

# Strip-HCAL Option

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Fine tuning!



at JSP meeting at  
Kwansei-kakuin univ.

# Motivation

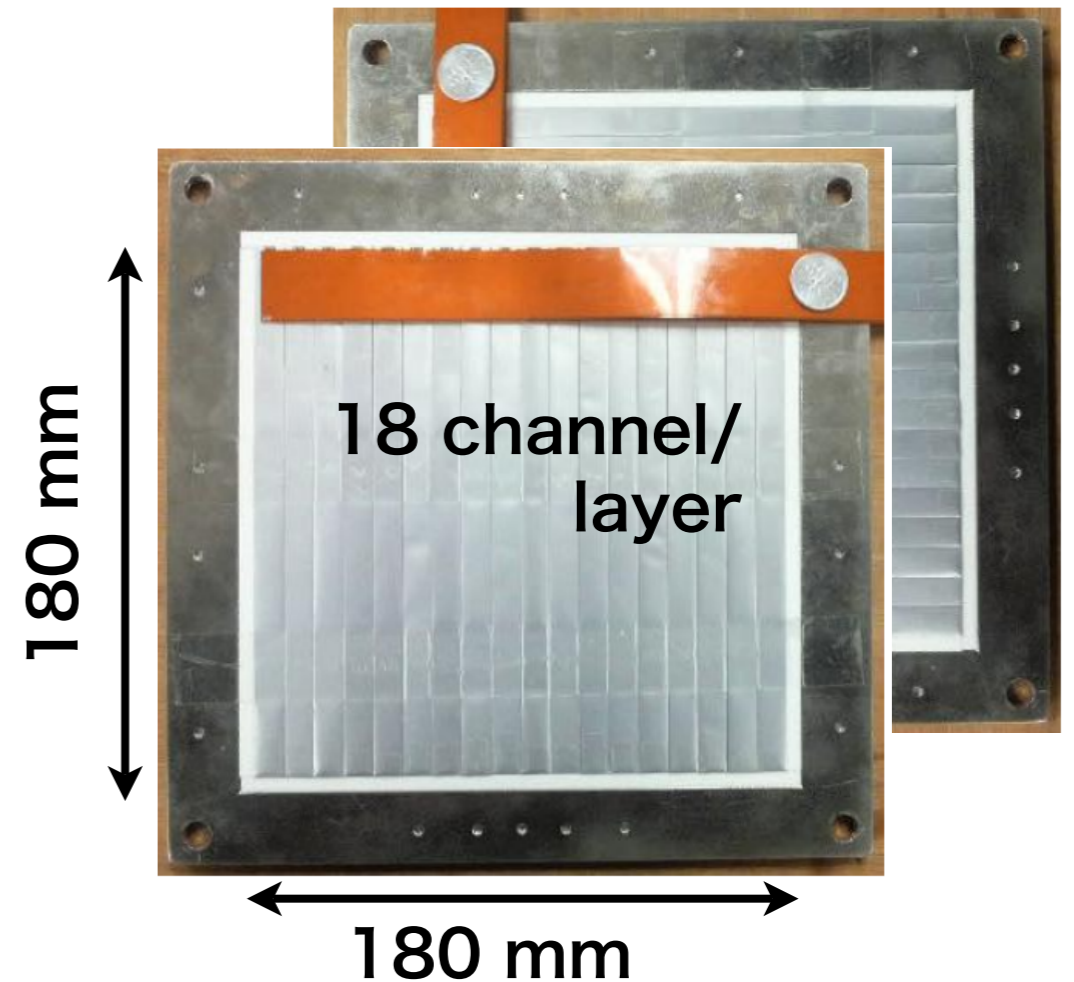
- Minimum pixel size of the Digital HCAL is 10 mm x 10 mm so far.
- Digital HCAL has very good performance on position,
- and the Semi-digital HCAL is being developed adding some energy discriminations to improve the energy resolution with three levels of energy discriminations.
- We suggest another way to make **10 mm x 10 mm** pixelated “**full analog**” HCAL by using scintillator strip technology.
- To make such an HCAL with **10 mm x 90 mm** scintillator strips, there is no more requirement of the cost nor mechanical technology from **the current analog HCAL with 30 mm x 30 mm tiles**. (No disadvantage, but potential of advantage)
- Challenge is to apply the strip splitting algorithm to the mip like tracks exist close to each others in a hadron cluster.

# Two-layer trial

We've already constructed a two-layer prototype in the frame of ScECAL 2nd prototype with 10 mm x 180 mm strips.

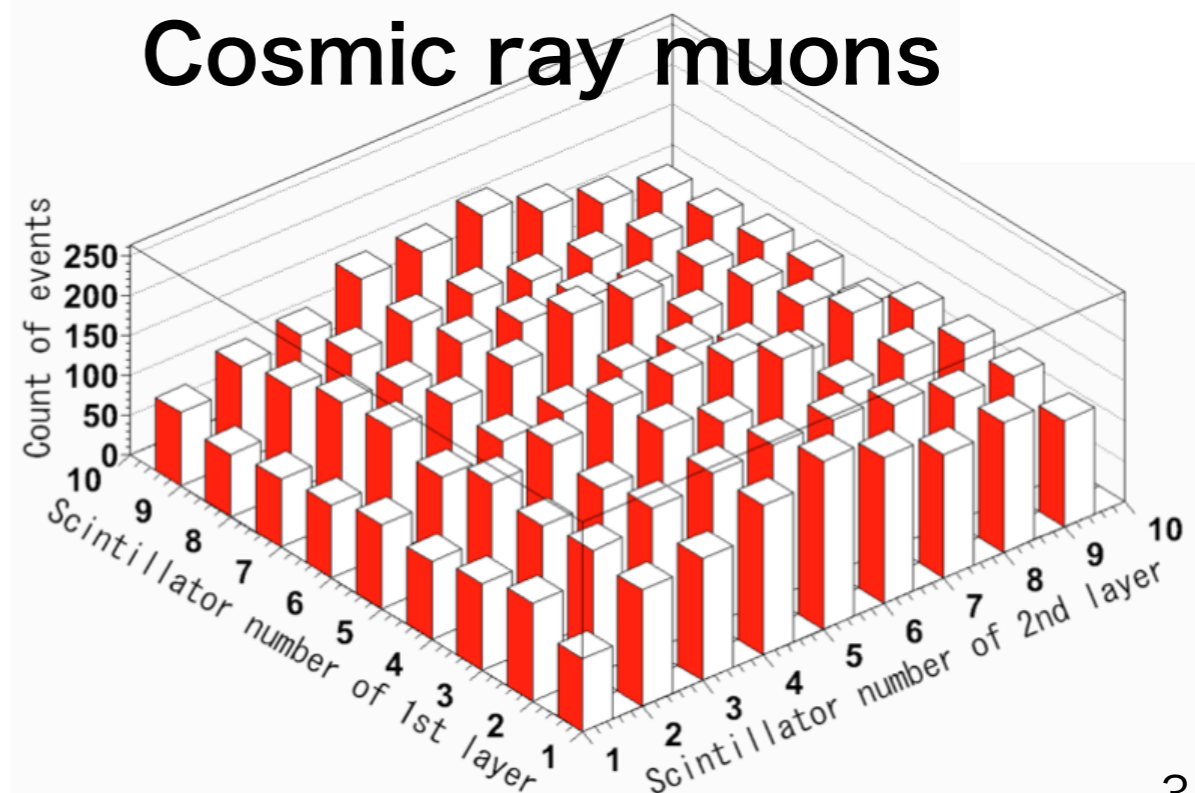
For the single muons, 10 mm x 10 mm granularity is not difficult with two layers.

Distribution of the zenith angle measured by this two-layer Strip - AHCAL prototype is consistent with MC result (by M. Harada 2011).



by M. Harada

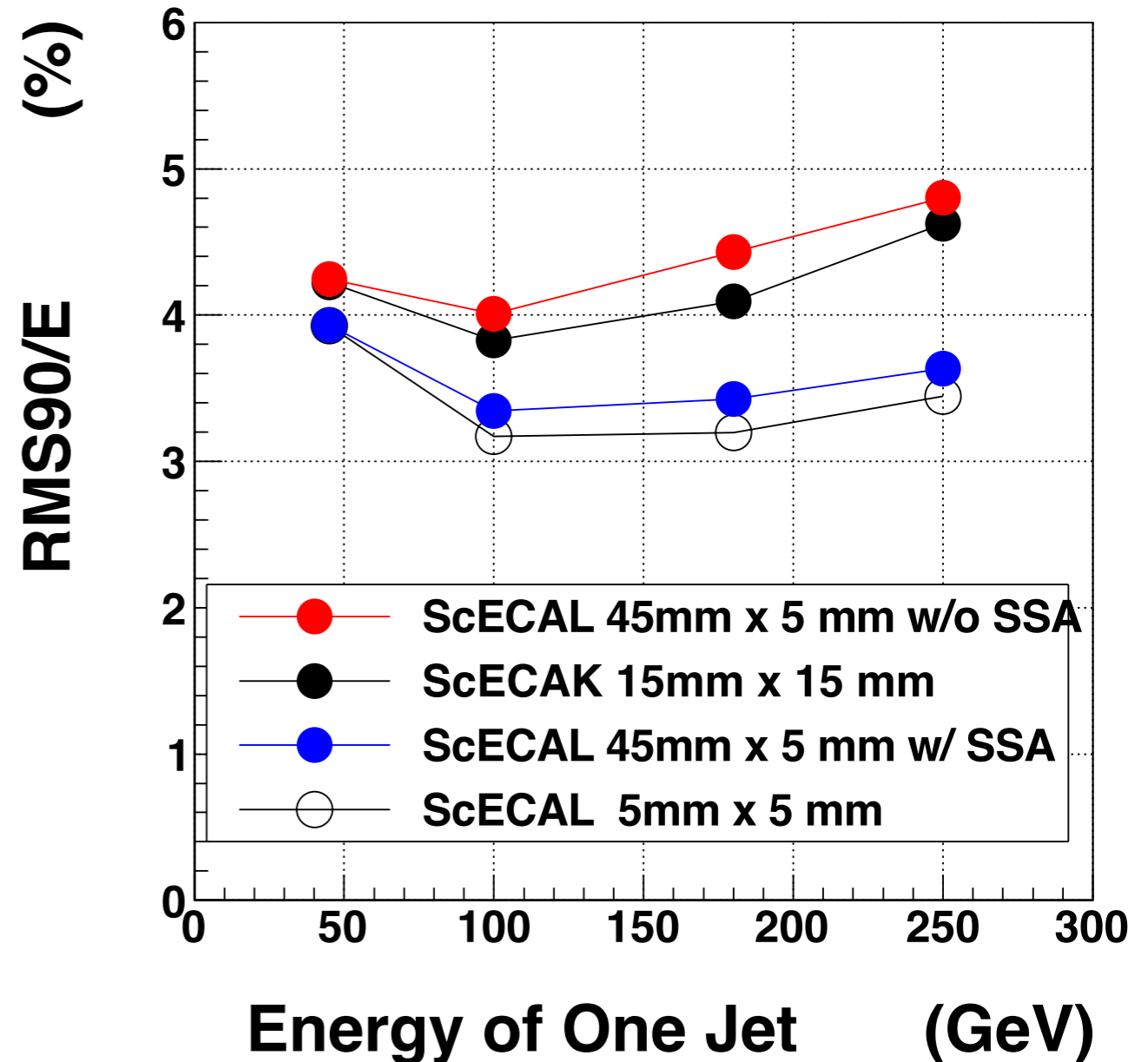
## Cosmic ray muons



# Strip Splitting Algorithm with PandoraPFA in ScECAL

- The same cell area ECAL, “45 mm x 5 mm” vs. “15 mm x 15 mm” have similar energy resolution to each others.
- “45 mm 5 mm strip ECAL with SSA” clearly has the better energy resolution than “15 mm x 15 mm”, and close to the real 5 mm x 5 mm tile ECAL.

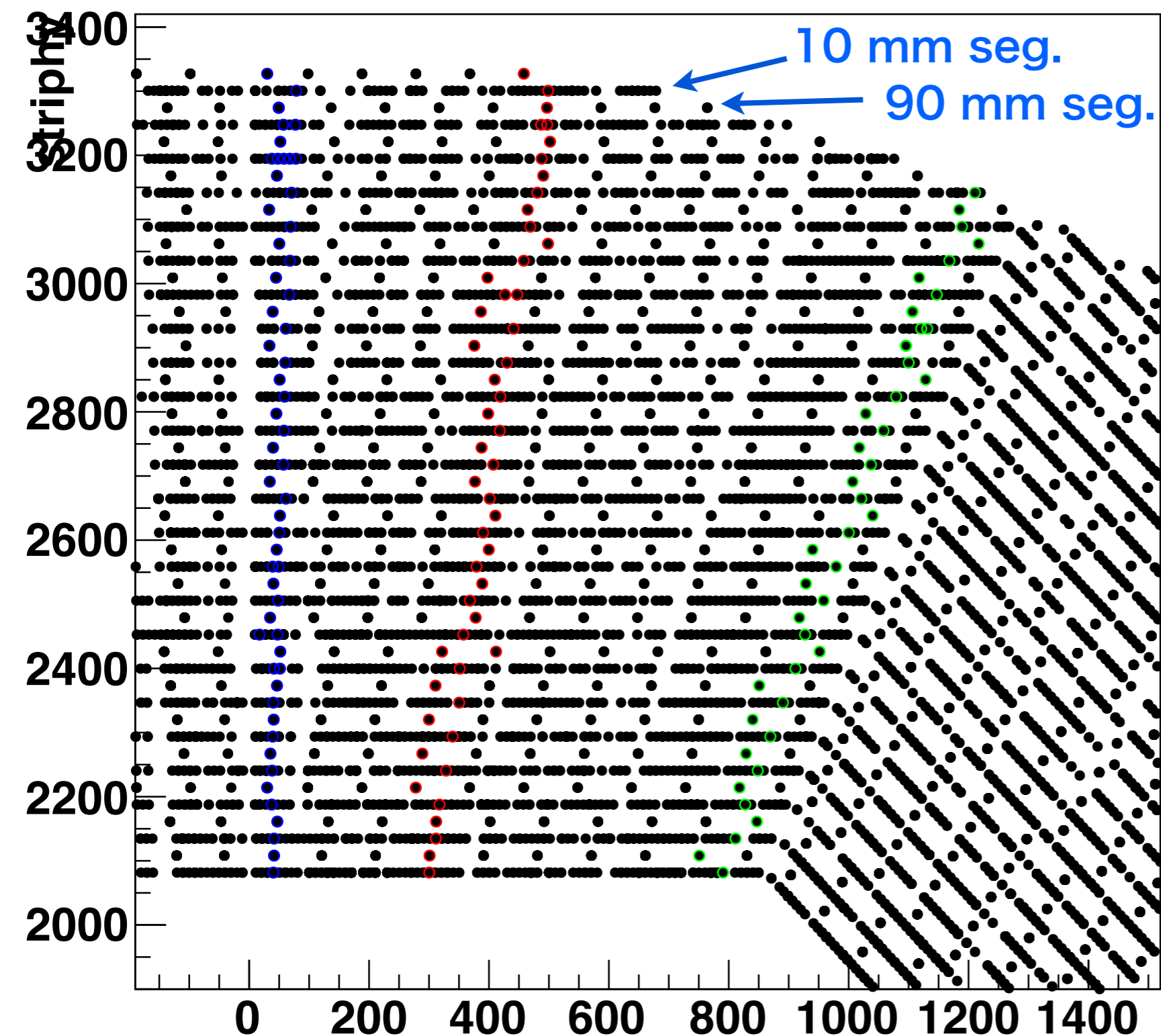
ScECAL in ILD\_o3-V5





# Strip Analog HCAL in Mokka tested by injecting 100 GeV muon

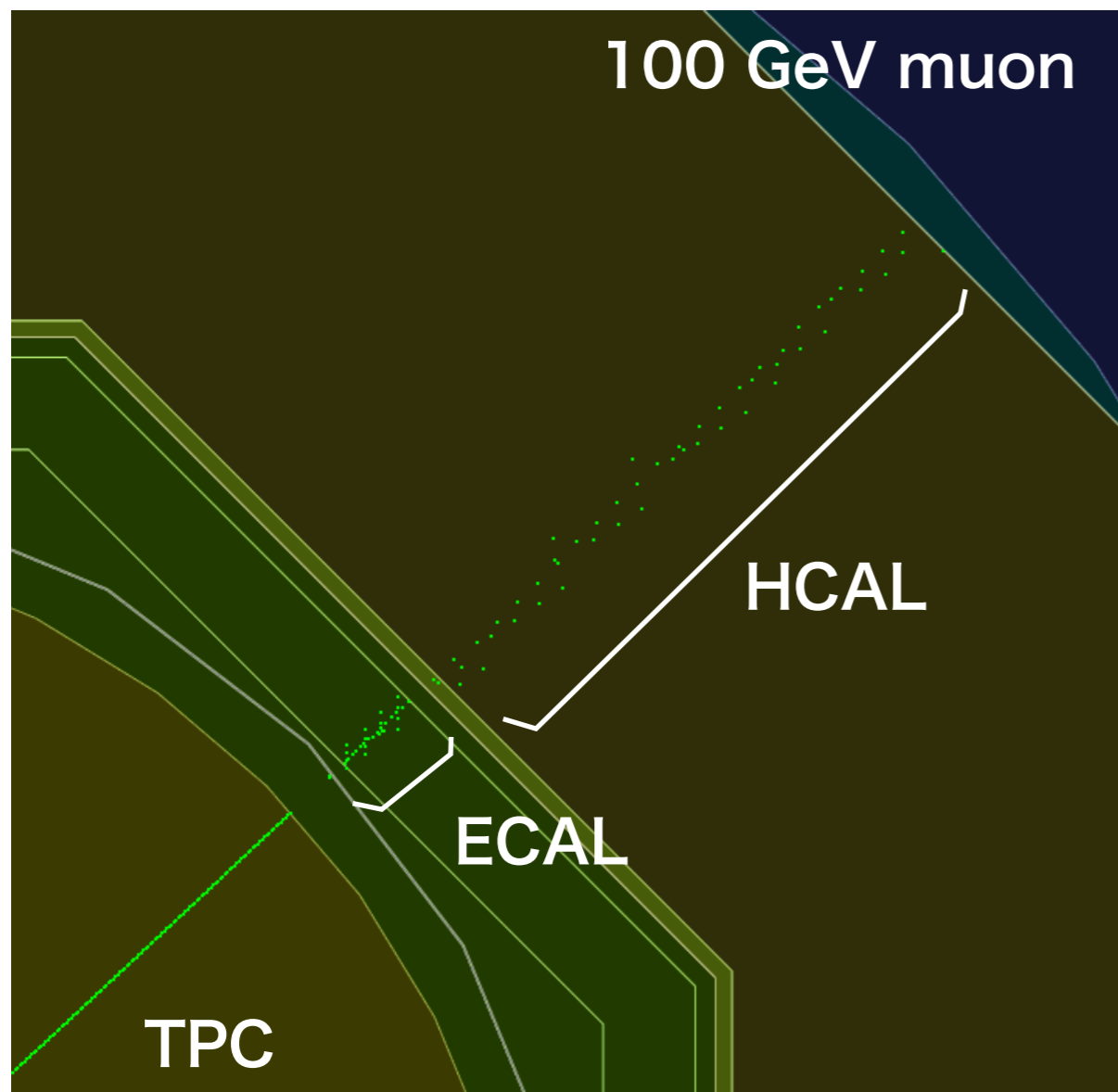
striphy:striphx



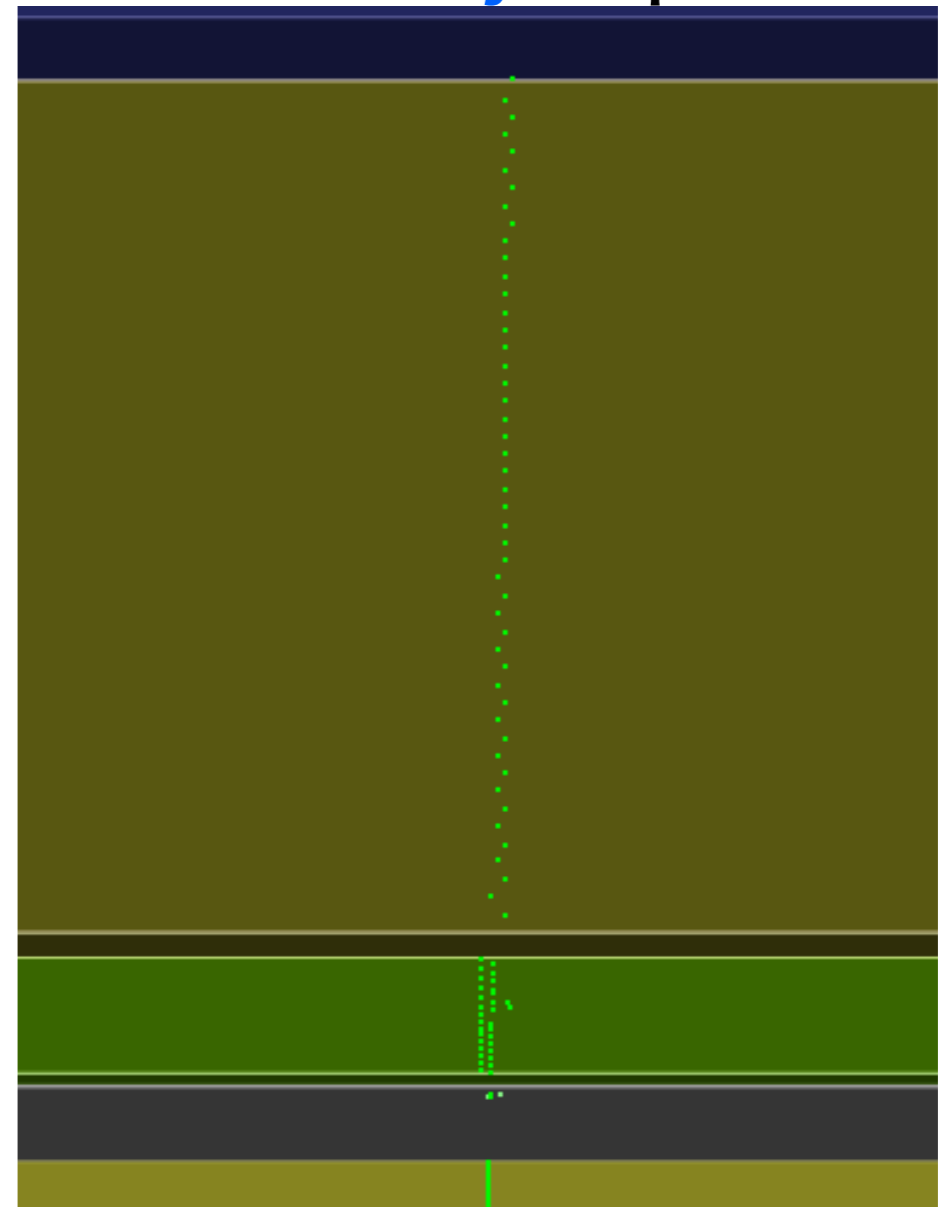
1. Black dots show centers of the strip positions in the barrel of HCAL in X-Y plane with hits by many 100 GeV muons.
2. Odd layers have 10 mm segmentation and the even layers have 90 mm segmentation.
3. Blue, red, and green circles show three muon events without SSA, respectively.
4. already checked all of the other staves.
5. not yet touched on Endcaps

# An event of 100 GeV muon without the strip splitting.

Before SSA :  $x - y$  plane



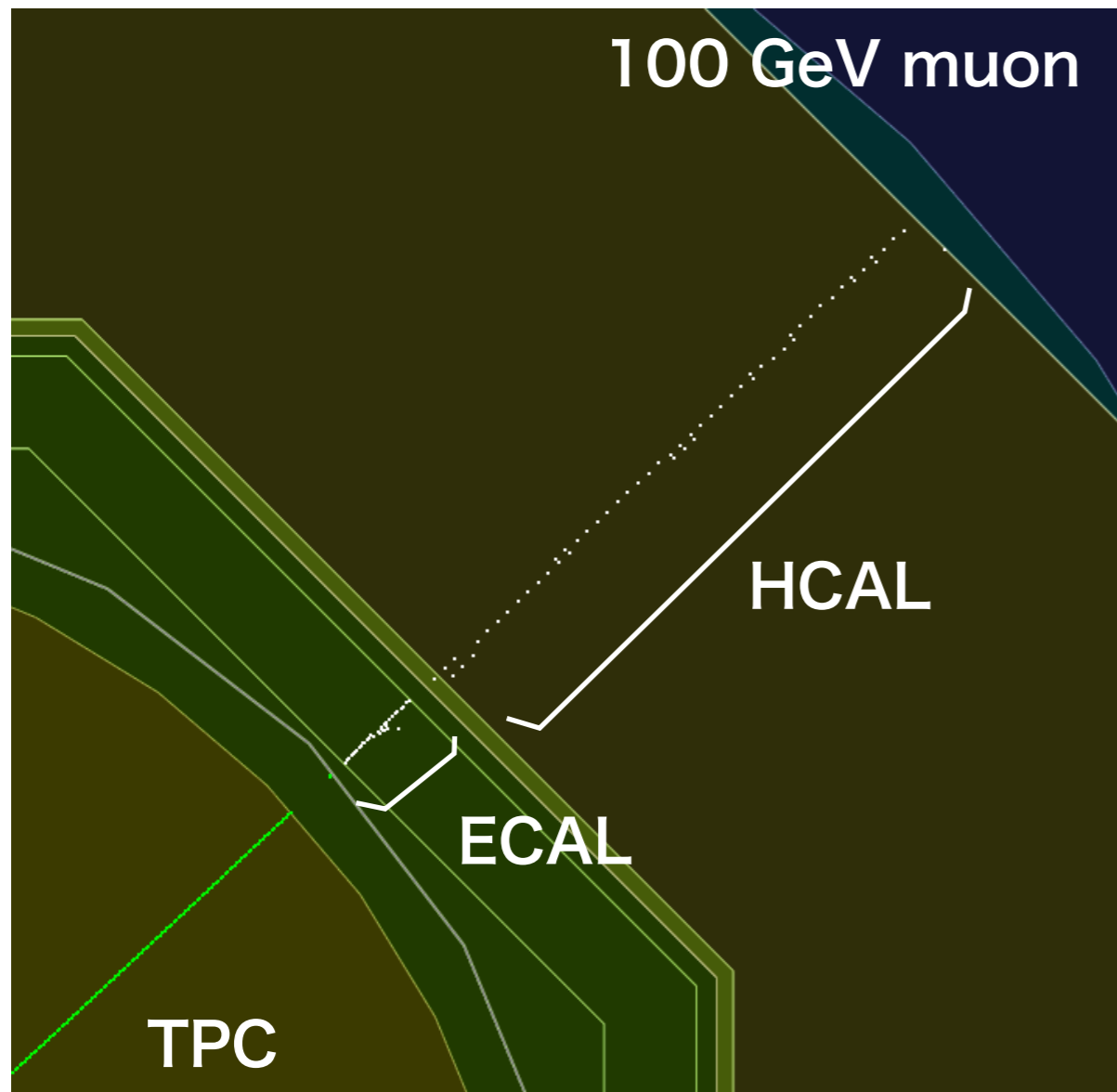
Before SSA :  $y - z$  plane



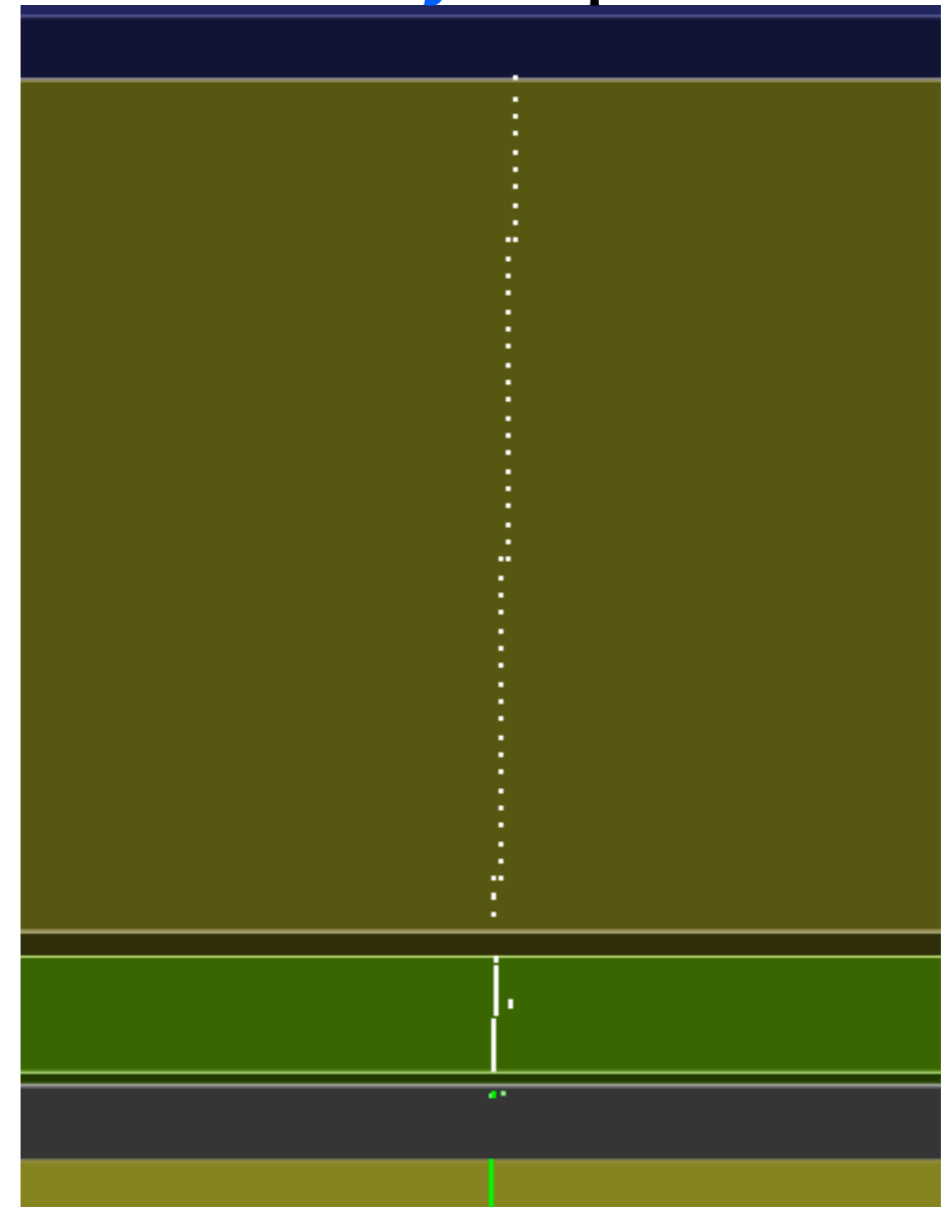
10 mm x 90 mm strips in HCAL.

# Clear muon track appears with **S**trip **S**plitting **A**lgorithm

after SSA : **x - y** plane



after SSA : **y - z** plane

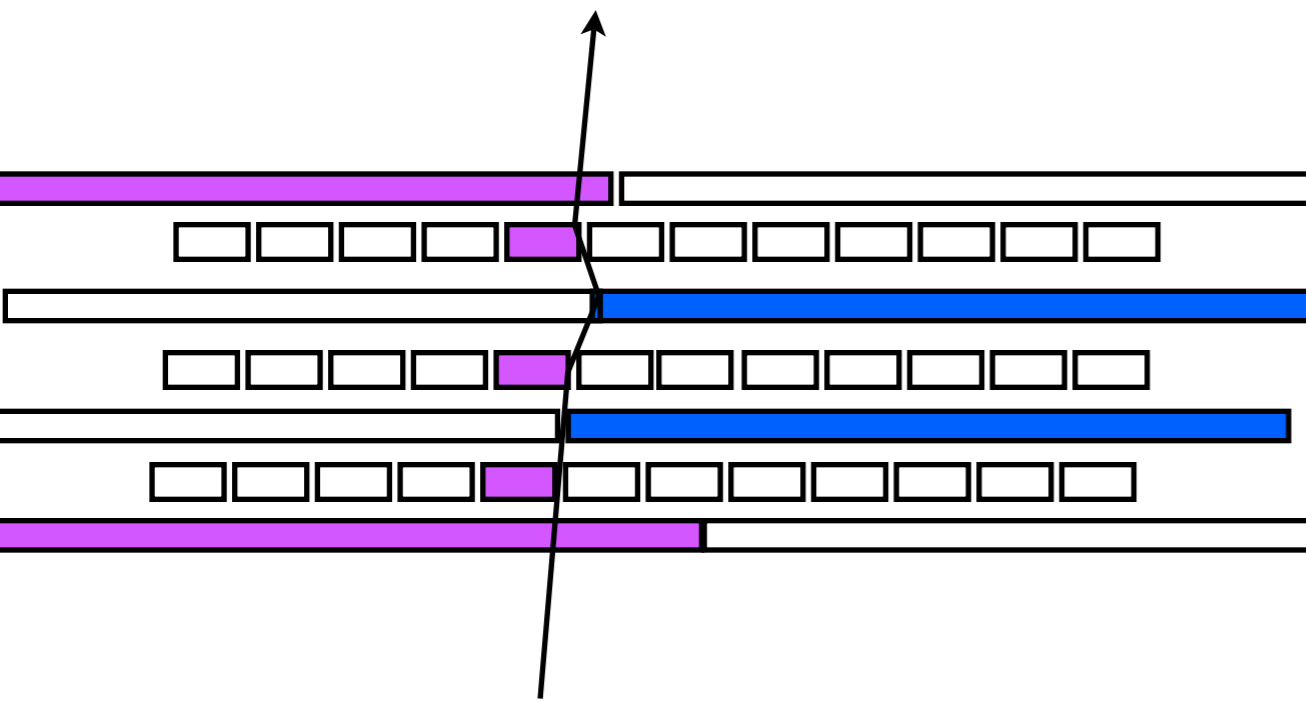


10 mm x 90 mm strips in HCAL.

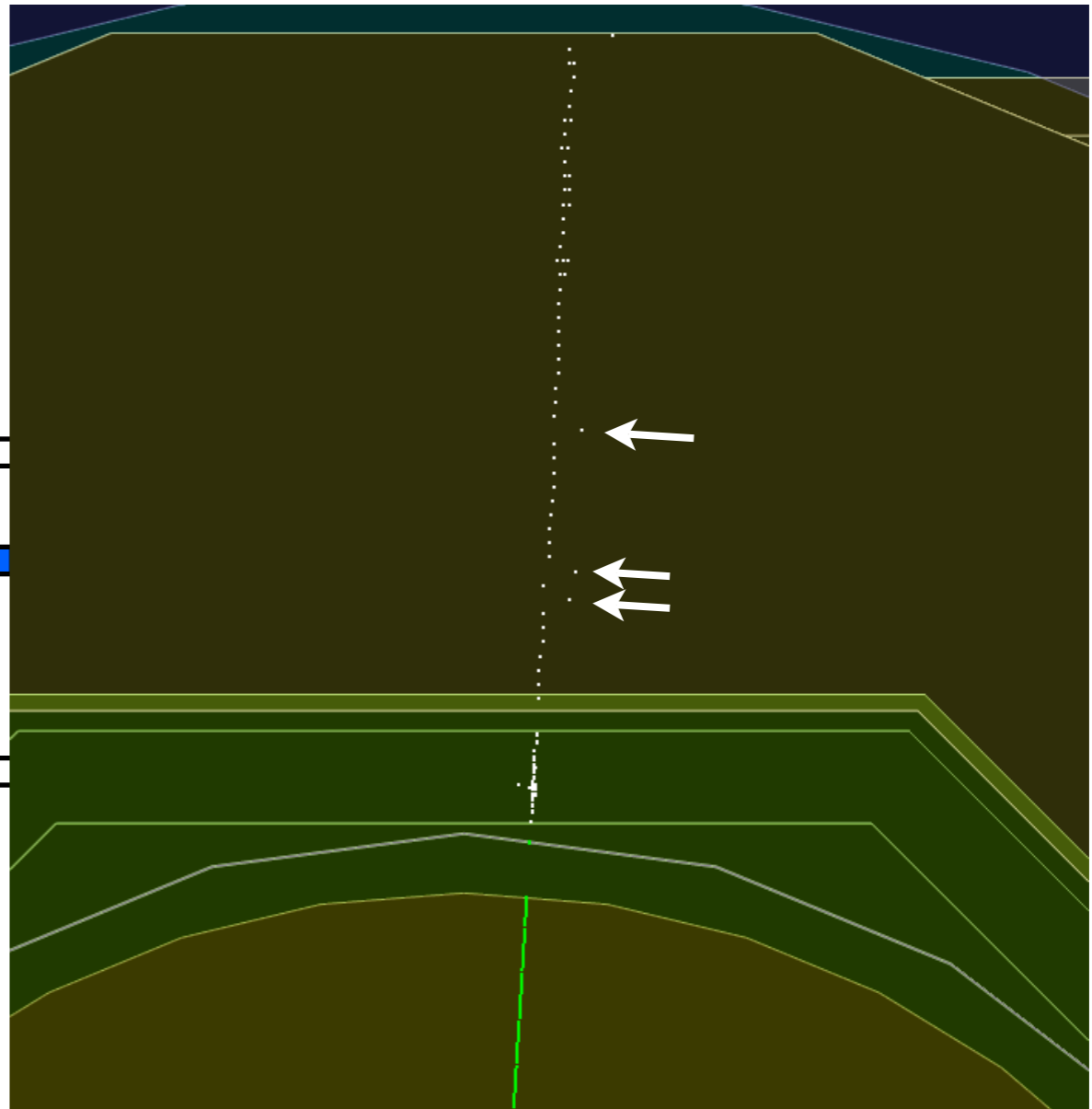
# Under investigation

Some events have reminded hits out of tracks

Detail what happened



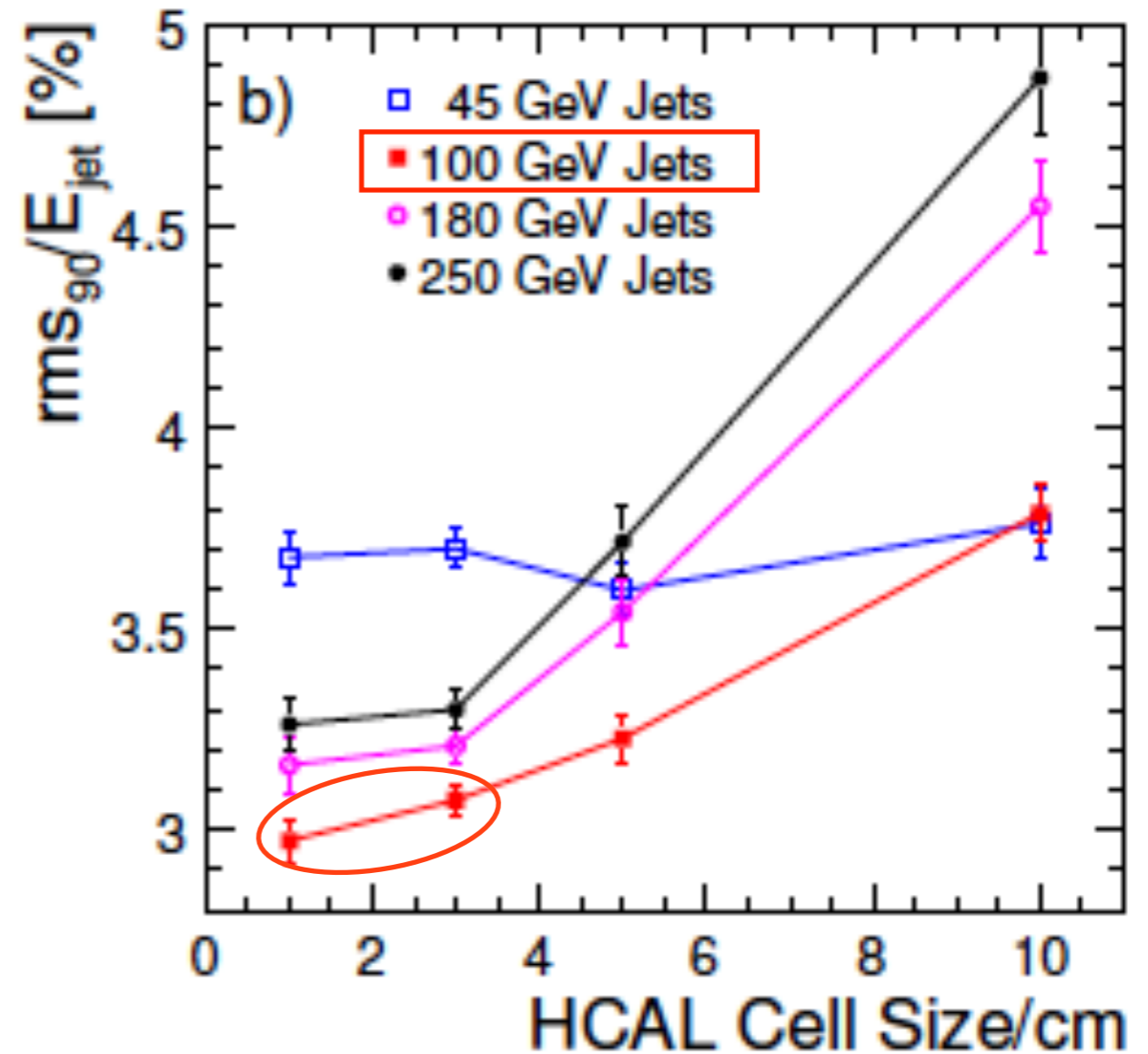
If this is natural or not





# A famous plot in the LOI (this is the reason why AHCAL tiles: 30 x 30 mm<sup>2</sup>)

100 GeV Jets have a room to make evaluation to use 10 mm x 10 mm segmentation, so I will show the case we use 100 GeV jets events to evaluate the performance.



# We need some tunes for 10 x 10 mm<sup>2</sup> tile HCAL

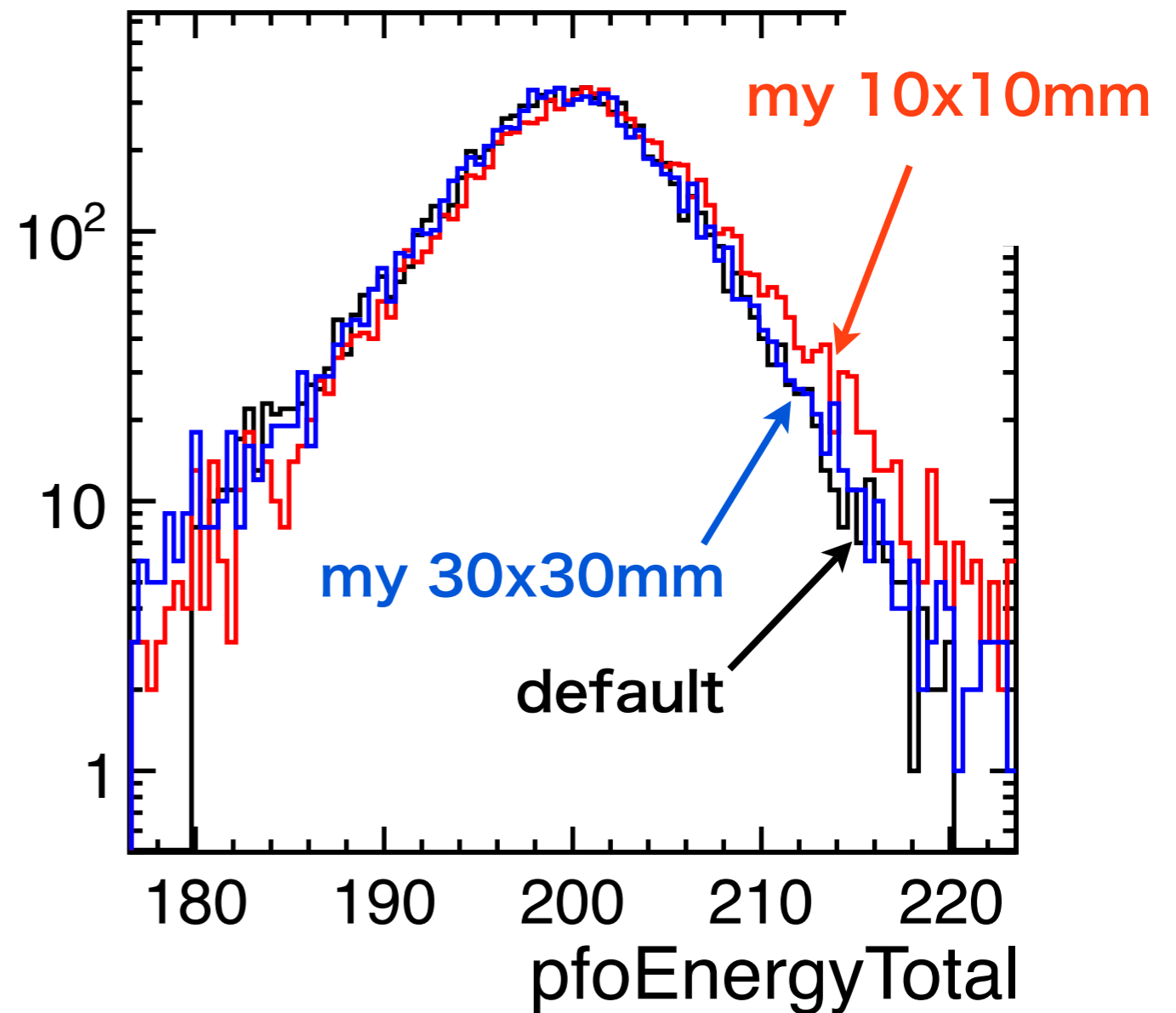
ECAL : ILD SiECAL

100 GeV uds jets were injected.

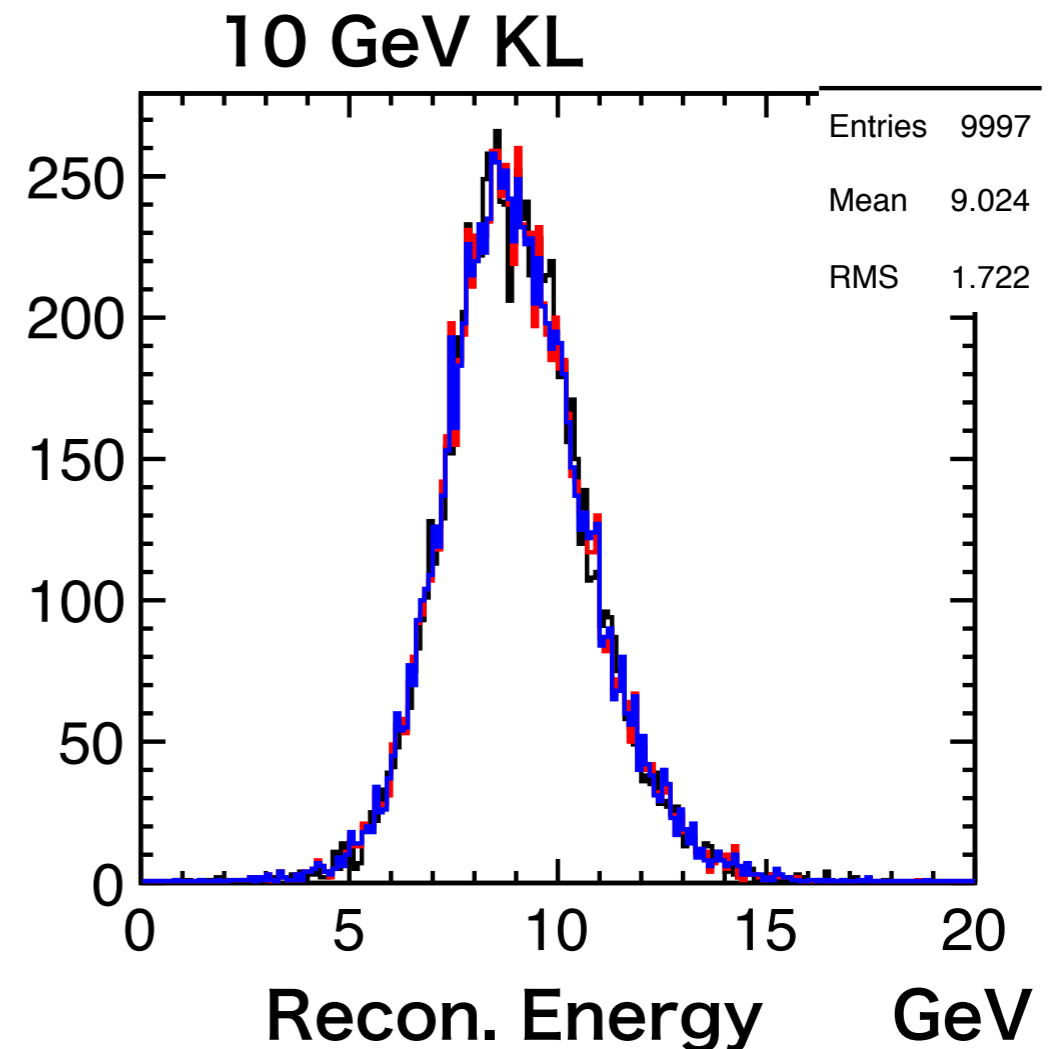
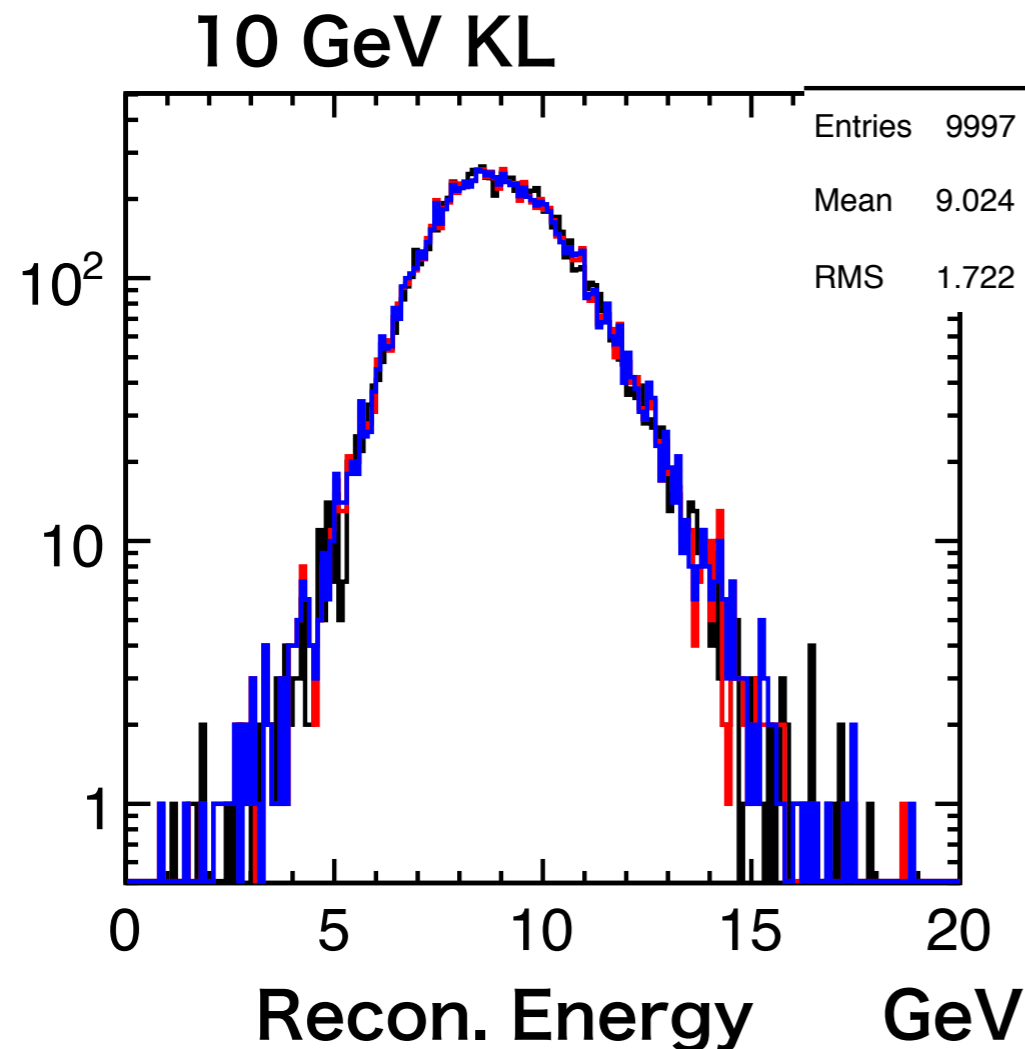
Jet Energy Resolution by using default ILD\_o1\_V5(DBD version: 30 x 30 mm<sup>2</sup> tile AHCAL) has better JER than 10 x 10 mm<sup>2</sup> tile AHCAL.

My 30 x 30 mm<sup>2</sup> model by using the same way to make 10 x 10 mm<sup>2</sup> has similar JER to the default HCAL. .... This means that we need some PandoraPFA tune for 10 x 10 mm<sup>2</sup> tile HCAL.

pfoEnergyTotal {180<pfoEnergyTotal&&pfoEnergyTotal<220}



# Energy means and resolutions of the single $K_L$ have no discrepancy



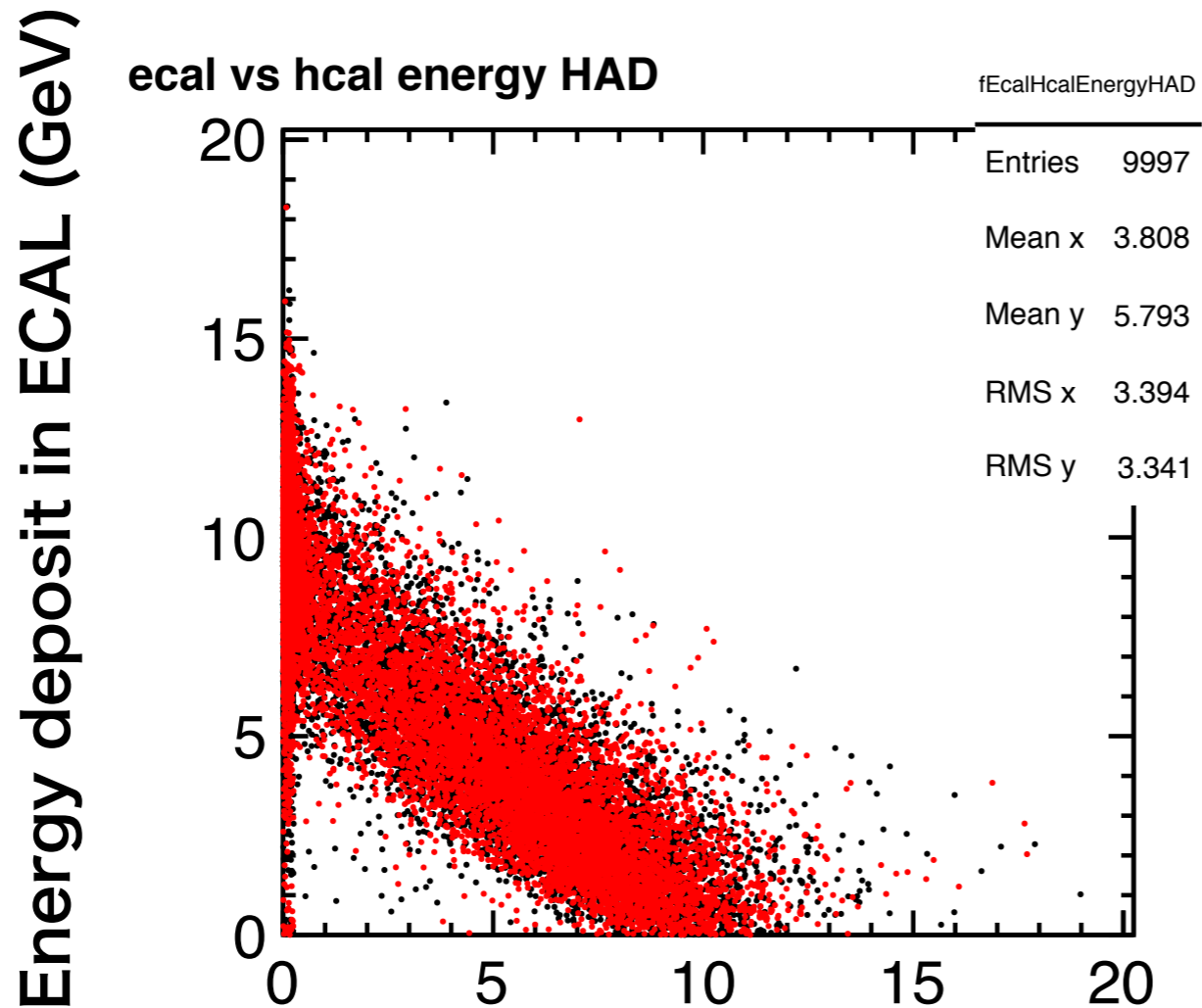
— :ILD\_o1\_V5(DBD version default)

— :10 x 10 mm<sup>2</sup> HCAL

— :10 x 90 mm<sup>2</sup> HCAL

→ Calibration is OK

# Correlation between ECAL and HCAL also OK.



Energy deposit in HCAL (GeV)

- :ILD\_o1\_V5(DBD version default)
- :10 x 10 mm<sup>2</sup> HCAL

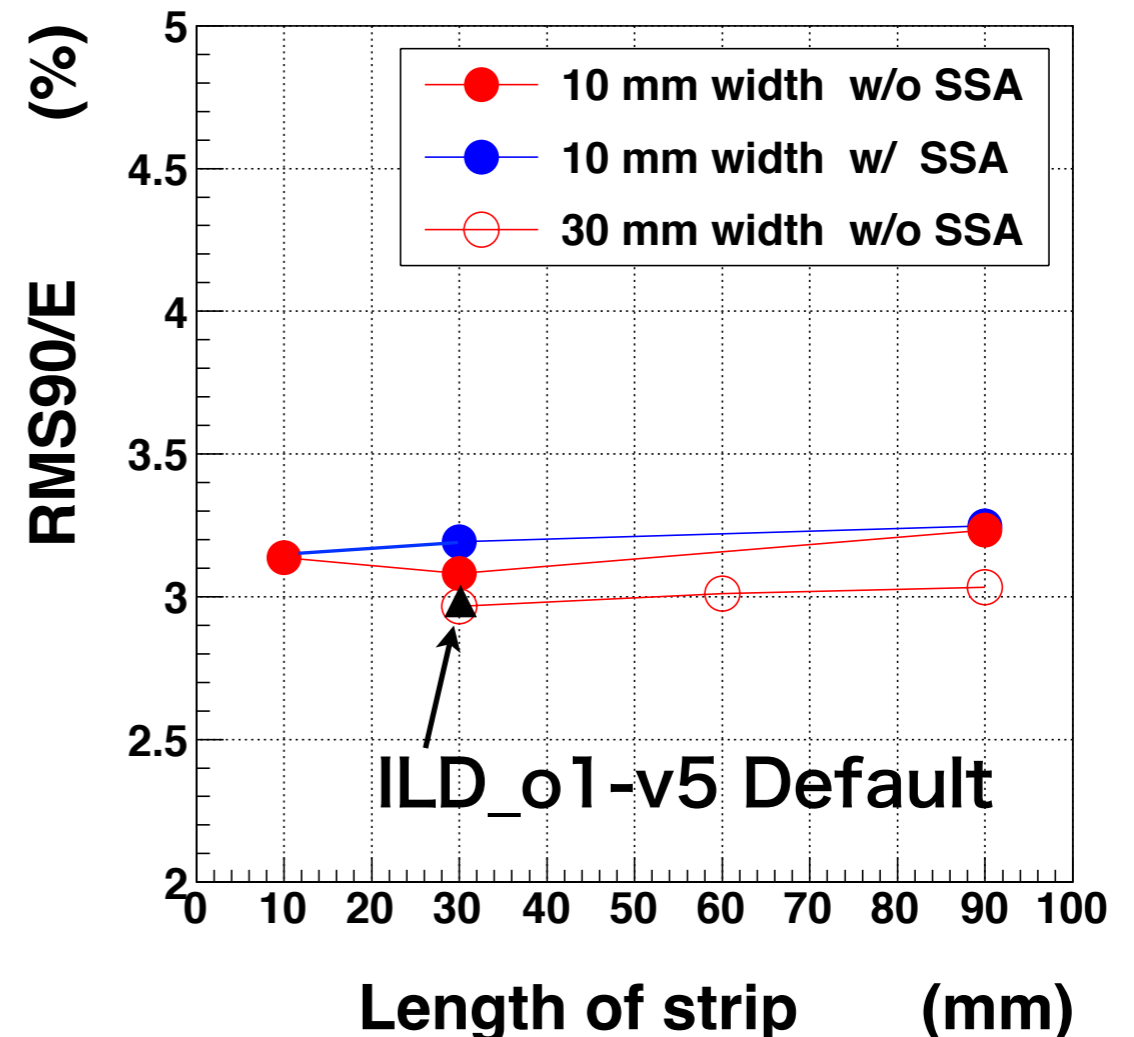
→ Calibration is OK

# uds 100 GeV JER with 10 mm width scintillator strip HCAL

Despite the problem of degrading with 10 mm x 10 mm scintillator strip HCAL, once I tried to measure JER of 100 GeV uds jets changing the length of strips. Strip width is 10 mm or 30 mm.

So far, there is no discrepancy between w/ SSA and w/o SSA, or rather degradation with SSA for 10 mm width strip HCAL (●, ●).

Surprisingly, JER is not so degraded with 30 x 60 mm<sup>2</sup> strip and 30 x 90 mm<sup>2</sup> strip HCAL even w/o SSA (○).



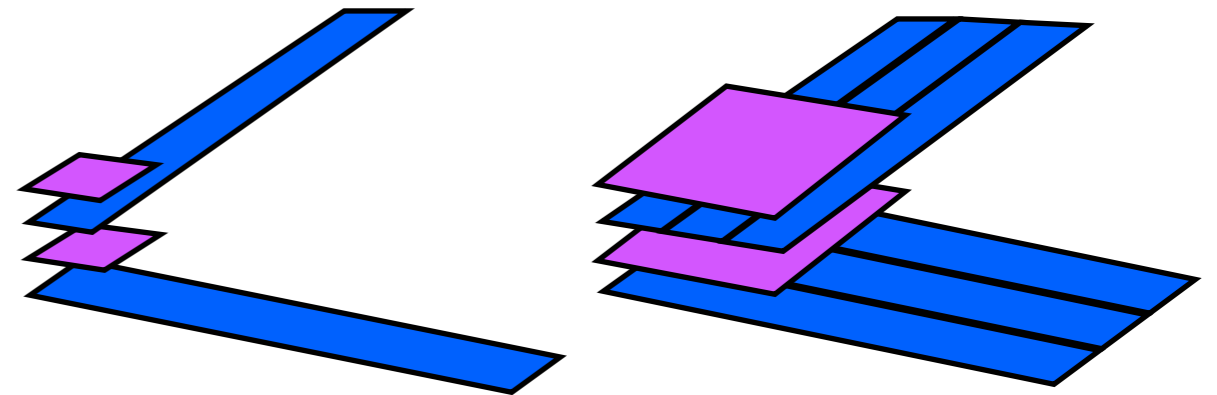
# Summary

1. Strip AHCAL has potential to have good position resolution without degrading of the energy resolution of single cluster.
2. Implementation of the strip AHCAL in the Mokka has been done.
  - I've not yet done the Endcap issues.
3. Strip splitting algorithm for the HCAL is also implemented.
4. AHCAL with 10 mm x 10 mm segmentation requires some tunes for PFA.
5. 30 mm x 30 mm, x 60 mm and x 90 mm strip HCAL have close performance of JER of 100 GeV jets from each others, even w/o SSA.



# Plan

1. Tune of PFA to get better JER of  $10 \times 10 \text{mm}^2$  than  $30 \times 30 \text{mm}^2$ ,
2. comparison of the performance of  $10 \times 10 \text{mm}^2$  and  $30 \times 30 \text{mm}^2$  with severer conditions in order to show the effects of finer segmentation,
3. endcap issues.
4. combinations of tile layers and strip layers,



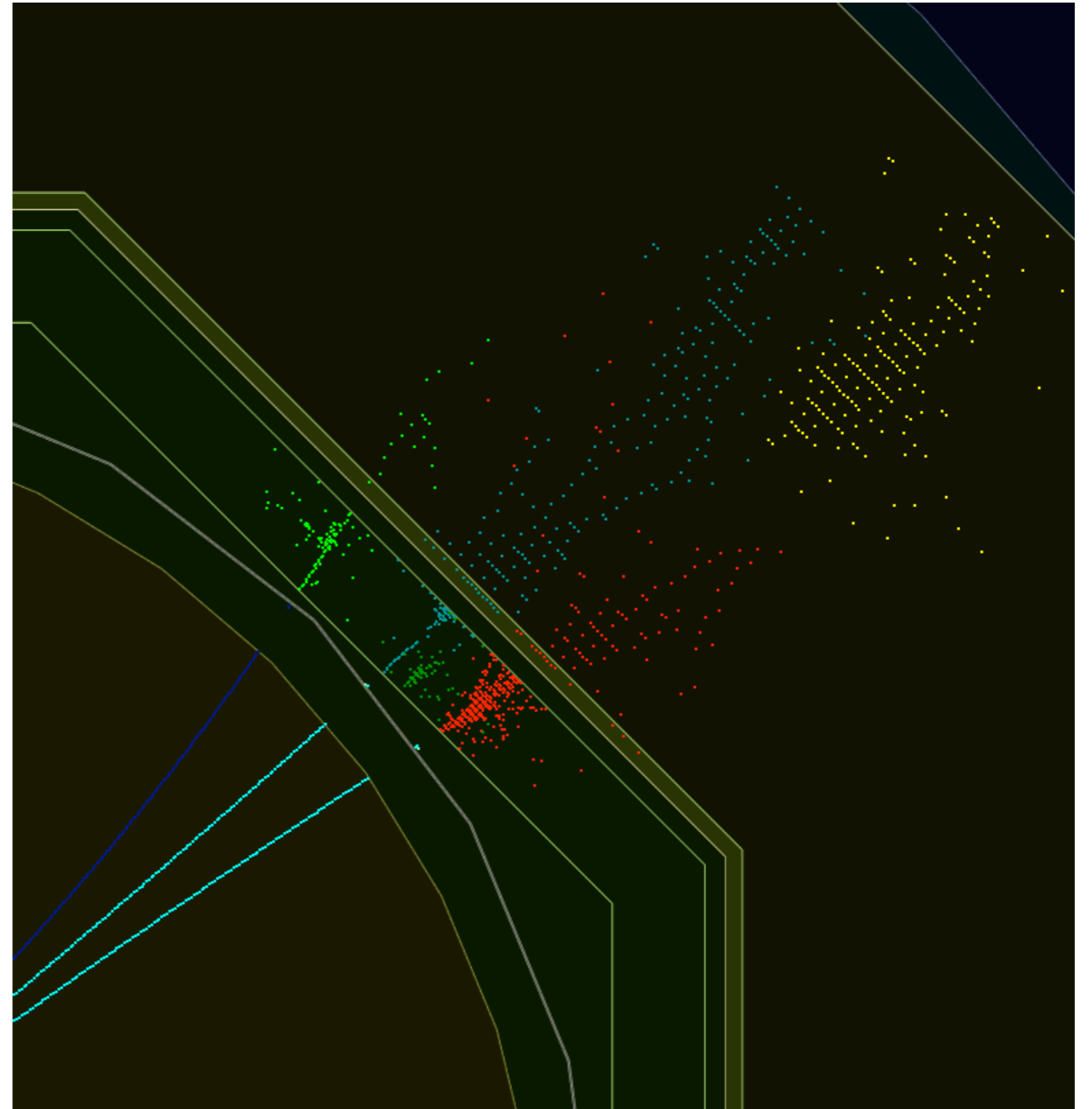
5. construction of a test beam module.
  - strip size are decided according to the simulation results.

**Back up**

# without the strip splitting.

White arrows show lacks of hit in the track and the circles show strange hits.

I'm afraid bugs, but I've not yet found them.



# with SSA

