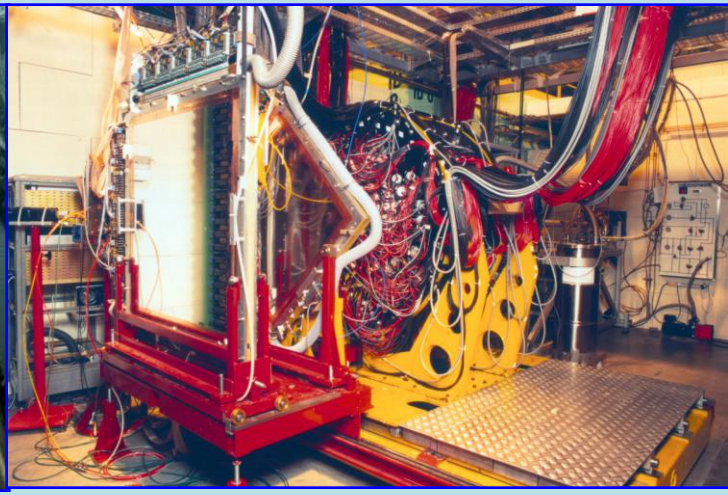
Evidence for Narrow N*(1685) Resonance



Viacheslav Kuznetsov

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and

Institute for Nuclear Research, 177312,Moscow

Results presented below, are now well established, confirmed by other groups, and are being widely debated.

A couple of years ago the situation was quite different: there was strong skepticism, doubts, collapse of GRAAL, …

At that time we needed very much any support. We have got it in Bochum!

The key results on the new nucleon resonance were in part obtained here, in this building…

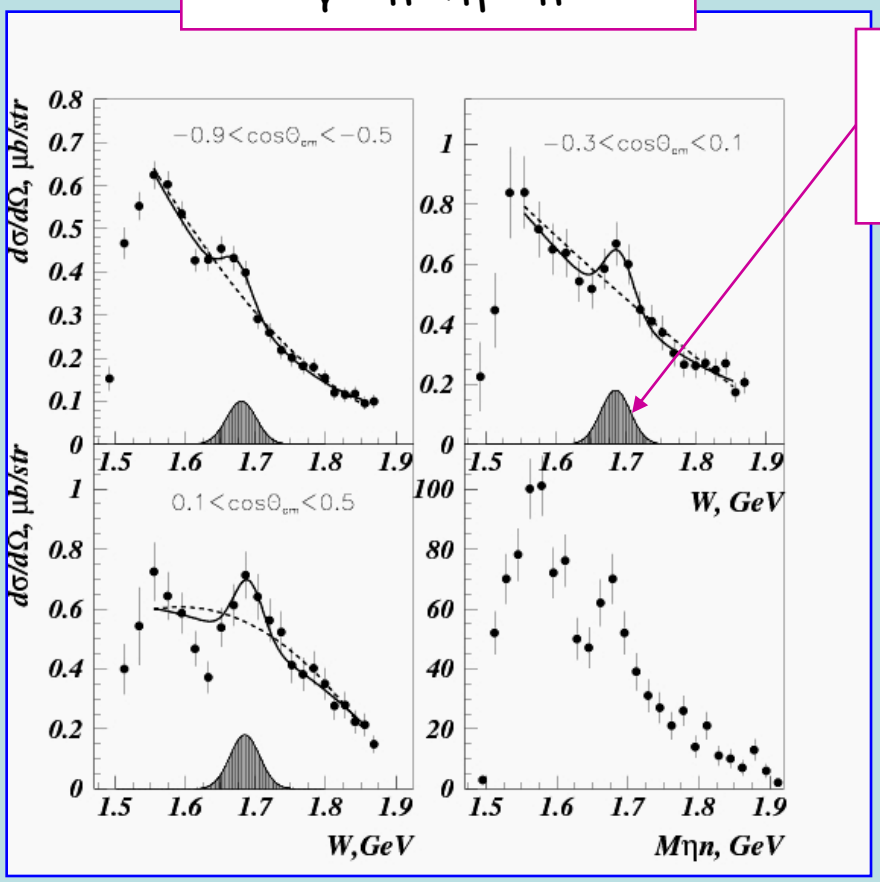
Dear Klaus, Thank you so much for that!

Narrow bump-like structure at W=1.68 GeV in quasi-free η photoproduction on the neutron at GRAAL

First report: V.Kuznetsov et al.(GRAAL Collaboration) NSTAR2004. March 2004, Grenoble(France), Proceeding NSTR2004, pg.197, hep-ex/0409032;

Publication: V.Kuznetsov et al., Phys. Lett. B**647**, 23, 2007(hep-ex/0606065)

$\gamma + n \rightarrow \eta + n$



Simulated signal of a narrow (Γ=10 MeV) resonance

The width of the peak in the quasi-free cross section is close to that expected due to Fermi motion of the target neutron. The width of the peak in M(η,n) (40 MeV FWHM) is close to the instrumental resolution!

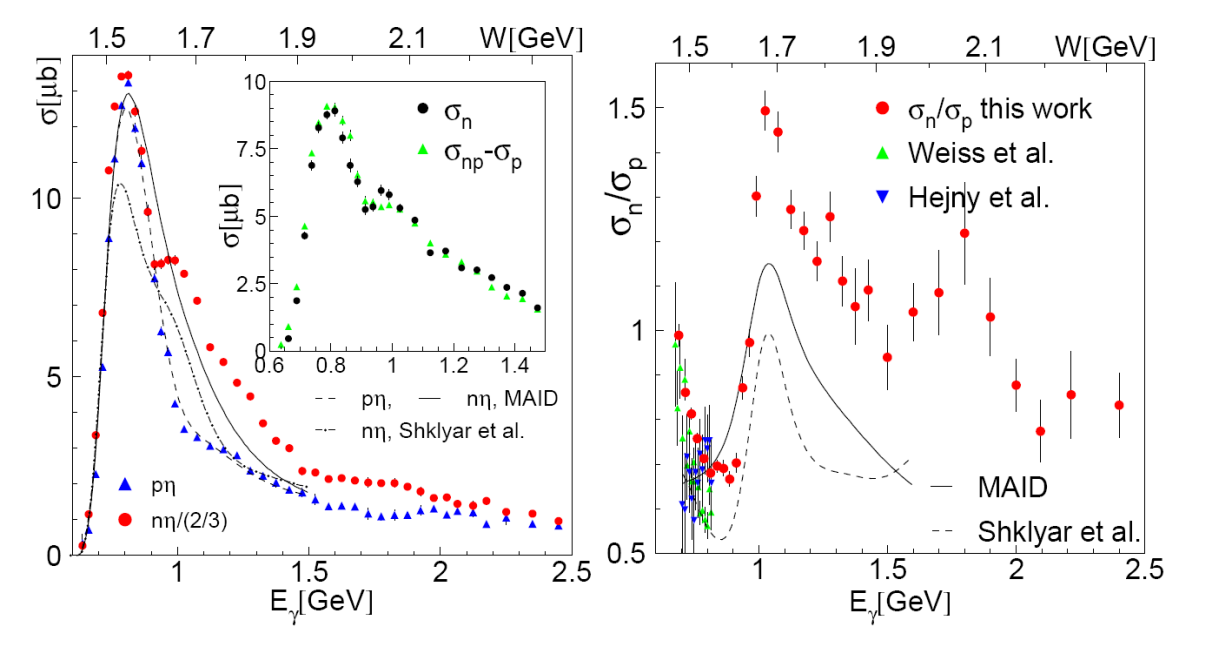
Eta photoproduction on the neutron. CB/TAPS results.

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

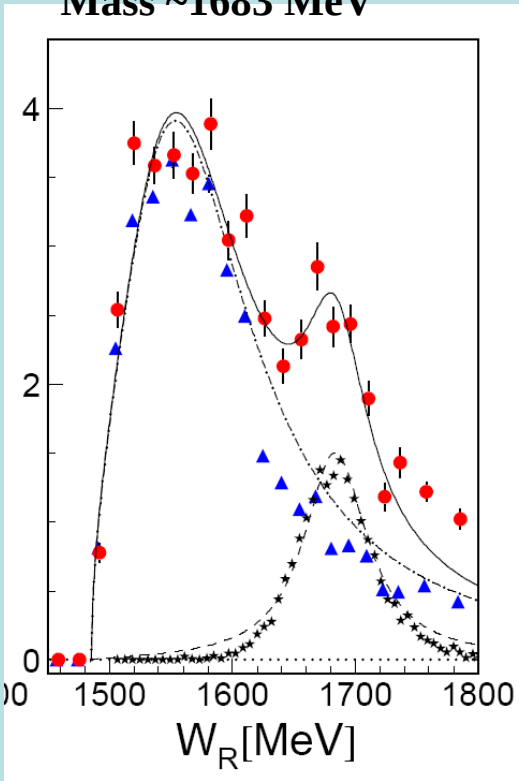
Quasi-free crosss ection is affected by the Fermi motion and rescattering effects

Peak in the inv. mass is Independent of these effects

Bump in quasi-free cross-section:



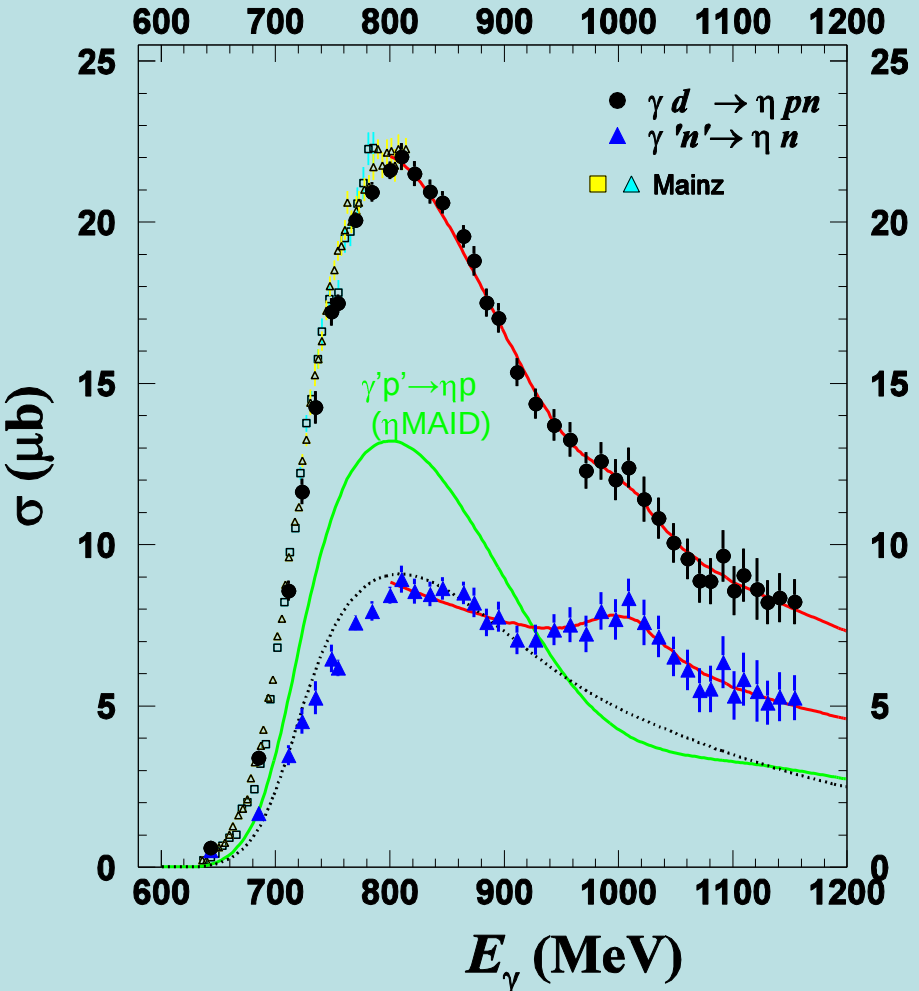
Peak in eta-neutron inv. Mass ~1683 MeV

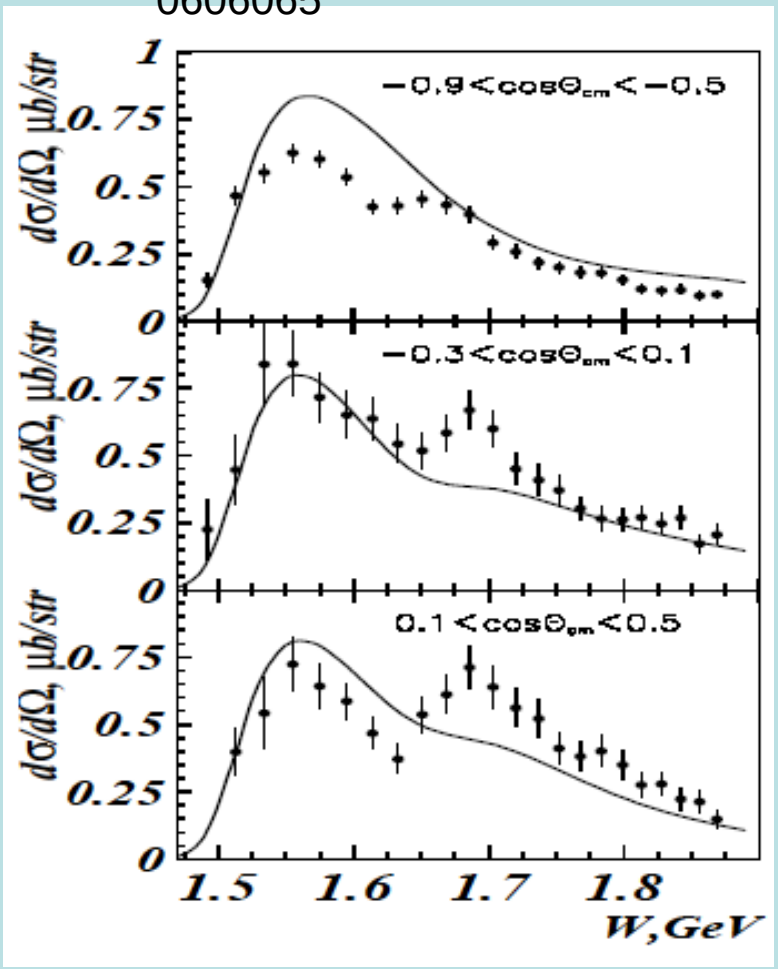


Evidence at LNS-Tohoku, Japan, (This slide is from J.Kasagi,Talk at Ykis 2006, Nov.2006)

Simple analysis: compared with GRAAL

GRAAL, V. Kuznetsov et al. hep-ex 0606065





Breit-Wigner + smooth BG

M ~ 1666 MeV

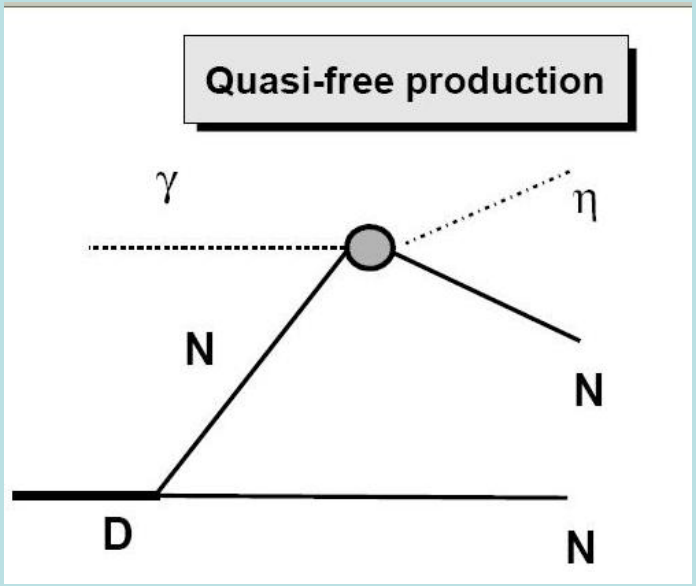
Γ ≦ 40 MeV

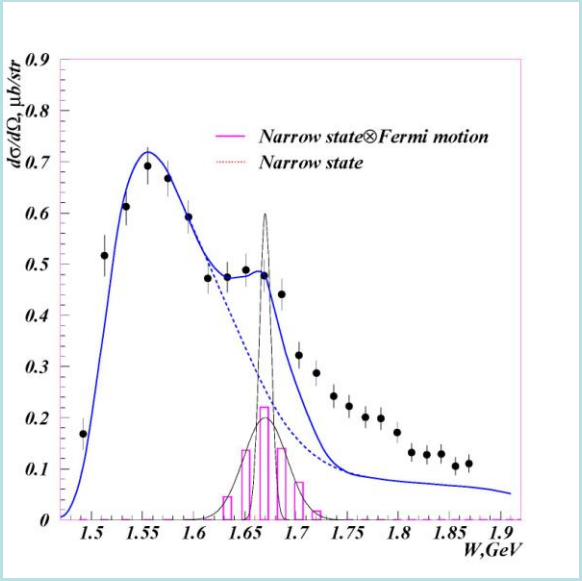
M ~ 1680 MeV

Γ ≦ 30 MeV

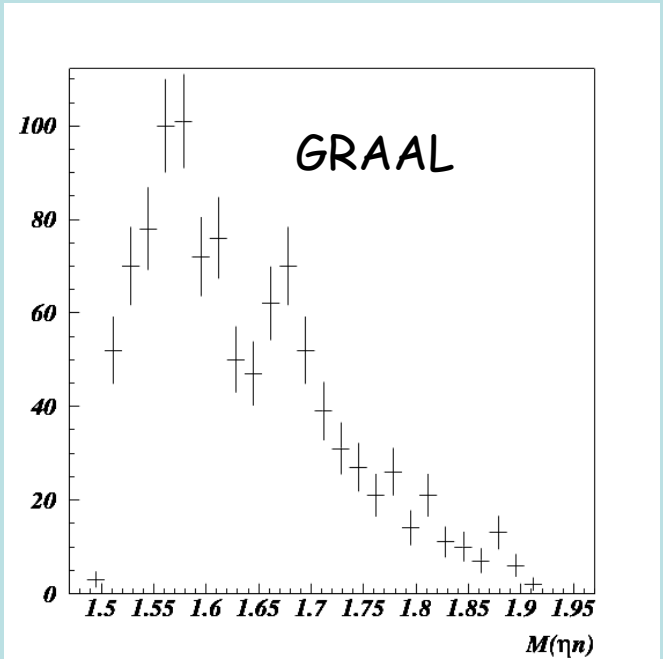
There is a resonance whose width smaller than 50 MeV, however, resonance parameters strongly depend on BG shape!!

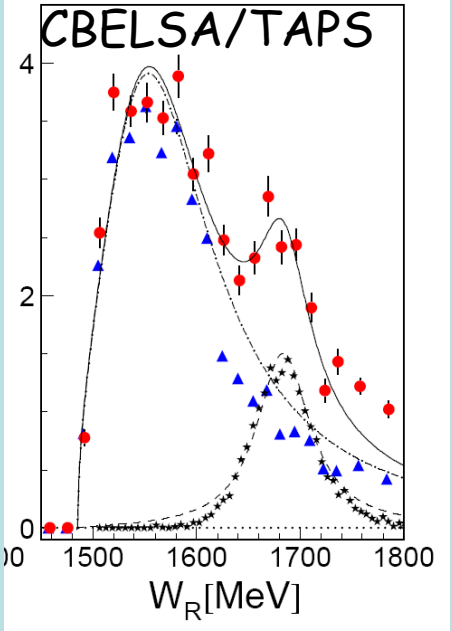
Quasi-free reactions: The nucleon bound in a deuteron target, is not at rest → Experimental cross section is smeared by Fermi motion





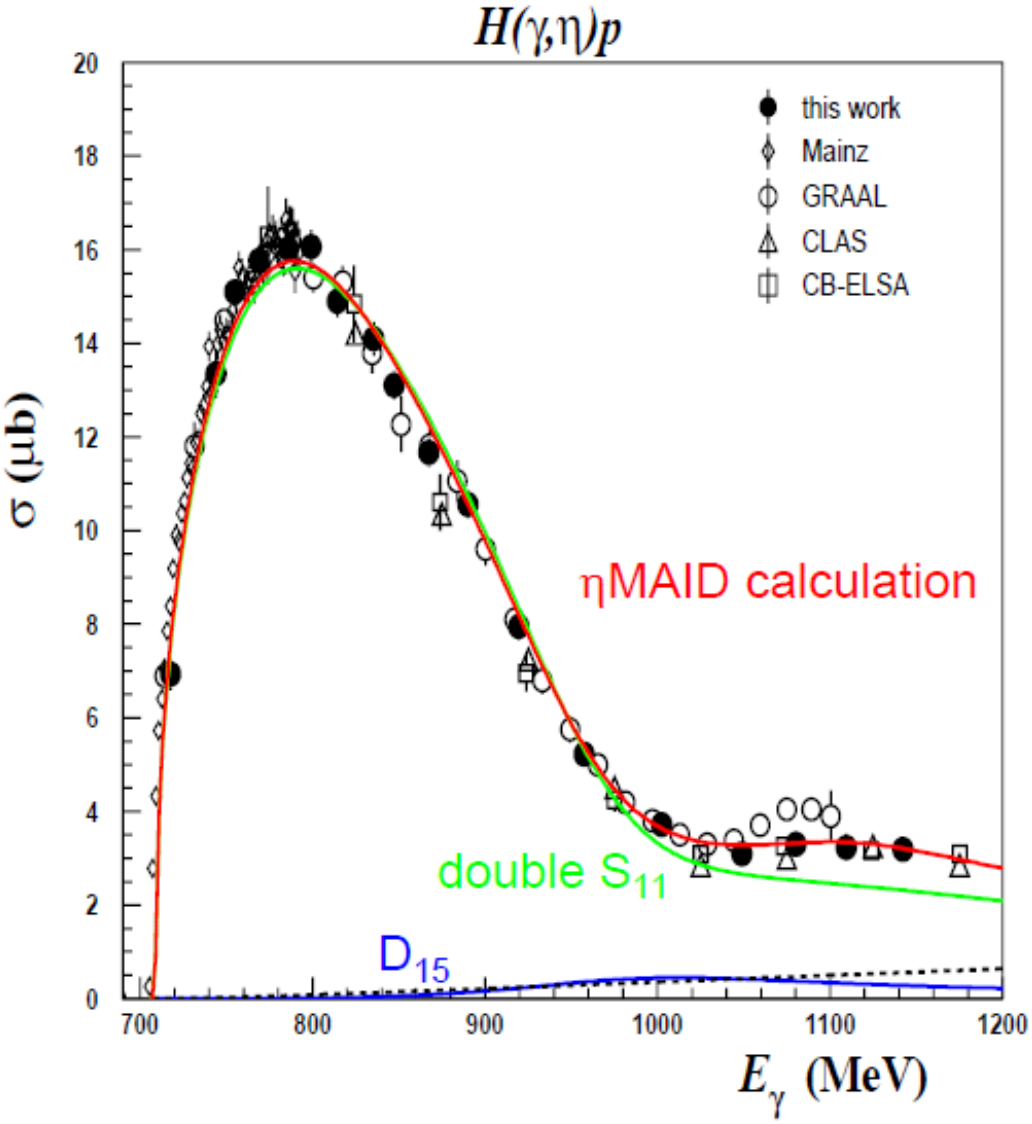
The width of the bump in the quasi-free cross section is close to that expected for a narrow resonance smeared by Fermi motion.





The invariant mass of the final-state η and the neutron is not affected by Fermi motion. The width of the peaks in the invariant-mass spectra are close to the instrumental resolution (40 MeV at GRAAL and 60 MeV at CBELSA/TAPS).

Total cross section for the $\gamma p \to \eta p$ reaction



For Eγ < 1.15 GeV
σ(LNS) ~σ(CLAS, ELSA)

σ(Eγ)~σ(ηMAID)
$S_{11}(1535)$ largest
$S_{11}(1650)$ destructive
D15(1675) very small
+ direct (Born, ρ,ω ex.)

Eγ > 1 GeV
γp→ηπN not negligible
σ(ηπN)~σ(ηp) at 1.1 GeV

A narrow structure near W=1.68 GeV (Eγ≈1.05 GeV) is not (or poorly) seen.

Intrepretations of this structure

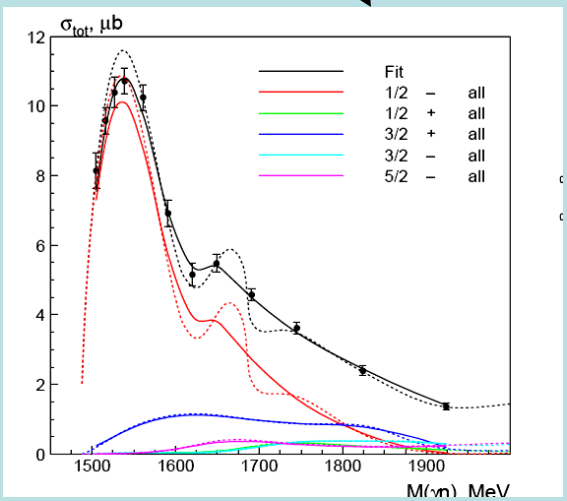
New narrow nucleon resonance N(1675) K.-S.Choi, S.-I. Nam, A.Hosaka, and H.-C.Kim, Phys. Lett. B **636,** 253 , 2006; Hep-ph/0512136.

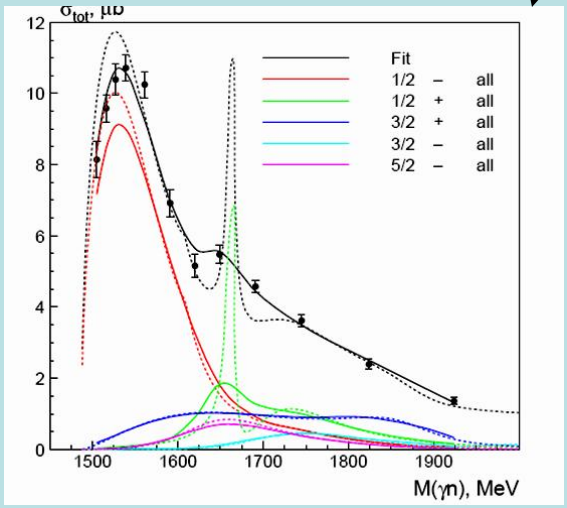
Interference of S11(1650) and P11(1710) .

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

Interference effects of S11(1535) and S11(1650) or narrow P11 resonance

A. Anisovich et al. ArXiv: 0809.3340

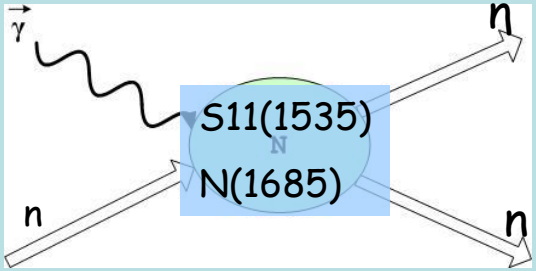


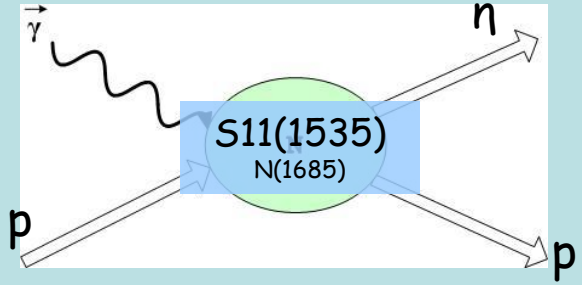


Simple test: Search for the signal of this resonance in other reactions.

Note: Assumptions on the interference of known resonances contradicts to the observed narrow peaks in the invariant-mass spectra. The structure in the calculated cross section is essentially wider!

Do we really see a narrow N(1685)resonance? Test with beam asymmetry data



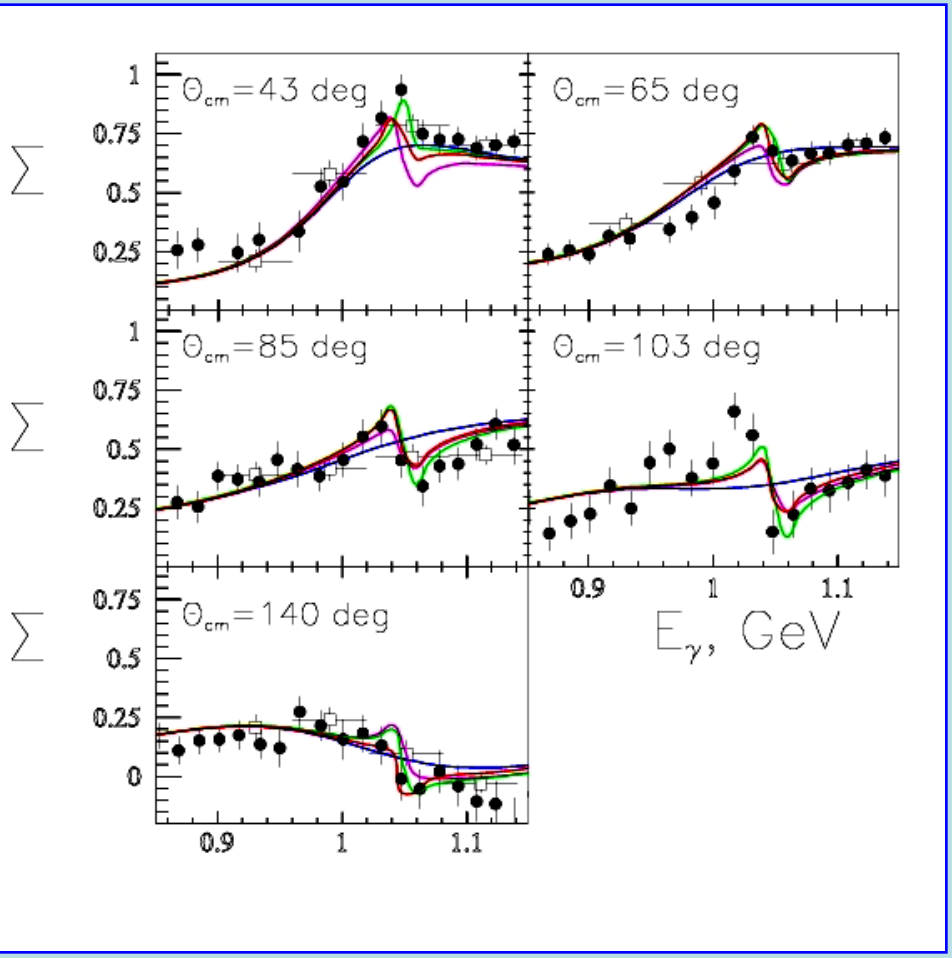


If photoexcitation of any resonance occurs on the neutron, it should also occur on the proton, even being suppressed by any reasons.

The signal of a weakly photoexcited resonance may not be seen in the cross section on the proton because of the S11(1535) dominance, but it should appear in polarization observables. On the contrary, interference of known resonances would not generate any structure on the proton.

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



Well pronounced structure at W=1.685 GeV

Fit: smooth SAID multipoles
+ a narrow resonance
Blue – SAID only
Magenta – SAID + narrow P11(1688)
Green – SAID +narrow P13(1688)
Red – SAID + narrow D13(1688)

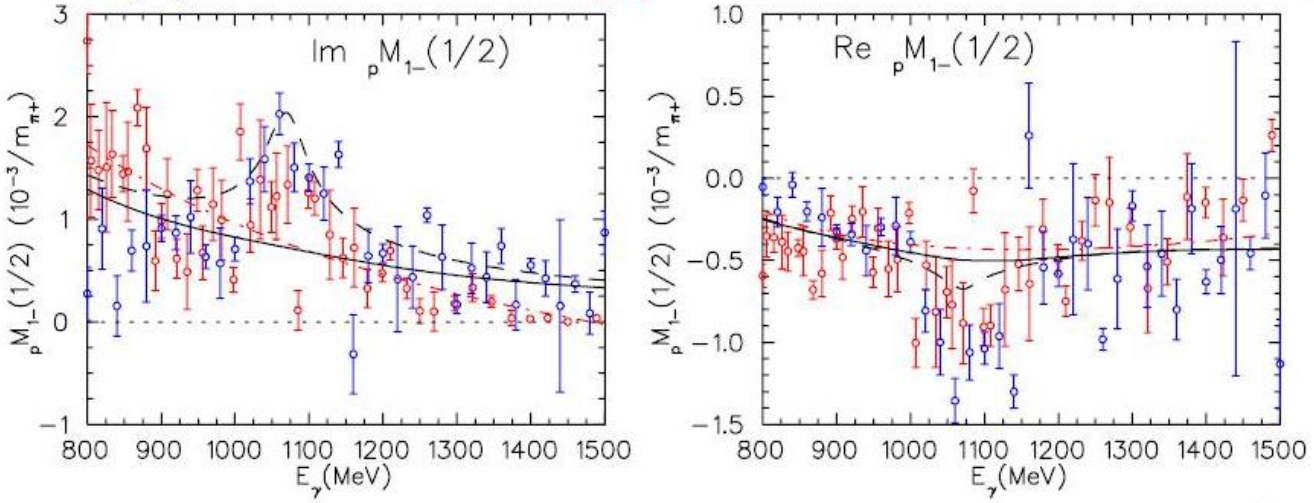
M=1.685 10 GeV, $\Gamma \leq 30$ MeV

New isobar model for pion photo- and electroproduction MAID2007

(This slide is from the talk of Sabit Kamalov at NSTAR2007, Bonn, September 2007).

Second P_{11} resonance (proton channel)

—— (○)MAID07, - · - · - (○) SAID06, - - - - with second P_{11}



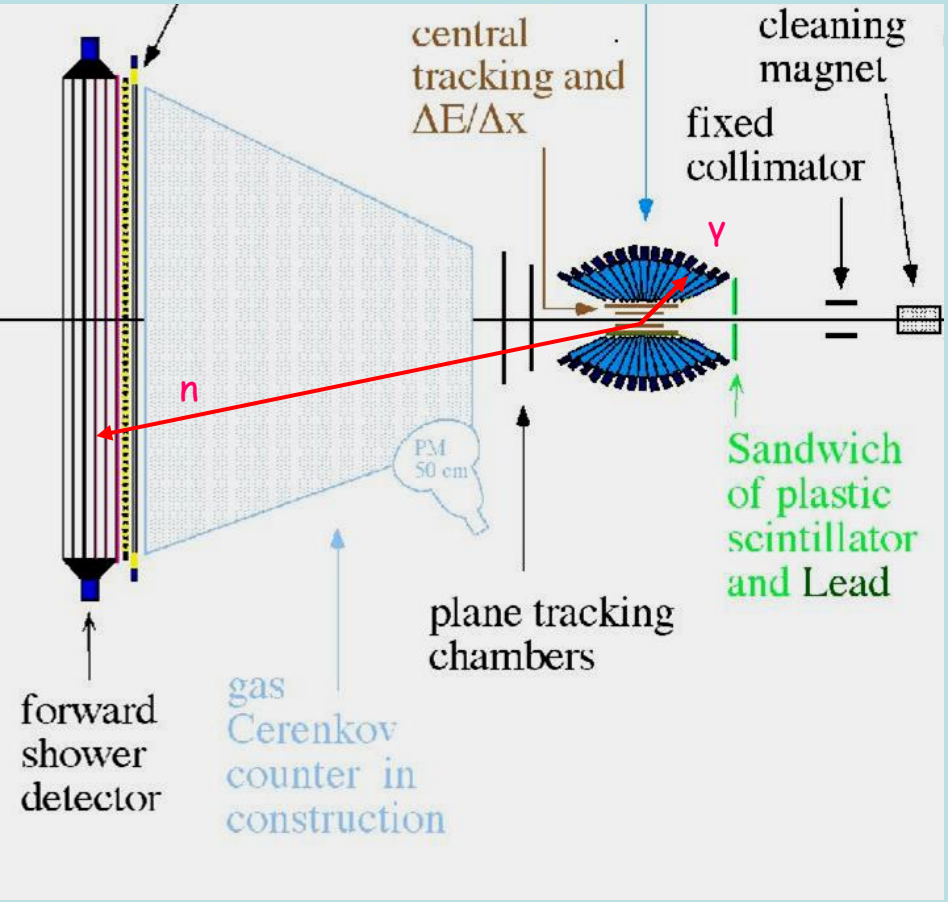
The contribution an additional P_{11} resonance in the ${}_pM_{1-}^{1/2}$ multipole with M_R=1700 MeV, Γ_{tot}=30 MeV, single pion branching ratio β_π=0.1, and helicity amplitude $A_{1/2}$=-0.030 GeV$^{-1/2}$. The solid and dashed curves are our global results without and with this resonance, respectively. The second P_{11} resonance is not included in the MAID07.

Backward-angles Compton scattering on the neutron at GRAAL

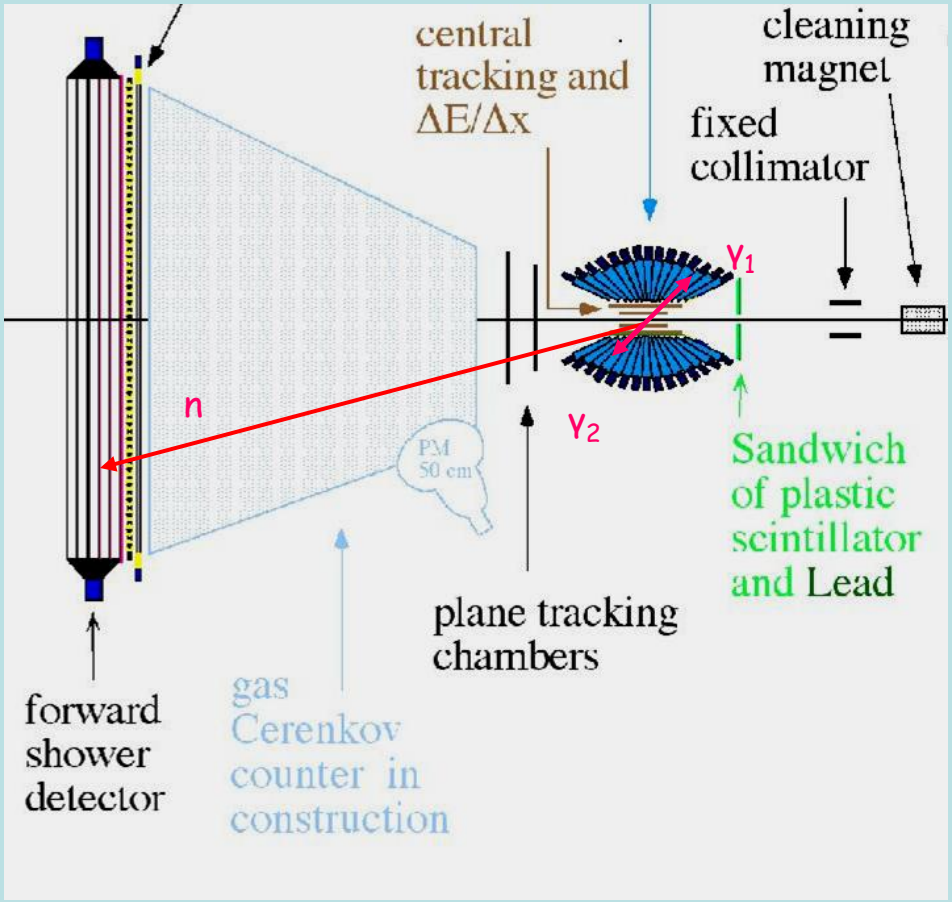
$\gamma n \rightarrow \gamma n$

*First **Very Preliminary** Results*

Compton Scattering



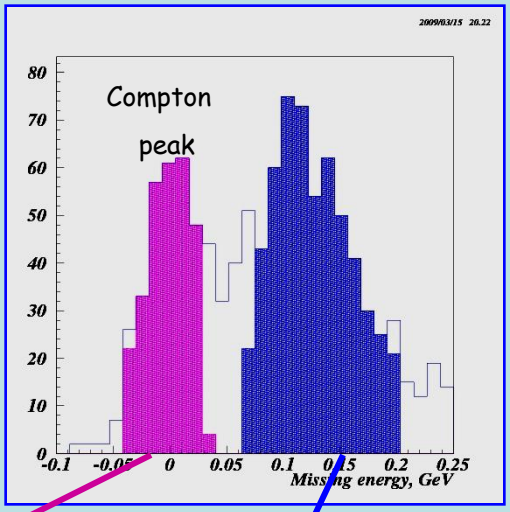
π^0 background

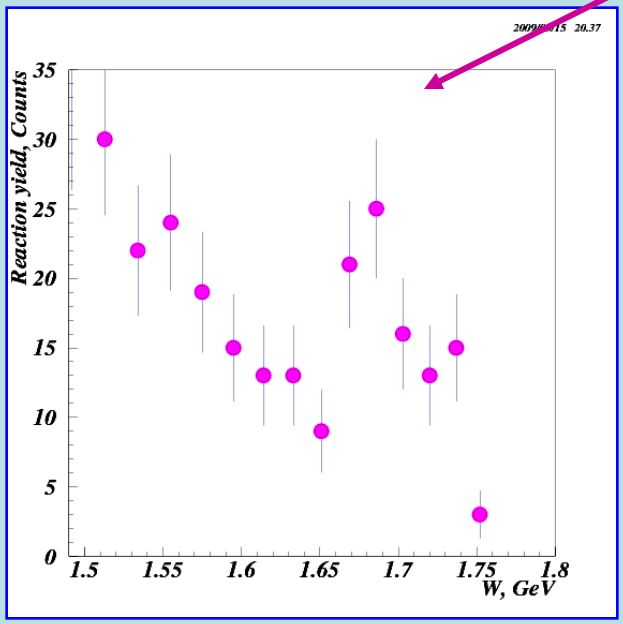


Very Preliminary!

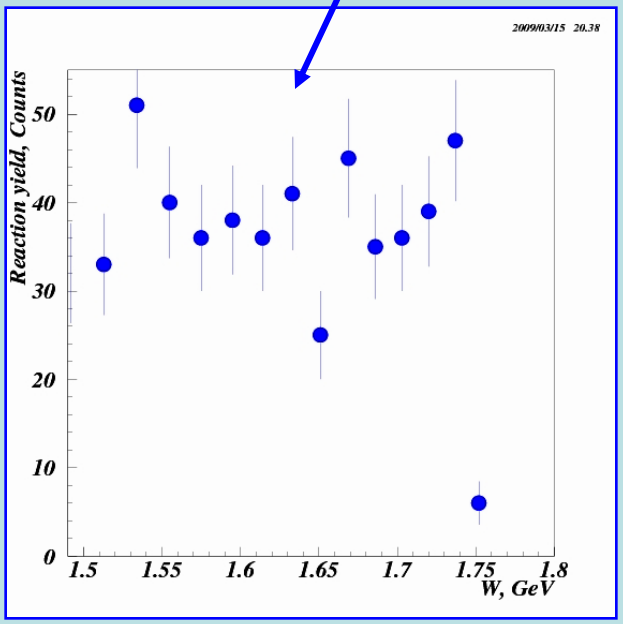
There is a bump-like structure at backward-angles Compton scattering on the neutron at W~1.68 GeV which similar to that observed in $\gamma n \rightarrow \eta n$

This structure is not seen in Compton scattering on the proton.



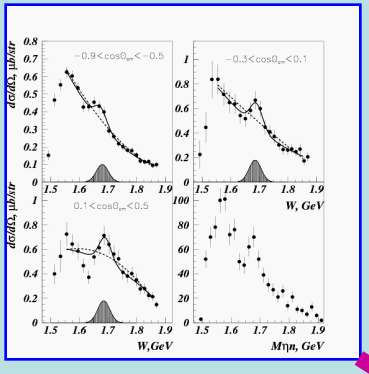


$\gamma n \rightarrow \gamma n$ + ~30%($\gamma n \rightarrow \pi^0 n$)

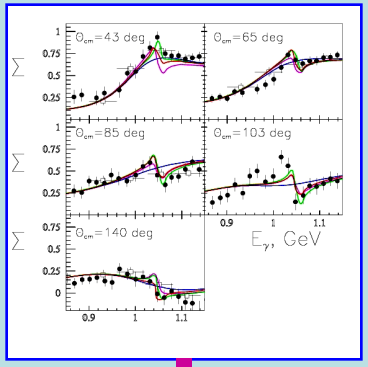


$\gamma n \rightarrow \pi^0 n$

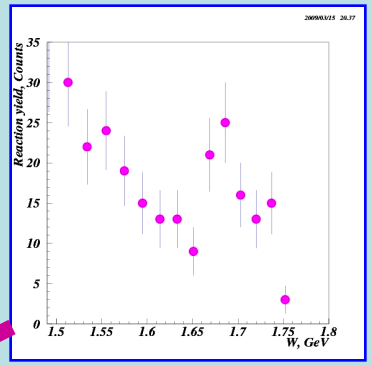
Graal γn→ηn

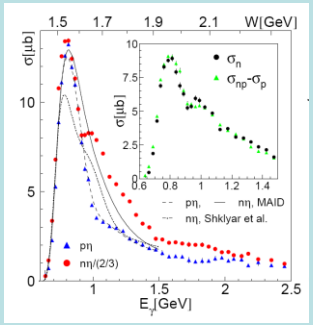


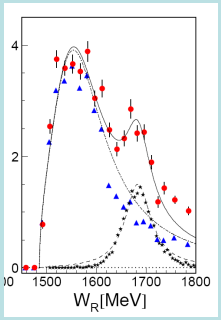
Graal γp→ηp



Graal γn→γn

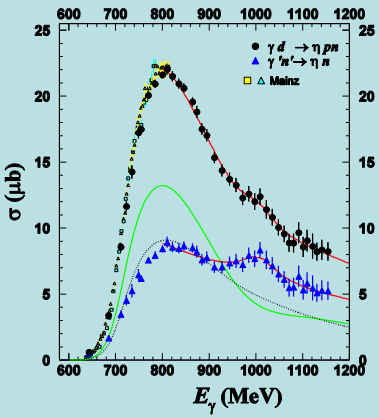






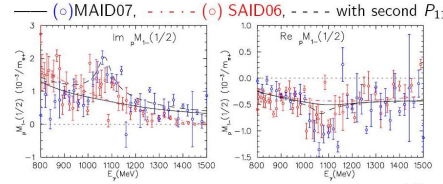
CBELSA/TAPS γn→ηn

N*(1685)



LNS-Sendai γn→ηn

Second P_{11} resonance (proton channel)



(○)MAID07, - - - - (○) SAID06, - - - - with second P_{11}

The contribution an additional P_{11} resonance in the ${}_pM_{1-}^{1/2}$ multipole with M_R=1700 MeV, Γ_{tot}=30 MeV, single pion branching ratio β_π=0.1, and helicity amplitude $A_{1/2}$=-0.030 GeV$^{-1/2}$. The solid and dashed curves are our global results without and with this resonance, respectively. The second P_{11} resonance is not included in the MAID07.

MAID pion photoproduction

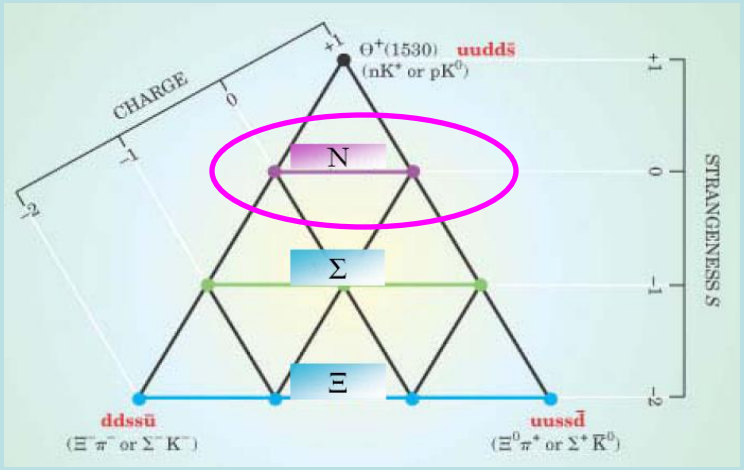
Properties of tentative N(1685)

- M=1685±10 MeV
- Γ≤30 MeV
- Isospin $\frac{1}{2}$
- S=0
- Strong photoexcitation on the neutron and suppressed photoexcitation on the proton
- Quantum numbers

P11, or P13, or D13

Reactions: γn→ηn; γn→γn ;

Expected properties of the second member of the χQM antidecuplet (D.Diakonov, V.Petrov, M.Polyakov)



- M= 1650 – 1690 MeV
- Γ≤30 MeV
- Isospin $\frac{1}{2}$
- S=0
- Strong photoexcitation on the neutron and suppressed (~100 times) photoexcitation on the proton
- Quantum numbers P11
- Reactions: γn→ηn; γn→γn; γn→ KΛ

Thank you for your attention!

Polarization Observables in pseudo-scalar meson photoproduction

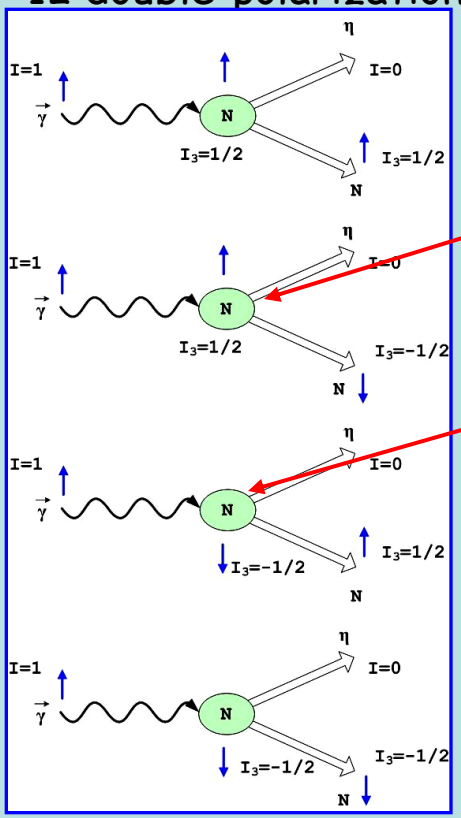
Unpolarized cross section **σ**

Beam asymmetry – Azimuthally asymmetry of the reaction yield relatively the linear polarization of the photon $\Sigma=(\sigma_{\parallel}-\sigma_{\perp})/(\sigma_{\parallel}+\sigma_{\perp})$:

Target asymmetry – Azimutal asymmetry of the reaction yield relatively the transverse polarization of the target nucleon $T=(\sigma_{\parallel}-\sigma_{\perp})/(\sigma_{\parallel}+\sigma_{\perp})$;

Recoil polarization – azimuthal asymmetry of the polarization of the recoil nucleon relatively reaction plane $P=(\sigma_{\parallel}-\sigma_{\perp})/(\sigma_{\parallel}+\sigma_{\perp})$

12 double-polarization observables



H↑↑

P11

H↑↓

S11(1535)

H↓↑

H↓↓

Helicity amplitudes :

$$\sigma \sim |H_{\uparrow\uparrow}|^2+|H_{\downarrow\downarrow}|^2+|H_{\downarrow\uparrow}|^2+|H_{\uparrow\downarrow}|^2$$

Dominates in cross section

S-P interference

$$\Sigma \sim \mathrm{Re}\{H_{\uparrow\uparrow}H^*_{\downarrow\downarrow}-H_{\uparrow\downarrow}H^*_{\downarrow\uparrow}\}$$

$$T \sim -\mathrm{Im}\{H_{\uparrow\downarrow}H^*_{\uparrow\uparrow}+H_{\downarrow\downarrow}H^*_{\downarrow\uparrow}\}$$

$$P \sim -\mathrm{Im}\{H_{\uparrow\uparrow}H^*_{\downarrow\uparrow}+H_{\uparrow\downarrow}H^*_{\downarrow\downarrow}\}$$

The signal of a weakly photoexcited P11 resonance may not be seen in the cross section, but might be well seen in the ∑ beam asymmetry data through the interference with S11(1535)