Exclusive Analysis with the Hermes Recoil Detector (Elastic Processes)

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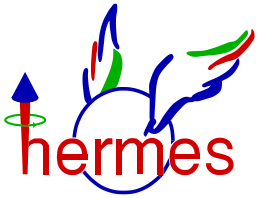
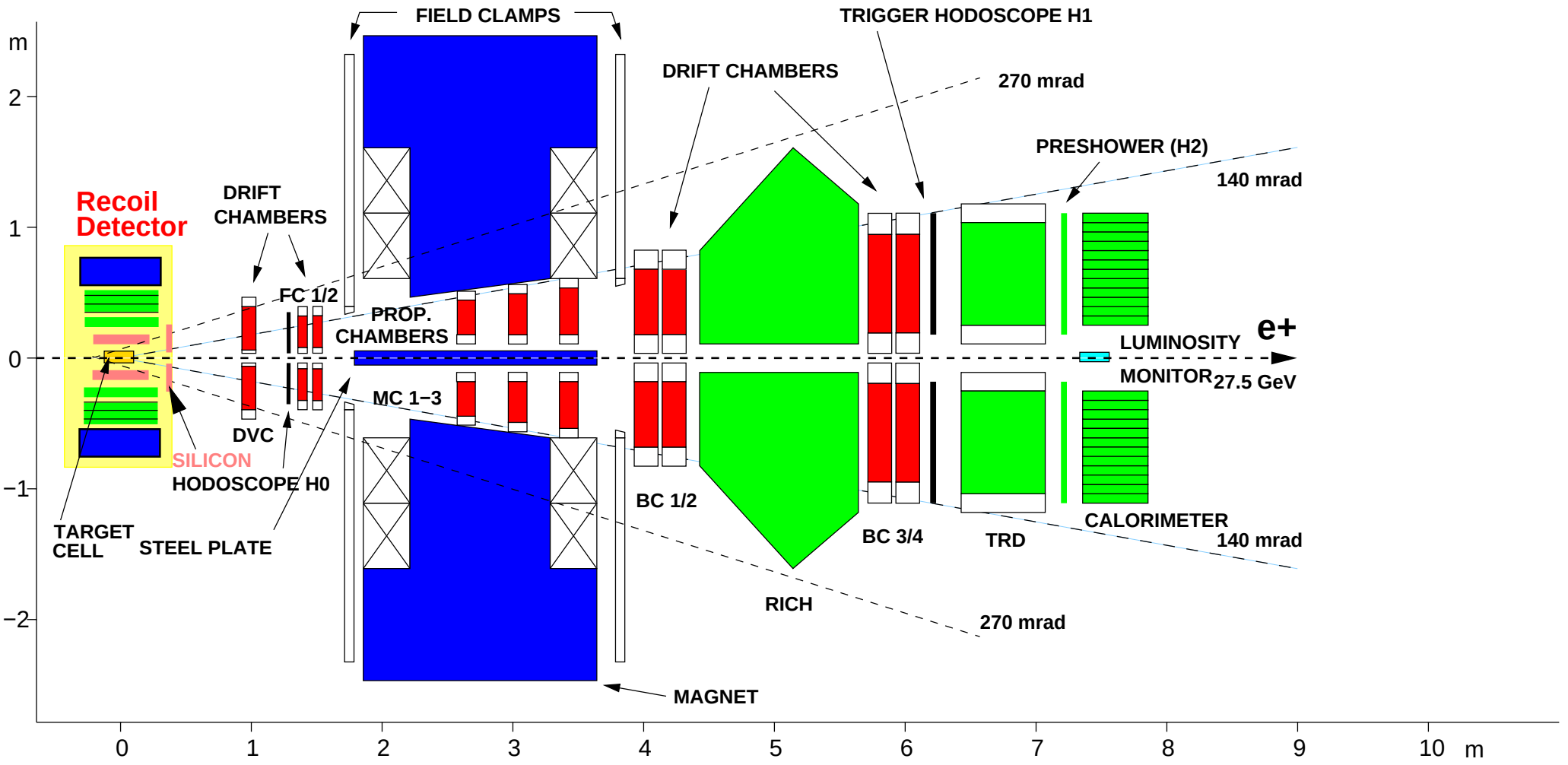
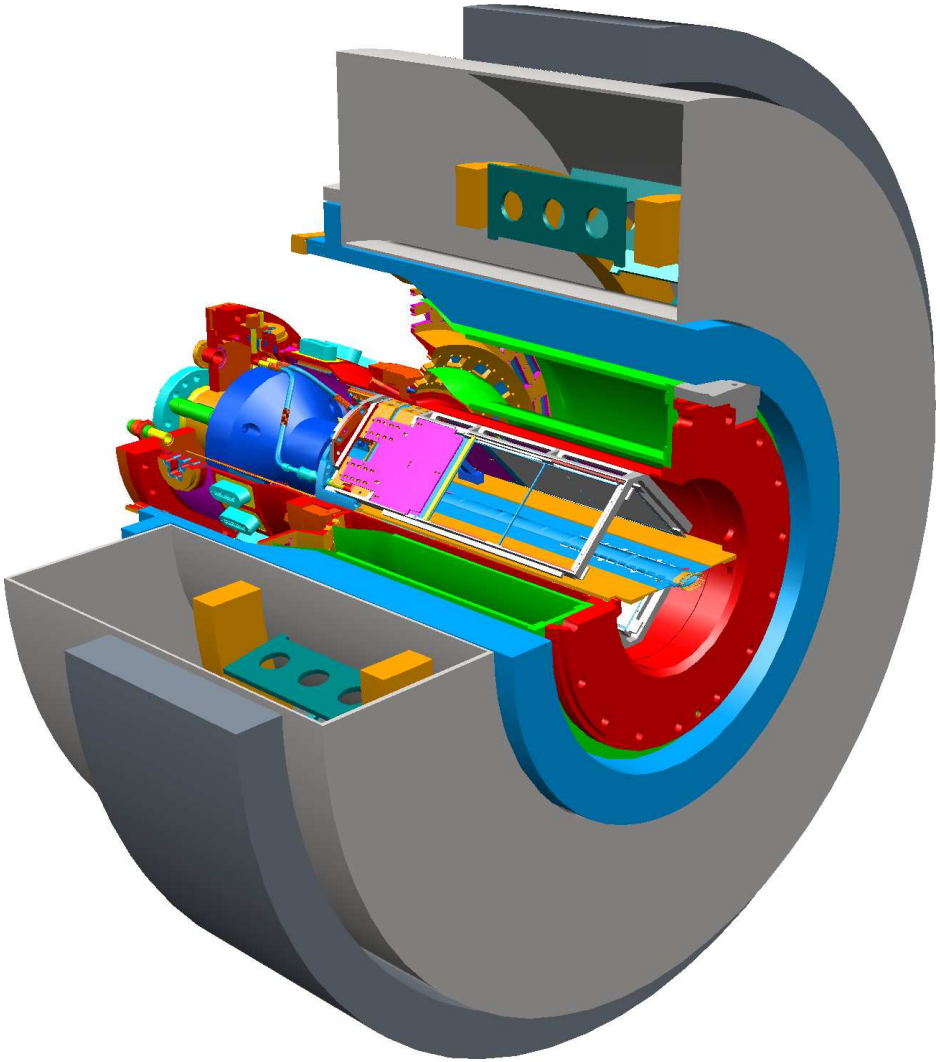


September 12, 2008

The HERMES Spectrometer



The Recoil Detector



Elastically Scattered Lepton Selection

The elastically scattered lepton is required to have:

- Momentum between 25 and 30 GeV/c
- PID1 $>$ 0 (Preshower Only)
  - Use of PID2+5 (Preshower, Calorimeter, and TRD) was originally tried, but excluded an unreasonably high number of events

$$\text{PID} = log_{10}(\frac{P_{lepton}(E, p, ...)}{P_{hadron}(E, p, ...)})$$

- Correct charge sign (positive for 2007)
- Preshower pulse between 0.01 and 100000 MeV
- TRD pulse between 16 and 100 keV

Only events with a single forward spectrometer track are selected.

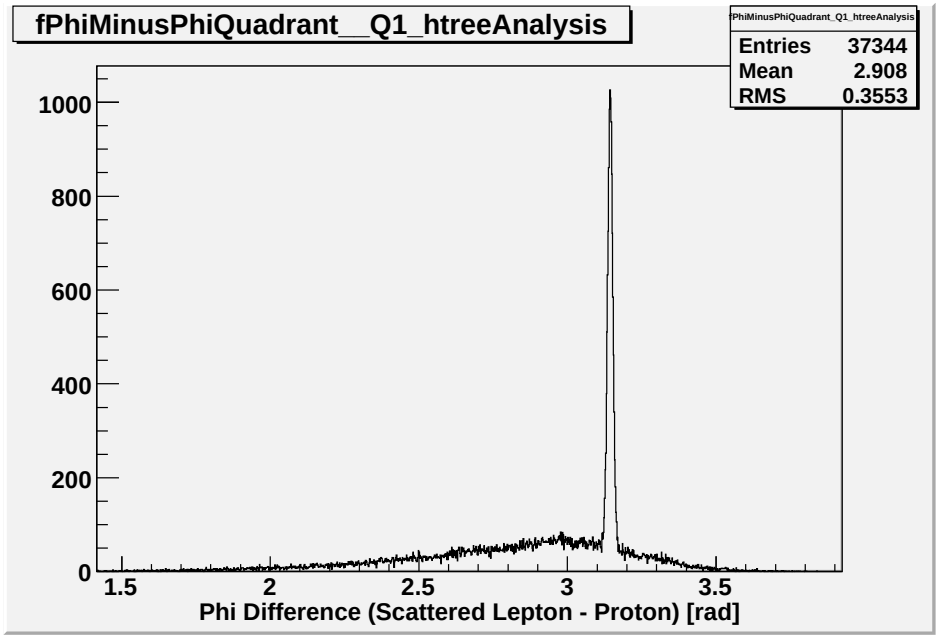
Elastically Scattered Proton Selection

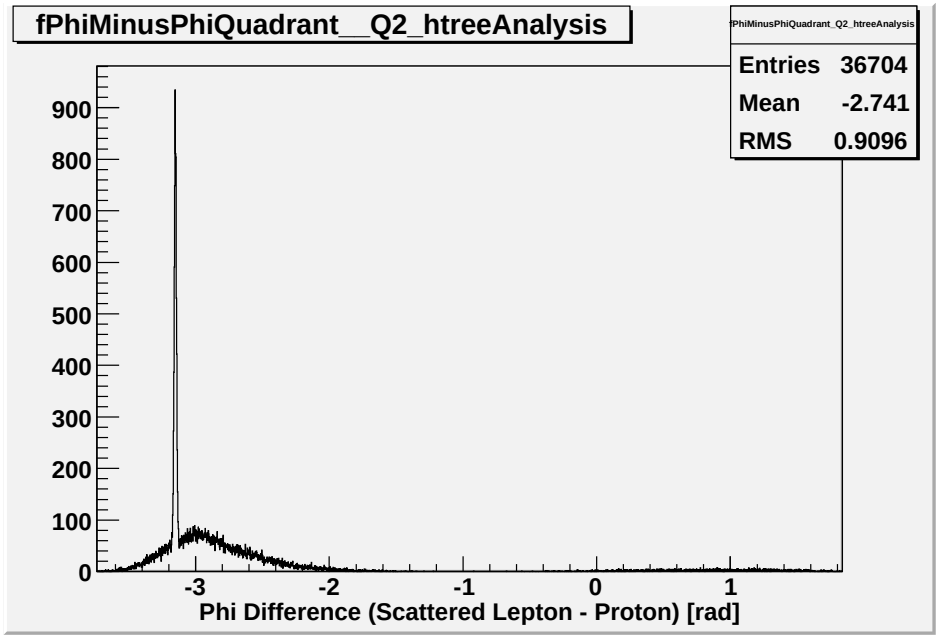
The proton is selected as the Pion Hypothesis with the highest momentum.

The following cuts were evaluated but discarded:

- At least four space points
- No more than one track (combined with the above requirement)

Correlation Requirements: ϕ Difference

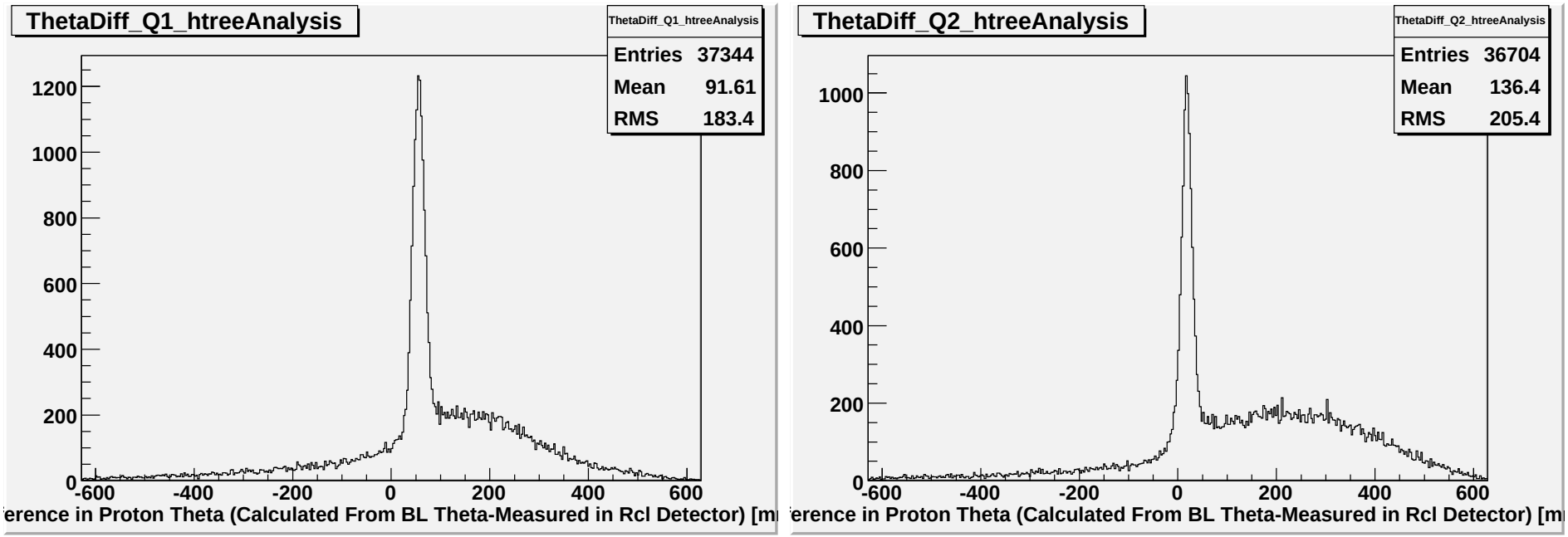




Lepton ϕ - Proton ϕ [rad] (Quadrants 1 and 2)

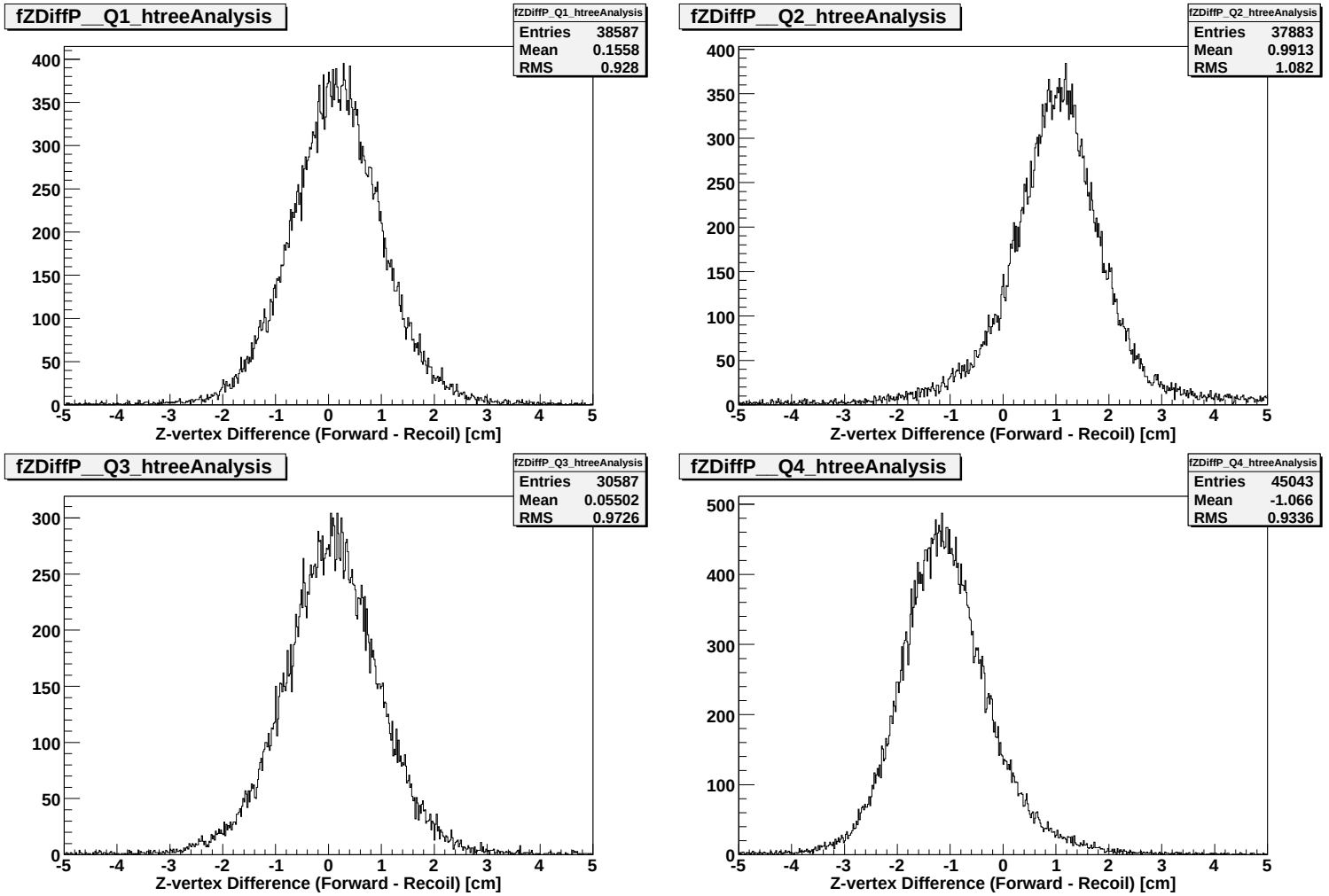
Correlation Requirements: θ Difference

The zenith angle θ of the proton after the collision can be calculated from the θ angle of the outgoing lepton. The difference between this calculated value and the value measured by the recoil detector is used for a cut.



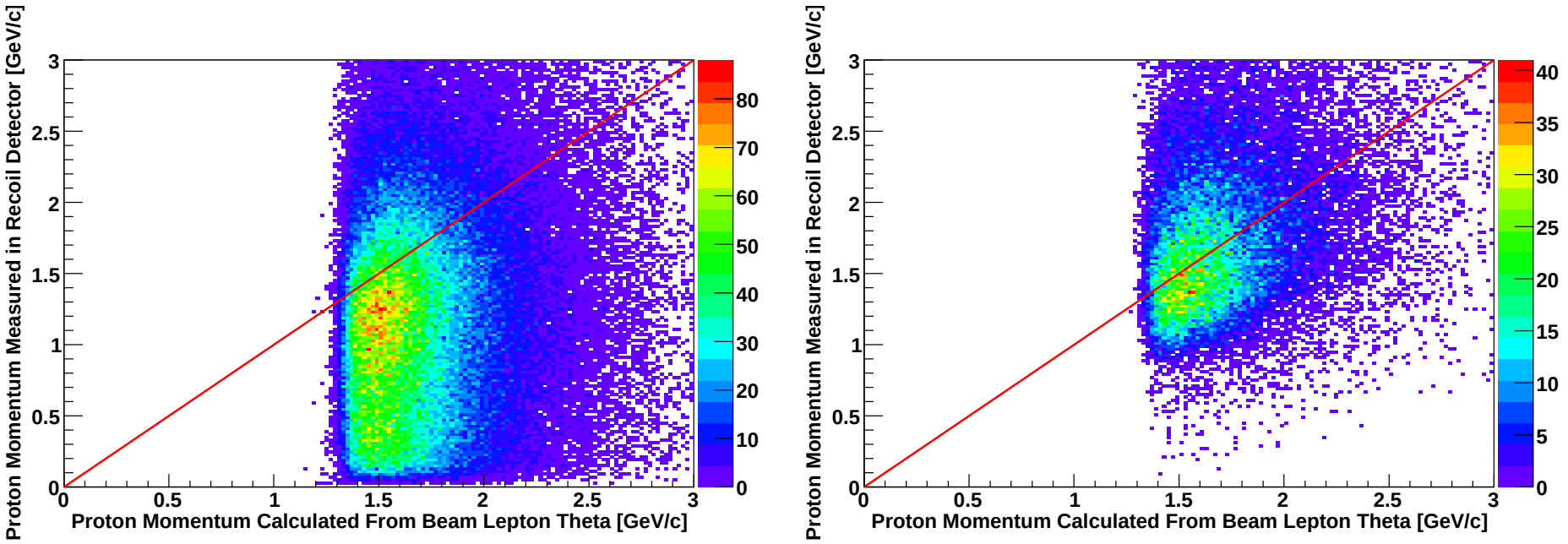
Calculated θ - Measured θ [mrad] (Quadrants 1 and 2)

Correlation Requirements: Z-vertex Difference



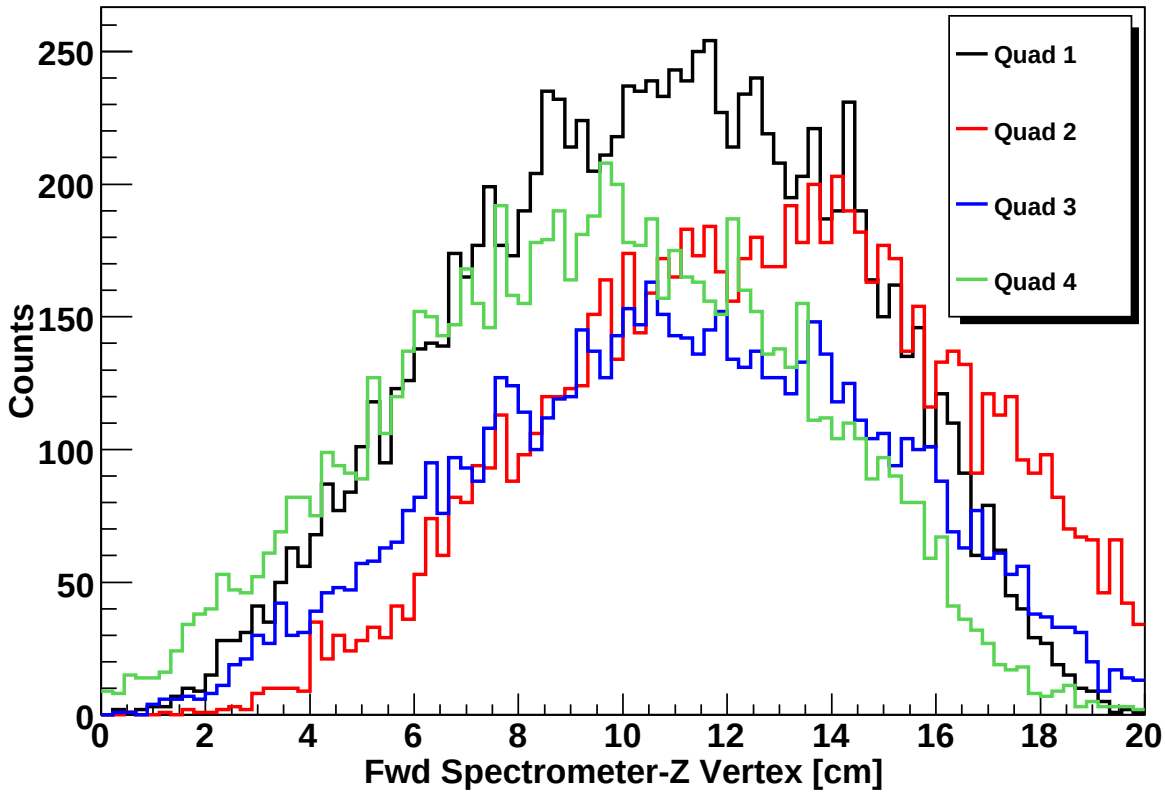
Z-vertex Forward Spectrometer - Z-vertex Recoil Detector [cm] (Quadrants 1-4)

Effect of Correlation Cuts



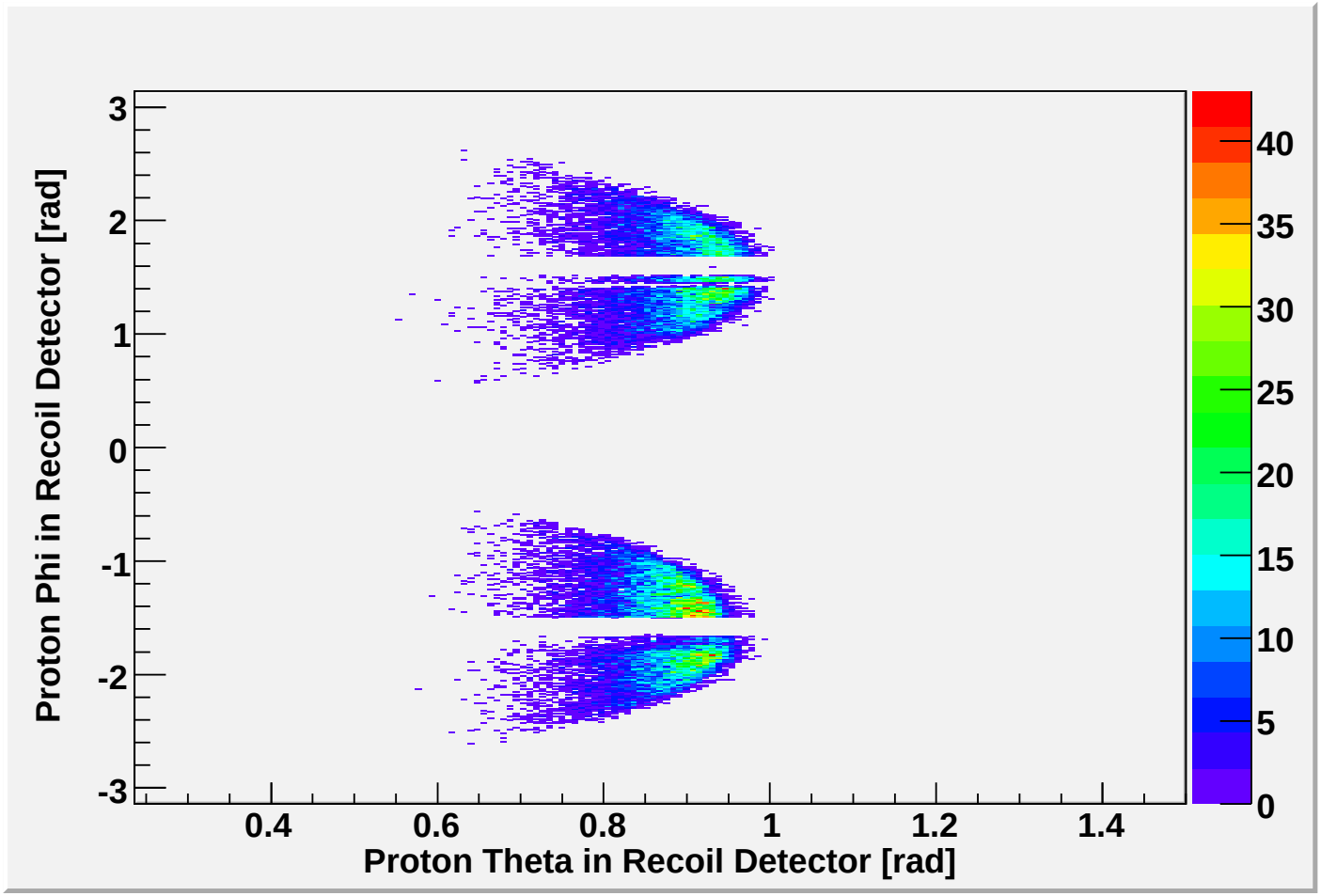
Calculated Proton Momentum vs. Measured [GeV/c] (All Quadrants)

Z-vertex Distributions



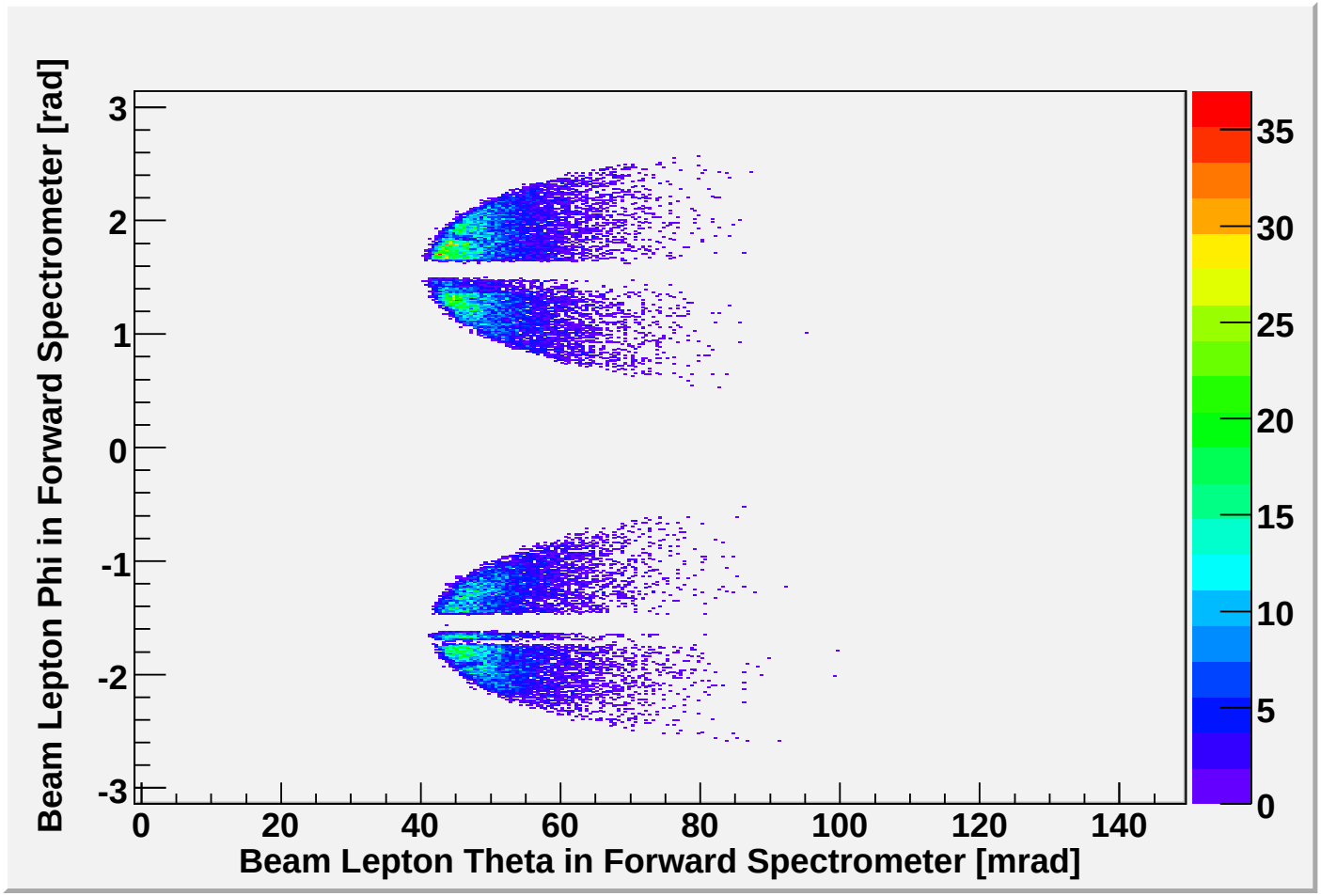
Distributions of Event Z-vertex Positions in the Forward Spectrometer by Proton Quadrant

Recoil Detector θ and ϕ Acceptance



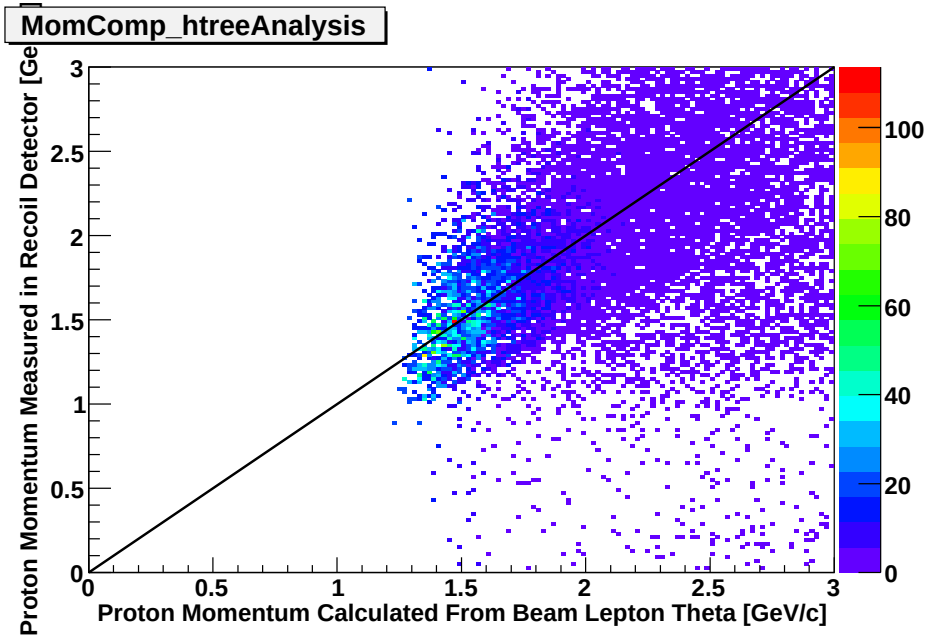
Plot of Proton θ and ϕ [rad]

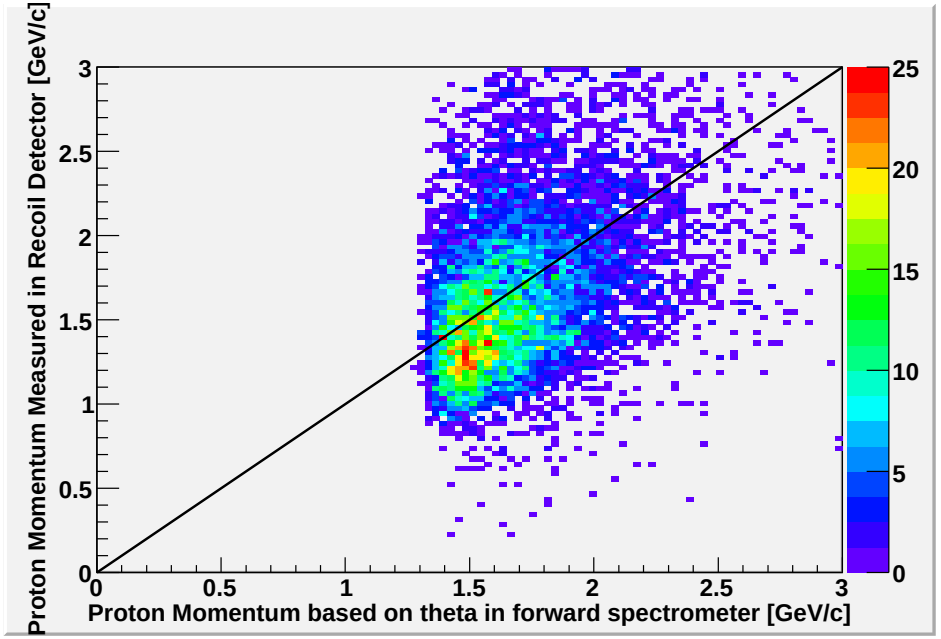
Forward Spectrometer θ and ϕ Acceptance



Histogram of Lepton ϕ [rad] vs. θ [mrad]

Proton Momentum Measurement





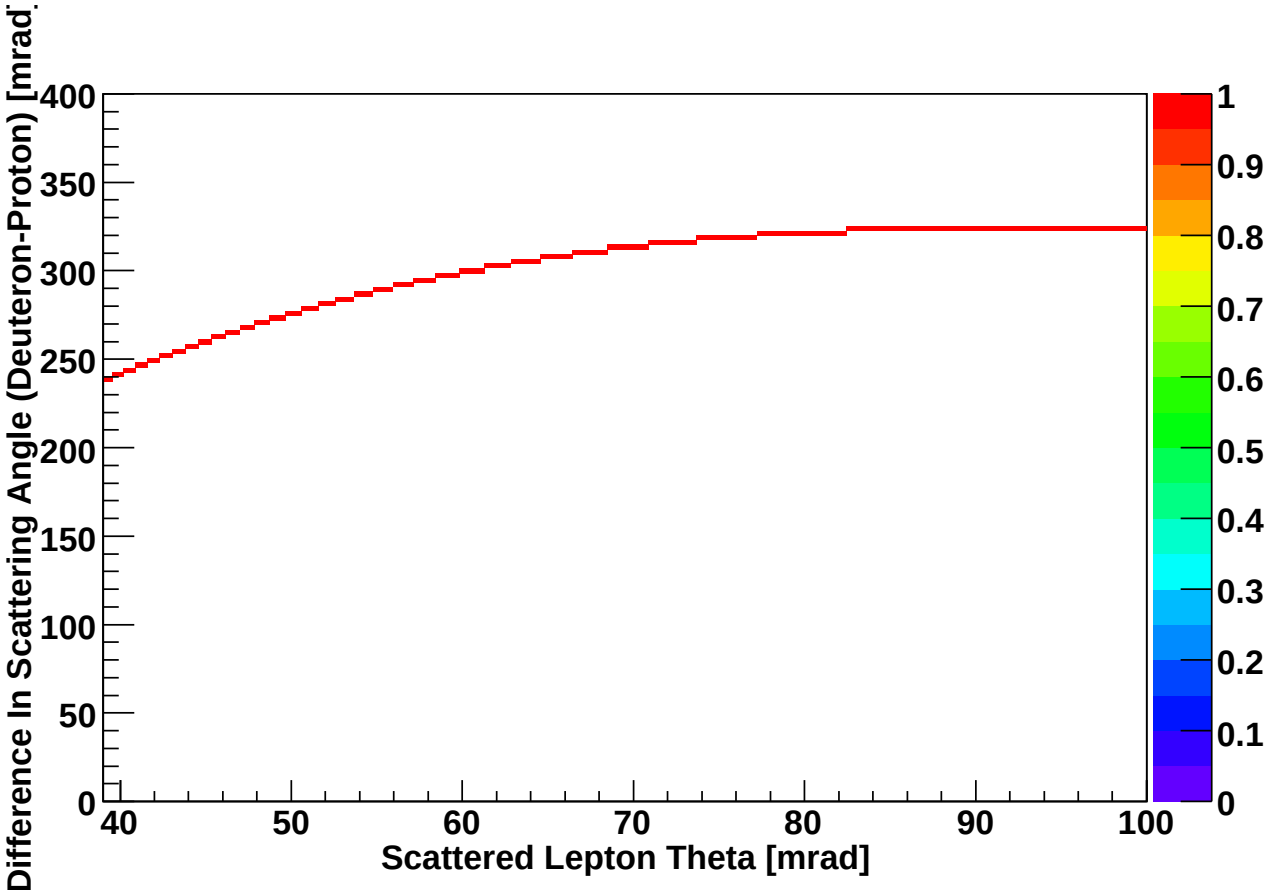
Comparison of Proton Momentum Measured and Calculated from Lepton θ [GeV/c]
(Monte Carlo and Quadrant 4)

Lepton-Deuteron Events

Deuteron data was analyzed for two puposes:

- In order to explore the possibility of detecting deuteron contamination in the proton sample by selecting purely elastic events.
- For comparison with the data from the lepton-proton elastic events

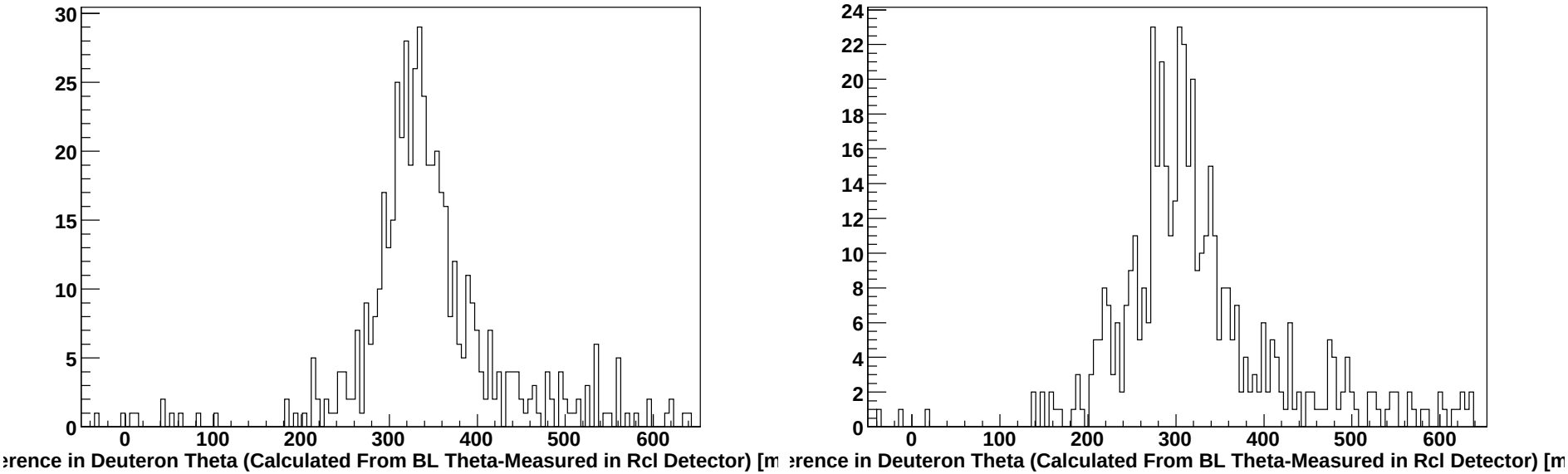
Resolution Between Elastic Proton and Deuteron Events



Difference in expected θ angles for protons vs deuterons [mrad]. The difference is sufficiently greater than the width of the θ peaks.

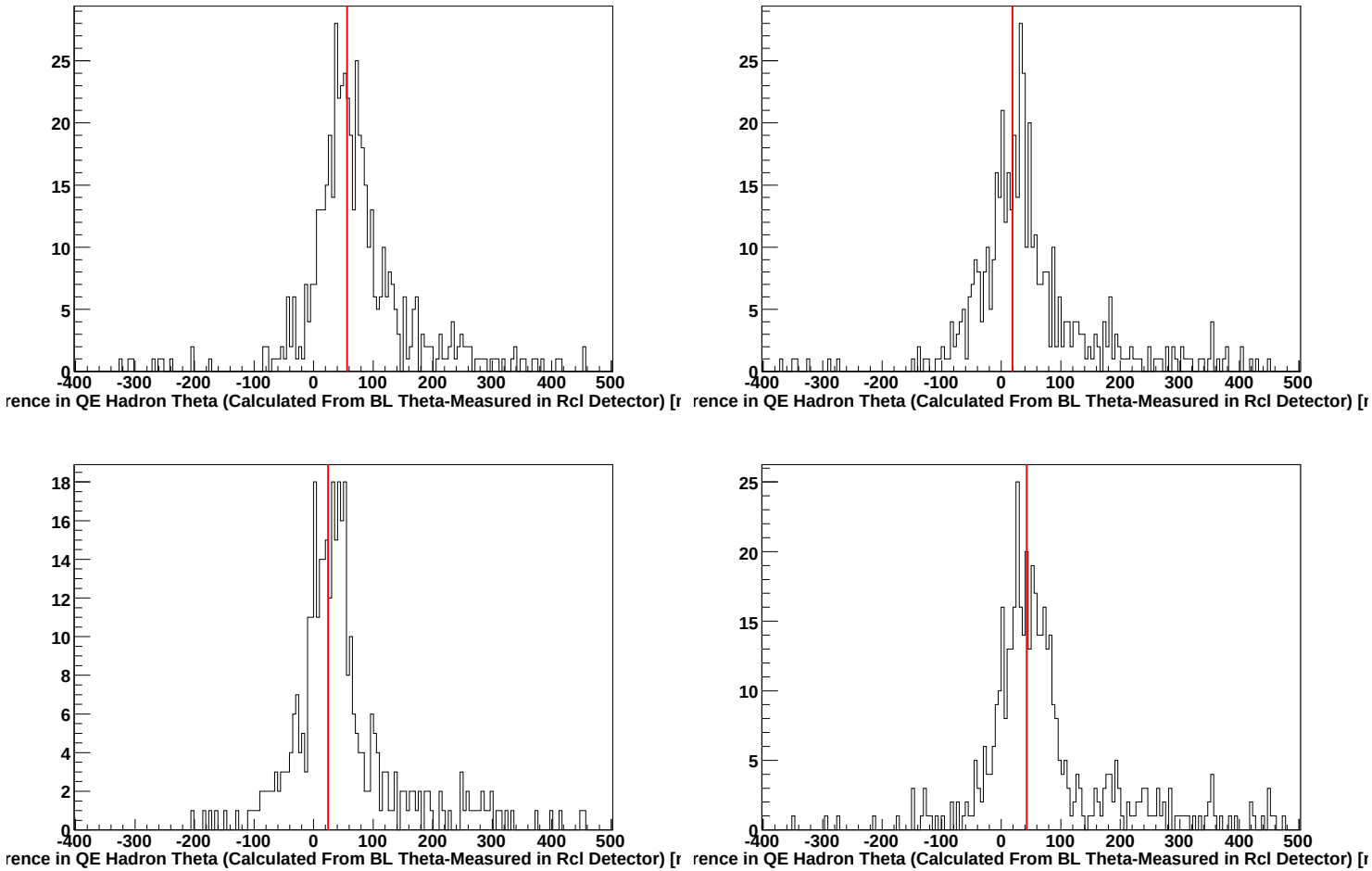
Search for Elastic Lepton-Deuteron Events

Since the ϕ and Z-vertex distributions should be roughly the same for deuteron targets as for proton targets. The correlation cuts on these variables were applied without the θ cut in order to reduce background in the search for purely elastic events.



Calculated θ - Measured θ for Elastic Deuteron Events [mrad] (Quadrants 1 and 2)

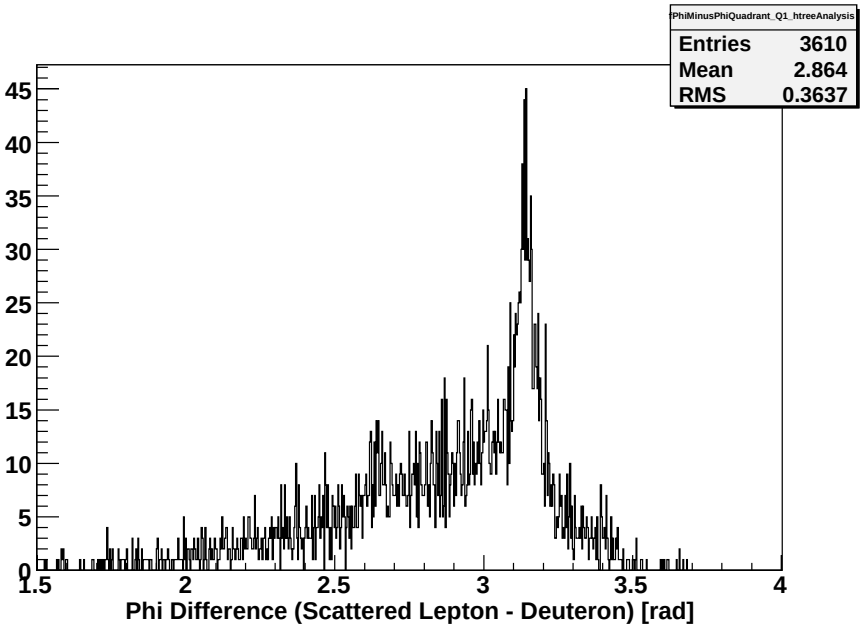
Quasi-Elastic Lepton-Nucleon Events

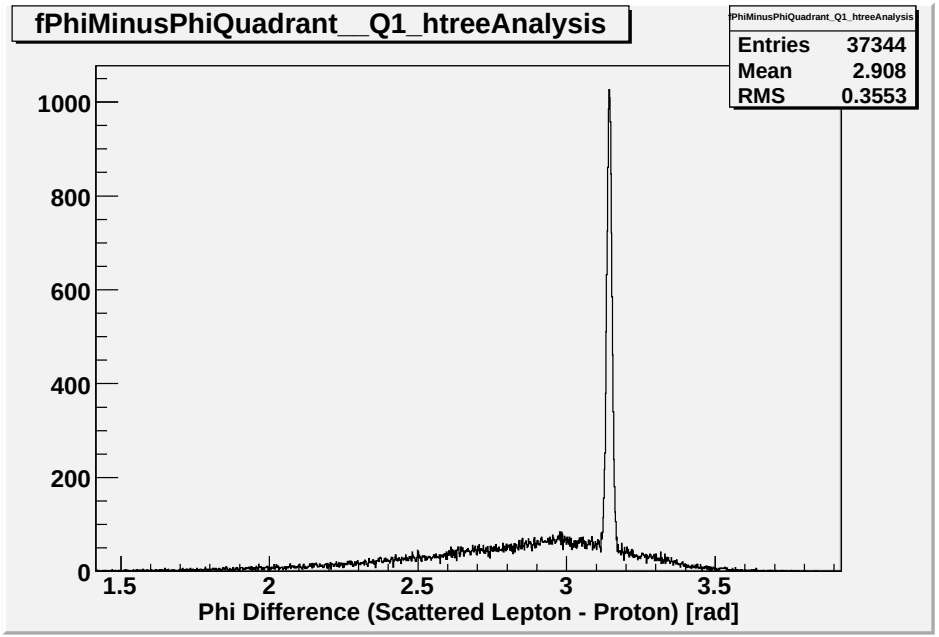


Calculated θ - Measured θ [mrad] for Quasi-Elastic Lepton-Nucleon Events (Quadrants 1-4). The red line is the mean of the peak from target data. Two-body kinematics are assumed for simplicity.

Quasi-Elastic Lepton-Nucleon Events

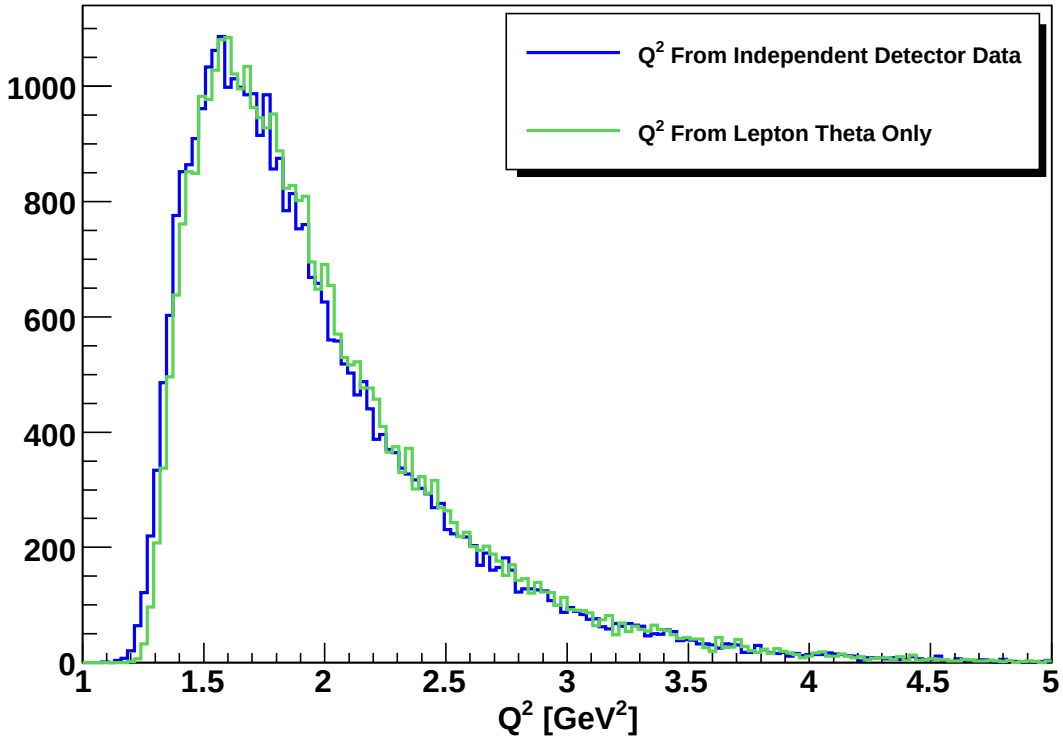
Although the dominance of quasi-elastic scattering is unfortunate when searching for deuteron contamination, the plots are useful for comparison with the elastic proton events. The peaks in the θ, ϕ and Z-vertex plots for the deuteron data are at or near the peaks from the proton target data, with greater σ because these are not purely elastic processes.





Comparison of ϕ Difference Histograms for Deuteron and Proton Data in Quadrant 1

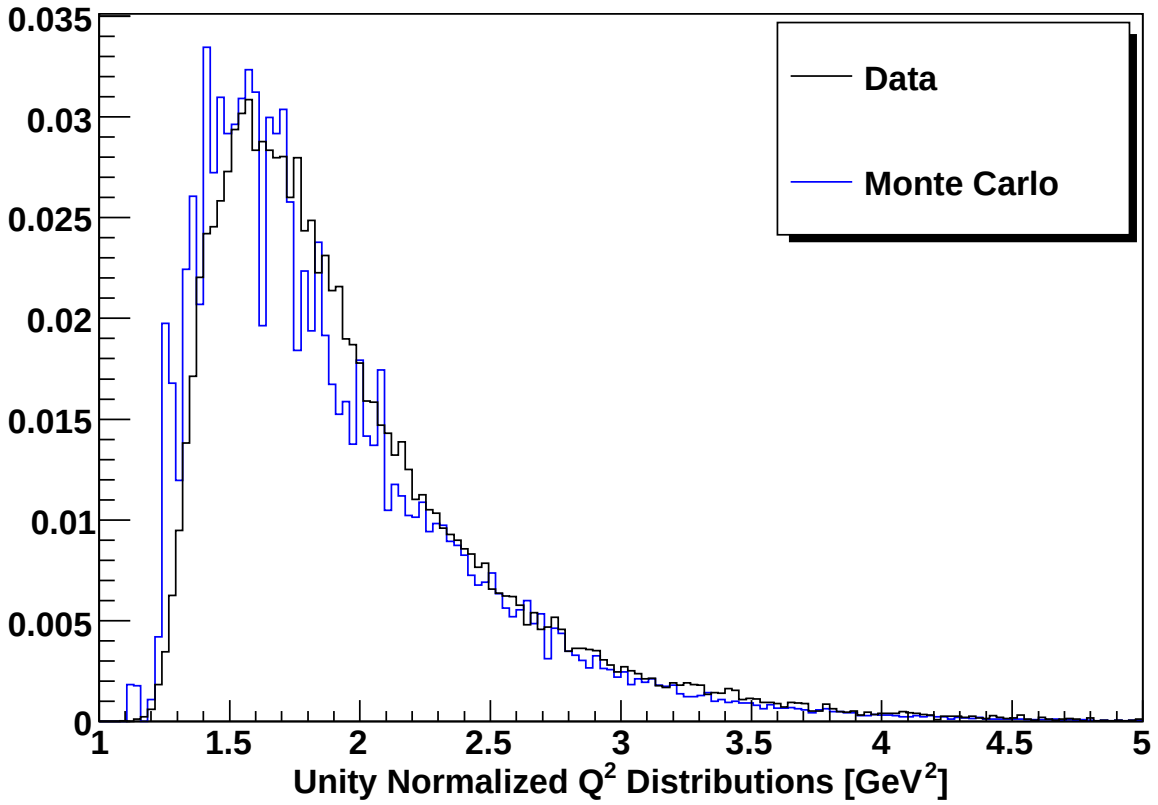
Q^2 Distributions



Q^2 Distributions of Elastic Events. In one case it is calculated from the independent measurements of lepton momentum and θ, in the other solely from lepton θ

$$Q^2 \overset{lab}{=} 4EE' \sin^2\left(\frac{\theta}{2}\right)$$

Q^2 Distributions



Q^2 Distributions of Elastic Events from Monte Carlo and Data, Using Independent Detector Variables and Normalized to Unity

Outlook

With a reasonable estimate of the integrated luminosity, the data could be used to estimate the detector efficiency. Such an estimate would help to improve confidence in the conclusions of other efficiency studies.

Once the detector efficiency and integrated luminosity are well known, calculation of the cross section and extraction of form factors is simple.

Thank you to everyone from HERMES who has helped me along the way!