Reconstruction and analysis efforts for inclusive physics

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(for the inclusive working group)

ePIC collaboration meeting

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Jefferson Lab, Virginia

Inclusive considerations

- Electron resolution → utilize both tracking and calorimetry
- Electron purity → pion suppression from E/p
- Hadronic final state → masking to avoid double-counting detector signals

Tracks, clusters, and matching are very important!

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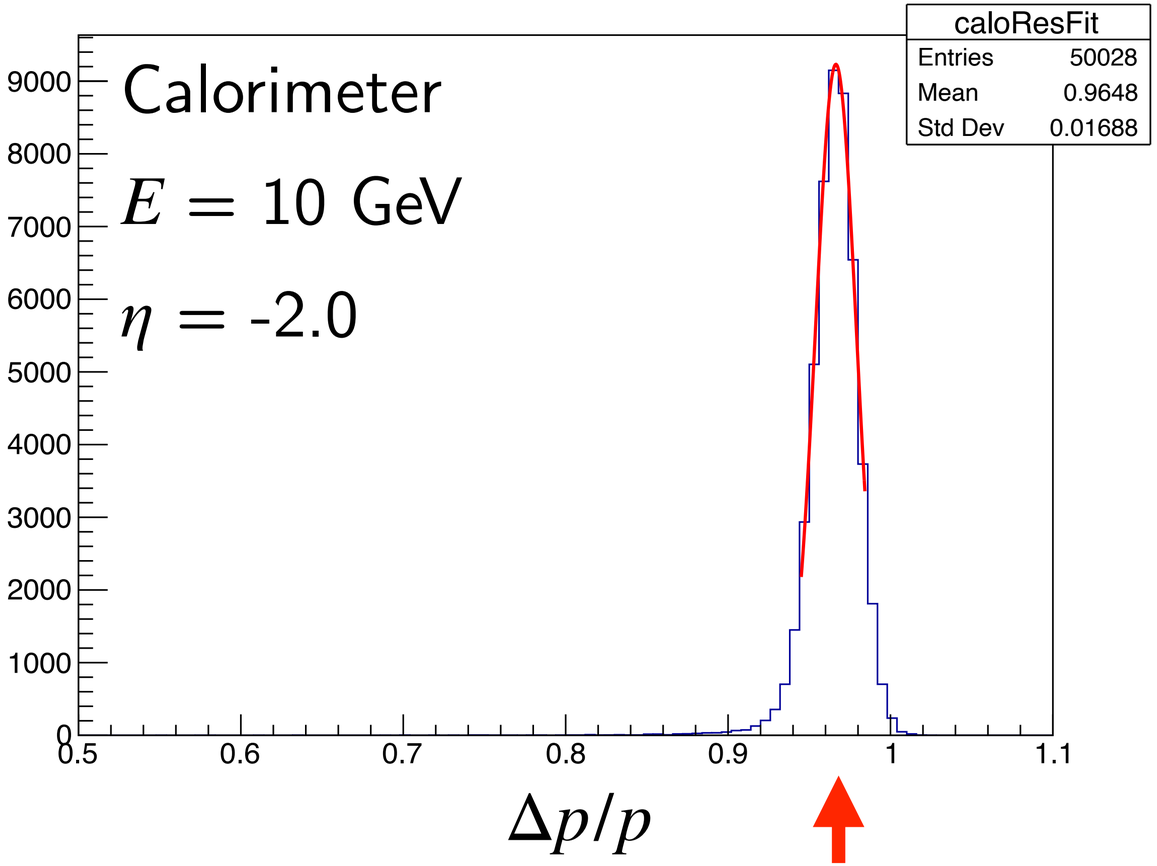
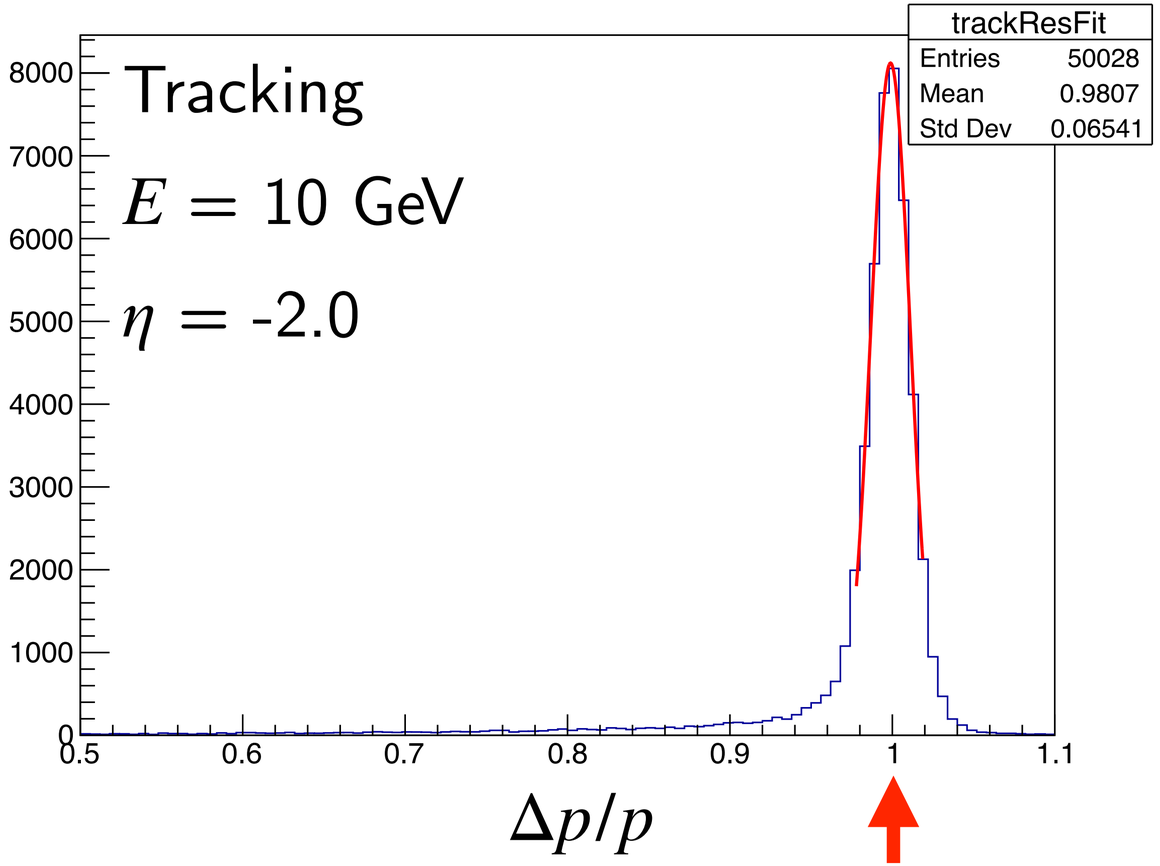
- Setting a baseline: initial look at resolutions from single e^- simulations (22.11.2 arches)
- Calorimeter clustering algorithms in EICrecon
- Track projection in EICrecon

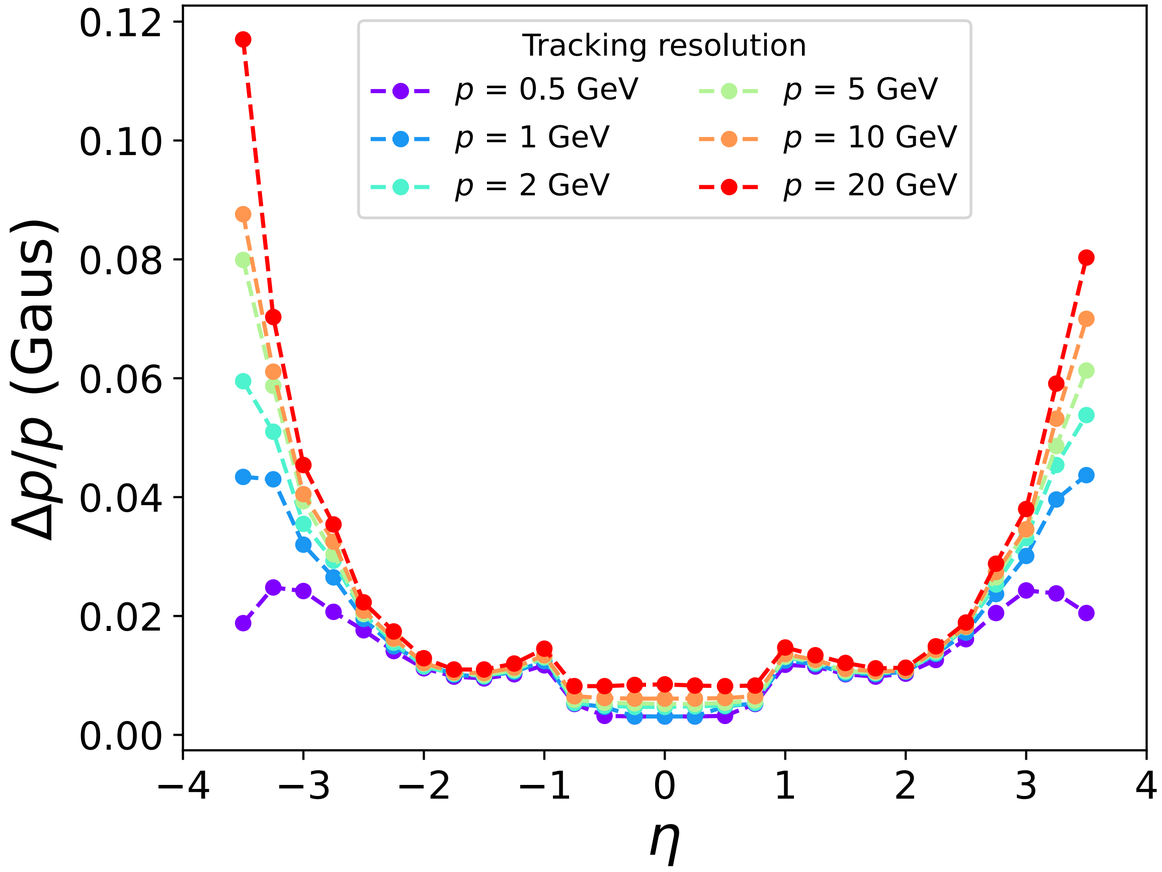
Resolutions from single electron simulations (22.11.2 arches)

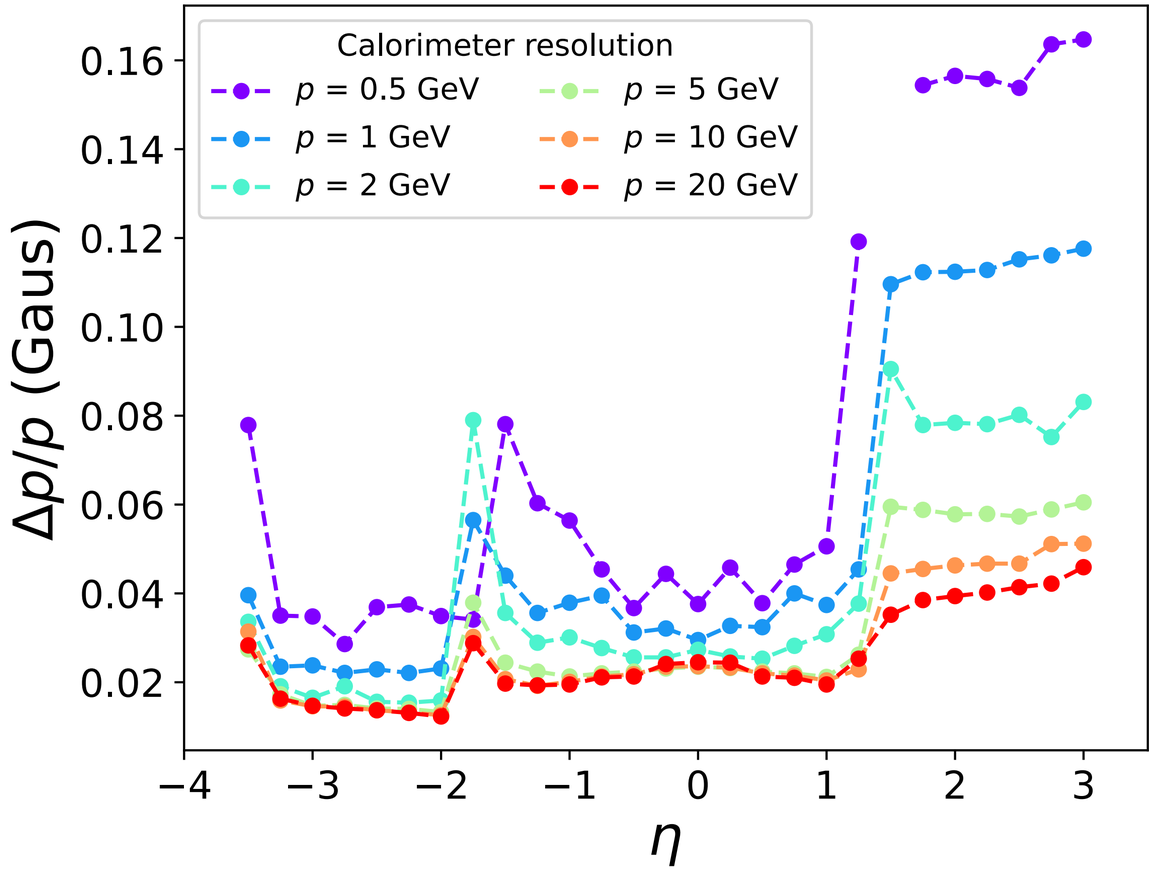




Calorimeter offset on order of 5%

Resolutions from single electron simulations (22.11.2 arches)

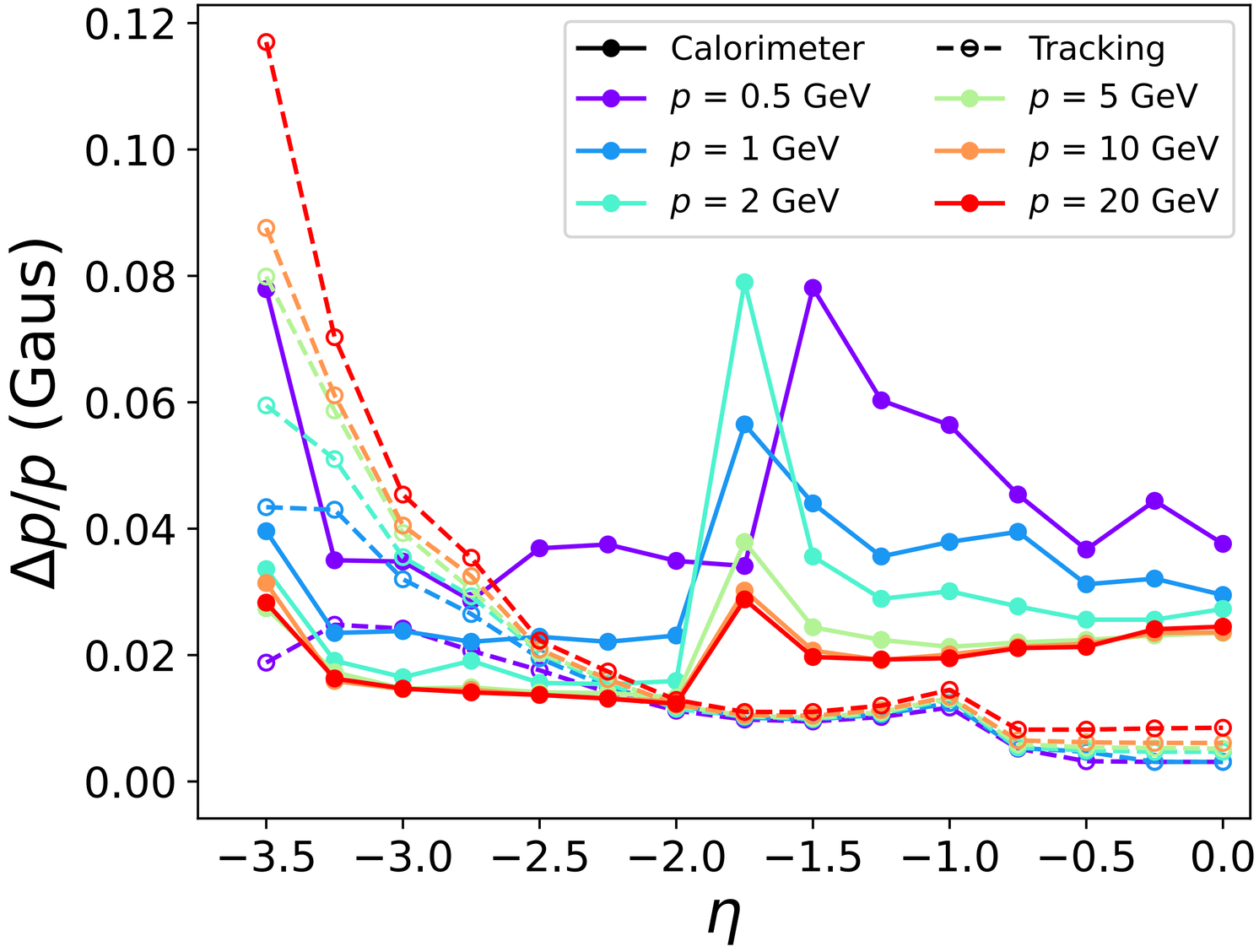




Width of Gaussian fit (does not include tails or offsets)

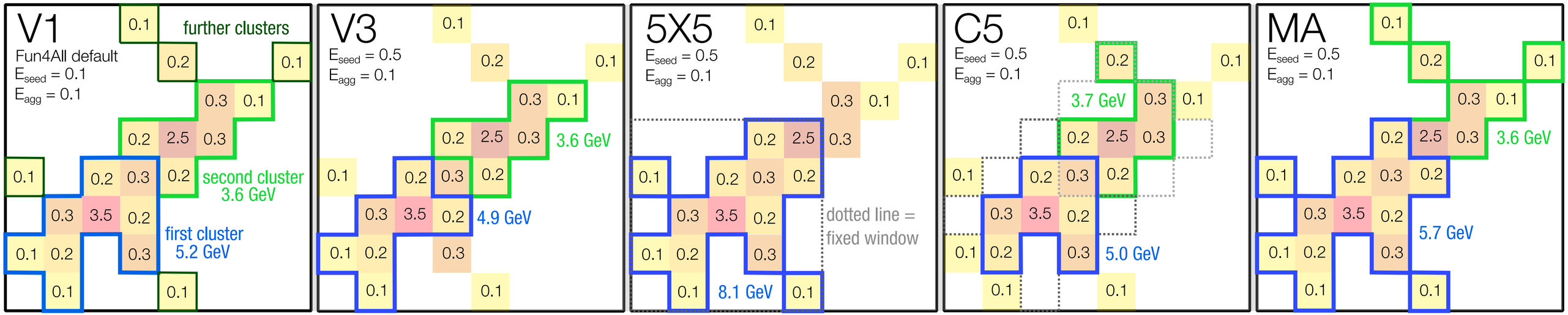
Comparison of tracking and calorimeter resolutions in backward region

- Better performance from calorimeter for $\eta \lesssim -2$
- Poor calorimeter performance at endcap/barrel boundary ($\eta \approx -1.8$)



Calorimeter clustering

Figure from F. Bock

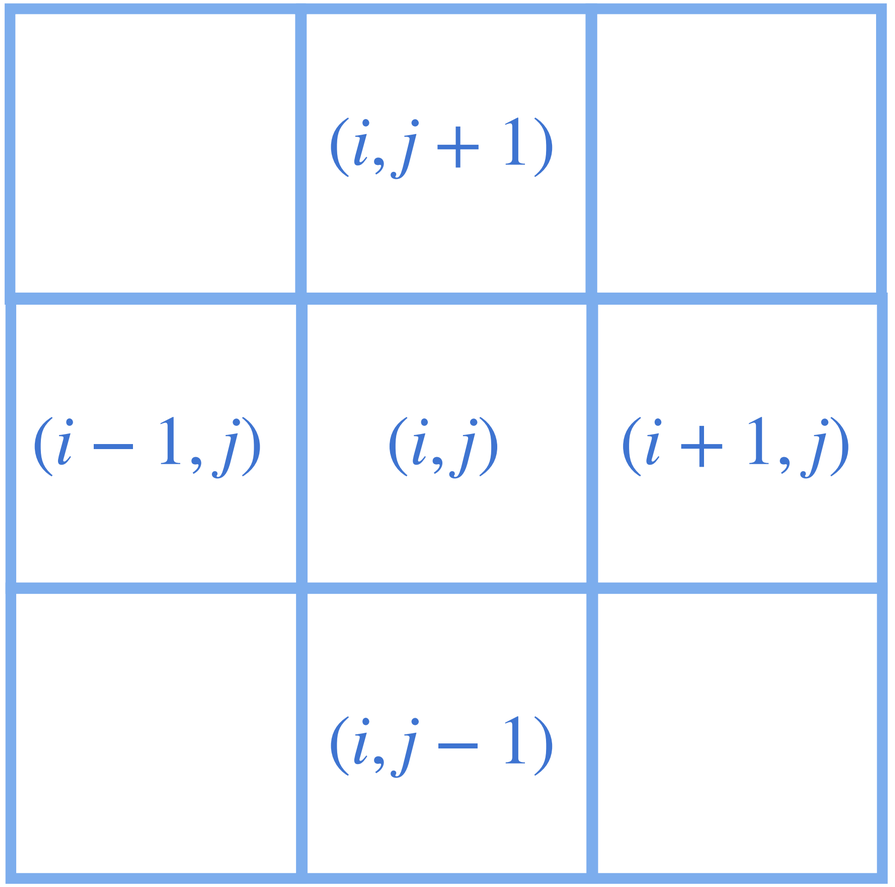


- Must attribute group of calorimeter hits to single particle
- Different algorithms give different efficiencies, resolutions, etc.
- Inclusive studies in fun4all used modified aggregation (MA) algorithm
  - Want to implement various algorithms in EICrecon for comparisons and optimization

Clustering in EICrecon

- "Island clustering" currently implemented in EICrecon
  - Uses depth-first search to cluster all adjacent hits above energy threshold
- Adjacency determined by hit separation and cell size (not optimal!)

- Currently working on implementing cell indexing in detector construction to determine adjacency
- (i, j) should account for wrap-around in barrel
- 3D indexing where necessary



Track projections

- Need to project tracks to other detector surfaces
  - Particle/electron ID, mask clusters for hadronic reconstruction, etc.
- An EICRecon algorithm has been implemented using the ACTS::Propagator class
- First obvious cross check is reconstruction of scattered electron

Example algorithm output

```
[Eemc_TrkPropagation] [trace] EemcTrkPropagation_processor event
[Eemc_TrkPropagation] [trace] Number of primary generated particles:
[Eemc_TrkPropagation] [trace]          1
[Eemc_TrkPropagation] [trace] Generated particle eta, p, E:
[Eemc_TrkPropagation] [trace]      -1.90      10.31      10.31
[Eemc_TrkPropagation] [trace] Number of reconstructed tracks:
[Eemc_TrkPropagation] [trace]          1
[Eemc_TrkPropagation] [trace] Reconstructed track p:
[Eemc_TrkPropagation] [trace]      10.72
[Eemc_TrkPropagation] [trace] Number of EEMC clusters:
[Eemc_TrkPropagation] [trace]          1
[Eemc_TrkPropagation] [trace] Cluster E, x, y, z:
[Eemc_TrkPropagation] [trace]       9.97     535.62    -124.55   -1840.03
[Eemc_TrkPropagation] [debug] Propagating through 1 trajectories
[Eemc_TrkPropagation] [trace]  -- trajectory 0 --
[Eemc_TrkPropagation] [trace]   Number of elements in trackTips 1
[Eemc_TrkPropagation] [trace]   Num measurement in trajectory: 6
[Eemc_TrkPropagation] [trace]   Num states in trajectory     : 16
[Eemc_TrkPropagation] [trace]     TrackPropagation. Propagating to surface # N4Acts7Surface11SurfaceTypeE
[Eemc_TrkPropagation] [trace]     propagation result is OK
[Eemc_TrkPropagation] [trace]     path len = 1923.4008
[Eemc_TrkPropagation] [trace]     pos x = 545.49713
[Eemc_TrkPropagation] [trace]     pos y = -127.51015
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Generated and reconstructed electron momentum (energy)

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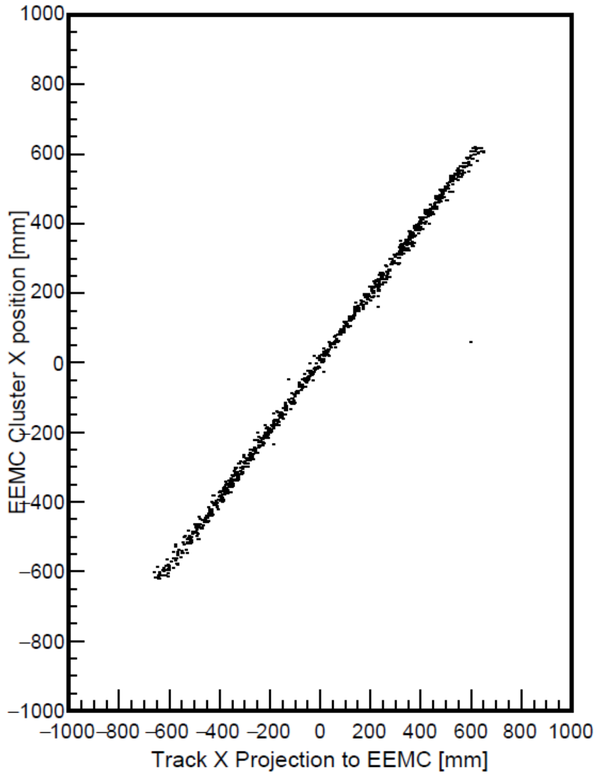
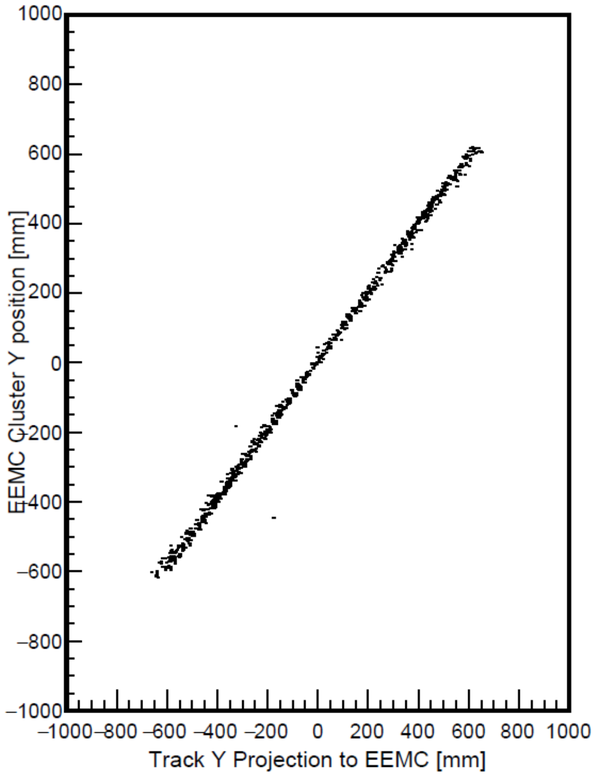
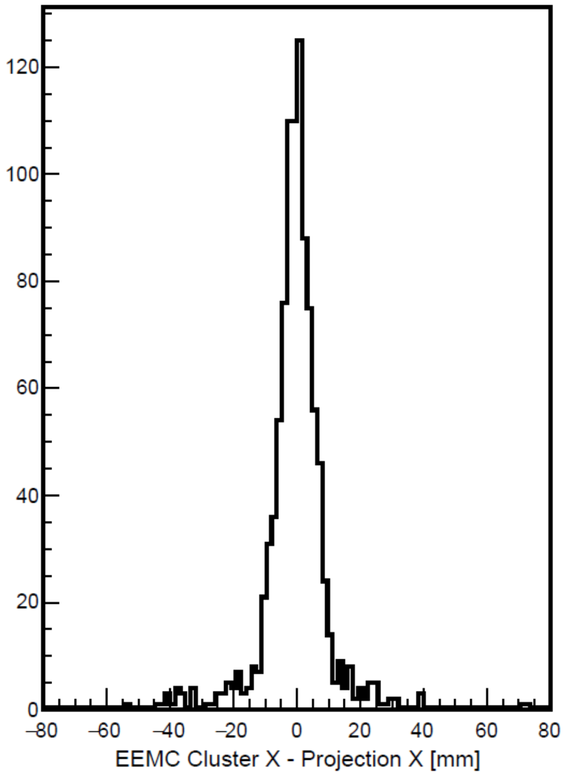
Generated and reconstructed electron momentum (energy)

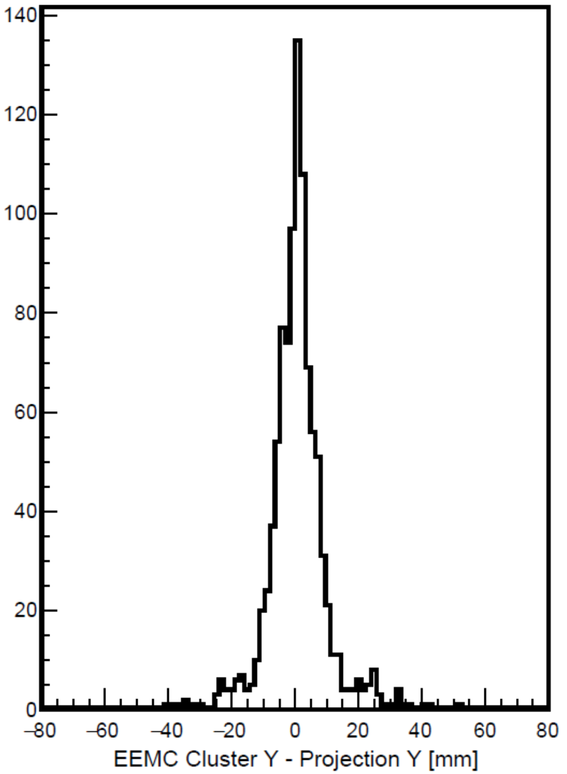
EEMC cluster and projected track position

Track projection performance









Single electrons generated

$1 < E < 20$ GeV

$160^\circ < \theta < 170^\circ$

Next steps for projections

- Track projection for other detectors
  - Requires small additions to current algorithm for cylindrical surfaces.

- Projections currently stored in EICrecon as a TrackPoint (cannot be written to ROOT files using an EICrecon 'factory'
  - Save as TrackSegment data type instead?

- For multi-track events, make sure that track projection is correctly associated with the corresponding track (and save this information in output)

- Ongoing confusion: inconsistencies between default parameters in .h files and reco_flags.py

Summary

- Inclusive physics relies on “bread and butter” of ePIC reconstruction performance, notably electron tracking, calorimetry, and matching
- Currently contributing to calorimeter clustering tools and algorithms
- Have implemented track projections to EEMC and are currently generalizing to include other detectors