NEW NARROW NUCLEON N*(1685)

M. V. Polyakov (Ruhr University Bochum & Petersburg NPI)

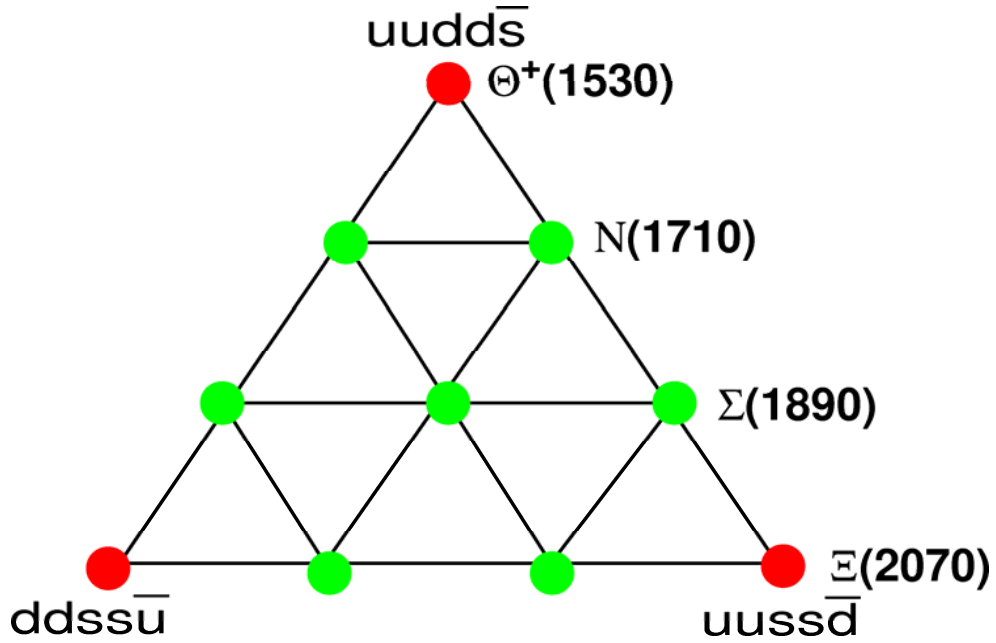
- Prediction of narrow N*
- "Neutron anomaly" in eta photoproduction
- Possible interpretations
- Evidence for narrow N* (1685) in beam asymmetry for eta photoproduction on FREE proton
- Conclusions and outlook

Brief and concentrated summary see:
V. Kuznetsov, M.V.P., JETP Lett., 88 (2008) 347

Detailed description of predictions and survey of data see:
V. Kuznetsov, M.V.P, et al., Acta Physica Polonica , 39 (2008) 1949

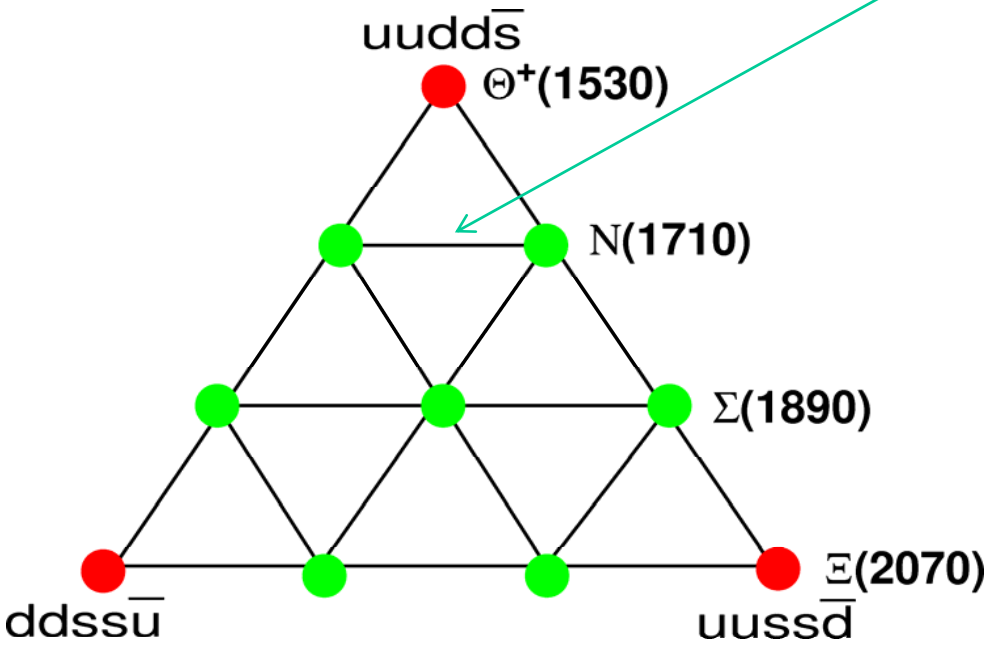
Anti-decuplet of baryons

D.Diakonov, V. Petrov, M.V.P., Z. Phys. A359 (1997) 302



I skip details of this predictions– just stress that it uses the picture of baryons as chiral solitons that is in many respects „abolish“ traditional quark model. The later model for the last 40 years guided the baryon spectroscopy. Maybe it is good time to reconsider the basics of the common view of the baryon spectrum?

Nonstrange pentaquark



Initially was identified with P11(1710)
/DPP '97/

Predicted properties:
- P11 quantum numbers
- weakly couples to pi N state, narrow
- significantly couples to eta N
- photopropuction on proton is suppressed by SU(3)

In 1997 very uncertain properties of P11(1710) were hardly but compatible with prediction of soliton picture of baryons, also at that time for us it was hard to believe that one could miss a narrow nucleon resonance around 1700 MeV after decades of baryon spectroscopy programme.

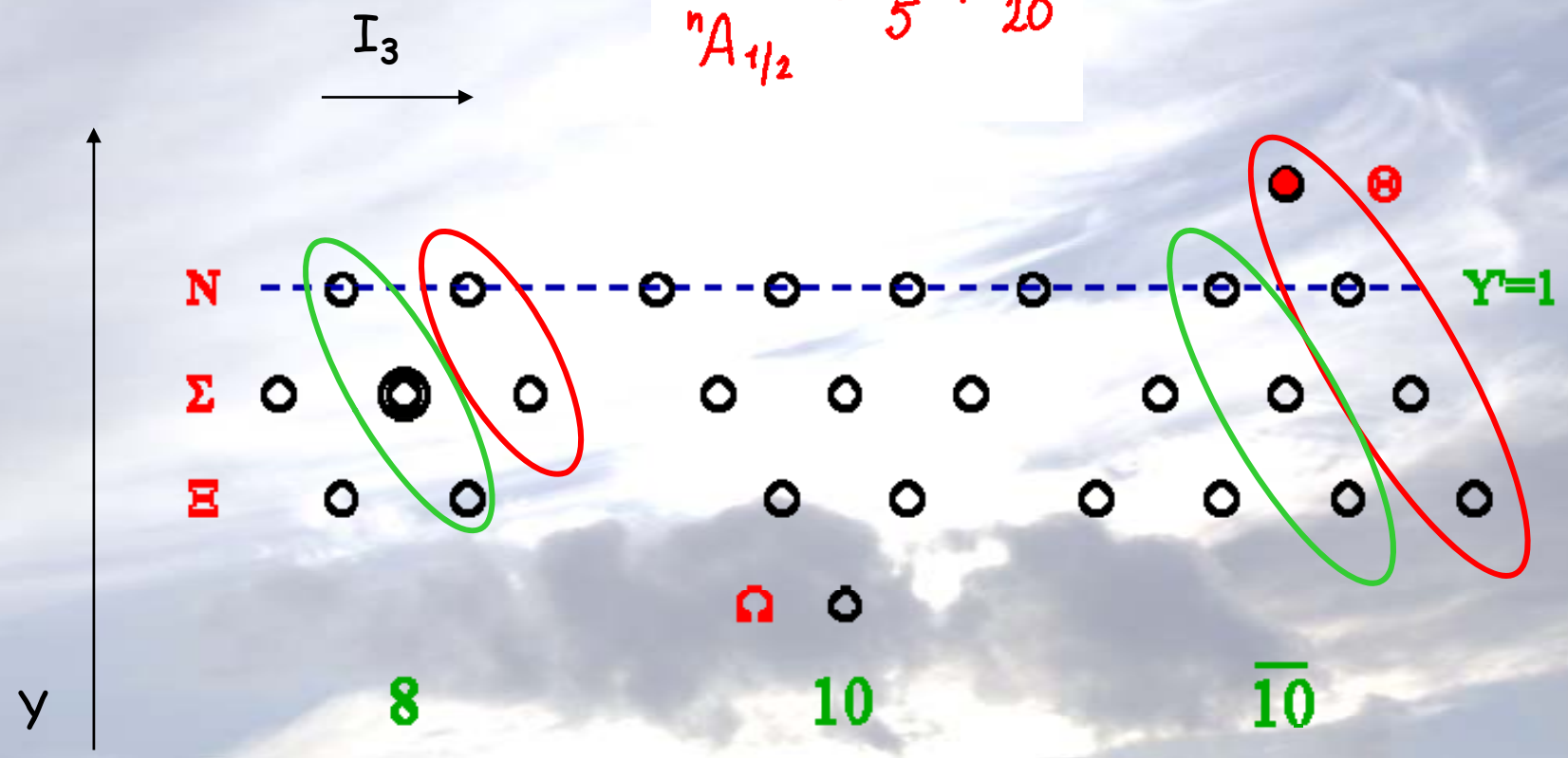
In 2003 it became clear that P11(1710) can not be member of anti-decouplet, therefore it was suggested in **/R. Arndt, et al. PRC 69 (2004) 035208 /** and **/D.Diakonov, V. Petrov PRD69 (2004) 094011/** an existence of new P11 narrow nucleon resonance with the mass in 1700 MeV region.

Photon has U-spin = 0. Good filter for multiplets

Anti-decuplet N* in the SU(3) limit can be photoexcited only from the neutron target

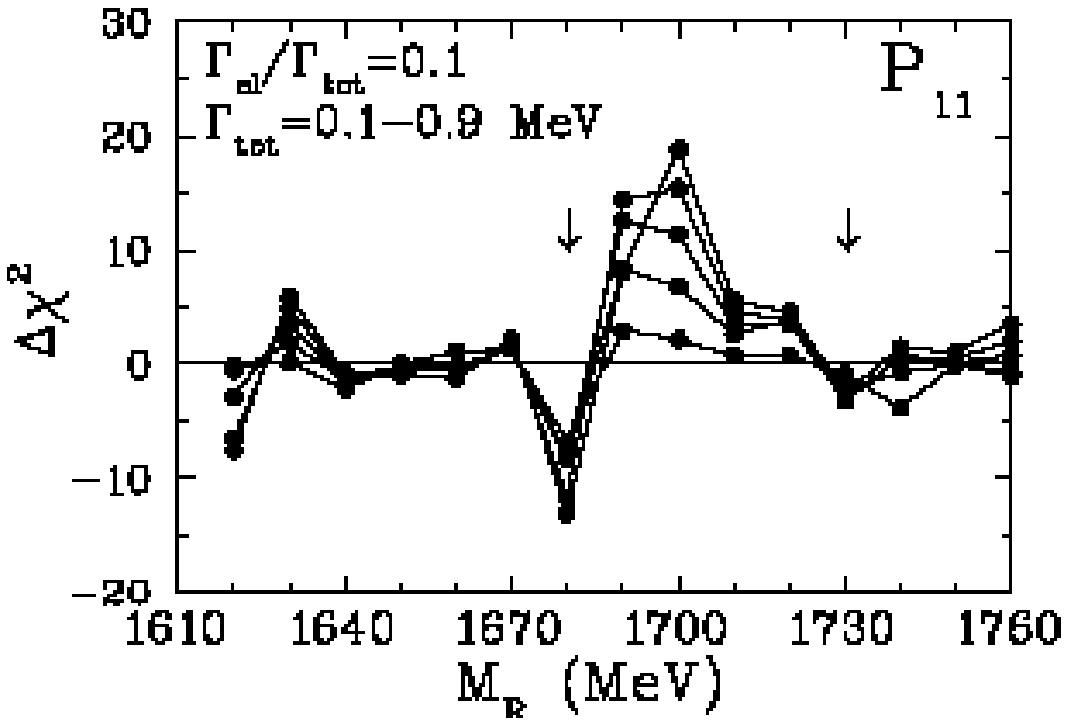
A. Rathke, M.V.P. EPJ A18 (2003) 691

$$\frac{{}^{p}A_{1/2}}{{}^{n}A_{1/2}} \sim \frac{1}{5} \div \frac{1}{20}$$



Modified PWA of pi N scattering – first hint on new narrow N*(1680)

Arndt, Azimov, Strakovsky, Workman,MVP, PRC04



Main conclusions of MPWA:

- mass ~1680
- width< 30 MeV
- Br(piN) < 5%
- most probable quantum #'s P11
- Br(eta N) ~ 10 -60 %

`` … 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…"

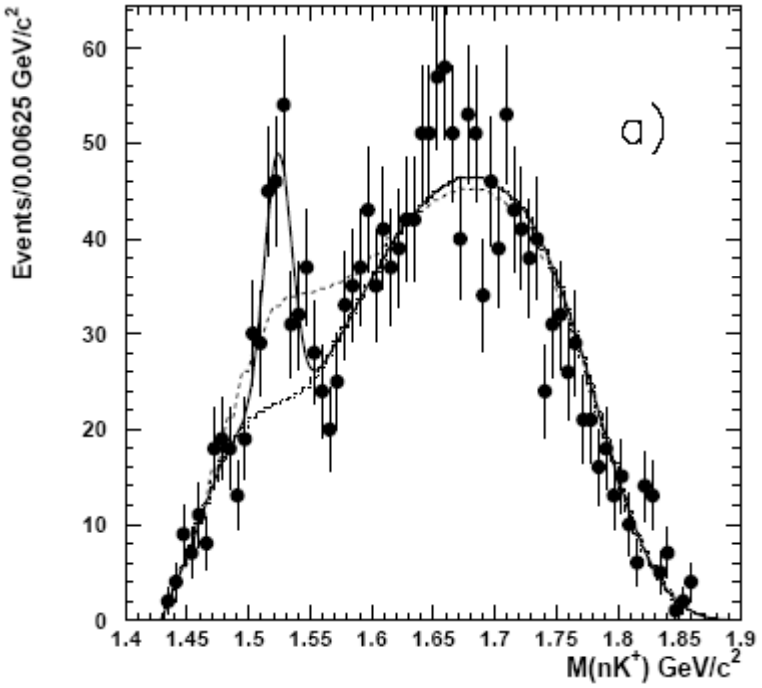
/Arndt, Azimov, Strakovsky, Workman,MVP, PRC04

/

Theta update

Takashi Nakano, et al. (The LEPS Collaboration)

Evidence of the Theta^+ in the gamma d → K+K- pn reaction, arXiv:0812.1035, accepted to PRC

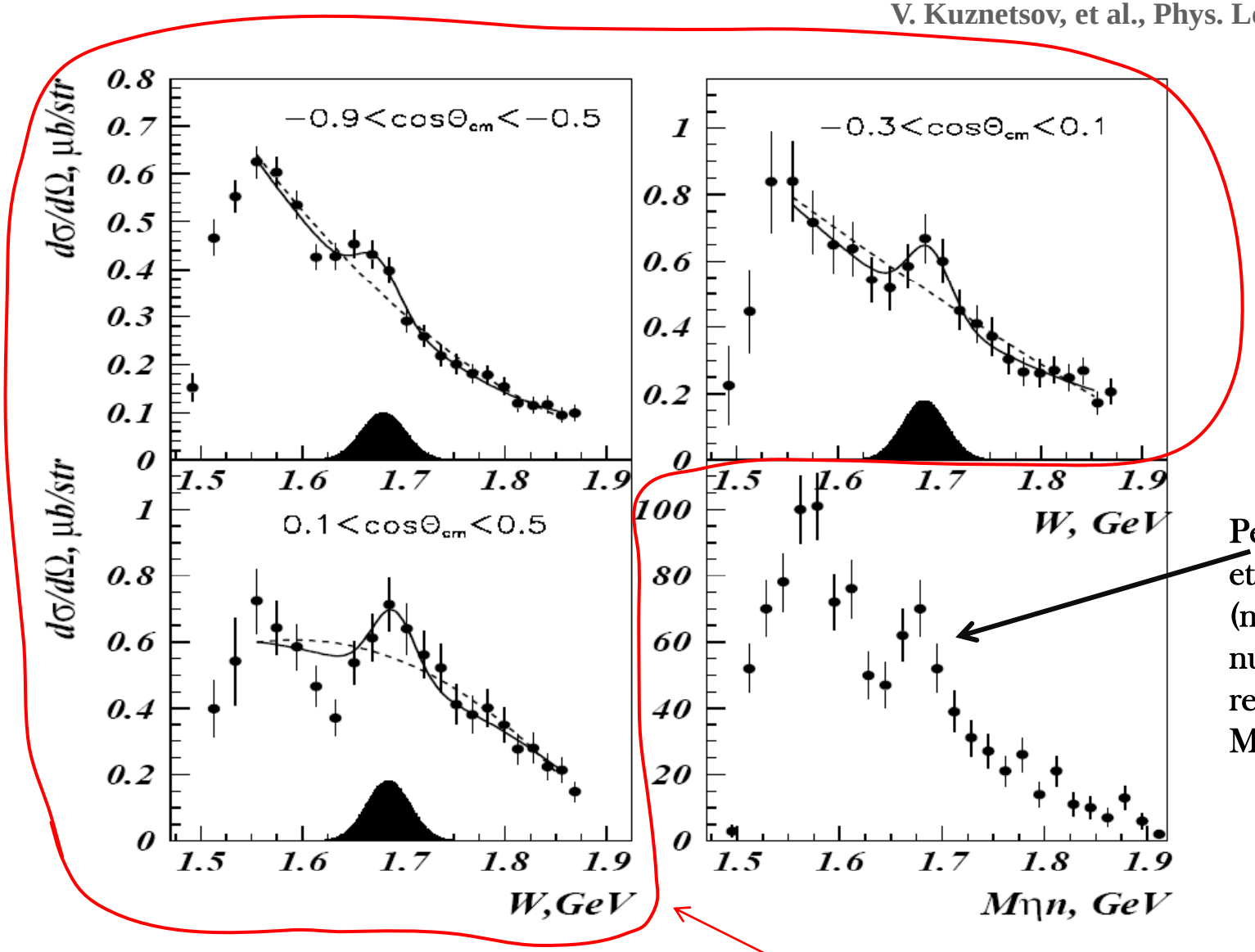


The most conservative estimate of significance ~ 5.2 sigma

In couple of monthes the „black box“ of blindly analyzed tripled data set will be opened.

Eta photoproduction on the neutron. First observation of „neutron anomaly“ in GRAAL data.

V. Kuznetsov, et al., NSTAR‘’04, hep-ex/0409032
V. Kuznetsov, et al., Phys. Lett. 647 (2007) 23



Peak in eta-neutron inv. (not affected by nuclear effects, only resolution)
Mass ~1680 MeV

Bump in quasi-free cross-section: „neutron anomaly“ (affected by nuclear effects)

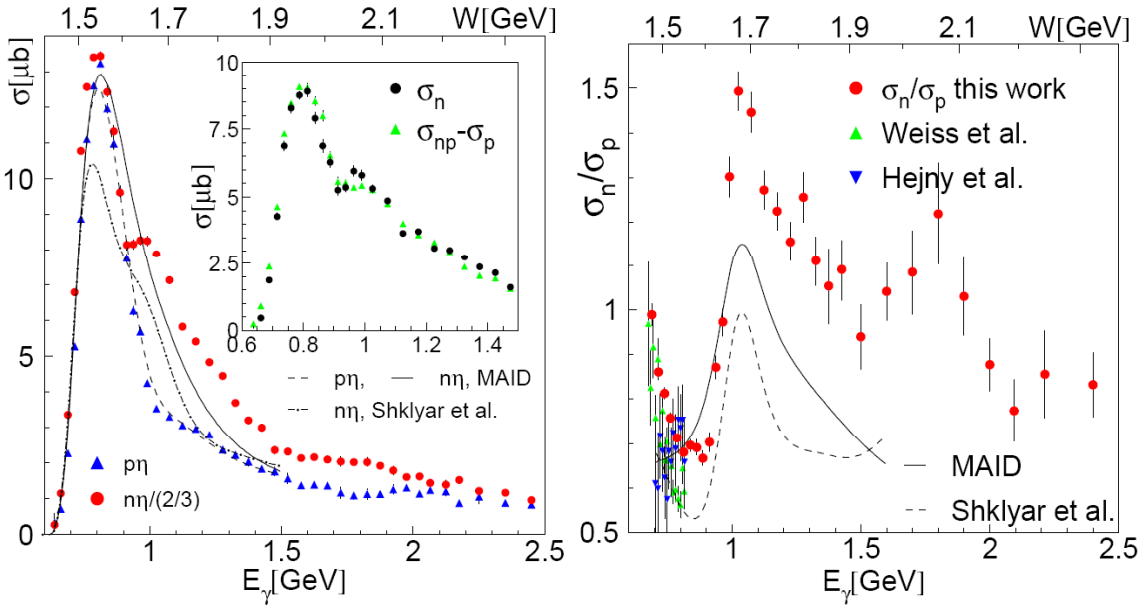
Eta photoproduction on the neutron. CB-ELSA/TAPS results.

I. Jaegle, et al., Phys. Rev. Lett. 100 (2008) 252002

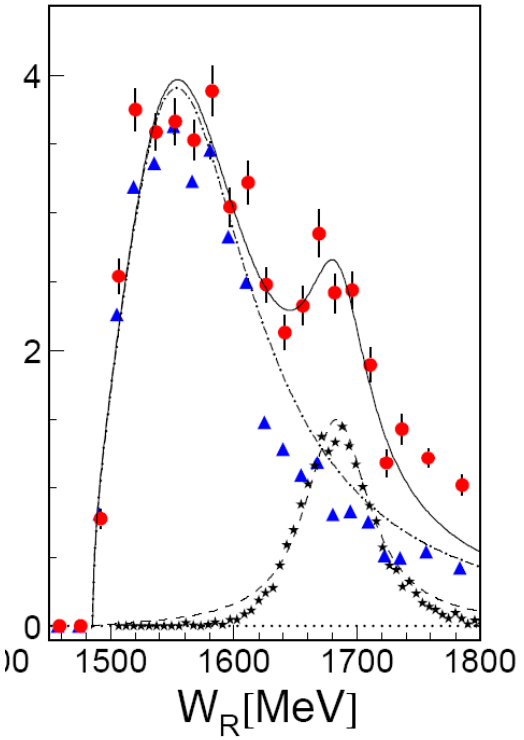
Note that the „neutron anomaly“ is affected by the Fermi motion, rescattering effects and the procedure of extraction quasi-free cross section

Peak in the inv. mass is Independent of these effects

Bump in quasi-free cross-section: „neutron anomaly“

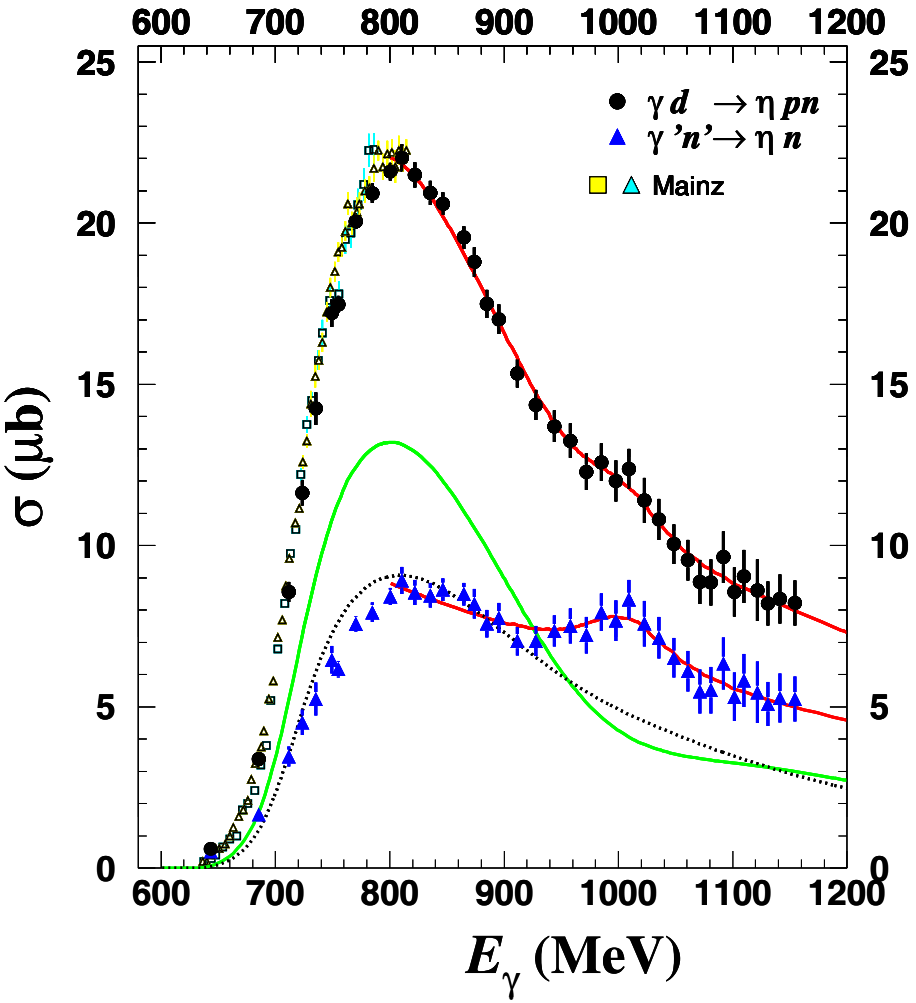


Peak in
eta-neutron inv.
Mass ~1683 MeV



Eta photoproduction on the neutron. LNS-Tohoku result.

F. Miyahara et al. Progr. Theor. Phys. Suppl. 168 (2007) 90



CB-ELSA/TAPS and LNS-Tohoku confirmed the „neutron anomaly“ discovered by V. Kuznetsov et al. in GRAAL data

CB-ELSA/TAPS also confirmed the presence of narrow peak in eta-n invariant mass.

Intrepretations of the „neutron anomaly“

✓**New narrow nucleon resonance with much stronger photocoupling to neutron. Was predicted before experiments as anti-decuplet member!**

A. Rathke, M.V.P. EPJ A18 (2003) 691
R. Arndt, et al. PRC 69 (2004) 035208
D.Diakonov, V. Petrov PRD69 (2004) 094011

✓**Effect of photo-excitation of D15(1675).**

L.Tiator, et al. Eta- MAID, 2005

✓**Coupled channel effect of S11(1650) and P11(1710) .**

V. Shklyar, H. Lenske , U. Mosel , PLB650 (2007) 172

✓**Either interference effects of S11(1535) and S11(1650) OR new narrow resonance**

A. Anisovich et al. ArXiv: 0809.3340

Effect of photo-excitation of D15(1675).

L.Tiator, et al. Eta- MAID, 2005

Requires too large eta-N branching ratio – 17%
In PDG Br=1 %, also SU(3) analysis gives Br=2-3%

V. Guzey, MVP , 2005

Contradicts data on neutron beam asymmetry

A. Fantini, et al. PRC 78 (2008) 01523

Ruled out by the analysis of **A. Anisovich et al. ArXiv:0809.3340**

Coupled channel effect of S11(1650) and P11(1710) .

V. Shklyar, H. Lenske , U. Mosel , PLB650 (2007) 172

Interference effects of S11(1535) and S11(1650)

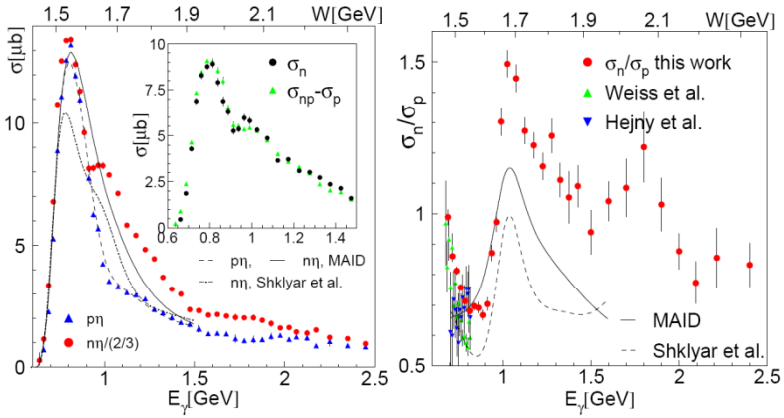
A. Anisovich et al. 0809.3340

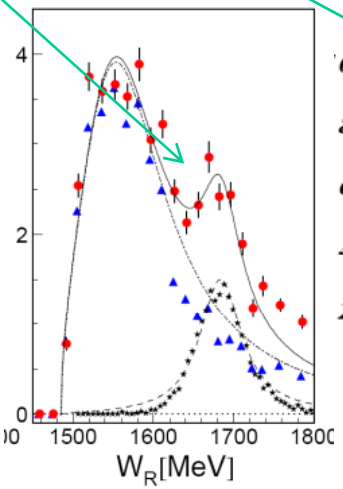
•Can not explain narrow peak in eta-neutron invariant mass observed by GRAAL and CB/TAPS (widths of the peaks are ~40 and ~60 MeV)

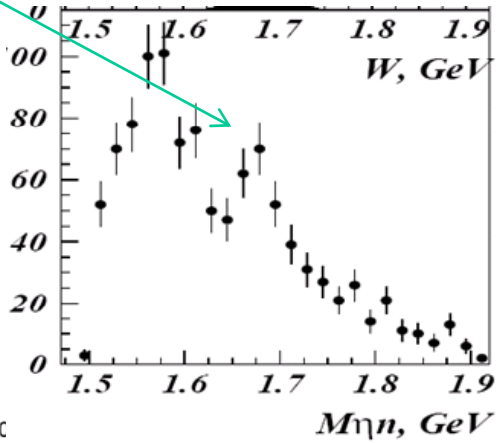
• Giessen and Bonn interpretations contradict each other! [A. Anisovich et al. ArXiv: 0809.3340]

•Require „fine tuning“ of neutron photocouplings .

•Predict absence of any narrow structure in the free proton channel observables

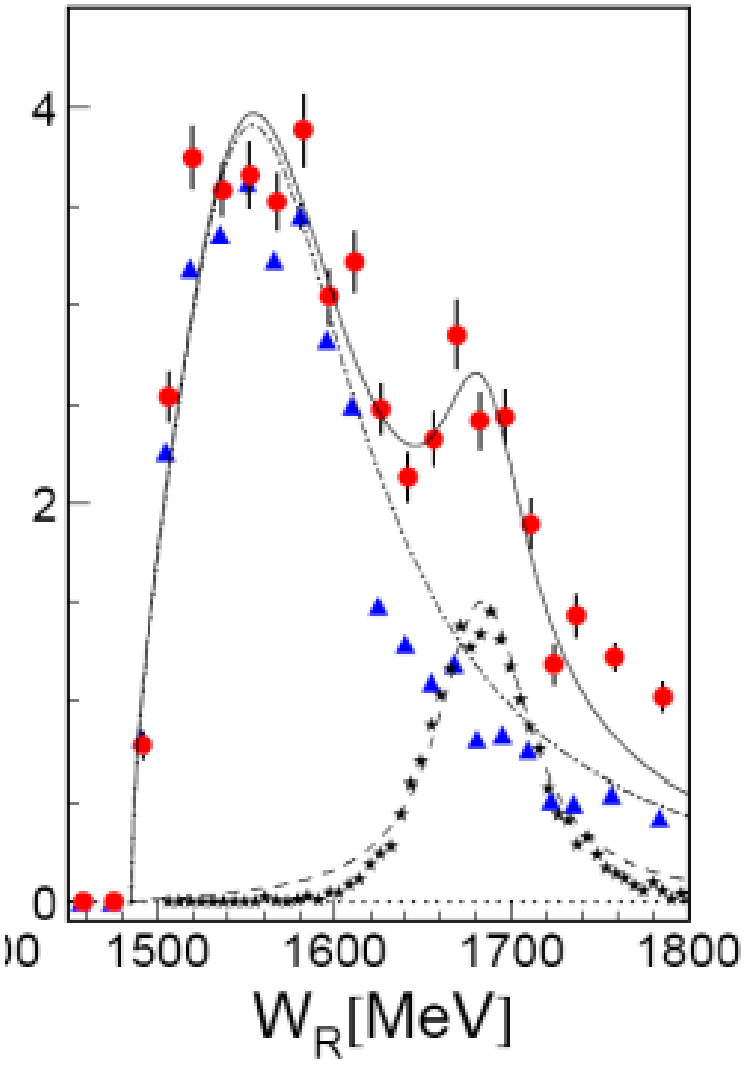






Eta-neutron invariant mass : not affected by nuclear effects

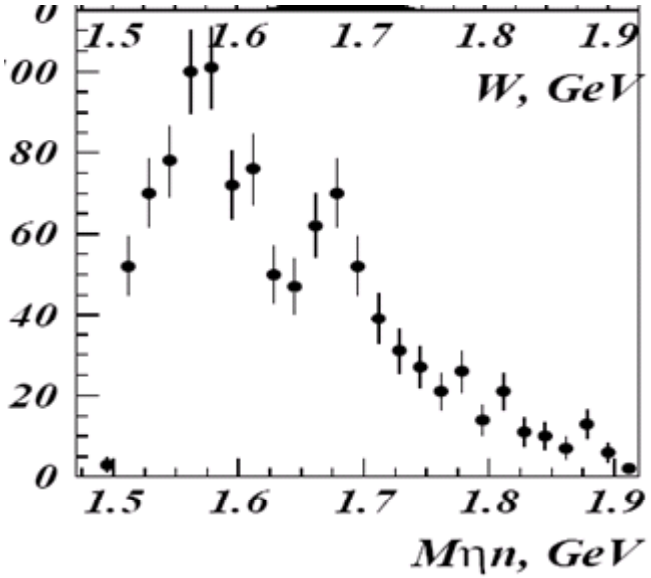
I. Jaegle, et al., Phys. Rev. Lett. 100 (2008) 252002



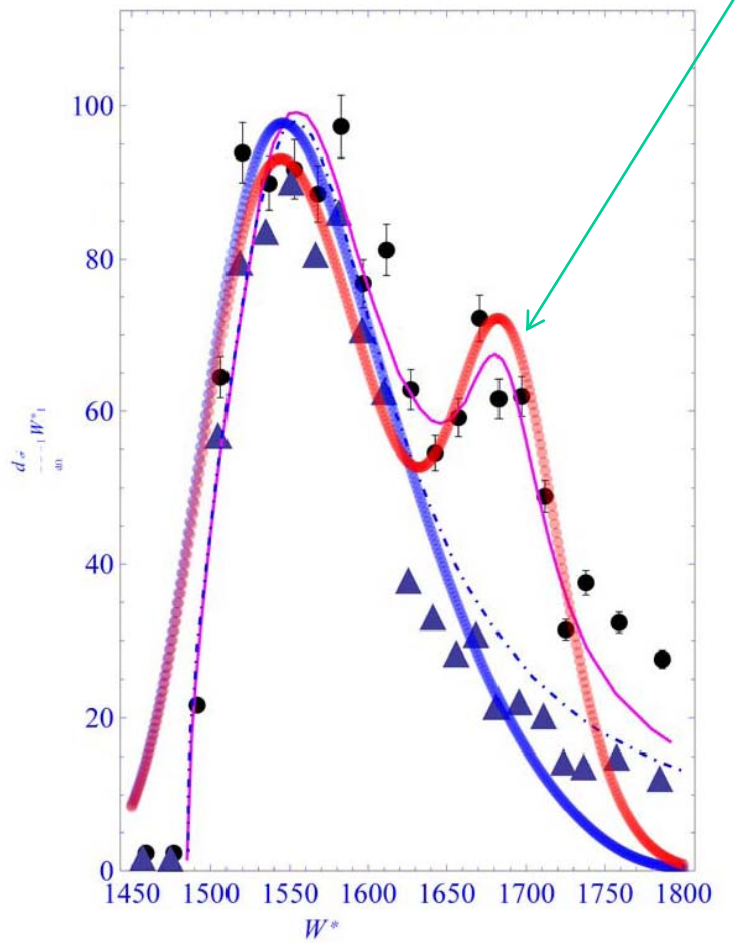
Explanation due to interference of known resonances can NOT describe the peak in eta-N invariant mass.

The narrow resonance with parameters predicted by us 5 years ago easily describes this experimental result!

V. Kuznetsov, et al., NSTAR''04, hep-ex/0409032
V. Kuznetsov, et al., Phys. Lett. 647 (2007) 23



Calculation of eta-n invariant mass: SAID multipoles+ N*(1685) added coherently (back of an envelope estimate)



The narrow resonance contribution to eta-N invariant mass smeared by experimental resolution (30 MeV Gaussian width).
Parameter of the resonance:

$$M = 1685 \text{ MeV}$$

$$\Gamma = 5\text{-}25 \text{ MeV}$$

$$\sqrt{Br(\eta N)} \cdot A^n_{1/2} = 17 \cdot 10^{-3} \text{ GeV}^{-1/2}$$

Parameters which has been predicted long before the CB-ELSA/TAPS and GRAAL data!!! See:

A. Rathke, M.V.P. EPJ A18 (2003) 691

R. Arndt, et al. PRC 69 (2004) 035208

D.Diakonov, V. Petrov PRD69 (2004) 094011

YA. Azimov, V. Kuznetsov, I. Strakovsky, M.V.P. EPJ A25 (2004) 325

Kim, Praszalowicz, Yang, MVP, PRD71 (2005) 094023

Red curve (SAID + narrow N(1685)) was obtained WITHOUT fitting!*

A signal of N*(1685) in the photoproduction off FREE proton is expected to be strongly suppressed as compared to the neutron channel.

$$\frac{{}^{p}A_{1/2}}{{}^{n}A_{1/2}} \sim \frac{1}{5} \div \frac{1}{20}$$

A. Rathke, M.V.P. EPJ A18 (2003) 691
Kim, Praszalowicz, Yang, MVP, PRD71 (2005) 094023

Therefore:

✓We choose to analyse photon beam asymmetry in which a weak resonance signal is encanced via interference with a smooth contributions

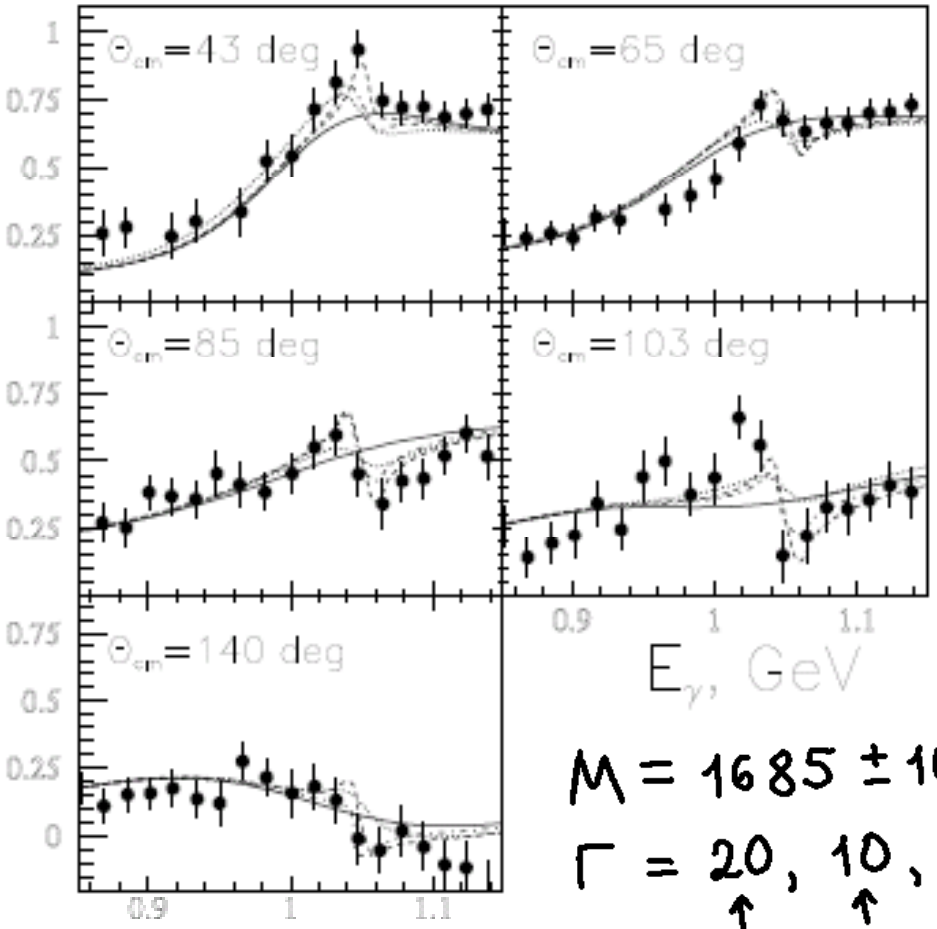
See M. Amarian, D. Diakonov, MVP, PRD78 (2008) 074003 for uses of interference to reveal Theta+ signal from CLAS data

✓ Narrowness of the signal requires careful studies of energy resolution and fine energy binning

✓ As the expected weak resonance signal is mostly due to interference it is not necessarily has a form of a peak → „interference pattern recognition“

GRAAL beam asymmetry for eta photoproduction on free proton with fine energy binning.

V. Kuznetsov, M.V.P, et al., hep-ex/0703003
V. Kuznetsov, M.V.P, et al., Acta Physica Polonica , 39 (2008) 1949
V. Kuznetsov, M.V.P., JETP Lett., 88 (2008) 347



One sees deviation of the data from SAID solution in narrow inv. energy interval W~1670 – 1710 MeV with pattern similar to interference of a narrow resonance with smooth amplitude.

Fit: smooth SAID multipoles + a resonance

χ^2 for narrow energy interval

SAID	74/24
SAID + P_{11}	52/22
SAID + P_{13}	22/20

$M = 1685 \pm 10$ MeV

$\Gamma = 20, 10, 10$ MeV

P_{11} P_{13} D_{13}

„Simple and consise explanation of recent data on eta photoproduction is an existence of a new narrow nucleon resonance with properties“:

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

- Mass: $M = 1685 \pm 10$ MeV
- Width: $\Gamma \lesssim 25$ MeV
- Photocouplings:

$\sqrt{B\Gamma_{\eta N}}\, A^n_{1/2} \sim 15 \times 10^{-3}\ \mathrm{GeV}^{-1/2}$

$\sqrt{B\Gamma_{\eta N}}\, A^p_{1/2} \sim 1 \times 10^{-3}\ \mathrm{GeV}^{-1/2}$

- Quantum numbers:

S_{11} is excluded

P_{11} is most probable $\leftarrow \pi N$

Properties very similar to that predicted for N* from anti-decuplet:

A. Rathke, M.V.P. EPJ A18 (2003) 691
YA. Azimov, V. Kuznetsov, I. Strakovsky, M.V.P. EPJ A25 (2004) 325

R. Arndt, et al. PRC 69 (2004) 035208

D.Diakonov, V. Petrov PRD69 (2004) 094011

$$\frac{{}^pA_{1/2}}{{}^nA_{1/2}} \sim \frac{1}{5} \div \frac{1}{20}$$

Conclusions

It seems that for many years we have been overlooking a narrow nucleon resonance with mass 1685 MeV and with stronger photocoupling to the neutron.

Double polarization observables can be of big help to establish quantum numbers of narrow N*(1685)! **G.-S. Yang and M.V.P. in preparation**

New narrow nucleon state – a challenge for standard PWA techinique,
we suggest to PWA groups to develope together new PWA procedure
based on Lagrange multiplyer method.
see, e.g. its application to analysis of polarized PDFs in Stratmann, Vogelsang, et al. PRL 101 (2008) 082001

„If you meet something, that looks, moves, smells and sounds like an elephant, that is ..... really an elephant“

(children saying:)

Focused workshop in Edinburgh, June 8-10

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SCOPE

The first statement on possible existence of a narrow nucleon resonance near 1680 MeV was based on the πN Partial Wave Analysis, though it suggested very small coupling with the πN channel. Then direct experimental evidences for the narrow bump in this mass area have been reported in the η photoproduction by three independent groups, first by GRAAL, and somewhat later by CB-ELSA and LNS.

The resonance interpretation imply unfamiliar features: a small total width (< 25 MeV), very small πN coupling, and strong isotopic asymmetry of photocoupling (production off neutron at least an order higher than off proton). These properties are very similar to those predicted for the non-strange member of the exotic anti-decuplet.

Alternative explanations of the observed bumps in terms of interference of known nucleon resonance have been suggested as well. It seems that, despite intensive studies of baryon spectroscopy world wide, we may have earlier missed a narrow nucleon resonance with mass around 1680 - 1690 MeV.

Therefore, the situation is worth a profound discussion, which may clarify the present status and suggest new directions for both experimental and theoretical investigations.

Many prominent speakers, we expect announcenments of new interesting results!
You are wellcome!

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