# Topoclustering Status

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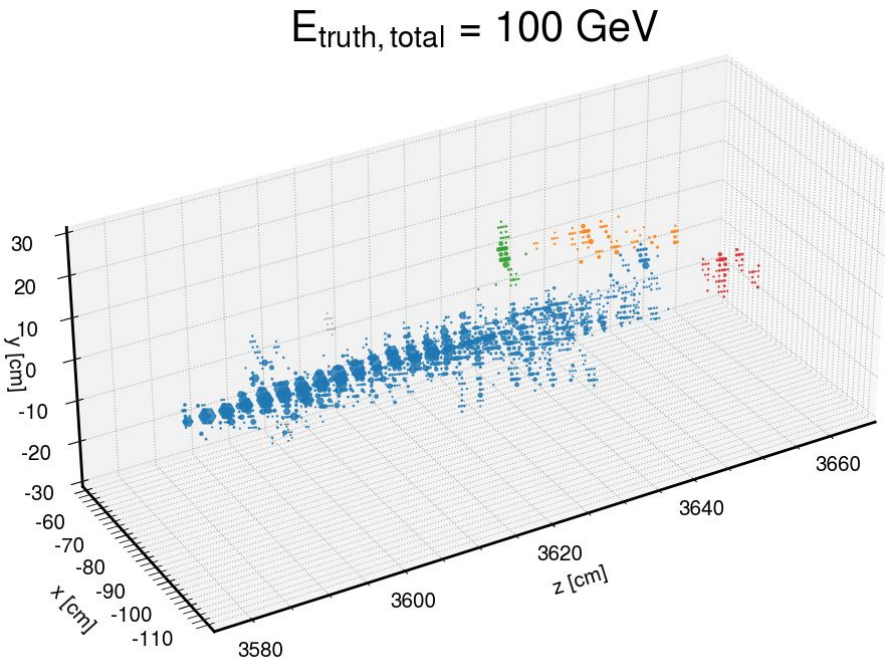
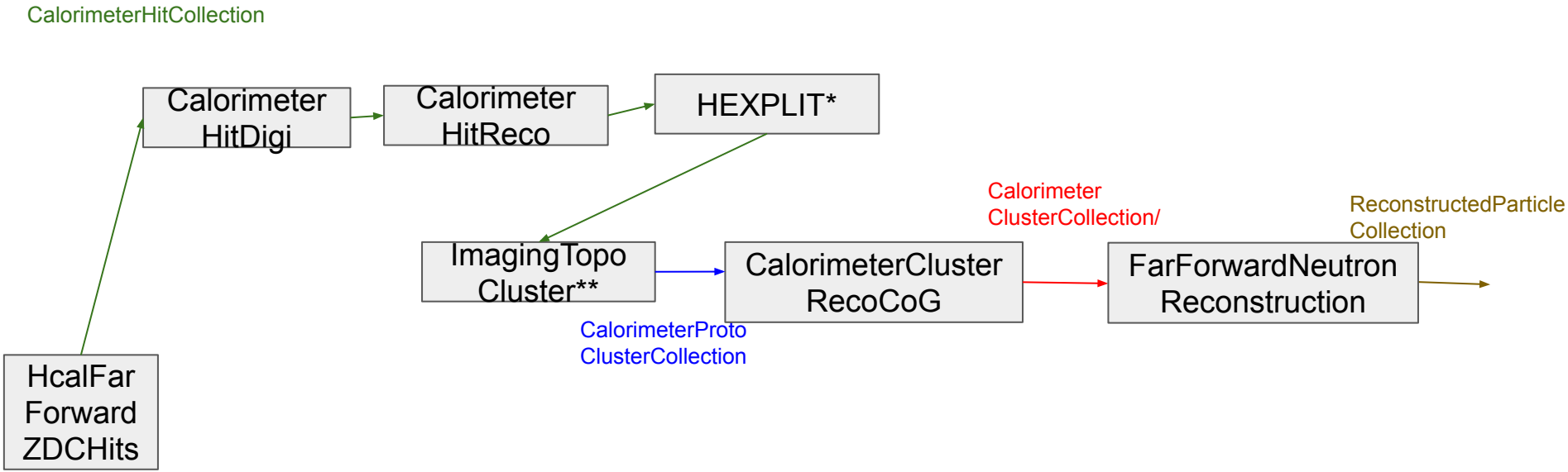


# Single neutron reconstruction in the SiPM-on-tile ZDC In EICrecon (similar will be implemented in Insert)




* https://doi.org/10.1016/j.nima.2023.169044

** https://doi.org/10.1140/epjc/s10052-017-5004-5

# HEXPLIT algorithm*

S. Paul, M. Arratia, NIMA 1060 (2024) 169044

- Takes advantage of overlapping cells
- Redistributes energy within a given hit into “subcell hits” in regions defined by overlap between cells.

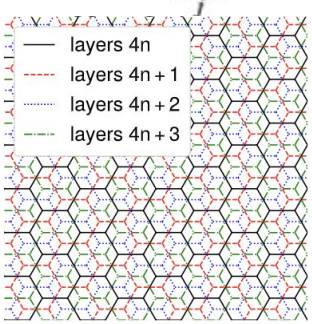
Define subcells with overlap and assign weights:

$$W_i = \prod_{j=1}^{N-1} \max(E_j, \delta),$$

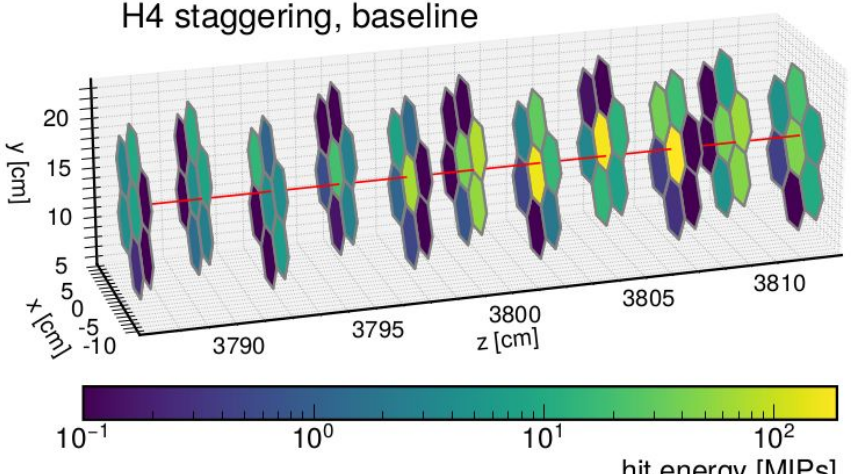
Product over overlapping cells, $j$, in neighboring layers

$$E_i = E_{\text{tile}} W_i / \sum_j W_j.$$

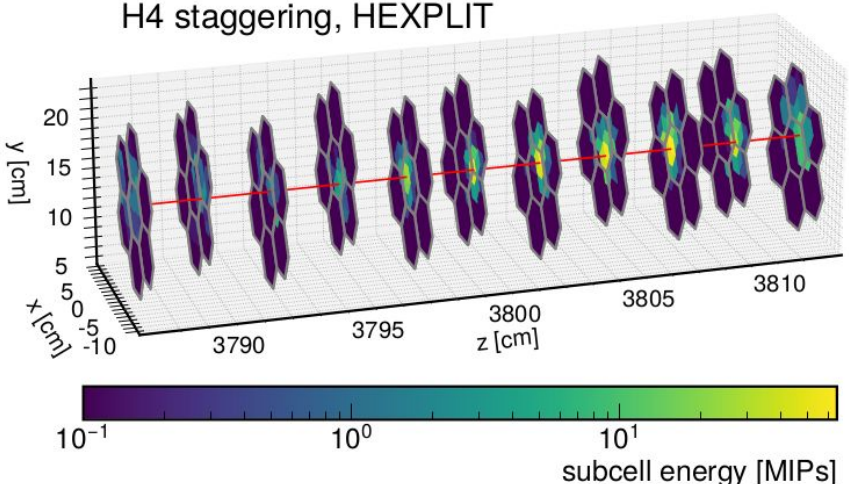
Energy in a given subcell, $i$




H4 staggering, baseline




H4 staggering, HEXPLIT



# 3D Topological clustering algorithm (ATLAS@LHC, H1@HERA)

Using pre-existing ImagingTopoClustering algorithm implemented by Chao Peng.

Starts with a definition of a neighbor:

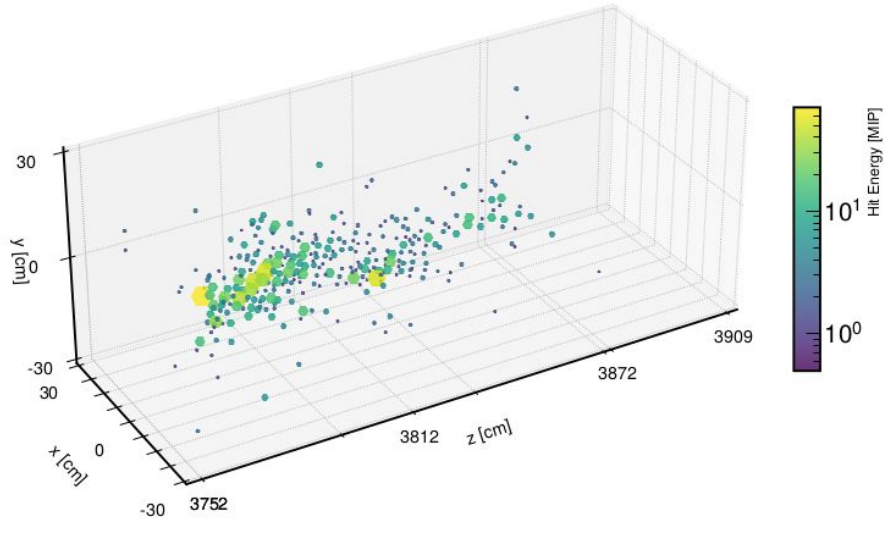
- Same layer: Δx and Δy cut
- Adjacent layers: Δφ and Δη cut

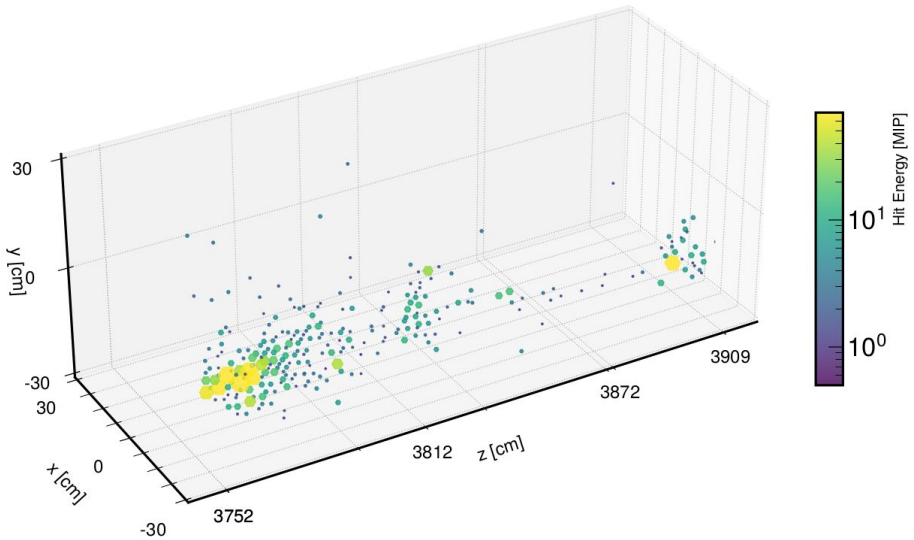
Algorithm:

- 3 thresholds are defined for cell energy: *S* for seeding proto-clusters, *N* for growth of proto-clusters, and *P* for the minimum energy of any hit included
- Define seed hits for proto-clusters as those above threshold *S,* and include their neighboring hits in the protoclusters that are above threshold *P*
- For any hit with energy greater than *N,* include all of that hit's neighbors above *P*. (and merge if it has neighbors in more than one protocluster)

https://github.com/eic/EICrecon/blob/main/src/algorithms/calorimetry/ImagingTopoCluster.h

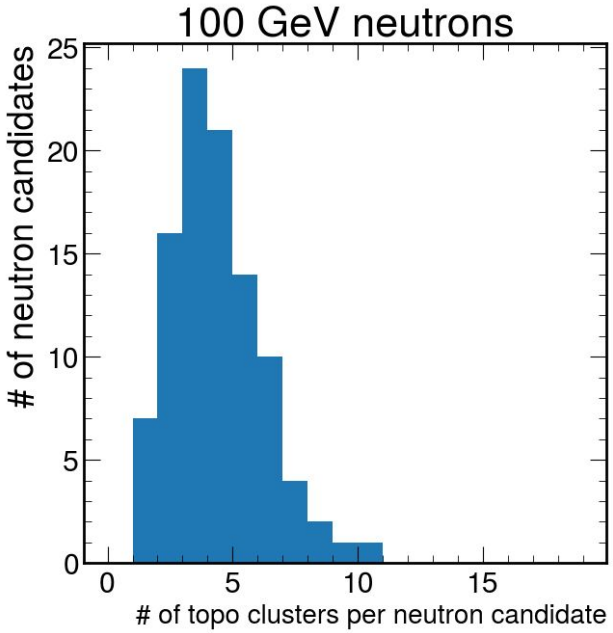
# Example 100 GeV neutron showers

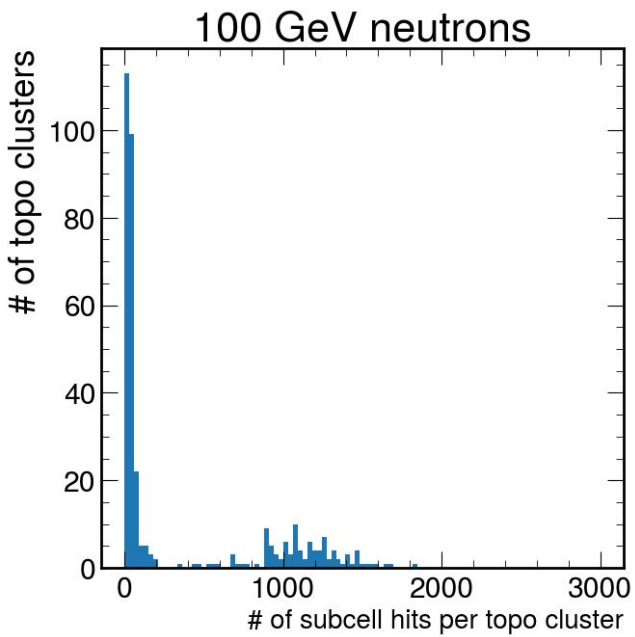


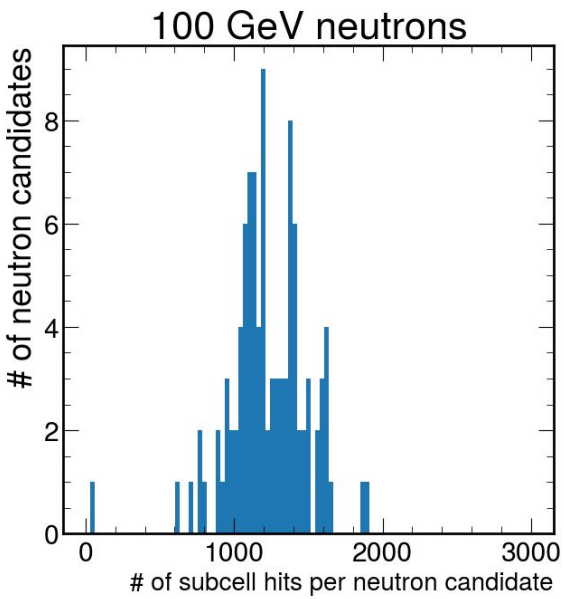




Due to high granularity, we EXPECT the topocluster to often yield more than one “cluster” per particle. This is expected, and seen in H1@HERA / ATLAS@LHC

# Topo clustering and merging into “neutron candidates” in EICrecon



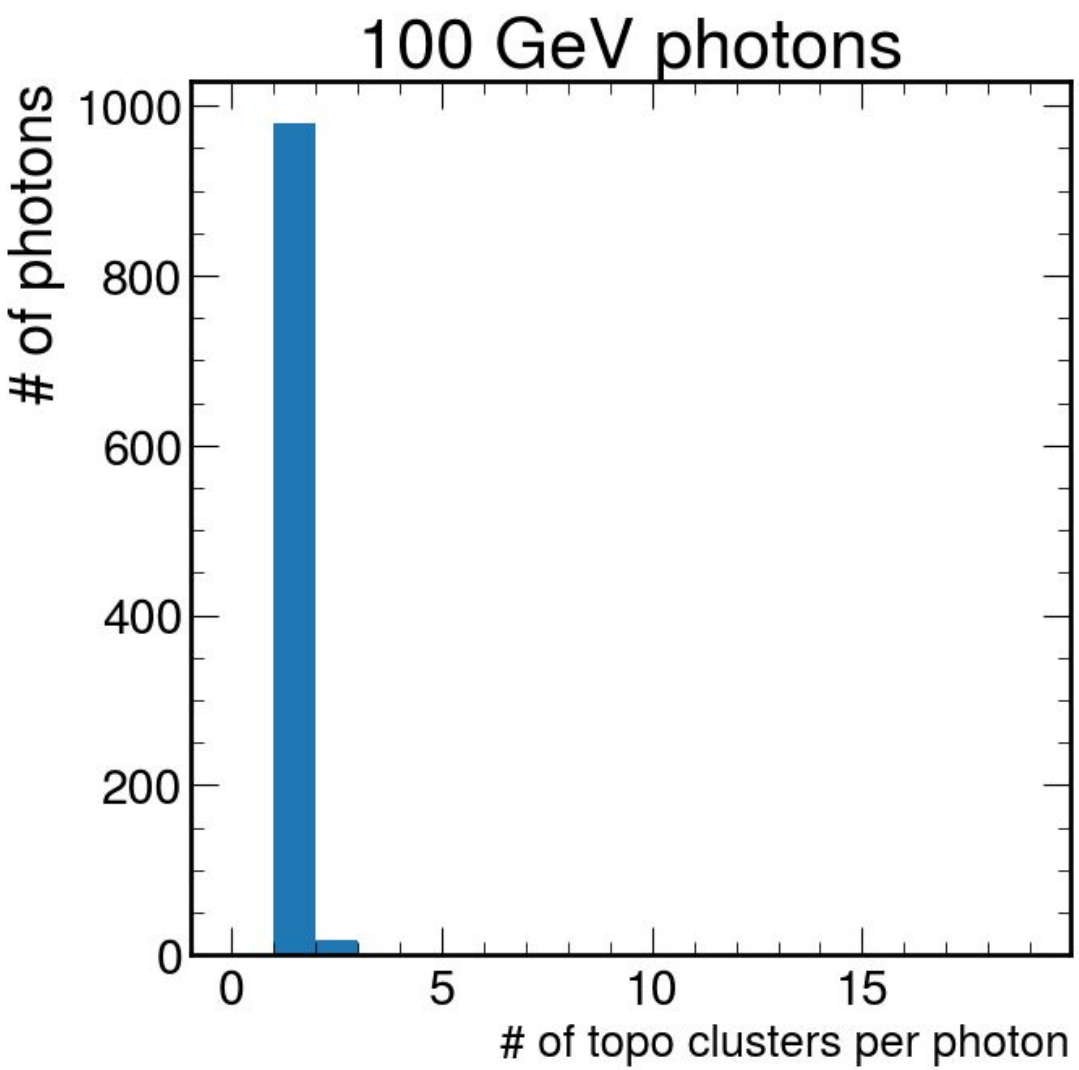




https://github.com/eic/EICrecon/blob/main/src/algorithms/reco/FarForwardNeutronReconstruction.cc

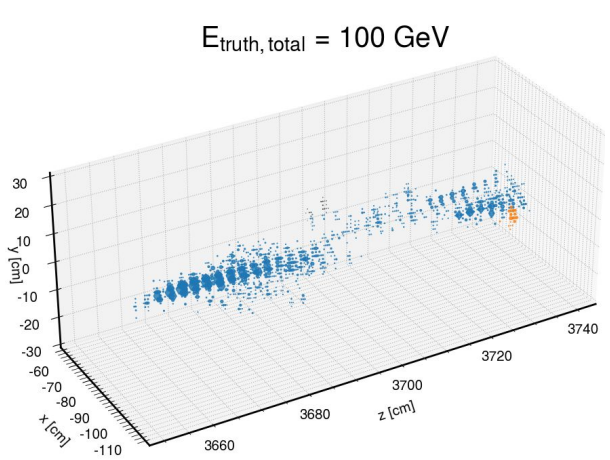
# For reference…

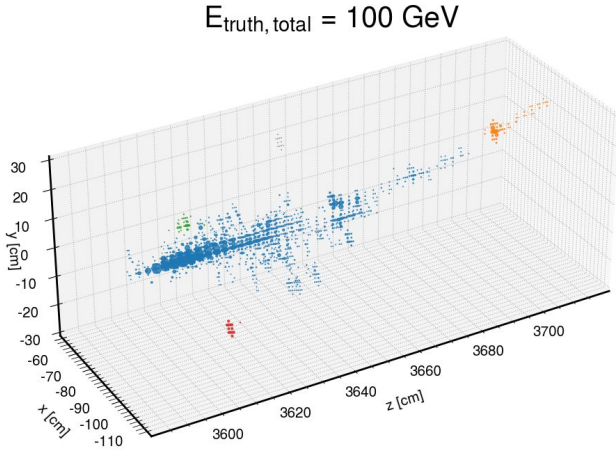
Photon showers usually have only one topo-cluster per shower

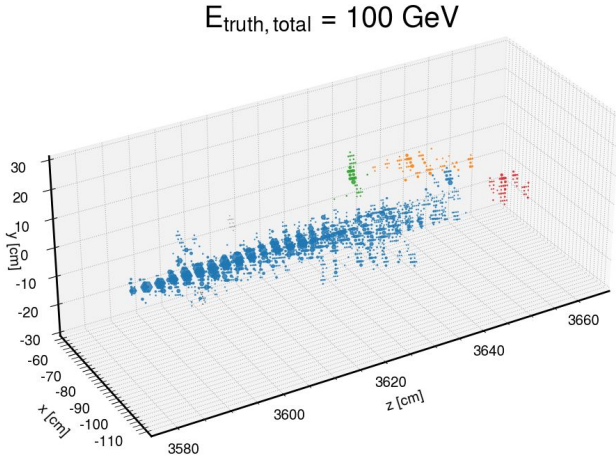


# Results of Clustering algorithm for neutron showers

Different colors represent different topoclusters formed by the imaging topoclustering algorithm. Shown are subcell hits (after HEXPLIT)



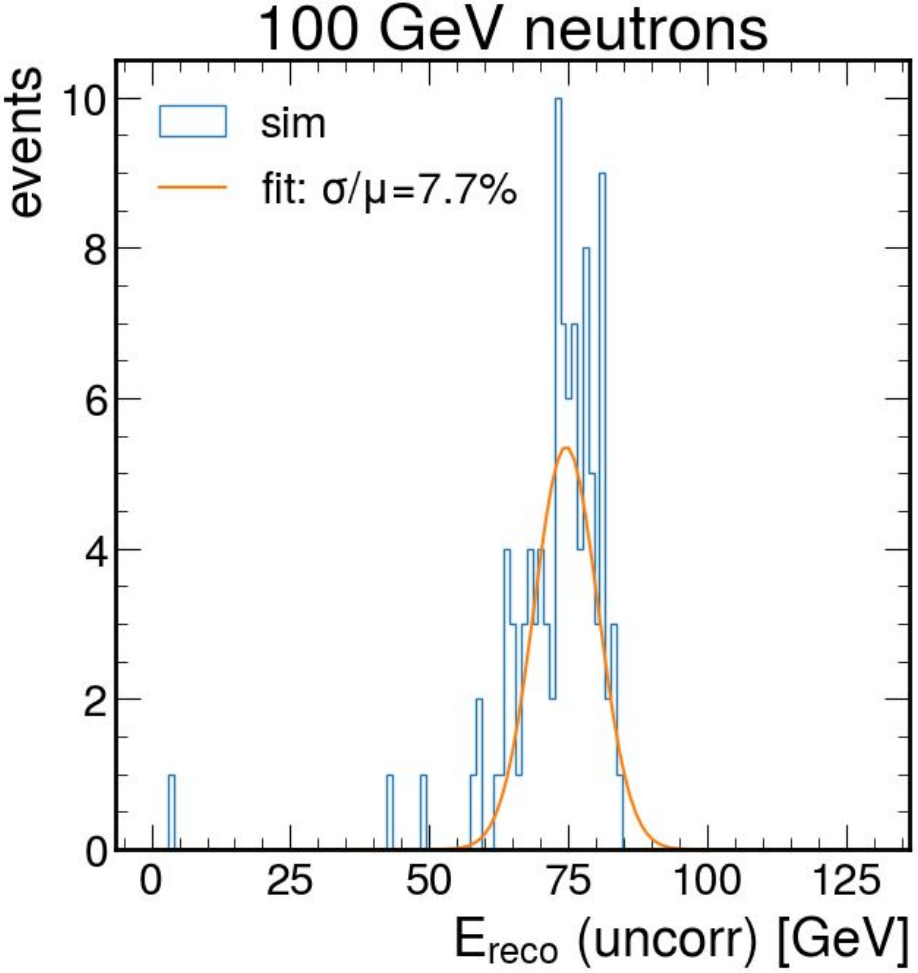



# Energy reconstruction (pre correction)

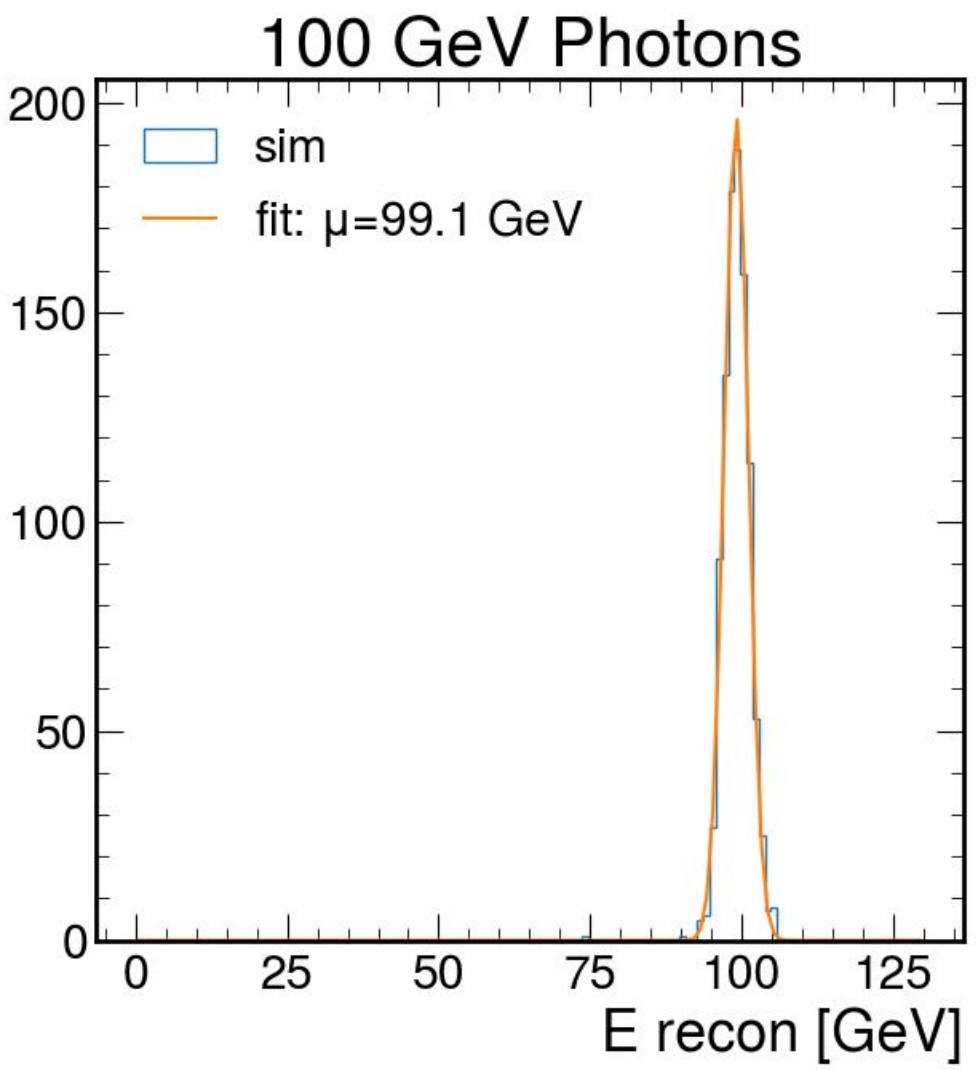
Sampling fraction calibrated with EM showers

About 30% below the truth energy of the neutrons.
This is expected due to non-compesated nature of Fe/Sc calorimeter
(e/h~1.2)



# For reference:

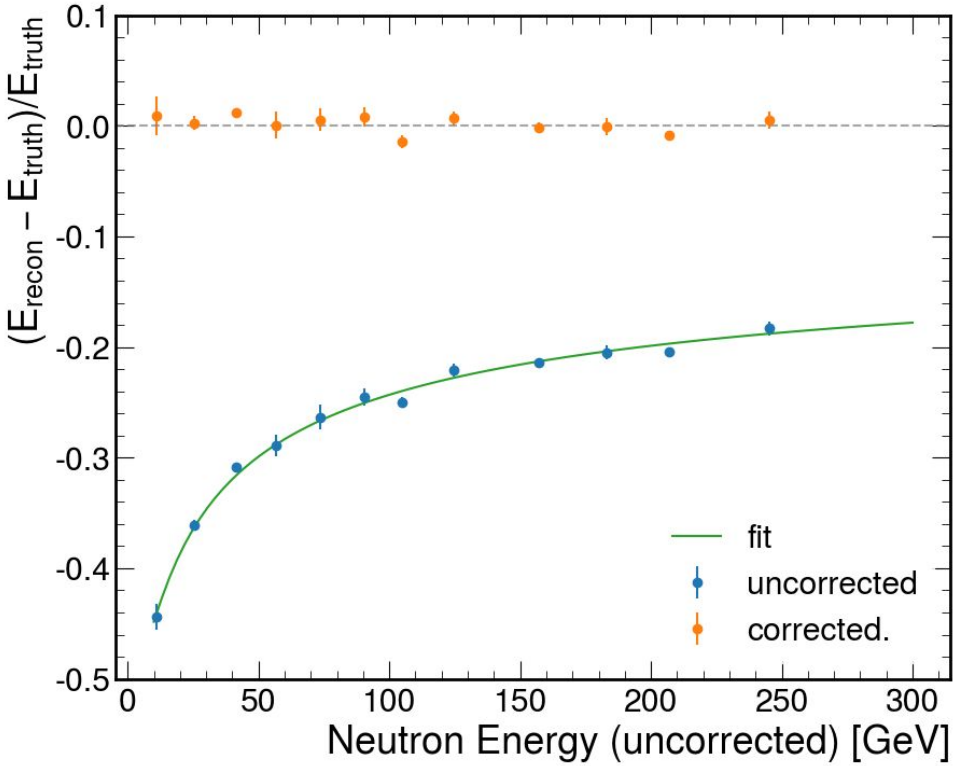
- Repeated procedure with photons
- Almost no difference between mean recon value and truth energy.



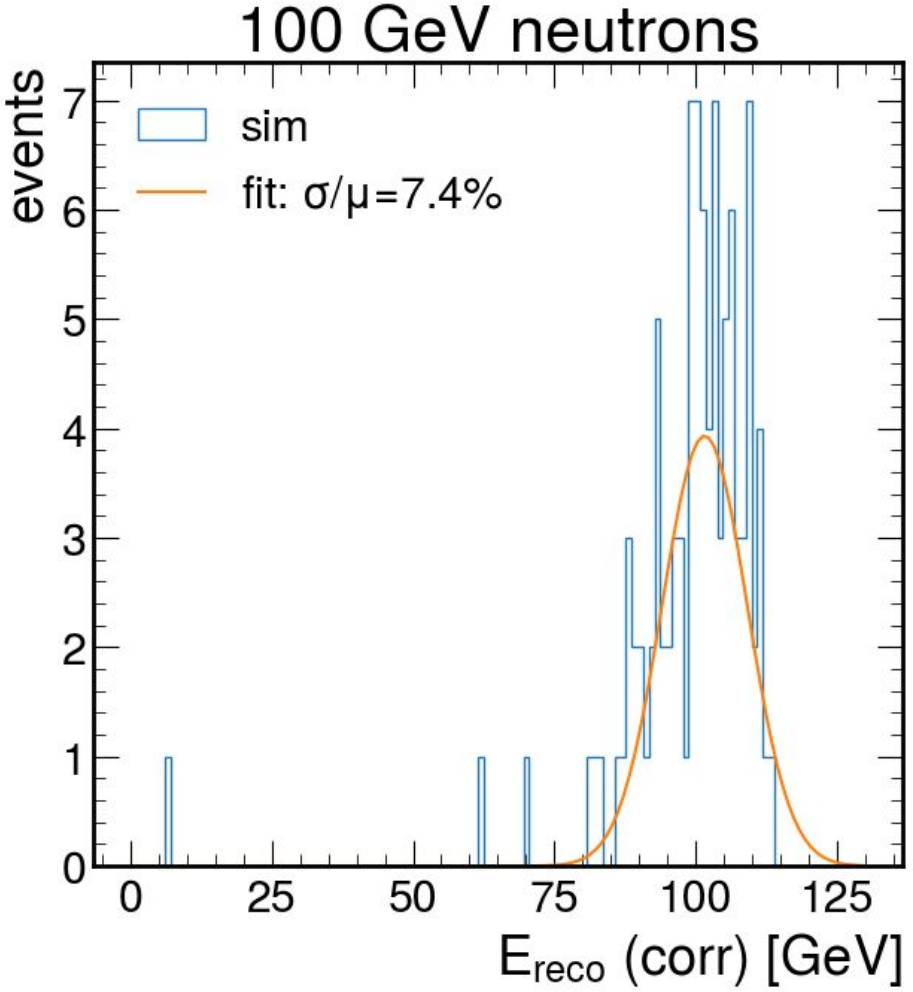
# Scale correction for neutron recon

- Uncorrected energy is the total energy of all clusters in ZDC
- Determined a functional form for the correction*:
- Ecorr=E/(1+a+b/sqrt(E)+c/E), where E is the uncorrected energy

*https://github.com/eic/EICrecon/pull/1454, merged into main two days ago.

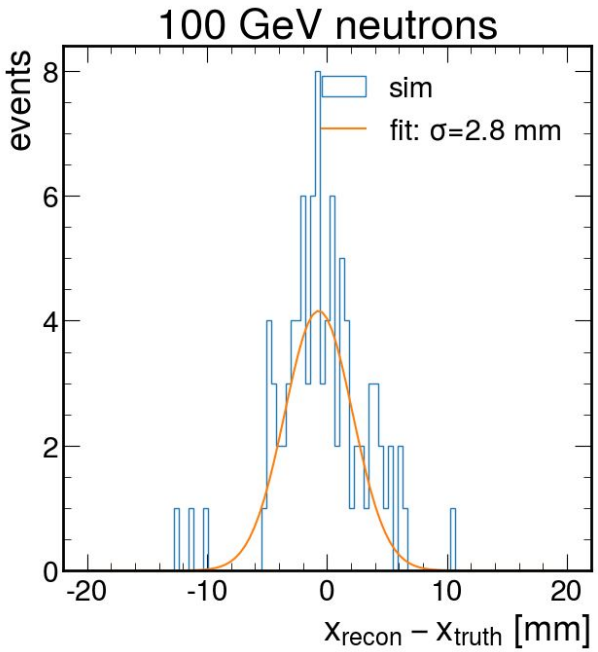


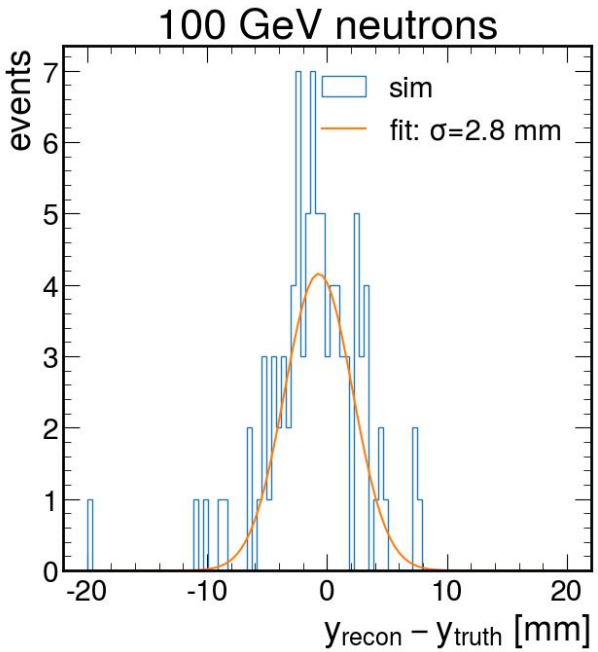
Reconstructed neutron energy after corrections



# Position reconstruction neutron showers in EICRECON

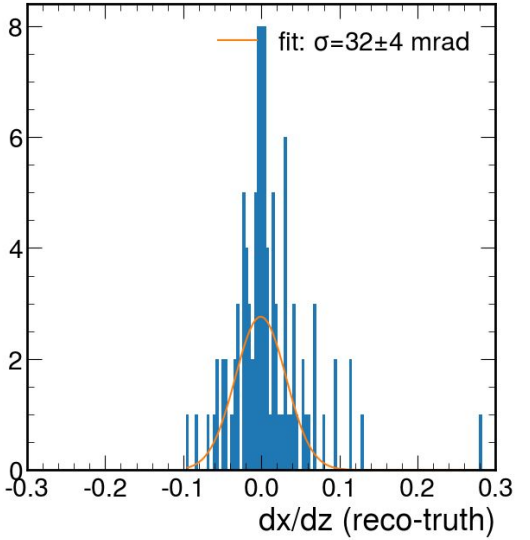
Determined using most energetic cluster in shower

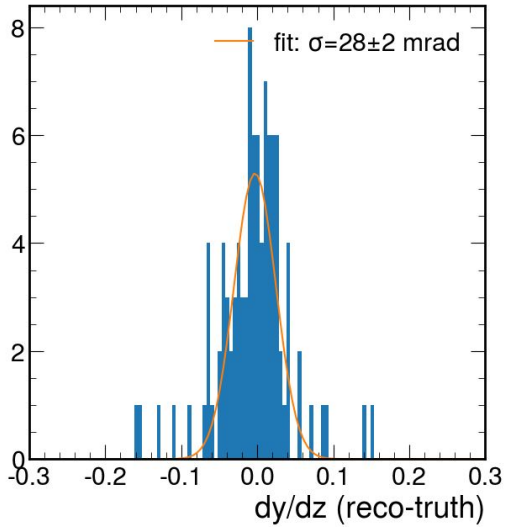


# Cluster shape parameters

- Determined the direction of the axis of the cluster as the eigenvector of the moment matrix (log-weighted CoG) corresponding to the largest eigenvalue
  - About 30 mrad of resolution
- Added this to the existing shape parameters

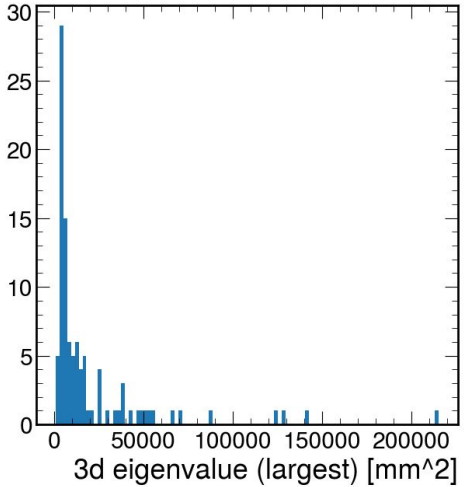


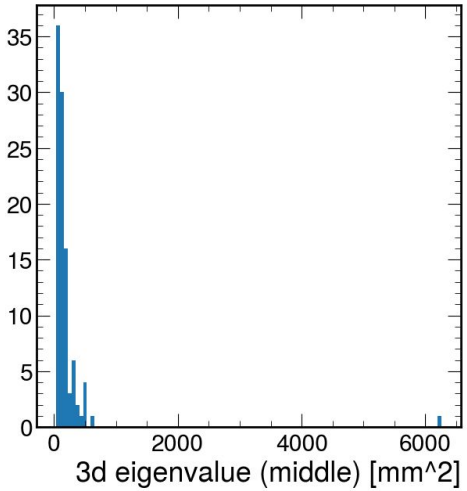



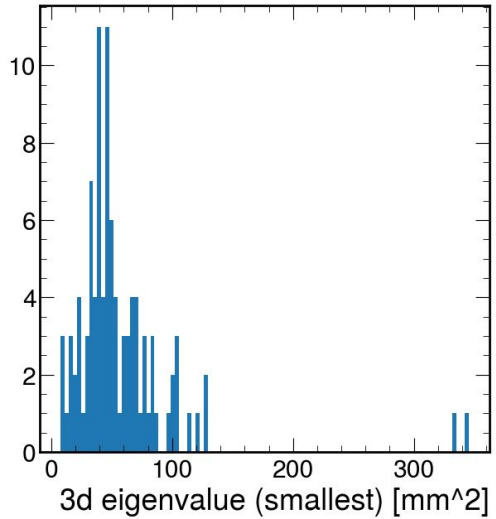

Draft pull request
https://github.com/eic/EICrecon/pull/1391

# Other shape parameters

- Existing shape parameters
  - 3D radius (weighted and unweighted)
  - 2D eigenvalues of weighted moment matrix in θ φ space
  - 3D eigenvalues of weighted moment matrix in x, y, z space
- Could be used for distinguishing between π0, single photons and neutrons



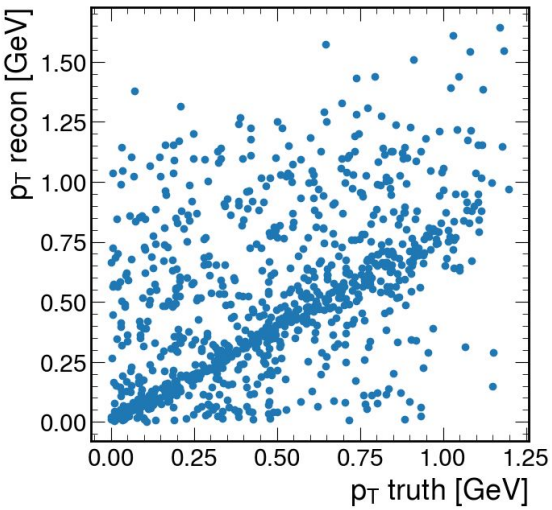
# Conclusions

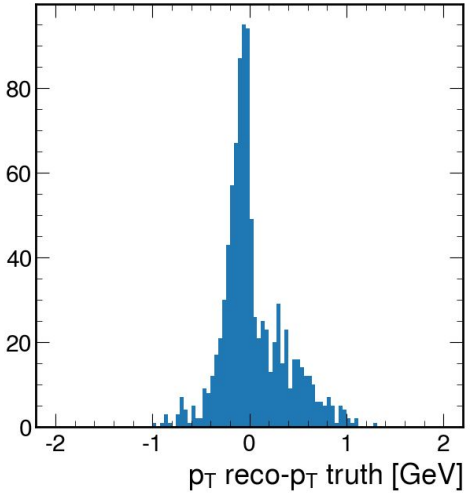
Topoclustering algorithm fed with HEXPLIT subcell-hits working reasonably well in SiPM-on-tile ZDC.

Next step: same code will be implemented in the Insert soon

# pT reconstruction

- Limitations of this approach:
  - Neutron energy will be biased due to non-compensated response
  - This biases the overall response for the lambda momentum
  - AI could improve this by identifying neutron and removing energy bias.



# Backup slide on the geometry of the detector