Polarimetry in Meson Photoproduction Reactions at MAMI

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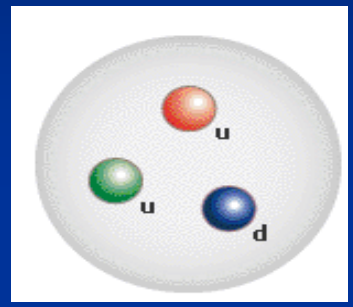
Structure

I. Motivation
II. Theoretical Overview
III. Experimental Setup
IV. Initial Data
V. Future Work

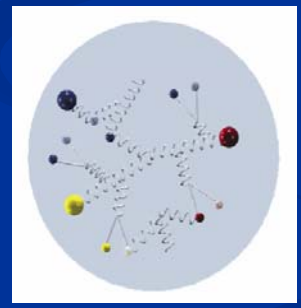
Nucleon Structure

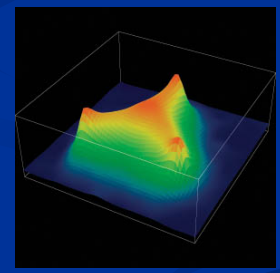
- Constituent quark models
- new lattice QCD calcs, holographic dual QCD -> different predictions of spectrum
- "Missing" nucleon resonances
- Polarization observables essential to eliminate model dependencies
- Recoil polarimeter pre-requisite for "complete measurement"

Constituent quark model



QCD models

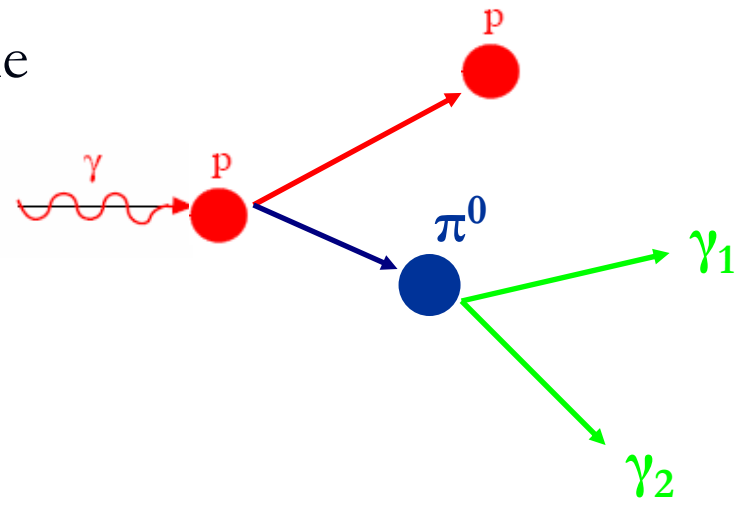




Polarization Observables in meson photoproduction

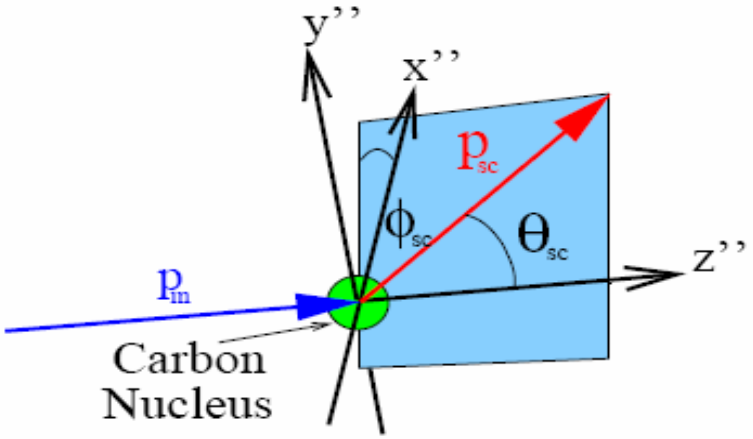
16 observables: dσ/dΩ, 3 single pol. observables, 12 double pol. observables

Lab frame



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

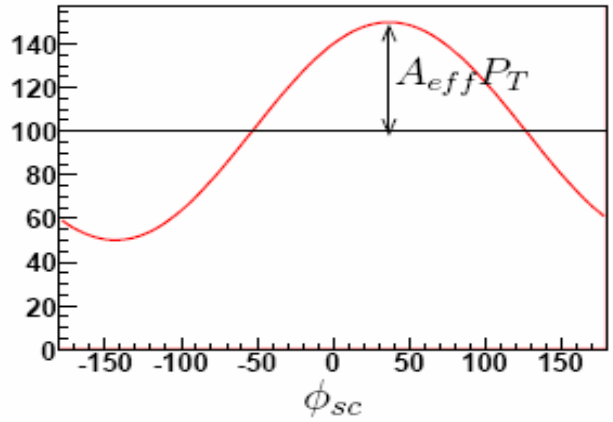
Measuring Proton Polarization



- Use Spin Orbit Interaction
- Scatter recoil proton on Carbon nuclei
- Azimuthal distribution is related to transverse polarisation

$$n(\phi_{sc}) = n_o\{1 + A_{eff}[P_y \cos\phi_{sc} - P_x \sin\phi_{sc}]\}$$

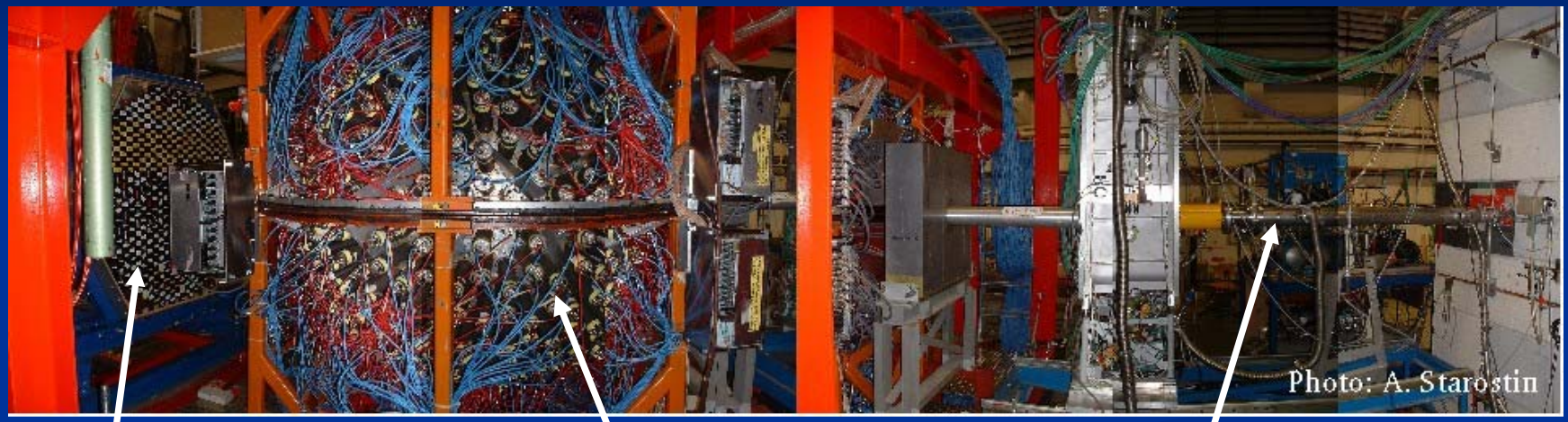
$$P_T = \sqrt{P_x^2 + P_y^2}$$



Apparatus

- MAinz MIcrotron- up to 1.5 GeV electron beam- tagged photon beam up to 1.4 GeV- photon beam can be polarized linearly (90%) or circularly (85%)
- Crystal Ball
  - 672 NaI scintillators
  - Covers 94% of 4π
  - good resolution: $\sigma_\theta = 2\text{-}3°$, $\sigma_\varphi = 2/\sin\theta$ for photons
- Edinburgh PID
  - 2 mm thick segmented plastic scintillator barrel
  - ΔE signal
- TAPS
  - 510 BaF_2 detectors
  - Covers forward angle region

Crystal Ball at MAMI setup

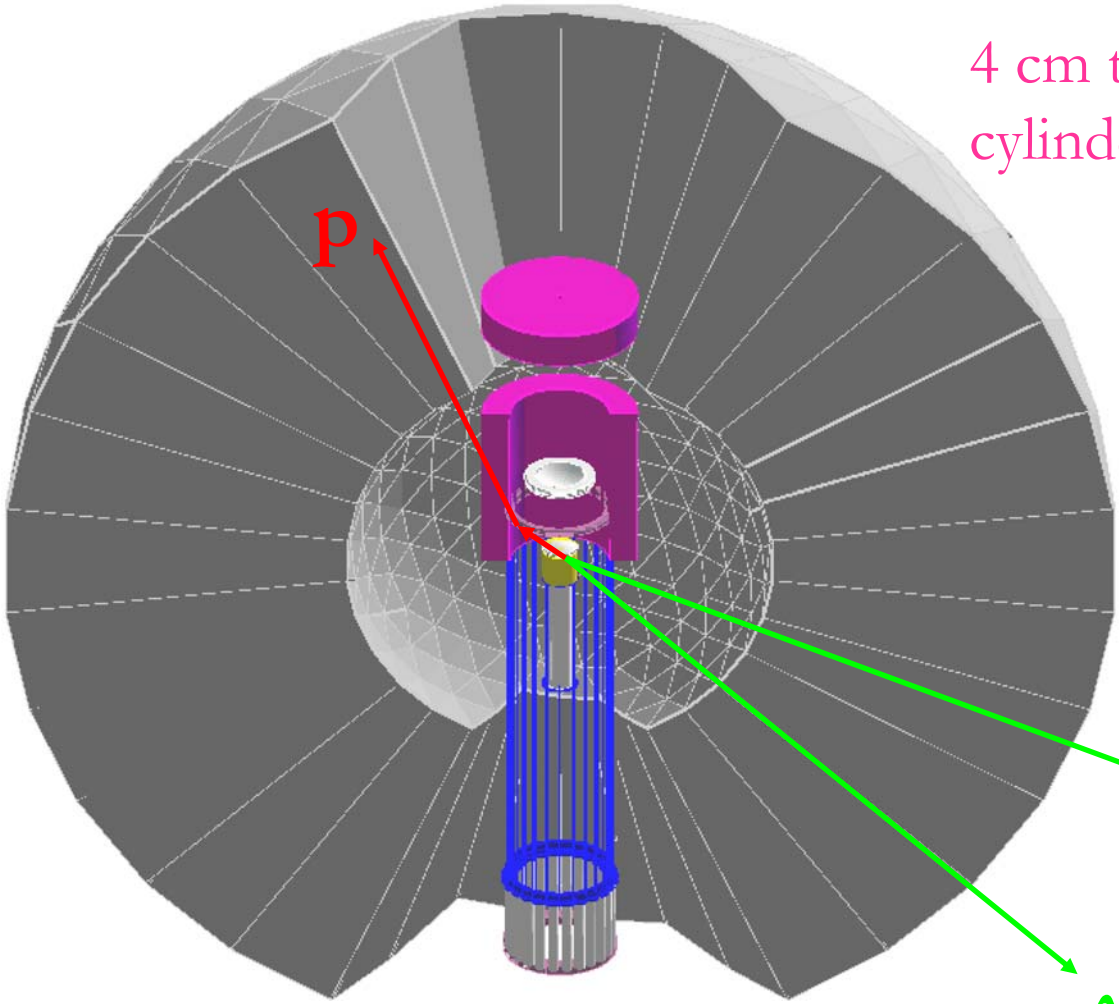


TAPS

Crystal Ball

Beam line

Experimental Setup



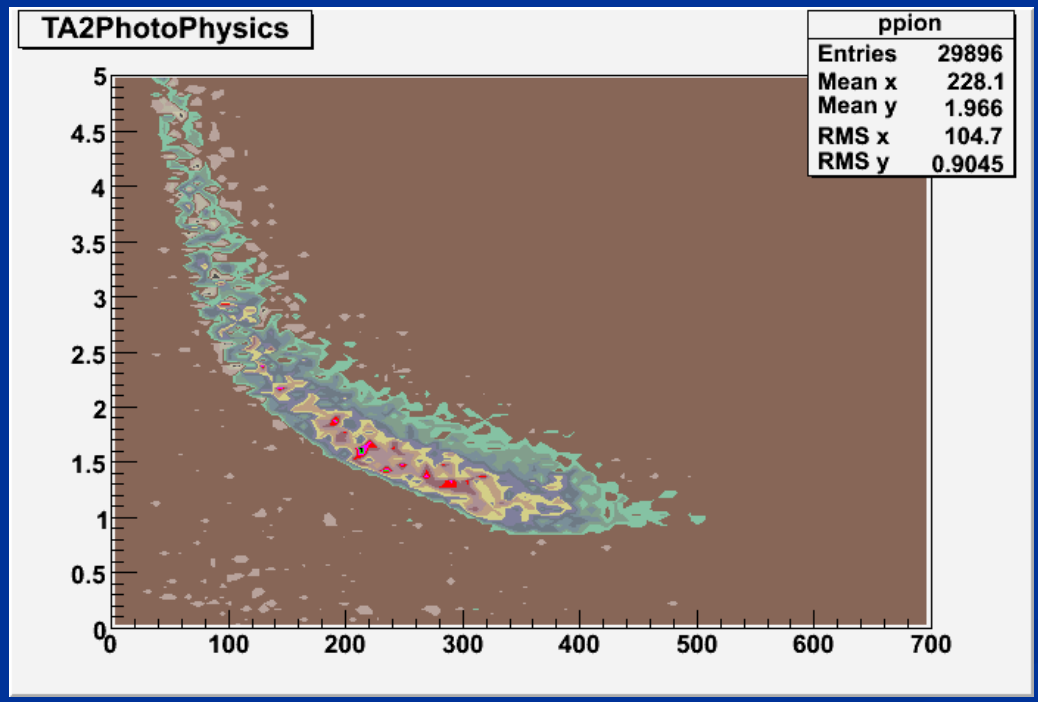
4 cm thick graphite cylinder

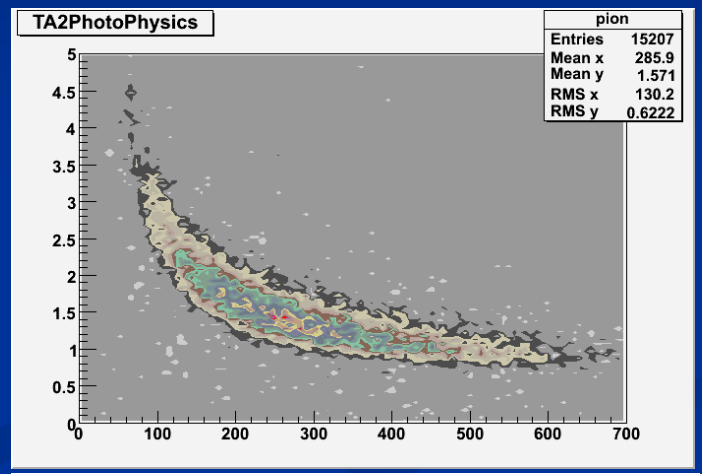
Reconstruct π^0 from γ's

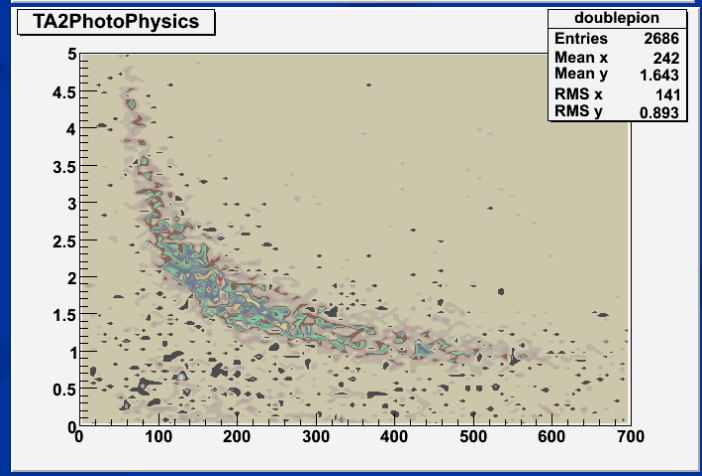
Event selection

- Look at single π^0 events, apply missing mass cut
- Compare φ-angle of missing 4-momentum to PID hits

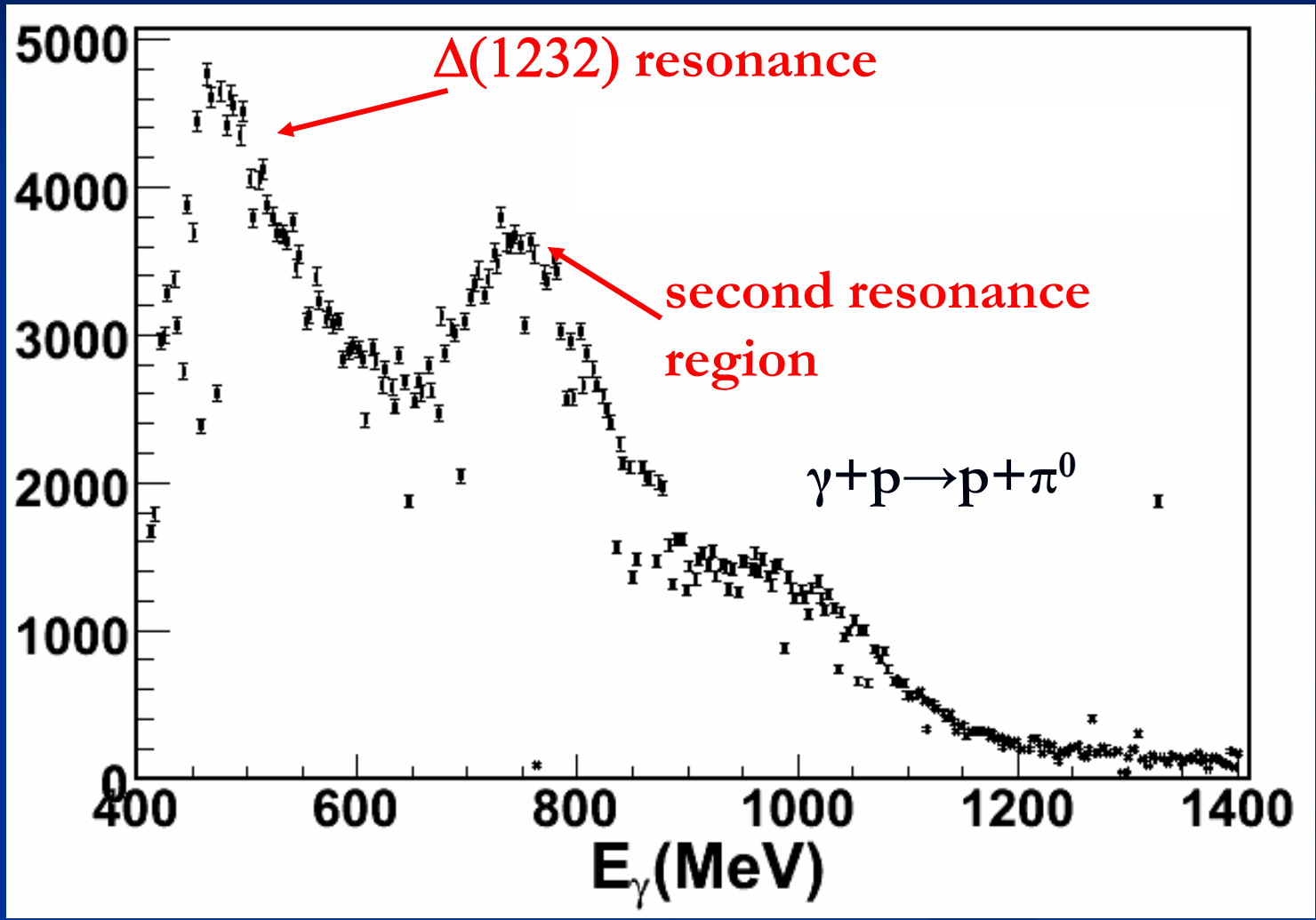
ΔE vs E (MeV)





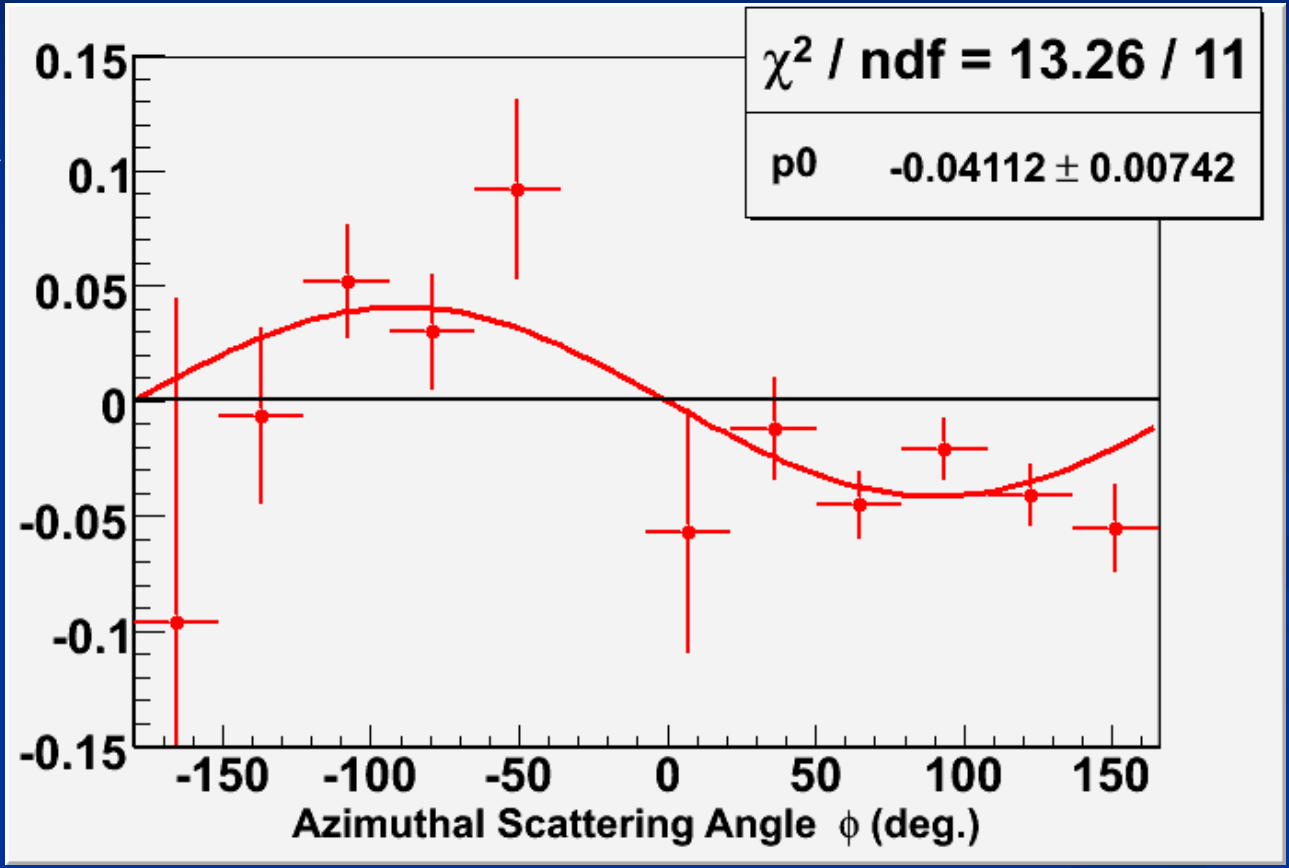


Results from test beamtimes (2x3 day runs)



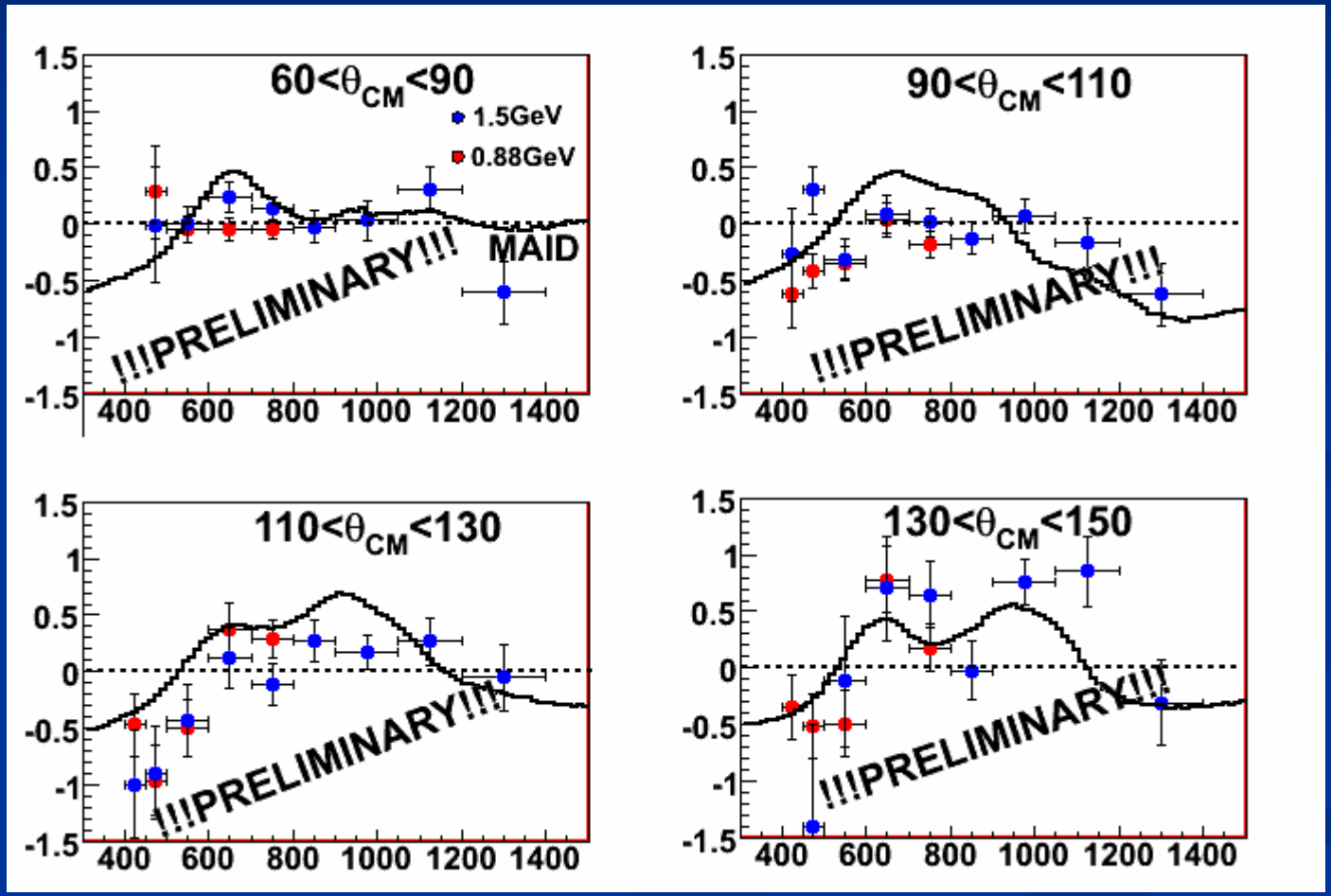
Initial Proton Asymmetry

Beam helicity asymmetry



$$\frac{N^+(\phi_p) - N^-(\phi_p)}{N^+(\phi_p) + N^-(\phi_p)} = C_x \, P_\gamma^{circ} \, A \sin\phi_p$$

Preliminary results from commissioning test



Summary and outlook

- Edinburgh recoil polarimeter - first measurements of beam-recoil observables in pion photoproduction
- ***Will allow the first complete measurement of experimental observables***
- Milestone in constraining the properties of the poorly established nucleon excitation spectrum

Future work

- **η photoproduction**
- Kinematic fit analysis, detailed modeling and assessment of analyzing powers
- 1000 hour approved beamtime to run later this year with linearly and circularly polarized beam
- Upgrade of polarimeter to make deuterium target and recoil neutron polarimetry measurements possible