TCS vertex reconstruction

Update

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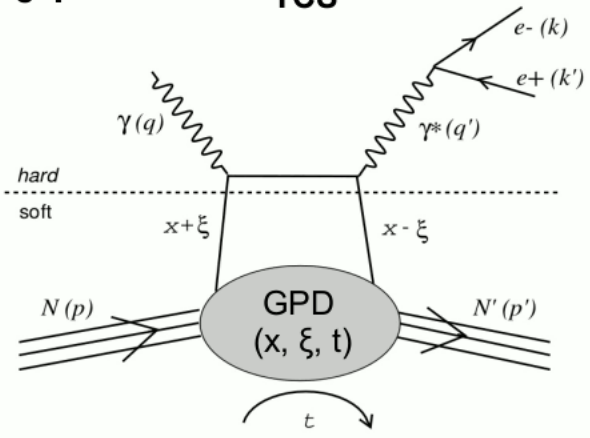
CPS Meeting
09/24/2021

Physics goals

$\gamma P \rightarrow e^+e^- P'$ =

TCS



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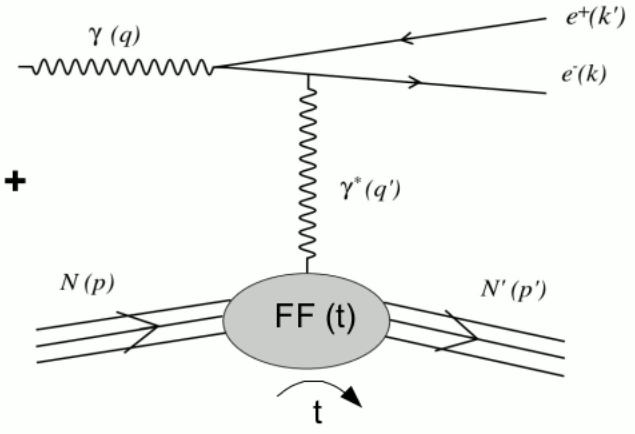
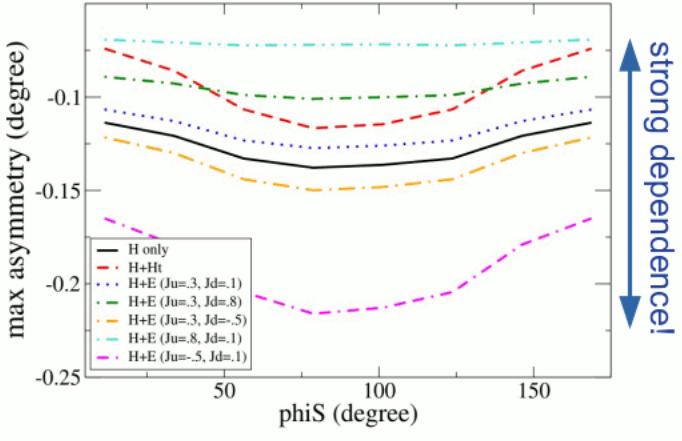
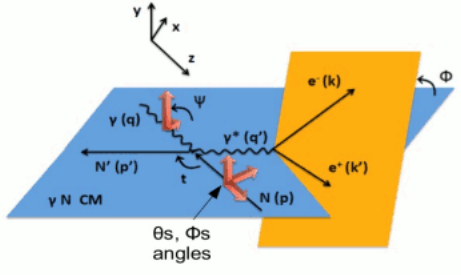
Bethe-Heitler



Sin(φ) moment of transverse spin asymmetry vs φ_S,
Dependence in GPD E and $J^{u,d}$ (VGG model)





TSA as a function of φ and φ_S

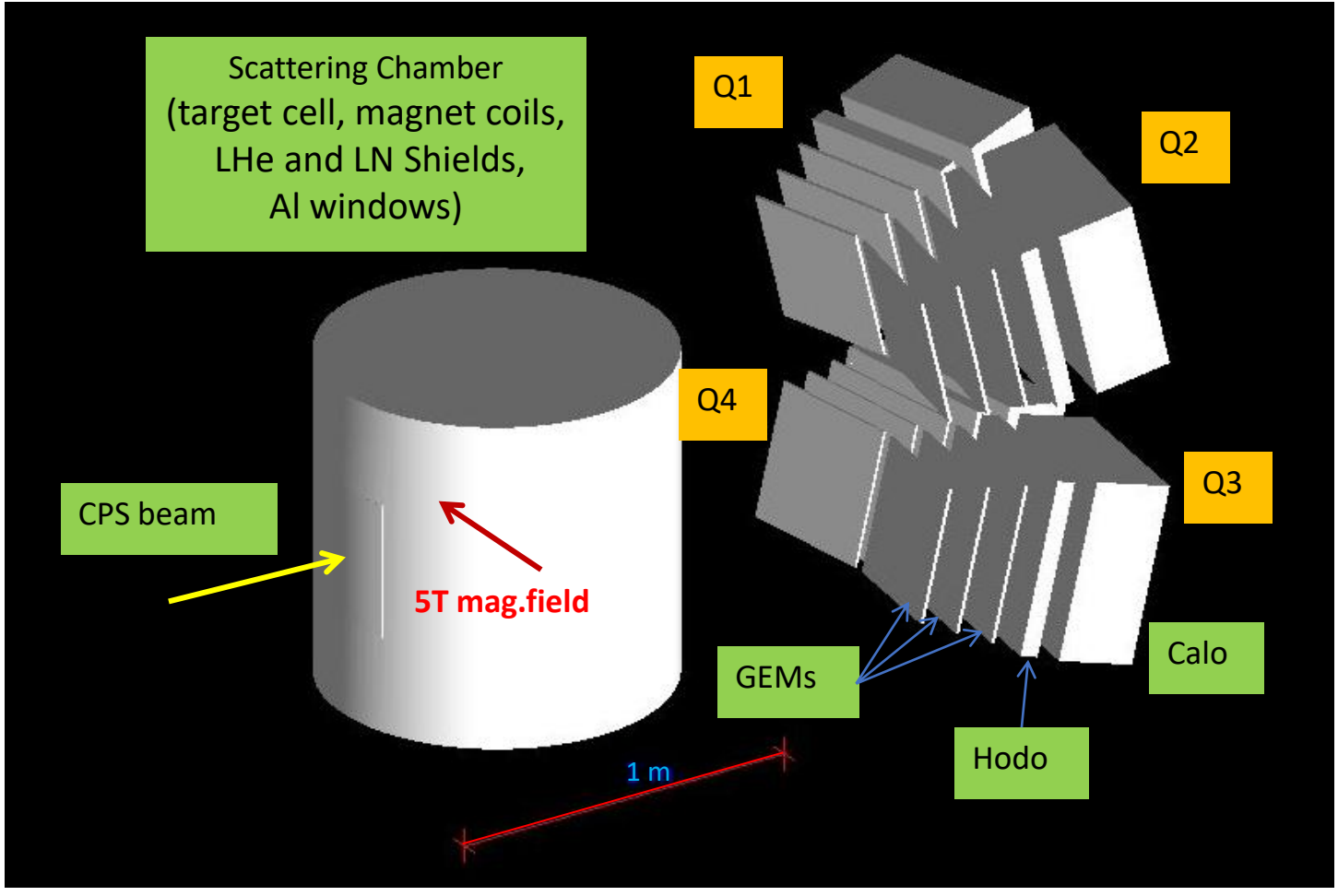
- Sensitive to Im(interference), BH cancels
- Strong dependence in angular momenta,

Sensitivity to GPD E (also to H, Ht)

Courtesy M.Boer

Proposed TCS setup

$$\gamma + p \rightarrow \gamma^* (e^+ + e^-) + p'$$



- Detect e^+, e^-, recoil p' in coincidence
- CPS bremsstrahlung photon beam
- UVA/Jlab NH_3 target, transversely polarized
- Detectors arranged in 4 quarters, oriented to target
- Triple-GEMs for e^+, e^-, p tracking
- Hodoscopes for recoil proton detection/PID
- $PbWO_4$ calorimeters for e^+, e^- detection/PID
- **Trigger based on calorimeter signals**

Before:

Demonstrate accuracy of reconstruction of TCS quantities, by vertex reconstruction and comparison of the reconstructed quantities with **true** quantities. Makes use of **true** parameters of tracks: particle ID, particle ID of origin, track ID, charge.

Now:

Demonstrate feasibility of offline analysis. Use only detector hit information. Select useful hits (energy clusters), backtrack (or regress) to obtain tracks at vertex.

Possible offline Analysis outline:

✓ Trigger: single crystal hits with Edep > 2.5 GeV in opposite calorimeter quadrants.
✓ Cluster calorimeter hits
✓ In each quadrant, find cluster of Max. Edep in calorimeter
- Take pair of max. Edep clusters in opposite quadrants, with max. sum of energy deposits, as e+ and e- candidates.

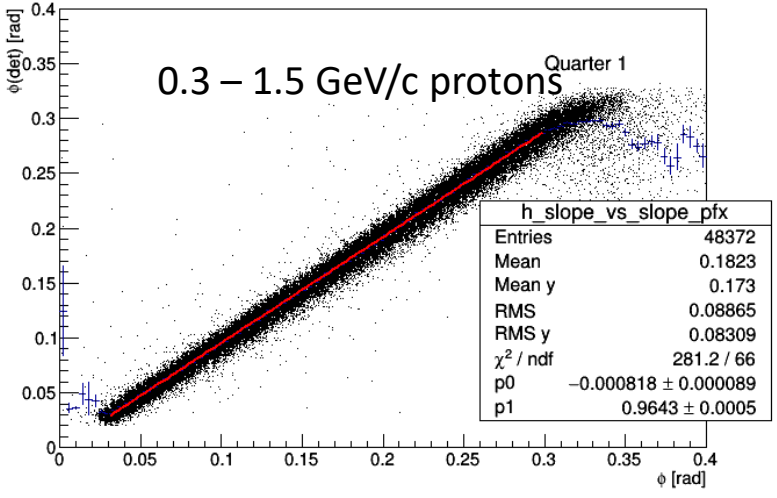
✓ Calculate ΔX and Δ Y widths of the clusters
- Search trackers for hits within Δ X and Δ Y (at least 2 hits in different layers needed)
- Construct straight track through tracker hits, make sure it hits calo. cluster
- Assign opposite charges to the pair of tracks, and momenta from calo. Edep-s
- Backtrack the assigned e+ and e- tracks to target

✓ Cluster hodoscope hits
- From the remaining calo. clusters, select calo. cluster and overlapping hodo. cluster such that $2800 < Edep(hodo) \times Edep(calo) < 4200\ MeV^2$
- Search for hits (at least 2 in different layers) in the trackers before the clusters (in ΔX x Δ Y ~ 2x2 cm^2 area)
- Derive momentum of the proton candidate from Ekin = Ehodo + Ecalo
- Backtrack proton candidate to target

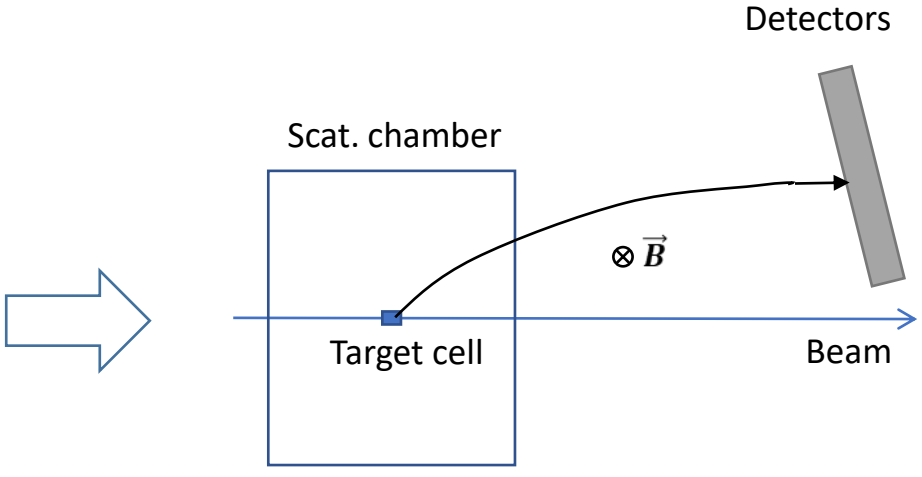
Calculate TCS quantities

Backup slides

Vertex reconstruction options



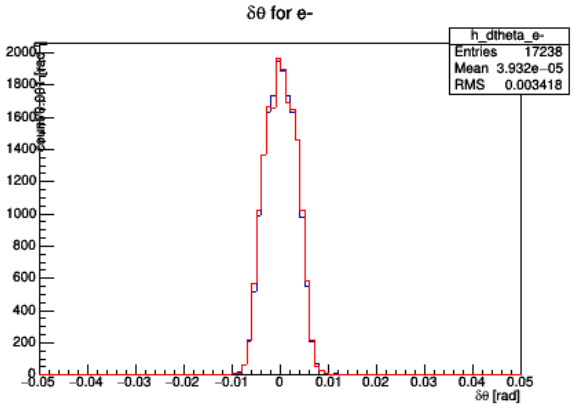
φ at vertex can be reconstructed by linear regression from φ (measured) at GEMs.

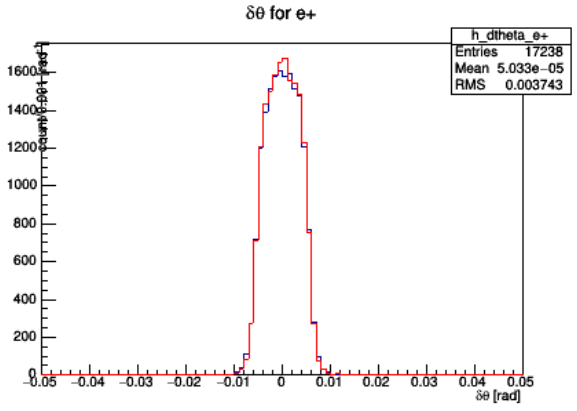


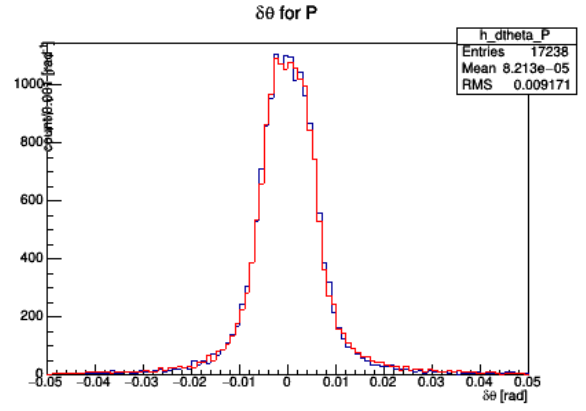
Charged track in target magnetic field, can be reconstructed by backtracking.

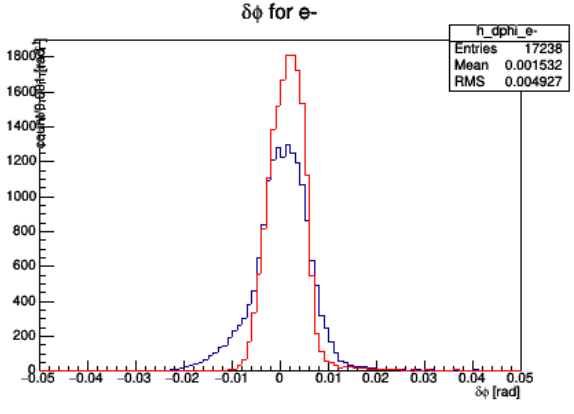
Accuracies of angle reconstruction

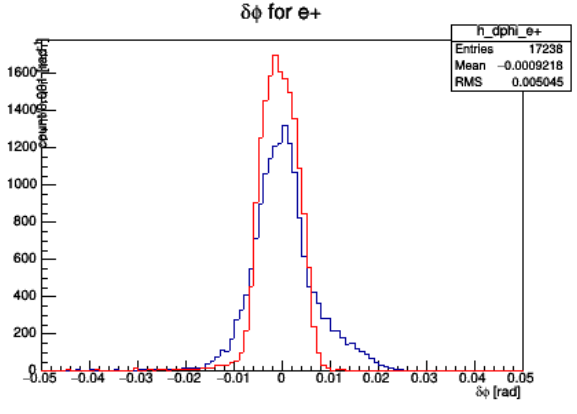
Red – backtracking, blue – regression.

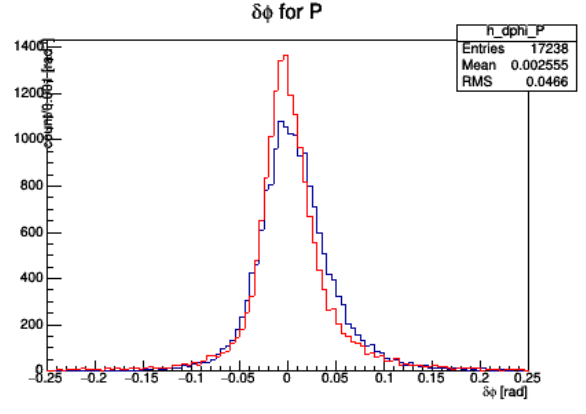








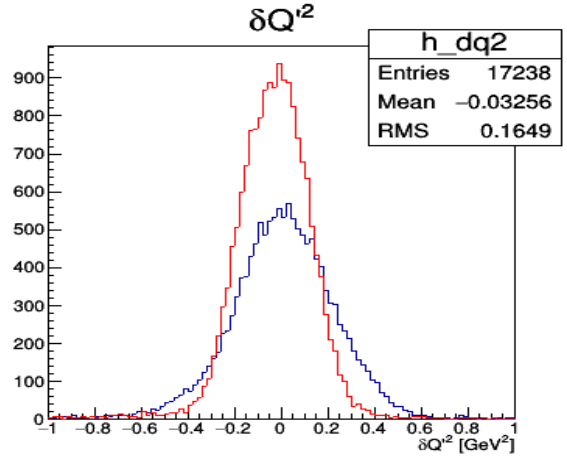


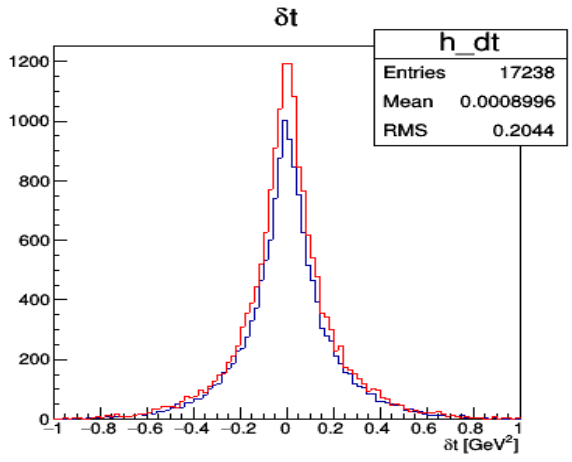


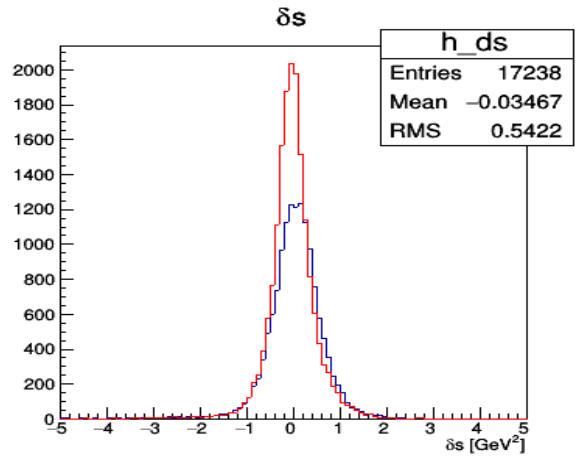
Note: histograms normalized to common integral. Note also different scale for proton.

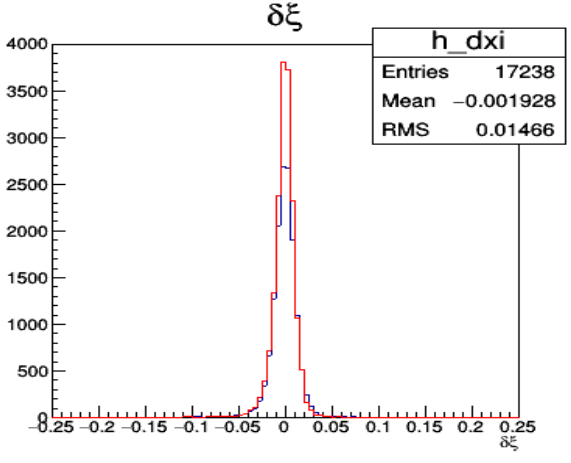
Accuracies of reconstruction of TCS quantities

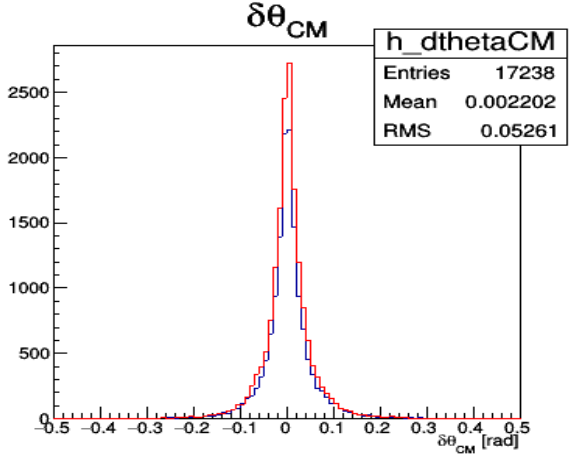
Red – backtracking, blue – regression.

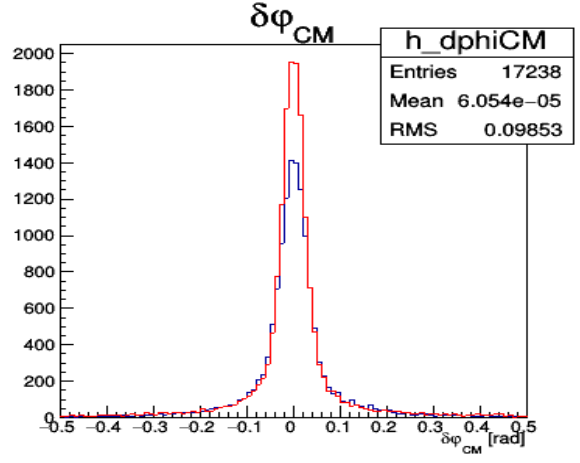






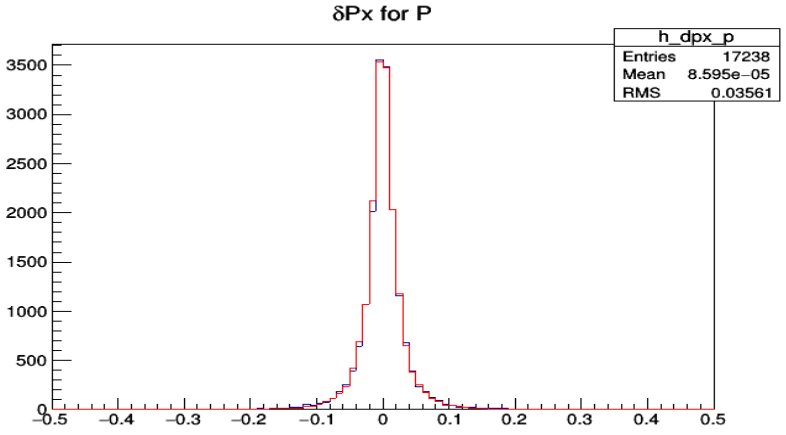


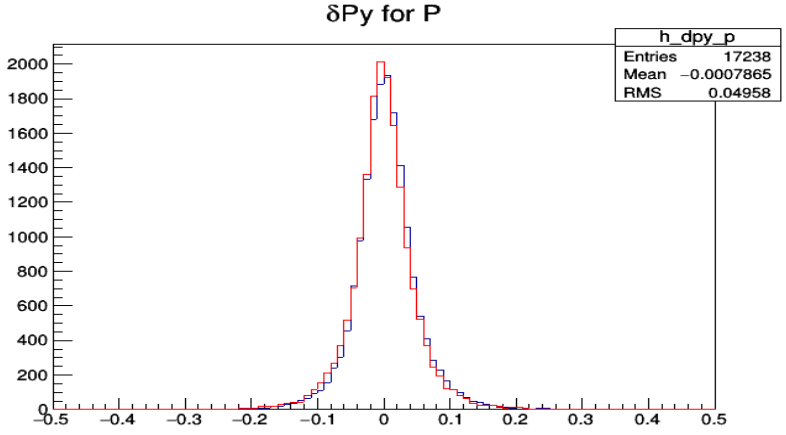


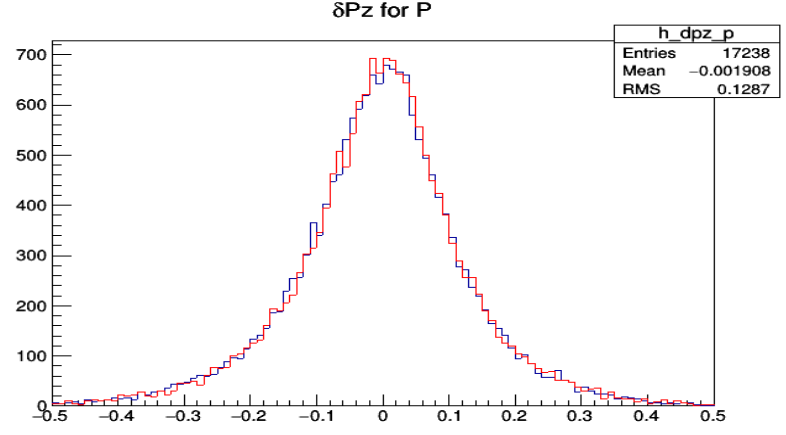


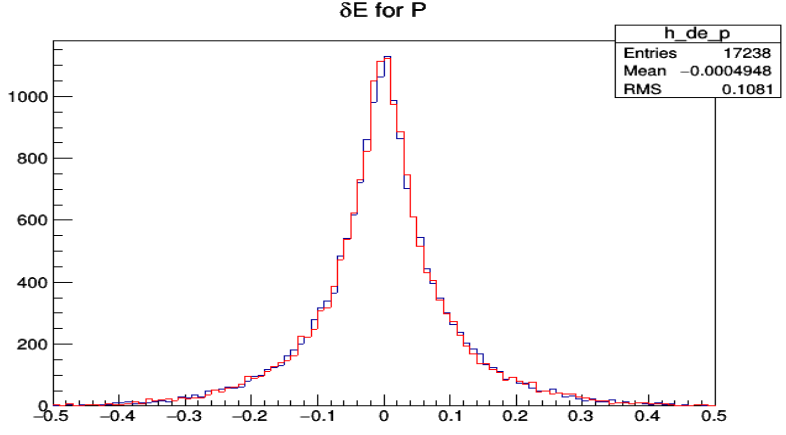
Accuracies of recoil proton reconstruction

Red – backtracking, blue – regression.

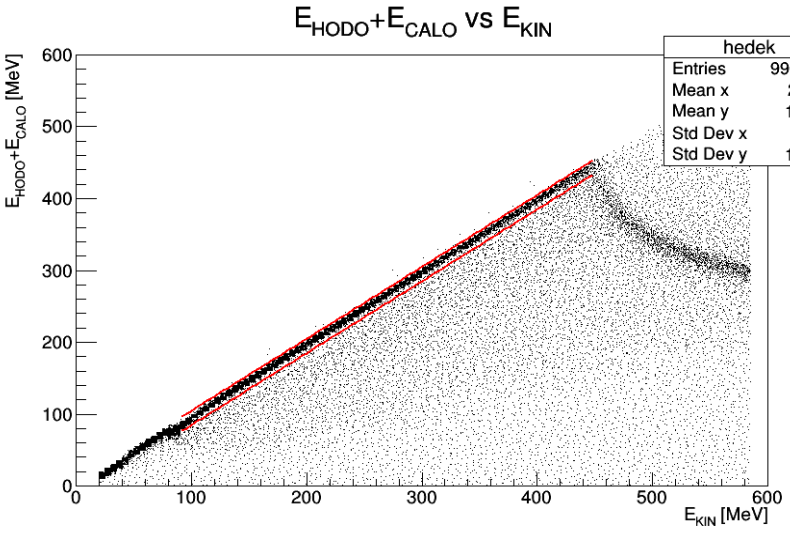


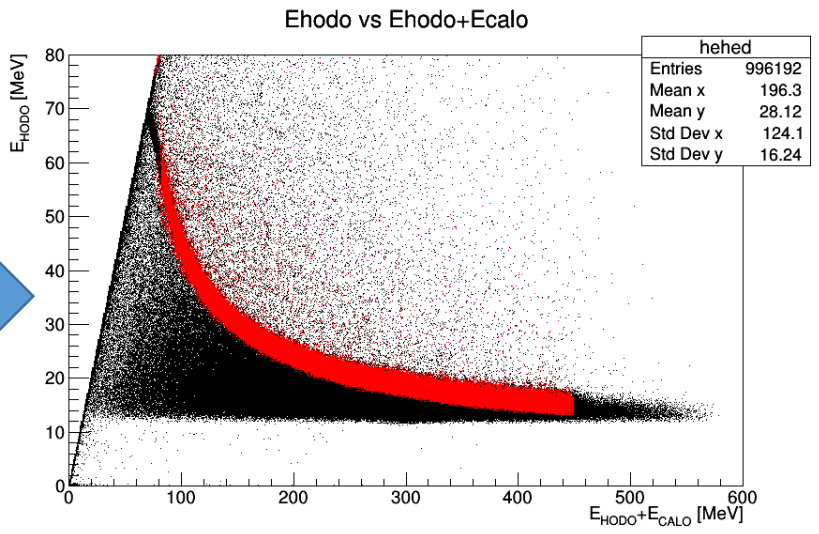


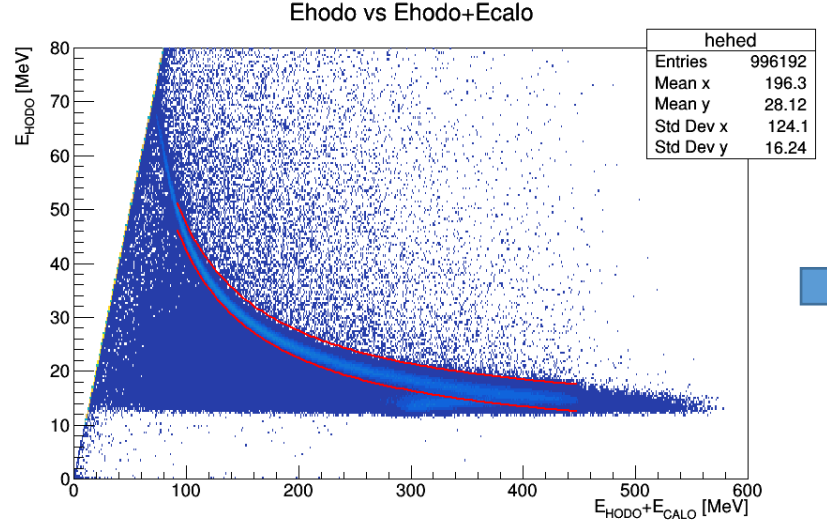


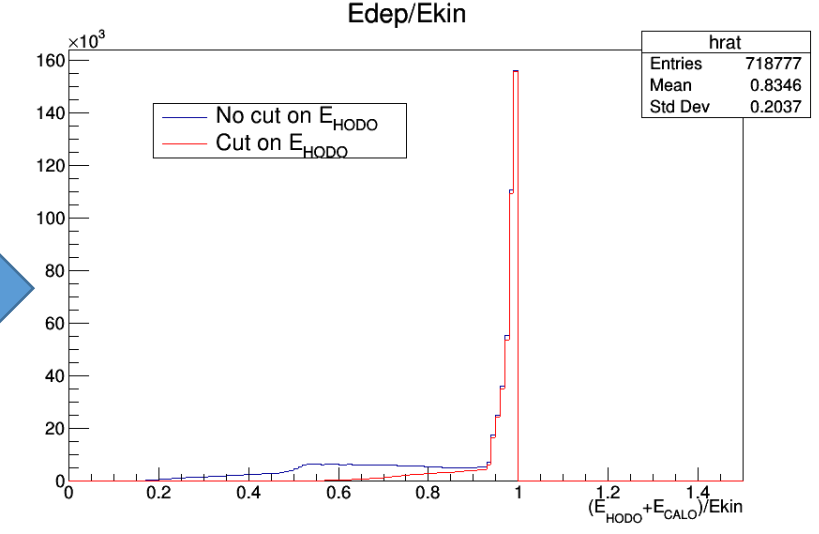


Proton E_{KIN} from hodoscopes and calorimeters









Note: proton tracks perpendicular to detector surface