E08-010 (N$\rightarrow$ Δ)
Analysis Update

Adam Blomberg

Core group

- **Temple University**
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- **Dalhousie University**
    - D. Anez[2]
- **St. Mary's University**
    - A.J. Sarty
- **Thomas Jefferson National Accelerator Facility**
    - D. Higinbotham
- **Massachusetts Institute of Technology**
    - S. Gilad

[1] Contact person
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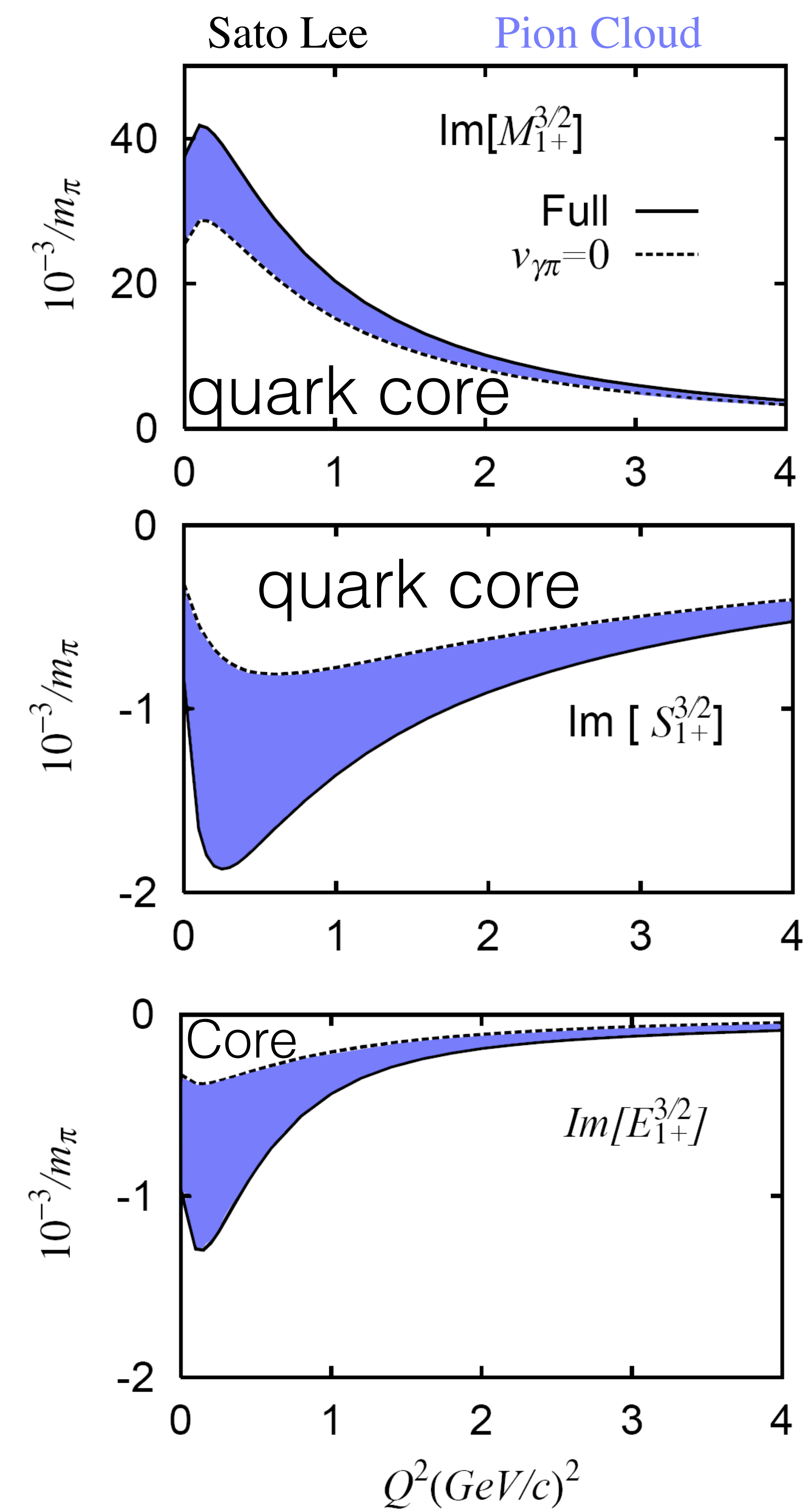
Motivation

Explore for non spherical components in the nucleon wave function

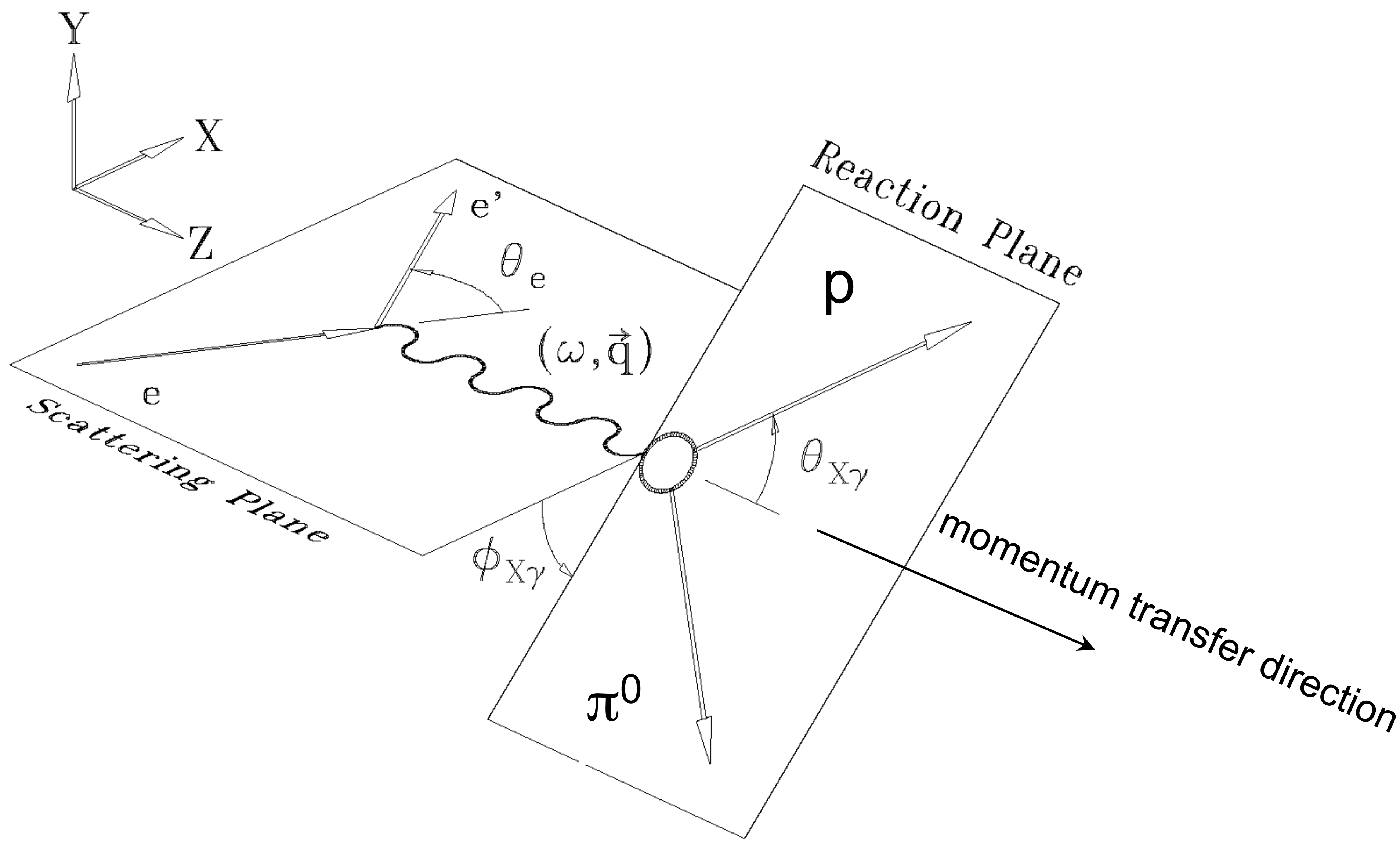
Quadrupole transition
Δ Resonance → H(e,e'p)π^0

Quark-gluon and Mesonic DOF

Low Q^2 → Pion cloud accentuated



Methodology



$N \rightarrow \Delta$

$H(e,e'p)\pi^0$

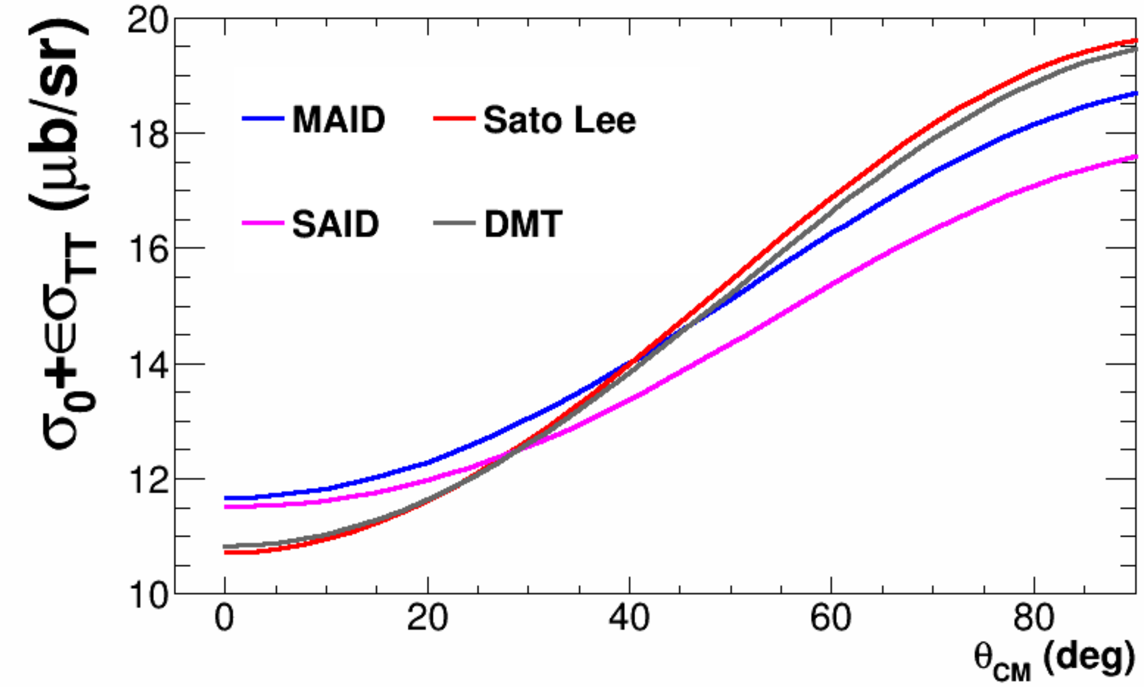
$$\sigma = J_\Omega \Gamma_\nu \frac{p_{cm}}{k_{cm}} (R_T + \epsilon_L R_L + \epsilon R_{TT} \cos 2\phi_{X_\gamma} + \nu_{LT} R_{LT} \cos \phi_{X_\gamma})$$

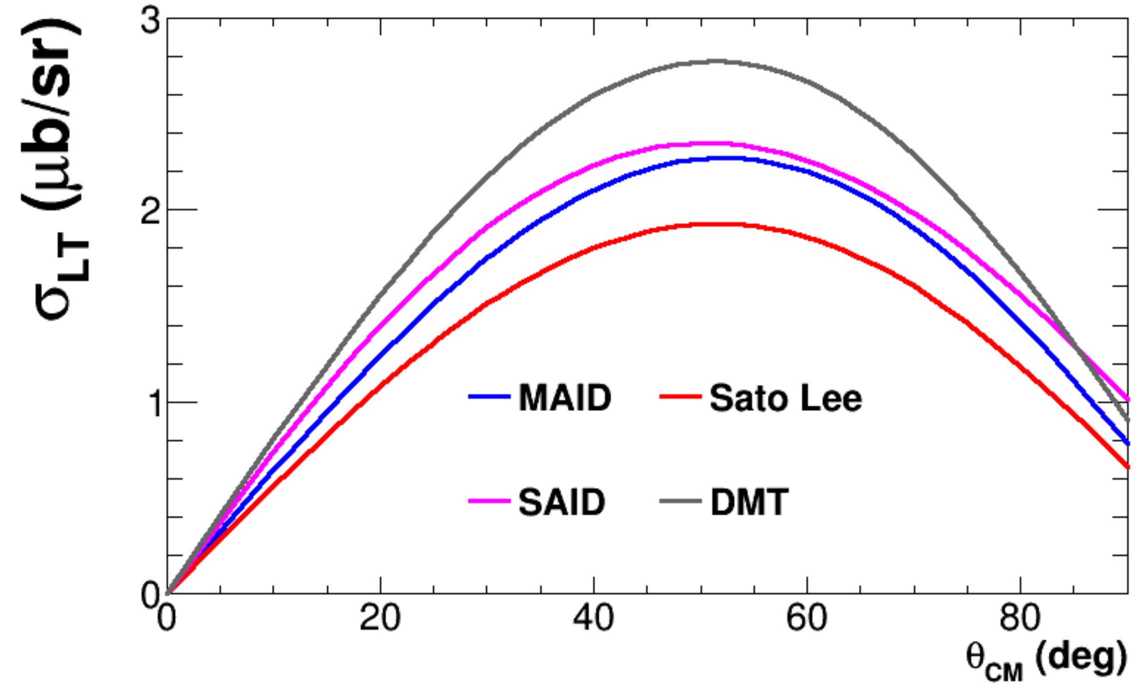
measure multiple azimuthal angles ϕ for fixed θ to extract

R_T, R_L, R_{TT}, R_{LT} = f(amplitudes(W,Q^2),g(θ))

Fit R_i vs. θ to get amplitudes(W,Q^2)

Methodology





$$\sigma = J_\Omega \Gamma_\nu \frac{p_{cm}}{k_{cm}} (R_T + \epsilon_L R_L + \epsilon R_{TT} \cos 2\phi_{X_\gamma} + \nu_{LT} R_{LT} \cos \phi_{X_\gamma})$$

Two in-plane measurements at $\phi = 0^\circ$ and $\phi = 180^\circ$ allows extraction of resonant amplitudes

$\sigma_0+\varepsilon\sigma_{TT} = g(R_T,R_L,R_{TT},\theta_{CM})$

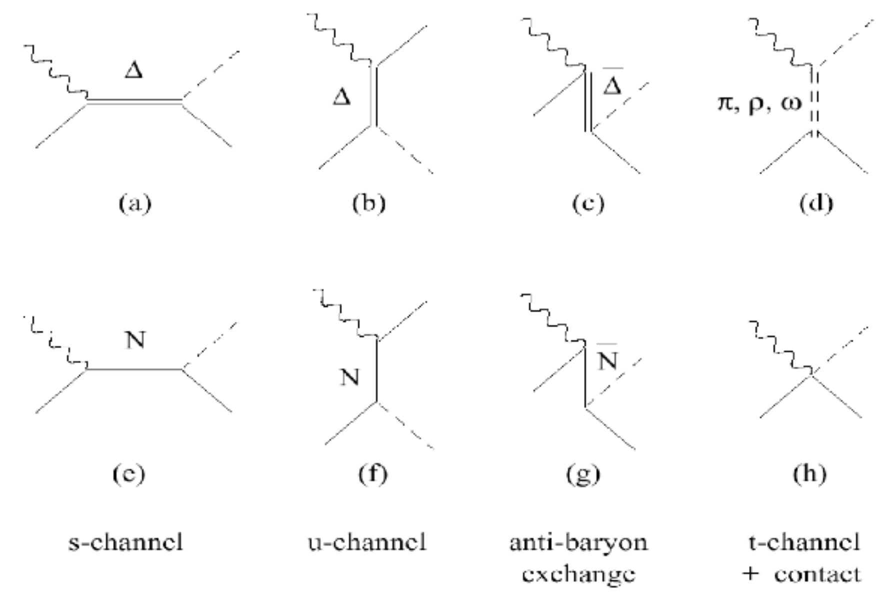
$\sigma_{LT} = f(R_{LT},\theta_{CM})$

Signal and BG Sensitivities

$$R_{TT} = 3\sin^2\theta\ (\ \mathrm{E2}\cdot\mathrm{M1} + (\mathrm{M1})^2 + \ldots\sum(\mathrm{background})\ )$$

$$R_{LT} = \text{-}6\cos\theta\sin\theta\ \ (\ \mathrm{C2}\cdot\mathrm{M1} + \ldots\sum(\mathrm{background})\ )$$

$$R_T + R_L = (\mathrm{M1})^2 + \ldots\sum(\mathrm{background})$$

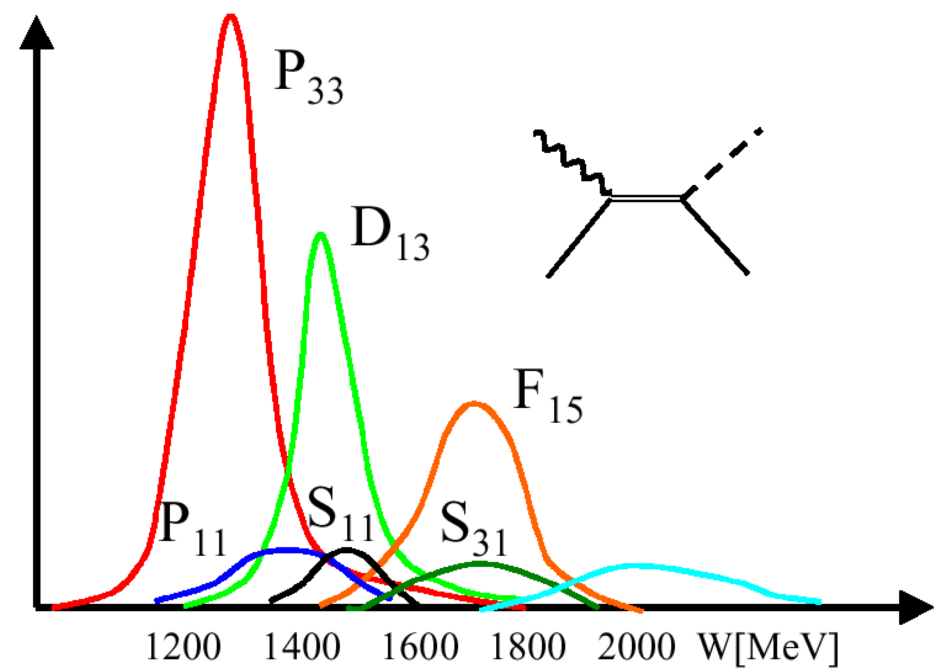


$R_{TT} \rightarrow$ sensitivity to EMR

$R_{LT} \rightarrow$ sensitivity to CMR

$R_T + R_L \rightarrow$ sensitivity to M1

$$CMR = \frac{C2}{M1}$$



Interfering background amplitudes introduce model uncertainty

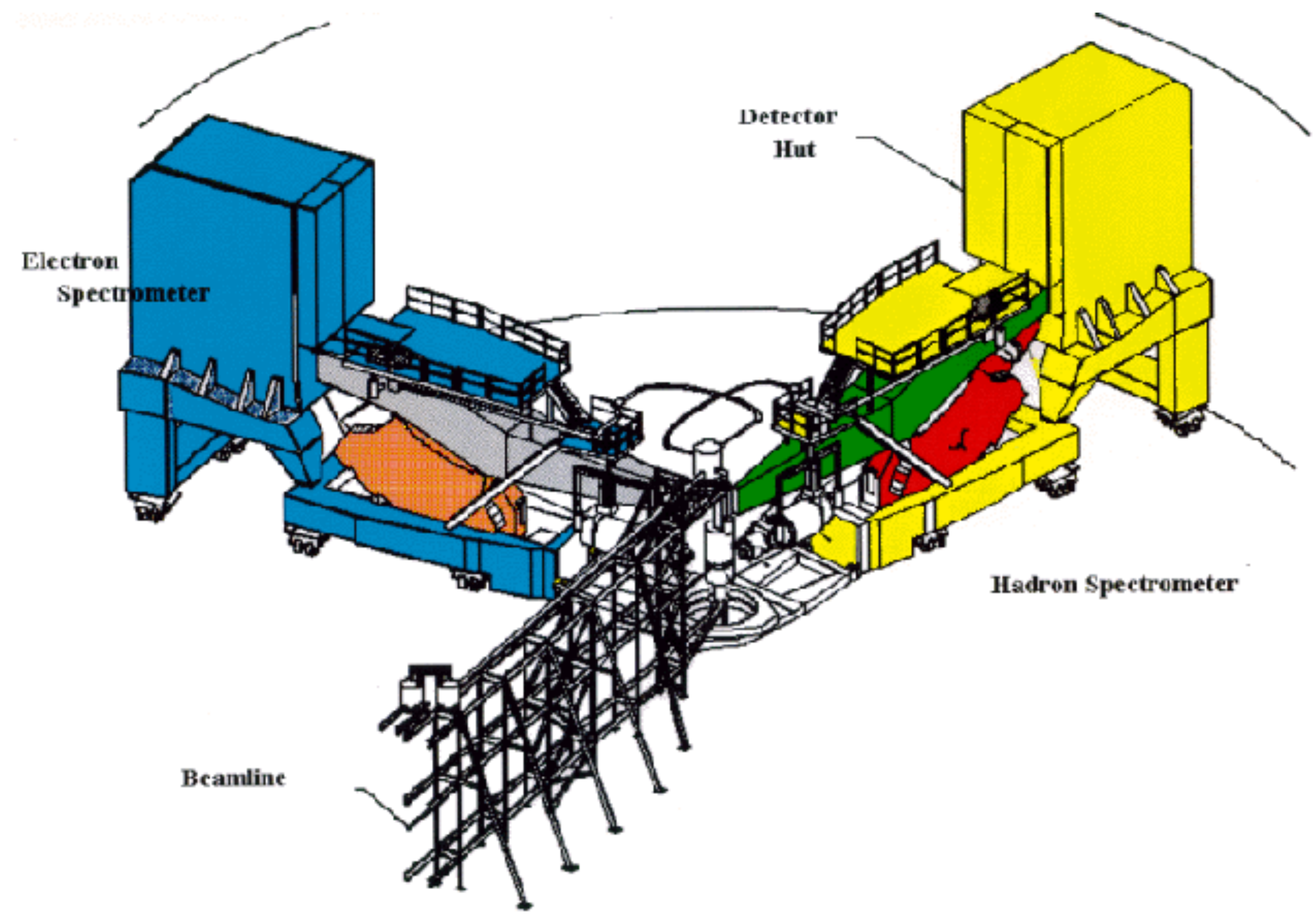
The experiment

- Data taken Feb-Mar 2011
- H(e,e'p)π^0

  N→Δ

  π^0 channel
- Two HRSs in coincidence
- 4 and 15 cm LH_2 targets
- Beam energy = 1.16 GeV
- 14 Kinematics
- $Q^2 = 0.04 - 0.13\ (GeV/c)^2$
- W = 1.17 - 1.232 GeV

Hall A Schematic



The Detectors

Vertical Drift Chamber (VDC)

Define Particle Tracks

Particle Momentum $\vec{p}$

Scintillators

DAQ Trigger

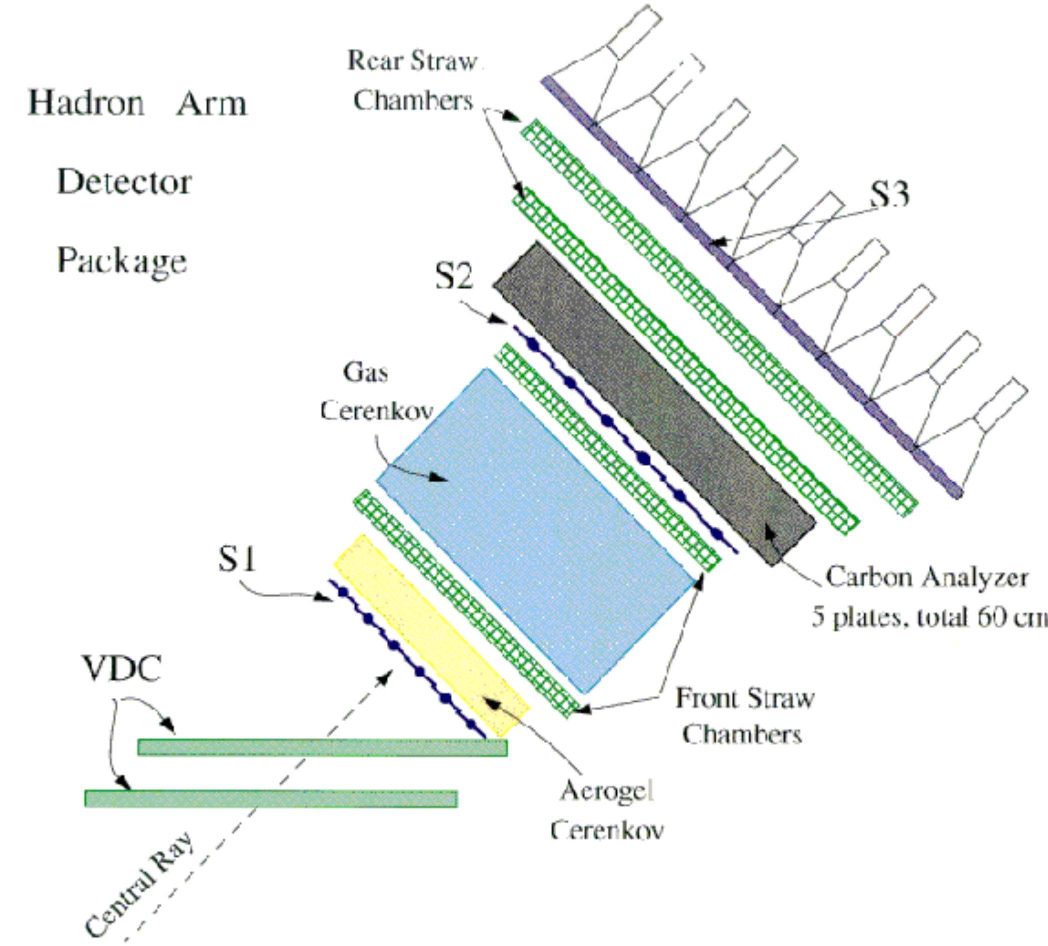
Coincident Timing

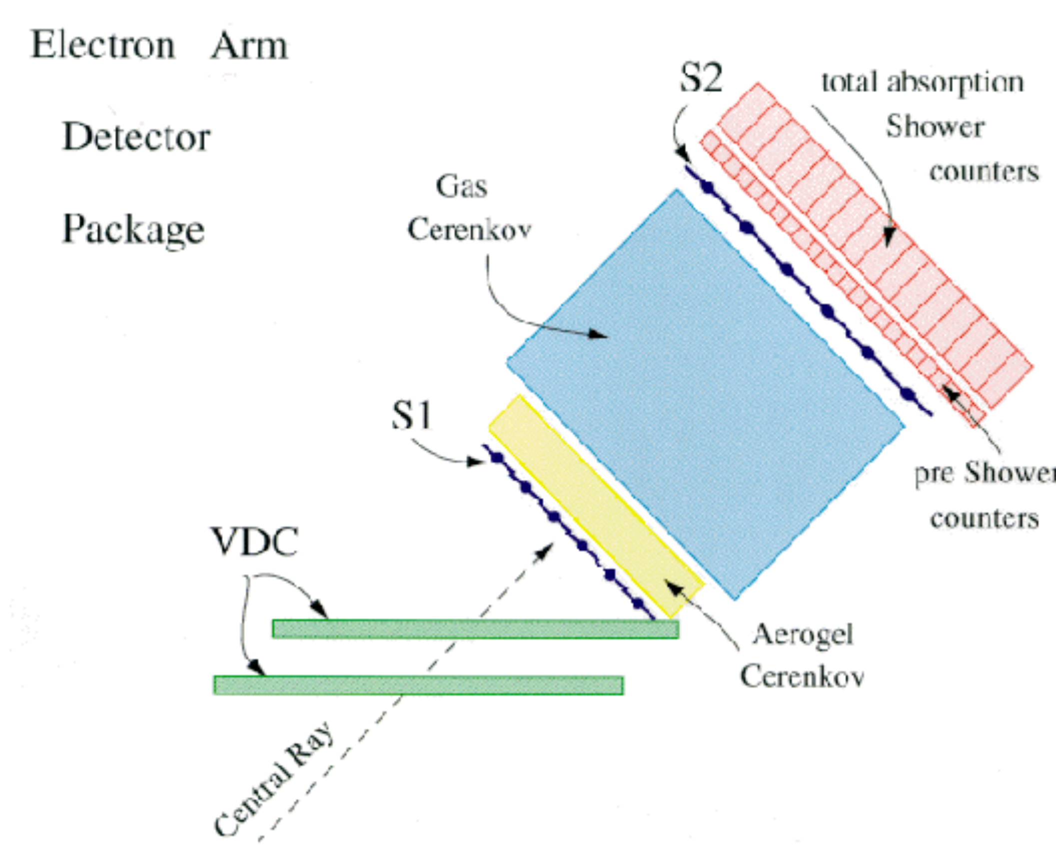
Particle Identification

Cherenkov (e^- only)

Lead Glass Showers

Scintillators





Parallel Analysis

Temple University (Temple) + St. Mary's University & Dalhousie University (SM&DU)

- Shared Work
  - Calibraitons
    - Mispointing
    - Current
    - PID
    - TOF
    - …
- Independent Work
  - Multi-track analysis
  - PS analysis
  - Multipole extraction

Preliminary Result Preview

Temple results

MAMI results Eur.Phys.J. A49 (2013) 136

MAID
DMT
SAID
Sato Lee

Parallel Analysis Preliminary Cross Section Results

SM&DU results normalized to MAID parallel cross section at Q^2=0.13 (Gev/c)^2
flat 16% enhancement to all cross sections

Parallel	SM&DU:	9.58 ± 0.05	scaled to	11.08 ± 0.06
	Temple:	11.28 ± 0.06	(no scaling)	11.28 ± 0.06
	MAMI:	11.10 ± 0.09	(no scaling)	11.10 ± 0.09

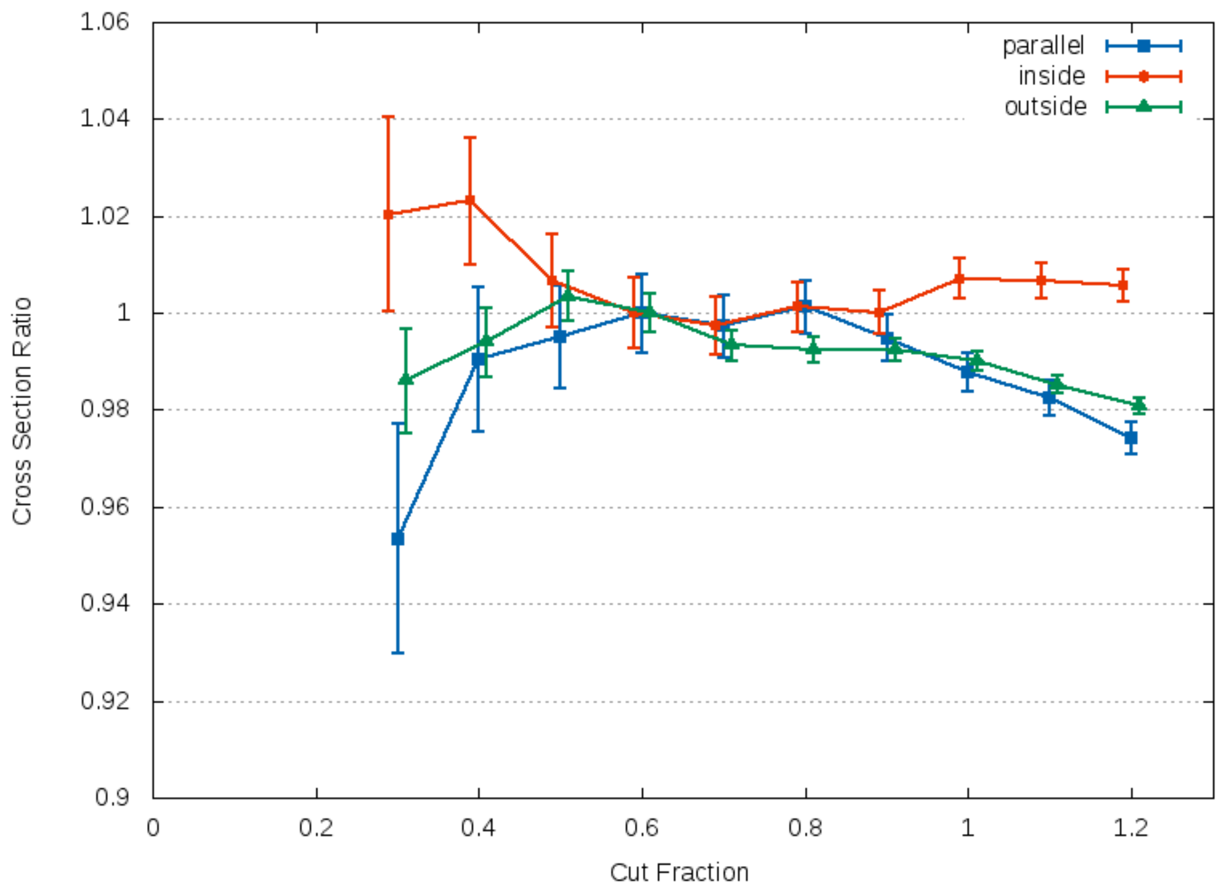
After this scaling there is agreement in some kinematics,
but disagreement in others:

$\theta_{pq} = 52^o$

Inside	SM&DU:	9.97 ± 0.13	scaled to	11.53 ± 0.16
	Temple:	11.53 ± 0.05	(no scaling)	11.53 ± 0.05
Outside	SM&DU:	15.62 ± 0.12	scaled to	18.07 ± 0.14
	Temple:	19.44 ± 0.05	(no scaling)	19.44 ± 0.05

Cross Sections shown are for Q^2=0.13 (Gev/c)^2 and W = 1232 MeV

Summary Statistics



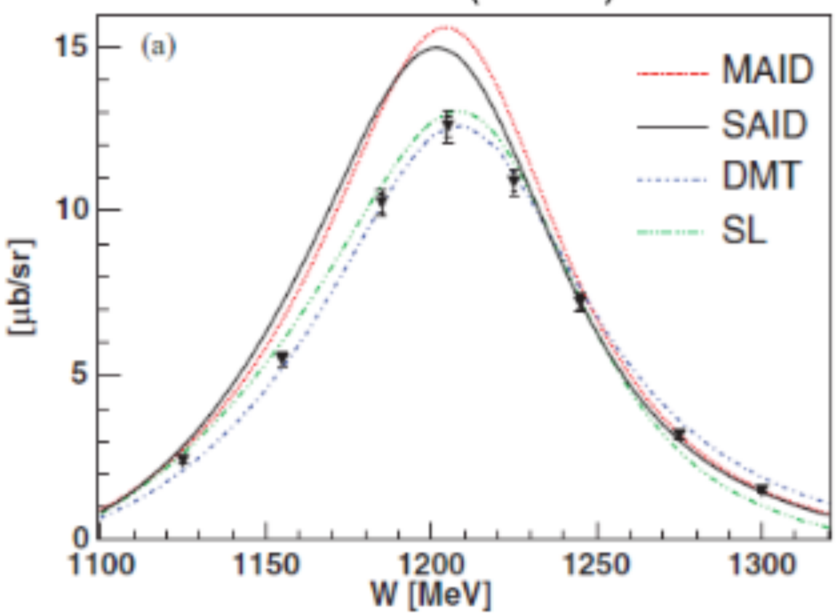
Cross Section Summary

Statistical Uncertainty	better than 1%
Model Uncertainty	better than 1%
Systematic Uncertainty	2 - 3%
Bin centering ratio	90 - 95 %

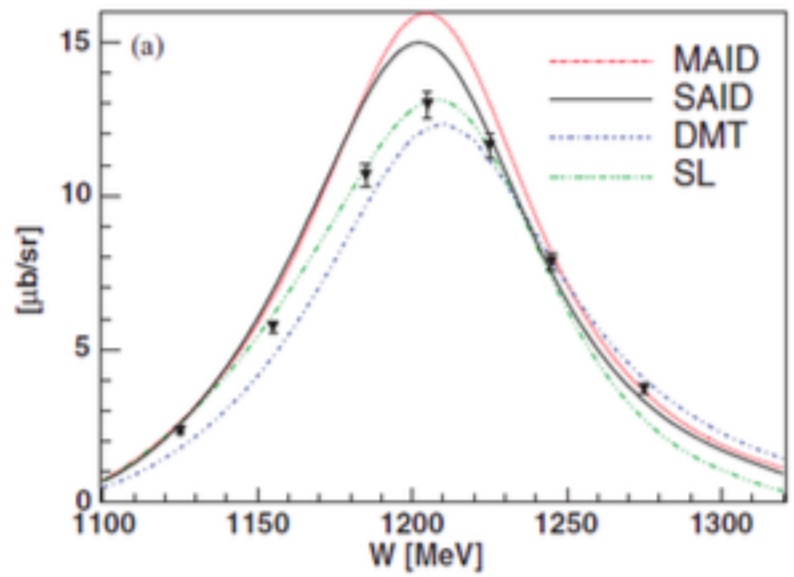
Preliminary Results: W scan

Parallel XS vs W: It is known that MAID fails / Sato Lee in good agreement with world data

Q^2=0.06 (GeV/c)^2



Q^2=0.20 (GeV/c)^2



MAMI results
Phys.Rev. C78 (2008) 025209

Q^2 = 0.13 (GeV/c)^2

Temple

Preliminary Results: Asymmetry and XS

■ Temple results

● MAMI results
Eur.Phys.J. A49 (2013) 136

Preliminary Results: Multipole extraction

Hall A
MAMI (2013)
MAMI (2007)
CLAS
Bates
Elsner et al
Pospischil et al

MAID
DMT
Sato Lee
SAID

ChEFT: PV
GH
HQM
Capstick
Lattice QCD
Large-Nc