

π^0 reconstruction from Run19 AuAu200 prototype test data

Xilin Liang

University of California, Riverside

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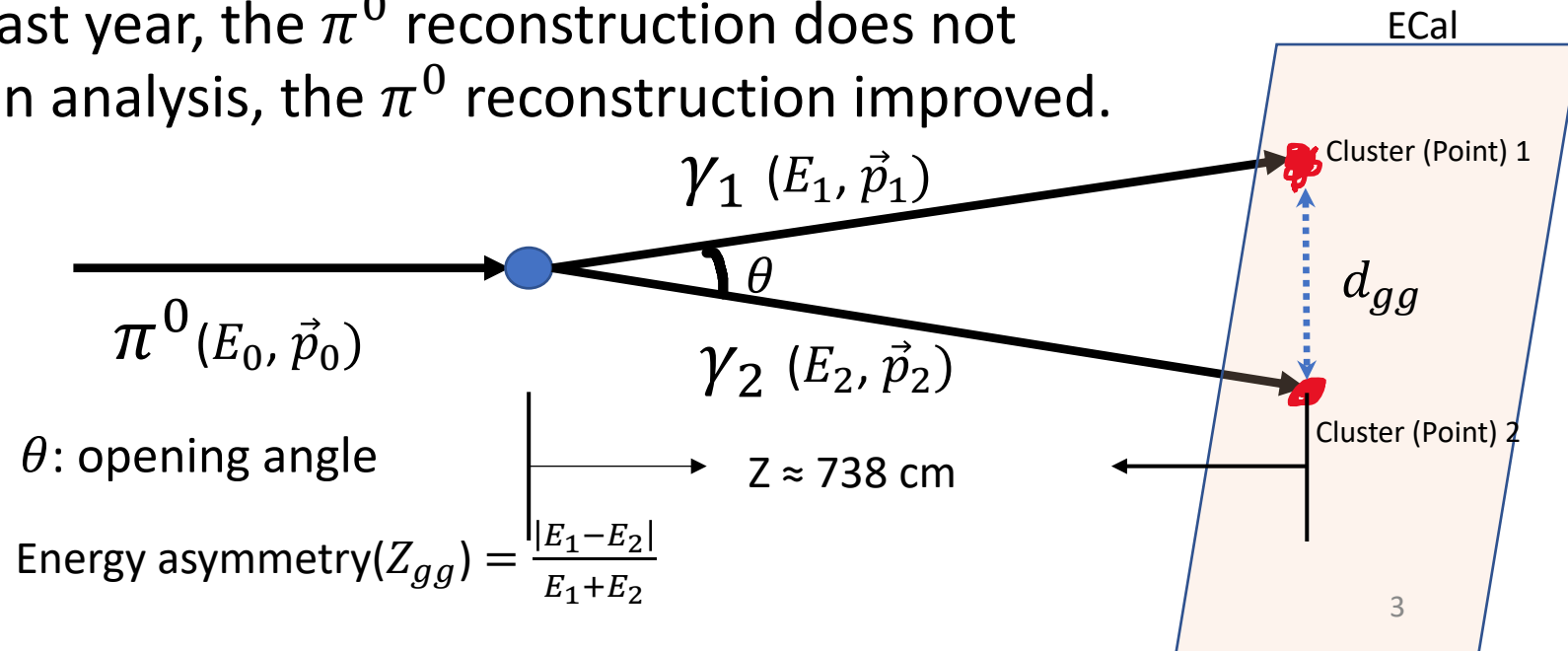
Jan. 17, 2020

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Introduction

- Sanity check of ECal prototype for Forward Calorimeter System (FCS) by using π^0 reconstruction from run19 AuAu200 data.
- π^0 decays to two photons, whose branch fraction is 98.8%.
- We use Cluster finder to get all the clusters in each event, where cluster represents a group of cells fired on ECal from EM shower of photon .
- We use Point maker to get all the points in each event, where point represents the reconstructed photon candidate which gets from cluster.
- On my last report on Sept last year, the π^0 reconstruction does not look well. Applying new gain analysis, the π^0 reconstruction improved.



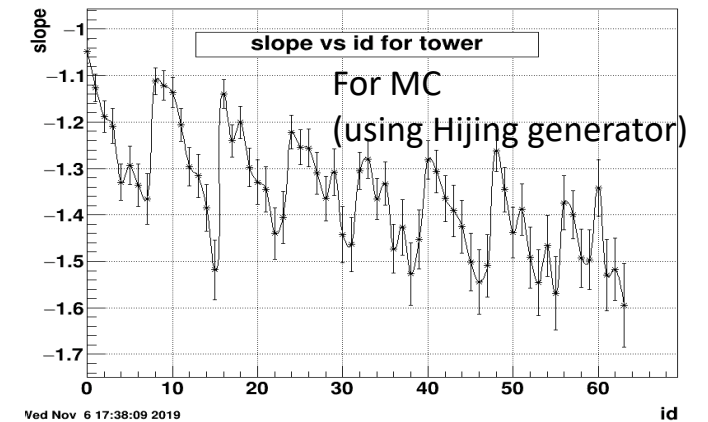
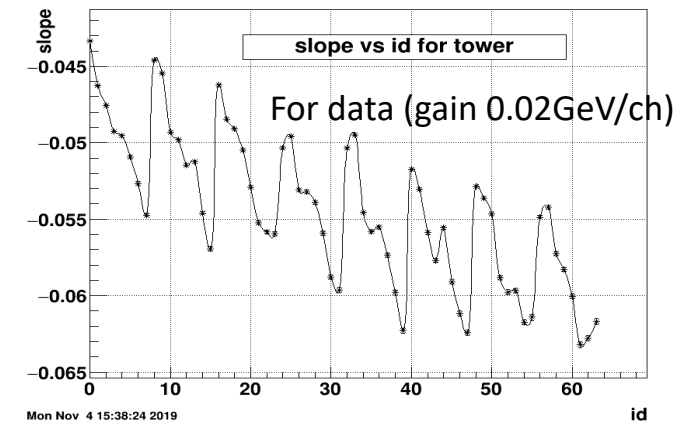
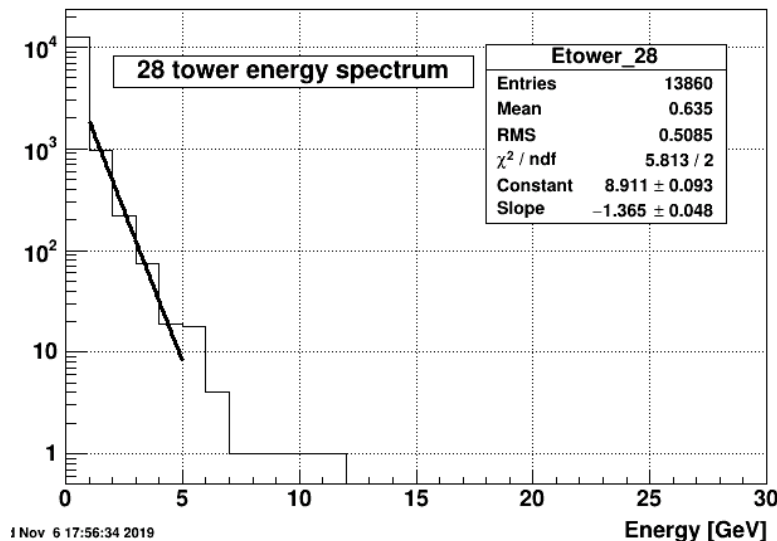
Data set

- We use the run19 AuAu200 data from STAR detector.
- Total amount of the data we use is about 29.5 M.
- Rough gain assigned to each channel is 0.0008 GeV / ADC Channel (detail in slide 5 and 6)
- The energy of a cell = sum of ADC in time bin [35 , 60] \times gain.

Gain analysis for data and MC

- MC: 40 k MC using Hijing generator (Heavy Ion Jet Interaction Generator)
- We draw the energy spectrum for each tower in ECal, which are the plots recording the energy of every hit for all the events.
- Next we use exponential function ($f(x)=\exp([0]+[1]*x)$) to fit the energy spectrum, where [1] is the slope from the fit.
 - Fitting range [30, 130] (GeV) for gain 0.02 GeV/ch data (Sep. meeting)
 - Fitting range [1,5] (GeV) for MC (using Hijing generator)

One example for tower energy spectrum from MC

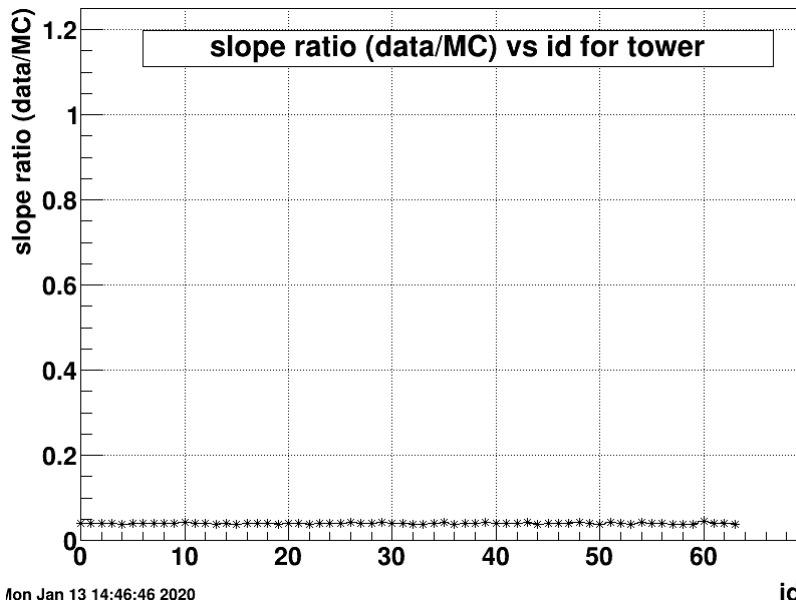


FCS ECal 8 × 8 tower

0	1	2	3	4	5	6	7
8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23
24	25	26	27	28	29	30	31
32	33	34	35	36	37	38	39
40	41	42	43	44	45	46	47
48	49	50	51	52	53	54	55
56	57	58	59	60	61	62	63

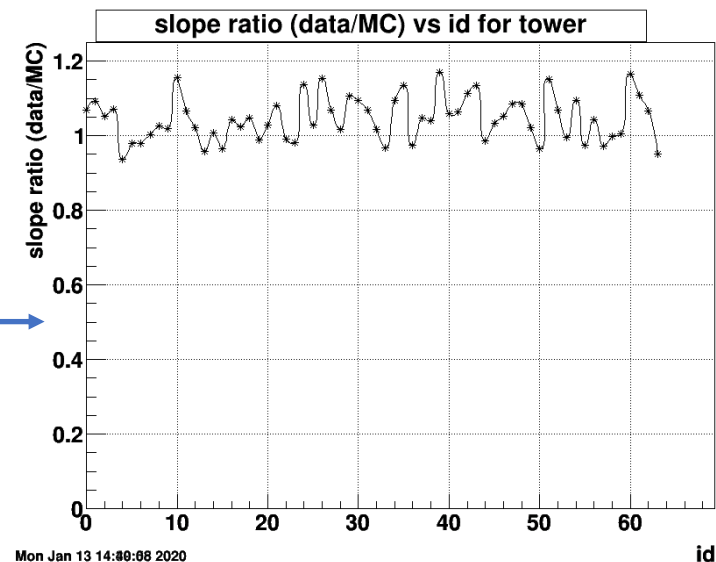
Gain analysis result

- Compare the slope from fit for tower energy spectrum between data and MC. Then use the formula to calculate the correct gain for data.
- $$\text{correct gain} = \frac{\text{slope from fit for data}(0.02)}{\text{slope from fit for MC}} \times \text{gain}(0.02\text{GeV/ch})$$
- Reason:
 - The energy spectrum for towers of data and MC should behave similarly, so they should have the similar distribution. If we use exponential function to express their spectra, their slope should be same.
- So we choose **0.0008 GeV/ch** for data



Before gain analysis:
The ratio is about 0.04

After gain analysis:
The ratio is close to 1



Event selection for single π^0 MC

- Generate 20k 20 GeV π^0 single particle event (using full FCS geometry).
 - $\eta=3$; full 2π coverage.
 - Gain 0.0008 GeV/ch

➤ Event selection for cluster finder:

- Keep only cluster at Ecal
- Each cluster energy is more than 0.5 GeV.
- Energy asymmetry ($Z_{gg} = \frac{|E_1 - E_2|}{E_1 + E_2}$) less than 0.7
- If there are two or more clusters in each event, loop all the possible pairs of clusters and keep all the possible pairs fit the event selection criteria.

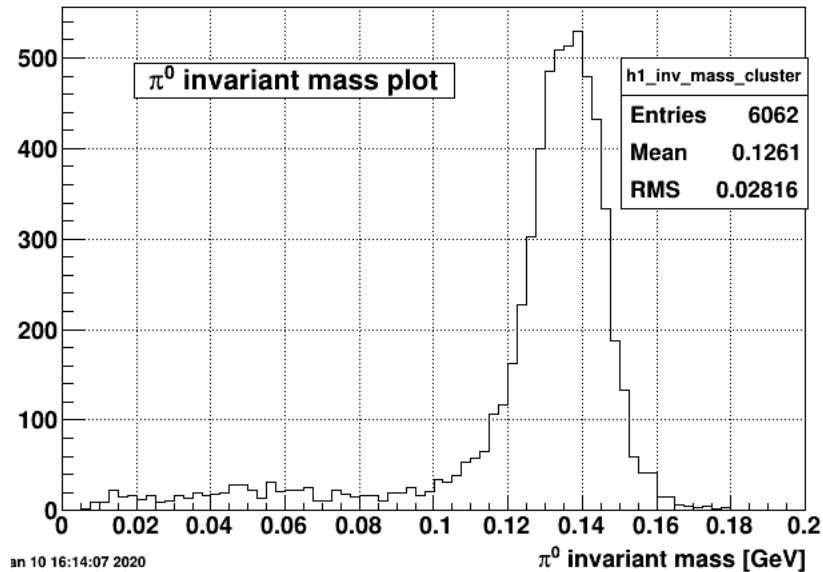
❖ Event selection for point maker:

- Keep only point at Ecal
- Each point energy is more than 0.5 GeV.
- Energy asymmetry ($Z_{gg} = \frac{|E_1 - E_2|}{E_1 + E_2}$) less than 0.7
- If there are two or more points in each event, loop all the possible pairs of points and keep all the possible pairs fit the event selection criteria.

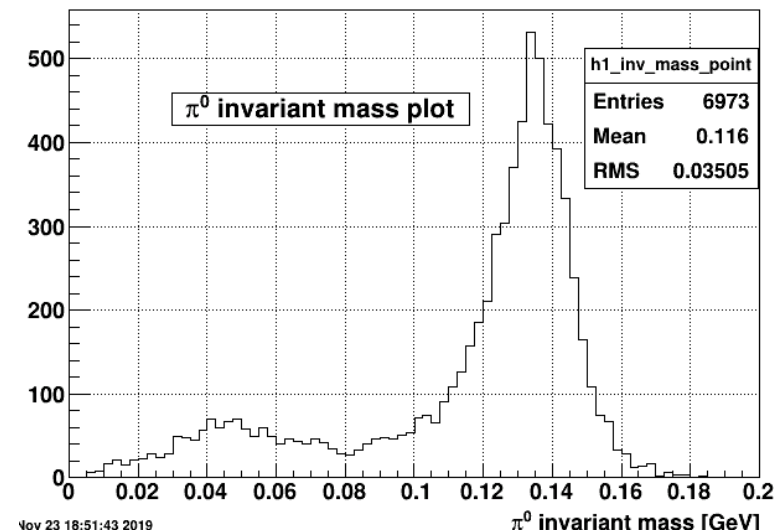
MC result

- The left plot is invariant mass plot for cluster finder analysis. There is a clear peak at about 0.138 GeV, which is close to π^0 invariant mass.
- The right plot is invariant mass plot for point maker analysis. There is a clear peak at about 0.135 GeV, which is π^0 invariant mass.

Cluster finder result



Point maker result

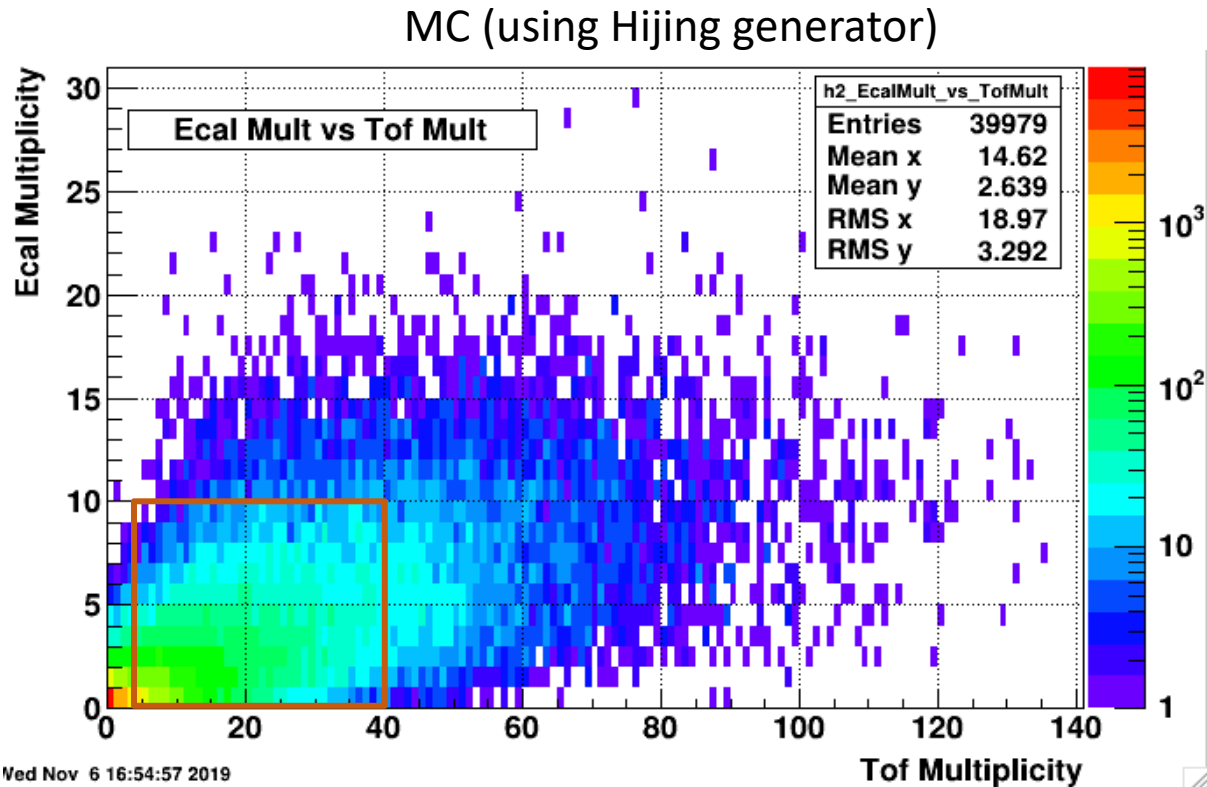


Event selection for data using cluster finder

- Step 1: Select clusters only at Ecal
- Step 2: Clusters energy cuts
 - Each cluster energy $> 1 \text{ GeV}$
 - $Z_{gg} < 0.7$
 - $10 \text{ GeV} < E_1 + E_2 < 20 \text{ GeV}$
- Step 3: Detector multiplicity cuts (detailed in slide 10)
 - $3 \leq \text{Tof multiplicity} \leq 40$
 - Ecal multiplicity (energy of hit $> 1 \text{ GeV}$) ≤ 10
- Step 4: Select the best pair of clusters
 - In each event, choose the pair of clusters whose total energy is highest

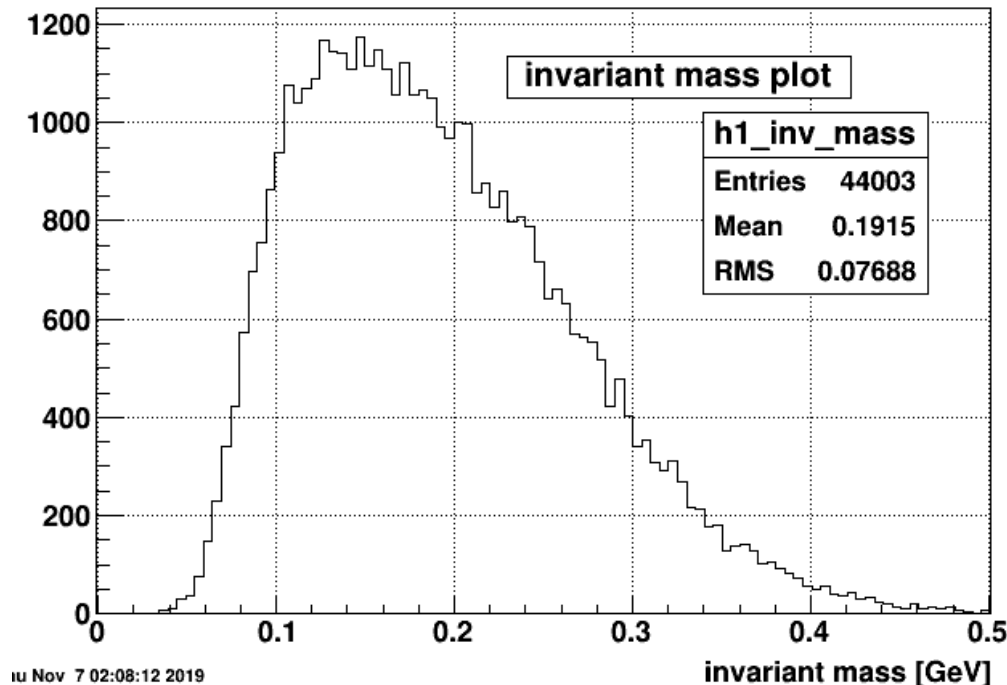
Ecal Multiplicity vs Tof Multiplicity

- Count the Ecal multiplicity when energy of hit > 1 GeV
- From the MC plot, we choose range to apply for data:
 - Tof Multiplicity: [3 , 40]
 - Ecal Multiplicity: [0 , 10]



Invariant mass plot (using cluster finder)

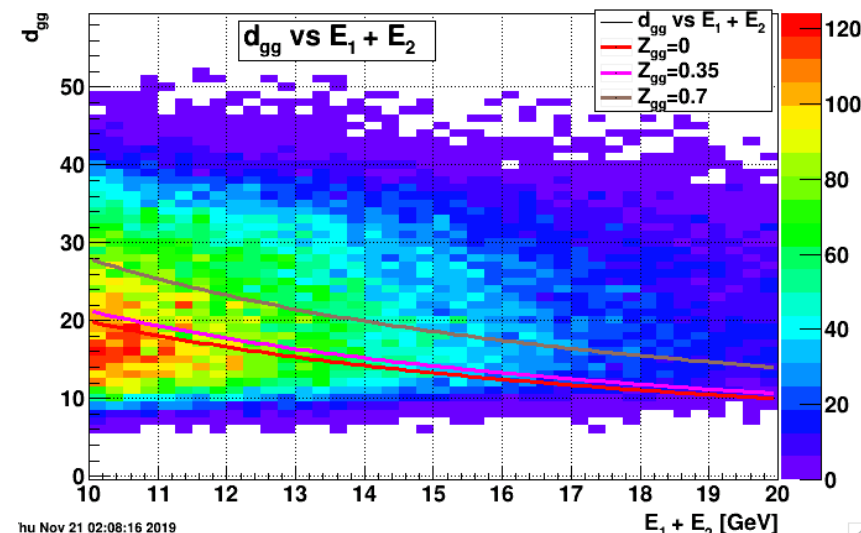
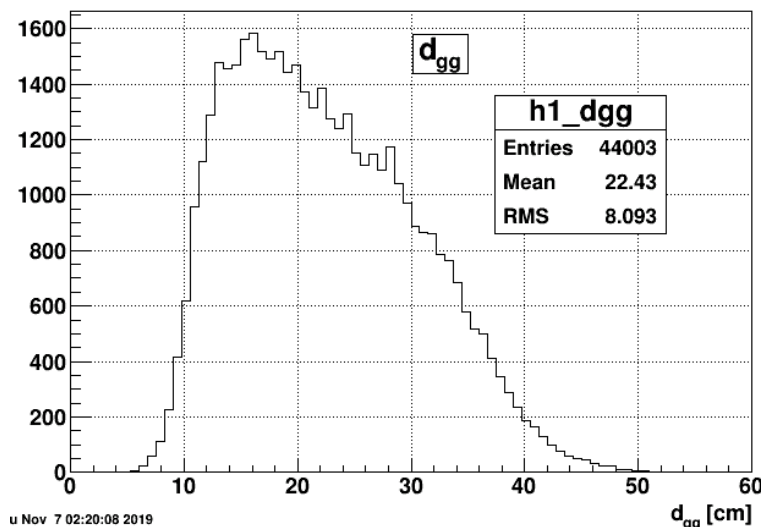
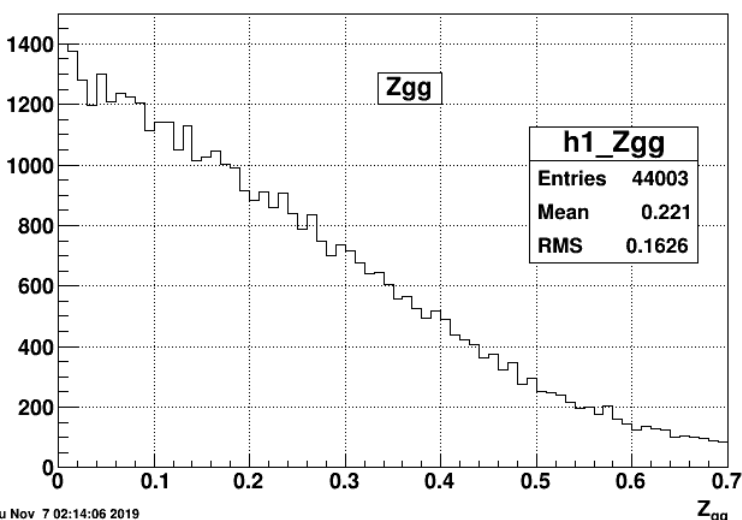
- From the invariant mass plot, we can see the wide peak between 0.1 GeV to 0.2 GeV, while the invariant mass of π^0 is 0.135 GeV. It can show hint to find out π^0 under this gain. However, it still contains some background so more cuts are needed to get a clear π^0 peak.



More plots (using cluster finder)

- Z_{gg} plot: Mostly it is decreasing.
- d_{gg} defines as distance between two clusters at Ecal.
- d_{gg} plot: Most data are at the range of 10 cm – 30 cm (2 - 6 cell size), which shows chance to see 10 GeV – 20 GeV π^0 .
- d_{gg} vs $E_1 + E_2$ plot: these three lines indicate the expected d_{gg} position for π^0 for given energy asymmetry (Z_{gg}).

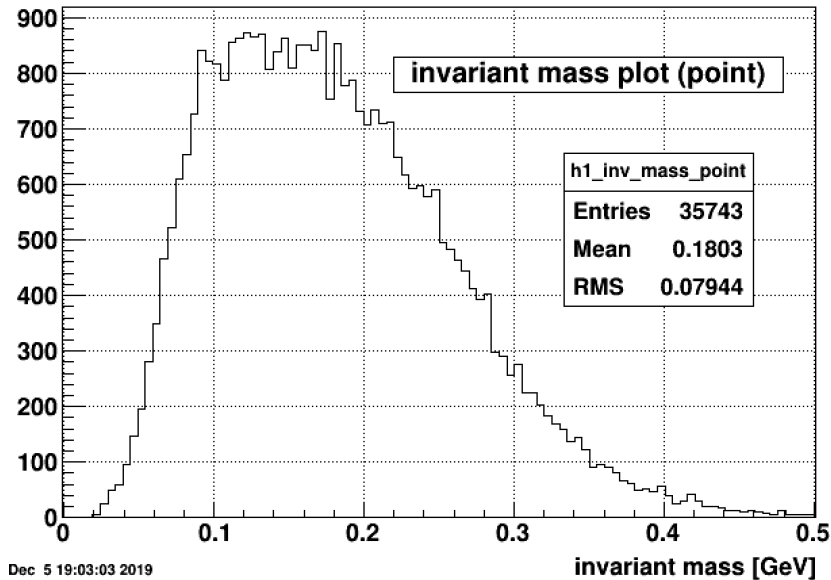
$$\text{Energy asymmetry}(Z_{gg}) = \frac{|E_1 - E_2|}{E_1 + E_2}$$



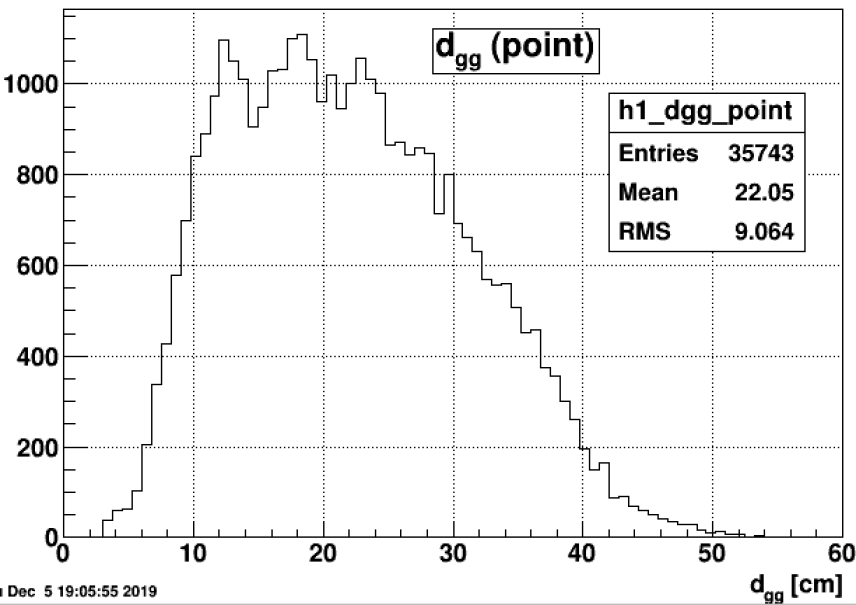
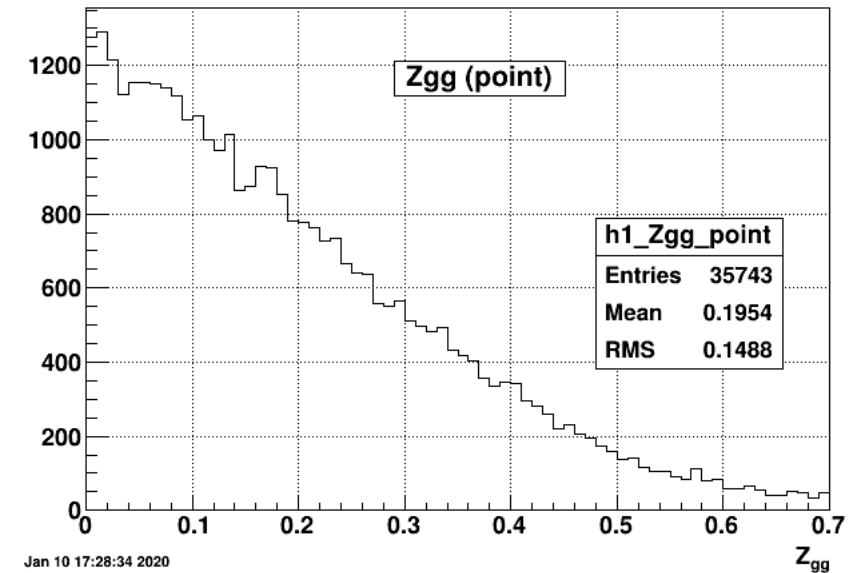
Event selection for data using point maker

- Step 1: Select **points** only at Ecal
- Step 2: **Points** energy cuts
 - Each **point** energy $> 1 \text{ GeV}$
 - $Z_{gg} < 0.7$
 - $10 \text{ GeV} < E_1 + E_2 < 20 \text{ GeV}$
- Step 3: Detector multiplicity cuts
 - $3 \leq \text{Tof multiplicity} \leq 40$
 - Ecal multiplicity (energy of hit $> 1 \text{ GeV}$) ≤ 10
- Step 4: Select the best pair of **points**
 - In each event, choose the pair of **points** whose total energy is highest

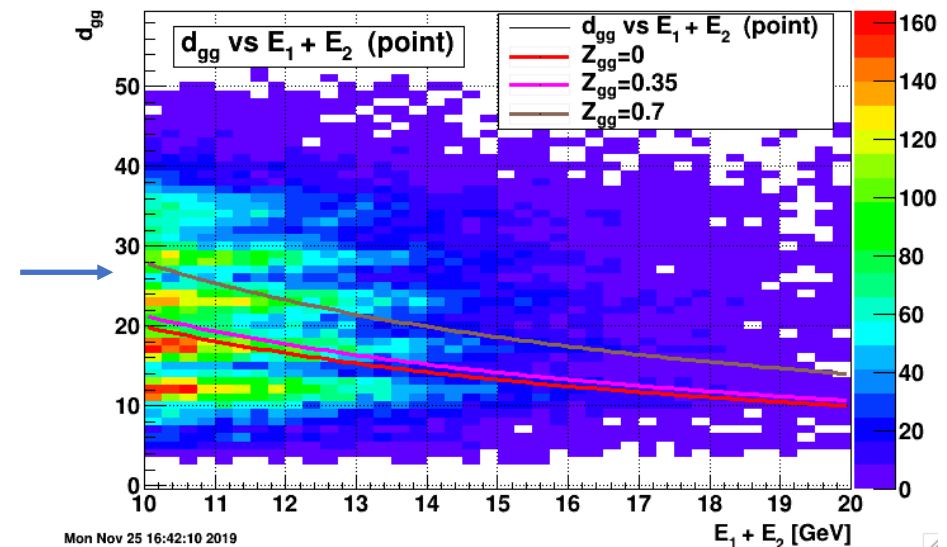
Result for data using point maker



The invariant mass plot shows peaks at range of 0.1 GeV to 0.2 GeV. It shows hint to find out π^0 .



These three lines indicate the expected d_{gg} position for π^0 for given energy asymmetry (Z_{gg}).



Conclusion and outlook

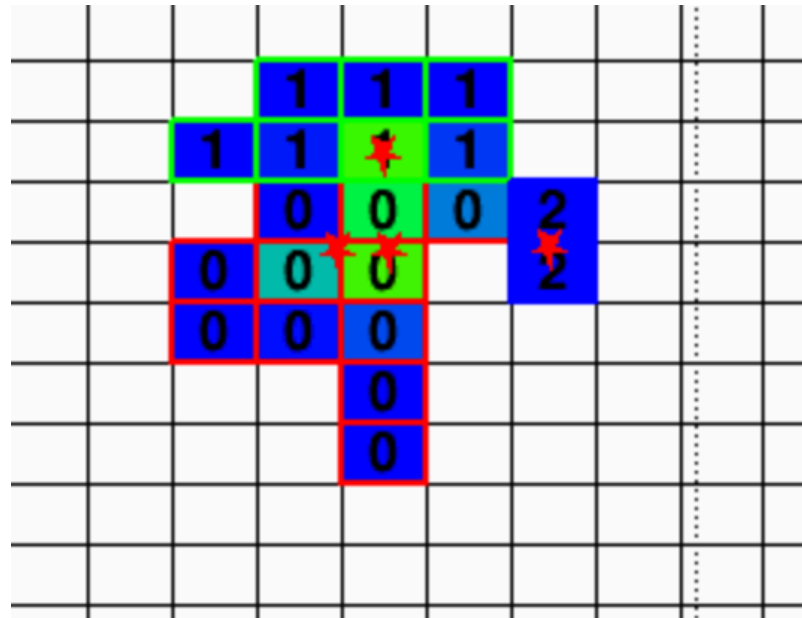
- We get the peak close to π^0 invariant mass using the cluster finder and point maker analysis, although the peak is wide. It shows hint to find out π^0 . More cuts are still needed to get the clear peak.
- From gain analysis, we get the gain which is close to the ideal gain for the prototype test data.
- Next to do: try to apply the gain 0.0015 GeV/ch, which is obtained from David's cosmic muon analysis.

Thank you for your attention!

Back up

Event display for cluster finder and point maker

- The number shows the cluster #
- The star symbol shows the point #

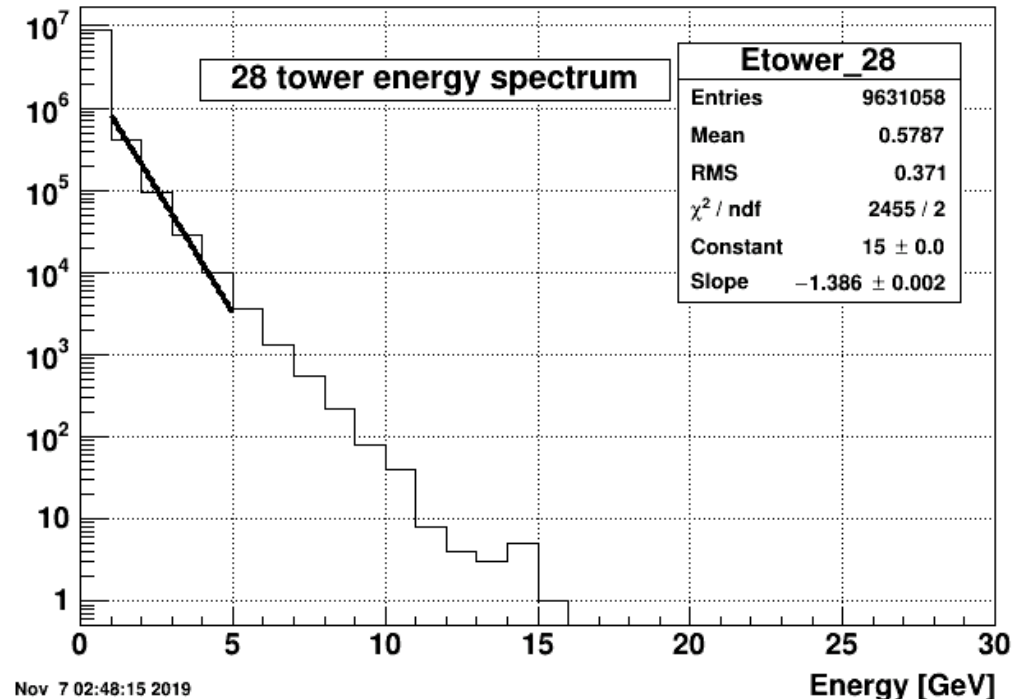
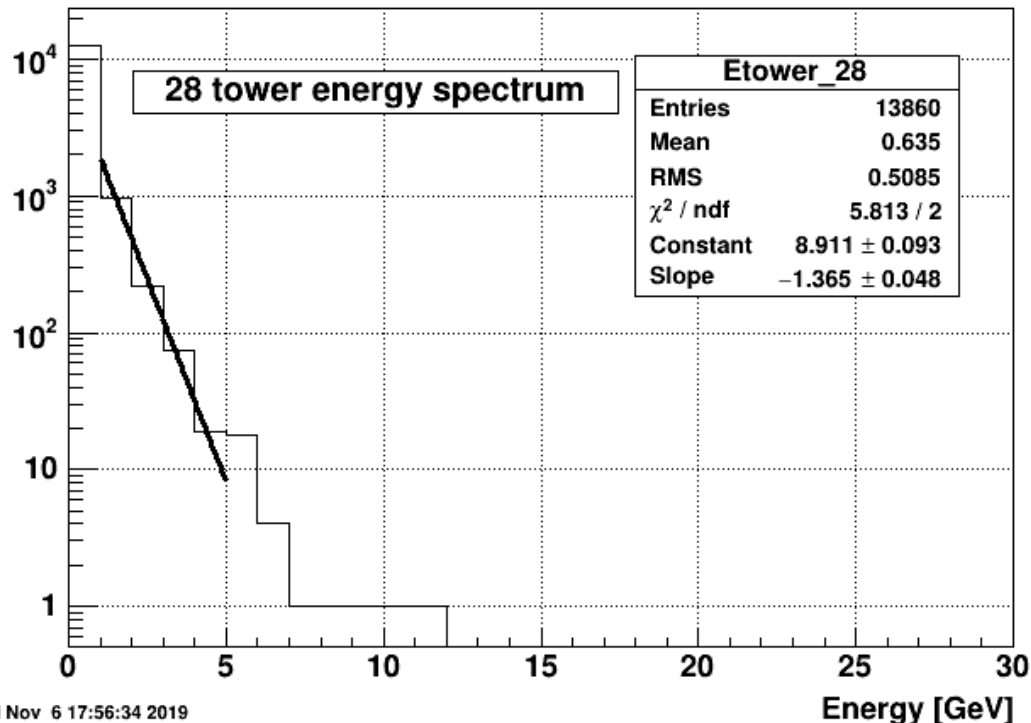


Tower energy spectrum comparison

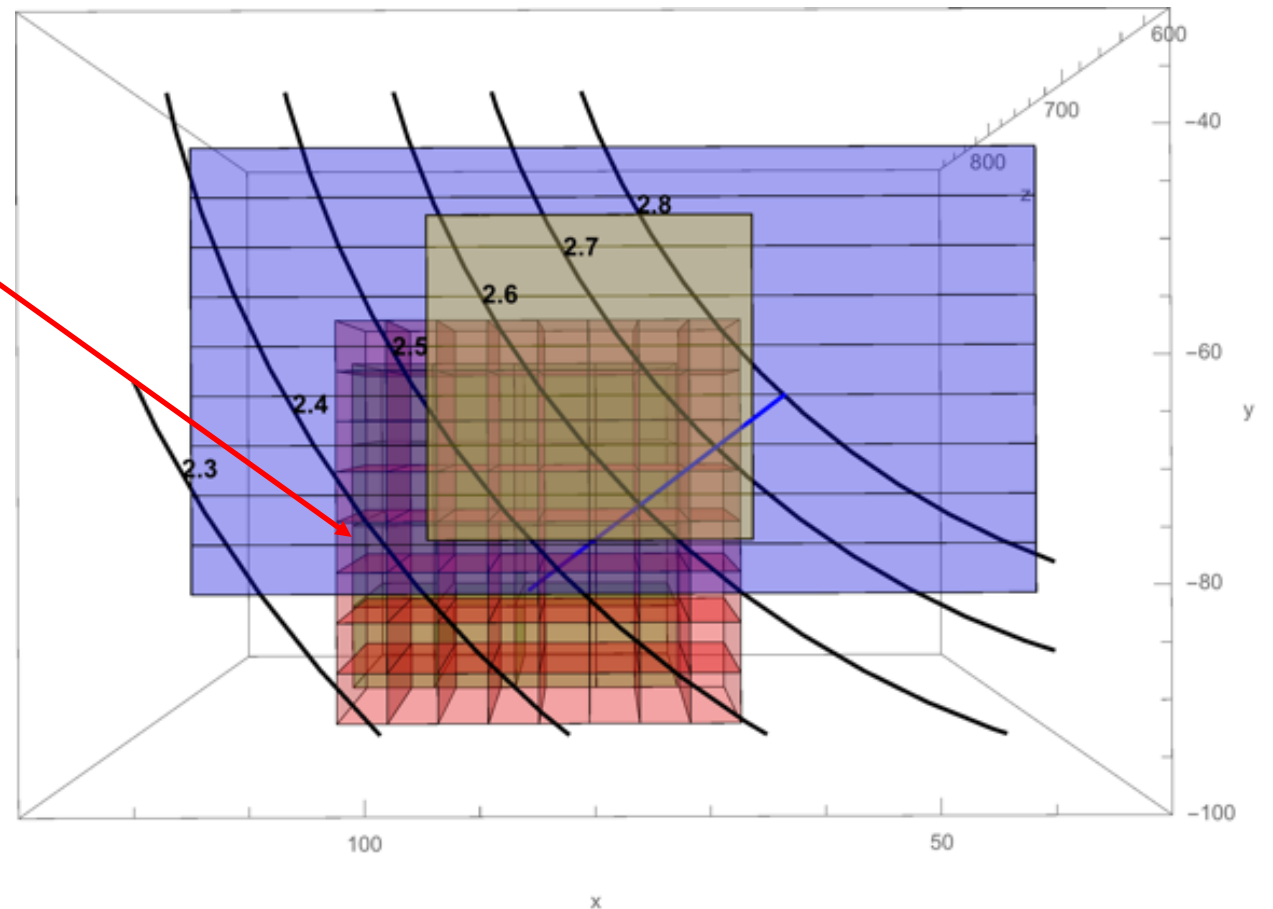
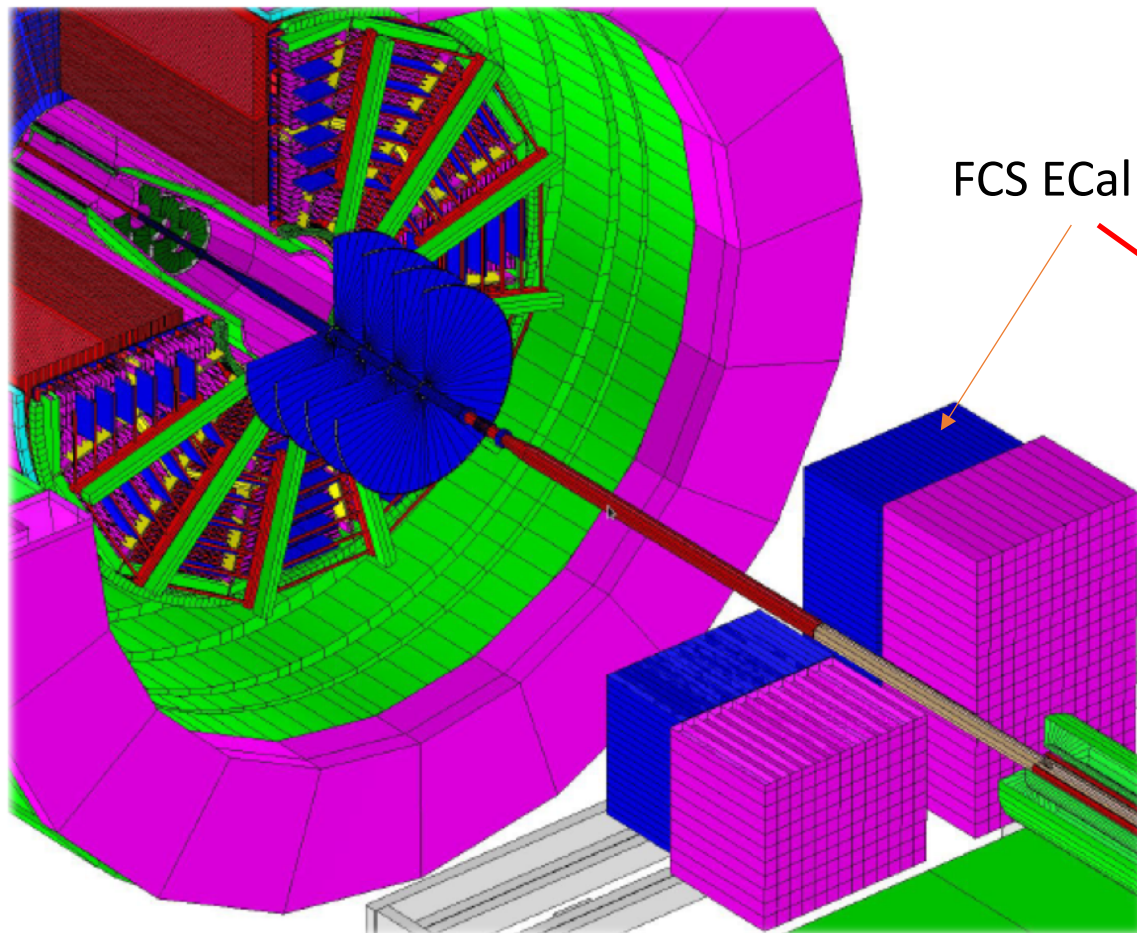
- We choose one of the tower energy spectrum to compare that for data and MC to check it really matches!
- Fitting range for both MC and data is [1,5]

MC: slope is -1.365

data: slope is -1.386

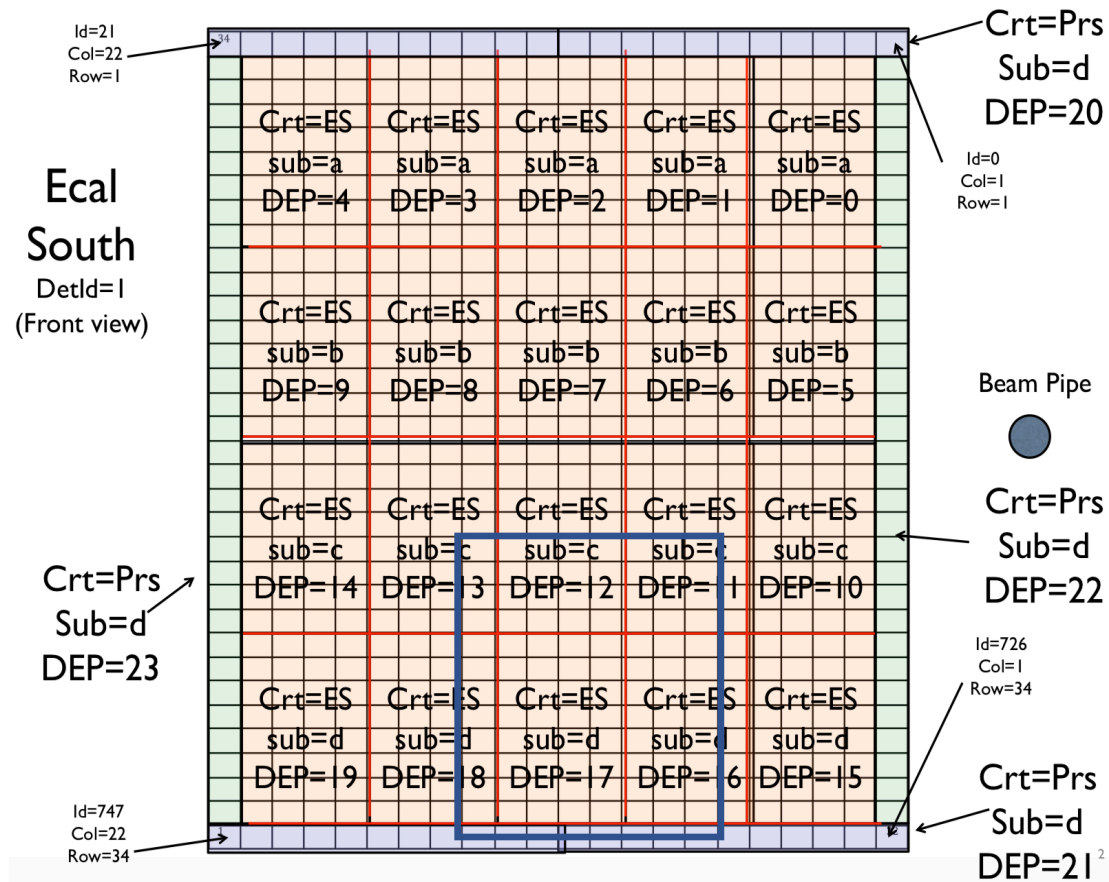


Forward upgrade detector design



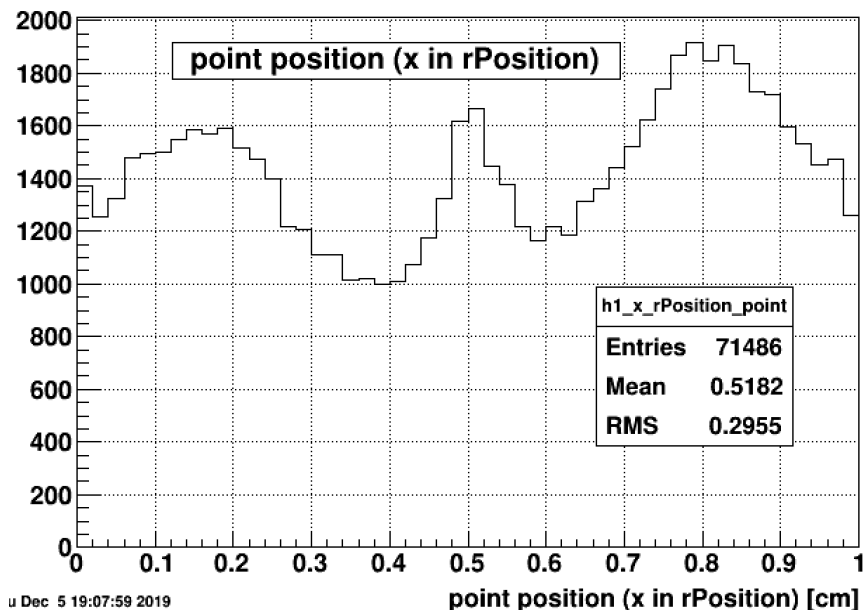
FCS full geometry and FCS prototype data

- Prototype data:
 - Det 1: Ecal South
 - Row : 27 – 34
 - Column: 9 - 16

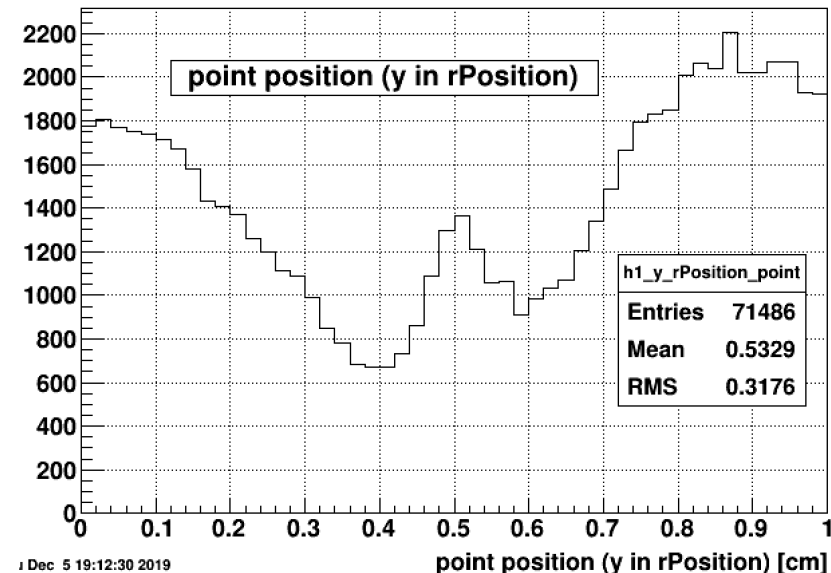


Result for data (using point maker)

- These two plots are point position in x (left plot) or y (right plot) direction in the cell relative to the cell size. The ideal situation for point maker is to get the evenly distribution in these two plots. To get this, we need to set shower shape scale (where shower shape scale is the transverse size of EM shower). The shower shape scale for data we apply is 2.0 .



u Dec 5 19:07:59 2019



u Dec 5 19:12:30 2019