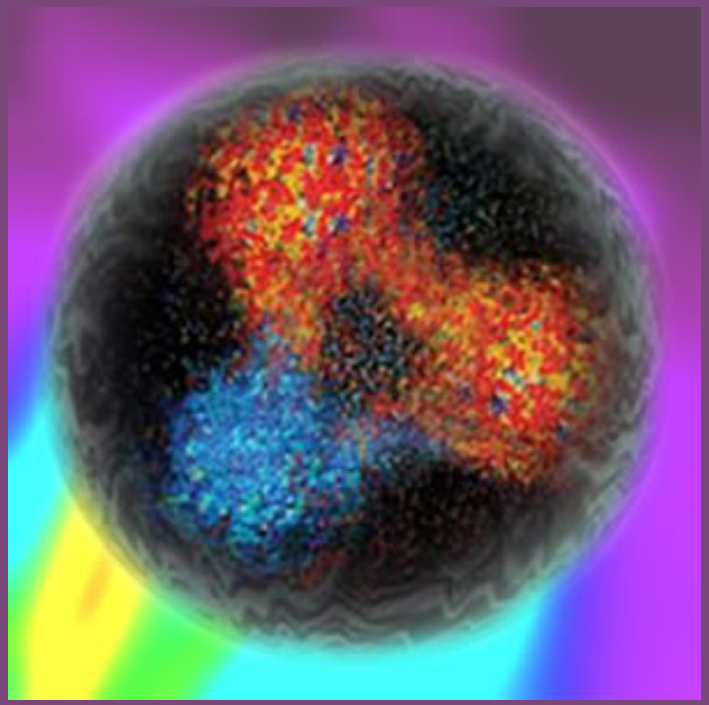
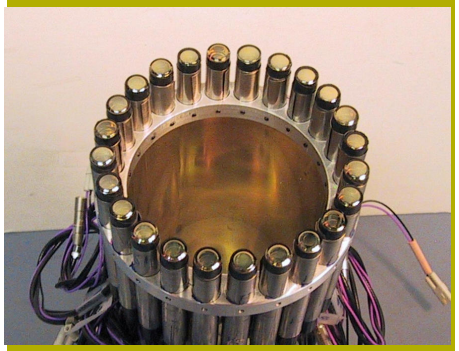
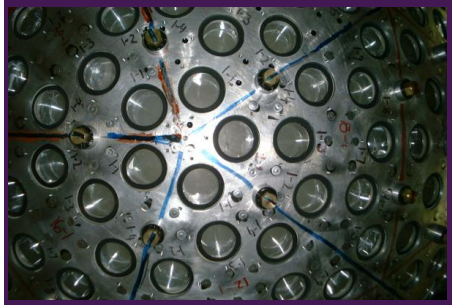






First measurement of the F Double Polarisation Observable with the Crystal Ball at MAMI

Pauline Hall Barrientos
University of Edinburgh

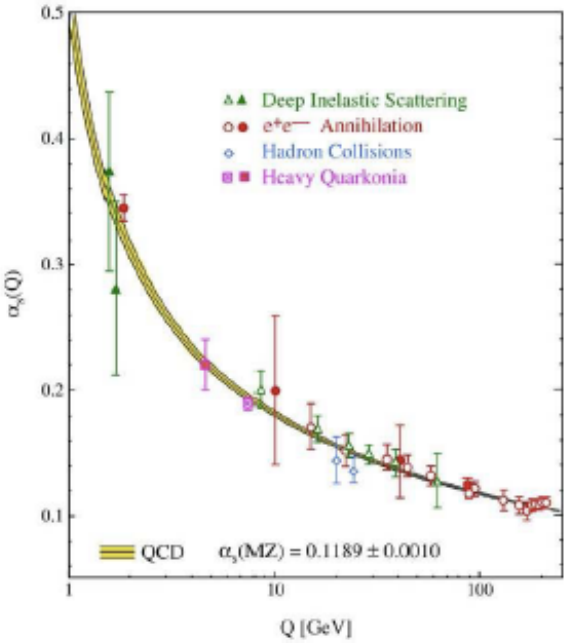
NSTAR May 2011

Overview

- Nonperturbative QCD
  - Near threshold reactions
- Meson Photoproduction
- **Ma**inz **Mi**crotron
- Analysis
- Summary

Understanding nonpertubative QCD

- QCD confinement at low energies
- Studies of the baryon resonances
  - Dynamics and interactions.
  - Degrees of freedom.
- Current data vs. theoretical predictions
  - Poorly established resonances
  - Missing resonances?
- Theory development



Studies in the near reaction threshold

- Accurate *pion photoproduction* data allows:

  πN interactions in all charge states

  New tests of isospin violations with polarised target asymmetries

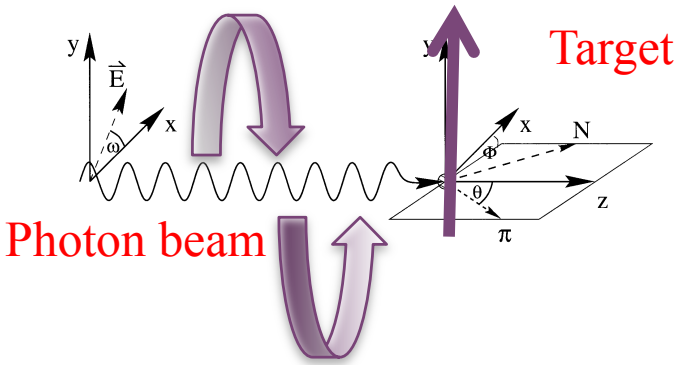
  Observable breakdown of Fermi-Watson (final state interaction) theorem.

  Challenge low energy QCD theories.

A.M. Bernstein, *PiN Newslett.* **15** (1999)

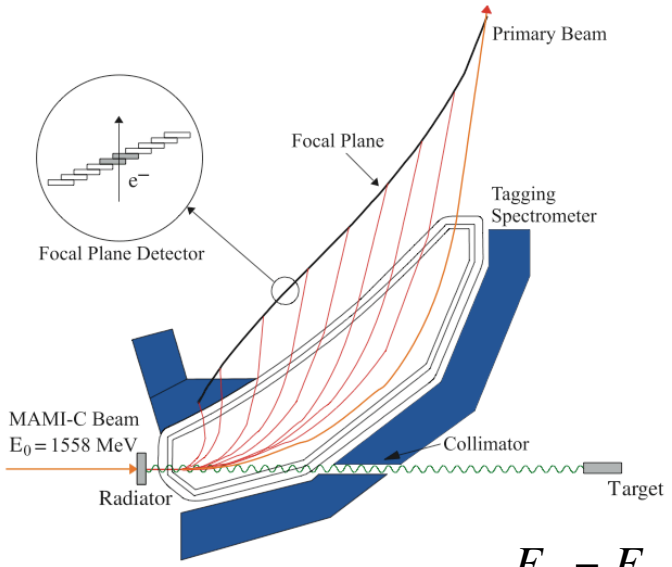
Meson Photoproduction

- Incident photons **excite** protons to a *metastable* state. Subsequently the proton decays by the emission of **mesons**.
- Four complex reaction amplitudes.
  - 16 observables can be measured.
  - Beam, target and recoiling nucleon can be polarised.
- Constrain the reaction amplitudes.
- ***'F'***, a transverse polarised proton target and circularly polarised photons.



I.Barker, A. Donnachie, Nucl Phys B 95 347 (1975)

Mainz Microtron - Germany



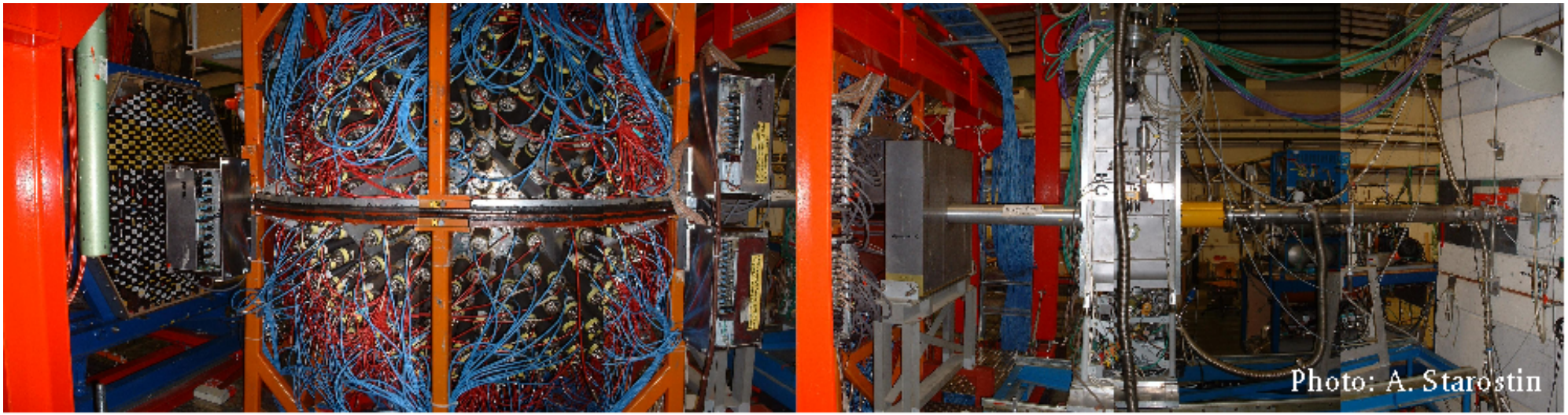
$$E_\gamma = E_o - E_{e^-}$$

- Racetrack microtron
- Electron beam up to 1.5 GeV
- Bremsstrahlung photons generated from interaction of an electron beam with a thin metal radiator.
- Glasgow photon tagging spectrometer

A2 Collaboration

http://wwwa2.kph.uni-mainz.de/A2/

MAMI A2 – Detectors

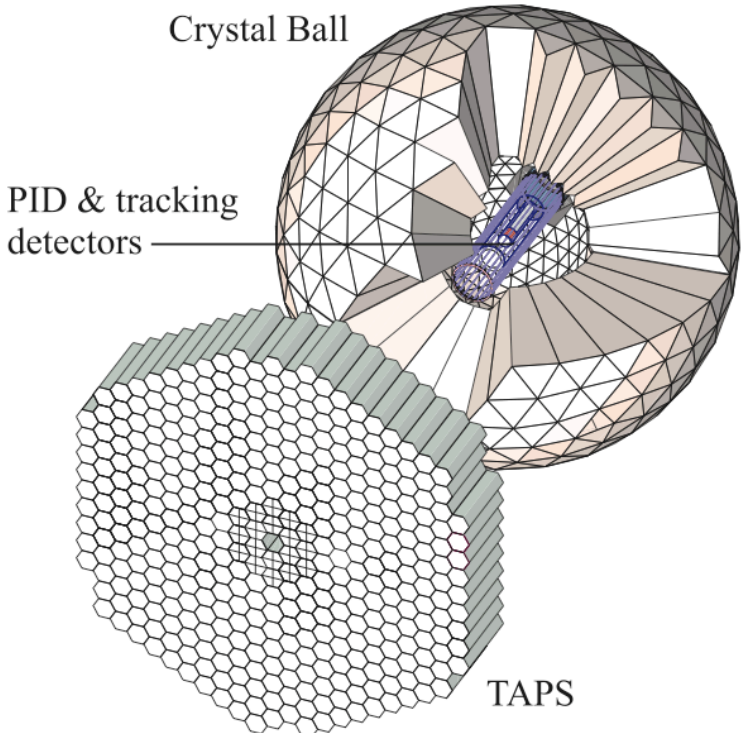


Beam Direction

http://wwwa2.kph.uni-mainz.de/cb/

Detectors– Crystal Ball and TAPS

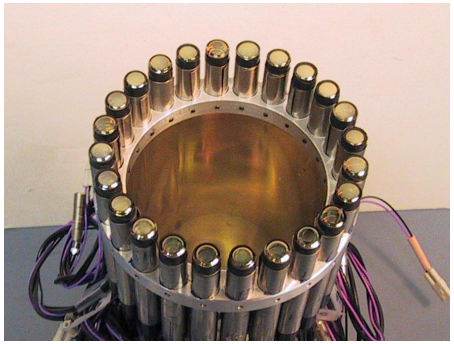
- CB Detects high energy photons
- 672 NaI scintillators
  - 96% of 4π sterdians
  - Precise measurement of photons
  - High segmentation, σ_{θ}=2-3° and σ_{ϕ}=2-3 ° resolution
- TAPS covers forward angle
  - Protons, pions and photons detected

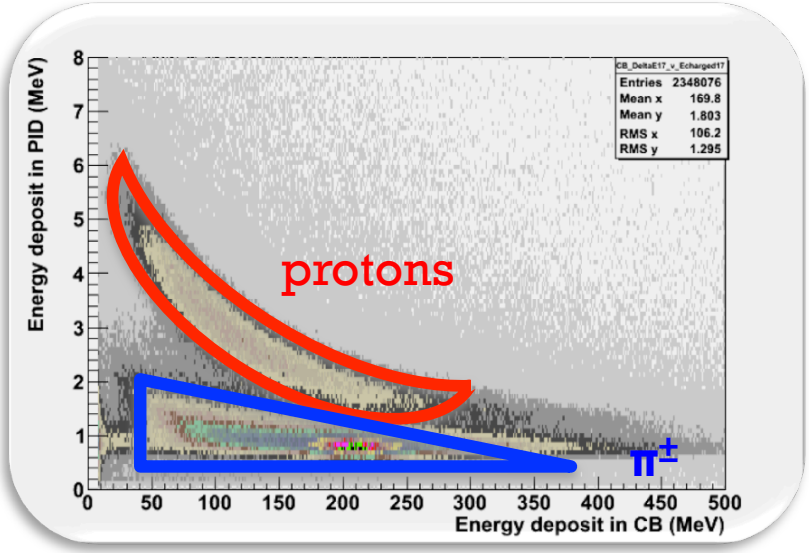


Edinburgh Particle Identification Detector

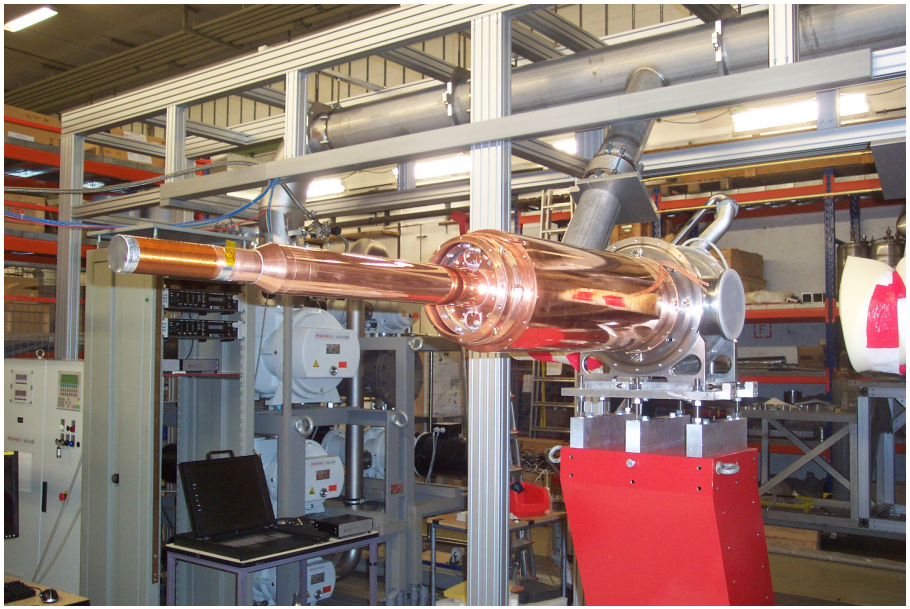
- 24 scintillator strips.
- Surrounds the target
- Detect charged particles

  CB energy deposited vs. energy in the PID
- Two clear ridges of protons and charged pions can be identified.





Polarised Target

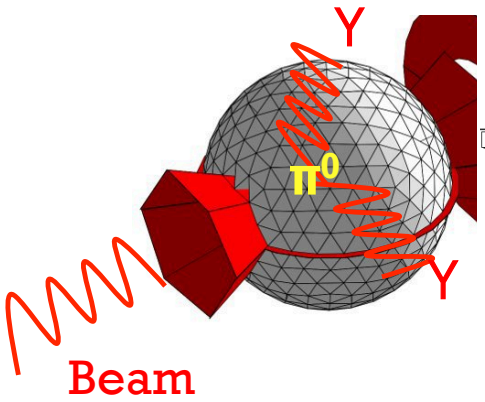


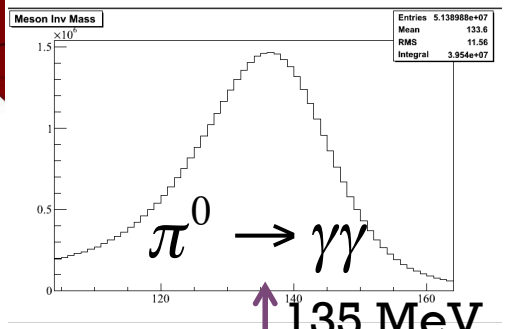
- Butanol target
- First production run in March 2010.
- Dynamic nuclear polarisation.
  - Electrons polarised by microwaves and transfer their polarisation to the protons.
  - Target cooled to 30 mK.
  - Holding coil (0.5 T) to prolong polarisation.
- NMR measures the polarisation.
- ~ 80% polarisation of protons

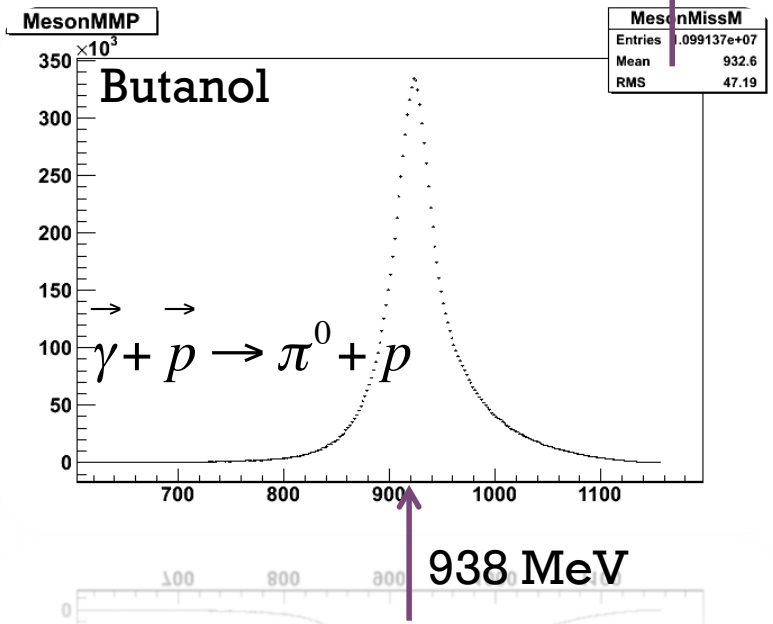
Analysis – Particle ID

- Data: February 2011 (~500 hours)

  Beam 150-450 MeV
- Reaction: $\vec{p} + \vec{\gamma} \rightarrow p + \pi^0$
- π^0 , detection of two gammas in the crystal ball.
- Proton, identified ePID and TAPS.
- Proton, can also be reconstructed from missing mass plots of π^0

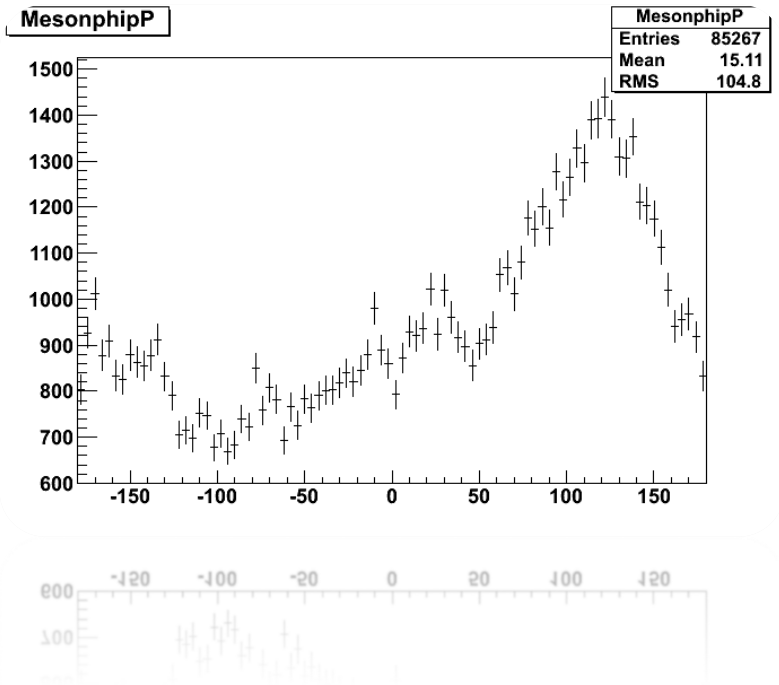






Analysis – Extracting F

π° Phi distribution beam = +1



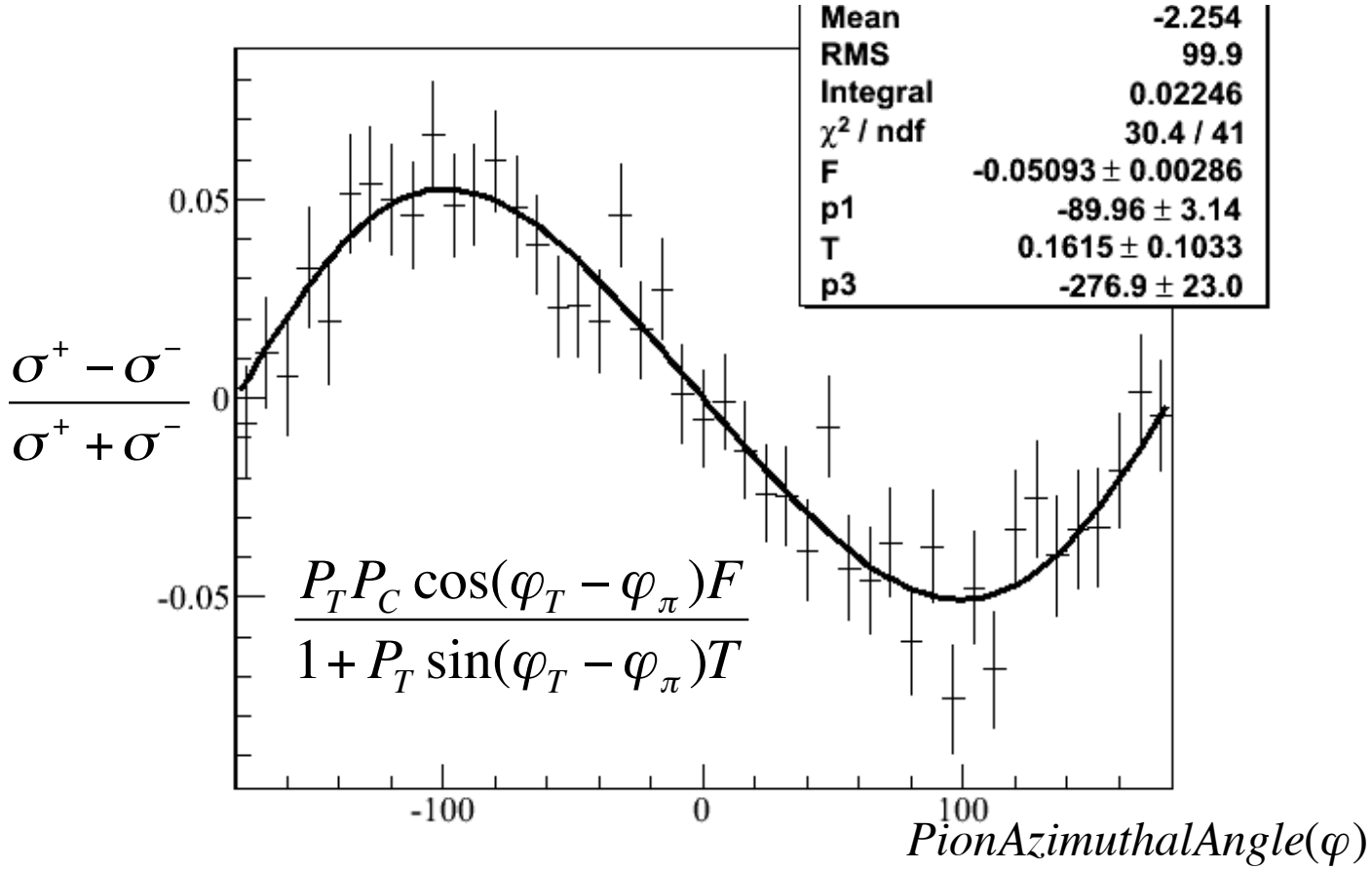
- F' can be extracted from the asymmetry of the pion azimuthal angle for different photon polarisation states (+ or -).

$$BeamAsymmetry = \frac{\sigma^{+} - \sigma^{-}}{\sigma^{+} + \sigma^{-}} = \frac{P_T P_C \cos(\varphi_T - \varphi_\pi) F}{1 + P_T \sin(\varphi_T - \varphi_\pi) T}$$

$$T\ \arg etAsymmetry = \frac{\sigma^{\uparrow} - \sigma^{\downarrow}}{\sigma^{\uparrow} + \sigma^{\downarrow}} = P_T \sin(\varphi_T - \varphi_\pi) T$$

Analysis – Extracting F

Beam asymmetry. Beam: 300-350MeV $65^0 < \theta < 80^0$

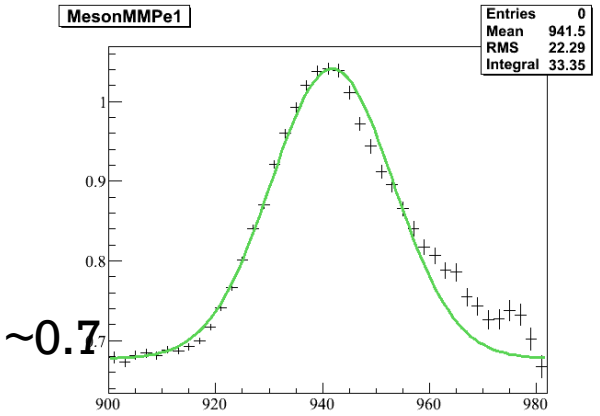


This process is done for a number of energy and polar angle bins.

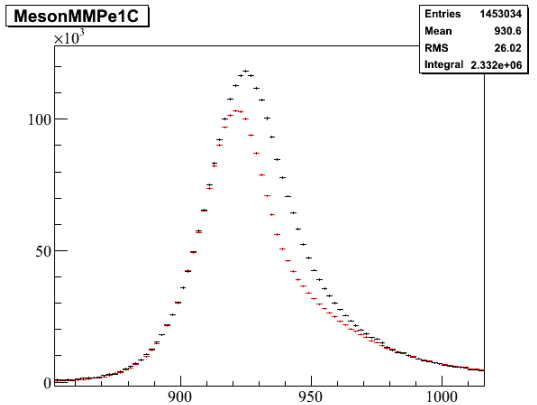
Analysis – Dilution Factor

- Measurement of 'F' is diluted by contributions of unpolarised carbon and oxygen in the Butanol.
- In January photoproduction on a carbon target (~150 hours).
- Scaling carbon.
- Dilution Factor: Butanol nuclei - Carbon nuclei/Butanol nuclei

Scale Factor: B/C

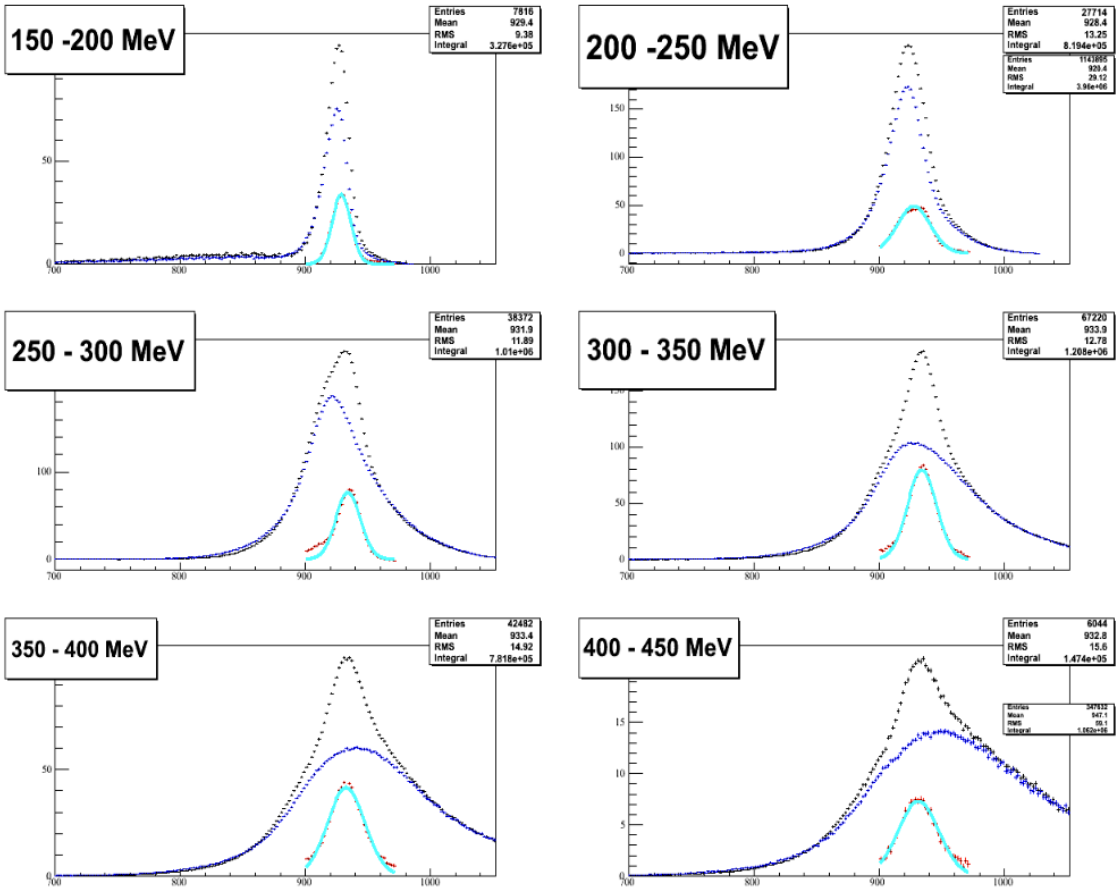


~0.7



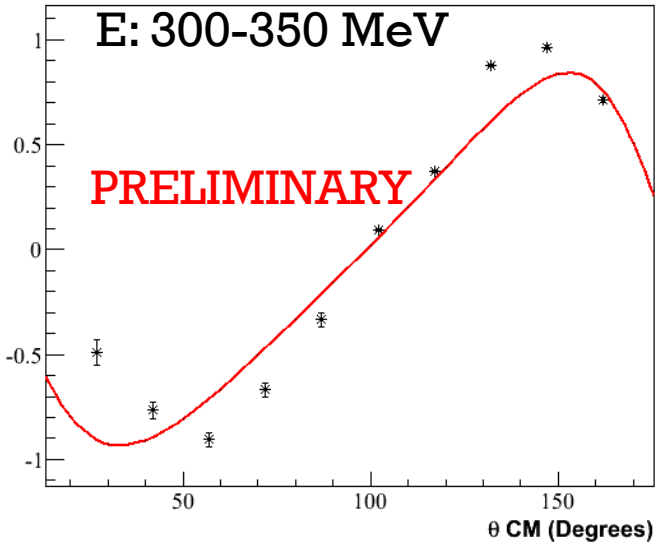
Butanol Scaled Carbon

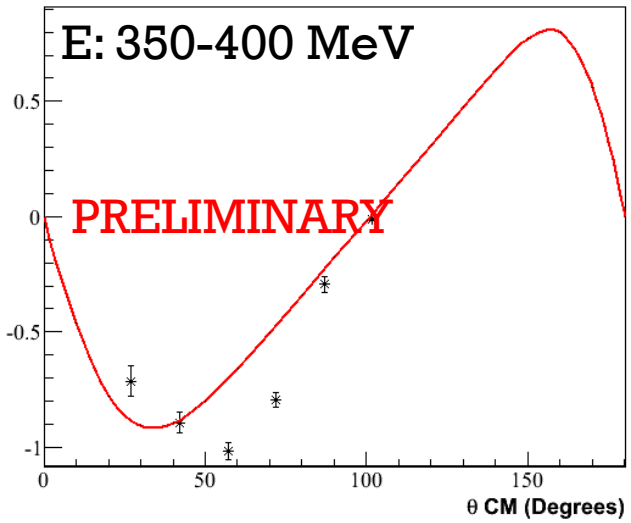
Analysis


150 -200 MeV
Entries 7816
Mean 929.4
RMS 9.38
Integral 3.276e+05
200 -250 MeV
Entries 27714
Mean 928.4
RMS 13.25
Integral 8.194e+05
250 - 300 MeV
Entries 38372
Mean 931.9
RMS 11.89
Integral 1.01e+06
300 - 350 MeV
Entries 67220
Mean 933.9
RMS 12.78
Integral 1.268e+06
350 - 400 MeV
Entries 42482
Mean 933.4
RMS 14.92
Integral 7.818e+05
400 - 450 MeV
Entries 6044
Mean 932.8
RMS 15.6
Integral 1.474e+05

Results

300-350 MeV

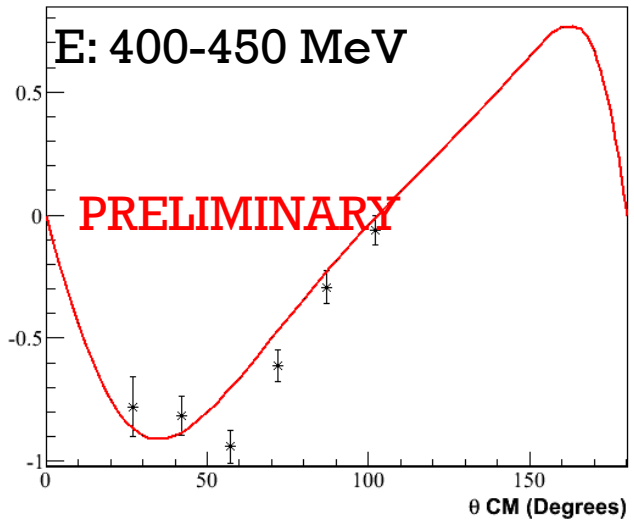




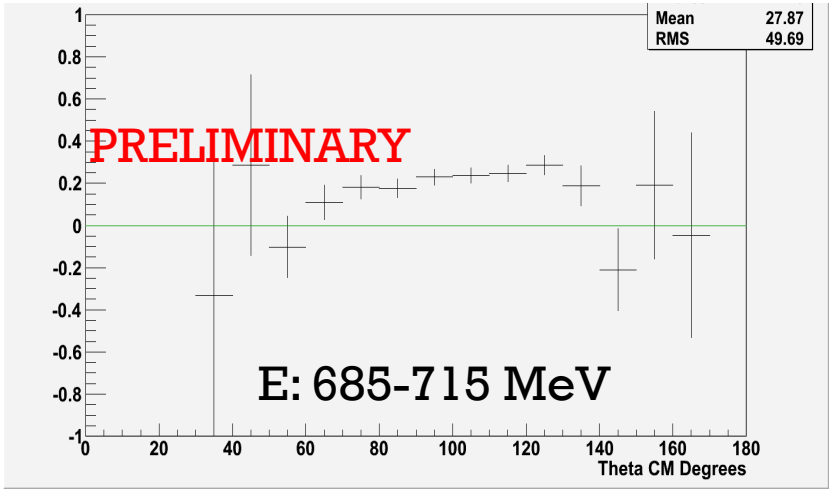
MAID

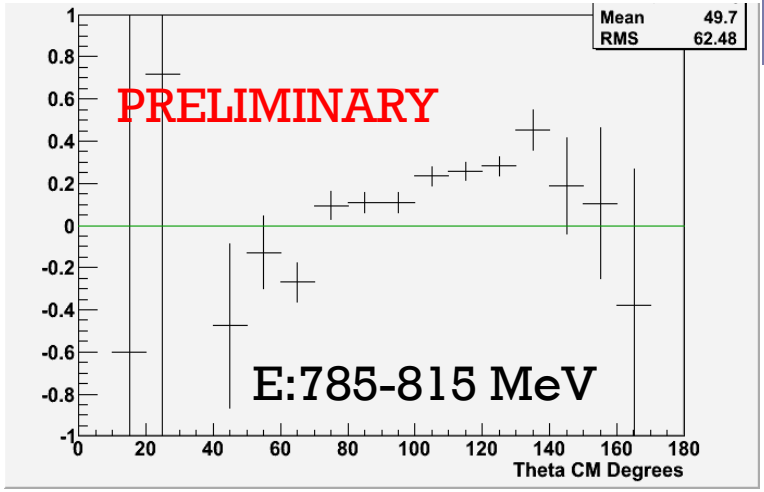
* ~125 hours of Feb butanol data

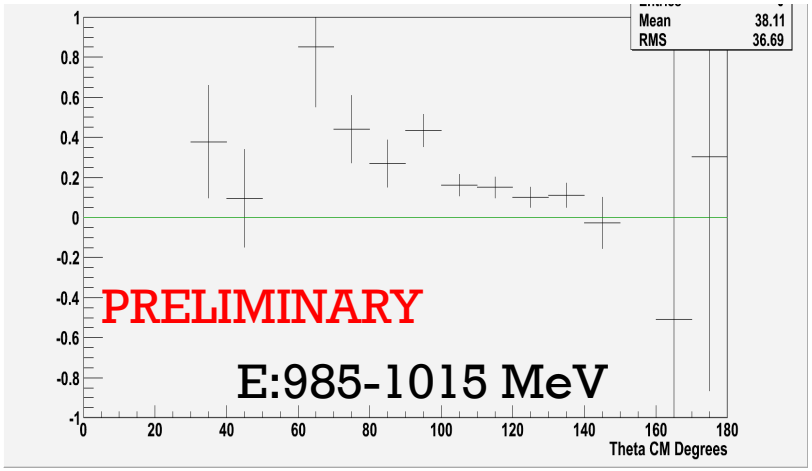
400-450 MeV

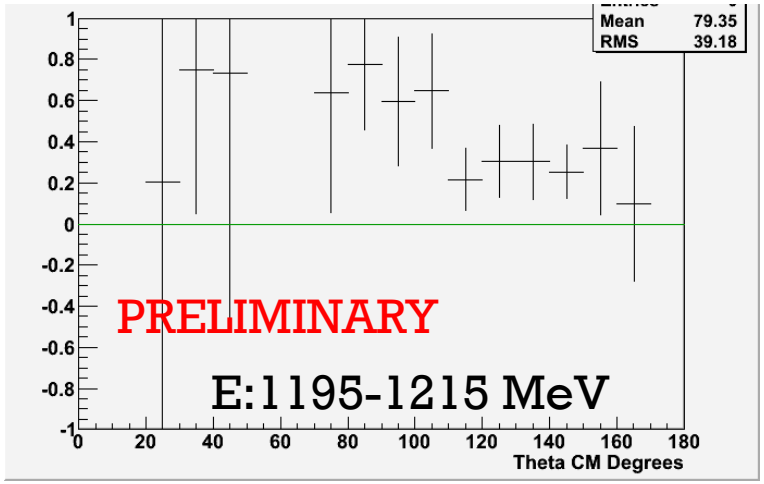


Results – S.Schumann









First measurement of F

- *Constrain* low energy QCD theories
- Sensitivity to isospin violations due to polarised target asymmetries.
- 'F' at near threshold reaction

  First measurement

  Unique observable.
- Data taken in January and February 2011
- Preliminary results are promising