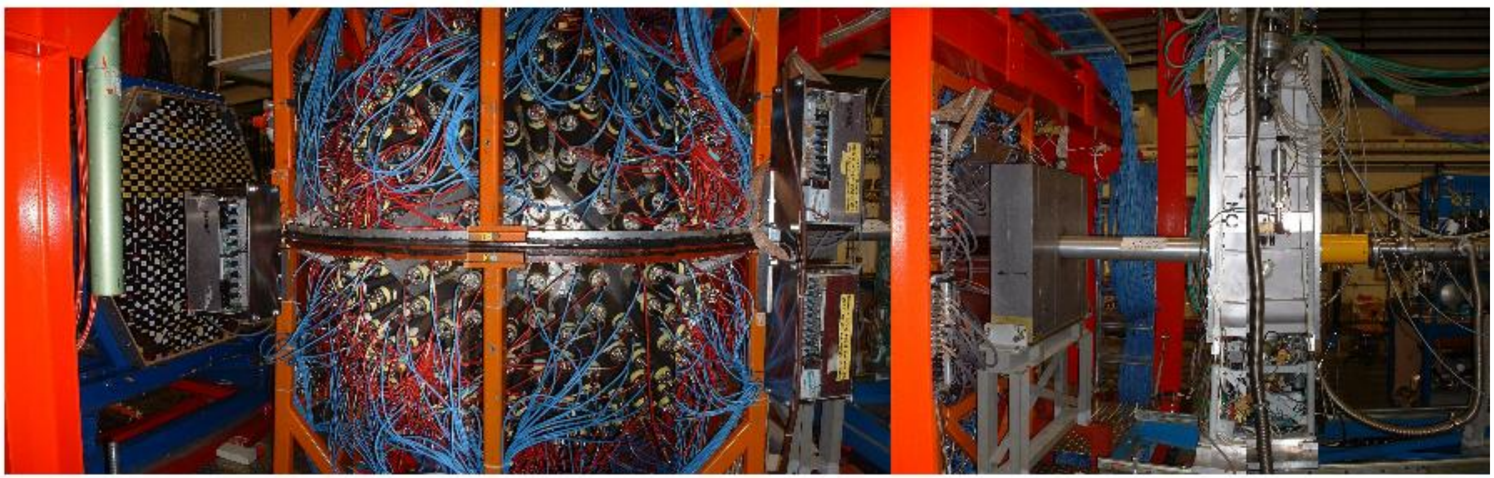
Resonances study at MAMI-C

V. Bekrenev PNPI



Experimental program of A2 collaboration on MAMI-C:

1. Mesons rare decays

2. Resonances study

3. Medium modification

Resonances study:

1. Double-polarization experiments – main goal

2. Study of multy particles final states as resonances filter

3. Deuteron as neuteron target

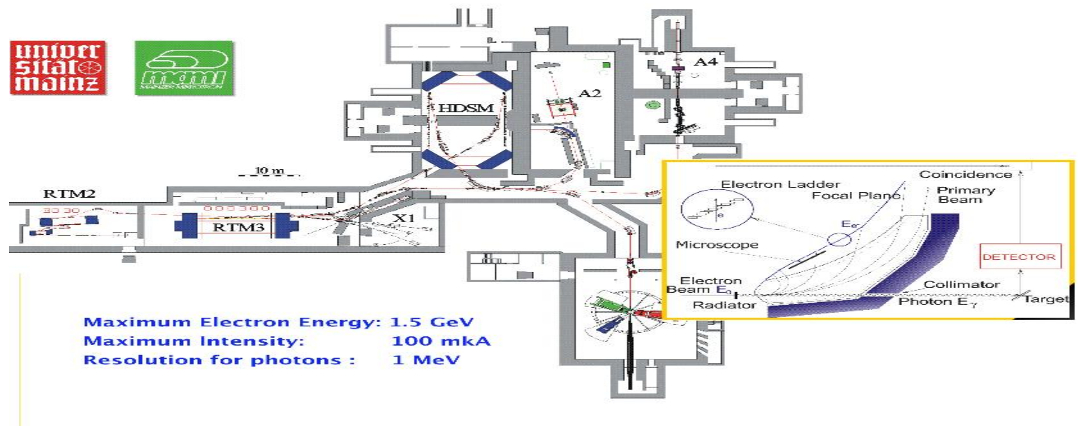
4. Threshold-crossing technique as a new tool for resonances

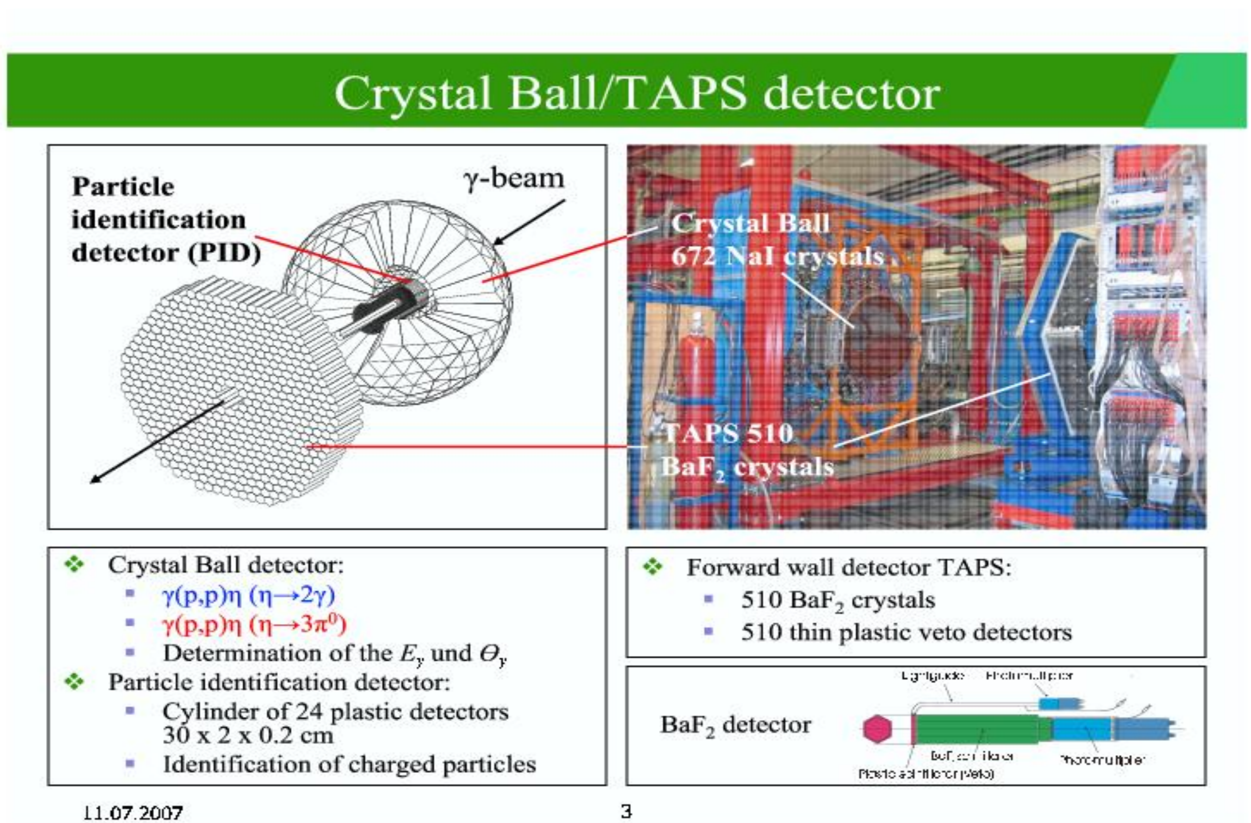
The similar programs are in progress at BONN(Crystal Barrel) and JLAB(CLAS)

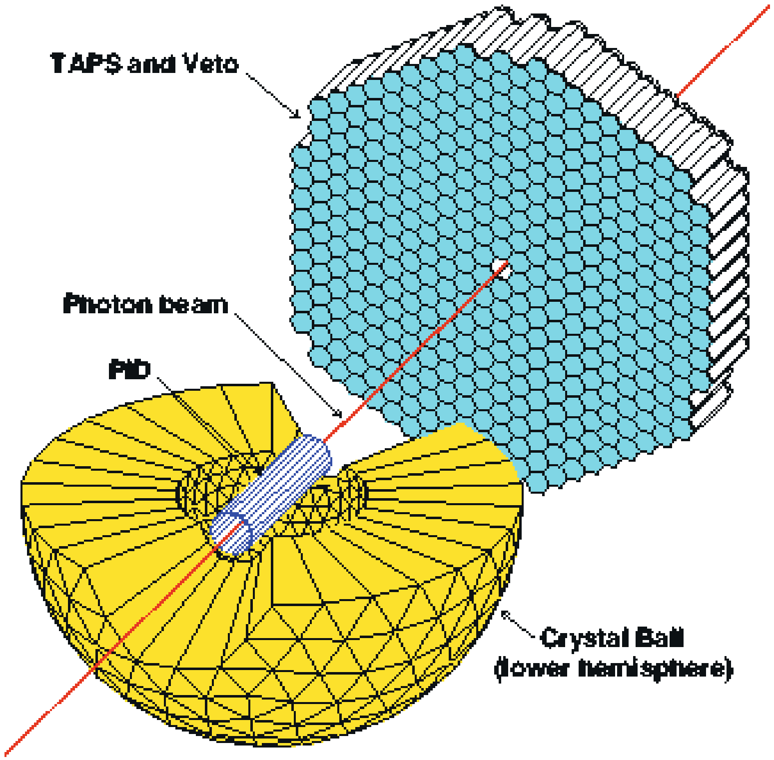
1. Comparison with the most sophisticated experimental sets(ELSA, CLAS)
2. Physics motivation and eperimental advantages
3. Analysis :
   - Bonn-Gatchina
   - Mainz-Tomsk
   - CLAS analysis

What is advantages of A2-collaboration in comparison with the best world experimental set?

The beam energy was increased from 850 to 1500, 1545, 1600 MeV







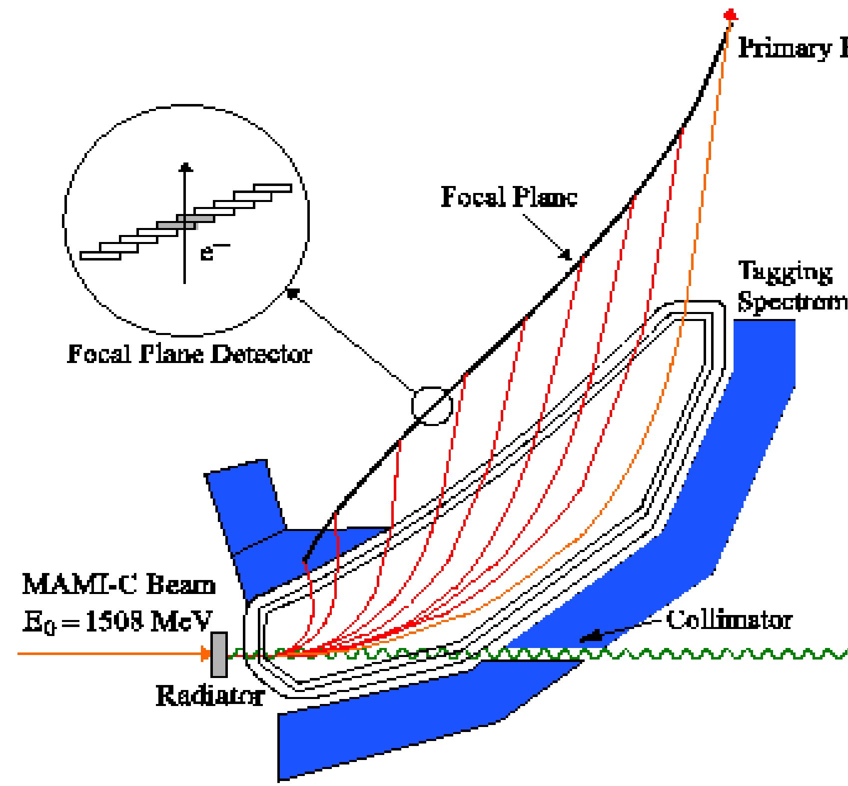
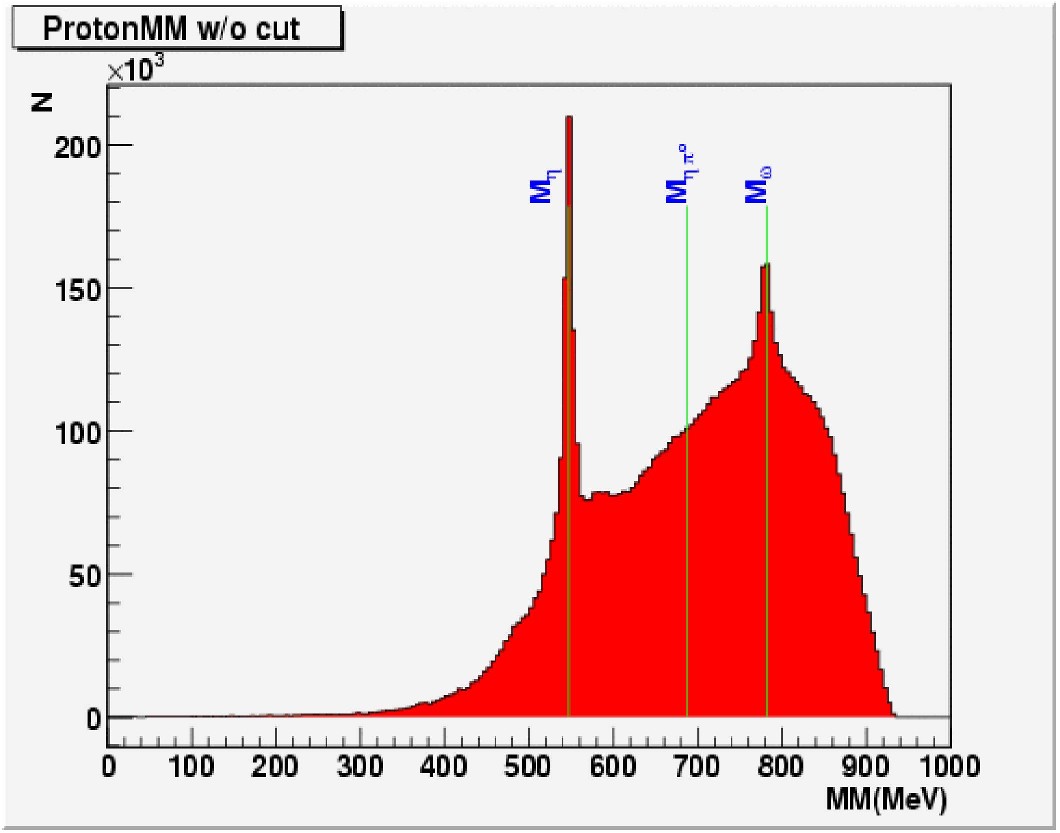
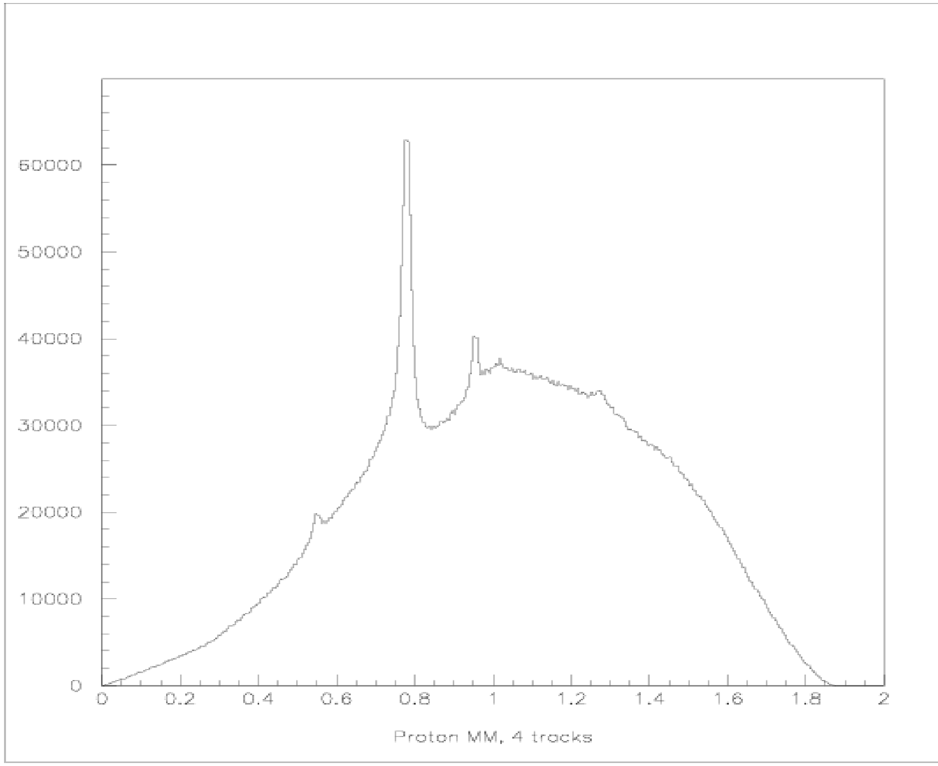


Figure 8: The Glasgow photon tagging spectro

Experimental set CB&TAPS and Tagger on MAMI-C:

1. **Standart resolution of CB&TAPS**
2. **Full and uniform solid angle.**
2. **The tagger beam energy resolution 4 MeV for tagger**
   1 MeV for microscope

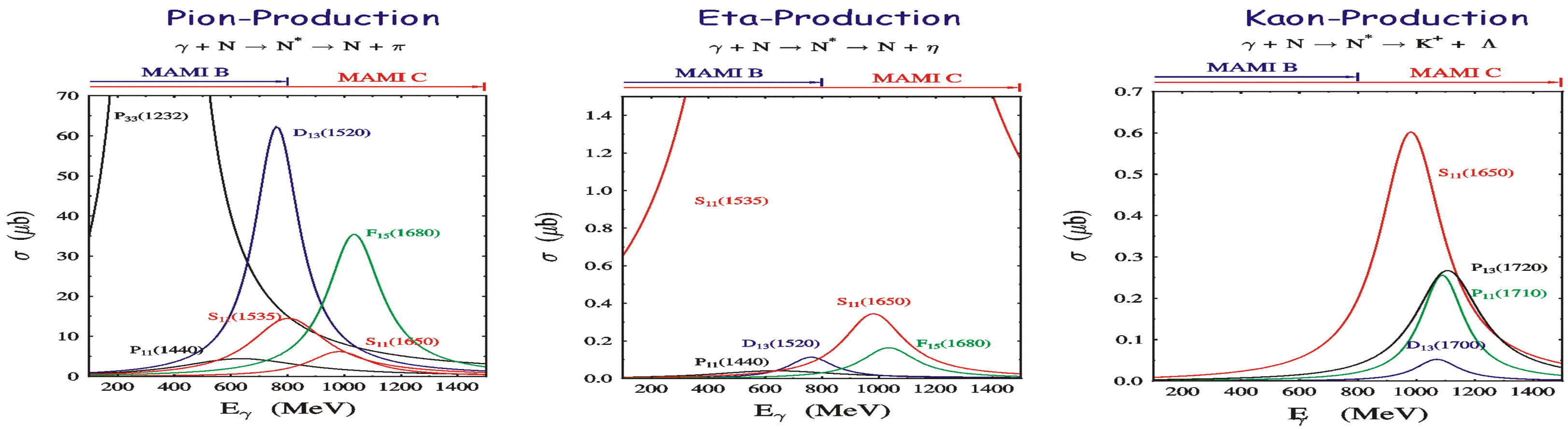




The comparison of missing-mass spectra from CB&TAPS and CLAS experimental sets. The CLAS is aimed mainly on study of charged final states using magnetic spectrometr. CB&TAPS is aimed on neuteral final states. Nevertheless the missing-mass resolutions for protons is ruther similar.

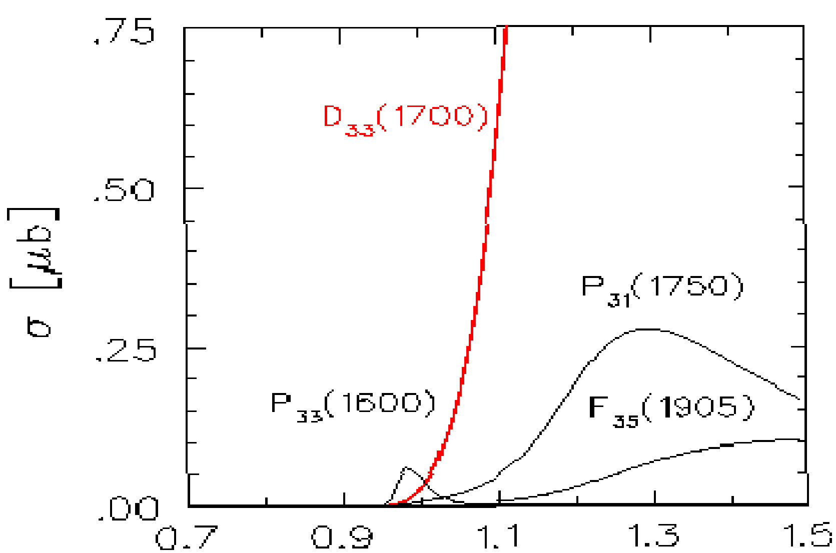
Physics motivation – resonances study

Nucleon Resonances



problem : overlapping resonances
polarization observable

MAMI C : polarized photons, polarized targets
and recoil-proton polarimeter



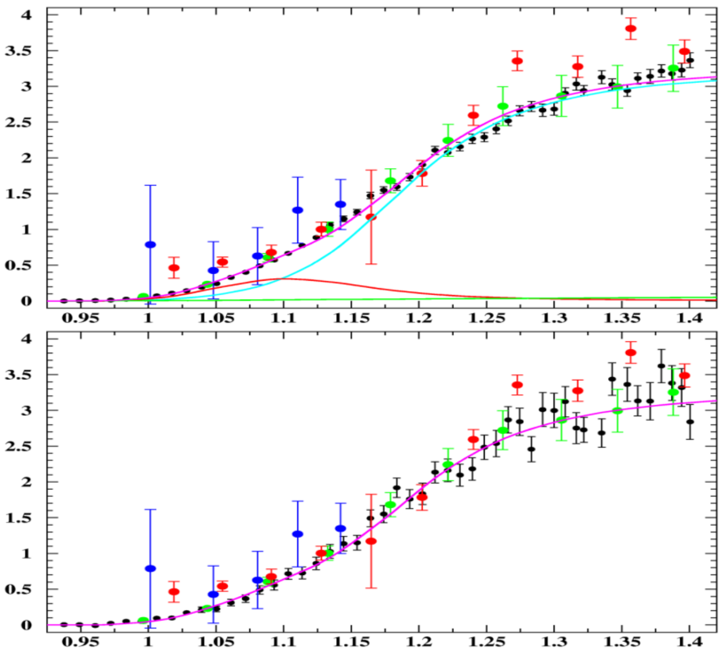
Two-body reaction -filters for well-known resonances. Double spin experiments-main a now.

Multy partical final states -additional filter for other poorly stadied resonanses

Reaction $\gamma\, p \to \pi^o(\gamma\gamma)\, \eta(\gamma\gamma)\, p$
filter for

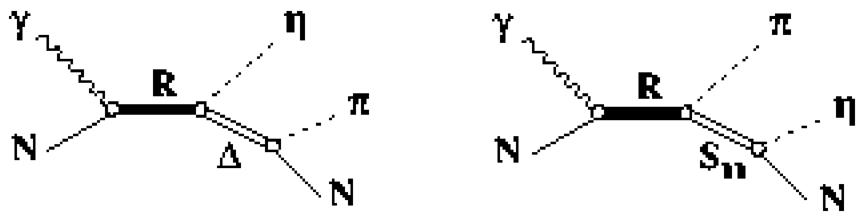
➢ D_{33} **(1700)**

γ p -> $\pi^o(\gamma\gamma)$ $\eta(\gamma\gamma)$ p



circles:
blue – Tohoku 06
red – CB@ELSA 04
(syst. err. 20% is not included)
green – GRAAL 08
black – this work

lines:
violet – best fit
light-blue – $\Delta(1700)D_{33}$
red – $\Delta(1600)P_{33}$
green – Born terms



Mainz-Tomsk model

Reaction model with two decays channels. The high statistics permits to study reaction mechanizm without additional data

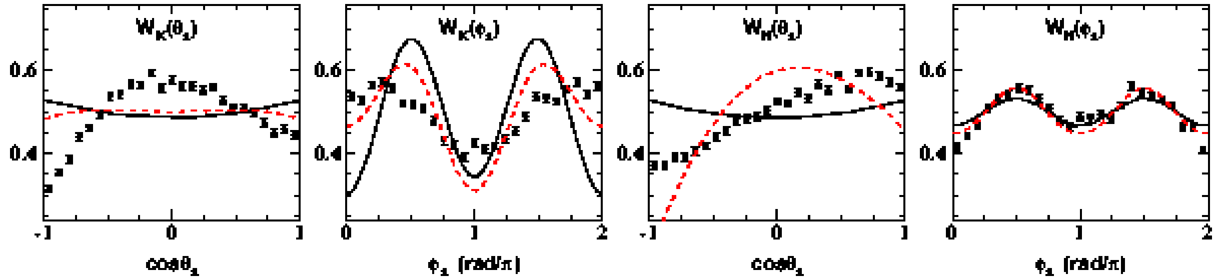
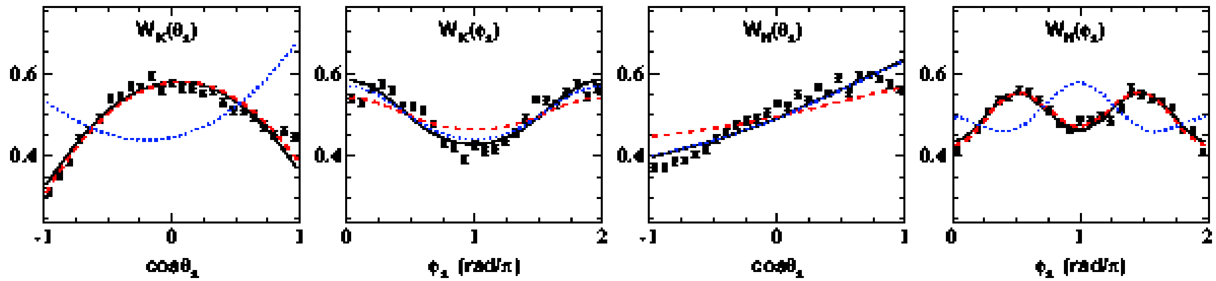


Fig. 10. Angular distributions averaged over the energy bin $E_\gamma = 1.3$–1.4 GeV. The curves are calculated with P_{33} (solid curve) and D_{35} (dashed curve) isobars. In both cases, the parameters were chosen to give the best description of $W_K(\theta_x)$ and $W_H(\phi_x)$.

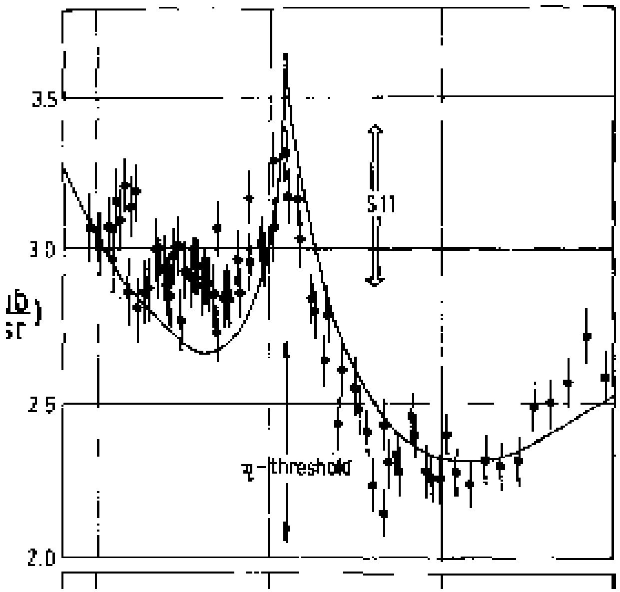


- **The high statistic permited to obtait the angle dependences of reaction cross-section. Fit of the Mainz-Tomsk model to the data gives the following parameters of the D_{33}(1700) resonance:**

$A_{3/2}$ / $A_{1/2}$ = 1.45 ± 0.04 ,
Γ(R̂(1232)$\varepsilon\tau\alpha$) / R̂$_{total}$ = (2.1 ± 0.2)% ,
Γ (R̂S_{11}(1535)$\pi\iota$ / R̂$_{total}$ = (0.10 ± 0.02)% ;

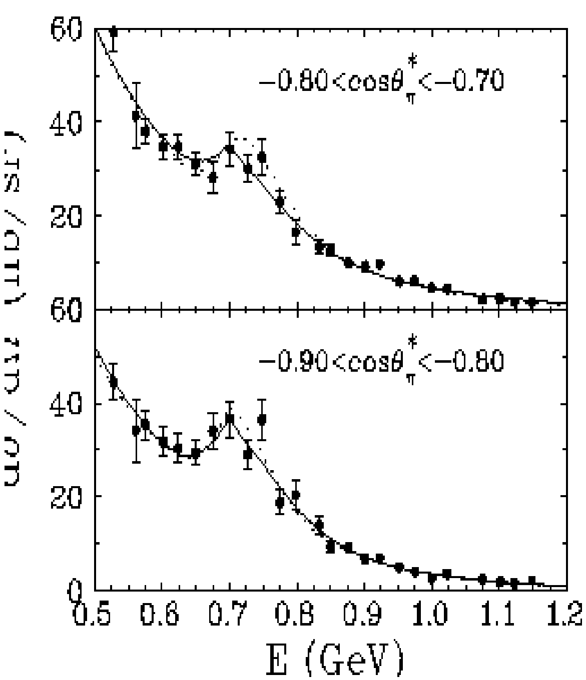
The first results for PDG

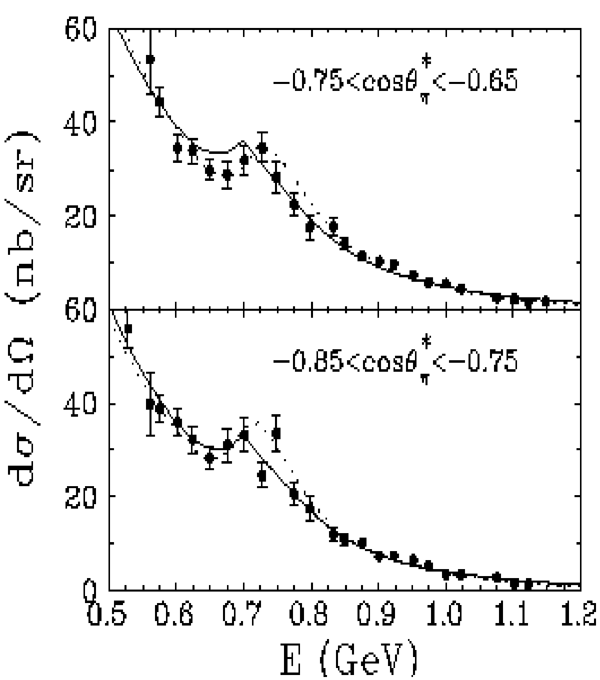
Threshold effects("cusp")



The "cusp" was observed in pion photoproduction
The same effect was observed in CB- ELSA data
The full width of the "cusp" is about 20 MeV

The effect is rather large and should be taken into account in data interpritation.
What is real width(energy resolution)?





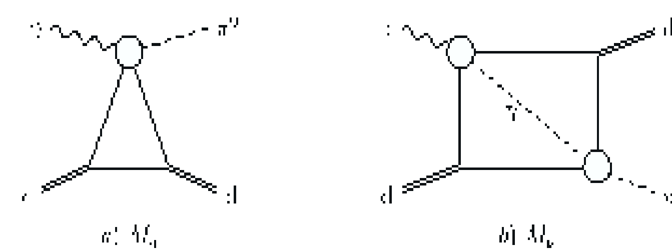
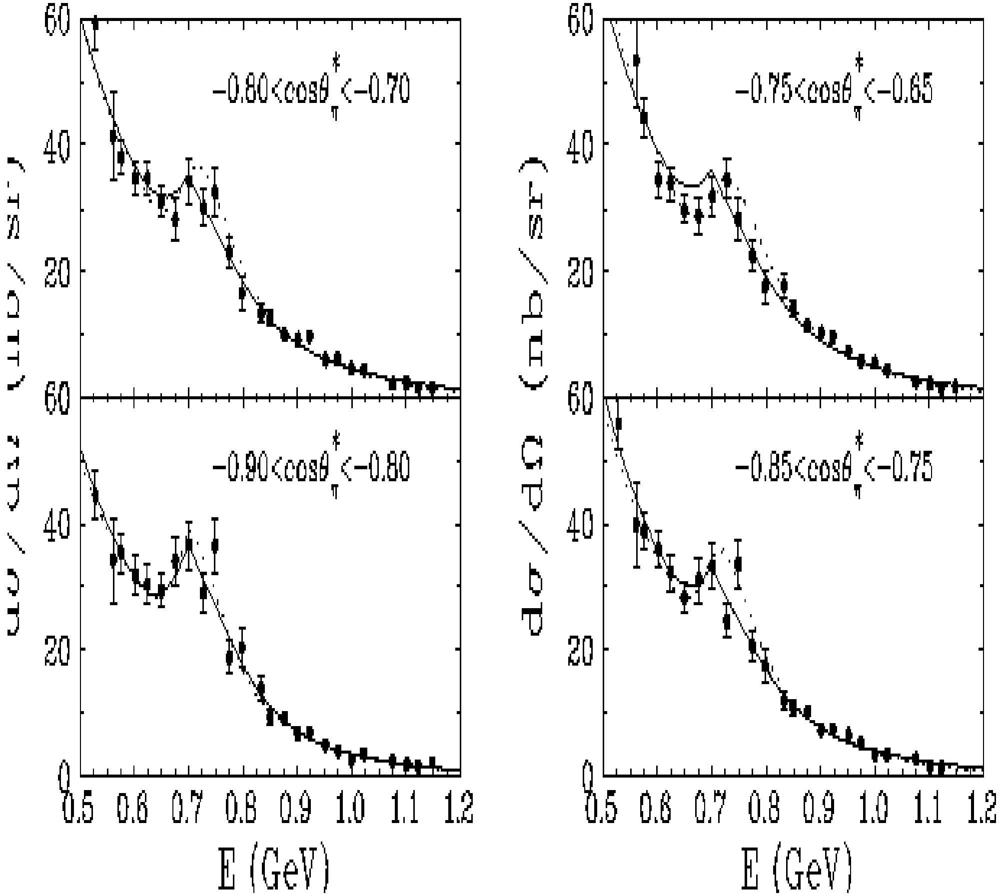
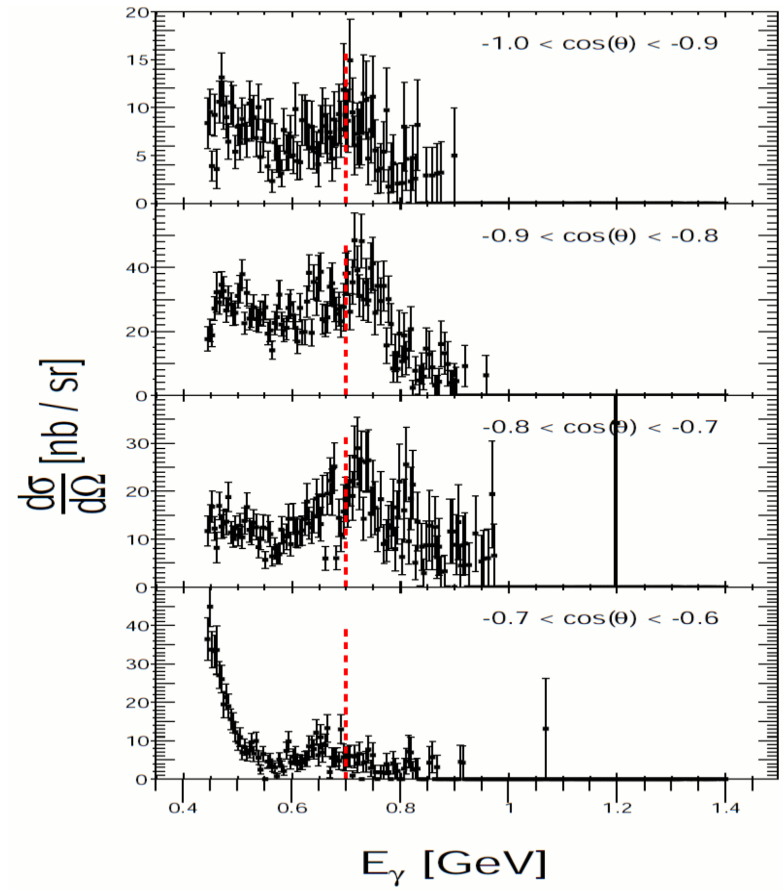


Fig. 1. Feynman diagrams for the $\gamma d \to \pi^0 d$ reaction considered in [24]: (a) single-scattering amplitude M_a; (b) double-scattering amplitude M_b. It was shown in [24] that (b) dominates over (a) at backward angles for $E_\gamma \sim 700$ MeV.

CLAS results

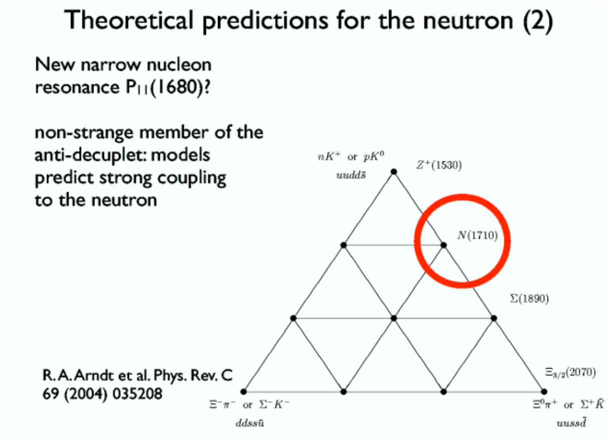


A2 results



Comparison of CLAS results and preliminary A2 results. The A2 result is mach more clear. The threshold effects really exists and rather large. To c effects the beam energy resolution must be less then 5 MeV. The thresho effects shoul be included into analysis.

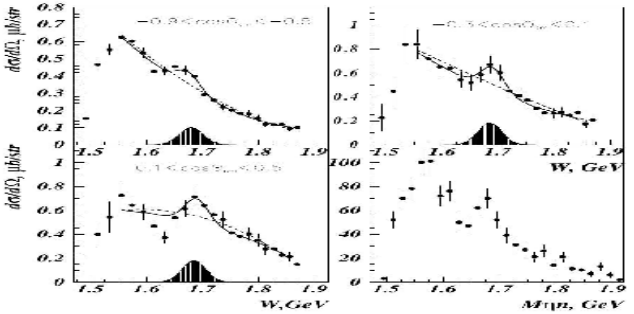
Missing resonances



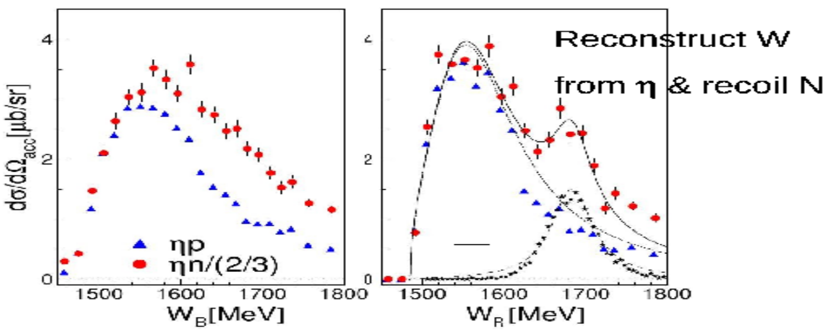
Pentaquark problem – looking for non-strange antidecuplet memmber - resonance R(1680):
BONN, MAINZ, PNPI-ITEP

What is seen for *d(γ,nη)* ?

V.Kuznetsov et al., arXiv:0807.2316 [hep-ex]



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



Kuznetsov background subtracted "peak" has width σ ~ 20 MeV

Integrated Strength of background subtracted structure ~ 10 μb/sr away from backward angles.

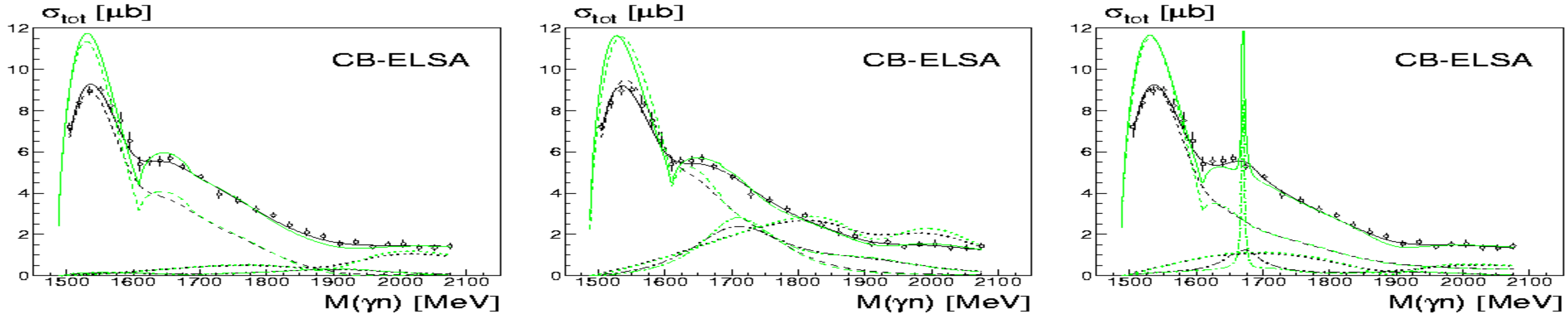
S_{11} background ~ 0.5 μb/sr in bump region.

If the bump is intrinsically narrow σ ~ 1 MeV then with suitably high E_γ resolution, then one should "easily see" a structure with a factor 20 lower cross section.

MAMI has much higher intensity than GRAAL or ELSA...aim to determine p(γ,pη) upper limit < 0.1 μb/sr (still needs to be quantified)

Bonn-Gatchina model analysis

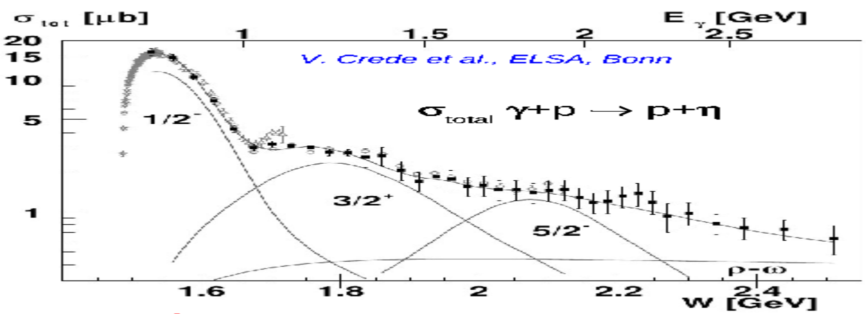
- basis: coupled channel isobar analysis with background terms



- different scenarios to reproduce 'bump' structure:
  - left: interference in S_{11}-sector: adjusting phases etc.
  - middle: introduction of conventional (broad) P_{11} resonance
  - right: introduction of very narrow P_{11} resonance

B. Krusche, Crystal Ball Collaboration meeting March 2009

Differing Pictures of W~1680 MeV Structure



At Mainz

- The excitation function (and with sufficient statistics the dσ/dΩ) can be measured to a tagged-photon energy resolution of ~1 MeV.
- π, multi-π, η, κΛ….channels can be measured simultaneously and compared.
- Σ asymmetry @ ~1.05 GeV is possible…energy bins?
- Circular single spin asymmetry possible for multi-meson final states.

Explanations of the ~1680 MeV bump observed in d(γ,n η).

Antidecuplet States
D. Diakonov et al., Z..Phys. A359:305,1997
M.V. Polyakov & A. Rathke, Eur. J. Phys. A18:691,2003
Baryon spectrum expressed as rotational excitations of a soliton. Expect strength in neutron photoproduction with analagous proton channels relatively suppressed

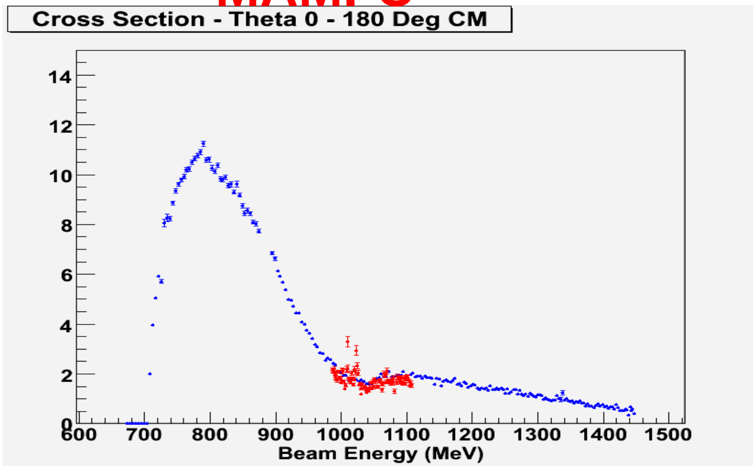
Alternative "Non-Exotic"
W.-T. Chiang et al., NPA700:429,2002
Eta-MAID…large D15 contribution
(assuming a 17% Nη decay branching ratio)
V. Shklyar et al, Phys.Lett. B650:172,2007
Coupled-channels effects of S_{11}(1535), S_{11}(1650), P_{11}(1710)

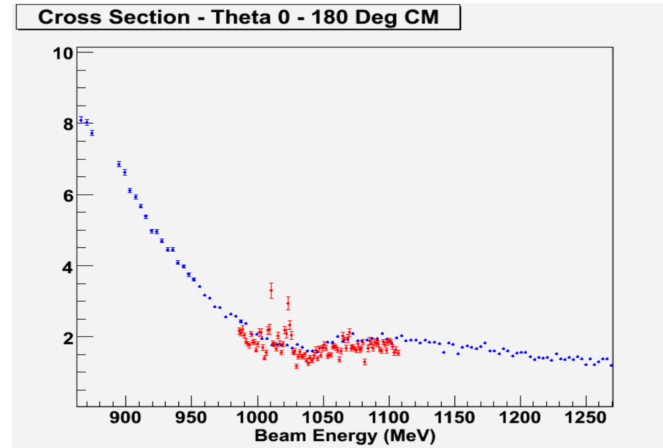
So far no confirmed structure in p(γ,p η).
Structure in the Legendre coefficients?
Structure in Σ ?
If there is a narrow structure it will not be smeared by Fermi motion.
Free-particle partial-wave analysis more straightforward.

So far the experimental evidence for narrow states is "not overwhelming" with several significant NULL results.
Spring-8 still "see" a 1540 MeV "Θ^{++}" bump

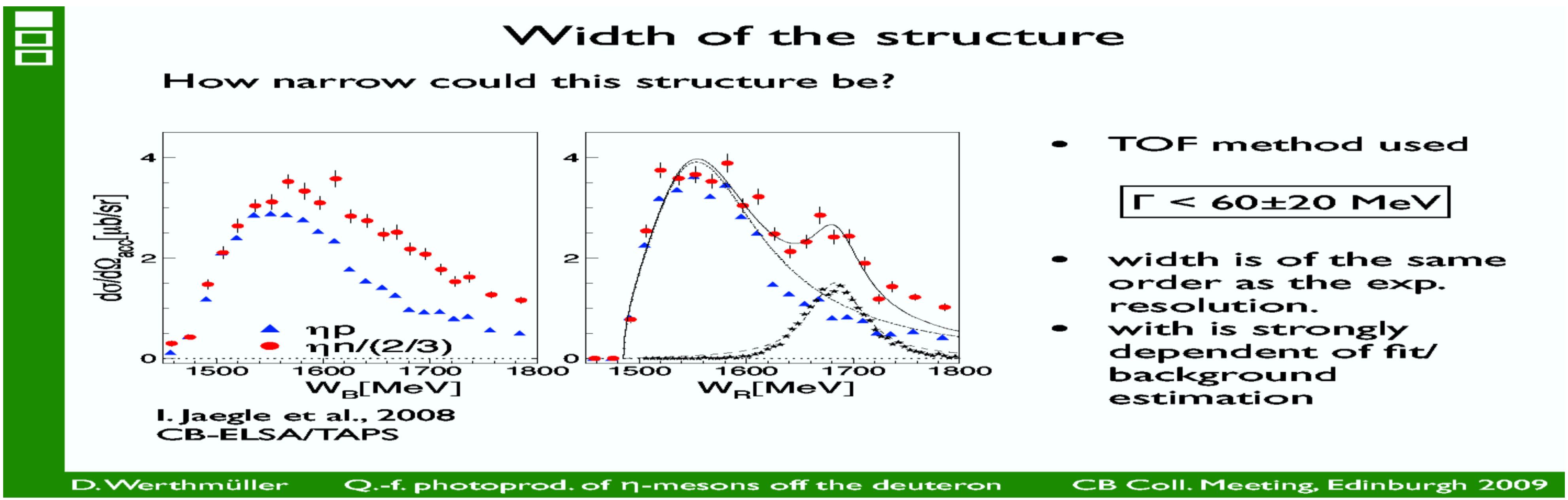
H(γ,ηp) @MAMI-C, J.R.M. Annand, Mainz, March 2009

The preliminary result of looking for R(1680) on MAMI-C



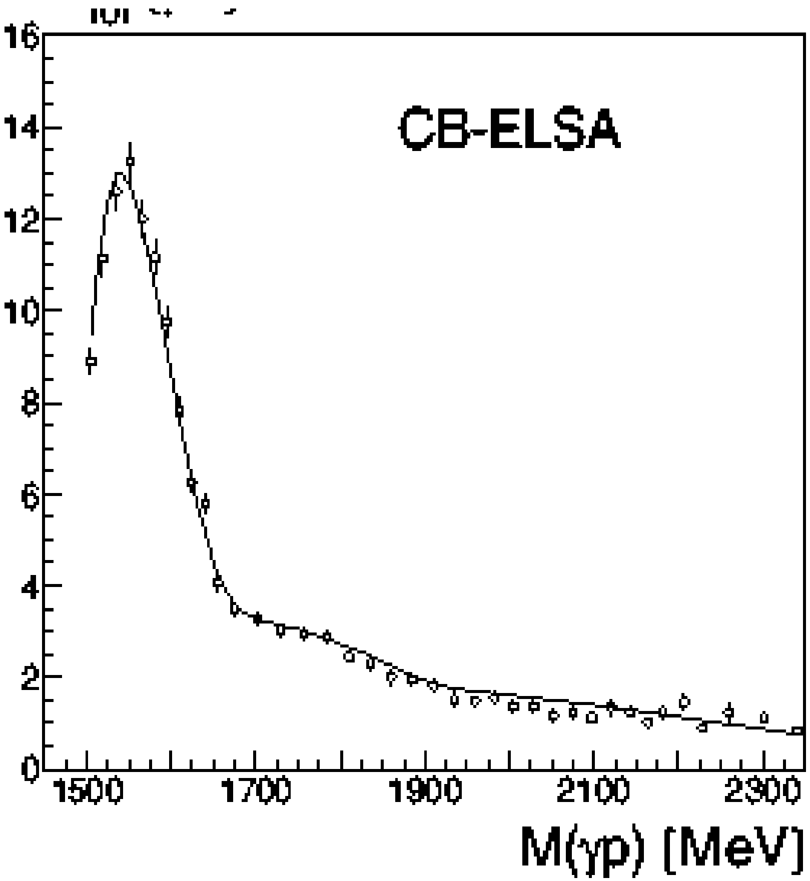


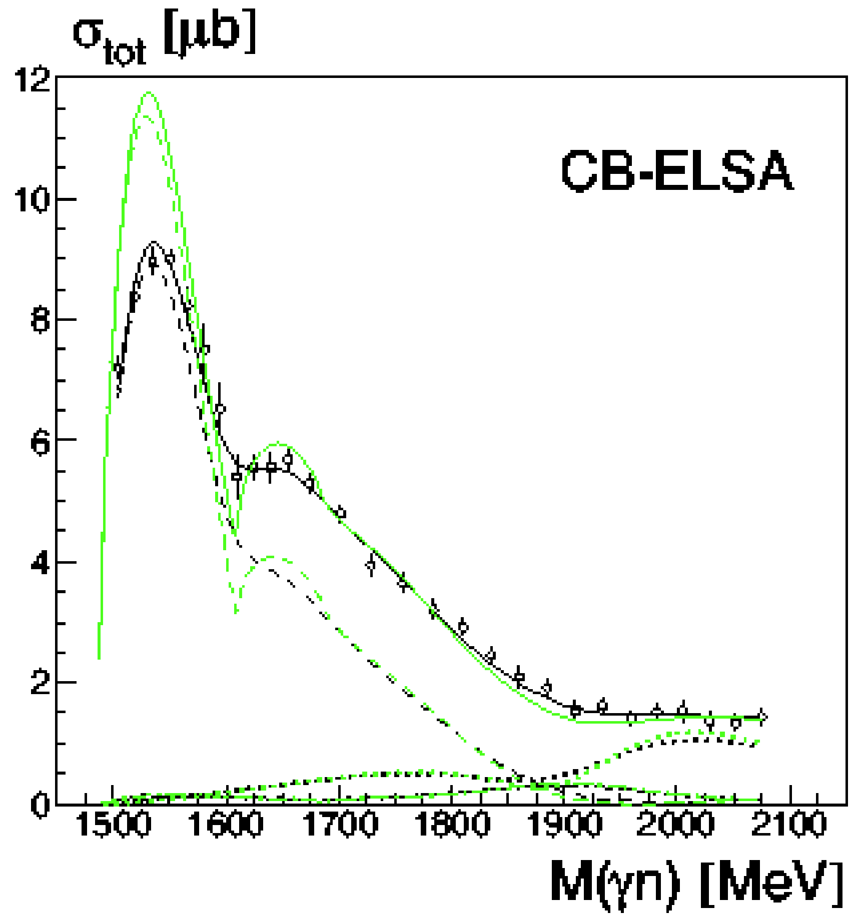
Results on proton with microscope



Results on neutron

Deuteron as neuteron target

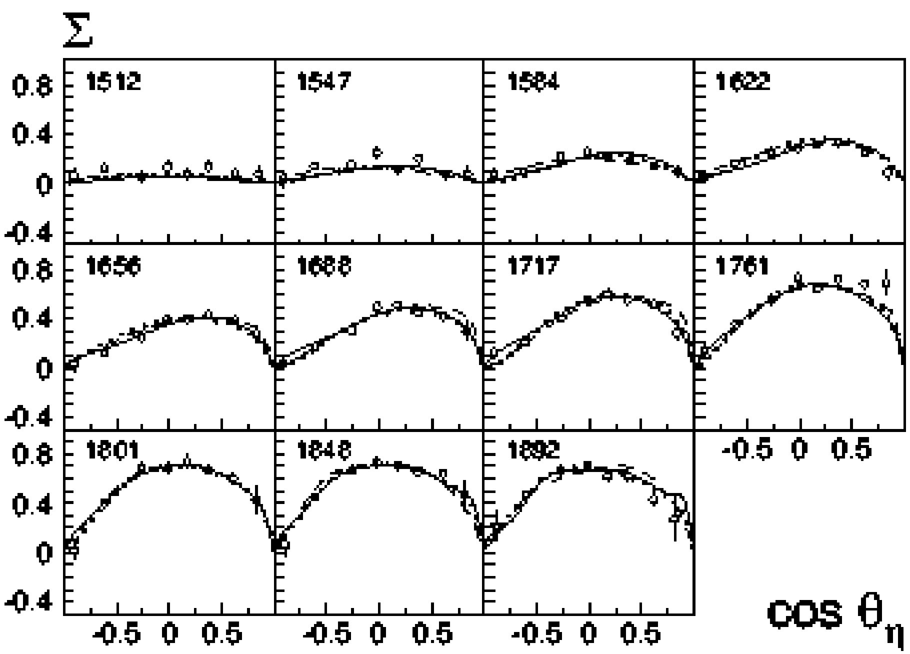




The total cross-section of eta-meson photoproduction on proton and neuteron from deuteron target in comparison with PWA Bonn-Gatchin group.

Deuteron as neuteron target

Fermi motion and FSI problem



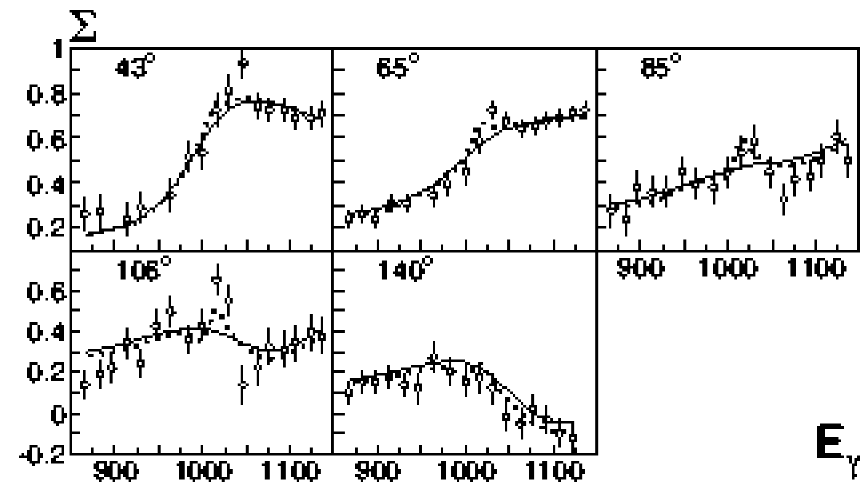
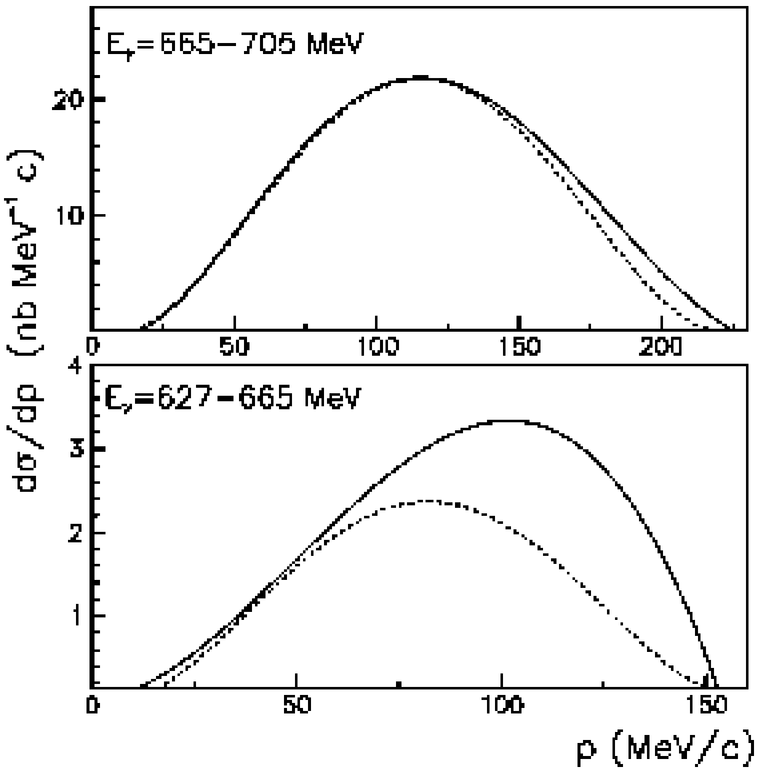
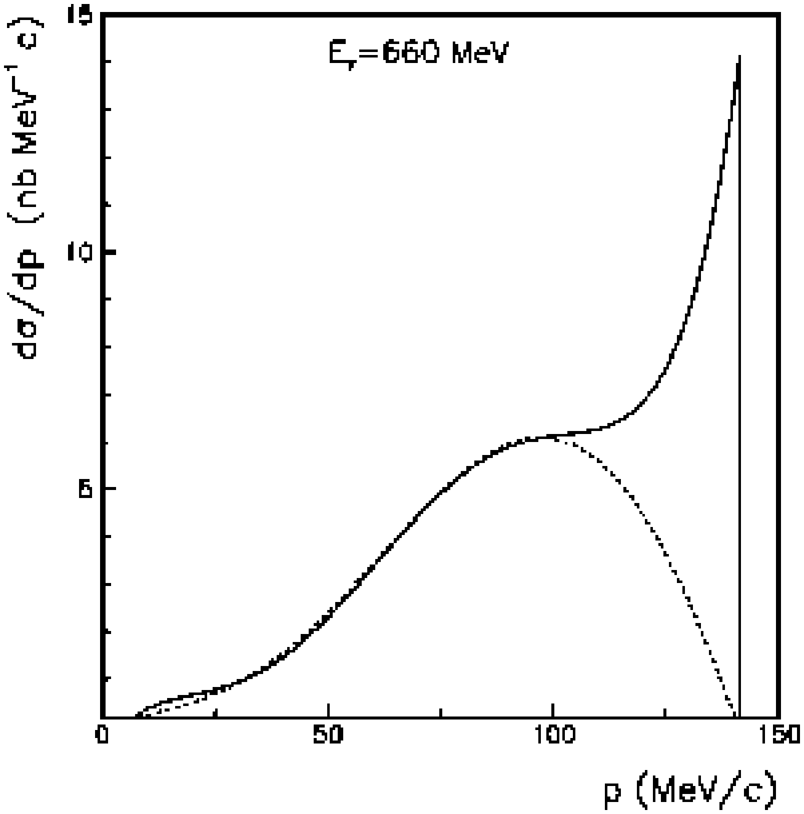


Fig. 12. Beam asymmetry for the reaction $\gamma p \to \eta p$ [17]. The PWA description is shown as solid line (solution 1) and dotted line (solution 3).

Bonn-Gatchina analysis of existing experimental data:
Fermi motion should be included, effect of FSI small

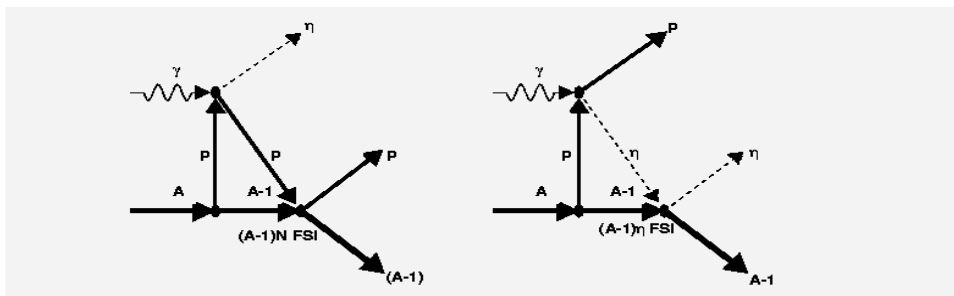
Fffect of FSI in eta-meson photoproduction on deuteron



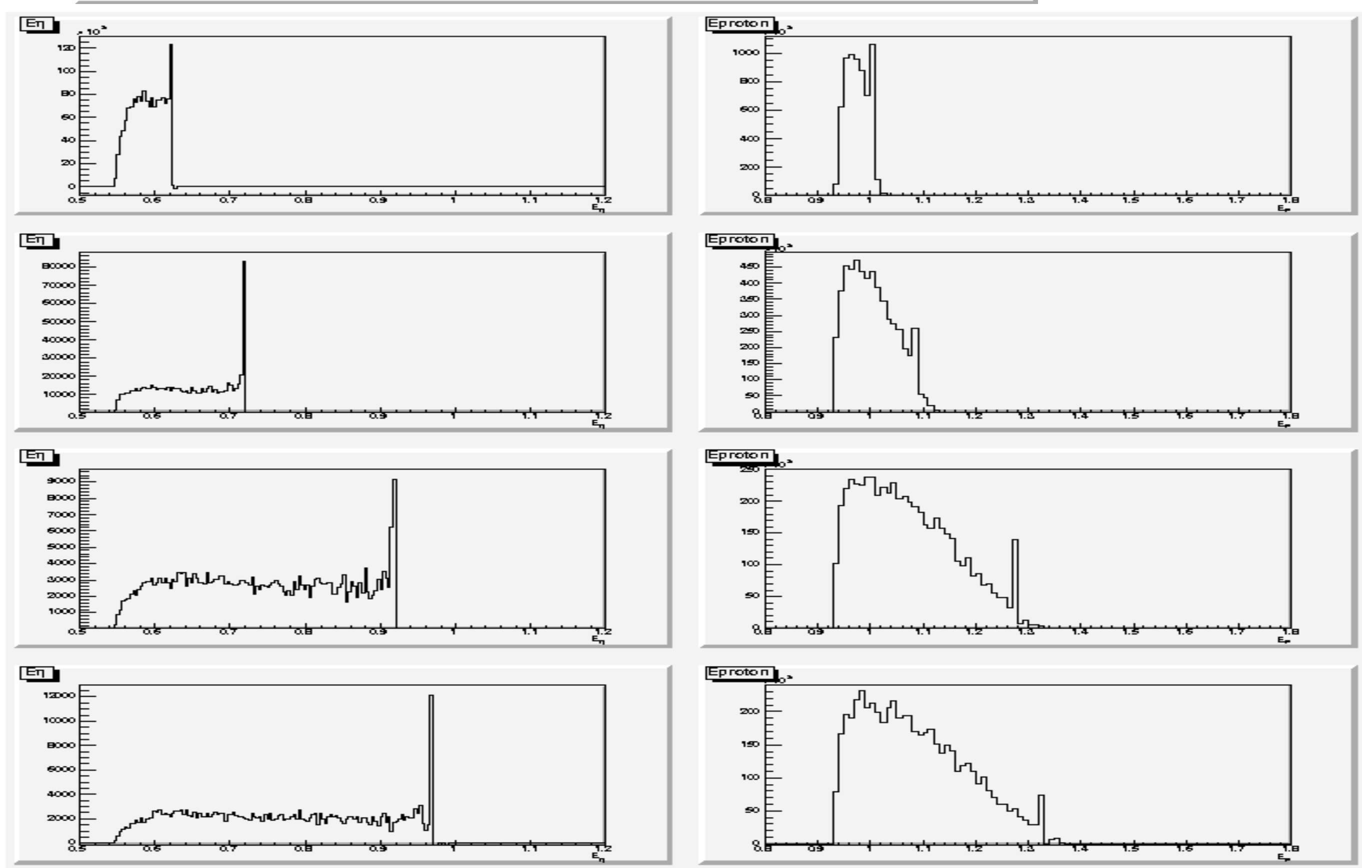


1. Strong influence of NN FSI
2. Good beam resolution is needed to observe effect
3. Qusi-free production is not seen?

Simulation of FSI



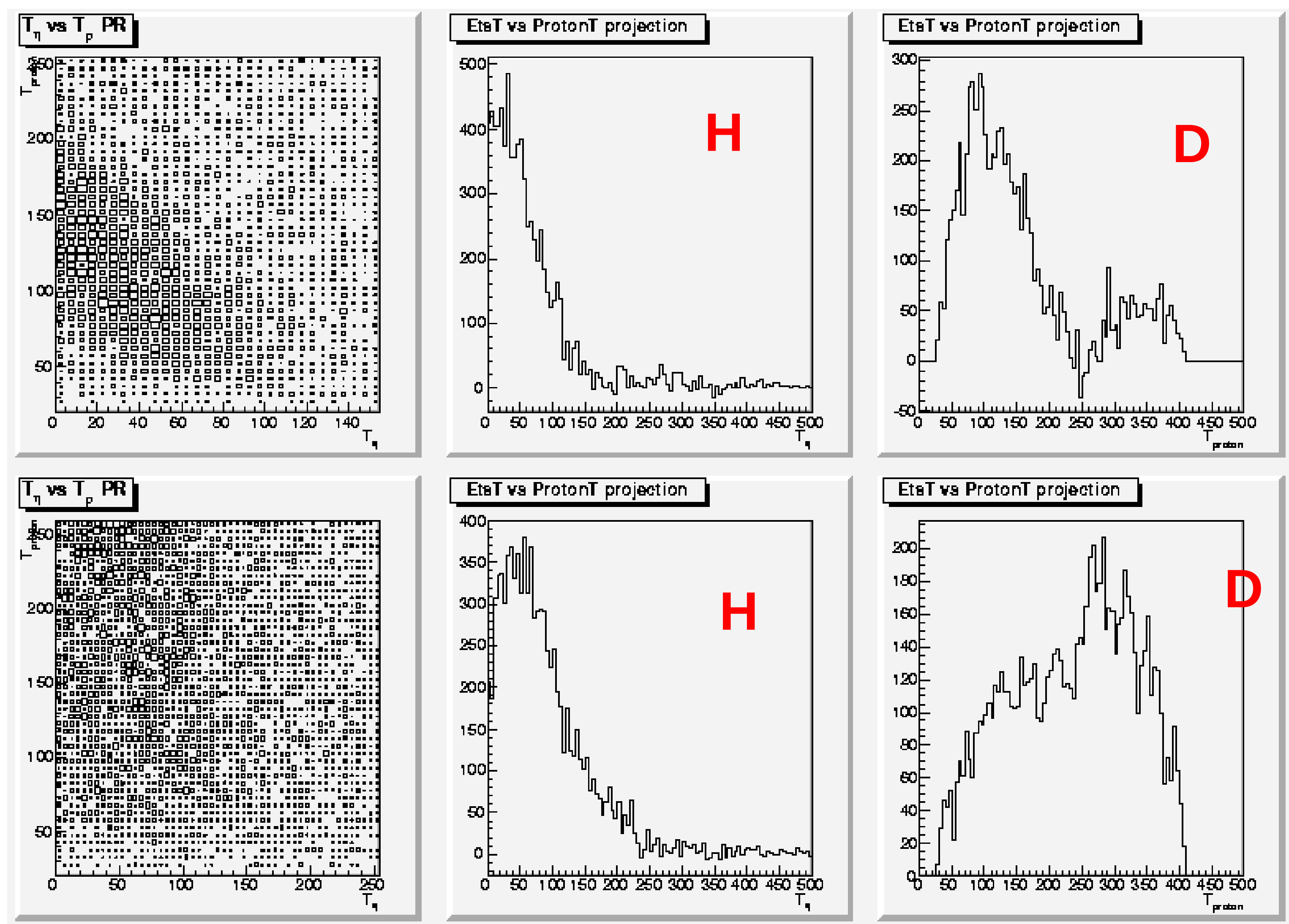
Reaction mechanizm with FSI



Meson spectrum

Proton spectrum

The preliminary results from CB&TAPS on MAMI-C



P

The energy spectra of protons(top) and mesons(bottom) from deuterium target
The spectra demonstrate not only Fermi smearing but some enhancement due t

Conclusion:

The main aim of A2 collaboration now – double-spin experiments for resonances study. The experiments must be carefully plannad.

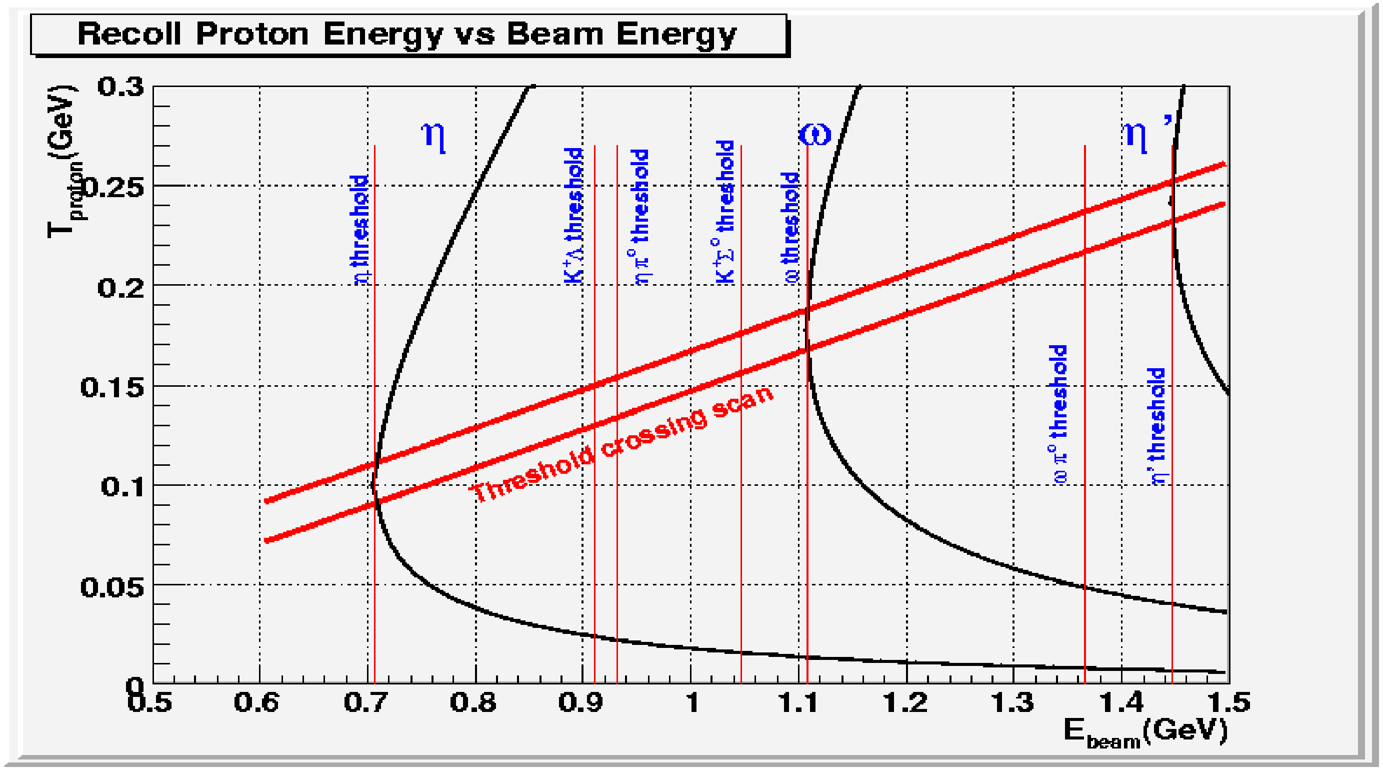
There are some indications on interesting physics probmems which shou be taken into account in experiments planning:
R(1680), FSI in deuteron, threshold effects.

All obtained experimental results are restricted by experimental resolutio or by Fermi motion.

How to improve results? Statistics and resolution? Impossible to expect a serious improvement in resolution or statistics. How can we use the ma advantage of CB&TAPS experimental set – good beam energy resolution

New method("threshold-crossing") for resonances study for CB&TAPS experimental set are developed.

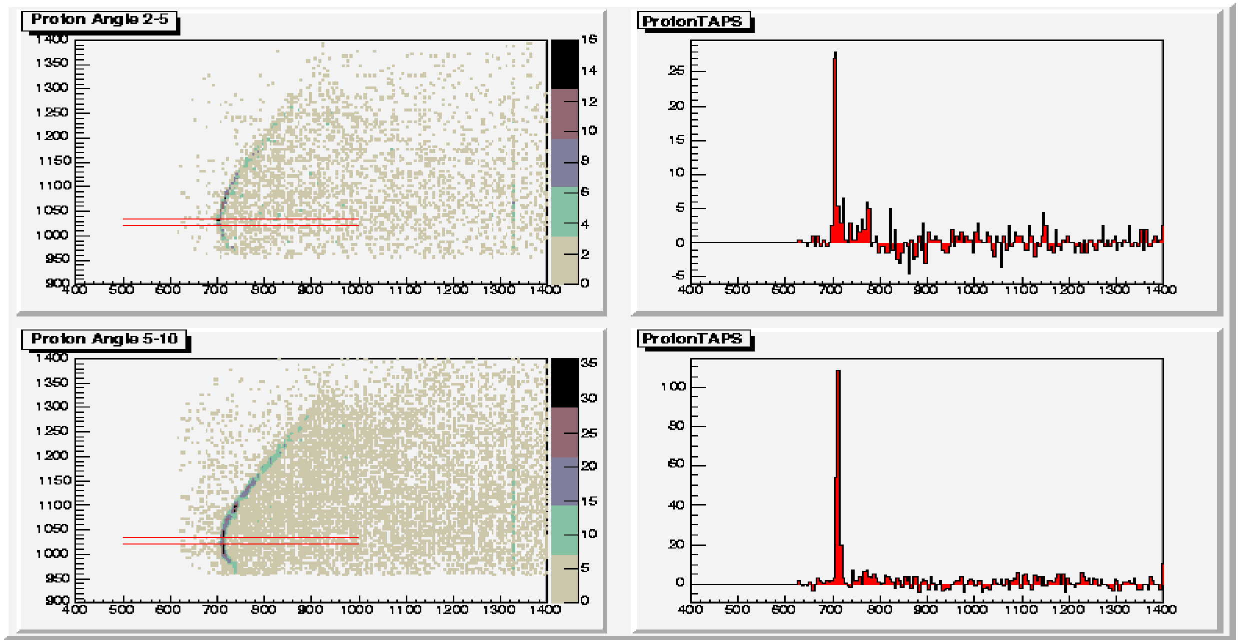
Threshold-crossing technique



1. The resolution is mainly determined by beam energy resolution
2. The MAX Jacobian peak is a best ratio signal/backgroung
3. The method permits to study narrow resonances
4. The "low" branch is sutable for resonances search for at high energy like ELSA or CLAS xperiments(poor beam energy and good recoil proton resolution

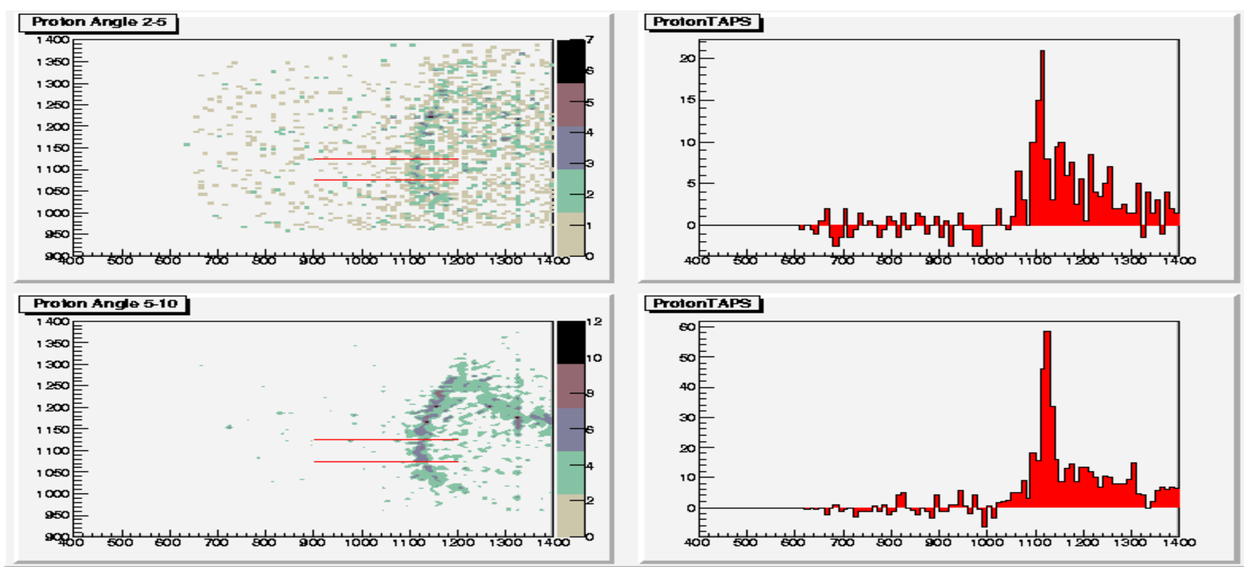
The preliminary experimental results from CB&TAPS on MAMI_C

The results of TC scan:



eta-meson scan 3-6 deg

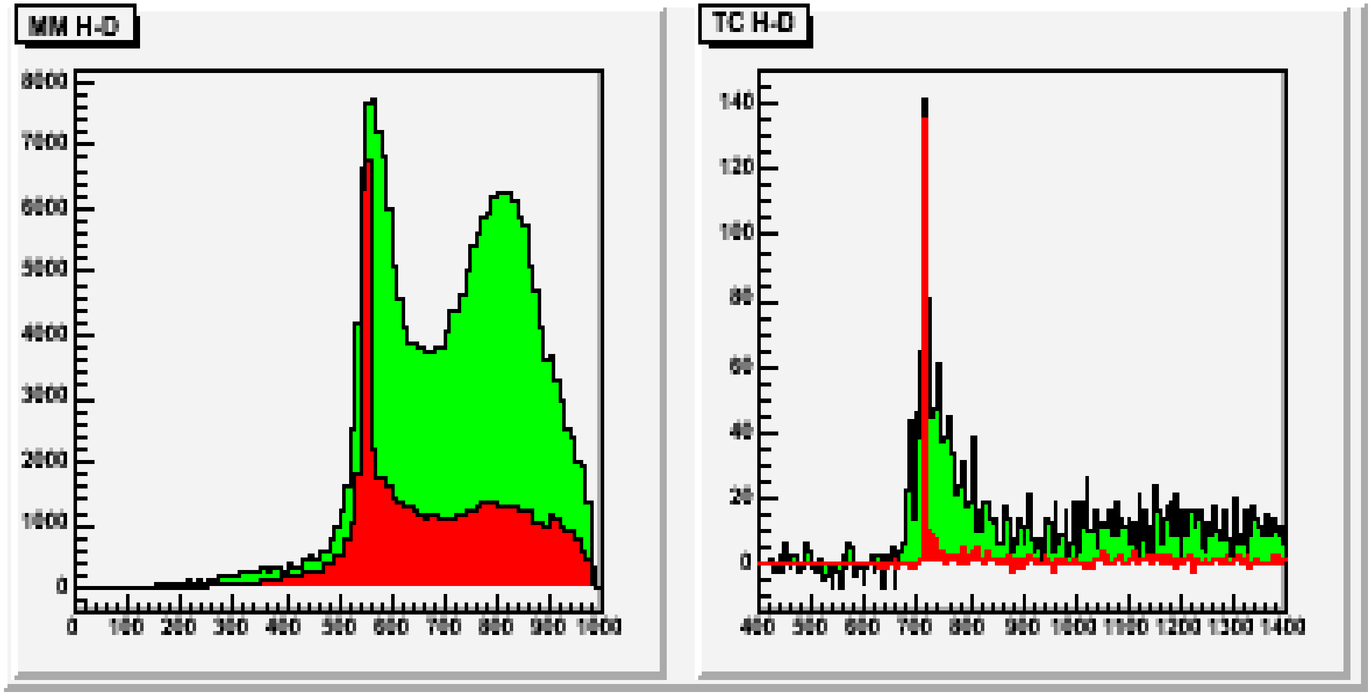
eta-meson scan 6-9 deg



omega-meson scan 3-6 deg

omega-meson scan 6-9 deg

The obtained width of omega-meson is in agreement with PDG



Comparison of MM and TC methods for hydrogen and deuteron targ

Hydroged target -red

Deuteron target green

The advantages of TC method :

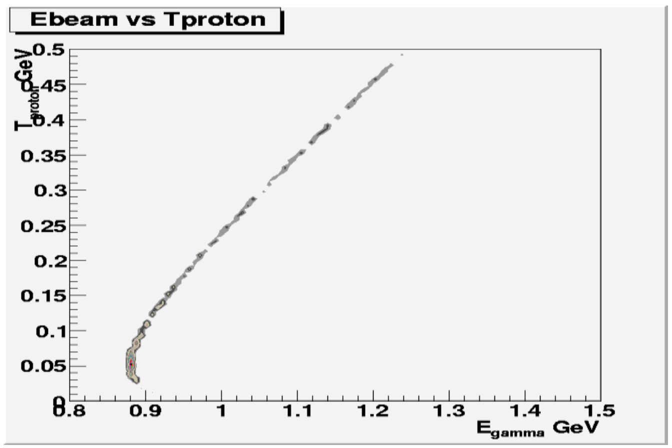
- **Better resolution(ratio width of hydrogen and deuterons peaks**
- **Better ratio peaks/background**

Microscope should improve TC method

Pentaquark problem still exist. Experiments are planned in MAINZ and PNPI-IHEP. The TC method may be applaied for looking for R(1680)(eta-neuteron system) on deuteron targetin reaction:

γ +D ->γ + N +(P) -> eta+N + (P) -> R(1680) + P

Two-body final state



Kinematics of R(1680) production

Reaction γ +D -> R + P

Kinematics of recoil proton

Experiment EPECUR in ITEP(ITEP-PNPI collaboration on pion beam)

1. two charged states
2. deuteron target

The TC method may be applied for pentaquark search for on D-target.
The experimental set must be added by proton detectors.

Conclusion:

The new experimental data with high statistics permit to study in details reaction mechanizm with a multy-particle final states.

The high beam energy resolution permits to find new unobservable effects in exita functions.

There are some indications on interesting physics problems - pentaquark, neuteron target, FSI in deuteron.

All obtained experimental results are restricted by experimental resolution or by F motion.

How to improve results? Statistics and resolution? Impossible to expet a serious improvement in resolution or statistics.

New method(“threshold-crossing”) for resonances study for CB&TAPS experimen are developed. The new experimental data with high beam energy resolution are n to confirm the sensivity of TC technique(microscope should be included).

The main aim of A2 collaboration now is a double-polarization experimen for resonances study. All item mentioned above should be taken into accout in planning of double-polarization experiments

Thank you