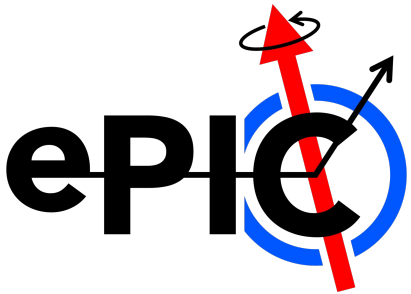
Update on eID Performance and Cross-section for eHe3

Shubham Yadav

Inclusive PWG meeting

14/10/2025



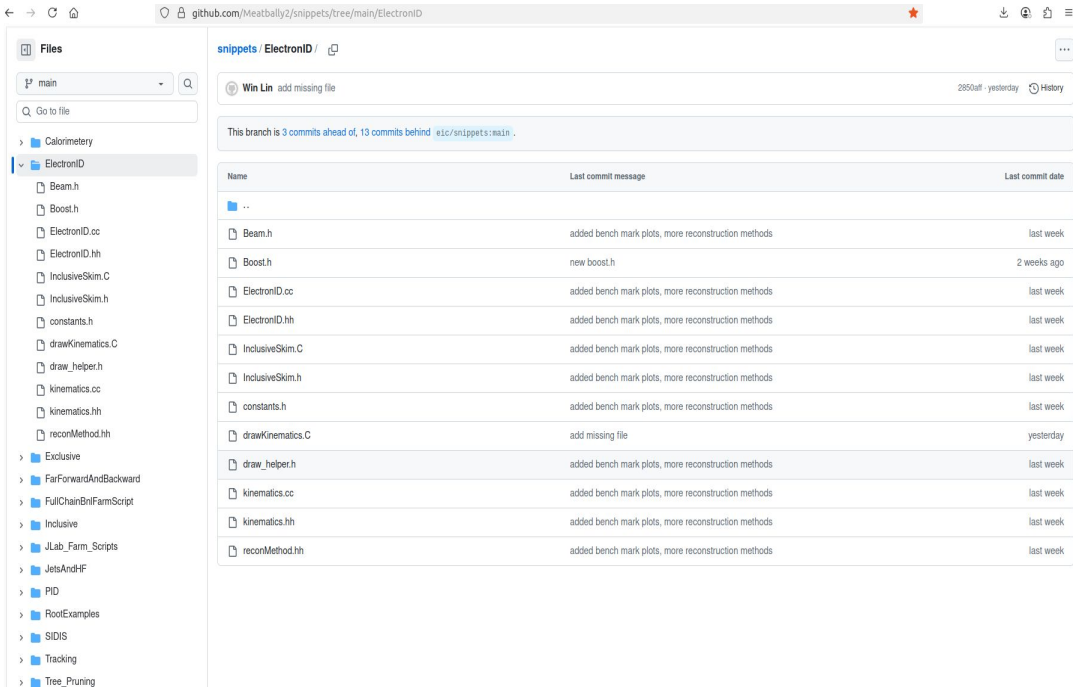
❑ eID based reconstruction

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

*Initially developed by Tyler.
*Win has added more files.

Truth ⟶ MC information

Reco ⟶ Reconstructed information



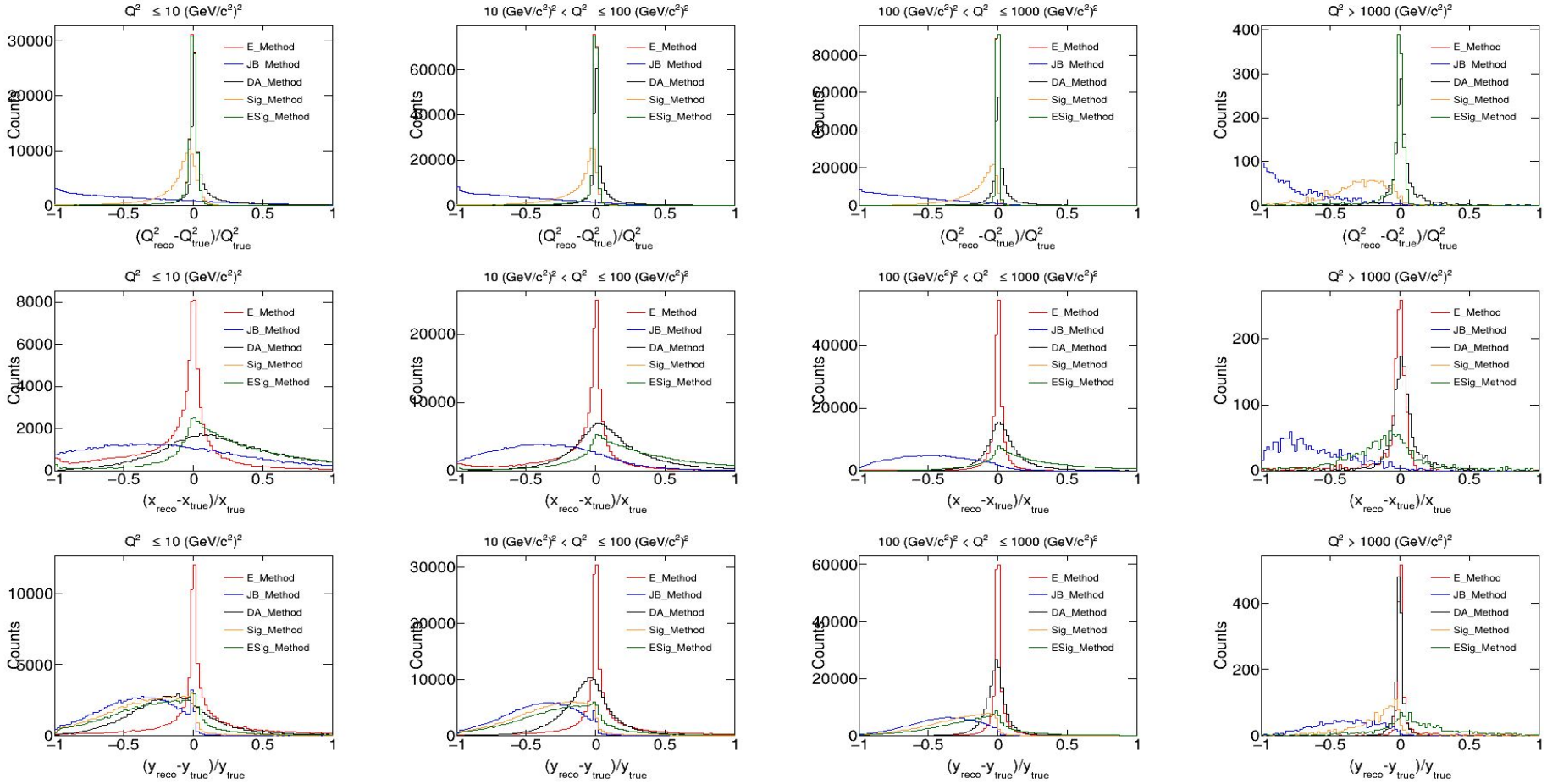
Various Reconstruction Method

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	$4E_0E - 4E_0^2(1-y)$	$\frac{Q^2}{2\Sigma}$
$E_0 \theta \Sigma$	$[E_0,\ \theta,\ \Sigma]$	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]	$[E_0,\ E,\ E_h]$	$\frac{E-E_0}{(xE_p)-E_0}$	$4E_0 y(xE_p)$	$E + E_h - E_0$
$E \Sigma T$	$[E,\ \Sigma,\ T]$	$\frac{\Sigma}{\Sigma+E\pm\sqrt{E^2+T^2}}$	$\frac{T^2}{1-y}$	$\frac{Q^2}{2\Sigma}$
$E_0 E T$	$[E_0,\ E,\ T]$	$\frac{2E_0-E\mp\sqrt{E^2-T^2}}{2E_0}$	$\frac{T^2}{1-y}$	$\frac{Q^2}{4E_0 y}$
Sigma (Σ) [9]	$[E_0,\ E,\ \Sigma,\ \theta]$	$y_{I\Sigma}$	$Q^2_{I\Sigma}$	$\frac{Q^2}{4E_0 y}$
eSigma ($e\Sigma$) [9]	$[E_0,\ E,\ \Sigma,\ \theta]$	$\frac{2E_0\Sigma}{(\Sigma+\Sigma_e)^2}$	$2E_0E(1+\cos\theta)$	$\frac{E(1+\cos\theta)(\Sigma+\Sigma_e)}{2\Sigma}$

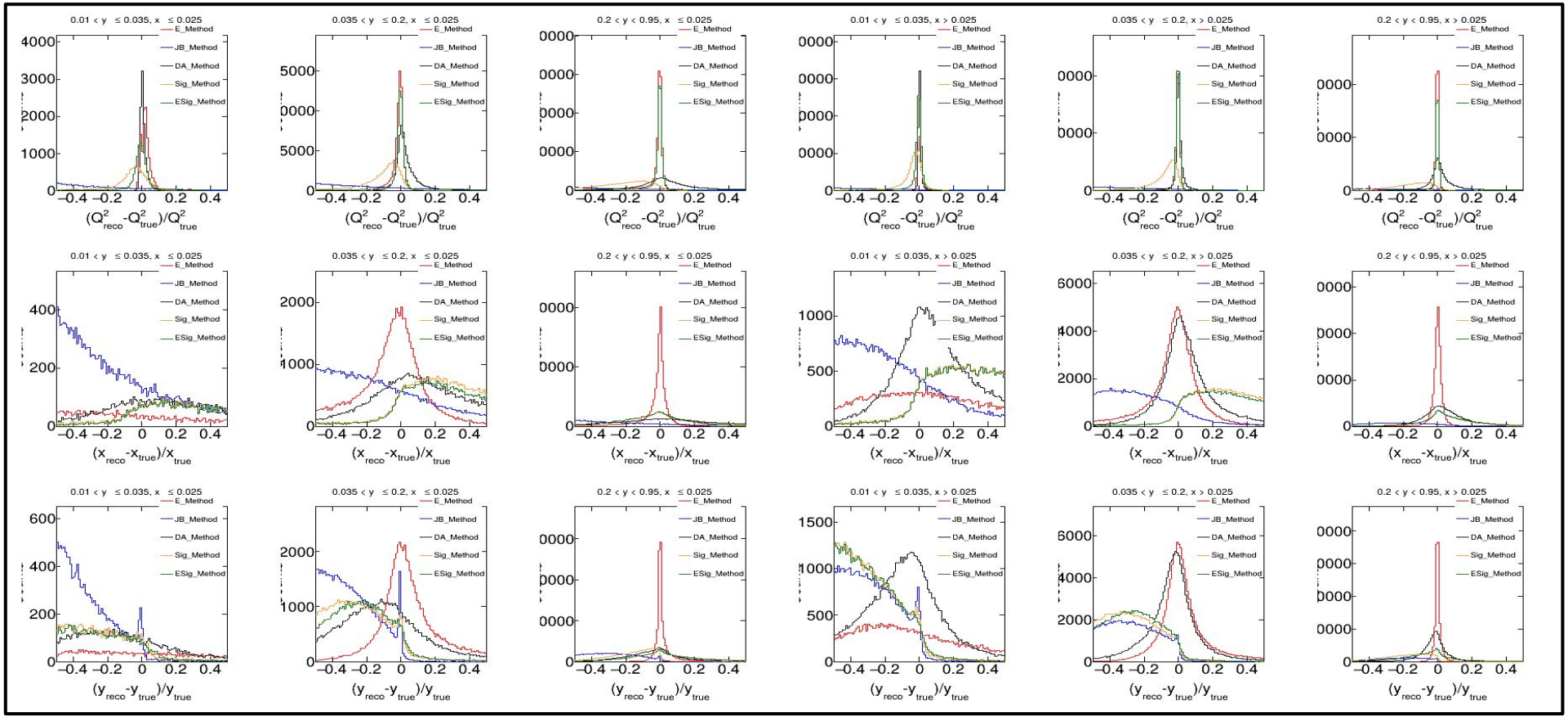
https://arxiv.org/pdf/2110.05505

Resolution performance of different Recon Methods at Q^2 ranges

epic sim. 25.07.0
eHe3 10x166



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

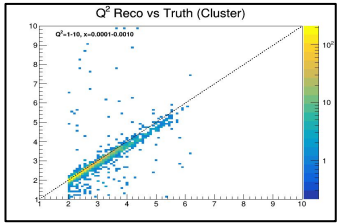
$0.0001 \leq x \leq 0.001$ | $0.001 \leq x \leq 0.01$ | $0.01 \leq x \leq 0.1$ | $0.1 \leq x \leq 1$

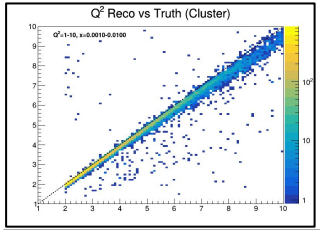
epic sim. 25.07.0
eHe3 10x166

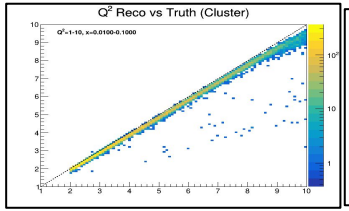
$1 \leq Q^2 \leq 10$

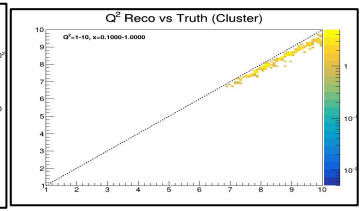
Plots are Q^2_{Reco} vs Q^2_{truth} in different ranges of Q^2 and x

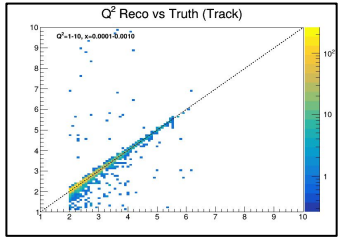
$10 \leq Q^2 \leq 100$

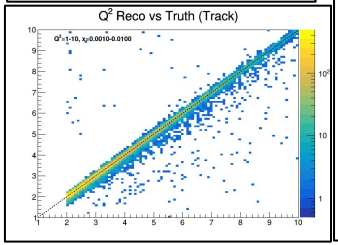


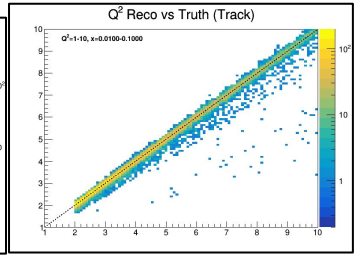


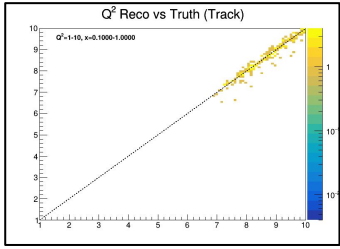


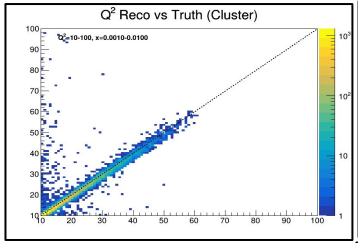


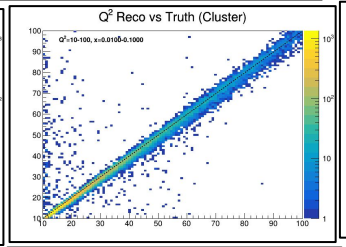


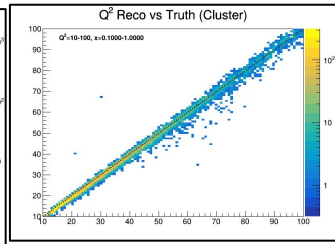


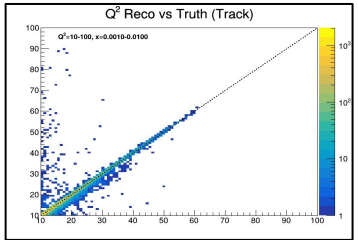


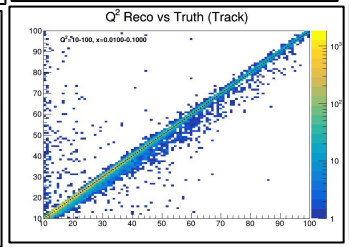


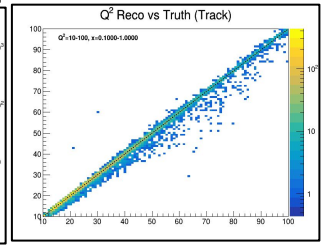












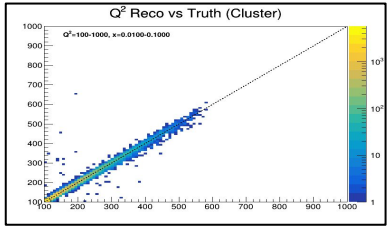
Response in (x,Q^2) Bins

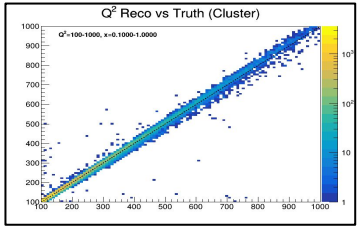
$0.01 \leq x \leq 0.1$

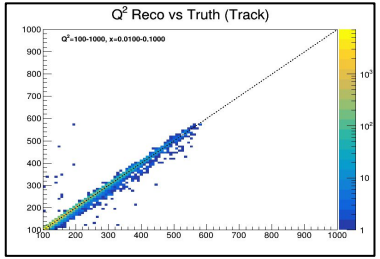
$0.1 \leq x \leq 1$

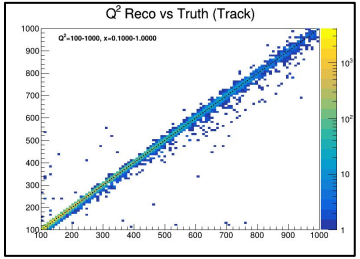
*No events for missing ranges

$100 \leq Q^2 \leq 1000$

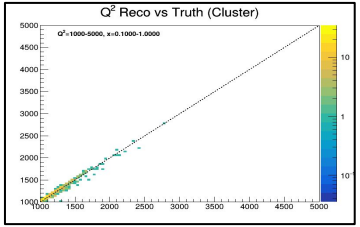


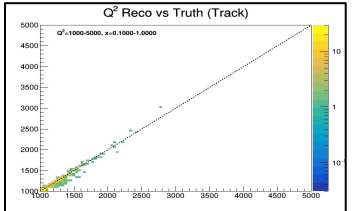






$1000 \leq Q^2 \leq 5000$





Response in (x,Q^2) Bins

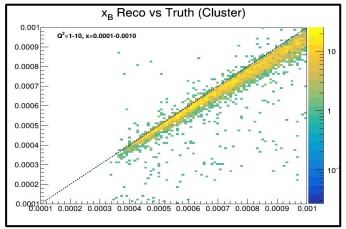
$0.0001 \le x \le 0.001$ | $0.001 \le x \le 0.01$ | $0.01 \le x \le 0.1$ | $0.1 \le x \le 1$

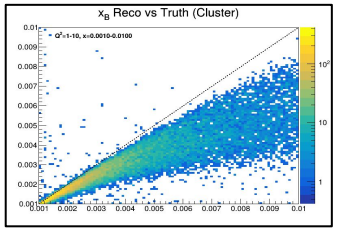
epic sim. 25.07.0
eHe3 10x166

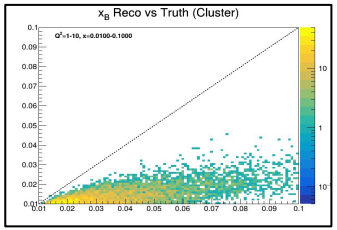
$1 \le Q^2 \le 10$

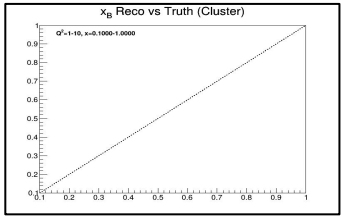
Plots are x_{Reco} vs x_{truth} in different ranges of Q^2 and x

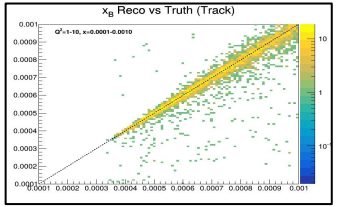
$10 \le Q^2 \le 100$

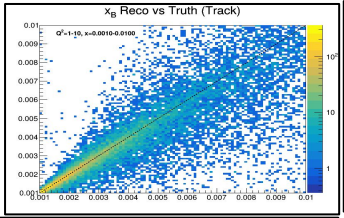


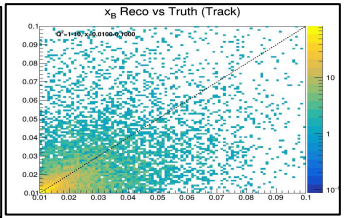


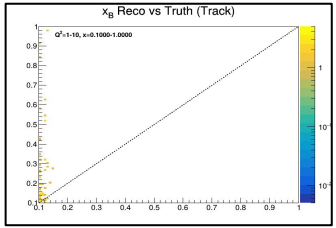


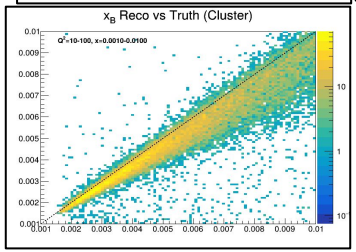


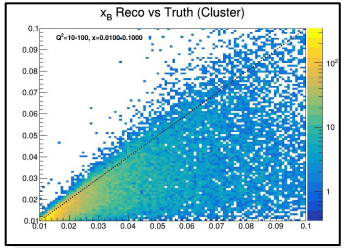


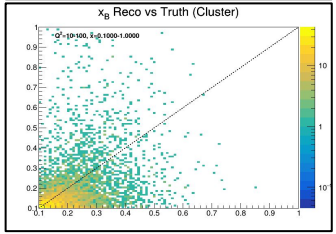


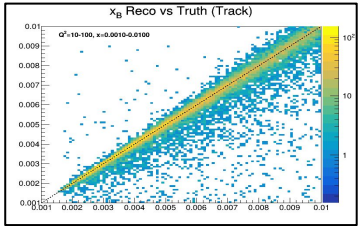


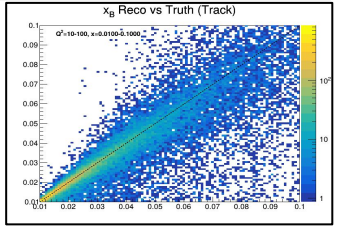


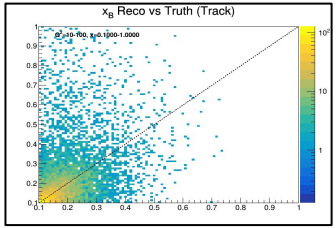












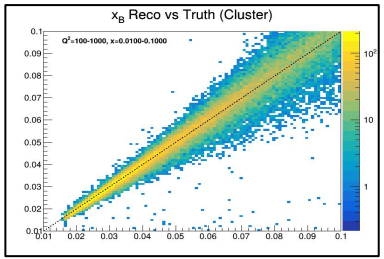
Response in (x,Q^2) Bins

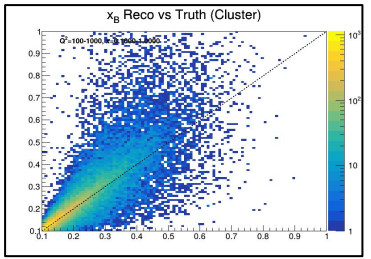
$0.01 \leq x \leq 0.1$

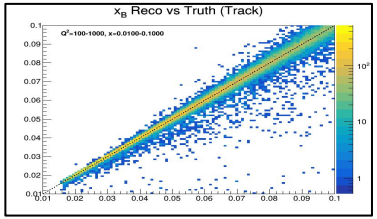
$0.1 \leq x \leq 1$

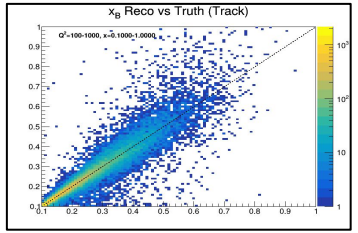
*No events for missing ranges

$100 \leq Q^2 \leq 1000$

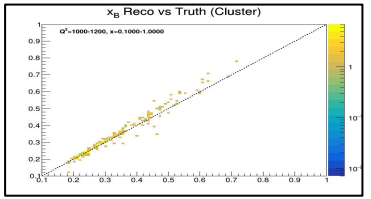


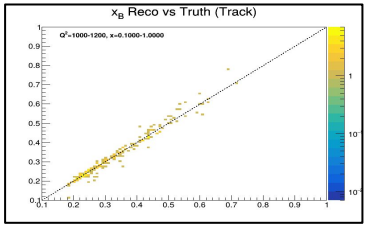






$1000 \leq Q^2 \leq 1200$





Response in (x,Q^2) Bins

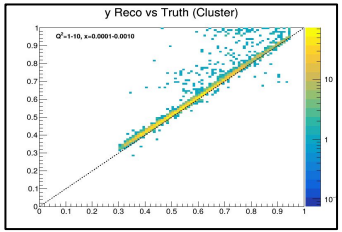
$0.0001 \leq x \leq 0.001$

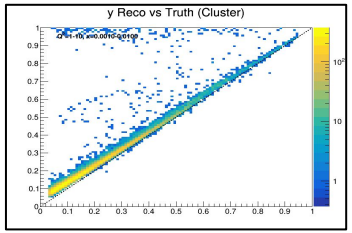
$0.001 \leq x \leq 0.01$

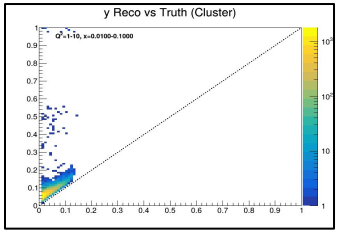
$0.01 \leq x \leq 0.1$

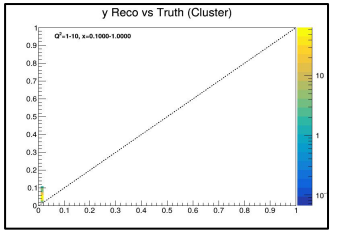
$0.1 \leq x \leq 1$

$1 \leq Q^2 \leq 10$



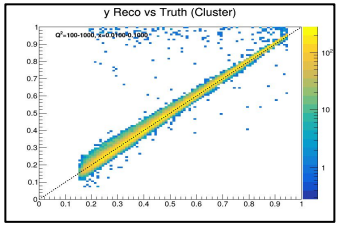


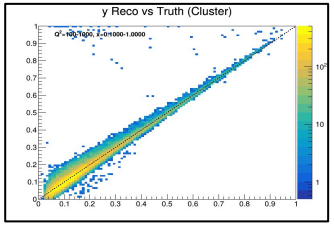




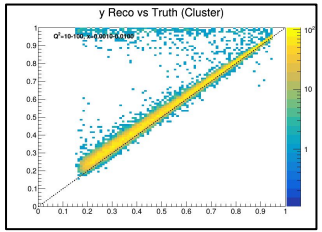
Plots are y_{Reco} vs y_{truth} in different ranges of Q^2 and x

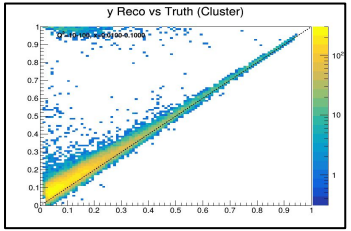
$10 \leq Q^2 \leq 100$

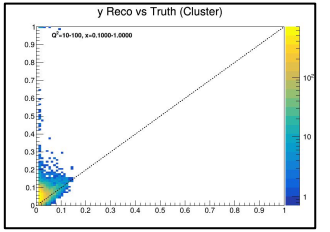




$100 \leq Q^2 \leq 1000$

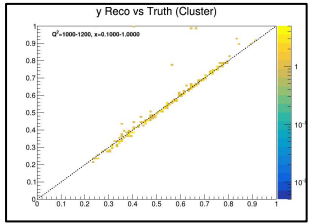






*No events for missing ranges

$1000 \leq Q^2 \leq 1200$



Resolution in (x,Q^2) Bins

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

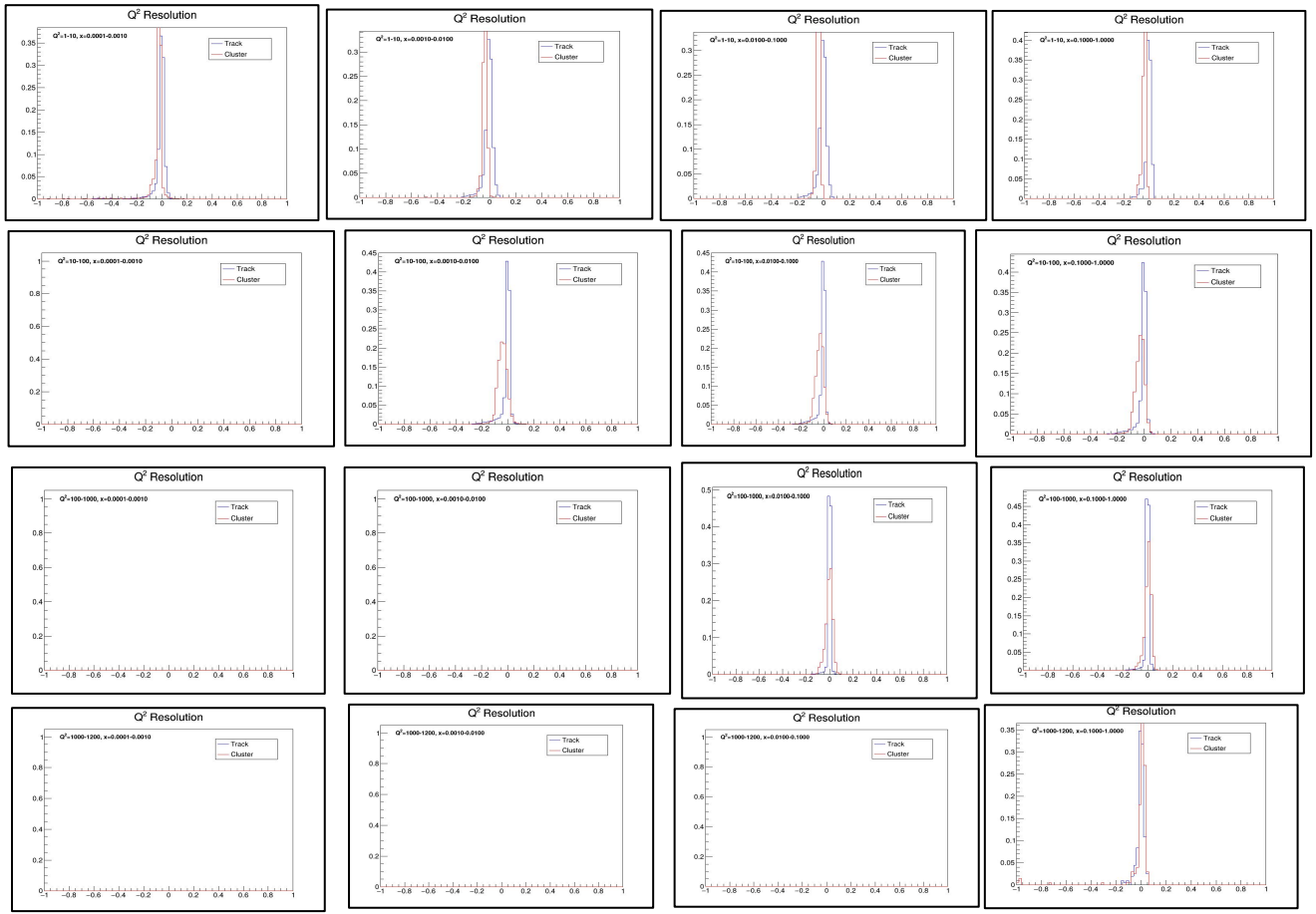
$$\frac{Q^2_{Reco} - Q^2_{truth}}{Q^2_{truth}}$$

$1 \leq Q^2 \leq 10$

$10 \leq Q^2 \leq 100$

$100 \leq Q^2 \leq 1000$

$1000 \leq Q^2 \leq 1200$



Resolution in (x,Q^2) Bins

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

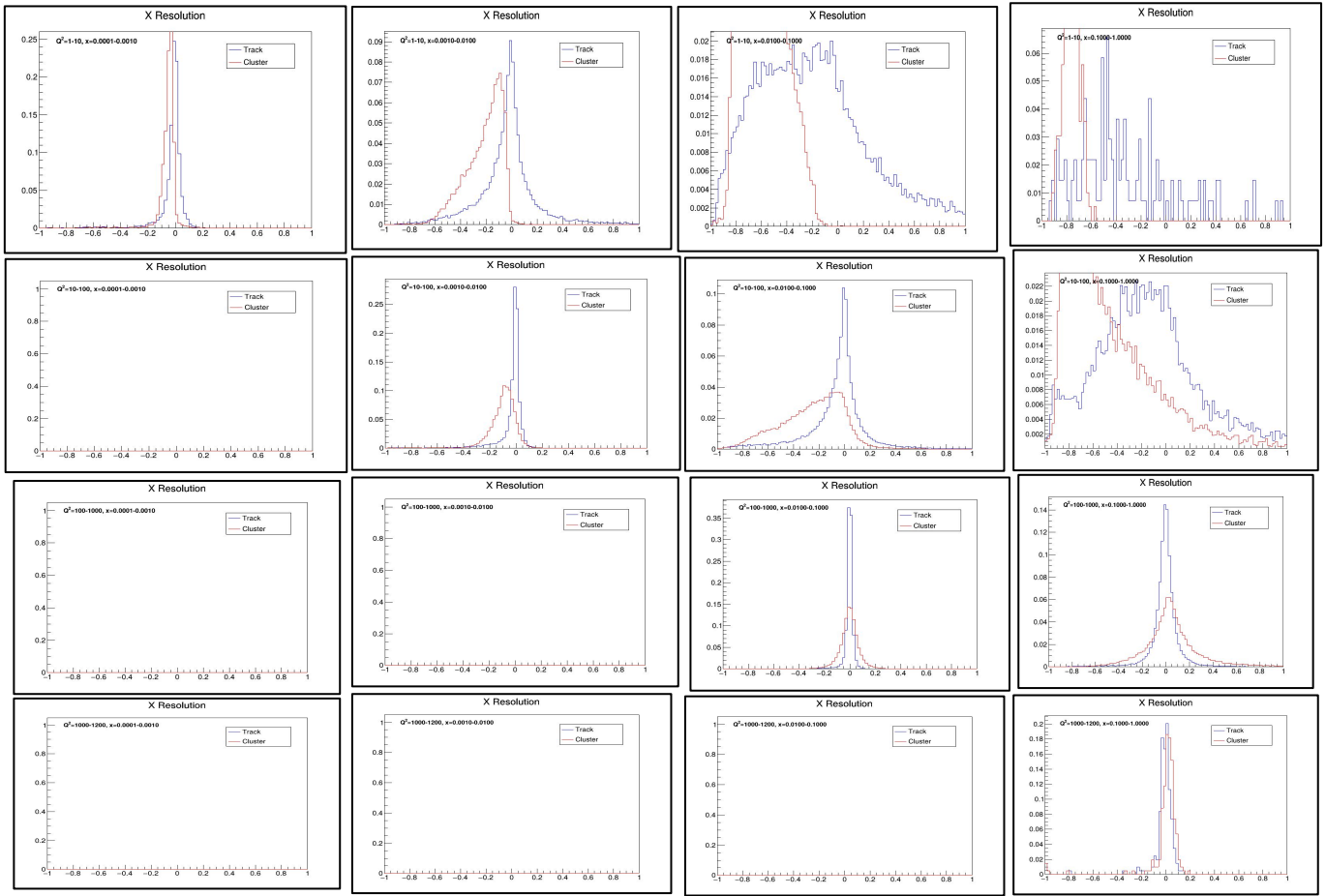
$$\frac{x_{Reco} - x_{truth}}{x_{truth}}$$

$1 \le Q^2 \le 10$

$10 \le Q^2 \le 100$

$100 \le Q^2 \le 1000$

$1000 \le Q^2 \le 1200$



Resolution in (x,Q^2) Bins

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

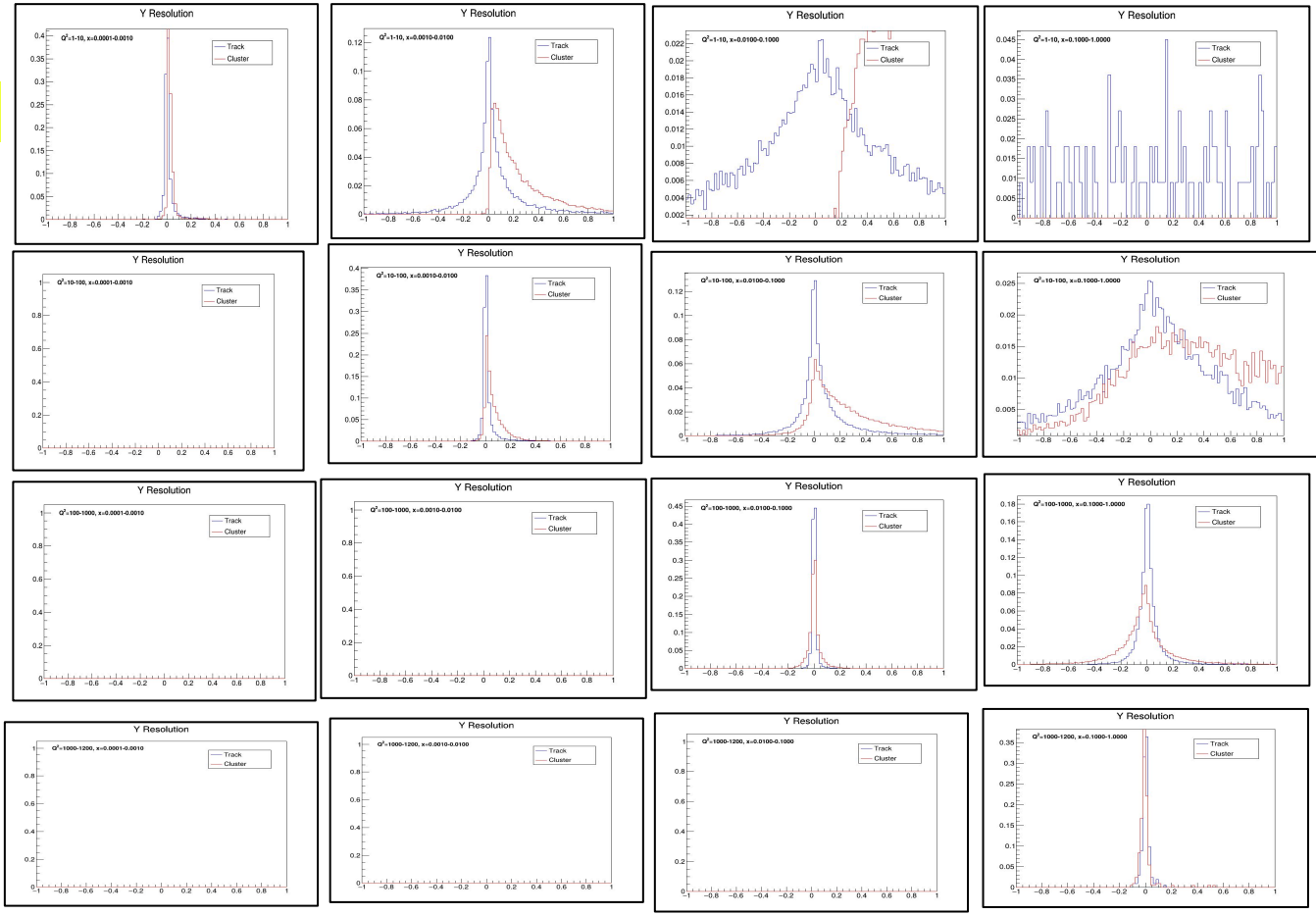
$$\frac{y_{Reco} - y_{truth}}{y_{truth}}$$

$1 \le Q^2 \le 10$

$10 \le Q^2 \le 100$

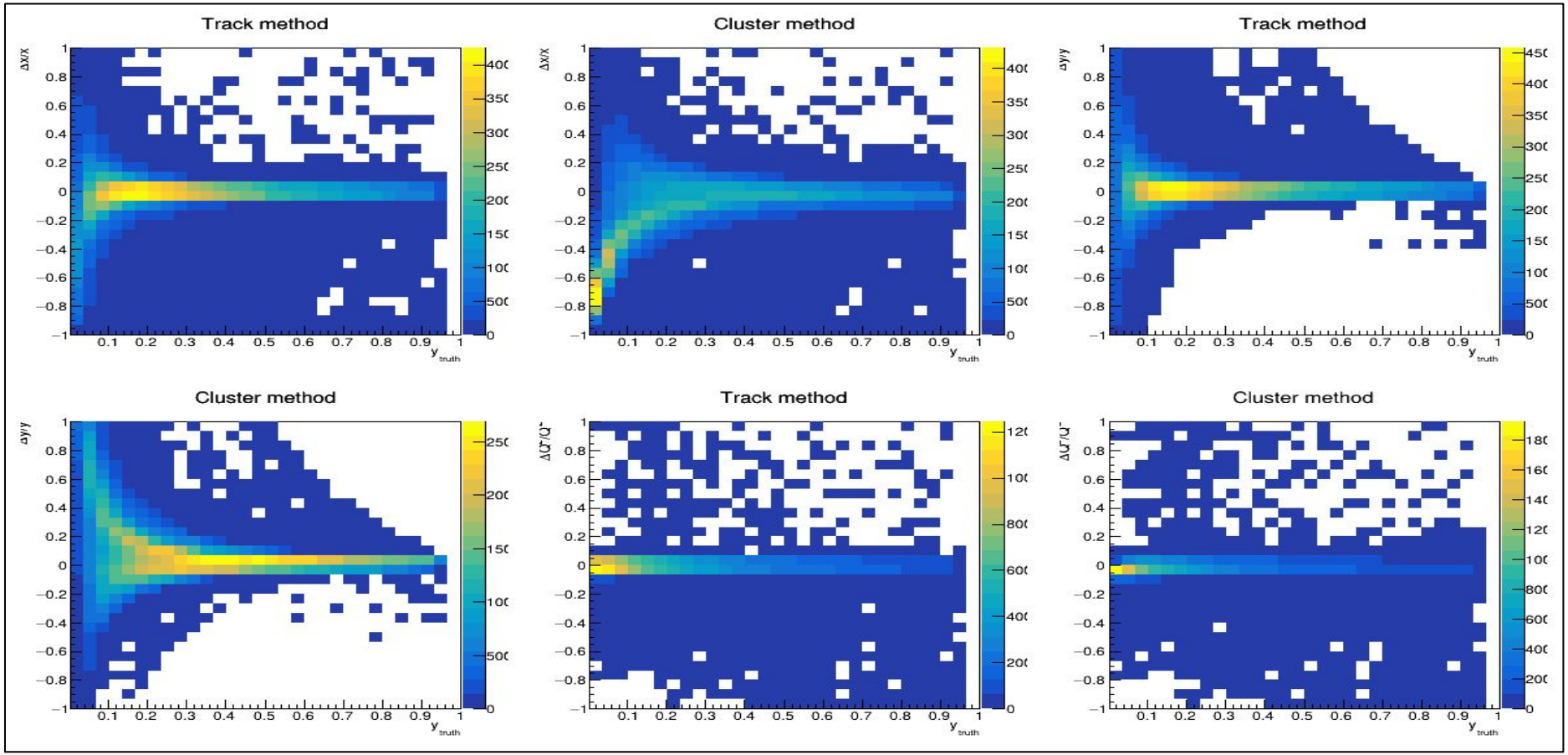
$100 \le Q^2 \le 1000$

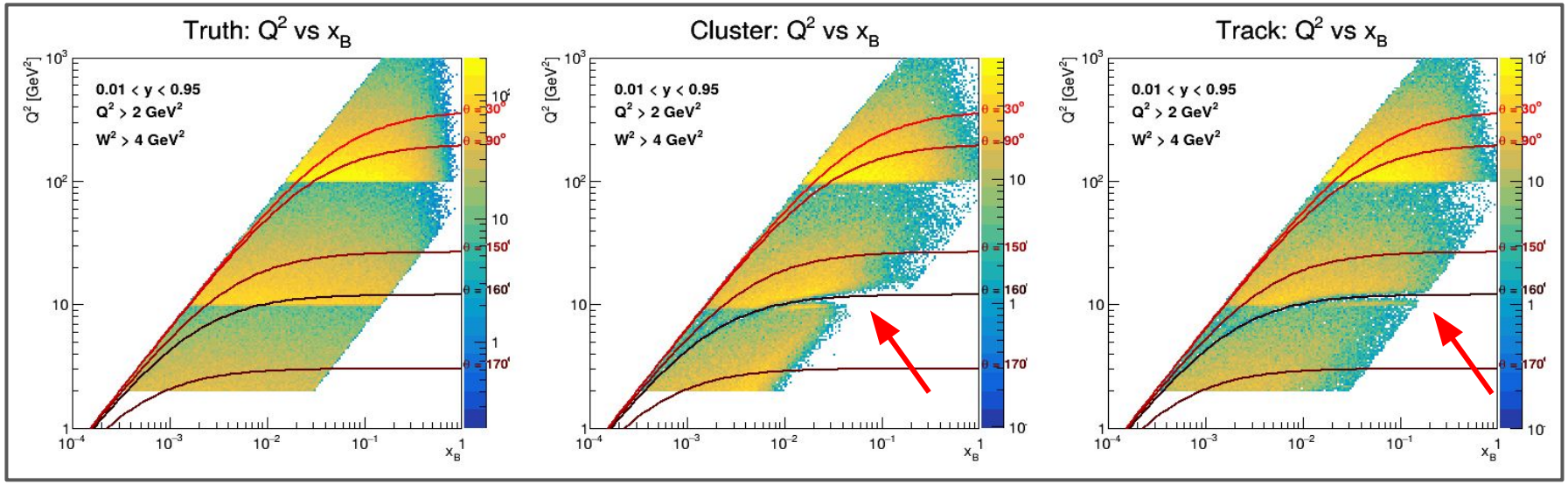
$1000 \le Q^2 \le 1200$

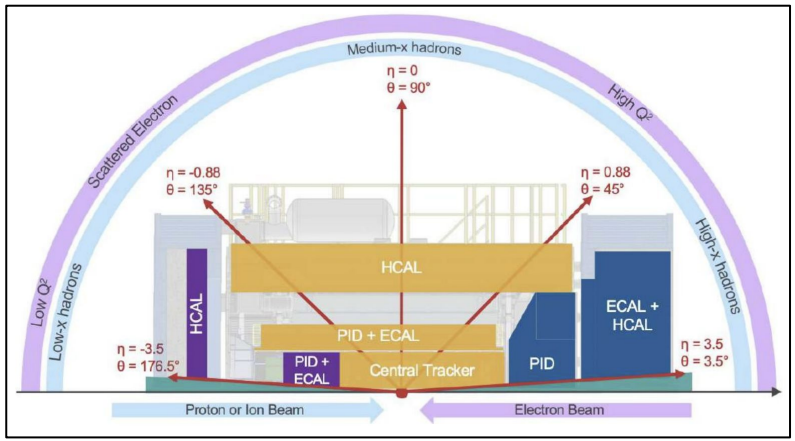


Resolution vs y_{truth}

epic sim. 25.07.0 eHe3 10x166







epic sim. 25.07.0
eHe3 10x166

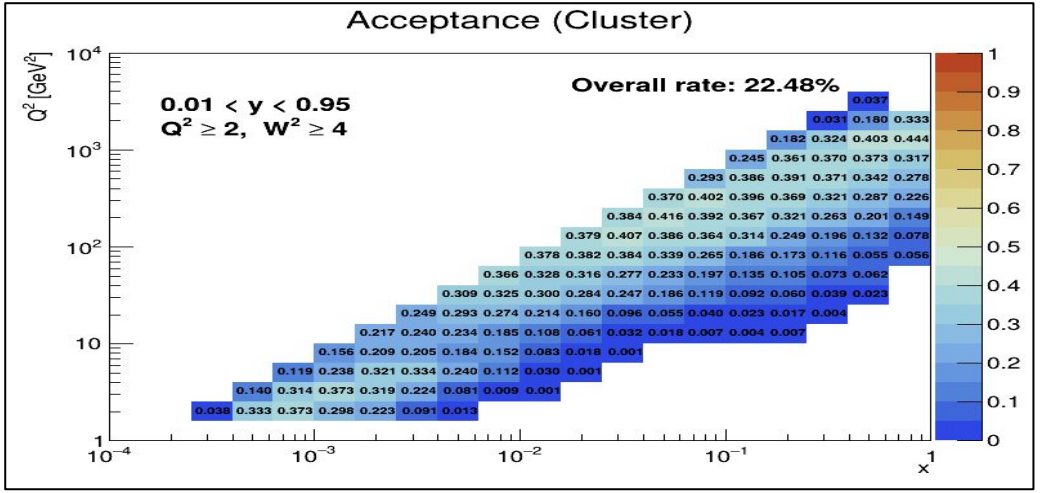
*Similar inefficiency in Win's Analysis

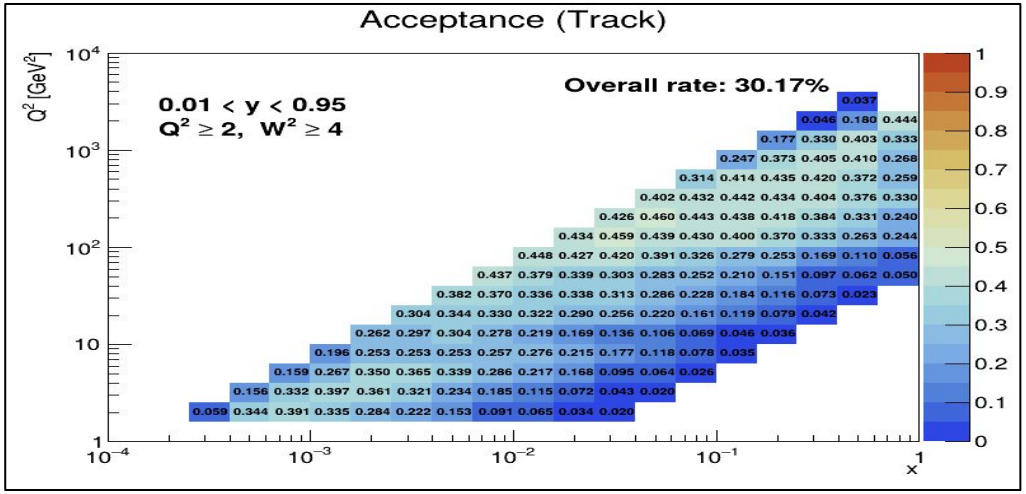
epic sim. 25.07.0
eHe3 (10x166)

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

Tyler's Slide

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



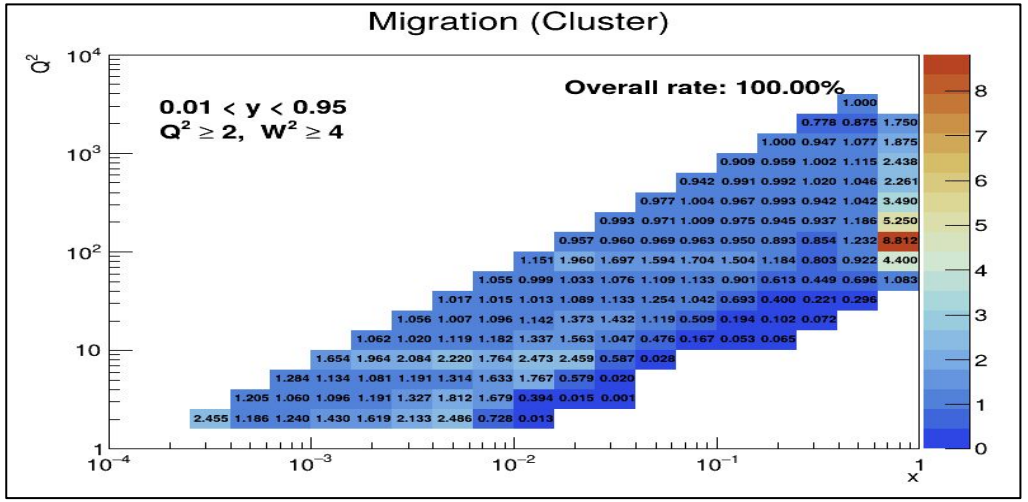


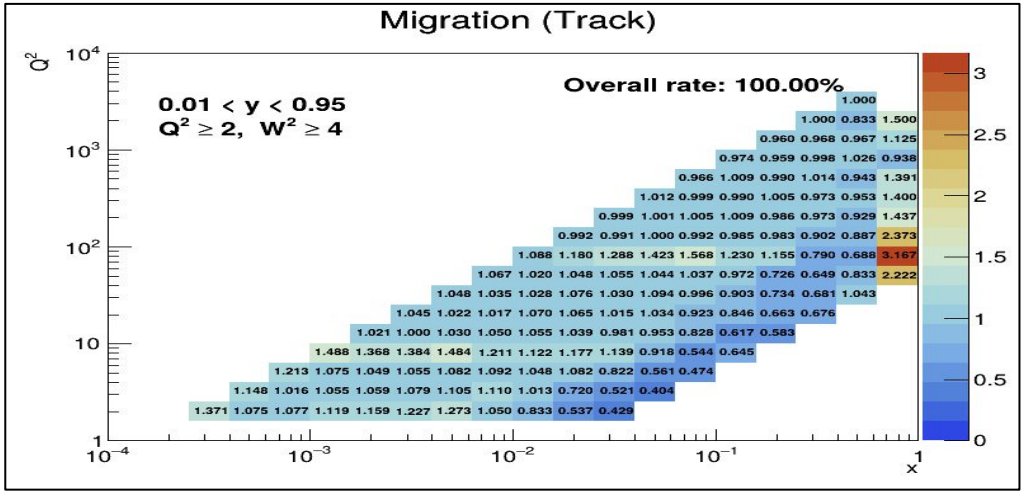
epic sim. 25.07.0
eHe3 (10x166)

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

Tyler's Slide

*No QED effect involved

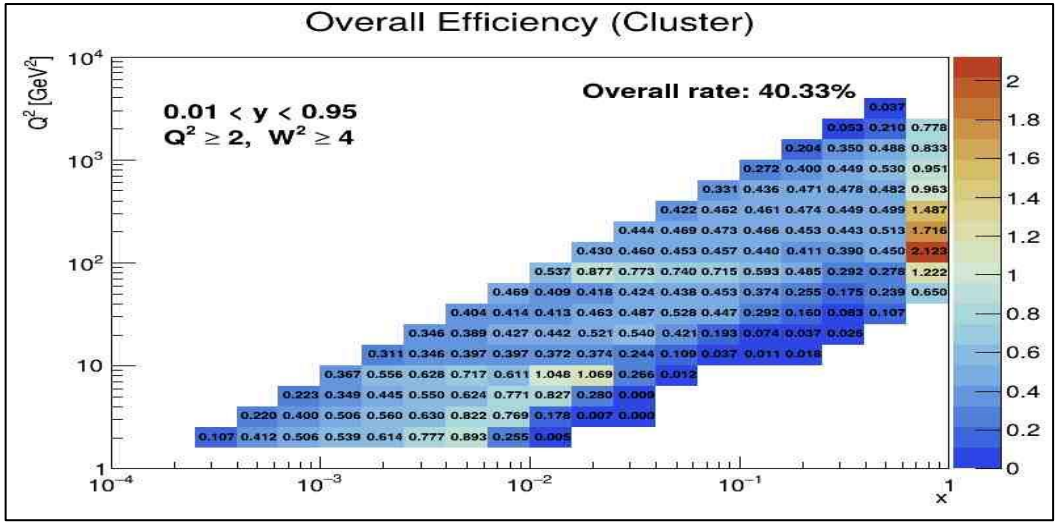


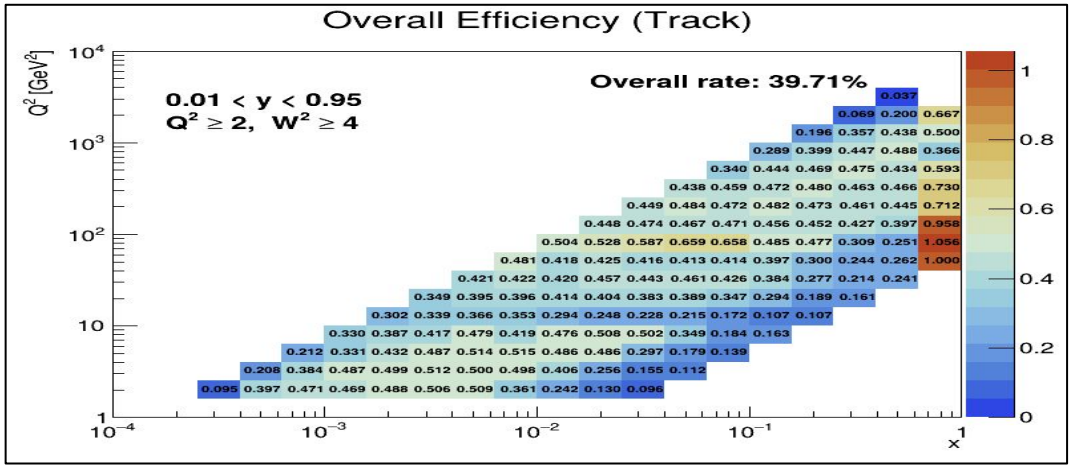


epic sim. 25.07.0
eHe3 (10x166)

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

Win's slide





Cross section from simulation files

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

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

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

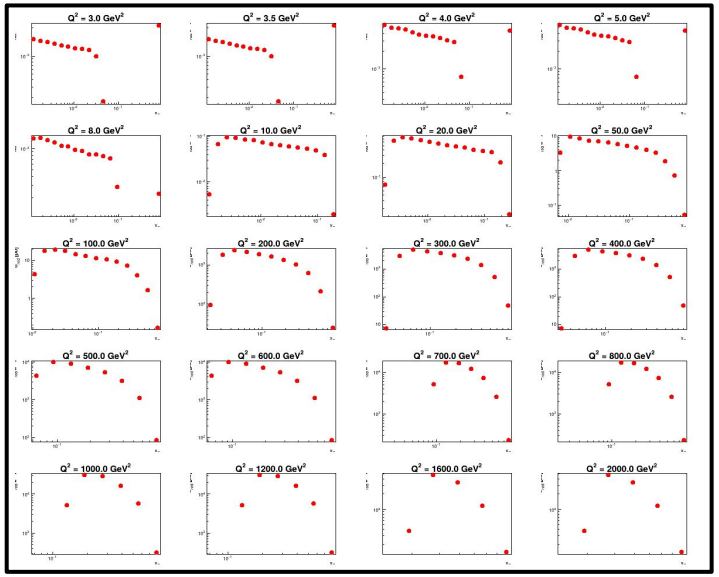
- Acceptance and bin migration corrections from simulation

$$C_{acc} = \frac{N_{rec}(x_{gen}, Q^2_{gen})}{N_{gen}(x_{gen}, Q^2_{gen})} \qquad C_{bin} = \frac{N_{rec}(x_{rec}, Q^2_{rec})}{N_{rec}(x_{gen}, Q^2_{gen})}$$

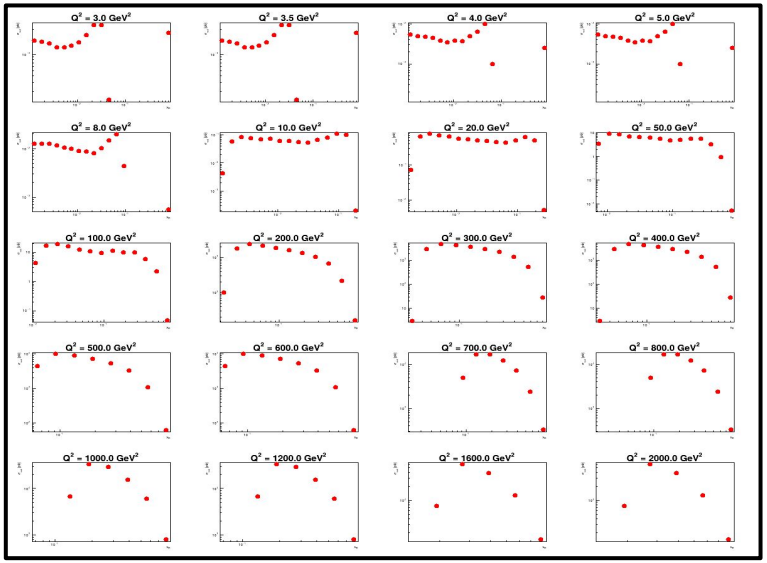
- Scale counts to integrated luminosity of $L = 1$ fb^{-1} .
- Bin volumes $\Delta x_B \Delta Q^2$ from Monte Carlo (account for cuts)

- Using same simulated events for analysis and corrections... *by definition* will obtain the generated distributions
- Detector and reconstruction performance determines *size of the corrections*

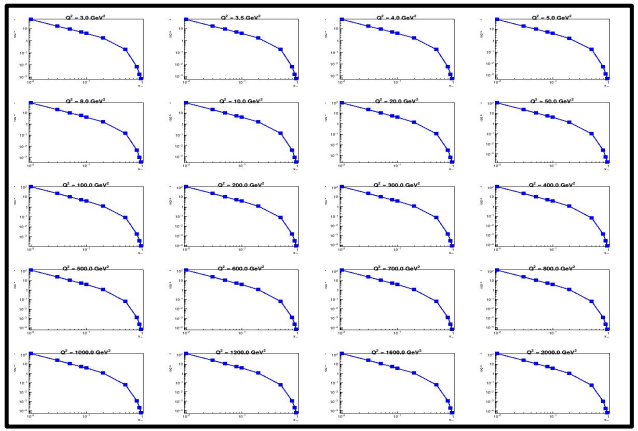
Tyler's Slide



C_{bin} correction



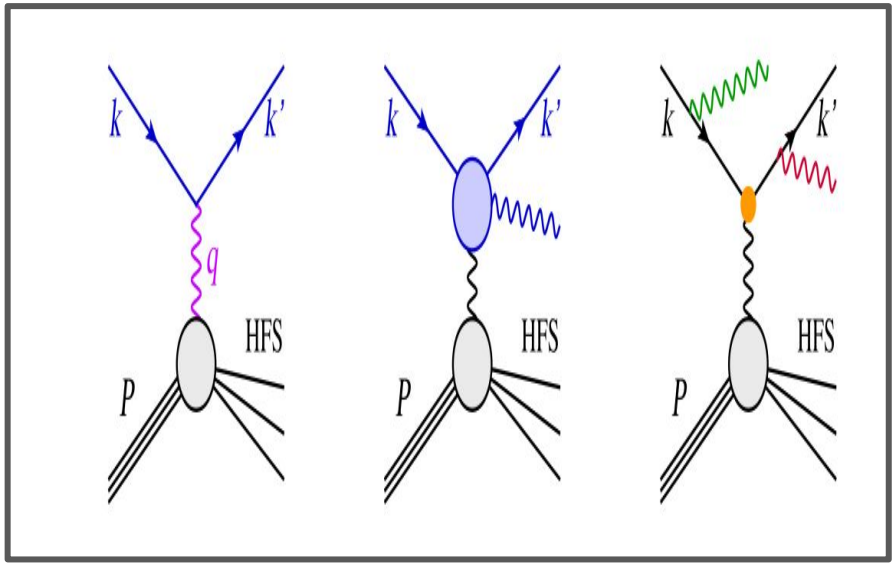
EPPS21nlo_CT18Anlo_He3

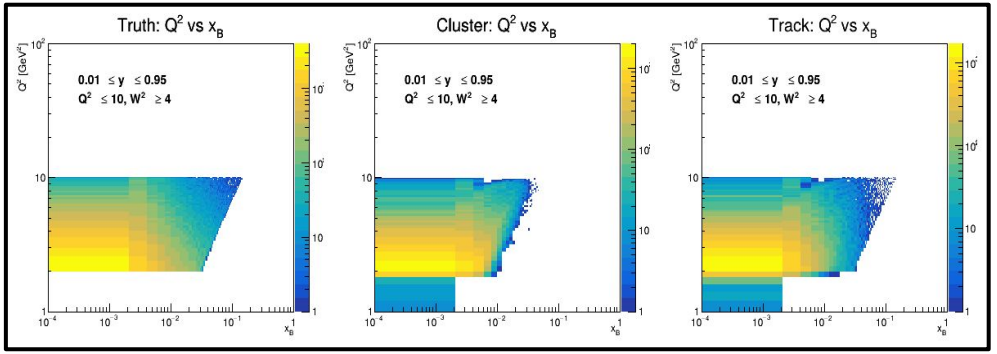


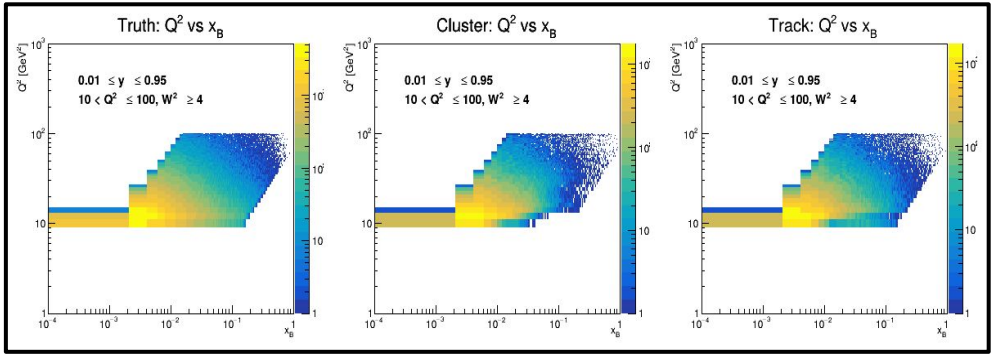
Details of Analysis eHe3(10x166GeV) *25.07.0

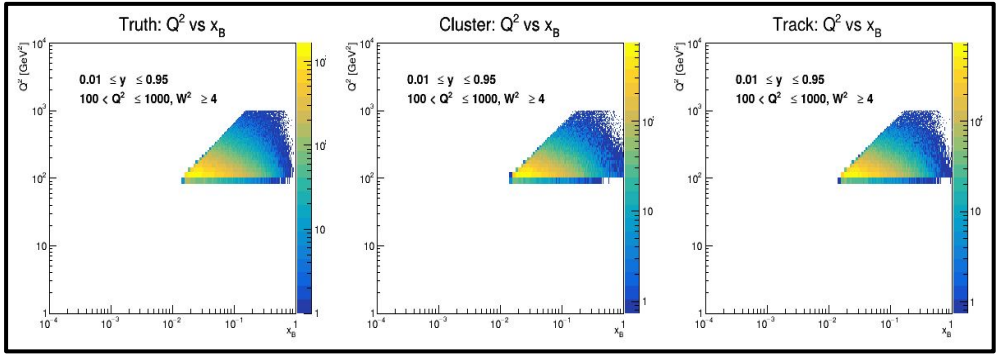
- eID based Reconstruction
- Electron method
- Only track Information
- Logarithmic binning
- Bin widths ($\Delta x \times \Delta Q^2$)

*Extra Slides









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

double C_{bin} = double(Nrec_recbin[ix_bin][iq]) / Nrec[ix_bin][iq];

- **What are these quantities**

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