Quark Spin in The Nucleon

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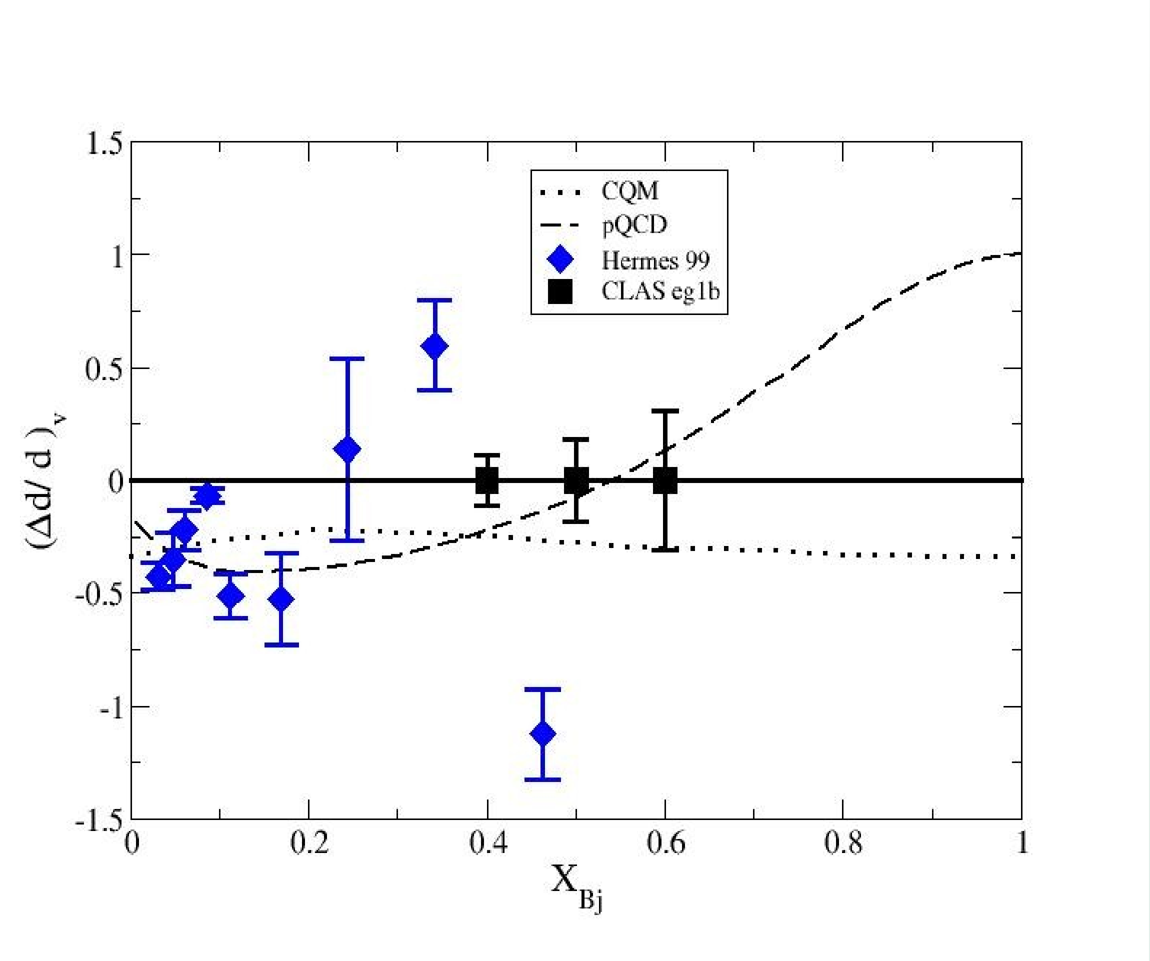
Outline

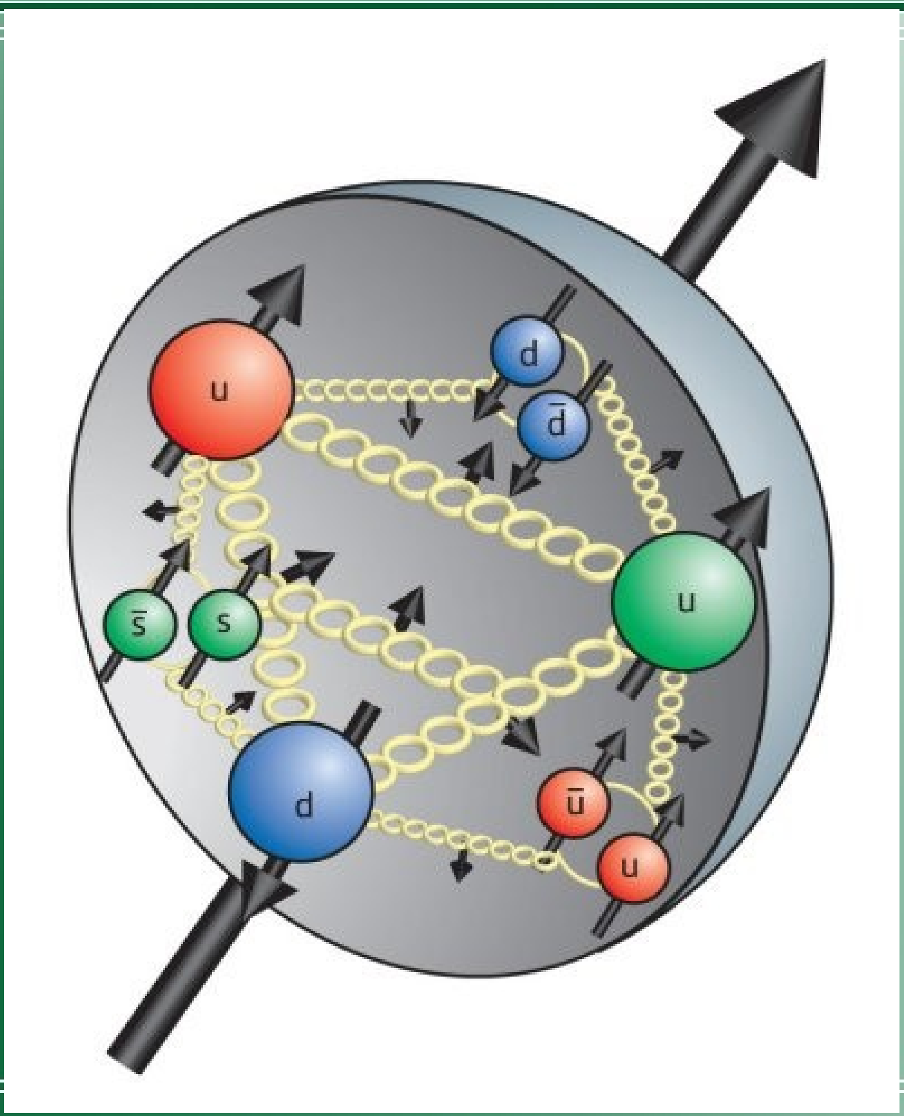
- Motivation
- Physics
- Experimental Setup
- Preliminary Results
- Detector Work in LDS

Motivation

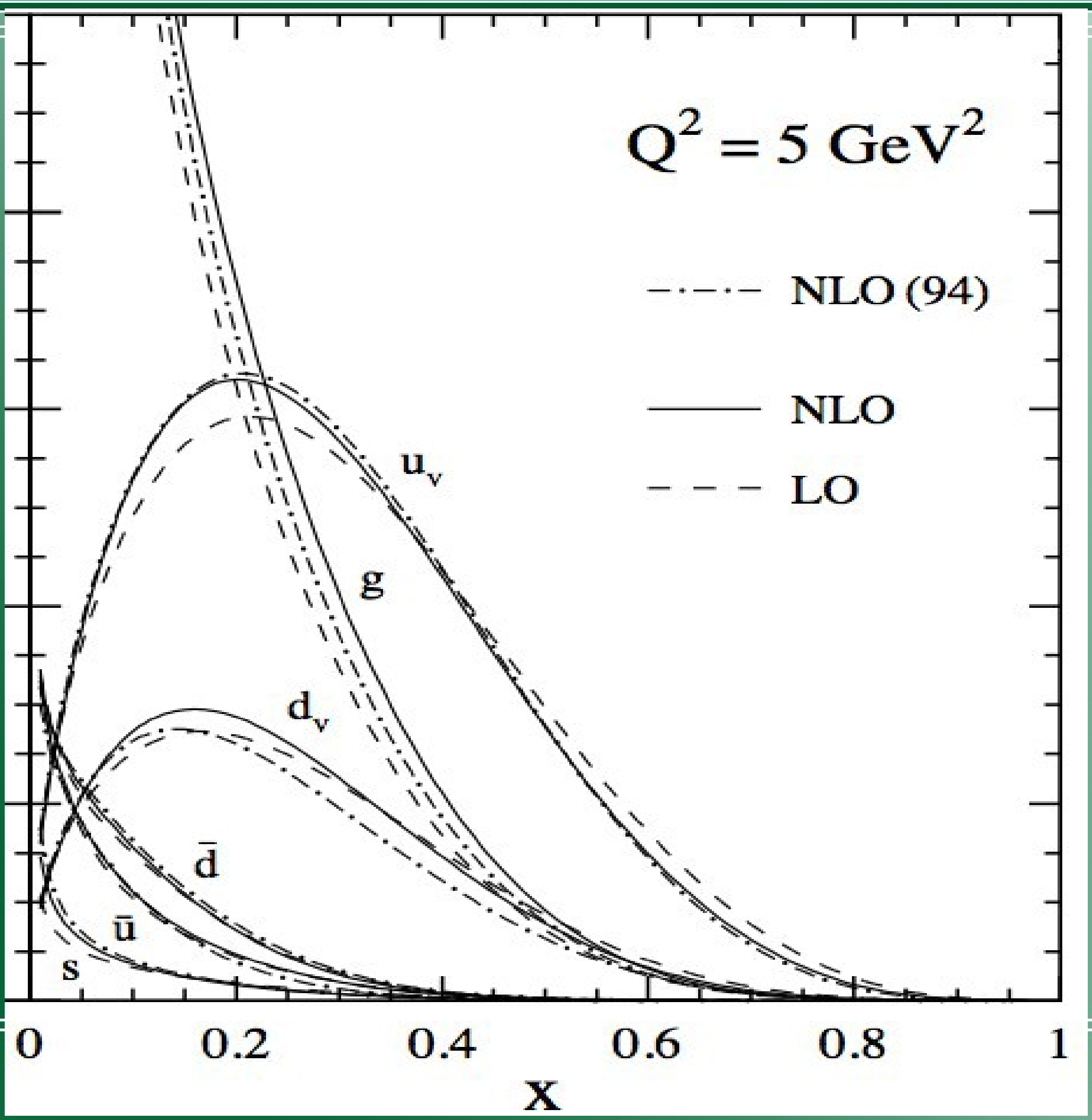
- "The proton spin crisis"
- Semi-Inclusive Double Spin Asymmetry Measurement
- Extraction of ($\Delta d/d$) observable
- The perturbative Quantum Chromodynamics(pQCD) vs the hyperfine perturbed Constituent Quark Model(CQM)



Quarks Inside the Nucleon

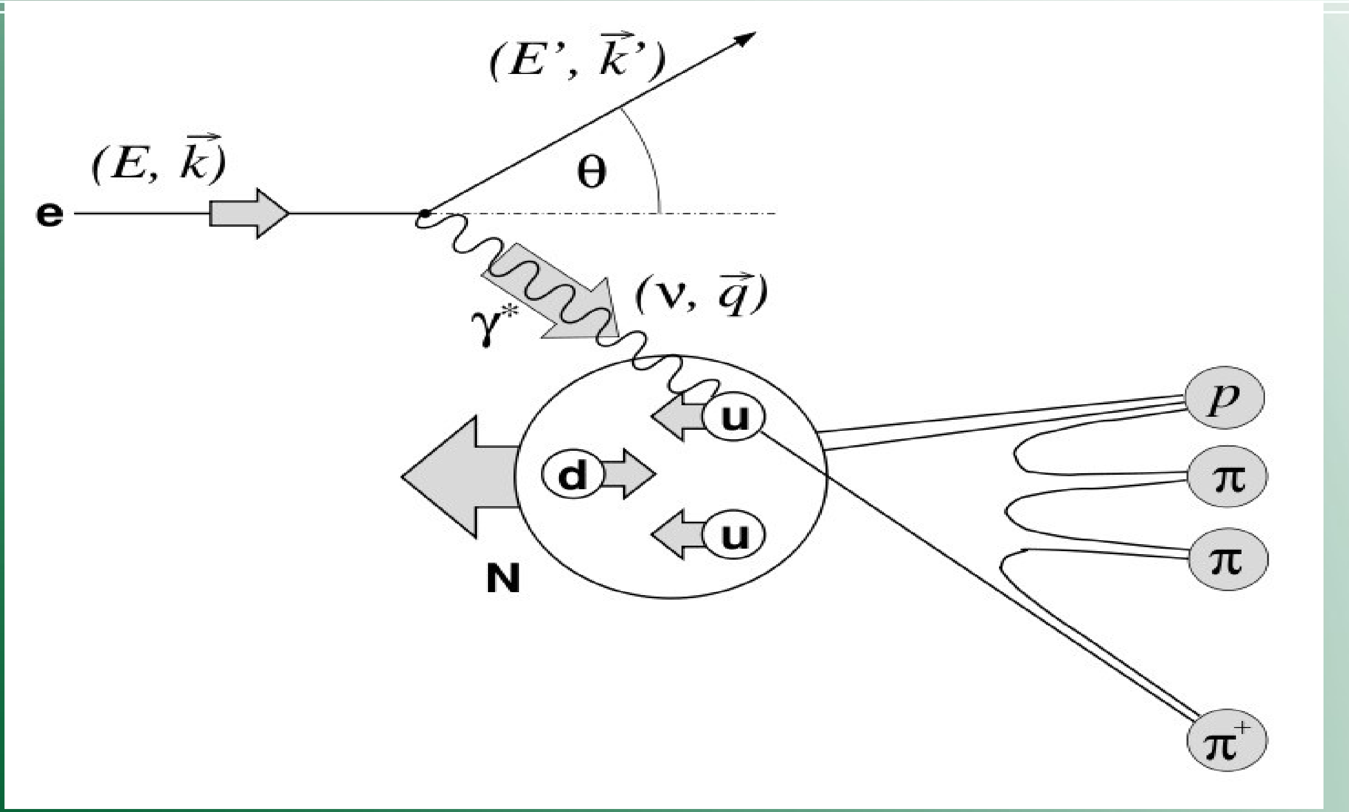


Valence Quark Region



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

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

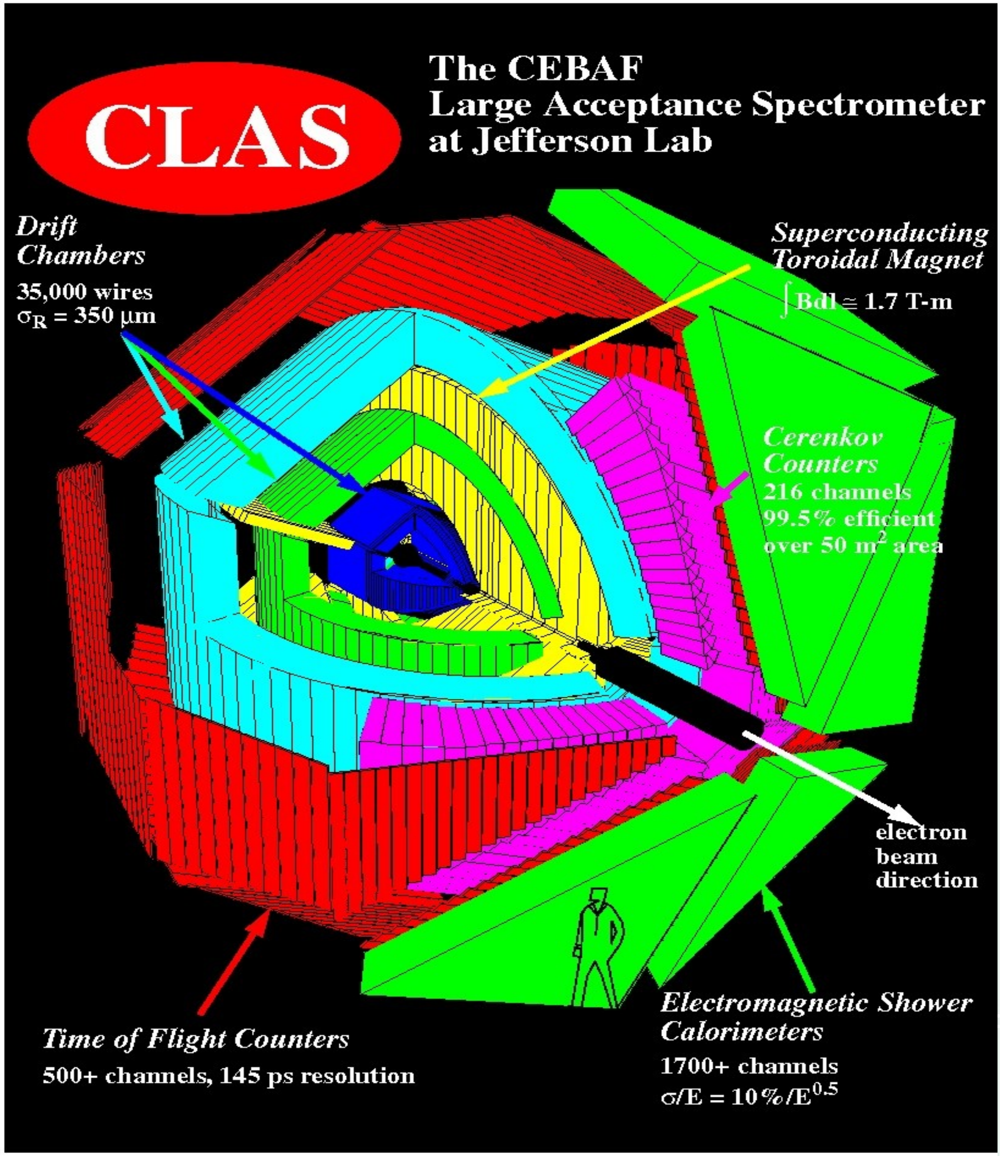
$$A_{1,p}^{\pi^+ \pm \pi^-} = \frac{4\Delta u_v(x) \pm \Delta d_v(x)}{4u_v(x) \pm d_v(x)}$$

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

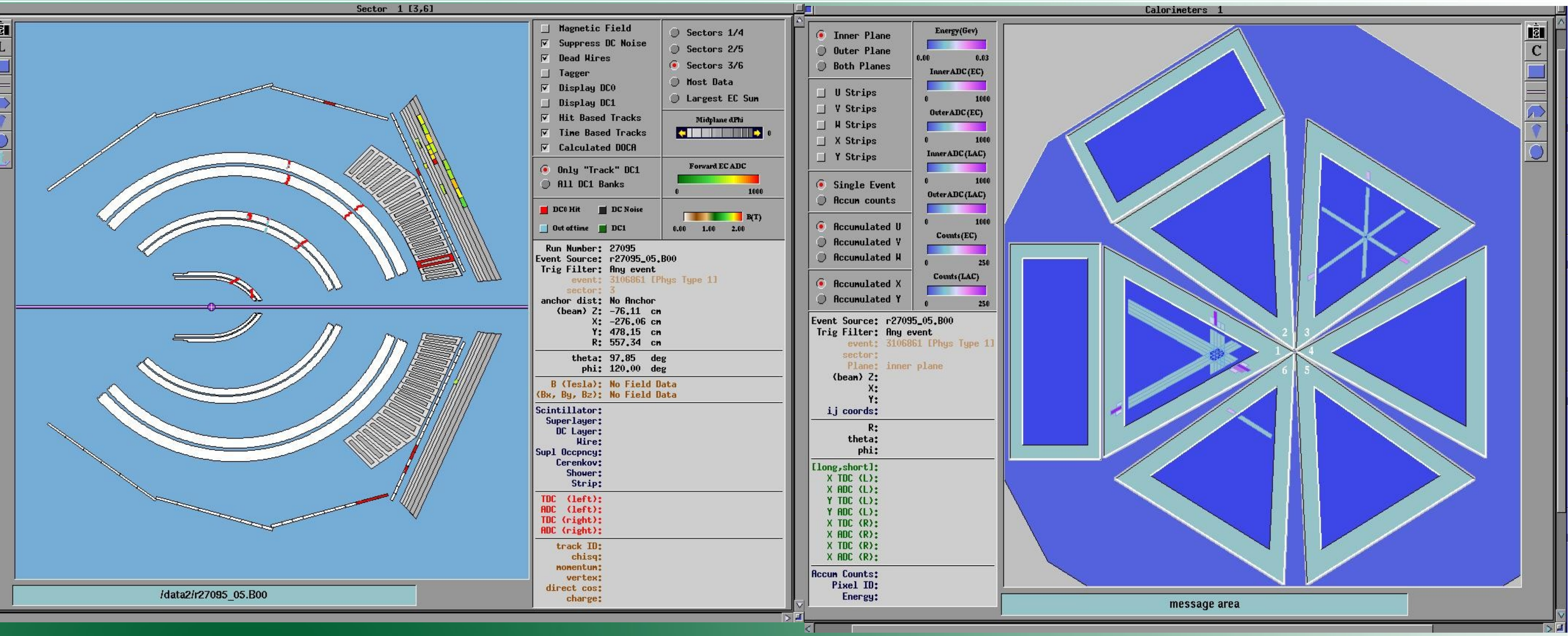
Semi Inclusive deep inelastic scattering provides and opportunity to determine the struck quark flavor.

The CEBAF Large Acceptance Spectrometer at JLab

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



Event Display



NH3 Target, inbending , 5.7 GeV beam energy

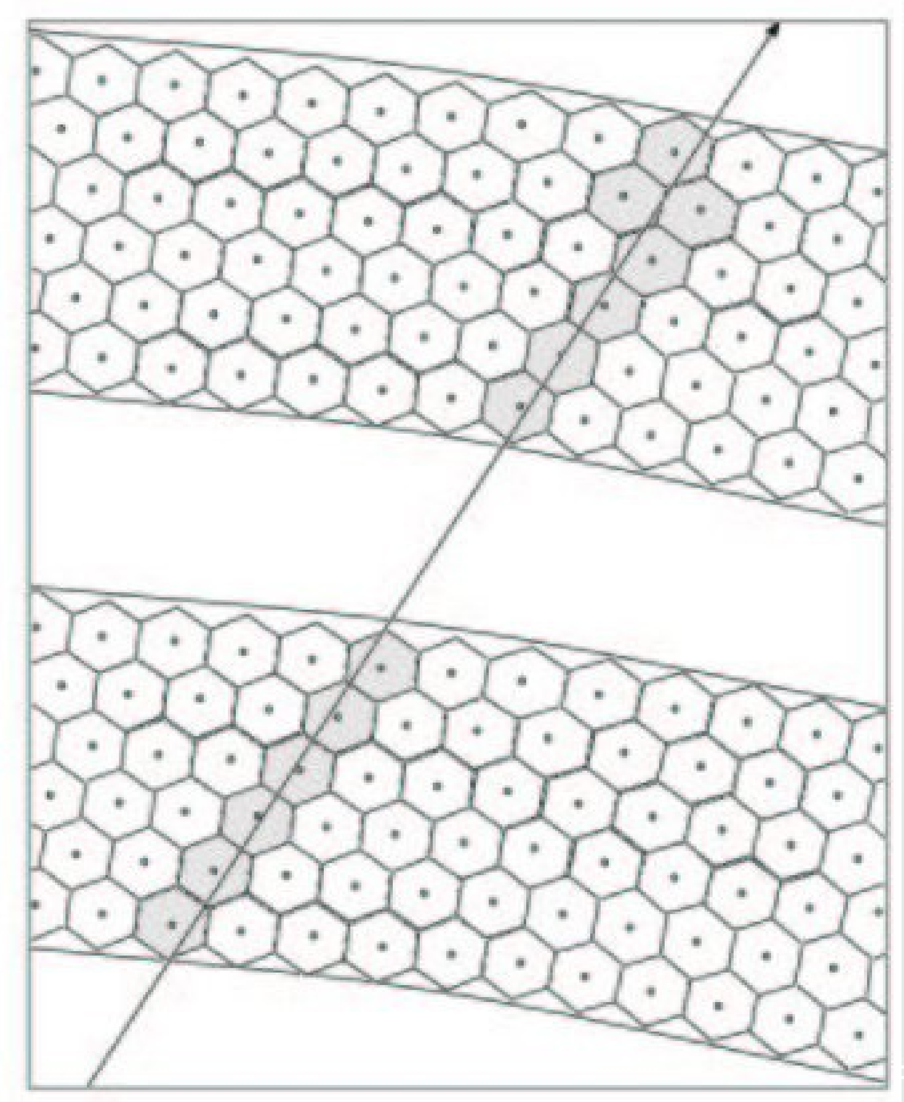
Target Materials

- 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)

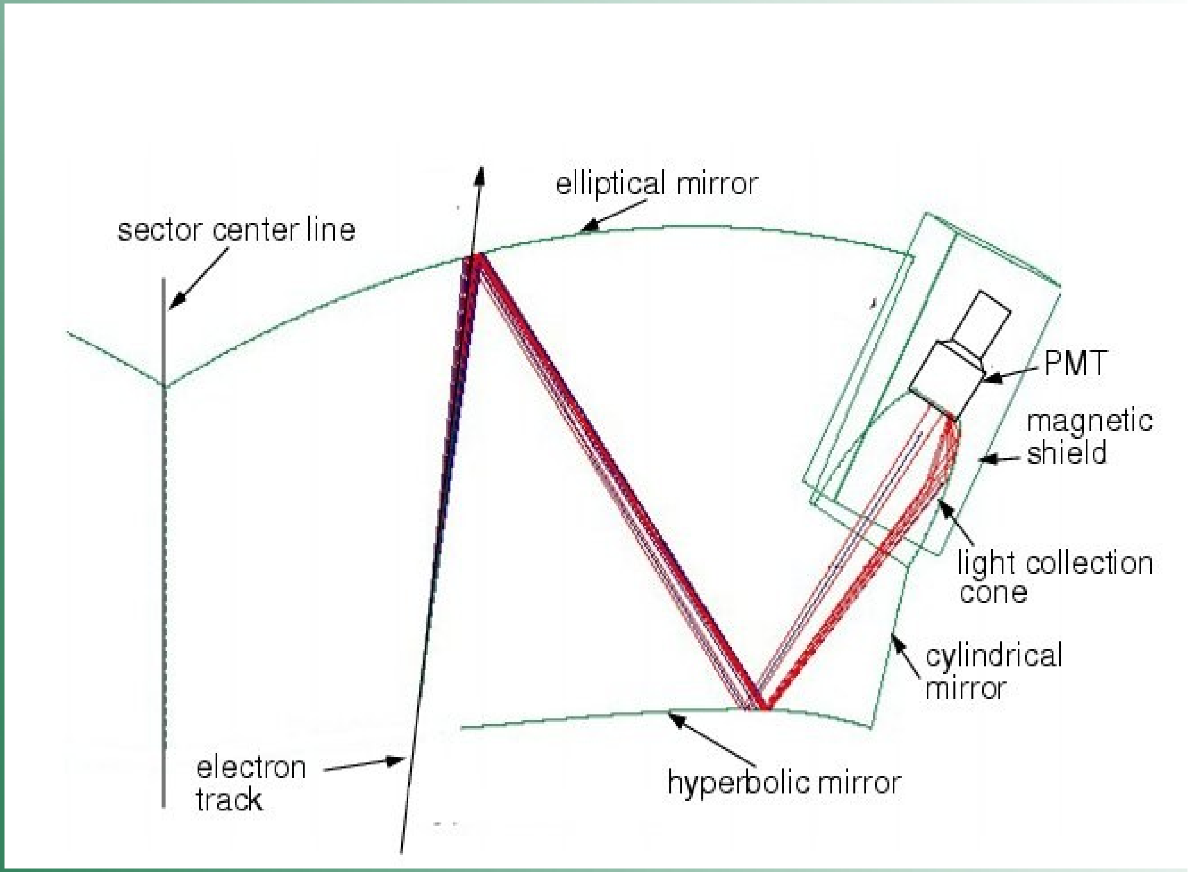
Drift Chambers

- The trajectory of the charged particle and momentum
- Three regions
- $ArCO_2$ (90/10%) - gas mixture
- The drift time and drift velocity



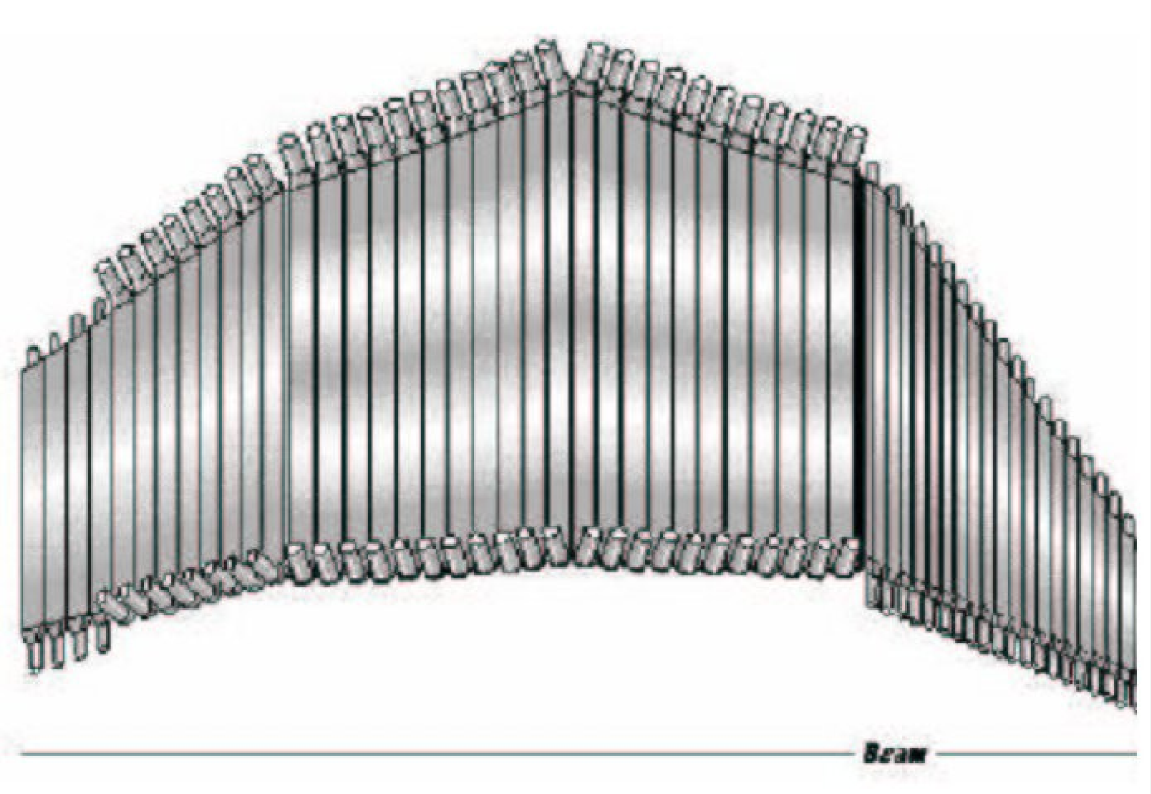
Cherenkov Detector

- 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



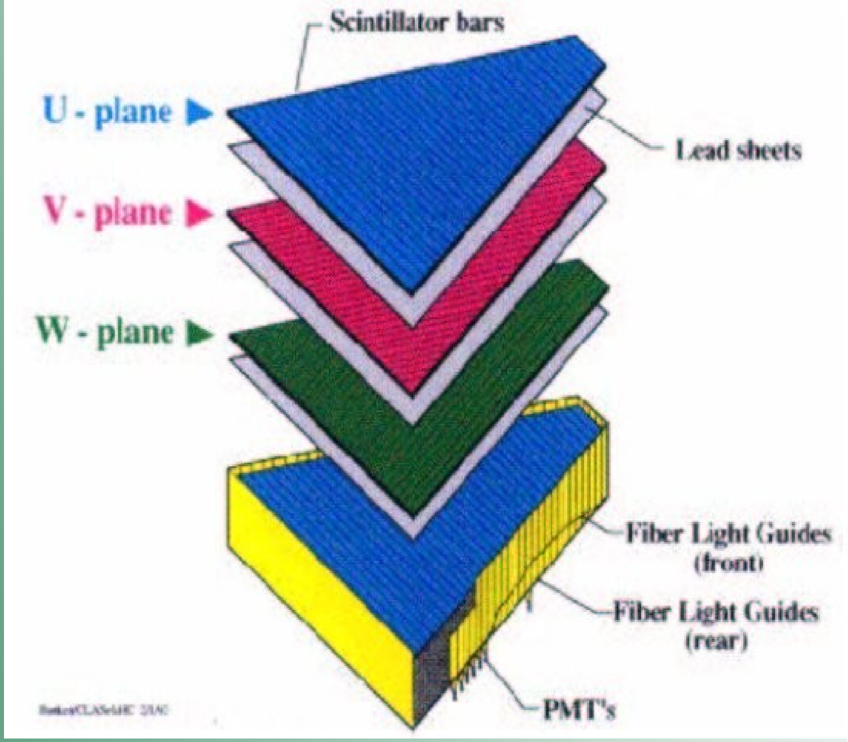
The CLAS TOF Scintillators

- 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

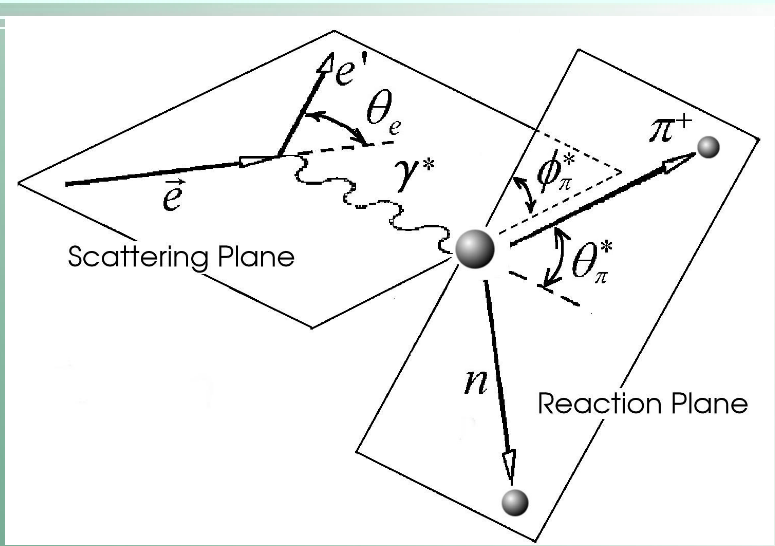
- 8 electromagnetic calorimeter modules
- Measures the total energy deposited by the crossing particle
- Neutron detection, efficiency>50% for E_n>0.5GeV
- Electron detection above 0.5 GeV
- Photon detection above 0.2 GeV



M. Amarian. e*t al., Nucl. Instr. And Meth.* **A460,** 239(2001)

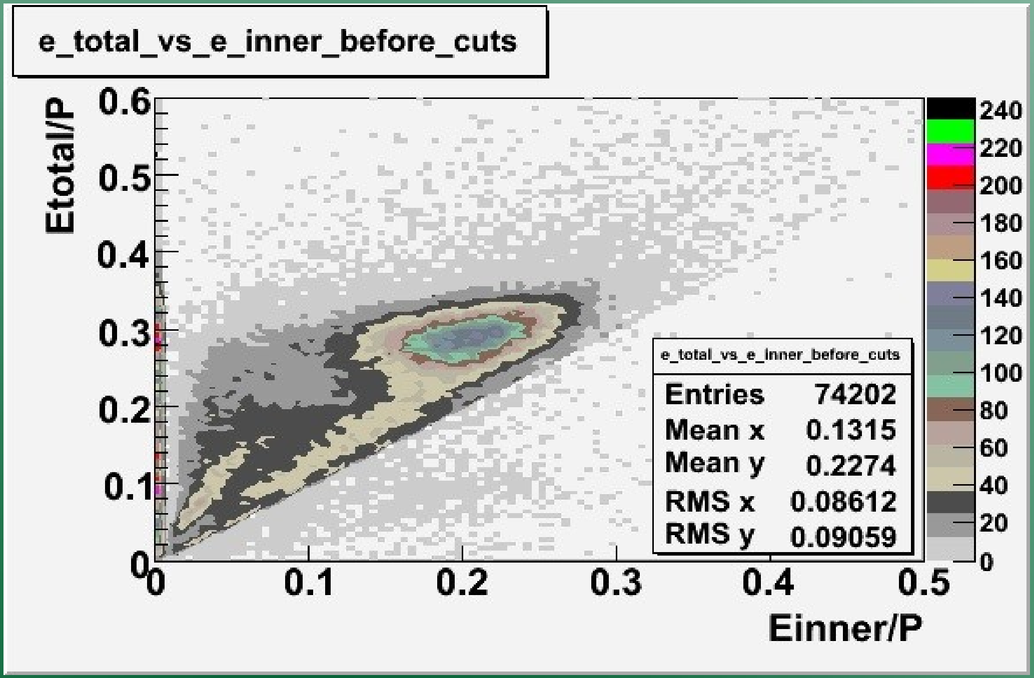
Kinematics of the exclusive single pion electroproduction

- 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

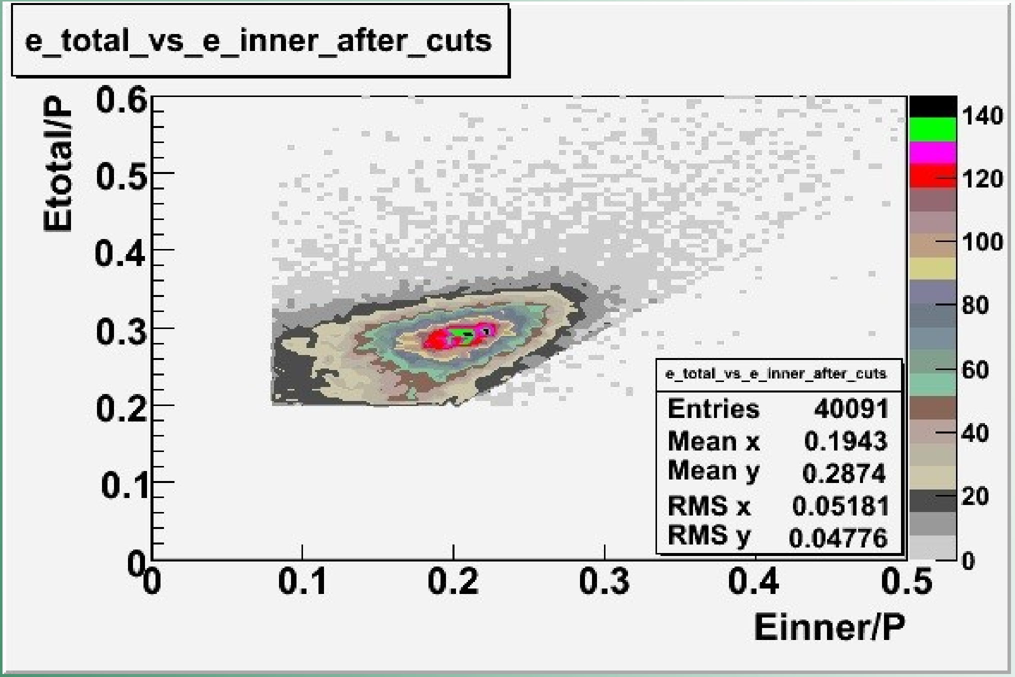


Particle Identification Using Electromagnetic calorimeter

Before EC Cuts

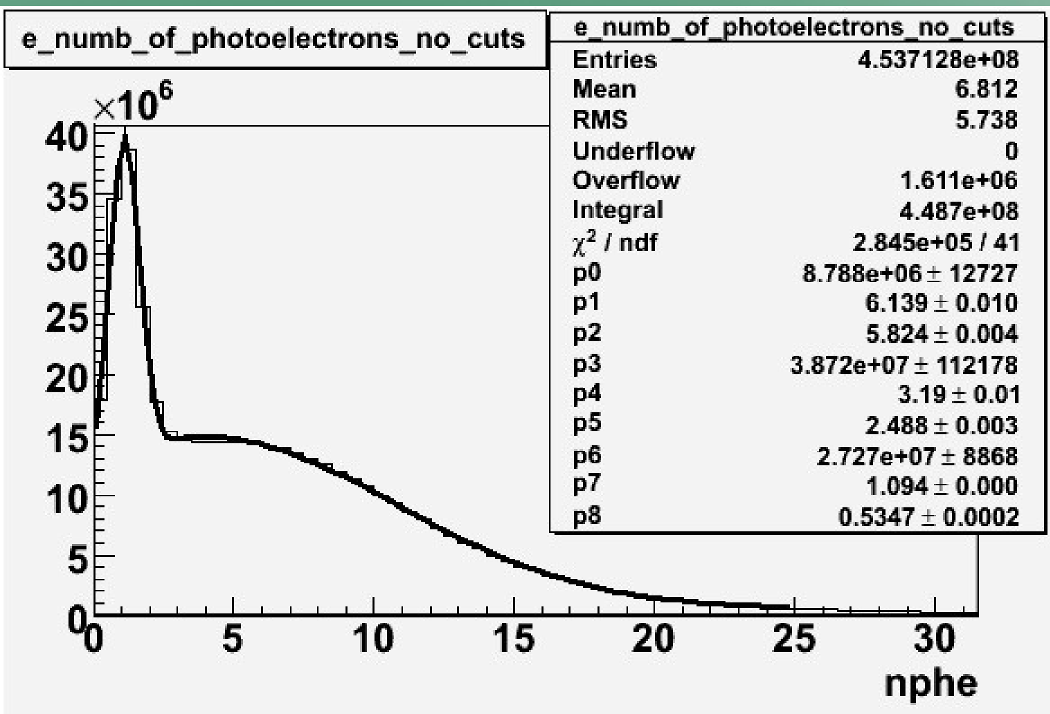


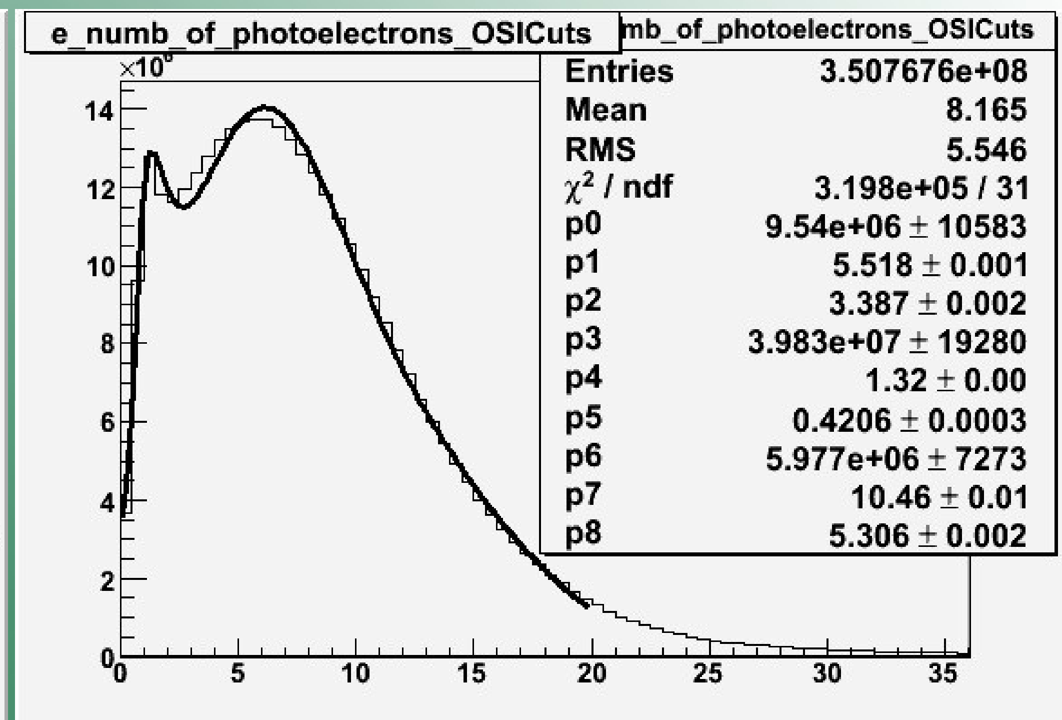
After EC Cuts



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

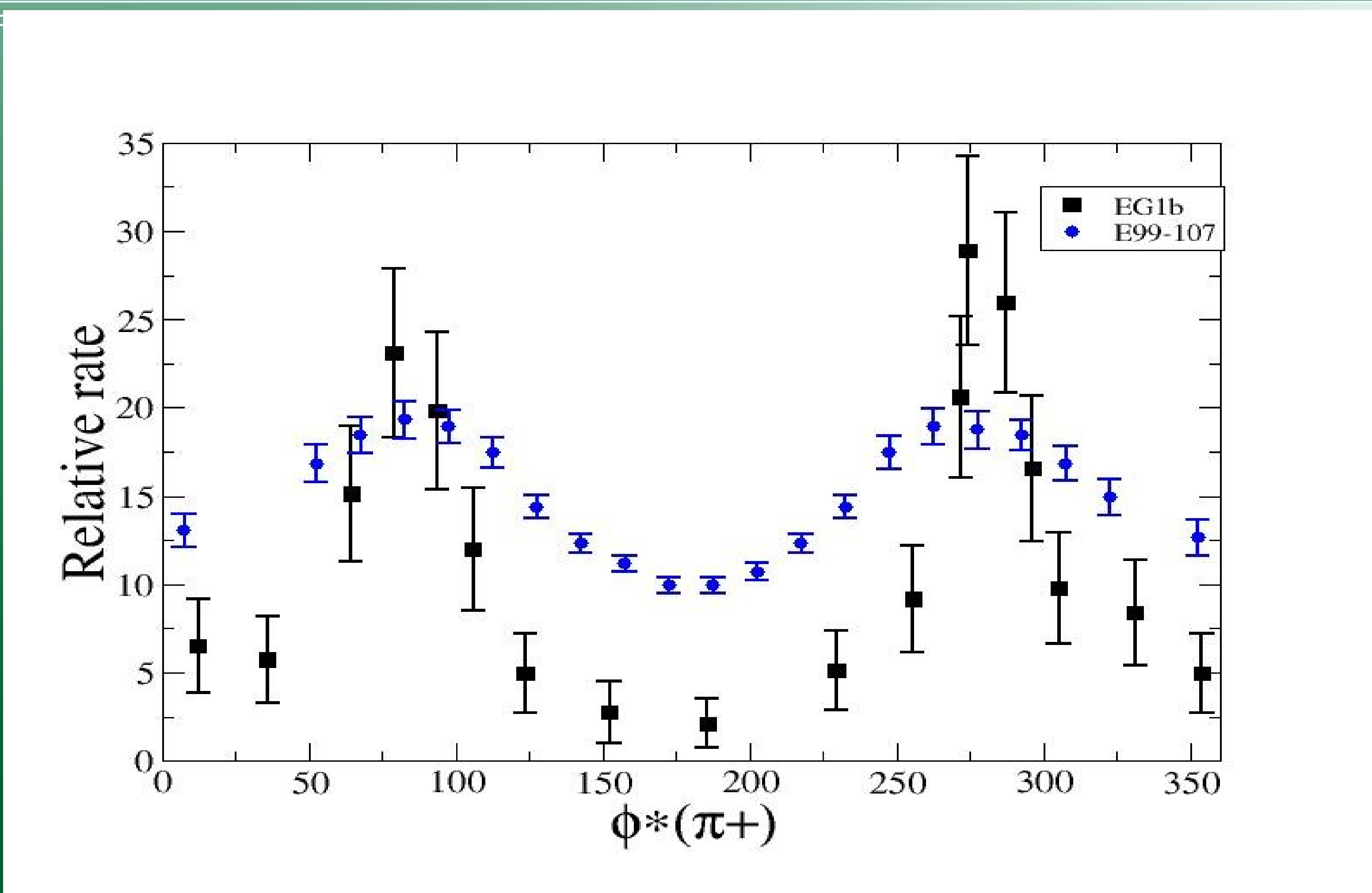
Pion Removal From The Electron Sample Using Cherenkov Counter





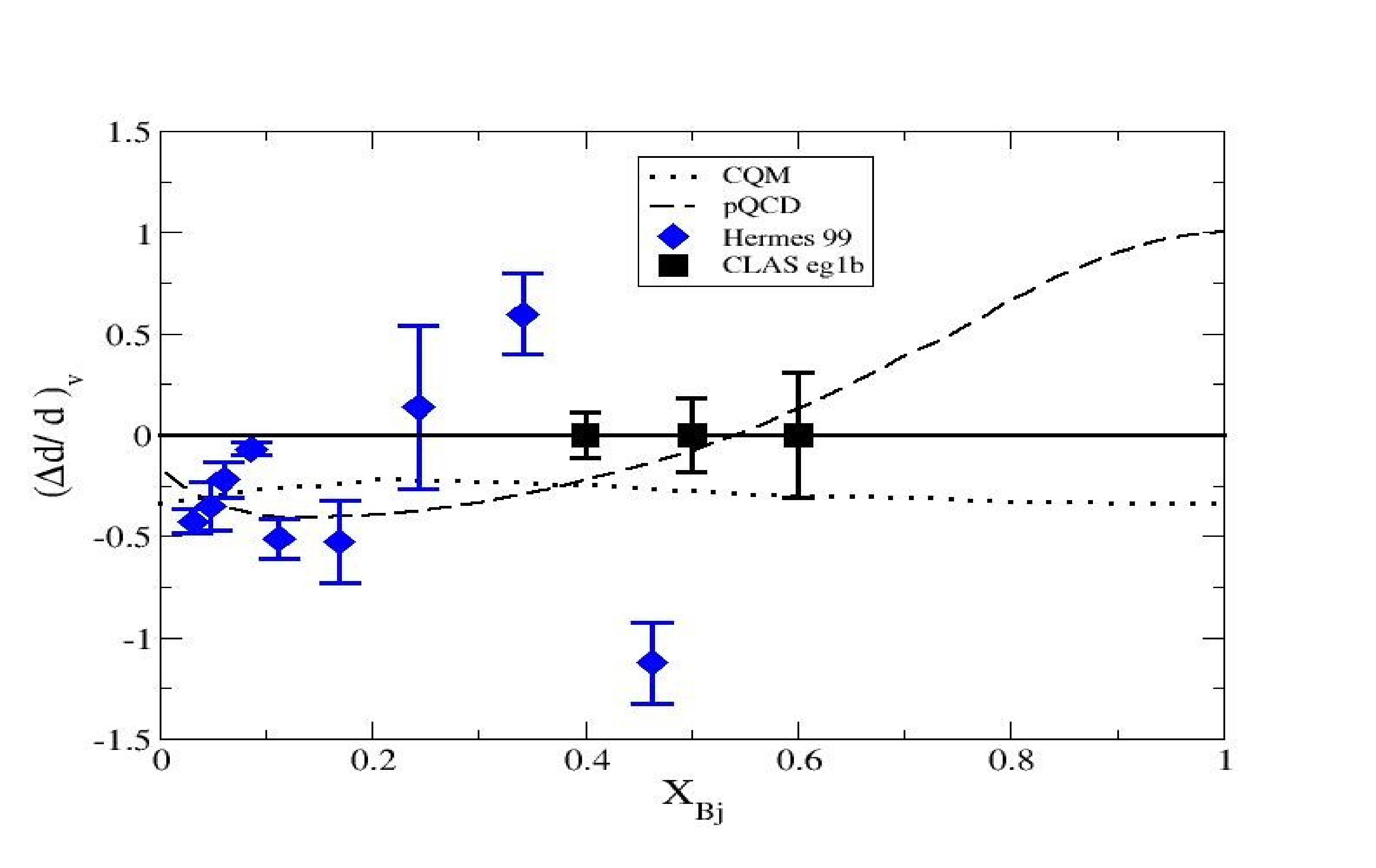
The pion contamination in electron sample is ~ 9.6 %, and for NPHE>2.5 ~ 4.03 %

Data Comparison



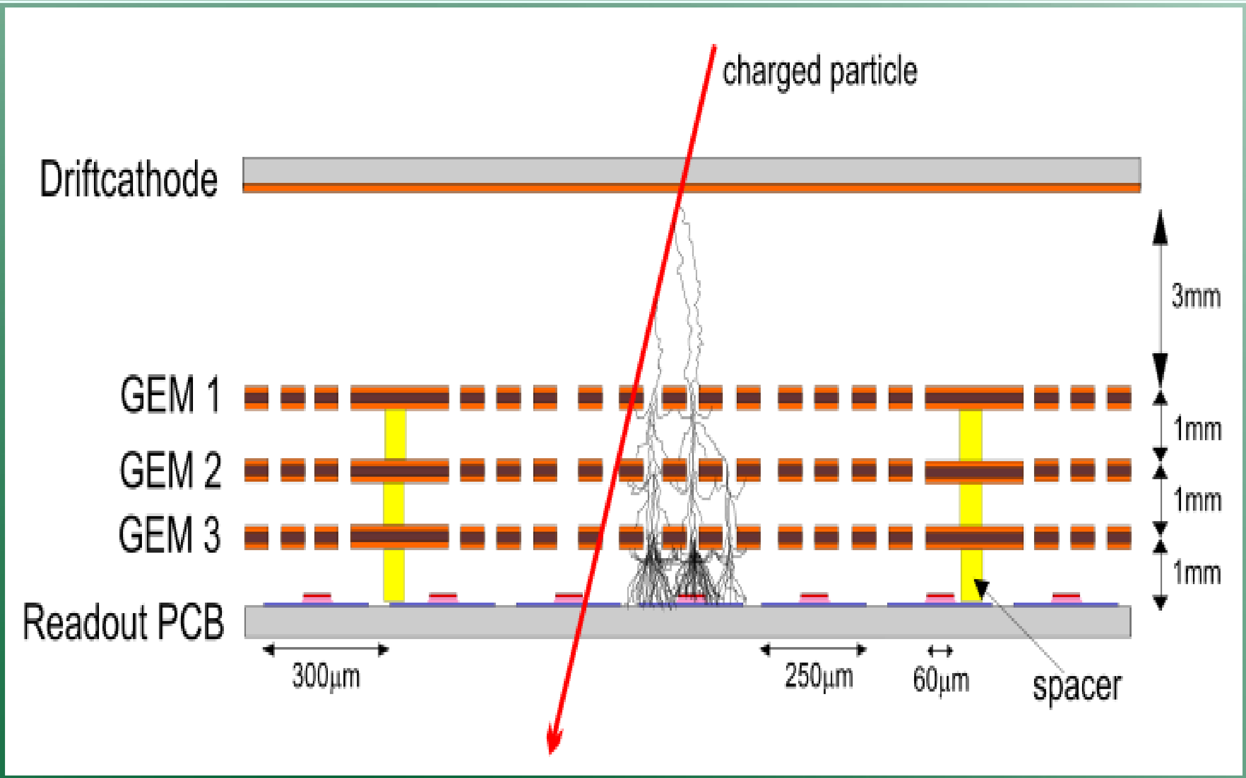
K. Park. (The CLAS Collaboration). *Phys. Rev.*, **C77**, 015208 (2008).

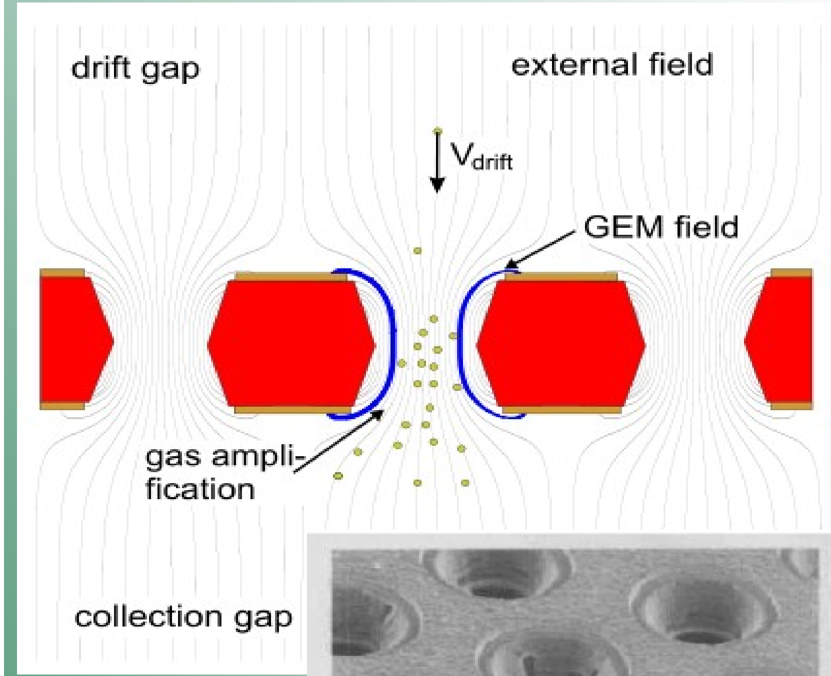
The Expected Precision of This Analysis

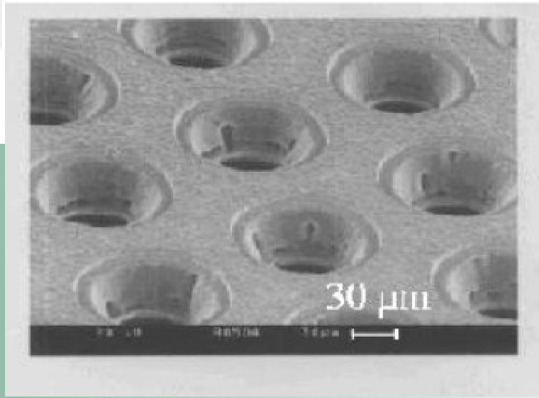


The ratio of polarized to unpolarized valence down quark distribution function vs Xbj

GEM Physics

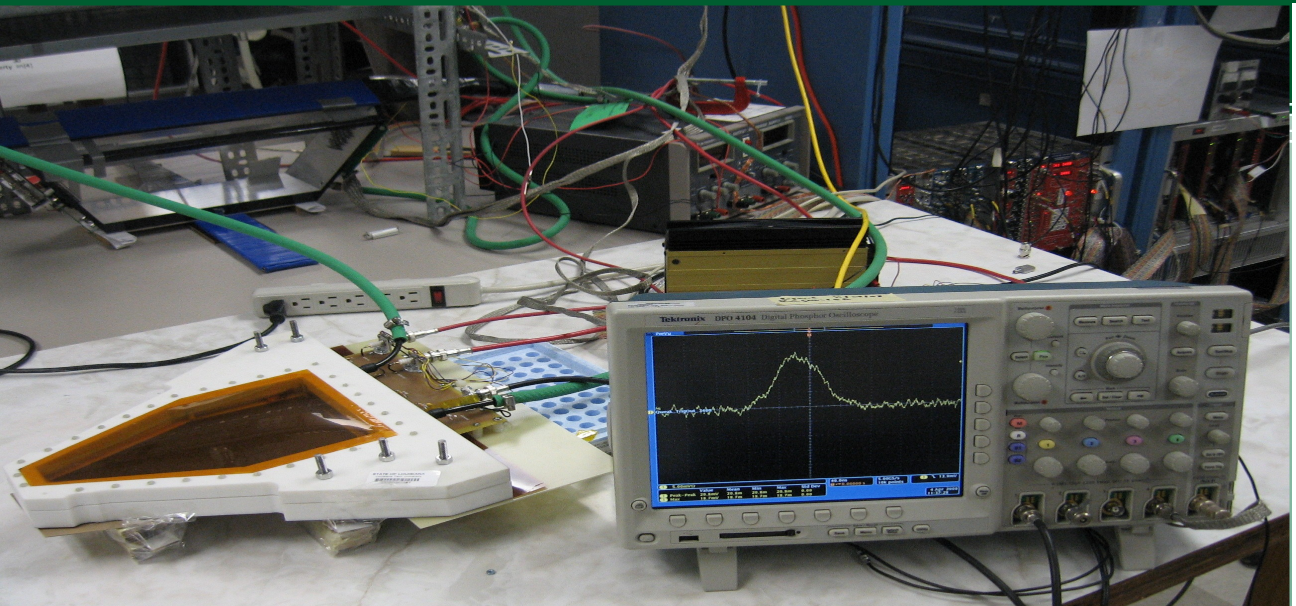


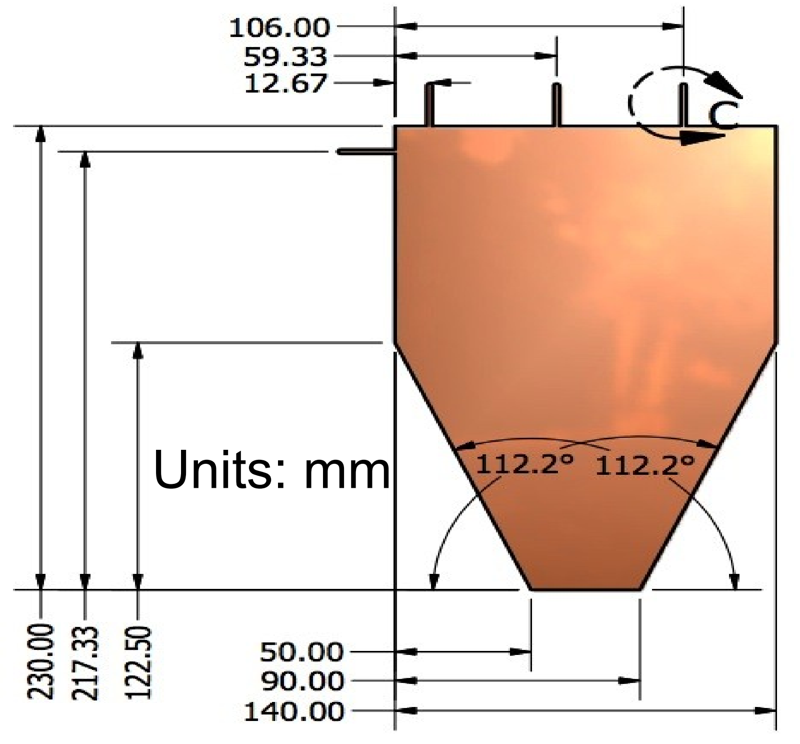


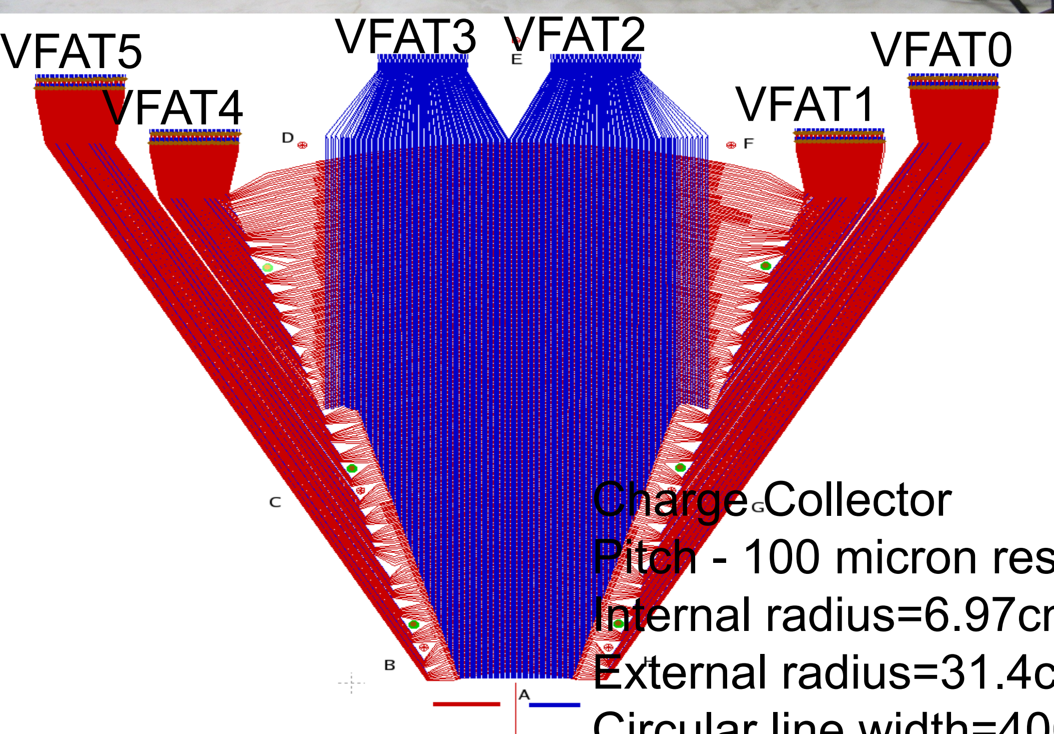


M. Ziegler, Ph.D Thesis, Development of a Triple GEM Detector for the LHCb Experiment(2002)

Qweak GEM Detector



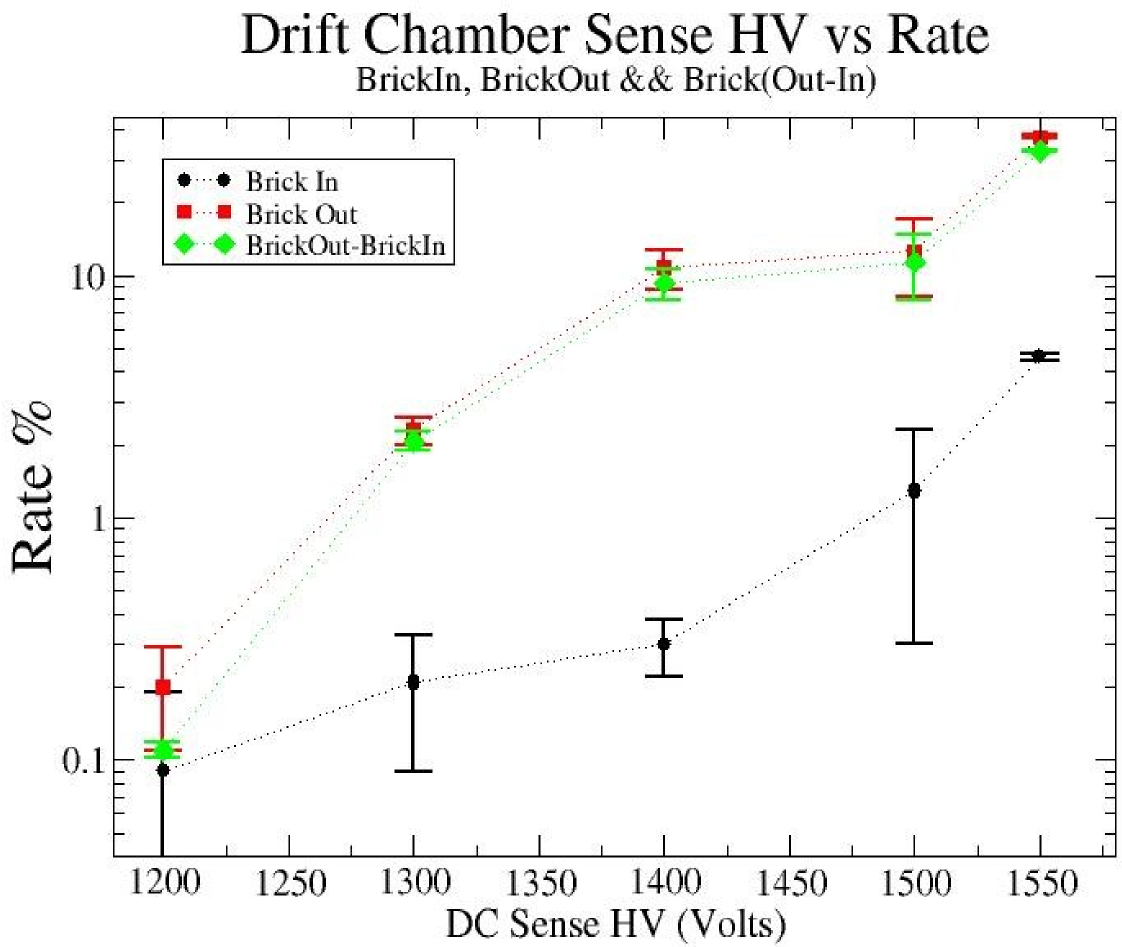




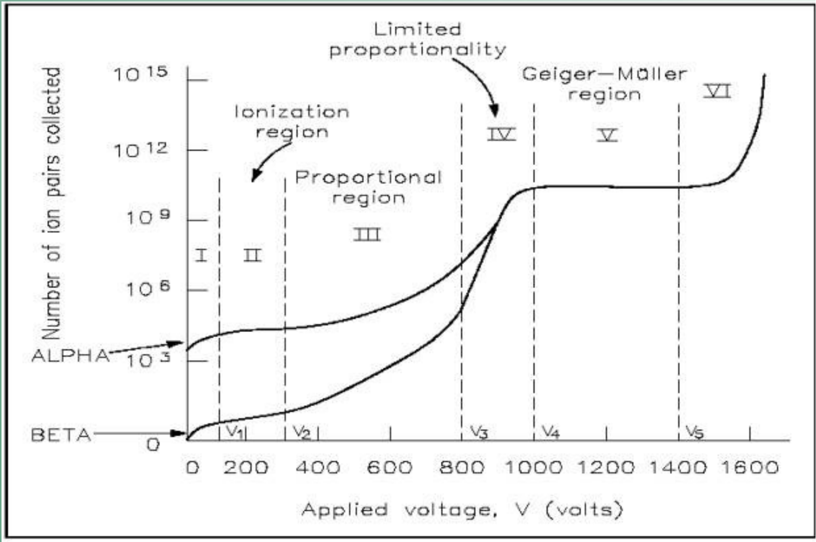
Charge Collector
Pitch - 100 micron resolution
Internal radius=6.97cm
External radius=31.4cm
Circular line width=400um

- The Ionization Chamber
- The Charge Collector
- The Amplifiers(GEM Foils)

Drift Chamber Plateau Measurement

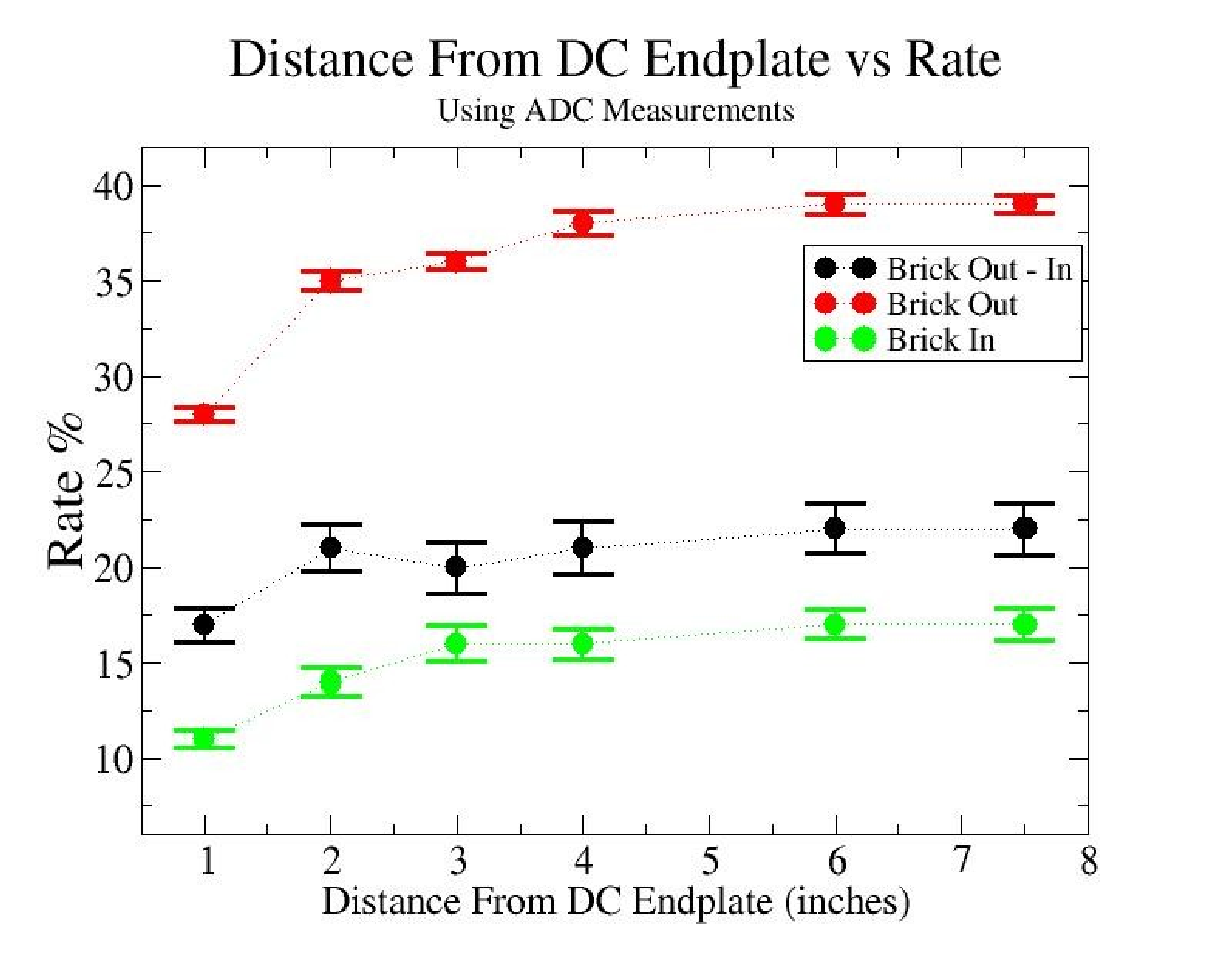


- 3 MeV electrons
- 2X4X8 Al brick shutter
- Scintillator + DC + RF
- ODU_Result=1400Volts



Rate=(DCSenseWire4 + FrontPMT + RF)/RF_Pulse

Drift Chamber(DC) Position Measurement



- DC sandwiched between PMTs
- DC Sense Voltage 1450 Volts
- Trigger = 3 PMTs + RF

Rate=ADC Counts(FC>1000 && ADC>80)/ADC Counts(FC>1000)