Nuclear Deep Inelastic Scattering Kinematics Reconstruction

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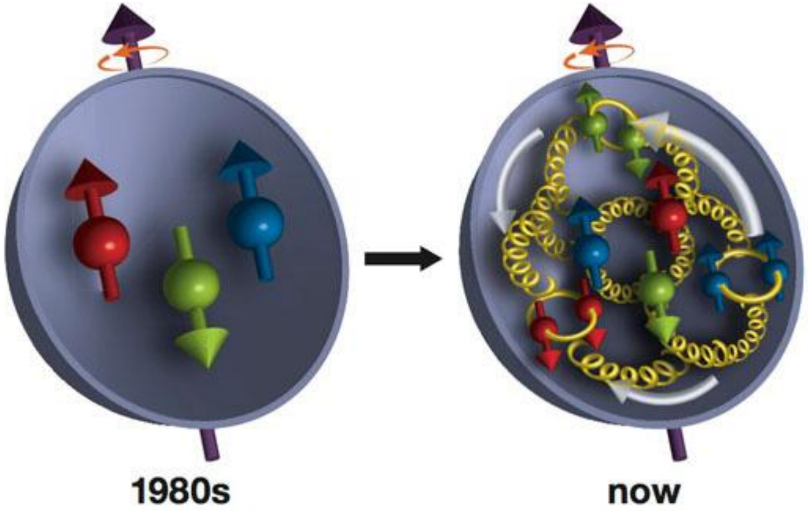
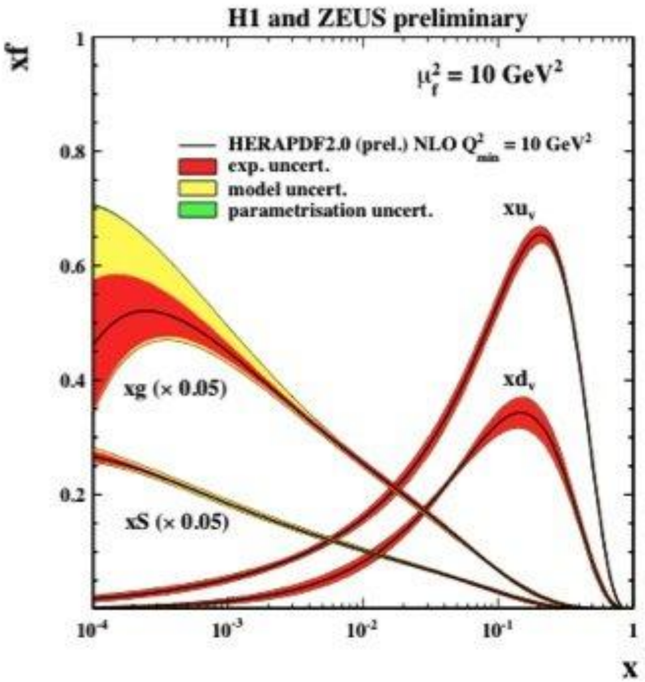
Motivation

- Goals of EIC: Proton Spin Problem, explore gluon saturation, etc.





Motivation

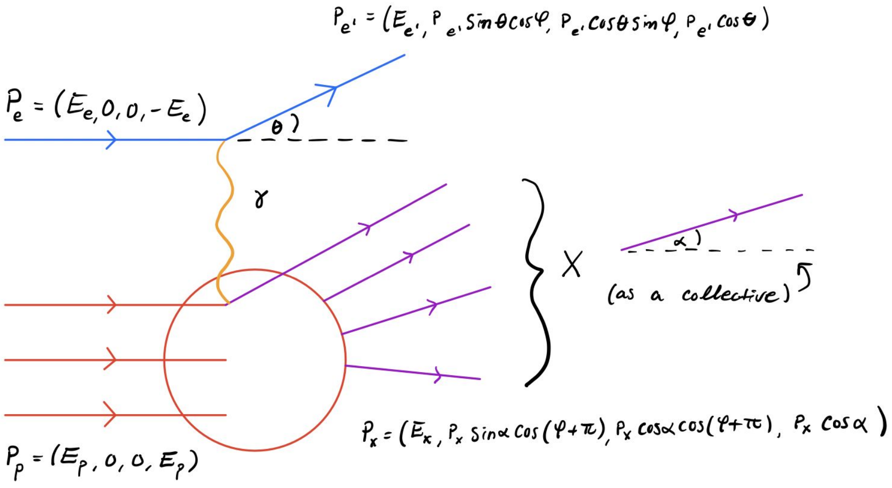
- In order to study these problems, we need to extract Parton Distribution Functions [F_1, F_2] (PDFs), they give a window into the protons structure.

$$\frac{d^2\sigma}{d\Omega dE'} = \frac{4\alpha^2 E'^2}{Q^4}\left[2\frac{F_1(x_B, Q^2)}{M}\sin^2\frac{\theta_e}{2} + \frac{F_2(x_B, Q^2)}{\nu}\cos^2\frac{\theta_e}{2}\right]$$

- PDFs are further related to DIS kinematic variables, x and Q^2; variables that give you information about the scattering.

Motivation

- In order to extract PDF's accurately, we need to be able to reconstruct DIS kinematics well.
- Studies relating to DIS reconstruction have been done at HERA for e-p scattering, but not for heavier nuclei.



(measure of the energy of virtual photon)

$$Q^2 = -q^2 = -(P_e - P_{e'})^2$$

$$x = \frac{Q^2}{2P_p \cdot q}$$

(measure of the energy of virtual photon)

Question

- How well can we reconstruct DIS kinematics for heavier nuclei?

How do we Reconstruct?

3 Different Methods: Scattered Electron, Jacquet-Blondel, and Double-Angle Methods.

Scattered Electron

$$y_e = 1 - \frac{\Sigma_e}{2E_e}$$

$$Q_e^2 = \frac{p_{t,e}^2}{1 - y_e},$$

Jacquet-Blondel

$$y_h = \frac{\Sigma_h}{2E_e}$$

$$Q_h^2 = \frac{p_{t,h}^2}{1 - y_h},$$

Double-Angle

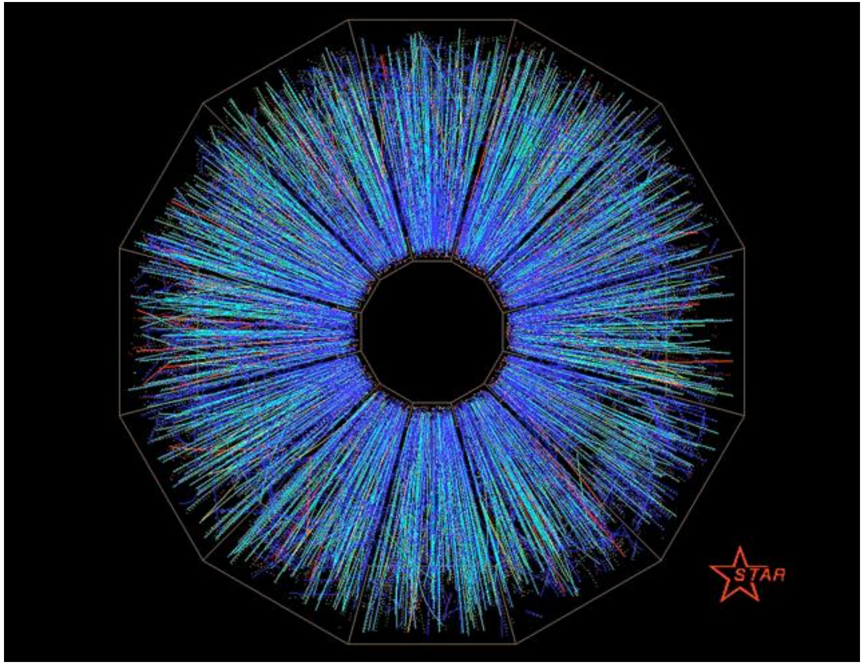
$$y_{DA} = \frac{\tan(\theta_h/2)}{\tan(\theta_e/2) + \tan(\theta_h/2)}$$

$$Q_{DA}^2 = 4E_e^2 \cdot \frac{\cot(\theta_e/2)}{\tan(\theta_e/2) + \tan(\theta_h/2)}.$$

$$\Sigma_h = \sum_i (E_i - p_{z,i})$$

Why are there 3 ways?

- Every collision's set of final state particles is different.

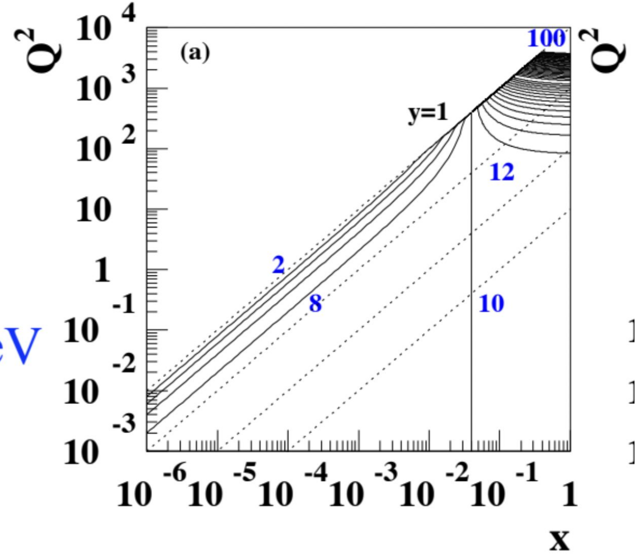


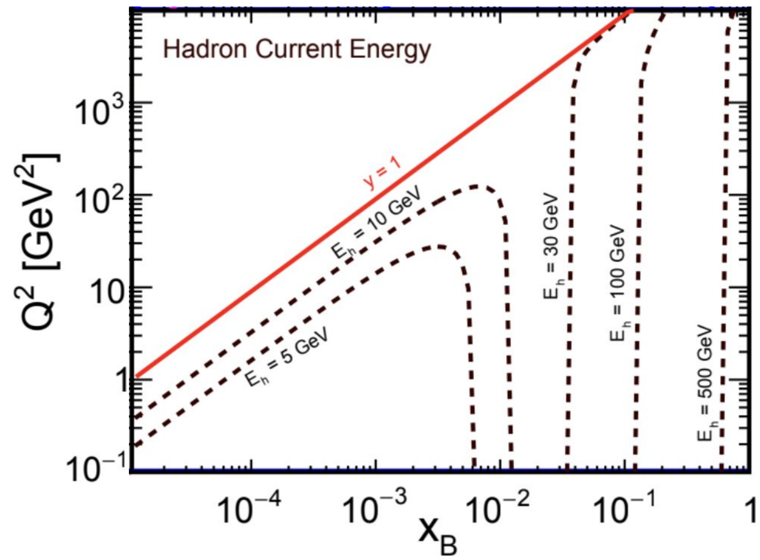
Why are there 3 ways?

- Depends on where you are in Q^2-x phase space!

Fixed E'_e

2GeV steps:
2GeV-100GeV



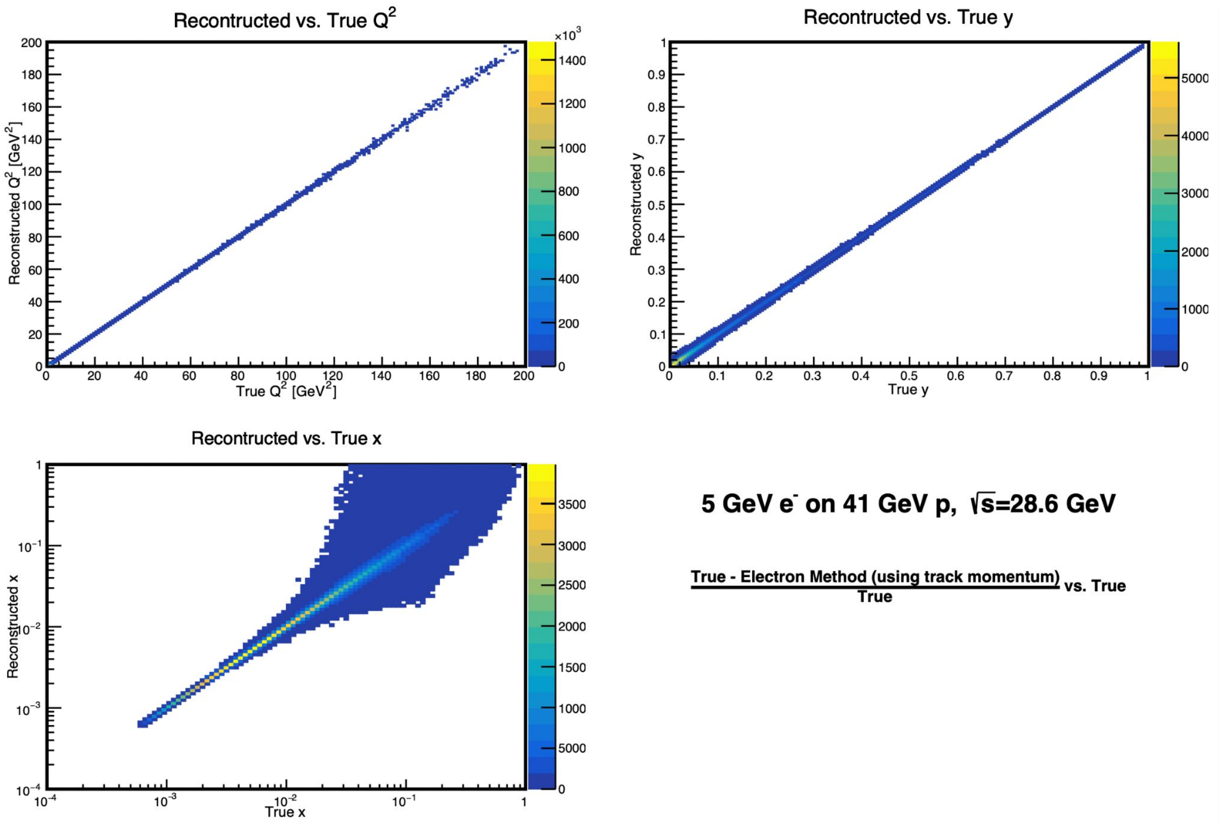


How do we conduct this study?

- Using pythia and BeAGLE
- Pythia is an ep generator and will cover our analysis with electron-proton scattering
- BeAGLE allows us to simulate electron-nucleus collisions, we will be looking at 3 nuclei: Deuterium, Carbon, and Gold.
- Apply detector resolution effects via. EICSmear

How do we measure the effectiveness of each method?

- Analyzing the resolutions of each reconstructed DIS variable for all three methods. (difference from true simulated value)

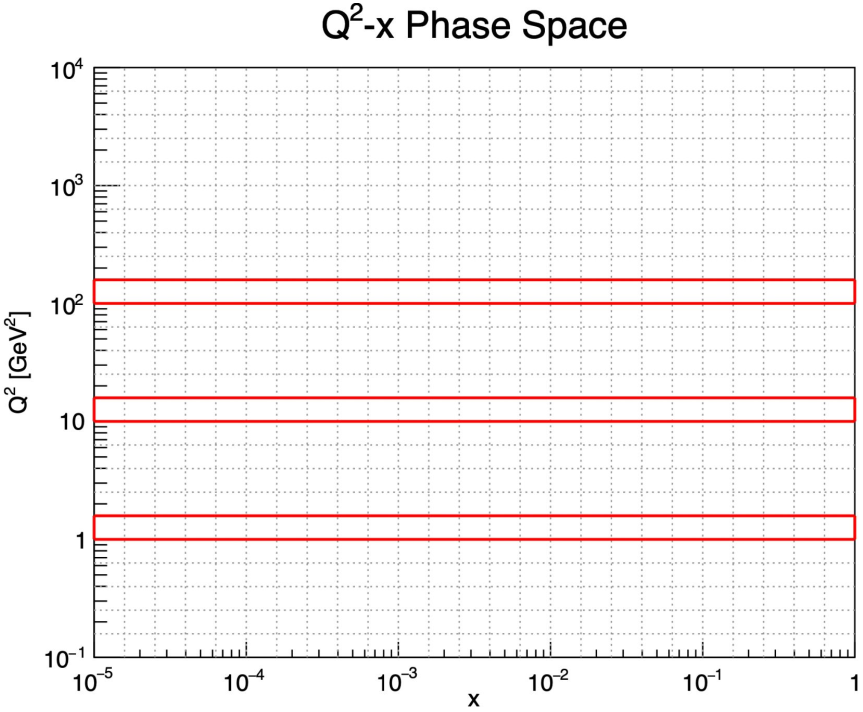


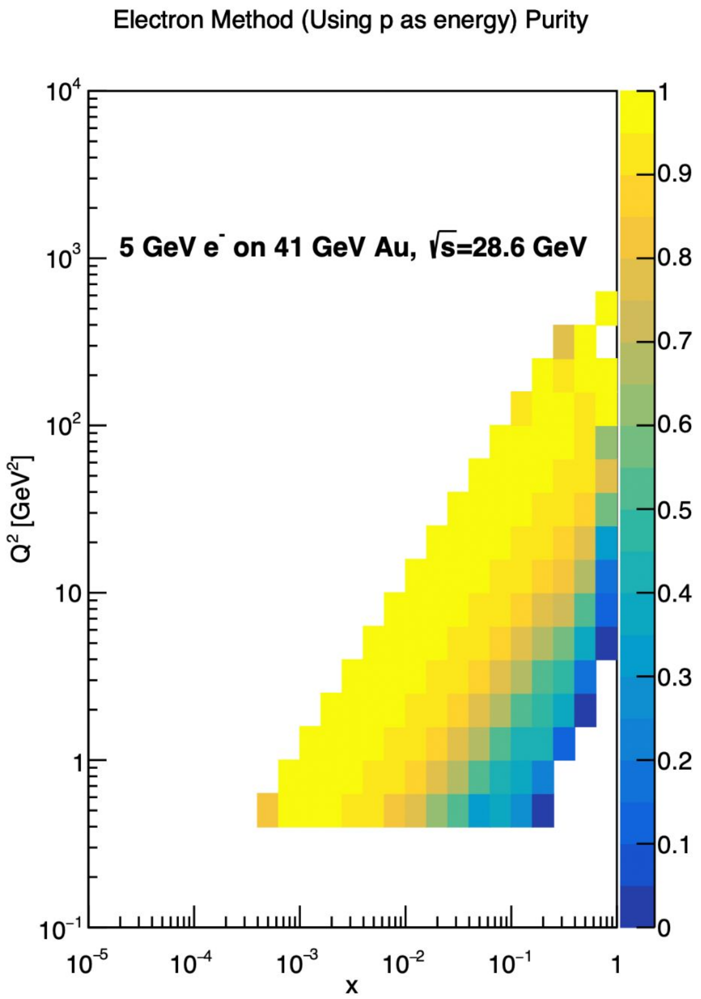
How do we measure the effectiveness of each method?

- Analyze bin migration of each method via purity and stability plots

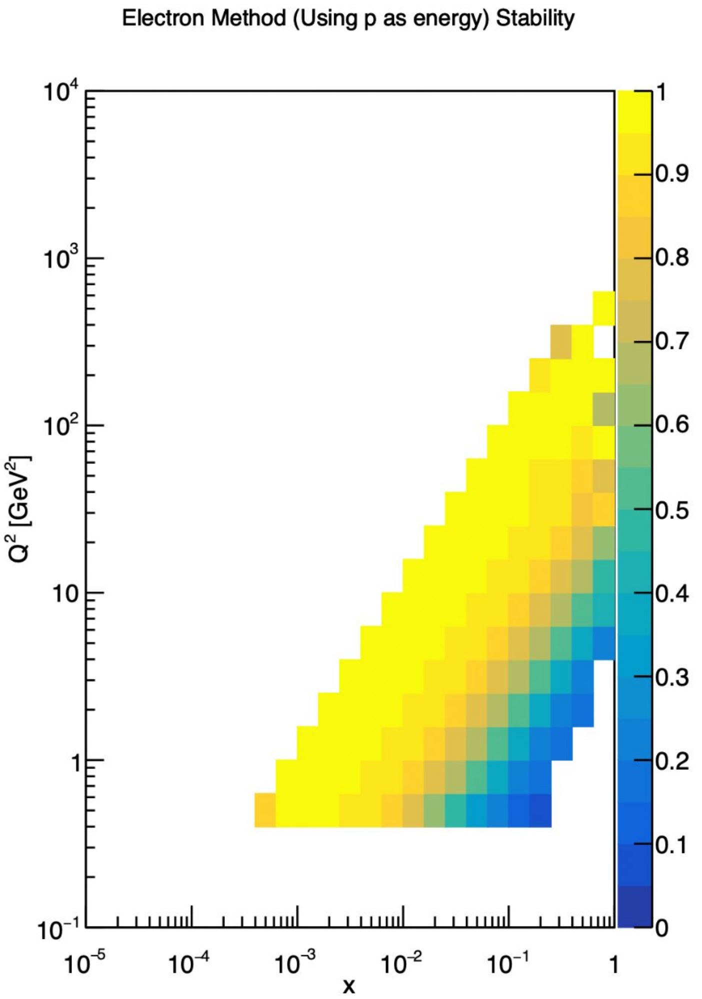
$$P(i) = N_{gen+rec}(i)/N_{rec}(i)$$

$$S(i) = N_{gen+rec}(i)/N_{gen}(i)$$



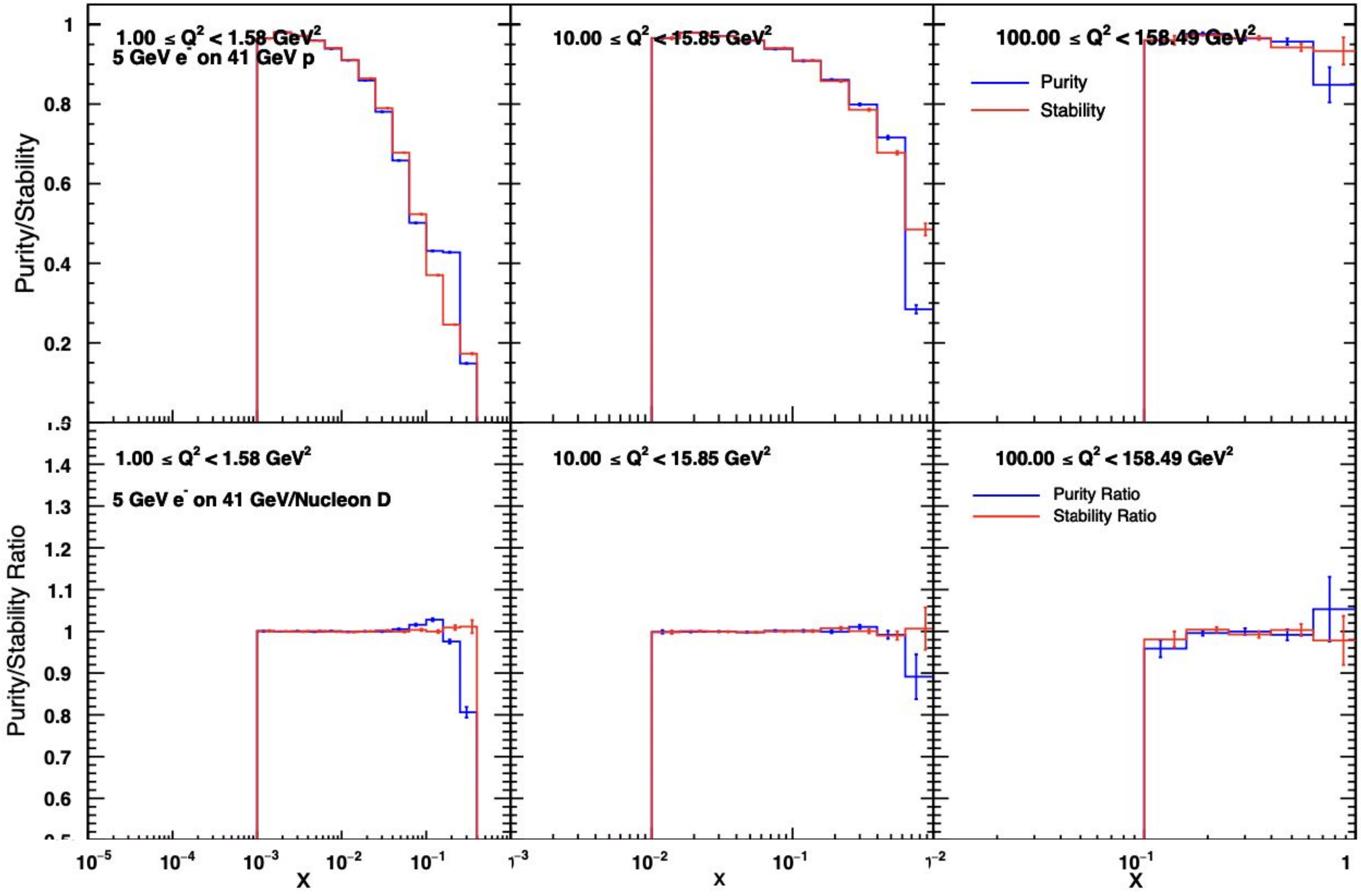


Electron Method (Using p as energy) Purity
5 GeV e- on 41 GeV Au, √s=28.6 GeV
Q² [GeV²]
x

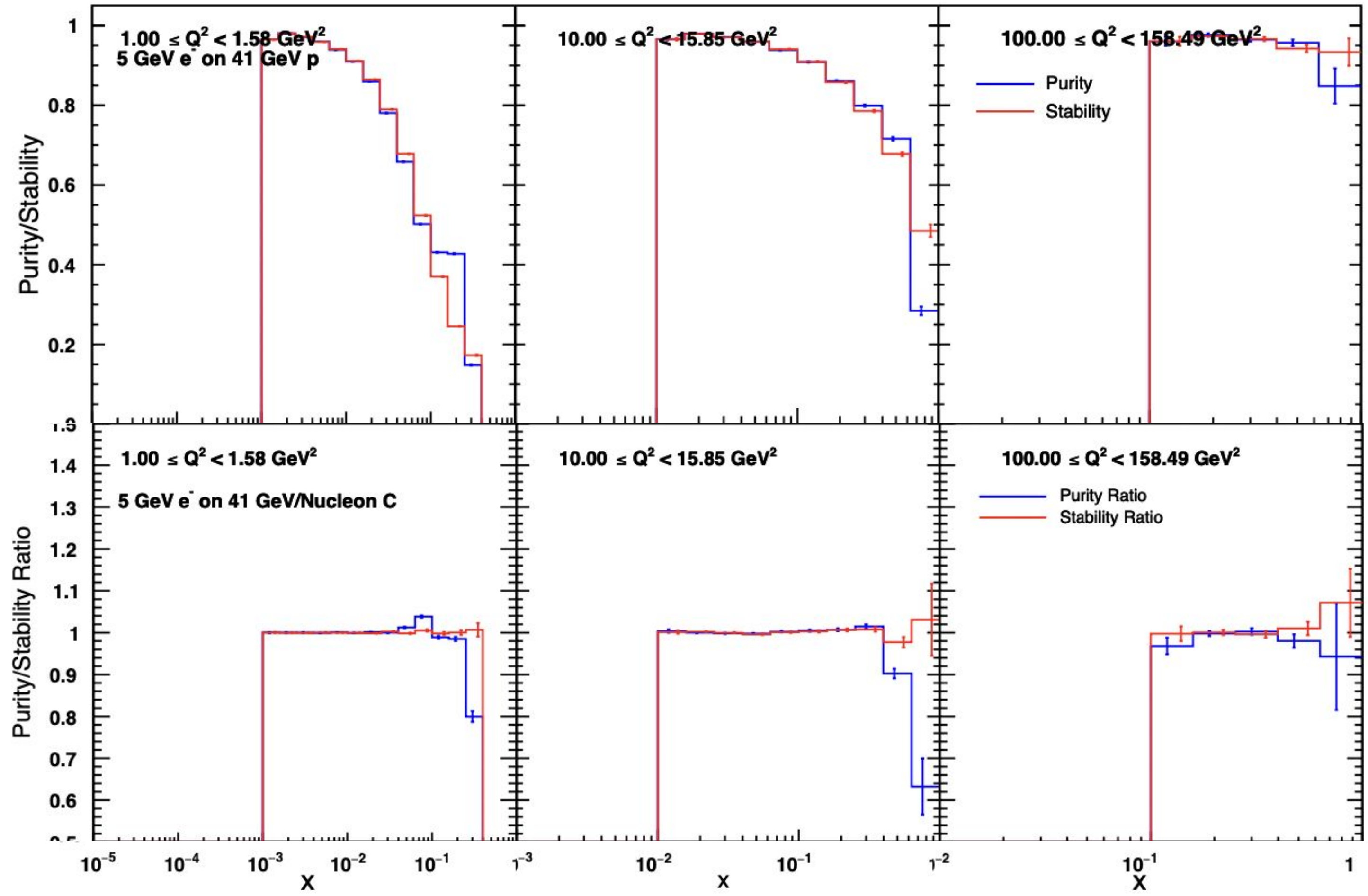


Electron Method (Using p as energy) Stability
Q² [GeV²]
x

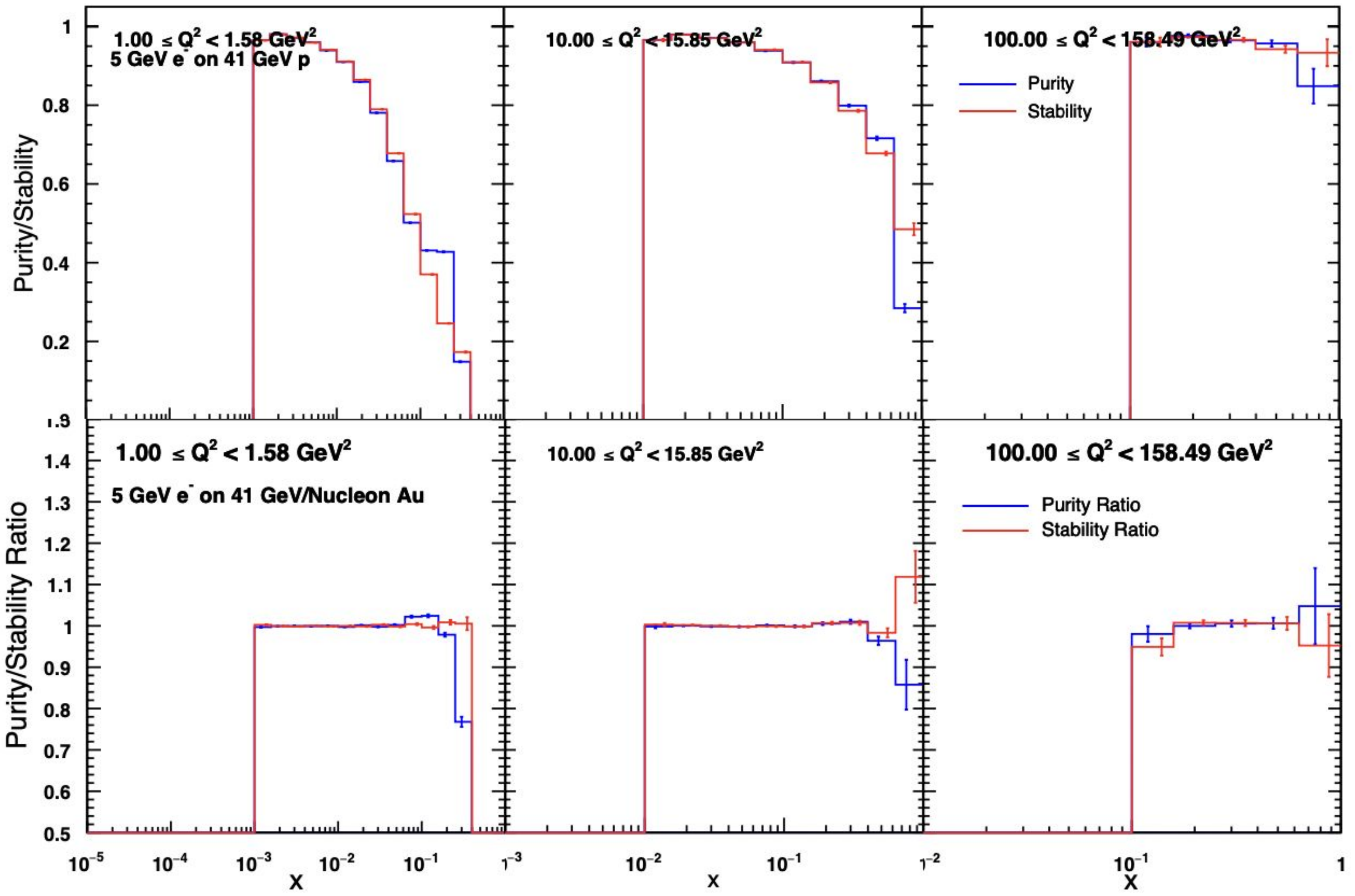
Electron Method (Using Track Momentum)



Electron Method (Using Track Momentum)



Electron Method (Using Track Momentum)



DA Method (Summing Over Hadrons Scattering off Nucleon)