



Simulation Statistics

By Sagar and Siddhant
Under the guidance of Dr. Ankhi Roy, Dr. Chris Pinkenburg, and Dr. Kolja Kauder

February 11, 2021

IIT Indore

Contents

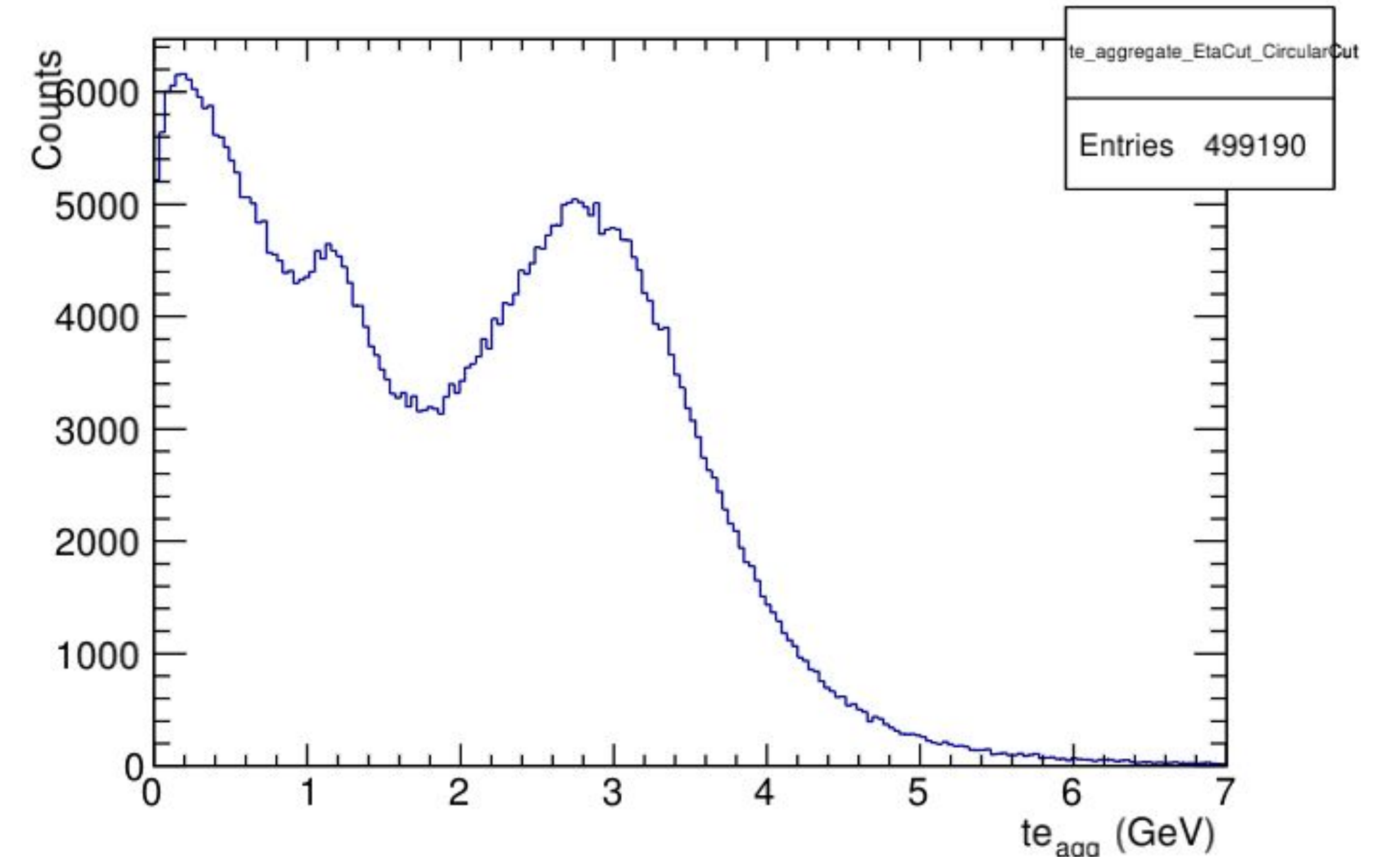
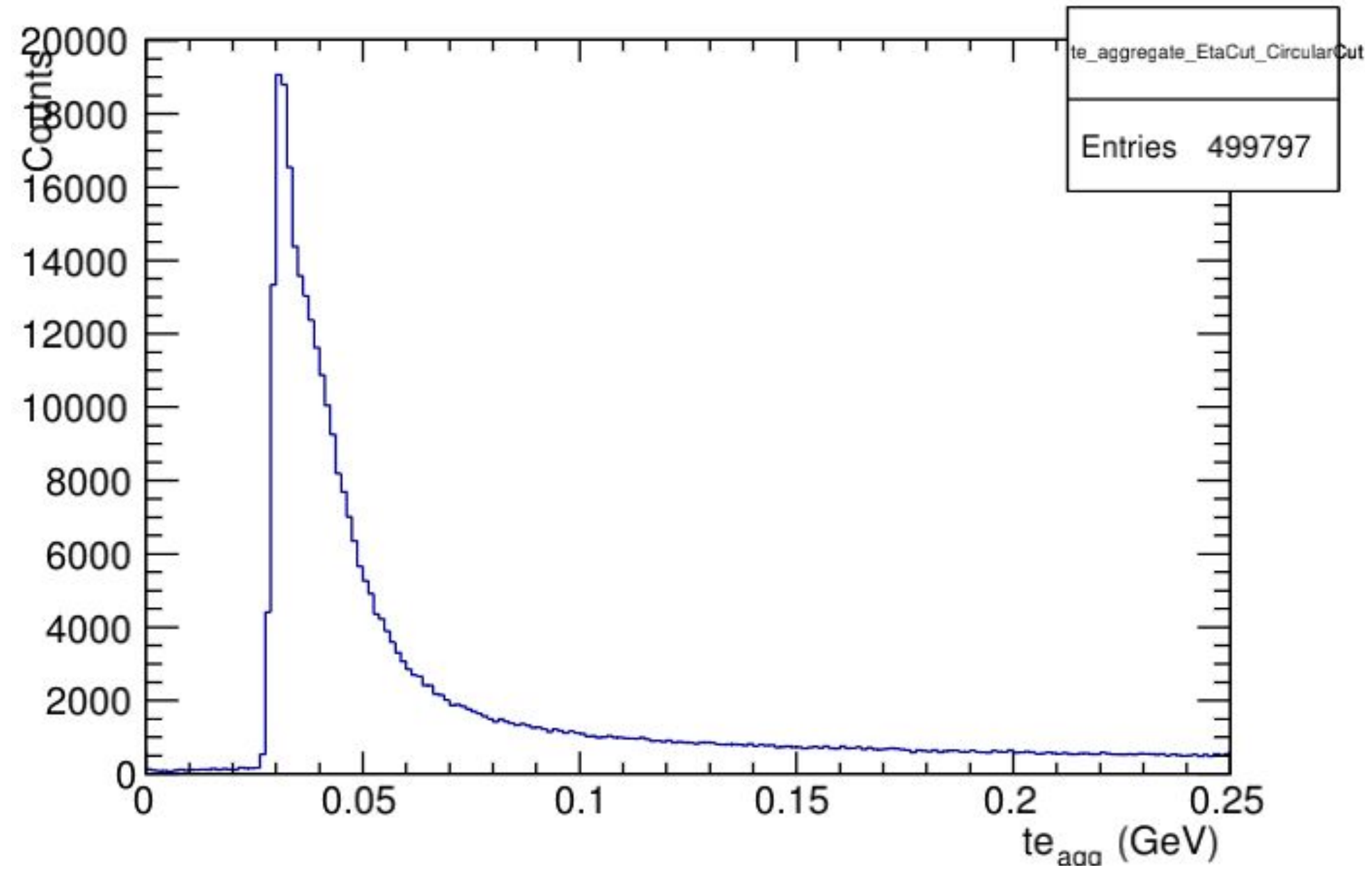
Histograms for energy resolution of detectors with manual clustering, theta-parametrized energy cut on aggregate towers of EMCs (FEMC and CEMC) to account for pion-MIPs, energy cuts on event energies to remove low energy noise, and slice-wise calibration, for the following detector-particle pairs:

- Pion: FHCAL + FEMC
- Pion: CEMC + HCALIN + HCALOUT

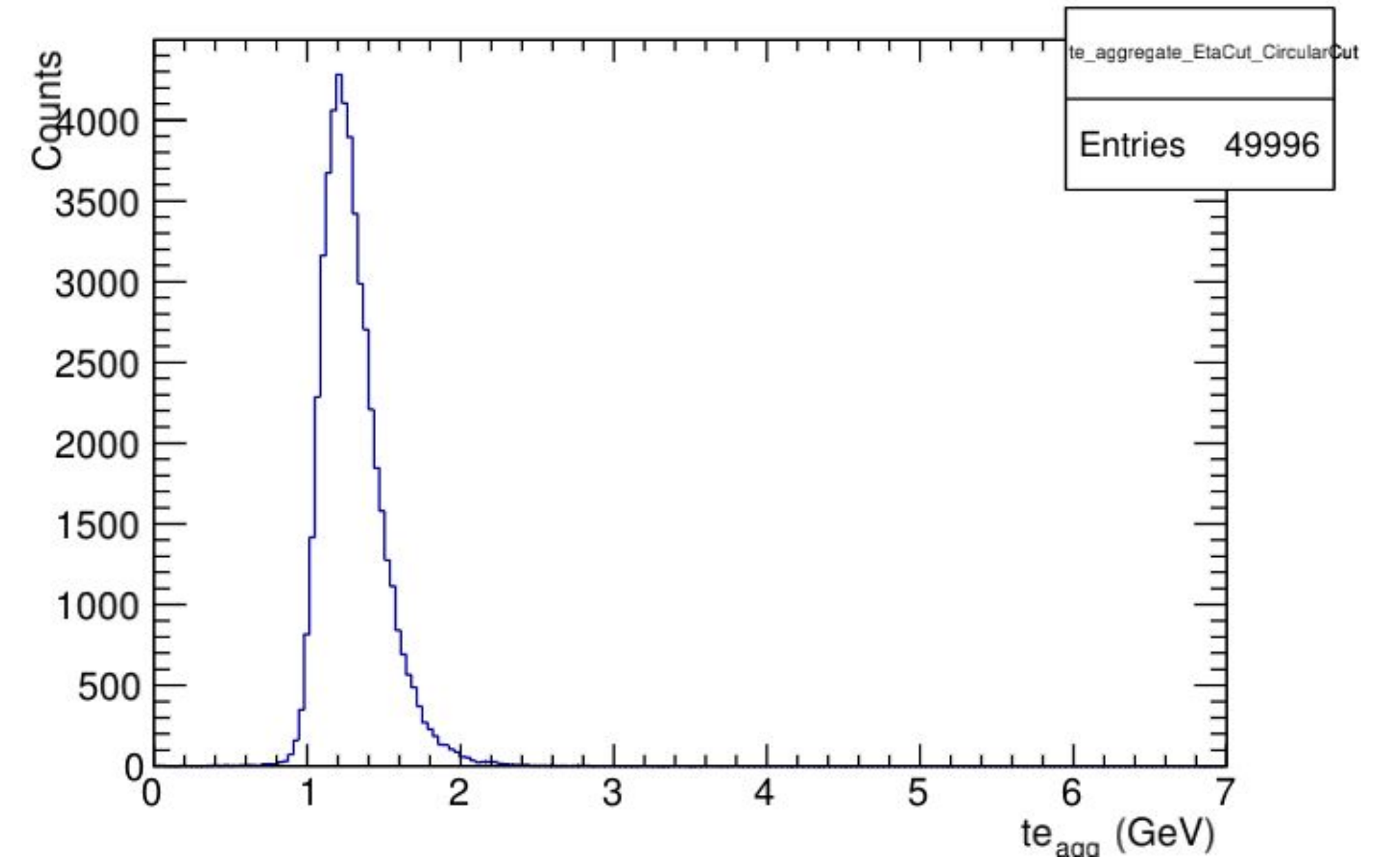
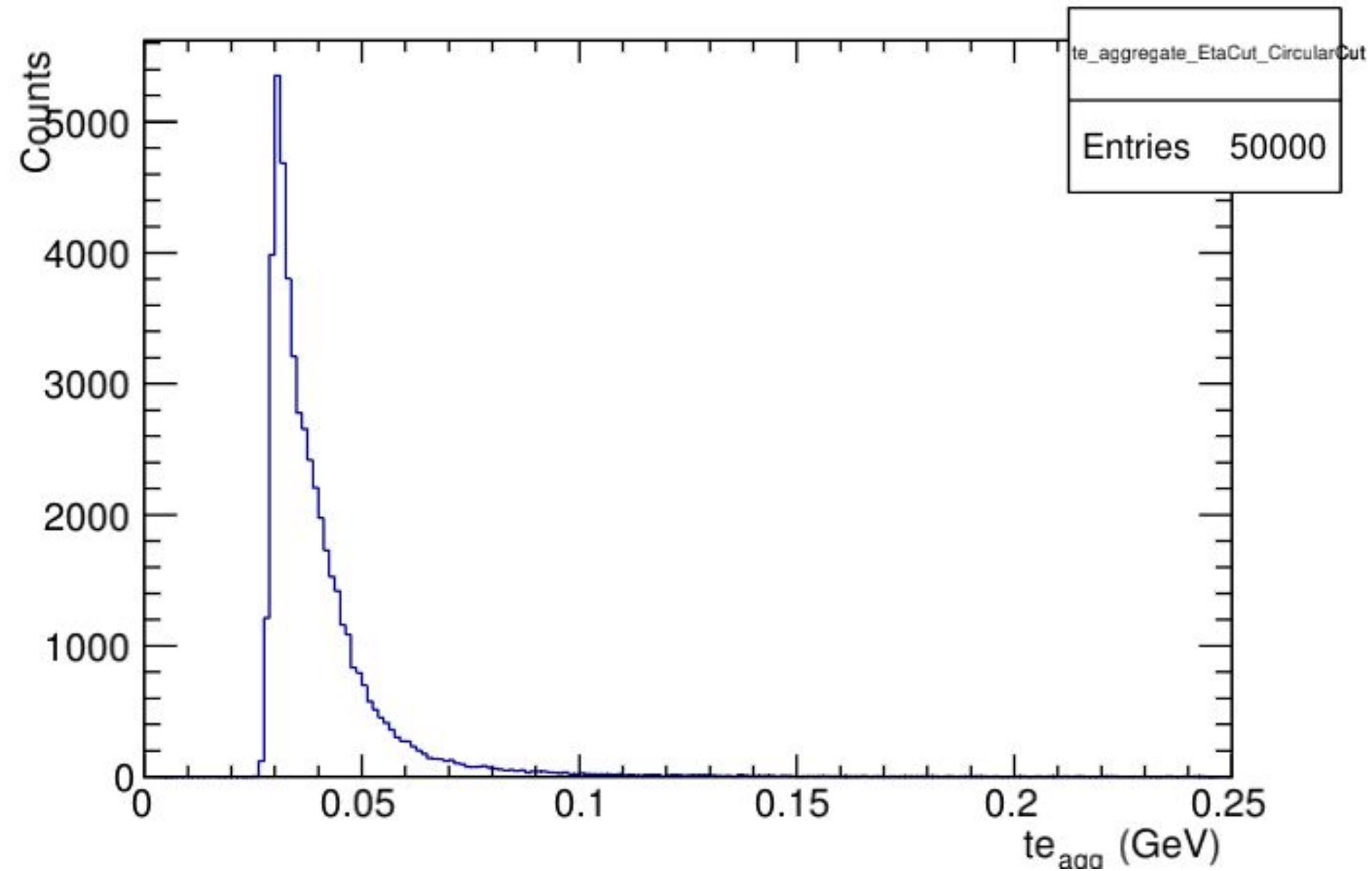
FEMC

FHCAL

4 GeV
pions
counts
500k



4 GeV
muons
counts
50k



Simulation Parameters

- Particle: π^-
- Events: 150,000 π^-
- (100,000 \rightarrow 0-30 GeV/c, 50,000 \rightarrow 0-3 GeV/c)
- Pseudorapidity (η): -0.96 to 0.92
- Azimuth (Φ): $-\pi$ to π

- Particle: π^-
- Events: 200,000 π^-
- (100,000 \rightarrow 0-30 GeV/c, 100,000 \rightarrow 0-3 GeV/c)
- Pseudorapidity (η): 1.4 to 3.0
- Azimuth (Φ): $-\pi$ to π

Cuts:

- Detector-wise η cuts, intersection for combinations
- Detector-wise Elliptical cuts in $d\phi$ vs $d\theta$ plots
- Energy cut of 100 MeV on event energy
- Theta-parametrized energy cut on aggregate towers of EMCs

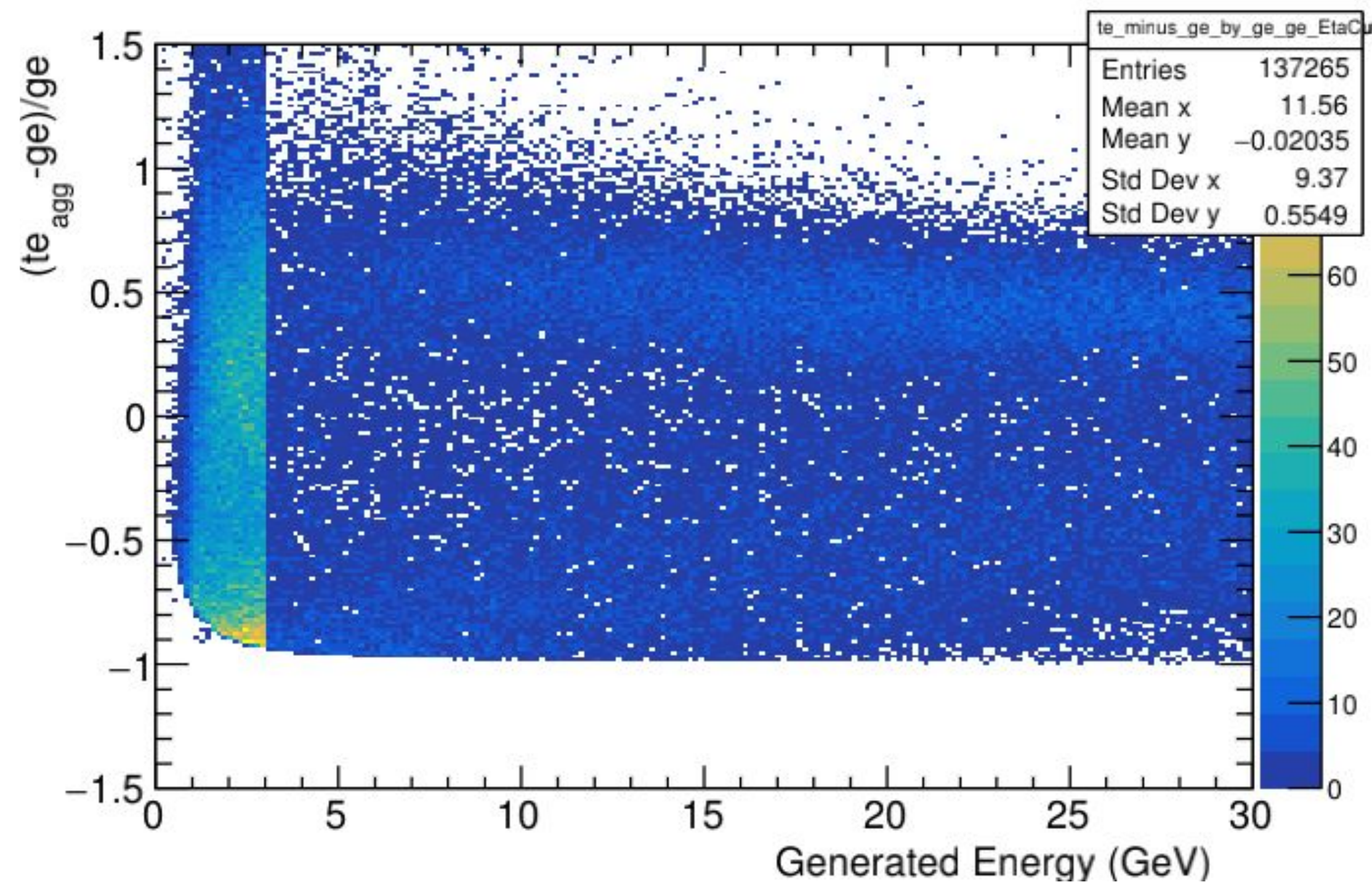
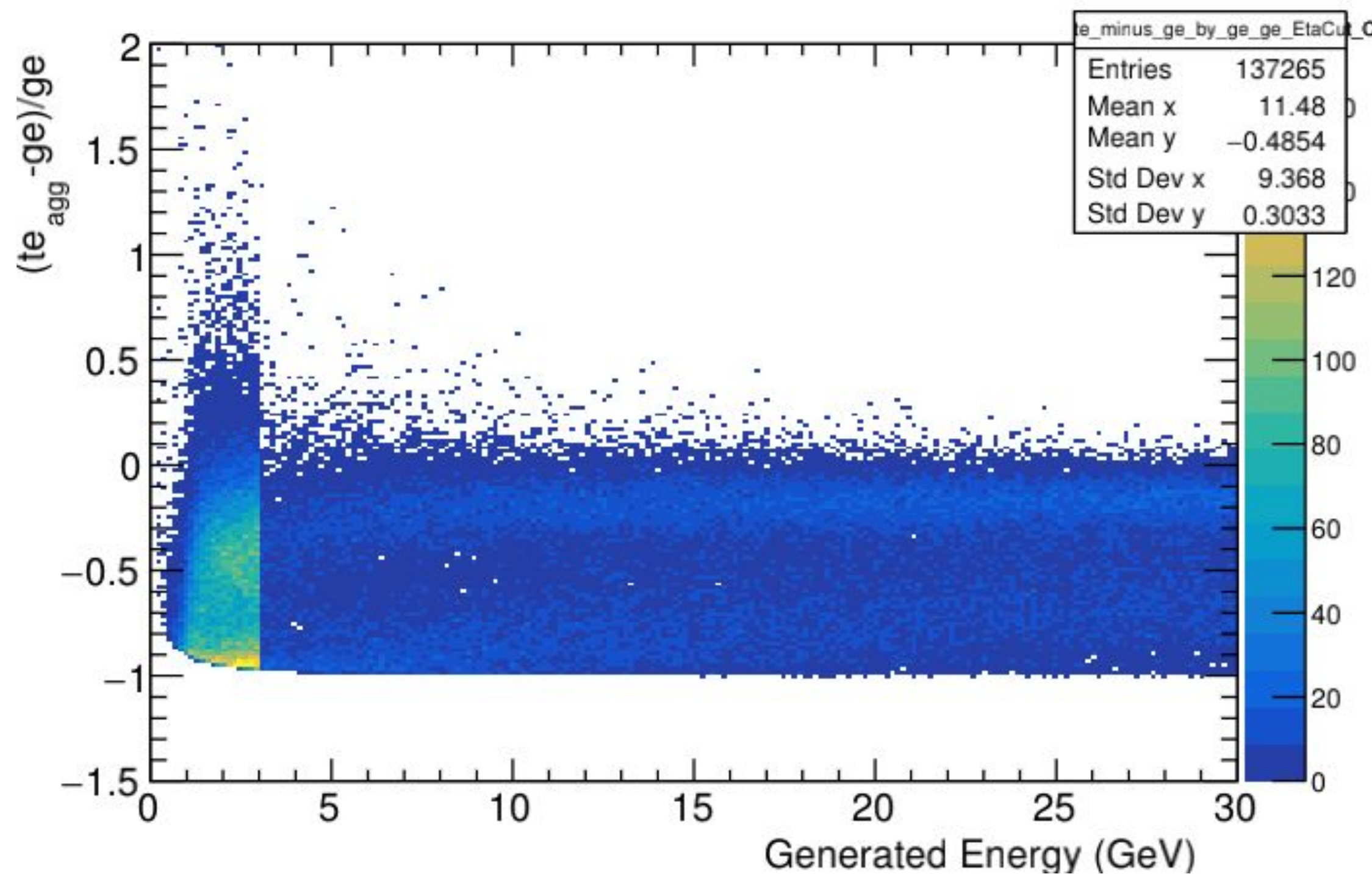
FEMC + FHCAL (π^-)

$(te_{agg} - ge)/ge$ vs ge

Explicit η cut: 1.4 to 3.0

$g\theta$ -parametrized Aggregate Energy Cuts on EMC Towers

After calibration



$$(te_{agg} \rightarrow \sum(\text{weight} * te / \text{calibrationFactor}) / \text{mean}(\sum(\text{weight} * te / \text{calibrationFactor}))$$

calibrationFactor(ge) = mean(te/ge) ; detector-wise; function of ge

weight = mean(te/ge) ; detector-wise; independent of ge

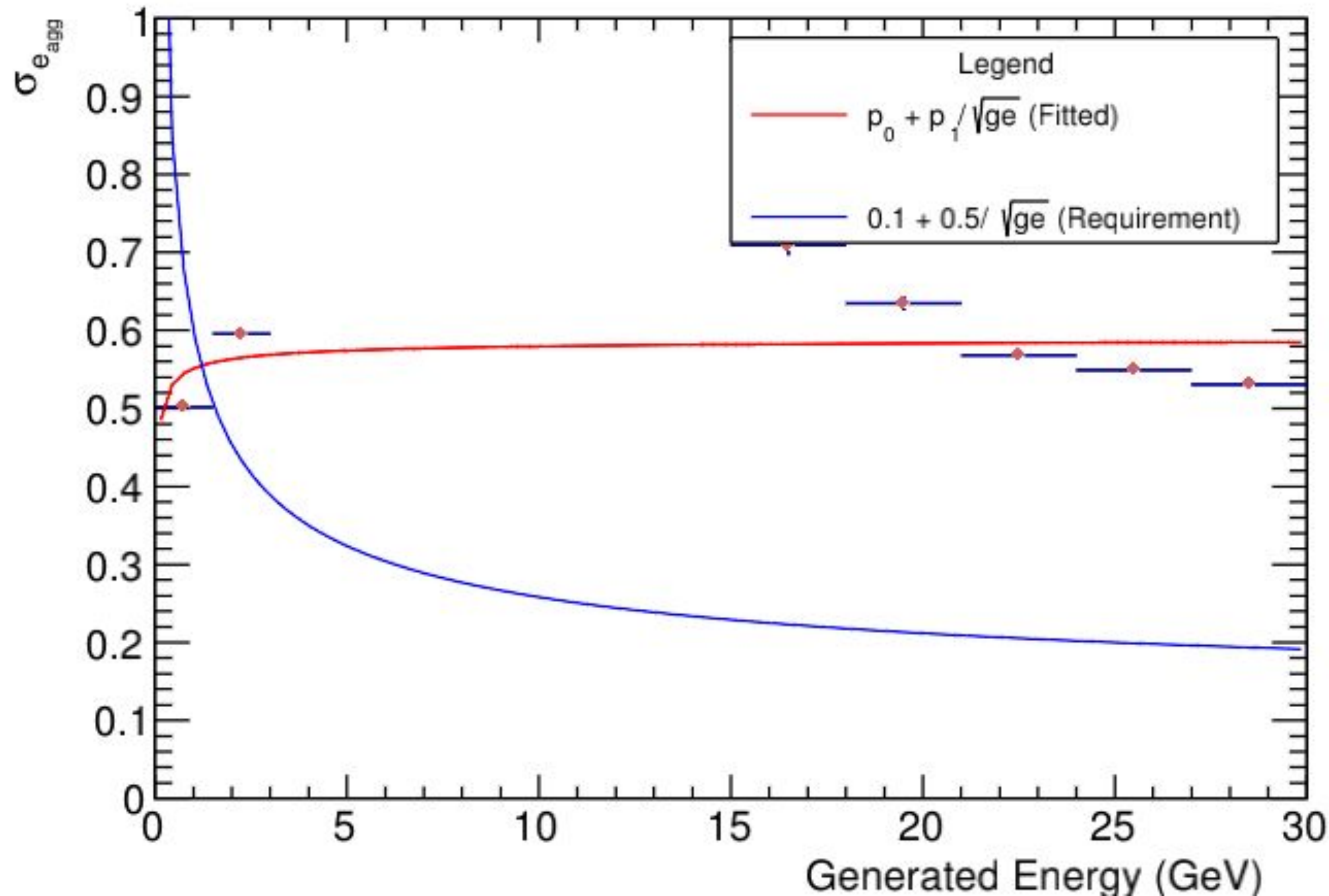
FEMC + FHCAL (π^-)

$\sigma_{e_{agg}}$ vs g_e

Explicit η cut: 1.4 to 3.0

Elliptical Cut for Manual Clustering

g_{θ} -parametrized Aggregate Energy Cuts on EMC Towers



σ_e refers to the standard deviation of the Gaussian fitted to a slice of the calibrated $(t_{e_{agg}} - g_e)/g_e$ vs g_e plot.

Number of bins = 11

Bin Width = 1.5 GeV

3.0 GeV

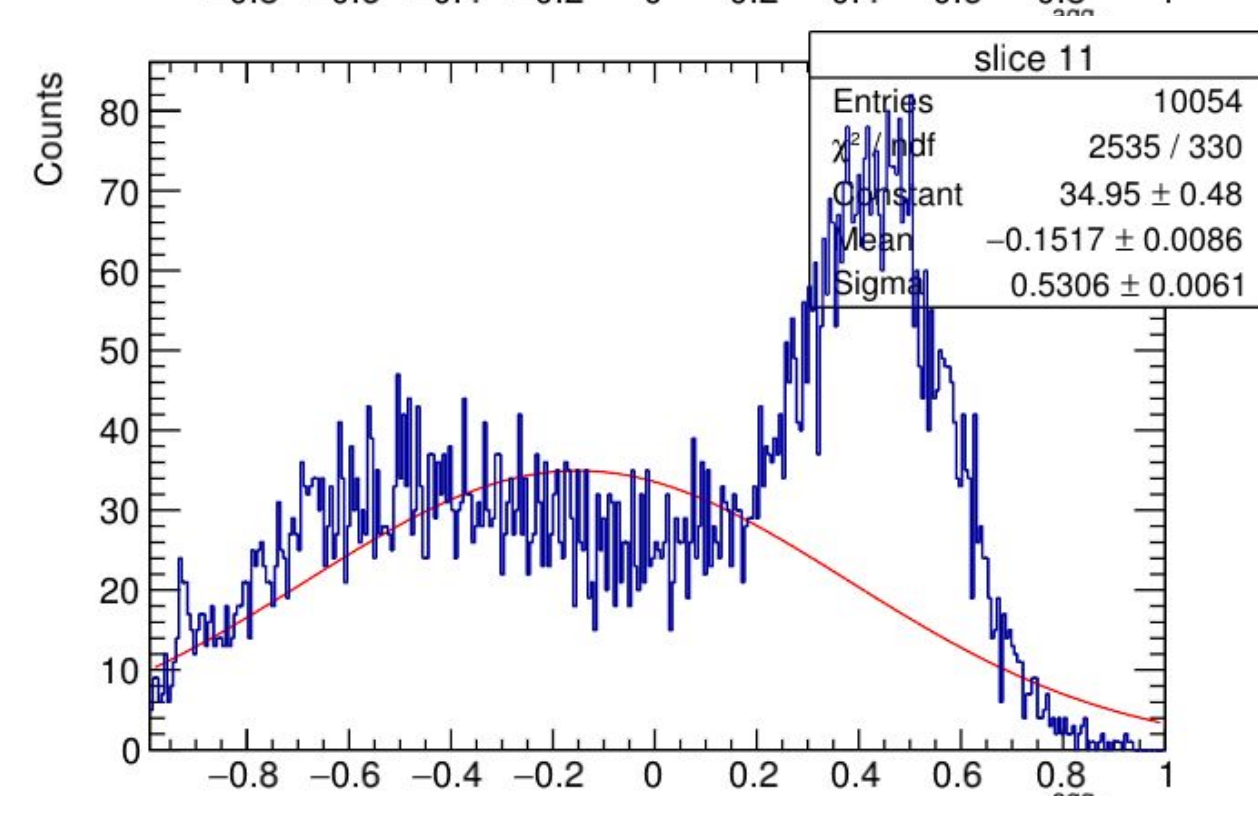
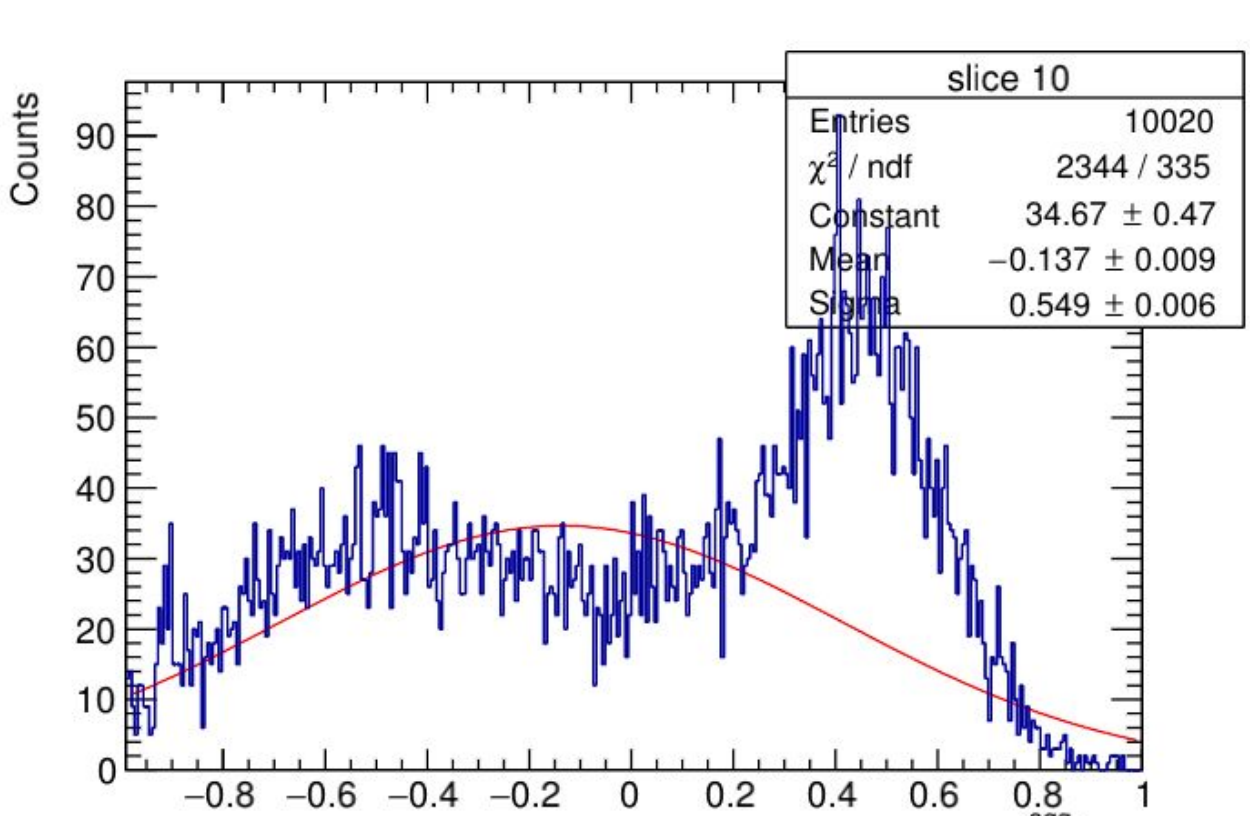
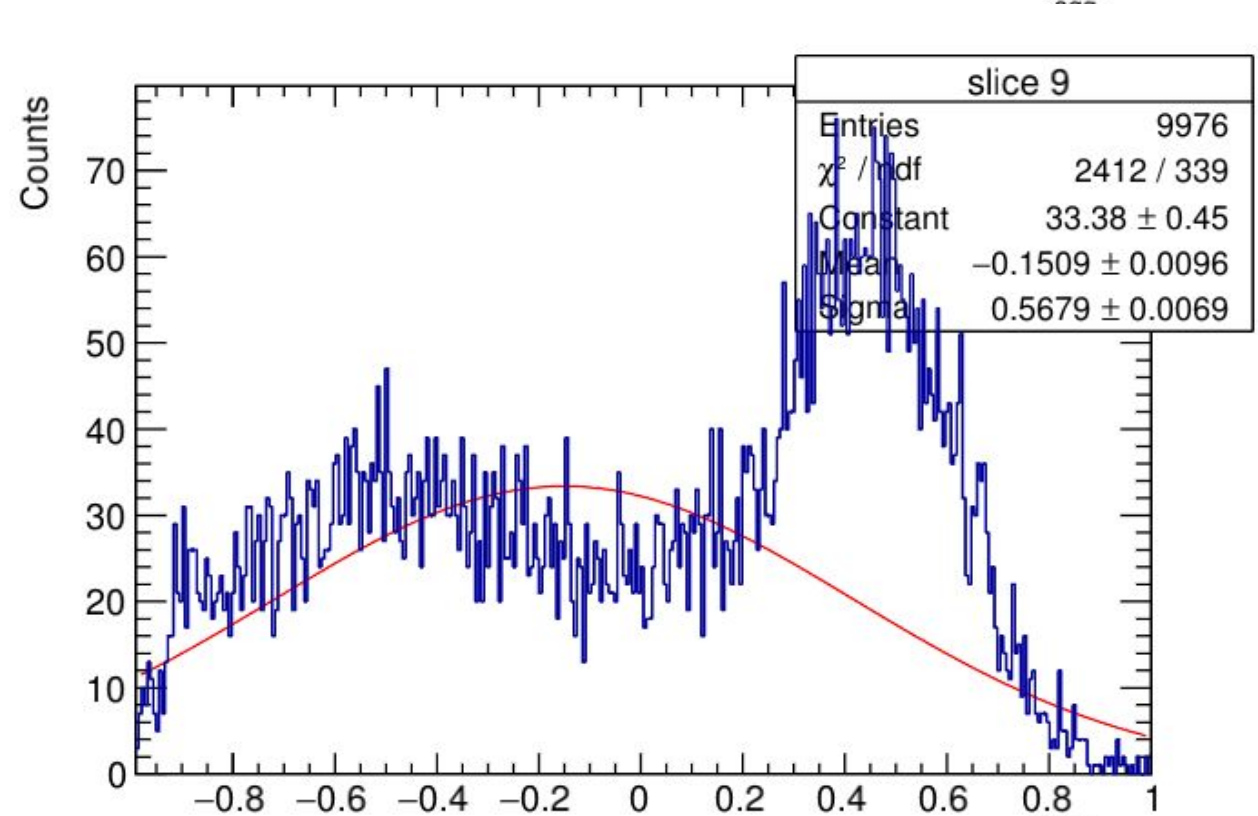
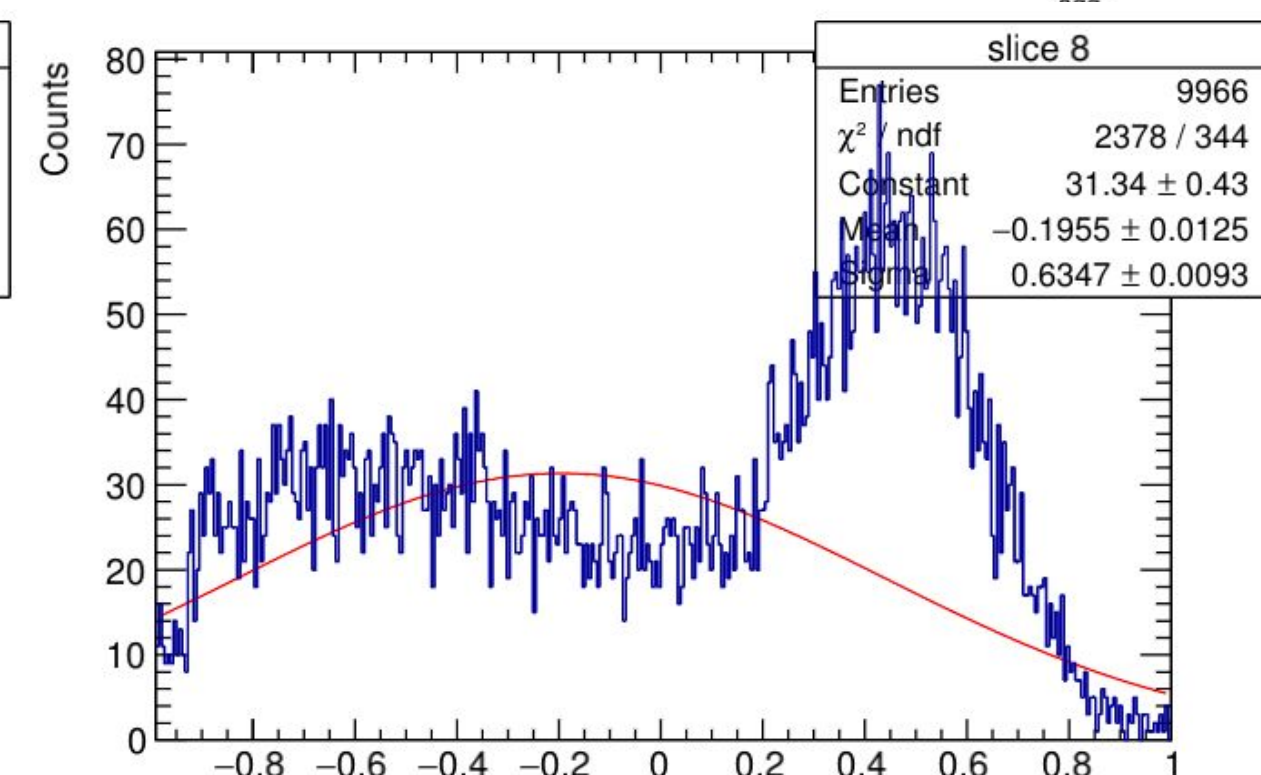
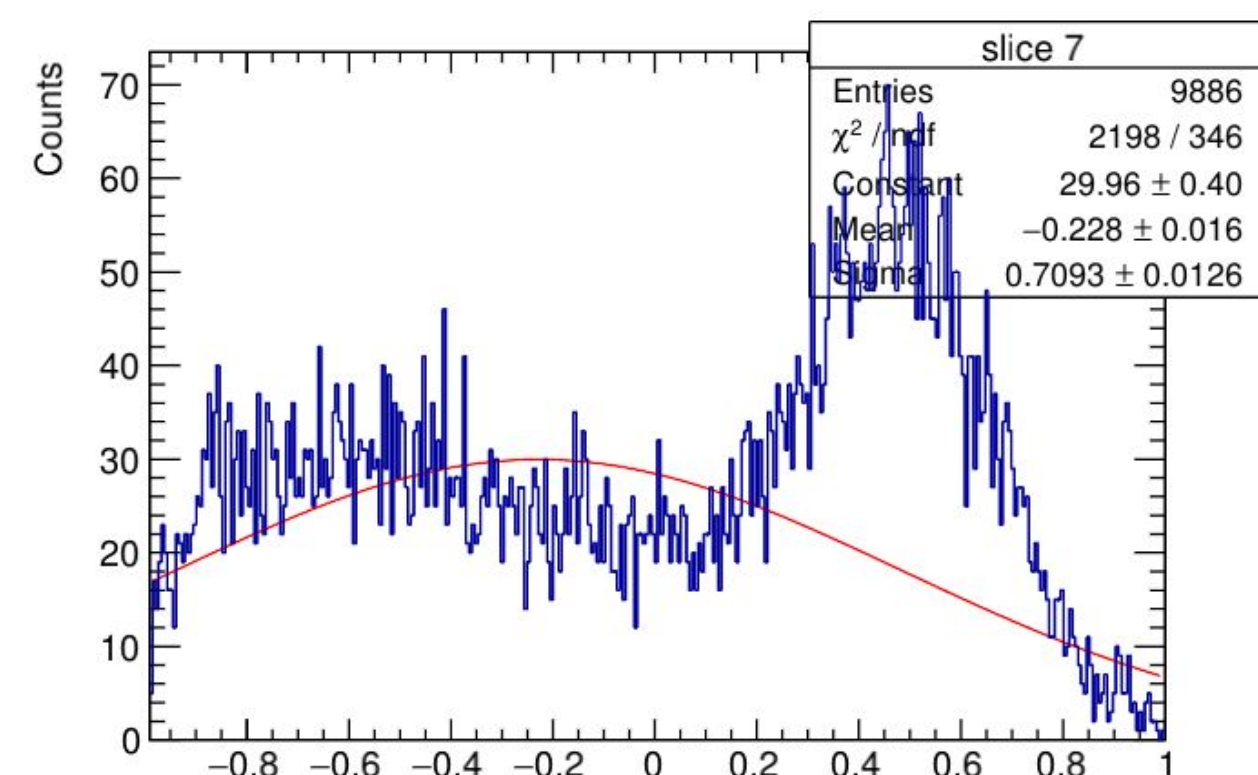
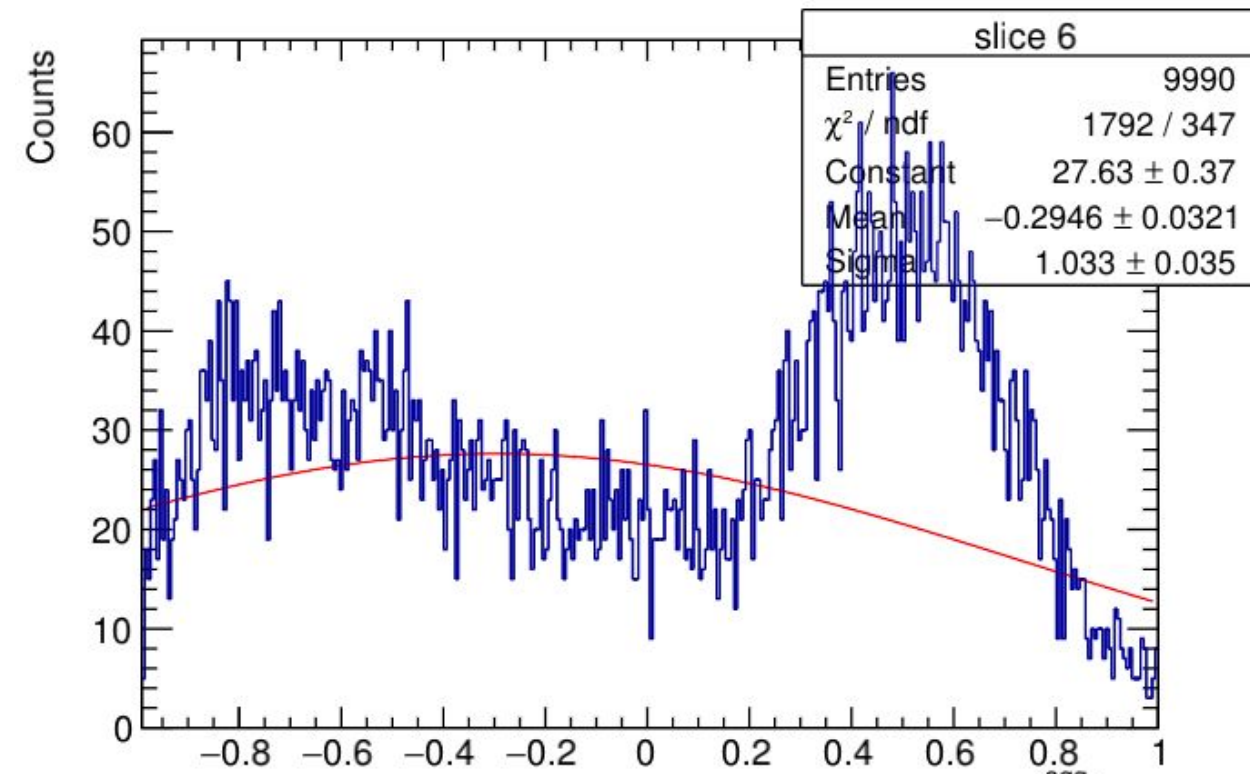
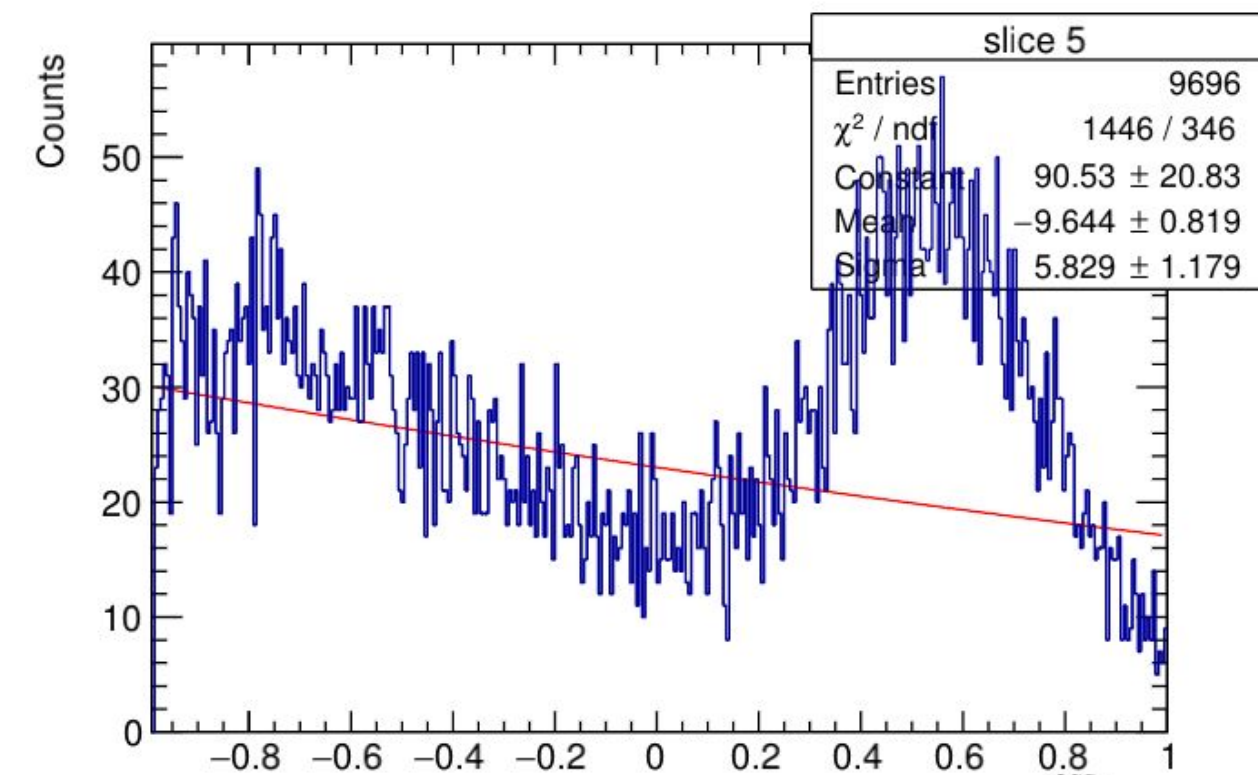
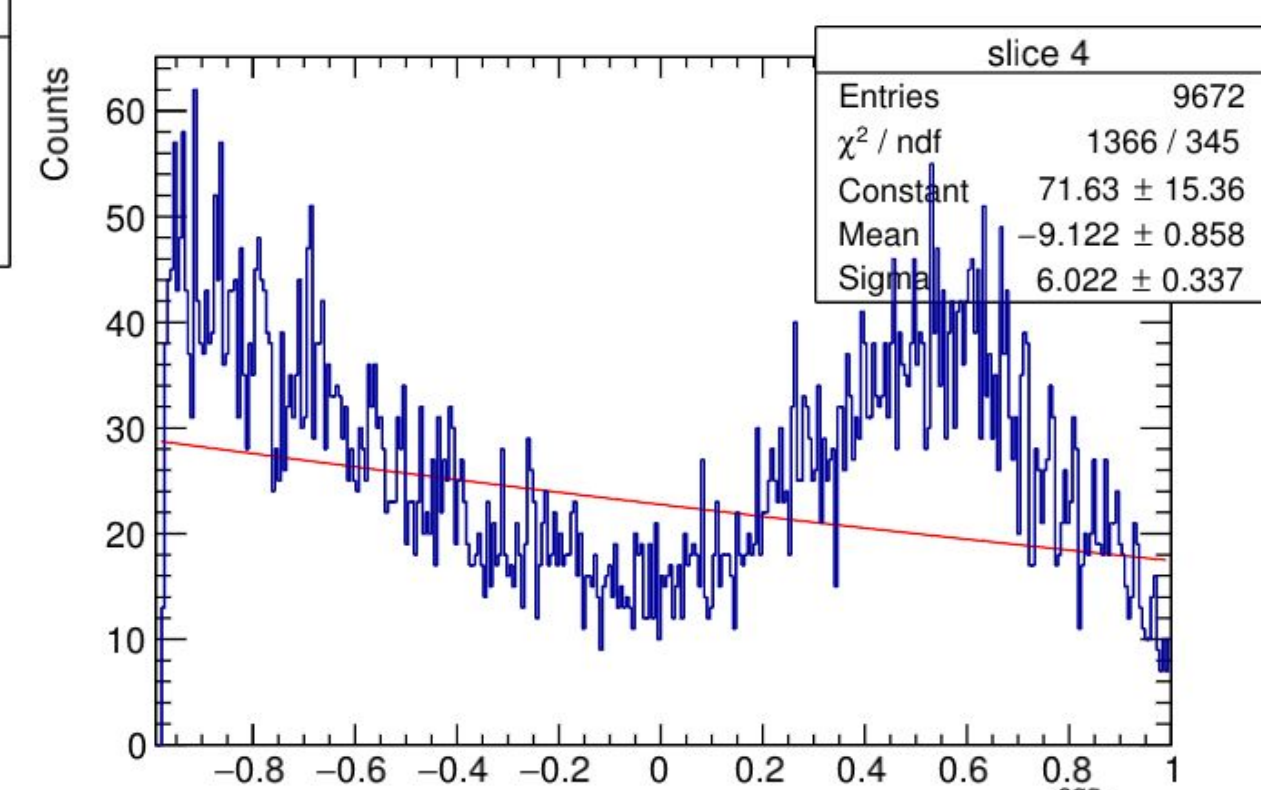
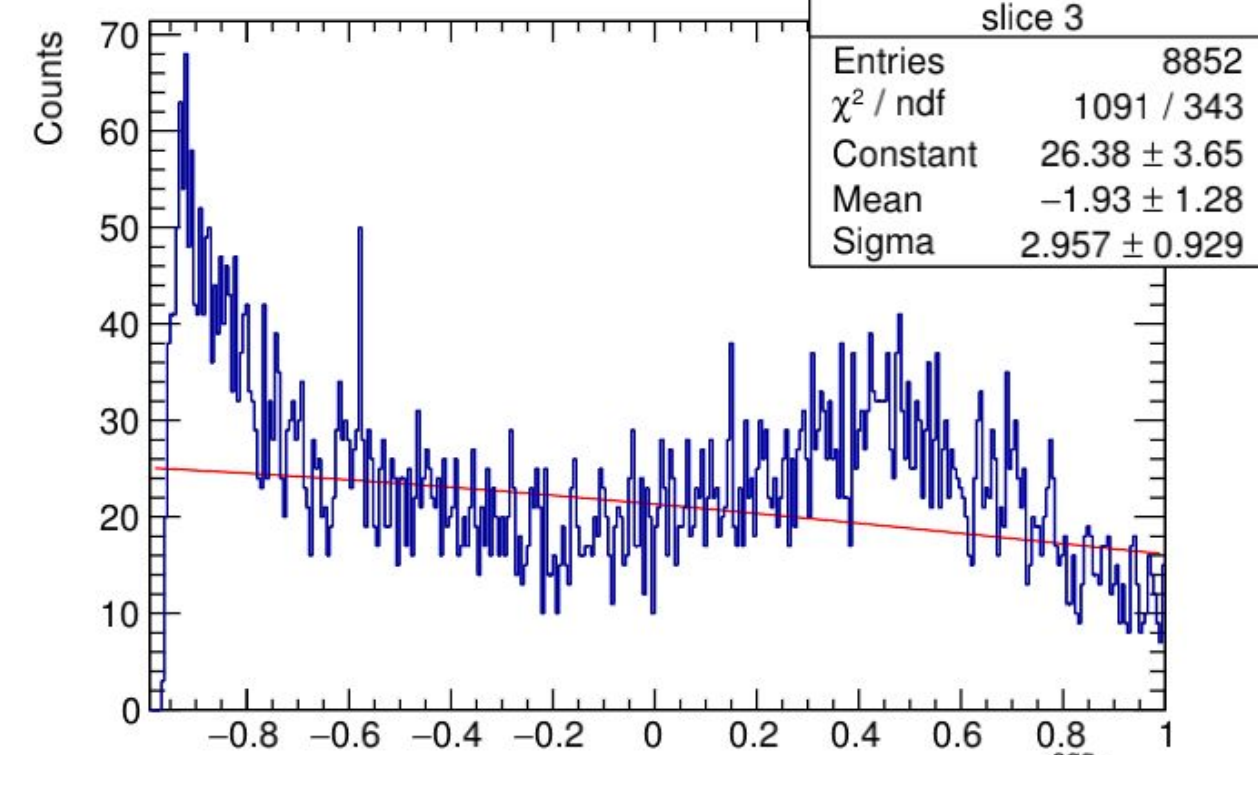
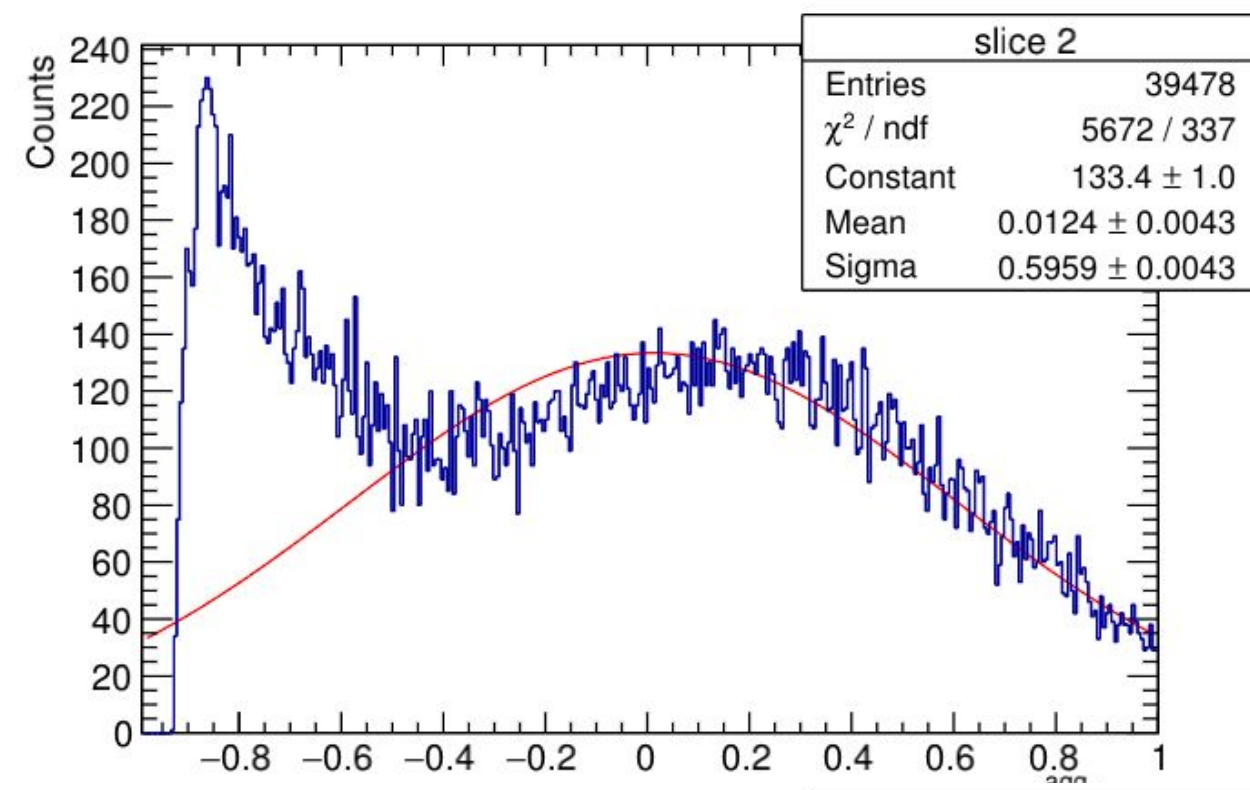
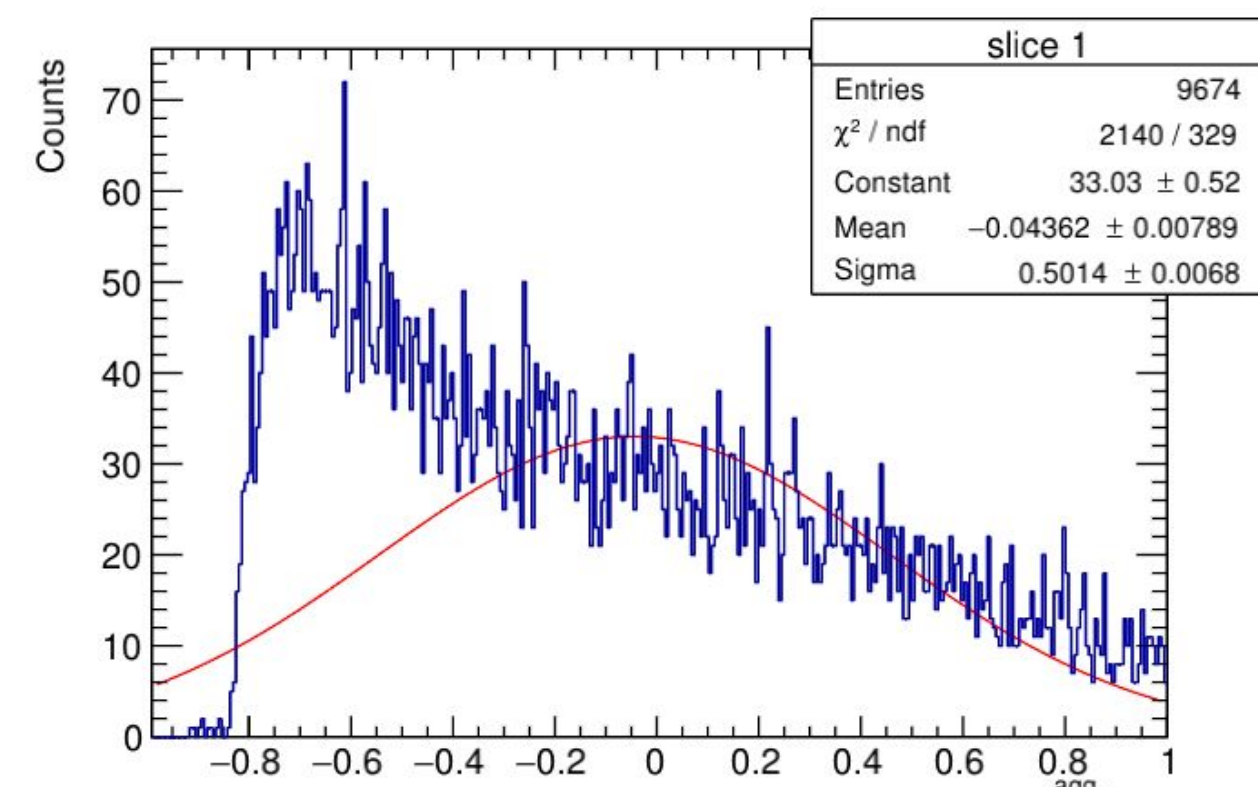
$g_e \in [0, 3)$

$g_e \in [3, 30]$

Fit Parameters !? :)

FEMC + FHCAL (π^-)

Fitted Gaussians



The x-axes denote $\Delta e_{\text{agg}} / \text{ge}$

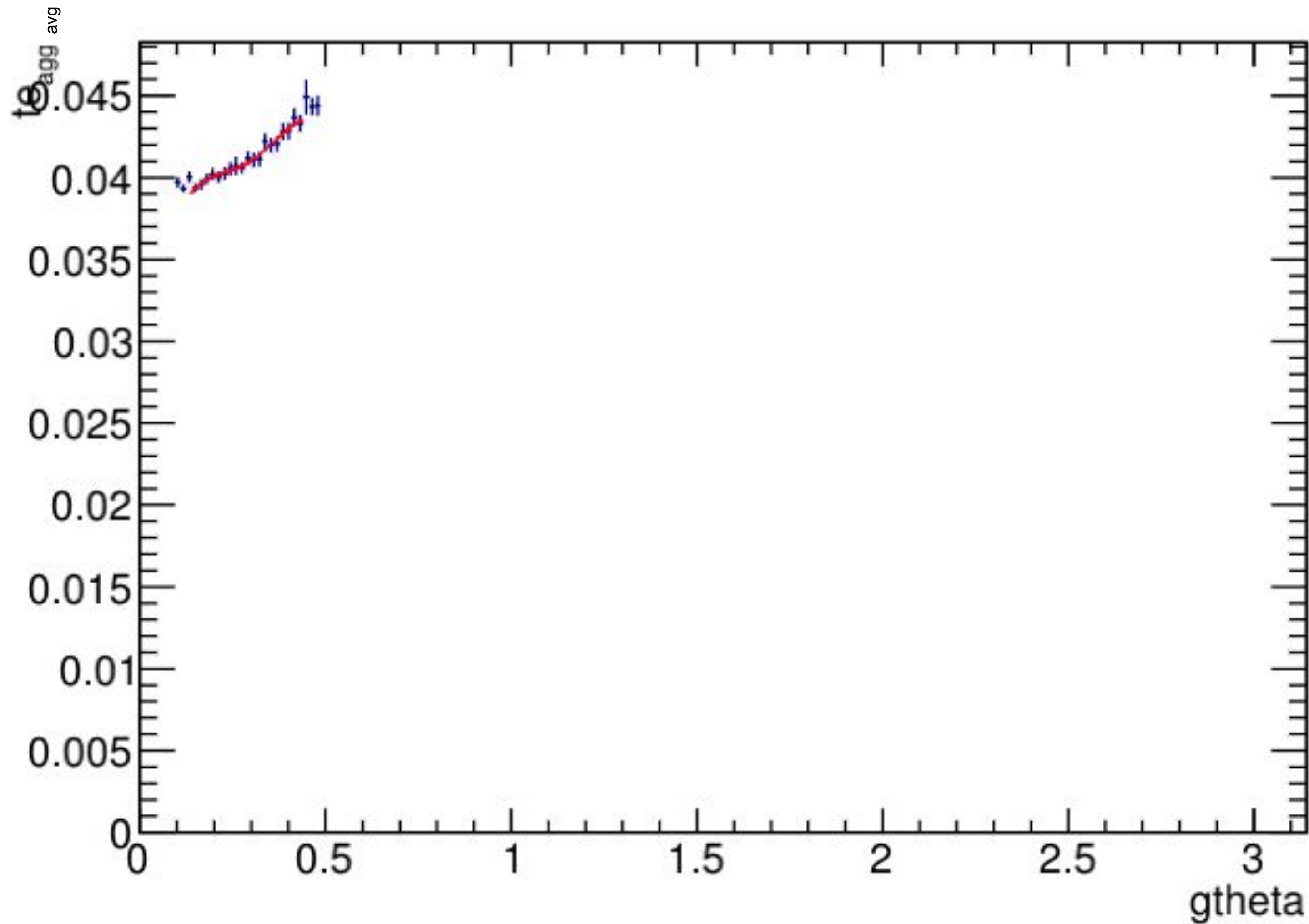
Appendix



FEMC + FHCAL (π^-)

FEMC (μ^-)

Theta-parametrization of muon-MIP energy



NO.	NAME	VALUE	ERROR	STEP SIZE	DERIVATIVE
1	p0	2.49951e-02	5.16075e-04	-3.09011e-04	1.17930e-06
2	p1	2.15109e-01	3.75189e-03	4.95006e-03	-2.51678e-07
3	p2	-1.15673e+00	1.17309e-02	-2.83627e-02	-3.83650e-07
4	p3	2.75562e+00	3.45780e-02	6.90804e-02	-3.58426e-08
5	p4	-2.31809e+00	6.05963e-02	6.05963e-02	-5.65843e-03

reduced_chi2 of theta fit: 0.279558

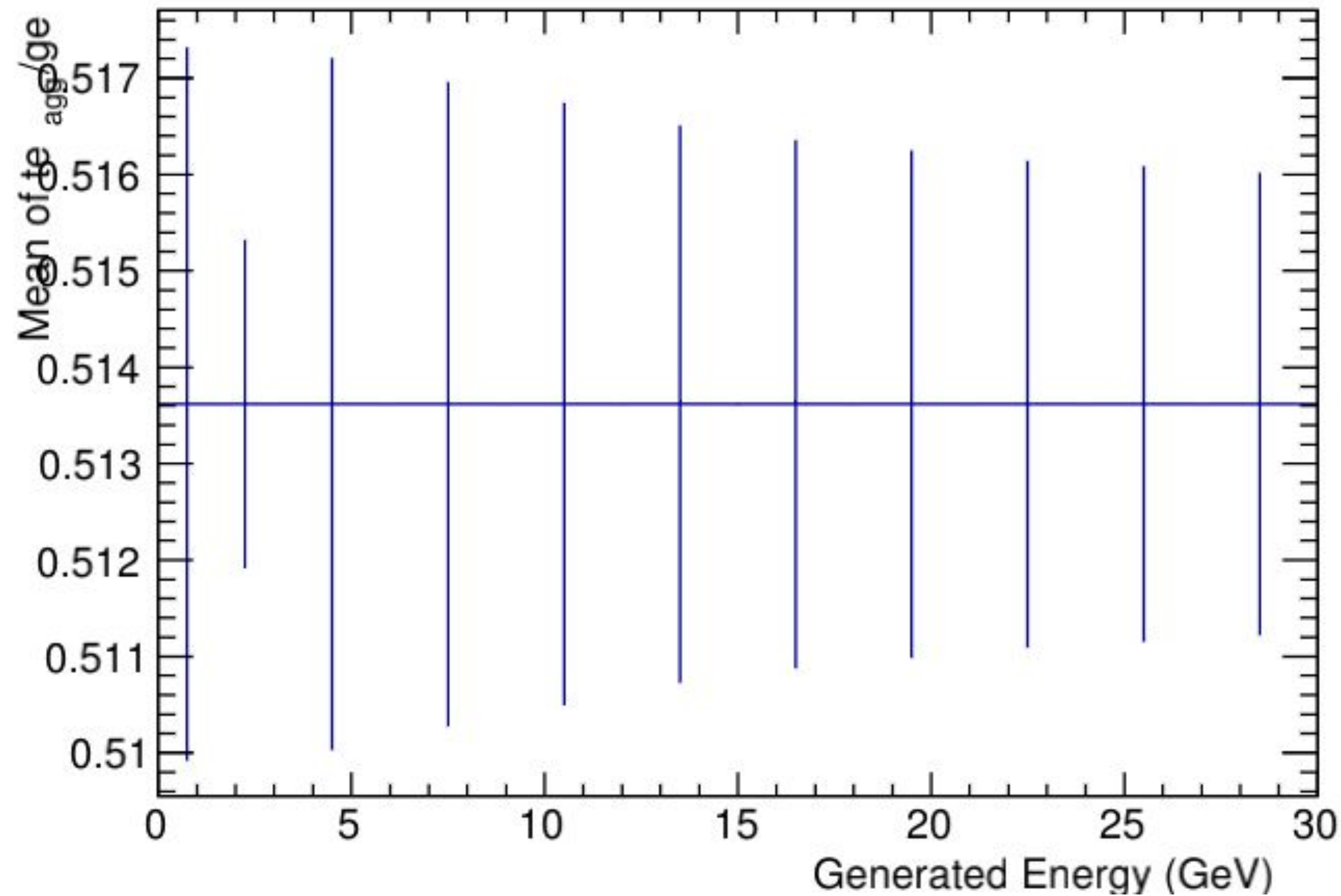
FEMC + FHCAL (π^-)

Elliptical cut on dphi vs dtheta

Explicit η cut: 1.4 to 3.0

gtheta-parametrized Aggregate Energy Cuts on EMC Towers

After calibration



$$(te_{agg} \rightarrow \sum(\text{weight} * te / \text{calibrationFactor}) / \text{mean}(\sum(\text{weight} * te / \text{calibrationFactor}))$$

Each slice of $(te_{agg} - ge)/ge$ vs ge plot will be calibrated on the basis of dividing by a calibration factor which equals to the Mean of te_{agg}/ge corresponding to that particular slice in this plot.

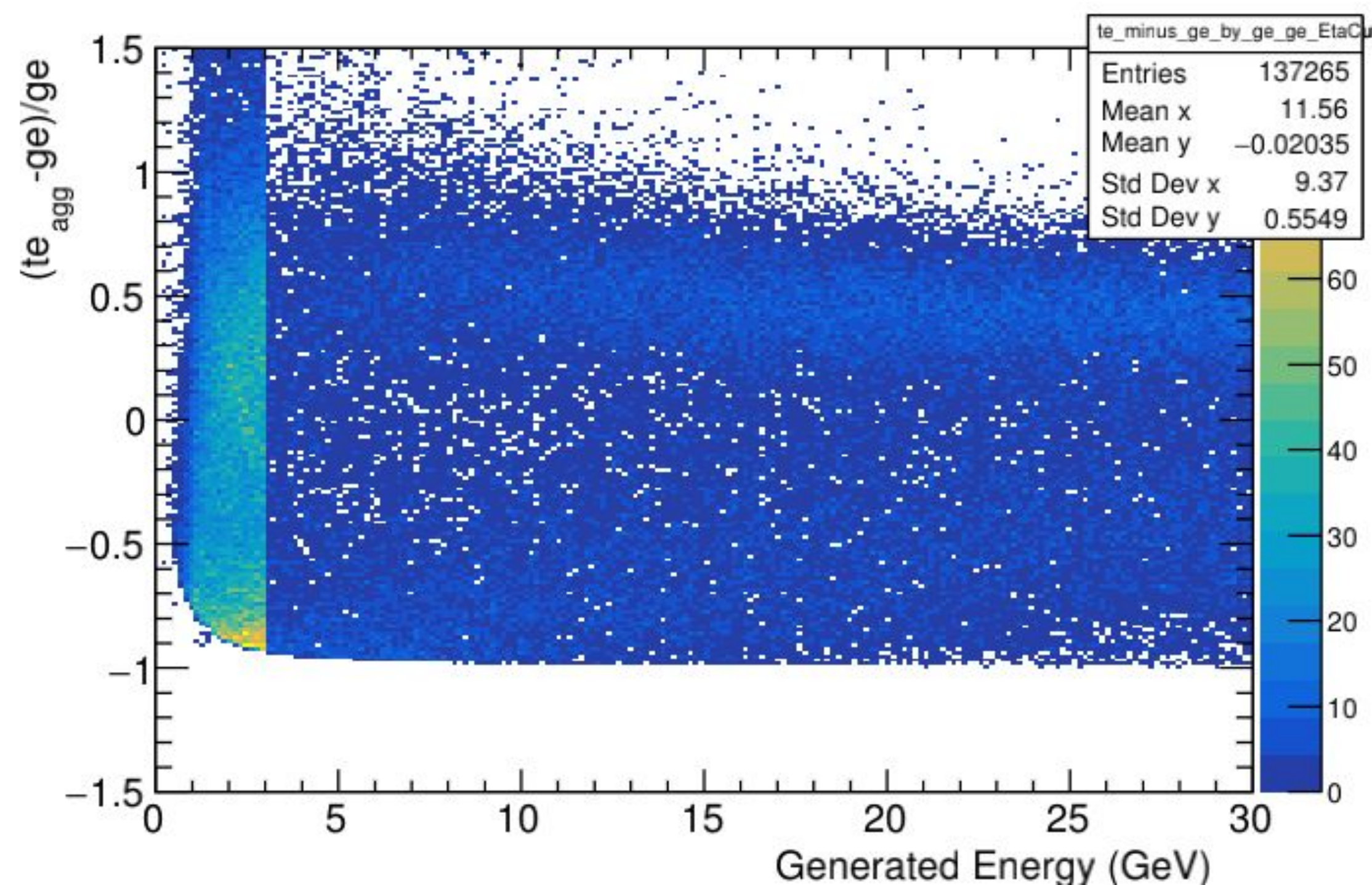
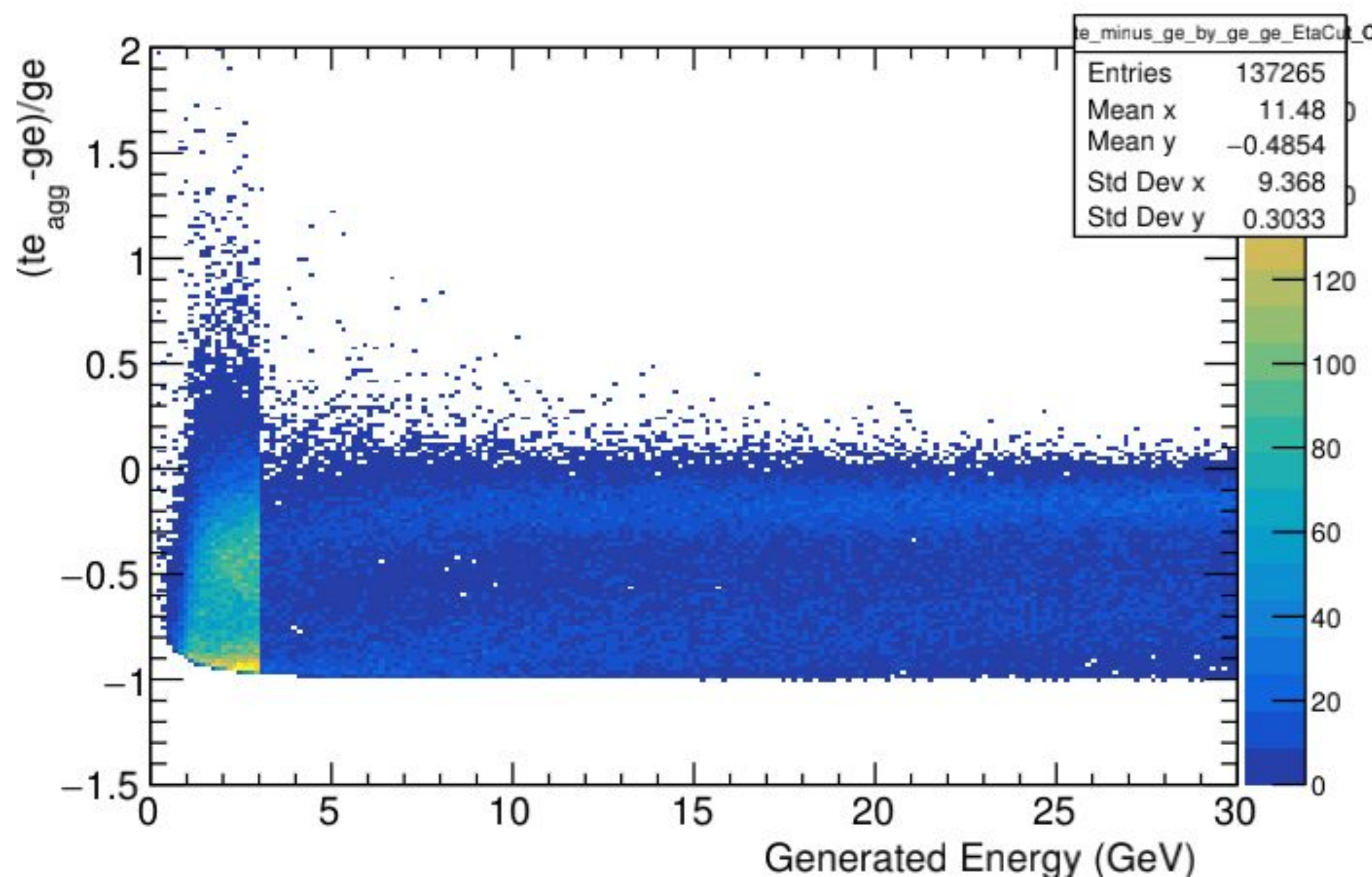
FEMC + FHCAL (π^-)

$(te_{agg} - ge)/ge$ vs ge

Explicit η cut: 1.4 to 3.0

$g\theta$ -parametrized Aggregate Energy Cuts on EMC Towers

After calibration



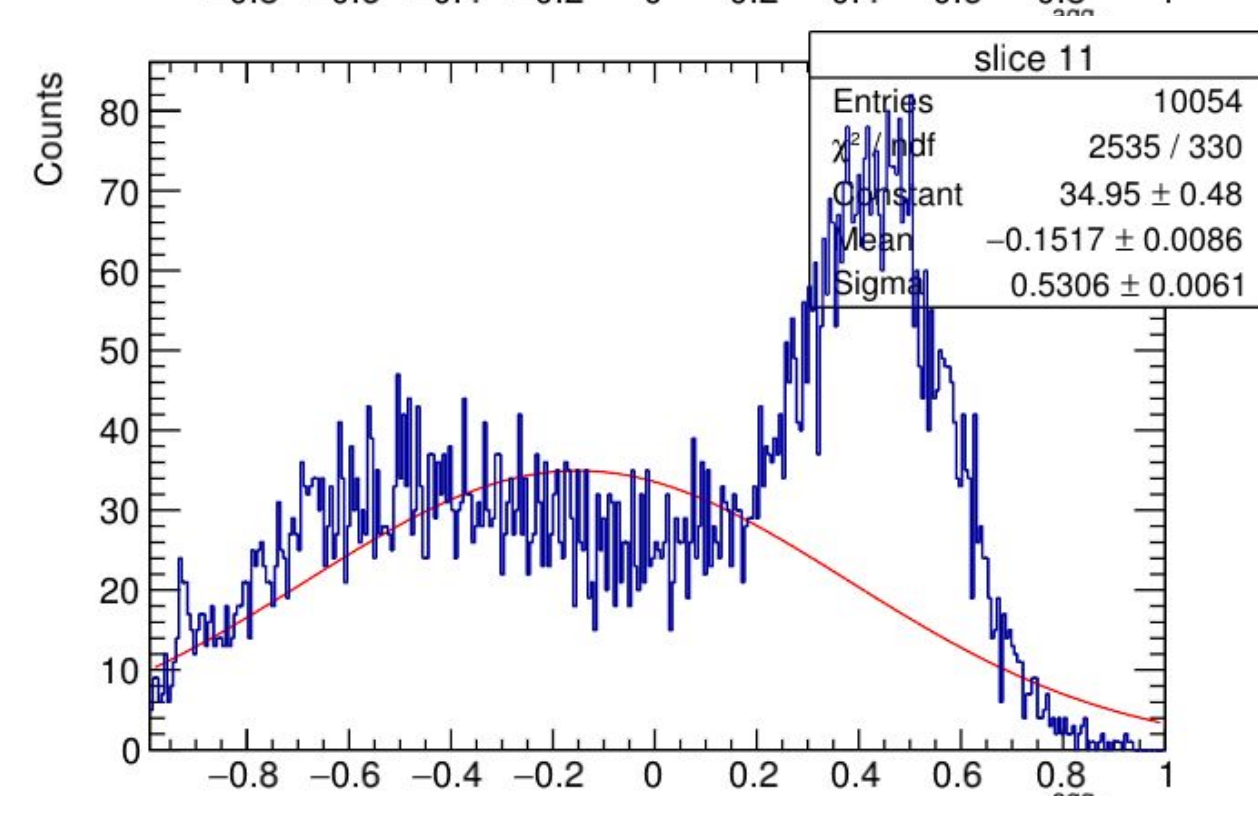
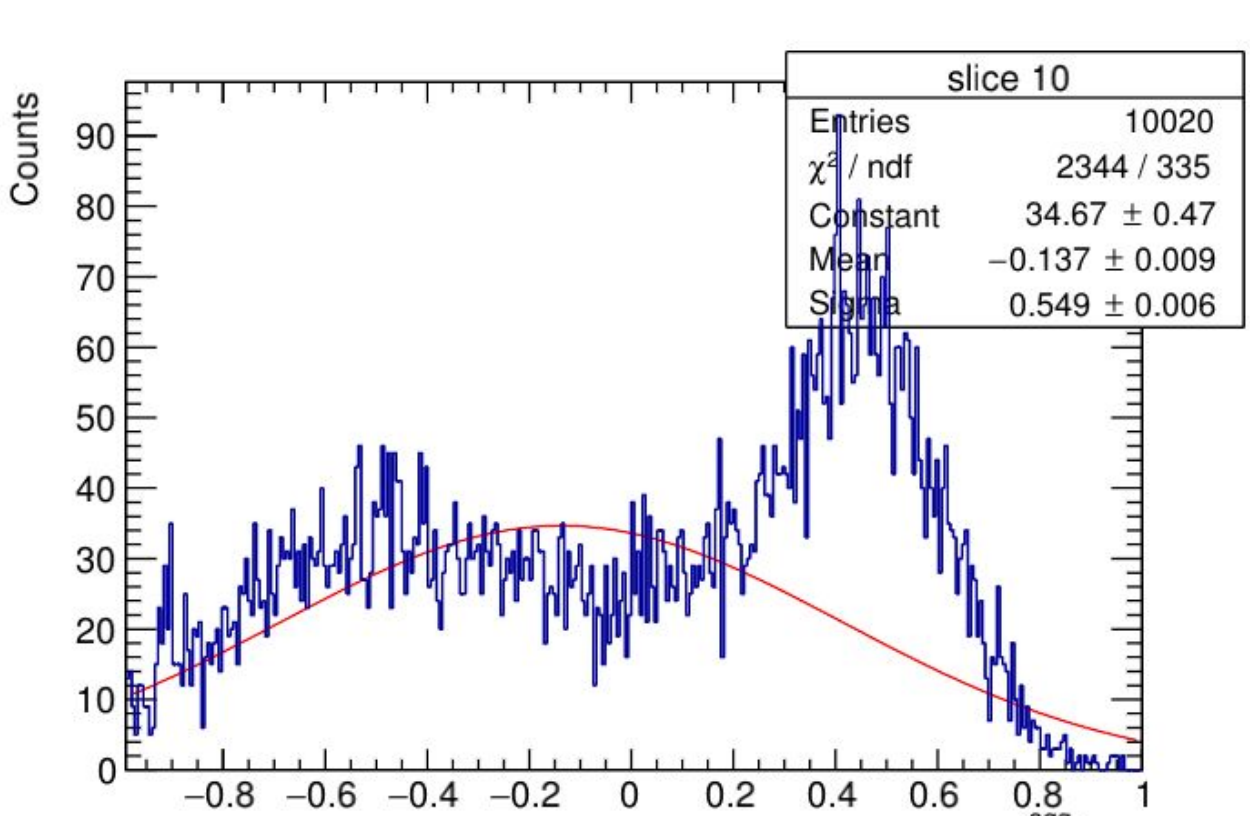
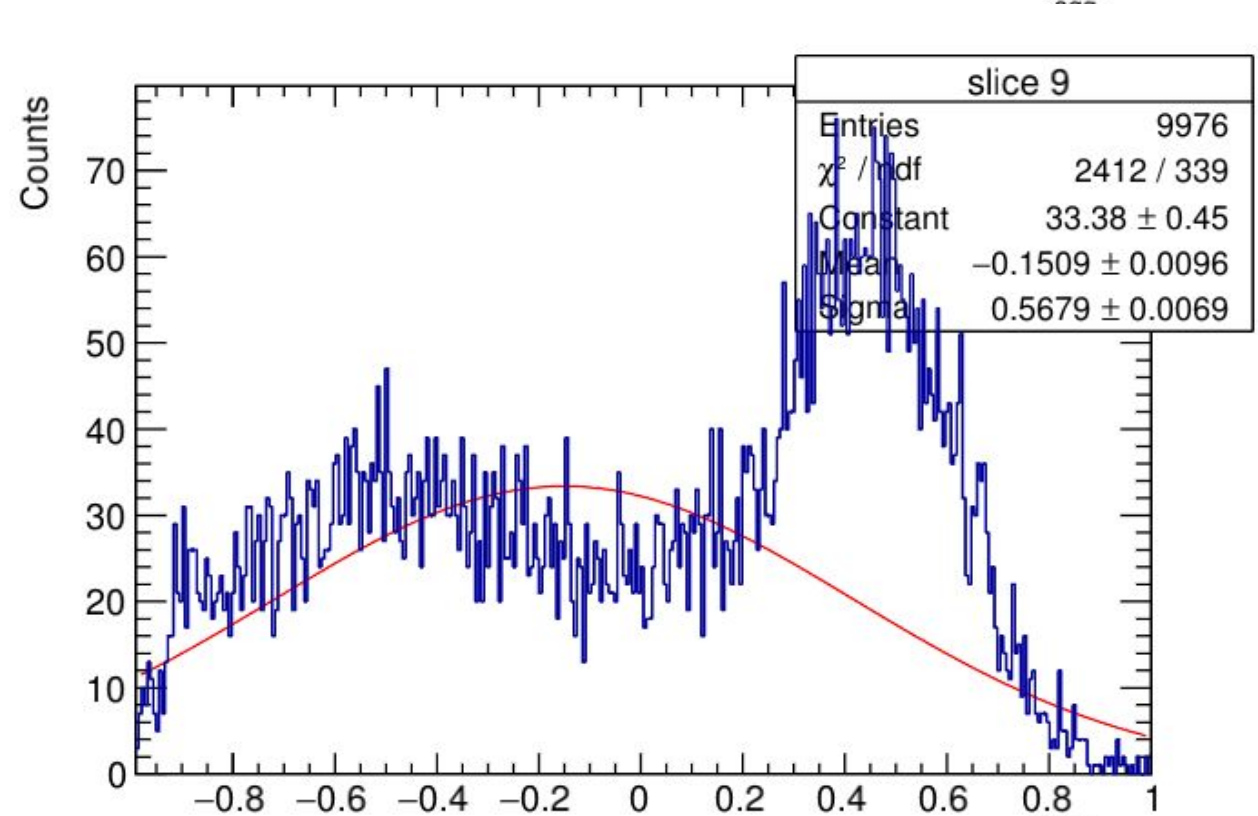
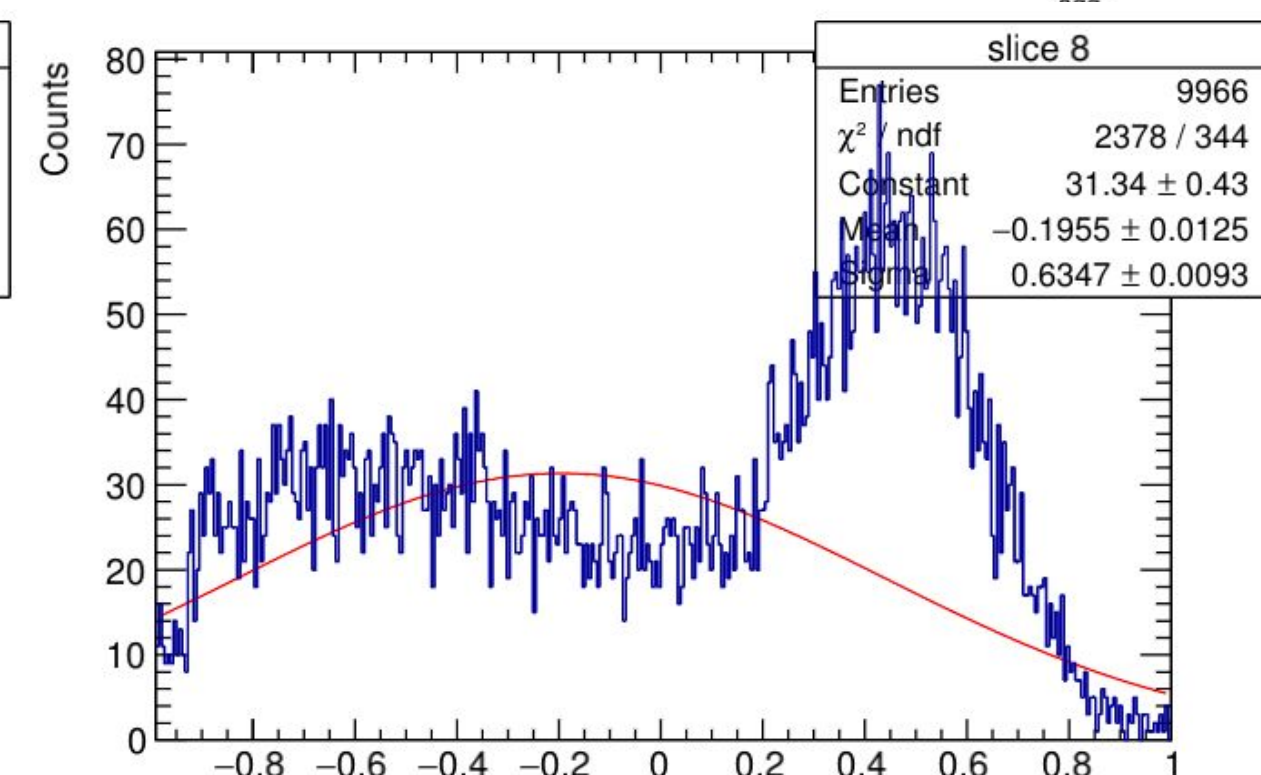
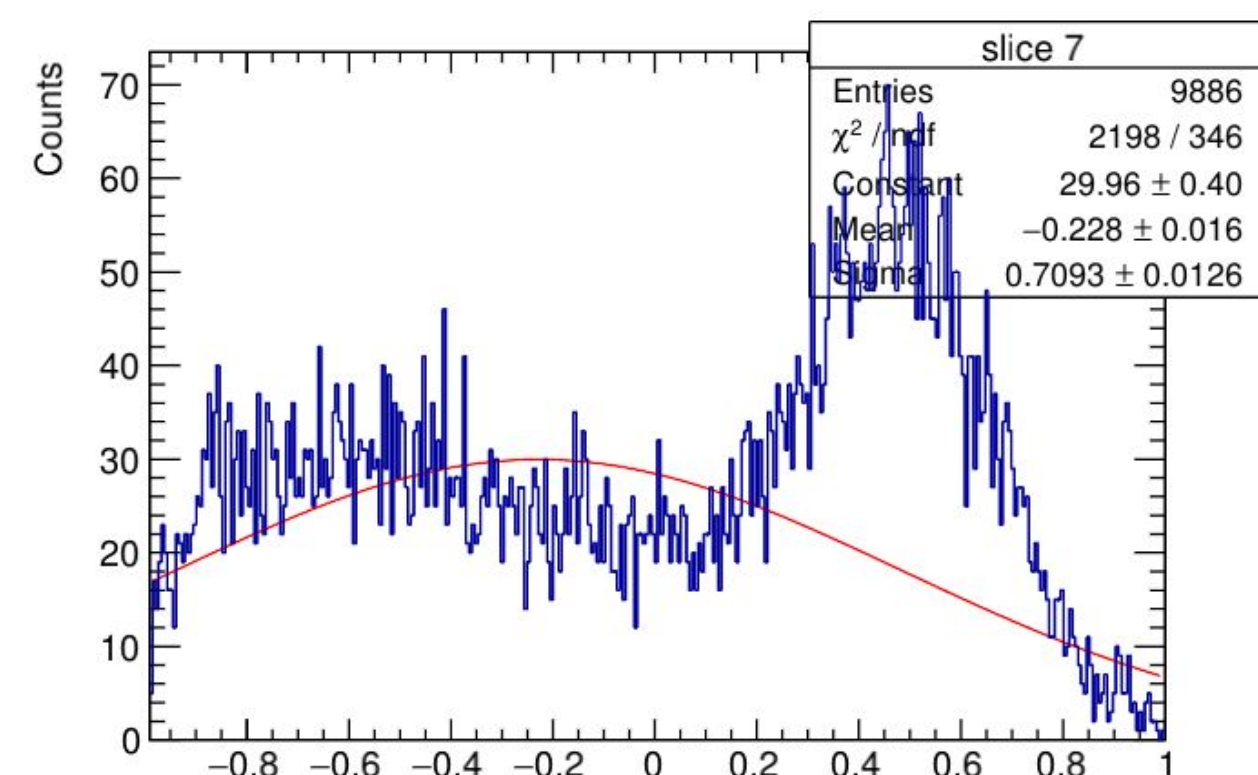
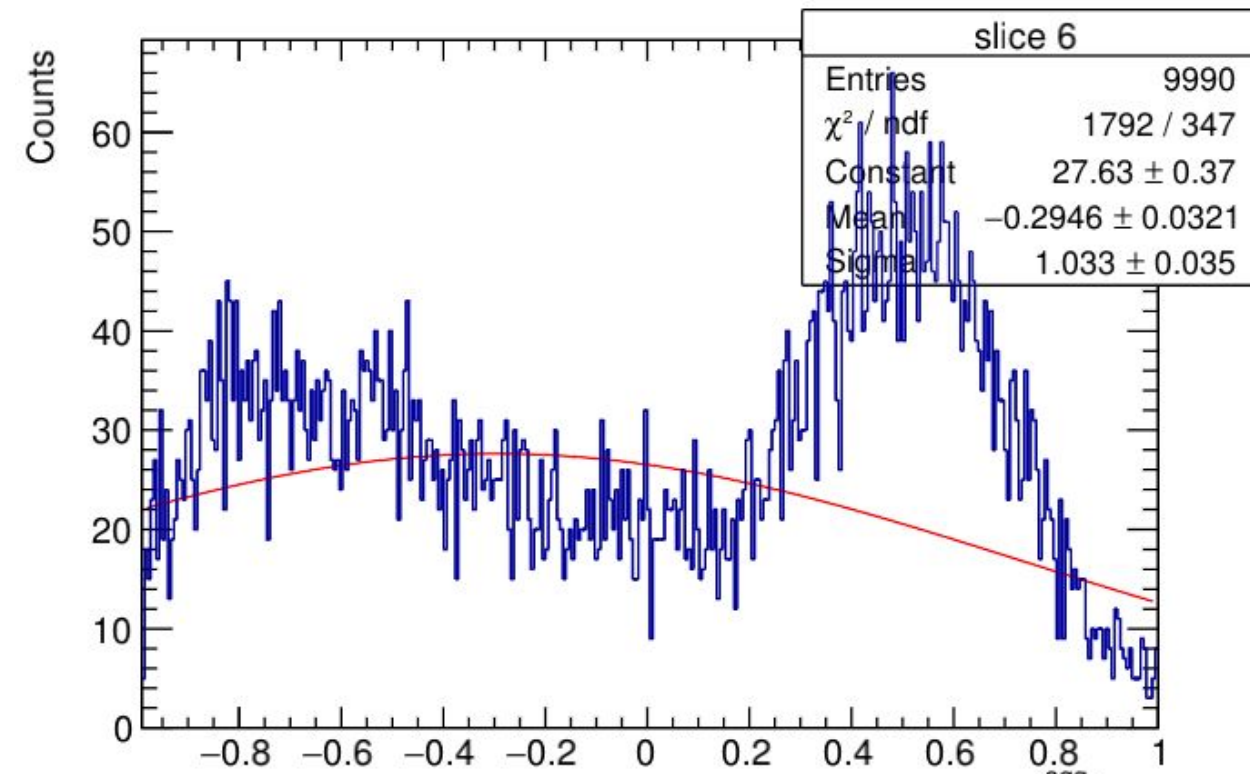
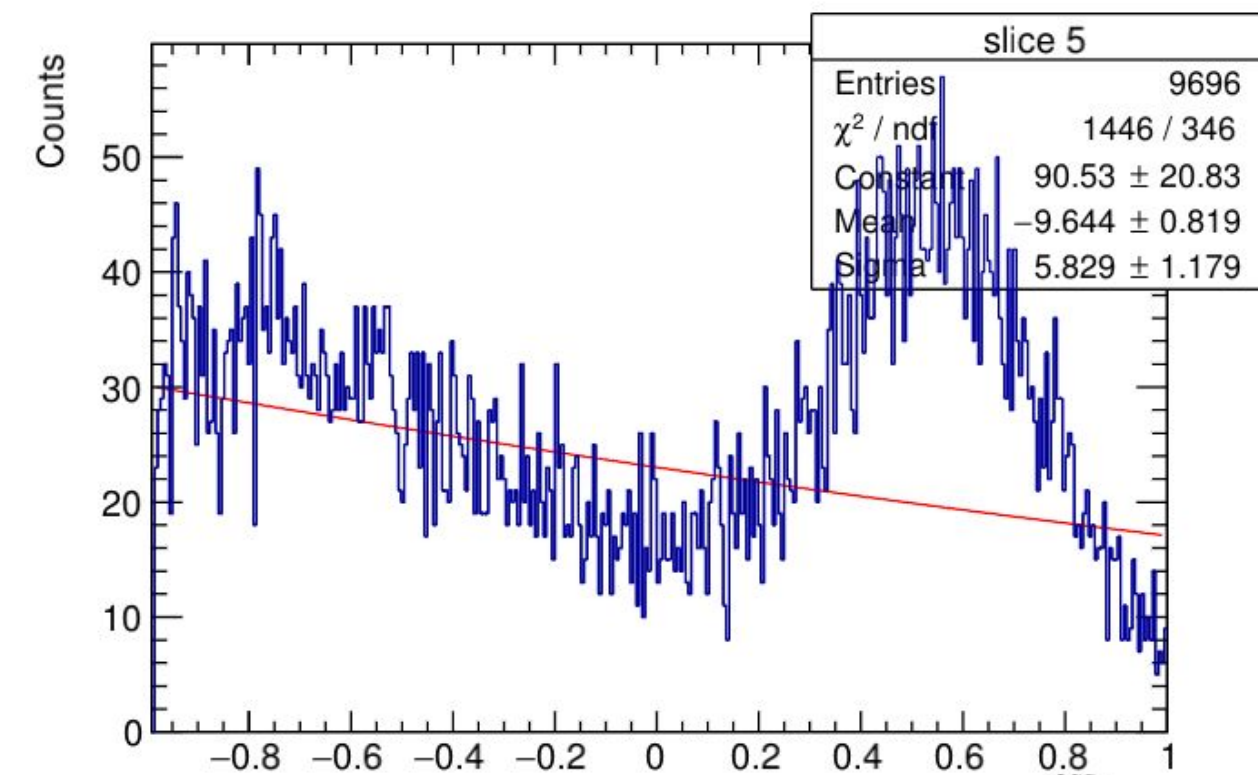
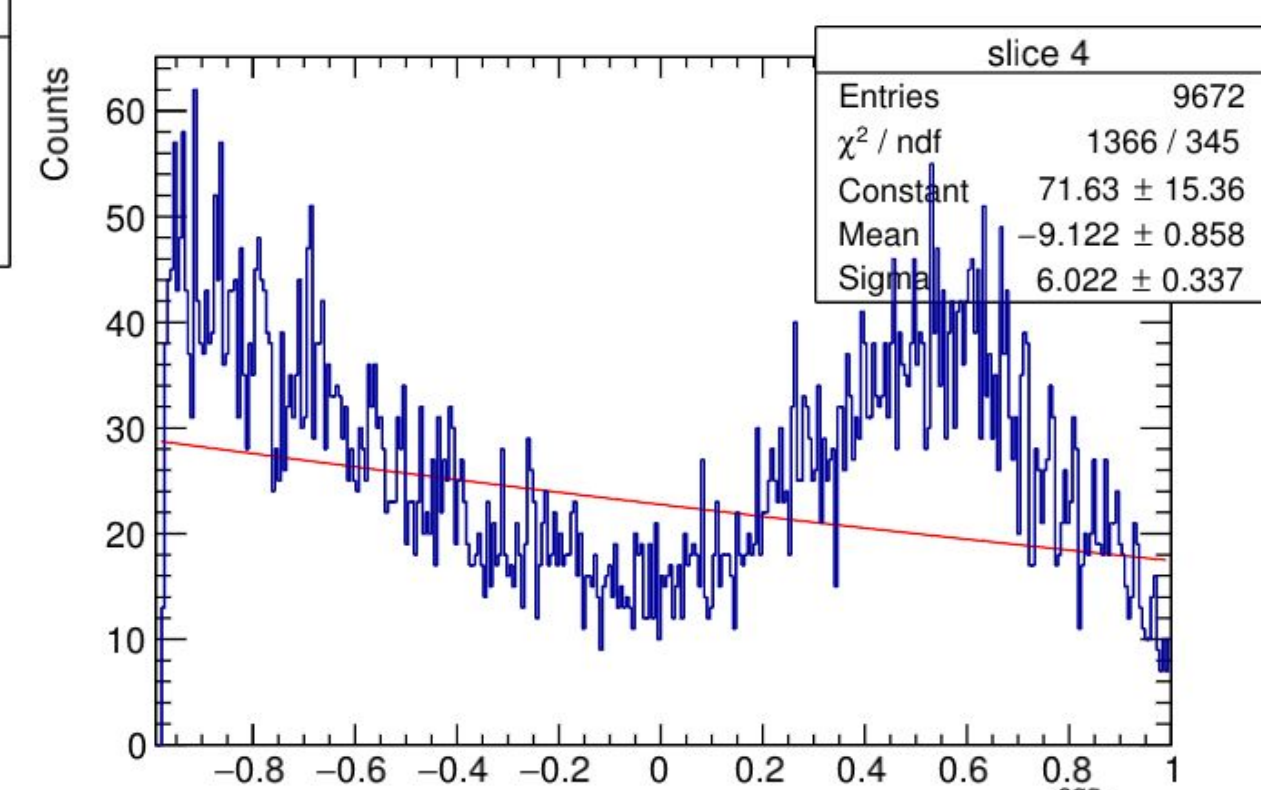
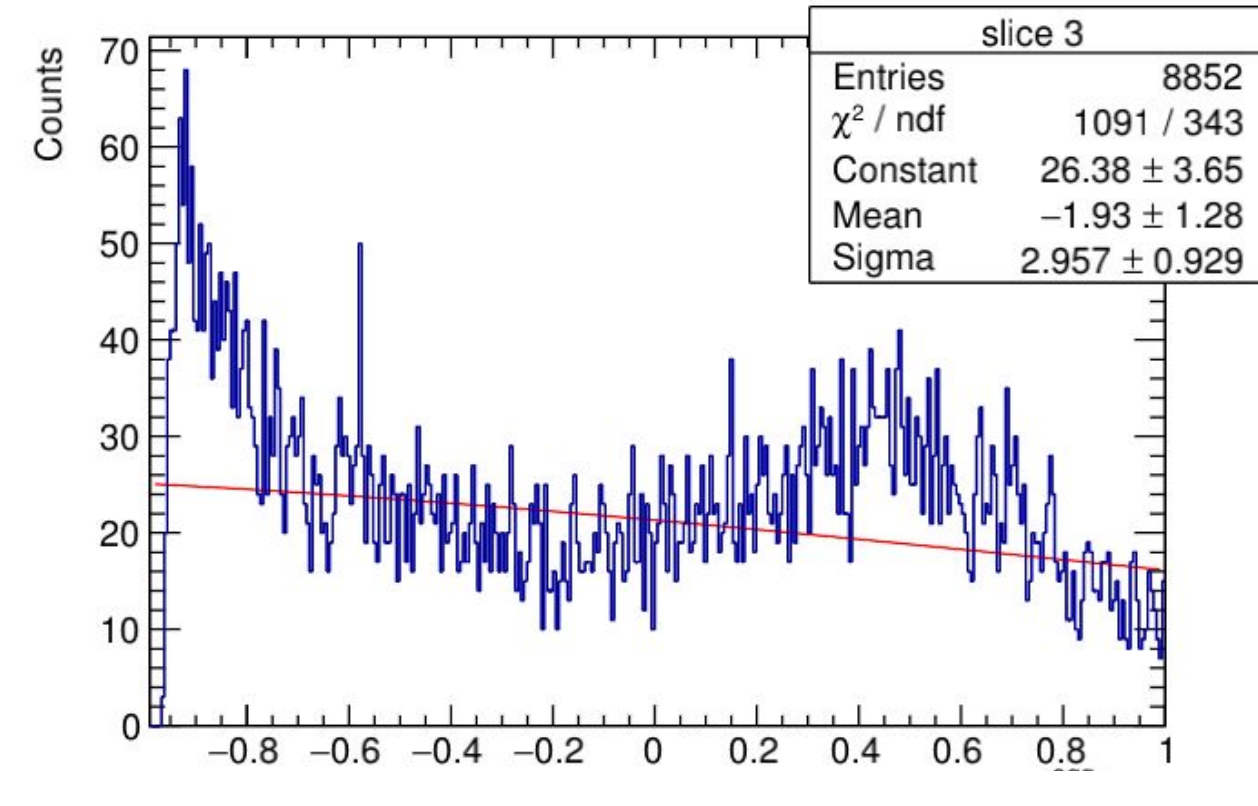
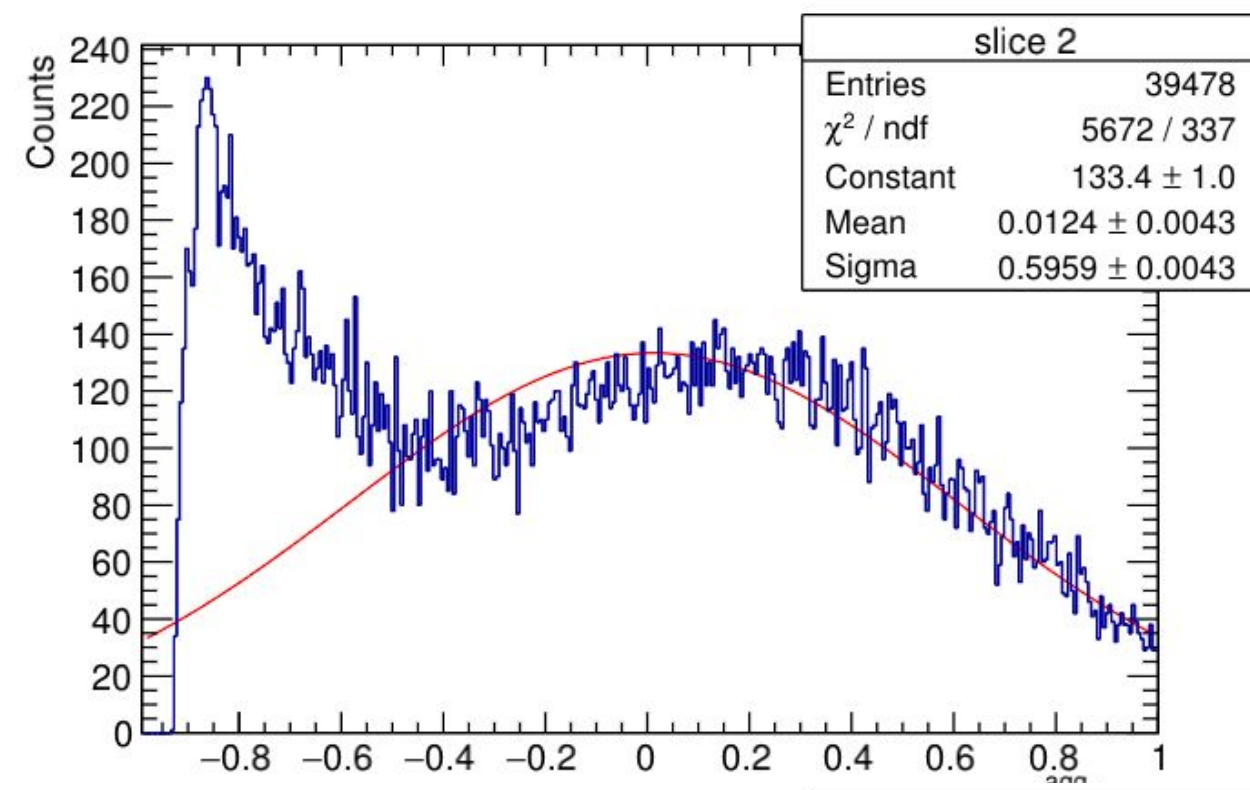
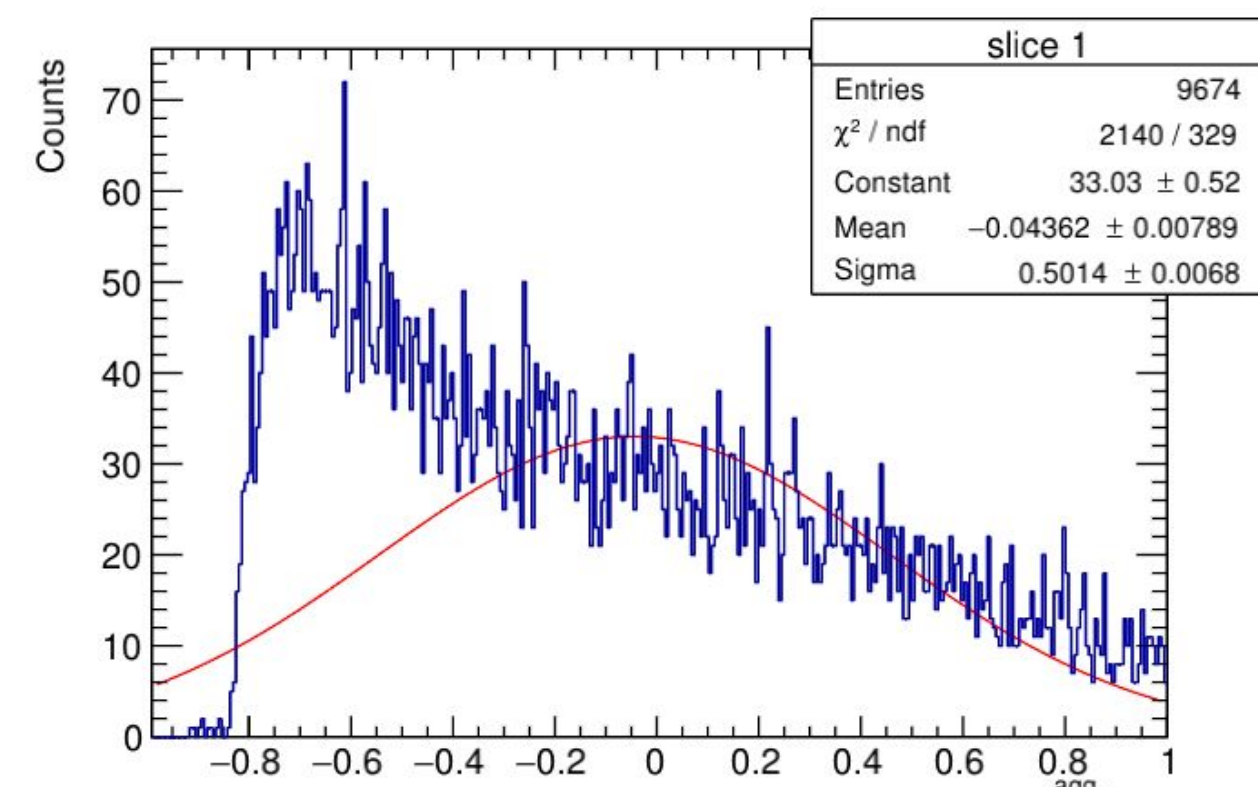
$$(te_{agg} \rightarrow \sum(\text{weight} * te / \text{calibrationFactor}) / \text{mean}(\sum(\text{weight} * te / \text{calibrationFactor}))$$

calibrationFactor(ge) = mean(te/ge) ; detector-wise; function of ge

weight = mean(te/ge) ; detector-wise; independent of ge

FEMC + FHCAL (π^-)

Fitted Gaussians



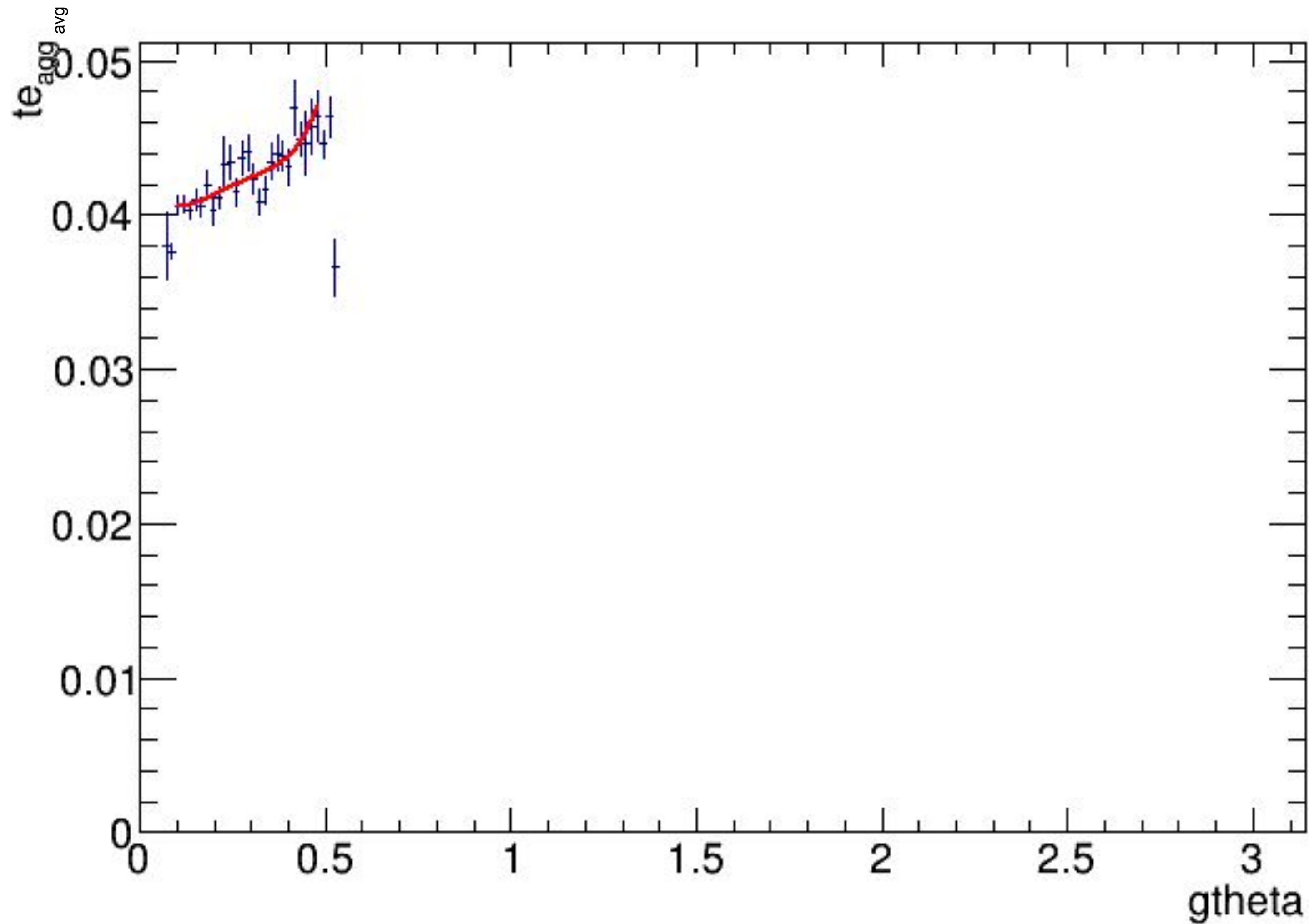
The x-axes denote $\Delta e_{\text{agg}} / \text{ge}$

A teal geometric graphic consisting of several overlapping triangles and quadrilaterals, creating a shield-like shape with a pointed bottom.

CEMC + HCALIN + HCALOUT (p_i^-)

CEMC (μ^-)

Theta-parametrization of muon-MIP energy



NO.	NAME	VALUE	ERROR	STEP SIZE	DERIVATIVE
1	p0	4.36565e-02	7.74845e-04	-3.89325e-04	1.24100e-07
2	p1	-6.83936e-02	7.24731e-03	7.19970e-03	-2.15257e-09
3	p2	5.00696e-01	2.35243e-02	-4.53787e-02	-1.48674e-08
4	p3	-1.35548e+00	6.59022e-02	1.16653e-01	8.33137e-10
5	p4	1.33188e+00	1.04638e-01	1.04638e-01	-5.47501e-08

reduced_chi2 of theta fit: 1.08146

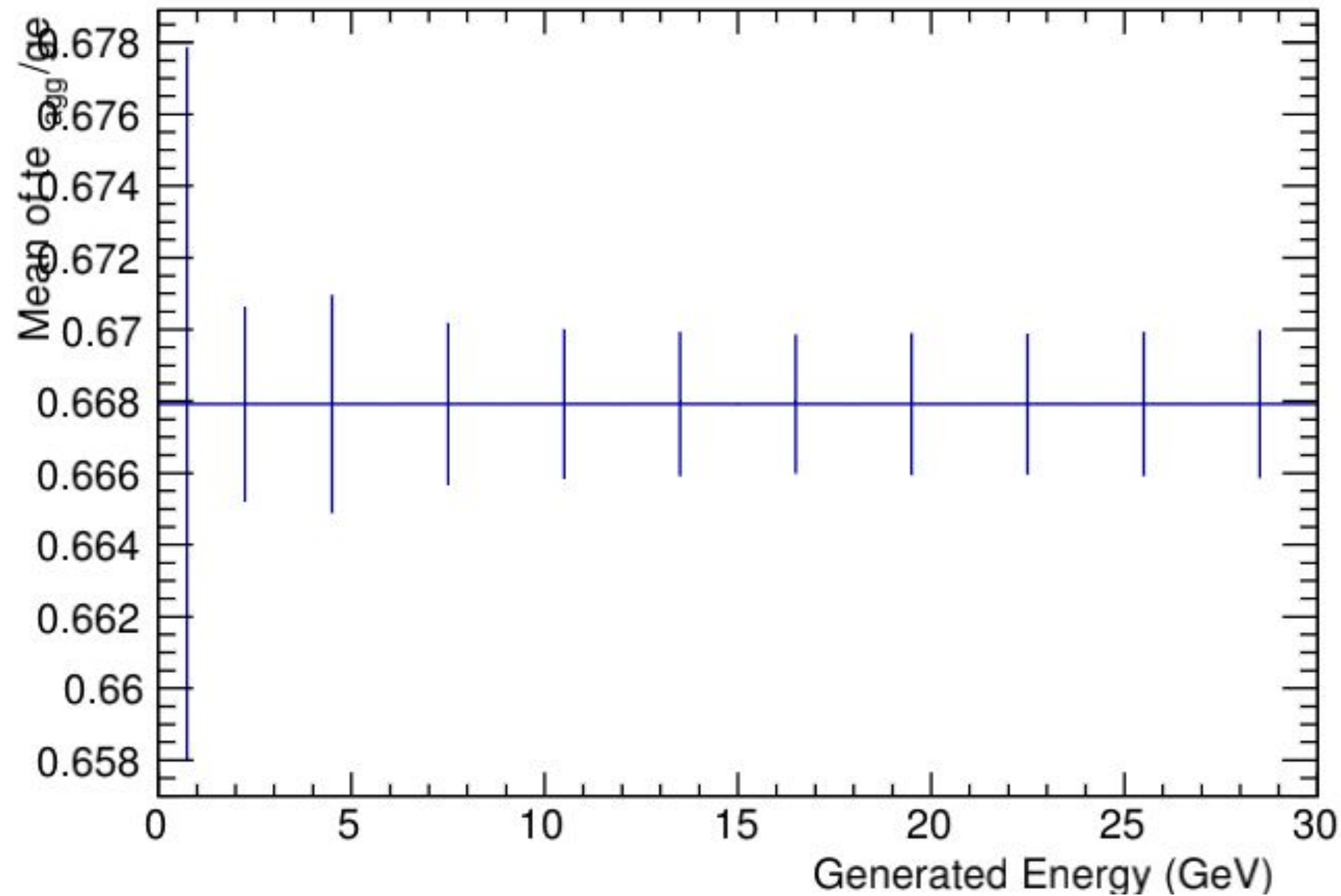
CEMC + HCALIN + HCALOUT (π^-)

Elliptical cut on dphi vs dtheta

Explicit η cut: -0.96 to 0.92

gtheta-parametrized Aggregate Energy Cut on EMC Towers

After calibration



$$(te_{agg} \rightarrow \sum(\text{weight} * te / \text{calibrationFactor}) / \text{mean}(\sum(\text{weight} * te / \text{calibrationFactor}))$$

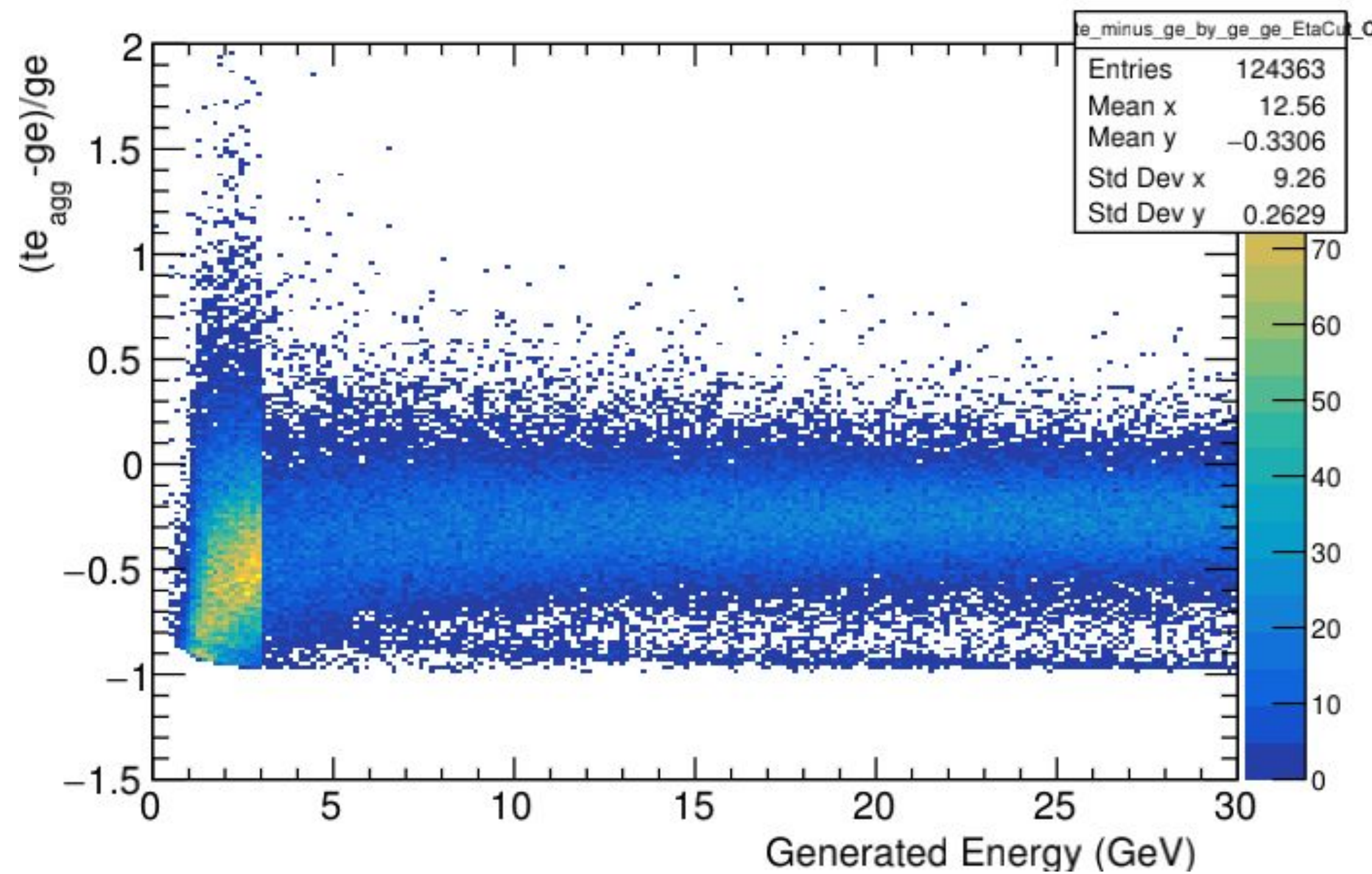
Each slice of $(te_{agg}-ge)/ge$ vs ge plot will be calibrated on the basis of dividing by a calibration factor which equals to the Mean of te_{agg}/ge corresponding to that particular slice in this plot.

CEMC + HCALIN + HCALOUT (π^-)

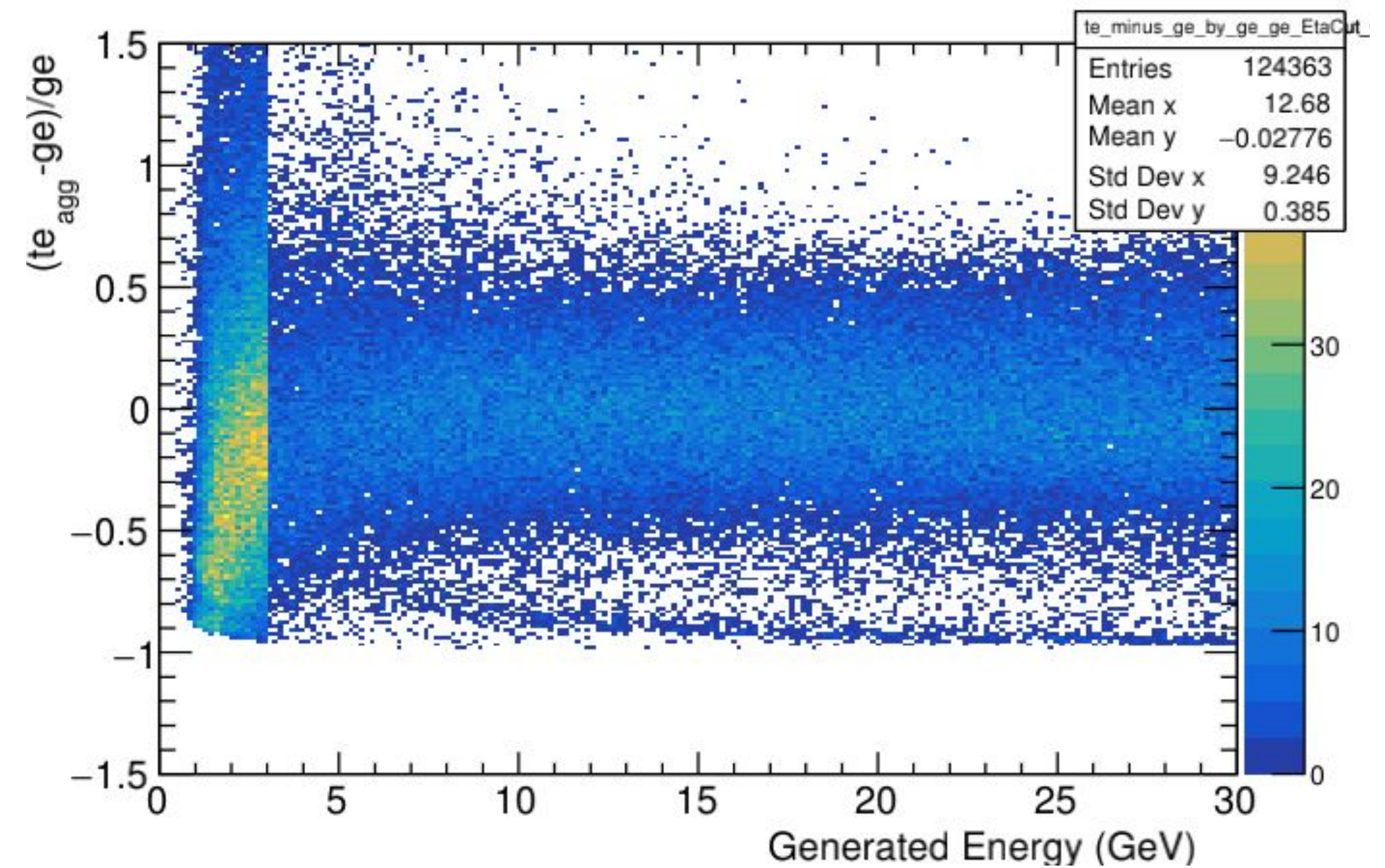
$(te_{agg} - ge)/ge$ vs ge

Explicit η cut: -0.96 to 0.92

g theta-parametrized Aggregate Energy Cut on EMC Towers



After calibration



$(te_{agg} \rightarrow \sum(\text{weight} * te / \text{calibrationFactor}) / \text{mean}(\sum(\text{weight} * te / \text{calibrationFactor}))$

$\text{calibrationFactor}(ge) = \text{mean}(te/ge)$; detector-wise; function of ge

$\text{weight} = \text{mean}(te/ge)$; detector-wise; independent of ge

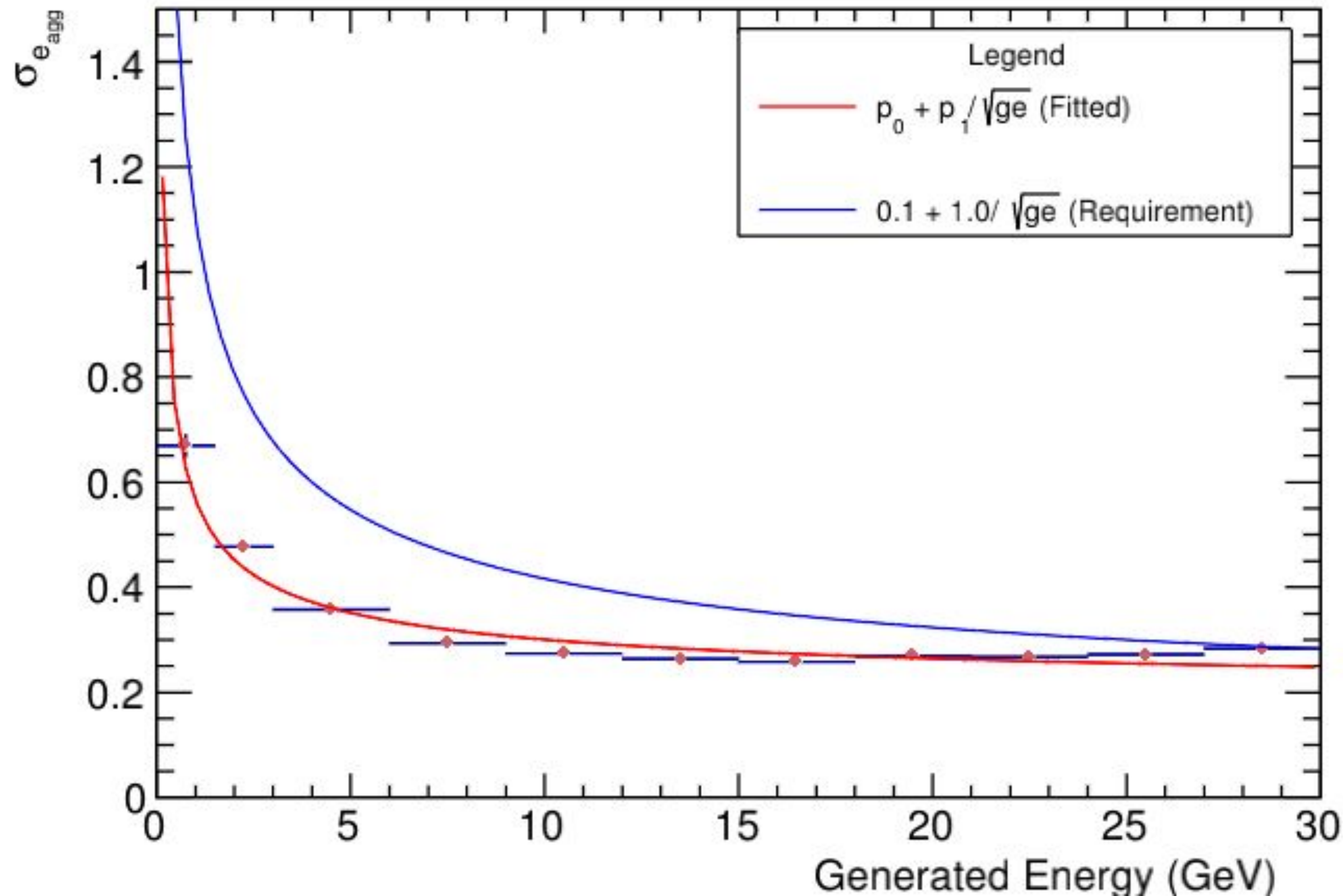
CEMC + HCALIN + HCALOUT (π^-)

$\sigma_{e_{agg}}$ vs g_e

Explicit η cut: -0.96 to 0.92

Elliptical Cut for Manual Clustering

g_{θ} -parametrized Aggregate Energy Cuts on EMC Towers



σ_e refers to the standard deviation of the Gaussian fitted to a slice of the calibrated $(t_{e_{agg}} - g_e)/g_e$ vs g_e plot.

Number of bins = 11

Bin Width = 1.5 GeV

3.0 GeV

$g_e \in [0, 3)$

$g_e \in [3, 30]$

Fit Parameters:

$p_0 = (0.177526 \pm 0.00191994)$

$p_1 = (0.388698 \pm 0.00640721) \text{ GeV}^{0.5}$

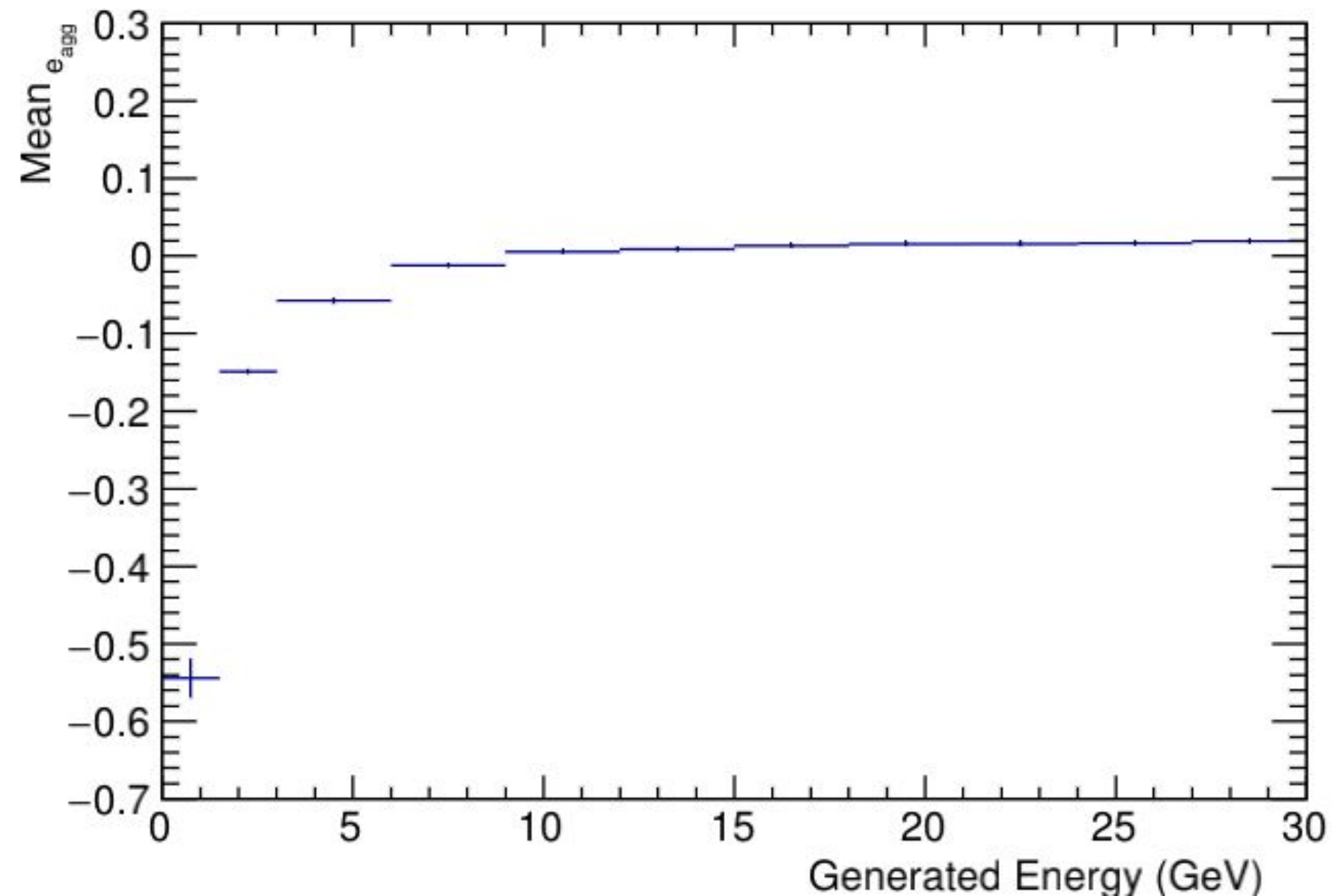
CEMC + HCALIN + HCALOUT (π^-)

Explicit η cut: -0.96 to 0.92

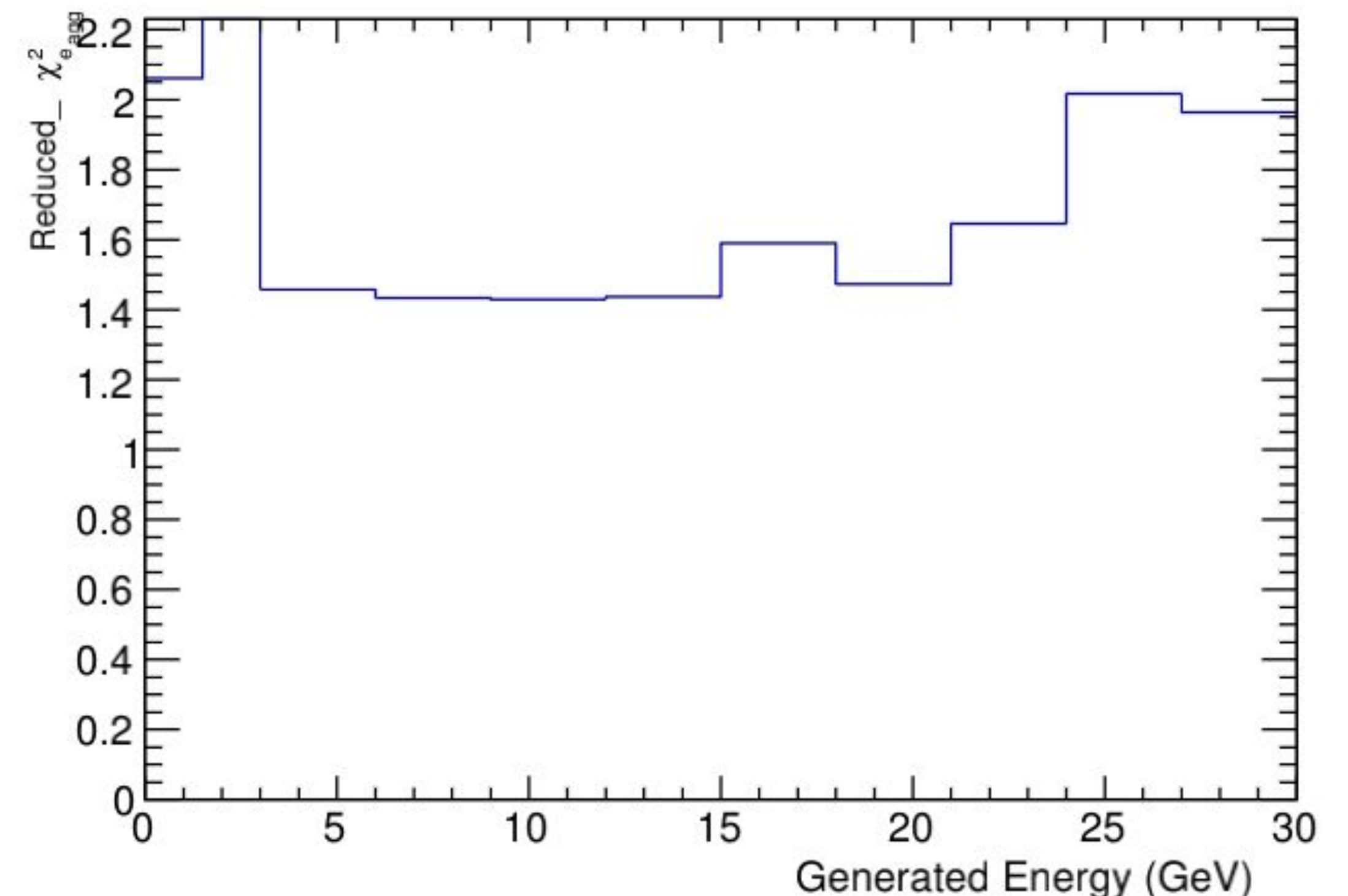
Elliptical Cut for Manual Clustering

gtheta-parametrized Energy Cut on Individual EMC Towers

100 MeV Aggregate Energy Cut



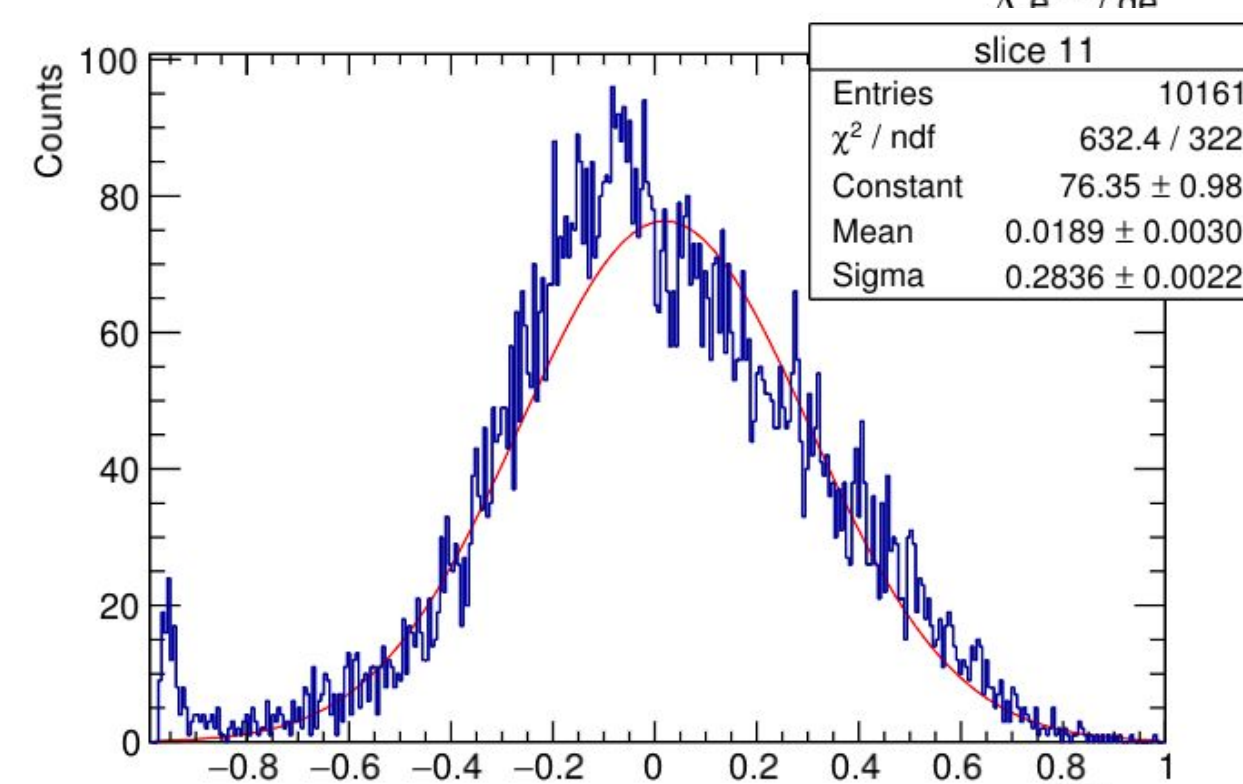
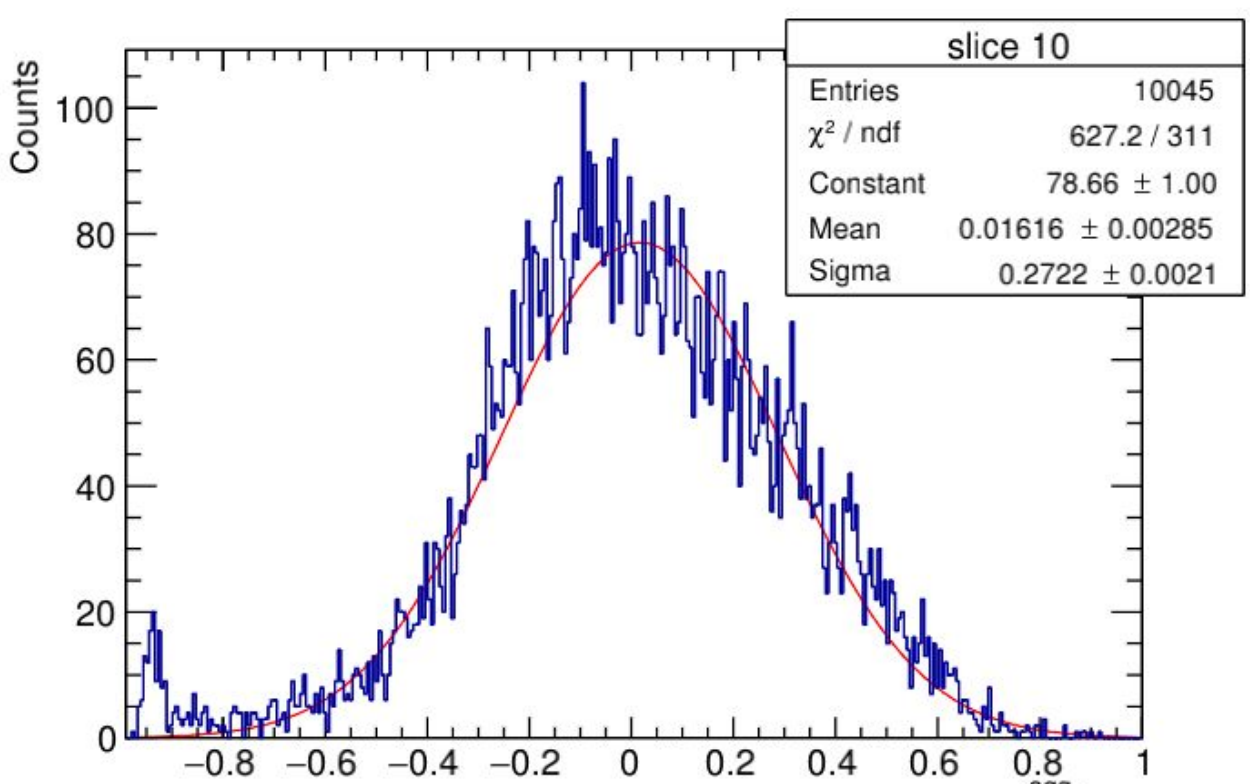
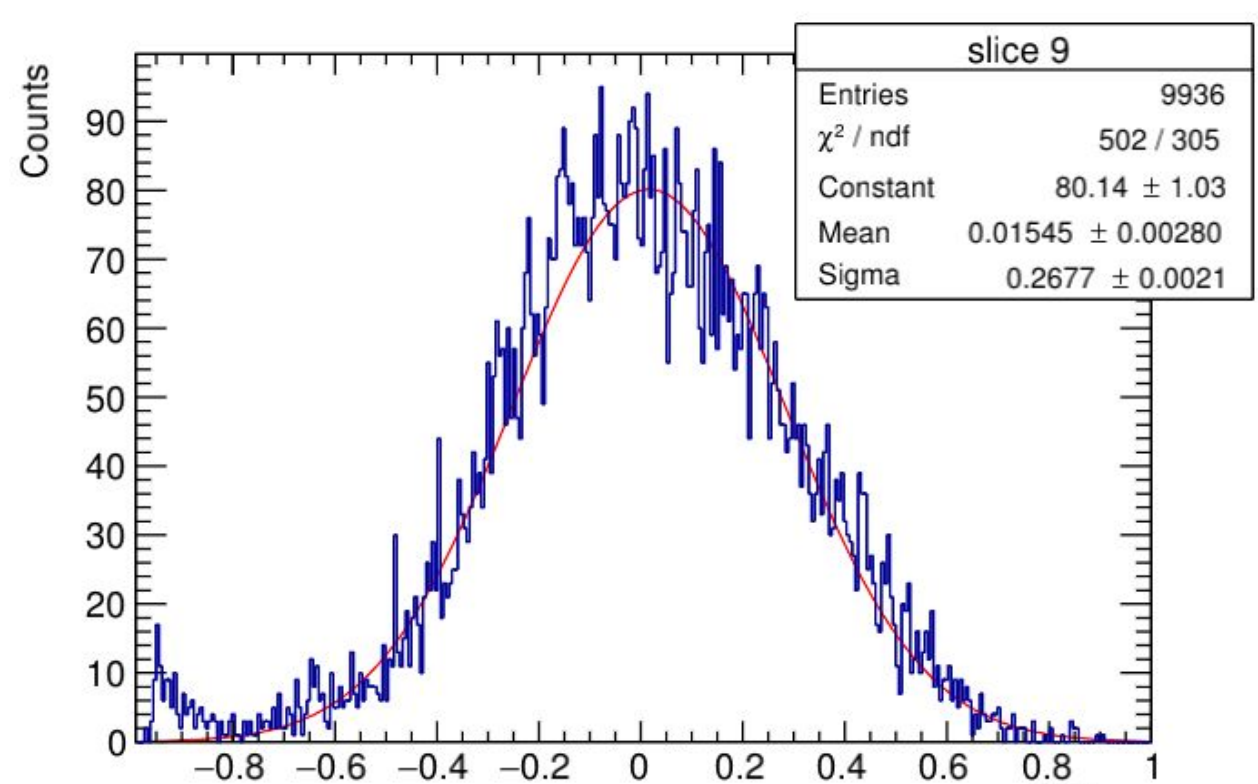
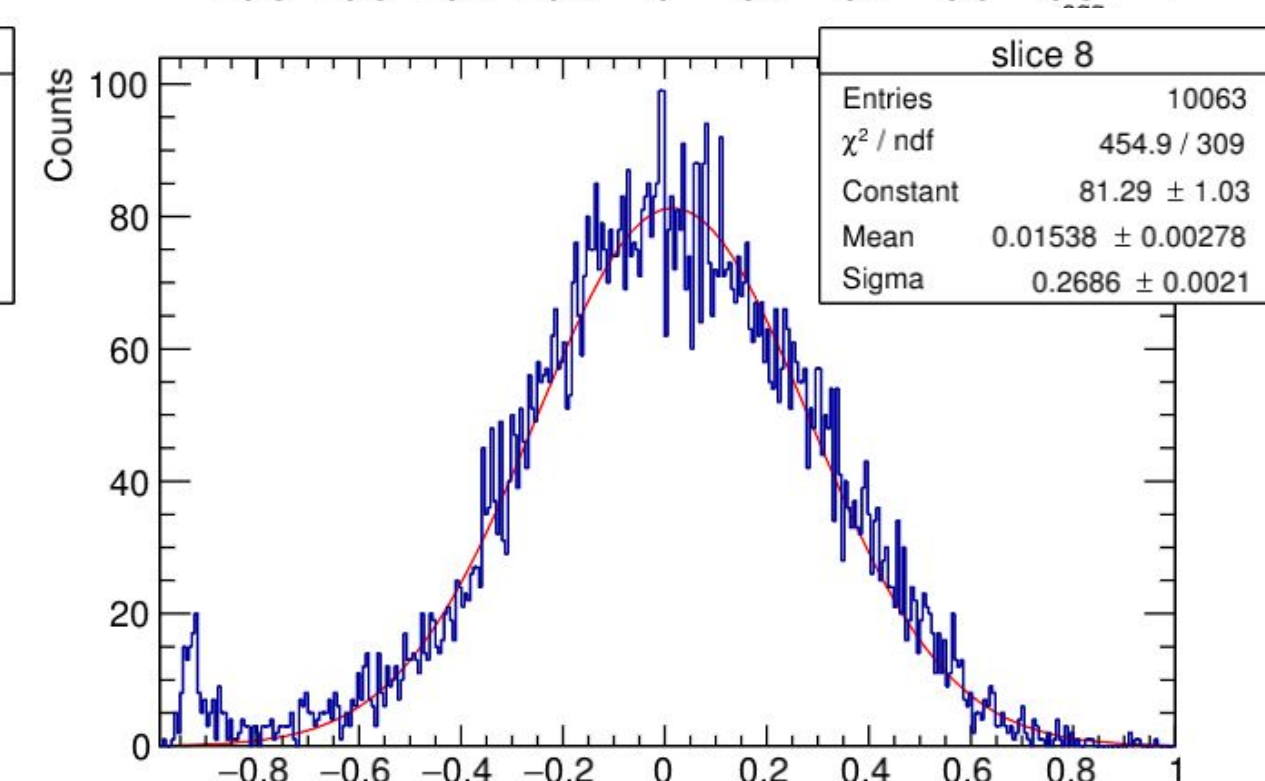
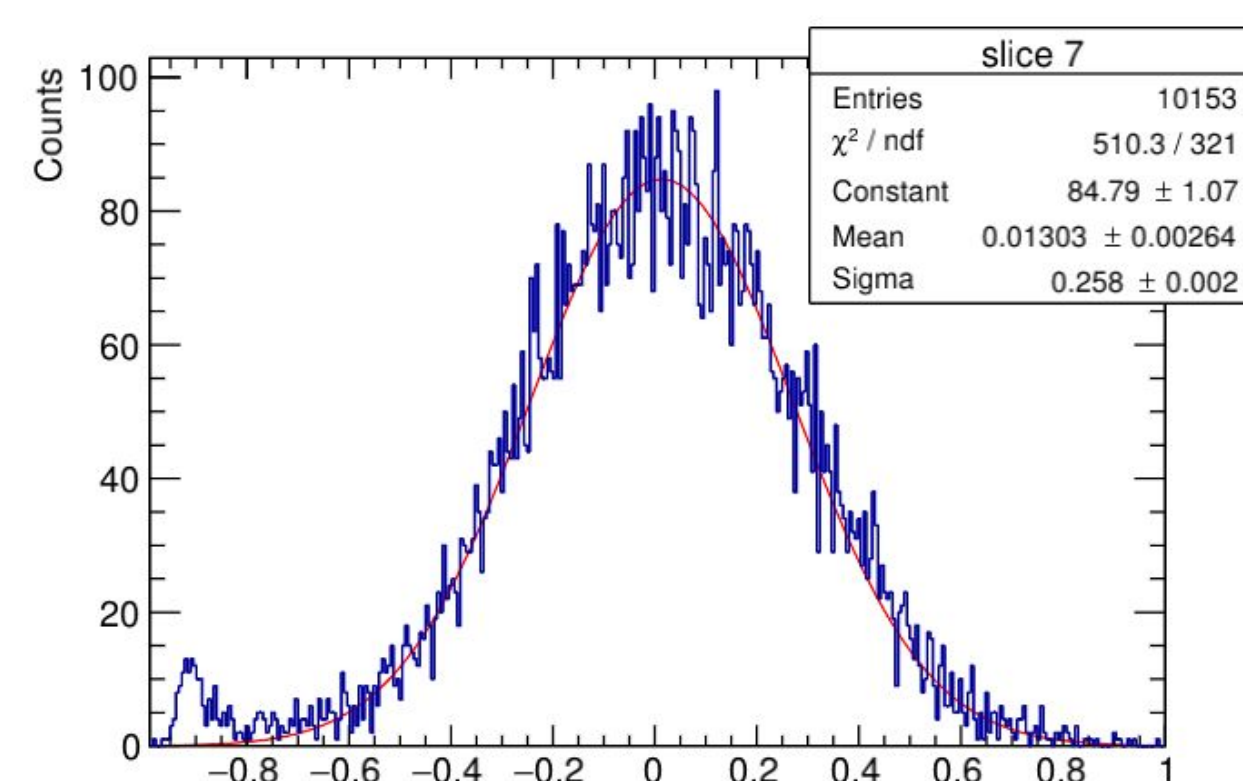
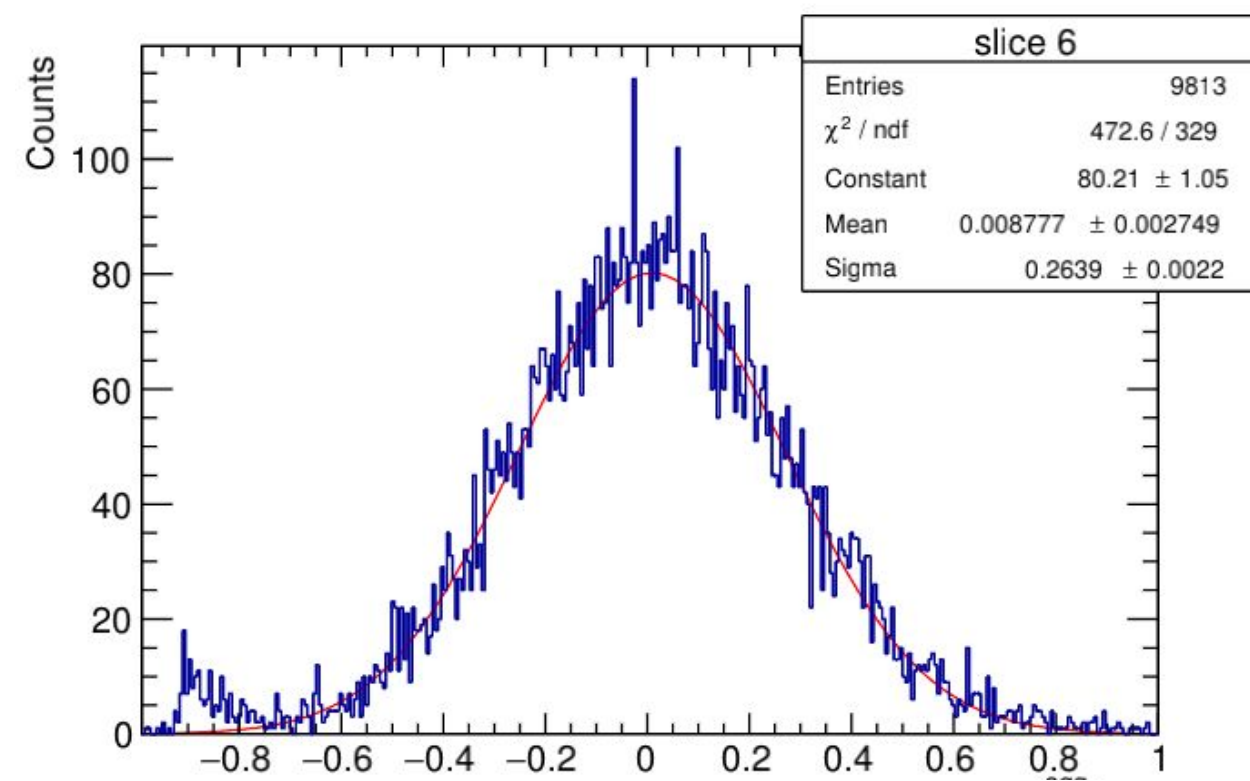
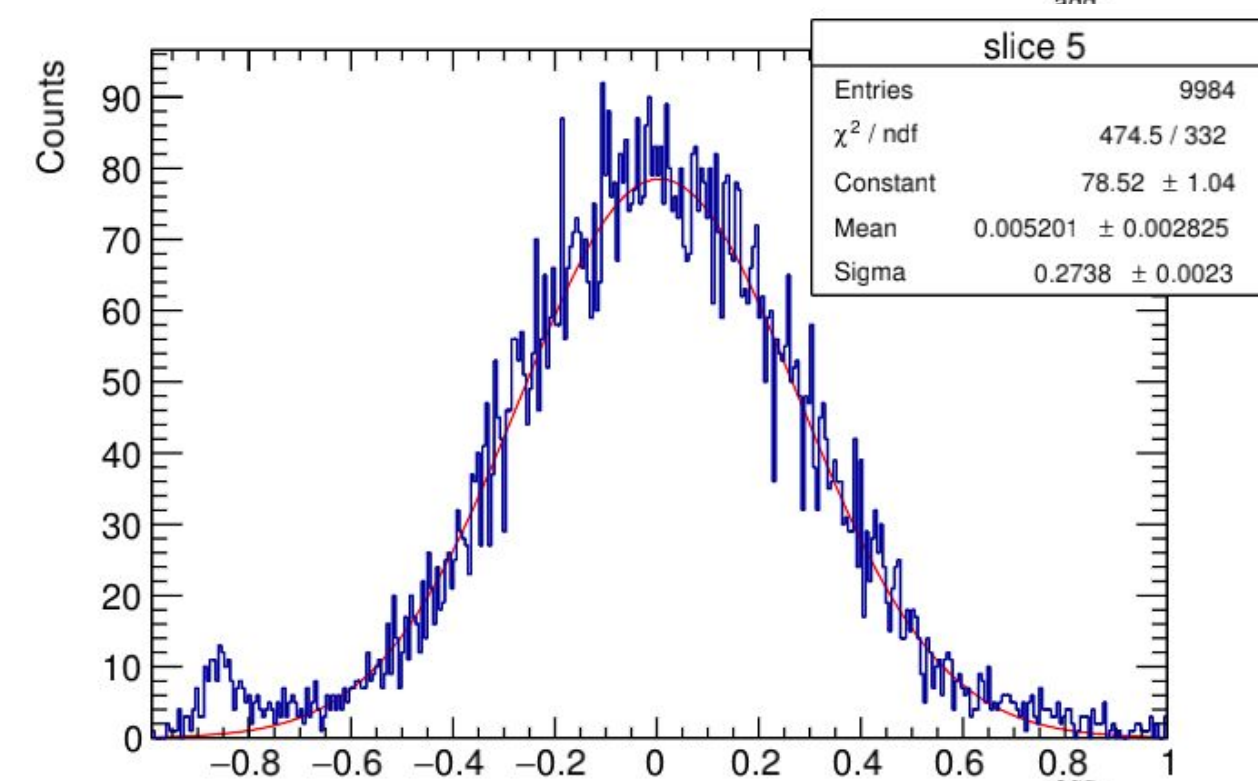
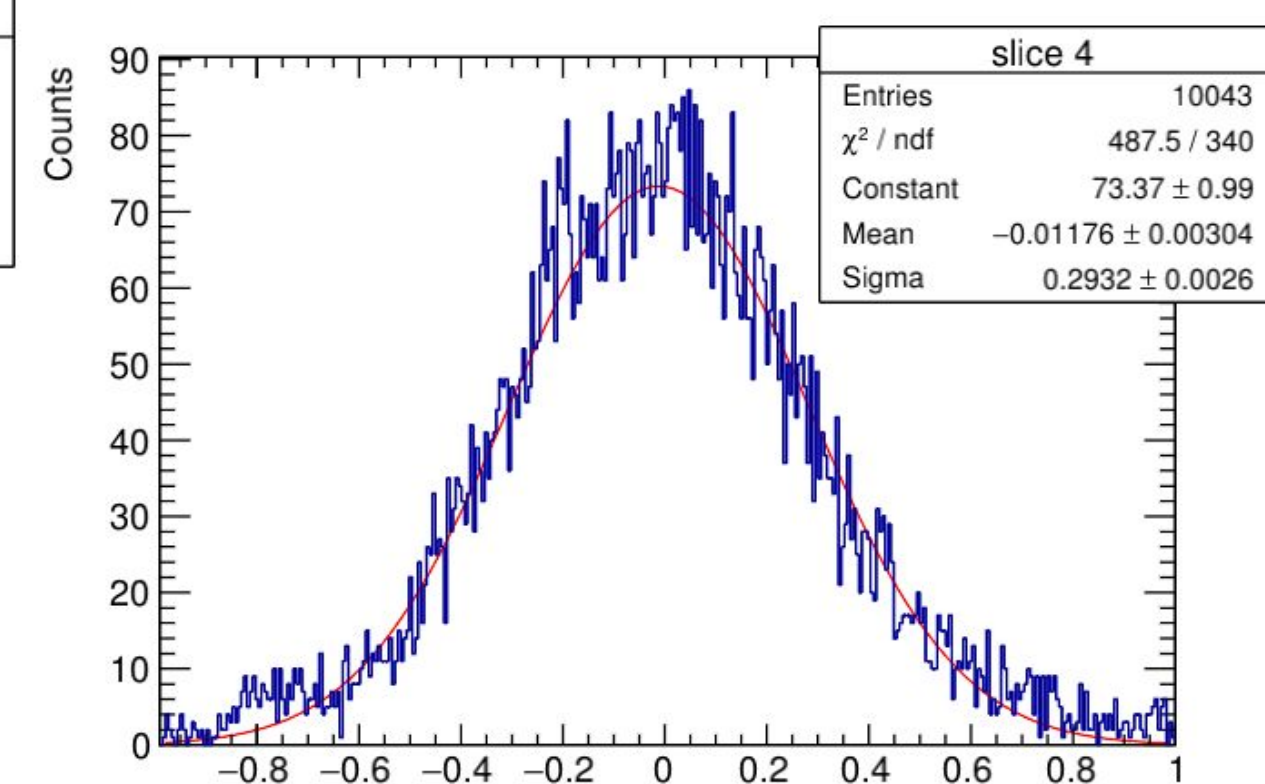
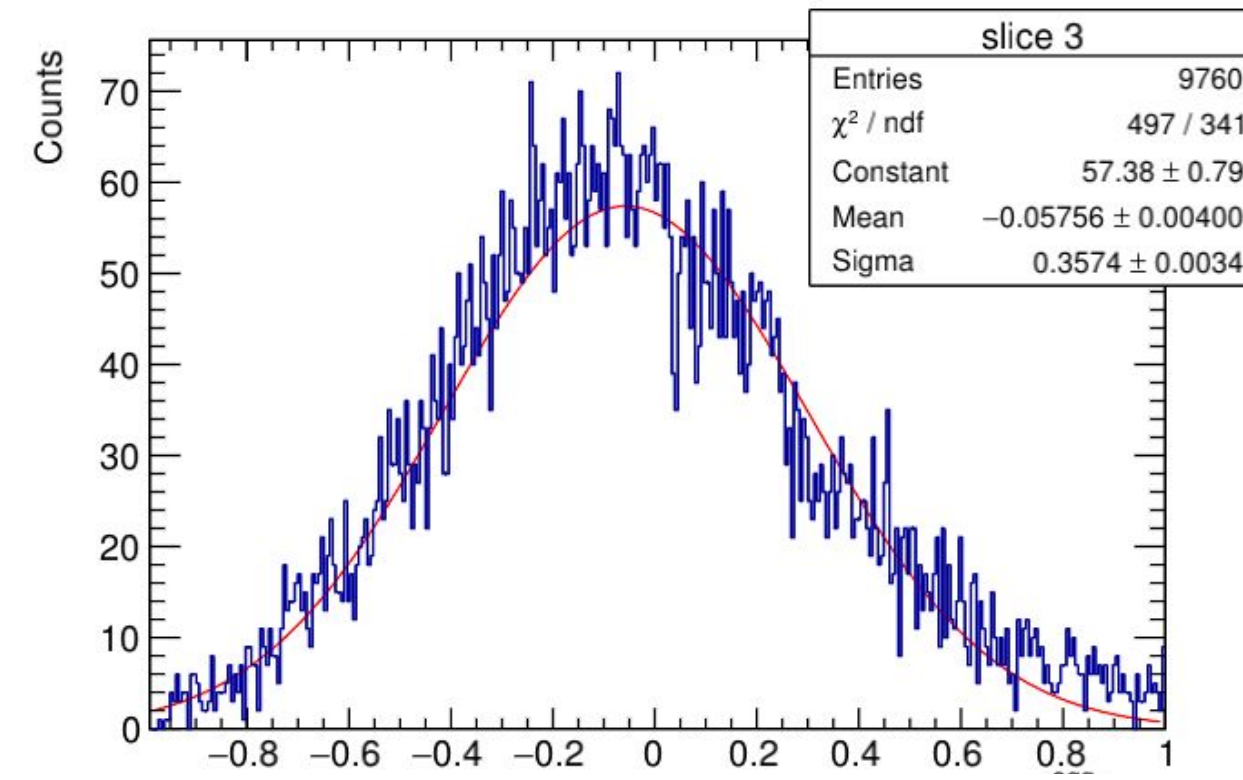
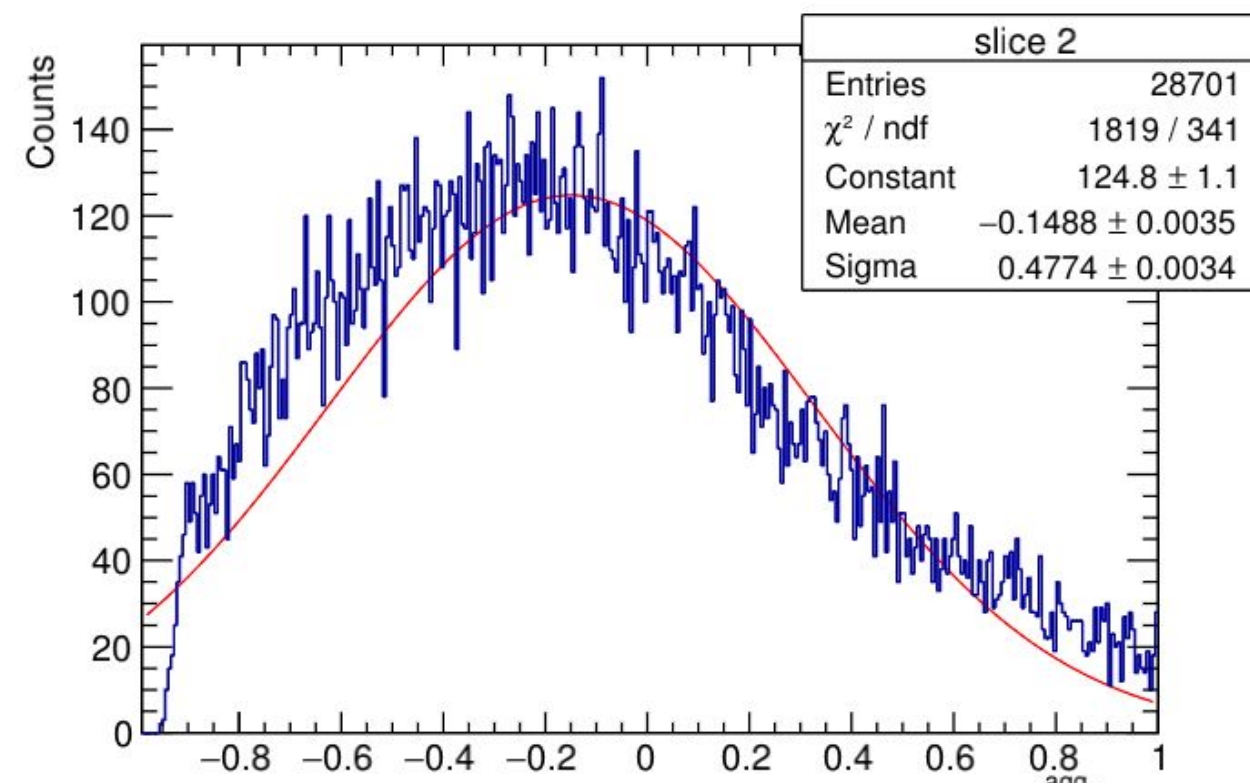
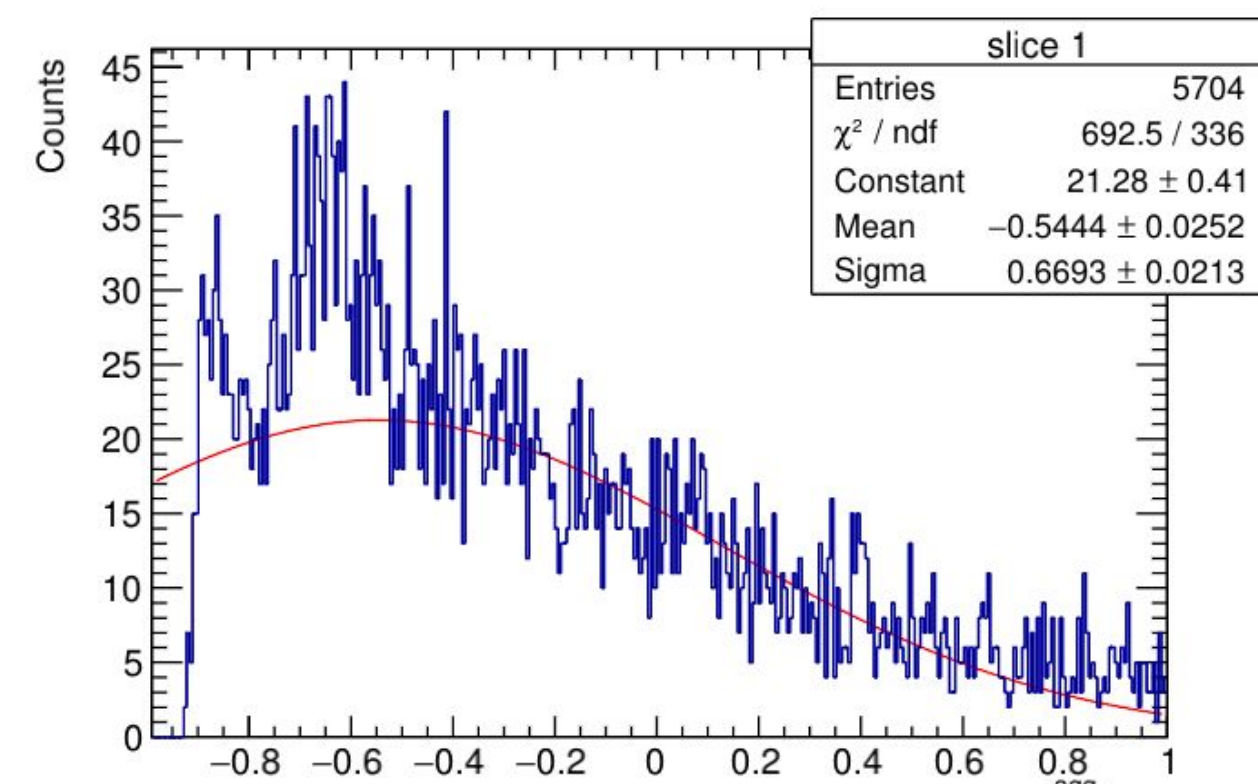
Mean of the Gaussians fitted to the slices of the calibrated $(te_{agg} - ge)/ge$ vs ge plot.



Reduced_ χ^2 of the Gaussians fitted to the slices of the calibrated $(te_{agg} - ge)/ge$ vs ge plot.

CEMC + HCALIN + HCALOUT (π^-)

Fitted Gaussians



The x-axes denote $\Delta e_{\text{agg}}/\text{ge}$

