PhD Proposal

Measurement of Polarized Valence Quark Distribution Functions using Polarized Proton and Deuteron Targets
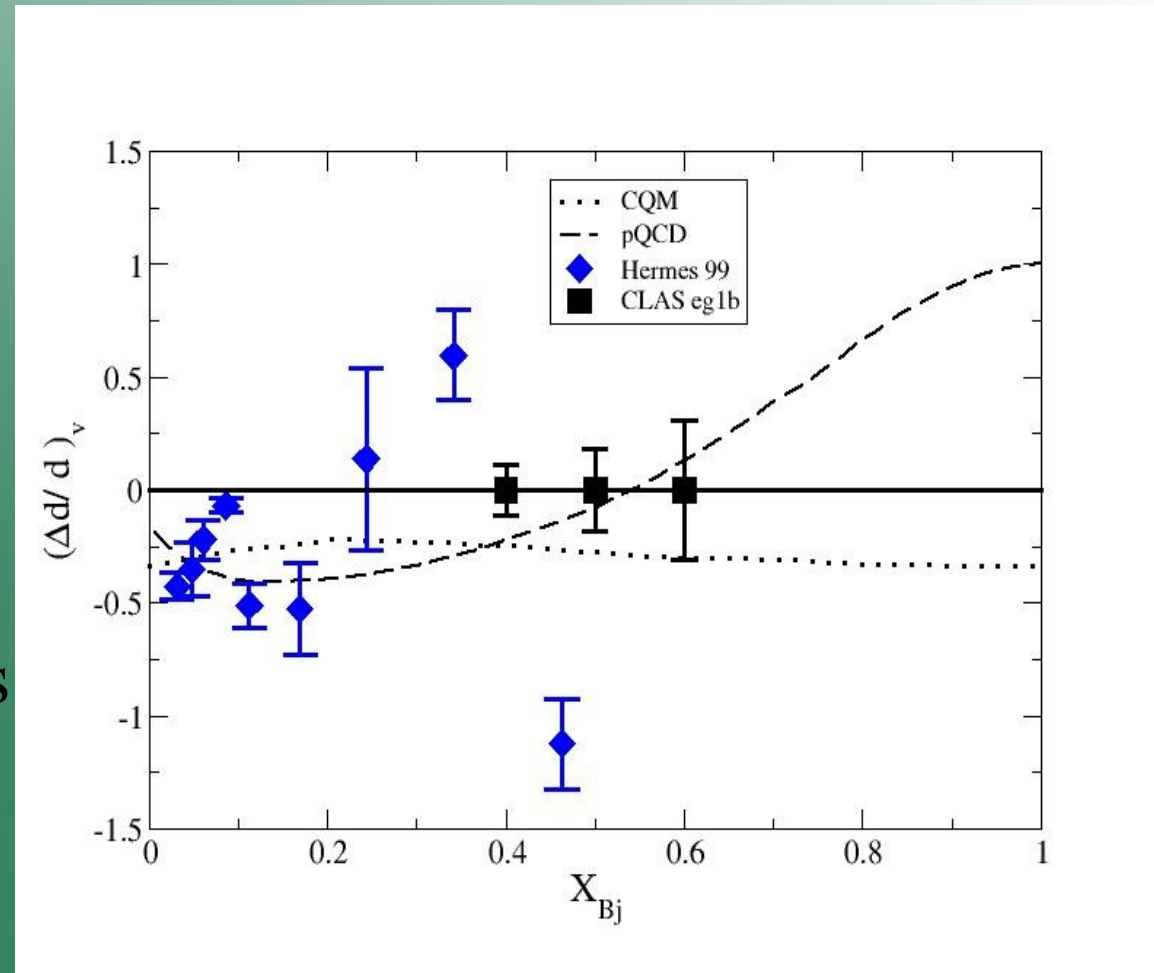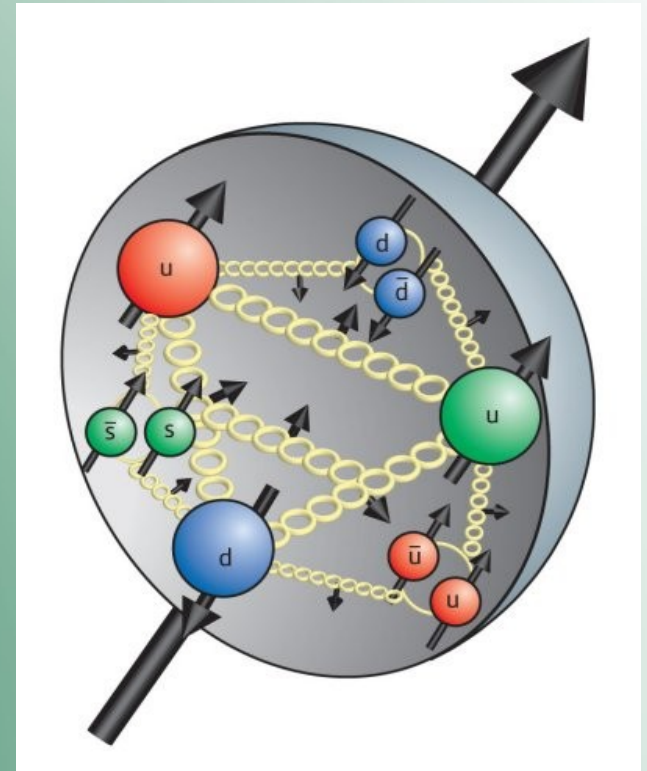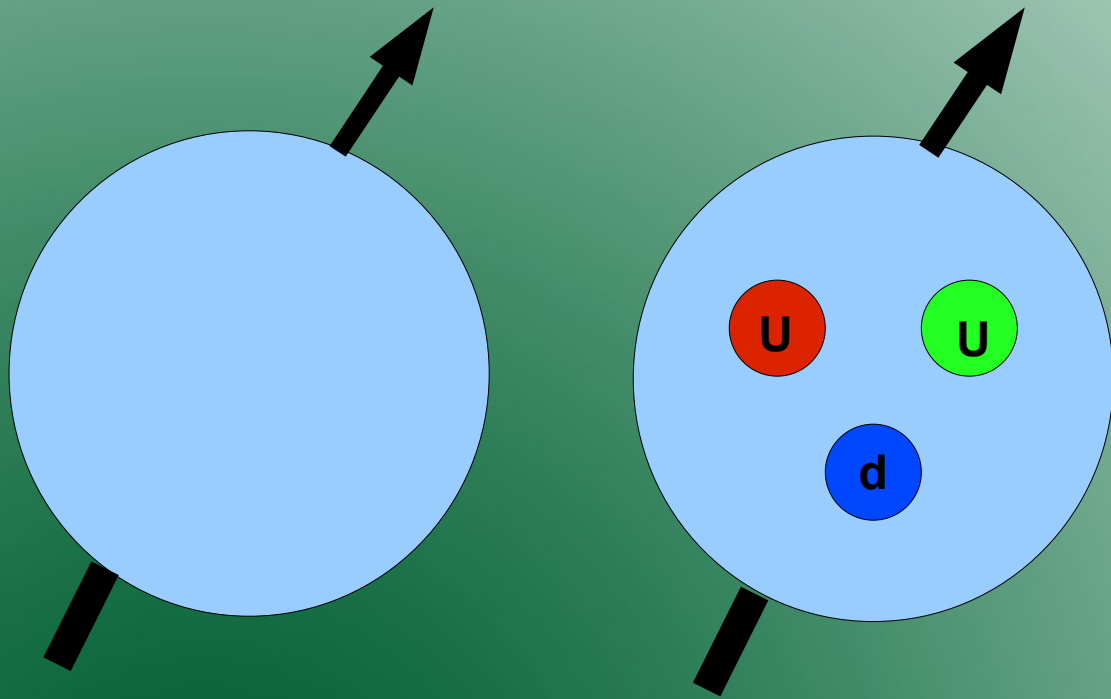
Tamar Didberidze

Outline

- Motivation
- Physics
- Experimental Setup
- Prelim Results
- Conclusions

Motivation

- "The proton spin crisis"

- Semi-Inclusive Double Spin Asymmetry Measurement

- Extraction of ($\Delta d/d$) observable

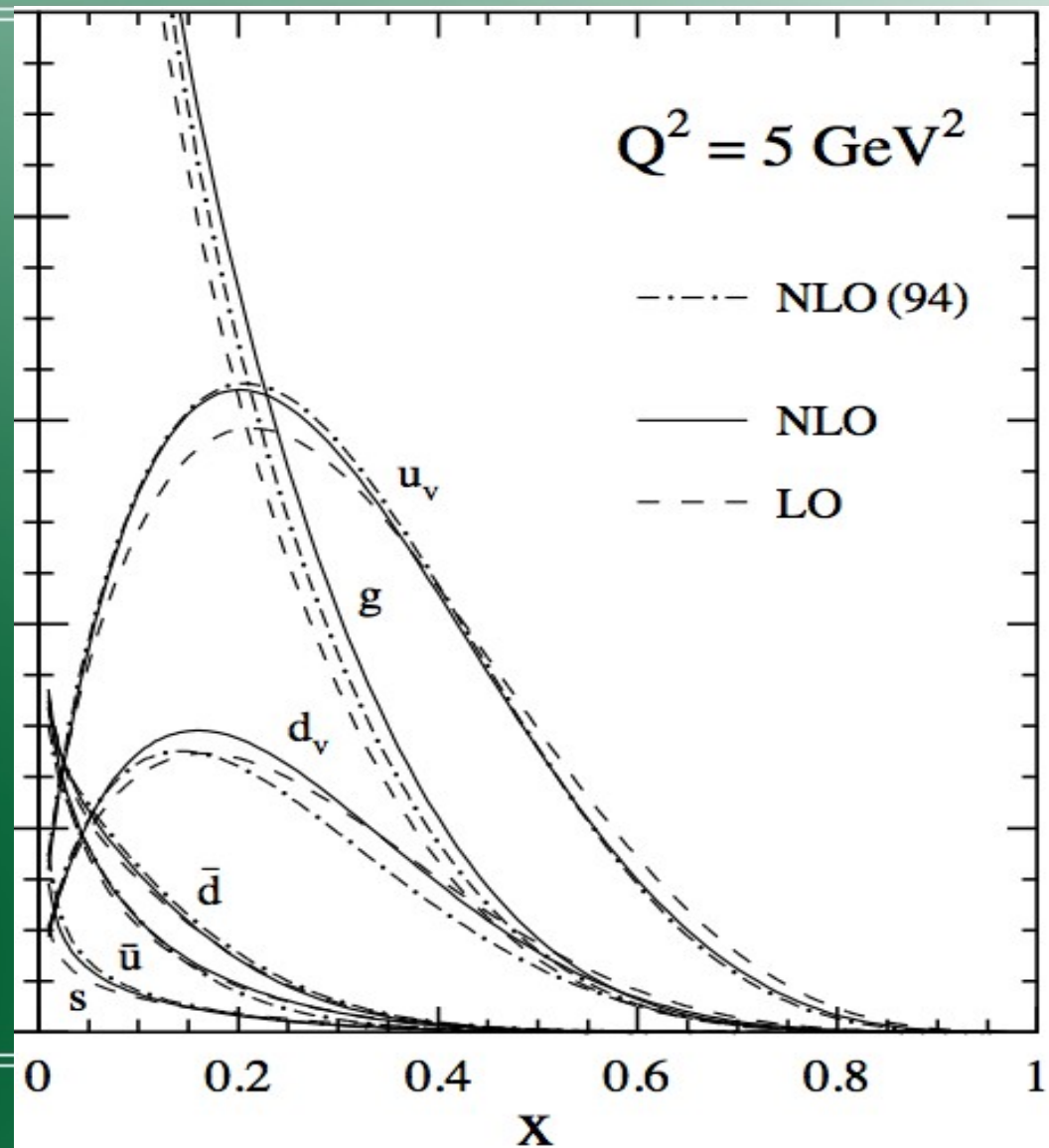- The perturbative Quantum Chromodynamics(pQCD) vs the hyperfine perturbed Constituent Quark Model(CQM)

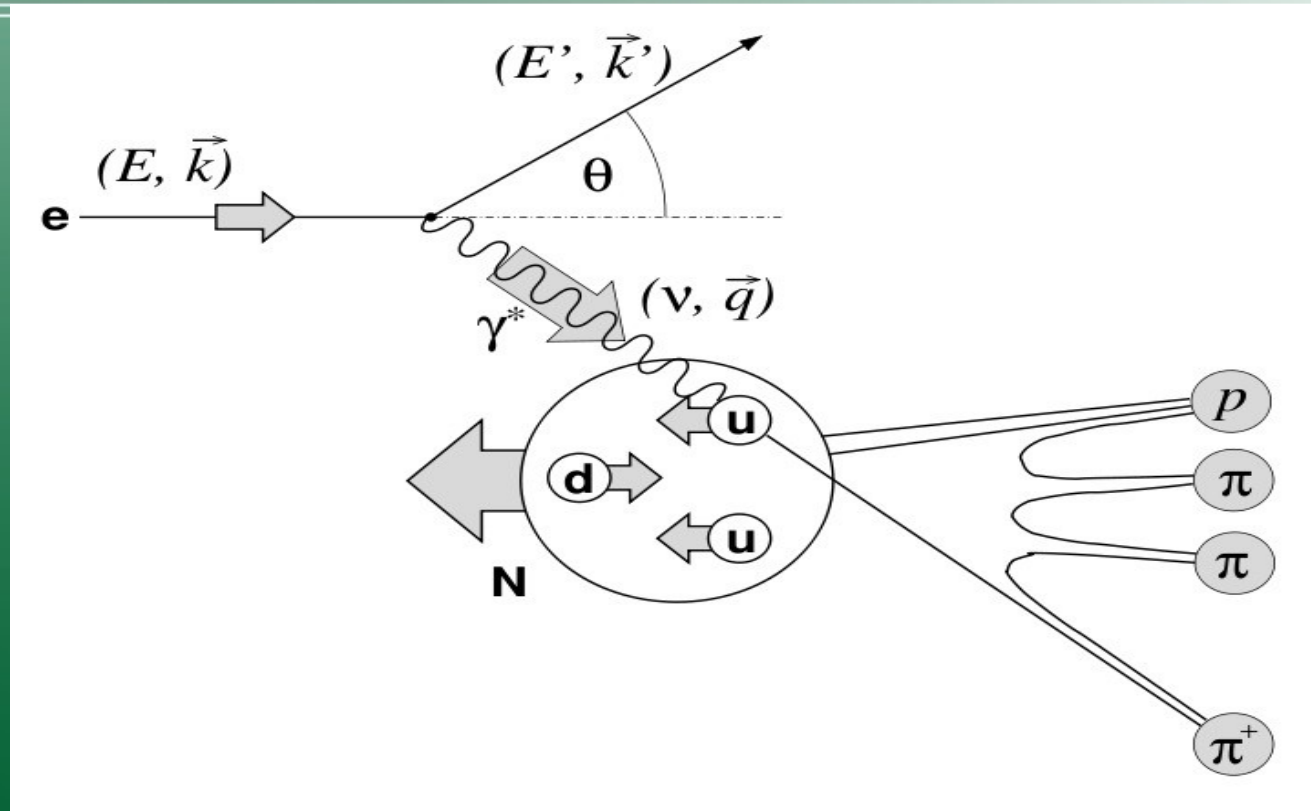# Deep Inelastic Scattering vs Q^2

Q^2 - Four Momentum Transferred Squared, d=(0.2GeV x fm)/Q

Valence Quark Region

$Q^2 = 5 \text{ GeV}^2$

$-\cdot-\cdot-$ NLO (94)

—— NLO

$---$ LO

u_v

g

d_v

$\bar{d}$

$\bar{u}$

s

X_bj>0.3

Semi Inclusive Deep Inelastic Scattering(SIDIS) Diagram

Fragmentation function

$$\frac{d^3\sigma^h_{1/2(3/2)}}{dx\,dQ^2\,dz} \approx \Sigma_q e_q^2 q^{+(-)}(x, Q^2) D_q^h(z, Q^2)$$

Semi Inclusive Double Spin Asymmetry

$$A_1^h = \frac{\sigma_{1/2}^h - \sigma_{3/2}^h}{\sigma_{1/2}^h + \sigma_{3/2}^h}$$

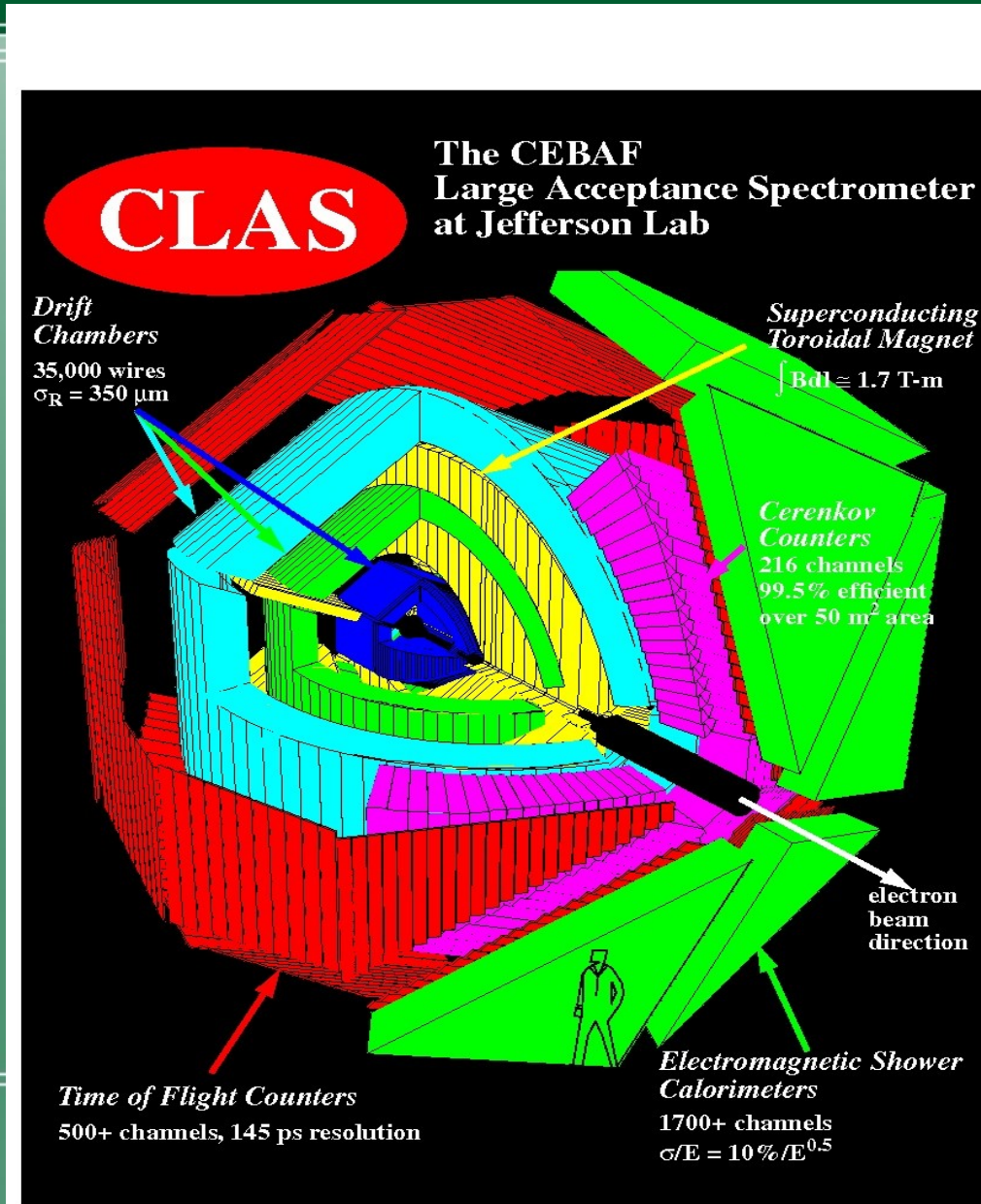$$A_{1,p}^{\pi^+ \pm \pi^-} = \frac{4\Delta u_v(x) \pm \Delta d_v(x)}{4 u_v(x) \pm d_v(x)}$$

$$A_{1,2H}^{\pi^+ \pm \pi^-} = \frac{\Delta u_v(x) + \Delta d_v(x)}{u_v(x) + d_v(x)}$$

Semi Inclusive deep inelastic scattering provides and opportunity to determine the struck quark flavor.

The CEBAF Large Acceptance Spectrometer at JLab

- Polarized electron beam
- Polarized targets
- Superconducting toroid magnet
- Drift chambers
- Cherenkov counter
- Electromagnetic calorimeter

CLAS

The CEBAF Large Acceptance Spectrometer at Jefferson Lab

Drift Chambers
35,000 wires
$\sigma_R \cong 350\ \mu m$

Superconducting Toroidal Magnet
$\int Bdl \cong 1.7$ T-m

Cerenkov Counters
216 channels
99.5% efficient over 50 m^2 area

electron beam direction

Time of Flight Counters
500+ channels, 145 ps resolution

Electromagnetic Shower Calorimeters
1700+ channels
$\sigma/E = 10\%/E^{0.5}$

Target Materials

- Frozen ammonia: the polarized proton and neutron

- For background elimination: C12, liquid Helium and Nitrogen

- Polarized using the Dynamic Nuclear Polarization(DNP) Method

- ~96% and ~46% polarization for the proton and neutron targets
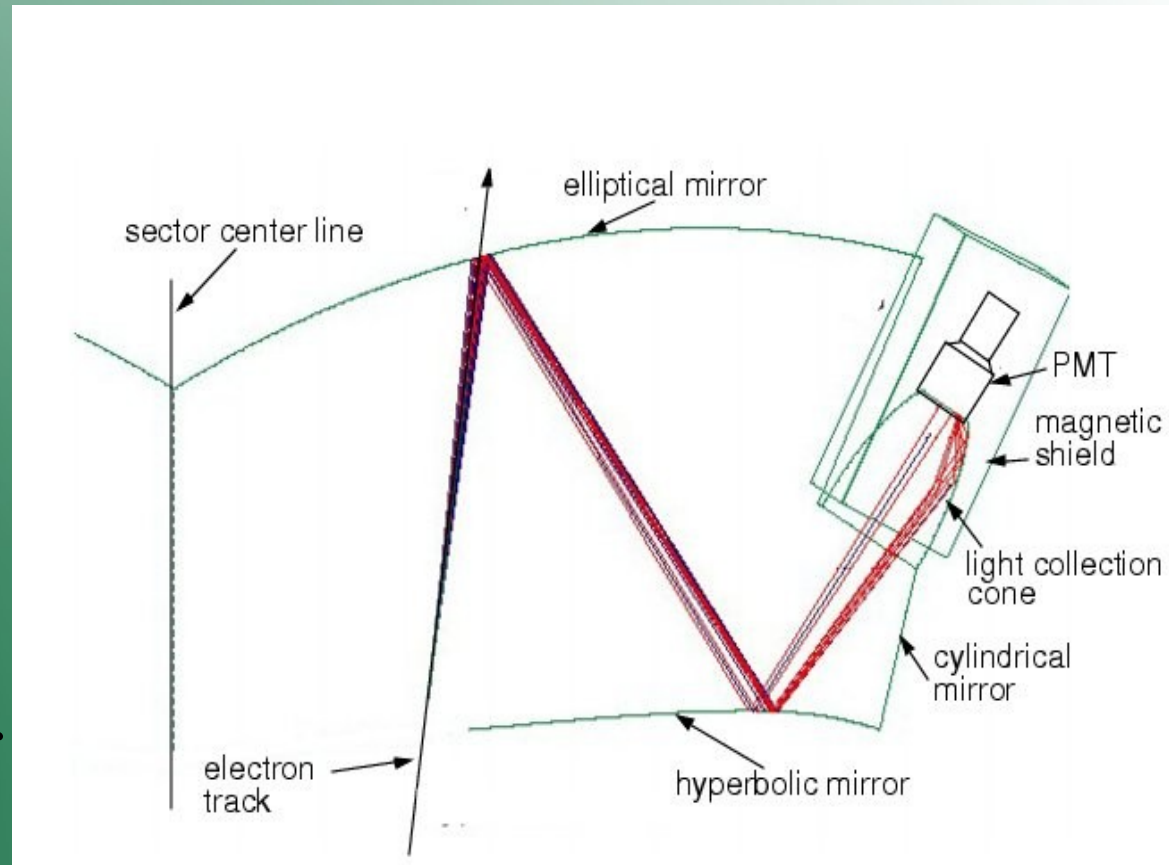
Y. Prok, PhD Thesis, University of Virginia(2004)

Drift Chambers

- The trajectory of the charged particle and momentum

- Three regions

- $ArCO_2$ (90/10%) - gas mixture

- The drift time and drift velocity
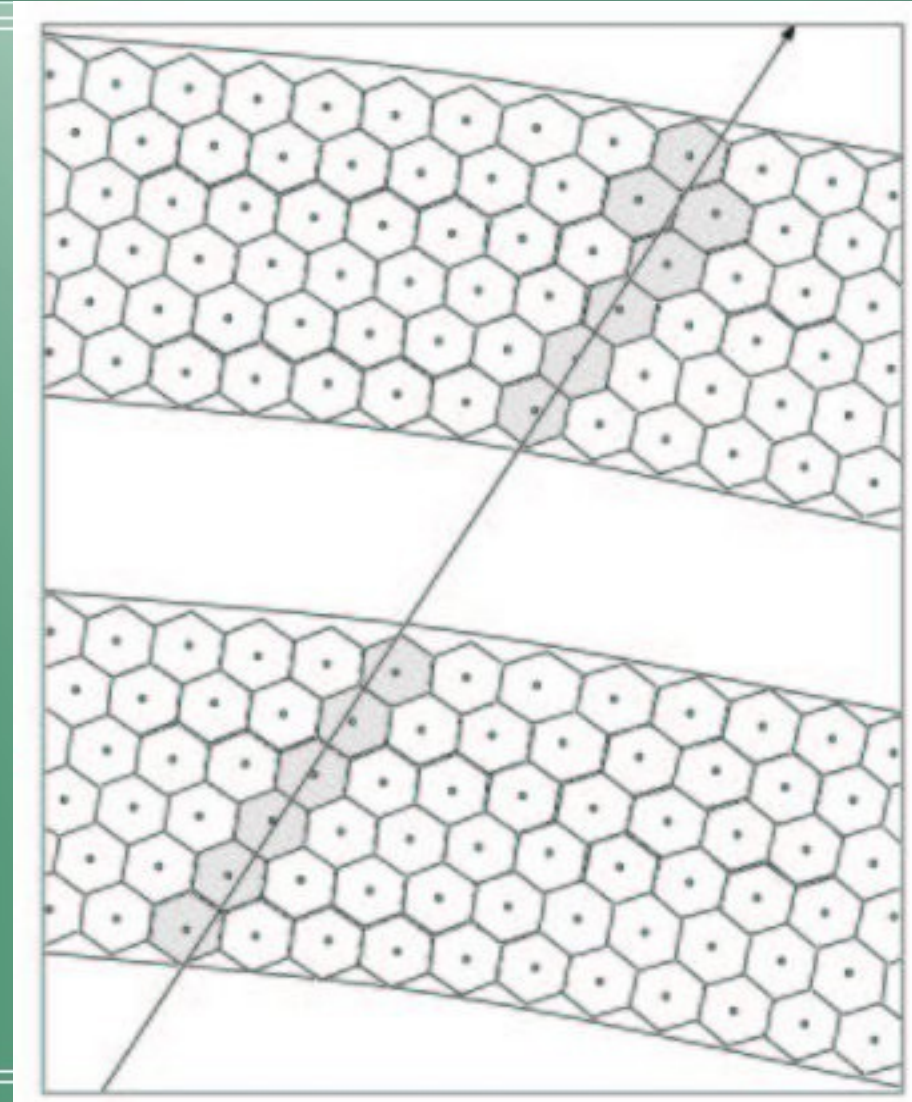
Cherenkov Detector

- The threshold detector

- Differentiate electrons from pions

- Gas – C_4F_{10} (n=1.00153, high photon yield)

- Thresholds: 9 MeV for electrons and 2.5 GeV for pions

The CLAS TOF Scintillators

- 288 scintillators

- The time of flight for charged particle

- Coincidence for charged particles

- 120ps – 250ps time resolution

- 30 cm to 450 cm long
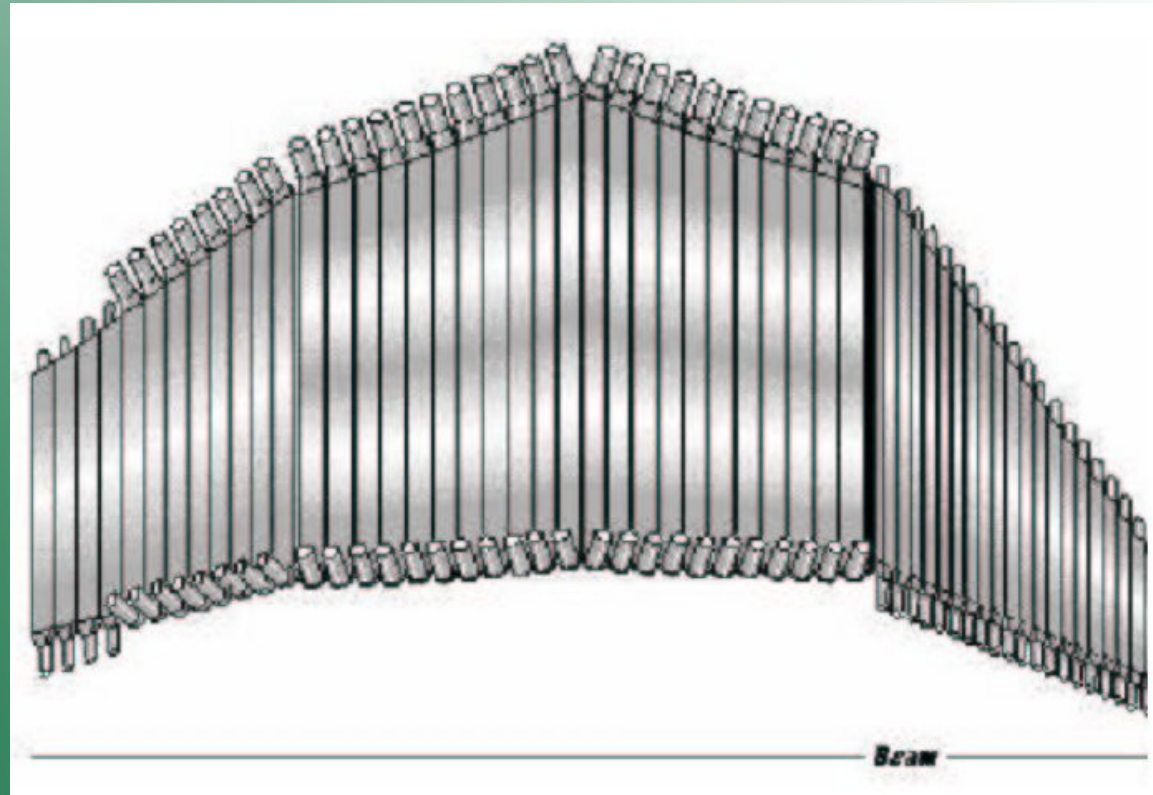
The CLAS Calorimeter

- 8 electromagnetic calorimeter modules

- Measures the total energy deposited by the crossing particle

- Neutron detection, efficiency>50% for E_n>0.5GeV

- Electron detection above 0.5 GeV

- Photon detection above 0.2 GeV

M. Amarian. e*t al., Nucl. Instr. And Meth.* **A460,** 239(2001)
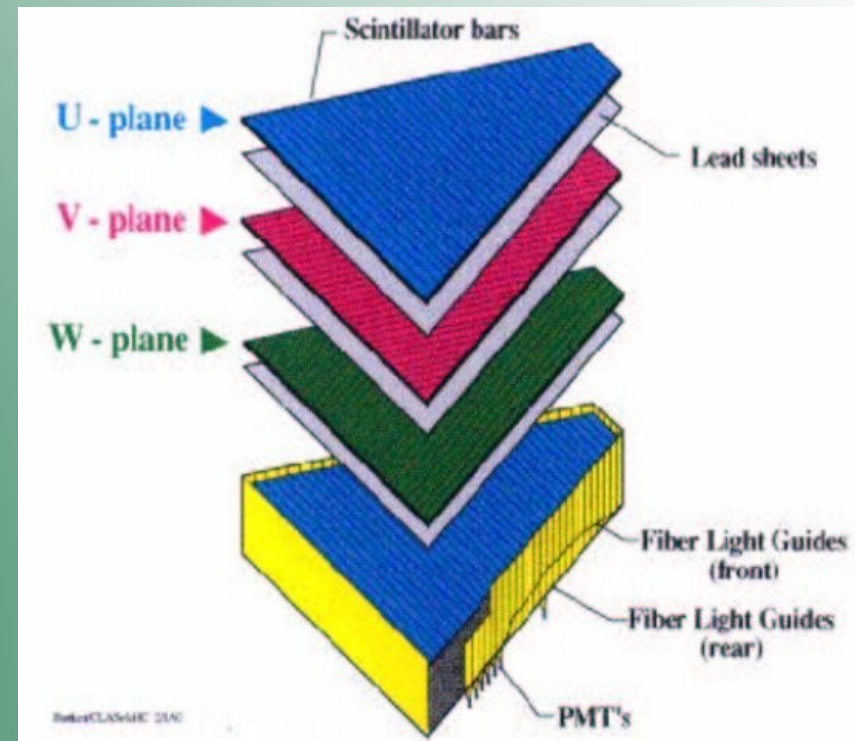
Kinematics of single pion electroproduction

- The virtual photon negative four-momentum transferred squared

- Invariant mass of the photon-nucleon system

- The polar angle of the outgoing pion in CMF

- The azimuthal angle of the outgoing pion in CMF
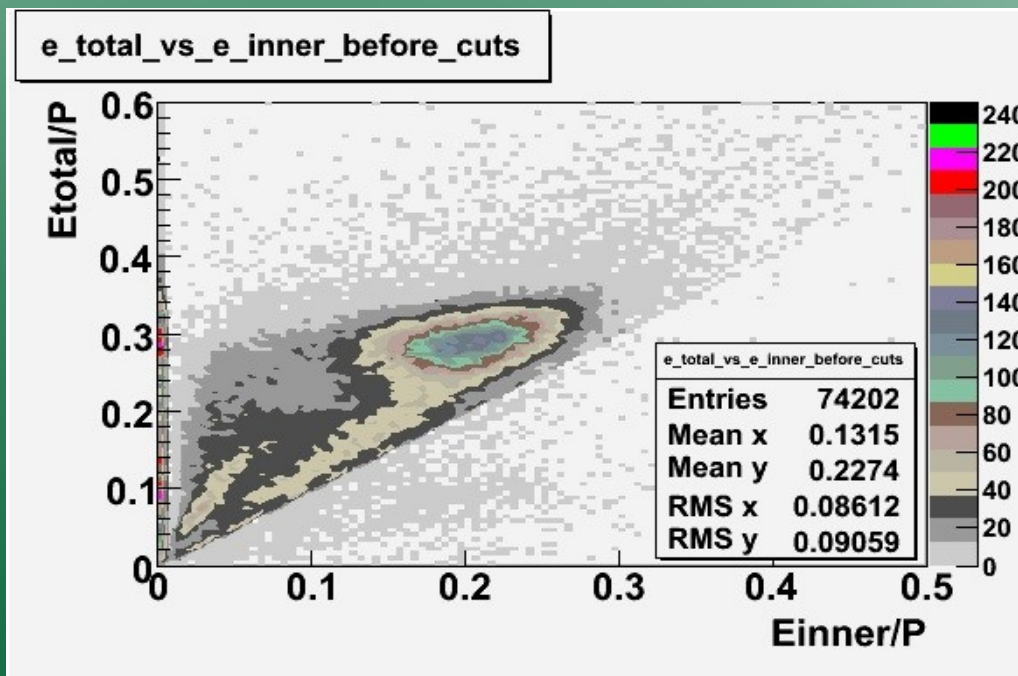
- The scattered electron angle
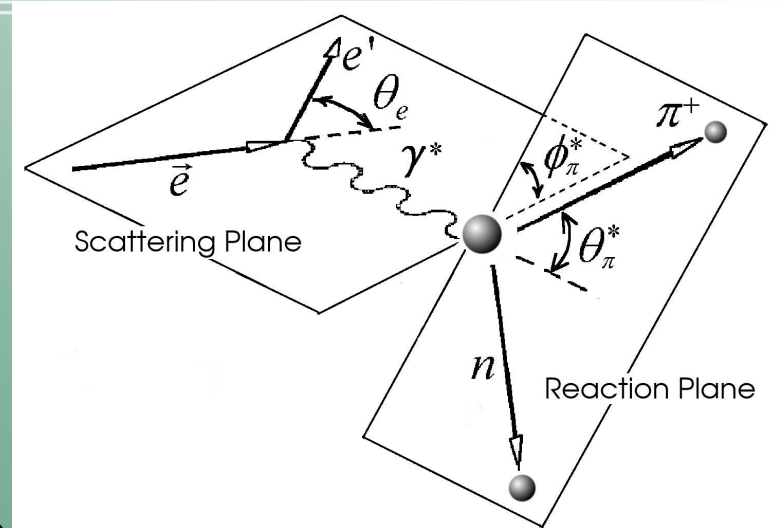
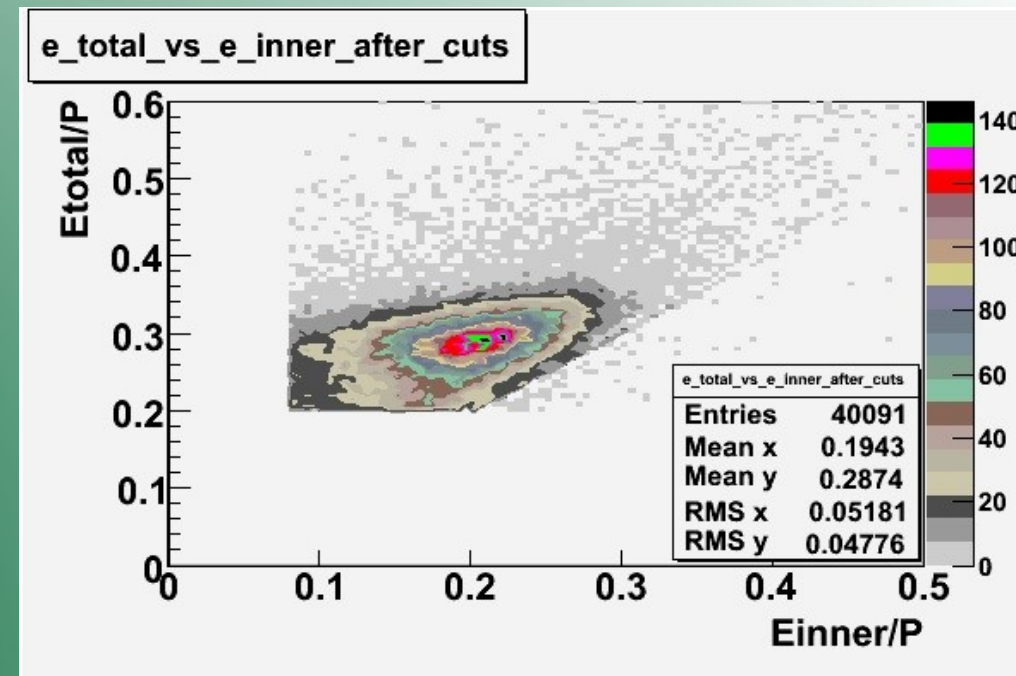$$\frac{d(W,Q^2)}{d(E_f,cos\theta_e)} = \frac{2M_pE_iE_f}{W}$$

$$\frac{\partial^5\sigma}{\partial E_f\partial\Omega_e\partial\Omega_\pi{}^*} = \frac{1}{2\pi}\Sigma\frac{1}{L_{int}A_{cc}\epsilon_{CC}\Delta W\,\Delta Q^2\Delta cos\theta_\pi{}^*\Delta\phi_\pi{}^*}\frac{d(W,Q^2)}{d(E_f,cos\theta_e)}$$

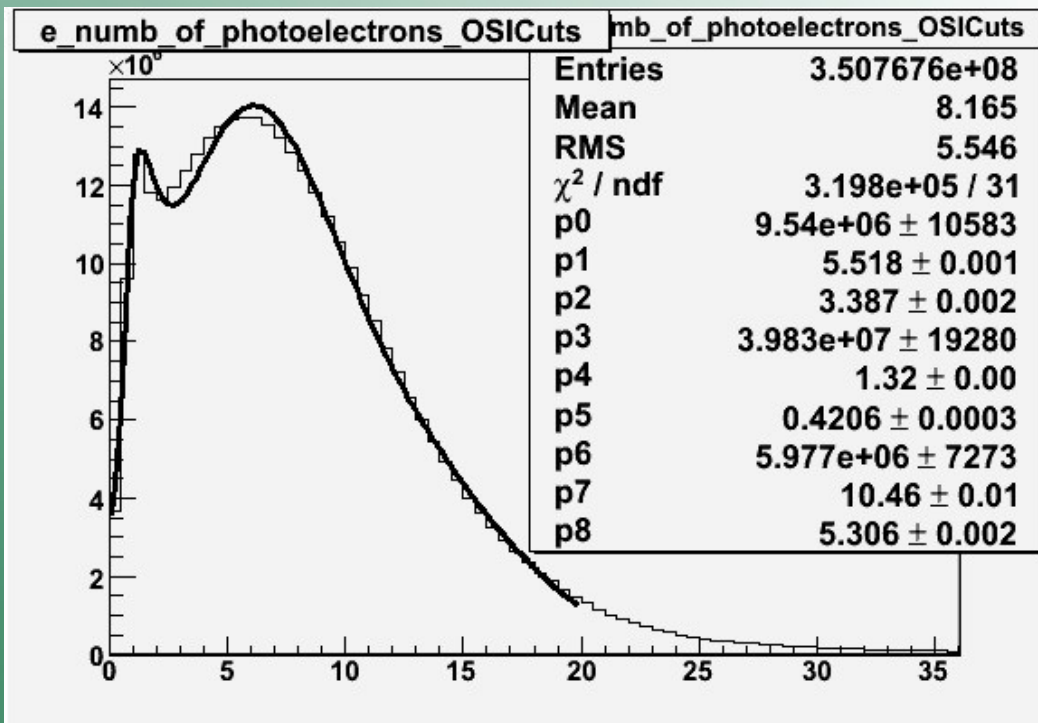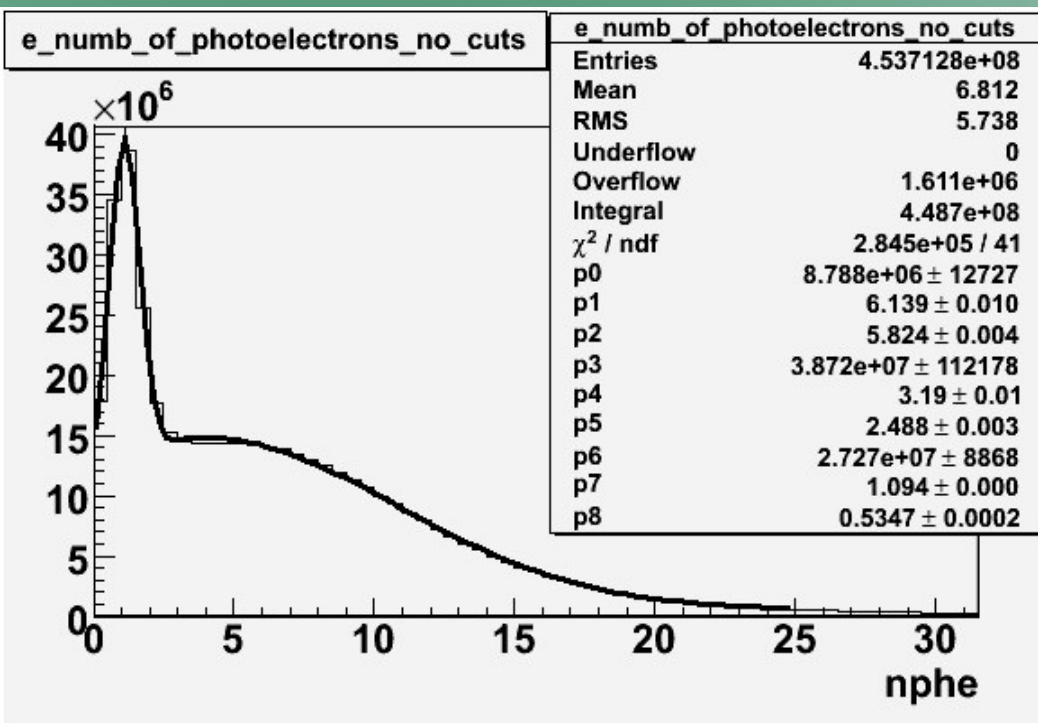# Particle Identification Using Electromagnetic calorimeter

After EC Cuts

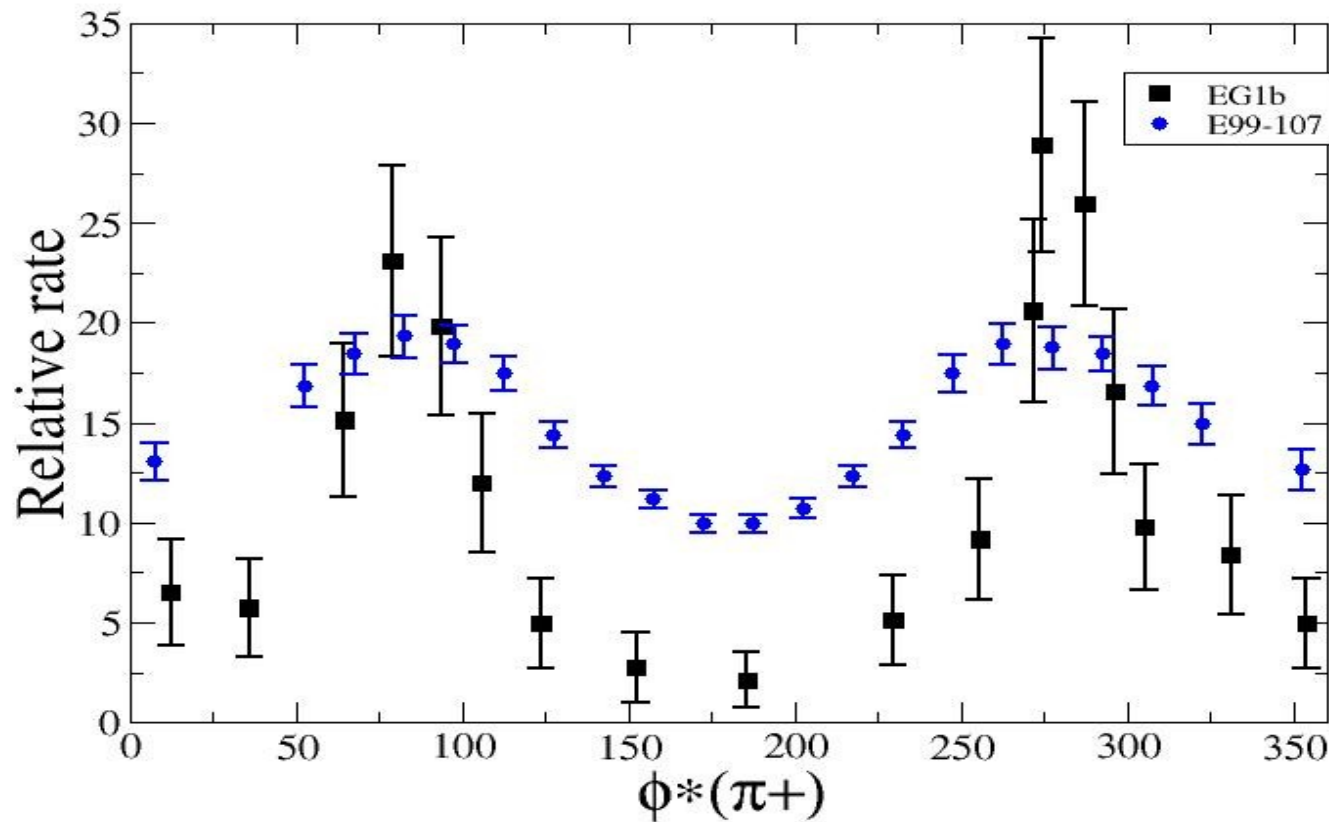Cuts on the energy deposited in the electromagnetic calorimeter (ECtotal>0.2*p and ECinner>0.06*p)

Pion Removal From The Electron Sample Using Cherenkov Counter

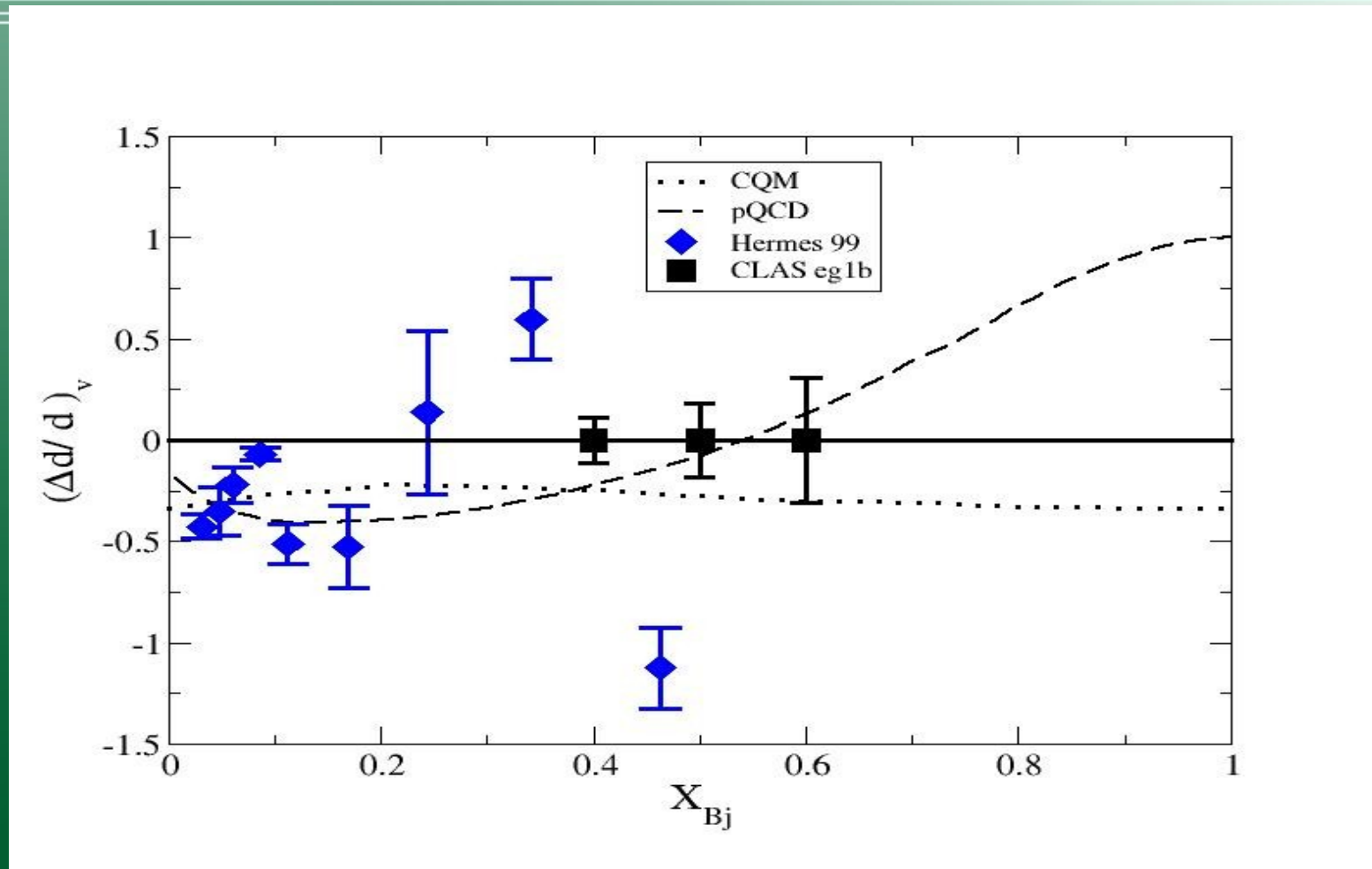The pion contamination in electron sample is ~ 9.6 %, and for NPHE>2.5 ~ 4.03 %

Data Comparison

φ_π^* vs Relative rate for fixed $\cos\theta_{pion}^{CM} = 0.5$ and $W = 1.45G$

K. Park. (The CLAS Collaboration). *Phys. Rev.*, **C77**, 015208 (2008).

The Expected Precision of This Analysis

The ratio of polarized to unpolarized valence down quark distribution function vs Xbj

Future Plans

- Measure asymmetries using the knowledge of the probe and target's polarization state

- The double spin asymmetries

- About three data points will be extracted from this analysis