

$N(1535) 1/2^-$ $I(J^P) = \frac{1}{2}(1/2^-)$ Status: ****Older and obsolete values are listed and referenced in the 2014 edition, Chinese Physics **C38** 070001 (2014). **$N(1535)$ POLE POSITION****REAL PART**

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
1500 to 1520 (\approx 1510) OUR ESTIMATE			
1500 \pm 4	SOKHOYAN	15A	DPWA Multichannel
1509 \pm 4 \pm 2	¹ SVARC	14	L+P $\pi N \rightarrow \pi N$
1510 \pm 50	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1499	ROENCHEN	15A	DPWA Multichannel
1490	SHKLYAR	13	DPWA Multichannel
1501 \pm 4	ANISOVICH	12A	DPWA Multichannel
1515	SHRESTHA	12A	DPWA Multichannel
1521 \pm 14	BATINIC	10	DPWA $\pi N \rightarrow N\pi, N\eta$
1502	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1525	VRANA	00	DPWA Multichannel
1487	HOEHLER	93	SPED $\pi N \rightarrow \pi N$

¹ Fit to the amplitudes of HOEHLER 79.**-2xIMAGINARY PART**

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
110 to 150 (\approx 130) OUR ESTIMATE			
128 \pm 9	SOKHOYAN	15A	DPWA Multichannel
118 \pm 9 \pm 2	² SVARC	14	L+P $\pi N \rightarrow \pi N$
260 \pm 80	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
104	ROENCHEN	15A	DPWA Multichannel
100	SHKLYAR	13	DPWA Multichannel
134 \pm 11	ANISOVICH	12A	DPWA Multichannel
123	SHRESTHA	12A	DPWA Multichannel
190 \pm 28	BATINIC	10	DPWA $\pi N \rightarrow N\pi, N\eta$
95	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
102	VRANA	00	DPWA Multichannel

² Fit to the amplitudes of HOEHLER 79. **$N(1535)$ ELASTIC POLE RESIDUE****MODULUS $|r|$**

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
15 to 35 (\approx 25) OUR ESTIMATE			
29 \pm 4	SOKHOYAN	15A	DPWA Multichannel
22 \pm 2 \pm 0.4	³ SVARC	14	L+P $\pi N \rightarrow \pi N$
120 \pm 40	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$

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

22	ROENCHEN	15A	DPWA	Multichannel
15	SHKLYAR	13	DPWA	Multichannel
31 ± 4	ANISOVICH	12A	DPWA	Multichannel
68	BATINIC	10	DPWA	$\pi N \rightarrow N\pi, N\eta$
16	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$

³Fit to the amplitudes of HOEHLER 79.

PHASE θ

<u>VALUE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
–30 to 0 (≈ -15) OUR ESTIMATE			
-20 ± 10	SOKHOYAN	15A	DPWA Multichannel
$-5 \pm 5 \pm 3$	⁴ SVARC	14	L+P $\pi N \rightarrow \pi N$
$+15 \pm 45$	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$

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

–46	ROENCHEN	15A	DPWA	Multichannel
–51	SHKLYAR	13	DPWA	Multichannel
-29 ± 5	ANISOVICH	12A	DPWA	Multichannel
12	BATINIC	10	DPWA	$\pi N \rightarrow N\pi, N\eta$
–16	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$

⁴Fit to the amplitudes of HOEHLER 79.

N(1535) INELASTIC POLE RESIDUE

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

Normalized residue in $N\pi \rightarrow N(1535) \rightarrow N\eta$

<u>MODULUS</u>	<u>PHASE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.43 ± 0.03	-76 ± 5	ANISOVICH	12A	DPWA Multichannel
• • •				
0.51	112	ROENCHEN	15A	DPWA Multichannel

Normalized residue in $N\pi \rightarrow N(1535) \rightarrow \Lambda K$

<u>MODULUS</u>	<u>PHASE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
• • •				
0.05	32	ROENCHEN	15A	DPWA Multichannel

Normalized residue in $N\pi \rightarrow N(1535) \rightarrow \Sigma K$

<u>MODULUS</u>	<u>PHASE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
• • •				
0.05	–69	ROENCHEN	15A	DPWA Multichannel

Normalized residue in $N\pi \rightarrow N(1535) \rightarrow \Delta\pi, D\text{-wave}$

<u>MODULUS</u>	<u>PHASE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.11 ± 0.02	160 ± 20	SOKHOYAN	15A	DPWA Multichannel
• • •				
0.12 ± 0.03	145 ± 17	ANISOVICH	12A	DPWA Multichannel

Normalized residue in $N\pi \rightarrow N(1535) \rightarrow N\sigma$

<u>MODULUS</u>	<u>PHASE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.16 \pm 0.07	25 \pm 40	SOKHOYAN	15A DPWA	Multichannel

Normalized residue in $N\pi \rightarrow N(1535) \rightarrow N(1440)\pi$

<u>MODULUS</u>	<u>PHASE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.21 \pm 0.14	-45 \pm 50	SOKHOYAN	15A DPWA	Multichannel

 $N(1535)$ BREIT-WIGNER MASS

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
1515 to 1545 (\approx 1530) OUR ESTIMATE			
1528 \pm 6	KASHEVAROV 17	DPWA	$\gamma p \rightarrow \eta p, \eta' p$
1517 \pm 4	SOKHOYAN 15A	DPWA	Multichannel
1526 \pm 2	⁵ SHKLYAR 13	DPWA	Multichannel
1538 \pm 1	⁵ SHRESTHA 12A	DPWA	Multichannel
1547.0 \pm 0.7	⁵ ARNDT 06	DPWA	$\pi N \rightarrow \pi N, \eta N$
1550 \pm 40	CUTKOSKY 80	IPWA	$\pi N \rightarrow \pi N$
1526 \pm 7	HOEHLER 79	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
1519 \pm 5	ANISOVICH 12A	DPWA	Multichannel
1553 \pm 8	BATINIC 10	DPWA	$\pi N \rightarrow N\pi, N\eta$
1546.7 \pm 2.2	ARNDT 04	DPWA	$\pi N \rightarrow \pi N, \eta N$
1526 \pm 2	PENNER 02C	DPWA	Multichannel
1530 \pm 10	BAI 01B	BES	$J/\psi \rightarrow p\bar{p}\eta$
1522 \pm 11	THOMPSON 01	CLAS	$\gamma^* p \rightarrow p\eta$
1542 \pm 3	VRANA 00	DPWA	Multichannel
1532 \pm 5	ARMSTRONG 99B	DPWA	$\gamma^* p \rightarrow p\eta$

⁵ Statistical error only. **$N(1535)$ BREIT-WIGNER WIDTH**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
125 to 175 (\approx 150) OUR ESTIMATE			
163 \pm 25	KASHEVAROV 17	DPWA	$\gamma p \rightarrow \eta p, \eta' p$
120 \pm 10	SOKHOYAN 15A	DPWA	Multichannel
131 \pm 12	⁶ SHKLYAR 13	DPWA	Multichannel
141 \pm 4	⁶ SHRESTHA 12A	DPWA	Multichannel
188.4 \pm 3.8	⁶ ARNDT 06	DPWA	$\pi N \rightarrow \pi N, \eta N$
240 \pm 80	CUTKOSKY 80	IPWA	$\pi N \rightarrow \pi N$
120 \pm 20	HOEHLER 79	IPWA	$\pi N \rightarrow \pi N$

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

128 ± 14	ANISOVICH	12A	DPWA	Multichannel
182 ± 25	BATINIC	10	DPWA	$\pi N \rightarrow N\pi, N\eta$
129 ± 8	PENNER	02C	DPWA	Multichannel
95 ± 25	BAI	01B	BES	$J/\psi \rightarrow p\bar{p}\eta$
143 ± 18	THOMPSON	01	CLAS	$\gamma^* p \rightarrow p\eta$
112 ± 19	VRANA	00	DPWA	Multichannel
154 ± 20	ARMSTRONG	99B	DPWA	$\gamma^* p \rightarrow p\eta$

⁶Statistical error only.

N(1535) DECAY MODES

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

Mode	Fraction (Γ_i/Γ)
Γ_1 $N\pi$	32–52 %
Γ_2 $N\eta$	30–55 %
Γ_3 $N\pi\pi$	3–14 %
Γ_4 $\Delta(1232)\pi$	
Γ_5 $\Delta(1232)\pi, D\text{-wave}$	1–4 %
Γ_6 $N\sigma$	2–10 %
Γ_7 $N(1440)\pi$	5–12 %
Γ_8 $p\gamma, \text{helicity}=1/2$	0.15–0.30 %
Γ_9 $n\gamma, \text{helicity}=1/2$	0.01–0.25 %

N(1535) BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{\text{total}}$					Γ_1/Γ
VALUE (%)	DOCUMENT ID	TECN	COMMENT		
32 to 52 (≈ 42) OUR ESTIMATE					
52 ± 5	SOKHOYAN	15A	DPWA	Multichannel	
35 ± 3	⁷ SHKLYAR	13	DPWA	Multichannel	
37 ± 1	⁷ SHRESTHA	12A	DPWA	Multichannel	
35.5 ± 0.2	⁷ ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$	
50 ± 10	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$	
38 ± 4	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$	

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

54 ± 5	ANISOVICH	12A	DPWA	Multichannel
46 ± 7	BATINIC	10	DPWA	$\pi N \rightarrow N\pi, N\eta$
36 ± 1	PENNER	02C	DPWA	Multichannel
35 ± 8	VRANA	00	DPWA	Multichannel

⁷Statistical error only.

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

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
30 to 55 (≈ 42) OUR ESTIMATE			
41 \pm 4	⁸ KASHEVAROV 17	DPWA	$\gamma p \rightarrow \eta p, \eta' p$
58 \pm 4	⁹ SHKLYAR 13	DPWA	Multichannel
33 \pm 5	ANISOVICH 12A	DPWA	Multichannel
41 \pm 2	⁹ SHRESTHA 12A	DPWA	Multichannel
53 \pm 1	PENNER 02C	DPWA	Multichannel
51 \pm 5	VRANA 00	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •			
50 \pm 7	BATINIC 10	DPWA	$\pi N \rightarrow N\pi, N\eta$
⁸ Assuming $A_{1/2} = 0.115 \text{ GeV}^{-1/2}$.			
⁹ Statistical error only.			

 $\Gamma(N\eta)/\Gamma(N\pi)$ Γ_2/Γ_1

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
• • • We do not use the following data for averages, fits, limits, etc. • • •			
0.95 \pm 0.03	AZNAURYAN 09	CLAS	π, η electroproduction

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

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
2.5 \pm 1.5	SOKHOYAN 15A	DPWA	Multichannel
1.8 \pm 0.8	¹⁰ SHRESTHA 12A	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •			
2.5 \pm 1.5	ANISOVICH 12A	DPWA	Multichannel
1 \pm 1	VRANA 00	DPWA	Multichannel
¹⁰ Statistical error only.			

 $\Gamma(N\sigma)/\Gamma_{\text{total}}$ Γ_6/Γ

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
6 \pm 4	SOKHOYAN 15A	DPWA	Multichannel
1.5 \pm 0.5	¹¹ SHRESTHA 12A	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •			
2 \pm 1	VRANA 00	DPWA	Multichannel
¹¹ Statistical error only.			

 $\Gamma(N(1440)\pi)/\Gamma_{\text{total}}$ Γ_7/Γ

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
12 \pm 8	SOKHOYAN 15A	DPWA	Multichannel
< 1	SHRESTHA 12A	DPWA	Multichannel
8 \pm 2	¹² STAROSTIN 03		$\pi^- p \rightarrow n3\pi^0$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
10 \pm 9	VRANA 00	DPWA	Multichannel
¹² This STAROSTIN 03 value is an estimate made using simplest assumptions.			

$N(1535)$ PHOTON DECAY AMPLITUDES AT THE POLE **$N(1535) \rightarrow p\gamma$, 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>
0.093 ± 0.009	8 ± 4	ANISOVICH	17D	DPWA Multichannel
0.050 ± 0.004	-14^{+12}_{-10}	¹³ ROENCHEN	14	DPWA

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

0.114 ± 0.008	10 ± 5	ANISOVICH	15A	DPWA Multichannel
0.106	5.2	ROENCHEN	15A	DPWA Multichannel
0.114 ± 0.008	10 ± 5	SOKHOYAN	15A	DPWA Multichannel

¹³T-Matrix amplitude

 $N(1535) \rightarrow n\gamma$, 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>
-0.088 ± 0.004	5 ± 4	ANISOVICH	17D	DPWA Multichannel
-0.095 ± 0.006	8 ± 5	ANISOVICH	15A	DPWA Multichannel

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

 $N(1535)$ BREIT-WIGNER PHOTON DECAY AMPLITUDES **$N(1535) \rightarrow p\gamma$, helicity-1/2 amplitude $A_{1/2}$**

<u>VALUE ($\text{GeV}^{-1/2}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.090 to 0.120 (≈ 0.105) OUR ESTIMATE			
0.101 ± 0.007	SOKHOYAN	15A	DPWA Multichannel
0.091 ± 0.004	¹⁴ SHKLYAR	13	DPWA Multichannel
0.128 ± 0.004	¹⁴ WORKMAN	12A	DPWA $\gamma N \rightarrow N\pi$
0.091 ± 0.002	¹⁴ DUGGER	07	DPWA $\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
0.105 ± 0.010	ANISOVICH	12A	DPWA Multichannel
0.059 ± 0.003	¹⁴ SHRESTHA	12A	DPWA Multichannel
0.066	DRECHSEL	07	DPWA $\gamma N \rightarrow \pi N$
0.090	PENNER	02D	DPWA Multichannel

¹⁴Statistical error only.

 $N(1535) \rightarrow n\gamma$, helicity-1/2 amplitude $A_{1/2}$

<u>VALUE ($\text{GeV}^{-1/2}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
-0.095 to -0.055 (≈ -0.075) OUR ESTIMATE			
-0.093 ± 0.011	ANISOVICH	13B	DPWA Multichannel
-0.058 ± 0.006	¹⁵ CHEN	12A	DPWA $\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
-0.049 ± 0.003	¹⁵ SHRESTHA	12A	DPWA Multichannel
-0.051	DRECHSEL	07	DPWA $\gamma N \rightarrow \pi N$
-0.024	PENNER	02D	DPWA Multichannel

¹⁵Statistical error only.

$N(1535) \rightarrow N\gamma$, ratio $A_{1/2}^n/A_{1/2}^p$

<u>VALUE (GeV^{-1/2})</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
-----------------------------------	--------------------	-------------

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

-0.84 ± 0.15	MUKHOPAD... 95B	IPWA
--------------	-----------------	------

N(1535) REFERENCESFor early references, see Physics Letters **111B** 1 (1982).

ANISOVICH	17D	PR C95 035211	A.V. Anisovich <i>et al.</i>	
KASHEVAROV	17	PRL 118 212001	V.L. Kashevarov <i>et al.</i>	(A2/MAMI Collab.)
ANISOVICH	15A	EPJ A51 72	A.V. Anisovich <i>et al.</i>	
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)
AZNAURYAN	09	PR C80 055203	I.G. Aznauryan <i>et al.</i>	(JLab CLAS 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>	(JLab CLAS Collab.)
ARNDT	06	PR C74 045205	R.A. Arndt <i>et al.</i>	(GWU)
ARNDT	04	PR C69 035213	R.A. Arndt <i>et al.</i>	(GWU, TRIU)
STAROSTIN	03	PR C67 068201	A. Starostin <i>et al.</i>	(BNL Crystal Ball Collab.)
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 <i>et al.</i>	(BES Collab.)
THOMPSON	01	PRL 86 1702	R. Thompson <i>et al.</i>	(JLab CLAS Collab.)
VRANA	00	PRPL 328 181	T.P. Vrana, S.A. Dytman, T.-S.H. Lee	(PITT, ANL)
ARMSTRONG	99B	PR D60 052004	C.S. Armstrong <i>et al.</i>	
MUKHOPAD...	95B	PL B364 1	N.C. Mukhopadhyay, J.F. Zhang, M. Benmerrouche	
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