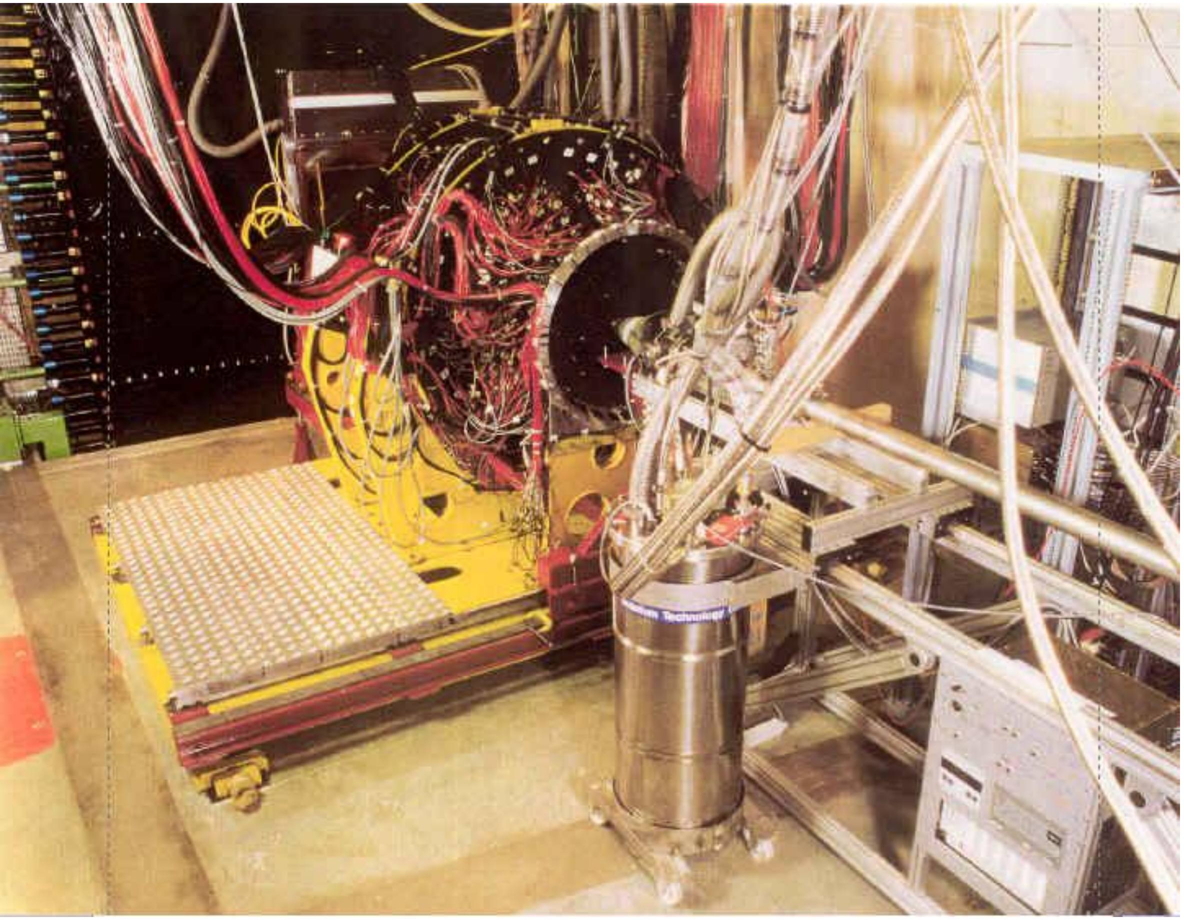
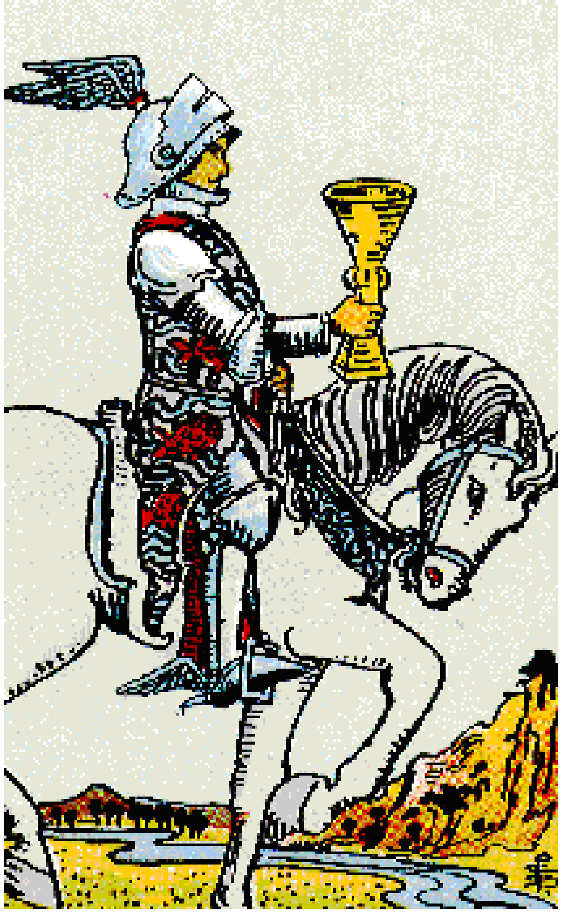
Search for new N(1685) resonance in $\gamma N \to \pi \eta N$ reactions

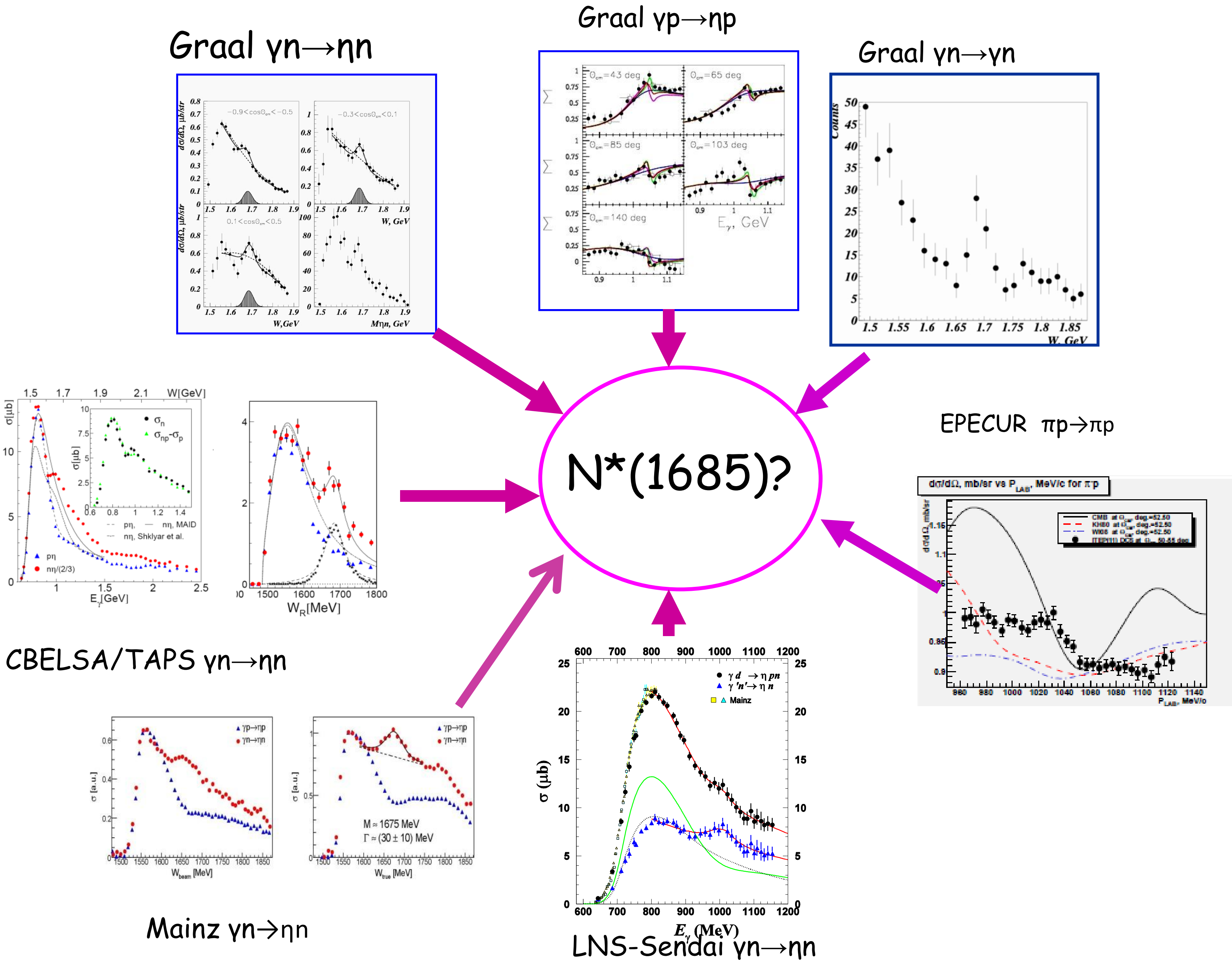
New analysis of the GRAAL data

To be published in JEPT Letters





V. Kuznetsov, HEPD Session December 2017


Graal γn→ηn
Graal γp→ηp
Graal γn→γn
N*(1685)?
EPECUR πp→πp
CBELSA/TAPS γn→ηn
Mainz γn→ηn
LNS-Sendai γn→ηn
M ≈ 1675 MeV
Γ ≈ (30 ± 10) MeV

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	$\gamma d \to \eta n (p)$

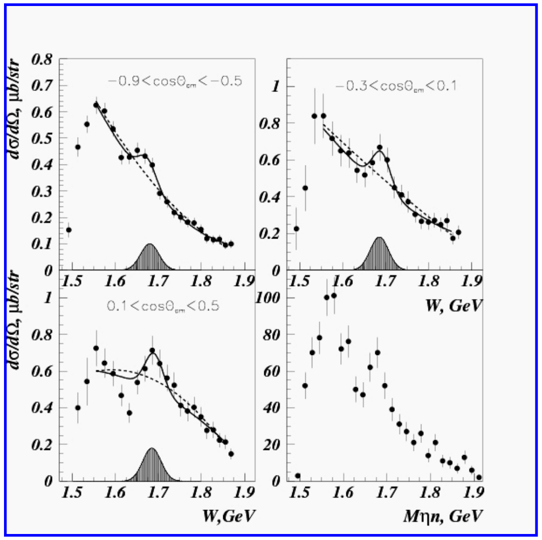
N(1685) WIDTH

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

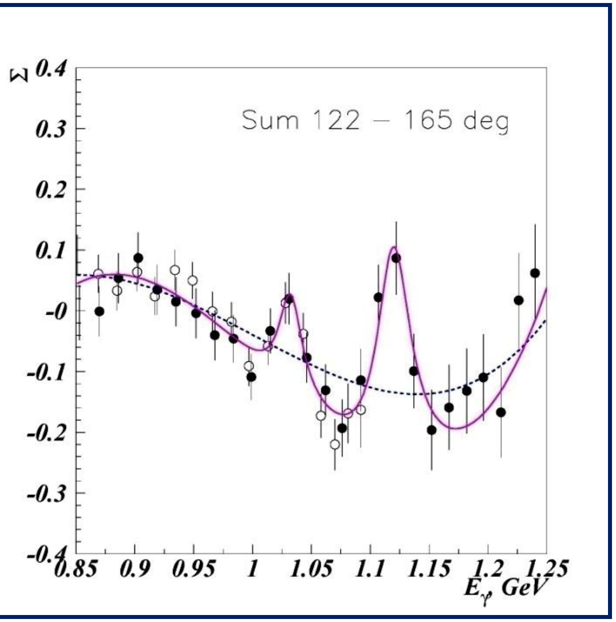
JAEGLE	11	EPJ A47 89	I. Jaegle *et al.*	(CBELSA/TAPS Collab.)
Also		PRL 100 252002	I. Jaegle *et al.*	(CBELSA/TAPS Collab.)
KUZNETSOV	11	PR C83 022201	V. Kuznetsov *et al.*	(GRAAL Collab.)
KUZNETSOV	11A	JETPL 94 503	V. Kuznetsov, M.V. Polyakov, M. Thurmann	(INRM+)
MART	11	PR D83 094015	T. Mart	(U. Indonesia)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

Первое наблюдение в $\gamma n \to \eta n$ реакции
V.Kuznetsov et al. (GRAAL Collaboration),
Phys. Lett. B**647**, 23 (2007)

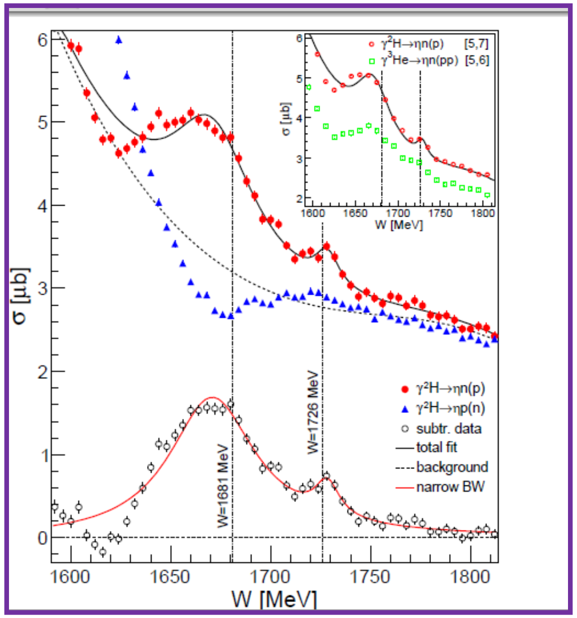


В 2008 – 2016 годах подтверждено коллаборациями CBELSA/TAPS (Бонн, Германия), LNS (Сёндэ, Япония), A2@MAMIC (Майнц, Германия), EPECUR(ИТЭФ-ПИЯФ, Россия.)

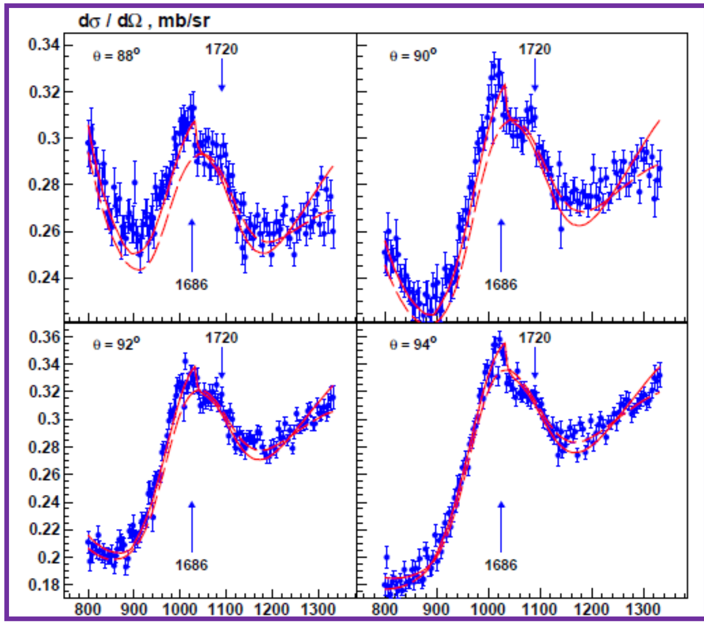
Two narrow structures at W ~ 1.68 and W ~ 1.72 GeV



Beam asymmetry for Compton Scattering at GRAAl
V.Kuznetsov et al., Phys.Rev. C**91**, 042201 (2015)



γn→ηn cross section
CBELSA/TAPS and A2@MAMIC Collaborations,
D. Wertmuller, L. Withauer, D. Glazier and B.Krushe, Phys. Rev. C 92, 069801 (2015).



$\pi^- p \rightarrow \pi^- p$ cross section
A. Gridnev et al, Phys.Rev. C93 (2016) no.6, 062201

Do we really see narrow resonances?

If so, this will be a challenge for Constituent Quark Model…

Alternative interpretations of the structure at W ~ 1.68 GeV:

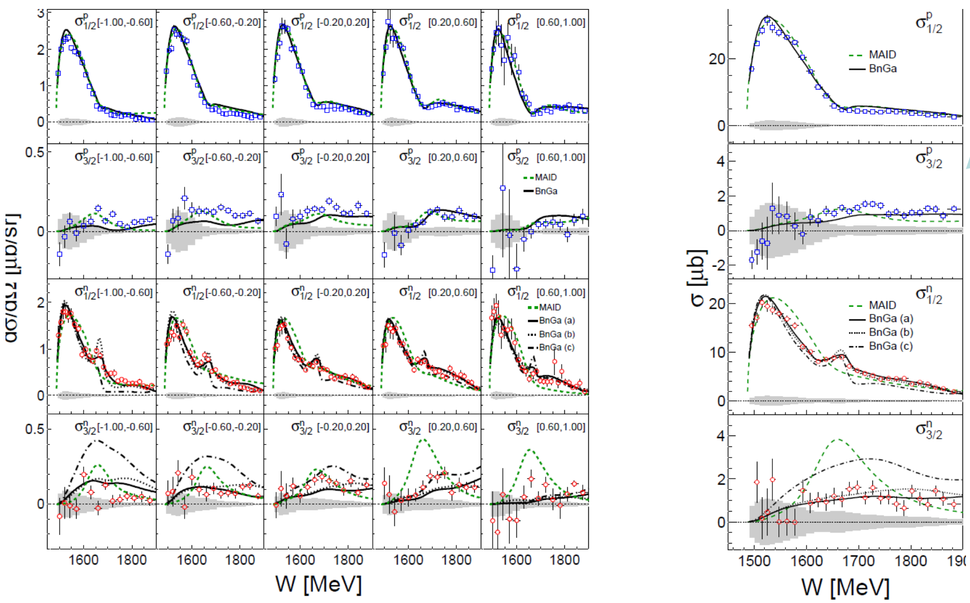
- **Interference of Known resonances** by A. Anisovch, V. Burkert, A. Sarantsev et al., A.V. Anisovich, V. Burkert, E. Klempt, V.A. Nikonov, A.V. Sarantsev, U. Thoma, Phys.Rev. C**95** 035211 (2017) and references therein;

- **Intermediate sub-threshold meson-nucleon state** M.Doring, K. Nakayama, PLB683, 145 (2010), nucl-th/0909.3538

Updates from 2017

L. Witthauer et al., Phys. Rev. Lett. **117**, 132502 (2016)
[A2@MAMI C Collaboration]
Measurement of Helicity-dependent γn→ηn cross sections

``…The extracted Legendre coefficients of the angular distributions for 1/2 are in good agreement with recent reaction model predictions assuming a narrow resonance in the P11 wave as the origin of this structure...”



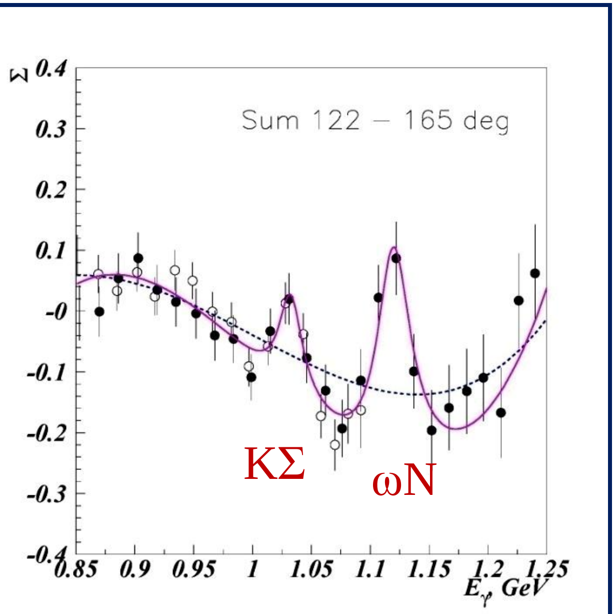
``Scrutinizing the evidence for N(1685)”
A.V. Anisovich, V. Burkert, E. Klempt, V.A. Nikonov, A.V. Sarantsev, U. Thoma
Phys.Rev. C**95** (2017), 035211
arXiv:1701.06387
`` …There is hence the suspicion that the dip might be a statistical fluctuation…a partial wave analysis without a narrow $J^P = 1/2^+$ resonance is excellent…”

Comments

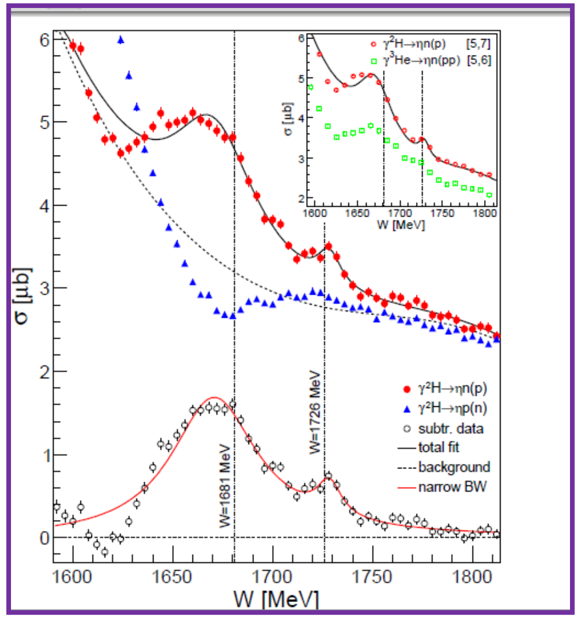
Comments on Comments

``New Narrow N(1685) and N(1722)? Remarks on the interpretation of the neutron anomaly as an intereference phenomenon”
V. Kuznetsov et al., JEPT Letters **105** (2017) no.10, 625-630

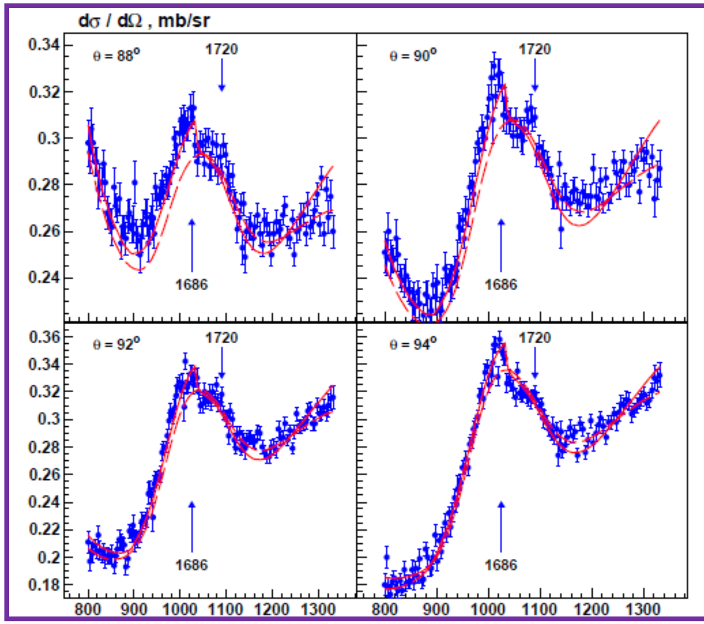
Two narrow structures at W ~ 1.68 and W ~ 1.72 GeV



γp→γp (GRAAL)



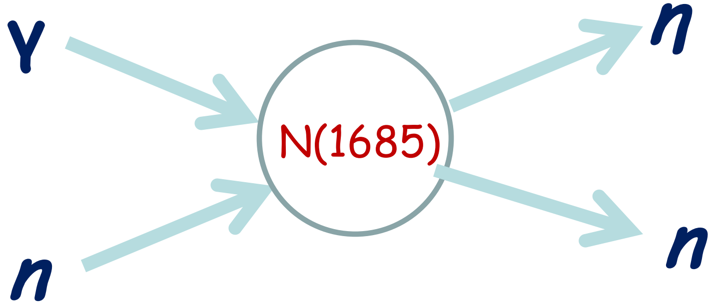
γn→ηn (CBELSA/TAPS)



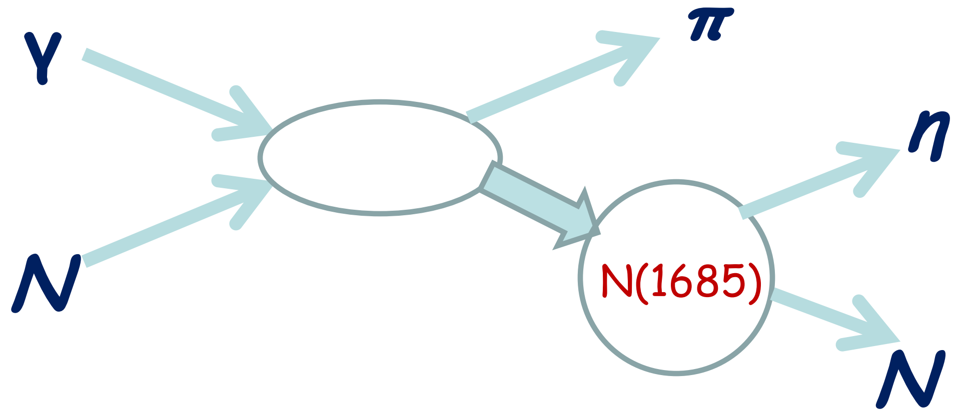
π⁻p→π⁻p (EPECUR)

- Questions the interpretation of N(1685) as the second member of the antidecuplet predicted by the Chiral Soliton Model;
- Favors ``cusps” since 1.68 and 1.72 GeV corresponds to KΣ and ωN thershols.

*If N(1685) does really exist, its signal should also be seen in multiparticle ”production” reactions in which it would manifest itself as a peak in the invariant mass spectra of the final-state products. Possible reactions could be **γN→πηN.***



Formation of N(1685)



Production of N(1685)

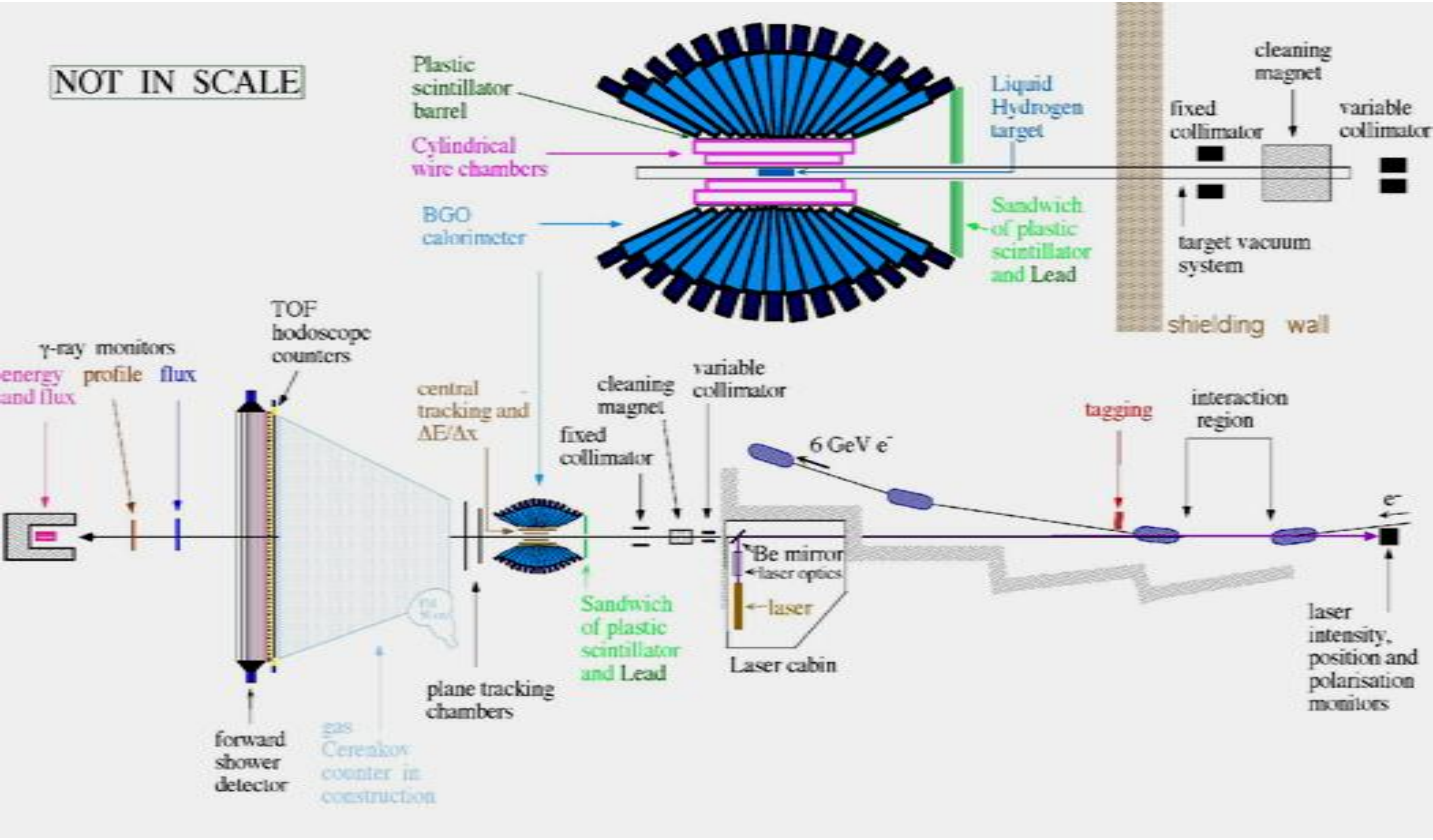
Search for N*(1685) resonances in

$$\gamma p \to \pi^0 \eta p$$
$$\gamma p \to \pi^+ \eta n$$
$$\gamma d \to \pi^+ \eta n(n)$$
$$\gamma d \to \pi^0 \eta p(n)$$
$$\gamma d \to \pi^- \eta p(p)$$
$$\gamma d \to \pi^0 \eta n(p)$$

New analysis of the GRAAL data

To be published in ***JEPT Letters, arXiv:*** [1705.05177]

GRAAL Setup


NOT IN SCALE
Plastic scintillator barrel
Cylindrical wire chambers
BGO calorimeter
Liquid Hydrogen target
Sandwich of plastic scintillator and Lead
fixed collimator
cleaning magnet
variable collimator
target vacuum system
shielding wall
TOF hodoscope counters
γ-ray monitors
energy and flux
profile
flux
central tracking and ΔE/Δx
cleaning magnet
variable collimator
fixed collimator
6 GeV e-
tagging
interaction region
e-
Be mirror
laser optics
laser
Laser cabin
Sandwich of plastic scintillator and Lead
plane tracking chambers
forward shower detector
gas Cerenkov counter in construction
laser intensity, position and polarisation monitors

Data analysis

- Selection of π, η and the recoil nucleon in the GRAAl detector;
-Cuts on the invariant mass of two photons from $\pi^0 \rightarrow 2\gamma$ and $\eta \rightarrow 2\gamma$ decays;
-Cuts on the η and N missing masses;
-Cuts on the coplanarity and the differences between missing and invariant masses assuming three two-body reactions

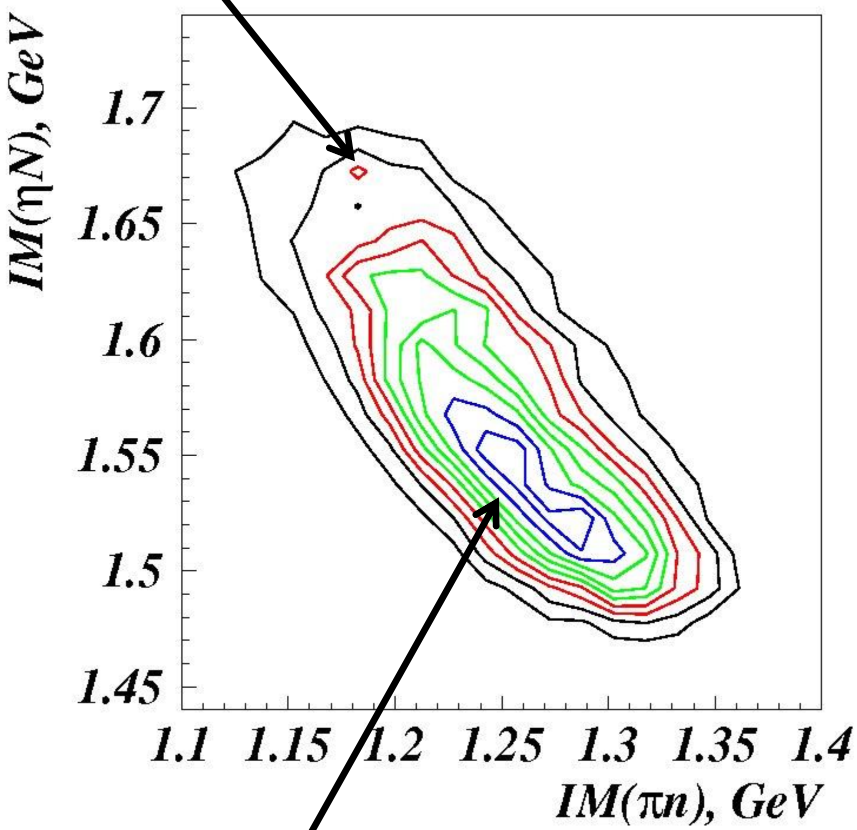
$$\gamma N \rightarrow \pi R(\eta N)$$
$$\gamma N \rightarrow \eta R(\pi N)$$
$$\gamma N \rightarrow R(\pi\eta)N$$

-Selection of events in the energy range of the incoming photons E_γ = 1.4 – 1.5 GeV

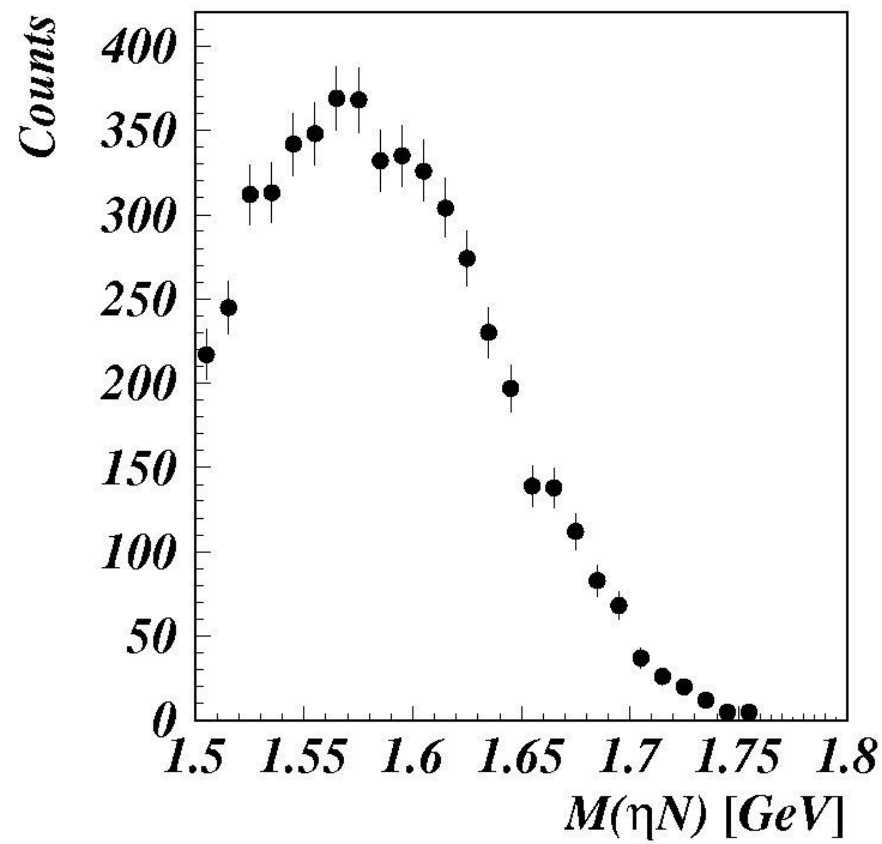
1.4 GeV is the $\gamma N \rightarrow \pi$ N(1685) threshold. 1.5 GeV is the limit of the GRAAL beam but it also allows to avoid the contribution from higher-lying resonances.

The results

Small enhancement at
IM(ηN) ~ 1.68 GeV



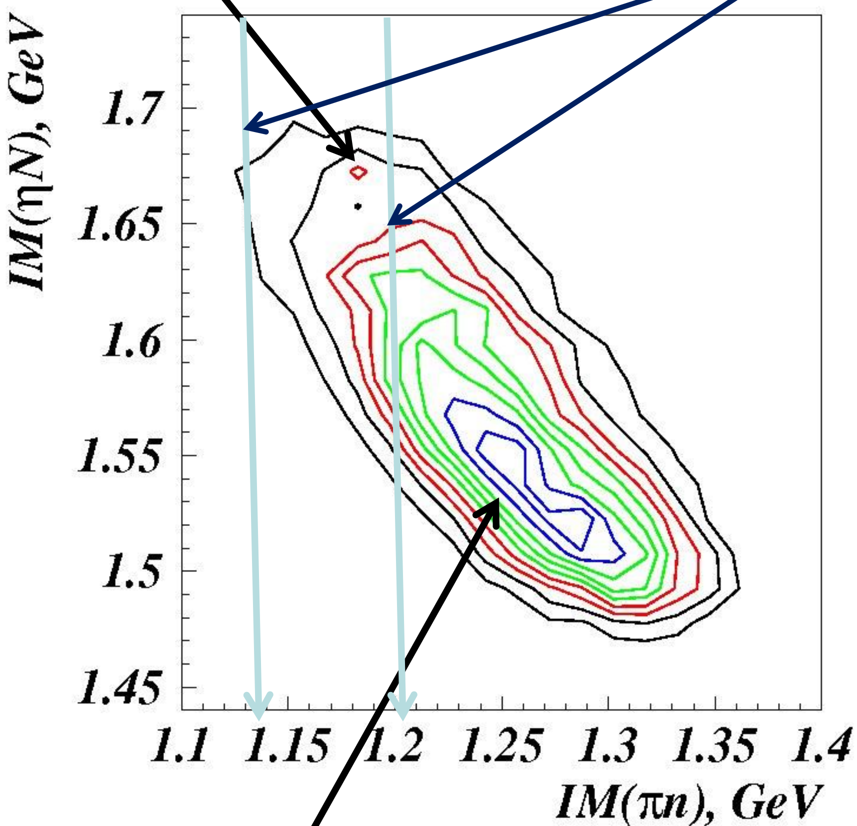
Dominating contribution of
γN→ηΔ events

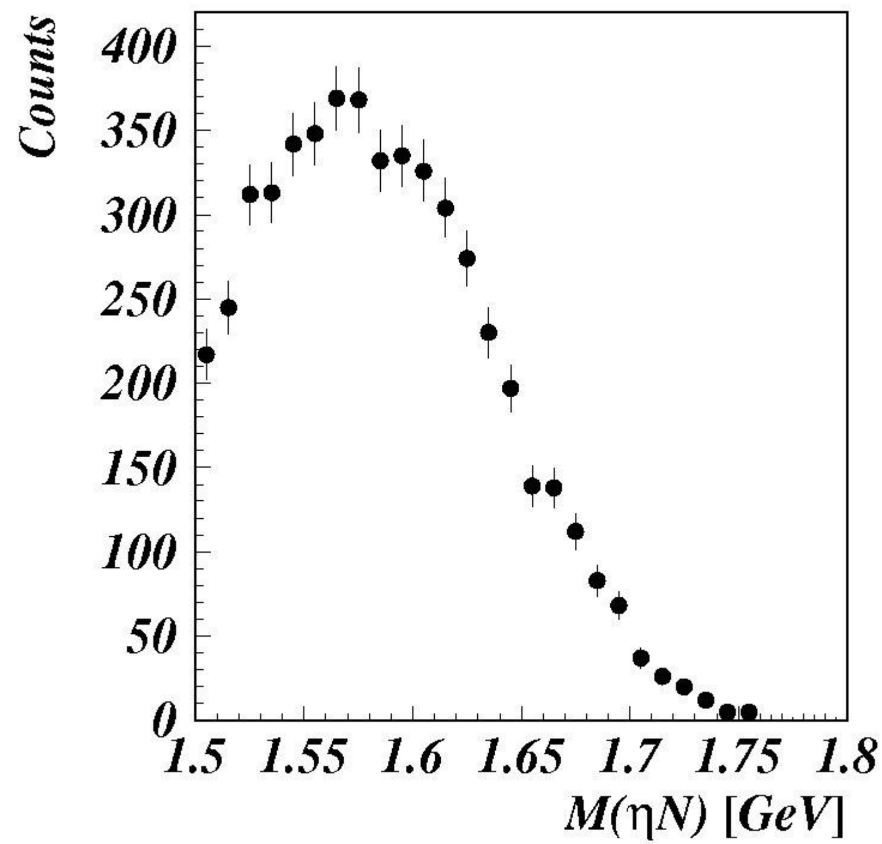


The results

Small enhancement at
IM(ηN) ~ 1.68 GeV

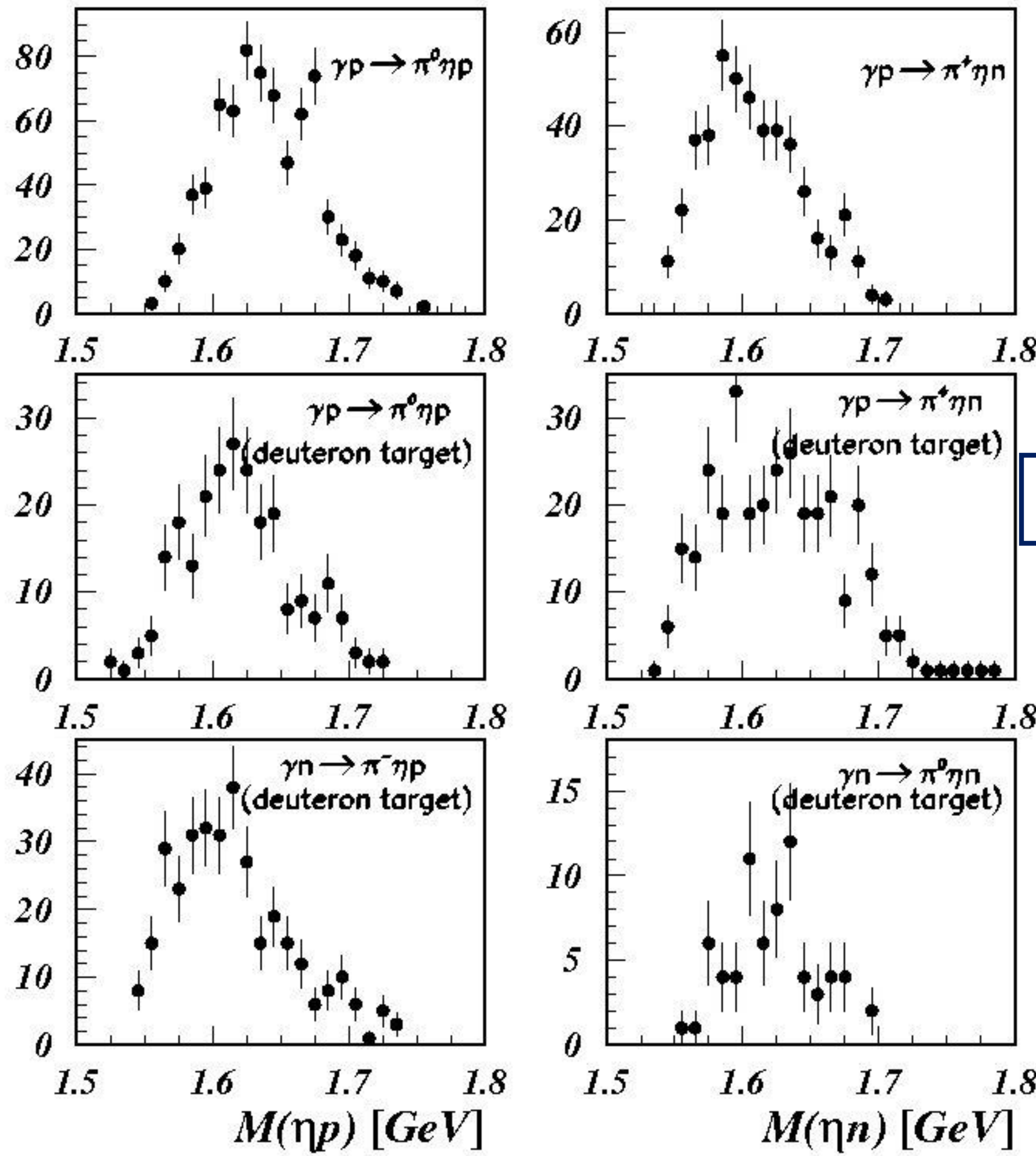
Cuts on the IM(πN)





Dominating contribution of
γN→ηΔ events

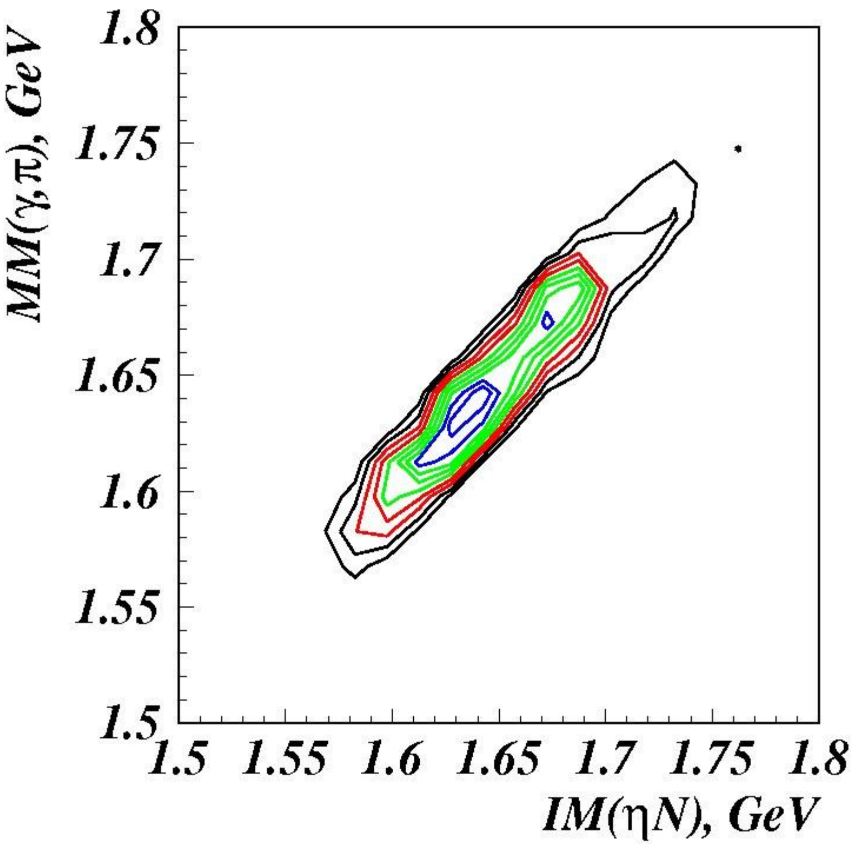
Spectra of extracted ηN masses

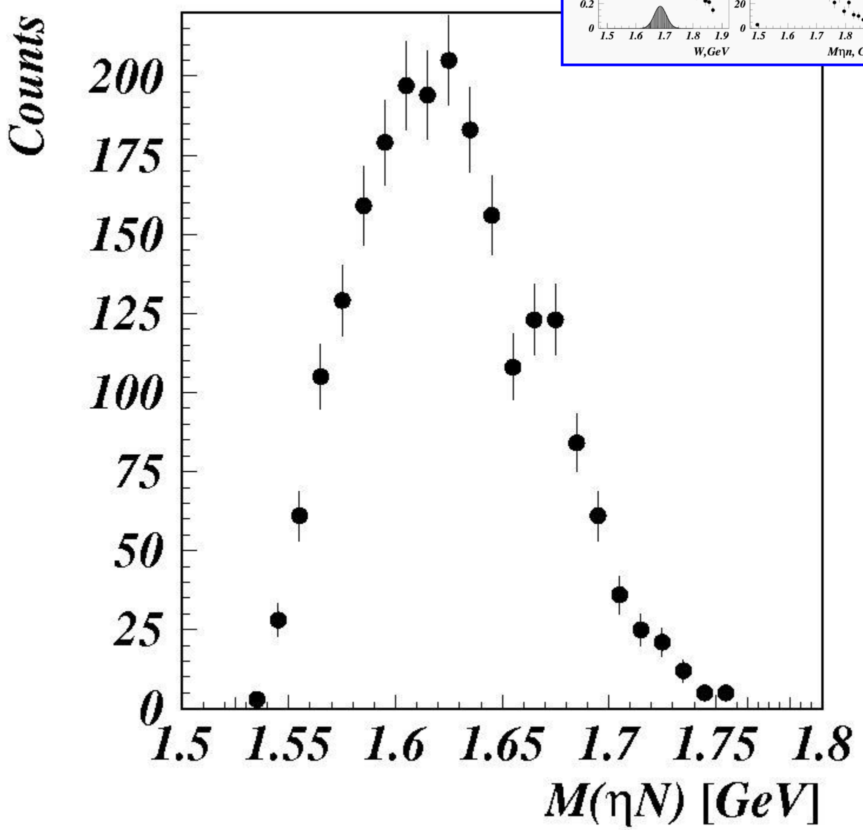


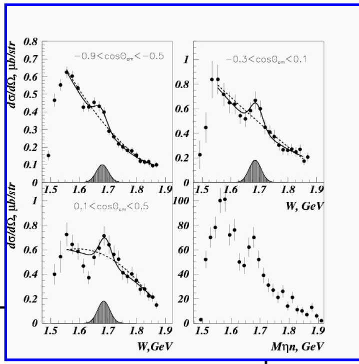
Peaks near ~ 1.68 GeV

Sum of all reactions under study

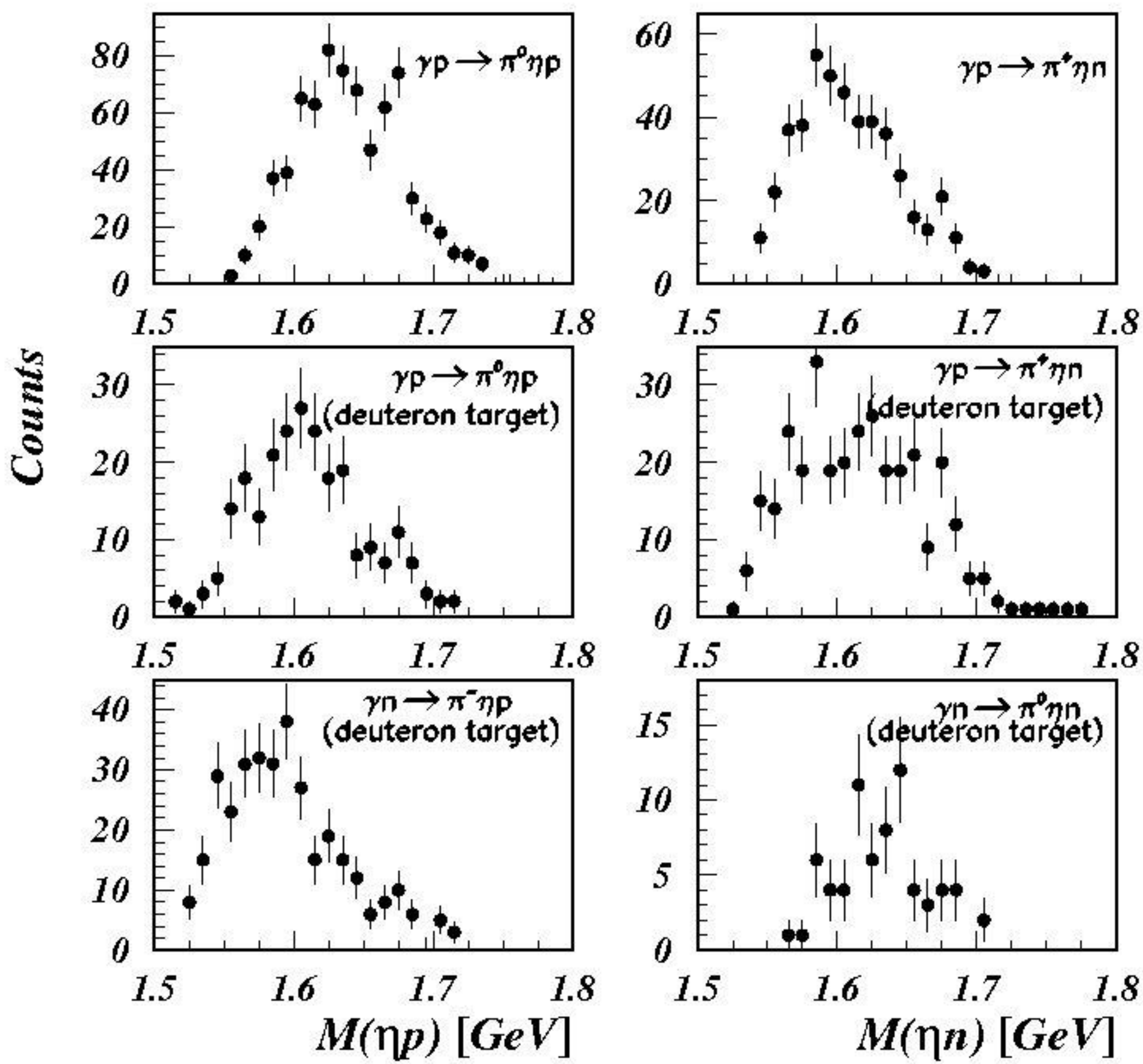
Enhancement at the same energy as in formation reactions (γn→ηn, Compton, πp→πp)

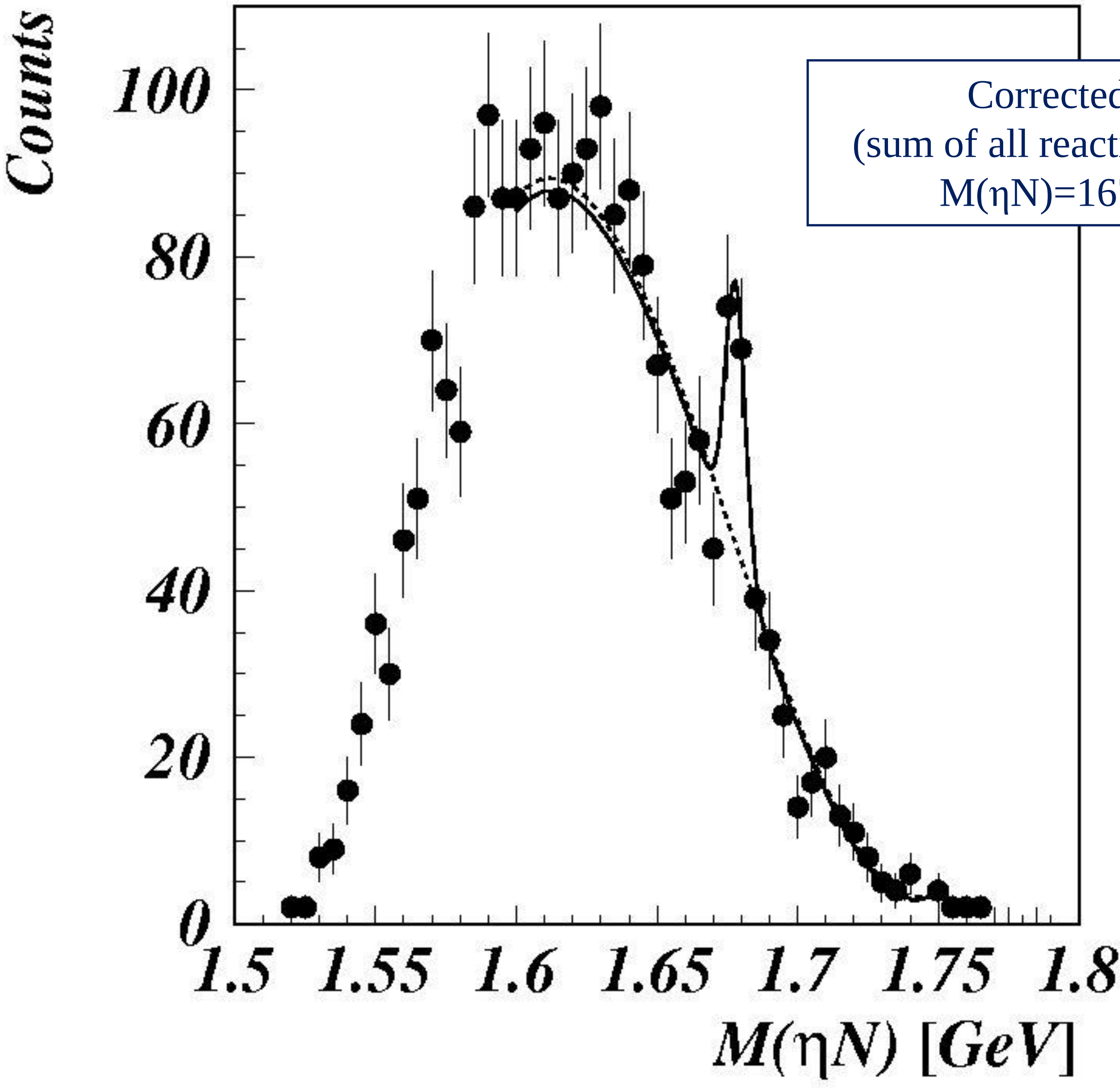






Corrected spectra





Corrected spectrum
(sum of all reactions under study)
M(ηN)=1678±10 MeV

Summary

-Peaks at ~ 1.68 GeV are observed in the M(ηN) spectra from $\gamma N \rightarrow \pi\eta N$ reaction;

- Unlikely this observation can be explained as interference phenomena or cusps;

- Quite likely they signal the existence of N^0(1685) and N^+(1685) resonances (i.e. the isospin-½ N(1685) resonance);

- Our observation requires the confirmation from other collaborations (A2@MAMI C, CBELSA/TAPS etc).

- If confirmed, this result will be a challenge for the physics of baryon resonances.

Continuation: *More analyses of available data and proposals of new dedicated experiments (Compton and $\gamma N \rightarrow \pi\eta N$) for the A2@MAMI C and BGO-OD facilities.*

Thank you so much!

Comments on the Interference of Known resonances

by A. Anisovch, V. Burkert, A. Sarantsev et al.

- Explains only the enhancement in the enhancement at W~ 1.68 GeV in **γn→ηn excitation function** but not the whole complex of experimental observations**;**
- Doesn't reproduce the second stucture at W ~ 1.72 GeV;
- Bugs in fitting of the quasifree γn→ηn cross.

Quite questionable!

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arXiv:1703.07425

FIELDS, PARTICLES, AND NUCLEI

New Narrow N(1685) and N(1726)? Remarks on the Interpretation of the Neutron Anomaly as an Interference Phenomenon[1]

V. Kuznetsov[a, b, *], V. Bellini[b, c], V. Brio[b, c], A. Gridnev[a], N. Kozlenko[a], F. Mammoliti[b, c], F. Tortorici[b, c], M. V. Polyakov[a, d], G. Russo[b, c], M. L. Sperduto[b, c], V. Sumachev[a], and C. M. Sutera[b]

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[b] *NFN—Sezione di Catania, Catania, I-95123 Italy*
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