Jet and HF WG Summary

Miguel, Brian, Ping, & Wangmei

EICUG Meeting

July 27, 2022

Contact Info

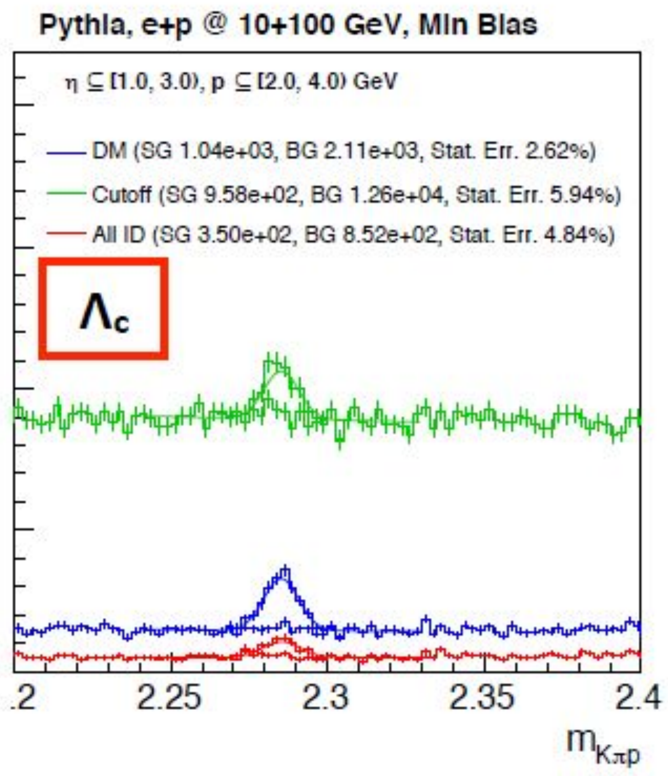
- Mailing List: eic-projdet-jethf-l@lists.bnl.gov
  - https://lists.bnl.gov/mailman/listinfo/eic-projdet-jethf-l
- Meeting Indico Pages: https://indico.bnl.gov/category/420/
- Wiki Page: https://wiki.bnl.gov/eic-project-detector/index.php/JetsHF
- Mattermost Chat
- Conveners
  - Miguel Arratia – miguel.arratia@ucr.edu
  - Brian Page – bpage@bnl.gov
  - Cheuk-Ping Wong – cpwong@lanl.gov
  - Wangmei Zha – first@ustc.edu.cn

Performance Benchmarks

Benchmark	Detector Component
Jet Energy Scale / Resolution	Tracking and Calorimetry; Hermiticity
HF Reconstruction Efficiency	Tracking/Vertexing and PID
Jet Substructure	Calorimeter Granularity
(Polarized) Jet Fragmentation	PID
Forward jets	Acceptance of calorimeters near beampipe
HF Tagged Jets	Tracking/Vertexing and PID
HF R_eA	Tracking/Vertexing and PID

Low Momentum PID

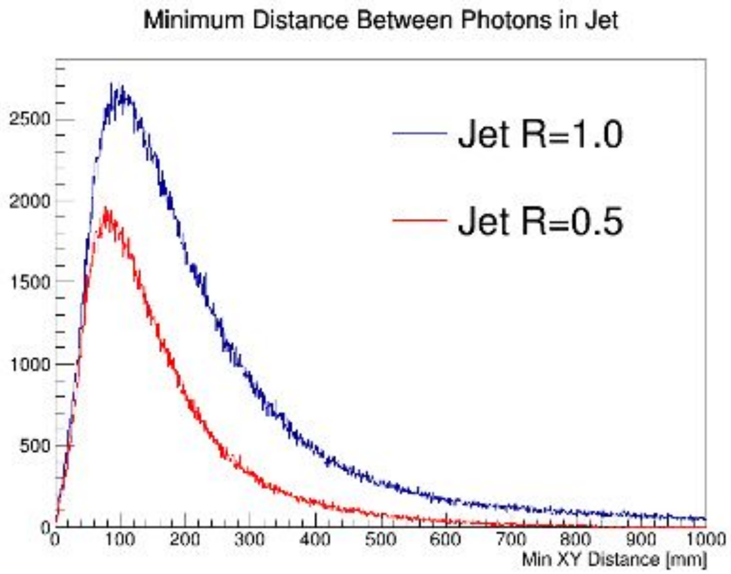
- ❑ Received charge from GD&I group to look at low momentum PID in barrel and forward endcap - below DIRC / dRICH in threshold mode
- ❑ Focus on pi/k/p separation for heavy flavor reconstruction - also think about e/pi ID for J/psi
- ❑ Some studies on impact of low-p cutoff on D0 and Lambda_c reconstruction have begun using detailed smearing (see Wenqing's presentation to Jets and HF, July 13)
- ❑ Lambda_c seen to be more sensitive than D0 to low-p PID cutoff
- ❑ Studies started before GD&I call - need more systematic exploration of cutoff effects



Introducing low momentum PID cutoff degrades statistical error by ~2x compared to perfect PID acceptance

Barrel Particle Occupancy

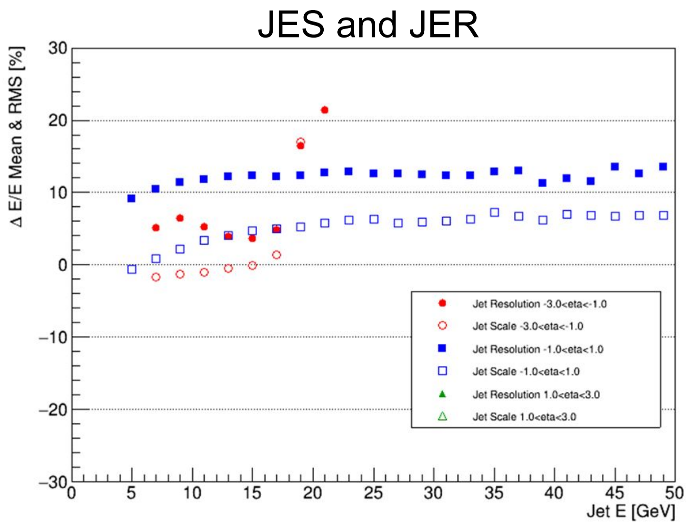
- Jet substructure measurements require position and energy of all jet components
- What granularity in Barrel ECal is needed to resolve photons ⟺ what is the 'density' of photons within a jet?
- Look at distance in the BECal between all photon pairs within a jet using pure simulation
- See that most probable separation between any two photons is ~10 cm - preliminary indication is that this is not a show-stopper for either BECal design
- Will need to look in more detail using full simulation - do we get confusion from charged particles? Backgrounds?

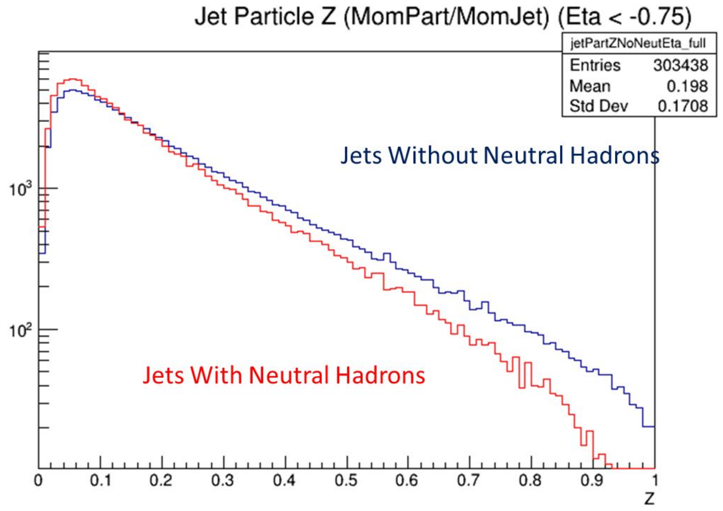


Negative HCal Study

- Reference design does not currently include an HCal in the electron-going endcap - is such a system needed?
  - Is an HCal necessary (physics impact, hermiticity)?
  - What should the performance of this system be?

- Good jet energy resolution achieved without endcap HCal at expense of biasing against jets with neutral hadrons



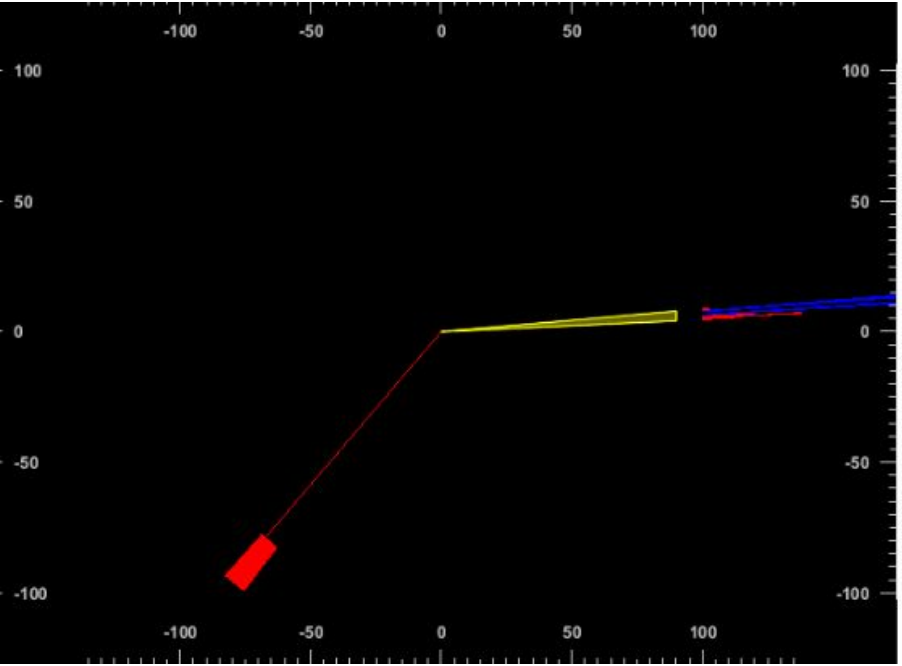


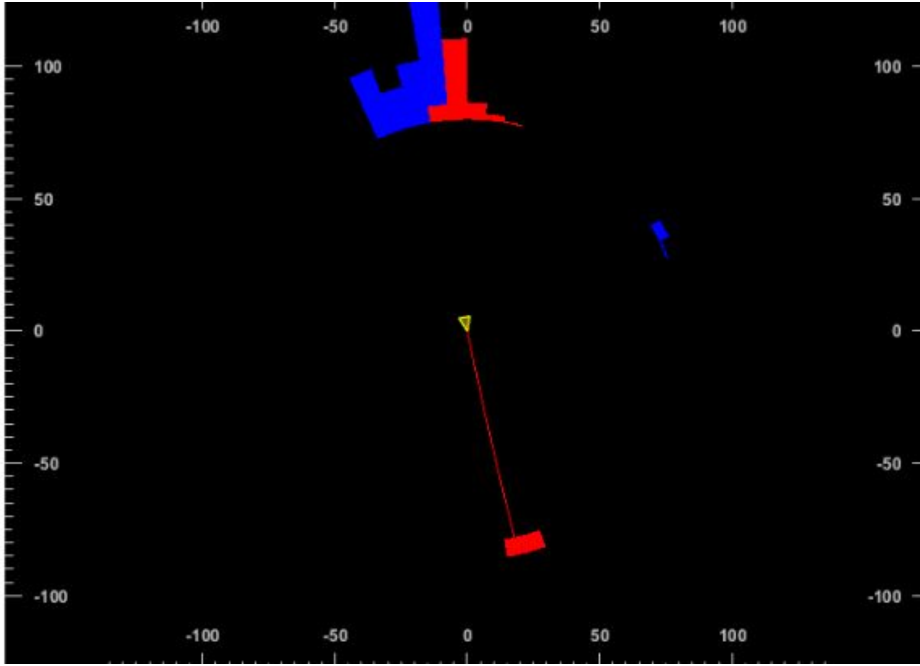
- Quantify impact of neutral bias on physics observables in pure simulation

- Explore viability of neutral hadron ID with negative HCal implemented in DD4hep for ATHENA design - optimize tower size and track/cluster matching procedure

A key benchmark channel: forward jets (high-x DIS)

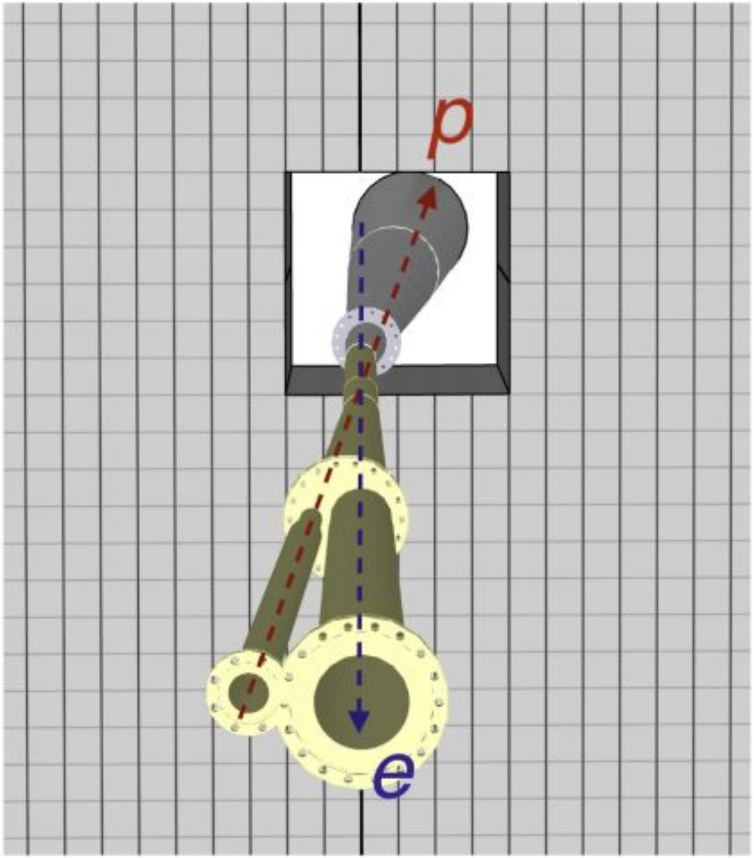
We must strive to ensure maximal acceptance up to η=4.0 (top requirement in YR)





Note, in low-y events, distinction between “jets” and “inclusive DIS” is artificial

Crossing angle and beam pipe envelope pose a challenge in this region

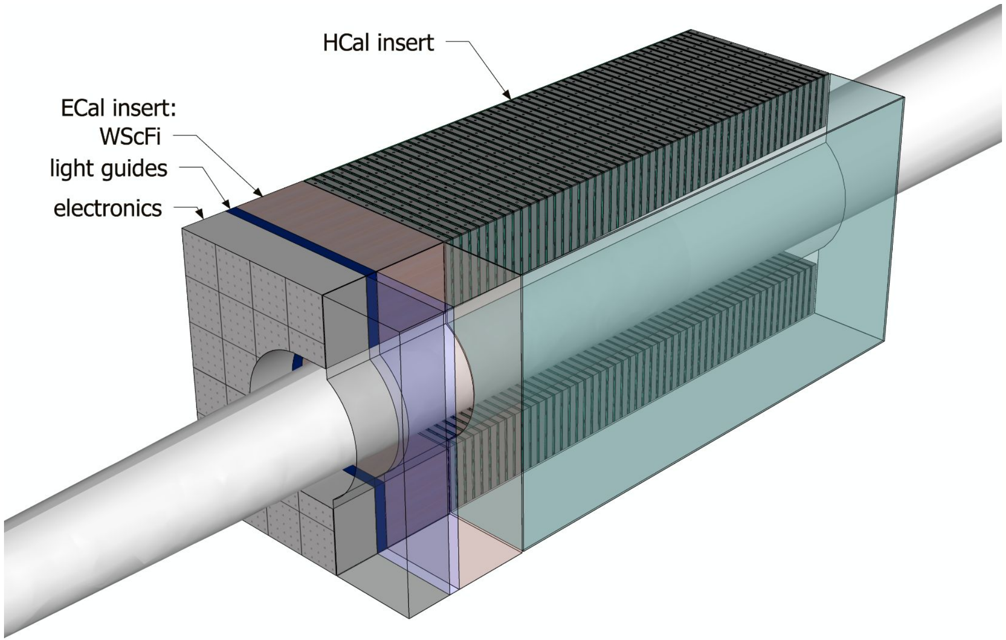


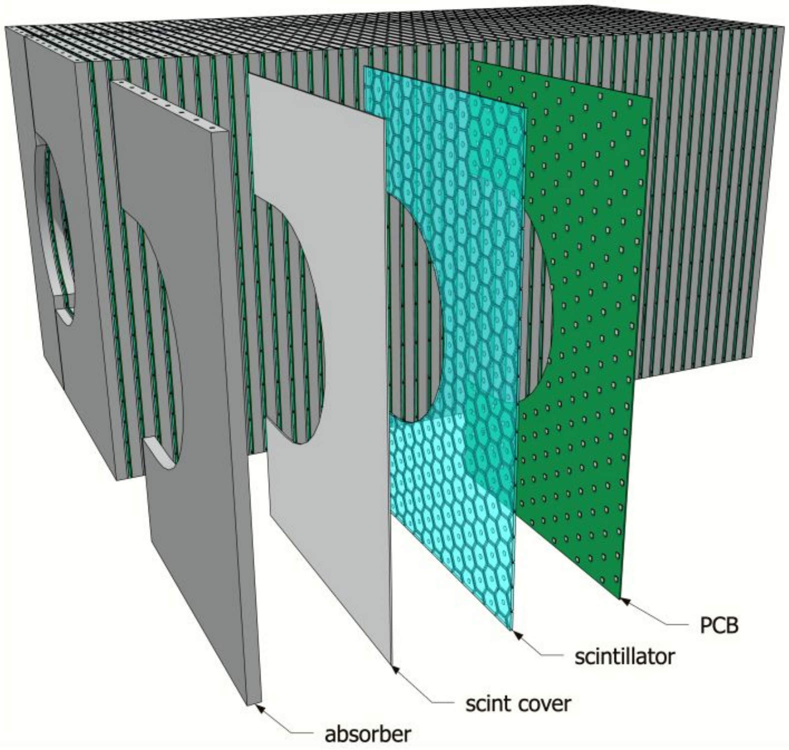
Detector in this region must

- **Fill all volume available,** which has complex shape, to maximize acceptance.
- **Keep clearance** to beampipe along entire volume, even when endcap slides open for maintenance
- **Integrate mechanically** with rest of HCAL and self-support.
- **Have high granularity** to constrain $\boldsymbol{\eta}$, and disentangle nearby showers
- **Contain magnetic flux** by having enough Fe.

Proposed solution:

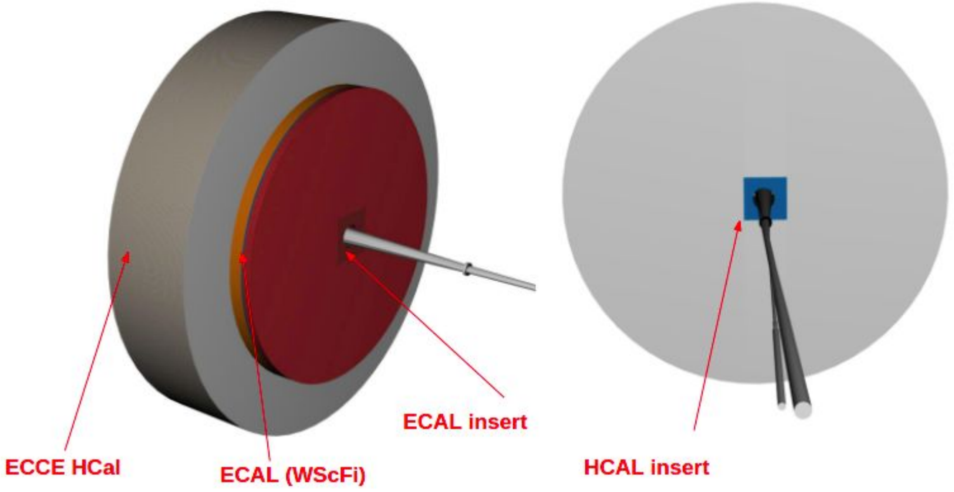
High density, fully compensated (e/h~1), high-granularity ECAL + HCAL system





CALIFORNIA EIC CONSORTIUM

Complete forward calorimeter endcap

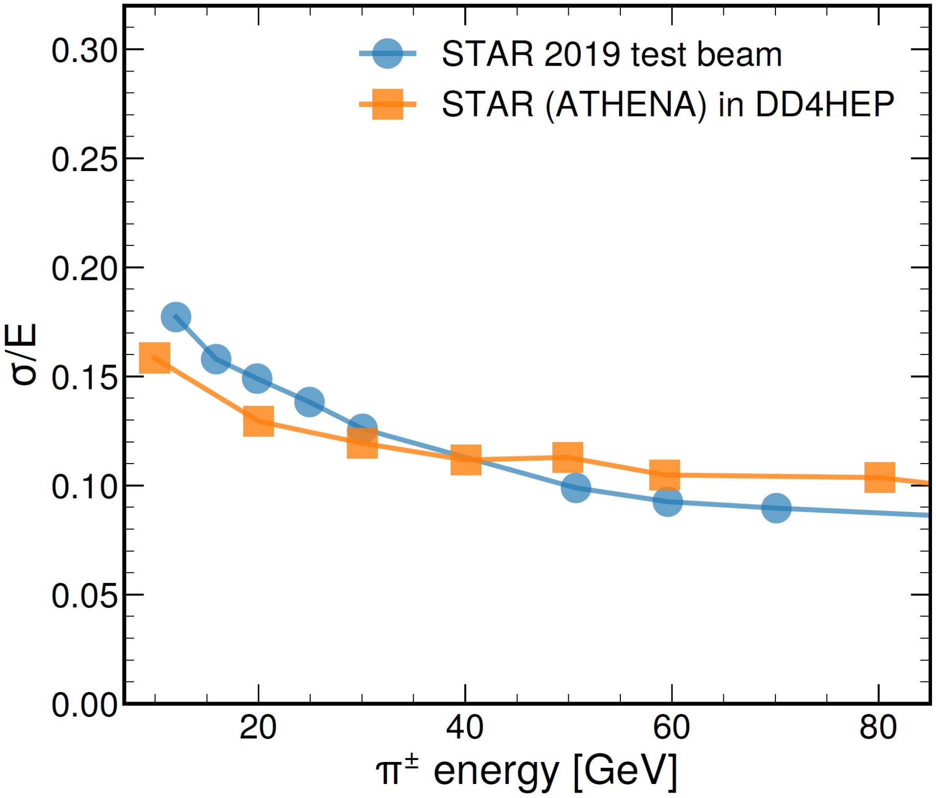


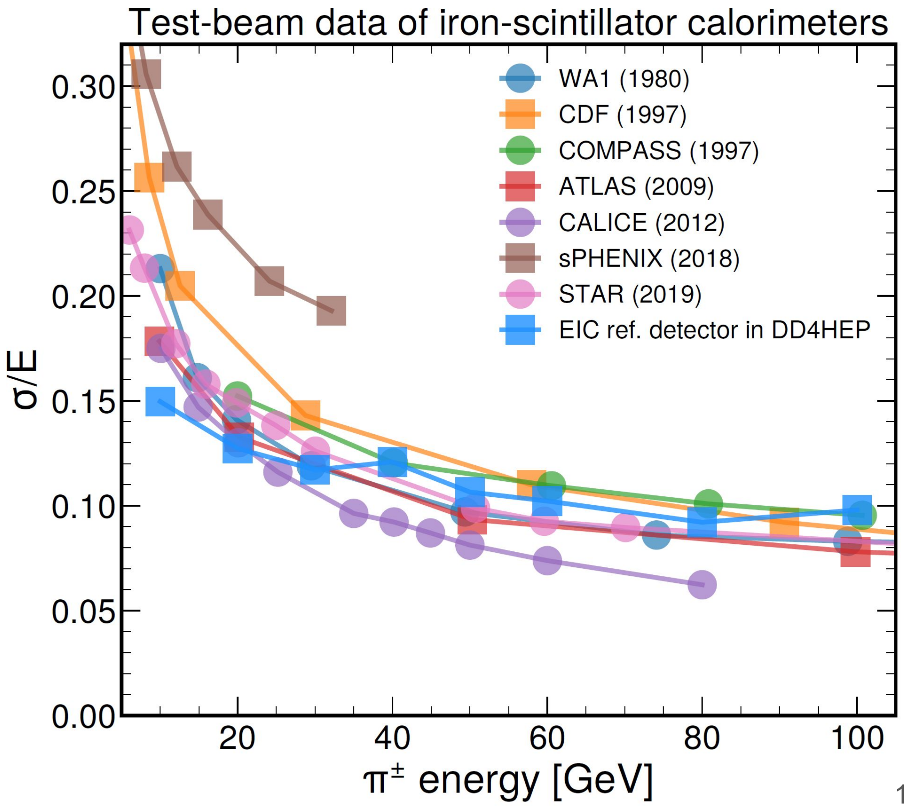
Implemented in DD4Hep
& validated against data by members of

CALIFORNIA EIC CONSORTIUM

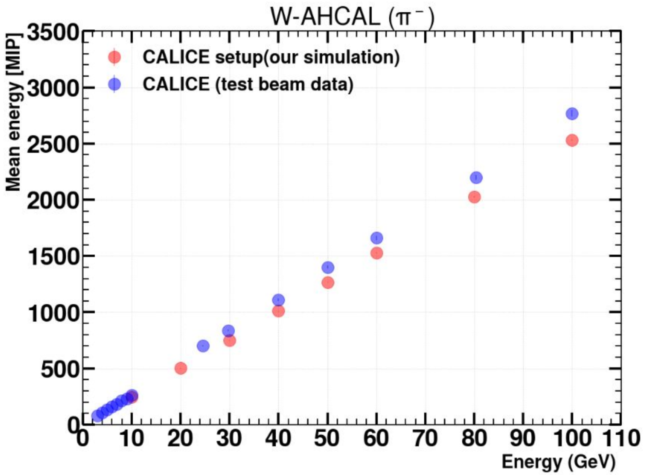
Ryan, Sean, Zhongling, Ananya, Liam, Barak, Bishnu, Sebouh

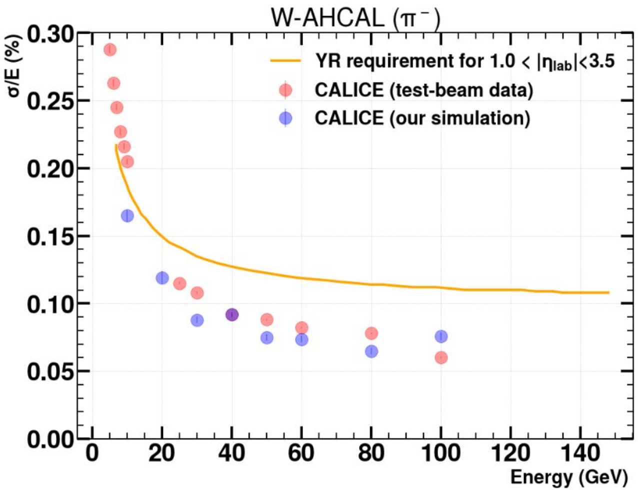
Validating the DD4Hep simulation of Fe/Sc calorimeter

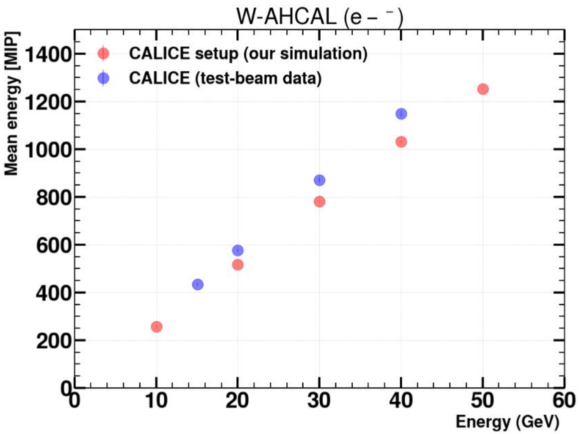


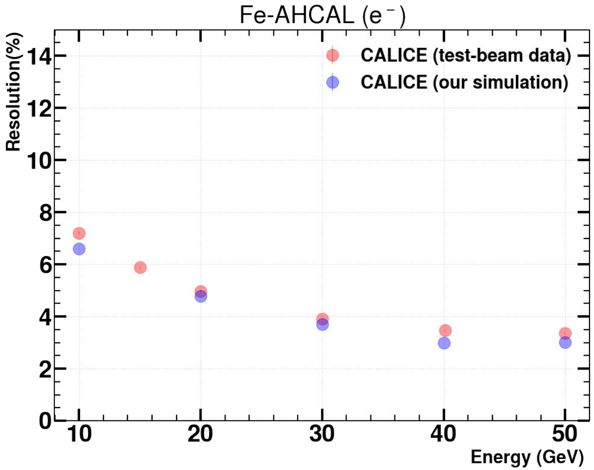


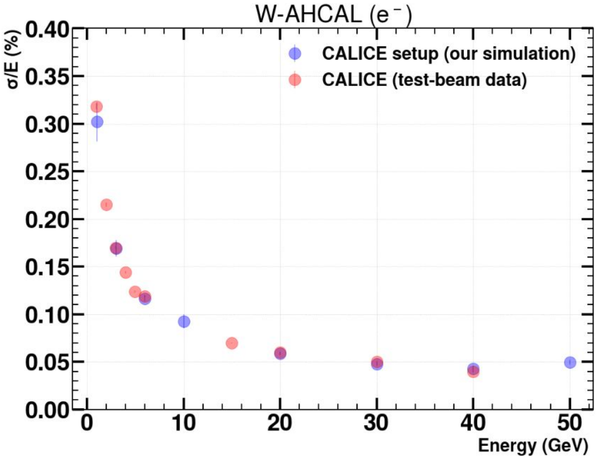
DD4Hep simulation also validated by benchmarking against CALICE data (similar to insert)





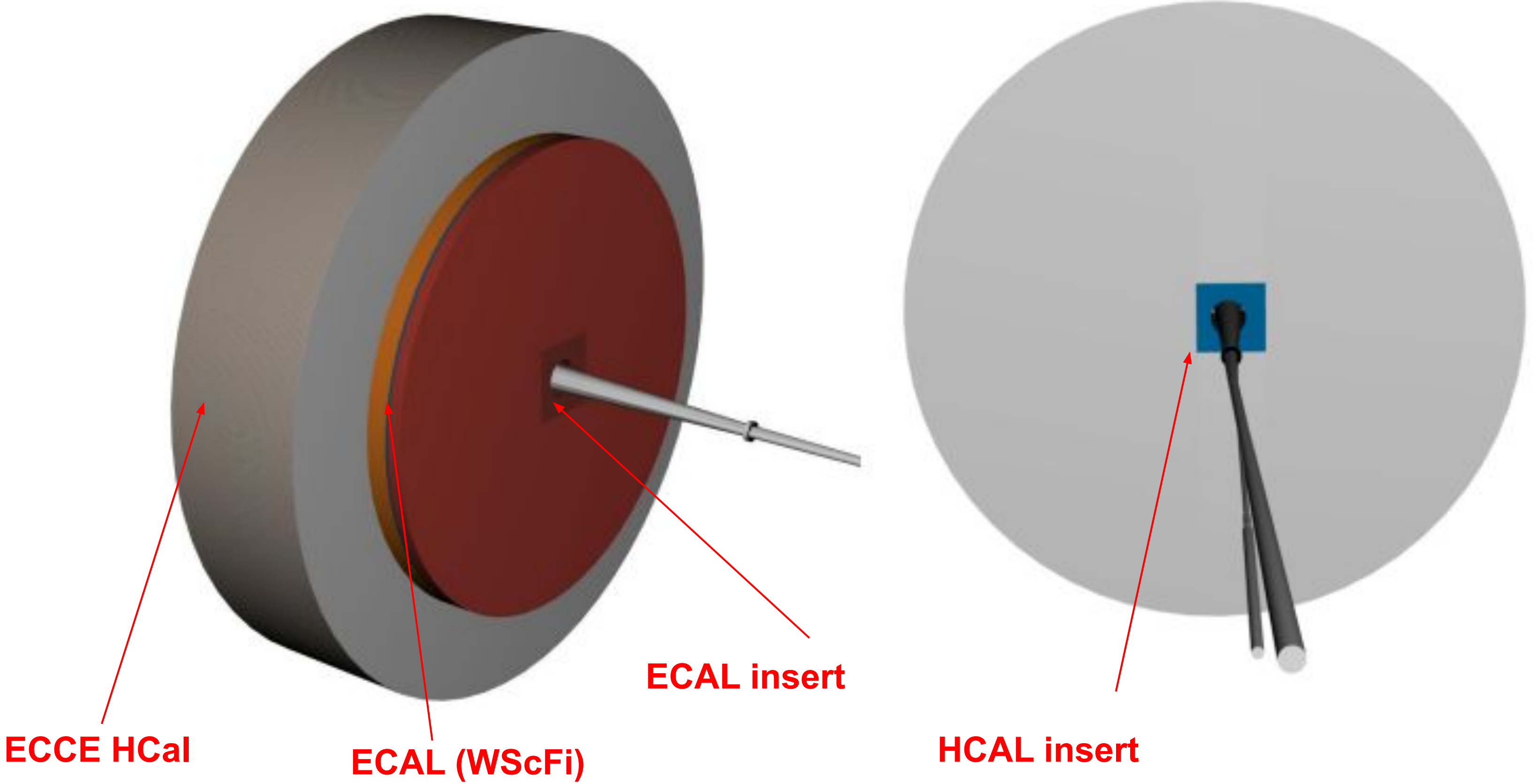




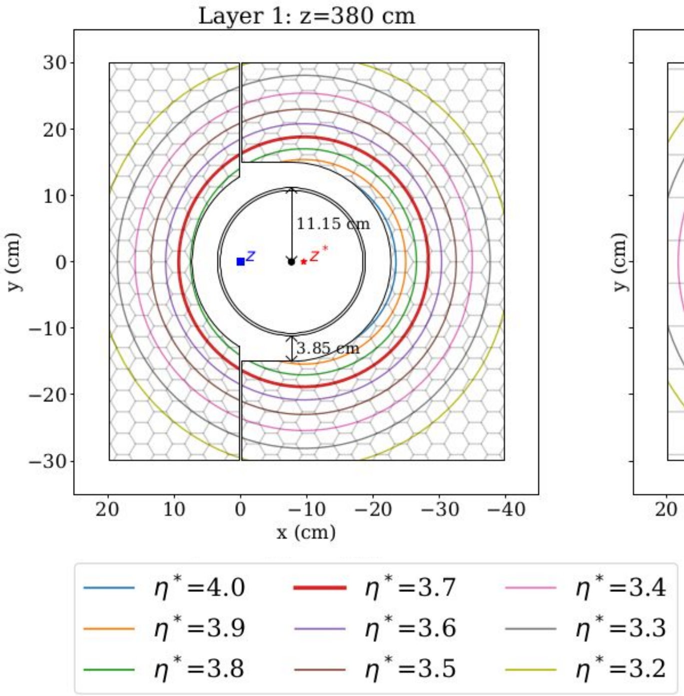


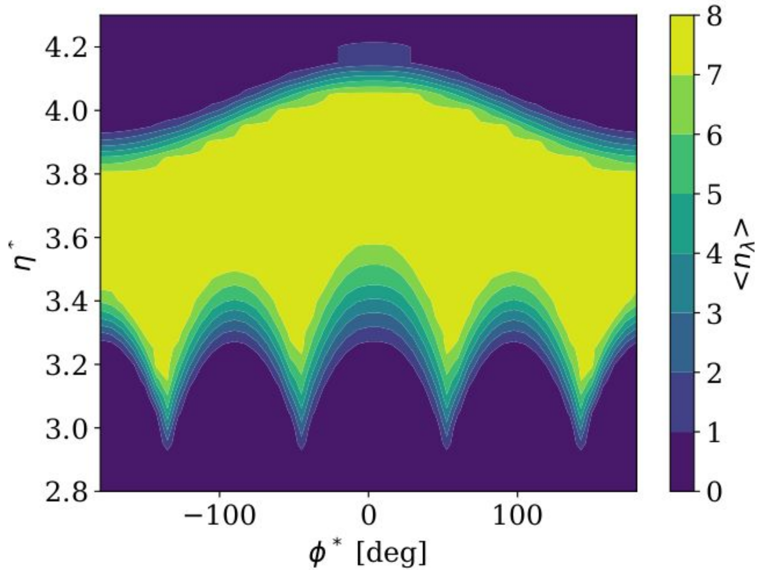
<u>DD4Hep simulation is validated to within ~10% against real data.</u>

Now that geometry is fully implemented (including near-beampipe),
we proceed to check acceptance & performance of single hadrons (then jets)



Insert acceptance and effective thickness



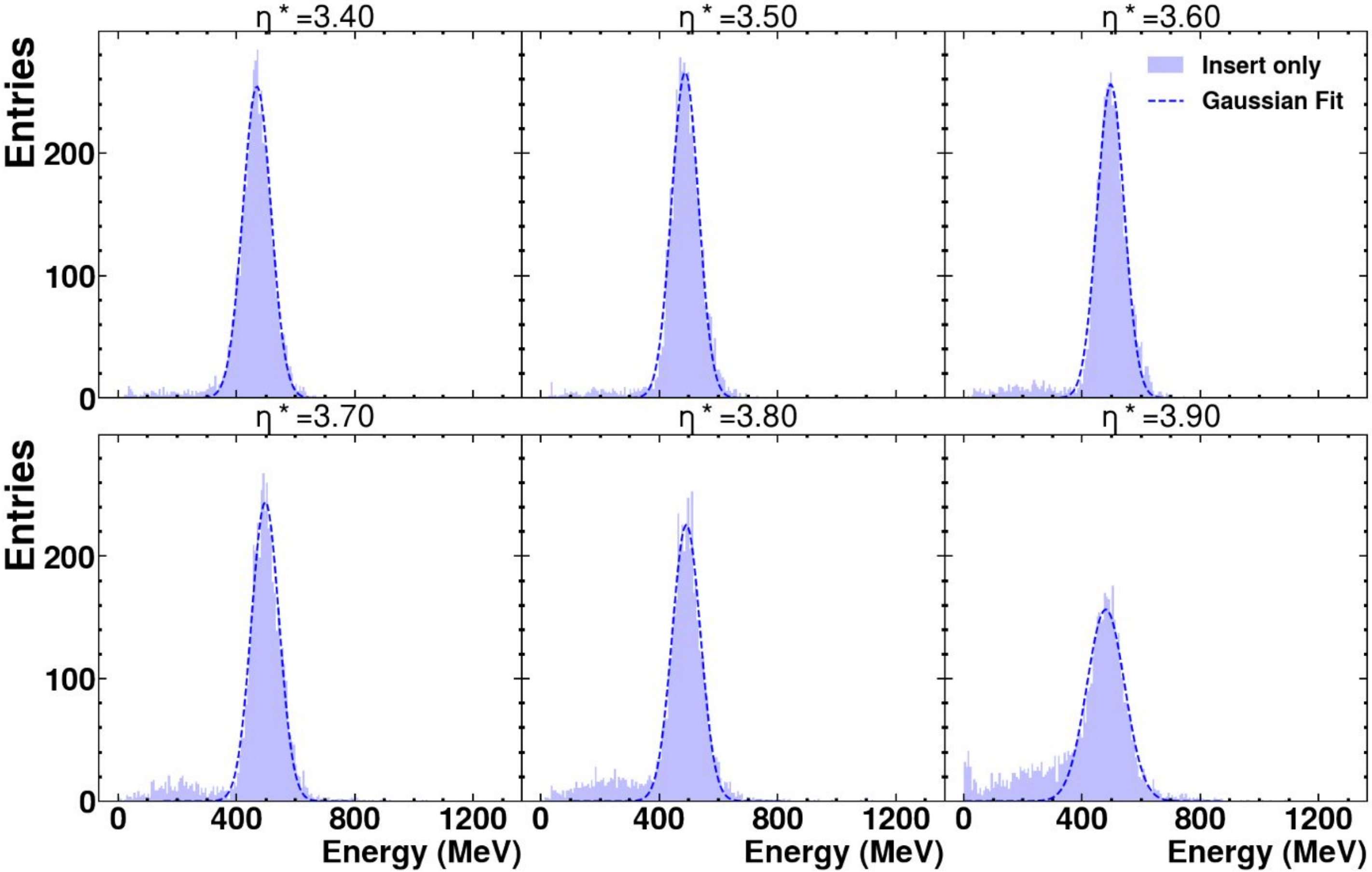


Note that angles defined wrt to proton (this is the appropriate way to define it)

Acceptance is optimal, only limited by beampipe and clearance.

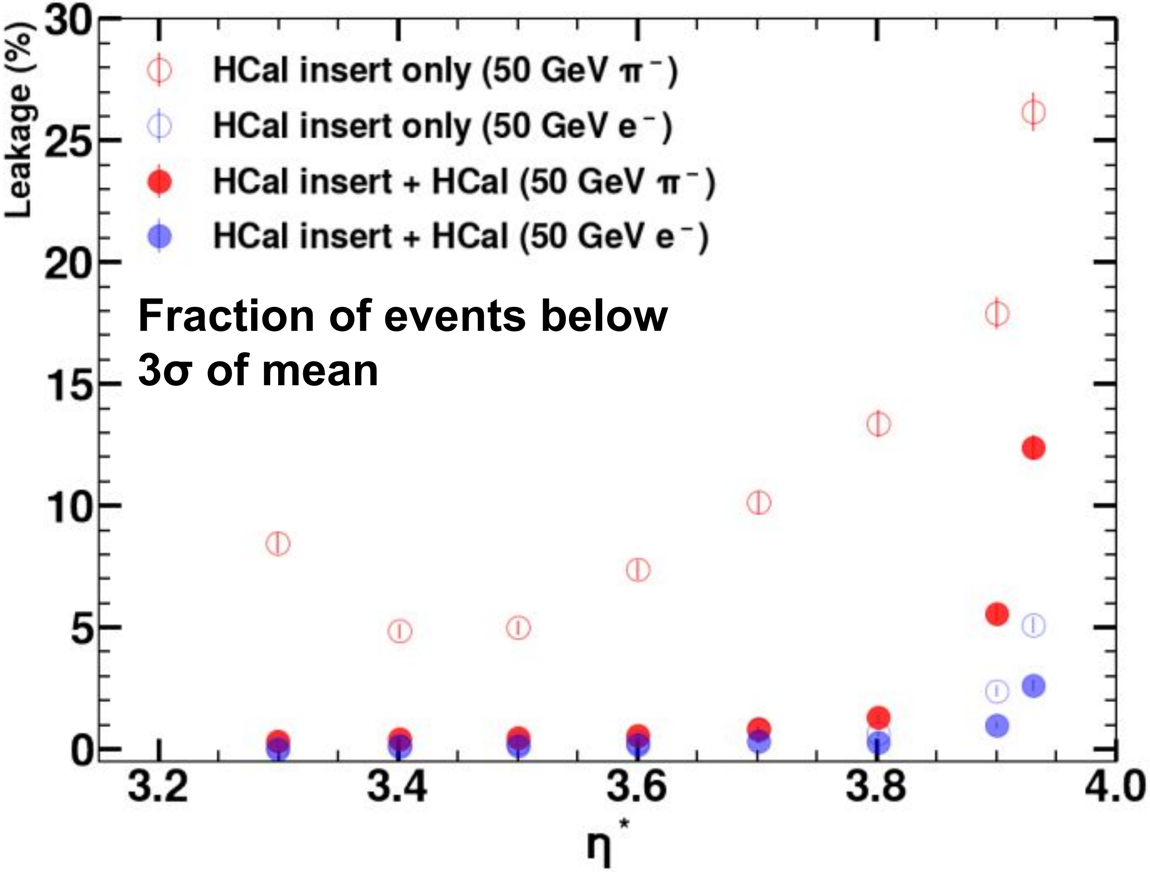
Small insert can complement larger HCAL by providing accurate showert-start position and angle in regions where material thickness is ~few interaction lengths

Response for 50 GeV pions vs η*



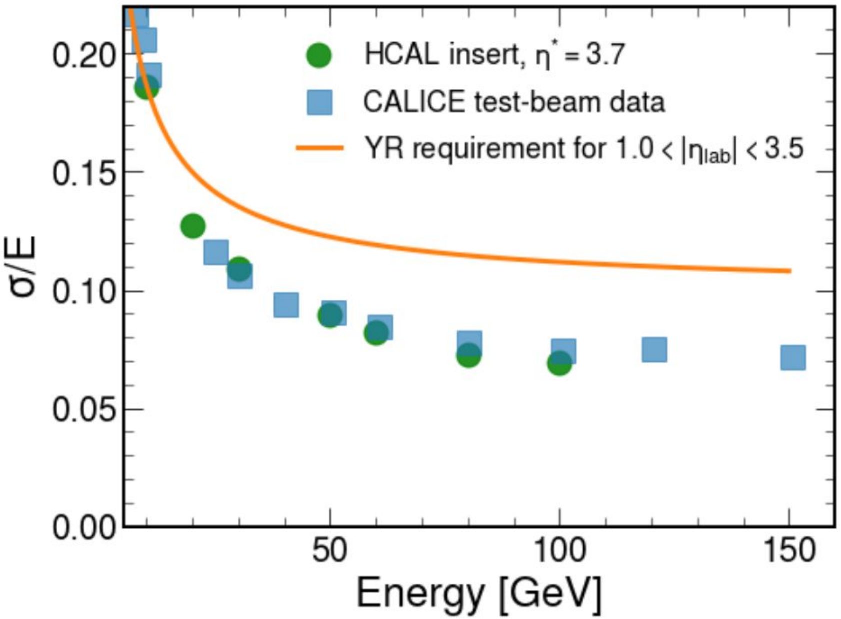
Leakage of EM-core of hadronic showers is minimized with W absorber in first layers.

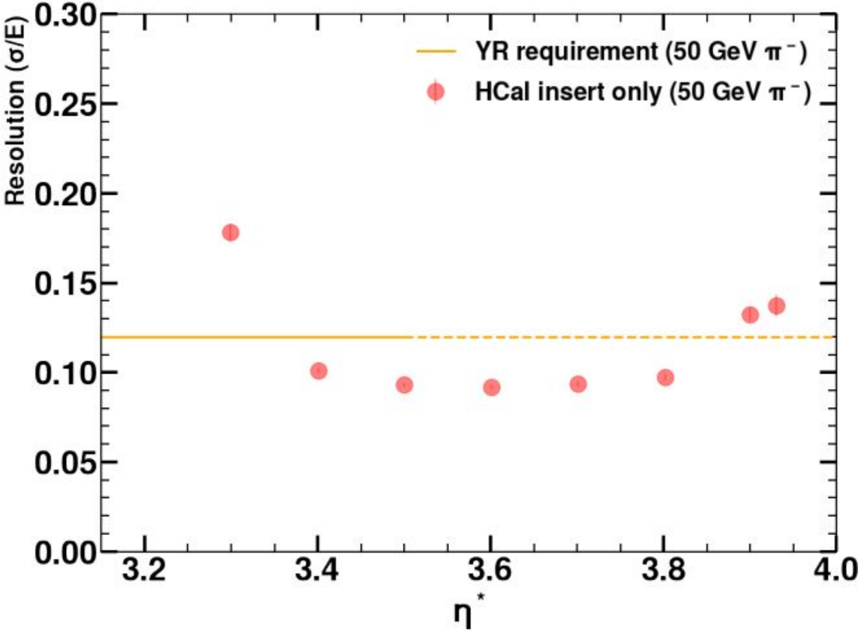
Quantifying non-gaussian tail due to leakage



Some fraction of energy leaks transversely to HCAL, other smaller fraction is completely lost.

Energy resolution and dependence on η*





Insert maximizes acceptance that meets YR requirements, even with basic algorithm (it also provides 5D shower info that can be used in more advance reco)

Summary

- ❑ Benchmark analyses have largely been identified - work to implement will proceed as simulation becomes available
- ❑ Much of the effort within the group to date has been focused on addressing specific detector issues: case for negative HCal, need for low-p PID, barrel ECal granularity, and design of forward calorimeter inserts
- ❑ DD4Hep geometry of entire forward endcap (ECAL + ECAL insert + HCAL + HCAL insert) is implemented and validated against test-beam data to within ~10% in both linearity and resolution. Single-hadron studies done, calorimetric jets next.
- ❑ Moving forward - reach out to the (large) number of groups that expressed interest in Jets & HF and work to map their interests and skill sets onto tasks needed for TDR

Charge to PWGs

The global charge for the physics studies groups is:

- Work with the Detector Working Groups to perform constant validation of the performances for physics observables. Emphasis should be placed on studies of key physics processes in the NAS report, the EIC whitepaper, Yellow Report, and detector proposals.
- When alternative technological solutions are examined, work with the detector groups to provide quantitative information on the physics performance of the proposed solutions.
- In collaboration with the Computing/Software and Simulations WGs, further develop simulation and data analysis tools. Organize workshops as needed to provide training in the use of these tools for collaborators.
- Over time, extend the existing scope of physics processes being studied, with an emphasis on those processes called out by the DPAP as being significant for the science program and yet not studied by the proto-collaborations.