N BARYONS
$(S = 0, I = 1/2)$

$p, N^+ = uud; \quad n, N^0 = udd$

MINIREVIEW GOES HERE
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$N(1440)\ P_{11}$

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

$N(1440)$ MASS

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
1430 to 1470 (≈ 1440) OUR ESTIMATE				
1462±10	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
1440±30	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
1410±12	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1465	LI	93	IPWA	$\gamma N \to \pi N$
1471	CUTKOSKY	90	IPWA	$\pi N \to \pi N$
1411	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
1472	[1] BAKER	79	DPWA	$\pi^- p \to n\eta$
1417	BARBOUR	78	DPWA	$\gamma N \to \pi N$
1460	BERENDS	77	IPWA	$\gamma N \to \pi N$
1380	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
1390	[3] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$N(1440)$ WIDTH

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
250 to 450 (≈ 350) OUR ESTIMATE				
391± 34	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
545±170	CUTKOSKY	90	IPWA	$\pi N \to \pi N$
340± 70	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
135± 10	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
315	LI	93	IPWA	$\gamma N \to \pi N$
334	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
113	[1] BAKER	79	DPWA	$\pi^- p \to n\eta$
331	BARBOUR	78	DPWA	$\gamma N \to \pi N$
279	BERENDS	77	IPWA	$\gamma N \to \pi N$
200	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
200	[3] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$N(1440)$ POLE POSITION

REAL PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
1385	[4] HOEHLER	93	SPED	$\pi N \to \pi N$
1360	[5] ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
1370	CUTKOSKY	90	IPWA	$\pi N \to \pi N$
1375±30	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1359	ARNDT	85	DPWA	See ARNDT 91
1381 or 1379	[6] LONGACRE	78	IPWA	$\pi N \to N\pi\pi$
1360 or 1333	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

*CITATION: L. Montanet et al., Physical Review D50, 1173 (1994) and 1995 off-year partial update for the 1996 edition (URL: http://pdg.lbl.gov/)

−2×IMAGINARY PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
164	[4] HOEHLER	93	SPED	$\pi N \to \pi N$
252	[5] ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
228	CUTKOSKY	90	IPWA	$\pi N \to \pi N$
180±40	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
200	ARNDT	85	DPWA	See ARNDT 91
209 or 210	[6] LONGACRE	78	IPWA	$\pi N \to N\pi\pi$
167 or 234	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

N(1440) ELASTIC POLE RESIDUE

MODULUS $|r|$

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
40	HOEHLER	93	SPED	$\pi N \to \pi N$
109	[5] ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
74	CUTKOSKY	90	IPWA	$\pi N \to \pi N$
52±5	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

PHASE θ

VALUE (°)	*DOCUMENT ID*		*TECN*	*COMMENT*
− 93	[5] ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
− 84	CUTKOSKY	90	IPWA	$\pi N \to \pi N$
−100±35	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

N(1440) DECAY MODES

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

	Mode	Fraction (Γ_i/Γ)
Γ_1	$N\pi$	60–70 %
Γ_2	$N\eta$	
Γ_3	$N\pi\pi$	30–40 %
Γ_4	$\Delta\pi$	20–30 %
Γ_5	$\Delta(1232)\pi$, P-wave	
Γ_6	$N\rho$	<8 %
Γ_7	$N\rho$, S=1/2, P-wave	
Γ_8	$N\rho$, S=3/2, P-wave	
Γ_9	$N(\pi\pi)^{I=0}_{S\text{-wave}}$	5–10 %
Γ_{10}	$p\gamma$	0.04–0.07 %
Γ_{11}	$p\gamma$, helicity=1/2	
Γ_{12}	$n\gamma$	0.001–0.05 %
Γ_{13}	$n\gamma$, helicity=1/2	

N(1440) BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ — Γ_1/Γ

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
0.6 to 0.7 OUR ESTIMATE				
0.69±0.03	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
0.68±0.04	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
0.51±0.05	HOEHLER	79	IPWA	$\pi N \to \pi N$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1440) \to N\eta$ — $(\Gamma_1\Gamma_2)^{1/2}/\Gamma$

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
seen	[1] BAKER	79	DPWA	$\pi^- p \to n\eta$
+0.328	[7] FELTESSE	75	DPWA	1488–1745 MeV

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 $N\pi \to N(1440) \to \Delta(1232)\pi$, P-wave $(\Gamma_1\Gamma_5)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.37 to +0.41 OUR ESTIMATE				
+0.39±0.02	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
+0.41	[2,8] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
+0.37	[3] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1440) \to N\rho$, S=1/2, P-wave $(\Gamma_1\Gamma_7)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
±0.07 to ±0.25 OUR ESTIMATE				
−0.11	[2,8] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
+0.23	[3] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1440) \to N\rho$, S=3/2, P-wave $(\Gamma_1\Gamma_8)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.18	[2,8] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1440) \to N(\pi\pi)^{I=0}_{S\text{-wave}}$ $(\Gamma_1\Gamma_9)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
±0.17 to ±0.25 OUR ESTIMATE				
+0.24±0.03	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
−0.18	[2,8] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
−0.23	[3] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

N(1440) PHOTON DECAY AMPLITUDES

$N(1440) \to p\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
−0.072 ±0.009 OUR ESTIMATE				
−0.085 ±0.003	LI	93	IPWA	$\gamma N \to \pi N$
−0.069 ±0.018	CRAWFORD	83	IPWA	$\gamma N \to \pi N$
−0.063 ±0.008	AWAJI	81	DPWA	$\gamma N \to \pi N$
−0.069 ±0.004	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 1)
−0.066 ±0.004	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 2)
−0.079 ±0.009	BRATASHEV...	80	DPWA	$\gamma N \to \pi N$
−0.068 ±0.015	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
−0.0584±0.0148	ISHII	80	DPWA	Compton scattering
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.066 ±0.017	ARNDT	90B	IPWA	See LI 93
−0.064	ARNDT	90B	FIT	See LI 93
−0.129	[9] WADA	84	DPWA	Compton scattering
−0.075 ±0.015	BARBOUR	78	DPWA	$\gamma N \to \pi N$
−0.125	[10] NOELLE	78		$\gamma N \to \pi N$
−0.076	BERENDS	77	IPWA	$\gamma N \to \pi N$
−0.087 ±0.006	FELLER	76	DPWA	$\gamma N \to \pi N$

$N(1440) \to n\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
+0.052±0.025 OUR ESTIMATE				
0.085±0.006	LI	93	IPWA	$\gamma N \to \pi N$
0.037±0.010	AWAJI	81	DPWA	$\gamma N \to \pi N$
0.030±0.003	FUJII	81	DPWA	$\gamma N \to \pi N$
0.023±0.009	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 1)
0.019±0.012	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 2)
0.056±0.015	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
−0.029±0.035	TAKEDA	80	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.050±0.019	ARNDT	90B	IPWA	See LI 93
0.045	ARNDT	90B	FIT	See LI 93
+0.059±0.016	BARBOUR	78	DPWA	$\gamma N \to \pi N$
0.062	[10] NOELLE	78		$\gamma N \to \pi N$

N(1440) FOOTNOTES

[1] BAKER 79 finds a coupling of the $N(1440)$ to the $N\eta$ channel near (but slightly below) threshold.

[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 and HOEHLER 94 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] ARNDT 91 (Soln SM90) also finds a second-sheet pole with real part = 1413 MeV, $-2\times$ imaginary part = 256 MeV, and residue = $(78-153i)$ MeV.

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

[7] An alternative which cannot be distinguished from this is to have a P_{13} resonance with M = 1530 MeV, Γ = 79 MeV, and elasticity = +0.271.

[8] LONGACRE 77 considers this coupling to be well determined.

[9] WADA 84 is inconsistent with other analyses; see the Note on N and Δ Resonances.

[10] Converted to our conventions using M = 1486 MeV, Γ = 613 MeV from NOELLE 78.

N(1440) REFERENCES

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

HOEHLER	94	πN Newsletter 10 (to be pub.)		(KARL)
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
ARNDT	90B	PR C42 1864	+Workman, Li, Roper	(VPI)
CUTKOSKY	90	PR D42 235	+Wang	(CMU)
ARNDT	85	PR D32 1085	+Ford, Roper	(VPI)
WADA	84	NP B247 313	+Egawa, Imanishi, Ishii, Kato, Ukai+	(INUS)
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)
BRATASHEV...	80	NP B166 525	Bratashevskij, Gorbenko, Derebchinskij+	(KFTI)
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
ISHII	80	NP B165 189	+Egawa, Kato, Miyachi+	(KYOT, INUS)
TAKEDA	80	NP B168 17	+Arai, Fujii, Ikeda, Iwasaki+	(TOKY, INUS)
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
BARBOUR	78	NP B141 253	+Crawford, Parsons	(GLAS)
LONGACRE	78	PR D17 1795	+Lasinski, Rosenfeld, Smadja+	(LBL, SLAC)
NOELLE	78	PTP 60 778		(NAGO)
BERENDS	77	NP B136 317	+Donnachie	(LEID, MCHS) 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
FELTESSE	75	NP B93 242	+Ayed, Bareyre, Borgeaud, David+	(SACL) IJP
LONGACRE	75	PL 55B 415	+Rosenfeld, Lasinski, Smadja+	(LBL, SLAC) IJP

$N(1520)\ D_{13}$

$I(J^P) = \frac{1}{2}(\frac{3}{2}^-)$ 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(1520) MASS

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1515 to 1530 (≈ 1520) OUR ESTIMATE				
1524± 4	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
1525±10	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
1519± 4	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1510	LI	93	IPWA	$\gamma N \to \pi N$
1504	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
1503	BARBOUR	78	DPWA	$\gamma N \to \pi N$
1510	BERENDS	77	IPWA	$\gamma N \to \pi N$
1510	[1] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
1520	[2] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

N(1520) WIDTH

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
110 to 135 (≈ 120) OUR ESTIMATE				
124± 8	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
120±15	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
114± 7	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
120	LI	93	IPWA	$\gamma N \to \pi N$
124	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
183	BAKER	79	DPWA	$\pi^- p \to n\eta$
135	BARBOUR	78	DPWA	$\gamma N \to \pi N$
105	BERENDS	77	IPWA	$\gamma N \to \pi N$
110	[1] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
150	[2] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

N(1520) POLE POSITION

REAL PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1510	[3] HOEHLER	93	ARGD	$\pi N \to \pi N$
1511	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
1510±5	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1510	ARNDT	85	DPWA	See ARNDT 91
1514 or 1511	[4] LONGACRE	78	IPWA	$\pi N \to N\pi\pi$
1508 or 1505	[1] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

−2×IMAGINARY PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
120	[3] HOEHLER	93	ARGD	$\pi N \to \pi N$
108	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
114±10	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
122	ARNDT	85	DPWA	See ARNDT 91
146 or 137	[4] LONGACRE	78	IPWA	$\pi N \to N\pi\pi$
109 or 107	[1] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

N(1520) ELASTIC POLE RESIDUE

MODULUS $|r|$

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
32	HOEHLER	93	ARGD	$\pi N \to \pi N$
33	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
35±2	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

PHASE θ

VALUE (°)	DOCUMENT ID		TECN	COMMENT
− 8	HOEHLER	93	ARGD	$\pi N \to \pi N$
−10	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
−12±5	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

$N(1520)$ DECAY MODES

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

	Mode	Fraction (Γ_i/Γ)
Γ_1	$N\pi$	50–60 %
Γ_2	$N\eta$	
Γ_3	$N\pi\pi$	40–50 %
Γ_4	$\Delta\pi$	15–25 %
Γ_5	$\Delta(1232)\pi$, S-wave	5–12 %
Γ_6	$\Delta(1232)\pi$, D-wave	10–14 %
Γ_7	$N\rho$	15–25 %
Γ_8	$N\rho$, S=1/2, D-wave	
Γ_9	$N\rho$, S=3/2, S-wave	
Γ_{10}	$N\rho$, S=3/2, D-wave	
Γ_{11}	$N(\pi\pi)^{I=0}_{S\text{-wave}}$	<8 %
Γ_{12}	$p\gamma$	0.45–0.53 %
Γ_{13}	$p\gamma$, helicity=1/2	
Γ_{14}	$p\gamma$, helicity=3/2	
Γ_{15}	$n\gamma$	0.34–0.48 %
Γ_{16}	$n\gamma$, helicity=1/2	
Γ_{17}	$n\gamma$, helicity=3/2	

$N(1520)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ — Γ_1/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.5 to 0.6 OUR ESTIMATE				
0.59±0.03	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
0.58±0.03	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
0.54±0.03	HOEHLER	79	IPWA	$\pi N \to \pi N$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1520) \to N\eta$ — $(\Gamma_1\Gamma_2)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.02	BAKER	79	DPWA	$\pi^- p \to n\eta$
+0.011	FELTESSE	75	DPWA	Soln A; see BAKER 79

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 $N\pi \to N(1520) \to \Delta(1232)\pi$, S-wave — $(\Gamma_1\Gamma_5)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.26 to −0.20 OUR ESTIMATE				
−0.18±0.05	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
−0.26	[1,5] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
−0.24	[2] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1520) \to \Delta(1232)\pi$, D-wave — $(\Gamma_1\Gamma_6)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.28 to −0.24 OUR ESTIMATE				
−0.29±0.03	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
−0.21	[1,5] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
−0.30	[2] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$(\Gamma_i\Gamma_f)^{½}/\Gamma_{total}$ in $N\pi \rightarrow N(1520) \rightarrow N\rho$, S=3/2, S-wave — $(\Gamma_1\Gamma_9)^{½}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.35 to −0.31 OUR ESTIMATE				
−0.35±0.03	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
−0.35	[1,5] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$
−0.24	[2] LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$

$(\Gamma_i\Gamma_f)^{½}/\Gamma_{total}$ in $N\pi \rightarrow N(1520) \rightarrow N(\pi\pi)^{I=0}_{S\text{-wave}}$ — $(\Gamma_1\Gamma_{11})^{½}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.22 to −0.06 OUR ESTIMATE				
−0.13	[1,5] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$
−0.17	[2] LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$

N(1520) PHOTON DECAY AMPLITUDES

$N(1520) \rightarrow p\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
−0.022 ±0.008 OUR ESTIMATE				
−0.020 ±0.002	LI	93	IPWA	$\gamma N \rightarrow \pi N$
−0.028 ±0.014	CRAWFORD	83	IPWA	$\gamma N \rightarrow \pi N$
−0.007 ±0.004	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
−0.032 ±0.005	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 1)
−0.032 ±0.004	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 2)
−0.031 ±0.009	BRATASHEV...	80	DPWA	$\gamma N \rightarrow \pi N$
−0.019 ±0.007	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
−0.0430±0.0063	ISHII	80	DPWA	Compton scattering
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.025 ±0.009	ARNDT	90B	IPWA	See LI 93
−0.023	ARNDT	90B	FIT	See LI 93
−0.012	WADA	84	DPWA	Compton scattering
−0.016 ±0.008	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$
−0.008	[6] NOELLE	78		$\gamma N \rightarrow \pi N$
−0.021	BERENDS	77	IPWA	$\gamma N \rightarrow \pi N$
−0.005 ±0.005	FELLER	76	DPWA	$\gamma N \rightarrow \pi N$

$N(1520) \rightarrow p\gamma$, helicity-3/2 amplitude $A_{3/2}$

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
+0.163 ±0.007 OUR ESTIMATE				
0.167 ±0.002	LI	93	IPWA	$\gamma N \rightarrow \pi N$
0.156 ±0.022	CRAWFORD	83	IPWA	$\gamma N \rightarrow \pi N$
0.168 ±0.013	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
0.178 ±0.003	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 1)
0.162 ±0.003	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 2)
0.166 ±0.005	BRATASHEV...	80	DPWA	$\gamma N \rightarrow \pi N$
0.167 ±0.010	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
0.1695±0.0014	ISHII	80	DPWA	Compton scattering
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.155 ±0.006	ARNDT	90B	IPWA	See LI 93
0.167	ARNDT	90B	FIT	See LI 93
0.168	WADA	84	DPWA	Compton scattering
+0.157 ±0.007	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$
0.206	[6] NOELLE	78		$\gamma N \rightarrow \pi N$
+0.075	BERENDS	77	IPWA	$\gamma N \rightarrow \pi N$
+0.164 ±0.008	FELLER	76	DPWA	$\gamma N \rightarrow \pi N$

$N(1520) \rightarrow n\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
−0.062±0.006 OUR ESTIMATE				
−0.058±0.003	LI	93	IPWA	$\gamma N \rightarrow \pi N$
−0.066±0.013	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
−0.067±0.004	FUJII	81	DPWA	$\gamma N \rightarrow \pi N$
−0.076±0.006	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 1)
−0.071±0.011	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 2)
−0.056±0.011	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
−0.050±0.014	TAKEDA	80	DPWA	$\gamma N \rightarrow \pi N$

• • • We do not use the following data for averages, fits, limits, etc. • • •

−0.059±0.014	ARNDT	90B	IPWA	See LI 93
−0.063	ARNDT	90B	FIT	See LI 93
−0.055±0.014	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$
−0.060	[6] NOELLE	78		$\gamma N \rightarrow \pi N$

$N(1520) \rightarrow n\gamma$, helicity-3/2 amplitude $A_{3/2}$

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
−0.137±0.013 OUR ESTIMATE				
−0.131±0.003	LI	93	IPWA	$\gamma N \rightarrow \pi N$
−0.124±0.009	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
−0.158±0.003	FUJII	81	DPWA	$\gamma N \rightarrow \pi N$
−0.147±0.008	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 1)
−0.148±0.009	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 2)
−0.144±0.015	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
−0.118±0.011	TAKEDA	80	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.126±0.015	ARNDT	90B	IPWA	See LI 93
−0.135	ARNDT	90B	FIT	See LI 93
−0.141±0.015	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$
−0.127	[6] NOELLE	78		$\gamma N \rightarrow \pi N$

N(1520) FOOTNOTES

[1] 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.

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

[3] See HOEHLER 93 and HOEHLER 94 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.

[4] 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.

[5] LONGACRE 77 considers this coupling to be well determined.

[6] Converted to our conventions using $M = 1528$ MeV, $\Gamma = 187$ MeV from NOELLE 78.

N(1520) REFERENCES

For early references, see Physics Letters **111B** 70 (1982). For very early references, see Reviews of Modern Physics **37** 633 (1965).

HOEHLER	94	πN Newsletter 10 (to be pub.)		(KARL)
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
ARNDT	90B	PR C42 1864	+Workman, Li, Roper	(VPI)
ARNDT	85	PR D32 1085	+Ford, Roper	(VPI)
WADA	84	NP B247 313	+Egawa, Imanishi, Ishii, Kato, Ukai+	(INUS)
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)
BRATASHEV...	80	NP B166 525	Bratashevskij, Gorbenko, Derebchinskij+	(KFTI)
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
ISHII	80	NP B165 189	+Egawa, Kato, Miyachi+	(KYOT, INUS)
TAKEDA	80	NP B168 17	+Arai, Fujii, Ikeda, Iwasaki+	(TOKY, INUS)
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
BARBOUR	78	NP B141 253	+Crawford, Parsons	(GLAS)
LONGACRE	78	PR D17 1795	+Lasinski, Rosenfeld, Smadja+	(LBL, SLAC)
NOELLE	78	PTP 60 778		(NAGO)
BERENDS	77	NP B136 317	+Donnachie	(LEID, MCHS) 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
FELTESSE	75	NP B93 242	+Ayed, Bareyre, Borgeaud, David+	(SACL) IJP
LONGACRE	75	PL 55B 415	+Rosenfeld, Lasinski, Smadja+	(LBL, SLAC) IJP

$N(1535)\ S_{11}$

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

$N(1535)$ MASS

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1520 to 1555 (≈ 1535) OUR ESTIMATE				
1534± 7	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
1550±40	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
1526± 7	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1518	LI	93	IPWA	$\gamma N \to \pi N$
1513	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
1511	BARBOUR	78	DPWA	$\gamma N \to \pi N$
1500	BERENDS	77	IPWA	$\gamma N \to \pi N$
1547± 6	BHANDARI	77	DPWA	Uses $N\eta$ cusp
1520	[1] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
1510	[2] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$N(1535)$ WIDTH

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
100 to 250 (≈ 150) OUR ESTIMATE				
151±27	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
240±80	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
120±20	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
84	LI	93	IPWA	$\gamma N \to \pi N$
136	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
180	BAKER	79	DPWA	$\pi^- p \to n\eta$
132	BARBOUR	78	DPWA	$\gamma N \to \pi N$
57	BERENDS	77	IPWA	$\gamma N \to \pi N$
139±33	BHANDARI	77	DPWA	Uses $N\eta$ cusp
135	[1] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
100	[2] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$N(1535)$ POLE POSITION

REAL PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1487	[3] HOEHLER	93	SPED	$\pi N \to \pi N$
1499	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
1510±50	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1461	ARNDT	85	DPWA	See ARNDT 91
1496 or 1499	[4] LONGACRE	78	IPWA	$\pi N \to N\pi\pi$
1519± 4	BHANDARI	77	DPWA	Uses $N\eta$ cusp
1525 or 1527	[1] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

−2×IMAGINARY PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
110	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
260±80	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
140	ARNDT	85	DPWA	See ARNDT 91
103 or 105	[4] LONGACRE	78	IPWA	$\pi N \to N\pi\pi$
140±32	BHANDARI	77	DPWA	Uses $N\eta$ cusp
135 or 123	[1] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

$N(1535)$ ELASTIC POLE RESIDUE

MODULUS $|r|$

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
23	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
120±40	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$

PHASE θ

VALUE (°)	DOCUMENT ID		TECN	COMMENT
−13	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
+15±45	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$

$N(1535)$ DECAY MODES

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

	Mode	Fraction (Γ_i/Γ)
Γ_1	$N\pi$	35–55 %
Γ_2	$N\eta$	30–55 %
Γ_3	$N\pi\pi$	1–10 %
Γ_4	$\Delta\pi$	<1 %
Γ_5	$\Delta(1232)\pi$, D-wave	
Γ_6	$N\rho$	<4 %
Γ_7	$N\rho$, S=1/2, S-wave	
Γ_8	$N\rho$, S=3/2, D-wave	
Γ_9	$N(\pi\pi)^{I=0}_{S\text{-wave}}$	<3 %
Γ_{10}	$N(1440)\pi$	<7 %
Γ_{11}	$p\gamma$	0.45–0.53 %
Γ_{12}	$p\gamma$, helicity=1/2	
Γ_{13}	$n\gamma$	0.34–0.48 %
Γ_{14}	$n\gamma$, helicity=1/2	

$N(1535)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ — Γ_1/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.35 to 0.55 OUR ESTIMATE				
0.51 ±0.05	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
0.50 ±0.10	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
0.38 ±0.04	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.297±0.026	BHANDARI	77	DPWA	Uses $N\eta$ cusp

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow N(1535) \rightarrow N\eta$ — $(\Gamma_1\Gamma_2)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.44 to +0.50 OUR ESTIMATE				
+0.47±0.02	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
+0.33	BAKER	79	DPWA	$\pi^- p \rightarrow n\eta$
+0.48	FELTESSE	75	DPWA	1488–1745 MeV

Note: Signs of couplings from $\pi N \rightarrow N\pi\pi$ 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 $N\pi \rightarrow N(1535) \rightarrow \Delta(1232)\pi$, D-wave — $(\Gamma_1\Gamma_5)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.04 to +0.06 OUR ESTIMATE				
+0.00±0.04	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
0.00	[1] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$
+0.06	[2] LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow N(1535) \rightarrow N\rho$, S=1/2, S-wave — $(\Gamma_1\Gamma_7)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.14 to −0.06 OUR ESTIMATE				
−0.10±0.03	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
−0.10	[1] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$
−0.09	[2] LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow N(1535) \rightarrow N(\pi\pi)^{I=0}_{S\text{-wave}}$ — $(\Gamma_1\Gamma_9)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.03 to +0.13 OUR ESTIMATE				
+0.07±0.04	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
+0.08	[1] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$
+0.09	[2] LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow N(1535) \rightarrow N(1440)\pi$ — $(\Gamma_1\Gamma_{10})^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.10±0.05	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$

N(1535) PHOTON DECAY AMPLITUDES

$N(1535) \rightarrow p\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
+0.068 ±0.010 OUR ESTIMATE				
0.061 ±0.003	LI	93	IPWA	$\gamma N \rightarrow \pi N$
0.095 ±0.011	[5] BENMERROU..	91		$\gamma p \rightarrow p\eta$
0.053 ±0.015	CRAWFORD	83	IPWA	$\gamma N \rightarrow \pi N$
0.077 ±0.021	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
0.083 ±0.007	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 1)
0.080 ±0.007	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 2)
0.029 ±0.007	BRATASHEV...	80	DPWA	$\gamma N \rightarrow \pi N$
0.065 ±0.016	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
0.0704±0.0091	ISHII	80	DPWA	Compton scattering
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.078	ARNDT	90B	IPWA	See LI 93
0.050	ARNDT	90B	FIT	See LI 93
0.055	WADA	84	DPWA	Compton scattering
+0.082 ±0.019	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$
0.046	[6] NOELLE	78		$\gamma N \rightarrow \pi N$
+0.034	BERENDS	77	IPWA	$\gamma N \rightarrow \pi N$
+0.070 ±0.004	FELLER	76	DPWA	$\gamma N \rightarrow \pi N$

$N(1535) \rightarrow n\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
−0.059±0.022 OUR ESTIMATE				
−0.046±0.005	LI	93	IPWA	$\gamma N \rightarrow \pi N$
0.035±0.014	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
−0.062±0.003	FUJII	81	DPWA	$\gamma N \rightarrow \pi N$
−0.075±0.019	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 1)
−0.075±0.018	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 2)
−0.098±0.026	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
−0.011±0.017	TAKEDA	80	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.050	ARNDT	90B	IPWA	See LI 93
−0.037	ARNDT	90B	FIT	See LI 93
−0.112±0.034	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$
−0.048	[6] NOELLE	78		$\gamma N \rightarrow \pi N$

N(1535) FOOTNOTES

[1] 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.

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

[3] See HOEHLER 93 and HOEHLER 94 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.

[4] 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.

[5] BENMERROUCHE 91 uses an effective Lagrangian approach to analyze η photoproduction data.

[6] Converted to our conventions using $M = 1548$ MeV, $\Gamma = 73$ MeV from NOELLE 78.

N(1535) REFERENCES

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

HOEHLER	94	πN Newsletter 10 (to be pub.)		(KARL)
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
BENMERROU...	91	PRL 67 1070	Benmerrouche, Mukhopadhyay	(RPI)
ARNDT	90B	PR C42 1864	+Workman, Li, Roper	(VPI)
ARNDT	85	PR D32 1085	+Ford, Roper	(VPI)
WADA	84	NP B247 313	+Egawa, Imanishi, Ishii, Kato, Ukai+	(INUS)
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)
BRATASHEV...	80	NP B166 525	Bratashevskij, Gorbenko, Derebchinskij+	(KFTI)
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
ISHII	80	NP B165 189	+Egawa, Kato, Miyachi+	(KYOT, INUS)
TAKEDA	80	NP B168 17	+Arai, Fujii, Ikeda, Iwasaki+	(TOKY, INUS)
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
BARBOUR	78	NP B141 253	+Crawford, Parsons	(GLAS)
LONGACRE	78	PR D17 1795	+Lasinski, Rosenfeld, Smadja+	(LBL, SLAC)
NOELLE	78	PTP 60 778		(NAGO)
BERENDS	77	NP B136 317	+Donnachie	(LEID, MCHS) IJP
BHANDARI	77	PR D15 192	+Chao	(CMU) 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
FELTESSE	75	NP B93 242	+Ayed, Bareyre, Borgeaud, David+	(SACL) IJP
LONGACRE	75	PL 55B 415	+Rosenfeld, Lasinski, Smadja+	(LBL, SLAC) IJP

$N(1650)\ S_{11}$

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

N(1650) MASS

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1640 to 1680 (≈ 1650) OUR ESTIMATE				
1659± 9	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
1650±30	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
1670± 8	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1674	LI	93	IPWA	$\gamma N \rightarrow \pi N$
1688	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
1672	MUSETTE	80	IPWA	$\pi^- p \rightarrow \Lambda K^0$
1680	SAXON	80	DPWA	$\pi^- p \rightarrow \Lambda K^0$
1680	BAKER	78	DPWA	$\pi^- p \rightarrow \Lambda K^0$
1694	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$
1700± 5	[1] BAKER	77	IPWA	$\pi^- p \rightarrow \Lambda K^0$
1680	[1] BAKER	77	DPWA	$\pi^- p \rightarrow \Lambda K^0$
1700	[2] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$
1675	KNASEL	75	DPWA	$\pi^- p \rightarrow \Lambda K^0$
1660	[3] LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$

$N(1650)$ WIDTH

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
145 to 190 (≈ 150) OUR ESTIMATE				
173±12	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
150±40	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
180±20	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
225	LI	93	IPWA	$\gamma N \to \pi N$
183	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
179	MUSETTE	80	IPWA	$\pi^- p \to \Lambda K^0$
120	SAXON	80	DPWA	$\pi^- p \to \Lambda K^0$
90	BAKER	78	DPWA	$\pi^- p \to \Lambda K^0$
193	BARBOUR	78	DPWA	$\gamma N \to \pi N$
130±10	[1] BAKER	77	IPWA	$\pi^- p \to \Lambda K^0$
90	[1] BAKER	77	DPWA	$\pi^- p \to \Lambda K^0$
170	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
170	KNASEL	75	DPWA	$\pi^- p \to \Lambda K^0$
130	[3] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$N(1650)$ POLE POSITION

REAL PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
1670	[4] HOEHLER	93	ARGD	$\pi N \to \pi N$
1657	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
1640±20	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1660	ARNDT	85	DPWA	See ARNDT 91
1648 or 1651	[5] LONGACRE	78	IPWA	$\pi N \to N\pi\pi$
1699 or 1698	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

−2×IMAGINARY PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
163	[4] HOEHLER	93	ARGD	$\pi N \to \pi N$
160	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
150±30	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
122	ARNDT	85	DPWA	See ARNDT 91
117 or 119	[5] LONGACRE	78	IPWA	$\pi N \to N\pi\pi$
174 or 173	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

$N(1650)$ ELASTIC POLE RESIDUE

MODULUS $|r|$

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
39	HOEHLER	93	ARGD	$\pi N \to \pi N$
54	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
60±10	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

PHASE θ

VALUE (°)	DOCUMENT ID		TECN	COMMENT
−37	HOEHLER	93	ARGD	$\pi N \to \pi N$
−38	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
−75±25	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

$N(1650)$ DECAY MODES

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

	Mode	Fraction (Γ_i/Γ)
Γ_1	$N\pi$	60–80 %
Γ_2	$N\eta$	
Γ_3	ΛK	3–11 %
Γ_4	ΣK	
Γ_5	$N\pi\pi$	5–20 %
Γ_6	$\Delta\pi$	3–7 %
Γ_7	$\Delta(1232)\pi$, D-wave	
Γ_8	$N\rho$	4–14 %
Γ_9	$N\rho$, $S=1/2$, S-wave	
Γ_{10}	$N\rho$, $S=3/2$, D-wave	
Γ_{11}	$N(\pi\pi)^{I=0}_{S\text{-wave}}$	<4 %
Γ_{12}	$N(1440)\pi$	<5 %
Γ_{13}	$p\gamma$	0.10–0.18 %
Γ_{14}	$p\gamma$, helicity=1/2	
Γ_{15}	$n\gamma$	0.03–0.18 %
Γ_{16}	$n\gamma$, helicity=1/2	

$N(1650)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ — Γ_1/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.6 to 0.8 OUR ESTIMATE				
0.89±0.07	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
0.65±0.10	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
0.61±0.04	HOEHLER	79	IPWA	$\pi N \to \pi N$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1650) \to N\eta$ — $(\Gamma_1\Gamma_2)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.09	[6] BAKER	79	DPWA	$\pi^- p \to n\eta$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1650) \to \Lambda K$ — $(\Gamma_1\Gamma_3)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.27 to −0.17 OUR ESTIMATE				
−0.22	BELL	83	DPWA	$\pi^- p \to \Lambda K^0$
−0.22	SAXON	80	DPWA	$\pi^- p \to \Lambda K^0$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.25	[7] BAKER	78	DPWA	See SAXON 80
−0.23±0.01	[1] BAKER	77	IPWA	$\pi^- p \to \Lambda K^0$
−0.25	[1] BAKER	77	DPWA	$\pi^- p \to \Lambda K^0$
0.12	KNASEL	75	DPWA	$\pi^- p \to \Lambda K^0$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1650) \to \Sigma K$ — $(\Gamma_1\Gamma_4)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.254	LIVANOS	80	DPWA	$\pi p \to \Sigma K$
0.066 to 0.137	[8] DEANS	75	DPWA	$\pi N \to \Sigma K$
0.20	KNASEL	75	DPWA	

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 $N\pi \to N(1650) \to \Delta(1232)\pi$, D-wave — $(\Gamma_1\Gamma_7)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.15 to 0.23 OUR ESTIMATE				
+0.12±0.04	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
+0.29	[2,9] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
+0.15	[3] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

*CITATION: L. Montanet et al., Physical Review D50, 1173 (1994) and 1995 off-year partial update for the 1996 edition (URL: http://pdg.lbl.gov/)

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1650) \to N\rho$, S=1/2, S-wave $(\Gamma_1\Gamma_9)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
±0.03 to ±0.19 OUR ESTIMATE				
−0.01±0.09	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
+0.17	[2,9] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
−0.16	[3] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1650) \to N\rho$, S=3/2, D-wave $(\Gamma_1\Gamma_{10})^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.17 to +0.29 OUR ESTIMATE				
+0.16±0.06	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
+0.29	[2,9] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1650) \to N(\pi\pi)^{I=0}_{S\text{-wave}}$ $(\Gamma_1\Gamma_{11})^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.04 to +0.18 OUR ESTIMATE				
+0.12±0.08	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
0.00	[2,9] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
+0.25	[3] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1650) \to N(1440)\pi$ $(\Gamma_1\Gamma_{12})^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.11±0.06	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$

$N(1650)$ PHOTON DECAY AMPLITUDES

$N(1650) \to p\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
+0.052±0.017 OUR ESTIMATE				
0.068±0.003	LI	93	IPWA	$\gamma N \to \pi N$
0.033±0.015	CRAWFORD	83	IPWA	$\gamma N \to \pi N$
0.050±0.010	AWAJI	81	DPWA	$\gamma N \to \pi N$
0.065±0.005	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 1)
0.061±0.005	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 2)
0.031±0.017	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.091	WADA	84	DPWA	Compton scattering
+0.048±0.017	BARBOUR	78	DPWA	$\gamma N \to \pi N$
+0.068±0.009	FELLER	76	DPWA	$\gamma N \to \pi N$

$N(1650) \to n\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
−0.011±0.028 OUR ESTIMATE				
−0.002±0.002	LI	93	IPWA	$\gamma N \to \pi N$
−0.008±0.004	AWAJI	81	DPWA	$\gamma N \to \pi N$
0.004±0.004	FUJII	81	DPWA	$\gamma N \to \pi N$
0.010±0.020	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 1)
0.008±0.019	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 2)
−0.068±0.040	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
−0.011±0.011	TAKEDA	80	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.045±0.024	BARBOUR	78	DPWA	$\gamma N \to \pi N$

$N(1650)$ $\gamma p \to \Lambda K^+$ AMPLITUDES

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $p\gamma \to N(1650) \to \Lambda K^+$ (E_{0+} amplitude)

VALUE (units 10^{-3})	DOCUMENT ID		TECN
7.8 ±0.3	WORKMAN	90	DPWA
• • • We do not use the following data for averages, fits, limits, etc. • • •			
8.13	TANABE	89	DPWA

$p\gamma \to N(1650) \to \Lambda K^+$ phase angle θ (E_{0+} amplitude)

VALUE (degrees)	DOCUMENT ID		TECN
−107 ±3	WORKMAN	90	DPWA
• • • We do not use the following data for averages, fits, limits, etc. • • •			
−107.8	TANABE	89	DPWA

N(1650) 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 and HOEHLER 94 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] BAKER 79 fixed this coupling during fitting, but the negative sign relative to the $N(1535)$ is well determined.

[7] The overall phase of BAKER 78 couplings has been changed to agree with previous conventions. Superseded by SAXON 80.

[8] The range given for DEANS 75 is from the four best solutions.

[9] LONGACRE 77 considers this coupling to be well determined.

N(1650) REFERENCES

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

HOEHLER	94	πN Newsletter 10 (to be pub.)		(KARL)
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)
ARNDT	85	PR D32 1085	+Ford, Roper	(VPI)
WADA	84	NP B247 313	+Egawa, Imanishi, Ishii, Kato, Ukai+	(INUS)
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
MUSETTE	80	NC 57A 37		(BRUX) IJP
SAXON	80	NP B162 522	+Baker, Bell, Blissett, Bloodworth+	(RHEL, BRIS) IJP
TAKEDA	80	NP B168 17	+Arai, Fujii, Ikeda, Iwasaki+	(TOKY, INUS)
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
KNASEL	75	PR D11 1	+Lindquist, Nelson+	(CHIC, WUSL, OSU, ANL) IJP
LONGACRE	75	PL 55B 415	+Rosenfeld, Lasinski, Smadja+	(LBL, SLAC) IJP

$N(1675)\ D_{15}$

$I(J^P) = \frac{1}{2}(\frac{5}{2}^-)$ 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).

$N(1675)$ MASS

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
1670 to 1685 (≈ 1675) OUR ESTIMATE				
1676± 2	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
1675±10	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
1679± 8	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1666	LI	93	IPWA	$\gamma N \rightarrow \pi N$
1685	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
1670	SAXON	80	DPWA	$\pi^- p \rightarrow \Lambda K^0$
1680	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$
1650	[1] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$
1660	[2] LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$

$N(1675)$ WIDTH

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
140 to 180 (≈ 150) OUR ESTIMATE				
159± 7	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
160±20	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
120±15	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
136	LI	93	IPWA	$\gamma N \rightarrow \pi N$
191	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
40	SAXON	80	DPWA	$\pi^- p \rightarrow \Lambda K^0$
88	BAKER	79	DPWA	$\pi^- p \rightarrow n\eta$
192	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$
130	[1] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$
150	[2] LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$

$N(1675)$ POLE POSITION

REAL PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
1656	[3] HOEHLER	93	ARGD	$\pi N \rightarrow \pi N$
1655	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
1660±10	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1661	ARNDT	85	DPWA	See ARNDT 91
1663 or 1668	[4] LONGACRE	78	IPWA	$\pi N \rightarrow N\pi\pi$
1649 or 1650	[1] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$

−2×IMAGINARY PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
126	[3] HOEHLER	93	ARGD	$\pi N \rightarrow \pi N$
124	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
140±10	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
142	ARNDT	85	DPWA	See ARNDT 91
146 or 171	[4] LONGACRE	78	IPWA	$\pi N \rightarrow N\pi\pi$
127 or 127	[1] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$

$N(1675)$ ELASTIC POLE RESIDUE

MODULUS $|r|$

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
23	HOEHLER	93	ARGD	$\pi N \rightarrow \pi N$
28	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
31±5	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$

*CITATION: L. Montanet et al., Physical Review D50, 1173 (1994) and 1995 off-year partial update for the 1996 edition (URL: http://pdg.lbl.gov/)

PHASE θ

VALUE (°)	DOCUMENT ID		TECN	COMMENT
−22	HOEHLER	93	ARGD	$\pi N \to \pi N$
−17	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
−30±10	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

$N(1675)$ DECAY MODES

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

	Mode	Fraction (Γ_i/Γ)
Γ_1	$N\pi$	40–50 %
Γ_2	$N\eta$	
Γ_3	ΛK	<1 %
Γ_4	ΣK	
Γ_5	$N\pi\pi$	50–60 %
Γ_6	$\Delta\pi$	50–60 %
Γ_7	$\Delta(1232)\pi$, D-wave	
Γ_8	$\Delta(1232)\pi$, G-wave	
Γ_9	$N\rho$	< 1–3 %
Γ_{10}	$N\rho$, S=1/2, D-wave	
Γ_{11}	$N\rho$, S=3/2, D-wave	
Γ_{12}	$N\rho$, S=3/2, G-wave	
Γ_{13}	$N(\pi\pi)^{I=0}_{S\text{-wave}}$	
Γ_{14}	$p\gamma$	0.005–0.014 %
Γ_{15}	$p\gamma$, helicity=1/2	
Γ_{16}	$p\gamma$, helicity=3/2	
Γ_{17}	$n\gamma$	0.07–0.11 %
Γ_{18}	$n\gamma$, helicity=1/2	
Γ_{19}	$n\gamma$, helicity=3/2	

$N(1675)$ BRANCHING RATIOS

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.4 to 0.5 OUR ESTIMATE				
0.47±0.02	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
0.38±0.05	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
0.38±0.03	HOEHLER	79	IPWA	$\pi N \to \pi N$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \to N(1675) \to N\eta$ — $(\Gamma_1\Gamma_2)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.07	BAKER	79	DPWA	$\pi^- p \to n\eta$
+0.009	FELTESSE	75	DPWA	Soln A; see BAKER 79

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \to N(1675) \to \Lambda K$ — $(\Gamma_1\Gamma_3)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
±0.04 to ±0.08 OUR ESTIMATE				
−0.01	BELL	83	DPWA	$\pi^- p \to \Lambda K^0$
+0.036	[5] SAXON	80	DPWA	$\pi^- p \to \Lambda K^0$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.034±0.006	DEVENISH	74B		Fixed-t dispersion rel.

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \to N(1675) \to \Sigma K$ — $(\Gamma_1\Gamma_4)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<0.003	[6] 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 $N\pi \rightarrow N(1675) \rightarrow \Delta(1232)\pi$, D-wave $\qquad (\Gamma_1\Gamma_7)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.46 to +0.50 OUR ESTIMATE				
+0.496±0.003	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
+0.46	[1,7] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$
+0.50	[2] LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
+0.5	[8] NOVOSELLER	78	IPWA	$\pi N \rightarrow N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow N(1675) \rightarrow N\rho$, S=1/2, D-wave $\qquad (\Gamma_1\Gamma_{10})^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.04±0.02	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow N(1675) \rightarrow N\rho$, S=3/2, D-wave $\qquad (\Gamma_1\Gamma_{11})^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.12 to −0.06 OUR ESTIMATE				
−0.03±0.02	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
−0.15	[1,7] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow N(1675) \rightarrow N(\pi\pi)^{I=0}_{S\text{-wave}}$ $\qquad (\Gamma_1\Gamma_{13})^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.03	[1,7] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$

N(1675) PHOTON DECAY AMPLITUDES

$N(1675) \rightarrow p\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
+0.018±0.010 OUR ESTIMATE				
0.012±0.002	LI	93	IPWA	$\gamma N \rightarrow \pi N$
0.021±0.011	CRAWFORD	83	IPWA	$\gamma N \rightarrow \pi N$
0.034±0.005	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
0.006±0.005	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 1)
0.006±0.004	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 2)
0.023±0.015	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
+0.022±0.010	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$
+0.034±0.004	FELLER	76	DPWA	$\gamma N \rightarrow \pi N$

$N(1675) \rightarrow p\gamma$, helicity-3/2 amplitude $A_{3/2}$

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
+0.018±0.009 OUR ESTIMATE				
0.021±0.002	LI	93	IPWA	$\gamma N \rightarrow \pi N$
0.015±0.009	CRAWFORD	83	IPWA	$\gamma N \rightarrow \pi N$
0.024±0.008	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
0.030±0.004	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 1)
0.029±0.004	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 2)
0.003±0.012	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
+0.015±0.006	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$
+0.019±0.009	FELLER	76	DPWA	$\gamma N \rightarrow \pi N$

$N(1675) \rightarrow n\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
−0.050±0.014 OUR ESTIMATE				
−0.060±0.003	LI	93	IPWA	$\gamma N \rightarrow \pi N$
−0.057±0.024	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
−0.033±0.004	FUJII	81	DPWA	$\gamma N \rightarrow \pi N$
−0.039±0.017	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 1)
−0.025±0.027	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 2)
−0.059±0.015	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
−0.021±0.011	TAKEDA	80	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.066±0.020	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$

$N(1675) \rightarrow n\gamma$, helicity-3/2 amplitude $A_{3/2}$

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
−0.070±0.006 OUR ESTIMATE				
−0.074±0.003	LI	93	IPWA	$\gamma N \rightarrow \pi N$
−0.077±0.018	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
−0.069±0.004	FUJII	81	DPWA	$\gamma N \rightarrow \pi N$
−0.066±0.026	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 1)
−0.071±0.022	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 2)
−0.059±0.020	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
−0.030±0.012	TAKEDA	80	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.073±0.014	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$

$N(1675)$ FOOTNOTES

[1] 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.

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

[3] See HOEHLER 93 and HOEHLER 94 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.

[4] 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.

[5] SAXON 80 finds the coupling phase is near 90°.

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

[7] LONGACRE 77 considers this coupling to be well determined.

[8] A Breit-Wigner fit to the HERNDON 75 IPWA.

$N(1675)$ REFERENCES

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

HOEHLER	94	πN Newsletter 10 (to be pub.)		(KARL)
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
ARNDT	85	PR D32 1085	+Ford, Roper	(VPI)
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
SAXON	80	NP B162 522	+Baker, Bell, Blissett, Bloodworth+	(RHEL, BRIS) IJP
TAKEDA	80	NP B168 17	+Arai, Fujii, Ikeda, Iwasaki+	(TOKY, INUS)
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
BARBOUR	78	NP B141 253	+Crawford, Parsons	(GLAS)
LONGACRE	78	PR D17 1795	+Lasinski, Rosenfeld, Smadja+	(LBL, SLAC)
NOVOSELLER	78	NP B137 509		(CIT) IJP
Also	78B	NP B137 445	Novoseller	(CIT) 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
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
HERNDON	75	PR D11 3183	+Longacre, Miller, Rosenfeld+	(LBL, SLAC)
LONGACRE	75	PL 55B 415	+Rosenfeld, Lasinski, Smadja+	(LBL, SLAC) IJP
DEVENISH	74B	NP B81 330	+Froggatt, Martin	(DESY, NORD, LOUC)

$N(1680)\ F_{15}$

$I(J^P) = \frac{1}{2}(\frac{5}{2}^+)$ 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(1680) MASS

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
1675 to 1690 (≈ 1680) OUR ESTIMATE				
1684± 4	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
1680±10	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
1684± 3	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1682	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
1680	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$
1660	[1] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$
1685	KNASEL	75	DPWA	$\pi^- p \rightarrow \Lambda K^0$
1670	[2] LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$

N(1680) WIDTH

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
120 to 140 (≈ 130) OUR ESTIMATE				
139± 8	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
120±10	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
128± 8	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
121	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
119	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$
150	[1] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$
155	KNASEL	75	DPWA	$\pi^- p \rightarrow \Lambda K^0$
130	[2] LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$

N(1680) POLE POSITION

REAL PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
1673	[3] HOEHLER	93	ARGD	$\pi N \rightarrow \pi N$
1670	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
1667±5	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1680	ARNDT	85	DPWA	See ARNDT 91
1668 or 1674	[4] LONGACRE	78	IPWA	$\pi N \rightarrow N\pi\pi$
1656 or 1653	[1] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$

−2×IMAGINARY PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
135	[3] HOEHLER	93	ARGD	$\pi N \rightarrow \pi N$
116	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
110±10	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
120	ARNDT	85	DPWA	See ARNDT 91
132 or 137	[4] LONGACRE	78	IPWA	$\pi N \rightarrow N\pi\pi$
145 or 143	[1] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$

N(1680) ELASTIC POLE RESIDUE

MODULUS $|r|$

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
44	HOEHLER	93	ARGD	$\pi N \rightarrow \pi N$
37	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
34±2	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$

*CITATION: L. Montanet et al., Physical Review D50, 1173 (1994) and 1995 off-year partial update for the 1996 edition (URL: http://pdg.lbl.gov/)

PHASE θ

VALUE (°)	DOCUMENT ID		TECN	COMMENT
−17	HOEHLER	93	ARGD	$\pi N \to \pi N$
−14	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
-25 ± 5	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

$N(1680)$ DECAY MODES

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

	Mode	Fraction (Γ_i/Γ)
Γ_1	$N\pi$	60–70 %
Γ_2	$N\eta$	
Γ_3	ΛK	
Γ_4	ΣK	
Γ_5	$N\pi\pi$	30–40 %
Γ_6	$\Delta\pi$	5–15 %
Γ_7	$\Delta(1232)\pi$, P-wave	6–14 %
Γ_8	$\Delta(1232)\pi$, F-wave	<2 %
Γ_9	$N\rho$	3–15 %
Γ_{10}	$N\rho$, S=1/2, F-wave	
Γ_{11}	$N\rho$, S=3/2, P-wave	<12 %
Γ_{12}	$N\rho$, S=3/2, F-wave	1–5 %
Γ_{13}	$N(\pi\pi)^{I=0}_{S\text{-wave}}$	5–20 %
Γ_{14}	$p\gamma$	0.21–0.35 %
Γ_{15}	$p\gamma$, helicity=1/2	
Γ_{16}	$p\gamma$, helicity=3/2	
Γ_{17}	$n\gamma$	0.02–0.04 %
Γ_{18}	$n\gamma$, helicity=1/2	
Γ_{19}	$n\gamma$, helicity=3/2	

$N(1680)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ — Γ_1/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.6 to 0.7 OUR ESTIMATE				
0.70 ± 0.03	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
0.62 ± 0.05	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
0.65 ± 0.02	HOEHLER	79	IPWA	$\pi N \to \pi N$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1680) \to N\eta$ — $(\Gamma_1\Gamma_2)^{1/2}/\Gamma$

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

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

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.0005 or 0.001	[5] CARRERAS	70	MPWA	t pole + resonance
0.0004	[5] BOTKE	69	MPWA	t pole + resonance
$0.003\ \pm0.002$	[5] DEANS	69	MPWA	t pole + resonance

$\Gamma(N\eta)/\Gamma(N\pi)$ — Γ_2/Γ_1

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<0.027	HEUSCH	66	RVUE	π^0, η photoproduction

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1680) \to \Lambda K$ — $(\Gamma_1\Gamma_3)^{1/2}/\Gamma$

Coupling to ΛK not required in the analyses of BAKER 77, SAXON 80, or BELL 83.

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.01	KNASEL	75	DPWA	$\pi^- p \to \Lambda K^0$
-0.009 ± 0.009	DEVENISH	74B		Fixed-t dispersion rel.

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1680) \to \Sigma K$ $(\Gamma_1\Gamma_4)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<0.001	[6] 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 $N\pi \to N(1680) \to \Delta(1232)\pi$, P-wave $(\Gamma_1\Gamma_7)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.31 to −0.21 OUR ESTIMATE				
−0.26±0.04	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
−0.27	[1,7] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
−0.25	[2] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.38	[8] NOVOSELLER	78	IPWA	$\pi N \to N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1680) \to \Delta(1232)\pi$, F-wave $(\Gamma_1\Gamma_8)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.03 to +0.11 OUR ESTIMATE				
+0.07±0.03	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
+0.07	[1,7] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
+0.08	[2] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
+0.05	[8] NOVOSELLER	78	IPWA	$\pi N \to N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1680) \to N\rho$, S=3/2, P-wave $(\Gamma_1\Gamma_{11})^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.30 to −0.10 OUR ESTIMATE				
−0.20±0.05	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
−0.23	[1,7] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
−0.30	[2] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.34	[8] NOVOSELLER	78	IPWA	$\pi N \to N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1680) \to N\rho$, S=3/2, F-wave $(\Gamma_1\Gamma_{12})^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.18 to −0.10 OUR ESTIMATE				
−0.13±0.03	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
−0.15	[1,7] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1680) \to N(\pi\pi)^{I=0}_{S\text{-wave}}$ $(\Gamma_1\Gamma_{13})^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.25 to +0.35 OUR ESTIMATE				
+0.29±0.04	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
+0.31	[1,7] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
+0.30	[2] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
+0.42	[8] NOVOSELLER	78	IPWA	$\pi N \to N\pi\pi$

$N(1680)$ PHOTON DECAY AMPLITUDES

$N(1680) \to p\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
−0.014±0.008 OUR ESTIMATE				
−0.006±0.002	LI	93	IPWA	$\gamma N \to \pi N$
−0.017±0.018	CRAWFORD	83	IPWA	$\gamma N \to \pi N$
−0.009±0.006	AWAJI	81	DPWA	$\gamma N \to \pi N$
−0.028±0.003	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 1)
−0.026±0.003	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 2)
−0.018±0.014	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.005±0.015	BARBOUR	78	DPWA	$\gamma N \to \pi N$
−0.009±0.002	FELLER	76	DPWA	$\gamma N \to \pi N$

$N(1680) \to p\gamma$, helicity-3/2 amplitude $A_{3/2}$

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
+0.135±0.017 OUR ESTIMATE				
0.154±0.002	LI	93	IPWA	$\gamma N \to \pi N$
0.132±0.010	CRAWFORD	83	IPWA	$\gamma N \to \pi N$
0.115±0.008	AWAJI	81	DPWA	$\gamma N \to \pi N$
0.115±0.003	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 1)
0.122±0.003	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 2)
0.141±0.014	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
+0.138±0.021	BARBOUR	78	DPWA	$\gamma N \to \pi N$
+0.121±0.010	FELLER	76	DPWA	$\gamma N \to \pi N$

$N(1680) \to n\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
+0.027±0.010 OUR ESTIMATE				
0.022±0.002	LI	93	IPWA	$\gamma N \to \pi N$
0.017±0.014	AWAJI	81	DPWA	$\gamma N \to \pi N$
0.032±0.003	FUJII	81	DPWA	$\gamma N \to \pi N$
0.026±0.005	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 1)
0.028±0.014	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 2)
0.044±0.012	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
0.025±0.010	TAKEDA	80	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
+0.037±0.010	BARBOUR	78	DPWA	$\gamma N \to \pi N$

$N(1680) \to n\gamma$, helicity-3/2 amplitude $A_{3/2}$

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
+0.035±0.011 OUR ESTIMATE				
−0.048±0.002	LI	93	IPWA	$\gamma N \to \pi N$
−0.033±0.013	AWAJI	81	DPWA	$\gamma N \to \pi N$
−0.023±0.005	FUJII	81	DPWA	$\gamma N \to \pi N$
−0.024±0.009	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 1)
−0.029±0.017	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 2)
−0.033±0.015	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
−0.035±0.012	TAKEDA	80	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.038±0.018	BARBOUR	78	DPWA	$\gamma N \to \pi N$

$N(1680)$ FOOTNOTES

[1] 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.

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

[3] See HOEHLER 93 and HOEHLER 94 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.

[4] 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.

[5] The parametrization used may be double counting.

[6] The range given is from 3 of 4 best solutions; not present in solution 1. DEANS 75 disagrees with $\pi^+ p \to \Sigma^+ K^+$ data of WINNIK 77 around 1920 MeV.

[7] LONGACRE 77 considers this coupling to be well determined.

[8] A Breit-Wigner fit to the HERNDON 75 IPWA.

N(1680) REFERENCES

For early references, see Physics Letters **111B** 70 (1982). For very early references, see Reviews of Modern Physics **37** 633 (1965).

HOEHLER	94	πN Newsletter 10 (to be pub.)		(KARL)
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
ARNDT	85	PR D32 1085	+Ford, Roper	(VPI)
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
SAXON	80	NP B162 522	+Baker, Bell, Blissett, Bloodworth+	(RHEL, BRIS) IJP
TAKEDA	80	NP B168 17	+Arai, Fujii, Ikeda, Iwasaki+	(TOKY, INUS)
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
BARBOUR	78	NP B141 253	+Crawford, Parsons	(GLAS)
LONGACRE	78	PR D17 1795	+Lasinski, Rosenfeld, Smadja+	(LBL, SLAC)
NOVOSELLER	78	NP B137 509		(CIT) IJP
Also	78B	NP B137 445	Novoseller	(CIT) IJP
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
FELLER	76	NP B104 219	+Fukushima, Horikawa, Kajikawa+	(NAGO, OSAK) IJP
DEANS	75	NP B96 90	+Mitchell, Montgomery+	(SFLA, ALAH) IJP
HERNDON	75	PR D11 3183	+Longacre, Miller, Rosenfeld+	(LBL, SLAC)
KNASEL	75	PR D11 1	+Lindquist, Nelson+	(CHIC, WUSL, OSU, ANL) IJP
LONGACRE	75	PL 55B 415	+Rosenfeld, Lasinski, Smadja+	(LBL, SLAC) IJP
DEVENISH	74B	NP B81 330	+Froggatt, Martin	(DESY, NORD, LOUC)
CARRERAS	70	NP B16 35	+Donnachie	(DARE, MCHS)
BOTKE	69	PR 180 1417		(UCSB)
DEANS	69	PR 185 1797	+Wooten	(SFLA)
HEUSCH	66	PRL 17 1019	+Prescott, Dashen	(CIT)

$N(1700)\ D_{13}$

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

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

N(1700) MASS

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1650 to 1750 (≈ 1700) OUR ESTIMATE				
1737±44	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
1675±25	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
1731±15	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1709	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
1650	SAXON	80	DPWA	$\pi^- p \to \Lambda K^0$
1690 to 1710	BAKER	78	DPWA	$\pi^- p \to \Lambda K^0$
1719	BARBOUR	78	DPWA	$\gamma N \to \pi N$
1670±10	[1] BAKER	77	IPWA	$\pi^- p \to \Lambda K^0$
1690	[1] BAKER	77	DPWA	$\pi^- p \to \Lambda K^0$
1660	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
1710	[3] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

N(1700) WIDTH

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
50 to 150 (≈ 100) OUR ESTIMATE				
250±220	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
90± 40	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
110± 30	HOEHLER	79	IPWA	$\pi N \to \pi N$

• • • We do not use the following data for averages, fits, limits, etc. • • •

166	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
70	SAXON	80	DPWA	$\pi^- p \rightarrow \Lambda K^0$
70 to 100	BAKER	78	DPWA	$\pi^- p \rightarrow \Lambda K^0$
126	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$
90± 25	[1] BAKER	77	IPWA	$\pi^- p \rightarrow \Lambda K^0$
100	[1] BAKER	77	DPWA	$\pi^- p \rightarrow \Lambda K^0$
600	[2] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$
300	[3] LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$

N(1700) POLE POSITION

REAL PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1700	[4] HOEHLER	93	SPED	$\pi N \rightarrow \pi N$
1660±30	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
not seen	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
1670	ARNDT	85	DPWA	See ARNDT 91
1710 or 1678	[5] LONGACRE	78	IPWA	$\pi N \rightarrow N\pi\pi$
1616 or 1613	[2] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$

−2×IMAGINARY PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
120	[4] HOEHLER	93	SPED	$\pi N \rightarrow \pi N$
90±40	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
not seen	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
80	ARNDT	85	DPWA	See ARNDT 91
607 or 567	[5] LONGACRE	78	IPWA	$\pi N \rightarrow N\pi\pi$
577 or 575	[2] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$

N(1700) ELASTIC POLE RESIDUE

MODULUS $|r|$

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
5	HOEHLER	93	SPED	$\pi N \rightarrow \pi N$
6±3	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$

PHASE θ

VALUE (°)	*DOCUMENT ID*		*TECN*	*COMMENT*
0±50	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$

N(1700) DECAY MODES

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

	Mode	Fraction (Γ_i/Γ)
Γ_1	$N\pi$	5–15 %
Γ_2	$N\eta$	
Γ_3	ΛK	<3 %
Γ_4	ΣK	
Γ_5	$N\pi\pi$	85–95 %
Γ_6	$\Delta\pi$	
Γ_7	$\Delta(1232)\pi$, S-wave	
Γ_8	$\Delta(1232)\pi$, D-wave	
Γ_9	$N\rho$	<35 %

Γ_{10}	$N\rho$, S=1/2, D-wave	
Γ_{11}	$N\rho$, S=3/2, S-wave	
Γ_{12}	$N\rho$, S=3/2, D-wave	
Γ_{13}	$N(\pi\pi)^{I=0}_{S\text{-wave}}$	
Γ_{14}	$p\gamma$	$\sim$ 0.01 %
Γ_{15}	$p\gamma$, helicity=1/2	
Γ_{16}	$p\gamma$, helicity=3/2	
Γ_{17}	$n\gamma$	
Γ_{18}	$n\gamma$, helicity=1/2	
Γ_{19}	$n\gamma$, helicity=3/2	

N(1700) BRANCHING RATIOS

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.05 to 0.15 OUR ESTIMATE				
0.01±0.02	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
0.11±0.05	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
0.08±0.03	HOEHLER	79	IPWA	$\pi N \to \pi N$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \to N(1700) \to \Lambda K$ — $(\Gamma_1\Gamma_3)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.06 to +0.04 OUR ESTIMATE				
−0.012	BELL	83	DPWA	$\pi^- p \to \Lambda K^0$
−0.012	SAXON	80	DPWA	$\pi^- p \to \Lambda K^0$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.04	[6] BAKER	78	DPWA	See SAXON 80
−0.03 ±0.004	[1] BAKER	77	IPWA	$\pi^- p \to \Lambda K^0$
−0.03	[1] BAKER	77	DPWA	$\pi^- p \to \Lambda K^0$
+0.026±0.019	DEVENISH	74B		Fixed-t dispersion rel.

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \to N(1700) \to \Sigma K$ — $(\Gamma_1\Gamma_4)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
not seen	LIVANOS	80	DPWA	$\pi p \to \Sigma K$
<0.017	[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 $\Delta(1232)\pi$.

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \to N(1700) \to \Delta(1232)\pi$, S-wave — $(\Gamma_1\Gamma_7)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
0.00 to ±0.08 OUR ESTIMATE				
+0.02±0.03	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
0.00	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
−0.16	[3] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \to N(1700) \to \Delta(1232)\pi$, D-wave — $(\Gamma_1\Gamma_8)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
±0.04 to ±0.20 OUR ESTIMATE				
+0.10±0.09	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
−0.12	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
+0.14	[3] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \to N(1700) \to N\rho$, S=3/2, S-wave — $(\Gamma_1\Gamma_{11})^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
±0.01 to ±0.13 OUR ESTIMATE				
−0.04±0.06	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
−0.07	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
+0.07	[3] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow N(1700) \rightarrow N(\pi\pi)^{I=0}_{S\text{-wave}}$ — $(\Gamma_1\Gamma_{13})^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
±0.02 to ±0.28 OUR ESTIMATE				
+0.02±0.02	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
0.00	[2] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$
+0.2	[3] LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$

N(1700) PHOTON DECAY AMPLITUDES

$N(1700) \rightarrow p\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
−0.017±0.012 OUR ESTIMATE				
−0.016±0.014	CRAWFORD	83	IPWA	$\gamma N \rightarrow \pi N$
−0.002±0.013	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
−0.028±0.007	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 1)
−0.029±0.006	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 2)
−0.024±0.019	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.033±0.021	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$
−0.014±0.025	FELLER	76	DPWA	$\gamma N \rightarrow \pi N$

$N(1700) \rightarrow p\gamma$, helicity-3/2 amplitude $A_{3/2}$

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
+0.002±0.020 OUR ESTIMATE				
−0.009±0.012	CRAWFORD	83	IPWA	$\gamma N \rightarrow \pi N$
0.029±0.014	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
−0.002±0.005	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 1)
0.014±0.005	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 2)
−0.017±0.014	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.014±0.025	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$
0.0 ±0.014	FELLER	76	DPWA	$\gamma N \rightarrow \pi N$

$N(1700) \rightarrow n\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
0.001±0.043 OUR ESTIMATE				
0.006±0.024	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
−0.002±0.013	FUJII	81	DPWA	$\gamma N \rightarrow \pi N$
−0.052±0.030	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 1)
−0.055±0.030	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 2)
0.052±0.035	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
+0.050±0.042	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$

$N(1700) \rightarrow n\gamma$, helicity-3/2 amplitude $A_{3/2}$

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
−0.003±0.038 OUR ESTIMATE				
−0.033±0.017	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
0.018±0.018	FUJII	81	DPWA	$\gamma N \rightarrow \pi N$
−0.037±0.036	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 1)
−0.035±0.024	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 2)
0.041±0.030	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
+0.035±0.030	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$

N(1700) $\gamma p \rightarrow \Lambda K^+$ AMPLITUDES

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $p\gamma \rightarrow N(1700) \rightarrow \Lambda K^+$ — (E_{2-} amplitude)

VALUE (units 10^{-3})	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •			
4.09	TANABE	89	DPWA

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $p\gamma \to N(1700) \to \Lambda K^+$ (M_{2-} amplitude)

VALUE (units 10^{-3})	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •			
−7.09	TANABE	89	DPWA

$p\gamma \to N(1700) \to \Lambda K^+$ phase angle θ (E_{2-} amplitude)

VALUE (degrees)	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •			
−35.9	TANABE	89	DPWA

N(1700) 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 and HOEHLER 94 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 couplings has been changed to agree with previous conventions.

[7] The range given is from the four best solutions.

N(1700) REFERENCES

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

HOEHLER	94	πN Newsletter 10 (to be pub.)		(KARL)
HOEHLER	93	πN Newsletter 9 1		(KARL)
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
TANABE	89	PR C39 741	+Kohno, Bennhold	(MANZ)
Also	89	NC 102A 193	Kohno, Tanabe, Bennhold	(MANZ)
ARNDT	85	PR D32 1085	+Ford, Roper	(VPI)
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
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
LONGACRE	75	PL 55B 415	+Rosenfeld, Lasinski, Smadja+	(LBL, SLAC) IJP
DEVENISH	74B	NP B81 330	+Froggatt, Martin	(DESY, NORD, LOUC)

$N(1710)$ 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.

$N(1710)$ 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. • • •				
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	[1] BAKER	77	IPWA	$\pi^- p \to \Lambda K^0$
1650	[1] BAKER	77	DPWA	$\pi^- p \to \Lambda K^0$
1720	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
1670	KNASEL	75	DPWA	$\pi^- p \to \Lambda K^0$
1710	[3] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$N(1710)$ 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. • • •				
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	$\gamma N \to \pi N$
160± 6	[1] BAKER	77	IPWA	$\pi^- p \to \Lambda K^0$
95	[1] BAKER	77	DPWA	$\pi^- p \to \Lambda K^0$
120	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
174	KNASEL	75	DPWA	$\pi^- p \to \Lambda K^0$
75	[3] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$N(1710)$ POLE POSITION

REAL PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
1690	[4] HOEHLER	93	SPED	$\pi N \to \pi N$
1636	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
1698	CUTKOSKY	90	IPWA	$\pi N \to \pi N$
1690±20	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1708 or 1712	[5] LONGACRE	78	IPWA	$\pi N \to N\pi\pi$
1720 or 1711	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

*CITATION: L. Montanet et al., Physical Review D50, 1173 (1994) and 1995 off-year partial update for the 1996 edition (URL: http://pdg.lbl.gov/)

−2×IMAGINARY PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
200	[4] HOEHLER	93	SPED	$\pi N \rightarrow \pi N$
544	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
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. • • •				
17 or 22	[5] LONGACRE	78	IPWA	$\pi N \rightarrow N \pi \pi$
123 or 115	[2] LONGACRE	77	IPWA	$\pi N \rightarrow N \pi \pi$

N(1710) ELASTIC POLE RESIDUE

MODULUS |*r*|

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
15	HOEHLER	93	SPED	$\pi N \rightarrow \pi N$
149	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
9	CUTKOSKY	90	IPWA	$\pi N \rightarrow \pi N$
8±2	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$

PHASE θ

VALUE (°)	DOCUMENT ID		TECN	COMMENT
149	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
−167	CUTKOSKY	90	IPWA	$\pi N \rightarrow \pi N$
175±35	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$

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}	$p\gamma$, helicity=1/2	
Γ_{13}	$n\gamma$, helicity=1/2	

N(1710) BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{\text{total}}$ $\qquad\Gamma_1/\Gamma$

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	$\pi N \rightarrow \pi N$

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

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	[6] BAKER	78	DPWA	See SAXON 80
−0.05±0.03	[1] BAKER	77	IPWA	$\pi^- p \to \Lambda K^0$
−0.10	[1] 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	[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 $N\pi \to N(1710) \to \Delta(1232)\pi$, 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	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
+0.20	[3] 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	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
−0.20	[3] 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	[2] 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	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
−0.28	[3] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$N(1710)$ PHOTON DECAY AMPLITUDES

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

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
−0.006±0.027 OUR ESTIMATE				
−0.037±0.002	LI	93	IPWA	$\gamma N \to \pi N$
0.006±0.018	CRAWFORD	83	IPWA	$\gamma N \to \pi N$
0.028±0.009	AWAJI	81	DPWA	$\gamma N \to \pi N$
−0.009±0.006	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 1)
−0.012±0.005	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 2)
0.015±0.025	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
+0.001±0.039	BARBOUR	78	DPWA	$\gamma N \to \pi N$
+0.053±0.019	FELLER	76	DPWA	$\gamma N \to \pi N$

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

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
+0.016±0.029 OUR ESTIMATE				
0.052±0.003	LI	93	IPWA	$\gamma N \to \pi N$
0.000±0.018	AWAJI	81	DPWA	$\gamma N \to \pi N$
−0.001±0.003	FUJII	81	DPWA	$\gamma N \to \pi N$
0.005±0.013	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 1)
0.011±0.021	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 2)
−0.017±0.020	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.028±0.045	BARBOUR	78	DPWA	$\gamma N \to \pi N$

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

$(\Gamma_i\Gamma_f)^{½}/\Gamma_{total}$ in $p\gamma \to N(1710) \to \Lambda K^+$ (M_{1-} amplitude)

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

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

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

$N(1710)$ 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 and HOEHLER 94 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 couplings has been changed to agree with previous conventions.

[7] The range given for DEANS 75 is from the four best solutions.

$N(1710)$ REFERENCES

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

HOEHLER	94	πN Newsletter 10 (to be pub.)		(KARL)
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

$N(1720)\ P_{13}$

$I(J^P) = \frac{1}{2}(\frac{3}{2}^+)$ 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. • • •				
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. • • •				
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	$\pi^- p \to \Lambda K^0$
285	BARBOUR	78	DPWA	$\gamma N \to \pi N$
200± 50	[1] BAKER	77	IPWA	$\pi^- p \to \Lambda K^0$
500	[1] BAKER	77	DPWA	$\pi^- p \to \Lambda K^0$
130	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
327	KNASEL	75	DPWA	$\pi^- p \to \Lambda K^0$
150	[3] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$N(1720)$ POLE POSITION

REAL PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
1686	[4] HOEHLER	93	SPED	$\pi N \rightarrow \pi N$
1675	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
1680±30	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1705	ARNDT	85	DPWA	See ARNDT 91
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
187	[4] HOEHLER	93	SPED	$\pi N \rightarrow \pi N$
114	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
120±40	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
80	ARNDT	85	DPWA	See ARNDT 91
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
15	HOEHLER	93	SPED	$\pi N \rightarrow \pi N$
11	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
8±2	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$

PHASE θ

VALUE (°)	DOCUMENT ID		TECN	COMMENT
−130	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
−160±30	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$

$N(1720)$ 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}	$p\gamma$	0.01–0.06 %
Γ_{13}	$p\gamma$, helicity=1/2	
Γ_{14}	$p\gamma$, helicity=3/2	
Γ_{15}	$n\gamma$	
Γ_{16}	$n\gamma$, helicity=1/2	
Γ_{17}	$n\gamma$, helicity=3/2	

$N(1720)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ $\qquad\Gamma_1/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
0.10 to 0.20 OUR ESTIMATE				
0.13±0.05	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
0.10±0.04	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
0.14±0.03	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$

*CITATION: L. Montanet et al., Physical Review D50, 1173 (1994) and 1995 off-year partial update for the 1996 edition (URL: http://pdg.lbl.gov/)

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ 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

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

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
+0.027±0.024 OUR ESTIMATE				
0.012±0.003	LI	93	IPWA	$\gamma N \to \pi N$
0.044±0.066	CRAWFORD	83	IPWA	$\gamma N \to \pi N$
−0.004±0.007	AWAJI	81	DPWA	$\gamma N \to \pi N$
0.051±0.009	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 1)
0.071±0.010	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 2)
0.038±0.050	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
+0.111±0.047	BARBOUR	78	DPWA	$\gamma N \to \pi N$

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

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
−0.026±0.010 OUR ESTIMATE				
−0.022±0.003	LI	93	IPWA	$\gamma N \to \pi N$
−0.024±0.006	CRAWFORD	83	IPWA	$\gamma N \to \pi N$
−0.040±0.016	AWAJI	81	DPWA	$\gamma N \to \pi N$
−0.058±0.010	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 1)
−0.011±0.011	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 2)
−0.014±0.040	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.063±0.032	BARBOUR	78	DPWA	$\gamma N \to \pi N$

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

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
+0.018±0.029 OUR ESTIMATE				
0.050±0.004	LI	93	IPWA	$\gamma N \to \pi N$
0.002±0.005	AWAJI	81	DPWA	$\gamma N \to \pi N$
−0.019±0.033	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 1)
0.001±0.038	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 2)
−0.003±0.034	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
+0.007±0.020	BARBOUR	78	DPWA	$\gamma N \to \pi N$

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

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
−0.033±0.059 OUR ESTIMATE				
−0.017±0.004	LI	93	IPWA	$\gamma N \to \pi N$
−0.015±0.019	AWAJI	81	DPWA	$\gamma N \to \pi N$
−0.139±0.039	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 1)
−0.134±0.044	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 2)
0.018±0.028	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
+0.051±0.051	BARBOUR	78	DPWA	$\gamma N \to \pi N$

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

$(\Gamma_i \Gamma_f)^{1/2}/\Gamma_{total}$ 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

$(\Gamma_i \Gamma_f)^{1/2}/\Gamma_{total}$ 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 and HOEHLER 94 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 $\pi N \rightarrow N\pi\pi$ 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 $\pi^+ p \rightarrow \Sigma^+ K^+$ data of WINNIK 77 around 1920 MeV.

N(1720) REFERENCES

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

HOEHLER	94	πN Newsletter 10 (to be pub.)		(KARL)
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)
ARNDT	85	PR D32 1085	+Ford, Roper	(VPI)
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

$N(1900)\ P_{13}$

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

OMITTED FROM SUMMARY TABLE

N(1900) MASS

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
≈ 1900 OUR ESTIMATE				
1879±17	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$

N(1900) WIDTH

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
498±78	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$

N(1900) DECAY MODES

	Mode
Γ_1	$N\pi$
Γ_2	$N\pi\pi$
Γ_3	$N\rho$, $S=1/2$, P-wave

N(1900) BRANCHING RATIOS

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

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
0.26±0.06	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$

*CITATION: L. Montanet et al., Physical Review D50, 1173 (1994) and 1995 off-year partial update for the 1996 edition (URL: http://pdg.lbl.gov/)

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1900) \to N\rho$, $S=1/2$, P-wave **$(\Gamma_1\Gamma_3)^{1/2}/\Gamma$**

VALUE	DOCUMENT ID		TECN	COMMENT
-0.34 ± 0.03	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$

N(1900) REFERENCES

MANLEY	92	PR D45 4002	+Saleski	(KENT)
Also	84	PR D30 904	Manley, Arndt, Goradia, Teplitz	(VPI)

N(1990) F_{17}

$I(J^P) = \frac{1}{2}(\frac{7}{2}^+)$ Status: ∗∗

OMITTED FROM SUMMARY TABLE

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 analyses do not agree very well with one another.

N(1990) MASS

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
≈ 1990 OUR ESTIMATE				
2086 ± 28	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
2018	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
1970 ± 50	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
2005 ± 150	HOEHLER	79	IPWA	$\pi N \to \pi N$
1999	BARBOUR	78	DPWA	$\gamma N \to \pi N$

N(1990) WIDTH

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
535 ± 120	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
295	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
350 ± 120	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
350 ± 100	HOEHLER	79	IPWA	$\pi N \to \pi N$
216	BARBOUR	78	DPWA	$\gamma N \to \pi N$

N(1990) POLE POSITION

REAL PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
1900 ± 30	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
not seen	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90

$-2\times$IMAGINARY PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
260 ± 60	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
not seen	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90

N(1990) ELASTIC POLE RESIDUE

MODULUS $|r|$

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
9 ± 3	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

PHASE θ

VALUE (°)	DOCUMENT ID		TECN	COMMENT
-60 ± 30	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

*CITATION: L. Montanet et al., Physical Review D50, 1173 (1994) and 1995 off-year partial update for the 1996 edition (URL: http://pdg.lbl.gov/)

$N(1990)$ DECAY MODES

	Mode
Γ_1	$N\pi$
Γ_2	$N\eta$
Γ_3	ΛK
Γ_4	ΣK
Γ_5	$N\pi\pi$
Γ_6	$p\gamma$, helicity=1/2
Γ_7	$p\gamma$, helicity=3/2
Γ_8	$n\gamma$, helicity=1/2
Γ_9	$n\gamma$, helicity=3/2

$N(1990)$ BRANCHING RATIOS

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.06±0.02	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
0.06±0.02	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
0.04±0.02	HOEHLER	79	IPWA	$\pi N \to \pi N$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \to N(1990) \to N\eta$ — $(\Gamma_1\Gamma_2)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.043	BAKER	79	DPWA	$\pi^- p \to n\eta$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \to N(1990) \to \Lambda K$ — $(\Gamma_1\Gamma_3)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.01	BELL	83	DPWA	$\pi^- p \to \Lambda K^0$
not seen	SAXON	80	DPWA	$\pi^- p \to \Lambda K^0$
−0.021±0.033	DEVENISH	74B		Fixed-t dispersion rel.

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \to N(1990) \to \Sigma K$ — $(\Gamma_1\Gamma_4)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
0.010 to 0.023	[1] DEANS	75	DPWA	$\pi N \to \Sigma K$
0.06	LANGBEIN	73	IPWA	$\pi N \to \Sigma K$ (sol. 1)

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \to N(1990) \to N\pi\pi$ — $(\Gamma_1\Gamma_5)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
not seen	LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$N(1990)$ PHOTON DECAY AMPLITUDES

$N(1990) \to p\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
0.030±0.029	AWAJI	81	DPWA	$\gamma N \to \pi N$
0.001±0.040	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.040	BARBOUR	78	DPWA	$\gamma N \to \pi N$

$N(1990) \to p\gamma$, helicity-3/2 amplitude $A_{3/2}$

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
0.086±0.060	AWAJI	81	DPWA	$\gamma N \to \pi N$
0.004±0.025	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
+0.004	BARBOUR	78	DPWA	$\gamma N \to \pi N$

$N(1990) \to n\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
−0.001	AWAJI	81	DPWA	$\gamma N \to \pi N$
−0.078±0.030	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.069	BARBOUR	78	DPWA	$\gamma N \to \pi N$

$N(1990) \rightarrow n\gamma$, helicity-3/2 amplitude $A_{3/2}$

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
-0.178	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
-0.116 ± 0.045	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
-0.072	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$

N(1990) FOOTNOTES

[1] The range given for DEANS 75 is from the four best solutions.

N(1990) REFERENCES

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

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
BELL	83	NP B222 389	+Blissett, Broome, Daley, Hart, Lintern+	(RL) IJP
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)
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
BARBOUR	78	NP B141 253	+Crawford, Parsons	(GLAS)
DEANS	75	NP B96 90	+Mitchell, Montgomery+	(SFLA, ALAH) IJP
LONGACRE	75	PL 55B 415	+Rosenfeld, Lasinski, Smadja+	(LBL, SLAC) IJP
DEVENISH	74B	NP B81 330	+Froggatt, Martin	(DESY, NORD, LOUC)
LANGBEIN	73	NP B53 251	+Wagner	(MUNI) IJP

$N(2000)\ F_{15}$

$I(J^P) = \frac{1}{2}(\frac{5}{2}^+)$ Status: ∗∗

OMITTED FROM SUMMARY TABLE

Older results have been retained simply because there is little information at all about this possible state.

N(2000) MASS

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
≈ 2000 OUR ESTIMATE				
1903 ± 87	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
1882 ± 10	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
2025	AYED	76	IPWA	$\pi N \rightarrow \pi N$
1970	[1] LANGBEIN	73	IPWA	$\pi N \rightarrow \Sigma K$ (sol. 2)
2175	ALMEHED	72	IPWA	$\pi N \rightarrow \pi N$
1930	DEANS	72	MPWA	$\gamma p \rightarrow \Lambda K$ (sol. D)

N(2000) WIDTH

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
490 ± 310	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
95 ± 20	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
157	AYED	76	IPWA	$\pi N \rightarrow \pi N$
170	[1] LANGBEIN	73	IPWA	$\pi N \rightarrow \Sigma K$ (sol. 2)
150	ALMEHED	72	IPWA	$\pi N \rightarrow \pi N$
112	DEANS	72	MPWA	$\gamma p \rightarrow \Lambda K$ (sol. D)

N(2000) DECAY MODES

	Mode
Γ_1	$N\pi$
Γ_2	$N\eta$
Γ_3	ΛK
Γ_4	ΣK
Γ_5	$N\pi\pi$
Γ_6	$\Delta(1232)\pi$, P-wave
Γ_7	$N\rho$, S=3/2, P-wave
Γ_8	$N\rho$, S=3/2, F-wave
Γ_9	$p\gamma$

N(2000) BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ — Γ_1/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.08±0.05	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
0.04±0.02	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
0.08	AYED	76	IPWA	$\pi N \rightarrow \pi N$
0.25	ALMEHED	72	IPWA	$\pi N \rightarrow \pi N$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow N(2000) \rightarrow N\eta$ — $(\Gamma_1\Gamma_2)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.03	BAKER	79	DPWA	$\pi^- p \rightarrow n\eta$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow N(2000) \rightarrow \Lambda K$ — $(\Gamma_1\Gamma_3)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
not seen	SAXON	80	DPWA	$\pi^- p \rightarrow \Lambda K^0$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow N(2000) \rightarrow \Sigma K$ — $(\Gamma_1\Gamma_4)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
0.022	[2] DEANS	75	DPWA	$\pi N \rightarrow \Sigma K$
0.05	[1] LANGBEIN	73	IPWA	$\pi N \rightarrow \Sigma K$ (sol. 2)

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow N(2000) \rightarrow \Delta(1232)\pi$, P-wave — $(\Gamma_1\Gamma_6)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.10±0.06	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow N(2000) \rightarrow N\rho$, S=3/2, P-wave — $(\Gamma_1\Gamma_7)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.22±0.08	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow N(2000) \rightarrow N\rho$, S=3/2, F-wave — $(\Gamma_1\Gamma_8)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.11±0.06	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $p\gamma \rightarrow N(2000) \rightarrow \Lambda K$ — $(\Gamma_9\Gamma_3)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
0.0022	DEANS	72	MPWA	$\gamma p \rightarrow \Lambda K$ (sol. D)

N(2000) FOOTNOTES

[1] Not seen in solution 1 of LANGBEIN 73.
[2] Value given is from solution 1 of DEANS 75; not present in solutions 2, 3, or 4.

$N(2000)$ REFERENCES

MANLEY	92	PR D45 4002	+Saleski	(KENT) IJP
Also	84	PR D30 904	Manley, Arndt, Goradia, Teplitz	(VPI)
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
AYED	76	Thesis CEA-N-1921		(SACL) IJP
DEANS	75	NP B96 90	+Mitchell, Montgomery+	(SFLA, ALAH) IJP
LANGBEIN	73	NP B53 251	+Wagner	(MUNI) IJP
ALMEHED	72	NP B40 157	+Lovelace	(LUND, RUTG) IJP
DEANS	72	PR D6 1906	+Jacobs, Lyons, Montgomery	(SFLA) IJP

$N(2080)\ D_{13}$

$I(J^P) = \frac{1}{2}(\frac{3}{2}^-)$ Status: ∗∗

OMITTED FROM SUMMARY TABLE

There is some evidence for two resonances in this wave between 1800 and 2200 MeV (see CUTKOSKY 80). However, the solution of HOEHLER 79 is quite different.

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).

$N(2080)$ MASS

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
≈ 2080 OUR ESTIMATE				
1804± 55	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
1920	BELL	83	DPWA	$\pi^- p \rightarrow \Lambda K^0$
1880±100	[1] CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
2060± 80	[1] CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
1900	SAXON	80	DPWA	$\pi^- p \rightarrow \Lambda K^0$
2081± 20	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1880	BAKER	79	DPWA	$\pi^- p \rightarrow n\eta$

$N(2080)$ WIDTH

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
450±185	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
320	BELL	83	DPWA	$\pi^- p \rightarrow \Lambda K^0$
180± 60	[1] CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$ (lower m)
300±100	[1] CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$ (higher m)
240	SAXON	80	DPWA	$\pi^- p \rightarrow \Lambda K^0$
265± 40	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
87	BAKER	79	DPWA	$\pi^- p \rightarrow n\eta$

$N(2080)$ POLE POSITION

REAL PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1880±100	[1] CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$ (lower m)
2050± 70	[1] CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$ (higher m)
• • • We do not use the following data for averages, fits, limits, etc. • • •				
not seen	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90

−2×IMAGINARY PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
160±80	[1] CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$ (lower m)
200±80	[1] CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$ (higher m)
• • • We do not use the following data for averages, fits, limits, etc. • • •				
not seen	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90

$N(2080)$ ELASTIC POLE RESIDUE

MODULUS $|r|$

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
10± 5	[1] CUTKOSKY	80	IPWA	$\pi N \to \pi N$ (lower m)
30±20	[1] CUTKOSKY	80	IPWA	$\pi N \to \pi N$ (higher m)

PHASE θ

VALUE (°)	DOCUMENT ID		TECN	COMMENT
100± 80	[1] CUTKOSKY	80	IPWA	$\pi N \to \pi N$ (lower m)
0±100	[1] CUTKOSKY	80	IPWA	$\pi N \to \pi N$ (higher m)

$N(2080)$ DECAY MODES

	Mode
Γ_1	$N\pi$
Γ_2	$N\eta$
Γ_3	ΛK
Γ_4	ΣK
Γ_5	$N\pi\pi$
Γ_6	$\Delta(1232)\pi$, S-wave
Γ_7	$\Delta(1232)\pi$, D-wave
Γ_8	$N\rho$, S=3/2, S-wave
Γ_9	$N(\pi\pi)^{I=0}_{S\text{-wave}}$
Γ_{10}	$p\gamma$, helicity=1/2
Γ_{11}	$p\gamma$, helicity=3/2
Γ_{12}	$n\gamma$, helicity=1/2
Γ_{13}	$n\gamma$, helicity=3/2
Γ_{14}	$p\gamma$

$N(2080)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ — Γ_1/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.23±0.03	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
0.10±0.04	[1] CUTKOSKY	80	IPWA	$\pi N \to \pi N$ (lower m)
0.14±0.07	[1] CUTKOSKY	80	IPWA	$\pi N \to \pi N$ (higher m)
0.06±0.02	HOEHLER	79	IPWA	$\pi N \to \pi N$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(2080) \to N\eta$ — $(\Gamma_1\Gamma_2)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
0.065	BAKER	79	DPWA	$\pi^- p \to n\eta$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(2080) \to \Lambda K$ — $(\Gamma_1\Gamma_3)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.04	BELL	83	DPWA	$\pi^- p \to \Lambda K^0$
+0.03	SAXON	80	DPWA	$\pi^- p \to \Lambda K^0$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(2080) \to \Sigma K$ — $(\Gamma_1\Gamma_4)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
0.014 to 0.037	[2] DEANS	75	DPWA	$\pi N \to \Sigma K$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(2080) \to \Delta(1232)\pi$, S-wave — $(\Gamma_1\Gamma_6)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.09±0.09	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(2080) \to \Delta(1232)\pi$, D-wave — $(\Gamma_1\Gamma_7)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.22±0.07	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(2080) \to N\rho$, S=3/2, S-wave — $(\Gamma_1\Gamma_8)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.24±0.06	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(2080) \to N(\pi\pi)^{I=0}_{S\text{-wave}}$ — $(\Gamma_1\Gamma_9)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
$+0.25\pm0.06$	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $p\gamma \to N(2080) \to N\eta$ — $(\Gamma_{14}\Gamma_2)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
0.0037	HICKS	73	MPWA	$\gamma p \to p\eta$

$N(2080)$ PHOTON DECAY AMPLITUDES

$N(2080) \to p\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE ($\mathrm{GeV}^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
-0.020 ± 0.008	AWAJI	81	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.026 ± 0.052	DEVENISH	74	DPWA	$\gamma N \to \pi N$

$N(2080) \to p\gamma$, helicity-3/2 amplitude $A_{3/2}$

VALUE ($\mathrm{GeV}^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
0.017 ± 0.011	AWAJI	81	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.128 ± 0.057	DEVENISH	74	DPWA	$\gamma N \to \pi N$

$N(2080) \to n\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE ($\mathrm{GeV}^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
0.007 ± 0.013	AWAJI	81	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.053 ± 0.083	DEVENISH	74	DPWA	$\gamma N \to \pi N$

$N(2080) \to n\gamma$, helicity-3/2 amplitude $A_{3/2}$

VALUE ($\mathrm{GeV}^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
-0.053 ± 0.034	AWAJI	81	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.100 ± 0.141	DEVENISH	74	DPWA	$\gamma N \to \pi N$

$N(2080)$ $\gamma p \to \Lambda K^+$ AMPLITUDES

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $p\gamma \to N(2080) \to \Lambda K^+$ — (E_{2-} amplitude)

VALUE (units 10^{-3})	DOCUMENT ID		TECN
5.5 ±0.3	WORKMAN	90	DPWA
• • • We do not use the following data for averages, fits, limits, etc. • • •			
4.09	TANABE	89	DPWA

$p\gamma \to N(2080) \to \Lambda K^+$ phase angle θ — (E_{2-} amplitude)

VALUE (degrees)	DOCUMENT ID		TECN
−48 ±5	WORKMAN	90	DPWA
• • • We do not use the following data for averages, fits, limits, etc. • • •			
−35.9	TANABE	89	DPWA

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $p\gamma \to N(2080) \to \Lambda K^+$ — (M_{2-} amplitude)

VALUE (units 10^{-3})	DOCUMENT ID		TECN
−6.7 ±0.2	WORKMAN	90	DPWA
• • • We do not use the following data for averages, fits, limits, etc. • • •			
−4.09	TANABE	89	DPWA

$N(2080)$ FOOTNOTES

[1] CUTKOSKY 80 finds a lower mass D_{13} resonance, as well as one in this region. Both are listed here.

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

N(2080) REFERENCES

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

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
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)
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
WINNIK	77	NP B128 66	+Toaff, Revel, Goldberg, Berny	(HAIF) I
DEANS	75	NP B96 90	+Mitchell, Montgomery+	(SFLA, ALAH) IJP
DEVENISH	74	PL 52B 227	+Lyth, Rankin	(DESY, LANC, BONN) IJP
HICKS	73	PR D7 2614	+Deans, Jacobs, Lyons+	(CMU, ORNL, SFLA) IJP

$N(2090)\ S_{11}$

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

OMITTED FROM SUMMARY TABLE

Any structure in the S_{11} wave above 1800 MeV is listed here. A few early results that are now obsolete have been omitted.

N(2090) MASS

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
≈ 2090 OUR ESTIMATE				
1928±59	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
2180±80	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
1880±20	HOEHLER	79	IPWA	$\pi N \to \pi N$

N(2090) WIDTH

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
414±157	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
350±100	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
95± 30	HOEHLER	79	IPWA	$\pi N \to \pi N$

N(2090) POLE POSITION

REAL PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
2150±70	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
1937 or 1949	[1] LONGACRE	78	IPWA	$\pi N \to N\pi\pi$

−2×IMAGINARY PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
350±100	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
139 or 131	[1] LONGACRE	78	IPWA	$\pi N \to N\pi\pi$

N(2090) ELASTIC POLE RESIDUE

MODULUS $|r|$

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
40±20	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

PHASE θ

VALUE (°)	*DOCUMENT ID*		*TECN*	*COMMENT*
0±90	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

$N(2090)$ DECAY MODES

	Mode
Γ_1	$N\pi$
Γ_2	ΛK
Γ_3	$N\pi\pi$

$N(2090)$ BRANCHING RATIOS

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.10±0.10	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
0.18±0.08	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
0.09±0.05	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow N(2090) \rightarrow \Lambda K$ **$(\Gamma_1\Gamma_2)^{1/2}/\Gamma$**

VALUE	DOCUMENT ID		TECN	COMMENT
not seen	SAXON	80	DPWA	$\pi^- p \rightarrow \Lambda K^0$

$N(2090)$ FOOTNOTES

[1] 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.

$N(2090)$ REFERENCES

MANLEY	92	PR D45 4002	+Saleski	(KENT) IJP
Also	84	PR D30 904	Manley, Arndt, Goradia, Teplitz	(VPI)
CUTKOSKY	80	Toronto Conf. 19	+Forsyth, Babcock, Kelly, Hendrick	(CMU, LBL) IJP
Also	79	PR D20 2839	Cutkosky, Forsyth, Hendrick, Kelly	(CMU, LBL)
SAXON	80	NP B162 522	+Baker, Bell, Blissett, Bloodworth+	(RHEL, BRIS) IJP
HOEHLER	79	PDAT 12-1	+Kaiser, Koch, Pietarinen	(KARLT) IJP
Also	80	Toronto Conf. 3	Koch	(KARLT) IJP
LONGACRE	78	PR D17 1795	+Lasinski, Rosenfeld, Smadja+	(LBL, SLAC)

$N(2100)$ P_{11}

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

OMITTED FROM SUMMARY TABLE

$N(2100)$ MASS

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
≈ 2100 OUR ESTIMATE				
1885±30	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
2125±75	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
2050±20	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$

$N(2100)$ WIDTH

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
113± 44	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
260±100	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
200± 30	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$

$N(2100)$ POLE POSITION

REAL PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
2120±40	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
not seen	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90

−2×IMAGINARY PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
240±80	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
not seen	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90

$N(2100)$ ELASTIC POLE RESIDUE

MODULUS $|r|$

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
14±7	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$

PHASE θ

VALUE (°)	DOCUMENT ID		TECN	COMMENT
35±25	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$

$N(2100)$ DECAY MODES

	Mode
Γ_1	$N\pi$
Γ_2	$N\pi\pi$
Γ_3	$\Delta(1232)\pi$, P-wave

$N(2100)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ — Γ_1/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.15±0.06	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
0.12±0.03	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
0.10±0.04	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow N(2100) \rightarrow \Delta(1232)\pi$, P-wave — $(\Gamma_1\Gamma_3)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.19±0.08	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$

$N(2100)$ REFERENCES

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	80	Toronto Conf. 19	+Forsyth, Babcock, Kelly, Hendrick	(CMU, LBL) IJP
Also	79	PR D20 2839	Cutkosky, Forsyth, Hendrick, Kelly	(CMU, LBL)
HOEHLER	79	PDAT 12-1	+Kaiser, Koch, Pietarinen	(KARLT) IJP
Also	80	Toronto Conf. 3	Koch	(KARLT) IJP

$N(2190)$ G_{17}

$I(J^P) = \frac{1}{2}(\frac{7}{2}^-)$ 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).

$N(2190)$ MASS

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
2100 to 2200 (≈ 2190) OUR ESTIMATE				
2127± 9	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
2200±70	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
2140±12	HOEHLER	79	IPWA	$\pi N \to \pi N$
2140±40	HENDRY	78	MPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
2098	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
2180	SAXON	80	DPWA	$\pi^- p \to \Lambda K^0$
2140	BAKER	79	DPWA	$\pi^- p \to n\eta$
2117	BARBOUR	78	DPWA	$\gamma N \to \pi N$

$N(2190)$ WIDTH

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
350 to 550 (≈ 450) OUR ESTIMATE				
550± 50	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
500±150	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
390± 30	HOEHLER	79	IPWA	$\pi N \to \pi N$
270± 50	HENDRY	78	MPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
238	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
80	SAXON	80	DPWA	$\pi^- p \to \Lambda K^0$
319	BAKER	79	DPWA	$\pi^- p \to n\eta$
220	BARBOUR	78	DPWA	$\gamma N \to \pi N$

$N(2190)$ POLE POSITION

REAL PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
2042	[1] HOEHLER	93	SPED	$\pi N \to \pi N$
2060	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
2100±50	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

−2×IMAGINARY PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
482	[1] HOEHLER	93	SPED	$\pi N \to \pi N$
464	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
400±160	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

$N(2190)$ ELASTIC POLE RESIDUE

MODULUS $|r|$

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
45	HOEHLER	93	SPED	$\pi N \to \pi N$
54	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
25±10	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

PHASE θ

VALUE (°)	*DOCUMENT ID*		*TECN*	*COMMENT*
−44	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
−30±50	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

$N(2190)$ 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	
Γ_4	ΣK	
Γ_5	$N\pi\pi$	
Γ_6	$N\rho$	
Γ_7	$N\rho$, S=3/2, D-wave	
Γ_8	$p\gamma$, helicity=1/2	
Γ_9	$p\gamma$, helicity=3/2	
Γ_{10}	$n\gamma$, helicity=1/2	
Γ_{11}	$n\gamma$, helicity=3/2	

$N(2190)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ — Γ_1/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.1 to 0.2 OUR ESTIMATE				
0.22±0.01	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
0.12±0.06	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
0.14±0.02	HOEHLER	79	IPWA	$\pi N \to \pi N$
0.16±0.04	HENDRY	78	MPWA	$\pi N \to \pi N$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(2190) \to N\eta$ — $(\Gamma_1\Gamma_2)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
+0.052	BAKER	79	DPWA	$\pi^- p \to n\eta$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(2190) \to \Lambda K$ — $(\Gamma_1\Gamma_3)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.02	BELL	83	DPWA	$\pi^- p \to \Lambda K^0$
−0.02	SAXON	80	DPWA	$\pi^- p \to \Lambda K^0$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(2190) \to \Sigma K$ — $(\Gamma_1\Gamma_4)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.014 to 0.019	[2] DEANS	75	DPWA	$\pi N \to \Sigma K$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(2190) \to N\rho$, S=3/2, D-wave — $(\Gamma_1\Gamma_7)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.25±0.03	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$

$N(2190)$ PHOTON DECAY AMPLITUDES

$N(2190) \to p\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.055	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
−0.030	BARBOUR	78	DPWA	$\gamma N \to \pi N$

$N(2190) \to p\gamma$, helicity-3/2 amplitude $A_{3/2}$

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.081	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
+0.180	BARBOUR	78	DPWA	$\gamma N \to \pi N$

$N(2190) \rightarrow n\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.042	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
−0.085	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$

$N(2190) \rightarrow n\gamma$, helicity-3/2 amplitude $A_{3/2}$

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.126	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
+0.007	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$

$N(2190)$ $\gamma p \rightarrow \Lambda K^+$ AMPLITUDES

$(\Gamma_i \Gamma_f)^{1/2}/\Gamma_{total}$ in $p\gamma \rightarrow N(2190) \rightarrow \Lambda K^+$ (E_{4-} amplitude)

VALUE (units 10^{-3})	DOCUMENT ID		TECN
2.5 ±1.0	WORKMAN	90	DPWA
• • • We do not use the following data for averages, fits, limits, etc. • • •			
2.04	TANABE	89	DPWA

$p\gamma \rightarrow N(2190) \rightarrow \Lambda K^+$ phase angle θ (E_{4-} amplitude)

VALUE (degrees)	DOCUMENT ID		TECN
− 4 ±9	WORKMAN	90	DPWA
• • • We do not use the following data for averages, fits, limits, etc. • • •			
−27.5	TANABE	89	DPWA

$(\Gamma_i \Gamma_f)^{1/2}/\Gamma_{total}$ in $p\gamma \rightarrow N(2190) \rightarrow \Lambda K^+$ (M_{4-} amplitude)

VALUE (units 10^{-3})	DOCUMENT ID		TECN
−7.0 ±0.7	WORKMAN	90	DPWA
• • • We do not use the following data for averages, fits, limits, etc. • • •			
−5.78	TANABE	89	DPWA

$N(2190)$ FOOTNOTES

[1] See HOEHLER 93 and HOEHLER 94 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.

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

$N(2190)$ REFERENCES

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

HOEHLER	94	πN Newsletter 10 (to be pub.)		(KARL)
HOEHLER	93	πN Newsletter 9 1		(KARL)
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
PDG	82	PL 111B	Roos, Porter, Aguilar-Benitez+	(HELS, CIT, CERN)
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
BARBOUR	78	NP B141 253	+Crawford, Parsons	(GLAS)
HENDRY	78	PRL 41 222		(IND, LBL) IJP
Also	81	ANP 136 1	Hendry	(IND)
WINNIK	77	NP B128 66	+Toaff, Revel, Goldberg, Berny	(HAIF) I
DEANS	75	NP B96 90	+Mitchell, Montgomery+	(SFLA, ALAH) IJP

$N(2200)\ D_{15}$

$I(J^P) = \frac{1}{2}(\frac{5}{2}^-)$ Status: ∗∗

OMITTED FROM SUMMARY TABLE

The mass is not well determined. A few early results have been omitted.

N(2200) MASS

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
≈ 2200 OUR ESTIMATE				
1900	BELL	83	DPWA	$\pi^- p \to \Lambda K^0$
2180±80	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
1920	SAXON	80	DPWA	$\pi^- p \to \Lambda K^0$
2228±30	HOEHLER	79	IPWA	$\pi N \to \pi N$

N(2200) WIDTH

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
130	BELL	83	DPWA	$\pi^- p \to \Lambda K^0$
400±100	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
220	SAXON	80	DPWA	$\pi^- p \to \Lambda K^0$
310± 50	HOEHLER	79	IPWA	$\pi N \to \pi N$

N(2200) POLE POSITION

REAL PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
2100±60	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

−2×IMAGINARY PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
360±80	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

N(2200) ELASTIC POLE RESIDUE

MODULUS $|r|$

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
20±10	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

PHASE θ

VALUE (°)	DOCUMENT ID		TECN	COMMENT
−90±50	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

N(2200) DECAY MODES

	Mode
Γ_1	$N\pi$
Γ_2	$N\eta$
Γ_3	ΛK

N(2200) BRANCHING RATIOS

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.10±0.03	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
0.07±0.02	HOEHLER	79	IPWA	$\pi N \to \pi N$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\rm total}$ in $N\pi \to N(2200) \to N\eta$ — $(\Gamma_1\Gamma_2)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
0.066	BAKER	79	DPWA	$\pi^- p \to n\eta$

*CITATION: L. Montanet et al., Physical Review D50, 1173 (1994) and 1995 off-year partial update for the 1996 edition (URL: http://pdg.lbl.gov/)

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow N(2200) \rightarrow \Lambda K$ **$(\Gamma_1\Gamma_3)^{1/2}/\Gamma$**

VALUE	DOCUMENT ID		TECN	COMMENT
−0.03	BELL	83	DPWA	$\pi^- p \rightarrow \Lambda K^0$
−0.05	SAXON	80	DPWA	$\pi^- p \rightarrow \Lambda K^0$

N(2200) REFERENCES

BELL	83	NP B222 389	+Blissett, Broome, Daley, Hart, Lintern+	(RL) IJP
CUTKOSKY	80	Toronto Conf. 19	+Forsyth, Babcock, Kelly, Hendrick	(CMU, LBL) IJP
Also	79	PR D20 2839	Cutkosky, Forsyth, Hendrick, Kelly	(CMU, LBL)
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

$N(2220)\ H_{19}$

$I(J^P) = \frac{1}{2}(\frac{9}{2}^+)$ 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(2220) MASS

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
2180 to 2310 (≈ 2220) OUR ESTIMATE				
2230± 80	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
2205± 10	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
2300±100	HENDRY	78	MPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
2050	BAKER	79	DPWA	$\pi^- p \rightarrow n\eta$

N(2220) WIDTH

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
320 to 550 (≈ 400) OUR ESTIMATE				
500±150	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
365± 30	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
450±150	HENDRY	78	MPWA	$\pi N \rightarrow \pi N$

N(2220) POLE POSITION

REAL PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
2135	[1] HOEHLER	93	ARGD	$\pi N \rightarrow \pi N$
2253	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
2160±80	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$

−2×IMAGINARY PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
400	[1] HOEHLER	93	ARGD	$\pi N \rightarrow \pi N$
640	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
480±100	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$

N(2220) ELASTIC POLE RESIDUE

MODULUS |r|

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
40	HOEHLER	93	ARGD	$\pi N \rightarrow \pi N$
85	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
45±20	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$

PHASE θ

VALUE (°)	DOCUMENT ID		TECN	COMMENT
−50	HOEHLER	93	ARGD	$\pi N \rightarrow \pi N$
−62	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
−45±25	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$

$N(2220)$ 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	

$N(2220)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ — Γ_1/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.1 to 0.2 OUR ESTIMATE				
0.15 ± 0.03	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
0.18 ± 0.015	HOEHLER	79	IPWA	$\pi N \to \pi N$
0.12 ± 0.04	HENDRY	78	MPWA	$\pi N \to \pi N$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(2220) \to N\eta$ — $(\Gamma_1\Gamma_2)^{1/2}/\Gamma$

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

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(2220) \to \Lambda K$ — $(\Gamma_1\Gamma_3)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
not required	BELL	83	DPWA	$\pi^- p \to \Lambda K^0$
not seen	SAXON	80	DPWA	$\pi^- p \to \Lambda K^0$

$N(2220)$ FOOTNOTES

[1] See HOEHLER 93 and HOEHLER 94 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.

$N(2220)$ REFERENCES

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

HOEHLER	94	πN Newsletter 10 (to be pub.)		(KARL)
HOEHLER	93	πN Newsletter 9 1		(KARL)
ARNDT	91	PR D43 2131	+Li, Roper, Workman, Ford	(VPI, TELE) IJP
BELL	83	NP B222 389	+Blissett, Broome, Daley, Hart, Lintern+	(RL) IJP
PDG	82	PL 111B	Roos, Porter, Aguilar-Benitez+	(HELS, CIT, CERN)
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
HENDRY	78	PRL 41 222		(IND, LBL) IJP
Also	81	ANP 136 1	Hendry	(IND)

*CITATION: L. Montanet et al., Physical Review D50, 1173 (1994) and 1995 off-year partial update for the 1996 edition (URL: http://pdg.lbl.gov/)

$N(2250)$ G_{19}

$I(J^P) = \frac{1}{2}(\frac{9}{2}^-)$ Status: ∗∗∗∗

$N(2250)$ MASS

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
2170 to 2310 (≈ 2250) OUR ESTIMATE				
2250± 80	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
2268± 15	HOEHLER	79	IPWA	$\pi N \to \pi N$
2200±100	HENDRY	78	MPWA	$\pi N \to \pi N$

$N(2250)$ WIDTH

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
290 to 470 (≈ 400) OUR ESTIMATE				
480±120	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
300± 40	HOEHLER	79	IPWA	$\pi N \to \pi N$
350±100	HENDRY	78	MPWA	$\pi N \to \pi N$

$N(2250)$ POLE POSITION

REAL PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
2187	[1] HOEHLER	93	SPED	$\pi N \to \pi N$
2243	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
2150±50	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

−2×IMAGINARY PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
388	[1] HOEHLER	93	SPED	$\pi N \to \pi N$
650	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
360±100	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

$N(2250)$ ELASTIC POLE RESIDUE

MODULUS $|r|$

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
21	HOEHLER	93	SPED	$\pi N \to \pi N$
47	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
20±6	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

PHASE θ

VALUE (°)	DOCUMENT ID		TECN	COMMENT
−37	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
−50±20	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

$N(2250)$ DECAY MODES

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

	Mode	Fraction (Γ_i/Γ)
Γ_1	$N\pi$	5–15 %
Γ_2	$N\eta$	
Γ_3	ΛK	

$N(2250)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ — Γ_1/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.05 to 0.15 OUR ESTIMATE				
0.10±0.02	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
0.10±0.02	HOEHLER	79	IPWA	$\pi N \to \pi N$
0.09±0.02	HENDRY	78	MPWA	$\pi N \to \pi N$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(2250) \to N\eta$ $(\Gamma_1\Gamma_2)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
-0.043	BAKER	79	DPWA	$\pi^- p \to n\eta$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(2250) \to \Lambda K$ $(\Gamma_1\Gamma_3)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
-0.02	BELL	83	DPWA	$\pi^- p \to \Lambda K^0$
not seen	SAXON	80	DPWA	$\pi^- p \to \Lambda K^0$

N(2250) FOOTNOTES

[1] See HOEHLER 93 and HOEHLER 94 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.

N(2250) REFERENCES

HOEHLER	94	πN Newsletter 10 (to be pub.)		(KARL)
HOEHLER	93	πN Newsletter 9 1		(KARL)
ARNDT	91	PR D43 2131	+Li, Roper, Workman, Ford	(VPI, TELE) IJP
BELL	83	NP B222 389	+Blissett, Broome, Daley, Hart, Lintern+	(RL) IJP
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
HENDRY	78	PRL 41 222		(IND, LBL) IJP
Also	81	ANP 136 1	Hendry	(IND)

$N(2600)$ $I_{1,11}$

$I(J^P) = \frac{1}{2}(\frac{11}{2}^-)$ Status: ∗∗∗

N(2600) MASS

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
2550 to 2750 (≈ 2600) OUR ESTIMATE				
2577 ± 50	HOEHLER	79	IPWA	$\pi N \to \pi N$
2700 ± 100	HENDRY	78	MPWA	$\pi N \to \pi N$

N(2600) WIDTH

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
500 to 800 (≈ 650) OUR ESTIMATE				
400 ± 100	HOEHLER	79	IPWA	$\pi N \to \pi N$
900 ± 100	HENDRY	78	MPWA	$\pi N \to \pi N$

N(2600) DECAY MODES

	Mode	Fraction (Γ_i/Γ)
Γ_1	$N\pi$	5–10 %

N(2600) BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ Γ_1/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.05 to 0.1 OUR ESTIMATE				
0.05 ± 0.01	HOEHLER	79	IPWA	$\pi N \to \pi N$
0.08 ± 0.02	HENDRY	78	MPWA	$\pi N \to \pi N$

N(2600) REFERENCES

HOEHLER	79	PDAT 12-1	+Kaiser, Koch, Pietarinen	(KARLT) IJP
Also	80	Toronto Conf. 3	Koch	(KARLT) IJP
HENDRY	78	PRL 41 222		(IND, LBL) IJP
Also	81	ANP 136 1	Hendry	(IND)

$N(2700)\ K_{1,13}$

$I(J^P) = \frac{1}{2}(\frac{13}{2}^+)$ Status: ∗∗

OMITTED FROM SUMMARY TABLE

$N(2700)$ MASS

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
≈ 2700 OUR ESTIMATE				
2612± 45	HOEHLER	79	IPWA	$\pi N \to \pi N$
3000±100	HENDRY	78	MPWA	$\pi N \to \pi N$

$N(2700)$ WIDTH

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
350± 50	HOEHLER	79	IPWA	$\pi N \to \pi N$
900±150	HENDRY	78	MPWA	$\pi N \to \pi N$

$N(2700)$ DECAY MODES

	Mode
Γ_1	$N\pi$

$N(2700)$ BRANCHING RATIOS

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

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
0.04±0.01	HOEHLER	79	IPWA	$\pi N \to \pi N$
0.07±0.02	HENDRY	78	MPWA	$\pi N \to \pi N$

$N(2700)$ REFERENCES

HOEHLER	79	PDAT 12-1	+Kaiser, Koch, Pietarinen	(KARLT) IJP
Also	80	Toronto Conf. 3	Koch	(KARLT) IJP
HENDRY	78	PRL 41 222		(IND, LBL) IJP
Also	81	ANP 136 1	Hendry	(IND)

$N(\sim 3000$ Region) Partial-Wave Analyses

OMITTED FROM SUMMARY TABLE

We list here miscellaneous high-mass candidates for isospin-1/2 resonances found in partial-wave analyses.

Our 1982 edition had an $N(3245)$, an $N(3690)$, and an $N(3755)$, each a narrow peak seen in a production experiment. Since nothing has been heard from them since the 1960's, we declare them to be dead. There was also an $N(3030)$, deduced from total cross-section and 180° elastic cross-section measurements; it is the KOCH 80 $L_{1,15}$ state below.

$N(\sim 3000)$ MASS

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
≈ 3000 OUR ESTIMATE				
2600	KOCH	80	IPWA	$\pi N \to \pi N\ D_{13}$
3100	KOCH	80	IPWA	$\pi N \to \pi N\ L_{1,15}$ wave
3500	KOCH	80	IPWA	$\pi N \to \pi N\ M_{1,17}$ wave
3500 to 4000	KOCH	80	IPWA	$\pi N \to \pi N\ N_{1,19}$ wave
3500±200	HENDRY	78	MPWA	$\pi N \to \pi N\ L_{1,15}$ wave
3800±200	HENDRY	78	MPWA	$\pi N \to \pi N\ M_{1,17}$ wave
4100±200	HENDRY	78	MPWA	$\pi N \to \pi N\ N_{1,19}$ wave

$N(\sim 3000)$ WIDTH

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1300 ± 200	HENDRY	78	MPWA	$\pi N \rightarrow \pi N$ $L_{1,15}$ wave
1600 ± 200	HENDRY	78	MPWA	$\pi N \rightarrow \pi N$ $M_{1,17}$ wave
1900 ± 300	HENDRY	78	MPWA	$\pi N \rightarrow \pi N$ $N_{1,19}$ wave

$N(\sim 3000)$ DECAY MODES

	Mode
Γ_1	$N\pi$

$N(\sim 3000)$ BRANCHING RATIOS

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

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
0.055 ± 0.02	HENDRY	78	MPWA	$\pi N \rightarrow \pi N$ $L_{1,15}$ wave
0.040 ± 0.015	HENDRY	78	MPWA	$\pi N \rightarrow \pi N$ $M_{1,17}$ wave
0.030 ± 0.015	HENDRY	78	MPWA	$\pi N \rightarrow \pi N$ $N_{1,19}$ wave

$N(\sim 3000)$ REFERENCES

KOCH	80	Toronto Conf. 3		(KARLT) IJP
HENDRY	78	PRL 41 222		(IND, LBL) IJP
Also	81	ANP 136 1	Hendry	(IND) IJP