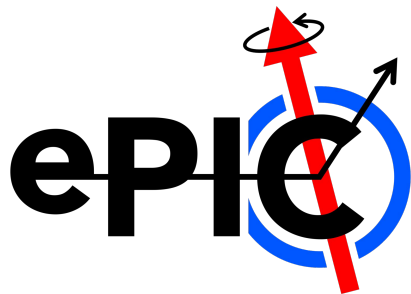


Update on eID Performance and Cross-section for eHe3

Shubham Yadav

Inclusive PWG meeting

14/10/2025



eID based reconstruction

<https://github.com/Meatbally2/snippets/tree/main/ElectronID>

*Initially developed by Tyler.

*Win has added more files.

Truth \longrightarrow MC information

Reco \longrightarrow Reconstructed information

The screenshot shows the GitHub repository for `snippets/ElectronID`. The left sidebar displays a file tree with the following structure:

- main
 - Calorimetry
 - ElectronID**
 - Beam.h
 - Boost.h
 - ElectronID.cc
 - ElectronID.hh
 - InclusiveSkim.C
 - InclusiveSkim.h
 - constants.h
 - drawKinematics.C
 - draw_helper.h
 - kinematics.cc
 - kinematics.hh
 - reconMethod.hh
 - Exclusive
 - FarForwardAndBackward
 - FullChainBrlFamScript
 - Inclusive
 - JLab_Farm_Scripts
 - JetsAndHF
 - PID
 - RootExamples
 - SIDS
 - Tracking
 - Tree_Pruning

The right pane shows the commit history for the `ElectronID` branch. It indicates the branch is 3 commits ahead of, 13 commits behind `alic/snippets:main`. The commit history table is as follows:

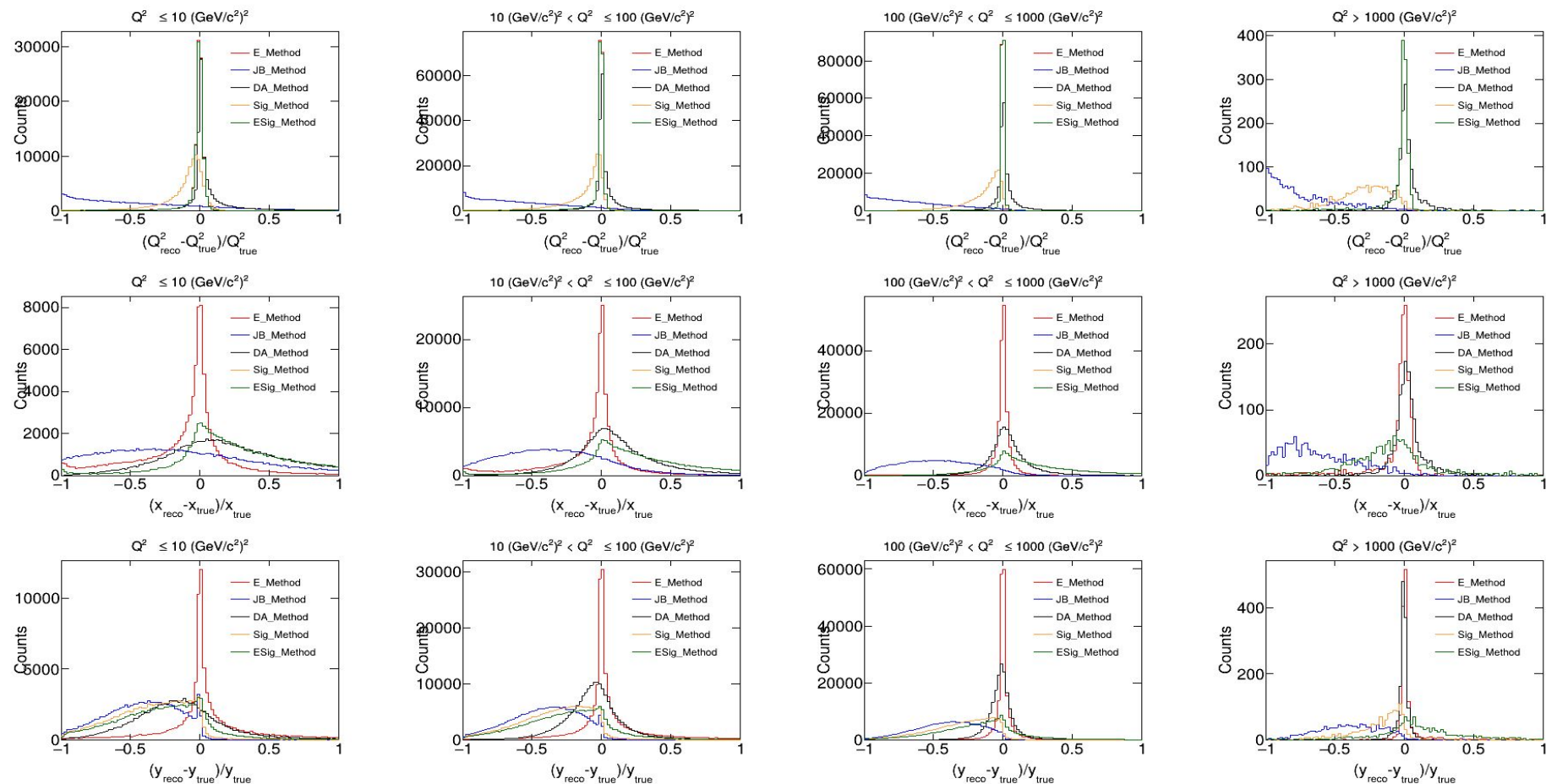
Name	Last commit message	Last commit date
..		
Beam.h	added bench mark plots, more reconstruction methods	last week
Boost.h	new boost.h	2 weeks ago
ElectronID.cc	added bench mark plots, more reconstruction methods	last week
ElectronID.hh	added bench mark plots, more reconstruction methods	last week
InclusiveSkim.C	added bench mark plots, more reconstruction methods	last week
InclusiveSkim.h	added bench mark plots, more reconstruction methods	last week
constants.h	added bench mark plots, more reconstruction methods	last week
drawKinematics.C	add missing file	yesterday
draw_helper.h	added bench mark plots, more reconstruction methods	last week
kinematics.cc	added bench mark plots, more reconstruction methods	last week
kinematics.hh	added bench mark plots, more reconstruction methods	last week
reconMethod.hh	added bench mark plots, more reconstruction methods	last week

Various Reconstruction Method

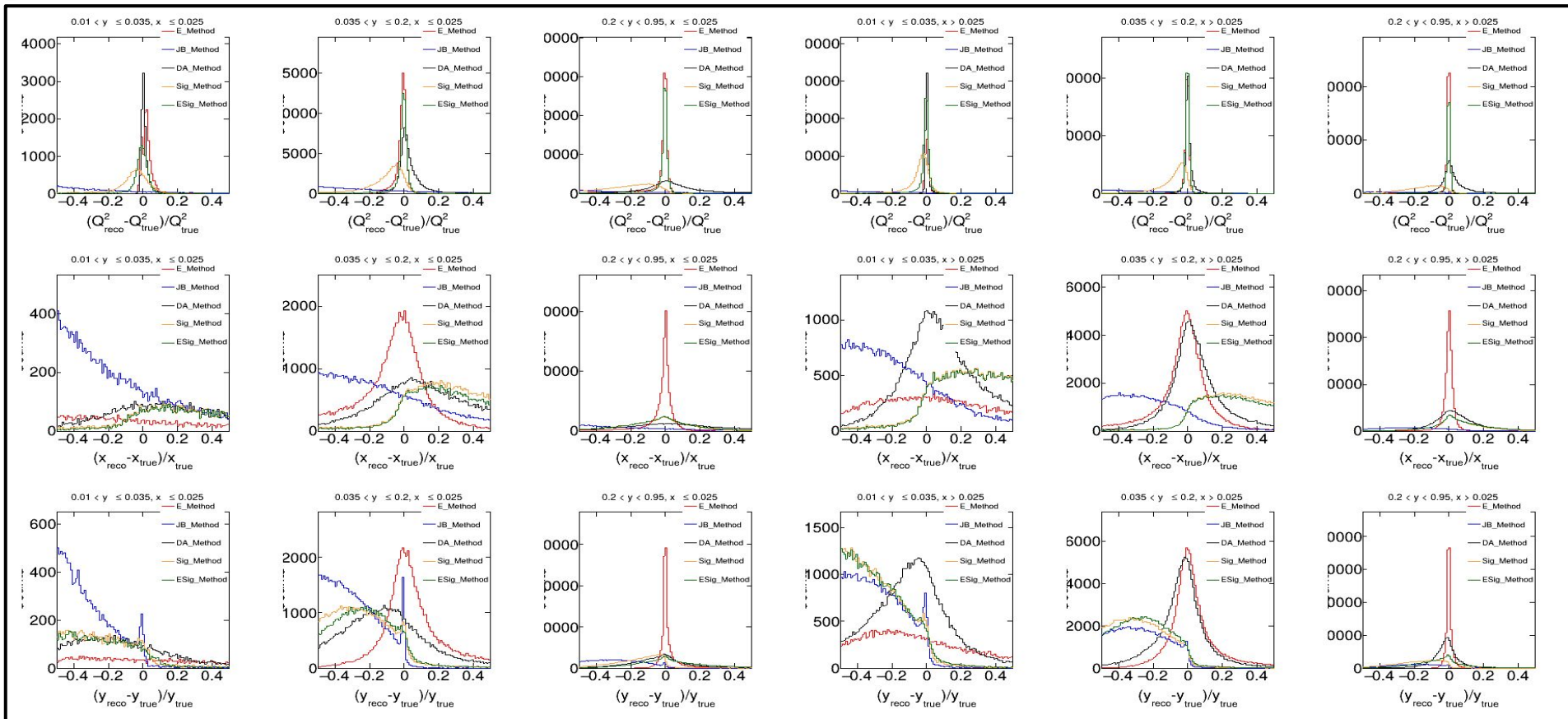
Method name	Observables	y	Q^2	$x \cdot E_p$
Electron (e)	$[E_0, E, \theta]$	$1 - \frac{\Sigma_e}{2E_0}$	$\frac{E^2 \sin^2 \theta}{1-y}$	$\frac{E(1+\cos \theta)}{2y}$
Double angle (DA) [6,7]	$[E_0, \theta, \gamma]$	$\frac{\tan \frac{\gamma}{2}}{\tan \frac{\gamma}{2} + \tan \frac{\theta}{2}}$	$4E_0^2 \cot^2 \frac{\theta}{2} (1-y)$	$\frac{Q^2}{4E_0 y}$
Hadron (h , JB) [4]	$[E_0, \Sigma, \gamma]$	$\frac{\Sigma}{2E_0}$	$\frac{T^2}{1-y}$	$\frac{Q^2}{2\Sigma}$
ISigma ($I\Sigma$) [9]	$[E, \theta, \Sigma]$	$\frac{\Sigma}{\Sigma + \Sigma_e}$	$\frac{E^2 \sin^2 \theta}{1-y}$	$\frac{E(1+\cos \theta)}{2y}$
IDA [7]	$[E, \theta, \gamma]$	y_{DA}	$\frac{E^2 \sin^2 \theta}{1-y}$	$\frac{E(1+\cos \theta)}{2y}$
$E_0 E \Sigma$	$[E_0, E, \Sigma]$	y_h	$4E_0 E - 4E_0^2 (1-y)$	$\frac{Q^2}{2\Sigma}$
$E_0 \theta \Sigma$	$[E_0, \theta, \Sigma]$	y_h	$4E_0^2 \cot^2 \frac{\theta}{2} (1-y)$	$\frac{Q^2}{2\Sigma}$
$\theta \Sigma \gamma$ [8]	$[\theta, \Sigma, \gamma]$	y_{DA}	$\frac{T^2}{1-y}$	$\frac{Q^2}{2\Sigma}$
Double energy (A4) [7]	$[E_0, E, E_h]$	$\frac{E-E_0}{(xE_p)-E_0}$	$4E_0 y (xE_p)$	$E + E_h - E_0$
$E \Sigma T$	$[E, \Sigma, T]$	$\frac{\Sigma}{\Sigma + E \pm \sqrt{E^2 + T^2}}$	$\frac{T^2}{1-y}$	$\frac{Q^2}{2\Sigma}$
$E_0 E T$	$[E_0, E, T]$	$\frac{2E_0 - E \pm \sqrt{E^2 - T^2}}{2E_0}$	$\frac{T^2}{1-y}$	$\frac{Q^2}{4E_0 y}$
Sigma (Σ) [9]	$[E_0, E, \Sigma, \theta]$	$y_{I\Sigma}$	$Q_{I\Sigma}^2$	$\frac{Q^2}{4E_0 y}$
$e\Sigma$ ($e\Sigma$) [9]	$[E_0, E, \Sigma, \theta]$	$\frac{2E_0 \Sigma}{(\Sigma + \Sigma_e)^2}$	$2E_0 E (1 + \cos \theta)$	$\frac{E(1+\cos \theta)(\Sigma + \Sigma_e)}{2\Sigma}$

<https://arxiv.org/pdf/2110.05505>

Resolution performance of different Recon Methods at Q^2 ranges



Resolution performance of different Recon Methods at x&y ranges



*For this analysis, I'm going with electron method

Response in (x, Q^2) Bins

epic sim. 25.07.0
eHe3 10x166

$$1 \leq Q^2 \leq 10$$

Plots are Q^2_{Reco} vs Q^2_{truth}
in different ranges of Q^2
and x

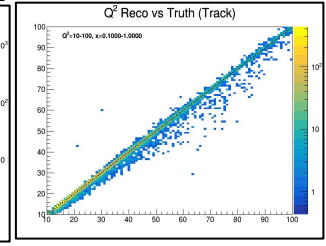
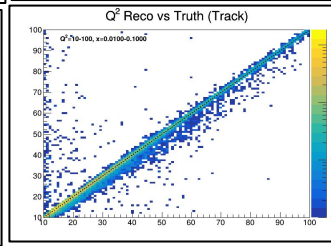
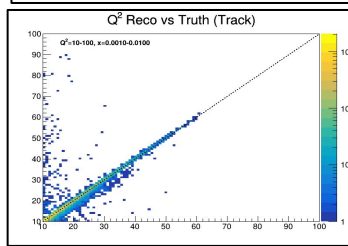
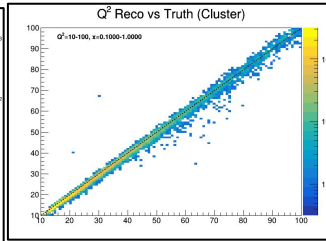
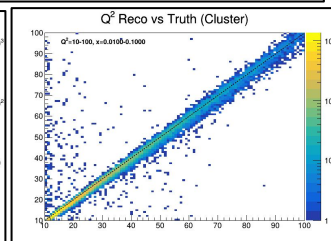
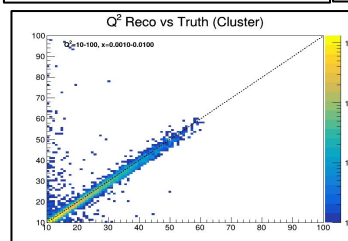
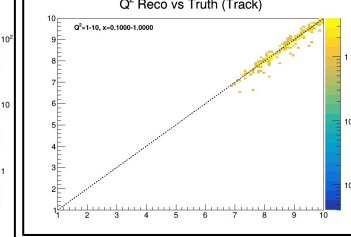
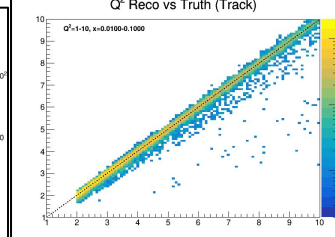
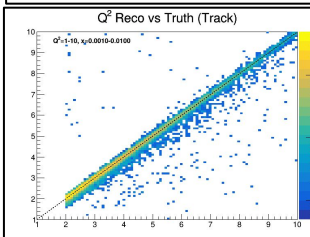
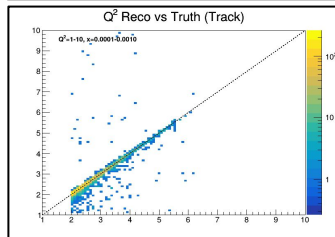
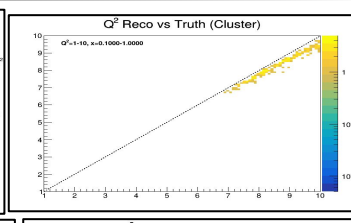
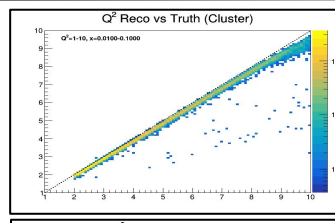
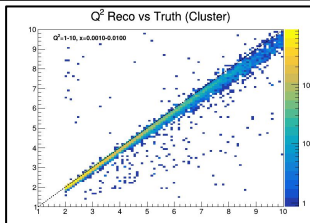
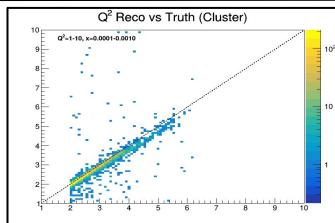
$$10 \leq Q^2 \leq 100$$

$$0.0001 \leq x \leq 0.001$$

$$0.001 \leq x \leq 0.01$$

$$0.01 \leq x \leq 0.1$$

$$0.1 \leq x \leq 1$$



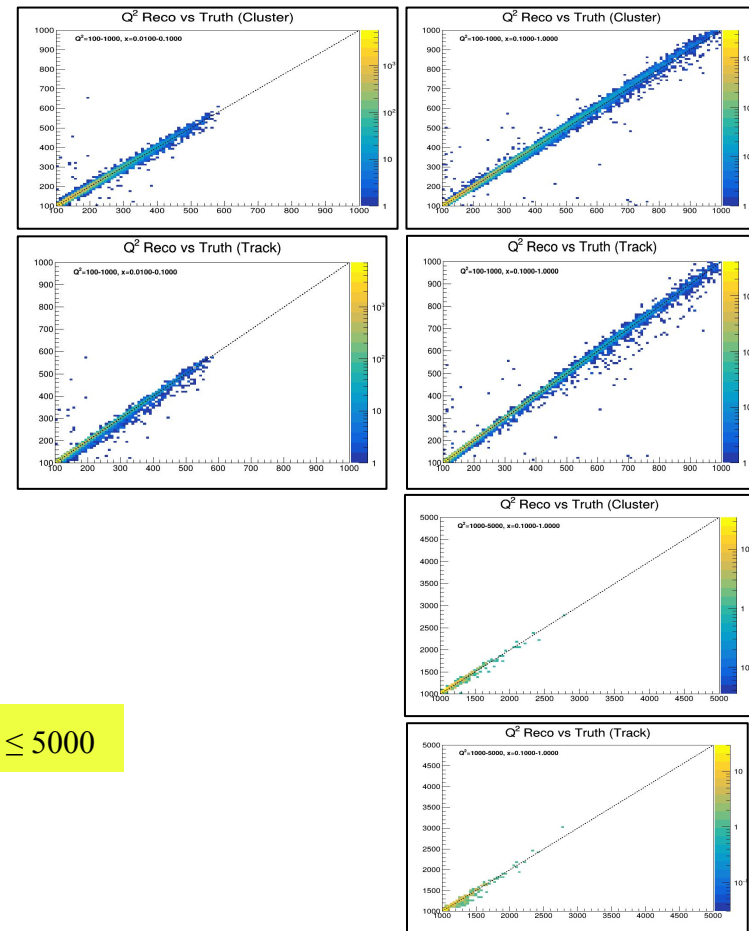
Response in (x,Q²) Bins

$$0.01 \leq x \leq 0.1$$

$$0.1 \leq x \leq 1$$

*No events for missing ranges

$$100 \leq Q^2 \leq 1000$$



$$1000 \leq Q^2 \leq 5000$$

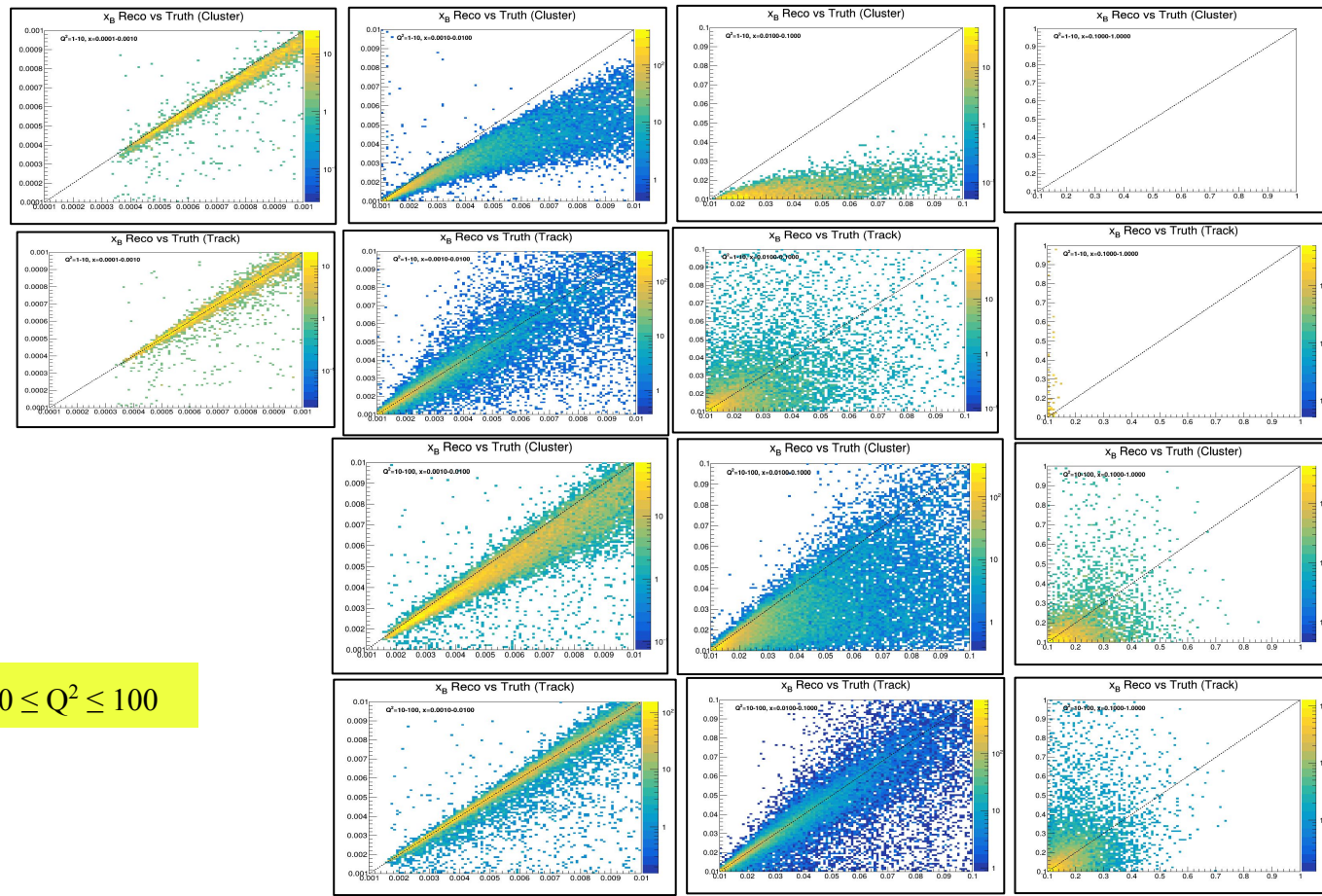
Response in (x, Q^2) Bins

 $0.0001 \leq x \leq 0.001$
 $0.001 \leq x \leq 0.01$
 $0.01 \leq x \leq 0.1$
 $0.1 \leq x \leq 1$

epic sim. 25.07.0
eHe3 10x166

 $1 \leq Q^2 \leq 10$

Plots are x_{Reco} vs x_{truth} in
different ranges of Q^2
and x

 $10 \leq Q^2 \leq 100$


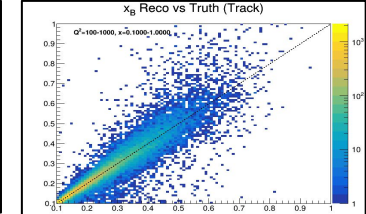
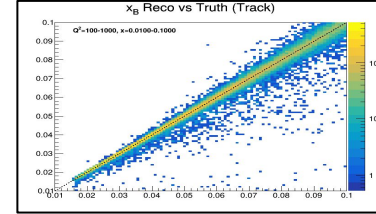
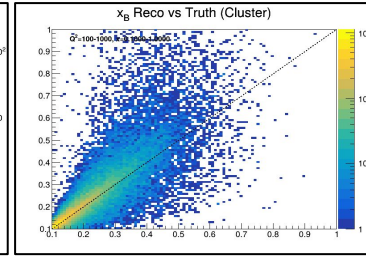
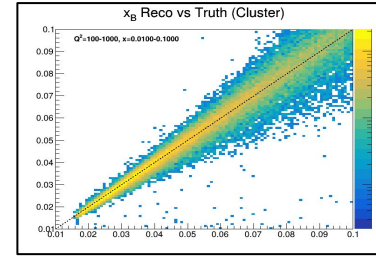
Response in (x, Q^2) Bins

$$0.01 \leq x \leq 0.1$$

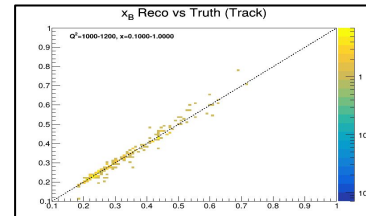
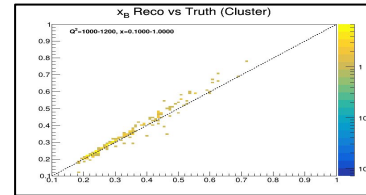
$$0.1 \leq x \leq 1$$

*No events for missing ranges

$$100 \leq Q^2 \leq 1000$$



$$1000 \leq Q^2 \leq 1200$$



Response in (x, Q^2) Bins

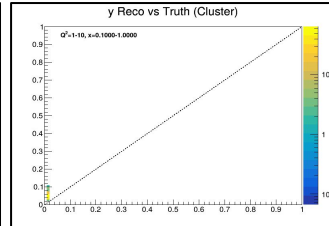
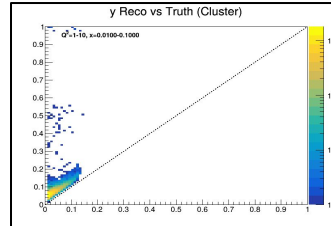
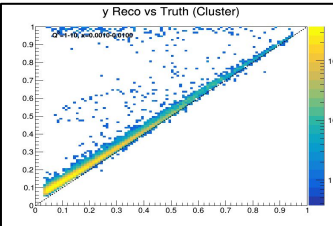
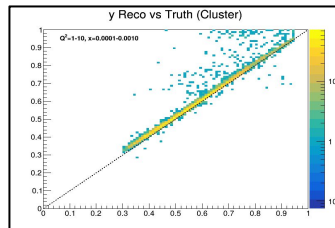
$$0.0001 \leq x \leq 0.001$$

$$0.001 \leq x \leq 0.01$$

$$0.01 \leq x \leq 0.1$$

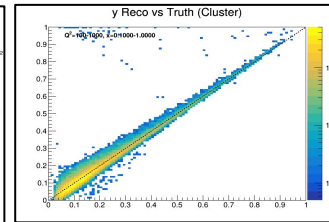
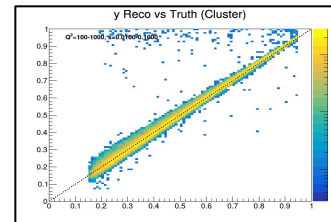
$$0.1 \leq x \leq 1$$

$$1 \leq Q^2 \leq 10$$

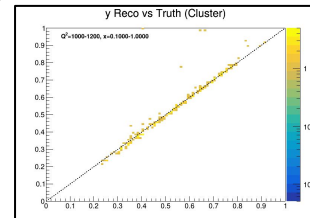
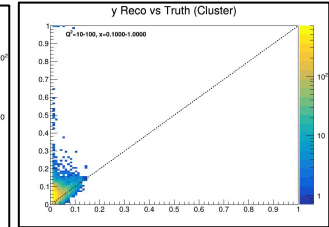
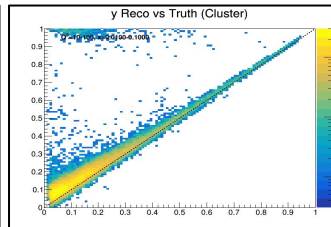
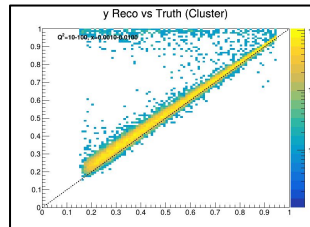


Plots are y_{Reco} vs y_{truth} in different ranges of Q^2 and x

$$10 \leq Q^2 \leq 100$$



$$100 \leq Q^2 \leq 1000$$



*No events for missing ranges

$$1000 \leq Q^2 \leq 1200$$

Resolution in (x, Q²) Bins

$$0.0001 \leq x \leq 0.001$$

$$0.001 \leq x \leq 0.01$$

$$0.01 \leq x \leq 0.1$$

$$0.1 \leq x \leq 1$$

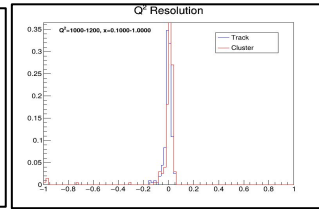
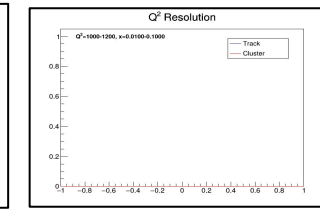
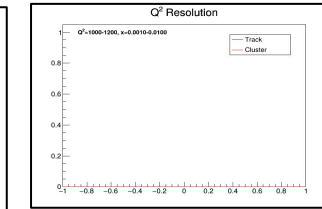
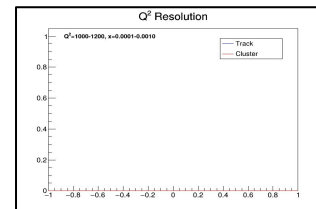
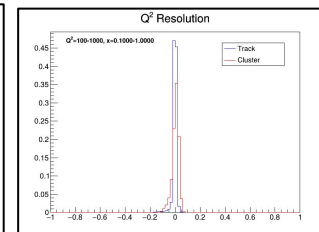
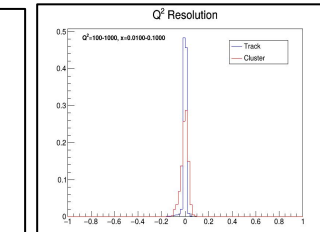
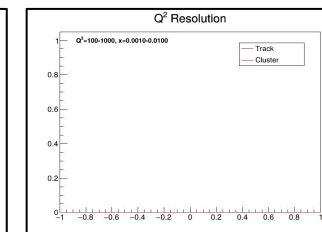
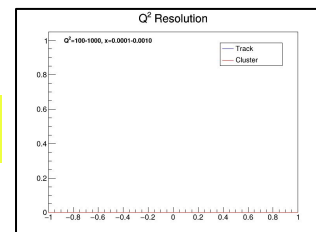
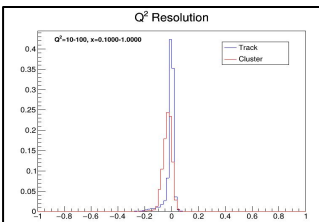
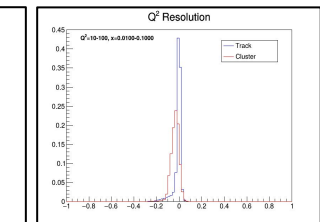
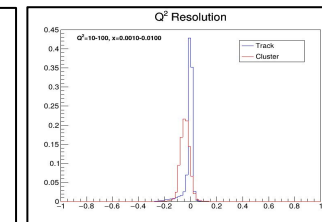
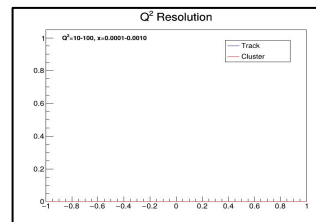
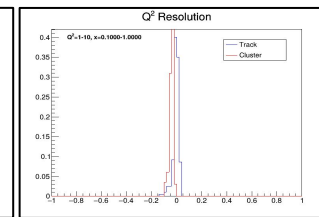
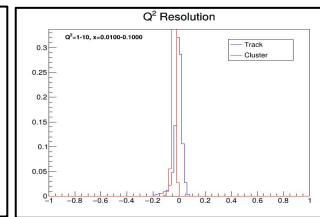
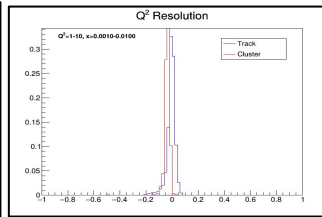
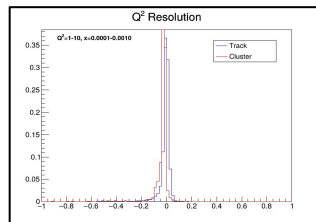
$$\frac{Q^2_{\text{Reco}}}{Q^2_{\text{truth}}}$$

$$1 \leq Q^2 \leq 10$$

$$10 \leq Q^2 \leq 100$$

$$100 \leq Q^2 \leq 1000$$

$$1000 \leq Q^2 \leq 1200$$



Resolution in (x, Q^2) Bins

$$0.0001 \leq x \leq 0.001$$

$$0.001 \leq x \leq 0.01$$

$$0.01 \leq x \leq 0.1$$

$$0.1 \leq x \leq 1$$

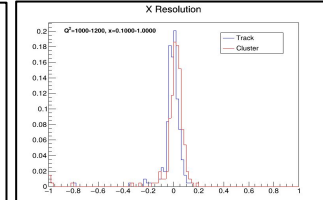
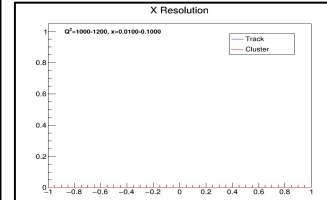
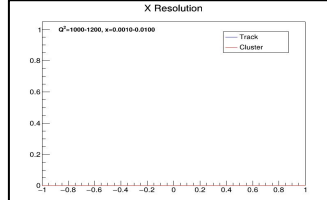
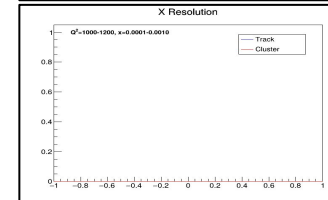
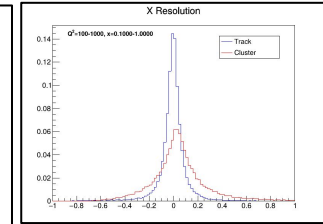
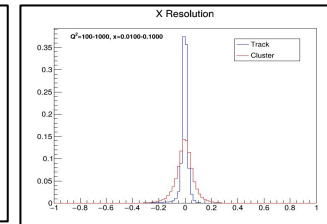
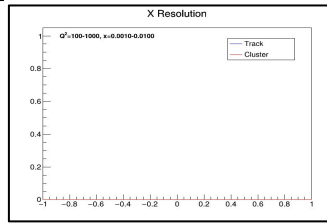
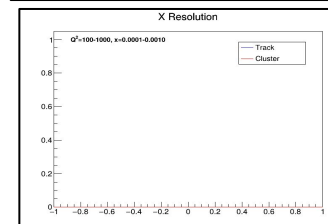
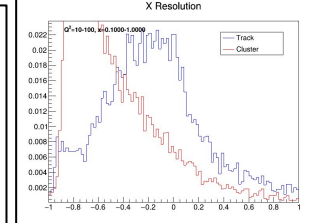
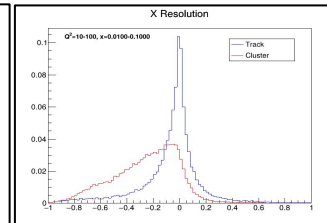
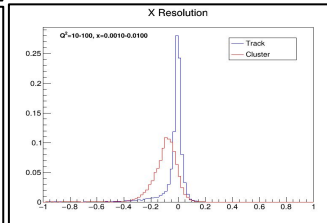
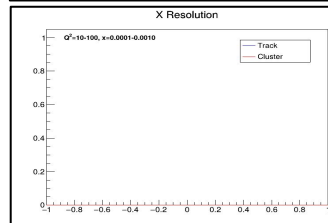
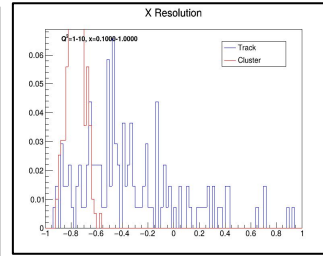
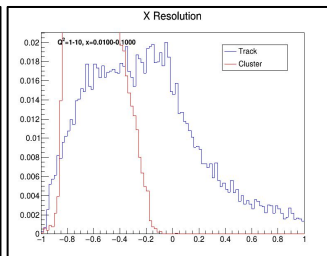
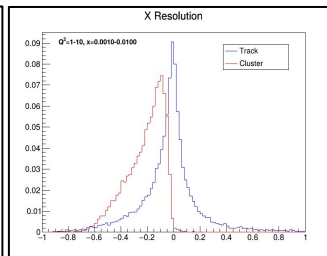
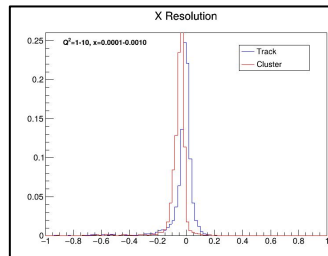
$$\frac{X_{\text{Reco}} - X_{\text{truth}}}{X_{\text{truth}}}$$

$$1 \leq Q^2 \leq 10$$

$$10 \leq Q^2 \leq 100$$

$$100 \leq Q^2 \leq 1000$$

$$1000 \leq Q^2 \leq 1200$$



Resolution in (x, Q^2) Bins

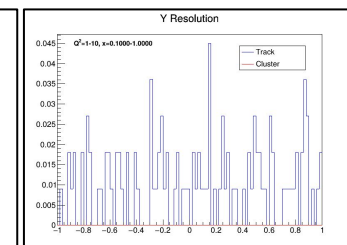
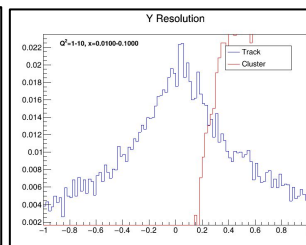
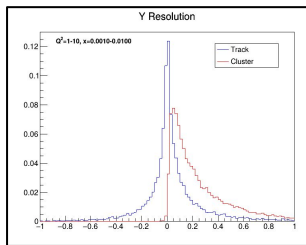
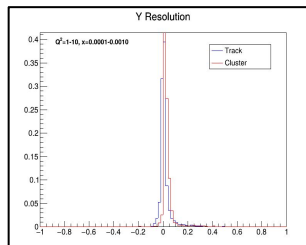
$$0.0001 \leq x \leq 0.001$$

$$0.001 \leq x \leq 0.01$$

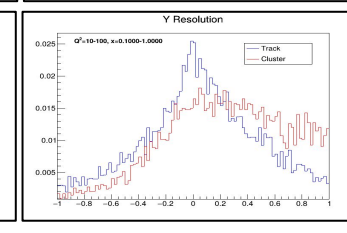
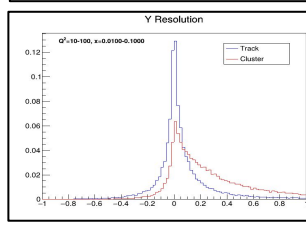
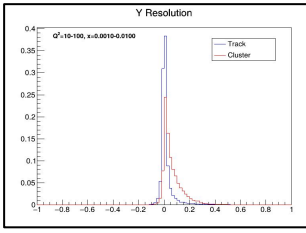
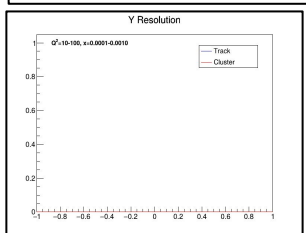
$$0.01 \leq x \leq 0.1$$

$$0.1 \leq x \leq 1$$

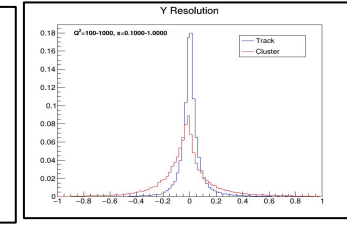
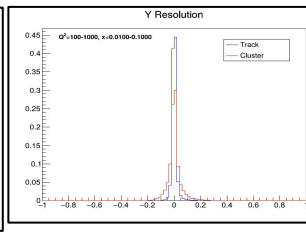
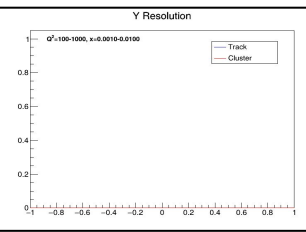
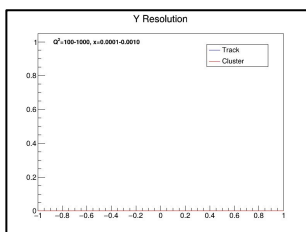
$$1 \leq Q^2 \leq 10$$



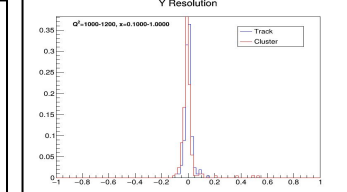
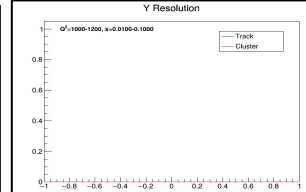
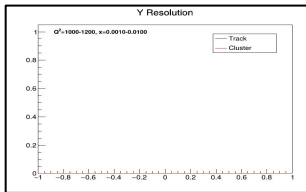
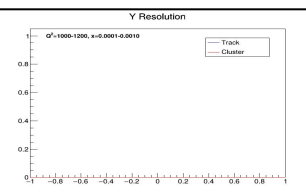
$$10 \leq Q^2 \leq 100$$



$$100 \leq Q^2 \leq 1000$$



$$1000 \leq Q^2 \leq 1200$$

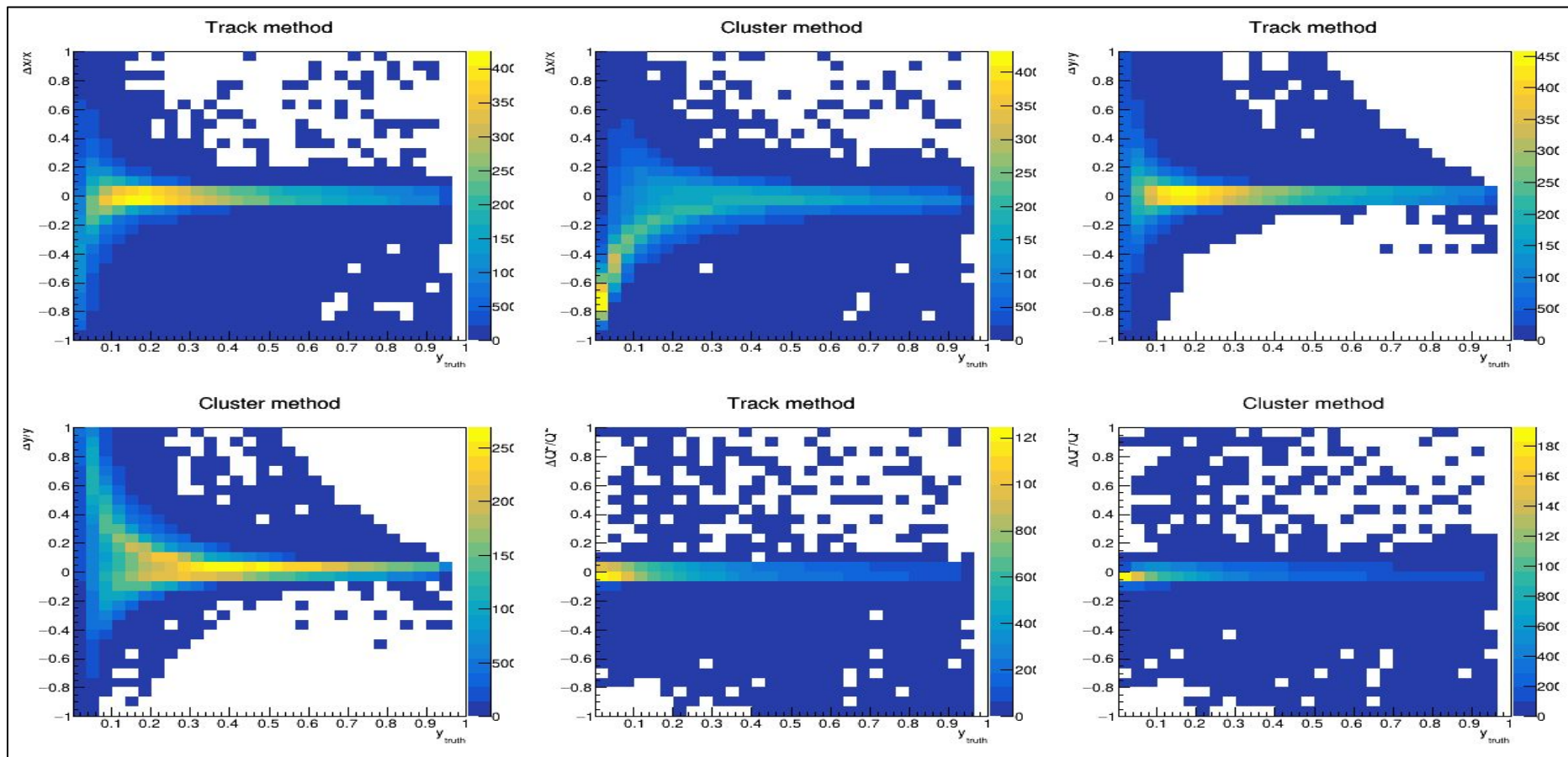


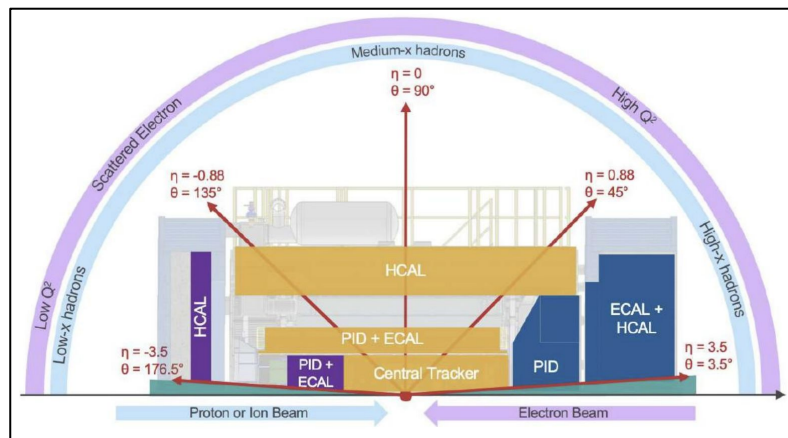
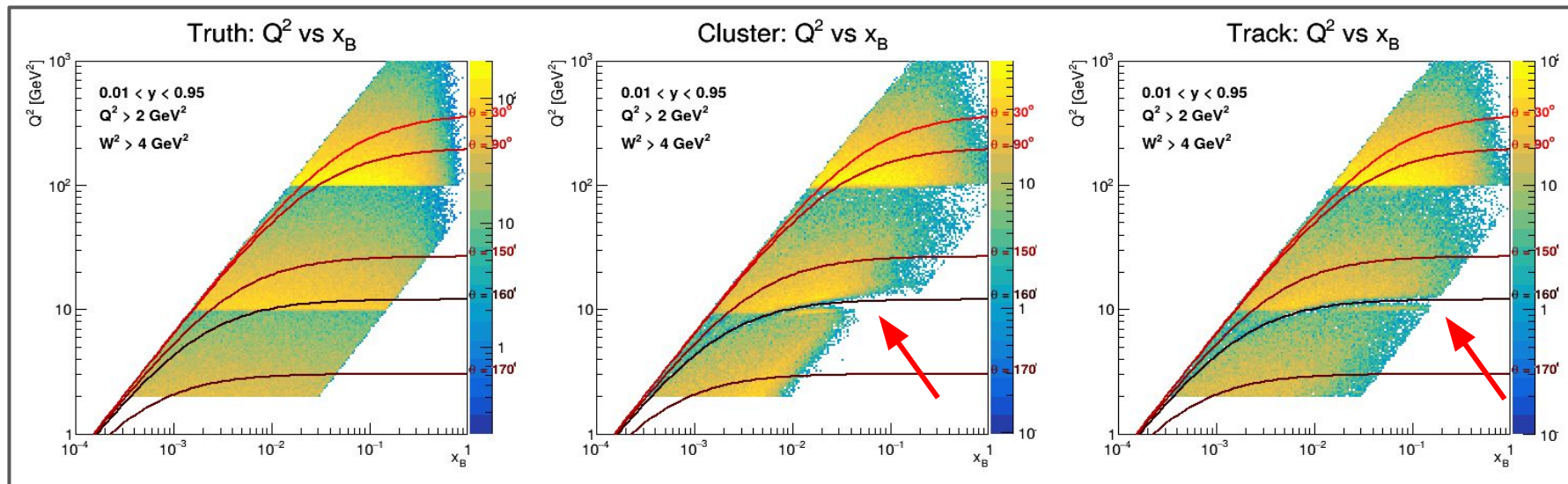
$$y_{\text{Reco}} - y_{\text{truth}}$$

$$y_{\text{truth}}$$

Resolution vs y_{truth}

epic sim. 25.07.0 eHe3 10x166





epic sim. 25.07.0
eHe3 10x166

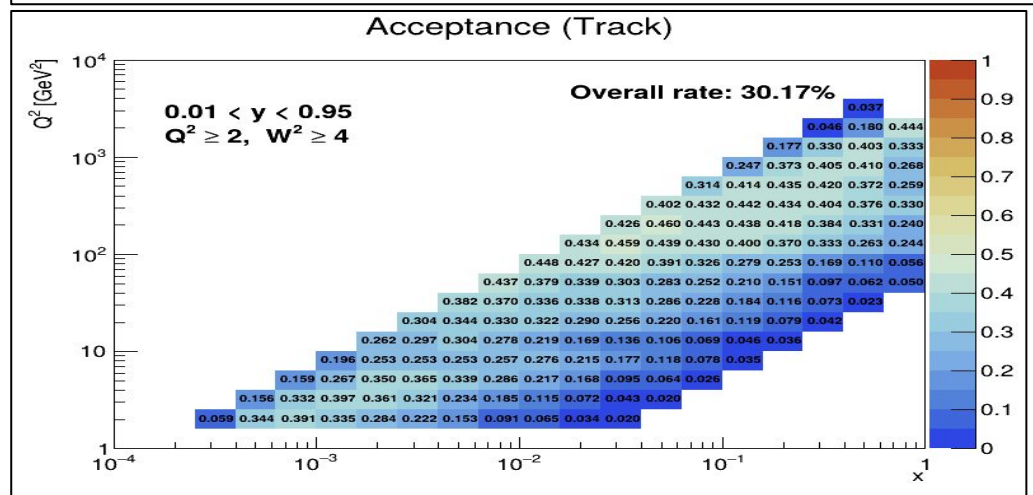
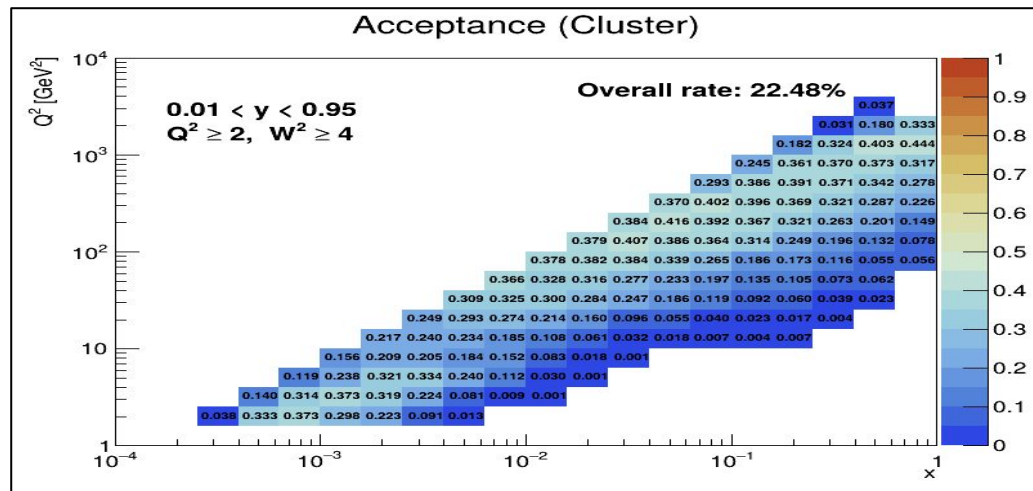
*Similar inefficiency in [Win's Analysis](#)

epic sim. 25.07.0
eHe3 (10x166)

$$C_{acc} = \frac{N_{rec}(x_{gen}, Q_{gen}^2)}{N_{gen}(x_{gen}, Q_{gen}^2)}$$

[Tyler's Slide](#)

*Poor Acceptance Rate, will try to improve using mix Recon. Methods for different ranges of observables.

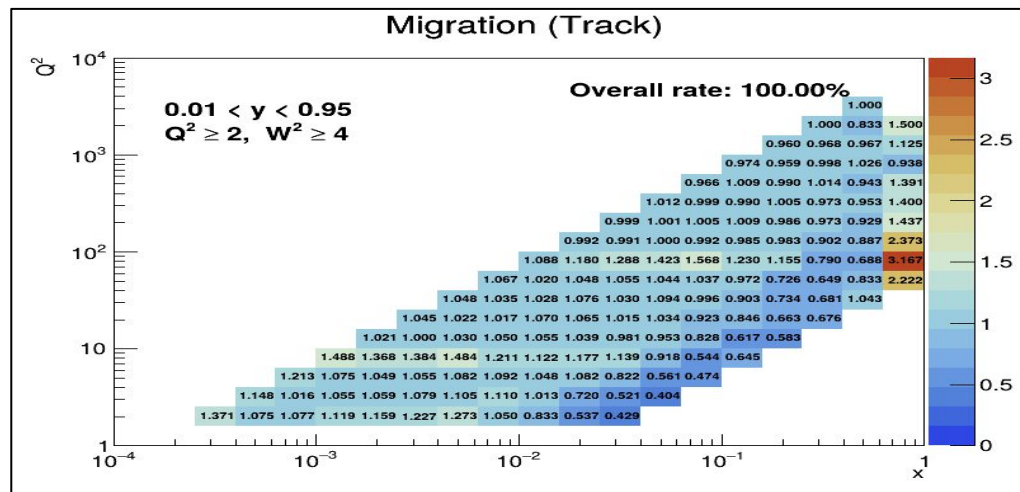
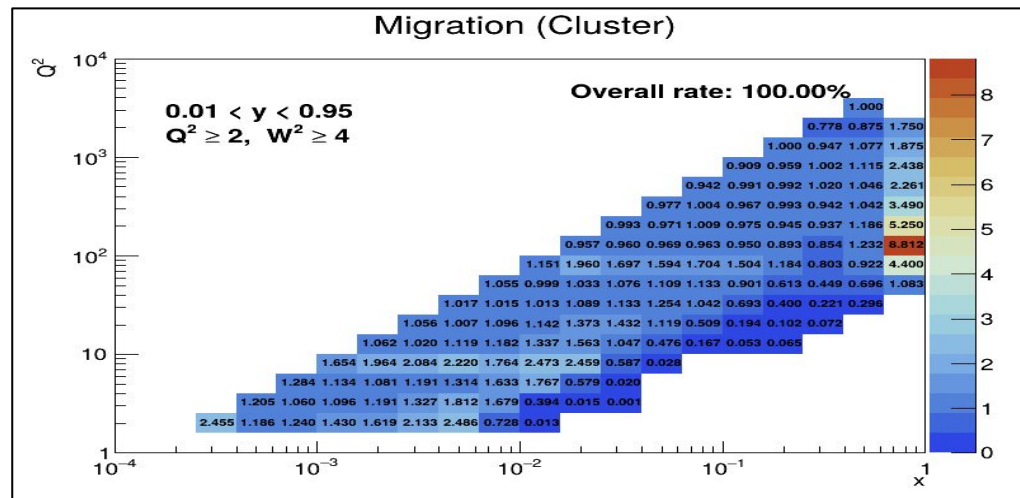


epic sim. 25.07.0
eHe3 (10x166)

$$C_{bin} = \frac{N_{rec}(x_{rec}, Q_{rec}^2)}{N_{rec}(x_{gen}, Q_{gen}^2)}$$

[Tyler's Slide](#)

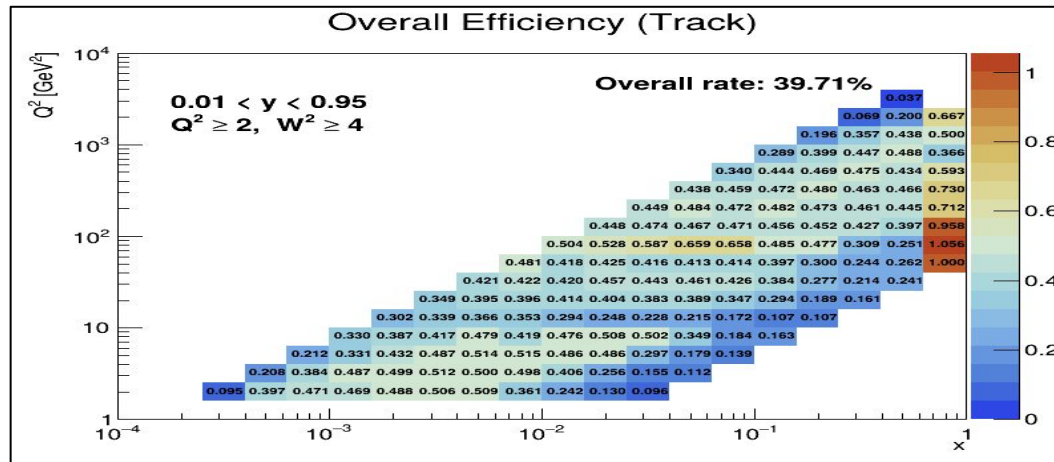
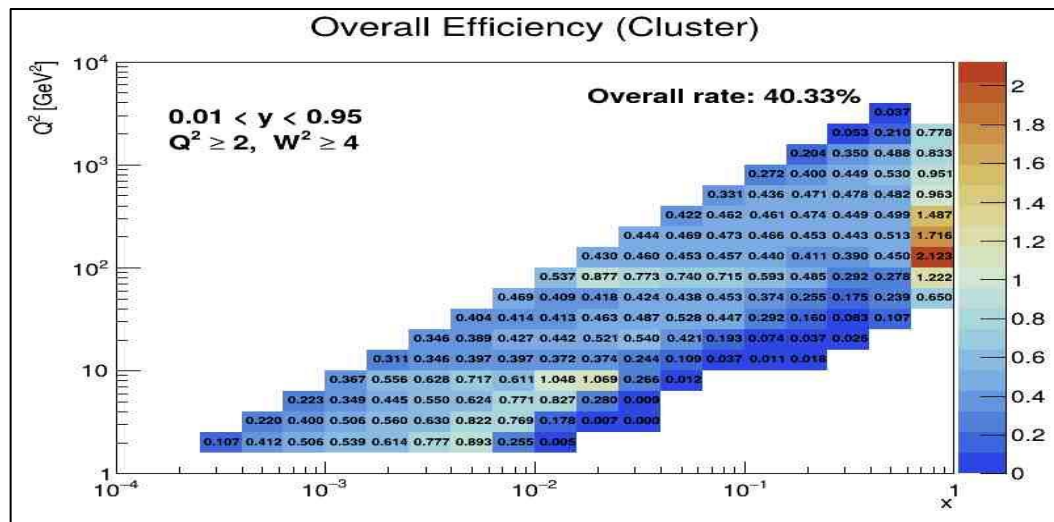
*No QED effect involved



epic sim. 25.07.0
eHe3 (10x166)

$$C_{\text{tot}} = C_{\text{acc}} \cdot C_{\text{bin}} = \frac{N_{\text{rec}}(x_{\text{rec}}, Q_{\text{rec}}^2)}{N_{\text{gen}}(x_{\text{gen}}, Q_{\text{gen}}^2)}$$

[Win's slide](#)



Cross section from simulation files

$$\frac{d\sigma}{dx_B dQ^2} = \frac{N}{C_{acc} \cdot C_{bin} L \cdot \Delta x_B \Delta Q^2}$$

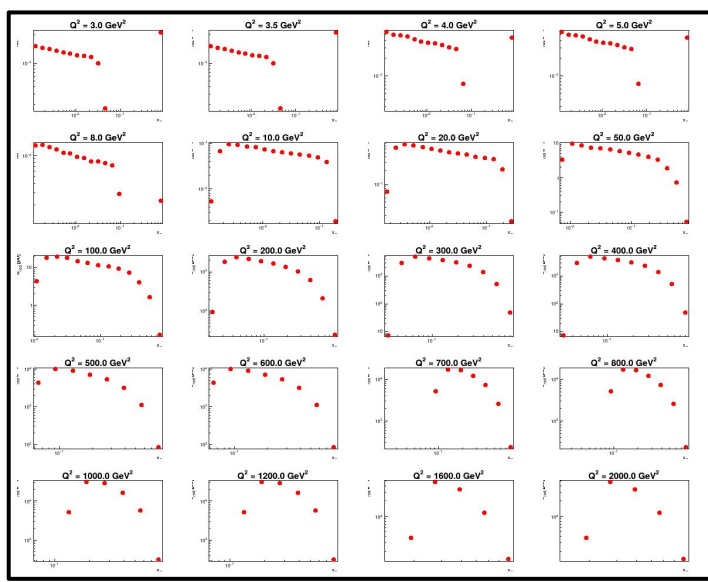
$$\sigma_{red} = \left(\frac{d\sigma}{dx_B dQ^2} \right) \cdot \frac{Q^4 x_B}{2\pi\alpha^2 Y_+ \hbar^2 c^2}$$

$$Y_+ = 1 + (1 - y)^2$$

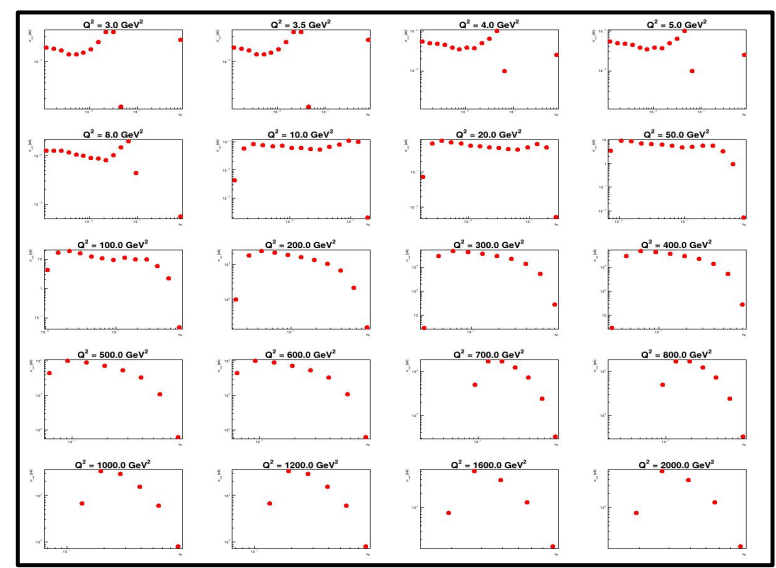
- Acceptance and bin migration corrections from simulation

$$C_{acc} = \frac{N_{rec}(x_{gen}, Q_{gen}^2)}{N_{gen}(x_{gen}, Q_{gen}^2)} \quad C_{bin} = \frac{N_{rec}(x_{rec}, Q_{rec}^2)}{N_{rec}(x_{gen}, Q_{gen}^2)}$$

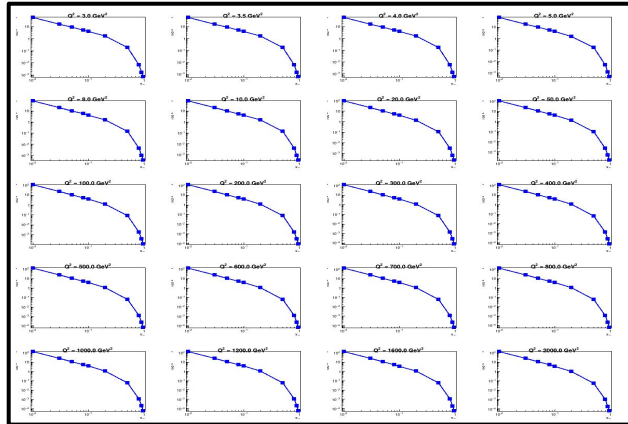
- Scale counts to integrated luminosity of $L = 1 \text{ fb}^{-1}$.
- Bin volumes $\Delta x_B \Delta Q^2$ from Monte Carlo (account for cuts)
- Using same simulated events for analysis and corrections...
by definition will obtain the generated distributions
- Detector and reconstruction performance determines
size of the corrections



C_{bin} correction



EPPS21nlo_CT18Anlo_He3

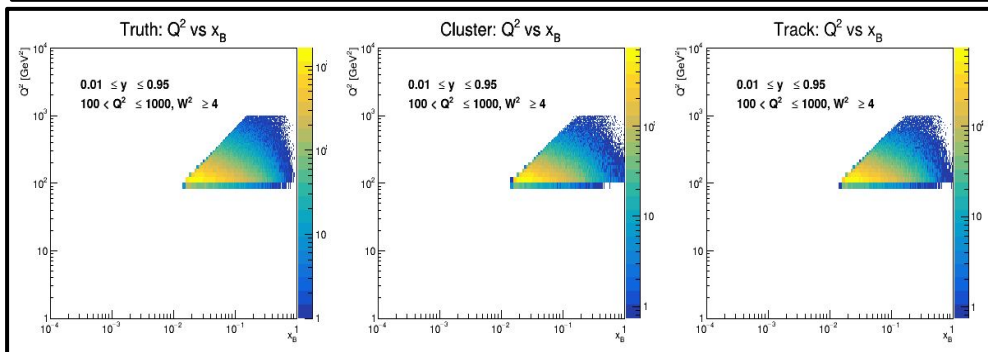
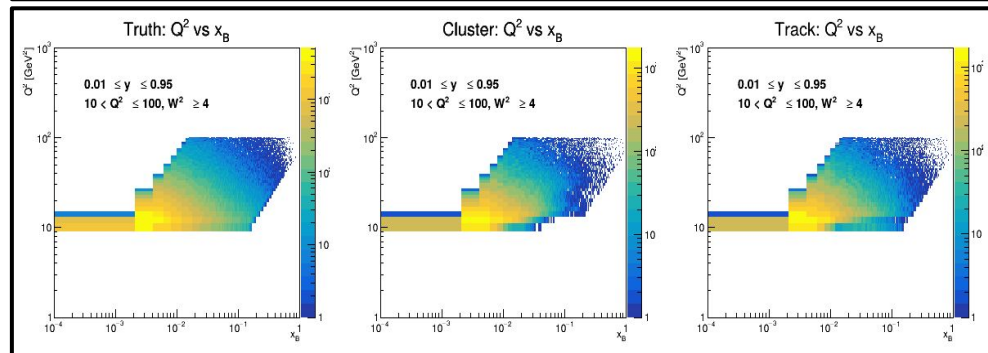
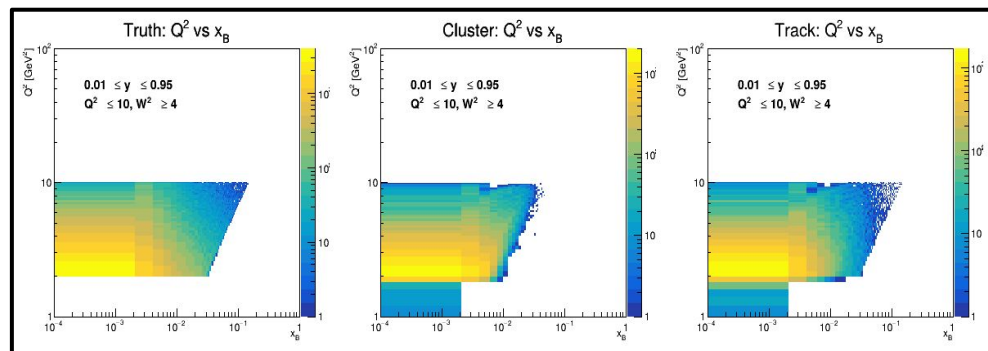
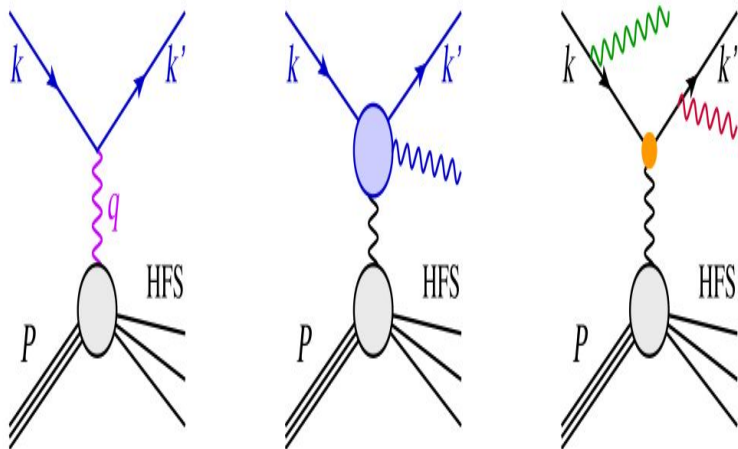


Details of Analysis

eHe3(10x166GeV) *25.07.0

- eID based Reconstruction
- Electron method
- Only track Information
- Logarithmic binning
- Bin widths ($\Delta x \times \Delta Q^2$)

*Extra Slides



$$C_{bin} = \frac{N_{rec}(x_{rec}, Q_{rec}^2)}{N_{rec}(x_{gen}, Q_{gen}^2)}$$

```
double C_bin = double(Nrec_recbin[ix_bin][iq]) / Nrec[ix_bin][iq];
```

♦ What are these quantities

Variable	Meaning	Filled in the event loop
<code>Ngen[ix][iq]</code>	Number of generated events in the true (MC) bin (x_B, Q^2)	<code>Ngen[ix][iq]++</code>
<code>Nrec[ix][iq]</code>	Number of reconstructed events (that pass detector selection) corresponding to the true MC bin	incremented if <code>positive_eID</code> is true
<code>Nrec_genbin[ix][iq]</code>	Number of reconstructed events whose reconstructed bin equals the generated bin (same (x_B, Q^2))	<code>if(ix==ix_rec && iq==iq_rec)</code>
<code>Nrec_recbin[ix_rec][iq_rec]</code>	Number of events reconstructed in this reconstructed bin , regardless of where they were generated	<code>Nrec_recbin[ix_rec][iq_rec]++</code>