Simulations for the calorimeter insert

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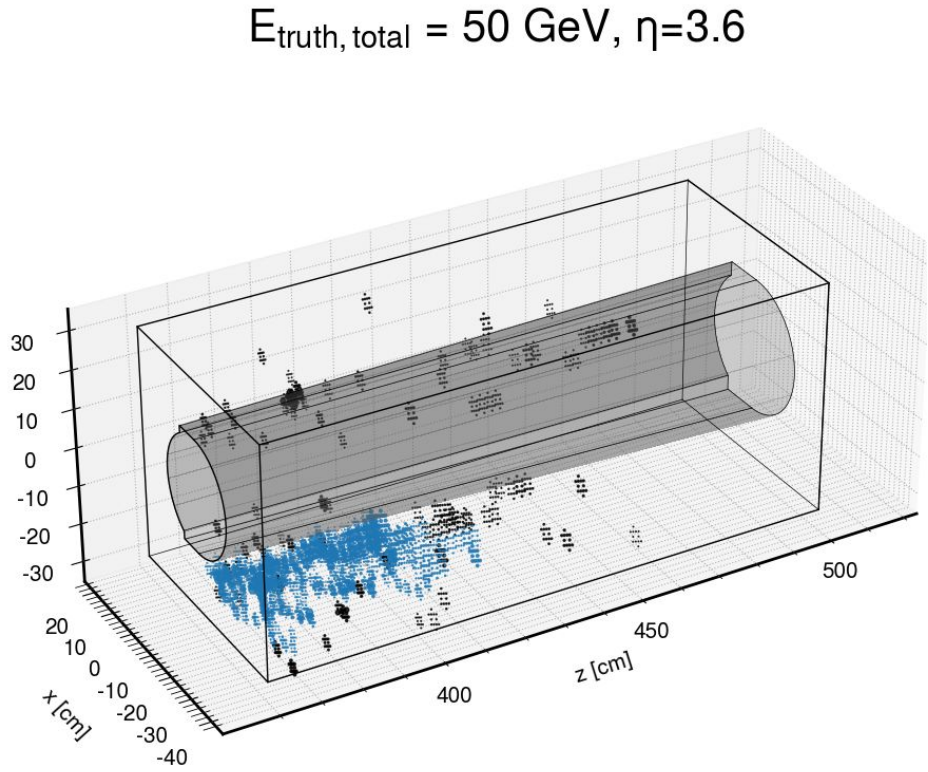
9/4/2024

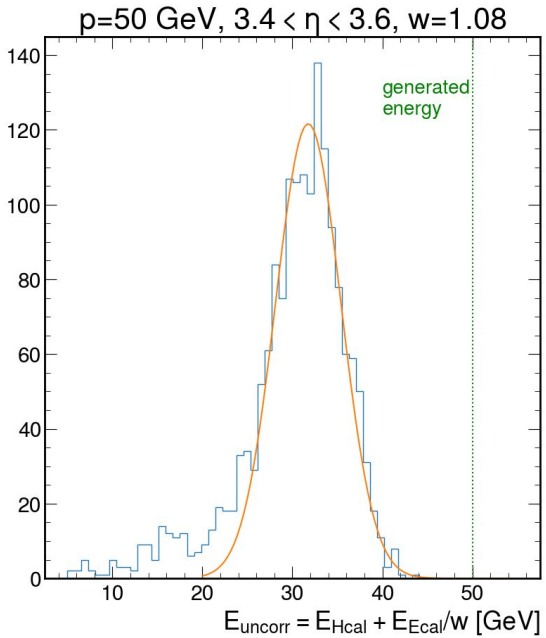
Neutron in Insert benchmark

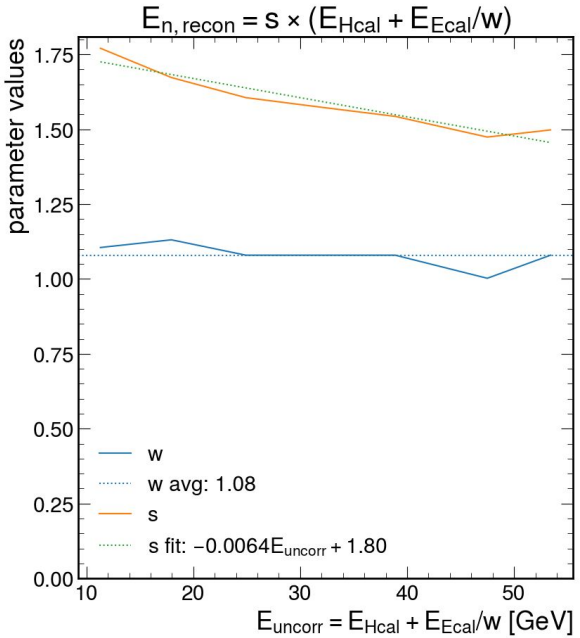
- Generates neutrons at 20-80 GeV, 3.0<η<4.0, full φ range
- Simulates them in the craterlake configuration FTFP_BERT physics
- Reconstructs clusters in Hcal insert and insert part of Ecal
- Reconstruct neutron kinematics:
  - Energy with strawman algorithm
  - Polar angle with HEXPLIT and log-scaled CoG



Energy reconstruction

- Hcal sampling fraction determined at EM scale
- To correct for e/h effects:
  - w parameter: relative energy scale of Ecal vs. Hcal
    - Determined by minimizing σ/μ ratio for gaussian fits to $E_{uncorr}=E_{Hcal}+w\,E_{Ecal}$ distribution
  - s parameter: Energy dependent overall scale of e/h. Determined as 1/μ of E_{uncorr}/E_{truth} distribution

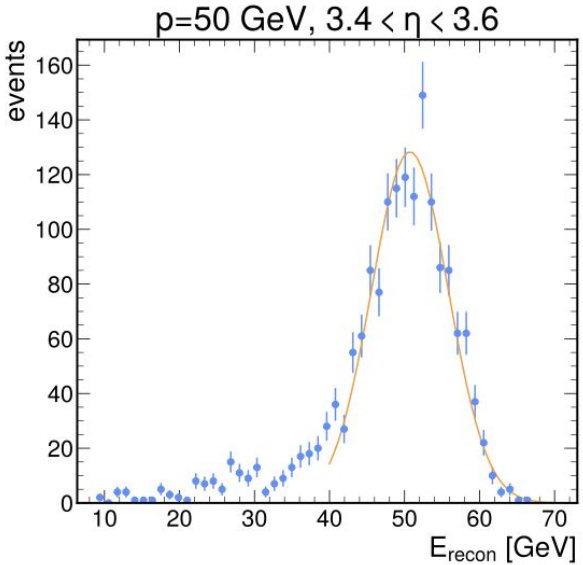


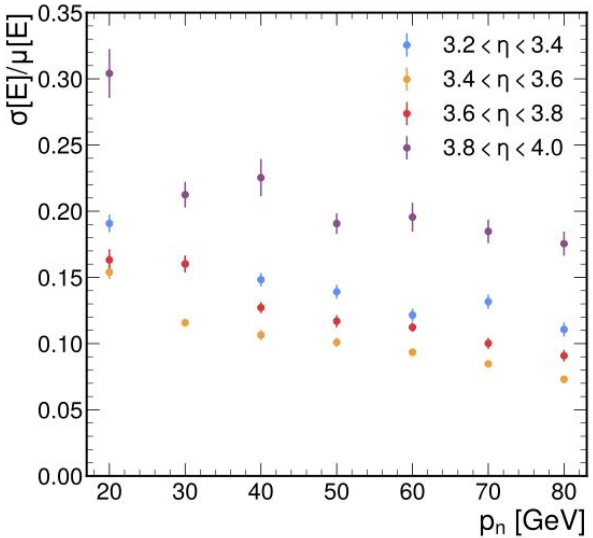


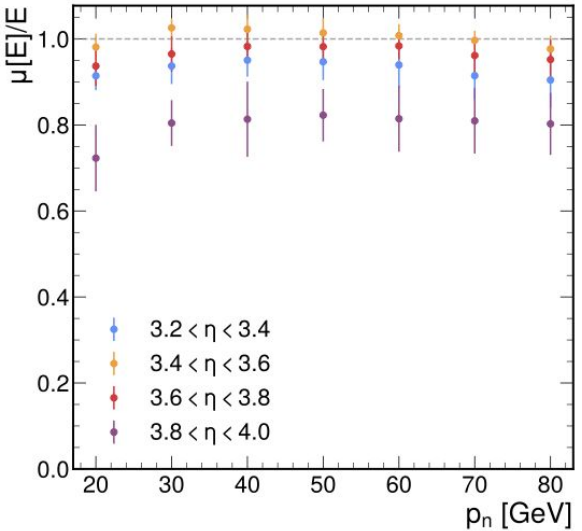
Energy resolution and scale

for 3.4<η<3.8:

- Energy resolution ~ 10%
- Energy scale ~ 100%





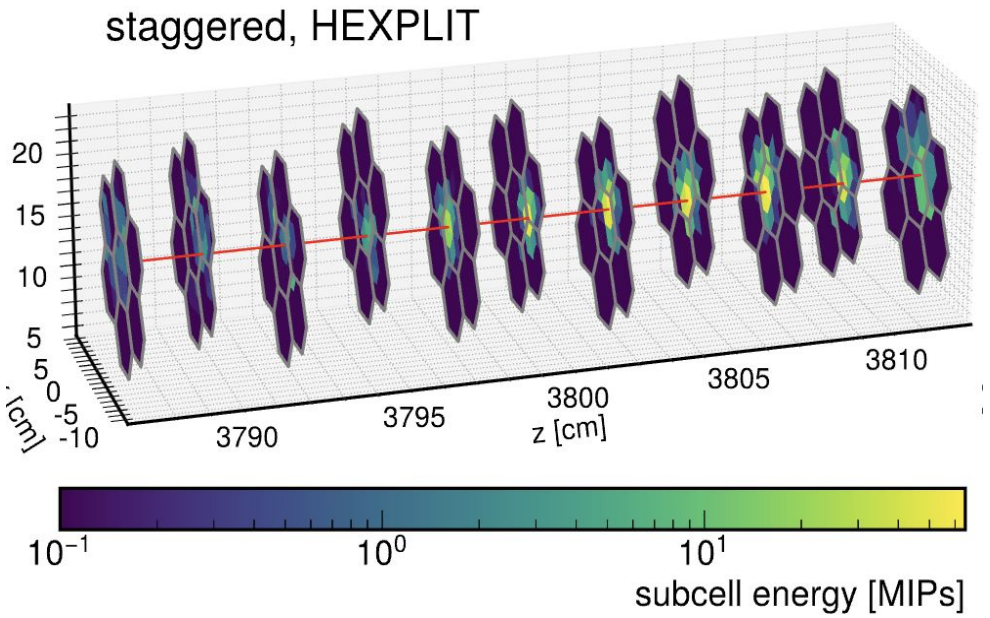


HEXPLIT algorithm*

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

Cuts:

- t<150 ns +(z at front face of ZDC or Insert)/(speed of light)
- E>0.5 MIP



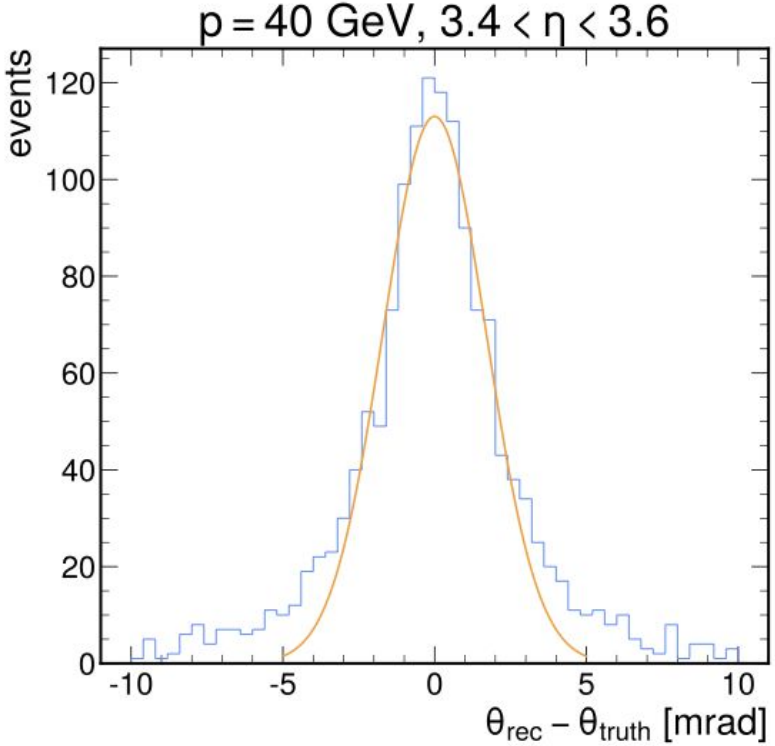
https://github.com/eic/EICrecon/blob/main/src/algorithms/calorimetry/HEXPLIT.cc

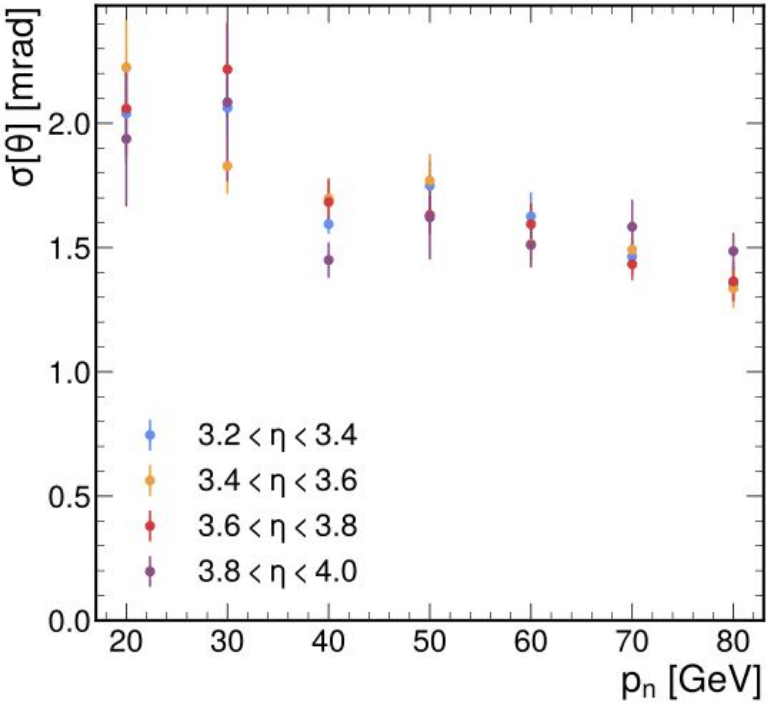
https://github.com/AIDASoft/DD4hep/blob/master/DDCore/src/segmentations/HexGrid.cpp

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

Polar-angle resolution

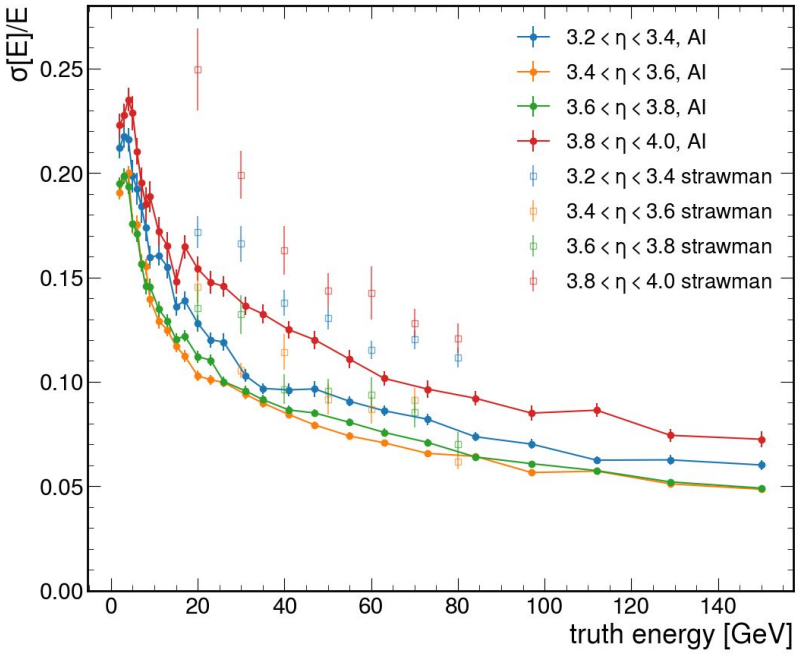
Around 1.5 - 2.2 mrad, depending on energy.

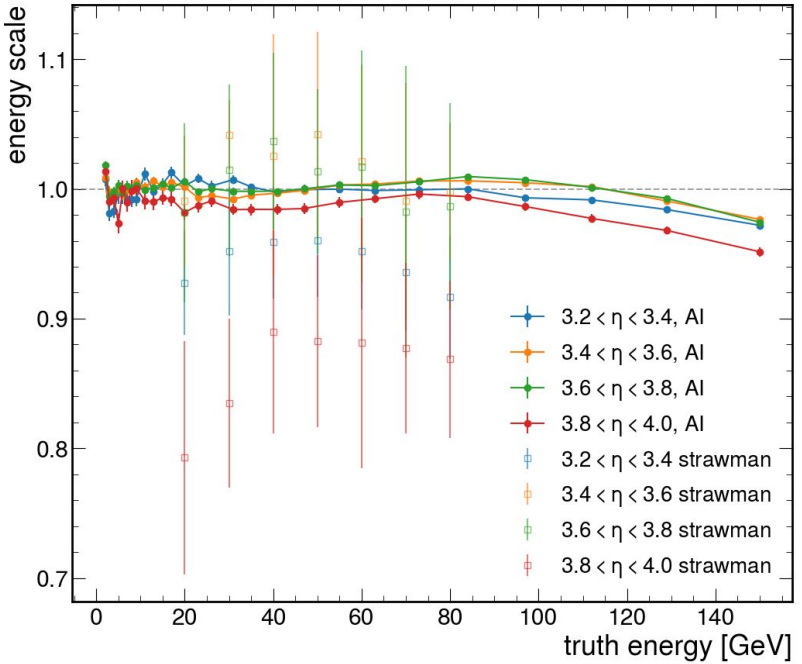




Improved energy reconstruction with machine learning

- Sebastián Morán independently ran an AI algorithm for reconstructing the energy of neutrons
- Gets even better results than my “strawman” reconstruction





Summary

- Created benchmark for neutron reconstruction with a “strawman” energy reconstruction, and CoG angle reconstruction:
  - ~10% energy resolution for part of the eta range further from the edges
  - ~1.5 mrad angle resolution
- Reconstruction with an AI produces better results for energy:
  - Resolution is better than with the strawman energy recon, especially near edges of detector
  - Scale is within a few percent over a wide range in energy and pseudorapidity ($3.2<\eta<4.0$)