ZDC update

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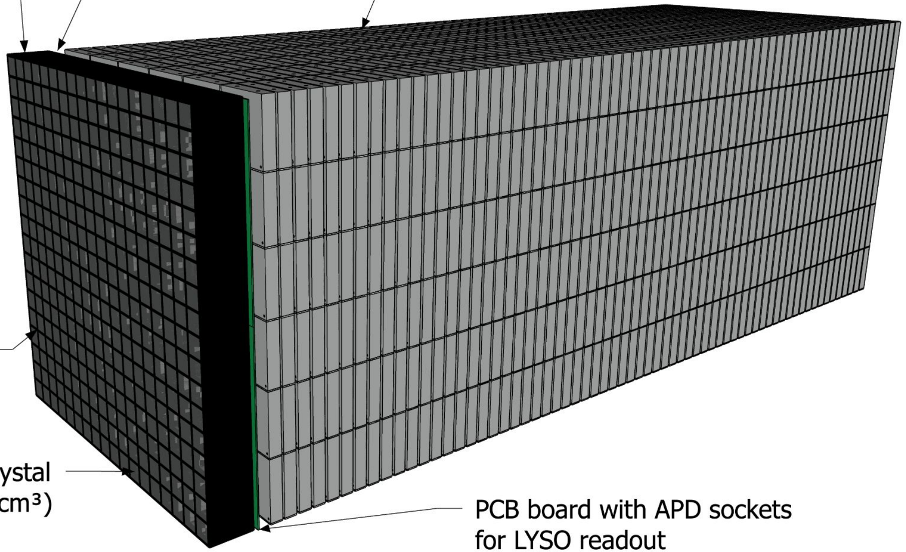
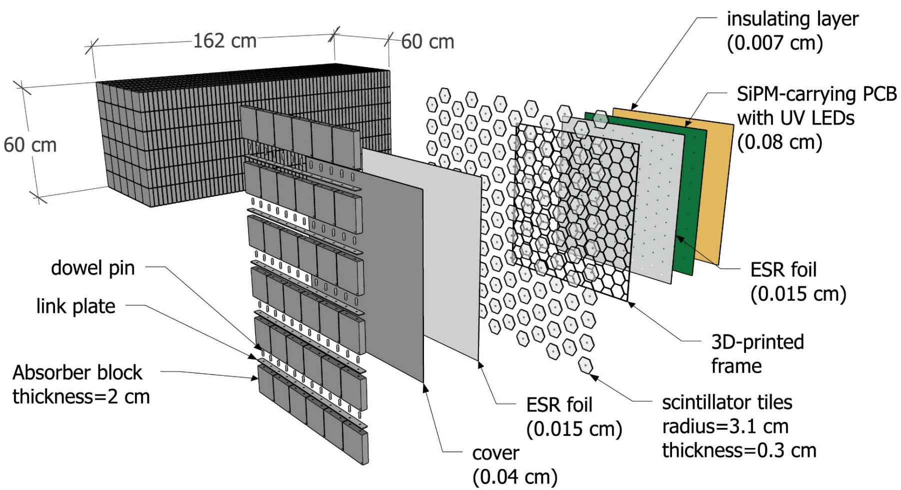
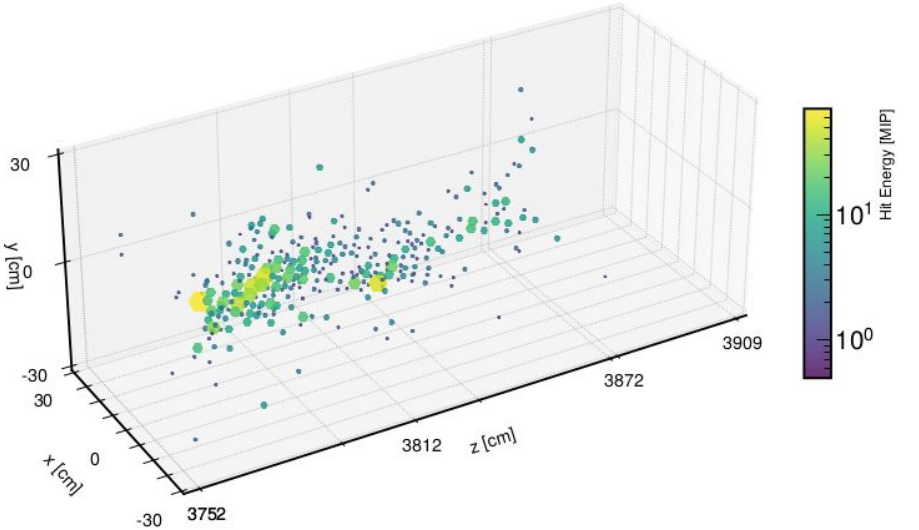


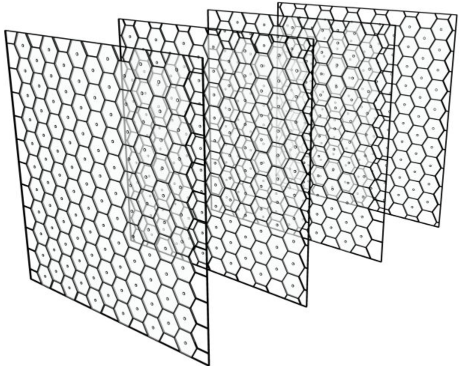
Outline

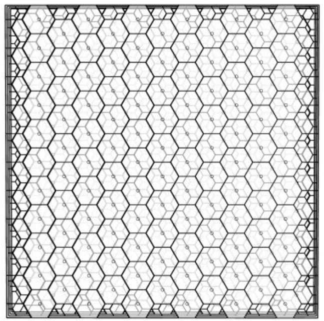
1) Updates on EICRecon algorithm developments for ZDC
2) Updated performance plots with combined LYSO ECAL + Fe/Sc system
3) Comment on neutron fluence

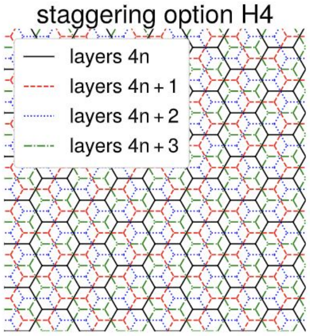
SiPM-on-tile Fe/Sc ZDC



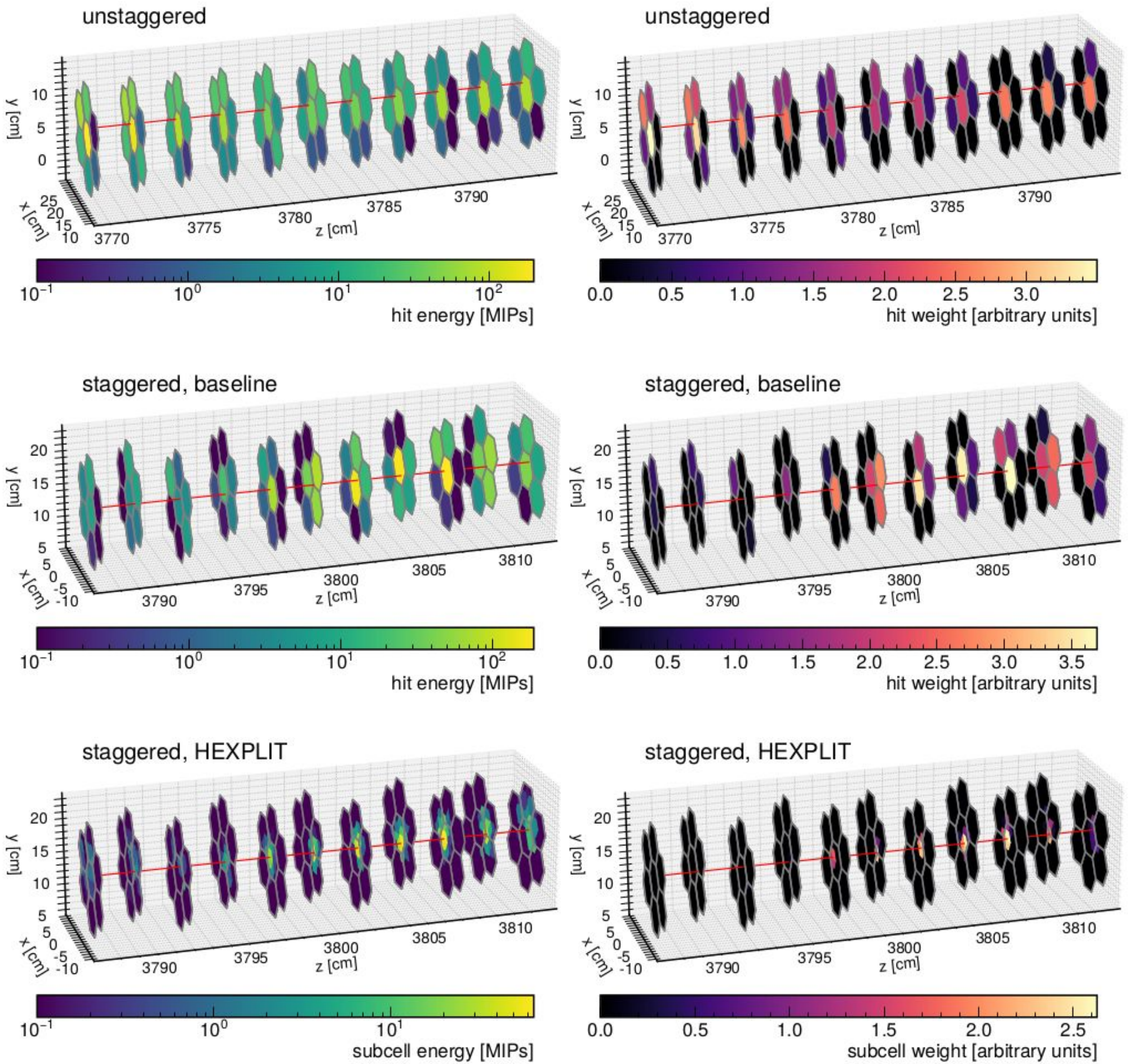








Staggered design and dedicated algorithm to improve position resolution



HEXPLIT algorithm

https://arxiv.org/abs/2308.06939

Core Portion of Neutron Shower

Formula for subcell reweighting

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

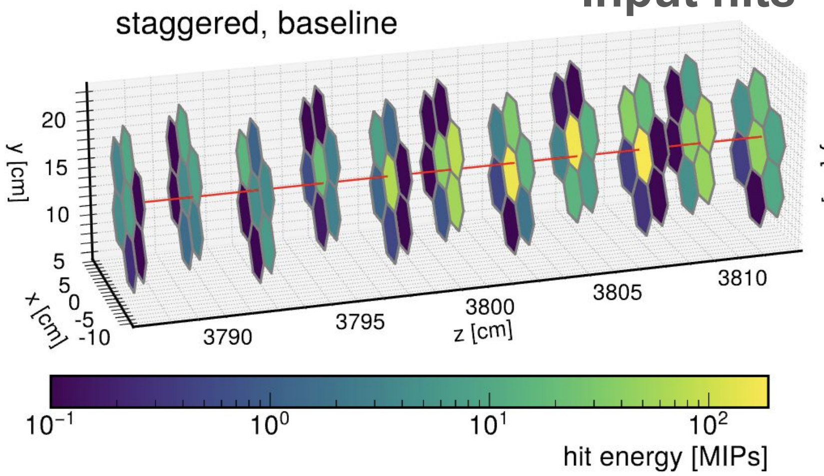
Product over overlapping cells, *j*, in neighboring layers

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

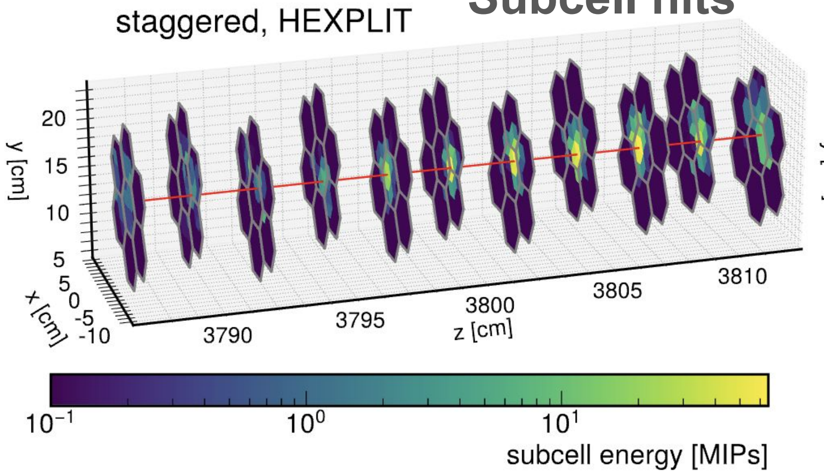
Energy in a given subcell, *i*

δ = energy threshold, set to 1 MIP.

Input hits



Subcell hits



LogWeightReco algorithm

Core Portion of Neutron Shower

Reconstruct shower from (subcell) hits

$$\vec{x}_{\text{recon}} = \frac{\sum_{i \in \text{subcells}} \vec{x}_i w_i}{\sum_{i \in \text{subcells}} w_i}$$

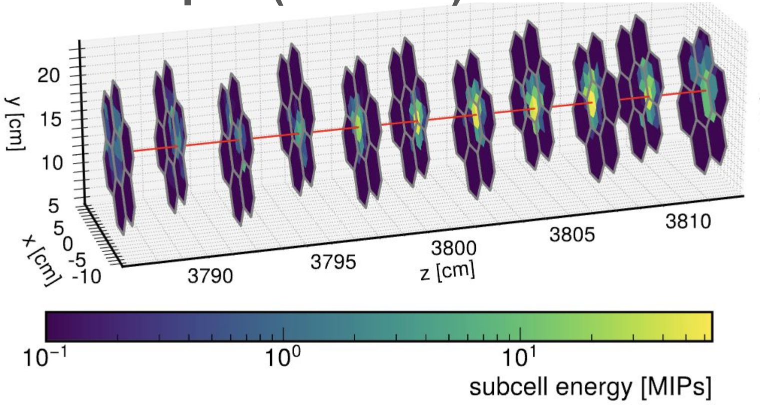
$$w_i = \max\left(0, w_0 + \ln \frac{E_i}{E_{\text{tot}}}\right)$$

w_0 is cutoff parameter, fine-tuned as a function of the reconstructed particle energy

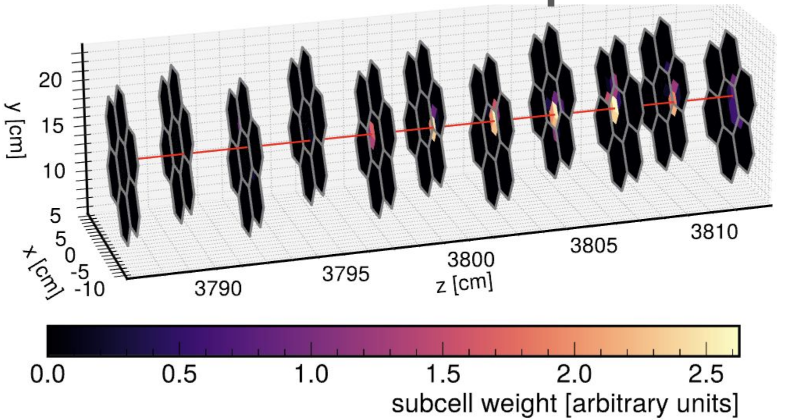
$$w_0 = \mathtt{w0\_a} + \mathtt{w0\_b} \log \frac{E_{\text{recon}}}{\mathtt{E0}} + \mathtt{w0\_c} \left(\log \frac{E_{\text{recon}}}{\mathtt{E0}}\right)^2$$

$$E_{\text{recon}} = \sum_{i \in \text{hits}} E_i / \mathtt{sf}$$

Input (subcell) hits



Contribution to cluster position

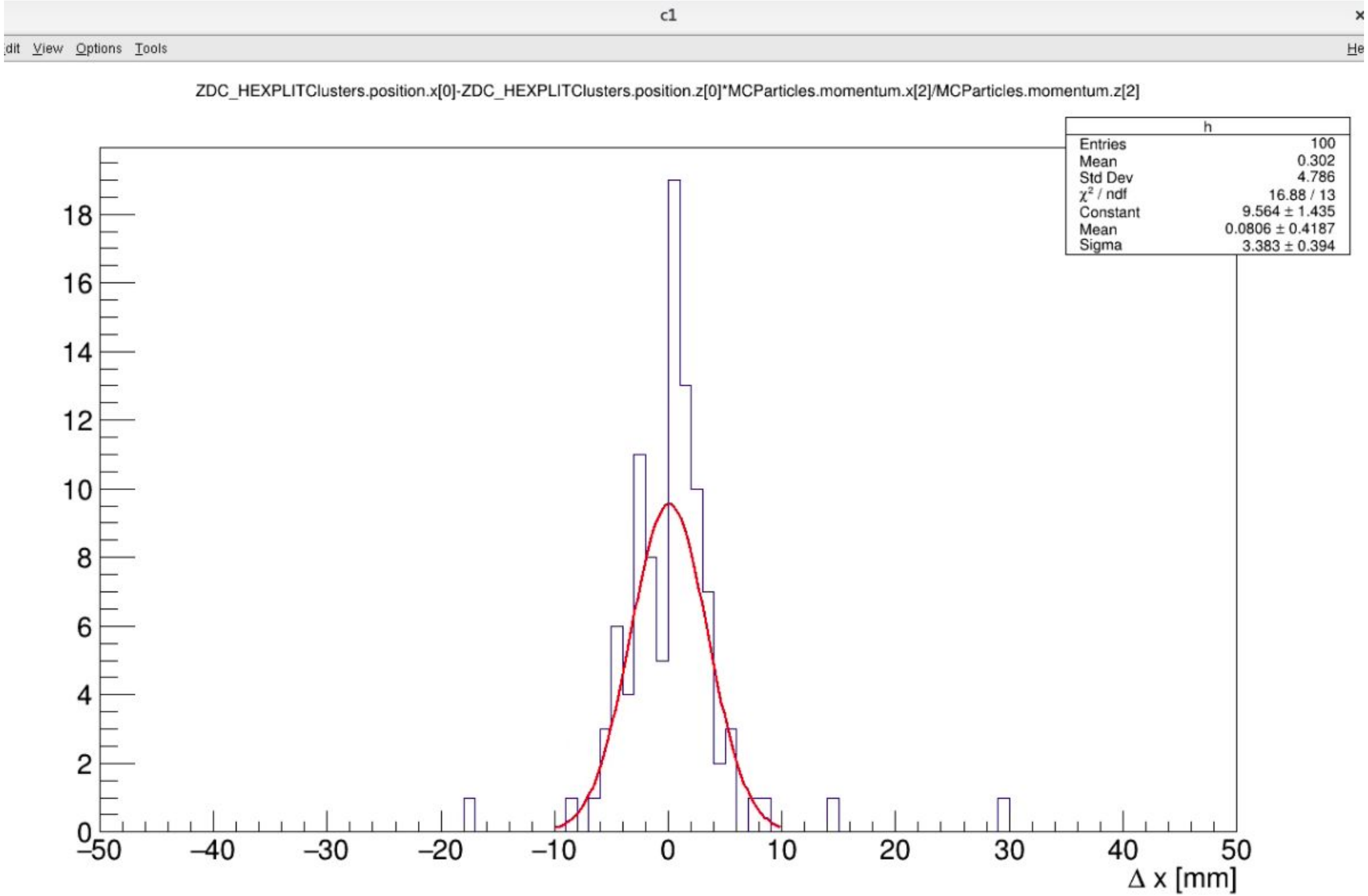


ZDC software in DD4HEP and ePIC

- DD4hep plugin for hexagonal segmentation and staggering was added to official DD4HEP core software https://github.com/AIDASoft/DD4hep/pull/1161
- ZDC Fe/SiPM-on-tile was added to official ePIC sim DD4HEP geometry model
- **New:** Digitization parameters tuned and added to EICrecon: https://github.com/eic/EICrecon/blob/sipmzdc/src/detectors/ZDC/ZDC.cc
- **New:** Fe/Sc + LYSO configuration added to dedicated branch of ePIC sim: https://github.com/eic/epic/tree/ZDC_LYSO
- **New:** new branch of EICRecon for ZDC algorithms: https://github.com/eic/EICrecon/tree/sipmzdc
- **New:** HEXPLIT algorithm C++ version is on EICrecon: https://github.com/eic/EICrecon/blob/sipmzdc/src/algorithms/calorimetry/HEXPLIT.cc
- **New:** LogWeighting position reco algorithm is on EICrecon: https://github.com/eic/EICrecon/blob/sipmzdc/src/algorithms/calorimetry/LogWeightReco.cc
- **New:** ZDC Physics Benchmark with Deeply-exclusive meson events: https://github.com/eic/physics_benchmarks/tree/demp_zdc/benchmarks/demp/analysis

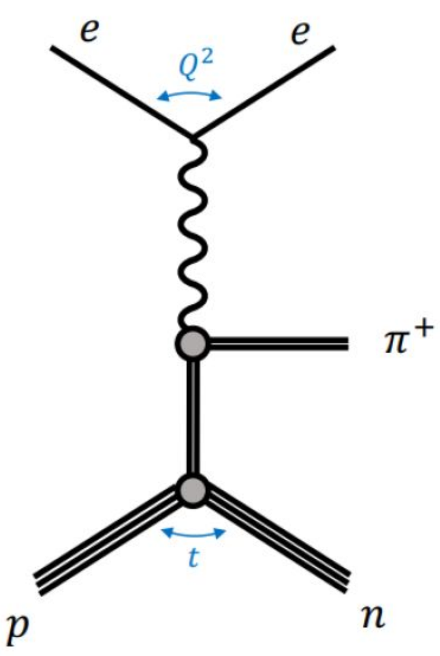
Credit: Seboh Paul, Barak Schmookler, Weibin Zhang, Bishnu Karki, Ryan Milton

Complete neutron reconstruction is now built in (part of EICrecon output)



ZDC Physics Benchmark

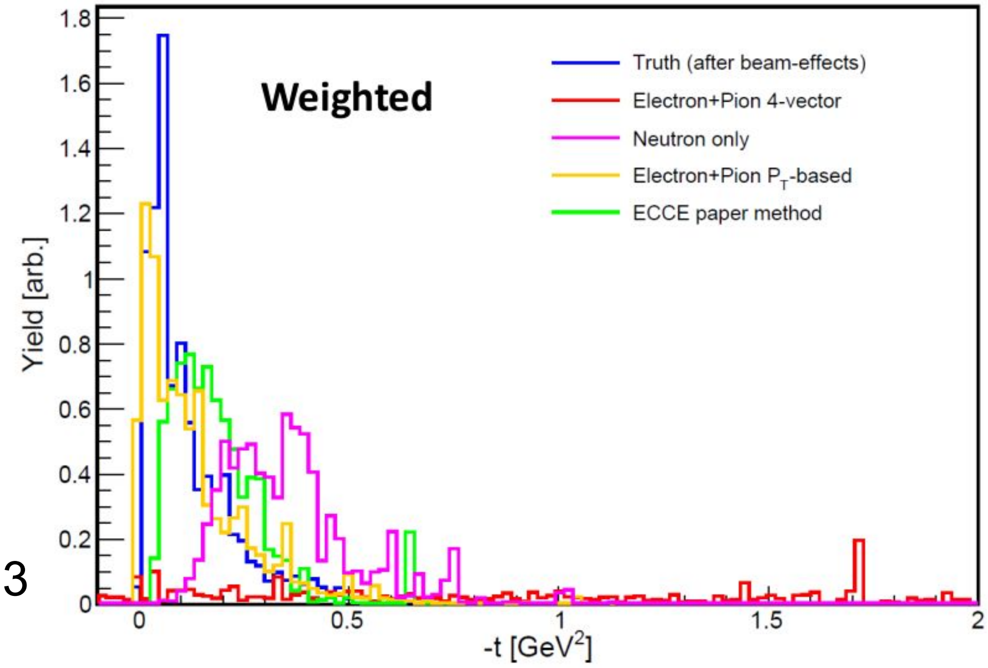
https://github.com/eic/physics_benchmarks/tree/demp_zdc/benchmarks/demp/



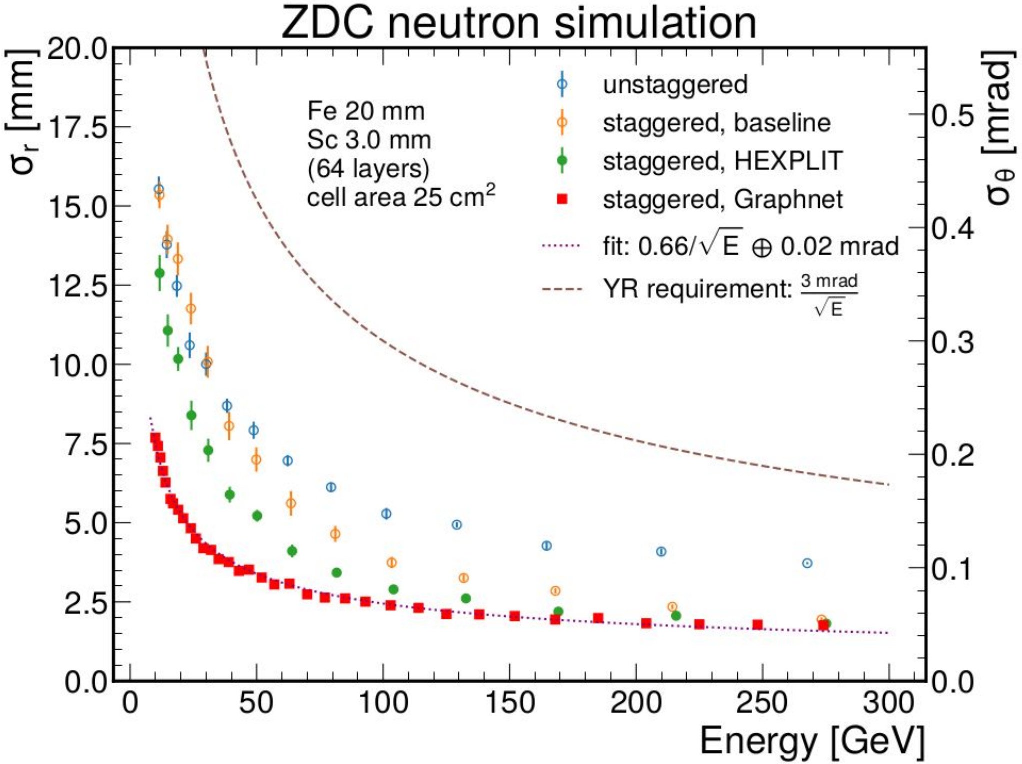
Events from DEMPgen read from S3

Includes full neutron reconstruction in ZDC

5x100 GeV – 10k events simulated



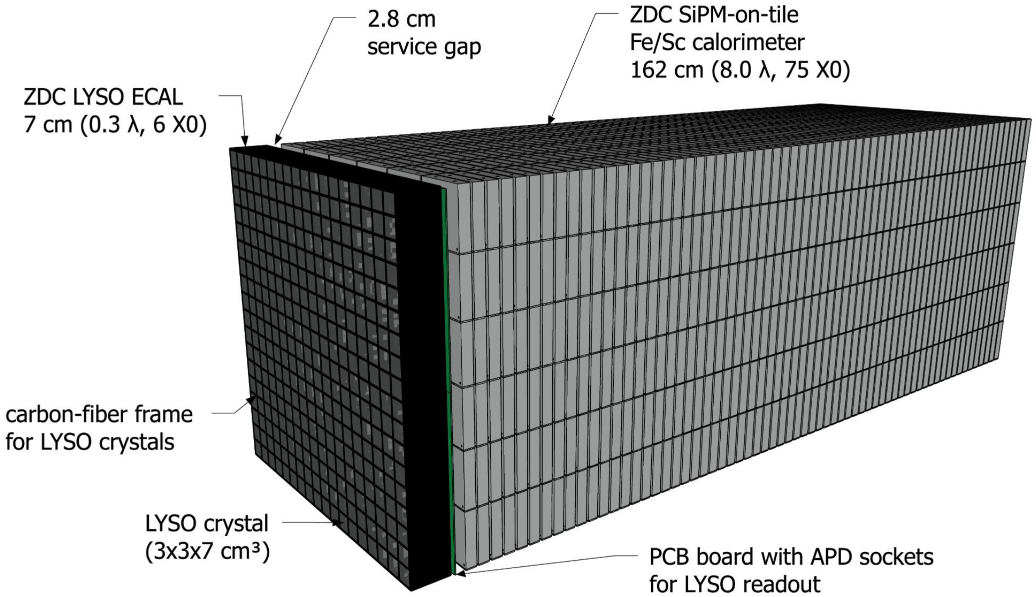
Update on neutron position resolution (Fe/Sc only)



GraphNet significantly improves angular resolution at low energy, but is similar to HEXPLIT algorithm at highest energies.

Credit: Bishnu Karki & Ryan Milton & Sebouh Paul

Suggestion of 11/20 TIC meeting was to combine/consolidate proposed designs Combined system could be: LYSO crystal ECAL and SiPM-on-tile Fe/Sc

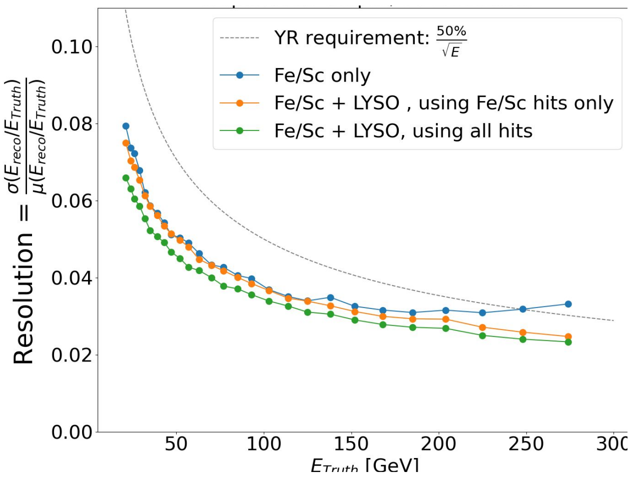


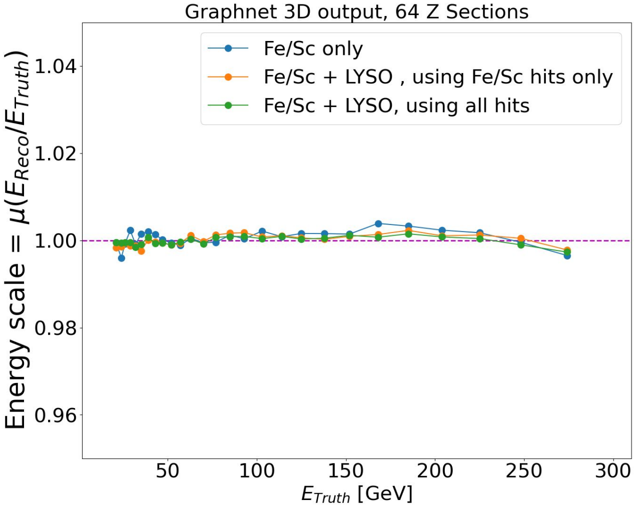
Meets all physics requirements while maximizing synergies with other ePIC subsystems, reducing cost and risks.

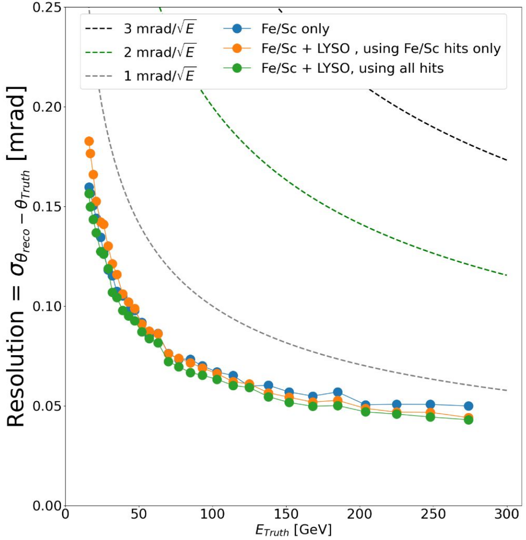
Low-energy ɣ→ LYSO
High-energy ɣ and π0→ Fe/Sc
High-energy neutrons → Fe/Sc

New: Combined LYSO + Fe/Sc neutron performance with GNNs

GNN yields optimal reconstruction, software compensated so response is linear



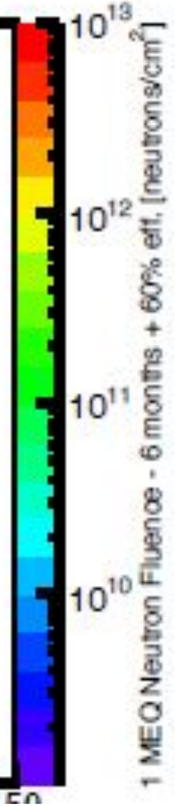


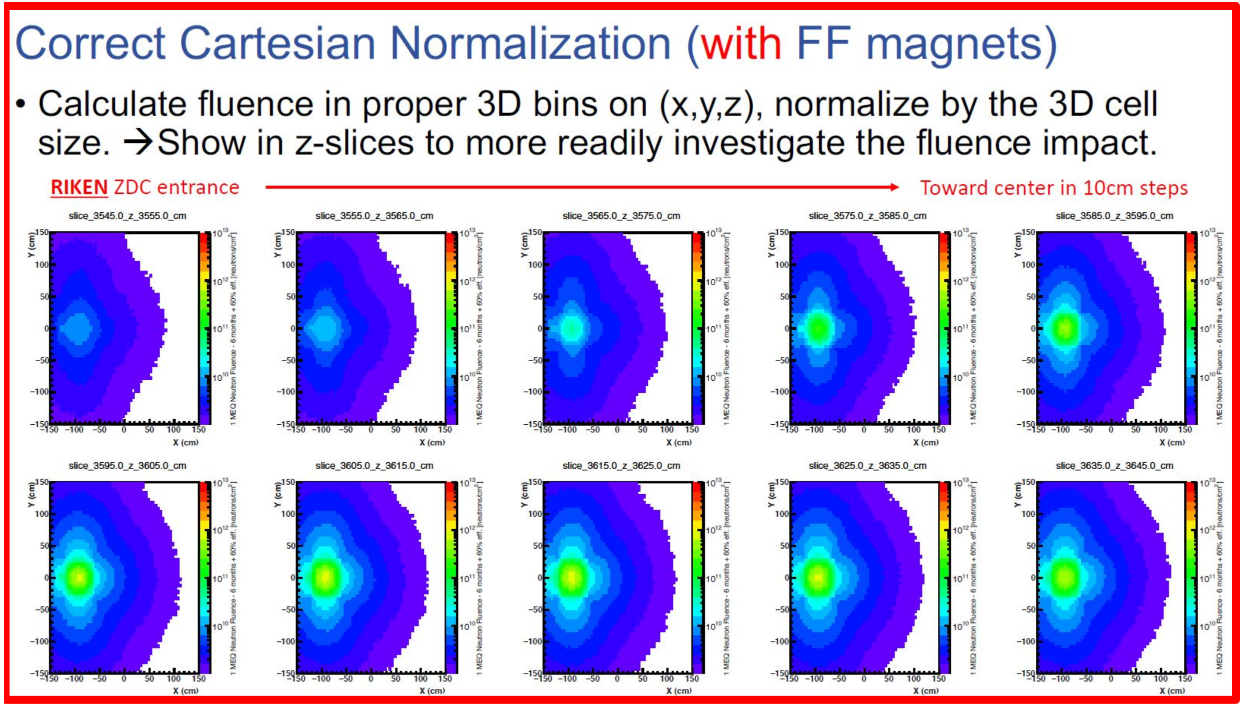


- Adding LYSO slightly improves energy resolution.
- No impact on the position resolution

Credit: Bishnu Karki, Sebastian Moran, Ryan Milton

Alex’s latest neutron fluence estimates (link):





Changing Pb from baseline to Fe as we propose would reduce these numbers by factor of 4!

Peak fluence only within ~1/9 of area

Seems manageable

Summary

1) Updates on EICRecon algorithm developments for ZDC
   → This is now rather advanced (or as advanced as anything else)
2) Updated performance plots with combined LYSO ECAL + Fe/Sc system
   → Likely final performance plots for single-neutrons
3) Comment on neutron fluence
   →Current estimates suggest manageable levels. We learnt that using Fe absorber is mitigation strategy. Hot spot is just ~10x10 cm2