

# Status of E04-007 Threshold $H(e,e'p)\pi^0$

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for

Co-spokespersons: J. Annand, D. Higinbotham, B. Moffit,  
V. Nelyubin, and B. Norum,

and

Ph. D. students K. Chirapatpimol, M. Shabestari,  
and

Hall A collaboration

Hall A Collaboration Meeting  
June 13-14 2008

# E04-007: Threshold $H(e,e'p)\pi^0$

## Precision Measurement of the Electroproduction of $\pi^0$ Near Threshold: A Test of Chiral QCD Dynamics

Co-spokespersons J. Annand, D. Higinbotham, R. Lindgren, B. Moffit, V. Nelyubin, and B. Norum,

Ph. D students K. Chirapatpimol, M. Shabestari,

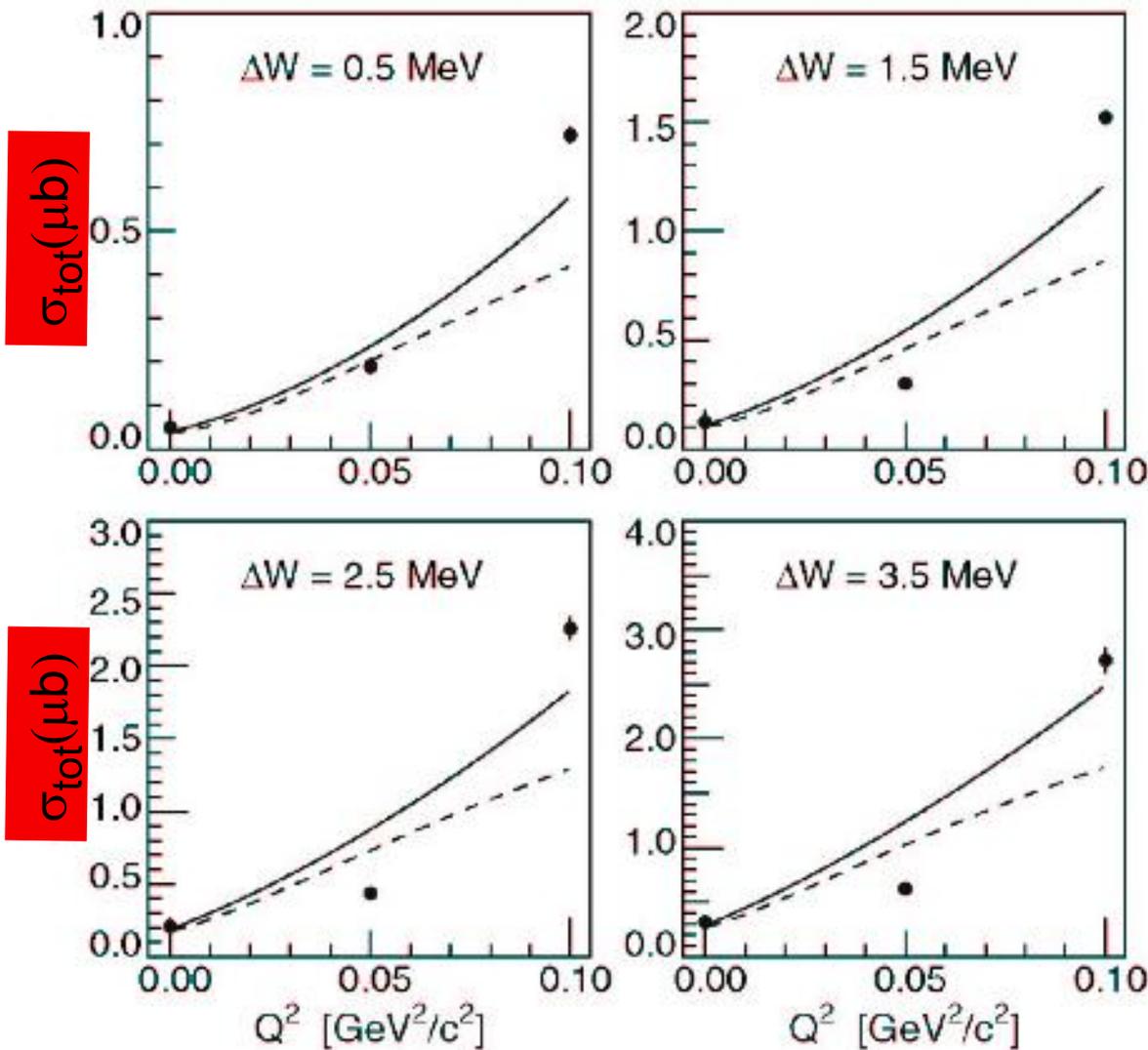
Hall A collaboration

Physics Goal: Extract high precision data in a fine grid of  $Q^2$  and  $W$  from  $Q^2 = 0.05 - 0.15$  in steps of  $0.01 \text{ (GeV/c)}^2$  and from  $\Delta W = 0 - 20 \text{ MeV}$  above threshold in steps of  $1 - 2 \text{ MeV}$ . Complete kinematic coverage from  $0 - 4 \text{ MeV}$  above threshold for proton momentum  $> 220 \text{ MeV/c}$

- $\sigma_T + \epsilon_L \sigma_L$  2 - 4 %
- $\sigma_{LT}$  3 - 6 %
- $\sigma_{TT}$  10 - 20 %
- $\sigma_{TL'}$  10-20 %
- $A_{TL'}$  5-20 %

First Approved Jan 2001 and Re-approved Jan 2004 for 16 days Scheduled for 32 Days

# Electro- $\pi^0$ production on the proton



$Q^2=0.10 \text{ (GeV/c)}^2$   
Distler PRL 80, 2294 (1998)

LEC's  
 $a_3 = -0.92$  and  $a_4 = -0.99$

$Q^2=0.05 \text{ (GeV/c)}^2$   
Merkel et al. PRL 88, 1230 (2002)

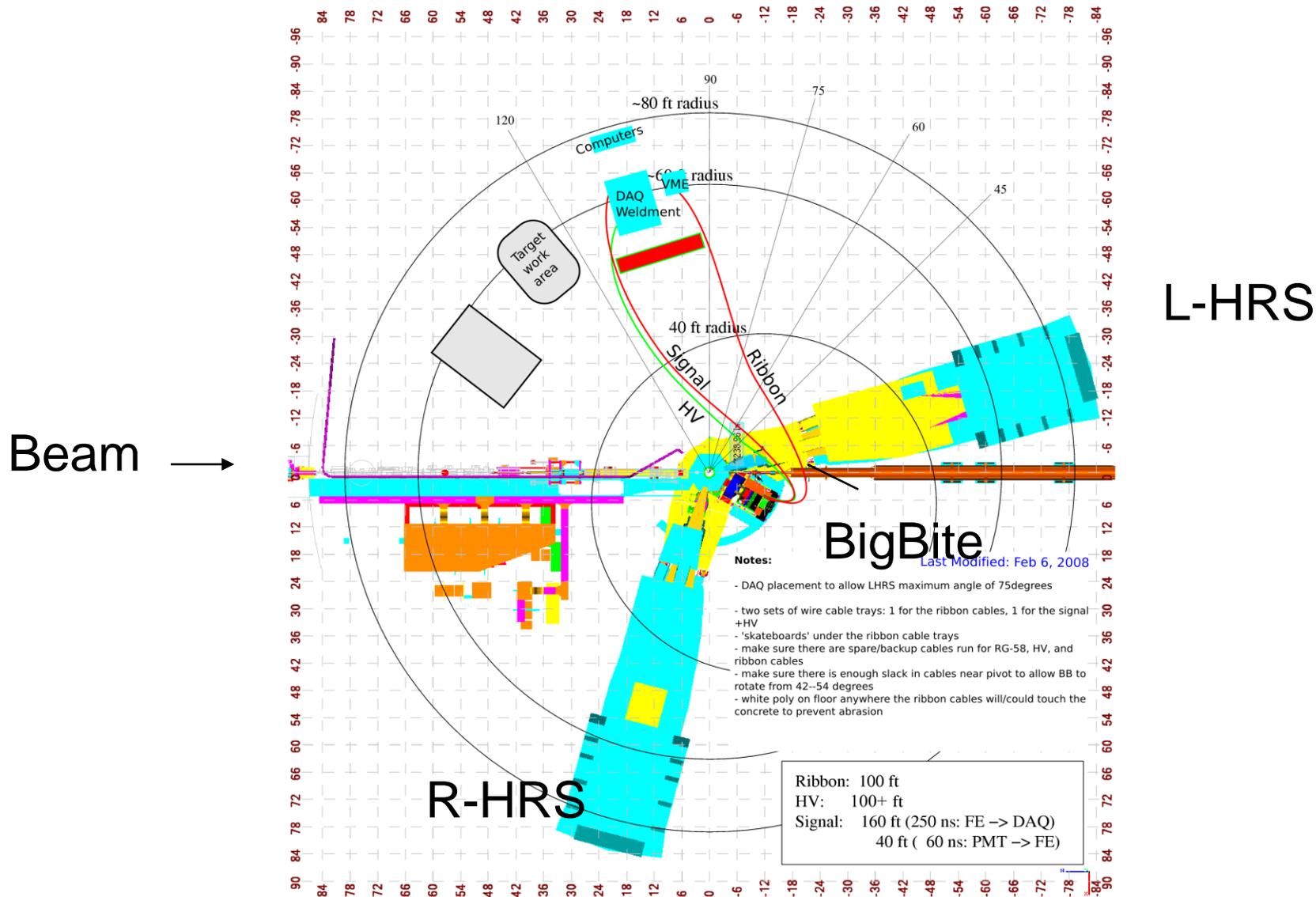
ChPT ———  
Bernard, et al. NP A607, 379(1996)

MAID -----

- Large deviations between ChPT and data
- Need data in a finer grid in  $Q^2$

# E04-007: Completed data taking May 8 2008

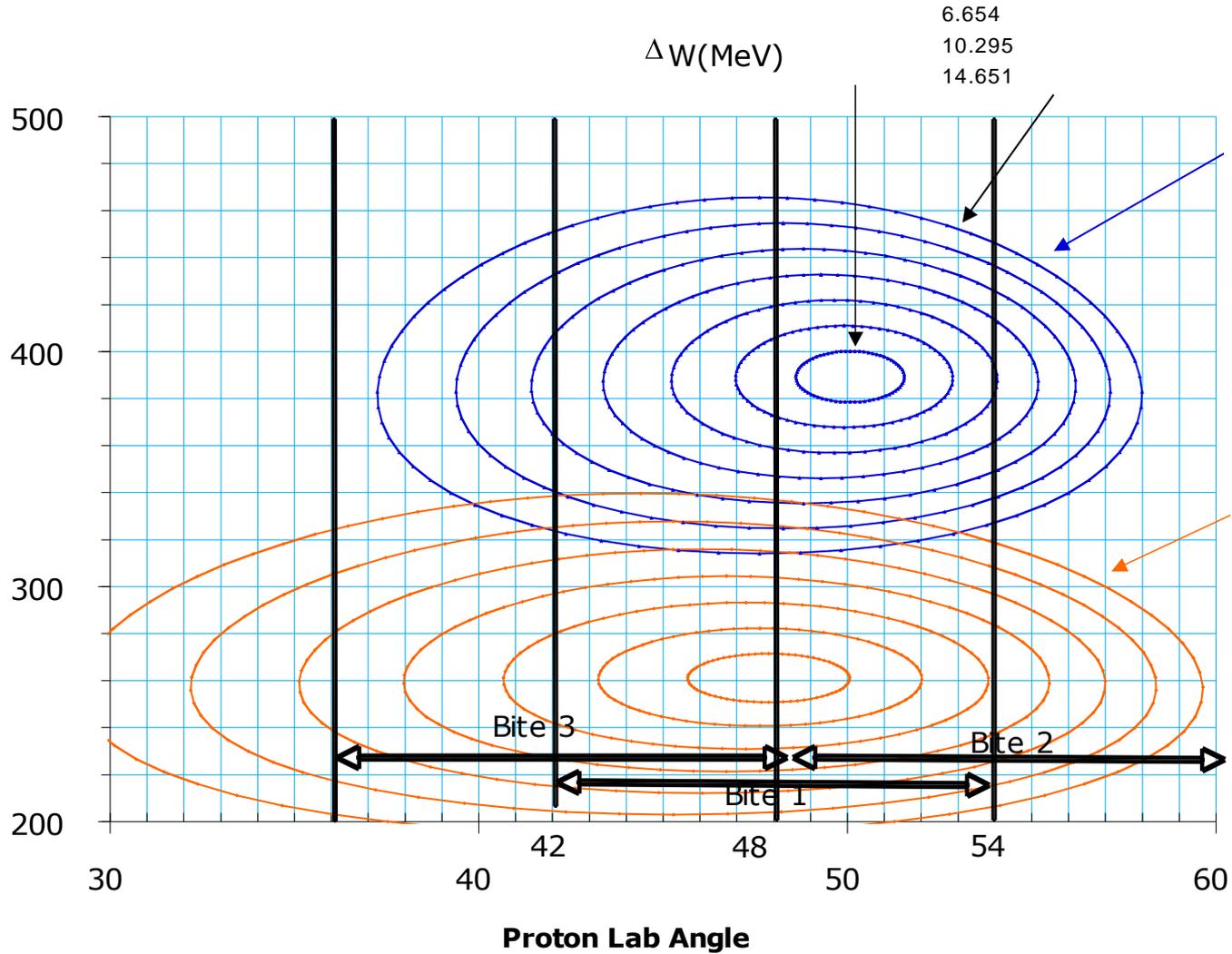
## $Q^2 = -0.045$ to $-0.50 \text{ GeV}^2$



# E04-007: Threshold $H(e,e'p)\pi^0$

- L- HRS defines  $Q^2, \Delta W$        $Q^2 = - 0.05 \text{ GeV}^2 - 0.15 \text{ GeV}^2$
- R-HRS used as luminosity monitor
- BigBite detects low momentum protons
  - Two MWDC ( 6 planes each) followed by two planes of scintillators
- Low momentum protons require:
  - New 6 cm long 1" Diameter Cell
  - New special flange with 0.003" Ti window
  - Custom  $^4\text{He}$  Bags
  - Sieve Slit for BigBite
  - Two triggers -  $\Delta E$  and E Plane
  - Two types of HRS triggers
  - MWDC with minimal mass
- New tracking code (Ole Hansen *et al.*)

# 1200 MeV



# E04-007: Summary of production kinematics for LH2

Kinematic	Energy GeV	BB Deg	HRS Deg	W GeV	$Q^2$ GeV <sup>2</sup>	Charge Coulombs
A	1.194	54	20.5	1073.8	-0.147	0.362
B	1.194	54	16.5	1073.8	-0.098	0.314
C	1.194	54	14.5	1073.8	-0.077	0.418
D	1.194	54	12.5	1073.8	-0.058	0.232
E	1.194	48	12.5	1073.8	-0.058	0.384
F	1.194	48	14.5	1073.8	-0.077	0.55
G	1.194	48	16.5	1073.8	-0.098	0.677
H	1.194	48	20.5	1073.8	-0.147	0.562
I	1.194	43.6	20.5	1073.8	-0.147	0.313
J	1.194	43.6	16.5	1073.8	-0.098	0.362
K	1.194	43.6	14.5	1073.8	-0.077	0.453
L	1.194	43.6	12.5	1073.8	-0.058	0.224
M	1.194	50.3	27.2	1194.0	-0.21	0.016
N	2.323	54	13.2	1073.8	-0.25	0.222
O	2.323	54	15.8	1073.8	-0.35	0.312
Q	2.323	54	18.2	1073.8	-0.45	0.336

# E04-007: Calibration Data

For each production kinematics we took:

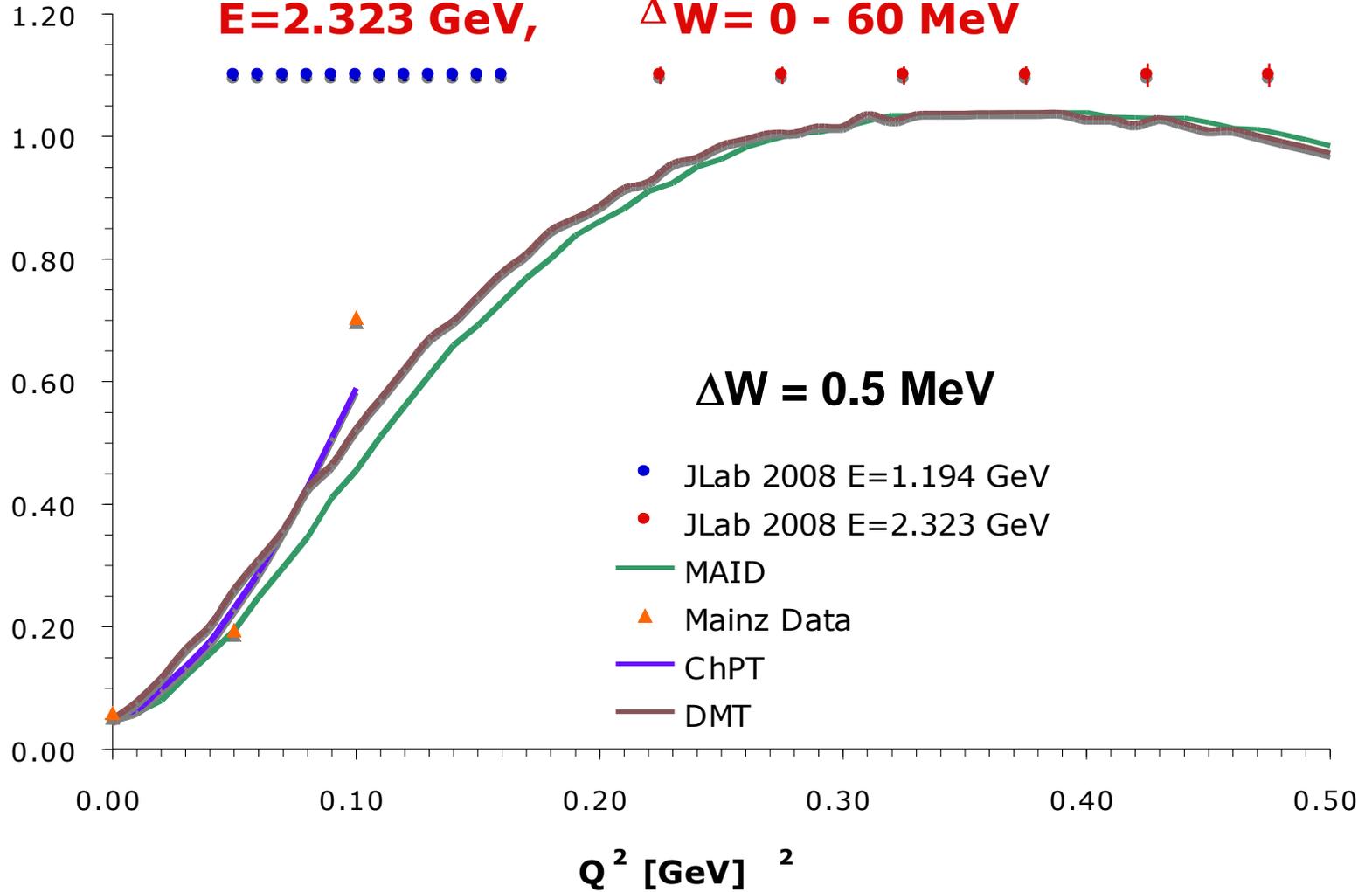
- Tantalum elastic - absolute beam energy- electron in HRS
- Proton elastic - electron in HRS, check cross section, proton in BigBite optics
- Carbon elastic and inelastic - check beam energy and cross section
  
- Quasi elastic deuterium data
- HRS Sieve slit data with hydrogen elastic
- BigBite Sieve Slit data with Quasi elastic from deuterium for oop optics
- Hydrogen data with collimated target cell
- Elastic recoil proton data with different currents in BigBite
- Production data with different beam currents (1- 6 ua)
- Data with different wire chamber high voltage and threshold. First time used for protons.
- Electronic 1 KHz pulser in data stream to measure computer dead time correction
- Production data with widely varied prescale factors.
  
- All end of run parameters on Excel spread sheet. Can search to find any particular run or number.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Kinemat ic	Run	Target	Time (minutes)	Events	LHRS p0 (GeV/c)	LHRS angle (deg)	BigBite I (A)	BigBite angle (deg)	T1 (pre/rea l)	T2 (pre/rea l)	T3 (pre/rea l)	T4 (pre/ al)
714	Q	4983	L1 6cm	23.503	1000917	1.93794	18.2	388.1	-54	12224 / 14669896 74	13022 / 15626924 14	12529 / 10900347	12309 41852
715	Q	4984	L1 6cm	22.73	1001632	1.93794	18.2	388.1	-54	12233 / 14680704 94	13022 / 15627438 44	12537 / 10907678	12312 41862
728	Q	4985	L1 6cm	21.607	1001895	1.93794	18.2	388.1	-54	12202 / 14642665 79	12994 / 15592960 33	12507 / 10881249	12268 41713
729	Q	4986	L1 6cm	22.53	1002955	1.93795	18.2	388.1	-54	12220 / 14664008 82	13019 / 15623143 63	12538 / 10908168	12297 41811
730	Q	4987	L1 6cm	21.964	1000288	1.93794	18.2	388.1	-54	12163 / 14595961 27	12952 / 15543057 17	12471 / 10850253	12205 41498
731	Q	4989	L1 6cm	29.943	1002612	1.93794	18.2	388.1	-54	12016 / 14419656 97	12783 / 15340770 88	12330 / 10727847	12162 41351
732	Q	4990	L1 6cm	27.213	1001252	1.93794	18.2	388.1	-54	12083 / 14500552 20	12856 / 15427530 44	12397 / 10785925	12196 41468
733	Q	4991	L1 6cm	37.008	1000589	1.93794	18.2	388.1	-54	12051 / 14461313 46	12840 / 15409129 85	12388 / 10778201	12300 41823
734	Q	4992	L1 6cm	21.394	1001411	1.93794	18.2	388.1	-54	12155 / 14586017 60	12928 / 15513904 39	12455 / 10836016	12201 41485
735	Q	4993	L1 6cm	27.693	1001331	1.93794	18.2	388.1	-54	12106 / 14527223 74	12885 / 15462980 69	12426 / 10810794	12249 41647
736	Q	4994	L1 6cm	36.695	700739	1.93794	18.2	388.1	-54	10366 / 12439504 24	11146 / 13375627 05	10571 / 9197619	10468 35592

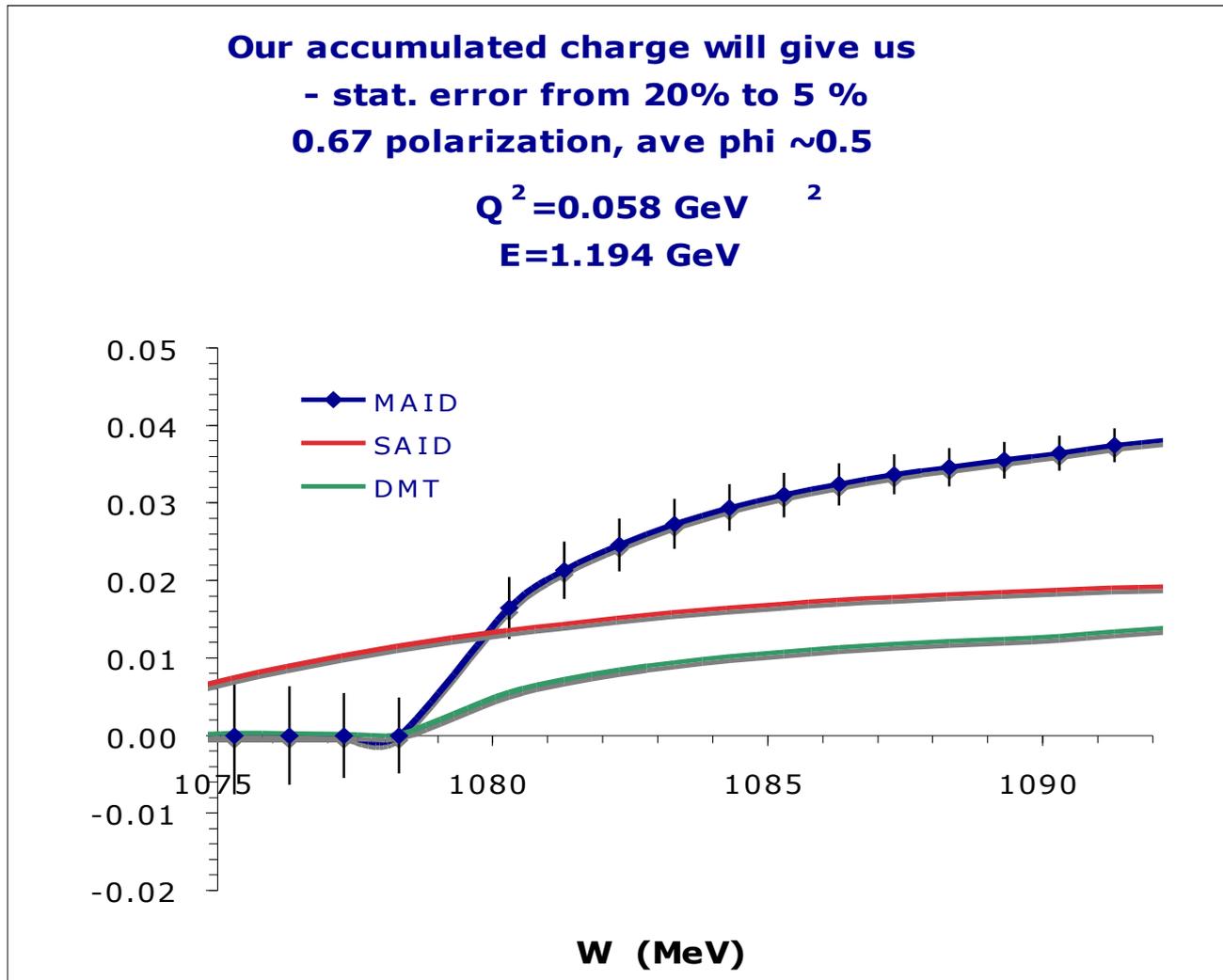
# $Q^2$ and $\Delta W$ Range of E04-007

**E=1.194 GeV,  $\Delta W=0 - 30$  MeV**

**E=2.323 GeV,  $\Delta W=0 - 60$  MeV**



# E04-007: Quality of Expected Asymmetry Data



Not in original proposal but we used polarized beam - allows us to measure  $A_{TL}$

# E04-007: Threshold $H(e,e'p)\pi^0$

3  $\mu\text{a}$  on 6 cm long  
Hydrogen Cell

S/N  $\sim$  2/1

Flat Randomized Background

Bin in 40 deg in  $\phi$  and 20 Deg in  $\theta$

10-15% loss in BigBite acceptance

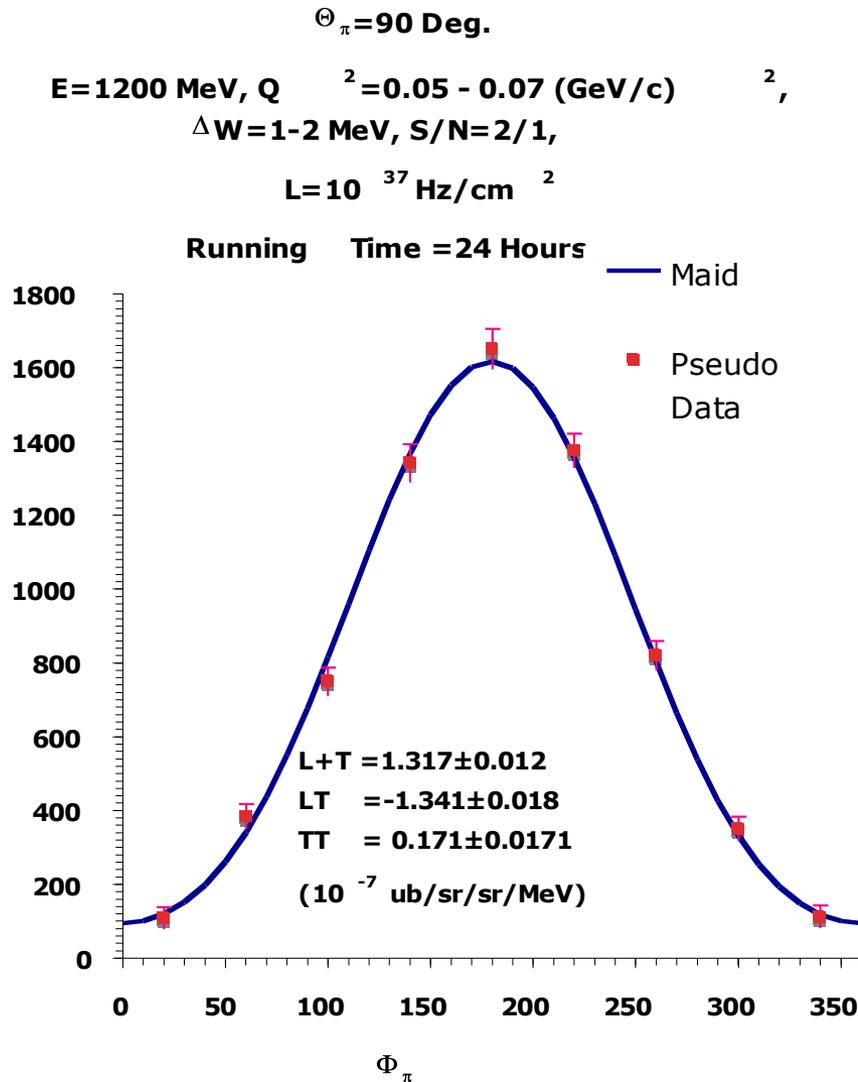
Least Squares fit to:

$$A+B\cos(\phi)+C\cos(2\phi)$$

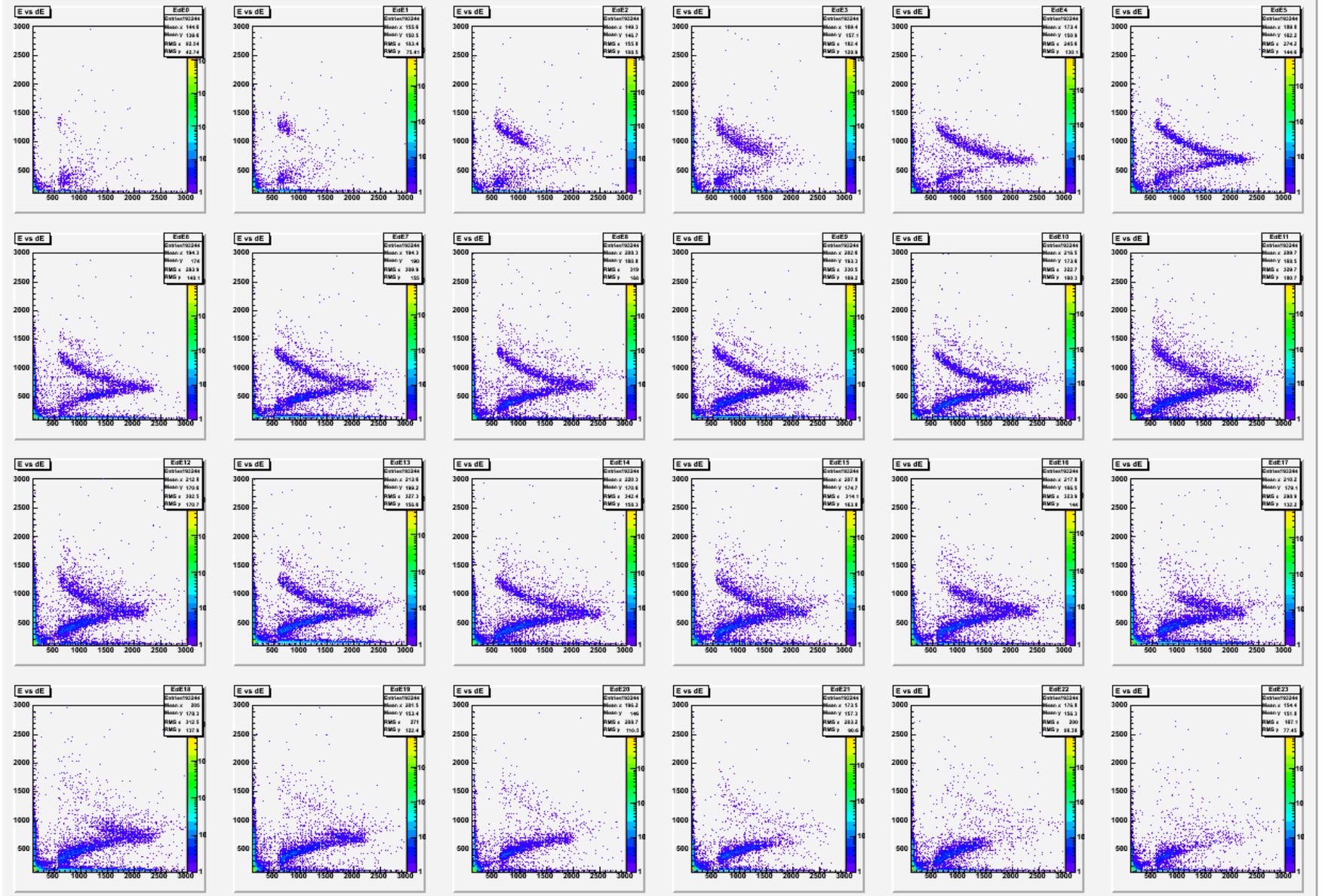
$$A\sim L+T \quad \text{Stat Er} \sim 1\%$$

$$B\sim LT \quad \text{Stat Er} \sim 1.5\%$$

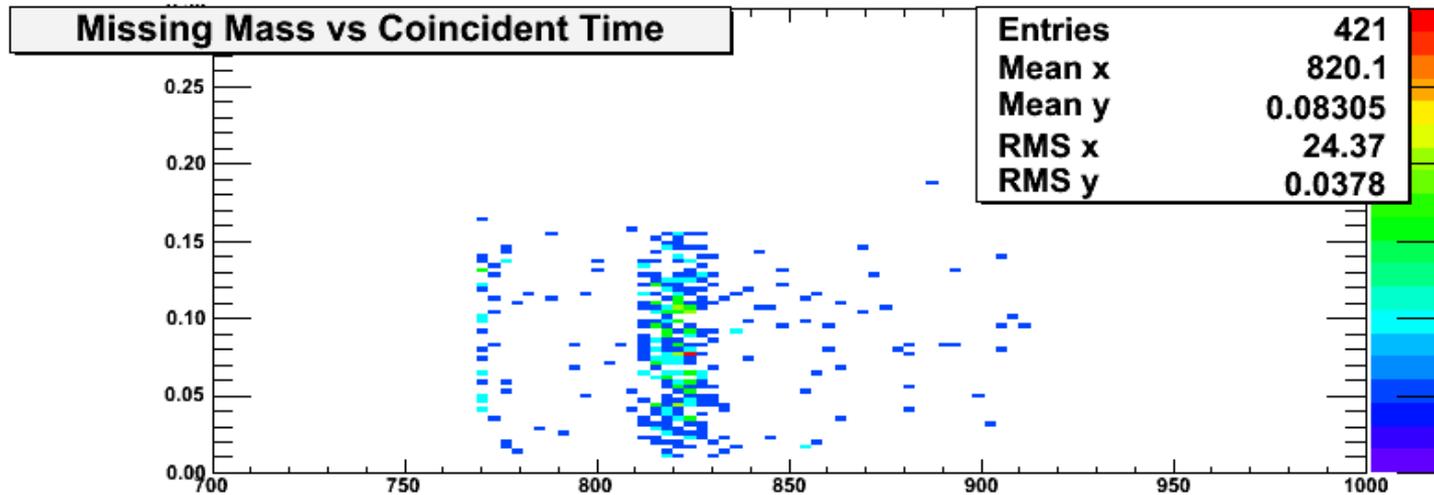
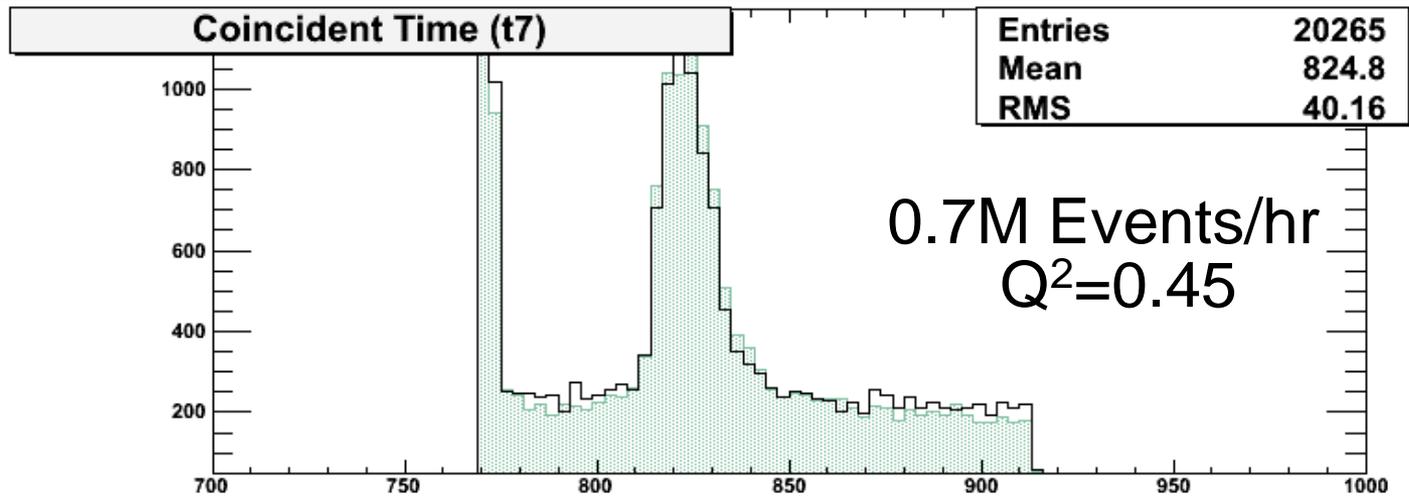
$$C\sim TT \quad \text{Stat Er} \sim 10\%$$



# E04-007: E- $\Delta E$ from 30 mm and 3 mm paddles



- Invariant Mass
- Trigger Plane
- Proton Momentum
- missing mass
- proton scattering angles
- coincident time
- Check the helicity detector
- BB MWDC1 coordinates



Prev

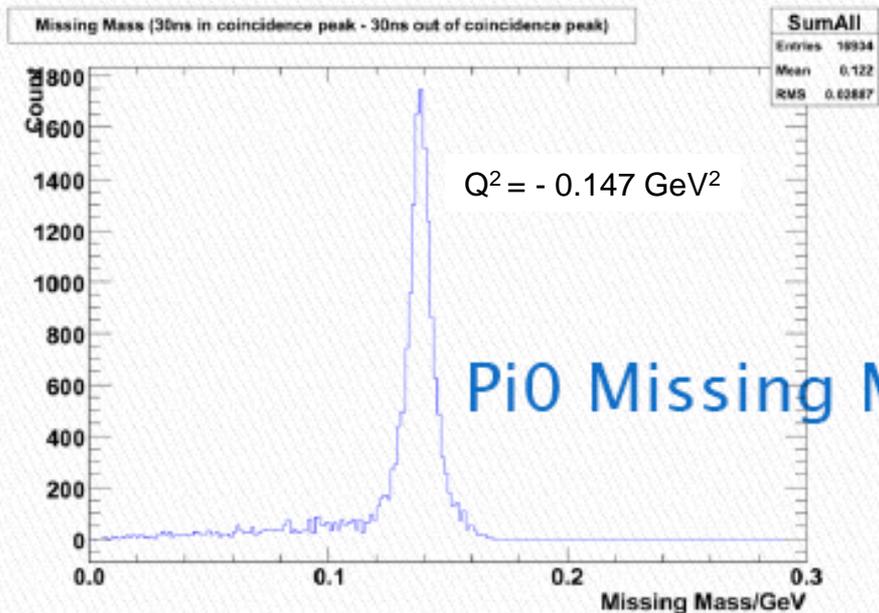
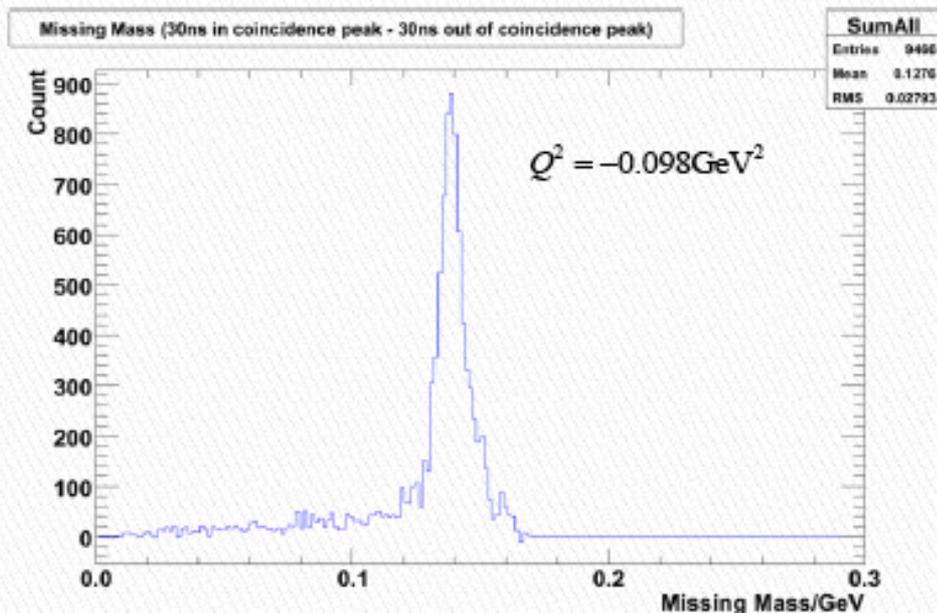
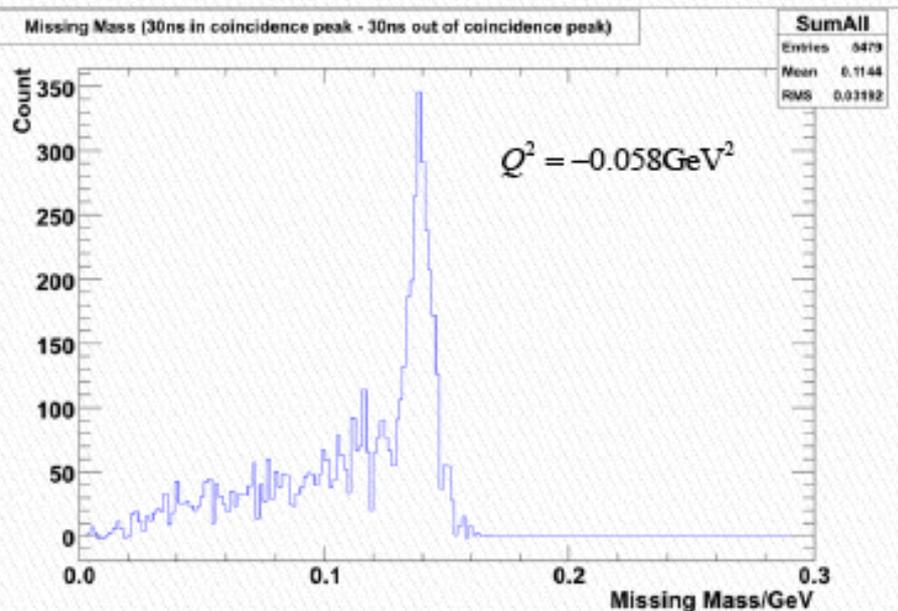
Next

Exit GUI

Run #4964

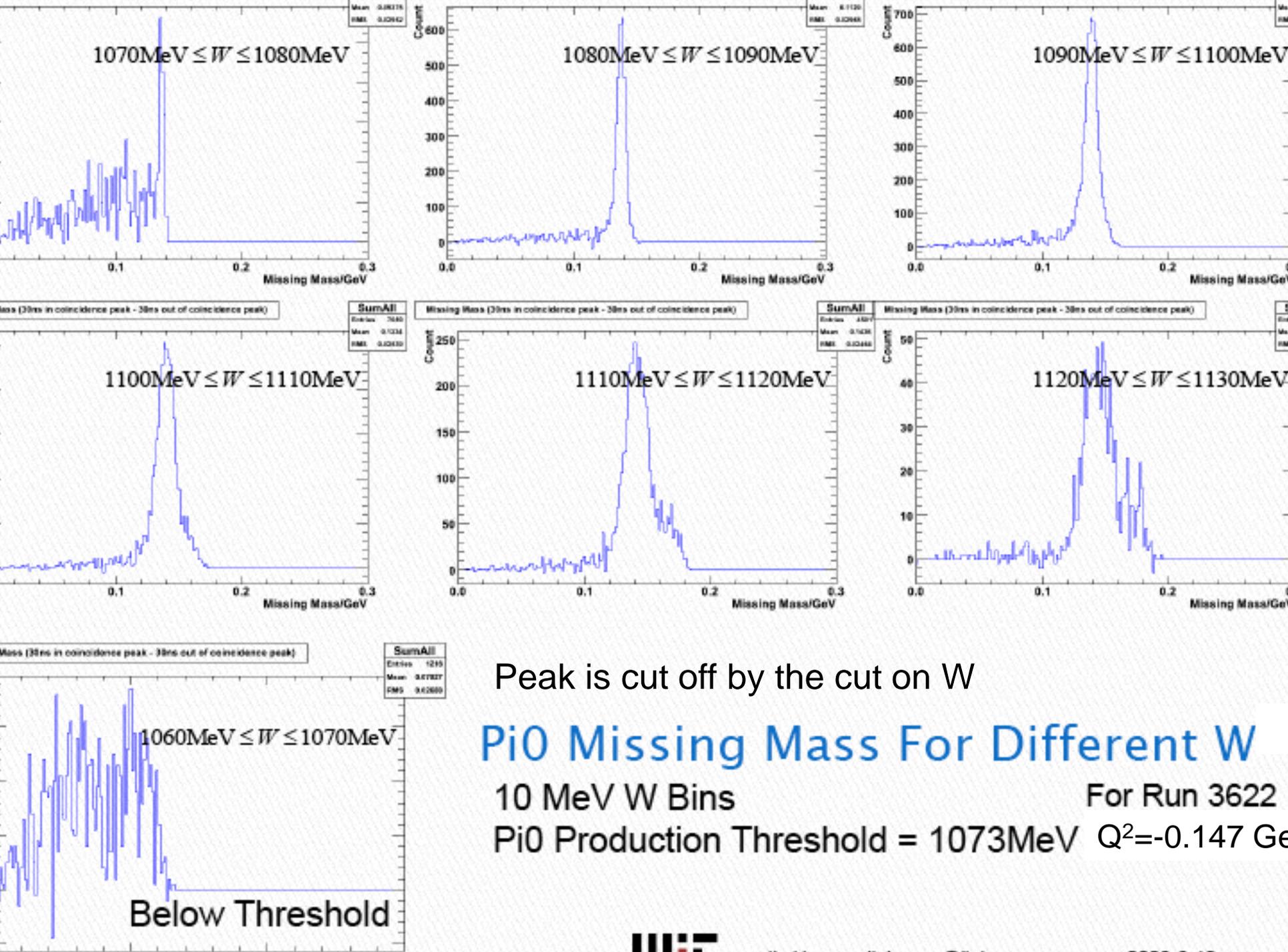
Print To File

# E04-007: BigBite "Online" Optics Jin Huang



E plane scintillator Trigger  
Cut on 30 ns peak - 30 ns background  
Cut on W above Threshold

Pi0 Missing Mass For Different  $Q^2$  Run

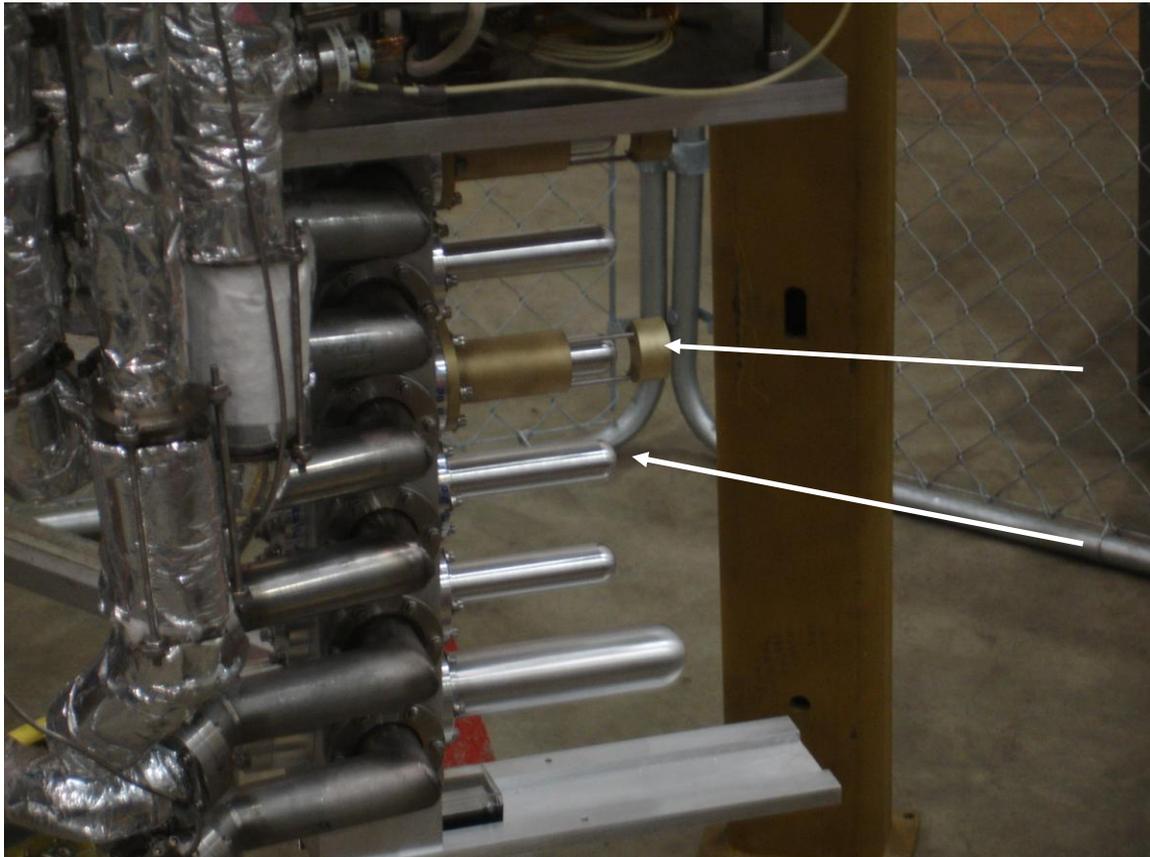


# E04-007: Beam Energy

QuickTime™ and a  
TIFF (Uncompressed) decompressor  
are needed to see this picture.

# E04-007: Special Equipment

## New 1" Diameter Cells

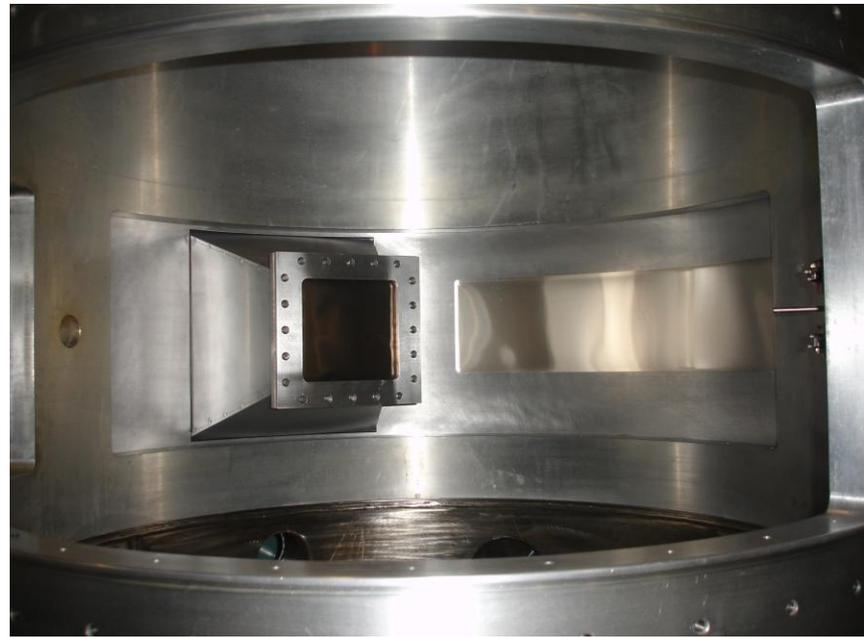


Collimator shielding  
Detectors from Cell  
Windows

Production cell

# E04-007: Special Equipment

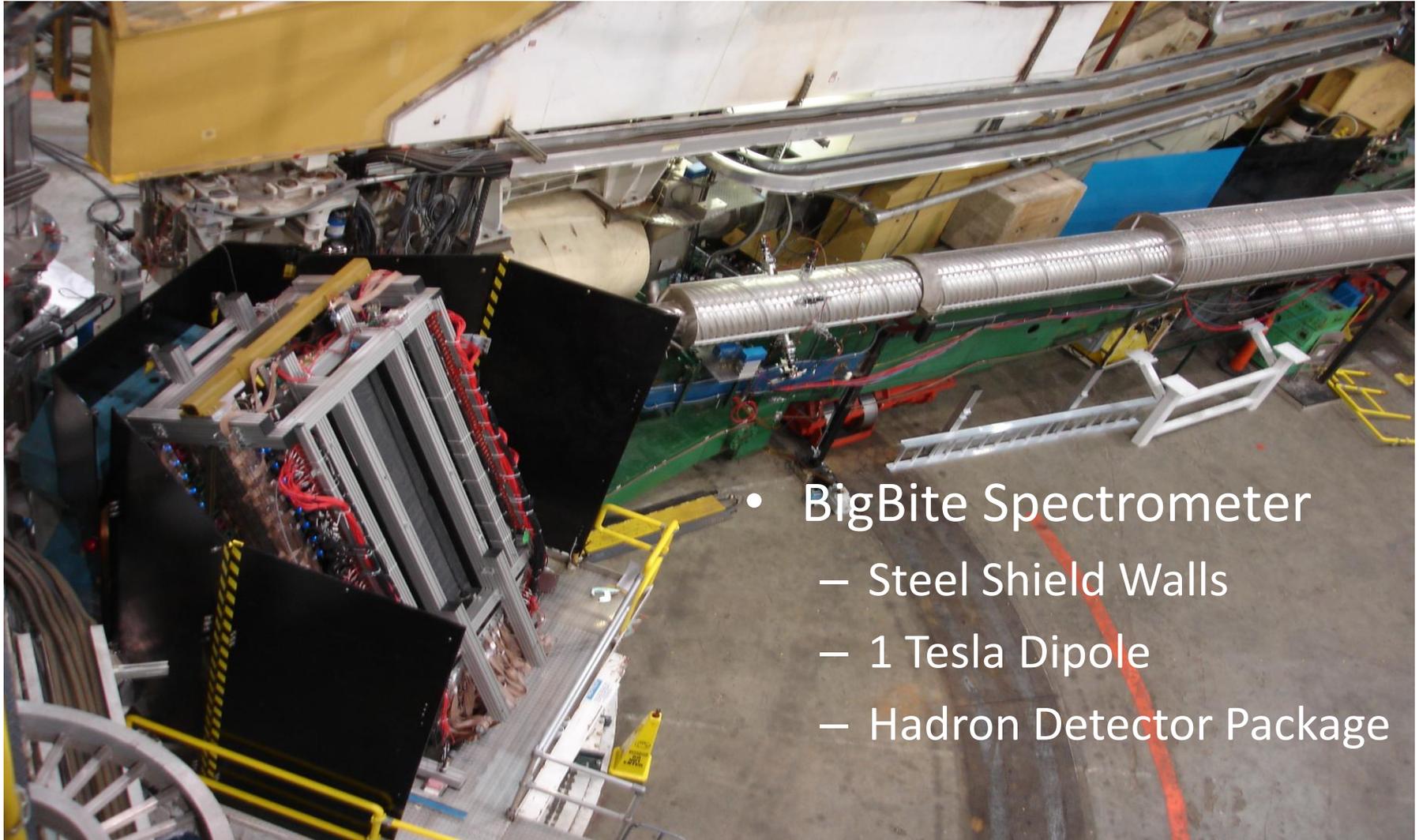
## Special Flange with 0.003" Ti Window



# E04-007: Custom 0.0035" thick polyurethane helium filled balloon



# E04-007: Installed In Hall A



# E04-007: Current Activity

- Ole Hansen - Tracking Code
- Miha Mihovilovic - Beam energy and initial BigBite calibration
- Jin Huang - BigBite Optics, Missing Mass, and Calibration
- Mitra Shabesatri - HRS and BigBite Optics and poster
- Khem Chirapatpimol - Elastic and inelastic Carbon data

# Summary

- Lots of data to work on and long way to go to absolute cross sections
- Preliminary data by Chiral Dynamics 2009 Workshop

# E04-007: Hadron detector package





# E04-007: Threshold $H(e, e'p)\pi^0$ Layout

## Target

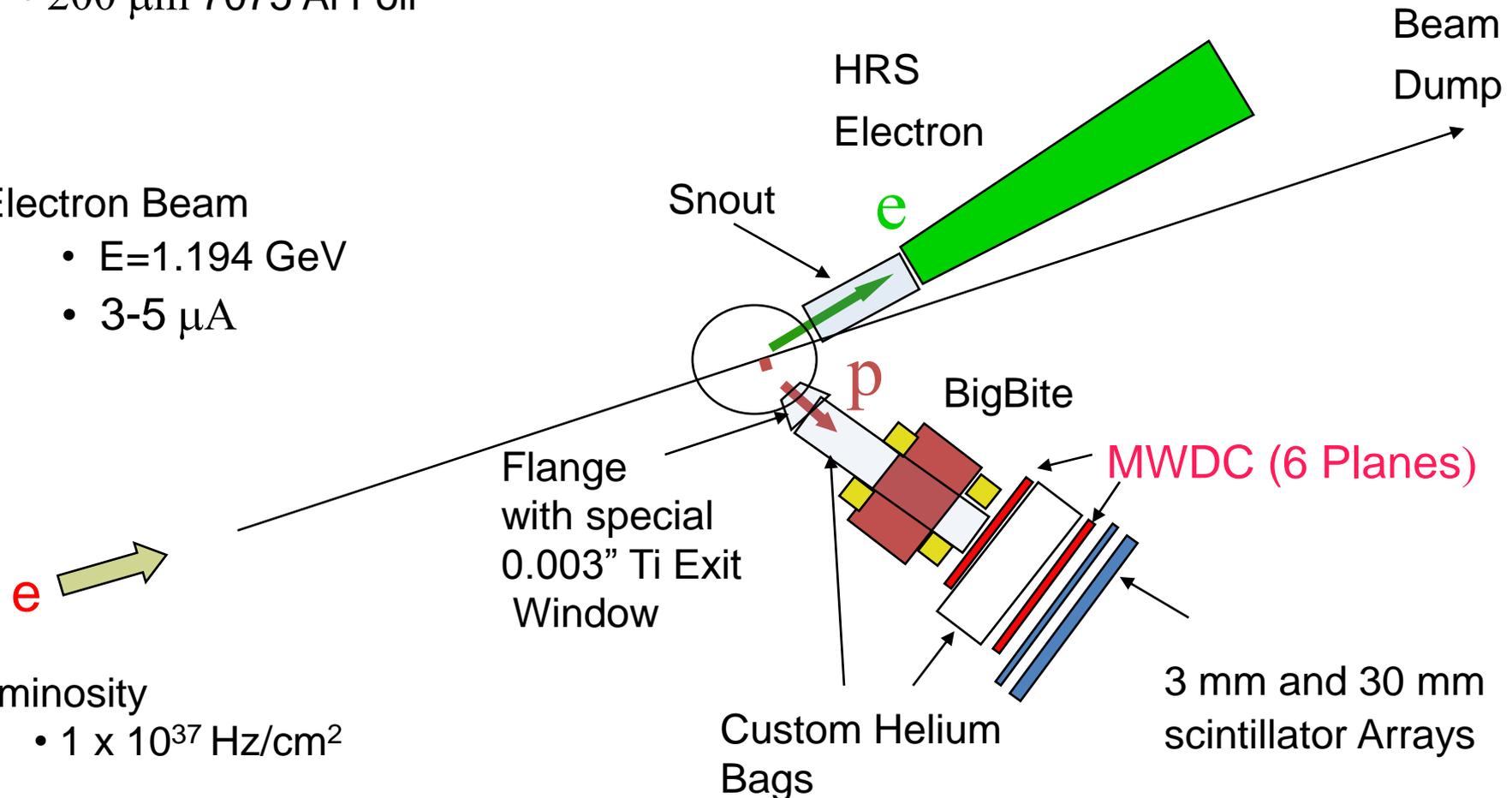
- New 6 cm long, 1" diameter LH2 cell
- 200  $\mu\text{m}$  7075 Al Foil

## Electron Beam

- $E=1.194$  GeV
- 3-5  $\mu\text{A}$

## Luminosity

- $1 \times 10^{37}$  Hz/cm<sup>2</sup>

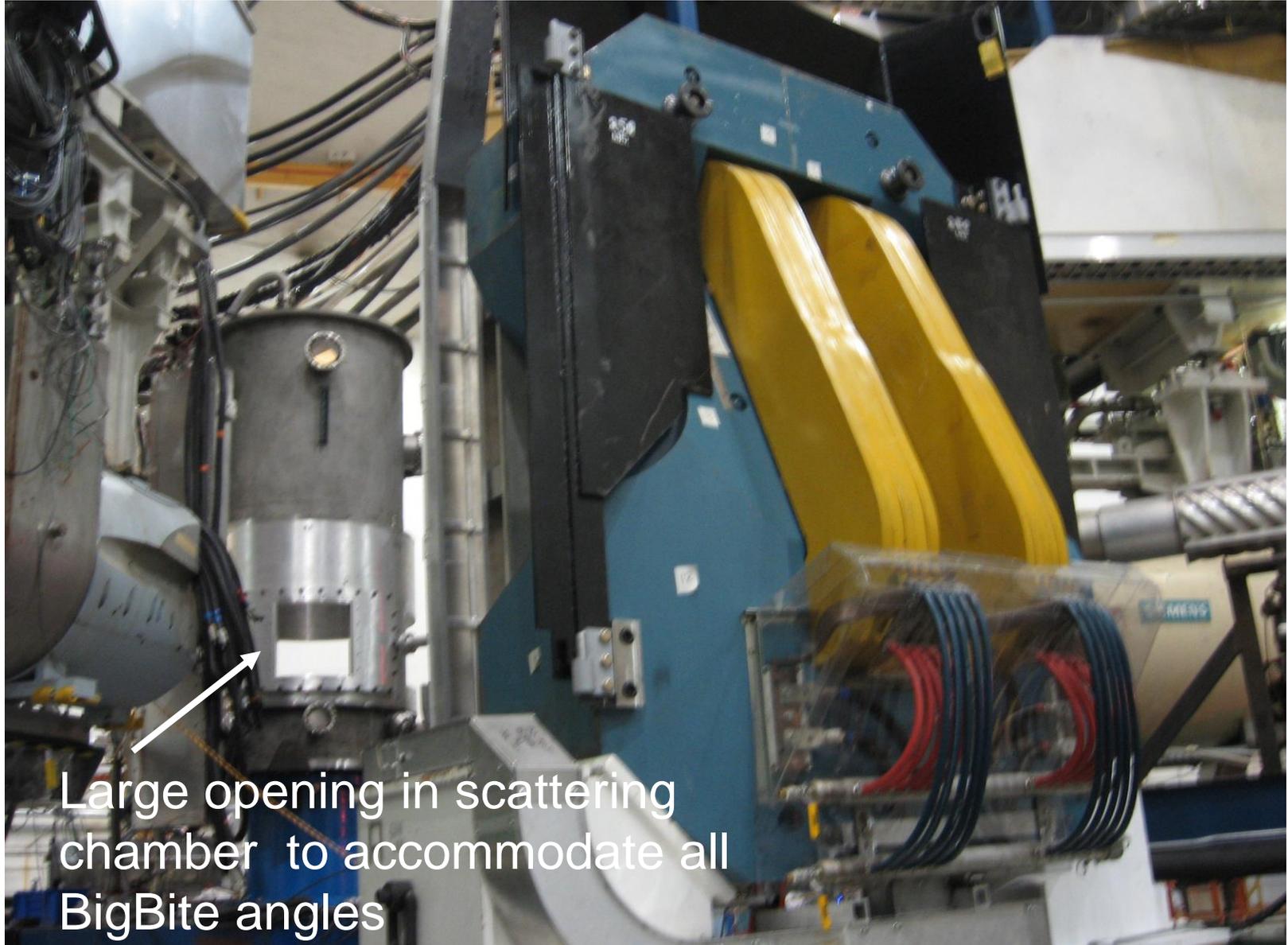


# E04-007:

Material traversed  
by low energy  
protons in BigBite

Material	Thickness(cm)	Density(gm/cm3)	Thickness(gm/cm2)	Distance	Distance
				from target	from BigBite
				center (cm)	Center (cm)
LH2	1.27	0.071	0.09017	1.27	
Aluminum	0.0127	2.7	0.03429	1.2827	
Vacuum	23.4	0	0	24.6827	
Ti	0.00762	4.54	0.0345948	24.69032	
Helium	46.8	0.000178	0.0083304	71.49032	
polyurethane	0.0102	0.95	0.00969	71.50052	
polyurethane	0.0102	0.95	0.00969	71.51072	
Helium	155.08	0.000178	0.02760424	226.59072	85.94072
polyurethane	0.0102	0.95	0.00969	226.60092	85.95092
Air(80%N <sub>2</sub> - 20% O <sub>2</sub> )	11	0.001293	0.014223	237.60092	96.95092
Al-kapton(C <sub>22</sub> H <sub>10</sub> N <sub>2</sub> O <sub>4</sub> )	0.003	1.42	0.00426	237.60392	96.95392
Ar-Ethane(C <sub>2</sub> H <sub>6</sub> )	0.3175	1.569	0.4981575	237.92142	97.27142
Cu-Mylar(C <sub>10</sub> H <sub>6</sub> O <sub>4</sub> )	0.00178	1.39	0.0024742	237.9232	97.2732
Ar-Ethane	0.635	1.569	0.996315	238.5582	97.9082
Cu-Mylar	0.00178	1.39	0.0024742	238.55998	97.90998
Ar-Ethane	0.635	1.569	0.996315	239.19498	98.54498
Cu-Mylar	0.00178	1.39	0.0024742	239.19676	98.54676
Ar-Ethane	0.635	1.569	0.996315	239.83176	99.18176
Cu-Mylar	0.00178	1.39	0.0024742	239.83354	99.18354
Al-kapton	0.003	1.42	0.00426	239.83654	99.18654
air	11	0.001293	0.014223	250.83654	110.18654
polyurethane(CH <sub>2</sub> )	0.0102	0.95	0.00969	250.84674	110.19674
Helium	70.2	0.000178	0.0124956	321.04674	180.39674
polyurethane	0.0102	0.95	0.00969	321.05694	180.40694
Al-kapton	0.003	1.42	0.00426	321.05994	180.40994
Ar-Ethane	0.3175	1.569	0.4981575	321.37744	180.72744
Cu-Mylar	0.00178	1.39	0.0024742	321.37922	180.72922
Ar-Ethane	0.635	1.569	0.996315	322.01422	181.36422
Cu-Mylar	0.00178	1.39	0.0024742	322.016	181.366
Ar-Ethane	0.635	1.569	0.996315	322.651	182.001
Cu-Mylar	0.00178	1.39	0.0024742	322.65278	182.00278
Ar-Ethane	0.635	1.569	0.996315	323.28778	182.63778
Cu-Mylar	0.00178	1.39	0.0024742	323.28956	182.63956
Al-kapton	0.003	1.42	0.00426	323.29256	182.64256
air	2	0.001293	0.002586	325.29256	184.64256
Black tape	0.0356	1.27	0.045212	325.32816	184.67816
3mm EJ204scintillator	0.3	1.032	0.3096	325.62816	184.97816
Black tAPE	0.0356	1.27	0.045212	325.66376	185.01376
Air	1	0.001293	0.001293	326.66376	186.01376
Black tape	0.0356	1.27	0.045212	326.69936	186.04936
30 mm EJ204scintillator	3	1.032	3.096	329.69936	189.04936
Black tAPE	0.0356	1.27	0.045212	329.73496	189.08496

# E04-007: BigBite installed



Large opening in scattering chamber to accommodate all BigBite angles