SciGlass: Performance Studies

Renee Fatemi, Dmitry Kalinkin

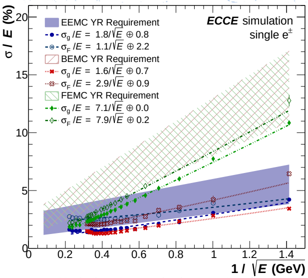
University of Kentucky

University of Kentucky

03/13/2023

Simulation studies

- **Fun4All for ECCE** with PANDA-like geometry



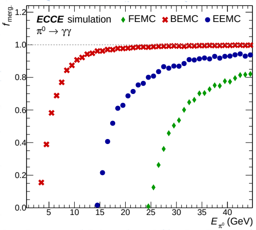


Figure 19: Fraction of neutral pions for which the showers from their decay photons are merged into a single cluster and can not be reconstructed using an invariant-mass-based approach for the different ECals.

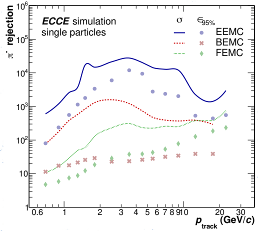


Figure 20: Pion rejection factor for the different ECals with $E/p > 1 - 1.6\sigma_e/E$ or based on a $\epsilon_e \approx 95\%$ cut.

https://arxiv.org/abs/2207.09437

- **Standalone Geant4** with optical photon propagation for beam tests
- **DD4hep-based ePIC simulation**

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Simulation studies

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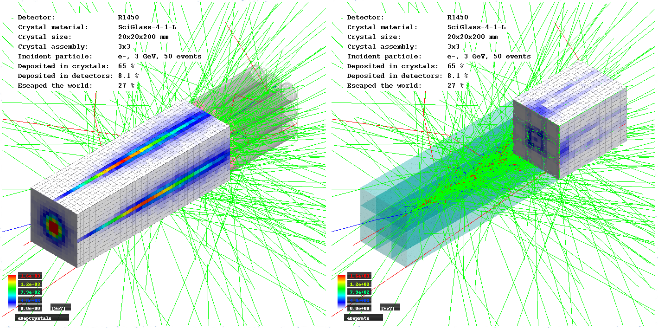
- **Standalone Geant4** with optical photon propagation for beam tests



- **DD4hep-based ePIC simulation** Subject of this talk

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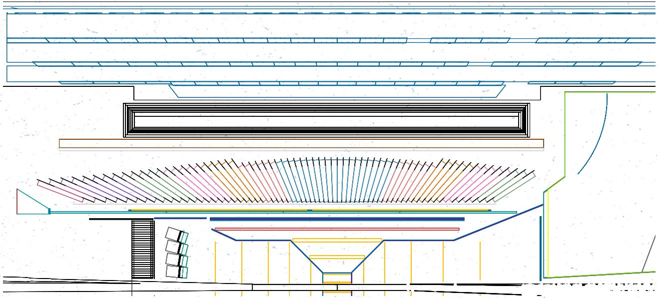
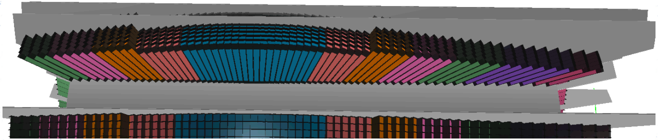
Simulation setup

- Single particle simulations
- Momentum direction sampled uniformly on a sphere
- Vertex at `(0, 0, 0)`
- ePIC 22.12.0 geometry
- `FTFP_BERT` physics list
- Particle momenta are used in place of reconstructed charged track momenta

SciGlass calorimeter geometry

Tower dimensions and placement implemented based on engineering design





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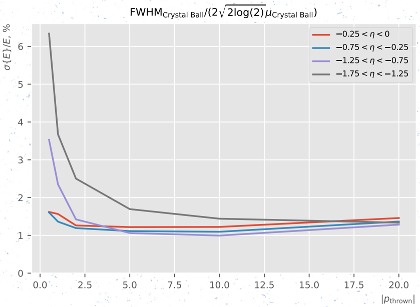
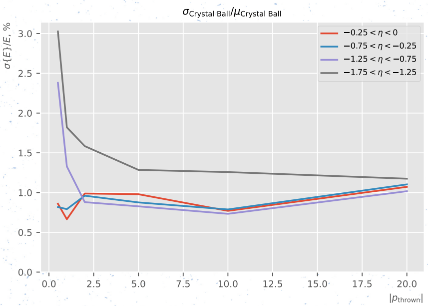
SciGlass material in Geant

- Density $4.22 g/cm^3$
- Energy deposits corrected according to the Birks' law with $kB = 0.0333$ mm/MeV (nominal for $PbWO_4$ at CMS)

Energy resolution





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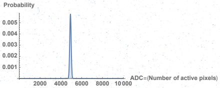
"kSiPM_photon_digitization" in Fun4All

» Defines a probability for a single pixel to fire:

$$P_{\text{pixel}} = 1 - \exp\left(-\frac{E_{\text{tower}} \times N_{\text{photoelectrons/GeV}}}{N_{\text{pixels}}}\right)$$

$$N_{\text{photons}} \sim \text{Binomial}(N_{\text{pixels}}, P_{\text{pixel}})$$

» Produces a following distribution of N_{photons} for a 1 GeV tower:



» And is converted back to energy using a "gain" of $\frac{1}{N_{\text{photoelectrons/GeV}}}$.

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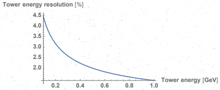
"kSiPM_photon_digitization" in Fun4All: resolution

» The resolution can be calculated as:

$$\frac{\delta E_{\text{tower}}}{E_{\text{tower}}} = \frac{N_{\text{pixels}}\sqrt{P_{\text{pixel}}\,(1 - P_{\text{pixel}})}}{N_{\text{pixels}}\,P_{\text{pixel}}}$$

» Which results in a following dependency:



» Note that this is for singular towers. For clusters or for full events, the observed resolution will degrade as the energy is split among several towers.

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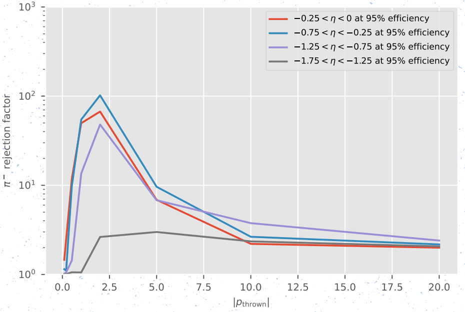
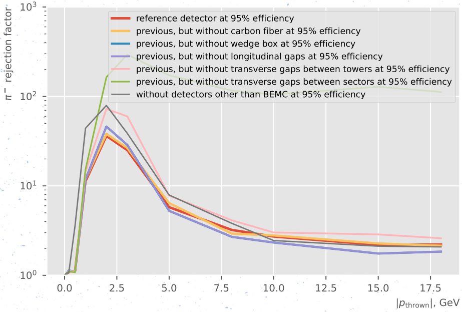
Pion rejection: η dependence





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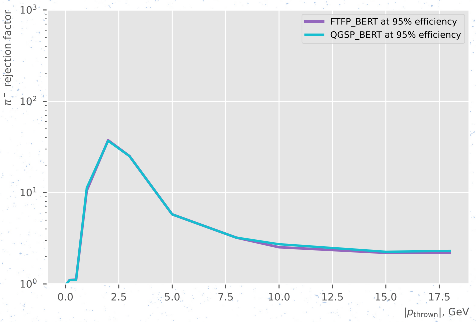
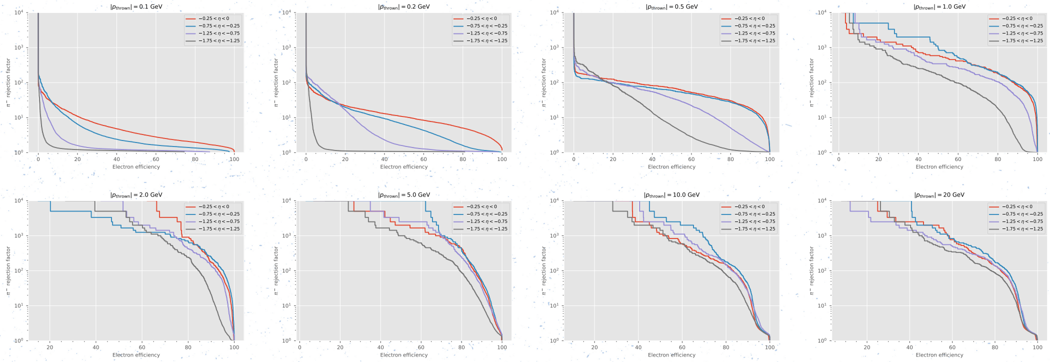
Systematics



Pion rejection: η dependence



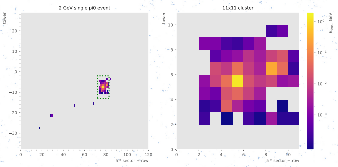
Island Clustering

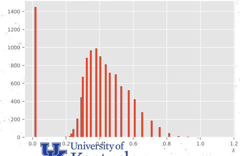
- Pick connected "islands" of hits
- Select islands with peak energy > threshold (50 MeV here)
- In each island, find hits that are local maxima w.r.t. 4 neighbours
- Select local maxima above a threshold (100 MeV here – yeah, should be 50)
- For hit h calculate its distance d_{hm} to each local maxima hit m, the weight is

$$\omega_{hm} \sim E_m \exp\left(-\frac{d_{hm}}{\lambda}\right)$$

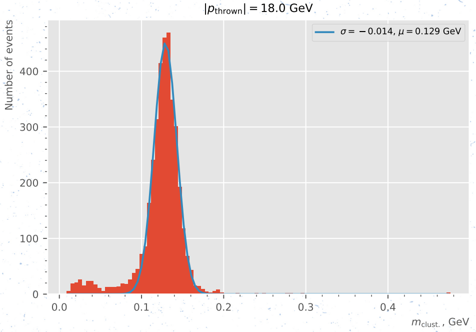
- Fraction proportional to ω_{hm} of energy E_h is attributed to a subcluster m.

For each island calculate $\chi^2 = \sum_h \left(\sum_m E_m \exp\left(-\frac{d_{hm}}{\lambda}\right) - E_h\right)^2$, minimize χ^2 over λ





π^0 reconstruction



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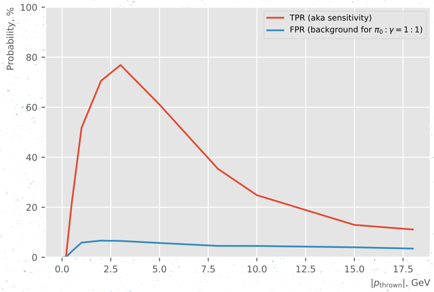
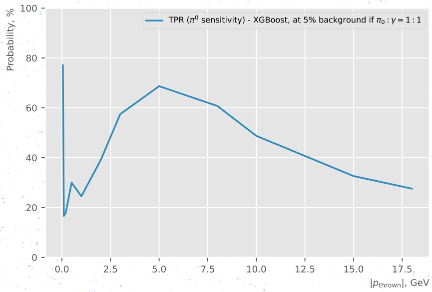
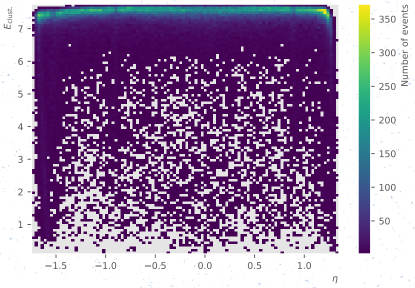
π^0/γ separation

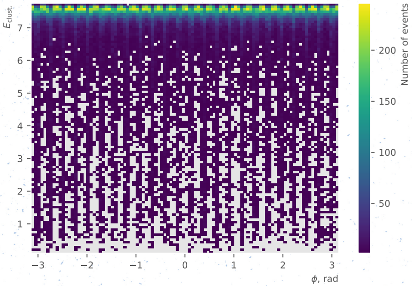




Naive method based on counting local maxima and ML based on 5x5 cluster information

Reconstructed cluster energy response





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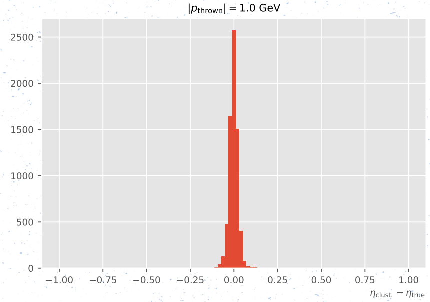
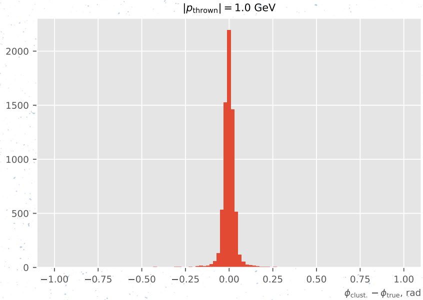
Angular resolution





Detector optimization using ML

TBD