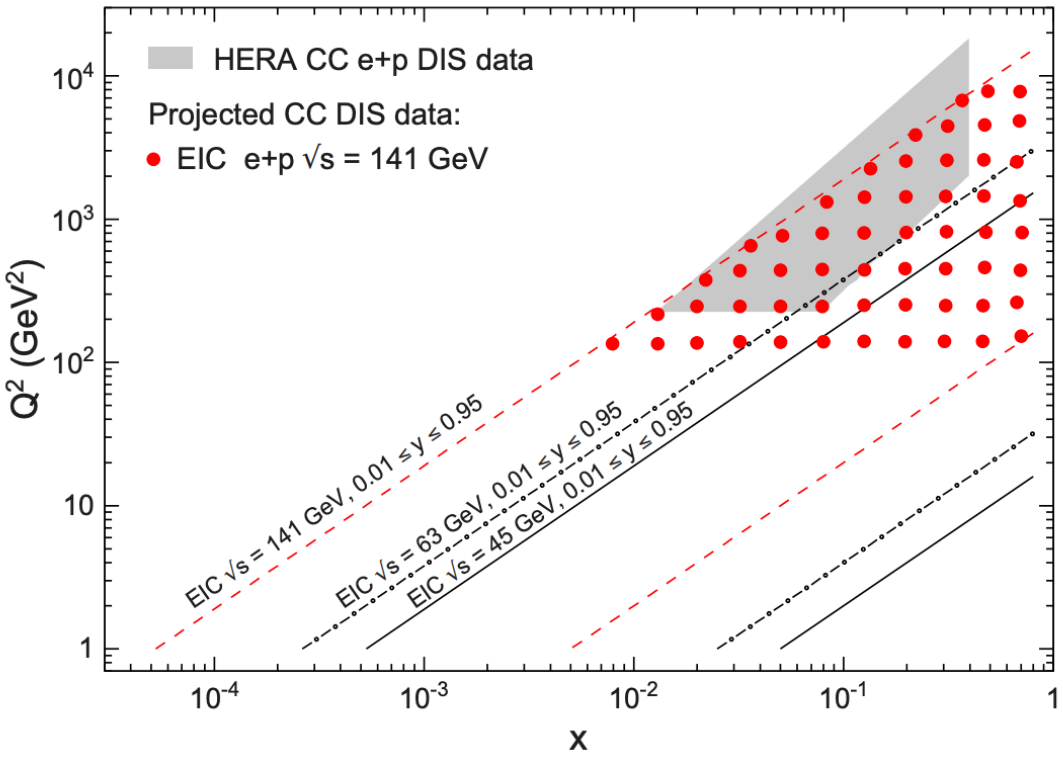
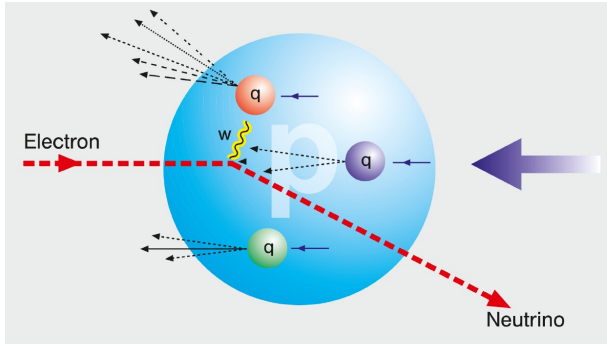
Update: Inclusive measurement in unpolarized ep collisions

Xiaoxuan Chu, 04/28/20

YR inclusive group

Charged Current Kinematics region at EIC





High energy is required in CC channel.

Data sample are simulated from Djangoh are 18x275 GeV

Kinematics:

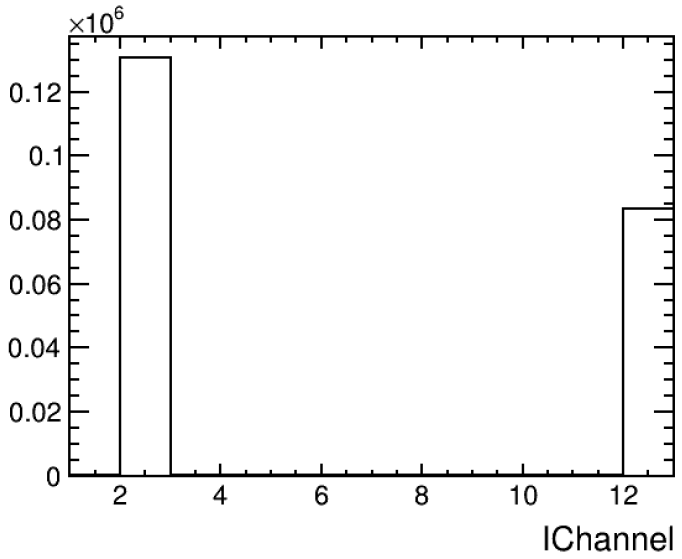
True level in hadronic scattering: trueQ2, trueY, trueX, are the kinematic variables of the event at the hard scattering vertex.

Radiative correction level, Q2, y, x. They are calculated from neutrino. Includes effects from radiative corrections. These are used in reconstructing measured reduced cross section to do impact study.

Reconstructed level: Q2 rec, y^{rec}, x^{rec}. Use Jacquet-Blondel method on hadronic final state to reconstruct.

Radiative correction impact

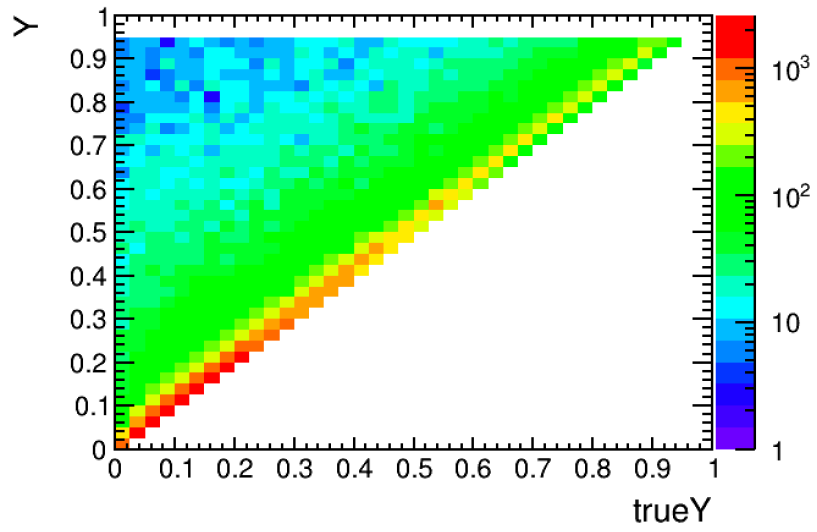
Kinematics: y



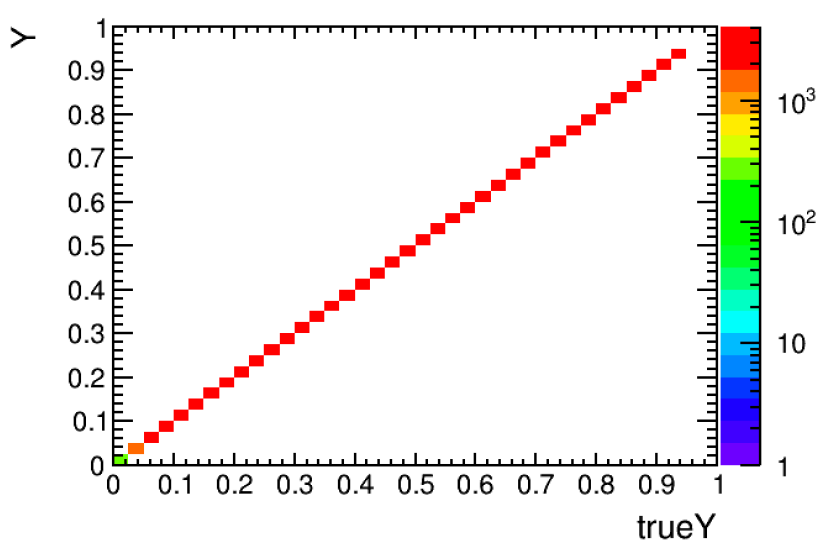
DJANGOH contains the Monte Carlo program HERACLES, which allows to take into account the complete one-loop electroweak radiative corrections and radiative scattering.

Ichannel = 2, non-radiative event
Ichannel = 12, radiative event

Ichannel = 12

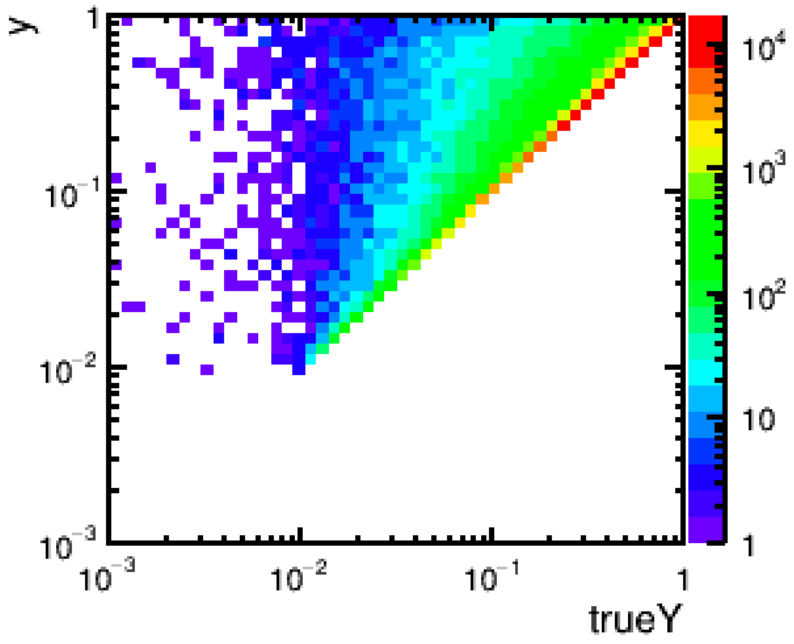


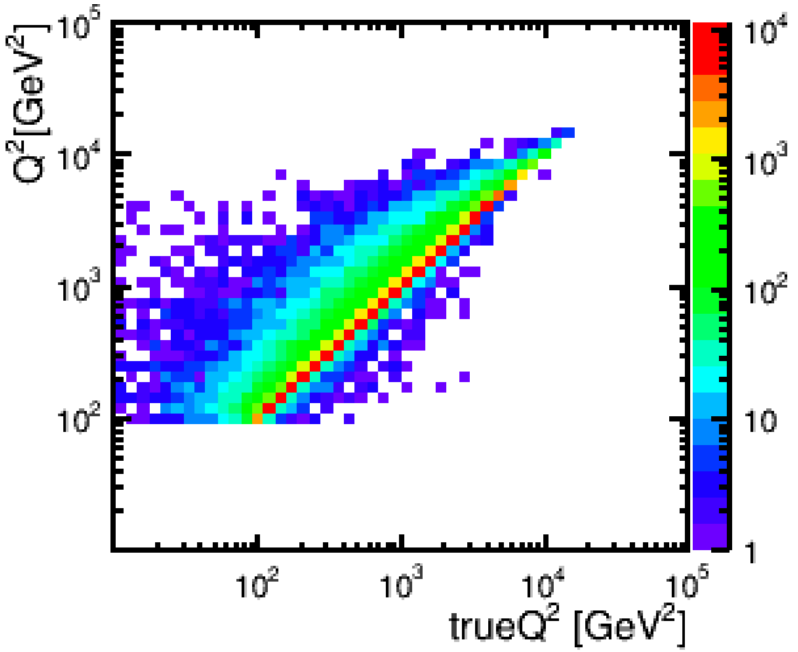
Ichannel = 2

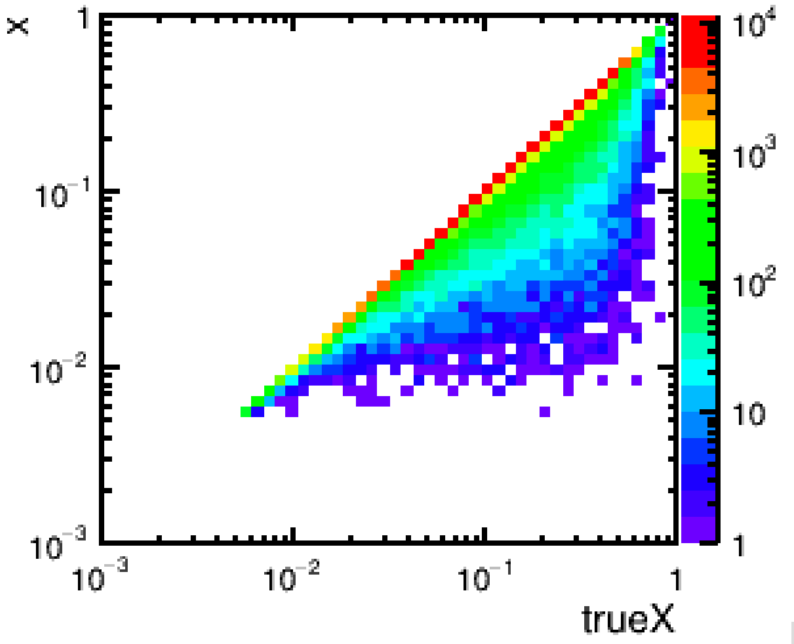


Kinematics with Rad Correction

Data sample : Int L = 10 fb-1, Kinematics settings: 0.01<y<0.95, 10^2 GeV^2 <Q^2<10^5 GeV^2







- At generator level, the input Q^2>100GeV^2 works on Q^2 level instead of trueQ^2 level, trueQ^2 can access lower Q^2
- Kinematics are smeared after including radiative corrections
- We will calculate reduced cross section on true level for impact study to make sure the cross section is as predicted.

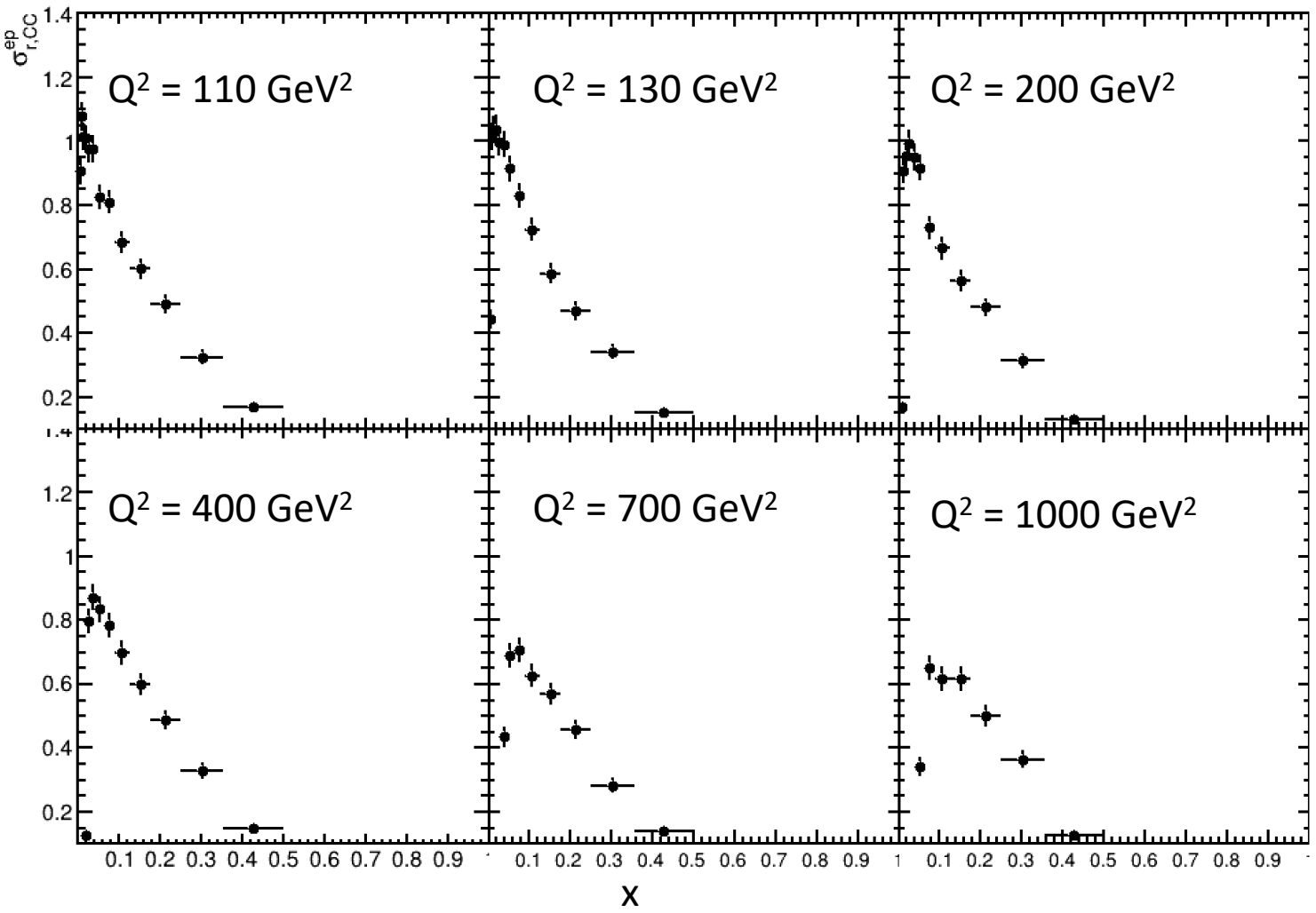
The reduced cross section for inclusive CC *ep* scattering

$$\sigma_{r,CC} = \frac{2\pi x_{Bj}}{G_F^2}\left[\frac{M_W^2+Q^2}{M_W^2}\right]^2 \frac{\mathrm{d}^2\sigma_{CC}}{\mathrm{d}x_{Bj}\mathrm{d}Q^2}$$

$G_F = 1.16 \times 10^{-5}\mathrm{GeV}^2$ and $M_W = 80.385$ GeV

Reconstruct Charged Current events cross section at true level

Int L = 10 fb-1, Kinematics settings: 0.01<y<0.95, 10^2 GeV^2 <Q^2<10^5 GeV^2



Reduced cross sections in different Q^2 bins.
Six example bins are listed here.

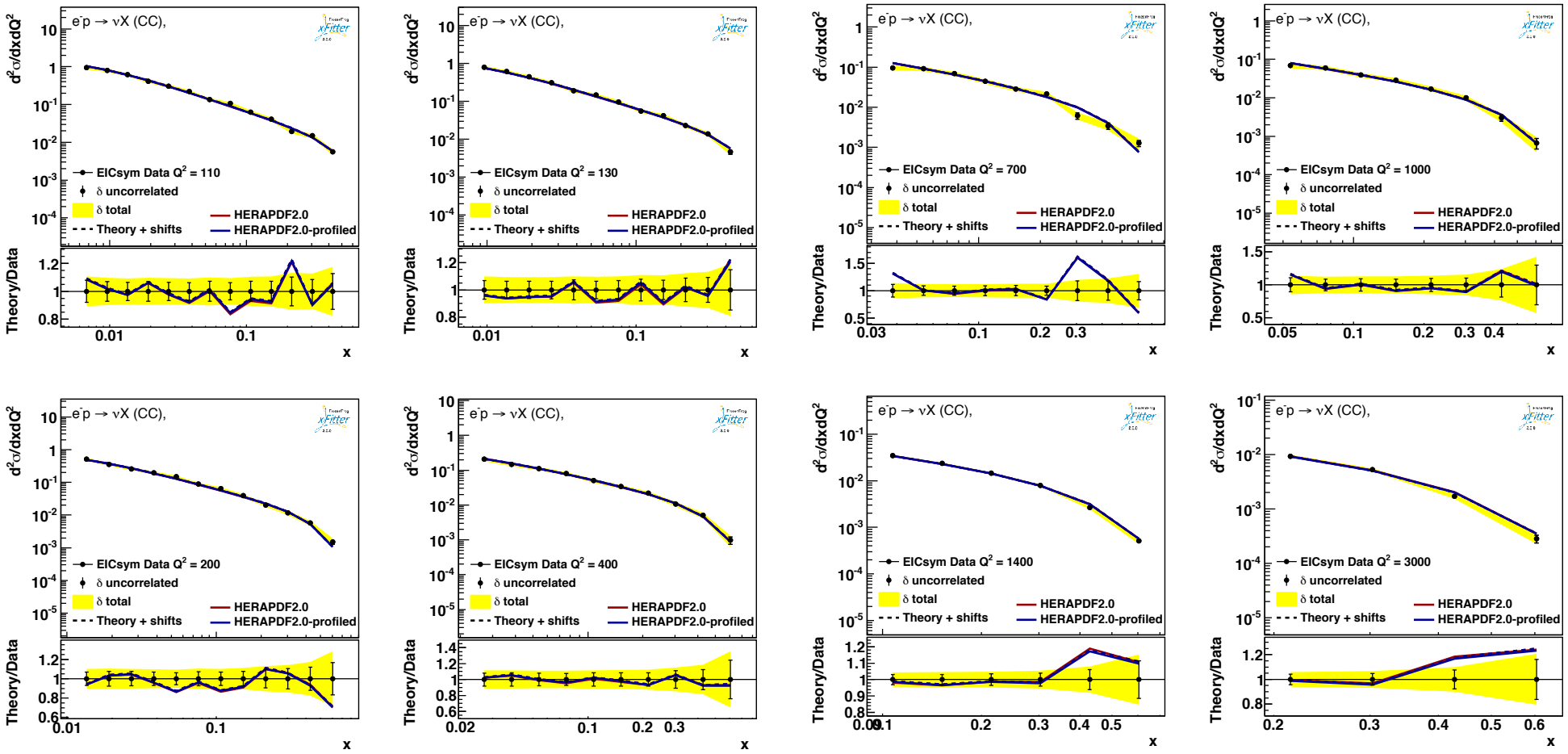
Prepare input table for global fit:
Q^2, x, red sigma, stat error, sys error

Sys error = 0.03*red sigma, 0.03 is a rough estimation from HERA data.

The table will exclude data points which are out of the phase-space boundary:
At fixed Q^2 bin, x_{min}: $Q2/(s*y_{max})$,
x_{max}: $Q2/(s*y_{min})$, $s = 4E_eE_p$

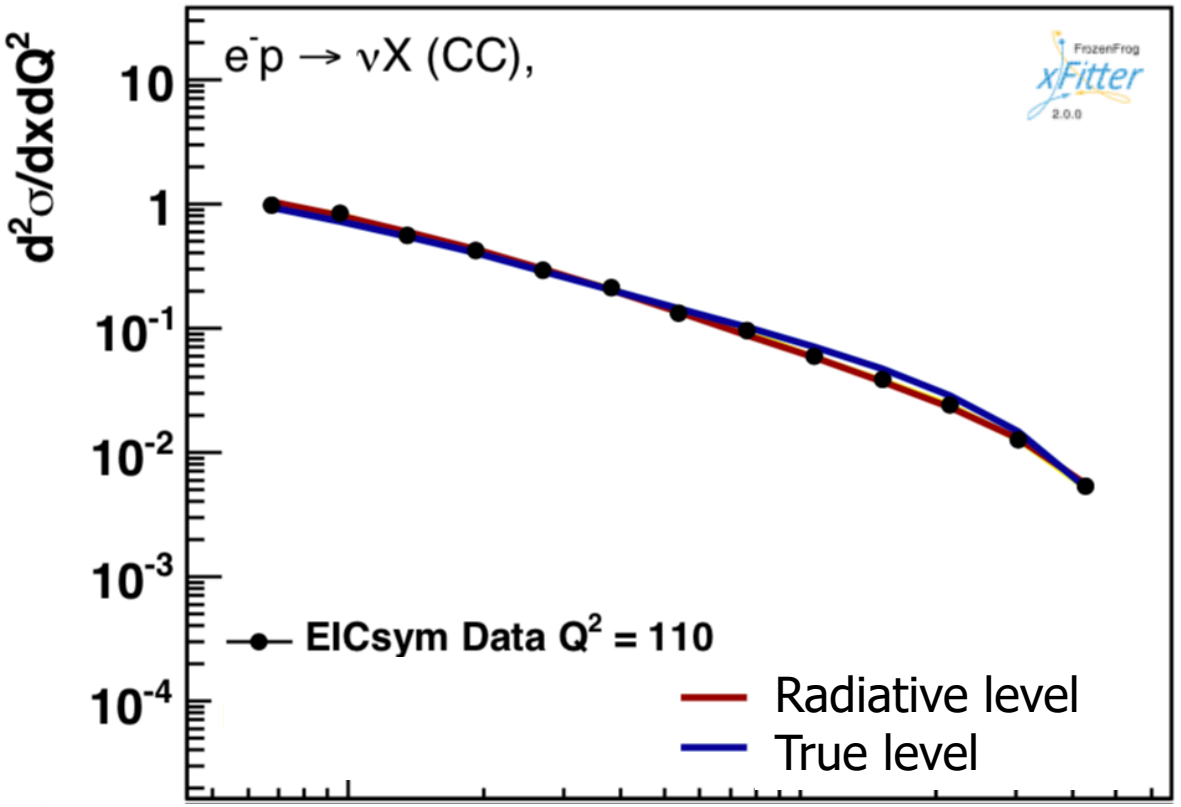
Reduced cross section at true level with xfitter

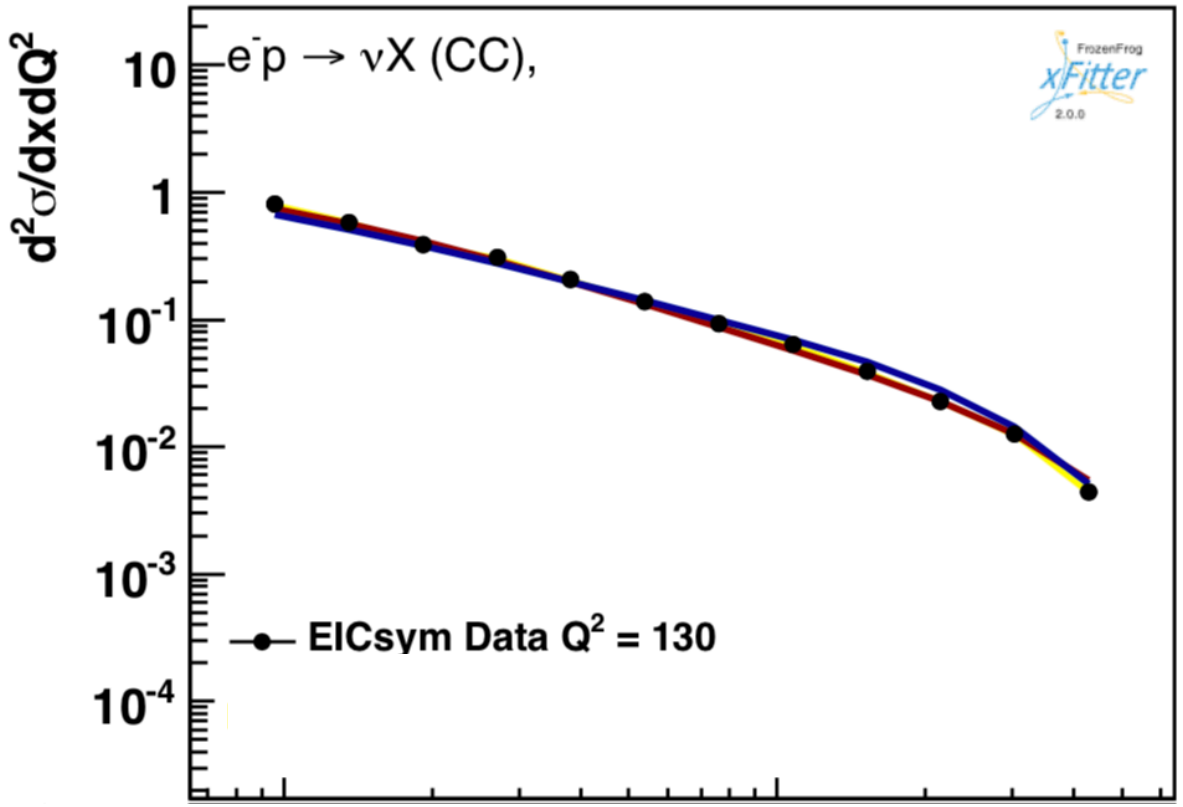
Cross section at EIC are from slides 8 results (yellow band)



EIC measurement at highest energy of Charged Current events works good in agreement of theory predictions and HERAPDF.

Radiative correction effect





Detector impact

PID impact (1)

Full acceptance, all final state hadrons:

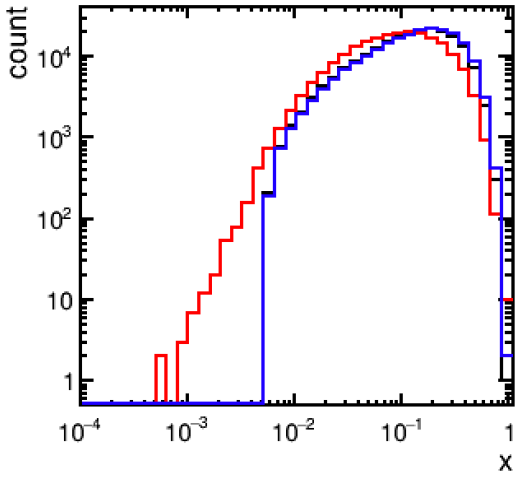
Kaon, proton, pion, neutron are detected:

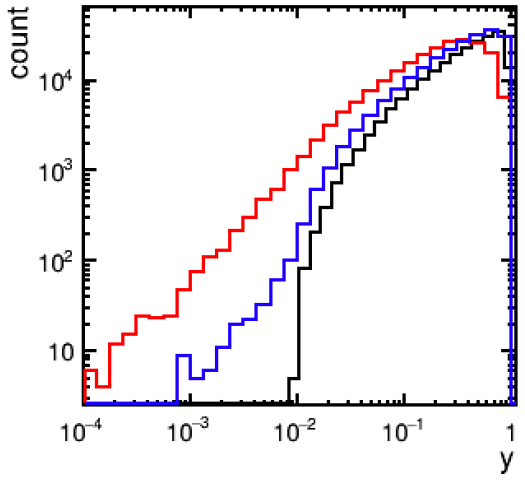
True level, radiative

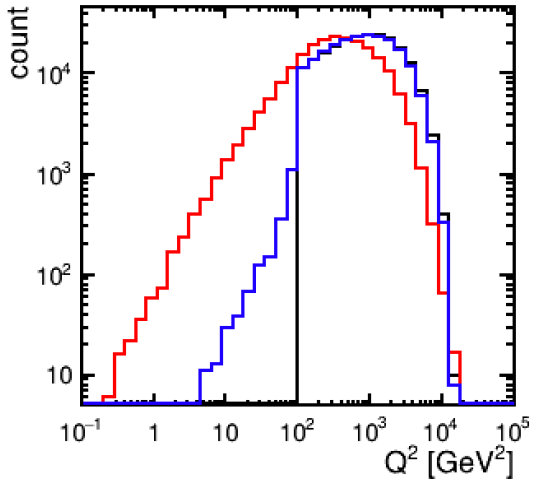
$$x^{rec} = \frac{Q^2_{JB}}{s y_{JB}}; \quad y^{rec} = \frac{(E-p_z)_h}{2E_e}; \quad recQ^2 = \frac{p^2_{t,h}}{1-y_{JB}}$$

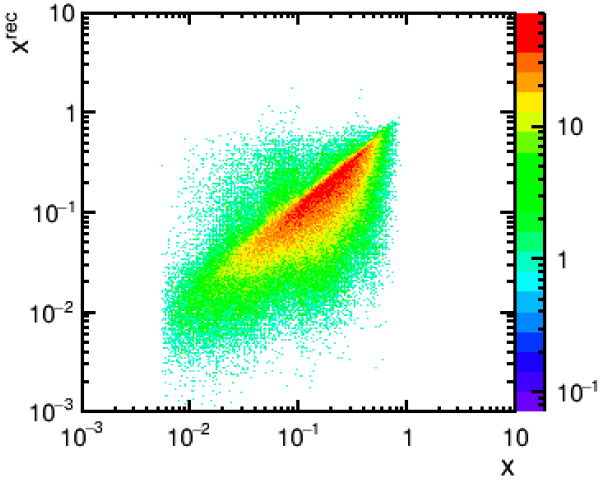
$$p^2_{t,h} = \left(\Sigma_h p_{x,h}\right)^2 + \left(\Sigma_h p_{y,h}\right)^2$$

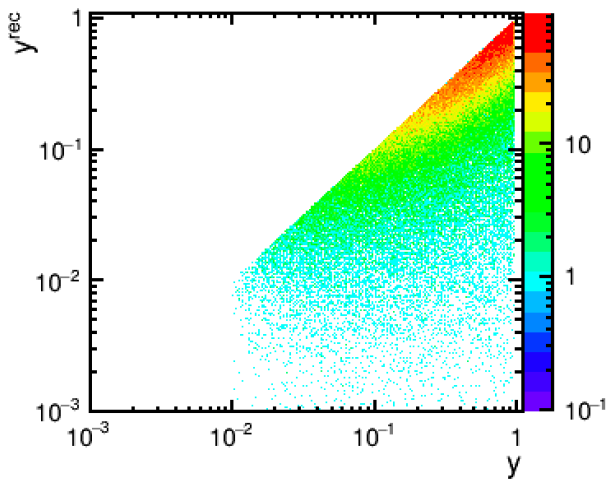
$$\left(E-p_z\right)_h = \Sigma_h \left(E_h - p_{z,h}\right)$$

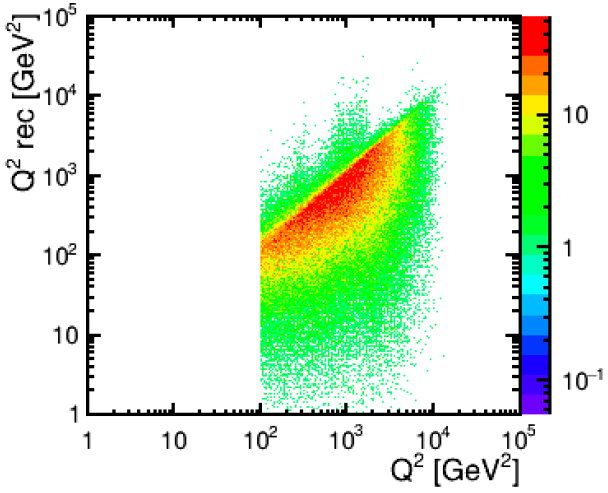












Final photons affect is not small, detecting the final photons are important.

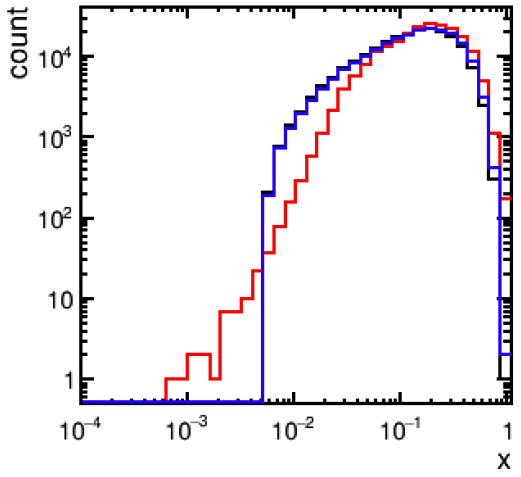
PID impact (2)

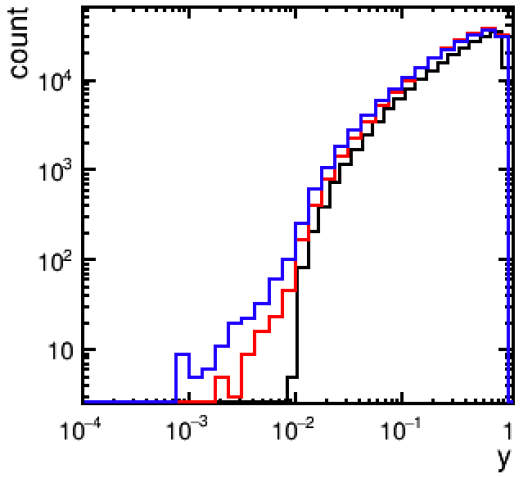
Full acceptance, all final state:

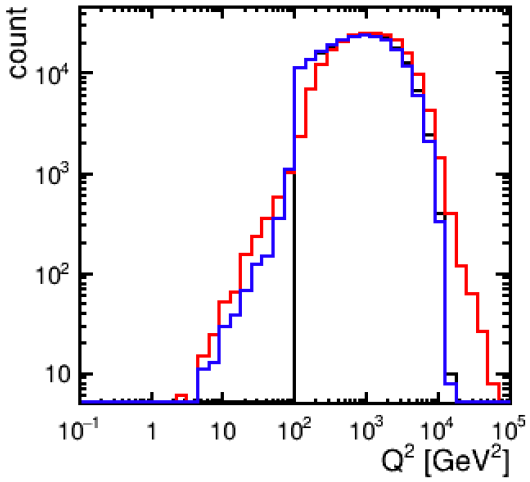
Kaon, proton, pion, neutron and photon are detected:

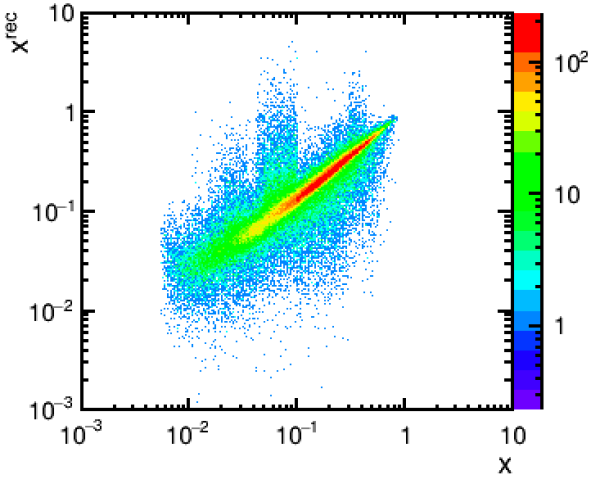
True level, radiative

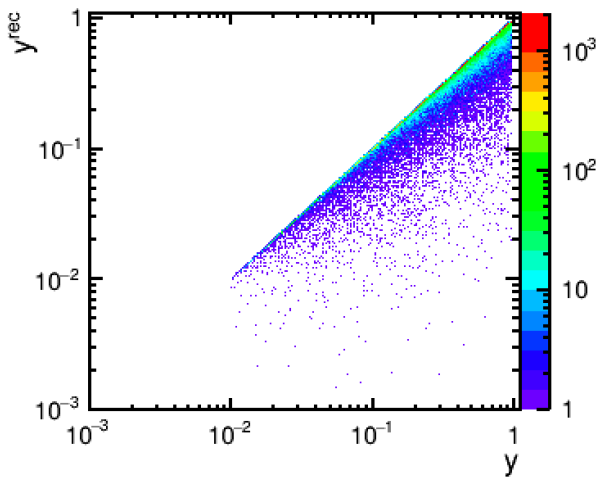
$$x^{rec} = \frac{Q^2_{JB}}{s y_{JB}}; \quad y^{rec} = \frac{(E - p_z)_h}{2E_e}; \quad recQ^2 = \frac{p^2_{t,h}}{1 - y_{JB}}$$

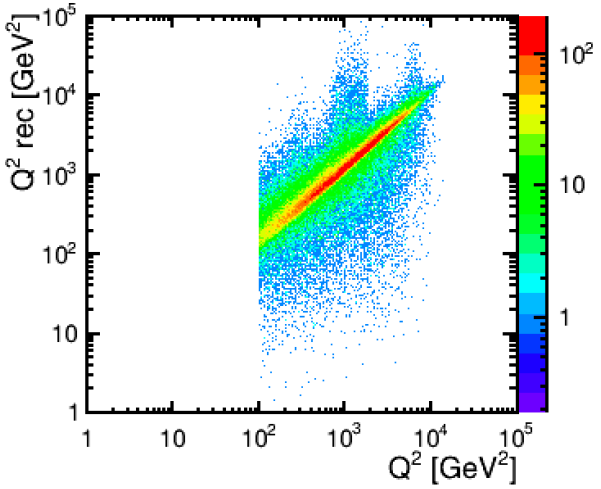












Final photons should be included.

What HERA did: https://arxiv.org/pdf/hep-ex/9606014.pdf

"Sum over all EMC (HAC) cells with energy deposits above 60 MeV (110 MeV)"

Those energy threshold would affect the measurement too. Try a rough energy threshold cut.

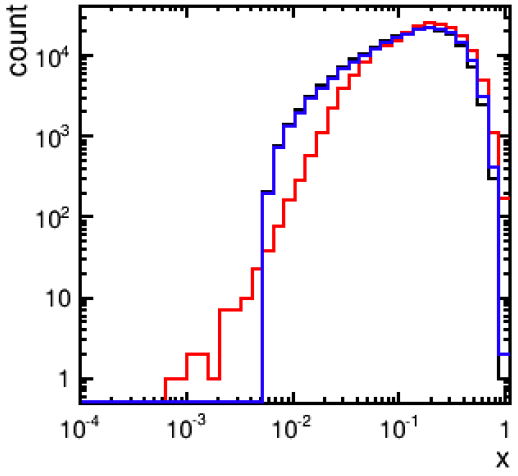
PID impact (3)

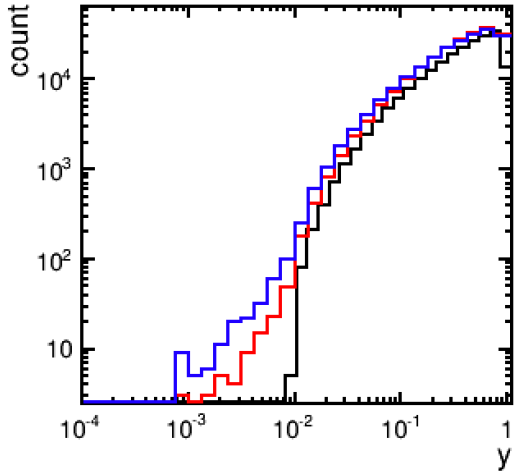
Full acceptance, all final state:

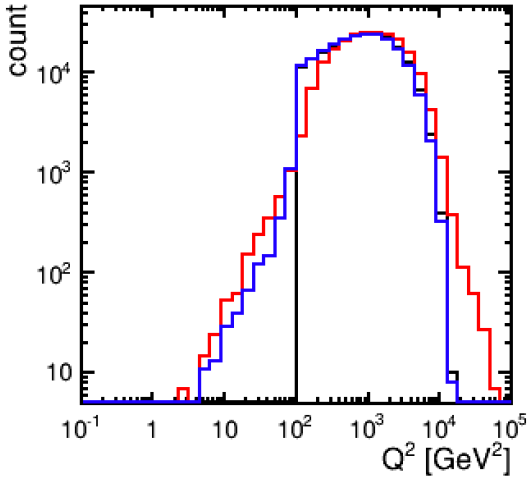
Kaon, proton, pion, neutron and photon are detected:

True level, radiative

$$x^{rec} = \frac{Q^2_{JB}}{s y_{JB}}; \quad y^{rec} = \frac{(E - p_z)_h}{2E_e}; \quad recQ^2 = \frac{p^2_{t,h}}{1 - y_{JB}}$$



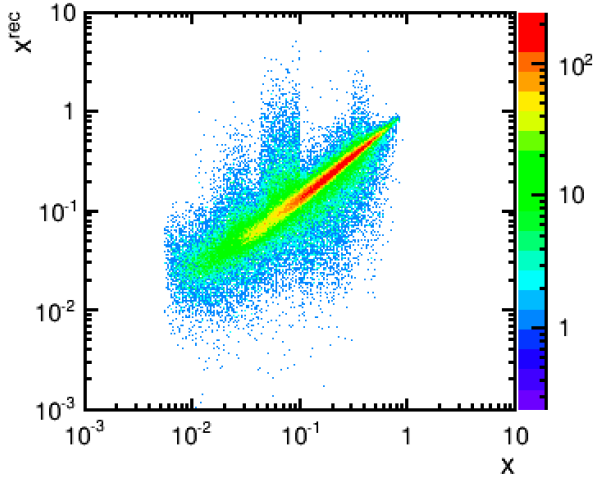


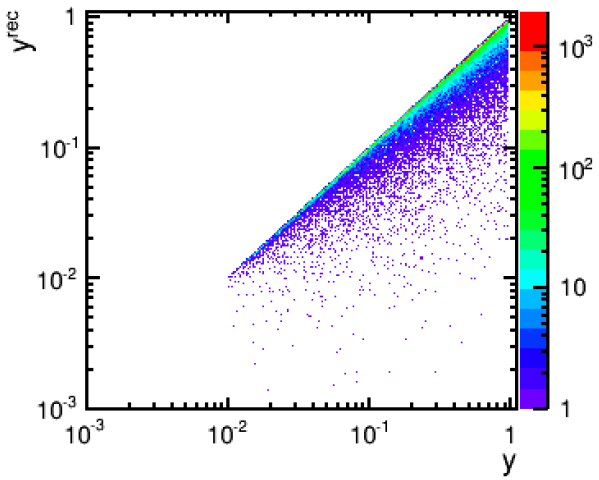


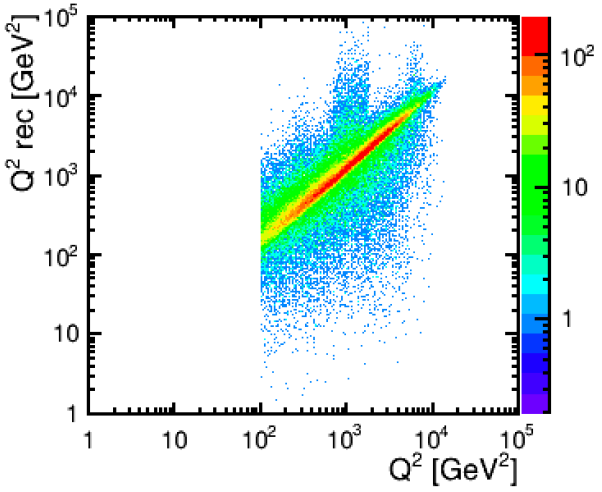
Rough study: Apply the same energy threshold as HERA did.

Photons: 60 MeV

Hadrons: 110 MeV



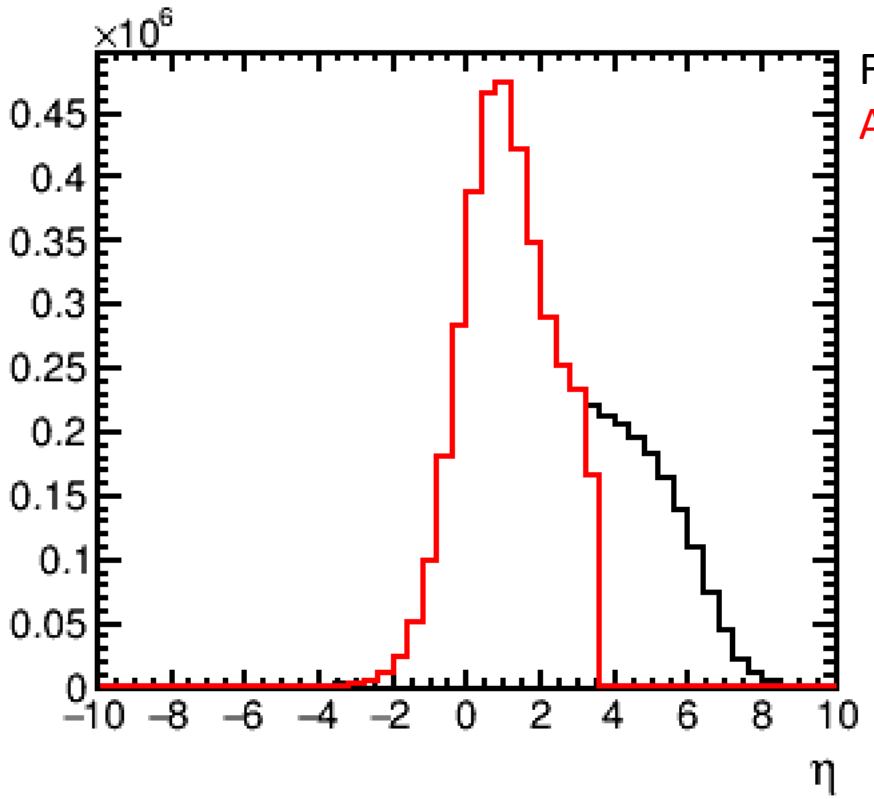




Detector acceptance

$EICDIRECTORY/PACKAGES/eic-smear/scripts/smearHandBook.cxx
The part will affect CC events with final state particles: : Kaon, proton, pion, neutron, photon
Total coverage of the handbook for tracker and hcal is -3.5 < eta < 3.5

Nparticles 5159113; Nparticles after Cut 3700076; losing ~30% of final particles

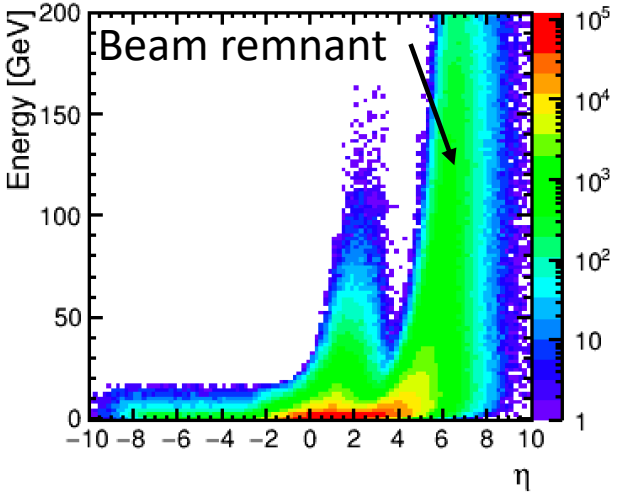


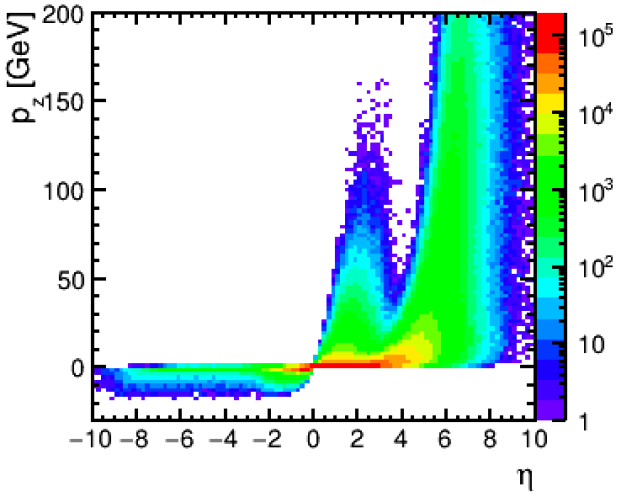
Full acceptance
Apply acceptance cut

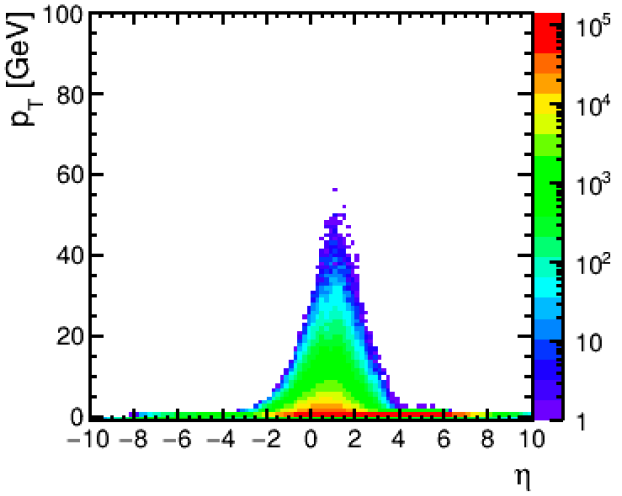
Detector acceptance effect final particles

$$x_{JB} = \frac{Q^2_{JB}}{s y_{JB}}; \quad y_{JB} = \frac{\text{sum}(E - p_z)_h}{2E_e}; \quad Q^2_{JB} = \frac{p^2_{t,h}}{1 - y_{JB}}$$

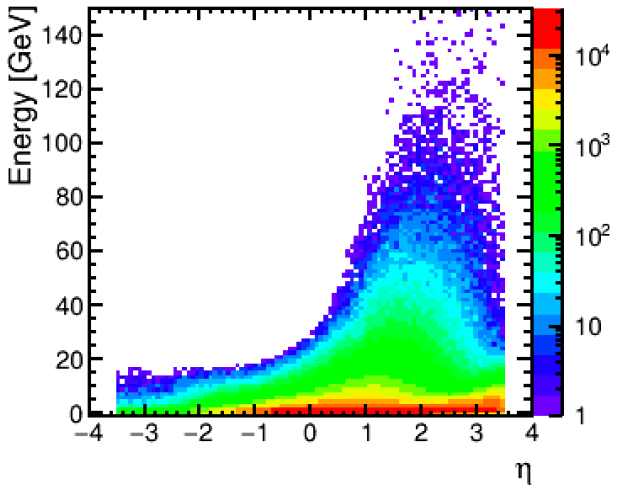
Perfect detector

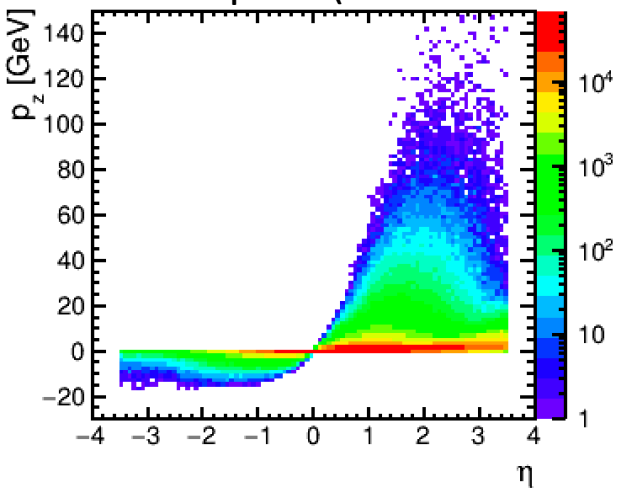


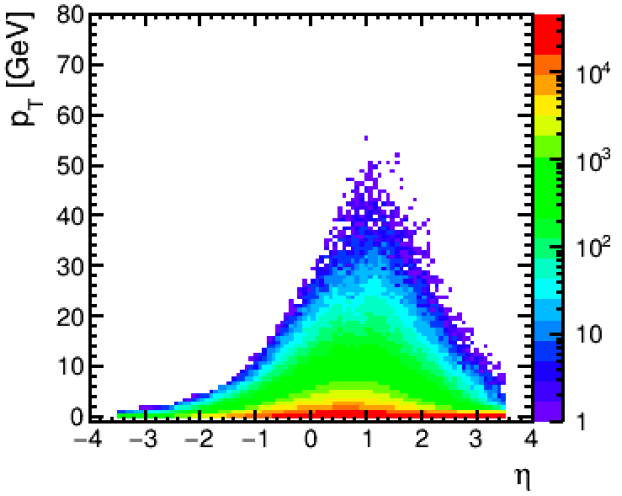




Detector accepted (-3.5 < eta < 3.5)





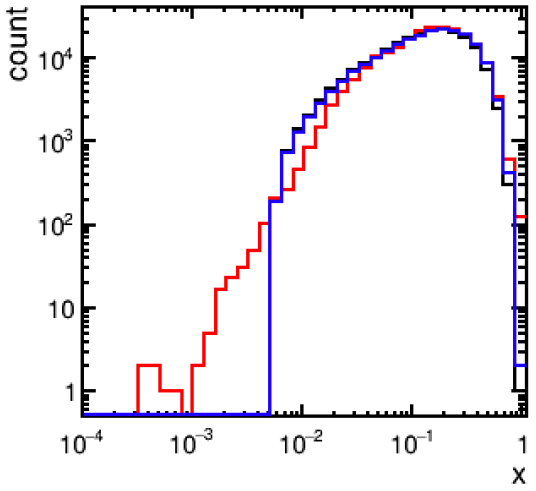


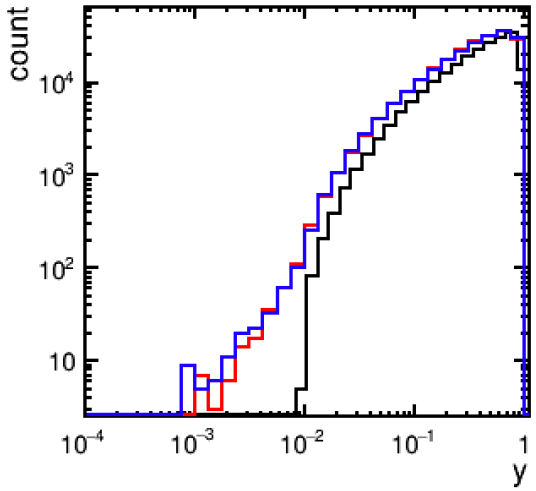
Detector acceptance effect on kine

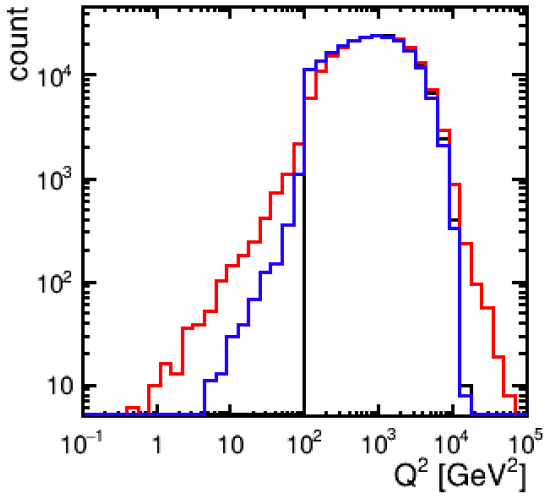
$x^{rec} = \frac{Q^2_{JB}}{s y_{JB}}$; $y^{rec} = \frac{(E - p_z)_h}{2E_e}$; $recQ^2 = \frac{p^2_{t,h}}{1 - y_{JB}}$

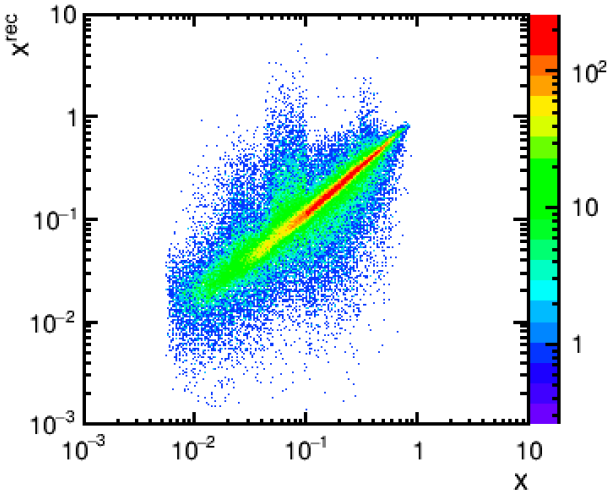
Detector accepted: all final photon, pion, proton, neutron are included, -3.5<eta<3.5

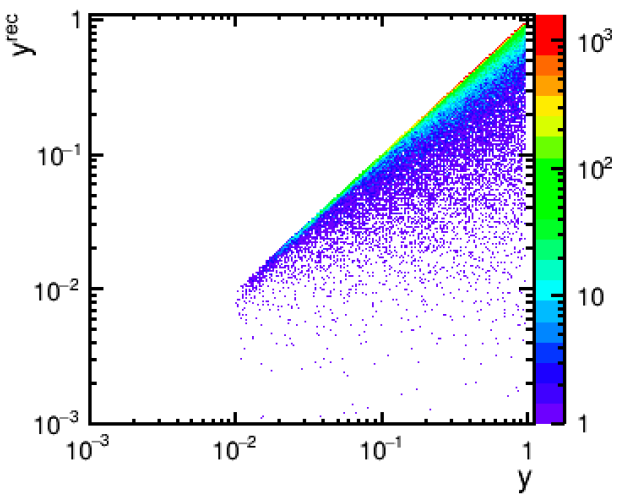
True level, radiative

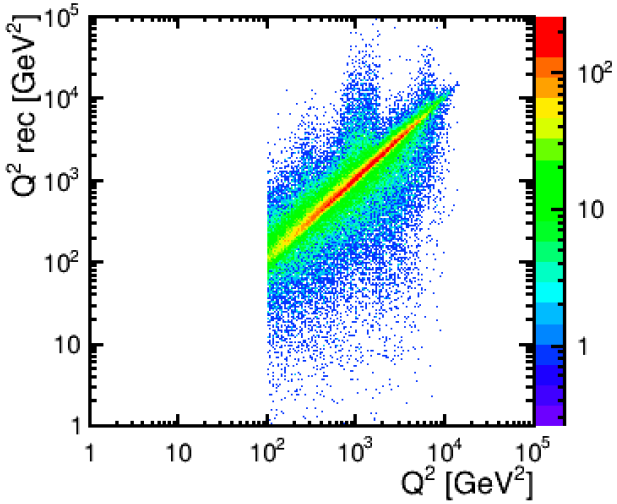










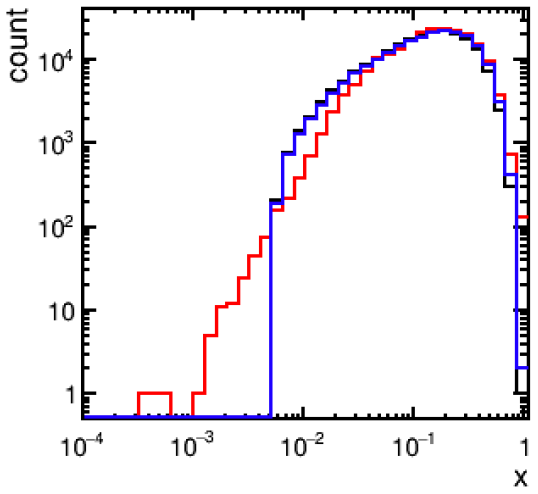


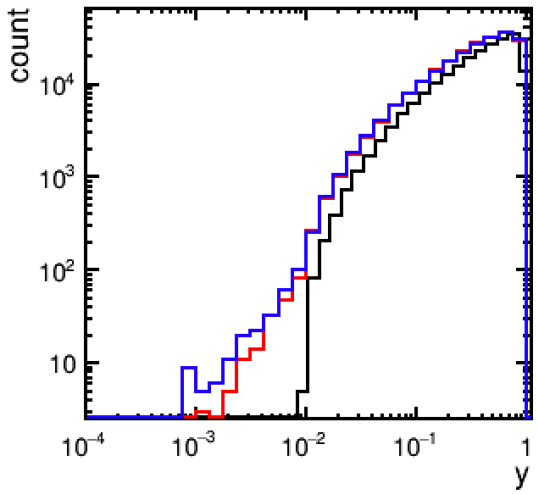
Detector acceptance effect on kine

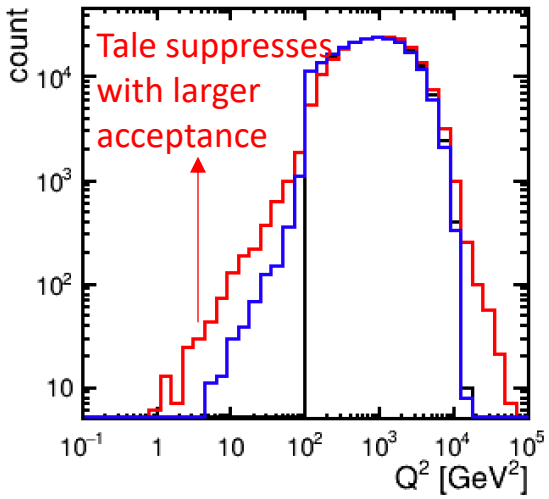
$x^{rec} = \frac{Q^2_{JB}}{s y_{JB}}$; $y^{rec} = \frac{(E-p_z)_h}{2E_e}$; $recQ^2 = \frac{p^2_{t,h}}{1-y_{JB}}$

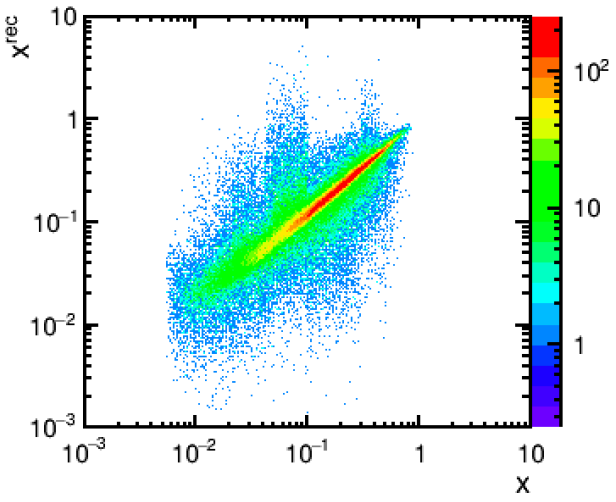
Detector accepted: all final photon, pion, proton, neutron are included, -4<eta<4

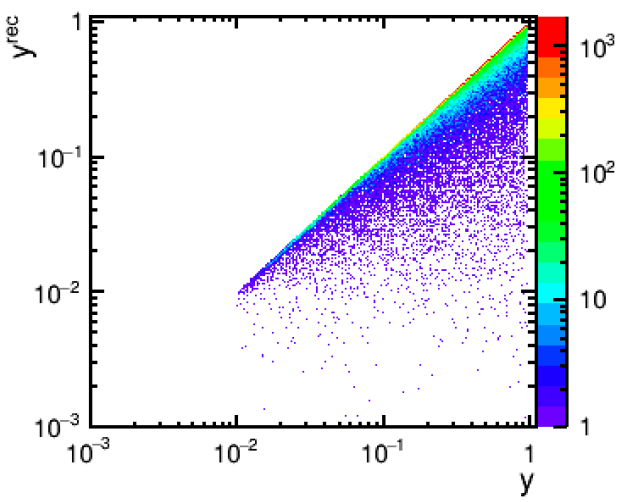
True level, radiative

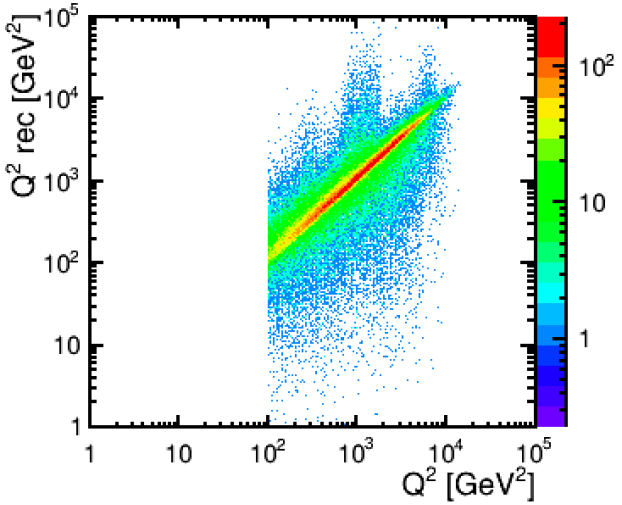












Smearing: very preliminary

$EICDIRECTORY/PACKAGES/eic-smear/scripts/smearHandBook.cxx

The part will affect CC events with final state hadronic state:

Total coverage of the handbook for tracker and hcal is -3.5 < eta < 3.5
Smear::Device SmearThetaHadronic(Smear::kTheta, "0.001");

Hcal:

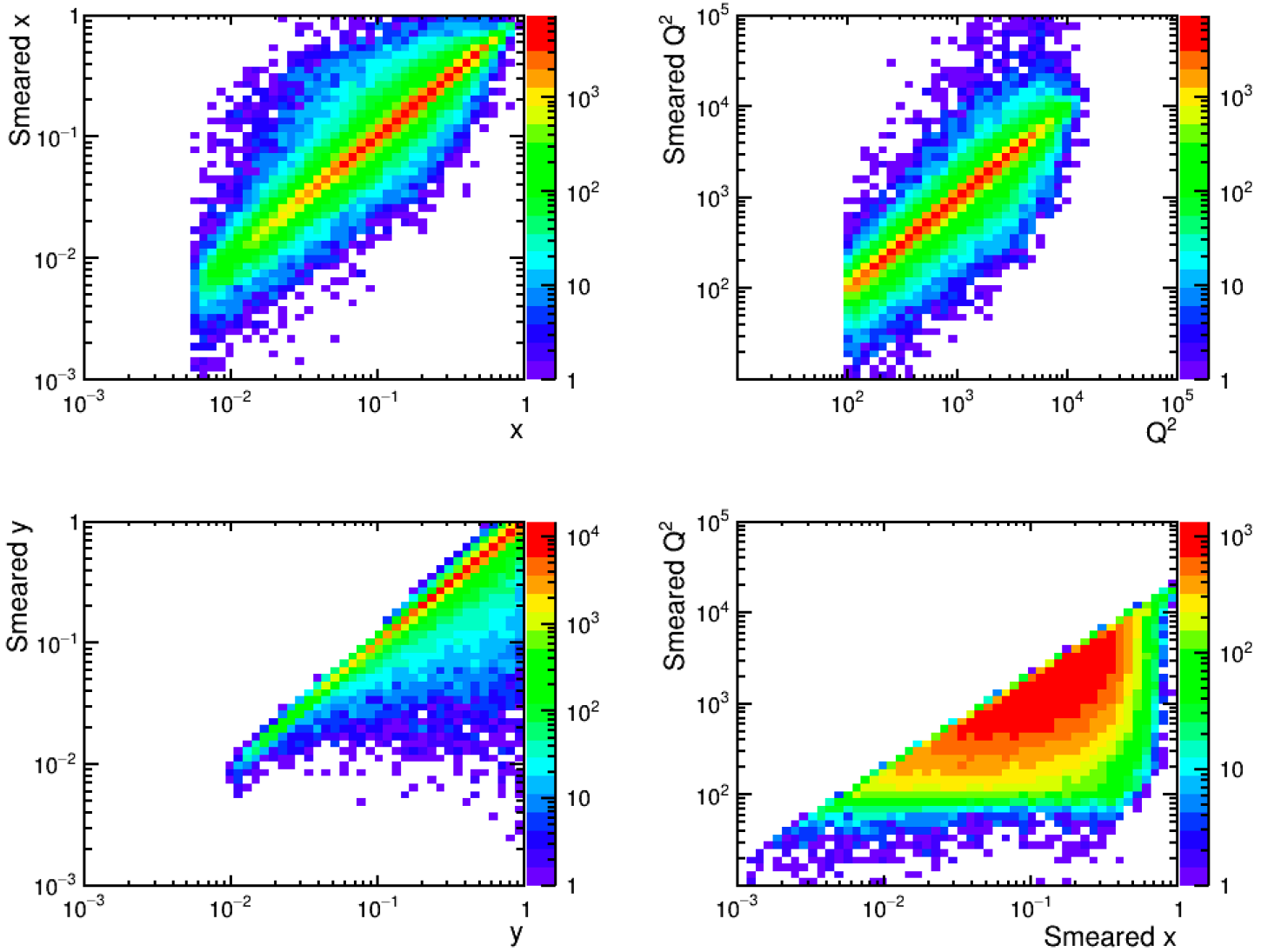
eta = -3.5 – -1: sigma_E/E ~ 0.45/sqrt(E)+0.06
eta = -1 – 1: sigma_E/E ~ 0.85/sqrt(E)+0.07
eta = 1 -- 3.5: sigma_E/E ~ 0.45/sqrt(E)+0.06

Tracking:

eta = -3.5 – -2.5: sigma_p/p ~ 0.1% p+2.0%
eta = -2.5 – -1: sigma_p/p ~ 0.05% p+1.0%
eta = -1 – +1: sigma_p/p ~ 0.05% p+0.5%
eta = 1 – 2.5: sigma_p/p ~ 0.05% p+1.0%
eta = 2.5 – 3.5: sigma_p/p ~ 0.1% p+2.0%

PIDMatrix is based on HERMES RICH.

Smeared kinematics, very preliminary



NC Smearing: very preliminary

$EICDIRECTORY/PACKAGES/eic-smear/scripts/smearHandBook.cxx

The part will affect NC events with final state electron:

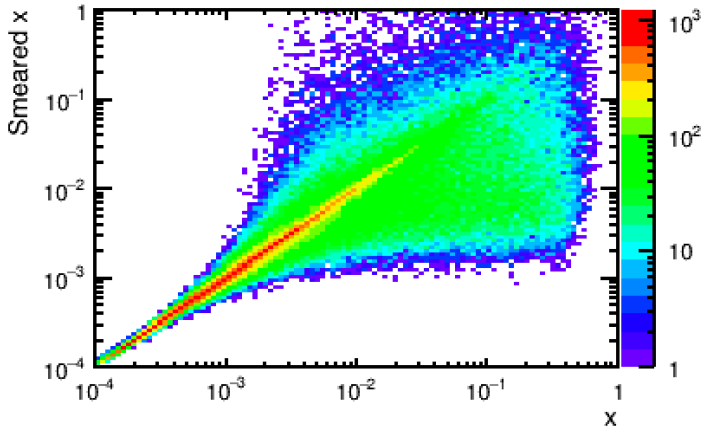
Total coverage of the handbook for emcal: -4.5 < eta < 4.5, The low Q^2 tagger settings are in progress, so far lowQ^2 tagger is not included in my results.

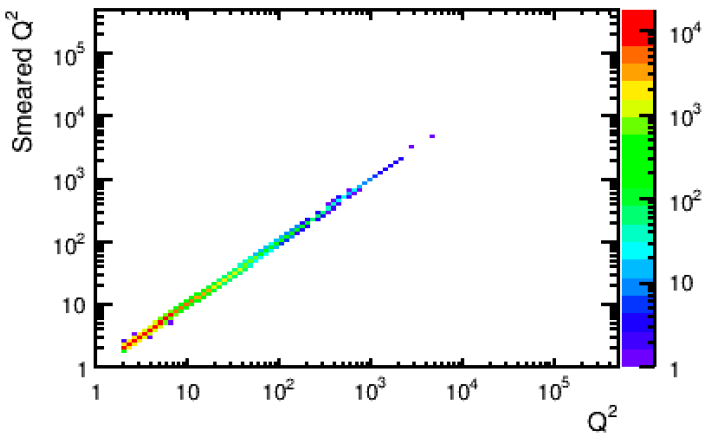
$$Q^2 = -q^2 = -(k_\mu - k'_\mu)^2$$

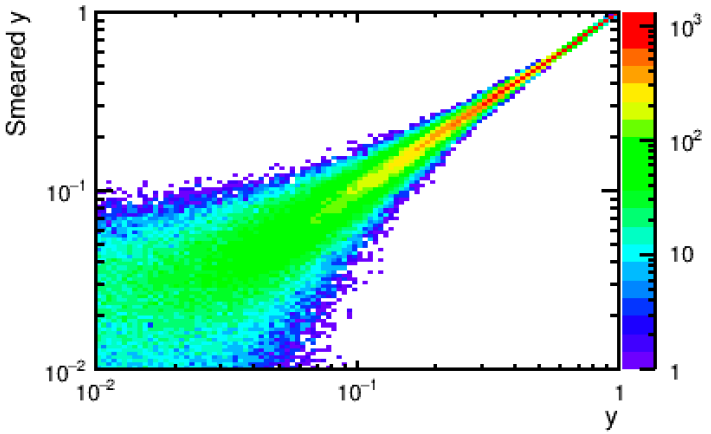
$$Q^2 = 2E_e E'_e(1 - \cos\Theta_{e'})$$

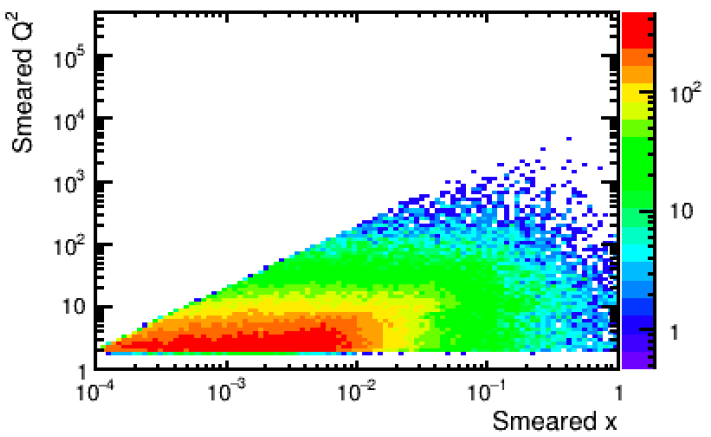
$$y = \frac{pq}{pk} = 1 - \frac{E'_e}{E_e}\cos^2\left(\frac{\theta'_e}{2}\right)$$

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









18x275 GeV

Summary

Charged current channel: final hadronic state

1. Radiative corrections effect
2. PID requirement: final state charged hadrons, neutrons, photons
3. Detector acceptance study
4. Eic-smear study is going on

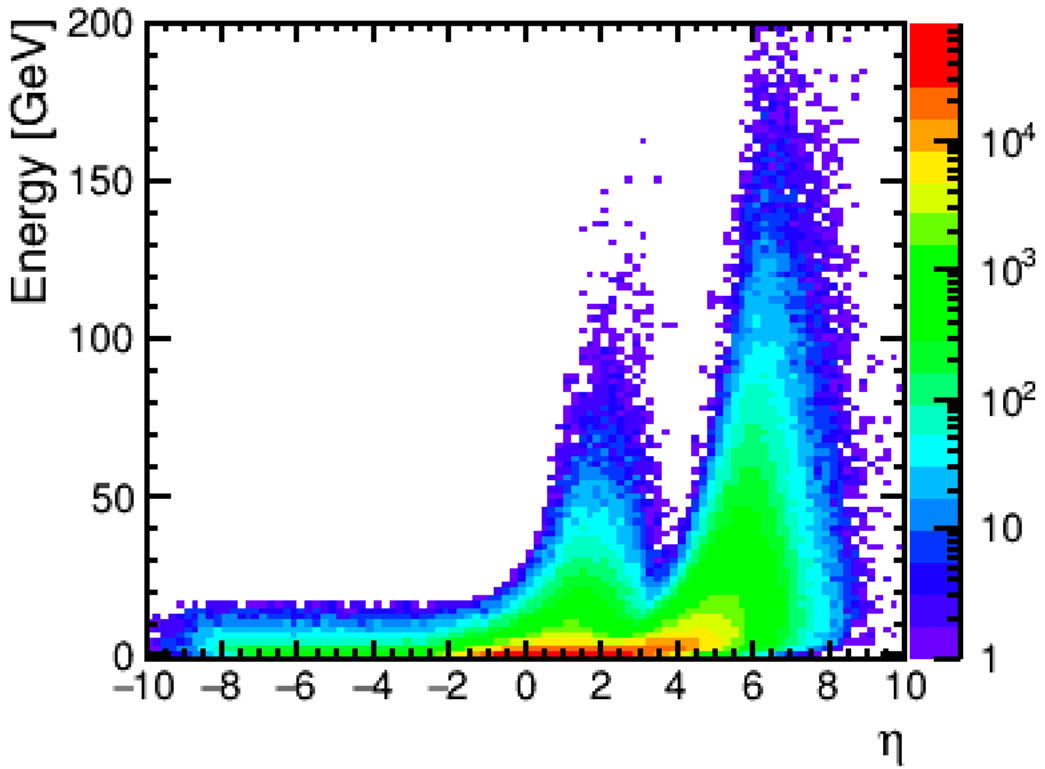
Neutral current channel: outgoing electron

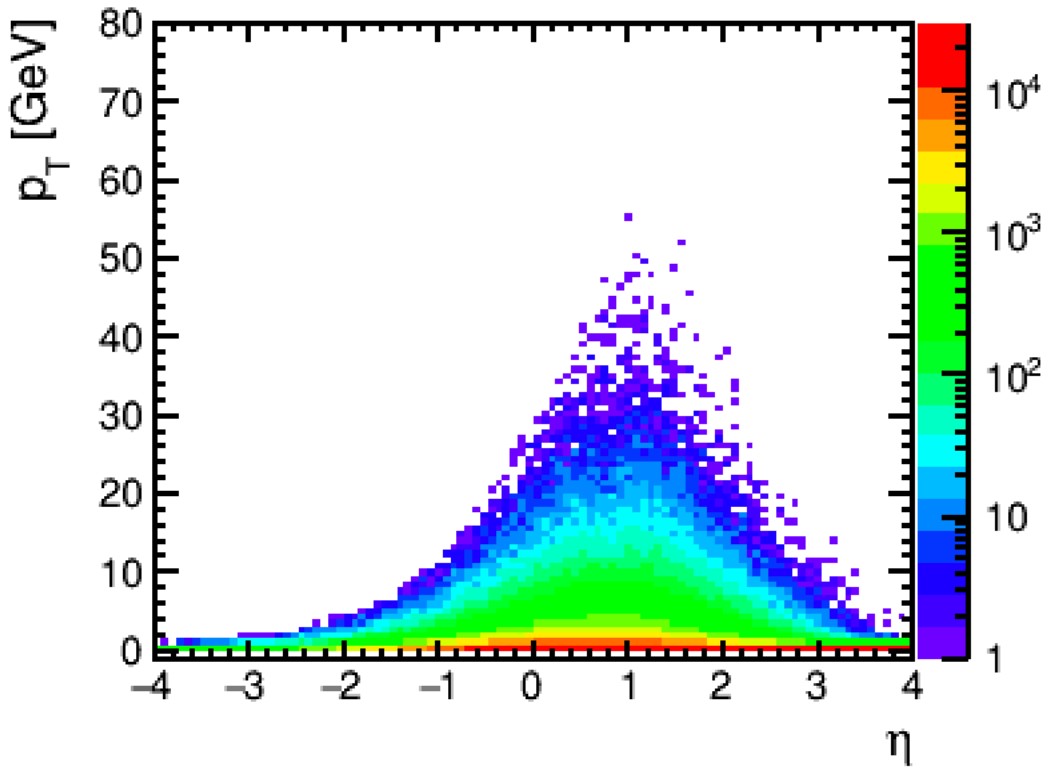
Electron PID requirements as function of rapidity

- Back up

Back up

Final state photons

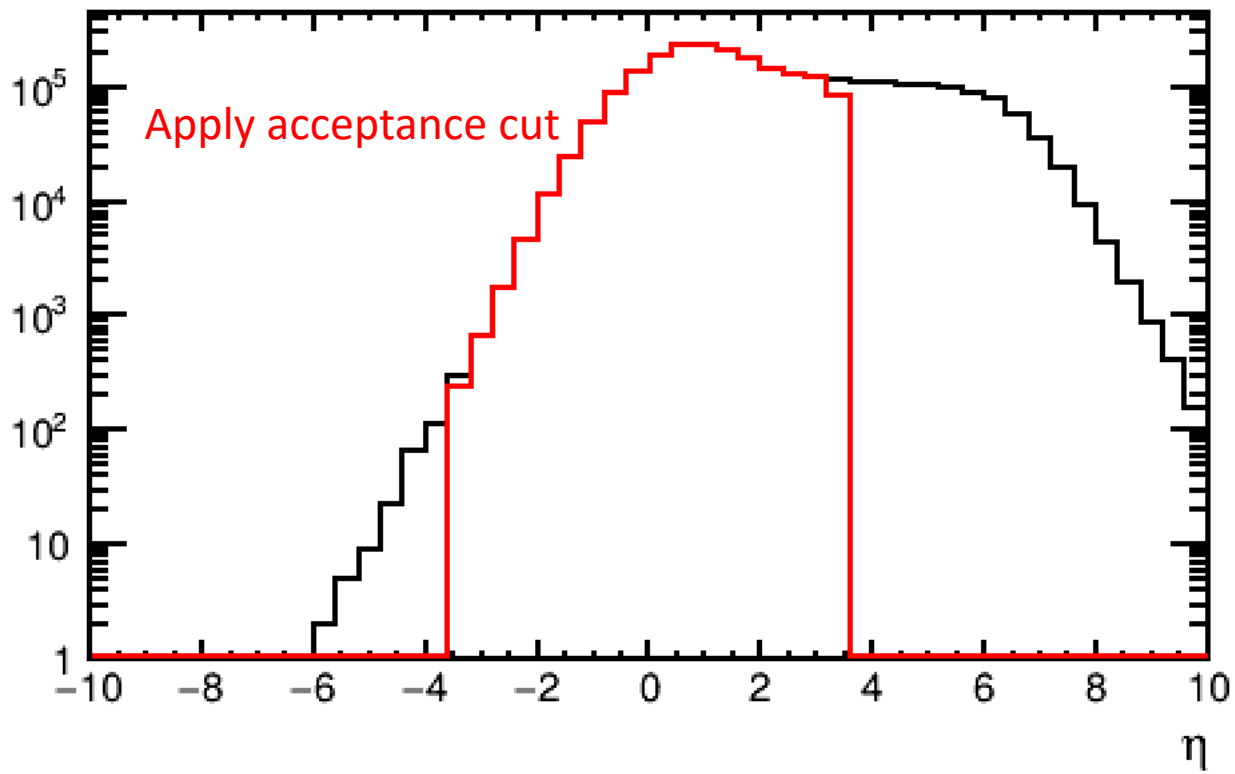




Detector acceptance

$EICDIRECTORY/PACKAGES/eic-smear/scripts/smearHandBook.cxx
The part will affect CC events with final state hadrons: : Kaon, proton, pion, neutron
Total coverage of the handbook for tracker and hcal is -3.5 < eta < 3.5

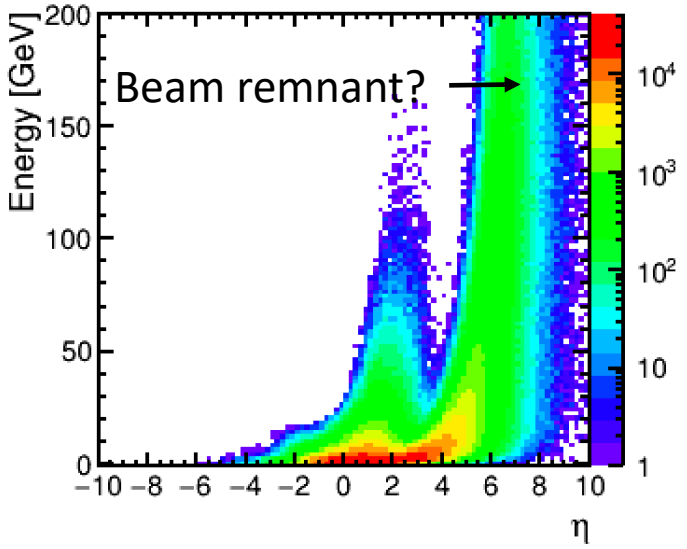
losing ~30% of final hadrons after eta cut

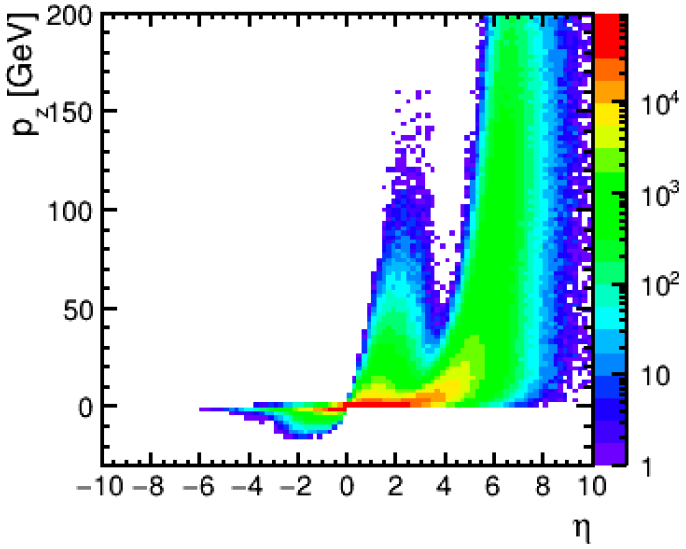


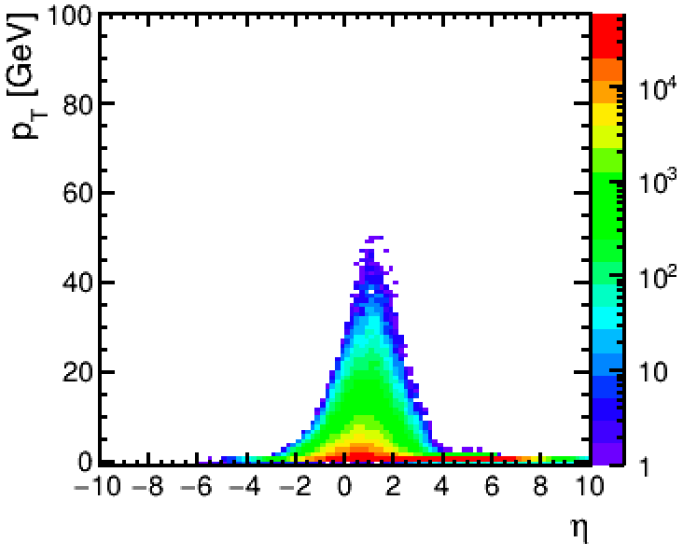
Detector acceptance effect final particles

$$x_{JB} = \frac{Q^2_{JB}}{s y_{JB}}; \quad y_{JB} = \frac{(E - p_z)_h}{2E_e}; \quad Q^2_{JB} = \frac{p^2_{t,h}}{1 - y_{JB}}$$

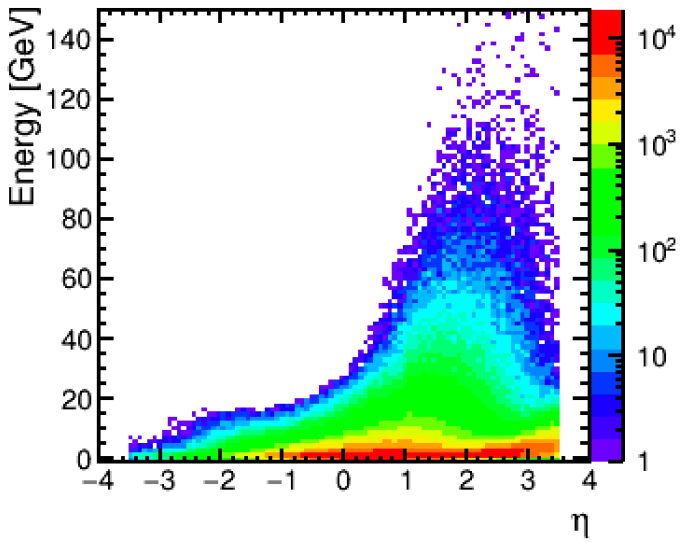
Perfect detector

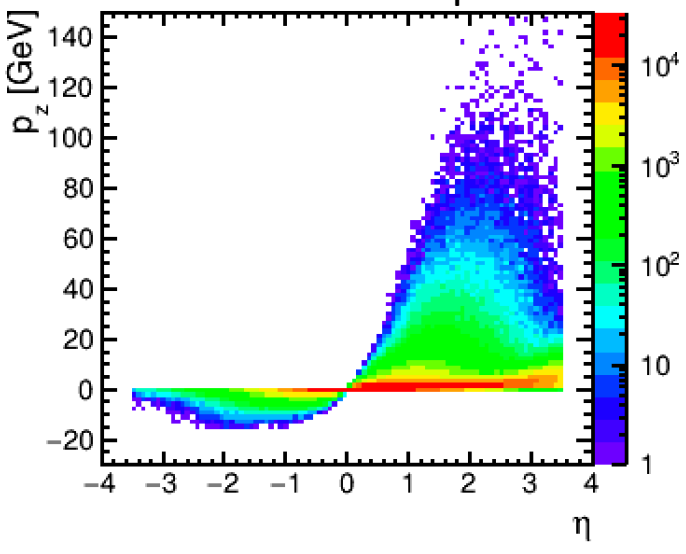


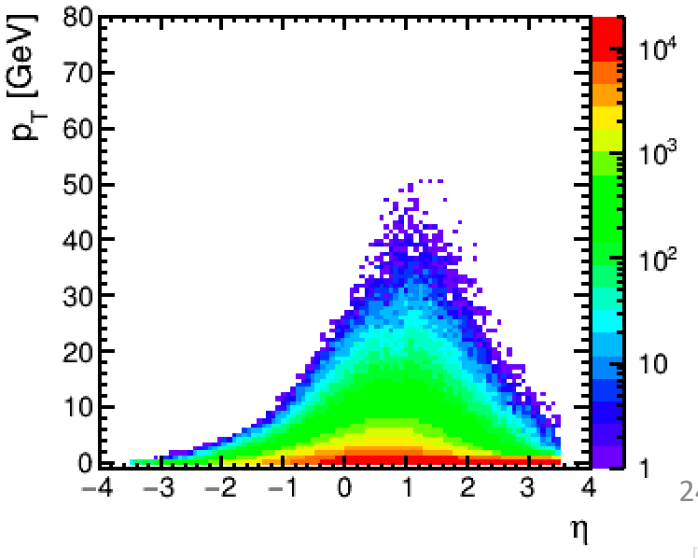




Detector accepted







Detector acceptance effect on kine

$$x^{rec} = \frac{Q^2_{JB}}{s y_{JB}}; \quad y^{rec} = \frac{(E - p_z)_h}{2E_e}; \quad recQ^2 = \frac{p^2_{t,h}}{1 - y_{JB}}$$

Perfect acceptance: all final pion, proton, neutron are included

True level, radiative