

$\Delta(1905) 5/2^+$ $I(J^P) = \frac{3}{2}(\frac{5}{2}^+)$ Status: ****Older and obsolete values are listed and referenced in the 2014 edition, Chinese Physics **C38** 070001 (2014). **$\Delta(1905)$ POLE POSITION****REAL PART**

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
1750 to 1800 (\approx 1770) OUR ESTIMATE			
1707 \pm 1	ROENCHEN 22	DPWA	Multichannel
1800 \pm 6	SOKHOYAN 15A	DPWA	Multichannel
1752 \pm 3 \pm 2	¹ SVARC 14	L+P	$\pi N \rightarrow \pi N$
1830 \pm 40	CUTKOSKY 80	IPWA	$\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1819	HUNT 19	DPWA	Multichannel
1795	ROENCHEN 15A	DPWA	Multichannel
1800 \pm 6	GUTZ 14	DPWA	Multichannel
1805 \pm 10	ANISOVICH 12A	DPWA	Multichannel
1819	ARNDT 06	DPWA	$\pi N \rightarrow \pi N, \eta N$
1793	VRANA 00	DPWA	Multichannel
1829	HOEHLER 93	SPED	$\pi N \rightarrow \pi N$

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

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
260 to 340 (\approx 300) OUR ESTIMATE			
127 \pm 4	ROENCHEN 22	DPWA	Multichannel
290 \pm 15	SOKHOYAN 15A	DPWA	Multichannel
346 \pm 6 \pm 2	¹ SVARC 14	L+P	$\pi N \rightarrow \pi N$
280 \pm 60	CUTKOSKY 80	IPWA	$\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
253	HUNT 19	DPWA	Multichannel
247	ROENCHEN 15A	DPWA	Multichannel
290 \pm 15	GUTZ 14	DPWA	Multichannel
300 \pm 15	ANISOVICH 12A	DPWA	Multichannel
247	ARNDT 06	DPWA	$\pi N \rightarrow \pi N, \eta N$
302	VRANA 00	DPWA	Multichannel
303	HOEHLER 93	SPED	$\pi N \rightarrow \pi N$

¹ Fit to the amplitudes of HOEHLER 79. **$\Delta(1905)$ ELASTIC POLE RESIDUE****MODULUS $|r|$**

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
15 to 25 (\approx 20) OUR ESTIMATE			
3.7 \pm 1.0	ROENCHEN 22	DPWA	Multichannel
19 \pm 2	SOKHOYAN 15A	DPWA	Multichannel
24 \pm 1 \pm 1	¹ SVARC 14	L+P	$\pi N \rightarrow \pi N$
25 \pm 8	CUTKOSKY 80	IPWA	$\pi N \rightarrow \pi N$

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

5.3	ROENCHEN	15A	DPWA	Multichannel
19 ± 2	GUTZ	14	DPWA	Multichannel
20 ± 2	ANISOVICH	12A	DPWA	Multichannel
15	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
25	HOEHLER	93	SPED	$\pi N \rightarrow \pi N$

¹ Fit to the amplitudes of HOEHLER 79.

PHASE θ

VALUE (°)	DOCUMENT ID	TECN	COMMENT
– 120 to – 30 (≈ – 45) OUR ESTIMATE			
– 92 ± 6	ROENCHEN	22	DPWA Multichannel
– 45 ± 4	SOKHOYAN	15A	DPWA Multichannel
– 114 ± 1 ± 2	¹ SVARC	14	L+P $\pi N \rightarrow \pi N$
– 50 ± 20	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$

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

– 89	ROENCHEN	15A	DPWA	Multichannel
– 45 ± 4	GUTZ	14	DPWA	Multichannel
– 44 ± 5	ANISOVICH	12A	DPWA	Multichannel
– 30	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$

¹ Fit to the amplitudes of HOEHLER 79.

$\Delta(1905)$ INELASTIC POLE RESIDUE

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

Normalized residue in $N\pi \rightarrow \Delta(1905) \rightarrow \Delta\pi$, P-wave

MODULUS	PHASE (°)	DOCUMENT ID	TECN	COMMENT
0.10 ± 0.01	– 109 ± 7	ROENCHEN	22	DPWA Multichannel
0.19 ± 0.07	10 ± 30	SOKHOYAN	15A	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.0870	72	ROENCHEN	15A	DPWA Multichannel
0.25 ± 0.06	0 ± 15	ANISOVICH	12A	DPWA Multichannel

Normalized residue in $N\pi \rightarrow \Delta(1905) \rightarrow \Delta\pi$, F-wave

MODULUS	PHASE (°)	DOCUMENT ID	TECN	COMMENT
0.017 ± 0.002	18 ± 8	ROENCHEN	22	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.009	64	ROENCHEN	15A	DPWA Multichannel

Normalized residue in $N\pi \rightarrow \Delta(1905) \rightarrow \Sigma K$

MODULUS	PHASE (°)	DOCUMENT ID	TECN	COMMENT
0.0020 ± 0.0002	154 ± 6	ROENCHEN	22	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.001	– 155	ROENCHEN	15A	DPWA Multichannel

Normalized residue in $N\pi \rightarrow \Delta(1905) \rightarrow N(1535)\pi$

MODULUS	PHASE (°)	DOCUMENT ID	TECN	COMMENT
0.025 ± 0.010	130 ± 35	GUTZ	14	DPWA Multichannel

Normalized residue in $N\pi \rightarrow \Delta(1905) \rightarrow \Delta(1232)\eta$

<u>MODULUS</u>	<u>PHASE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.07±0.02	40 ± 20	GUTZ	14	DPWA Multichannel

$\Delta(1905)$ BREIT-WIGNER MASS

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
1855 to 1910 (\approx 1880) OUR ESTIMATE			
1883 ± 19	GOLOVATCH	19	DPWA $\gamma p \rightarrow \pi^+ \pi^- p$
1866 ± 9	¹ HUNT	19	DPWA Multichannel
1856 ± 6	SOKHOYAN	15A	DPWA Multichannel
1857.8± 1.6	¹ ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1910 ± 30	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
1905 ± 20	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1856 ± 6	GUTZ	14	DPWA Multichannel
1861 ± 6	ANISOVICH	12A	DPWA Multichannel
1818 ± 8	¹ SHRESTHA	12A	DPWA Multichannel
1873 ± 77	VRANA	00	DPWA Multichannel

¹Statistical error only.

$\Delta(1905)$ BREIT-WIGNER WIDTH

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
270 to 400 (\approx 330) OUR ESTIMATE			
327 ± 69	GOLOVATCH	19	DPWA $\gamma p \rightarrow \pi^+ \pi^- p$
289 ± 20	¹ HUNT	19	DPWA Multichannel
325 ± 15	SOKHOYAN	15A	DPWA Multichannel
320.6± 8.6	¹ ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
400 ± 100	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
260 ± 20	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
325 ± 15	GUTZ	14	DPWA Multichannel
335 ± 18	ANISOVICH	12A	DPWA Multichannel
278 ± 18	¹ SHRESTHA	12A	DPWA Multichannel
461 ± 111	VRANA	00	DPWA Multichannel

¹Statistical error only.

$\Delta(1905)$ DECAY MODES

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

Mode	Fraction (Γ_i/Γ)
Γ_1 $N\pi$	9–15%
Γ_2 $N\pi\pi$	>65%
Γ_3 $\Delta(1232)\pi$	>48%
Γ_4 $\Delta(1232)\pi$, P -wave	8–43%
Γ_5 $\Delta(1232)\pi$, F -wave	40–58%

Γ_6	$N\rho, S=3/2, P\text{-wave}$	17–35%
Γ_7	$N(1535)\pi$	< 1 %
Γ_8	$N(1680)\pi, P\text{-wave}$	5–15%
Γ_9	$\Delta(1232)\eta$	2–6%
Γ_{10}	$N\gamma$	0.012–0.036 %
Γ_{11}	$N\gamma, \text{helicity}=1/2$	0.002–0.006 %
Γ_{12}	$N\gamma, \text{helicity}=3/2$	0.01–0.03 %

$\Delta(1905)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{\text{total}}$ Γ_1/Γ

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
9–15% OUR ESTIMATE			
17 ±1	¹ HUNT	19	DPWA Multichannel
13 ±2	SOKHOYAN	15A	DPWA Multichannel
12.2±0.1	¹ ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
8 ±3	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
15 ±2	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
13 ±2	GUTZ	14	DPWA Multichannel
13 ±2	ANISOVICH	12A	DPWA Multichannel
6 ±1	¹ SHRESTHA	12A	DPWA Multichannel
9 ±1	VRANA	00	DPWA Multichannel

¹Statistical error only.

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
>65% OUR ESTIMATE			
0.85±0.15	GOLOVATCH	19	DPWA $\gamma p \rightarrow \pi^+\pi^-p$

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

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
8–43% OUR ESTIMATE			
8.4± 0.5	¹ HUNT	19	DPWA Multichannel
33 ±10	SOKHOYAN	15A	DPWA Multichannel
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
45 ±14	ANISOVICH	12A	DPWA Multichannel
28 ± 7	¹ SHRESTHA	12A	DPWA Multichannel
23 ± 1	VRANA	00	DPWA Multichannel

¹Statistical error only.

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

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
40–58% OUR ESTIMATE			
49±9	¹ HUNT	19	DPWA Multichannel
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
64±8	¹ SHRESTHA	12A	DPWA Multichannel
44±1	VRANA	00	DPWA Multichannel

¹Statistical error only.

$\Gamma(N\rho, S=3/2, P\text{-wave})/\Gamma_{\text{total}}$ Γ_6/Γ

VALUE (%)	DOCUMENT ID	TECN	COMMENT
17-35% OUR ESTIMATE			
26±9	¹ HUNT	19	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •			
< 6	¹ SHRESTHA	12A	DPWA Multichannel
24±1	VRANA	00	DPWA Multichannel
¹ Statistical error only.			

$\Gamma(N(1535)\pi)/\Gamma_{\text{total}}$ Γ_7/Γ

VALUE (%)	DOCUMENT ID	TECN	COMMENT
< 1 % OUR ESTIMATE			
<1	GUTZ	14	DPWA Multichannel

$\Gamma(N(1680)\pi, P\text{-wave})/\Gamma_{\text{total}}$ Γ_8/Γ

VALUE (%)	DOCUMENT ID	TECN	COMMENT
5-15% OUR ESTIMATE			
10±5	SOKHOYAN	15A	DPWA Multichannel

$\Gamma(\Delta(1232)\eta)/\Gamma_{\text{total}}$ Γ_9/Γ

VALUE (%)	DOCUMENT ID	TECN	COMMENT
2-6% OUR ESTIMATE			
4±2	GUTZ	14	DPWA Multichannel

$\Delta(1905)$ PHOTON DECAY AMPLITUDES AT THE POLE

$\Delta(1905) \rightarrow N\gamma$, helicity-1/2 amplitude $A_{1/2}$

MODULUS ($\text{GeV}^{-1/2}$)	PHASE ($^\circ$)	DOCUMENT ID	TECN	COMMENT
0.055±0.004	-159 ± 2	ROENCHEN	22	DPWA Multichannel
0.025±0.005	-28 ± 12	SOKHOYAN	15A	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.053	89	ROENCHEN	15A	DPWA Multichannel

$\Delta(1905) \rightarrow N\gamma$, helicity-3/2 amplitude $A_{3/2}$

MODULUS ($\text{GeV}^{-1/2}$)	PHASE ($^\circ$)	DOCUMENT ID	TECN	COMMENT
-0.168±0.020	172 ± 0.9	ROENCHEN	22	DPWA Multichannel
-0.050±0.004	5 ± 10	SOKHOYAN	15A	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
-0.030	80	ROENCHEN	15A	DPWA Multichannel

$\Delta(1905)$ BREIT-WIGNER PHOTON DECAY AMPLITUDES

$\Delta(1905) \rightarrow N\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE ($\text{GeV}^{-1/2}$)	DOCUMENT ID	TECN	COMMENT
0.017 to 0.027 (≈ 0.022) OUR ESTIMATE			
0.019±0.0076	GOLOVATCH	19	DPWA $\gamma p \rightarrow \pi^+ \pi^- p$
0.077±0.010	¹ HUNT	19	DPWA Multichannel
0.025±0.005	SOKHOYAN	15A	DPWA Multichannel
0.020±0.002	¹ DUGGER	13	DPWA $\gamma N \rightarrow \pi N$
0.019±0.002	¹ WORKMAN	12A	DPWA $\gamma N \rightarrow \pi N$

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

0.025±0.005	GUTZ	14	DPWA	Multichannel
0.025±0.004	ANISOVICH	12A	DPWA	Multichannel
0.066±0.018	¹ SHRESTHA	12A	DPWA	Multichannel
0.018	DRECHSEL	07	DPWA	$\gamma N \rightarrow \pi N$

¹Statistical error only.

$\Delta(1905) \rightarrow N\gamma$, helicity-3/2 amplitude $A_{3/2}$

<u>VALUE (GeV^{-1/2})</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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–0.055 to –0.035 (\approx –0.045) OUR ESTIMATE

–0.0432±0.0173	GOLOVATCH	19	DPWA	$\gamma p \rightarrow \pi^+ \pi^- p$
–0.053 ±0.029	¹ HUNT	19	DPWA	Multichannel
–0.050 ±0.005	SOKHOYAN	15A	DPWA	Multichannel
–0.049 ±0.005	¹ DUGGER	13	DPWA	$\gamma N \rightarrow \pi N$
–0.038 ±0.004	WORKMAN	12A	DPWA	$\gamma N \rightarrow \pi N$

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

–0.050 ±0.005	GUTZ	14	DPWA	Multichannel
–0.049 ±0.004	ANISOVICH	12A	DPWA	Multichannel
–0.223 ±0.029	¹ SHRESTHA	12A	DPWA	Multichannel
–0.028	DRECHSEL	07	DPWA	$\gamma N \rightarrow \pi N$

¹Statistical error only.

$\Delta(1905)$ REFERENCES

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

ROENCHEN	22	EPJ A58 229	D. Roenchen <i>et al.</i>	(JULI, GWU, BONN+)
GOLOVATCH	19	PL B788 371	E. Golovatch <i>et al.</i>	(CLAS Collab.)
HUNT	19	PR C99 055205	B.C. Hunt, D.M. Manley	
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.)
GUTZ	14	EPJ A50 74	E. Gutz <i>et al.</i>	(CBELSA/TAPS Collab.)
PDG	14	CP C38 070001	K. Olive <i>et al.</i>	(PDG Collab.)
SVARC	14	PR C89 045205	A. Svarc <i>et al.</i>	(RBI Zagreb, UNI Tuzla)
DUGGER	13	PR C88 065203	M. Dugger <i>et al.</i>	(JLab CLAS Collab.)
ANISOVICH	12A	EPJ A48 15	A.V. Anisovich <i>et al.</i>	(BONN, PNPI)
SHRESTHA	12A	PR C86 055203	M. Shrestha, D.M. Manley	(KSU)
WORKMAN	12A	PR C86 015202	R. Workman <i>et al.</i>	(GWU)
DRECHSEL	07	EPJ A34 69	D. Drechsel, S.S. Kamalov, L. Tiator	(MAINZ, JINR)
ARNDT	06	PR C74 045205	R.A. Arndt <i>et al.</i>	(GWU)
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