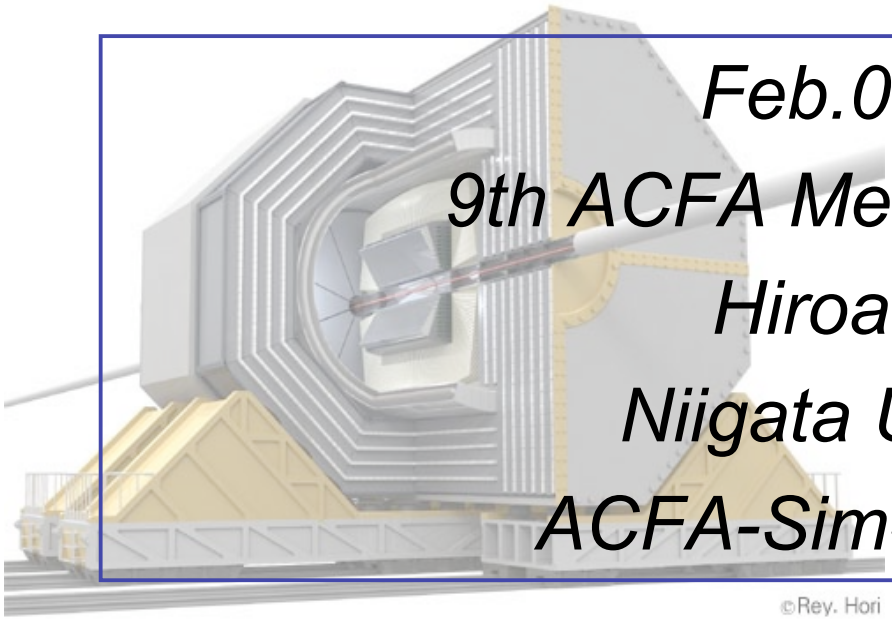
Calorimeter segmentation dependence of PFA performance



Feb.05.2007

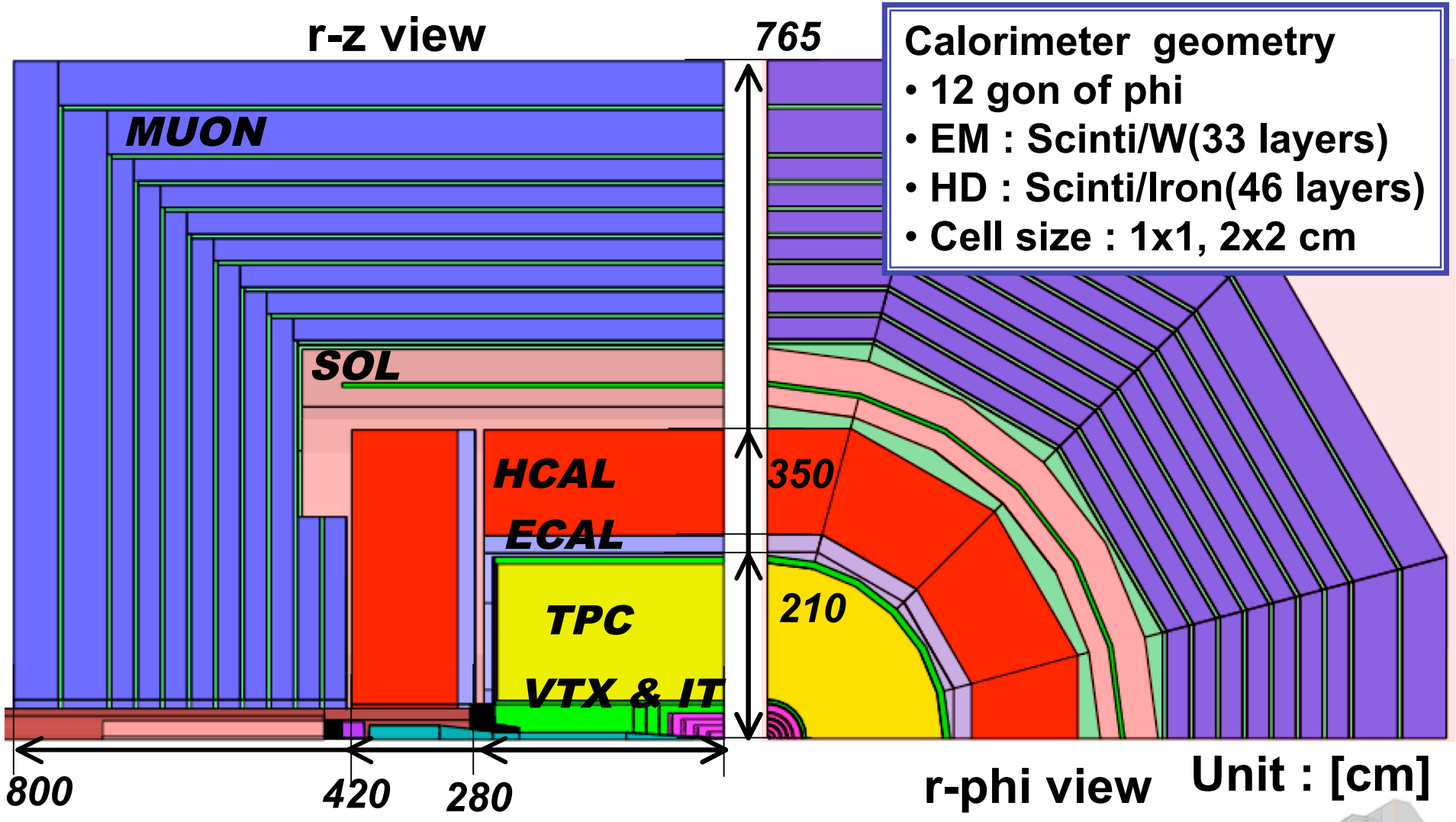
9th ACFA Meeting @Beijing

Hiroaki Ono

Niigata University

ACFA-Sim-J members

GLD full simulator geometry (Jupiter)

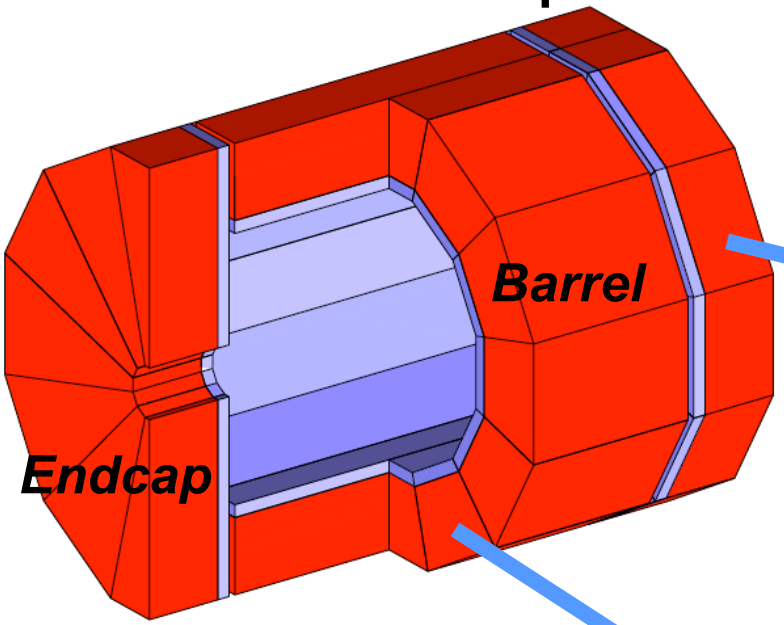


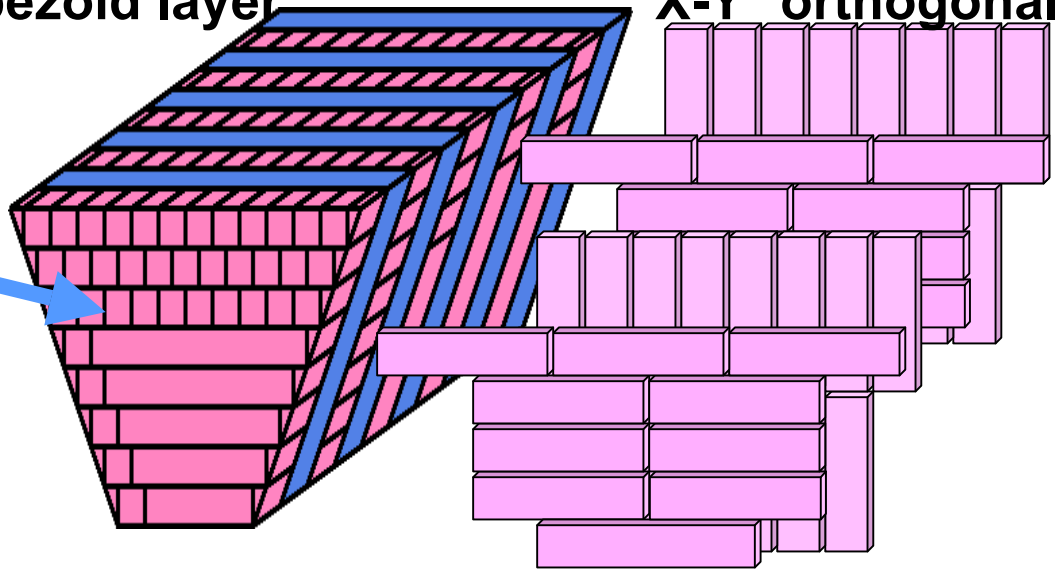
Calorimeter geometry
- 12 gon of phi
- EM : Scinti/W(33 layers)
- HD : Scinti/Iron(46 layers)
- Cell size : 1x1, 2x2 cm

Calorimeter Cell/Strip Layer Structure

Endcap : X-Y trapezoid layer

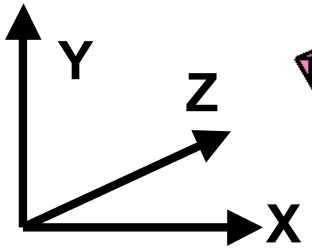
X-Y orthogonal

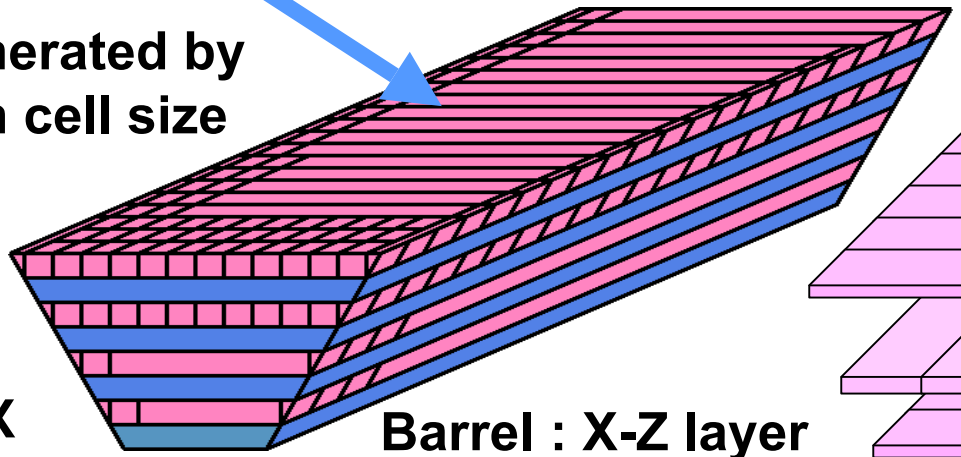


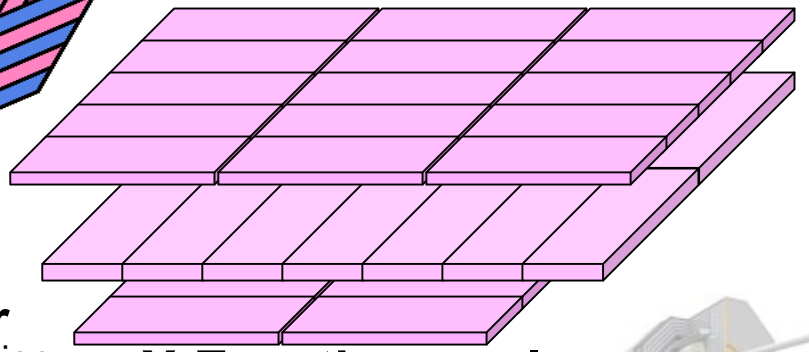


1x1cm cells merged to be strip/large cell.

Events generated by 1x1,2x2 cm cell size



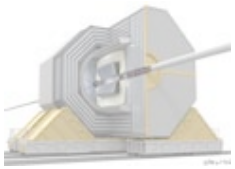




Barrel : X-Z layer

X-Z orthogonal

Calorimeter segmentation dependence of PFA performance



Particle Flow Algorithm (PFA)

Jet energy measured by

- Charged : *Tracker*

$$\delta P_t / P_t^2 = 5 \times 10^{-5} (GeV/c)^{-1}$$

- Photon : *EM calorimeter*

$$\sigma / E = 15\% / \sqrt{E} \oplus 1\%$$

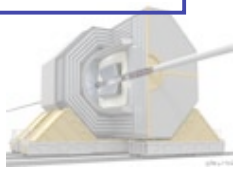
- Neutral hadron : *EM/HD calorimeter*

$$\sigma / E = 40\% / \sqrt{E} \oplus 2\%$$

Required performance to separate W/Z mass.

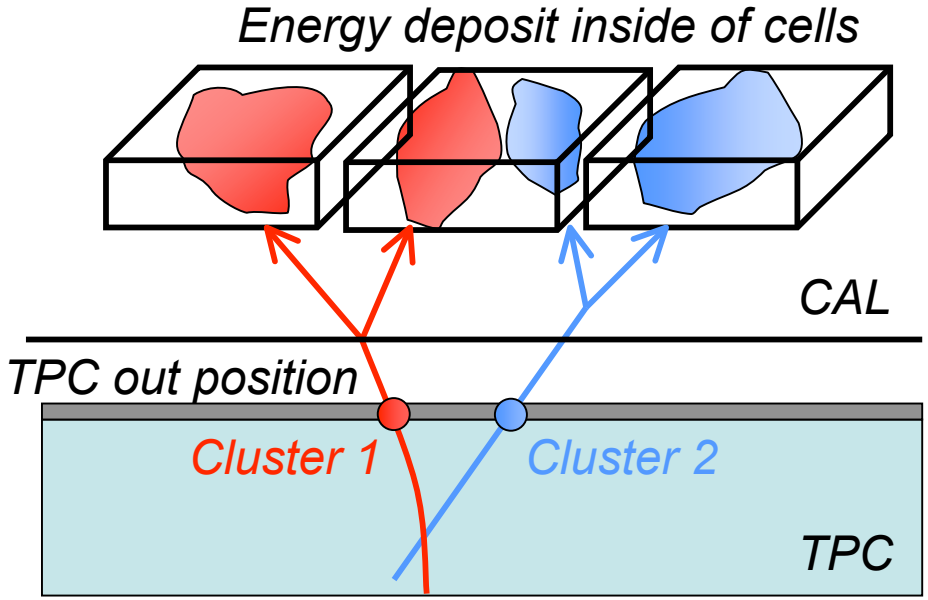
$$\sigma(E_j) / E_j < 30\% / \sqrt{E_j}$$

Charged and neutral cluster separation is important for PFA



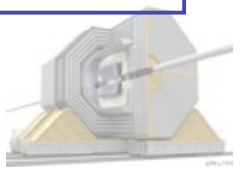
Cheated (Perfect clustering) PFA

- **Different mother particle's CAL hits have been clustered as different cluster (perfect clustering).**
- **Use track information for charged particle and remove charged track related cluster from CAL. (PFA)**
- **Hits can separate inside of cell (Infinite segmentation)**



Switch merge inside of cell or not.

- Not merged:
  - Infinite segmentation
- Merge hits:
  - Merge inside of cell hits and clustered as largest energy deposit mother.

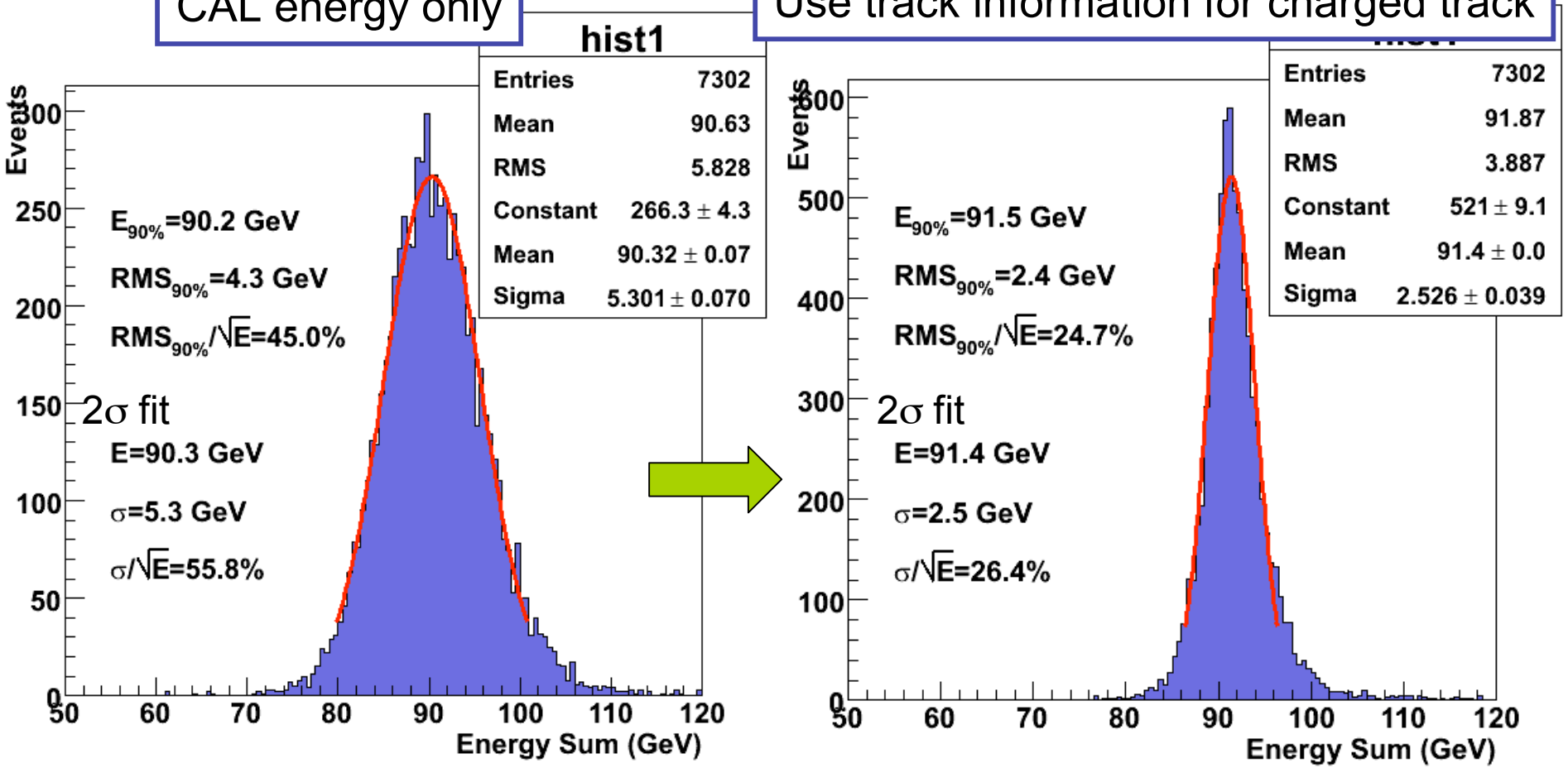


Cheated PFA performance

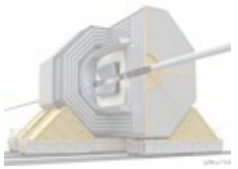
(Z->qq(uds) E_{cm}=91.2 GeV, Infinite segmentation)

CAL energy only

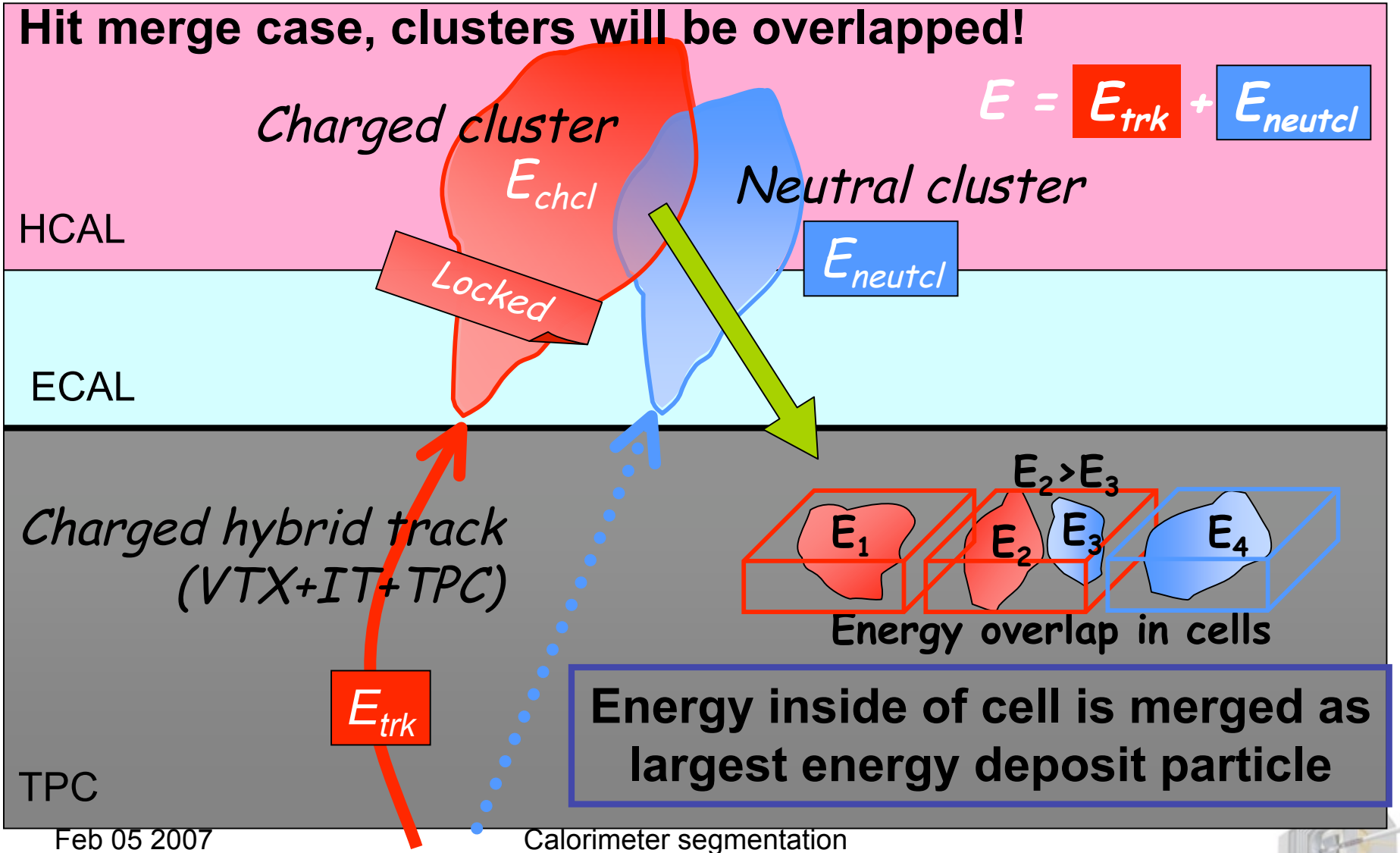
Use track information for charged track



PFA can be improved the jet energy resolution.



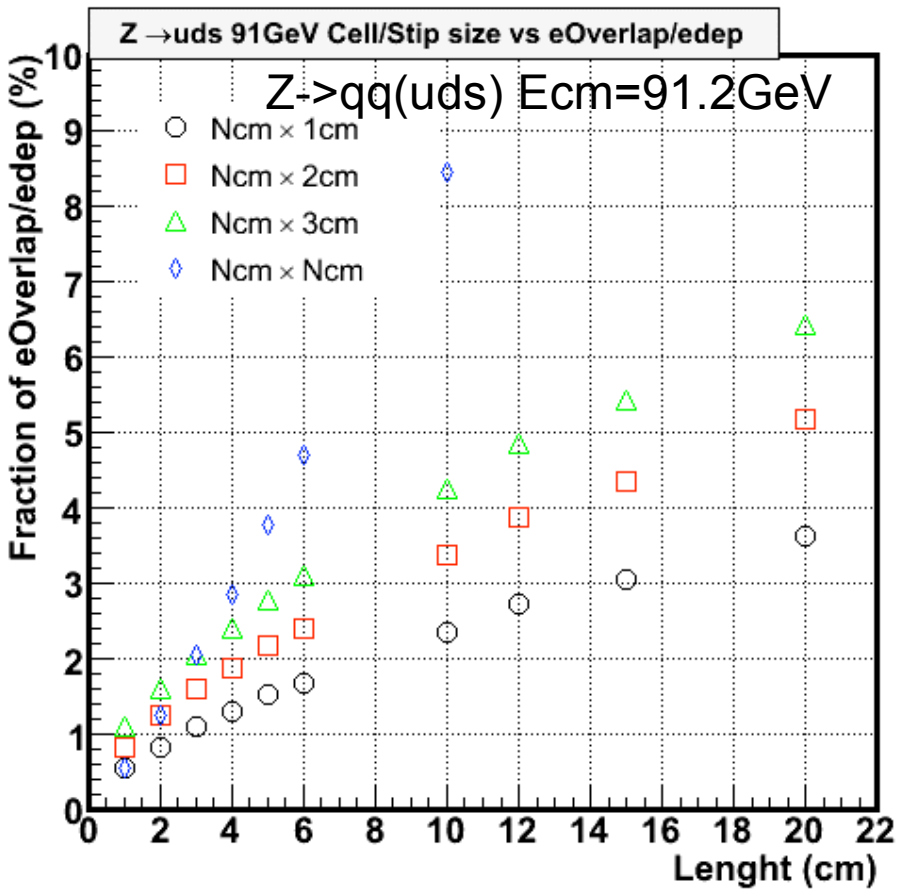
Charged and neutral cluster overlap

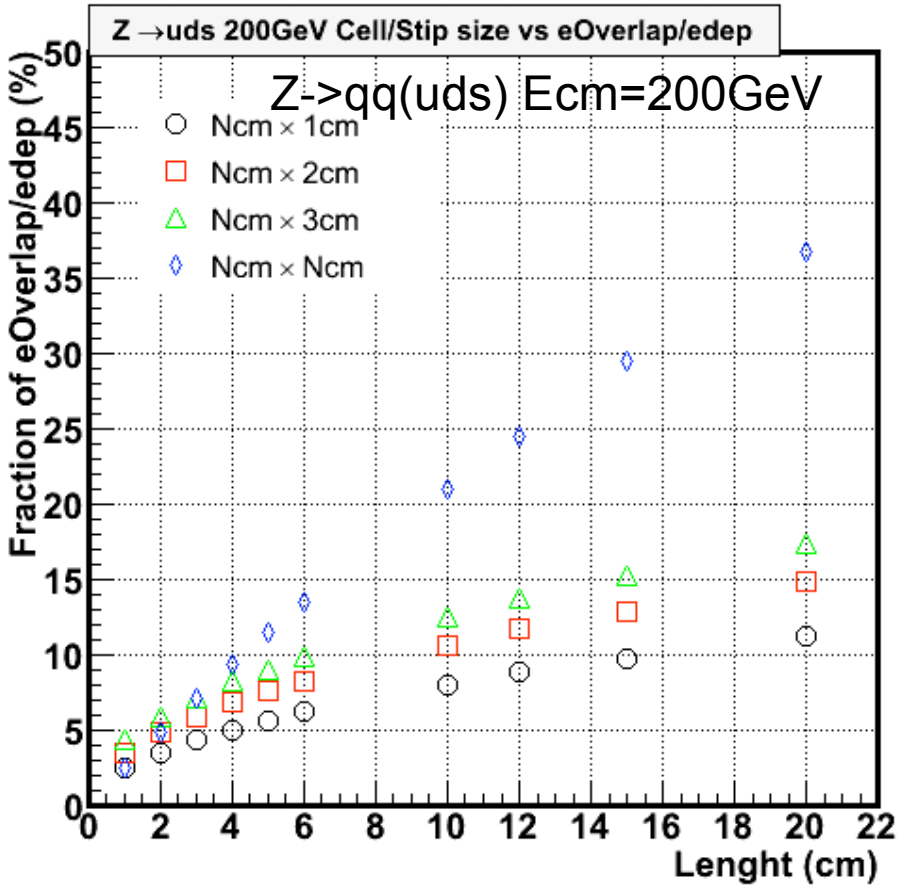


Cell by cell overlapping (hits merged)

Fraction of cluster overlap inside of one cell.
It strongly depends on the segmentation of calorimeter.

Fraction = (ΣEdep >1 mother hit)/(ΣEdep in cell)

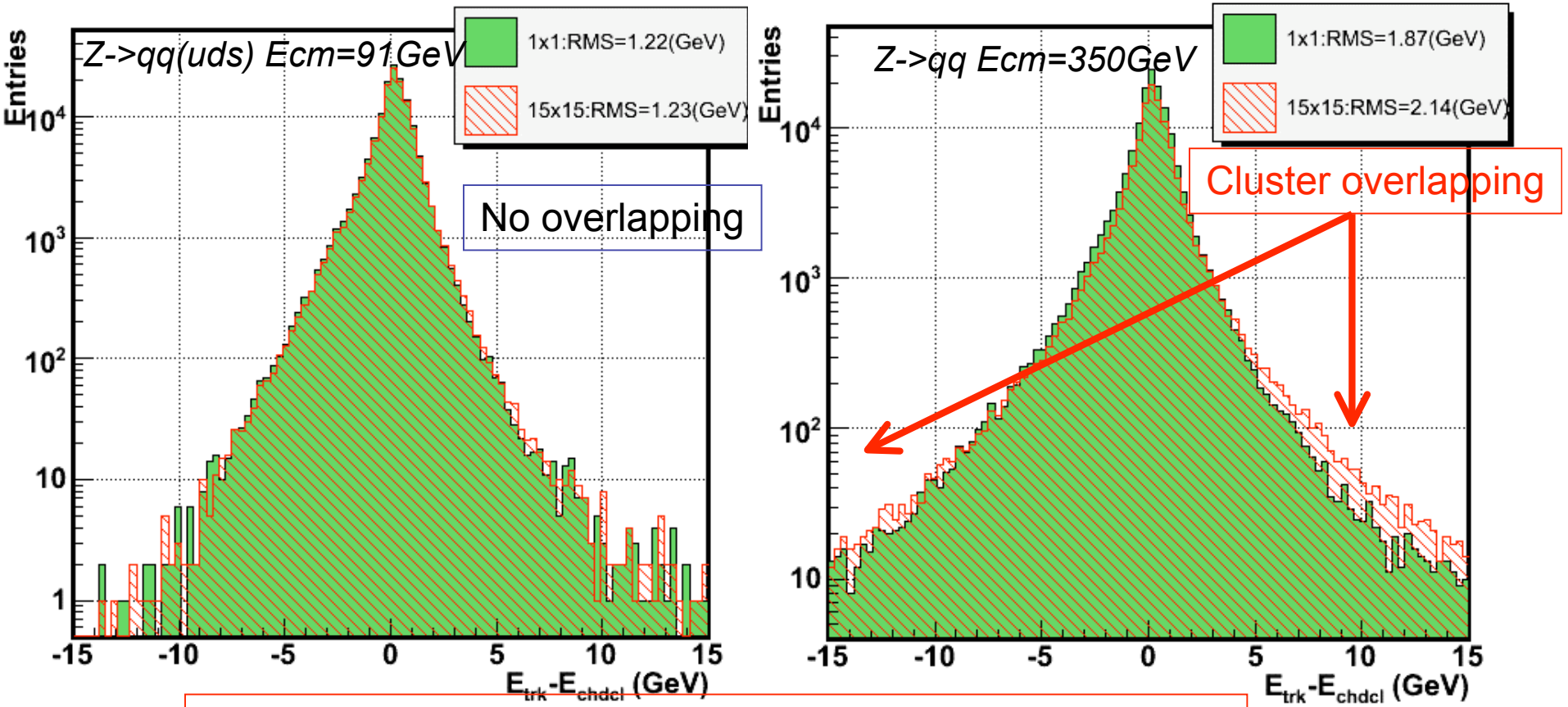




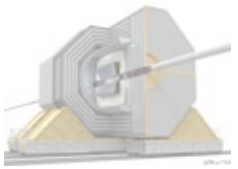
dependence of PFA performance

Charged and neutral cluster overlapping (track by track)

Difference of track and charged cluster energy (E_{trk}-E_{chdcl}) will change because of *cluster overlapping between charged* and *neutral* in a cell.

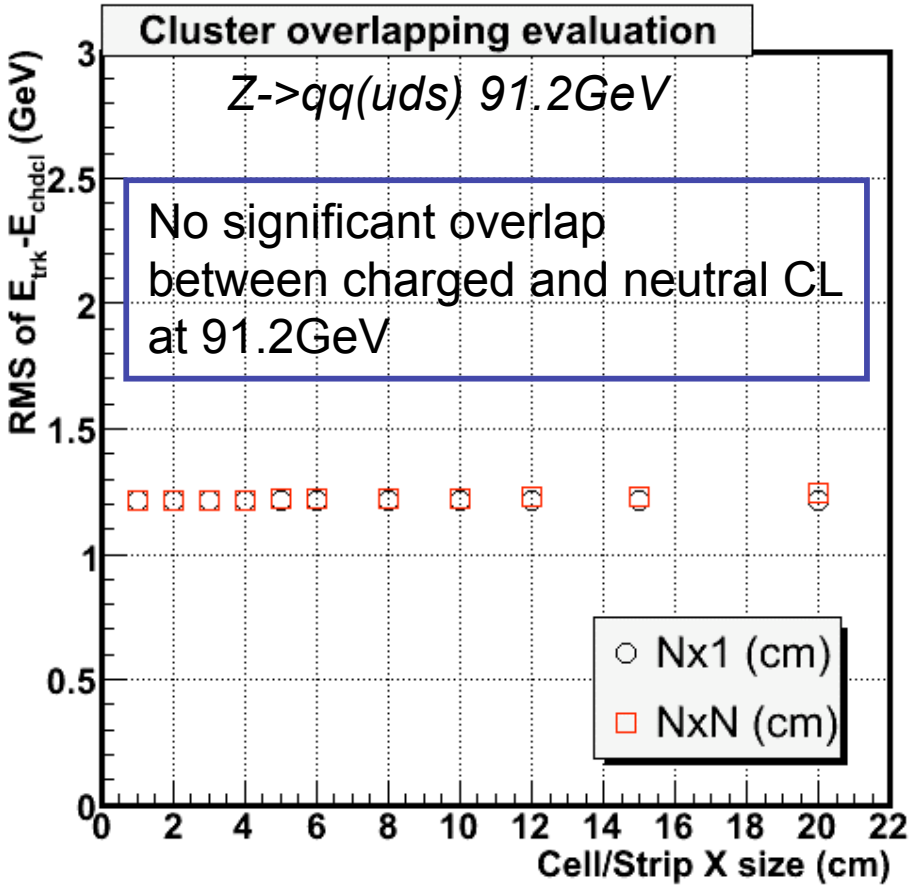


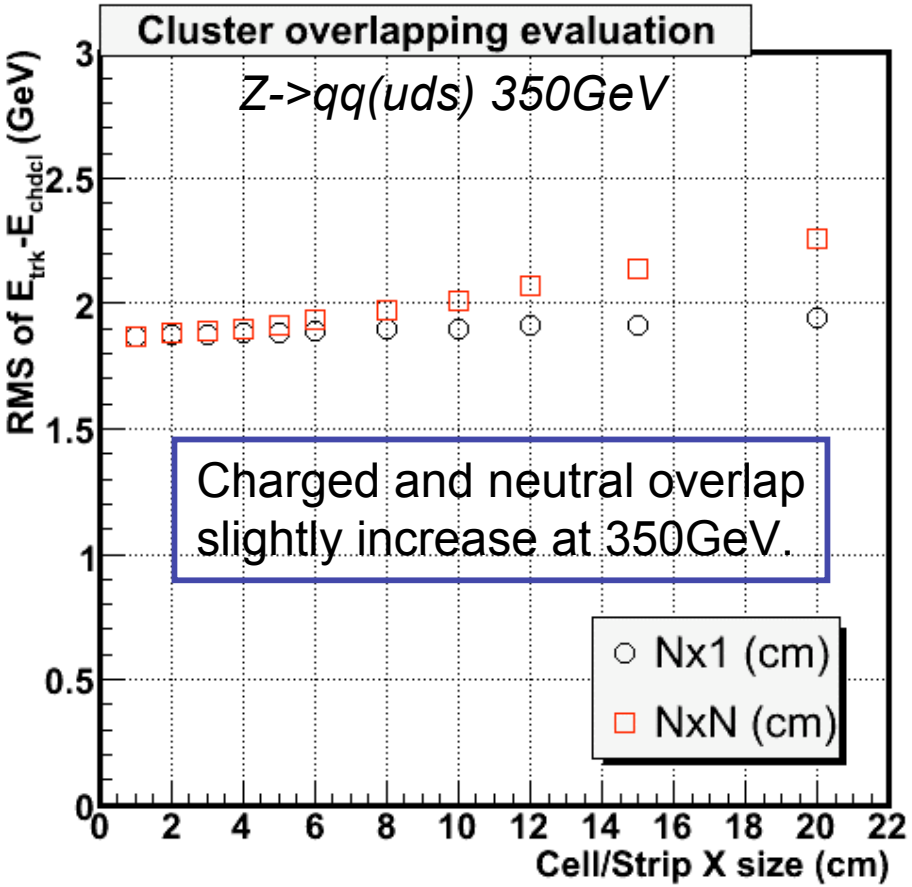
Difference of RMS : Sqrt(2.14*2.14-1.87*1.87)=1.04 (GeV)
at 1x1 and 15x15(cm) segmentation, E_{cm}=350GeV



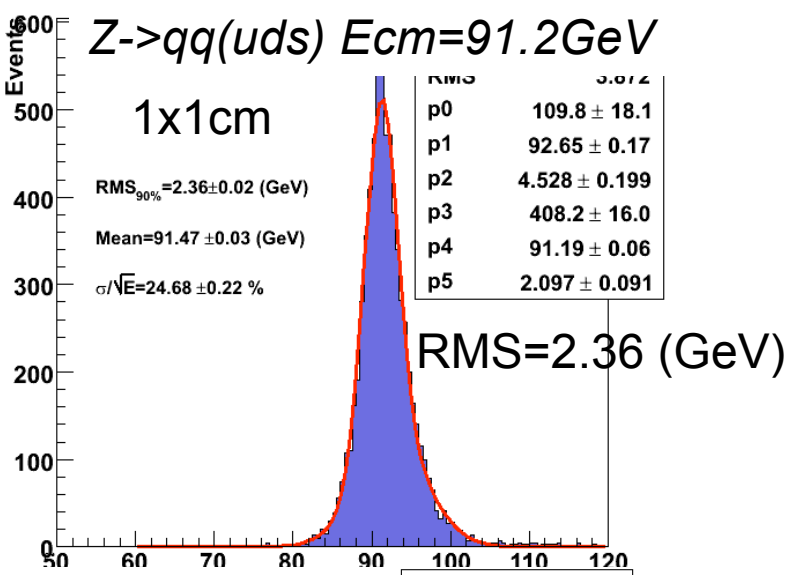
Charged and neutral cluster overlap

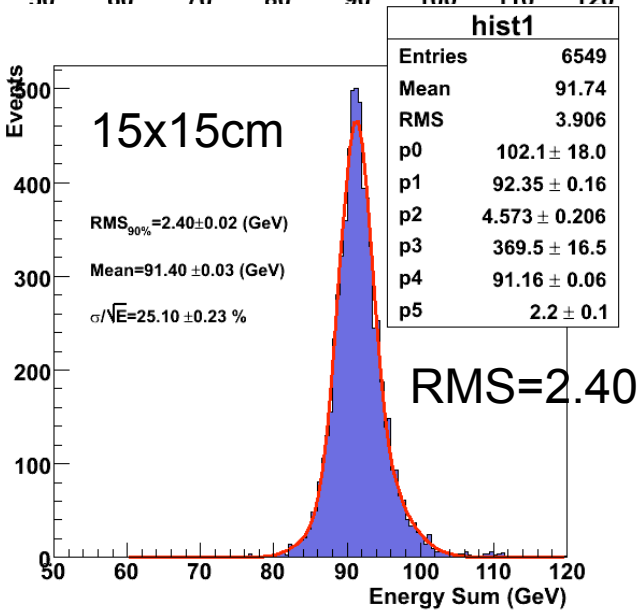
- Vertical : RMS of E_{track} and related $E_{cluster}$ difference (E_{trk}-E_{chdcl})
- Horizontal : Segmentation of calorimeter (nxn(cm)=cell, nx1(cm)=strip)

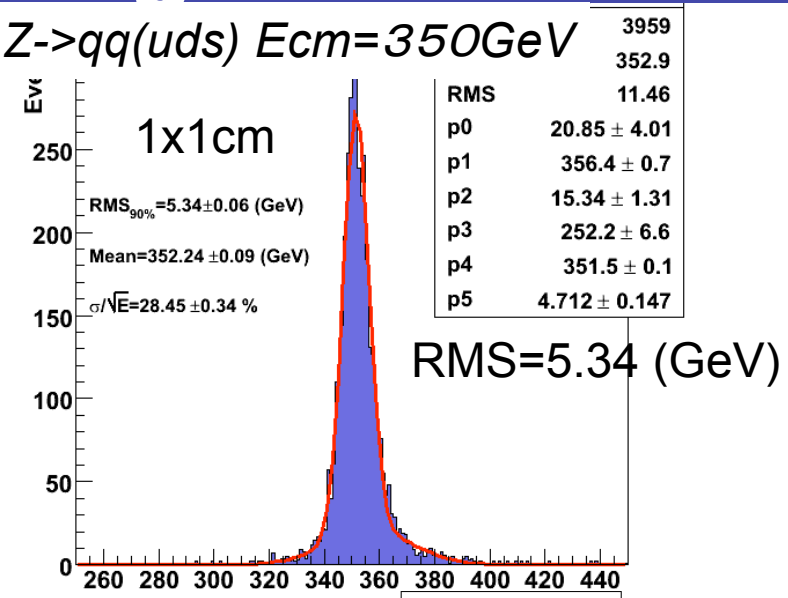


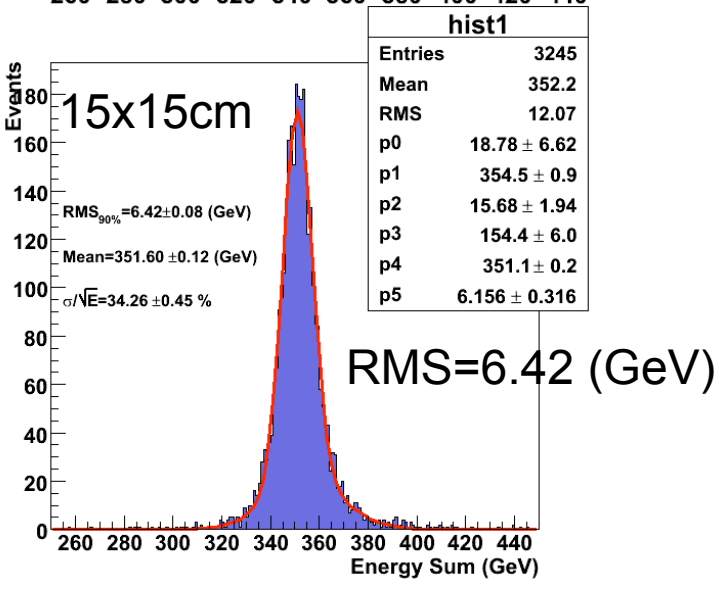


Jet energy resolution with different segmentations

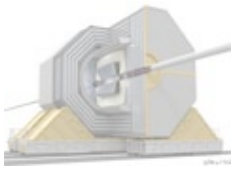




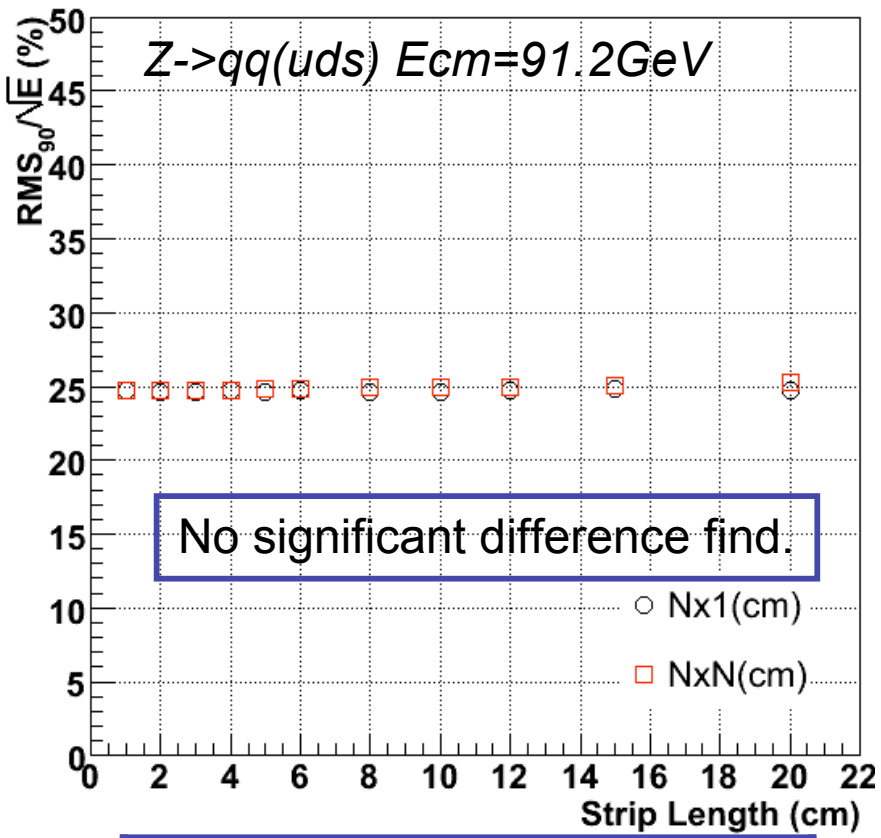




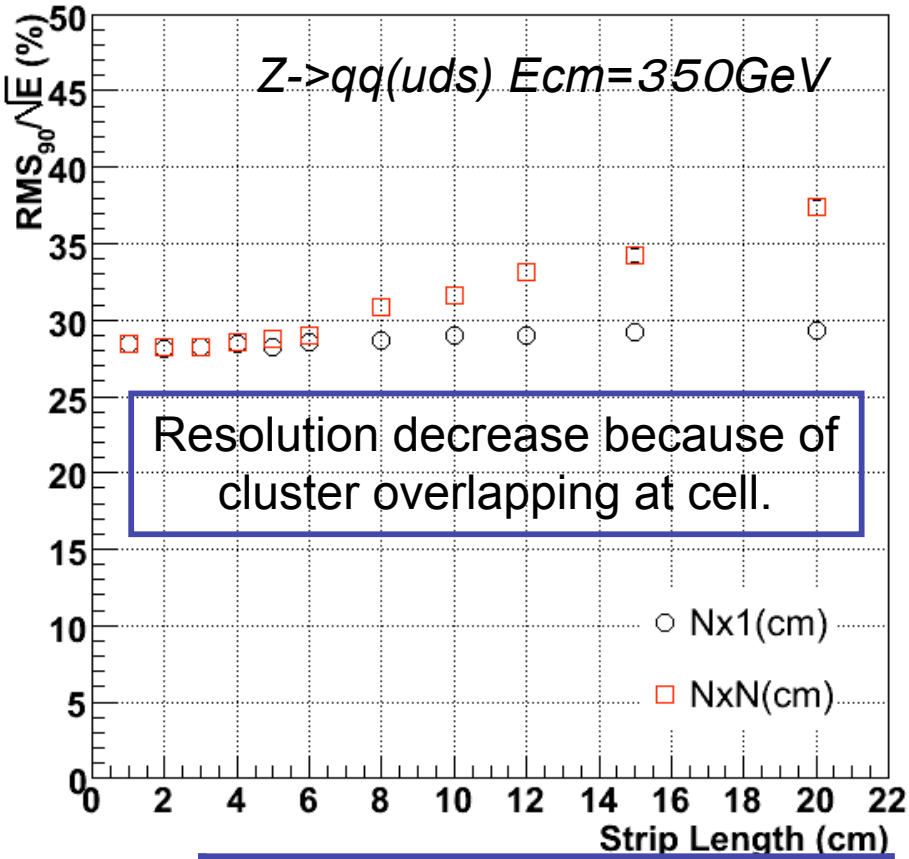
Calorimeter s
dependence of



Jet energy resolution with different segmentations



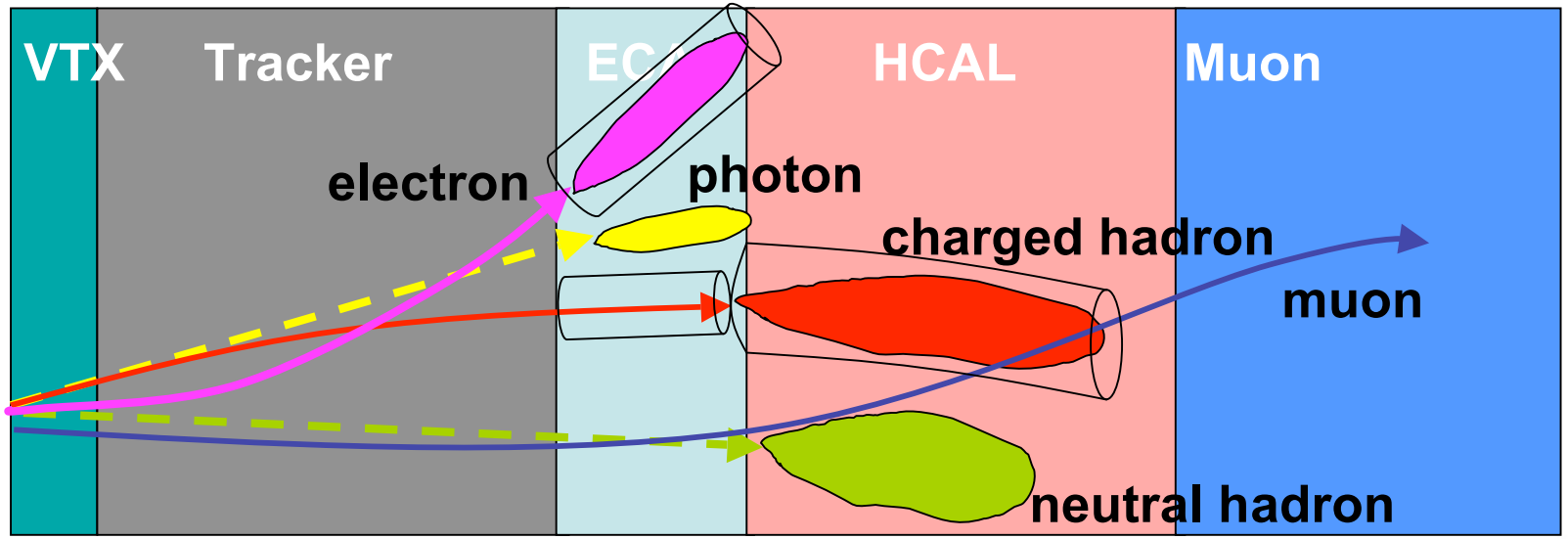
1x1(cm)	24.7 ± 0.2%
5x5(cm)	24.8 ± 0.2%
10x10(cm)	25.0 ± 0.2%

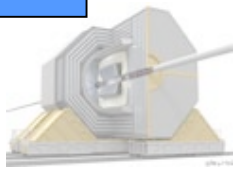


1x1(cm)	28.4 ± 0.3%
5x5(cm)	28.8 ± 0.3%
10x10(cm)	31.6 ± 0.4%

Realistic GLD-PFA scheme

1. Small clustering (Nearest neighbors)
2. Photon finding. (Likelihood method)
3. Charged particle finding.
4. Neutral hadron finding. (Likelihood method)
5. Other satellite hits. (Muon use true hits)





Realistic PFA performance test

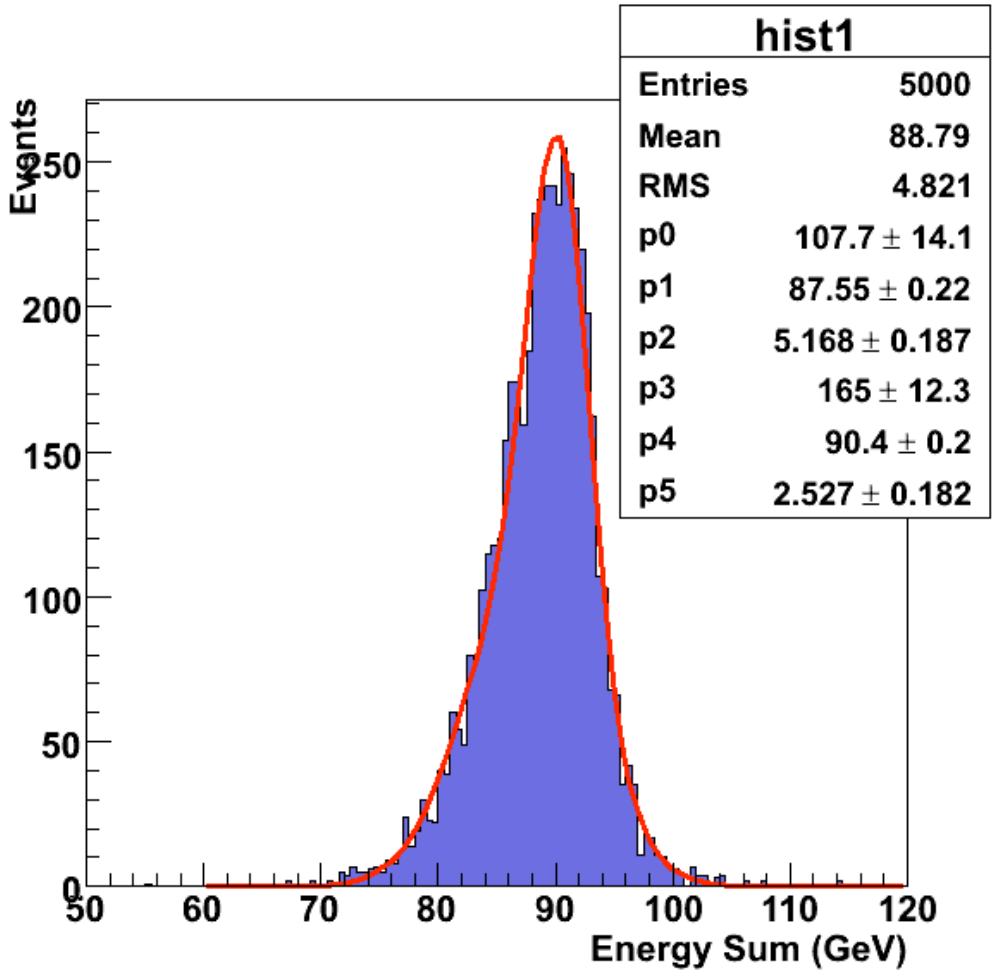
e+e-->Z->qq(uds)

Ecm= 91, 350 GeV

Variation of cell size
- **1cmx1cm**
- **2cmx2cm**
- **4cmx4cm**
- **5cmx5cm**
- **10cmx10cm**

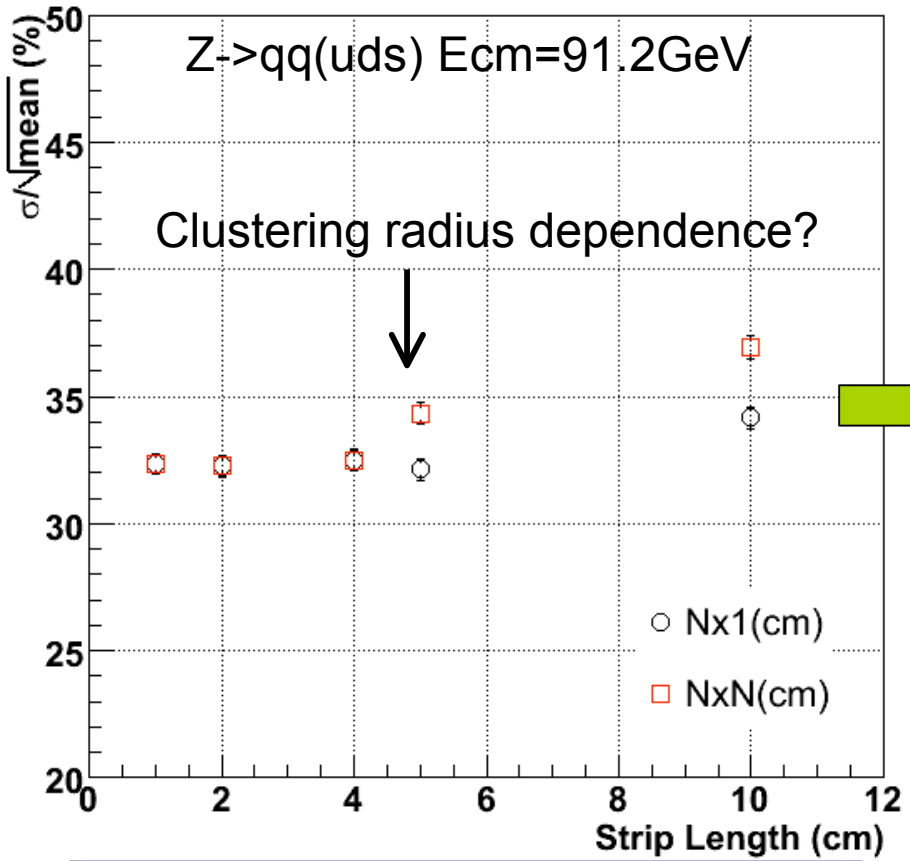
Strip size use Ncm x 1cm

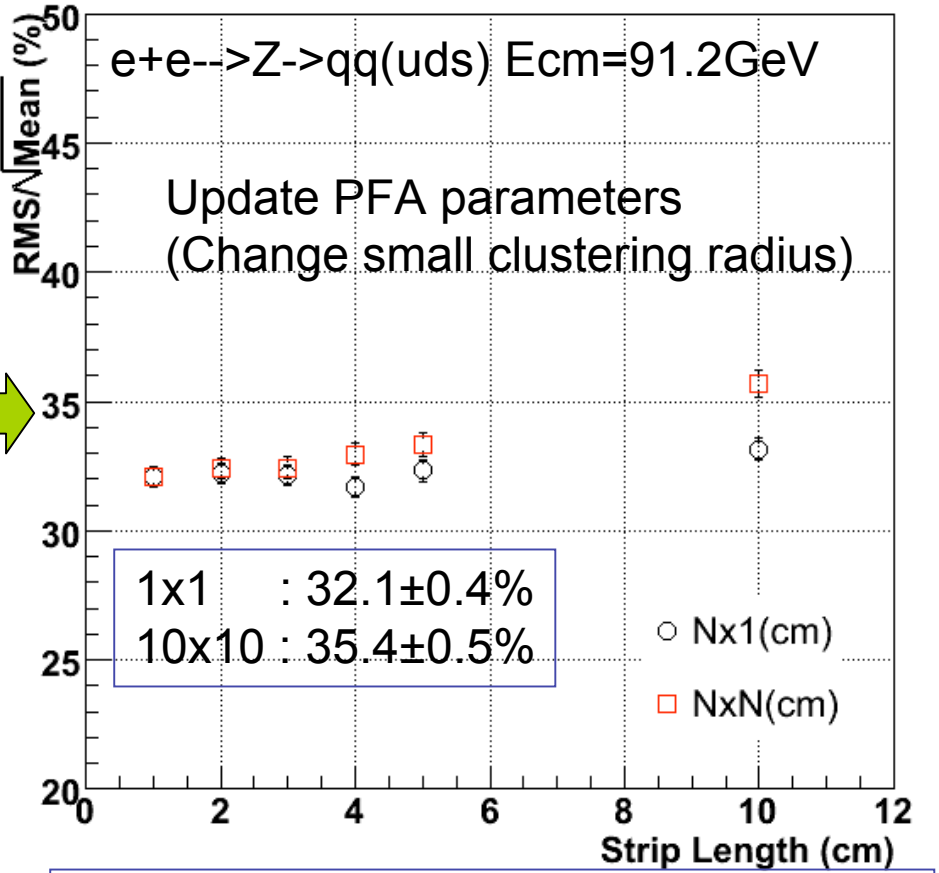
EM/HD different cell size
EM:1cmx1cm, 4cmx4cm
HD:1,2,4,5,10cm cells



Cell/Strip Size dependence of Realistic PFA performance

Same PFA scheme applied to cell/strip calorimeter, no strip clustering!



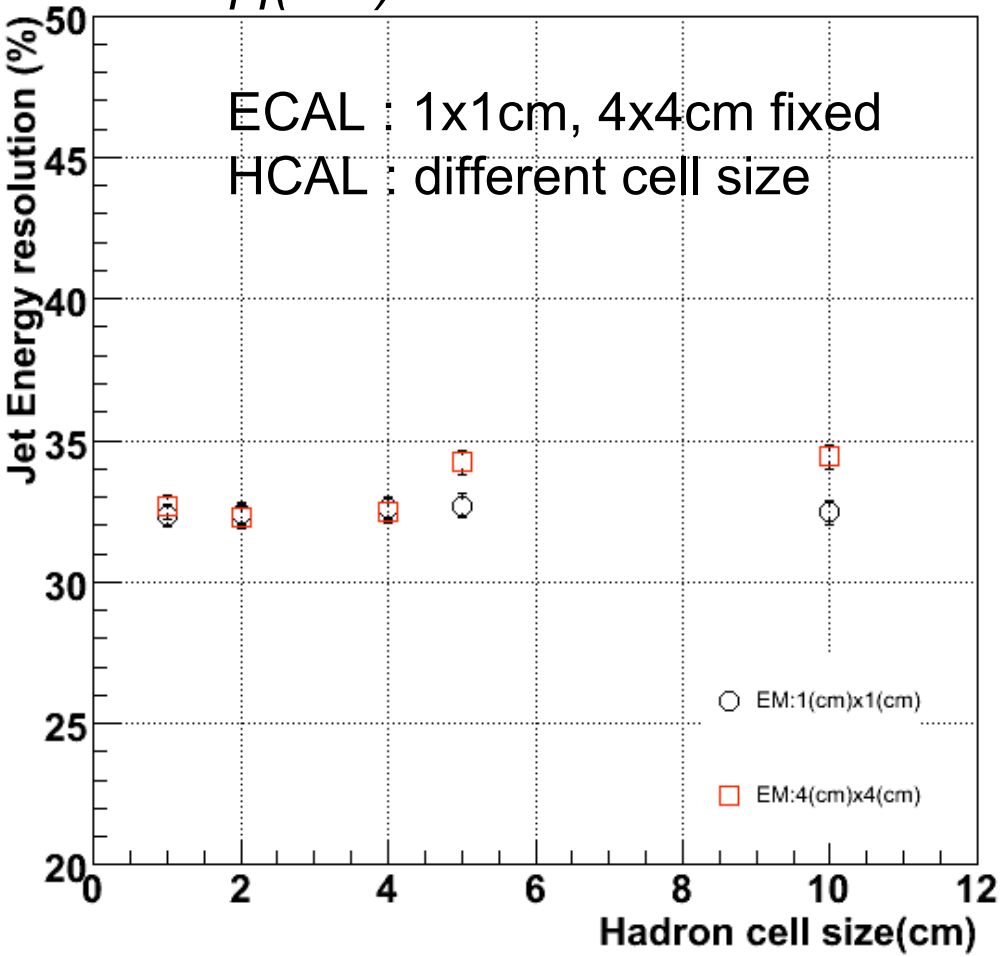


Previous default setup of GLD-PFA

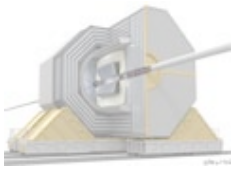
Clustering performance depends on the segmentation of the calorimeter.

PFA with EM/HD different cell size

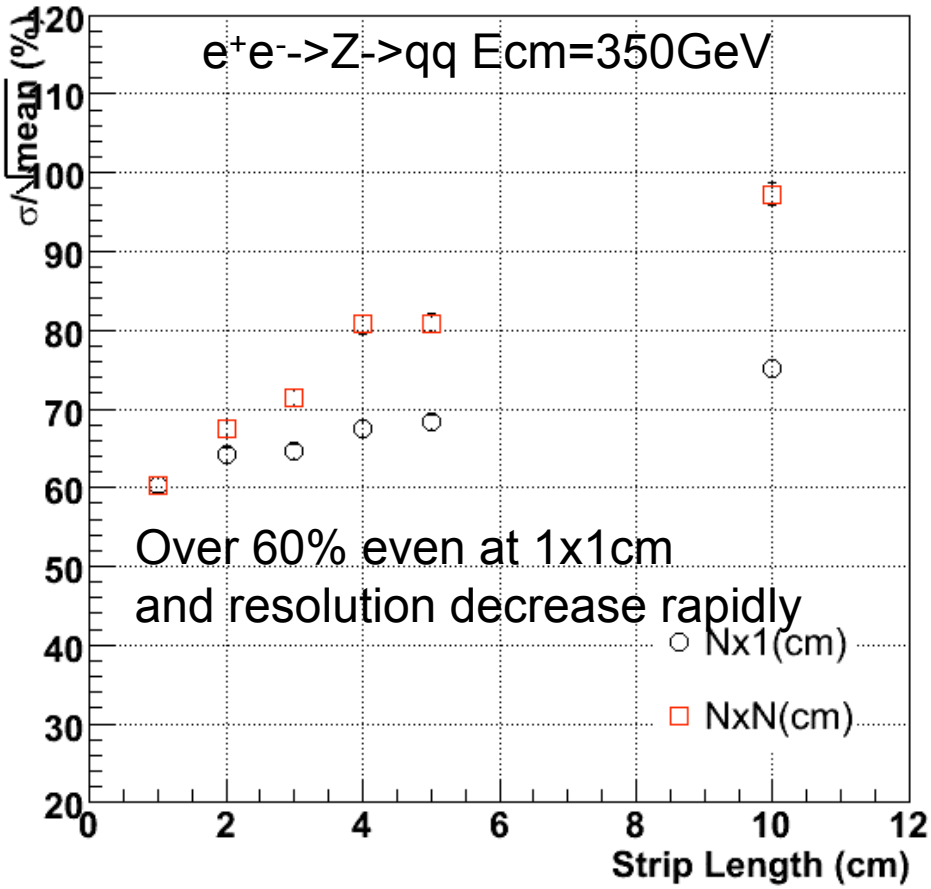
Z->qq(uds) Ecm=91.2GeV

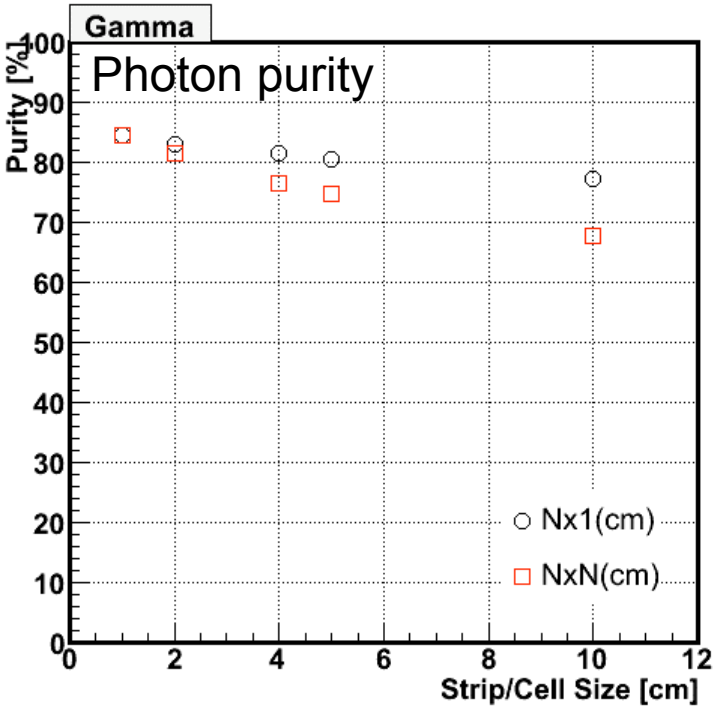


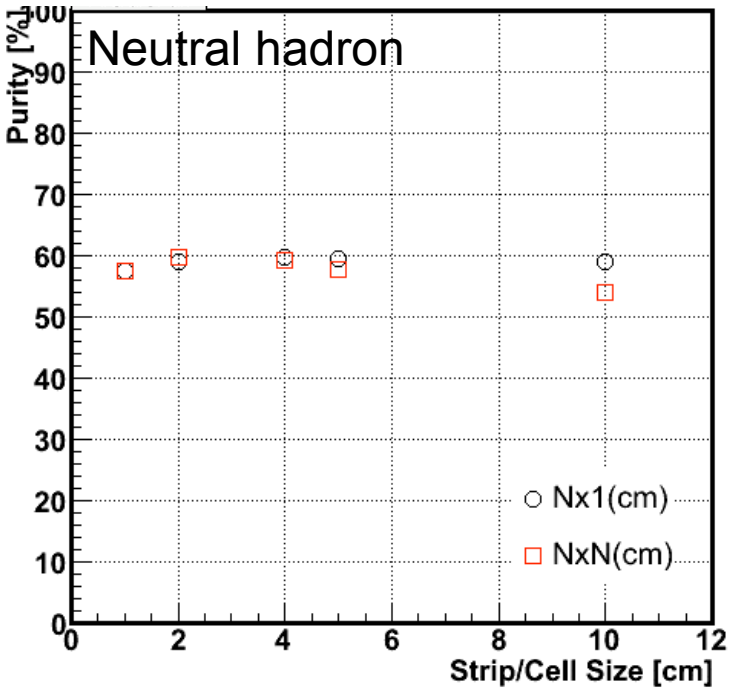
- Different cell size of EM/HD calorimeter with GLD-PFA default parameters.
- Ecm=91GeV case, hadron segmentation will not affect for jet energy resolution compare to the EM segmentation.



Ecm=350GeV PFA performance and purity



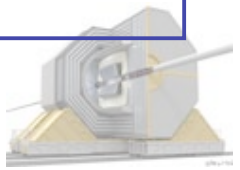




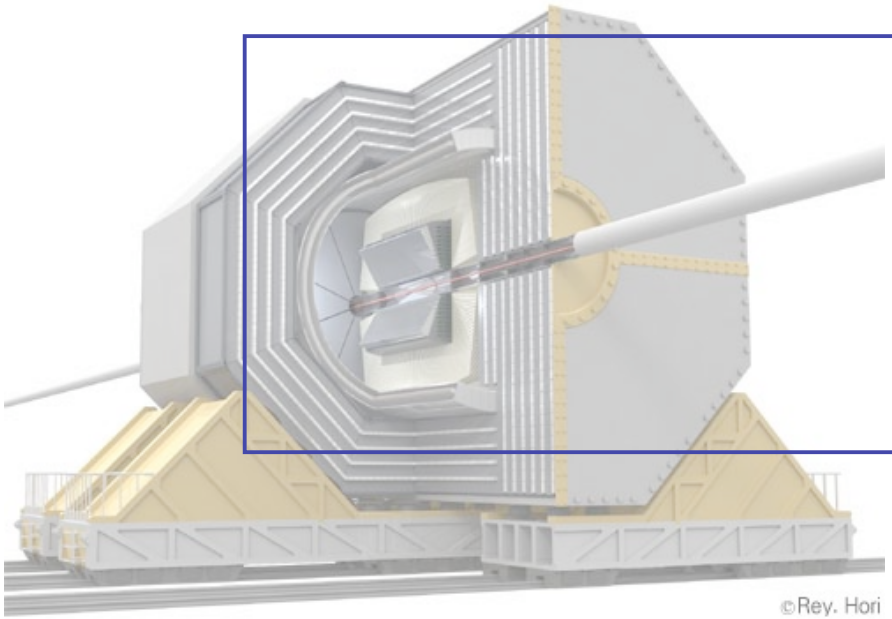
Now analyzing different EM/HD segmentation

Conclusion

- In cheated PFA, Z->qq event has analyzed about charged and neutral cluster overlap contribution.
  - Ecm=91GeV : Almost no segmentation effect has been observed both cell/strip shape.
  - Ecm=350GeV: jet energy resolution has slightly decreased by larger segmentation in cell case.
- In realistic PFA, jet resolution and clustering performance depend on the calorimeter segmentation.
  - PFA performance rapidly decrease at higher energy.
- Now strip clustering method is developed for better jet clustering performance and resolution.



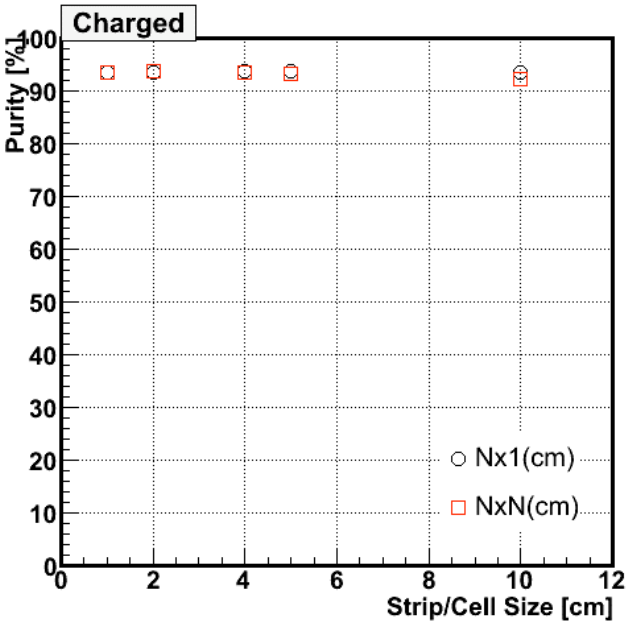
Appendix

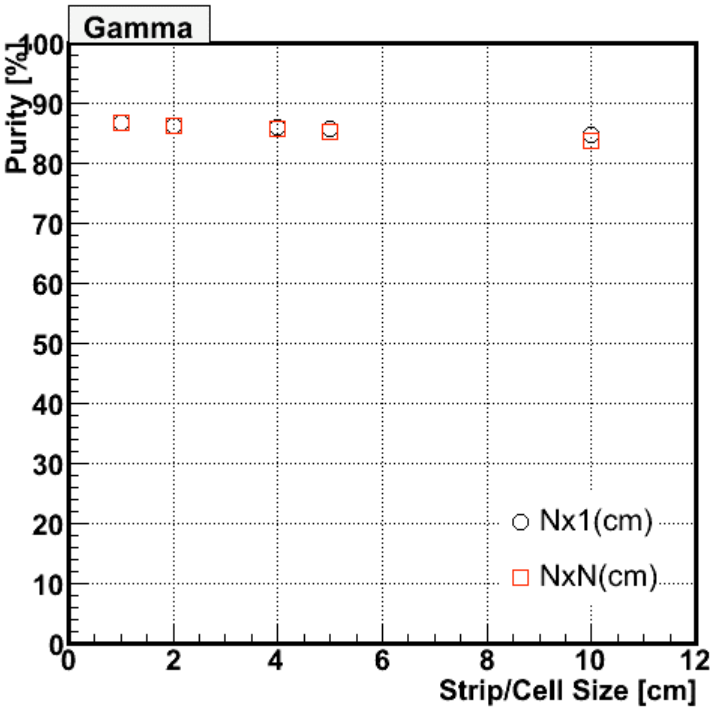


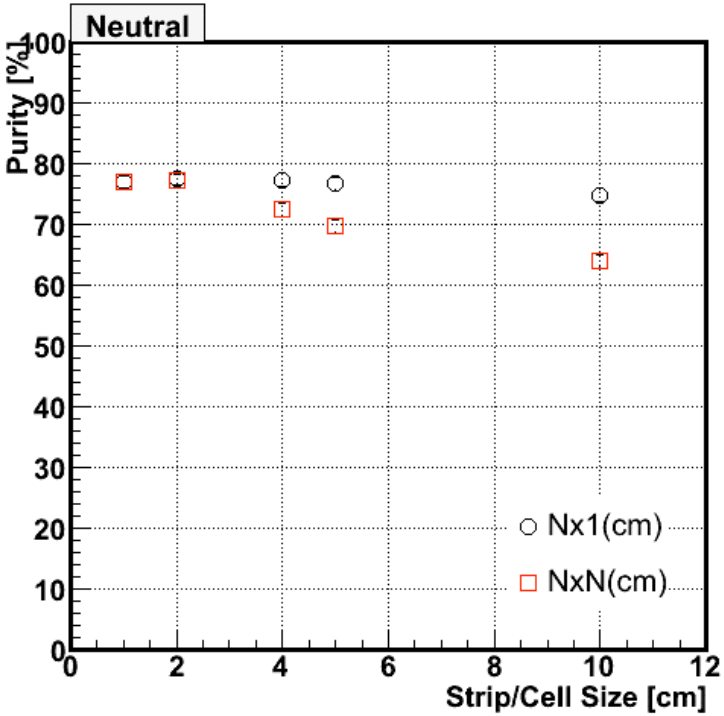
PFA performance purity as a function of segmentation

e+e-->Z->qq(uds) Ecm=91GeV

Neutral hadron purity reduced significantly by size. cell size larger than 2cm and Nx1cm case, reduction is much small.



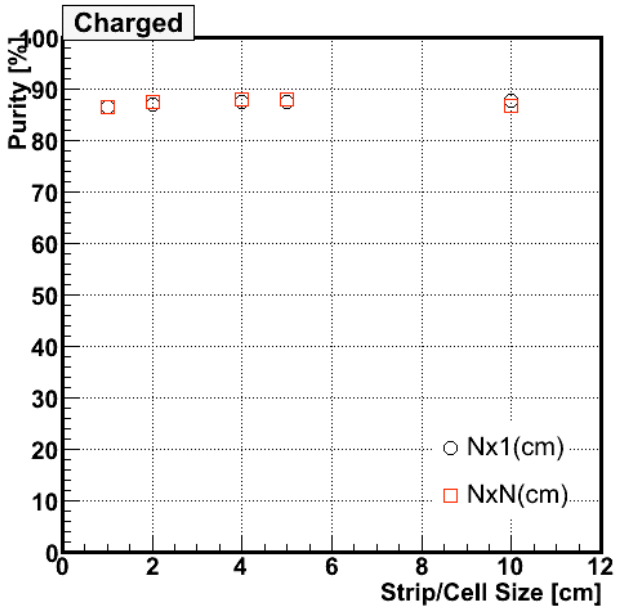


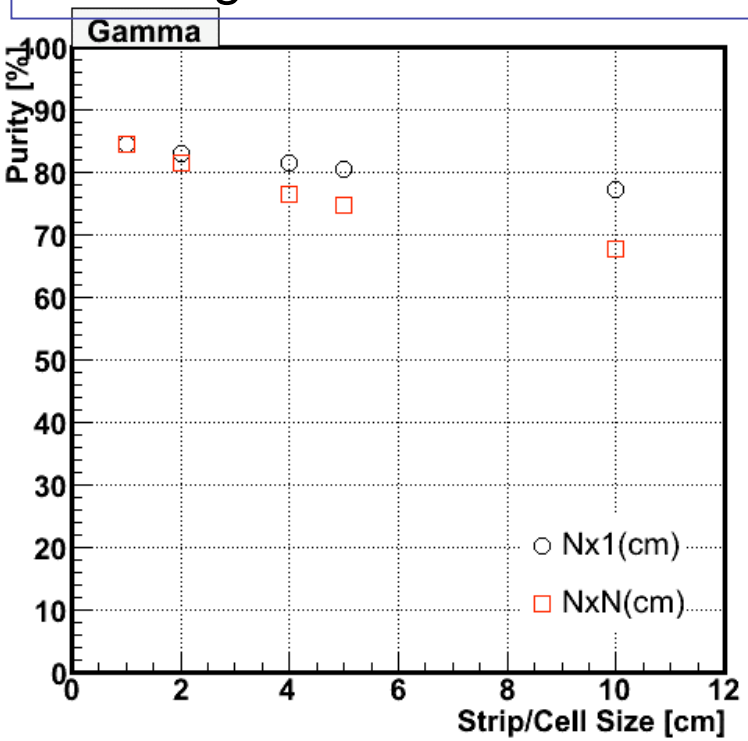


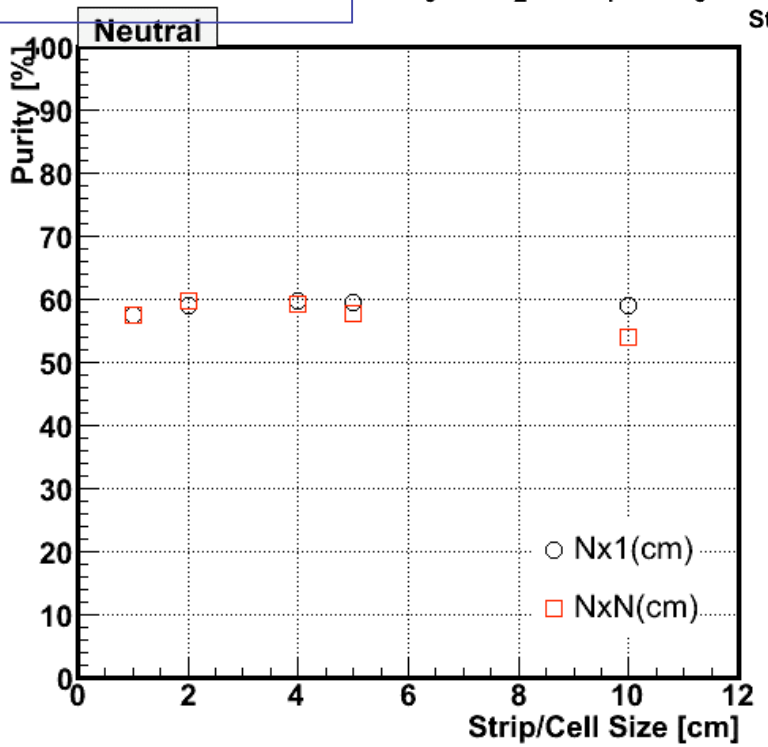
PFA performance purity as a function of segmentation

e+e-->Z->qq(uds) Ecm=350GeV

Reason of low jet energy resolution looks
- Gamma purity reduce by segmentation
- Low purity of neutral hadron.
- These goes to the Satellites hit and confusion







dependence of PFA performance