Jet and heavy flavor studies for the future Electron-Ion Collider

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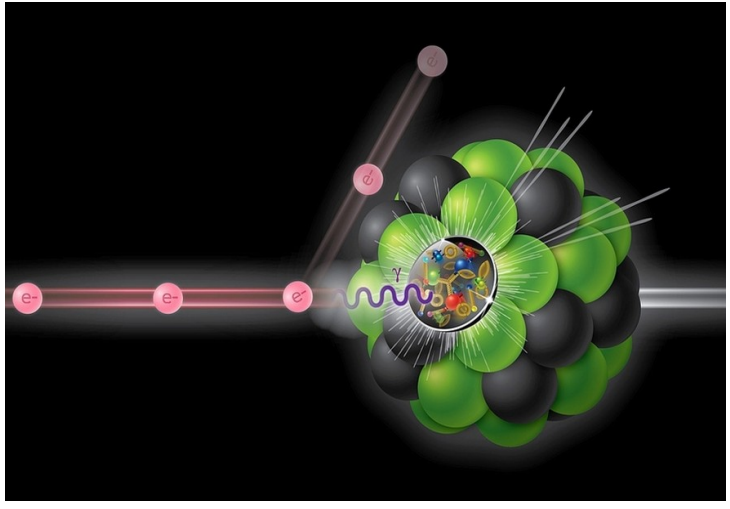

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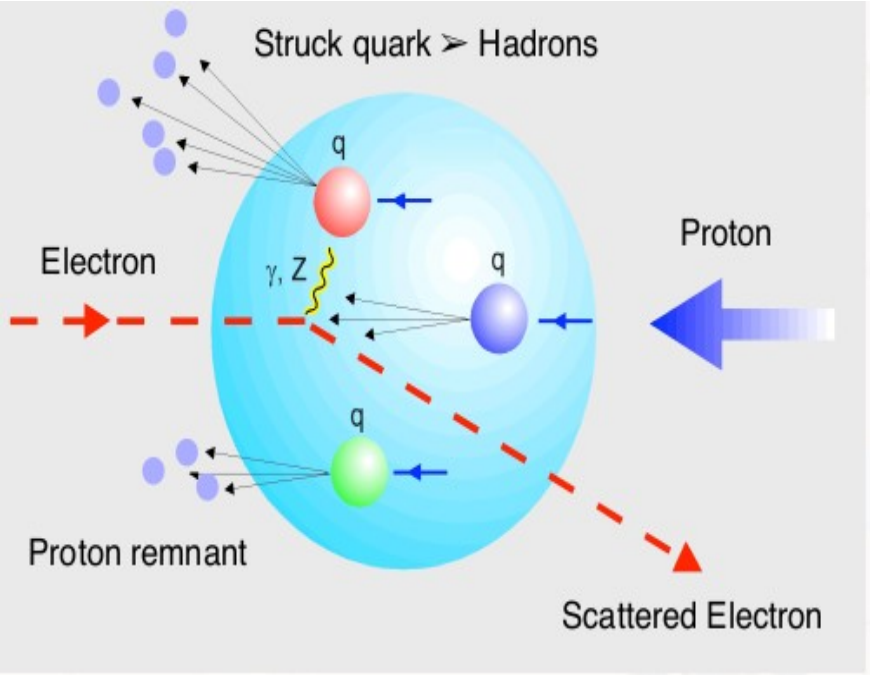
Outline

- Introduction
  - *Why to measure Jets at future EIC*
- Analysis Approach
  - *Event Generation Simulation (**Pythia 8.3**)*
  - *Generating **Jets** and **b jets** with PYTHIA*
  - *Detector Simulation (**EIC Recon**)*
  - *Detector response for **b jets***
- Summary and Outlook

Jet Observation at future EIC can probe TMD PDFs and FFs



- Jet observables can probe the transverse-momentum-dependent parton-distribution functions (PDFs) and fragmentation functions (FFs).

Collins Function

Hadron-in-jet Collins asymmetries as function of z_h (longitudinal momentum fraction).

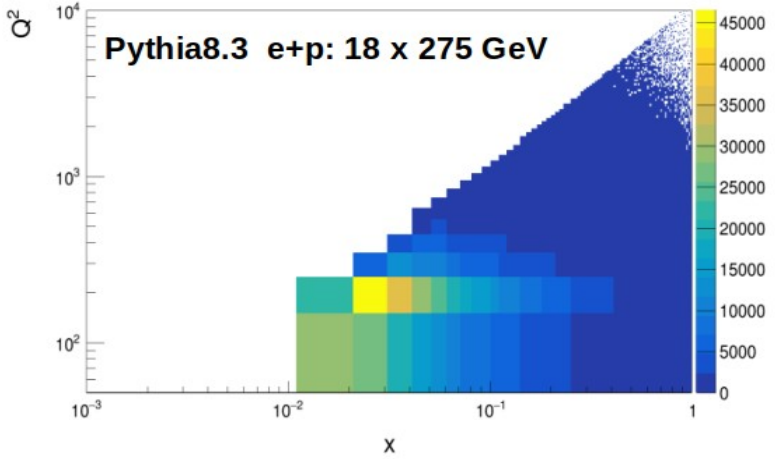
$$z_h = |p_{jet} \cdot p_{hadron}| / |p_{jet}^2|$$

Sivers Quark Function

Sivers asymmetry is sensitive to transverse momentum imbalance.

$$q_T = |p_T^e + p_T^{jet}|$$

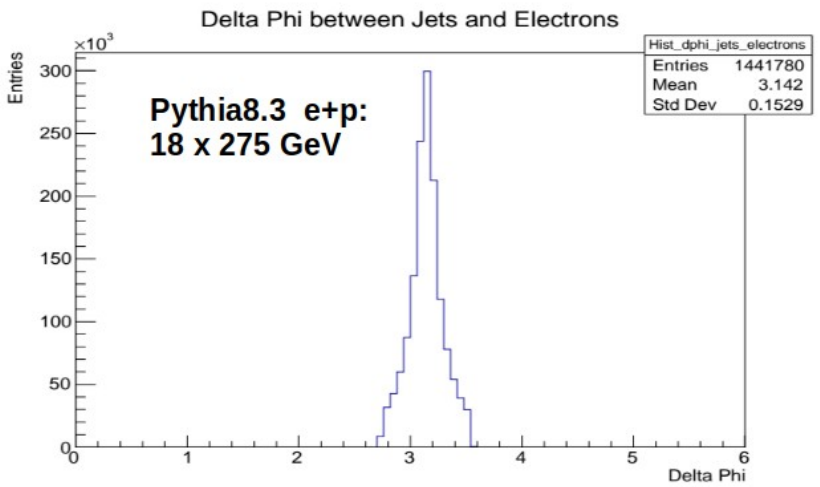
Jet Study using PYTHIA 8.3

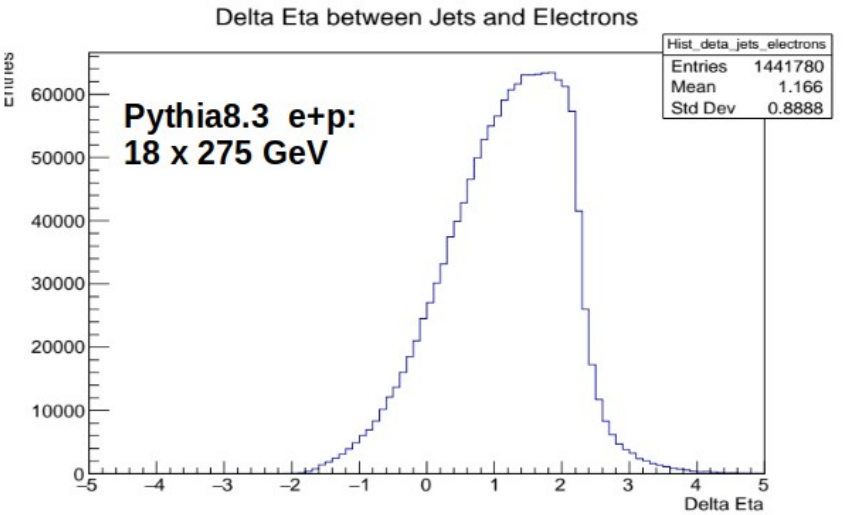


- Pythia8, generate e+p (unpolarized) SIDIS.
- 10^7 events, selected with
- $Q^2 > 25\ GeV^2$
- $0.1 < y < 0.85$
- EIC aims to look into small momentum fraction (x) over a wide range of momentum transfers Q^2.

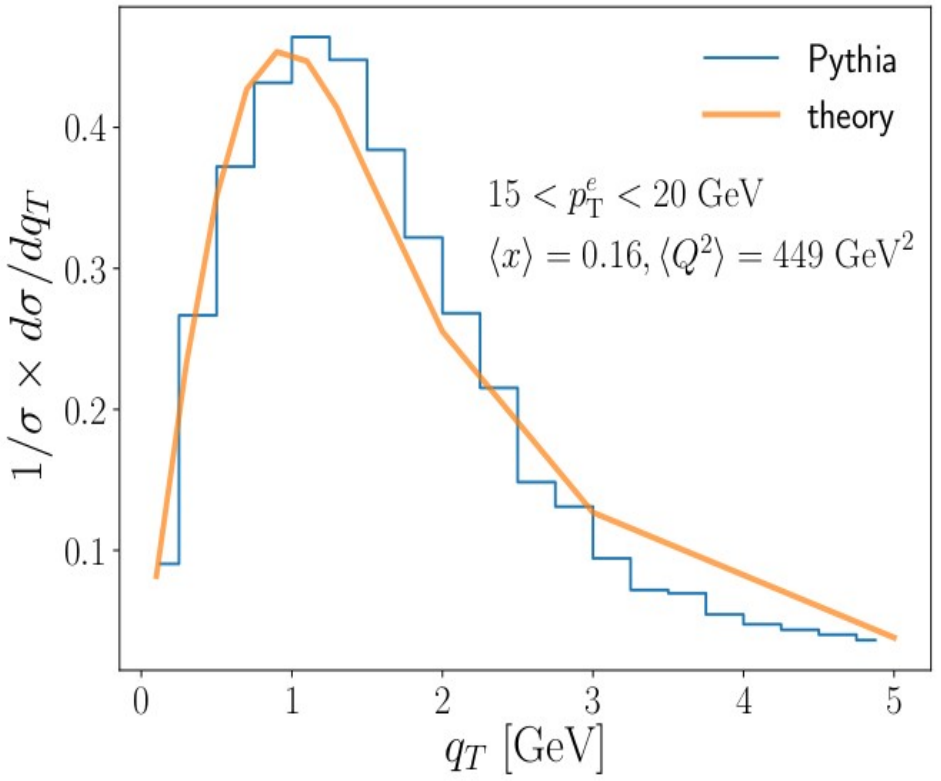
$|\phi_{jet} - \phi_e - \pi| < 0.4$

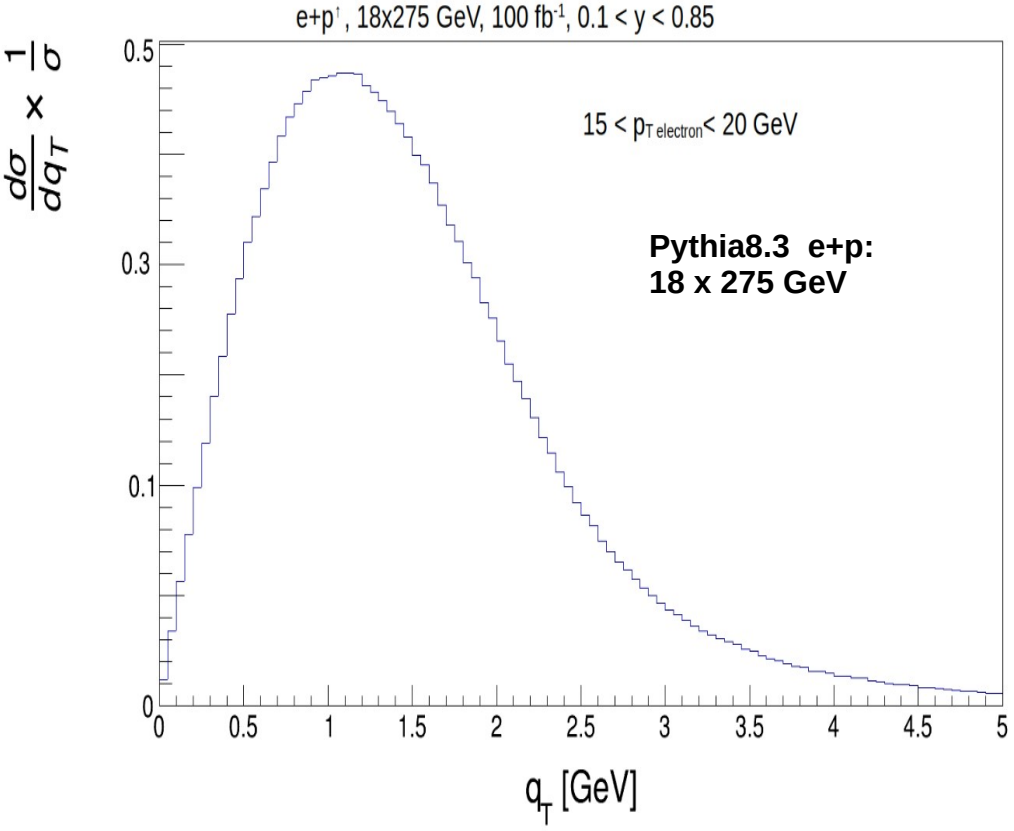
Back to Back Events





Arratia, Kang, Prokudin, Ringer Phys. Rev. D **102**, 074015





- Normalized differential cross section distribution of the transverse momentum imbalance $\mathbf{q_T}$ for jets.

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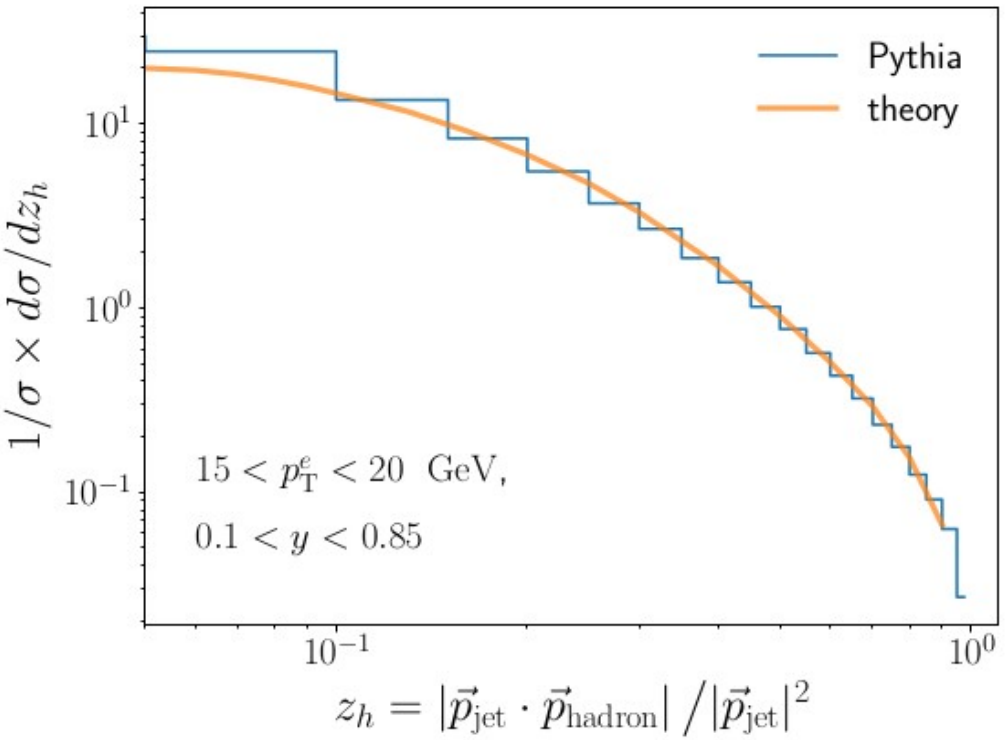
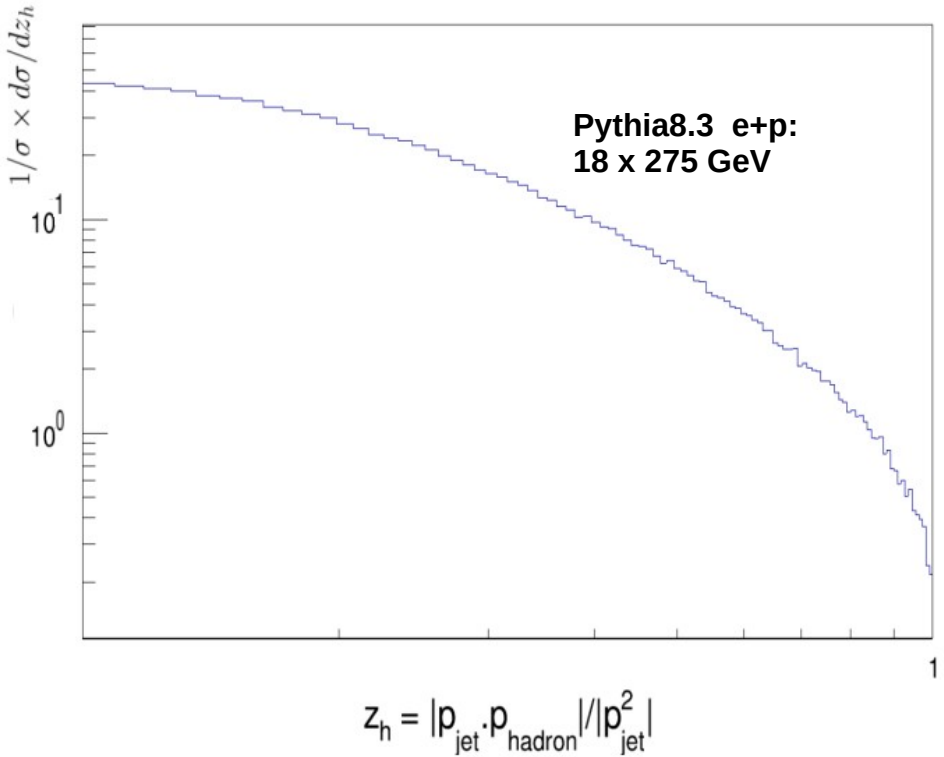


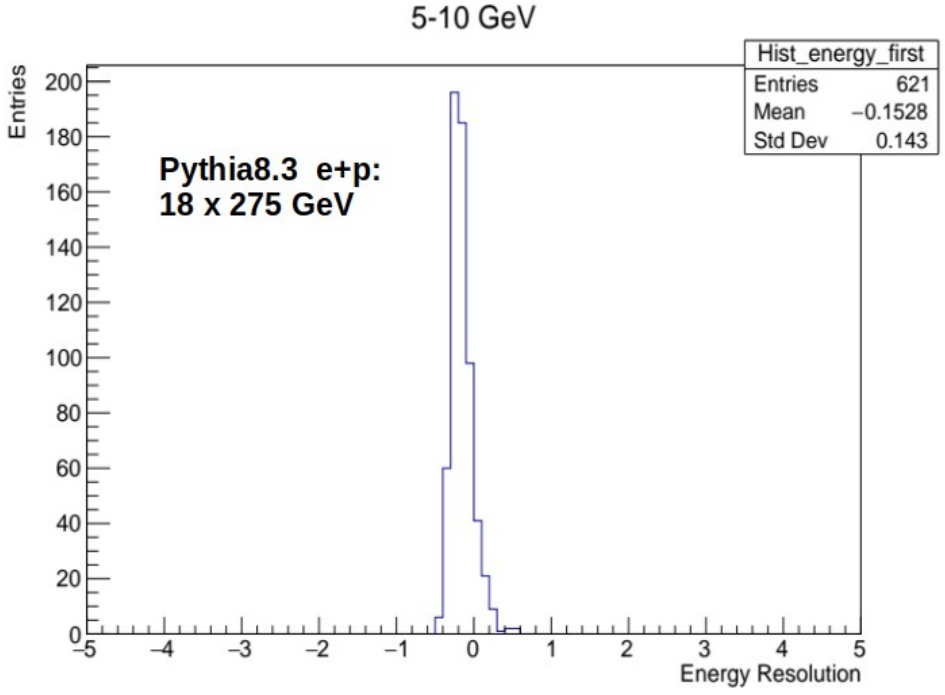


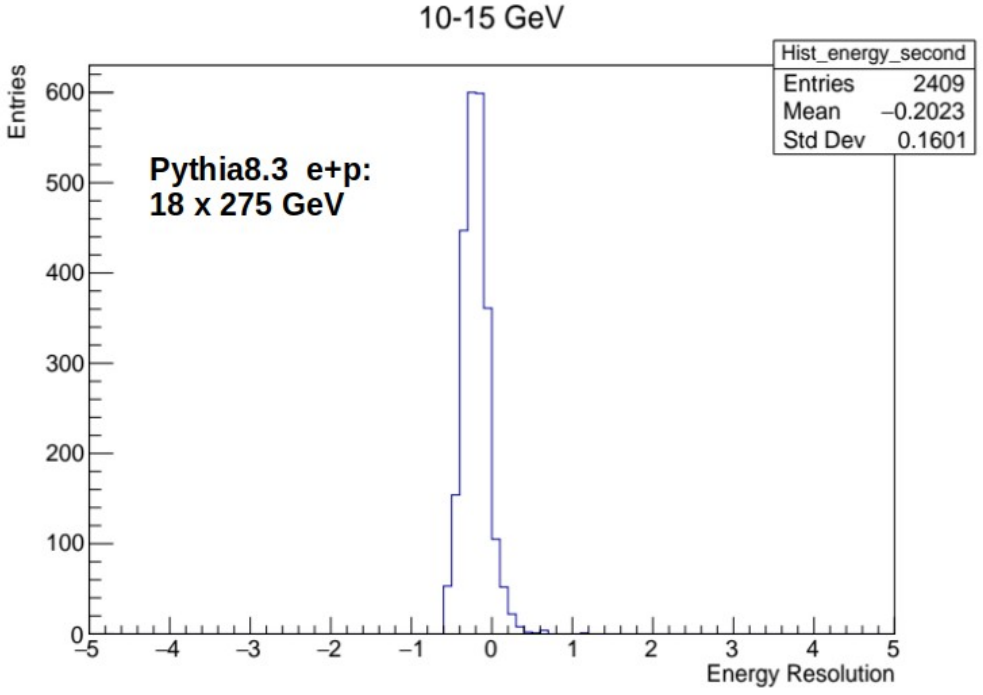
- Hadron-in-jet distributions as a function of z_h

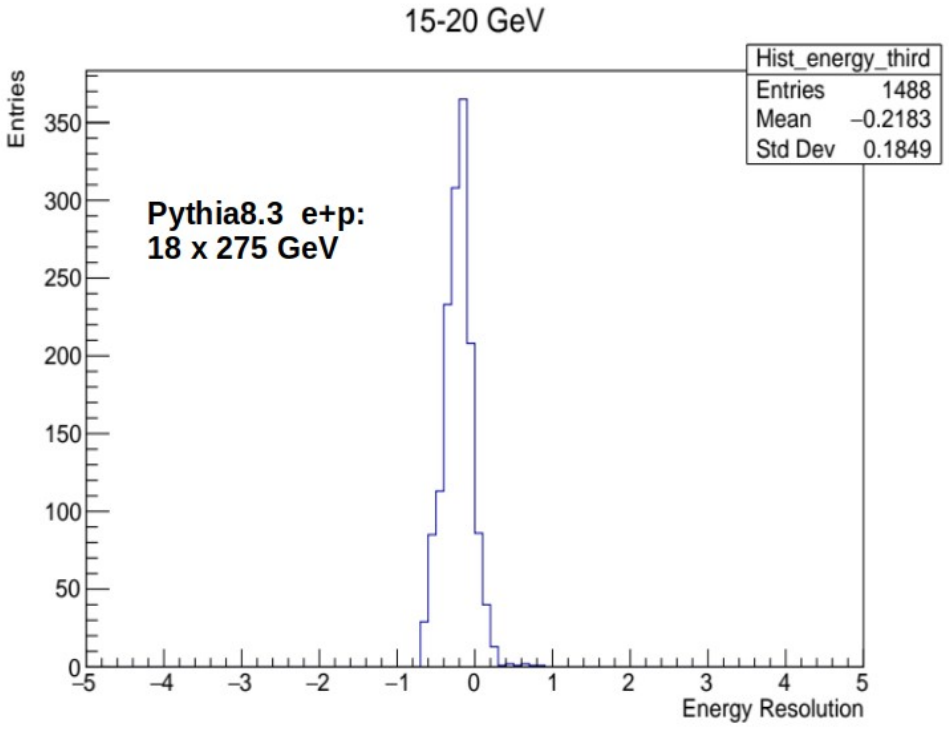
Pythia 8.3 Heavy Flavor Jet Analysis / b Jets

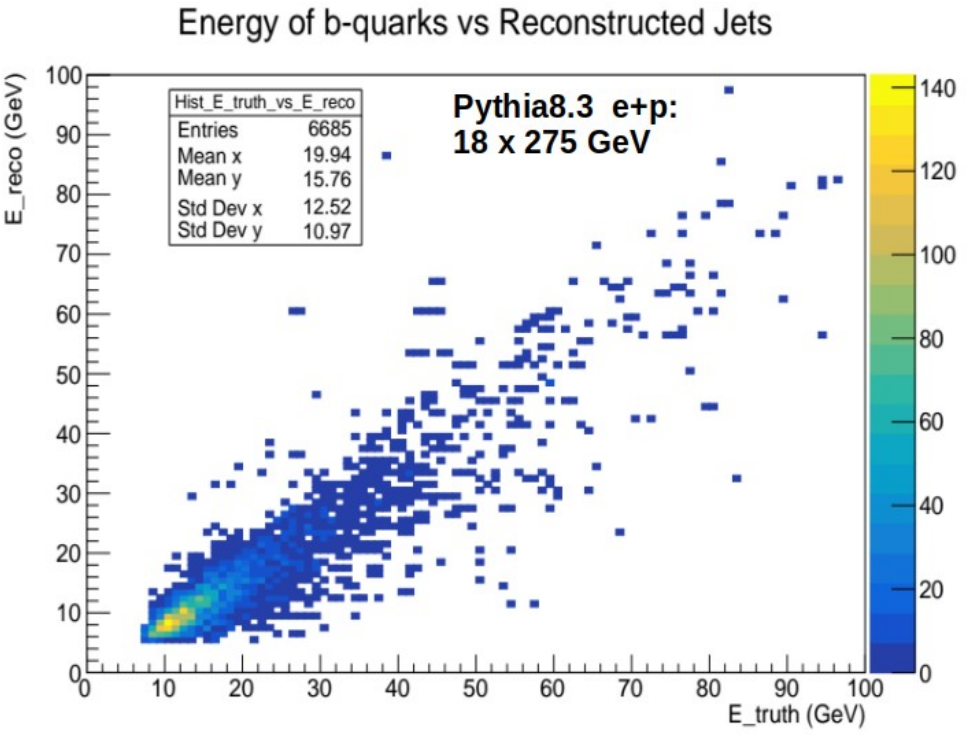
- Heavy quarks play a special role within the EIC. They are created in the initial collision and can probe the parton (quark or gluon) evolution processes.
- Jet identified with **anti-kT algorithm** are compared with initial parton energy where **pT > 5 GeV/c** and **R = 1.0** (jet cone radius).
- We find the true and reconstructed jets closest to b and $\bar{b}$.

$$\text{Resolution} = \frac{E_{reco} - E_{truth}}{E_{truth}}$$





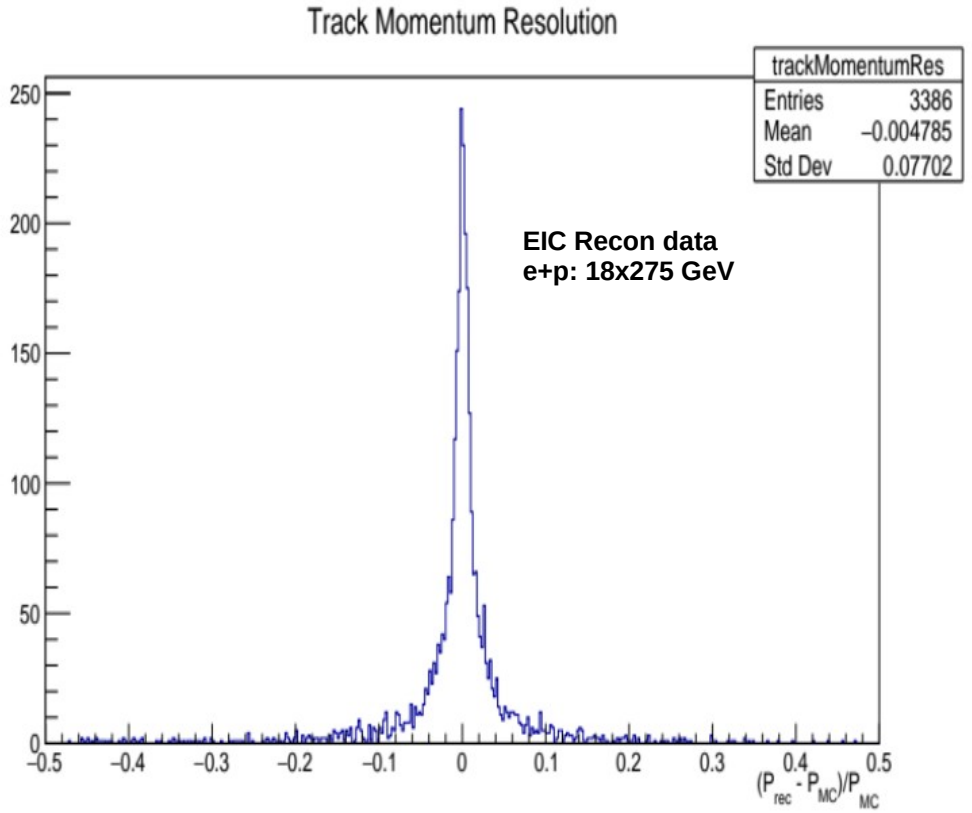




- Good resolution up to **E_parton = 20 GeV** for **18x275 GeV beam energies**.
- The 2D plot shows the energy correlation between true jets and reconstructed jets. At higher energies, we observe that the linear trend begins to distort, indicating that the energy resolution worsens at these higher energies.

Detector Simulation EIC Recon

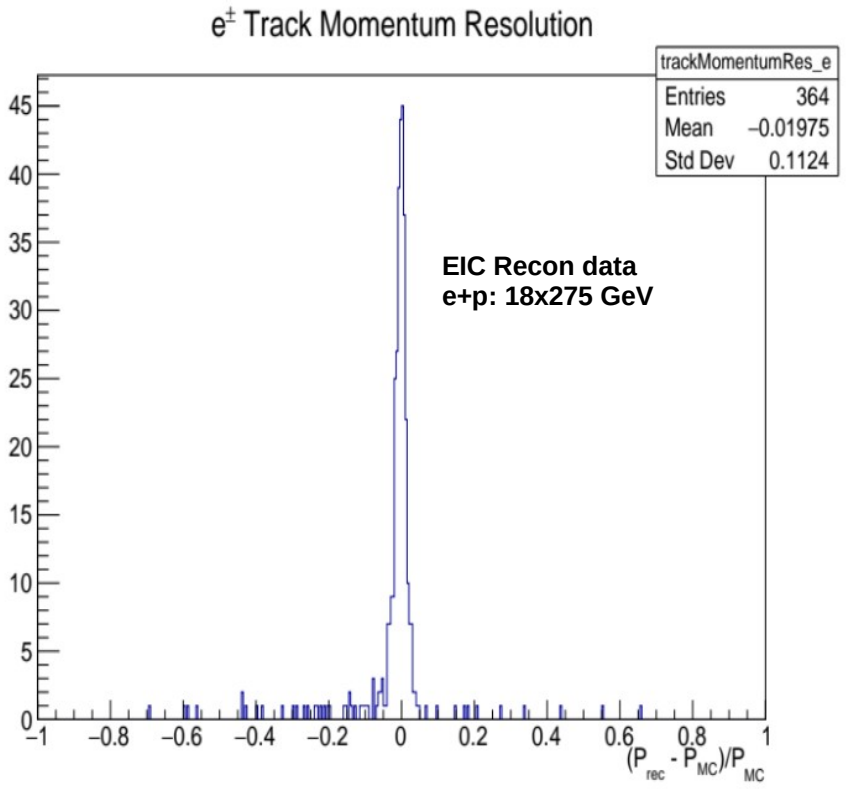
Momentum Resolution

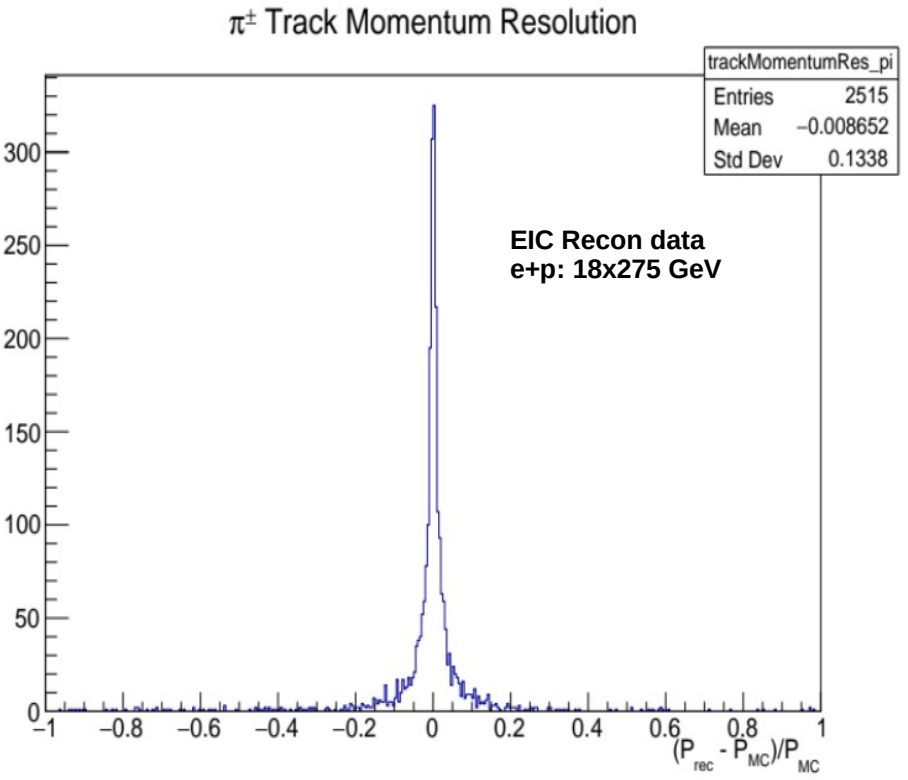


- Data taken from EIC data campaign
- e+p , @ 18 x 275 GeV beam energies
- Q^2 min = 100 GeV
- **MCParticles.generatorStatus == 1** to choose stable particles.
- **ReconstructedChargedParticles.momentum** for final reconstructed tracks.
- **ReconstructedChargedParticleAssociations.simID** used to make the association.

$$\text{Resolution} = \frac{E_{reco} - E_{truth}}{E_{truth}}$$

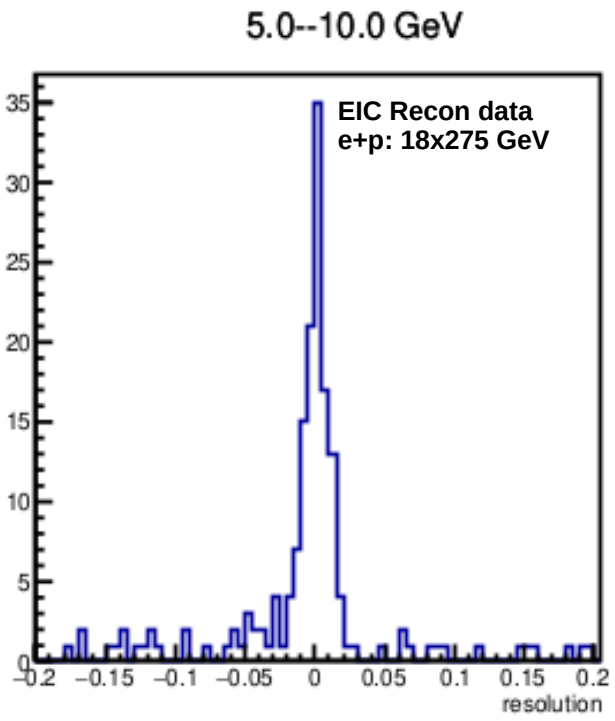
Momentum Resolution and Particle Identification

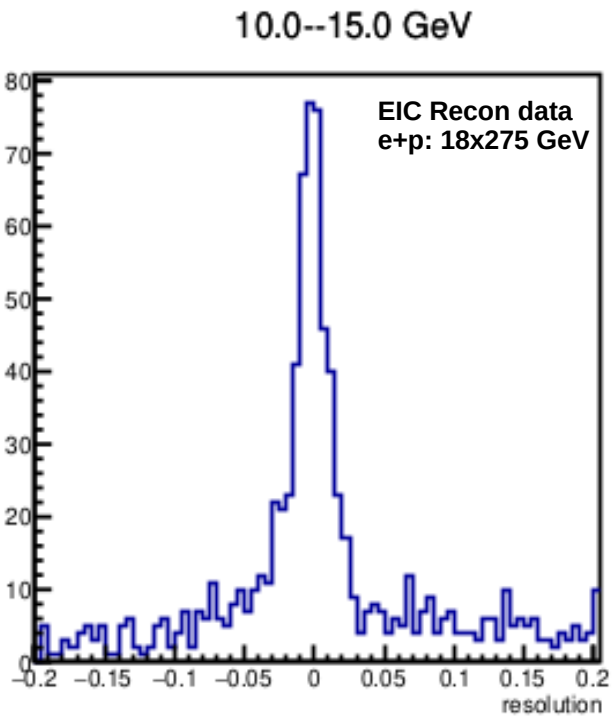




- We reproduced several momentum resolution and particle identification results from the EIC Recon framework using Data Campaign outputs. This process has solidified our understanding of the EIC Recon framework, giving us confidence to move forward with our individual analyses.

EIC Recon Heavy Flavor Jet Analysis / b Jets



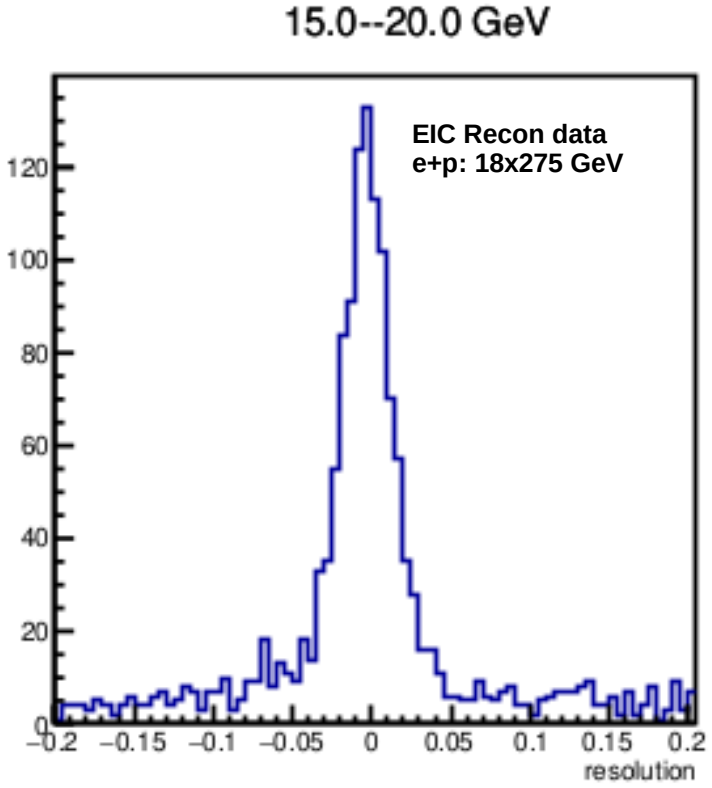


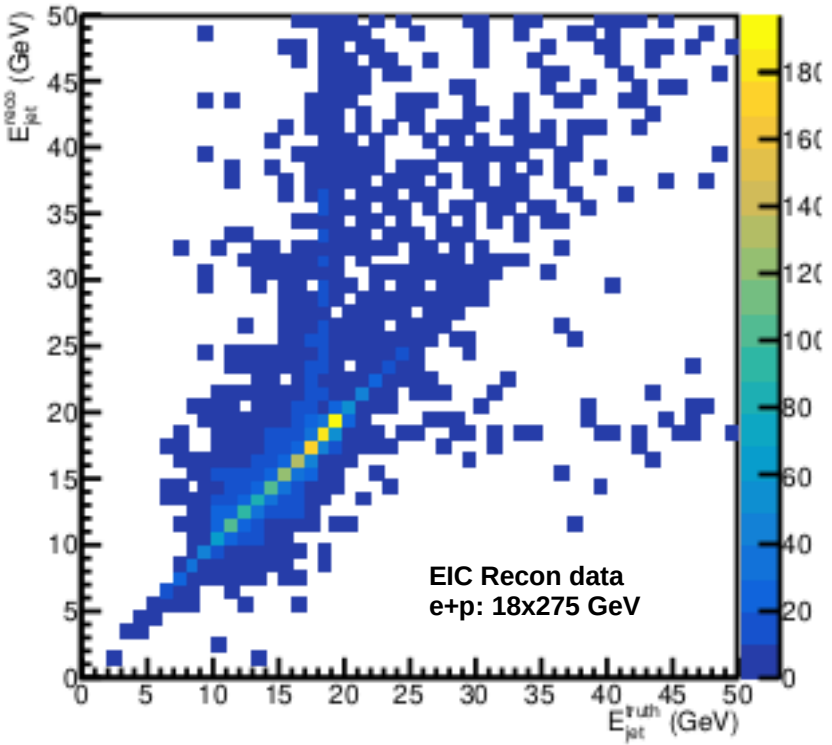
- Identify bottom (b) Jets
- Data Campaign outputs used
- e+p, @ 18x275 GeV beam energies
- R = 1.0 jet cone radius
- Minimum Jet Energy > 1 GeV
- 1.4 < eta < 4.0

$$\text{Resolution} = \frac{E_{reco} - E_{truth}}{E_{truth}}$$

https://indico.bnl.gov/event/20186/contributions/79394/attachments/49227/83935/main.pdf

EIC Recon Heavy Flavor Jet Analysis / b Jets





- The resolution is good for jet energies up to 20 GeV.
- Up to 20 GeV, the 2D energy correlation plot shows a clear linear trend, consistent with the observations in the energy resolution histograms.

Summary and Outlook

- We use PYTHIA 8.3 to generate the back-to-back electron - jet events. And calculated the energy resolution of tagged bottom jets in e+p collisions at 18x275 GeV.

- We calculated the energy resolution for bottom jets in EIC recon data in e+p collisions at 18x275 GeV.

- The energy resolution for b-jets worsen at energies above 20 GeV both in PYTHIA and EIC Recon data. Event generator and detector response presents an alignment.

Thank you for your attention …