UNIVERSITY OF BIRMINGHAM | SCHOOL OF PHYSICS AND ASTRONOMY

Update on Kinematic Fitting for DIS events at ePIC

L. Gonella, P. G. Jones, S. Maple, P. R. Newman

A quick reminder about kinematic fitting in BAT

- Reconstruction is overconstrained: only need 2 quantities to obtain x, y, Q^2
- From the measured quantities $\vec{D} = \{E_e, \theta_e, \delta_h, p_{t,h}\}$ we can use a kinematic fit to reconstruct an additional piece of information: $\vec{\lambda} = \{x, y, E_\gamma\}$

E_γ is energy of an ISR photon

- For a kinematic fit, we use a **likelihood** function based on our knowledge of the detector resolutions:

Likelihood

$$P(\vec{D}|\vec{\lambda}) \propto \frac{1}{\sqrt{2\pi}\sigma_E} e^{-\frac{(E_e - E_e^\lambda)^2}{2\sigma_E^2}} \frac{1}{\sqrt{2\pi}\sigma_\theta} e^{-\frac{(\theta_e - \theta_e^\lambda)^2}{2\sigma_\theta^2}} \frac{1}{\sqrt{2\pi}\sigma_{\delta_h}} e^{-\frac{(\delta_h - \delta_h^\lambda)^2}{2\sigma_{\delta_h}^2}} \frac{1}{\sqrt{2\pi}\sigma_{P_{T,h}}} e^{-\frac{(P_{T,h} - P_{T,h}^\lambda)^2}{2\sigma_{P_{T,h}}^2}}$$

- A Bayesian method can also be applied in which information from our knowledge of the cross sections is encoded as a **prior**:

Prior

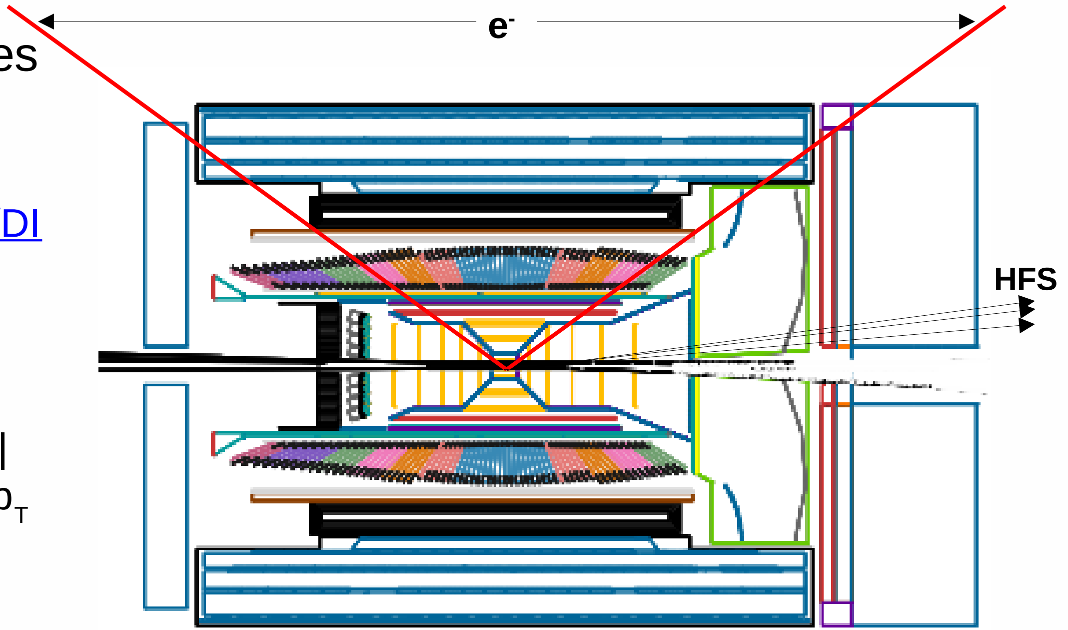
$$P_o(\vec{\lambda}) = \frac{1 + (1-y)^2}{x^3 y^2} \frac{[1 + (1 - E_\gamma/A)^2]}{E_\gamma/A}$$

Reconstructing Simulation Output

- NC DIS events passed through ePIC-Arches geometry, $Q^2 > 100$ GeV^2
  - Files available at http://S3/eictest/EPIC/RECO/22.11.2/epic_arches/DIS/NC/18x275/minQ2=100/
- Perform a basic reconstruction using only calorimeter information
  - Choose events where electron is scattered with $|\eta| < 1.3$ and $p_T > 10$ GeV (electron chosen as highest p_T cluster in EcalBarrelSciGlassClusters) → Add all ECAL clusters within $\Delta R < 0.5$
  - Choose events with $y > 0.01$
  - All other clusters used for HFS:

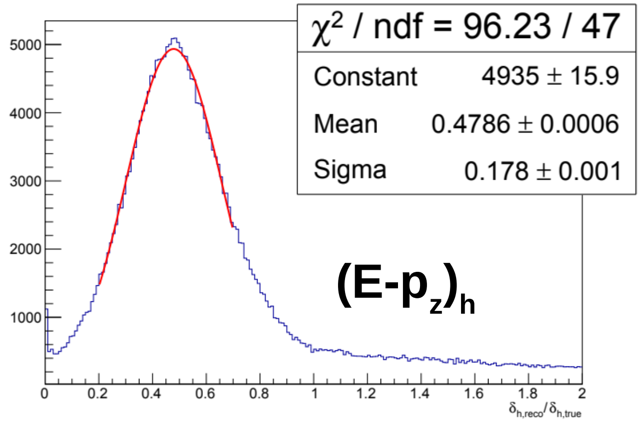
$$\delta_h = \Sigma E_i(1 - \cos(\theta_i))$$

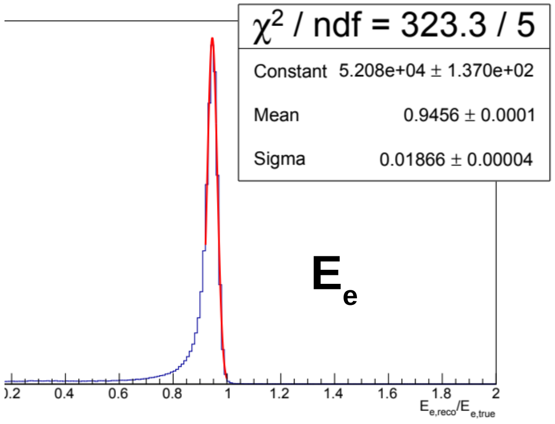
$$P_{T,h}^2 = (\Sigma p_x)^2 + (\Sigma p_y)^2$$

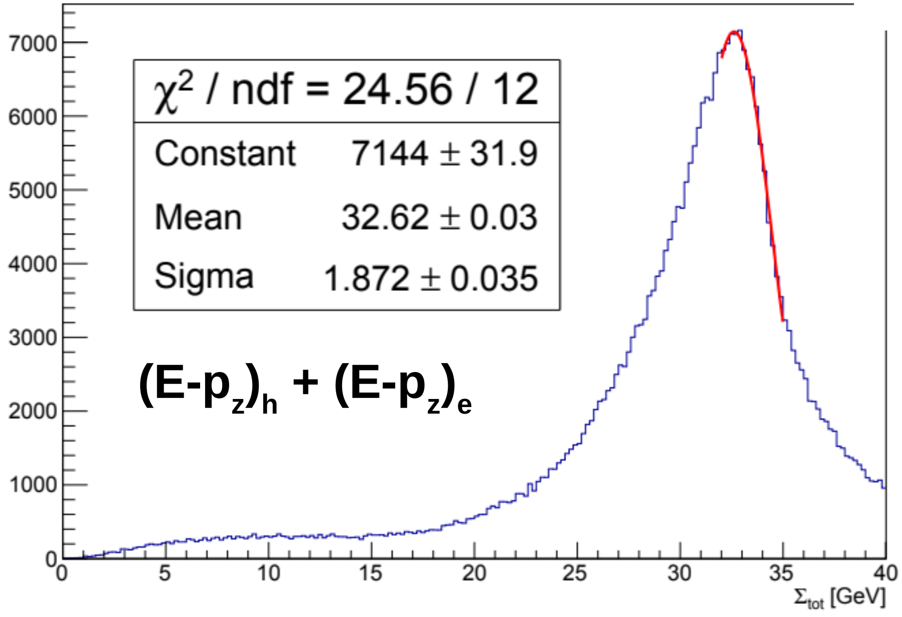


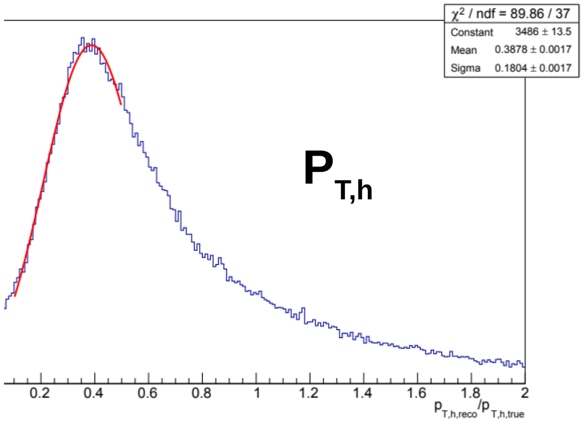
"Calibration"

- Electron and HFS energies are underestimated
  → Sum of E-pz for electron peaked at 32GeV (should be peaked at $2E_{e,beam}$ = 36GeV)





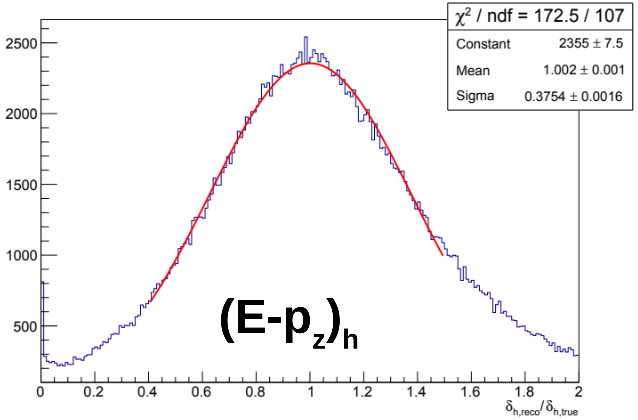


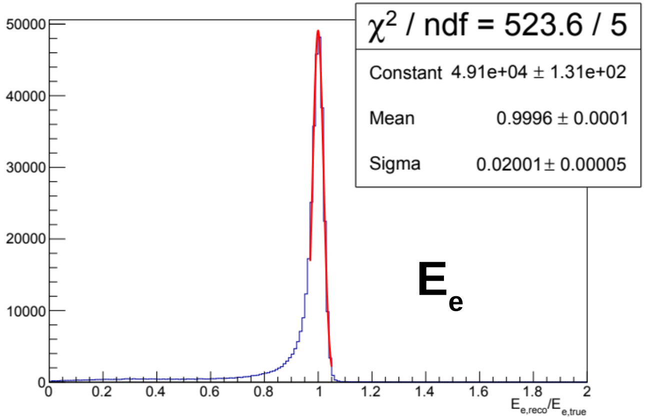


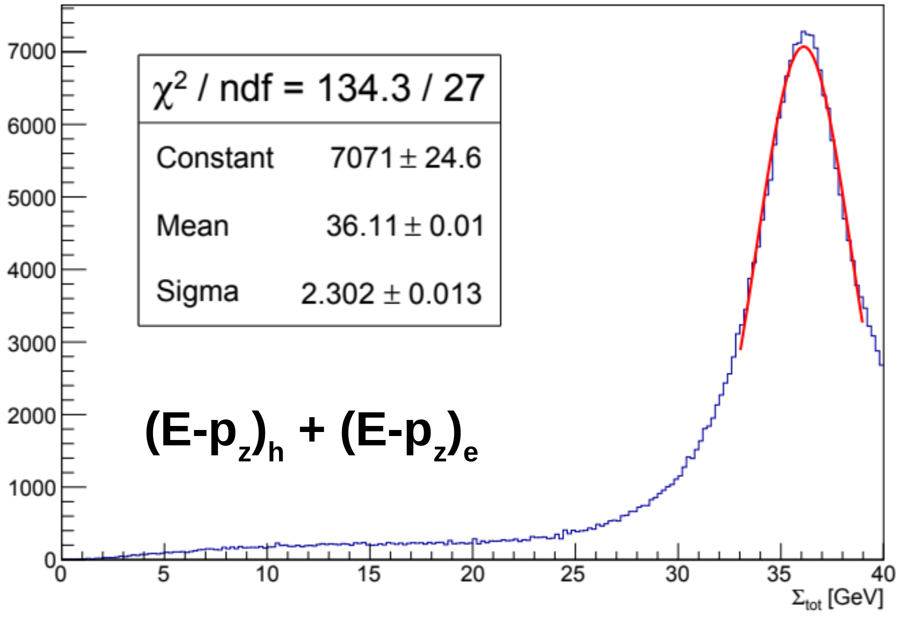
- Use position of peaks compared to MC to apply calibration factor

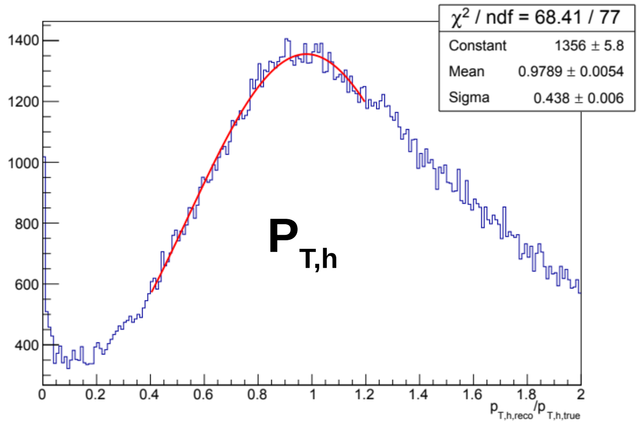
"Calibration"

- Apply calibration
  → E-pz sum now peaked at 36 GeV as expected



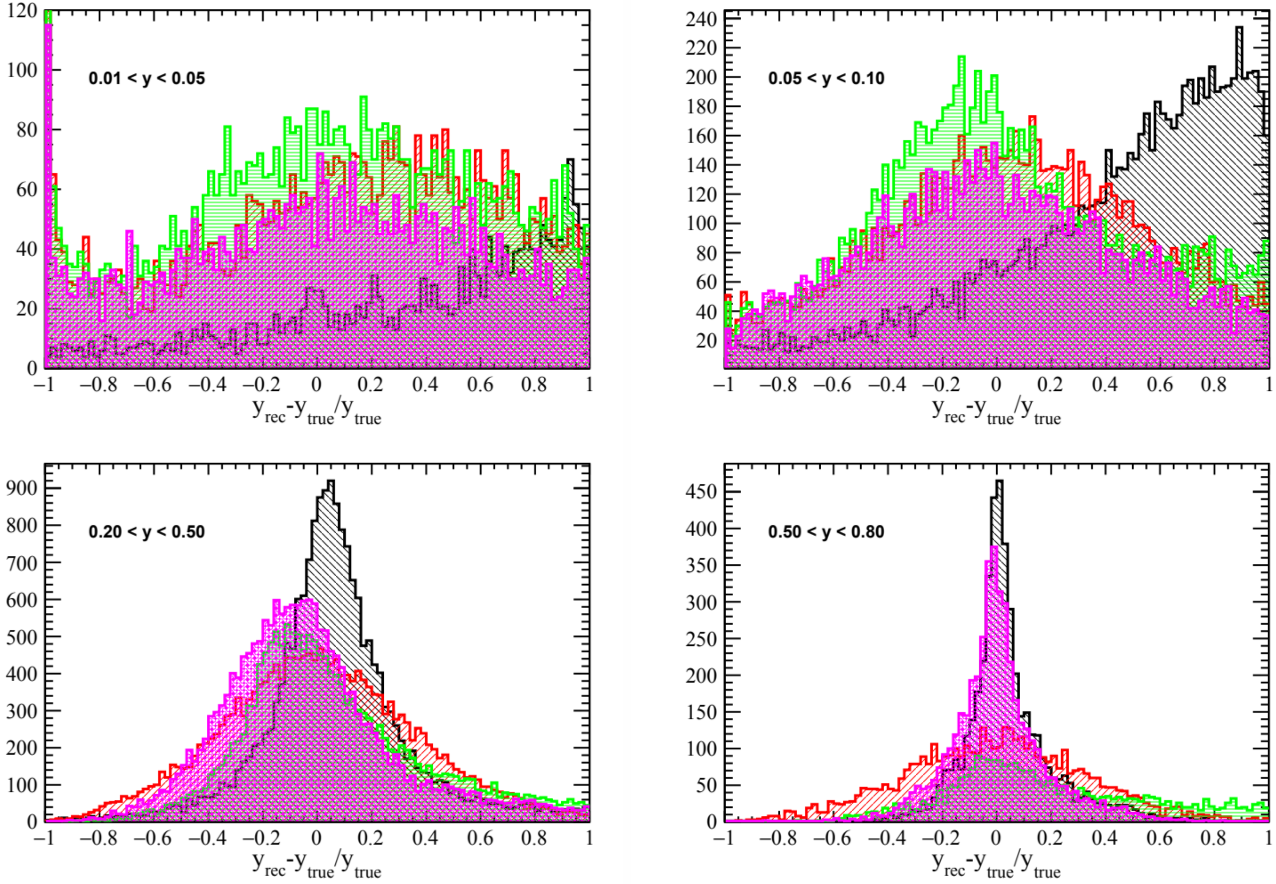


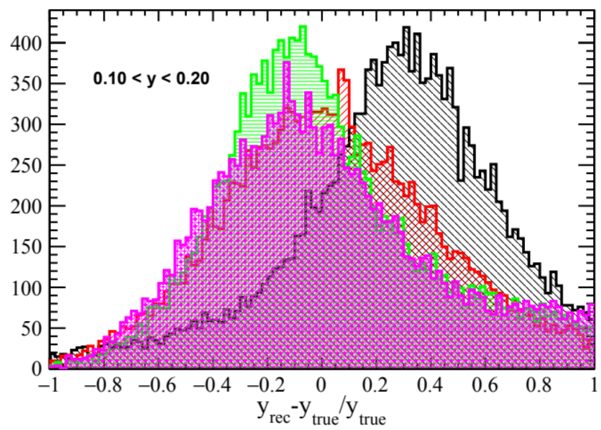




- Gaussian widths of new fits are used as inputs to kinematic fitting model

Resolution on y (Calorimeter only reconstruction)



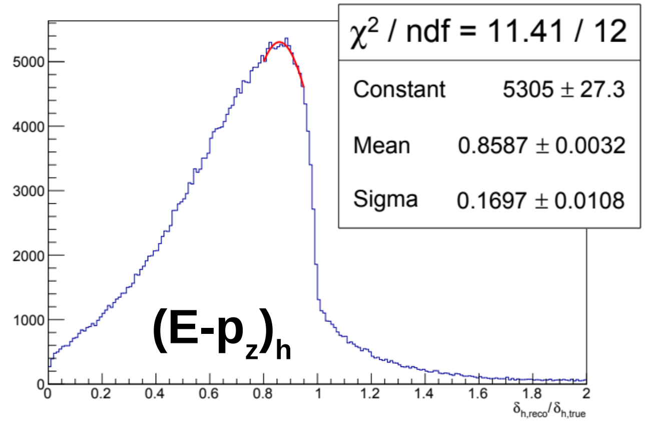


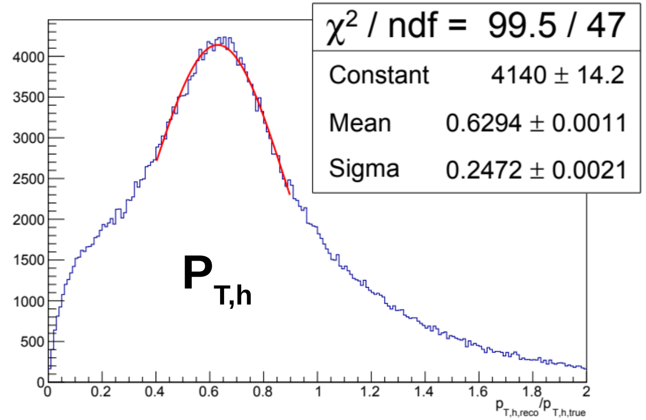
- All methods perform quite poor at low y with calorimeter only reconstruction → might improve by taking angles from tracks instead of position of clusters
- Kinematic fit performing somewhere between e-method and hadron based methods in each region → need better parametrisation

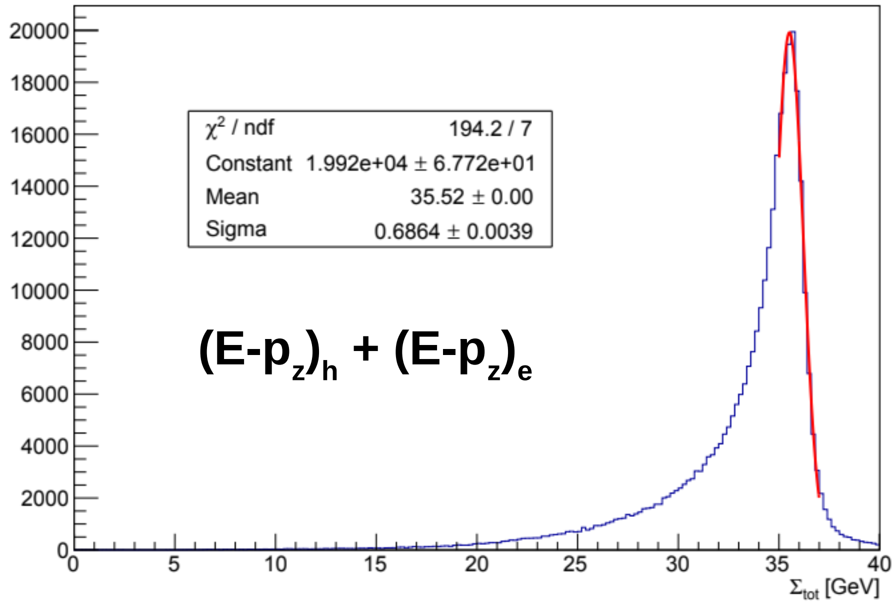
Electron method **e-Σ method** **JB method** **Kinematic Fit**

Track only reconstruction

- Take electron as highest p_T track → energy distribution from tracks is unbiased → no calibration necessary for e^-
- Still need to calibrate hadrons

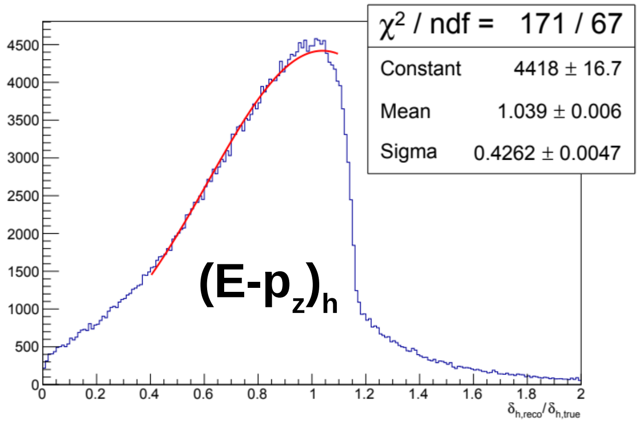


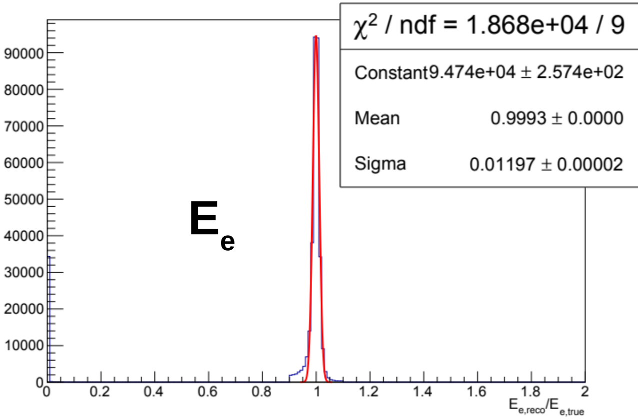


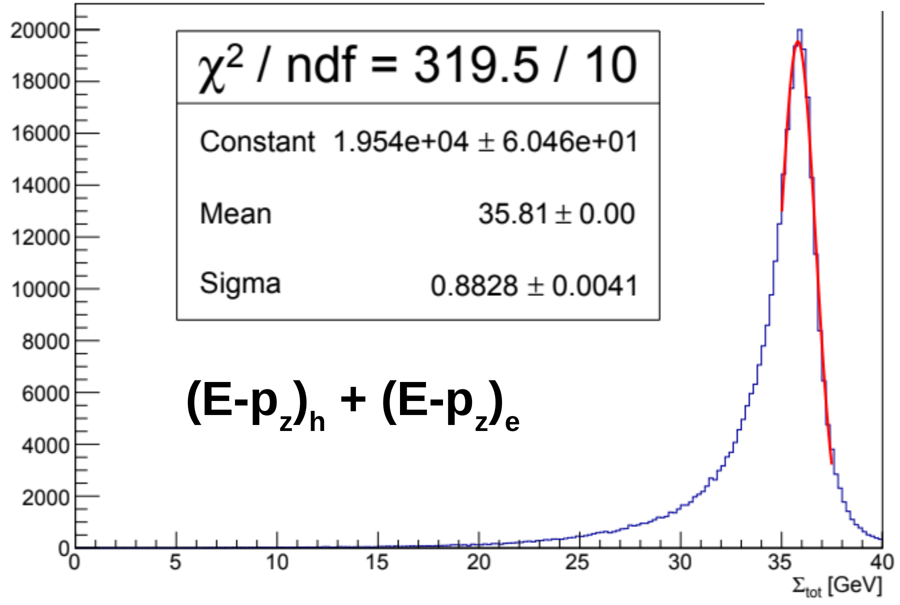


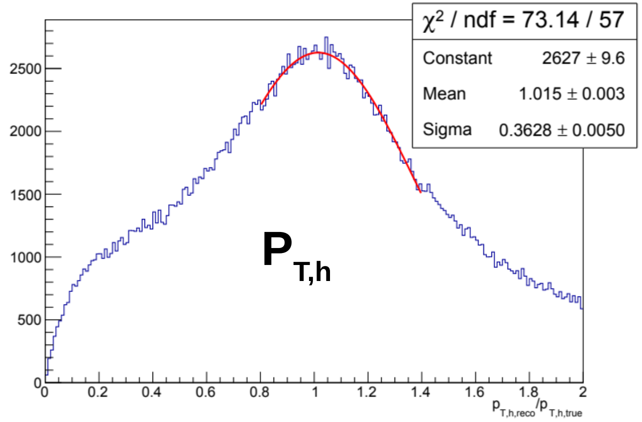
Track only reconstruction

- Hadron resolutions comparable
- Electron energy resolution improved from ~1.8% to ~1.2%
  - Should the tracker be winning here?



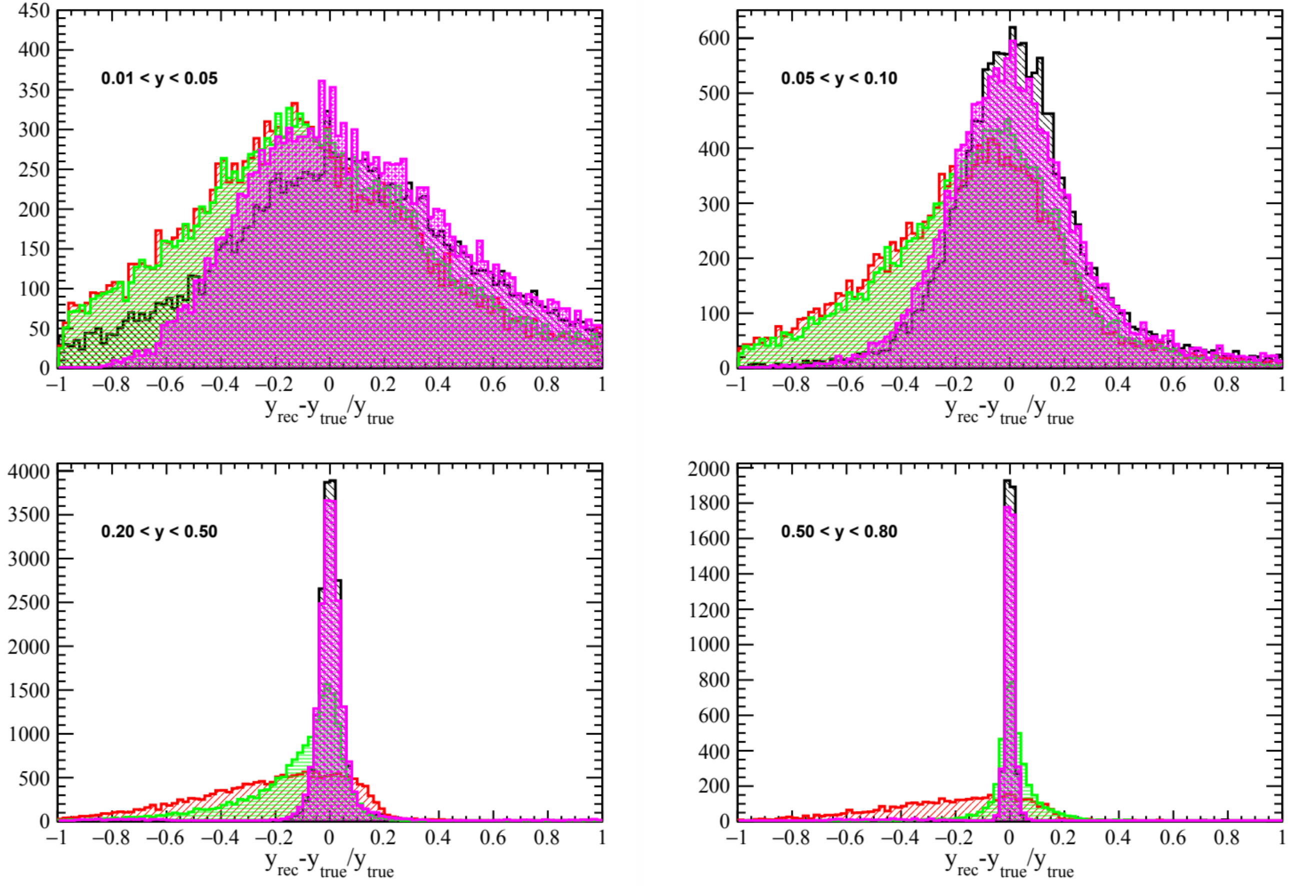






Fits used as input for model as before

Resolution on y (Tracker only reconstruction)



- Track only reconstruction outperforms **this** calorimeter only for all methods in all y ranges
  - Most notable improvement seen in electron based methods → significant gains from precise electron angle measurement?
- Fit performs comparable to best method in each region → promising as ISR not yet included

Electron method **e-Σ method** **JB method** **Kinematic Fit**

Summary

- A fit of all detector information makes it possible to exceed the performance of traditional reconstruction methods for x, y, Q^2, as well as identifying and accounting for the effect of possible ISR photons
- This method was applied to ePIC full simulation NC DIS data that was reconstructed using either the calorimeters or tracker alone
  - No reconstruction method performed well when calorimeter information alone was used
  - Tracking only reconstruction improved the quality of the electron measurement while keeping a similar quality of HFS reconstruction
  - The Kinematic fit gave comparable performance to the best reconstruction in each y bin

Next Steps

- Improve reconstruction by intelligently combining track and calorimeter information
- Look into electron energy measurement to understand difference in performance between calorimeter and tracker
- Repeat studies with events containing ISR to fully leverage kinematic fitting method