Clustering in Scintillator strip

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ILD software and Integration WS at DESY

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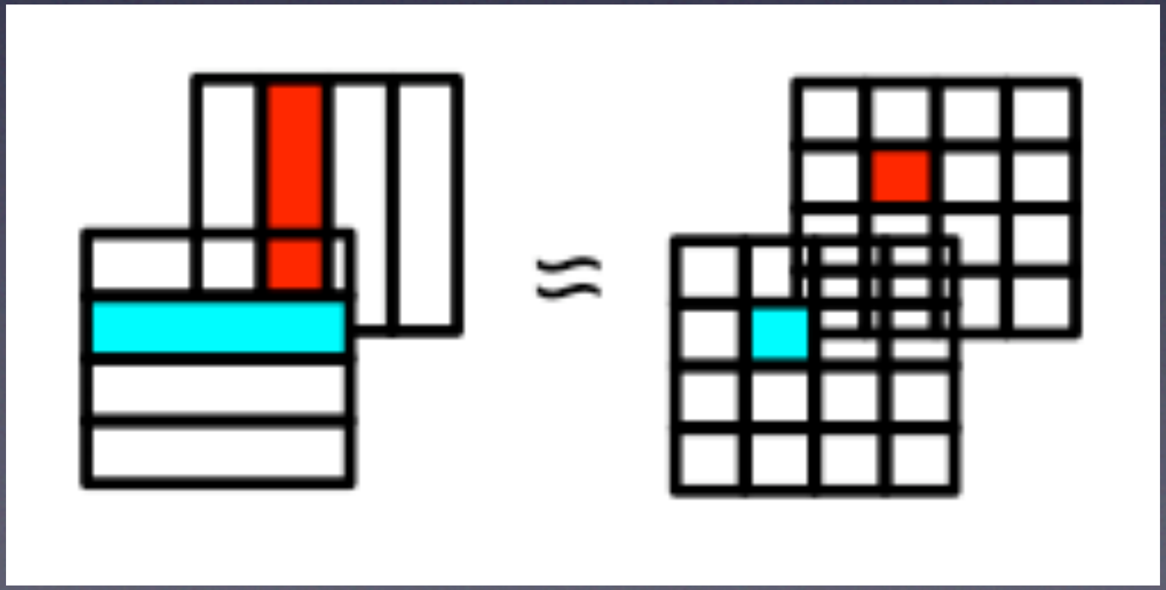
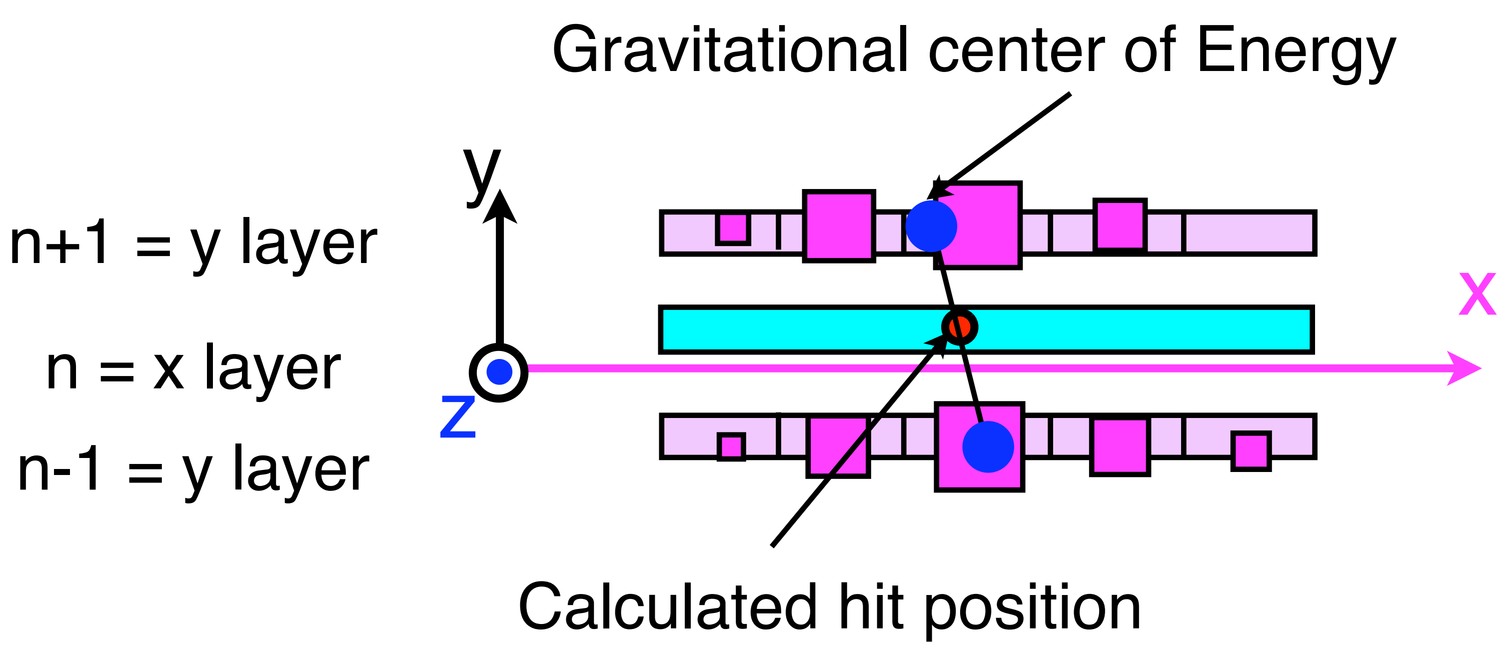
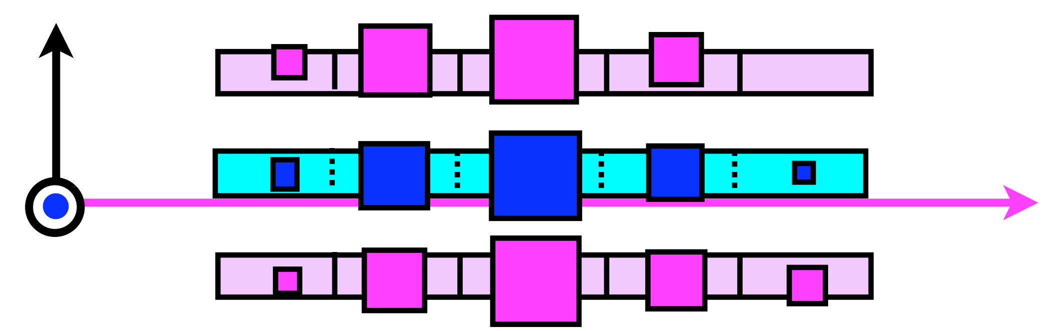


New approach for the Strip Clustering

Triplet method → Split method





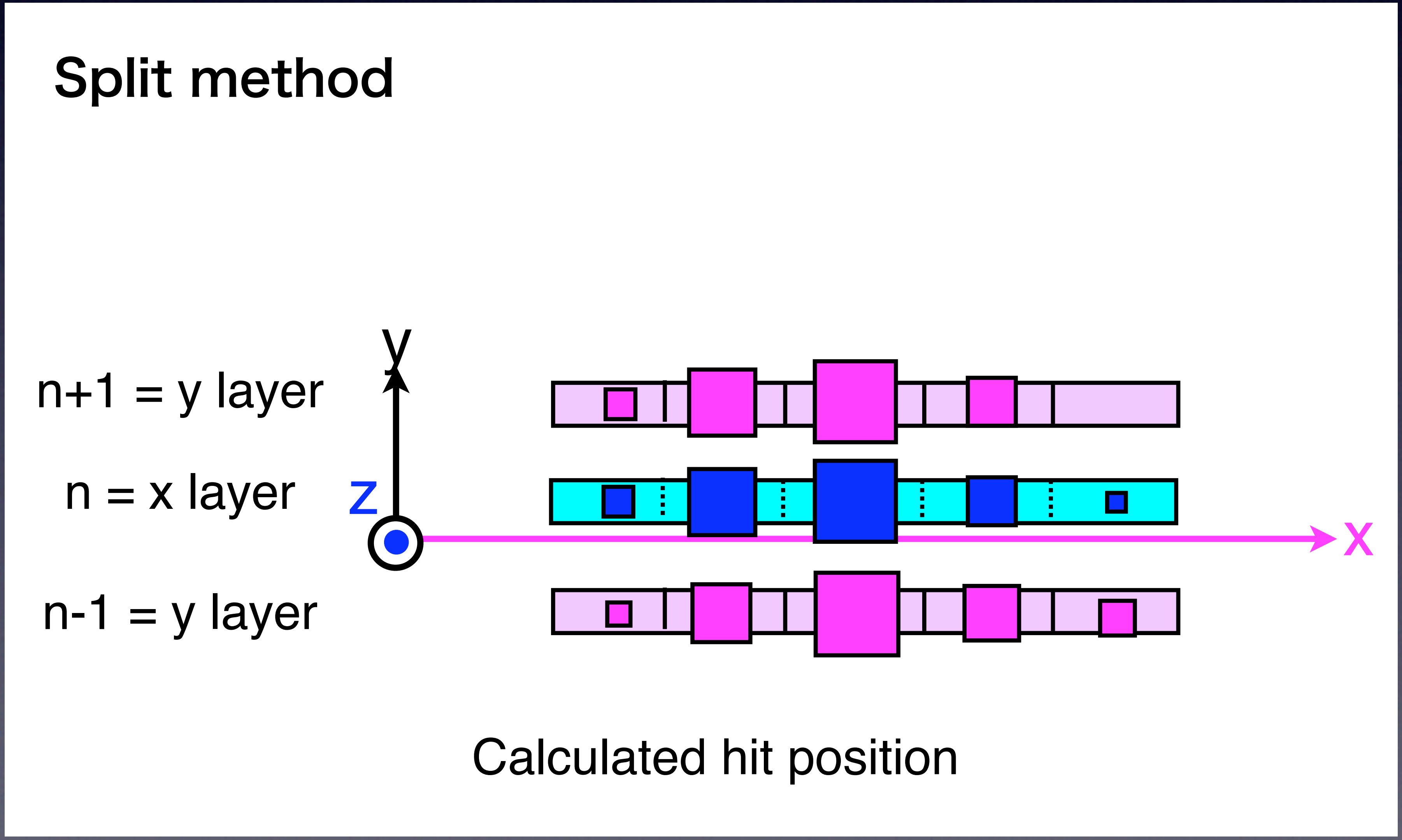
Split the energy of a scintillator in “n” layer into square cells corresponding to the energy in cells in n ± 1 layer.

Split method

- Note that we do not need to give strip shape information to the PFA processor.
- Energy in split cells are calculated as a fraction of total energy in a scintillator.
- This is suitable for the PandoraPFA which requires 5 x 5 mm^2 segmentation
- Simple way

Procedure of Split method

1. get energy on this (sky blue) scintillator strip.
2. Split the strip into 5 mm x 5 mm square cells (dot lines).
3. look at the energy on the overlap strips in above and below (purple cells, these have longitudinal direction in z)

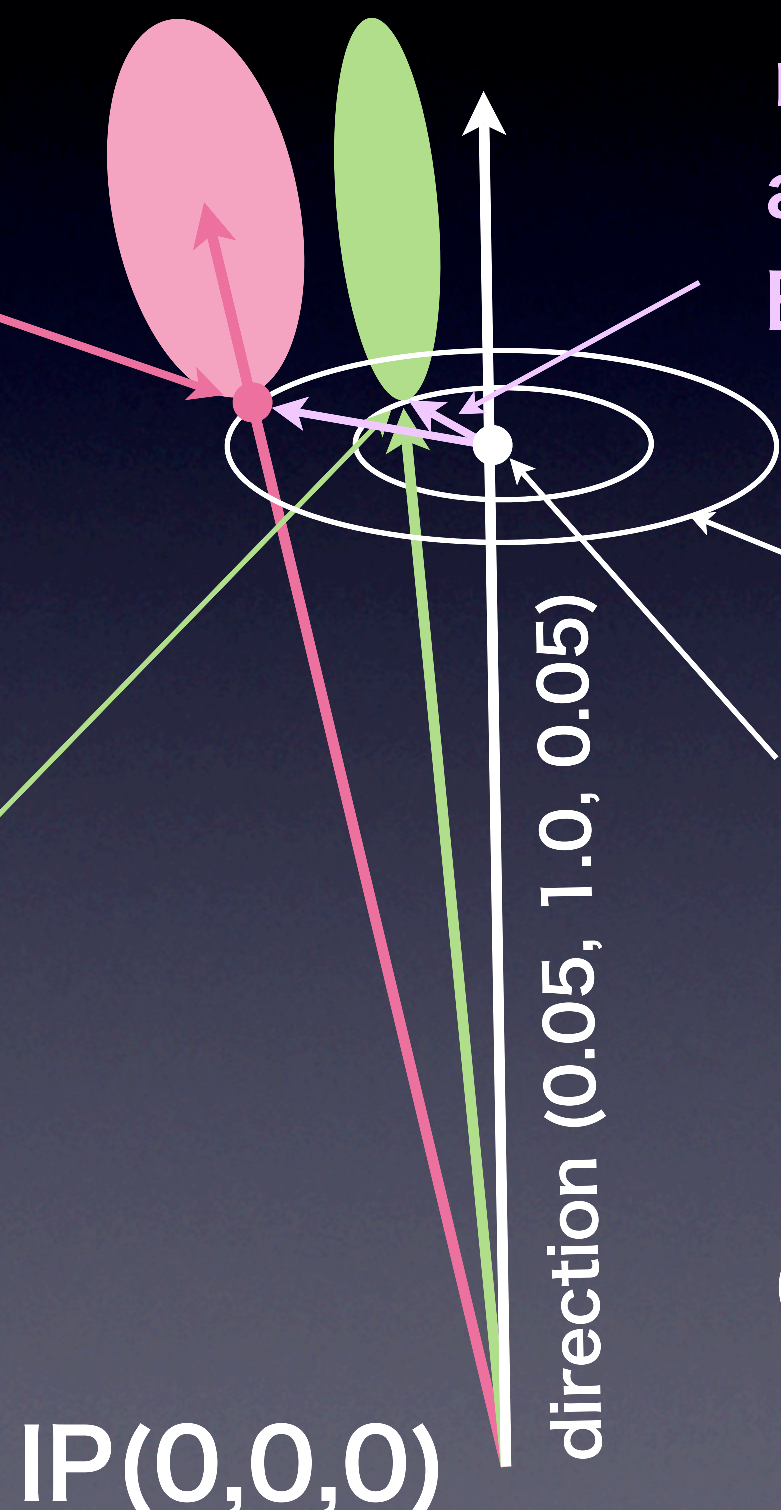


4. Share the original energy in this strip into the split cells according to the energy size in the above and below scintillator strips.
5. the position and energy of each split cell is turned over to the PandoraPFA.

Position Resolution for 10 GeV single photons

Position of the center of energy projected on Ecal inner surface befor the procedure for strip (x, y=1850 mm, z). Each hit position is center of the scintillator strip.

Distance between reconstructed PFO and MC true on the Ecal innter surface.



Ecal inner surface.

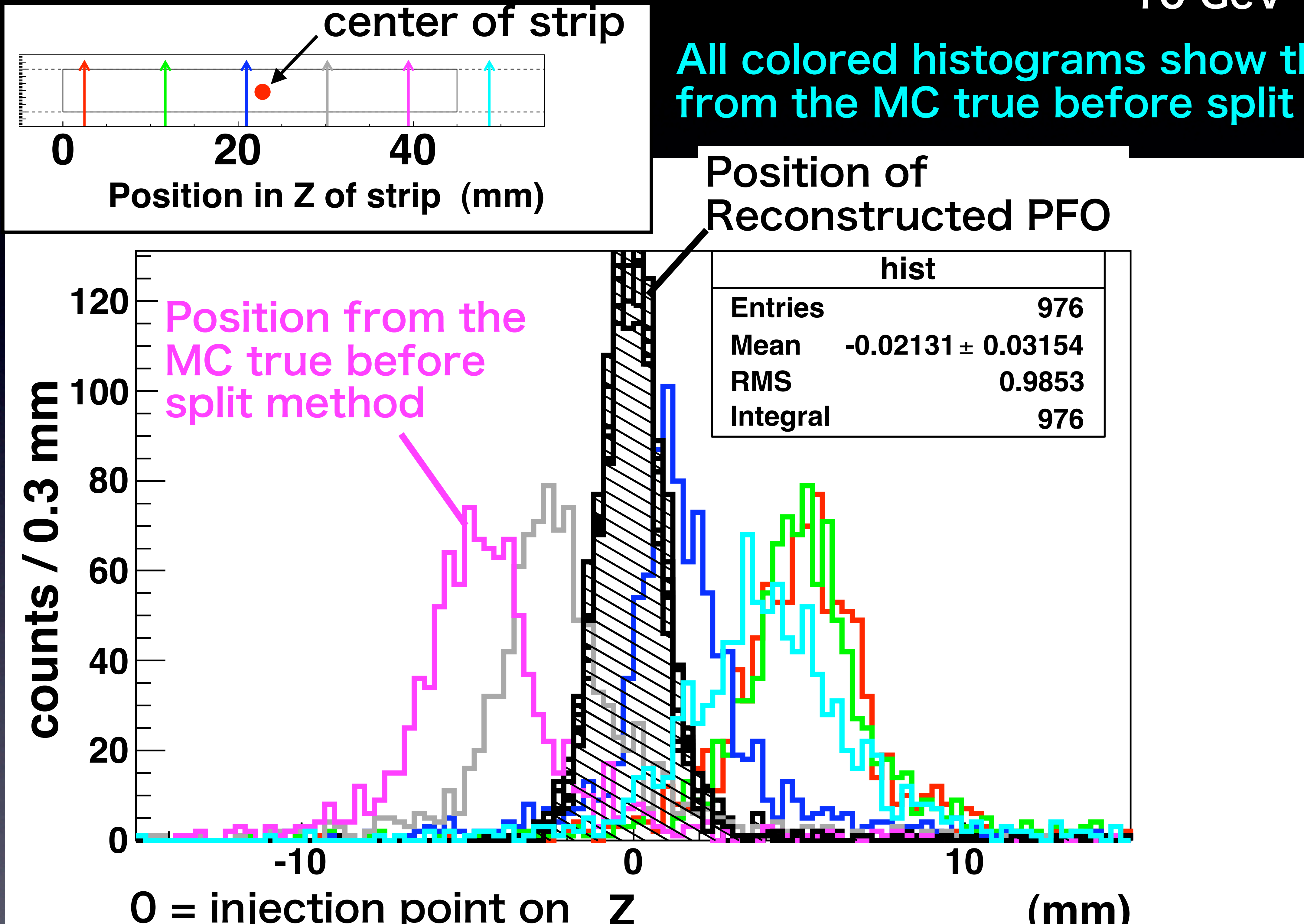
Position where PFO momentum after the split method points on the Ecal inner surface (x, y=1850 mm, z).

Position which MC true momentum points on the Ecal inner surface (x, y=1850 mm, z).

Distributions of distances from the MC true

10 GeV 1000 photons

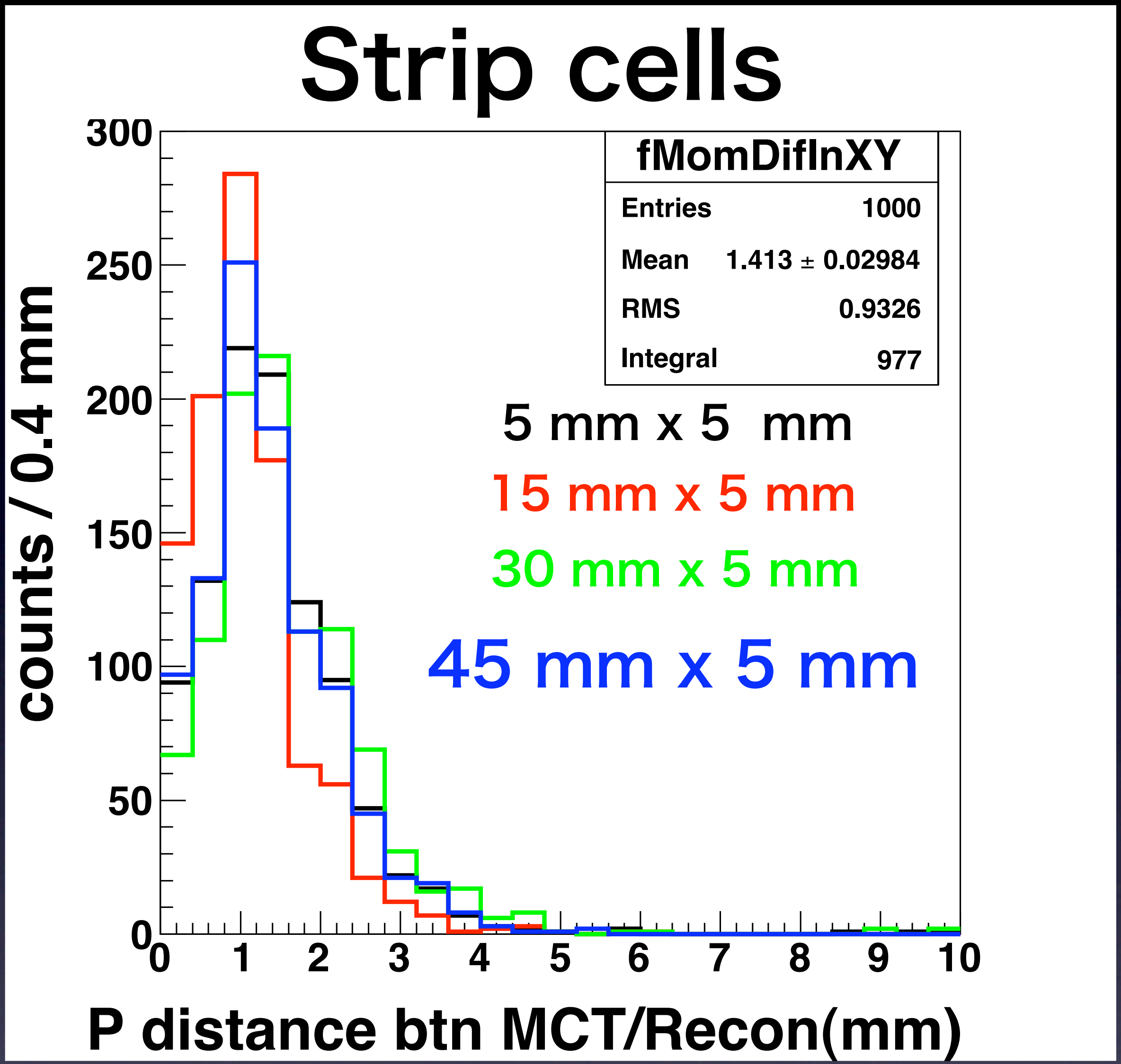
All colored histograms show the positions from the MC true before split method

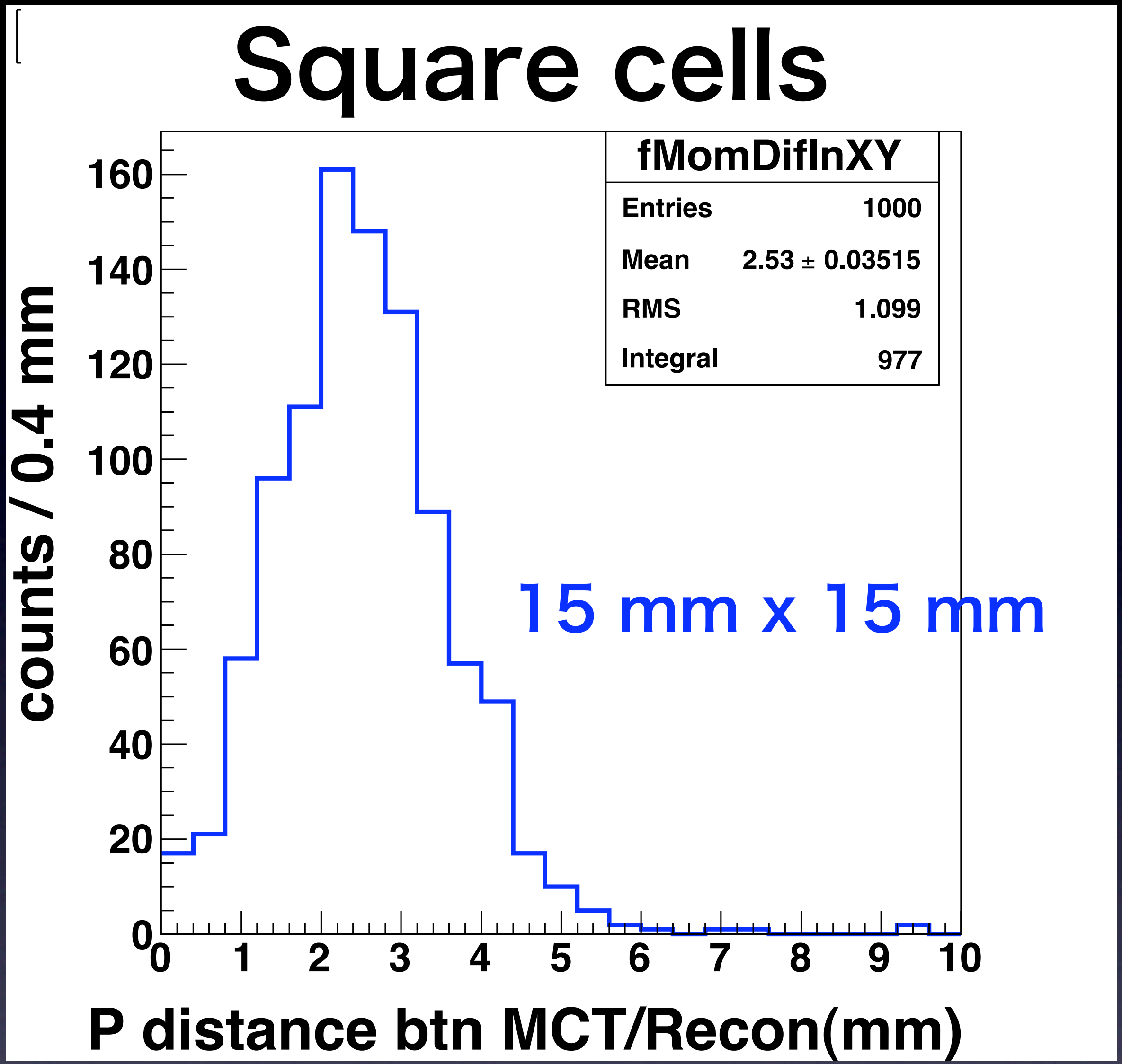


- Any position injection can be corrected by split method (ignore isolate hits).

Comparison of position resolution depending on Strip size and shape

10 GeV 1000 photons

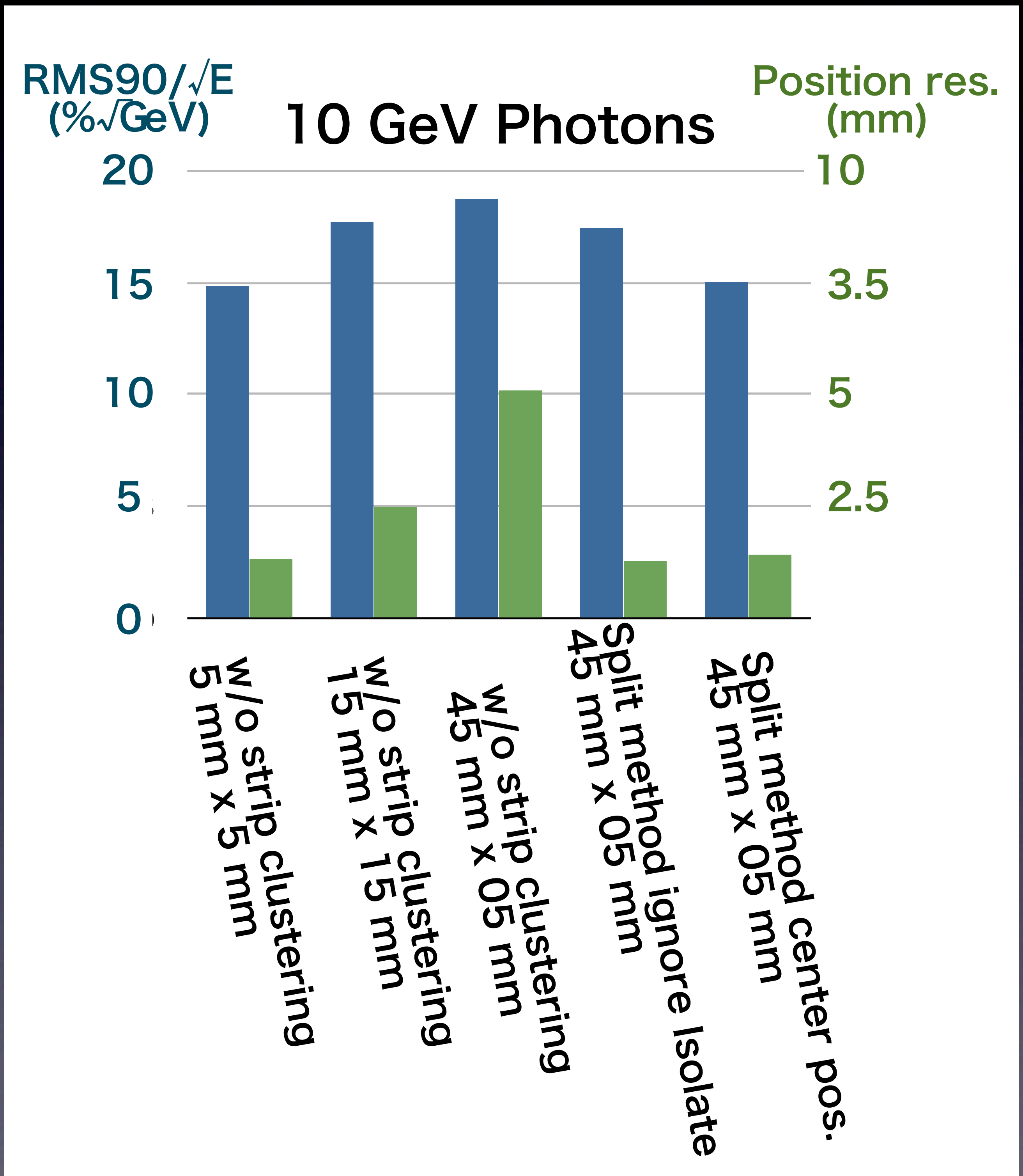




Cell size (mm x mm)	distance on ECAL inner surface	for 1PFO events
5 x 5	1.33 mm,	1.16 mm
15 x 5	1.05 mm	0.97 mm
30 x 5	1.53 mm	1.23 mm
45 x 5	1.32 mm	1.15 mm
15 x 15	2.42mm	2.34 mm

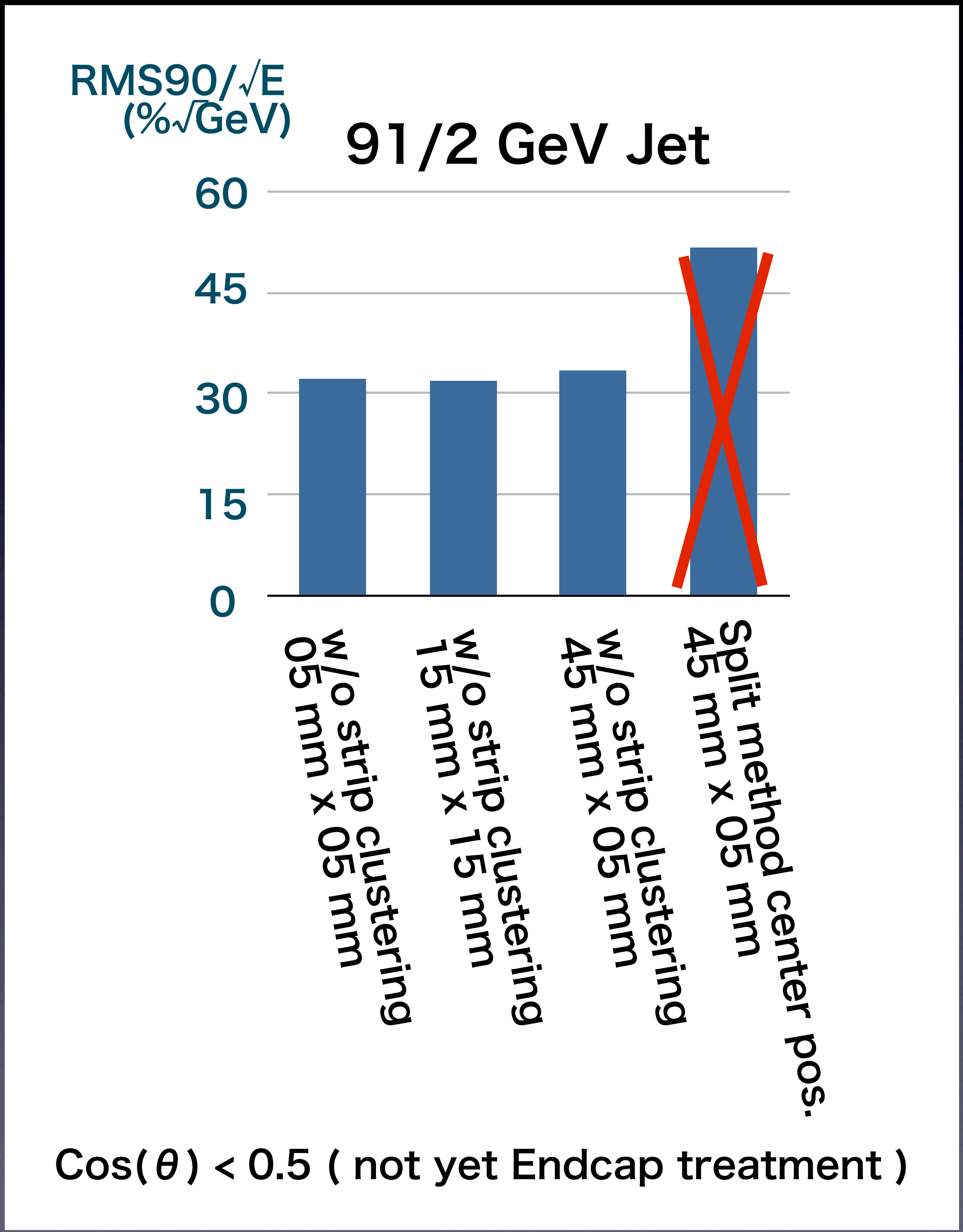
15 mm x 15 mm square cells (right) has two times worse position resolution than 45 mm x 5 mm strip cells after split method although both has the same area.

Comparison of RMS90/√E between some conditions of cell shape and method



- Energy: summing up momenta of PFOs
- w/o procedure for strips, both energy resolution and position resolution degrade for the scintillator strip.
- Split method improves both energy resolution and position resolution.
- "Split method ignore isolate" means that isolate hits are not counted in the case where does not exist any hit in above nor below neighbors
- "Split method center pos." means that energy of isolate hits mentioned above are put the center cell of split cells.

Still some problems are there in my the split method



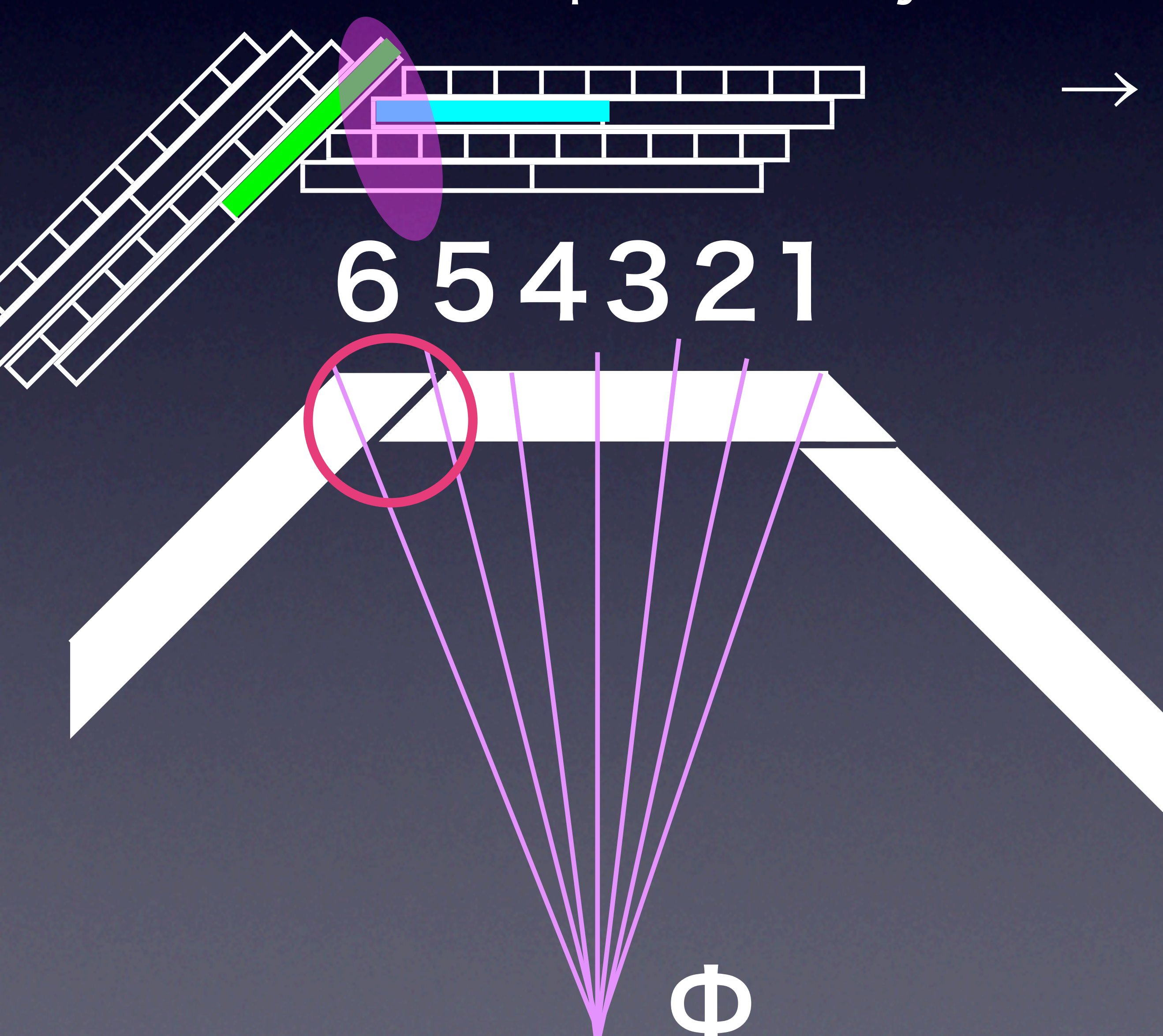
- Even w/o any procedure for the strip clustering, i.e. directly turned over the energy and position (center of strip) Those size and shape cells have almost the same Jet energy resolution for Z pole.
- These w/o procedure case should lead us to the worst performance. However, split method makes energy resolution more degrade for 45 mm x 5 mm strip ScECAL so far.
  I believe that this is not real performance of the Scint.Strip. from some reasons.

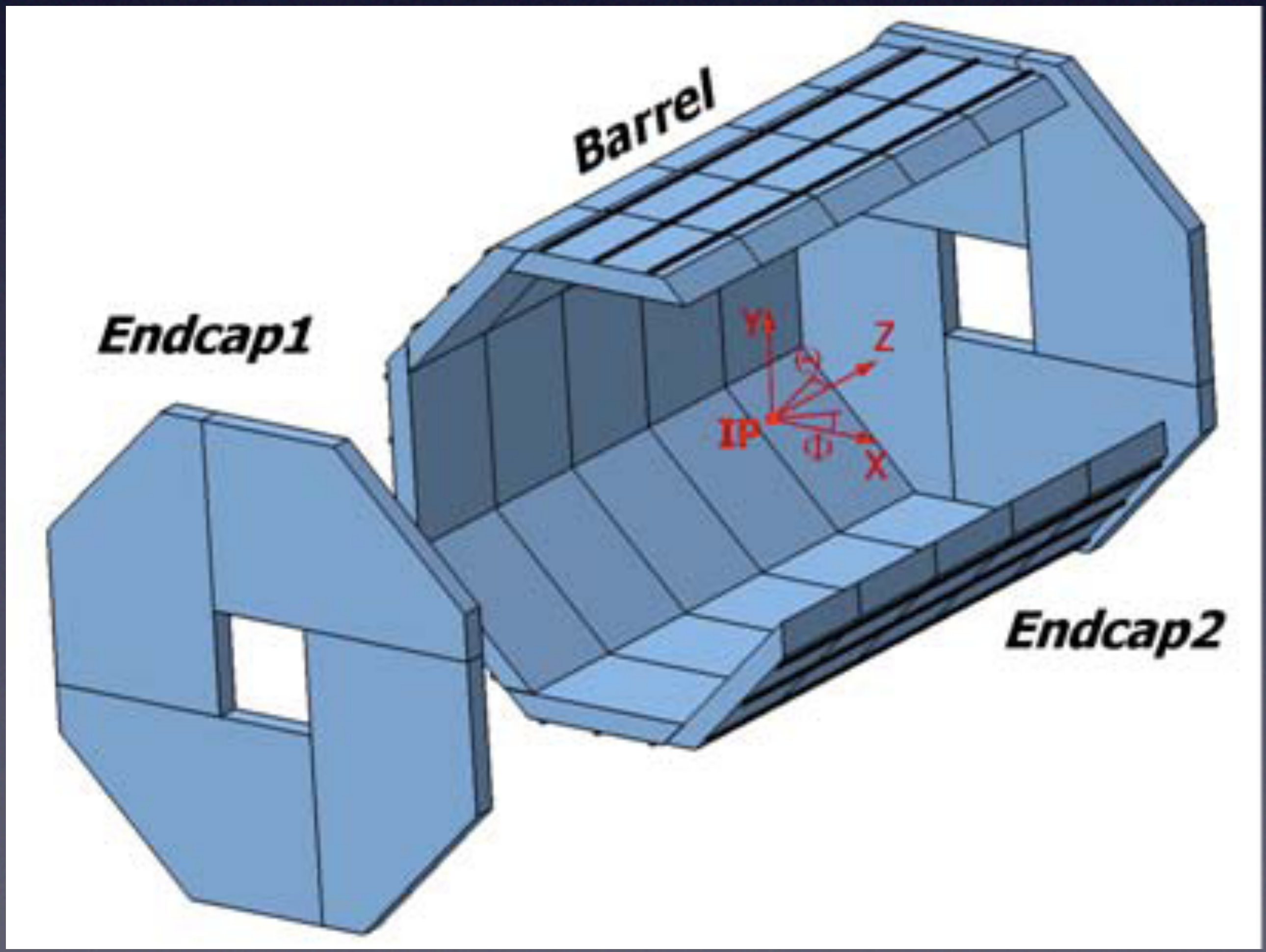
Does problem comes from the boundaries of staves?

To calculate split fraction for blue scintillator, we do not refer green scintillator so far.

We need to make another algorithm to make pseudo layers dedicating for ScECAL

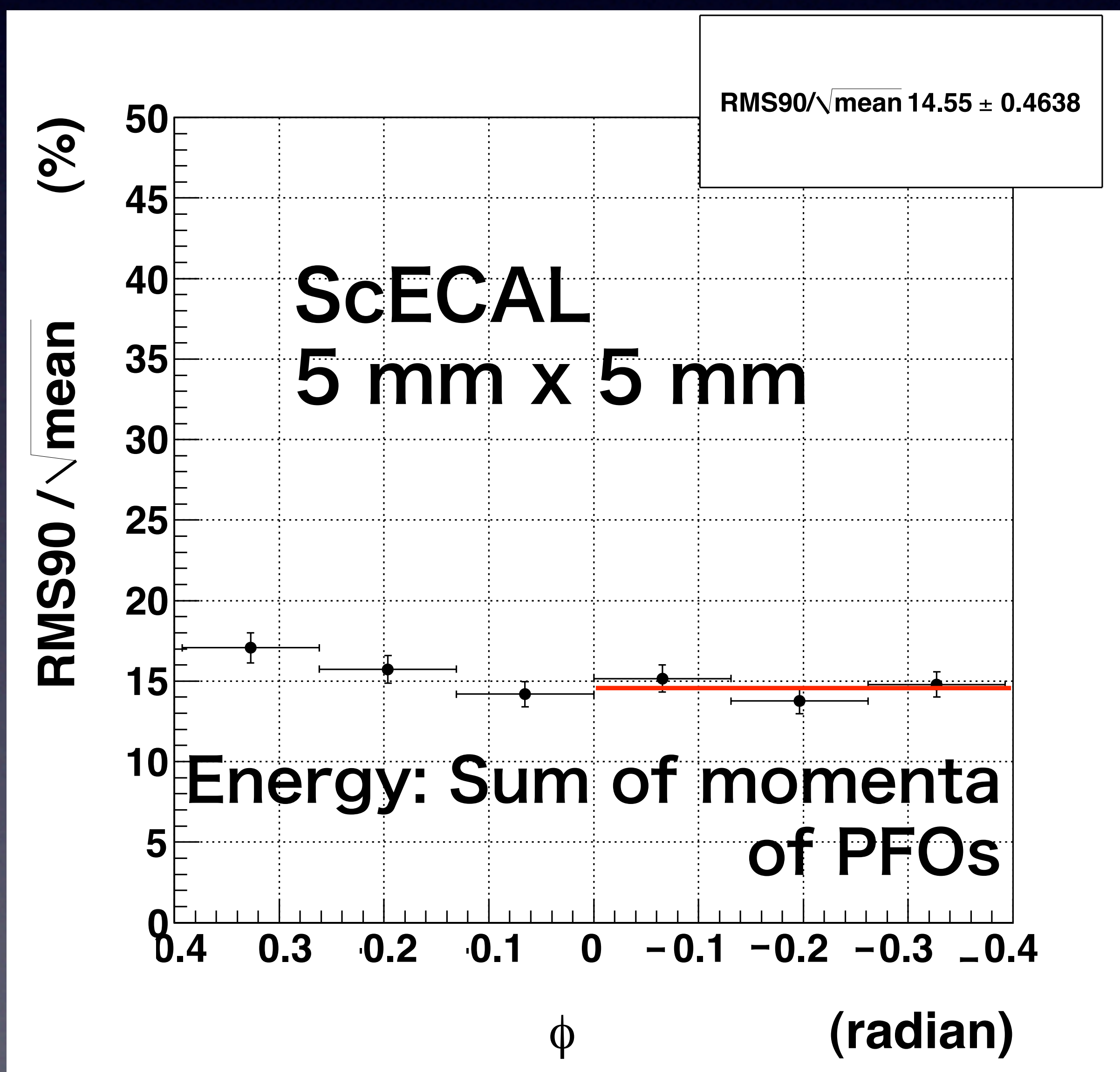
→ Check the Φ dependence

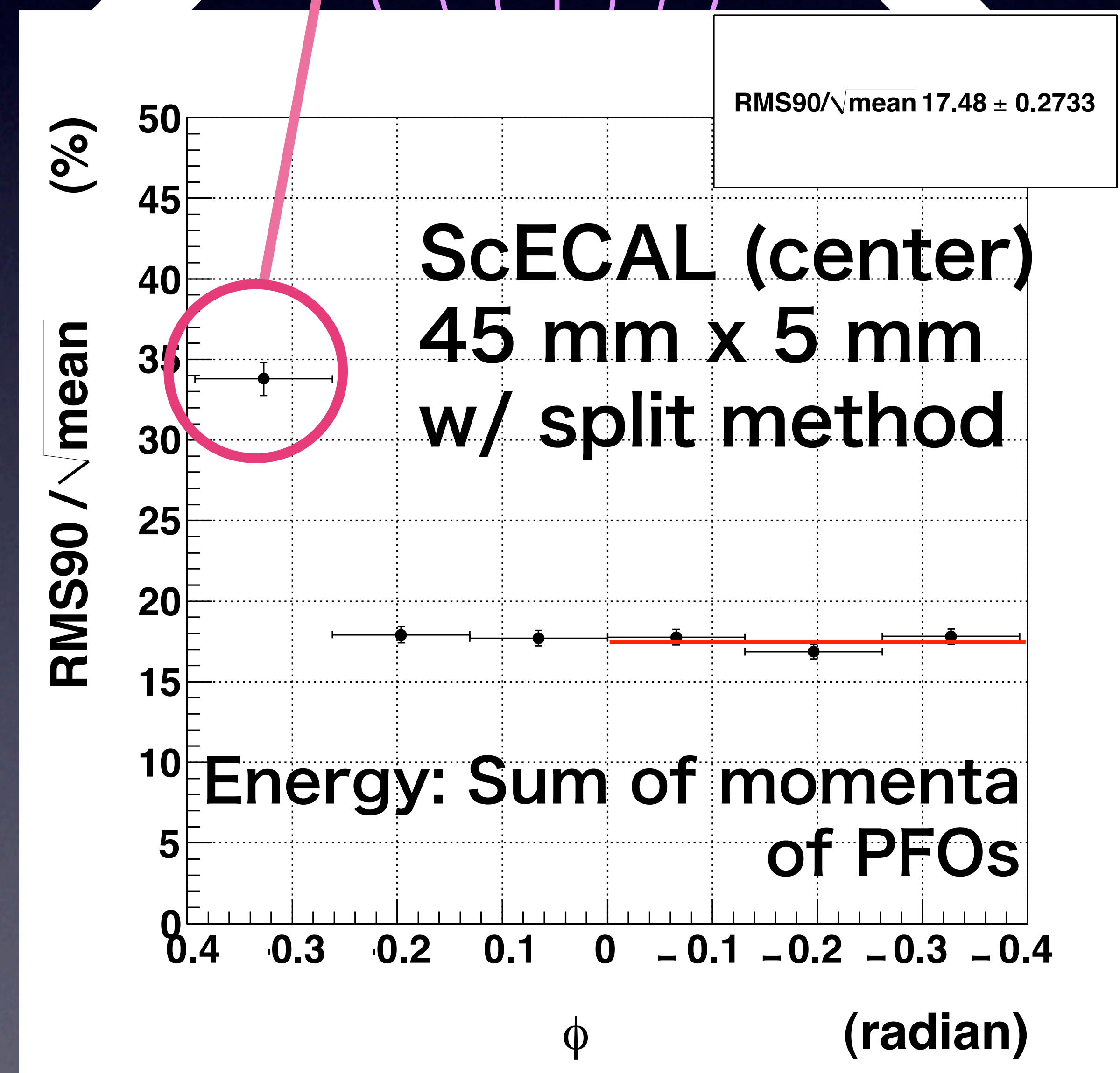




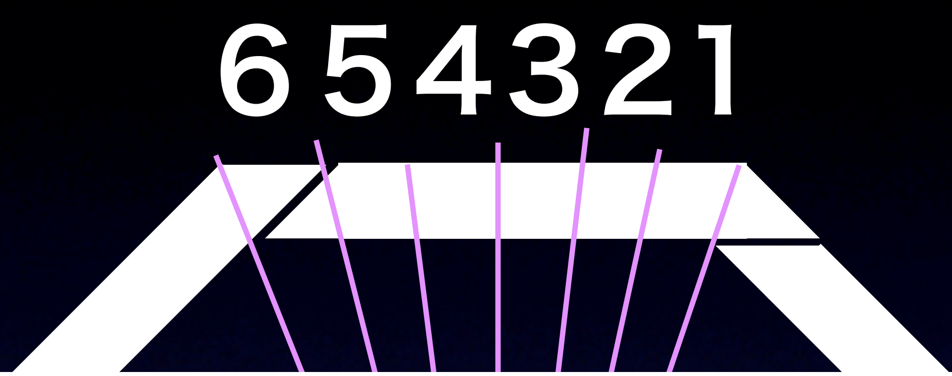
Φ dependence of the energy resolution
10 GeV single photon

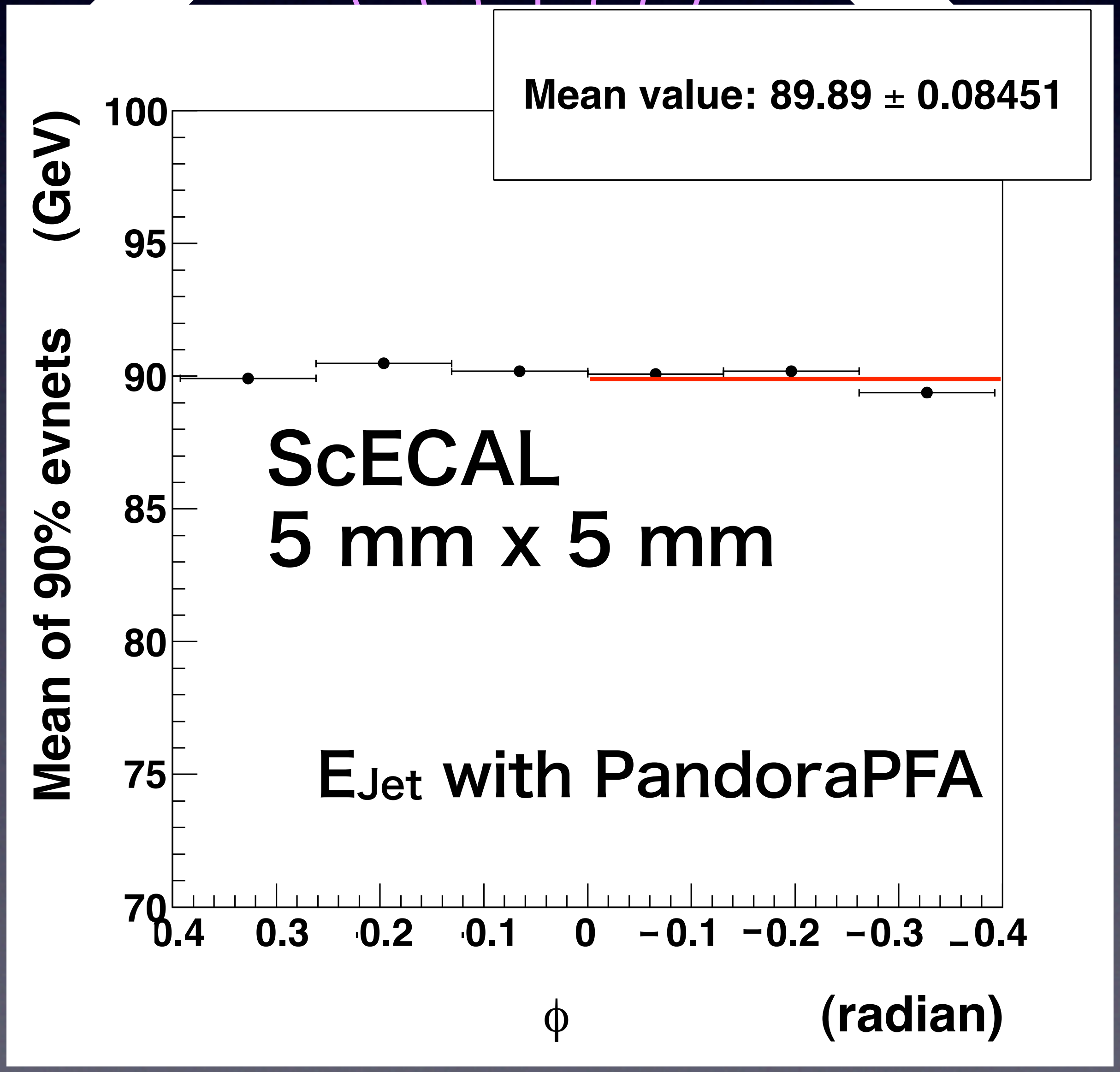
It gets degradation at the boundary of staves



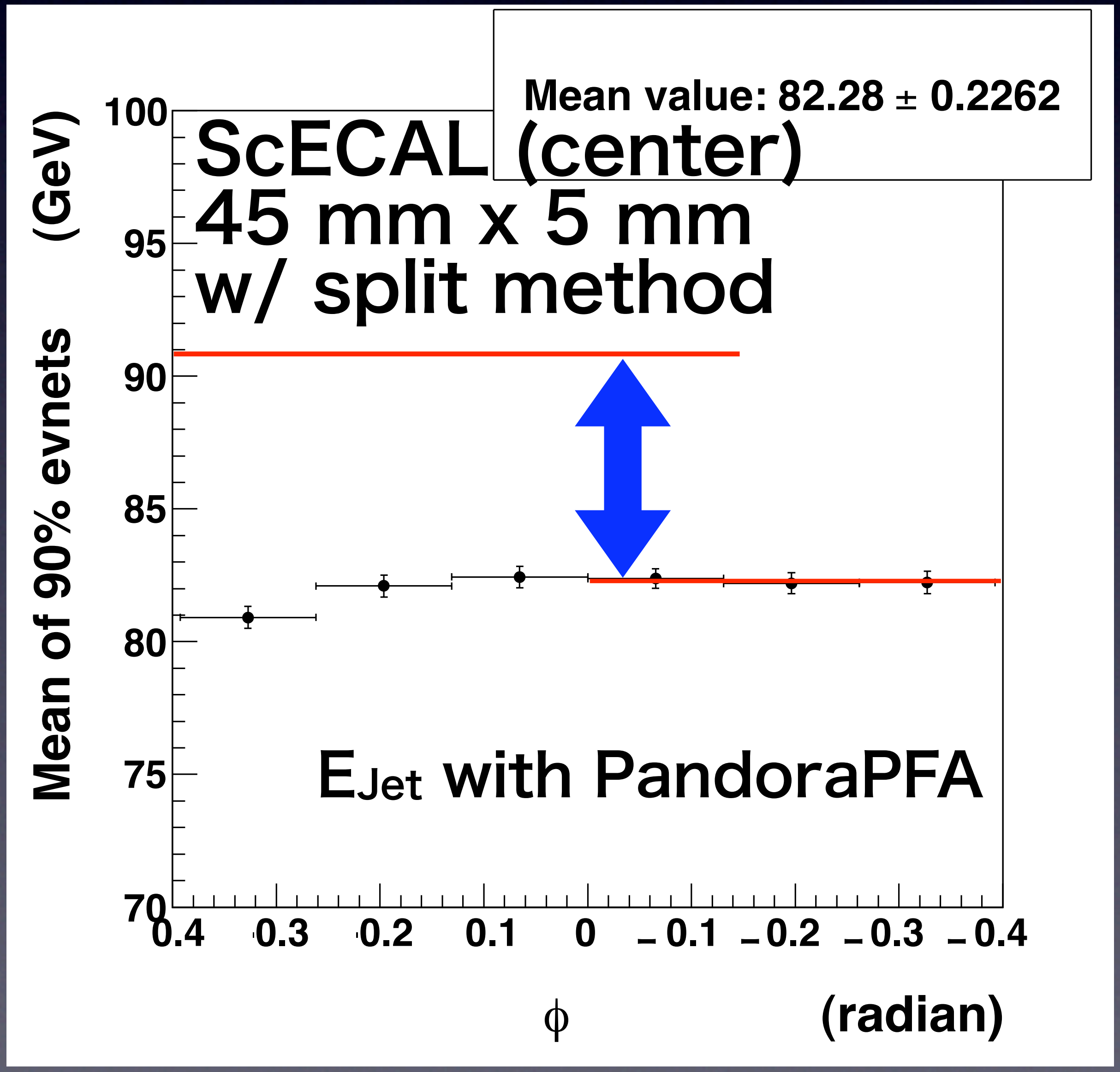


Φ dependence of E (mean of 90% events)
Z pole Jets





lost the energy



Example of Jet an event in a log file

ScECAL 5 mm x 5 mm

```
[ VERBOSE "MyPandoraPFAProcessor"]  UNASSOC BAD TRACK :    pi+- : 0.990022 Etrack 0.986248 r : 1025.64 z int : -2450 CLOSEST :
1648.75 e 1.72637
[ VERBOSE "MyPandoraPFAProcessor"]  FWD TRACK       : 0.302164
[ VERBOSE "MyPandoraPFAProcessor"]  Track  Energy         66.5722
[ VERBOSE "MyPandoraPFAProcessor"]  Photon Energy          12.37
[ VERBOSE "MyPandoraPFAProcessor"]  Hadronic Energy        12.48
[ VERBOSE "MyPandoraPFAProcessor"]  Low EM                 0
[ VERBOSE "MyPandoraPFAProcessor"]  Low Had                0.85042
[ MESSAGE "MyPandoraPFAProcessor"] PandoraPFA::performPFA   Event               : 2
[ MESSAGE "MyPandoraPFAProcessor"] PandoraPFA::performPFA   PFA  Energy         : 91.4222
[ MESSAGE "MyPandoraPFAProcessor"] PandoraPFA::performPFA   PFA+ Energy         : 92.6724+-2.87498
[ MESSAGE "MyPandoraPFAProcessor"] PandoraPFA::performPFA   PFA+nu+fwd Energy : 92.9746+-2.87498
```

ScECAL (center) 45 mm x 5 mm

```
[ VERBOSE "MyPandoraPFAProcessor"]  UNASSOC BAD TRACK :    pi+- : 0.990022 Etrack 0.986248 r : 1025.64 z int : -2450 CLOSEST : 1648
[ VERBOSE "MyPandoraPFAProcessor"]  UNASSOC BAD TRACK :    pi+- : 5.61901 Etrack 5.62459 r : 1865.23 z int : 719.374 CLOSEST : 9999
[ VERBOSE "MyPandoraPFAProcessor"]  UNASSOC BAD TRACK :    pi+- : 7.15412 Etrack 7.14791 r : 1867.89 z int : 626.441 CLOSEST : 643.1
[ VERBOSE "MyPandoraPFAProcessor"]  FWD TRACK       : 0.302164
[ VERBOSE "MyPandoraPFAProcessor"]  Track  Energy         53.7997
[ VERBOSE "MyPandoraPFAProcessor"]  Photon Energy          31.4706
[ VERBOSE "MyPandoraPFAProcessor"]  Hadronic Energy        2.83594
[ VERBOSE "MyPandoraPFAProcessor"]  Low EM                 2.31627
[ VERBOSE "MyPandoraPFAProcessor"]  Low Had                0.717551
[ MESSAGE "MyPandoraPFAProcessor"] PandoraPFA::performPFA   Event               : 2
[ MESSAGE "MyPandoraPFAProcessor"] PandoraPFA::performPFA   PFA  Energy         : 88.1063
[ MESSAGE "MyPandoraPFAProcessor"] PandoraPFA::performPFA   PFA+ Energy         : 89.3565+-1.58842
[ MESSAGE "MyPandoraPFAProcessor"] PandoraPFA::performPFA   PFA+nu+fwd Energy : 89.6586+-1.58842
```

in many case charged pions are lost and photons increase.

$\boxed{\text{MIP like cluster} \rightarrow \text{Photon like?}}$

In my code (split method) for 45 x 5 mm^2-> 9x (5 mm x 5 mm)

- PandoraPFA calls a method (ResolveStripHits) to make Strip-clustering
  - input argument: vector<MyCaloHitExtended*>ecalTempHit(layer by layer)
  - CalorimeteHit *calh=ecalTempHit[ilayer][ihit]->getCaloeimeterHit();
  - ---> layerhits[ilayer][cellid]
  - CalorimeterHit * striphit = const_cast<CalorimeterHit*>(ic->second->getCalorimterHit()); TOTAL N hits (45 mm x 5 mm).
  - CalorimterHitImpl * newcalhit = new CalorimeterHitImp(); TOTAL N x 9 hits. setEnergy, setPosition, setType, setRawHit(striphit), cetCellID (how is SimCalorimeteHits?)
  - MyCaloHitExtended * splithitExtended = newMyCalohitExtended(newcalhit, CALHITTYPE_ECAL, x, y, z)
  - splithitExtended ->setPseudoEnergy(splitenergy), setEnergyEM(splitenergy), setEnergyInMips(splitenergy*EcalToMIP) ,setEnergyHad(0),setPhysicalLayer(ilayer), setModule(module), setXYZ(splitcellpos[0], ...[1], ...[2]
  - splitHitsLayer[ilayer]push_back(splithitExtended)
  - Once ecalTempHit[ilayer] clear (initialized)→ ecalTempHit[ilayer].push_buck(splitHitsLayer[ilayer][ihit]
  - then 5 mm x 5 mm cell information is turned over to PandoraPAProcessor.

summary of this talk

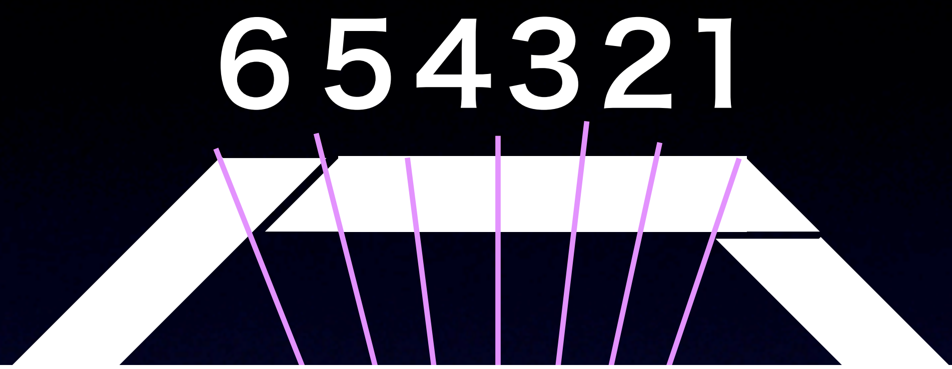
- Without (pre-)strip clustering, both energy resolution and position resolution of 45 mm x 5 mm strip ScECAL are degraded for the single photon events
- With (pre-)strip clustering, both energy resolution and position resolution of 45 mm x 5 mm strip ScECAL are near 5 mm x 5 mm ScECAL for the single photon events.
- For $\sqrt{s}$ = 91 GeV two jets events, jet energy resolutions with both 15 mm x 15 mm cell ScECAL and 45 mm x 5 mm strip ScECAL are ~30% w/o (pre-)strip clustering procedure (w/o tune). Split method makes it degrade so far.
- Influence of boundary between staves is not enough to explain the degrading of Energy resolution of strip (pre-) clustering.
- In many case, charged pions are lost and photons increase.

Plan

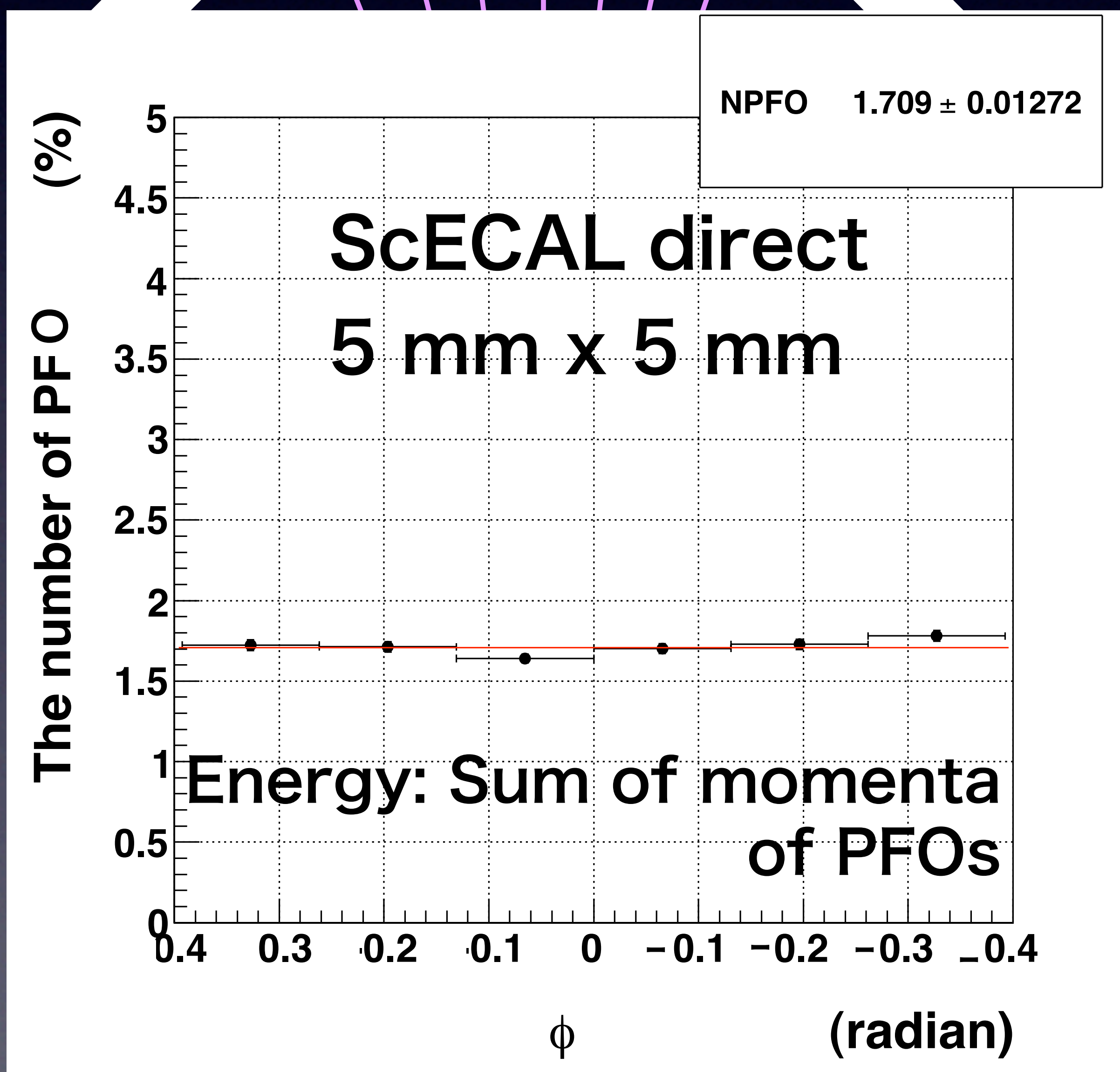
- Jet ennergy resolution with Strip segmentation degrades, 30%($5x5mm^2$)-->50%($45x5mm^2$)
  - To know the reasons
    - see what happen
    - When does mismatch occur?
      - check the code
  - Tune PFAProcessor → We learn PandoraPFANew here
  - We need a processor to make Pseudo-layers to give the scintillator strip information full play for ScECAL in PandoaraPFA
  - Add some algorithm to avoid ghost.
- Fix the boundary
  - between Staves
  - Endocap, Endcap-barrel
- Square and Strip hybrid ECAL (Mokka is already available by Gabriel and Paulo)
  - ScECAL $5x5mm^2$ layers + $45x5mm^2$ layers -->
  - SiECAL $5x5mm^2$ layers + $45x5mm^2$ layers -->

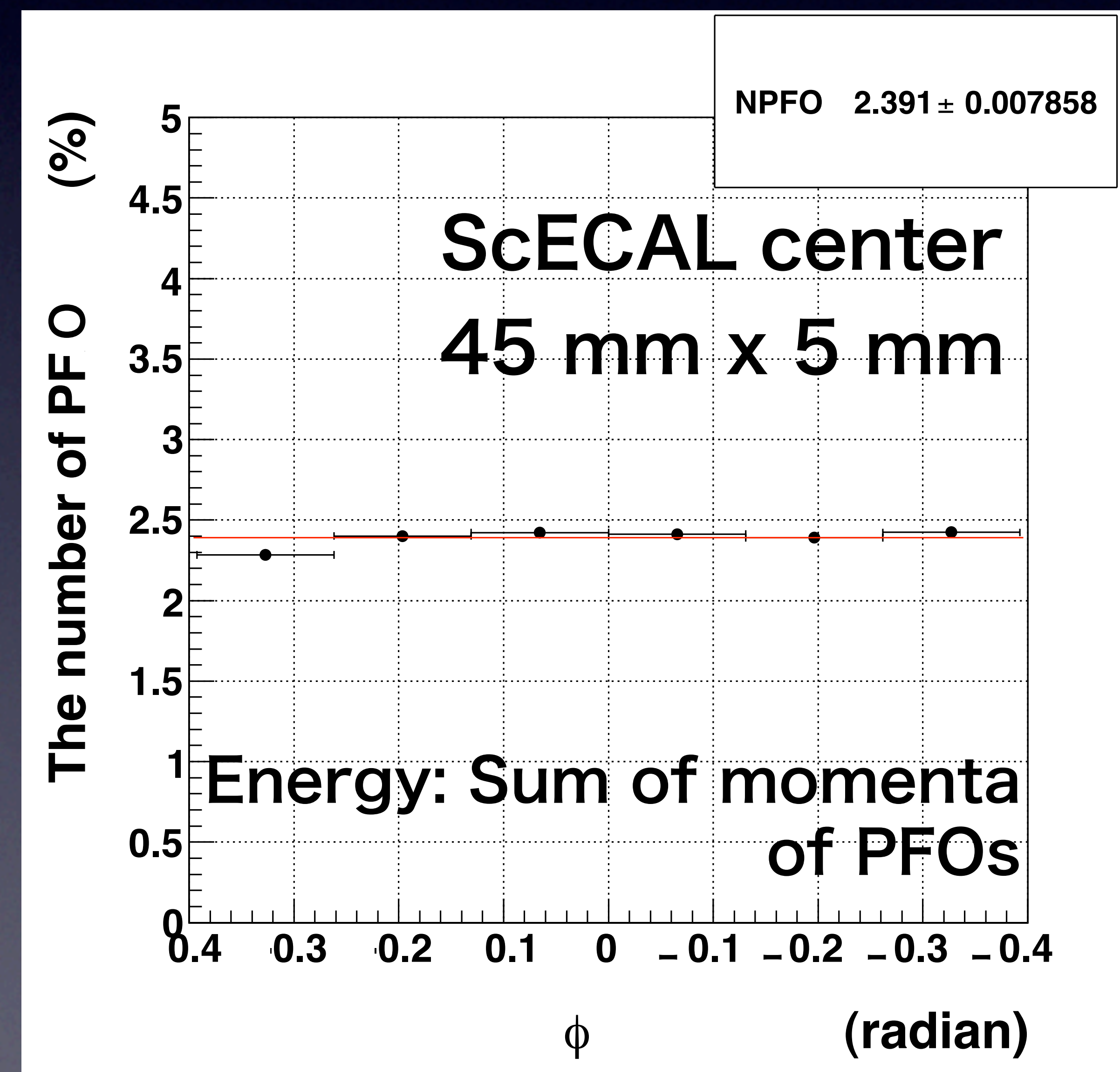
Back up

Φ dependence of the number of PFO
10 GeV single photon

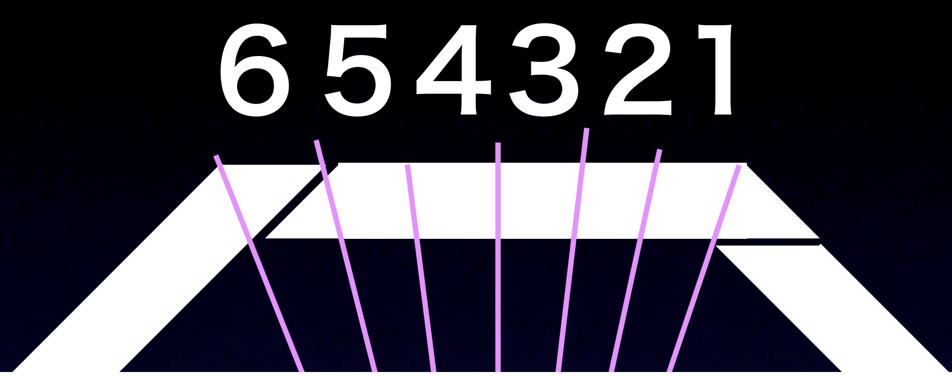


It degrades everywhere for stripScE

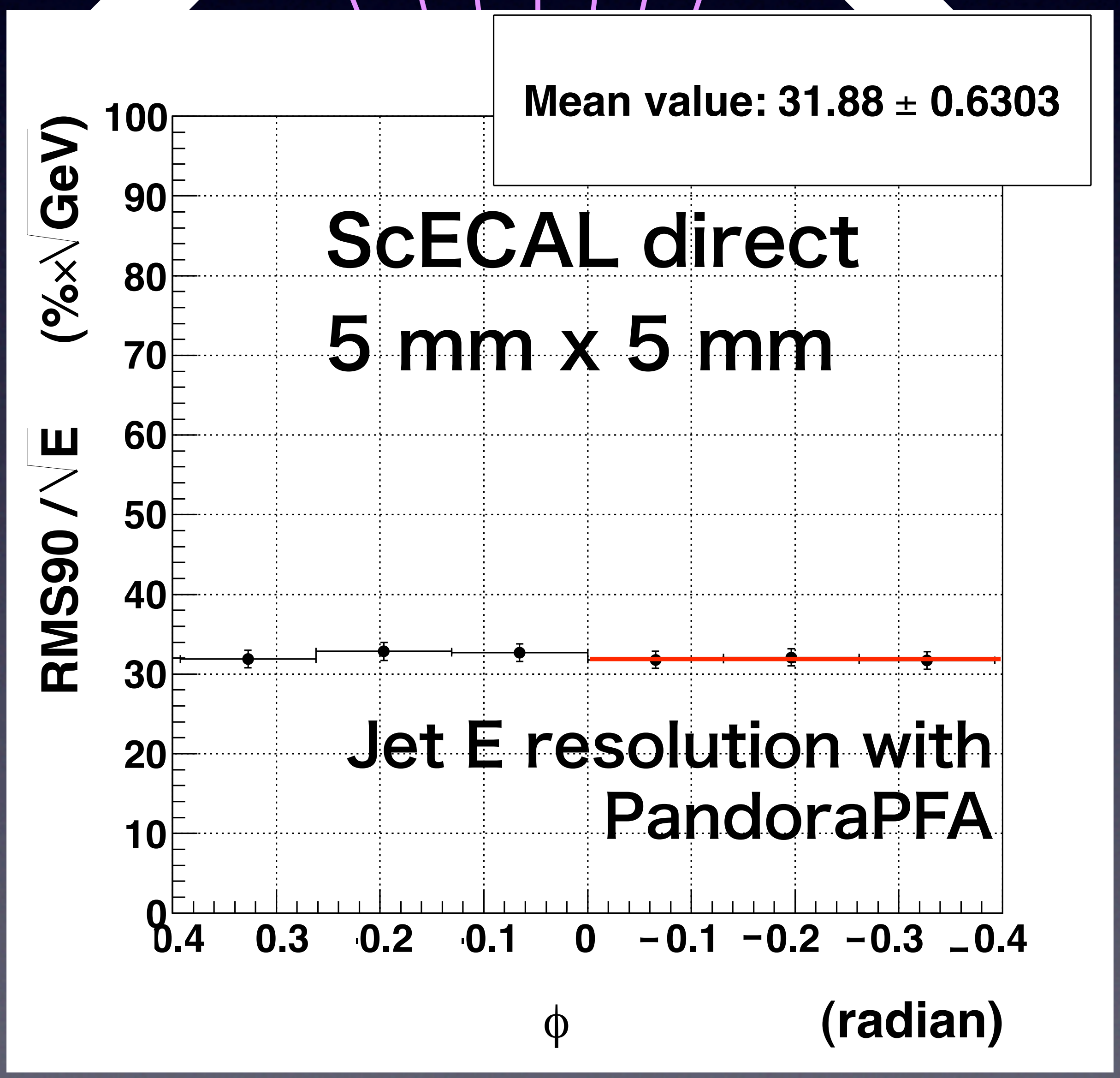


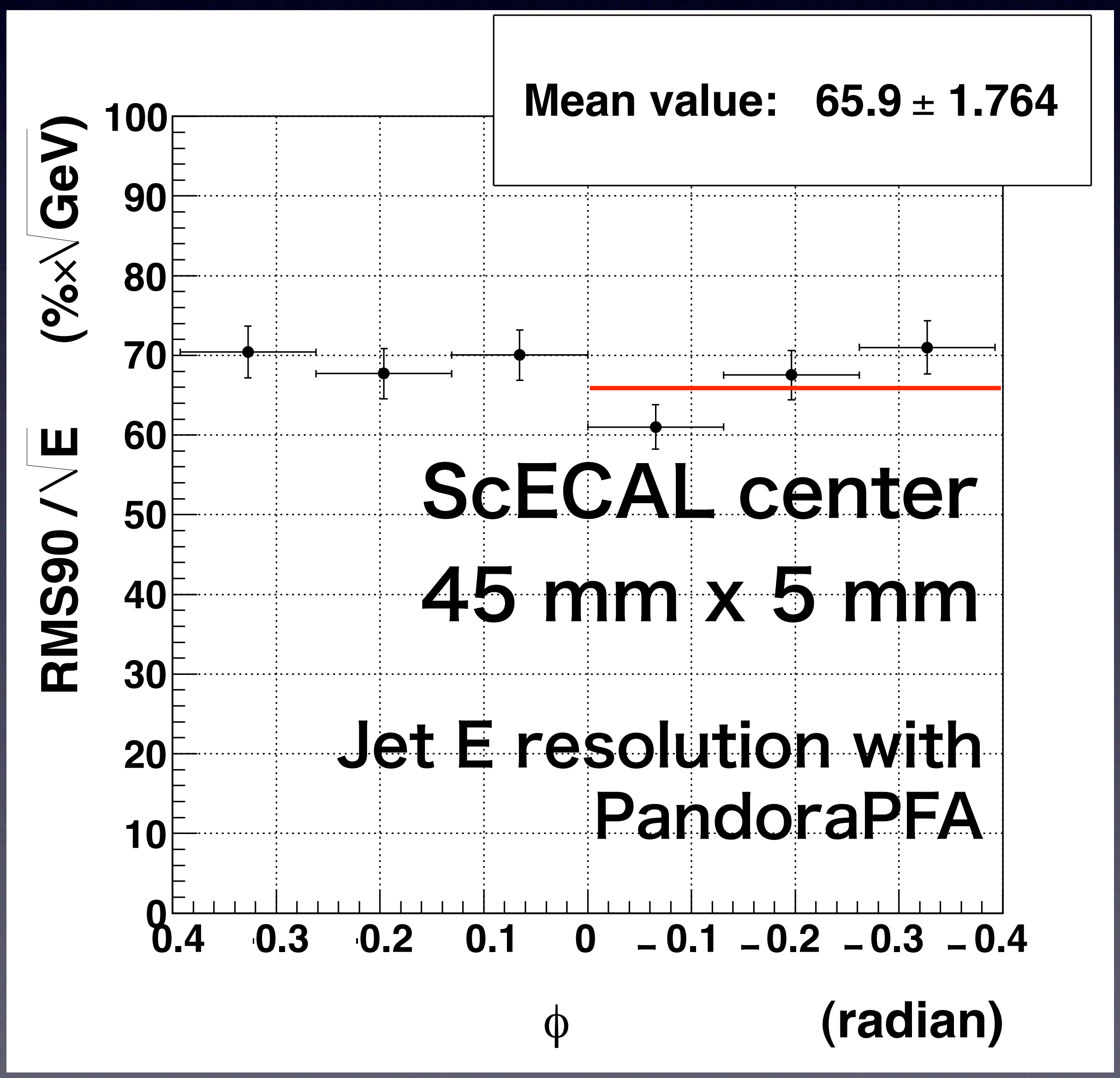


Φ dependence of RMS90/√E Z pole Jet

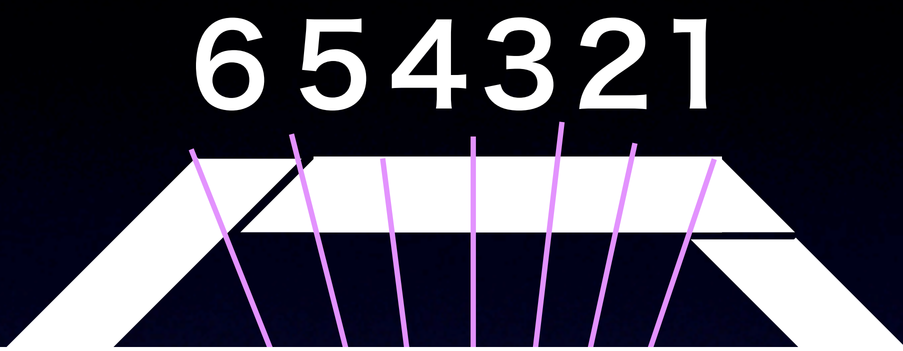


It degrades everywhere for stripScE

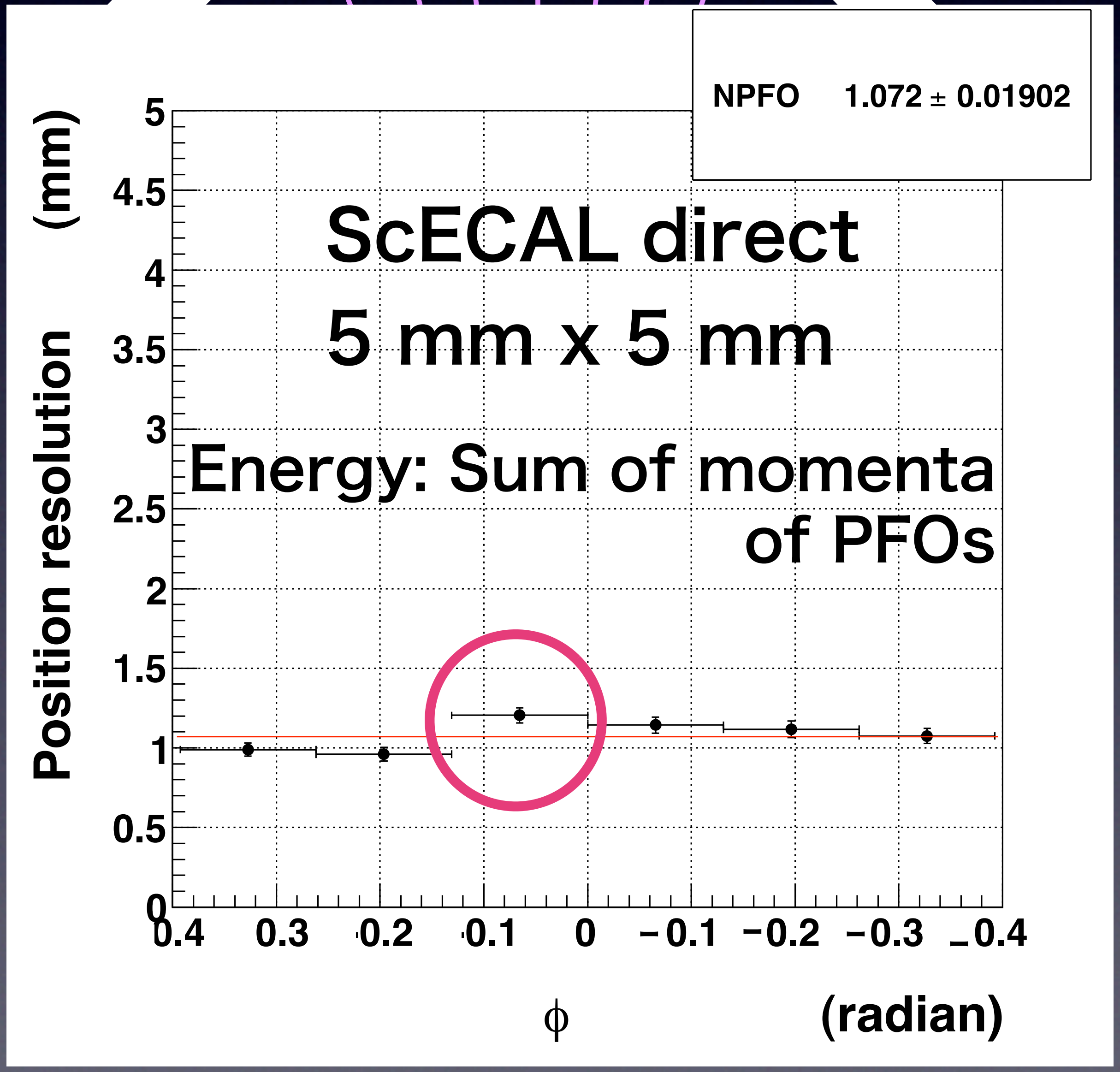


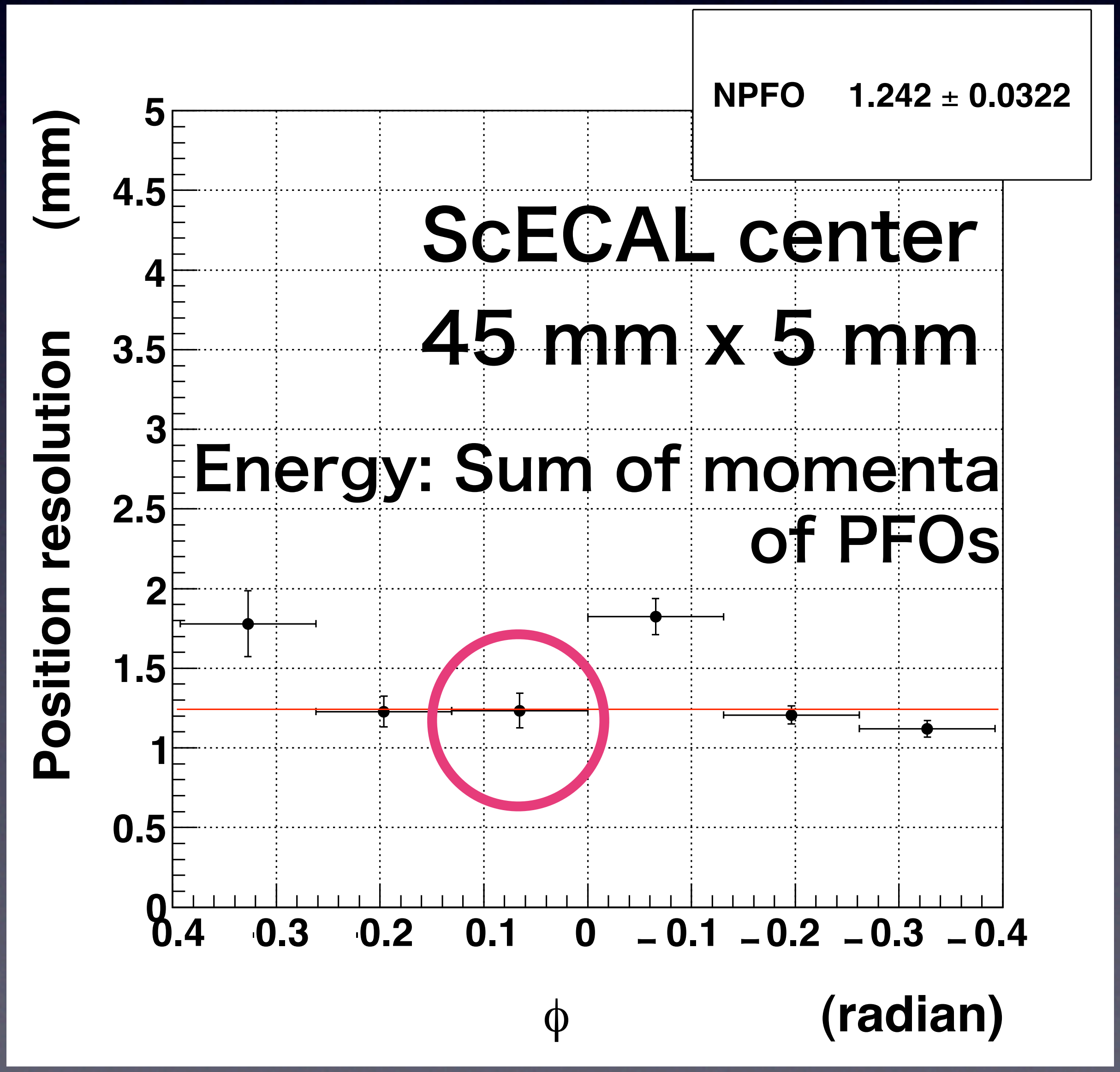


Φ dependence of the position resolution 10 GeV single photon



It gets degradation at the boundary of staves



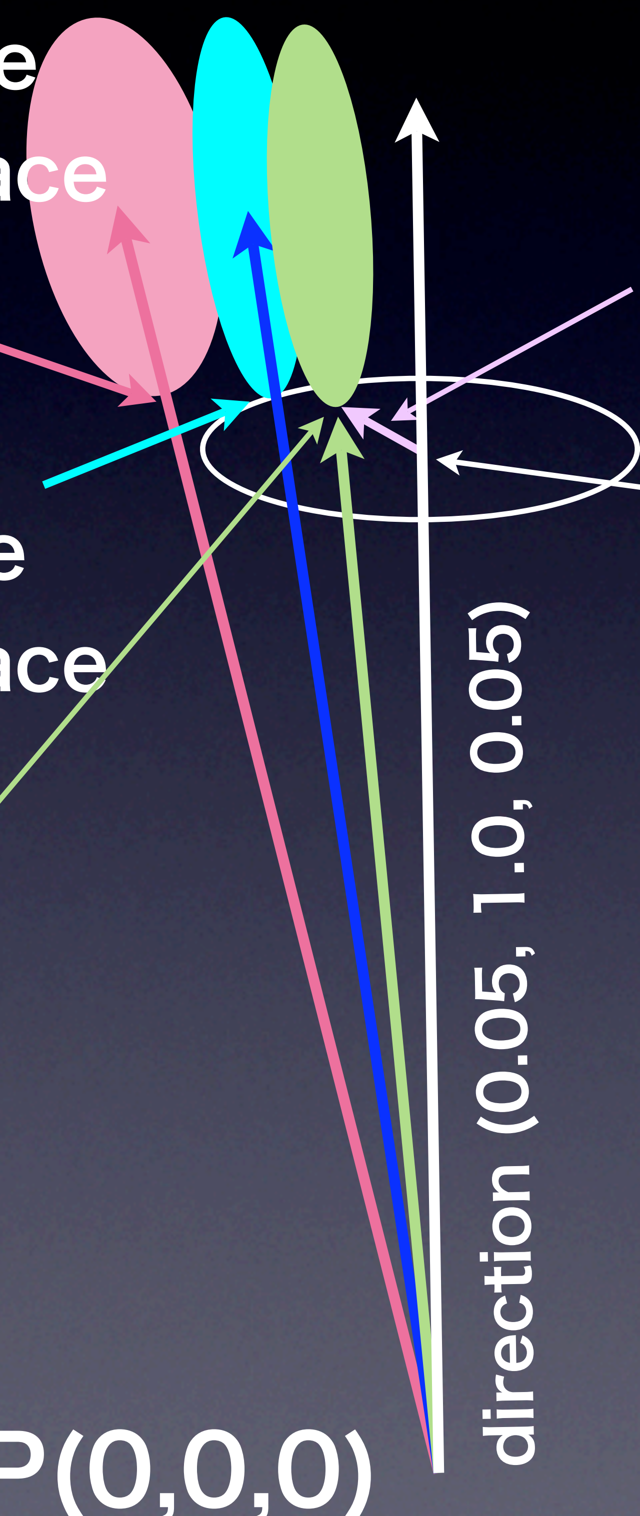


Position Resolution for single 10 GeV single photon

Position of the center of energy befor the procedure projected on Ecal inner surface (x, y=1850 mm, z)

Position of the center of energy after the procedure projected on Ecal inner surface (x, y=1850 mm, z)

Position where PFO momentum points on the Ecal inner surface (x, y=1850 mm, z)



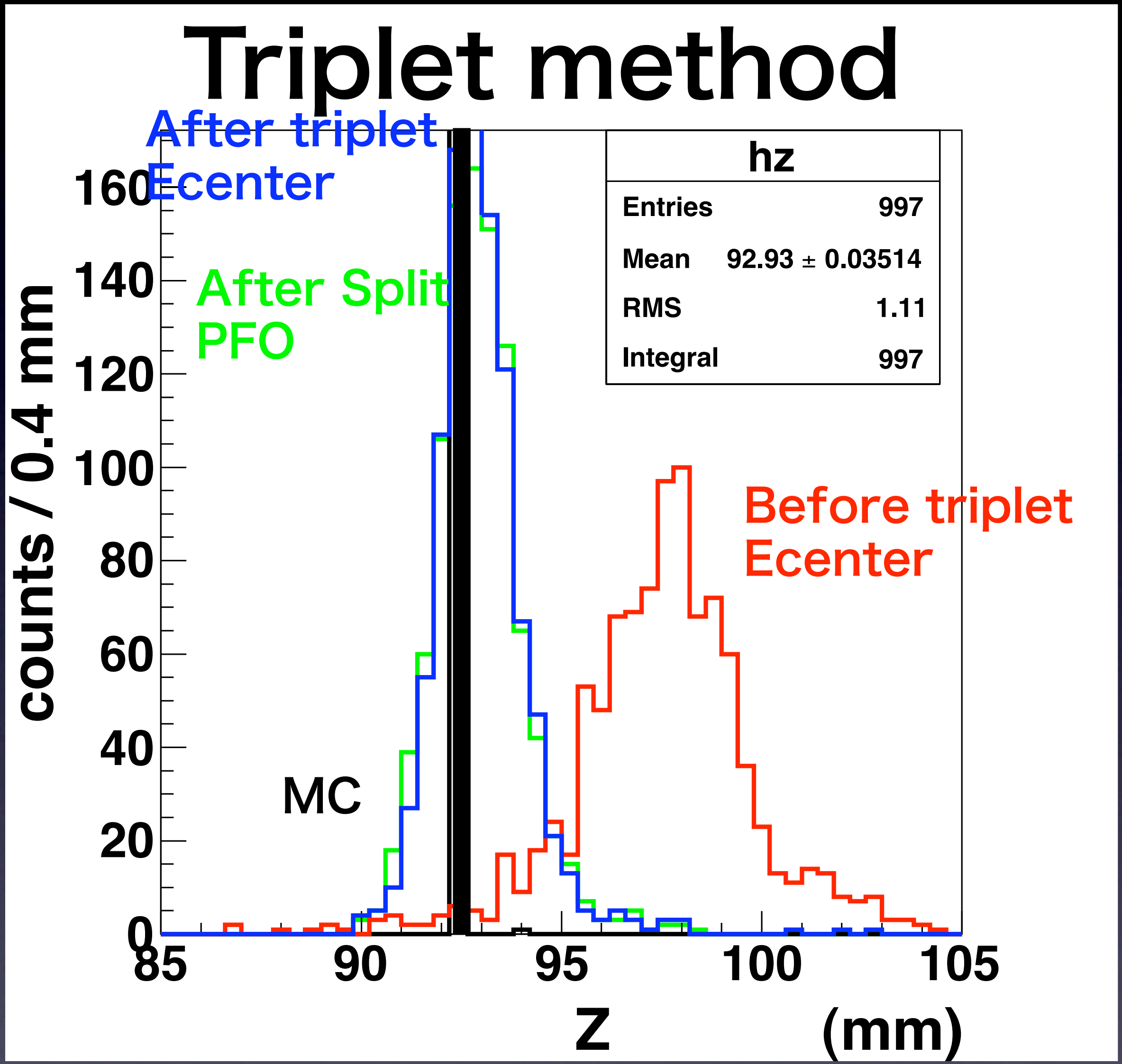
Distance between reconstructed PFO and MC true ont the Ecal innter surface

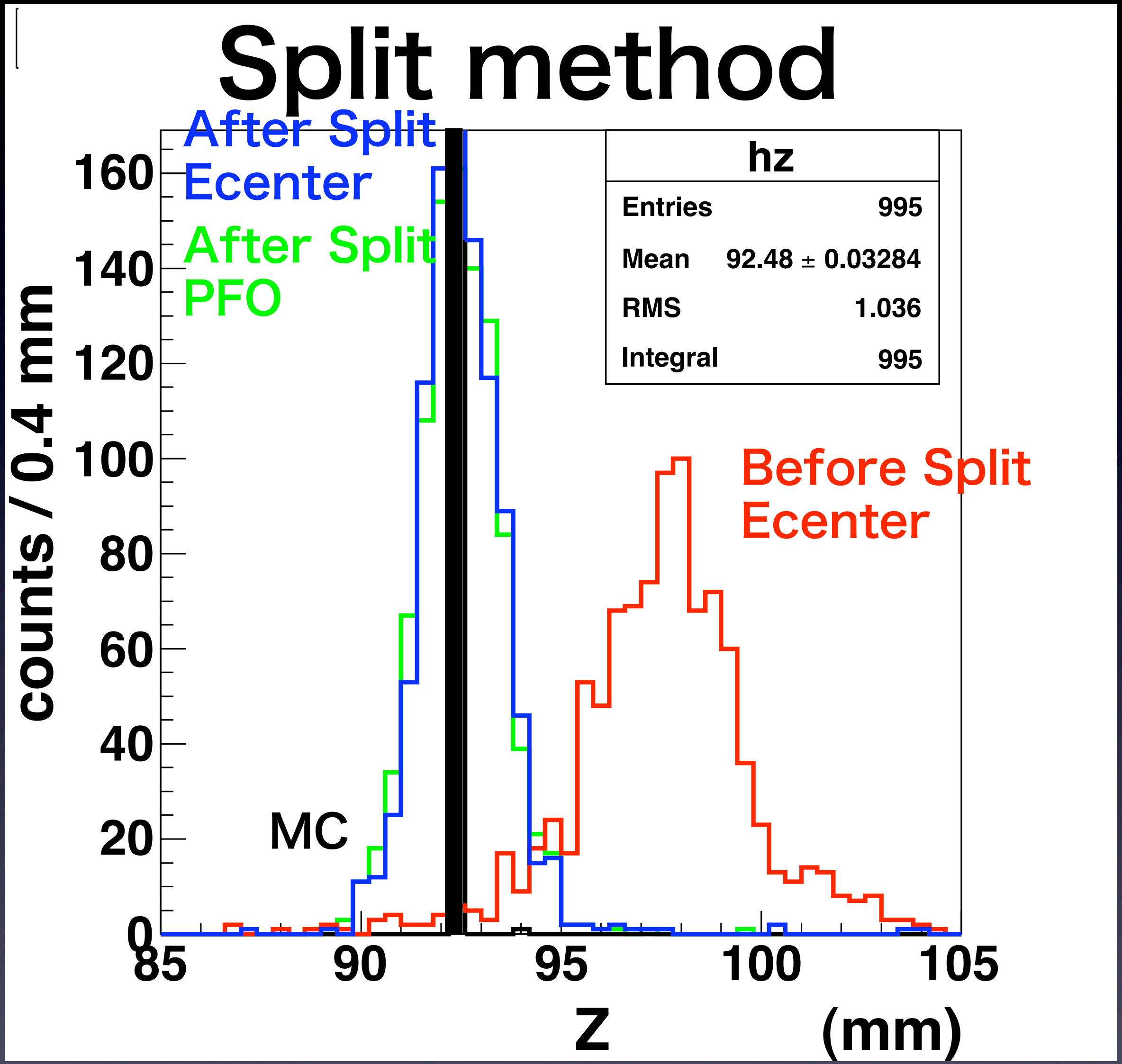
Position which MC true momentum points on the Ecal inner surface (x, y=1850 mm, z)

Cluster Position distribution in Z by Triplet method and Split method

10 GeV 1000 photon

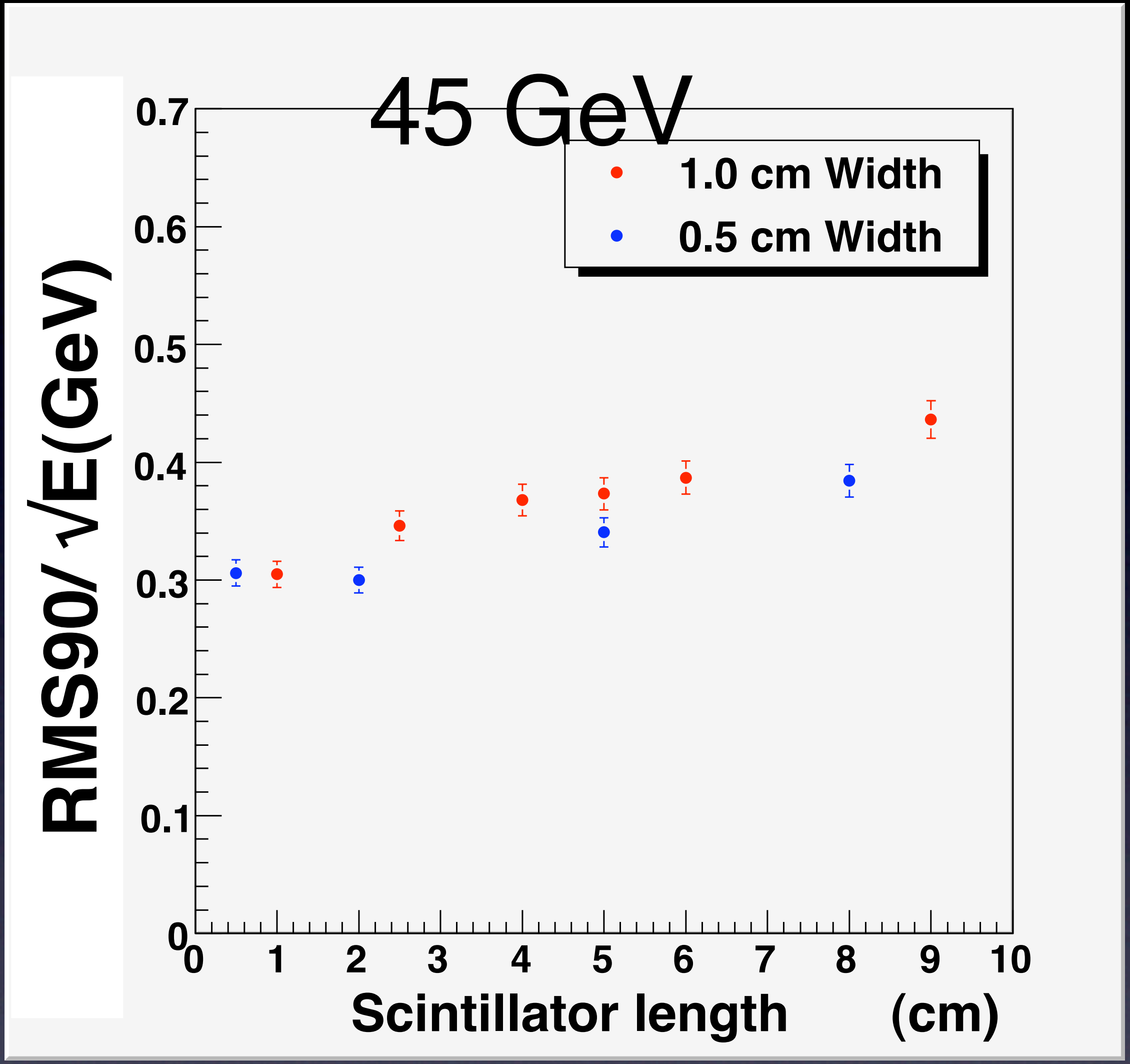
using 45 mm x 5 mm cells

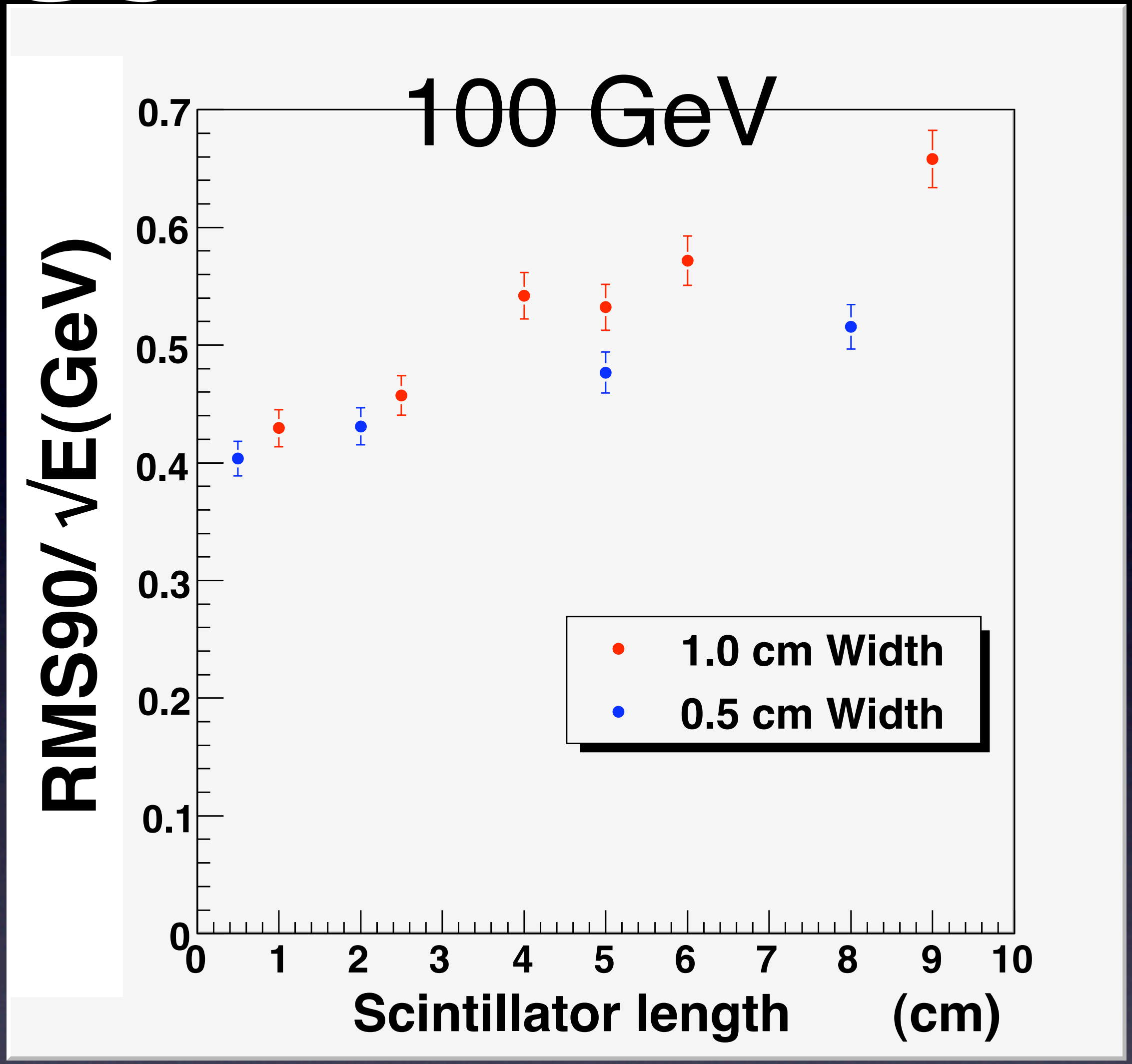




- With both triplet method and split method, procedures correct the positions.
- PFO momenta also correct directions after implemented the procedures.
- In this case isolate hits are ignored in the split method.

Sc. length dependence of the Jet energy resol.n





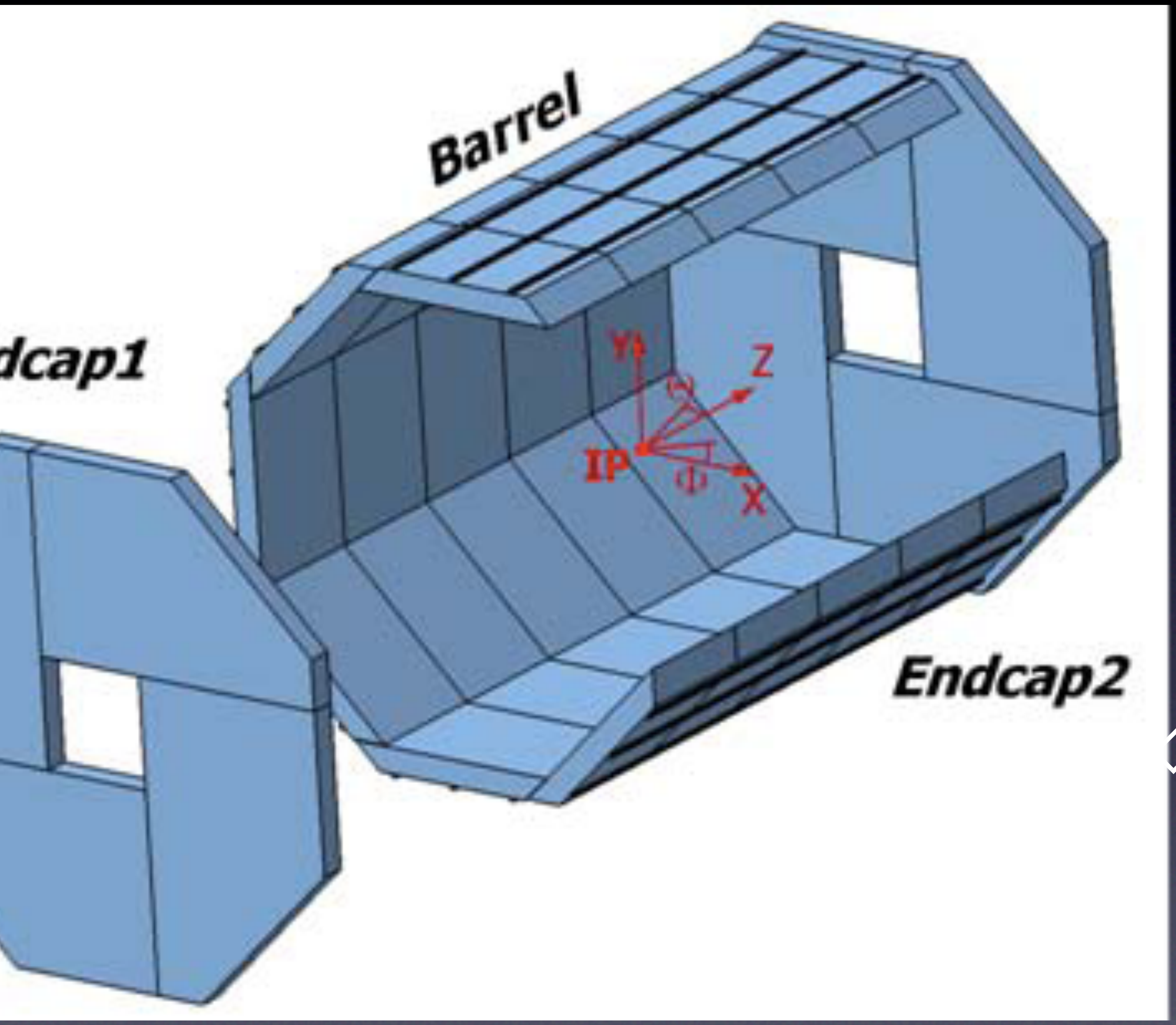
We are happy if we can prevent the length dependence of *E*-resolution with strip clustering.

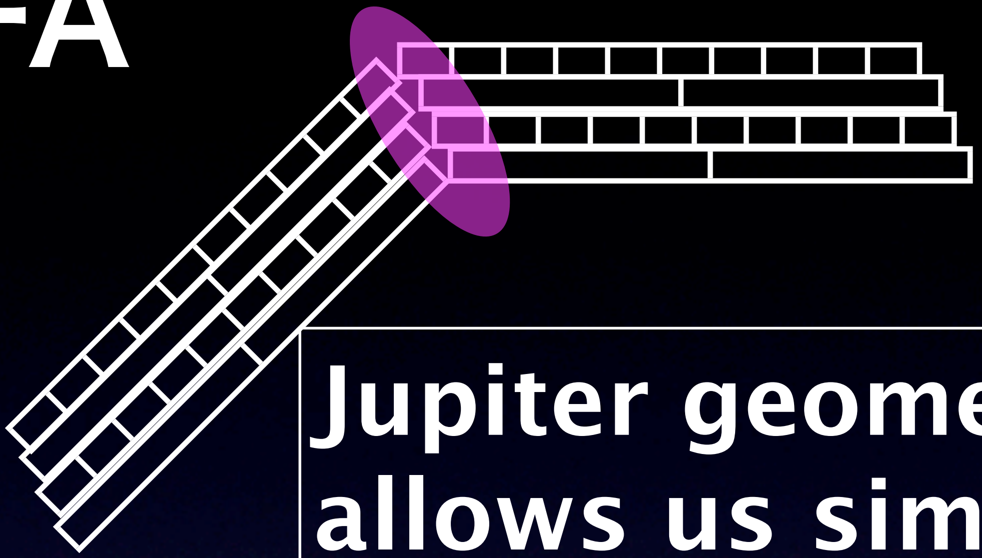
→for 45 GeV jets, the length dependence of *E*-resol is prevented to a few cm,

→0.5 cm Scintillator is better than 1.0 cm,

→we need to improve the clustering method when we see 100 GeV Jets with 5 cm length Scintillator.

Status of the Strip Clustering with PandoraPFA



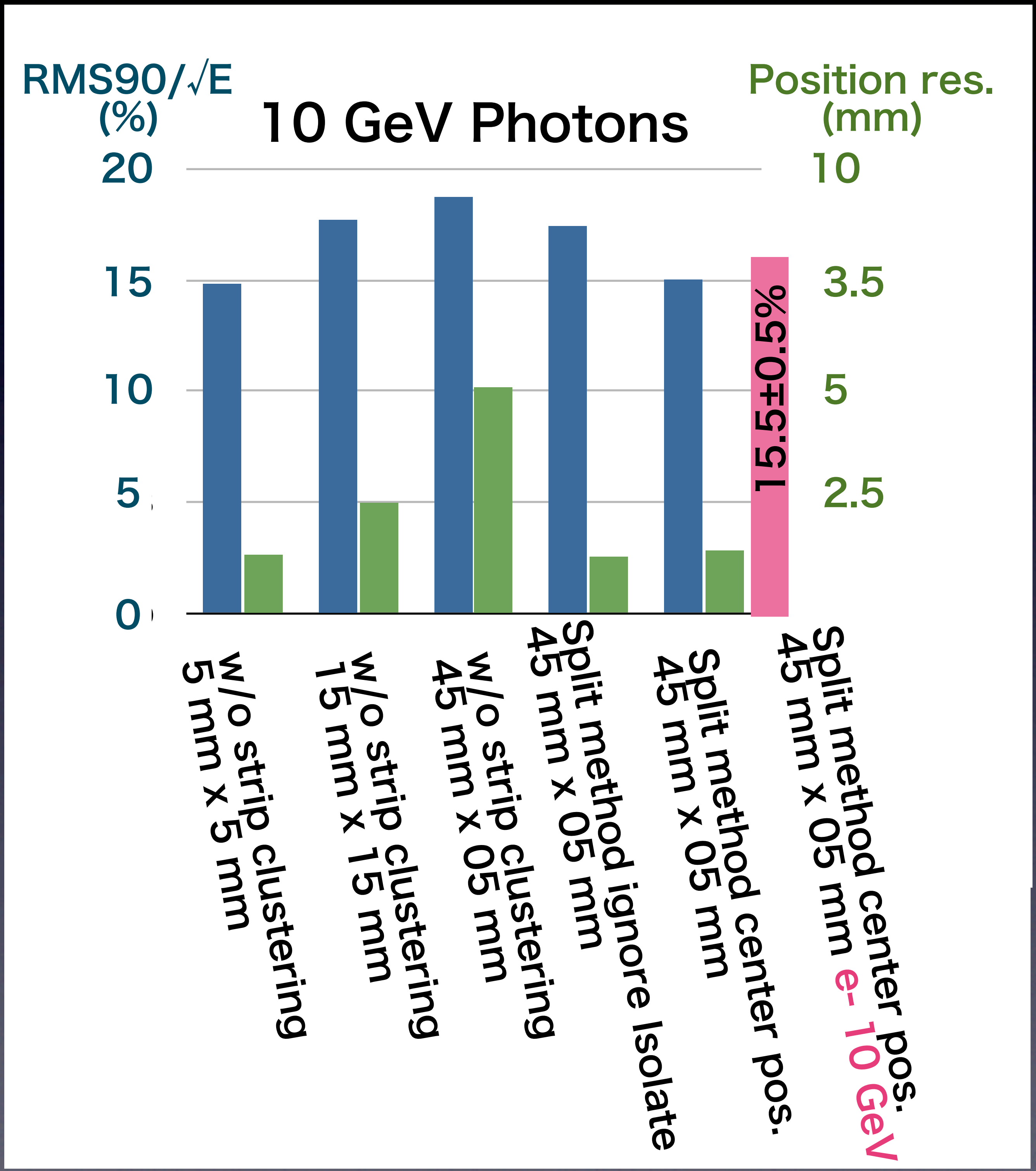


Jupiter geometry allows us simple strip clustering

Neighbor cells are in different layers in Mokka's case

Study of suitable cell ID coding and algorithm to search neighbor cells are ongoing.

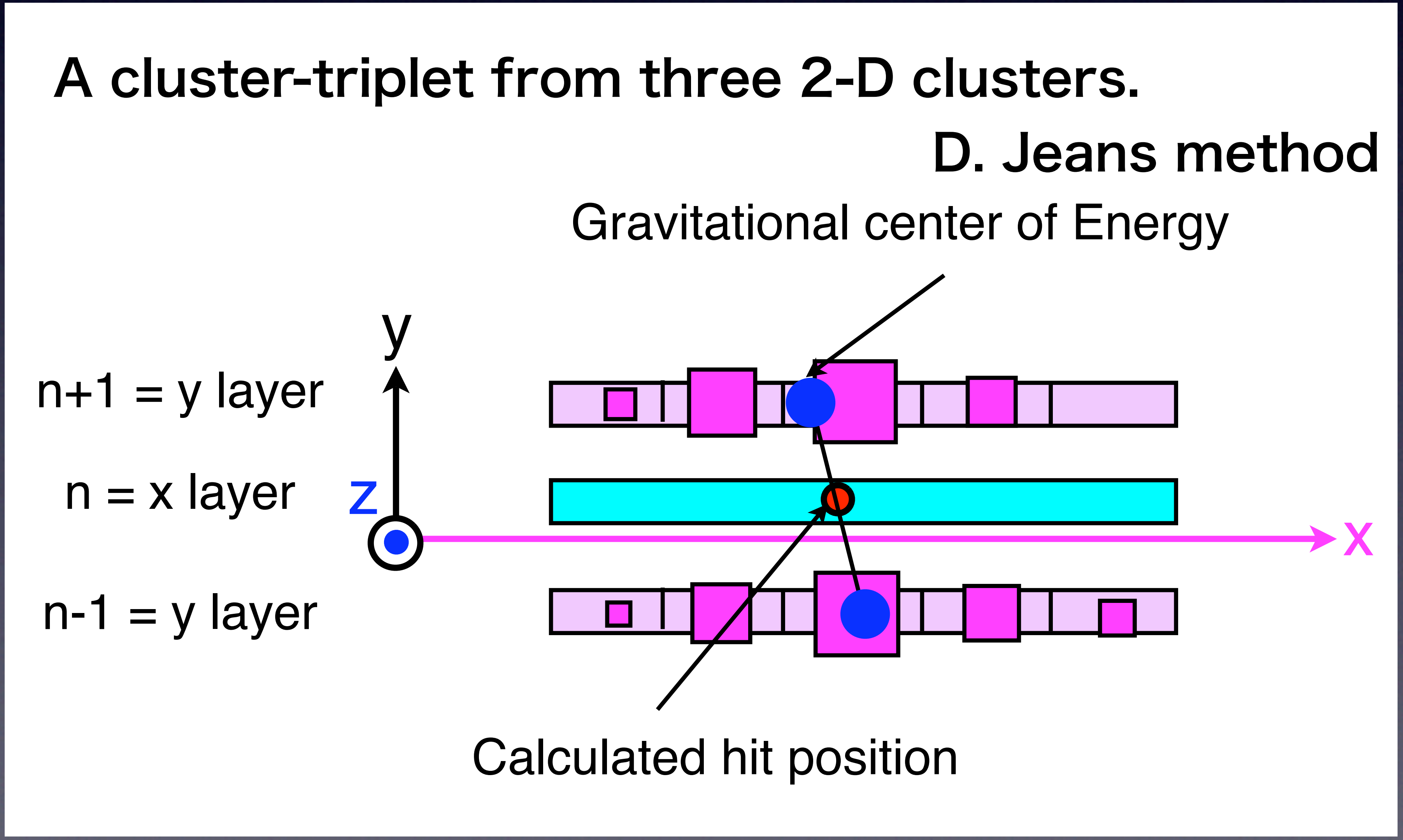
Comparison of RMS90/√E between some conditions of cell shape and method

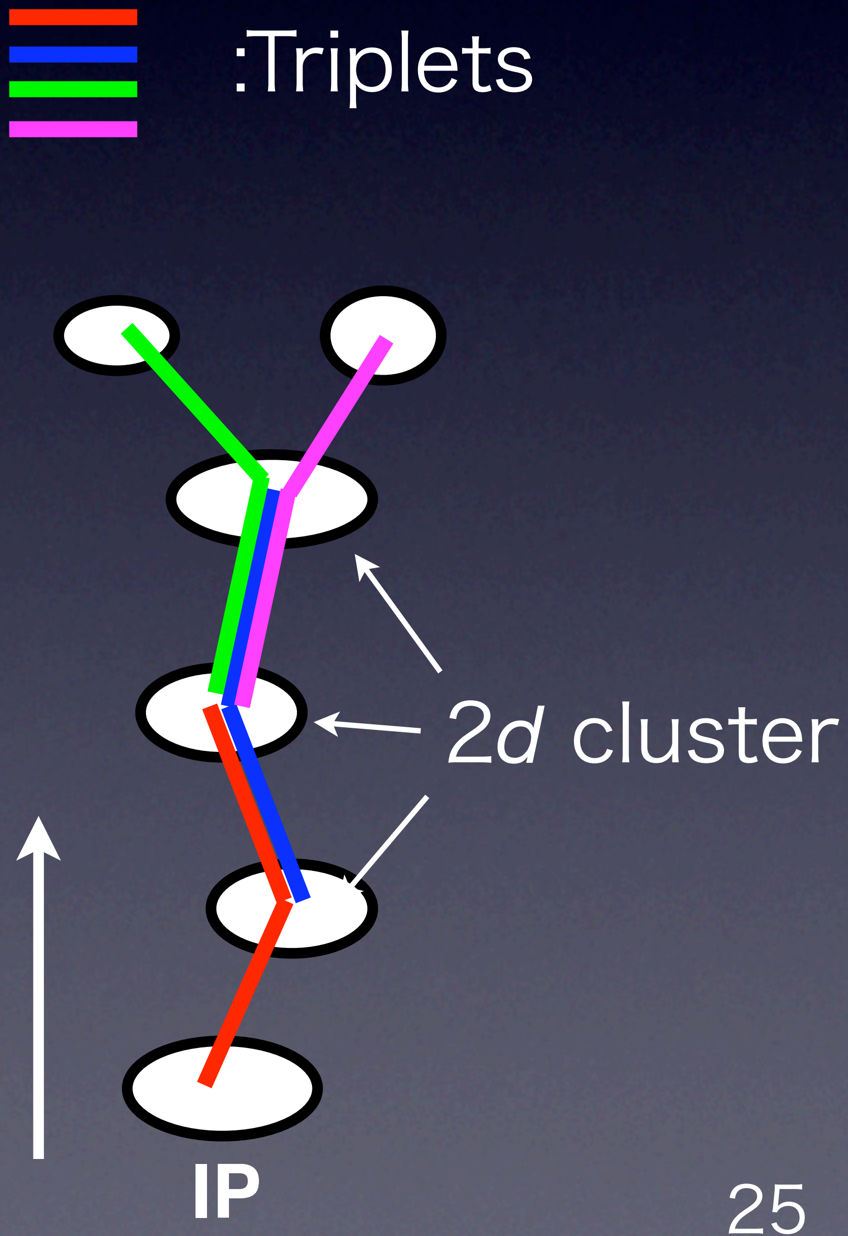


- w/o procedure for strips, both energy resolution and position resolution degrade for the scintillator strip.
- Split method improves both energy resolution and position resolution.
- "Split method ignore isolate" means that isolate hits are not counted in the case where does not exist any hit in above nor below neighbors
- "Split method ignore center pos." means that energy of isolate hits mentioned above are put the center of scintillator strip.

Procedure of the triplet method

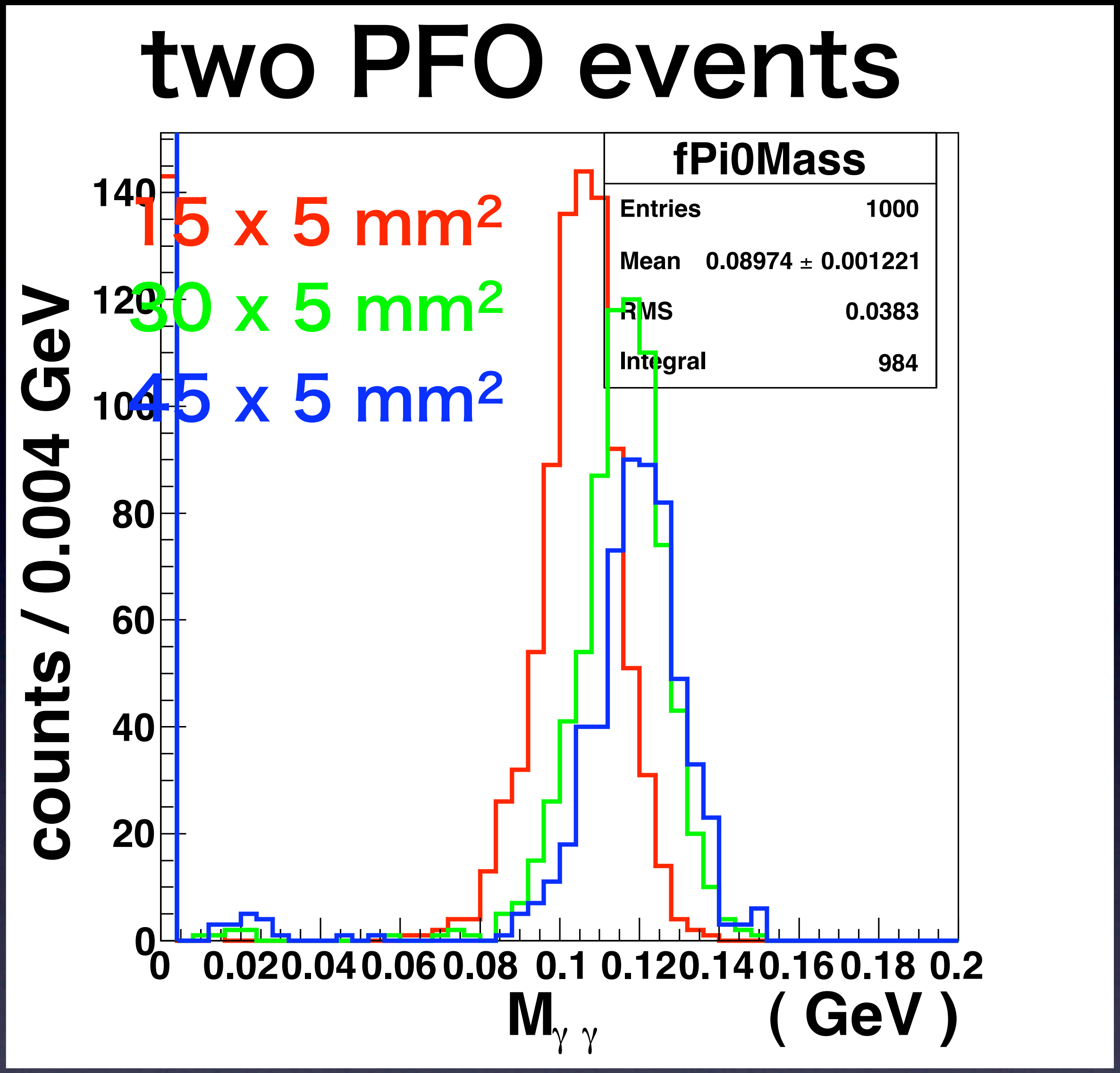
1. **2-D** clusters are reconstructed.
2. Each “**triplet**“ is reconstructed from three **2-D** clusters.
3. An **ECAL cluster** is reconstructed with “**triplet**s”.
4. PandoraPFA

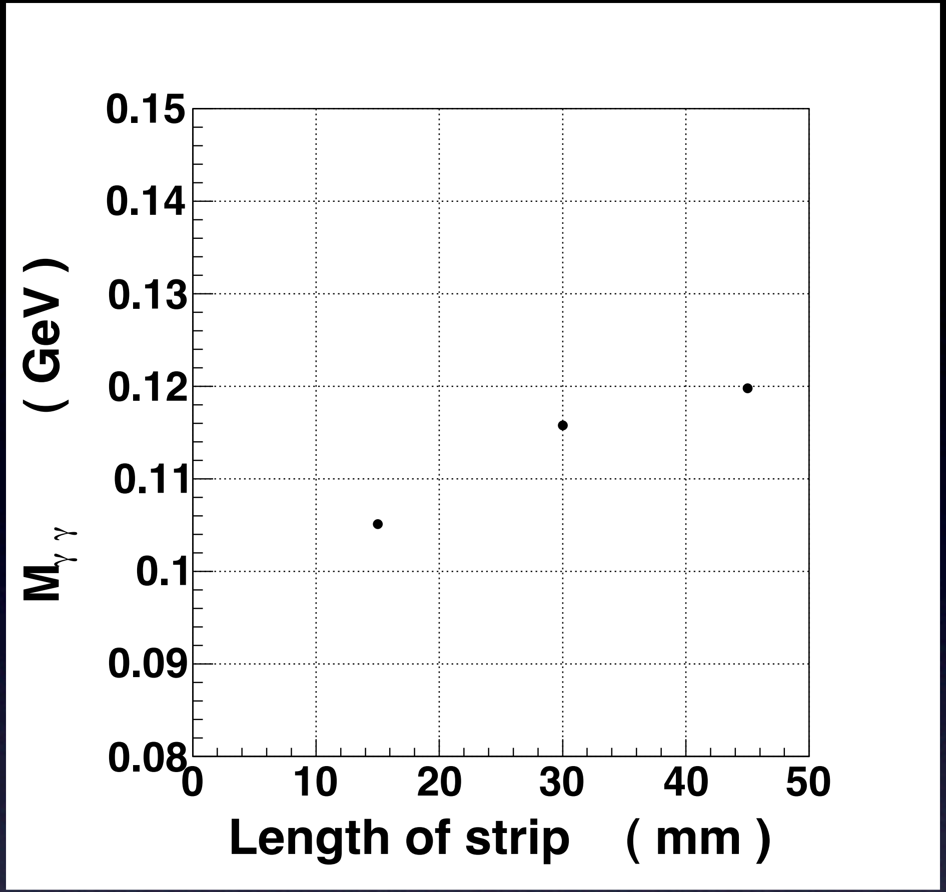


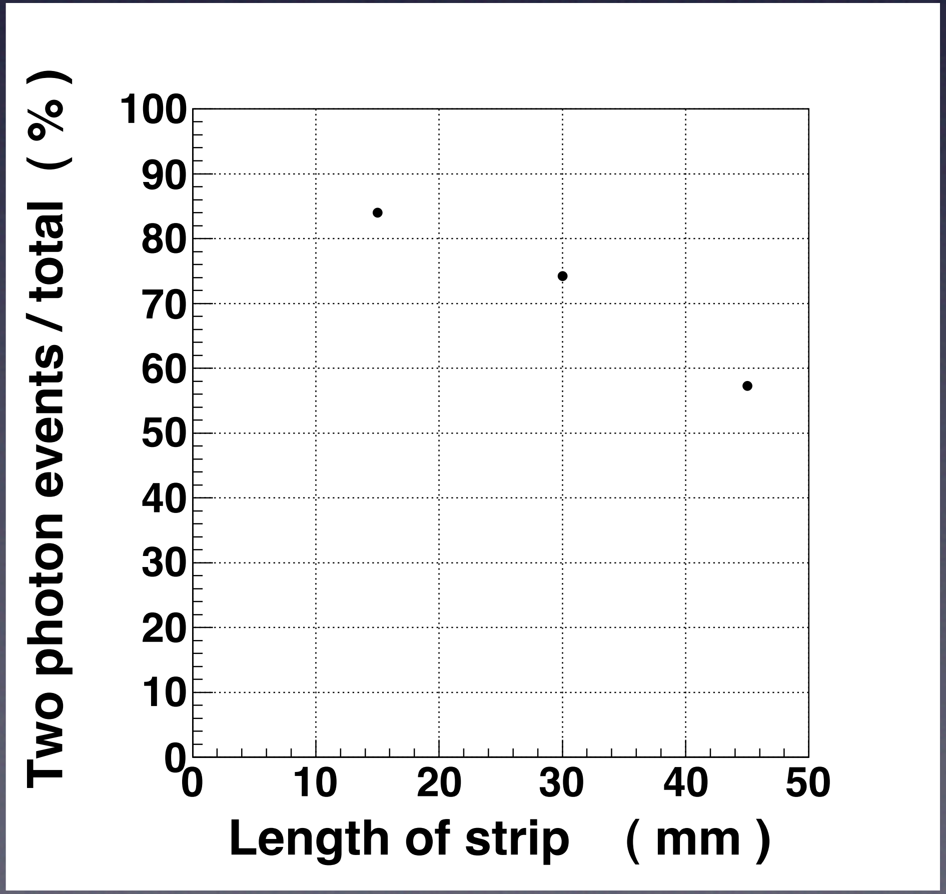


Invariant mass of two gamma from π^0

10 GeV 1000 pion

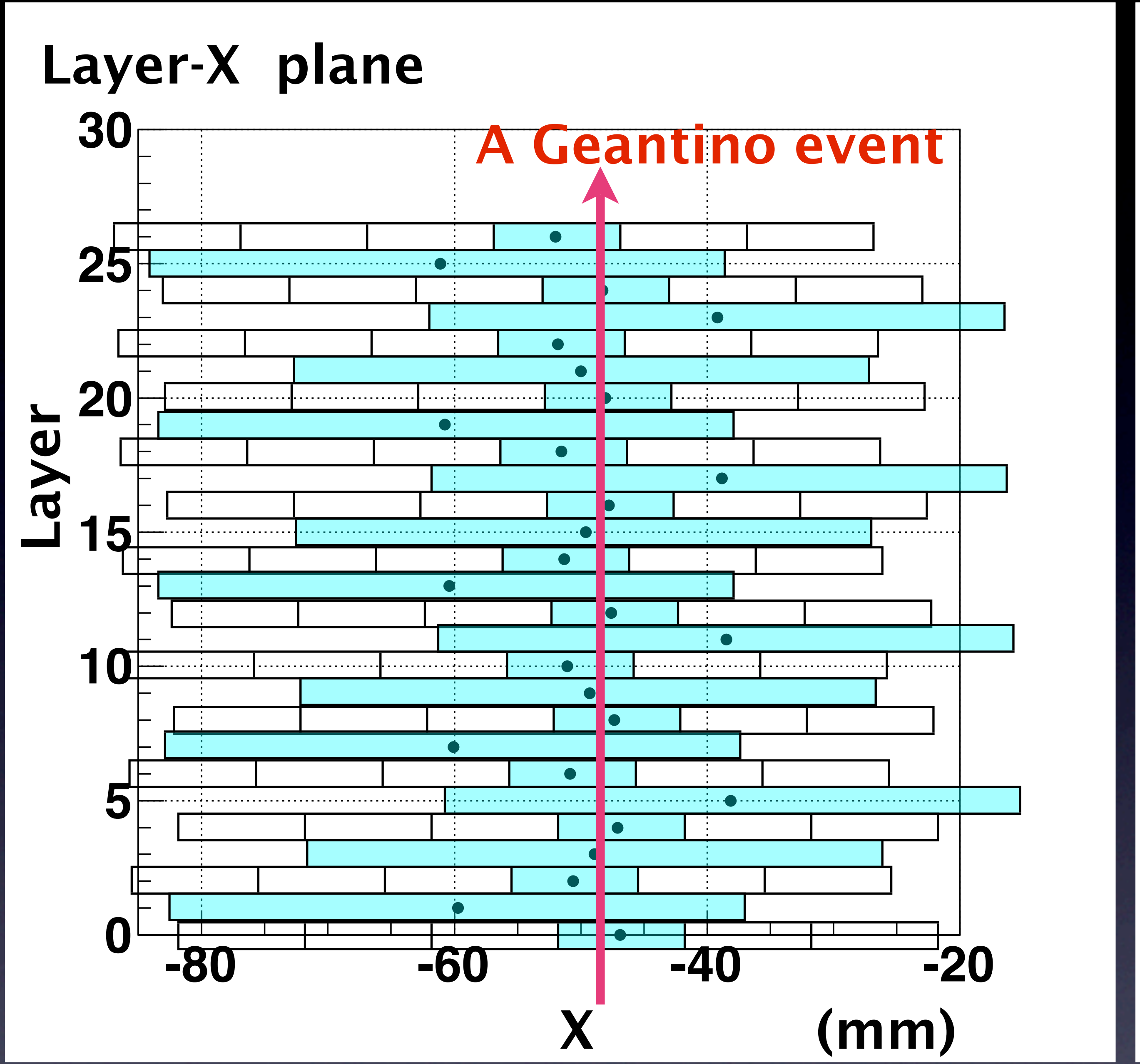


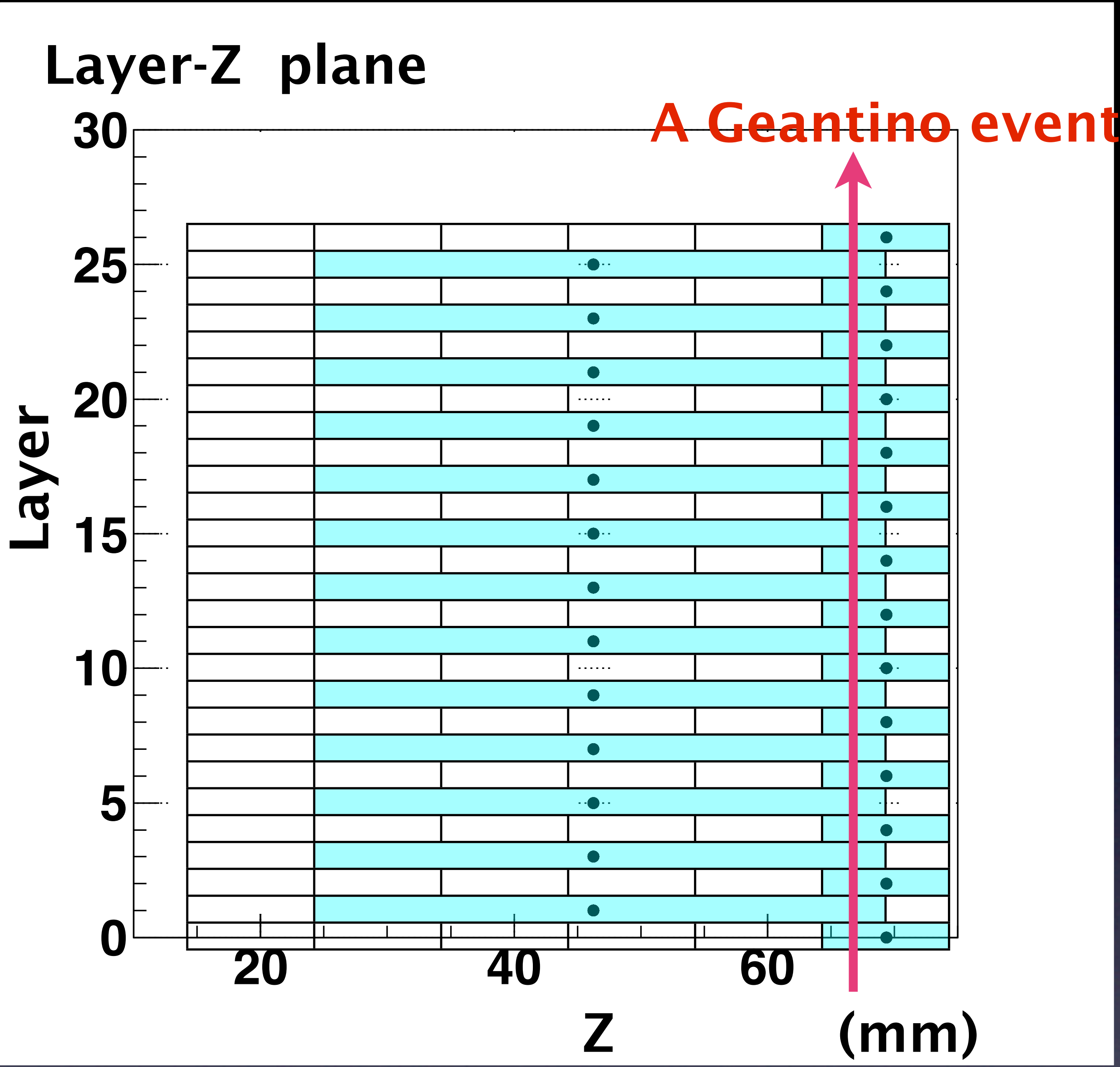




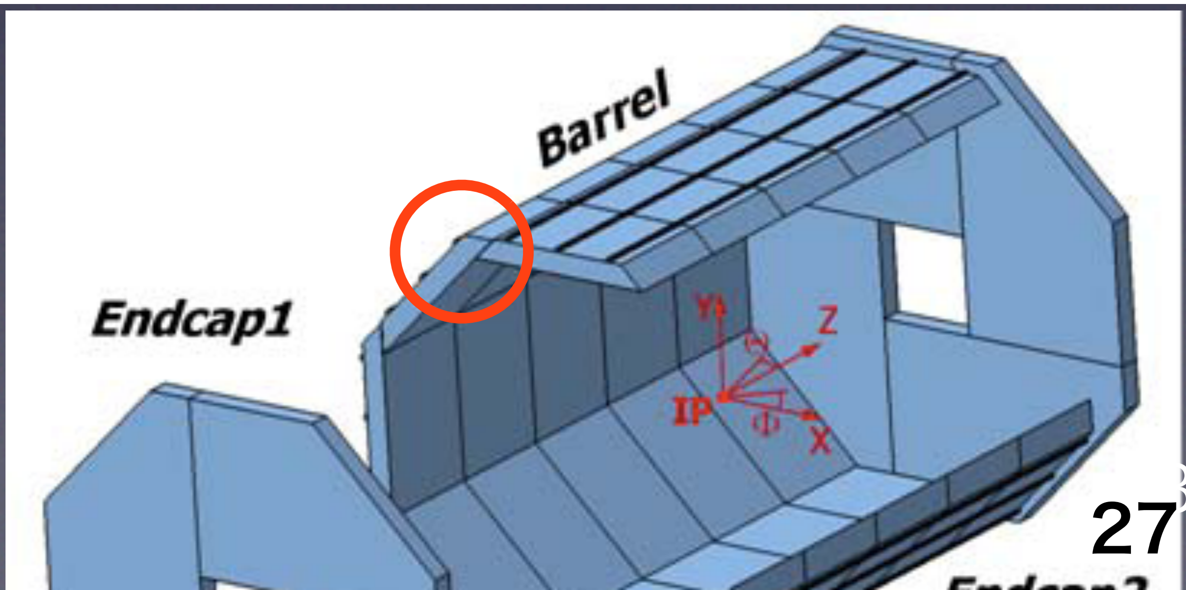
- Reconstructed masses depend on length of scintillator strips.
- PFO recognition also...

New merged cell ID was done



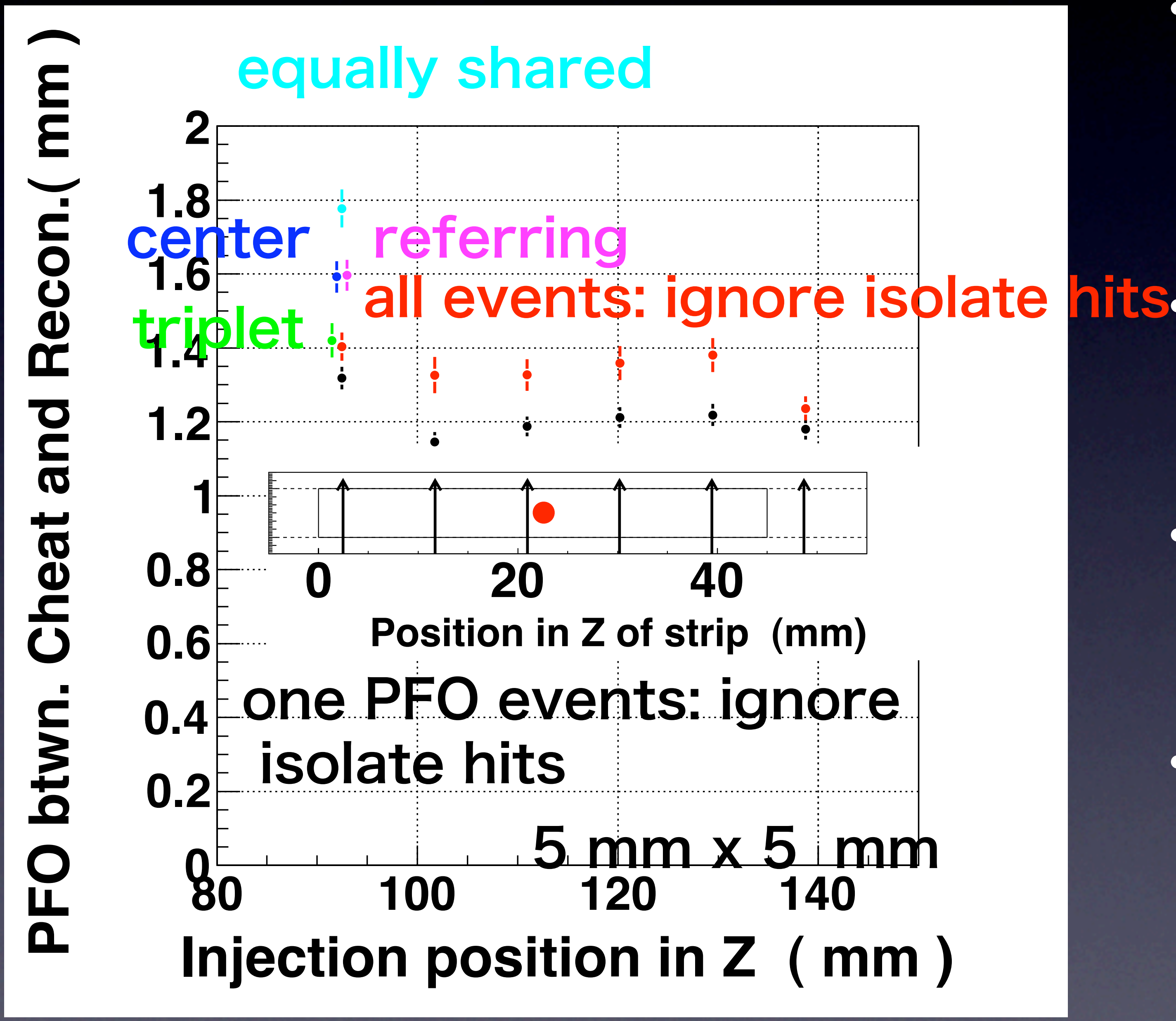


Trapezoid Shape makes shift between layers



Distance between MC true and recon.ed PFO projected on ECAL surface 10 GeV 1000 photon

- Again, when isolate hits are ignored, position resolution is better.
- Injection position resolution is small.



- Red dots show injection position dependence of position resolution using data all events.
- Black dots show the same but using only one PFO events.
- blue dots shows position dependence with equally shared method.
- blue and purple show the position response with center method and referring method
- green shows the position resolutions using triplet method.

Triplet vs. Split

	triplet	Split
Clustering	Pre-clustering and to turn over to the PandoraPDA	Turn over to the PandoraPFA
Returned position in the longitudinal direction of a strip	One position / strip, referring to above below layer energy	Split into 5 mm x 5 mm square cells ⇒ suit the PandoraPFA procedure
Procedure	Rather complicated	Simple then easy for the boundary treatment
Isolate hits	ignore if it is not included in any calorimeter track	We can choose some methods

Plan

- Jet ennergy resolution with Strip segmentation degrades, 30%(5x5mm^2)-->50%(45x5mm^2)
  - lack of understanding to use some class?
  - treatment of boundary hits between staves (then, Endcap-barrel)
  - Tune of PandoraPFA (using PandoraPFANew)
- Pi0 mass resolution
  - Φdependence(boundary between staves)
  - #of PFO (σE(Φ, θ)),
  - #of Cell/PFO,
- Once try to use PandoraPFANew (we should be required to use near future)
  - DESY --> learn How to use New PandoraPFA
- Square and Strip hybrid ECAL (Mokka is already available by Gabriel and Paulo)
  - ScECAL 5x5mm^2 layers + 45x5mm^2 layers -->
  - SiECAL 5x5mm^2 layers + 45x5mm^2 layers -->