

$N(1440) 1/2^+$ $I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$ Status: ****

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

 $N(1440)$ POLE POSITION**REAL PART**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
1360 to 1380 (\approx 1370) OUR ESTIMATE			
1369 \pm 3	SOKHOYAN	15A	DPWA Multichannel
1363 \pm 2 \pm 2	¹ SVARC	14	L+P $\pi N \rightarrow \pi N$
1375 \pm 30	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● 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 \pm 4	ANISOVICH	12A	DPWA Multichannel
1363 \pm 11	BATINIC	10	DPWA $\pi N \rightarrow N\pi, N\eta$
1359	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1383	VRANA	00	DPWA Multichannel
1385	HOEHLER	93	SPED $\pi N \rightarrow \pi N$

¹ Fit to the amplitudes of HOEHLER 79.

- 2xIMAGINARY PART

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
160 to 190 (\approx 175) OUR ESTIMATE			
189 \pm 5	SOKHOYAN	15A	DPWA Multichannel
180 \pm 4 \pm 5	¹ SVARC	14	L+P $\pi N \rightarrow \pi N$
180 \pm 40	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● 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 \pm 7	ANISOVICH	12A	DPWA Multichannel
151 \pm 13	BATINIC	10	DPWA $\pi N \rightarrow N\pi, N\eta$
162	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
316	VRANA	00	DPWA Multichannel
164	HOEHLER	93	SPED $\pi N \rightarrow \pi N$

¹ Fit to the amplitudes of HOEHLER 79.

 $N(1440)$ ELASTIC POLE RESIDUE**MODULUS $|r|$**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
46 to 54 (\approx 50) OUR ESTIMATE			
49 \pm 3	SOKHOYAN	15A	DPWA Multichannel
50 \pm 1 \pm 2	¹ SVARC	14	L+P $\pi N \rightarrow \pi N$
52 \pm 5	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$

• • • 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	$\pi N \rightarrow N\pi, N\eta$
38	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
40	HOEHLER	93	SPED	$\pi N \rightarrow \pi N$

¹ Fit to the amplitudes of HOEHLER 79.

PHASE θ

<u>VALUE ($^{\circ}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
–100 to –80 (\approx –90) OUR ESTIMATE			
– 82 ± 5	SOKHOYAN	15A	DPWA Multichannel
– $88 \pm 1 \pm 2$	¹ SVARC	14	L+P $\pi N \rightarrow \pi N$
– 100 ± 35	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$

• • • 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	$\pi N \rightarrow N\pi, N\eta$
– 98	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$

¹ 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 $N\pi \rightarrow N(1440) \rightarrow N\eta$

<u>MODULUS</u>	<u>PHASE ($^{\circ}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.078	– 27	ROENCHEN	15A	DPWA Multichannel

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

<u>MODULUS</u>	<u>PHASE ($^{\circ}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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 $N\pi \rightarrow N(1440) \rightarrow \Lambda K$

<u>MODULUS</u>	<u>PHASE ($^{\circ}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.016	145	ROENCHEN	15A	DPWA Multichannel

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

<u>MODULUS</u>	<u>PHASE ($^{\circ}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.027	113	ROENCHEN	15A	DPWA Multichannel

Normalized residue in $N\pi \rightarrow N(1440) \rightarrow N(\pi\pi)_{S=0}^{I=0}$

<u>MODULUS</u>	<u>PHASE ($^{\circ}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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	$\pi N \rightarrow \pi N, \eta N$
1440 ± 30	CUTKOSKY	80 IPWA	$\pi N \rightarrow \pi N$
1410 ± 12	HOEHLER	79 IPWA	$\pi N \rightarrow \pi N$
● ● ● 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	$\pi N \rightarrow N\pi, N\eta$
1518 ± 5	PENNER	02C DPWA	Multichannel
1479 ± 80	VRANA	00 DPWA	Multichannel

¹Statistical error only. **$N(1440)$ BREIT-WIGNER WIDTH**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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	$\pi N \rightarrow \pi N, \eta N$
340 ± 70	CUTKOSKY	80 IPWA	$\pi N \rightarrow \pi N$
135 ± 10	HOEHLER	79 IPWA	$\pi N \rightarrow \pi N$
● ● ● 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	$\pi N \rightarrow N\pi, N\eta$
668 ± 41	PENNER	02C DPWA	Multichannel
490 ± 120	VRANA	00 DPWA	Multichannel

¹Statistical error only. **$N(1440)$ DECAY MODES**

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

<u>Mode</u>	<u>Fraction (Γ_i/Γ)</u>
Γ_1 $N\pi$	55–75 %

Γ_2	$N\eta$	<1 %
Γ_3	$N\pi\pi$	17–50 %
Γ_4	$\Delta(1232)\pi$, <i>P</i> -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

$\Gamma(N\pi)/\Gamma_{\text{total}}$ 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 $\pi N \rightarrow \pi N, \eta N$
68 ± 4	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
51 ± 5	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
• • • 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 $\pi N \rightarrow N\pi, N\eta$
57 ± 1	PENNER	02C	DPWA Multichannel
72 ± 5	VRANA	00	DPWA Multichannel

¹Statistical error only.

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

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

¹Statistical error only.

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

¹Statistical error only.

$N(1440)$ PHOTON DECAY AMPLITUDES AT THE POLE

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

<u>MODULUS ($\text{GeV}^{-1/2}$)</u>	<u>PHASE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
-0.044 ± 0.005	-40 ± 8	SOKHOYAN	15A	DPWA Multichannel
$-0.054^{+0.004}_{-0.003}$	5^{+2}_{-5}	ROENCHEN	14	DPWA

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

-0.060	-23	ROENCHEN	15A	DPWA Multichannel
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$N(1440)$ BREIT-WIGNER PHOTON DECAY AMPLITUDES

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

<u>VALUE ($\text{GeV}^{-1/2}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
-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 $\gamma N \rightarrow N\pi$
-0.051 ± 0.002	¹ DUGGER	07	DPWA $\gamma N \rightarrow \pi N$

• • • 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 $\gamma N \rightarrow \pi N$
-0.087	PENNER	02D	DPWA Multichannel

¹Statistical error only.

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

<u>VALUE ($\text{GeV}^{-1/2}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.035 to 0.055 (≈ 0.045) OUR ESTIMATE			
0.013 ± 0.012	¹ HUNT	19	DPWA Multichannel
0.043 ± 0.012	ANISOVICH	13B	DPWA Multichannel
0.048 ± 0.004	¹ CHEN	12A	DPWA $\gamma N \rightarrow \pi N$

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

0.040 ± 0.005	¹ SHRESTHA	12A	DPWA Multichannel
0.054	DRECHSEL	07	DPWA $\gamma N \rightarrow \pi N$
0.121	PENNER	02D	DPWA Multichannel

¹Statistical error only.

N(1440) REFERENCESFor early references, see Physics Letters **111B** 1 (1982).

HUNT	19	PR C99 055205	B.C. Hunt, D.M. Manley	
SHKLYAR	16	PR C93 045206	V. Shklyar, H. Lenske, U. Mosel	(GIES)
ROENCHEN	15A	EPJ A51 70	D. Roenchen <i>et al.</i>	
SOKHOYAN	15A	EPJ A51 95	V. Sokhoyan <i>et al.</i>	(CBELSA/TAPS Collab.)
PDG	14	CP C38 070001	K. Olive <i>et al.</i>	(PDG Collab.)
ROENCHEN	14	EPJ A50 101	D. Roenchen <i>et al.</i>	
Also		EPJ A51 63 (errat.)	D. Roenchen <i>et al.</i>	
SVARC	14	PR C89 045205	A. Svarc <i>et al.</i>	(RBI Zagreb, UNI Tuzla)
ANISOVICH	13B	EPJ A49 67	A.V. Anisovich <i>et al.</i>	
SHKLYAR	13	PR C87 015201	V. Shklyar, H. Lenske, U. Mosel	(GIES)
ANISOVICH	12A	EPJ A48 15	A.V. Anisovich <i>et al.</i>	(BONN, PNPI)
CHEN	12A	PR C86 015206	W. Chen <i>et al.</i>	(DUKE, GWU, MSST, ITEP+)
SHRESTHA	12A	PR C86 055203	M. Shrestha, D.M. Manley	(KSU)
WORKMAN	12A	PR C86 015202	R. Workman <i>et al.</i>	(GWU)
BATINIC	10	PR C82 038203	M. Batinic <i>et al.</i>	(ZAGR)
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>	(JLab CLAS Collab.)
ARNDT	06	PR C74 045205	R.A. Arndt <i>et al.</i>	(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 <i>et al.</i>	(CMU, LBL) IJP
Also		PR D20 2839	R.E. Cutkosky <i>et al.</i>	(CMU, LBL) IJP
HOEHLER	79	PDAT 12-1	G. Hohler <i>et al.</i>	(KARLT) IJP
Also		Toronto Conf. 3	R. Koch	(KARLT) IJP