The BigBite Spectrometer: Tracking and Optics for the measurement of G_E^n at High Q^2 in Hall A

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E02-013 Collaboration
Hall A Collaboration

October 28, 2006

Abstract

The G_E^n experiment, a measurement of the electric form factor of the neutron between the Q^2 range 1.2 to 3.5 GeV^2 through $\vec{e}(^3\vec{H}e, e'n)$ has been carried out in Jefferson Lab's Hall A. This experiment was made possible by the arrival of the BigBite spectrometer, a non-focusing large momentum and angular acceptance spectrometer. With a recently constructed detector package in BigBite, efforts are now being made to understand and optimize the reconstruction of charged particle tracks and momenta. The data taken during G_E^n provide a good opportunity for understanding the behavior and performance of the spectrometer. However, identifying tracks from charged particles accurately and efficiently is especially challenging given the high background rates up to 20 MHz at the detectors. Results showing the performance of the track reconstruction and the momentum resolution of the spectrometer will be presented.

Outline

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3. BigBite Spectrometer
4. Detector Track Reconstruction
5. Optics and Momentum Reconstruction
6. Summary

G_E^n Measurement Motivation

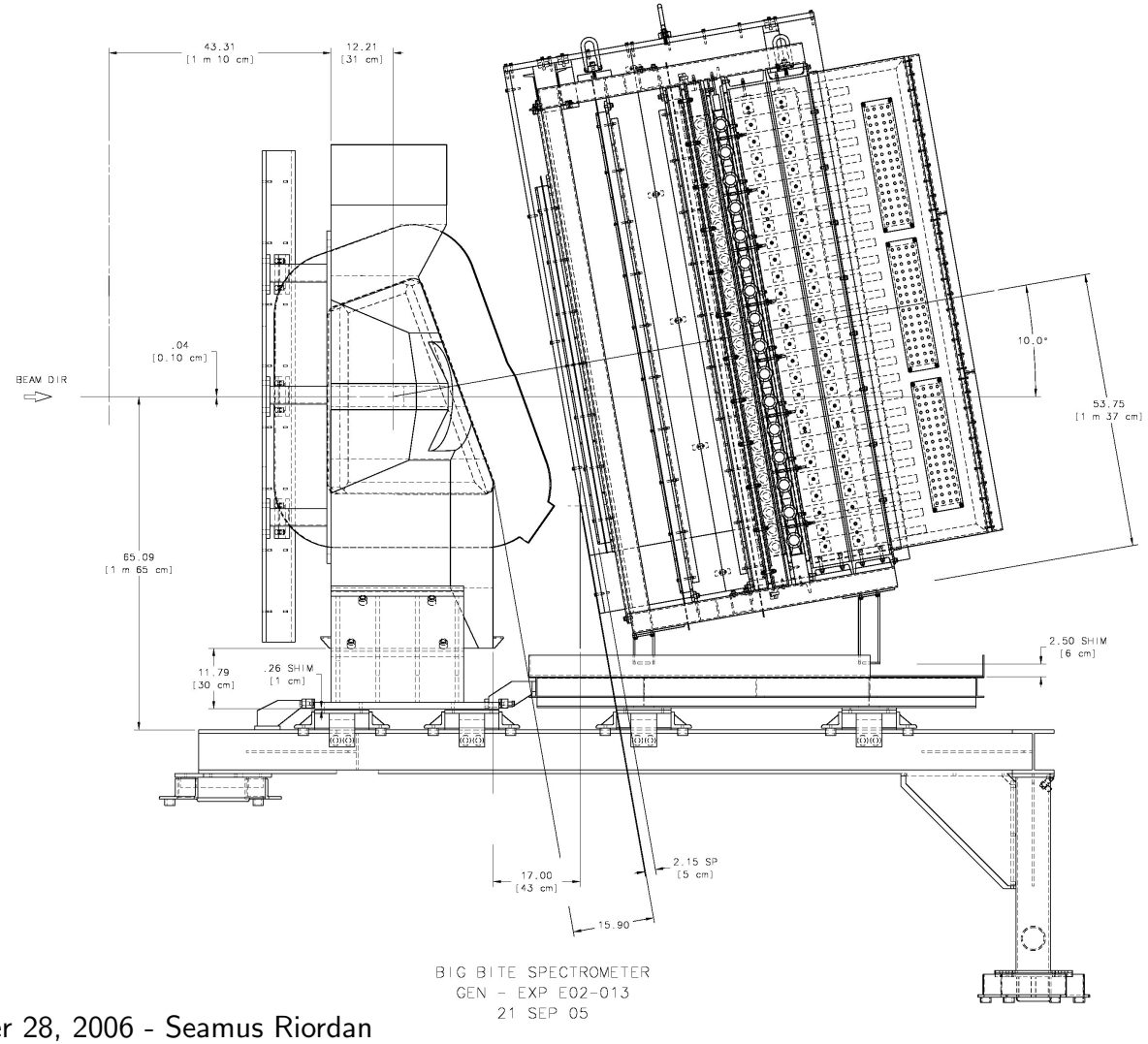
- G_E^n not well known compared to other nucleon form factors. Current high Q^2 measurements have generally have large error bars
- Understanding the structure of the nucleon plays an important role in QCD and hadronic physics
- At high Q^2 pQCD can be applied for theorhetical predictions, DIS is prevalent
- We wish to know where and how pQCD breaks down and give experimental evidence for theory to compare against
- New G_E^n measurments will help constrain GPDs

The BigBite Spectrometer

- Non-focusing large angular and momentum acceptance spectrometer
- Approximately 75msr solid angle subtended for this experiment
- Single dipole magnet of field approximately 1.2T
- Accepting electrons between 1.2$\sim$1.5 GeV/c
- Newly constructed detector package first used for G_E^n

Detector set consists of:

- Large Dipole Magnet
- Drift Chambers
- Lead-glass Preshower
- Scintillator Plane
- Lead-glass Shower


43.31
[1 m 10 cm]
12.21
[31 cm]
.04
[0.10 cm]
BEAM DIR
10.0°
53.75
[1 m 37 cm]
65.09
[1 m 65 cm]
2.50 SHIM
[6 cm]
11.79
[30 cm]
.26 SHIM
[1 cm]
17.00
[43 cm]
2.15 SP
[5 cm]
15.90
BIG BITE SPECTROMETER
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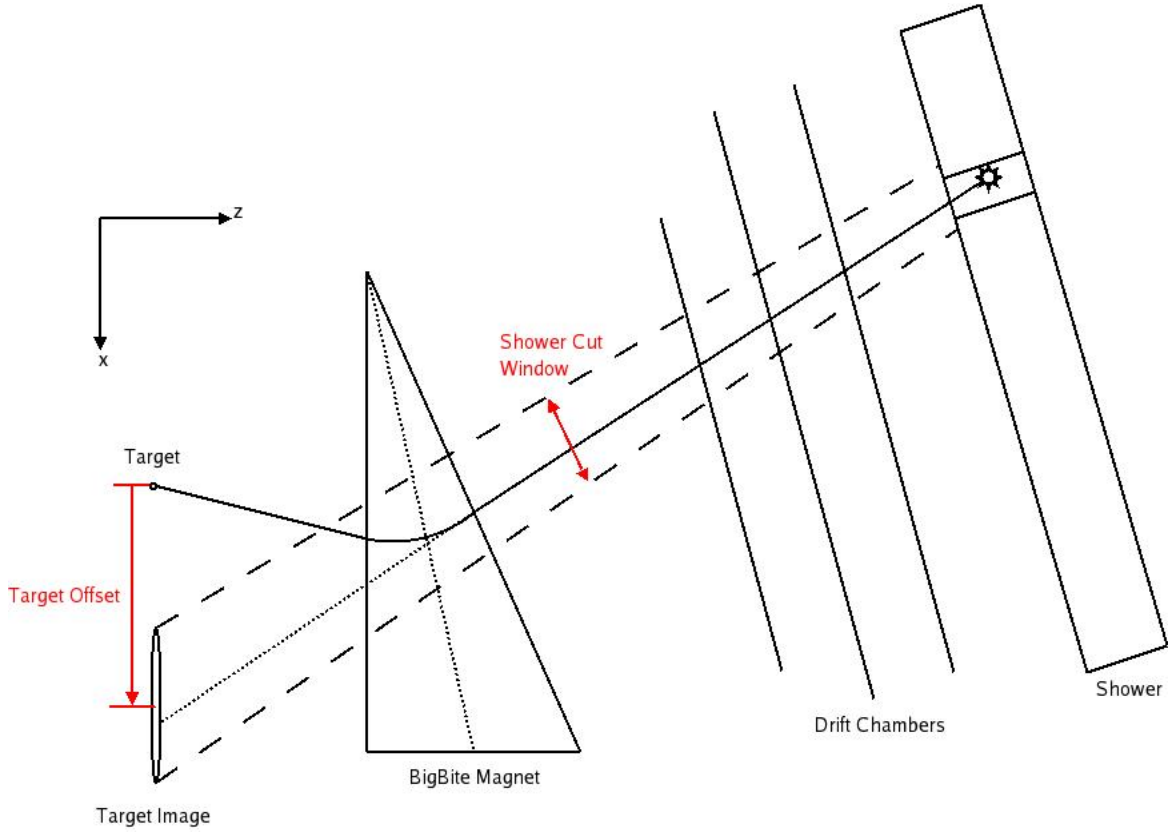
Detector Track Reconstruction

Trigger defined by sum across shower blocks

Rates in drift chambers up to 20MHz

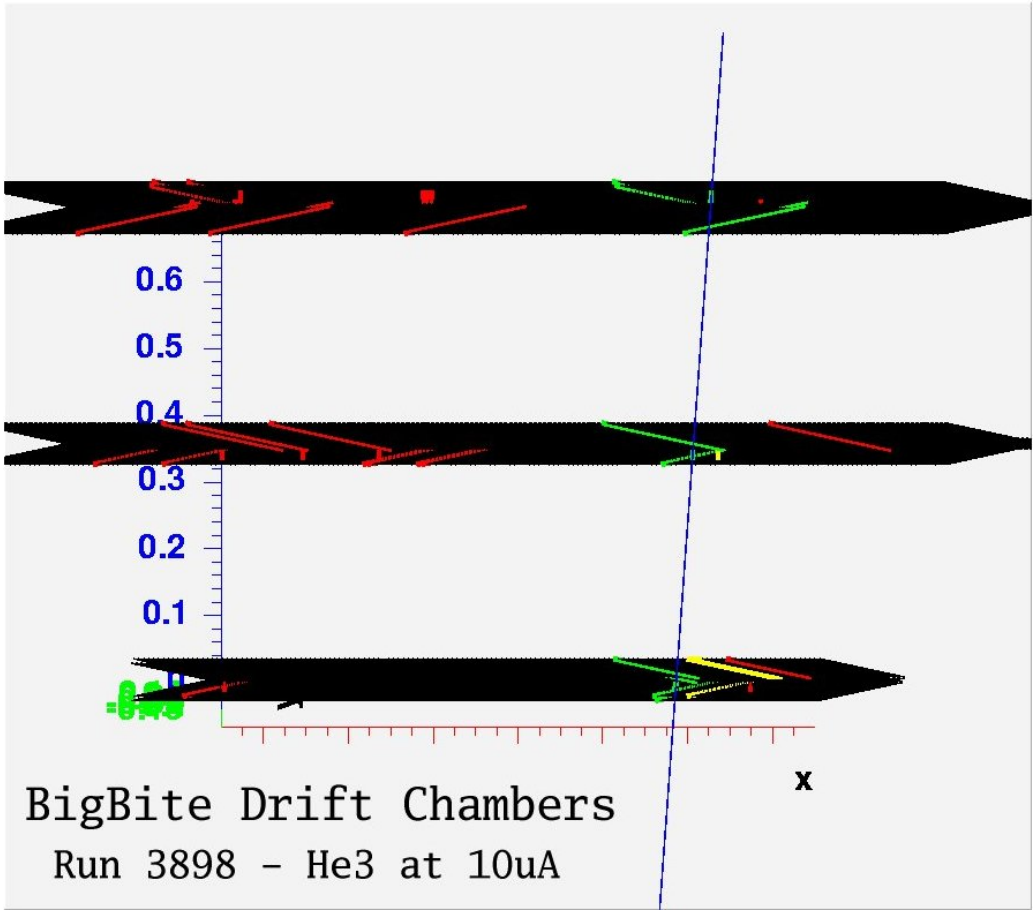
Raw signal to noise about 1:50

Track reconstruction starts at shower to help cut out background

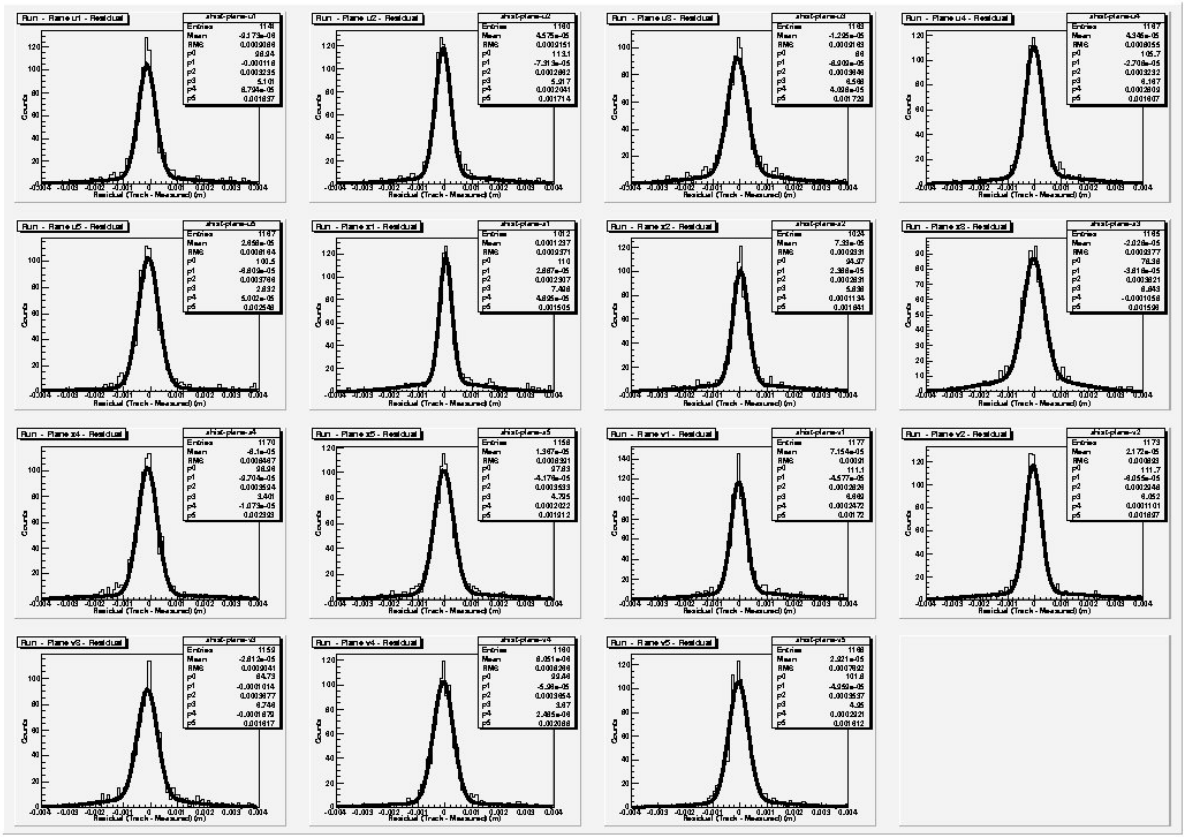


Cuts effective area to search by factor of 10

Chambers iterate over combinations of remaining wire hits to identify track

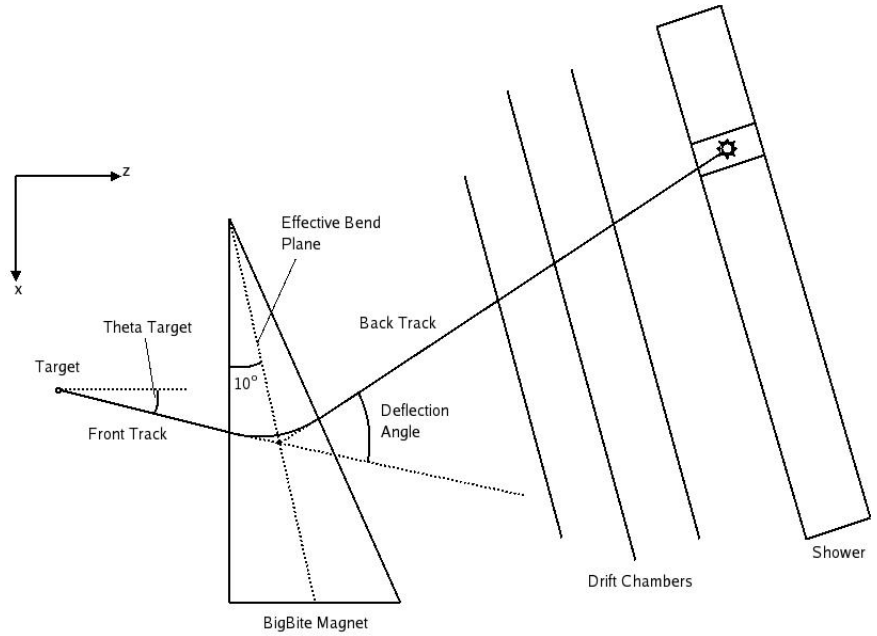


Spacial resolution acheived 300$\sim$350μm.



Optics and Momentum Reconstruction

Optics are done using simple dipole model with first order corrections

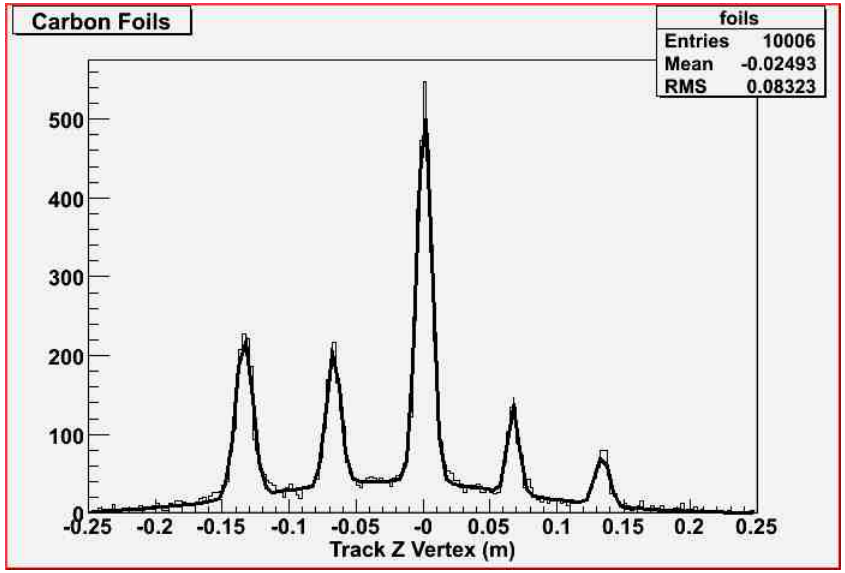


Treat all interaction at magnetic midplane

Fit track back to vertex assuming no change in "non-dispersive" direction to beam position

First order corrections are applied

Use carbon foil data to ensure fitting done correctly



Resolution along beamline 0.5cm sigma.

Scattering angle of elastic events from H_2 target used to calibrate momentum:

$$p_{elas} = \frac{E_{beam} m_p}{m_p + E_{beam}(1 - \cos\theta_{scat})} \tag{1}$$

Use simple equation for momentum

$$p = \frac{c_0 + c_x x_{bend}}{\vartheta_{def}} + c_\vartheta \vartheta_{targ} + c_y y_{det} + c_\varphi y'_{det} \tag{2}$$

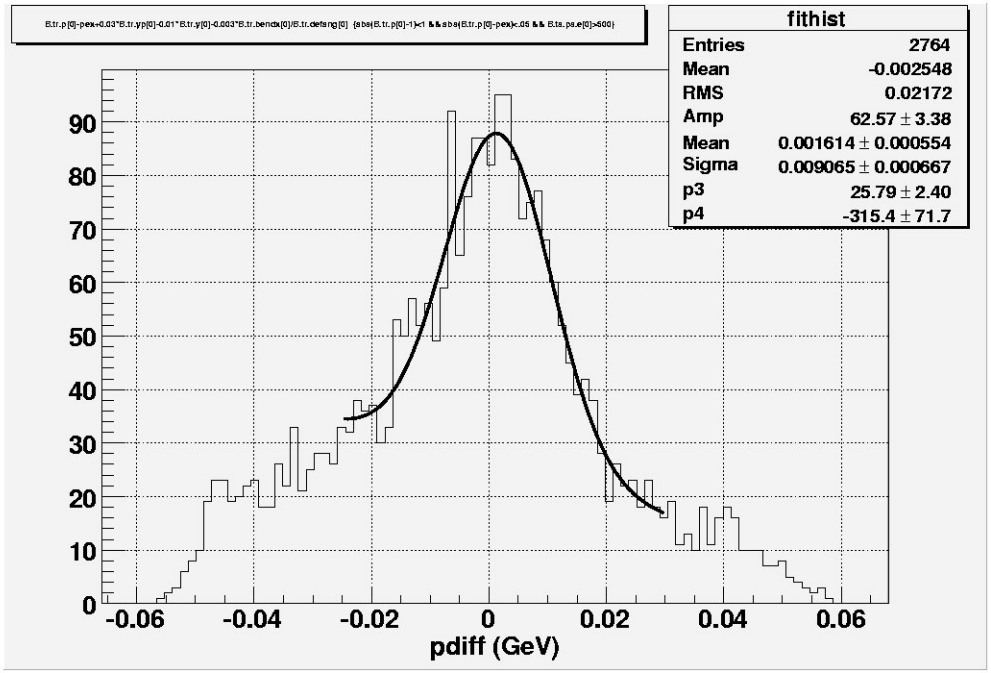
$$\vartheta_{def} = \cos^{-1}\left(\frac{\vec{x}_{front} \cdot \vec{x}_{back}}{|\vec{x}_{front}||\vec{x}_{back}|}\right) \tag{3}$$

Expected resolution:

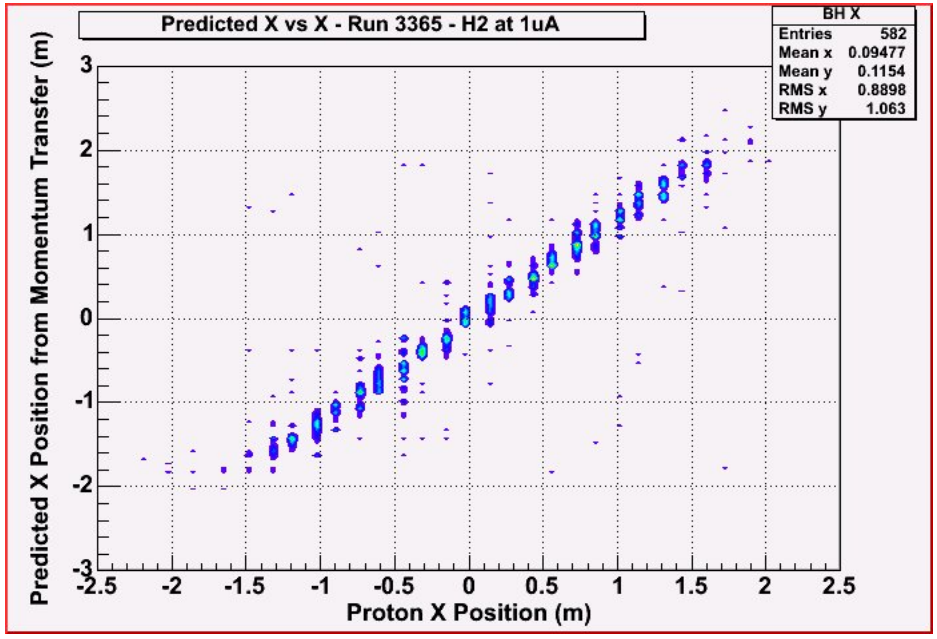
Need to add in..

Spacial resolution 300$\sim$350μm

Momentum resolution roughly 0.9%



Measured tracks in agreement with coincidence on neutron arm



(inplane angle... proton momentum resolution from elastics...)

Both arms must be used to identify quasielastic neutron scattering

Add in something easily showing quasielastics...

Summary

The BigBite spectrometer has allowed us to take data measuring G_E^n due to is large angular and momentum acceptance. Its relatively simple design allows us to do simple data analysis but allows for a large background which is moderately difficult to see through. Our current standing on the analysis of this new spectrometer is slightly above expectations in its performance. Due to the success of BigBite for measuring G_E^n a number of other experiments using this spectromter in Hall A at CEBAF have been approved.

Additional documentation can be found at:

http://hallaweb.jlab.org/experiment/E02-013/offline/bbtracking.pdf