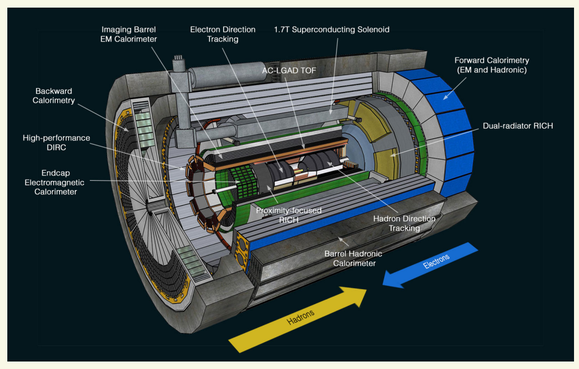
Development and Simulation of Backward Hadronic calorimeter for the ePIC detector at EIC

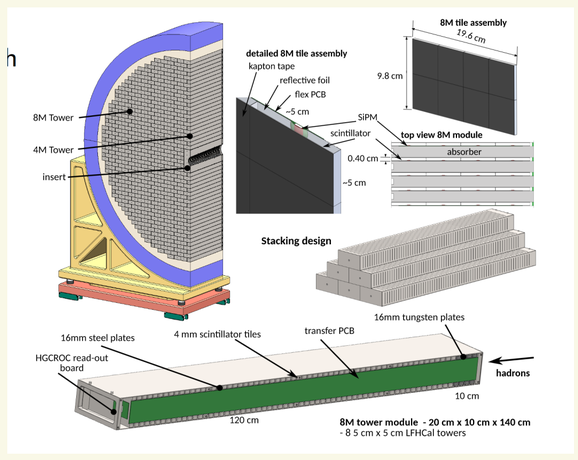
EPIC detector



The Electron-Ion-Collider (EIC) is a new particle accelerator planned for the late 2020s. The EIC will be built at Brookhaven National Laboratory and will be the first polarized electron-proton collider. Some of the main physics goals are:

- Hadron properties (mass and spin)
- 3D imagining of the nucleus
- Studies of the dense nuclear medium

The ePIC backward Hadronic Calorimeter



The backward hadronic calorimeter (negative HCal, nHCal) is a tail-catcher type calorimeter under development, to be located in the electron-going direction.

- Distinguish charged and neutral hadronic showers coming from jets originating from fragmentation of small-x partons
- Vector meson production in the dimuon channel

Design

Sampling calorimeter with 10 alternating layers, $2.4\lambda_0$ (red), similar to Belle-II KLM, and inspired by LFHCAL:

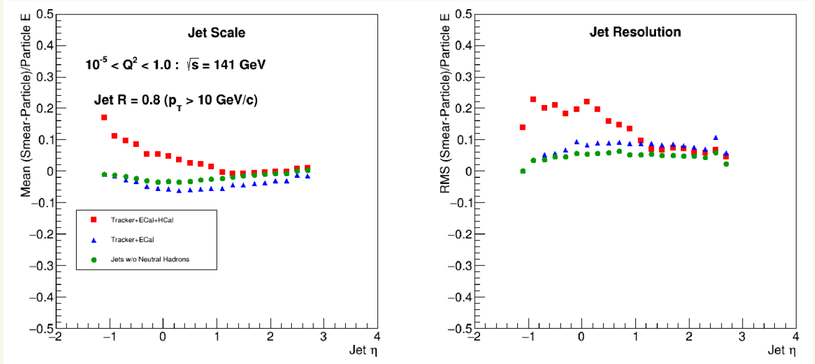
- shashlik type sampling calorimeter
- non-magnetic steel 4 cm
- plastic scintillator 4 mm
- wavelength shifting fibers
- Electronics to follow solutions of other calorimetry systems HGCROCv3 FEEs placed in front of nHCal

Design is inspired by LFHCAL Light collection by Silicon Photomultipliers MPPC S14160-1315PS

HCal Function at the EIC

- Muon identification
- Smaller particle momentum in backward regions - calorimeter as a **neutral veto**

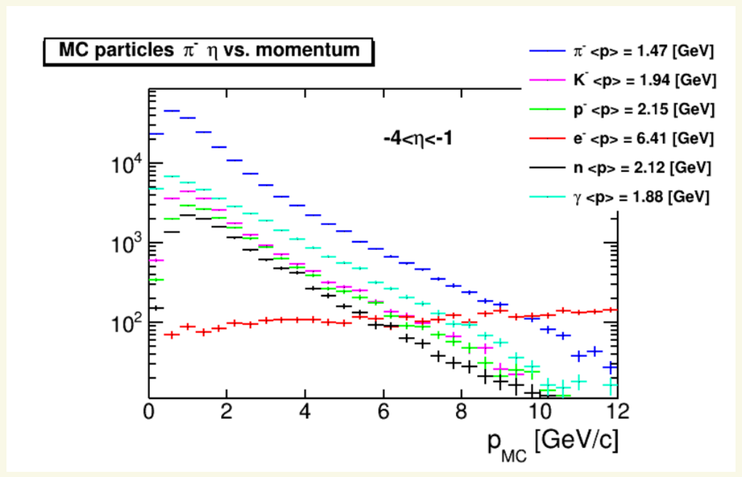
Low energy neutrons in jets



- Using **all detector** parts → **big error** in jet energy measurent
- Some jets actually come from lower-energy jets with neutral hadrons whose energy got **smeared**
- **Neutron Energy** smearing at low energy-jets (steeply falling spectrum) push measurements higher, especially at low η
- At higher Q^2, the bias exists but is less severed
- A better method is to select jets without a neutral hadron, using HCal as a neutral hadron **veto**

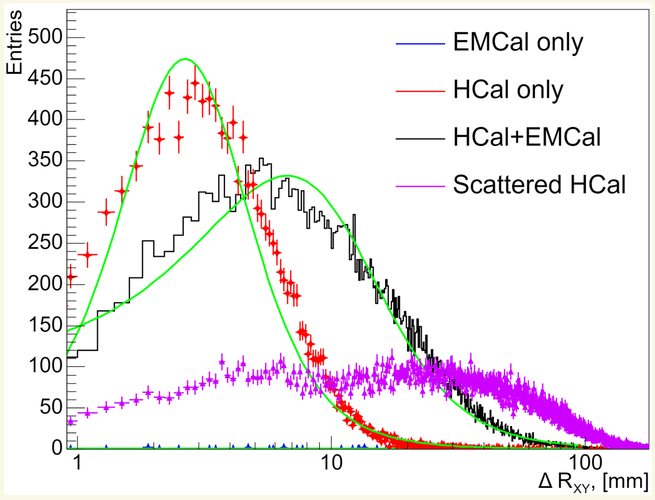
Science Requirements and Detector Concepts for the Electron-Ion Collider: EIC Yellow Report arxiv.org/abs/2103.05419

Scattering of neutrons



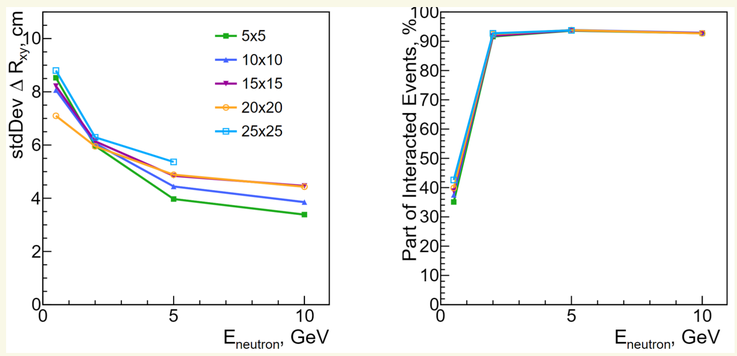
Monte-Carlo particles going into nHCal direction Mean momentum of neutrons $\bar{p} = 2.12$ GeV/c

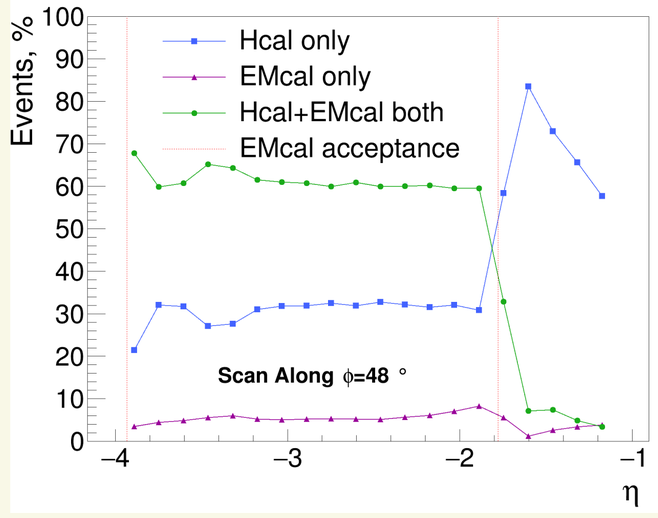
- Shoot single neutrons and compare ideal projections to RECO clusters
- Vary energy and tile size to obtain scaling



Work in progress on software compensation and neutron reconstruction with machine learning https://arxiv.org/abs/2310.04442

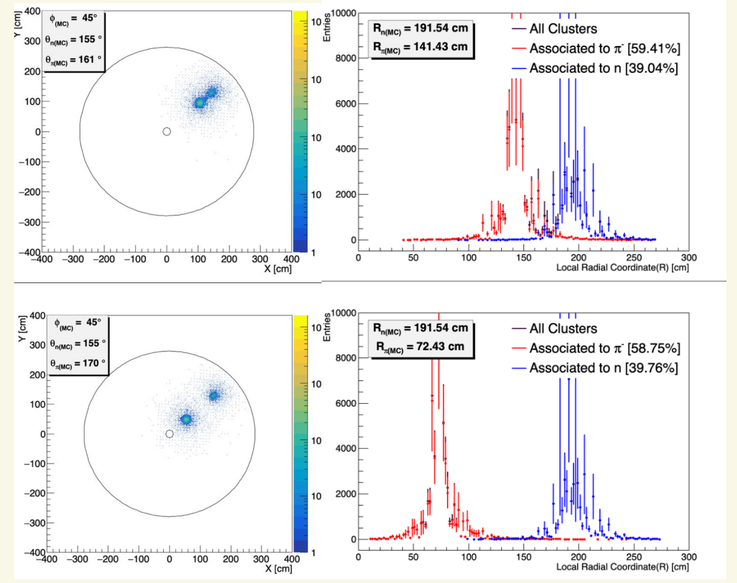
Position Resolution Study





- 38% of neutrons scatter in backward EMCal
- 93% cluster reconstruction efficiency for 5 GeV neutrons
- Scattered neutron may fall out of a jet reconstruction cone

2-particle position resolution



Conclusion

- Work in progress on neutron detection with machine learning
- Position resolution study with single particles done, following with 2-particles 10 cm x 10 cm is a good choice (can use up to 25 cm x 25 cm)
- Need realistic study with track projections and cluster matching in DIS events
- Jet performance study:
  - Work in progress, but initial studies show nHCal provides at least 20% improvement in energy resolution when vetoing jets with neutrals
  - Continue in realistic DIS events
- VM performance: nHCal especially important for J/ψ, while ρ_0 and ϕ are measured in KK channel decaying to dimuons

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