

# **Summary Calorimeter Clustering Workshop ORNL, 11-14th April 2023**

**April 19, 2023**

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# Impressions & Aim of the Workshop



- Workshop meant as a hackathon/ joint coding session in a friendly atmosphere
- Lots of help from around the table and discussions on how to solve coding problems/ learn from each other
- Grouping on different topics

# What we had set out to do over the week!

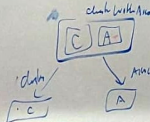
PLUS

Captureboard

- one-to-many relation for cluster vs cells
- many-to-many relation for particles to cells/cluster
- sorted list of objects by #quantity
- too many auto's
  - missing documentation both
  - too much commented code
- pre-req package build list → instruction
- missing debug info
- missing vs empty collection
  - confs / debug info to verbose or not enough
- unclear responsibilities

OHCal #  
LHCAL #  
BENC #  
FENC #  
EENC #

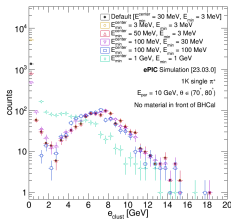
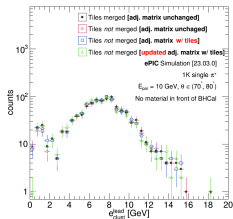
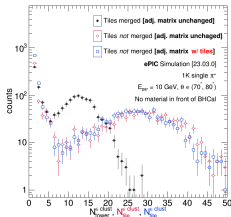
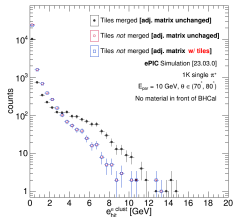
• Check LFHCal logging



- OHCal transition towers → tiles as cells  
→ thresholds Derek EICrecon #598 ↑
- OHCal calibration workflow Derek
- check flow for all calorimeters → implement corresponding CI-checks
- identify "trivial" CI check Dima ddhep eicrecon
- track matching ECals + HCals Nea/Tyler ↑
- match cluster/trajectories Nathan/Reber eicrecon #578 ↑  
HC associations
- proper implementation of insert in epic/eicrecon Bishnu ↑
- cluster splitting Dhruv  
→ cluster properties → shape distributions ↑
- try integrating "pandora" into eicrecon for particle flow Oskar ↑
- LFHCal calos epic #406 eicrecon #551 ↑
- check realism of geom implementation  
→ pEcal Zhonglin
- ML clustering Eva/Hannah

## Color code:

- red: What we are struggling with/PR's
- blue: What we wanna achieve this week
- green: Volunteers
- black: progress



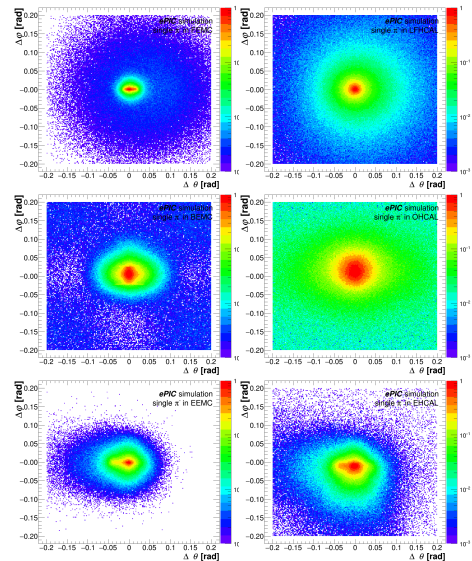
## Main contributor: Derek Anderson

- OHCal clustering: transition from towers to tiles as input for clusterization  
[EICrecon#598](#)

- Completed transition successfully!
- Process was relatively straightforward (and a good exercise in extending the adjacency matrix)
- Default energy parameters work okay for single particles

- Develop calibration workflow for OHCal
  - Next step is to exercise calibration workflow for tile-based clustering
  - Will compare calibrated BHCal energies for *tower-* vs. *tile-* based clusterization.





## Main contributors: Nicolas Schmidt, Tyler Kutz

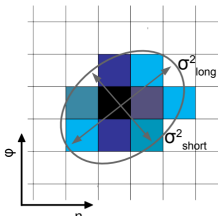
- Matching performance evaluation for future particle flow approach
- Based on ACTS track propagation to virtual surfaces  
→ sub tower-size matching performance in all calorimeters
- Allows for calibration of HCals by matching clusters with ECals
- Current status:  
→ matching processor for performance studies written, see [EICrecon#606](#)  
→ matching factory in preparation

## Main contributor: Dmitry Kalinkin

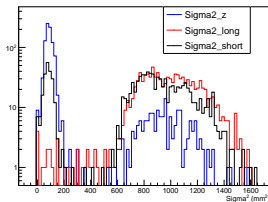
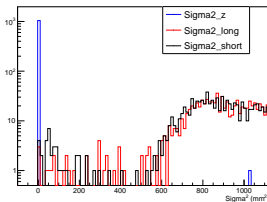
- Wrote first unit tests, starting with one for the CalorimeterIslandCluster algorithm [EICrecon#605](#)
- ...while implementing those, an important bug in clustering was discovered [EICrecon#610](#)
- Few changes for EcalEndcapN clustering [EICrecon#603](#), [EICrecon#611](#) (to be tested...)

# Cluster properties

**Main contributor: Dhevan Gangadharan**



- 3D Cluster shape analysis implemented in EICrecon. Covariance matrix computed from cluster hit distributions. Eigenvalues are then computed, which should correspond to the RMS sizes of the cluster along the axes of a tilted ellipsoid.
- Left-most plot show the results of simulations with a single 10 GeV electron hitting a simple block CAL head on with no Z dimensionality to the hits.
- Right-most plot includes a simple Gaussian smearing in Z with sigma=10mm.
- x-y-z profiling used with no E weights
- PR submitted, see [EICrecon#616](#)  
→ one should check performance in a more realistic scenario requiring 3D cluster profiling, such as the LFHCAL. Also, x-y-z vs eta-phi-z with E weights should be explored.



## Main contributor: Nathan Brei

- This PR ([EICrecon#578](#)) allows eicrecon to use PODIO associations correctly, resolving a major source of confusion, entropy, and bugs.
- Converts three problematic factories into multifactories supporting multiple outputs
- Fixed PODIO ownership issue
- New model factories `MatchClusters_factory`, `ParticlesWithTruthPID_factory`, `TrackingResult_factory`
- Output files now written using PODIO's frame writer, which is incompatible with older EventStore
- `JEventProcessorPODIO` used to maintain a list of factories that have thrown an exception. After it crashed once, it would never be called again. Now, it will be called again on every event.

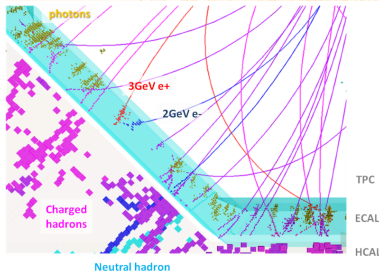
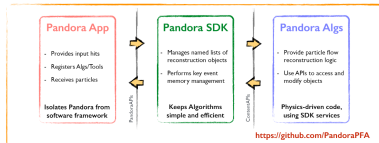
**THANKS Nathan!**

## Main contributors: Peter Steinberg & Nathan Brei

- Important piece of EICrecon infrastructure that had never worked in previous testing
  - ▶ Association algorithms had been implemented in HCAL
  - ▶ However, while there were no obvious errors, the containers were always empty!
- Solution (thanks to Nathan), turned out to be due to the fact that the truth associations were not the primary output, but were a container filled separately
  - ▶ This is fixed with "multifactories" ([EICrecon#578](#))
  - ▶ Associations of clusters to truth worked in EICrecon at runtime, but PODIO files were broken due to meaningless pointers (would be nice if clusters had a simple ID as a member variable)
- Changes propagated to ([EICrecon#600](#)) (open)
  - ▶ (re-)fixed the units problem in the digi/reco sequence (although this will be retired with the new geometry)
  - ▶ Every dummy algorithm now explicitly requests its clusters, so the algorithms are run beforehand (the reason the containers were usually empty)
- Now that Nathan's major [EICrecon#578](#) is accepted, ongoing work to rebase these changes with the new functionality and PODIO association schemes.

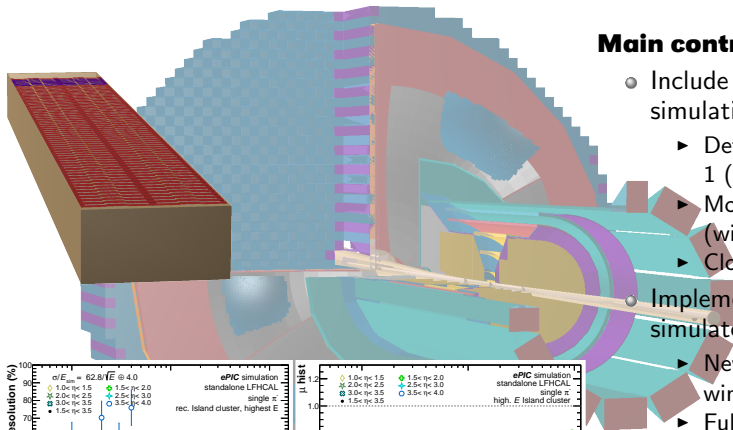
# Explore PANDORA integration for Particle Flow Reconstruction

## Main contributor: Oskar Hartbrich



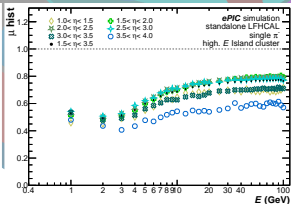
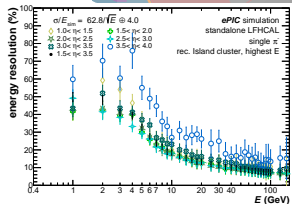
- PandoraPFA is an open source particle flow algorithm (PFA) reconstruction framework originally developed for ILC/CLiC
  - ▶ comes with a largely variety of algorithms that can be configured and chained
  - ▶ e.g. also used for liquid Argon reconstruction
- well defined interfaces to supply detector information (tracks, hits, geometry) into PandoraPFA and receive back outputs
  - ▶ development seems to have ceased for years now
- Do we want to try and include this into EICRecon? Or just learn from their algorithms?
  - ▶ IJCLab likely has some experience from ILD participation: Roman Poeschl et al.

# LFHCal integration & reconstruction

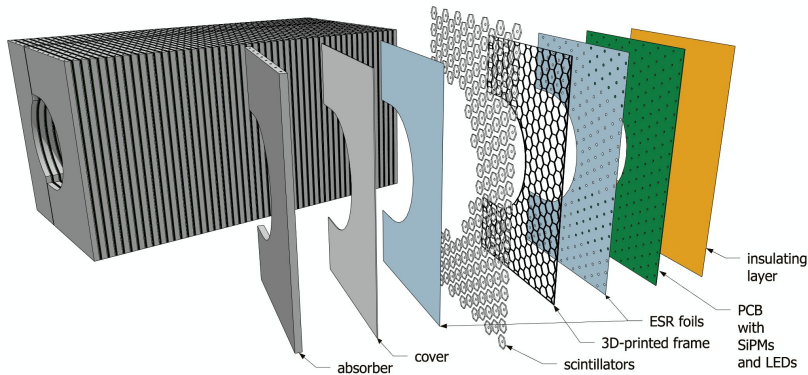


## Main contributor: Friederike Bock

- Include more realistic geometry of LFHCal in simulation stack [epic#406](#)
  - ▶ Detailed module geometry of LFHCal option 1 (simplified WLS option)
  - ▶ Module placements for two options (with/without insert)
  - ▶ Close to merging
- Implemented proper processing of LFHCal simulated hits to clusters [EICrecon#591](#)
  - ▶ New feature in digitizer to cut on time window
  - ▶ Full chain working for LFHCal
  - ▶ Post processors for LFHCal and FEMC
  - ▶ Reorganization to have each calo in their own directory



# Increase Realism of Forward Insert

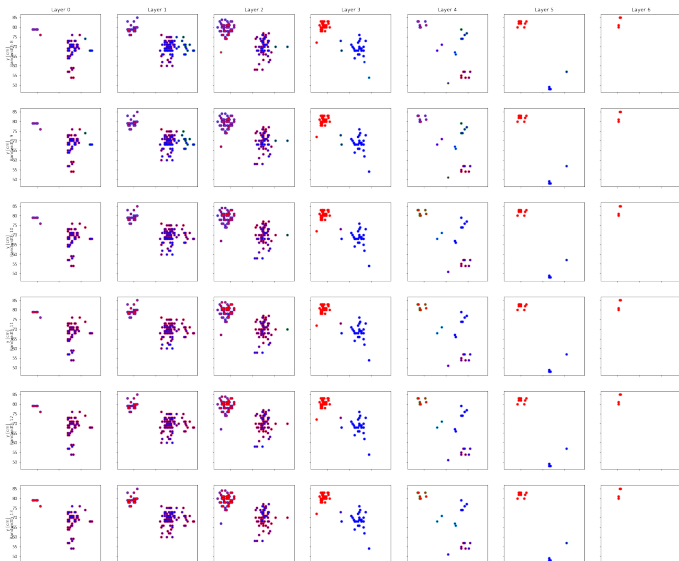


## Main contributor: Bishnu Kharki

- Implement more realistic geometry of the tiling & dead spaces in the within the layers
- Start working on clustering algorithm within insert & joining clusters with LFHCaI

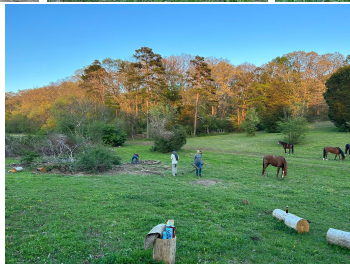


# ML based clusterization



**Main contributors: Hannah Bossi, Ewa Glimos, Tanner Mengel**

- Lots of literature research
- First ideas being implemented following the CMS approach
- More details in Ewa's/Hannah's presentation





# Evening entertainment - Operations





**Annual workshop around Easter  
at ORNL**

## **BURNING CALO**

**Let's keep up the good work and  
see you latest in a year in person  
again!**