$N(1710)$ P_{11}

$I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$ Status: ∗∗∗

Most of the results published before 1975 are now obsolete and have been omitted. They may be found in our 1982 edition, Physics Letters **111B** (1982).

The various partial-wave analyses do not agree very well.

N(1710) BREIT-WIGNER MASS

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1680 to 1740 (≈ 1710) OUR ESTIMATE				
1717±28	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
1700±50	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
1723± 9	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1720±10	ARNDT	96	IPWA	$\gamma N \to \pi N$
1766±34	[1] BATINIC	95	DPWA	$\pi N \to N\pi$, $N\eta$
1706	CUTKOSKY	90	IPWA	$\pi N \to \pi N$
1692	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
1730	SAXON	80	DPWA	$\pi^- p \to \Lambda K^0$
1690	BAKER	79	DPWA	$\pi^- p \to n\eta$
1650 to 1680	BAKER	78	DPWA	$\pi^- p \to \Lambda K^0$
1721	BARBOUR	78	DPWA	$\gamma N \to \pi N$
1625±10	[2] BAKER	77	IPWA	$\pi^- p \to \Lambda K^0$
1650	[2] BAKER	77	DPWA	$\pi^- p \to \Lambda K^0$
1720	[3] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
1670	KNASEL	75	DPWA	$\pi^- p \to \Lambda K^0$
1710	[4] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

N(1710) BREIT-WIGNER WIDTH

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
50 to 250 (≈ 100) OUR ESTIMATE				
480±230	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
93± 30	CUTKOSKY	90	IPWA	$\pi N \to \pi N$
90± 30	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
120± 15	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
105± 10	ARNDT	96	IPWA	$\gamma N \to \pi N$
185± 61	BATINIC	95	DPWA	$\pi N \to N\pi$, $N\eta$
540	BELL	83	DPWA	$\pi^- p \to \Lambda K^0$
200	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
550	SAXON	80	DPWA	$\pi^- p \to \Lambda K^0$
97	BAKER	79	DPWA	$\pi^- p \to n\eta$
90 to 150	BAKER	78	DPWA	$\pi^- p \to \Lambda K^0$

167	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$
160±6	[2] BAKER	77	IPWA	$\pi^- p \rightarrow \Lambda K^0$
95	[2] BAKER	77	DPWA	$\pi^- p \rightarrow \Lambda K^0$
120	[3] LONGACRE	77	IPWA	$\pi N \rightarrow N \pi \pi$
174	KNASEL	75	DPWA	$\pi^- p \rightarrow \Lambda K^0$
75	[4] LONGACRE	75	IPWA	$\pi N \rightarrow N \pi \pi$

N(1710) POLE POSITION

REAL PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1670 to 1770 (≈ 1720) OUR ESTIMATE				
1770	ARNDT	95	DPWA	$\pi N \rightarrow N \pi$
1690	[5] HOEHLER	93	SPED	$\pi N \rightarrow \pi N$
1698	CUTKOSKY	90	IPWA	$\pi N \rightarrow \pi N$
1690±20	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1636	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
1708 or 1712	[6] LONGACRE	78	IPWA	$\pi N \rightarrow N \pi \pi$
1720 or 1711	[3] LONGACRE	77	IPWA	$\pi N \rightarrow N \pi \pi$

−2×IMAGINARY PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
80 to 380 (≈ 230) OUR ESTIMATE				
378	ARNDT	95	DPWA	$\pi N \rightarrow N \pi$
200	[5] HOEHLER	93	SPED	$\pi N \rightarrow \pi N$
88	CUTKOSKY	90	IPWA	$\pi N \rightarrow \pi N$
80±20	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
544	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
17 or 22	[6] LONGACRE	78	IPWA	$\pi N \rightarrow N \pi \pi$
123 or 115	[3] LONGACRE	77	IPWA	$\pi N \rightarrow N \pi \pi$

N(1710) ELASTIC POLE RESIDUE

MODULUS $|r|$

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
37	ARNDT	95	DPWA	$\pi N \rightarrow N \pi$
15	HOEHLER	93	SPED	$\pi N \rightarrow \pi N$
9	CUTKOSKY	90	IPWA	$\pi N \rightarrow \pi N$
8±2	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
149	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90

PHASE θ

VALUE (°)	*DOCUMENT ID*		*TECN*	*COMMENT*
−167	ARNDT	95	DPWA	$\pi N \rightarrow N \pi$
−167	CUTKOSKY	90	IPWA	$\pi N \rightarrow \pi N$
175±35	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
149	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90

N(1710) DECAY MODES

The following branching fractions are our estimates, not fits or averages.

	Mode	Fraction (Γ_i/Γ)
Γ_1	$N\pi$	10–20 %
Γ_2	$N\eta$	
Γ_3	ΛK	5–25 %
Γ_4	ΣK	
Γ_5	$N\pi\pi$	40–90 %
Γ_6	$\Delta\pi$	15–40 %
Γ_7	$\Delta(1232)\pi$, P-wave	
Γ_8	$N\rho$	5–25 %
Γ_9	$N\rho$, S=1/2, P-wave	
Γ_{10}	$N\rho$, S=3/2, P-wave	
Γ_{11}	$N(\pi\pi)^{I=0}_{S\text{-wave}}$	10–40 %
Γ_{12}	$p\gamma$	0.002–0.05%
Γ_{13}	$p\gamma$, helicity=1/2	0.002–0.05%
Γ_{14}	$n\gamma$	0.0–0.02%
Γ_{15}	$n\gamma$, helicity=1/2	0.0–0.02%

N(1710) BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ — Γ_1/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.10 to 0.20 OUR ESTIMATE				
0.09±0.04	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
0.20±0.04	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
0.12±0.04	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.08±0.14	BATINIC	95	DPWA	$\pi N \rightarrow N\pi$, $N\eta$

$\Gamma(N\eta)/\Gamma_{total}$ — Γ_2/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.16±0.10	BATINIC	95	DPWA	$\pi N \rightarrow N\pi$, $N\eta$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow N(1710) \rightarrow N\eta$ — $(\Gamma_1\Gamma_2)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.22	BAKER	79	DPWA	$\pi^- p \rightarrow n\eta$
+0.383	FELTESSE	75	DPWA	Soln A; see BAKER 79

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1710) \to \Lambda K$ — $(\Gamma_1\Gamma_3)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.12 to +0.18 OUR ESTIMATE				
+0.16	BELL	83	DPWA	$\pi^- p \to \Lambda K^0$
+0.14	SAXON	80	DPWA	$\pi^- p \to \Lambda K^0$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.12	[7] BAKER	78	DPWA	See SAXON 80
−0.05±0.03	[2] BAKER	77	IPWA	$\pi^- p \to \Lambda K^0$
−0.10	[2] BAKER	77	DPWA	$\pi^- p \to \Lambda K^0$
0.10	KNASEL	75	DPWA	$\pi^- p \to \Lambda K^0$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1710) \to \Sigma K$ — $(\Gamma_1\Gamma_4)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.034	LIVANOS	80	DPWA	$\pi p \to \Sigma K$
0.075 to 0.203	[8] DEANS	75	DPWA	$\pi N \to \Sigma K$

Note: Signs of couplings from $\pi N \to N\pi\pi$ analyses were changed in the 1986 edition to agree with the baryon-first convention; the overall phase ambiguity is resolved by choosing a negative sign for the $\Delta(1620)$ S_{31} coupling to $\Delta(1232)\pi$.

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1710) \to \Delta(1232)\pi$, *P*-wave — $(\Gamma_1\Gamma_7)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
±0.16 to ±0.22 OUR ESTIMATE				
−0.21±0.04	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
−0.17	[3] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
+0.20	[4] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1710) \to N\rho$, S=1/2, *P*-wave — $(\Gamma_1\Gamma_9)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
±0.09 to ±0.19 OUR ESTIMATE				
+0.05±0.06	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
+0.19	[3] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
−0.20	[4] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1710) \to N\rho$, S=3/2, *P*-wave — $(\Gamma_1\Gamma_{10})^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.31	[3] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1710) \to N(\pi\pi)^{I=0}_{S\text{-wave}}$ — $(\Gamma_1\Gamma_{11})^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
±0.14 to ±0.22 OUR ESTIMATE				
+0.04±0.05	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
−0.26	[3] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
−0.28	[4] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$N(1710)$ PHOTON DECAY AMPLITUDES

$N(1710) \rightarrow p\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
+0.009±0.022 OUR ESTIMATE				
0.007±0.015	ARNDT	96	IPWA	$\gamma N \rightarrow \pi N$
0.006±0.018	CRAWFORD	83	IPWA	$\gamma N \rightarrow \pi N$
0.028±0.009	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
−0.009±0.006	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 1)
−0.012±0.005	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 2)
0.015±0.025	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.037±0.002	LI	93	IPWA	$\gamma N \rightarrow \pi N$
+0.001±0.039	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$
+0.053±0.019	FELLER	76	DPWA	$\gamma N \rightarrow \pi N$

$N(1710) \rightarrow n\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
−0.002±0.014 OUR ESTIMATE				
−0.002±0.015	ARNDT	96	IPWA	$\gamma N \rightarrow \pi N$
0.000±0.018	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
−0.001±0.003	FUJII	81	DPWA	$\gamma N \rightarrow \pi N$
0.005±0.013	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 1)
0.011±0.021	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 2)
−0.017±0.020	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.052±0.003	LI	93	IPWA	$\gamma N \rightarrow \pi N$
−0.028±0.045	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$

$N(1710)$ $\gamma p \rightarrow \Lambda K^+$ AMPLITUDES

$(\Gamma_i \Gamma_f)^{1/2} / \Gamma_{total}$ in $p\gamma \rightarrow N(1710) \rightarrow \Lambda K^+$ (M_{1-} amplitude)

VALUE (units 10^{-3})	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •			
−10.6 ±0.4	WORKMAN	90	DPWA
− 7.21	TANABE	89	DPWA

$p\gamma \rightarrow N(1710) \rightarrow \Lambda K^+$ phase angle θ (M_{1-} amplitude)

VALUE (degrees)	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •			
215 ±3	WORKMAN	90	DPWA
176.3	TANABE	89	DPWA

N(1710) FOOTNOTES

[1] BATINIC 95 finds a second state with a 6 MeV mass difference.
[2] The two BAKER 77 entries are from an IPWA using the Barrelet-zero method and from a conventional energy-dependent analysis.
[3] LONGACRE 77 pole positions are from a search for poles in the unitarized T-matrix; the first (second) value uses, in addition to $\pi N \rightarrow N\pi\pi$ data, elastic amplitudes from a Saclay (CERN) partial-wave analysis. The other LONGACRE 77 values are from eyeball fits with Breit-Wigner circles to the T-matrix amplitudes.
[4] From method II of LONGACRE 75: eyeball fits with Breit-Wigner circles to the T-matrix amplitudes.
[5] See HOEHLER 93 for a detailed discussion of the evidence for and the pole parameters of N and Δ resonances as determined from Argand diagrams of πN elastic partial-wave amplitudes and from plots of the speeds with which the amplitudes traverse the diagrams.
[6] LONGACRE 78 values are from a search for poles in the unitarized T-matrix. The first (second) value uses, in addition to $\pi N \rightarrow N\pi\pi$ data, elastic amplitudes from a Saclay (CERN) partial-wave analysis.
[7] The overall phase of BAKER 78 couplings has been changed to agree with previous conventions.
[8] The range given for DEANS 75 is from the four best solutions.

N(1710) REFERENCES

For early references, see Physics Letters **111B** 70 (1982).

ARNDT	96	PR C53 430	+Strakovsky, Workman	(VPI)	
ARNDT	95	PR C52 2120	+Strakovsky, Workman, Pavan	(VPI, BRCO)	
BATINIC	95	PR C51 2310	+Slaus, Svarc, Nefkens	(BOSK, UCLA)	
HOEHLER	93	πN Newsletter 9 1		(KARL)	
LI	93	PR C47 2759	+Arndt, Roper, Workman	(VPI)	
MANLEY	92	PR D45 4002	+Saleski	(KENT)	IJP
Also	84	PR D30 904	Manley, Arndt, Goradia, Teplitz	(VPI)	
ARNDT	91	PR D43 2131	+Li, Roper, Workman, Ford	(VPI, TELE)	IJP
CUTKOSKY	90	PR D42 235	+Wang	(CMU)	
WORKMAN	90	PR C42 781		(VPI)	
TANABE	89	PR C39 741	+Kohno, Bennhold	(MANZ)	
Also	89	NC 102A 193	Kohno, Tanabe, Bennhold	(MANZ)	
BELL	83	NP B222 389	+Blissett, Broome, Daley, Hart, Lintern+	(RL)	IJP
CRAWFORD	83	NP B211 1	+Morton	(GLAS)	
PDG	82	PL 111B	Roos, Porter, Aguilar-Benitez+	(HELS, CIT, CERN)	
AWAJI	81	Bonn Conf. 352	+Kajikawa	(NAGO)	
Also	82	NP B197 365	Fujii, Hayashii, Iwata, Kajikawa+	(NAGO)	
FUJII	81	NP B187 53	+Hayashii, Iwata, Kajikawa+	(NAGO, OSAK)	
ARAI	80	Toronto Conf. 93		(INUS)	
Also	82	NP B194 251	Arai, Fujii	(INUS)	
CRAWFORD	80	Toronto Conf. 107		(GLAS)	
CUTKOSKY	80	Toronto Conf. 19	+Forsyth, Babcock, Kelly, Hendrick	(CMU, LBL)	IJP
Also	79	PR D20 2839	Cutkosky, Forsyth, Hendrick, Kelly	(CMU, LBL)	IJP
LIVANOS	80	Toronto Conf. 35	+Baton, Coutures, Kochowski, Neveu	(SACL)	IJP
SAXON	80	NP B162 522	+Baker, Bell, Blissett, Bloodworth+	(RHEL, BRIS)	IJP
BAKER	79	NP B156 93	+Brown, Clark, Davies, Depagter, Evans+	(RHEL)	IJP
HOEHLER	79	PDAT 12-1	+Kaiser, Koch, Pietarinen	(KARLT)	IJP
Also	80	Toronto Conf. 3	Koch	(KARLT)	IJP
BAKER	78	NP B141 29	+Blissett, Bloodworth, Broome+	(RL, CAVE)	IJP
BARBOUR	78	NP B141 253	+Crawford, Parsons	(GLAS)	
LONGACRE	78	PR D17 1795	+Lasinski, Rosenfeld, Smadja+	(LBL, SLAC)	
BAKER	77	NP B126 365	+Blissett, Bloodworth, Broome, Hart+	(RHEL)	IJP
LONGACRE	77	NP B122 493	+Dolbeau	(SACL)	IJP
Also	76	NP B108 365	Dolbeau, Triantis, Neveu, Cadiet	(SACL)	IJP
FELLER	76	NP B104 219	+Fukushima, Horikawa, Kajikawa+	(NAGO, OSAK)	IJP
DEANS	75	NP B96 90	+Mitchell, Montgomery+	(SFLA, ALAH)	IJP
FELTESSE	75	NP B93 242	+Ayed, Bareyre, Borgeaud, David+	(SACL)	IJP
KNASEL	75	PR D11 1	+Lindquist, Nelson+	(CHIC, WUSL, OSU, ANL)	IJP
LONGACRE	75	PL 55B 415	+Rosenfeld, Lasinski, Smadja+	(LBL, SLAC)	IJP