$N(1535)\ 1/2^-$

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

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

$N(1535)$ POLE POSITION

REAL PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
1500 to 1520 (≈ 1510) OUR ESTIMATE				
1500± 4	SOKHOYAN	15A	DPWA	Multichannel
1509± 4±2	[1] SVARC	14	L+P	$\pi N \to \pi N$
1510±50	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1496	HUNT	19	DPWA	Multichannel
1499	ROENCHEN	15A	DPWA	Multichannel
1490	SHKLYAR	13	DPWA	Multichannel
1501± 4	ANISOVICH	12A	DPWA	Multichannel
1521±14	BATINIC	10	DPWA	$\pi N \to N\pi$, $N\eta$
1502	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
1525	VRANA	00	DPWA	Multichannel
1487	HOEHLER	93	SPED	$\pi N \to \pi N$

[1] Fit to the amplitudes of HOEHLER 79.

−2×IMAGINARY PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
110 to 150 (≈ 130) OUR ESTIMATE				
128± 9	SOKHOYAN	15A	DPWA	Multichannel
118± 9±2	[2] SVARC	14	L+P	$\pi N \to \pi N$
260±80	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
119	HUNT	19	DPWA	Multichannel
104	ROENCHEN	15A	DPWA	Multichannel
100	SHKLYAR	13	DPWA	Multichannel
134±11	ANISOVICH	12A	DPWA	Multichannel
190±28	BATINIC	10	DPWA	$\pi N \to N\pi$, $N\eta$
95	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
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 (≈ 25) OUR ESTIMATE				
29± 4	SOKHOYAN	15A	DPWA	Multichannel
22± 2±0.4	[3] SVARC	14	L+P	$\pi N \to \pi N$
120±40	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

• • • 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	$\pi N \to N\pi$, $N\eta$
16	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN

[3] Fit to the amplitudes of HOEHLER 79.

PHASE θ

VALUE (°)	DOCUMENT ID		TECN	COMMENT
−30 to 0 (≈ −15) OUR ESTIMATE				
−20±10	SOKHOYAN	15A	DPWA	Multichannel
− 5± 5±3	[4] SVARC	14	L+P	$\pi N \to \pi N$
+15±45	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • 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	$\pi N \to N\pi$, $N\eta$
−16	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN

[4] Fit 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 $N\pi \to N(1535) \to N\eta$

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.43±0.03	−76 ± 5	ANISOVICH	12A	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.51	112	ROENCHEN	15A	DPWA	Multichannel

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

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.05	32	ROENCHEN	15A	DPWA	Multichannel

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

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.05	−69	ROENCHEN	15A	DPWA	Multichannel

Normalized residue in $N\pi \to N(1535) \to \Delta\pi$, D-wave

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.11±0.02	160 ± 20	SOKHOYAN	15A	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.12±0.03	145 ± 17	ANISOVICH	12A	DPWA	Multichannel

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

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.16±0.07	25 ± 40	SOKHOYAN	15A	DPWA	Multichannel

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

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.21±0.14	−45 ± 50	SOKHOYAN	15A	DPWA	Multichannel

N(1535) BREIT-WIGNER MASS

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
1515 to 1545 (≈ 1530) OUR ESTIMATE				
1525 ± 2	[5] HUNT	19	DPWA	Multichannel
1528 ± 6	KASHEVAROV	17	DPWA	$\gamma p \rightarrow \eta p, \eta' p$
1517 ± 4	SOKHOYAN	15A	DPWA	Multichannel
1526 ± 2	[5] SHKLYAR	13	DPWA	Multichannel
1547.0± 0.7	[5] ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
1550 ±40	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
1526 ± 7	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1519 ± 5	ANISOVICH	12A	DPWA	Multichannel
1538 ± 1	[5] SHRESTHA	12A	DPWA	Multichannel
1553 ± 8	BATINIC	10	DPWA	$\pi N \rightarrow N\pi, N\eta$
1546.7± 2.2	ARNDT	04	DPWA	$\pi N \rightarrow \pi N, \eta N$
1526 ± 2	PENNER	02C	DPWA	Multichannel
1530 ±10	BAI	01B	BES	$J/\psi \rightarrow p\overline{p}\eta$
1522 ±11	THOMPSON	01	CLAS	$\gamma^* p \rightarrow p\eta$
1542 ± 3	VRANA	00	DPWA	Multichannel
1532 ± 5	ARMSTRONG	99B	DPWA	$\gamma^* p \rightarrow p\eta$

[5] Statistical error only.

N(1535) BREIT-WIGNER WIDTH

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
125 to 175 (≈ 150) OUR ESTIMATE				
147 ± 5	[6] HUNT	19	DPWA	Multichannel
163 ±25	KASHEVAROV	17	DPWA	$\gamma p \rightarrow \eta p, \eta' p$
120 ±10	SOKHOYAN	15A	DPWA	Multichannel
131 ±12	[6] SHKLYAR	13	DPWA	Multichannel
188.4± 3.8	[6] ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
240 ±80	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
120 ±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
141 ± 4	[6] SHRESTHA	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	$J/\psi \to p\overline{p}\eta$
143 ±18	THOMPSON	01	CLAS	$\gamma^* p \to p\eta$
112 ±19	VRANA	00	DPWA	Multichannel
154 ±20	ARMSTRONG	99B	DPWA	$\gamma^* p \to p\eta$

[6] Statistical 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-wave	1–4 %
Γ_6	$N\rho$	
Γ_7	$N\rho$, S=1/2	
Γ_8	$N\rho$, S=3/2 , D-wave	
Γ_9	$N\sigma$	2–10 %
Γ_{10}	$N(1440)\pi$	5–12 %
Γ_{11}	$p\gamma$, helicity=1/2	0.15–0.30 %
Γ_{12}	$n\gamma$, helicity=1/2	0.01–0.25 %

N(1535) BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ Γ_1/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
32 to 52 (≈ 42) OUR ESTIMATE				
42 ± 2	[7] HUNT	19	DPWA	Multichannel
52 ± 5	SOKHOYAN	15A	DPWA	Multichannel
35 ± 3	[7] SHKLYAR	13	DPWA	Multichannel
35.5± 0.2	[7] ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
50 ±10	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
38 ± 4	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
54 ± 5	ANISOVICH	12A	DPWA	Multichannel
37 ± 1	[7] SHRESTHA	12A	DPWA	Multichannel
46 ± 7	BATINIC	10	DPWA	$\pi N \to N\pi$, $N\eta$
36 ± 1	PENNER	02C	DPWA	Multichannel
35 ± 8	VRANA	00	DPWA	Multichannel

[7] Statistical error only.

$\Gamma(N\eta)/\Gamma_{total}$ Γ_2/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
30 to 55 (≈ 42) OUR ESTIMATE				
43±3	[8] HUNT	19	DPWA	Multichannel
41±4	[9] KASHEVAROV	17	DPWA	$\gamma p \to \eta p, \eta' p$
58±4	[8] SHKLYAR	13	DPWA	Multichannel
33±5	ANISOVICH	12A	DPWA	Multichannel
53±1	PENNER	02C	DPWA	Multichannel
51±5	VRANA	00	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
41±2	[8] SHRESTHA	12A	DPWA	Multichannel
50±7	BATINIC	10	DPWA	$\pi N \to N\pi, N\eta$

[8] Statistical error only.
[9] Assuming $A_{1/2}$ = 0.115 GeV$^{-1/2}$.

$\Gamma(N\eta)/\Gamma(N\pi)$ Γ_2/Γ_1

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

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

VALUE (%)	DOCUMENT ID		TECN	COMMENT
<1.1	[10] HUNT	19	DPWA	Multichannel
2.5±1.5	SOKHOYAN	15A	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
2.5±1.5	ANISOVICH	12A	DPWA	Multichannel
1.8±0.8	[10] SHRESTHA	12A	DPWA	Multichannel
1 ±1	VRANA	00	DPWA	Multichannel

[10] Statistical error only.

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

VALUE (%)	DOCUMENT ID		TECN	COMMENT
14±2	[11] HUNT	19	DPWA	Multichannel

[11] Statistical error only.

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

VALUE (%)	DOCUMENT ID		TECN	COMMENT
<0.3	[12] HUNT	19	DPWA	Multichannel

[12] Statistical error only.

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

VALUE (%)	DOCUMENT ID		TECN	COMMENT
<1	[13] HUNT	19	DPWA	Multichannel
6 ±4	SOKHOYAN	15A	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1.5±0.5	[13] SHRESTHA	12A	DPWA	Multichannel
2 ±1	VRANA	00	DPWA	Multichannel

[13] Statistical error only.

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

VALUE (%)	DOCUMENT ID		TECN	COMMENT
< 0.01	[14] HUNT	19	DPWA	Multichannel
12 ±8	SOKHOYAN	15A	DPWA	Multichannel
8 ±2	[14] STAROSTIN	03		$\pi^- p \to n 3\pi^0$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
< 1	[14] SHRESTHA	12A	DPWA	Multichannel
10 ±9	VRANA	00	DPWA	Multichannel

[14] This value is an estimate made using simplest assumptions.

N(1535) PHOTON DECAY AMPLITUDES AT THE POLE

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

MODULUS ($GeV^{-1/2}$)	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.093±0.009	8 ± 4	ANISOVICH	17D	DPWA	Multichannel
0.050±0.004	-14^{+12}_{-10}	[15] 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

[15] T-Matrix amplitude

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

MODULUS ($GeV^{-1/2}$)	PHASE (°)	DOCUMENT ID		TECN	COMMENT
−0.088±0.004	**5 ± 4**	ANISOVICH	17D	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •					
−0.095±0.006	8 ± 5	ANISOVICH	15A	DPWA	Multichannel

N(1535) BREIT-WIGNER PHOTON DECAY AMPLITUDES

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

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
0.090 to 0.120 (≈ 0.105) OUR ESTIMATE				
0.107±0.003	[16] HUNT	19	DPWA	Multichannel
0.101±0.007	SOKHOYAN	15A	DPWA	Multichannel
0.091±0.004	[16] SHKLYAR	13	DPWA	Multichannel
0.128±0.004	[16] WORKMAN	12A	DPWA	$\gamma N \to N\pi$
0.091±0.002	[16] DUGGER	07	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.105±0.010	ANISOVICH	12A	DPWA	Multichannel
0.059±0.003	[16] SHRESTHA	12A	DPWA	Multichannel
0.066	DRECHSEL	07	DPWA	$\gamma N \to \pi N$
0.090	PENNER	02D	DPWA	Multichannel

[16] Statistical error only.

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

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
−0.095 to −0.055 (≈ − 0.075) OUR ESTIMATE				
-0.055 ± 0.006	[17] HUNT	19	DPWA	Multichannel
-0.093 ± 0.011	ANISOVICH	13B	DPWA	Multichannel
-0.058 ± 0.006	[17] CHEN	12A	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
-0.049 ± 0.003	[17] SHRESTHA	12A	DPWA	Multichannel
-0.051	DRECHSEL	07	DPWA	$\gamma N \rightarrow \pi N$
-0.024	PENNER	02D	DPWA	Multichannel

[17] Statistical error only.

$N(1535) \rightarrow N\gamma$, ratio $A^n_{1/2}/A^p_{1/2}$

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •			
-0.84 ± 0.15	MUKHOPAD...	95B	IPWA

N(1535) REFERENCES

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

HUNT	19	PR C99 055205	B.C. Hunt, D.M. Manley	
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)
AZNAURYAN	09	PR C80 055203	I.G. Aznauryan *et al.*	(JLab CLAS Collab.)
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)
ARNDT	04	PR C69 035213	R.A. Arndt *et al.*	(GWU, TRIU)
STAROSTIN	03	PR C67 068201	A. Starostin *et al.*	(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 *et al.*	(BES Collab.)
THOMPSON	01	PRL 86 1702	R. Thompson *et al.*	(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 *et al.*	
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 *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