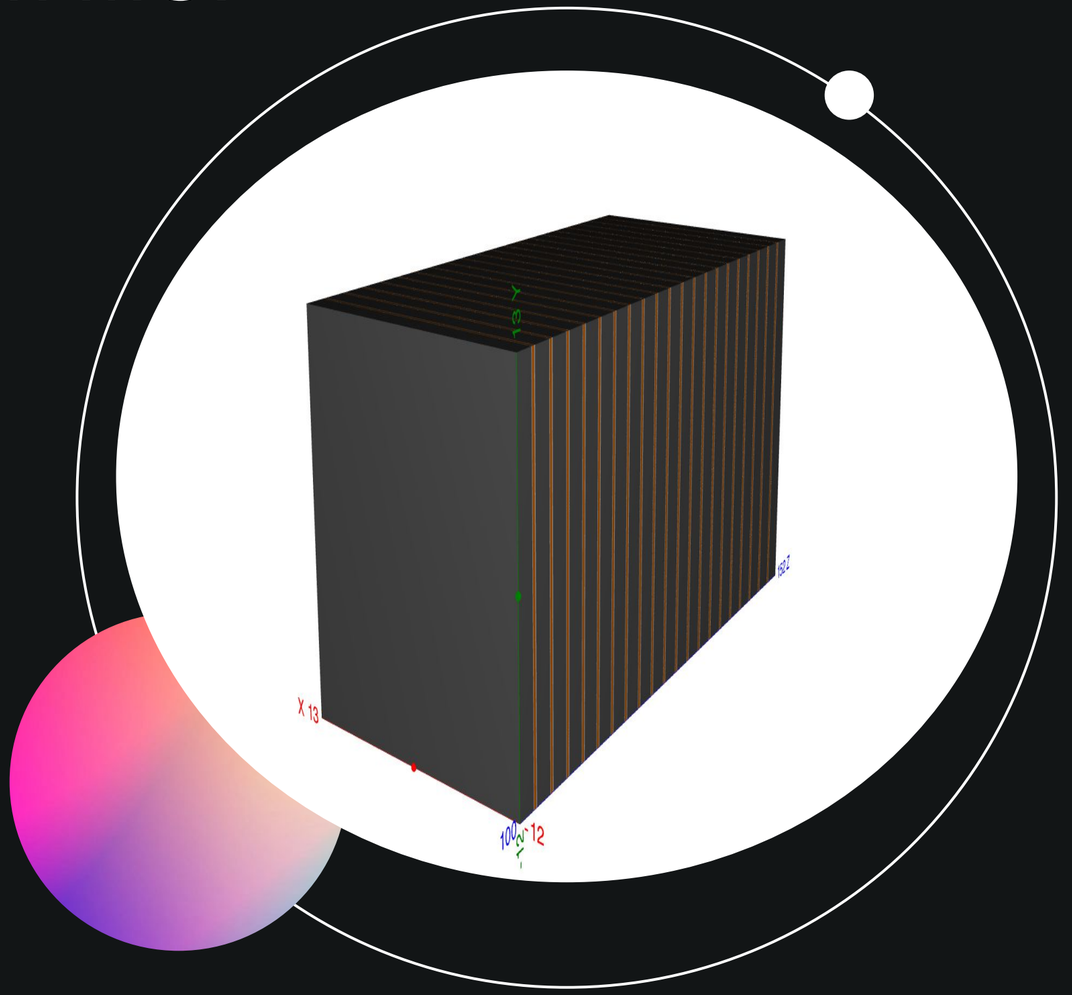
Studying ePIC ZDC Response in MC: Single-Neutron Response and Electron Test-Beam Studies



EIC PRESENTATION 08/13/2025

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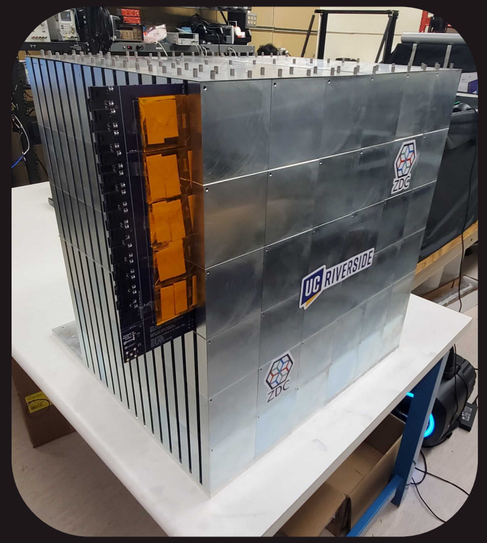
Introduction

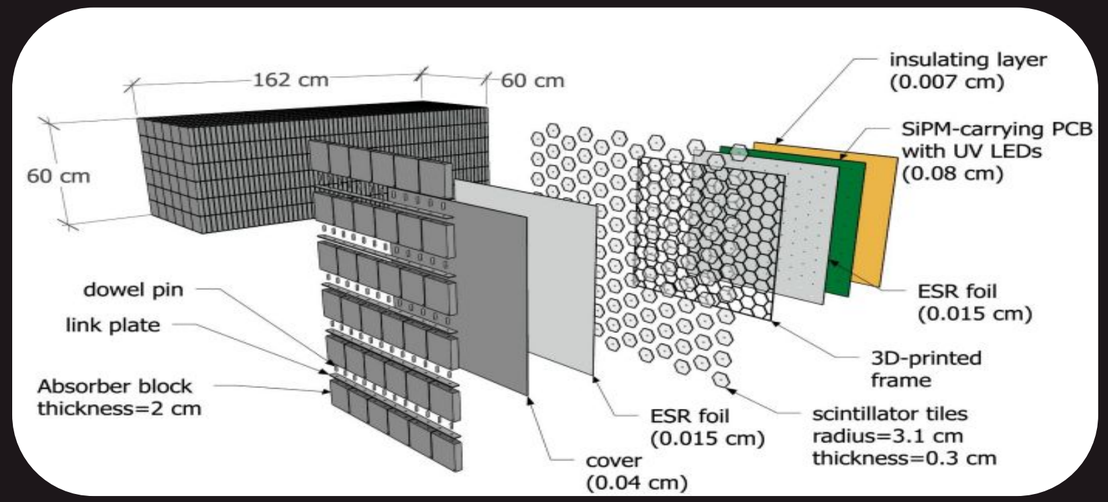
Improving our understanding of the ZDC performance & calibration which entails for us to looked into single fired neutron simulations from the ZDC (full sized) + looked at electron test beam studies

Importance and Relevance

Studied simulations that reflected real studies that contribute towards EIC production. Electron beam or showers are easier to detect and calibrate for the ZDC
the electron simulations are motivated by a future beamtest at Fermilab. detects particles that were scattered at very small angles.

ZDC & Prototype

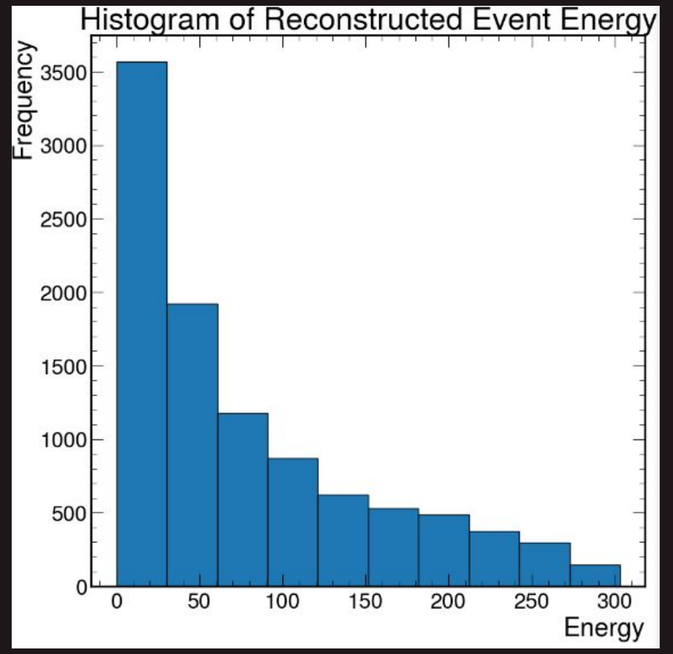


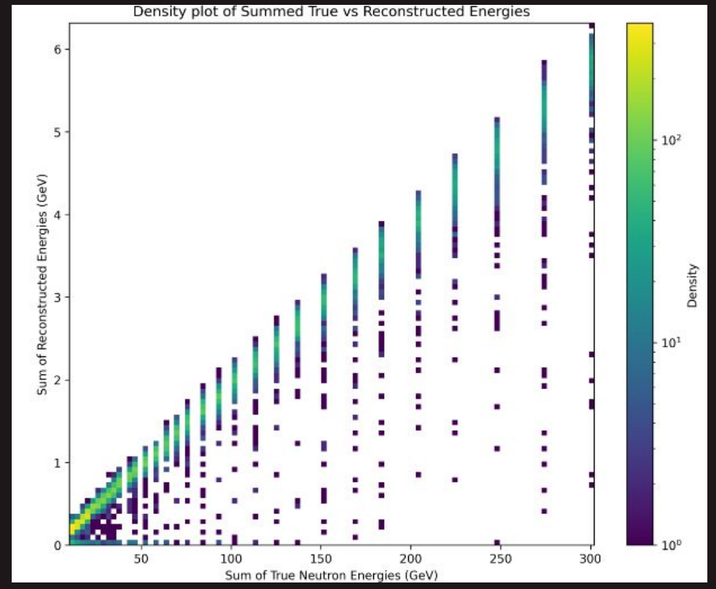


- ZDC prototype
  - dimensions: 25 x 25 cm²
  - 20 layers
  - Each layer thickness is mainly 2 cm of steel + 0.3 cm of scintillator. Each scintillator is a hexagon with a radius of 3.1 cm
- ZDC
  - dimensions: 60 x 60 cm²
  - 64 layers
  - Each layer is again mainly 2 cm of steel + 0.3 cm of scintillator. Each scintillator is a 5x5cm^2 square. Each scintillator is a hexagon with a radius of 3.1 cm

Analyzing the single fired Neutron simulation

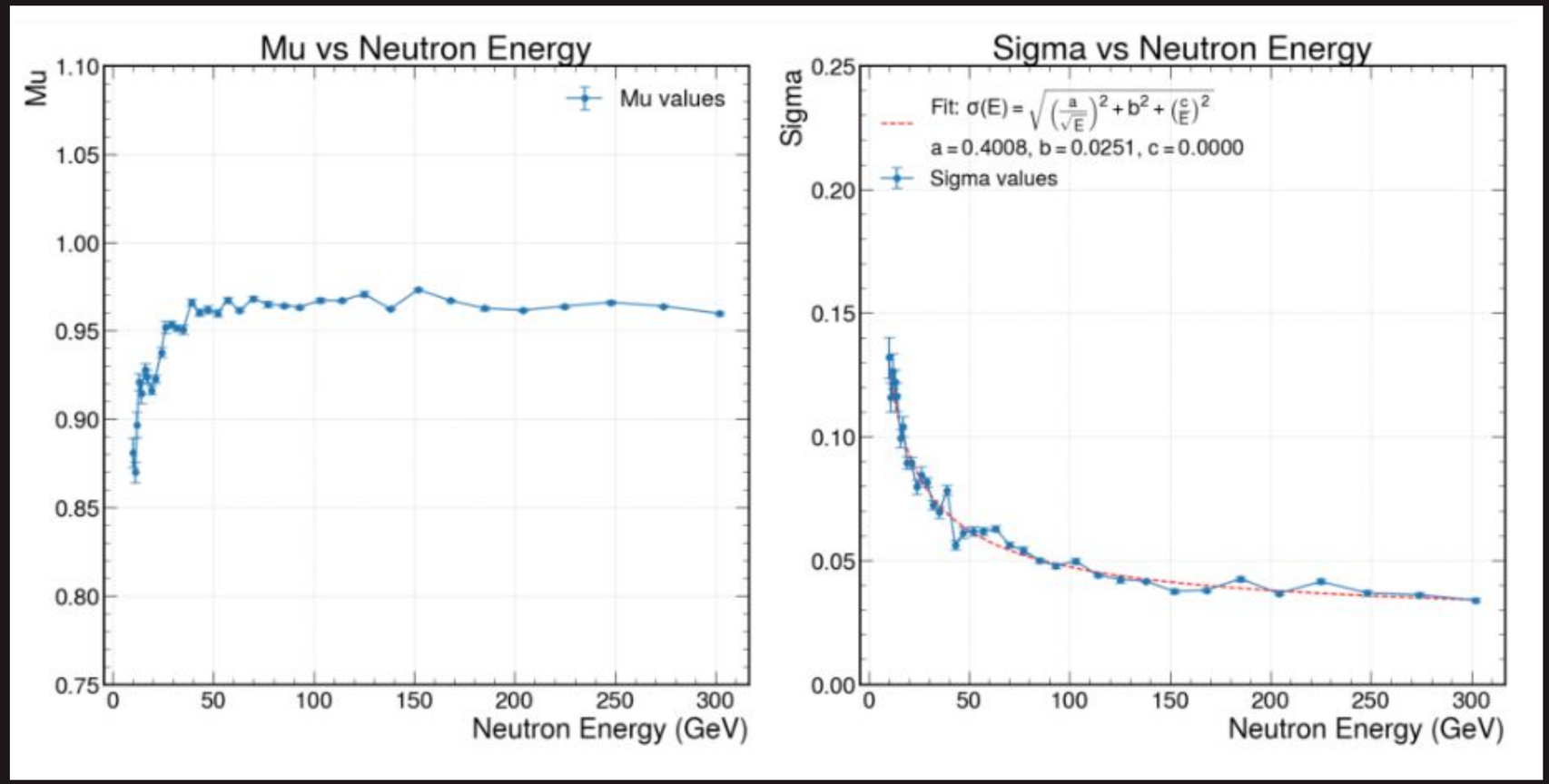
- Plotted the reconstructed energies of the ZDC (full sized)
- the tails are cleaned up by a theta cut and they occur due to the shower not being fully contained





Neutron Energy Response & Resolution

- S: stochastic fluctuations in the shower of particles in the calorimeter, N: noise arising from sources like electronics, C: constant term from passage through "dead" material
- extract S, N, & C terms from fitting the resolution to give better background for its performance
- use these to look at other simulations of the ZDC



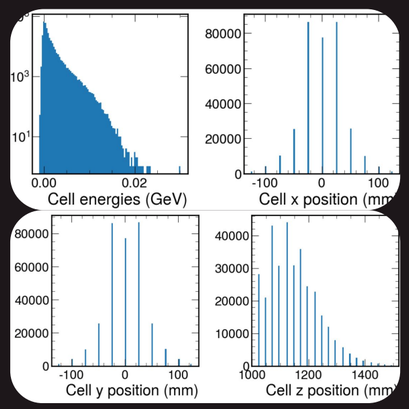
$$\sigma(E) = \sqrt{\left(\frac{N}{\sqrt{E}}\right)^2 + s^2 + \left(\frac{c}{E}\right)^2}$$

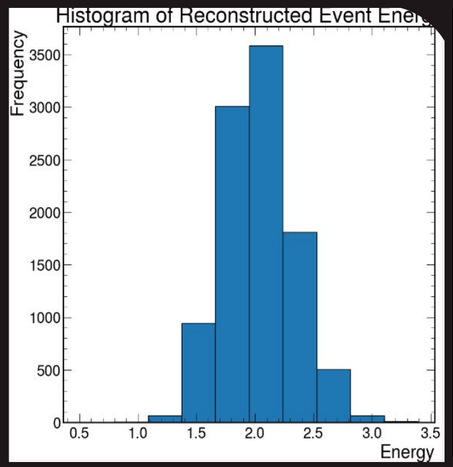
Electron Test Beam Studies

- The dimensions of the ZDC prototype are 30 x 30 cm2
- For the eltron test beam studies we simulated specific 2, 4, 8, 12, 20, 30 GeV electrons motivated by Fermilab energies

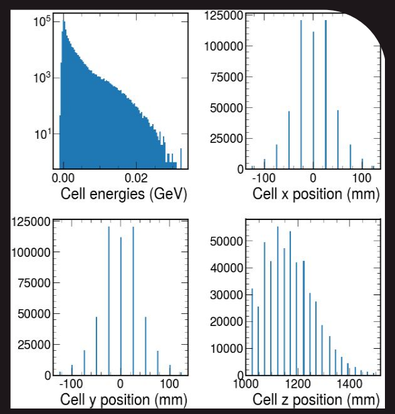
Electron energy distributions

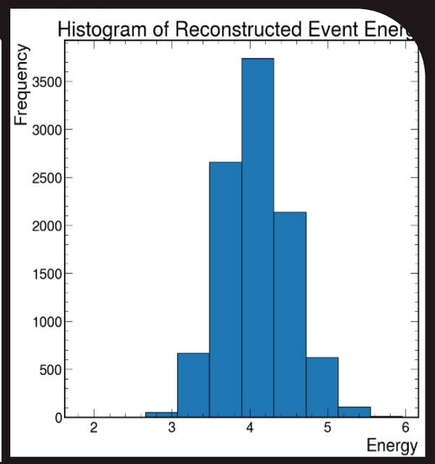
2 GeV



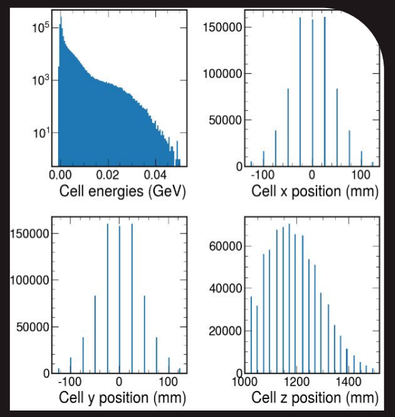


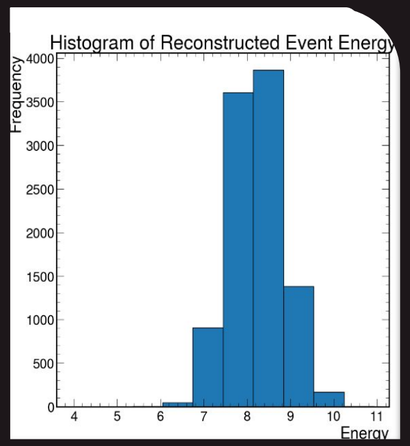
4 GeV



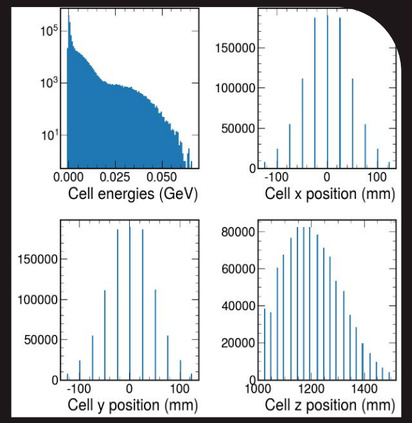


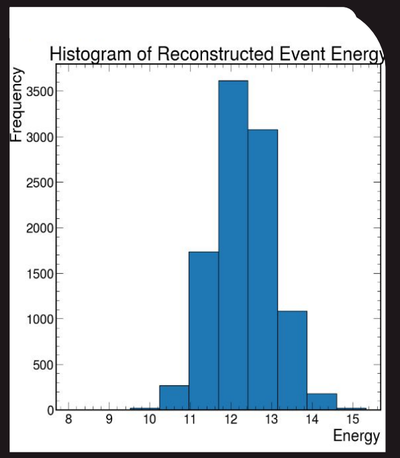
8 GeV



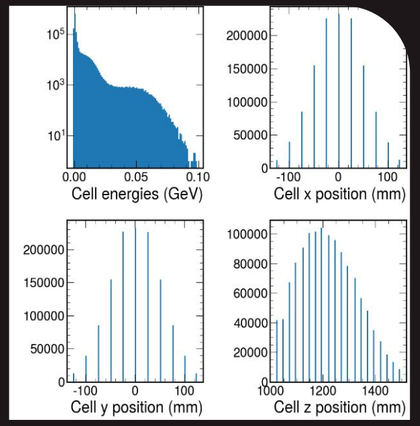


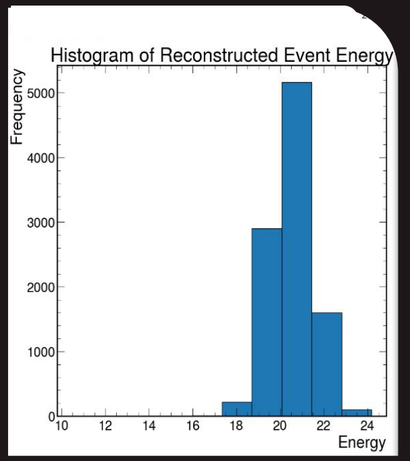
12 GeV



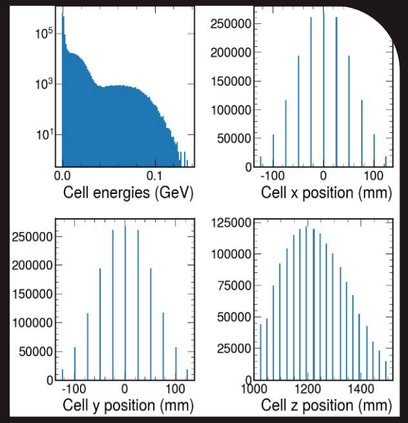


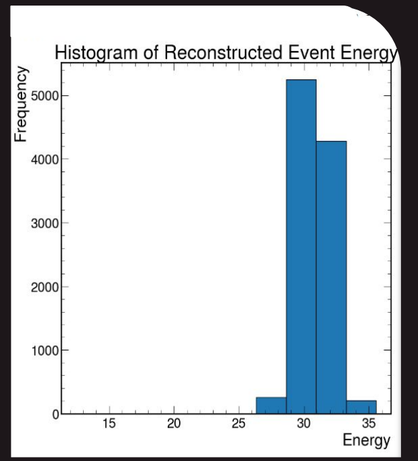
20 GeV



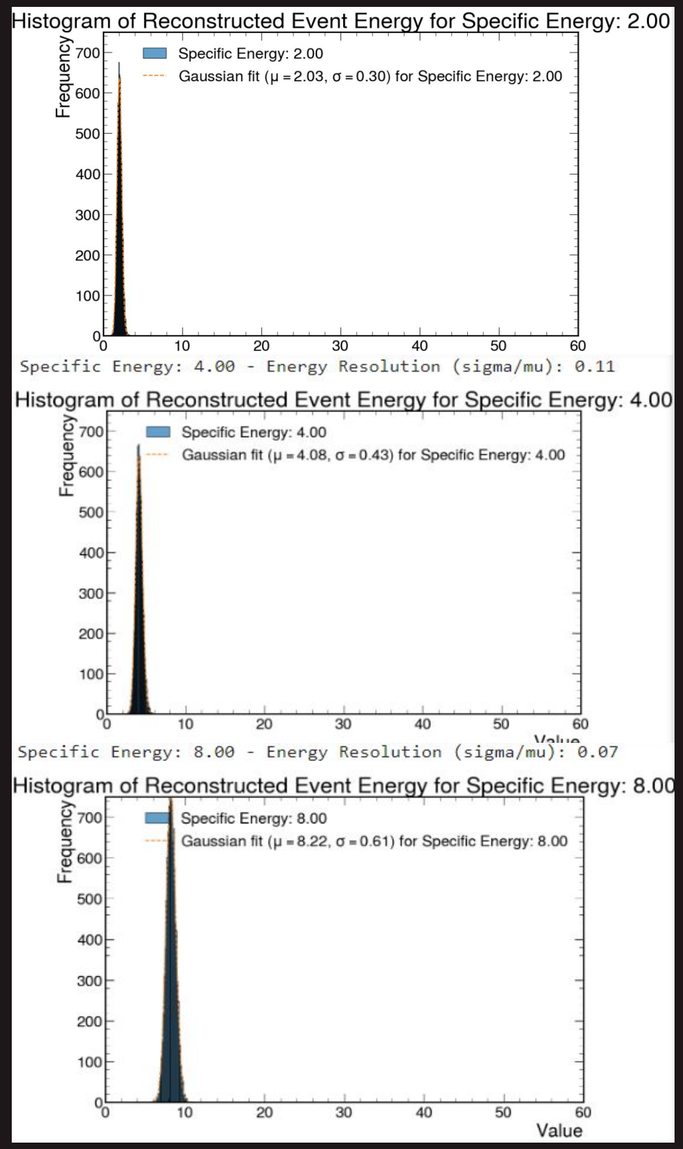


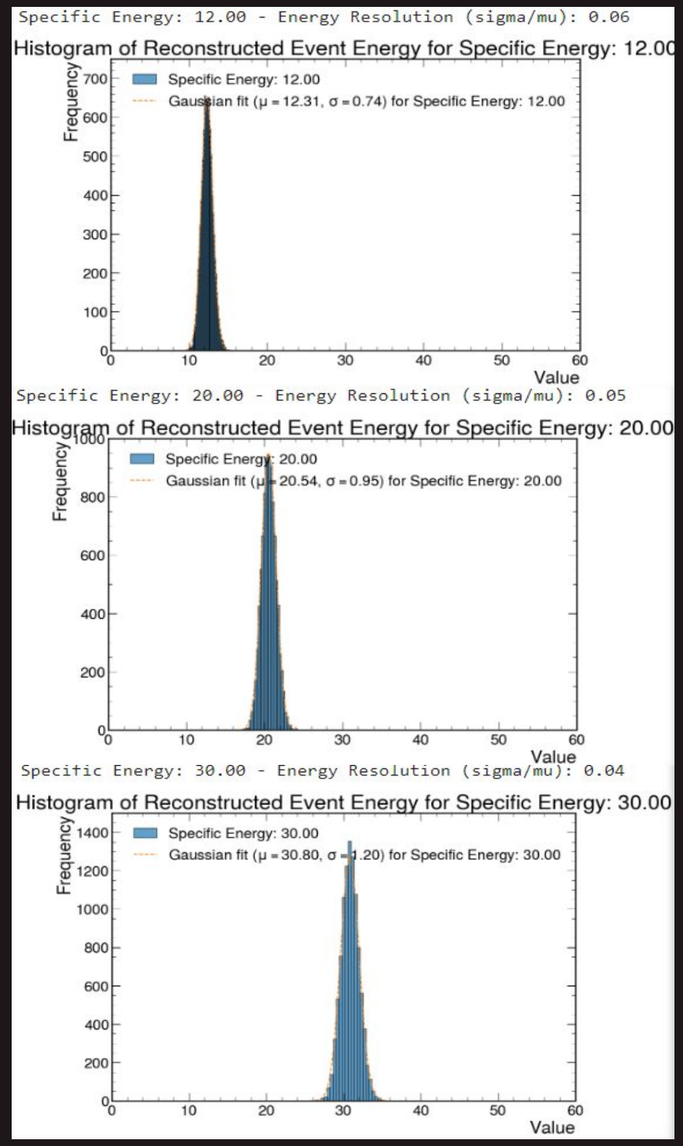
30 GeV

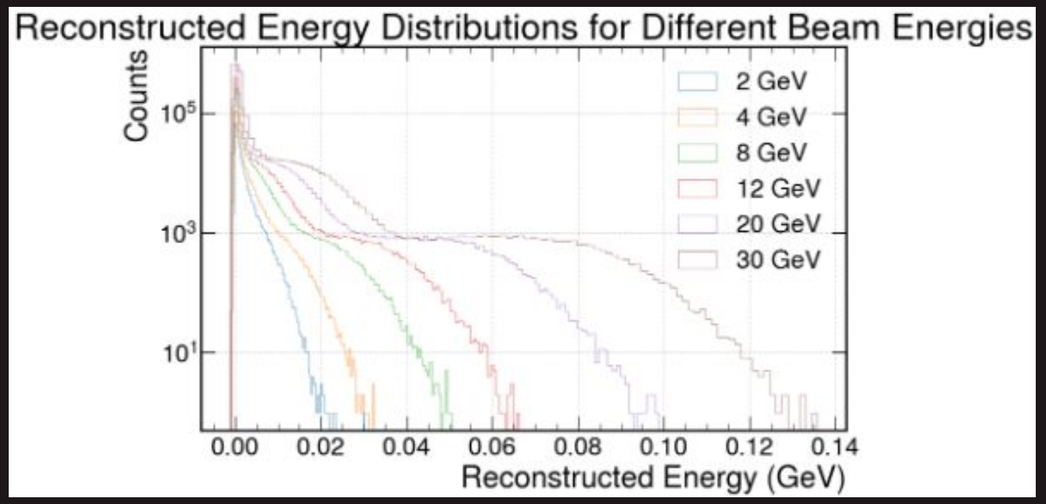




Electron Energy Reconstruction

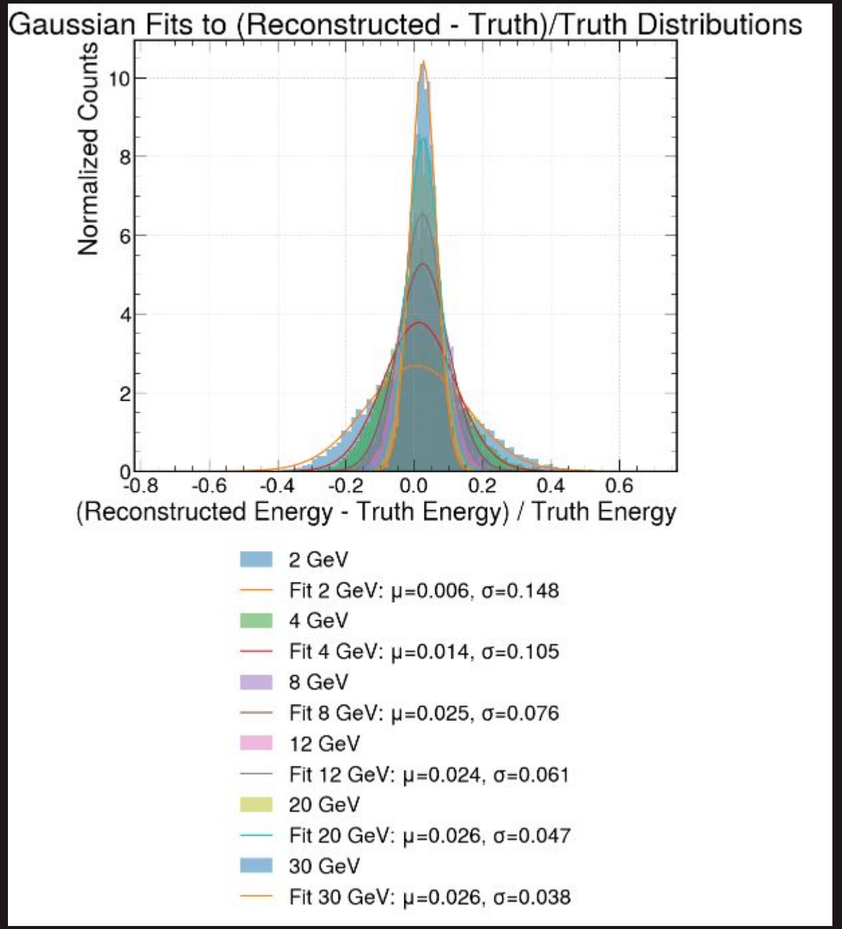


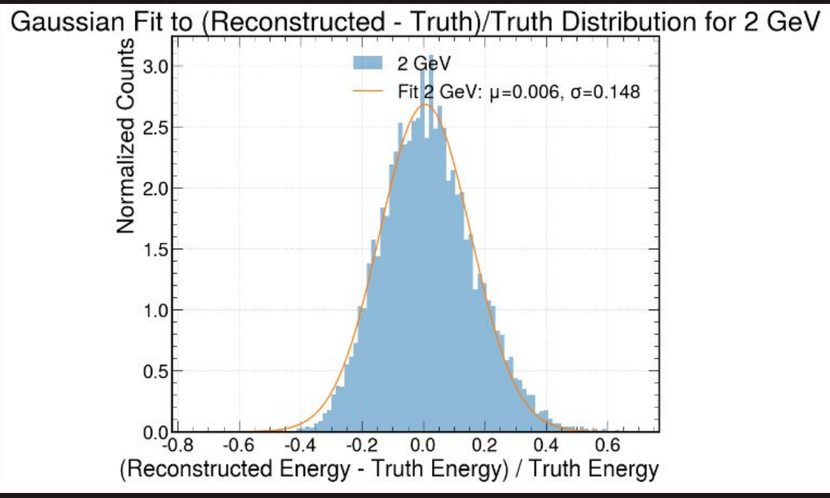


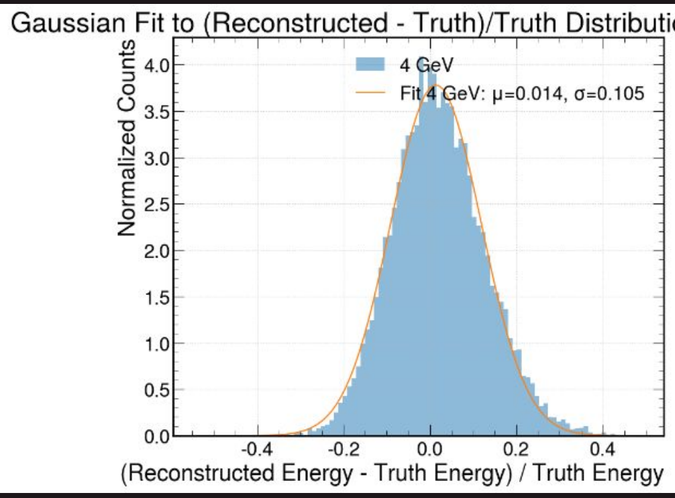


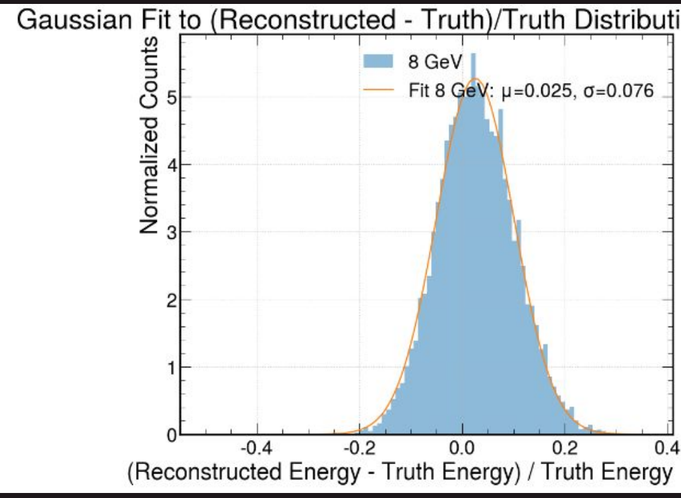
Looking into electron simulation studies

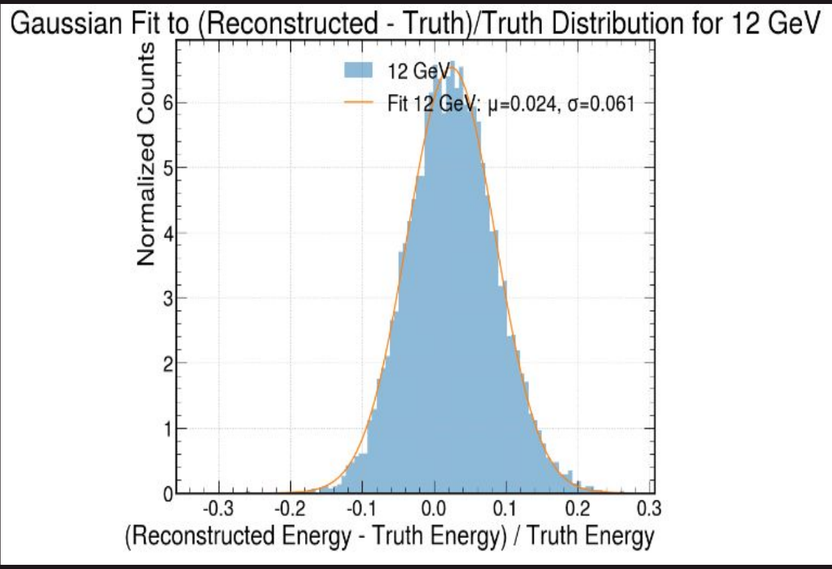
- able to reconstruct electron energies w/ expect reconstructed resolution
- I did this by combining the energies per event divided by the sampling fraction, which is 0.02.

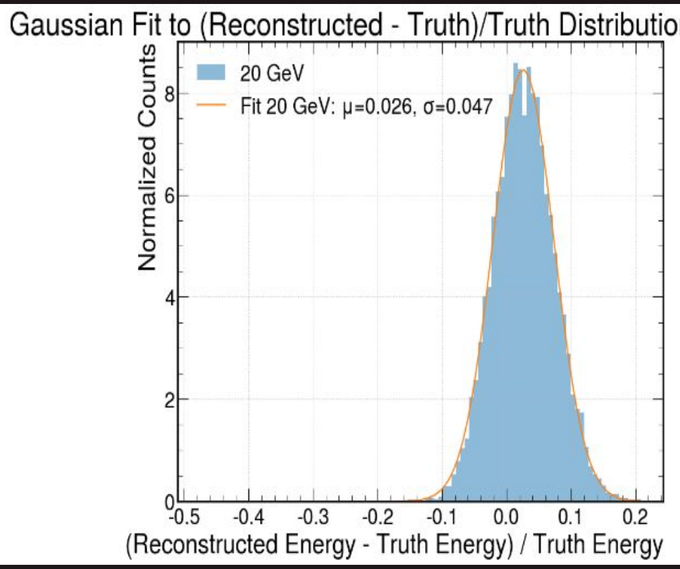


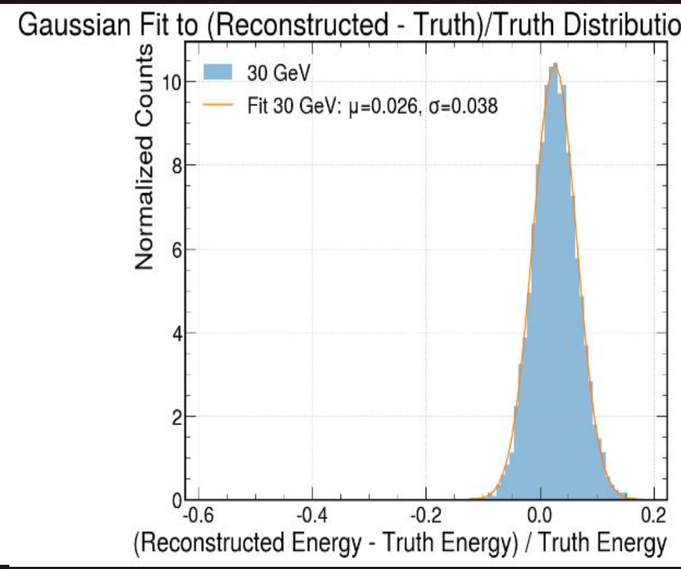

Gaussian Fit to (Reconstructed - Truth)/Truth Distribution for 2 GeV
2 GeV
Fit 2 GeV: μ=0.006, σ=0.148
Normalized Counts
(Reconstructed Energy - Truth Energy) / Truth Energy


Gaussian Fit to (Reconstructed - Truth)/Truth Distribution for 4 GeV
4 GeV
Fit 4 GeV: μ=0.014, σ=0.105
Normalized Counts
(Reconstructed Energy - Truth Energy) / Truth Energy


Gaussian Fit to (Reconstructed - Truth)/Truth Distribution for 8 GeV
8 GeV
Fit 8 GeV: μ=0.025, σ=0.076
Normalized Counts
(Reconstructed Energy - Truth Energy) / Truth Energy


Gaussian Fit to (Reconstructed - Truth)/Truth Distribution for 12 GeV
12 GeV
Fit 12 GeV: μ=0.024, σ=0.061
Normalized Counts
(Reconstructed Energy - Truth Energy) / Truth Energy


Gaussian Fit to (Reconstructed - Truth)/Truth Distribution for 20 GeV
20 GeV
Fit 20 GeV: μ=0.026, σ=0.047
Normalized Counts
(Reconstructed Energy - Truth Energy) / Truth Energy


Gaussian Fit to (Reconstructed - Truth)/Truth Distribution for 30 GeV
30 GeV
Fit 30 GeV: μ=0.026, σ=0.038
Normalized Counts
(Reconstructed Energy - Truth Energy) / Truth Energy

Concluding our findings

- Our findings demonstrated good single-neutron energy responses & resolution
- Our preliminary results provide ZDC energy distributions which could be used in comparison to a future test beam at FermiLab