$N(1680)\ F_{15}$

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

Most of the results published before 1975 were last included in our 1982 edition, Physics Letters **111B** 1 (1982). Some further obsolete results published before 1984 were last included in our 2006 edition, Journal of Physics, G **33** 1 (2006).

N(1680) BREIT-WIGNER MASS

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1680 to 1690 (≈ 1685) OUR ESTIMATE				
1685 ± 5	ANISOVICH	10	DPWA	Multichannel
1680.1 ± 0.2	ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
1684 ± 4	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
1680 ± 10	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
1684 ± 3	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1680 ± 7	BATINIC	10	DPWA	$\pi N \to N\pi, N\eta$
1684 ± 8	THOMA	08	DPWA	Multichannel
1683.2 ± 0.7	ARNDT	04	DPWA	$\pi N \to \pi N, \eta N$
1679 ± 3	VRANA	00	DPWA	Multichannel
1679 ± 5	ARNDT	96	IPWA	$\gamma N \to \pi N$
1678	ARNDT	95	DPWA	$\pi N \to N\pi$
1660	[1] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
1670	[2] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

N(1680) BREIT-WIGNER WIDTH

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
120 to 140 (≈ 130) OUR ESTIMATE				
117 ± 12	ANISOVICH	10	DPWA	Multichannel
128.0 ± 1.1	ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
139 ± 8	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
120 ± 10	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
128 ± 8	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
142 ± 7	BATINIC	10	DPWA	$\pi N \to N\pi, N\eta$
105 ± 8	THOMA	08	DPWA	Multichannel
134.4 ± 3.8	ARNDT	04	DPWA	$\pi N \to \pi N, \eta N$
128 ± 9	VRANA	00	DPWA	Multichannel
124 ± 4	ARNDT	96	IPWA	$\gamma N \to \pi N$
126	ARNDT	95	DPWA	$\pi N \to N\pi$
150	[1] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
130	[2] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

N(1680) POLE POSITION

REAL PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1665 to 1680 (≈ 1675) OUR ESTIMATE				
1672±4	ANISOVICH	10	DPWA	Multichannel
1674	ARNDT	06	DPWA	$\pi N \rightarrow \pi N$, ηN
1673	[3] HOEHLER	93	ARGD	$\pi N \rightarrow \pi N$
1667±5	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1666±8	BATINIC	10	DPWA	$\pi N \rightarrow N\pi$, $N\eta$
1674±5	THOMA	08	DPWA	Multichannel
1678	ARNDT	04	DPWA	$\pi N \rightarrow \pi N$, ηN
1667	VRANA	00	DPWA	Multichannel
1670	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
1670	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
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*
110 to 135 (≈ 120) OUR ESTIMATE				
114±12	ANISOVICH	10	DPWA	Multichannel
115	ARNDT	06	DPWA	$\pi N \rightarrow \pi N$, ηN
135	[3] HOEHLER	93	ARGD	$\pi N \rightarrow \pi N$
110±10	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
135± 6	BATINIC	10	DPWA	$\pi N \rightarrow N\pi$, $N\eta$
95±10	THOMA	08	DPWA	Multichannel
120	ARNDT	04	DPWA	$\pi N \rightarrow \pi N$, ηN
122	VRANA	00	DPWA	Multichannel
120	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
116	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
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*
42	ARNDT	06	DPWA	$\pi N \rightarrow \pi N$, ηN
44	HOEHLER	93	ARGD	$\pi N \rightarrow \pi N$
34±2	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
44	BATINIC	10	DPWA	$\pi N \rightarrow N\pi$, $N\eta$
43	ARNDT	04	DPWA	$\pi N \rightarrow \pi N$, ηN
40	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
37	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90

PHASE θ

VALUE (°)	DOCUMENT ID		TECN	COMMENT
$-$ 4	ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
-17	HOEHLER	93	ARGD	$\pi N \to \pi N$
-25 ± 5	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
-19	BATINIC	10	DPWA	$\pi N \to N\pi, N\eta$
1	ARNDT	04	DPWA	$\pi N \to \pi N, \eta N$
$+$ 1	ARNDT	95	DPWA	$\pi N \to N\pi$
-14	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90

$N(1680)$ DECAY MODES

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

	Mode	Fraction (Γ_i/Γ)
Γ_1	$N\pi$	0.65 to 0.70
Γ_2	$N\eta$	(0.0 $\pm$1.0) %
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}	$p\gamma$	0.21–0.32 %
Γ_{15}	$p\gamma$, helicity=1/2	0.001–0.011 %
Γ_{16}	$p\gamma$, helicity=3/2	0.20–0.32 %
Γ_{17}	$n\gamma$	0.021–0.046 %
Γ_{18}	$n\gamma$, helicity=1/2	0.004–0.029 %
Γ_{19}	$n\gamma$, helicity=3/2	0.01–0.024 %

$N(1680)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ — Γ_1/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.65 to 0.70 OUR ESTIMATE				
0.66 $\pm$0.08	ANISOVICH	10	DPWA	Multichannel
0.701$\pm$0.001	ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
0.70 $\pm$0.03	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
0.62 $\pm$0.05	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
0.65 $\pm$0.02	HOEHLER	79	IPWA	$\pi N \to \pi N$

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

0.67 ±0.03	BATINIC	10	DPWA	$\pi N \to N\pi$, $N\eta$
0.72 ±0.15	THOMA	08	DPWA	Multichannel
0.670±0.004	ARNDT	04	DPWA	$\pi N \to \pi N$, ηN
0.69 ±0.02	VRANA	00	DPWA	Multichannel
0.68	ARNDT	95	DPWA	$\pi N \to N\pi$

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

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

$\Gamma(N\eta)/\Gamma_{total}$ $\quad\Gamma_2/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
0.00 ±0.01	VRANA	00	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.004 ±0.002	BATINIC	10	DPWA	$\pi N \to N\pi$, $N\eta$
<0.01	THOMA	08	DPWA	Multichannel
$0.0015^{+0.0035}_{-0.0010}$	TIATOR	99	DPWA	$\gamma p \to p\eta$

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

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

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 $\quad(\Gamma_1\Gamma_7)^{1/2}/\Gamma$

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	[1,5] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
−0.25	[2] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$\Gamma(\Delta(1232)\pi$, P-wave$)/\Gamma_{total}$ $\quad\Gamma_7/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
0.14±0.03	VRANA	00	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.08±0.03	THOMA	08	DPWA	Multichannel

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

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	[1,5] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
+0.08	[2] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$\Gamma(\Delta(1232)\pi, F\text{-wave})/\Gamma_{total}$ Γ_8/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.01 ± 0.01	VRANA	00	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.04 ± 0.03	THOMA	08	DPWA	Multichannel

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ 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	[1,5] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
-0.30	[2] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$\Gamma(N\rho, S=3/2, P\text{-wave})/\Gamma_{total}$ Γ_{11}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.05 ± 0.01	VRANA	00	DPWA	Multichannel

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ 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	[1,5] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

$\Gamma(N\rho, S=3/2, F\text{-wave})/\Gamma_{total}$ Γ_{12}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.03 ± 0.01	VRANA	00	DPWA	Multichannel

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ 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				
$+0.29\pm0.04$	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
$+0.31$	[1,5] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
$+0.30$	[2] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$\Gamma(N(\pi\pi)^{I=0}_{S\text{-wave}})/\Gamma_{total}$ Γ_{13}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.09 ± 0.01	VRANA	00	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.11 ± 0.05	THOMA	08	DPWA	Multichannel

$N(1680)$ PHOTON DECAY AMPLITUDES

Papers on γN amplitudes predating 1981 may be found in our 2006 edition, Journal of Physics, G **33** 1 (2006).

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

VALUE (GeV$^{-1/2}$)	*DOCUMENT ID*		*TECN*	*COMMENT*
−0.015±0.006 OUR ESTIMATE				
−0.012±0.006	ANISOVICH	10	DPWA	Multichannel
−0.017±0.001	DUGGER	07	DPWA	$\gamma N \rightarrow \pi N$
−0.010±0.004	ARNDT	96	IPWA	$\gamma N \rightarrow \pi N$
−0.017±0.018	CRAWFORD	83	IPWA	$\gamma N \rightarrow \pi N$
−0.009±0.006	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.025	DRECHSEL	07	DPWA	$\gamma N \rightarrow \pi N$
−0.006±0.002	LI	93	IPWA	$\gamma N \rightarrow \pi N$

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

VALUE (GeV$^{-1/2}$)	*DOCUMENT ID*		*TECN*	*COMMENT*
+0.133±0.012 OUR ESTIMATE				
0.136±0.012	ANISOVICH	10	DPWA	Multichannel
0.134±0.002	DUGGER	07	DPWA	$\gamma N \rightarrow \pi N$
0.145±0.005	ARNDT	96	IPWA	$\gamma N \rightarrow \pi N$
0.132±0.010	CRAWFORD	83	IPWA	$\gamma N \rightarrow \pi N$
0.115±0.008	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.134	DRECHSEL	07	DPWA	$\gamma N \rightarrow \pi N$
0.154±0.002	LI	93	IPWA	$\gamma N \rightarrow \pi N$

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

VALUE (GeV$^{-1/2}$)	*DOCUMENT ID*		*TECN*	*COMMENT*
+0.029±0.010 OUR ESTIMATE				
0.030±0.005	ARNDT	96	IPWA	$\gamma N \rightarrow \pi N$
0.017±0.014	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
0.032±0.003	FUJII	81	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.028	DRECHSEL	07	DPWA	$\gamma N \rightarrow \pi N$
0.022±0.002	LI	93	IPWA	$\gamma N \rightarrow \pi N$

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

VALUE (GeV$^{-1/2}$)	*DOCUMENT ID*		*TECN*	*COMMENT*
−0.033±0.009 OUR ESTIMATE				
−0.040±0.015	ARNDT	96	IPWA	$\gamma N \rightarrow \pi N$
−0.033±0.013	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
−0.023±0.005	FUJII	81	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.038	DRECHSEL	07	DPWA	$\gamma N \rightarrow \pi N$
−0.048±0.002	LI	93	IPWA	$\gamma N \rightarrow \pi N$

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 $\pi N \rightarrow N\pi\pi$ 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 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.

N(1680) REFERENCES

For early references, see Physics Letters **111B** 1 (1982). For very early references, see Reviews of Modern Physics **37** 633 (1965).

ANISOVICH	10	EPJ A44 203	A.V. Anisovich *et al.*	(BONN, PNPI)	
BATINIC	10	PR C82 038203	M. Batinic *et al.*	(ZAGR)	
THOMA	08	PL B659 87	U. Thoma *et al.*	(CB-ELSA Collab.)	
DRECHSEL	07	EPJ A34 69	D. Drechsel, S.S. Kamalov, L. Tiator	(MAINZ, JINR)	
DUGGER	07	PR C76 025211	M. Dugger *et al.*	(Jefferson Lab CLAS Collab.)	
ARNDT	06	PR C74 045205	R.A. Arndt *et al.*	(GWU)	
PDG	06	JPG 33 1	W.-M. Yao *et al.*	(PDG Collab.)	
ARNDT	04	PR C69 035213	R.A. Arndt *et al.*	(GWU, TRIU)	
VRANA	00	PRPL 328 181	T.P. Vrana, S.A. Dytman,, T.-S.H. Lee	(PITT+)	
TIATOR	99	PR C60 035210	L. Tiator *et al.*		
ARNDT	96	PR C53 430	R.A. Arndt, I.I. Strakovsky, R.L. Workman	(VPI)	
ARNDT	95	PR C52 2120	R.A. Arndt *et al.*	(VPI, BRCO)	
HOEHLER	93	πN Newsletter 9 1	G. Hohler	(KARL)	
LI	93	PR C47 2759	Z.J. Li *et al.*	(VPI)	
MANLEY	92	PR D45 4002	D.M. Manley, E.M. Saleski	(KENT)	IJP
Also		PR D30 904	D.M. Manley *et al.*	(VPI)	
ARNDT	91	PR D43 2131	R.A. Arndt *et al.*	(VPI, TELE)	IJP
BELL	83	NP B222 389	K.W. Bell *et al.*	(RL)	IJP
CRAWFORD	83	NP B211 1	R.L. Crawford, W.T. Morton	(GLAS)	
PDG	82	PL 111B 1	M. Roos *et al.*	(HELS, CIT, CERN)	
AWAJI	81	Bonn Conf. 352	N. Awaji, R. Kajikawa	(NAGO)	
Also		NP B197 365	K. Fujii *et al.*	(NAGO)	
FUJII	81	NP B187 53	K. Fujii *et al.*	(NAGO, OSAK)	
CUTKOSKY	80	Toronto Conf. 19	R.E. Cutkosky *et al.*	(CMU, LBL)	IJP
Also		PR D20 2839	R.E. Cutkosky *et al.*	(CMU, LBL)	IJP
SAXON	80	NP B162 522	D.H. Saxon *et al.*	(RHEL, BRIS)	IJP
BAKER	79	NP B156 93	R.D. Baker *et al.*	(RHEL)	IJP
HOEHLER	79	PDAT 12-1	G. Hohler *et al.*	(KARLT)	IJP
Also		Toronto Conf. 3	R. Koch	(KARLT)	IJP
LONGACRE	78	PR D17 1795	R.S. Longacre *et al.*	(LBL, SLAC)	
LONGACRE	77	NP B122 493	R.S. Longacre, J. Dolbeau	(SACL)	IJP
Also		NP B108 365	J. Dolbeau *et al.*	(SACL)	IJP
LONGACRE	75	PL 55B 415	R.S. Longacre *et al.*	(LBL, SLAC)	IJP