ePIC HCal Update

ePIC Calorimetry Meeting

March 1st, 2023

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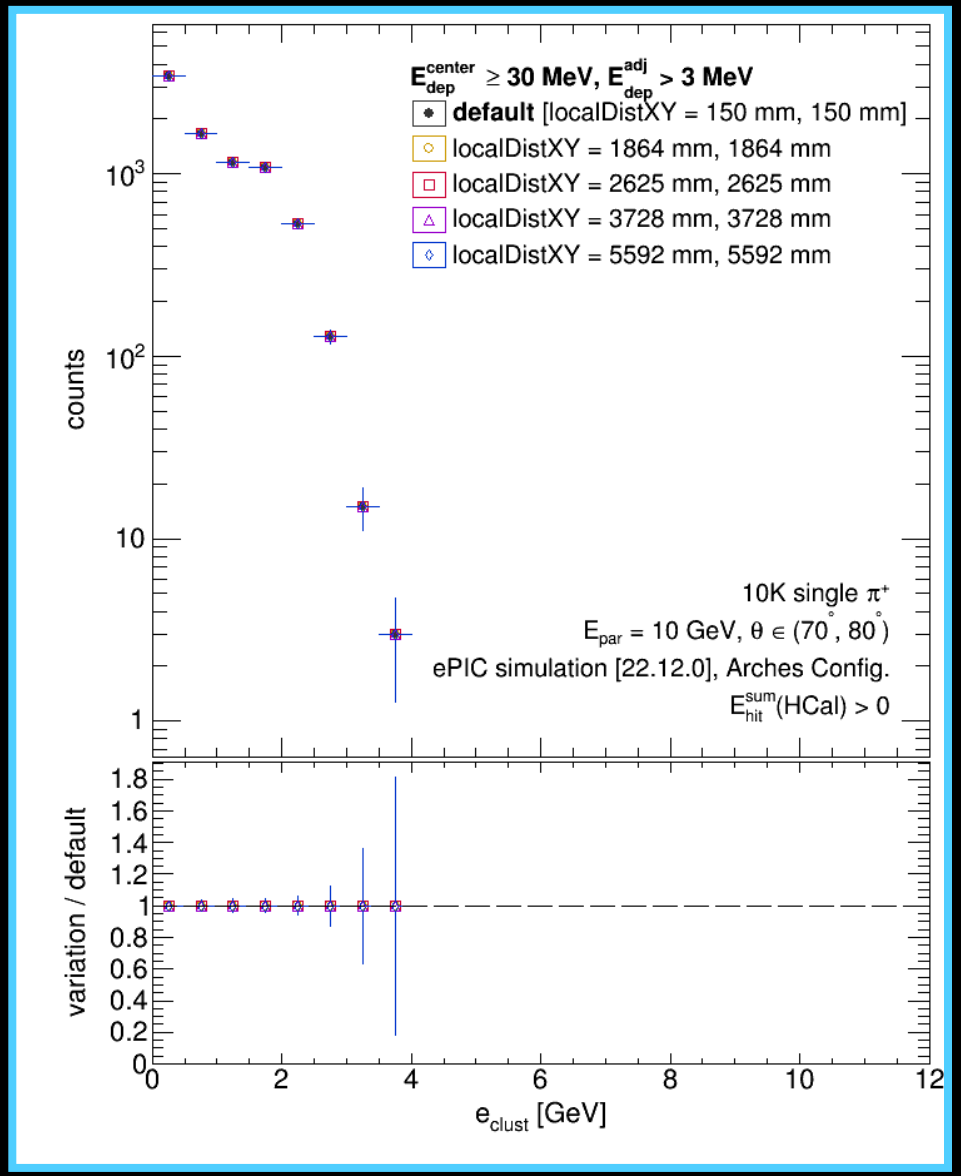
Previous Update

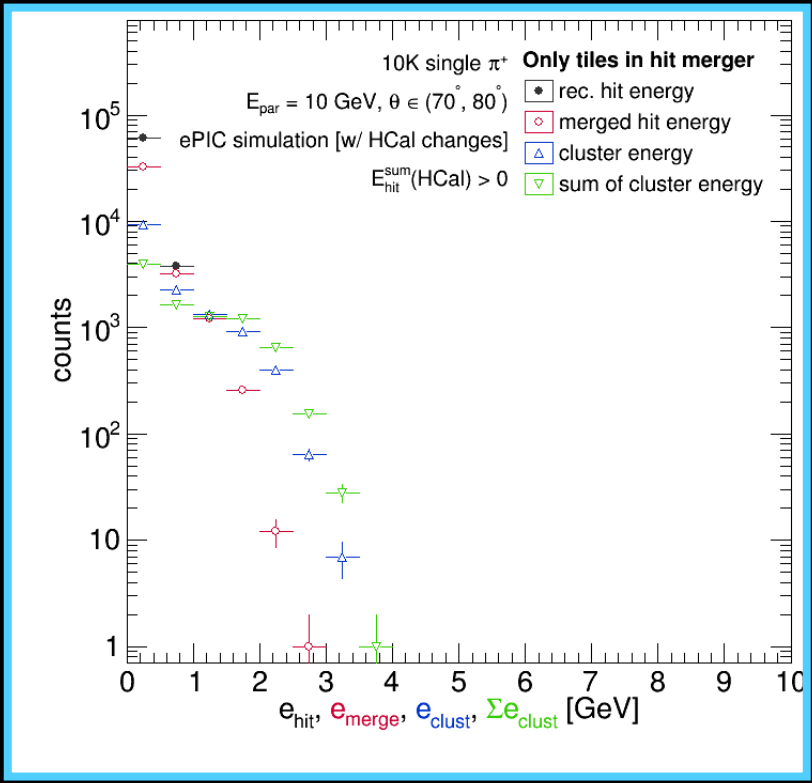
- In last update, was looking into BHCal clustering
  - Clustering didn't seem to be working
  - e.g. varying distance parameters didn't do anything
  - (previous slides in backup)

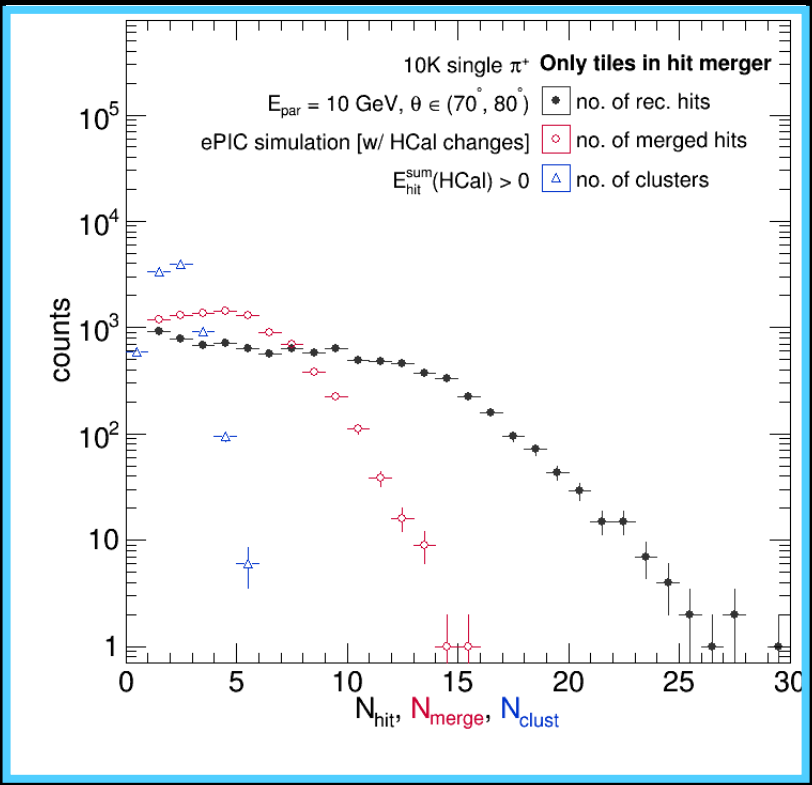
☞ **Proved to be issue with readout structure & hit merging**

- **Shown:** reconstructed cluster energy ca. February 1st
  - 10 GeV single π^+
  - Parameters in backup



Changes to Readout & Hit Merging





Changes to BHCal Readout [PR merged]

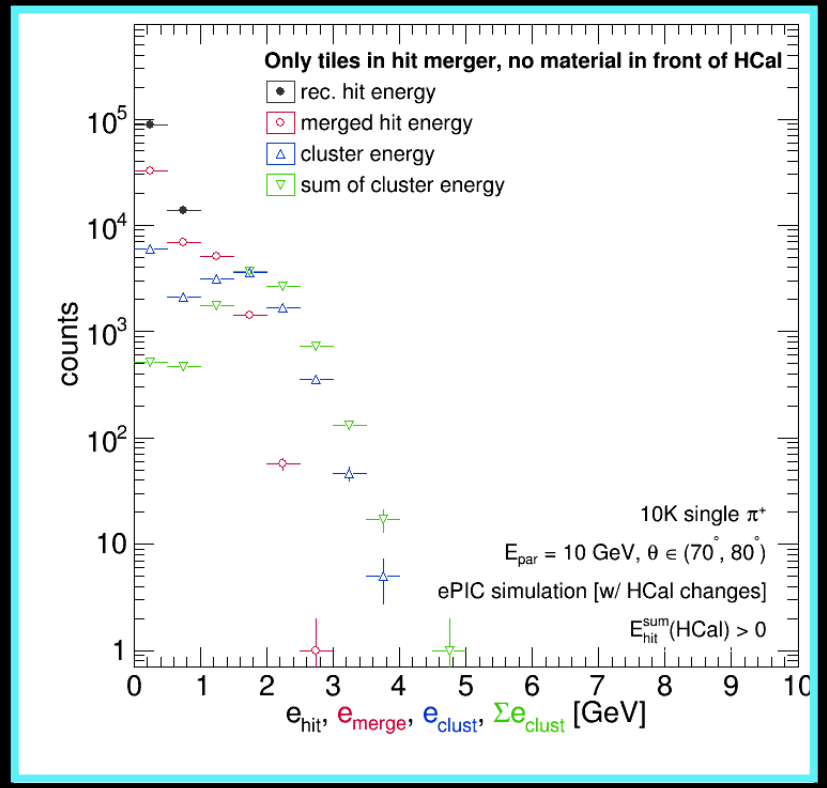
- `<id>system:8,sector:5,tower:6,tile:3</id>` → `<id>system:8,barrel:3,sector:6,tower:6,tile:9</id>`
- `(+ changes to volume IDs in *geo.cpp)`

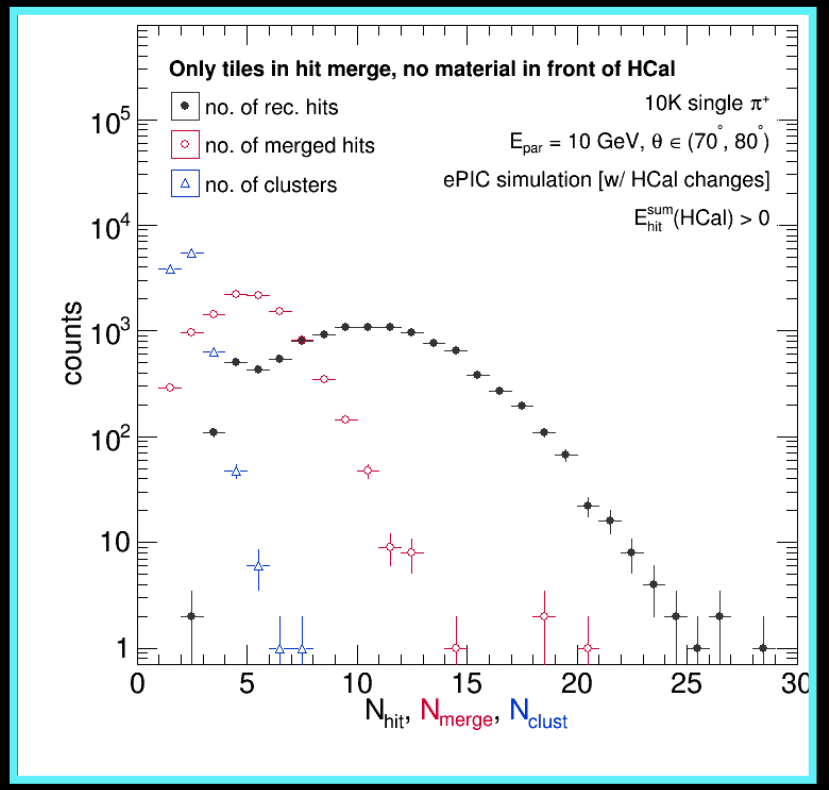
Changes to BHCal Hit Merging [PR merged]

- `u_fields = {“tower”,”tile”} → {“tile”}`
- `u_refs = {1, 0} → {0}`

- Impact of readout & hit merging changes
  - **Left:** hit vs. cluster energy
  - **Right:** no. of hits vs. no. of clusters
- Varying u_fields shown in backup

Removing Material in Front of BHCal





- Energy was still off…
  - How do we end up w/ at most 4 GeV for 10 GeV π^+?
  - ∴ Checked energy/multiplicity distributions without material in front of BHCal

- **Shown:** energy (left) and multiplicity (right) w/ only BHCal
  - Energy still way off!

☞ Turned out to be issue w/ digitization parameters

Changes to Digitization

Changes to Digitization

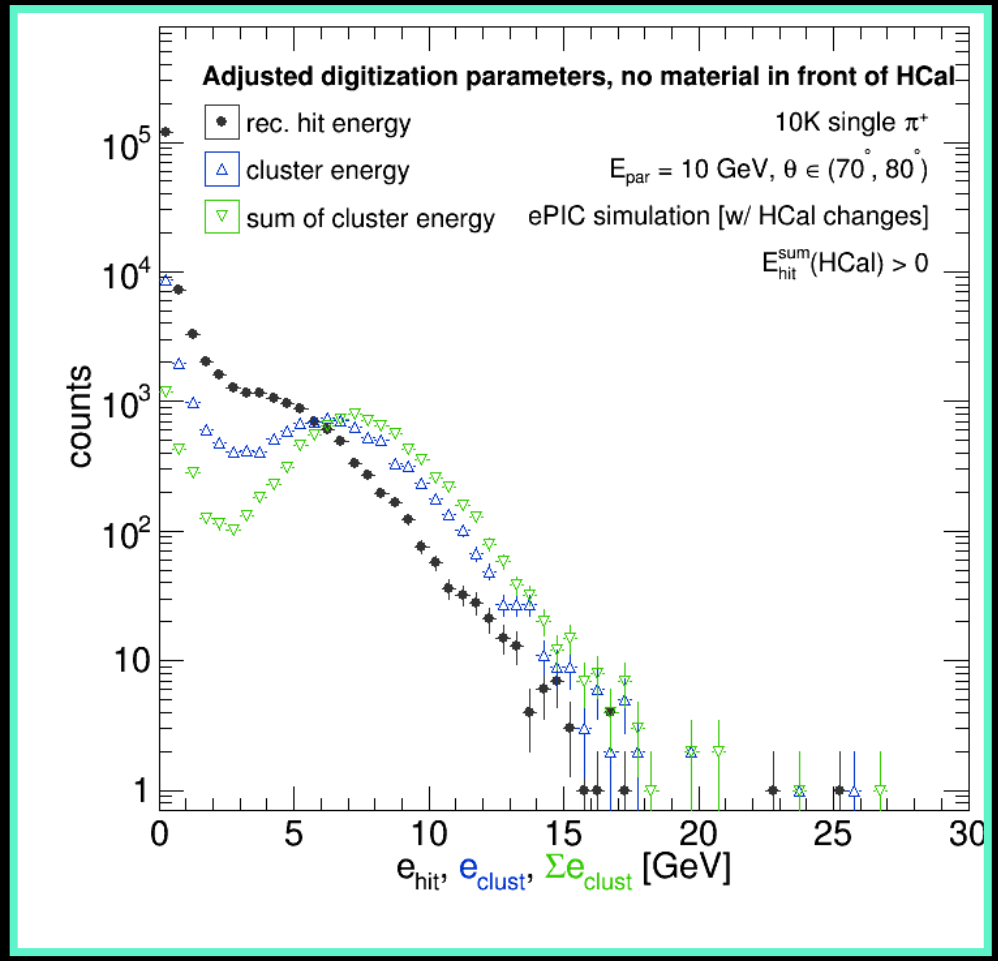
- m_capADC = 256 → 65536
- m_dyRangeADC = 50 MeV → 1.0 GeV
- m_resolutionTDC = 1.0 ns → 1.0 ps
- u_fields = {} → {“tile”}
- u_refs = {} → {0}
- m_geoSvcName = “ActsGeometryProvider” → “geoServiceName”
- m_readout = “” → “HcalBarrelHits”
- (+ relevant changes to reco. hit parameters)

Changes to Clustering

- m_input_tag = “HcalBarrelmergedHits” → “HcalBarrelRecHits”

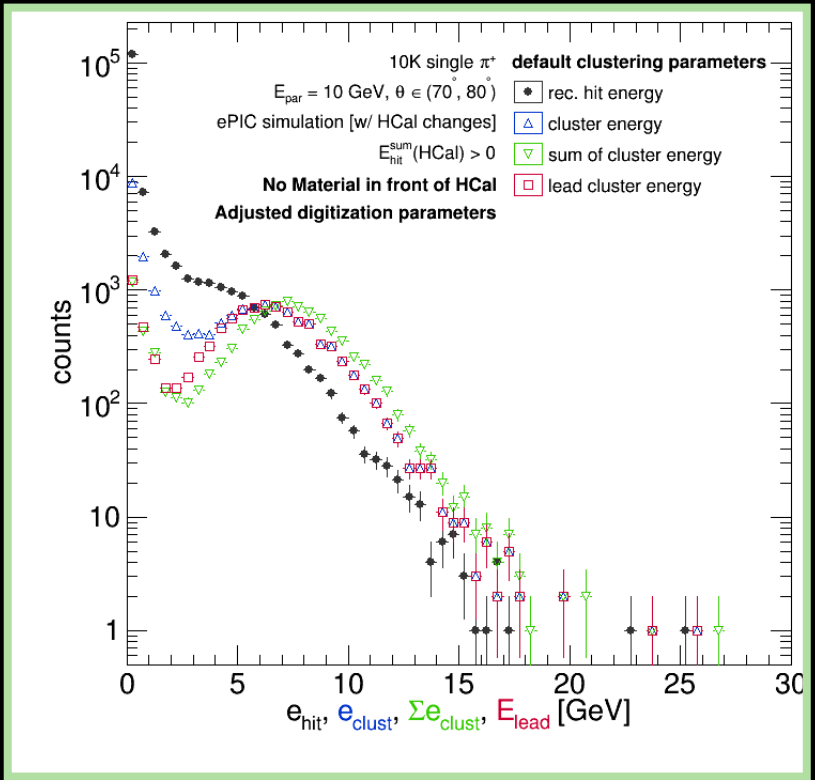
Changes to HCal.cc

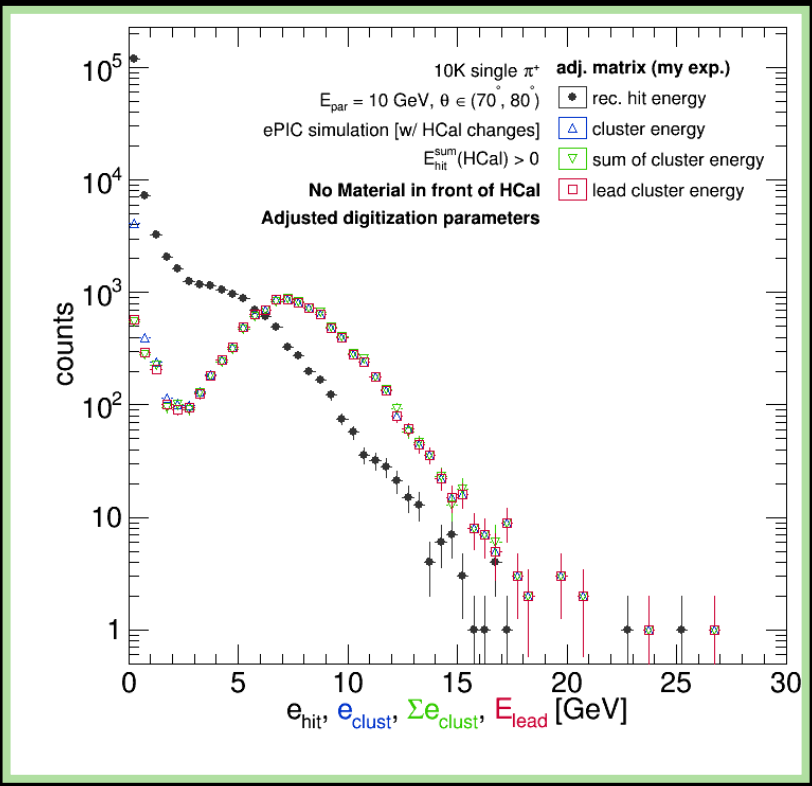
- comment out adding merged hits factory (line 48)



- **Shown:** impact of digitization changes on energy
  - Multiplicity in backup

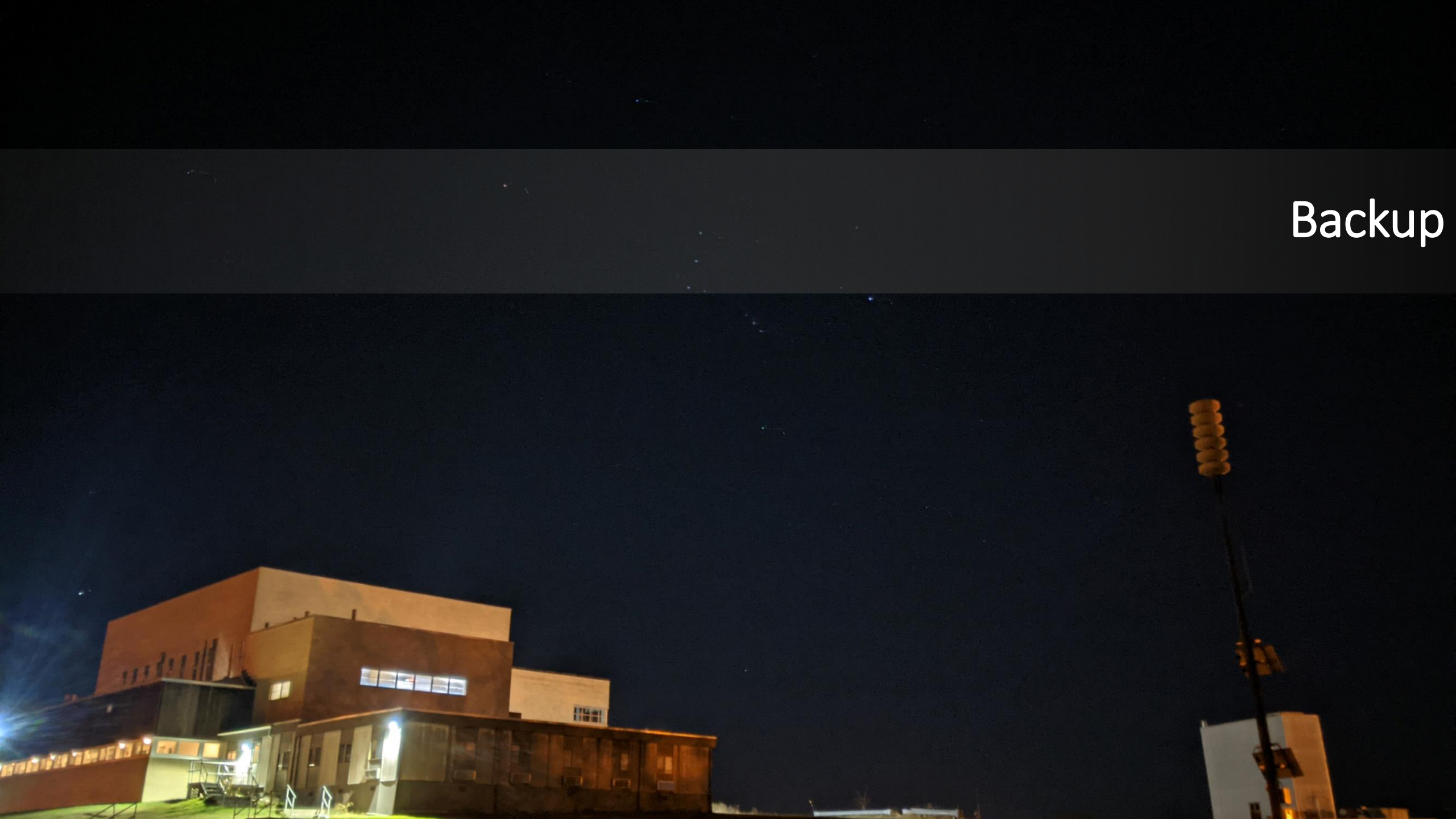
Tuning Clustering





- After readout + digitization changes, next step is to tune clustering
  - Default parameters not optimized for BHCal
  - ☞ Based on distance between hits & are too small
- Dmitry implemented method to cluster based on Cell ID rather than distance
  - **Left:** hit vs. cluster energy w/ default clustering parameters
  - **Right:** same but w/ clustering based on Cell ID
    - › Adjacency Matrix in backup

Backup



Backup | simulation parameters

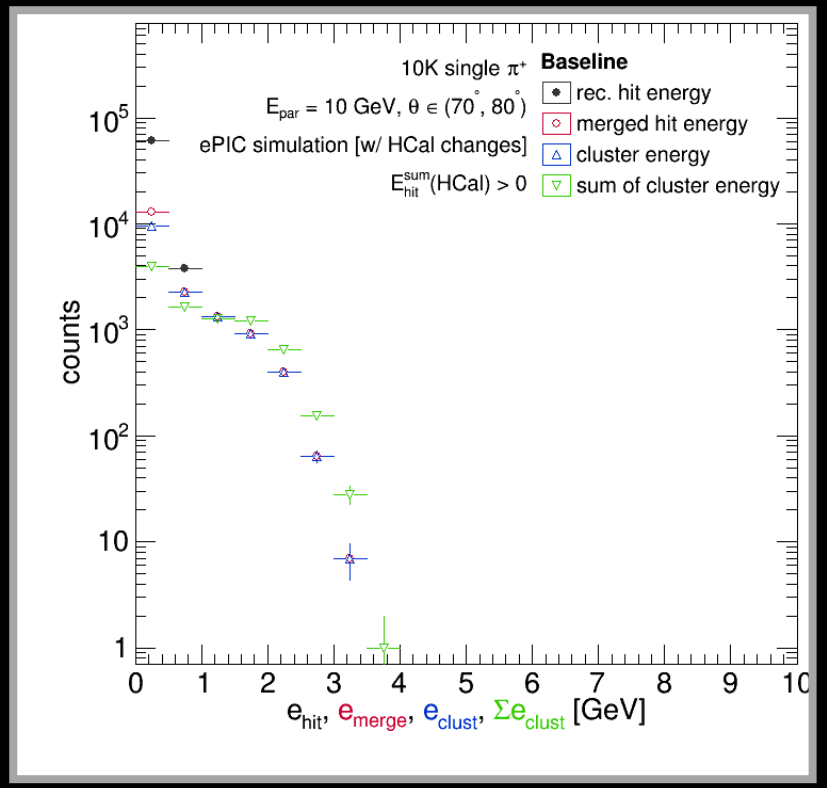
Simulation Parameters

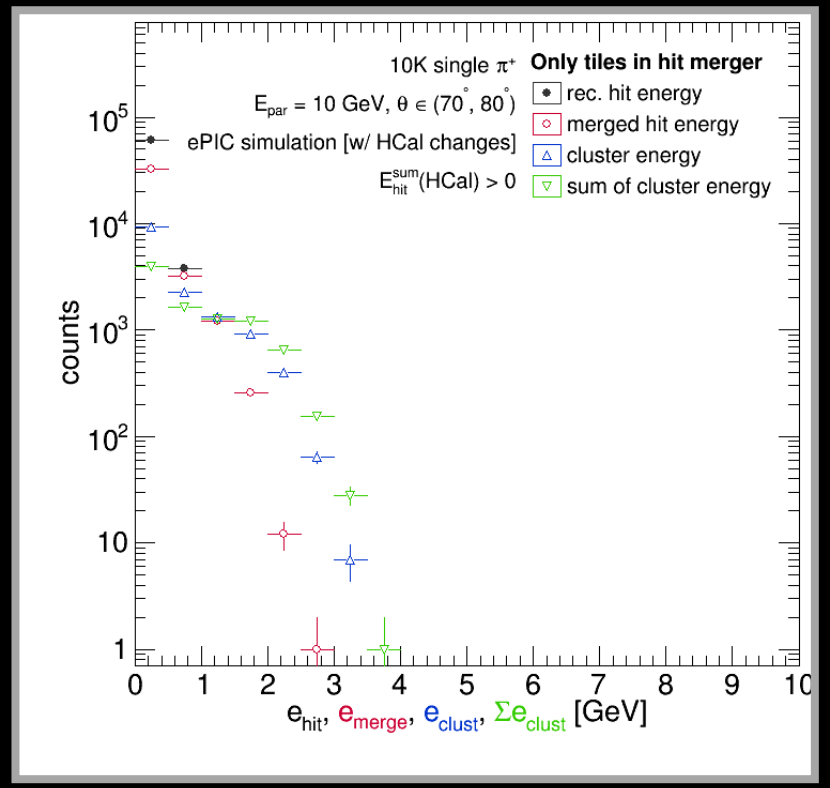
- gun.energy = 2*GeV, 5*GeV, 10*GeV
- gun.particle = "pi+"
- gun.distribution = "cos(theta)"
- gun.thetaMin = 70*degree [$\eta \sim 0.35$]
- gun.thetaMax = 80*degree [$\eta \sim 0.18$]
- **22.12.0 Geometry [Arches] + changes described**

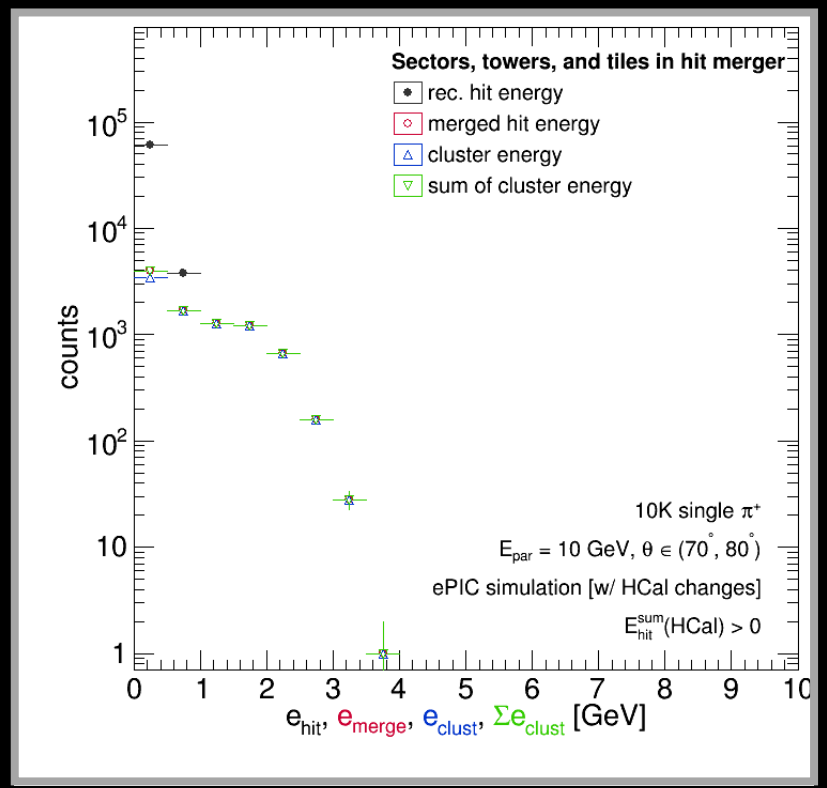
Reconstruction

- EICRecon

Backup | varying u_fields in hit merging (energy)

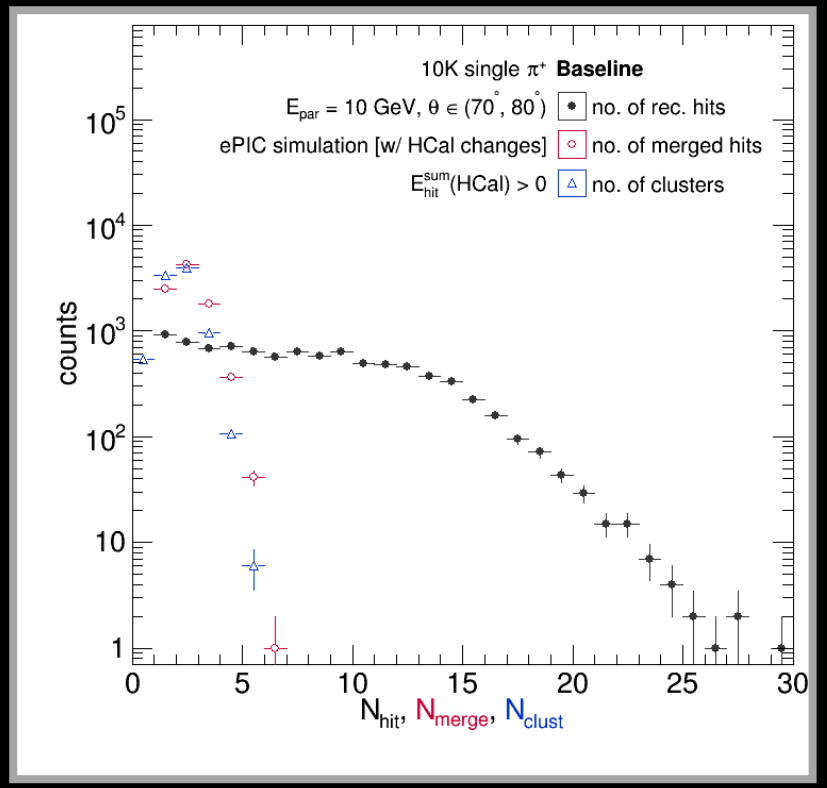


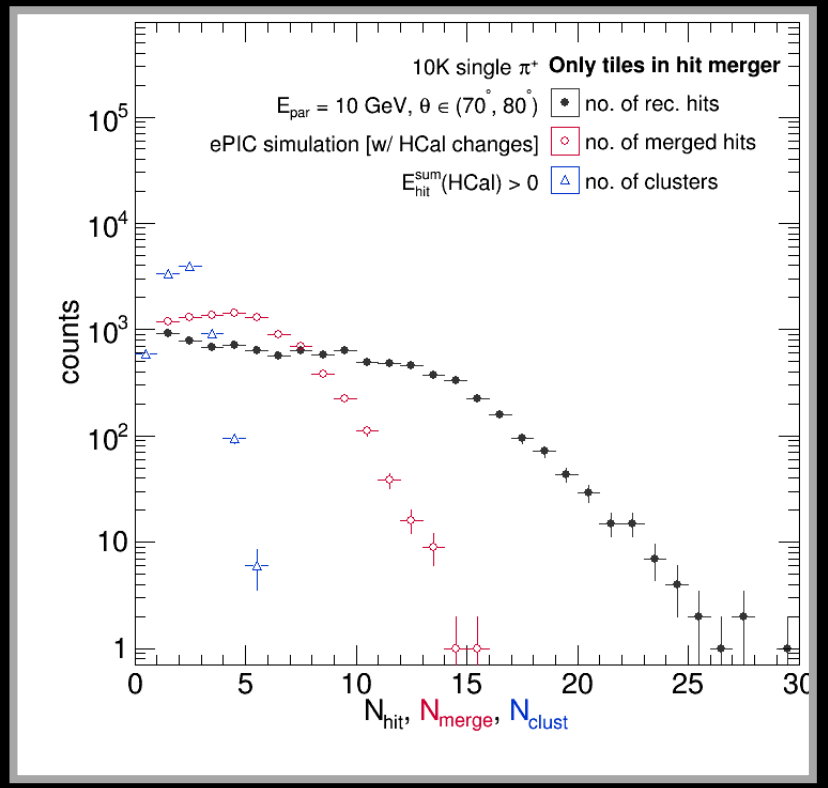


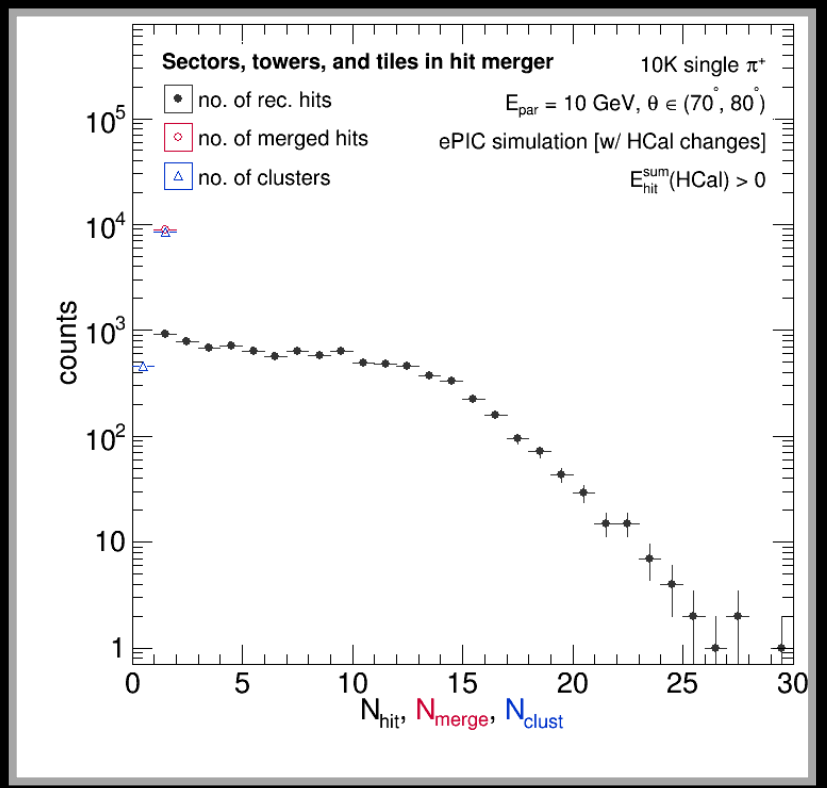


- Impact of varying hit merging fields on energy
  - **Left:** merging tiles and towers
  - **Center:** merging only tiles
  - **Right:** merging tiles, towers, and sectors
- **Note:** this is w/ changes to BHCal readout

Backup | varying u_fields in hit merging (multiplicity)







- Impact of varying hit merging fields on energy
  - **Left:** merging tiles and towers
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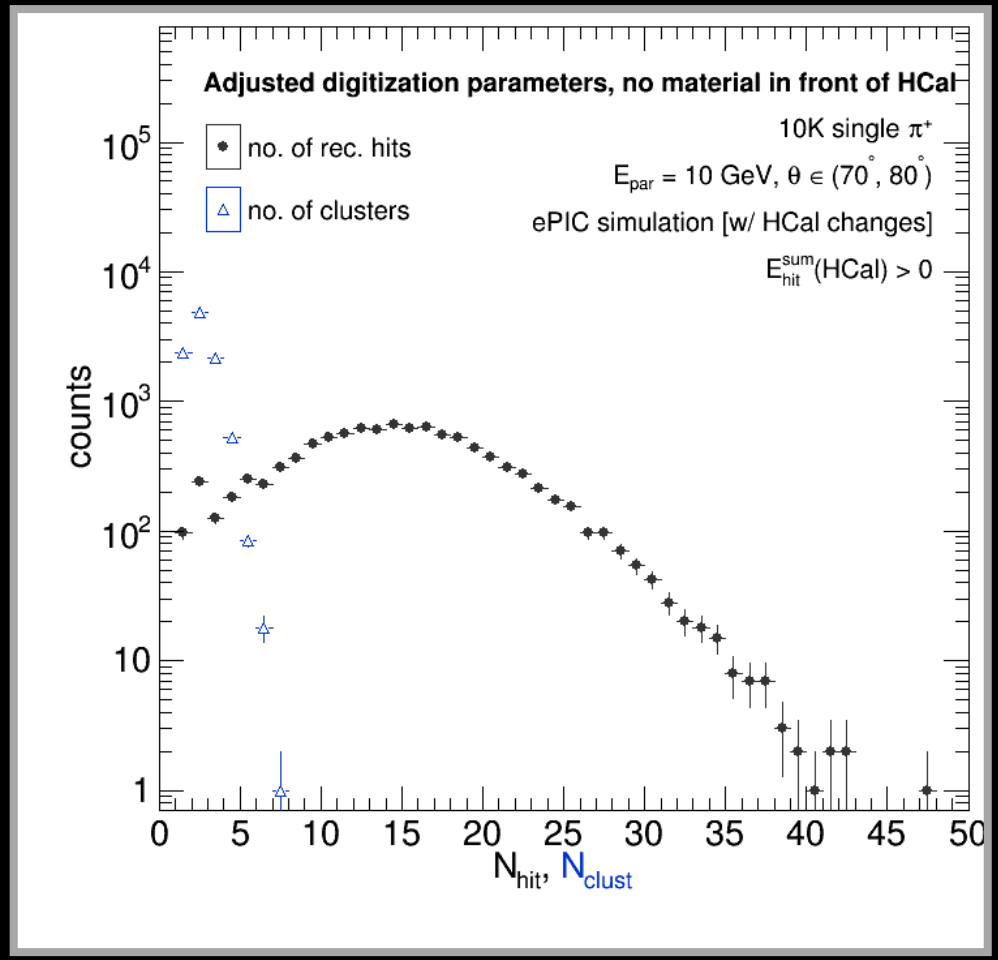
  - **Right:** merging tiles, towers, and sectors
- **Note:** this is w/ changes to BHCal readout

Backup | multiplicity after digitization changes

- **Shown:** impact of digitization changes on hit/cluster multiplicity



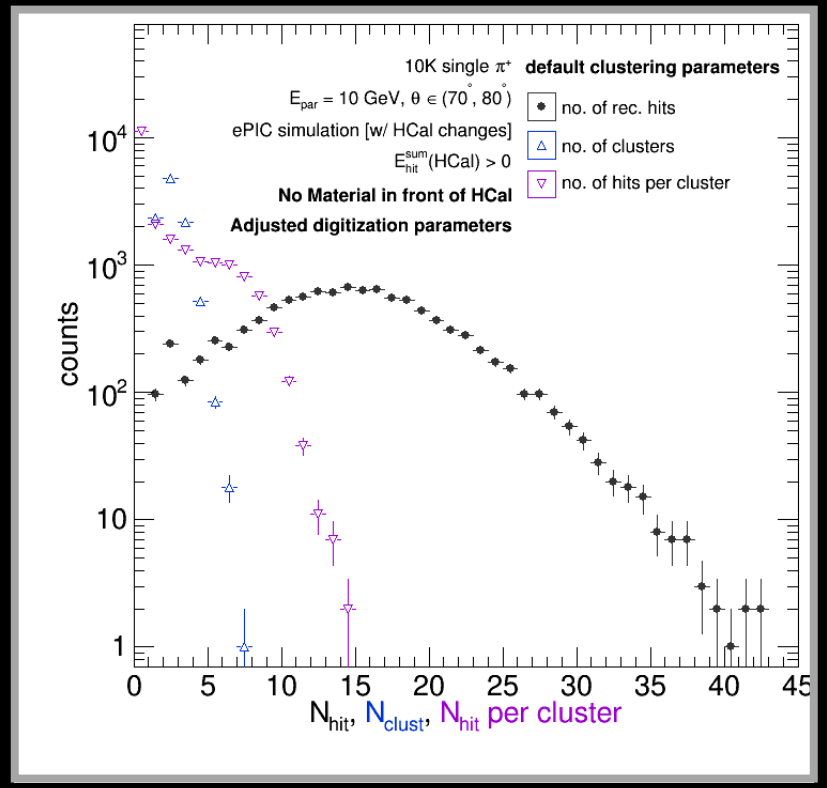
Backup | adjacency matrix expression

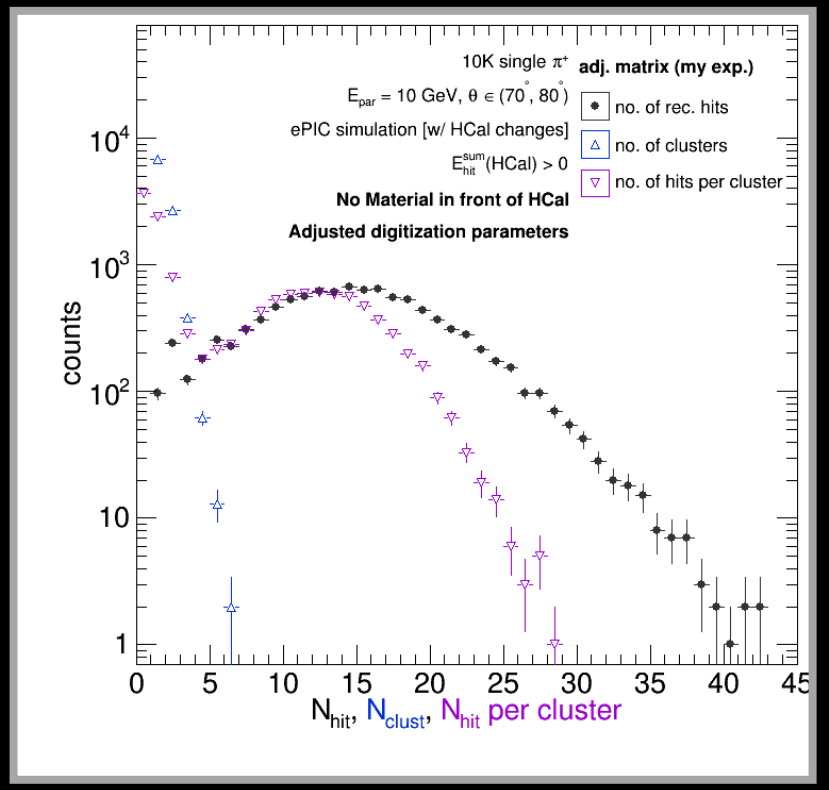
```
(
  ((|s_1-s_2|==0) && (|t_1-t_2|==1)) == 1) +
  ((|s_1-s_2|==0) && (|(t_1%24)-(t_2%24)|==0)) == 1) +
  ((|s_1-s_2|==1) && (|(t_1%24)-(t_2%24)|==0)) == 1) +
  ((|(s_1%31)-(s_2%31)|==0) && (|(t_1%24)-(t_2%24)|==0)) == 1)
) == 1
```

- **Explanation**
  i. 1st term checks for adjacency in eta
  ii. 2nd term checks for adjacency in phi in a sector
  iii. 3rd term checks for adjacency in phi across neighboring sectors
  iv. 4th term checks for adjacency in phi across wraparound

- **Note:** using shorthand
  - `|*| = abs(*)`
  - `(x%y) = fmod(x, y)`
  - `s_i = sector_i`
  - `t_i = tower_i`

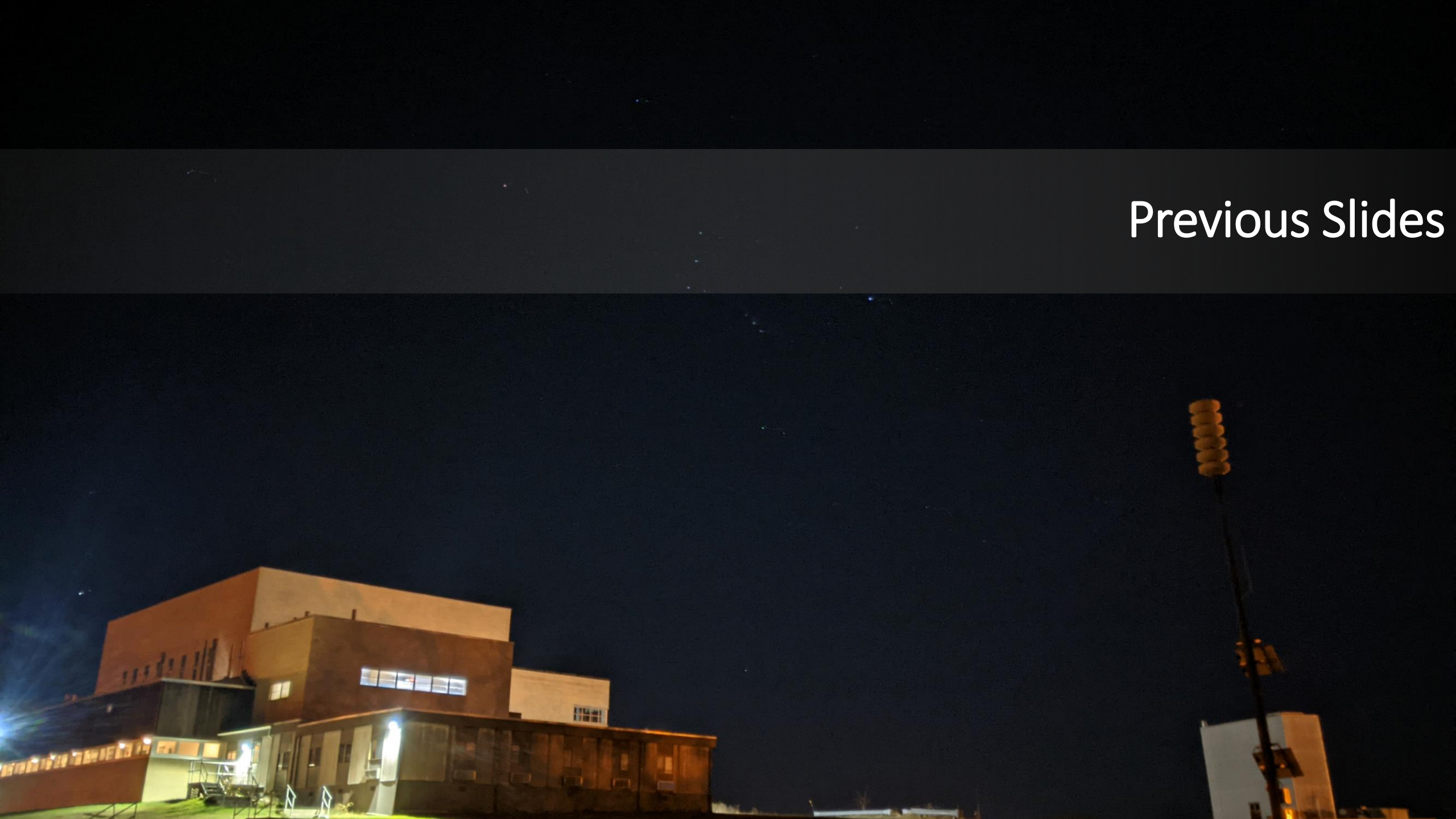
Backup | clustering and multiplicity





- Impact of clustering parameters on multiplicity
  - **Left:** w/ default clustering parameters
  - **Right:** w/ clustering based on Cell ID

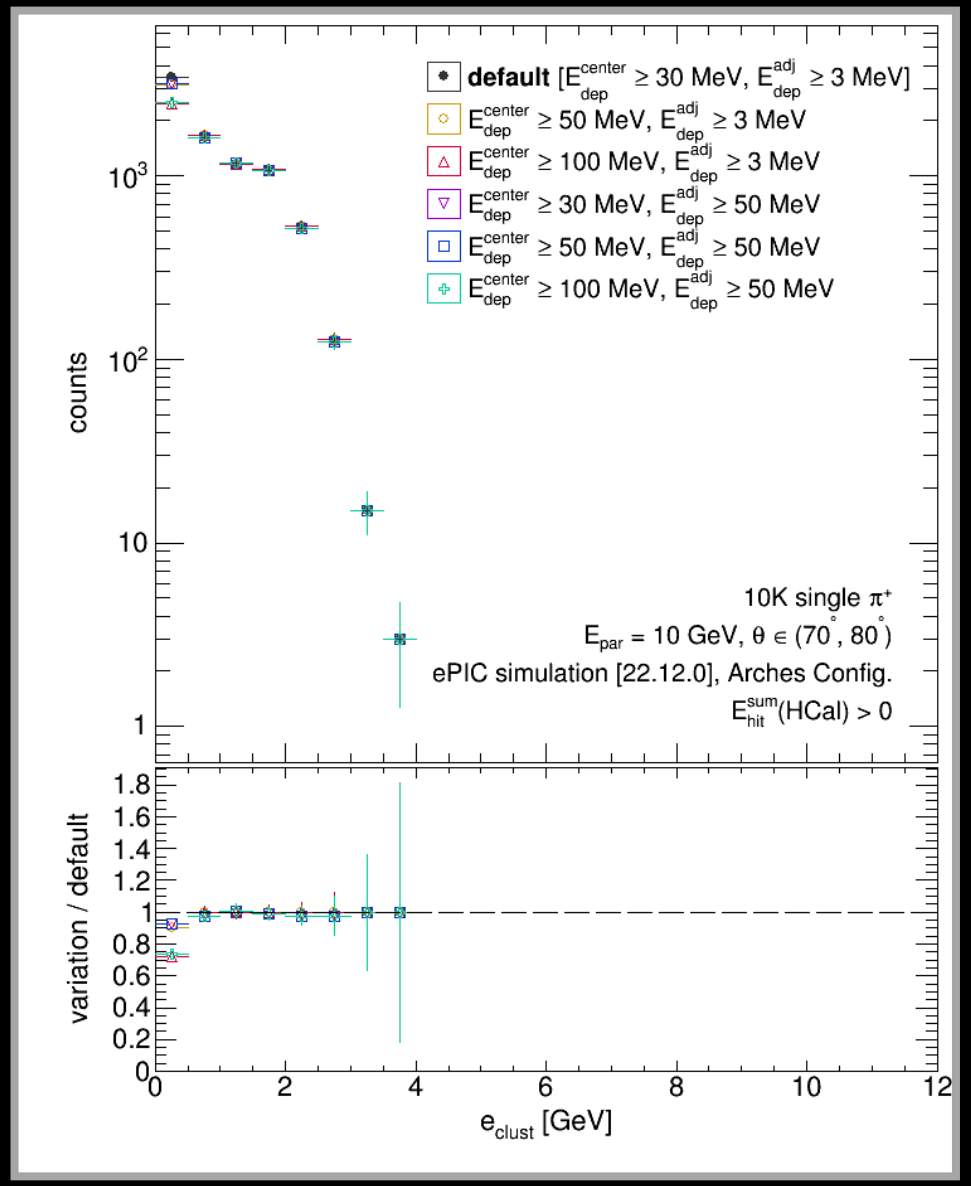
Previous Slides



Varying Energy Parameters | cluster energy

- Checking clustering in HCAL:
  - Varied energy thresholds:
    a) **minClusterHitEdep**
    b) **minClusterCenterEdep**
- Variations:
  - minClusterHitEdep
    - 3 MeV*, 50 MeV
  - minClusterCenterEdep
    - 30 MeV*, 50 MeV, 100 MeV
  - ☞ (* = Default)

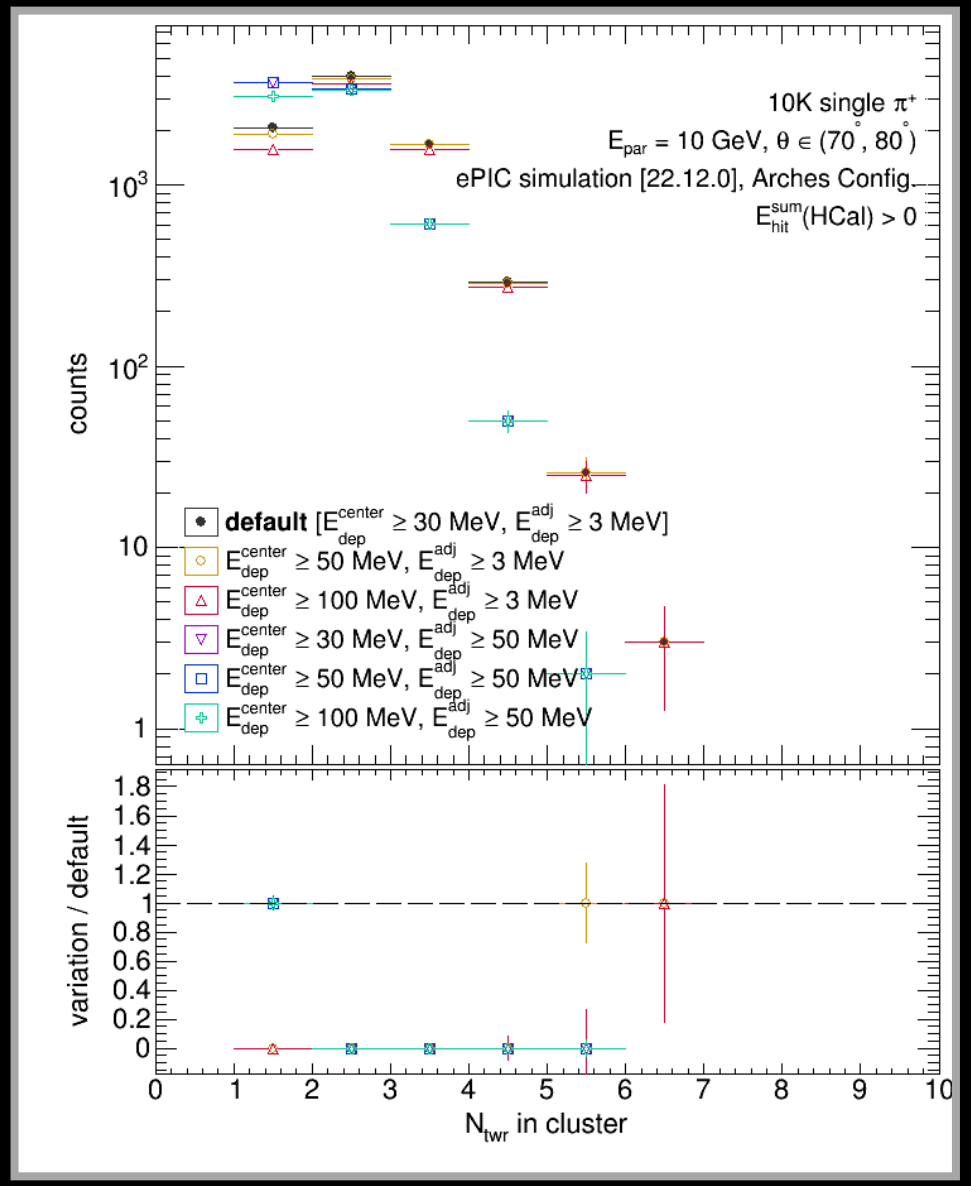
- **Shown:** reconstructed cluster energy
  - 10 GeV single π^+
  - Parameters in backup
  - Additional energies in backup



Varying Energy Parameters | no. of towers in cluster

- Checking clustering in HCAL:
  - Varied energy thresholds:
    a) **minClusterHitEdep**
    b) **minClusterCenterEdep**
- Variations:
  - minClusterHitEdep
    - 3 MeV*, 50 MeV
  - minClusterCenterEdep
    - 30 MeV*, 50 MeV, 100 MeV
  - ☞ (* = Default)

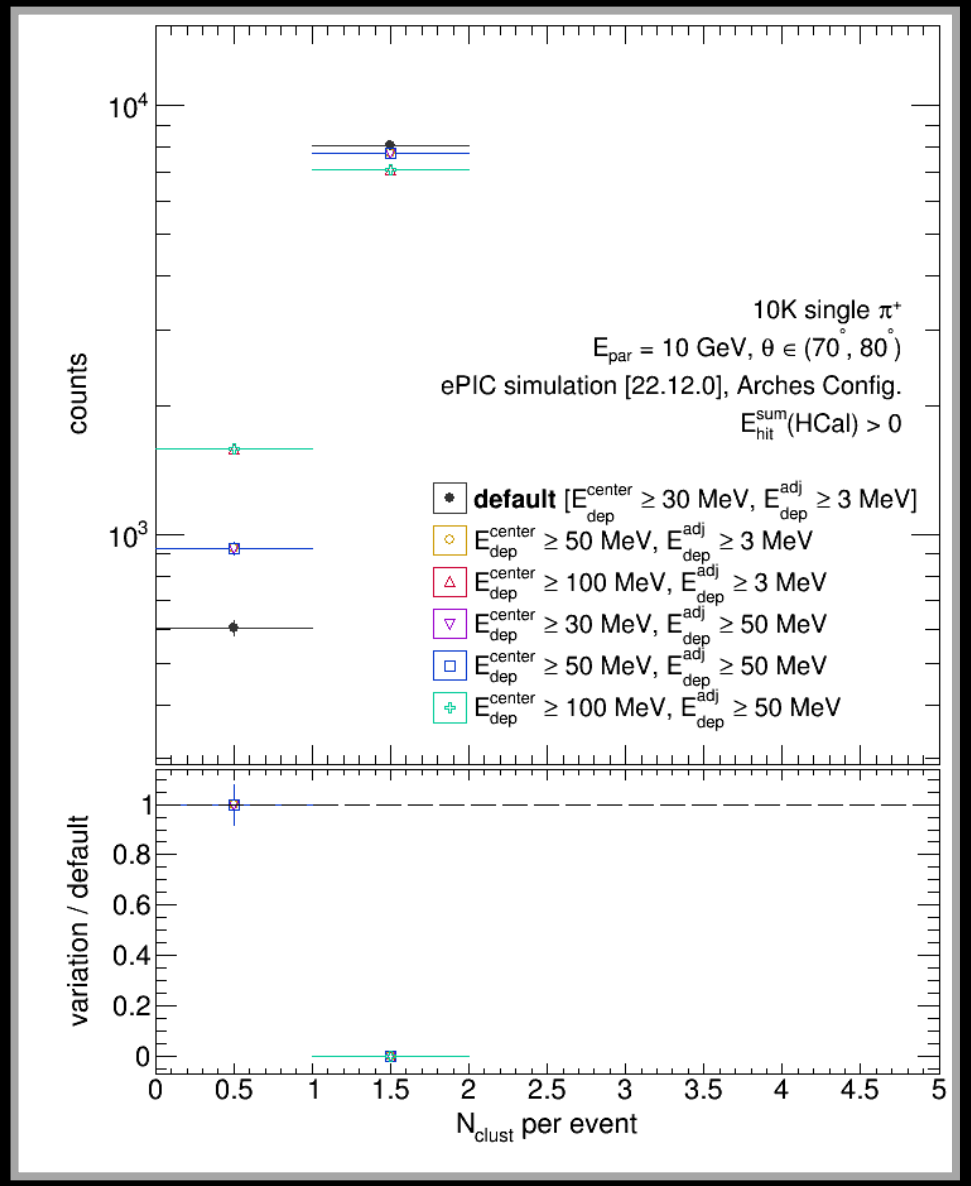
- **Shown:** no. of towers in a reconstructed cluster
  - 10 GeV single π^+
  - Parameters in backup
  - Additional energies in backup



Varying Energy Parameters | no. of clusters in event

- Checking clustering in HCAL:
  - Varied energy thresholds:
    a) **minClusterHitEdep**
    b) **minClusterCenterEdep**
- Variations:
  - minClusterHitEdep
    - 3 MeV*, 50 MeV
  - minClusterCenterEdep
    - 30 MeV*, 50 MeV, 100 MeV
  - ☞ (* = Default)

- **Shown:** no. of reconstructed clusters in an event
  - 10 GeV single π^+
  - Parameters in backup
  - Additional energies in backup

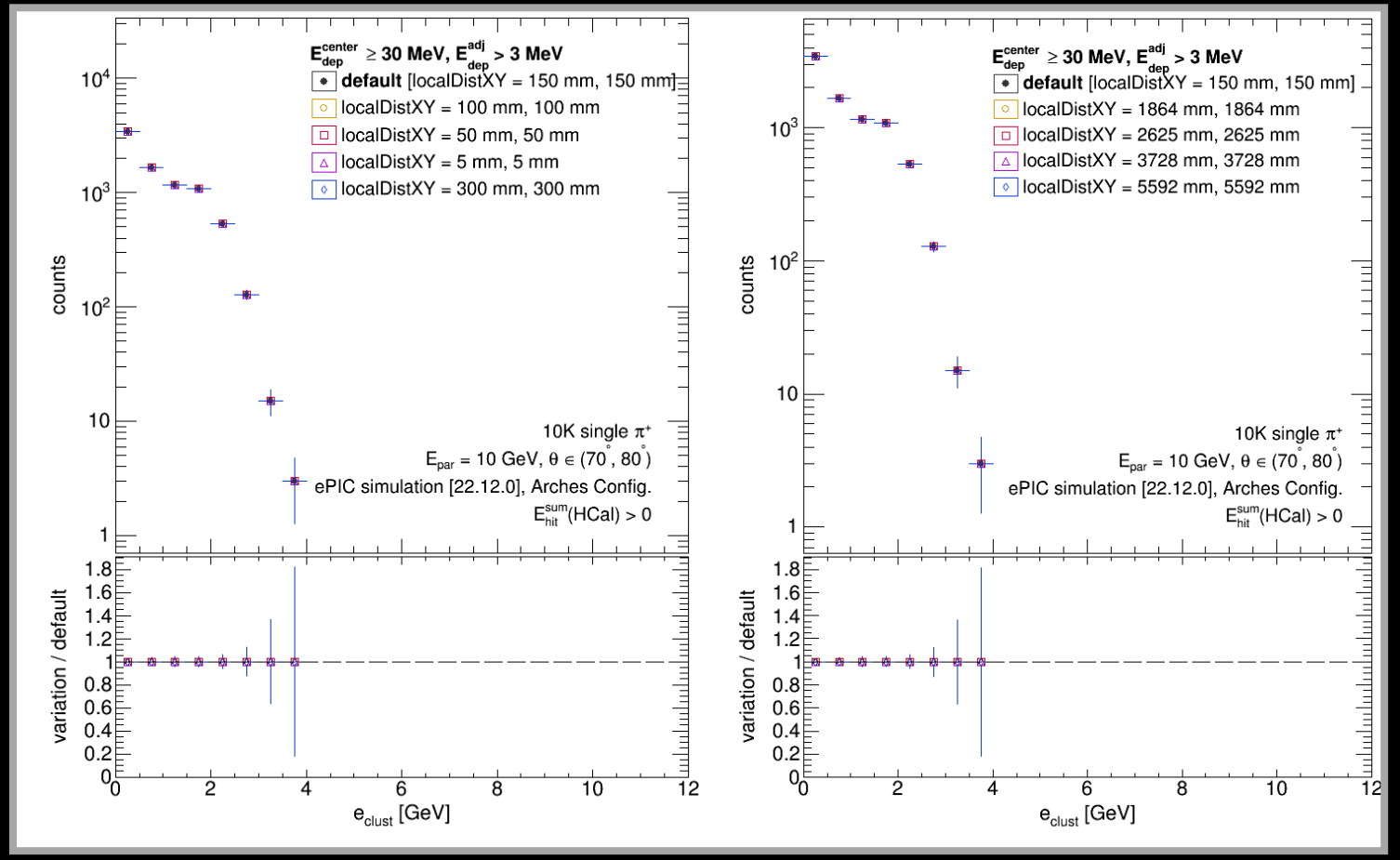


Varying Distance Parameters | cluster energy

- Checking clustering in HCAL:
  - Varied distance scales:
    a) **localDistXY**
    b) **dimScaledLocalDistXY**
    c) **sectorDist**

☞ Varying them doesn't change anything?

- **Shown:** reconstructed cluster energy
  - 10 GeV single π^+
  - Parameters in backup



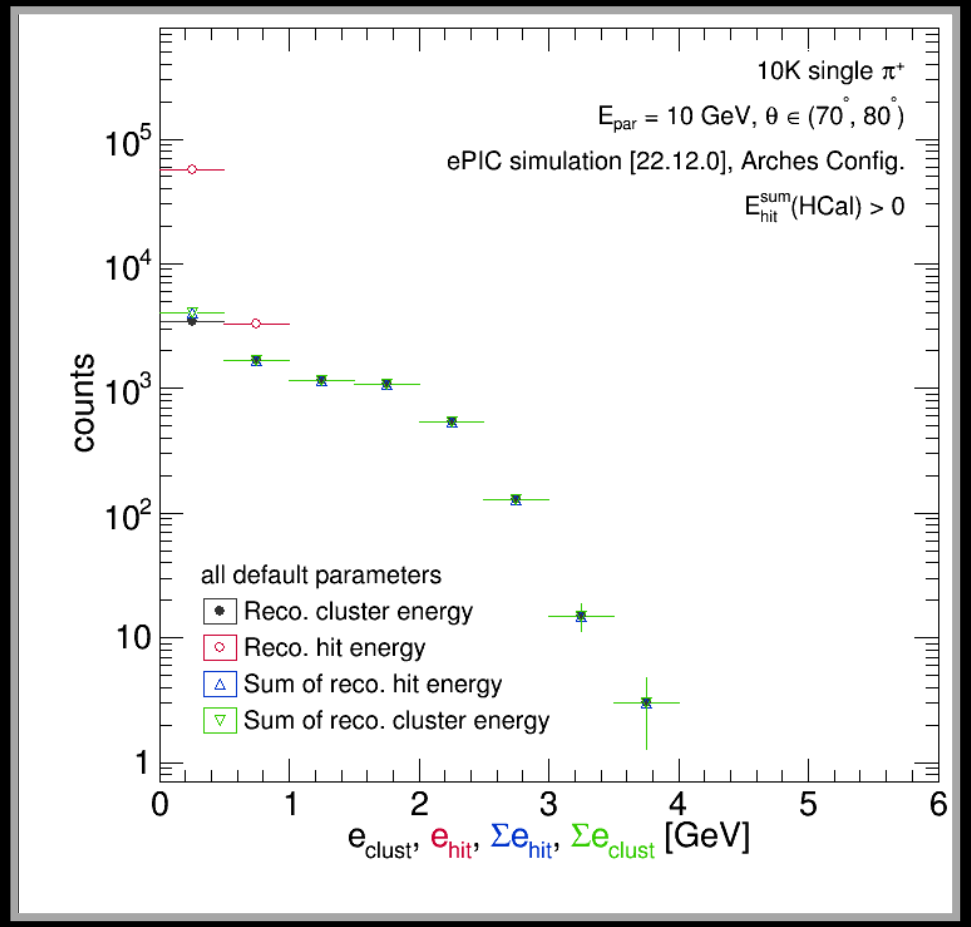
Varying Distance Par.s | cluster energy vs. hits/sums

- Checking clustering in HCAL:
  - Varied distance scales:
    a) **localDistXY**
    b) **dimScaledLocalDistXY**
    c) **sectorDist**

☞ Varying them doesn't change anything?

- **Shown:** cluster energy vs. sum of hit/cluster energies vs. hit energy
  - Using default clustering parameters
    - localDistXY = 15 mm, 15 mm
    - dimScaledLocalDistXY = 50 (mm), 50 (mm)
    - sectorDist = 5 cm

  ☞ **Clusters get almost everything in BHCal despite small distance scales?**



Next Steps

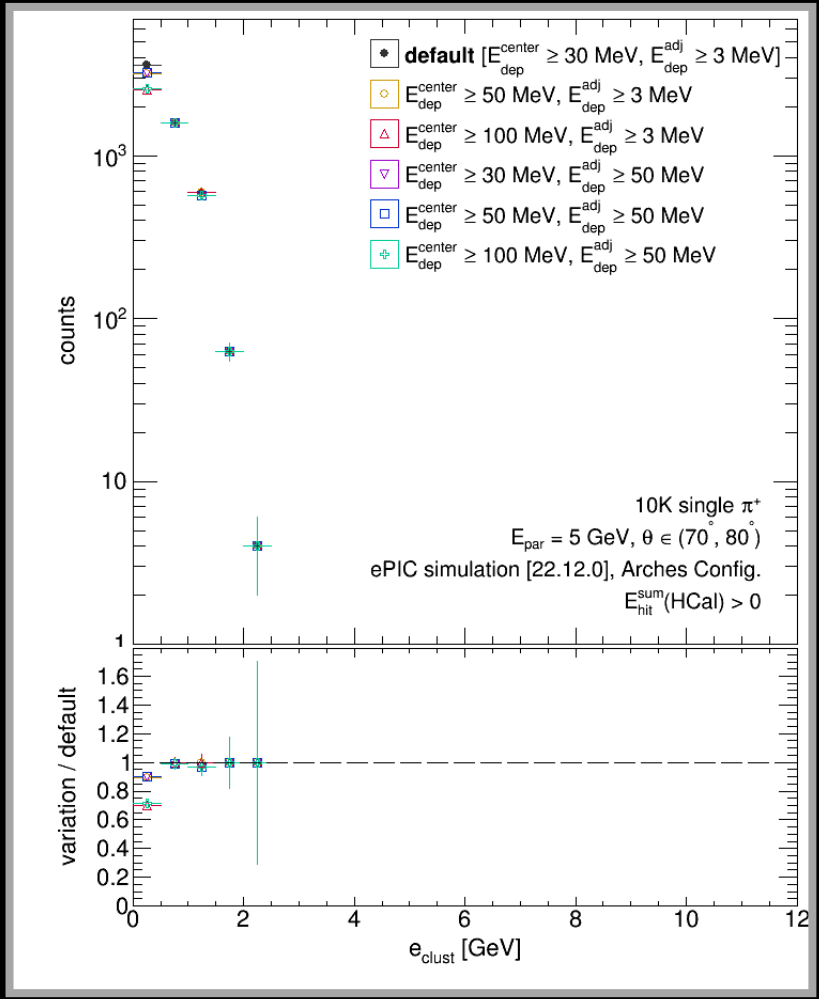
Keep looking into clustering

- Resolve what's going on w/ distance scales
- Look at displacement b/n clusters and inciting track

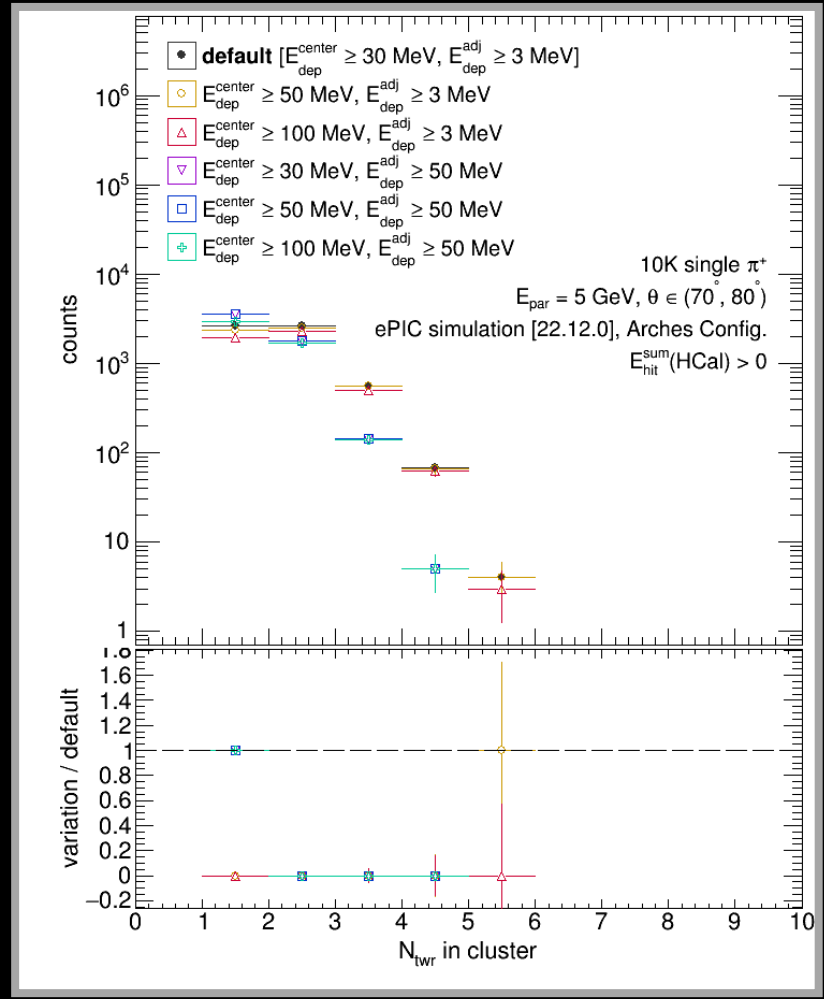
Study impact of Barrel EMCal design on HCal response

- Compare resolution of HCal clusters for both choices of Barrel EMCal

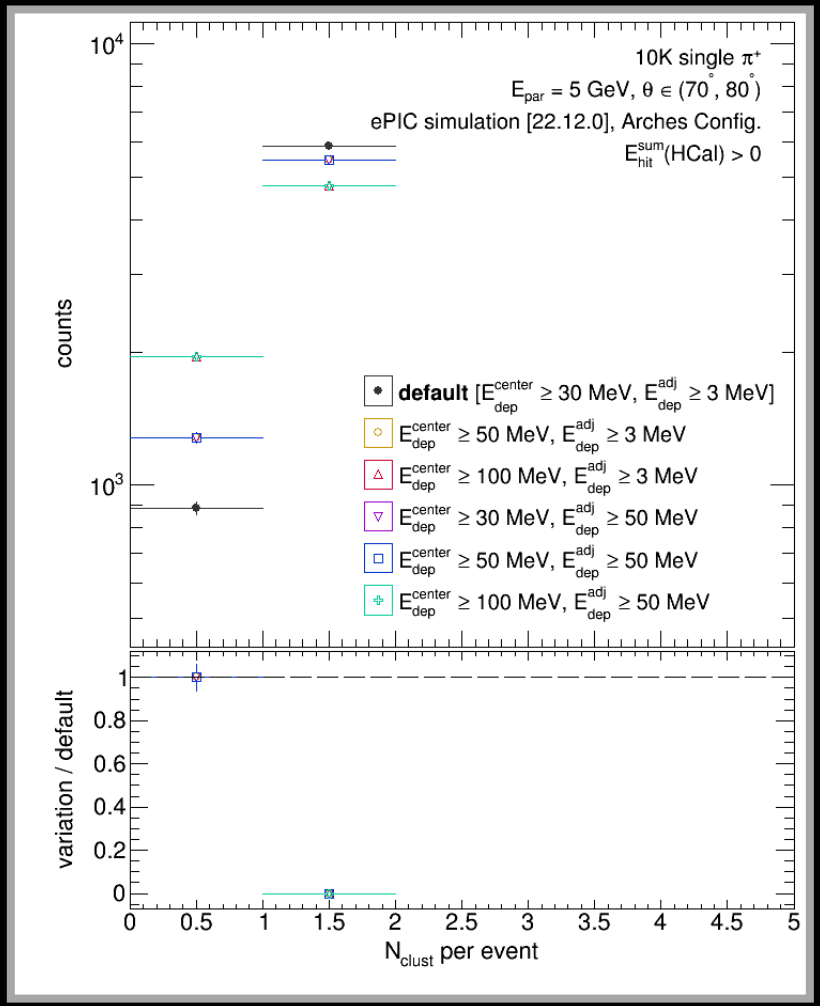
Backup | 5 GeV single π^+



Cluster Energy

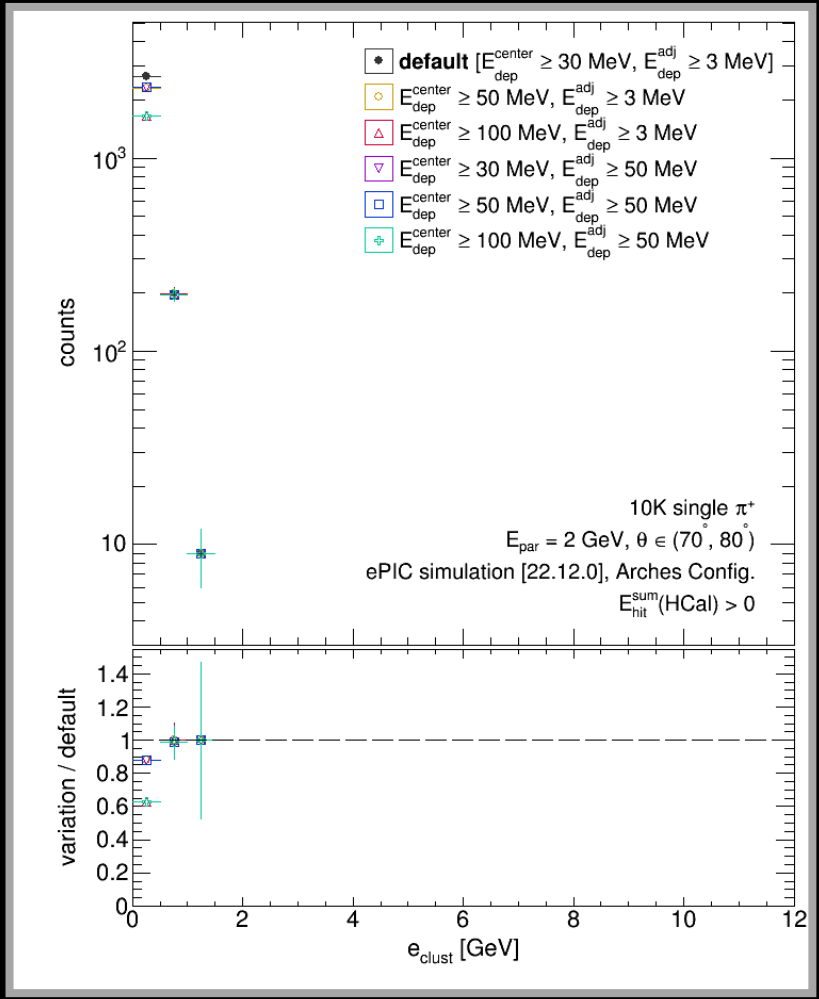


No. of towers in cluster

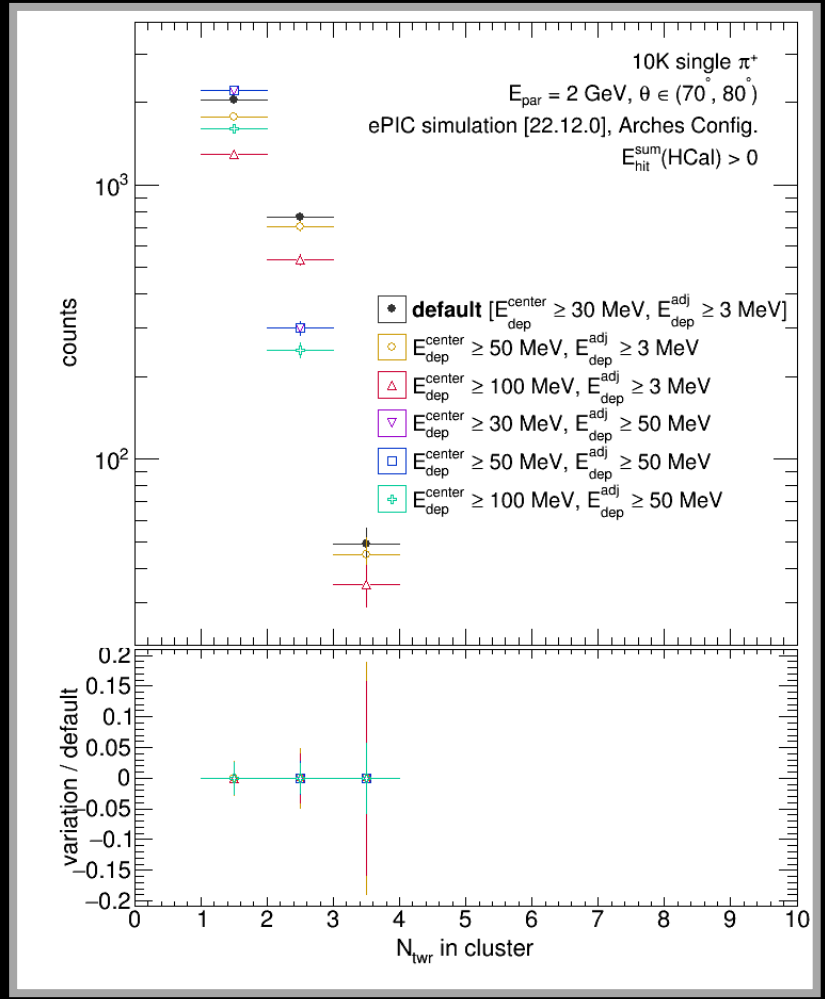


No. of clusters in event

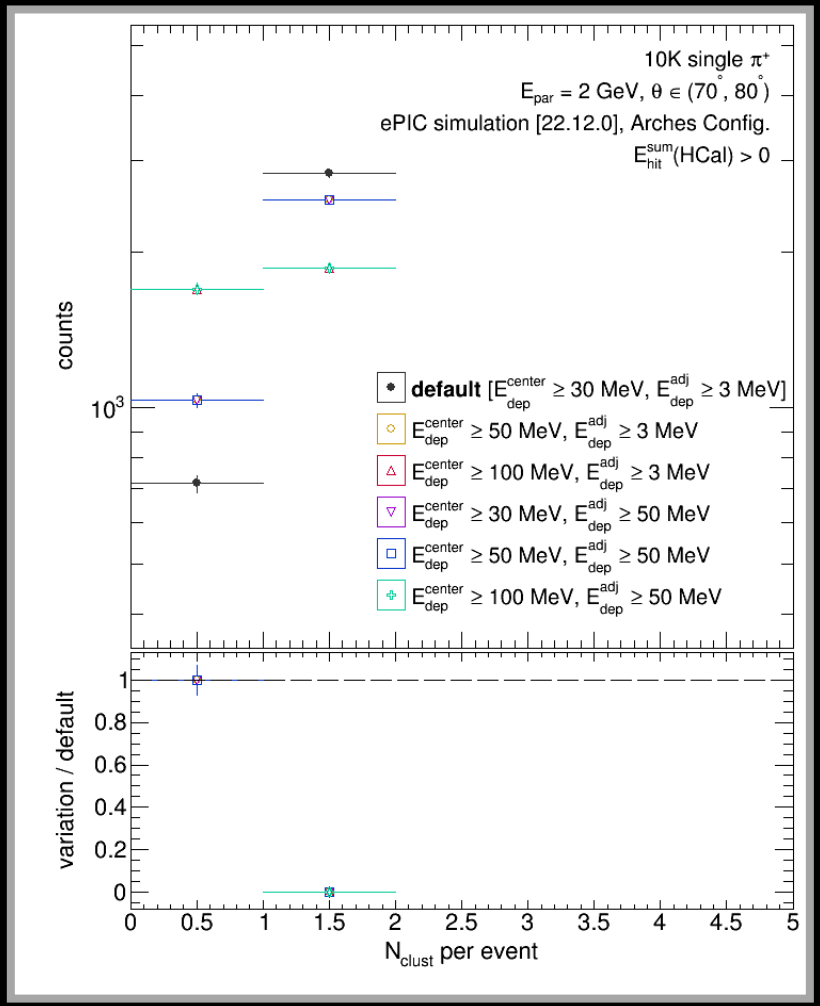
Backup | 2 GeV single π^+



Cluster Energy



No. of towers in cluster



No. of clusters in event