# First look at EEmcCal response in ECCE

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# Electron ID and background algorithms

I. ***e-/$\pi$- Discrimination*** - cannot separate e- and $\pi$- from tracking alone.
   A. $A_{PV}$ requires $\pi$-/e- of ~0.001 to remain statistics limited
   B. $A_{LL}$ requires $\pi$-/e- of ~0.01 to remain statistics limited

II. ***Pair Symmetric Backgrounds*** - correctly ID the e- but it doesn't originate from the beam.
   A. Dalitz decays
   B. Pair production from material interactions.

| $E^{e^-}_{beam}$ (GeV) | $\eta$ bin | $P^{e^-}_{min}$ (GeV) | Max $\pi^-/e^-$ | final $\pi^-/e^-$ ratio |
|---|---|---|---|---|
| 18 | (-3.5,-2) | 0.9 | 200 | 0.02 |
| 18 | (-2,-1) | 0.9 | 800 | 0.08 |
| 18 | (-1, 0) | 1.0 | 1000 | 0.1 |
| 18 | (0, 1) | 1.8 | 100 | 0.01 |
| 10 | (-3.5,-2) | 1.4 | 10 | 0.001 |
| 10 | (-2,-1) | 0.5 | 400 | 0.04 |
| 10 | (-1, 0) | 0.6 | 800 | 0.08 |
| 10 | (0, 1) | 1.0 | 1000 | 0.1 |
| 5 | (-3.5,-2) | 2.8 | 0.1 | 0.00001 |
| 5 | (-2,-1) | 0.4 | 100 | 0.01 |
| 5 | (-1, 0) | 0.3 | 500 | 0.05 |
| 5 | (0, 1) | 0.5 | 1000 | 0.1 |

**Table 8.1:** The minimum detected $e^-$ momentum (column 3), the maximum $\pi^-/e^-$ ratio for electrons with $p^{e-} > P^{e-}_{min}$ (column 4) and the final $\pi^-/e-$ ratio after the $10^4$ suppression determined for the original baseline detector (column 5) for each $e^-$ beam energy and scattered electron $\eta$ bin. The calculation of $P^{e^-}_{min}$ includes a $Q^2 > 1$ GeV$^2$ and $y < 0.95$ requirement.

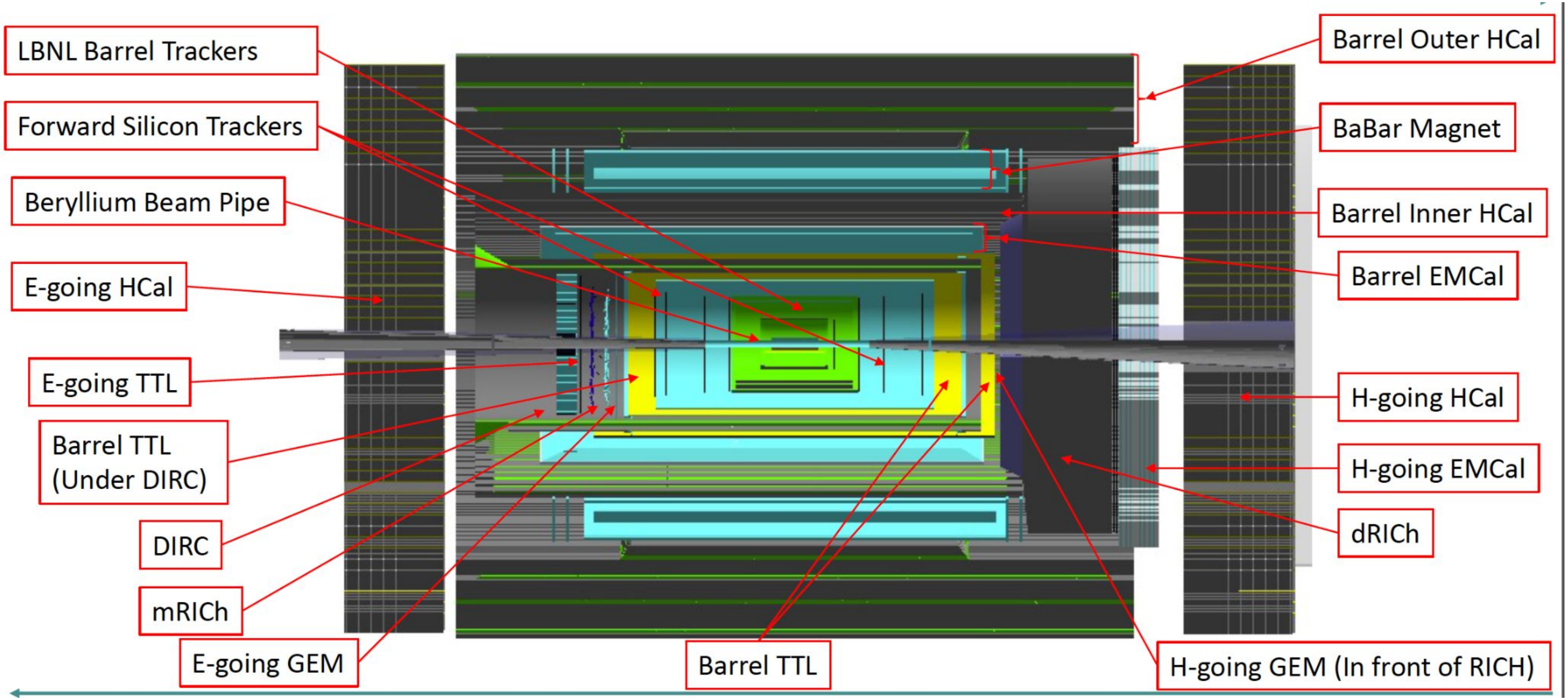
From the Yellow Report
*https://arxiv.org/pdf/2103.05419.pdf*

# Electron ID and background studies

1. Revisit e-/e+/$\pi$-/$\pi$+/$\gamma$ yields by detector region using full event simulations
   a. PYTHIA6 ep 18x100 GeV low Q2
   b. PYTHIA6 ep 18x100 GeV high Q2
2. Study basic detector response with single particle flat e-/$\pi$+ simulations
   a. EEMC/CEMC response as a function of particle momentum.
   b. Tracking reconstruction as a function of particle momentum.
3. Baseline E/P study
   a. Determine E/p threshold for each momentum bin for fixed reconstruction efficiency (90%,95%).
   b. Determine pi- suppression as a function of momentum.
   c. Repeat with additional information from DIRC/mRICH
4. Investigate HCAL and ECAL in-cluster topologies
   a. Study tower multiplicity and energy distribution for the scattered e- clusters, as a function e- p and $\eta$
   b. Repeat study for clusters associated with $\pi$- and pair-symmetric backgrounds.
   c. Investigate photon contribution to energy of scattered e- clusters
5. Investigate HCAL and ECAL out-of-cluster event topologies (*this idea from Barak Schmookler*)
   a. Study track and tower multiplicities in events outside of e- cluster
   b. Repeat study for $\pi$- and pair symmetric e- clusters
6. Feed *in-cluster* and *out-of-cluster* topologies into machine learning algos for an improved e-/$\pi$-/$\gamma$ ID.

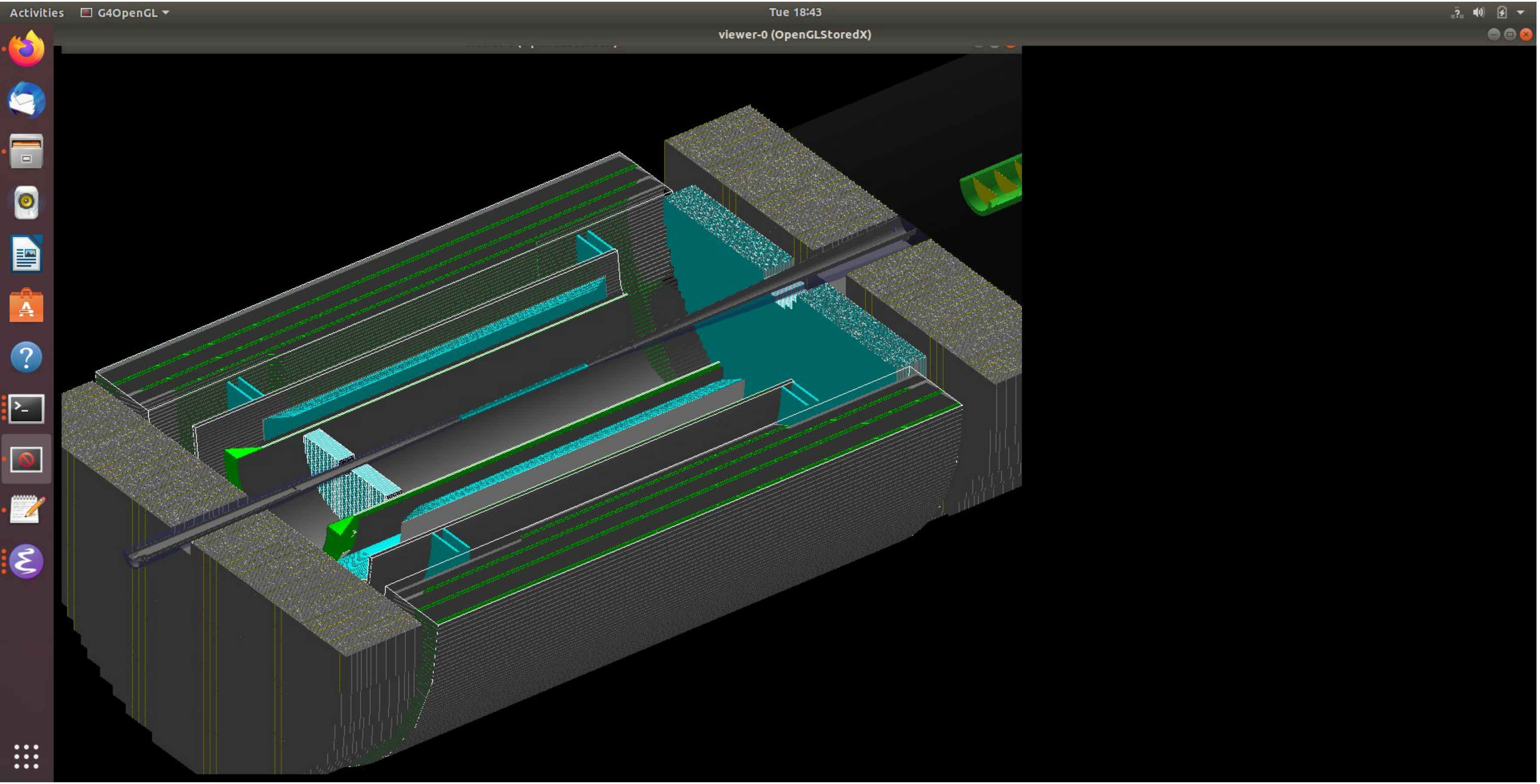
START with ECCE detector because simulations available, but would like to expand to ATHENA and CORE.

# ECCE Detector

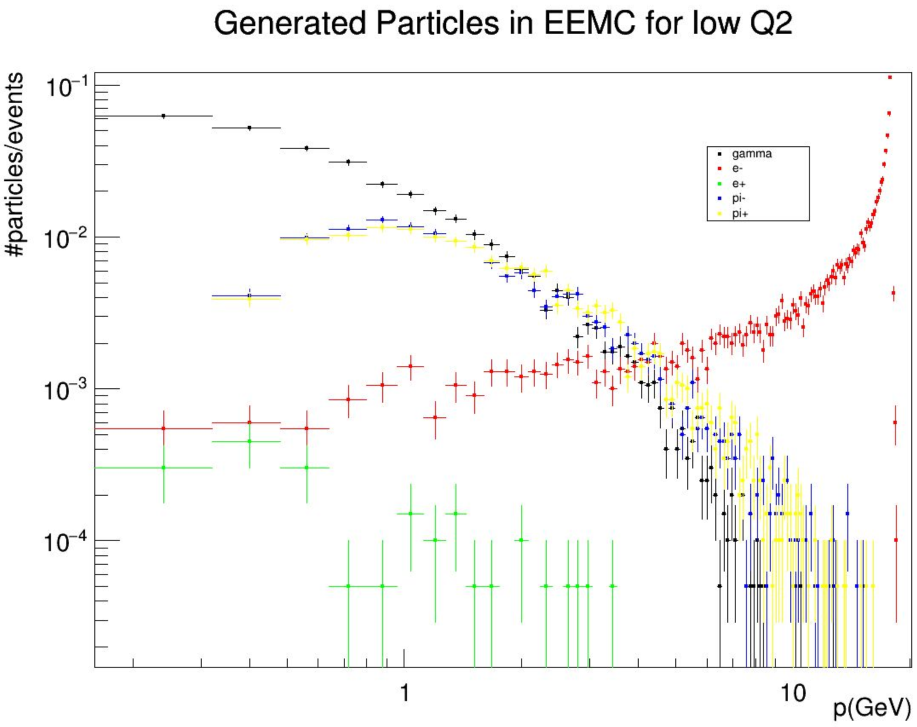


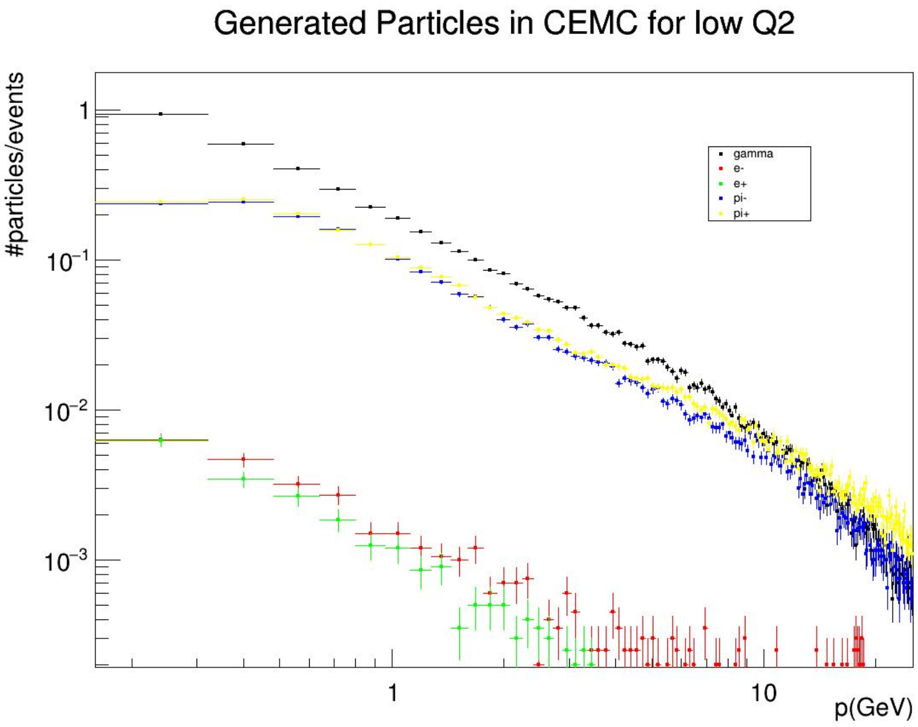

*Cameron Dean, ECCE 3rd Simulation Workshop*

# ECCE Detector

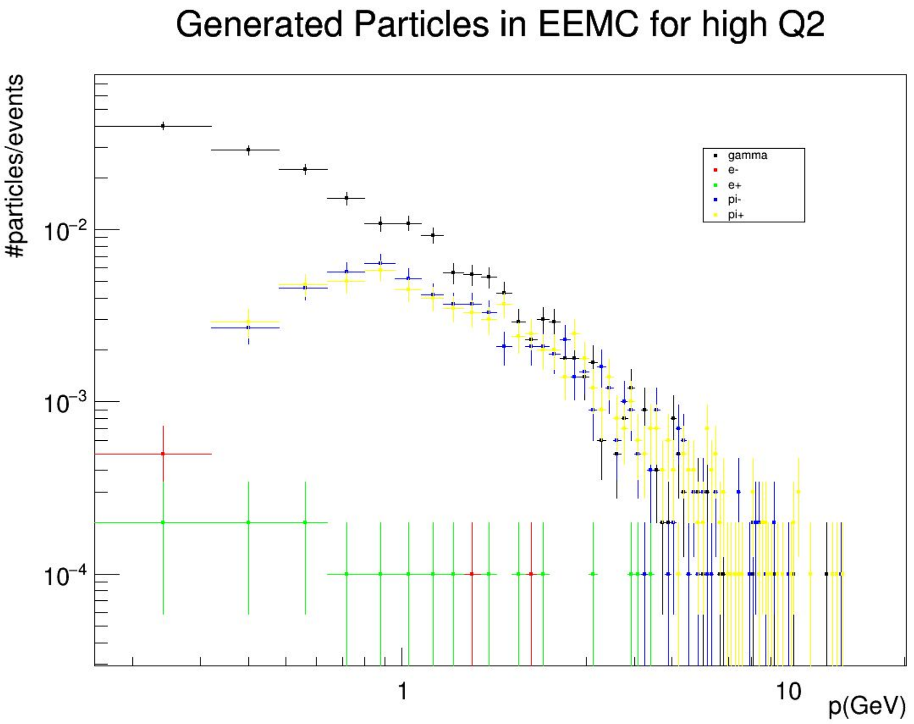


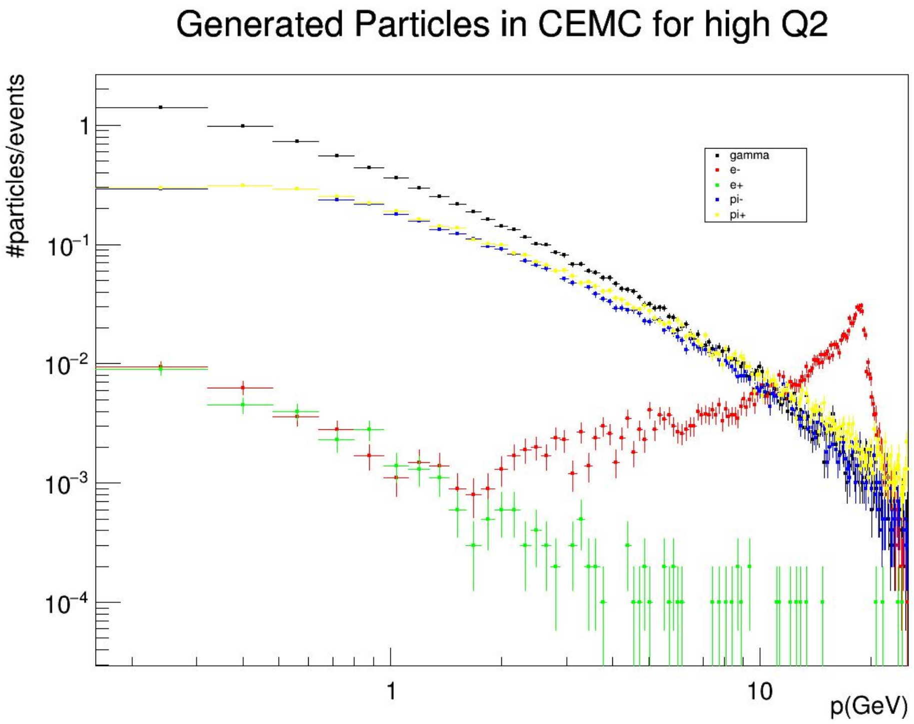
# 1a. Generated Distributions for 18x100 low $Q^2$ Pythia



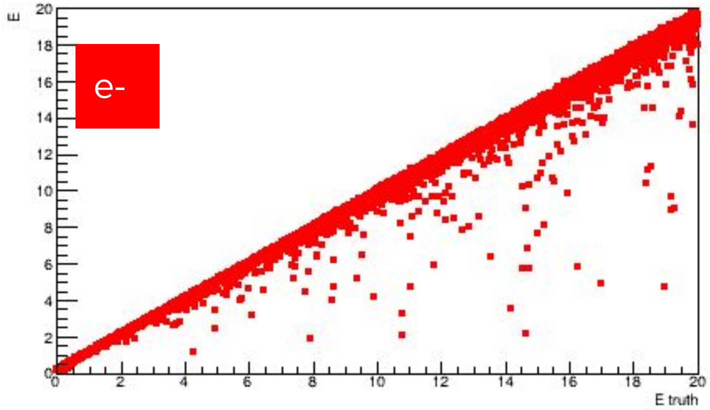
# 1b. Generated Distributions for 18x100 high $Q^2$ Pythia

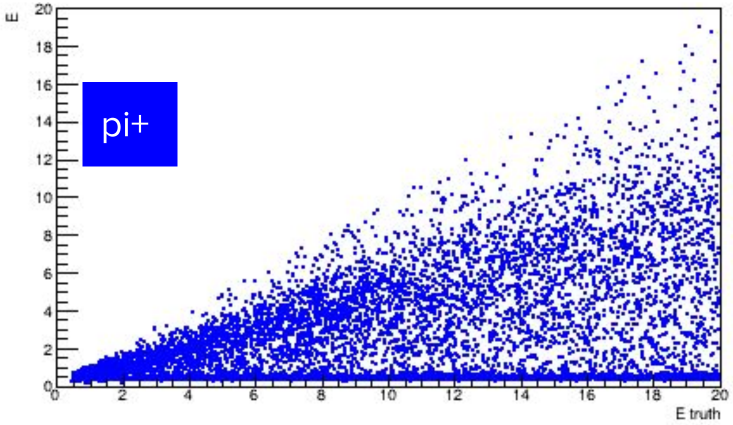


# 2a. Calo Response

EEMC



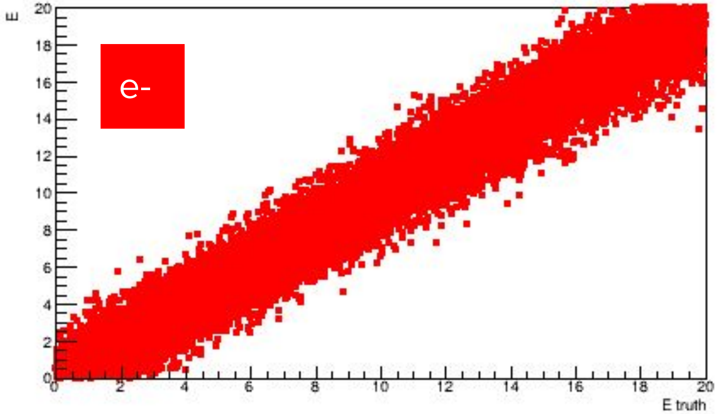

Single e-/**π**+ simulation

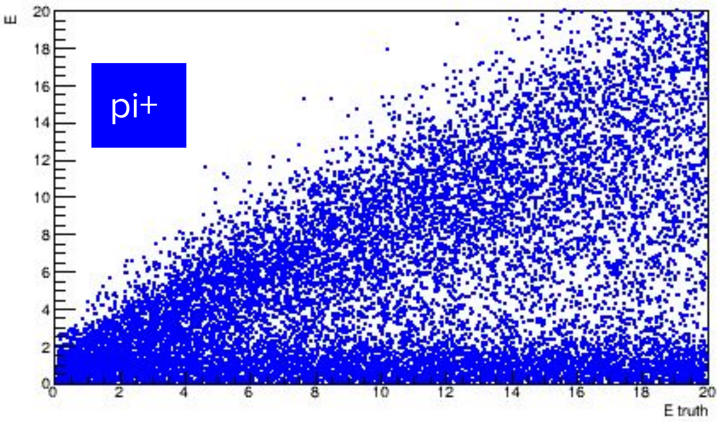
Eliminate clustering effects - sum all tower energies and plot vs thrown energy.

$E_{e-}$ resolution much better for EEMC than CEMC

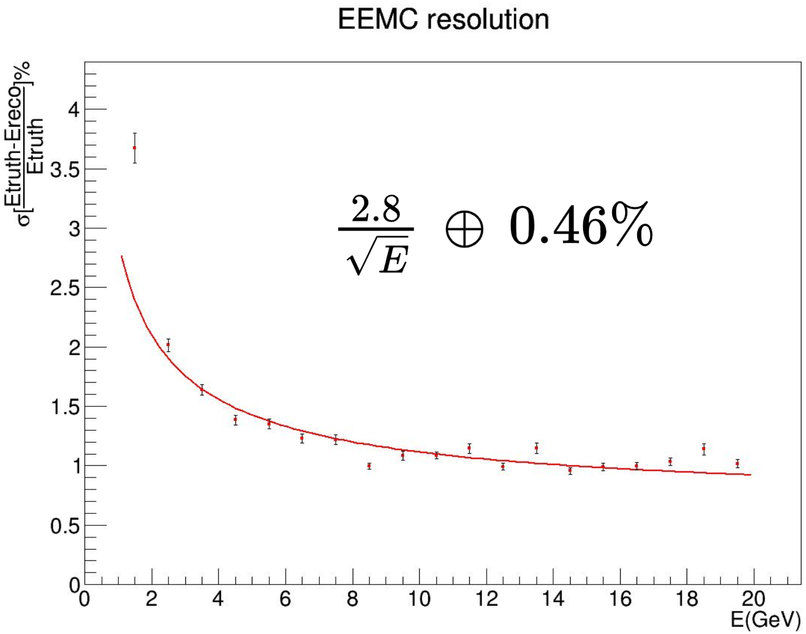
Broad **π**+ response.

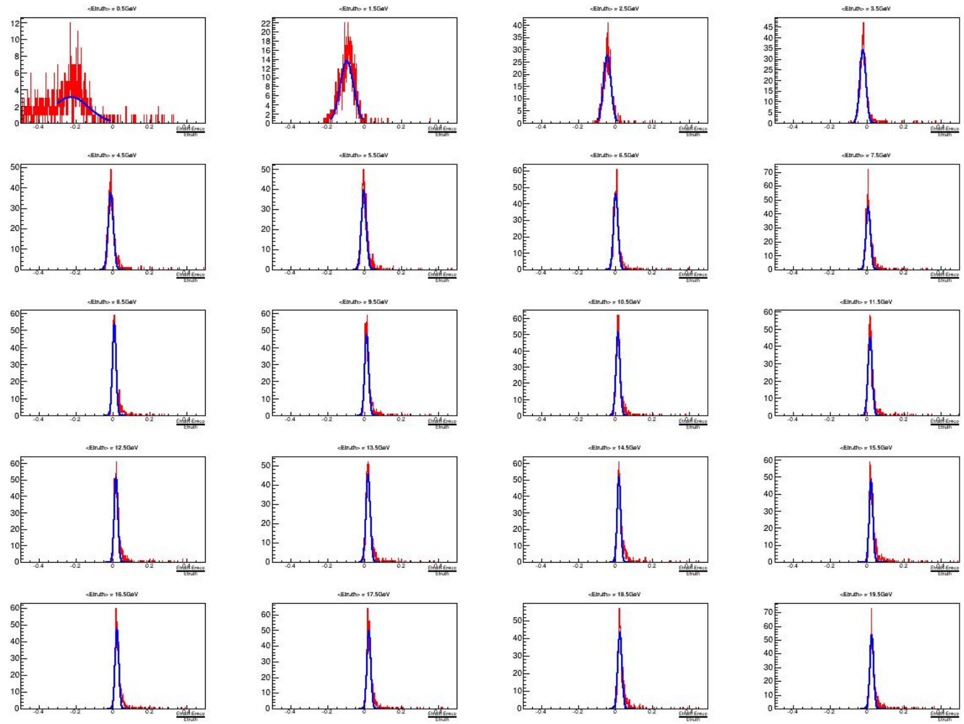
CEMC



# Single particle e-  EEMC Tower Sum



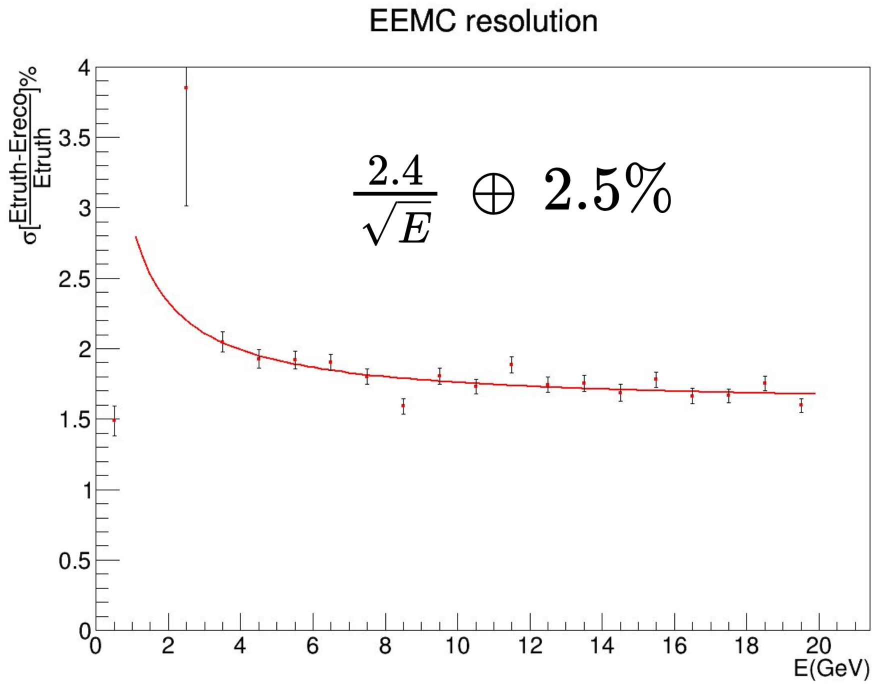



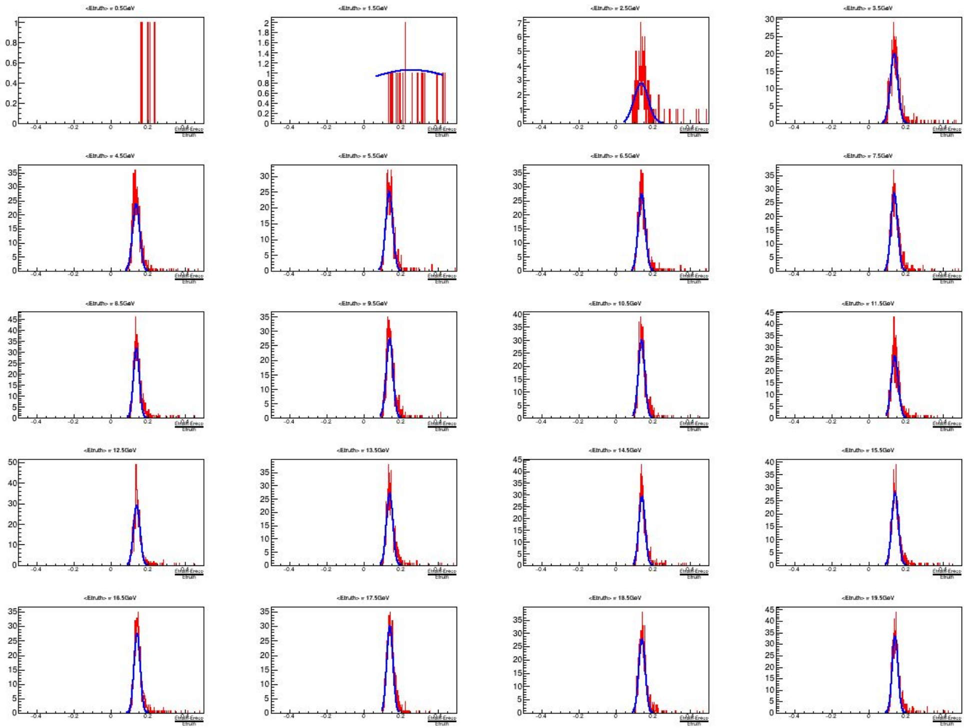
**Note:** Can get just as good of a fit including 1/E term, but it doesn't physically make sense for this simulation.

# Single particle e- EEMC Clusters

e- is matched to cluster if

$$\Delta R = \sqrt{\Delta\phi^2 + \Delta\eta^2} < 0.22$$



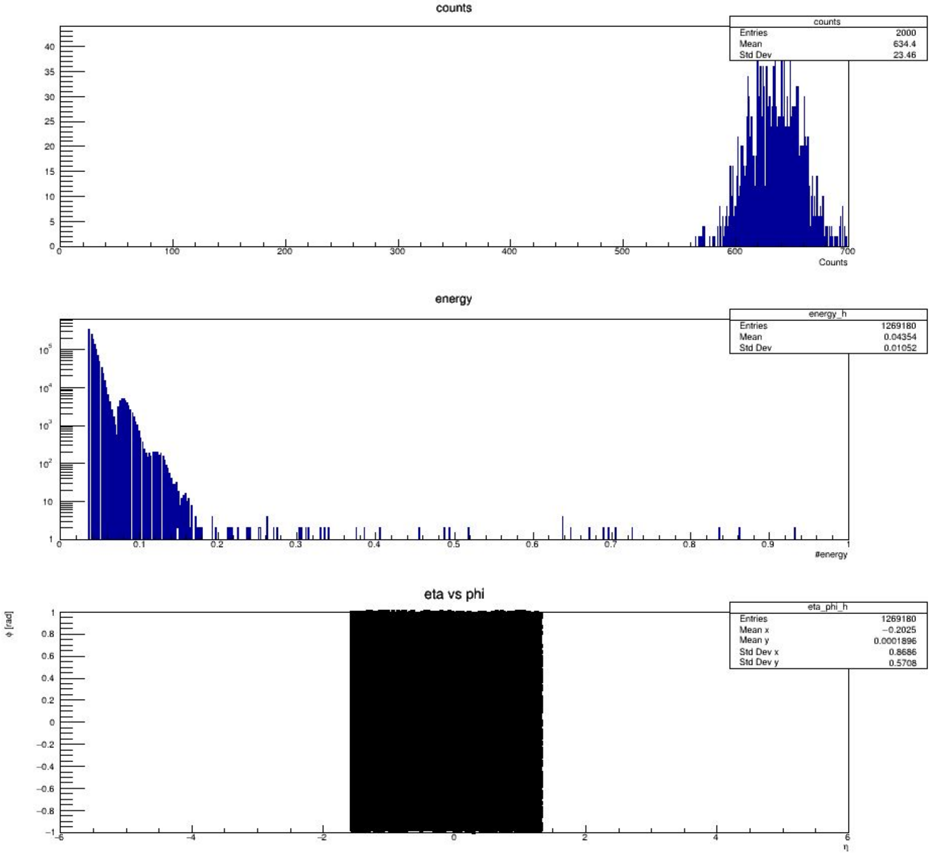



# Single particle e-  CEMC Clusters

<#clusters>/event in CEMC is 636!
<#clusters>/event in EEMC is 1.2.

Matching in CEMC is fraught. Looks like simulation incorporates realistic estimates of noise, but cluster threshold is not set high enough to eliminate “noise clusters”.

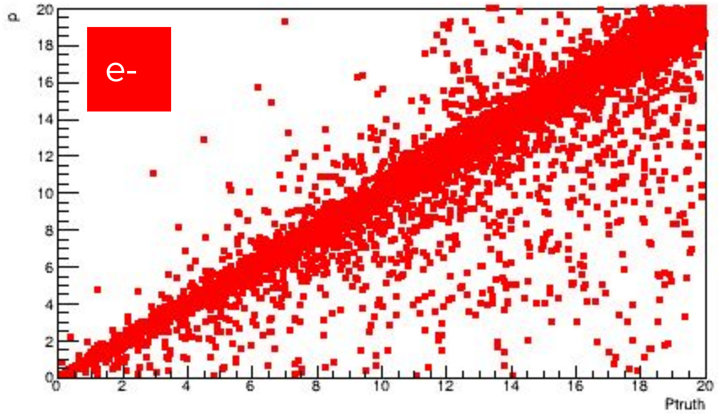
It is possible to find resolution using cluster energies “close” to truth energy.

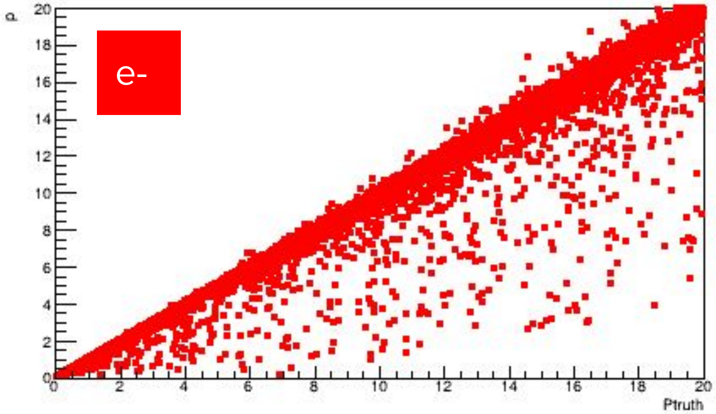


# 2b. Track Reconstruction

EEMC

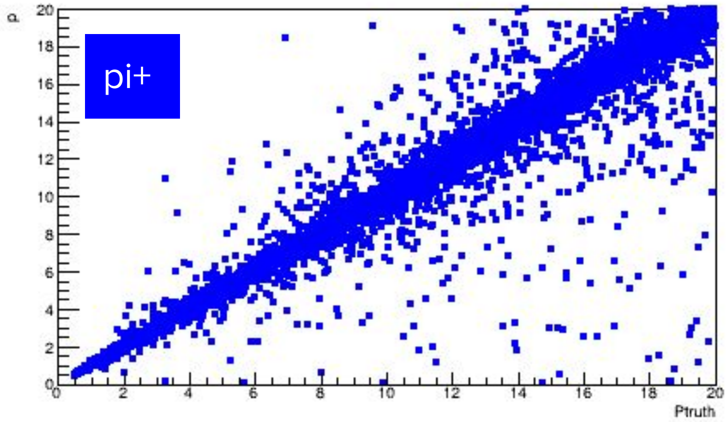
CEMC

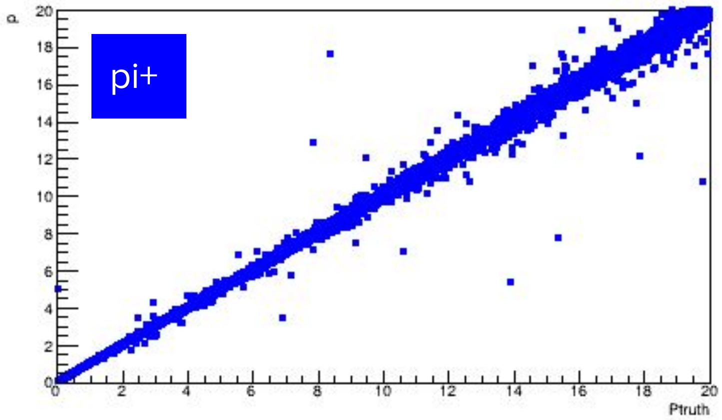



Single e-/π+ simulation.

Tracking resolution better in central than backward region.

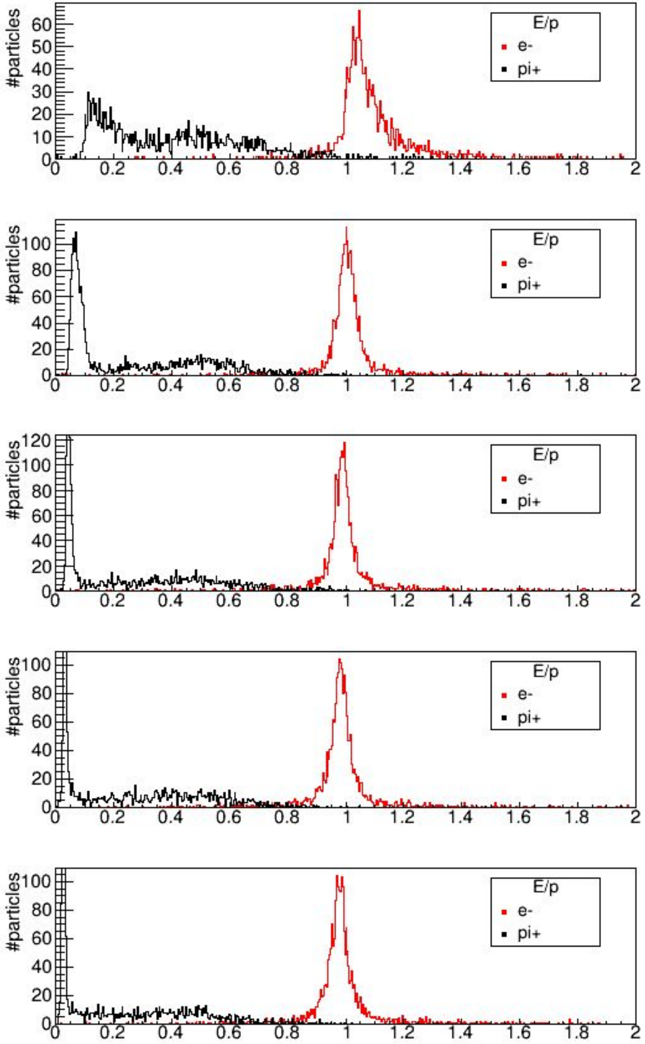



Resolution better for π+ than e- in central region.

Are these material effects?

# 3. E/P in EEMC



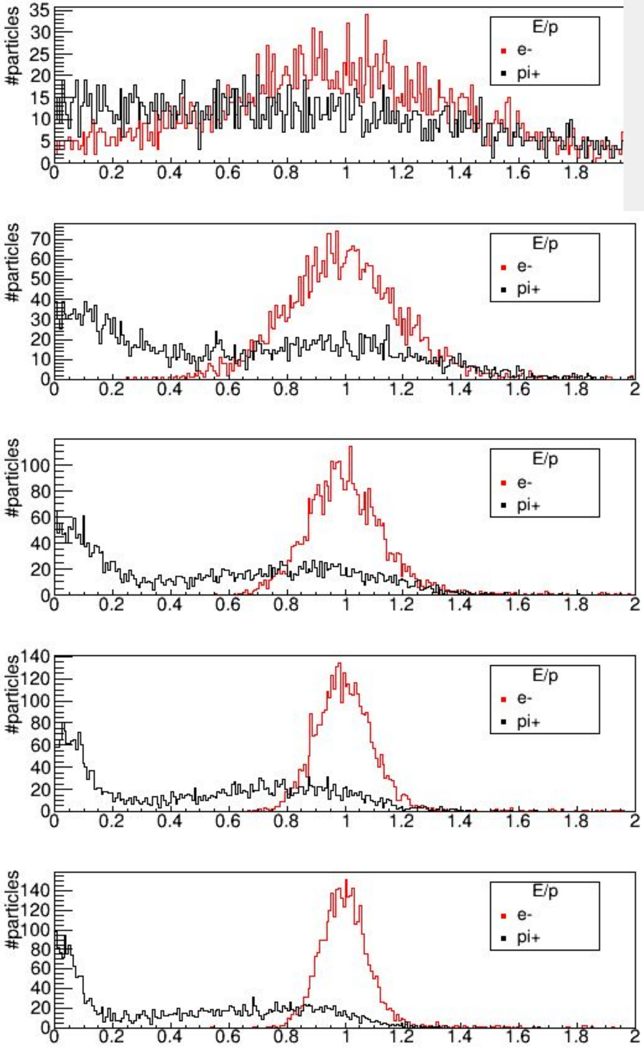

P = 2 GeV

P = 6 GeV

P = 10 GeV

P = 14 GeV

P = 18 GeV




# 3. E/P in CEMC

# Next Steps

1. Determine E/P thresholds for given electron reconstruction efficiency
2. Make first estimate of pion suppression factors
3. Start studying cluster topologies.