$N(1650)\ 1/2^-$

$I(J^P) = \frac{1}{2}(\frac{1}{2}^-)$ 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				
1658±10	ANISOVICH	17A	DPWA	Multichannel
1660± 5	[1] ANISOVICH	17A	L+P	γp, $\pi^- p \to K\Lambda$
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. • • •				
1672	ROENCHEN	15A	DPWA	Multichannel
1652± 7	SOKHOYAN	15A	DPWA	Multichannel
1650	SHKLYAR	13	DPWA	Multichannel
1647± 6	ANISOVICH	12A	DPWA	Multichannel
1655	SHRESTHA	12A	DPWA	Multichannel
1646± 8	BATINIC	10	DPWA	$\pi N \to N\pi$, $N\eta$
1648	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
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				
102± 8	ANISOVICH	17A	DPWA	Multichannel
59±16	[1] ANISOVICH	17A	L+P	γp, $\pi^- p \to K\Lambda$
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. • • •				
137	ROENCHEN	15A	DPWA	Multichannel
102± 8	SOKHOYAN	15A	DPWA	Multichannel
89	SHKLYAR	13	DPWA	Multichannel
103± 8	ANISOVICH	12A	DPWA	Multichannel
123	SHRESTHA	12A	DPWA	Multichannel
204±17	BATINIC	10	DPWA	$\pi N \to N\pi$, $N\eta$
80	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
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	$\pi N \to \pi N$, ηN
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	$\pi N \to \pi N$, ηN
−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	γp, $\pi^- p \to K\Lambda$
• • • 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 $N\pi \rightarrow N(1650) \rightarrow \Sigma K$

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 $N\pi \rightarrow N(1650) \rightarrow \Delta\pi$, 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 $N\pi \rightarrow N(1650) \rightarrow N\sigma$

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

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

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 (≈ 1650) OUR ESTIMATE				
1634 ± 5	KASHEVAROV	17	DPWA	$\gamma p \rightarrow \eta p, \eta' p$
1654 ± 6	SOKHOYAN	15A	DPWA	Multichannel
1665 ± 2	[1] SHKLYAR	13	DPWA	Multichannel
1664 ± 2	[1] SHRESTHA	12A	DPWA	Multichannel
1634.7± 1.1	[1] ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
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. • • •				
1651 ± 6	ANISOVICH	12A	DPWA	Multichannel
1652 ± 9	BATINIC	10	DPWA	$\pi N \rightarrow N\pi, N\eta$
1665 ± 2	PENNER	02C	DPWA	Multichannel
1647 ±20	BAI	01B	BES	$J/\psi \rightarrow p\overline{p}\eta$
1689 ±12	VRANA	00	DPWA	Multichannel

[1] Statistical error only.

N(1650) BREIT-WIGNER WIDTH

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
100 to 150 (≈ 125) OUR ESTIMATE				
128 ±16	KASHEVAROV	17	DPWA	$\gamma p \rightarrow \eta p, \eta' p$
102 ± 8	SOKHOYAN	15A	DPWA	Multichannel
147 ±14	[1] SHKLYAR	13	DPWA	Multichannel
126 ± 3	[1] SHRESTHA	12A	DPWA	Multichannel
115.4± 2.8	[1] ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
150 ±40	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
180 ±20	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$

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

104 ±10	ANISOVICH	12A	DPWA	Multichannel
202 ±16	BATINIC	10	DPWA	$\pi N \to N\pi$, $N\eta$
138 ± 7	PENNER	02C	DPWA	Multichannel
145 $^{+80}_{-45}$	BAI	01B	BES	$J/\psi \to p\overline{p}\eta$
202 ±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	$N\pi\pi$	8–36 %
Γ_5	$\Delta(1232)\pi$	
Γ_6	$\Delta(1232)\pi$, *D*-wave	6–18 %
Γ_7	$N\sigma$	2–18 %
Γ_8	$N(1440)\pi$	6–26 %
Γ_9	$p\gamma$, helicity=1/2	0.04–0.20 %
Γ_{10}	$n\gamma$, helicity=1/2	0.003–0.17 %

N(1650) BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ — Γ_1/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
50 to 70 (≈ 60) OUR ESTIMATE				
51± 4	SOKHOYAN	15A	DPWA	Multichannel
74± 3	[1] SHKLYAR	13	DPWA	Multichannel
57± 2	[1] SHRESTHA	12A	DPWA	Multichannel
65±10	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
61± 4	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
51± 4	ANISOVICH	12A	DPWA	Multichannel
79± 6	BATINIC	10	DPWA	$\pi N \to N\pi$, $N\eta$
100	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
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				
28 ±11	[1] KASHEVAROV	17	DPWA	$\gamma p \rightarrow \eta p, \eta' p$
< 3	SHKLYAR	13	DPWA	Multichannel
18 ± 4	ANISOVICH	12A	DPWA	Multichannel
21 ± 2	[2] SHRESTHA	12A	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
13 ± 5	BATINIC	10	DPWA	$\pi N \rightarrow N\pi, N\eta$
1.0± 0.6	PENNER	02C	DPWA	Multichannel
6 ± 1	VRANA	00	DPWA	Multichannel

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

[2] Statistical error only.

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

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

[1] Statistical error only.

$\Gamma(\Delta(1232)\pi, D\text{-wave})/\Gamma_{total}$ — Γ_6/Γ

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

[1] Statistical error only.

$\Gamma(N\sigma)/\Gamma_{total}$ — Γ_7/Γ

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

$\Gamma(N(1440)\pi)/\Gamma_{total}$ — Γ_8/Γ

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

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

$N(1650) \to p\gamma$, 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

$N(1650) \to n\gamma$, 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

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

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
0.035 to 0.055 (≈ 0.045) OUR ESTIMATE				
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 ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
−0.040 to 0.030 (≈ −0.010) OUR ESTIMATE				
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).

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