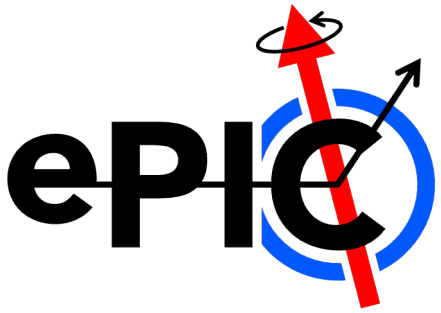
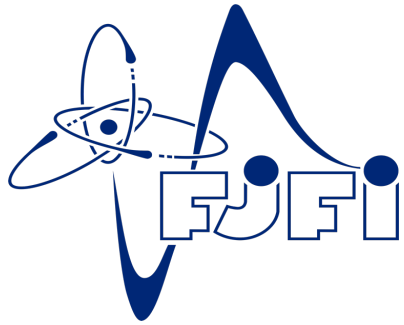
Testing EICRecon Clustering Algorithm on Backward HCal

Leszek Kosarzewski, **Subhadip Pal**, Alexandr Prozorov





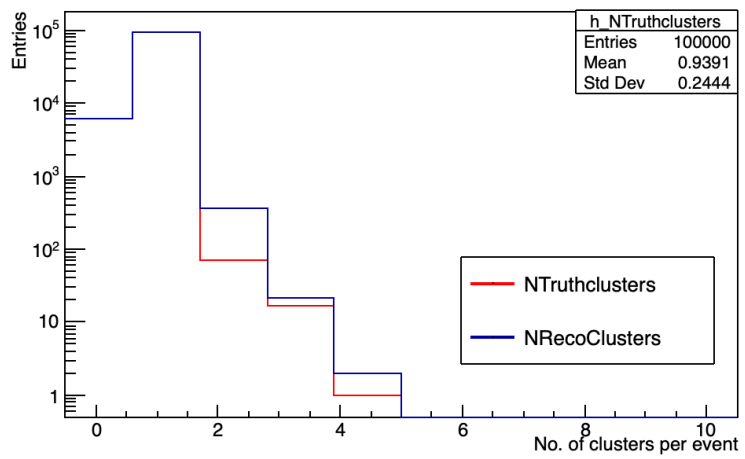
ePIC calorimetry meeting – May 8, 2024

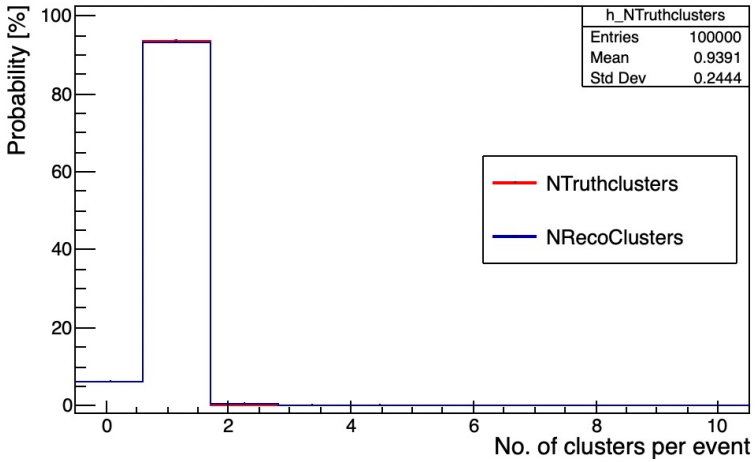
Setup

- 1 neutron/event, 100k events and p = 5 GeV
- $\theta = 170^\circ$ and $\varphi = 45^\circ$

- Only Backward HCal was taken into account (not the whole ePIC geometry)
- Alternating Steel and Scintilator slices
- 10 cm. x 10 cm. Polystyrene tiles

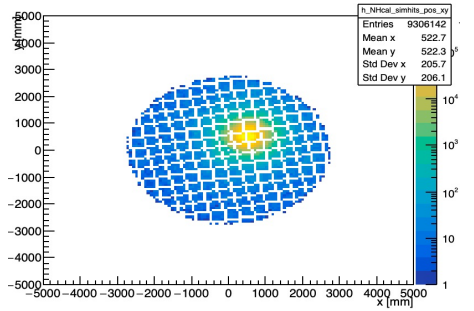
Hit and Cluster Positions



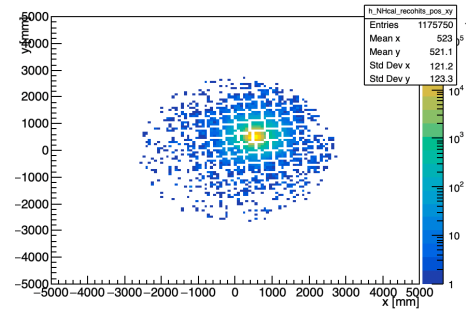


Events seen with no. of clusters > 1

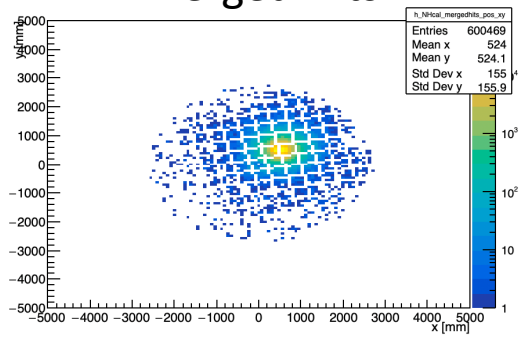
Simulated Hits



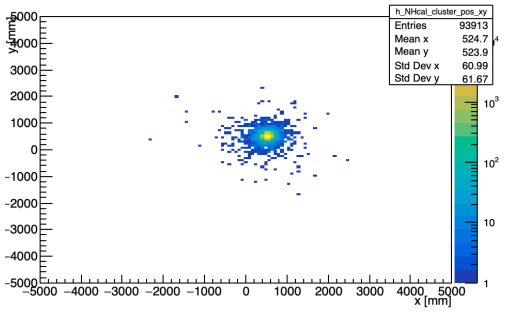
Reconstructed Hits



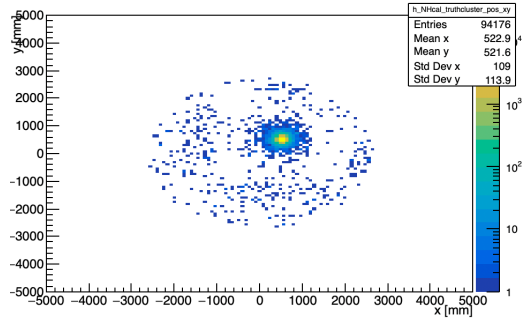
Merged Hits



Reconstructed Clusters (Island Clustering)

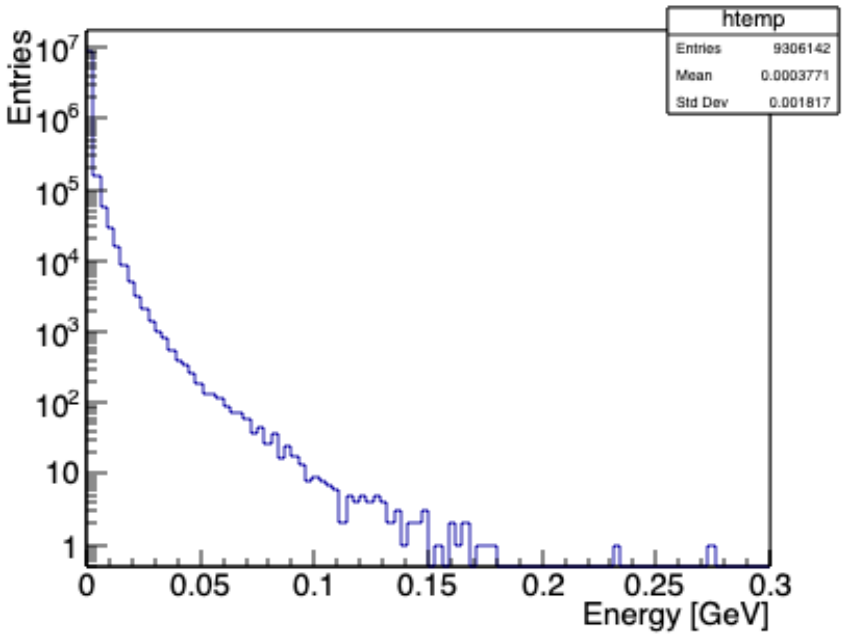


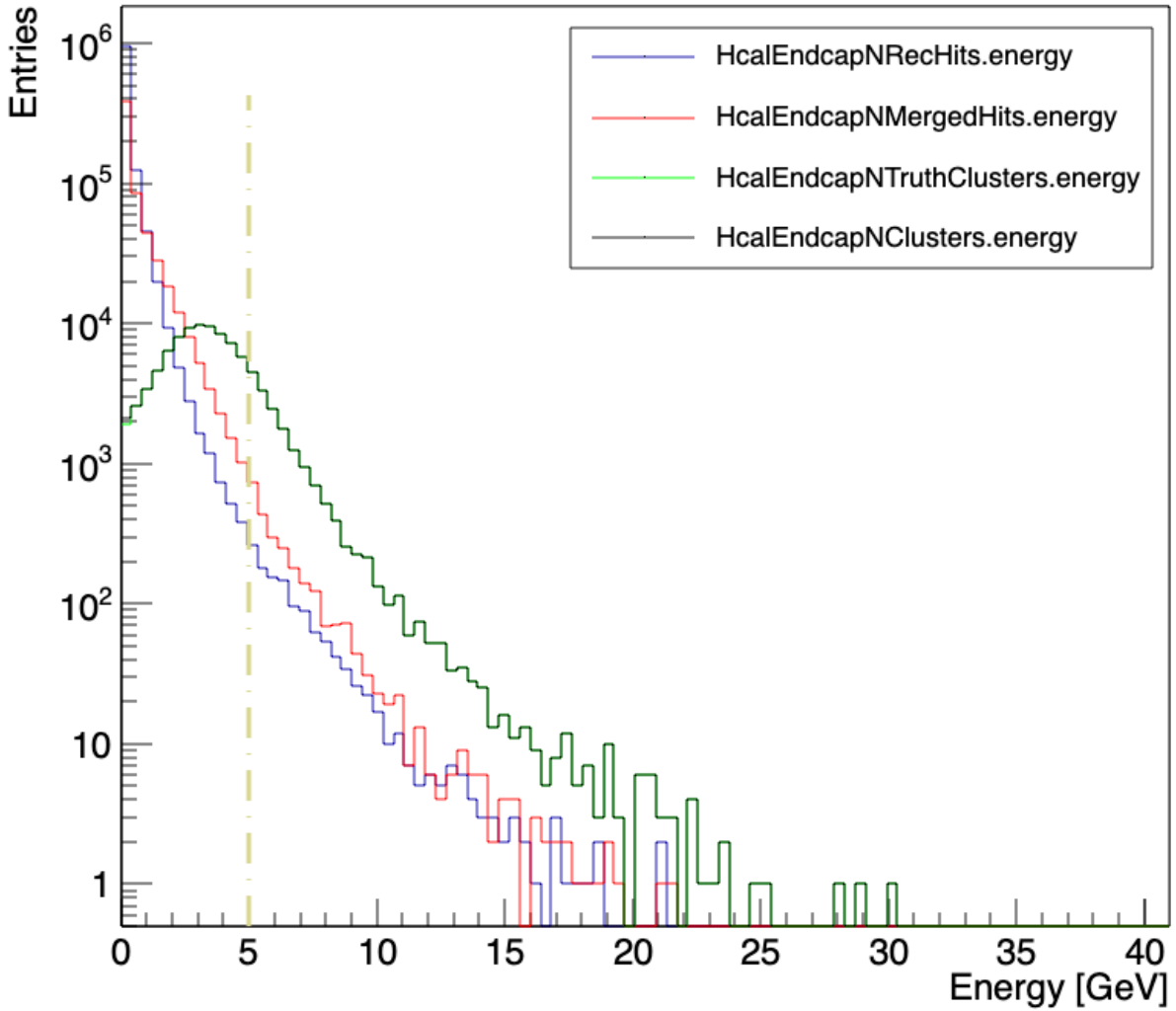
Truth Clusters



Hit and Cluster Energies

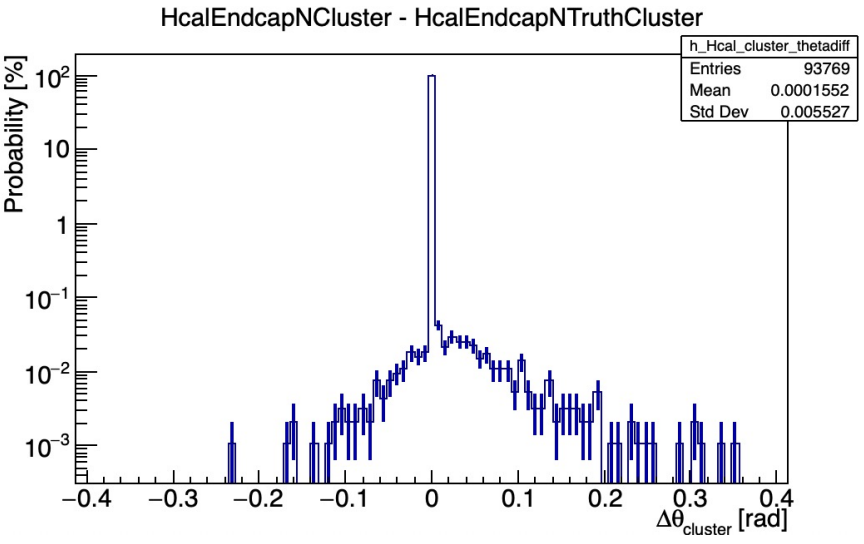
Simulated Hits

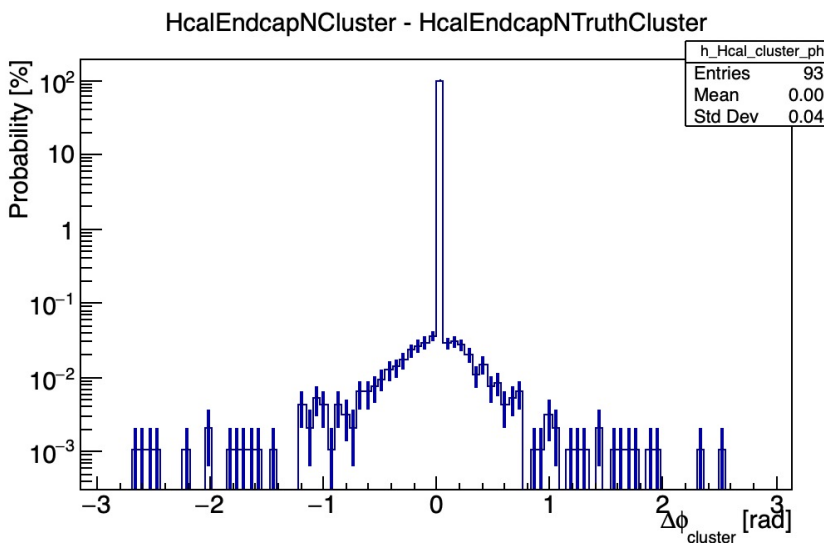


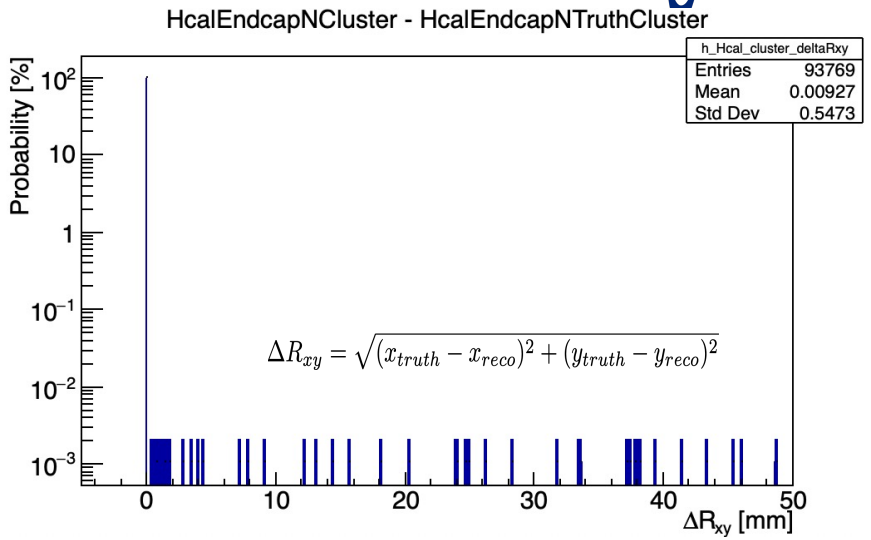


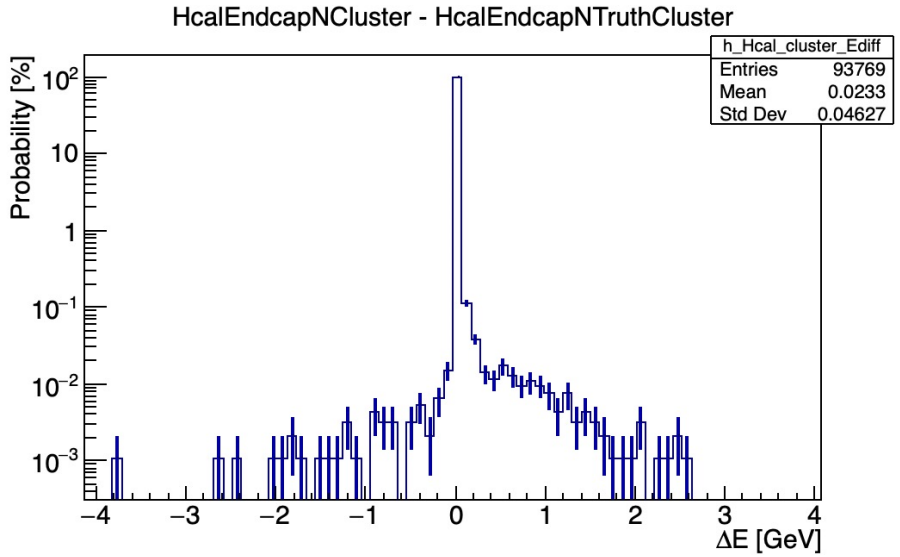
Sampling fraction (0.0095) corrected at Reconstructed Hits stage

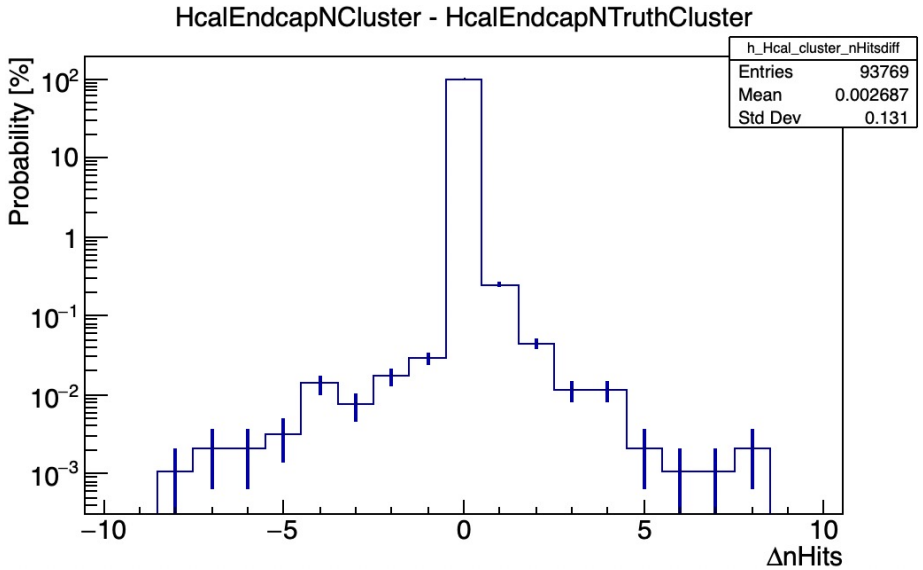
Comparison between Truth and Reco clusters











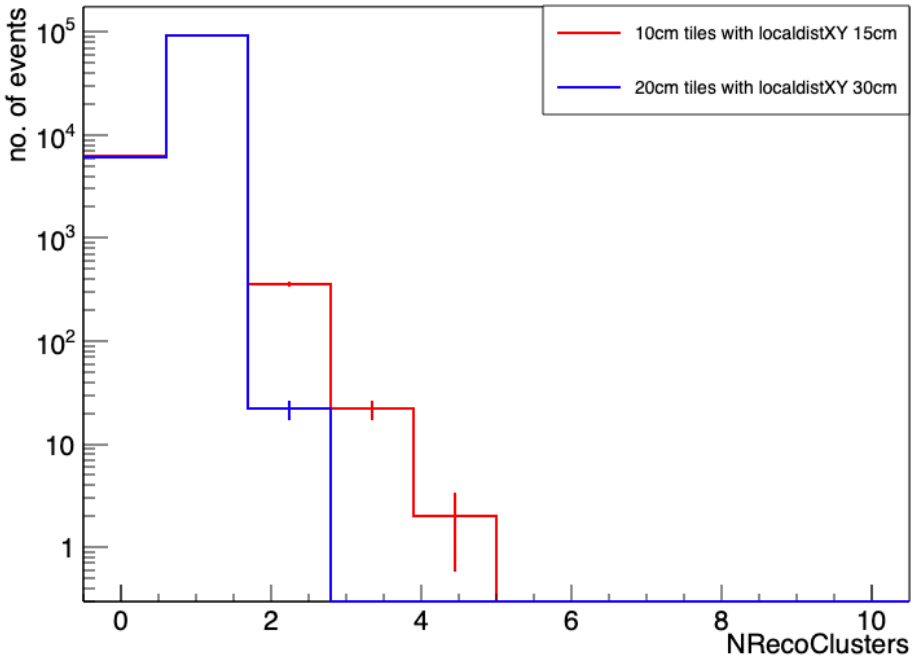
Highest energy truth and reco clusters are compared for an Event

Scaling of the algorithm with segmentation

- 10cm tiles with localdistXY 15cm
- 20cm tiles with localdistXY 30cm

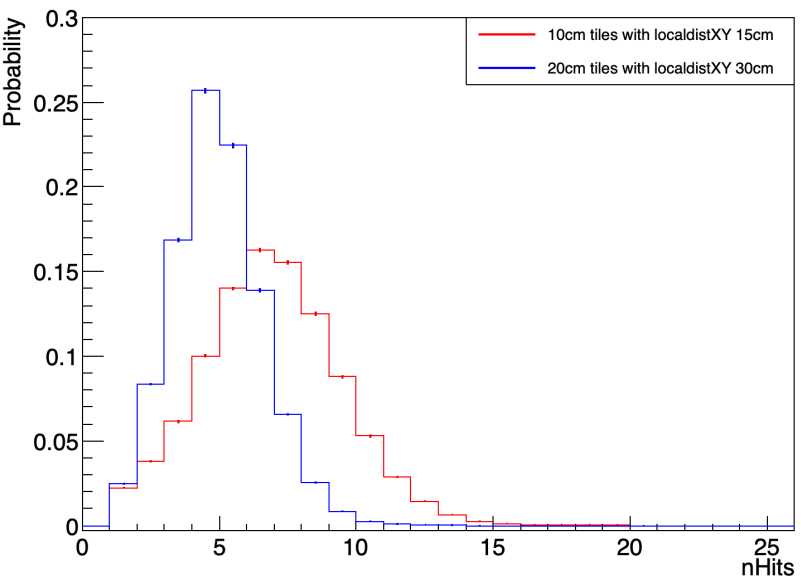
neighbourhood parameter to cluster merged hits [Island clustering]

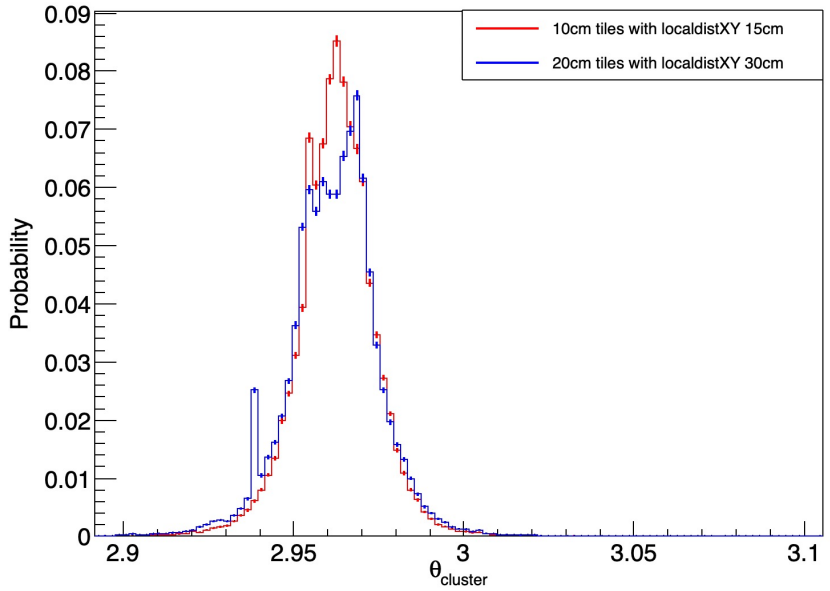
```
static edm4hep::Vector2f localDistXY(const CaloHit
&h1, const CaloHit &h2) {
const auto delta =h1.getLocal() - h2.getLocal();
return {delta.x, delta.y};
}
```

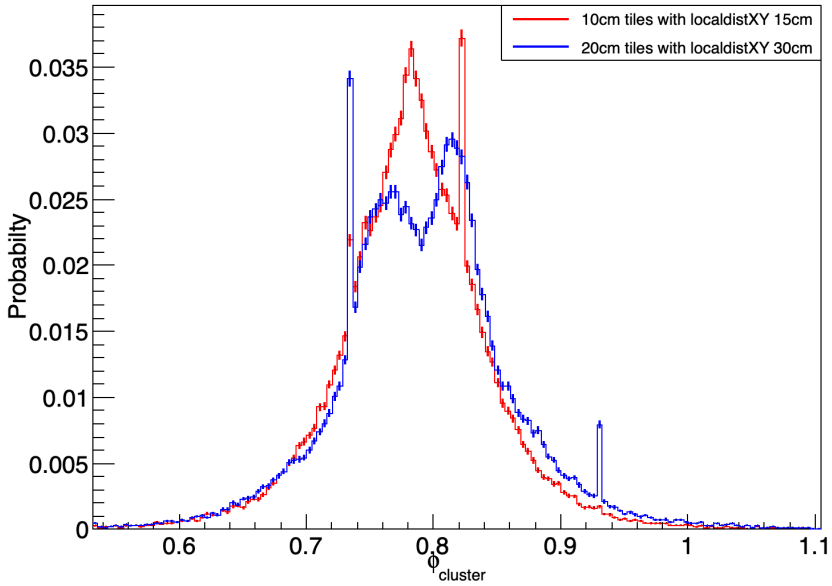


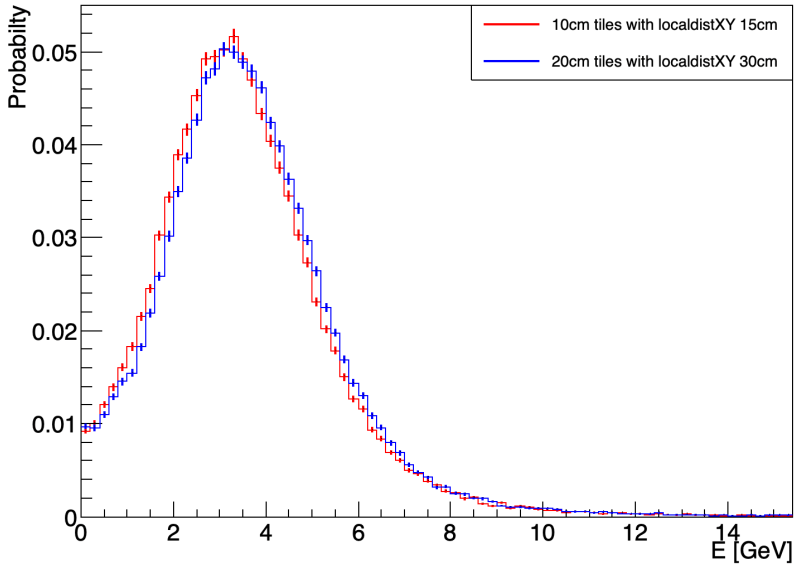
Less split clusters in case of 20cm tiles with localdistXY 30cm

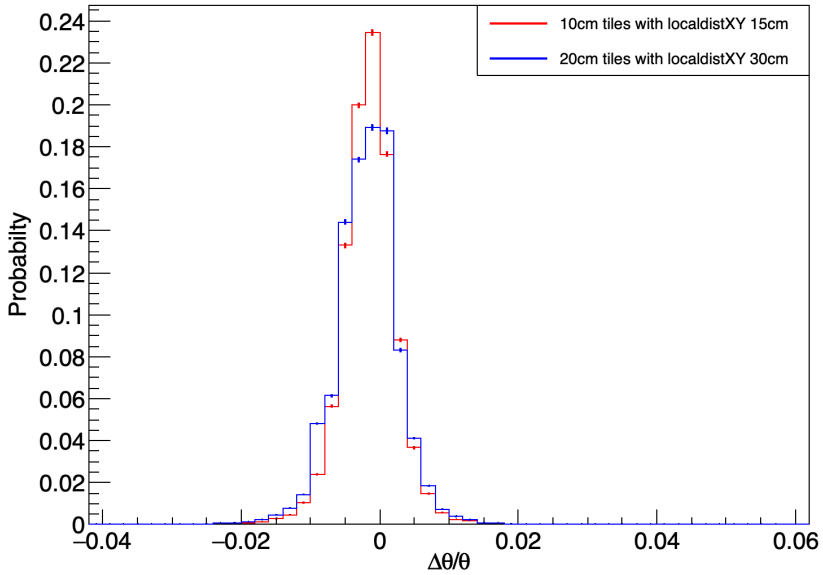
Scaling of the algorithm with segmentation

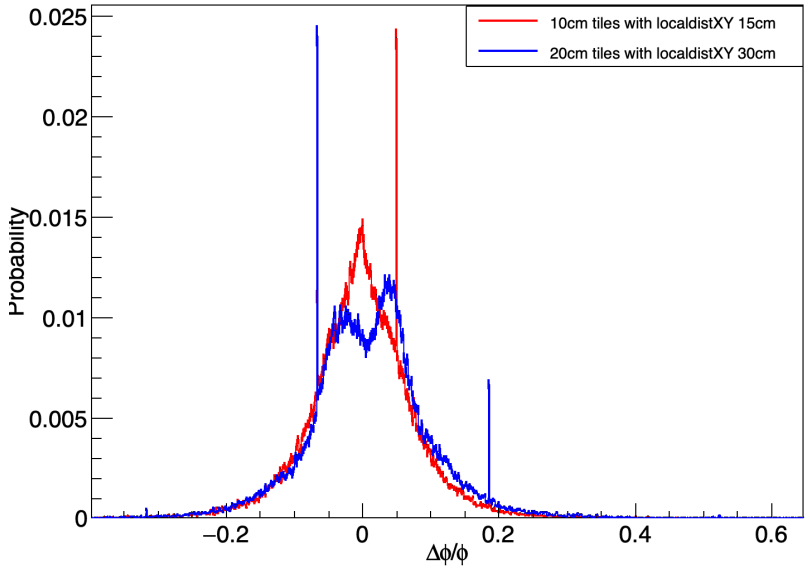




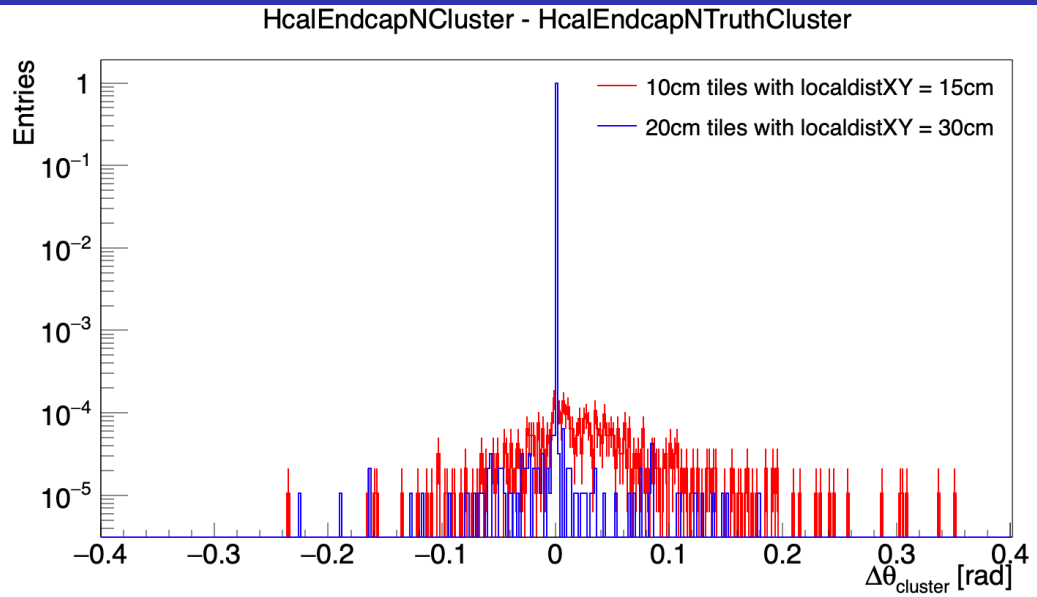


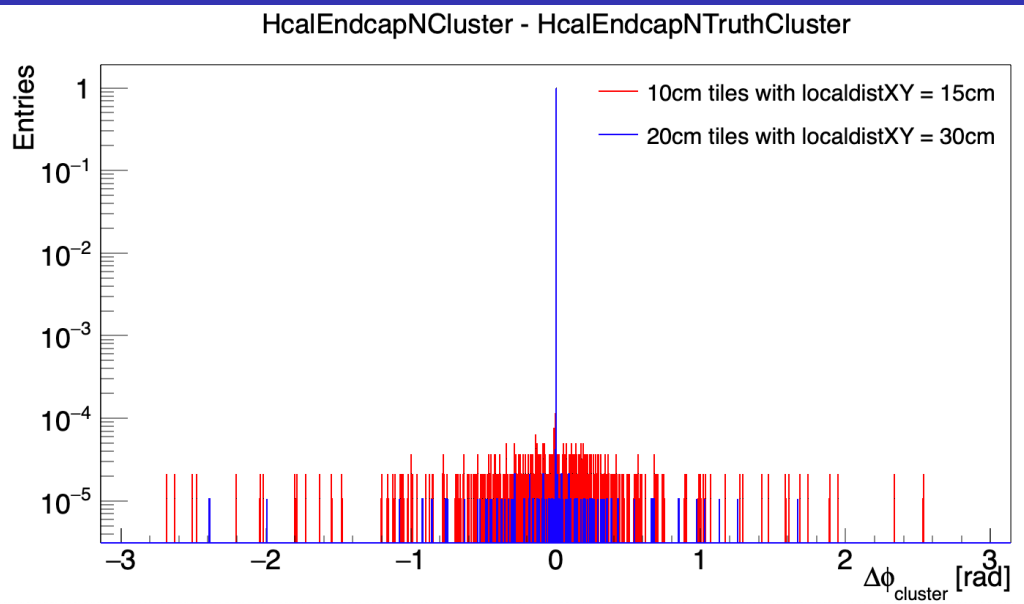


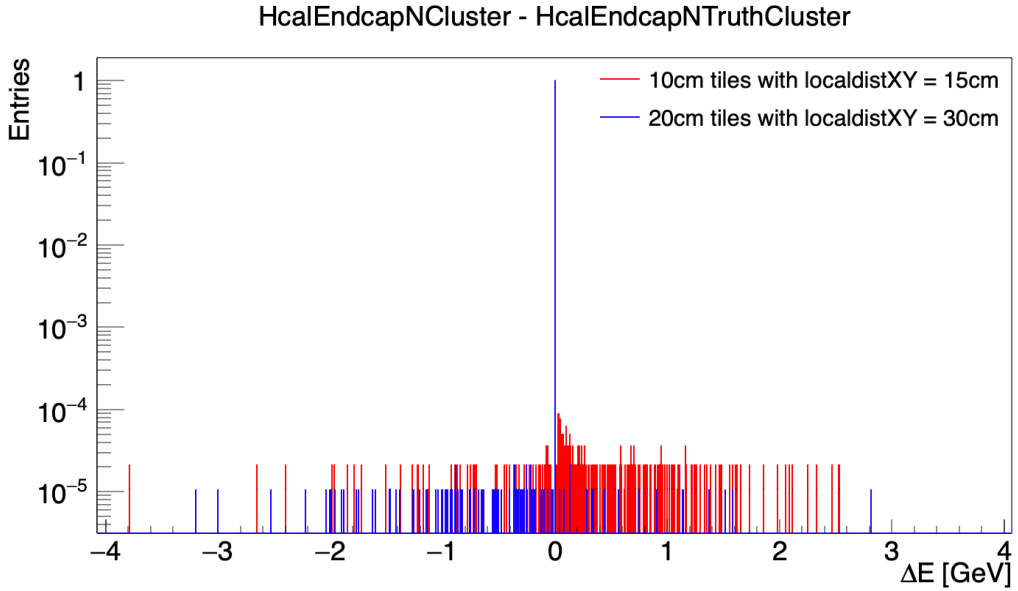


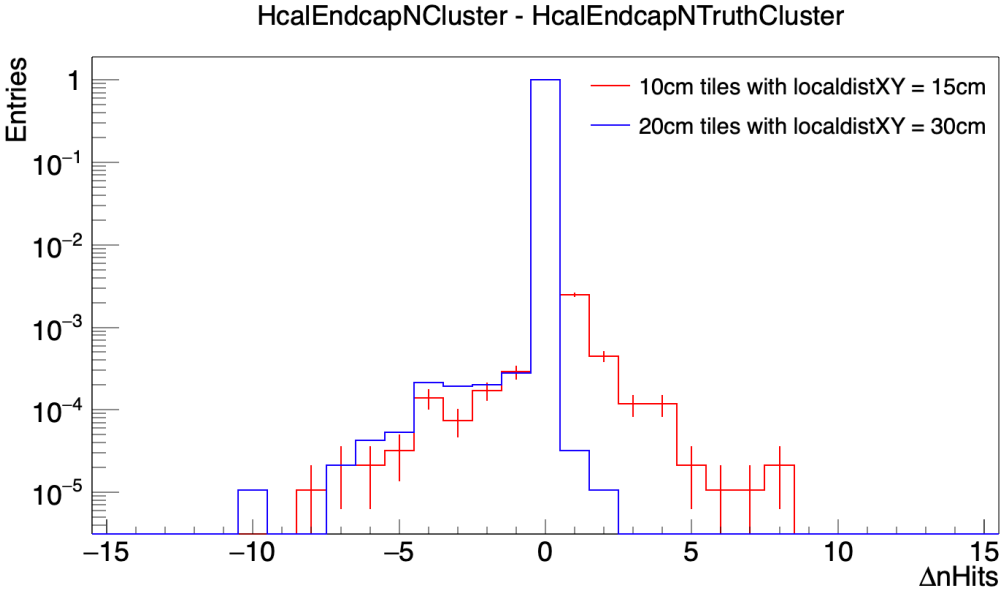


Scaling of the algorithm with segmentation









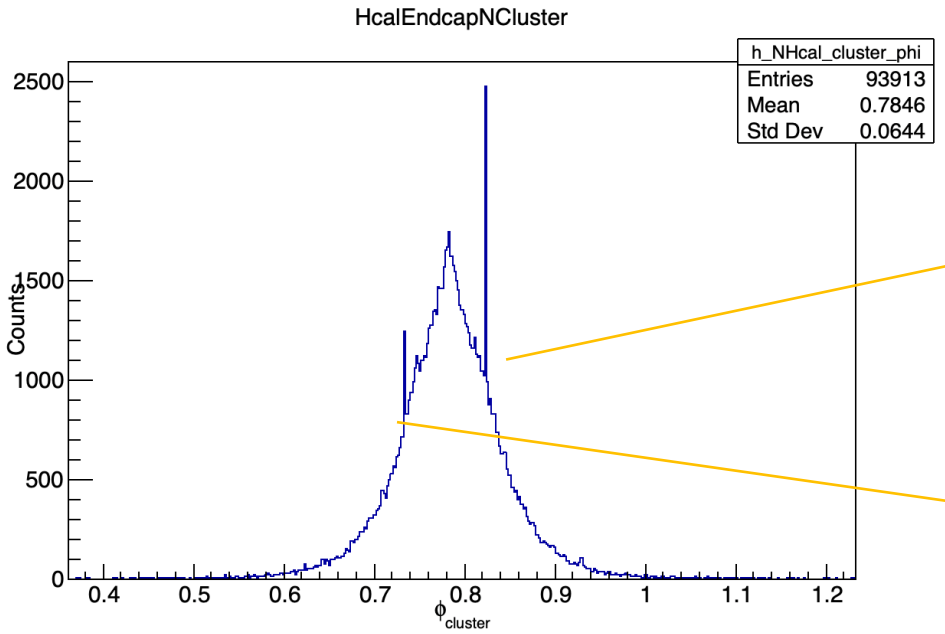
Less discrepancy in case of
20cm tiles with localdistXY 30cm

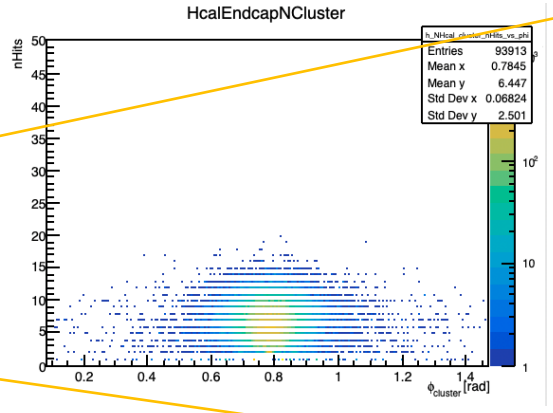
Summary

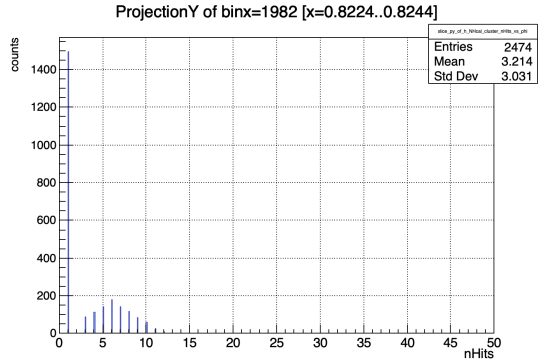
- ❑ > 90 % events had 1 reconstructed cluster.
  - Some events found with number of clusters > 1 and some with no clusters.
- ❑ Truth clusters were more in number (94.18 k) than reco clusters (93.91k) and more dispersed.
- ❑ Sampling fraction might need to be revisited.
  - Calculated based on pion simulations. Not working perfect with neutrons (shifted mean in cluster energy distribution).
- ❑ > 90% truth clusters agree with reco clusters on different observables (θ, φ, nHits, energy, R_{xy})
- ❑ The algorithm scaled well with segmentations.
- ❑ Abrupt spikes on θ, φ distributions of cluster [coming from clusters with nHits = 1]
- ❑ Truth clusters agree more with reco clusters when larger tiles (20cm x 20 cm) were used.

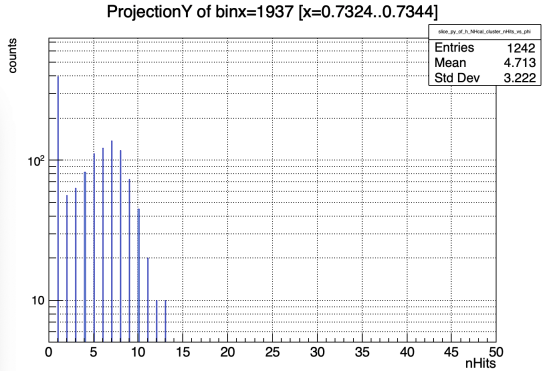
Thank You

Backup

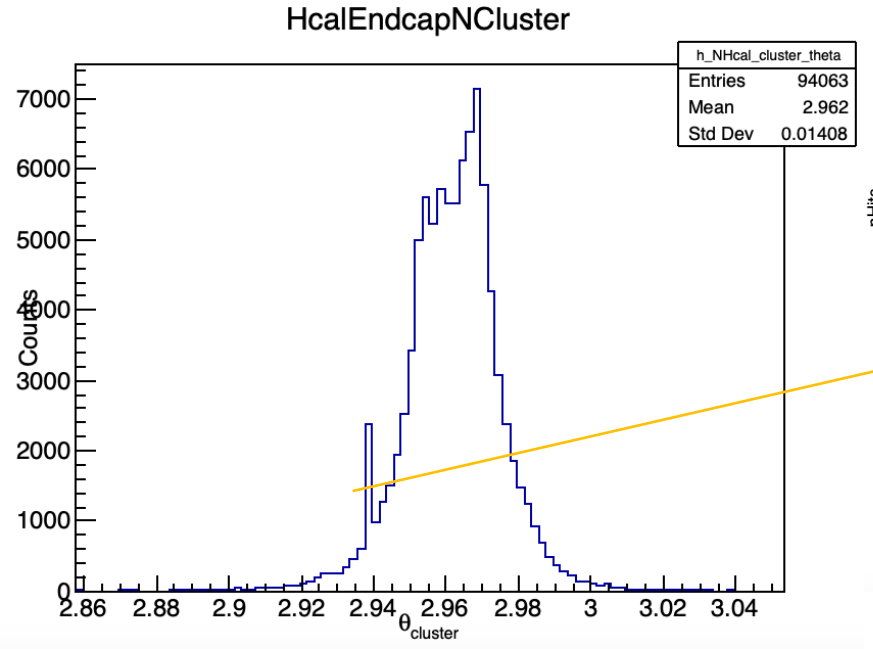

HcalEndcapNCluster
h_NHcal_cluster_phi
Entries 93913
Mean 0.7846
Std Dev 0.0644
Counts
$\phi_{cluster}$

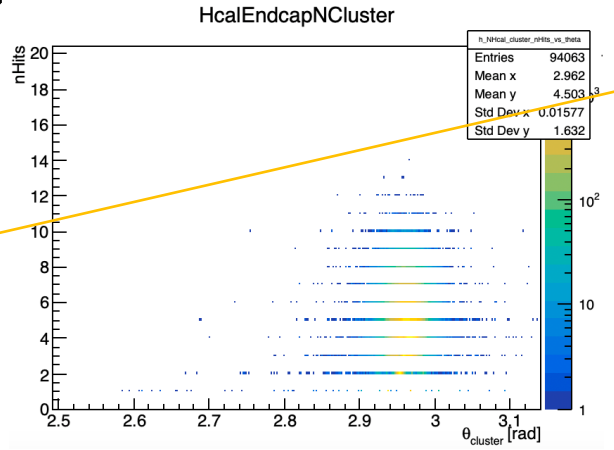

HcalEndcapNCluster
Entries 93913
Mean x 0.7845
Mean y 6.447
Std Dev x 0.06824
Std Dev y 2.501
nHits
$\phi_{cluster}$ [rad]

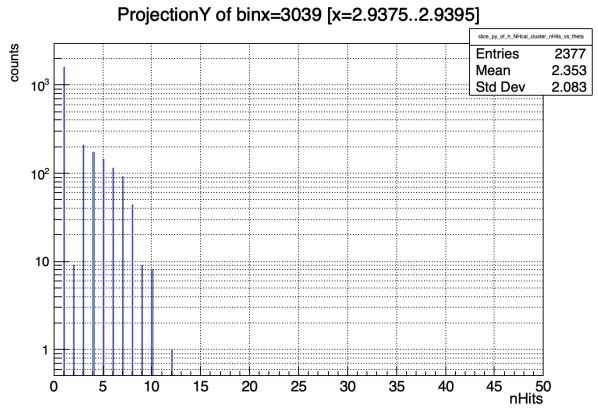

ProjectionY of binx=1982 [x=0.8224..0.8244]
Entries 2474
Mean 3.214
Std Dev 3.031
counts
nHits


ProjectionY of binx=1937 [x=0.7324..0.7344]
Entries 1242
Mean 4.713
Std Dev 3.222
counts
nHits

Backup


HcalEndcapNCluster
h_NHcal_cluster_theta
Entries 94063
Mean 2.962
Std Dev 0.01408
Counts
θcluster


HcalEndcapNCluster
h_NHcal_cluster_nHits_vs_theta
Entries 94063
Mean x 2.962
Mean y 4.503
Std Dev x 0.01577
Std Dev y 1.632
nHits
θcluster [rad]


ProjectionY of binx=3039 [x=2.9375..2.9395]
Entries 2377
Mean 2.353
Std Dev 2.083
counts
nHits

Questions

1. How to optimize logWeightBase parameter? Which observable to compare?
2. Truth clustering might also be erroneous. [cell id of highest energy rec hit within a merged hit is matched to mc hit which then traced back to track based on the 1st Hit contribution there.]

3. Can use ΔR_{xy} vs W^0 to optimize it.

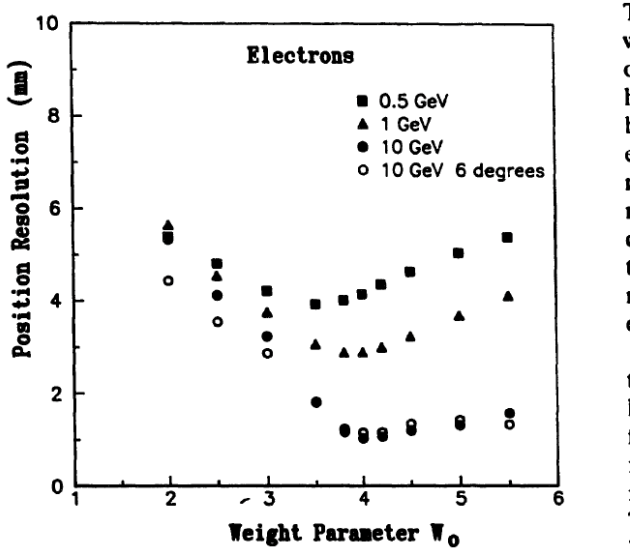


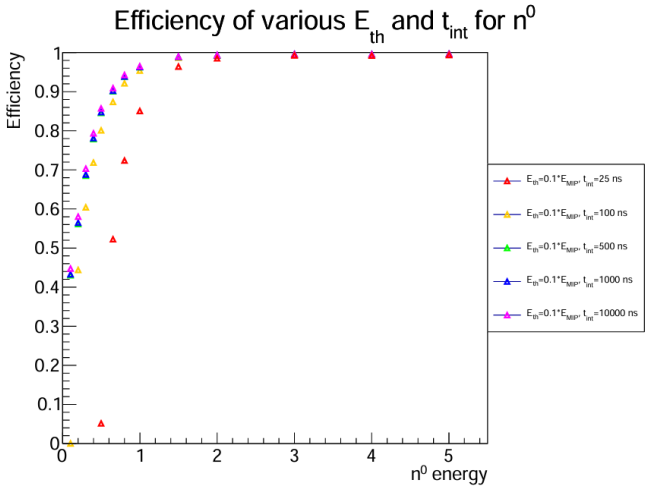
Fig. 3. The dependence of the resolution, σ_x (in millimeters), of the x coordinate determination on the logarithmic weight parameter W_0 used in eq. (5). The results are shown for electrons with normal incidence at incident energies of 0.5, 1, and 10 GeV by the solid squares, triangles, and circles, respectively. Results for 10 GeV electrons at a 6° angle of incidence are shown by the open circles. The resolutions are obtained from Gaussian fits of the distribution of differences between calculated and incident position. The fit uncertainties of the extracted resolutions are smaller than the size of the points.

```
"HcalEndcapNRecHits", {"HcalEndcapNRawHits"}, {"HcalEndcapNRecHits"},
{
  .capADC = HcalEndcapN_capADC,
  .dyRangeADC = HcalEndcapN_dyRangeADC,
  .pedMeanADC = HcalEndcapN_pedMeanADC,
  .pedSigmaADC = HcalEndcapN_pedSigmaADC,
  .resolutionTDC = HcalEndcapN_resolutionTDC,
  .thresholdFactor = 0.0,
  .thresholdValue = 41.0, // 0.1875 MeV deposition out of 200 MeV max (per layer)
  .sampFrac = 0.0095, // from latest study - implement at level of reco hits rath
  .readout = "HcalEndcapNHits",
},
app   // TODO: Remove me once fixed
:
```

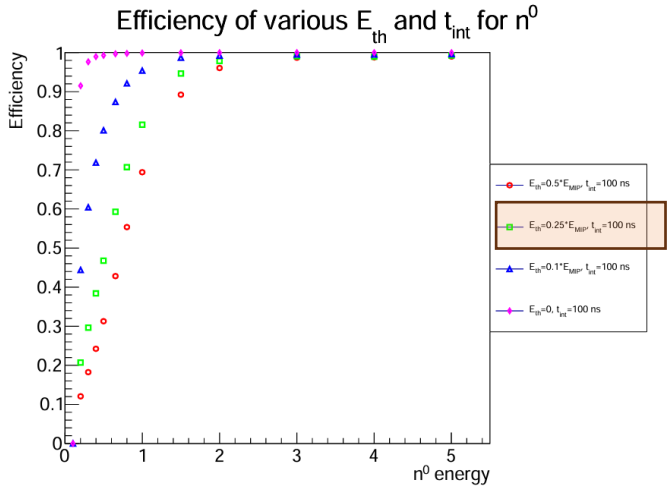
How?

Questions

Integration time dependence



Threshold dependence

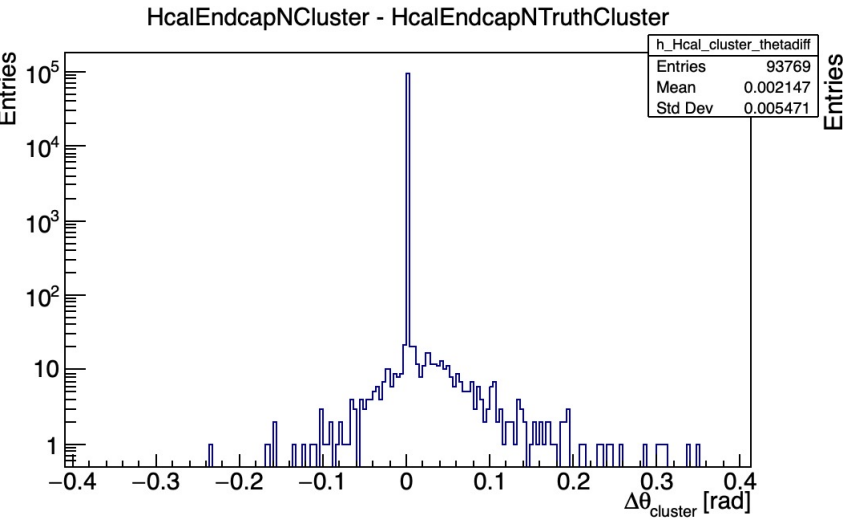


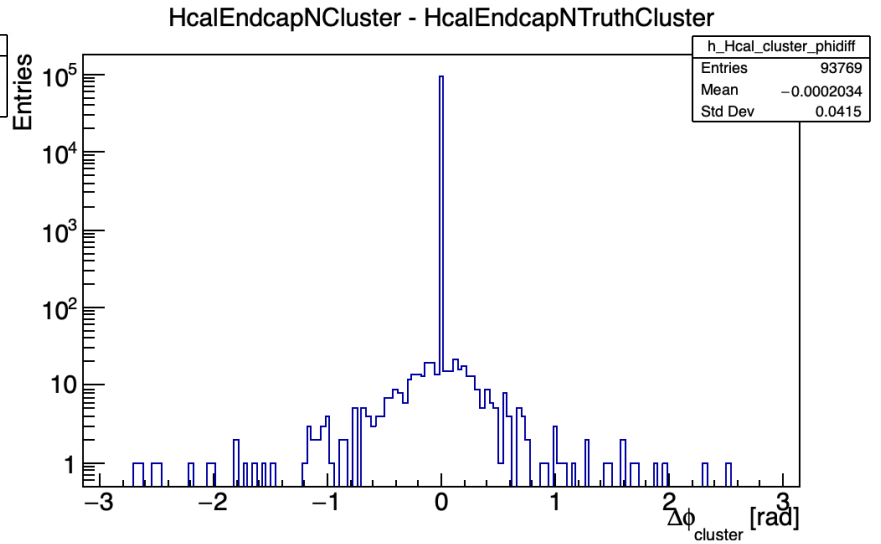
Sam Corey, OSU

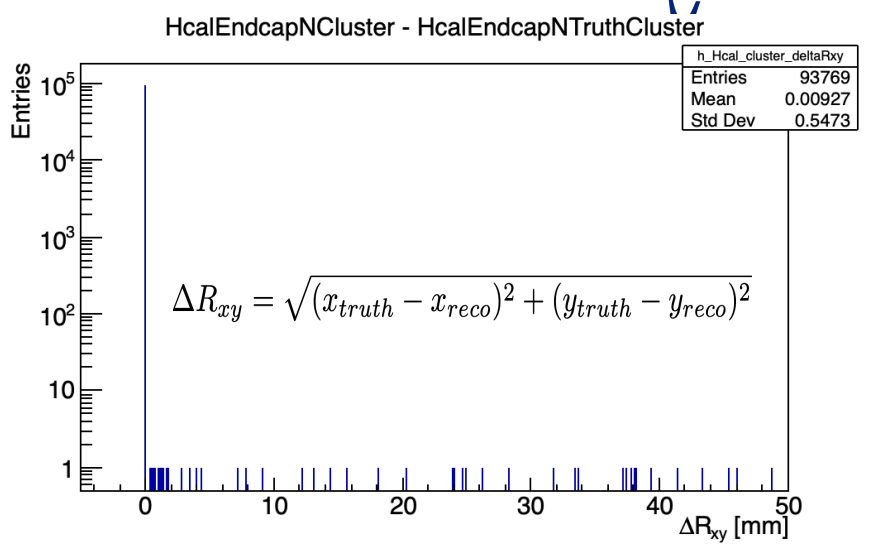
- Efficiency of requiring a hit with a sum of hit contributions energy integrated up to t_{int} and passing a threshold E_{th}, $t_0 = 0$ (t_0 from first hit - see backup)
- Checked with simulation only - no digitization
- E_{MIP} is $0.75\,\mathrm{MeV}$ per layer
- E_{th} has the biggest impact
- $100\,\mathrm{ns}$ is good enough, but lower energy neutrons may need longer times
- 60% efficiency for $E = 300\,\mathrm{MeV}$ neutrons $E_{th} = 0.1 \times E_{MIP} = 75\,\mathrm{keV}$ and $100\,\mathrm{ns}$

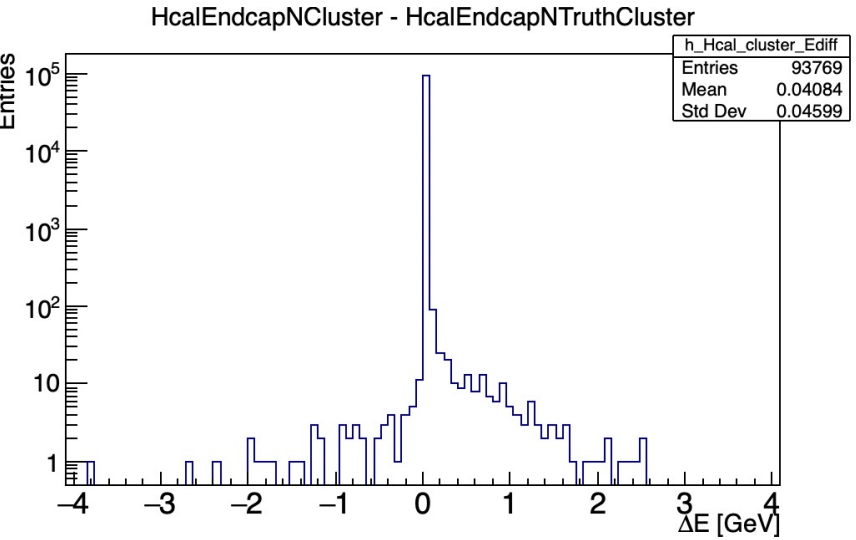
```
app->Add(new JOmniFactoryGeneratorT<CalorimeterHitDigi_fac
  "HcalEndcapNRawHits", {"HcalEndcapNHits"}, {"HcalEndcapN
  {
    .tRes = 0.0 * dd4hep::ns,
    .capADC = HcalEndcapN_capADC,
    .capTime = 100, // given in ns, 4 samples in HGCROC
    .dyRangeADC = HcalEndcapN_dyRangeADC,
    .pedMeanADC = HcalEndcapN_pedMeanADC,
    .pedSigmaADC = HcalEndcapN_pedSigmaADC,
    .resolutionTDC = HcalEndcapN_resolutionTDC,
    .corrMeanScale = 1.0,
    .readout = "HcalEndcapNHits",
  },
  app   // TODO: Remove me once fixed
));
app->Add(new JOmniFactoryGeneratorT<CalorimeterHitReco_fac
  "HcalEndcapNRecHits", {"HcalEndcapNRawHits"}, {"HcalEndc
  {
    .capADC = HcalEndcapN_capADC,
    .dyRangeADC = HcalEndcapN_dyRangeADC,
    .pedMeanADC = HcalEndcapN_pedMeanADC,
    .pedSigmaADC = HcalEndcapN_pedSigmaADC,
    .resolutionTDC = HcalEndcapN_resolutionTDC,
    .thresholdFactor = 0.0,
    .thresholdValue = 41.0, // 0.1875 MeV deposition out o
    .sampFrac = 0.0095, // from latest study - implement a
    .readout = "HcalEndcapNHits",
  },
```

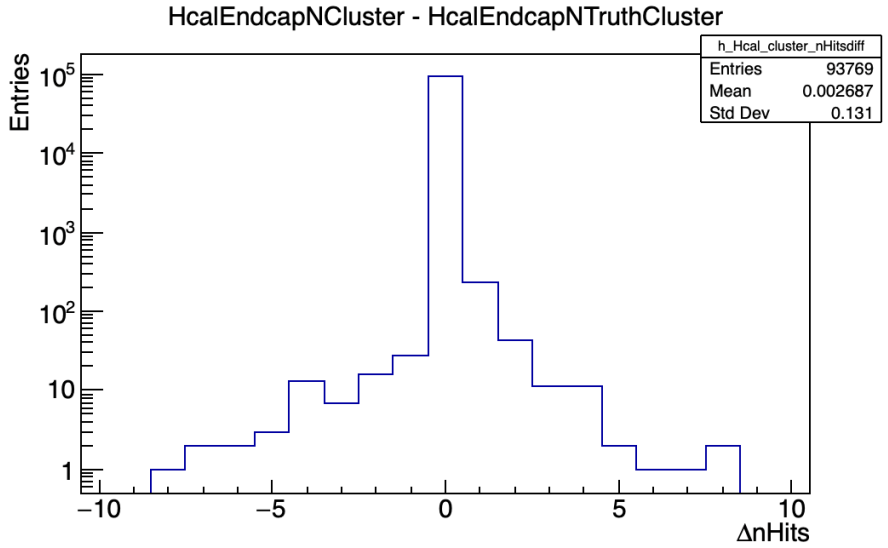
Comparison between Truth and Reco clusters











Highest energy truth and reco clusters are compared for an Event

$$W_i = W_0 + \ln\left(\frac{E_i}{E_T}\right)$$

$$\Rightarrow \ln\left(\frac{E_i}{E_T}\right) = W_i - W_0$$

$$\Rightarrow E_i = E_T e^{-(W_0 - W_i)}$$