Baryon resonances in pi-p and p-p collisions

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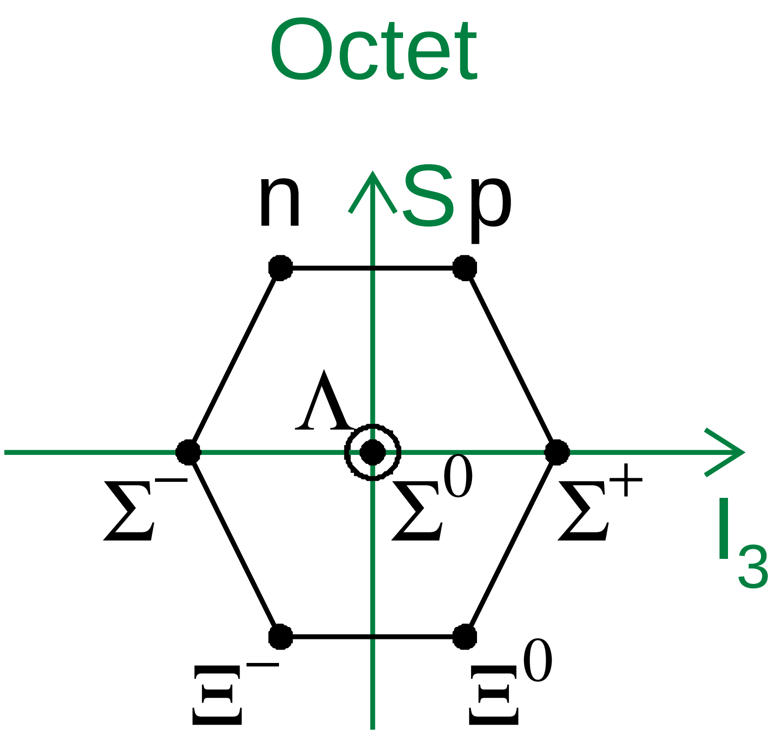
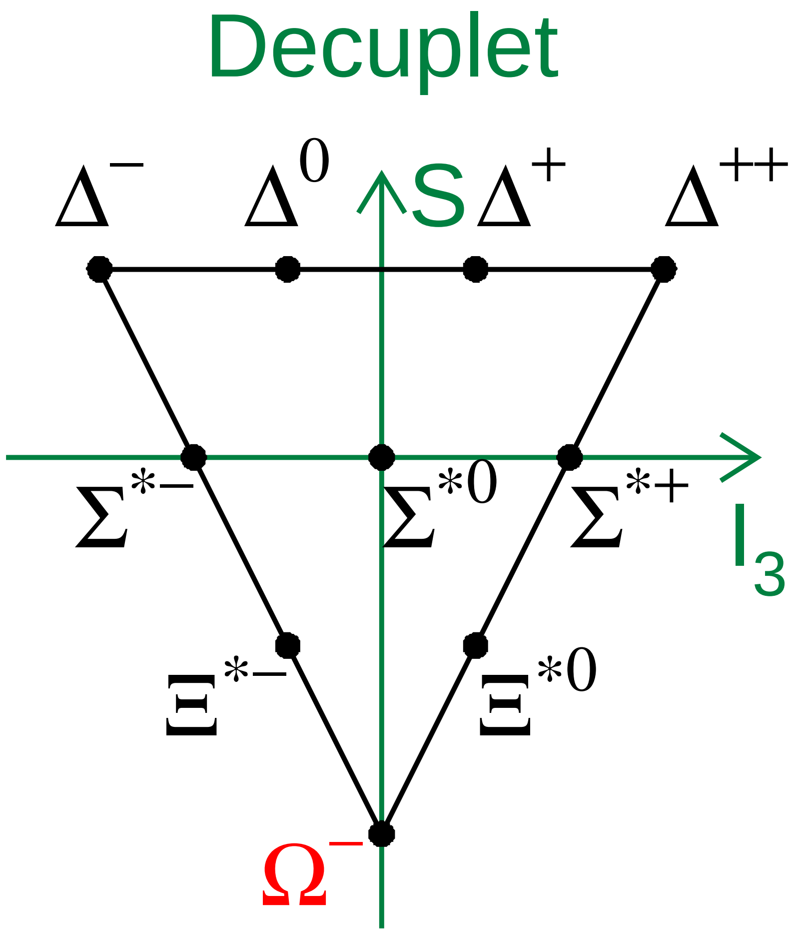
3 generations of quarks

$$3 \otimes 3 \otimes 3 = 10_S \oplus 8_M \oplus 8_M \oplus 1_A$$





0.0.1 The spin wave function

$S = 3/2:$ $\quad \uparrow\uparrow\uparrow$ **fully symmetric**

$S = 1/2:$ $\quad \frac{1}{\sqrt{2}}(\uparrow\downarrow - \downarrow\uparrow)\uparrow$ **mixed symmetry**

0.0.2 The flavor wave function

$\mathrm{SU}(2) \otimes \mathrm{SU}(3) = \mathrm{SU}(6)$.

$$6 \otimes\ 6 \otimes\ 6 = 56_{\mathrm{S}} \oplus\ 70_{\mathrm{M}} \oplus\ 70_{\mathrm{M}} \oplus\ 20_{\mathrm{A}}$$

$$56 = {}^{4}10 \oplus^{2} 8.$$

$$70 = {}^{2}10 \oplus {}^{4}8 \oplus {}^{2}8 \oplus {}^{2}1.$$

$$20 = {}^{2}8\ \oplus\ {}^{4}1.$$

3^{rd} band	$(56, 1_3^-)$	S_1	$S=3/2; L=1;$ N=1	$\Delta_{1/2^-}(1900)$	$\Delta_{3/2^-}(1940)$	$\Delta_{5/2^-}(1930)$			1950 MeV
		S_2	$S=1/2; L=1;$ N=1	$\mathbf{N_{1/2^-}(1895)}$	$\mathbf{N_{3/2^-}(1875)}$				1866 MeV
	$(70, 3_3^-)$	S_3	$S=1/2; L=3;$ N=0			$\mathbf{\Delta_{5/2^-}(2223)}$	$\Delta_{7/2^-}(2200)$		2223 MeV
		S_5	$S=3/2; L=3;$ N=0		$\mathbf{N_{3/2^-}(2150)}$	$\mathbf{N_{5/2^-}(2060)}$	$N_{7/2^-}(2190)$	$N_{9/2^-}(2250)$	2223 MeV
		S_4	$S=1/2; L=3;$ N=0						2151 MeV
	$(56, 3_3^-)$, $(20, 3_3^-)$, $(70, 2_3^-)$, $(70, 1_3^-)$, $(70, 1_3^-)$, $(20, 1_3^-)$:					Many states predicted, no candidates known			
2^{nd} band	$(56, 2_2^+)$	S_1	$S=3/2; L=2;$ N=0	$\Delta_{1/2^+}(1910)$	$\Delta_{3/2^+}(1920)$	$\Delta_{5/2^+}(1905)$	$\Delta_{7/2^+}(1950)$		1950 MeV
		S_2	$S=1/2; L=2;$ N=0		$N_{3/2^+}(1720)$	$N_{5/2^+}(1620)$			1779 MeV
	$(70, 2_2^+)$	S_3	$S=1/2; L=2;$ N=0		$\Delta_{3/2^+}$	$\Delta_{5/2^+}$			1950 MeV
		S_5	$S=3/2; L=2;$ N=0	$\mathbf{N_{1/2^+}(1880)}$	$N_{3/2^+}(1960)$	$\mathbf{N_{5/2^+}(2000)}$	$N_{7/2^+}(1990)$		1950 MeV
		S_4	$S=1/2; L=2;$ N=0		$N_{3/2^+}(1900)$	$N_{5/2^+}(1860)$			1866 MeV
	$(20, 1_2^+)$	S_6	$S=1/2; L=1;$ N=0	$N_{1/2^+}$	$N_{3/2^+}$				∼1800 MeV
	$(56, 0_2^+)$	S_1	$S=3/2; L=0;$ N=1		$\Delta_{3/2^+}(1600)$				1631 MeV
		S_2	$S=1/2; L=0;$ N=1	$N_{1/2^+}(1440)$					1423 MeV
	$(70, 0_2^+)$	S_3	$S=1/2; L=0;$ N=1	$\Delta_{1/2^+}$					1631 MeV
		S_5	$S=3/2; L=0;$ N=1		$N_{3/2^+}$				1631 MeV
		S_4	$S=1/2; L=0;$ N=1	$N_{1/2^+}$					1530 MeV
1^{st} band	$(70, 1_1^-)$	S_3	$S=1/2; L=1;$ N=0	$\Delta_{1/2^-}(1620)$	$\Delta_{3/2^-}(1700)$				1631 MeV
		S_5	$S=3/2; L=1;$ N=0	$N_{1/2^-}(1650)$	$N_{3/2^-}(1700)$	$N_{5/2^-}(1675)$			1631 MeV
		S_4	$S=1/2; L=1;$ N=0	$N_{1/2^-}(1535)$	$N_{3/2^-}(1520)$				1530 MeV
Ground	$(56, 0_0^+)$	S_1	$S=3/2; L=0;$ N=0			$\Delta_{3/2^+}(1232)$			1232 MeV
state		S_2	$S=1/2; L=0;$ N=0		$N_{1/2^+}(939)$				939 MeV

Parity doublets of N and Δ resonances at high mass region

Parity doublets must not interact by pion emission

and could have a small coupling to πN.

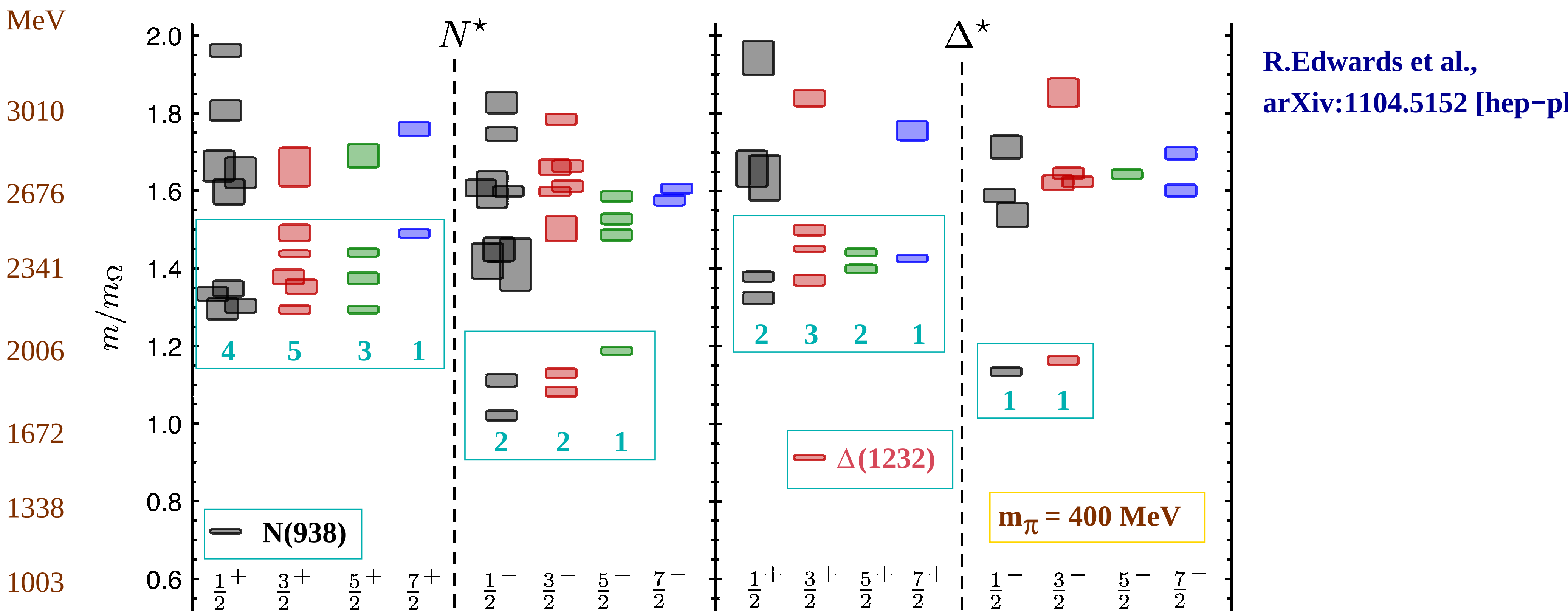
$J=\frac{1}{2}$	$N_{1/2+}(1880)$	**	$N_{1/2-}(1890)$	**	$\Delta_{1/2+}(1910)$	****	$\Delta_{1/2-}(1900)$	**
$J=\frac{3}{2}$	$N_{3/2+}(1900)$	***	$N_{3/2-}(1875)$	**	$\Delta_{3/2+}(1940)$	***	$\Delta_{3/2-}(1990)$	**
$J=\frac{5}{2}$	$N_{5/2+}(1880)$	**	$N_{5/2-}(2060)$	**	$\Delta_{5/2+}(1940)$	****	$\Delta_{5/2-}(1930)$	***
$J=\frac{7}{2}$	$N_{7/2+}(1980)$	**	$N_{7/2-}(2170)$	****	$\Delta_{7/2+}(1920)$	****	$\Delta_{7/2-}(2200)$	*
$J=\frac{9}{2}$	$N_{9/2+}(2220)$	****	$N_{9/2-}(2250)$	****	$\Delta_{9/2+}(2300)$	**	$\Delta_{9/2-}(2400)$	**

$J=\frac{5}{2}$	$N_{5/2+}(2090)$	**	$N_{5/2-}(2060)$	**	$\Delta_{5/2+}(1940)$	****	$\Delta_{5/2-}(1930)$	***
$J=\frac{7}{2}$	$N_{7/2+}(2100)$	**	$N_{7/2-}(2150)$	****	$\Delta_{7/2+}(1950)$	****	$\Delta_{7/2-}(2200)$	*
$J=\frac{9}{2}$	$N_{9/2+}(2220)$	****	$N_{9/2-}(2250)$	****	$\Delta_{9/2+}(2300)$	**	$\Delta_{9/2-}(2400)^a$	**

Holographic QCD (AdS/QCD)

L,S,N	κ_{gd}	Resonance					Pred.
0,$\frac{1}{2}$,0	$\frac{1}{2}$	$N(940)$				**input:**	**0.94**
0,$\frac{3}{2}$,0	**0**	$\Delta(1232)$					**1.27**
0,$\frac{1}{2}$,1	$\frac{1}{2}$	$N(1440)$					**1.40**
1,$\frac{1}{2}$,0	$\frac{1}{4}$	$N(1535)$	$N(1520)$				**1.53**
1,$\frac{3}{2}$,0	**0**	$N(1650)$	$N(1700)$	$N(1675)$			**1.64**
1,$\frac{1}{2}$,0	**0**	$\Delta(1620)$	$\Delta(1700)$		L,S,N**=0,$\frac{3}{2}$,1:**	$\Delta(1600)$	**1.64**
2,$\frac{1}{2}$,0	$\frac{1}{2}$	$N(1720)$	$N(1680)$		L,S,N**=0,$\frac{1}{2}$,2:**	$N(1710)$	**1.72**
1,$\frac{1}{2}$,1	$\frac{1}{4}$	$N(1890)$	$N(1880)$				**1.82**
1,$\frac{3}{2}$,1	**0**	$\Delta(1900)$	$\Delta(1940)$	$\Delta(1930)$			**1.92**
2,$\frac{3}{2}$,0	**0**	$\Delta(1910)$	$\Delta(1920)$	$\Delta(1905)$	$\Delta(1950)$		**1.92**
2,$\frac{3}{2}$,0	**0**	$N(1875)$	$N(1900)$	$N(1880)$	$N(1980)$		**1.92**
0,$\frac{1}{2}$,3	$\frac{1}{2}$	$N(????)$					**2.03**
3,$\frac{1}{2}$,0	$\frac{1}{4}$	$N(2075)$	$N(2185)$	L,S,N**=1,$\frac{1}{2}$,2:**	$N(????)$	$N(????)$	**2.12**
3,$\frac{3}{2}$,0	**0**	$N(2200)$	$N(2250)$	L,S,N**=1,$\frac{1}{2}$,2:**	$\Delta(2223)$	$\Delta(2200)$	**2.20**
4,$\frac{1}{2}$,0	$\frac{1}{2}$	$N(2220)$					**2.27**
4,$\frac{3}{2}$,0	**0**	$\Delta(2390)$	$\Delta(2300)$	$\Delta(2420)$	$\|L,N$**=3,1:**	$\Delta(2400)$ $\Delta(2350)$	**2.43**
5,$\frac{1}{2}$,0	$\frac{1}{4}$	$N(2600)$					**2.57**

0.0.3 Baryons on the lattice



a Lattice and quark models predict more states than observed (missing resonances)

b Lattice and quark models predict even-odd staggering (exp: parity doublets)

c $3/2^+$: 5 states expected, $N(1720)3/2^+$, $N(1900)3/2^+$, tentative $N(1960)3/2^+$, $N(2200)3/2^+$

Problems in the baryon spectroscopy and/or quark model:

- **Problem: The number of predicted three quark states exceeds dramatically the number of discovered baryons.**

  1. **Possible solution: Most of the information comes from the analysis of the πN elastic data. Analysis of πN inelastic data, the γN data taken by CLAS, MAMI, GRAAL and CB-ELSA, NN data taken by TOF, ANKE and HADES and data on J/Ψ decay can provide an important information about missing states**
  2. **The new understanding of strong interactions at low and intermediate energies is needed.**

- **Problem: The unambiguous analysis of a reaction with fermions and vector particles can not be done without information about polarization observables**

  1. **Possible solution: In γN collision reactions the single polarization observables are measured now by all collaborations. The double polarization data are measured and available from GRAAL, CLAS, MAMI and CB-ELSA**
  2. **A combined analysis of the large data sets including different initial and final states**

Baryon sector: the partial wave analysis groups

- **SAID (GWU,USA): Analysis of elastic πN data in energy independent method and then in the K-matrix approach. Fit of the $\gamma n \to \pi N, \eta N$ data as a sum of BW amplitudes and now also in the framework of K-matrix/P-vector approach.**
- **MAID (Mainz): Energy dependent analysis of photoproduction data on γN to πN, ηp, $K\Lambda$, $K\Sigma$. Parameterization of partial waves as a sum of Breit-Wigner amplitudes with dispersion corrections. Development of energy independent approach for photoproduction.**
- **Bonn-Gatchina: Energy dependent analysis of pion induced (inelastic) and almost all photoproduction data. K-matrix/P-vector and now N/D-dispersion approach. Minimization: χ^2 for 2 body final state and maximum likelihood for multi-body final states. Development of energy independent approach for photoproduction.**
- **Juelich group: Energy dependent approach. Pion induced data (elastic and inelastic), $\gamma p \to \pi N$ (all data) and $\gamma p \to K\Lambda$ (low energy). Unitarity, analyticity and chiral constraints.**
- **Other PWA groups: OSAKA (T. Sato), Giessen (V. Shklyar), M. Manley (Kent Uni)**

Bonn-Gatchina partial wave analysis group

Search for baryon states

1. **Analysis of single and double meson photoproduction reactions.**
   $\gamma p \to \pi N, \eta N, K\Lambda, K\Sigma, \pi\pi N, \pi\eta N$**, CB-ELSA, CLAS, GRAAL, LEPS.**
2. **Analysis of single and double meson production in pion-induced reactions.**
   $\pi N \to \pi N, \eta N, K\Lambda, K\Sigma, \pi\pi N$**.**
3. **Analysis of hyperon production** $NN \to NN\pi$ **(TOF, WASA, PNPI, HADES) and**
   $NN \to K\Lambda p$ **HADES.**

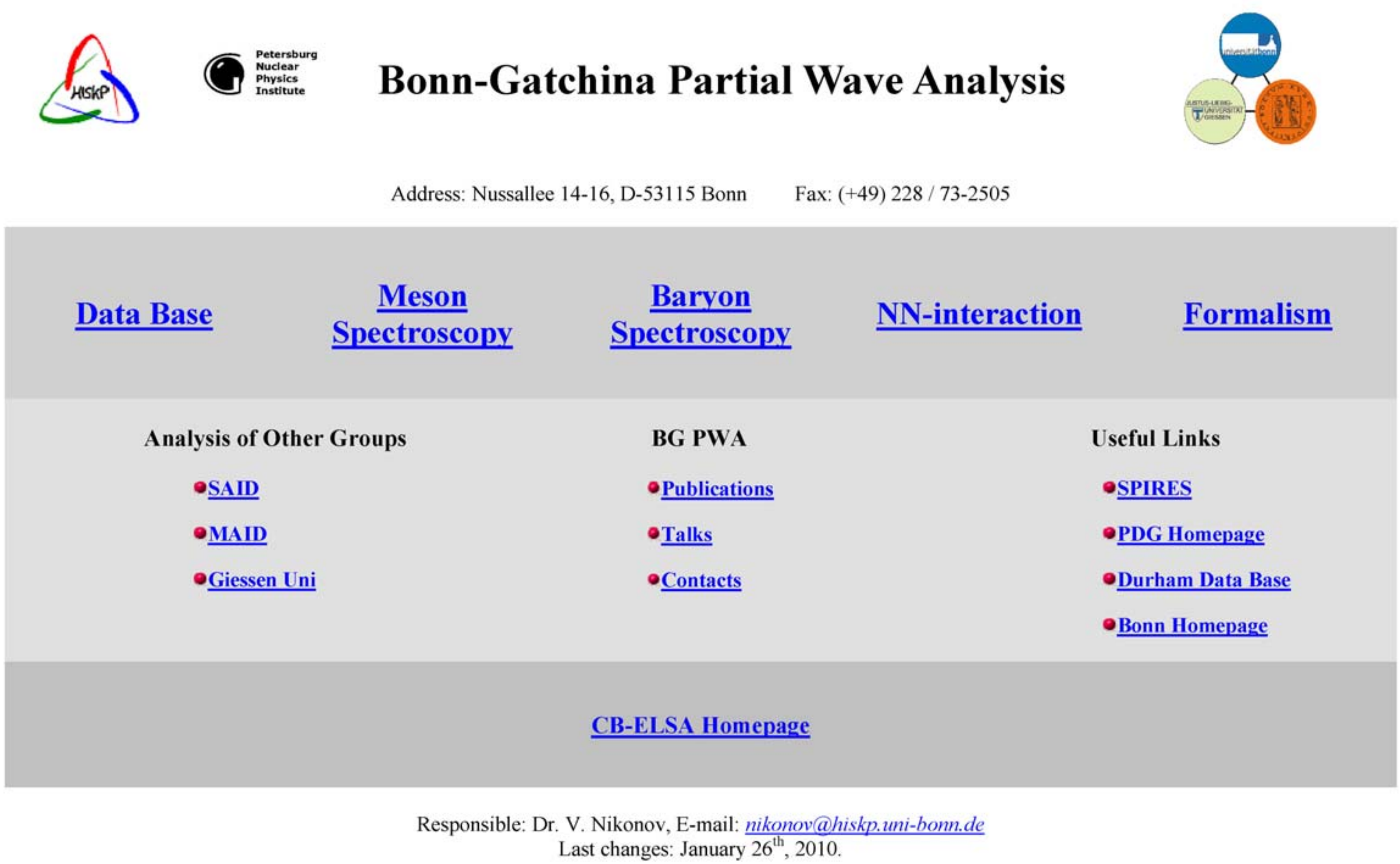
Search for meson states

1. **Analysis of the BES III data on** J/Ψ **decays**
   (A.Sarantsev in collaboration with JINR Dubna).
2. **Possibly in nearest future an analysis of COMPAS data.**

Bonn-Gatchina partial wave analysis group:

A. Anisovich, E. Klempt, V. Nikonov, A. Sarantsev, U. Thoma.

http://pwa.hiskp.uni-bonn.de/



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Bonn-Gatchina Partial Wave Analysis

Address: Nussallee 14-16, D-53115 Bonn   Fax: (+49) 228 / 73-2505

Data Base | Meson Spectroscopy | Baryon Spectroscopy | NN-interaction | Formalism

Analysis of Other Groups
- SAID
- MAID
- Giessen Uni

BG PWA
- Publications
- Talks
- Contacts

Useful Links
- SPIRES
- PDG Homepage
- Durham Data Base
- Bonn Homepage

CB-ELSA Homepage

Responsible: Dr. V. Nikonov, E-mail: *nikonov@hiskp.uni-bonn.de*
Last changes: January 26th, 2010.

Baryon data base

DATA	MAID	SAID	BnGa
$\pi N \to \pi N$ ampl.	SAID energy fixed	all data	SAID or Hoehler energy fixed
$\gamma p \to \pi N$	$\frac{d\sigma}{d\Omega}, \Sigma, T, P, E$		$+G, H, E$
$\gamma n \to \pi N$	$\frac{d\sigma}{d\Omega}, \Sigma, T, P$		$\frac{d\sigma}{d\Omega}, \Sigma, T, P$
$\gamma n \to \eta n$			$\frac{d\sigma}{d\Omega}, \Sigma$
$\gamma p \to \eta p$	$\frac{d\sigma}{d\Omega}, \Sigma, T$	$\frac{d\sigma}{d\Omega}, \Sigma$	$\frac{d\sigma}{d\Omega}, \Sigma, T, P, H, E$
$\gamma p \to K^+\Lambda$	$\frac{d\sigma}{d\Omega}, P$	–	$\frac{d\sigma}{d\Omega}, \Sigma, P, T, C_x, C_z, O_{x'}, O_{z'}$
$\gamma p \to K^+\Sigma^0$	$\frac{d\sigma}{d\Omega}, P$	–	$\frac{d\sigma}{d\Omega}, \Sigma, P, C_x, C_z$
$\gamma p \to K^0\Sigma^+$	–	–	$\frac{d\sigma}{d\Omega}, \Sigma, P$
$\pi^- p \to \eta n$	–	$\frac{d\sigma}{d\Omega}$	$\frac{d\sigma}{d\Omega}$
$\pi^- p \to K^0\Lambda$	–	–	$\frac{d\sigma}{d\Omega}, P, \beta$
$\pi^- p \to K^0\Sigma^0$	–	–	$\frac{d\sigma}{d\Omega}, P$
$\pi^+ p \to K^+\Sigma^+$	–	–	$\frac{d\sigma}{d\Omega}, P, \beta$
$\pi^- p \to \pi^0\pi^0 n$	–	–	$\frac{d\sigma}{d\Omega}$
$\gamma p \to \pi^0\pi^0 p$	–	–	$\frac{d\sigma}{d\Omega}, \Sigma, E, I_c, I_s, G$
$\gamma p \to \pi^0\eta p$	–	–	$\frac{d\sigma}{d\Omega}, \Sigma, I_c, I_s$
$\gamma p \to \omega p$	–	–	$\frac{d\sigma}{d\Omega}, \Sigma, E, G, \rho^0_{ij}, \rho^2_{ij}, \rho^2_{ij}$

The inelastic reactions are very important !

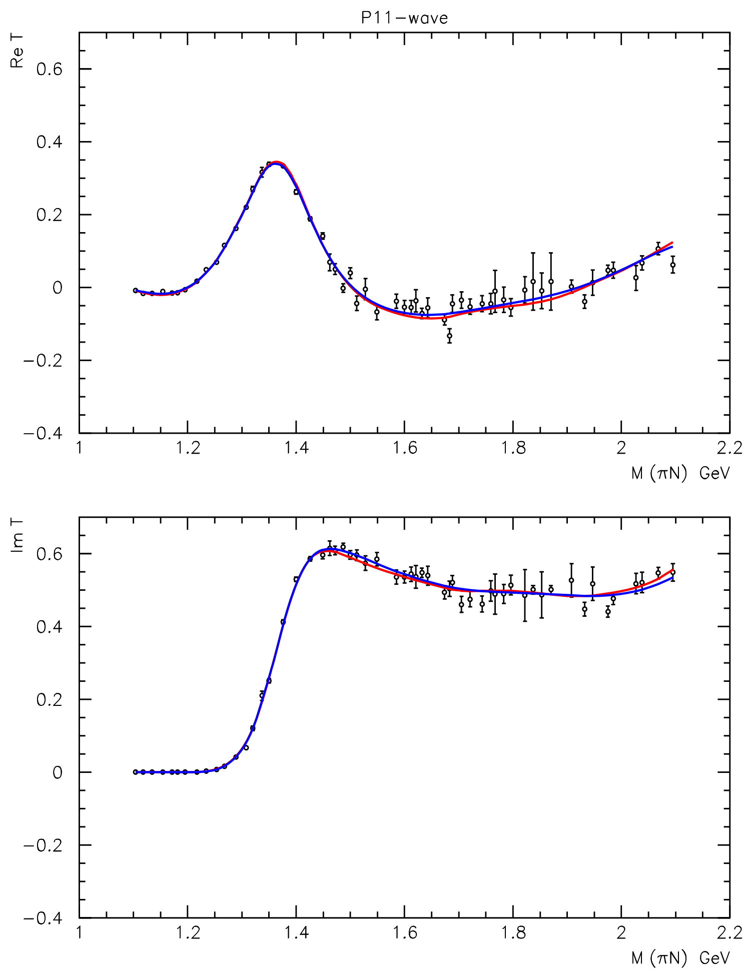
Recent SAID analysis of $\pi N \to \pi N$ data

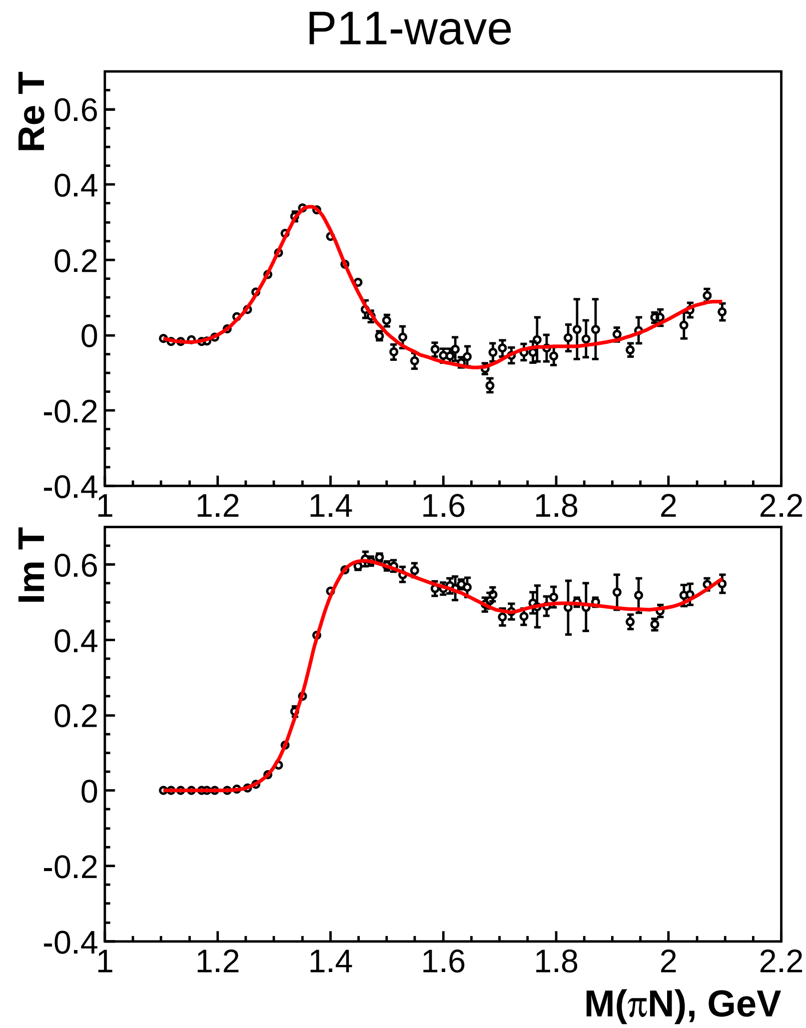
Hoehler et al.(Karlsruhe-Helsinki), Cutcosky et al.(Carnegie Mellon), Arndt et al.(George Washington)

The latest analysis of SAID (GWU) of πN elastic data as well as $\gamma p \to \pi^0 p$ and $\gamma p \to \pi^+ n$ did not confirm the set of states observed in earlier analysis of πN elastic data. CLAS (M. Dugger et al.). Phys.Rev.C79:065206,2009.

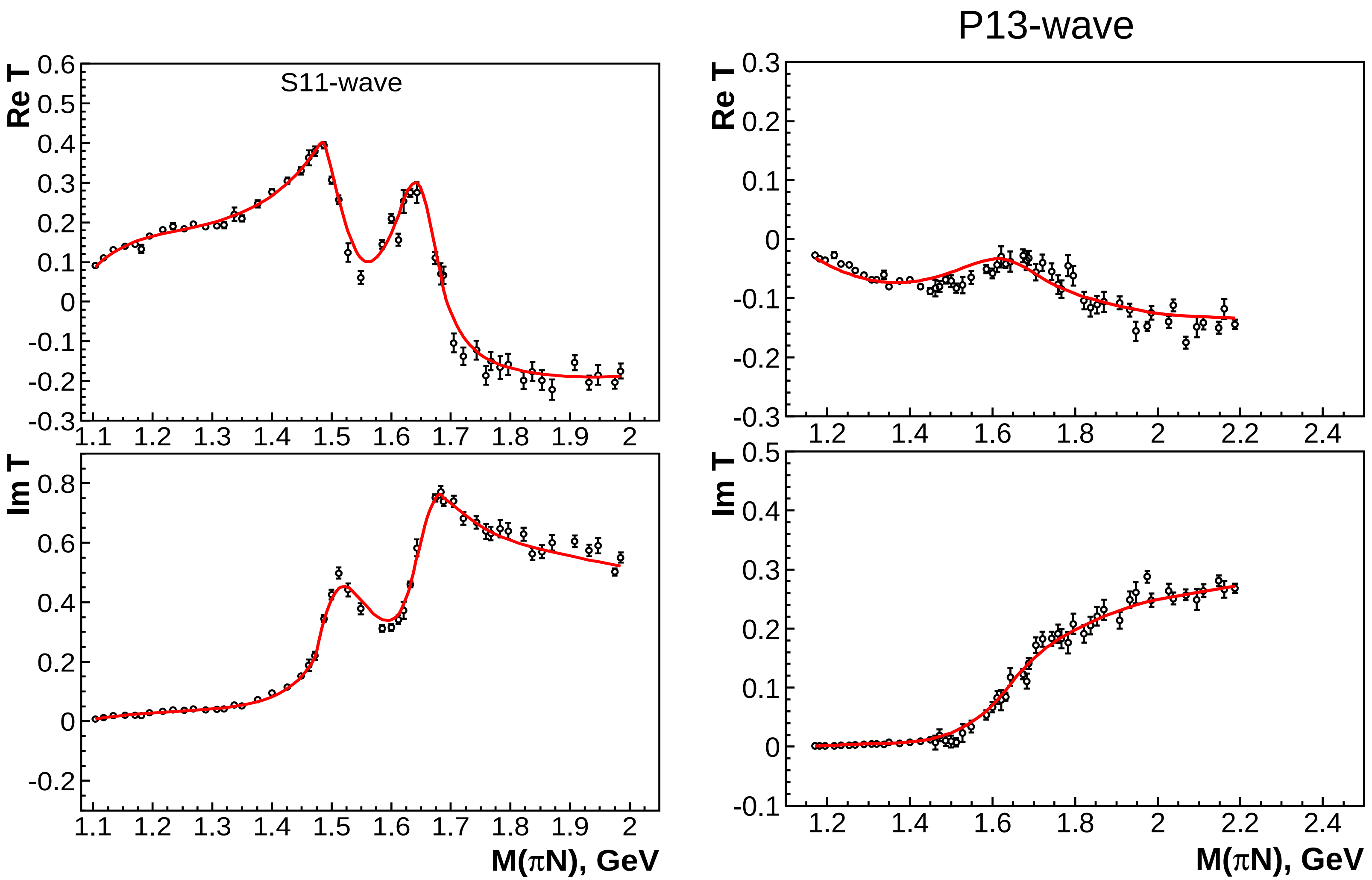
State	PDG (Pole position)(MeV)		Bonn-Gatchina 2011 (MeV)	
	Mass	Width	Mass	Width
$P_{11}(1710)^{***}$	1720 ± 50	230 ± 150	1690 ± 10	170 ± 20
$P_{33}(1600)^{***}$	1550 ± 100	300 ± 100	1500 ± 25	230 ± 50
$P_{33}(1920)^{***}$	1900 ± 50	200^{+100}_{-50}	1890 ± 30	300 ± 60
$D_{13}(1720)^{***}$	1680 ± 50	100 ± 50	1770 ± 40	420 ± 180
$D_{13}(1875)$			1860 ± 25	200 ± 25
$P_{11}(1880)$			1860 ± 35	235 ± 65
$S_{11}(1895)$			1907 ± 15	100^{+40}_{-15}
$P_{13}(1900)$			1910 ± 30	280 ± 50
$D_{15}(2060)$			2040 ± 15	390 ± 25

$N\pi \to N\pi$ P_{11} wave





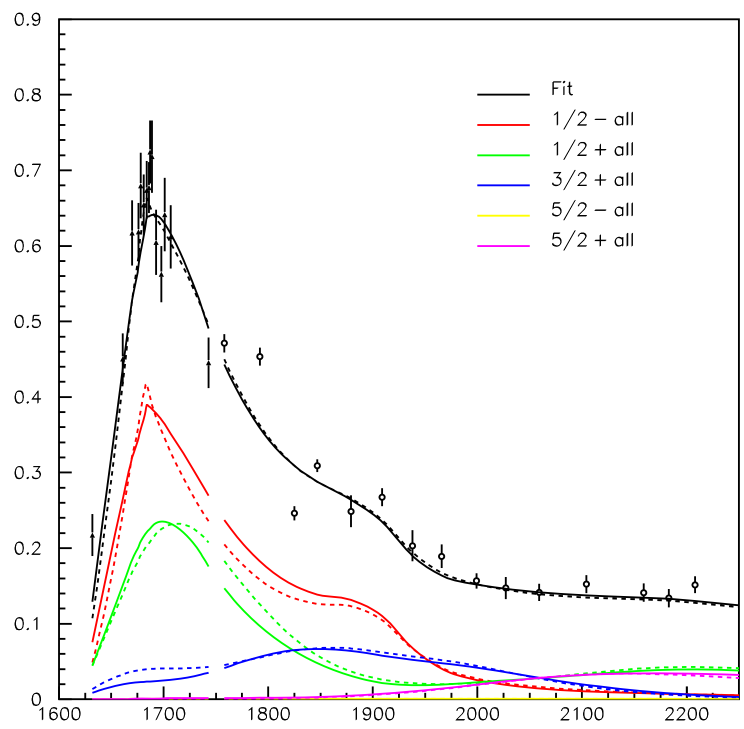
$N\pi \to N\pi$ S_{11} and P_{13} waves



The fit of the the $\pi^- p \to K\Lambda$ reaction

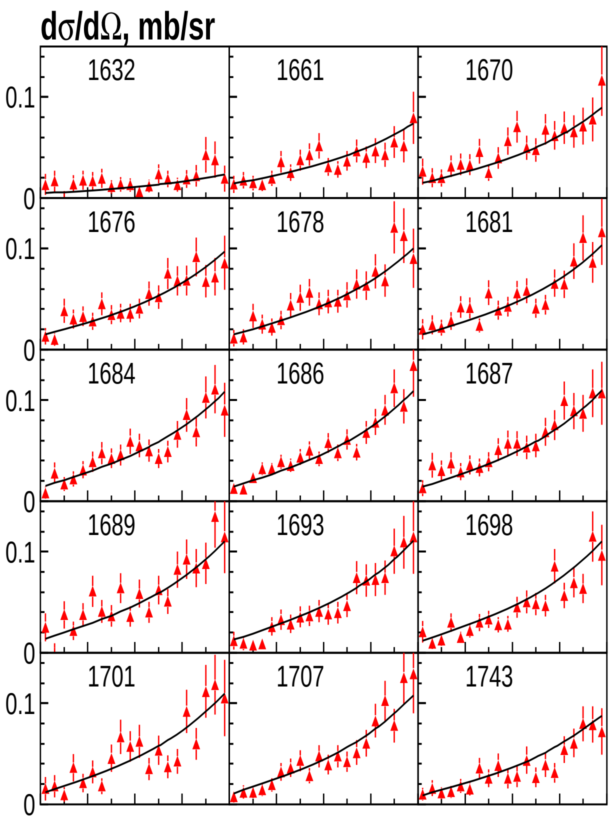
Full experiment for $\pi N \to K\Lambda$: differential cross section, analyzing power, rotation parameter.

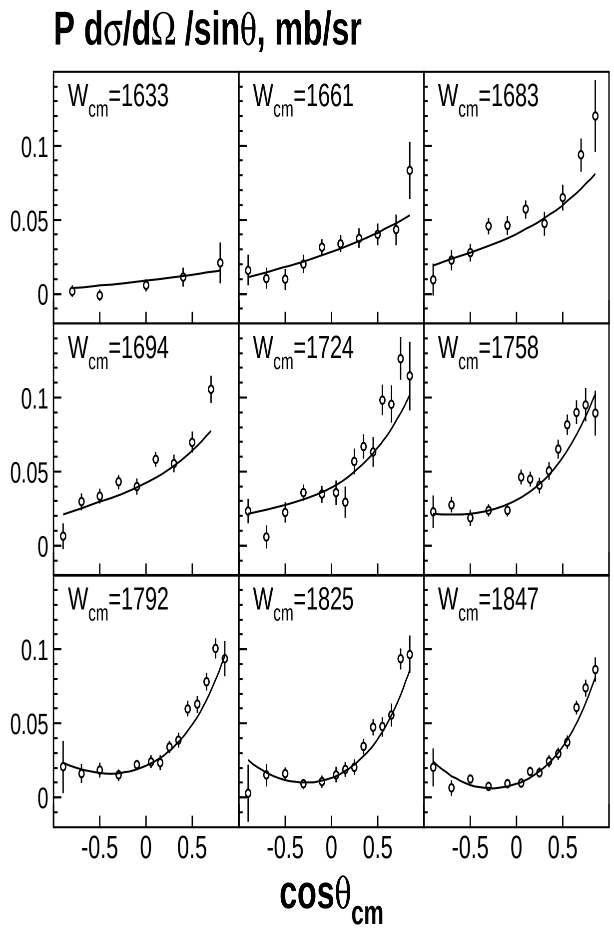
A clear evidence for resonances which are hardly seen (or not seen) in the elastic reactions: $N(1710)P_{11}$, $N(1900)P_{13}$,

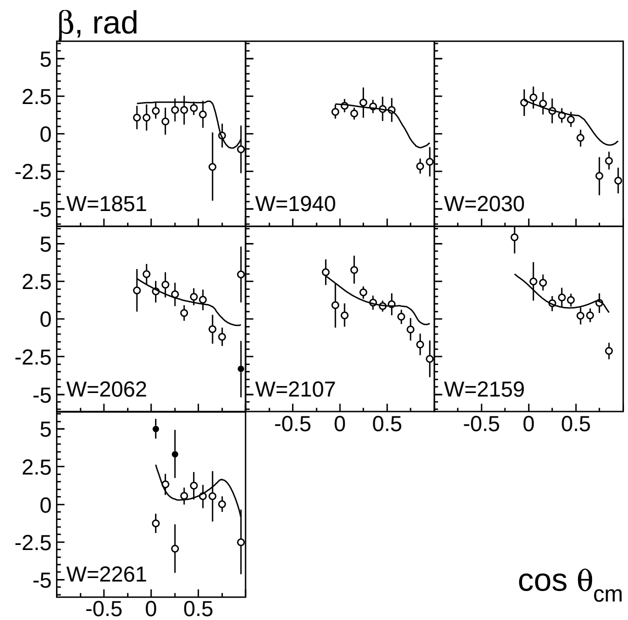


The total cross section for the reaction $\pi^- p \to K^0\Lambda$ and contributions from leading partial waves.

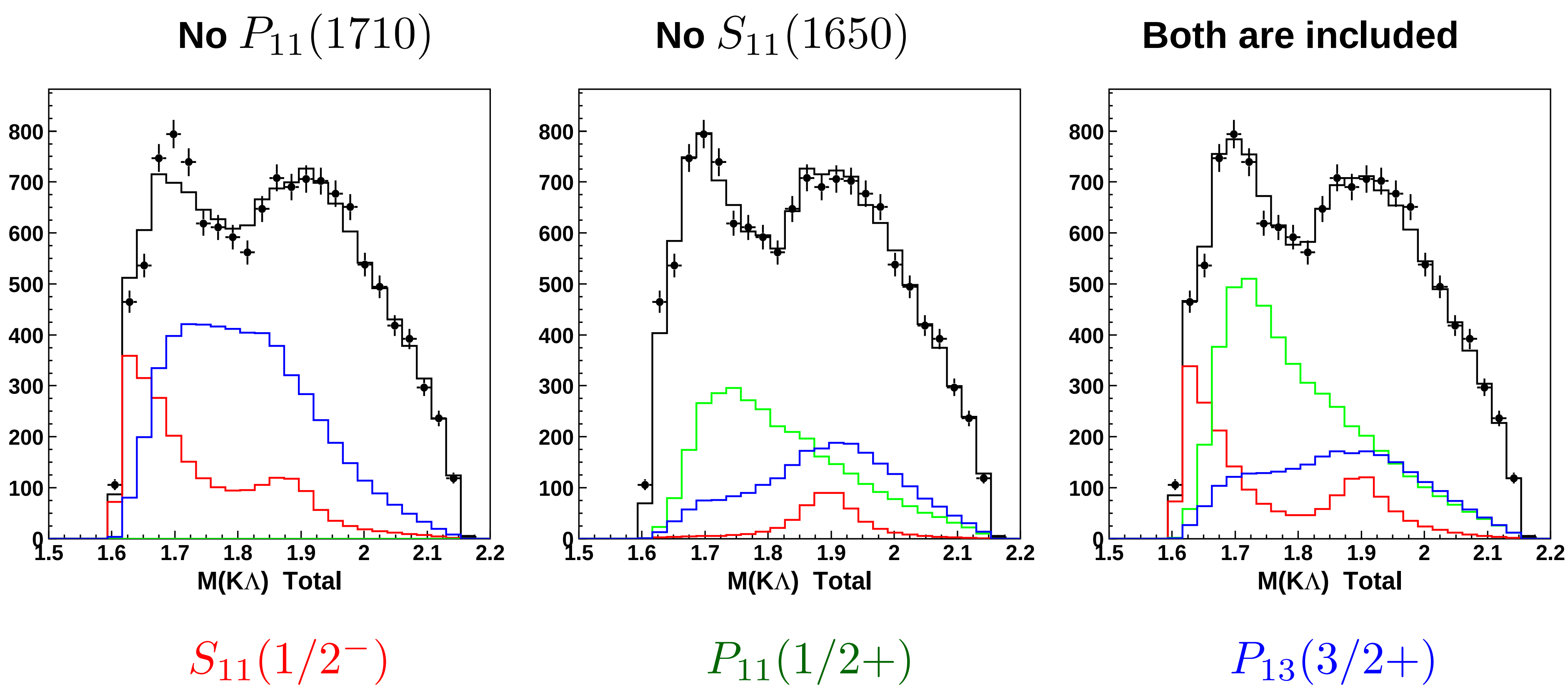
The fit of the the $\pi^- p \to K\Lambda$ reaction (differential cross section)



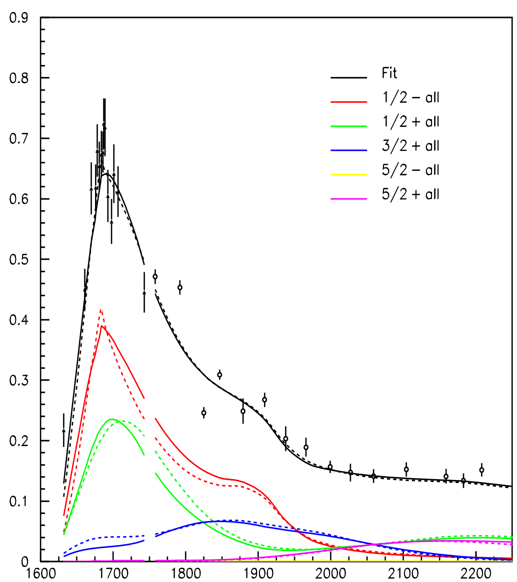


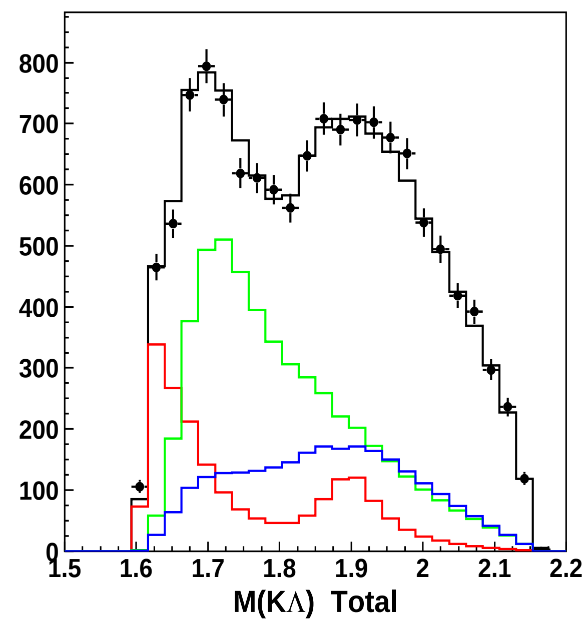


Partial wave analysis of HADES $pp \to K^+ \Lambda p$ data (E.Epple)



Partial wave contributions to $\pi^- p \to K\Lambda$ and $pp \to K^+\Lambda p$



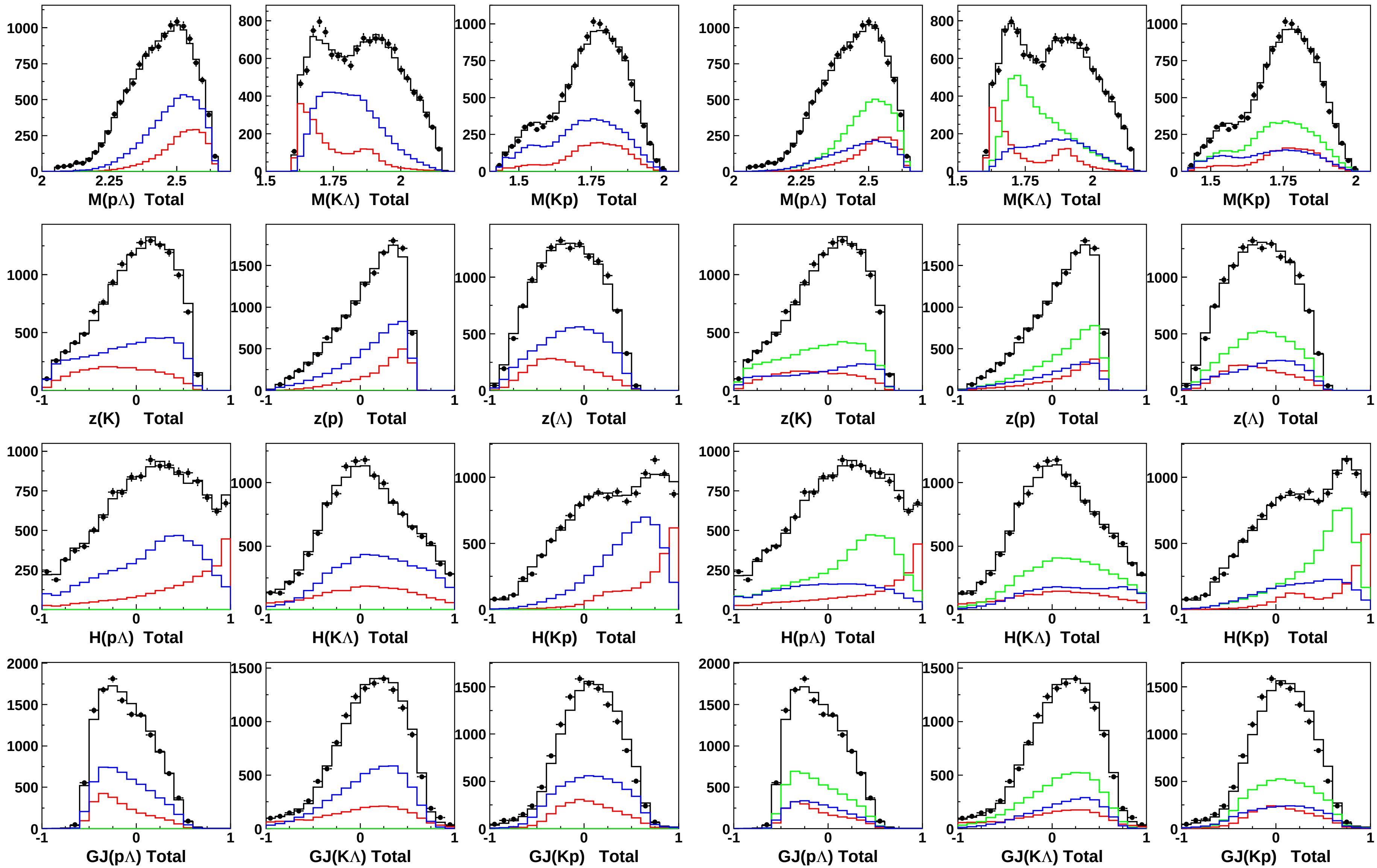


$\pi N + \gamma N$	$pp \to K^+\Lambda p$
$P_{11}(1710)$	
1690 ± 10 168 ± 27	1692 ± 9 170 ± 20
$S_{11}(1895)$	
1891 ± 7 84 ± 22	1907 ± 15 100^{+40}_{-15}
$P_{13}(1900)$	
1906 ± 19 290 ± 55	1910 ± 30 280 ± 50

$S_{11}(1/2^-)$ $P_{11}(1/2+)$ $P_{13}(3/2+)$

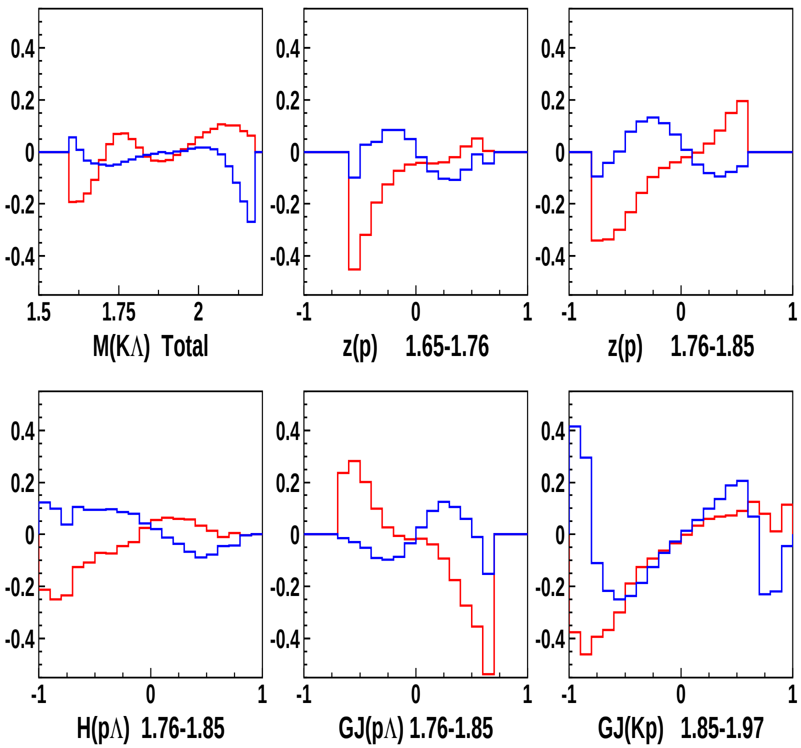
For HADES $pp \to K^+\Lambda p$ only systematic errors are given.

However there is a problem:
these solutions have similar angular distributions



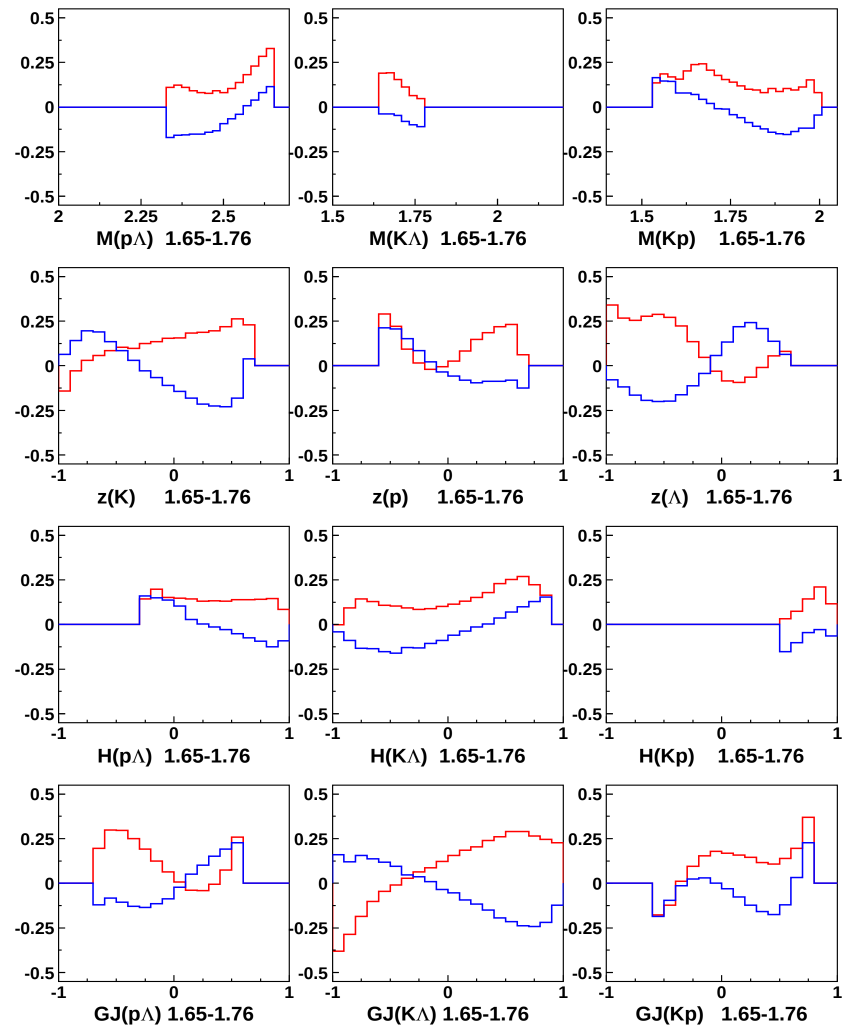
Possible solution: Recoil or target asymmetry

Recoil asymmetry



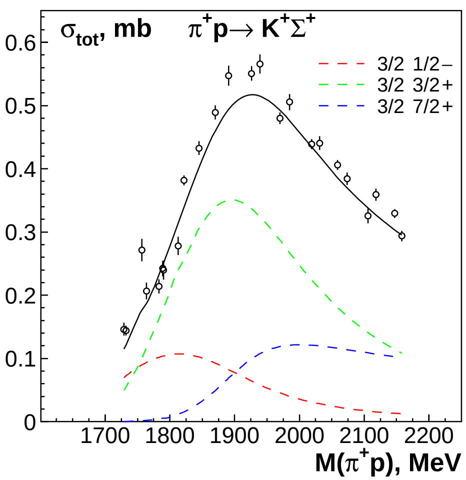
All contributions

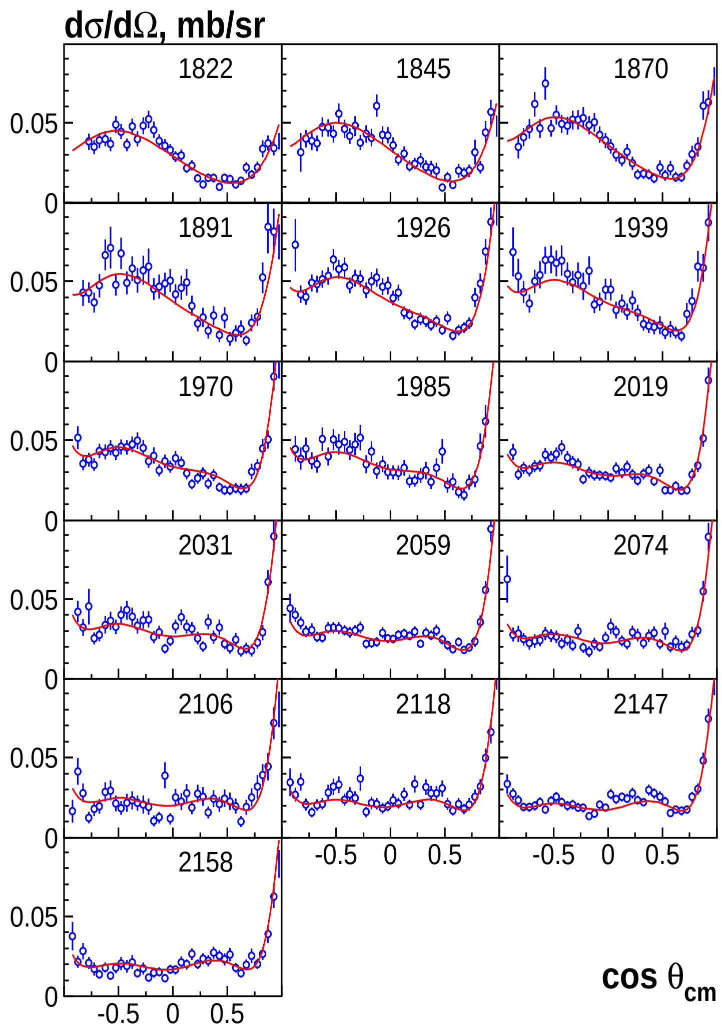
Target asymmetry

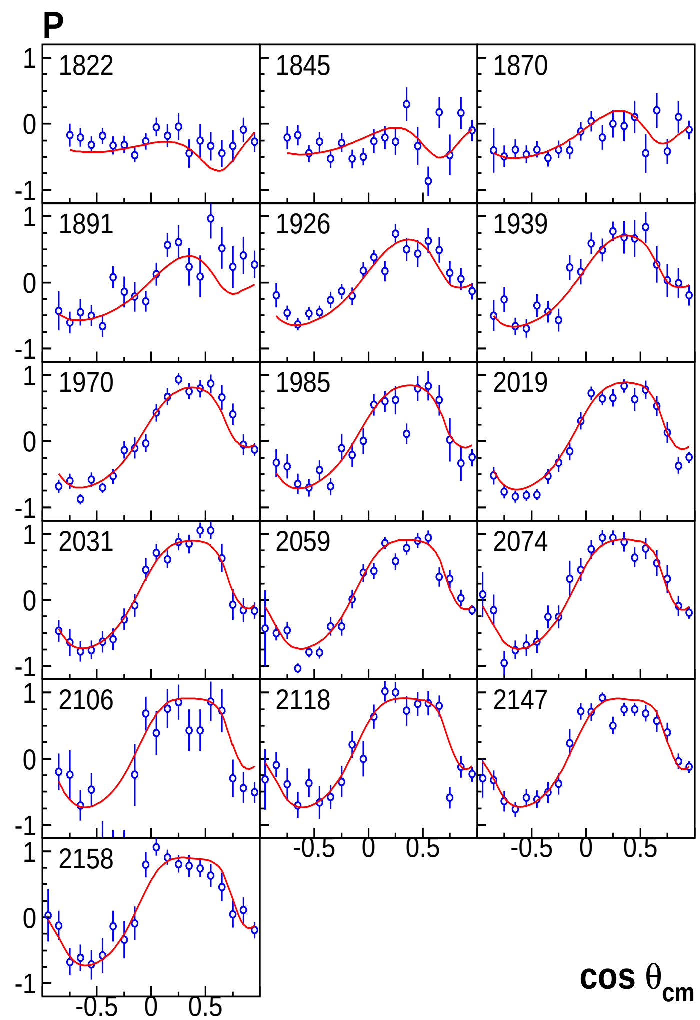


No $P_{11}(1710)$

The fit of the the $\pi^+ p \to K^+ \Sigma^+$ reaction with BG2011-02

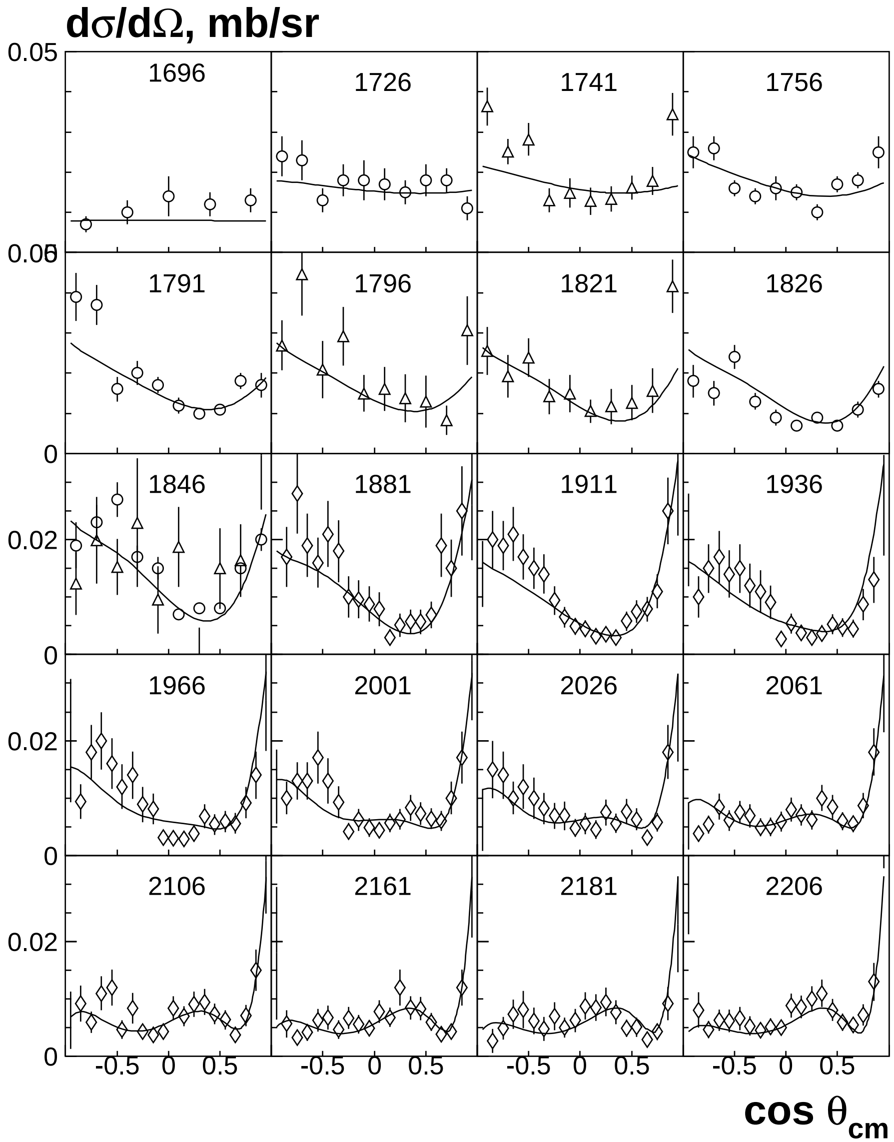




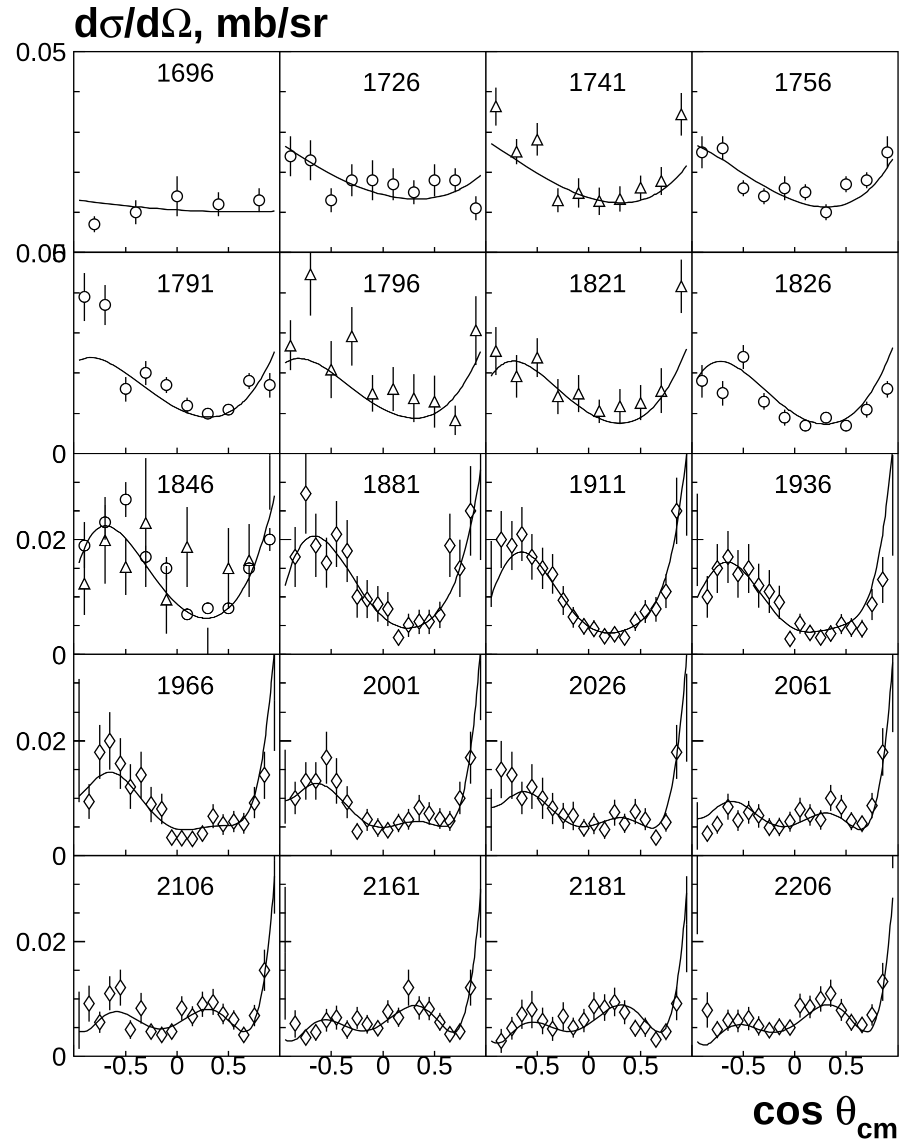


The fit of the the $\pi^- p \rightarrow K^0\Sigma^0$ differential cross section

BG2011-02 M



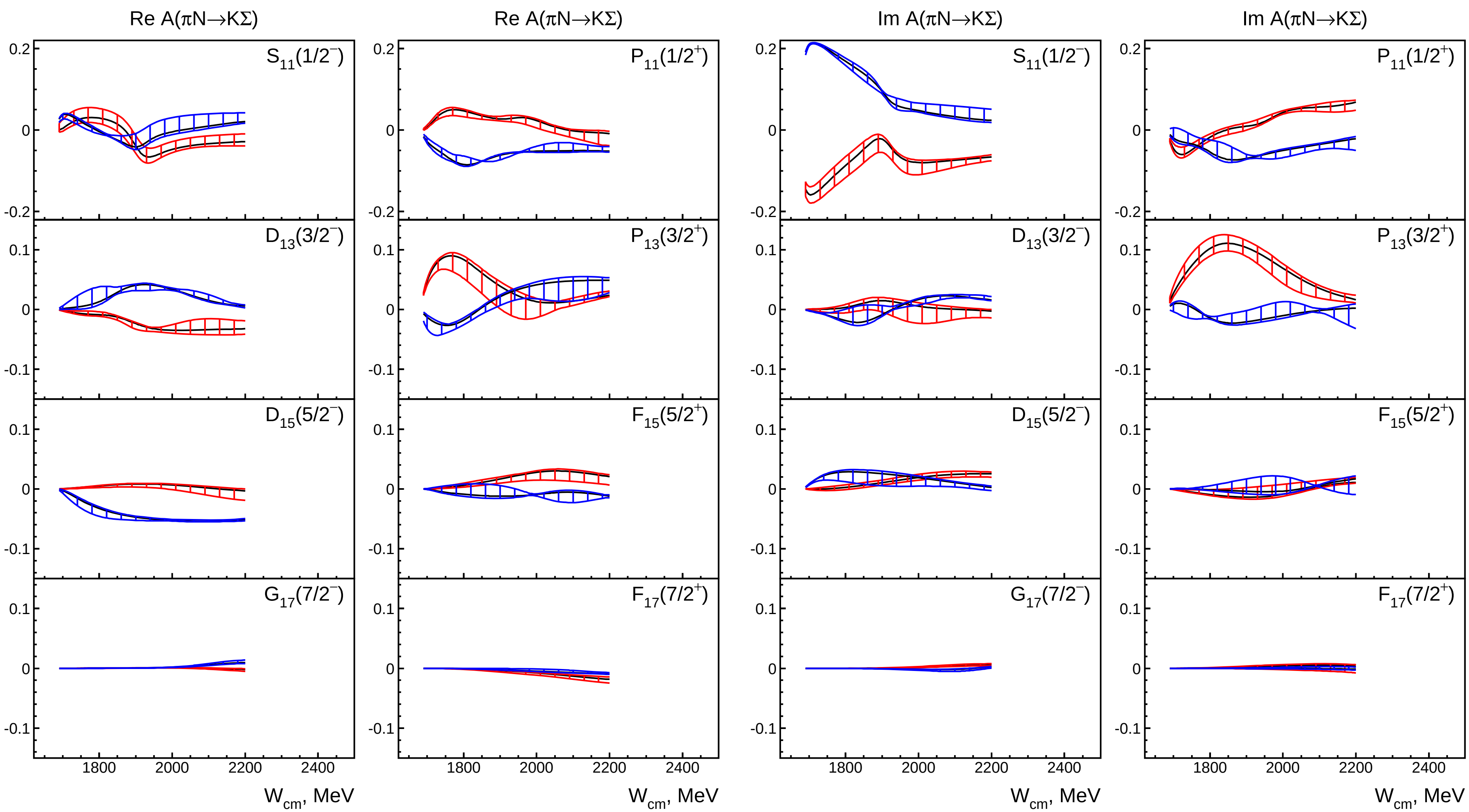
BG2013-02 S_{11}, D_{13}, F_{15}



The best solution was found with changed signs for S_{11}, D_{13} and F_{15} partial waves:

The I=1/2 $\pi N \to K\Sigma$ unitary amplitudes:

BG2011-02 M and BG2013-02



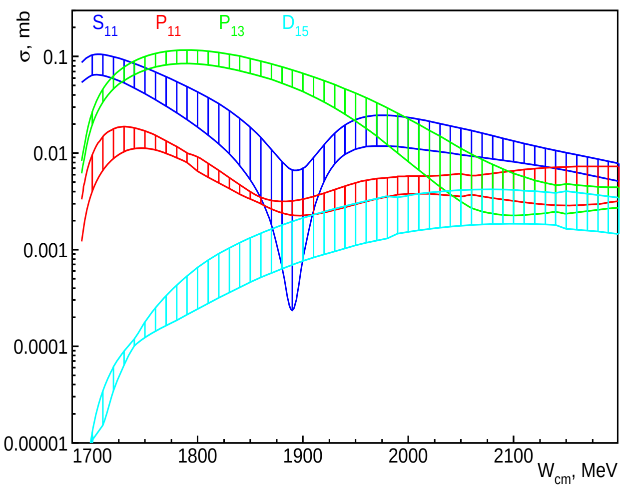
Quality of the description of the $K\Sigma$ data with the solutions BG2011-02 M and BG2013-02

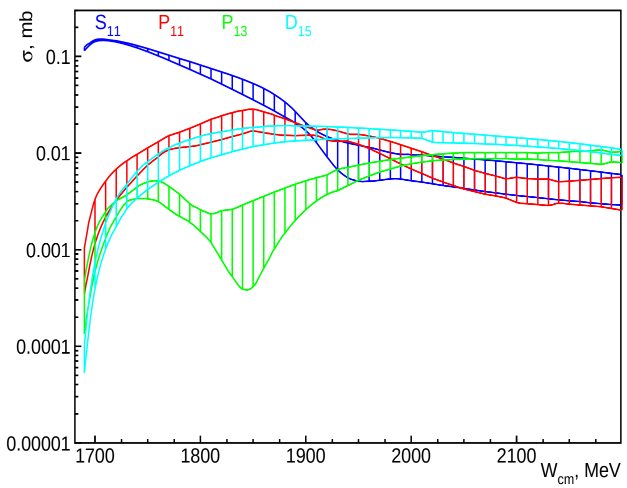
Obs.	BnGa 2011-02M	BnGa 2013-02	N		Obs.	BnGa 2011-02M	BnGa 2013-02	N	
		$\pi^+ p \to K^+\Sigma^+$					$\pi^- p \to K^0\Sigma^0$		
$d\sigma/d\Omega$	1.46	1.35	743	(var.)	$d\sigma/d\Omega$	1.02	0.69	220	(RAL)
P	1.42	1.48	351	(var.)	P	1.53	1.21	85	(RAL)
β	2.09	1.89	7	(RAL)	$d\sigma/d\Omega$	2.22	1.91	95	(RAL)
		$\pi^- p \to K^+\Sigma^-$					$\gamma p \to K^0\Sigma^+$		
$d\sigma/d\Omega$	2.45	2.42	130	(var.)	$d\sigma/d\Omega$	3.25	4.00	48	(CLAS)
		$\gamma p \to K^+\Sigma^0$			$d\sigma/d\Omega$	1.28	1.45	160	(SAPHIR)
$d\sigma/d\Omega$	1.30	1.49	1590	(CLAS)	$d\sigma/d\Omega$	0.87	0.94	72	(CBT)
$d\sigma/d\Omega$	1.45	1.40	1145	(MAMI)	P	0.96	0.82	72	(CBT)
P	2.43	2.17	344	(CLAS)	$d\sigma/d\Omega$	0.61	0.72	72	(CBT)
Σ	2.45	1.99	42	(GRAAL)	P	1.66	1.35	24	(CBT)
C_x	2.13	2.56	94	(CLAS)	Σ	2.04	1.68	15	(CBT)
C_z	2.13	2.06	94	(CLAS)					

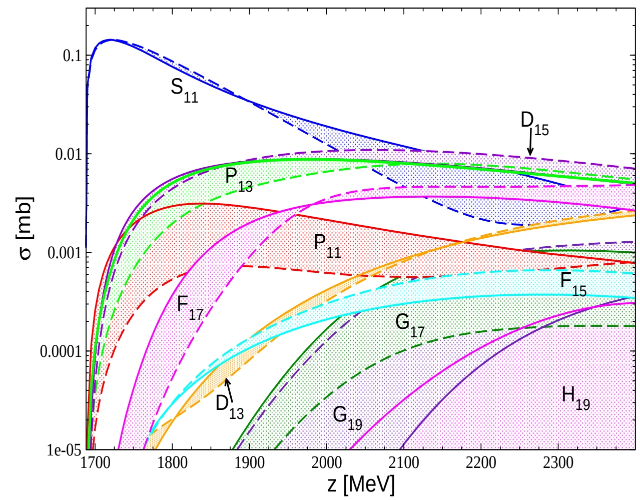
Partial wave contributions to the $\pi^- p \to K^0 \Sigma^0$ total cross section

BG2011-02 M | **BG2013-02** | **Bonn-Jülich**

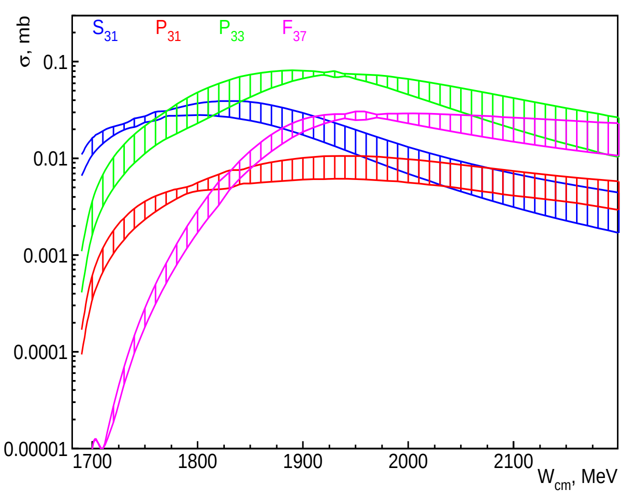
I=1/2

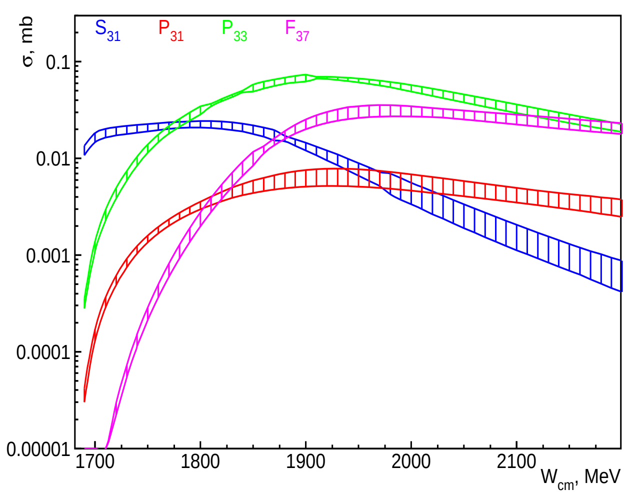


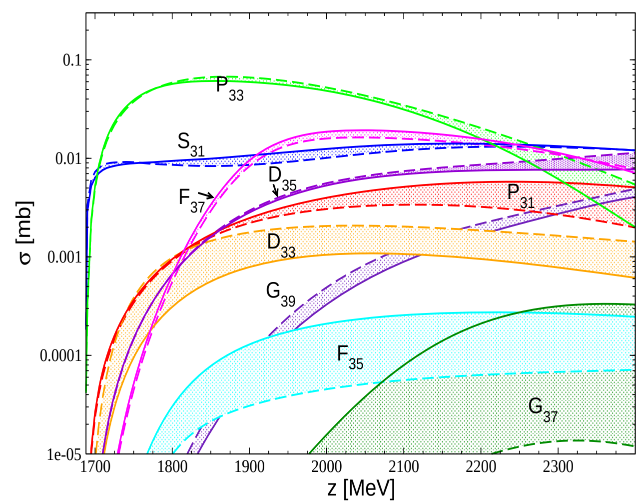




I=3/2





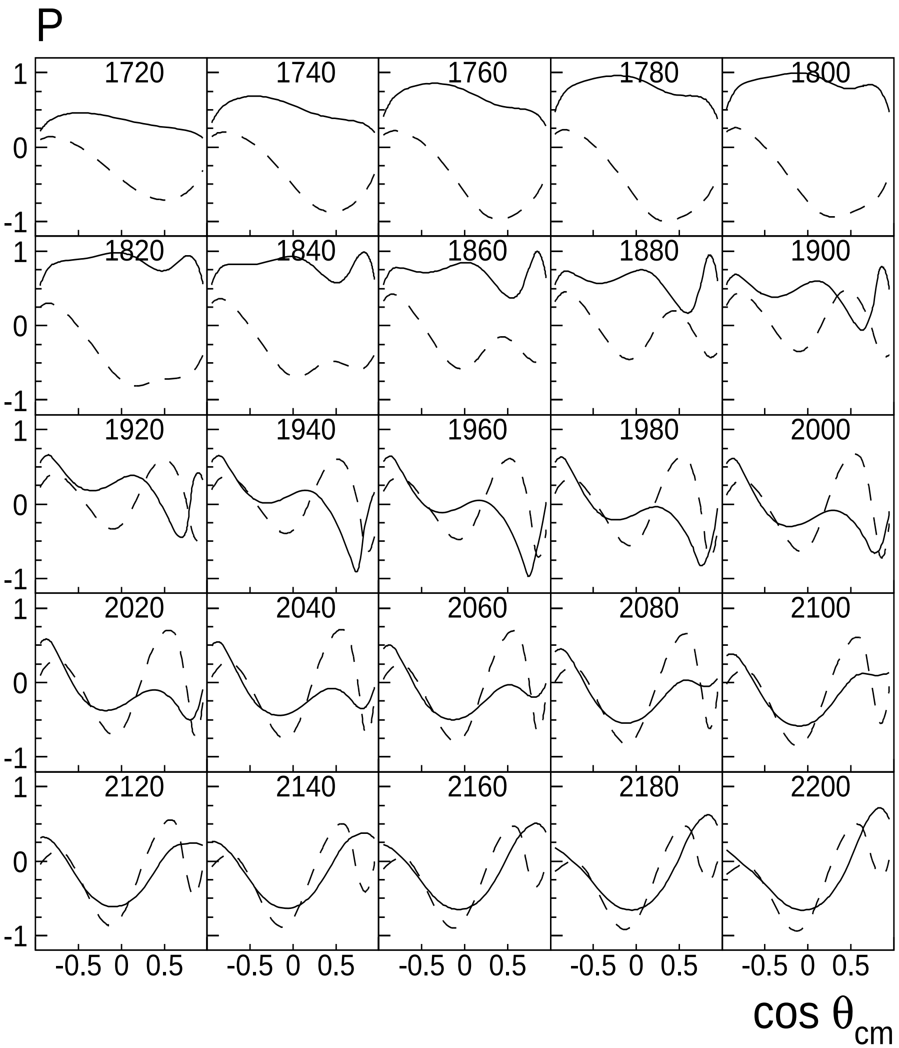


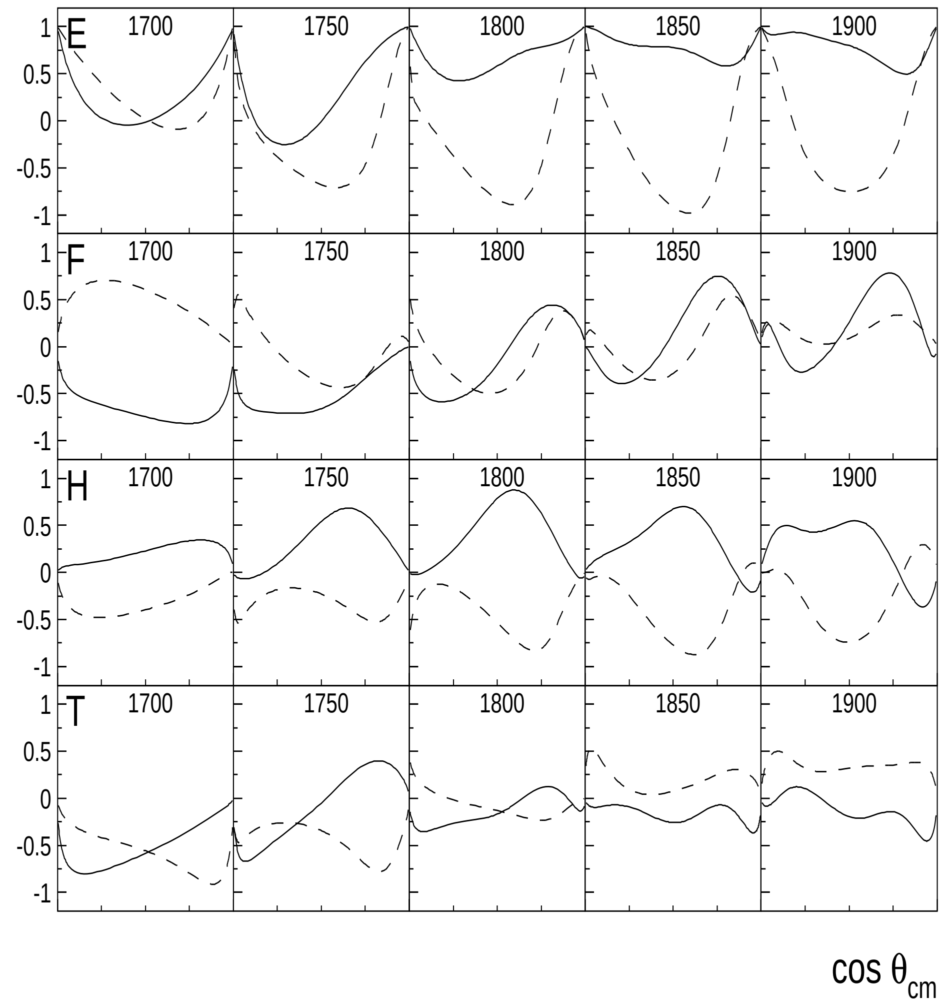
How to resolve this ambiguity? Measure more polarization observables

BG2011-02 M (dashed) **BG2013-02 (solid)**

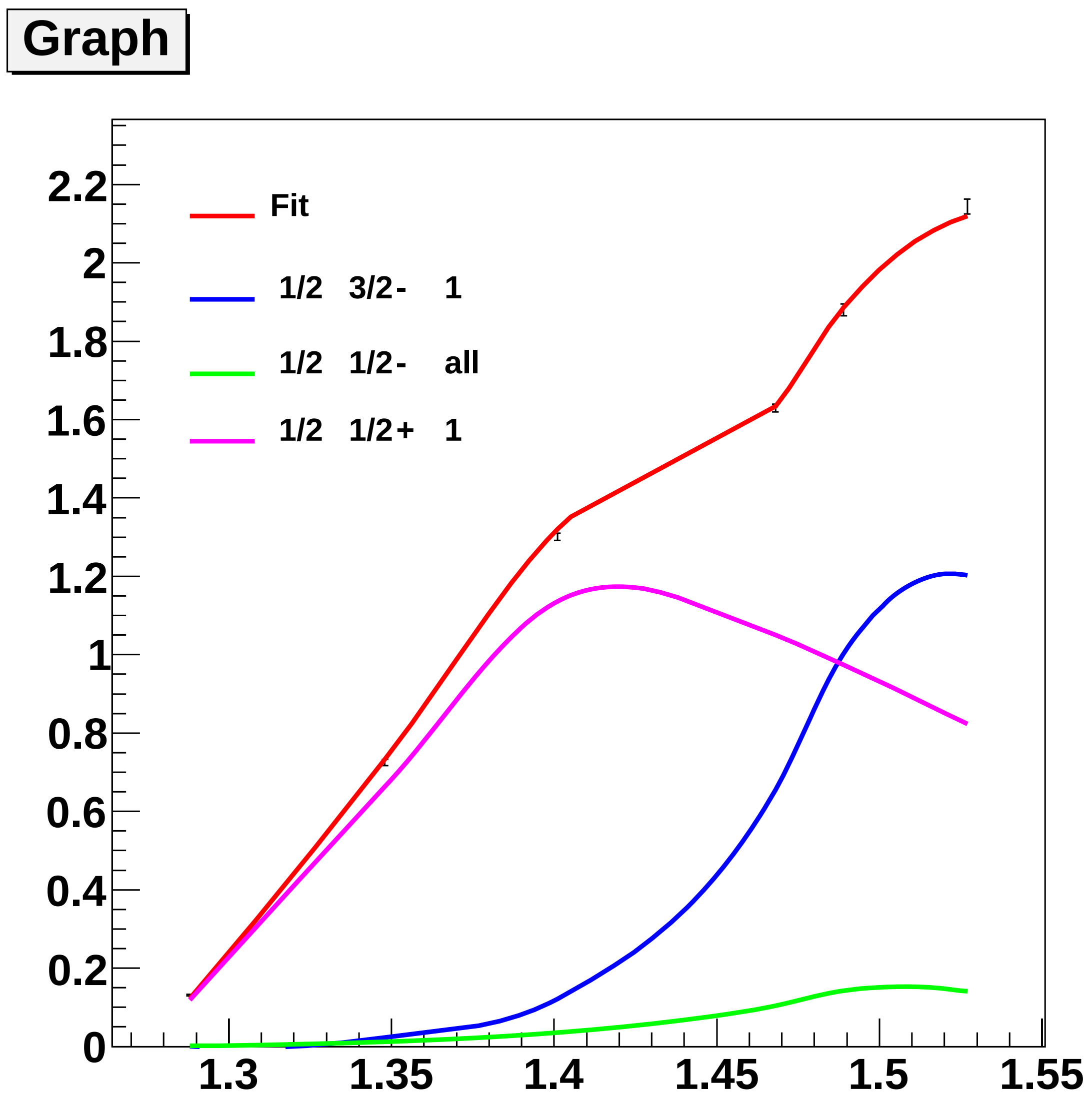
$$\pi^- p \to K^+ \Sigma^-$$

$$\gamma p \to K^0 \Sigma^+$$





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



Fit of the data

P_{11} **-partial wave**

D_{13} **-partial wave**

S_{11} **-partial wave**

$M_{pole} = 1369 \pm 3$

$\Gamma_{pole} = 189 \pm 5$

$M_{BW} = 1430 \pm 10$

$\Gamma_{BW} = 360 \pm 30$

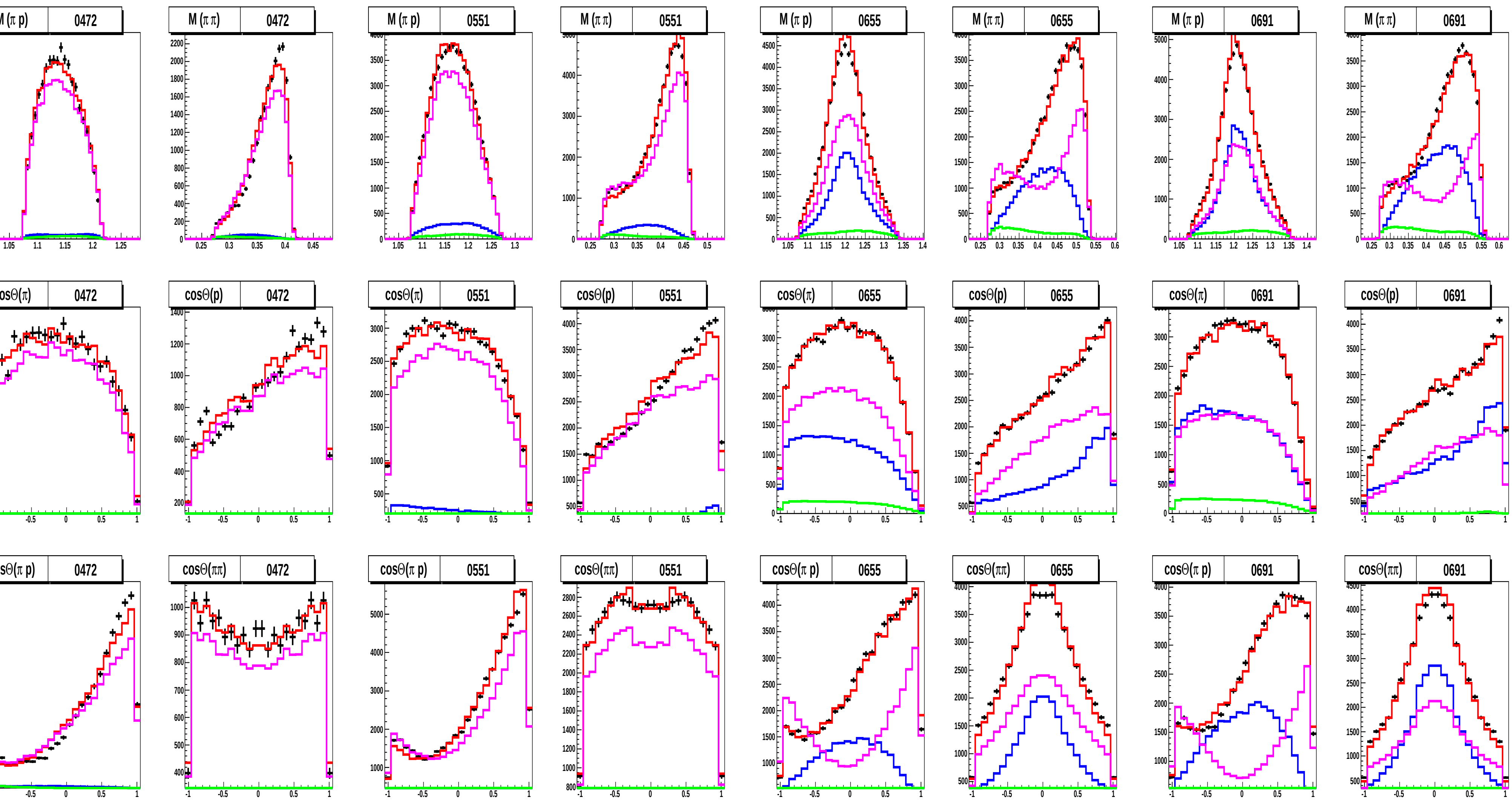
Br(πN)=63$\pm$2%

Br($\Delta(1232)\pi$)=20$\pm$ 7%

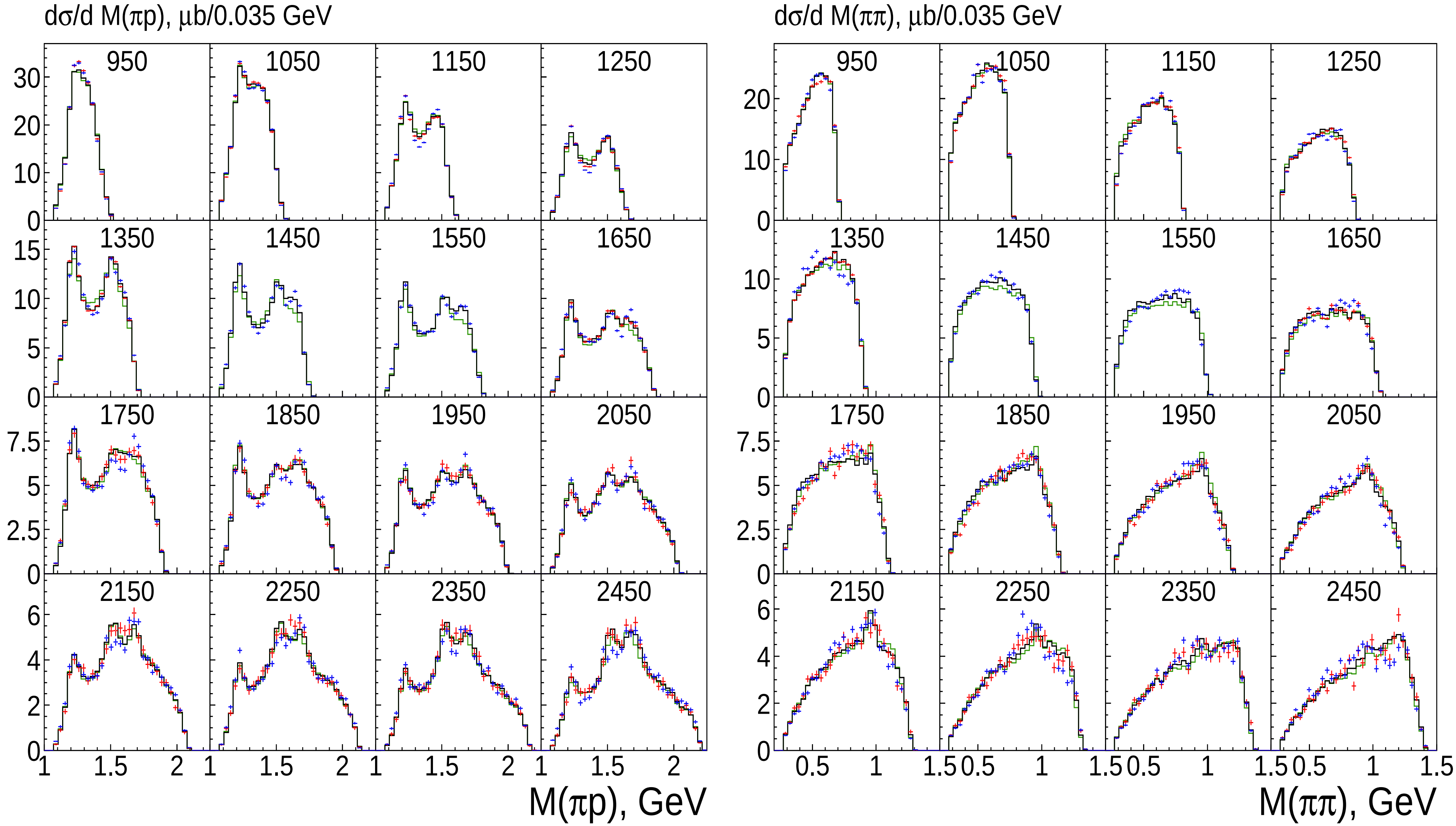
Br($N\sigma$)=17$\pm$ 6%

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

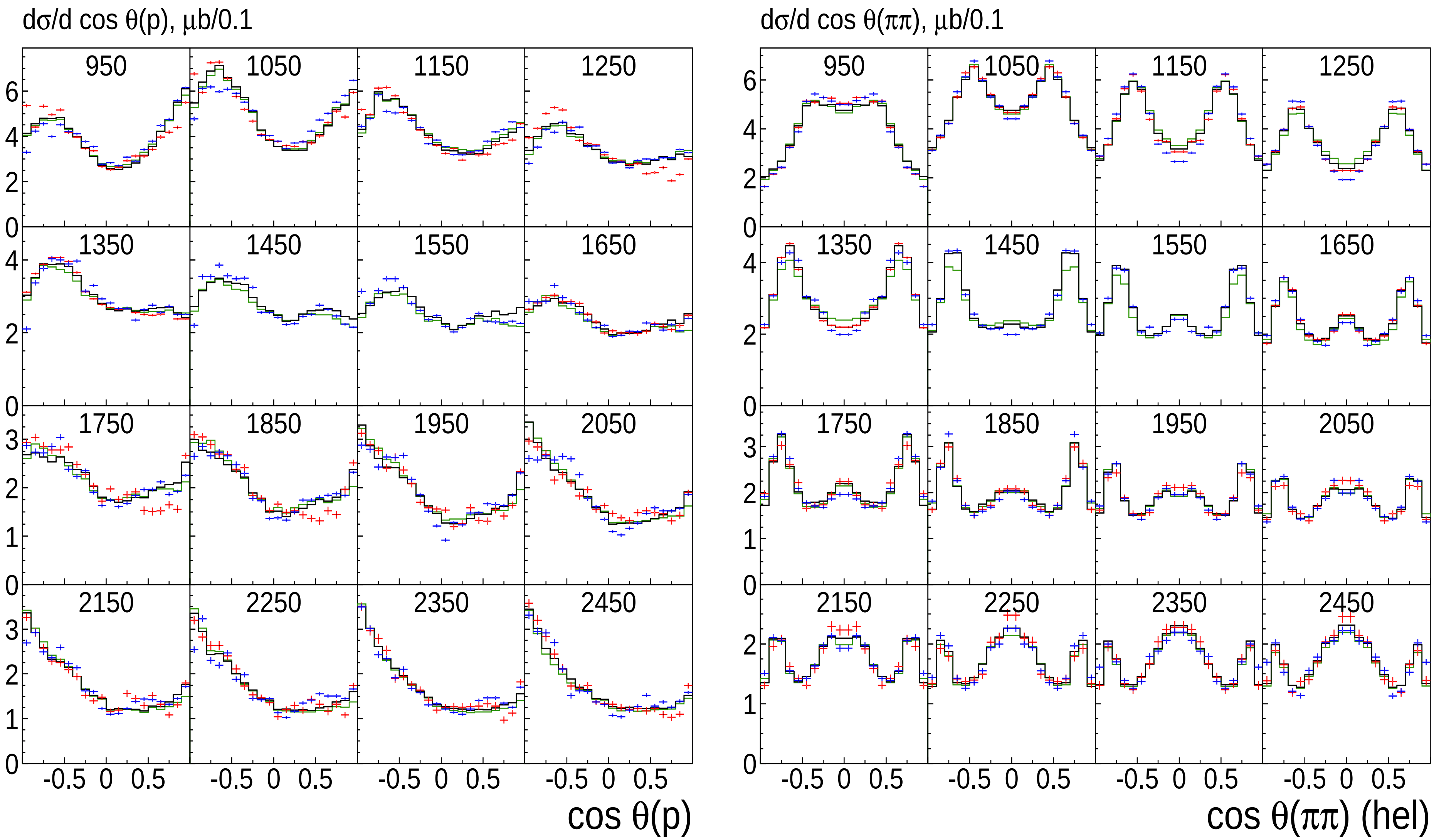
Differential cross sections for 472, 551, 665 and 691 MeV/c data.



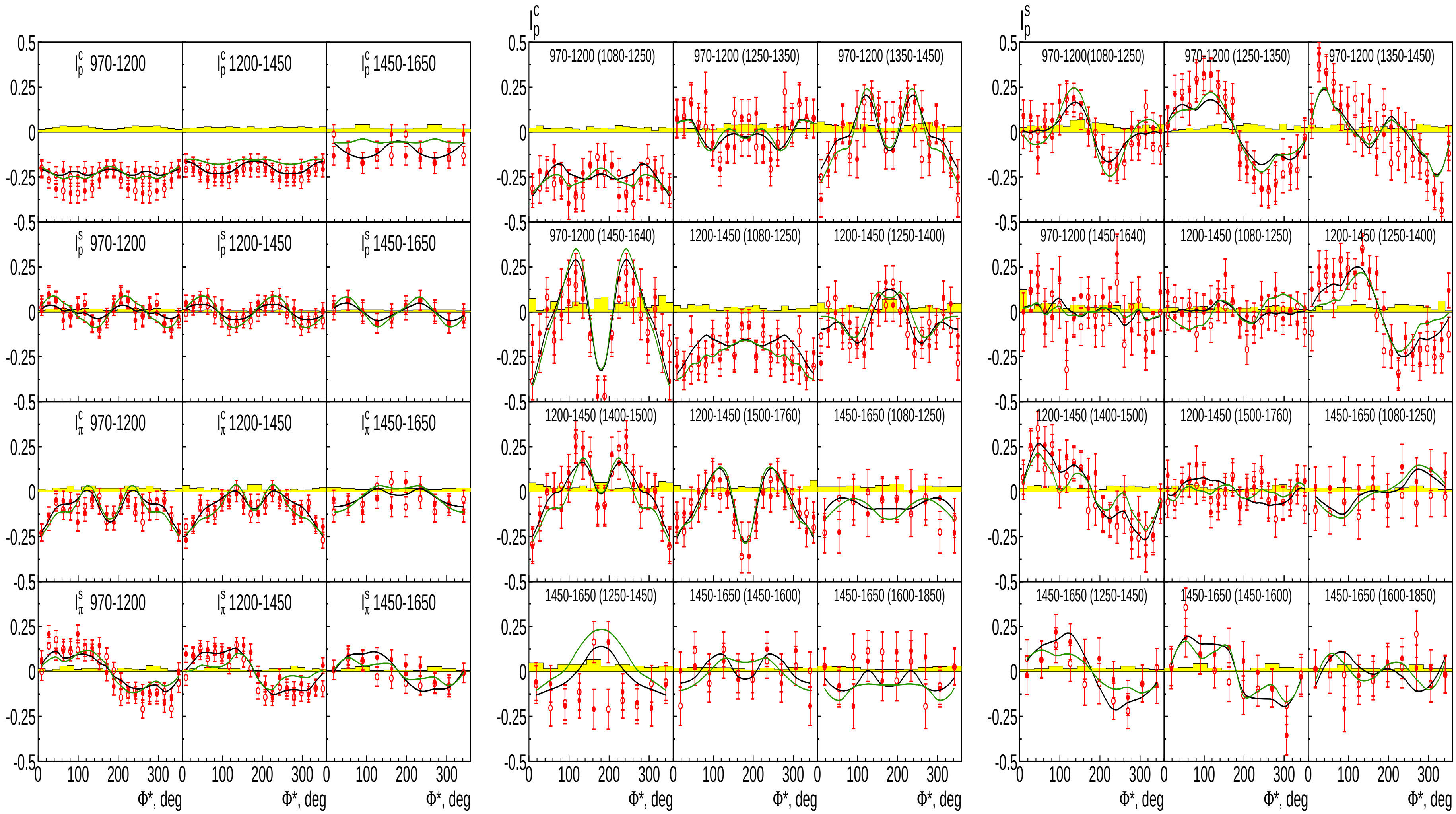
Differential cross section $\gamma p \to p\pi^0\pi^0$ (CB-ELSA)



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



I^c and I^s for $\gamma p \to p\pi^0\pi^0$ (CB-ELSA)



Width and branching ratios of resonances in the $2^{\rm nd}$ and $3^{\rm rd}$ resonance region

	Γ **(MeV)**	$N\pi$	$N\pi\pi$
$N(1440)1/2^+$	**325$\pm$125**	**0.65$\pm$0.10**	**0.35$\pm$0.05**
$N(1520)3/2^-$	**113$\pm$13**	**0.60$\pm$0.10**	**0.25$\pm$0.10**
$N(1535)1/2^-$	**150$\pm$25**	**0.45$\pm$0.10**	**0.05$\pm$0.05**
$N(1650)5/2^-$	**155$\pm$30**	**0.70$\pm$0.20**	**0.15$\pm$0.05**
$N(1675)5/2^-$	**150$\pm$20**	**0.40$\pm$0.05**	**0.55$\pm$0.05**
$N(1680)5/2^+$	**130$\pm$10**	**0.68$\pm$0.03**	**0.35$\pm$0.05**
$N(1700)3/2^-$	**175$\pm$75**	**0.65$\pm$0.10**	**0.35$\pm$0.05**
$N(1710)1/2^+$	**150$\pm$100**	**0.13$\pm$0.08**	**0.65$\pm$0.25**
$N(1720)3/2^+$	**275$\pm$125**	**0.11$\pm$0.03**	**0.80$\pm$0.10**
$\Delta(1620)1/2^-$	**140$\pm$10**	**0.25$\pm$0.05**	**0.15$\pm$0.05**
$\Delta(1700)3/2^-$	**300$\pm$100**	**0.15$\pm$0.05**	**0.75$\pm$0.05**

SUMMARY

- **6 new baryon states were observed in the combined analysis of πN and γN data.**
- **πN inelastic data play a notable role in the analysis.**
- **Unfortunately the πN data on number of important final states either do not exist or missing:**
  e.g. data on $\pi^- p \to \pi^+\pi - p$ and $\pi^- p \to \eta n$ would provide an important constrain to the analysis.
- **The baryon resonances can be successfully studied in NN collision reactions.**
- **Analysis of polarization observables in NN collision reactions can provide a unique solution and reveal a signal from weak states.**