EIC User Group & ePIC Joint Collaboration Meeting 2025 - JLab

Early Science DVMP Studies on 10x100 and 10x130 Beam Energy Configurations

$$e(k) + p(p) \rightarrow e(k') + p(p') + J/\psi(ee^+)$$

By Olaiya Olokunboyo || UNH

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Exclusive Physics at ePIC

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  - Exclusive – all final state particles are detected and identified

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  - Diffractive – very small scattering angles of particles in the beam

Detector	Acceptance
Zero-Degree Calorimeter (ZDC)	$\theta < 5.5$ mrad $(\approx \eta > 6)$
Roman Pots (RP)	$0.0^{\star} > \theta < 5$ mrad $(\approx \eta > 6)$
Off-Momentum Detectors (OMD)	$0.0 > \theta < 5$ mrad $(\approx \eta > 6)$
B0 Detector	$5.5 < \theta < 20$ mrad $(\approx 4.6 < \eta < 5.9)$

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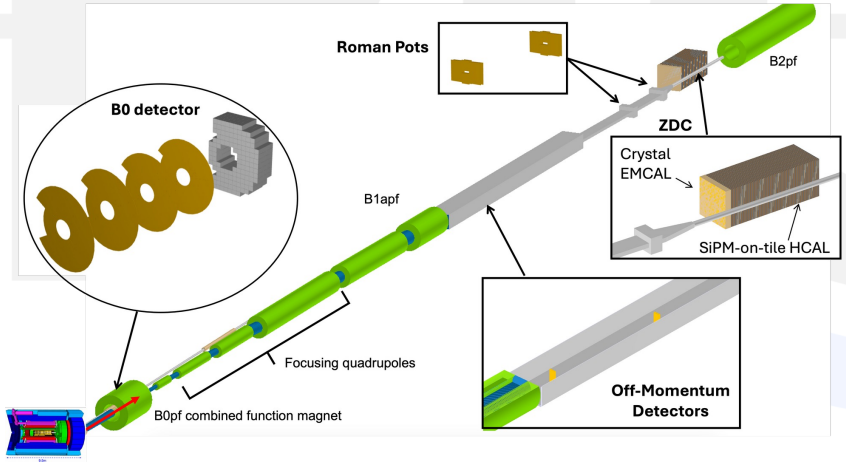
- Useful for the study of all parts of the ePIC detector:
  - Far forward – detection of scattered beam hadrons

RP
Detection of forward scattered protons and nuclei

B0
Detection of forward scattered protons and γ



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Detection of forward scattered neutrons and γ

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Detection of forward scattered protons and nuclei

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  - Central barrel – highest Q^2 scattered electron reconstruction, photon detection

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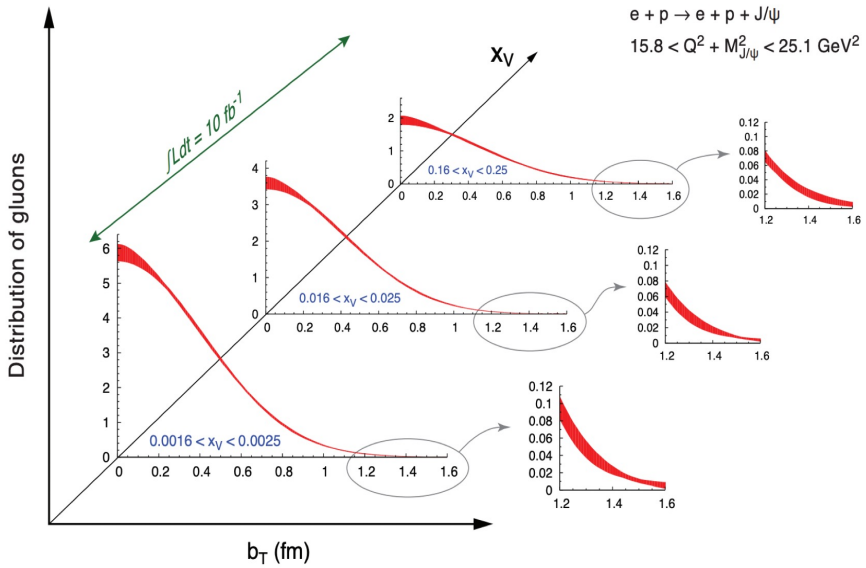
  - Central barrel – highest Q^2 scattered electron reconstruction, photon detection
  - Far backward – use of tagger for lowest Q^2 events

Motivations

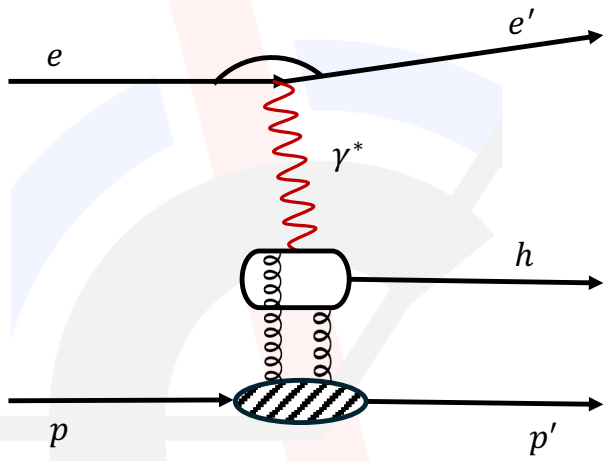


J/Ψ production: transverse spatial distribution of gluons

Events are generated using lAger generator.

Designed to support DVMP processes, central in probing the partonic structure of hadrons and nuclei via GPDs.

Deeply Virtual Meson Production



$e + p \rightarrow e' + J/\psi + p'$,
this process provides with measurement of all particles in the event with high precision.

S. Joosten, Argonne l/A-event Generator, GitLab repository, 2021.
Eur. Phys. J., 6 vol. A52 (2016)

Electron vertex kinematics

Interaction variables kinematic description at the scattering electron vertex.

The Electron Method

$$Q^2 = -q^2 = -(k - k')^2$$

$$y = \frac{q \cdot p}{k \cdot p} \quad || \quad x = \frac{Q^2}{2q \cdot p}$$

The Jaquet-Blondel (JB) Method

$$Q^2 = \frac{p_{T,h}^2}{1 - y}$$

$$y = \frac{\Sigma_h}{2E_e} \quad || \quad x = \frac{Q^2}{4E_e E_p y}$$

$$p_{T,h}^2 = \left(\sum p_x\right)^2 + \left(\sum p_y\right)^2$$

$$\Sigma_h = \sum E - \sum p_z$$

The ElectronSigma (eΣ) Method

$$p_{T,e'}^2 = (p_x)^2 + (p_y)^2$$

$$\Sigma_{e'} = E - p_z$$

$$\Sigma_{tot} = \Sigma_{e'} + \Sigma_h$$

$$y_e = 1 - \frac{\Sigma_{e'}}{2E_e}$$

$$Q_e^2 = \frac{p_{T,e'}^2}{1 - y_e}$$

$$y_\Sigma = \frac{\Sigma_h}{\Sigma_{tot}}$$

$$Q_\Sigma^2 = \frac{p_{T,e'}^2}{1 - y_\Sigma}$$

$$x_\Sigma = \frac{Q_\Sigma^2}{4E_e E_p y_\Sigma}$$

$$y_{e\Sigma} = \frac{Q_e^2}{4E_e E_p x_\Sigma}$$

Whilst there are more ways to calculate these variables than listed, only few methods which are implemented into the EICrecon reconstruction framework are considered.

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10x100 June 2025 Campaign Data
Plots in the backup slides

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Proton 4-momentum transfer, t

At the proton vertex, the Mandelstam variable *t* denotes the 4-momentum transfer between the scattered proton and the beam proton. It is one of the parameters which GPDs depend on, alongside *x*.

4-Momentum Transfer

$$t = (p - p')^2$$

https://github.com/eic/Glouns_DIstribution_From_J_Psi/blob/main/j_Psi_analysis.c

Proton 4-momentum transfer, t

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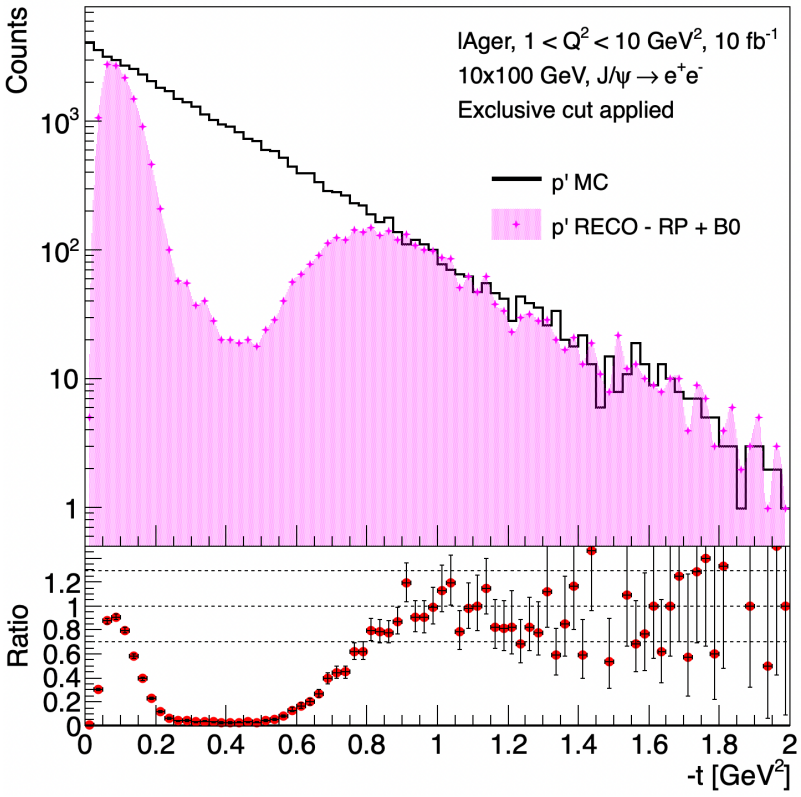

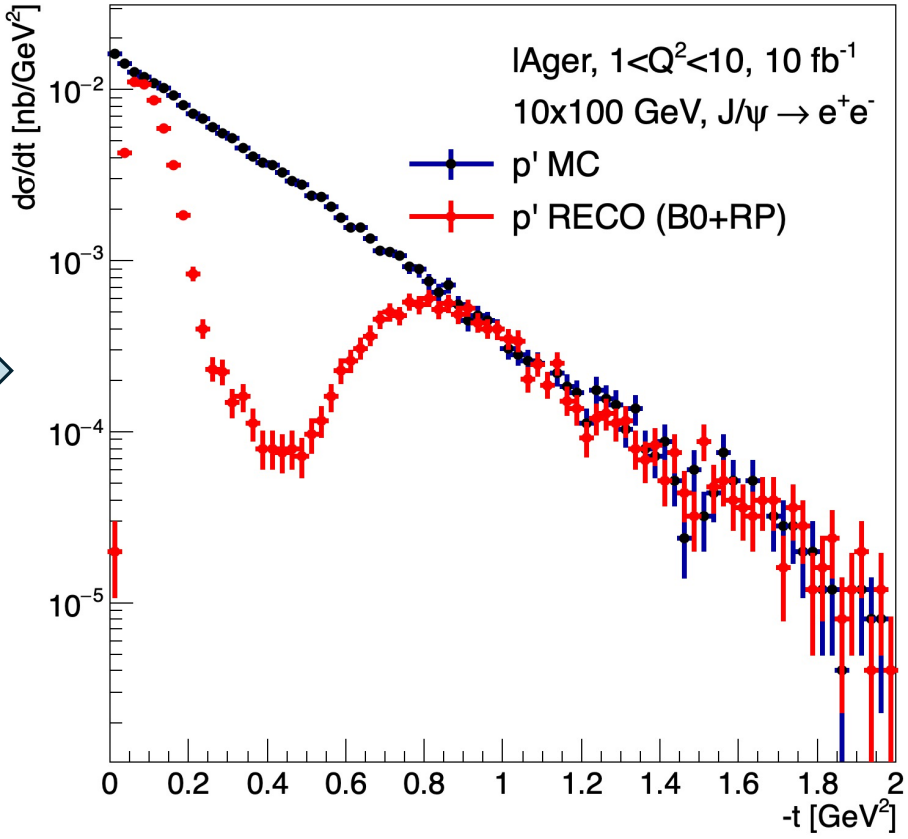

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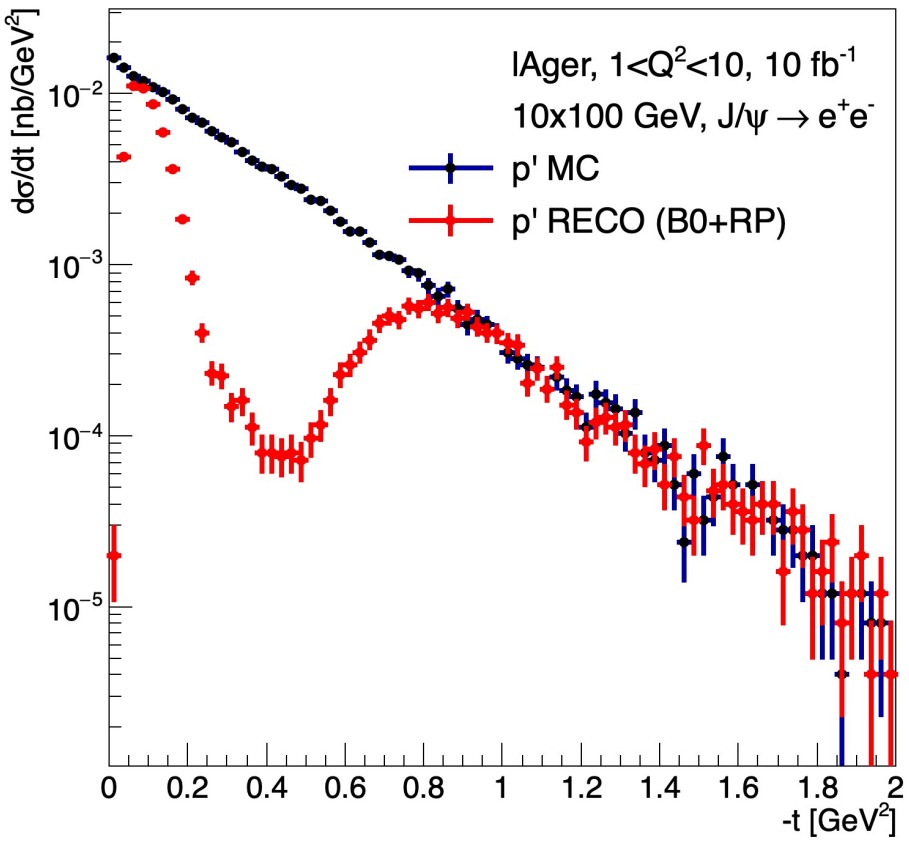

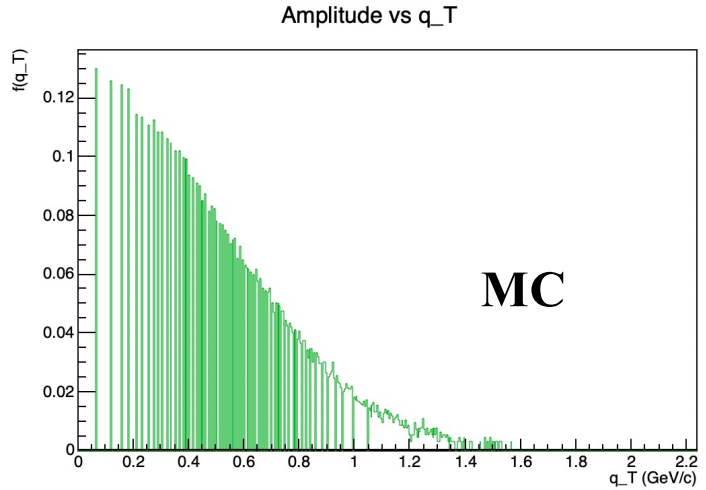

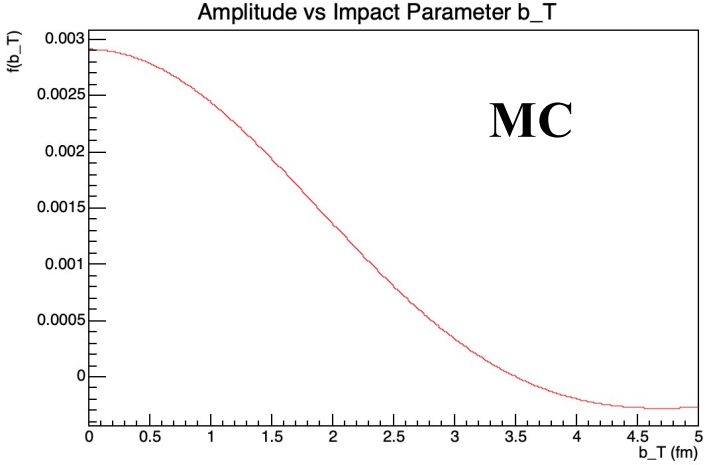

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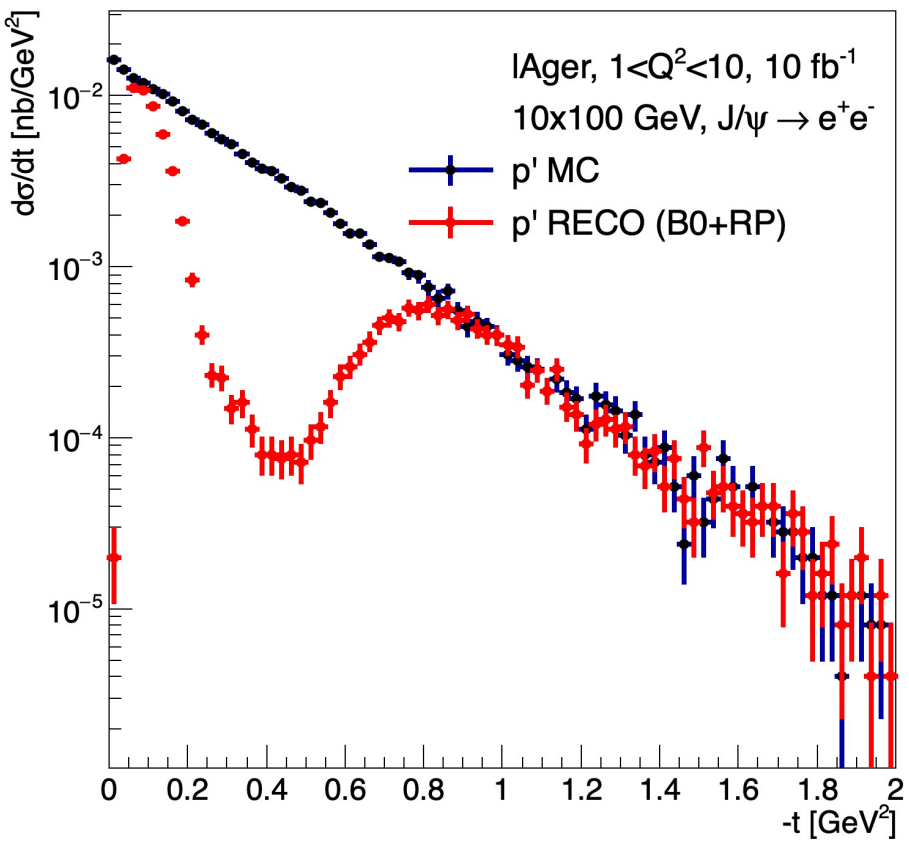
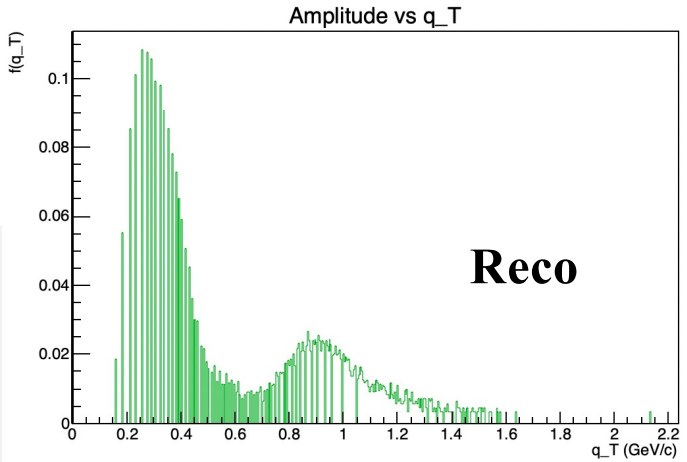
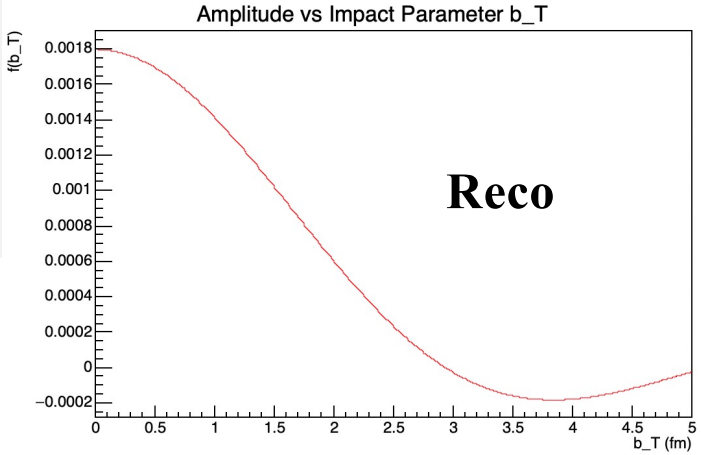
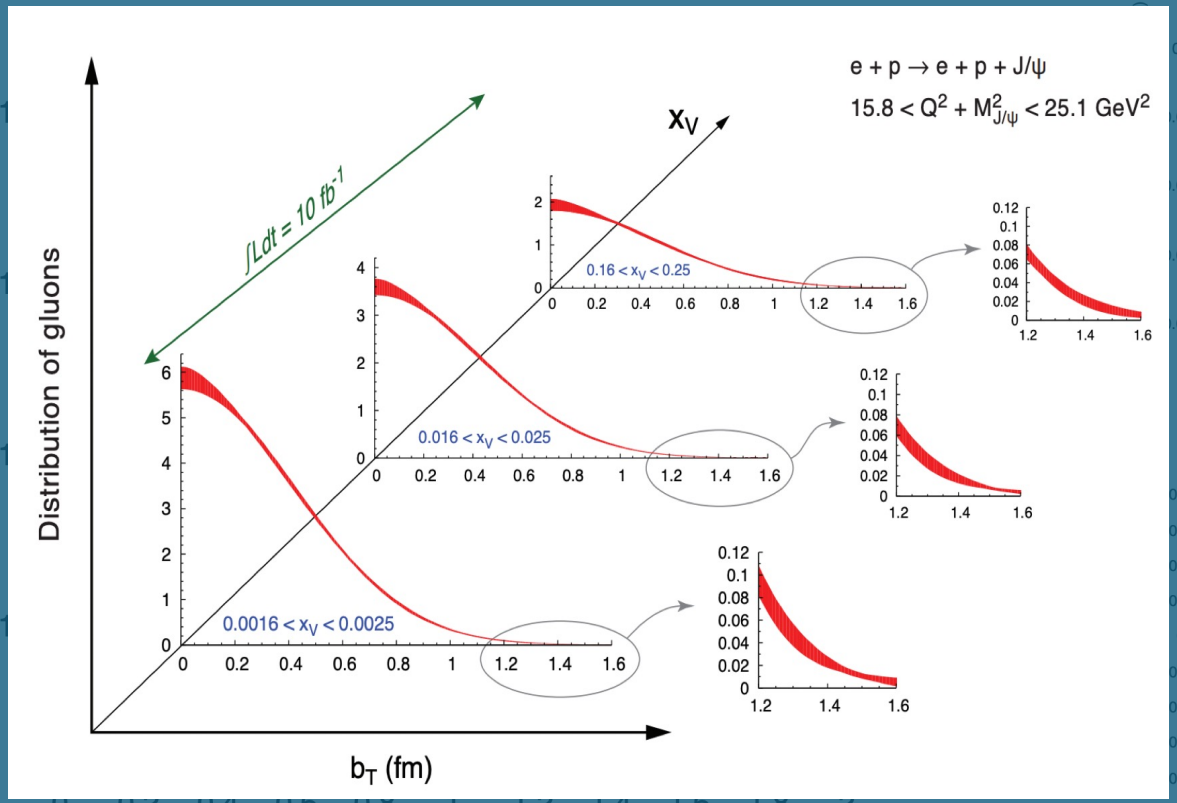






Proton 4-momentum transfer, t

End Goal



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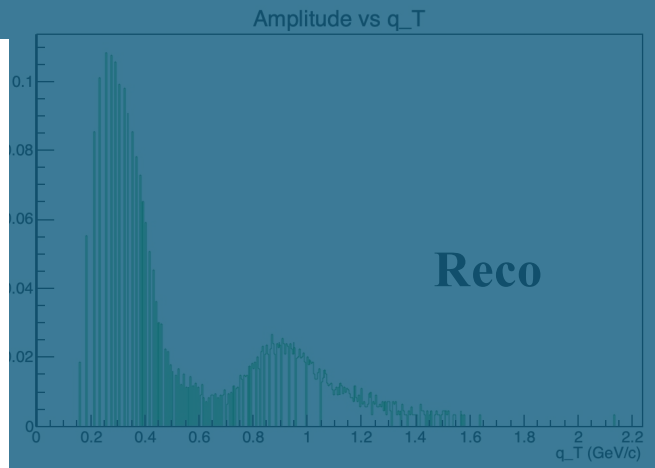
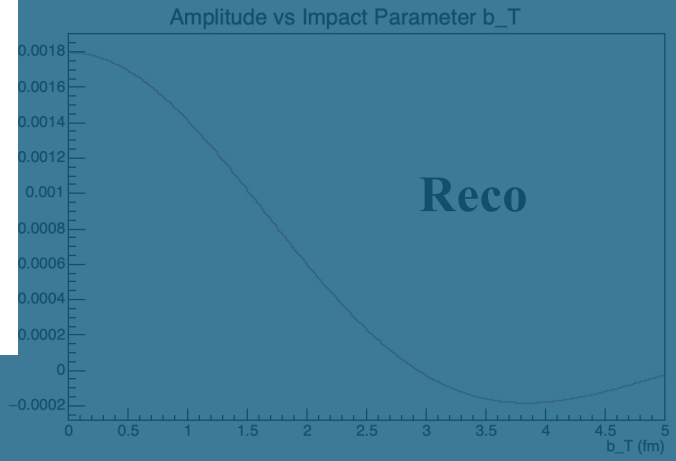
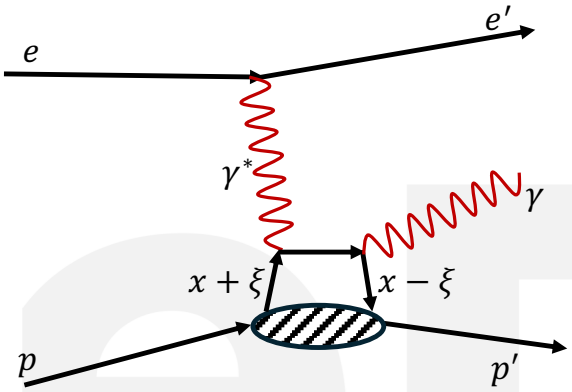




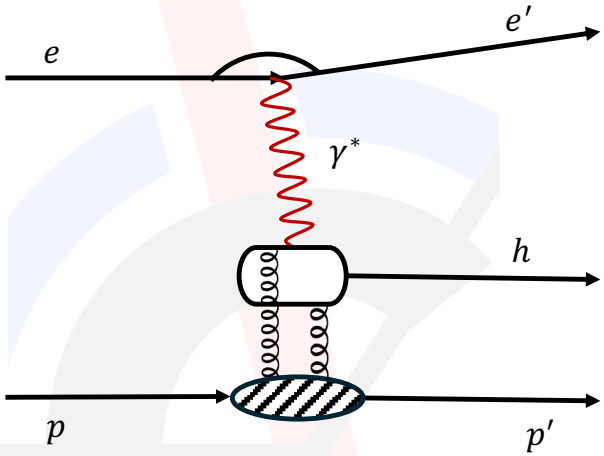
Thank You

Deeply Virtual Photon Scattering



$e + p \rightarrow e' + \gamma + p'$,
this process for electron scattering oof a proton producing additioinal photon in the final state.

Deeply Virtual Meson Production



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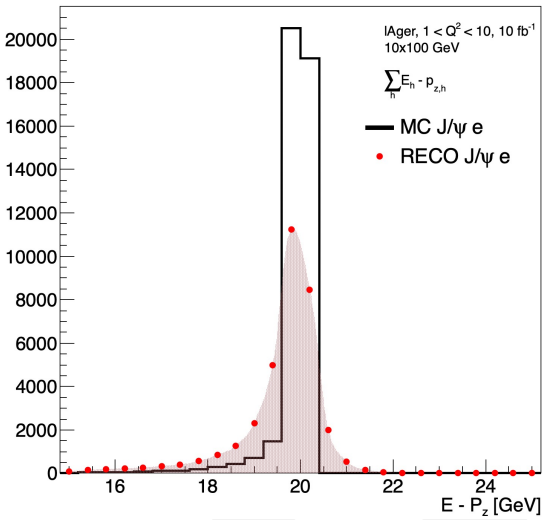

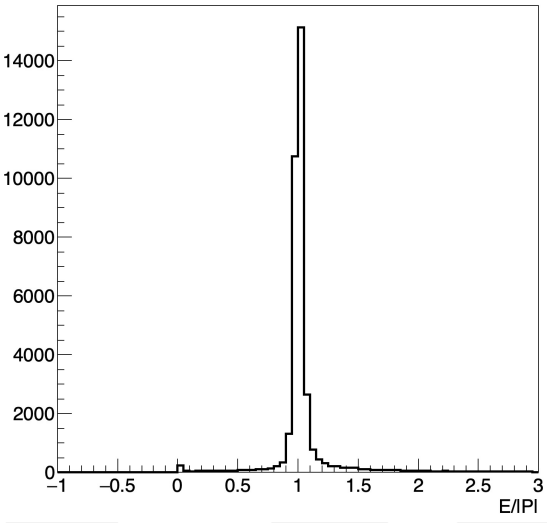

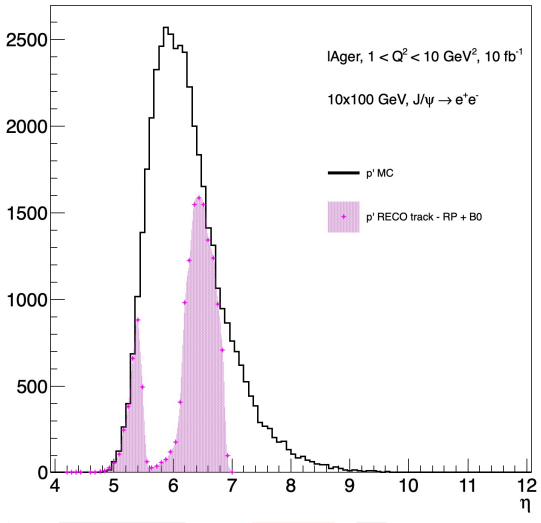

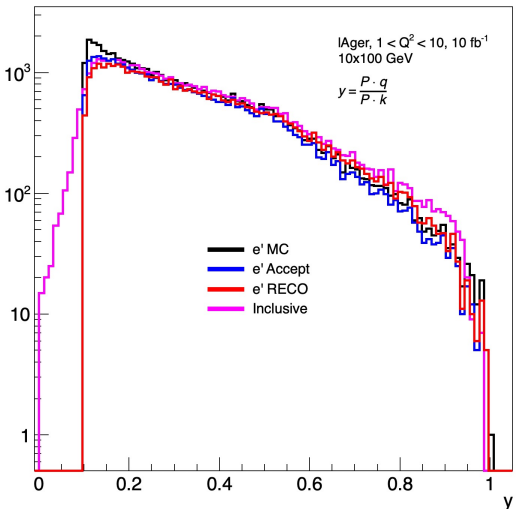

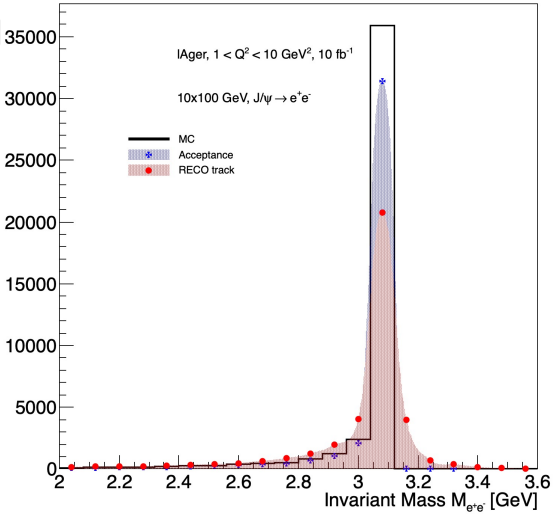

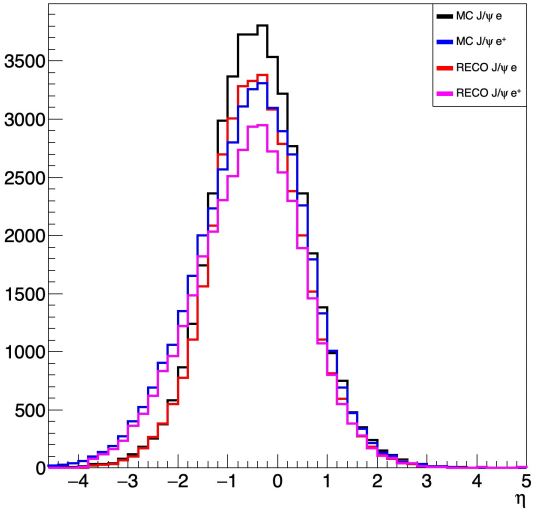

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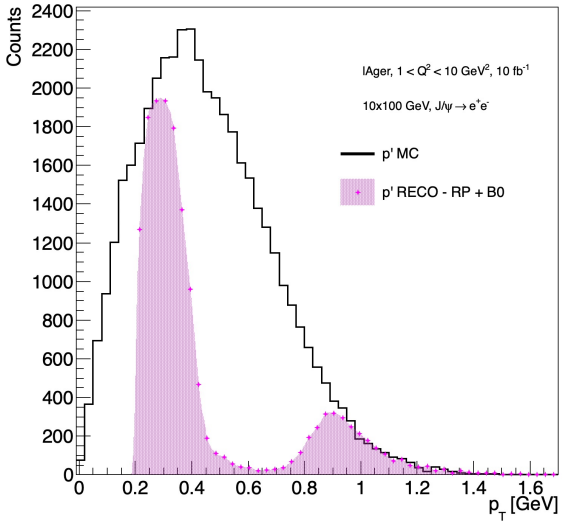

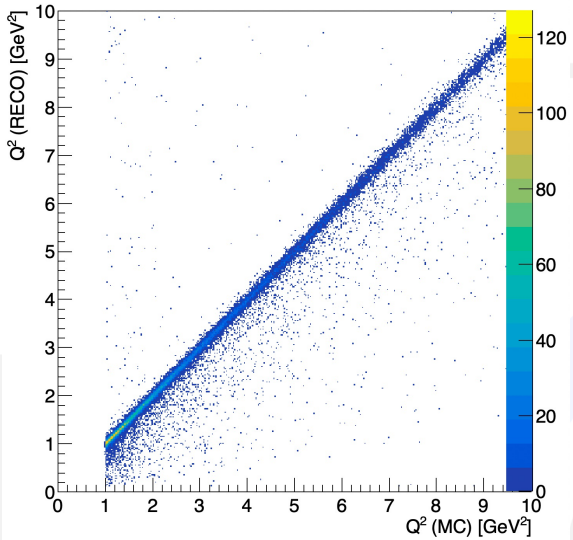

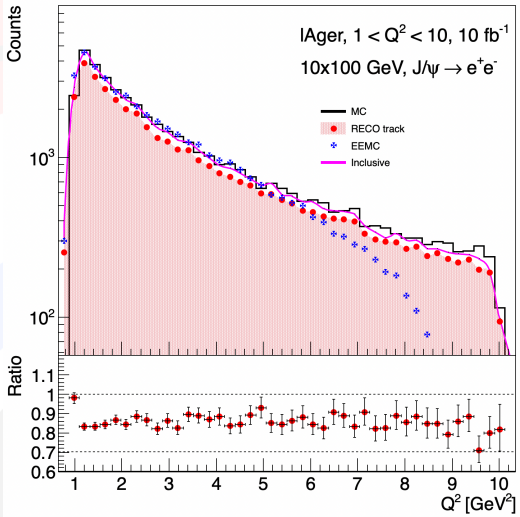

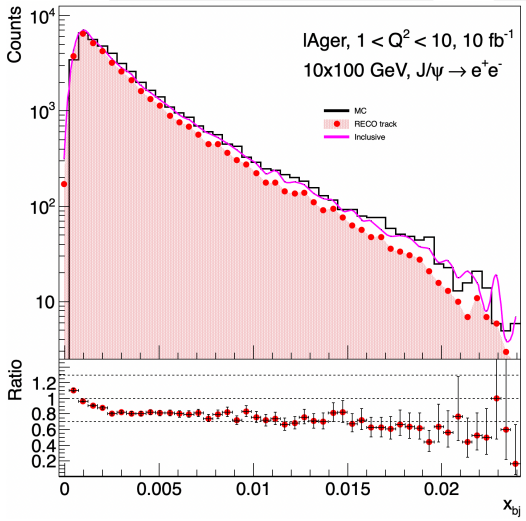

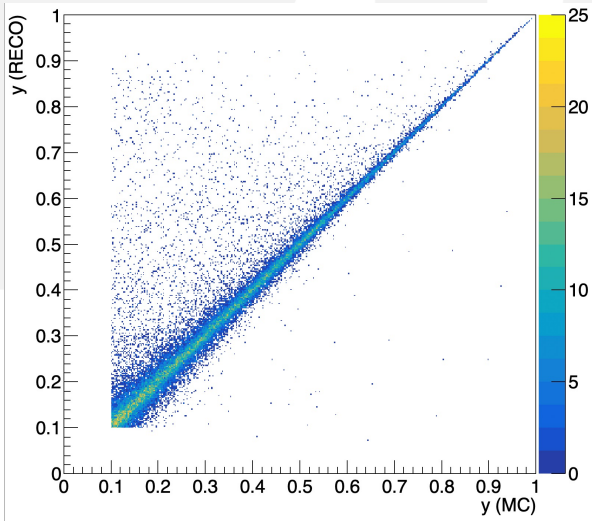

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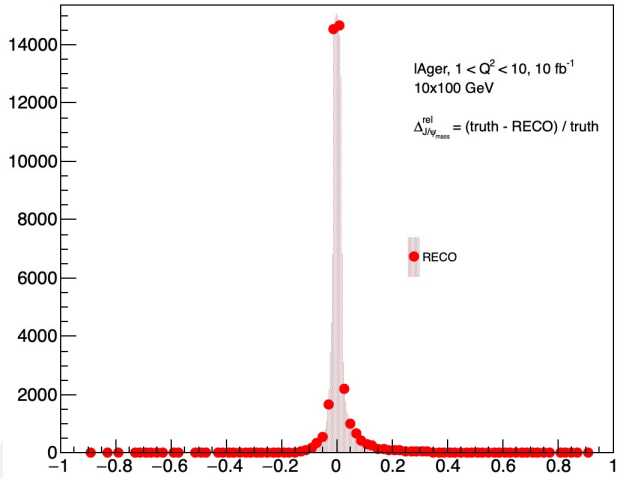

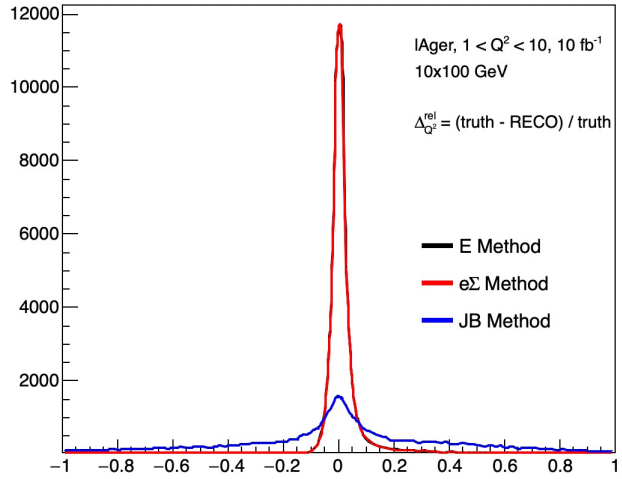

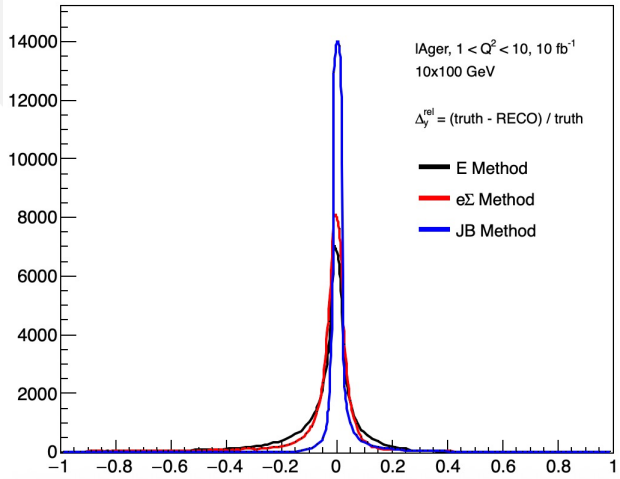

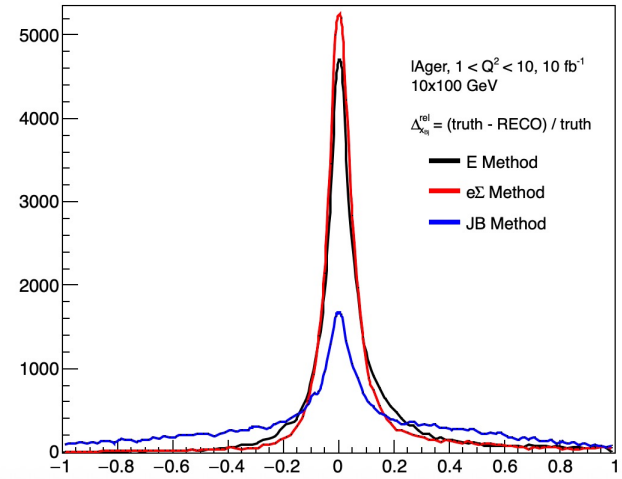

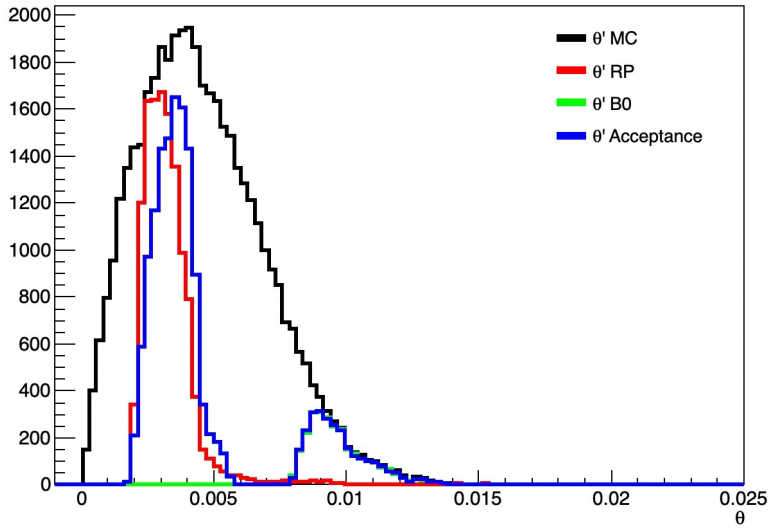

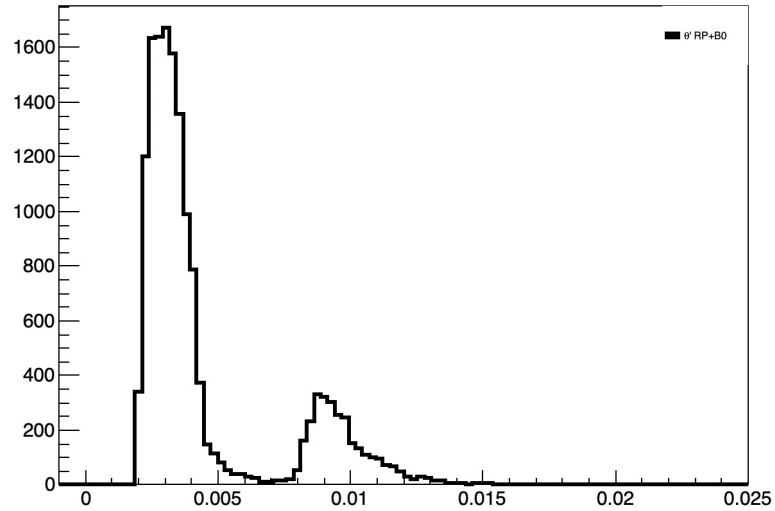

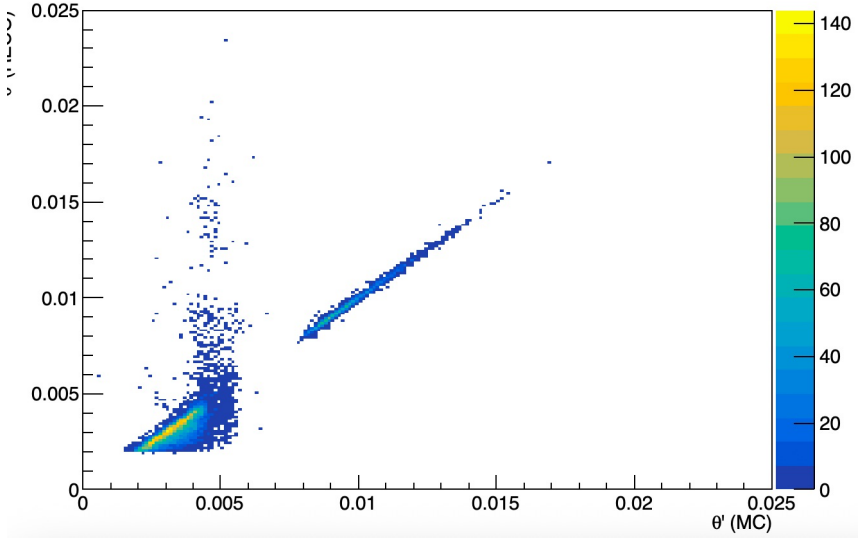

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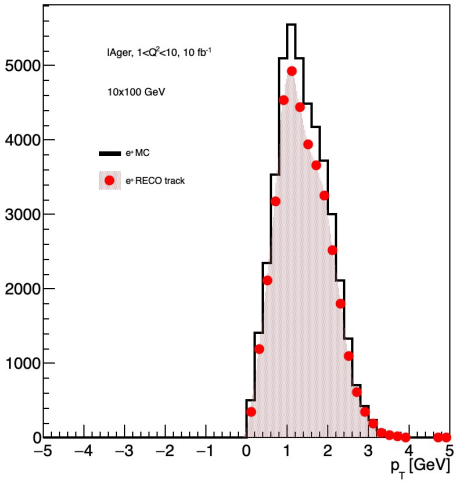

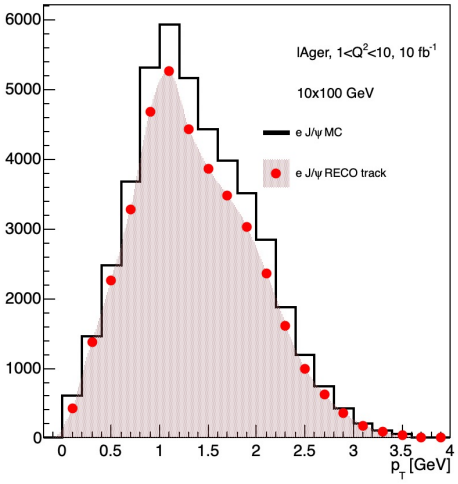

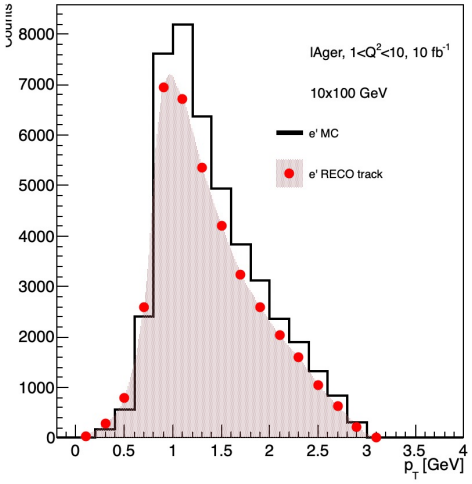

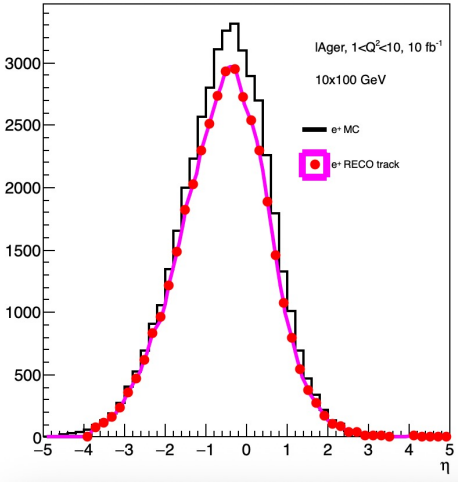

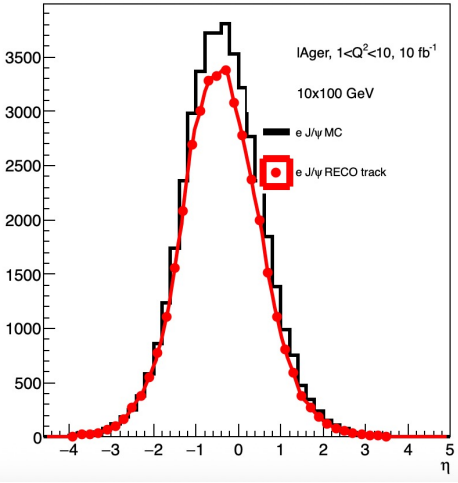

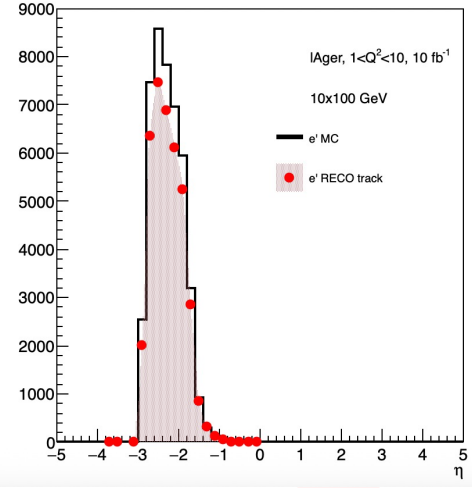

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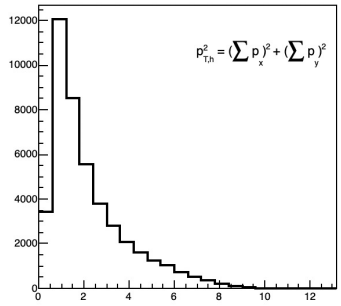

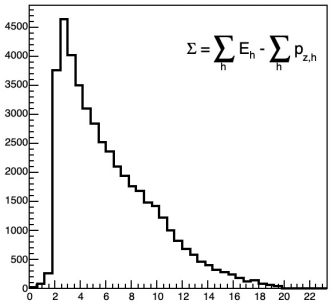

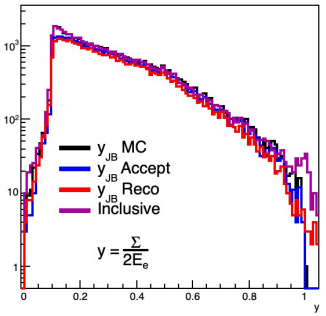

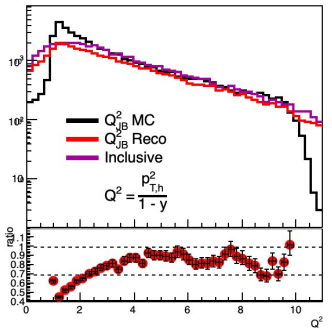

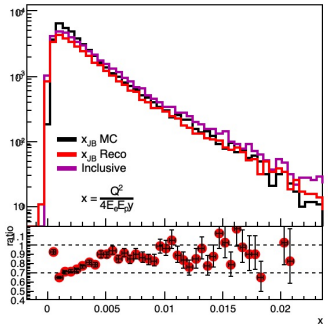

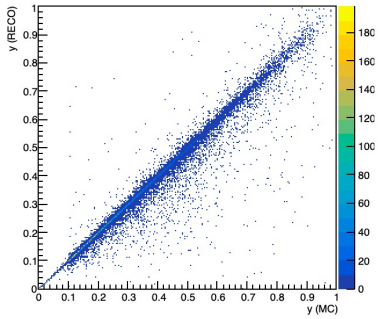

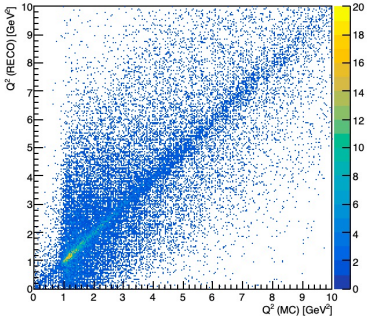

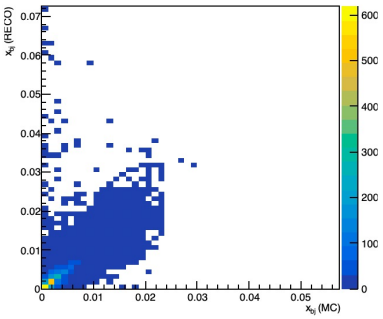

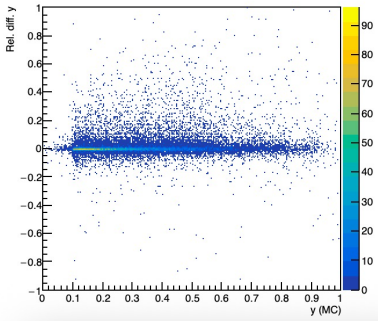

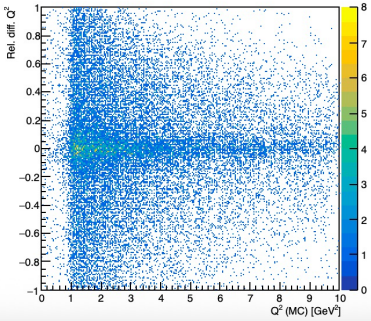

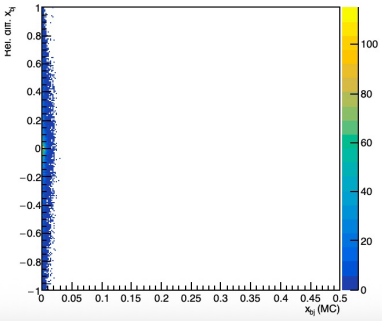

10x100 June 2025 Campaign Data