Bonn-Gatchina partial wave analysis: search for high spin baryon states

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Bonn-Gatchina Partial Wave Analysis

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

Analysis of Other Groups

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

CB-ELSA Homepage

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Last changes: January 26th, 2010.

Search for baryon states

1. **Analysis of single meson 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.**
2. **Analysis of single meson and double meson pion-induced reactions.**
   $\pi N \to \pi N, \eta N, K\Lambda, K\Sigma, \pi\pi N$**.**

Search for meson states

1. **Analysis of the $p\bar{p}$ annihilation at rest and $\pi\pi$ interaction data.**
2. **Analysis of the $p\bar{p}$ annihilation in flight into two and tree meson final state.**
3. **Analysis of the J/Ψ decays (BES III collaboration).**

Analysis of NN interaction

1. **Analysis of single and double meson production $NN \to \pi NN$ and $\pi\pi NN$**
2. **Analysis of hyperon production $NN \to K\Lambda p$**

A combined analysis of data from different experiments

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

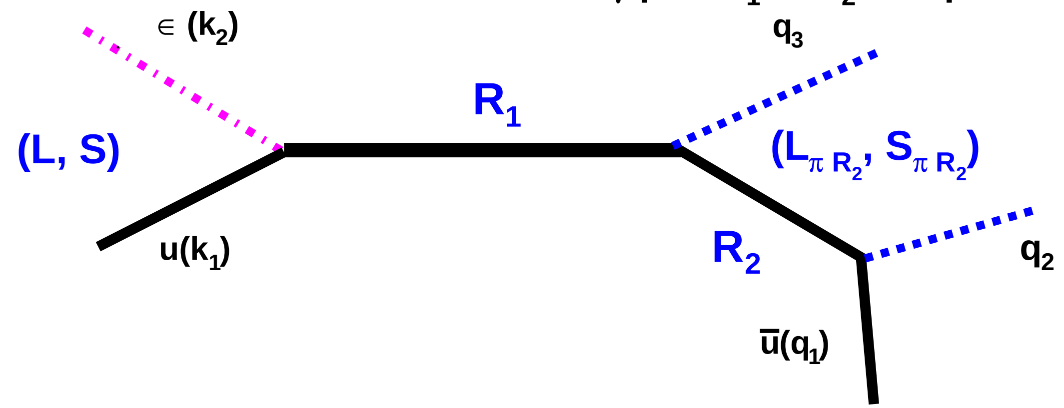
A. Anisovich, E. Klempt, A. Sarantsev and U. Thoma, Eur. Phys. J. A 24, 111 (2005)

A. V. Anisovich and A. V. Sarantsev, Eur. Phys. J. A 30 (2006) 427

A. V. Anisovich, V. V. Anisovich, E. Klempt, V. A. Nikonov and A. V. Sarantsev, Eur. Phys. J. A 34 (2007) 129.

Resonance amplitudes for meson photoproduction

$\gamma\, p \to R_1 \to R_2\, \pi \to p\, \pi\, \pi$



General form of the angular dependent part of the amplitude:

$$\bar{u}(q_1)\tilde{N}_{\alpha_1\dots\alpha_n}(R_2\to\mu N)F^{\alpha_1\dots\alpha_n}_{\beta_1\dots\beta_n}(q_1+q_2)\tilde{N}^{(j)\beta_1\dots\beta_n}_{\gamma_1\dots\gamma_m}(R_1\to\mu R_2)$$
$$F^{\gamma_1\dots\gamma_m}_{\xi_1\dots\xi_m}(P)V^{(i)\mu}_{\xi_1\dots\xi_m}(R_1\to\gamma N)u(k_1)\varepsilon_\mu$$

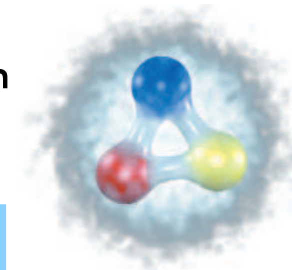
$$F^{\mu_1\dots\mu_L}_{\nu_1\dots\nu_L}(p) = (m+\hat{p})O^{\mu_1\dots\mu_L}_{\alpha_1\dots\alpha_L}\frac{L+1}{2L+1}\;\; g^{\perp}_{\alpha_1\beta_1} - \frac{L}{L+1}\sigma_{\alpha_1\beta_1}\;\;\prod_{i=2}^{L} g_{\alpha_i\beta_i}O^{\beta_1\dots\beta_L}_{\nu_1\dots\nu_L}$$

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

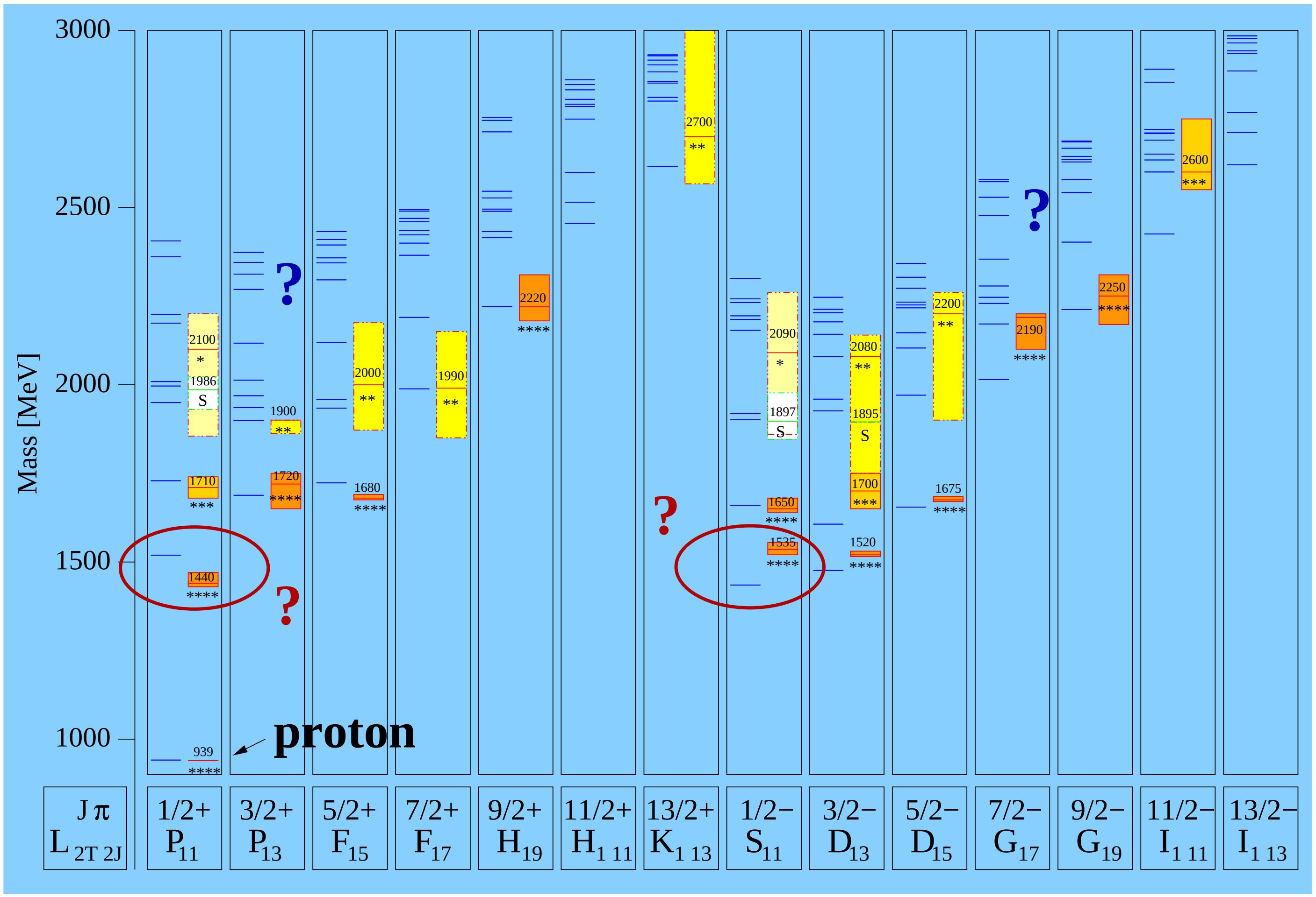
N*- resonances in the quark model

Nukleon

10^{-15} m



U. Loering, B. Metsch, H. Petry et al. (Bonn)



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Constituent quarks

Confinement-potential

Residual interaction

Data Base

Pion induced reactions (χ^2 analysis).

Observable	$N_{\rm data}$	$\frac{\chi^2}{N_{\rm data}}$		Observable	$N_{\rm data}$	$\frac{\chi^2}{N_{\rm data}}$	
$N^*_{1/2-}$ $S_{11}(\pi N\to\pi N)$	104	1.81	SAID	$\Delta_{1/2-}$ $S_{31}(\pi N\to\pi N)$	112	2.27	SAID
$N^*_{1/2+}$ $P_{11}(\pi N\to\pi N)$	112	2.49	SAID	$\Delta_{1/2+}$ $P_{31}(\pi N\to\pi N)$	104	2.01	SAID
$N^*_{3/2+}$ $P_{13}(\pi N\to\pi N)$	112	1.90	SAID	$\Delta^*_{3/2+}$ $P_{33}(\pi N\to\pi N)$	120	2.53	SAID
$\Delta^*_{3/2-}$ $D_{33}(\pi N\to\pi N)$	108	2.56	SAID	$N^*_{3/2-}$ $D_{13}(\pi N\to\pi N)$	96	2.16	SAID
$N^*_{5/2-}$ $D_{15}(\pi N\to\pi N)$	96	3.37	SAID	$\Delta_{5/2+}$ $F_{35}(\pi N\to\pi N)$	62	1.32	SAID
$\Delta_{7/2+}$ $F_{37}(\pi N\to\pi N)$	72	2.86	SAID	$N^*_{7/2-}$ $G_{17}(\pi N\to\pi N)$	102	2.69	SAID
$d\sigma/d\Omega(\pi^- p\to n\eta)$	70	1.96	Richards *et al.*	$d\sigma/d\Omega(\pi^- p\to n\eta)$	84	2.67	CBALL
$d\sigma/d\Omega(\pi^- p\to K\Lambda)$	598	1.68	RAL	$P(\pi^- p\to K\Lambda)$	355	1.96	RAL+ANL
				$\beta(\pi^- p\to K\Lambda)$	72	2.45	RAL
$d\sigma/d\Omega(\pi^+ p\to K^+\Sigma)$	609	1.24	RAL	$P(\pi^+ p\to K^+\Sigma)$	307	1.49	RAL
				$\beta(\pi^+ p\to K^+\Sigma)$	7	1.97	RAL
$d\sigma/d\Omega(\pi^- p\to K^0\Sigma^0)$	259	0.85	RAL	$P(\pi^- p\to K^0\Sigma^0)$	95	1.25	RAL

Data Base

π and η photoproduction reactions (χ^2 analysis).

Observable	$N_{\rm data}$	$\frac{\chi^2}{N_{\rm data}}$		Observable	$N_{\rm data}$	$\frac{\chi^2}{N_{\rm data}}$	
$d\sigma/d\Omega(\gamma p\to p\pi^0)$	1106	1.34	CB-ELSA	$d\sigma/d\Omega(\gamma p\to p\pi^0)$	861	1.46	GRAAL
$d\sigma/d\Omega(\gamma p\to p\pi^0)$	592	2.11	CLAS	$d\sigma/d\Omega(\gamma p\to p\pi^0)$	1692	1.25	TAPS@MAMI
$E(\gamma p\to p\pi^0)$	140	1.23	A2-GDH	$\Sigma(\gamma p\to p\pi^0)$	1492	3.26	SAID db
$P(\gamma p\to p\pi^0)$	607	3.23	SAID db	$T(\gamma p\to p\pi^0)$	389	3.71	SAID db
$H(\gamma p\to p\pi^0)$	71	1.26	SAID db	$G(\gamma p\to p\pi^0)$	75	1.50	SAID db
$O_x(\gamma p\to p\pi^0)$	7	1.77	SAID db	$O_z(\gamma p\to p\pi^0)$	7	0.46	SAID db
$d\sigma/d\Omega(\gamma p\to n\pi^+)$	1583	1.64	SAID db	$d\sigma/d\Omega(\gamma p\to n\pi^+)$	408	0.62	A2-GDH
$\Sigma(\gamma p\to n\pi^+)$	899	3.48	SAID db	$E(\gamma p\to n\pi^+$	231	1.55	A2-GDH
$P(\gamma p\to n\pi^+)$	252	2.90	SAID db	$T(\gamma p\to n\pi^+)$	661	3.21	SAID db
$H(\gamma p\to p\pi^+)$	71	3.90	SAID db	$G(\gamma p\to p\pi^+)$	86	5.64	SAID db
$d\sigma/d\Omega(\gamma p\to p\eta)$	680	1.47	CB-ELSA	$d\sigma/d\Omega(\gamma p\to p\eta)$	100	2.16	TAPS
$\Sigma(\gamma p\to p\eta)$	51	2.26	GRAAL 98	$\Sigma(\gamma p\to p\eta)$	100	2.02	GRAAL 07
$T(\gamma p\to p\eta)$	50	1.48	Phoenics				

Data Base

Kaon photoproduction (χ^2 analysis).

Observable	$N_{\rm data}$	$\frac{\chi^2}{N_{\rm data}}$		Observable	$N_{\rm data}$	$\frac{\chi^2}{N_{\rm data}}$	
$C_x(\gamma p \to \Lambda K^+)$	160	1.23	CLAS	$C_x(\gamma p \to \Sigma^0 K^+)$	94	2.20	CLAS
$C_z(\gamma p \to \Lambda K^+)$	160	1.41	CLAS	$C_z(\gamma p \to \Sigma^0 K^+)$	94	2.00	CLAS
$d\sigma/d\Omega(\gamma p \to \Lambda K^+)$	1320	0.81	CLAS09	$d\sigma/d\Omega(\gamma p \to \Sigma^0 K^+)$	1280	2.06	CLAS
$P(\gamma p \to \Lambda K^+)$	1270	2.21	CLAS09	$P(\gamma p \to \Sigma^0 K^+)$	95	1.45	CLAS
$\Sigma(\gamma p \to \Lambda K^+)$	66	1.53	GRAAL	$\Sigma(\gamma p \to \Sigma^0 K^+)$	42	0.90	GRAAL
$\Sigma(\gamma p \to \Lambda K^+)$	45	1.65	LEP	$\Sigma(\gamma p \to \Sigma^0 K^+)$	45	1.11	LEP
$T(\gamma p \to \Lambda K^+)$	66	1.26	GRAAL 09	$d\sigma/d\Omega(\gamma p \to \Sigma^+ K^0)$	48	3.76	CLAS
$O_x(\gamma p \to \Lambda K^+)$	66	1.30	GRAAL 09	$O_z(\gamma p \to \Lambda K^+)$	66	1.54	GRAAL 09
$d\sigma/d\Omega(\gamma p \to \Sigma^+ K^0)$	72	0.74	CB-ELSA 10	$P(\gamma p \to \Sigma^+ K^0)$	24	1.06	CB-ELSA 10
$\Sigma(\gamma p \to \Sigma^+ K^0)$	15	1.13	CB-ELSA 10				

Data Base

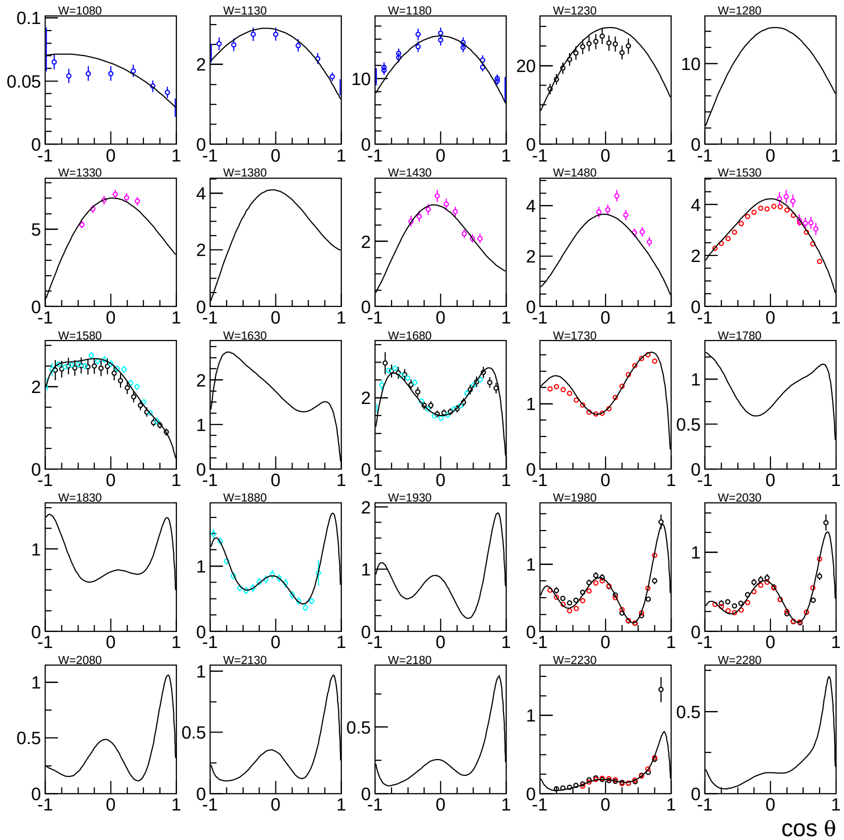
Multi-meson final states (maximum likelihood analysis).

$d\sigma/d\Omega(\pi^- p \to n\pi^0\pi^0)$	**CBALL**				
$\mathrm{d}\sigma/\mathrm{d}\Omega(\gamma \mathrm{p} \to \mathrm{p}\pi^0\pi^0)$	**CB-ELSA (1.4 GeV)**	$\mathrm{E}(\gamma \mathrm{p} \to \mathrm{p}\pi^0\pi^0)$	**16**	**1.91**	**MAMI**
$\mathrm{d}\sigma/\mathrm{d}\Omega(\gamma \mathrm{p} \to \mathrm{p}\pi^0\eta)$	**CB-ELSA (3.2 GeV)**	$\Sigma(\gamma \mathrm{p} \to \mathrm{p}\pi^0\eta)$	**180**	**2.37**	**GRAAL**
$\mathrm{d}\sigma/\mathrm{d}\Omega(\gamma \mathrm{p} \to \mathrm{p}\pi^0\pi^0)$	**CB-ELSA (3.2 GeV)**	$\Sigma(\gamma \mathrm{p} \to \mathrm{p}\pi^0\pi^0)$	**128**	**0.96**	**GRAAL**
$\mathrm{d}\sigma/\mathrm{d}\Omega(\gamma \mathrm{p} \to \mathrm{p}\pi^0\eta)$	**CB-ELSA (3.2 GeV)**	$\Sigma(\gamma \mathrm{p} \to \mathrm{p}\pi^0\eta)$	**180**	**2.37**	**GRAAL**
$\mathrm{I_c}(\gamma \mathrm{p} \to \mathrm{p}\pi^0\eta)$	**CB-ELSA (3.2 GeV)**	$\mathrm{I_s}(\gamma \mathrm{p} \to \mathrm{p}\pi^0\eta)$	**CB-ELSA (3.2 GeV)**		

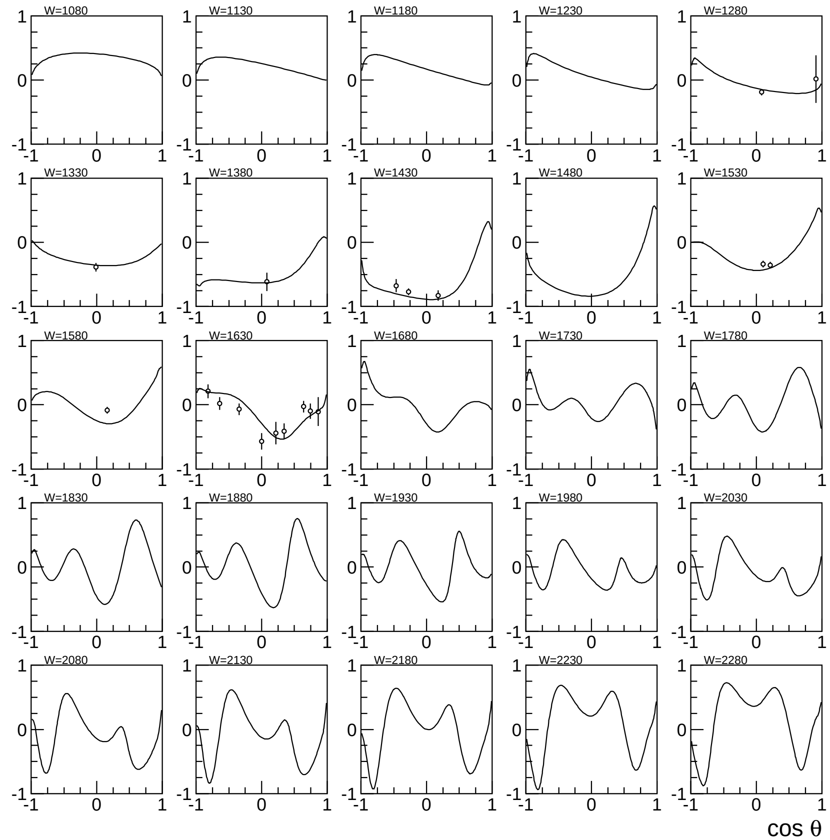
In $\pi N \rightarrow meson - baryon$ experiment three observables are needed for a complete experiment: differential cross section, analyzing power and rotation parameter.

For a complete photoproduction experiment 8 observables are needed. But...

polarization observables are more sensitive to small contributions.



$d\sigma/d\Omega$



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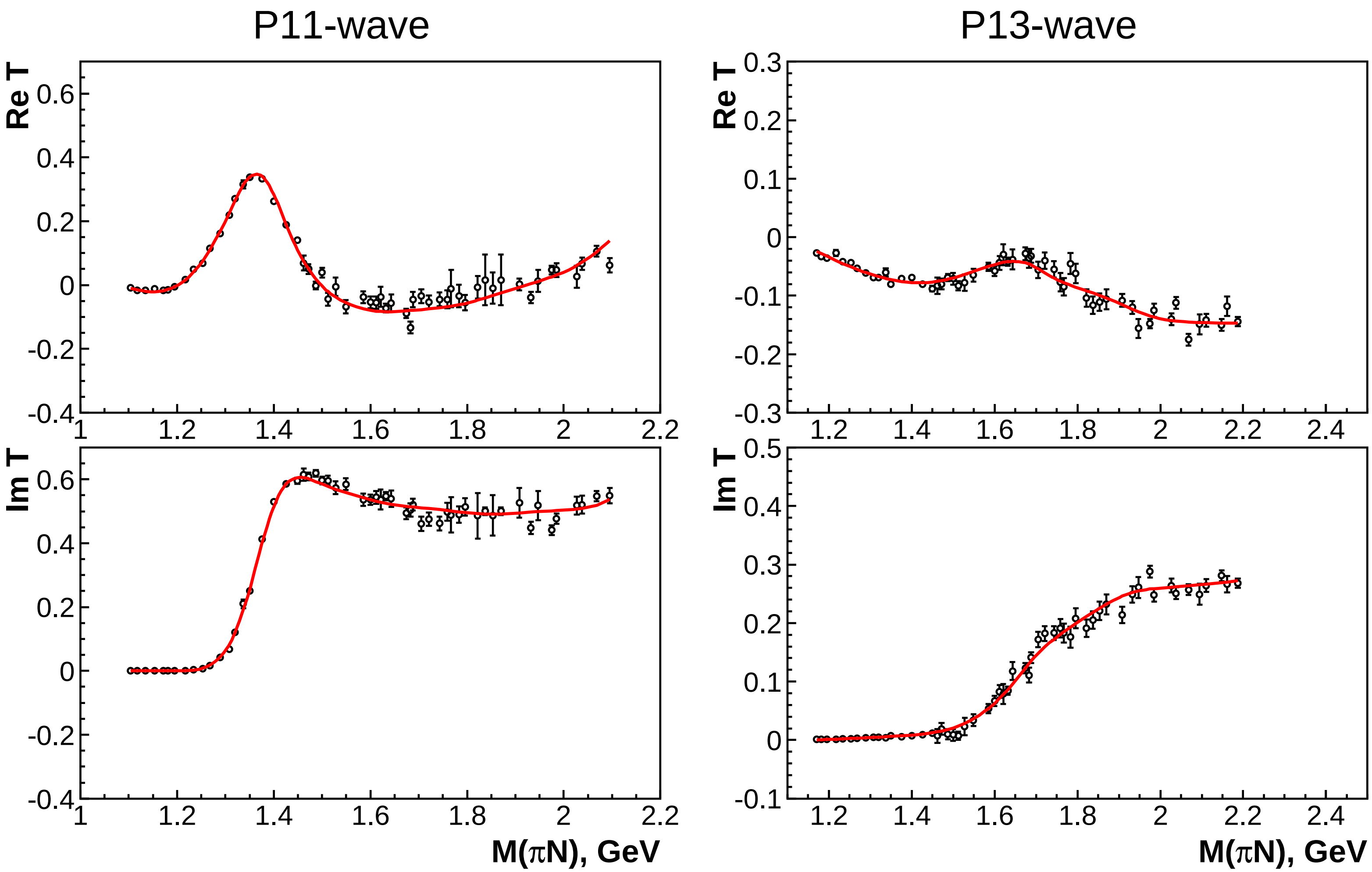
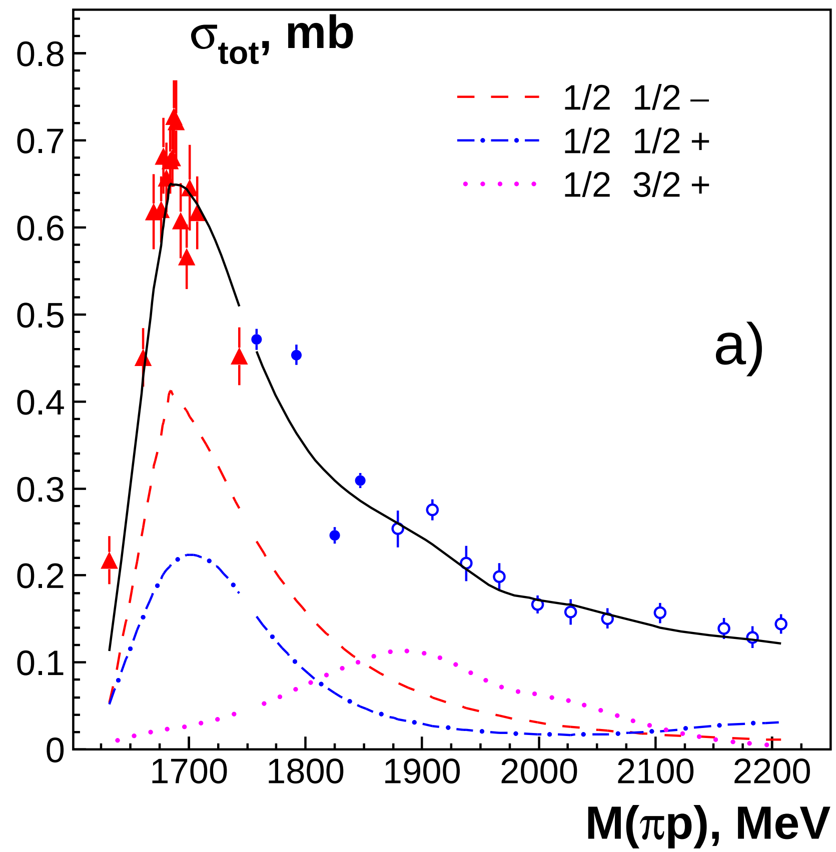
The SAID energy independent solution for P_{11} and P_13 partial waves



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.

Amplitude for the πN transition into channels πN, ηN, $K\Lambda$ and $K\Sigma$:

$$A_{\pi N} = \omega^* \left[G(s,t) + H(s,t) i(\vec{\sigma}\vec{n})\right] \omega' \qquad \vec{n}_j = \varepsilon_{\mu\nu j} \frac{q_\mu k_\nu}{|\vec{k}||\vec{q}|} .$$

$$G(s,t) = \sum_L \left[(L+1) F_L^+(s) + L F_L^-(s)\right] P_L(z) ,$$

$$H(s,t) = \sum_L \left[F_L^+(s) - F_L^-(s)\right] P'_L(z) .$$

$z = \cos\Theta$**, the angle of the final meson in c.m.s.**

$$|A|^2 = \frac{1}{2} \mathrm{Tr}\left[A^*_{\pi N} A_{\pi N}\right] = |G(s,t)|^2 + |H(s,t)|^2 (1 - z^2)$$

and the recoil asymmetry can be calculated as:

$$P = \frac{\mathrm{Tr}\left[A^*_{\pi N} \sigma_2 A_{\pi N}\right]}{2|A|^2 \cos\phi} = \sin\Theta \frac{2Im\left(H^*(s,t) G(s,t)\right)}{|A|^2} .$$

Near threshold, only contributions from S and P-waves are expected. For the $S_{2I,2J}$ and $P_{2I,2J}$ amplitudes we have

$$\underline{S_{2I,1}}; \quad G = F_0^+; \quad H = 0; \quad |A|^2 = |F_0^+|^2 \tag{1}$$

$$\underline{P_{2I,1}}; \quad G = F_1^- z; \quad H = -F_1^-; \quad |A|^2 = |F_1^-|^2 \tag{2}$$

$$\underline{P_{2I,3}}; \quad G = 2F_1^+ z; \quad H = F_1^+; \quad |A|^2 = |F_1^+|^2(3z^2+1)$$

where the indices $(2I, 2J)$ remind of the isospin I and the spin J of the partial waves.

The recoil asymmetry vanishes unless different amplitudes interfere.

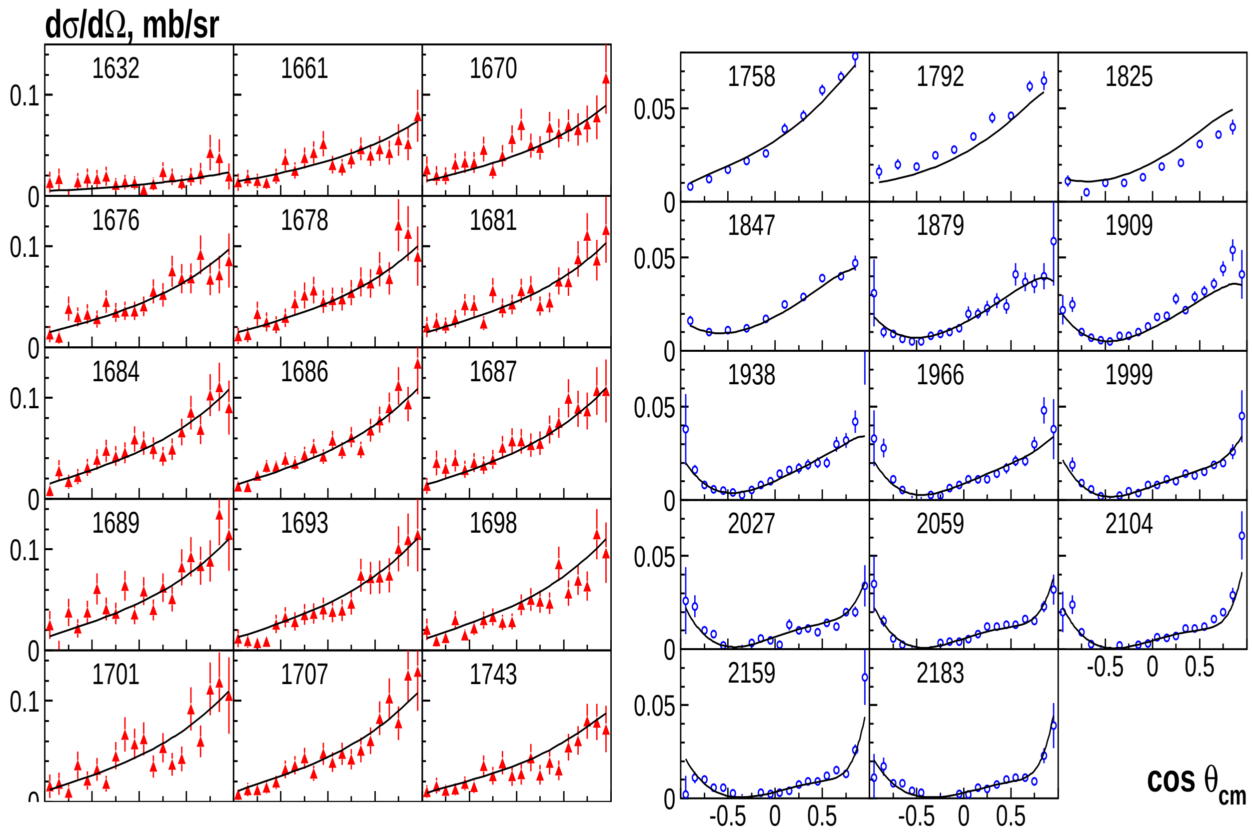
$$\underline{S_{2I,1}+P_{2I,1}}: \quad P\frac{|A|^2}{\sin\Theta} = -2Im(F_0^+ F_1^{-*}) \quad |A|^2 = |F_0^+|^2 + |F_1^-|^2 + 2zRe(F_0^{+*} F_1^-)$$

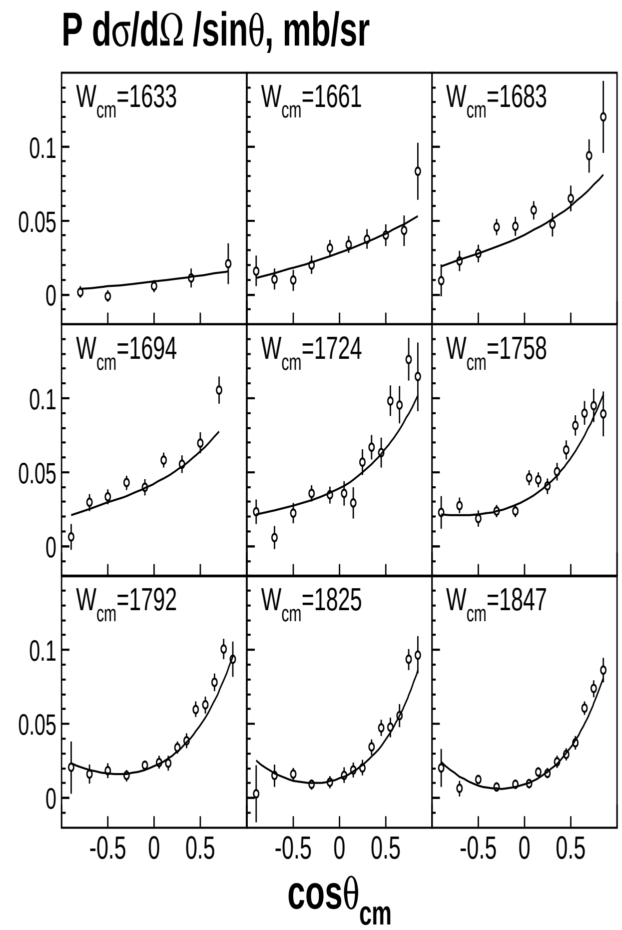
$$\underline{S_{2I,1}+P_{2I,3}}: \quad P\frac{|A|^2}{\sin\Theta} = 2Im(F_0^+ F_1^{+*}) \quad |A|^2 = |F_0^+|^2 + |F_1^+|^2(3z^2+1) + 4zRe(F_0^{+*} F_1^+)$$

$$\underline{P_{2I,1}+P_{2I,3}}: \quad P\frac{|A|^2}{\sin\Theta} = 6zIm(F_1^{+*} F_1^-) \quad |A|^2 = |F_1^+ - F_1^-|^2 + z^2 \quad 3|F_1^+|^2 - 2Re(F_1^{+*} F_1^-) \quad .$$

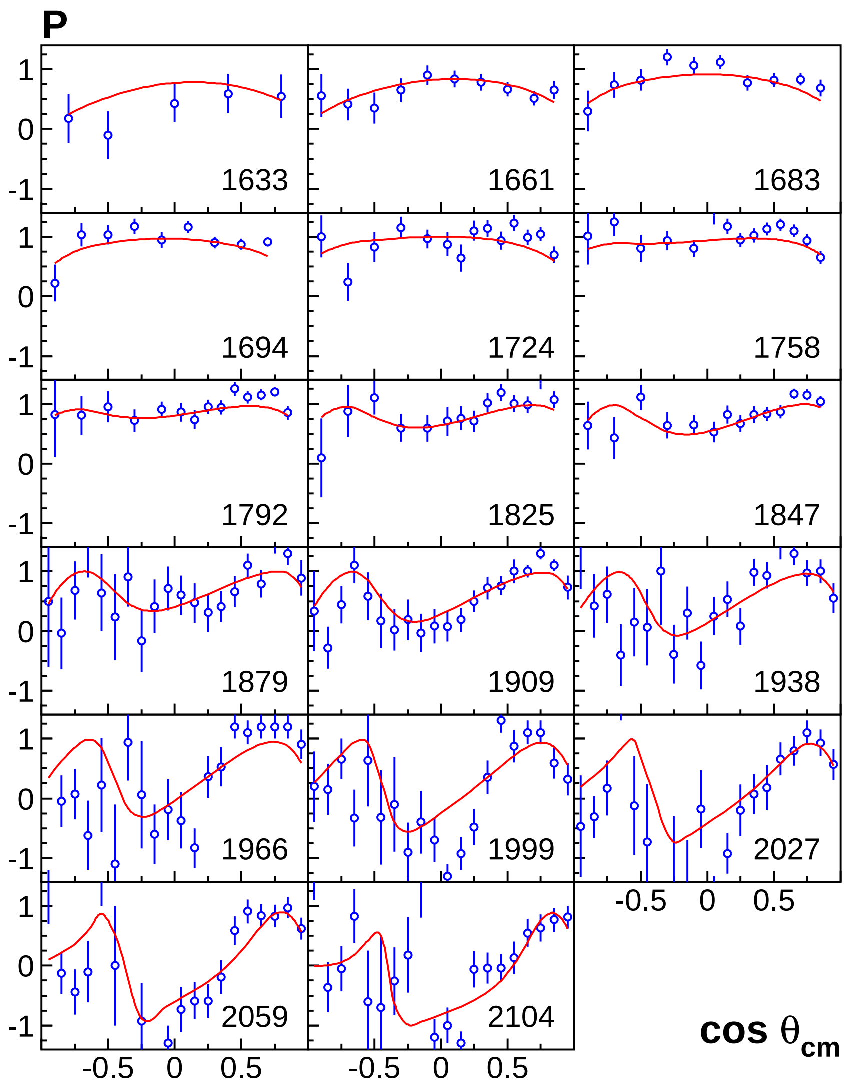
where $|A|^2$ represents the angular distribution and $P\,|A|^2/\sin\Theta$ an observable proportional to the recoil polarization parameter P.

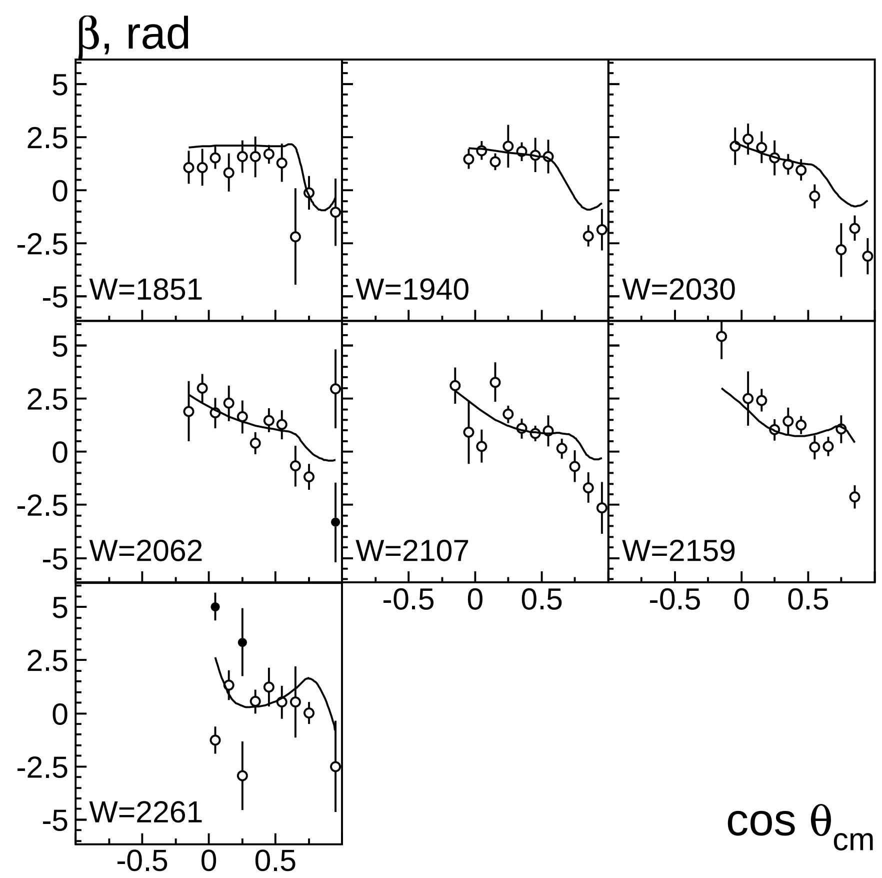
The fit of the the $\pi^- p \rightarrow K\Lambda$ reaction (differential cross section)



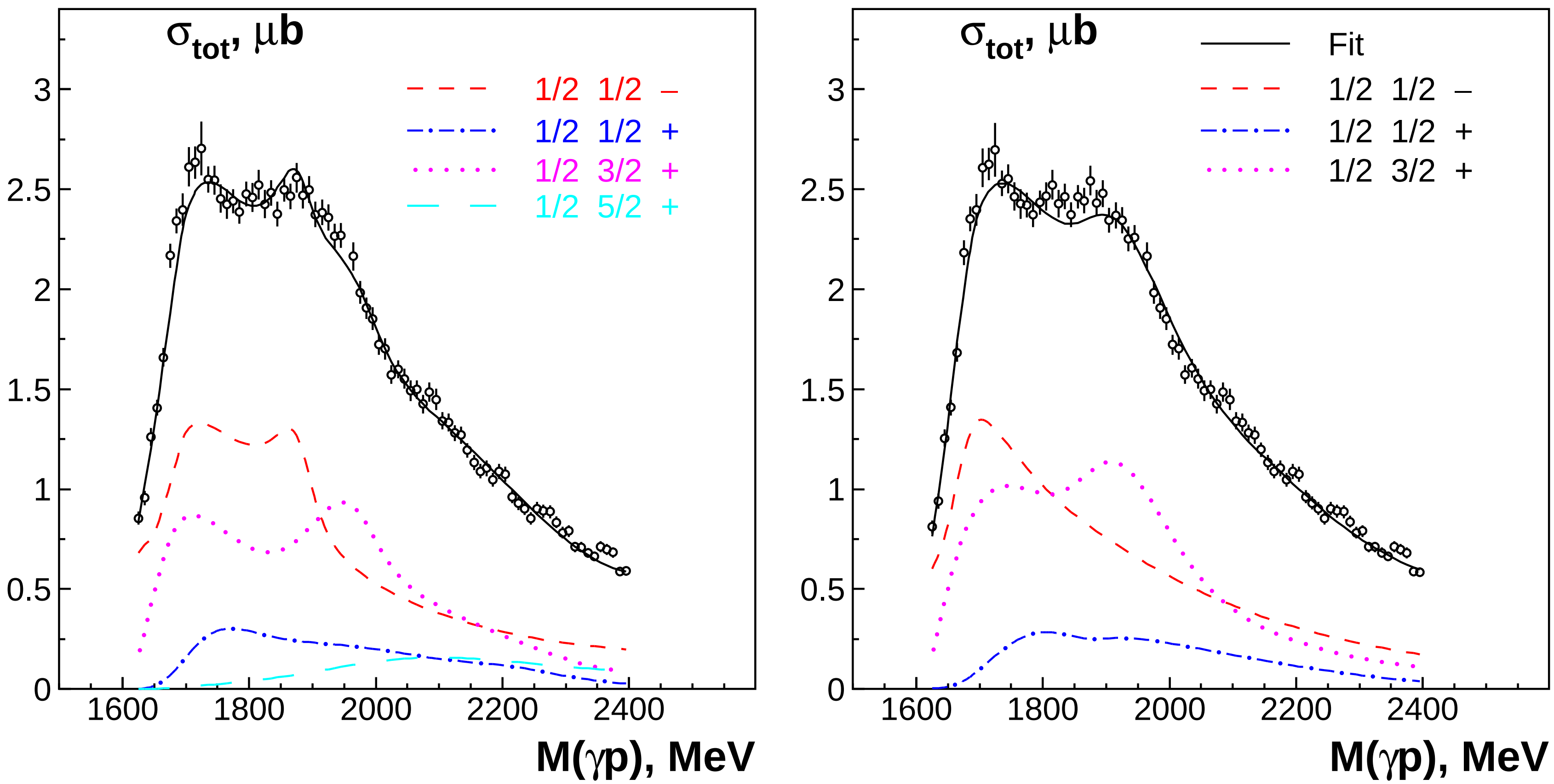


The fit of the the $\pi^- p \to K\Lambda$ reaction





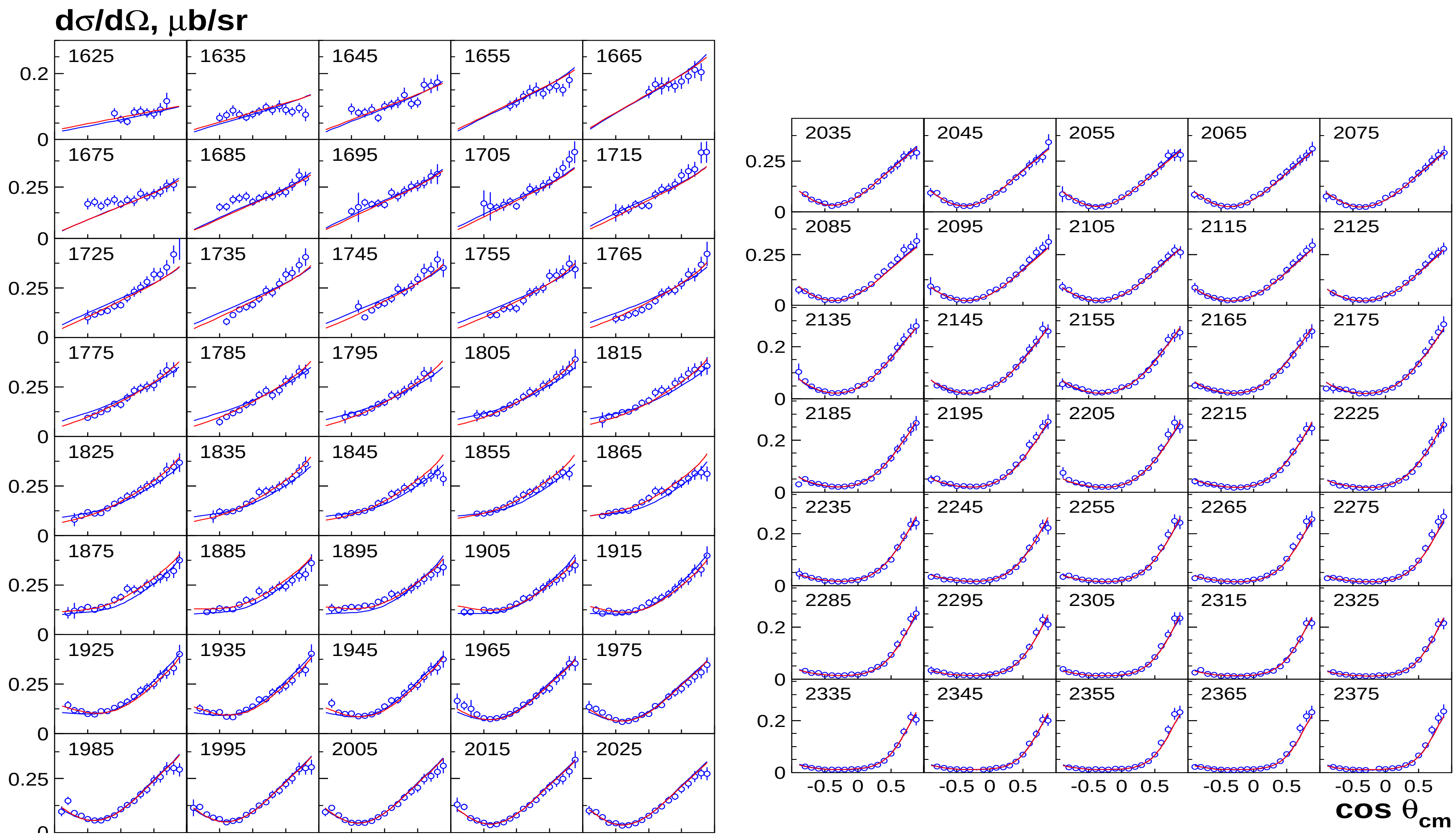
The $\gamma p \rightarrow K\Lambda$ reaction (CLAS 2009)



In the first solution the new S_{11} state with mass 1890 ± 10 MeV and width 90 ± 10 MeV is introduced in the fit.

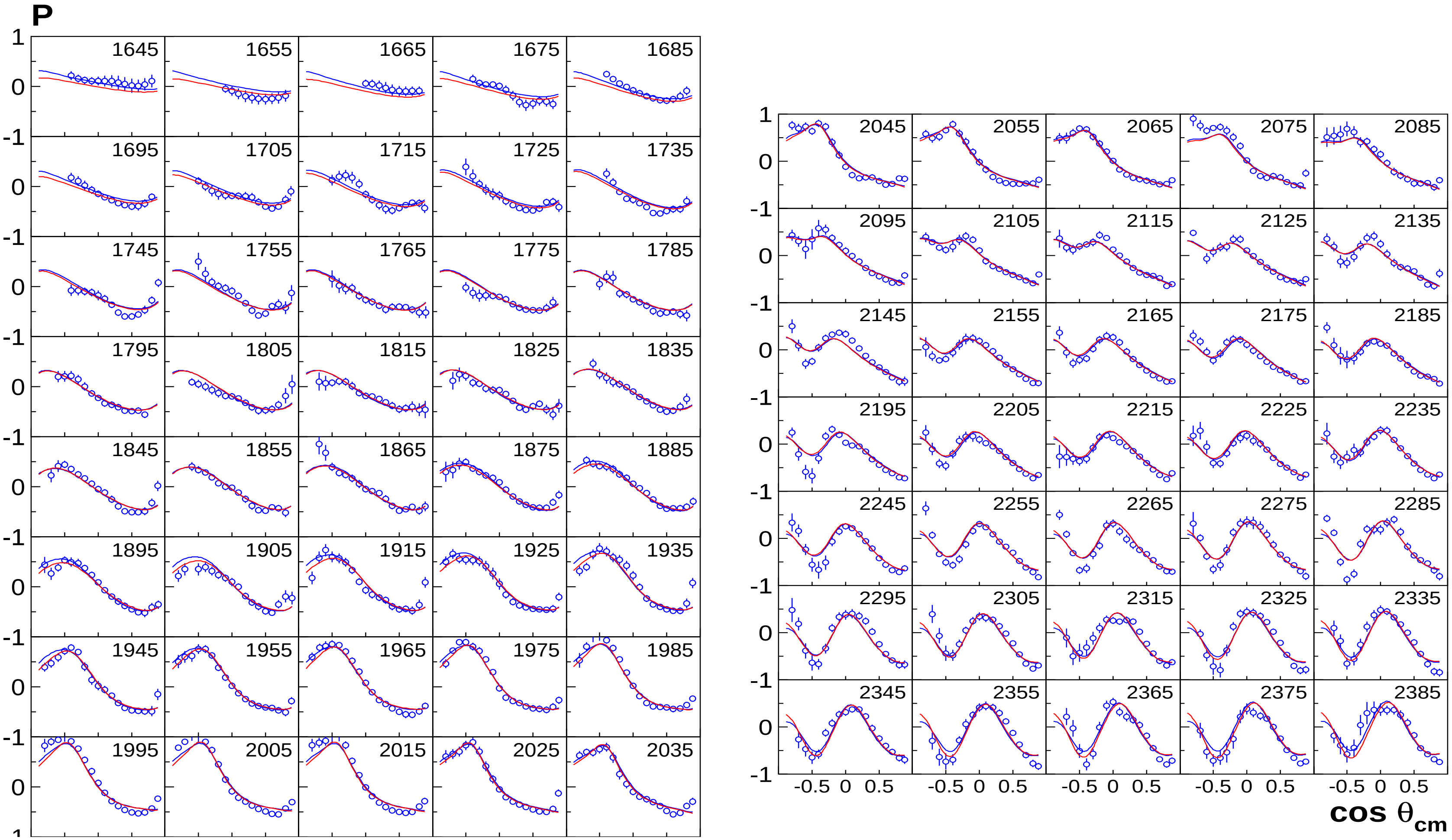
The fit of the $\gamma p \to K\Lambda$ differential cross section

(CLAS 2009)



The fit of the $\gamma p \rightarrow K\Lambda$ recoil asymmetry

(CLAS 2009)

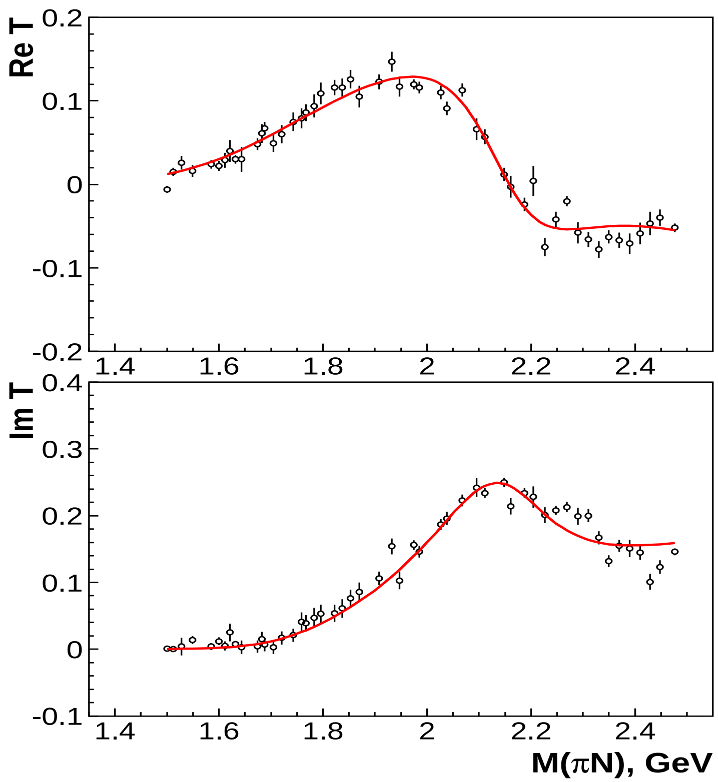


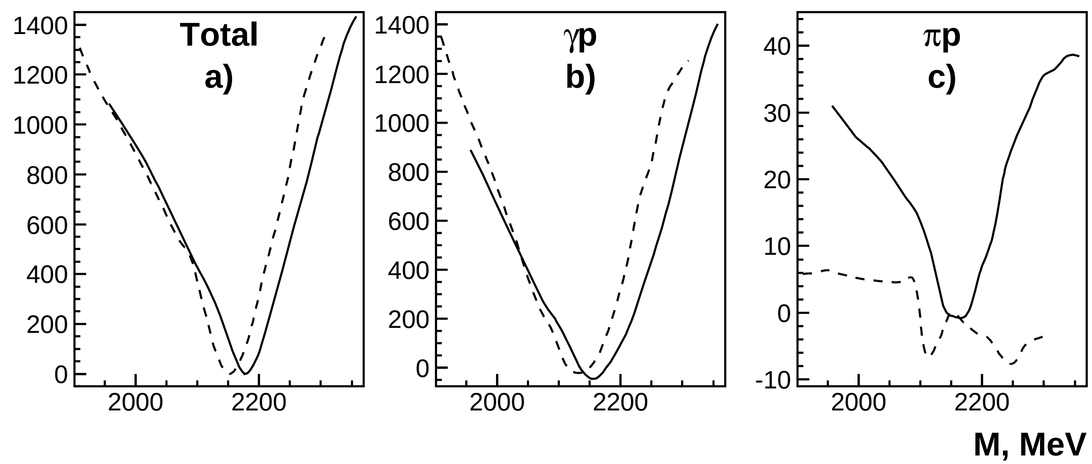
Pole position of baryon states (Re and -2Im) in the mass region 1900-2300 MeV

State		Solution 1	Solution 2	Arndt	Hoehler	Cutcosky
$N(1875)\,\frac{1}{2}^+$	**Re**	1860 ± 20	1840 ± 30		1885 ± 30 **(Manley)**	
$*$	**-2Im**	160 ± 20	320 ± 50		113 ± 44 **(Manley)**	
$N(1890)\,\frac{1}{2}^-$	**Re**	1890 ± 15	1890 ± 15	–	1880 ± 20	–
$*$	**-2Im**	90 ± 15	90 ± 15	–	95 ± 30	–
$N(1880)\,\frac{3}{2}^-$	**Re**	1885 ± 10	1870 ± 15	–	–	1880 ± 100
$**$	**-2Im**	190 ± 20	180 ± 20	–	–	180 ± 60
$N(2130)\,\frac{3}{2}^-$	**Re**	2135 ± 25	2130 ± 25	–	2081 ± 20	2050 ± 70
$**$	**-2Im**	310 ± 30	300 ± 30	–	265 ± 40	200 ± 60
$N(1900)\,\frac{3}{2}^+$	**Re**	1915 ± 20	1900 ± 25	–	–	–
$**$	**-2Im**	240 ± 30	260 ± 40	–	–	–
$N(2000)\,\frac{5}{2}^+$	**Re**	$1800-1950$	$1800-1950$	1807	1882 ± 10	–
$**$	**-2Im**	$100-300$	$100-300$	109	95 ± 20	–
$N(2100)\,\frac{5}{2}^+$	**Re**	2090^{+20}_{-40}	2110^{+20}_{-80}	–	–	–
	-2Im	560 ± 100	540 ± 100	–	–	–
$N(2070)\,\frac{5}{2}^-$	**Re**	2050 ± 30	2065 ± 20	–	–	–
	-2Im	370 ± 30	360 ± 30	–		–
$N(1990)\,\frac{7}{2}^+$	**Re**	1980 ± 25	2100 ± 30	–	~ 1935	1900 ± 30
$**$	**-2Im**	180 ± 30	300 ± 60	–	~ 260	260 ± 60
$N(2190)\,\frac{7}{2}^-$	**Re**	2160 ± 15	2150 ± 20	2070	2042	2100 ± 50
$****$	**-2Im**	320 ± 30	290 ± 30	520	480	400 ± 160

G_{17}: pole position and Breit-Wigner parameters

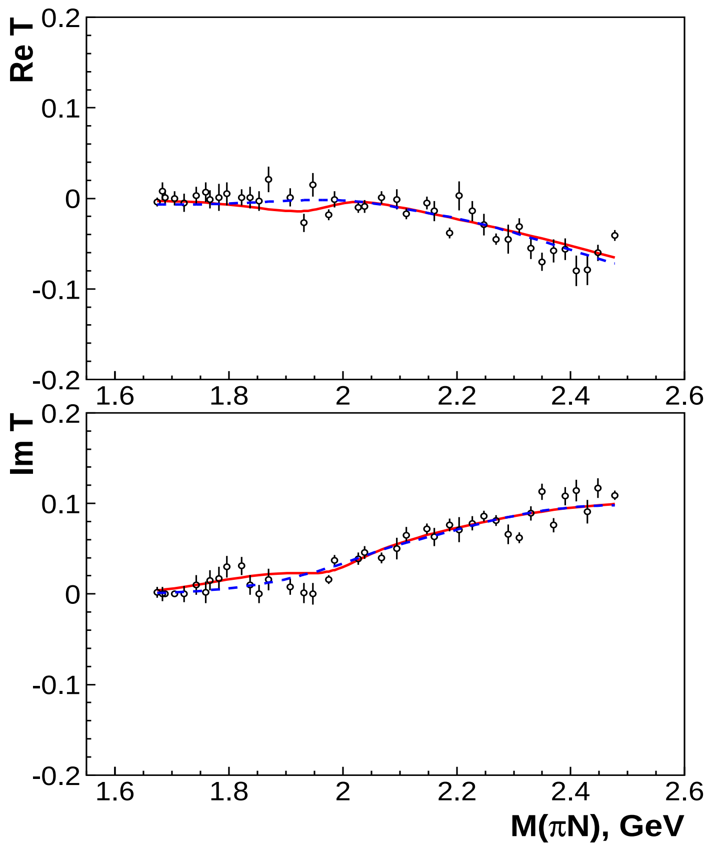
State		Solution 1	Solution 2	Arndt	Hoehler	Cutcosky
$N(2190)\frac{7}{2}^-$	Re	2160 ± 15	2150 ± 20	2070	2042	2100 ± 50
$****$	-2Im	320 ± 30	290 ± 30	520	480	400 ± 160
BW	M	2180	2165	2152.4 ± 1.4	2140 ± 12	2200 ± 70
parameters	Γ	330	300	484 ± 13	390 ± 30	500 ± 150

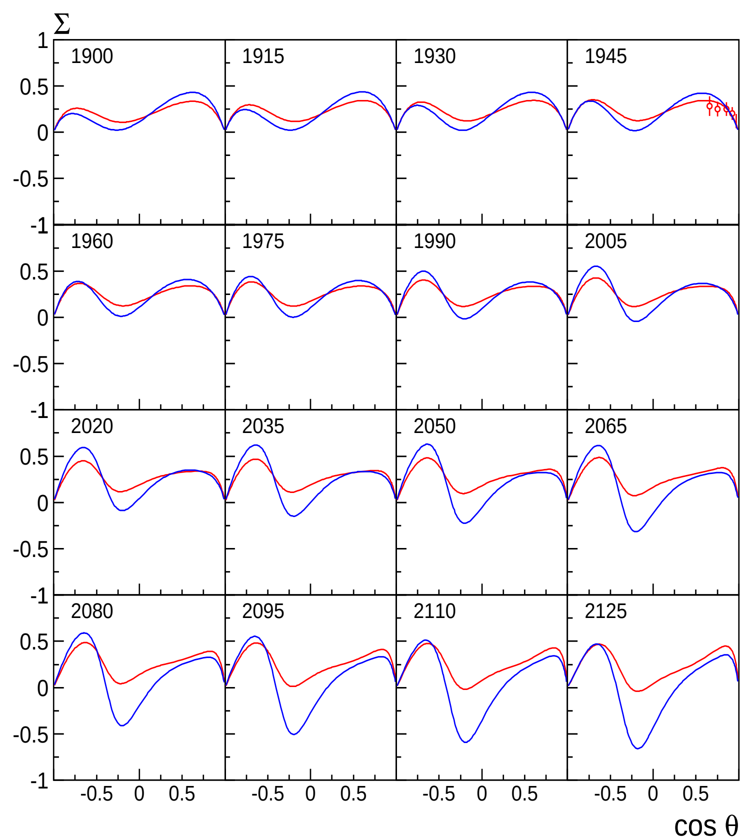




Pole position of F_{17} and helicity couplings (absolute value (10^{-3} GeV$^{\frac{1}{2}}$)/phase (degrees)

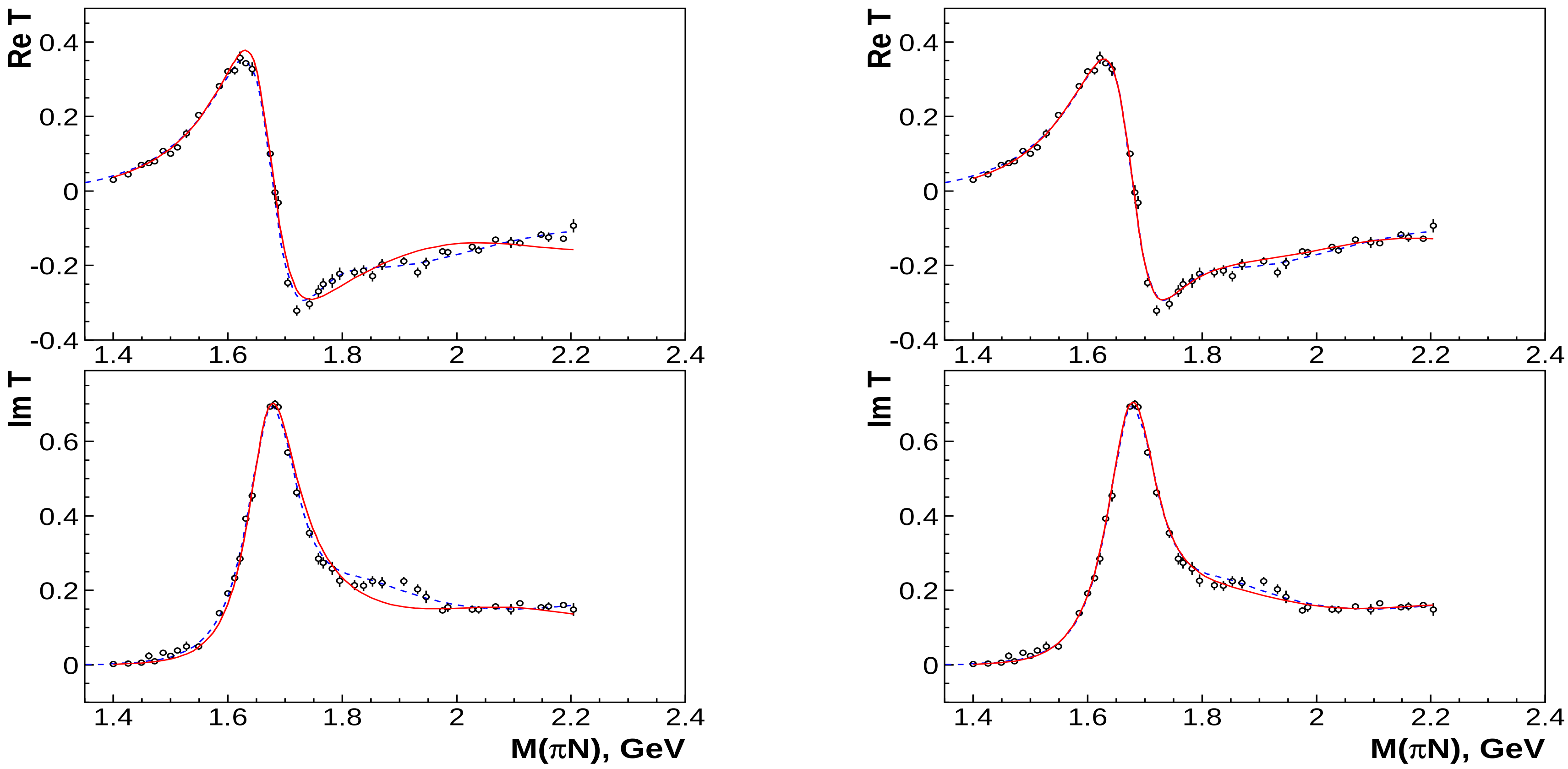
State		Solution 1	$A(\frac{1}{2})/A(\frac{3}{2})$	Solution 2	$A(\frac{1}{2})/A(\frac{3}{2})$
$N(1990)\frac{7}{2}^{+}$	Re	1980 ± 25	$15/14^{o}$	2100 ± 30	$76/50^{o}$
$**$	-2Im	180 ± 30	$28/3^{o}$	300 ± 60	$78/45^{o}$





Pole position of F_{15}: two and three pole solution

State		Solution 1	Solution 2	Arndt	Hoehler	Cutcosky
$N(2000)\frac{5}{2}^{+}$	**Re**	$1800-1950$	$1800-1950$	1807	1882 ± 10	$-$
$**$	**-2Im**	$100-300$	$100-300$	109	95 ± 20	$-$
$N(2100)\frac{5}{2}^{+}$	**Re**	2090^{+20}_{-40}	2110^{+20}_{-80}	$-$	$-$	$-$
	-2Im	560 ± 100	540 ± 100	$-$	$-$	$-$



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	$\frac{1}{4}$	$N(1890)$	$N(1875)$				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	$N(1880)$	$N(1900)$	$N(1880)$	$N(1980)$		1.92
0,$\frac{1}{2}$,3	$\frac{1}{2}$	$N(????)$					2.03
3,$\frac{1}{2}$,0	$\frac{1}{4}$	$N(2070)$	$N(2170)$	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

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.

$J=\frac{1}{2}$	$N_{1/2+}(1880)$	*	$N_{1/2-}(1890)$	*	$\Delta_{1/2+}(1910)$	****	$\Delta_{1/2-}(1900)^a$	**
$J=\frac{3}{2}$	$N_{3/2+}(1900)$	**	$N_{3/2-}(1875)$	**	$\Delta_{3/2+}(1940)^a$	***	$\Delta_{3/2-}(1990)^a$	*
$J=\frac{5}{2}$	$N_{5/2+}(1880)$	**	$N_{5/2-}(2070)$		$\Delta_{5/2+}(1940)$	****	$\Delta_{5/2-}(1930)^a$	***
$J=\frac{7}{2}$	$N_{7/2+}(1980)$	**	$N_{7/2-}(2170)$	****	$\Delta_{7/2+}(1920)$	****	$\Delta_{7/2-}(2200)$	*
$J=\frac{9}{2}$	$N_{9/2+}(2220)$	****	$N_{9/2-}(2250)$	****	$\Delta_{9/2+}(2300)$	**	$\Delta_{9/2-}(2400)^a$	**

$J=\frac{5}{2}$	$N_{5/2+}(2100)$	**	$N_{5/2-}(2070)$		$\Delta_{5/2+}(1940)$	****	$\Delta_{5/2-}(1930)^a$	***
$J=\frac{7}{2}$	$N_{7/2+}(2100)$	**	$N_{7/2-}(2170)$	****	$\Delta_{7/2+}(1920)$	****	$\Delta_{7/2-}(2200)$	*
$J=\frac{9}{2}$	$N_{9/2+}(2220)$	****	$N_{9/2-}(2250)$	****	$\Delta_{9/2+}(2300)$	**	$\Delta_{9/2-}(2400)^a$	**

Summary

- **The analysis of (almost) all available data for production of baryons in the pion and photo induced reaction is completed.**
- **We have observed a set of new states in the region 1800-2150 MeV, however, this number is much less than that predicted by the classical quark model.**
- **The low spin states fit very well the AdS/QCD prediction as well as the idea about chiral restoration at high energies.**
- **There are two solutions for the** $N_{\frac{7}{2}+}$ **lowest state which should be distinguished from analysis of beam asymmetry data on photoproduction of hyperon-kaon final states which have to be released in 3-4 months.**
- **The situation for** $N(\frac{5}{2}^+)$ **can be resolved with reanalysis of** πN **elastic data and an analysis of new data on double pion photoproduction.**
- **The search for the chiral partner of** $\Delta_{7/2^+}(1920)$ **state is the main subject in our current analysis of double pion and** $\pi^0\eta$ **photoproduction data**