D^0 Reconstruction

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July 8, 2025

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Physics Goal and Strategy

Overall Objective

- Extract Gluon Sivers Asymmetry via charm production in DIS
- Use $D^0 \to K^-\pi^+$ as a clean probe of charm dynamics
- Access gluon transverse momentum distributions

Analysis Strategy

- Reconstruct D^0 candidates from kaon-pion pairs
- Select DIS events: $Q^2 > 1$ GeV^2, $W > 5$ GeV, $0.1 < y < 0.9$
- Match Reco to MC particles to validate candidates
- Bin in azimuthal and kinematic variables for asymmetry extraction

File Source and Used Branches

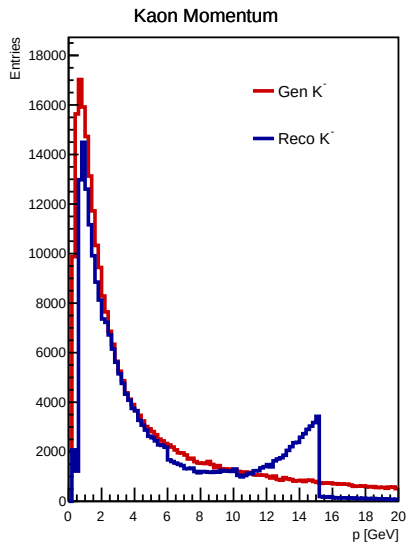
DIS Dataset Location

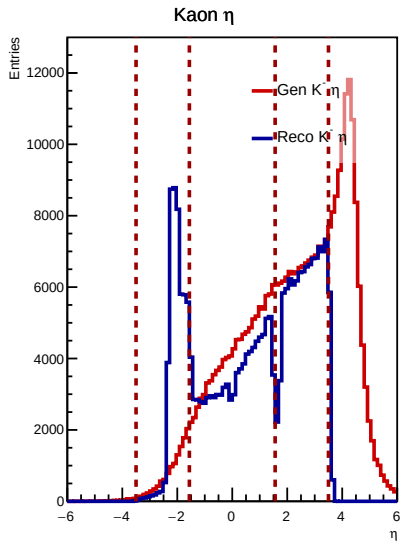
root://dtn-eic.jlab.org//work/eic2/EPIC/RECO/25.03.1/epic_craterlake/DIS/NC/18x275/minQ2=10/

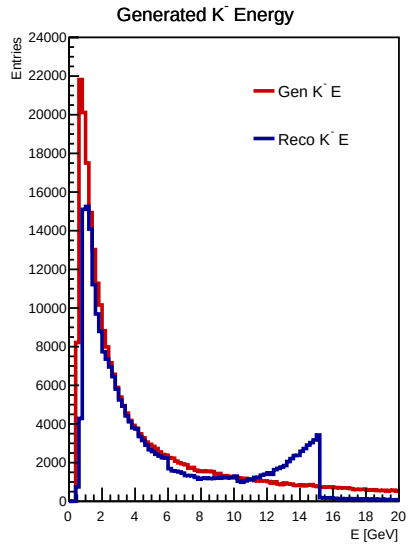
Used Branches

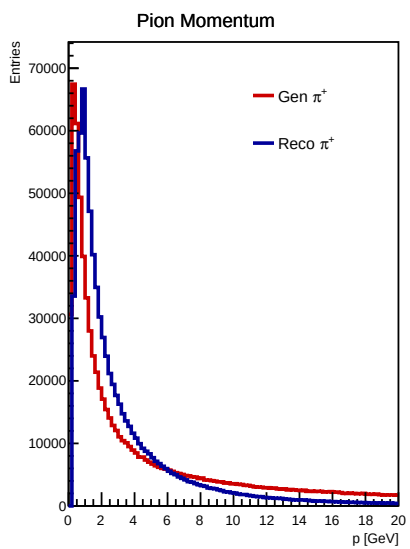
- MCParticles
- ReconstructedChargedParticles
- ReconstructedChargedParticleAssociations
- InclusiveKinematicsElectron

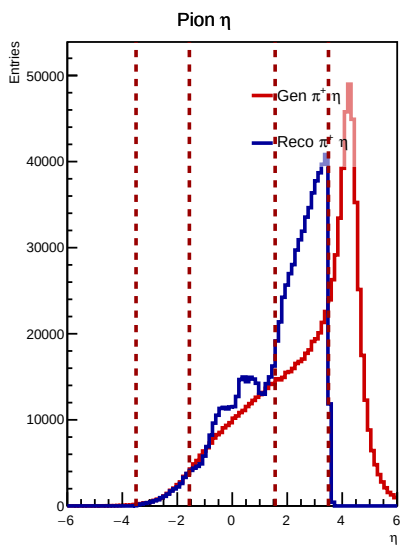
Final State and Matched Particles (Before Cuts)

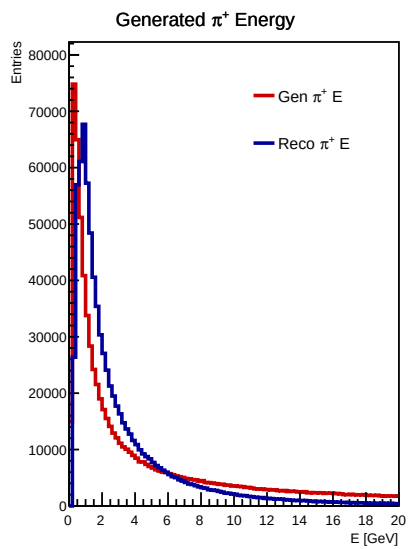












Reco–MC Association with Weights

Purpose of Association Weighting

- Multiple reconstructed particles can be associated with multiple MCParticles
- Each association has a weight (confidence of match)
- Keep only the match with the highest weight per reconstructed particle

Branches Used

- `ReconstructedChargedParticles`
- `MCParticles`
- `ReconstructedChargedParticleAssociations.reco`
- `ReconstructedChargedParticleAssociations.sim`
- `ReconstructedChargedParticleAssociations.weight`

Final-State Particle Cuts by η Region

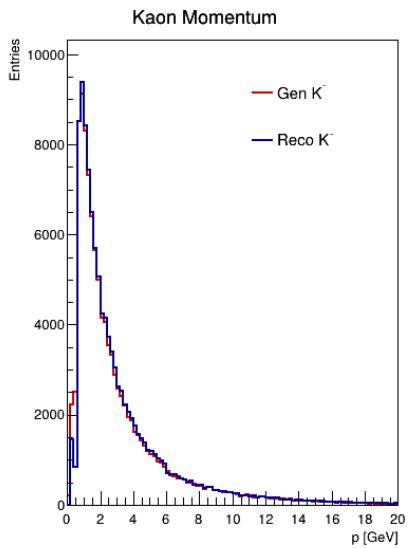
Motivation

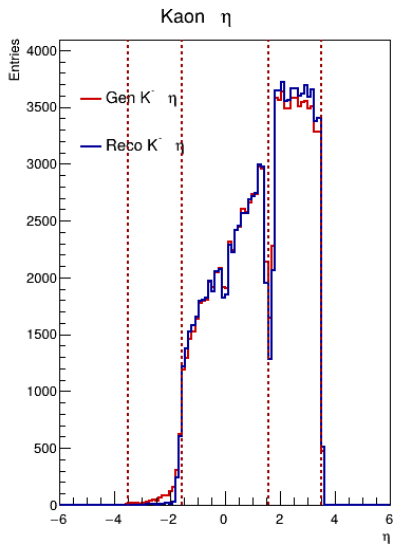
- Particle ID and tracking performance vary across detector acceptance
- Apply momentum cuts based on η region to improve signal purity

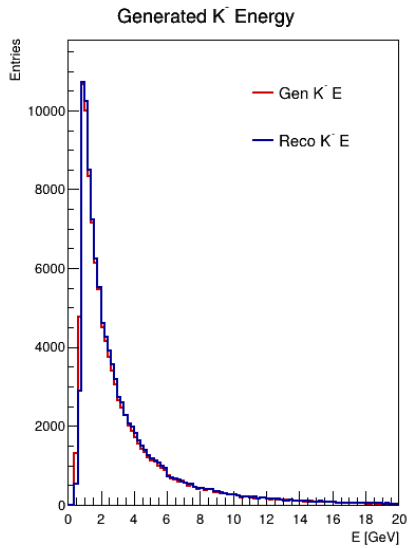
Momentum Cuts

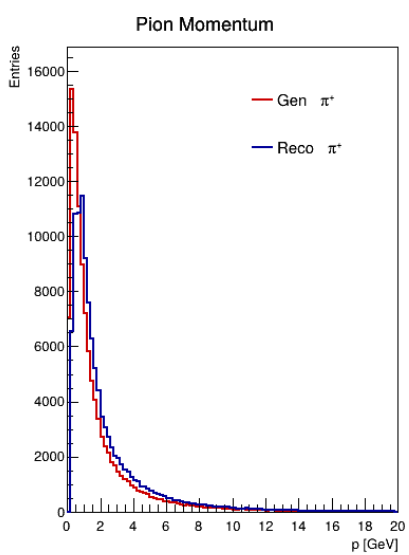
- **Kaon Cut:**
  - $-3.5 < \eta < -1.56 \Rightarrow p < 2.0$ GeV
  - $-1.56 < \eta < 1.56 \Rightarrow p < 6.0$ GeV
  - $1.56 < \eta < 3.5 \Rightarrow p < 20.0$ GeV
- **Pion Cut:** (same as kaon)
  - $-3.5 < \eta < -1.56 \Rightarrow p < 2.0$ GeV
  - $-1.56 < \eta < 1.56 \Rightarrow p < 6.0$ GeV
  - $1.56 < \eta < 3.5 \Rightarrow p < 20.0$ GeV

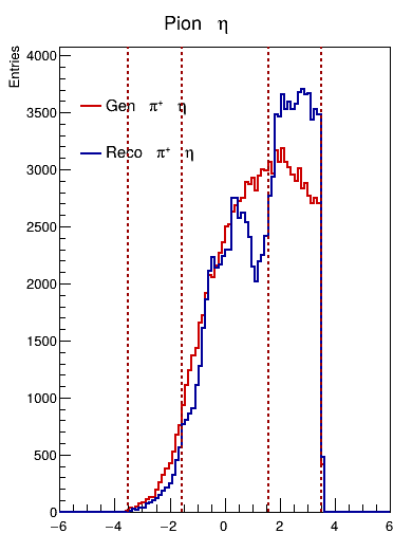
Final State and Matched Particles (After Cuts)

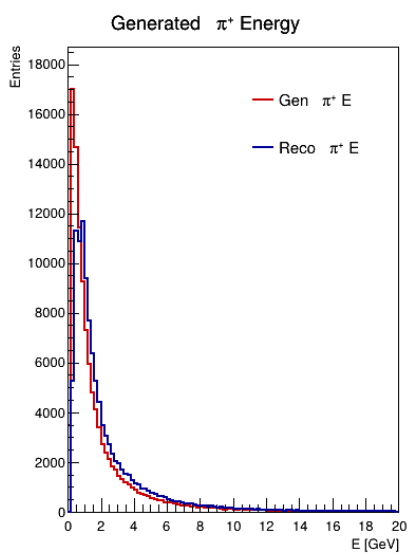




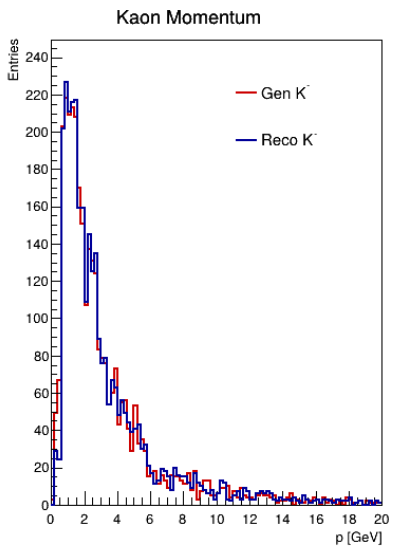


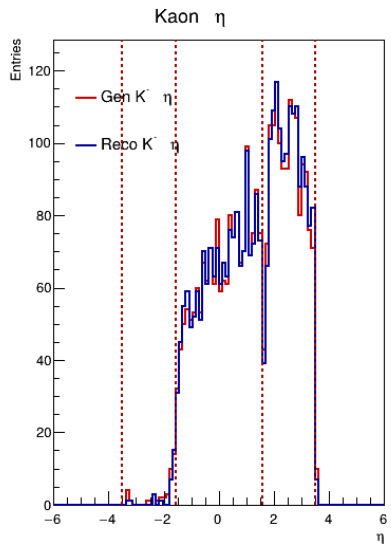


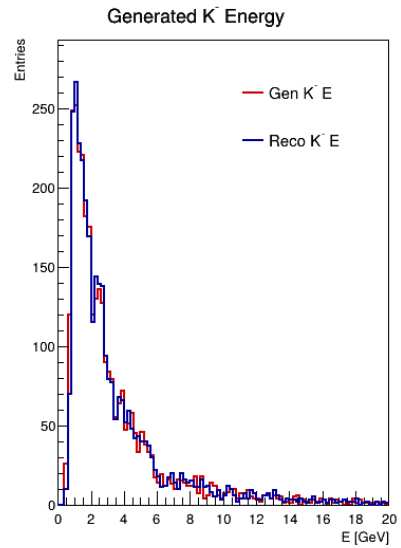


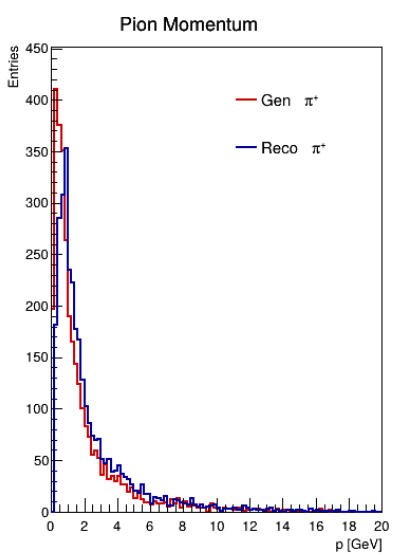


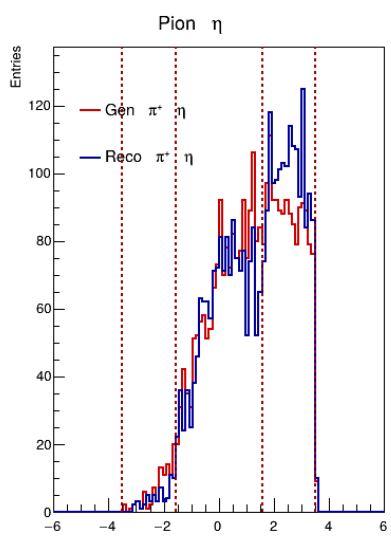
Final State and Matched Particles (Truth D0s)

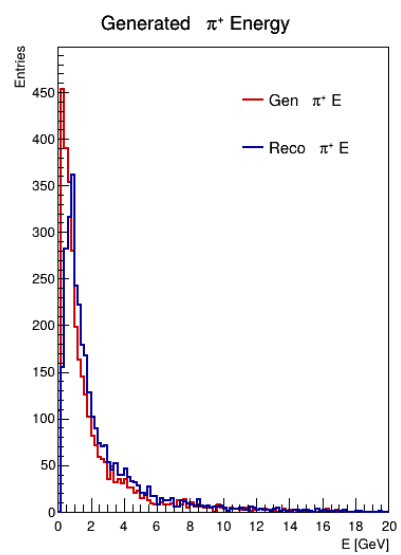












DIS Event Selection Cuts

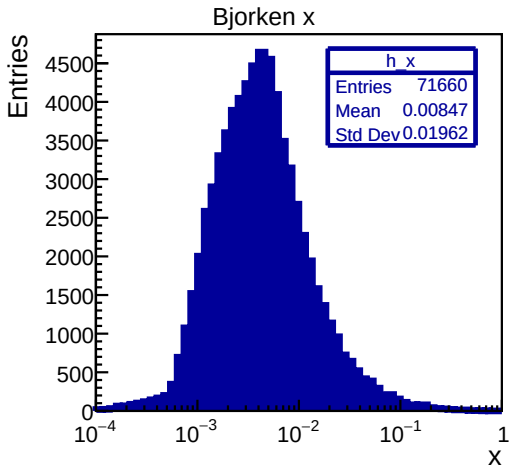
Available Kinematic Reconstruction Methods (Branches)

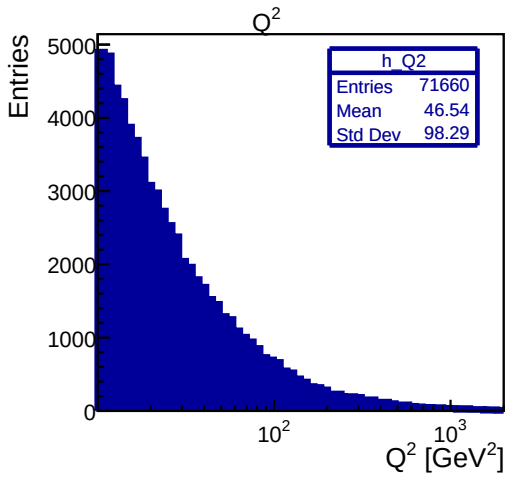
- `InclusiveKinematicsElectron`
- `InclusiveKinematicsDA` (Double Angle)
- `InclusiveKinematicsJB` (Jacquet-Blondel)
- `InclusiveKinematicsSigma`

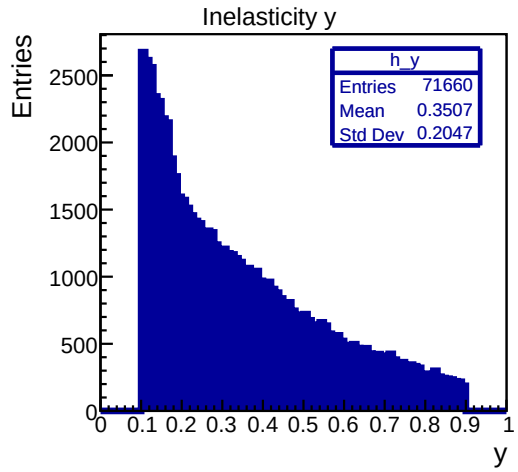
Cuts Applied (Using `InclusiveKinematicsElectron`)

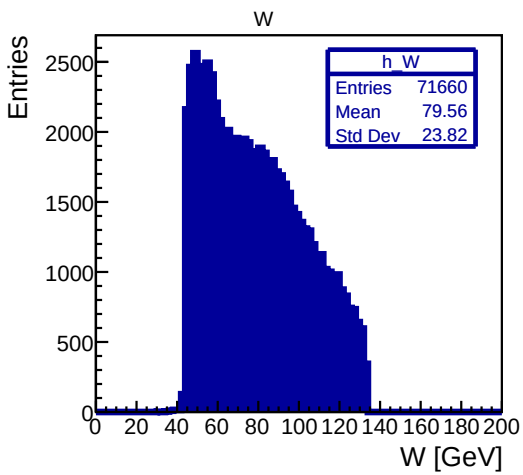
- $Q^2 > 1$ GeV^2
- $W > 5$ GeV
- $0.1 < y < 0.9$

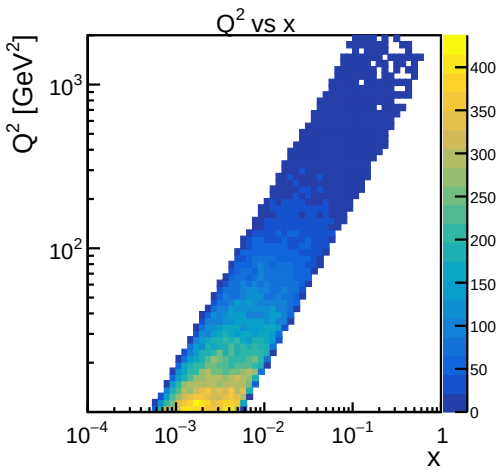
DIS Kinematic Distributions (After Cuts)



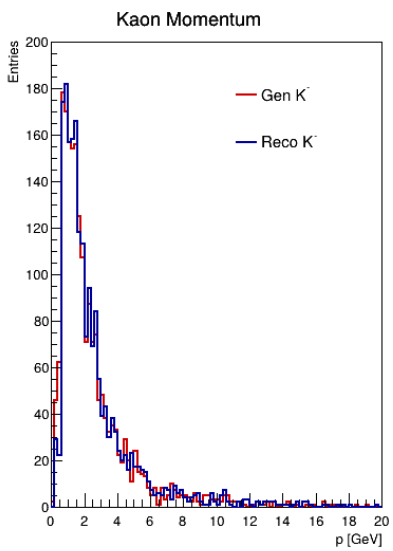


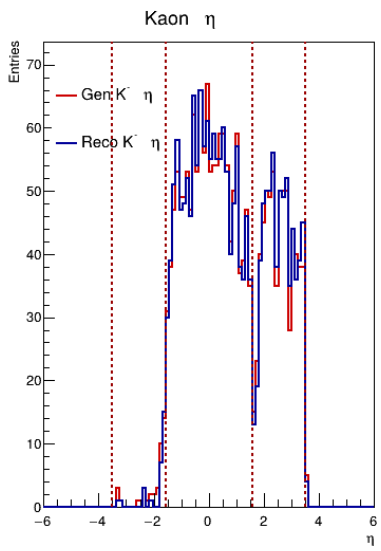


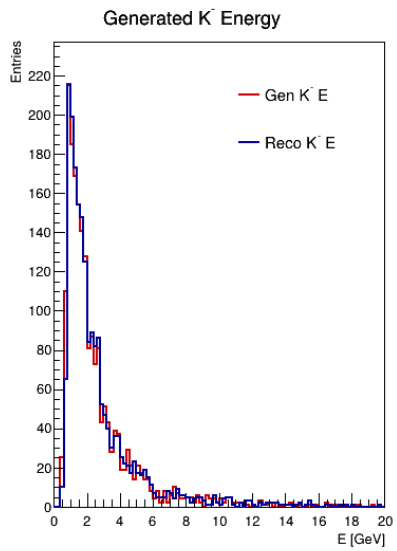


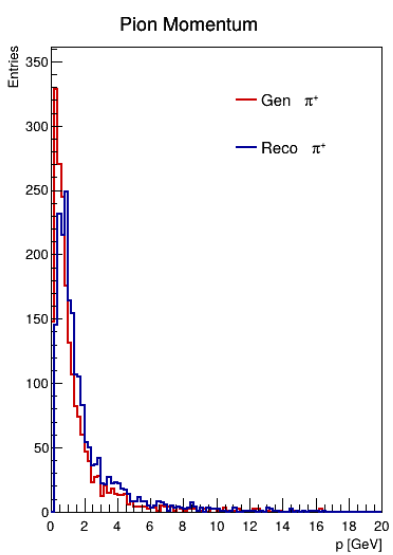


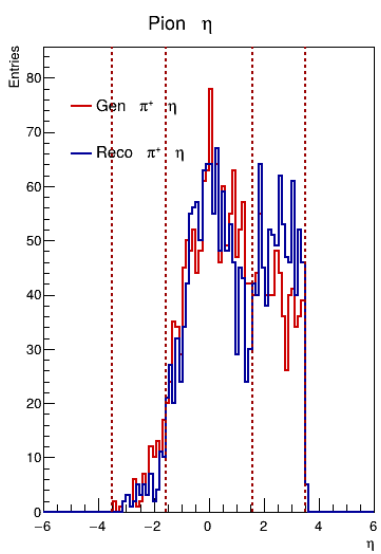
Final State and Matched Particles (After DIS Cuts)

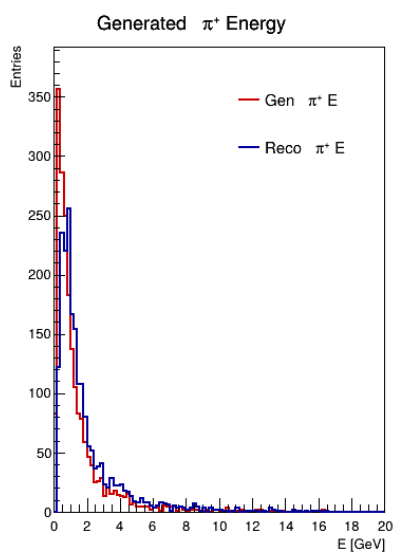




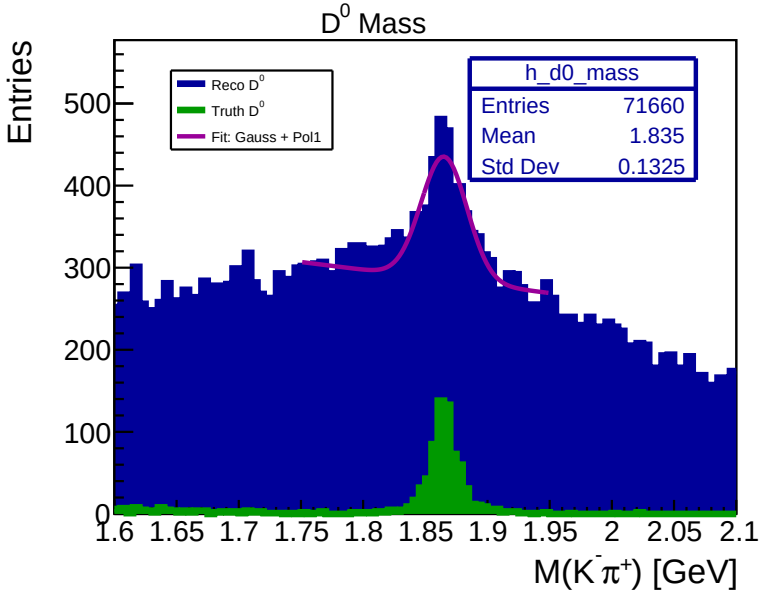


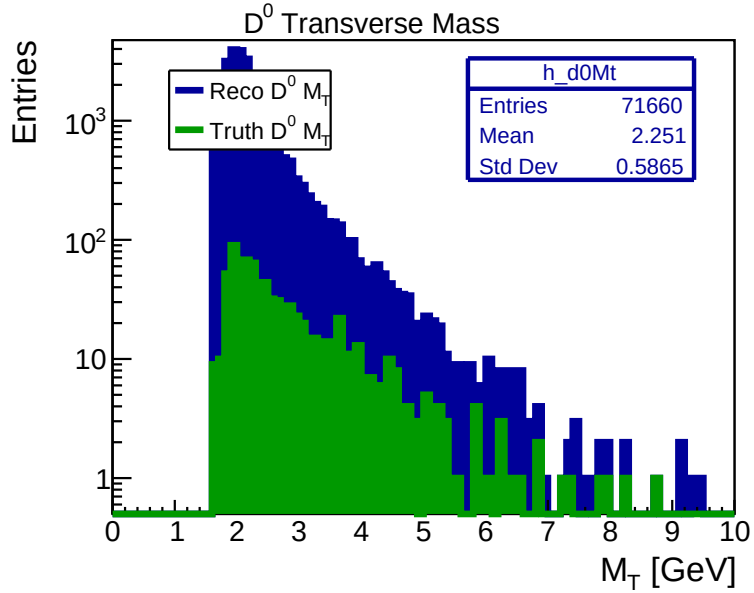


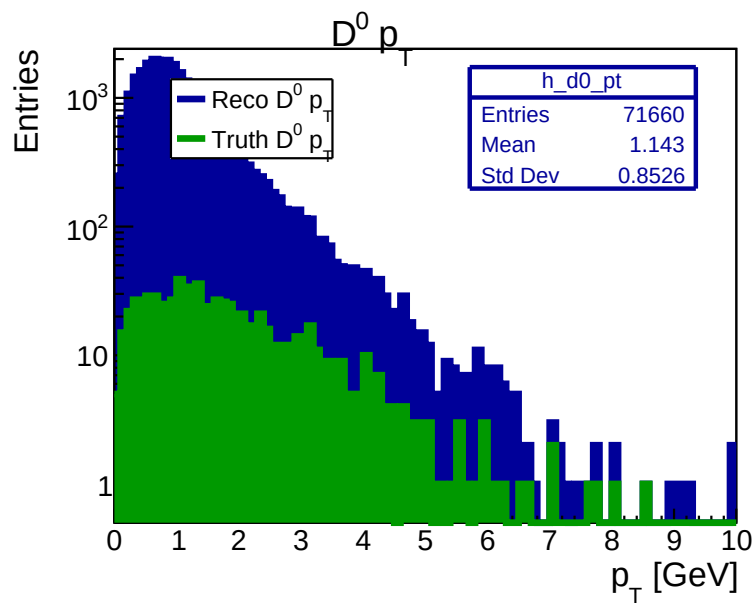


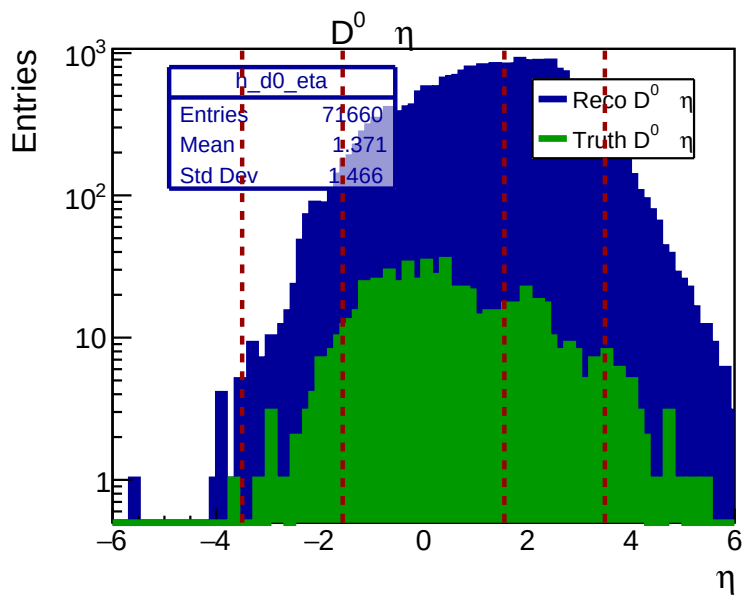


$D^0 \to K^-\pi^+$ Reconstruction: Mass and Kinematics

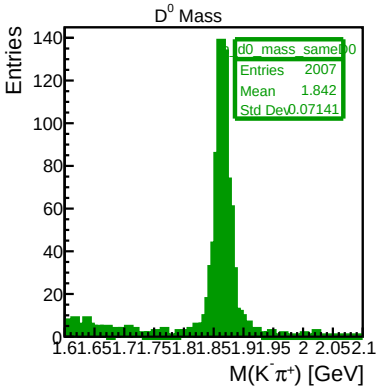


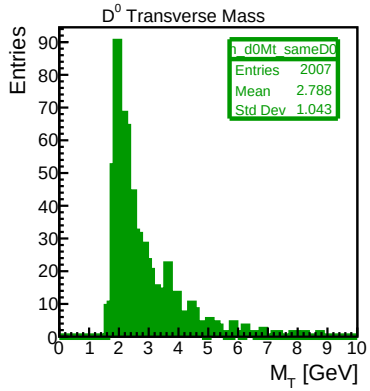


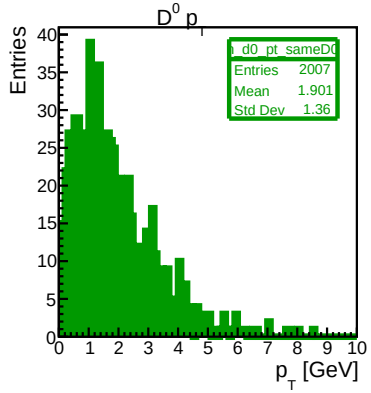


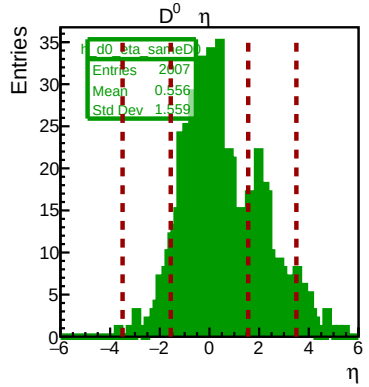


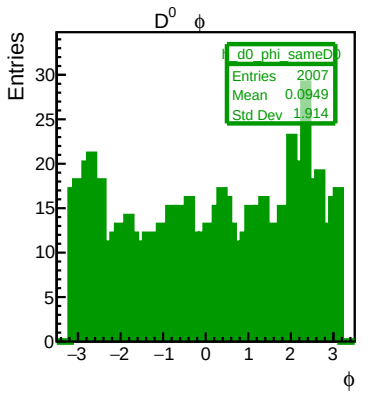
Truth-Level D^0 Distributions

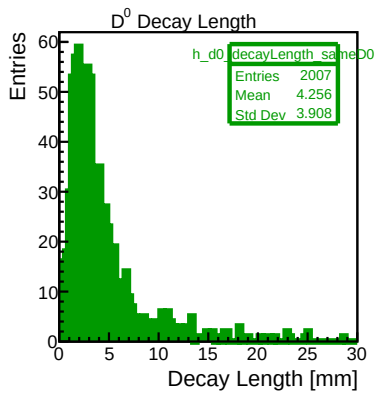


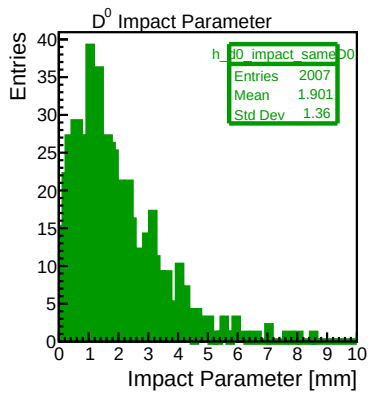


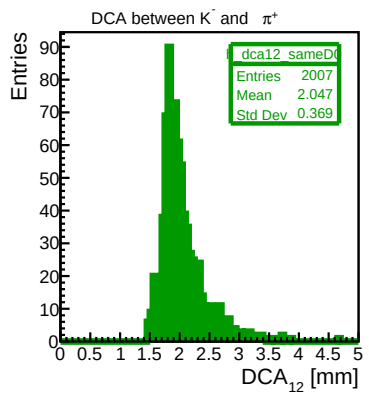


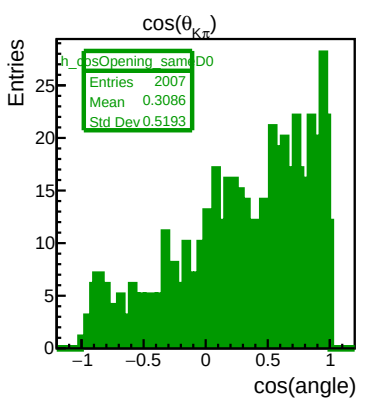






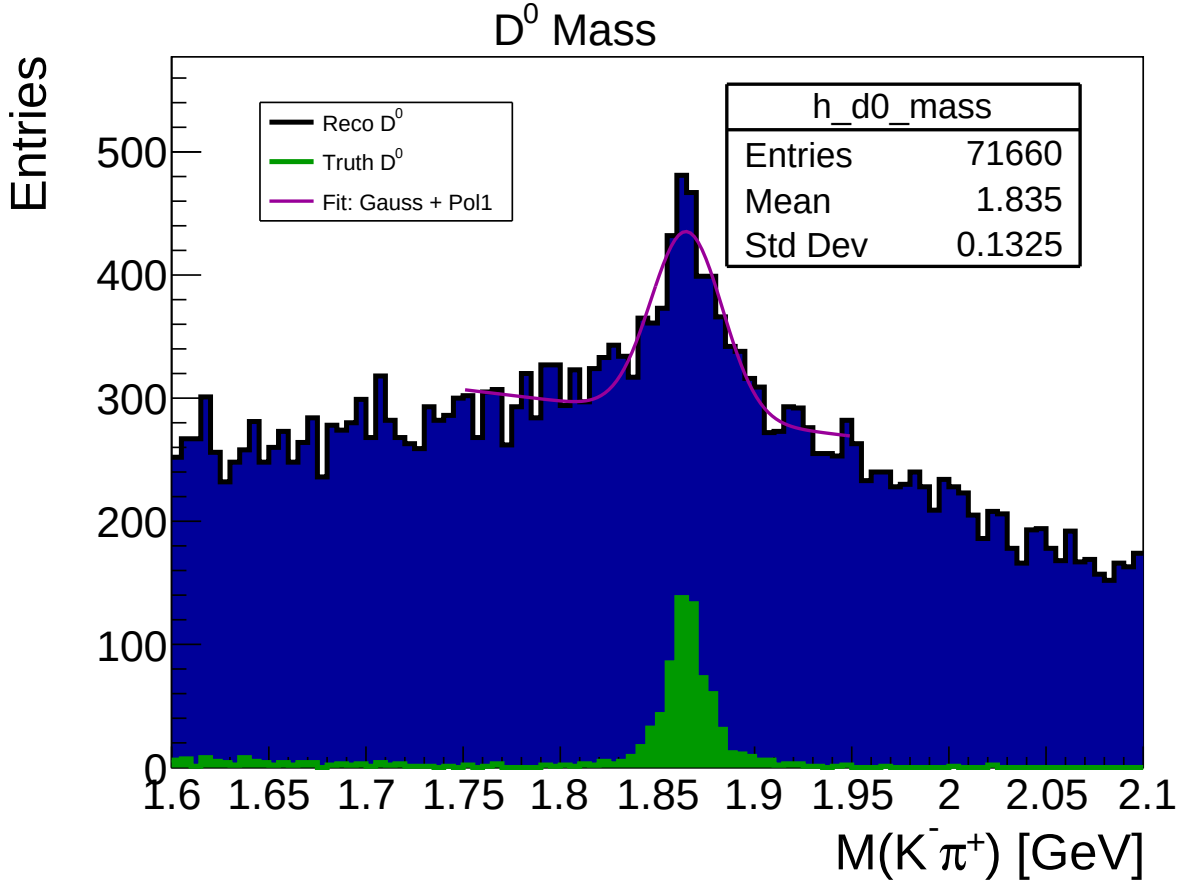






D^0 Event Statistics Summary

Decay Channel	DIS Events	Generated D^0	Reconstructed D^0
$K^-\pi^+$	71,900	2,007	1,200



The fitting procedure for asymmetry extraction is still under optimization.

Injecting Asymmetries via Spin-Dependent Weights

Procedure for Toy Model Asymmetry

- Assign random spin state (up or down) to each event
- Apply spin-dependent weight:

$$\text{Spin Up:} \quad w = 1 + A \cdot \cos(\phi_{\text{true}})$$

$$\text{Spin Down:} \quad w = 1 + A \cdot \cos(\phi_{\text{true}} + \pi)$$

- Fill histograms of reconstructed azimuthal angle ϕ_{rec} with these weights
- Extract asymmetry as:

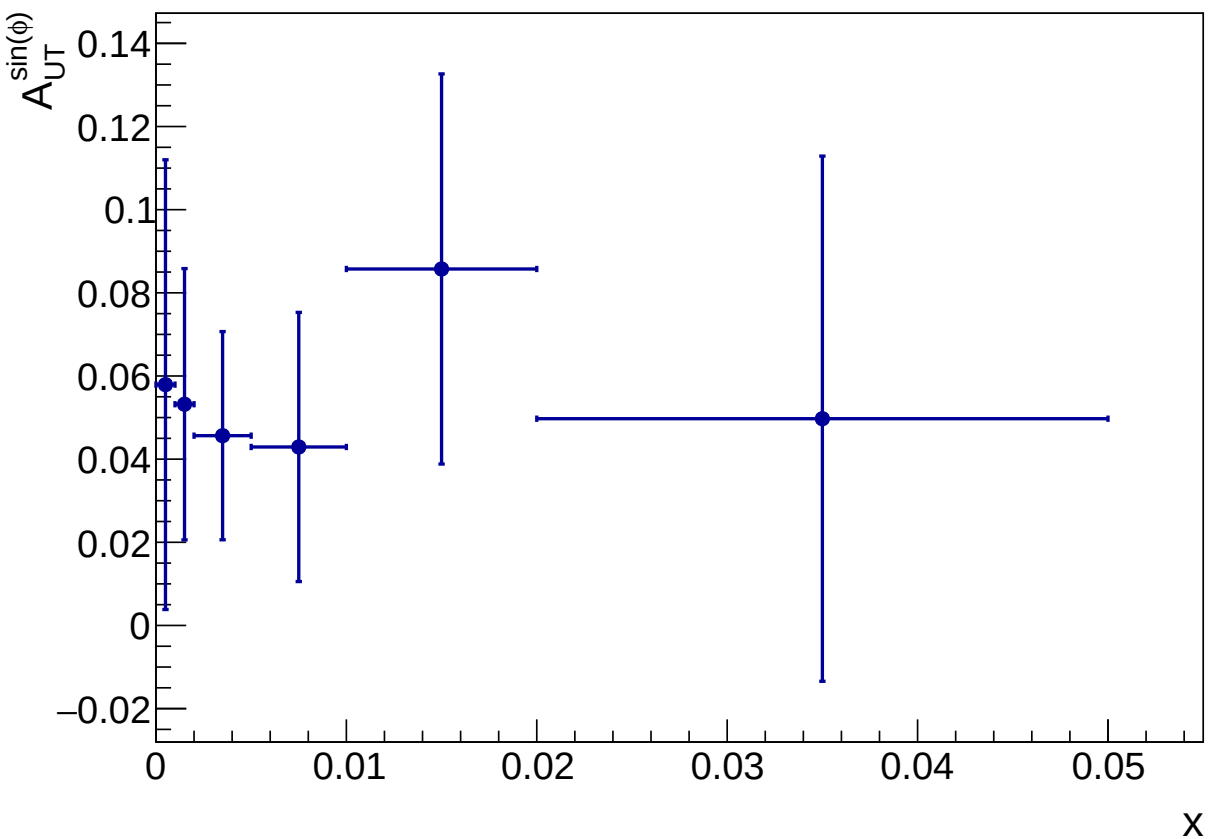
$$A_{\text{rec}}(\phi) = \frac{N^{\uparrow}(\phi) - N^{\downarrow}(\phi)}{N^{\uparrow}(\phi) + N^{\downarrow}(\phi)}$$

- Fit the result with a cosine to check reconstruction performance

Injected Asymmetry in x Bins

Procedure

A constant asymmetry amplitude $A = 0.05$ was introduced in all events



Next Steps

1. Identify potential sources of misidentification
2. Improve D0 Mass fit procedure
3. Finalize DIS selection
4. Introduce realistic parameterizations for asymmetry weighting