

$$\Delta(1920) \ 3/2^+$$

$$I(J^P) = \frac{3}{2}(\frac{3}{2}^+) \text{ Status: } ***$$

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

$\Delta(1920)$ POLE POSITION

REAL PART

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
1850 to 1950 (\approx 1900) OUR ESTIMATE			
1875 \pm 30	SOKHOYAN	15A	DPWA Multichannel
1906 \pm 10 \pm 2	¹ SVARC	14	L+P $\pi N \rightarrow \pi N$
1900 \pm 80	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1910	HUNT	19	DPWA Multichannel
1715	ROENCHEN	15A	DPWA Multichannel
1875 \pm 30	GUTZ	14	DPWA Multichannel
1890 \pm 30	ANISOVICH	12A	DPWA Multichannel
1880	VRANA	00	DPWA Multichannel
1900	HOEHLER	93	SPED $\pi N \rightarrow \pi N$

¹Fit to the amplitudes of HOEHLER 79.

−2×IMAGINARY PART

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
200 to 400 (\approx 300) OUR ESTIMATE			
300 \pm 40	SOKHOYAN	15A	DPWA Multichannel
310 \pm 20 \pm 11	¹ SVARC	14	L+P $\pi N \rightarrow \pi N$
300 \pm 100	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
472	HUNT	19	DPWA Multichannel
882	ROENCHEN	15A	DPWA Multichannel
300 \pm 40	GUTZ	14	DPWA Multichannel
300 \pm 60	ANISOVICH	12A	DPWA Multichannel
120	VRANA	00	DPWA Multichannel

¹Fit to the amplitudes of HOEHLER 79.

$\Delta(1920)$ ELASTIC POLE RESIDUE

MODULUS $|r|$

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
8 to 24 (\approx 16) OUR ESTIMATE			
16 \pm 6	SOKHOYAN	15A	DPWA Multichannel
26 \pm 3 \pm 2	¹ SVARC	14	L+P $\pi N \rightarrow \pi N$
24 \pm 4	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
38	ROENCHEN	15A	DPWA Multichannel
16 \pm 6	GUTZ	14	DPWA Multichannel
17 \pm 8	ANISOVICH	12A	DPWA Multichannel

¹Fit to the amplitudes of HOEHLER 79.

PHASE θ

<u>VALUE ($^{\circ}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
–150 to –50 (\approx –100) OUR ESTIMATE			
– 50 \pm 25	SOKHOYAN	15A DPWA	Multichannel
–130 \pm 5 \pm 3	¹ SVARC	14 L+P	$\pi N \rightarrow \pi N$
–150 \pm 30	CUTKOSKY	80 IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
146	ROENCHEN	15A DPWA	Multichannel
– 50 \pm 25	GUTZ	14 DPWA	Multichannel
– 40 \pm 20	ANISOVICH	12A DPWA	Multichannel
¹ Fit to the amplitudes of HOEHLER 79.			

 $\Delta(1920)$ INELASTIC POLE RESIDUE

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

Normalized residue in $N\pi \rightarrow \Delta(1920) \rightarrow \Delta\eta$

<u>MODULUS</u>	<u>PHASE ($^{\circ}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.15 \pm 0.04	70 \pm 20	GUTZ	14 DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.17 \pm 0.08	70 \pm 20	ANISOVICH	12A DPWA	Multichannel

Normalized residue in $N\pi \rightarrow \Delta(1920) \rightarrow \Sigma K$

<u>MODULUS</u>	<u>PHASE ($^{\circ}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.09 \pm 0.03	80 \pm 40	ANISOVICH	12A DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.17	–35	ROENCHEN	15A DPWA	Multichannel

Normalized residue in $N\pi \rightarrow \Delta(1920) \rightarrow \Delta\pi, P$ -wave

<u>MODULUS</u>	<u>PHASE ($^{\circ}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.20 \pm 0.08	–105 \pm 25	SOKHOYAN	15A DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.069	131	ROENCHEN	15A DPWA	Multichannel
0.20 \pm 0.12	–120 \pm 30	ANISOVICH	12A DPWA	Multichannel

Normalized residue in $N\pi \rightarrow \Delta(1920) \rightarrow \Delta\pi, F$ -wave

<u>MODULUS</u>	<u>PHASE ($^{\circ}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.37 \pm 0.10	–90 \pm 20	SOKHOYAN	15A DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.013	–115	ROENCHEN	15A DPWA	Multichannel
0.28 \pm 0.07	–95 \pm 35	ANISOVICH	12A DPWA	Multichannel

Normalized residue in $N\pi \rightarrow \Delta(1920) \rightarrow N(1535)\pi$

<u>MODULUS</u>	<u>PHASE ($^{\circ}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.03 \pm 0.02	35 \pm 45	GUTZ	14 DPWA	Multichannel

Normalized residue in $N\pi \rightarrow \Delta(1920) \rightarrow N_{a_0}(980)$

<u>MODULUS</u>	<u>PHASE ($^{\circ}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.03 \pm 0.02	–85 \pm 45	GUTZ	14 DPWA	Multichannel

Normalized residue in $N\pi \rightarrow \Delta(1920) \rightarrow N(1440)\pi$

<u>MODULUS</u>	<u>PHASE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.04 \pm 0.03	undefined	SOKHOYAN	15A DPWA	Multichannel

Normalized residue in $N\pi \rightarrow \Delta(1920) \rightarrow N(1520)\pi$, S-wave

<u>MODULUS</u>	<u>PHASE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.05 \pm 0.05	undefined	SOKHOYAN	15A DPWA	Multichannel

 $\Delta(1920)$ BREIT-WIGNER MASS

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
1870 to 1970 (\approx 1920) OUR ESTIMATE			
1976 \pm 49	HUNT	19	DPWA Multichannel
1880 \pm 30	SOKHOYAN	15A	DPWA Multichannel
2146 \pm 32	¹ SHRESTHA	12A	DPWA Multichannel
1920 \pm 80	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
1868 \pm 10	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1880 \pm 30	GUTZ	14	DPWA Multichannel
1900 \pm 30	ANISOVICH	12A	DPWA Multichannel
2057 \pm 1	PENNER	02C	DPWA Multichannel
1889 \pm 100	VRANA	00	DPWA Multichannel

¹Statistical error only. **$\Delta(1920)$ BREIT-WIGNER WIDTH**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
240 to 360 (\approx 300) OUR ESTIMATE			
509 \pm 170	HUNT	19	DPWA Multichannel
300 \pm 40	SOKHOYAN	15A	DPWA Multichannel
400 \pm 80	¹ SHRESTHA	12A	DPWA Multichannel
300 \pm 100	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
220 \pm 80	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
300 \pm 40	GUTZ	14	DPWA Multichannel
310 \pm 60	ANISOVICH	12A	DPWA Multichannel
525 \pm 32	PENNER	02C	DPWA Multichannel
123 \pm 53	VRANA	00	DPWA Multichannel

¹Statistical error only. **$\Delta(1920)$ DECAY MODES**

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

Mode	Fraction (Γ_i/Γ)
Γ_1 $N\pi$	5–20 %
Γ_2 ΣK	2–6 %
Γ_3 $N\pi\pi$	>46 %

Γ_4	$\Delta(1232)\pi$	>46 %
Γ_5	$\Delta(1232)\pi$, <i>P</i> -wave	2–28 %
Γ_6	$\Delta(1232)\pi$, <i>F</i> -wave	44–72 %
Γ_7	$N(1440)\pi$, <i>P</i> -wave	4–86 %
Γ_8	$N(1520)\pi$, <i>S</i> -wave	<5 %
Γ_9	$N(1535)\pi$	<2 %
Γ_{10}	$N a_0(980)$	seen
Γ_{11}	$\Delta(1232)\eta$	5–17 %
Γ_{12}	$N\gamma$	0.01–0.84 %
Γ_{13}	$N\gamma$, helicity=1/2	0.0–0.42 %
Γ_{14}	$N\gamma$, helicity=3/2	0.01–0.42 %

$\Delta(1920)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{\text{total}}$					Γ_1/Γ
<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
5–20 % OUR ESTIMATE					
10.5±3.0	¹ HUNT	19	DPWA	Multichannel	
8 ±4	SOKHOYAN	15A	DPWA	Multichannel	
20 ±5	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$	
14 ±4	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
8 ±4	GUTZ	14	DPWA	Multichannel	
8 ±4	ANISOVICH	12A	DPWA	Multichannel	
16 ±4	¹ SHRESTHA	12A	DPWA	Multichannel	
15 ±1	PENNER	02C	DPWA	Multichannel	
5 ±4	VRANA	00	DPWA	Multichannel	

¹Statistical error only.

$\Gamma(\Sigma K)/\Gamma_{\text{total}}$					Γ_2/Γ
<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
2–6 % OUR ESTIMATE					
4 ±2	ANISOVICH	12A	DPWA	Multichannel	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
2.1±0.3	PENNER	02C	DPWA	Multichannel	

$\Gamma(\Delta(1232)\pi, P\text{-wave})/\Gamma_{\text{total}}$					Γ_5/Γ
<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
2–28 % OUR ESTIMATE					
< 1.6	¹ HUNT	19	DPWA	Multichannel	
18 ±10	SOKHOYAN	15A	DPWA	Multichannel	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
22 ±12	ANISOVICH	12A	DPWA	Multichannel	
7 ±5	¹ SHRESTHA	12A	DPWA	Multichannel	
41 ±3	VRANA	00	DPWA	Multichannel	

¹Statistical error only.

$\Gamma(\Delta(1232)\pi, F\text{-wave})/\Gamma_{\text{total}}$ Γ_6/Γ

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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44-72 % OUR ESTIMATE

58 ± 14	SOKHOYAN	15A	DPWA Multichannel
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• • • We do not use the following data for averages, fits, limits, etc. • • •

45 ± 20	ANISOVICH	12A	DPWA Multichannel
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 $\Gamma(N(1440)\pi, P\text{-wave})/\Gamma_{\text{total}}$ Γ_7/Γ

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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4-86 % OUR ESTIMATE

77 ± 9	¹ HUNT	19	DPWA Multichannel
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< 4	SOKHOYAN	15A	DPWA Multichannel
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• • • We do not use the following data for averages, fits, limits, etc. • • •

< 20	¹ SHRESTHA	12A	DPWA Multichannel
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53 ± 8	VRANA	00	DPWA Multichannel
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¹Statistical error only. $\Gamma(N(1520)\pi, S\text{-wave})/\Gamma_{\text{total}}$ Γ_8/Γ

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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<5 OUR ESTIMATE

< 5	SOKHOYAN	15A	DPWA Multichannel
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 $\Gamma(N(1535)\pi)/\Gamma_{\text{total}}$ Γ_9/Γ

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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<2 OUR ESTIMATE

< 2	GUTZ	14	DPWA Multichannel
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 $\Gamma(N_{a_0}(980))/\Gamma_{\text{total}}$ Γ_{10}/Γ

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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seen OUR ESTIMATE

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

4 ± 2	HORN	08A	DPWA Multichannel
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 $\Gamma(\Delta(1232)\eta)/\Gamma_{\text{total}}$ Γ_{11}/Γ

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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5-17 % OUR ESTIMATE

11 ± 6	GUTZ	14	DPWA Multichannel
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• • • We do not use the following data for averages, fits, limits, etc. • • •

15 ± 8	ANISOVICH	12A	DPWA Multichannel
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 $\Delta(1920)$ PHOTON DECAY AMPLITUDES AT THE POLE **$\Delta(1920) \rightarrow N\gamma$, 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>
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0.110 ± 0.030	-50 ± 20	SOKHOYAN	15A	DPWA Multichannel
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0.190 ^{+0.050} _{-0.022}	-160 ⁺²⁴ ₋₁₁	ROENCHEN	14	DPWA
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• • • We do not use the following data for averages, fits, limits, etc. • • •

-0.192	46	ROENCHEN	15A	DPWA Multichannel
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$\Delta(1920) \rightarrow N\gamma$, helicity-3/2 amplitude $A_{3/2}$

<u>MODULUS ($\text{GeV}^{-1/2}$)</u>	<u>PHASE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
-0.100 ± 0.040	0 ± 20	SOKHOYAN	15A	DPWA Multichannel
$-0.398^{+0.070}_{-0.067}$	-110^{+4}_{-5}	ROENCHEN	14	DPWA
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.522	67	ROENCHEN	15A	DPWA Multichannel

 $\Delta(1920)$ BREIT-WIGNER PHOTON DECAY AMPLITUDES $\Delta(1920) \rightarrow N\gamma$, helicity-1/2 amplitude $A_{1/2}$

<u>VALUE ($\text{GeV}^{-1/2}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
-0.028 ± 0.010	¹ HUNT	19	DPWA Multichannel
0.110 ± 0.030	SOKHOYAN	15A	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •			
0.110 ± 0.030	GUTZ	14	DPWA Multichannel
$0.130^{+0.030}_{-0.060}$	ANISOVICH	12A	DPWA Multichannel
0.051 ± 0.010	¹ SHRESTHA	12A	DPWA Multichannel
-0.007	PENNER	02D	DPWA Multichannel

¹Statistical error only. $\Delta(1920) \rightarrow N\gamma$, helicity-3/2 amplitude $A_{3/2}$

<u>VALUE ($\text{GeV}^{-1/2}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
-0.043 ± 0.014	¹ HUNT	19	DPWA Multichannel
-0.105 ± 0.035	SOKHOYAN	15A	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •			
-0.105 ± 0.035	GUTZ	14	DPWA Multichannel
$-0.115^{+0.025}_{-0.050}$	ANISOVICH	12A	DPWA Multichannel
0.017 ± 0.015	¹ SHRESTHA	12A	DPWA Multichannel
-0.001	PENNER	02D	DPWA Multichannel

¹Statistical error only. $\Delta(1920)$ REFERENCESFor early references, see Physics Letters **111B** 1 (1982).

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.)
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	12A	EPJ A48 15	A.V. Anisovich <i>et al.</i>	(BONN, PNPI)
SHRESTHA	12A	PR C86 055203	M. Shrestha, D.M. Manley	(KSU)
HORN	08A	EPJ A38 173	I. Horn <i>et al.</i>	(CB-ELSA Collab.)
Also		PRL 101 202002	I. Horn <i>et al.</i>	(CB-ELSA Collab.)

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	π N 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
