$N(1440)\ 1/2^+$

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

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

N(1440) POLE POSITION

REAL PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1360 to 1380 (≈ 1370) OUR ESTIMATE				
1374± 3±4	[1] HOFERICHT...	24	RVUE	$\pi N \to \pi N$
1353± 1	ROENCHEN	22	DPWA	Multichannel
1369± 3	SOKHOYAN	15A	DPWA	Multichannel
1363± 2±2	[2] SVARC	14	L+P	$\pi N \to \pi N$
1375±30	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1360	HUNT	19	DPWA	Multichannel
1355	ROENCHEN	15A	DPWA	Multichannel
1386	SHKLYAR	13	DPWA	Multichannel
1370± 4	ANISOVICH	12A	DPWA	Multichannel
1363±11	BATINIC	10	DPWA	$\pi N \to N\pi,\ N\eta$
1359	ARNDT	06	DPWA	$\pi N \to \pi N,\ \eta N$
1383	VRANA	00	DPWA	Multichannel
1385	HOEHLER	93	SPED	$\pi N \to \pi N$

[1] Roy-Steiner equations and Pade methods applied to πN scattering amplitudes and pionic atom data.
[2] Fit to the amplitudes of HOEHLER 79.

−2×IMAGINARY PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
180 to 205 (≈ 190) OUR ESTIMATE				
215±18±8	[1] HOFERICHT...	24	RVUE	$\pi N \to \pi N$
203± 2	ROENCHEN	22	DPWA	Multichannel
189± 5	SOKHOYAN	15A	DPWA	Multichannel
180± 4±5	[2] SVARC	14	L+P	$\pi N \to \pi N$
180±40	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
186	HUNT	19	DPWA	Multichannel
215	ROENCHEN	15A	DPWA	Multichannel
277	SHKLYAR	13	DPWA	Multichannel
190± 7	ANISOVICH	12A	DPWA	Multichannel
151±13	BATINIC	10	DPWA	$\pi N \to N\pi,\ N\eta$
162	ARNDT	06	DPWA	$\pi N \to \pi N,\ \eta N$
316	VRANA	00	DPWA	Multichannel
164	HOEHLER	93	SPED	$\pi N \to \pi N$

[1] Roy-Steiner equations and Pade methods applied to πN scattering amplitudes and pionic atom data.
[2] Fit to the amplitudes of HOEHLER 79.

N(1440) ELASTIC POLE RESIDUE

MODULUS |r|

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
50 to 60 (≈ 55) OUR ESTIMATE				
58±15±17	[1] HOFERICHT...	24	RVUE	$\pi N \to \pi N$
59± 1	ROENCHEN	22	DPWA	Multichannel
49± 3	SOKHOYAN	15A	DPWA	Multichannel
50± 1± 2	[2] SVARC	14	L+P	$\pi N \to \pi N$
52± 5	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
62	ROENCHEN	15A	DPWA	Multichannel
126	SHKLYAR	13	DPWA	Multichannel
48± 3	ANISOVICH	12A	DPWA	Multichannel
44	BATINIC	10	DPWA	$\pi N \to N\pi,\ N\eta$
38	ARNDT	06	DPWA	$\pi N \to \pi N,\ \eta N$
40	HOEHLER	93	SPED	$\pi N \to \pi N$

[1] Roy-Steiner equations and Pade methods applied to πN scattering amplitudes and pionic atom data.
[2] Fit to the amplitudes of HOEHLER 79.

PHASE θ

VALUE (°)	DOCUMENT ID		TECN	COMMENT
−100 to −80 (≈ −90) OUR ESTIMATE				
− 65± 2±11	[1] HOFERICHT...	24	RVUE	$\pi N \to \pi N$
−104± 2	ROENCHEN	22	DPWA	Multichannel
− 82± 5	SOKHOYAN	15A	DPWA	Multichannel
− 88± 1± 2	[2] SVARC	14	L+P	$\pi N \to \pi N$
−100±35	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
− 98	ROENCHEN	15A	DPWA	Multichannel
− 60	SHKLYAR	13	DPWA	Multichannel
− 78± 4	ANISOVICH	12A	DPWA	Multichannel
− 88	BATINIC	10	DPWA	$\pi N \to N\pi,\ N\eta$
− 98	ARNDT	06	DPWA	$\pi N \to \pi N,\ \eta N$

[1] Roy-Steiner equations and Pade methods applied to πN scattering amplitudes and pionic atom data.
[2] Fit to the amplitudes of HOEHLER 79.

N(1440) INELASTIC POLE RESIDUE

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

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

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.084±0.002	−28 ± 2	ROENCHEN	22	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.078	−27	ROENCHEN	15A	DPWA	Multichannel

Normalized residue in $N\pi \to N(1440) \to \Delta\pi$, P-wave

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.27±0.02	38 ± 5	SOKHOYAN	15A	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.27±0.02	40 ± 5	ANISOVICH	12A	DPWA	Multichannel

Normalized residue in $N\pi \to N(1440) \to \Lambda K$

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.025±0.005	−92 ± 43	ROENCHEN	22	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.016	145	ROENCHEN	15A	DPWA	Multichannel

Normalized residue in $N\pi \to N(1440) \to \Sigma K$

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.002±0.003	−32 ± 77	ROENCHEN	22	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.027	113	ROENCHEN	15A	DPWA	Multichannel

Normalized residue in $N\pi \to N(1440) \to N\,(\pi\pi)^{I=0}_{S-wave}$

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.21±0.04	−136 ± 4	SOKHOYAN	15A	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.21±0.05	−135 ± 7	ANISOVICH	12A	DPWA	Multichannel

$N(1440)$ BREIT-WIGNER MASS

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
1410 to 1470 (≈ 1440) OUR ESTIMATE				
1417 ± 4	[1] HUNT	19	DPWA	Multichannel
1430 ±10	SOKHOYAN	15A	DPWA	Multichannel
1515 ±15	[1] SHKLYAR	13	DPWA	Multichannel
1485.0± 1.2	[1] ARNDT	06	DPWA	$\pi N \to \pi N,\ \eta N$
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. • • •				
1430 ± 8	ANISOVICH	12A	DPWA	Multichannel
1412 ± 2	[1] SHRESTHA	12A	DPWA	Multichannel
1439 ±19	BATINIC	10	DPWA	$\pi N \to N\pi,\ N\eta$
1518 ± 5	PENNER	02C	DPWA	Multichannel
1479 ±80	VRANA	00	DPWA	Multichannel

[1] Statistical error only.

$N(1440)$ BREIT-WIGNER WIDTH

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
250 to 450 (≈ 350) OUR ESTIMATE				
257± 11	[1] HUNT	19	DPWA	Multichannel
360± 30	SOKHOYAN	15A	DPWA	Multichannel
605± 90	[1] SHKLYAR	13	DPWA	Multichannel

284± 18	[1]	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
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. • • •					
365± 35		ANISOVICH	12A	DPWA	Multichannel
248± 5	[1]	SHRESTHA	12A	DPWA	Multichannel
437±141		BATINIC	10	DPWA	$\pi N \to N\pi$, $N\eta$
668± 41		PENNER	02C	DPWA	Multichannel
490±120		VRANA	00	DPWA	Multichannel

[1] Statistical error only.

N(1440) DECAY MODES

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

	Mode	Fraction (Γ_i/Γ)
Γ_1	$N\pi$	55–75 %
Γ_2	$N\eta$	<1 %
Γ_3	$N\pi\pi$	17–50 %
Γ_4	$\Delta(1232)\pi$, P-wave	6–27 %
Γ_5	$N\sigma$	11–23 %
Γ_6	$p\gamma$, helicity=1/2	0.035–0.048 %
Γ_7	$n\gamma$, helicity=1/2	0.02–0.04 %

N(1440) BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ Γ_1/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
55 to 75 (≈ 65) OUR ESTIMATE				
59 ±2	[1]	HUNT	19	DPWA Multichannel
63 ±2		SOKHOYAN	15A	DPWA Multichannel
56 ±2	[1]	SHKLYAR	13	DPWA Multichannel
78.7±1.6	[1]	ARNDT	06	DPWA $\pi N \to \pi N$, ηN
68 ±4		CUTKOSKY	80	IPWA $\pi N \to \pi N$
51 ±5		HOEHLER	79	IPWA $\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
62 ±3		ANISOVICH	12A	DPWA Multichannel
64.8±0.9	[1]	SHRESTHA	12A	DPWA Multichannel
62 ±4		BATINIC	10	DPWA $\pi N \to N\pi$, $N\eta$
57 ±1		PENNER	02C	DPWA Multichannel
72 ±5		VRANA	00	DPWA Multichannel

[1] Statistical error only.

$\Gamma(N\eta)/\Gamma_{total}$ Γ_2/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0±1		VRANA	00	DPWA Multichannel

$\Gamma(\Delta(1232)\pi, P\text{-wave})/\Gamma_{total}$ Γ_4/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
6 to 27 (≈ 15) OUR ESTIMATE				
22 ±4	[1] HUNT	19	DPWA	Multichannel
12 $^{+5}_{-3}$	SHKLYAR	16	DPWA	Multichannel
20 ±7	SOKHOYAN	15A	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
21 ±8	ANISOVICH	12A	DPWA	Multichannel
6.5±0.8	[1] SHRESTHA	12A	DPWA	Multichannel
16 ±1	VRANA	00	DPWA	Multichannel

[1] Statistical error only.

$\Gamma(N\sigma)/\Gamma_{total}$ Γ_5/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
16±3	[1] HUNT	19	DPWA	Multichannel
27 $^{+4}_{-9}$	SHKLYAR	16	DPWA	Multichannel
17±6	SOKHOYAN	15A	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
17±7	ANISOVICH	12A	DPWA	Multichannel
27±1	[1] SHRESTHA	12A	DPWA	Multichannel
12±1	VRANA	00	DPWA	Multichannel

[1] Statistical error only.

N(1440) PHOTON DECAY AMPLITUDES AT THE POLE

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

MODULUS ($GeV^{-1/2}$)	PHASE (°)	DOCUMENT ID		TECN	COMMENT
−0.090±0.007	−30 ± 3	ROENCHEN	22	DPWA	Multichannel
−0.044±0.005	−40 ± 8	SOKHOYAN	15A	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •					
−0.060	−23	ROENCHEN	15A	DPWA	Multichannel

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

MODULUS ($GeV^{-1/2}$)	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.041±0.005	23 ± 10	ANISOVICH	17E	DPWA	Multichannel

N(1440) BREIT-WIGNER PHOTON DECAY AMPLITUDES

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

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
−0.080 to −0.050 (≈ −0.065) OUR ESTIMATE				
−0.091±0.007	[1] HUNT	19	DPWA	Multichannel
−0.061±0.006	SOKHOYAN	15A	DPWA	Multichannel
−0.085±0.003	[1] SHKLYAR	13	DPWA	Multichannel
−0.056±0.001	[1] WORKMAN	12A	DPWA	$\gamma N \to N\pi$
−0.051±0.002	[1] DUGGER	07	DPWA	$\gamma N \to \pi N$

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

−0.061±0.008	ANISOVICH	12A	DPWA	Multichannel
−0.084±0.003	[1] SHRESTHA	12A	DPWA	Multichannel
−0.061	DRECHSEL	07	DPWA	$\gamma N \to \pi N$
−0.087	PENNER	02D	DPWA	Multichannel

[1] Statistical error only.

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

VALUE ($GeV^{-1/2}$)	*DOCUMENT ID*		*TECN*	*COMMENT*
0.035 to 0.055 (≈ 0.045) OUR ESTIMATE				
0.013±0.012	[1] HUNT	19	DPWA	Multichannel
0.053±0.007	ANISOVICH	17E	DPWA	Multichannel
0.048±0.004	[1] CHEN	12A	DPWA	$\gamma N \to \pi N$

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

0.043±0.012	ANISOVICH	13B	DPWA	Multichannel
0.040±0.005	[1] SHRESTHA	12A	DPWA	Multichannel
0.054	DRECHSEL	07	DPWA	$\gamma N \to \pi N$
0.121	PENNER	02D	DPWA	Multichannel

[1] Statistical error only.

$N(1440)$ REFERENCES

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

HOFERICHT...	24	PL B853 138698	M. Hoferichter *et al.*	(BERN, MADU, BONN+)
ROENCHEN	22	EPJ A58 229	D. Roenchen *et al.*	(JULI, GWU, BONN+)
HUNT	19	PR C99 055205	B.C. Hunt, D.M. Manley	
ANISOVICH	17E	PR C96 055202	A.V. Anisovich *et al.*	(BONN, PNPI, JLAB+)
SHKLYAR	16	PR C93 045206	V. Shklyar, H. Lenske, U. Mosel	(GIES)
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.)
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)
PENNER	02C	PR C66 055211	G. Penner, U. Mosel	(GIES)
PENNER	02D	PR C66 055212	G. Penner, U. Mosel	(GIES)
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