Newman, P.G. Roll and F.E. Steigert, Phys. Rev. 122 (1961) 1842

1961PA04 G. Parry, H.D. Scott and S. Swierszczewski, Proc. Phys. Soc. (London) 77 (1961) 230

1961PI04 W.T. Pinkston and G.R. Satchler, Nucl. Phys. 27 (1961) 270

1961PR07 V. Presperin and L.A. Kulchitskii, Zh. Eksp. Teor. Fiz. 41 (1961) 60; JETP (Sov. Phys.) 14 (1962) 46

1961PU1B Pullen, Wilkinson and Whitehead, Proc. Rutherford Jub. Int. Conf., Manchester, England; Ed. J.B. Birks (Academic Press Inc., New York, 1961) 565

1961RA1B Radvanyi et al., Proc. Rutherford Jub. Int. Conf., Manchester, England; Ed. J.B. Birks (Academic Press Inc., New York, 1961) 197

1961RO1C Roalsvig, Gupta and Hasiam, Can. J. Phys. 39 (1961) 663

1961RO1G Robson, Nucl. Phys. 22 (1961) 34; Nucl. Phys. 22 (1961) 47

1961RO1H Rodenberg, Z. Phys. 162 (1961) 347

1961SA1B Sakamoto, Nucl. Phys. 25 (1961) 687

1961SA1E Sanderson, Nucl. Phys. 26 (1961) 420

1961SC09 A.W. Schardt, Phys. Rev. 122 (1961) 1871

1961SE10 R.E. Segel, M.J. Bine, Phys. Rev. 124 (1961) 814.

1961SE13 W. Sebaoun and H. Gauvin, J. Phys. Rad. 22 (1961) 771

1961SH1C Shklyarevskii, Zh. Eksp. Teor. Fiz. 41 (1961) 451; JETP (Sov. Phys.) 14 (1962) 324

1961SJ1B Sjogren and Sawa, Ark. Fys. 19 (1961) 417

1961ST22 V.I. Strizhak, V.V. Bobyr and L.Y. Grona, Zh. Eksp. Teor. Fiz. 41 (1961) 313; JETP (Sov. Phys.) 14 (1962) 225

1961TA06 A.E. Taylor and E. Wood, Nucl. Phys. 25 (1961) 642

1961TE02 A. Tejera, M. Mazari, A. Jaidar and G. Lopez, Rev. Mex. Fis. 10 (1961) 229

1961TH03 I.M. Thorson and L. Katz, Proc. Phys. Soc. (London) 77 (1961) 166

1961TR1B True and Warburton, Nucl. Phys. 22 (1961) 426

1961VA10 V.J. Vanhuyse and W.C. Barber, Nucl. Phys. 26 (1961) 233

1961VA17 S.S. Vasilev, V.M. Komarov and A.M. Popova, Izv. Akad. Nauk SSSR Ser. Fiz. 25 (1961) 1117; Bull. Acad. Sci. Phys. 25 (1960) 1124

1961VA1C Valter, et al., Ukr. Fiz. Zh. 6 (1961) 457

1961VA38 S.S. Vasilev, V.V. Komarov and A.M. Popova, Zh. Skep. Teor. Fiz. 41 (1961) 1757; JETP (Sov. Phys.) 14 (1962) 1249

1961WI1A Wilkinson, Wollan and Koehler, Ann. Rev. Nucl. Sci. 11 (1961) 303

1961WI1G Williams, Caplan and Stewart, Proc. Phys. Soc. (London) 78 (1961) 1125

1961WO08 E.A. Wolicki, H.D. Holmgren and R.I. Johnston, Proc. Rutherford Jub. Int. Conf., Manchester, England; Ed. J.B. Birks (Academic Press Inc., New York, 1961) 533

1961YA08 T. Yanabu, J. Phy. Soc. Jpn. 16 (1961) 2118

1961YO1A Yoccoz, J. Phys. Rad. 22 (1961) 685

1961ZD02 R.A. Zdanis, C.A. Bruns, G.E. Owen, L. Madansky and S. Edwards, Nucl. Phys. 28 (1961) 550

1961ZI02   J. Zimanyi, J. Ero, L. Pocs and J. Szentpeteryi, Zh. Eksp. Teor. Fiz. 40 (1961) 709; JETP (Sov. Phys.) 13 (1961) 496

1962AG01   J. Aguilar, J.B.A. England and A. Garcia, An. Real. Soc. Espan. Fis. y Quim. (Madrid) A58 (1962) 319; Phys. Abs. 12699 (1963)

1962AL01   W.P. Alford, O.M. Bilaniuk and D.B. Marsh, Bull. Amer. Phys. Soc. 7 (1962) 60, R8

1962AL09   R.G. Allas, T.H. Braid, L.L. Lee Jr. and J.P. Schiffer, Bull. Amer. Phys. Soc. 7 (1962) 411, S1

1962AL18   G. Albouy, M. Gusakow, N. Poffe, H. Sergolle and L. Valentin, J. Phys. Rad. 23 (1962) 1000

1962AU1A   Austin, Slamon, Clegg, Foley and Newton, Proc. Phys. Soc. (London) 80 (1962) 383

1962BA15   R. Barjon, Y. Flamant, J. Perchereau and A. Rode, J. Phys. Rad. 23 (1962) 60

1962BA1C   Barker and Treacy, Nucl. Phys. 38 (1962) 33

1962BA1D   Barber, Ann. Rev. Nucl. Sci. 12 (1962) 1

1962BA25   R. Barjon, Y. Flamant, J. Perchereau and A. Rode, Nucl. Phys. 36 (1962) 247

1962BE16   E.H. Berkowitz, Phys. Rev. 126 (1962) 2168

1962BE21   H. Beaumevieille, N. Longequeue and J.P. Longequeue, Compt. Rend. 255 (1962) 1340

1962BE24   E. Berkowitz, S. Bashkin, R.R. Carlson, S.A. Coon and E. Norbeck, Phys. Rev. 128 (1962) 247

1962BE43   Y.A. Berezhnoi, A.P. Klyucharev, Y.N. Ranyuk and N.Y. Rutkevich, Zh. Skep. Teor. Fiz. 43 (1962) 1248; JETP (Sov. Phys.) 16 (1963) 883

1962BL10   S.L. Blatt and W.E. Meyerhof, Bull. Amer. Phys. Soc. 7 (1962) 624, W8

1962BL1E   Blokhintsev, Dolinskii and Popov, Zh. Eksp. Teor. Fiz. 43 (1962) 2290; JETP (Sov. Phys.) 16 (1963) 1618

1962BO06   R. Bouchez, M. Dubus, J. Duclos, D. Hamilton, P. Perrin and R. Quivy, Compt. Rend. 254 (1962) 2744

1962BO1H   Bonazzola, Borello, Costa and Ferroni, Nucl. Phys. 34 (1962) 637

1962BO33   P.H. Bowen, G.C. Cox, G.B. Huxtable, J.P. Scanlon, J.J. Thresher and A. Langsford, Nucl. Phys. 30 (1962) 475

1962BR10   C.P. Browne, W.E. Dorenbusch and J.R. Erskine, Phys. Rev. 125 (1962) 992

1962BR11   E. Bradford and B.A. Robson, Nucl. Phys. 29 (1962) 442

1962BR14   L.B. Brown and H.B. Knowles, Phys. Rev. 125 (1962) 1339

1962BU1B   Bunyan, Aust. J. Phys. 15 (1962) 123

1962CA29   J. Catala, A. Garcia and J. de Rubia, An. Real. Soc. Espan. Fis. y Quim. A58 (1962) 227

1962CH02   L.F. Chase Jr., Bull. Amer. Phys. Soc. 7 (1962) 61, R14

1962CH26   V.P. Chizhov, et al., Nucl. Phys. 34 (1962) 562

1962CL13   A.B. Clegg, Nucl. Phys. 38 (1962) 353

1962CO1E   Cook, Nucl. Instrum. Meth. 15 (1962) 137

1962DE03   W.E. Del Bianco and W.E. Stephens, Phys. Rev. 126 (1962) 709

1962DE1F   de Laet, Compt. Rend. 254 (1962) 87

1962DE1G   Deconninck, Demortier, de Vroey, Meulders and Simonet, Ann. Soc. Sci. Bruxelles 76 (1962) 69; Phys. Abs. 20676 (1962)

1962DE1H   Dehnhard, Kamke and Kramer, Phys. Lett. 3 (1962) 52

1962DO1A   Dodge and Barber, Phys. Rev. 127 (1962) 1746

1962DO1B   Donovan et al., Bull. Amer. Phys. Soc. 7 (1962) 287

1962ED02   R.D. Edge and G.A. Peterson, Phys. Rev. 128 (1962) 2750

1962EL01   A.J. Elwyn and R.O. Lane, Nucl. Phys. 31 (1962) 78

1962EL1C   El Nadi and Sherif, Proc. Phys. Soc. (London) 80 (1962) 1041

1962FE12   V.N. Fetisov, Izv. Akad. Nauk SSSR Ser. Fiz. 26 (1962) 1525

1962FI1C   Firk, Lokan and Bowey, Padua (1963) 804

1962FO03   K.J. Foley, G.L. Salmon and A.B. Clegg, Nucl. Phys. 31 (1962) 43

1962FU11   H. Fuchs, D. Haag, K.H. Lindenberger and U. Meyer-Berkhout, Z. Naturforsch. A17 (1962) 439

1962GA02   G.T. Garvey, A.M. Smith, J.C. Hiebert and F.E. Steigert, Phys. Rev. Lett. 8 (1962) 25

1962GA17   A. Garcia, J. Kirk, J.B.A. England and P.E. Hodgson, Nucl. Phys. 38 (1962) 372

1962GO1J   Gorshkov, Zyabkin and Tsvetkov, Atomn. Energ. (USSR) 13 (1962) 65

1962GO1R   Goswami and Pal, Nucl. Phys. 35 (1962) 544

1962GO24   S. Gorodetzky, P. Fintz and A. Gallmann, Compt. Rend. 255 (1962) 1505

1962GU01   G.D. Gutsche, H.D. Holmgren, L.M. Cameron and R.L. Johnston, Phys. Rev. 125 (1962) 648

1962HE10   K.O. Hermann and J.A. Scheer, Z. Phys. 170 (1962) 162

1962HO13   H.D. Holmgren and E.A. Wolicki, Nucl. Phys. 38 (1962) 489

1962HU1D   Huber et al., Helv. Phys. Acta 35 (1962) 557

1962IM01   W.L. Imhof, R.G. Johnson, F.J. Vaughn and M. Walt, Phys. Rev. 125 (1962) 1334

1962JO09   C.M. Jones, G.C. Phillips, R.W. Harris and E.H. Beckner, Nucl. Phys. 37 (1962) 1

1962JO14   J.C. Jodogne, P.C. Macq and J. Steyaert, Phys. Lett. 2 (1962) 325

1962KA1E   Kawai, Terasewa and Izumo, Prog. Theor. Phys. 27 (1962) 404

1962KA37 J. Kantele and D.G. Gardner, Nucl. Phys. 35 (1962) 353

1962KJ01 J. Kjellman, T. Dazel and J.H. Neiler, Nucl. Phys. 30 (1962) 131

1962KJ02 J. Kjellman and A. Nilsson, Ark. Fys. 20 (1961-1962) 507

1962KJ04 J. Kjellman and A. Nilsson, Ark. Fys. 22 (1962) 277

1962KU02 H. Kuan, P.R. Almond and G.U. Din, Bull. Amer. Phys. Soc. 7 (1962) 111, A4

1962KU1C Kunz, Phys. Rev. 128 (1962) 1343

1962KU1D Kurath, Electronmag. Lifetimes Properties of Nucl. States, N.A.S.-N.R.C. Pub. 974 (1962) 10

1962LA03 N.O. Lassen, Phys. Lett. 1 (1962) 65

1962LA05 N.O. Lassen, Phys. Lett. 1 (1962) 161

1962LA15 N.O. Lassen, Nucl. Phys. 38 (1962) 442

1962LE1A Levin, Nucl. Phys. 36 (1962) 119

1962LI05 P. Lipnik, J.P. Deutsch, L. Grenacs and P.C. Macq, Nucl. Phys. 30 (1962) 312

1962LI13 F.F. Liu, F.J. Loeffler, T.R. Palfrey and Y.S. Kim, Phys. Rev. 128 (1962) 2784

1962MA19 A. Marques, A.J.P.L. Policarpo and W.R. Phillips, Nucl. Phys. 36 (1962) 45.

1962MA1F Madsen and Henley, Nucl. Phys. 33 (1962) 1

1962MA1H Mattkhiz, Neudachin and Smirnov, Bull. Acad. Sci. USSR Phys. 26 (1962) 1211; Izv. Akad. Nauk Fiz. 26 (1962) 1199

1962MA1L MacLeod and Reid, AERE-R-4131 (1962)

1962MA1P Majling, Zh. Eksp. Teor. Fiz. 42 (1962) 831; JETP (Sov. Phys.) 15 (1962) 579

1962MA22 T. Mayer-Kuckuk and F.C. Michel, Phys. Rev. 127 (1962) 545

1962MC11 D.K. McDaniels, D.L. Hendrie, R.H. Bassel and G.R. Satchler, Phys. Lett. 1 (1962) 295

1962MC12 R.L. McGrath, Phys. Rev. 127 (1962) 2138

1962MC14 R.E. McDonald and W.E. Meyerhof, Bull. Amer. Phys. Soc. 7 (1962) 605, G6

1962MI07 J. Miller, C.G. Schuhl, G. Tamas and C. Tzara, Phys. Lett. 2 (1962) 76

1962MO16 W.T. Morton and T.G. Walker, Phil. Mag. 7 (1962) 741

1962NA04 M.A. Nagarajan and W.M. MacDonald, Bull. Amer. Phys. Soc. 7 (1962) 269, CB11

1962NE01 E. Newman, Phys. Rev. 125 (1962) 600

1962NE14 B.M.K. Nefkens, Bull. Amer. Phys. Soc. 7 (1962) 550, T6

1962NI02 A. Nilsson and J. Kjellman, Nucl. Phys. 32 (1962) 177

1962NI1C Nishida, Prog. Theor. Phys. 28 (1962) 564

1962NI1D S.G. Nilsson, J. Sawicki and N.K. Glendenning, Nucl. Phys. 33 (1962) 239

1962NO03   J.S. Nodvik, C.B. Duke and M.A. Melkanoff, Phys. Rev. 125 (1962) 975

1962NO04   M. Nomoto, Phys. Rev. 127 (1962) 1693

1962NO08   I. Nonaka, I. Saji, A. Suzuki, M. Yamaguchi, R. Eisberg, Y. Ishizaki, K. Kikuchi, K. Matsuda, T. Mikumo and Y. Nakajima, J. Phys. Soc. Jpn. 17 (1962) 1817

1962PA08   Parikh, Nucl. Phys. 38 (1962) 529

1962PO02   A.J.P.L. Policarpo and W.R. Phillips, Conf. Low Energy Nucl. Phys. Harwell, AERE-R-4131, 20 (1962) 7a.4.

1962RE1B   Rethmeier et al, Nucl. Instrum. Meth. 17 (1962) 273; Nucl. Phys. 38 (1962) 322

1962RE1C   Rebolia and Viano, Nuovo Cim. 26 (1962) 1426

1962RO14   L. Rosen, P. Darriulat, H. Faraggi and A. Garin, Nucl. Phys. 33 (1962) 458

1962RO1F   Robson, Nucl. Phys. 30 (1962) 316

1962RO1L   Robson, Nucl. Phys. 33 (1962) 594

1962RO25   D.J. Rowe, A.B. Clegg, G.L. Salmon and P.S. Fisher, Proc. Phys. Soc. (London) 80 (1962) 1205

1962SA05   G.L. Salmon, A.B. Clegg, K.J. Foley, P.S. Fisher and D.J. Rowe, Proc. Phys. Soc. (London) 79 (1962) 14

1962SA09   J.T. Sample, W.K. Dawson and G.C. Neilson, Bull. Amer. Phys. Soc. 7 (1962) 454, GA7

1962SA1G   Sanderson, Nucl. Phys. 35 (1962) 557

1962SA1J   Sakamoto, Takemiya and Tanaka, Prog. Theor. Phys. 27 (1962) 24

1962SE02   F.D. Seward, Phys. Rev. 125 (1962) 335

1962SE1A   Serov and Guzhovskii, Atomn. Energ. (USSR) 12 (1962) 5

1962SE1G   Seaman and Quinton, Aust. J. Phys. 15 (1962) 574

1962SI09   S. Singh and J.M. Alexander, Phys. Rev. 128 (1962) 711

1962SL02   R.J. Slobodrian, Phys. Rev. 125 (1962) 1003

1962SM02   A.M. Smith and F.E. Steigert, Phys. Rev. 125 (1962) 988

1962ST11   L. Stewart and L. Rosen, Bull. Amer. Phys. Soc. 7 (1962) 434, BA7

1962ST12   F.A. St. Romain, T.W. Bonner, R.L. Bramblett and J. Hanna, Phys. Rev. 126 (1962) 1794

1962ST18   M.F. Steuer and B.E. Wenzel, Bull. Amer. Phys. Soc. 7 (1962) 605, G11

1962ST1F   Strnad, Nucl. Phys. 35 (1962) 451

1962TA13   D.I. Tambovtsev, Ukr. Fiz. Zh. 7 (1962) 244; Nucl. Sci. Abstr. 16, 3442, Abstr. 26347 (1962); Phys. Abs. 20672 (1962)

1962TE02   A.R. Tejera, Bull. Amer. Phys. Soc. 7 (1962) 570, D6

1962TE05　K. Tesch, Nucl. Phys. 37 (1962) 412

1962VA1A　Vasilyev, Komarcv and Popova, Zh. Skep. Teor. Fiz. 43 (1962) 737; JETP (Sov. Phys.) 16 (1963) 521

1962VA25　S.S. Vasilyev, V.V. Komarov and A.M. Popova, Nucl. Phys. 38 (1962) 344

1962VI01　N. Vinh-Mau and G.E. Brown, Nucl. Phys. 29 (1962) 89

1962WA17　J.D. Walecka, Phys. Rev. 126 (1962) 663

1962WA24　K.H. Wang, S.D. Baker and J.A. McIntyre, Phys. Rev. 127 (1962) 187

1962WA31　E.K. Warburton and H.O. Funsten, Phys. Rev. 128 (1962) 1810

1962WE1C　Wegner, Rev. Sci. Instrum. 33 (1962) 271

1962WI05　R.J. Wilson, J.M. Fowler, J.B. Reynolds and J.J. Wesolowski, Bull. Amer. Phys. Soc. 7 (1962) 286, FB10

1962WI09　D.J. Williams and F.E. Steigert, Nucl. Phys. 30 (1962) 373

1962WO02　S.S.M. Wong and E. Bleuler, Phys. Rev. 125 (1962) 280

1962WO08　C. Wong, J.D. Anderson, J.W. McClure and B.D. Walker, Phys. Rev. 128 (1962) 2339

1962YA04　S. Yamabe, M. Takeda, M. Kondo, S. Kato, T. Yamazaki, N. Takahashi, N. Kawai and R. Chiba, J. Phys. Soc. Jpn. 17 (1962) 729

1962ZH1B　Zhdanov and Fedotov, Zh. Eksp. Teor. Fiz. 43 (1962) 835; JETP (Sov. Phys.) 16 (1963) 590

1962ZI01　J. Zimanyi, J. Ero, L. Pocs and I. Szentpetery, Nucl. Phys. 33 (1962) 524

1962ZU01　C. Zupancic, J.V. Kane and P.F. Donovan, Bull. Amer. Phys. Soc. 7 (1962) 287, FB12

1963AL15　D.E. Alburger, Phys. Rev. 131 (1963) 1624

1963AN12　G.B. Andreev, A.S. Deineko and I.Y. Malakhov, Izv. Akad. Nauk SSSR Ser. Fiz. 27 (1963) 1305; Bull. Acad. Sci. URRS 27 (1963) 1282

1963AN1B　Anderson and Bond, Nucl. Phys. 43 (1963) 330

1963AZ01　L.S. Azhgirey, Y.P. Kumekin, M.G. Meshcheryakov, S.B. Nurushev, G.D. Stoletov and D.T. Huang, Nucl. Phys. 43 (1963) 213

1963AZ1B　Azhgirey et al., Zh. Eksp. Teor. Fiz. 44 (1963) 177; JETP (Sov. Phys.) 17 (1963) 123

1963AZ1C　L.S. Azhgirey et al, Dokl. Akad. Nauk 145 (1962) 1249

1963BA1F　Bartolini, Donaldson and Passell, Bull. Amer. Phys. Soc. 8 (1963) 477

1963BA1K　Balashov and Fetisov, Zh. Eksp. Teor. Fiz. 45 (1963) 532; JETP (Sov. Phys.) 18 (1964) 365

1963BA1Q　Ballini and Saunier, J. Physique 24 (1963) 904

1963BA1X　Batty, Stafford and Gilmore, Padua (1963) 1160A

1963BA1Y Bassel, Satchler and Drisko, 3rd Conf. on Reactions between Complex Nuclei (1963) 45

1963BE18 J.A. Becker and J.D. Fox, Nucl. Phys. 42 (1963) 669

1963BE1R Bennett and Grant, 3rd Conf. on Reaction between Complex Nuclei (1963) 50

1963BE31 B.A. Benetskii and I.M. Frank, Zh. Skep. Teor. Fiz. 44 (1963) 454; JETP (Sov. Phys.) 17 (1963) 309

1963BL05 S.L. Blatt and D. Kohler, Bull. Amer. Phys. Soc. 8 (1963) 290, A3

1963BO15 R. Bouchez, J. Duclos and P. Perrin, Nucl. Phys. 43 (1963) 628

1963BO1D Borisdolebskii, Usp. Fiz. Nauk 81 (1963) 271; Sov. Phys. Usp. 6 (1964) 715

1963BO1J Boschitz, Padua (1963) 640

1963BO1M Bouchez, Duclos, Merchez, Perrin and Szabo, J. Phys. 24 (1963) 809

1963BO21 E. Boeker and C.C. Jonker, Phys. Lett. 6 (1963) 80

1963BO36 P. Bounin and G.R. Bishop, J. Phys. 24 (1963) 974

1963BR16 D.W. Braben, T.K. Alexander and G.C. Neilson, Bull. Amer. Phys. Soc. 8 (1963) 487, T13

1963BU18 N.A. Burgov, G.V. Danilyan, B.S. Dolbilkin, L.E. Lazareva and F.A. Nikolaev, Izv. Akad. Nauk SSSR Ser. Fiz. 27 (1963) 866; Bull. Acad. Sci. USSR Phys. Ser. 27 (1964) 856

1963BU1E Burge, Giles and Hodgson, Proc. Phys. Soc. (London) 81 (1963) 832

1963BU1G Burgov, Danilyan, Dolbilkin, Lazareva and Nikolaev, Zh. Eksp. Teor. Fiz. 45 (1963) 1693; JETP (Sov. Phys.) 18 (1964) 1159

1963BU24 A. Budzanowski, L. Freindl, K. Grotowski, M. Rzeszutko, M. Slapa, J. Szmider and P.E. Hodgson, Nucl. Phys. 49 (1963) 144

1963CA09 R.R. Carlson and E. Norbeck, Phys. Rev. 131 (1963) 1204

1963CA1E Catala, Garcia and Bolta, An. Real. Soc. Espan. Fis. y Quim. A59 (1963) 133

1963CA1J Catala, Garcia and Bolta, An. Real. Soc. Espan. Fis. y Quim. A59 (1963) 127; Phys. Abs. 22167 (1964)

1963CH20 A. Chatterjee, Nucl. Phys. 47 (1963) 511

1963CO1D Costa et al., Phys. Lett. 6 (1963) 226

1963CO35 M. Coste, L. Marquez and S. Shafroth, J. Phys. 24 (1963) 906

1963CU05 J.B. Cumming, Nucl. Phys. 49 (1963) 417

1963CU1B Cummings, Ann. Rev. 13 (1963) 261

1963CZ1A Czyz, Phys. Rev. 131 (1963) 2141

1963DA1B Dar, Phys. Lett. 7 (1963) 339

1963DE02 L.J. Denes and W.W. Daehnick, Bull. Amer. Phys. Soc. 8 (1963) 25, F1

1963DE27 G. Deconninck, M. De Vroey, J.P. Meulders and J. Simonet, Nucl. Phys. 49 (1963) 424

1963DE35 X. De Bouard, J.G. Fox, B. Geoffrion, N. Marty, C. Rolland and B. Tatischeff, J. Phys. 24 (1963) 1059

1963DI04 J.K. Dickens, D.A. Haner and C.N. Waddell, Phys. Rev. 129 (1963) 743

1963DI16 J.K. Dickens, D.A. Haner and C.N. Waddell, Phys. Rev. 132 (1963) 2159

1963DR1B Drisko, Satchler and Dassel, 3rd Conf. on Reactions between Complex Nuclei (1963) 85

1963DU12 J.L. Duggan, P.D. Miller and R.F. Gabbard, Nucl. Phys. 46 (1963) 336

1963DU1C Duorah and Kushwaha, Nuovo Cim. 27 (1963) 530

1963ED1B Edvi-Lewis, Proc. Phys. Soc. (London) 81 (1963) 856

1963EL1C Elton, Padua (1963) 1093

1963ER1A Ero, Pocs, Szentpetery and Zimanyi, Padua (1963) 558A

1963FE03 L. Feldman, B.B. Baliga and M. Nessin, Bull. Amer. Phys. Soc. 8 (1963) 290, A6

1963FI05 T.R. Fisher, Phys. Rev. 130 (1963) 2388

1963FI1B Finck et al., Z. Phys. 174 (1963) 337

1963FR1F Freind et al., Acta Phys. Pol. 23 (1963) 619

1963FU05 H. Fuchs and D. Haag, Z. Physik 171 (1963) 403

1963FU1D Fujii, Prog. Theor. Phys. 29 (1963) 374

1963GA05 G.T. Garvey, A.M. Smith and J.C. Hiebert, Phys. Rev. 130 (1963) 2397

1963GA1G Ganguly and Sil, Indian J. Phys. 37 (1963) 389

1963GL04 N.W. Glass and R.W. Peterson, Phys. Rev. 130 (1963) 299

1963GO04 J. Goldemberg and Y. Torizuka, Phys. Rev. 129 (1963) 312

1963GO1M Goldberg, May and Stehn, BNL-400, 2nd Ed., Vol. 1 (1963)

1963GO1P Goldemberg, Torizuka, Barber and Walecka, Nucl. Phys. 43 (1963) 242

1963GO1Q Goswami and Pal, Nucl. Phys. 44 (1963) 294

1963HA1E Hayward, Rev. Mod. Phys. 35 (1963) 324

1963HO08 A. Hofmann, Z. Phys. 173 (1963) 402

1963HO19 H.D. Holmgren, L.M. Cameron and R.L. Johnston, Nucl. Phys. 48 (1963) 1

1963HO1D Hooton and Ashcroft, Proc. Phys. Soc. (London) 81 (1963) 193

1963HO1E Hortig, Werner and Gentner, 3rd Conf. on Reactions between Complex Nuclei (1963) 178

1963HO1H Horie and Tanifuji, Phys. Lett. 3 (1963) 294

1963HO1J Honda, Kudo and Ui, Nucl. Phys. 44 (1963) 472

1963HU02 M.N. Huberman, M. Kamegai and G.C. Morrison, Phys. Rev. 129 (1963) 791

1963HU05 W.F. Huang and R.C. Ritter, Phys. Rev. 130 (1963) 2366

1963HU10 J.N. Huffaker and E. Greuling, Phys. Rev. 132 (1963) 738

1963HW01 C.F. Hwang, G. Clausnitzer, D.H. Nordby, S. Suwa and J.H. Williams, Phys. Rev. 131 (1963) 2602

1963JA07 A.N. James and H.G. Pugh, Nucl. Phys. 42 (1963) 441

1963JO1F Johansson and Wickenberg, Padua (1963) 1009A

1963JO1G Joseph et al., Helv. Phys. Acta 36 (1963) 494

1963KA1E Karadeniz and Lemeille, J. Phys. 24 (1963) 915

1963KA20 M. Kamegai, Phys. Rev. 131 (1963) 1701

1963KI02 H.J. Kim and E.F. Shrader, Phys. Rev. 129 (1963) 1275

1963KI03 Y.S. Kim, Phys. Rev. 129 (1963) 1293

1963KI14 H.J. Kim and E.F. Shrader, Phys. Rev. 131 (1963) 2594

1963KI1C Kim, Liu, Loeffler and Palfrey, Phys. Rev. 129 (1963) 1362

1963KI1D Kim, Nucl. Phys. 49 (1963) 651

1963KO03 M. Kondo, T. Yamazaki and S. Yamabe, J. Phys. Soc. Jpn. 18 (1963) 22

1963KO1C Kolesov, Korotkikh and Malashkina, Izv. Akad. Nauk SSSR Ser. Fiz. 27 (1963) 903

1963KU03 D. Kurath, Phys. Rev. 130 (1963) 1525

1963KU12 J.A. Kuehner, E. Almqvist and D.A. Bromley, Phys. Rev. 131 (1963) 1254

1963KU1F Kukhtevich et al., Sov. Prog. in Neutron Phys., Consult. Bureau (1963) 205; Phys. Abs. 12240 (1964)

1963KU1L Kuehner and Almqvist, 3rd Conf. on Reactions between Complex Nuclei (1963) 11

1963LA07 R.A. LaSalle, J.G. Cramer Jr. and W.W. Eidson, Phys. Lett. 5 (1963) 170

1963LA1E Lal and Sample, Bull. Amer. Phys. Soc. 8 (1963) 487

1963LA1F Langsford, Bowen, Cox and Riddle, Padua (1963) 1150

1963LE03 J.C. Legg, Phys. Rev. 129 (1963) 272

1963LE05 Y.K. Lee, L.W. Mo and C.S. Wu, Phys. Rev. Lett. 10 (1963) 253

1963LE19 C. Lemeille, D. Manesse, L. Marquez, N. Saunier and J.L. Quebert, J. Phys. 24 (1963) 908

1963LE1H Lewis, Walecka, Goldemberg and Barber, Phys. Rev. Lett. 10 (1963) 493

1963LO1A Loncke, Phys. Lett. 4 (1963) 284

1963LU10   H.F. Lutz, J.B. Mason and M.D. Karvelis, Nucl. Phys. 47 (1963) 521

1963MA1D Matthies, Neudachin and Smirnov, Nucl. Phys. 49 (1963) 97

1963MA1E Mattkhiz, Neudachin and Smirnov, Izv. Akad. Nauk. SSSR Ser. Fiz. 27 (1963) 1273

1963MC1B McCarthy, Padua (1963) 94

1963ME04   D.F. Measday, P.S. Fisher, A. Kalmykov, F.A. Nikolaev and A.B. Clegg, Nucl. Phys. 45 (1963) 98

1963ME11   L. Medveczky, Acta Phys. Aad. Sci. Hung. 16 (1963) 155

1963MI02   P.D. Miller, G.C. Morrison, N. Gale and G. Dearnaley, Bull. Amer. Phys. Soc. 8 (1963) 292, A16

1963MI1B Mihailovic and Rosina, Nucl. Phys. 40 (1963) 252

1963MI1H Mikumo, Padua (1963) 1046

1963MO04 I.L. Morgan, D.O. Nellis, R. Benjamin and J.B. Ashe, Bull. Amer. Phys. Soc. 8 (1963) 120, M6

1963MO1B Morrison, Gale, Hussain and Murray, 3rd Conf. on Reactions between Complex Nuclei (1963) 168

1963MU08   K.M. Murray and W.L. Bendel, Phys. Rev. 132 (1963) 1134

1963NA04   M.A. Nagarajan, Nucl. Phys. 42 (1963) 454

1963NA1C Nagahara et al., Padua (1963) 850A

1963NA1D Nagahara et al., Padua (1963) 821

1963NE02   B.M.K. Nefkens, Phys. Rev. Lett. 10 (1963) 55

1963NE1H Nemilov and Pobedonotsev, Zh. Eksp. Teor. Fiz. 45 (1963) 103; JETP (Sov. Phys.) 18 (1964) 76

1963NI02   Y. Nishida, Nucl. Phys. 43 (1963) 598

1963OG1A Ogloblin, Nucl. Phys. 47 (1963) 408

1963OP1A Oparin, Saukov and Shuvalov, Atomn. Energ. (USSR) 15 (1963) 411; J. Nucl. Energ. 18 (1964) 596

1963PA15   V.M. Pankratov and I.N. Serikov, Zh. Eksp. Teor. Fiz. 44 (1963) 887; JETP (Sov. Phys.) 17 (1963) 604

1963PE04   D.C. Peaslee, Phys. Rev. 129 (1963) 808; Erratum Phys. Rev. 135 (1964) AB2

1963PE10   R.W. Peterson and N.W. Glass, Phys. Rev. 130 (1963) 292

1963PH1A Phillips, Bronson, Pitts, Barnard, Weil and Belote, Padua (1963) 1070

1963PO06   C.H. Poppe, C.F. Hwang, D.H. Nordby and J.H. Williams, Bull. Amer. Phys. Soc. 8 (1963) 538, S8

1963PO1B Potter, Nucl. Phys. 45 (1963) 33

1963PU02 K.H. Purser and B.H. Wildenthal, Nucl. Phys. 44 (1963) 22; Erratum Nucl. Phys. 50 (1964) 694

1963RE09 N.W. Reay, N.M. Hintz and L.L. Lee Jr., Nucl. Phys. 44 (1963) 338

1963RE1C Reynolds, Scarl, Swanson, Waters and Zdanis, Phys. Rev. 129 (1963) 1790

1963RI03 R.C. Ritter, L. van der Zwan, Bull. Amer. Phys. Soc. 8 (1963) 291, A11

1963RO01 G. Roy and G.M. Temmer, Bull. Amer. Phys. Soc. 8 (1962) 12, BA12

1963RO1K Rodberg, Nucl. Phys. 47 (1963) 1

1963RO1L Roturier, Pham Khac Ham, Buret and Petit, J. Phys. 24 (1963) 811

1963RO22 B.A. Robson and E. Weigold, Nucl. Phys. 46 (1963) 321

1963RU1C Ruel and Brennan, Phys. Rev. 129 (1963) 866

1963SA1E Sachs, Chasman and Bromley, 3rd Conf. on Reactions between Complex Nuclei (1963) 90

1963SA1G Saji et al., Padua (1963) 851A

1963SC21 H. Schmid and W. Scholz, Z. Phys. 175 (1963) 430

1963SE04 J.B. Seaborn, G.E. Mitchell, N.R. Fletcher and R.H. Davis, Phys. Rev. 129 (1963) 2217

1963SE17 P.A. Seeger and R.W. Kavanagh, Astrophys. J. 137 (1963) 704

1963SE1F Sellschop and Mingay, Padua (1963) 425

1963SE1G Sellschop and Mingay, Padua (1963) 545

1963SE1P Seth, Padua (1963) 267

1963SE23 P.A. Seeger and R.W. Kavanagh, Nucl. Phys. 46 (1963) 577

1963SH1A Shapiro and Kolybasov, Nucl. Phys. 49 (1963) 515

1963SH1E Shumilov, Klyucharev and Rutkevich, Zh. Eksp. Teor. Fiz. 45 (1963) 1356; JETP (Sov. Phys.) 18 (1964) 934

1963ST1A Strzalkowski, Nukleonika 8 (1963) 301

1963SY01 G.D. Symons and P.B. Treacy, Nucl. Phys. 46 (1963) 93

1963TA1B Takeda and Nakasima, 3rd Conf. on Reactions between Complex Nuclei (1963) 159

1963VA04 S.S. Vasilyev, V.V. Komarov and A.M. Popova, Nucl. Phys. 40 (1963) 443

1963VA1C Valentin, Albouy, Cohen and Gusakow, Phys. Lett. 7 (1963) 163

1963VA23 R. Van Dantzig and L.A.C. Koerts, Nucl. Phys. 48 (1963) 177

1963VI1A Vinh-Mau. Ann. Phys. 8 (1963) 1

1963WA18 H.D. Warren and A.P. Batson, Nucl. Phys. 48 (1963) 361

1963WA20 W.K. Warburton and L.F. Chase Jr., Phys. Rev. 132 (1963) 2273

1963WI05   D.H. Wilkinson, D.E. Alburger, A. Gallmann and P.F. Donovan, Phys. Rev. 130 (1963) 1953

1963WI1G   Wilkins and Igo, 3rd Conf. on Reactions between Complex Nuclei (1963) 241

1963ZA1B   Zamick, Ann. Phys. 21 (1963) 550

1963ZH1A   Zhdanov and Fedotov, Zh. Eksp. Teor. Fiz. 45 (1963) 455; JETP (Sov. Phys.) 18 (1964) 313

1964AD1A   Adams and Hintz, Nucl. Phys. 59 (1964) 601

1964AD1B   Adam, Palla and Quittner, Acta Phys. Hungar. 17 (1964) 353

1964AF1A   Afanasyev, Kosmach and Ostroumov, Zh. Eksp. Teor. Fiz. 47 (1964) 1687; JETP (Sov. Phys.) 20 (1965) 1134

1964AL18   D.E. Alburger and P.D. Parker, Phys. Rev. 135 (1964) B294

1964AL1J   Allas et al., Phys. Rev. Lett. 13 (1964) 628

1964AL1Q   Aleksic, Popic and Stepancic, Paris (1964) 793

1964AL20   R.G. Allas, S.S. Hanna, L. Meyer-Schutzmeister and R.E. Segel, Nucl. Phys. 58 (1964) 122

1964AL33   F.R. Allum, T.W. Quirk and B.M. Spicer, Nucl. Phys. 53 (1964) 545

1964AM1C   Amaldi et al., Phys. Rev. Lett. 13 (1964) 341

1964AM1D   Amit and Latz, Nucl. Phys. 58 (1964) 297

1964BA14   A.M. Baxter, K.G. McIntyre, G.G. Shute and D. Robson, Nucl. Phys. 52 (1964) 385

1964BA16   J.K. Bair, C.M. Jones and H.B. Willard, Nucl. Phys. 53 (1964) 209

1964BA1C   Balashov, Boyarkina and Rotter, Nucl. Phys. 59 (1964) 417

1964BA1P   Balashov and Boyarkina, Izv. Akad. Nauk SSSR Ser. Fiz. 26 (1964) 359

1964BA1R   Bapber, Nucl. Instrum. Meth. 28 (1964) 220

1964BA29   R.W. Bauer, J.D. Anderson and C. Wong, Nucl. Phys. 56 (1964) 117

1964BE08   R.W. Bercaw and F.B. Shull, Phys. Rev. 133 (1964) B632

1964BE1E   Bertozzi et al., Paris (1964) 1026

1964BI1H   Bishop and Bottino, Phys. Lett. 10 (1964) 308

1964BL12   J.L. Black, G.A. Jones and P.B. Treacy, Nucl. Phys. 54 (1964) 689

1964BL1C   Blieden, Phys. Lett. 9 (1964) 176

1964BL1D   Blieden, Bull. Amer. Phys. Soc. 9 (1964) 171, and Private Communication (1964)

1964BR13   H.C. Bryant, J.G. Beery, E.R. Flynn and W.T. Leland, Nucl. Phys. 53 (1964) 97

1964BR1A   Breuer, Z. Phys. 178 (1964) 268

1964BR1H   Brown, Paris (1964) 129

1964BR1L Bromley, Symp. on Nucl. Spectrosc. with Direct Reactions, ANL 6878 (1964)

1964BR1N Brix et al., Paris (1964) 41

1964BR25 T.A. Brinkley, B.A. Robson and E.W. Titterton, Proc. Phys. Soc. (London) 84 (1964) 201

1964BU1E Budzanowski et al., Paris (1964) 102

1964BU1F Budzanowski, Paris (1964) 102

1964CA05 R.R. Carlson, E. Norbeck and V. Hart, Bull. Amer. Phys. Soc. 9 (1964) 419, DA9

1964CA07 E.B. Carter, G.E. Mitchell and R.H. Davis, Phys. Rev. 133 (1964) B1421

1964CA18 R.R. Carlson and M. Throop, Phys. Rev. 136 (1964) B630

1964CA1G Carlson and Kibler, SUI 64-21 (1964)

1964CH04 L.F. Chase Jr., W.W. True and E.K. Warburton, Bull. Amer. Phys. Soc. 9 (1964) 56, FA10

1964CH1C Chaudhri, NP 14500 (1964)

1964CL05 R.L. Clarke and W.G. Cross, Nucl. Phys. 53 (1964) 177

1964CL1A Clegg, Phys. Lett. 8 (1964) 43

1964CL1D Clegg, Nucl. Phys. 57 (1964) 509

1964CR11 H.L. Crannell and T.A. Griffy, Phys. Rev. 136 (1964) B1580

1964CR1B Cromer and Palmieri, Ann. Phys. 30 (1964) 32

1964DA03 W.W. Daehnick and R. Sherr, Phys. Rev. 133 (1964) B934

1964DA07 W.W. Daehnick, Phys. Rev. 135 (1964) B1168

1964DA1B W.W. Daehnick and L.J. Denes, Phys. Rev. 136 (1964) B1325.

1964DA1D Dar, Nucl. Phys. 55 (1964) 305

1964DE1E Deshpande and Fulbright, UR 875 61 (1964)

1964DE1H Dehnhard, Kamke and Kramer, Phys. Lett. 12 (1964) 113

1964DE1J Dehnhard, Kamke and Kramer, Ann. Phys. 14 (1964) 201

1964DU1D Duck, Nucl. Phys. 57 (1964) 643

1964EC03 S.F. Eccles, H.F. Lutz and J. Stevens, Bull. Amer. Phys. Soc. 9 (1964) 704, B9

1964EI01 W.W. Eidson, J.G. Cramer Jr., D.E. Blatchley and R.D. Bent, Nucl. Phys. 55 (1964) 613

1964EI1C Eichler, Tombrello and Bahcall, Phys. Lett. 13 (1964) 146

1964EL1B El-Nadi and Riad, Nucl. Phys. 50 (1964) 33

1964EN1B Engesser, Thompson and Ferguson, USNRDL TR 791 (1964)

1964ET02   J.E. Etter, M.A. Waggoner, H.D. Holmgren, C. Moazed and A.A. Jaffe, Phys. Lett. 12 (1964) 42

1964FI02   T.R. Fisher and W. Whaling, Phys. Rev. 133 (1964) B1502

1964FI1D   Fintz, Unpublished Thesis, Univ. of Strasbourg (1964)

1964GA1E   Garin et al., J. Phys. 25 (1964) 768

1964GE10   D.S. Gemmell, J.R. Erskine and J.P. Schiffer, Phys. Rev. 134 (1964) B110

1964GI05   R.A. Giles and E.J. Burge, Nucl. Phys. 50 (1964) 327

1964GI1A   Gillet and Melkanoff, Phys. Rev. 133 (1964) B1190

1964GI1B   Gillet, Nucl. Phys. 51 (1964) 410

1964GI1C   Gillet and Vinh Mau, Nucl. Phys. 54 (1964) 321

1964GO14   J. Goldemberg and W.C. Barber, Phys. Rev. 134 (1964) B963

1964GO15   J. Goldemberg, W.C. Barber, F.H. Lewis Jr. and J.D. Walecka, Phys. Rev. 134 (1964) B1022

1964GO1J   Goldberg, Rudakov and Serikov, Zh. Eksp. Teor. Fiz. 47 (1964) 571; JETP (Sov. Phys.) 20 (1965) 381

1964GR1L   Greider, Private Communication (1964)

1964GR1M   Gradsztajn, Phys. Rev. Lett. 13 (1964) 240; Erratum Phys. Rev. Lett. 14 (1965) 126

1964GU05   F. Gudden, Phys. Lett. 10 (1964) 313

1964HA1F   Hanser et al., Bull. Amer. Phys. Soc. 9 (1964) 444

1964HA1L   Haybron and McManus, Phys. Rev. 136 (1964) B1730

1964HA23   I. Hall and N.W. Tanner, Nucl. Phys. 53 (1964) 673

1964HA34   D. Hasselgren, P.U. Renberg, O. Sundberg and G. Tibell, Phys. Lett. 9 (1964) 166

1964HE1H   Heras, 4B(II)/C122, Paris (1964)

1964HI09   J.C. Hiebert and G.T. Garvey, Phys. Rev. 135 (1964) B346

1964HO1C   Hodgson, Congres Int. de Phys. Nucl. Paris, 1964, Vol. 1 (CRNS, Paris, 1964) 257

1964HO1D   Honda, Kudo, Ui and Horie, Phys. Lett. 10 (1964) 99

1964JA03   J.C. Jacmart, J.P. Garron, M. Riou and C. Ruhla, Phys. Lett. 8 (1964) 269

1964JI1A   Jibuti, Kopaleishvili and Mamasakhlisov, Nucl. Phys. 52 (1964) 345

1964JO14   J.C. Jodogne and P.C. Macq, J. Phys. (Paris) 25 (1964) 803

1964JO1E   Joseph, Grin, Vaucher and Alder, Helv. Phys. Acta 37 (1964) 222

1964KA08   R.W. Kavanagh, Phys. Rev. 133 (1964) B1504

1964KE1F   Kermode, Proc. Phys. Soc. (London) 84 (1964) 557

1964KI1D   Kihara et al., J. Phys. Soc. Jpn. 19 (1964) 2236

1964KU1G Kurath, Phys. Rev. 134 (1964) B1025

1964LA07 R.A. LaSalle, J.G. Cramer Jr. and R.D. Bent, Bull. Amer. Phys. Soc. 9 (1964) 407, CA9

1964LE1C Letessier, Phys. Lett. 10 (1964) 102

1964LE1D F.H. Lewis Jr. and J.D. Walecka Phys. Rev. 133 (1964) B849

1964LI1B Lindskog, Sundstrom and Sparrman, Perturbed Angular Correlations (Amsterdam, North-Holland Publ. Company, 1964) 411

1964LI1D Lim and McCarthy, Phys. Rev. 133 (1964) B1006

1964LI1E Lim and McCarthy, Phys. Rev. Lett. 13 (1964) 446

1964LO05 J.-P. Longequeue, N. Longequeue and H. Beaumevieille, Phys. Lett. 9 (1964) 171

1964LO1E Longequeue, CEA 2416 (1964)

1964MA1G Mamasakhlisov, Izv. Akad. Nauk SSSR Ser. Fiz. 28 (1964) 1550

1964MA26 D. Manesse, M. Coste, C. Lemeille, L. Marquez and N. Saunier, Nucl. Phys. 55 (1964) 433

1964MA2A Maier, Edelstein and Siegel, Phys. Rev. 133 (1964) B663

1964MA57 M. Mazari, A. Jaidar, G. Lopez, A. Tejera, J. Careaga, R. Dominguez and F. Alba, Proc. 2nd Int. Conf. on Nucl. Masses, Vienna, Austria, 1963; Ed. W.H. Johnson Jr. (Springer Verlag, Vienna, 1964) 305

1964MI04 R. Middleton and D.J. Pullen, Nucl. Phys. 51 (1964) 50

1964MI08 G.E. Mitchell, E.B. Carter and R.H. Davis, Phys. Rev. 133 (1964) B1434

1964MI12 I.V. Mitchell and T.R. Ophel, Nucl. Phys. 58 (1964) 529

1964MI1E Mikesha, Z. Phys. 177 (1964) 441

1964MO02 R.C. Morrison, J.R. Stewart and J.S. O'Connell, Bull. Amer. Phys. Soc. 9 (1964) 57, FA12

1964MO07 F.P. Mooring and R.E. Segel, Bull. Amer. Phys. Soc. 9 (1964) 434, EC10

1964MO1D Morgan, Bull. Amer. Phys. Soc. 9 (1964) 653

1964NA02 M.A. Nagarajan and A.P. Arya, Nucl. Phys. 50 (1964) 61

1964NA1C Nataf, Congres Int. de Phys. Nucl., Paris, 1964, Vol. 1 (CRNS, Paris, 1964) 421

1964NA1G Nash, Nuovo Cim. 32 (1964) 727

1964NE01 E. Newman, R.H. Bassel, R.S. Bender, J.R. Donaldson and K.S. Toth, Bull. Amer. Phys. Soc. 9 (1964) 57, FA14

1964NE1E Neudachin, Shevchenko and Yudin, Phys. Lett. 10 (1964) 180

1964OL1A Ollerhead, Chasman and Bromley, Phys. Rev. 134 (1964) B74

1964OL1B Olkhovskii and Tsekhmistrenko, Ukr. Fiz. Zh. 9 (1964) 251; Phys. Abs. 22145 (1964)

1964PA1E   Pasechnik, Putcherov, Saltykov and Tambovtsev, Congres Int. de Phys. Nucl., Paris, 1964 (CNRS, Paris, 1964)

1964PA1H   Paquette and Reeves, Astrophys. J. 140 (1964) 1319

1964PE20   J.L. Perkin, Nucl. Phys. 60 (1964) 561

1964PH1A   Phillips, Rev. Mod. Phys. 36 (1964) 1085

1964PU01   D.J. Pullen, J.R. Rook and R. Middleton, Nucl. Phys. 51 (1964) 88

1964RA1A   Rand and Hofstadter, Proc. 12th Int. Conf. on High Energy Phys., Dubna, Vol. 1 (1964) 895

1964RE1B   Reeder and Markowitz, Congres Int. de Phys. Nucl., Paris, 1964 (CRNS, Paris, 1964) 213

1964RI07   B.W. Ridley and J.F. Turner, Nucl. Phys. 58 (1964) 497

1964RI1D   Ritter, Bull. Amer. Phys. Soc. 9 (1964) 348

1964RO1F   Rosier, Deschamps and Avignon, Congres Int. de Phys. Nucl., Paris, 1964 (CRNS, Paris, 1964)

1964RO23   D.J. Rowe, G.L. Salmon, A.B. Clegg and D. Newton, Nucl. Phys. 54 (1964) 193

1964RU1A   Rustgi, Nucl. Phys. 59 (1964) 460

1964SA1E   Saint-Pierre, in Photographie Corpusculaire III, Ed. Demers (Presses Univ. de Montreal, 1964) 462

1964SA1J   Sadeh, Catz and Amiel, Nucl. Phys. 52 (1964) 25

1964SA1K   Sawada, Melkanoff and Saxon, Congres Int. de Phys. Nucl., Paris, 1964 (CRNS, Paris, 1964)

1964SA1L   Satchler and Haybron, Phys. Lett. 11 (1964) 313

1964SC07   F.H. Schmidt, R.E. Brown, J.B. Gerhart and W.A. Kolasinski, Nucl. Phys. 52 (1964) 353

1964SC1F   Scroggs, Zobel and Maienschein, IEEE Trans Nucl. Sci. (USA) NS-11, No.1 (1964) 365; Phys. Abs. 15036 (1964)

1964SE05   H.M. Sen Gupta, J. Rotblat, E.A. King and J.B.A. England, Nucl. Phys. 50 (1964) 549

1964SE09   S. Seki, M. Yamanouchi and M. Miwa, J. Phys. Soc. Jpn. 19 (1964) 1999

1964SH1B   Shklyarevsky, Nucl. Phys. 54 (1964) 125

1964SH1J   Sherman, Congres Int. de Phys. Nucl., Paris, 1964 (CRNS, 1964)

1964SH24   Y.M. Shin and W.E. Stephens, Phys. Rev. 136 (1964) B660

1964ST15   T. Stovall and N.M. Hintz, Phys. Rev. 135 (1964) B330

1964ST16   D.J. Steinberg, J.N. Palmieri and A.M. Cormack, Nucl. Phys. 56 (1964) 46

1964ST1B Stovall, Phys. Rev. 133 (1964) B268

1964ST25 J.R. Stehn, M.D. Goldberg, B.N. Magurno and R. Wiener-Chasman, BNL-325, 2nd Ed., Suppl. 2, Vol. 1 (1964)

1964ST30 D.T. Stewart and P.W. Martin, Nucl. Phys. 60 (1964) 349

1964SU1B Sund, Nascimento, Walton and Herring, Bull. Amer. Phys. Soc. 9 (1964) 382

1964SY02 G.D. Symons, Phys. Lett. 10 (1964) 89

1964SZ1A Szabo, CEA 2407 (1964)

1964TA05 N.W. Tanner, G.C. Thomas and E.D. Earle, Nucl. Phys. 52 (1964) 29

1964TA1E Tamura and Terasawa, Phys. Lett. 8 (1964) 41

1964TA1G Taran and Gorbunov, Zh. Eksp. Teor. Fiz. 46 (1964) 1492; JETP (Sov. Phys.) 19 (1964) 1010

1964TE1G Temmer, Bull. Amer. Phys. Soc. 9 (1964) 678

1964TI03 R.M. Tisinger, Jr., P.W. Keaton and G.E. Owen, Phys. Rev. 135 (1964) B892

1964TO1A M.E. Toms, Nucl. Phys. 50 (1964) 561

1964VO1B Volkov, Phys. Lett. 12 (1964) 118

1964WA1J Walter and Coche, Compt. Rend. 259 (1964) 2817

1964WU01 C.S. Wu, Rev. Mod. Phys. 36 (1964) 618

1964YU1A Yuasa, Phys. Lett. 8 (1964) 318

1964ZA1A C.D. Zafiratos, Phys. Rev. 136 (1964) B1279

1964ZI1A Zingl, Acta Phys. Aust. 17 (1964) 190; Phys. Abs. 15199 (1964)

1965AL17 P.R. Almond and J.R. Risser, Nucl. Phys. 72 (1965) 436

1965AL1B D.E. Alburger and P.F. Donovan, Rev. Mod. Phys. 37 (1965) 448

1965BA11 D. Bachelier, M. Bernas, I. Brissaud, C. Detraz, N. Ganguly and P. Radvanyi, Compt. Rend. 260 (1965) 4987

1965BA1M Barrett, Hill and Hodgson, Nucl. Phys. 62 (1965) 133

1965BA2D Bartis, Bull. Amer. Phys. Soc. 10 (1965) 10

1965BA2E Balashov and Rotter, Nucl. Phys. 61 (1965) 138

1965BA2G Bazhanov, Komar, Kulikov and Ogurtzov, Phys. Lett. 19 (1965) 239

1965BA31 H.W. Barz, R. Fulle, D. Netzband, R. Reif, K. Schlott and J. Slotta, Nucl. Phys. 73 (1965) 473

1965BA54 D.J. Baugh, G.W. Greenlees, J.S. Lilley and S. Roman, Nucl. Phys. 65 (1965) 33

1965BE1H Beregi, Zelenskaja, Neudatchin and Smirnov, Nucl. Phys. 66 (1965) 513

1965BE1L Bernstein and Terrell, Bull. Amer. Phys. Soc. 10 (1965) 103

1965BE1U   Benioff and Person, Phys. Rev. 140 (1965) B844

1965BE1V   Beck, Thesis, Univ. of Strasbourg (1965)

1965BH1A   Bhatia and Detenbeck, Private Communication (1965)

1965BI1B   G.R. Bishop, Phys. Lett. 17 (1965) 310

1965BI1G   Bishop et al., Suppl. Nuovo Cim. 3 (1965) 1179

1965BL09   F.J. Bloore and S. Brenner, Nucl. Phys. 69 (1965) 320

1965BL1F   Blin-Stoyle and Rosina, Nucl. Phys. 70 (1965) 321

1965BO14   R. Bock, M. Grosse-Schulte, W. Von Oertzen and R. Rudel, Phys. Lett. 18 (1965) 45

1965BR08   C.P. Browne, W.A. Schier and I.F. Wright, Nucl. Phys. 66 (1965) 49

1965BR13   R.E. Brown, J.S. Blair, D. Bodansky, N. Cue and C.D. Kavaloski, Phys. Rev. 138 (1965) B1394

1965BR18   J.D. Bronson, W.D. Simpson, W.R. Jackson and G.C. Phillips, Nucl. Phys. 68 (1965) 241

1965BR1E   Bradberry and Steuer, Bull. Amer. Phys. Soc. 10 (1965) 261

1965BR28   C.P. Browne, W.E. Dorenbusch and F.H. O'Donnell, Nucl. Phys. 72 (1965) 194

1965BR42   O.D. Brill, Yad. Fiz. 1 (1965) 55; Sov. J. Nucl. Phys. 1 (1965) 37

1965BU1H   Burcham, Baugh, Rolph and Scarrott, Bull. Amer. Phys. Soc. 10 (1965) 1203

1965CA1F   Campbell, Nucl. Phys. 64 (1965) 273

1965CL02   C.M. Class, J.E. Price and J.R. Risser, Nucl. Phys. 71 (1965) 433

1965CL1B   Clark and Zolotar, Bull. Amer. Phys. Soc. 10 (1965) 9

1965CL1E   Clegg, Nucl. Phys. 66 (1965) 185

1965CO25   S. Cohen and D. Kurath, Nucl. Phys. 73 (1965) 1; Erratum Nucl. Phys. 89 (1966) 707

1965CV1A   Cvelbar, Hudoklin and Potokar, Nucl. Instrum. Meth. 33 (1965) 349

1965DA1D   Danos and Fuller, Ann. Rev. Nucl. Sci. 15 (1965) 29

1965DE14   X. de Bouard, Ann. Phys. 10 (1965) 23

1965DE1C   T. Deforest Jr., et al., Phys. Lett. 16 (1965) 311.

1965DE1F   Deconninck, Mem. Acad. Roy. Belgique Cl. Sci. 35 (1965) No. 2; Phys. Abs. 7222 (1966)

1965DE1K   T. DeForest Jr., Phys. Rev. 139 (1965) B1217; Phys. Rev. 158 (1967) 1222 (Erratum).

1965DE1R   Dehnhard, Rev. Mod. Phys. 37 (1965) 450

1965DE26   V.K. Deshpande, Nucl. Phys. 70 (1965) 561

1965DI06   G. Din and J.L. Weil, Nucl. Phys. 71 (1965) 641

1965DI1C   Dittmer et al., Bull. Amer. Phys. Soc. 10 (1965) 122

1965DO14 R.E. Donaldson, L. Passell, W. Bartolini and D. Groves, Phys. Rev. 138 (1965) B1116

1965DO1H Donovan, Rev. Mod. Phys. 37 (1965) 501

1965DU01 L.M.C. Dutton, J.D. Jafar, H.B. Van der Raay, D.G. Ryan, J.A. Stiegelmair, R.K. Tandon and J.F. Reading, Phys. Lett. 16 (1965) 331

1965DU1C Duck, Rev. Mod. Phys. 37 (1965) 418

1965DZ1A Dzhibuti et al., Izv. Akad. Nauk SSSR Ser. Fiz. 29 (1965) 1131

1965DZ1B Dzhibuti, Mamasakhlisov and Macharadze, Yad. Fiz. 1 (1965) 976

1965FA1C Wang, Chen and Sze, Acta Phys. Sin. 21 (1965) 140

1965FI05 P. Fintz, Ann. Phys. (Paris) 10 (1965) 435

1965FO1F Foldy and Walecka, Phys. Rev. 140 (1965) B1339

1965FR17 M.P. Fricke and G.R. Satchler, Phys. Rev. 139 (1965) B567

1965FR1E Frahn and Wiechers, Nucl. Phys. 74 (1965) 65

1965GA02 A. Gallman, F. Hibou, P. Fintz, P.E. Hodgson and E.K. Warburton, Phys. Rev. 138 (1965) B560

1965GA1H Garin, Marquez and Qurbert, Nucl. Phys. 69 (1965) 140

1965GI1F Gibson, Johnston and Griffiths, Nucl. Phys. 70 (1965) 114

1965GL04 R.N. Glover and A.D.W. Jones, Phys. Lett. 16 (1965) 69

1965GO1D Goldanskii, Usp. Fiz. Nauk 87 (1965) 255

1965GR1F Greider, Ann. Rev. Nucl. Sci. 15 (1965) 291

1965GR1H Grechukhin, Nucl. Phys. 62 (1965) 273

1965GR1V Grin, Vaucher, Joseph, Alder and Loude, Helv. Phys. Acta 38 (1965) 368

1965GR1W Grin et al., Helv. Phys. Acta 38 (1965) 666

1965GU04 F. Gudden and P. Strehl, Z. Phys. 185 (1965) 111

1965HA17 D. Hasselgren, P.U. Renberg, O. Sundberg and G. Tibell, Nucl. Phys. 69 (1965) 81

1965HA28 R.M. Haybron and H. McManus, Phys. Rev. 140 (1965) B638

1965IN1A Inopin, Kresnin and Tishchenko, Yad. Fiz. 2 (1965) 802

1965IS05 M.M. Islam and P.B. Treacy, Nucl. Phys. 70 (1965) 236

1965JA03 B.K. Jain and N. Sarma, Phys. Rev. 137 (1965) B800

1965JA1A Jacmart, Cahiers Phys. (France) 19 (1965) 1

1965JA1D Jackson, Phys. Lett. 14 (1965) 118

1965KA1G Kamke, Krug and Richter, Rev. Mod. Phys. 37 (1965) 453

1965KI04 M. Kihara, J. Phys. Soc. Jpn. 20 (1965) 1313

1965KO1E Korzh et al., J. Nucl. Energy 19 (1965) 141

1965KR1A Kramer, Rev. Mod. Phys. 37 (1965) 346

1965KR1B Kramer, Ann. Phys. 15 (1965) 278

1965KU14 V.N. Kuzmin and R.M. Yakovlev, Izv. Akad. Nauk SSSR Ser. Fiz. 29 (1965) 1237; Bull. Acad. Sci. USSR Phys. Ser. 29 (1966) 1241

1965KU1B Kudo, Prog. Theor. Phys. 34 (1965) 942

1965KU1E Kudeyarov, Matthies, Neudachin and Smirnov, Nucl. Phys. 65 (1965) 529

1965LA08 J. Lang, R. Muller, W. Wolfli, R. Bosch and P. Marmier, Phys. Lett. 15 (1965) 248

1965LA1D Lawson and Cook, Bull. Amer. Phys. Soc. 10 (1965) 155

1965LA1F Lang et al, Helv. Phys. Acta 38 (1965) 368

1965LE1B Lee and Siemssen, Bull. Amer. Phys. Soc. 10 (1965) 510

1965LE1D Lewis, Bull. Amer. Phys. Soc. 10 (1965) 583

1965LO02 N. Longequeue, H. Beaumevieille, J.-P. Longequeue, M. Sandon and E. Ligeon, Compt. Rend. 260 (1965) 517

1965MA1K Marion, Nucl. Phys. 68 (1965) 463

1965MA1N Malvano and Ricco, Nuovo Cim. 35 (1965) 484

1965MA1X MacDonald, Phys. Lett. 19 (1965) 293

1965MA54 J.H.E. Mattauch, W. Thiele and A.H. Wapstra, Nucl. Phys. 67 (1965) 1

1965MC04 P.G. McManigal, R.D. Eandi, S.N. Kaplan and B.J. Moyer, Phys. Rev. 137 (1965) B620

1965MC1F McCarthy, Rev. Mod. Phys. 37 (1965) 388

1965MI03 K. Min and W.D. Whitehead, Phys. Rev. 137 (1965) B301

1965MO15 S.J. Moss and W. Haeberli, Nucl. Phys. 72 (1965) 417

1965MO1J Moooring and Monohan, Bull. Amer. Phys. Soc. 10 (1965) 513

1965MU1B Mukherjee and Majumdar, Ann. Phys. 16 (1965) 360

1965NE1B Neudachin and Smirnov, At. Energy Rev. 3 (1965) 157

1965NE1C Neudatchin and Smirnov, Nucl. Phys. 66 (1965) 25

1965NI1B Nilsson, Sawa and Gylden, Ark. Fys. 30 (1965) 505

1965NO1A Norbeck, Mancusi, Carlson and Berkowitz, Rev. Mod. Phys. 37 (1965) 455

1965OL01 W.C. Olsen, W.K. Dawson, G.C. Neilson and J.T. Sample, Nucl. Phys. 61 (1965) 625

1965OV01 J.C. Overley, R.R. Borchers, Nucl. Phys. 65 (1965) 156.

1965PE17 R.H. Pehl, J. Cerny, E. Rivet and B.G. Harvey, Phys. Rev. 140 (1965) B605

1965PH1A Phillips, Rev. Mod. Phys. 37 (1965) 409

1965PO03   A.M. Poskanzer, P.L. Reeder and I. Dostrovsky, Phys. Rev. 138 (1965) B18

1965RA1F   Rand, Phys. Rev. 140 (1965) B1605

1965RE1B   Reitan, Nucl. Phys. 64 (1965) 113

1965RI1A   Riou, Rev. Mod. Phys. 37 (1965) 375

1965RI1C   Rickey and Matluck, Bull. Amer. Phys. Soc. 10 (1965) 442

1965RO05   J.P. Roalsvig, Can. J. Phys. 43 (1965) 1015

1965RO1J   Roalsvig, Can. J. Phys. 43 (1965) 330

1965SA15   D.G. Sargood and G.D. Putt, Aust. J. Phys. 18 (1965) 491

1965SA1K   Sakamoto, Nucl. Phys. 66 (1965) 531

1965SC12   W.A. Schier and C.P. Browne, Phys. Rev. 138 (1965) B857

1965SE06   R.E. Segel, S.S. Hanna and R.G. Allas, Phys. Rev. 139 (1965) B818

1965SE1D   Seaborn and Eisenberg, Nucl. Phys. 70 (1965) 264

1965SH10   S.N. Shumilov, A.P. Klyucharev and N.Y. Rutkevich, Pisma Zh. Eksp. Teor. Fiz. 2 (1965) 213; JETP Lett. (USSR) 2 (1965) 135

1965SH11   S.N. Shumilov, A.P. Klyucharev and N.Y. Rutkevich, Pisma Zh. Eksp. Teor. Fiz. 2 (1965) 347; JETP Lett. (USSR) 2 (1965) 220

1965SH1A   Shumilov, Klyucharev and Rutkevich, Yad. Fiz. 2 (1965) 1030

1965SH1E   Shapiro and Timashev, Yad. Fiz. 2 (1965) 459

1965SH1G   Shevchenko and Yudin, At. Energy Rev. 3 (1965) 3

1965SI05   D.G. Simons and R.W. Detenbeck, Phys. Rev. 137 (1965) B1471

1965SI12   R.H. Siemssen, M. Cosack and R. Felst, Nucl. Phys. 69 (1965) 209

1965SI13   R.H. Siemssen, M. Cosack and R. Felst, Nucl. Phys. 69 (1965) 227

1965SL1C   Slee, Bull. Amer. Phys. Soc. 10 (1965) 461

1965ST02   D.M. Stanojevic, N.R. Berovic and F.M. Boreli, Nucl. Phys. 61 (1965) 235

1965ST22   P.H. Stelson and L. Grodzins, Nucl. Data A1 (1965) 21

1965SW1B   Swan, Rev. Mod. Phys. 37 (1965) 336

1965TA1E   Tanner, Nucl. Phys. 63 (1965) 383

1965TJ1A   Tjin A Djie and Brockman, Nucl. Phys. 74 (1965) 417

1965TO06   J.H. Towle and B.E.F. Macefield, Nucl. Phys. 66 (1965) 65

1965UB1A   Uberall, Phys. Rev. 139 (1965) B1239

1965UB1B   Uberall, Phys. Rev. 137 (1965) B502

1965UB1C   Uberall, Nuovo Cim. 38 (1965) 669

1965VA23   L. Valentin, Nucl. Phys. 62 (1965) 81

1965VE03   V.V. Verbinski and J.C. Courtney, Nucl. Phys. 73 (1965) 398

1965VO1A   Volkov, Nucl. Phys. 74 (1965) 33

1965WA04   B.D. Walker, C. Wong, J.D. Anderson and J.W. McClure, Phys. Rev. 137 (1964) B1504

1965WA1N   Warsh, Roy and Edwards, Nucl. Phys. 74 (1965) 551

1965WI11   J.H. Williamson, Nucl. Phys. 69 (1965) 481

1965WI17   R.M. Wilenzick, K.K. Seth, P.R. Bevington and H.W. Lewis, Nucl. Phys. 62 (1965) 511

1965WI1H   Willmes et al., Bull. Amer. Phys. Soc. 10 (1965) 525

1965WU1A   Wu, Alph-, Beta- and Gamma-Ray Spectroscopy, Vol. 2 (Amsterdam, North-Holland Pub. Co., 1965) 1365

1965WY02   J.M. Wyckoff, B. Ziegler, H.W. Koch and R. Uhlig, Phys. Rev. 137 (1965) B576

1965YA02   T. Yanabu, S. Yamashita, K. Takimoto and K. Ogino, J. Phys. Soc. Jpn. 20 (1965) 1303

1965YO1B   Young, Enge and Chen, Bull. Amer. Phys. Soc. 10 (1965) 539

1965YU1C   Yuasa and Hourani, Rev. Mod. Phys. 37 (1965) 399

1965ZE1B   Zelenskaya, Mailing, Neudachin and Smirnov, Yad. Fiz. 2 (1965) 427

1965ZH1A   Zhdanov, Kuzmin and Yakovlev, Izv. Akad. Nauk SSSR Ser. Fiz. 29 (1965) 239

1966AD1E   Adyasevich and Antonenko, Yad. Fiz. 3 (1966) 649

1966AF1A   Afanasyev et al., Bull. Acad. Sci. USSR Phys. 30 (1966) 376

1966AG1A   Agee and Rosen, LA-3538-MS (1966)

1966AR01   H. Artus, Z. Phys. 189 (1966) 355

1966AR1D   Arima, 2nd Symp. on the Struct. of Low-Medium Mass Nucl, April 1966 (1966) 77

1966BA01   F.C. Barker, J.R. Patterson, J.M. Poate and E.W. Titterton, Phys. Lett. 21 (1966) 318

1966BA1A   Bahcall, Nucl. Phys. 75 (1966) 10

1966BA2K   Bassel, Satchler and Drisko, Nucl. Phys. 89 (1966) 419

1966BA2W   Baldweg et al., Proc. Conf. Nucl. Reactions, Jan. 1966, Rossendorf, Ed. J. Schintlmeister, ZFK-122 (1966) 161

1966BA2Y   Baggett et al., NBS Publication 277 (1966)

1966BA34   E.B. Bazhanov, A.P. Komar, A.V. Kulikov and V.I. Ogurtsov, Yad. Fiz. 3 (1966) 711; Sov. J. Nucl. Phys. 3 (1966) 522

1966BA35   A.C.L. Barnard, J.B. Swint and T.B. Clegg, Nucl. Phys. 86 (1966) 130

1966BA42   F.J. Bartis, Nuovo Cim. B45 (1966) 113

1966BE05   J. Benn, E.B. Dally, H.H. Muller, R.E. Pixley, H.H. Staub and H. Winkler, Phys. Lett. 20 (1966) 43

1966BE1B   Berggren and Tyren, Ann. Rev. Nucl. Sci. 16 (1966) 153

1966BE1E   Beaumevieille et al., J. Phys. C1-150 (1966)

1966BE1Q   Beer, SAL 6 (1966)

1966BE1R   Benetskii, Proc. P. N. Lebedev Phys. URRS 33 (1966) 99

1966BE31   F. Beck, Ann. Phys. 1 (1966) 503

1966BI1B   Bishop, Costa, Ferroni, Malvano and Ricco, Nuovo Cim. B42 (1966) 158

1966BL19   L.N. Blumberg, et al. Phys. Rev. 147 (1966) 812

1966BO1N   A. Bottino, G. Ciocchetti and A. Molinari, Nucl. Phys. 89 (1966) 192

1966BO1P   Boeker, Ned. Tijdschrift Natuurkde (Netherlands) 32 (1966) 285; Phys. Abs. 16674 (1967)

1966BO1X   M. Bouten, L. Schotsmans and P. Van Leuven, Phys. Lett. 22 (1966) 510

1966BO28   O.V. Bormot, V.K. Dolinov, Y.V. Melikov and A.F. Tulinov, Yad. Fiz. 4 (1966) 316; Sov. J. Nucl. Phys. 4 (1967) 227

1966BR17   D.A. Bromley, J.C. Overley and P.D. Parker, Phys. Rev. Lett. 17 (1966) 705

1966BR1D   Broder, Dovbenko, Kolesov, Latshuk and Sadokhin, FEI-32 (1966)

1966BR1G   Browne, F. S. U. Isobaric Spin Conf. (1966) 136

1966BR1U   Brink, Proc. Int. School Enrico Fermi, Course 36; Ed. C. Bloch (Academic Press, 1966) 247

1966BR1X   Brown et al., Bull. Amer. Phys. Soc. 11 (1966) 316

1966BR2E   Breuer, Private Communication (1966)

1966CA1J   Calboreanu et al., Proc. 2nd Int. Symp. on Polariz. Phenom. of Nucleons, Karlsruhe, 1965 (Basel, Birkhauser Verlag, 1966) 502

1966CH1L   Chen et al., Bull. Amer. Phys. Soc. 11 (1966) 26

1966CI1A   Cindro, Rev. Mod. Phys. 38 (1966) 391

1966CO09   B.C. Cook, J.E.E. Baglin, J.N. Bradford and J.E. Griffin, Phys. Rev. 143 (1966) 724

1966CO24   A.A. Cowley, G. Heymann, R.L. Keizer and M.J. Scott, Nucl. Phys. 86 (1966) 363

1966CR04   R.M. Craig, J.C. Dore, G.W. Greenlees, J. Lowe and D.L. Watson, Nucl. Phys. 79 (1966) 177

1966CR07   H. Crannell, Phys. Rev. 148 (1966) 1107

1966CR14   R.M. Craig, J.C. Dore, G.W. Greenless, J. Lowe and D.L. Watson, Nucl. Phys. 83 (1966) 493

1966DA1C Daehnick and Denes, Bull. Amer. Phys. Soc. 11 (1966) 30

1966DA1F Davies, Krieger and Baranger, Nucl. Phys. 84 (1966) 545

1966DA1H Das, Ali and Sen Gupta, Sci. Res. (Pakistan) 3 (1966) 73; Phys. Abs. 13609 (1967)

1966DA1J P. Darriulat, Nucl. Phys. 76 (1966) 118

1966DE09 L.J. Denes, W.W. Daehnick and R.M. Drisko, Phys. Rev. 148 (1966) 1097

1966DE1G Delorme and Ericson, J. Phys. C1-120 (1966)

1966DE1K De Forest and Walecka, Adv. Phys. 15 (1966) 1, 491

1966DO11 R.E. Donaldson, D.J. Groves and R.K. Pearson, Phys. Rev. 146 (1966) 660

1966DO1B Dore, Griffith and Roman, Proc. 2nd Int. Symp. on Polariz. Phenom. of Nucleons, Karlsruhe, 1965 (Basel, Biekhauser Verlag, 1966) 60

1966DR04 Y.G. Dragunov, Y.V. Melikov and A.F. Tulinov, Yad. Fiz. 4 (1966) 314; Sov. J. Nucl. Phys. 4 (1967) 225

1966DR1E Drake, Conde and Hopkins, Bull. Amer. Phys. Soc. 11 (1966) 741

1966DR1F D. Drechsel, J.B. Seaborn and W. Greiner, Phys. Rev. Lett. 17 (1966) 488

1966DU08 B. Duelli, F. Hinterberger, G. Mairle, U. Schmidt-Rohr, P. Turek and G. Wagner, Phys. Lett. 23 (1966) 485

1966DU1D Duck, Nucl. Phys. 84 (1966) 586

1966DU1E Dudnikova and Mikhailov, Bull. Acad. Sci. USSR Phys. Ser. 30 (1966) 190; Izv. Akad. Nauk SSSR Ser. Fiz. 30 (1966) 185

1966EM01 J.McL. Emmerson, J.C.W. Madden, C.M.P. Johnson, N. Middlemas, A.B. Clegg and W.S.C. Williams, Nucl. Phys. 77 (1966) 305

1966EU01 H. Euringer, H. Neuert and H. Scholermann, Z. Naturforsch. A21 (1966) 977

1966EV1B Evans, Brown and Marion, Rev. Sci. Instrum. 37 (1966) 991

1966FE1C Ferguson, Antwerp 1965 Neutron Conf. (North-Holland, 1966) 63

1966FI1C Firk, Nucl. Instrum. Meth. 43 (1966) 312

1966FI1D Firk, Bull. Amer. Phys. Soc. 11 (1966) 367

1966FI1E Firk and Bowey, Antwerp 1965 Neutron Conf. (North-Holland, 1966) 553

1966FO06 G.M. Fossa, G. Ricco and C. Manfredotti, Nuovo Cim. B43 (1966) 347

1966FR18 A.J. Frasca, R.W. Finlay, R.D. Koshel and R.L. Cassola, Phys. Rev. 144 (1966) 854

1966FR1G Fricke, Gross, morton and Zucker, Bull. Amer. Phys. Soc. 11 (1966) 13

1966FR1H Friar, Nucl. Phys. 84 (1966) 150

1966FR1J Friar, Bull. Amer. Phys. Soc. 11 (1966) 914

1966FU02 S.C. Fultz, J.T. Caldwell, B.L. Berman, R.L. Bramblett and R.R. Harvey, Phys. Rev. 143 (1966) 790

1966FU1C Fuller, Antwerp 1965 Neutron Conf. (North-Holland, 1966) 359

1966GA09 A. Gallman, P. Fintz and P.E. Hodgson, Nucl. Phys. 82 (1966) 161

1966GA10 R.M. Gaedke and K.S. Toth, Nucl. Phys. 83 (1966) 353

1966GE03 D.G. Gerke, D.R. Tilley, N.R. Fletcher and R.M. Williamson, Nucl. Phys. 75 (1966) 609

1966GI1A Gillet, Proc. Int. School Enrico Fermi, Course 36; Ed. C. Bloch (Academic Press, 1966) 43

1966GL01 R.N. Glover and A.D.W. Jones, Nucl. Phys. 84 (1966) 673

1966GL1B R.N. Glover and A.D.W. Jones, Nucl. Phys. 81 (1966) 268

1966GO1B Goldanskii, Ann. Rev. Nucl. Sci. 16 (1966) 1

1966GO1C Goldemberg and Pratt, Rev. Mod. Phys. 38 (1966) 311

1966GO1L Gorodetzky et al., J. Phys. C1-112 (1966)

1966GR1L Grin, Joseph, Alder, Vaucher and Loude, Helv. Phys. Acta 39 (1966) 214

1966GR1M Grin, Proc. 2nd Int. Symp. on Polariz. Phenom. of Nucleons, Karlsruhe, 1965 (Basel, Birkhauser Verlag, 1966) 155

1966HA10 G. Hanke and D. Kamke, Z. Phys. 190 (1966) 468

1966HA18 E.C. Halbert, Y.E. Kim and T.T.S. Kuo, Phys. Lett. 20 (1966) 657

1966HA19 B.G. Harvey, J.R. Meriwether, J. Mahoney, A. Bussiere de Nercy and D.J. Horen, Phys. Rev. 146 (1966) 712

1966HA1M Hayward, Proc. Int. School Enrico Fermi, Course 36; Ed. C. Bloch (Academic Press, 1966) 559

1966HA1R D.R. Harrington, Phys. Rev. 147 (1966) 685

1966HA21 R.L. Hahn and E. Ricci, Phys. Rev. 146 (1966) 650

1966HA51 R.M. Haybron, Nucl. Phys. 79 (1966) 33

1966HE1C R.C. Herndon and Y.C. Tang, Phys. Rev. 149 (1966) 735

1966HO1F Hoot, Bull. Amer. Phys. Soc. 11 (1966) 316

1966HU1H Huang, Barrows and Gabbard, Bull. Amer. Phys. Soc. 11 (1966) 510

1966JA03 O.N. Jarvis, B. Rose and J.P. Scanlon, Nucl. Phys. 77 (1966) 161

1966JA05 R. Jahr, K. Kayser, A. Kostka and J.P. Wurm, Nucl. Phys. 76 (1966) 79

1966JA07 O.N. Jarvis and G.F. Cox, Nucl. Phys. 79 (1966) 297

1966JA08 O.N. Jarvis, Nucl. Phys. 79 (1966) 305

1966JA1A   Jacob and Maris, Rev. Mod. Phys. 38 (1966) 121

1966JA1B   Jacquot, Braun, Gerber and Cuer, J. Phys. C1-57 (1966)

1966JA1J   Jahr and Santo, Z. Naturforsch. A21 (1966) 964

1966JO1A   Jodogne, J. Phys. C1-110 (1966)

1966JO1B   Joseph et al., Antwerp 1965 Neutron Conf. (North-Holland, 1966) 507

1966KA1A   Kadmenskii, Bull. Acad. Sci. USSR Phys. Ser. 30 (1966) 145; Izv. Akad. Nauk SSSR Ser. Fiz. 30 (1966) 138

1966KA1C   Katz, Proc. Int. Conf. Eelctromag. Int. Dubna, Feb. 1967, Vol. 4 (Moscow, 1967) 97

1966KA1E   Kaminskii, JETP Lett. (USSR) 4 (1966) 43

1966KE06   E.M. Kellogg and W.E. Stephens, Phys. Rev. 149 (1966) 798

1966KE08   E.M. Kellogg and R.W. Zurmuhle, Phys. Rev. 152 (1966) 890

1966KE16   I. Kelson and G.T. Garvey, Phys. Lett. 23 (1966) 689

1966KI09   K.G. Kibler, Phys. Rev. 152 (1966) 932

1966KO1D   Kozlowski, Kusch and Wojtkowska, INR 661/IA/PL (1966)

1966KO1F   H.S. Kohler and R.J. McCarthy, Nucl. Phys. 88 (1966) 529

1966KR02   S.J. Krieger, M. Baranger and K.T.R. Davies, Phys. Lett. 22 (1966) 607

1966LA04   T. Lauritsen and F. Ajzenberg-Selove, Nucl. Phys. 78 (1966) 1

1966LE1J   F.H. Lewis Jr., Nucl. Phys. 80 (1966) 465

1966LI1F   Liu and Ho, Acta Phys. Sinica (China) 22 (1966) 569

1966LO04   W.A. Lochstet and W.E. Stephens, Phys. Rev. 141 (1966) 1002

1966LO18   N. Longequeue, J.F. Cavaignac, E. Ligeon, J.P. Longequeue and H. Beaumevieille, J. Phys. (Paris) 27 (1966) 649

1966MA1P   MacFarlane, Nucl. Spin-Parity Assignments, Ed. Gove (Academic Press, 1966) 411

1966MA1R   J.H. Manley and W.E. Stein, Phys. Rev. 144 (1966) 956

1966MA1T   Maison, Langevin and Loiseaux, J. Phys. C1-36 (1966)

1966MA2Q   R.M. May, Phys. Lett. 19 (1966) 689

1966MA2R   Mafethe and Hodgson, Proc. Phys. Soc. (London) 87 (1966) 429

1966MA38   S.K. Mark, P.M. Portner and R.B. Moore, Can. J. Phys. 44 (1966) 2961

1966MC05   R.L. McGrath, Phys. Rev. 145 (1966) 802

1966ME05   W.E. Meyerhof, Phys. Rev. Lett. 16 (1966) 1114

1966ME1E   Melikov, Vestnik Mosk. Univ. Fiz. Astron. Nov-Dec., No. 6 (1966) 102

1966ME1H   Meyer-Schutzmeister, 2nd Symp. on the Struct. of Low-Medium Mass Nuclei, Apr. 1966 (1966) 195

1966MI04   J. Miller, C. Schuhl, G. Tamas and C. Tzara, J. Phys. (Paris) 27 (1966) 8

1966MI1M Mizera, Gerhart and Slee, Bull. Amer. Phys. Soc. 11 (1966) 316; RLO 13885 (1966)

1966MO05 J. Mosner, G. Schmidt and J. Schintlmeister, Nucl. Phys. 75 (1966) 113

1966MO08 H. Morinaga, Phys. Lett. 21 (1966) 78

1966MO09 F.P. Mooring, J.E. Monahan and C.M. Huddleston, Nucl. Phys. 82 (1966) 16

1966MO1C Morgan et al., Antwepp 1965 Neutron Conf. (North-Holland, 1966) 537

1966MO1H F.B. Morinigo, Nucl. Phys. 77 (1966) 289

1966NE1D Nemets, Rudchik and Tokarevskii, Bull. Acad. Sci. USSR Phys. 30 (1966) 452

1966NG01 D.-C. Nguyen, J. Phys. Soc. Jpn. 21 (1966) 2462; Erratum J. Phys. Soc. Jpn. 22 (1967) 684

1966NO1A Nomoto, Nucl. Phys. 81 (1966) 180

1966OK1B Okamoto, Bull. Amer. Phys. Soc. 11 (1966) 627

1966PE1E Peterson, Ziegler and Cole, Bull. Amer. Phys. Soc. 11 (1966) 120

1966PH1C Phillips, Valkovic, Duck and Simpson, Bull. Amer. Phys. Soc. 11 (1966) 751

1966PI02 L.L. Pinsonneault and J.M. Blair, Phys. Rev. 141 (1966) 961

1966PO09 A.M. Poskanzer, S.W. Cosper, E.K. Hyde and J. Cerny, Phys. Rev. Lett. 17 (1966) 1271

1966PR1C Proca, Isabelle and Goldemberg, J. Phys. C1-105 (1966)

1966RA1C R. Raphael and H. Uberall, Phys. Rev. 143 (1966) 671

1966RA1E R. Raphael and H. Uberall, Nucl. Phys. 85 (1966) 327

1966RA1G Raphael and Uberall, Bull. Amer. Phys. Soc. 11 (1966) 367

1966RO1D Roos et al., Bull. Amer. Phys. Soc. 11 (1966) 26

1966RO1E Rotter and Zhusupov, Ann. Phys. 17 (1966) 57

1966RO1X Rosier, Deschamps and Avignon, Antwerp 1965 Neutron Conf. (North Holland, 1966) 501

1966SA1C G.R. Satchler, Nucl. Phys. 85 (1966) 273

1966SA1D Satchler, Lectures in Theor. Phys., Vol. VIIIC (Univ. of Colorado Press, Boulder, 1966) 73

1966SC12 J.P. Schapira, J.O. Newton, R.S. Blake and D.J. Jacobs, Nucl. Phys. 80 (1966) 565

1966SC1L Schmidt, Cramer and Kolasinski, Bull. Amer. Phys.Soc. 11 (1966) 99

1966SC22 J.J. Schwartz, W.P. Alford, L.M. Blau and D. Cline, Nucl. Phys. 88 (1966) 539

1966SC23 D. Schwalm and B. Povh, Nucl. Phys. 89 (1966) 401

1966SH1B Shumilov, Klyucharev and Rutkevich, JETP Lett. (USSR) 22 (1966) 1198

1966SH1F I.S. Shapiro and S.F. Timashev, Nucl. Phys. 79 (1966) 46

1966SI1E Simenog, Ukr. Fiz. Zh. (USSR) 11 (1966) 471; Phys. Abs. 33560 (1966)

1966SK03 L. Sklavenitis, Compt. Rend. B263 (1966) 833

1966SO1B Sorokin, Bull. Acad. Sci. USSR Phys. 30 (1966) 225

1966ST17 B.Z. Stepancic, D.M. Stanojevic, R.V. Popic and M.R. Aleksic, Bull. Inst. Nucl. Sci. Boris Kidrich (Belgrade) 17 (1966) 237

1966ST1L G.L. Strobel, Nucl. Phys. 86 (1966) 535

1966SU1F Suffert, Feldman and Hanna, Bull. Amer. Phys. Soc. 11 (1966) 316

1966SW04 J.B. Swint, A.C.L. Barnard, T.B. Clegg and J.L. Weil, Nucl. Phys. 86 (1966) 119

1966UB01 H. Uberall, Phys. Rev. Lett. 17 (1966) 1292

1966VA1D N. Van Giai, J. Sawicki and N. Vinh Mau, Phys. Rev. 141 (1966) 913

1966VI1A Vidal et al., J. Phys. C1-128 (1966)

1966WA10 E.K. Warburton, J.W. Olness, K.W. Jones, C. Chasman, R.A. Ristinen and D.H. Wilkinson, Phys. Rev. 148 (1966) 1072

1966WA16 M.A. Waggoner, J.E. Etter, H.D. Holmgren and C. Moazed, Nucl. Phys. 88 (1966) 81

1966WA1C Warburton and Alburger, Nucl. Spin-Parity Assign., Ed. Gove (Academic Press, 1966) 114

1966WE1B Weinberg, Antwerp 1965 Neutron Conf. (Noth Holland, 1966) 37

1966WI01 H.H. Williams, E.K. Warburton, K.W. Jones and J.W. Olness, Phys. Rev. 144 (1966) 801

1966WI1E D.H. Wilkinson and M.E. Mafethe, Nucl. Phys. 85 (1966) 97

1966YA04 A.I. Yavin, R.A. Hoffswell, L.H. Jones and T.M. Noweir, Phys. Rev. Lett. 16 (1966) 1049

1966YO1B Yoccoz, J. Phys. C1-3 (1966)

1966YO1C Yoccoz, Proc. Int. School Enrico Fermi, Course 36; Ed. C. Bloch (Academic Press, 1966) 474

1966ZA01 C.D. Zafiratos, F. Ajzenberg-Selove and F.S. Dietrich, Nucl. Phys. 77 (1966) 81; Erratum Nucl. Phys. 89 (1966) 706

1966ZE1A Zelenskaya and Smirnov, Bull. Acad. Sci. USSR Phys. 30 (1966) 283

1967AB1D Abul-Magd, Yad. Fiz. 6 (1967) 288

1967AD1E Adams, Adams and Calvert, AERE-NP/GEN-49 (1967)

1967AD1F Adelberger, Cocke and Davids, Bull. Amer. Phys. Soc. 12 (1967) 1194

1967AF02 N.G. Afanasev, V.A. Goldshtein, S.V. Dementii, V.G. Vlasenko, I.M. Arkatov and Y.I. Titov, Yad. Fiz. 5 (1967) 1134; Sov. J. Nucl. Phys. 5 (1967) 808

1967AF04   N.G. Afanasev, V.D. Kovalev, A.S. Omelaenko, G.A. Savitskii, V.M. Khvastunov and N.G. Shevchenko, Yad. Fiz. 5 (1967) 318; Sov. J. Nucl. Phys. 5 (1967) 223

1967AG1A   Aguilar, Peris, de la Rubia and Pineda, An. Real. Soc. Espan. Fis. y Quim. 63 (1967) 217

1967AL03   D.E. Alburger and D.H. Wilkinson, Phys. Rev. 153 (1967)1061

1967AL16   A.U. Aldzhauakhiri, A.V. Spasskii, I.B. Teplov and L.N. Fateeva, Yad. Fiz. 6 (1967) 248; Sov. J. Nucl. Phys. 6 (1968) 180

1967AL1F   Aldrich and Carlson, Bull. Amer. Phys. Soc. 12 (1967) 1177

1967AM03   U. Amaldi Jr., G.C. Venuti, G. Cortellessa, E. De sanctis, S. Frullani, R. Lombard and P. Salvadori, Phys. Lett. B25 (1967) 24

1967AM1E   Amaldi, Proc. Int. Conf. Electromag. Int. Dubna, Feb., 1967, Vol. 3 (Moscow, 1967) 110

1967AN08   B. Antolkovic, G. Paic, D. Rendic and P. Tomas, Izv. Akad. Nauk SSSR Ser. Fiz. 31 (1967) 110; Bull. Acad. Sci. USSR Phys. Ser. 31 (1968) 107

1967AN11   Y.P. Antufev, I.I. Miroshnichenko, V.I. Noga and P.V. Sorokin, Yad. Fiz. 6 (1967) 431; Sov. J. Nucl. Phys. 6 (1968) 312

1967AR17   K.P. Artemov, V.Z. Goldberg, V.P. Rudakov and I.N. Serikov, Yad. Fiz. 6 (1967) 13; Sov. J. Nucl. Phys. 6 (1968) 9

1967AR1A   Artus et al., Int. Nucl. Phys. Conf., Gatlinburg, 1966 (Academic Press, 1967) 314

1967AS1B   Assousa et al., Bull. Amer. Phys. Soc. 12 (1967) 500

1967AU05   E.G. Auld, D.G. Crabb, J.G. McEwen, L. Bird, C. Whitehead and E. Wood, Nucl. Phys. A101 (1967) 65

1967AU1B   J. Audouze, M. Epherre and H. Reeves, Nucl. Phys. A97 (1967) 144

1967AU1F   Augustson et al., Bull. Amer. Phys. Soc. 12 (1967) 483

1967BA12   G. Baron and H. Rouhaninejad, J. Phys. (Paris) 28 (1967) 142

1967BA1E   Bang, Zelemskaya, Magzumov and Neudachin, Sov. J. Nucl. Phys. 4 (1967) 688

1967BA1K   W.H. Bassichis and J.P. Svenne, Phys. Rev. Lett. 18 (1967) 80

1967BA2D   Baranger, Int. Nucl. Phys. Conf., Gatlinburg, 1966 (Academic Press, 1967) 659

1967BA2G   Ball and Cerny, Bull. Amer. Phys. Soc. 12 (1967) 1144

1967BA2N   Barrett and Walecka, Int. Nucl. Phys. Conf., Gatlinburg, 1966 (Academic Press, 1967) 703

1967BA2P   D.J. Baugh, G.J.B. Pyle, P.M. Rolph and S.M. Scarrott, Nucl. Phys. A95 (1967) 115

1967BA78   G. Backenstoss, S. Charalambus, H. Daniel, H. Koch, G. Poelz, H. Schmitt and L. Tauscher, Phys. Lett. B25 (1967) 547

1967BE1P   H.A. Bentz, R. Engfer and W. Buhring, Nucl. Phys. A101 (1967) 527

1967BE1Q H.W. Bertini, Phys. Rev. 162 (1967) 976

1967BE43 M. Bernheim, T. Stovall and D. Vinciguerra, Phys. Lett. B25 (1967) 461

1967BH1B Bhatia, et al., Bull. Amer. Phys. Soc. 12 (1967) 66

1967BI1K G.R. Bishop, Phys. Rev. Lett. 19 (1967) 659

1967BL1D Blokhintsev and Dolinskii, Sov. J. Nucl. Phys. 5 (1967) 79

1967BO04 M. Bouten, P. Van Leuven and H. Depuydt, Nucl. Phys. A94 (1967) 687

1967BO17 A.P. Borden and R.C. Ritter, Phys. Rev. 159 (1967) 875

1967BO1G E. Boeker, Nucl. Phys. A91 (1967) 27

1967BO1W Bolta, Garcia, Pascual and Senent, An. Real. Soc. Espan. Fis. y Quim. 63 (1967) 221

1967BO1X Bouten and van Leuven, Ann. Phys. 43 (1967) 421

1967BR1E D.M. Brink and E. Boeker, Nucl. Phys. A91 (1967) 1

1967BR1F F.P. Brady, J.A. Jungerman and J.C. Young, Nucl. Phys. A98 (1967) 241

1967BR1N Broadhurst and Pyle, Nucl. Instrum. Meth. 48 (1967) 117

1967BR1P G.R. Brookes, R. Railton, J.G. Rutherglen and I.L. Smith, Nucl. Phys. A94 (1967) 73

1967BR23 D.L. Broder, A.G. Dovbenko, V.E. Kolesov, A.I. Lashuk and I.P. Sadokhin, Izv. Akad. Nauk SSSR Ser. Fiz. 31 (1967) 327; Bull. Acad. Sci. USSR Phys. Ser. 31 (1968) 311

1967CA02 A.L. Catz and S. Amiel, Nucl. Phys. A92 (1967) 222

1967CA1C Caldwell, UCRL 50287 (1967)

1967CA1K Carlson et al., Bull. Amer. Phys. Soc. 12 (1967) 483

1967CA1T Calboreanu et al., Rev. Roum. Phys. 12 (1967) 263

1967CE1B Cerny and Fleming, Private Communication (1967)

1967CH04 R. Chapman and A.M. Macleod, Nucl. Phys. A94 (1967) 324

1967CH19 C. Chasman, K.W. Jones, R.A. Ristinen and D.E. Alburger, Phys. Rev. 159 (1967) 830

1967CH1R J.S. Chalmers and A.M. Saperstein, Phys. Rev. 156 (1967) 1099

1967CO03 W.R. Coker, M.M. Duncan, J.L. Duggan and P.D. Miller, Nucl. Phys. A91 (1967) 97

1967CO1F Comfort and Baglin, Bull. Amer. Phys. Soc. 12 (1967) 34

1967CO1V Corley et al., Bull. Amer. Phys. Soc. 12 (1967) 1190

1967CO32 S. Cohen and D. Kurath, Nucl. Phys. 101 (1967) 1

1967CR01 H. Crannell, T.A. Griffy, L.R. Suelzle and M.R. Yearian, Nucl. Phys. A90 (1967) 152

1967CR02 H. Crannell, H.A. Dahl and F.H. Lewis Jr., Phys. Rev. 155 (1967) 1062

1967CR04 M.A. Crosby and J.C. Legg, Nucl. Phys. A95 (1967) 639

1967CZ1B Czyz, Lesniak and Malecki, Ann. Phys. 42 (1967) 97

1967DA1H J. Da Providencia, Nucl. Phys. A90 (1967) 597

1967DE03 L.J. Denes and W.W. Daehnick, Phys. Rev. 154 (1967) 928

1967DE14 D. Dehnhard, D.S. Gemmell and Z. Vager, Nucl. Phys. A104 (1967) 202

1967DE1J Dehnhard, Hoot and Pyle, Bull. Amer. Phys. Soc. 12 (1967) 893

1967DE1K Dehnhard and Siemssen, Bull. Amer. Phys. Soc. 12 (1967) 17

1967DE1P Devanathan, Bull. Amer. Phys. Soc. 12 (1967) 12

1967DI01 G.U. Din, M.A. Nagarajan and R. Pollard, Nucl. Phys. A93 (1967) 190

1967DR1C Drake et al., Bull. Amer. Phys. Soc. 12 (1967) 34

1967DR1D Drake, Tomusiak and Caplan, Bull. Amer. Phys. Soc. 12 (1967) 666

1967DR1E D. Drechsel, J.B. Seaborn and W. Greiner, Phys. Rev. 162 (1967) 983

1967DU1E Duelli et al., Int. Nucl. Phys. Conf., Gatlinburg, 1966 (Academic Press, 1967) 136

1967EA01 L.G. Earwaker, Nucl. Phys. A90 (1967) 56

1967EL1B L.R.B. Elton and A. Swift, Nucl. Phys. A94 (1967) 52

1967EL1C L.R. Elton and D.F. Jackson, Phys. Rev. 155 (1967) 1070

1967EL1D El-Nadi, Ismail and Rihan, Nuovo Cim. B50 (1967) 224

1967EL1E L.R.B. Elton, Phys. Lett. B25 (1967) 60

1967EN1C Engfer and Turck, Z. Phys. 205 (1967) 90

1967EP1B Epstein et al., Bull. Amer. Phys. Soc. 12 (1967) 1197

1967EV1C J.A. Evans and R.P.J. Perazzo, Nucl. Phys. A103 (1967) 225

1967FA06 J.A. Fannon, E.J. Burge, D.A. Smith and N.K. Ganguly, Nucl. Phys. A97 (1967) 263

1967FE04 L. Feldman, B.B. Baliga and M. Nessin, Phys. Rev. 157 (1967) 921

1967FE05 S. Ferroni, V. Gracco, D.B. Isabelle, R. Malvano and M. Sanzone, Nucl. Phys. A98 (1967) 409

1967FE06 P. Fessenden and D.R. Maxson, Phys. Rev. 158 (1967) 948

1967FI07 W. Fitz, R. Jahr and R. Santo, Nucl. Phys. A101 (1967) 449

1967FI1E Firk, Int. Nucl. Phys. Conf., Gatlinburg, 1966 (Academic Press, 1967) 352

1967FL1F Flamant et al., Compt. Rend. 264 A/B (1967) 1283

1967FO1B Fowler, Caughlan and Zimmerman, Ann. Rev. Astron. Astrophys. 5 (1967) 525

1967FO1F Fortune, Gary, Trost and Fletcher, Bull. Amer. Phys. Soc. 12 (1967) 1197

1967FR10 J.L. Friedes, H. Palevsky, R.J. Sutter, G.W. Bennett, G.J. Igo, W.D. Simpson and D.M. Corley, Nucl. Phys. A104 (1967) 294

1967FR1D   Friar and Walecka, Int. Nucl. Phys. Conf., Gatlinburg, 1966 (Academic Press, 1967) 401

1967FR1E   D.E. Frederick, Nucl. Phys. A101 (1967) 250

1967FR20   M.P. Fricke, E.E. Gross, B.J. Morton and A. Zucker, Phys. Rev. 156 (1967) 1207

1967FU1A   Funsten and Holt, Bull. Amer. Phys. Soc. 12 (1966) 1176

1967GA01   H. Gauvin and R. Chastel, J. Phys. (Paris) 28 (1967) 129

1967GA06   D.S. Gale and J.M. Blair, Phys. Rev. 161 (1967) 1061

1967GI1D   Ginaven, Gross, Malanify and Morton, Bull. Amer. Phys. Soc. 12 (1967) 500

1967GL1B   Glavina et al., Bull. Amer. Phys. Soc. 12 (1967) 651

1967GO01   B. Gottschalk, K.H. Wang and K. Strauch, Nucl. Phys. A90 (1967) 83

1967GO1A   G. Goldring , H.M. Loebenstein , I. Plesser and M.W. Sachs, Phys. Lett. B25 (1967) 538

1967GR1N   Gray, Fortune, Trost and Fletcher, Bull. Amer. Phys. Soc. 12 (1967) 1197

1967GR1P   G.A. Grin, C. Joseph, C.Y. Wong and T. Tamura, Phys. Lett. B25 (1967) 387

1967HA10   K.B. Haque and J.G. Valatin, Nucl. Phys. A95 (1967) 97

1967HA1N   Hanser et al., Bull. Amer. Phys. Soc. 12 (1967) 516

1967HA1P   Hanser, Unpublished Thesis, MIT (1967)

1967HA1U   R.M. Haybron, M.B. Johnson and R.J. Metzger, Phys. Rev. 156 (1967) 1136

1967HA20   R.L. Hahn and E. Ricci, Nucl. Phys. A101 (1967) 353

1967HO1M   Horowitz and Sherman, Bull. Amer. Phys. Soc. 12 (1967) 632

1967HO1N   Hoot, Int. Nucl. Phys. Conf., Gatlinberg, 1966 (Academic Press, 1967) 144

1967HS1A   L.S. Hsu, Phys. Lett. B25 (1967) 588

1967HU10   J.N. Huffaker and C.E. Laird, Nucl. Phys. A92 (1967) 584

1967IS1A   Isabelle, Proc. Int. Conf. Electromag. Int. Dubna, Feb. 1967, Vol. 3 (Moscow, 1967) 85

1967JA1C   D.F. Jackson, Nucl. Phys. A90 (1967) 209

1967JA1G   Jarmie and Bryant, Bull. Amer. Phys. Soc. 12 (1967) 11

1967JO1F   Johansson, Sundberg and Tibell, Int. Nucl. Phys. Conf., Gatlinburg, 1966 (Academic Press, 1967) 63

1967KA05   M. Kamimura, K. Ikeda and A. Arima, Nucl. Phys. A95 (1967) 129

1967KA09   D. Kamke and J. Krug, Z. Phys. 201 (1967) 301

1967KA1C   S. Kaufman and C.O. Hower, Phys. Rev. 154 (1967) 924

1967KE1K   Kelly and Uberall, Bull. Amer. Phys. Soc. 12 (1967) 666

1967KE1L   F.J. Kelly and H. Uberall, Phys. Rev. 158 (1967) 987

1967KI03   K.G. Kibler, Phys. Rev. 155 (1967) 1110

1967KO14   J.J. Kolata, R. Auble and A. Galonsky, Phys. Rev. 162 (1967) 957

1967KO1N   Kolata and Galonsky, Bull. Amer. Phys. Soc. 12 (1967) 540

1967KR1C   Krieger, Baranger and Davies, Int. Nucl. Phys. Conf., Gatlinburg, 1966 (Academic Press, 1967) 720

1967KU11   H.W. Kuehne, P. Axel and D.C. Sutton, Phys. Rev. 163 (1967) 1278

1967KU1N   Kurath, Int. Nucl. Phys. Conf., Gatlinburg, 1966 (Academic Press, 1967) 861

1967LA09   H.A. Lamme and E. Boeker, Phys. Lett. B24 (1967) 367

1967LA1G   A. Lande, Phys. Rev. Lett. 18 (1967) 496

1967LA1K   G.H. Lamot, C. Fayard, J.N. Massot, E. El Baz and J. Lafoucrnere, Nucl. Phys. A99 (1967) 633

1967LA1N   Lane, Elwyn, Mooring and Langsdorf, Bull. Amer. Phys. Soc. 12 (1967) 87

1967LE13   H.K. Lee and H. McManus, Phys. Rev. 161 (1967) 1087

1967LE1G   Lee and McManus, Int. Nucl. Phys. Conf., Gatlinburg, 1966 (Academic Press, 1967) 178

1967LE1H   Levinger, Proc. Int. Conf. Electromag. Int. Dubna, Feb. 1967, Vol. 3 (Moscow, 1967) 411

1967LI06   R.H. Lindsay and J.J. Veit, Phys. Rev. 157 (1967) 933

1967LO1B   Loiseaux, Maison and Langevin, J. Phys. 28 (1967) 11

1967LO1H   Longequeue et al., Int. Nucl. Phys. Conf., Gatlinburg, 1966 (Academic Press, 1967) 284

1967LO1J   Longequeue, Cavaignac, Giorni and Bouchez, Compt. Rend. 264 A/B (1967) 1032

1967MA11   L. Marquez, J.P. Laugier, R. Ballini, C. Lemeille, N. Saunier and J. Rey, Nucl. Phys. A97 (1967) 321

1967MA1G   Magelson, Thesis, Univ. of California, Berkeley (1967)

1967MA1K   Mathur, Buchanan and Morgan, Bull. Amer. Phys. Soc. 12 (1967) 107

1967MA1N   May, Cohen and O-Keefe, Bull. Amer. Phys. Soc. 12 (1967) 37

1967MA1P   Marangoni and Saruis, Phys. Lett. B24 (1967) 218

1967ME11   D.F. Measday and J.N. Palmieri, Phys. Rev. 161 (1967) 1071

1967ME1G   Meyer-Schutzmeister, Int. Nucl. Phys. Conf., Gatlinburg, 1966 (Academic Press, 1967) 404

1967ME1N   Meier, Thomason and Walter, Bull. Amer. Phys. Soc. 12 (1967) 1197

1967MO1N   F.B. Morinigo, Nucl. Phys. A90 (1967) 113

1967MO1Q Morrison, Schiffer, Siemssen and Zeidman, Bull. Amer. Phys. Soc. 12 (1967) 501

1967MO1R M. Morita, Phys. Rev. 161 (1967) 1028

1967MO21 J. Mosner, G. Schmidt and J. Schintlmeister, Nucl. Phys. A103 (1967) 238

1967MU1F Murphy and Uberall, Bull. Amer. Phys. Soc. 12 (1967) 54

1967NA06 H. Nakamura, J. Phys. Soc. Jpn. 22 (1967) 685

1967NE09 E. Newman, L.C. Becker, B.M.Preedom and J.C. Hiebert, Nucl. Phys. A100 (1967) 225

1967NE1F Nemets and Rudchik, Sov. J. Nucl. Phys. 4 (1967) 694

1967NE1G Nemirovskii, Yad. Fiz. 6 (1967) 40

1967NO02 I. Nonaka, T. Mikumo, M. Koike, K. Matsuda, A. Suzuki, Y. Nagahara, K. Kikuchi and T. Maki, J. Phys. Soc. Jpn. 22 (1967) 949

1967NO1A J.V. Noble, Phys. Rev. 162 (1967) 934

1967NO1C J.V. Noble, Phys. Rev. 161 (1967) 945

1967OD01 F.H. O'Donnell and C.P. Browne, Phys. Rev. 158 (1967) 957

1967PA10 M.K. Pal and A.P. Stamp, Phys. Rev. 158 (1967) 924

1967PA1L Palevsky, Int. Nucl. Phys. Conf., Gatlinburg, 1966 (Academic Press, 1967) 1060

1967PA1T Parker, Allen, Yerke and Stotland, Bull. Amer. Phys. Soc. 12 (1967) 501

1967PA1U Park, Bull. Amer. Phys. Soc. 12 (1967) 1172

1967PA25 H. Palevsky, J.L. Friedes, R.J. Sutter, G.W. Bennett, G.J. Igo, W.D. Simpson, G.C. Phillips, D.M. Corley, N.S. Wall, R.L. Stearns et al., Phys. Rev. Lett. 18 (1967) 1200

1967PE05 E.L. Petersen, I. Slaus, J.W. Verba, R.F. Carlson and J.R. Richardson, Nucl. Phys. A102 (1967) 145

1967PE07 G.A. Peterson, Phys. Lett. B25 (1967) 549

1967PE1B Pecka, Maddison and Knowles, Bull. Amer. Phys. Soc. 12 (1967) 33

1967PE1E Perey et al., Bull. Amer. Phys. Soc. 12 (1967) 512

1967PL1B Ploughe, Springer and Kness, Bull. Amer. Phys. Soc. 12 (1967) 214

1967PO01 R.V. Poore, P.E. Shearin, D.R. Tilley and R.M. Williamson, Nucl. Phys. A92 (1967) 97

1967RE01 D. Rendic, Nucl. Phys. A91 (1967) 604

1967RE1E J.F. Reading, Phys. Rev. 156 (1967) 1110

1967RI08 K.E. Richie and B.T. Wright, Phys. Rev. 159 (1967) 839

1967RI1B Ripka, Int. Nucl. Phys. Conf., Gatlinburg, 1966 (Academic Press, 1967) 833

1967RO1G Rowe, Private Communication (1967)

1967RO1L   M. Rosen, R. Raphael and H. Uberall, Phys. Rev. 163 (1967) 927

1967RU1A   M.L. Rustgi, Phys. Lett. B24 (1967) 229

1967SA13   G.R. Satchler, Nucl. Phys. A100 (1967) 497

1967SA1K   G.R. Satchler, Nucl. Phys. A100 (1967) 481

1967SA1L   Satchler, Int. Nucl. Phys. Conf., Gatlinburg, 1966 (Academic Press, 1967) 1

1967SC1K   Schier, Anderson, Bernard and Plattner, Bull. Amer. Phys. Soc. 12 (1967) 33

1967SC29   J.P. Schiffer, G.C. Morrison, R.H. Siemssen and B. Zeidman, Phys. Rev. 164 (1967) 1274

1967SE08   W.A. Seale, Phys. Rev. 160 (1967) 809

1967SH1L   Shaw and Clayton, (1967)

1967SI1A   R.H. Siemssen and D. Dehnhard, Phys. Rev. Lett. 19 (1967) 377

1967SI1C   Sitenko, Ismatov and Tartakovski, Yad. Fiz. 5 (1967) 573

1967SM1A   I.L. Smith, J. Garvey, J.G. Rutherglen and G.R. Brookes, Nucl. Phys. B1 (1967) 483

1967SO07   M. Soga, Phys. Rev. 163 (1967) 995

1967SO1A   Soga, Bull. Amer. Phys. Soc. 12 (1967) 501

1967SU03   K. Sugimoto, K. Nakai, K. Matuda and T. Minamisono, Phys. Lett. B25 (1967) 130

1967SU1C   R.J. Sutter, J.L. Friedes, H. Palevsky, G.W. Bennett, G.J. Igo, W.D. Simpson, G.C. Phillips, D.M. Corley, N.S. Wall and R.L. Stearns, Phys. Rev. Lett. 19 (1967) 1189

1967SY1A   Synchrocyclotron Group, Lyon Univ. Rept. No. Lycen 6747 (1967)

1967TA1B   B. Tatischeff, Nucl. Phys. A98 (1967) 384

1967TA1C   Takimoto, Mem. Coll. Sci. Univ. Kyoto 31, Ser. A. 267, Feb. 1967 (1967)

1967TA1D   Tanner, Proc. Int. Conf. Electromag. Int. Dubna, Feb. 1967, Vol. 3 (Moscow, 1967) 277

1967TH1H   Thomason, Schaller and Walter, Bull. Amer. Phys. Soc. 12 (1967) 88

1967THZX   M.J. Throop, Bull. Amer. Phys. Soc. 12 (1967) 484, BD13

1967TU02   M. Turk, Z. Naturforsch. A22 (1967) 411

1967UI01   H. Ui, Phys. Rev. 161 (1967) 1099

1967VA1J   Van der Zwan, Bull. Amer. Phys. Soc. 12 (1967) 651

1967VA1K   N. Van Giai and J. Sawicki, Phys. Rev. 156 (1967) 1077

1967VE1C   B.J. Verhaar and L.D. Tolsma, Nucl. Phys. A90 (1967) 612

1967VE1D   Verbinski, Perey, Dickens and Burrus, ORNL TM 1891 (1967)

1967WA1E   Walecka, Int. Nucl. Phys. Conf., Gatlinburg, 1966 (Academic Press, 1967) 289

1967WA1F Walecka, Proc. Int. Conf. Electromag. Int., Dubna, Feb. 1967, Vol. 3 (Moscow, 1967) 28

1967WA1M Wang et al., Chin. J. Phys. 5 (1967) 1

1967WI1J Wiest and Huang, Bull. Amer. Phys. Soc. 12 (1967) 633

1967WY1B Wyborny and Carlson, Bull. Amer. Phys. Soc. 12 (1967) 1177

1967YO04 J. Yoccoz and S. Jang, Nucl. Phys. A92 (1967) 505

1967ZA1B Zafiratos and Slee, Bull. Amer. Phys. Soc. 12 (1967) 893

1967ZI1A Zickendraht, Z. Phys. 200 (1967) 194

1968AF1A Afanasyev et al., Proc. 1967 Int. Conf. on Nucl. Struct., Tokyo, Japan (1968)

1968AM1A Almadi et al., Tokyo (1968) 369

1968BA2G Backenstoss et al., Proc. Int. Conf. Nucl. Struct., Tokyo, Japan, 1967; Suppl. J. Phys. Soc. Jpn. 24 (1968) 500

1968BR1M Brassard, Scholz and Bromley, Proc. 1967 Int. Conf. on Nucl. Struct., Tokyo, Japan (1968)

1968BR1N Brix, Proc. 1967 Int. Conf. on Nucl. Struct., Tokyo, Japan (1968)

1968BU1D Buttlar, Goldman, Huber and Kramer, Tokyo (1968) 390

1968CH05 L.F. Chase Jr., R.E. McDonald, W.W. True and E.K. Warburton, Phys. Rev. 166 (1968) 997

1968CH1L Chanut et al., Proc. 1967 Int. Conf. on Nucl. Struct., Tokyo, Japan (1968)

1968GA1H Garvey, Haight and Lynch, PUO-937-275 (1968)

1968GO01 P. Goldhammer, J.R. Hill and J. Nachamkin, Nucl. Phys. A106 (1968) 62

1968HE1N Herling, Cohen and Silverstein, Proc. 1967 Int. Conf. on Nucl. Struct., Tokyo, Japan (1968)

1968HI1C Hirooka et al., Prog. Theor. Phys. 40 (1968) 808

1968HI1H Hinterberger et al., Tokyo (1968) 274

1968JA1G Jackson, Tokyo (1968) 105

1968KA1L Kammuri and Yoshida, (1968)

1968KA1M Kamimura, Ikeda and Arima, Proc. 1967 Int. Conf. on Nucl. Struct., Tokyo, Japan (1968)

1968MI1E Mittelstaedt, Ristig, Rohl and Stockle, Tokyo (1968) 34

1968MI1H Mikumo, Seki and Tagishi, Proc. 1967 Int. Conf. on Nucl. Struct., Tokyo, Japan (1968)

1968NO1E Nomoto, Proc. 1967 Int. Conf. on Nucl. Struct., Tokyo, Japan (1968)

1968OK1D   Okano, Kikuchi, Nishimura and Harada, Proc. 1967 Int. Conf. on Nucl. Struct., Tokyo, Japan (1968)

1968OL01   J.W. Olness and E.K. Warburton, Phys. Rev. 166 (1968) 1004

1968RO1L   Roos et al., Proc. 1967 Int. Conf. on Nucl. Struct., Tokyo, Japan (1968)

1968SO1B   Soga, Tokyo (1968) 50

1968TA1P   Taketani, Yamaguchi, Kokame and Muto, Tokyo (1968) 270

1968TA1V   Taketani, Muto, Yamaguchi and Kokame, Tokyo (1968) 277

1968VO1D   Von Oertzen, Gutbrod, Voos and Bock, Proc. 1967 Int. Conf. on Nucl. Struct., Tokyo, Japan (1968)

1968YA1C   Yanabu et al., Tokyo (1968) 261

1968YA1G   Yamaji, Yoshida and Yoshida, Proc. 1967 Int. Conf. on Nucl. Struct., Tokyo, Japan (1968)

1968YU1B   Yuasa, Hourany and Sakamoto, Proc. 1967 Int. Conf. on Nucl. Struct., Tokyo, Japan (1968)

1969BA06   G.C. Ball and J. Cerny, Phys. Rev. 177 (1969) 1466

1970AJ04   F. Ajzenberg-Selove, Nucl. Phys. A152 (1970) 1

BL62C   Unknown Source

FR68A   Unknown Source

GO61I   Unknown Source