Fun4All Software Validation

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Work Detail

❖ Energy resolution and parameterization of energy resolution of Calorimeters in Fun4All framework – to be used in EIC-smear
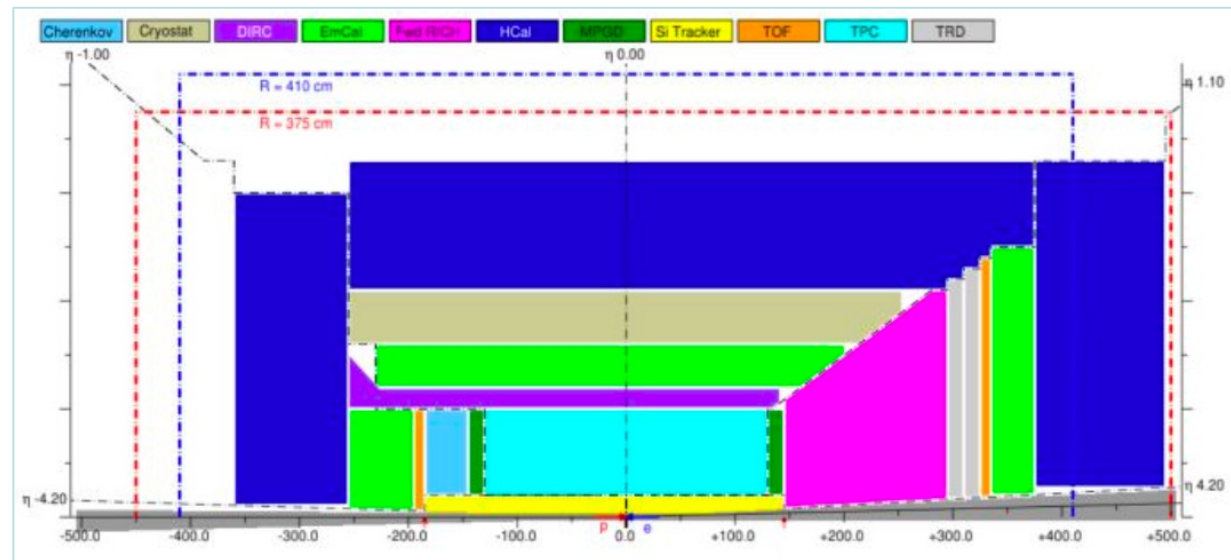
Details of Calorimeters:

Electromagnetic Calorimeters (EMCAL):
Lead Tungstate (PWO) crystals

- Midrapidity (Barrel) (CEMC): $-1.5 < \eta < 1.2$
- Forward rapidity (Ion/forward direction) (FEMC): $1.3 < \eta < 3.3$
- Backward rapidity (Electron/backward direction) (EEMC): $-3.5 < \eta < -1.7$

Hadronic Calorimeters (HCAL): Steel absorber (inner), Al Absorber (outer) + plastic scintillator

- Forward region (FHCAL): $1.2 < \eta < 3.5$
- Barrel (HCALIN, HCALOUT): $-1.1 < \eta < 1.1$

| Cherenkov | Cryostat | DIRC | EmCal | Fwd RICH | HCal | MPGD | Si Tracker | TOF | TPC | TRD |

Ref.: EIC Yellow Report

Work Detail

❖ Particles used : e-, π^-
❖ Events analyzed: 100000 (0-30 GeV) + 50000 (0-15 GeV)

Electrons: Resolution obtained separately for CEMC, FEMC, EEMC
Pions: Resolution for common eta regions: -1.1 < η < 1.1 (CEMC, HCALIN, HCALOUT) and 1.3 < η < 3.3 (FEMC, FHCAL)

❖ Considering simplest case:
  ▪ Photon digitization noise turned off.
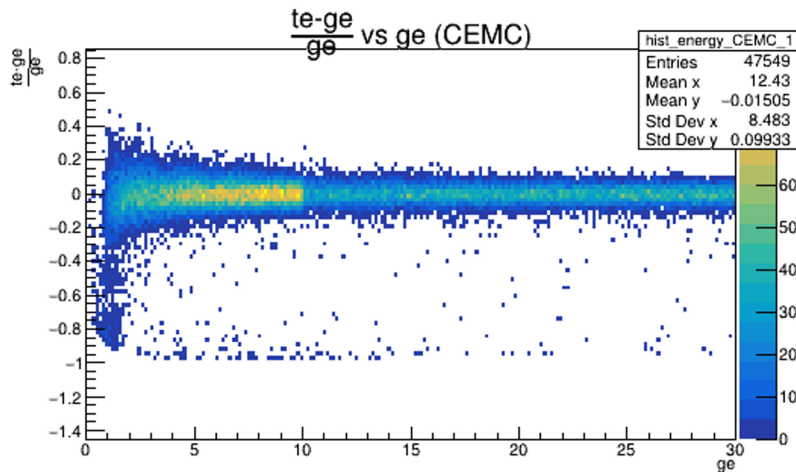 ▪ Manual clustering performed on towers – circular cuts phi vs eta differences.
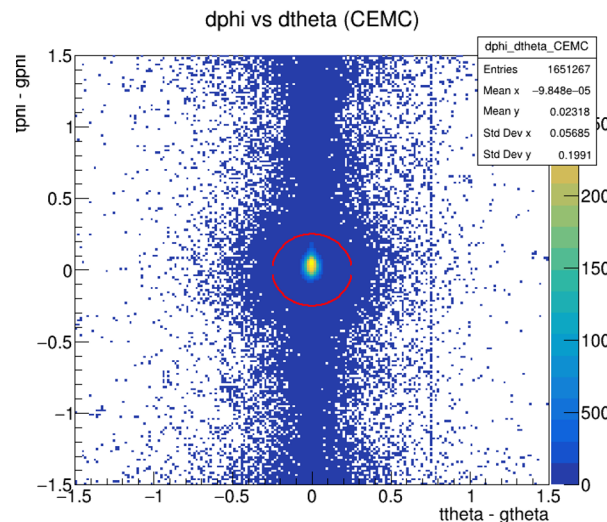
Electron: Calibration
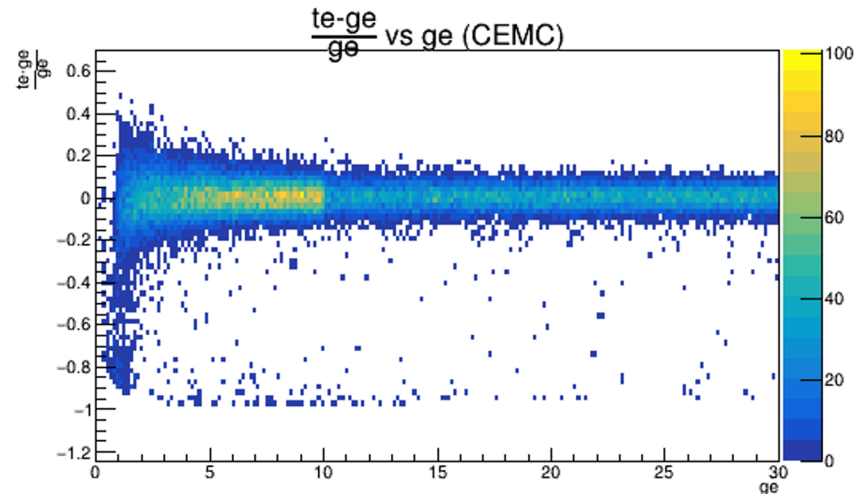
Electron calibration procedure:

- Obtain ratio of reconstructed tower energy (te) to generated (ge) versus generated (ge)

- Parameterize using a suitable fit function
- Do the calibration as:
  te(calibrated) = te(raw)/fit_function

CEMC:

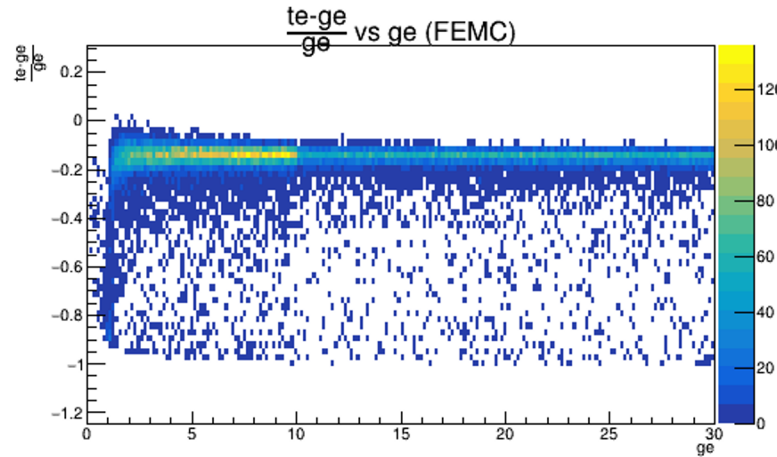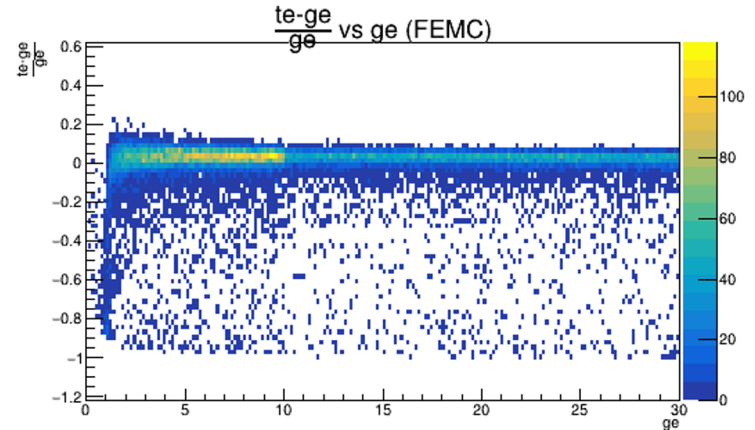Before   After

Electron: Calibration

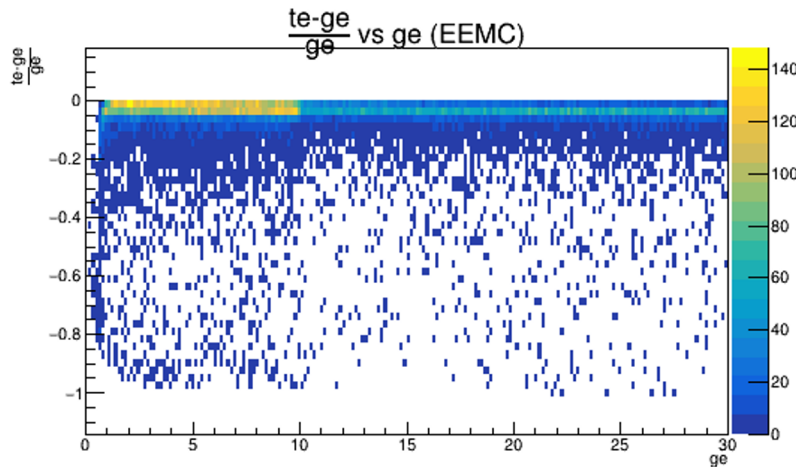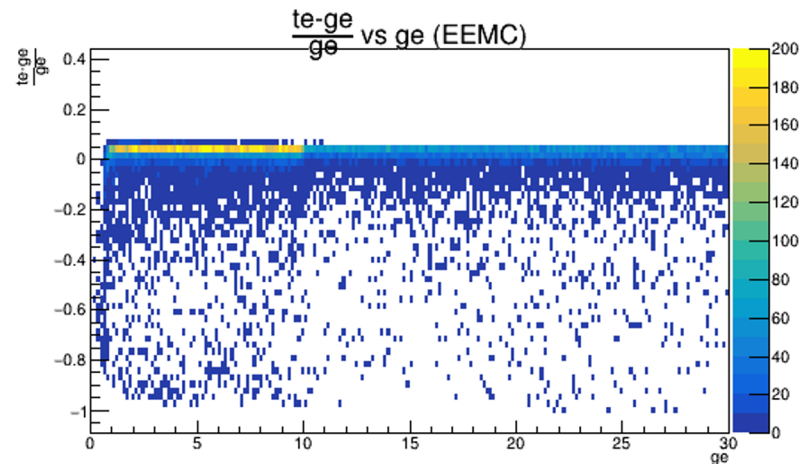**FEMC:**   Before   After

EEMC: Before   After
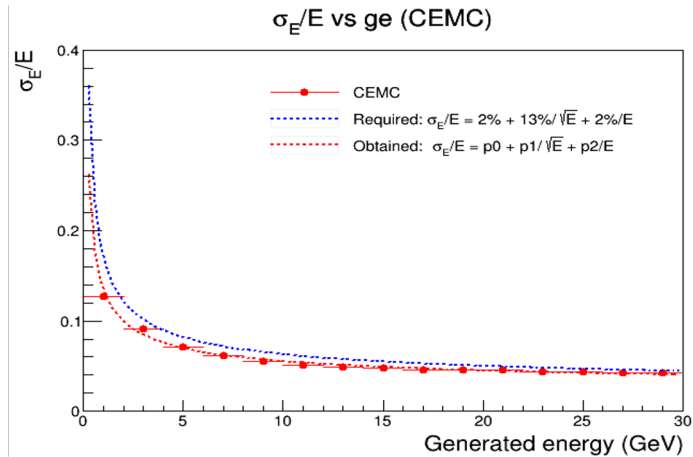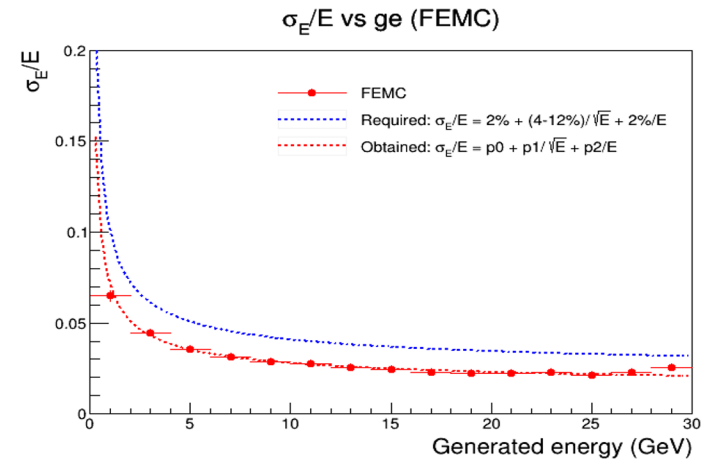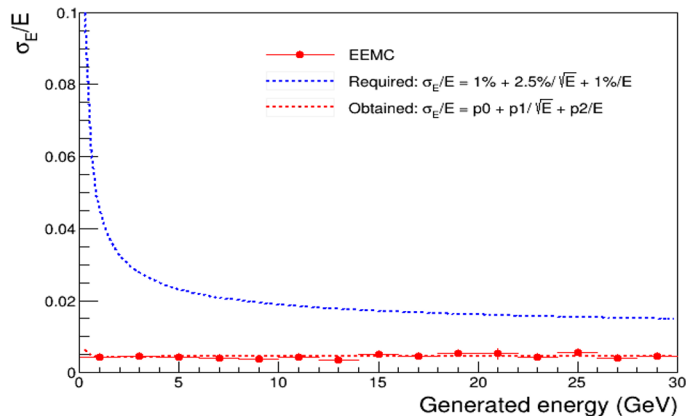
Electron: Energy Resolution

CEMC:

$\sigma_E/E = 2.0520\% + 10.534\%/\sqrt{E} + 2\%/E$

FEMC:

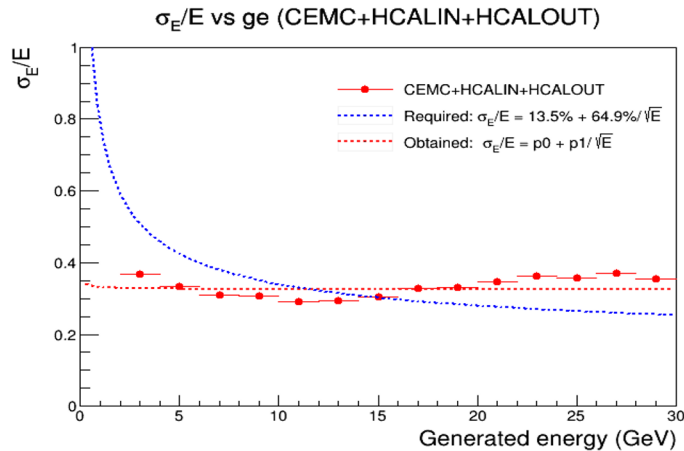$\sigma_E/E = 1.15892\% + 4.84642\%/\sqrt{E} + 1.08484\%/E$

EEMC:

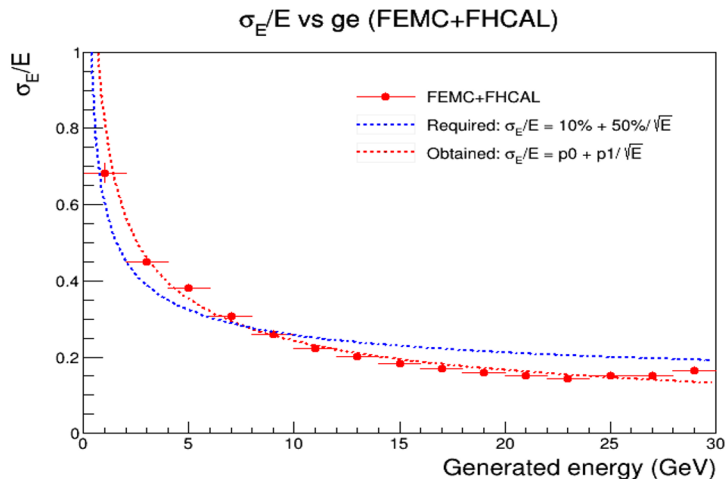$\sigma_E/E = 0.493094\% + 0.162239\%/\sqrt{E} + 0.117333\%/E$

Pion: Energy Resolution

Barrel region: CEMC + HCALIN + HCALOUT

$\sigma_E/E = 32.253\% + 0.979982\%/\sqrt{E}$

Forward region: FEMC + FHCAL

$\sigma_E/E = -2.06291\% + 83.4022\%/\sqrt{E}$

Experience and Interest

Panjab University

S. No.	Manpower	Current work	Interest	Availability
1	Lokesh Kumar (Faculty) *(lokesh@pu.ac.in)*	Fun4ALL validation – energy resolution of calorimeters	DWG: Calorimetry/PID PWG: Jets/HF	As a supervisor
2	Simran (Student)	- same -	- same -	Till March-2022

IIT Indore

| S. No.	Manpower	Current work	Interest	Availability
1	Ankhi Roy (Faculty) *(ankhi@iiti.ac.in)*	Fun4ALL validation – energy resolution of calorimeters	PID, Calorimetry, Exclusive	As a supervisor
2	Sagar (Student)	- same -	- same -	One year
3	Siddhant (Student)	- same -	- same -	One year

Back-up

Pion: Calibration

**Pion calibration procedure:**

- Obtain ratio of reconstructed tower energy (te) to generated (ge) versus generated (ge)

- Parameterize using a suitable fit function
- Calibrate the tower energy of respective calorimeter as: te(scaled) = [te(raw)/fit_function] * (mean of te/ge)
- Add the corresponding scaled tower energies
- Obtain te/ge vs ge for summed-up scaled energies and fit using a function.
- Calculate the final calibrated tower energy as: te(calibrated) = te(summed)/fit_Function

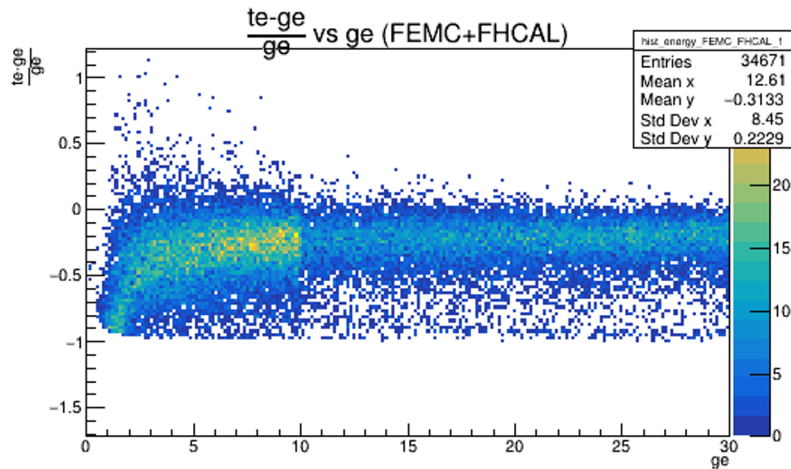**Before**   **After**

Barrel region:
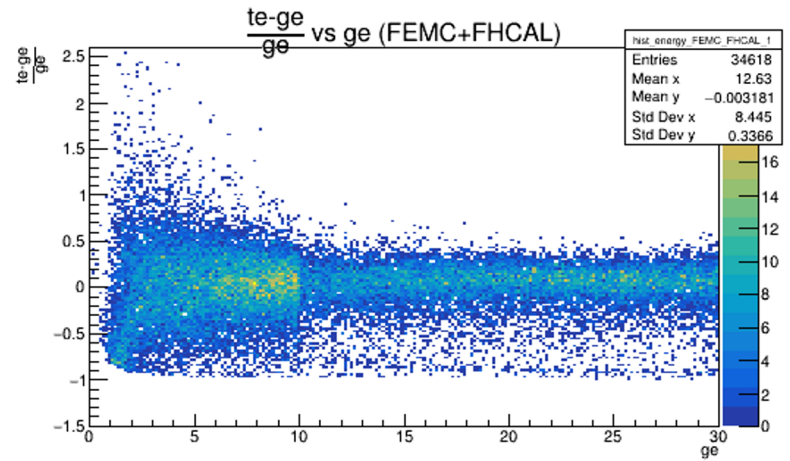CEMC +
HCALIN +
HCALOUT
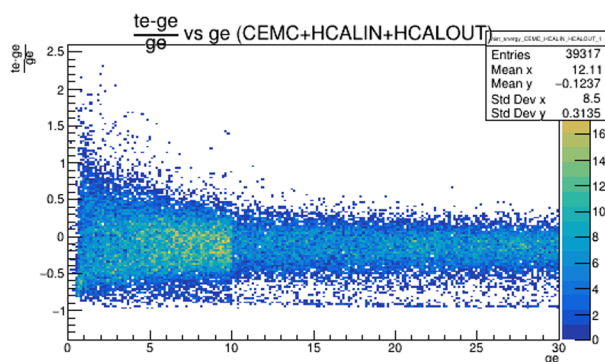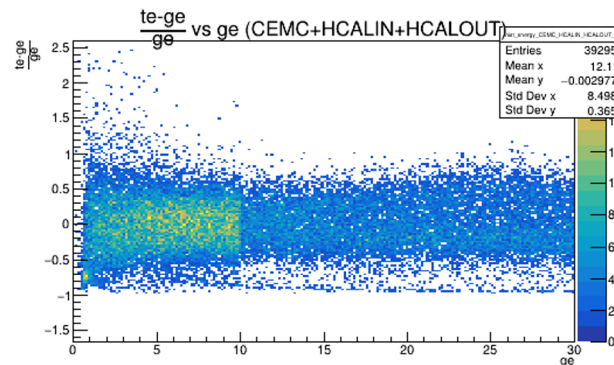
Pion: Calibration

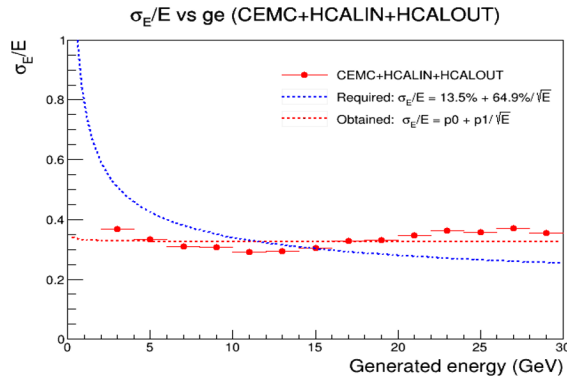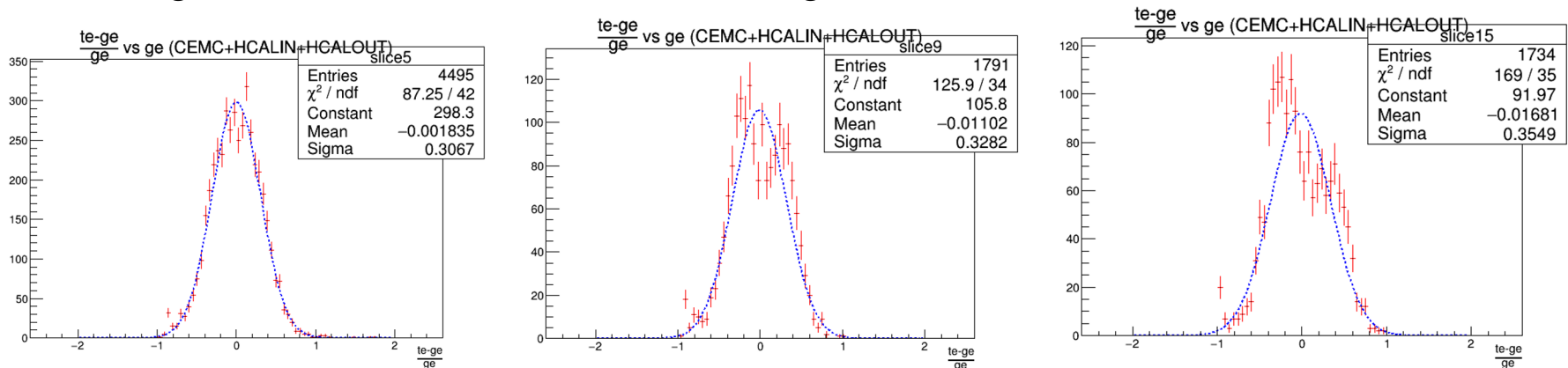**Forward region: F**EMC + FHCAL

Before

After

Pion: Energy Resolution

Barrel region: CEMC + HCALIN + HCALOUT

$$\sigma_E/E = 32.253\% + 0.979982\%/\sqrt{E}$$

- Unexpected worsening in energy resolution at high energies for barrel calorimeters.
- Arising due to a second peak appearing in the case of ΔE/E distribution at high energies – not observed for forward region.

Summary & Outlook

- ❖ Study of energy resolution of calorimeters within Fun4All framework

- ❖ Electrons show acceptable results.

- ❖ Pion energy resolution has issue towards higher energies – further investigation required.

Next steps:

- ❖ Investigate issue in case of barrel for pions.

- ❖ Turn on the photon digitization to see the affect of noise on resolution.

Future directions:

- ❖ Tracking QA

- ❖ Study different input generators Pythia6, Pythia8, SARTE..