$N(1720)\ P_{13}$

$I(J^P) = \frac{1}{2}(\frac{3}{2}^+)$ 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).

N(1720) MASS

VALUE (MeV)		*DOCUMENT ID*		*TECN*	*COMMENT*
1650 to 1750 (≈ 1720) OUR ESTIMATE					
1717±31		MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
1700±50		CUTKOSKY	80	IPWA	$\pi N \to \pi N$
1710±20		HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
1713±10		ARNDT	96	IPWA	$\gamma N \to \pi N$
1820		ARNDT	95	DPWA	$\pi N \to N\pi$
1711±26		BATINIC	95	DPWA	$\pi N \to N\pi$, $N\eta$
1720		LI	93	IPWA	$\gamma N \to \pi N$
1785		CRAWFORD	80	DPWA	$\gamma N \to \pi N$
1690		SAXON	80	DPWA	$\pi^- p \to \Lambda K^0$
1710 to 1790		BAKER	78	DPWA	$\pi^- p \to \Lambda K^0$
1809		BARBOUR	78	DPWA	$\gamma N \to \pi N$
1640±10	[1]	BAKER	77	IPWA	$\pi^- p \to \Lambda K^0$
1710	[1]	BAKER	77	DPWA	$\pi^- p \to \Lambda K^0$
1750	[2]	LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
1850		KNASEL	75	DPWA	$\pi^- p \to \Lambda K^0$
1720	[3]	LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

N(1720) WIDTH

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
100 to 200 (≈ 150) OUR ESTIMATE				
380±180	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
125± 70	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
190± 30	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
153± 15	ARNDT	96	IPWA	$\gamma N \to \pi N$
354	ARNDT	95	DPWA	$\pi N \to N\pi$
235± 51	BATINIC	95	DPWA	$\pi N \to N\pi$, $N\eta$
200	LI	93	IPWA	$\gamma N \to \pi N$
308	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
120	SAXON	80	DPWA	$\pi^- p \to \Lambda K^0$
447	BAKER	79	DPWA	$\pi^- p \to n\eta$

300 to 400	BAKER	78	DPWA	$\pi^- p \rightarrow \Lambda K^0$
285	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$
200± 50	[1] BAKER	77	IPWA	$\pi^- p \rightarrow \Lambda K^0$
500	[1] BAKER	77	DPWA	$\pi^- p \rightarrow \Lambda K^0$
130	[2] LONGACRE	77	IPWA	$\pi N \rightarrow N \pi \pi$
327	KNASEL	75	DPWA	$\pi^- p \rightarrow \Lambda K^0$
150	[3] LONGACRE	75	IPWA	$\pi N \rightarrow N \pi \pi$

N(1720) POLE POSITION

REAL PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1717	ARNDT	95	DPWA	$\pi N \rightarrow N \pi$
1686	[4] HOEHLER	93	SPED	$\pi N \rightarrow \pi N$
1680±30	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1675	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
1716 or 1716	[5] LONGACRE	78	IPWA	$\pi N \rightarrow N \pi \pi$
1745 or 1748	[2] LONGACRE	77	IPWA	$\pi N \rightarrow N \pi \pi$

−2×IMAGINARY PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
388	ARNDT	95	DPWA	$\pi N \rightarrow N \pi$
187	[4] HOEHLER	93	SPED	$\pi N \rightarrow \pi N$
120±40	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
114	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
124 or 126	[5] LONGACRE	78	IPWA	$\pi N \rightarrow N \pi \pi$
135 or 123	[2] LONGACRE	77	IPWA	$\pi N \rightarrow N \pi \pi$

N(1720) ELASTIC POLE RESIDUE

MODULUS $|r|$

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

PHASE θ

VALUE (°)	*DOCUMENT ID*		*TECN*	*COMMENT*
− 70	ARNDT	95	DPWA	$\pi N \rightarrow N \pi$
−160±30	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−130	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90

$N(1720)$ 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	1–15 %
Γ_4	ΣK	
Γ_5	$N\pi\pi$	>70 %
Γ_6	$\Delta\pi$	
Γ_7	$\Delta(1232)\pi$, P-wave	
Γ_8	$N\rho$	70–85 %
Γ_9	$N\rho$, S=1/2, P-wave	
Γ_{10}	$N\rho$, S=3/2, P-wave	
Γ_{11}	$N(\pi\pi)^{I=0}_{S\text{-wave}}$	
Γ_{12}	$p\gamma$	0.003–0.10 %
Γ_{13}	$p\gamma$, helicity=1/2	0.003–0.08 %
Γ_{14}	$p\gamma$, helicity=3/2	0.001–0.03 %
Γ_{15}	$n\gamma$	0.002–0.39 %
Γ_{16}	$n\gamma$, helicity=1/2	0.0–0.002 %
Γ_{17}	$n\gamma$, helicity=3/2	0.001–0.39 %

$N(1720)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{\text{total}}$ — Γ_1/Γ

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
0.10 to 0.20 OUR ESTIMATE				
0.13±0.05	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
0.10±0.04	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
0.14±0.03	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.16	ARNDT	95	DPWA	$\pi N \to N\pi$
0.18±0.04	BATINIC	95	DPWA	$\pi N \to N\pi$, $N\eta$

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

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.002±0.01	BATINIC	95	DPWA	$\pi N \to N\pi$, $N\eta$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \to N(1720) \to N\eta$ — $(\Gamma_1\Gamma_2)^{1/2}/\Gamma$

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.08	BAKER	79	DPWA	$\pi^- p \to n\eta$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1720) \to \Lambda K$ — $(\Gamma_1\Gamma_3)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.14 to −0.06 OUR ESTIMATE				
−0.09	BELL	83	DPWA	$\pi^- p \to \Lambda K^0$
−0.11	SAXON	80	DPWA	$\pi^- p \to \Lambda K^0$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.09	[6] BAKER	78	DPWA	See SAXON 80
−0.06±0.02	[1] BAKER	77	IPWA	$\pi^- p \to \Lambda K^0$
−0.09	[1] BAKER	77	DPWA	$\pi^- p \to \Lambda K^0$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1720) \to \Sigma K$ — $(\Gamma_1\Gamma_4)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.051 to 0.087	[7] 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 $N\pi \to N(1720) \to \Delta(1232)\pi$, P-wave — $(\Gamma_1\Gamma_7)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
±0.27 to ±0.37 OUR ESTIMATE				
−0.17	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1720) \to N\rho$, S=1/2, P-wave — $(\Gamma_1\Gamma_9)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.34±0.05	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
−0.26	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
+0.40	[3] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1720) \to N\rho$, S=3/2, P-wave — $(\Gamma_1\Gamma_{10})^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.15	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1720) \to N(\pi\pi)^{I=0}_{S\text{-wave}}$ — $(\Gamma_1\Gamma_{11})^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.19	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

$N(1720)$ PHOTON DECAY AMPLITUDES

$N(1720) \rightarrow p\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE (GeV$^{-1/2}$)	*DOCUMENT ID*		*TECN*	*COMMENT*
+0.018±0.030 OUR ESTIMATE				
−0.015±0.015	ARNDT	96	IPWA	$\gamma N \rightarrow \pi N$
0.044±0.066	CRAWFORD	83	IPWA	$\gamma N \rightarrow \pi N$
−0.004±0.007	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
0.051±0.009	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 1)
0.071±0.010	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 2)
0.038±0.050	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.012±0.003	LI	93	IPWA	$\gamma N \rightarrow \pi N$
+0.111±0.047	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$

$N(1720) \rightarrow p\gamma$, helicity-3/2 amplitude $A_{3/2}$

VALUE (GeV$^{-1/2}$)	*DOCUMENT ID*		*TECN*	*COMMENT*
−0.019±0.020 OUR ESTIMATE				
0.007±0.010	ARNDT	96	IPWA	$\gamma N \rightarrow \pi N$
−0.024±0.006	CRAWFORD	83	IPWA	$\gamma N \rightarrow \pi N$
−0.040±0.016	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
−0.058±0.010	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 1)
−0.011±0.011	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 2)
−0.014±0.040	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.022±0.003	LI	93	IPWA	$\gamma N \rightarrow \pi N$
−0.063±0.032	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$

$N(1720) \rightarrow n\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE (GeV$^{-1/2}$)	*DOCUMENT ID*		*TECN*	*COMMENT*
+0.001±0.015 OUR ESTIMATE				
0.007±0.015	ARNDT	96	IPWA	$\gamma N \rightarrow \pi N$
0.002±0.005	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
−0.019±0.033	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 1)
0.001±0.038	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 2)
−0.003±0.034	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.050±0.004	LI	93	IPWA	$\gamma N \rightarrow \pi N$
+0.007±0.020	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$

$N(1720) \rightarrow n\gamma$, helicity-3/2 amplitude $A_{3/2}$

VALUE (GeV$^{-1/2}$)	*DOCUMENT ID*		*TECN*	*COMMENT*
−0.029±0.061 OUR ESTIMATE				
−0.005±0.025	ARNDT	96	IPWA	$\gamma N \rightarrow \pi N$
−0.015±0.019	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
−0.139±0.039	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 1)
−0.134±0.044	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 2)
0.018±0.028	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				

-0.017 ± 0.004	LI	93	IPWA	$\gamma N \to \pi N$
$+0.051 \pm 0.051$	BARBOUR	78	DPWA	$\gamma N \to \pi N$

$N(1720)$ $\gamma p \to \Lambda K^+$ AMPLITUDES

$(\Gamma_i \Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $p\gamma \to N(1720) \to \Lambda K^+$ (E_{1+} amplitude)

VALUE (units 10^{-3})	*DOCUMENT ID*		*TECN*
10.2 ±0.2	WORKMAN	90	DPWA
• • • We do not use the following data for averages, fits, limits, etc. • • •			
9.52	TANABE	89	DPWA

$p\gamma \to N(1720) \to \Lambda K^+$ phase angle θ (E_{1+} amplitude)

VALUE (degrees)	*DOCUMENT ID*		*TECN*
−124 ±2	WORKMAN	90	DPWA
• • • We do not use the following data for averages, fits, limits, etc. • • •			
−103.4	TANABE	89	DPWA

$(\Gamma_i \Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $p\gamma \to N(1720) \to \Lambda K^+$ (M_{1+} amplitude)

VALUE (units 10^{-3})	*DOCUMENT ID*		*TECN*
−4.5 ±0.2	WORKMAN	90	DPWA
• • • We do not use the following data for averages, fits, limits, etc. • • •			
3.18	TANABE	89	DPWA

$N(1720)$ FOOTNOTES

[1] The two BAKER 77 entries are from an IPWA using the Barrelet-zero method and from a conventional energy-dependent analysis.

[2] LONGACRE 77 pole positions are from a search for poles in the unitarized T-matrix; the first (second) value uses, in addition to $\pi N \to N\pi\pi$ 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.

[3] From method II of LONGACRE 75: eyeball fits with Breit-Wigner circles to the T-matrix amplitudes.

[4] 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.

[5] LONGACRE 78 values are from a search for poles in the unitarized T-matrix. The first (second) value uses, in addition to $\pi N \to N\pi\pi$ data, elastic amplitudes from a Saclay (CERN) partial-wave analysis.

[6] The overall phase of BAKER 78 copulings has been changed to agree with previous conventions.

[7] The range given is from the four best solutions. DEANS 75 disagrees with $\pi^+ p \to \Sigma^+ K^+$ data of WINNIK 77 around 1920 MeV.

$N(1720)$ 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
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)
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
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
WINNIK	77	NP B128 66	+Toaff, Revel, Goldberg, Berny	(HAIF) I
DEANS	75	NP B96 90	+Mitchell, Montgomery+	(SFLA, ALAH) IJP
KNASEL	75	PR D11 1	+Lindquist, Nelson+	(CHIC, WUSL, OSU, ANL) IJP
LONGACRE	75	PL 55B 415	+Rosenfeld, Lasinski, Smadja+	(LBL, SLAC) IJP