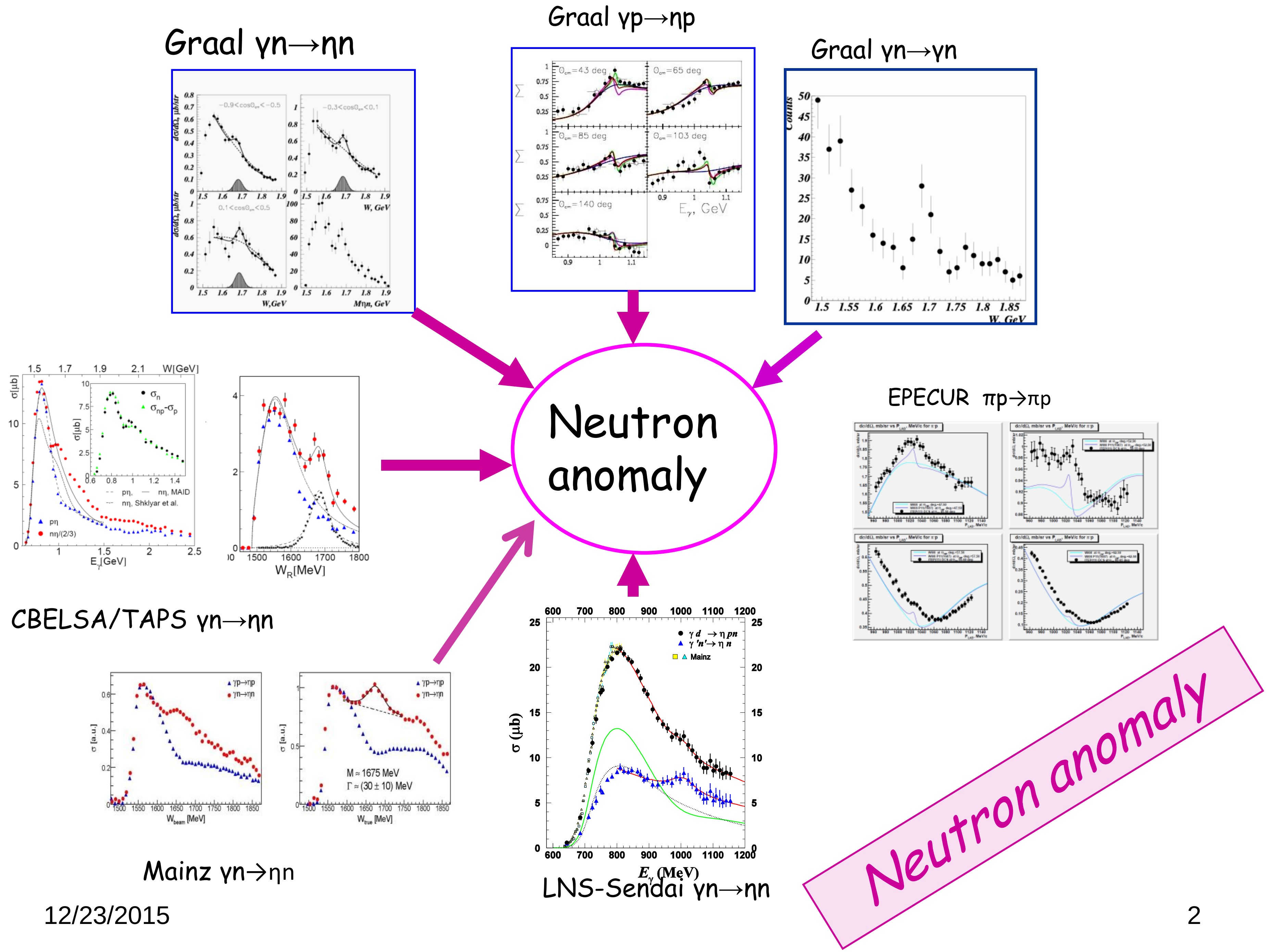
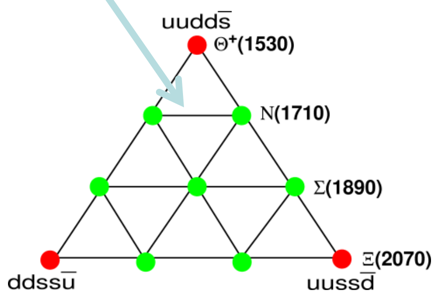
Recent Updates from GRAAL

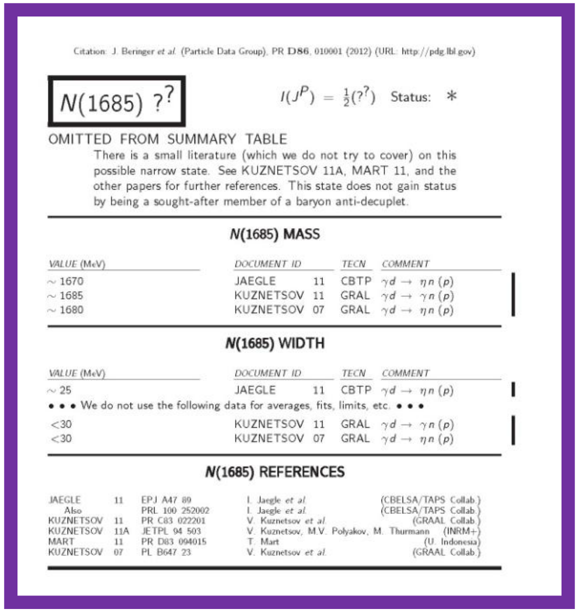
Viacheslav Kuznetsov, PNPI,
in collaboration with Nuclear Physics Group (University of Catania and INFI-Catania) and Maxim Polyakov (Ruhr-Universitat-Bochum)


Graal γn→ηn
Graal γp→ηp
Graal γn→γn
Neutron anomaly
EPECUR πp→πp
CBELSA/TAPS γn→ηn
Mainz γn→ηn
LNS-Sendai γn→ηn
M ≈ 1675 MeV
Γ ≈ (30 ± 10) MeV
Neutron anomaly

Different interpretations

Narrow N*(1685) resonance
Several publications…





Citation: J. Beringer *et al.* (Particle Data Group), PR **D86**, 010001 (2012) (URL: http://pdg.lbl.gov)

$N(1685)$?? $I(J^P) = \frac{1}{2}(?^?)$ Status: *

OMITTED FROM SUMMARY TABLE

There is a small literature (which we do not try to cover) on this possible narrow state. See KUZNETSOV 11A, MART 11, and the other papers for further references. This state does not gain status by being a sought-after member of a baryon anti-decuplet.

$N(1685)$ MASS

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
~ 1670	JAEGLE	11	CBTP	$\gamma d \to \eta n (p)$
~ 1685	KUZNETSOV	11	GRAL	$\gamma d \to \gamma n (p)$
~ 1680	KUZNETSOV	07	GRAL	$\gamma d \to \eta n (p)$

$N(1685)$ WIDTH

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
~ 25	JAEGLE	11	CBTP	$\gamma d \to \eta n (p)$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<30	KUZNETSOV	11	GRAL	$\gamma d \to \gamma n (p)$
<30	KUZNETSOV	07	GRAL	$\gamma d \to \eta n (p)$

$N(1685)$ REFERENCES

JAEGLE	11	EPJ A47 89	I. Jaegle *et al.*	(CBELSA/TAPS Collab.)
Also		PRL 100 252002	I. Jaegle *et al.*	(CBELSA/TAPS Collab.)
KUZNETSOV	11	PR C83 022201	V. Kuznetsov *et al.*	(GRAAL Collab.)
KUZNETSOV	11A	JETPL 94 503	V. Kuznetsov, M.V. Polyakov, M. Thurmann	(INRM+)
MART	11	PR D83 094015	T. Mart	(U. Indonesia)
KUZNETSOV	07	PL B647 23	V. Kuznetsov *et al.*	(GRAAL Collab.)

Interference of well-known wide isospin ½ resonances (S11(1535),S11(!650), P11(1710)…. Bonn-Gatchina Group (A.Sarantsev et al.,) Giessen Group (A. Mozel et al.,) and several others.
Widely discussed in literature!

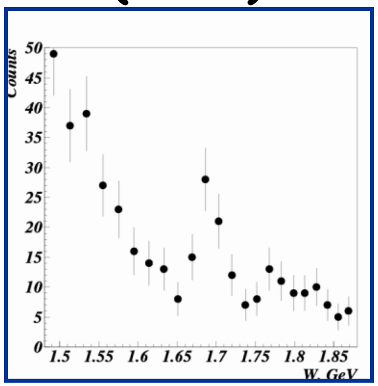
Neutron Anomaly

- **Intermediate sub-threshold KΣ and KΛ states (cusp effect)**

M.Doring, K. Nakayama, PLB683, 145 (2010), nucl-th/0909.3538

Comments on the interpretation of neutron anomaly in terms of the specific interference of well-known resonances.

V.Kuznetsov et al., Phys.Rev. C83 (2011) 022201



One major challenge for this interpretation is the observation of a narrow enhancement at W~1.68 GeV in Compton scattering on the neutron (γn→γn),

Comments on "Interference phenomena in the $J^p = 1/2^-$ - wave in η photoproduction" by A.V. Anisovich, E. Klempt, B. Krusche, V.A. Nikonov, A.V. Sarantsev, U. Thoma, D. Werthmuller, arXiv:1501.02093v1 [nucl-ex].

Viacheslav Kuznetsov
[1] *Petersburg Nuclear Physics Institute, Gatchina, 188300, St. Petersburg, Russia*

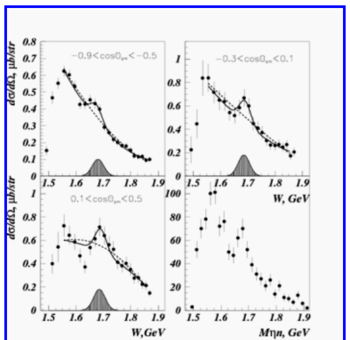
The authors of Ref. [1] claimed that " ... narrow structure observed in the excitation function of $\gamma n \to \eta n$ can be reproduced fully with a particular interference pattern in the $J^p = 1/2^-$ partial wave..." while a narrow structure in Compton scattering off the neutron is "...a stand-alone observation unrelated to the structure observed in $\gamma n \to \eta n$...". The source for the second statement may be a simple numerical error. If so, the interpretation of the narrow structure in $\gamma n \to \eta n$ as interference effects in the $J^p = 1/2^-$-wave and some conclusions from Ref. [1] are questionable.

In accordance with (corrected) calculations by A. Anisovich et al., the total cross-section of N*(1685) should be 10-25 nb. Therefore, if N*(1685) does exist, its peak should be clearly seen in the Compton cross-section on the neutron.

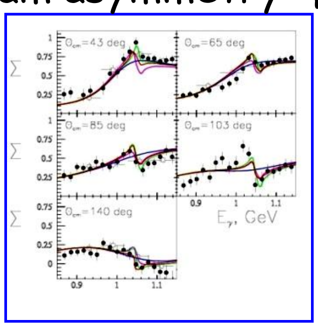
The observation of the peak in Comtpon scattering on the neutron is in fact refutes the explanation of the neutrons anomaly in terms of interference phenomena. This interference cannot generate a peak in eta photoproduction, which is governed by isospin-1/2 resonances, simultaneously genenerate the same peak in Compton scattering, which is governed by isospin-1/2 and isospin-3/2 resonances, and generate neither of peak in pion photoproduction on the neutron, which is governed by the same resonances as Compton scattering.

One benchmark signature of N*(1685) is the strong photoexcitation on the neutron and suppressed (but not zero) photoexcitation on the proton. Such a resonance would appear in cross section on the proton as a minor peak/dip structure which may not be resolved in experiment. On the contrary, its signal may be amplified in polarization observables being amplified due to the interference with other resonances.

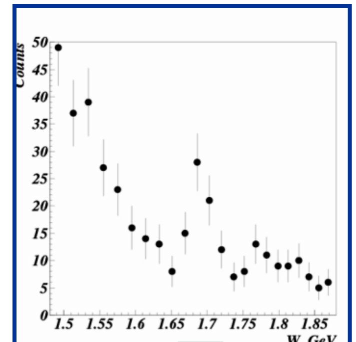
Cross section γn→ηn



Beam asymmetry γp→ηp



Cross section γn→γn



Beam asymmetry γp→γp

?

Compton scattering $\gamma p \to \gamma p$ on the proton at GRAAL: Surprising results

Evidence for narrow resonant structures at $W \approx 1.68$ GeV and $W \approx 1.72$ GeV in real Compton scattering off the proton

V. Kuznetsov,[1,*] F. Mammoliti,[2,3] V. Bellini,[2,3] G. Gervino,[4,5] F. Ghio,[6,7] G. Giardina,[8] W. Kim,[9] G. Mandaglio,[2,8] M. L. Sperduto,[2,3] and C. M. Sutera[2,3]

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[3]*Dipartimento di Fisica ed Astronomia, Universitá di Catania, I-95123 Catania, Italy*
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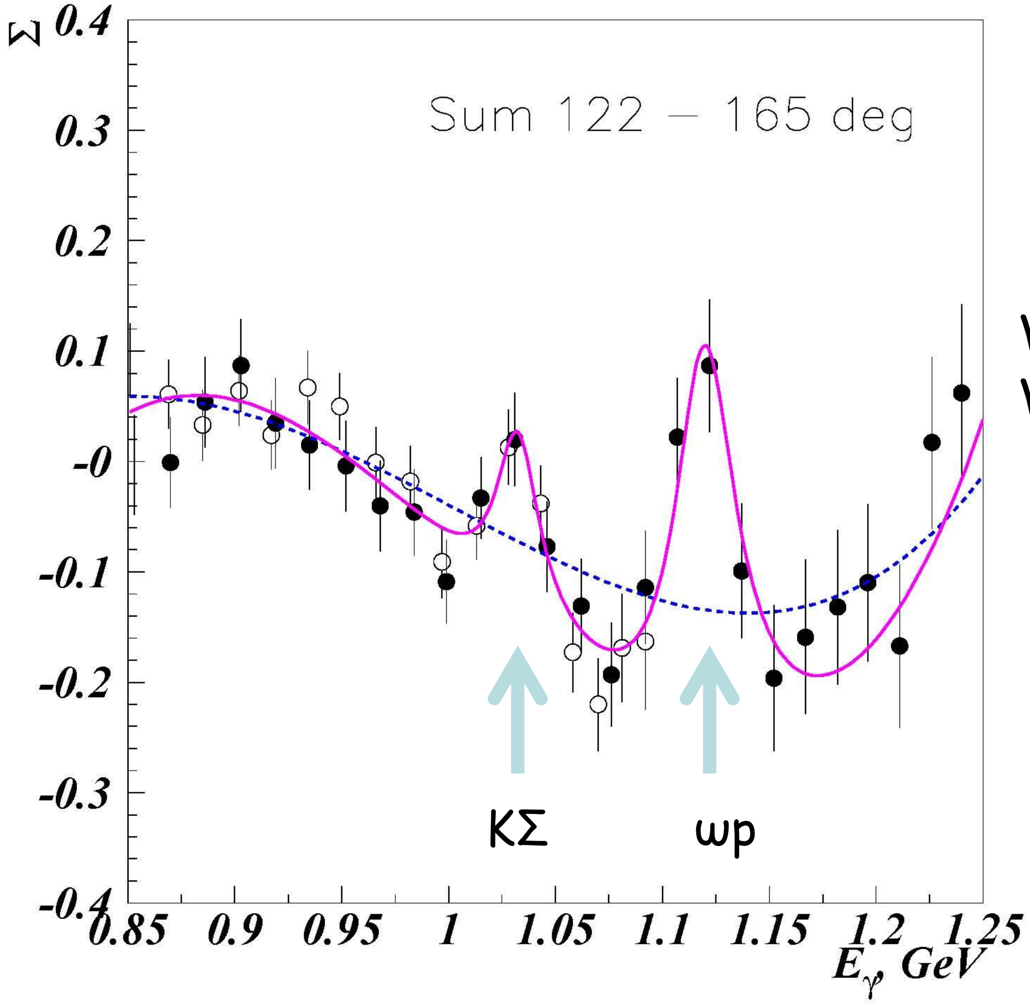
[7]*Instituto Superiore di Sanitá, viale Regina Elena 299, I-00161 Roma, Italy*
[8]*Dipartimento di Fisica e di Scienze della Terra - Università di Messina, salita Sperone 31, 98166 Messina, Italy*
[9]*Kyungpook National University, 702-701, Daegu, Republic of Korea*

(Received 18 January 2015; published 6 April 2015)

First measurement of the beam asymmetry Σ for Compton scattering off the proton in the energy range $E_\gamma = 0.85$–1.25 GeV is presented. The data reveal two narrow structures at $E_\gamma = 1.036$ and $E_\gamma = 1.119$ GeV. They may signal narrow resonances with masses near 1.68 and 1.72 GeV, or they may be generated by the sub-threshold $K\Lambda$ and ωp production. Their decisive identification requires additional theoretical and experimental

Two narrow (Γ~20 MeV) structures at W~1.68 and W~1.72 GeV in the beam asymmetry data for Compton scattering off the proton at GRAAL



W_1 = 1681 ±1 MeV
W_2 = 1726 ±1 MeV

PHYSICAL REVIEW C **92**, 069801 (2015)

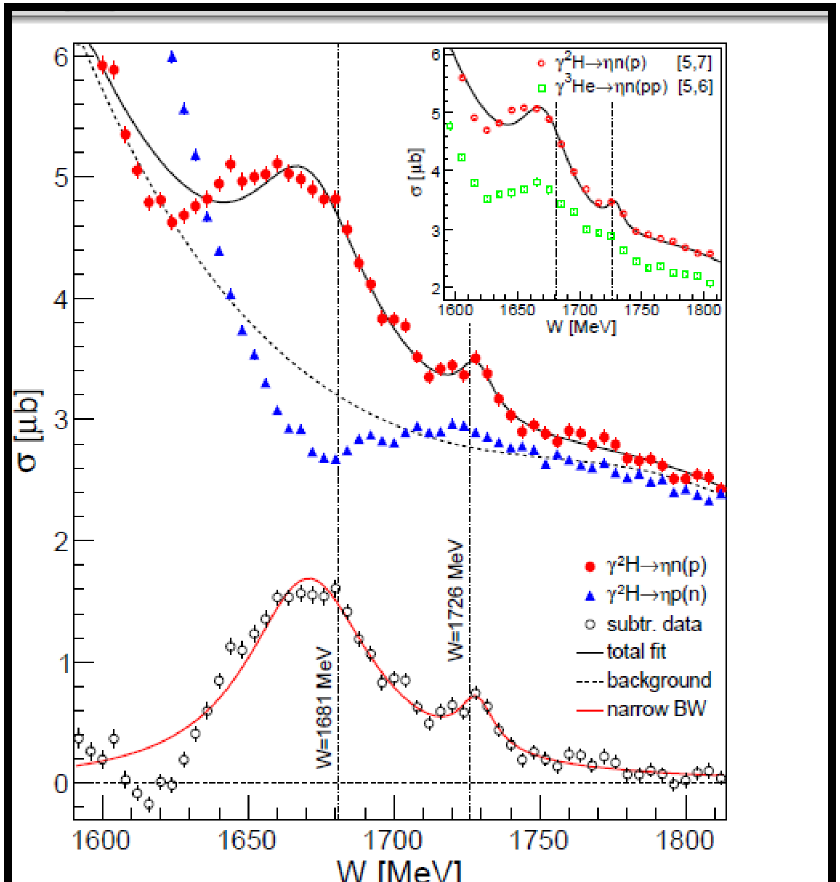
Comment on "Evidence for narrow resonant structures at $W \approx 1.68$ GeV and $W \approx 1.72$ GeV in real Compton scattering off the proton"

D. Werthmüller,[1,2] L. Witthauer,[2] D. I. Glazier,[1] and B. Krusche[2]
[1]*School of Physics and Astronomy, University of Glasgow, Glasgow G12 8QQ, Scotland, United Kingdom*
[2]*Departement Physik, Universität Basel, CH-4056 Basel, Switzerland*

(Received 8 July 2015; published 11 December 2015)

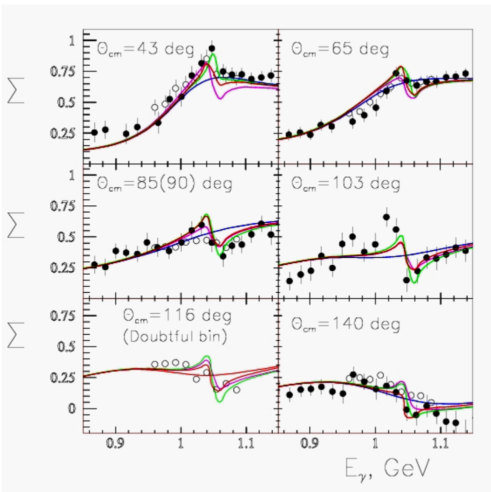
We comment on the statement by Kuznetsov *et al.* that the structure around $W = 1.72$ GeV seen in the beam asymmetry in Compton scattering off the proton is not observed in the total cross section of η photoproduction on the neutron.

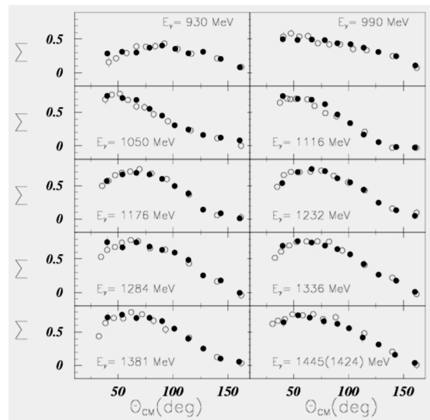
Observation of two narrow structure at W~1.68 and W~1.72 GeV in γn→ηn at A2@MaMiC and CBELSA/TAPS

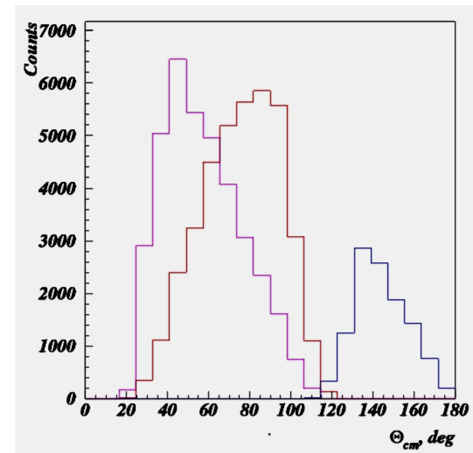


Revised analysis of the beam asymmetry Σ for eta photoproduction off the proton $\gamma p \rightarrow \eta p$

Previous GRAAL data







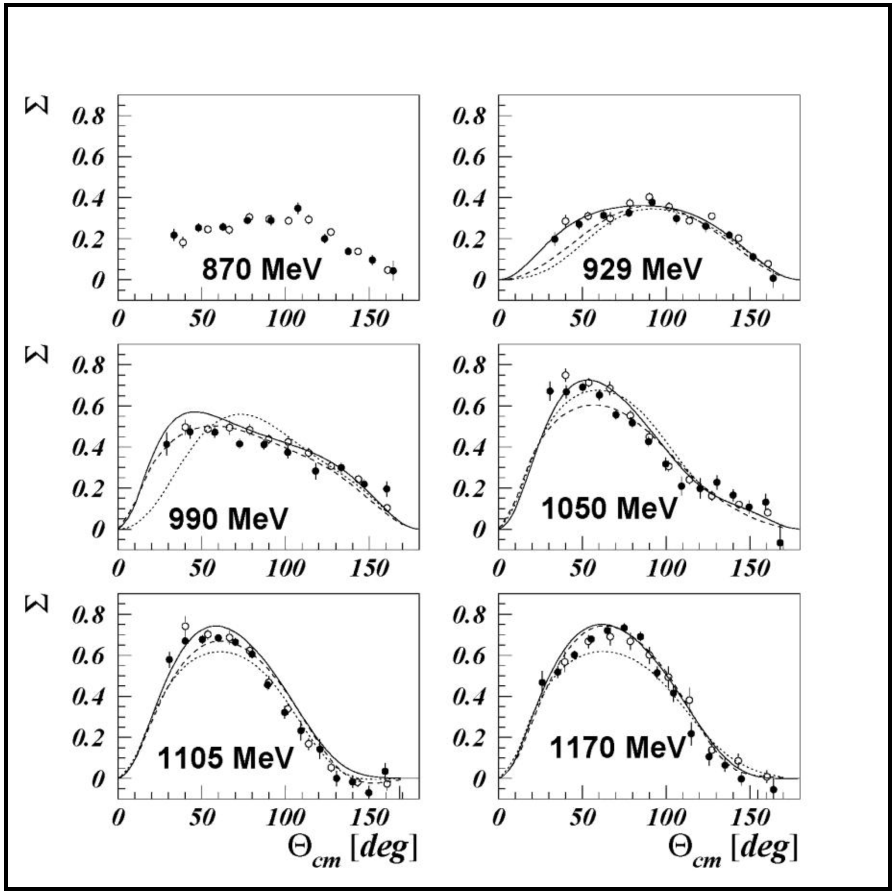
V. Kuznetsov, M.V.P, et al., Acta Physica Polonica , 39 (2008) 1949
V. Kuznetsov, M.V.P., JETP Lett., 88 (2008) 347

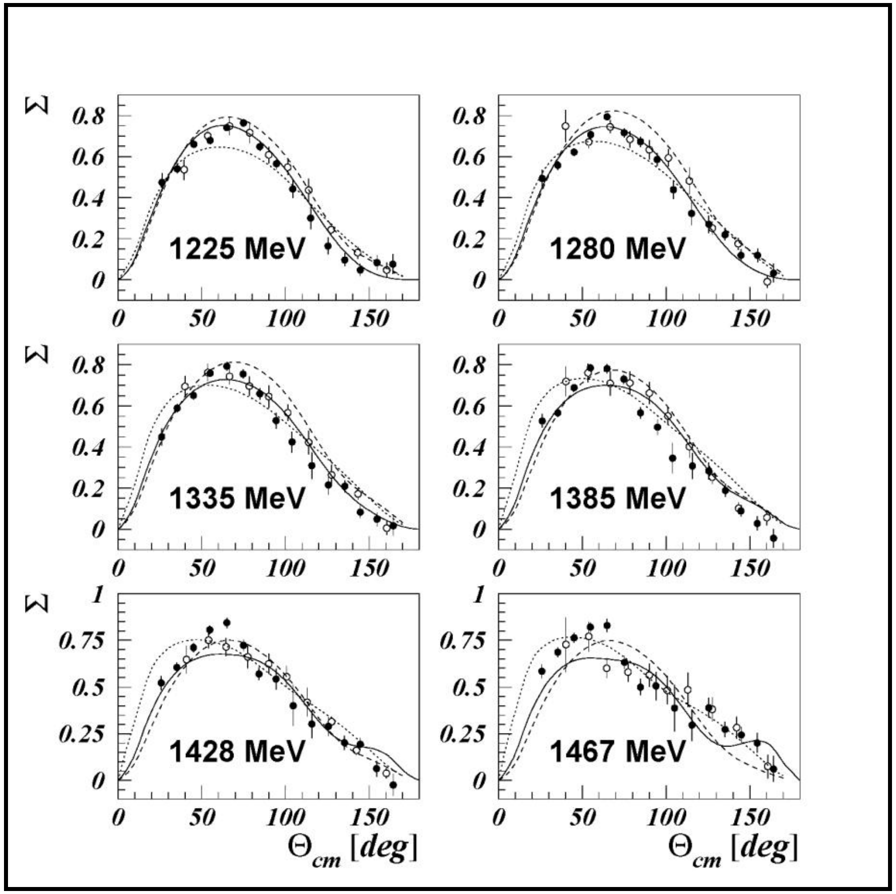
Fine energy binning
Observation of resonant structure at W~1.68 GeV,
~10% of available statiscs was used

O.Baratlini et al., Eur.Phys.J. A33 (2007) 169-184
(black points)
Wide energy binning/
Bugs in analysis. The critics remains unreplied during 8 years.

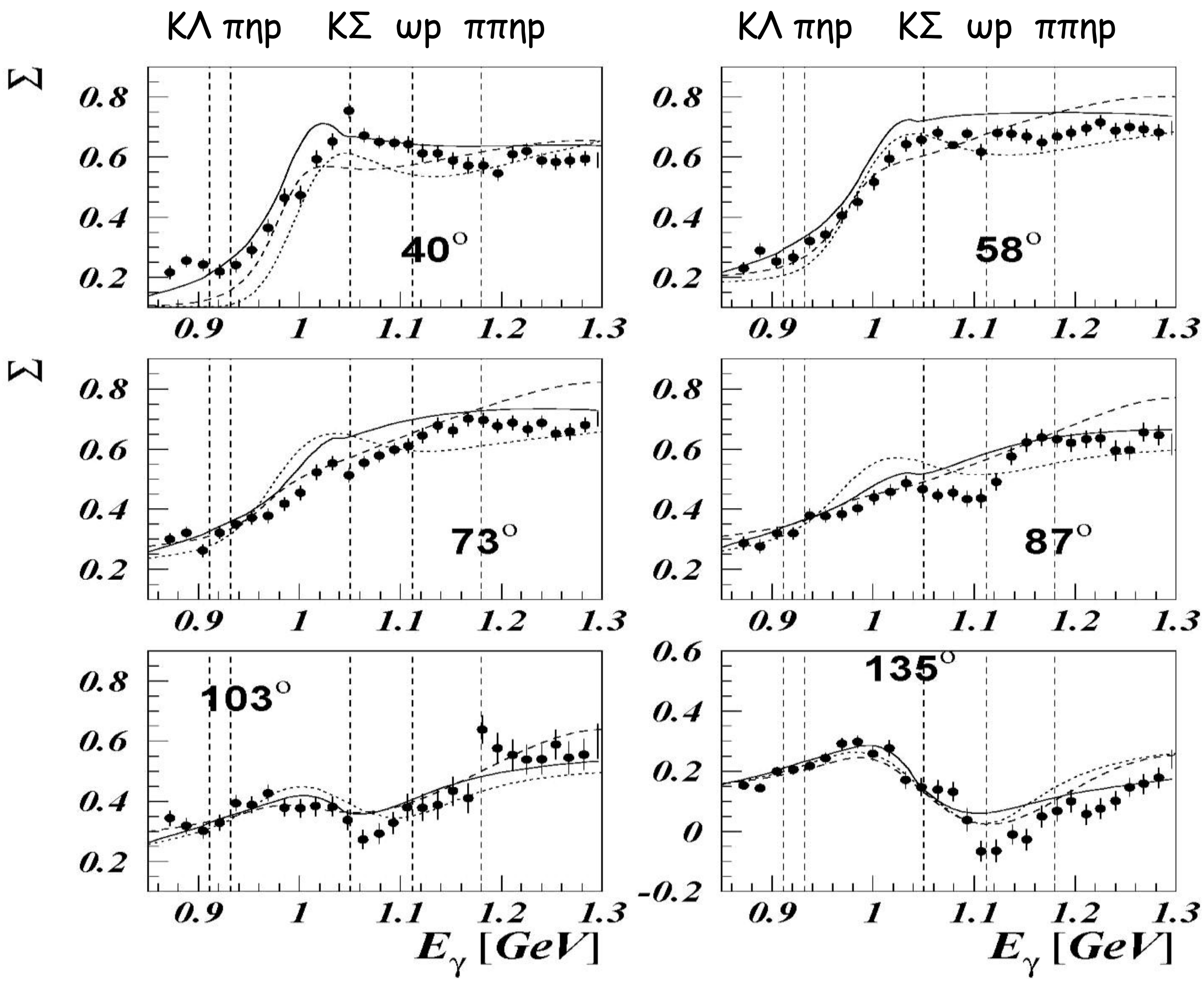
Wide energy binning

New data – black circles, old data
(O.Baratlini et al., Eur.Phys.J. A33 (2007) 169-184) – open circles
Solid line – Boga, dased line – SAID, dotted line –Eta-Maid.





New data with fine energy binning



Summary:

-Several narrow peculiarities close to meson-nucelon thresholds are observed;

- This favors the assumption of the cusp effect. However, there are open questions: i)why some of them are better on the neutron: ii) Could cusps occur in Comptons scattering and not manifest theirselves ;in pion photoproduction;

- There might be other explanations (for example, formation of bound meson-nucleon states)?

Critical issues:

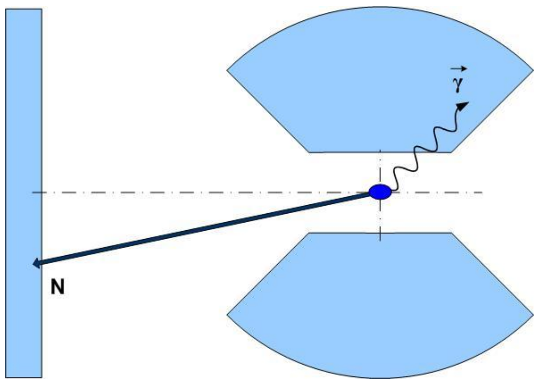
-To provide more experimental data;

-To perform a combined PWA of new data. Cusps are apriori S-wave effects.....

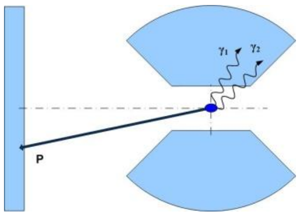
Thank you for your attention!

Compton scattering and the π^0 background.

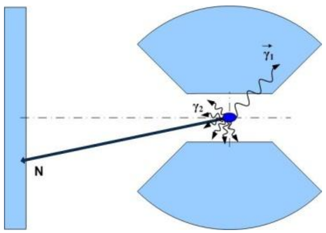
Compton scattering



π^0 background



Symmetric π0 decay, two photon hits are mixed in one BGO cluster.

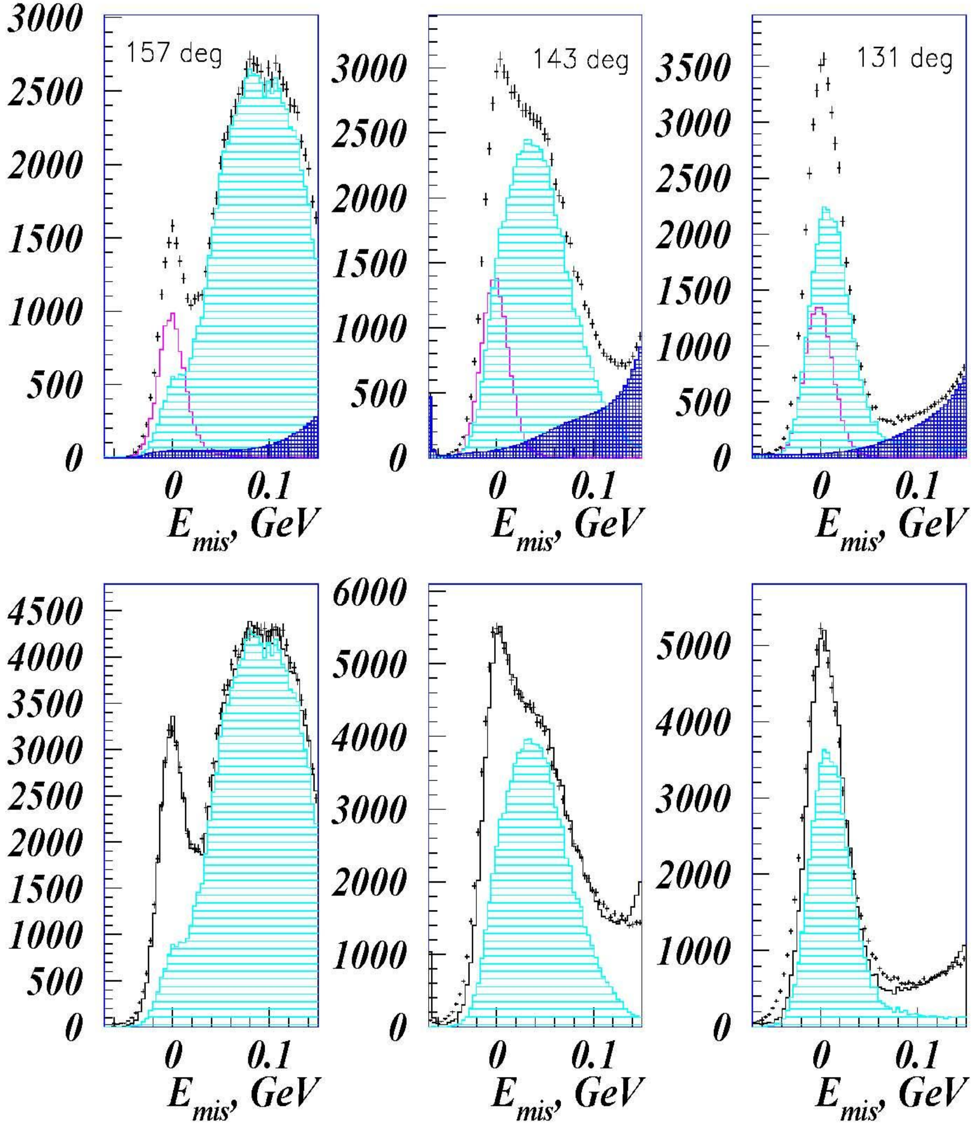


Asymmetric π0 decays, the second low-energy photon may not be detected.

Main identification parameter is
Missing energy

$$E_{mis} = E_{\gamma} - E_{\gamma'} - T_p(\Theta_p)$$

Simulation and Data

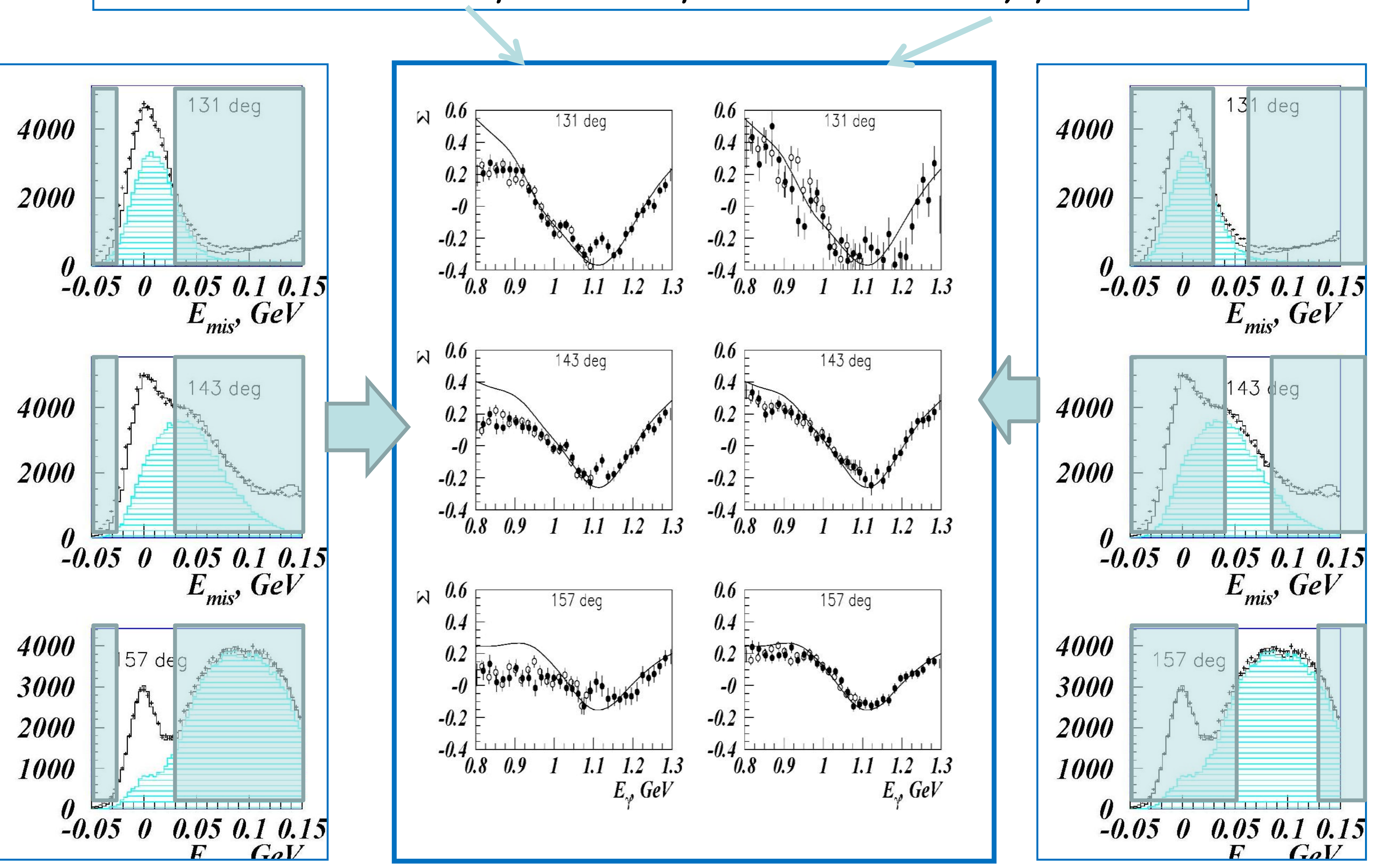


Simulations:
Magenta: Compton
Green : the pion background
Blue: other reactions

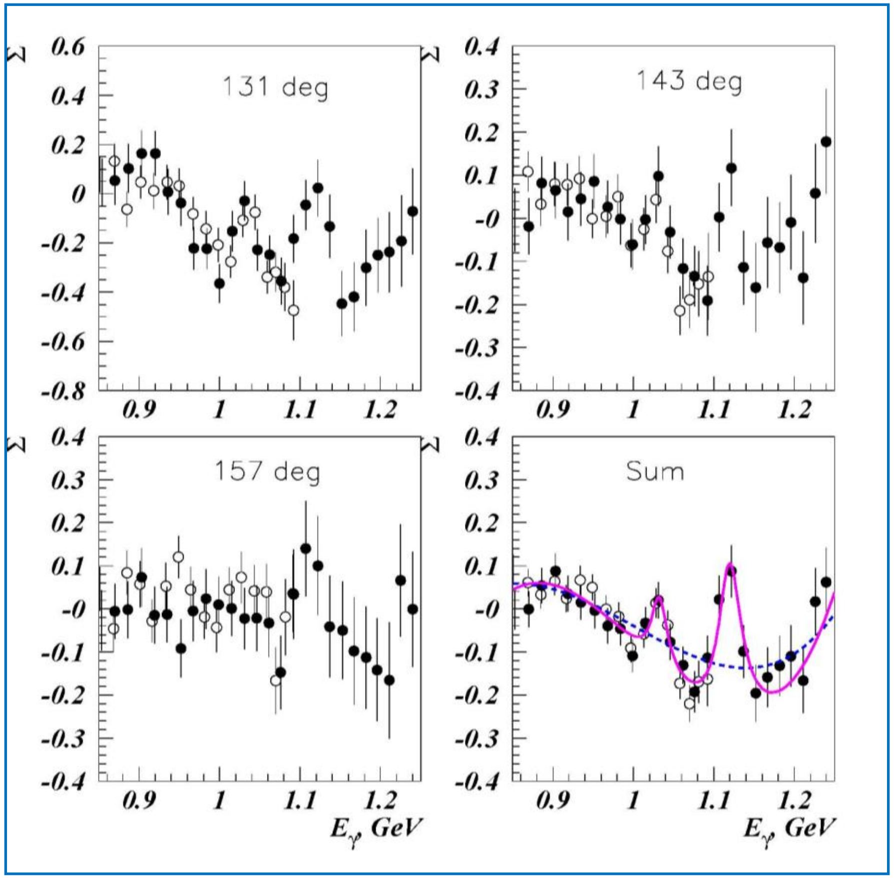
Data:
Green is the estimated contamination of pion photoproduction.

Beam asymmetry with the main and side-band cuts.

Mixture of Comptons and pions *Mostly pions*



Beam Asymmetry for Compton scattering



Two narrow resonant structures!

Fits:

4-order polynomial (background hypothesis)

χ^2=77/39

4-order polynomial+BW1+BW2

$$BW = \frac{(E_\gamma - E_r)\sin(\varphi) + \Gamma\cos(\varphi)}{(E_\gamma - E_r)^2 + \frac{\Gamma^2}{4}}$$

χ^2=27/33

Results

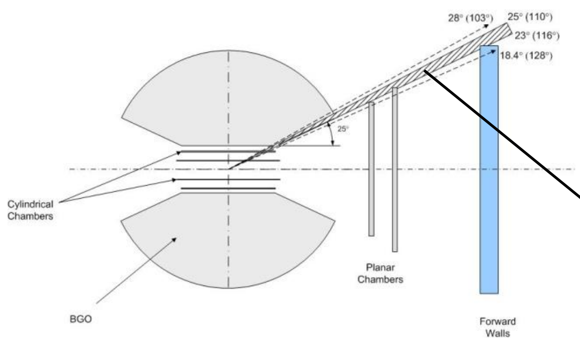
$E_1 = 1.036\ GeV$	$\Gamma_1 = 25\ MeV$	$W_1 = 1.681 \pm 0.006\ GeV$	$\Gamma_{w1} = 16 \pm 6\ MeV$
$E_2 = 1.119\ GeV$	$\Gamma_2 = 35\ MeV$	$W_2 = 1.726 \pm 0.007\ GeV$	$\Gamma_{w1} = 21 \pm 8\ MeV$

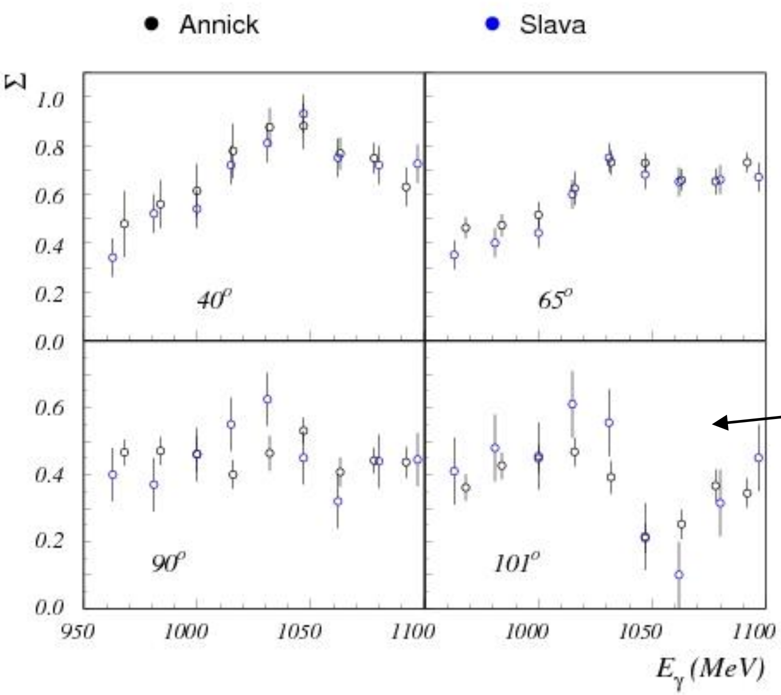
Summary:

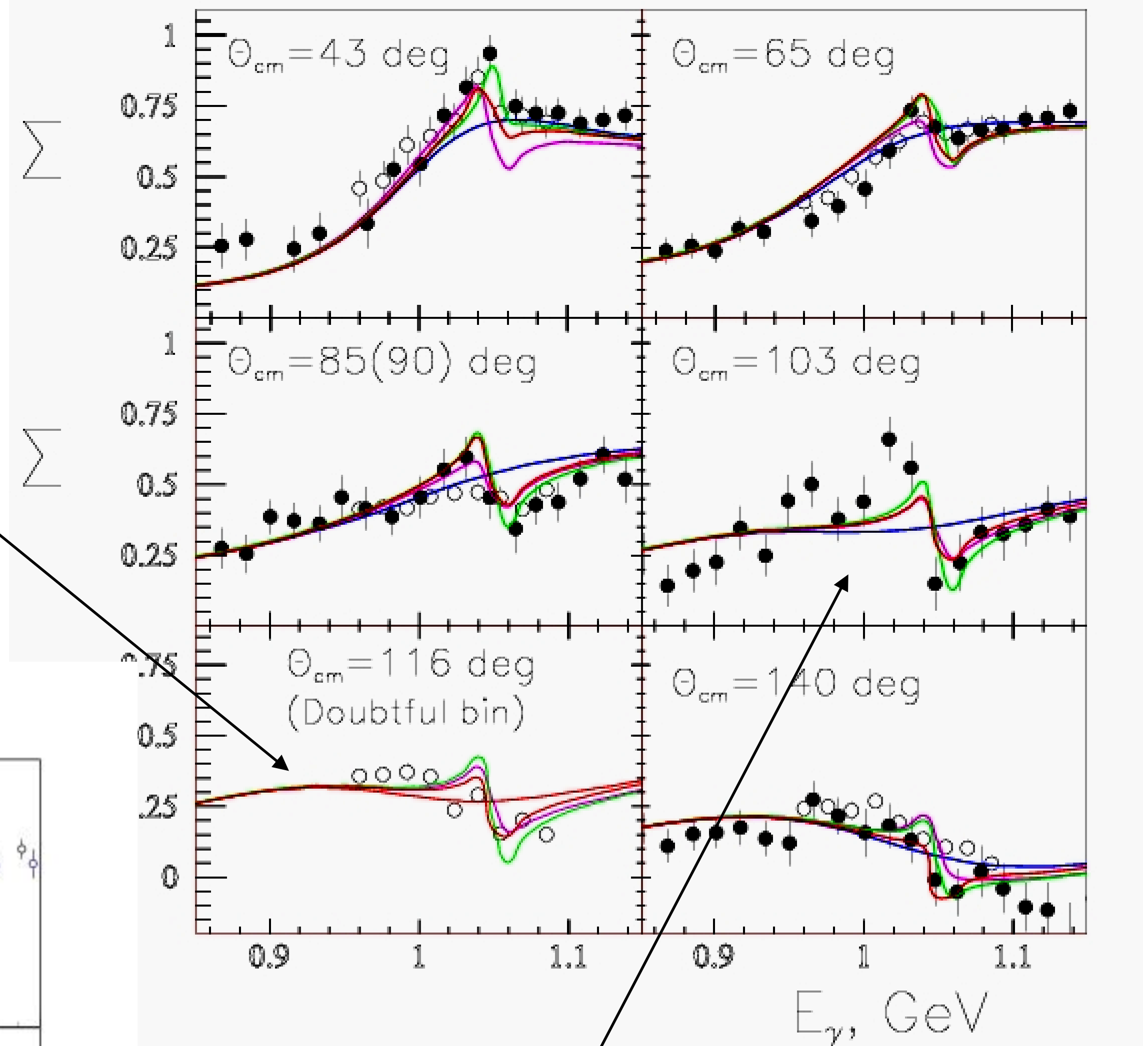
- Two resonant structures at $W\sim1.68$ and $W\sim1.72$ GeV are observed;
- One more challenge for the explanation of the ``neutron anomaly" in terms of the interference of well-known resonances;
- $W\sim1.68$ GeV and $W\sim1.72$ GeV are close to the thresholds of $K\Lambda$ and ωp photoproductions. This favors the assumption of the cusp effect. However, there are open questions: i)why it is not seen in pionphotoduction; ii) Could it occur in Comptons scattering; iii) Why the structure at $W\sim1.72$ GeV is not seen in η photoproduction?
- The only explanation that accommodates all experimental findings at $W\sim1.68$ GeV is the existence of N*(1685) resonance. The observation of the second structure at $W\sim1.72$ GeV adds more puzzle.....

Thank you for your attention!

Comparison of O.Bartalini et al. (open circles) and our results (black circles). Main difference is at 103/116 deg.







The same structure at 103 deg!

Comparison of preliminary results done by A.Lleres (A.Lleres, private communication (E-mail from Feb 5, 2007).

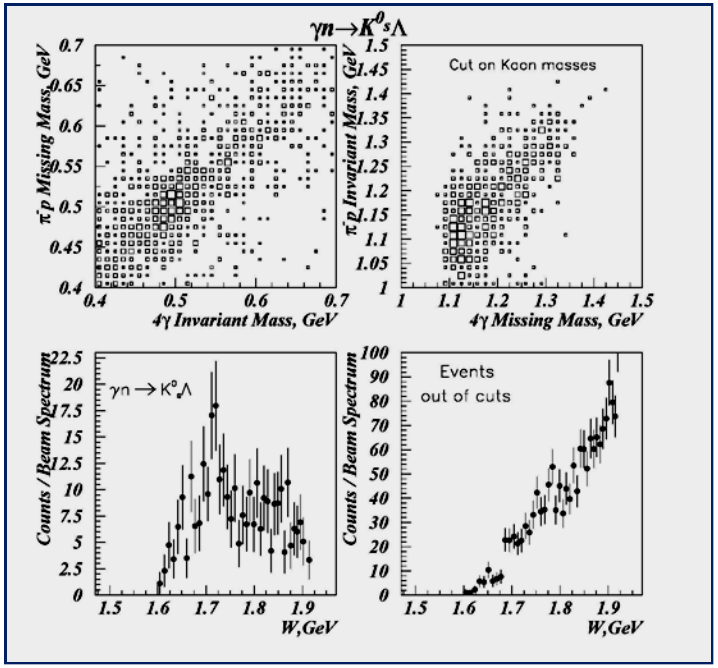
Resonant Structure at W~1.72 GeV?

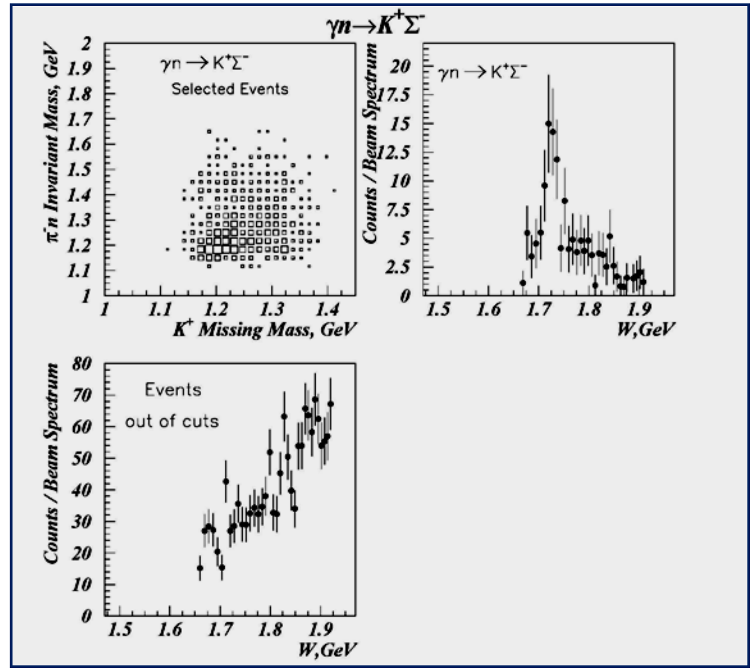
Some other results

$\gamma n \to K^0_s\Lambda$, $\gamma n \to K^+\Sigma^-$

Old (2003) preliminary GRAAL Analysis (remains uncompleted)

V.Kuznetsov for the GRAAL Collaboration, Talk at Worksho "Pentaquarks 2004", Trento, February 2004.



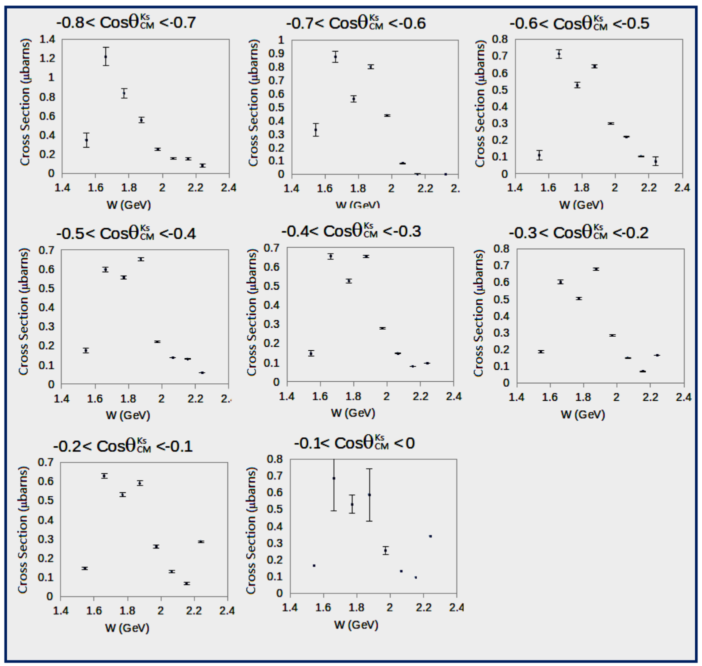


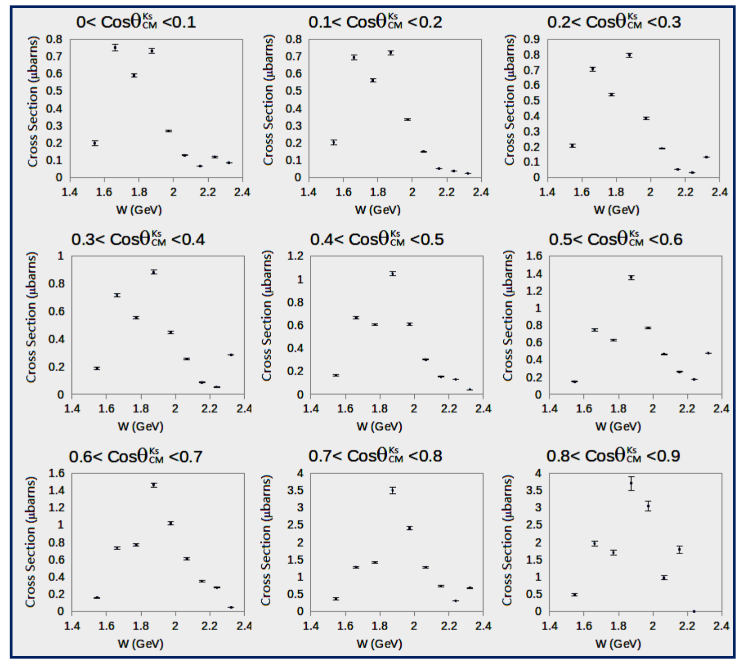
Peak near W~1.72 GeV?

Preliminary data on $\gamma n \to K^0_s \Lambda$ from CLAS

Talk of Taylor at NSATR2013 Workshop

Peak at 1.7 GeV!

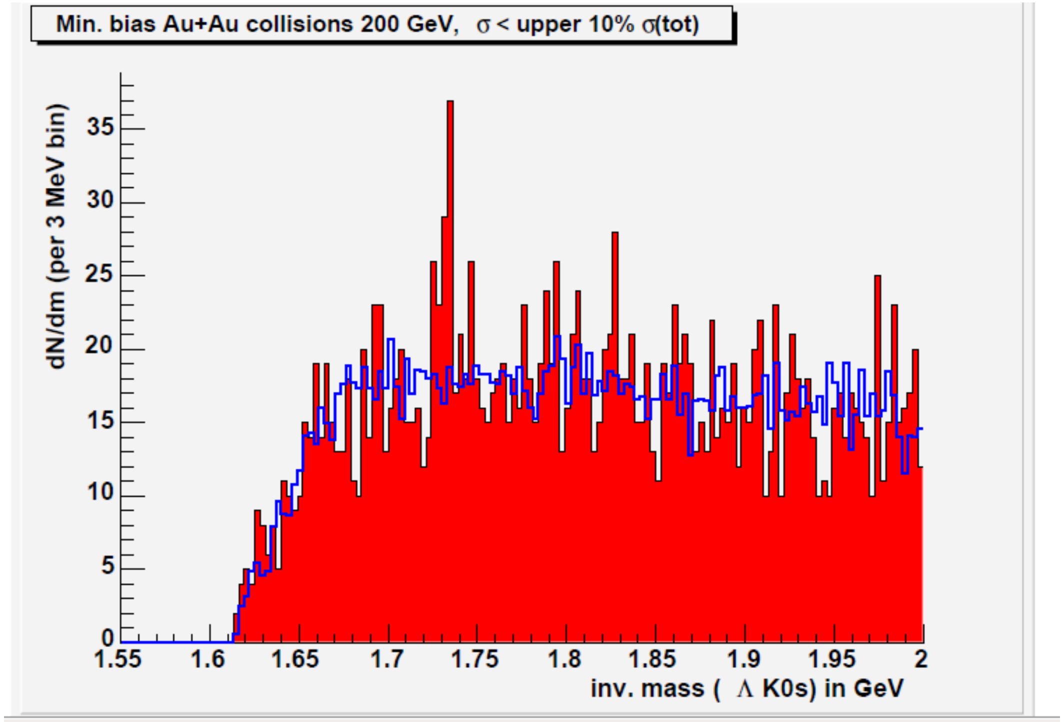




Old (2003) preliminary results from STAR

S. Kabana for the STAR Collaboration, Talk at Worksho "Pentaquarks 2004", Trento, February 2004.

S. Kabana for the STAR Collaboration,
PoS of 20th Winter Workshop on Nuclear DynamicsTrelawny Beach, Jamaica March 15{20, 2004)



SAID PWA

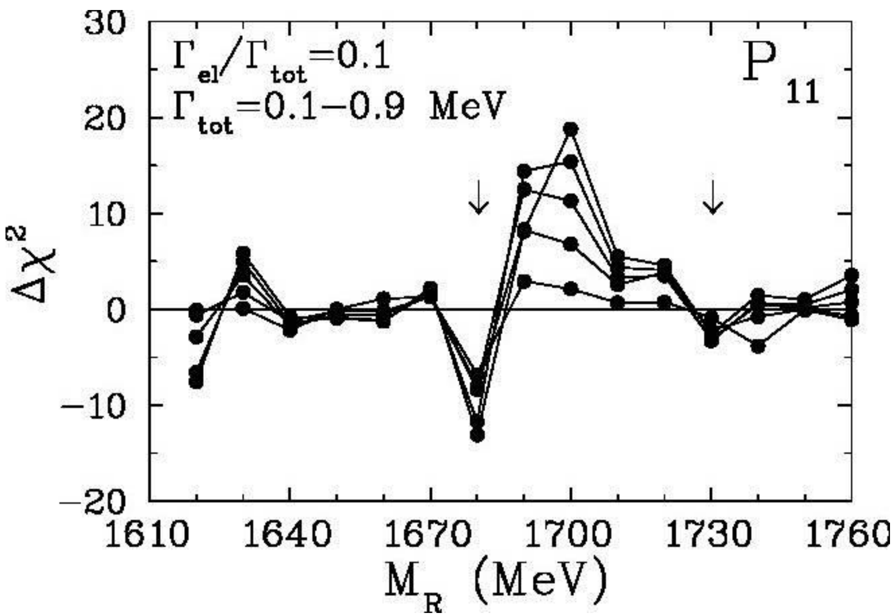
R.Arndt, Ya.Azimov, M.Polyakov, I.Strakovsky, R.Workman

``Nonstrange and other flavor partners of the exotic θ^+ baryon"

Phys.Rev. C69 (2004) 035208

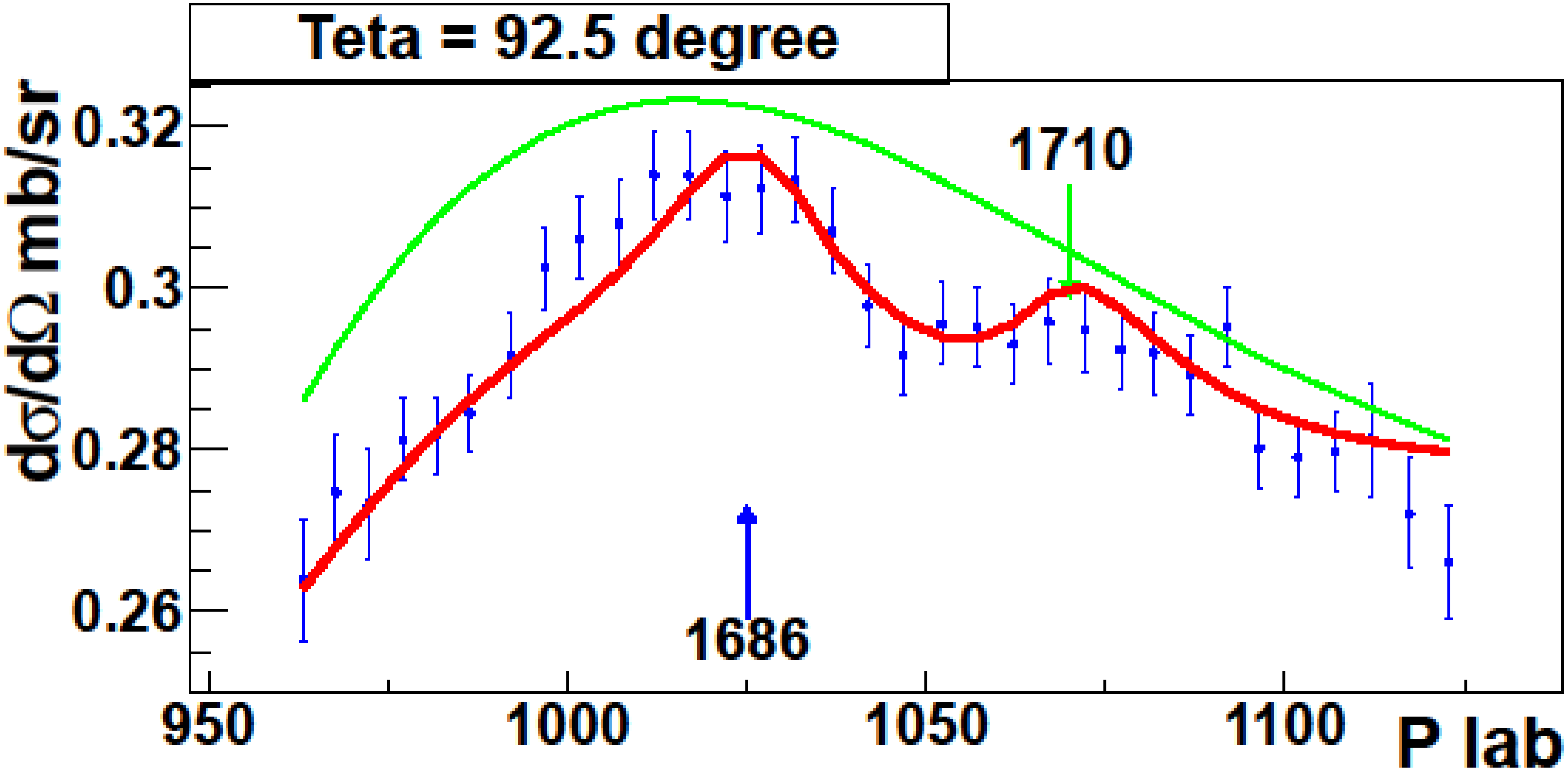
Nucl-th/0312126;

`` … given our present knowledge of the θ^+, the state commonly known as the N(1710) is not the appropriate candidate to be a member of the antidecuplet. Instead we suggest candidates with nearby masses, N(1680) (more promising) and/or N(1730) (less promising, but not excluded). Our analysis suggests that the appropriate state should be rather narrow and very inelastic…"



Recent updates from EPECUR $\pi^- p \rightarrow \pi^- p$

A. Gridnev, Private Communication



Interpretations:

Narrow resonance

- Y.Azimov, V.Kuznetsov, M.Polaykov, and I.Strakovsky, Eur. Phys. J. A **25**, 325, 2005.
- A.Fix, L.Tiator, and M.Polyakov, Eur. Phys. J. A **32**, 311, 2007.
- K.S.Choi, S.I. Nam, A.Hosaka, and H-C.Kim, Phys. Lett. B **636**, 253, 2006.
- K.S.Choi, S.I. Nam, A.Hosaka, and H-C.Kim, Prog. Theor. Phys. Suppl. **168**, 97, 2008.
- G.S.Yang, H.S.Kim, Arxiv:1204.5644

- **Interference of Known resonances** V. Shklyar, H. Lenske , U. Mosel , PLB650 (2007) 172 (Giessen group): A. Anisovich et al. EPJA 41, 13 (2009), hep-ph/0809.3340 (Bonn-Gatchina group); X.-H. Zong and Q.Zhao, Arxiv:1106.2892

- **Intermediate sub-threshold meson-nucleon state**

M.Doring, K. Nakayama, PLB683, 145 (2010), nucl-th/0909.3538

Thank you for your attention!