E04-007 Status Report

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Hall A Collaboration Meeting

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Physics Division Liaison: V. A. Sulkosky

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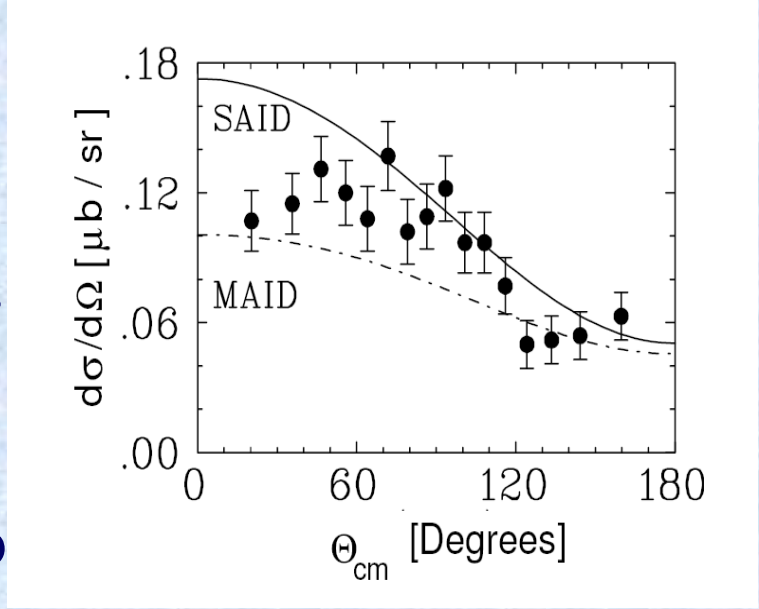
June 11, 2009

Jefferson Lab

E04-007: Precision Measurements of Electroproduction of π^0 near Threshold

Motivation:

Existing measurements, in particular those from Mainz, have shown strong disagreements with the predictions of Chiral Perturbation Theory (ChPT).
Measured cross-sections disagree with phenomenological models of SAID and MAID



$$Q^2 = 0.1\left(GeV/c\right)^2$$

$$\Delta W = 1(MeV) - 2(MeV)$$

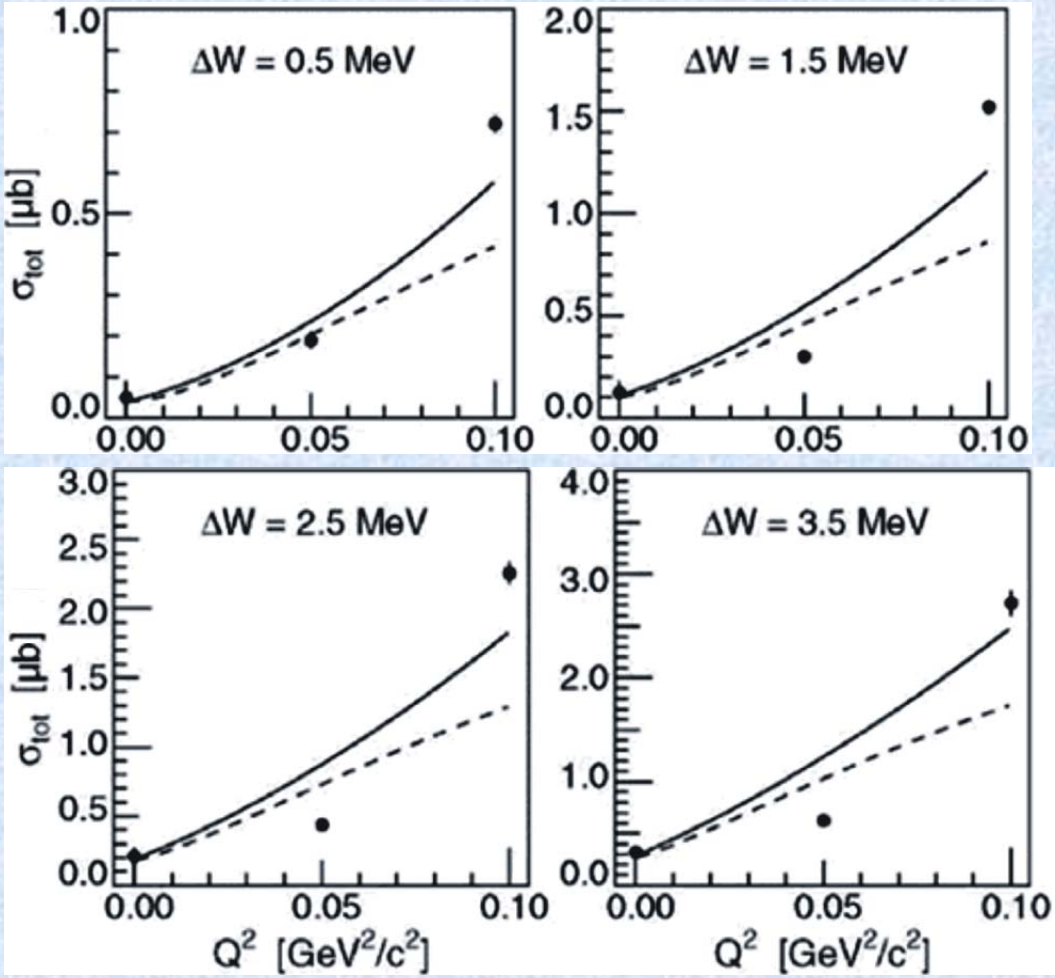
Previous $P(e, e'p)\pi^0$ Data

Required LECs derived from measurements at

$$Q^2 = 0.1(GeV/c)^2$$

$$Q^2 = 0.05(GeV/c)^2$$

- Dashed line: MAID
- Data points: Mainz
- Solid line: ChPT



References:

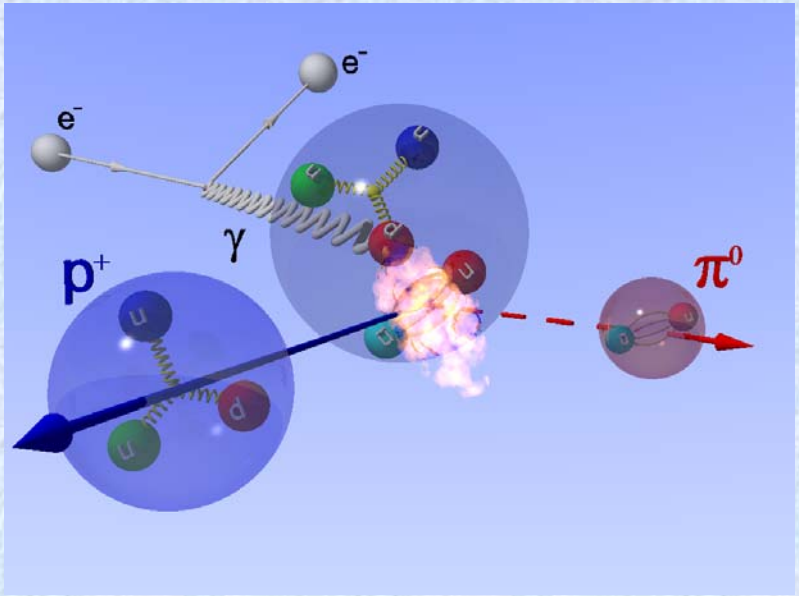
Bernard, et al. NP A607,379(1996)
Distler PRL 80, 2294 (1998)
Merkel et al. PRL 88, 1230 (2002)

E04-007 Experiment

Experiment Goal:

Making high precision cross-section measurement of $H(e,e'p)\pi^0$ reaction near threshold in a fine grid of Q^2 and W,
$Q^2 = 0.045 - 0.45\ (GeV/c)^2$
$\Delta W = 0 - 30$ MeV above threshold.

Longitudinally polarized beam (67% polarized) allows extraction of the helicity dependent structure function, $\sigma_{LT'}$.



Experiment ran March 2008 - May 2008

E04-007 Experiment

Obtaining the total cross section involves determination of the structure functions, $\sigma_T + \varepsilon_L \sigma_L$, σ_{TL}, and σ_{TT} for which the out of plane ϕ dependence of the cross section will be used.

The desired "five-fold" cross section is related to the mentioned structure functions through (in CM)

$$\frac{d\sigma_v}{d\Omega_\pi^*} = \frac{d\sigma_T}{d\Omega_\pi^*} + \varepsilon_L \frac{d\sigma_L}{d\Omega_\pi^*} + \left[2\varepsilon_L(1+\varepsilon)\right]^{1/2} \frac{d\sigma_{TL}}{d\Omega_\pi^*}\cos\phi + \varepsilon \frac{d\sigma_{TT}}{d\Omega_\pi^*}\cos 2\phi + h\left[2\varepsilon_L(1-\varepsilon)\right]^{1/2} \frac{d\sigma_{LT'}}{d\Omega_\pi^*}\sin\phi$$

Which appears in cross section as

$$\frac{d\sigma}{d\Omega_e\, d\Omega_\pi^*\, dE'} = \Gamma \frac{d\sigma_v}{d\Omega_\pi^*}$$

and asymmetry is given by

$$A_{LT'} = \frac{A_m}{P_e \left\langle \mathrm{Sin}\phi_\pi^* \right\rangle}, \qquad A_m = \frac{N_p^+ - N_p^-}{N_p^+ + N_p^-}.$$

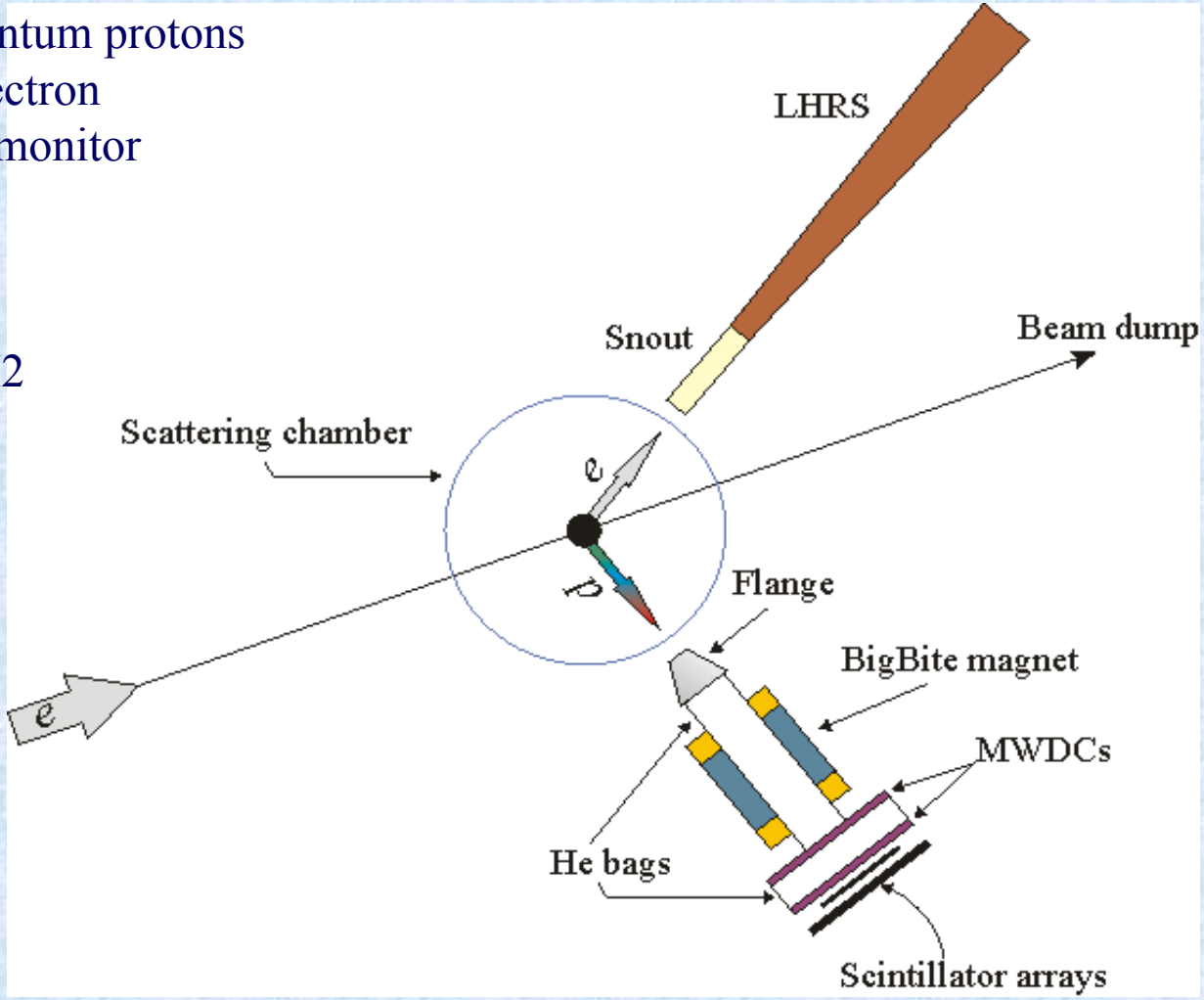
Experiment Configuration

BigBite: detects low momentum protons
LHRS: detects scattered electron
RHRS: used as luminosity monitor

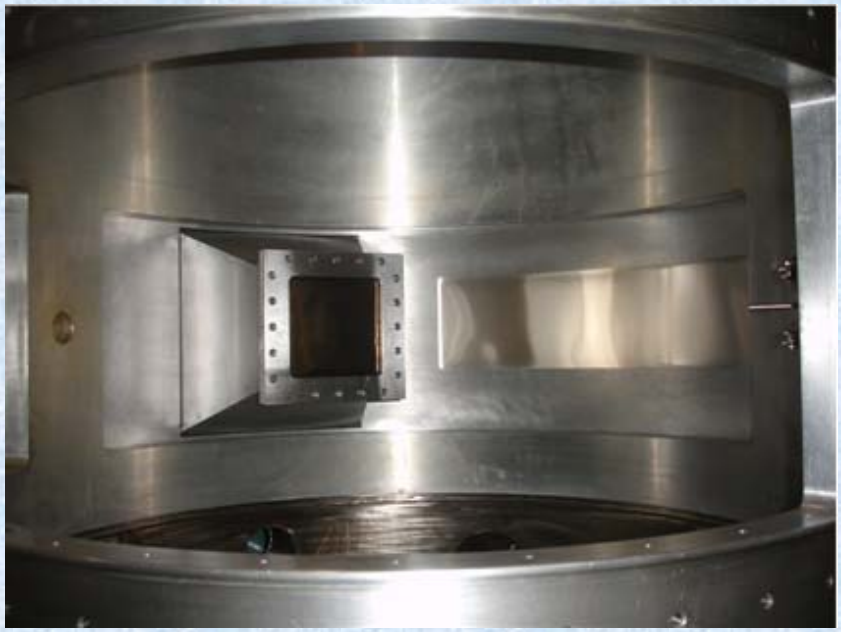
Target:
6 cm long, 1" diameter LH2

Electron beam:
E = 1.194 & 2.323 GeV
I = 3–8 μA

Luminosity : 10^{37} Hz/cm^2



Target



LH2 cells:
-6 cm long & 2.54 cm diameter
-Thin 0.005” Al windows
-Collimators shield the detectors from the cell windows

Special flange with 0.003” Ti window

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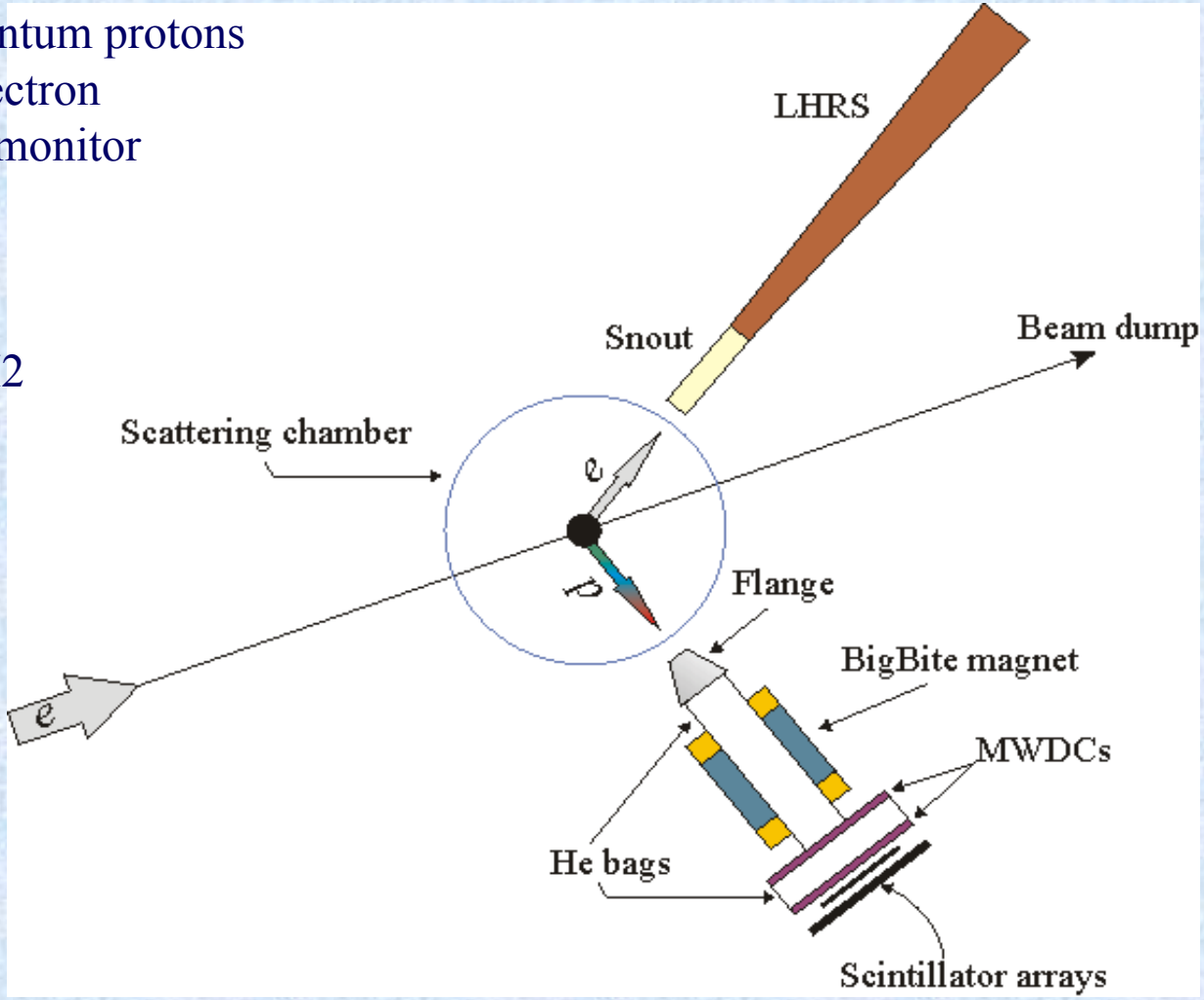


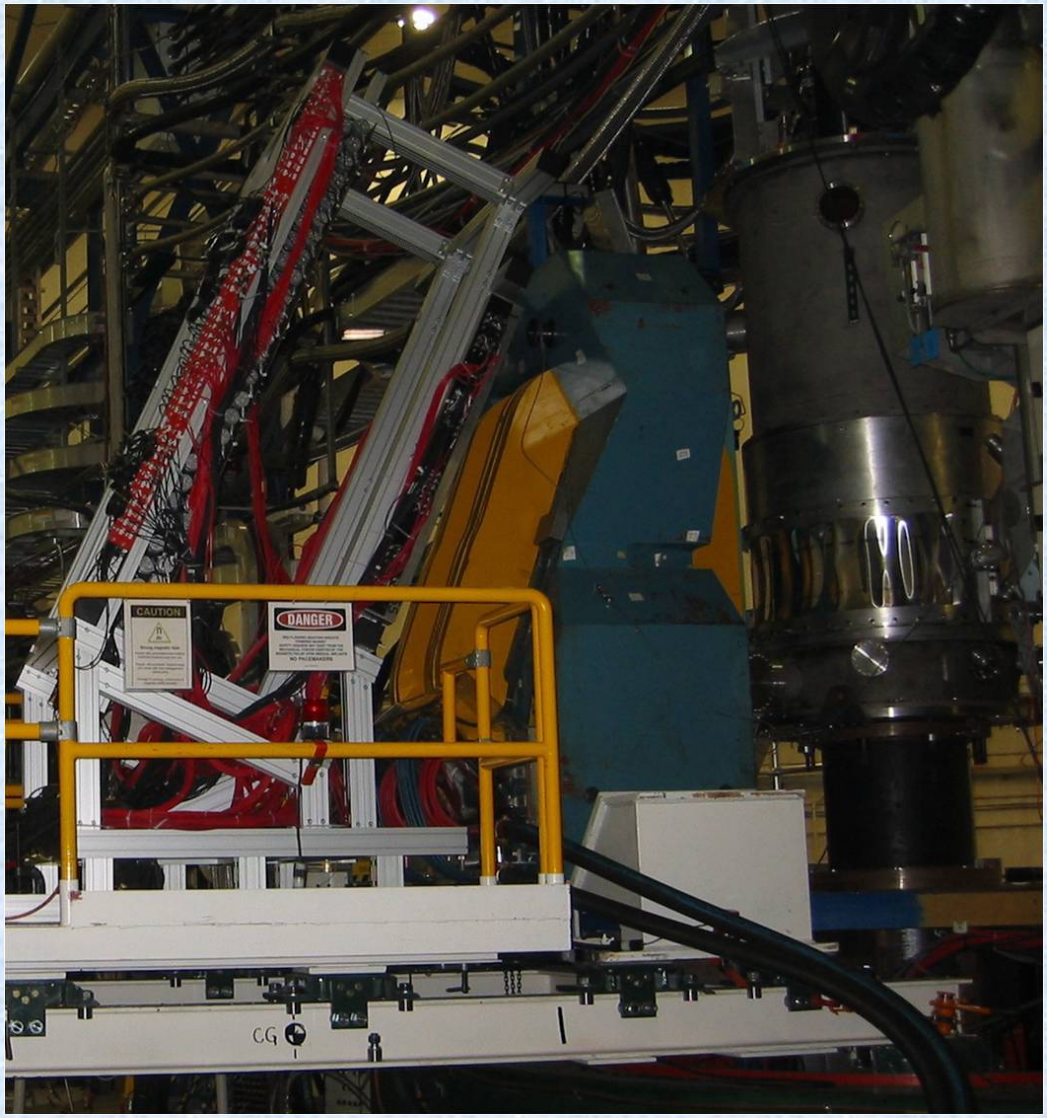
BigBite Spectrometer

MWDC
Proton tracking

Scintillators
Proton trigger and PID

Magnet

He bag
Low-density path for the proton



Wire Chambers & Scintillators

MWDC:

Front chamber: 6 wire planes

140 cm x 35 cm

Back chamber: 6 wire planes

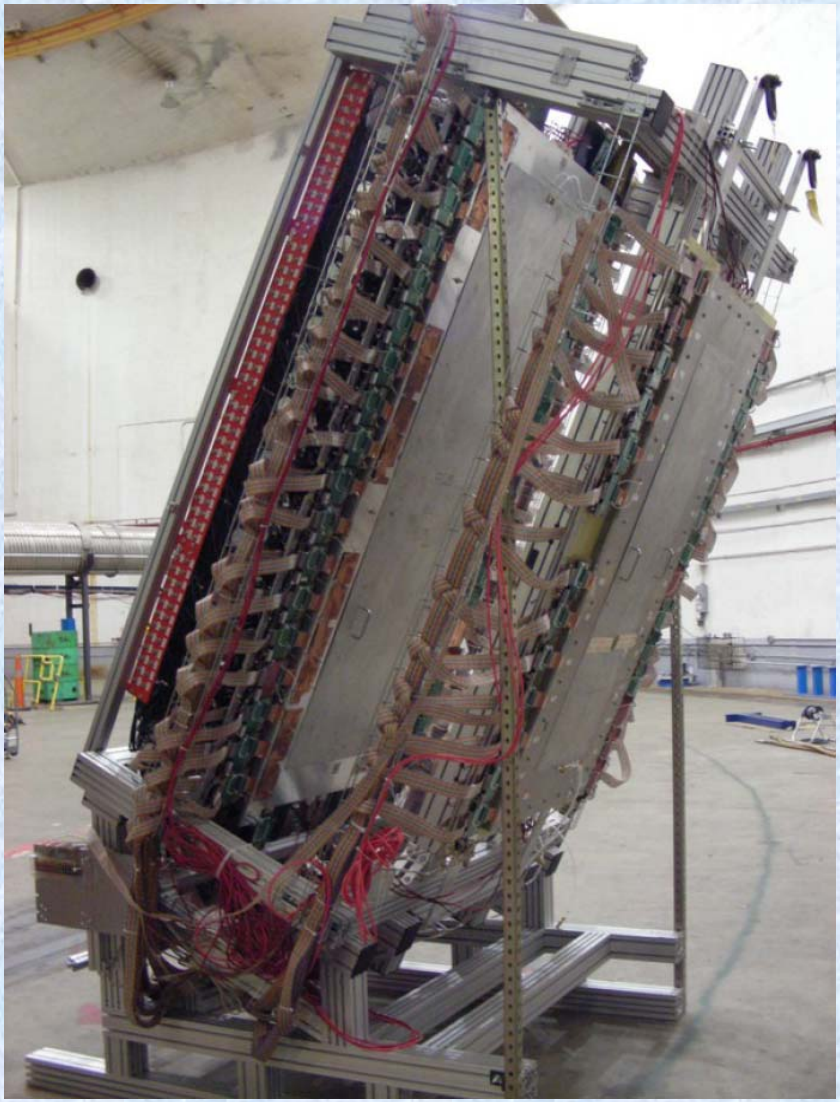
200 cm x 50 cm

2052 signal wires

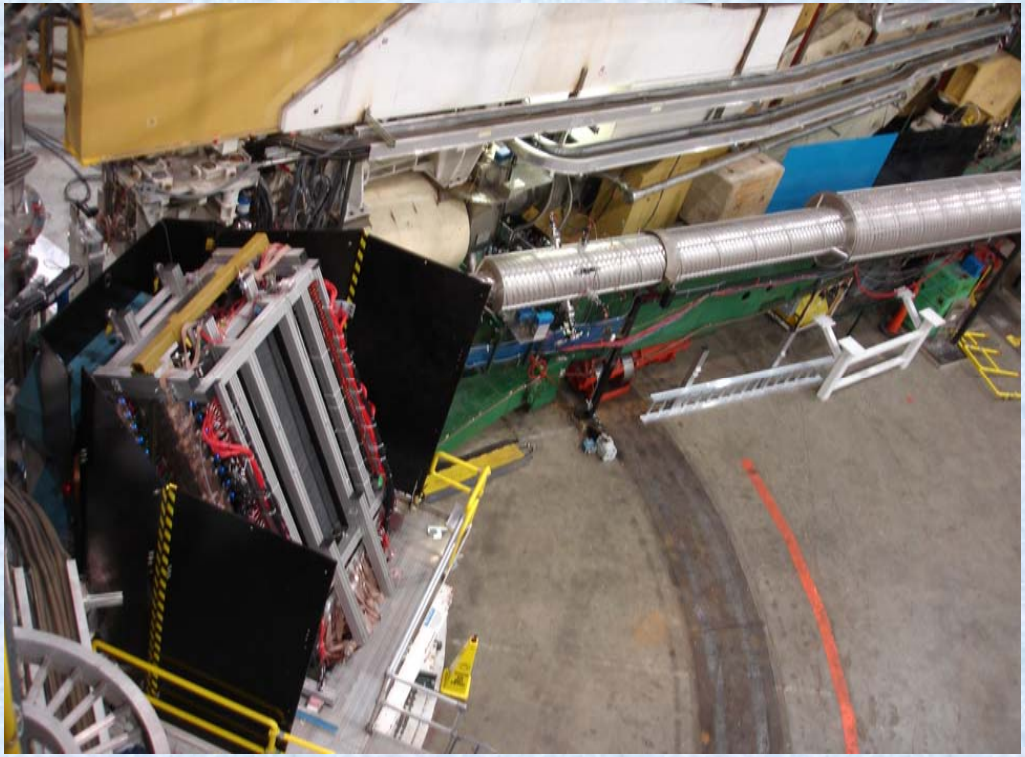
Scintillators:

ΔE plane: 3 mm

E plane: 30 mm



BigBite Spectrometer



Magnet: 1 Tesla dipole
He bag: Custom 0.0035" thick polyurethane, helium filled

BigBite spectrometer was shielded with a steel wall.

MWDC and Scintillators all mounted at 43.6^{o} from the beam line

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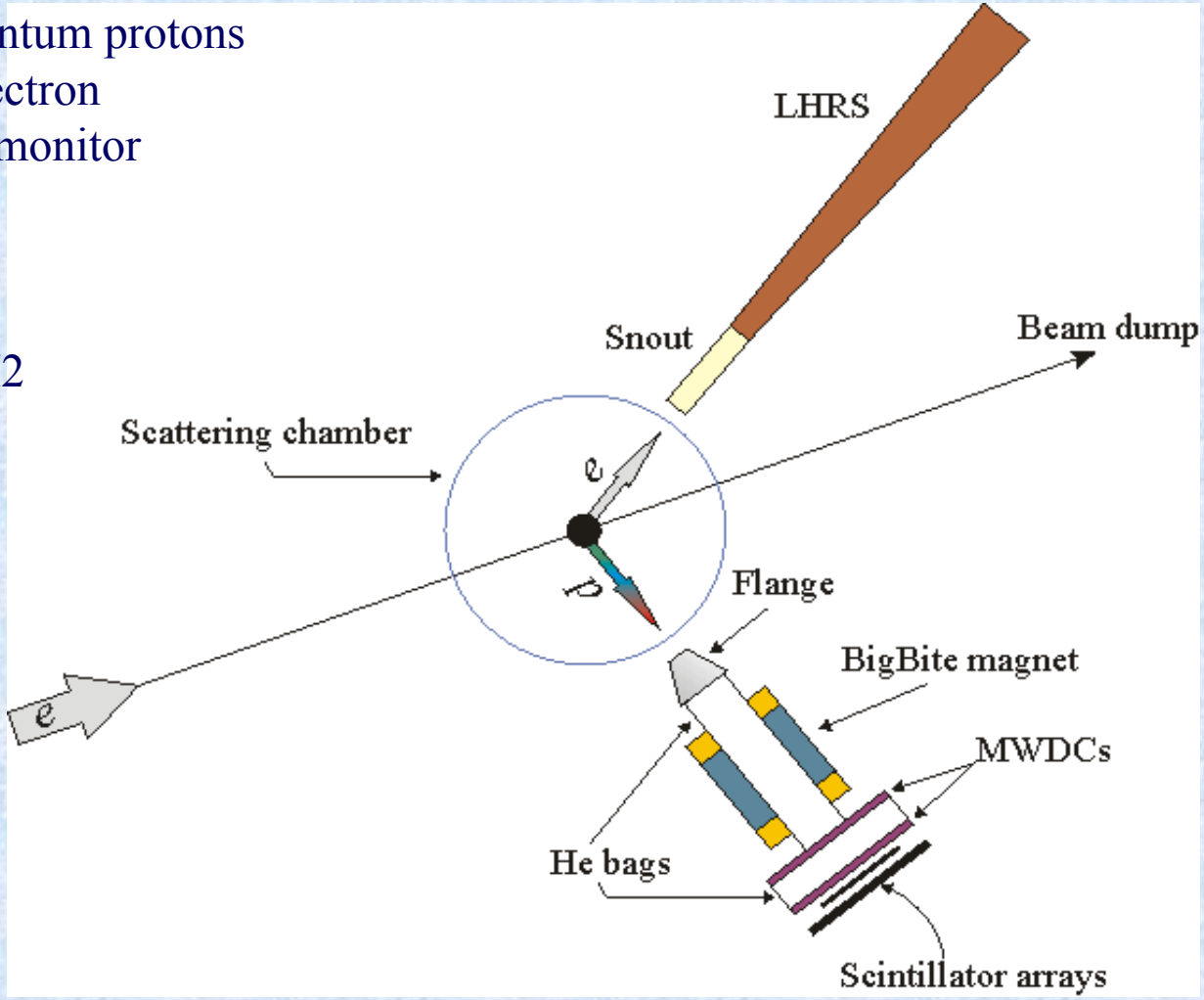
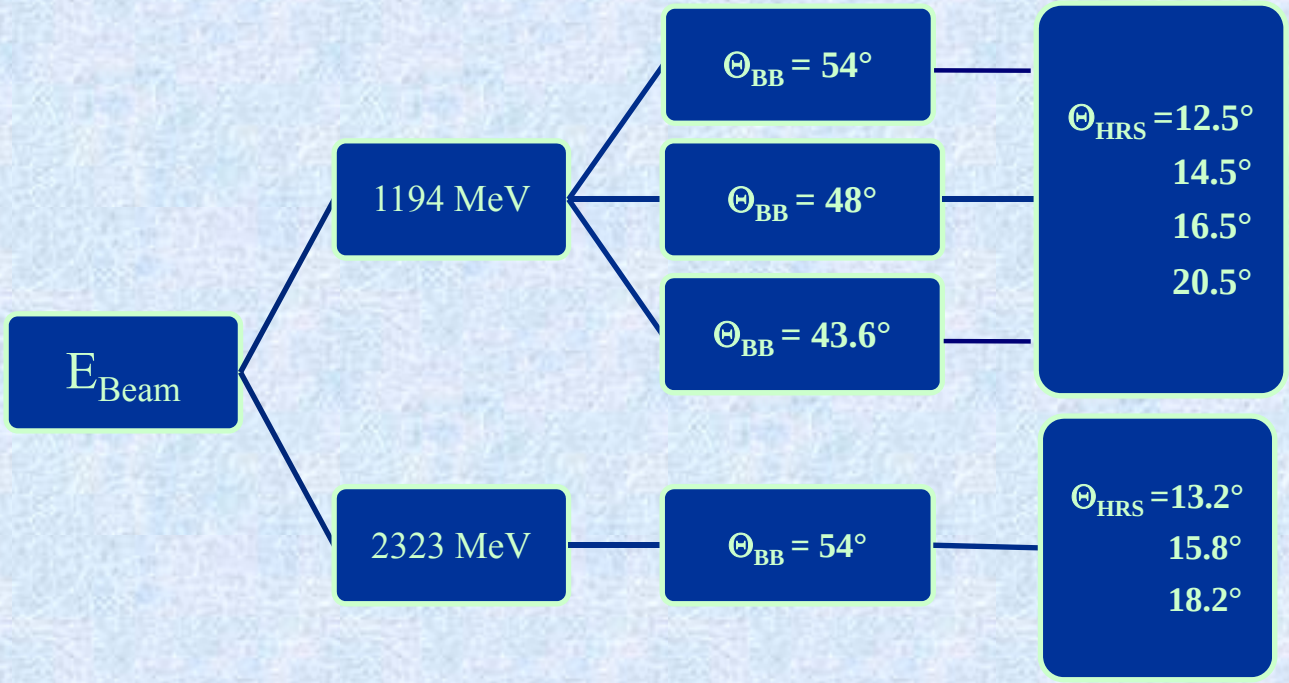


Kinematical Layout



Data Analysis

Data: 15 Kinematics

accumulated charge @1.194 GeV = 4.8 Coulombs

accumulated charge @2.323 GeV = 0.8 Coulombs

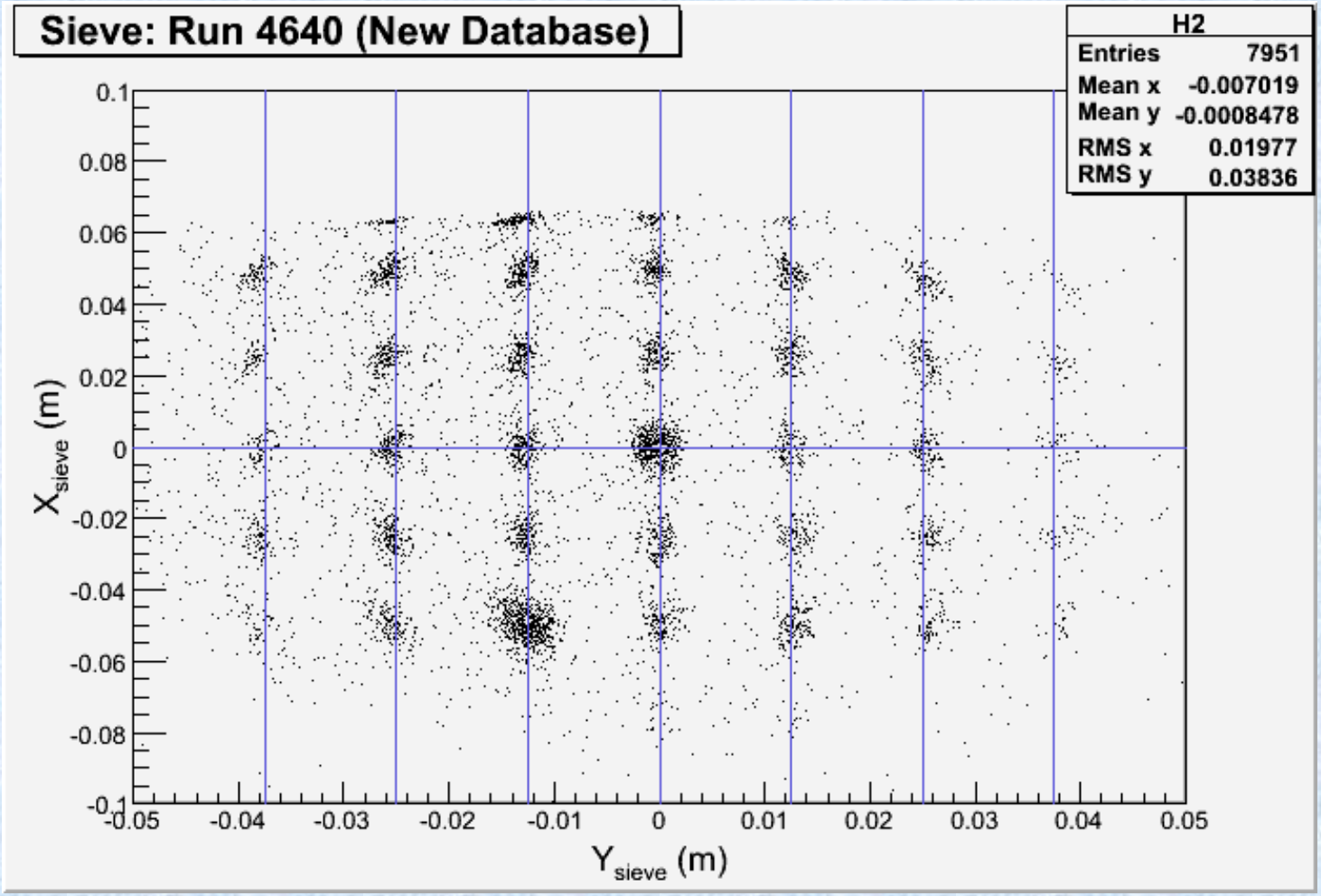
HRS Optics : Nearly complete

PID: Near completion

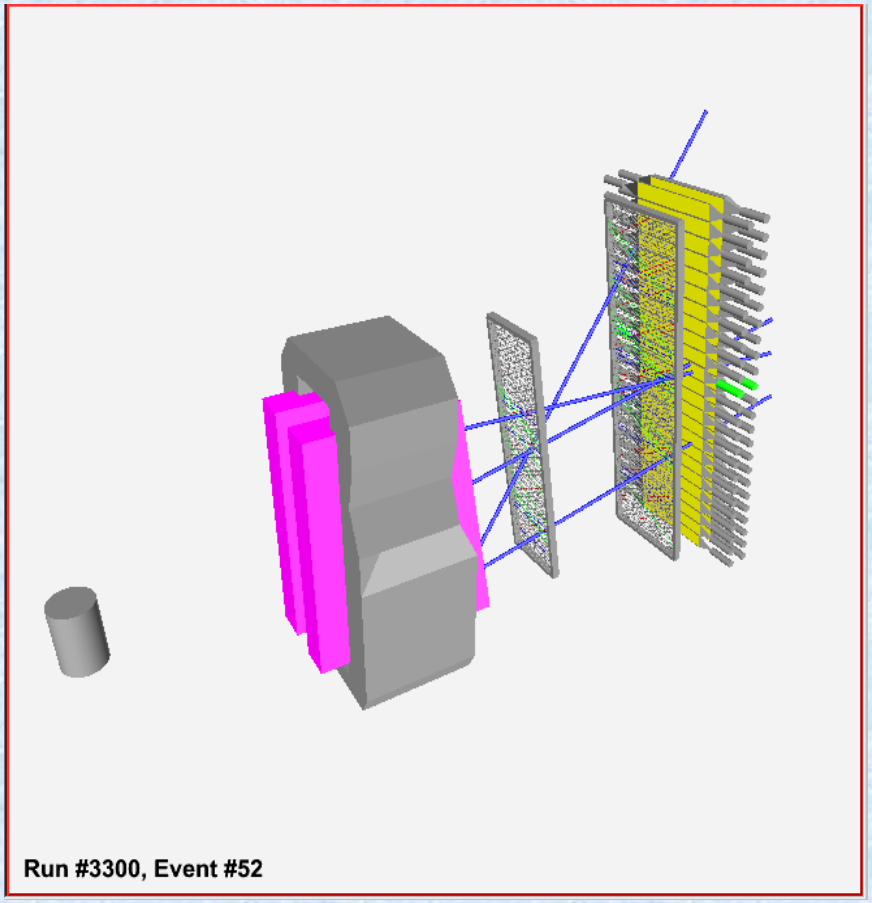
BigBite Optics: In progress

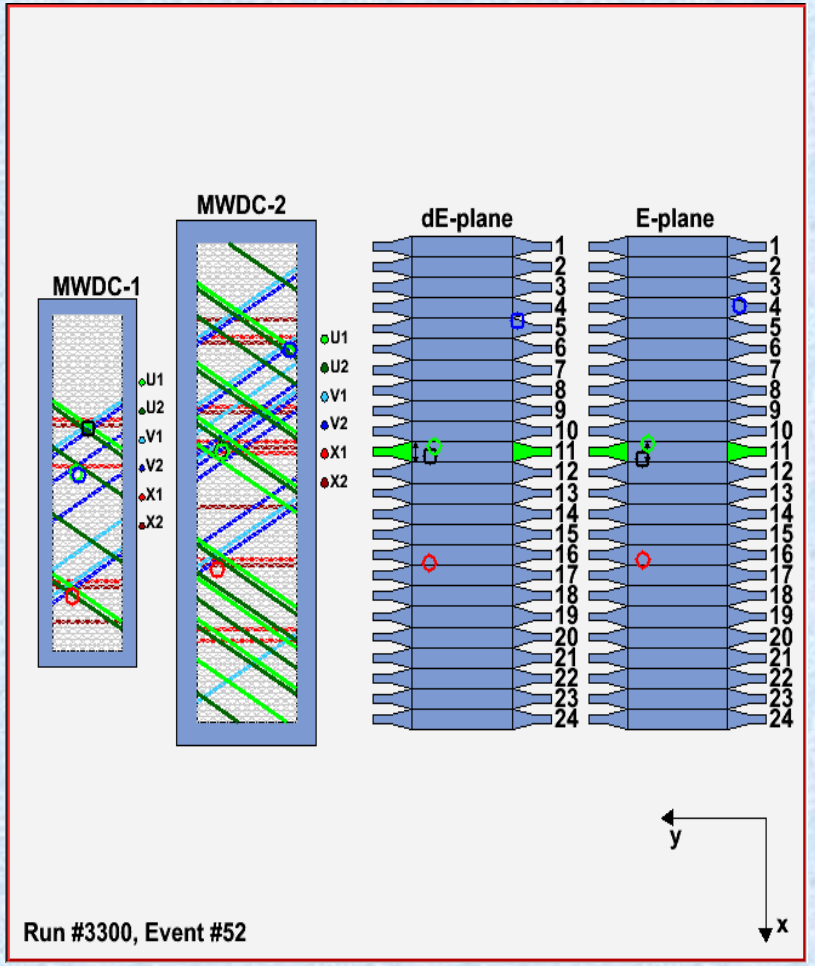
Timing Corrections: In progress

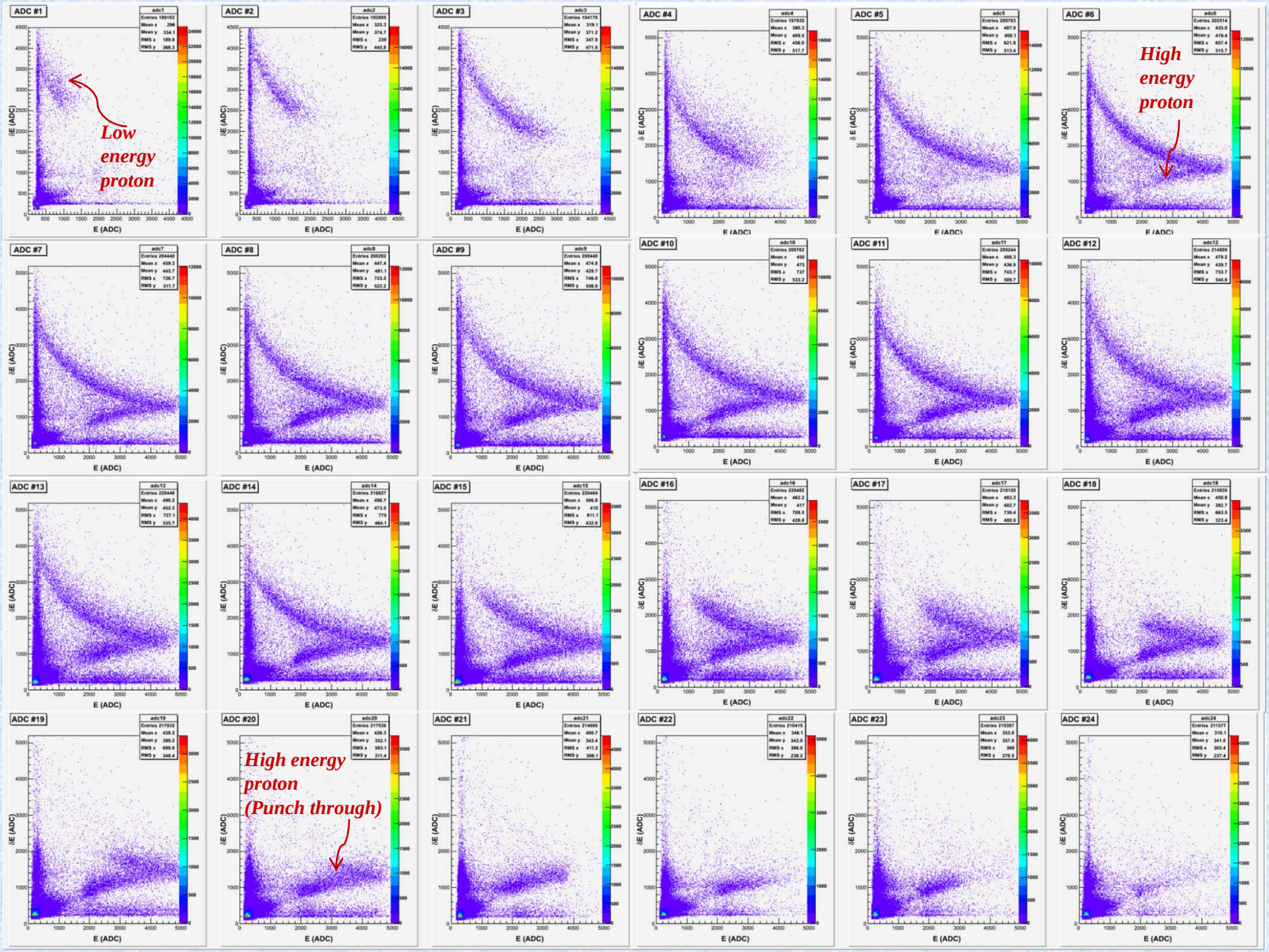
Calibrations: HRS Optics



PID & BigBite Optics

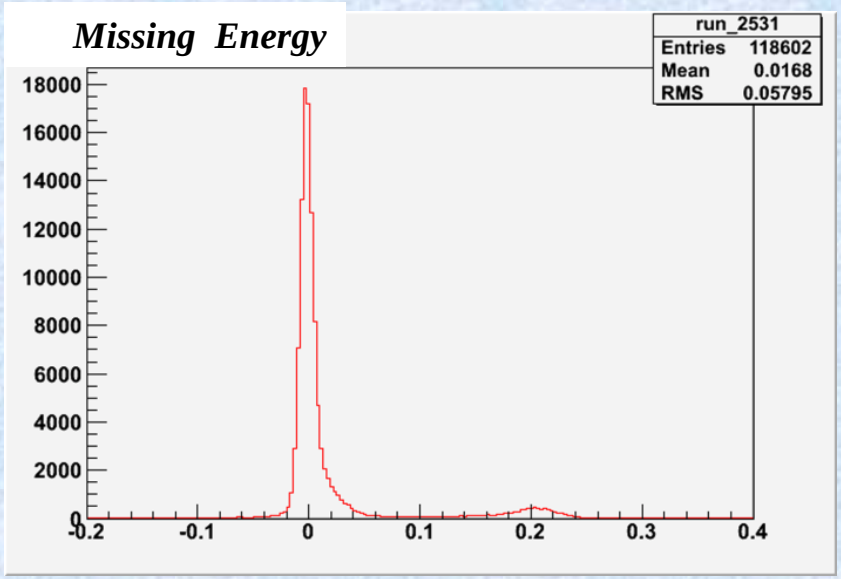


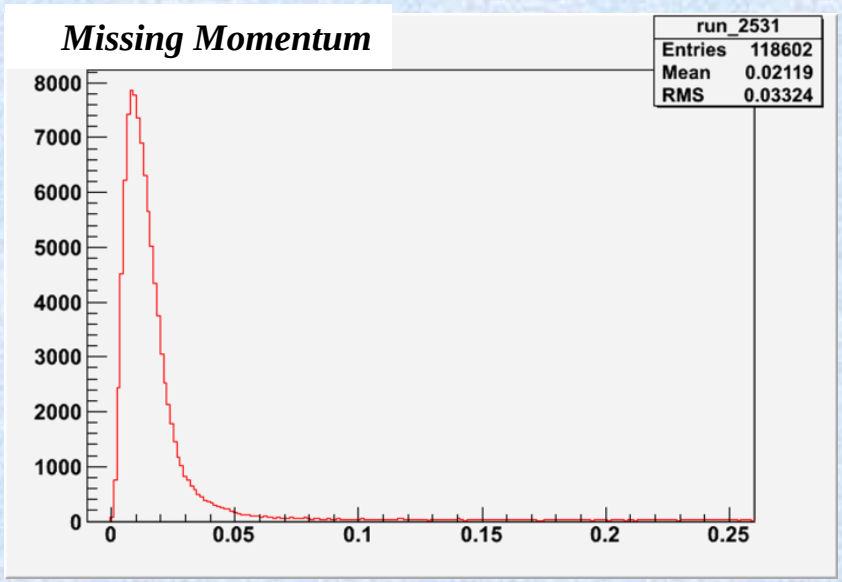


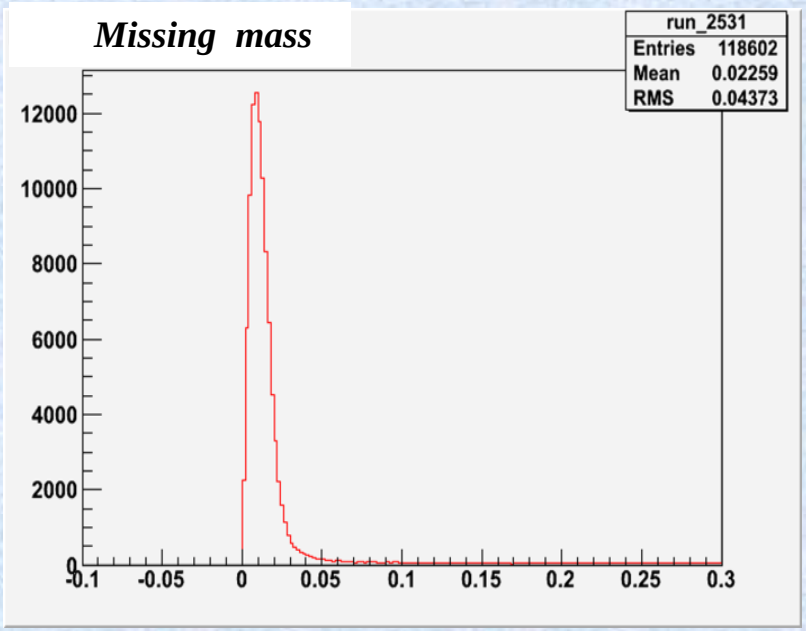

ADC #1
Low energy proton
ADC #2
ADC #3
ADC #4
ADC #5
ADC #6
High energy proton
ADC #7
ADC #8
ADC #9
ADC #10
ADC #11
ADC #12
ADC #13
ADC #14
ADC #15
ADC #16
ADC #17
ADC #18
ADC #19
ADC #20
High energy proton (Punch through)
ADC #21
ADC #22
ADC #23
ADC #24
δE (ADC)
E (ADC)

Calibrations: BigBite Optics

Elastic $H(e,e'p)$





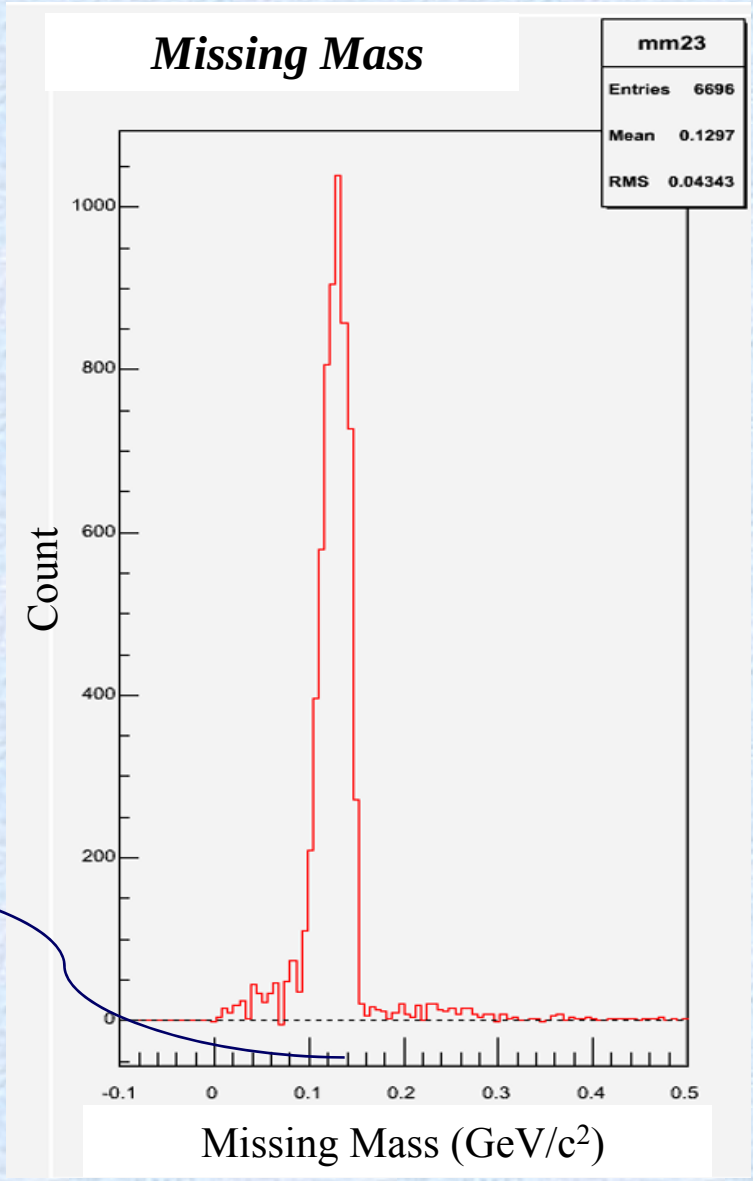


Calibrations: BigBite Optics

Production Run

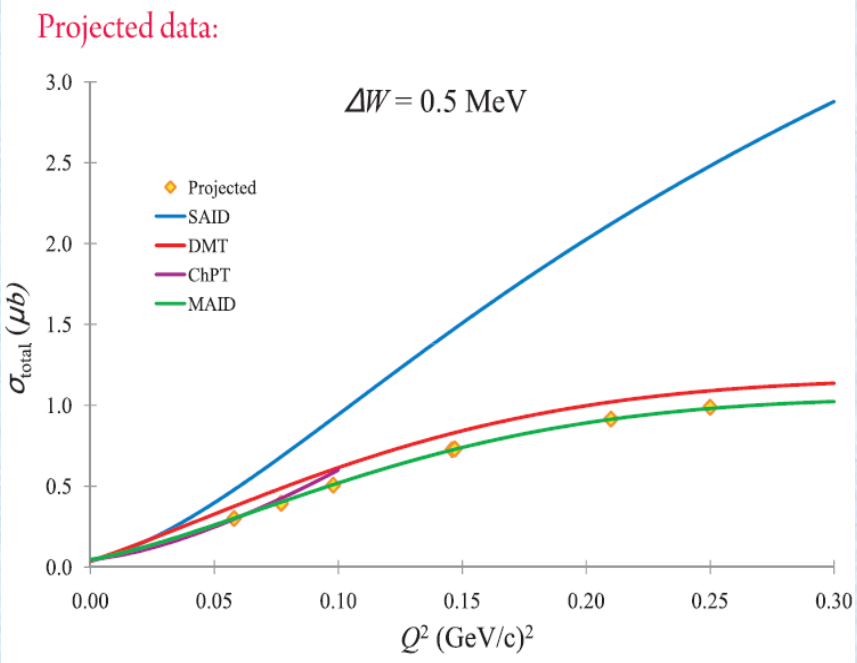
$E_{Beam} = 1.194$ GeV
$\Theta_{BB} = 48^{o}$
$\Theta_{LHRS} = 20.5^{o}$
$Q^2 = 0.15$ (GeV/c)^2

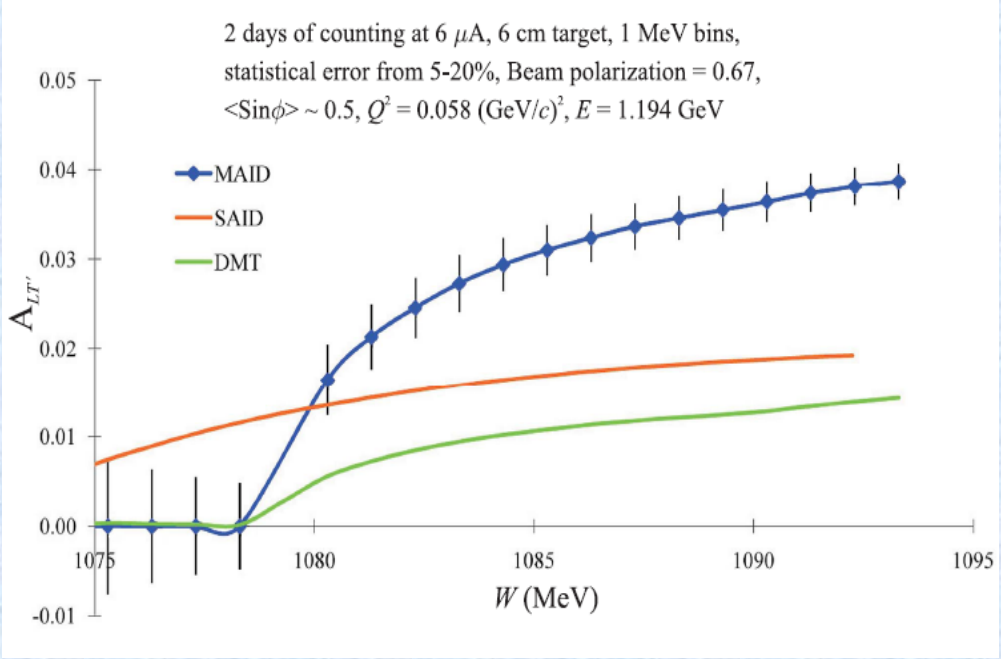
$M_{\pi 0} = 0.135$ GeV/c^2



Summary

- Precise data in fine bins of Q^2 and ΔW has been taken and is currently being analyzed.
- We expect relative σ_{tot} by December 2009
- Asymmetry and Preliminary results by the end of Summer 2009





Thanks!