

# Resonance parameters from pion photoproduction data using L+P method

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- Method
- Input and results
- Conclusions



The function we fit to data consists of pole terms and non-singular part:

$$T(\omega) = \sum_{i=1}^k \frac{a_{-1}^{(i)}}{\omega_j - \omega} + \sum_{n=0}^M c_n Z(\omega)^n + \sum_{n=0}^N d_n W(\omega)^n + \sum_{n=0}^K e_n Y(\omega)^n$$

The non-singular part is represented by three Pietarinen expansions.  $Z$ ,  $W$  and  $Y$  are conformal mapping variables.

$$Z(\omega) = \frac{\alpha - \sqrt{x_P - \omega}}{\alpha + \sqrt{x_P - \omega}}, \quad W(\omega) = \frac{\beta - \sqrt{x_Q - \omega}}{\beta + \sqrt{x_Q - \omega}}, \quad Y(\omega) = \frac{\gamma - \sqrt{x_R - \omega}}{\gamma + \sqrt{x_R - \omega}}$$

The function to be minimized reads:

$$\chi^2 = \chi_{data}^2 + \chi_{Pen}^2$$

$$\chi_{Pen}^2 = \lambda_1 \sum_{k=1}^N c_k^2 k^3 + \lambda_2 \sum_{k=1}^M d_k^2 k^3 + \lambda_3 \sum_{k=1}^K e_k^2 k^3$$



For energy dependent solutions - discrepancy parameter

$$D = \frac{1}{2 \cdot N_{data}} \sum_{i=1}^{N_{data}} \left[ \left( \frac{ReT_i^{fit} - ReT_i^{exp}}{Err_i^{Re}} \right)^2 + \left( \frac{ImT_i^{fit} - ImT_i^{exp}}{Err_i^{Im}} \right)^2 \right]$$

Error of energy dependent solutions

$$Err_i^{Re} = 0.05 \frac{\sum_{k=1}^{N_{data}} |ReT_k^{ED}|}{N_{data}} + 0.05 |ReT_i^{ED}|$$

$$Err_i^{Im} = 0.05 \frac{\sum_{k=1}^{N_{data}} |ImT_k^{ED}|}{N_{data}} + 0.05 |ImT_i^{ED}|$$

For single energy solutions

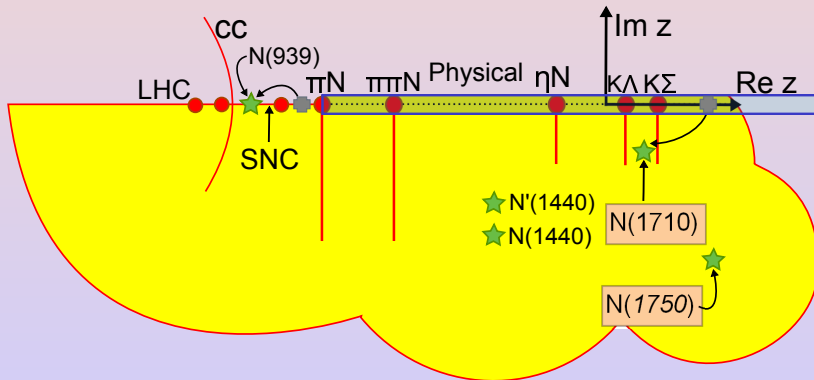
$$\chi^2 = \frac{1}{2 \cdot N_{data}} \sum_{i=1}^{N_{data}} \left[ \left( \frac{ReT_i^{fit} - ReT_i^{exp}}{Err_i^{Re}} \right)^2 + \left( \frac{ImT_i^{fit} - ImT_i^{exp}}{Err_i^{Im}} \right)^2 \right]$$



# Error analysis

In L+P method we have two kind of errors:

1. Statistical (error from MINUIT)
2. Systematic (error of method)



Juelich group

arXiv:1211.6998v1

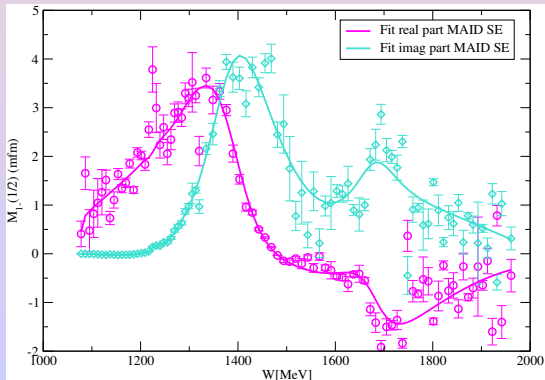
Input:

1. MAID electromagnetic multipoles - MD07 ED and MD07 SE solutions.
2. SAID electromagnetic multipoles - CM12 ED and GWU SE solutions.



# $P_{11}(M_{1-})$ multipole

$P_{11}(M_{1-}(\frac{1}{2}))$		Re	$-2Im$	$\frac{ r_1 }{\theta_1}$	Re	$-2Im$	$\frac{ r_2 }{\theta_2}$
MAID	SE	$1379 \pm 6$	$183 \pm 8$	$0.394 \pm 0.008$ $-(36 \pm 6)^\circ$	$1678 \pm 8$	$99 \pm 37$	$0.062 \pm 0.018$ $-(16 \pm 6)^\circ$



Threshold positions			$\chi^2$
-1037	$1077\pi N$	$1215\pi\pi N$	3.03
-810	$1077\pi N$	$1370^{Real}(\pi\Delta)$	2.74
-3417	$1077\pi N$	$1362^{free}$	2.73

PDG	Re $-2Im$	PDG Estimate
N(1440)	1350 to 1380 160 to 220	1365 190
N(1710)	1670 to 1770 80 to 380	1710 200
N(2100)		



# $P_{11}(M_{1-})$ multipole

$P_{11}(M_{1-}(\frac{1}{2}))$	Re	$-2Im$	$\frac{ r_1 }{\theta_1}$	Re	$-2Im$	$\frac{ r_2 }{\theta_2}$
MAID SE	1375	181	0.399 $-35^\circ$	1680	123	0.057 $-14^\circ$

Threshold positions			$\chi^2$
-1037	$1077\pi N$	$1215\pi\pi N$	3.03





# $P_{11} (M_{1-})$ multipole

$P_{11}(M_{1-}(\frac{1}{2}))$	Re	$-2Im$	$\begin{matrix}  r_1  \\ \theta_1 \end{matrix}$	Re	$-2Im$	$\begin{matrix}  r_2  \\ \theta_2 \end{matrix}$
MAID SE	1375	181	$0.399$ $-35^\circ$	1680	123	$0.057$ $-14^\circ$
	1383	188	0.390 $-32$	1675	78	0.076 $-18$

Threshold positions			$\chi^2$
-1037	$1077\pi N$	$1215\pi\pi N$	3.03
-810	$1077\pi N$	$1370\text{Real}(\pi\Delta)$	2.74



# $P_{11}(M_{1-})$ multipole

$P_{11}(M_{1-}(\frac{1}{2}))$	Re	$-2Im$	$\frac{ r_1 }{\theta_1}$	Re	$-2Im$	$\frac{ r_2 }{\theta_2}$
MAID SE	1375	181	0.399 $-35^\circ$	1680	123	0.057 $-14^\circ$
	1383	188	0.390 $-32$	1675	78	0.076 $-18$
	1383	179	0.393 $-42$	1680	95	0.053 $-17$

Threshold positions			$\chi^2$
-1037	$1077\pi N$	$1215\pi\pi N$	3.03
-810	$1077\pi N$	$1370^{Real}(\pi\Delta)$	2.74
876	$1077\pi N$	$1362^{free}$	2.73



# $P_{11}(M_{1-})$ multipole

$P_{11}(M_{1-}(\frac{1}{2}))$	Re	$-2Im$	$ r_1 $ $\theta_1$	Re	$-2Im$	$ r_2 $ $\theta_2$
MAID SE	1375	181	0.399 $-35^\circ$	1680	123	0.057 $-14^\circ$
	1383	188	0.390 $-32$	1675	78	0.076 $-18$
	1383	179	0.393 $-42$	1680	95	0.053 $-17$
<b>AV <math>\pm</math> SD</b>	<b>1379 <math>\pm</math> 4</b>	<b>183 <math>\pm</math> 5</b>	<b>0.394 <math>\pm</math> 0.005</b> <b><math>-(36 \pm 5)^\circ</math></b>	<b>1678 <math>\pm</math> 3</b>	<b>99 <math>\pm</math> 23</b>	<b>0.062 <math>\pm</math> 0.012</b> <b><math>-(16 \pm 2)^\circ</math></b>

$$\bar{x} = \frac{\sum_{i=1}^N x_i}{N} ; SD = \sqrt{\frac{\sum_{i=1}^N (x_i - \bar{x})^2}{N-1}}$$

Threshold positions			$\chi^2$
-1037	$1077\pi N$	$1215\pi\pi N$	3.03
-810	$1077\pi N$	$1370^{Real}(\pi\Delta)$	2.74
876	$1077\pi N$	$1362^{free}$	2.73



# P11 ( $M_{1-}$ ) multipole

$P_{11}(M_{1-}(\frac{1}{2}))$	Re	-2Im	$\frac{ r_1 }{\theta_1}$	Re	-2Im	$\frac{ r_2 }{\theta_2}$
MAID SE	1375	181	0.399 -35°	1680	123	0.057 -14°
	1383	188	0.390 -32	1675	78	0.076 -18
	1383	179	0.393 -42	1680	95	0.053 -17
AV ± SD	1379 ± 4	183 ± 5	0.394 ± 0.005 -(36 ± 5)°	1678 ± 3	99 ± 23	0.062 ± 0.012 -(16 ± 2)°
AV ±SD ±MIN	1379 <sup>+4</sup> <sub>±2</sub>	183 <sup>+5</sup> <sub>±3</sub>	0.394 <sup>+0.005</sup> <sub>±0.003</sub> -(36 <sup>+5</sup> <sub>±1</sub> )°	1678 <sup>+3</sup> <sub>±5</sub>	99 <sup>+23</sup> <sub>±14</sub>	0.062 <sup>+0.012</sup> <sub>±0.006</sub> -(16 <sup>+2</sup> <sub>±4</sub> )°
AV ± error	1379 ± 6	183 ± 8	0.394 ± 0.008 -(36 ± 6)°	1678 ± 8	99 ± 37	0.062 ± 0.018 -(16 ± 6)°

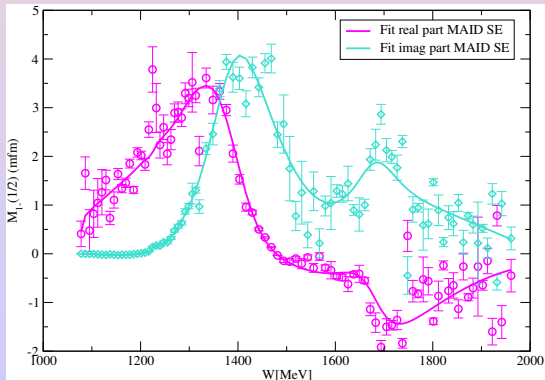
$$\bar{x} = \frac{\sum_{i=1}^N x_i}{N} ; SD = \sqrt{\frac{\sum_{i=1}^N (x_i - \bar{x})^2}{N-1}}$$

Threshold positions			$\chi^2$
-1037	1077 $\pi N$	1215 $\pi\pi N$	3.03
-810	1077 $\pi N$	1370 <sup>Real</sup> ( $\pi\Delta$ )	2.74
876	1077 $\pi N$	1362 <sup>free</sup>	



# $P_{11}(M_{1-})$ multipole

$P_{11}(M_{1-}(\frac{1}{2}))$		Re	$-2Im$	$\frac{ r_1 }{\theta_1}$	Re	$-2Im$	$\frac{ r_2 }{\theta_2}$
MAID	SE	$1379 \pm 6$	$183 \pm 8$	$0.394 \pm 0.008$ $-(36 \pm 6)^\circ$	$1678 \pm 8$	$99 \pm 37$	$0.062 \pm 0.018$ $-(16 \pm 6)^\circ$



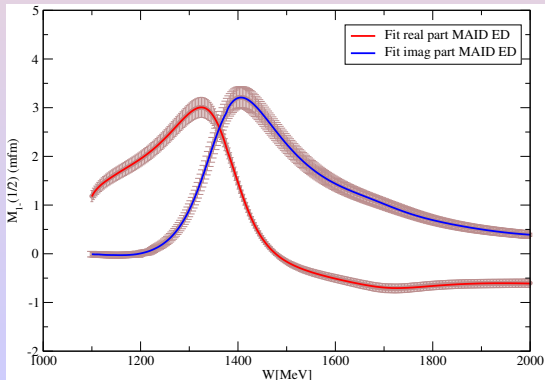
Threshold positions			$\chi^2$
-1037	$1077\pi N$	$1215\pi\pi N$	3.03
-810	$1077\pi N$	$1370^{Real}(\pi\Delta)$	2.74
-3417	$1077\pi N$	$1362^{free}$	2.73

PDG	Re $-2Im$	PDG Estimate
N(1440)	1350 to 1380 160 to 220	1365 190
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N(2100)		



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$P_{11}(M_{1-}(\frac{1}{2}))$		Re	$-2Im$	$\frac{ r_1 }{\theta_1}$	Re	$-2Im$	$\frac{ r_2 }{\theta_2}$
MAID	SE	$1379 \pm 6$	$183 \pm 8$	$0.394 \pm 0.008$ $-(36 \pm 6)^\circ$	$1678 \pm 8$	$99 \pm 37$	$0.062 \pm 0.018$ $-(16 \pm 6)^\circ$
	ED	$1367 \pm 2$	$190 \pm 5$	$0.306 \pm 0.015$ $-(44 \pm 5)^\circ$	$1694 \pm 34$	$269 \pm 79$	$0.029 \pm 0.013$ $(65 \pm 14)^\circ$



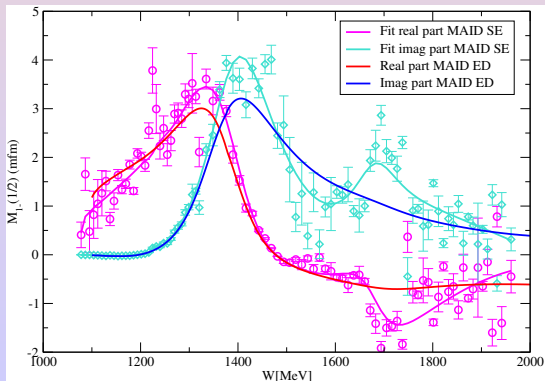
Threshold positions			D
309	$1077\pi N$	$1215\pi\pi N$	0.0031
494	$1077\pi N$	$1370^{Real}(\pi\Delta)$	0.0028
123	$1077\pi N$	$1515^{free}$	0.0015

PDG	Re $-2Im$	PDG Estimate
N(1440)	1350 to 1380 160 to 220	1365 190
N(1710)	1670 to 1770 80 to 380	1720 239
N(2100)		



# $P_{11}(M_{1-})$ multipole

$P_{11}(M_{1-}(\frac{1}{2}))$		Re	$-2Im$	$\frac{ r_1 }{\theta_1}$	Re	$-2Im$	$\frac{ r_2 }{\theta_2}$
MAID	ED	$1367 \pm 2$	$190 \pm 5$	$0.306 \pm 0.015$ $-(44 \pm 5)^\circ$	$1694 \pm 34$	$269 \pm 79$	$0.029 \pm 0.013$ $(65 \pm 14)^\circ$
	SE	$1379 \pm 6$	$183 \pm 8$	$0.394 \pm 0.008$ $-(36 \pm 6)^\circ$	$1678 \pm 8$	$99 \pm 37$	$0.062 \pm 0.018$ $-(16 \pm 6)^\circ$

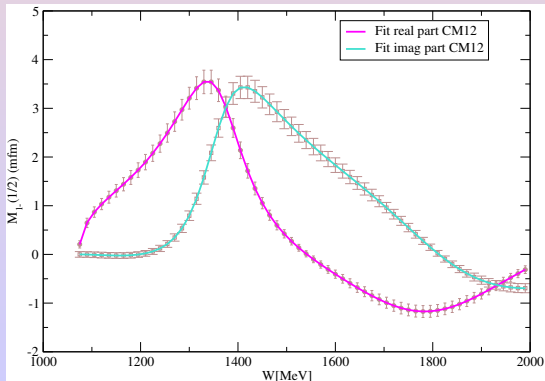


PDG	Re $-2Im$	PDG Estimate
N(1440)	1350 to 1380 160 to 220	1365 190
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N(2100)		



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$P_{11}(M_{1-}(\frac{1}{2}))$		Re	$-2Im$	$\frac{ r_1 }{\theta_1}$	Re	$-2Im$	$\frac{ r_2 }{\theta_2}$
MAID	ED	$1367 \pm 2$	$190 \pm 5$	$0.306 \pm 0.015$ $-(44 \pm 5)^\circ$	$1694 \pm 34$	$269 \pm 79$	$0.029 \pm 0.013$ $(65 \pm 14)^\circ$
	SE	$1379 \pm 6$	$183 \pm 8$	$0.394 \pm 0.008$ $-(36 \pm 6)^\circ$	$1678 \pm 8$	$99 \pm 37$	$0.062 \pm 0.018$ $-(16 \pm 6)^\circ$
CM12	ED	$1360 \pm 5$	$183 \pm 9$	$0.290 \pm 0.054$ $-(61 \pm 5)^\circ$	$1789 \pm 13$	$550 \pm 28$	$0.609 \pm 0.045$ $(98 \pm 7)^\circ$



Threshold positions			$D$
900	$1077\pi N$	$1215\pi\pi N$	0.0013
900	$1077\pi N$	$1370^{Real}(\pi\Delta)$	0.0015
871	$1077\pi N$	$1375^{free}$	0.0012

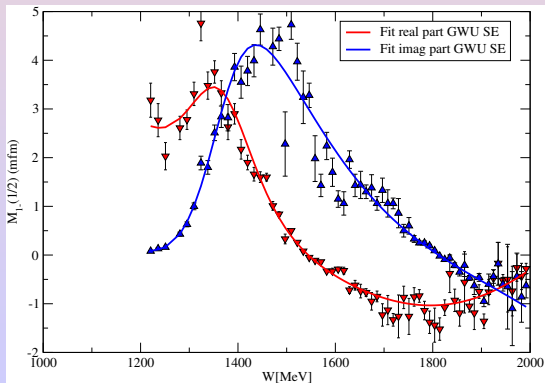
PDG	Re $-2Im$	PDG Estimate
N(1440)	1350 to 1380 160 to 220	1365 190
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N(2100)		





# $P_{11}(M_{1-})$ multipole

$P_{11}(M_{1-}(\frac{1}{2}))$		Re	$-2Im$	$\begin{matrix}  r_1  \\ \theta_1 \end{matrix}$	Re	$-2Im$	$\begin{matrix}  r_2  \\ \theta_2 \end{matrix}$
MAID	ED	$1367 \pm 2$	$190 \pm 5$	$0.306 \pm 0.015$ $-(44 \pm 5)^\circ$	$1694 \pm 34$	$269 \pm 79$	$0.029 \pm 0.013$ $(65 \pm 14)^\circ$
	SE	$1379 \pm 6$	$183 \pm 8$	$0.394 \pm 0.008$ $-(36 \pm 6)^\circ$	$1678 \pm 8$	$99 \pm 37$	$0.062 \pm 0.018$ $-(16 \pm 6)^\circ$
CM12	ED	$1360 \pm 5$	$183 \pm 9$	$0.290 \pm 0.054$ $-(61 \pm 5)^\circ$	$1789 \pm 13$	$550 \pm 28$	$0.609 \pm 0.045$ $(98 \pm 7)^\circ$
GWU	SE	$1367 \pm 10$	$253 \pm 11$	$0.547 \pm 0.058$ $-(75 \pm 7)^\circ$			



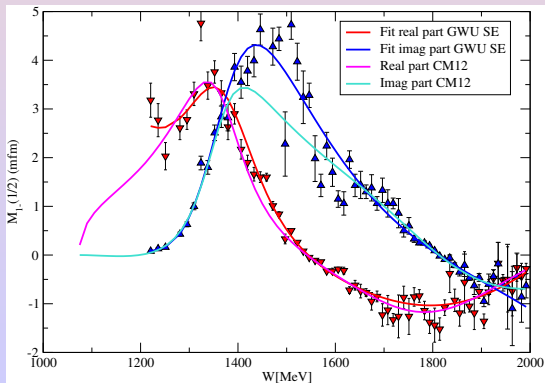
Threshold positions			$\chi^2$
-1256	$1077\pi N$	$1215\pi\pi N$	3.02
-12191	$1077\pi N$	$1370\text{Real}(\pi\Delta)$	3.05
-10673	$1077\pi N$	$1324^{\text{free}}$	2.97

PDG	Re $-2Im$	PDG Estimate
N(1440)	1350 to 1380 160 to 220	1365 190
N(1710)	1670 to 1770 80 to 380	1710 230
N(2100)		



# $P_{11}(M_{1-})$ multipole

$P_{11}(M_{1-}(\frac{1}{2}))$		Re	$-2Im$	$\begin{matrix}  r_1  \\ \theta_1 \end{matrix}$	Re	$-2Im$	$\begin{matrix}  r_2  \\ \theta_2 \end{matrix}$
MAID	ED	$1367 \pm 2$	$190 \pm 5$	$0.306 \pm 0.015$ $-(44 \pm 5)^\circ$	$1694 \pm 34$	$269 \pm 79$	$0.029 \pm 0.013$ $(65 \pm 14)^\circ$
	SE	$1379 \pm 6$	$183 \pm 8$	$0.394 \pm 0.008$ $-(36 \pm 6)^\circ$	$1678 \pm 8$	$99 \pm 37$	$0.062 \pm 0.018$ $-(16 \pm 6)^\circ$
CM12	ED	$1360 \pm 5$	$183 \pm 9$	$0.290 \pm 0.054$ $-(61 \pm 5)^\circ$	$1789 \pm 13$	$550 \pm 28$	$0.609 \pm 0.045$ $(98 \pm 7)^\circ$
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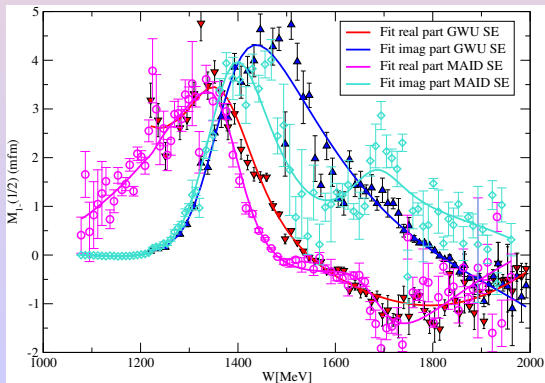


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N(1440)	1350 to 1380 160 to 220	1365 190
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$P_{11}(M_{1-}(\frac{1}{2}))$		Re	$-2Im$	$ r_1 $ $\theta_1$	Re	$-2Im$	$ r_2 $ $\theta_2$
MAID	ED	$1367 \pm 2$	$190 \pm 5$	$0.306 \pm 0.015$ $-(44 \pm 5)^\circ$	$1694 \pm 34$	$269 \pm 79$	$0.029 \pm 0.013$ $(65 \pm 14)^\circ$
	SE	$1379 \pm 6$	$183 \pm 8$	$0.394 \pm 0.008$ $-(36 \pm 6)^\circ$	$1678 \pm 8$	$99 \pm 37$	$0.062 \pm 0.018$ $-(16 \pm 6)^\circ$
CM12	ED	$1360 \pm 5$	$183 \pm 9$	$0.290 \pm 0.054$ $-(61 \pm 5)^\circ$	$1789 \pm 13$	$550 \pm 28$	$0.609 \pm 0.045$ $(98 \pm 7)^\circ$
GWU	SE	$1367 \pm 10$	$253 \pm 11$	$0.547 \pm 0.058$ $-(75 \pm 7)^\circ$			

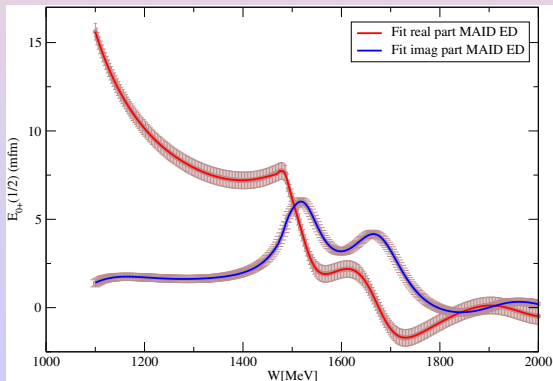


PDG	Re $-2Im$	PDG Estimate
N(1440)	1350 to 1380 160 to 220	1365 190
N(1710)	1670 to 1770 80 to 380	1720 230
N(2100)		



# $S_{11}(E_{0+})$ multipole

$S_{11}(E_{0+}(\frac{1}{2}))$		Re	$-2Im$	$\begin{matrix}  r_1  \\ \theta_1 \end{matrix}$	Re	$-2Im$	$\begin{matrix}  r_2  \\ \theta_2 \end{matrix}$
MAID	ED	$1516 \pm 3$	$94 \pm 5$	$0.234 \pm 0.013$ $-(2 \pm 10)^\circ$	$1678 \pm 4$	$135 \pm 5$	$0.289 \pm 0.019$ $(12 \pm 7)^\circ$
	SE						



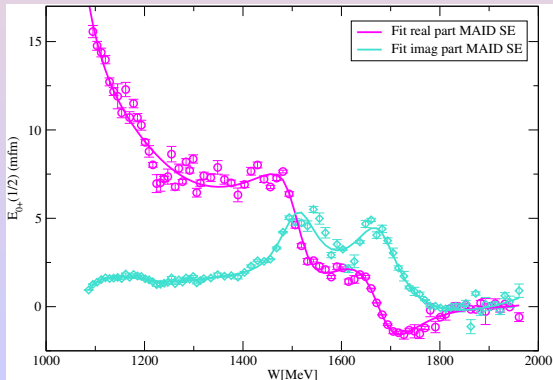
Threshold positions			$D$
$-3778$	$1077\pi N$	$1215\pi\pi N$	$0.0120$
$-131$	$1077\pi N$	$1486\eta N$	$0.0100$
$-393$	$1077\pi N$	$1379$	$0.0098$

PDG	Re $-2Im$	PDG Estimate
N(1535)	1490 to 1530 90 to 250	1510 170
N(1650)	1640 to 1670 100 to 170	1655 135
N(1895)		



# $S_{11}(E_{0+})$ multipole

$S_{11}(E_{0+}(\frac{1}{2}))$		Re	$-2Im$	$\begin{matrix}  r_1  \\ \theta_1 \end{matrix}$	Re	$-2Im$	$\begin{matrix}  r_2  \\ \theta_2 \end{matrix}$
MAID	ED	$1516 \pm 3$	$94 \pm 5$	$0.234 \pm 0.013$ $-(2 \pm 10)^\circ$	$1678 \pm 4$	$135 \pm 5$	$0.289 \pm 0.019$ $(12 \pm 7)^\circ$
	SE	$1511 \pm 7$	$93 \pm 9$	$0.210 \pm 0.023$ $-(5 \pm 8)^\circ$	$1681 \pm 4$	$113 \pm 7$	$0.231 \pm 0.025$ $-(21 \pm 7)^\circ$



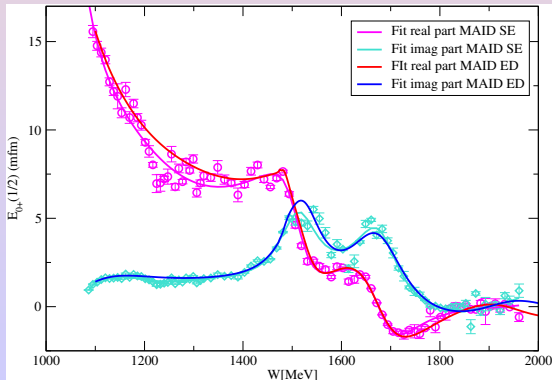
Threshold positions			$\chi^2$
-950	$1077\pi N$	$1215\pi\pi N$	3.88
-395	$1077\pi N$	$1486\eta N$	3.86
876	$1077\pi N$	$1112^{free}$	3.53

PDG	Re $-2Im$	PDG Estimate
N(1535)	1490 to 1530 90 to 250	1510 170
N(1650)	1640 to 1670 100 to 170	1655 135
N(1895)		



# $S_{11}(E_{0+})$ multipole

$S_{11}(E_{0+}(\frac{1}{2}))$		Re	$-2Im$	$\frac{ r_1 }{\theta_1}$	Re	$-2Im$	$\frac{ r_2 }{\theta_2}$
MAID	ED	$1516 \pm 3$	$94 \pm 5$	$0.234 \pm 0.013$ $-(2 \pm 10)^\circ$	$1678 \pm 4$	$135 \pm 5$	$0.289 \pm 0.019$ $(12 \pm 7)^\circ$
	SE	$1511 \pm 7$	$93 \pm 9$	$0.210 \pm 0.023$ $-(5 \pm 8)^\circ$	$1681 \pm 4$	$113 \pm 7$	$0.231 \pm 0.025$ $-(21 \pm 7)^\circ$

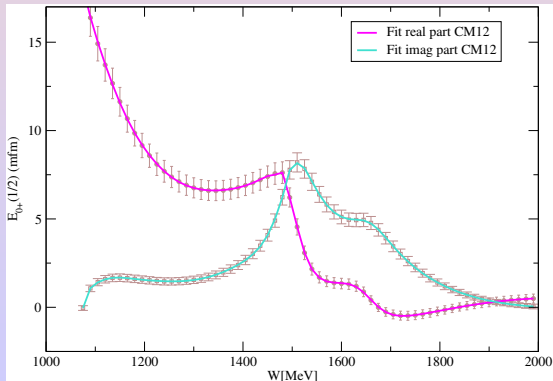


PDG	Re $-2Im$	PDG Estimate
N(1535)	1490 to 1530 90 to 250	1510 170
N(1650)	1640 to 1670 100 to 170	1655 135
N(1895)		



# $S_{11}(E_{0+})$ multipole

$S_{11}(E_{0+}(\frac{1}{2}))$		Re	$-2Im$	$\frac{ r_1 }{\theta_1}$	Re	$-2Im$	$\frac{ r_2 }{\theta_2}$
MAID	ED	$1516 \pm 3$	$94 \pm 5$	$0.234 \pm 0.013$ $-(2 \pm 10)^\circ$	$1678 \pm 4$	$135 \pm 5$	$0.289 \pm 0.019$ $(12 \pm 7)^\circ$
	SE	$1511 \pm 7$	$93 \pm 9$	$0.210 \pm 0.023$ $-(5 \pm 8)^\circ$	$1681 \pm 4$	$113 \pm 7$	$0.231 \pm 0.025$ $-(21 \pm 7)^\circ$
CM12	ED	$1501 \pm 6$	$95 \pm 11$	$0.245 \pm 0.038$ $-(25 \pm 10)^\circ$	$1655 \pm 11$	$127 \pm 17$	$0.119 \pm 0.032$ $-(18 \pm 23)^\circ$



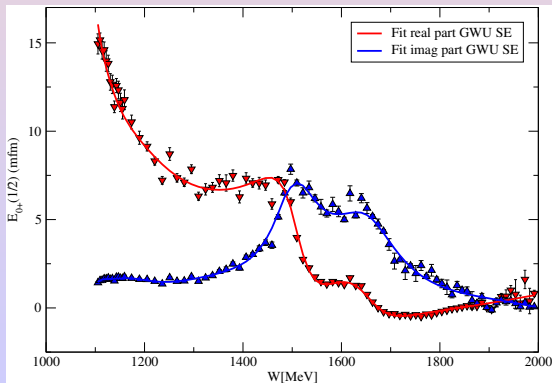
Threshold positions			$D$
142	$1077\pi N$	$1215\pi\pi N$	0.0049
900	$1077\pi N$	$1486\eta N$	0.0035
889	$1077\pi N$	$1112^{free}$	0.0031

PDG	Re $-2Im$	PDG Estimate
N(1535)	1490 to 1530 90 to 250	1510 170
N(1650)	1640 to 1670 100 to 170	1655 135
N(1895)		



# S11 ( $E_{0+}$ ) multipole

$S_{11}(E_{0+}(\frac{1}{2}))$		Re	-2Im	$\frac{ r_1 }{\theta_1}$	Re	-2Im	$\frac{ r_2 }{\theta_2}$
MAID	ED	$1516 \pm 3$	$94 \pm 5$	$0.234 \pm 0.013$ $-(2 \pm 10)^\circ$	$1678 \pm 4$	$135 \pm 5$	$0.289 \pm 0.019$ $(12 \pm 7)^\circ$
	SE	$1511 \pm 7$	$93 \pm 9$	$0.210 \pm 0.023$ $-(5 \pm 8)^\circ$	$1681 \pm 4$	$113 \pm 7$	$0.231 \pm 0.025$ $-(21 \pm 7)^\circ$
CM12	ED	$1501 \pm 6$	$95 \pm 11$	$0.245 \pm 0.038$ $-(25 \pm 10)^\circ$	$1655 \pm 11$	$127 \pm 17$	$0.119 \pm 0.032$ $-(18 \pm 23)^\circ$
GWU	SE	$1501 \pm 3$	$112 \pm 9$	$0.312 \pm 0.025$ $-(18 \pm 4)^\circ$	$1650 \pm 2$	$117 \pm 16$	$0.153 \pm 0.028$ $-(8 \pm 10)^\circ$



Threshold positions			$\chi^2$
-9935	$1077\pi N$	$1215\pi\pi N$	3.02
-4986	$1077\pi N$	$1486\eta N$	2.53
556	$1077\pi N$	$1499^{free}$	2.47

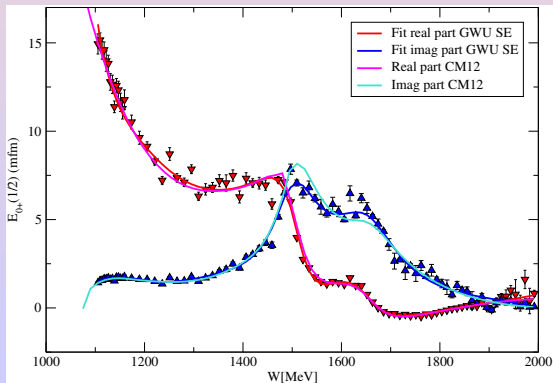
PDG	Re -2Im	PDG Estimate
N(1535)	1490 to 1530 90 to 250	1510 170
N(1650)	1640 to 1670 100 to 170	1655 130
N(1895)		





# S11 ( $E_{0+}$ ) multipole

$S_{11}(E_{0+}(\frac{1}{2}))$		Re	$-2Im$	$\begin{matrix}  r_1  \\ \theta_1 \end{matrix}$	Re	$-2Im$	$\begin{matrix}  r_2  \\ \theta_2 \end{matrix}$
MAID	ED	$1516 \pm 3$	$94 \pm 5$	$0.234 \pm 0.013$ $-(2 \pm 10)^\circ$	$1678 \pm 4$	$135 \pm 5$	$0.289 \pm 0.019$ $(12 \pm 7)^\circ$
	SE	$1511 \pm 7$	$93 \pm 9$	$0.210 \pm 0.023$ $-(5 \pm 8)^\circ$	$1681 \pm 4$	$113 \pm 7$	$0.231 \pm 0.025$ $-(21 \pm 7)^\circ$
CM12	ED	$1501 \pm 6$	$95 \pm 11$	$0.245 \pm 0.038$ $-(25 \pm 10)^\circ$	$1655 \pm 11$	$127 \pm 17$	$0.119 \pm 0.032$ $-(18 \pm 23)^\circ$
GWU	SE	$1501 \pm 3$	$112 \pm 9$	$0.312 \pm 0.025$ $-(18 \pm 4)^\circ$	$1650 \pm 2$	$117 \pm 16$	$0.153 \pm 0.028$ $-(8 \pm 10)^\circ$

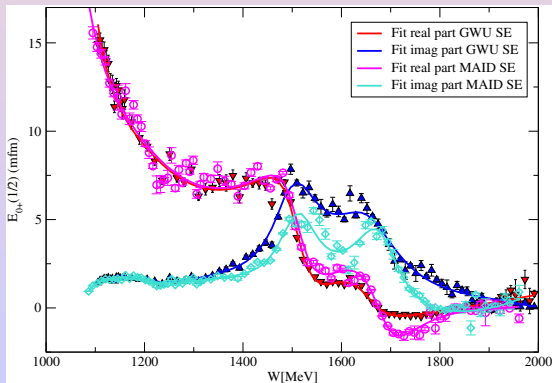


PDG	Re $-2Im$	PDG Estimate
N(1535)	1490 to 1530 90 to 250	1510 170
N(1650)	1640 to 1670 100 to 170	1655 135
N(1895)		



# S11 ( $E_{0+}$ ) multipole

$S_{11}(E_{0+}(\frac{1}{2}))$		Re	$-2Im$	$\begin{matrix}  r_1  \\ \theta_1 \end{matrix}$	Re	$-2Im$	$\begin{matrix}  r_2  \\ \theta_2 \end{matrix}$
MAID	ED	$1516 \pm 3$	$94 \pm 5$	$0.234 \pm 0.013$ $-(2 \pm 10)^\circ$	$1678 \pm 4$	$135 \pm 5$	$0.289 \pm 0.019$ $(12 \pm 7)^\circ$
	SE	$1511 \pm 7$	$93 \pm 9$	$0.210 \pm 0.023$ $-(5 \pm 8)^\circ$	$1681 \pm 4$	$113 \pm 7$	$0.231 \pm 0.025$ $-(21 \pm 7)^\circ$
CM12	ED	$1501 \pm 6$	$95 \pm 11$	$0.245 \pm 0.038$ $-(25 \pm 10)^\circ$	$1655 \pm 11$	$127 \pm 17$	$0.119 \pm 0.032$ $-(18 \pm 23)^\circ$
GWU	SE	$1501 \pm 3$	$112 \pm 9$	$0.312 \pm 0.025$ $-(18 \pm 4)^\circ$	$1650 \pm 2$	$117 \pm 16$	$0.153 \pm 0.028$ $-(8 \pm 10)^\circ$

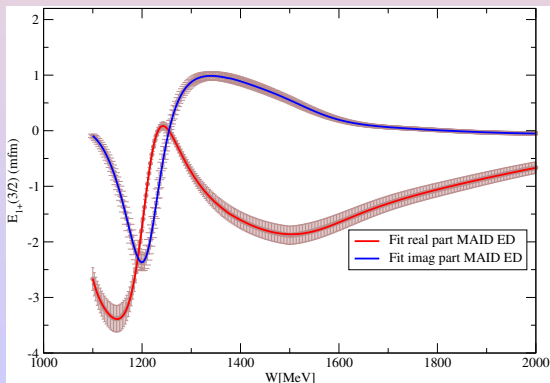


PDG	Re $-2Im$	PDG Estimate
N(1535)	1490 to 1530 90 to 250	1510 170
N(1650)	1640 to 1670 100 to 170	1655 135
N(1895)		



# P33 ( $E_{1+}$ ) multipole

$P_{33}(E_{1+}(\frac{3}{2}))$		Re	$-2Im$	$\frac{ r_1 }{\theta_1}$	Re	$-2Im$	$\frac{ r_2 }{\theta_2}$
MAID	ED	$1211 \pm 1$	$99 \pm 1$	$0.184 \pm 0.005$ $-(155 \pm 2)^\circ$	$1550 \pm 11$	$347 \pm 41$	$0.0087 \pm 0.024$ $(127 \pm 9)^\circ$
	SE						



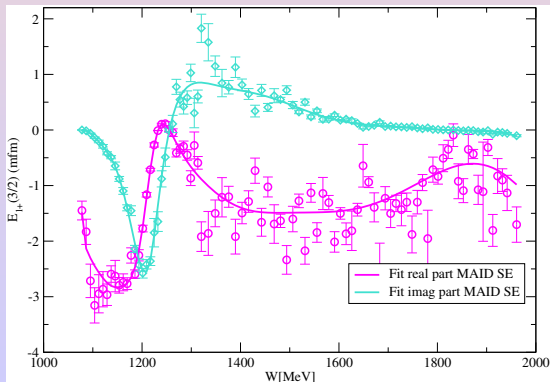
Threshold positions			$D$
838	$1077\pi N$	$1215\pi N$	0.0020
167	$1077\pi N$	$1370^{Real}(\pi\Delta)$	0.0019
534	$1077\pi N$	$1222^{free}$	0.0009

PDG	Re $-2Im$	PDG Estimate
$\Delta(1232)$	1209 to 1211 98 to 102	1210 100
$\Delta(1600)$	1460 to 1560 200 to 350	1510 275
$\Delta(1920)$		



# P33 ( $E_{1+}$ ) multipole

$P33(E_{1+}(\frac{3}{2}))$		Re	$-2Im$	$\frac{ r_1 }{\theta_1}$	Re	$-2Im$	$\frac{ r_2 }{\theta_2}$
MAID	ED	$1211 \pm 1$	$99 \pm 1$	$0.184 \pm 0.005$ $-(155 \pm 2)^\circ$	$1550 \pm 11$	$347 \pm 41$	$0.0087 \pm 0.024$ $(127 \pm 9)^\circ$
	SE	$1215 \pm 4$	$87 \pm 1$	$0.154 \pm 0.011$ $-(155 \pm 8)^\circ$			



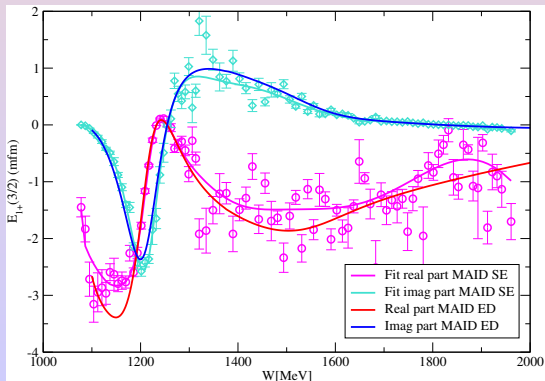
Threshold positions			$\chi^2$
$-2754$	$1077\pi N$	$1215\pi N$	3.38
$-1759$	$1077\pi N$	$1370^{Real}(\pi\Delta)$	3.34
$46$	$1077\pi N$	$1467^{free}$	3.21

PDG	Re $-2Im$	PDG Estimate
$\Delta(1232)$	1209 to 1211 98 to 102	1210 100
$\Delta(1600)$	1460 to 1560 200 to 350	1510 200
$\Delta(1920)$		



# $P_{33}(E_{1+}(\frac{3}{2}))$ multipole

$P_{33}(E_{1+}(\frac{3}{2}))$		Re	$-2Im$	$\begin{matrix}  r_1  \\ \theta_1 \end{matrix}$	Re	$-2Im$	$\begin{matrix}  r_2  \\ \theta_2 \end{matrix}$
MAID	ED	$1211 \pm 1$	$99 \pm 1$	$0.184 \pm 0.005$ $-(155 \pm 2)^\circ$	$1550 \pm 11$	$347 \pm 41$	$0.0087 \pm 0.024$ $(127 \pm 9)^\circ$
	SE	$1215 \pm 4$	$87 \pm 1$	$0.154 \pm 0.011$ $-(155 \pm 8)^\circ$			

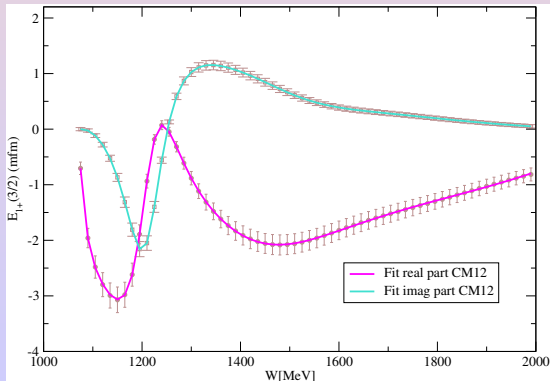


PDG	Re $-2Im$	PDG Estimate
$\Delta(1232)$	1209 to 1211 98 to 102	1210 100
$\Delta(1600)$	1460 to 1560 200 to 350	1510 275
$\Delta(1920)$		



# $P_{33}(E_{1+})$ multipole

$P_{33}(E_{1+}(\frac{3}{2}))$		Re	$-2Im$	$\begin{matrix}  r_1  \\ \theta_1 \end{matrix}$	Re	$-2Im$	$\begin{matrix}  r_2  \\ \theta_2 \end{matrix}$
MAID	ED	$1211 \pm 1$	$99 \pm 1$	$0.184 \pm 0.005$ $-(155 \pm 2)^\circ$	$1550 \pm 11$	$347 \pm 41$	$0.0087 \pm 0.024$ $(127 \pm 9)^\circ$
	SE	$1215 \pm 4$	$87 \pm 1$	$0.154 \pm 0.011$ $-(155 \pm 8)^\circ$			
CM12	ED	$1211 \pm 1.5$	$101 \pm 1$	$0.183 \pm 0.006$ $-(154 \pm 2)^\circ$	$1470 \pm 31$	$396 \pm 51$	$0.127 \pm 0.099$ $(109^\circ \pm 20)$



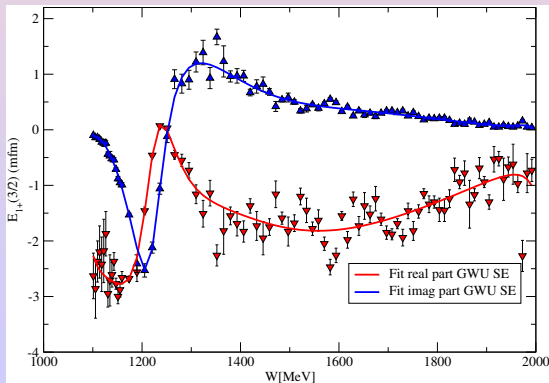
Threshold positions			D
883	$1077\pi N$	$1215\pi\pi N$	0.0012
899	$1077\pi N$	$1370^{Real}(\pi\Delta)$	0.0012
818	$1077\pi N$	$1218^{free}$	0.0009

PDG	Re $-2Im$	PDG Estimate
$\Delta(1232)$	1209 to 1211 98 to 102	1210 100
$\Delta(1600)$	1460 to 1560 200 to 350	1510 270
$\Delta(1920)$		



# $P_{33}(E_{1+})$ multipole

$P_{33}(E_{1+}(\frac{3}{2}))$		Re	$-2Im$	$ r_1 $ $\theta_1$	Re	$-2Im$	$ r_2 $ $\theta_2$
MAID	ED	$1211 \pm 1$	$99 \pm 1$	$0.184 \pm 0.005$ $-(155 \pm 2)^\circ$	$1550 \pm 11$	$347 \pm 41$	$0.0087 \pm 0.024$ $(127 \pm 9)^\circ$
	SE	$1215 \pm 4$	$87 \pm 1$	$0.154 \pm 0.011$ $-(155 \pm 8)^\circ$			
CM12	ED	$1211 \pm 1.5$	$101 \pm 1$	$0.183 \pm 0.006$ $-(154 \pm 2)^\circ$	$1470 \pm 31$	$396 \pm 51$	$0.127 \pm 0.099$ $(109^\circ \pm 20)$
GWU	SE	$1220 \pm 2$	$85 \pm 3$	$0.146 \pm 0.004$ $-(143 \pm 2)^\circ$			

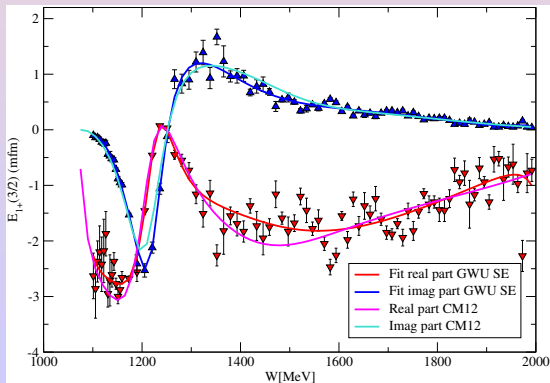


Threshold positions			$\chi^2$
754	$1077\pi N$	$1215\pi\pi N$	3.00
615	$1077\pi N$	$1370\text{Real}(\pi\Delta)$	3.02
-1267	$1077\pi N$	$1155\text{free}$	2.98

PDG	Re $-2Im$	PDG Estimate
$\Delta(1232)$	1209 to 1211 98 to 102	1210 100
$\Delta(1600)$	1460 to 1560 200 to 350	1510 200
$\Delta(1920)$		

# $P_{33}(E_{1+})$ multipole

$P_{33}(E_{1+}(\frac{3}{2}))$		Re	$-2Im$	$\begin{matrix}  r_1  \\ \theta_1 \end{matrix}$	Re	$-2Im$	$\begin{matrix}  r_2  \\ \theta_2 \end{matrix}$
MAID	ED	$1211 \pm 1$	$99 \pm 1$	$0.184 \pm 0.005$ $-(155 \pm 2)^\circ$	$1550 \pm 11$	$347 \pm 41$	$0.0087 \pm 0.024$ $(127 \pm 9)^\circ$
	SE	$1215 \pm 4$	$87 \pm 1$	$0.154 \pm 0.011$ $-(155 \pm 8)^\circ$			
CM12	ED	$1211 \pm 1.5$	$101 \pm 1$	$0.183 \pm 0.006$ $-(154 \pm 2)^\circ$	$1470 \pm 31$	$396 \pm 51$	$0.127 \pm 0.099$ $(109^\circ \pm 20)$
GWU	SE	$1220 \pm 2$	$85 \pm 3$	$0.146 \pm 0.004$ $-(143 \pm 2)^\circ$			



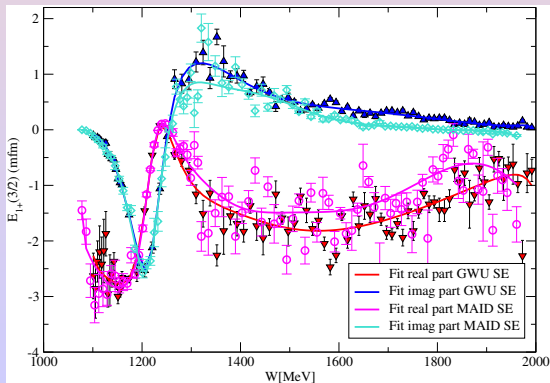
PDG	Re $-2Im$	PDG Estimate
$\Delta(1232)$	1209 to 1211 98 to 102	1210 100
$\Delta(1600)$	1460 to 1560 200 to 350	1510 275
$\Delta(1920)$		





# $P33(E_{1+})$ multipole

$P33(E_{1+}(\frac{3}{2}))$		Re	$-2Im$	$\begin{matrix}  r_1  \\ \theta_1 \end{matrix}$	Re	$-2Im$	$\begin{matrix}  r_2  \\ \theta_2 \end{matrix}$
MAID	ED	$1211 \pm 1$	$99 \pm 1$	$0.184 \pm 0.005$ $-(155 \pm 2)^\circ$	$1550 \pm 11$	$347 \pm 41$	$0.0087 \pm 0.024$ $(127 \pm 9)^\circ$
	SE	$1215 \pm 4$	$87 \pm 1$	$0.154 \pm 0.011$ $-(155 \pm 8)^\circ$			
CM12	ED	$1211 \pm 1.5$	$101 \pm 1$	$0.183 \pm 0.006$ $-(154 \pm 2)^\circ$	$1470 \pm 31$	$396 \pm 51$	$0.127 \pm 0.099$ $(109^\circ \pm 20)$
GWU	SE	$1220 \pm 2$	$85 \pm 3$	$0.146 \pm 0.004$ $-(143 \pm 2)^\circ$			

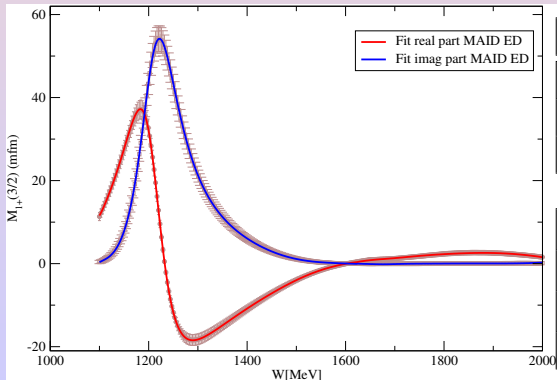


PDG	Re $-2Im$	PDG Estimate
$\Delta(1232)$	1209 to 1211 98 to 102	1210 100
$\Delta(1600)$	1460 to 1560 200 to 350	1510 275
$\Delta(1920)$		



# $P_{33}(M_{1+})$ multipole

$P_{33}(M_{1+}(\frac{3}{2}))$		Re	$-2Im$	$\frac{ r_1 }{\theta_1}$	Re	$-2Im$	$\frac{ r_2 }{\theta_2}$
MAID	ED	$1209 \pm 1$	$99 \pm 1$	$2.963 \pm 0.061$ $-(31 \pm 2)^\circ$	$1498 \pm 32$	$326 \pm 40$	$0.499 \pm 0.114$ $-(149 \pm 21)^\circ$
	SE						

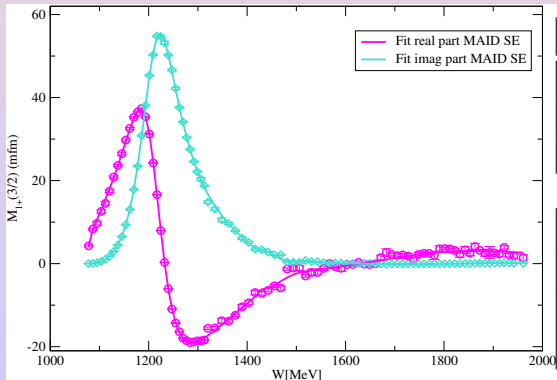


Threshold positions			D
-5238	$1077\pi N$	$1215\pi\pi N$	0.0129
-218	$1077\pi N$	$1370^{Real}(\pi\Delta)$	0.0150
900	$1077\pi N$	$1265^{free}$	0.0089

PDG	Re $-2Im$	PDG Estimate
$\Delta(1232)$	1209 to 1211 98 to 102	1210 100
$\Delta(1600)$	1460 to 1560 200 to 350	1510 200
$\Delta(1920)$		

# $P_{33}(M_{1+})$ multipole

$P_{33}(M_{1+}(\frac{3}{2}))$		Re	$-2Im$	$\frac{ r_1 }{\theta_1}$	Re	$-2Im$	$\frac{ r_2 }{\theta_2}$
MAID	ED	$1209 \pm 1$	$99 \pm 1$	$2.963 \pm 0.061$ $-(31 \pm 2)^\circ$	$1498 \pm 32$	$326 \pm 40$	$0.499 \pm 0.114$ $-(149 \pm 21)^\circ$
	SE	$1210 \pm 1$	$101 \pm 1$	$3.010 \pm 0.023$ $-(30 \pm 1)^\circ$			



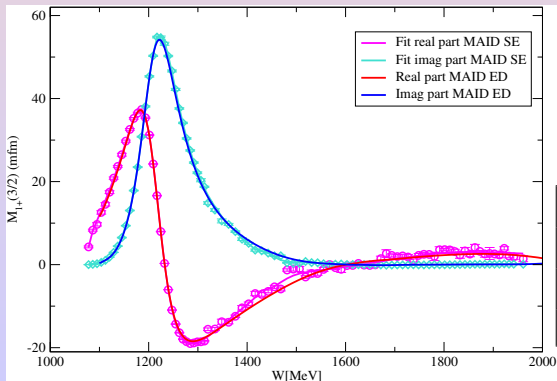
Threshold positions			$\chi^2$
-1670	$1077\pi N$	$1215\pi\pi N$	3.26
-7265	$1077\pi N$	$1370^{Real}(\pi\Delta)$	3.27
-387	$1077\pi N$	$1250^{free}$	3.24

PDG	Re $-2Im$	PDG Estimate
$\Delta(1232)$	1209 to 1211 98 to 102	1210 100
$\Delta(1600)$	1460 to 1560 200 to 350	1510 200
$\Delta(1920)$		



# $P_{33}(M_{1+})$ multipole

$P_{33}(M_{1+}(\frac{3}{2}))$		Re	$-2Im$	$\frac{ r_1 }{\theta_1}$	Re	$-2Im$	$\frac{ r_2 }{\theta_2}$
MAID	ED	$1209 \pm 1$	$99 \pm 1$	$2.963 \pm 0.061$ $-(31 \pm 2)^\circ$	$1498 \pm 32$	$326 \pm 40$	$0.499 \pm 0.114$ $-(149 \pm 21)^\circ$
	SE	$1210 \pm 1$	$101 \pm 1$	$3.010 \pm 0.023$ $-(30 \pm 1)^\circ$			

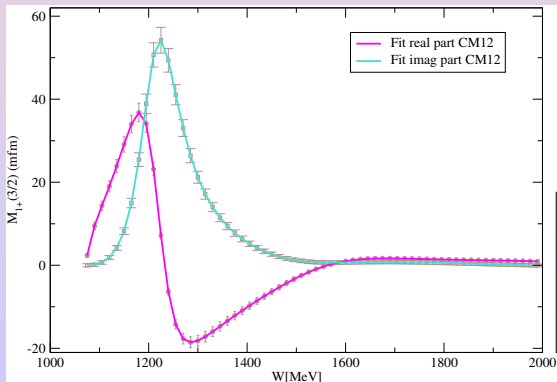


PDG	Re $-2Im$	PDG Estimate
$\Delta(1232)$	1209 to 1211 98 to 102	1210 100
$\Delta(1600)$	1460 to 1560 200 to 350	1510 275
$\Delta(1920)$		



# $P_{33}(M_{1+})$ multipole

$P_{33}(M_{1+}(\frac{3}{2}))$		Re	$-2Im$	$\frac{ r_1 }{\theta_1}$	Re	$-2Im$	$\frac{ r_2 }{\theta_2}$
MAID	ED	$1209 \pm 1$	$99 \pm 1$	$2.963 \pm 0.061$ $-(31 \pm 2)^\circ$	$1498 \pm 32$	$326 \pm 40$	$0.499 \pm 0.114$ $-(149 \pm 21)^\circ$
	SE	$1210 \pm 1$	$101 \pm 1$	$3.010 \pm 0.023$ $-(30 \pm 1)^\circ$			
CM12	ED	$1211 \pm 1$	$101 \pm 2$	$2.974 \pm 0.041$ $-(26 \pm 2)^\circ$	$1522 \pm 19$	$409 \pm 35$	$1.195 \pm 0.204$ $-(132 \pm 8)^\circ$



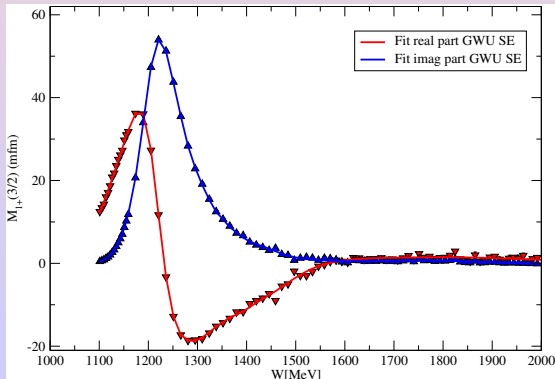
Threshold positions			$\chi^2$
900	$1077\pi N$	$1215\pi\pi N$	0.0008
788	$1077\pi N$	$1370^{Real}(\pi\Delta)$	0.0005
818	$1077\pi N$	$1238^{free}$	0.0002

PDG	Re $-2Im$	PDG Estimate
$\Delta(1232)$	1209 to 1211 98 to 102	1210 100
$\Delta(1600)$	1460 to 1560 200 to 350	1510 270
$\Delta(1920)$		



# $P_{33}(M_{1+})$ multipole

$P_{33}(M_{1+}(\frac{3}{2}^-))$		Re	$-2Im$	$ r_1 $ $\theta_1$	Re	$-2Im$	$ r_2 $ $\theta_2$
MAID	ED	$1209 \pm 1$	$99 \pm 1$	$2.963 \pm 0.061$ $-(31 \pm 2)^\circ$	$1498 \pm 32$	$326 \pm 40$	$0.499 \pm 0.114$ $-(149 \pm 21)^\circ$
	SE	$1210 \pm 1$	$101 \pm 1$	$3.010 \pm 0.023$ $-(30 \pm 1)^\circ$			
CM12	ED	$1211 \pm 1$	$101 \pm 2$	$2.974 \pm 0.041$ $-(26 \pm 2)^\circ$	$1522 \pm 19$	$409 \pm 35$	$1.195 \pm 0.204$ $-(132 \pm 8)^\circ$
GWU	SE	$1211 \pm 0.5$	$101 \pm 1$	$3.008 \pm 0.035$ $-(27 \pm 1)^\circ$	$1512 \pm 17$	$408 \pm 44$	$1.173 \pm 0.221$ $-(144 \pm 10)^\circ$

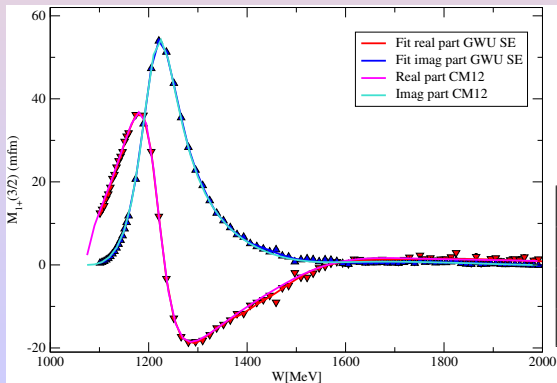


Threshold positions			$\chi^2$
-1116	$1077\pi N$	$1215\pi\pi N$	2.94
60	$1077\pi N$	$1370\text{Real}(\pi\Delta)$	2.86
639	$1077\pi N$	$1238^{\text{free}}$	2.84

PDG	Re $-2Im$	PDG Estimate
$\Delta(1232)$	1209 to 1211 98 to 102	1210 100
$\Delta(1600)$	1460 to 1560 200 to 350	1512 200
$\Delta(1920)$		

# $P_{33}(M_{1+})$ multipole

$P_{33}(M_{1+}(\frac{3}{2}^-))$		Re	$-2Im$	$ r_1 $ $\theta_1$	Re	$-2Im$	$ r_2 $ $\theta_2$
MAID	ED	$1209 \pm 1$	$99 \pm 1$	$2.963 \pm 0.061$ $-(31 \pm 2)^\circ$	$1498 \pm 32$	$326 \pm 40$	$0.499 \pm 0.114$ $-(149 \pm 21)^\circ$
	SE	$1210 \pm 1$	$101 \pm 1$	$3.010 \pm 0.023$ $-(30 \pm 1)^\circ$			
CM12	ED	$1211 \pm 1$	$101 \pm 2$	$2.974 \pm 0.041$ $-(26 \pm 2)^\circ$	$1522 \pm 19$	$409 \pm 35$	$1.195 \pm 0.204$ $-(132 \pm 8)^\circ$
GWU	SE	$1211 \pm 0.5$	$101 \pm 1$	$3.008 \pm 0.035$ $-(27 \pm 1)^\circ$	$1512 \pm 17$	$408 \pm 44$	$1.173 \pm 0.221$ $-(144 \pm 10)^\circ$

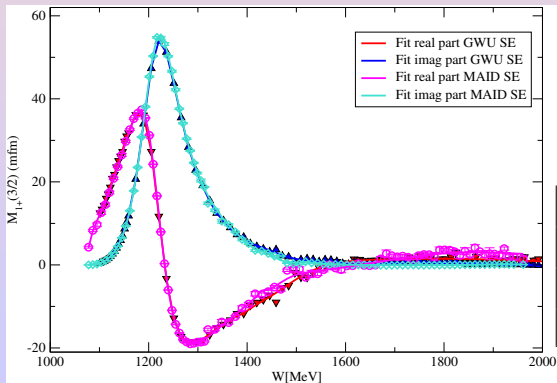


PDG	Re $-2Im$	PDG Estimate
$\Delta(1232)$	1209 to 1211 98 to 102	1210 100
$\Delta(1600)$	1460 to 1560 200 to 350	1510 275
$\Delta(1920)$		



# $P_{33}(M_{1+})$ multipole

$P_{33}(M_{1+}(\frac{3}{2}^-))$		Re	$-2Im$	$\begin{matrix}  r_1  \\ \theta_1 \end{matrix}$	Re	$-2Im$	$\begin{matrix}  r_2  \\ \theta_2 \end{matrix}$
MAID	ED	$1209 \pm 1$	$99 \pm 1$	$2.963 \pm 0.061$ $-(31 \pm 2)^\circ$	$1498 \pm 32$	$326 \pm 40$	$0.499 \pm 0.114$ $-(149 \pm 21)^\circ$
	SE	$1210 \pm 1$	$101 \pm 1$	$3.010 \pm 0.023$ $-(30 \pm 1)^\circ$			
CM12	ED	$1211 \pm 1$	$101 \pm 2$	$2.974 \pm 0.041$ $-(26 \pm 2)^\circ$	$1522 \pm 19$	$409 \pm 35$	$1.195 \pm 0.204$ $-(132 \pm 8)^\circ$
GWU	SE	$1211 \pm 0.5$	$101 \pm 1$	$3.008 \pm 0.035$ $-(27 \pm 1)^\circ$	$1512 \pm 17$	$408 \pm 44$	$1.173 \pm 0.221$ $-(144 \pm 10)^\circ$



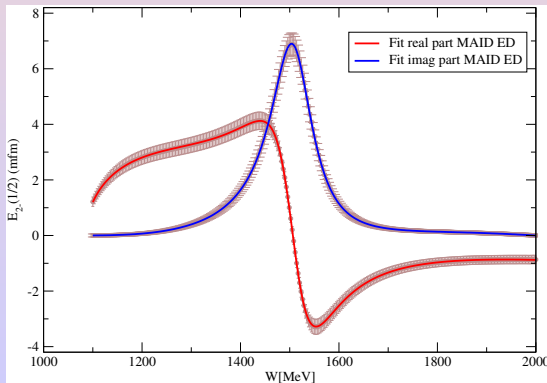
PDG	Re $-2Im$	PDG Estimate
$\Delta(1232)$	1209 to 1211 98 to 102	1210 100
$\Delta(1600)$	1460 to 1560 200 to 350	1510 275
$\Delta(1920)$		





# D13 ( $E_{2-}$ ) multipole

$D13(E_{2-}(\frac{1}{2}))$		Re	$-2Im$	$\frac{ r_1 }{\theta_1}$	Re	$-2Im$	$\frac{ r_2 }{\theta_2}$
MAID	ED	$1509 \pm 1$	$106 \pm 2$	$0.375 \pm 0.004$ $(11 \pm 2)^\circ$			
	SE						

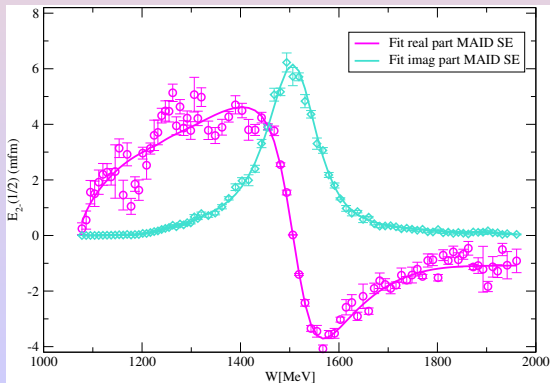


Threshold positions			D
485	$1077\pi N$	$1215\pi\pi N$	0.0035
528	$1077\pi N$	$1370\text{Real}(\pi\Delta)$	0.0033
48	$1077\pi N$	$1700\text{Real}(\rho N)$	0.0017
898	$1077\pi N$	$1717\text{free}$	0.0006
PDG	Re $-2Im$	PDG Estimate	
N(1520)	1505 to 1515 105 to 120	1510 110	
N(1700)	1650 to 1750 100 to 300	1700 -	
N(1875)			



# D13 ( $E_{2-}$ ) multipole

$D13(E_{2-}(\frac{1}{2}))$		Re	$-2Im$	$\frac{ r_1 }{\theta_1}$	Re	$-2Im$	$\frac{ r_2 }{\theta_2}$
MAID	ED	$1509 \pm 1$	$106 \pm 2$	$0.375 \pm 0.004$ $(11 \pm 2)^\circ$			
	SE	$1514 \pm 5$	$120 \pm 7$	$0.385 \pm 0.029$ $(12 \pm 3)^\circ$			



Threshold positions			$\chi^2$
-6892	$1077\pi N$	$1215\pi\pi N$	2.77
-96	$1077\pi N$	$1370^{Real}(\pi\Delta)$	2.79
-232	$1077\pi N$	$1700^{Real}(\rho N)$	3.02
900	$1077\pi N$	$1193^{free}$	2.61

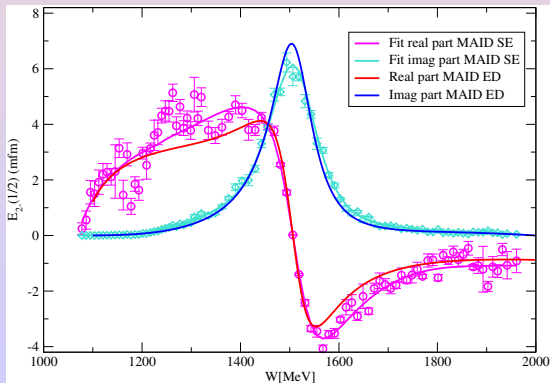
  

PDG	Re $-2Im$	PDG Estimate
$N(1520)$	1505 to 1515 105 to 120	1510 110
$N(1700)$	1650 to 1750 100 to 300	1700
$N(1875)$		



# D13 ( $E_{2-}$ ) multipole

$D13(E_{2-}(\frac{1}{2}))$		Re	$-2Im$	$ r_1 $ $\theta_1$	Re	$-2Im$	$ r_2 $ $\theta_2$
MAID	ED	$1509 \pm 1$	$106 \pm 2$	$0.375 \pm 0.004$ $(11 \pm 2)^\circ$			
	SE	$1514 \pm 5$	$120 \pm 7$	$0.385 \pm 0.029$ $(12 \pm 3)^\circ$			

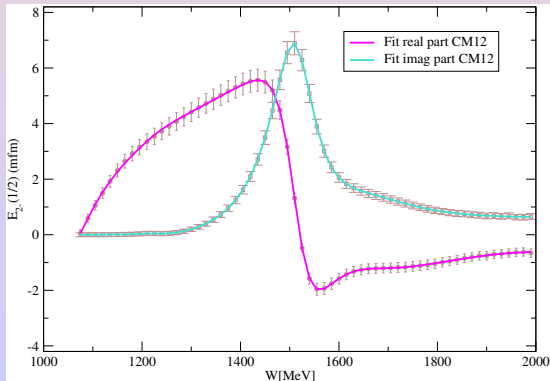


PDG	Re $-2Im$	PDG Estimate
N(1520)	1505 to 1515 105 to 120	1510 110
N(1700)	1650 to 1750 100 to 300	1700 -
N(1875)		



# D13 ( $E_{2-}$ ) multipole

$D13(E_{2-}(\frac{1}{2}))$		Re	$-2Im$	$\frac{ r_1 }{\theta_1}$	Re	$-2Im$	$\frac{ r_2 }{\theta_2}$
MAID	ED	$1509 \pm 1$	$106 \pm 2$	$0.375 \pm 0.004$ ( $11 \pm 2$ ) $^\circ$			
	SE	$1514 \pm 5$	$120 \pm 7$	$0.385 \pm 0.029$ ( $12 \pm 3$ ) $^\circ$			
CM12	ED	$1514 \pm 1$	$109 \pm 5$	$0.373 \pm 0.027$ ( $16 \pm 3$ ) $^\circ$	$1638 \pm 26$	$362 \pm 41$	$0.382 \pm 0.091$ ( $4 \pm 16$ ) $^\circ$



Threshold positions			D
900	$1077\pi N$	$1215\pi\pi N$	0.0028
832	$1077\pi N$	$1370^{Real}(\pi\Delta)$	0.0034
900	$1077\pi N$	$1700^{Real}(\rho N)$	0.0036
900	$1077\pi N$	$1232^{free}$	0.0028

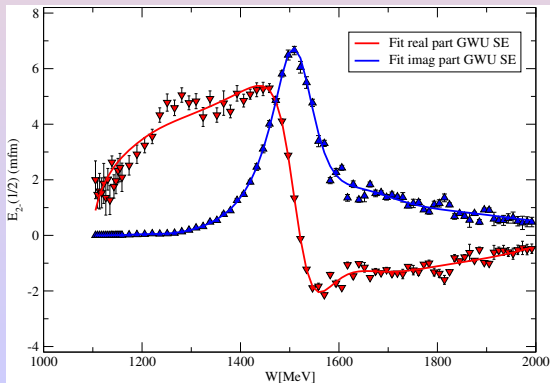
  

PDG	Re $-2Im$	PDG Estimate
N(1520)	1505 to 1515 105 to 120	1510 110
N(1700)	1650 to 1750 100 to 300	1700
N(1875)		



# D13 ( $E_{2-}$ ) multipole

$D13(E_{2-}(\frac{1}{2}))$		Re	$-2Im$	$ r_1 $ $\theta_1$	Re	$-2Im$	$ r_2 $ $\theta_2$
MAID	ED	$1509 \pm 1$	$106 \pm 2$	$0.375 \pm 0.004$ $(11 \pm 2)^\circ$			
	SE	$1514 \pm 5$	$120 \pm 7$	$0.385 \pm 0.029$ $(12 \pm 3)^\circ$			
CM12	ED	$1514 \pm 1$	$109 \pm 5$	$0.373 \pm 0.027$ $(16 \pm 3)^\circ$	$1638 \pm 26$	$362 \pm 41$	$0.382 \pm 0.091$ $(4 \pm 16)^\circ$
GWU	SE	$1514 \pm 2$	$111 \pm 1.5$	$0.382 \pm 0.007$ $(14 \pm 4)^\circ$	$1654 \pm 20$	$257 \pm 57$	$0.187 \pm 0.087$ $-(1 \pm 10)^\circ$



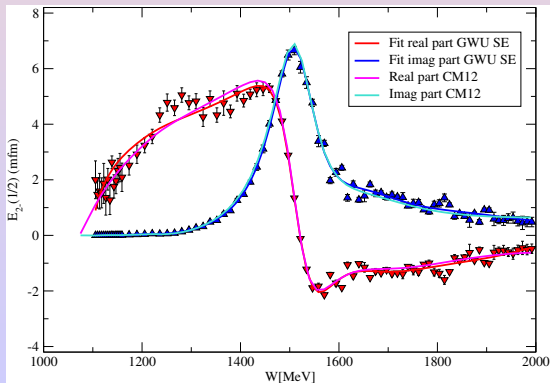
Threshold positions			$\chi^2$
775	$1077\pi N$	$1215\pi\pi N$	2.68
716	$1077\pi N$	$1370\text{Real}(\pi\Delta)$	2.66
831	$1077\pi N$	$1700\text{Real}(\rho N)$	2.57
179	$1077\pi N$	$1717\text{free}$	2.33

PDG	Re $-2Im$	PDG Estimate
N(1520)	1505 to 1515 105 to 120	1510 110
N(1700)	1650 to 1750 100 to 300	1700
N(1875)		



# D13 ( $E_{2-}$ ) multipole

$D13(E_{2-}(\frac{1}{2}))$		Re	$-2Im$	$\frac{ r_1 }{\theta_1}$	Re	$-2Im$	$\frac{ r_2 }{\theta_2}$
MAID	ED	$1509 \pm 1$	$106 \pm 2$	$0.375 \pm 0.004$ ( $11 \pm 2$ )°			
	SE	$1514 \pm 5$	$120 \pm 7$	$0.385 \pm 0.029$ ( $12 \pm 3$ )°			
CM12	ED	$1514 \pm 1$	$109 \pm 5$	$0.373 \pm 0.027$ ( $16 \pm 3$ )°	$1638 \pm 26$	$362 \pm 41$	$0.382 \pm 0.091$ ( $4 \pm 16$ )°
GWU	SE	$1514 \pm 2$	$111 \pm 1.5$	$0.382 \pm 0.007$ ( $14 \pm 4$ )°	$1654 \pm 20$	$257 \pm 57$	$0.187 \pm 0.087$ $-(1 \pm 10)$ °

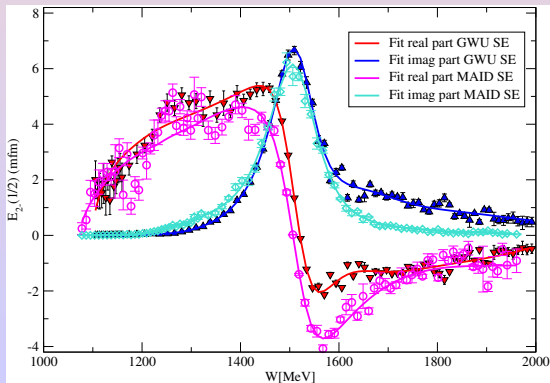


PDG	Re $-2Im$	PDG Estimate
N(1520)	1505 to 1515 105 to 120	1510 110
N(1700)	1650 to 1750 100 to 300	1700
N(1875)		



# D13 ( $E_{2-}$ ) multipole

$D13(E_{2-}(\frac{1}{2}))$		Re	$-2Im$	$ r_1 $ $\theta_1$	Re	$-2Im$	$ r_2 $ $\theta_2$
MAID	ED	$1509 \pm 1$	$106 \pm 2$	$0.375 \pm 0.004$ $(11 \pm 2)^\circ$			
	SE	$1514 \pm 5$	$120 \pm 7$	$0.385 \pm 0.029$ $(12 \pm 3)^\circ$			
CM12	ED	$1514 \pm 1$	$109 \pm 5$	$0.373 \pm 0.027$ $(16 \pm 3)^\circ$	$1638 \pm 26$	$362 \pm 41$	$0.382 \pm 0.091$ $(4 \pm 16)^\circ$
GWU	SE	$1514 \pm 2$	$111 \pm 1.5$	$0.382 \pm 0.007$ $(14 \pm 4)^\circ$	$1654 \pm 20$	$257 \pm 57$	$0.187 \pm 0.087$ $-(1 \pm 10)^\circ$



PDG	Re $-2Im$	PDG Estimate
N(1520)	1505 to 1515 105 to 120	1510 110
N(1700)	1650 to 1750 100 to 300	1700
N(1875)		



# $D_{33}(E_{2-})$ multipole

$D_{33}(E_{2-}(\frac{3}{2}))$		$Re$	$-2Im$	$\begin{matrix}  r_1  \\ \theta_1 \end{matrix}$
MAID	ED	$1649 \pm 2$	$223 \pm 4$	$0.874 \pm 0.015$ $-(175 \pm 3)^\circ$
	SE	$1671 \pm 10$	$376 \pm 7$	$1.792 \pm 0.170$ $-(160 \pm 9)^\circ$
CM12	ED	$1650 \pm 4$	$255 \pm 11$	$0.672 \pm 0.048$ $-(177 \pm 3)^\circ$
GWU	SE	$1662 \pm 4$	$324 \pm 8$	$1.075 \pm 0.054$ $-(161 \pm 4)^\circ$





# F15 ( $E_{3-}$ ) multipole

$F_{15}(E_{3-}(\frac{1}{2}))$		Re	-2Im	$\frac{ r_1 }{\theta_1}$	Re	-2Im	$\frac{ r_2 }{\theta_2}$
MAID	ED	$1663 \pm 1$	$118 \pm 3$	$0.150 \pm 0.004$ $-(3 \pm 2)^\circ$	$1801 \pm 18$	$141 \pm 41$	$0.007 \pm 0.005$ $(32 \pm 23)^\circ$
	SE	$1669 \pm 2$	$113 \pm 2$	$0.145 \pm 0.007$ $(2 \pm 2)^\circ$			
CM12	ED	$1674 \pm 2.5$	$113 \pm 4$	$0.157 \pm 0.008$ $-(5 \pm 3)^\circ$			
GWU	SE	$1677 \pm 2$	$115 \pm 4$	$0.174 \pm 0.010$ $(1 \pm 3)^\circ$	$1923 \pm 72$	$172 \pm 52$	$0.081 \pm 0.051$ $-(62 \pm 90)^\circ$

$F_{37}(M_{3+}(\frac{3}{2}))$		Re	-2Im	$\frac{ r_1 }{\theta_1}$
MAID	ED	$1898 \pm 2$	$271 \pm 4$	$0.339 \pm 0.012$ $-(11 \pm 2)^\circ$
	SE	$1880 \pm 8$	$240 \pm 10$	$0.283 \pm 0.036$ $-(24 \pm 7)^\circ$
CM12	ED	$1884 \pm 4$	$231 \pm 9$	$0.278 \pm 0.019$ $-(16 \pm 3)^\circ$
GWU	SE	$1882 \pm 2$	$236 \pm 4$	$0.283 \pm 0.007$ $-(17 \pm 2)^\circ$



- The method is well suited for extraction of baryon resonance parameters from photoproduction data.
- The method is very robust. Variation of inelastic threshold position do not produce significant change of resonance parameters.
- The method gives reliable results for both input data sets (SE, ED solutions).

