The Results of ScECAL FNAL-TB
~ Reconstruction of π^0 ~

CALICE collaboration Meeting, Daegu

20 February 2009

CALICE ScECAL group

Yuji SUDO, University of Tsukuba

Outline

- Setting for production of π^0
- Method of strip clustering
- Event selection
- Result of π^0 reconstruction
- Summary

Setting for production of π^0

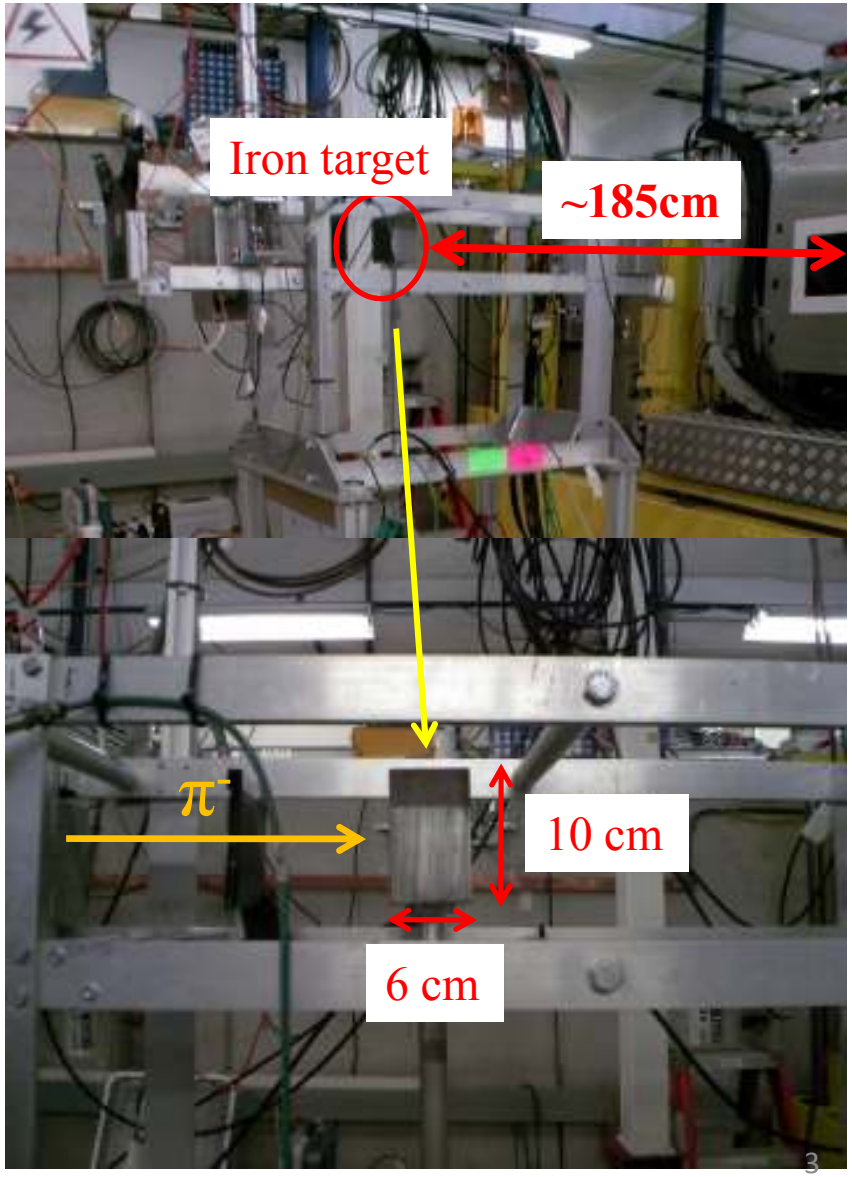
- To produce π^0, π^- beam was injected into Iron target.
- Size of the Iron target : 10x10 cm^2, thickness 6 cm
- The Iron target was put in ~185 cm upstream of ScECal.

(The distance of EMCAL from interaction point is 185 cm.)

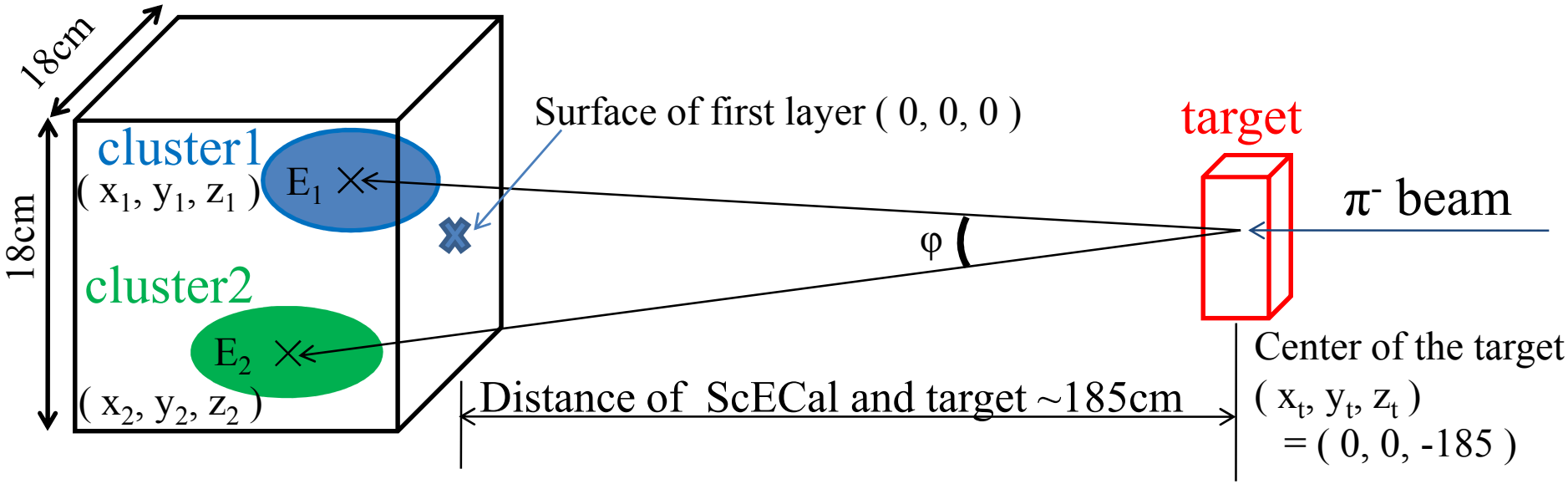
- Number of triggered events

16 GeV	419,114 events
25 GeV	341,882 events
32 GeV	337,838 events

In total 1,098,834 events



Reconstruction of Invariant Mass in 2 γ system



$$(\text{Invariant Mass}) = \text{sqrt}(2*E_1*E_2*(1-\cos(\varphi)))$$

In case two gammas have equal energy,

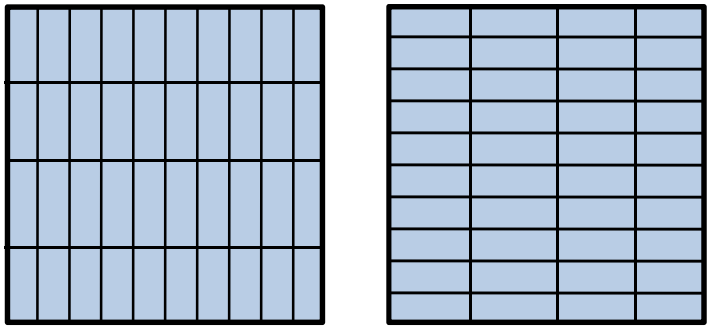
Energy of π^0 (GeV)	3	4	5	10	15
Distance of two clusters (cm)	16.7	12.5	10.0	5.0	3.3

Strip Clustering

1. Define X and Y layers according to strips orientation.
2. Select a strip which has the largest output in X layers. The strip is called seed strip.
3. Connect seed strip and the neighbor strips (upper, lower, left, right, forward and backward) (E of neighbor strip <= 1.2*(E of seed strip))
4. Connected strips are defined as new seeds. Repeat 3 until no more neighbor strip remains.
5. Using other strips, repeat 2 – 4.
6. For Y layers, make clusters using the same method.
7. Finally, the Y cluster is connected to the X cluster, in case energy center of a cluster in Y layers is located within +- 2.85 cm in X and Y from energy center of a cluster in X layers.

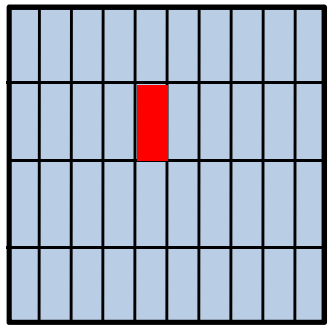
** This strip clustering is not the official algorithm for ScECal.

1

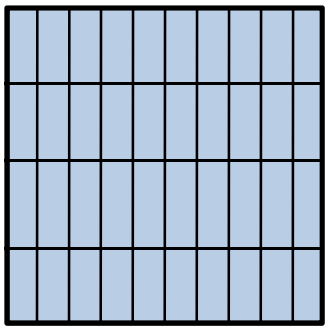


X layer Y layer

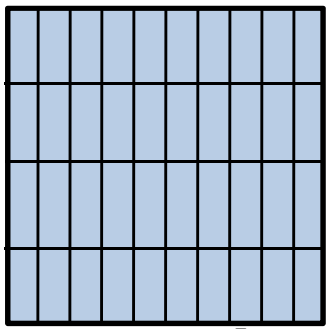
2



Layer i



Layer i-2



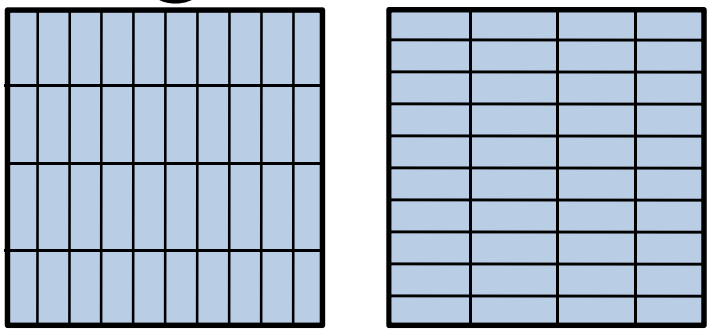
Layer i+2

Strip Clustering

1. Define X and Y layers according to strips orientation.
2. Select a strip which has the largest output in X layers. The strip is called seed strip.
3. Connect seed strip and the neighbor strips (upper, lower, left, right, forward and backward) (E of neighbor strip <= 1.2*(E of seed strip))
4. Connected strips are defined as new seeds. Repeat 3 until no more neighbor strip remains.
5. Using other strips, repeat 2 – 4.
6. For Y layers, make clusters using the same method.
7. Finally, the Y cluster is connected to the X cluster, in case energy center of a cluster in Y layers is located within +- 2.85 cm in X and Y from energy center of a cluster in X layers.

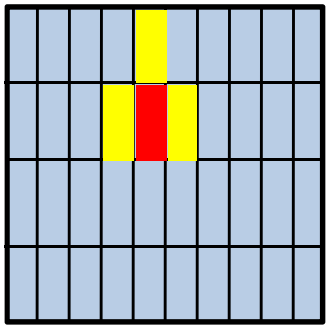
** This strip clustering is not the official algorithm for ScECal.

1

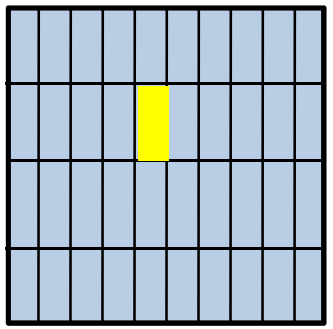


X layer Y layer

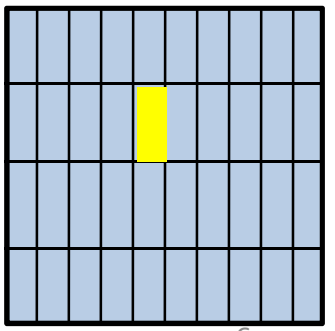
3



Layer i



Layer i-2



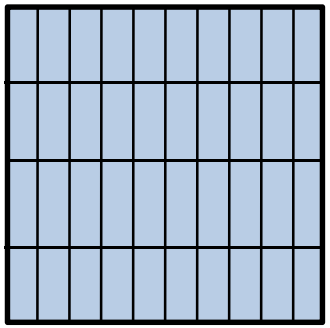
Layer i+2

Strip Clustering

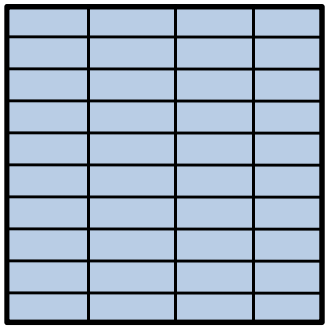
1. Define X and Y layers according to strips orientation.
2. Select a strip which has the largest output in X layers. The strip is called seed strip.
3. Connect seed strip and the neighbor strips (upper, lower, left, right, forward and backward) (E of neighbor strip <= 1.2*(E of seed strip))
4. Connected strips are defined as new seeds. Repeat 3 until no more neighbor strip remains.
5. Using other strips, repeat 2 – 4.
6. For Y layers, make clusters using the same method.
7. Finally, the Y cluster is connected to the X cluster, in case energy center of a cluster in Y layers is located within +- 2.85 cm in X and Y from energy center of a cluster in X layers.

** This strip clustering is not the official algorithm for ScECal.

1

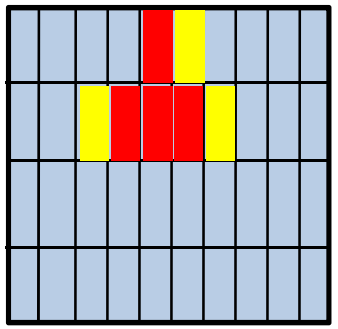


X layer

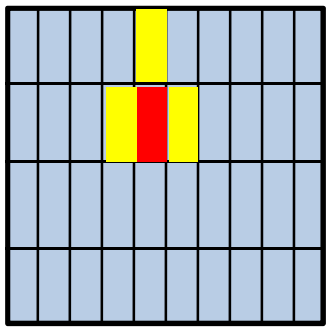


Y layer

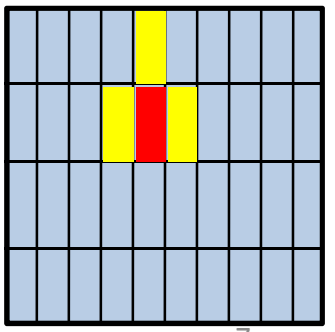
4



Layer i



Layer i-2



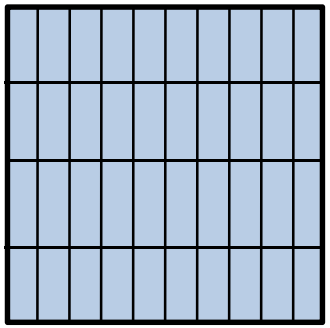
Layer i+2

Strip Clustering

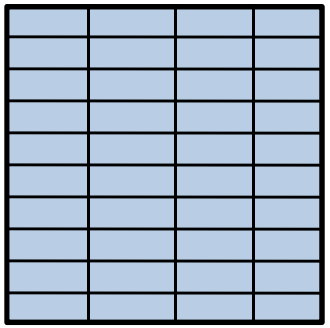
1. Define X and Y layers according to strips orientation.
2. Select a strip which has the largest output in X layers. The strip is called seed strip.
3. Connect seed strip and the neighbor strips (upper, lower, left, right, forward and backward) (E of neighbor strip <= 1.2*(E of seed strip))
4. Connected strips are defined as new seeds. Repeat 3 until no more neighbor strip remains.
5. Using other strips, repeat 2 – 4.
6. For Y layers, make clusters using the same method.
7. Finally, the Y cluster is connected to the X cluster, in case energy center of a cluster in Y layers is located within +- 2.85 cm in X and Y from energy center of a cluster in X layers.

** This strip clustering is not the official algorithm for ScECal.

1

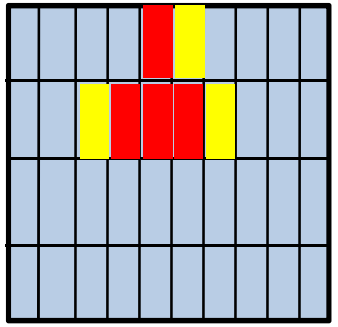


X layer

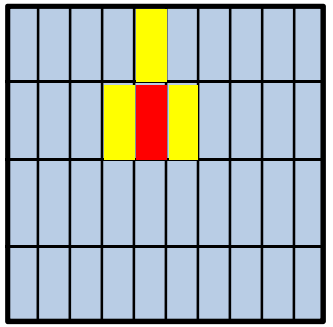


Y layer

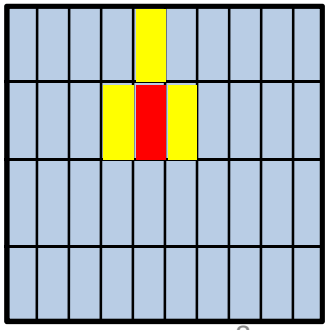
4



Layer i



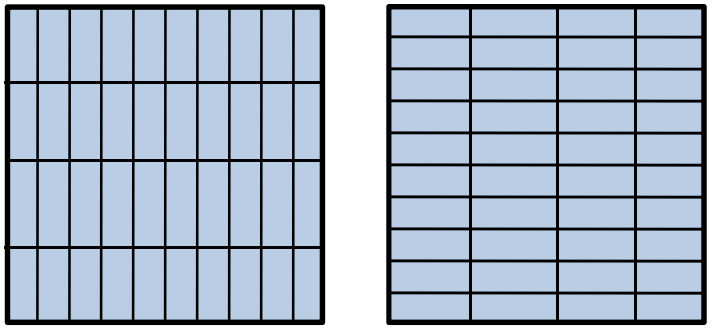
Layer i-2

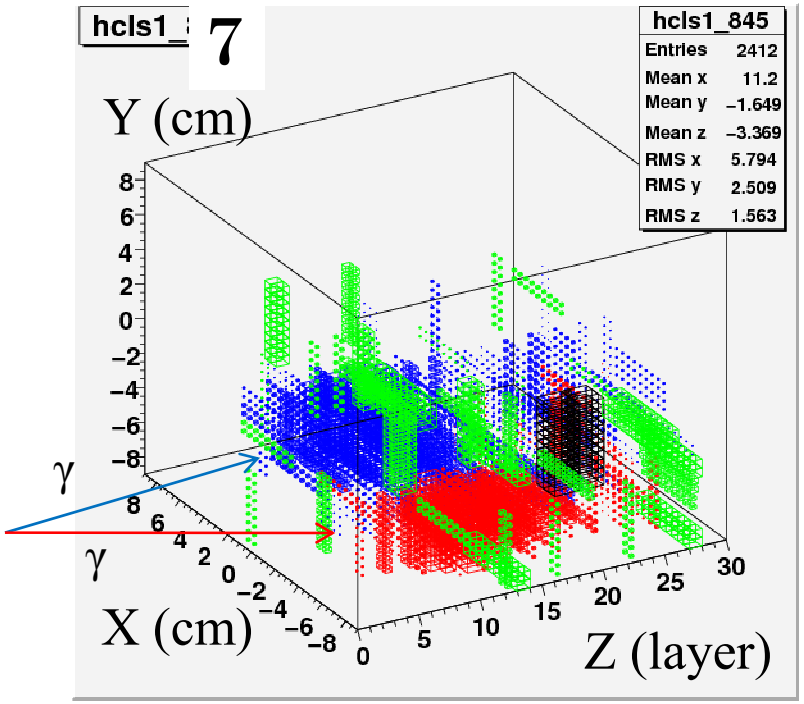


Layer i+2

Strip Clustering

1. Define X and Y layers according to strips orientation.
2. Select a strip which has the largest output in X layers. The strip is called seed strip.
3. Connect seed strip and the neighbor strips (upper, lower, left, right, forward and backward) (E of neighbor strip <= 1.2*(E of seed strip))
4. Connected strips are defined as new seeds. Repeat 3 until no more neighbor strip remains.
5. Using other strips, repeat 2 – 4.
6. For Y layers, make clusters using the same method.
7. Finally, the Y cluster is connected to the X cluster, in case energy center of a cluster in Y layers is located within +- 2.85 cm in X and Y from energy center of a cluster in X layers.





** This strip clustering is not the official algorithm for ScECal.

Event Selection for 2 γ Events

1. Select EM shower events.
2. Select 2 γ events using cluster information.

	π^- 16GeV	25GeV	32GeV	total
All events	419,114	341,882	337,838	1,098,834
> 50 MIPs, > 30 hits (in front half), > 60% of total E (in front half)	83,319	66,823	65,856	215,998
clsx=2 & clsy=2 *	11,594	12,688	14,928	39,165
40% <= Ecls1 <=85% **	9,540	9,820	11,302	30,662
15% <= Ecls2 <=60%	8,396	9,099	10,572	28,067
Ecls3 <= 5%	2,957	3,038	3,382	9,377
Sum. E other cls <= 13%	2,691	2,819	3,134	8,644
-7 <= cluster center <= 7 cm	1,549	1,418	1,584	4,551

* X and Y clusters have energy more than 8% of E_{tot} of ScECal.
** Energy ratio of cluster and total energy of ScECal. E_{cls} / E_{tot}

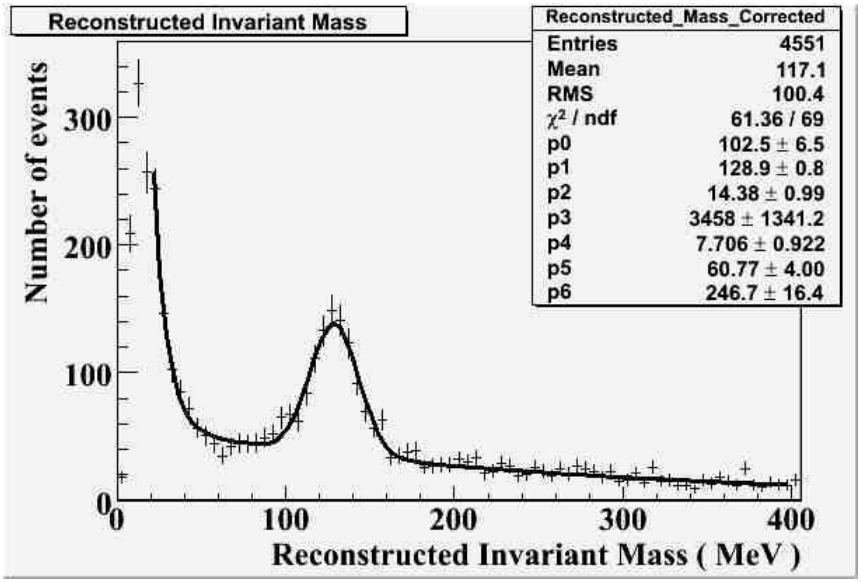
Reconstructed Invariant Mass from 2 Clusters

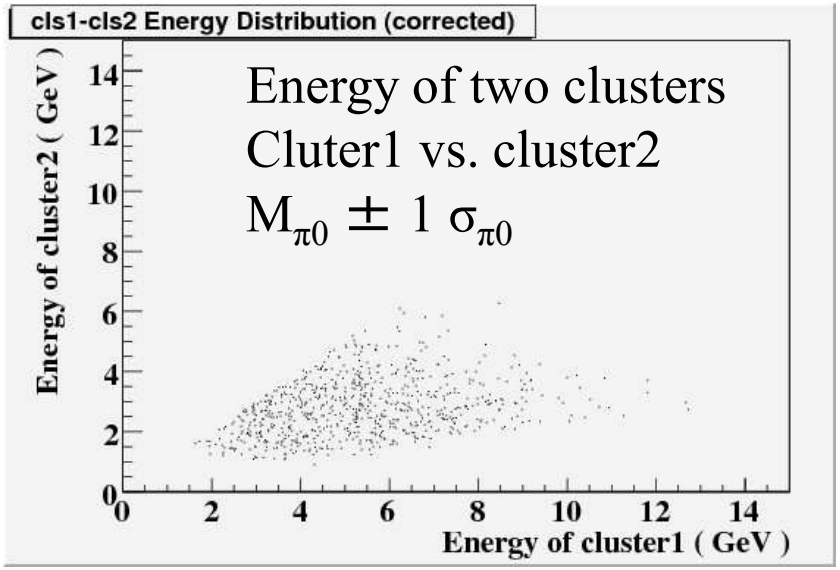
Result of TB

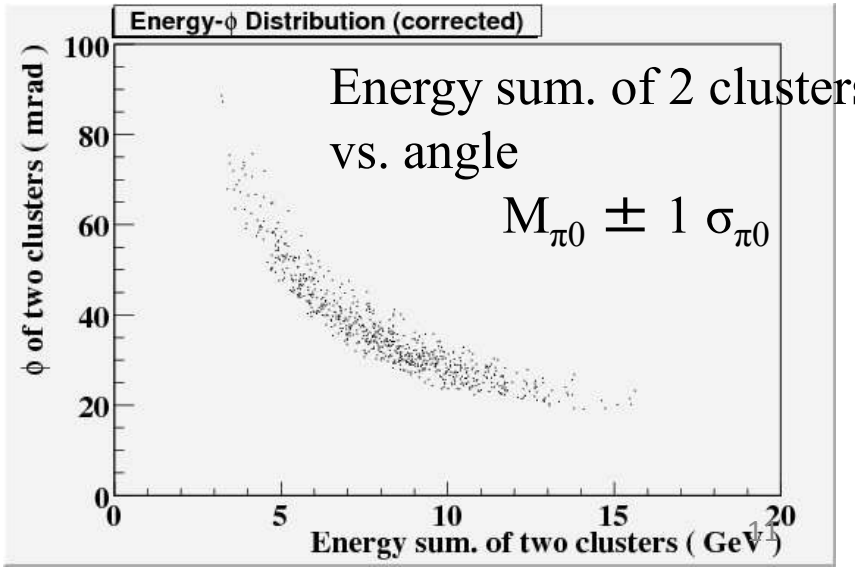
Fitting function

$p_0*\exp(-(x-p_1)^2/2p_2^2)$
$+ p_3*\exp(-x/p_4) + p_5*\exp(-x/p_6)$

pi0 candidates 757 +- 72 events
Chi2/NDF = 61.36/69
p1 = $M_{\pi 0}$ = 128.86 $\pm$ 0.81 (MeV/c^2)
p2 = $\sigma_{\pi 0}$ = 14.38 $\pm$ 0.99 (MeV/c^2)







Event Selection for 2 γ Events , Result of Mokka

We simulated ScECal TB by Mokka with TB geometry.
And we are preparing to release the ScECal module for Mokka.

1. Select EM shower events.
2. Select 2 γ events using cluster information.

	π- 16GeV	25GeV	32GeV	total
All events	267,000	241,252	200,141	708,393
> 50 MIPs, > 30 hits (in front half), > 60% of total E (in front half)	41,701	50,598	44,283	136,582
clsx=2 & clsy=2 *	6,641	12,275	11,884	30,800
40% <= Ecls1 <=85% **	5,381	9,615	9,173	24,169
15% <= Ecls2 <=60%	4,856	9,044	8,708	22,608
Ecls3 <= 5%	1,725	3,173	2,932	7,830
Sum. E other cls <= 13%	1,683	3,052	2,776	7,511
-7 <= cluster center <= 7 cm	781	1,475	1,393	3,649

* X and Y clusters have energy more than 8% of E_{tot} of ScECal.
** Energy ratio of cluster and total energy of ScECal. E_{cls} / E_{tot}

Reconstructed Invariant Mass from 2 Clusters

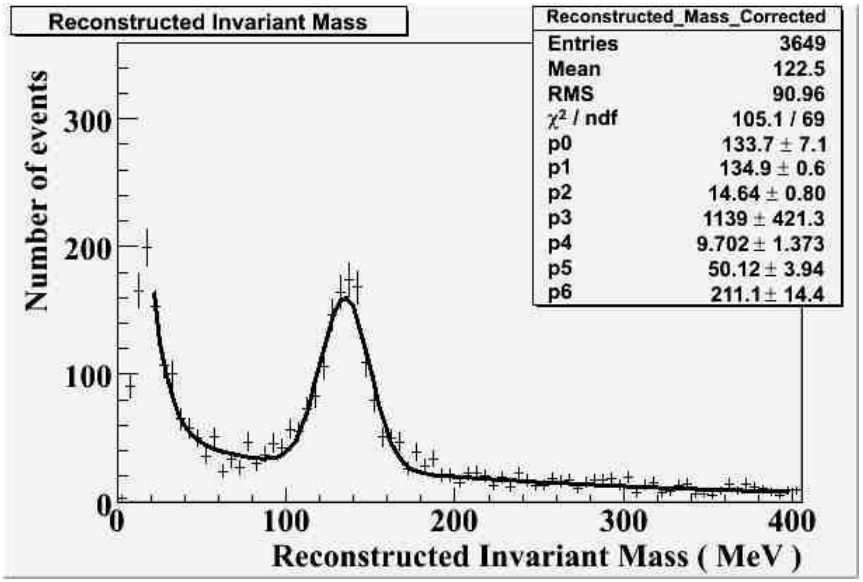
Mokka for ScECal

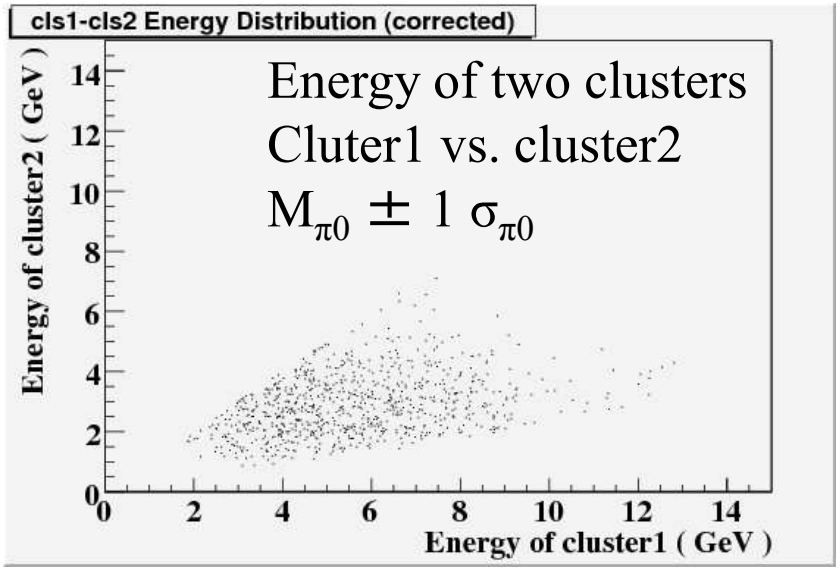
Saturation effect of MPPC doesn't be included.

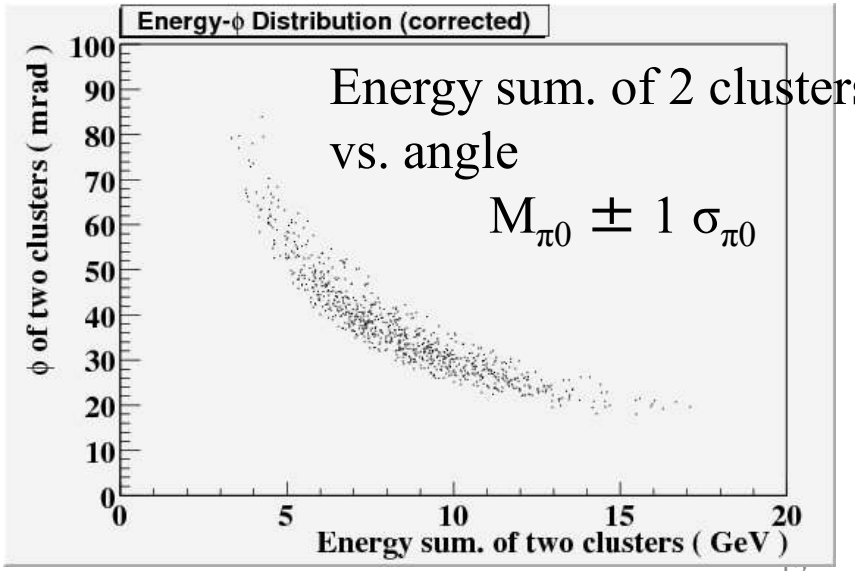
Chi2/NDF = 105.1/69

p1 = $M_{\pi 0}$ = 134.93 ± 0.64 (MeV/c^2)

P2 = $\sigma_{\pi 0}$ = 14.64 ± 0.81 (MeV/c^2)







Summary

- Tried to reconstruct the invariant mass of pi0 with scintillator strip EM calorimeter.

- Result of Test Beam

  $M_{\pi 0} = 128.86 \pm 0.81$ (MeV/c^2)

  $\sigma_{\pi 0} = 14.38 \pm 0.99$ (MeV/c^2)

- Result of Mokka (without MPPC effect)

  $M_{\pi 0} = 134.93 \pm 0.64$ (MeV/c^2)

  $\sigma_{\pi 0} = 14.64 \pm 0.81$ (MeV/c^2)

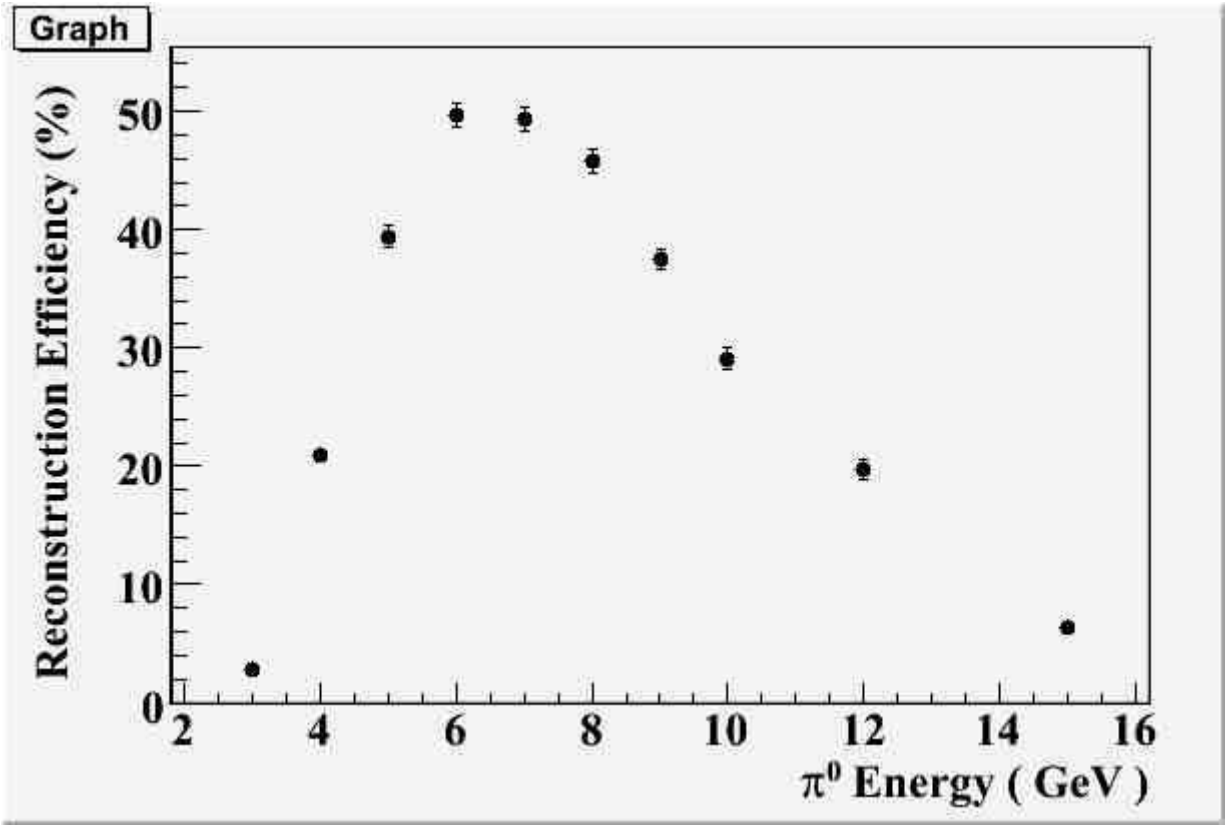
- We can reconstruct the invariant mass of π^0 meson.
- But there is 4.5% deviation for π^0 mass.
  * Calibration has not finished yet.
  * Clustering algorithm needs to be optimized .
  *

Backup

Reconstruction efficiency for π^0

Result of reconstruction efficiency using strip clustering as I showed before.
We generated 3 ~ 15 GeV π^0 by Mokka and apply exact same event selection for TB.

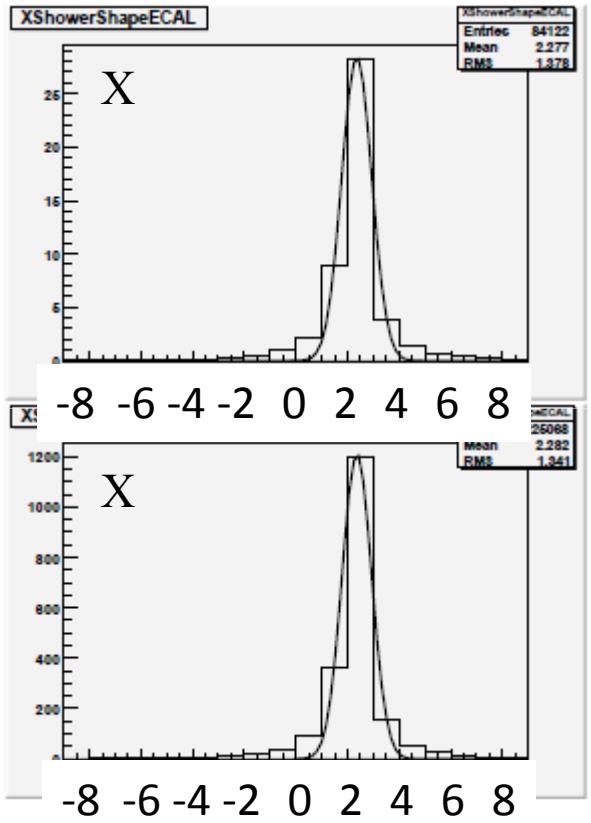
$E_{\pi 0}$ (GeV)	3	4	5	6	7	8	9	10	12	15
Efficiency (%)	2.76	20.9	39.4	49.7	49.4	45.8	37.5	29.1	19.7	6.31
Uncertainty (%)	0.24	0.6	0.9	1.0	1.0	1.0	0.9	0.9	0.8	0.51

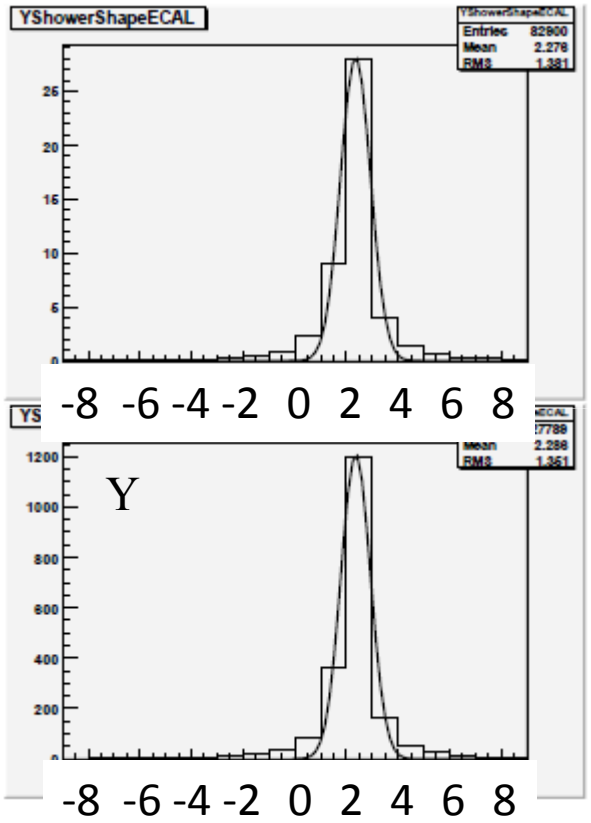


Shower Shape of γ in X and Y

1GeV/c

32GeV/c





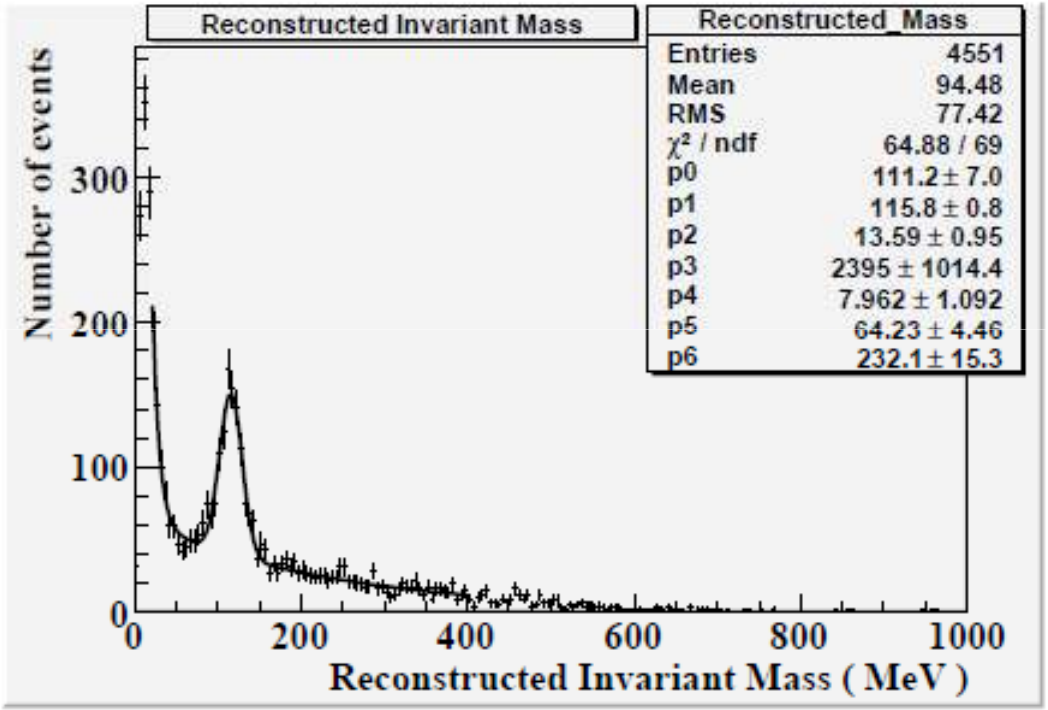
1GeV/c : σ = 0.58 ± 0.08 cm

3 - 32GeV/c : σ = 0.57 ± 0.03 cm

Clustering range is decided ±5σ(= ±2.85cm) in X and Y.

Reconstructed Invariant Mass from 2 Clusters before cluster energy correction

Result of TB



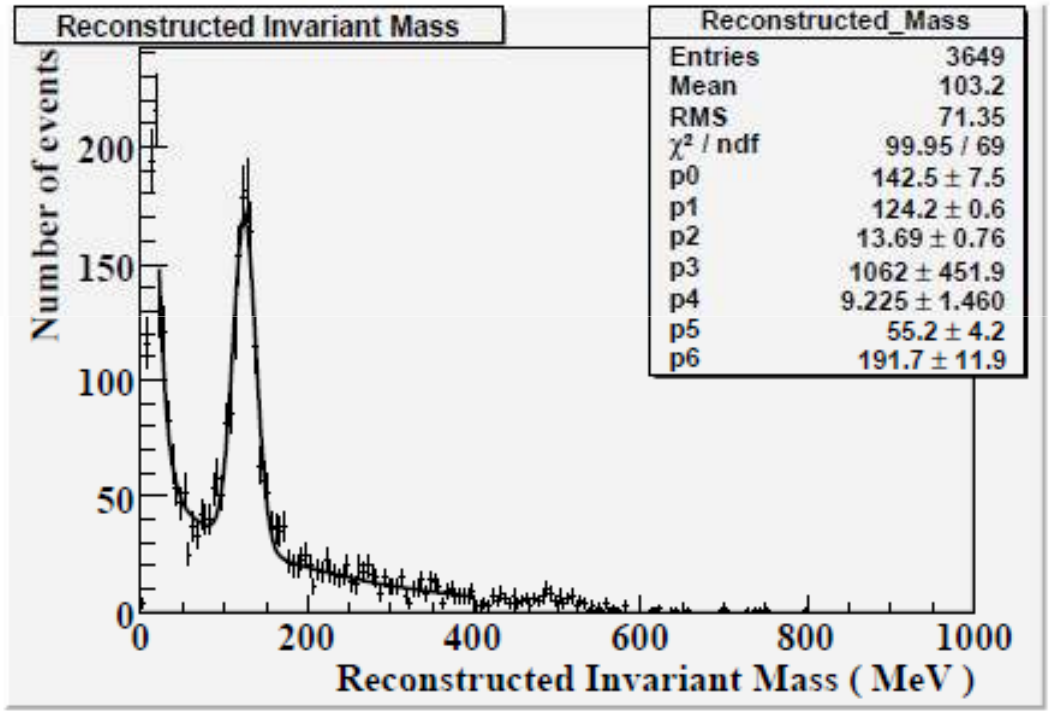
Chi2/NDF = 64.88/69

p1 = $M_{\pi 0}$ = 115.78 ± 0.75 (MeV/c^2)

p2 = $\sigma_{\pi 0}$ = 13.59 ± 0.95 (MeV/c^2)

Reconstructed Invariant Mass from 2 Clusters before cluster energy correction

Result of Mokka

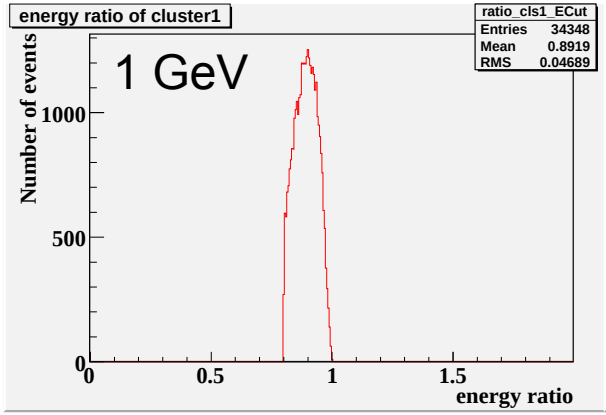


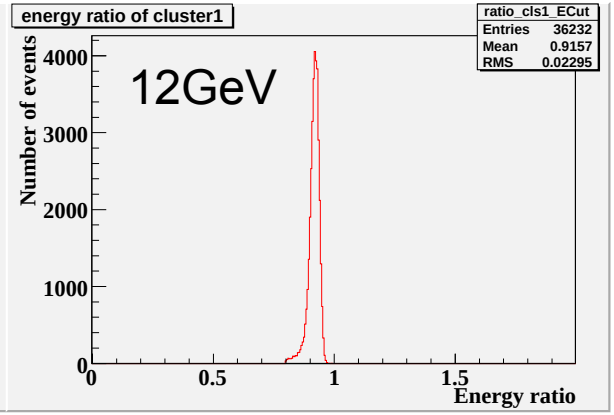
Chi2/NDF = 64.88/69

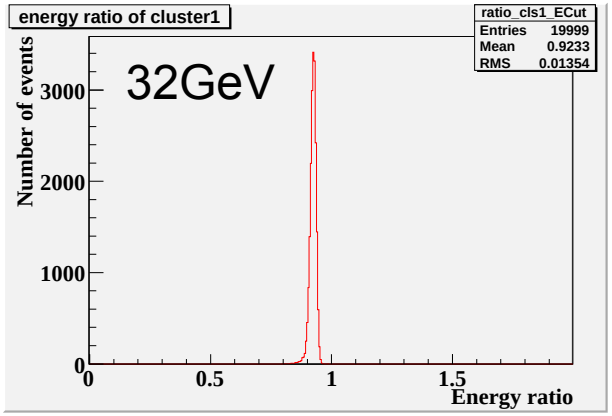
p1 = $M_{\pi 0}$ = 124.22 $\pm$ 0.59 (MeV/c^2)

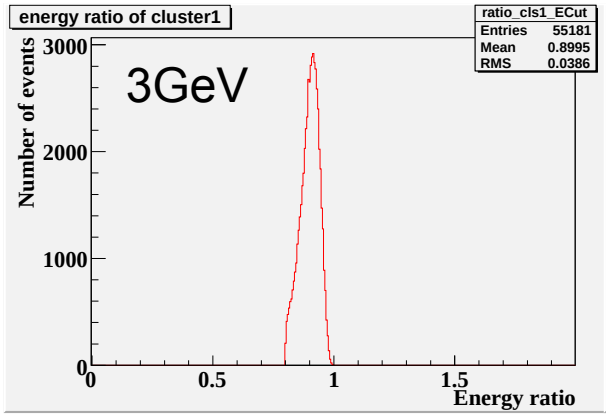
p2 = $\sigma_{\pi 0}$ = 13.69 $\pm$ 0.76 (MeV/c^2)

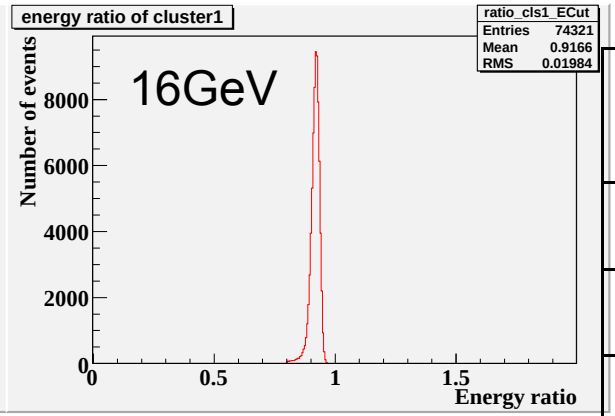
Energy of Cluster and correction constant

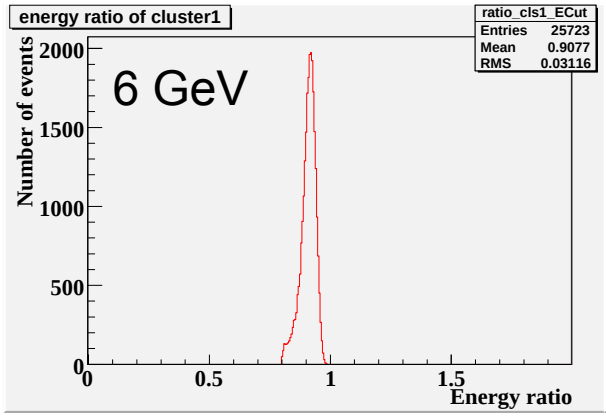


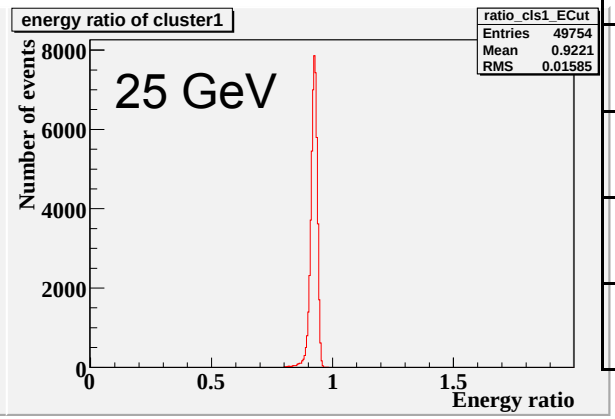












momentum (GeV/c)	Correction constant	range (MIP)
1	0.892	<150
3	0.900	450
6	0.908	910
12	0.916	1810
16	0.917	2420
25	0.922	3770
32	0.923	3770<

Correction for Cluster Energy

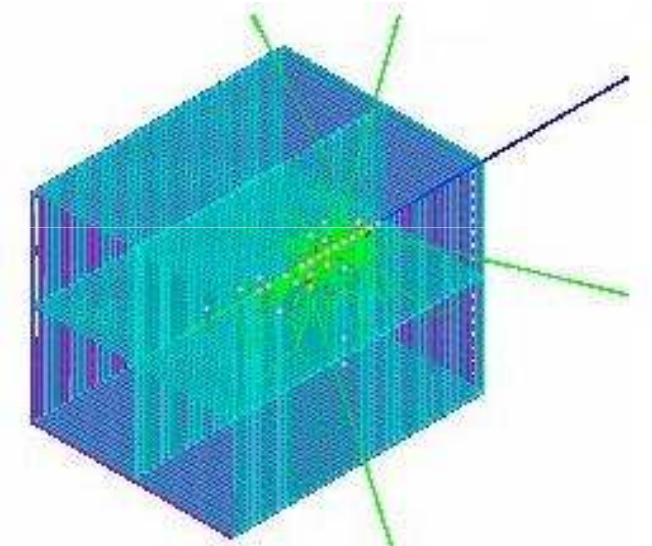
Ratio of the cluster energy and total energy of ScECal for e^- is defined as a correction constant.

In case cluster energy is 1.5 GeV, complement the correction constant between 1 and 3 GeV with linear function.

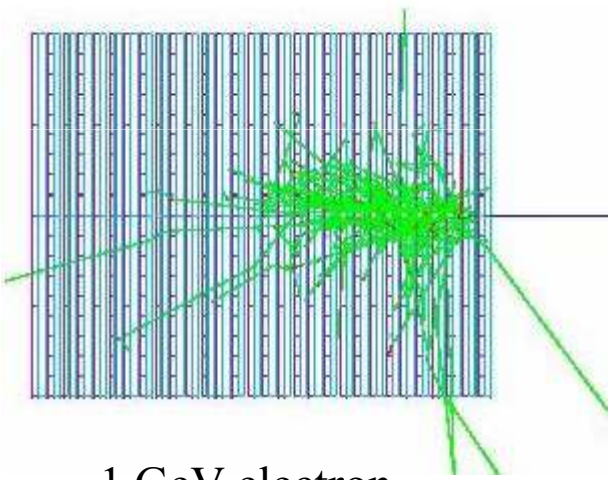
Ecls1 is energy of cluster1, Ecls2 is energy of cluster2, correction constant for each clusters are c1 and c2, φ is angle between clusters,

$$M_{\gamma\gamma} = \sqrt{2}\, E_{cls1}/c1\, E_{cls2}/c2\, (1-\cos\varphi)$$

Mokka ScECal Event Display



1 GeV electron



1 GeV electron

ScECal Response for e^- (Mokka)

- Saturation effect of MPPC doesn't be included.
- Fitting result for linear function (1 ~ 12 GeV)
  (ScECal response) = aX(GeV) + b MIP
  a = 151.49 ± 0.11 MIP/GeV
  b = -0.07 ± 0.37 MIP
- Deviation from linearity ~0.4%