Neutral Current Inclusive measurement in unpolarized ep collisions

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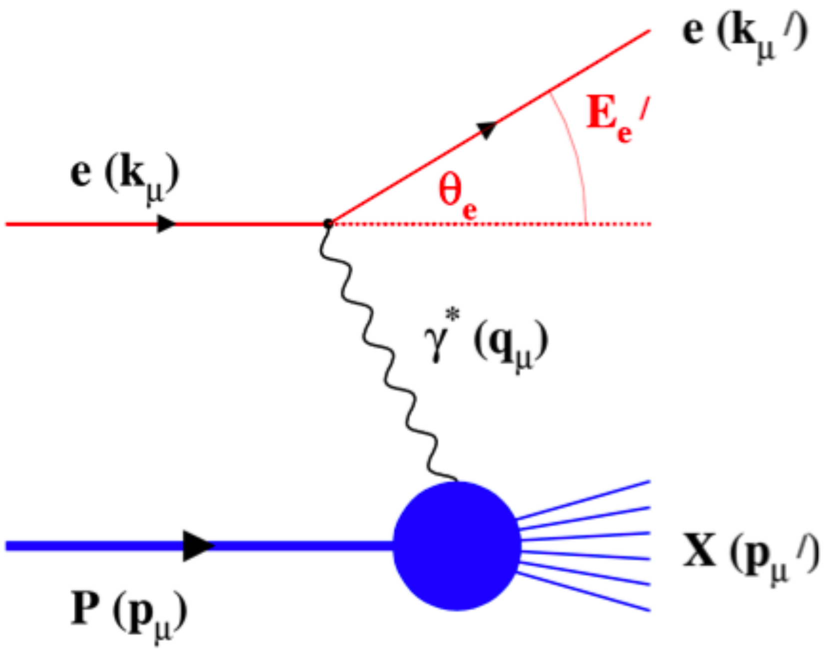
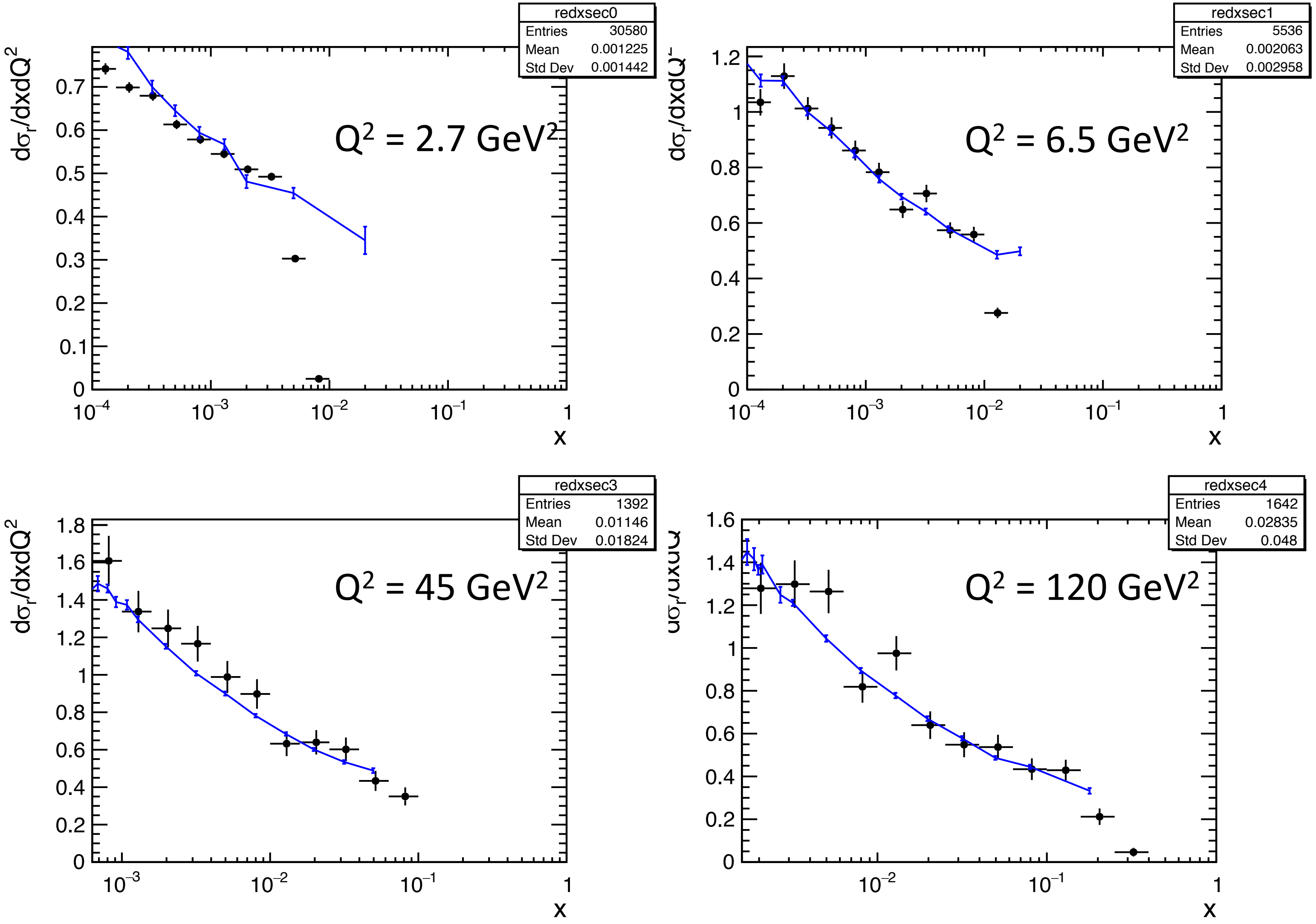
2nd EIC YR workshop

Outline

1. Measurement of reduced cross section at HERA energy, reproducing HERA data by EIC simulation.
2. EIC NC data at highest energy can reduce Proton PDFs uncertainty band.
3. Lepton Identification study.
4. Smear effect on outgoing electron.



Reproduce HERA data by Djangoh

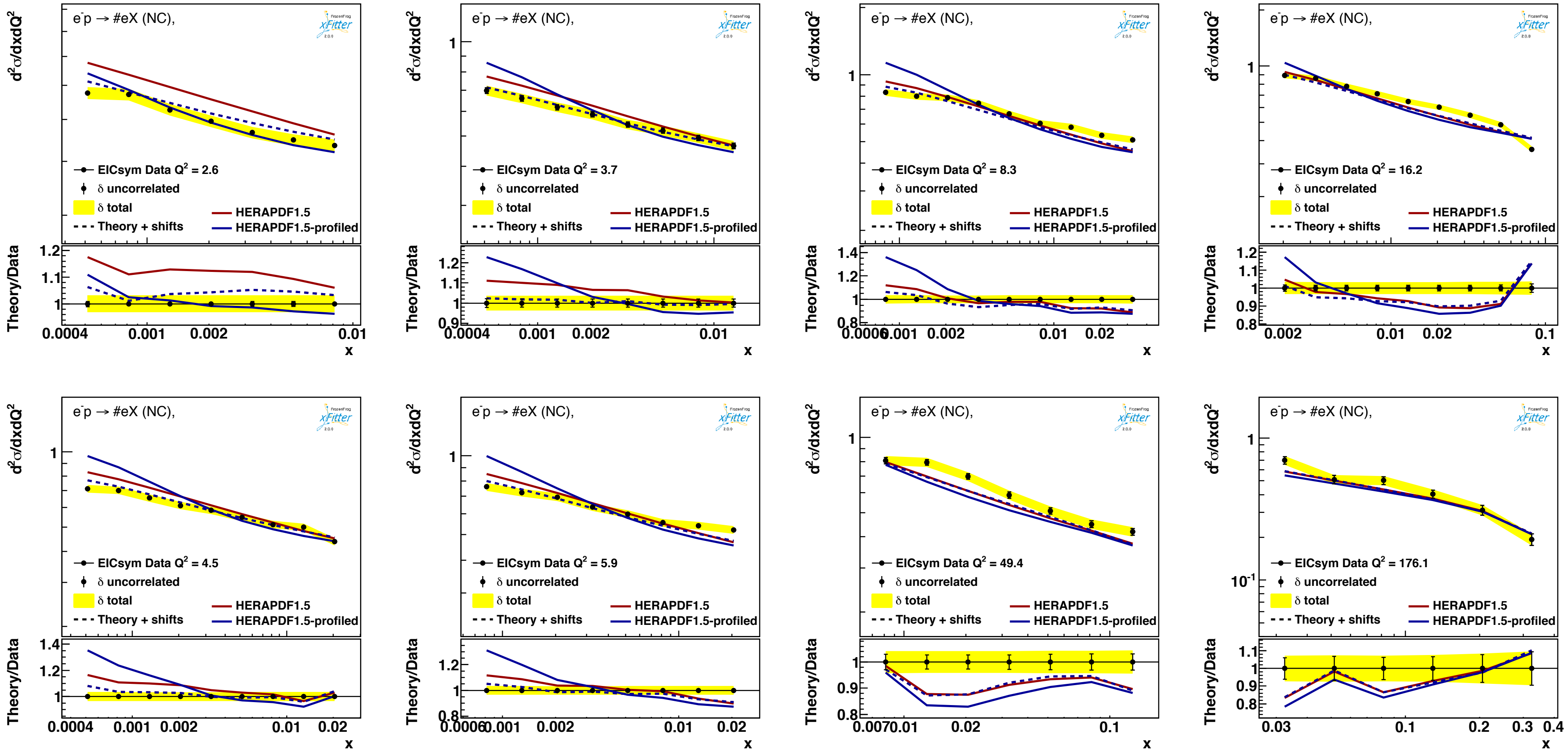


HERA data

EIC Djangoh

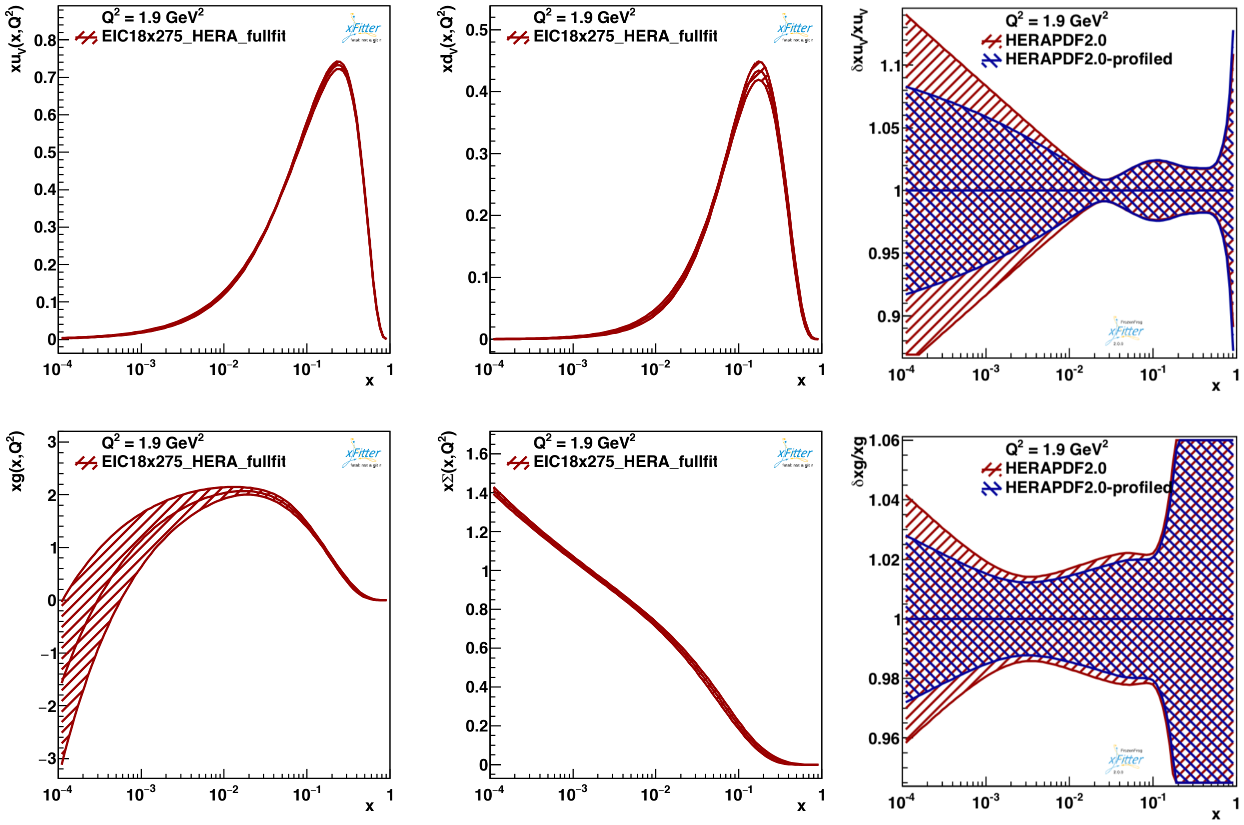
Reduced cross sections at EIC

ep NC events with DJANGOH for 18 GeV x 275 GeV



Impact of NC@EIC on PDFs: very preliminary

5 GeV x 100 GeV 10 GeV x 100 GeV 18 GeV x 275 GeV



$$\sigma_{r,NC} = F_2(x,Q^2) - \frac{y^2}{[1+(1-y)^2]} * F_L(x,Q^2)$$

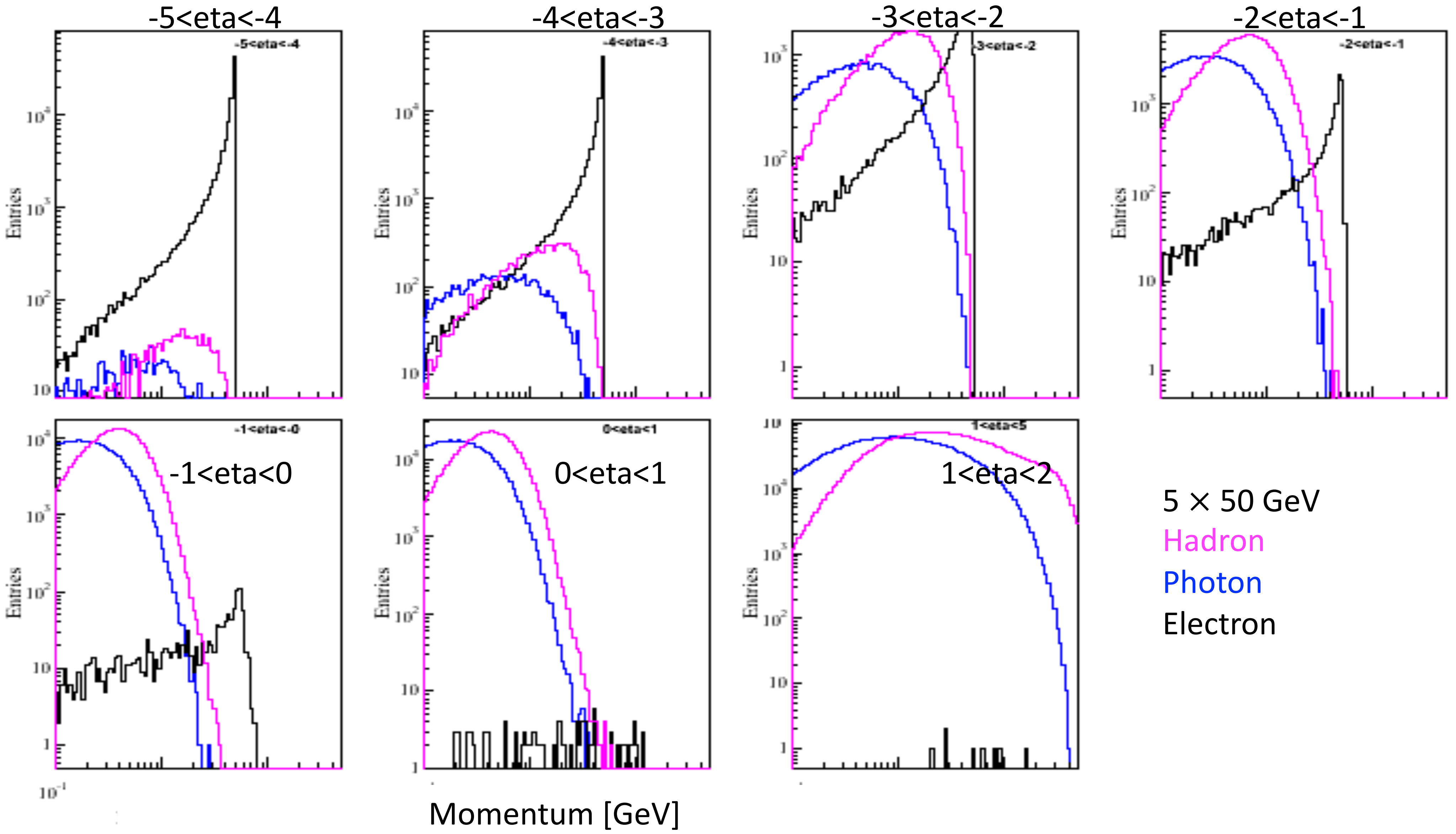
$F_2(x,Q^2) \rightarrow q(x,Q^2) - \bar{q}(x,Q^2)$

$F_L(x,Q^2) \rightarrow g(x,Q^2)$

First full fit results from EIC NC in combination with HERA data.

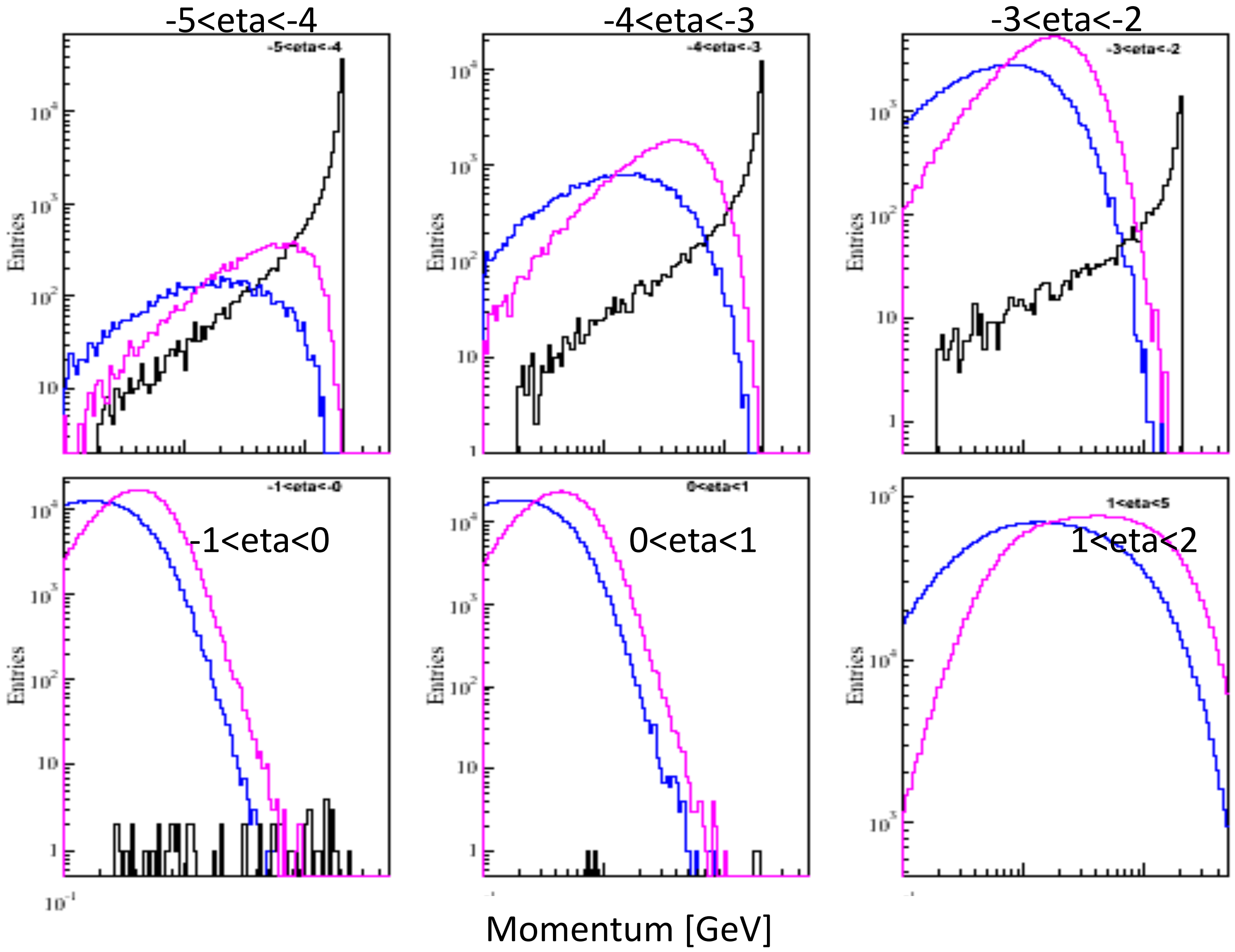
To separate the structure function F_L and F_2 for a given x and Q^2, one needs to measure cross section for different y and hence different collision energies.

Lepton PID (1)



-5<eta<-4
-4<eta<-3
-3<eta<-2
-2<eta<-1
-1<eta<0
0<eta<1
1<eta<2
Entries
Momentum [GeV]
5 × 50 GeV
Hadron
Photon
Electron

Lepton PID (2)



20 × 250 GeV
Hadron
Photon
Electron

- **Lepton PID: hadron and photon suppression are required to ensure good lepton identification.**

Kinematics reconstruction

$$Q^2 = -q^2 = -(k_\mu - k'_\mu)^2$$

$$Q^2 = 2E_e E'_e(1-\cos\Theta_{e'})$$

Measure of resolution power

$$y = \frac{pq}{pk} = 1 - \frac{E'_e}{E_e}\cos^2\left(\frac{\theta'_e}{2}\right)$$

Measure of inelasticity

$$x = \frac{Q^2}{2pq} = \frac{Q^2}{sy}$$

Measure of momentum fraction of struck quark

https://wiki.bnl.gov/eic/index.php/DIS_Kinematics

$$\frac{\delta x_e}{x_e} = \frac{1}{y_e}\frac{\delta E'_e}{E_e} \oplus \left[\frac{x_e}{E_e/E_p} - 1\right]\tan\frac{\theta'_e}{2}\delta\theta'_e$$

$$\frac{\delta y_e}{y_e} = \left(1-\frac{1}{y_e}\right)\frac{\delta E'_e}{E_e} \oplus \left[\frac{1}{y_e} - 1\right]\cot\frac{\theta'_e}{2}\delta\theta'_e$$

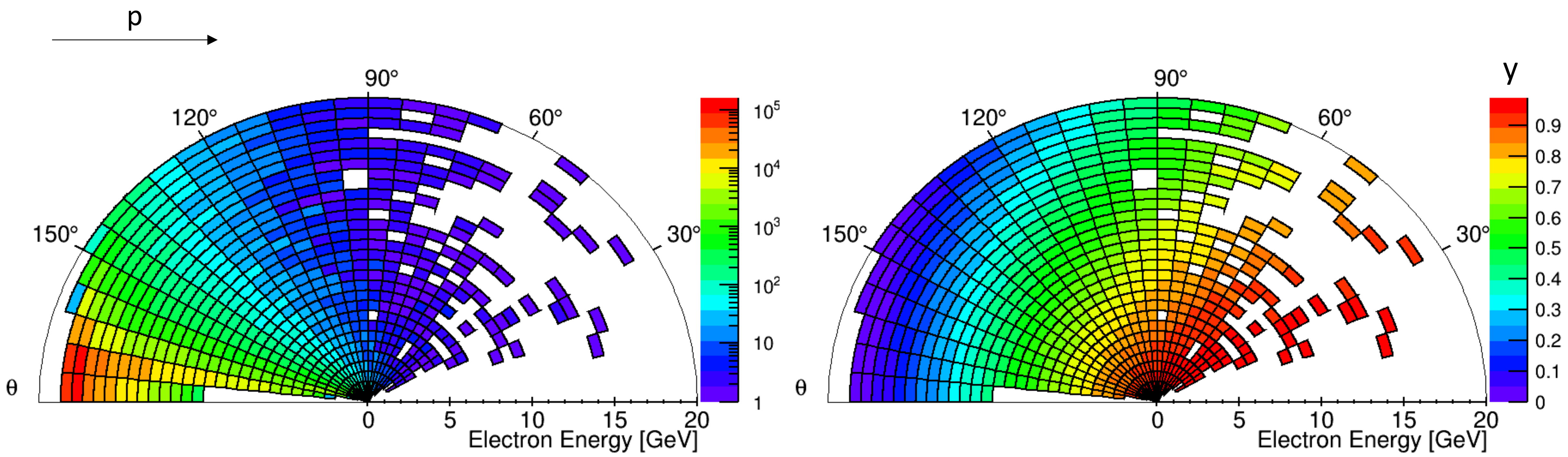
diverges for $y_e \to 0$ depends on E'_e

$$\frac{\delta Q^2_e}{Q^2_e} = \frac{\delta E'_e}{E_e} \oplus \tan\frac{\theta'_e}{2}\delta\theta'_e$$

diverges for $\theta'_e \to 180^o$ depends on E'_e and θ'_e

- **NC kinematics reconstruction: focus on energy and theta of the outgoing electrons.**
- **Resolution diverges when y is close to 0.**

Inelasticity requirement

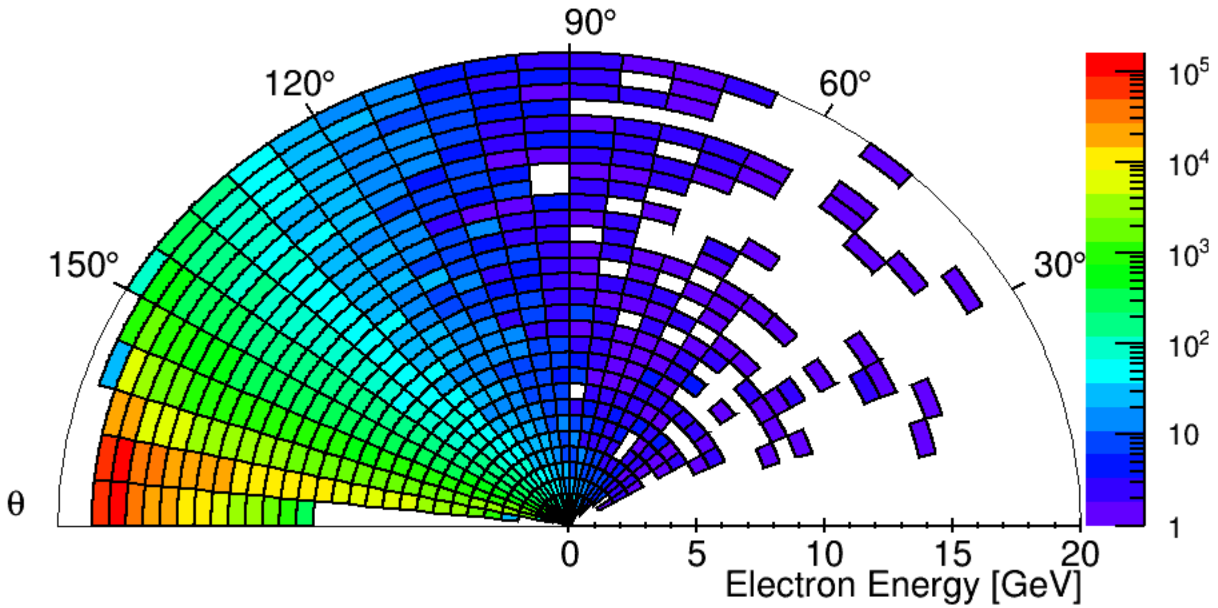


Outgoing electron hit map

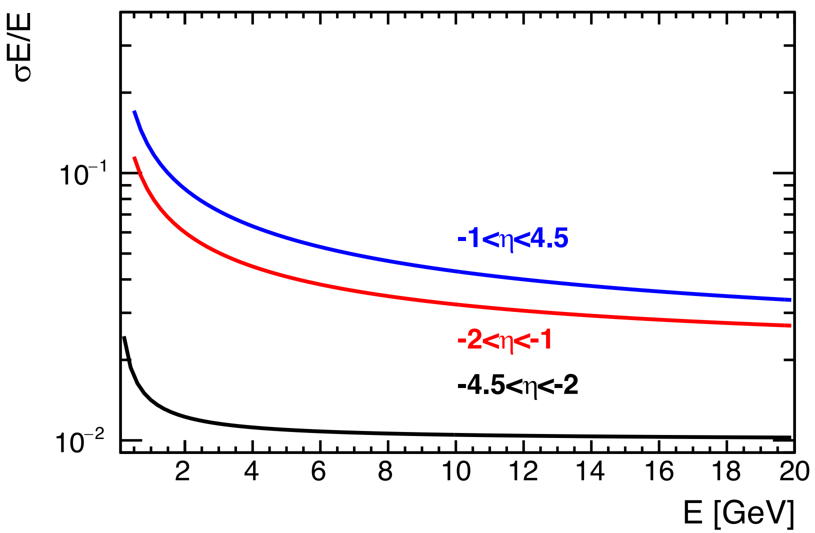
y distribution map on electron

- **Small y: electron energy is large and the outgoing direction is backward.**
- **Minimum y cut is required to ensure high resolution.**

EIC Smear

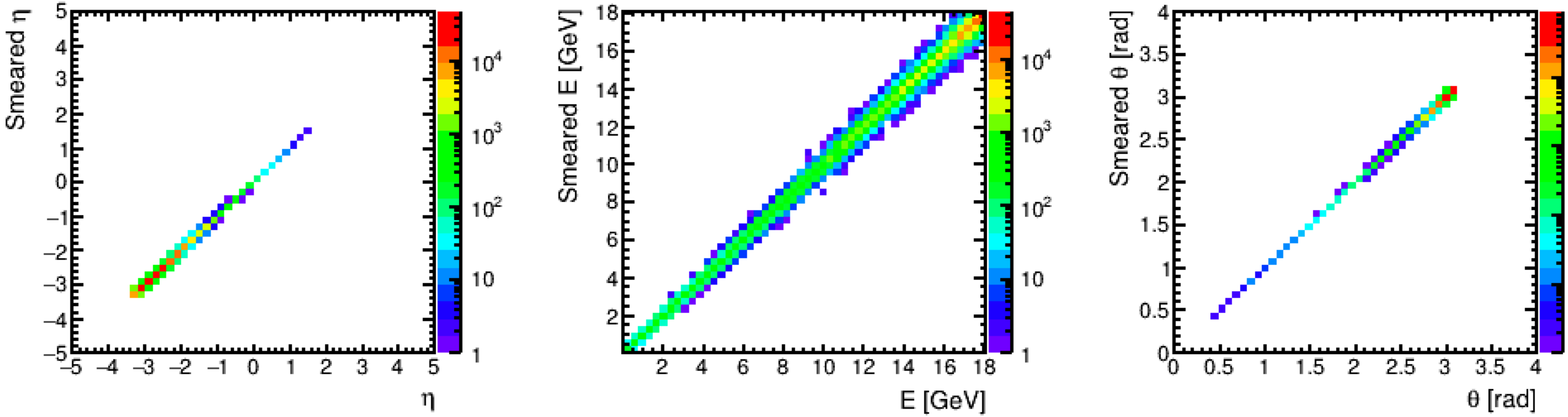


Outgoing electron hit map



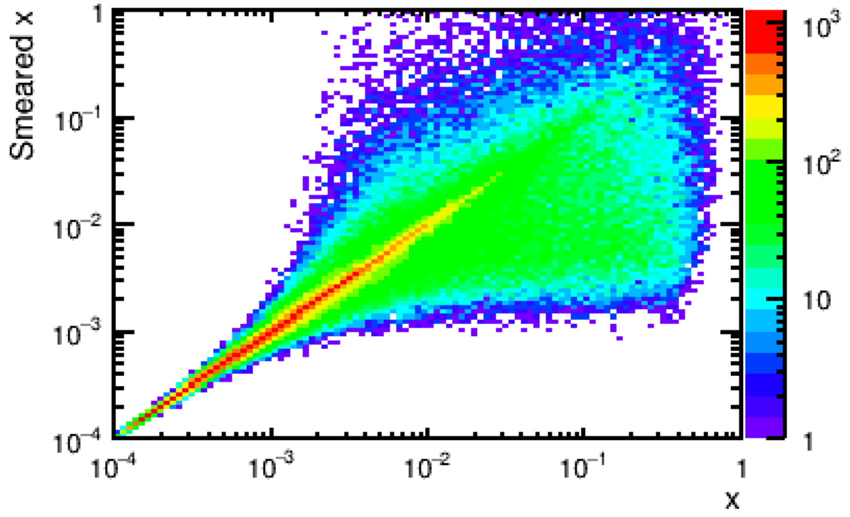
Total coverage of the handbook for emcal: -4.5 < eta < 4.5
Smear::Device SmearThetaEmcal(Smear::kTheta, "0.001");
EMcal:
eta = -4.5 – -2: sigma_E~sqrt(pow (0.01*E,2) + pow(0.01,2)*E)
eta = -2 – -1: sigma_E~ sqrt(pow (0.02*E,2) + pow(0.08,2)*E)
eta = -1 – 4.5: sigma_E~ sqrt(pow (0.02*E,2) + pow(0.12,2)*E)

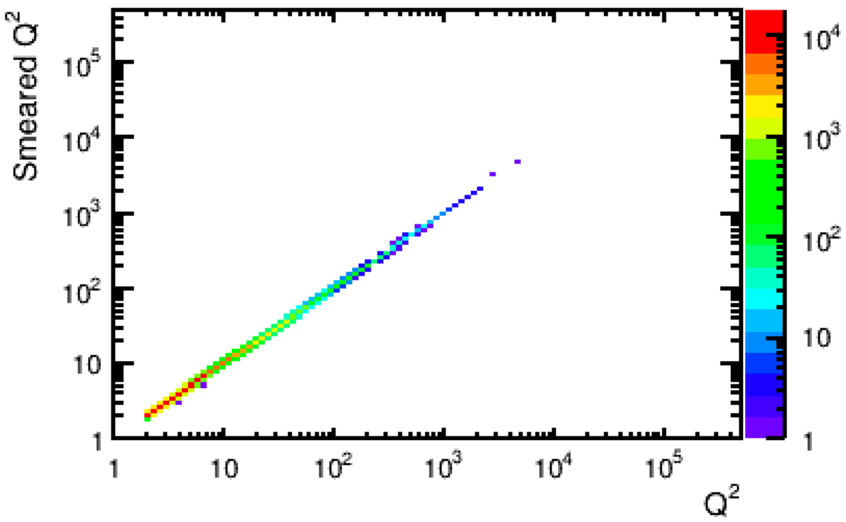
Smeared final electron kinematics



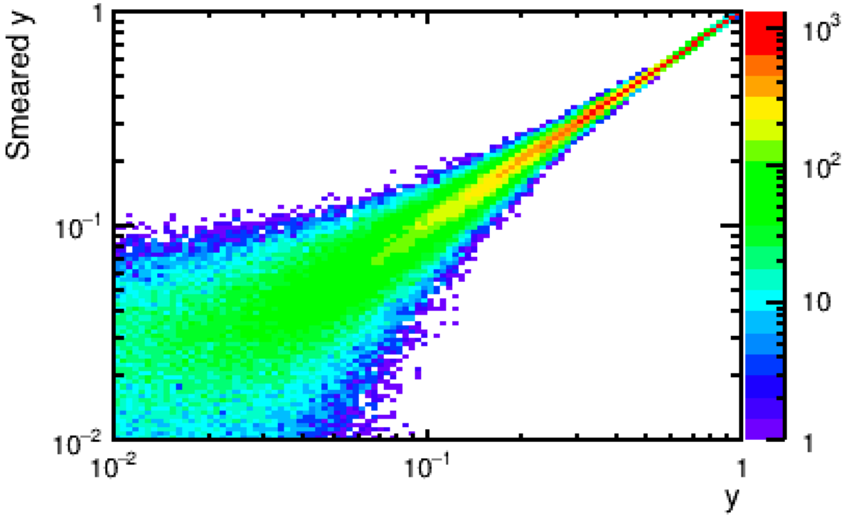
The current parameter set up in EIC smear handbook is very preliminary.

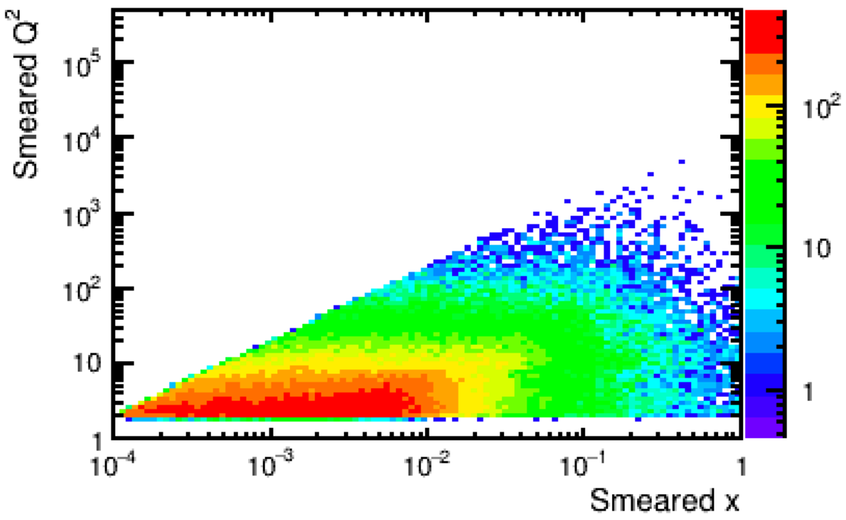
Smeared kinematics: Smeared Vs true level





Needs to be compared with true level phase space.





Summary

Neutral current channel: final state electrons

1. **EIC NC data at true level can improve PDFs constraint.**
2. **Low inelasticity events affect resolution, $y>0.01$.**
3. **Lepton PID is critical: the lepton needs to be identified with high purity from the hadron and photon samples.**
4. **EIC-smear study is on-going.**

Backup: Reproduce HERA data by Djangoh (2)