Narrow Nucleon Resonances: Predictions, Evidence, Perspectives

Summary Talk Experiment

D G Ireland (University of Glasgow)

Discussion Questions…

- **Can the familiar physics (without narrow baryons) suggest a consistent fit to recently observed structures in $\gamma N \rightarrow \eta N$.?**
- **Do we have any reasons to expect narrow (i.e., $\Gamma < \Gamma_{\Delta}$) non-strange baryonic states (Nucleon- or Delta-like) having non-exotic nature?**
- **Could we consider any other reactions (different from $\gamma N \rightarrow \eta N$) to look for such narrow non-strange baryon?**
- **Do we need exotica (baryonic and/or mesonic), or Why we are looking for it? Could we leave exotica alone and forget about it?**
- **Might exotica, if it exists, require revising the constituent quark model?**
- **May the Chiral Soliton Approach present an adequate model for complete QCD description of baryons?**

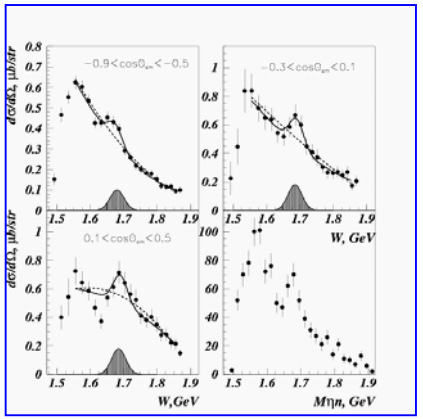
Slava Kuznetsov

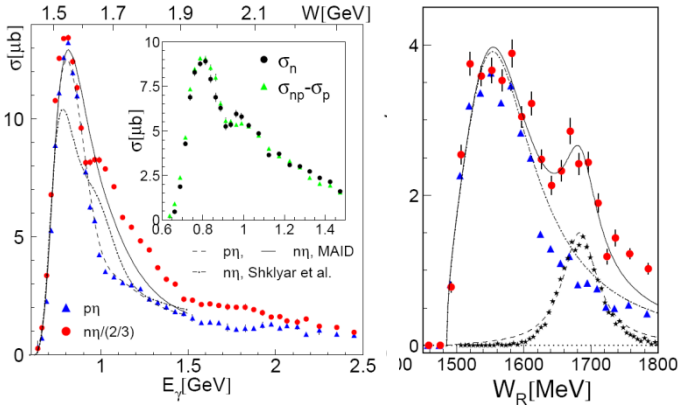
Observation of N(1685): Open questions and new results from GRAAL

Kyungpook National University, South Korea

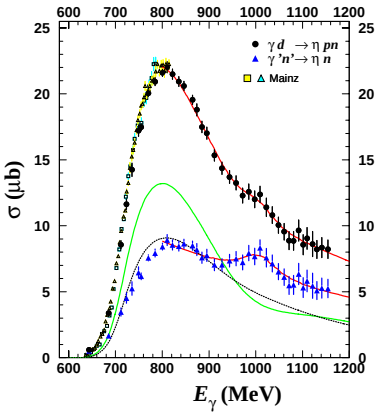
Data Sets

Graal γn→ηn, V.Kuznetsov et al., Phys Lett. B647, 22,(2007); hep-ex/0606065.



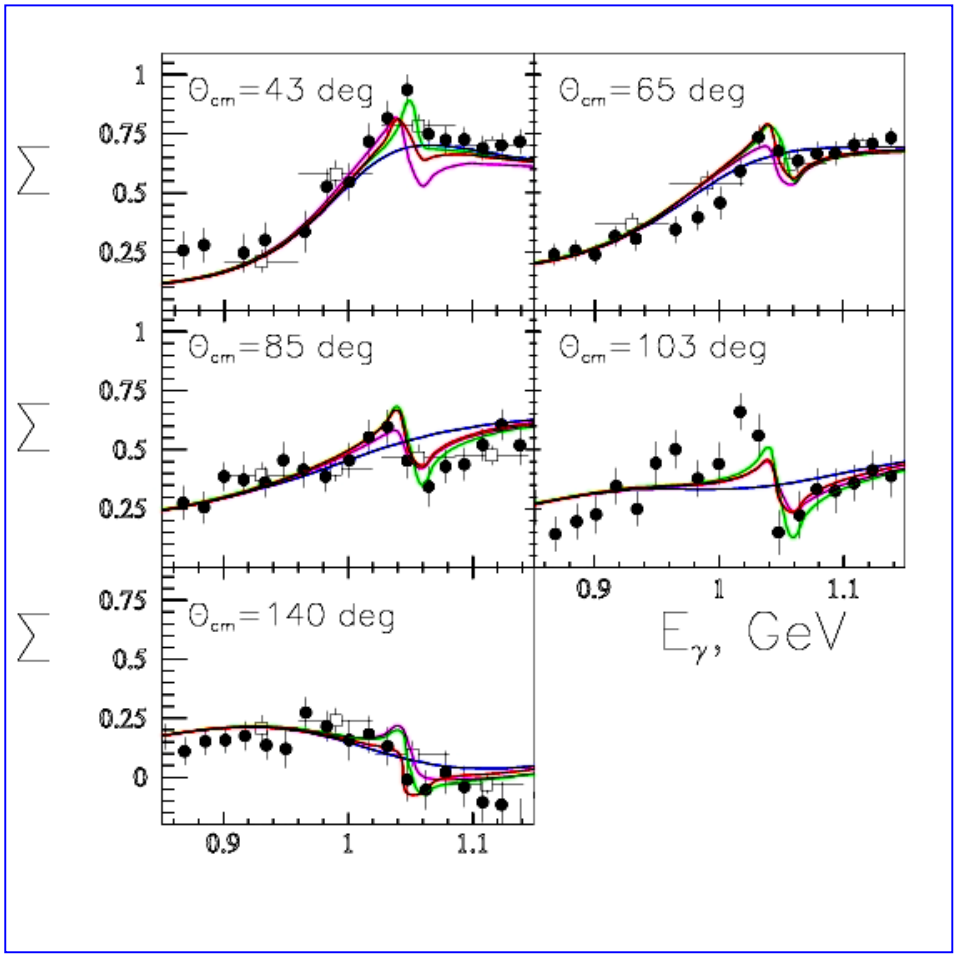


LNS-Sendai γn→ηn, Talk of H.Shimizu



CBELSA/TAPS γn→ηn, J.Jeagle, Phys. Rev. Lett. 100:252002 (2008); nucl-ex/0804.4841 (Talk of B.Krusche)

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



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

Comments on publication of O.Bartalini et.al . nucl-ex/07071385 are in backup slides.

Important message…

Quasi-free Cross section is cut-, analysis-, and facility-dependent.

The procedure of its fitting still has to be established!

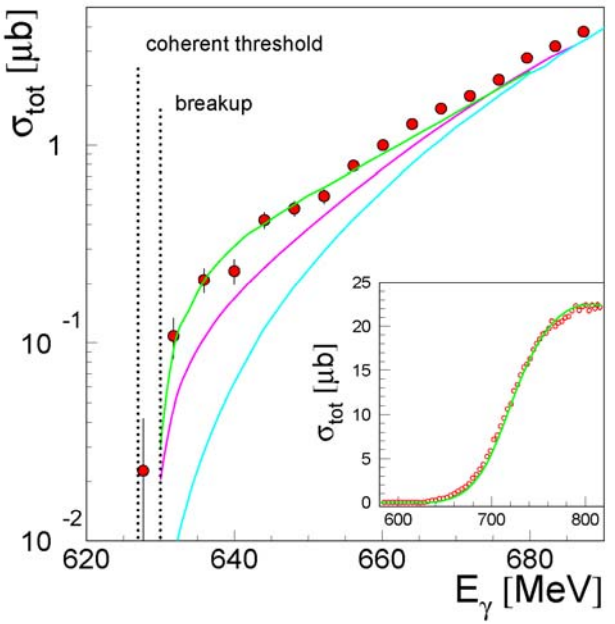
Bernd Krusche

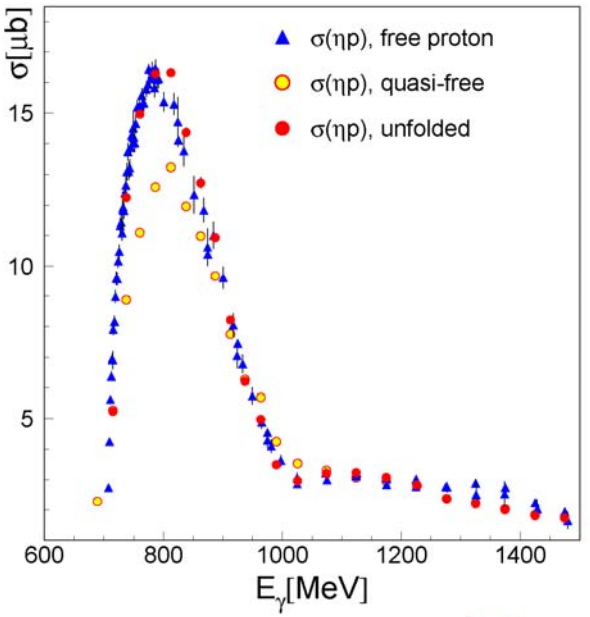
Meson photoproduction off the deuteron

University of Basel, Switzerland

the (much simpler) η case

- **no complication from coherent process, no significant FSI efffects, more or less controllable Fermi motion effects**

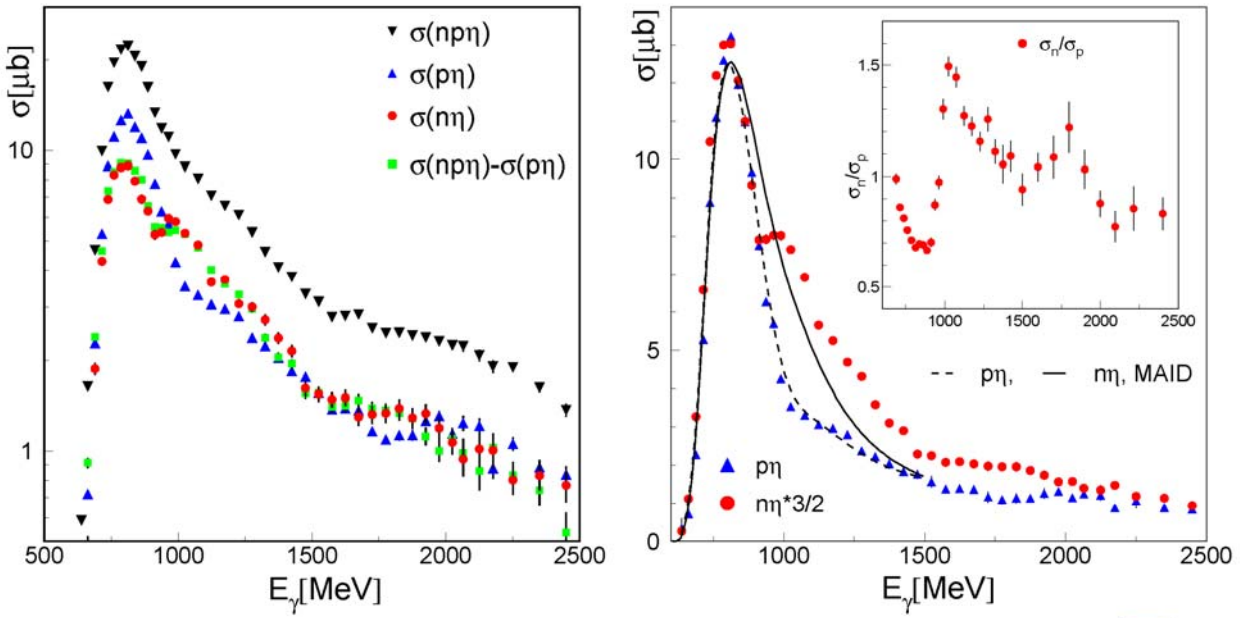




B. Krusche, Narrow Nucleon Resonances, Edinburgh, June 2009

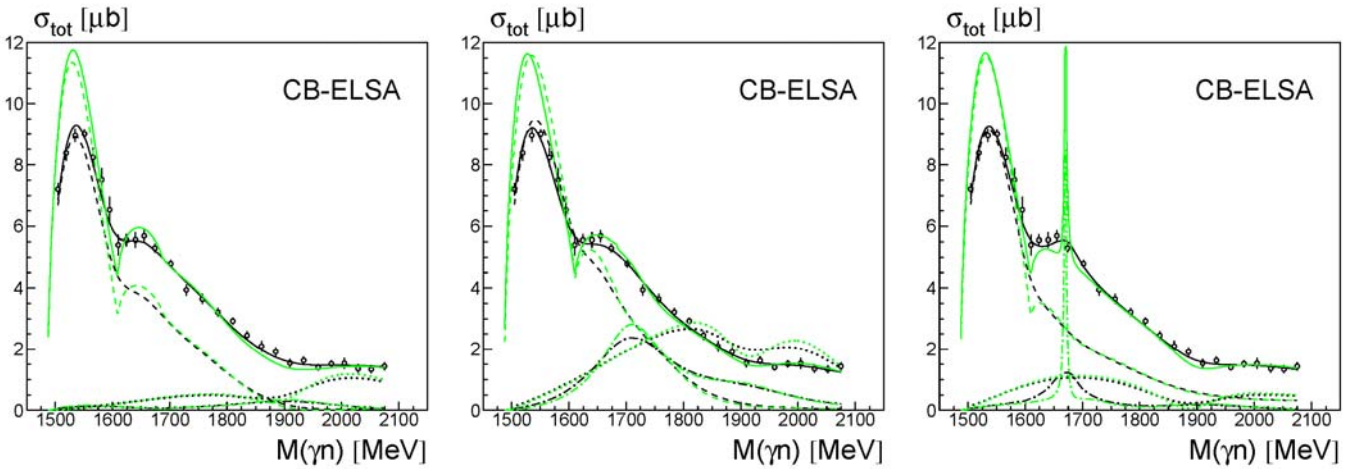
quasifree η-photoproduction off the deuteron (PhD thesis I.Jaegle)

- cross section for $\gamma n \rightarrow \eta n$ from two analyses with very different systematics:
  (1) η in coincidence with recoil neutrons
  (2) difference of inclusive cross section and η in coincidence with recoil protons



Bonn-Gatchina model analysis

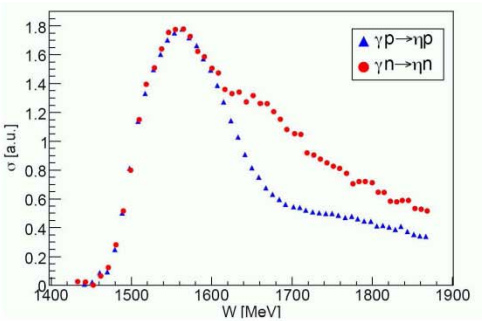
- basis: coupled channel isobar analysis with background terms



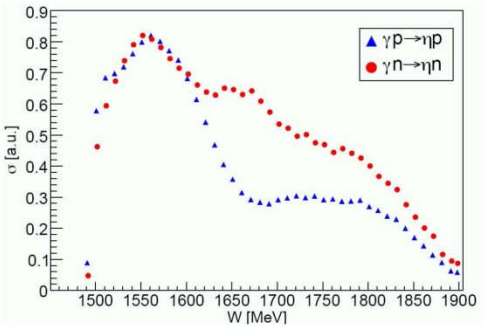
- different scenarios to reproduce 'bump' structure:
  - left: interference in S_{11}-sector: adjusting phases etc.
  - middle: introduction of conventional (broad) P_{11} resonance
  - right: introduction of very narrow P_{11} resonance

preliminary excitation functions (PhD thesis D. Werthmüller)

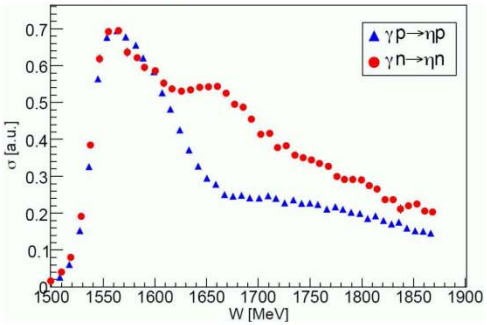
- $W = f(E_\gamma)$, $130 < \Delta\Phi < 220$



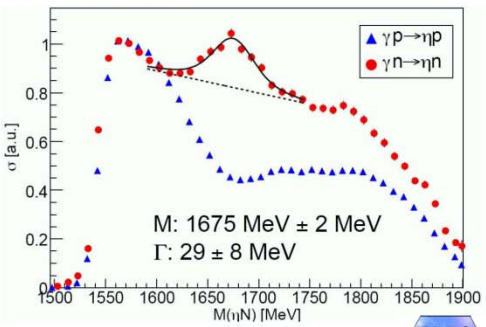
- $W = f(n, \eta)$, $130 < \Delta\Phi < 220$



- $W = f(E_\gamma)$, $170 < \Delta\Phi < 190$



- $W = f(n, \eta)$, $170 < \Delta\Phi < 190$



B. Krusche, Narrow Nucleon Resonances, Edinburgh, June 2009

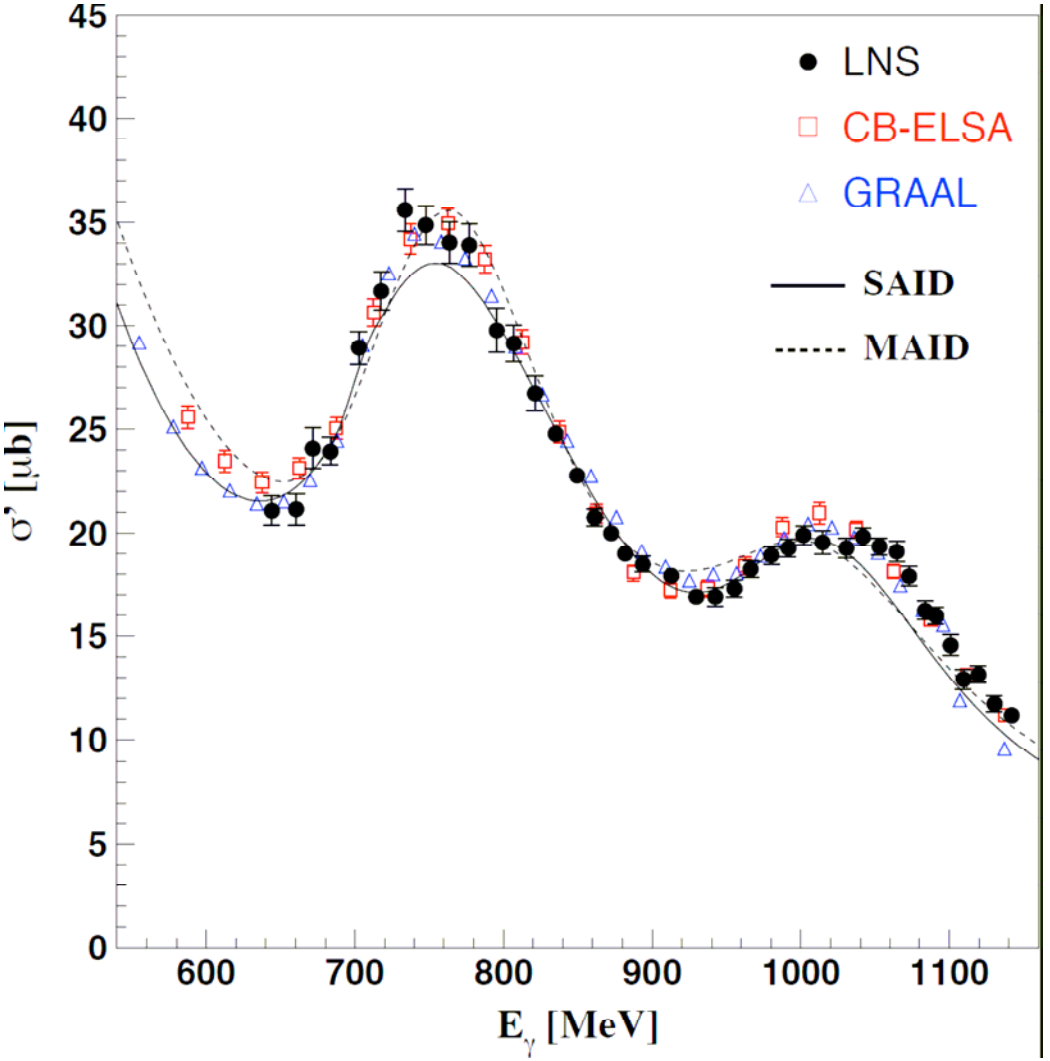
Hajime Shimizu

Photoproduction of η / π ° on the deuteron at 1 GeV

Tohoku University, Japan


7.5 TON

Good agreement



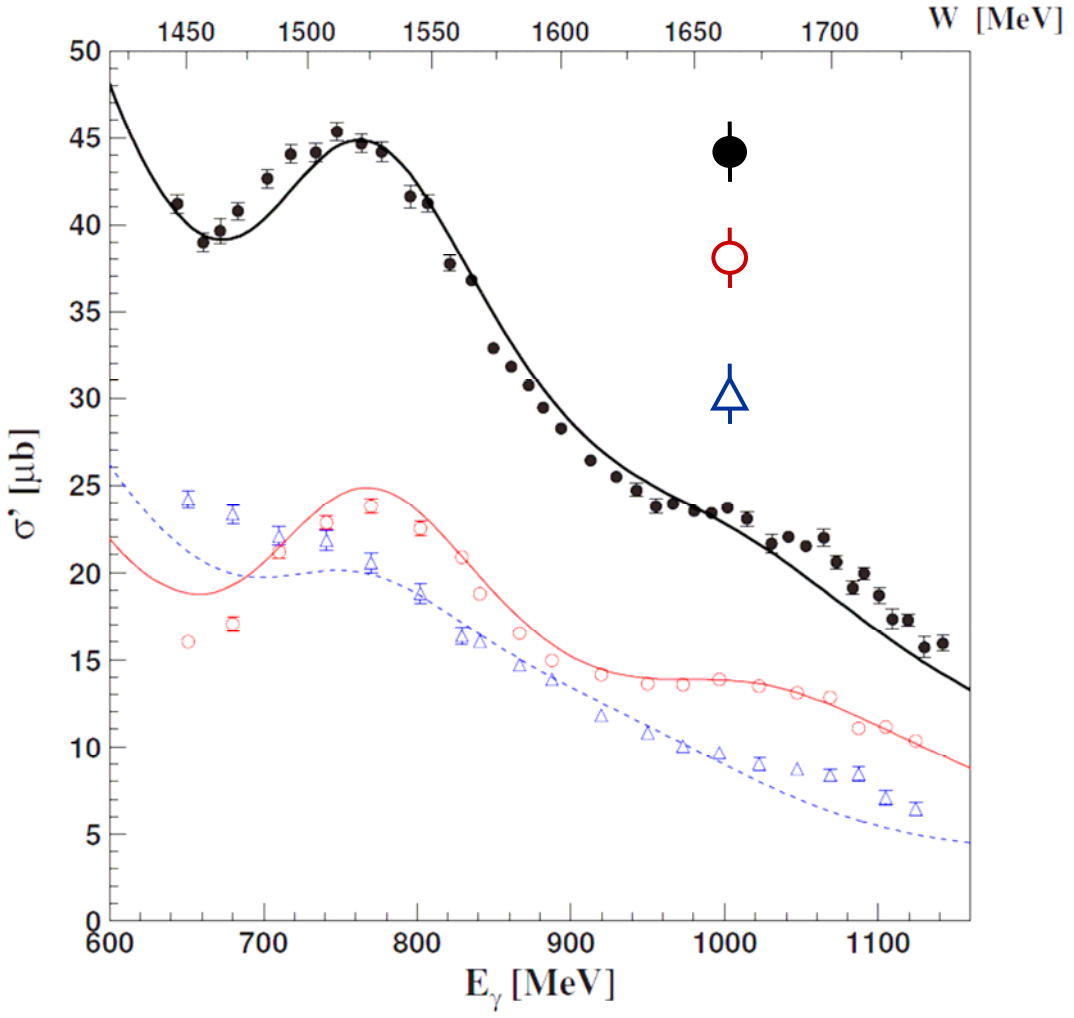
Need tools for analysis…

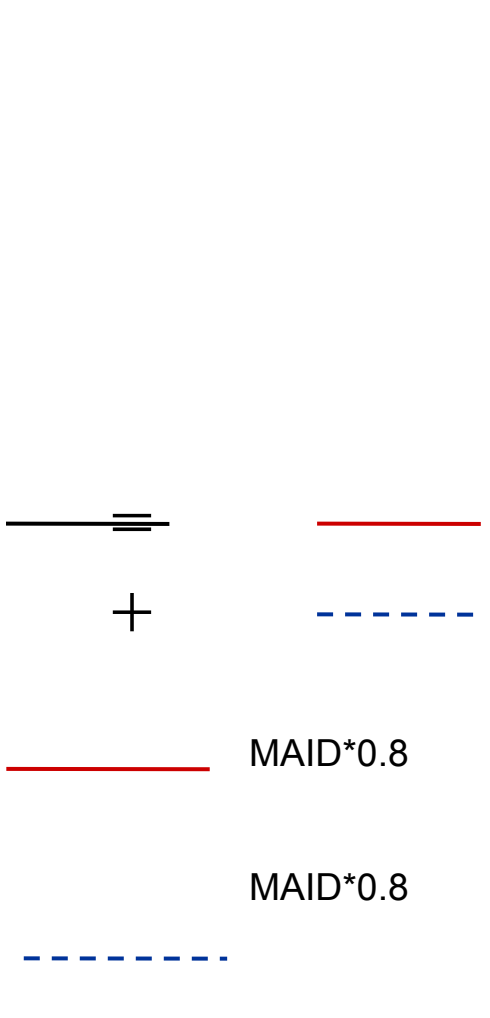
- **to analyze data for meson production on the DEUTERON**
- **to analyze data at least for the QF process**
- **to extract neutron information**

despite many theoretical works reproducing deuteron data to a certain degree.

Disagreement between theoretical and experimental results is still open question for $\gamma d \to \pi^0 np$ **in the 2nd resonance region.**

Effects of FSI?

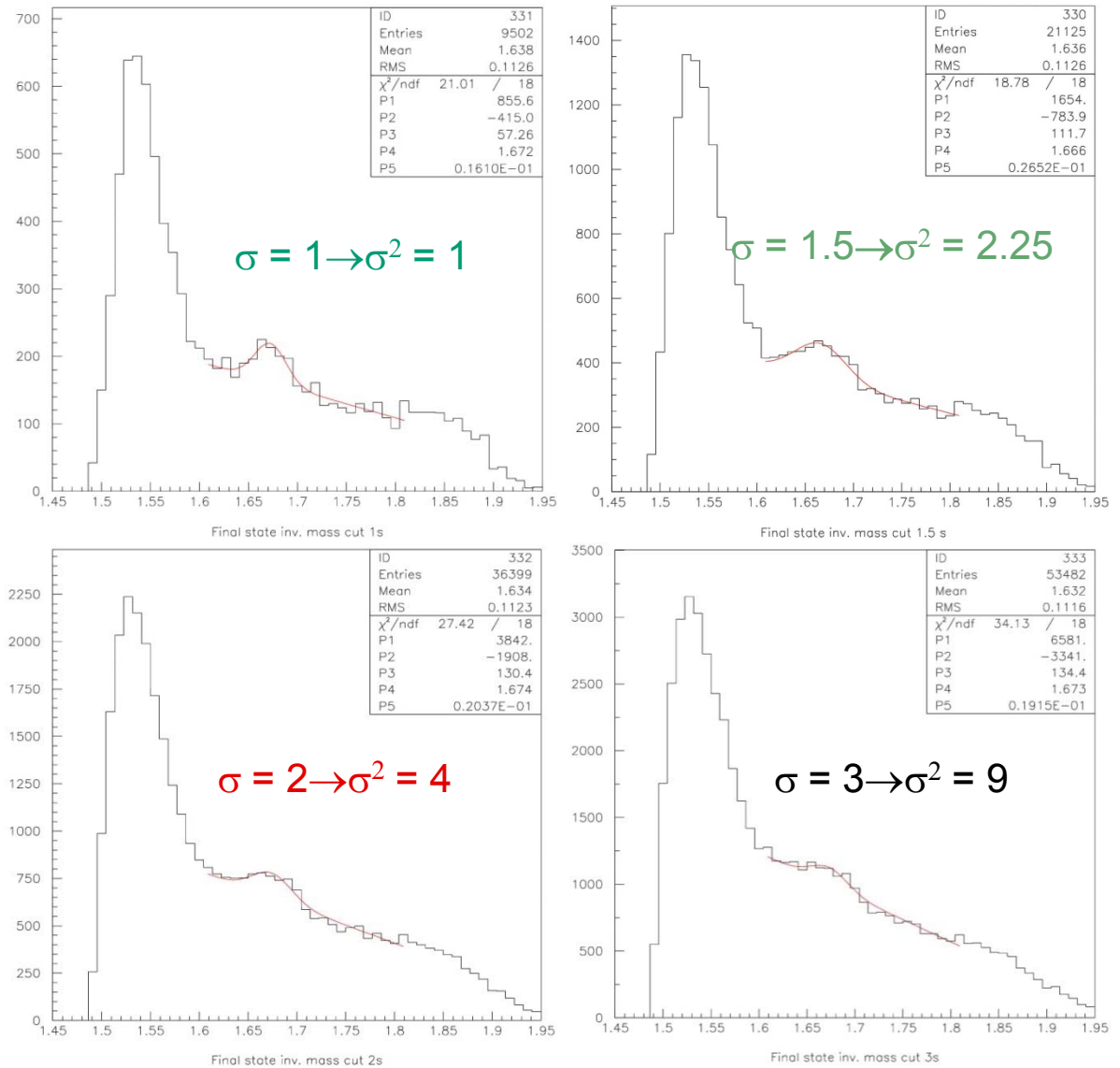


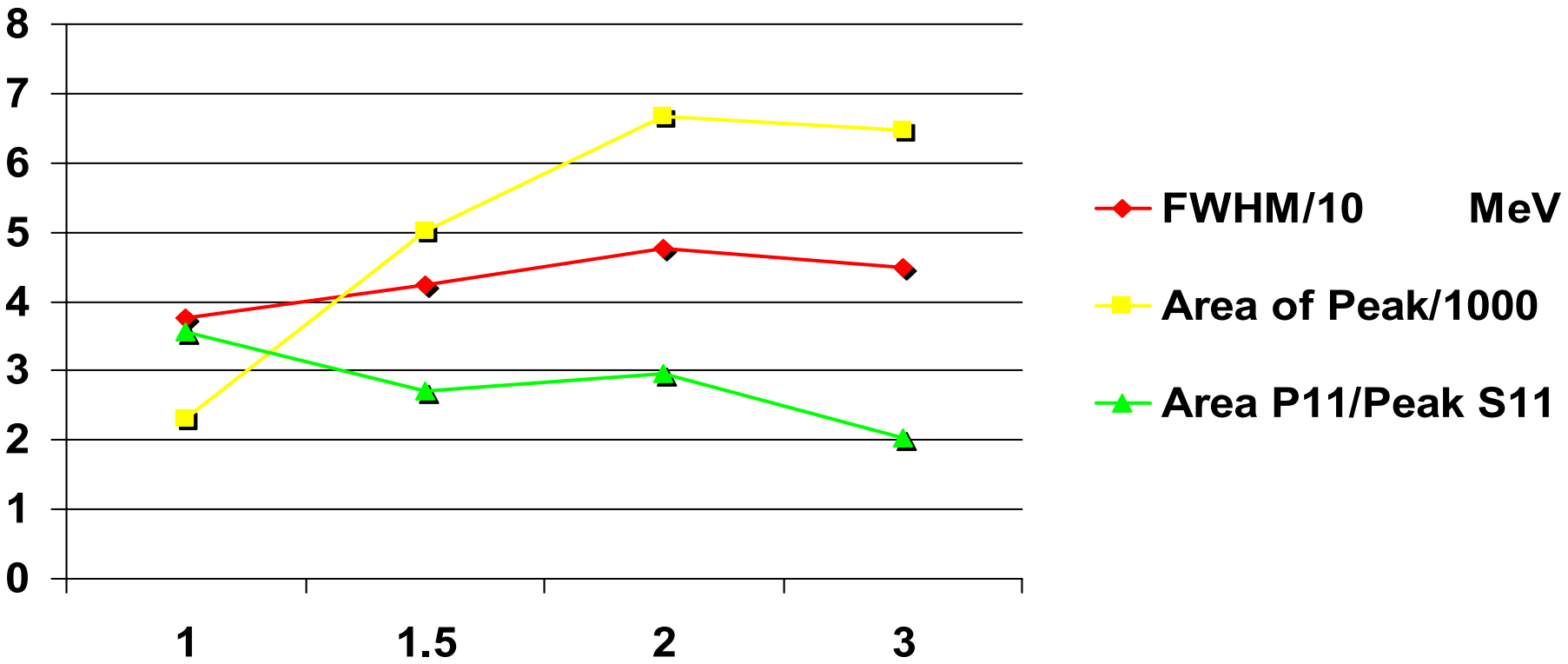


Carlo Schaerf

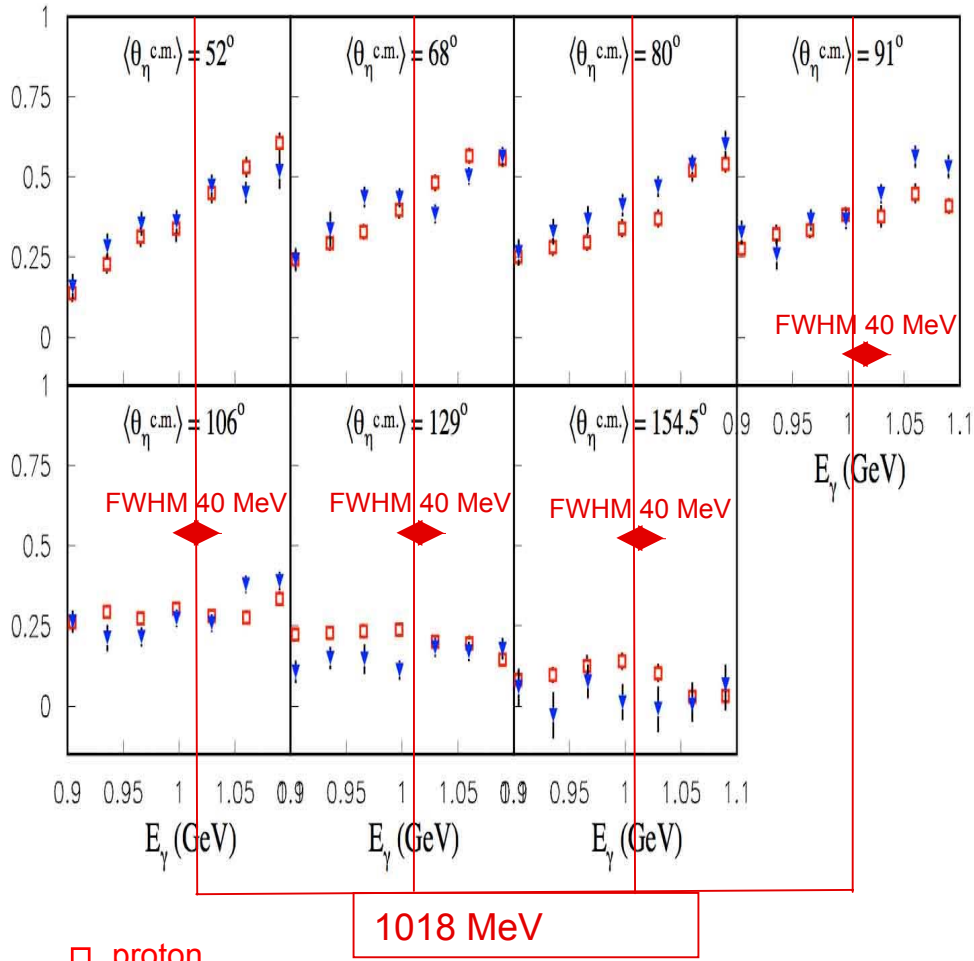
Eta photoproduction on the proton and the neutron at GRAAL

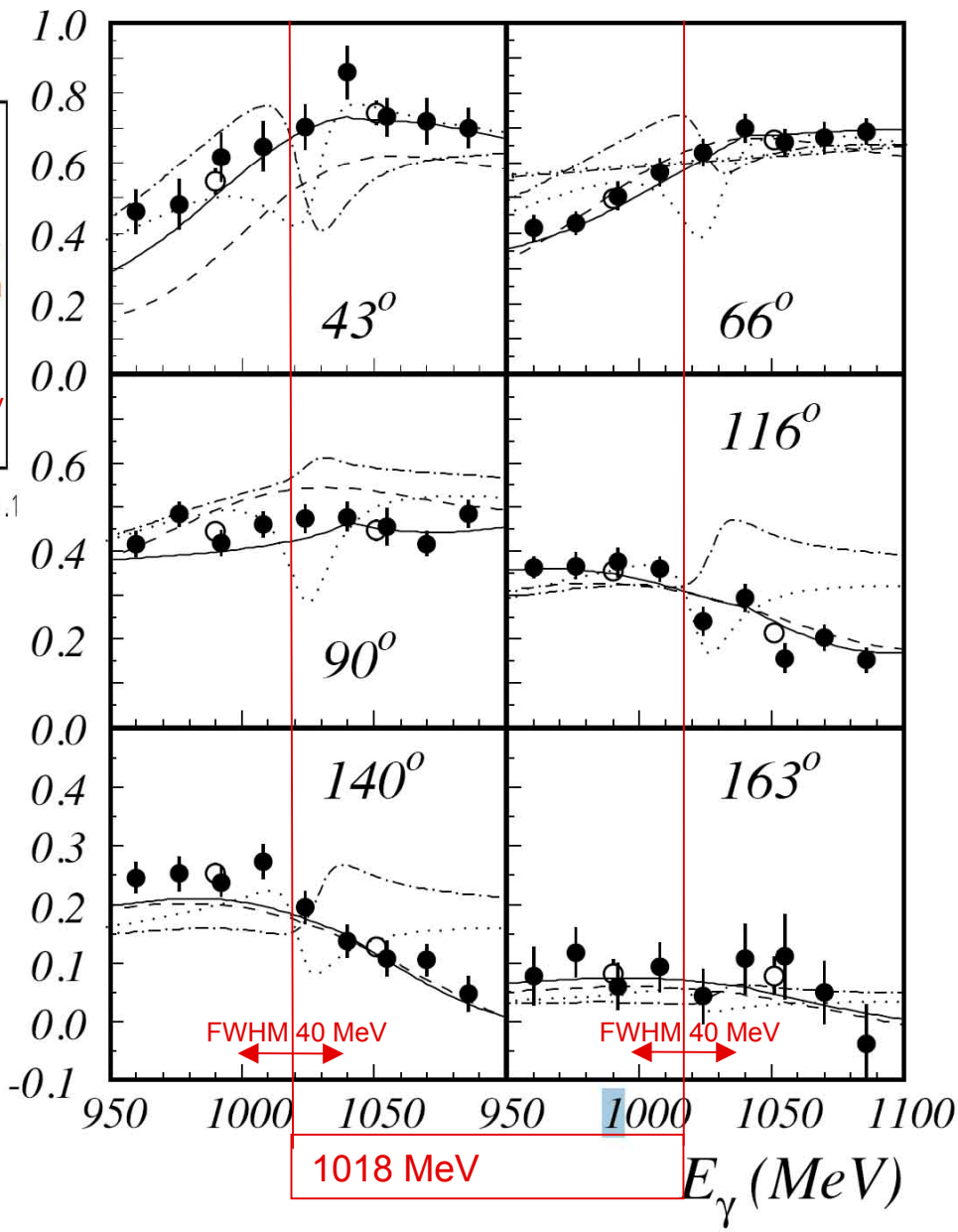
Instituto Nazionale di Fisica Nucleare, Italy


ID 331
Entries 9502
Mean 1.638
RMS 0.1126
χ²/ndf 21.01 / 18
P1 855.6
P2 −415.0
P3 57.26
P4 1.672
P5 0.1610E−01
σ = 1→σ² = 1
Final state inv. mass cut 1s
ID 330
Entries 21125
Mean 1.636
RMS 0.1126
χ²/ndf 18.78 / 18
P1 1654.
P2 −783.9
P3 111.7
P4 1.666
P5 0.2652E−01
σ = 1.5→σ² = 2.25
Final state inv. mass cut 1.5 s
ID 332
Entries 36399
Mean 1.634
RMS 0.1123
χ²/ndf 27.42 / 18
P1 3842.
P2 −1908.
P3 130.4
P4 1.674
P5 0.2037E−01
σ = 2→σ² = 4
Final state inv. mass cut 2s
ID 333
Entries 53482
Mean 1.632
RMS 0.1116
χ²/ndf 34.13 / 18
P1 6581.
P2 −3341.
P3 134.4
P4 1.673
P5 0.1915E−01
σ = 3→σ² = 9
Final state inv. mass cut 3s


8
7
6
5
4
3
2
1
0
1
1.5
2
3
FWHM/10 MeV
Area of Peak/1000
Area P11/Peak S11

Comparing p/n beam asymmetry



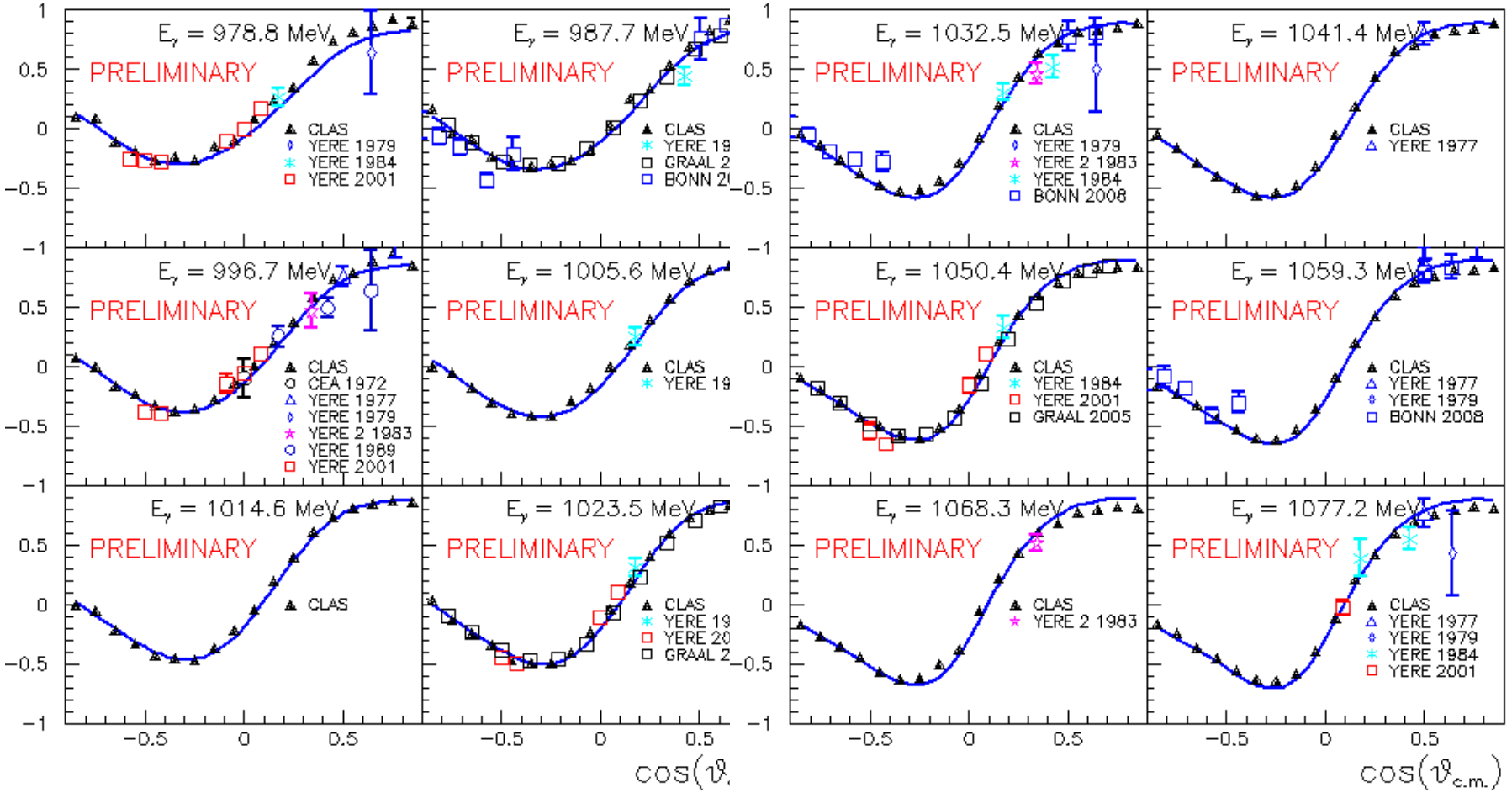


Mike Dugger

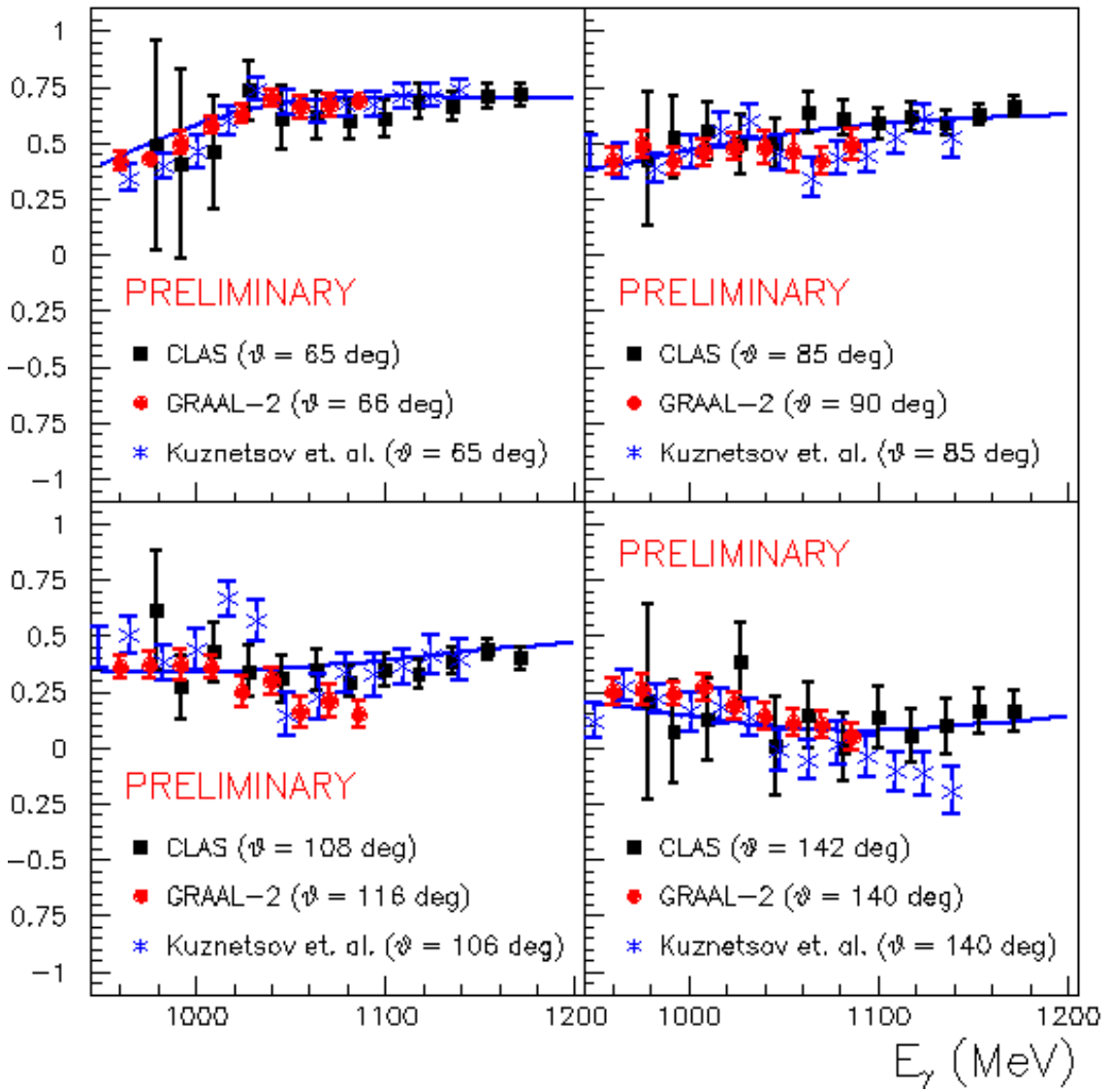
CLAS beam asymmetry measurements for π °, π+, and eta photoproduction off the proton with incident photon energies between 0.95 to 1.2 GeV

Arizona State University, United States

Preliminary Σ results for π^0



Preliminary Σ results for η

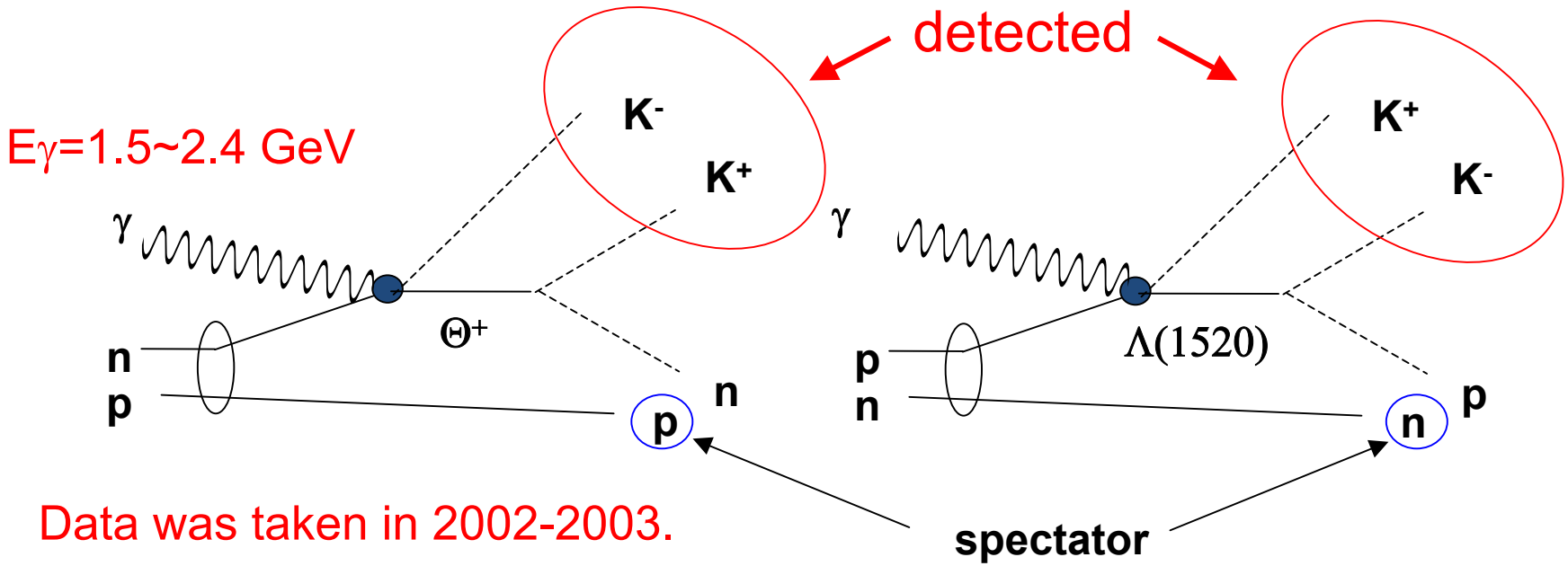


Takashi Nakano

Update on the Theta+ study at LEPS

Osaka University, Japan

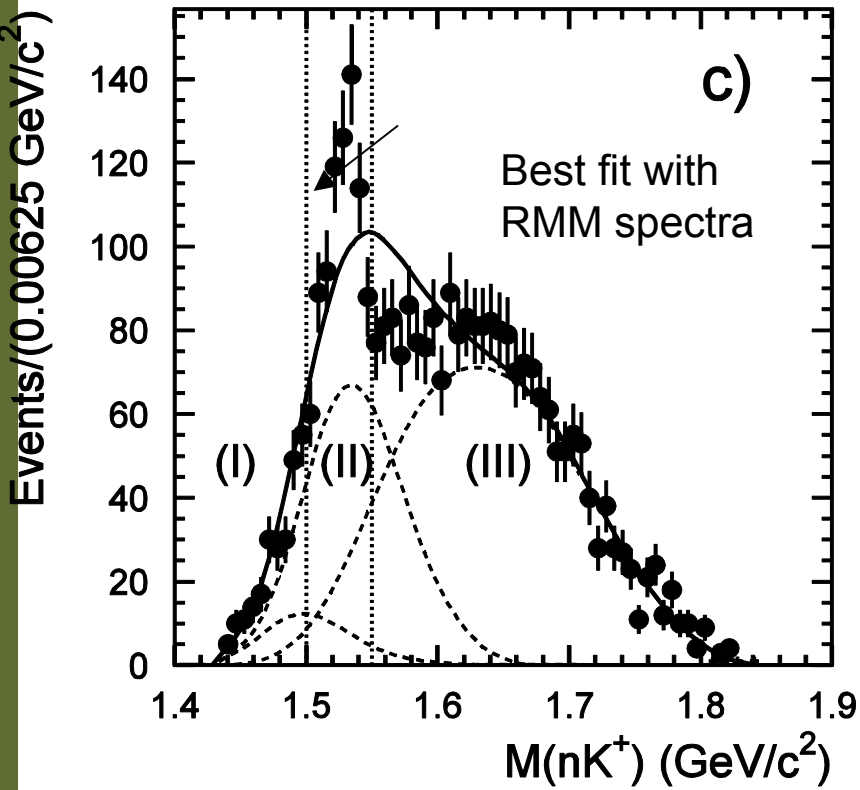
Quasi-free production of Θ^+ and $\Lambda(1520)$

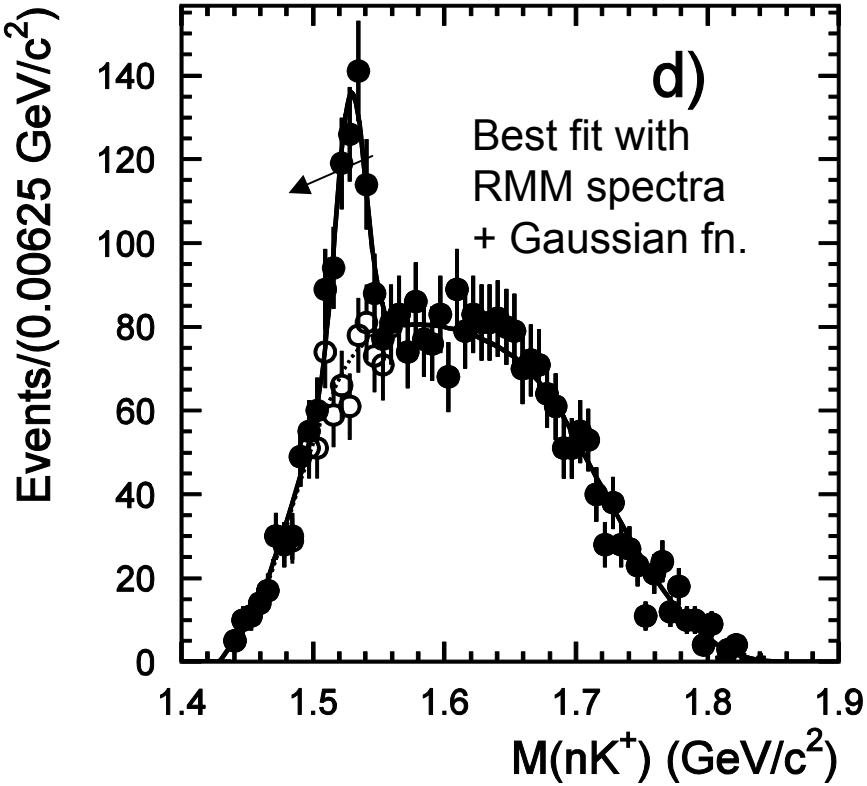


Data was taken in 2002-2003.

- Both reactions are quasi-free processes.
- Fermi-motion should be corrected.
- Existence of a spectator nucleon characterize both reactions.

Test with MC data





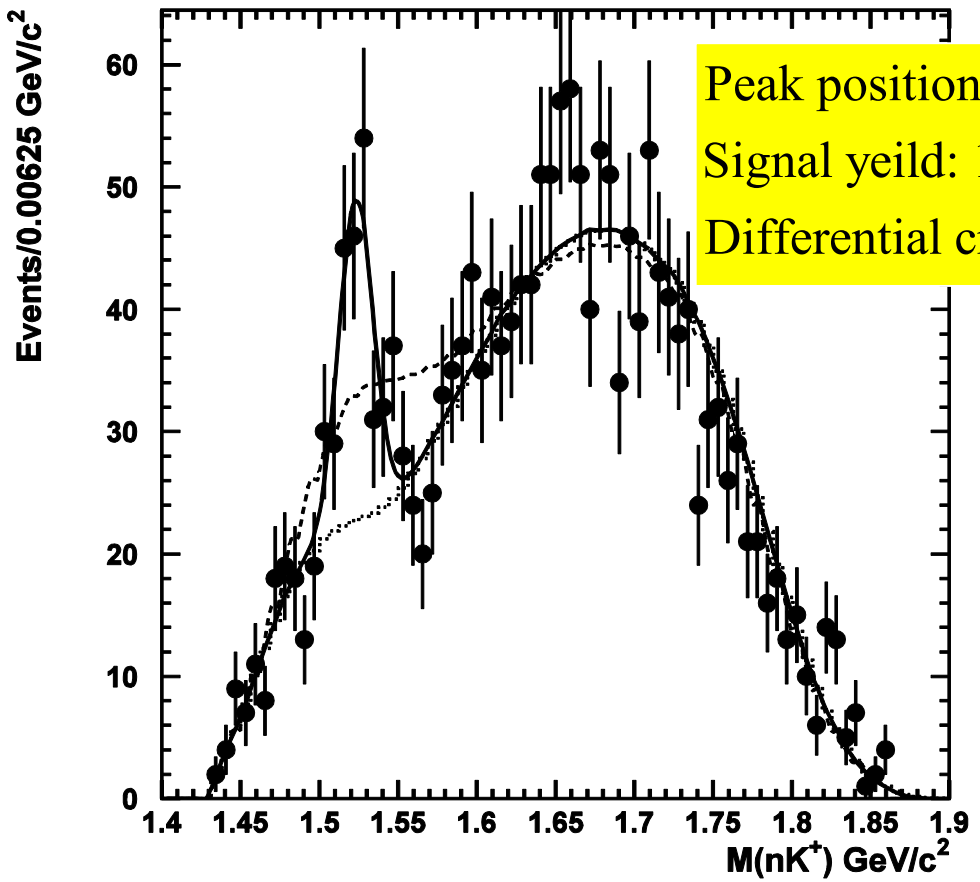
$-2\ln L = 114.6$ for $ndf = 61$

$-2\ln L = 58.4$ for $ndf = 59$

$\Delta(-2\ln L) = 56.2$ for $\Delta ndf = 2$ $\longrightarrow 7.2\sigma$

Results of Θ^+ analysis

nK⁺ invariant mass with MMSA Fermi motion effect corrected.



Peak position: 1.527 ± 0.002 GeV/c^2

Signal yeild: 116 ± 21 events

Differential cross-section: 12 ± 2 nb/sr

"The narrow peak appears only after Fermi motion correction."

$\Delta(-2\ln L) = 31.1$ for $\Delta ndf = 2$ $\longrightarrow$ 5.2σ $\quad \mathrm{Prob}(5.2\sigma) = 2\times10^{-7}$

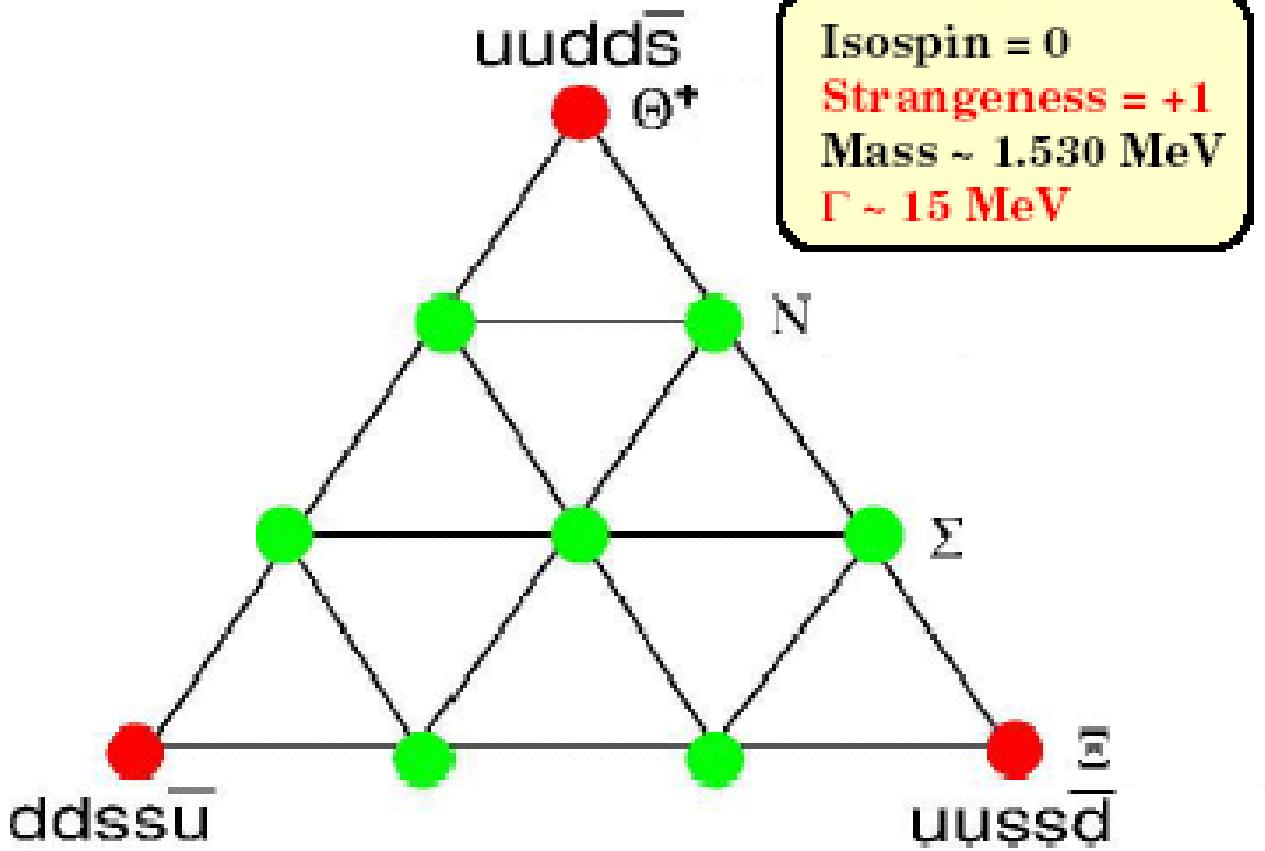
Igor Alekseev

Search for narrow pion-proton states in s-channel at EPECUR: experiment status

Institute for Theoretical and Experimental Physics, Russia

Pentaquark Antidecuplet

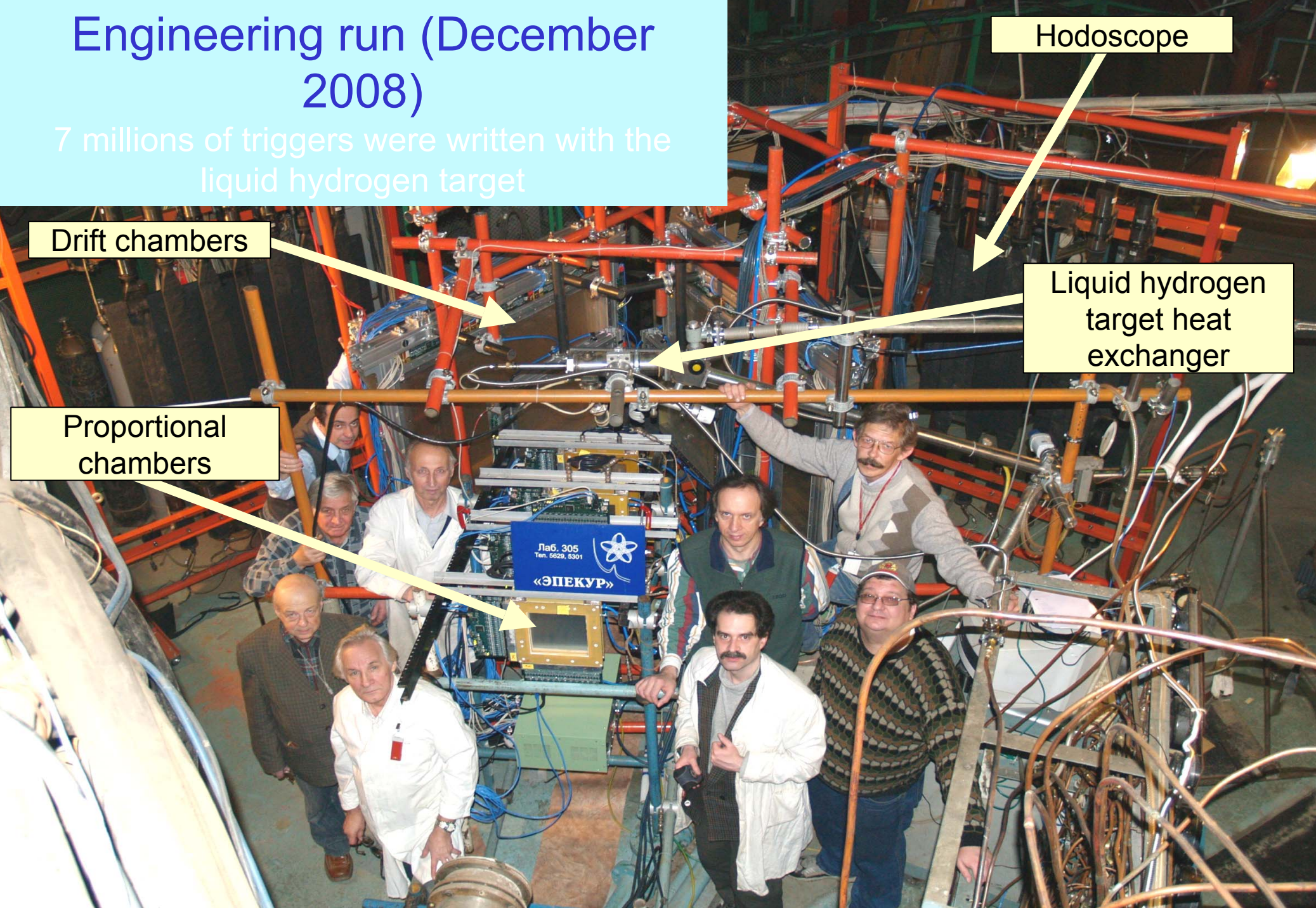
$[\overline{10}]$ Spin = ½ **NEW MULTIPLET** D.Diakonov et al. Z. Phys A359, 1997, 305



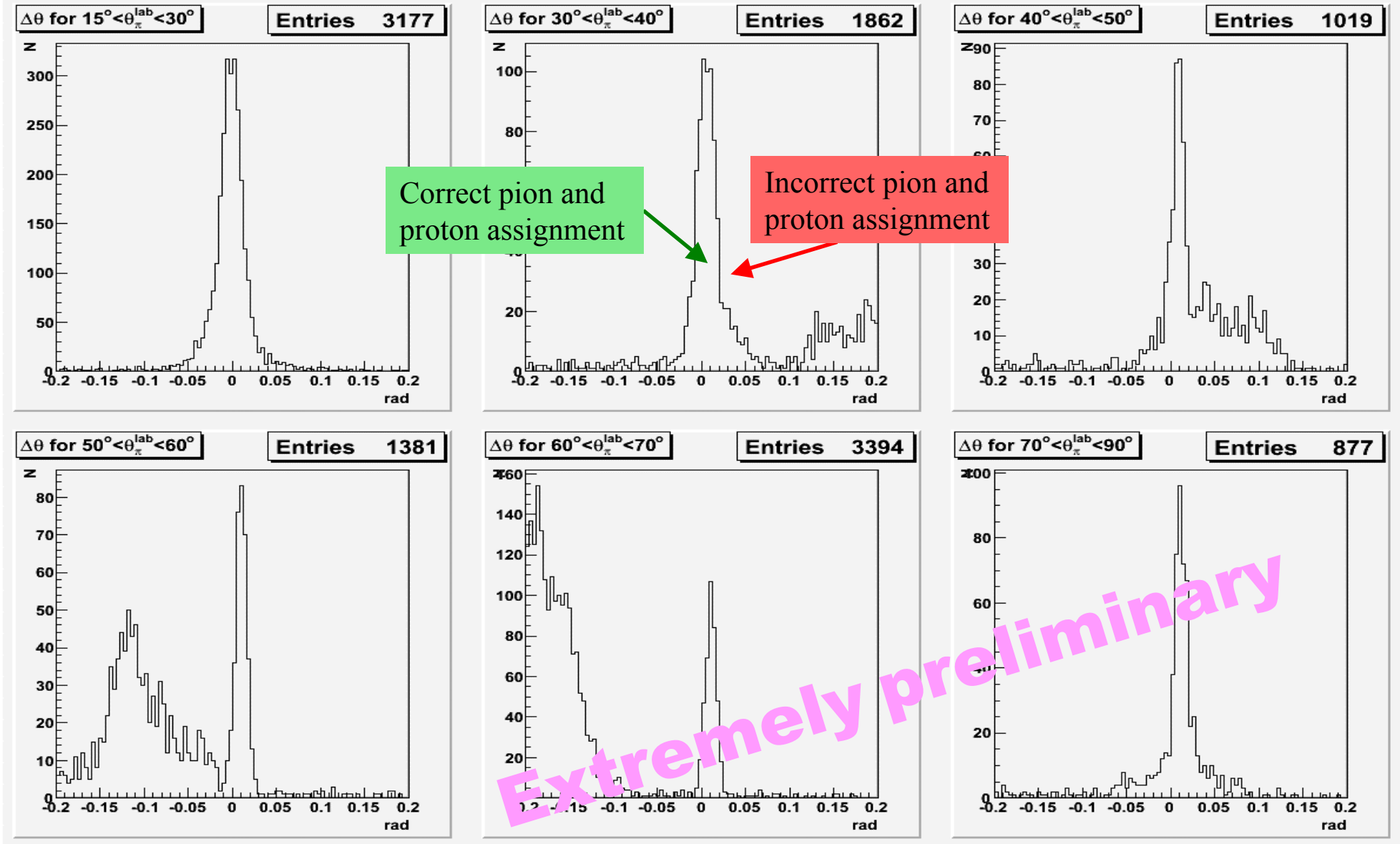
Isospin = 0
Strangeness = +1
Mass ~ 1.530 MeV
Γ ~ 15 MeV

Engineering run (December 2008)

7 millions of triggers were written with the liquid hydrogen target



Elastic events selection



Michael Ostrick

Crystal Ball at MAMI-C: Recent Results and Perspectives

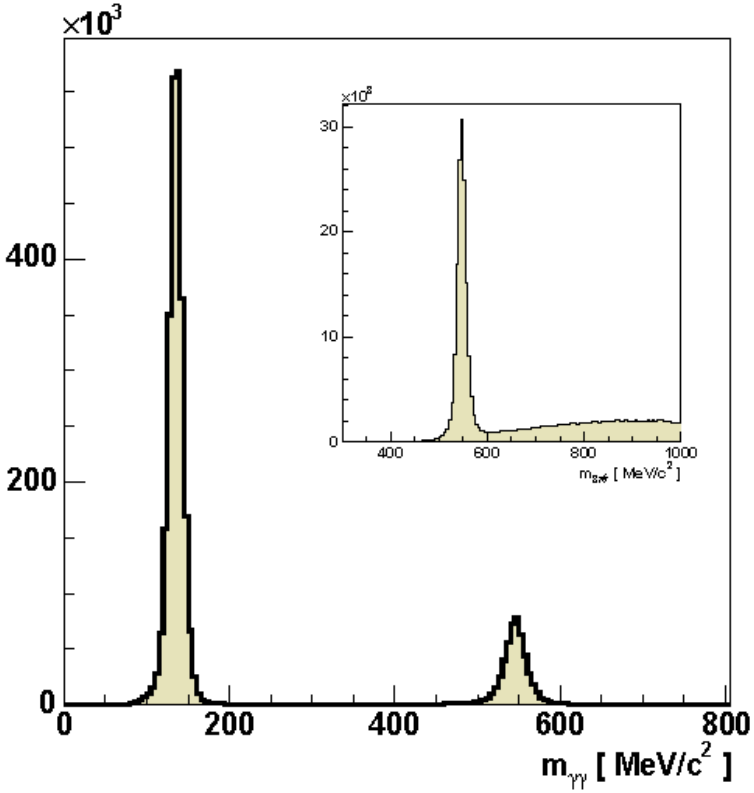
Universität Mainz, Germany

Volker Crede

Search for new Baryon States at ELSA

Florida State University, United States

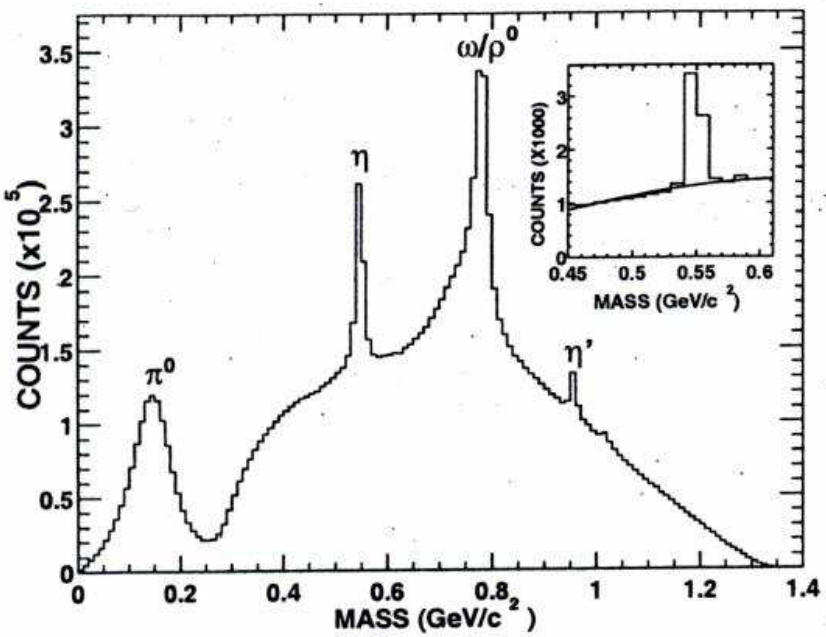
Study of $\gamma p \rightarrow p\eta$ with CB-ELSA/TAPS



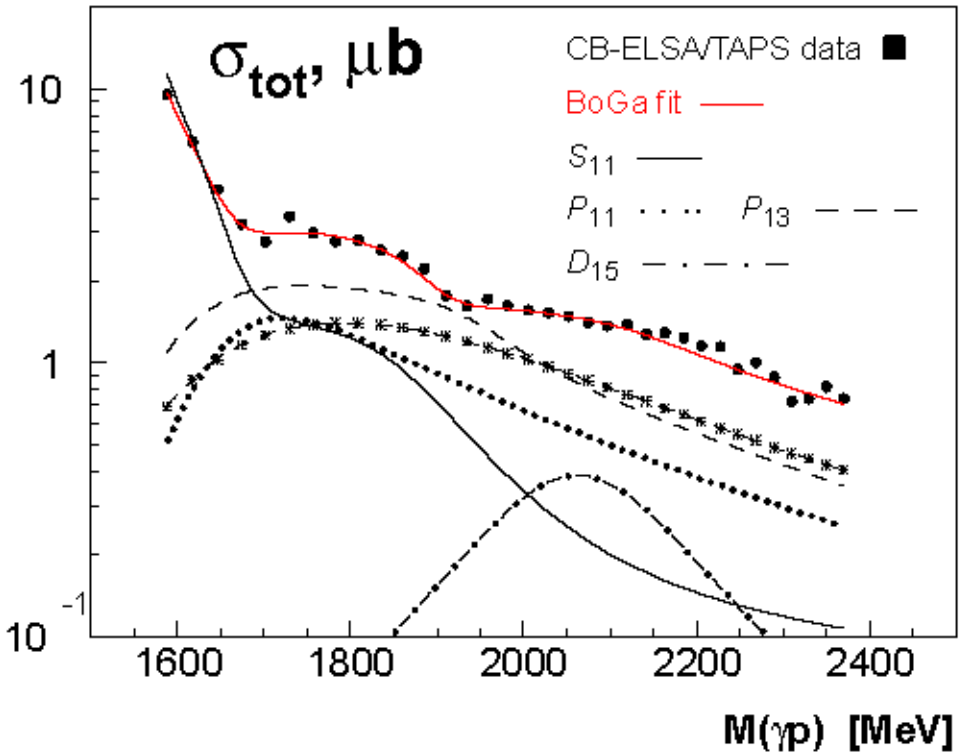
$\left\{ \begin{array}{l} \eta \rightarrow 3\pi^0, \gamma\gamma \\ \text{(CB-ELSA/TAPS)} \end{array} \right.$

$\left\{ \begin{array}{l} \gamma\, p \rightarrow p\, X\ \text{(missing mass)} \\ \text{(CLAS)} \end{array} \right.$

M. Dugger et al., PRL **89**, 222002 (2002)



Analysis of $\gamma p \rightarrow p\eta$: Total Cross Section



Isopsin Filter

➜ Only N^* resonances can contribute!

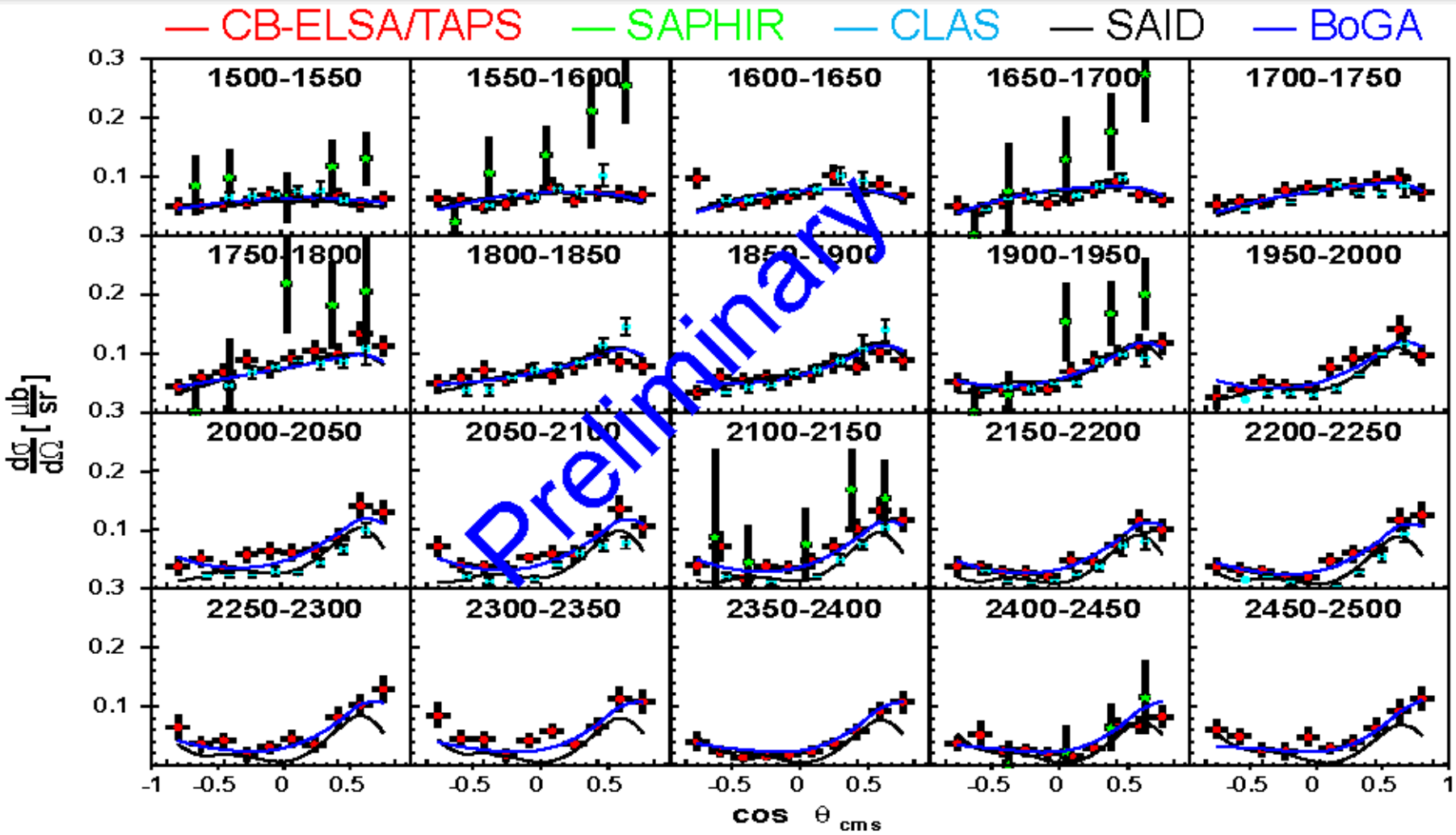
Bonn-Gatchina (PWA) group:
Hint for N* resonance $(2070)D_{15}$
(Phys. Rev. Lett. **D94**, 012004 (2005))

1. Confirmed in 2009 analysis!
2. $N(1720)P_{13} \rightarrow p\eta$?
   ➜ η-MAID:
   $N(1710)P_{11} \rightarrow p\eta$ significant!

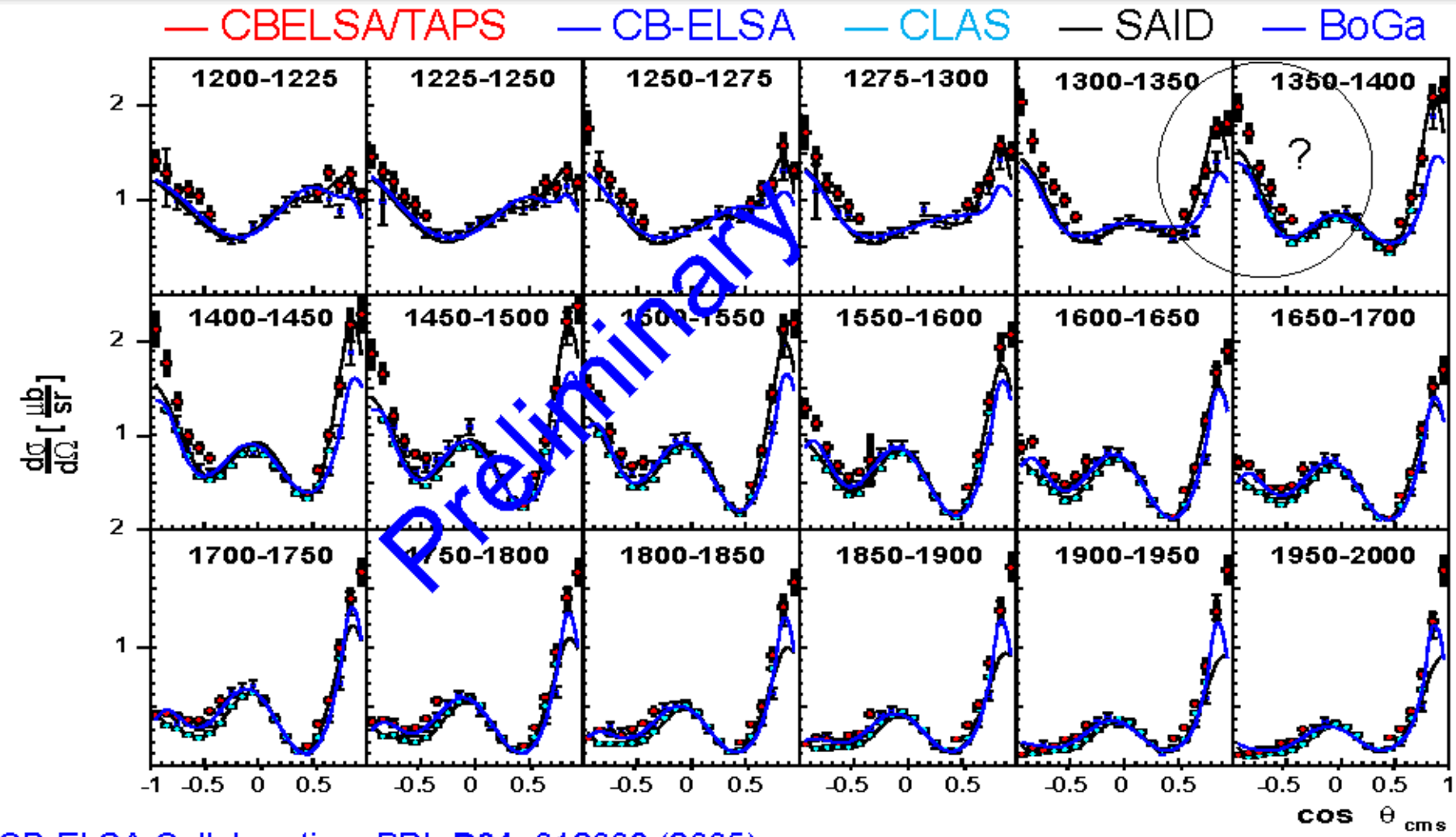
Resonances dominantly contributing:

$N(1535)S_{11}$, $(N(1720)P_{13})^?$, $N(2070)D_{15}$

Differential Cross Sections for $\gamma p \longrightarrow p\eta'$



Differential Cross Sections for $\gamma p \longrightarrow p\pi^0$



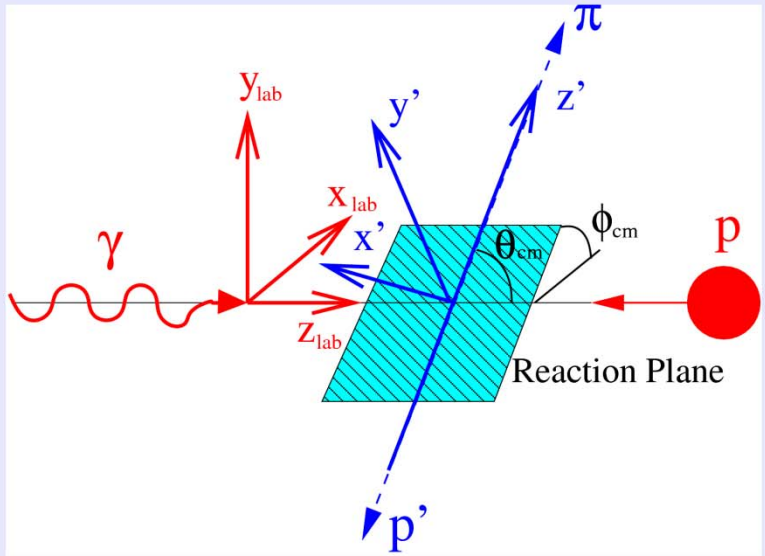
CB-ELSA Collaboration, PRL **D94**, 012003 (2005)

Derek Glazier

Recoil polarization measurements in meson photoproduction

University of Edinburgh, Scotland

Beam-Recoil Observables



$$\rho_f \frac{d\sigma}{d\Omega} = \frac{1}{2}\frac{d\sigma}{d\Omega_{un}} \{1 - P_\gamma^T \Sigma \cos 2\phi - \sigma_{x'} \left(P_\gamma^T O_x \sin 2\phi + P_\gamma^C C_x\right) + \sigma_{y'} \left(P - P_\gamma^T T \cos 2\phi\right) - \sigma_{z'} \left(P_\gamma^T O_z \sin 2\phi + P_\gamma^C C_z\right)\}$$

Linear P_γ^T and Circular P_γ^C beam polarisation

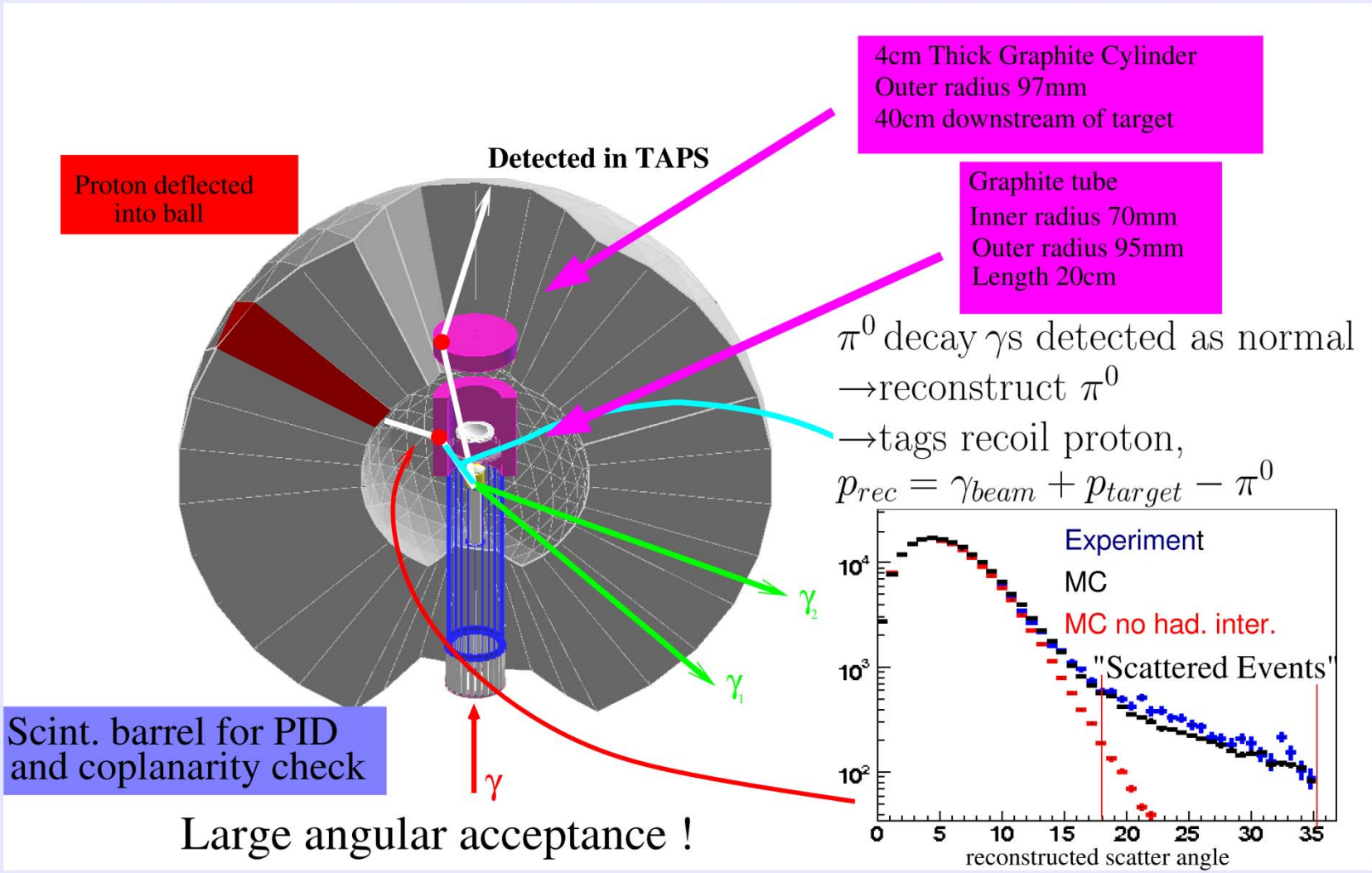
+ **Recoil Polarisation Measurement**

$\Rightarrow$ access to 6 photoproduction observables

No Magnetic Field $\Rightarrow$ Only measure tranverse polarisation

$\therefore$ We can measure P, T, O_x, C_x

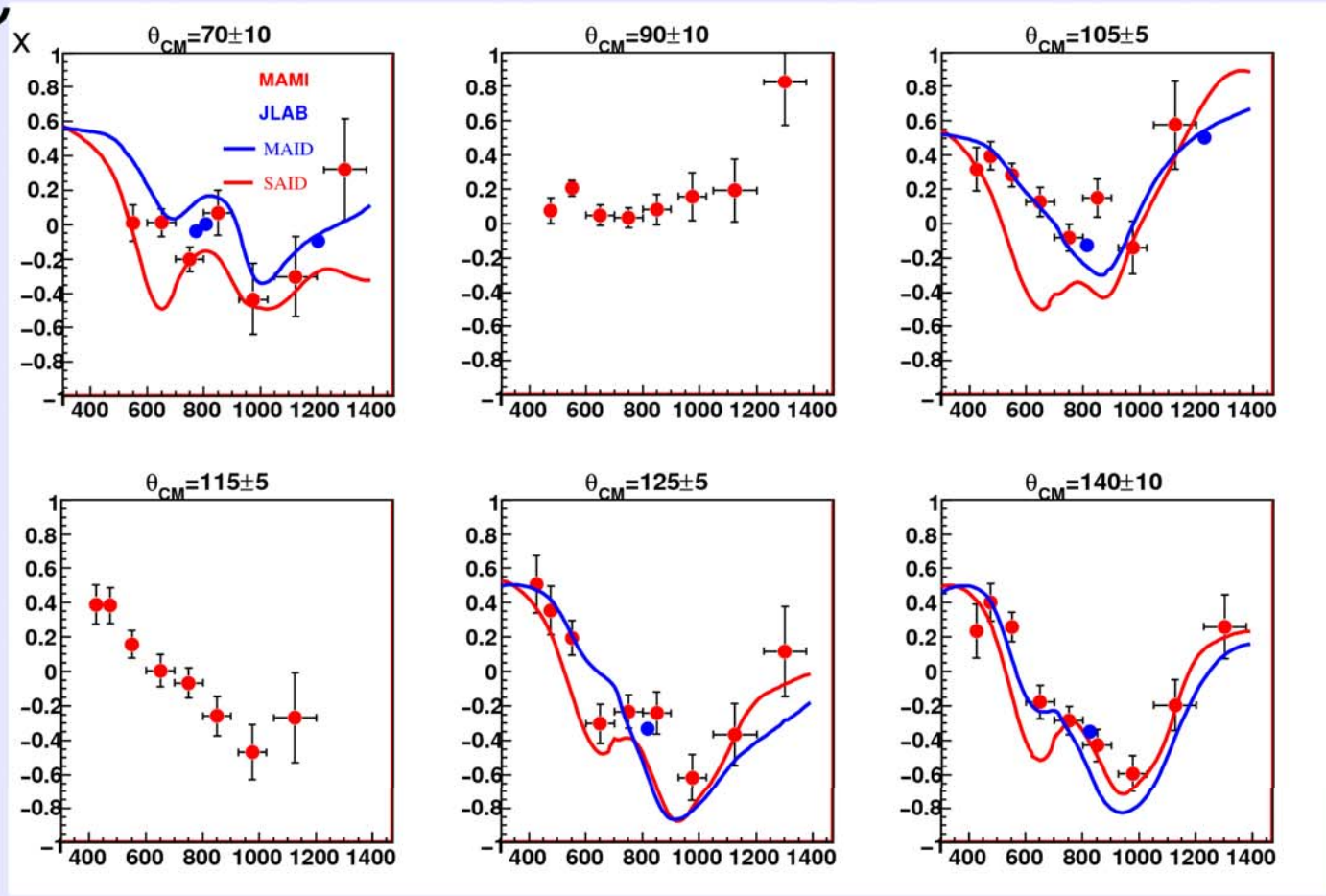
Proton Polarimeter



Preliminary π^o C_x Results

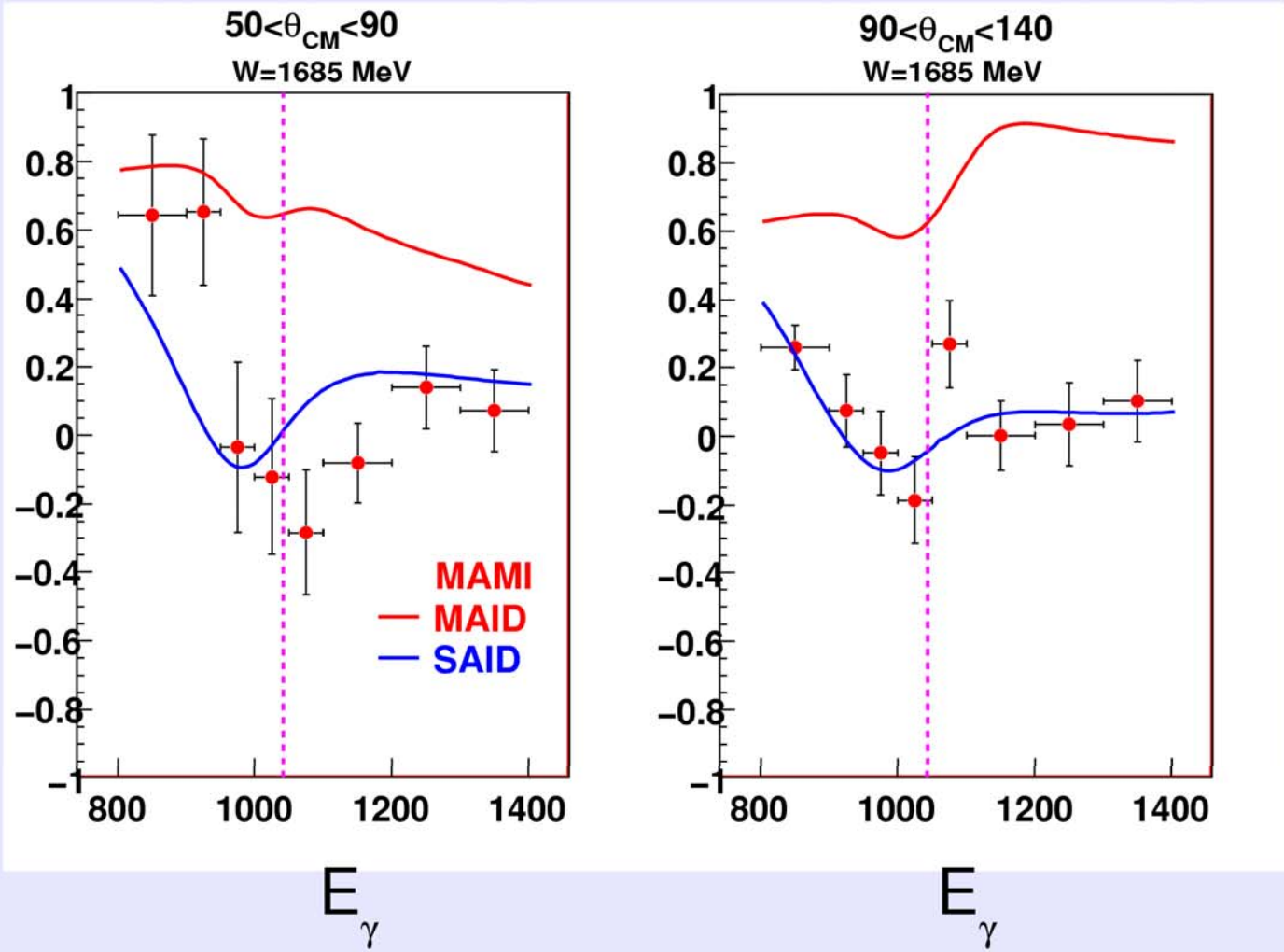
- Divide real data asymmetries by MC analysing pow.

C_x



Very Preliminary η C_x Results

Do we see any narrow structure around 1685 MeV ?



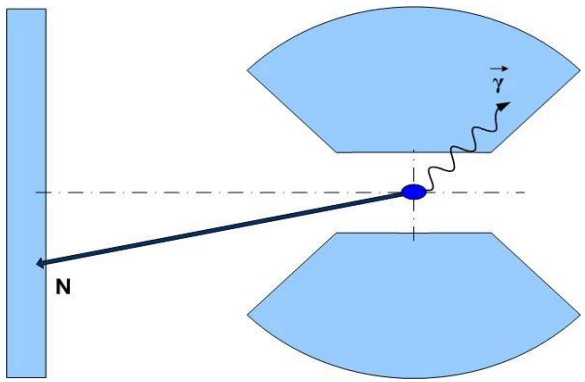
Slava Kuznetsov

Search for N*(1685) in Real Compton scattering: First results

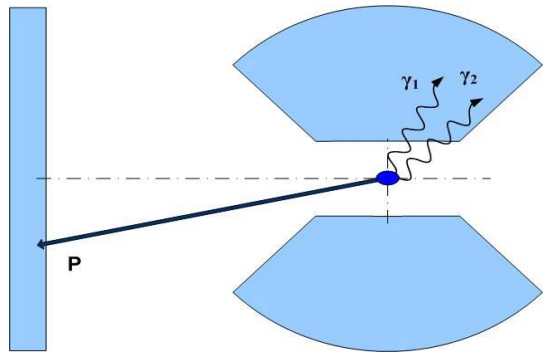
Kyungpook National University, South Korea

The main problem of Compton scattering measurements is the π^0 background.

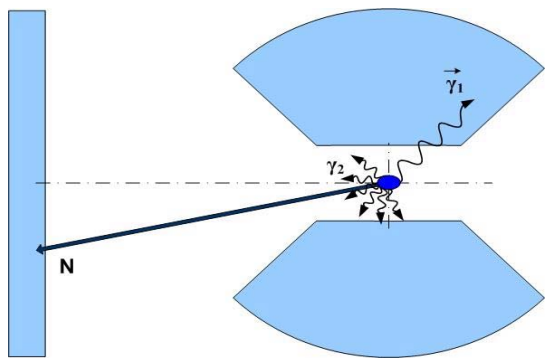
Compton scattering



π^0 background



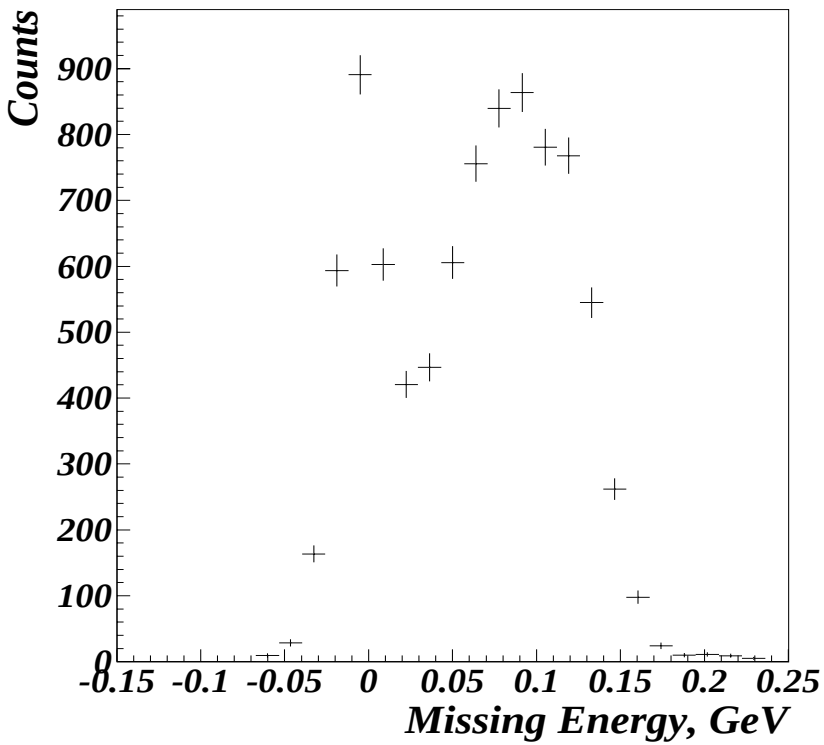
Symmetric π0 decay, two photon hits are mixed in one BGO cluster.



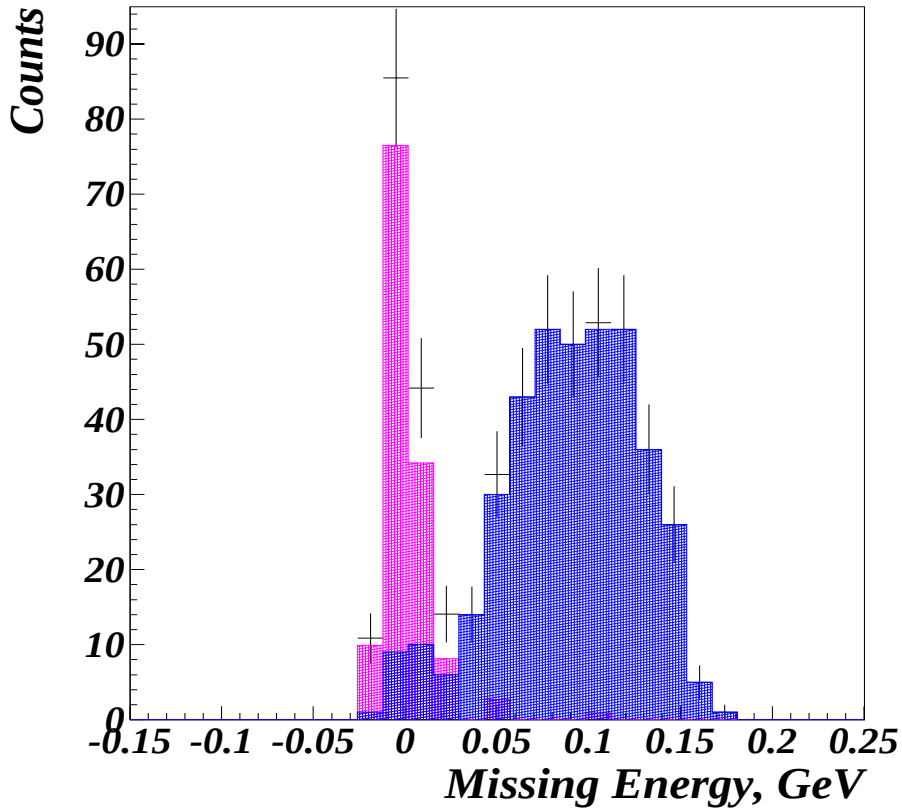
Asymmetric π0 decays, the second low-energy photon may not be detected.

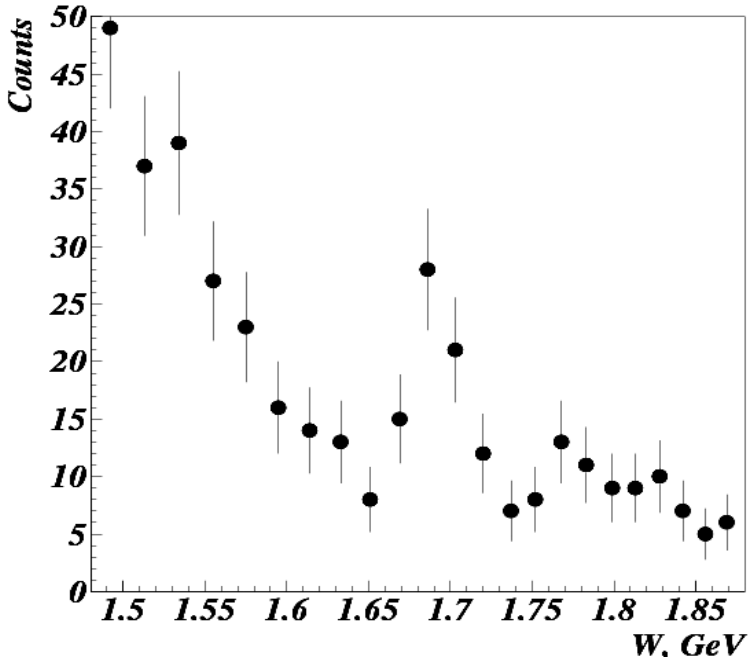
γp→γp on the free proton at 150<Θcm<165 deg

Data

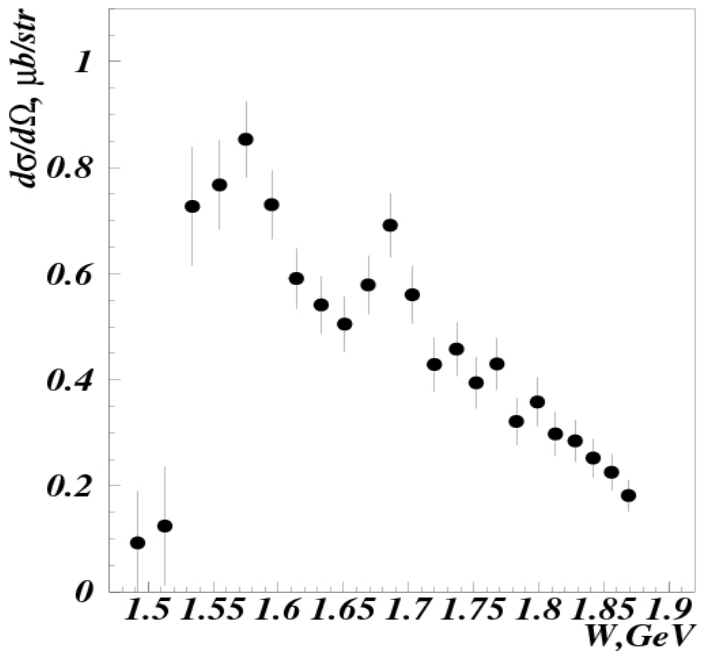


Simulations



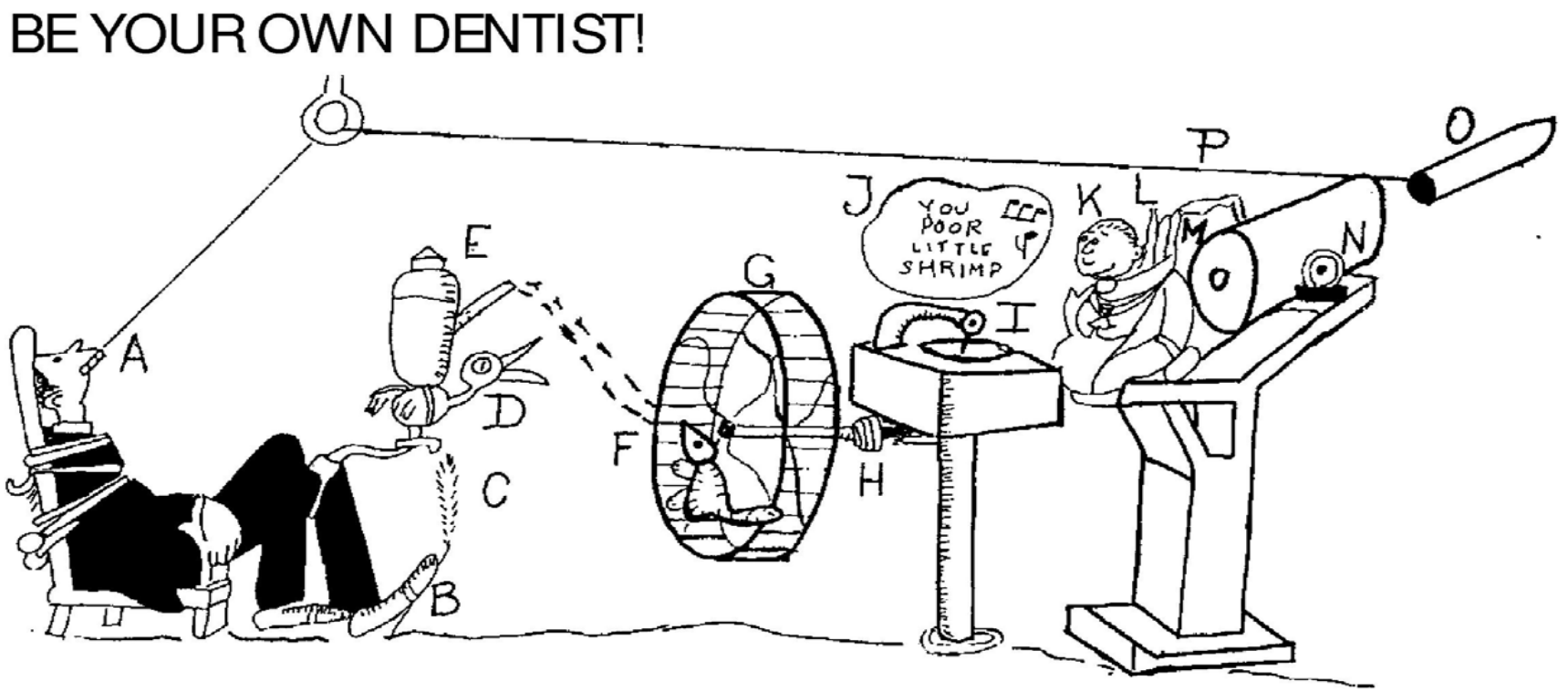

Counts
50
45
40
35
30
25
20
15
10
5
0
1.5
1.55
1.6
1.65
1.7
1.75
1.8
1.85
W, GeV

γn→γn


dσ/dΩ, μb/str
1
0.8
0.6
0.4
0.2
0
1.5
1.55
1.6
1.65
1.7
1.75
1.8
1.85
1.9
W,GeV

γn→ηn

Occam's Razor in action



Occam's Razor

William of Occam
(or Ockham, ca. 1285-1349)

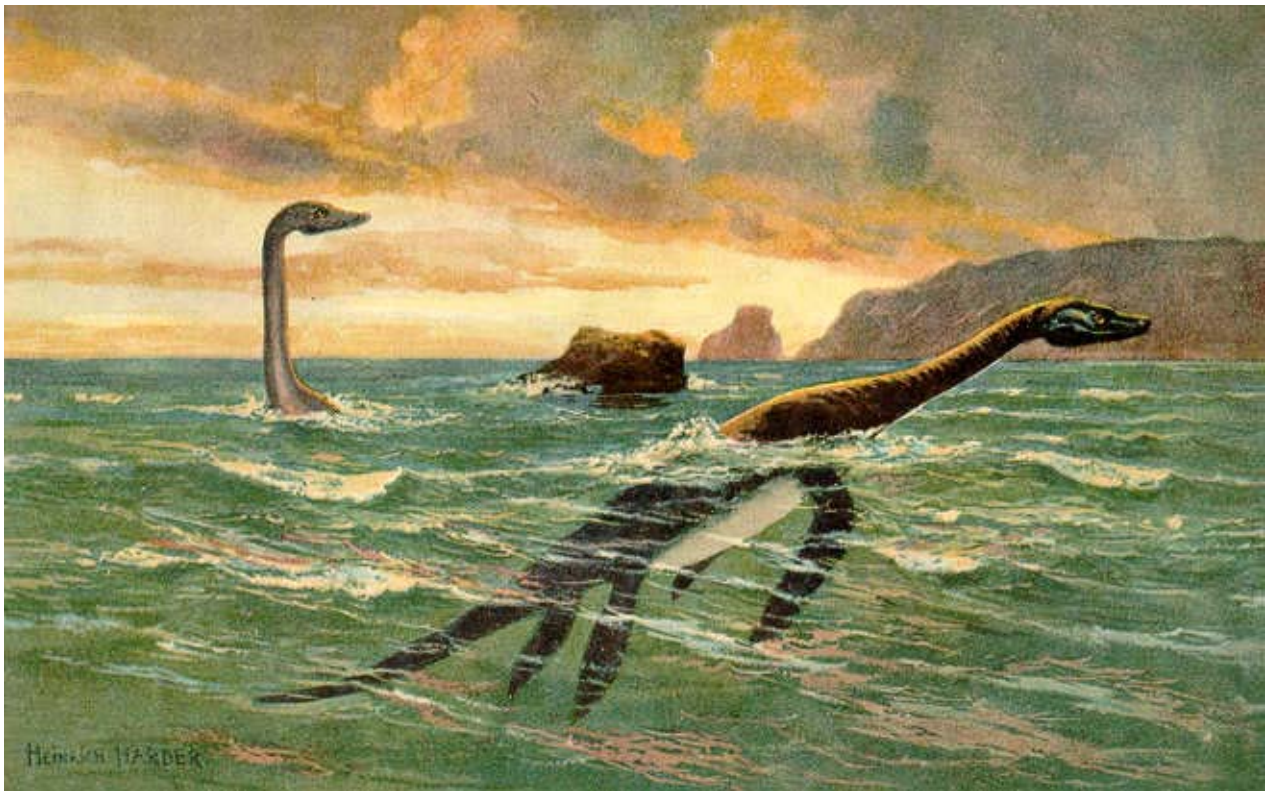
"Pluralitas non est ponenda sine necessitate"

- plurality should not be posited without necessity

Experimental Issues

- Data consistency
- Different experiments
- Subtleties of analyses
- Statistical measures
- Deciding on the best explanation (given the data)

Be careful what you are looking for…



You might just see it in your data…