$$\boxed{N(1650)\ 1/2^-}$$ $I(J^P) = \frac{1}{2}(\frac{1}{2}^-)$ Status: ∗∗∗∗

Older and obsolete values are listed and referenced in the 2014 edition, Chinese Physics **C38** 070001 (2014).

N(1650) POLE POSITION

REAL PART

VALUE (MeV)		DOCUMENT ID		TECN	COMMENT
1640 to 1670 (≈ 1655) OUR ESTIMATE					
1664± 4		AFZAL	20	DPWA	Multichannel
1658±10		ANISOVICH	17A	DPWA	Multichannel
1660± 5	[1]	ANISOVICH	17A	L+P	$\gamma p, \pi^- p \to K\Lambda$
1660± 3.5±1	[2]	SVARC	14	L+P	$\pi N \to \pi N$
1640±20		CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
1656		HUNT	19	DPWA	Multichannel
1672		ROENCHEN	15A	DPWA	Multichannel
1652± 7		SOKHOYAN	15A	DPWA	Multichannel
1650		SHKLYAR	13	DPWA	Multichannel
1647± 6		ANISOVICH	12A	DPWA	Multichannel
1646± 8		BATINIC	10	DPWA	$\pi N \to N\pi, N\eta$
1648		ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
1663		VRANA	00	DPWA	Multichannel
1670		HOEHLER	93	ARGD	$\pi N \to \pi N$

[1] Statistical error only.
[2] Fit to the amplitudes of HOEHLER 79.

−2×IMAGINARY PART

VALUE (MeV)		DOCUMENT ID		TECN	COMMENT
100 to 170 (≈ 135) OUR ESTIMATE					
98± 6		AFZAL	20	DPWA	Multichannel
102± 8		ANISOVICH	17A	DPWA	Multichannel
59±16	[1]	ANISOVICH	17A	L+P	$\gamma p, \pi^- p \to K\Lambda$
167± 8±2	[2]	SVARC	14	L+P	$\pi N \to \pi N$
150±30		CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
130		HUNT	19	DPWA	Multichannel
137		ROENCHEN	15A	DPWA	Multichannel
102± 8		SOKHOYAN	15A	DPWA	Multichannel
89		SHKLYAR	13	DPWA	Multichannel
103± 8		ANISOVICH	12A	DPWA	Multichannel
204±17		BATINIC	10	DPWA	$\pi N \to N\pi, N\eta$
80		ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
240		VRANA	00	DPWA	Multichannel
163		HOEHLER	93	ARGD	$\pi N \to \pi N$

[1] Statistical error only.
[2] Fit to the amplitudes of HOEHLER 79.

N(1650) ELASTIC POLE RESIDUE

MODULUS |*r*|

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
25 to 55 (≈ 45) OUR ESTIMATE				
27± 6	SOKHOYAN	15A	DPWA	Multichannel
47± 3±1	[1] SVARC	14	L+P	$\pi N \to \pi N$
60±10	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
37	ROENCHEN	15A	DPWA	Multichannel
19	SHKLYAR	13	DPWA	Multichannel
24± 3	ANISOVICH	12A	DPWA	Multichannel
100	BATINIC	10	DPWA	$\pi N \to N\pi, N\eta$
14	ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
39	HOEHLER	93	ARGD	$\pi N \to \pi N$

[1] Fit to the amplitudes of HOEHLER 79.

PHASE *θ*

VALUE (°)	DOCUMENT ID		TECN	COMMENT
−80 to −50 (≈ − 70) OUR ESTIMATE				
−60±20	SOKHOYAN	15A	DPWA	Multichannel
−47± 3±1	[1] SVARC	14	L+P	$\pi N \to \pi N$
−75±25	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−59	ROENCHEN	15A	DPWA	Multichannel
−46	SHKLYAR	13	DPWA	Multichannel
−75±12	ANISOVICH	12A	DPWA	Multichannel
−65	BATINIC	10	DPWA	$\pi N \to N\pi, N\eta$
−69	ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
−37	HOEHLER	93	ARGD	$\pi N \to \pi N$

[1] Fit to the amplitudes of HOEHLER 79.

N(1650) INELASTIC POLE RESIDUE

The "normalized residue" is the residue divided by $\Gamma_{pole}/2$.

Normalized residue in $N\pi \to N(1650) \to N\eta$

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.29±0.03	134 ± 10	ANISOVICH	12A	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.21	48	ROENCHEN	15A	DPWA	Multichannel

Normalized residue in $N\pi \to N(1650) \to \Lambda K$

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.26±0.10	110 ± 20	ANISOVICH	17A	DPWA	Multichannel
0.10±0.10	95 ± 33	[1] ANISOVICH	17A	L+P	$\gamma p, \pi^- p \to K\Lambda$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.20	−54	ROENCHEN	15A	DPWA	Multichannel
0.23±0.09	85 ± 9	ANISOVICH	12A	DPWA	Multichannel

[1] Statistical error only.

Normalized residue in $N\pi \to N(1650) \to \Sigma K$

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.026	-74	ROENCHEN	15A	DPWA	Multichannel

Normalized residue in $N\pi \to N(1650) \to \Delta\pi$, *D*-wave

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.19 ± 0.06	-30 ± 20	SOKHOYAN	15A	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.23 ± 0.04	-30 ± 20	ANISOVICH	12A	DPWA	Multichannel

Normalized residue in $N\pi \to N(1650) \to N\sigma$

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.20 ± 0.15	undefined	SOKHOYAN	15A	DPWA	Multichannel

Normalized residue in $N\pi \to N(1650) \to N(1440)\pi$

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.30 ± 0.17	undefined	SOKHOYAN	15A	DPWA	Multichannel

N(1650) BREIT-WIGNER MASS

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
1635 to 1665 ($\approx$ 1650) OUR ESTIMATE				
1657 ± 6	GOLOVATCH	19	DPWA	$\gamma p \to \pi^+ \pi^- p$
1666 ± 3	[1] HUNT	19	DPWA	Multichannel
1634 ± 5	KASHEVAROV	17	DPWA	$\gamma p \to \eta p, \eta' p$
1654 ± 6	SOKHOYAN	15A	DPWA	Multichannel
1665 ± 2	[1] SHKLYAR	13	DPWA	Multichannel
1634.7 ± 1.1	[1] ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
1650 ± 30	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
1670 ± 8	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1651 ± 6	ANISOVICH	12A	DPWA	Multichannel
1664 ± 2	[1] SHRESTHA	12A	DPWA	Multichannel
1652 ± 9	BATINIC	10	DPWA	$\pi N \to N\pi, N\eta$
1665 ± 2	PENNER	02C	DPWA	Multichannel
1647 ± 20	BAI	01B	BES	$J/\psi \to p\overline{p}\eta$
1689 ± 12	VRANA	00	DPWA	Multichannel

[1] Statistical error only.

N(1650) BREIT-WIGNER WIDTH

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
100 to 150 ($\approx$ 125) OUR ESTIMATE				
154 ± 28	GOLOVATCH	19	DPWA	$\gamma p \to \pi^+ \pi^- p$
133 ± 7	[1] HUNT	19	DPWA	Multichannel
128 ± 16	KASHEVAROV	17	DPWA	$\gamma p \to \eta p, \eta' p$
102 ± 8	SOKHOYAN	15A	DPWA	Multichannel

147 $\pm$14	[1] SHKLYAR	13	DPWA	Multichannel
115.4$\pm$ 2.8	[1] ARNDT	06	DPWA	$\pi N \to \pi N,\ \eta N$
150 $\pm$40	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
180 $\pm$20	HOEHLER	79	IPWA	$\pi N \to \pi N$

$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$

104 $\pm$10	ANISOVICH	12A	DPWA	Multichannel
126 $\pm$ 3	[1] SHRESTHA	12A	DPWA	Multichannel
202 $\pm$16	BATINIC	10	DPWA	$\pi N \to N\pi,\ N\eta$
138 $\pm$ 7	PENNER	02C	DPWA	Multichannel
145 $^{+80}_{-45}$	BAI	01B	BES	$J/\psi \to p\overline{p}\eta$
202 $\pm$40	VRANA	00	DPWA	Multichannel

[1] Statistical error only.

N(1650) DECAY MODES

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

	Mode	Fraction (Γ_i/Γ)
Γ_1	$N\pi$	50–70 %
Γ_2	$N\eta$	15–35 %
Γ_3	ΛK	5–15 %
Γ_4	$N\pi\pi$	20–58 %
Γ_5	$\Delta(1232)\pi$, D-wave	6–18 %
Γ_6	$N\rho$	12–22 %
Γ_7	$N\rho$, $S=1/2$, S-wave	$<$4 %
Γ_8	$N\rho$, $S=3/2$, D-wave	12–18 %
Γ_9	$N\sigma$	2–18 %
Γ_{10}	$N(1440)\pi$	6–26 %
Γ_{11}	$p\gamma$, helicity=1/2	0.04–0.20 %
Γ_{12}	$n\gamma$, helicity=1/2	0.003–0.17 %

N(1650) BRANCHING RATIOS

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

VALUE (%)	DOCUMENT ID		TECN	COMMENT
50 to 70 ($\approx$ 60) OUR ESTIMATE				
64$\pm$ 4	[1] HUNT	19	DPWA	Multichannel
51$\pm$ 4	SOKHOYAN	15A	DPWA	Multichannel
74$\pm$ 3	[1] SHKLYAR	13	DPWA	Multichannel
65$\pm$10	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
61$\pm$ 4	HOEHLER	79	IPWA	$\pi N \to \pi N$

$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$

51$\pm$ 4	ANISOVICH	12A	DPWA	Multichannel
57$\pm$ 2	[1] SHRESTHA	12A	DPWA	Multichannel
79$\pm$ 6	BATINIC	10	DPWA	$\pi N \to N\pi,\ N\eta$
100	ARNDT	06	DPWA	$\pi N \to \pi N,\ \eta N$

	DOCUMENT ID		TECN	COMMENT
65± 4	PENNER	02C	DPWA	Multichannel
74± 2	VRANA	00	DPWA	Multichannel

[1] Statistical error only.

$\Gamma(N\eta)/\Gamma_{total}$ Γ_2/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
15 to 35 (≈ 25) OUR ESTIMATE				
33 ± 4	MUELLER	20	DPWA	Multichannel
0.8± 0.6	[1] HUNT	19	DPWA	Multichannel
28 ±11	[2] KASHEVAROV	17	DPWA	$\gamma p \to \eta p, \eta' p$
< 3	SHKLYAR	13	DPWA	Multichannel
18 ± 4	ANISOVICH	12A	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
21 ± 2	[1] SHRESTHA	12A	DPWA	Multichannel
13 ± 5	BATINIC	10	DPWA	$\pi N \to N\pi, N\eta$
1.0± 0.6	PENNER	02C	DPWA	Multichannel
6 ± 1	VRANA	00	DPWA	Multichannel

[1] Statistical error only.
[2] Assuming $A_{1/2} = 0.045$ GeV$^{-1/2}$.

$\Gamma(\Lambda K)/\Gamma_{total}$ Γ_3/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
5 to 15 (≈ 10) OUR ESTIMATE				
3.5±0.2	[1] HUNT	19	DPWA	Multichannel
10 ±5	ANISOVICH	12A	DPWA	Multichannel
4 ±1	[1] SHKLYAR	05	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
8 ±1	[1] SHRESTHA	12A	DPWA	Multichannel
2.7±0.4	PENNER	02C	DPWA	Multichannel

[1] Statistical error only.

$\Gamma(N\pi\pi)/\Gamma_{total}$ Γ_4/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.12±0.02	GOLOVATCH	19	DPWA	$\gamma p \to \pi^+\pi^- p$

$\Gamma(\Delta(1232)\pi, D\text{-wave})/\Gamma_{total}$ Γ_5/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
< 0.2	[1] HUNT	19	DPWA	Multichannel
12 ±6	SOKHOYAN	15A	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
19 ±9	ANISOVICH	12A	DPWA	Multichannel
7 ±2	[1] SHRESTHA	12A	DPWA	Multichannel
2 ±1	VRANA	00	DPWA	Multichannel

[1] Statistical error only.

$\Gamma(N\rho, S=1/2, S\text{-wave})/\Gamma_{total}$ Γ_7/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
1.8±1.7	[1] HUNT	19	DPWA	Multichannel

[1] Statistical error only.

$\Gamma(N\rho, S=3/2, D\text{-wave})/\Gamma_{total}$ Γ_8/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
15 ± 3	[1] HUNT	19	DPWA	Multichannel

[1] Statistical error only.

$\Gamma(N\sigma)/\Gamma_{total}$ Γ_9/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
12 ± 4	[1] HUNT	19	DPWA	Multichannel
10 ± 8	SOKHOYAN	15A	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<1	[1] SHRESTHA	12A	DPWA	Multichannel
1 ± 1	VRANA	00	DPWA	Multichannel

[1] Statistical error only.

$\Gamma(N(1440)\pi)/\Gamma_{total}$ Γ_{10}/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
2 ± 1	[1] HUNT	19	DPWA	Multichannel
16 ± 10	SOKHOYAN	15A	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<1	[1] SHRESTHA	12A	DPWA	Multichannel
3 ± 1	VRANA	00	DPWA	Multichannel

[1] Statistical error only.

$N(1650)$ PHOTON DECAY AMPLITUDES AT THE POLE

$N(1650) \rightarrow p\gamma$, helicity-1/2 amplitude A$_{1/2}$

MODULUS (GeV$^{-1/2}$)	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.032 ± 0.006	7 ± 7	ANISOVICH	17D	DPWA	Multichannel
$0.023^{+0.003}_{-0.008}$	6^{+28}_{-15}	ROENCHEN	14	DPWA	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.032 ± 0.007	-2 ± 11	ANISOVICH	15A	DPWA	Multichannel
0.059	-14	ROENCHEN	15A	DPWA	Multichannel
0.032 ± 0.006	-2 ± 11	SOKHOYAN	15A	DPWA	Multichannel

$N(1650) \rightarrow n\gamma$, helicity-1/2 amplitude A$_{1/2}$

MODULUS (GeV$^{-1/2}$)	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.016 ± 0.004	-28 ± 10	ANISOVICH	17D	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.019 ± 0.006	0 ± 15	ANISOVICH	15A	DPWA	Multichannel

$N(1650)$ BREIT-WIGNER PHOTON DECAY AMPLITUDES

$N(1650) \rightarrow p\gamma$, helicity-1/2 amplitude A$_{1/2}$

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
0.035 to 0.055 ($\approx$ 0.045) OUR ESTIMATE				
0.0605 ± 0.0077	GOLOVATCH	19	DPWA	$\gamma p \rightarrow \pi^+\pi^- p$
0.048 ± 0.003	[1] HUNT	19	DPWA	Multichannel
0.032 ± 0.006	SOKHOYAN	15A	DPWA	Multichannel

0.063 ±0.006	[1] SHKLYAR	13	DPWA	Multichannel
0.055 ±0.030	[1] WORKMAN	12A	DPWA	$\gamma N \to N\pi$
0.022 ±0.007	[1] DUGGER	07	DPWA	$\gamma N \to \pi N$

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

0.033 ±0.007	ANISOVICH	12A	DPWA	Multichannel
0.030 ±0.003	[1] SHRESTHA	12A	DPWA	Multichannel
0.033	DRECHSEL	07	DPWA	$\gamma N \to \pi N$
0.049	PENNER	02D	DPWA	Multichannel

[1] Statistical error only.

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

VALUE $(\mathrm{GeV}^{-1/2})$	DOCUMENT ID		TECN	COMMENT
−0.040 to 0.030 (≈ − 0.010) OUR ESTIMATE				
0.001±0.006	[1] HUNT	19	DPWA	Multichannel
0.025±0.020	ANISOVICH	13B	DPWA	Multichannel
−0.040±0.010	[1] CHEN	12A	DPWA	$\gamma N \to \pi N$

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

0.011±0.002	[1] SHRESTHA	12A	DPWA	Multichannel
0.009	DRECHSEL	07	DPWA	$\gamma N \to \pi N$
−0.011	PENNER	02D	DPWA	Multichannel

[1] Statistical error only.

$N(1650)$ REFERENCES

For early references, see Physics Letters **111B** 1 (1982).

AFZAL	20	PRL 125 152002	F. Afzal et al.	(CBELSA/TAPS Collab.)
MUELLER	20	PL B803 135323	J. Mueller et al.	(CBELSA/TAPS Collab.)
GOLOVATCH	19	PL B788 371	E. Golovatch et al.	(CLAS Collab.)
HUNT	19	PR C99 055205	B.C. Hunt, D.M. Manley	
ANISOVICH	17A	PRL 119 062004	A.V. Anisovich et al.	
ANISOVICH	17D	PR C95 035211	A.V. Anisovich et al.	
KASHEVAROV	17	PRL 118 212001	V.L. Kashevarov et al.	(A2/MAMI Collab.)
ANISOVICH	15A	EPJ A51 72	A.V. Anisovich et al.	
ROENCHEN	15A	EPJ A51 70	D. Roenchen et al.	
SOKHOYAN	15A	EPJ A51 95	V. Sokhoyan et al.	(CBELSA/TAPS Collab.)
PDG	14	CP C38 070001	K. Olive et al.	(PDG Collab.)
ROENCHEN	14	EPJ A50 101	D. Roenchen et al.	
Also		EPJ A51 63 (errat.)	D. Roenchen et al.	
SVARC	14	PR C89 045205	A. Svarc et al.	(RBI Zagreb, UNI Tuzla)
ANISOVICH	13B	EPJ A49 67	A.V. Anisovich et al.	
SHKLYAR	13	PR C87 015201	V. Shklyar, H. Lenske, U. Mosel	(GIES)
ANISOVICH	12A	EPJ A48 15	A.V. Anisovich et al.	(BONN, PNPI)
CHEN	12A	PR C86 015206	W. Chen et al.	(DUKE, GWU, MSST, ITEP+)
SHRESTHA	12A	PR C86 055203	M. Shrestha, D.M. Manley	(KSU)
WORKMAN	12A	PR C86 015202	R. Workman et al.	(GWU)
BATINIC	10	PR C82 038203	M. Batinic et al.	(ZAGR)
DRECHSEL	07	EPJ A34 69	D. Drechsel, S.S. Kamalov, L. Tiator	(MAINZ, JINR)
DUGGER	07	PR C76 025211	M. Dugger et al.	(JLab CLAS Collab.)
ARNDT	06	PR C74 045205	R.A. Arndt et al.	(GWU)
SHKLYAR	05	PR C72 015210	V. Shklyar, H. Lenske, U. Mosel	(GIES)
PENNER	02C	PR C66 055211	G. Penner, U. Mosel	(GIES)
PENNER	02D	PR C66 055212	G. Penner, U. Mosel	(GIES)
BAI	01B	PL B510 75	J.Z. Bai et al.	(BES Collab.)
VRANA	00	PRPL 328 181	T.P. Vrana, S.A. Dytman, T.-S.H. Lee	(PITT, ANL)
HOEHLER	93	πN Newsletter 9 1	G. Hohler	(KARL)

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
HOEHLER	79	PDAT 12-1	G. Hohler *et al.*	(KARLT) IJP
Also		Toronto Conf. 3	R. Koch	(KARLT) IJP