Update on BO EMCAL studies

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Introduction and outline

The Team

- BGU group: Zvi (PI), Michael (Post), Eden (Student)
- We anticipate collaboration with Jerusalem (Moshe Friedman) and Tel-Aviv (Eli Piasetzky)

Past B0 studies

- First acceptance studies of B0 EMCAL, Nov 15, https://indico.bnl.gov/event/17756/

Outline

- B0 ECAL performance (continue)
- Reconstruction with EICrecon
- Towards particle ID in B0 detector:
  - Tracking in B0TRK
  - Photon ID

Simulation setup

Particle Gun using DDSIM

- Default simulation setup (275GeV mag. field)
- ddsim with particle gun (*SIM.gun.particle = 'gamma'* or *'e+'*)
- Energy: from 0 to 60 GeV
- Angle: from 2.5 to 30 mrad (*SIM.gun.distribution = 'cos(theta)'*)
- Particles along the hadron-beam (*SIM.crossingAngleBoost = -25.0*mrad*)
- Coordinates (eta) defined with respect to the hadron beam axis

Reconstruction using EICrecon

- Collections: *B0ECalRecHits,B0ECalClusters,B0TrackerRecHits,MCParticles*

Conventions

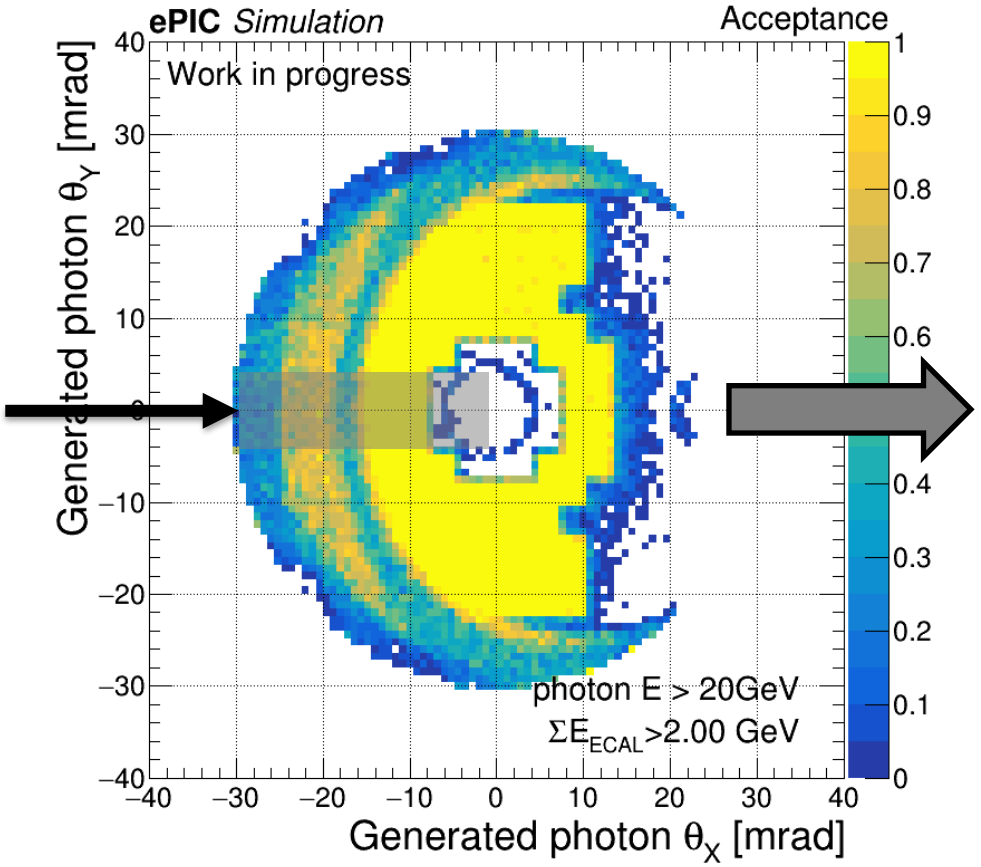
- Coordinates (eta) defined with respect to the hadron beam axis

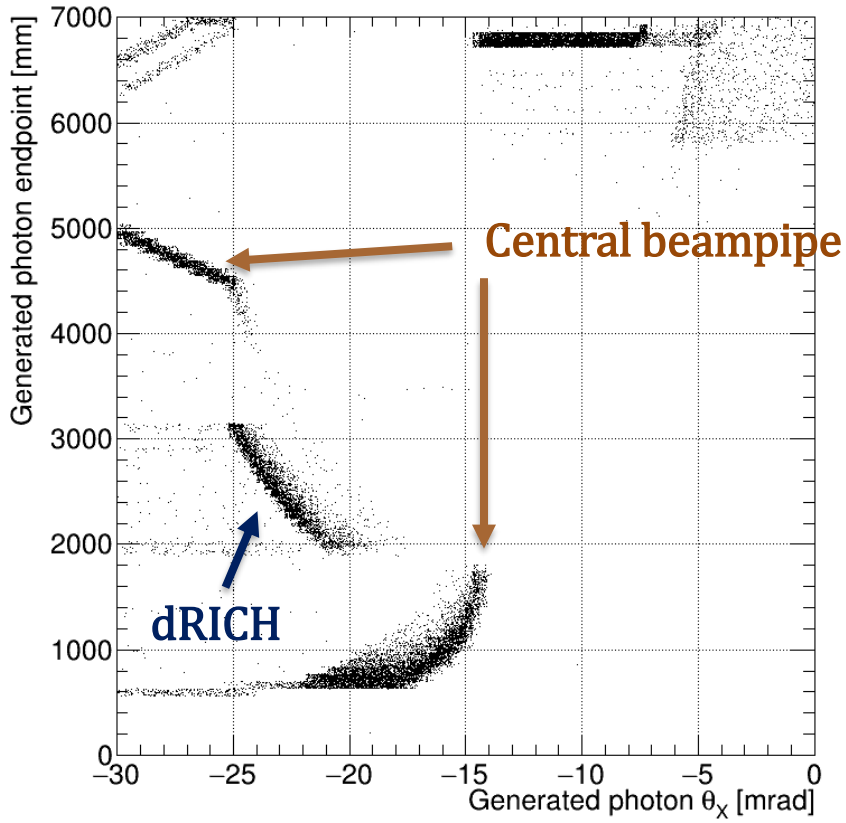
Reminder from last time

Acceptance in X-Y plane

- Last time we identified a region where photons within the geometrical acceptance of the B0ECAL intersect with the beampipe and converted to electron-positron pairs.

Plot photon endpoint along the X axis (θ_Y~0)





Reminder from last time

Photon acceptance

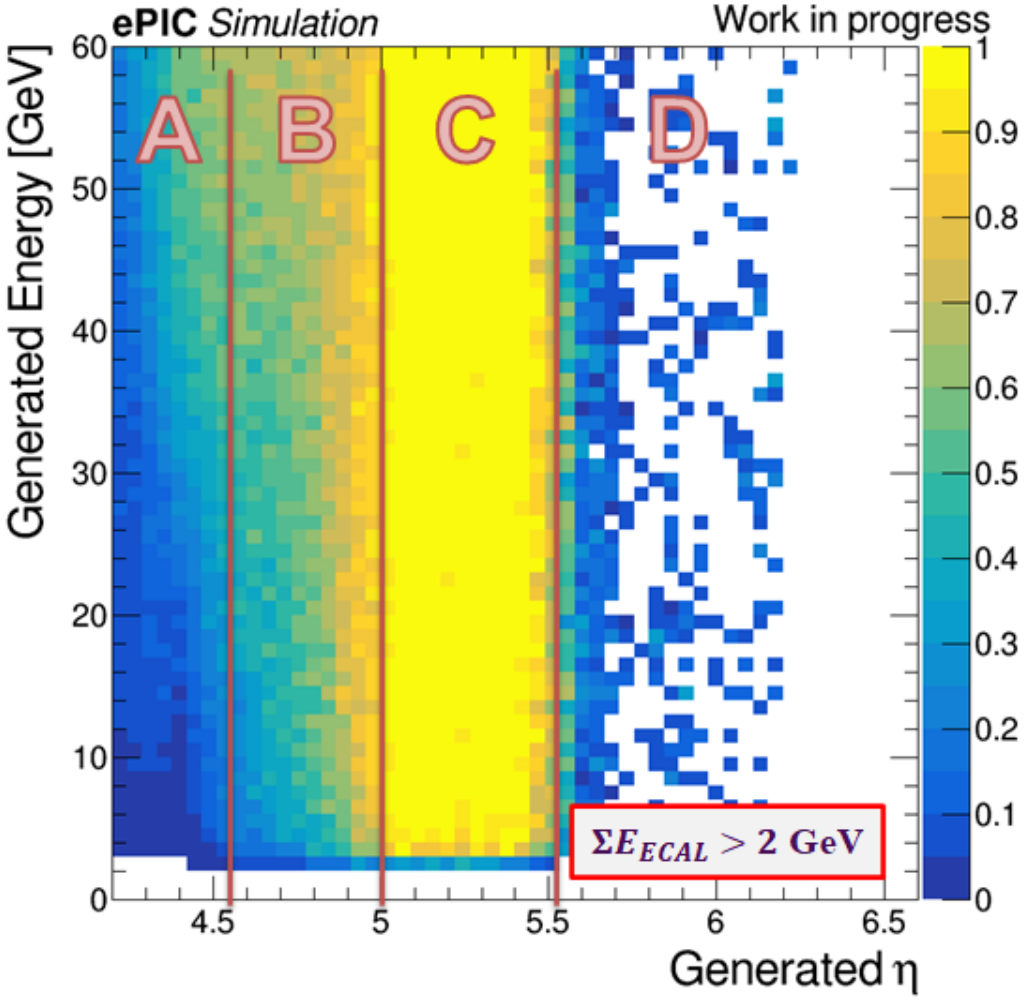
Photon acceptance can be divided into 4 regions:

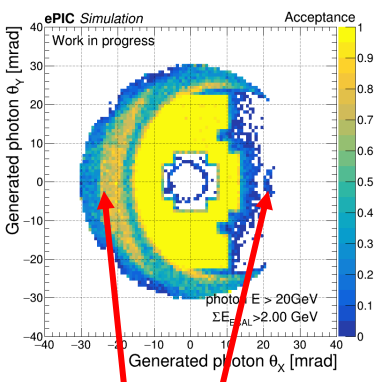
A. Outside EMCAL acceptance (low eta), overlaps with the dRICH acceptance

B. Within EMCAL acceptance and crossing the central beampipe ($\theta_X < -15$) or outside EMCAL acceptance ($\theta_X > 15$)

C. Within EMCAL acceptance, and within the central beampipe – photons interact with B0ECAL

D. Outside EMCAL acceptance (high eta), overlaps with ZDC acceptance



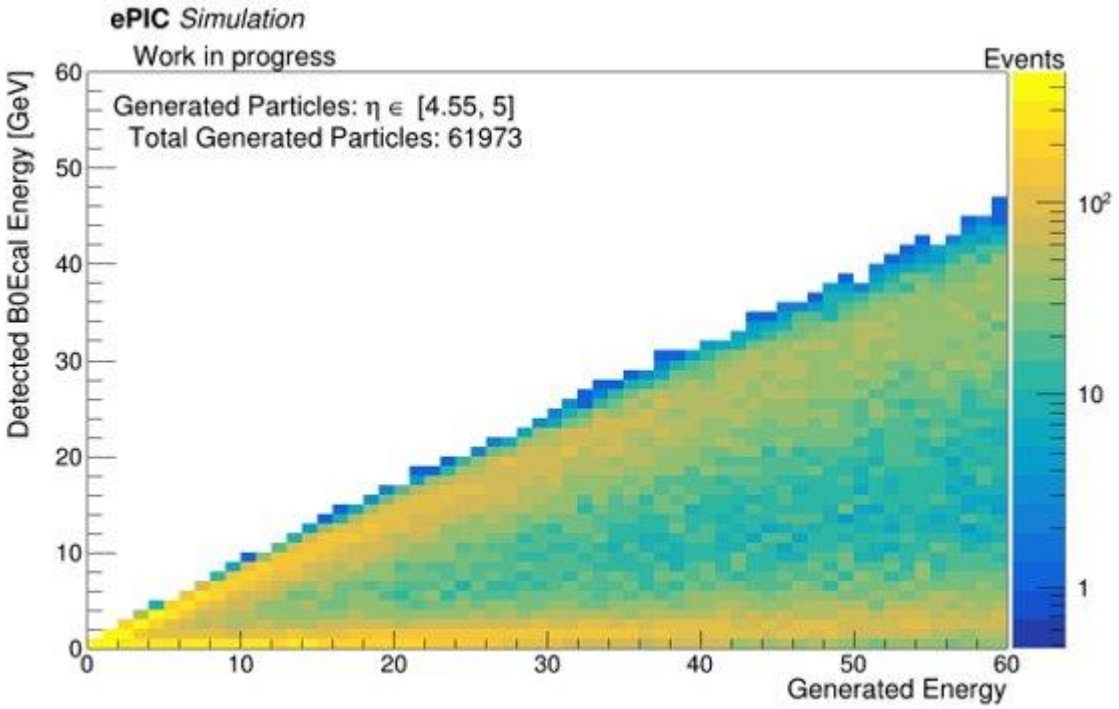


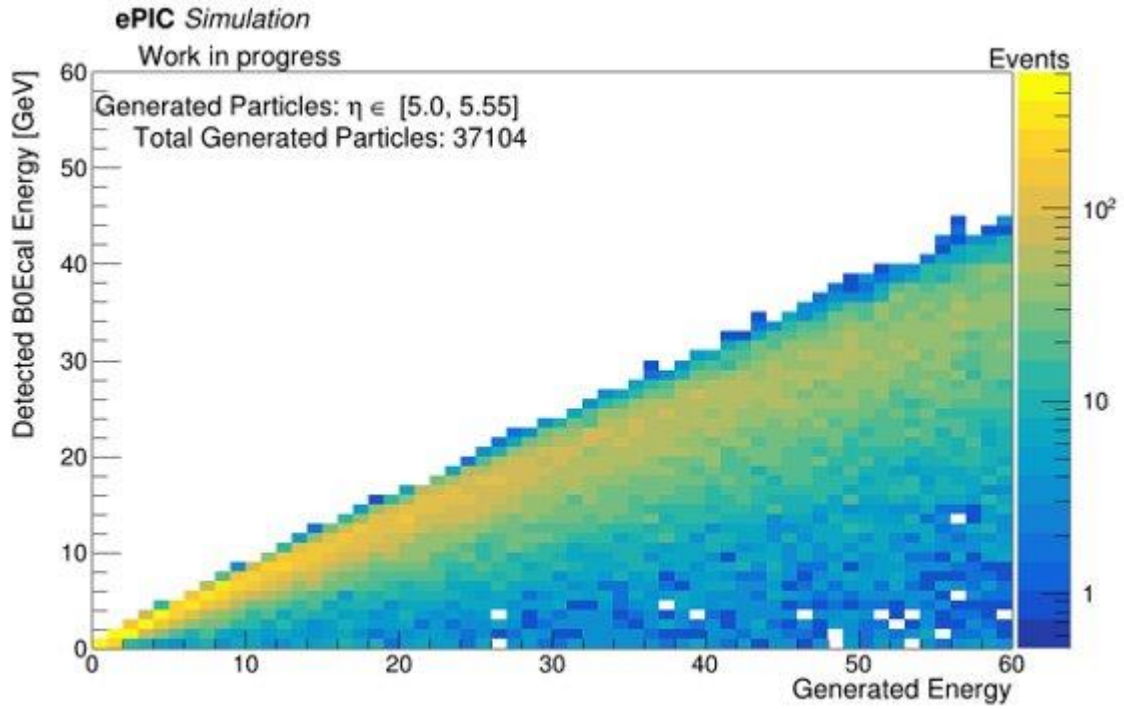
Region B

B0 detector performance (sim)

Energy response in region B and C

- Using energy deposits in B0ECAL cells to study the truth level detector response
- When photons interact before the B0ECAL energy response is not defined (resolution and bias)

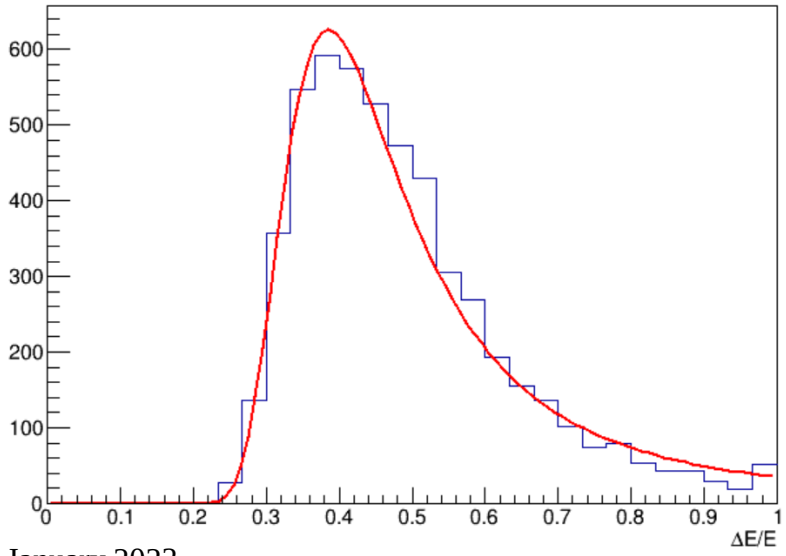


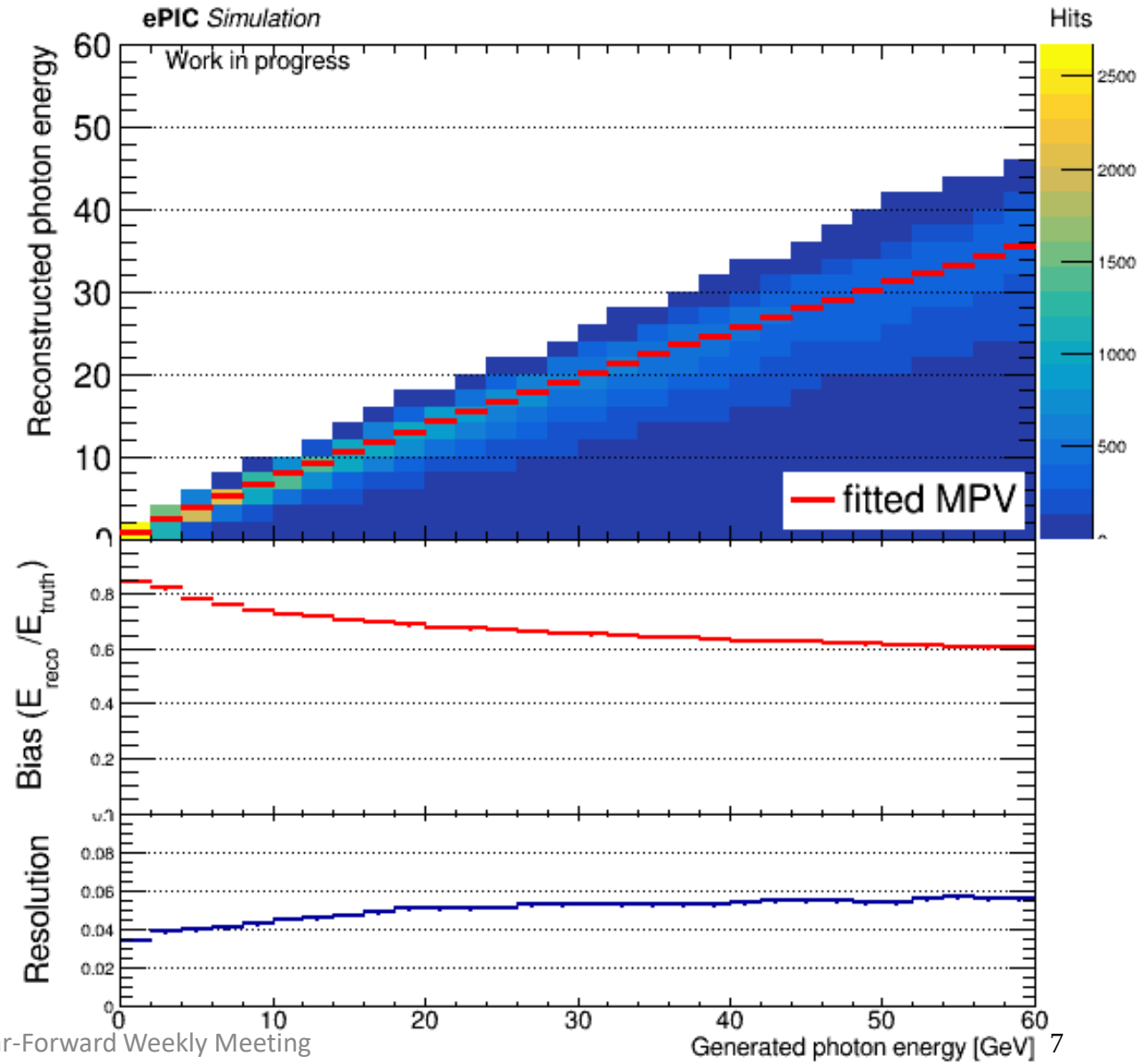


B0 detector performance (sim)

Energy response

- To study the entire detector's sensitive area beampipe was removed from the simulation.
- Fit landau to each slice in E+ΔE to extract bias and resolution (example of last bin)





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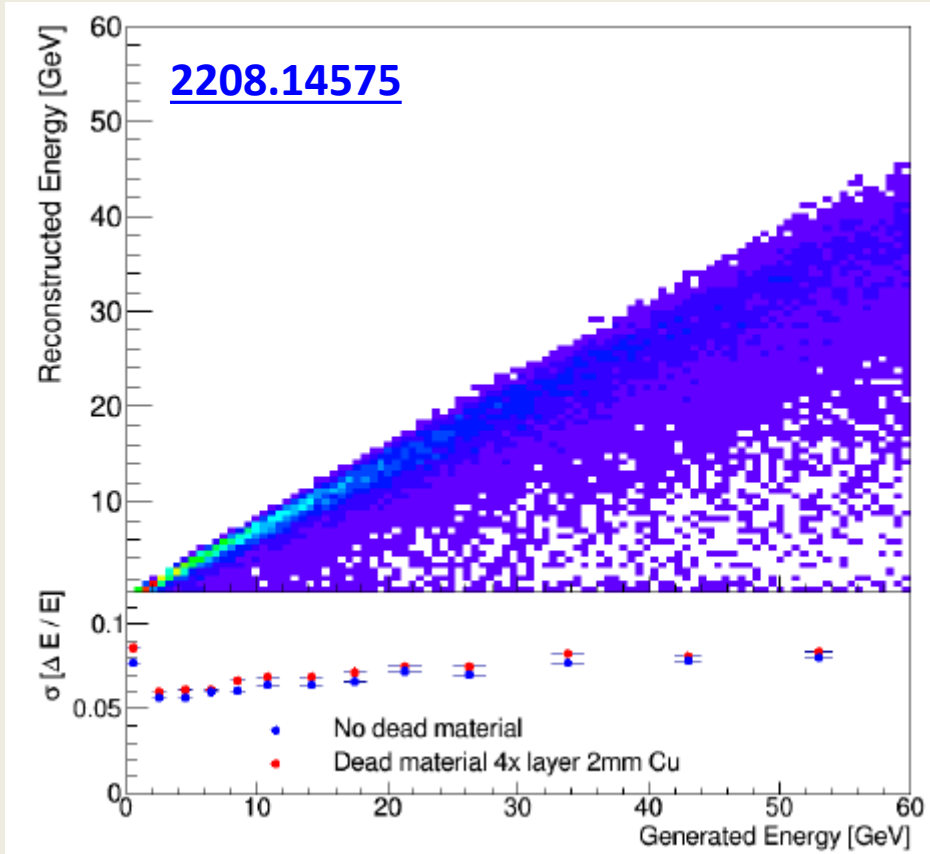
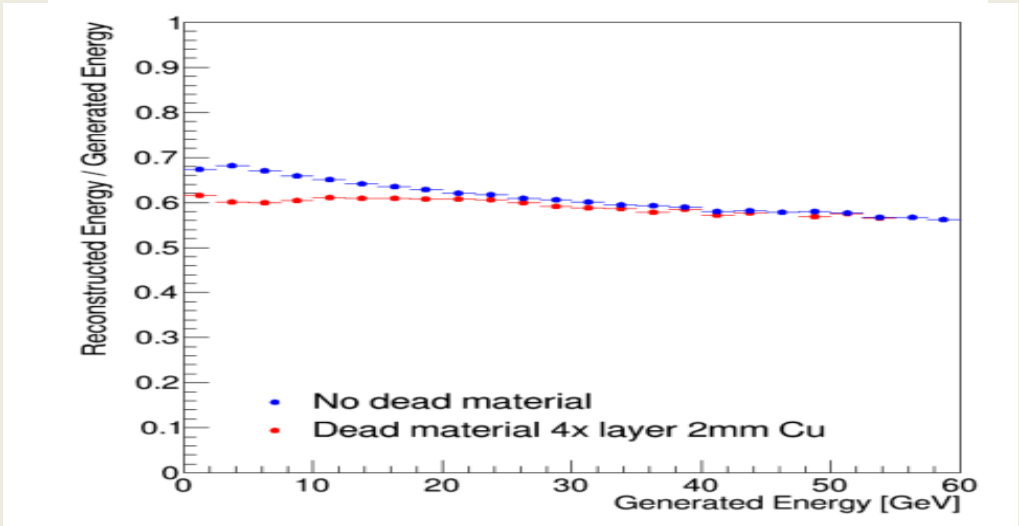
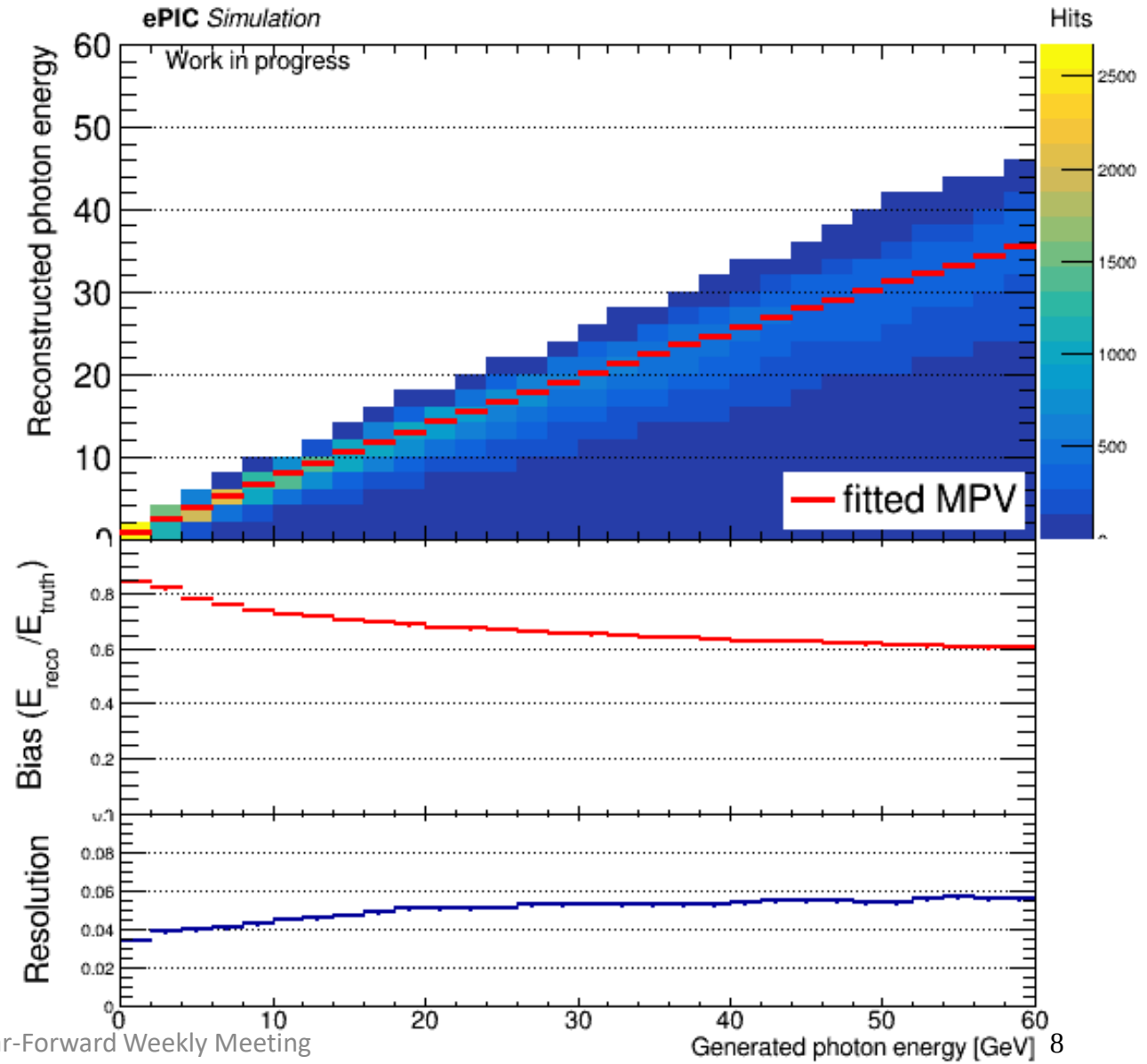






B0 detector performance (reco)

Reconstruction of hits/clusters in B0

- Implemented in :

https://github.com/eic/EICrecon/blob/main/src/detectors/B0ECAL/

https://github.com/eic/EICrecon/blob/main/src/detectors/B0TRK/

- B0TRK was added to the main sequence (https://github.com/eic/EICrecon/pull/421)

```
void InitPlugin(JApplication *app) {
    InitJANAPlugin(app);
    app->Add(new JFactoryGeneratorT<RawCalorimeterHit_factory_B0ECalRawHits>());
    app->Add(new JFactoryGeneratorT<CalorimeterHit_factory_B0ECalRecHits>());
    app->Add(new JFactoryGeneratorT<ProtoCluster_factory_B0ECalTruthProtoClusters>());
    app->Add(new JFactoryGeneratorT<ProtoCluster_factory_B0ECalIslandProtoClusters>());
    app->Add(new JFactoryGeneratorT<Cluster_factory_B0ECalClusters>());
    app->Add(new JFactoryGeneratorT<Cluster_factory_B0ECalMergedClusters>());
    app->Add(new JFactoryGeneratorT<TruthCluster_factory_B0ECalTruthProtoClusters>());
}
```

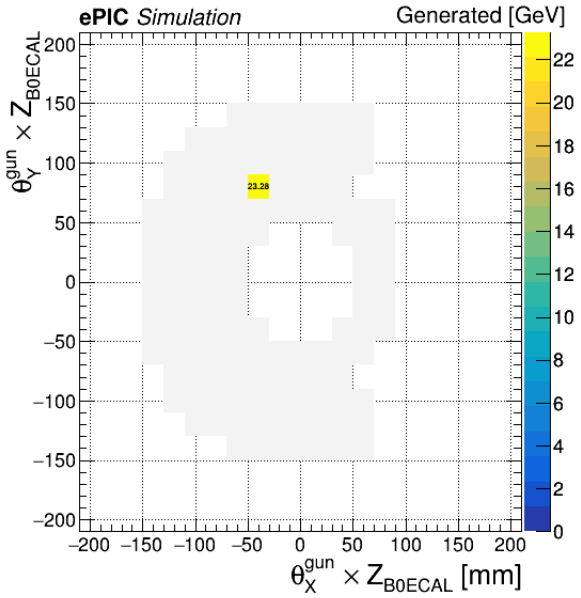
ECAL Reco sequence:

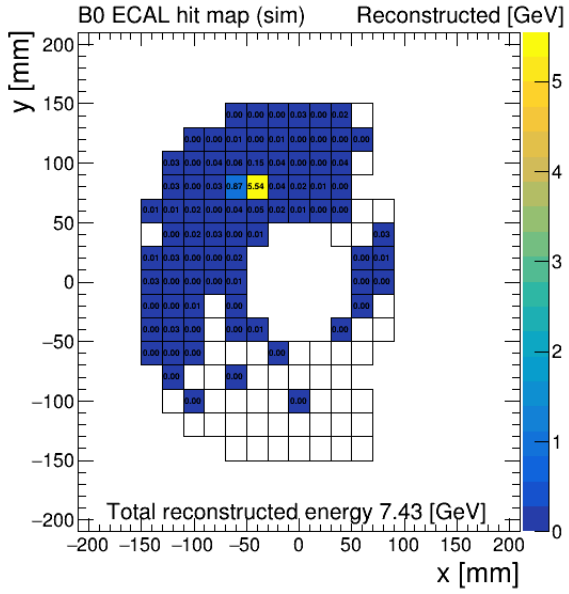
- RawHits constructed from DDSIM Hits (E→ADC)
- RawHits → RecoHits (ADC →E)
- Clustering using RecoHits

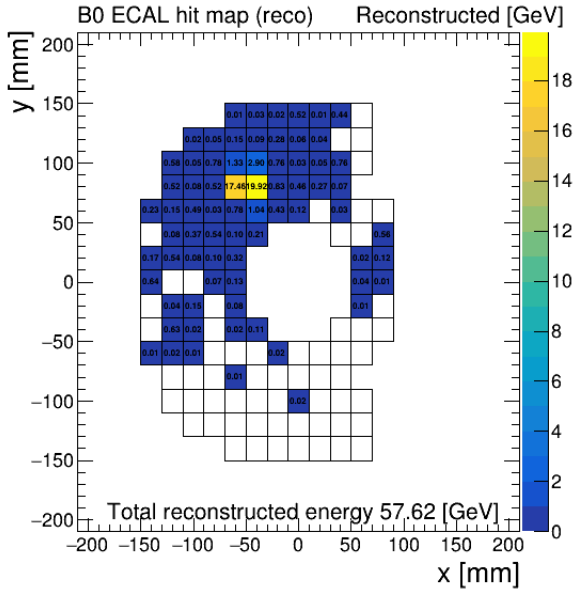
B0 detector performance (reco)

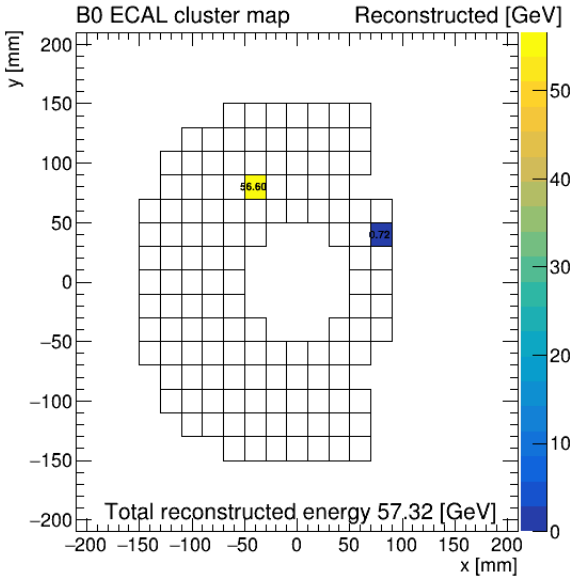
Reconstruction of hits/clusters in B0

- Work in progress – RecoHits in reconstruction is not identical to RawHits in simulation
- Cell energy response is truncated at 20 GeV





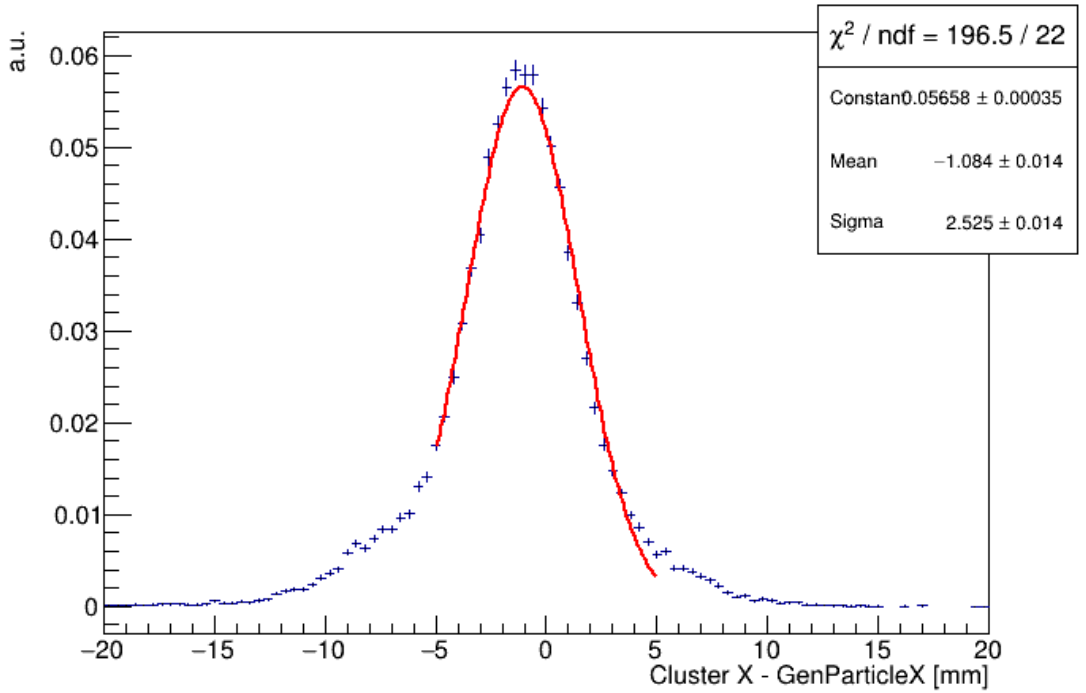


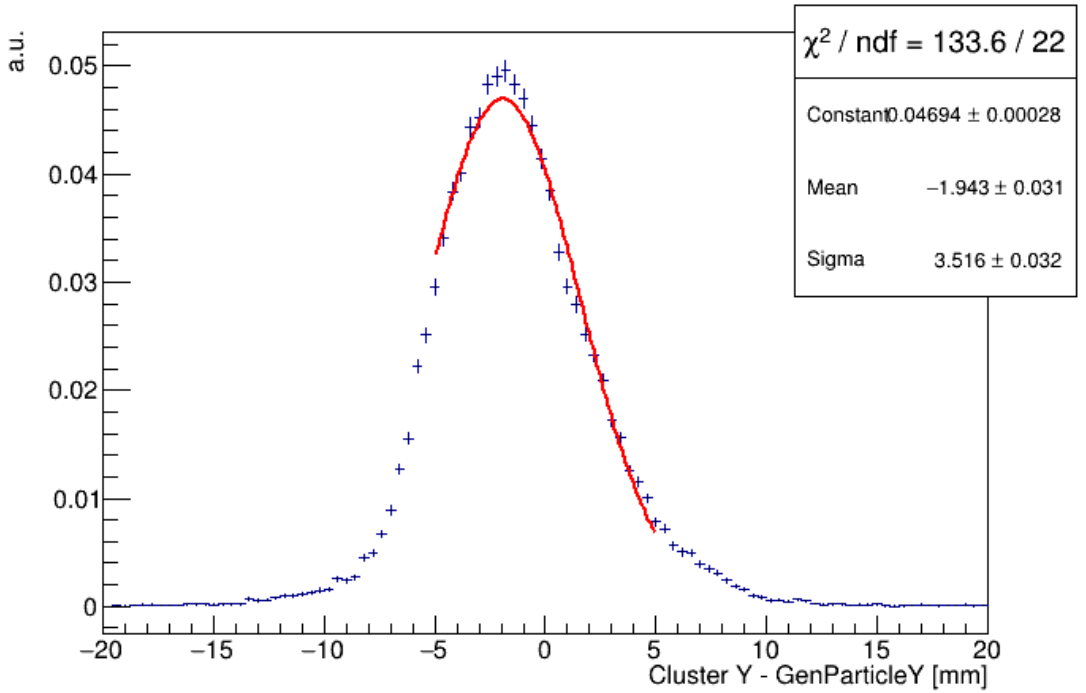


B0 detector performance (reco)

Reconstruction of clusters in B0

- Cluster position resolution (B0ECAL segmentation)
- Events with cluster_n==1 and photon end point in B0ECAL (15% of simulated events)
- Resolution of ~ 3 mm

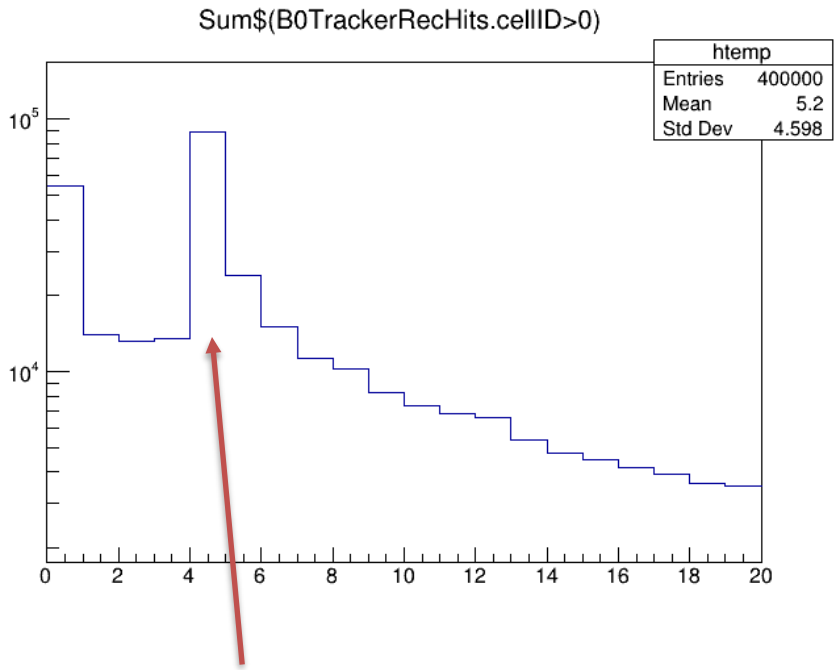




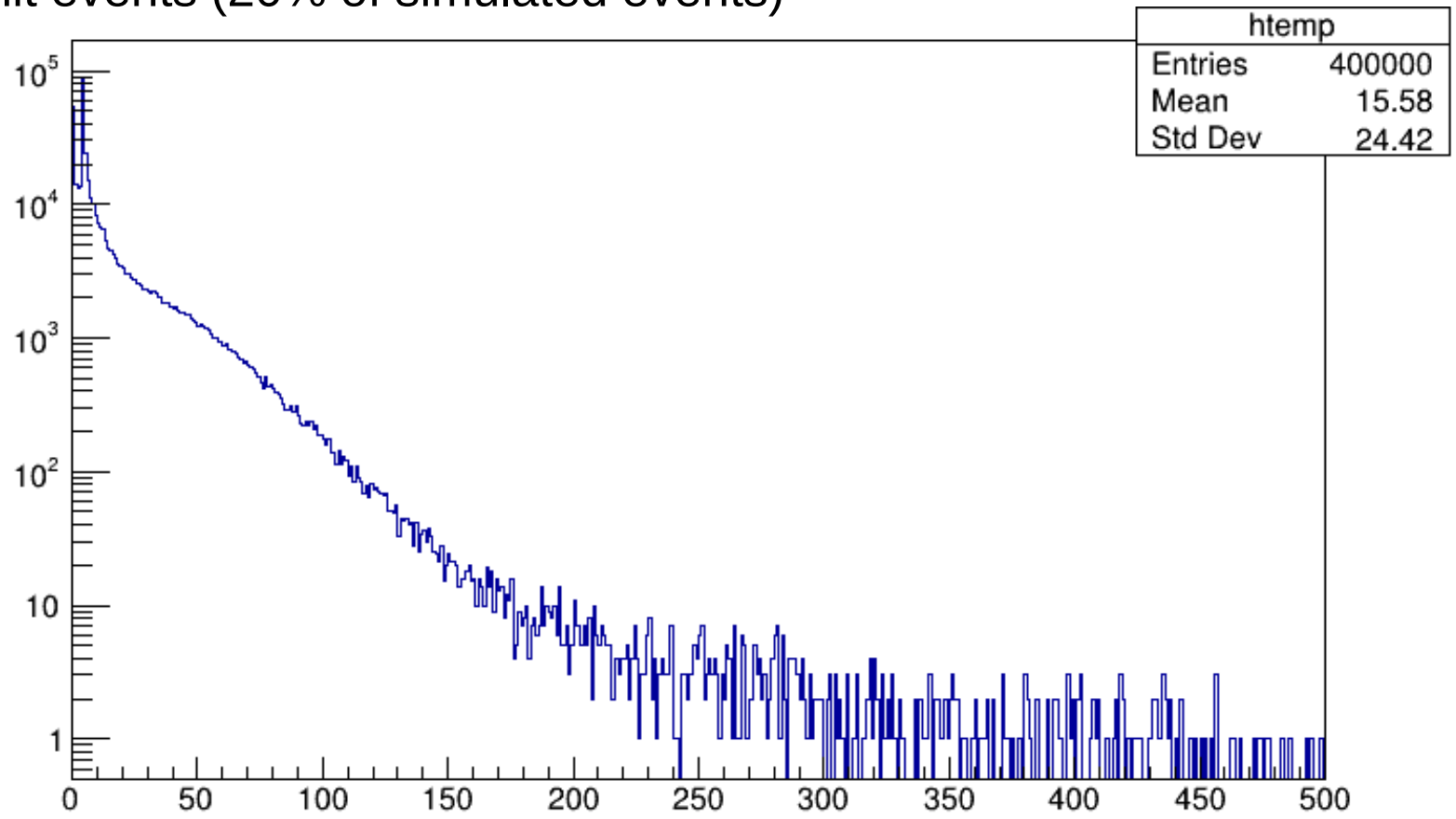
B0 detector performance (reco)

Reconstruction of Tracks B0

- Simulated single electrons events show large distribution of hits in the tracking layers
- We can reconstruct a track for 4 hit events (20% of simulated events)



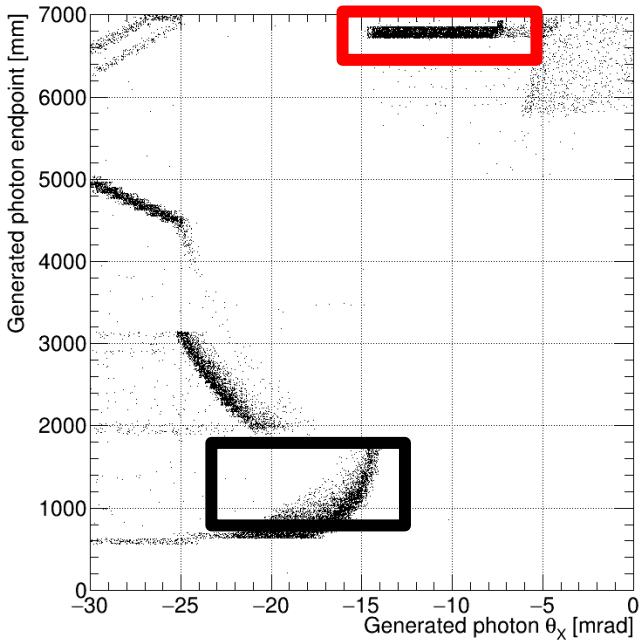
Good electrons (4 hits in tracker)

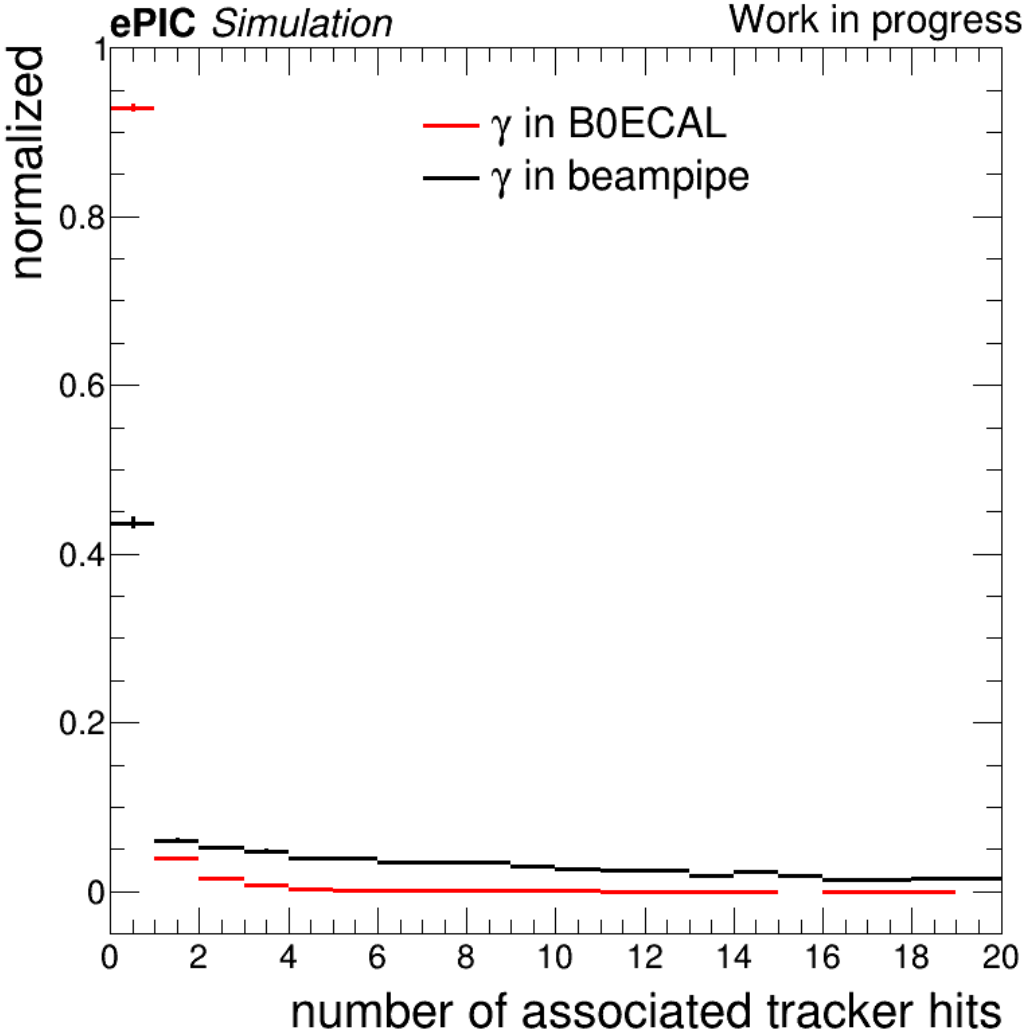


Towards photon ID in the ECAL

Reconstruction of photons

- Photons are identified as EM clusters with no associated tracks (we discard photon conversions)
- Suggest using shower shape variables to identify photons





Summary and discussion

Summary:

- Some issues with the EICrecon B0ECAL algorithm
- Multiple tracks are observed in the B0Tracker
- Track veto can reject ~50% of converted photons

Next steps:

- Circulate draft for the collaboration meeting by Thursday (?)
- Understand RECO (energy response)
- Track reconstruction (consider using GNN for multiple tracks) – synergy with RomanPot reco
- Photon ID
  - Track veto + shower shape variables to train photon ID vs photon conversions, synergy with ZDC reco

Backup

Photon acceptance

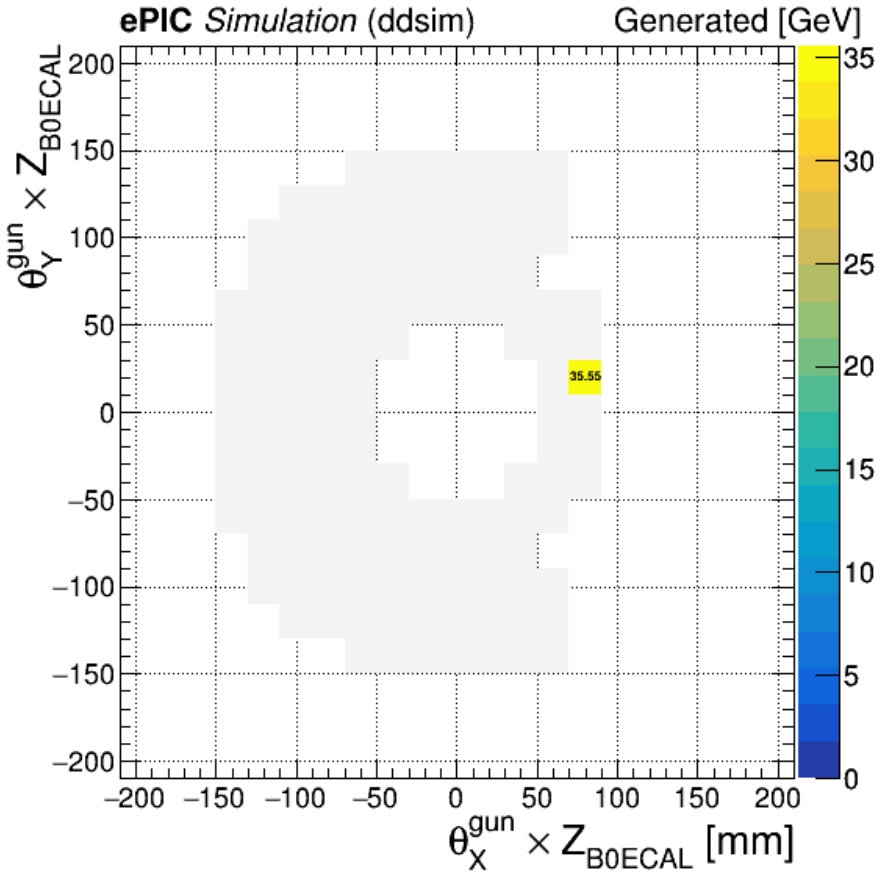
Definition

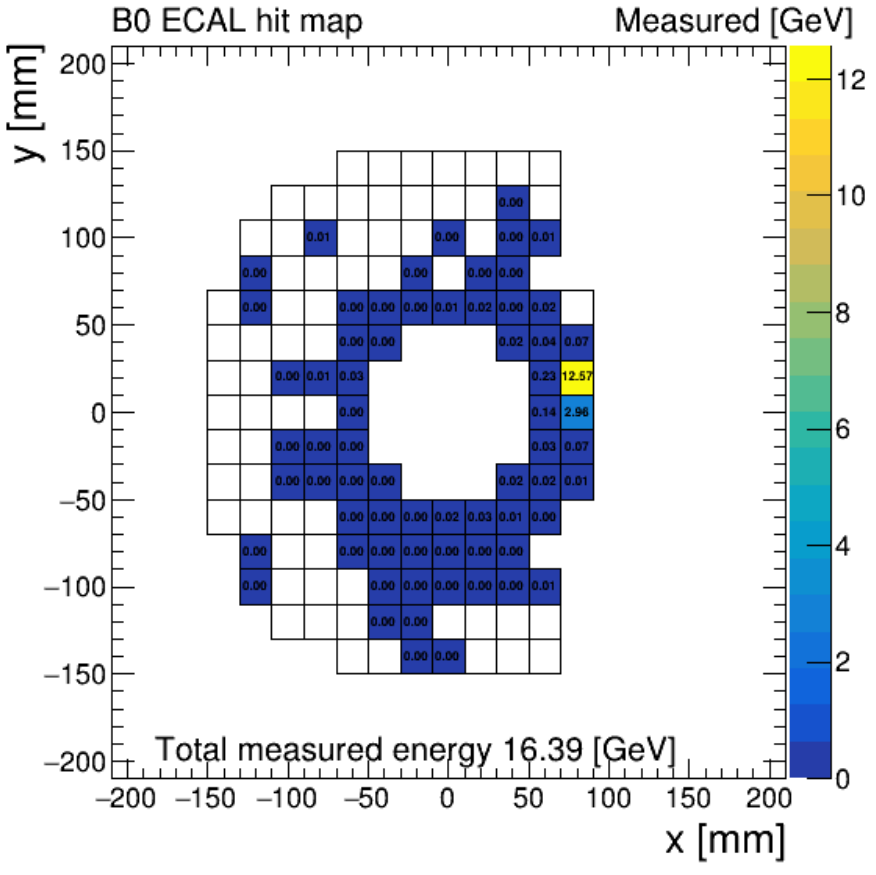
- Acceptance – events with energy deposit in the EMCAL (above given threshold) / total events

Example:

Photon detected

Photon pointing to B0 ECAL, deposit ~45% of its energy in a small cone





Photon acceptance

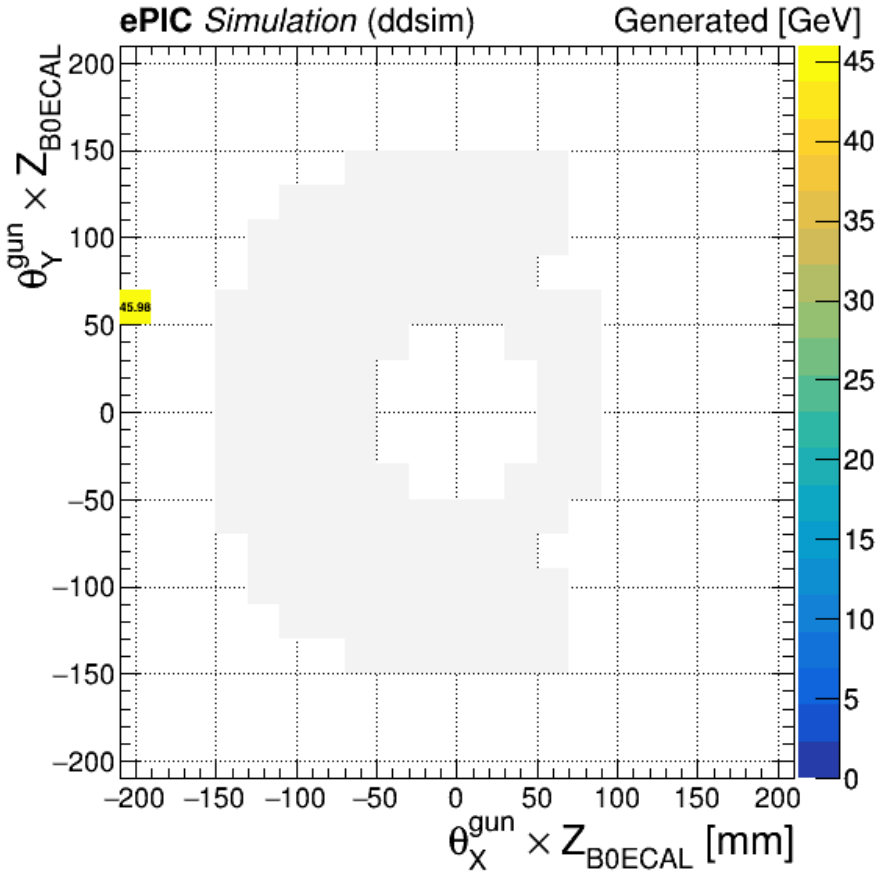
Definition

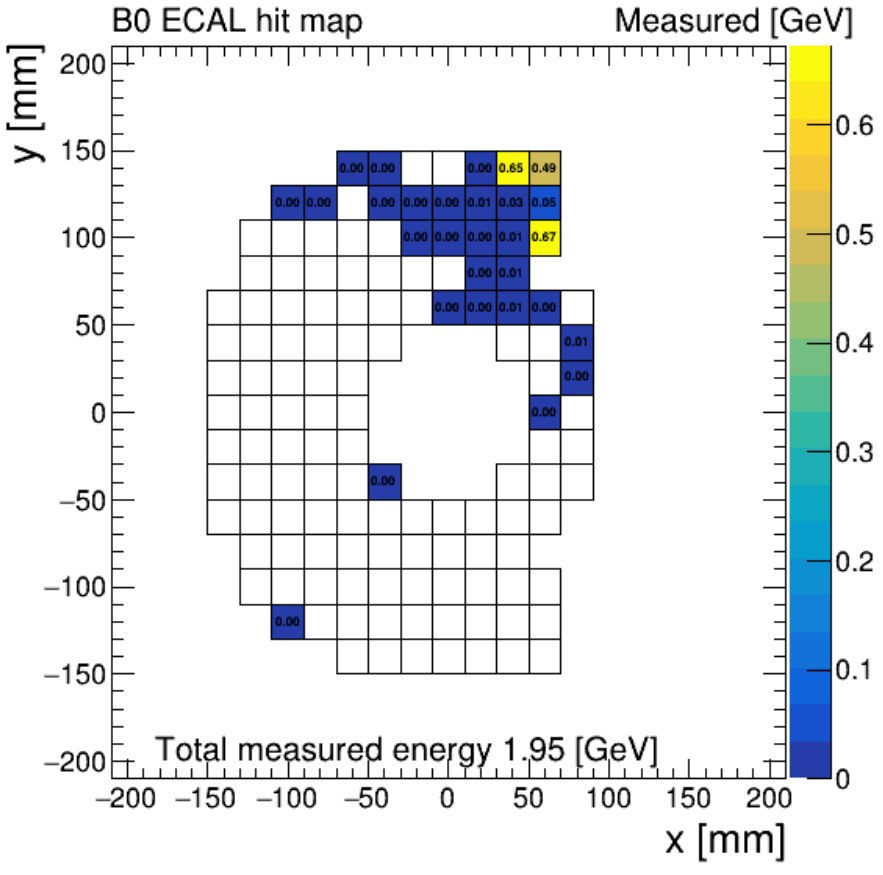
- Acceptance – events with energy deposit in the EMCAL (above given threshold) / total events

Example:

Photon detected

Photon outside B0 ECAL fiducial volume is measured by ECAL





Photon acceptance

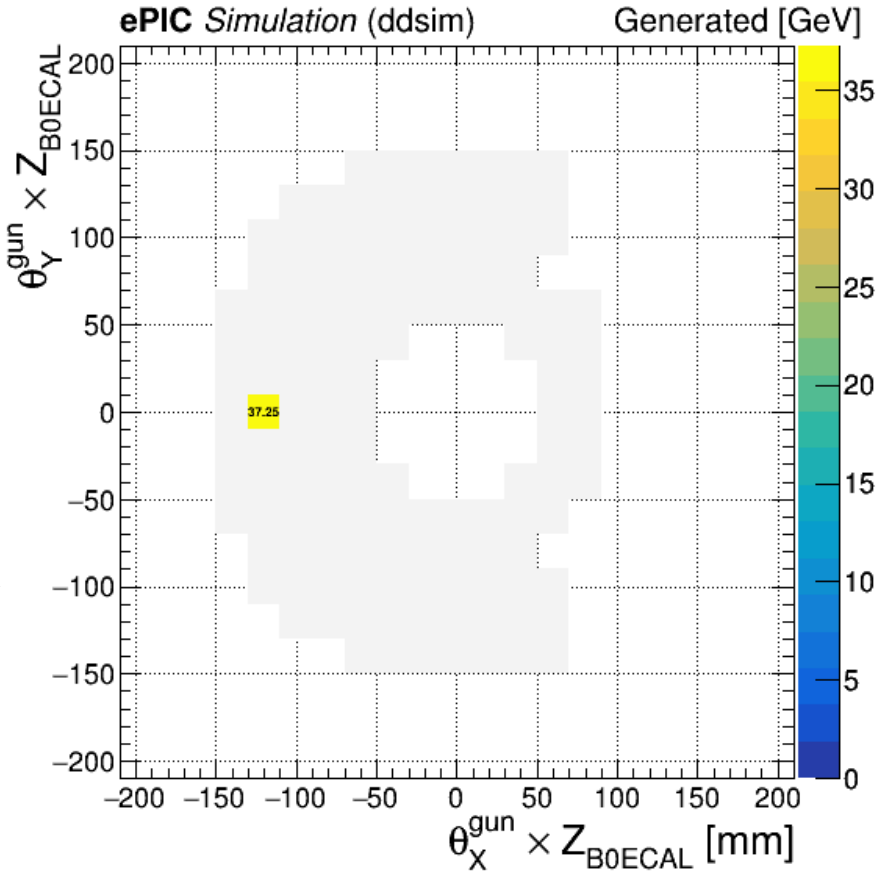
Definition

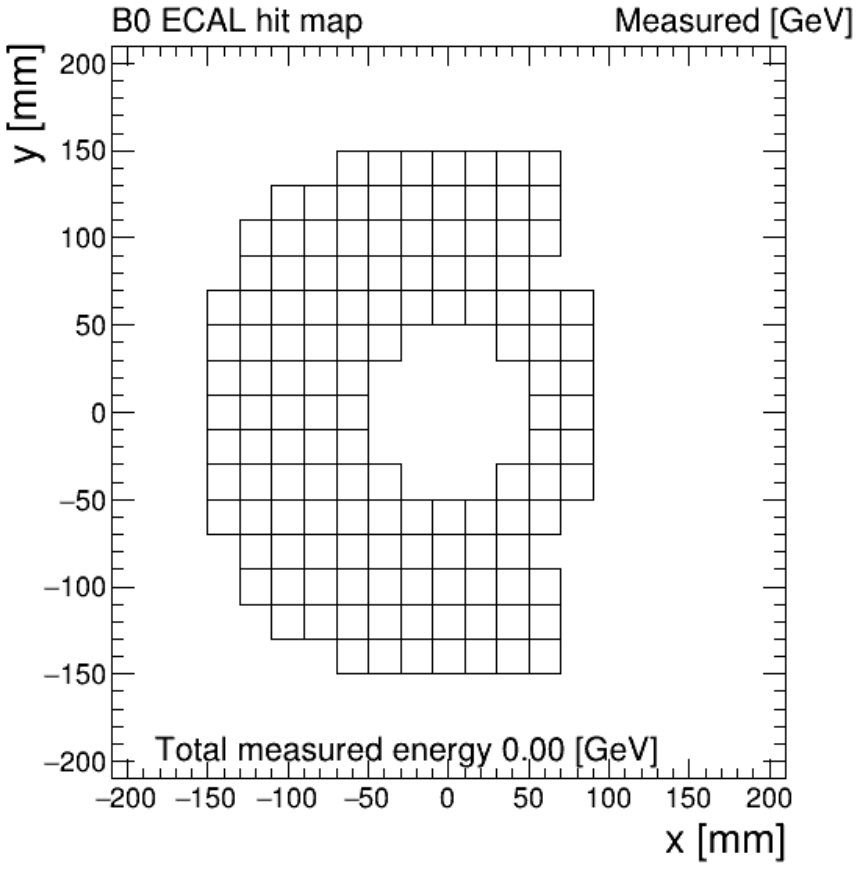
- Acceptance – events with energy deposit in the EMCAL (above given threshold) / total events

Example:

Photon undetected

Photon within B0 ECAL fiducial volume didn't reach the detector





Photon acceptance

Definition

- Acceptance – events with energy deposit in the EMCAL (above given threshold) / total events

Example:

Photon detected

Photon pointing to B0 ECAL, deposit ~5% of its energy ~everywhere