

# Qweak Tracking System

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# Outline

- Tracking system components
- Measurements performed
- Subsystem performance
- Initial  $Q^2$  result
- Future work

# Qweak Tracking System Components

Region II Horizontal Drift Chambers

Virginia Tech

Region III Vertical Drift Chambers

William & Mary

Trigger Scintillator

George Washington U.

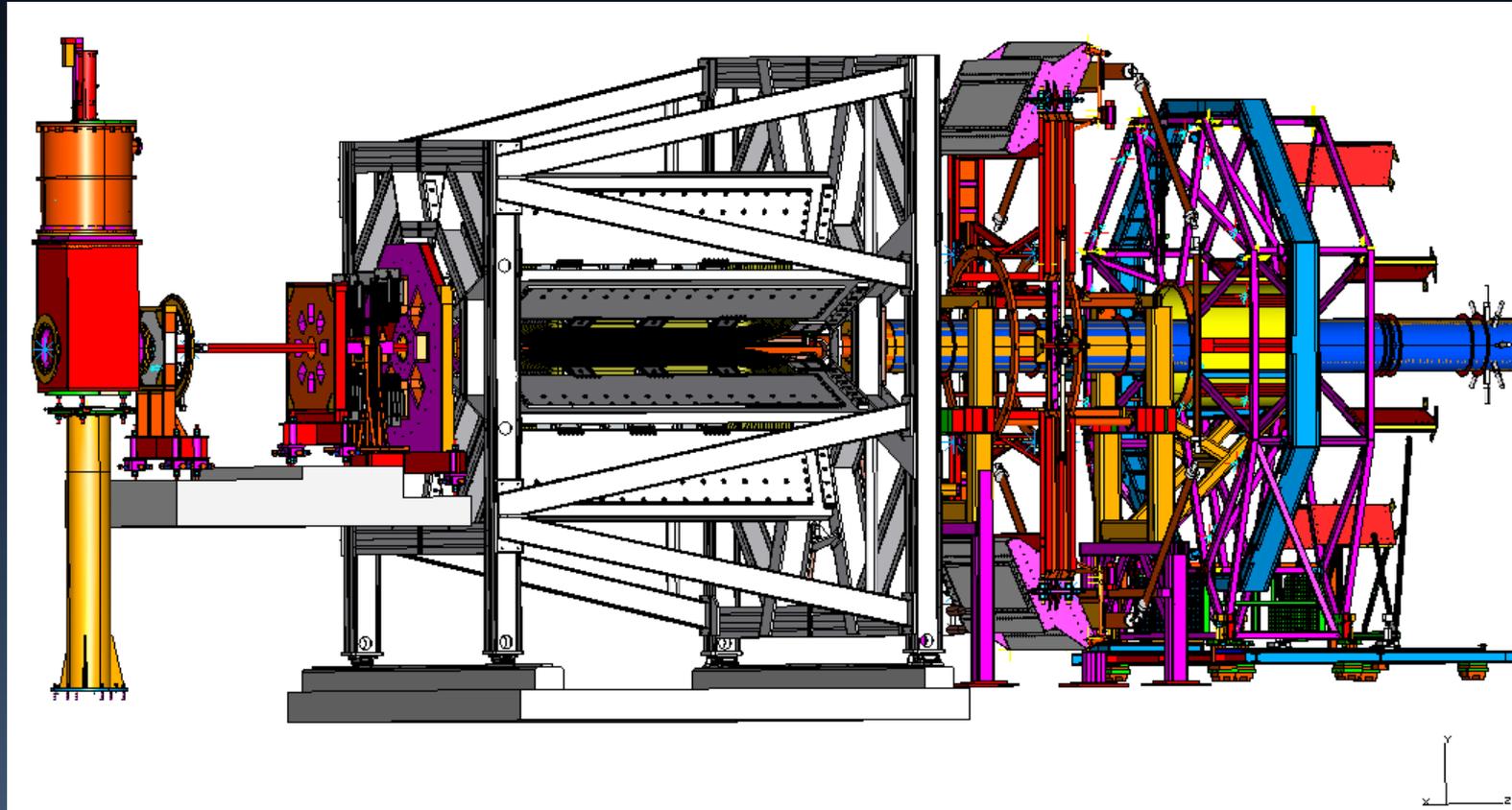
Focal Plane Scanner

U. Winnipeg

Tracking Software

all + Ohio U.

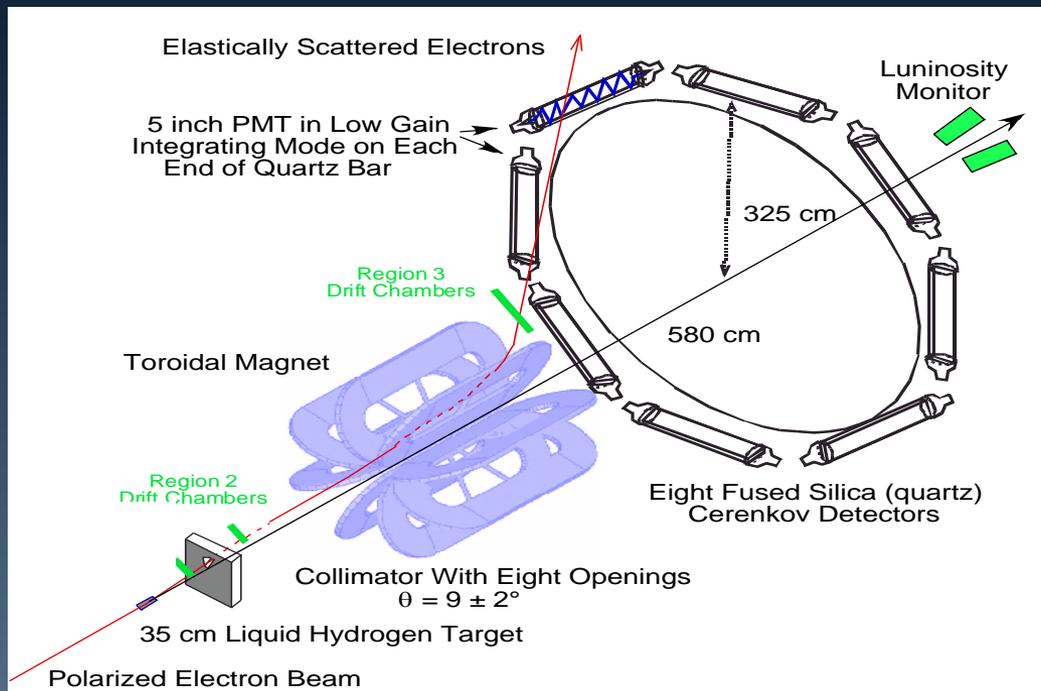
# APPARATUS



50 pA beam current, two opposite octants instrumented, rotator system for each region to cover all octants  
Focal plane scanner to monitor profile in one octant at high current

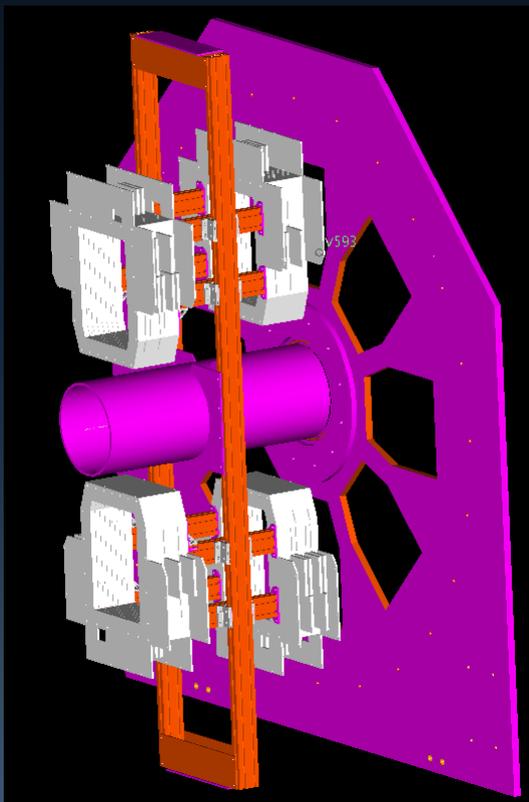
# Why do we need the tracking system?

$$A = \frac{\sigma_R - \sigma_L}{\sigma_R + \sigma_L} = \left[ \frac{-G_F}{4\pi\alpha\sqrt{2}} \right] (Q^2 Q_{weak}^p + Q^4 B(Q^2))$$

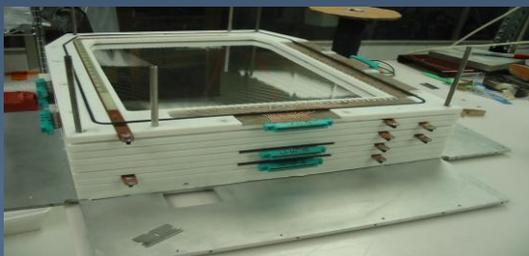


- 0.5% error budget of  $Q^2$  for final 4%  $Q_{weak}$  measurement

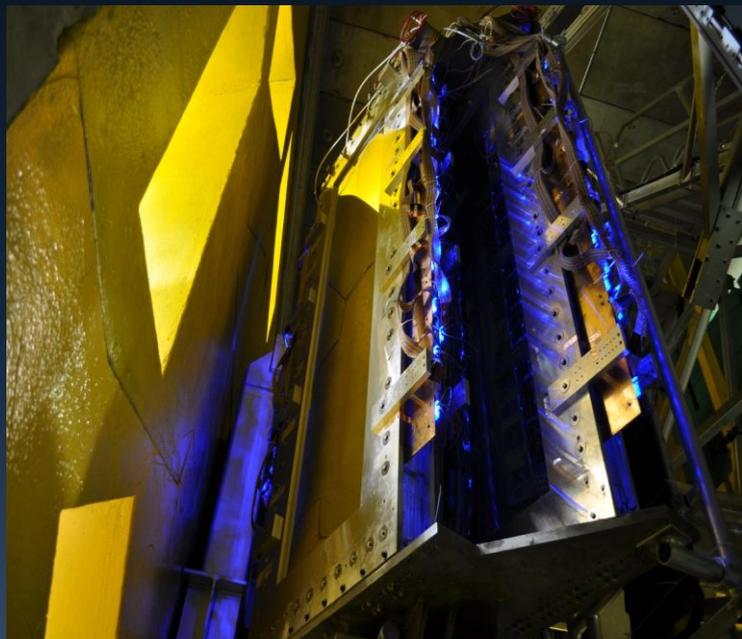
# Region 2 Horizontal Drift Chambers



- Built and tested at Virginia Tech
- 24 wire planes, 4 chambers, 2 packages
- X,U,V directions
- Measure target vertex and angle of scattered electrons
- > 99 % single plane efficiency
- 200  $\mu\text{m}$  single plane resolution



# Region 3 Vertical Drift Chambers



- Built and tested at W&M
- 8 wire planes, 4 chambers, 2 packages
- U,V directions
- Ensure elastic events
- Map out the Main Detector analog response
- > 99 % single plane efficiency
- 225  $\mu\text{m}$  single plane resolution



# Other components



- Trigger Scintillator
  - One per tracking octant
  - Mounted on Region III rotator behind VDCs



- Focal Plane Scanner
  - Cherenkov detector with small active area
  - Located in bottom octant in front or behind main detector
  - Link between tracking measurements and parity running

# Tracking Running Modes

**Full tracking with R2 + R3 (50 pA)**

**R3 rate = 100 Hz**

**R2 rate = 50k Hz**

**R3/MD tracking R3 (25 nA)**

**R3 rate = 75k Hz**

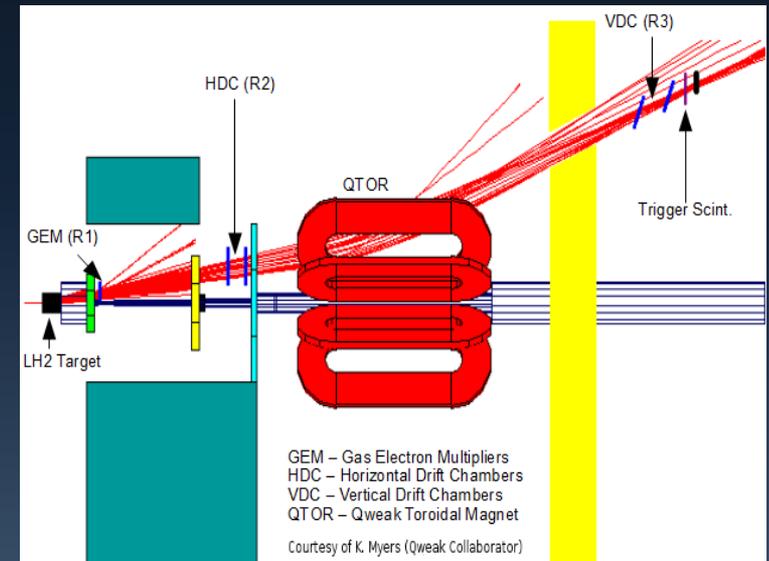
**R2 off**

**Beam Energy: 1157.5MeV(Run II)**

**1160MeV(Run I)**

**QTOR: 8900 Amps(Run II) 8921**

**Amps(Run I)**



dominated moller events  
are bent away by magnet

# Data Taken so far

- Run I

Jan 2011

Mar 2011: partial

May 2011: partial

**37 shifts**

- Run II

Nov 2011

Jan 2012 (underway)

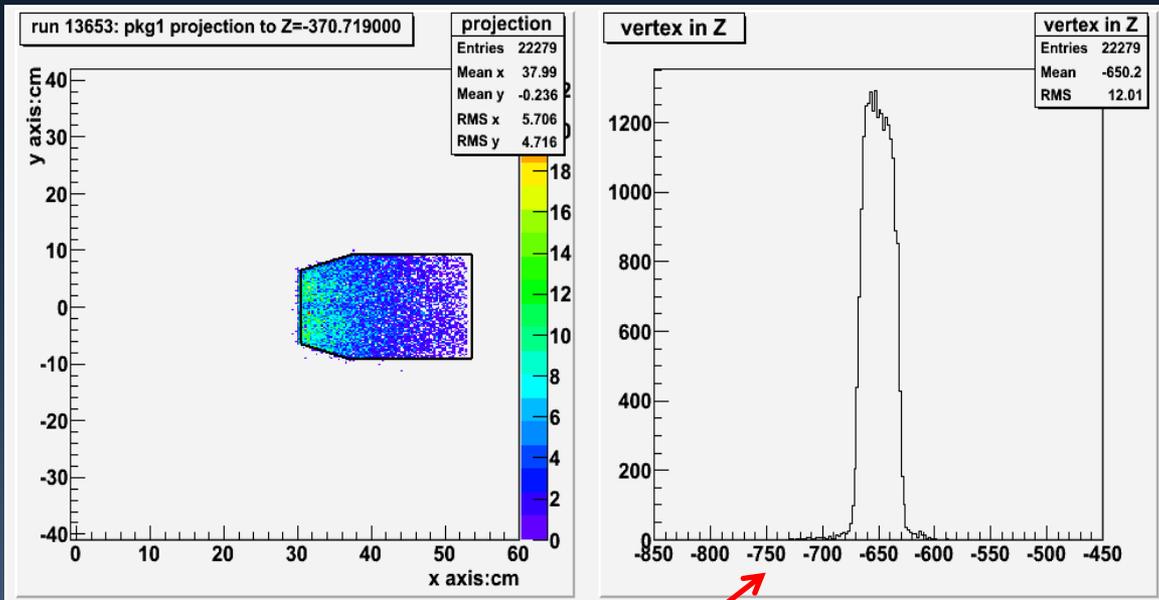
# What we've got

- Study systematic dependencies  
raster size, beam rate, beam positions
- Change the target  
LH2 target, solid target, optics target
- Rotate the chamber  
cover all octants
- Stability check  
Qtor scan

# R2 Tracking

50 pA, 35 cm LH2 target

R2+R3+MD, one track per event, no other filters

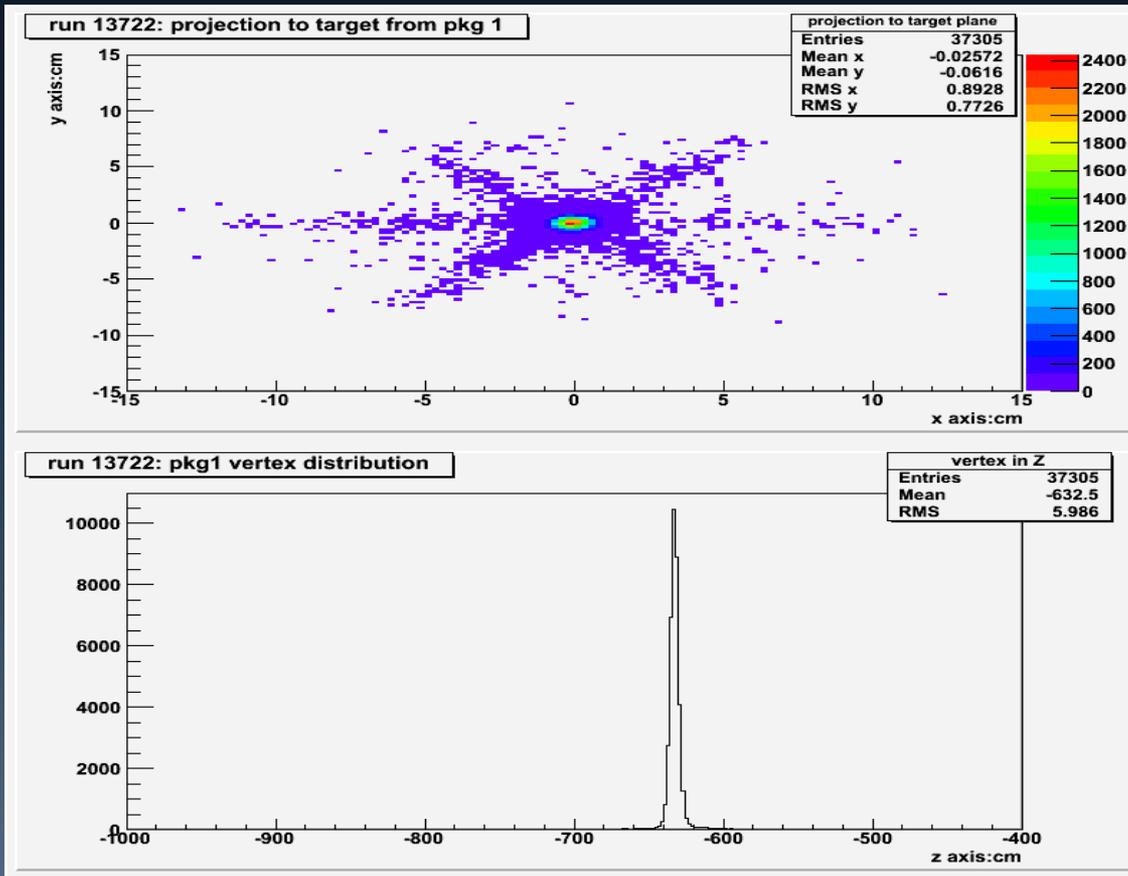


Vertex RMS: 12cm(ideal=10cm)

- 250  $\mu\text{m}$  average residual
- Scattering angle measured to be around  $7.8^\circ$  ( $7^\circ - 11^\circ$  design)
- Reconstruction of aperture of defining collimator
- Target vertex reconstruction

# a even more rigorous checking...

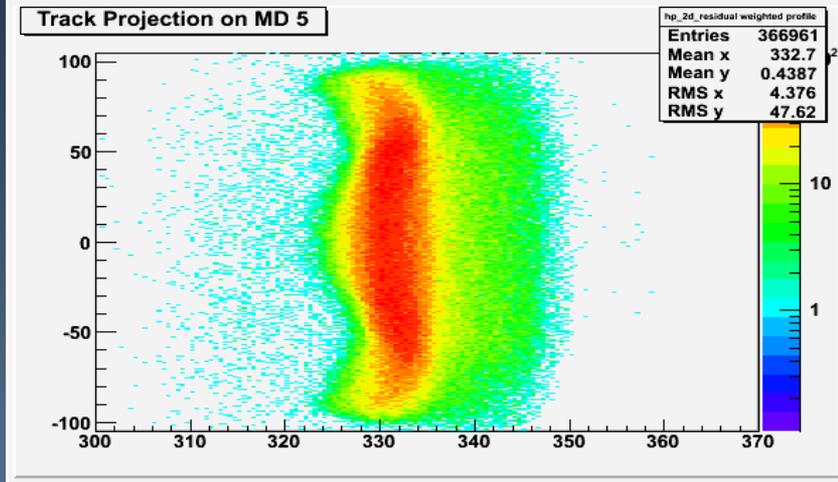
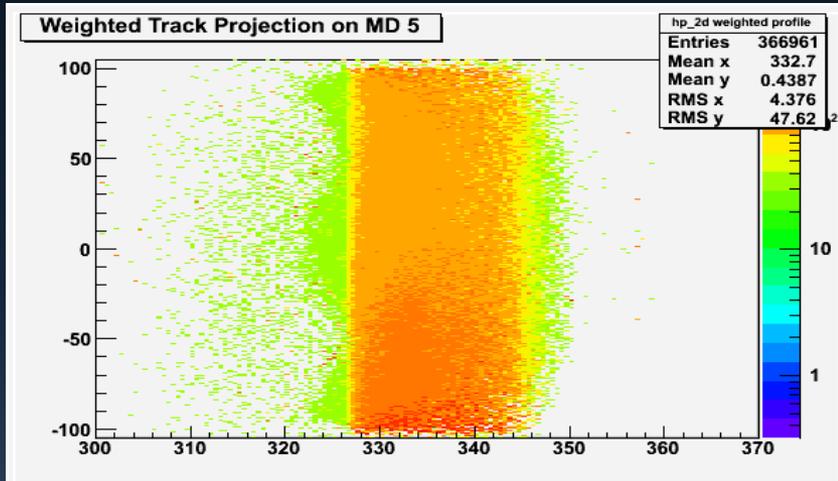
R2+R3+MD, one track per event, no other filters



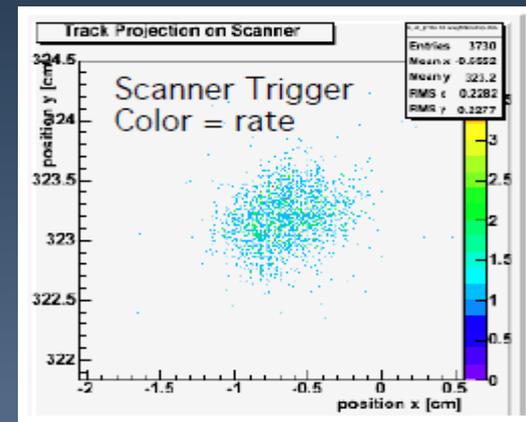
- DS solid target
- Projection back to target plane
- $1*1 \text{ cm}^2$  area
- Stripes are due to pathological cases: moller+cosmic rays(< few percent)

Vertex RMS: 5.9cm VS  $\delta$  function

# R3 Tracking



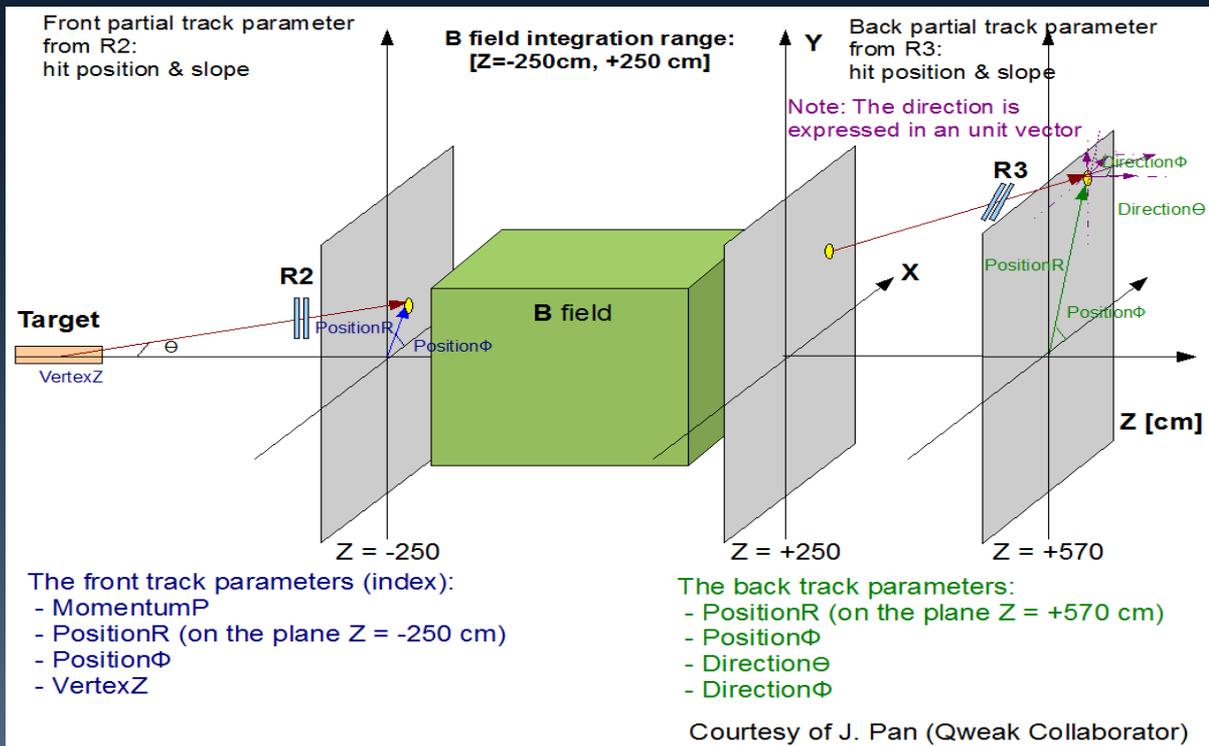
- Average track residual 260  $\mu\text{m}$
- Tracks projected to the Z of the MD
- Top weighted by MD phototubes P+M
- Lower unweighted version



1\*1  $\text{cm}^2$   
active  
scanner  
area

# $Q^2$ result

How do we calculate the  $Q^2$ ?



Swim the R2 track to see if it matches R3 track

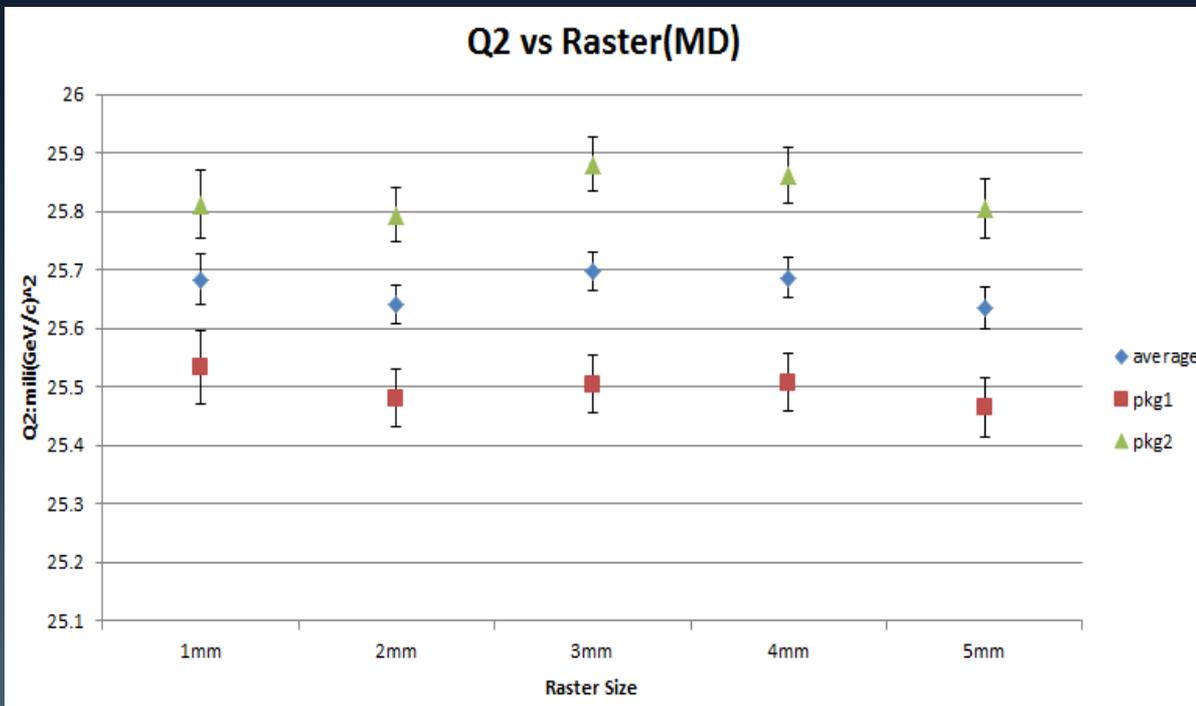
If not, change the momentum, then repeat the process

If R2 matches R3, using beam energy E at vertex and scattering angle  $\theta$

$$\frac{2M_p E^2 (1 - \cos\theta)}{M_p + E(1 - \cos\theta)}$$

# Systematic study

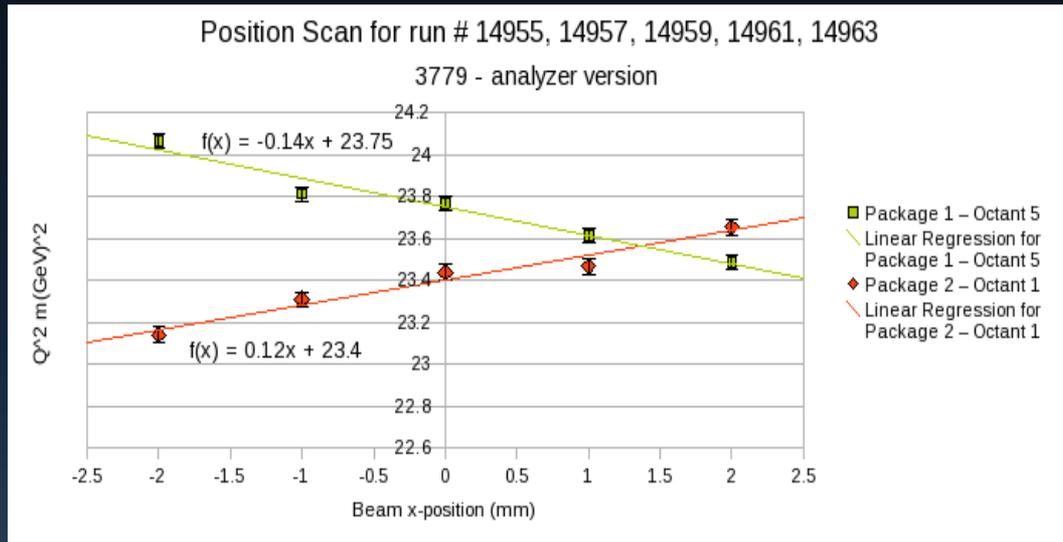
## Raster Size



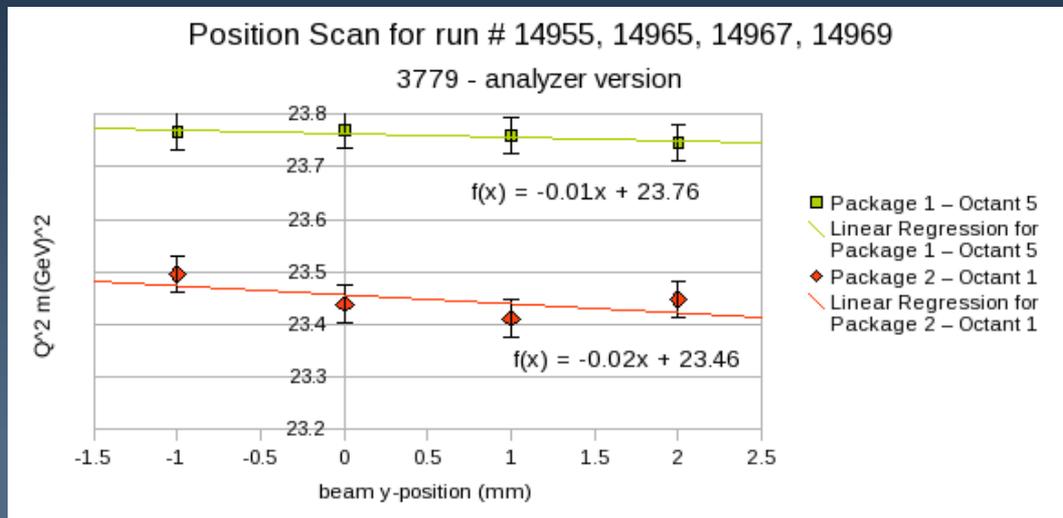
- R2+R3+md
- One track per event

- Absolute value still needs to be updated
- Relative change
- Largest point-to-point  $Q^2$  variation is 0.2%
- does not depend on raster size

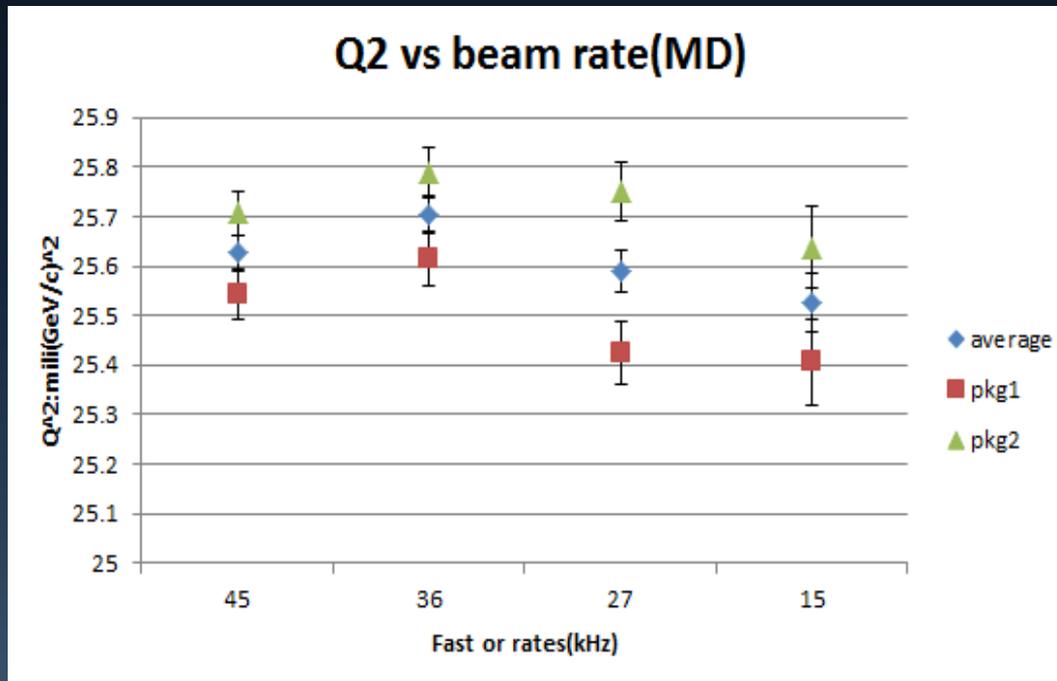
# Beam position



- R2+R3+md
- One track per event
- 1mm step change in x, y direction
- Smooth dependence of central value of  $Q^2$  on beam position

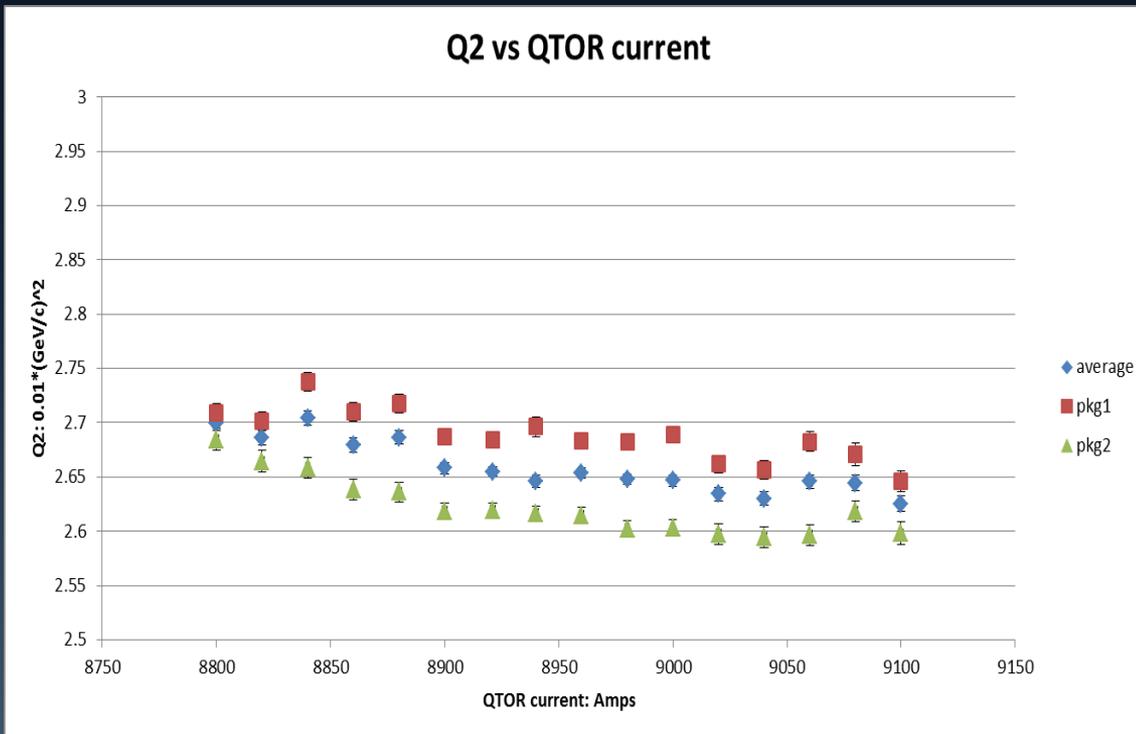


# Beam rate



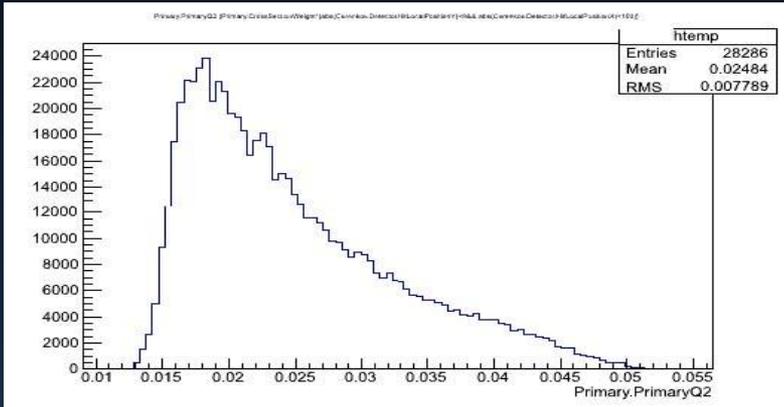
- R2+R3+md
- One track per event
- Change beam current(use HDC fast rates as proxy)
- Only took less than 10min runs each
- Need to take more data with more statistics

# QTOR



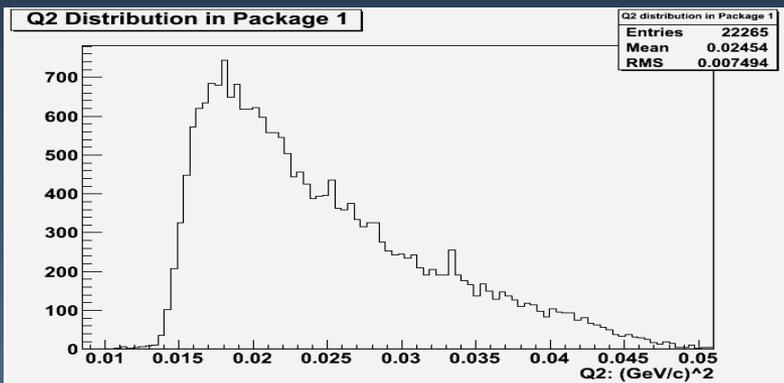
- R2+R3+md
- One track per event
- Change QTOR current
- Serve as stability checks
- Generally smooth
- Needs to study more

# MC Data



- Relying on MC data to compensate the energy loss in the target or radiation loss
- Using both Geant3 and Geant4 to compare with the real data

mc data:  $\langle Q^2 \rangle \sim 0.2484(\text{GeV}/c)^2$



- “by-eye” comparison, mc uses higher energy(1162MeV)
- Study is underway...

real data:  $\langle Q^2 \rangle \sim 0.2454(\text{GeV}/c)^2$

# Conclusion

- R2 and R3 subsystem have behaved well
- 3 periods of tracking data
- Completed part of systematic study
- MC data is generated under Geant3 and Geant4 separately

# Near Future Work

- Study cuts
- Implement the geometry for all octants
- Replay all the data we've collected so far
- Detailed Comparison of MC with Real Data

**Thank you!**