

Petersburg
Nuclear
Physics
Institute

Partial wave analysis in the Bonn-Gatchina framework

Bonn/Gatchina PWA group:

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Problems in the baryon spectroscopy and/or quark model:

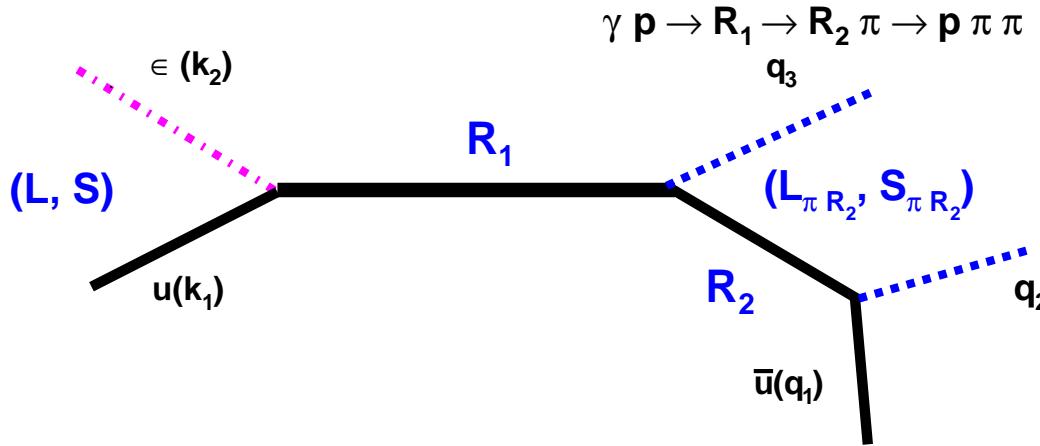
1. **Problem:** The number of predicted three quark states exceeds dramatically the number of discovered baryons.
2. **Possible solution:** Most of the information comes from the analysis of meson induced reactions and meson-baryon final states. Photoproduction data taken by CLAS, GRAAL, LEPS and CB-ELSA can provide an important information about missing states.
 - (a) **problem:** The unambiguous analysis of photoproduction reactions can not be done without polarization information available.
 - (b) **problem:** Signals in simple reactions are expected to be mostly weak. Strong signals from new resonances can be found in multi-meson final states.
 - (c) **Possible solution 1:** The single polarization observables are measured now by almost all collaborations. In the nearest future single and double polarization data will be available from CLAS and CB-ELSA.
 - (d) **Possible solution 2:** A combined analysis of the large data sets.

For combined analysis of all available data a new approach is needed:

1. Fully relativistically invariant.
2. Convenient for combined analysis of single and multi-meson photoproduction.
3. Energy dependent, which allow us to apply directly the unitarity and analyticity conditions.
4. Convenient for calculation of the triangle and box diagrams or projection of the t and u-channel exchange amplitudes to the partial waves in s-channel.

more information on <http://pwa.hiskp.uni-bonn.de/>

Example: resonance amplitudes for meson photoproduction



The general form of the angular dependent part of the amplitude:

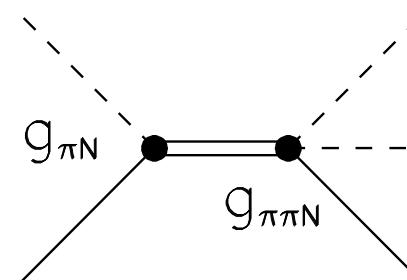
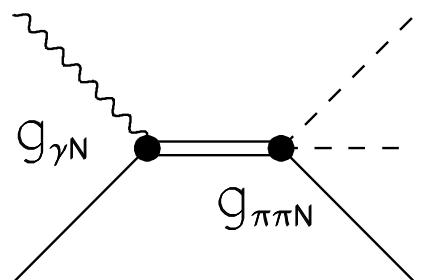
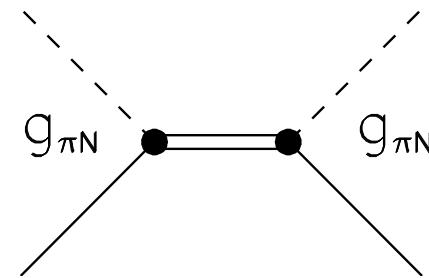
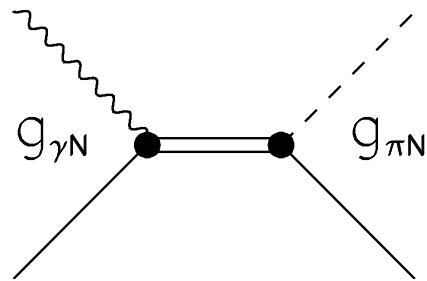
$$\bar{u}(q_1) \tilde{N}_{\alpha_1 \dots \alpha_n}(R_2 \rightarrow \mu N) F_{\beta_1 \dots \beta_n}^{\alpha_1 \dots \alpha_n}(q_1 + q_2) \tilde{N}_{\gamma_1 \dots \gamma_m}^{(j)\beta_1 \dots \beta_n}(R_1 \rightarrow \mu R_2)$$

$$F_{\xi_1 \dots \xi_m}^{\gamma_1 \dots \gamma_m}(P) V_{\xi_1 \dots \xi_m}^{(i)\mu}(R_1 \rightarrow \gamma N) u(k_1) \varepsilon_\mu$$

$$F_{\nu_1 \dots \nu_L}^{\mu_1 \dots \mu_L}(p) = (m + \hat{p}) O_{\alpha_1 \dots \alpha_L}^{\mu_1 \dots \mu_L} \frac{L+1}{2L+1} \left(g_{\alpha_1 \beta_1}^\perp - \frac{L}{L+1} \sigma_{\alpha_1 \beta_1} \right) \prod_{i=2}^L g_{\alpha_i \beta_i} O_{\nu_1 \dots \nu_L}^{\beta_1 \dots \beta_L}$$

$$\sigma_{\alpha_i \alpha_j} = \frac{1}{2} (\gamma_{\alpha_i} \gamma_{\alpha_j} - \gamma_{\alpha_j} \gamma_{\alpha_i})$$

Combined analysis of the different reactions:



$$BW = \frac{g_i g_j}{M^2 - s - i \sum_k g_k^2 \rho_k}, \quad g_k = g_{\pi N}, g_{\gamma N}, g_{\pi\pi N}, \dots$$

$$M\Gamma = \sum_k g_k^2 \rho_k$$

K-matrix approach

The fit with Breit-Wigner resonances is most strait-forward approach to identify pole singularities in the amplitude.

However in fitting pion induced reactions the unitarity condition plays a significant role.

Simplest solution: the K-matrix approach.

$$S = \frac{I + i\hat{\rho}\hat{K}}{I - i\hat{\rho}\hat{K}} = I + 2i\hat{\rho}A(s), \quad A(s) = \hat{K}(I - i\hat{\rho}\hat{K})^{-1}$$

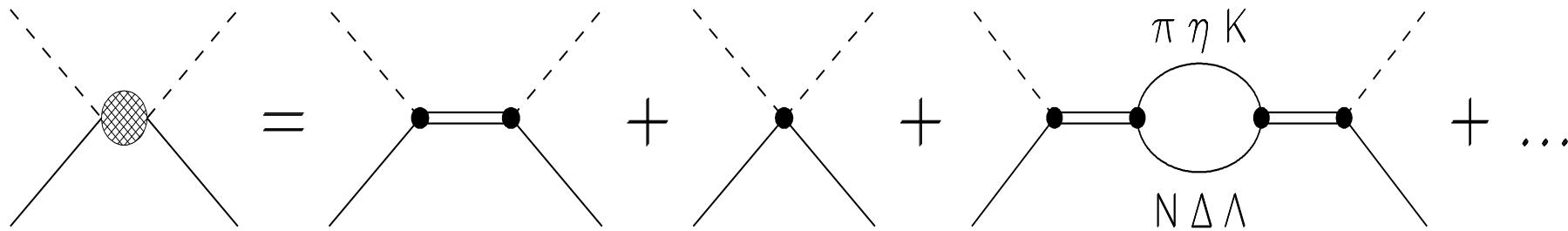
To fulfill analyticity condition the elements of K -matrix must have a form:

$$K_{ij} = \sum_{\alpha} \frac{g_i^{\alpha} g_j^{\alpha}}{M_{\alpha}^2 - s} + f_{ij}$$

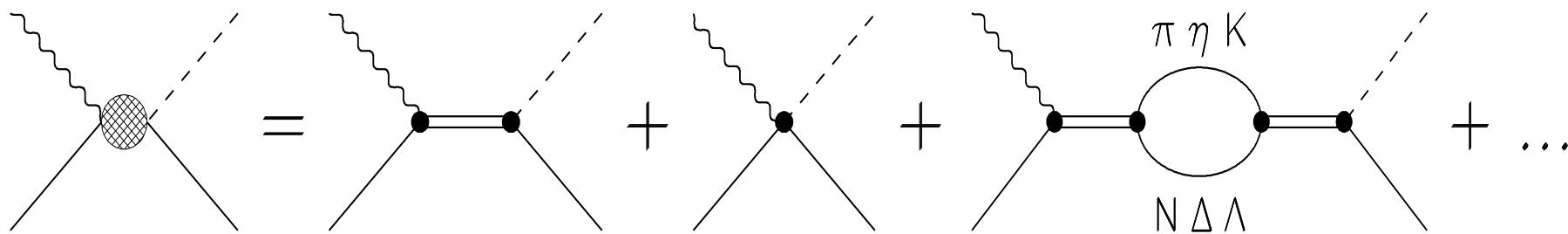
The photoproduction amplitude is different from the πN scattering amplitude by the first interaction:

$$A_k = \textcolor{red}{P}_j (I - i\rho K)^{-1}_{jk} \quad P_j = \sum_{\alpha} \frac{\textcolor{red}{g}_{\gamma N}^{\alpha} g_j^{\alpha}}{M_{\alpha}^2 - s} + \textcolor{blue}{F}_j$$

The amplitude elastic scattering can be described as a sum of the diagrams:



And for photoproduction:



However to have a full correspondence the dispersion corrections are needed. Right now we included a dispersion correction as subtracted integral for continuation of the K-matrix elements below threshold. Full dispersion correction: is one of the first priority objectives.

The fitted reactions with two particle final states.

Observable	N_{data}	w_i	$\frac{\chi^2}{N_{\text{data}}}$		Observable	N_{data}	w_i	$\frac{\chi^2}{N_{\text{data}}}$	
$\sigma(\gamma p \rightarrow p\pi^0)$	1106	7	0.99	CB-ELSA	$\sigma(\gamma p \rightarrow p\pi^0)$	861	3	3.22	GRAAL
$\Sigma(\gamma p \rightarrow p\pi^0)$	469	2.3	3.75	GRAAL	$\Sigma(\gamma p \rightarrow p\pi^0)$	593	2.3	2.13	SAID
$P(\gamma p \rightarrow p\pi^0)$	594	3	2.58	SAID	$T(\gamma p \rightarrow p\pi^0)$	380	3	3.85	SAID
$\sigma(\gamma p \rightarrow n\pi^+)$	1583	2.8	1.07	SAID					
$\sigma(\gamma p \rightarrow p\eta)$	667	30	0.84	CB-ELSA	$\sigma(\gamma p \rightarrow p\eta)$	100	7	1.69	TAPS
$\Sigma(\gamma p \rightarrow p\eta)$	51	10	1.82	GRAAL 98	$\Sigma(\gamma p \rightarrow p\eta)$	100	10	2.11	GRAAL 04
$C_x(\gamma p \rightarrow \Lambda K^+)$	160	5	1.71	CLAS	$C_z(\gamma p \rightarrow \Lambda K^+)$	160	7	1.95	CLAS
$\sigma(\gamma p \rightarrow \Lambda K^+)$	1377	5	2.02	CLAS	$\sigma(\gamma p \rightarrow \Lambda K^+)$	720	1	1.53	SAPHIR
$P(\gamma p \rightarrow \Lambda K^+)$	202	6.5	1.65	CLAS	$P(\gamma p \rightarrow \Lambda K^+)$	66	3	2.89	GRAAL
$\Sigma(\gamma p \rightarrow \Lambda K^+)$	66	5	2.19	GRAAL	$\Sigma(\gamma p \rightarrow \Lambda K^+)$	45	10	1.98	LEP
$C_x(\gamma p \rightarrow \Sigma^0 K^+)$	94	5	2.70	CLAS	$C_z(\gamma p \rightarrow \Sigma^0 K^+)$	94	5	2.77	CLAS
$\sigma(\gamma p \rightarrow \Sigma^0 K^+)$	1280	3	2.10	CLAS	$\sigma(\gamma p \rightarrow \Sigma^0 K^+)$	660	1	1.33	SAPHIR
$P(\gamma p \rightarrow \Sigma^0 K^+)$	95	6	1.58	CLAS	$\Sigma(\gamma p \rightarrow \Sigma^0 K^+)$	42	5	1.04	GRAAL
$\Sigma(\gamma p \rightarrow \Sigma^0 K^+)$	45	10	0.62	LEP	$\sigma(\gamma p \rightarrow \Sigma^+ K^0)$	48	2.3	3.51	CLAS
$\sigma(\gamma p \rightarrow \Sigma^+ K^0)$	120	5	0.98	SAPHIR	$\sigma(\gamma p \rightarrow \Sigma^+ K^0)$	72	5	1.17	CB-ELSA

Three particle final states reactions fitted with maximum likelihood method.

Observable	
$\sigma(\gamma p \rightarrow p\pi^0\pi^0)$	CB-ELSA (1.4 GeV)
$\sigma(\gamma p \rightarrow p\pi^0\pi^0)$	TAPS
$\sigma(\gamma p \rightarrow p\pi^0\eta)$	CB-ELSA (3.2 GeV)
$E(\gamma p \rightarrow p\pi^0\pi^0)$	MAMI
$\Sigma(\gamma p \rightarrow p\pi^0\pi^0)$	GRAAL
$\sigma(\pi^- p \rightarrow n\pi^0\pi^0)$	CRYSTAL BALL

23 baryon resonances used in the fit:

$N(1440)P_{11}$	$N(1520)D_{13}$	$N(1535)S_{11}$	$N(1650)S_{11}$
$N(1675)D_{15}$	$N(1680)F_{15}$	$N(1700)D_{13}$	$N(1710)P_{11}$
$N(1720)P_{13}$	$N(1860)P_{11}$	$N(1875)D_{13}$	$N(1900)P_{13}$
$N(2000)F_{15}$	$N(2070)D_{15}$	$N(2170)D_{13}$	
$\Delta(1232)P_{33}$	$\Delta(1600)P_{33}$	$\Delta(1620)S_{31}$	$\Delta(1700)D_{33}$
$\Delta(1905)F_{35}$	$\Delta(1920)P_{33}$	$\Delta(1940)D_{33}$	$\Delta(1950)F_{37}$

Rejected t - and u -channel exchange amplitudes

K-matrix:

S_{11} -wave: 2-pole 5-channel: $(\pi N, \eta N, K\Lambda, K\Sigma, \Delta(1232)\pi)$;

P_{11} -wave: 3-pole 4-channel: $(\pi N, \Delta(1232)\pi, K\Sigma \text{ and } N\sigma)$;

D_{33} -wave: 3-pole 5-channel: $K(\pi N, \Delta(1232)\pi \text{ (*S,D-waves*)}, \Delta(1232)\eta,$

$S_{11}(1535)\pi$;

P_{13} -wave: 3-pole 8-channel: $(\pi N, \eta N, \Delta(1232)\pi \text{ (*P- and F-waves*)}, N\sigma,$

$D_{13}(1520)\pi, K\Lambda \text{ and } K\Sigma)$.

$\gamma p \rightarrow \pi^0 p$ from Crystal Barrel at ELSA ($E_\gamma \leq 3.2$ GeV)

$\Delta(1232)P_{33}$

$N(1520)D_{13}$

S_{11}

$N(1680)F_{15}$

$\Delta(1700)D_{33}$

Non-resonance contributi-

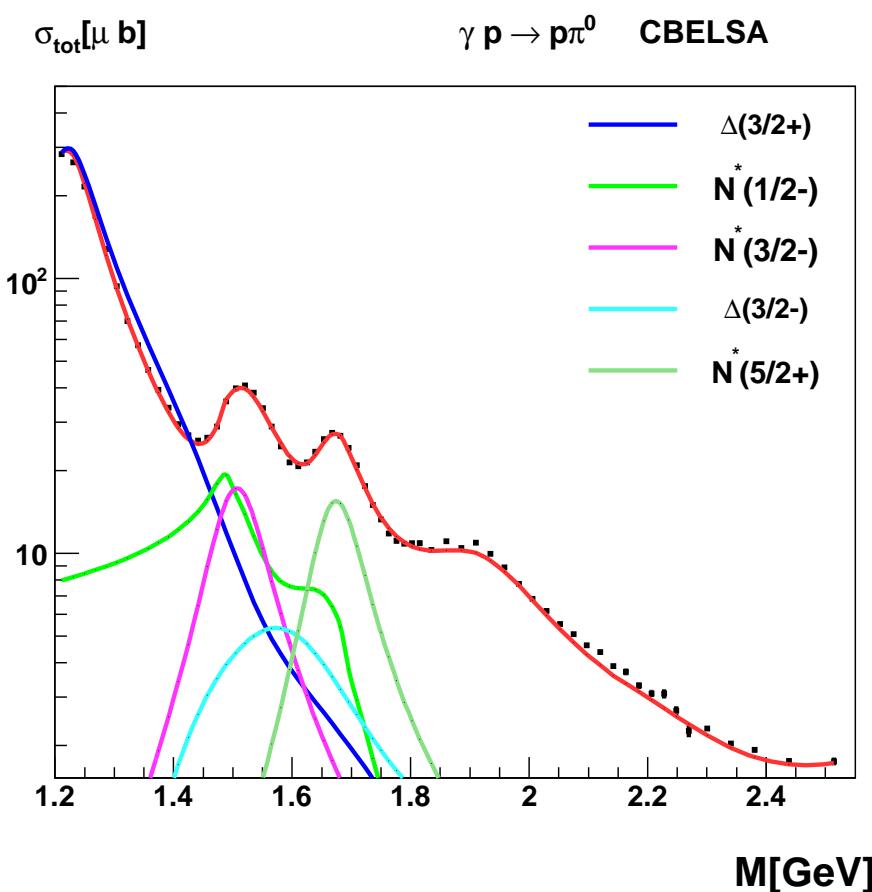
on:

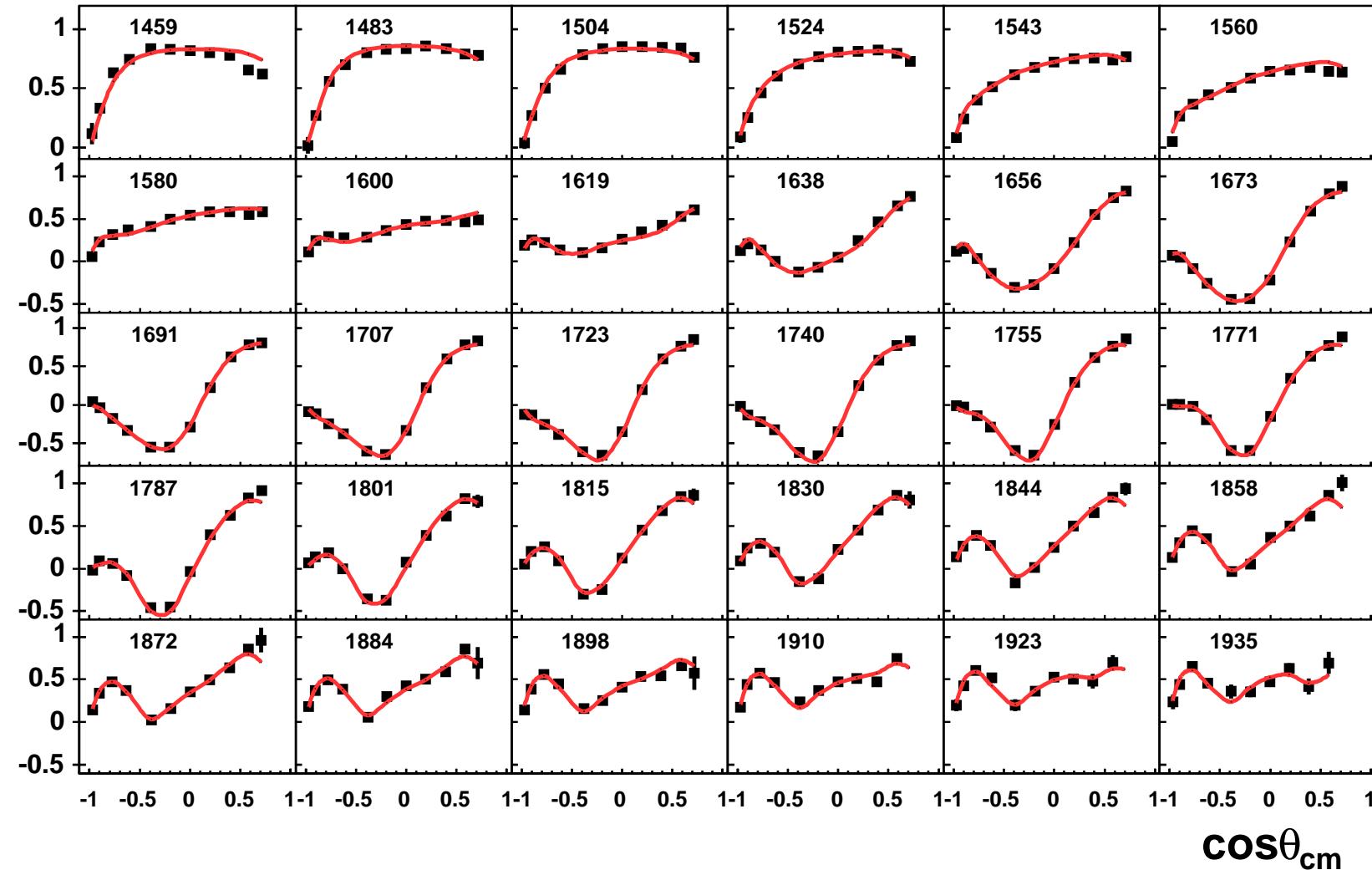
t-channel $\rho - \omega$ exchange,

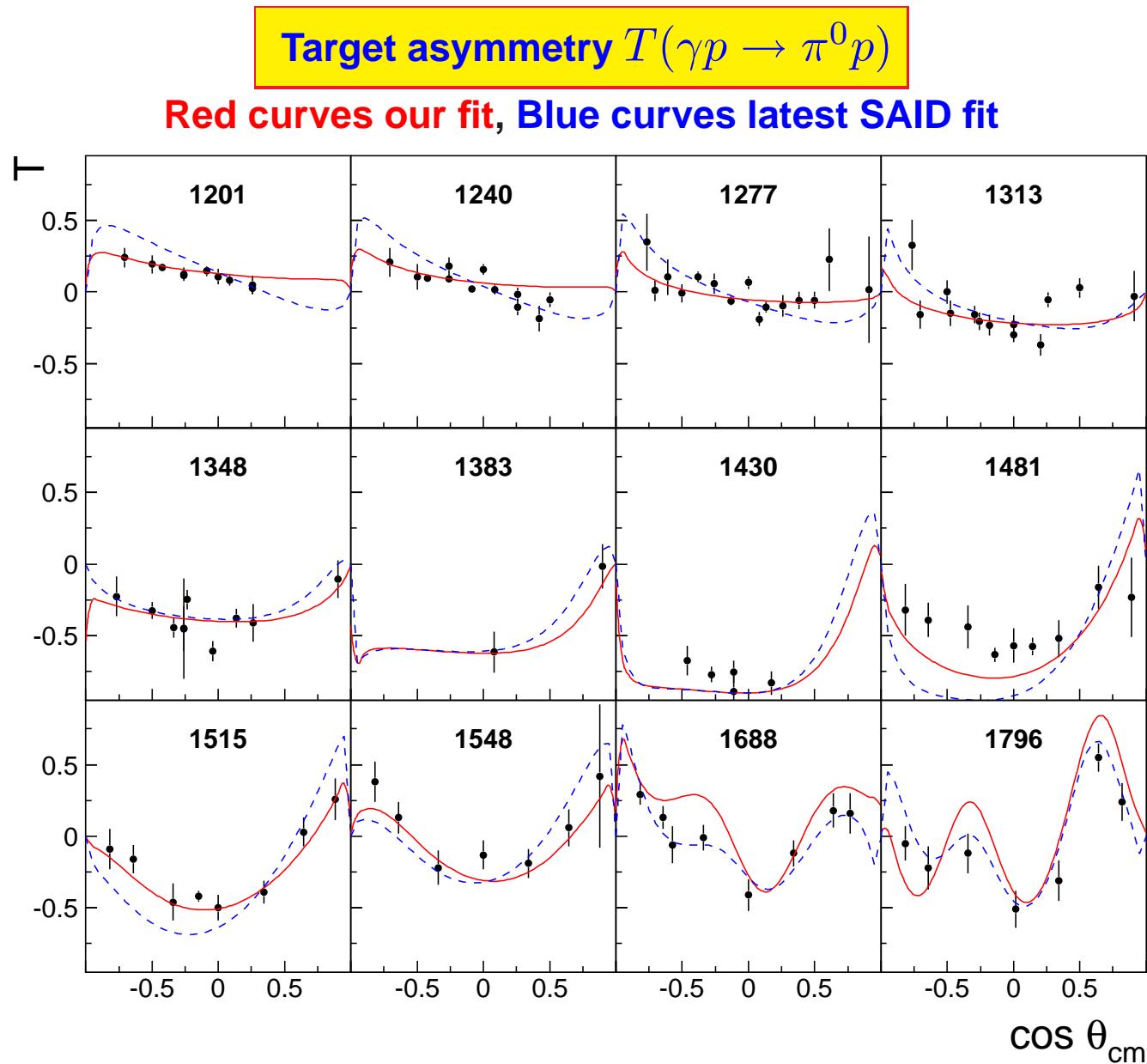
u-exchange and non-

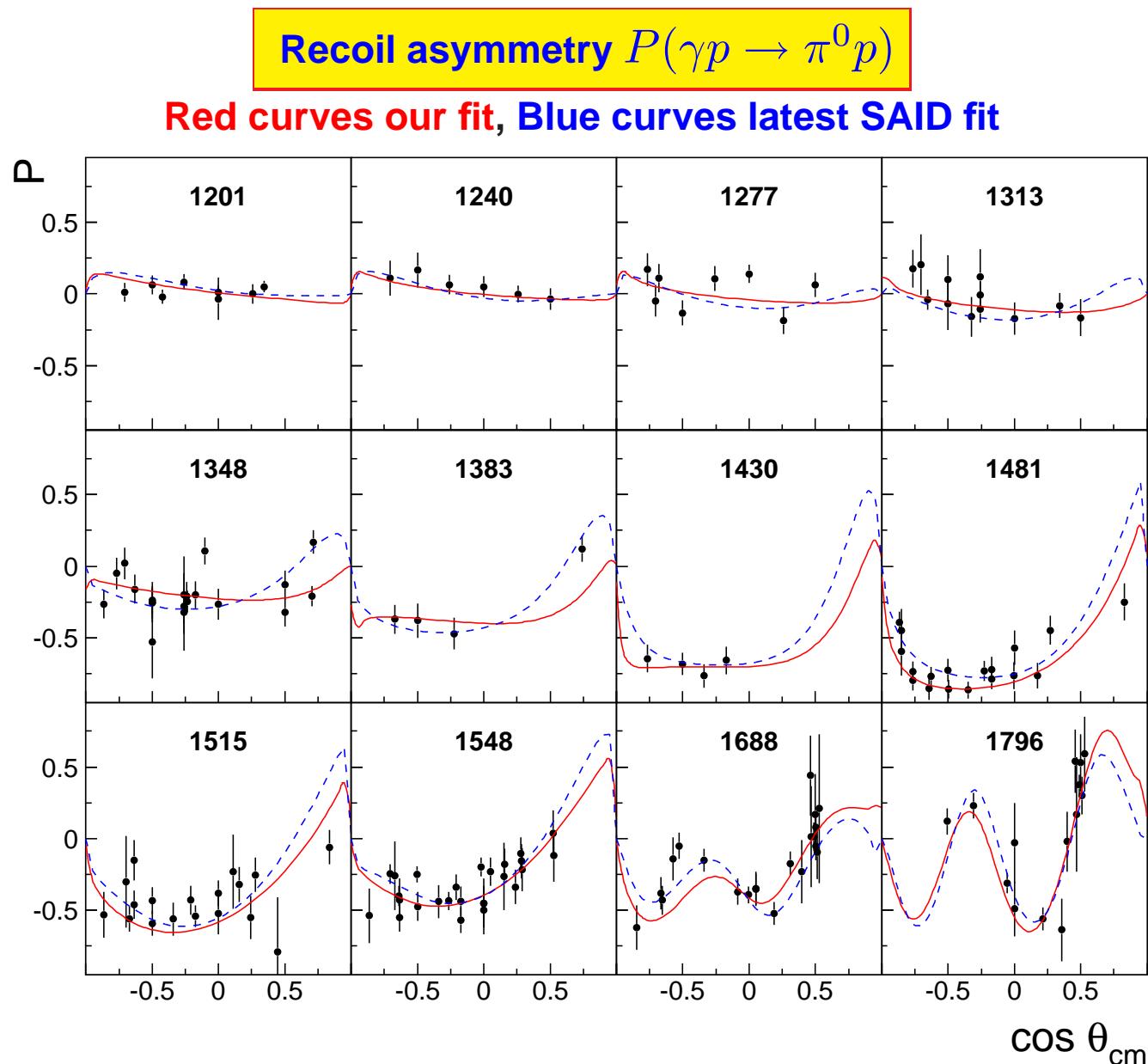
resonance production in

$J^P = 3/2^+$ wave



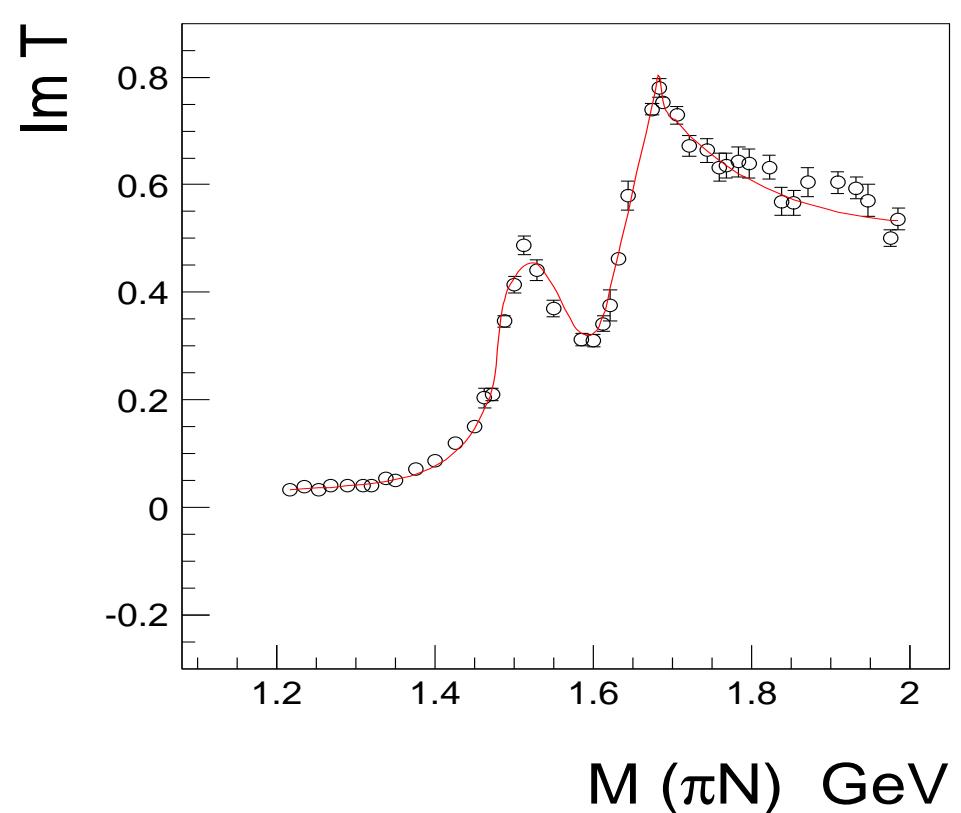
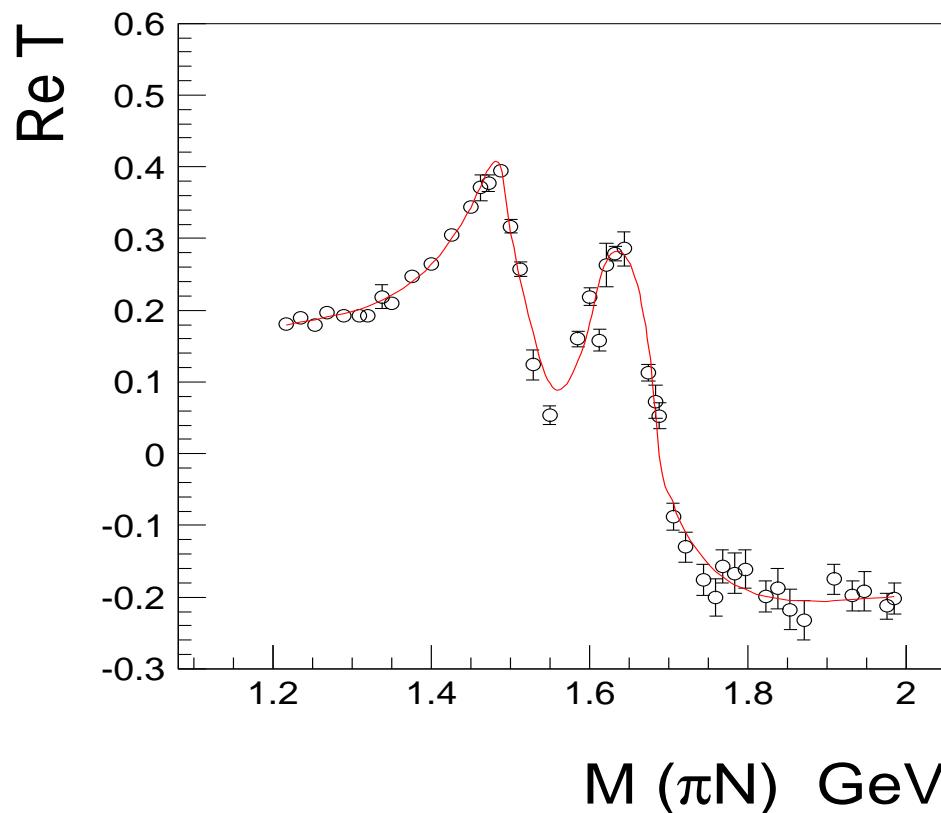
Beam asymmetry $\Sigma(\gamma p \rightarrow \pi^0 p)$ from GRAAL 04





$N\pi \rightarrow N\pi$, S_{11} wave (2 pole 4 or 5 channel K-matrix)

S_{11}

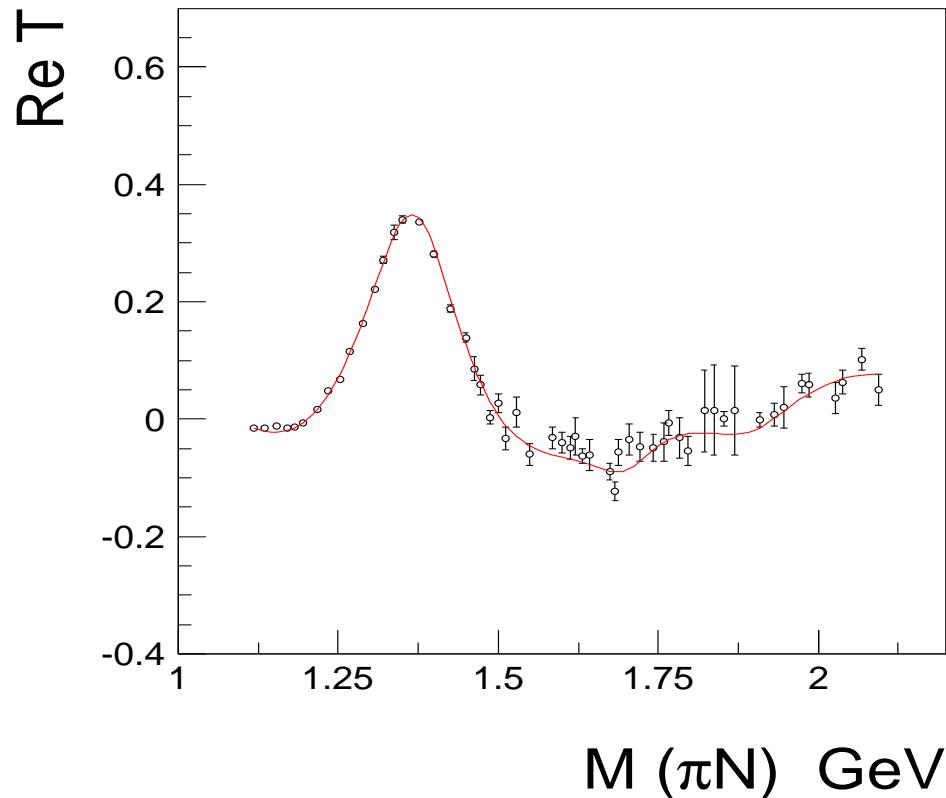


T-matrix poles: $M = 1508^{+10}_{-30} \text{ MeV}$, $2 \text{ Im} = 165 \pm 15 \text{ MeV}$;

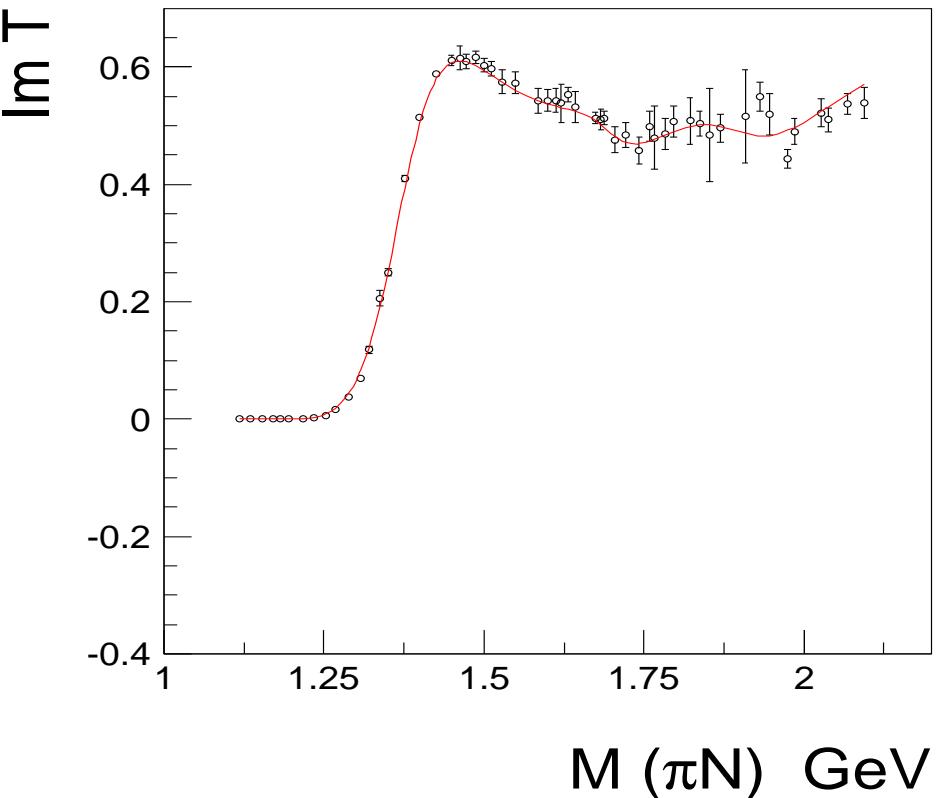
$M = 1645 \pm 15 \text{ MeV}$, $2 \text{ Im} = 187 \pm 20 \text{ MeV}$

$N\pi \rightarrow N\pi P_{11}$ wave (3 pole 4 channel K-matrix)

P_{11}

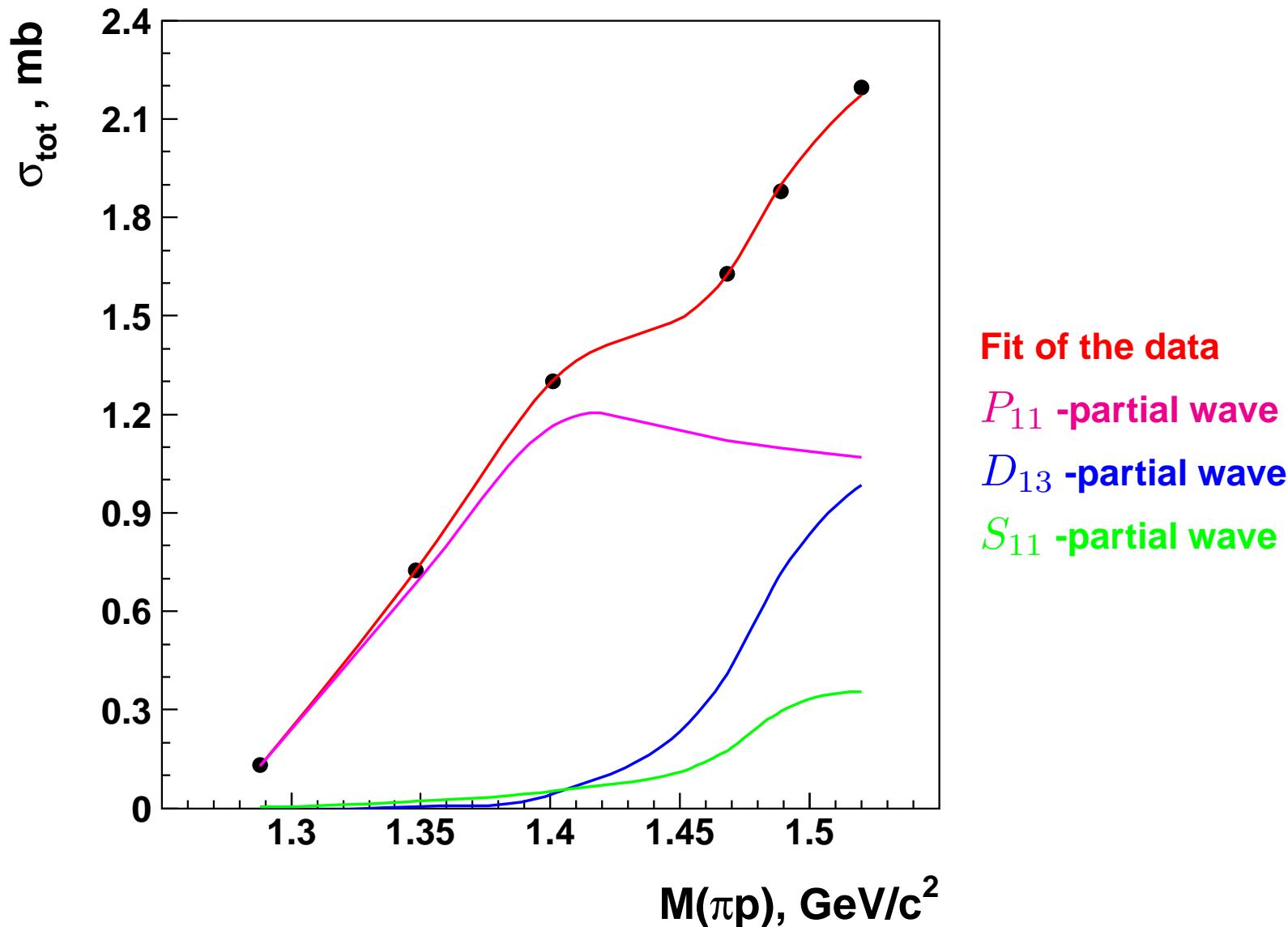


P_{11}



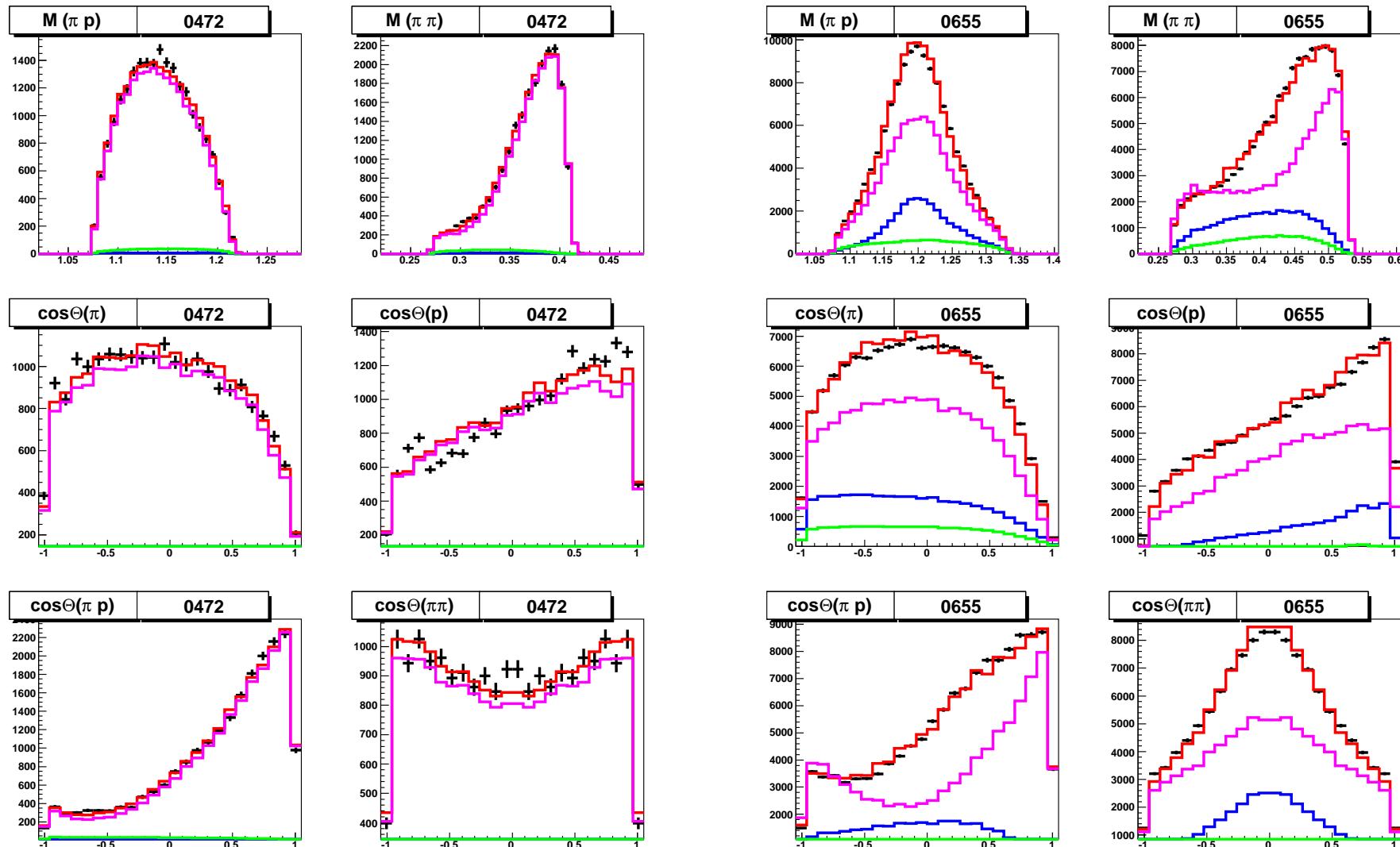
T-matrix poles: $M = 1371 \pm 7 \text{ MeV}, 2 \text{ Im} = 192 \pm 20 \text{ MeV};$

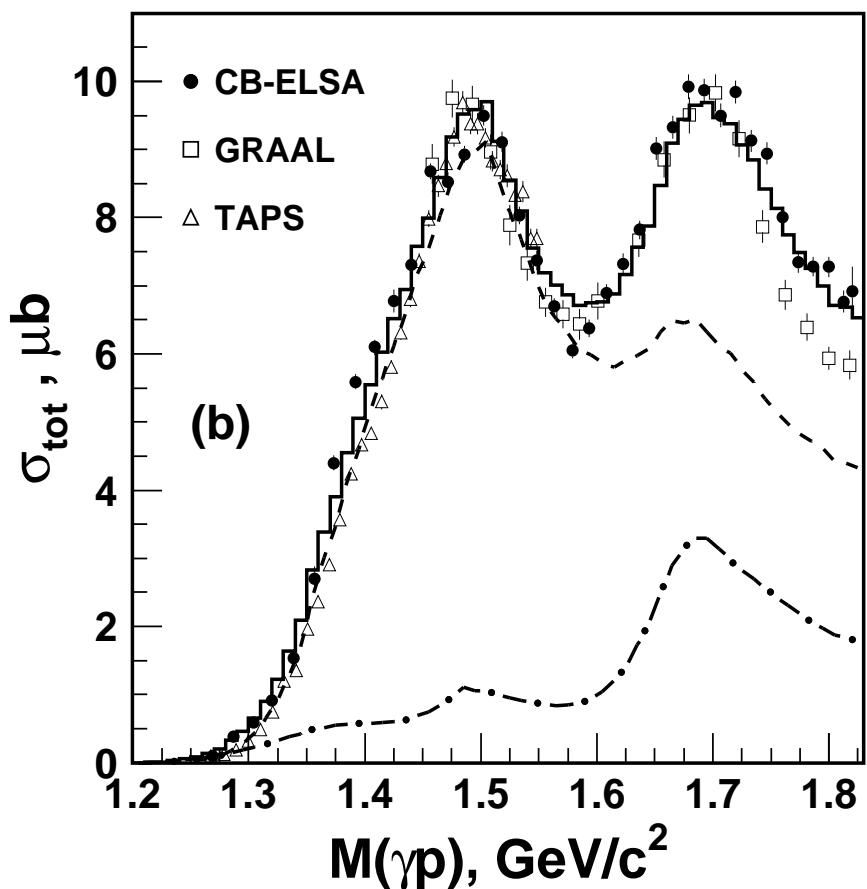
$M = 1850 \pm 10 \text{ MeV}, 2 \text{ Im} = 150 \pm 20 \text{ MeV}$

$\pi^- p \rightarrow n \pi^0 \pi^0$ (Crystal Ball) total cross section

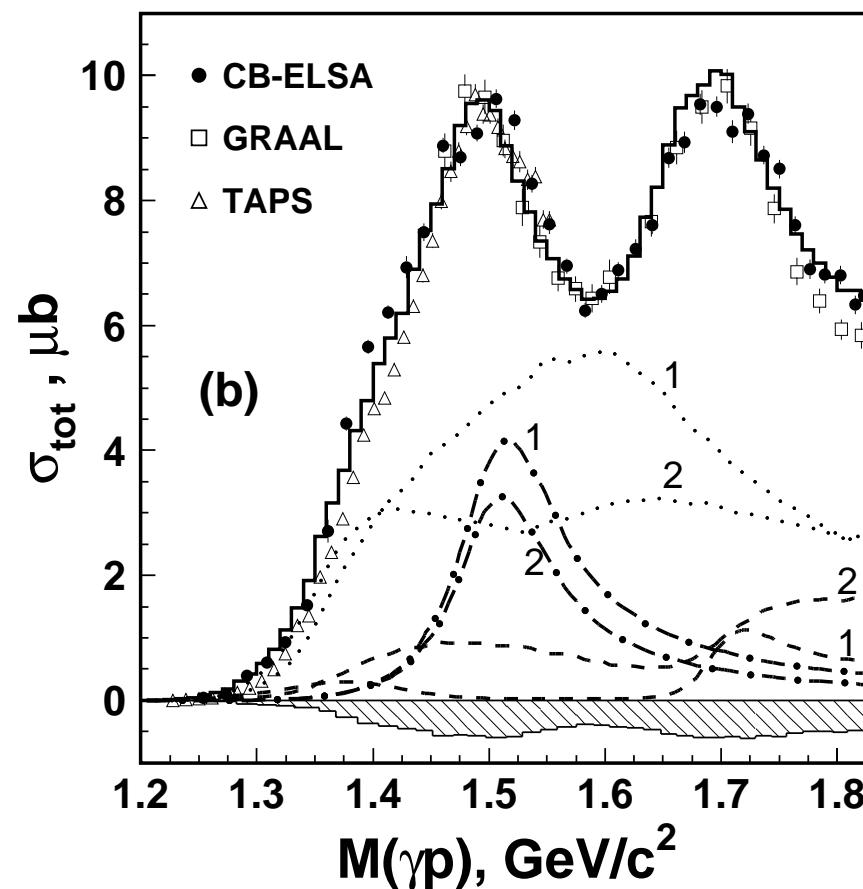
$$\pi^- p \rightarrow n \pi^0 \pi^0$$
 (Crystal Ball)

Differential cross sections for 472 and 665 MeV/c data.



$\gamma p \rightarrow p\pi^0\pi^0$ (CB-ELSA)


PWA corrected cross section and contributions from $\Delta(1232)\pi$ (dashed) and $N\sigma$ (dash-dotted) final states.



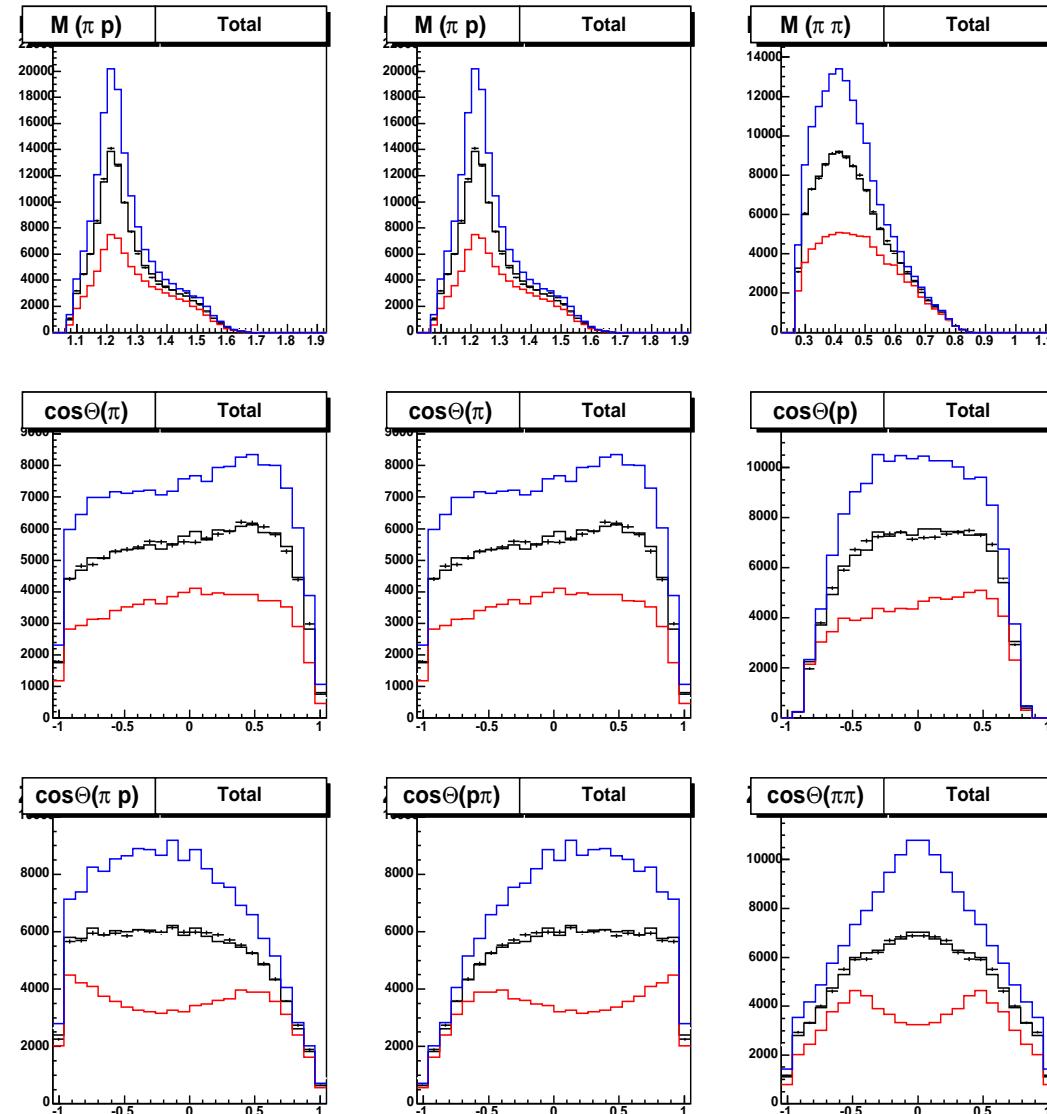
Contributions from D_{33} (dotted), P_{11} (dashed) and D_{13} (dash-dotted) partial waves.

The $\gamma p \rightarrow \pi^0 \pi^0 p$ differential cross section for the total energy region.

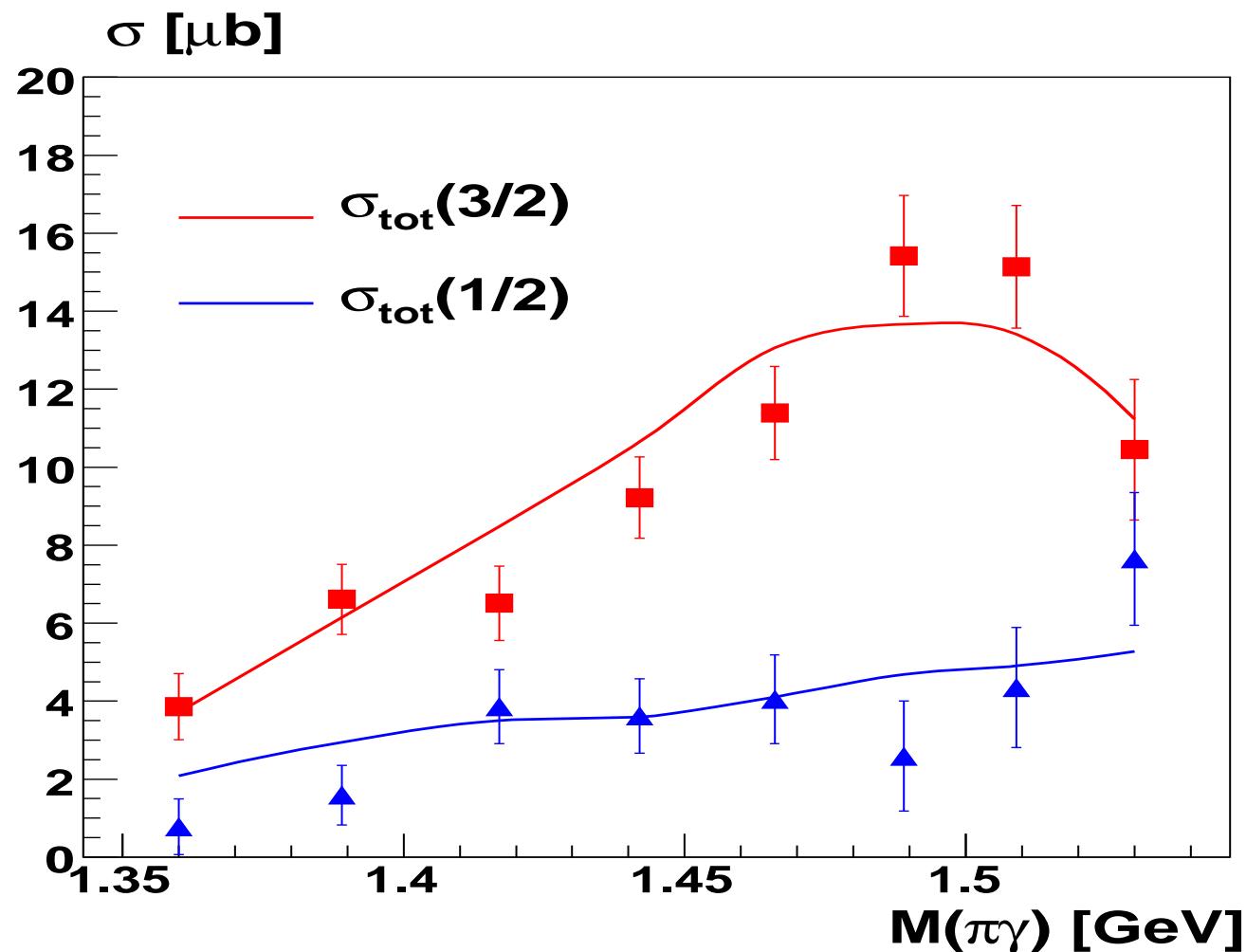
The fit of the unpolarized data and prediction for the double polarization measurements.

Red curve: only helicity 1/2 amplitudes contributed to the cross section.

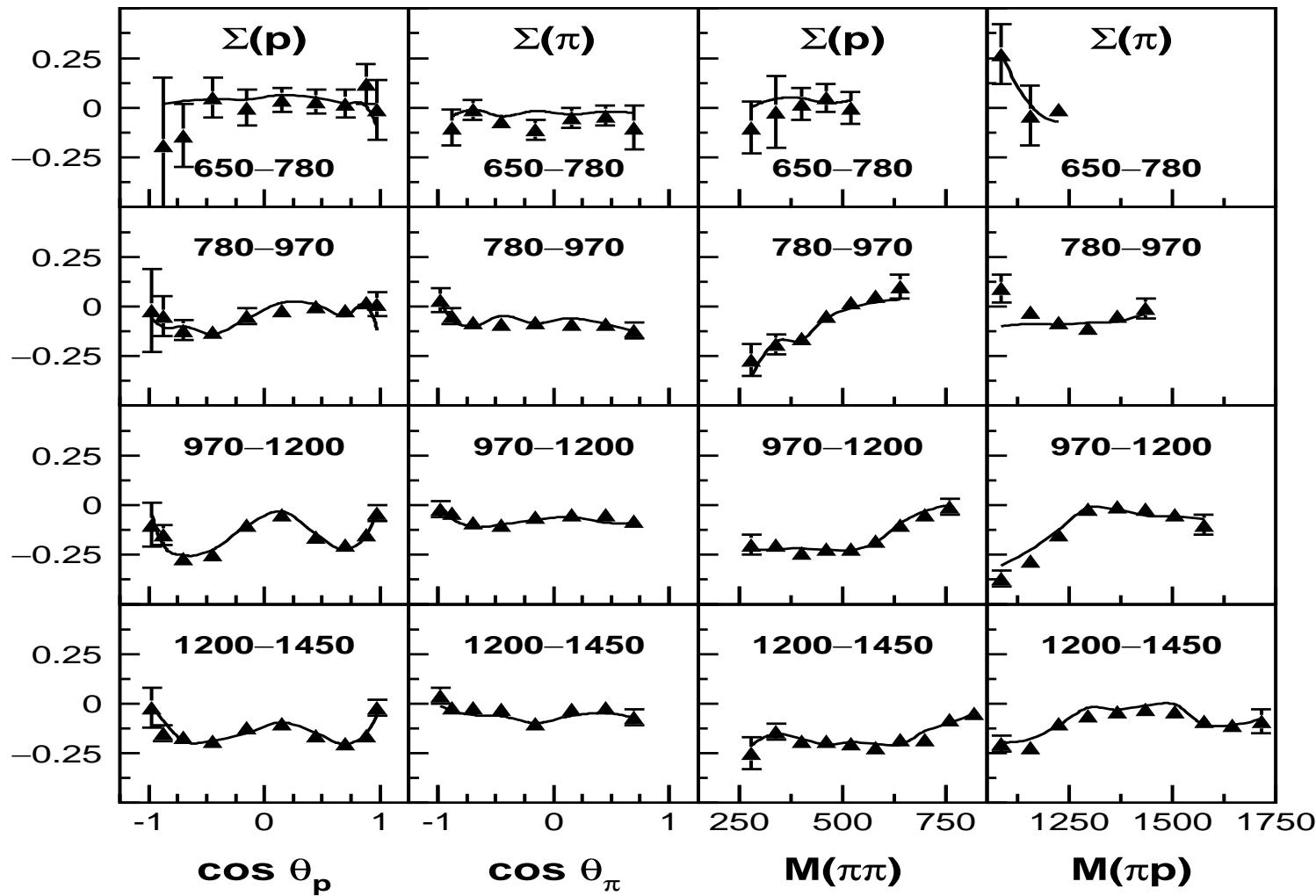
Blue curve: only helicity 3/2 amplitudes.



The $\gamma p \rightarrow \pi^0 \pi^0 p$ helicity 3/2 and 1/2 differential cross sections



The $\gamma p \rightarrow \pi^0 \pi^0 p$ beam asymmetry from the GRAAL collaboration.



Properties of $N(1440)P_{11}$. The left column lists mass, width, partial widths of the Breit-Wigner resonance; the right column pole position and squared couplings to the final state at the pole position.

M	$=$	$1436 \pm 15 \text{ MeV}$	M_{pole}	$=$	$1371 \pm 7 \text{ MeV}$
Γ	$=$	$335 \pm 40 \text{ MeV}$	Γ_{pole}	$=$	$192 \pm 20 \text{ MeV}$
$\Gamma_{\pi N}$	$=$	$205 \pm 25 \text{ MeV}$	$g_{\pi N}$	$=$	$(0.51 \pm 0.05) \cdot e^{-i\pi \frac{(35 \pm 5)}{180}}$
$\Gamma_{\sigma N}$	$=$	$71 \pm 17 \text{ MeV}$	$g_{\sigma N}$	$=$	$(0.82 \pm 0.16) \cdot e^{-i\pi \frac{(20 \pm 13)}{180}}$
$\Gamma_{\pi\Delta}$	$=$	$59 \pm 15 \text{ MeV}$	$g_{\pi\Delta}$	$=$	$(-0.57 \pm 0.08) \cdot e^{i\pi \frac{(25 \pm 20)}{180}}$
T-matrix: $A_{1/2} = 0.055 \pm 0.020 \text{ GeV}$ $\phi = (70 \pm 30)^\circ$					

$\gamma p \rightarrow \eta p$ from Crystal Barrel at ELSA ($E_\gamma \leq 3.2$ GeV)

Main resonance contributions:

$N(1535)S_{11}$

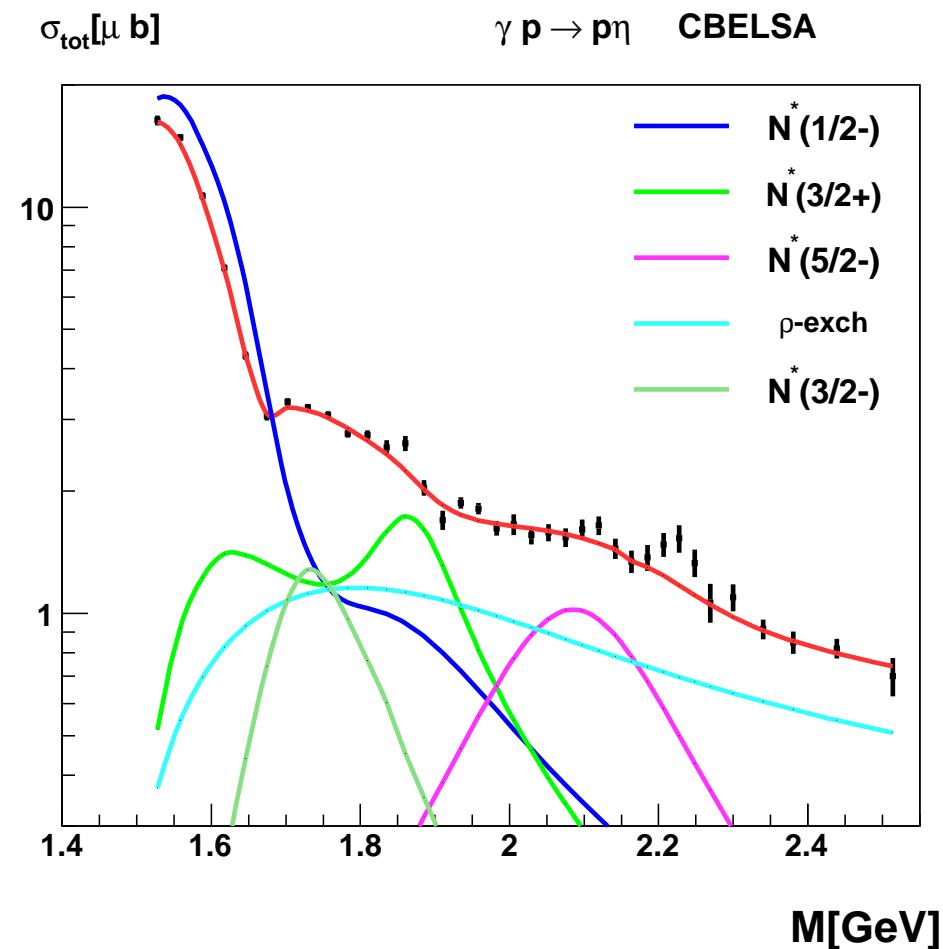
$N(1650)S_{11}$

$N(1720)P_{13}$

new $N(2070)D_{15}$

Non-resonance contribution: reggeized t-channel
 $\rho - \omega$ exchange.

No evidence for third
 $N(1800)S_{11}$



New preliminary CBELSA data for quasi-free $\gamma p \rightarrow \eta p$ and $\gamma n \rightarrow \eta n$ reactions (deuteron target) are analysed.

Motivation:

Several experiments (CRAAL, CBELSA, LNS-Tohoku) observed a bump at $W \sim 1.67 - 1.68$ GeV in quasi-free $\gamma n \rightarrow \eta n$ reaction (deuteron target). Bump not seen in η protoproduction on proton.

What is the nature of such effect?

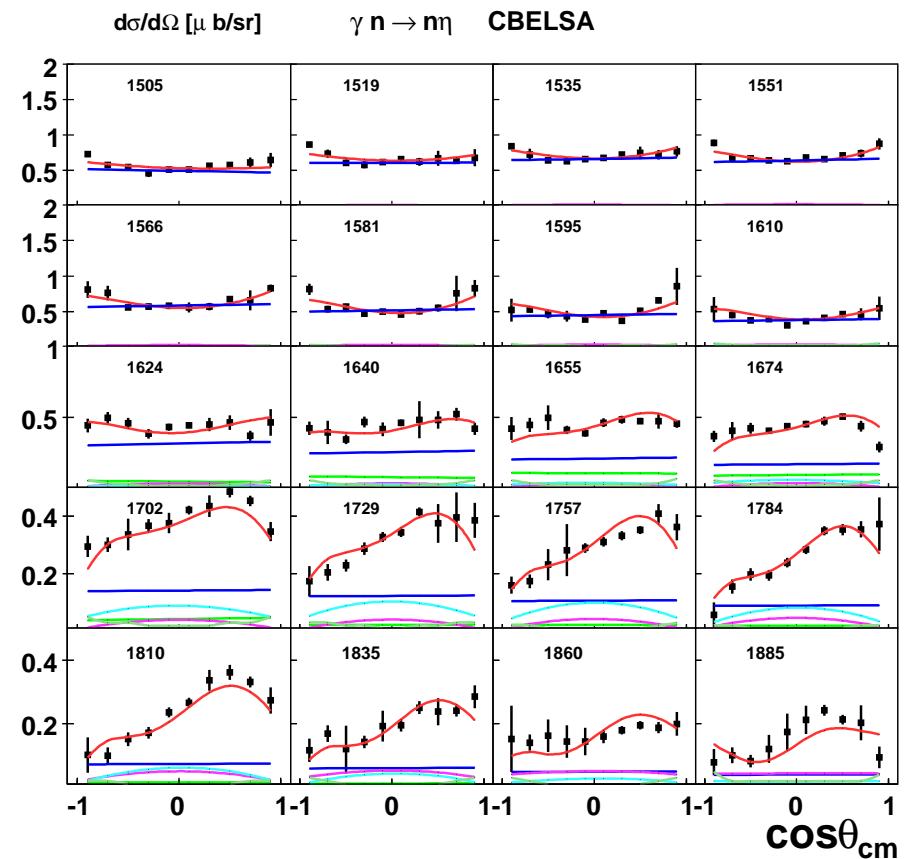
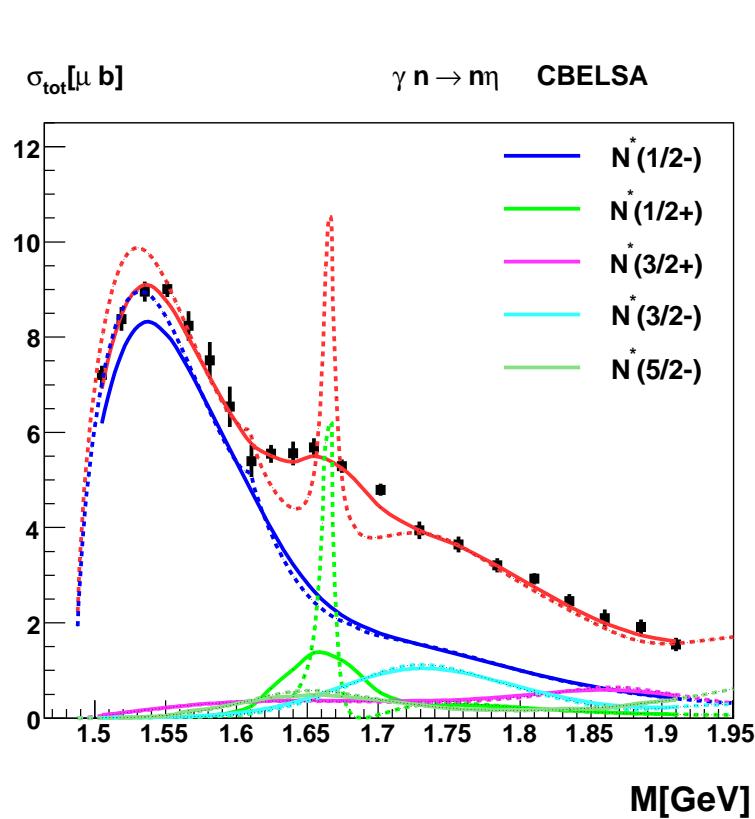
1. Contribution from well-known resonances with large γn coupling?
2. Interference effect between well-known resonances?
3. Evidence for a new resonance with unusual properties (possible narrow width, much stronger photocoupling to the neutron than to the proton)?

Possible existing explanation

1. D_{15} with large γn photocoupling (MAID group)
2. Existence of narrow $P_{11}(1670)$ which looks like a wider bump due to neutron motion in deuteron (see A. Fix, L. Tiator, M.V. Polyakov, nucl-th/0702034).
It could be the second P_{11} member of the anti-decuplet of exotic baryons (pentaquarks) which is expected in the mass region 1.65 – 1.7 GeV with a total width of about 10 – 15 MeV.
3. Contribution from several existing resonances in the region 1650-1700 MeV ($S_{11}(1650)$ and $P_{11}(1710)$) (see V. Shklyar, A. Leshke and U. Mosel, nucl-th/0611036)
4. Interference effect in largest waves (S_{11} or P_{13} which are big in $\gamma p \rightarrow \eta p$)

Two different class of solutions are found:

- 1. solutions with narrow state in the mass region 1665 MeV;**
- 2. solutions with strong destructive interference in S_{11} wave.**



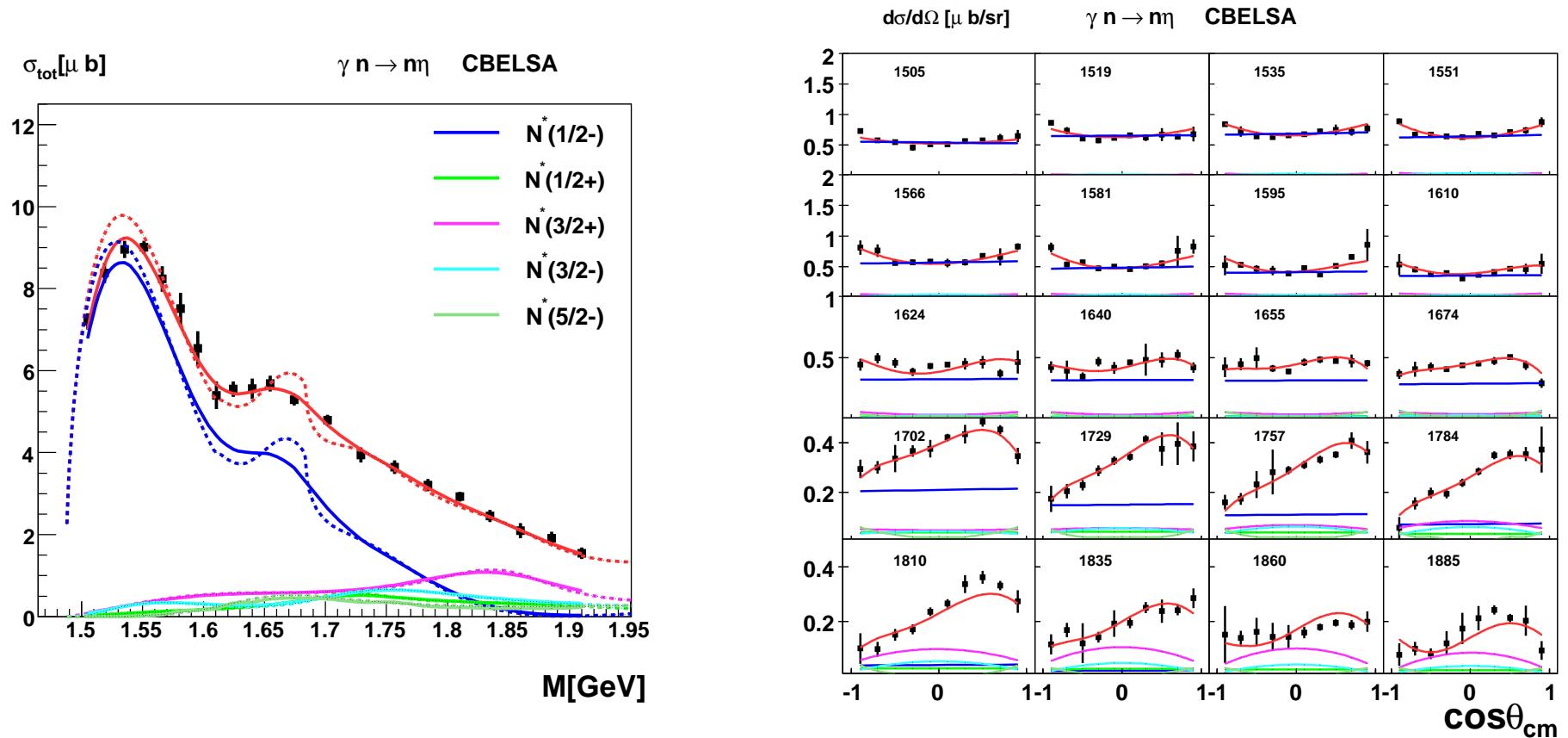
The total and differential cross section for the reaction $\gamma n \rightarrow \eta n$ obtained on the deuteron target. The PWA result from the solution with narrow P_{11} (**solution 1**) is shown as the black solid line and contributions as the colored solid lines. The dashed curves show the corresponding cross sections on the free neutron target (no Fermi motion).

The P_{11} resonance mass was found to be 1665 ± 3 MeV and width parameter finished at 10 MeV which was the lower fit boundary (goes to lower value when fitted freely).

$$\chi^2/N = 390/210$$

The helicity amplitude of the narrow P_{11} state is equal to 0.024 ± 0.002 GeV $^{-1/2}$, assuming that $\Gamma_{\eta N} = \frac{1}{2}\Gamma_{tot}$

To investigate a quantum numbers of a narrow state we fitted the data with S_{11} , P_{13} , D_{13} , D_{15} and F_{15} resonances. The χ^2 was found to be very similar for the first 3 states and equal to the fit with the P_{11} state.



The total and differential cross section for the reaction $\gamma n \rightarrow \eta n$ obtained on the deuteron target. The PWA result from the solution with S_{11} interference (**solution 2**) is shown. The dashed curves show the corresponding cross sections on the free neutron target (no Fermi motion).

Solution 2

$$\chi^2/N = 292/210$$

$$S_{11}(1535) : A_{1/2} = -(0.110 \pm 0.040) \text{ GeV}^{-1/2}$$

K-matrix couplings: $g_{\gamma p} = 0.77$, $g_{\gamma n} = 2.35$

$$S_{11}(1650) : A_{1/2} = 0.07 \pm 0.04 \text{ GeV}^{-1/2}$$

K-matrix couplings: $g_{\gamma p} = 0.46$, $g_{\gamma n} = -0.56$

Summary

1. An approach for the combined analysis of the pion and photo induced reaction with two and multi particle final states is developed.
2. The combined analysis of more than 45 different reactions identify the properties of low-lying baryons .
3. PWA of the preliminary CB-ELSA data on η photoproduction on deuteron is performed. The structure at 1670 MeV observed in the η photoproduction data off neutron can be explained either

by a contribution of a narrow state with mass 1665 ± 3 MeV or
by the interference in the S_{11} wave.
No other mechanism can explain this reaction
4. Evidence for a new resonances $P_{11}(1860)$, $P_{13}(1900)$ and $D_{15}(2070)$.

Properties of the low-lying baryons.

	$S_{11}(1535)$	PDG	$S_{11}(1650)$	PDG	$D_{13}(1520)$	PDG
Mass	1508^{+10}_{-30}	1495–1515	1645 ± 15	1640–1680	1509 ± 7	1505–1515
Γ_{tot}	165 ± 15	90–150	187 ± 20	150–170	113 ± 12	110–120
M_{BW}	1548 ± 15	1520–1555	1655 ± 15	1640–1680	1520 ± 10	1515–1530
Γ_{tot}^{BW}	170 ± 20	100–200	180 ± 20	145–190	125 ± 15	110–135
$A_{1/2}$	86 ± 25	90 ± 30	95 ± 25	53 ± 16	7 ± 15	-(24 ± 9)
$A_{3/2}$					137 ± 12	166 ± 5
Γ_{miss}	-	$< 4\%$	-	4–12 %	$13 \pm 5\%$	15–25 %
$\Gamma_{\pi N}$	$37 \pm 9\%$	35–55 %	$70 \pm 15\%$	55–90 %	$58 \pm 8\%$	50–60 %
$\Gamma_{\eta N}$	$40 \pm 10\%$	30–55 %	$15 \pm 6\%$	3–10 %	$0.2 \pm 0.1\%$	0.23 ± 0.04 %
$N\sigma$	-	-	-	$< 4\%$	$< 4\%$	$< 8\%$
$\Gamma_{K\Lambda}$	-		$5 \pm 5\%$	-	-	-
$\Gamma_{K\Sigma}$	-		-		-	-
$\Gamma_{\Delta\pi(L < J)}$	-		-		$12 \pm 4\%$	5–12 %
$\Gamma_{\Delta\pi(L > J)}$	$23 \pm 8\%$	$< 1\%$	$10 \pm 5\%$	$< 1\%$	$14 \pm 5\%$	10–14 %
$\Gamma_{P_{11}\pi}$	-		-		$2 \pm 2\%$	

Properties of the low-lying baryons.

	$D_{13}(1700)$	PDG	$D_{15}(1675)$	PDG	$P_{13}(1720)$	PDG
Mass	1710 ± 15	1630–1670	1639 ± 10	1655–1665	1630 ± 90	1660–1690
Γ_{tot}	155 ± 25	50–150	180 ± 20	125–155	460 ± 80	115–275
M_{BW}	1740 ± 20	1650–1750	1678 ± 15	1670–1685	1790 ± 100	1700–1750
Γ_{tot}^{BW}	180 ± 30	50–150	220 ± 25	140–180	690 ± 100	150–300
$A_{1/2}$	20 ± 16	-(18±13)	25 ± 10	19±8	150 ± 80	18±30
$A_{3/2}$	75 ± 30	-(2±24)	44 ± 12	-(15±9)	120 ± 80	19±20
Γ_{miss}	20 ± 15	<35 %	20 ± 8	1–3 %	-	70–85 %
$\Gamma_{\pi N}$	8 ± 5 %	5–15 %	30 ± 8 %	40–50 %	9 ± 5 %	10–20 %
$\Gamma_{\eta N}$	10 ± 5 %	0±1 %	3 ± 3 %	0–1 %	10 ± 7 %	4±1 %
$N\sigma$	18 ± 12 %		10 ± 5 %		3 ± 3 %	
$\Gamma_{K\Lambda}$	1 ± 1		3 ± 2 %		12 ± 9	-
$\Gamma_{K\Sigma}$	<1 %		<1 %		<1 %	
$\Gamma_{\Delta\pi(L < J)}$	10 ± 5		24 ± 8		38 ± 20 %	
$\Gamma_{\Delta\pi(L > J)}$	20 ± 11 %		<3 %		6 ± 6 %	10–14 %
$\Gamma_{P_{11}\pi}$	14 ± 8		<3 %		–	
$\Gamma_{D_{13}\pi}$	–		4 ± 4		24 ± 20 %	

Properties of the low-lying baryons.

	$F_{15}(1680)$	PDG	$S_{31}(1620)$	PDG	$D_{33}(1700)$	PDG
Mass	1674 ± 5	$1665-1675$	1615 ± 25	$1580-1620$	1610 ± 35	$1620-1700$
Γ_{tot}	95 ± 10	$105-135$	180 ± 35	$100-130$	320 ± 60	$150-250$
	1684 ± 8	$1675-1690$	1650 ± 25	$1615-1675$	1770 ± 40	$1670-1770$
Γ_{tot}^{BW}	105 ± 8	$120-140$	250 ± 60	$120-180$	630 ± 150	$200-400$
$A_{1/2}$	$-(12 \pm 8)$	$-(15 \pm 6)$	130 ± 50	27 ± 11	125 ± 30	104 ± 15
$A_{3/2}$	120 ± 15	133 ± 12			150 ± 60	85 ± 22
Γ_{miss}	$2 \pm 2\%$	$3-15\%$	$10 \pm 7\%$	$7-25\%$	$15 \pm 10\%$	$30-55\%$
$\Gamma_{\pi N}$	$72 \pm 15\%$	$60-70\%$	$22 \pm 12\%$	$10-30\%$	$15 \pm 8\%$	$10-20\%$
$\Gamma_{\eta N}$	$< 1\%$	$0 \pm 1\%$	-	-	-	-
$N\sigma$	$11 \pm 5\%$	$5-20\%$	-	-	-	-
$\Gamma_{K\Lambda}$	$< 1\%$		-	-	-	-
$\Gamma_{K\Sigma}$	$< 1\%$					
$\Gamma_{\Delta\pi(L < J)}$	$8 \pm 3\%$	$6-14\%$	48 ± 25	$30-60\%$		
					$70 \pm 20\%$	$30-60\%$
$\Gamma_{\Delta\pi(L > J)}$	$4 \pm 3\%$	$< 2\%$				
$\Gamma_{P_{11}\pi}$	-		$19 \pm 12\%$		$< 5\%$	
$\Gamma_{D_{13}\pi}$	-		-		$< 3\%$	