Status of reconstruction in ECAL and barrel-endcap bridging

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Requirements on ECAL design from physics analyses

Prompt photons:

- interested in p_T > 3-4 GeV, high background from π^0, η, etc.
- Requirement: energy resolution at high (> 5 GeV) energies, π/γ separation

Charmonia (χ_{c1}, χ_{c2}):

- need to separate χ_{c1}, χ_{c2} from decay into J/ψ γ
- Requirement: energy resolution at low (< 1 GeV) energies

Online polarizability measurement:

- measure azimuthal asymmetry of π^0 production
- Requirement: energy and position resolution, π/γ separation

Current reconstruction workflow

1) per-cell energy calibration: energy deposition in scintillator layers → energy deposition in the entire cell

2) clustering: identifying groups of neighboring cells

3) reconstruction: get particle position and energy from cluster using empirical expressions, barrel/endcap are reconstructed separately

4) π/γ ID: based on cluster shape analysis

Caveats:

- empirical calibrations in the reconstruction step sensitive to ECAL setup, maintenance is time-consuming

- no reconstruction of individual photons in case of $\pi 0$ ID (yet)

- only full simulation of ECAL showers

- barrel and endcap reconstructed are not bridged at this point
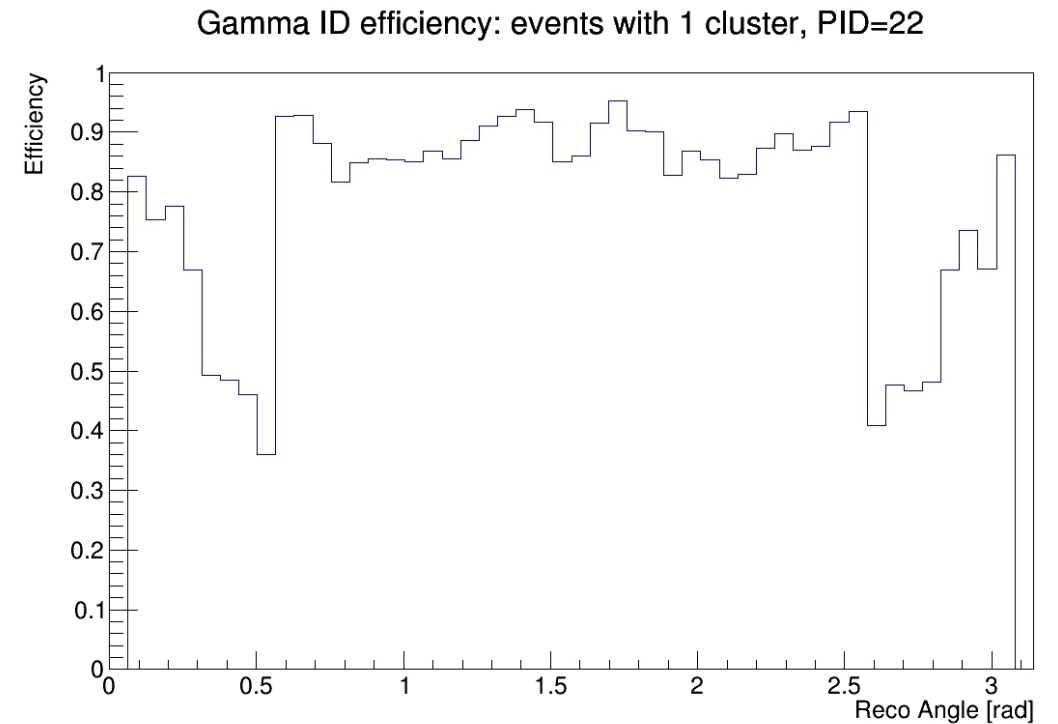

Cluster (from π^0)

Endcap+

Hit (Cell)
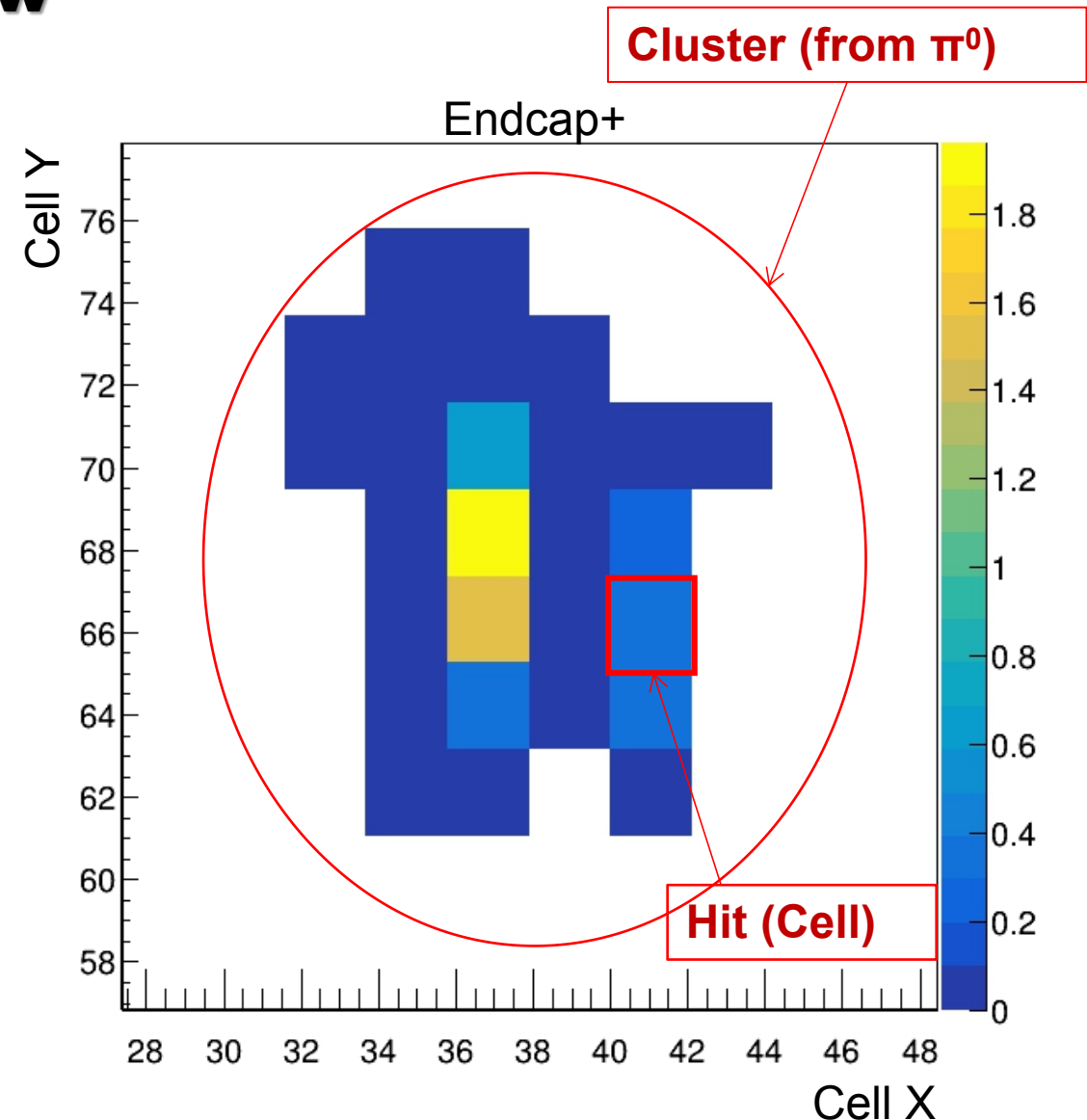
Barrel/endcap bridging

- not implemented yet: if a photon hits the gap between barrel and endcap, two clusters are reconstructed

Questions:
- what is the selection criteria for bridged clusters?
- how to reconstruct energy?
- how to reconstruct position?

Gamma ID efficiency: events with 1 cluster, PID=22

Energy reconstruction of bridged clusters

Comparing two reconstructions:
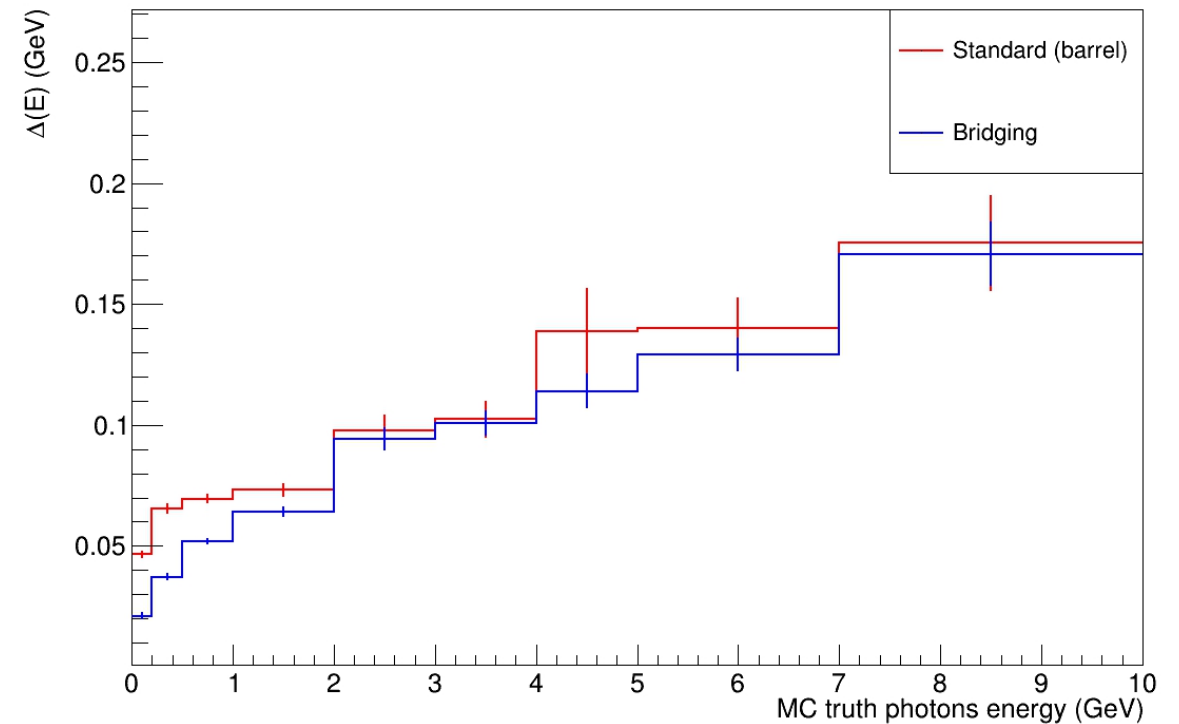**1) standard reconstruction in barrel for polar angle 45° < θ < 60°**
2) bridged reconstruction where energy was reconstructed as sum of barrel annd endcap clusters

Standard reconstruction: bias
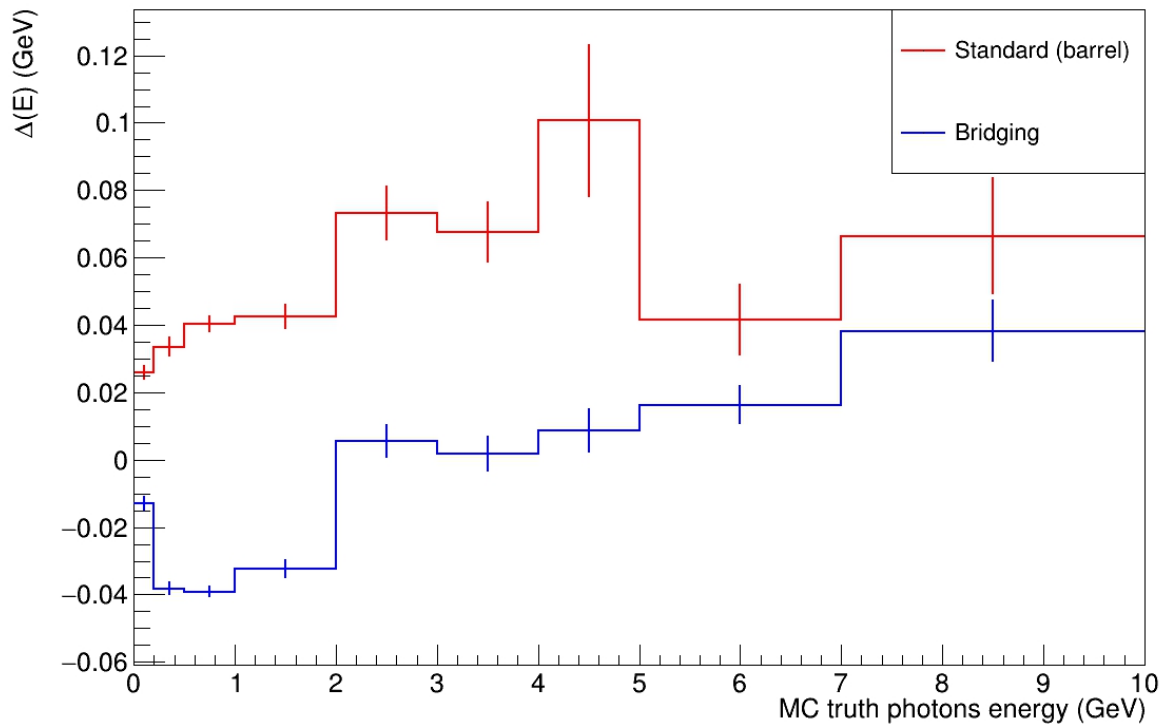
Standard reconstruction: resolution
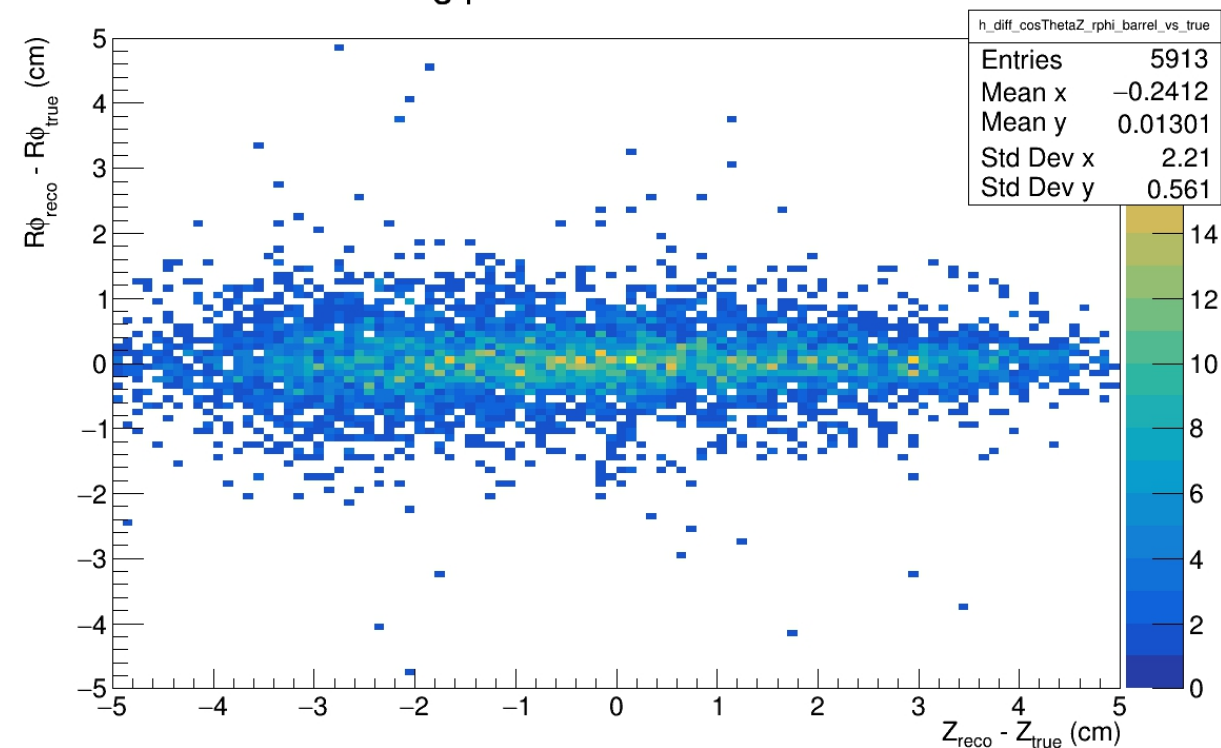
Bias within acceptable limits
Strange(?) effect with better energy resolution at low energies

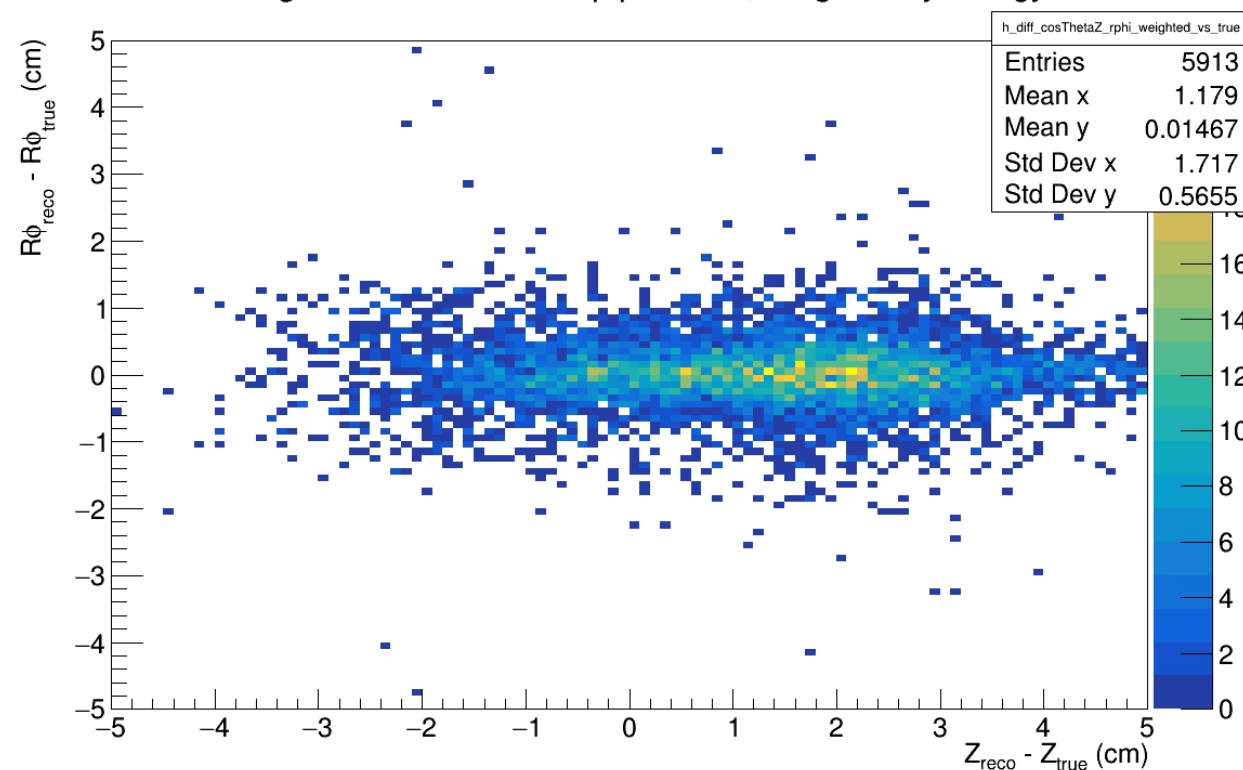# Position reconstruction of bridged clusters

Two methods:

1) position of the bridged cluster is the position of the barrel cluster

2) position of the bridged cluster is the weighted sum of positions of barrel/endcap clusters

Using position of barrel cluster

h_diff_cosThetaZ_rphi_barrel_vs_true	
Entries	5913
Mean x	−0.2412
Mean y	0.01301
Std Dev x	2.21
Std Dev y	0.561

Using sum of barrel/endcap positions, weighted by energy

h_diff_cosThetaZ_rphi_weighted_vs_true	
Entries	5913
Mean x	1.179
Mean y	0.01467
Std Dev x	1.717
Std Dev y	0.5655

Position of barrel cluster still has some bias: possibly due to energy-dependent position corrections
→ for position correction, use sum of barrel+endcap energies, not barrel energy?

Selection criteria for bridging

Bridged clusters

Bridged clusters
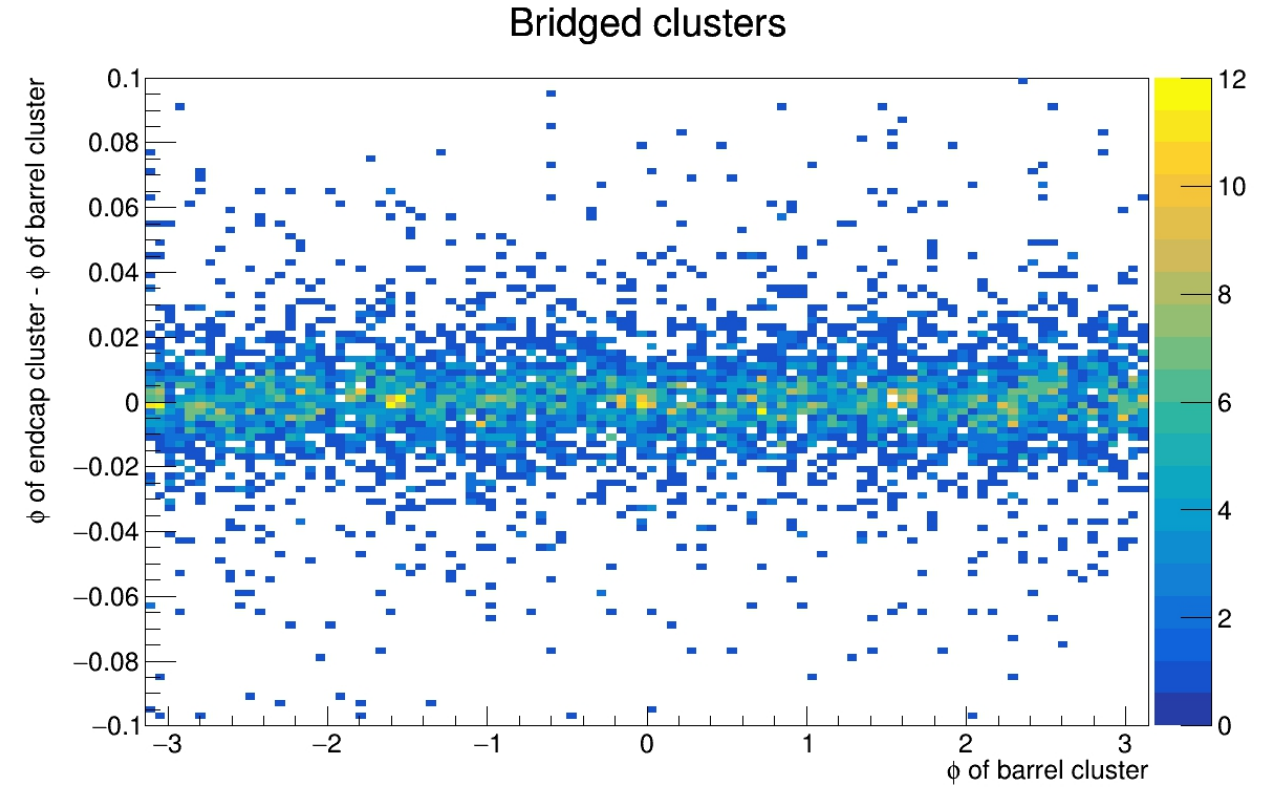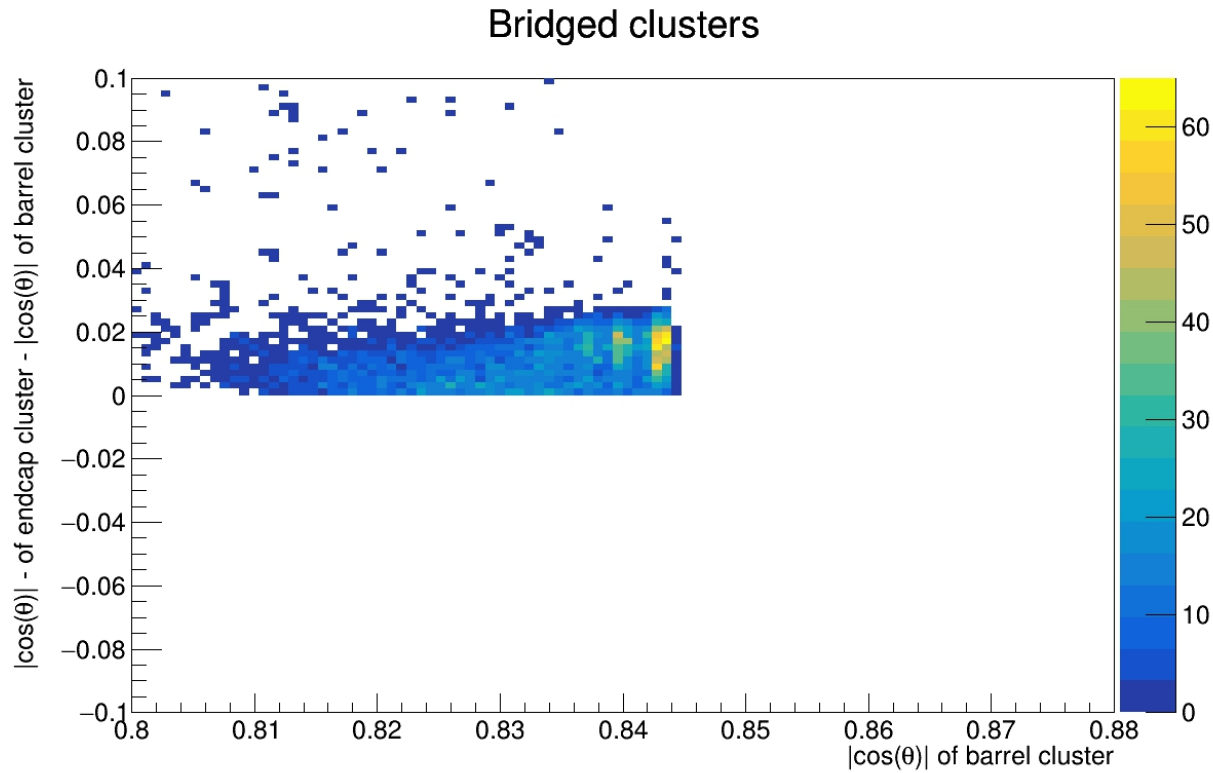
proposed criteria: $0.805 < \cos(\theta_{barrel}) < 0.85$; $\Delta(\cos(\theta)) < 0.03$; $|\Delta\varphi| < 0.04$

Conclusions and outlook

- When bridging, summing energies of barrel and endcap clusters is sufficiently precise for energy reconstruction;

- for position reconstruction, taking the position of the barrel cluster is sufficient as temporary solution: need updated energy-dependent calibrations for gap region;

- selection criteria for bridging two clusters: $0.805 < \cos(\theta_{barrel}) < 0.85$; $\Delta(\cos(\theta)) < 0.03$; $|\Delta\varphi| < 0.04$.

Next steps:

- implement bridging of barrel/endcap clusters in ECAL;

- continue the work of researching the application of machine learning to reconstruction in ECAL, including energy/position reconstruction of π^0 if identified accordingly.