Inclusive Kinematic Reconstruction in Juggler Framework

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Work completed

- Implementation of true kinematic variables using the generated scattered electron (https://eicweb.phy.anl.gov/EIC/juggler/-/blob/master/JugFast/src/components/InclusiveKinematicsTruth.cpp)
- Implementation of scattered electron method (https://eicweb.phy.anl.gov/EIC/juggler/-/blob/master/JugReco/src/components/InclusiveKinematicsElectron.cpp)
- Implementation of Jacquet-Blondel method (https://eicweb.phy.anl.gov/EIC/juggler/-/blob/master/JugReco/src/components/InclusiveKinematicsJB.cpp)
- Implementation of Double-Angle method (https://eicweb.phy.anl.gov/EIC/juggler/-/blob/master/JugReco/src/components/InclusiveKinematicsDA.cpp)

Details of truth kinematics implementation

- Extracts the true electron and proton beam 4-momentum vectors, including the event-by-event fluctuations.
- Extracts the 4-momentum of the scattered electron and records the index of this electron in the particle list.
- Calculates the kinematic quantities (Q^2, x, y, nu, W) using their Lorentz-invariant forms
- Comments: this will not work for charge current events; also, in the presence of QED radiation on the incoming or outgoing electron line, the vertex (true) kinematics will be different than the kinematics calculated using the scattered electron as done in this implementation.

Details of scattered electron kinematics implementation

- Extracts the electron and proton 4-momentum vectors, ignoring the event-by-event fluctuations.
- For the electron associated with the true generated scattered electron, we calculate the momentum and angles using the tracking information. Then, assuming the particle was reconstructed as an electron, the energy is calculated using the above momentum.
- Calculates the kinematic quantities (Q^2, x, y, nu, W) using their Lorentz-invariant forms.

Details of JB and DA kinematics implementation

- Extracts the electron and proton 4-momentum vectors, ignoring the event-by-event fluctuations.
- All reconstructed particles are used in the hadronic final state sum except for the particle associated with the true scattered electron.
- For charged particles, the tracker is used to reconstruct the momentum vector. The magnitude of this momentum and the true PID of the particle are then used to calculate the energy.
- Neutral particles are reconstructed using the calorimeter clusters and true PID values. How are merged clusters being handled?
- The particles are transformed into the colinear frame before performing the standard kinematic calculations.

JB and DA equations used

$$y_{JB} = \frac{\Sigma_h}{2E_e}$$

$$\tan\left(\frac{\gamma}{2}\right) = \frac{\Sigma_h}{p_{t,h}}$$

$$Q_{JB}^2 = \frac{p_{t,h}^2}{1 - y_{JB}} = \frac{\left(\sum_i p_{x,i}\right)^2 + \left(\sum_i p_{y,i}\right)^2}{1 - y_{JB}}$$

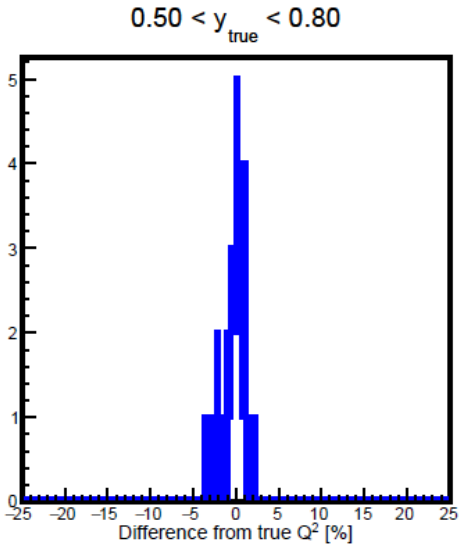
$$y_{DA} = \frac{\tan\gamma/2}{\tan\theta/2 + \tan\gamma/2}$$

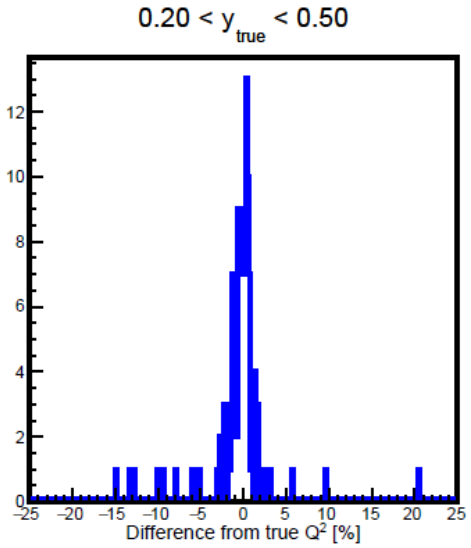
$$Q_{DA}^2 = 4E_e^2 \frac{\cot\theta/2}{\tan\theta/2 + \tan\gamma/2}$$

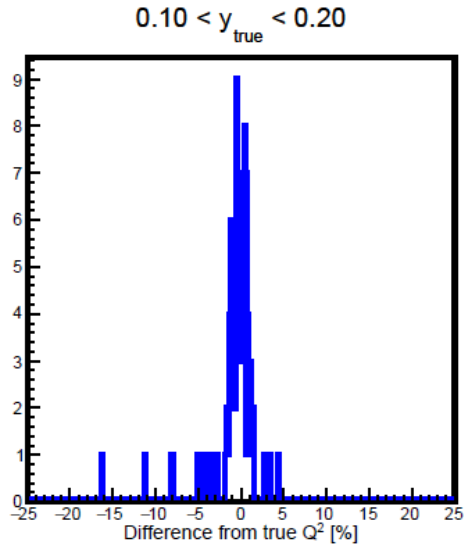
$$\Sigma_h = \sum_i (E_i - p_{z,i}) = \sum_i E_i - \sum_i p_{z,i}$$

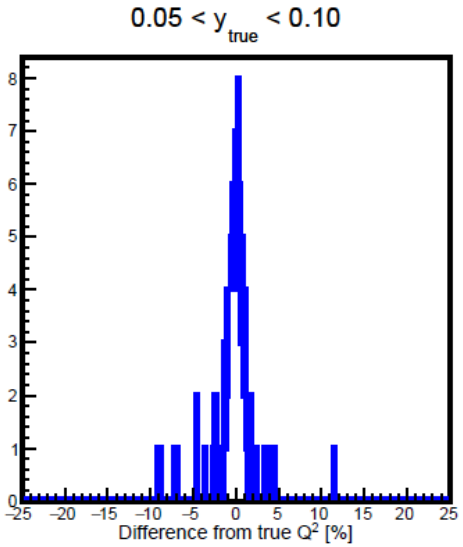
$$x = \frac{Q^2}{(sy)}$$

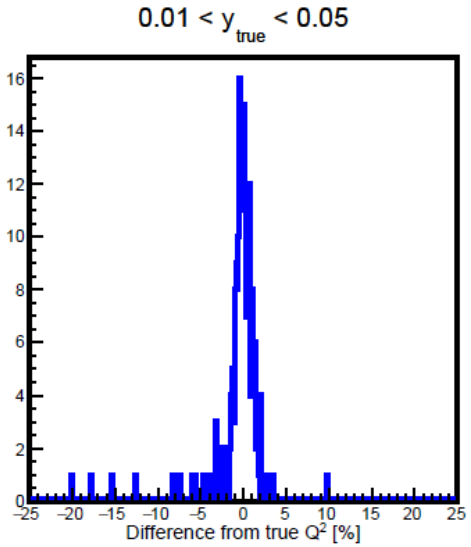
First results – electron method I









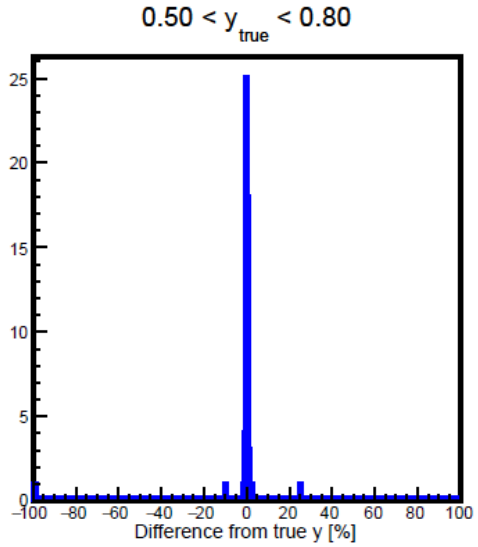


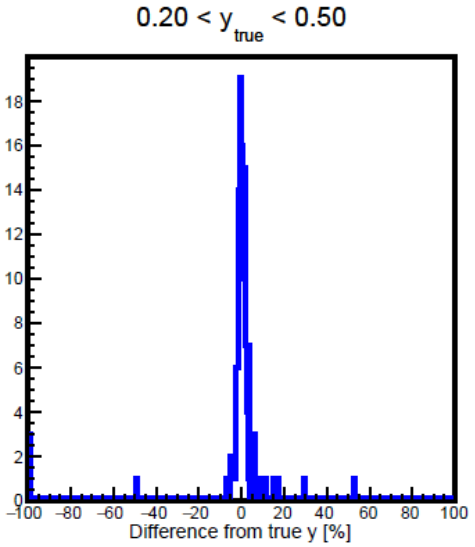
18 GeV e⁻ on 275 GeV p, $\sqrt{s}$=141 GeV

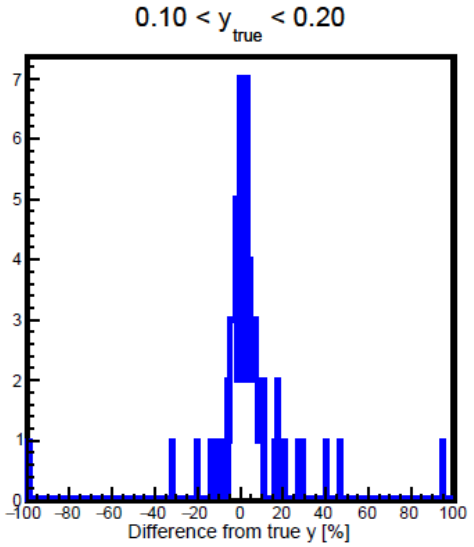
Q^2 > 10 GeV^2

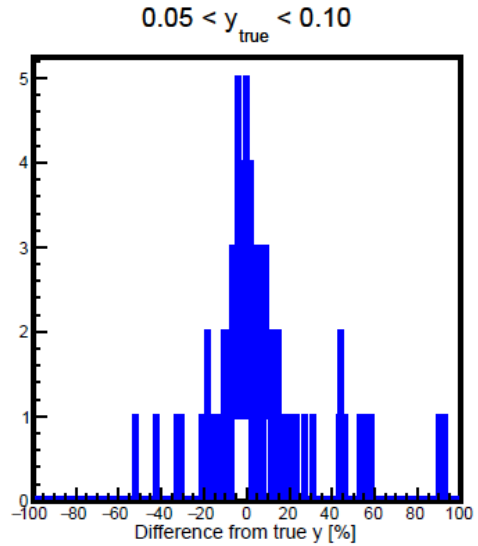
Electron Method

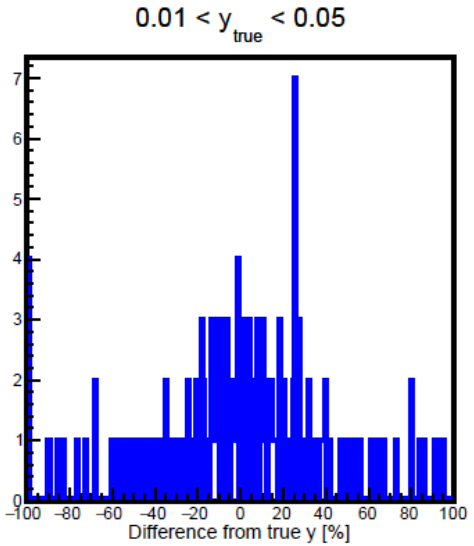
First results – electron method II











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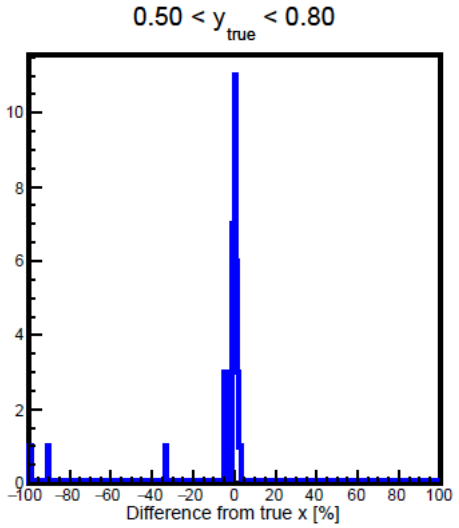
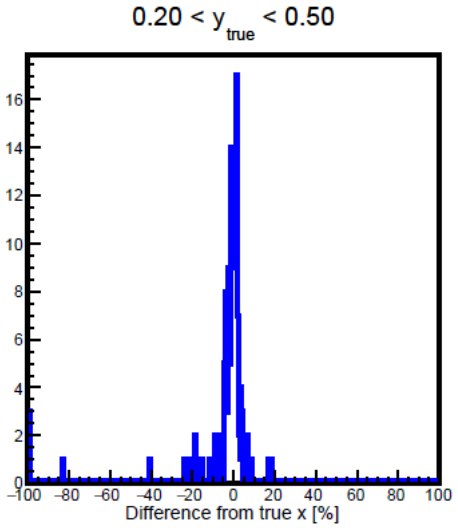
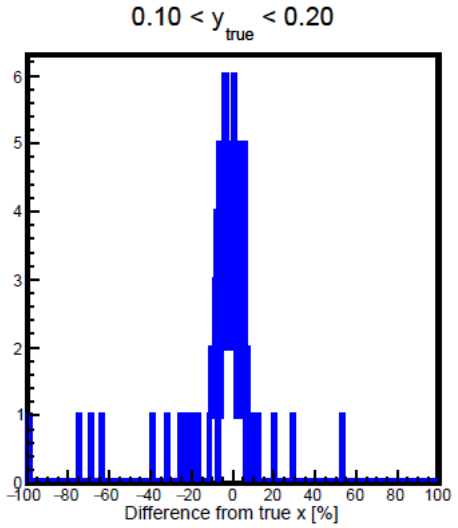
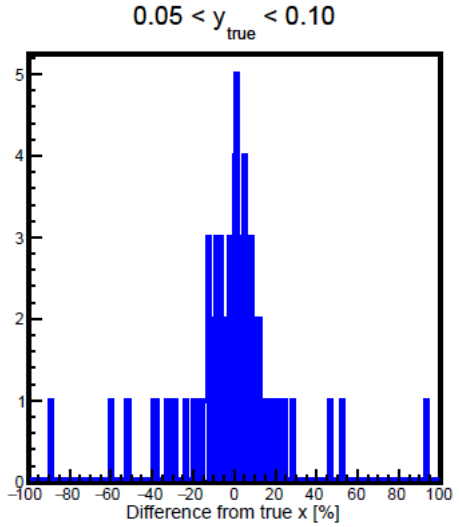
Electron Method

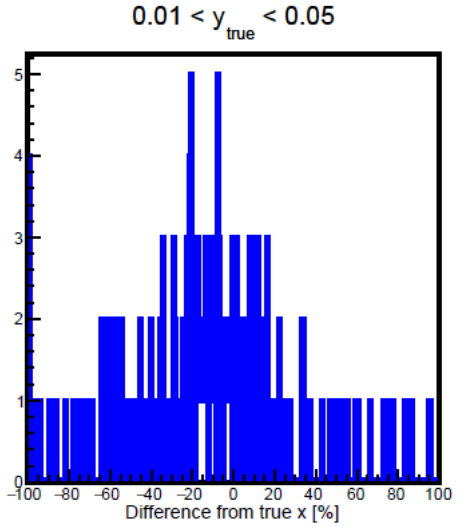
First results – electron method III











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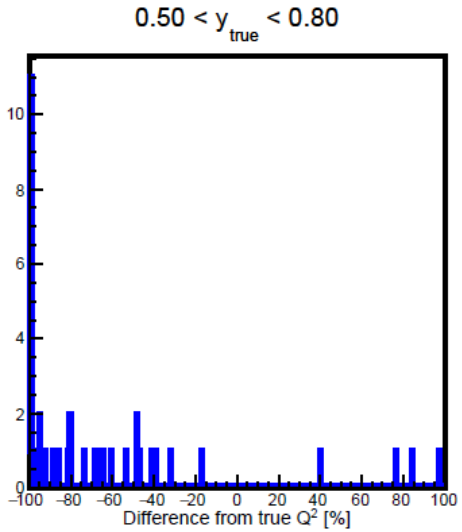
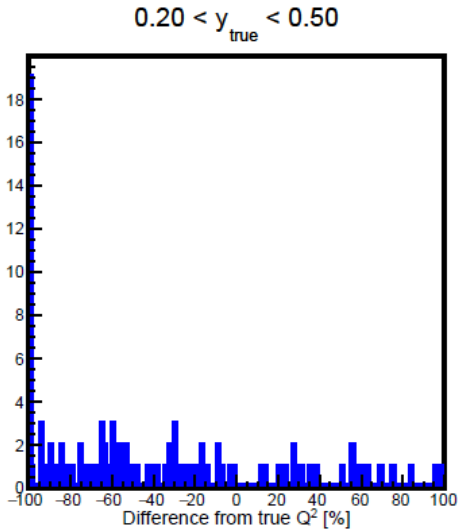
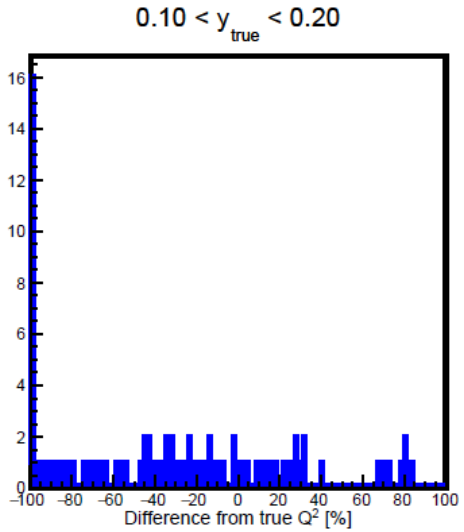
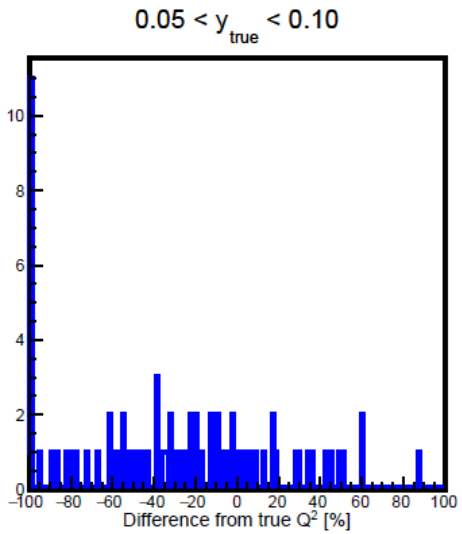
Electron Method

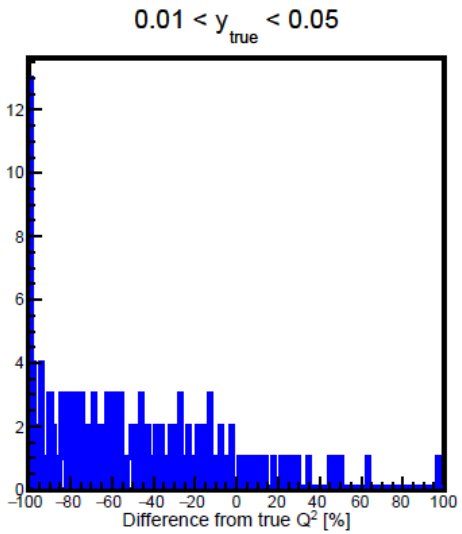
First results – JB method I











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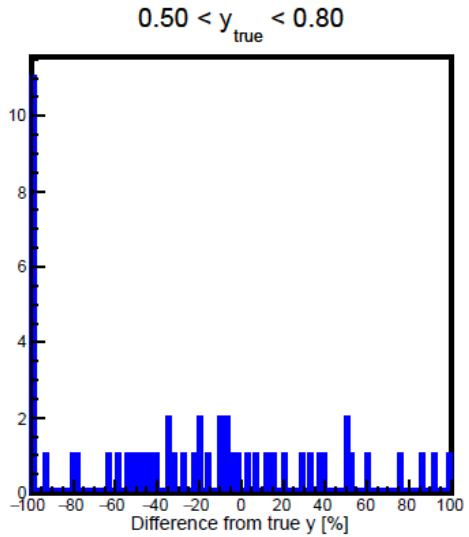
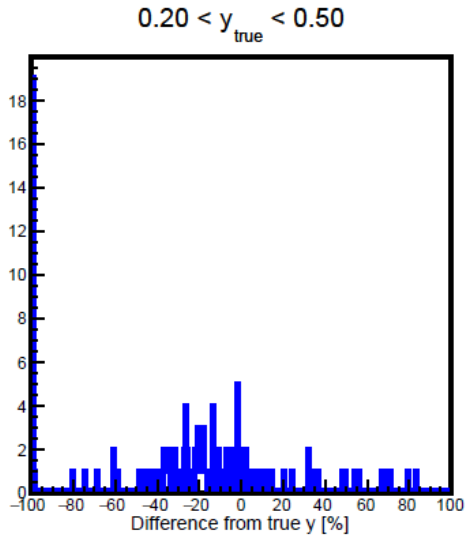
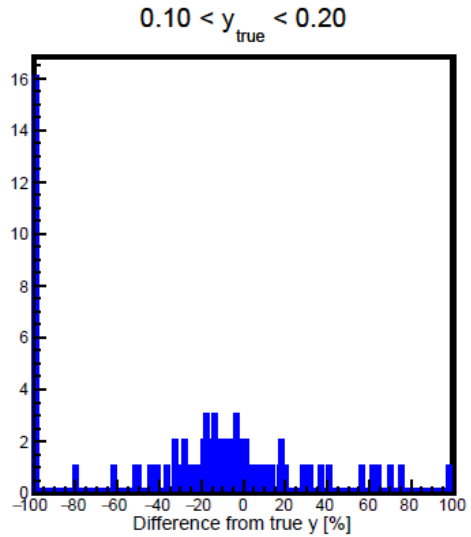
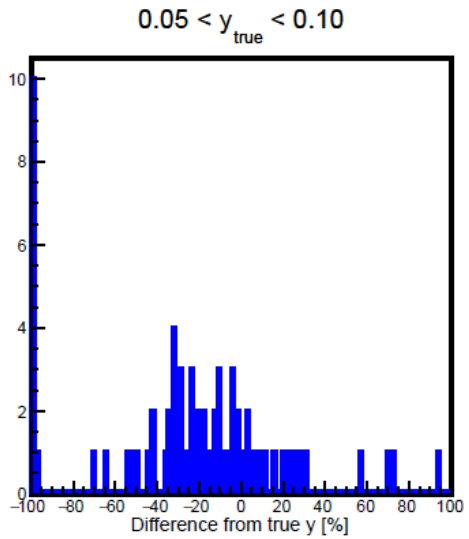
JB Method

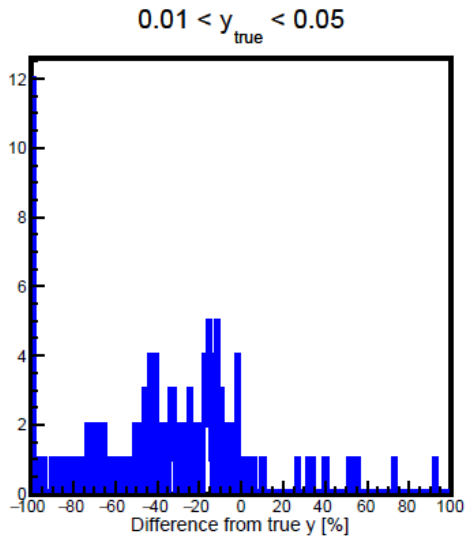
First results – JB method II











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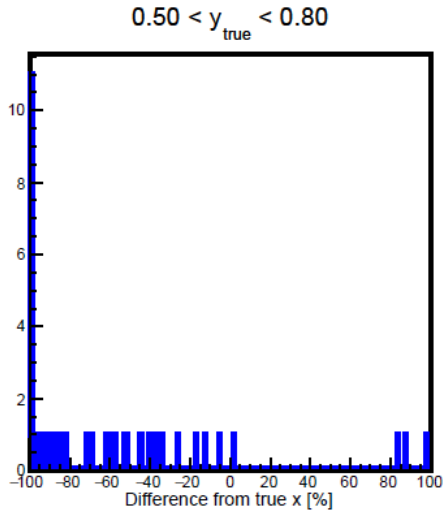
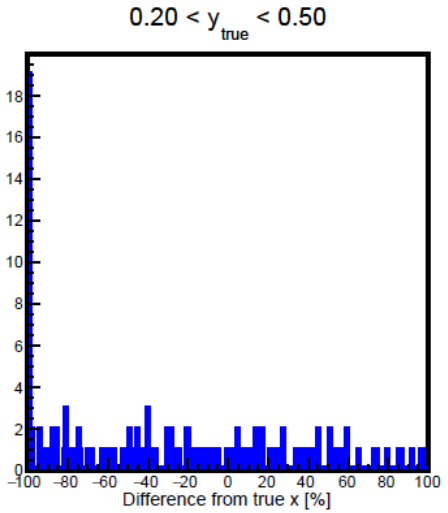
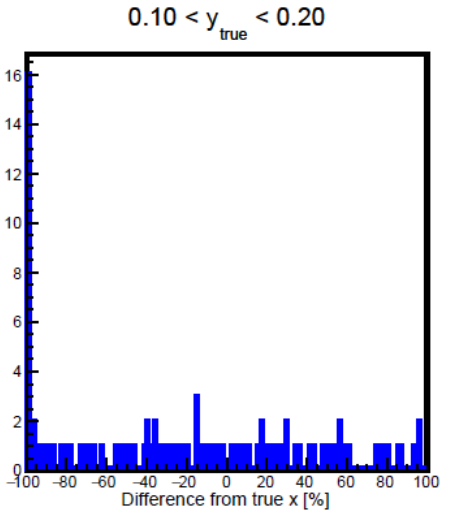
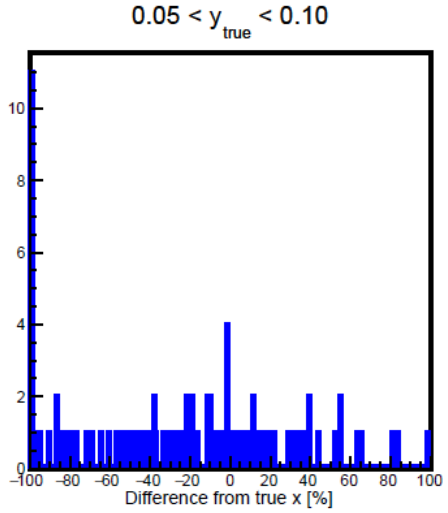
JB Method

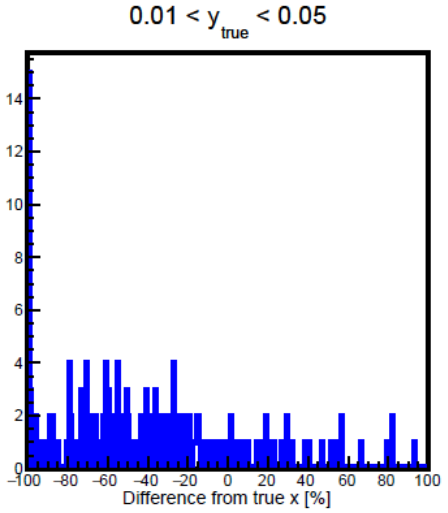
First results – JB method III











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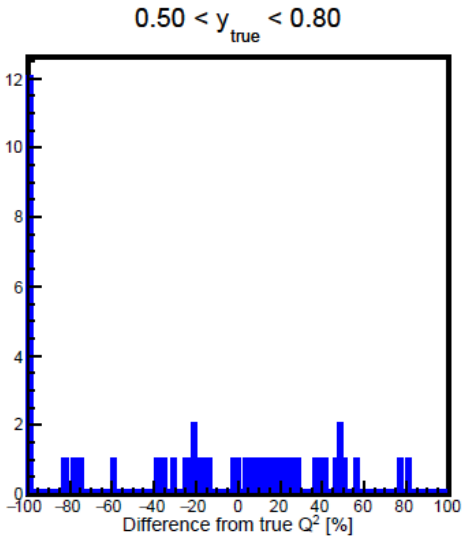
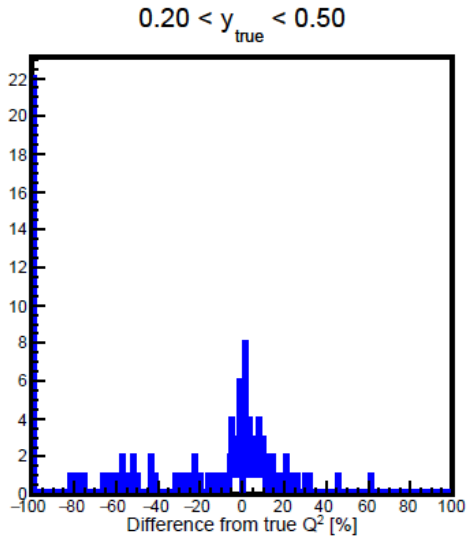
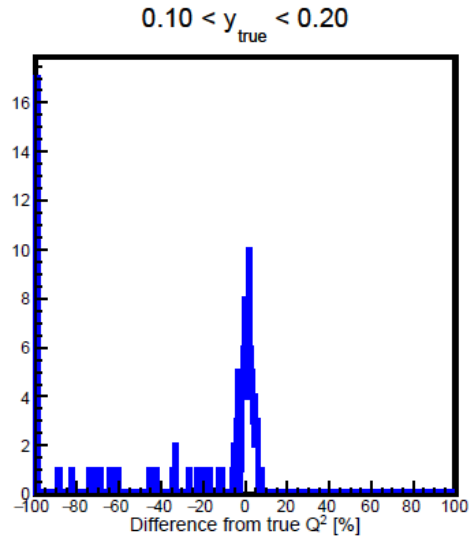
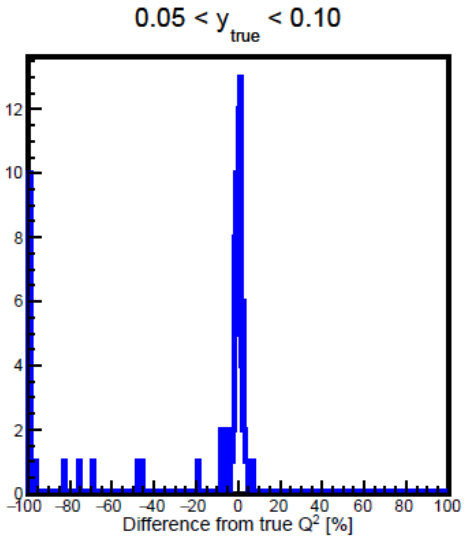
JB Method

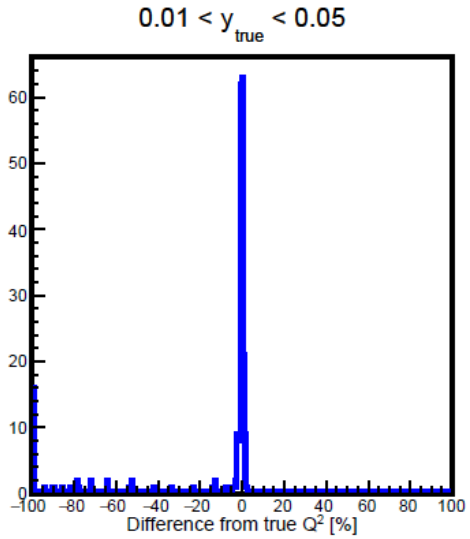
First results – DA method I











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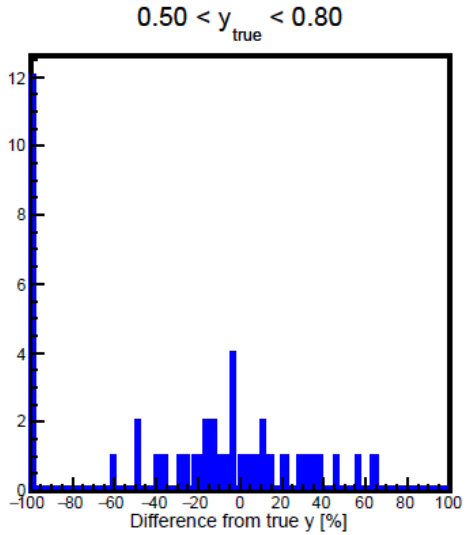
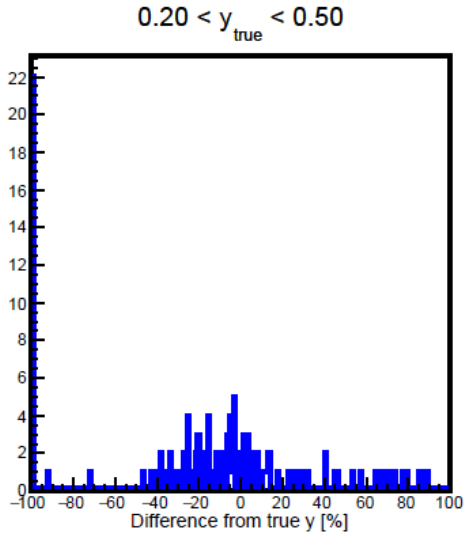
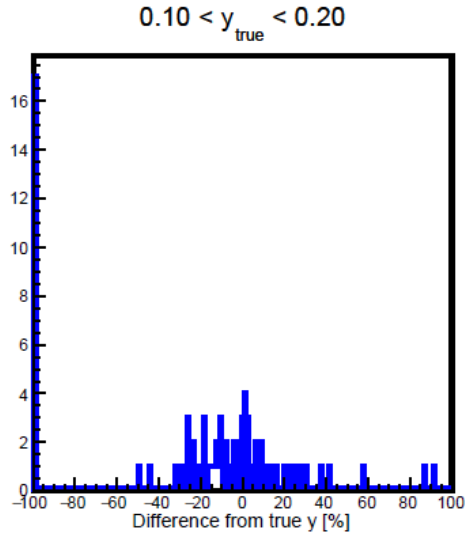
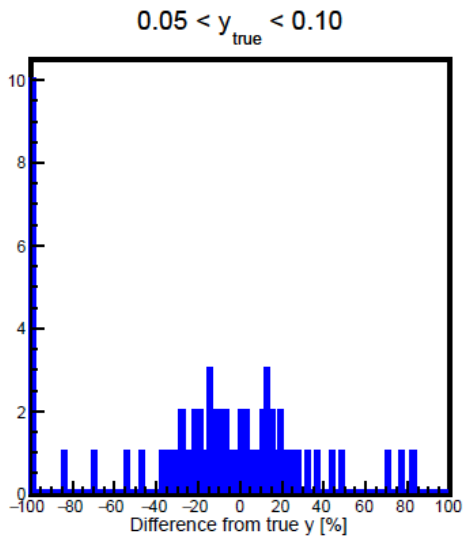
DA Method

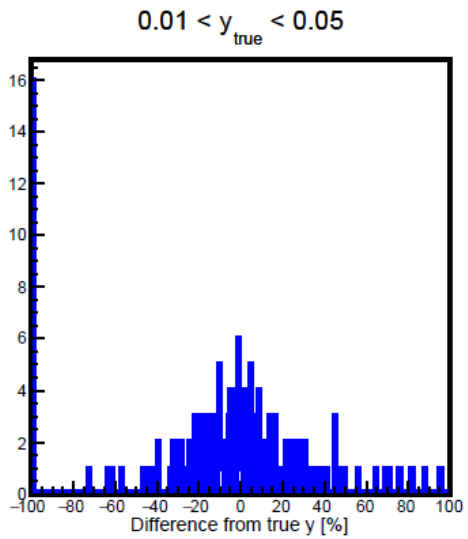
First results – DA method II











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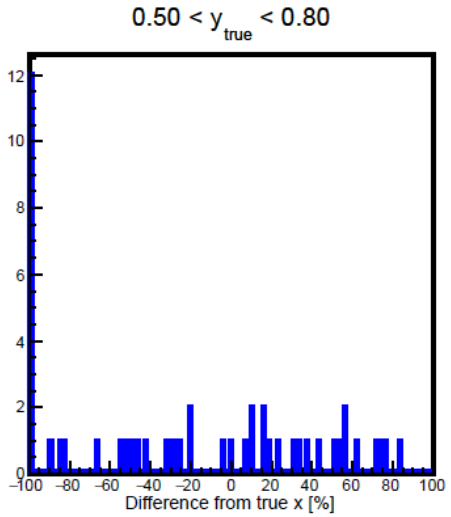
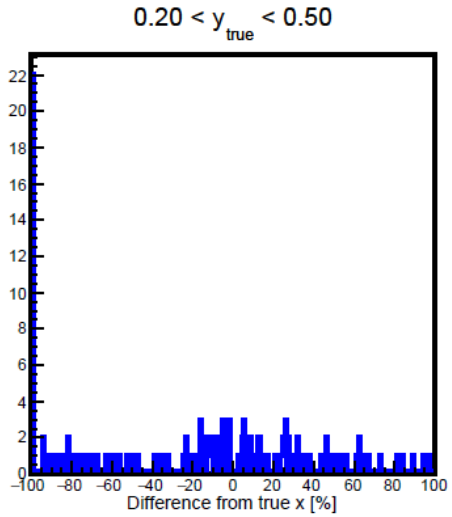
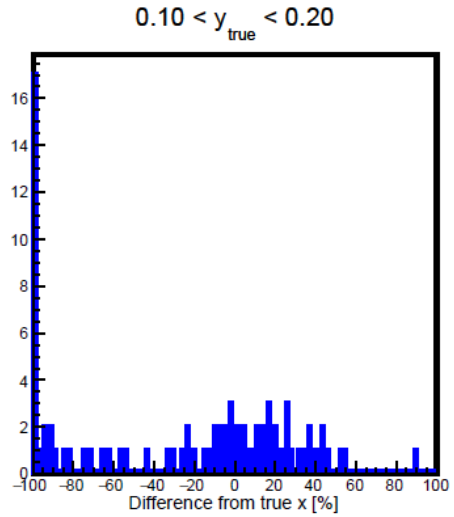
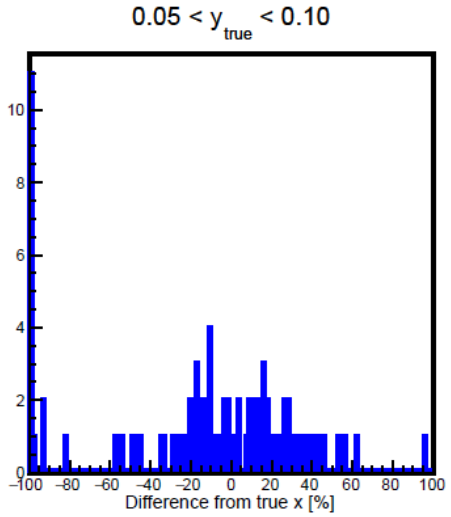
DA Method

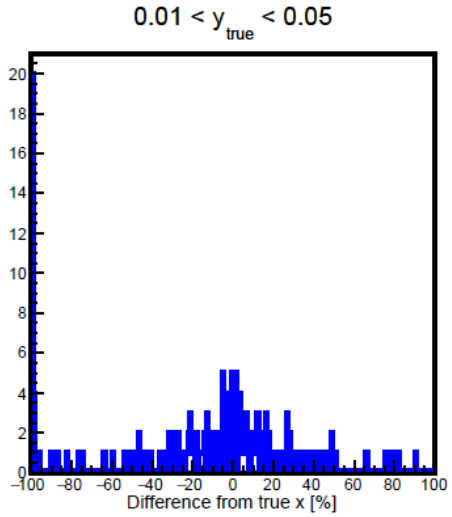
First results – DA method III











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DA Method

Summary

- Three different kinematic reconstruction methods have been implemented in the *Juggler* framework.
- Scattered electron method works well. Only uses tracking detector information.
- Other two methods show missing events and poor resolution right now.
- How do these results compare to other analyses?