

N(1680) F_{15}

$$I(J^P) = \frac{1}{2}(5^+)$$
 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 (\approx 1685) OUR ESTIMATE			
1680.1 \pm 0.2	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1684 \pm 4	MANLEY	92	IPWA $\pi N \rightarrow \pi N \& N\pi\pi$
1680 \pm 10	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
1684 \pm 3	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1684 \pm 8	THOMA	08	DPWA Multichannel
1683.2 \pm 0.7	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
1679 \pm 3	VRANA	00	DPWA Multichannel
1679 \pm 5	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
1678	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
1674 \pm 12	BATINIC	95	DPWA $\pi N \rightarrow N\pi, N\eta$
1660	¹ LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$
1670	² LONGACRE	75	IPWA $\pi N \rightarrow N\pi\pi$

N(1680) BREIT-WIGNER WIDTH

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
120 to 140 (\approx 130) OUR ESTIMATE			
128.0 \pm 1.1	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
139 \pm 8	MANLEY	92	IPWA $\pi N \rightarrow \pi N \& N\pi\pi$
120 \pm 10	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
128 \pm 8	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
105 \pm 8	THOMA	08	DPWA Multichannel
134.4 \pm 3.8	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
128 \pm 9	VRANA	00	DPWA Multichannel
124 \pm 4	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
126	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
126 \pm 20	BATINIC	95	DPWA $\pi N \rightarrow N\pi, N\eta$
150	¹ LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$
130	² LONGACRE	75	IPWA $\pi N \rightarrow N\pi\pi$

N(1680) POLE POSITION

REAL PART

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
1665 to 1680 (\approx 1675) OUR ESTIMATE			
1674	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1673	³ HOEHLER	93	ARGD $\pi N \rightarrow \pi N$
1667 \pm 5	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1674 \pm 5	THOMA	08	DPWA Multichannel
1678	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
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

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
110 to 135 (\approx 120) OUR ESTIMATE			
115	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
135	³ HOEHLER	93	ARGD $\pi N \rightarrow \pi N$
110 \pm 10	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
95 \pm 10	THOMA	08	DPWA Multichannel
120	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
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 $|r|$

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
42	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
44	HOEHLER	93	ARGD $\pi N \rightarrow \pi N$
34 \pm 2	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
43	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
40	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
37	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90

PHASE θ

<u>VALUE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
– 4	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
– 17	HOEHLER	93	ARGD $\pi N \rightarrow \pi N$
– 25 \pm 5	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$

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

1	ARNDT	04	DPWA	$\pi N \rightarrow \pi N, \eta N$
+ 1	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
- 14	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ 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} $N(\pi\pi)_{S\text{-wave}}^{I=0}$	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

$\Gamma(N\pi)/\Gamma_{\text{total}}$					Γ_1/Γ
VALUE	DOCUMENT ID	TECN	COMMENT		
0.65 to 0.70 OUR ESTIMATE					
0.701 \pm 0.001	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$	
0.70 \pm 0.03	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$	
0.62 \pm 0.05	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$	
0.65 \pm 0.02	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.72 \pm 0.15	THOMA	08	DPWA	Multichannel	
0.670 \pm 0.004	ARNDT	04	DPWA	$\pi N \rightarrow \pi N, \eta N$	
0.69 \pm 0.02	VRANA	00	DPWA	Multichannel	
0.68	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$	
0.69 \pm 0.04	BATINIC	95	DPWA	$\pi N \rightarrow N\pi, N\eta$	

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

VALUE	DOCUMENT ID	TECN	COMMENT
not seen	BAKER	79	DPWA $\pi^- p \rightarrow n\eta$

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

VALUE	DOCUMENT ID	TECN	COMMENT
0.00 ± 0.01	VRANA	00	DPWA Multichannel
<0.01	THOMA	08	DPWA Multichannel
0.0015 ^{+0.0035} _{-0.0010}	TIATOR	99	DPWA $\gamma p \rightarrow p\eta$
0.01 ± 0.004	BATINIC	95	DPWA $\pi N \rightarrow N\pi, N\eta$

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

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

Note: Signs of couplings from $\pi N \rightarrow N\pi\pi$ 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 $\Delta(1232)\pi$.

$(\Gamma_i \Gamma_f)^{1/2} / \Gamma_{\text{total}}$ in $N\pi \rightarrow N(1680) \rightarrow \Delta(1232)\pi, P\text{-wave}$ $(\Gamma_1 \Gamma_7)^{1/2} / \Gamma$

VALUE	DOCUMENT ID	TECN	COMMENT
-0.31 to -0.21 OUR ESTIMATE			
-0.26 ± 0.04	MANLEY	92	IPWA $\pi N \rightarrow \pi N \& N\pi\pi$
-0.27	^{1,5} LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$
-0.25	² LONGACRE	75	IPWA $\pi N \rightarrow N\pi\pi$

$\Gamma(\Delta(1232)\pi, P\text{-wave}) / \Gamma_{\text{total}}$ Γ_7 / Γ

VALUE	DOCUMENT ID	TECN	COMMENT
0.14 ± 0.03	VRANA	00	DPWA Multichannel
0.08 ± 0.03	THOMA	08	DPWA Multichannel

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

VALUE	DOCUMENT ID	TECN	COMMENT
+0.03 to +0.11 OUR ESTIMATE			
+0.07 ± 0.03	MANLEY	92	IPWA $\pi N \rightarrow \pi N \& N\pi\pi$
+0.07	^{1,5} LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$
+0.08	² LONGACRE	75	IPWA $\pi N \rightarrow N\pi\pi$

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

VALUE	DOCUMENT ID	TECN	COMMENT
0.01 ± 0.01	VRANA	00	DPWA Multichannel
0.04 ± 0.03	THOMA	08	DPWA Multichannel

$(\Gamma_i \Gamma_f)^{1/2} / \Gamma_{\text{total}}$ in $N\pi \rightarrow N(1680) \rightarrow N\rho, S=3/2, P\text{-wave}$	$(\Gamma_1 \Gamma_{11})^{1/2} / \Gamma$		
VALUE	DOCUMENT ID	TECN	COMMENT
−0.30 to −0.10 OUR ESTIMATE			
−0.20 ± 0.05	MANLEY	92	IPWA $\pi N \rightarrow \pi N \& N\pi\pi$
−0.23	^{1,5} LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$
−0.30	² LONGACRE	75	IPWA $\pi N \rightarrow N\pi\pi$

$\Gamma(N\rho, S=3/2, P\text{-wave}) / \Gamma_{\text{total}}$	Γ_{11} / Γ		
VALUE	DOCUMENT ID	TECN	COMMENT
0.05 ± 0.01	VRANA	00	DPWA Multichannel

$(\Gamma_i \Gamma_f)^{1/2} / \Gamma_{\text{total}}$ in $N\pi \rightarrow N(1680) \rightarrow N\rho, S=3/2, F\text{-wave}$	$(\Gamma_1 \Gamma_{12})^{1/2} / \Gamma$		
VALUE	DOCUMENT ID	TECN	COMMENT
−0.18 to −0.10 OUR ESTIMATE			
−0.13 ± 0.03	MANLEY	92	IPWA $\pi N \rightarrow \pi N \& N\pi\pi$
−0.15	^{1,5} LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$

$\Gamma(N\rho, S=3/2, F\text{-wave}) / \Gamma_{\text{total}}$	Γ_{12} / Γ		
VALUE	DOCUMENT ID	TECN	COMMENT
0.03 ± 0.01	VRANA	00	DPWA Multichannel

$(\Gamma_i \Gamma_f)^{1/2} / \Gamma_{\text{total}}$ in $N\pi \rightarrow N(1680) \rightarrow N(\pi\pi)_{S\text{-wave}}^{I=0}$	$(\Gamma_1 \Gamma_{13})^{1/2} / \Gamma$		
VALUE	DOCUMENT ID	TECN	COMMENT
+0.25 to +0.35 OUR ESTIMATE			
+0.29 ± 0.04	MANLEY	92	IPWA $\pi N \rightarrow \pi N \& N\pi\pi$
+0.31	^{1,5} LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$
+0.30	² LONGACRE	75	IPWA $\pi N \rightarrow N\pi\pi$

$\Gamma(N(\pi\pi)_{S\text{-wave}}^{I=0}) / \Gamma_{\text{total}}$	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			
−0.017 ± 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 ($\text{GeV}^{-1/2}$)	DOCUMENT ID	TECN	COMMENT
+0.133±0.012 OUR ESTIMATE			
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 ($\text{GeV}^{-1/2}$)	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 ($\text{GeV}^{-1/2}$)	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).

THOMA	08	PL B659 87	U. Thoma <i>et al.</i>	(CB-ELSA Collab.)
DRECHSEL	07	EPJ A34 69	D. Drechsel, S.S. Kamalov, L. Tiator	(MAINZ, JINR)
DUGGER	07	PR C76 025211	M. Dugger <i>et al.</i>	(Jefferson Lab CLAS Collab.)
ARNDT	06	PR C74 045205	R.A. Arndt <i>et al.</i>	(GWU)
PDG	06	JPG 33 1	W.-M. Yao <i>et al.</i>	(PDG Collab.)
ARNDT	04	PR C69 035213	R.A. Arndt <i>et al.</i>	(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 <i>et al.</i>	
ARNDT	96	PR C53 430	R.A. Arndt, I.I. Strakovsky, R.L. Workman	(VPI)
ARNDT	95	PR C52 2120	R.A. Arndt <i>et al.</i>	(VPI, BRCO)
BATINIC	95	PR C51 2310	M. Batinic <i>et al.</i>	(BOSK, UCLA)
Also		PR C57 1004 (erratum)	M. Batinic <i>et al.</i>	
HOEHLER	93	π N Newsletter 9 1	G. Hohler	(KARL)
LI	93	PR C47 2759	Z.J. Li <i>et al.</i>	(VPI)
MANLEY	92	PR D45 4002	D.M. Manley, E.M. Saleski	(KENT) IJP
Also		PR D30 904	D.M. Manley <i>et al.</i>	(VPI)
ARNDT	91	PR D43 2131	R.A. Arndt <i>et al.</i>	(VPI, TELE) IJP
BELL	83	NP B222 389	K.W. Bell <i>et al.</i>	(RL) IJP
CRAWFORD	83	NP B211 1	R.L. Crawford, W.T. Morton	(GLAS)
PDG	82	PL 111B 1	M. Roos <i>et al.</i>	(HELS, CIT, CERN)
AWAJI	81	Bonn Conf. 352	N. Awaji, R. Kajikawa	(NAGO)
Also		NP B197 365	K. Fujii <i>et al.</i>	(NAGO)
FUJII	81	NP B187 53	K. Fujii <i>et al.</i>	(NAGO, OSAK)
CUTKOSKY	80	Toronto Conf. 19	R.E. Cutkosky <i>et al.</i>	(CMU, LBL) IJP
Also		PR D20 2839	R.E. Cutkosky <i>et al.</i>	(CMU, LBL) IJP
SAXON	80	NP B162 522	D.H. Saxon <i>et al.</i>	(RHEL, BRIS) IJP
BAKER	79	NP B156 93	R.D. Baker <i>et al.</i>	(RHEL) IJP
HOEHLER	79	PDAT 12-1	G. Hohler <i>et al.</i>	(KARLT) IJP
Also		Toronto Conf. 3	R. Koch	(KARLT) IJP
LONGACRE	78	PR D17 1795	R.S. Longacre <i>et al.</i>	(LBL, SLAC)
LONGACRE	77	NP B122 493	R.S. Longacre, J. Dolbeau	(SACL) IJP
Also		NP B108 365	J. Dolbeau <i>et al.</i>	(SACL) IJP
LONGACRE	75	PL 55B 415	R.S. Longacre <i>et al.</i>	(LBL, SLAC) IJP