# An improvement of strip calorimeter reconstruction

29th May 2013

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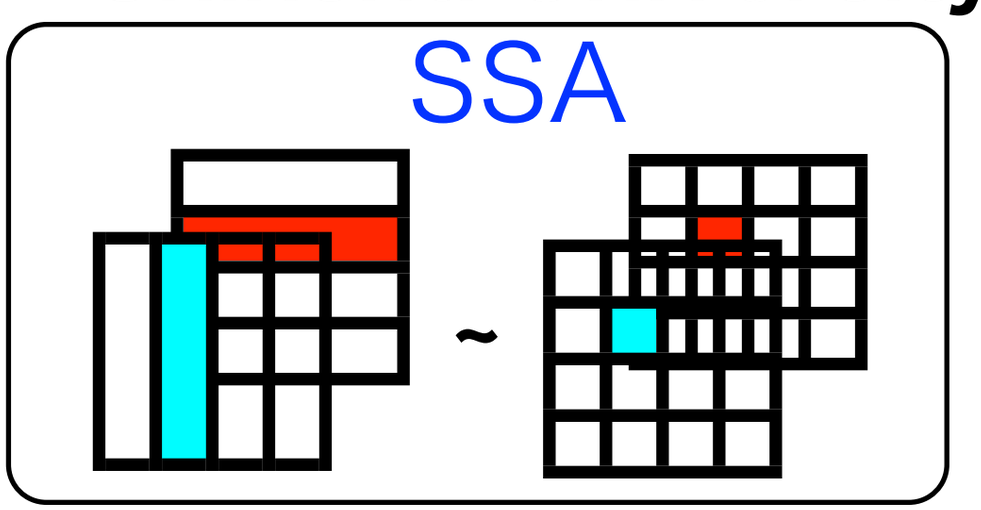

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4. applying to the strip scintillator HCAL,
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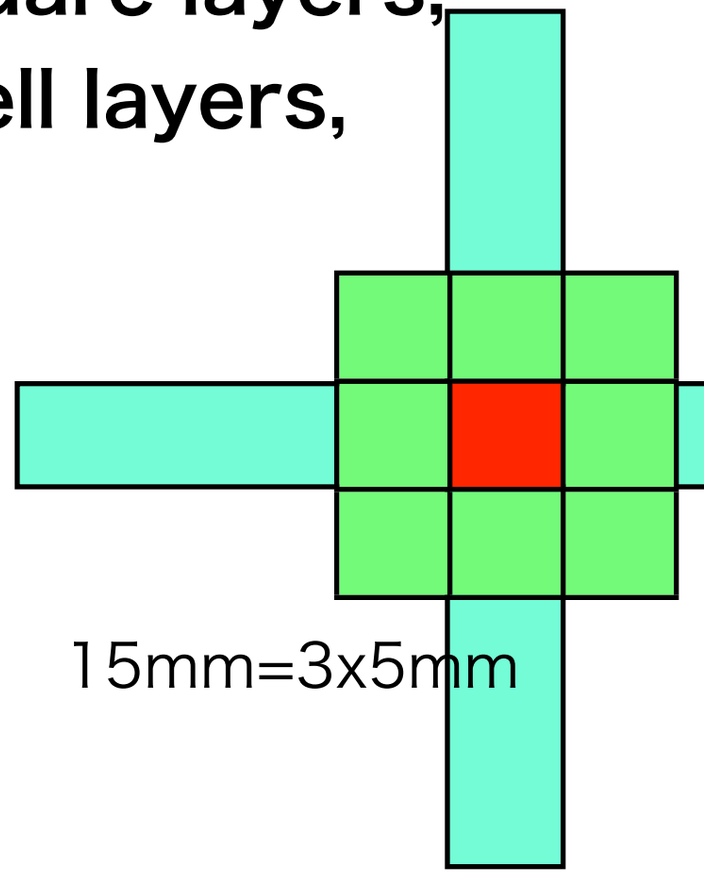
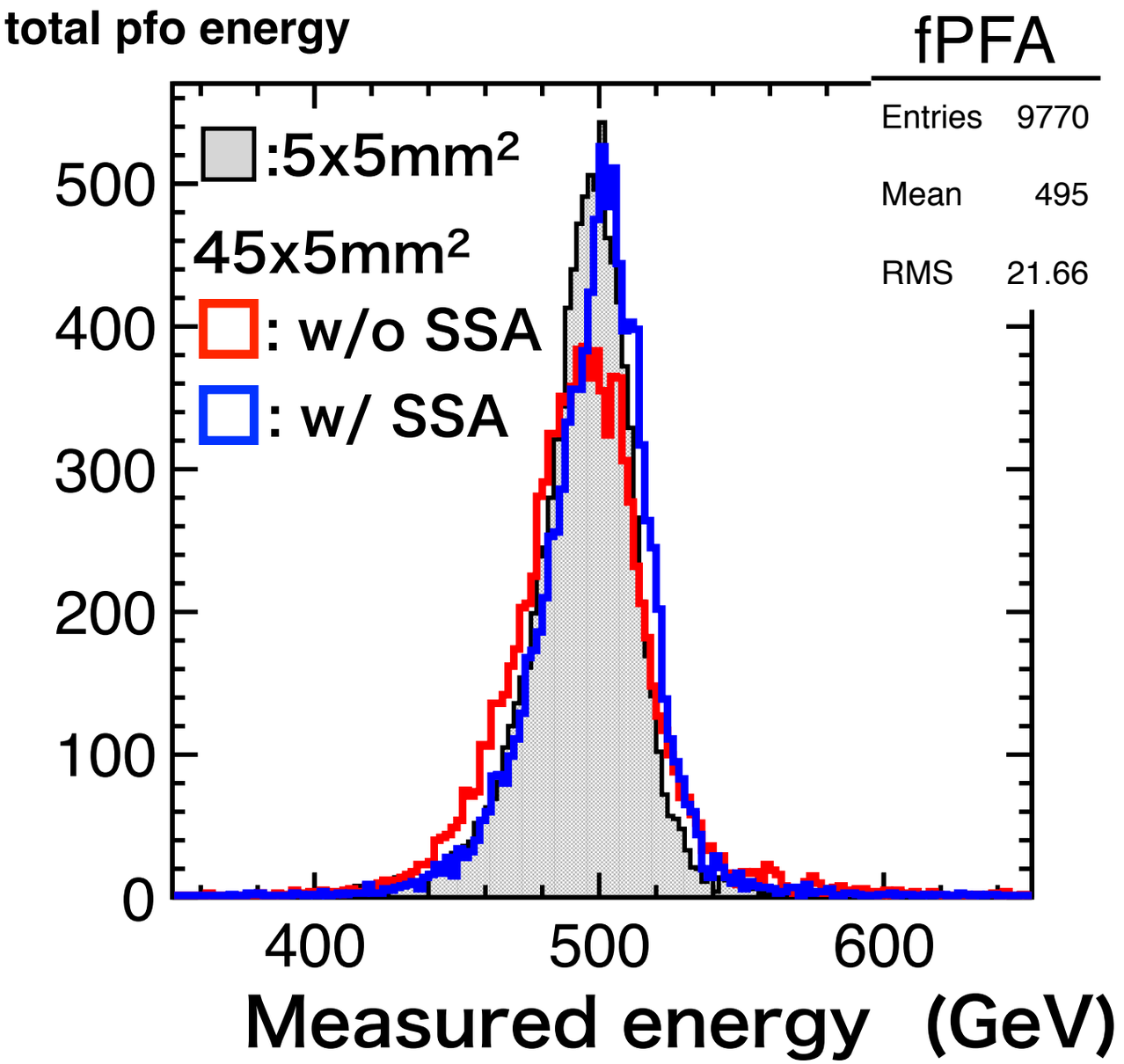



- we use 0.5 mm thick scintillator layers to avoid detail tuning of PandoraPFA in this talk.

ILD_o3_v05+ilcsoft version v01-16

# Energy Spectrum of 250 GeV two jets

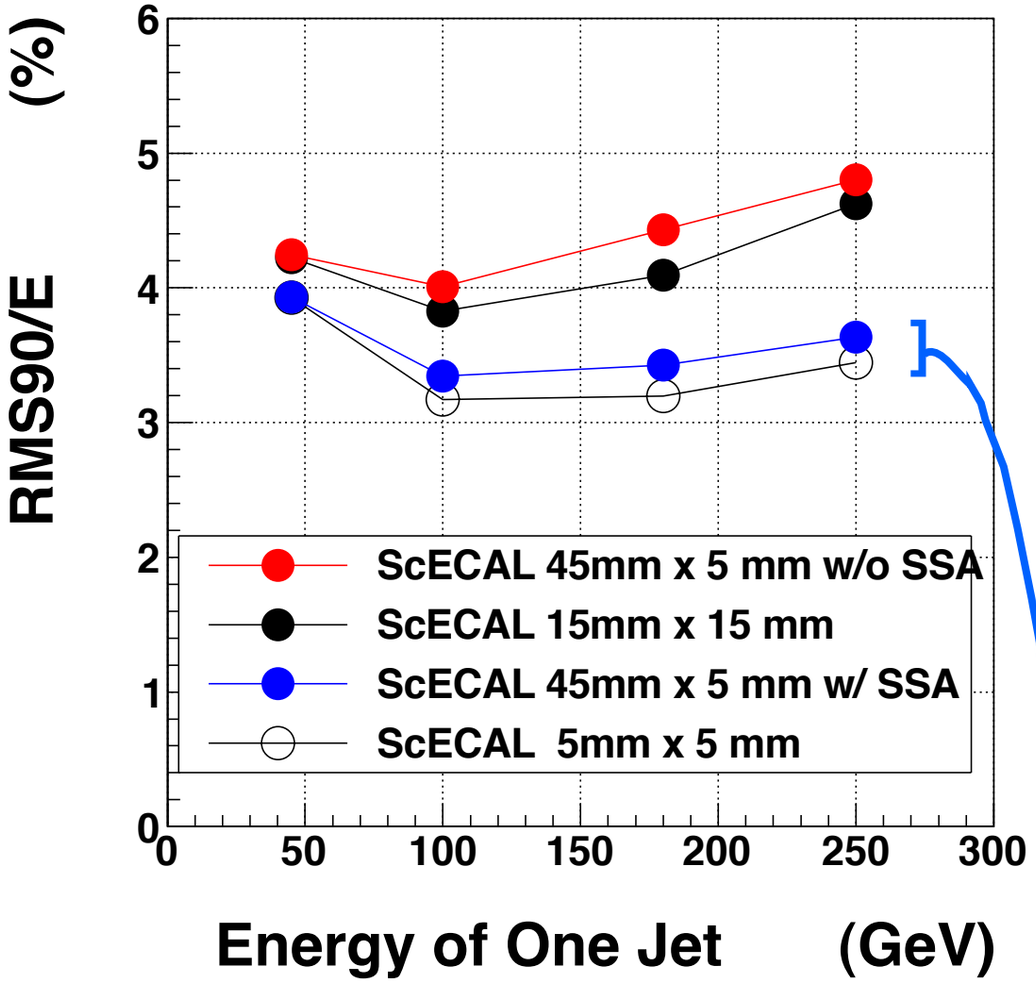



- RMS90/E
  5 x 5 mm²: 3.44±0.03%,
  45x 5 mm²:
  w/o SSA : 4.80±0.05%,
  w/ SSA : 3.63±0.03%.

- SSA clearly improves the jet energy reconstruction.

# Two Jet Energy Resolution

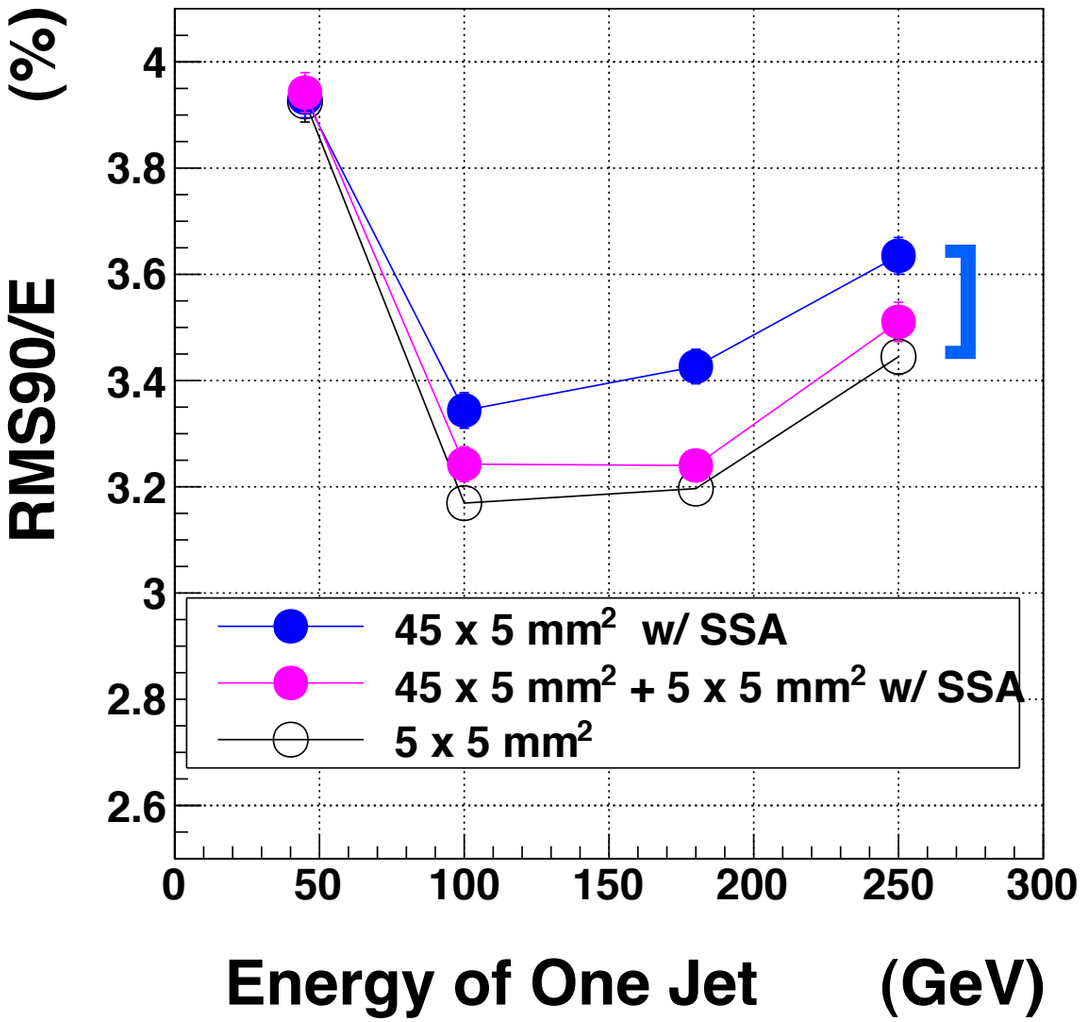
## depending on the jet energy




- JER is significantly improved by SSA ( ● → ● ) especially for high energy.
- Comparison of JER between 45 x 5 mm² ECAL with SSA and 15 x 15 mm² ECAL ( ● → ● ) shows also good performance of SSA.
- Performance of 45 x 5 mm² ECAL with SSA is close to that of 5 x 5 mm² ECAL ( ○ → ● ).
- Still a room to be improved

# More improvement

## 45 x 5 mm² + 5 x 5 mm² alternate




Configuration of (45x5 + 5x5)mm²;
tile-stripX-tile-stripZ-...
all layers are scintillator sensors

- One of the reason of degrading JER with strip ECAL + SSA comes from the two fold ambiguity (ghost).
- Easiest way to avoid this phenomenon is to put 5 x 5 mm² segmentation layers in between strip layers.
- The 5 x 5 mm² layers between strip layers improve JER well.
- but 5 x 5 mm² is difficult:

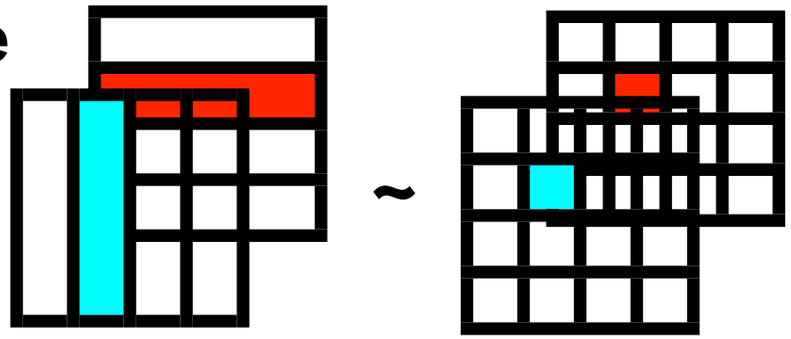
➡ use Si-layers for 5 x 5 mm²

➡ use 10 x 10 or 15 x 15 mm² cells with a special algorithm.

# How to use 15 x 15 mm² tile layers

In case we use 5 x 5 mm² tile scintillator, every strip energy is split into the virtual 5 x 5 mm² cells, by referring 5 x 5 mm² cells in the nearest layers.

we do not use the merit of this location of layers.



also OK, but this means that we lose some information.

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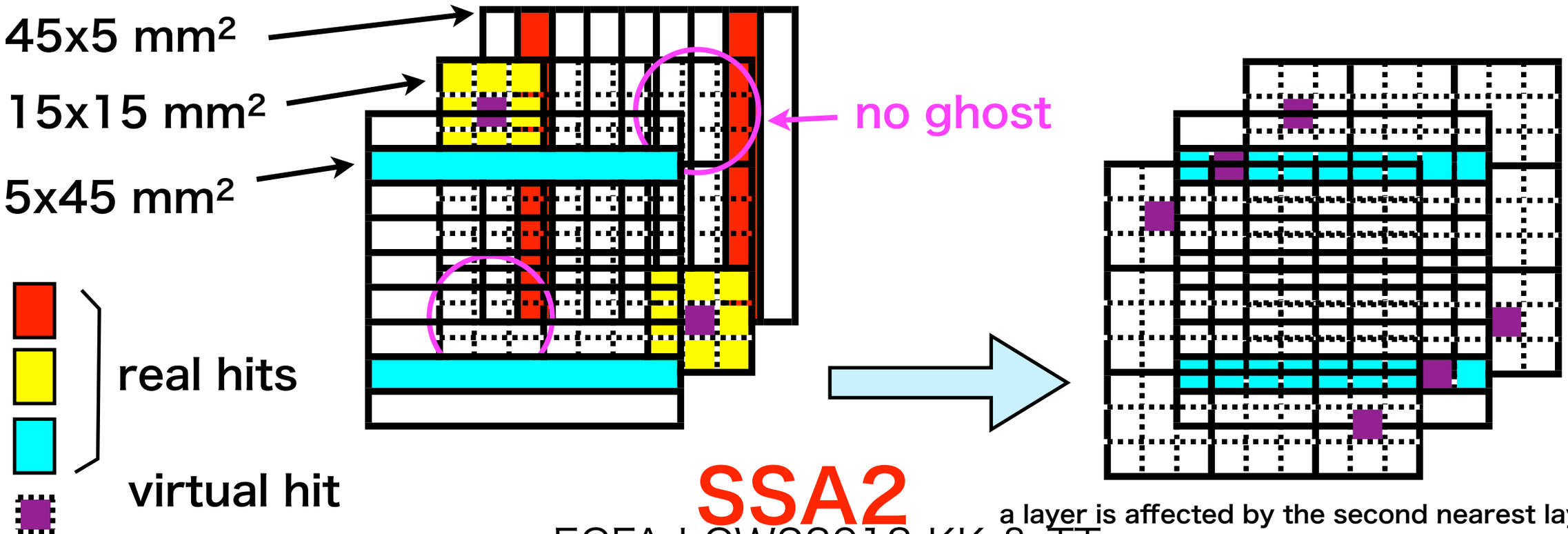
1st step: tile hits are split by referring strip hits

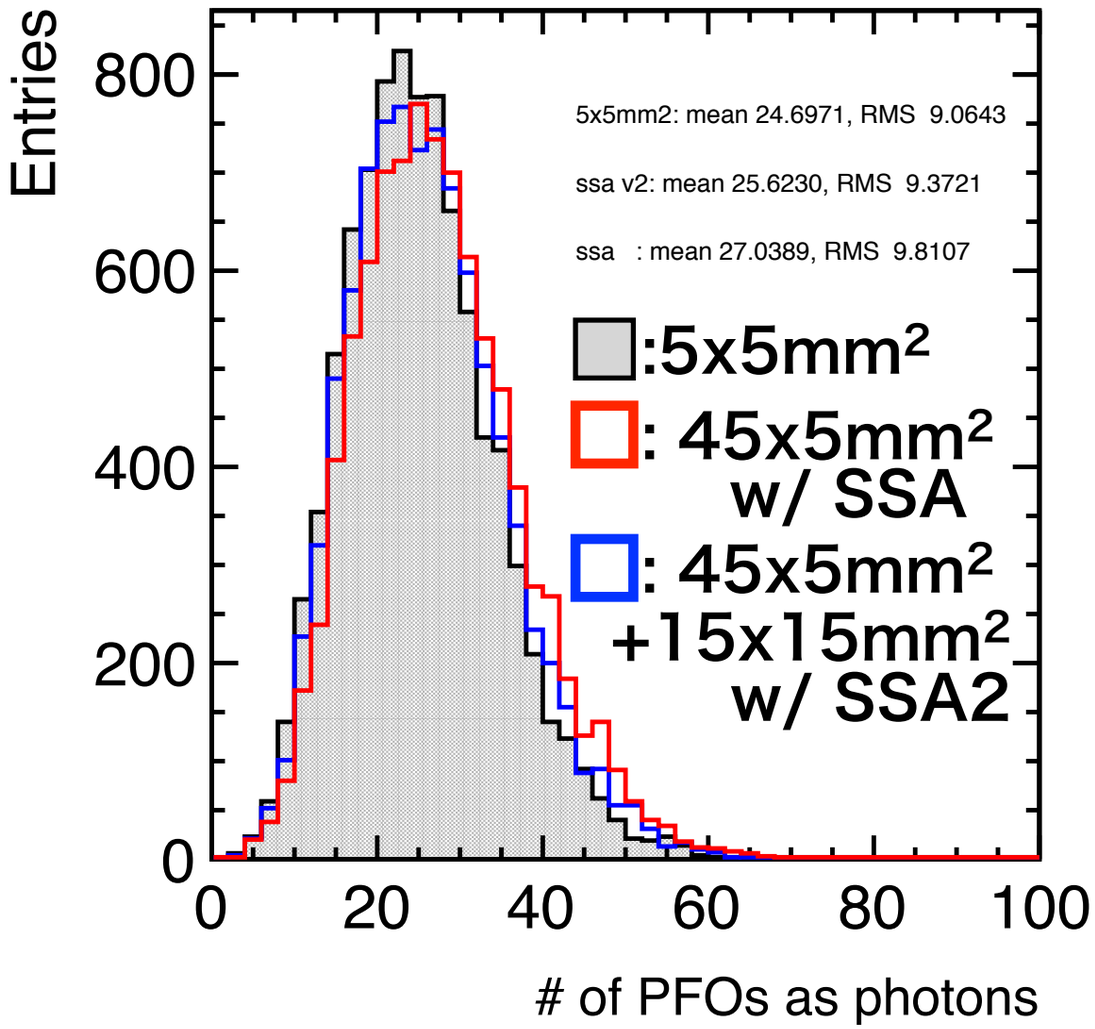
2nd step: strip hits are split by referring virtual tile hits




**SSA2** a layer is affected by the second nearest layers

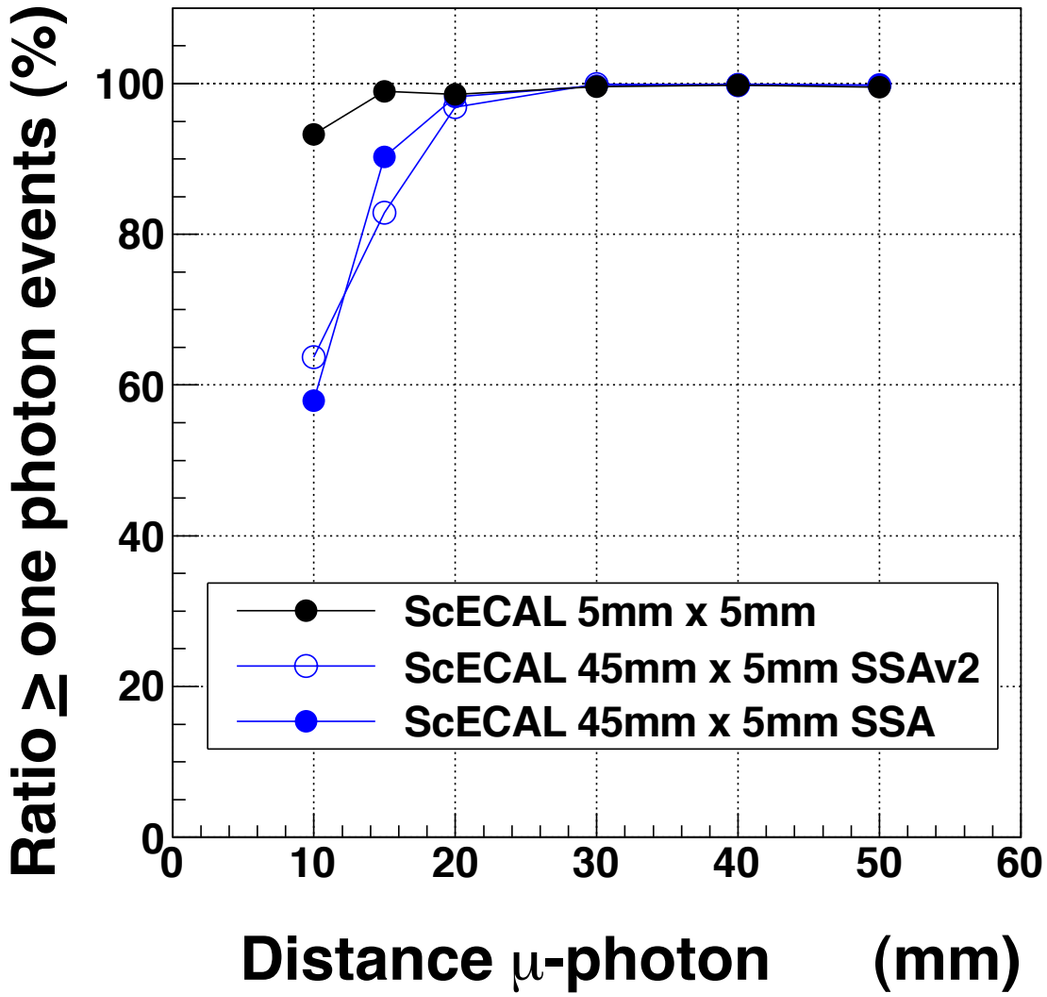
# Ghost rejection and Separation

## # of PFO photons in 100 GeV jets




**# of photons are improved. ghosts are prevented.**

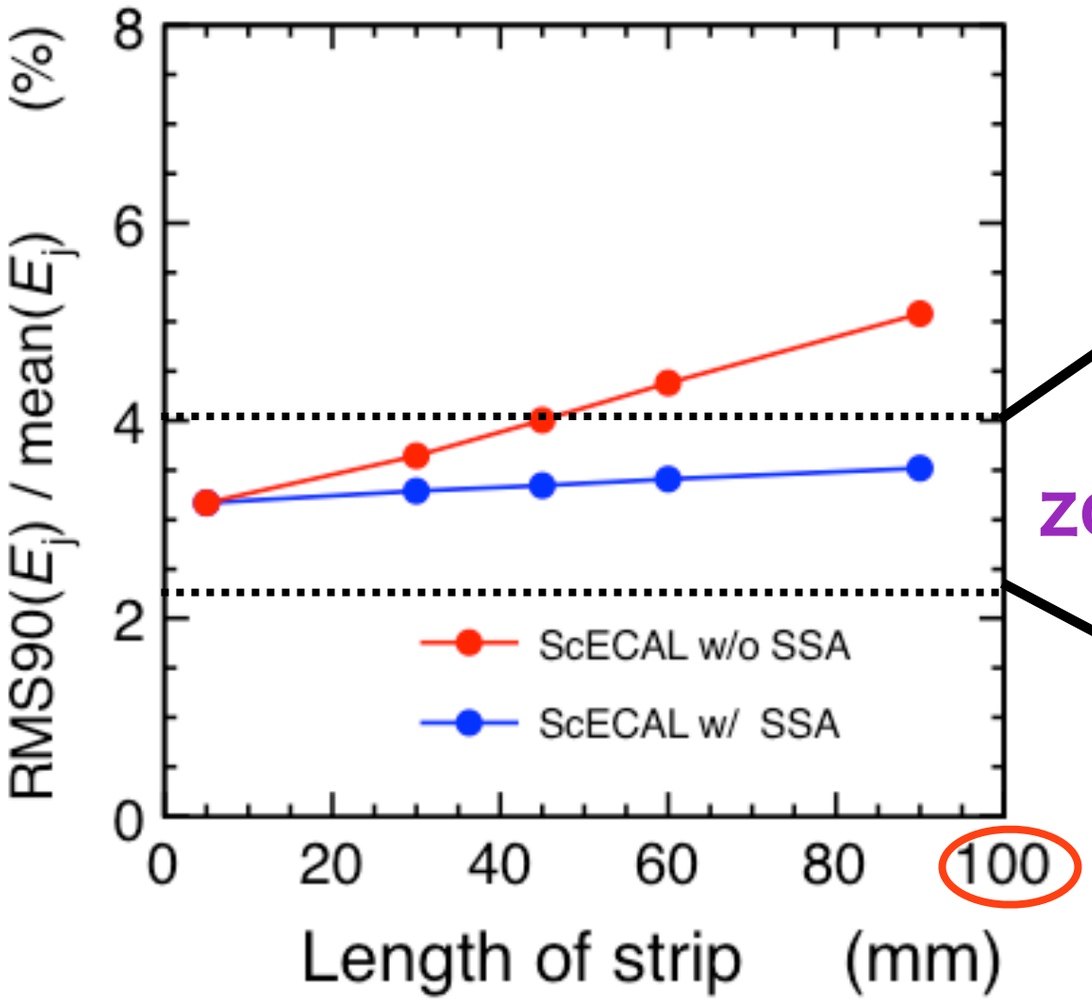
## $\mu$-$\gamma$ separation on barrel 500 GeV, 10 GeV



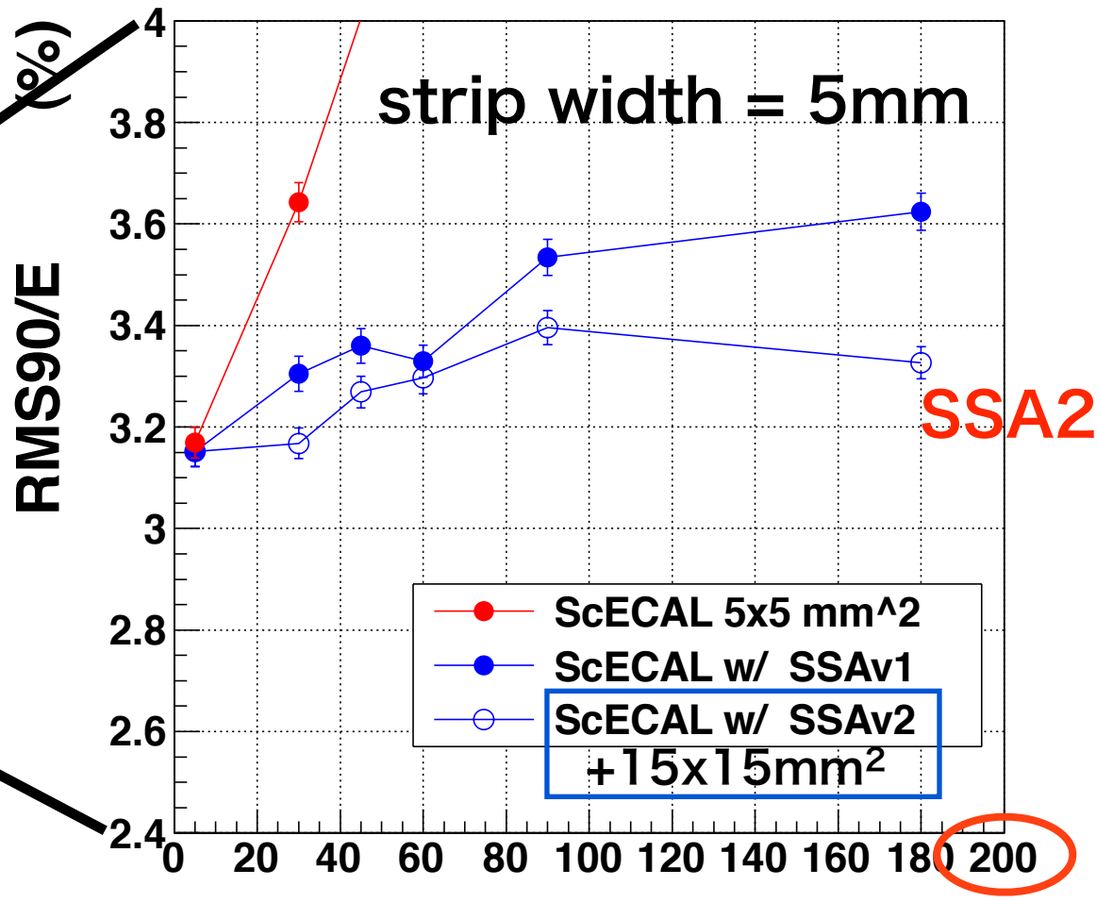

Every method has 20 mm separation. SSA2 does not improve SSA.

**Separation power is controlled width of 45 x 5 mm strips.**

# JER(100GeV)-strip length




zoom up



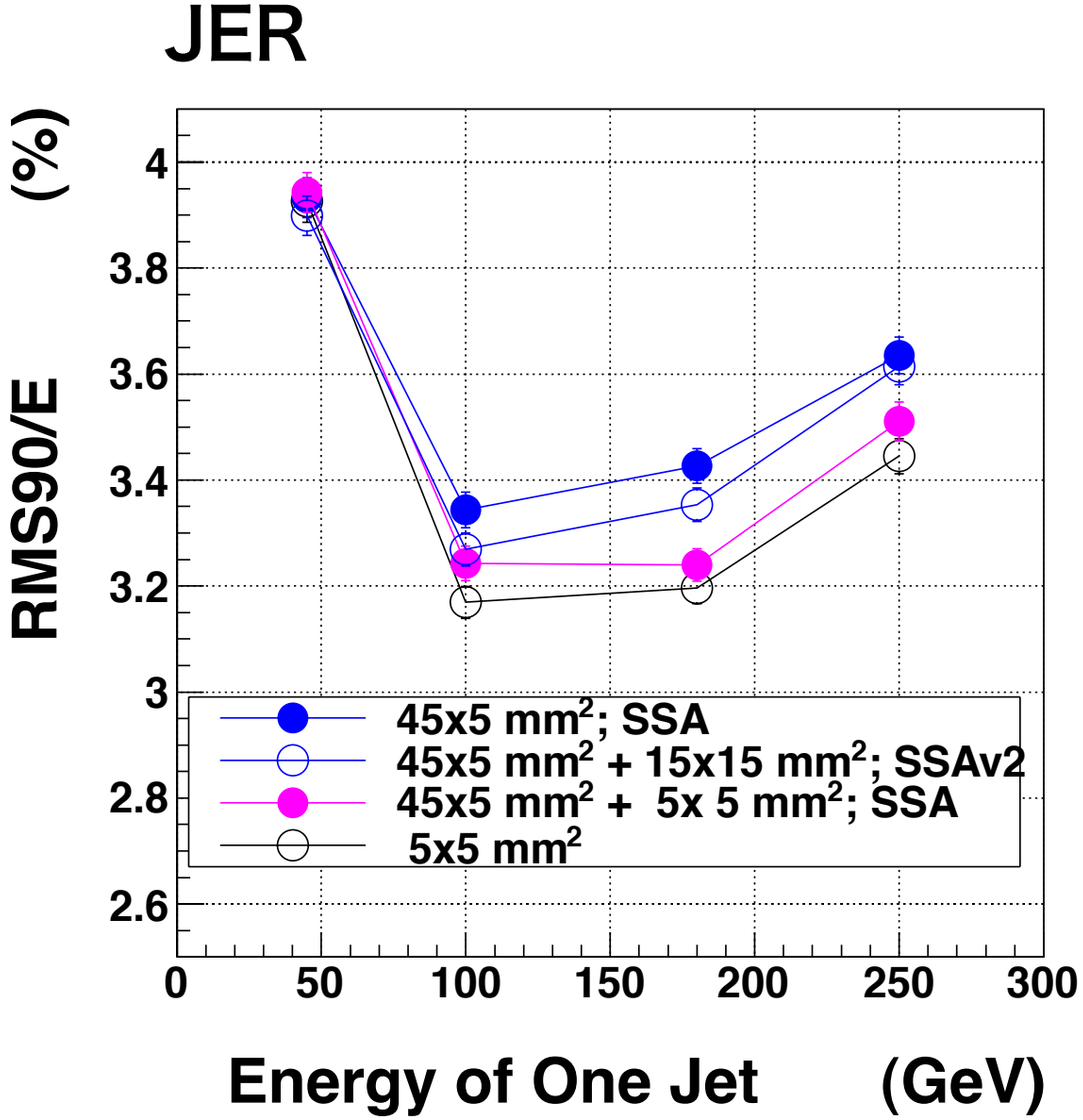

in ILD-DBD
SSA

Jet energy resolution for
100 GeV is clearly improved
by using SSA2.

- 30 mm long with SSAv2 is good choice(?)
- We even can make fiber ECAL(?)
  Fiber scintillator is technologically realistic.

# JER with

## 45 x 5 mm² + 15 x 15 mm² alternate



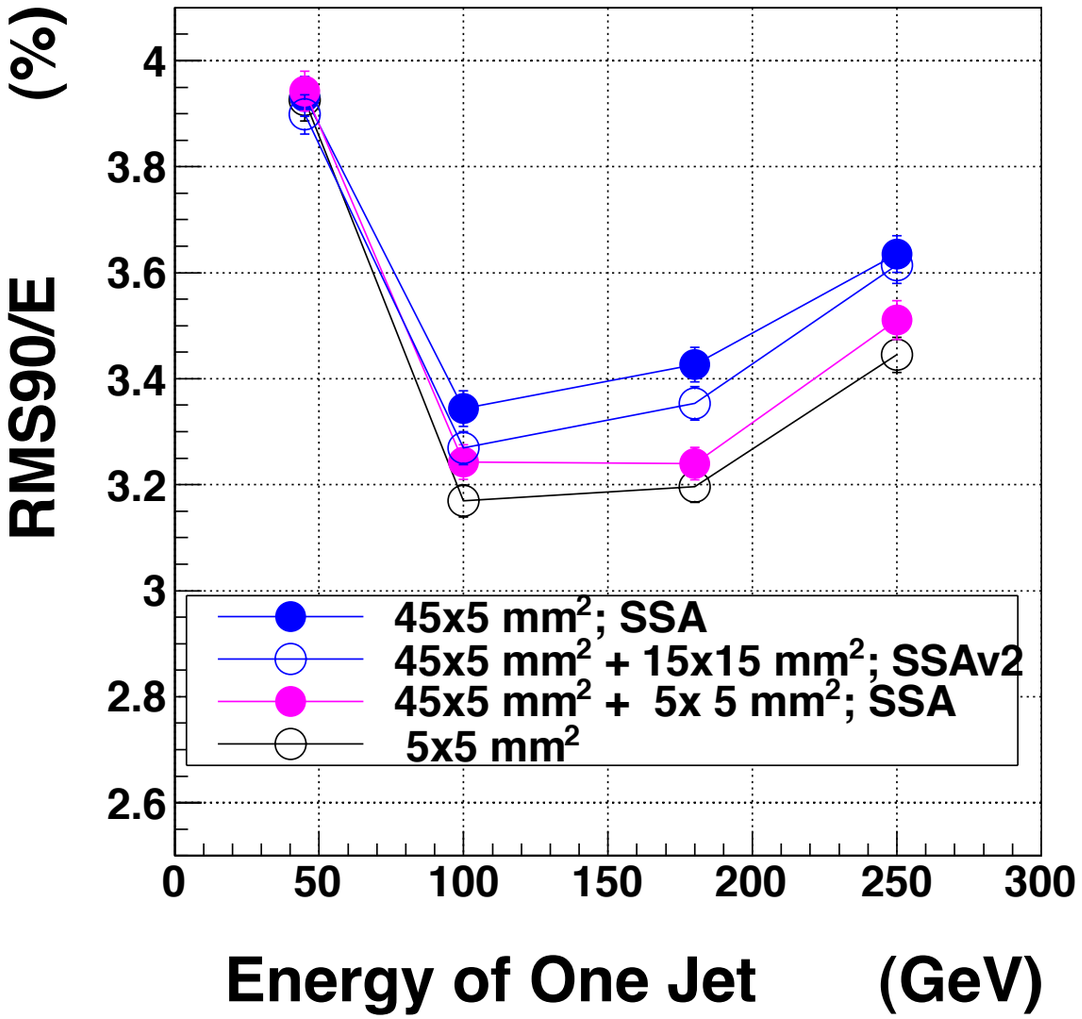

JER is improved especially up to 200 GeV

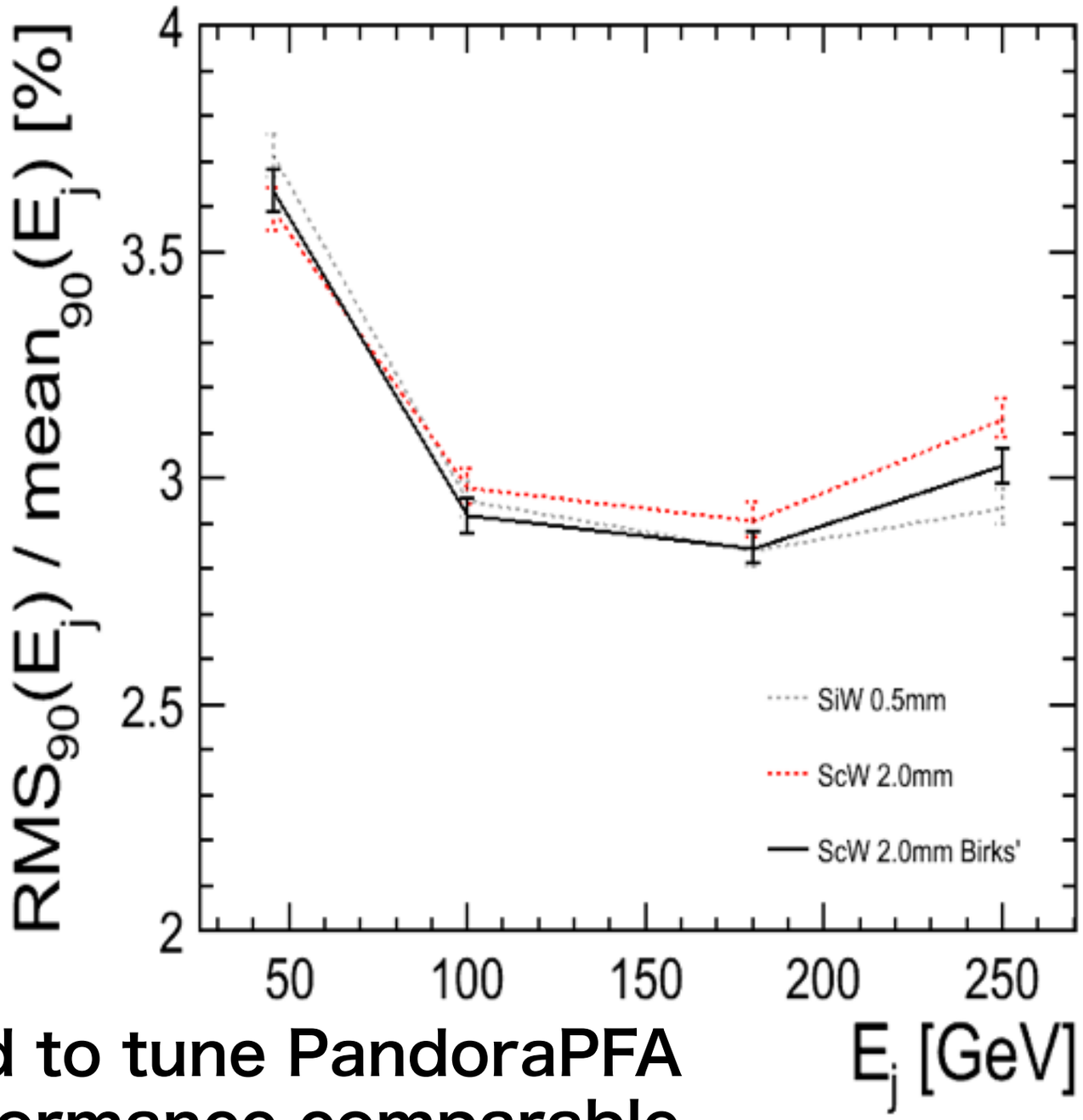
effect decreases as jet energy increases.

10 x 10 mm² tile layers can be expected to make more effective improvement

# Pandora PFA tune for 5x5mm²

## ScECAL




In Ecal cost reduction study:

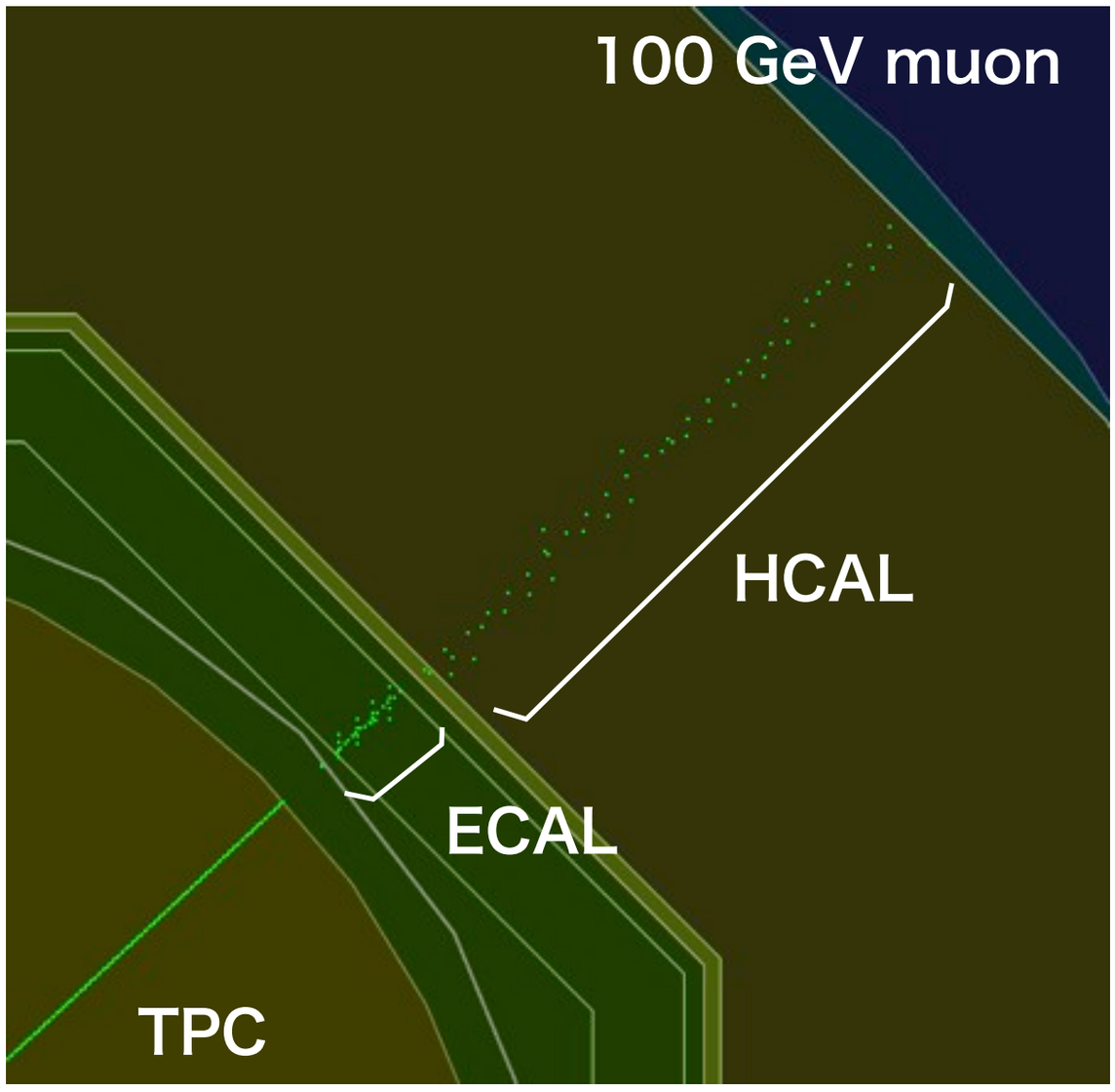
John Marshall has succeeded to tune PandoraPFA having 5x5 mm ScECAL performance comparable with the SiECAL

➡ I'll introduce his tune.

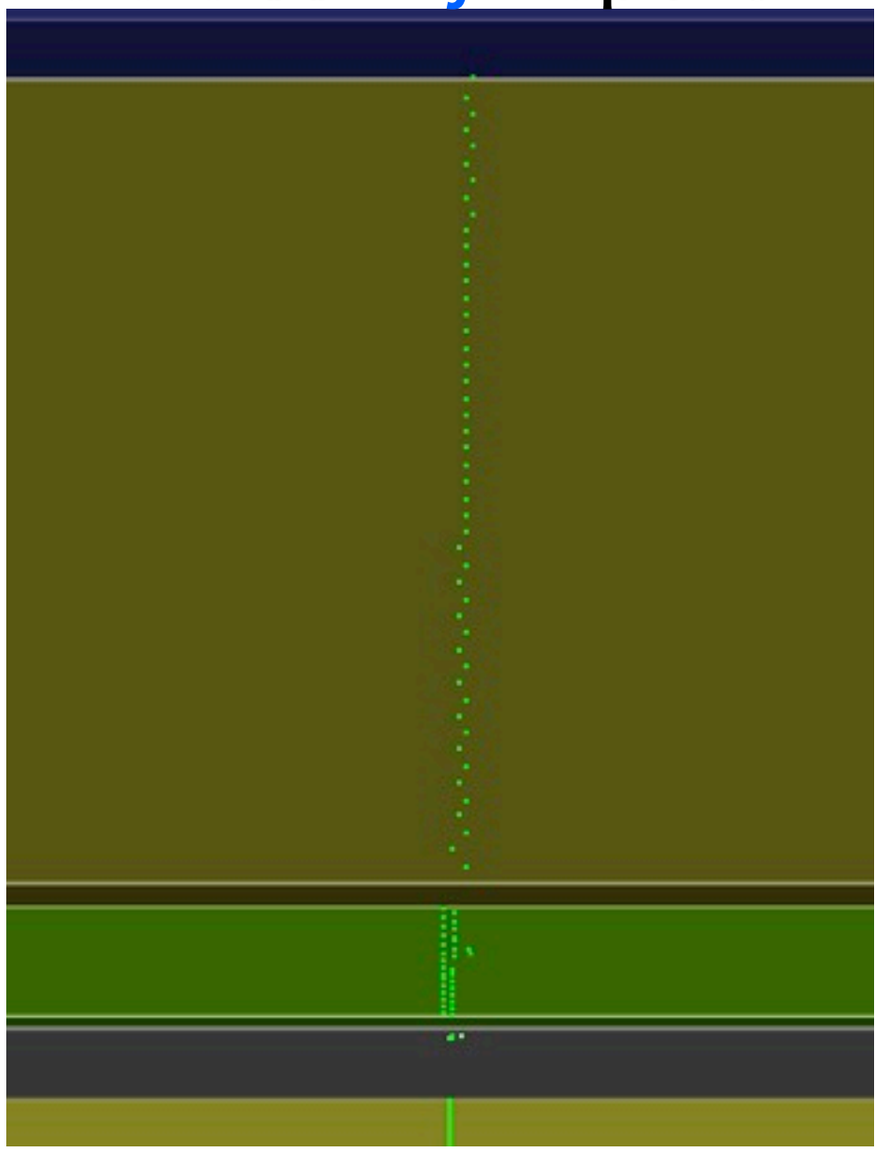
# Applying to the strip HCAL

## An event of 100 GeV muon without SSA

Before SSA : x - y plane




Before SSA : y - z plane

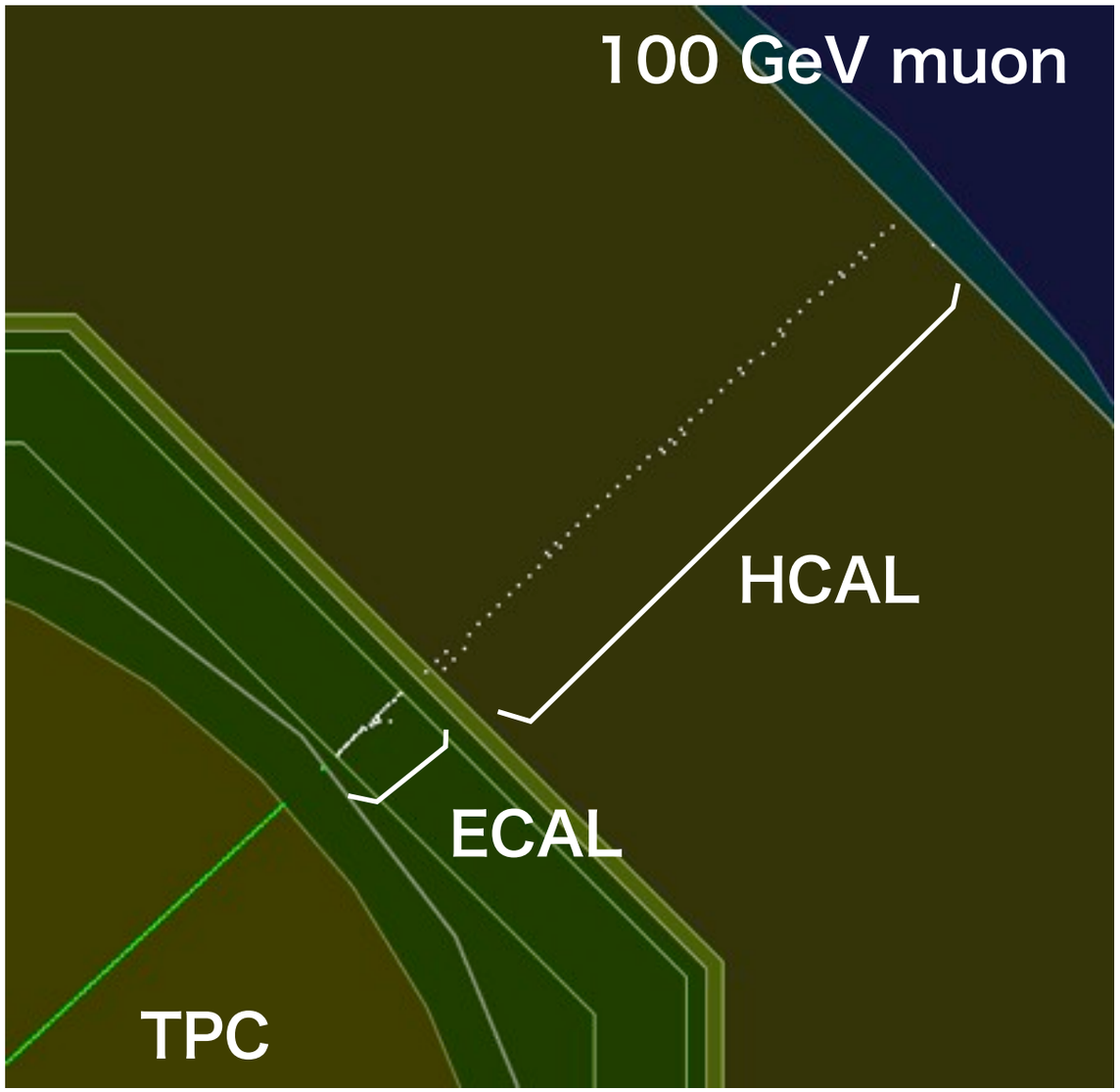


**10 mm x 90 mm strips in HCAL.**

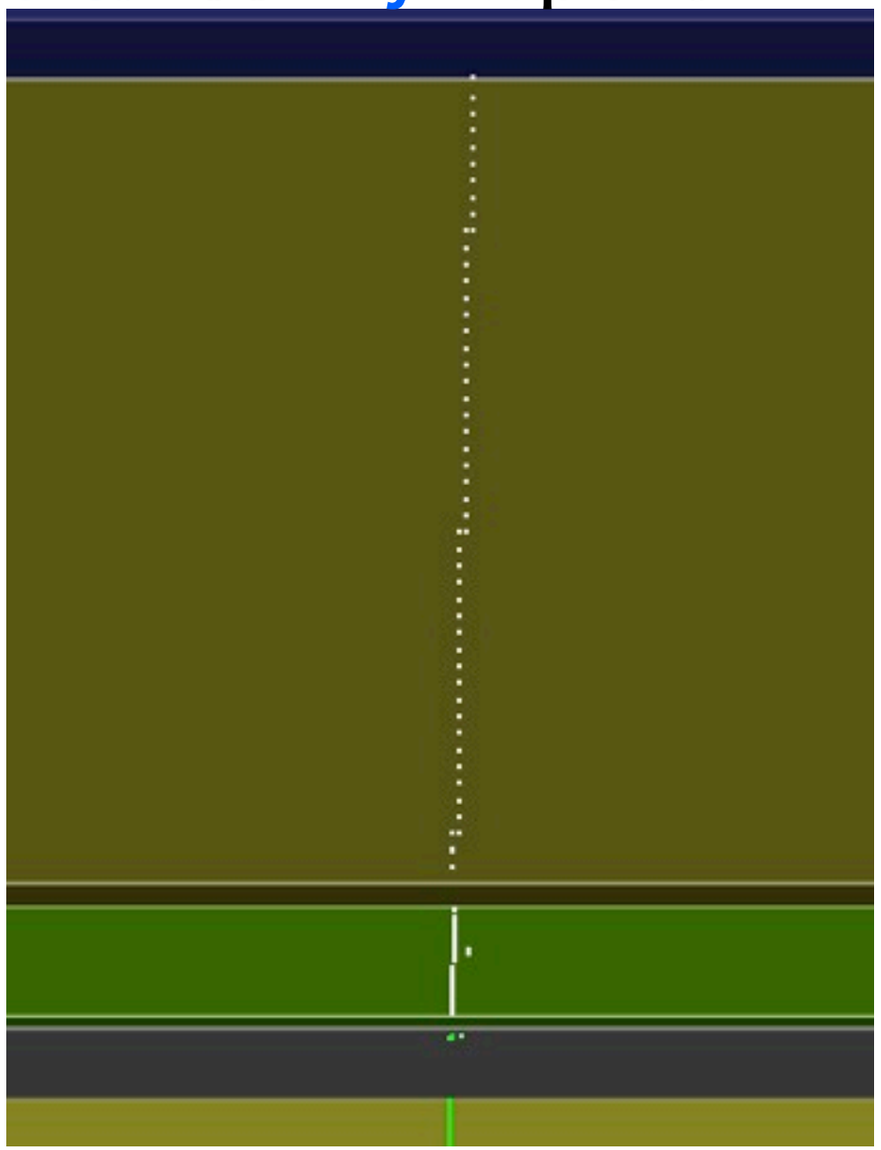
# Application to the strip HCAL

## Clear muon track in HCAL appears with SSA

after SSA : x - y plane




after SSA : y - z plane



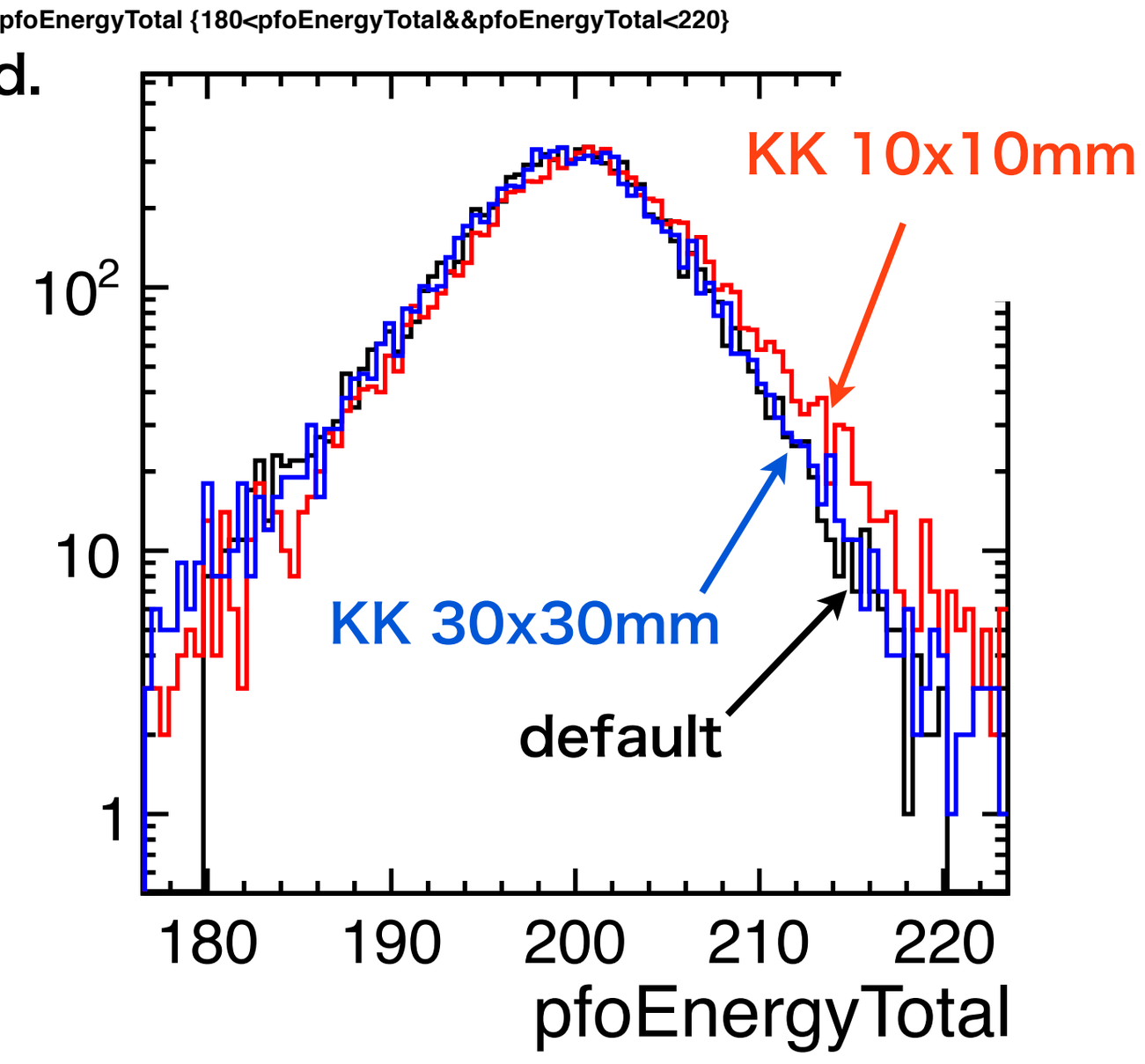
**10 mm x 90 mm strips in HCAL.**

# We need some tunes for 10 x 10 mm² tile HCAL

ECAL : ILD SiECAL
100 GeV uds two jets were injected.

Even after calibration with 10 GeV photon and 10 GeV kaon, Jet energy resolution by our 10x10 mm² tile AHCAL has degradation from the default ILD_o1_V5(DBD version: 30 x 30 mm² tile AHCAL).

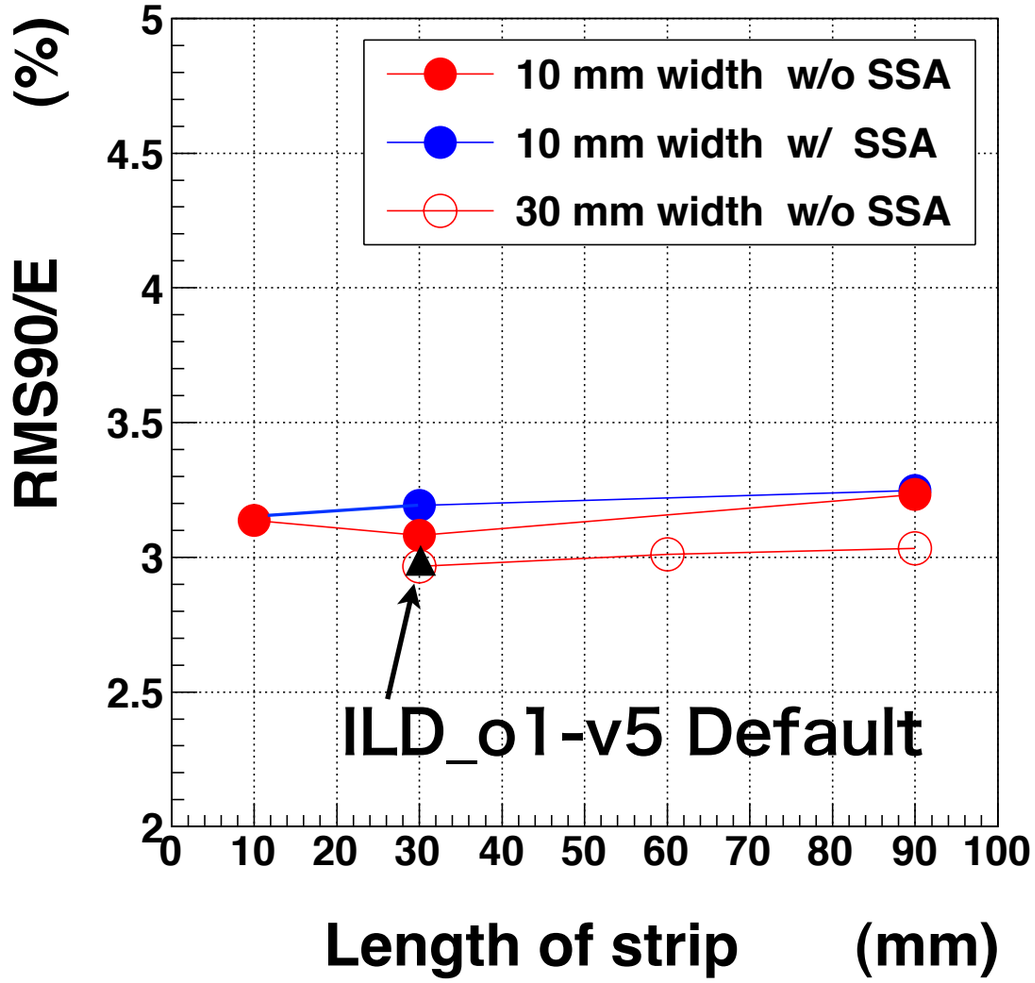
Our 30 x 30 mm² model by using the same way to make 10 x 10 mm² has similar JER to the default HCAL. .... This means that we need some PandoraPFA tune for 10 x 10 mm² tile HCAL.




ILD-DBD-AHCAL is 30x30 mm²

# 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 we 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 mm² strip and 30 x 90 mm² strip HCAL even w/o SSA ( ○ ).

scECAL

scHCAL

## Summary

1. With alternate strip and 5 x 5 mm$^2$ square layers, jet energy resolution is almost the same as we use pure 5 x 5 mm$^2$ square ScECAL.
2. With alternate strip and 15 x 15 mm$^2$ square layers, jet energy resolution is improved by using new split procedure.
3. New method potentially have good ghost rejection power, but does not improve separation power.
4. SSA was applied to the strip AHCAL.
5. In current step PandoraPFA tune is more important than the granularity of HCAL.
   - ➡ need better tuning of the PandoraPFA,
   - ➡ severer test condition

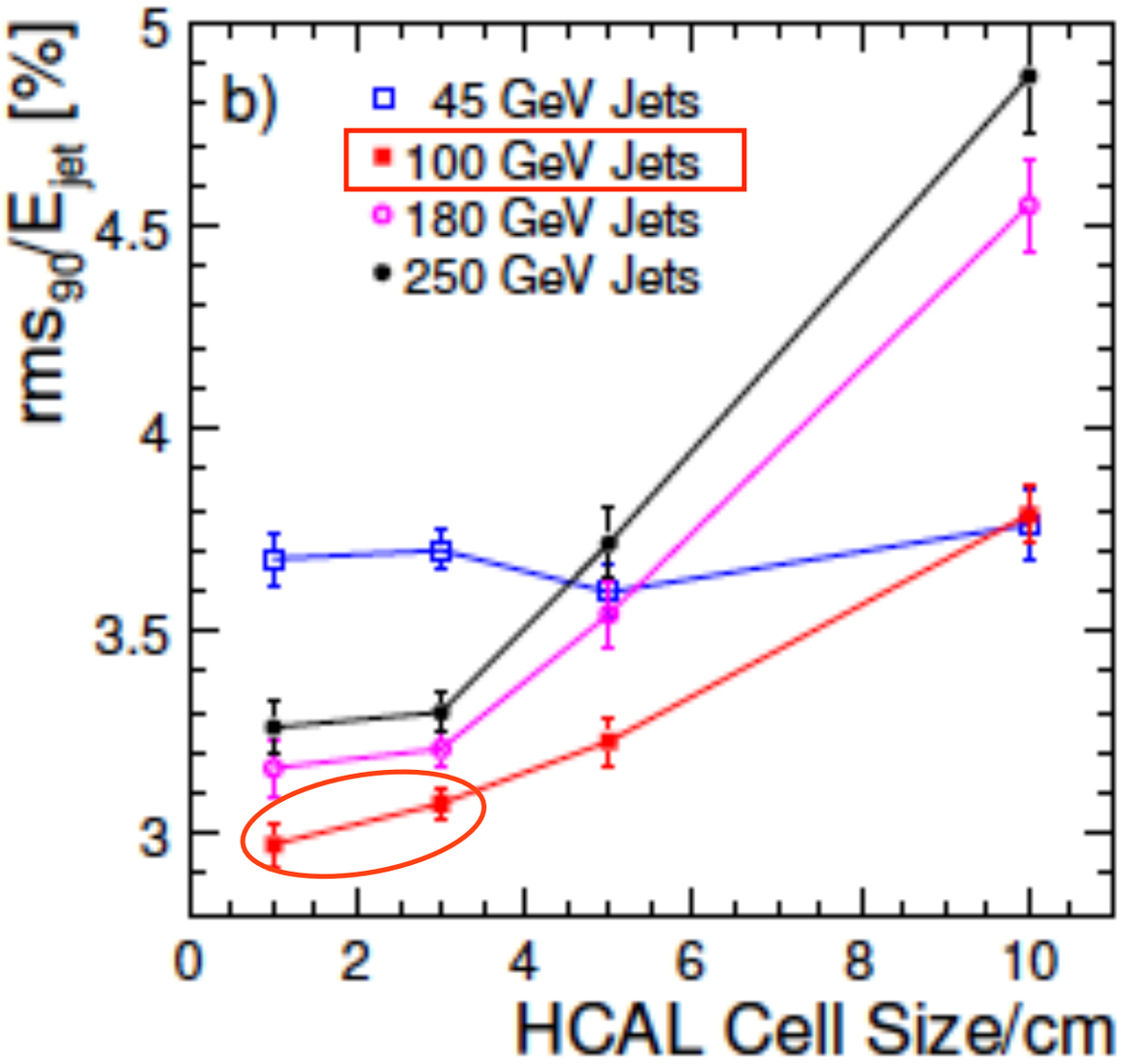
Plan:

1. Study on alternate strip and 10 x 10 $mm^2$ tile cell layers.
2. Study on alternate fiber scintillator layers (2 mm x 180 mm ) with tile scintillator layers.
3. Study with severer conditions, for example more multiple jets events
4. PandoraPFA tune according to the John's method,
5. Test strip AHCAL with severer conditions.

# Backup

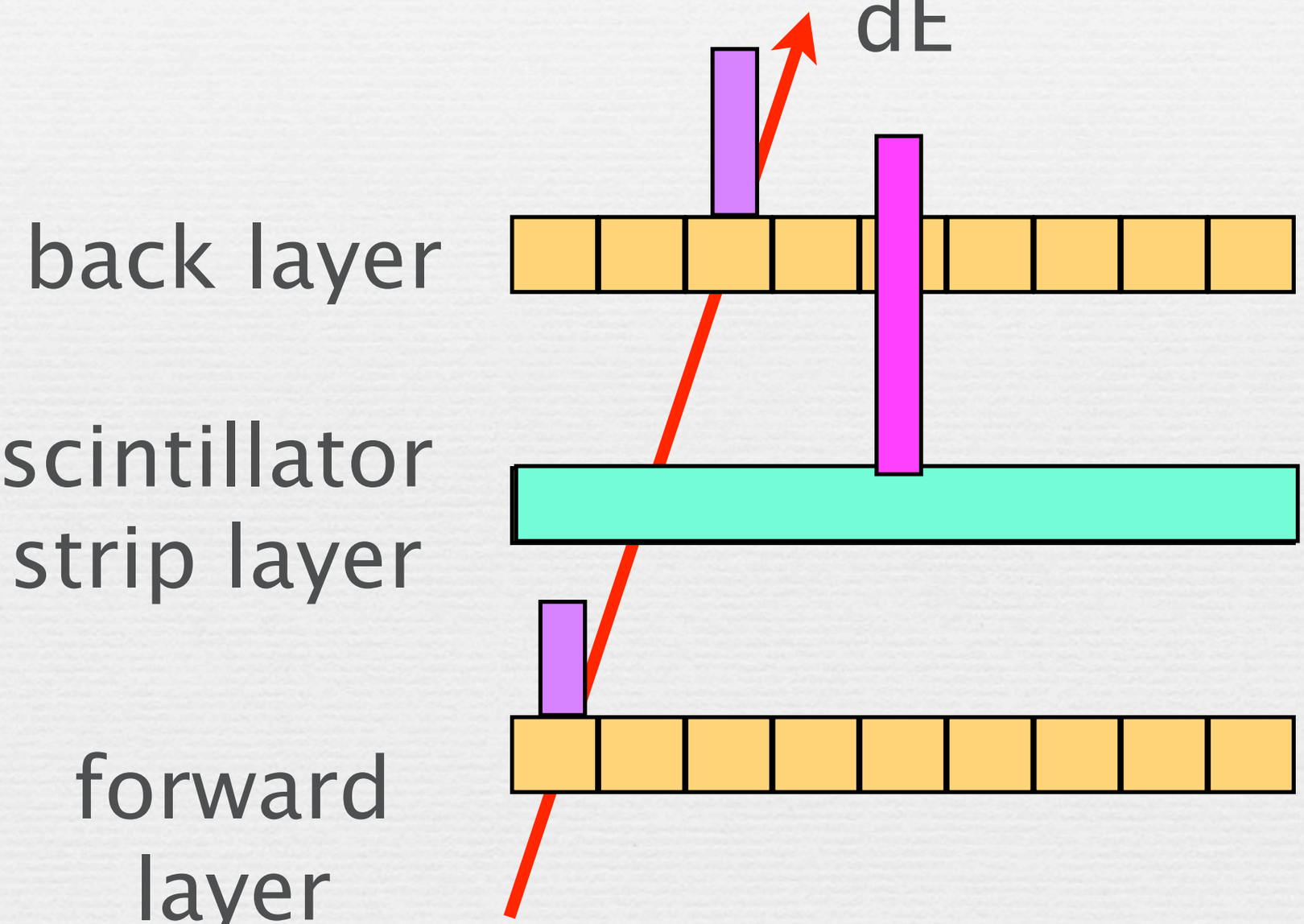
# A famous plot in the LOI
## (this is the reason why AHCAL tiles: 30 x 30 mm²)

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 uds jet events to evaluate the performance.



# SSA

- Strip Splitting Algorithm



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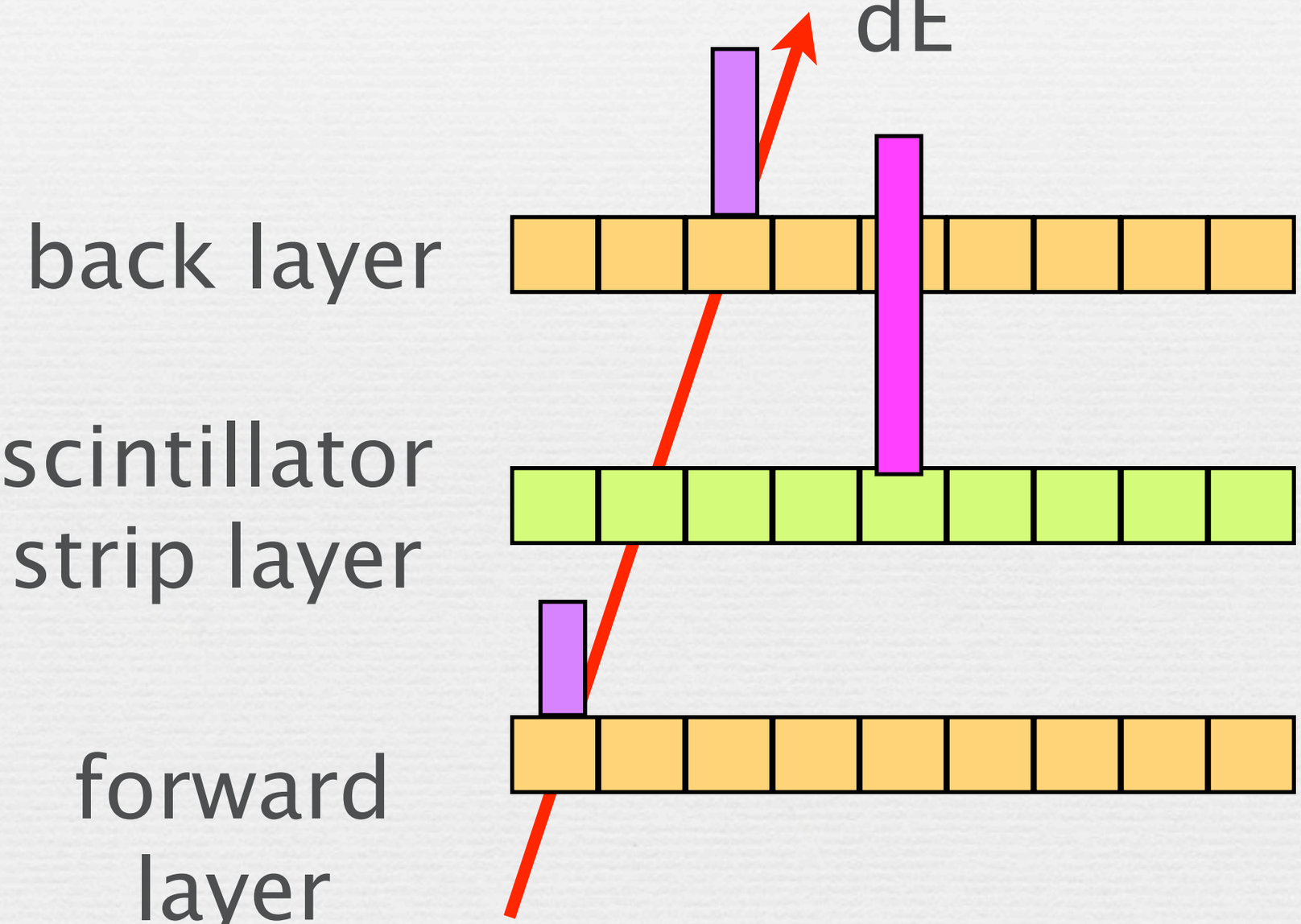
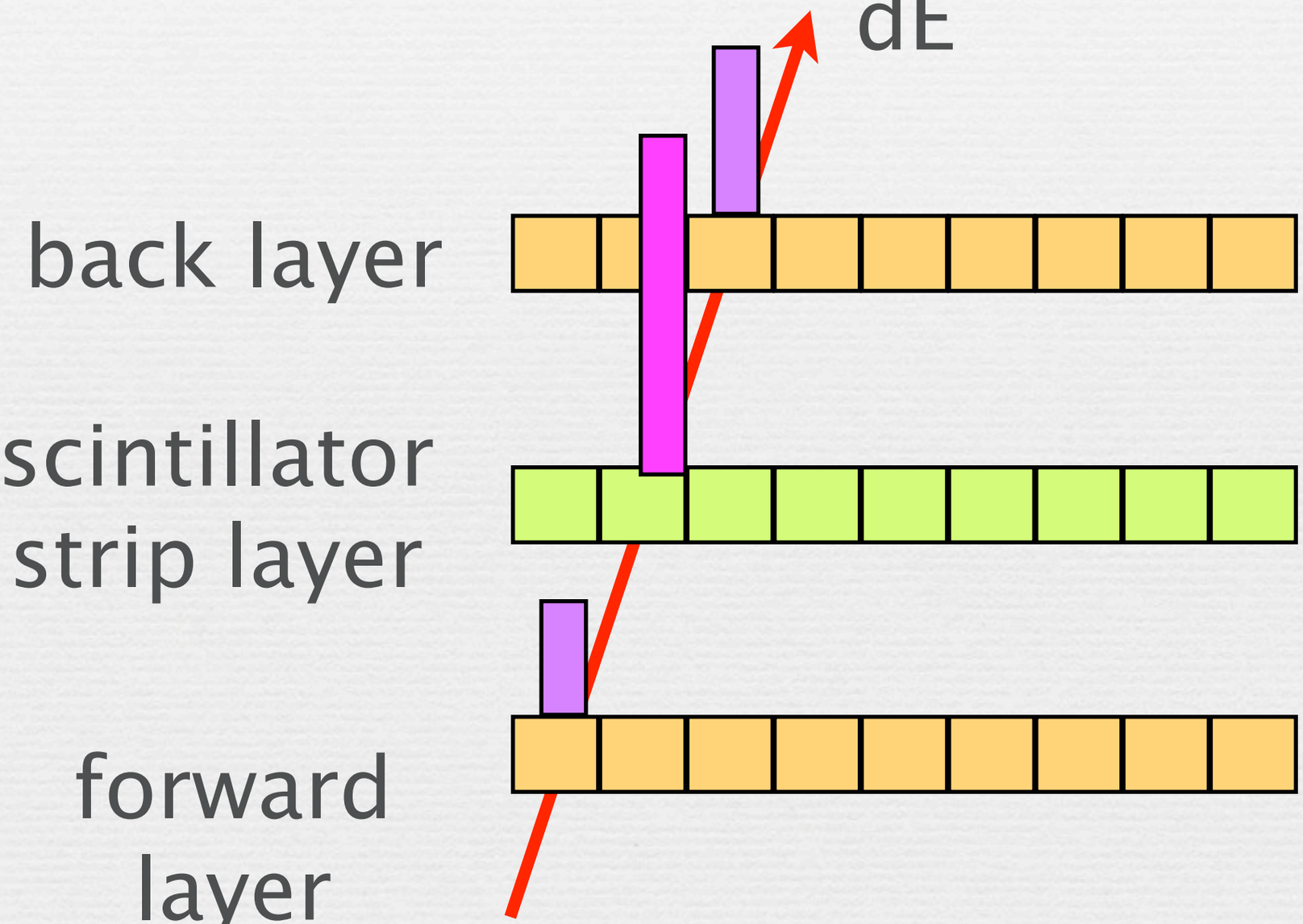
- Strip Splitting Algorithm



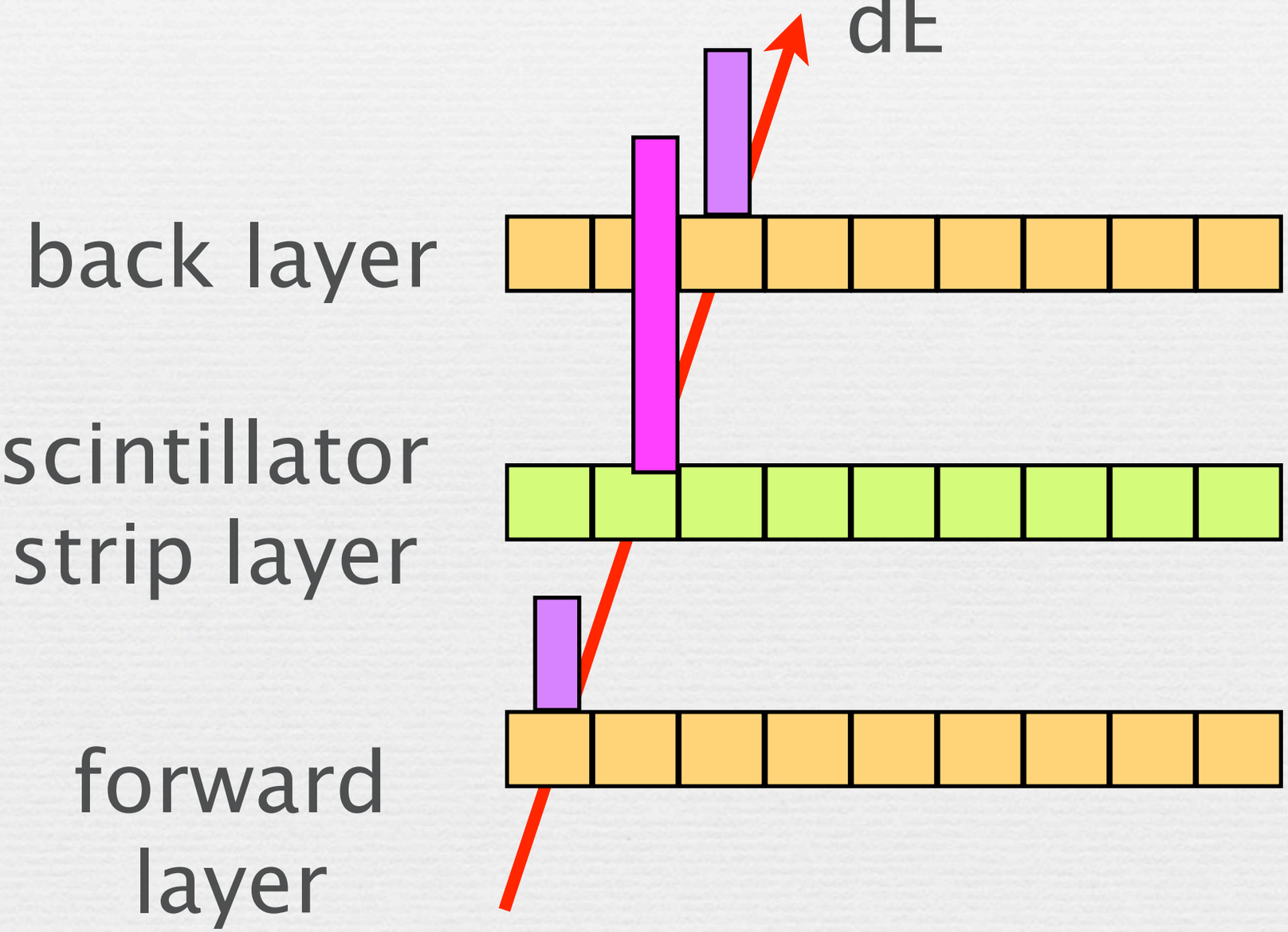
# SSA

- Strip Splitting Algorithm



# SSA

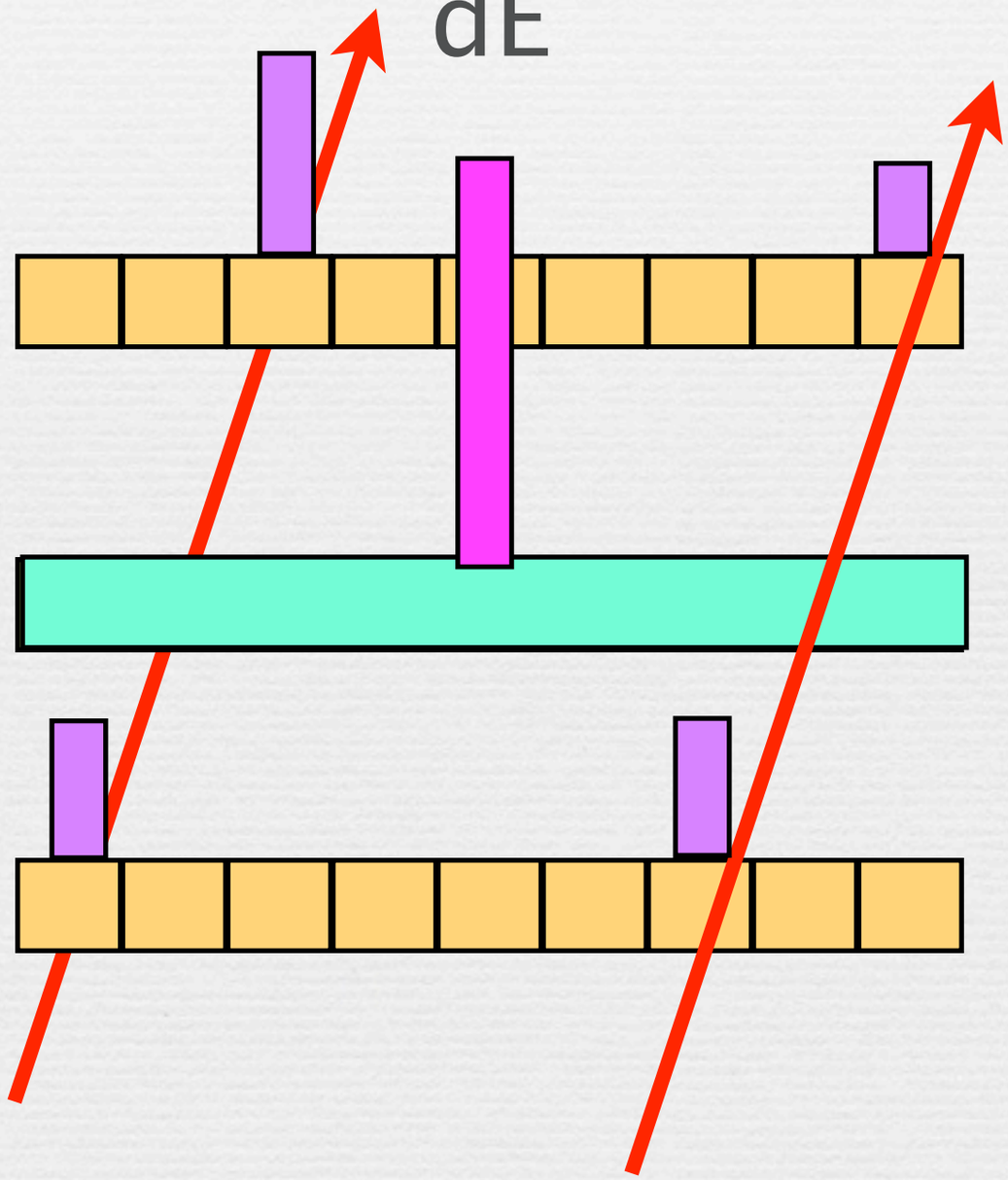
- Strip Splitting Algorithm




this info.
will be passed to PANDORA

# SSA-II

- Strip Splitting Algorithm



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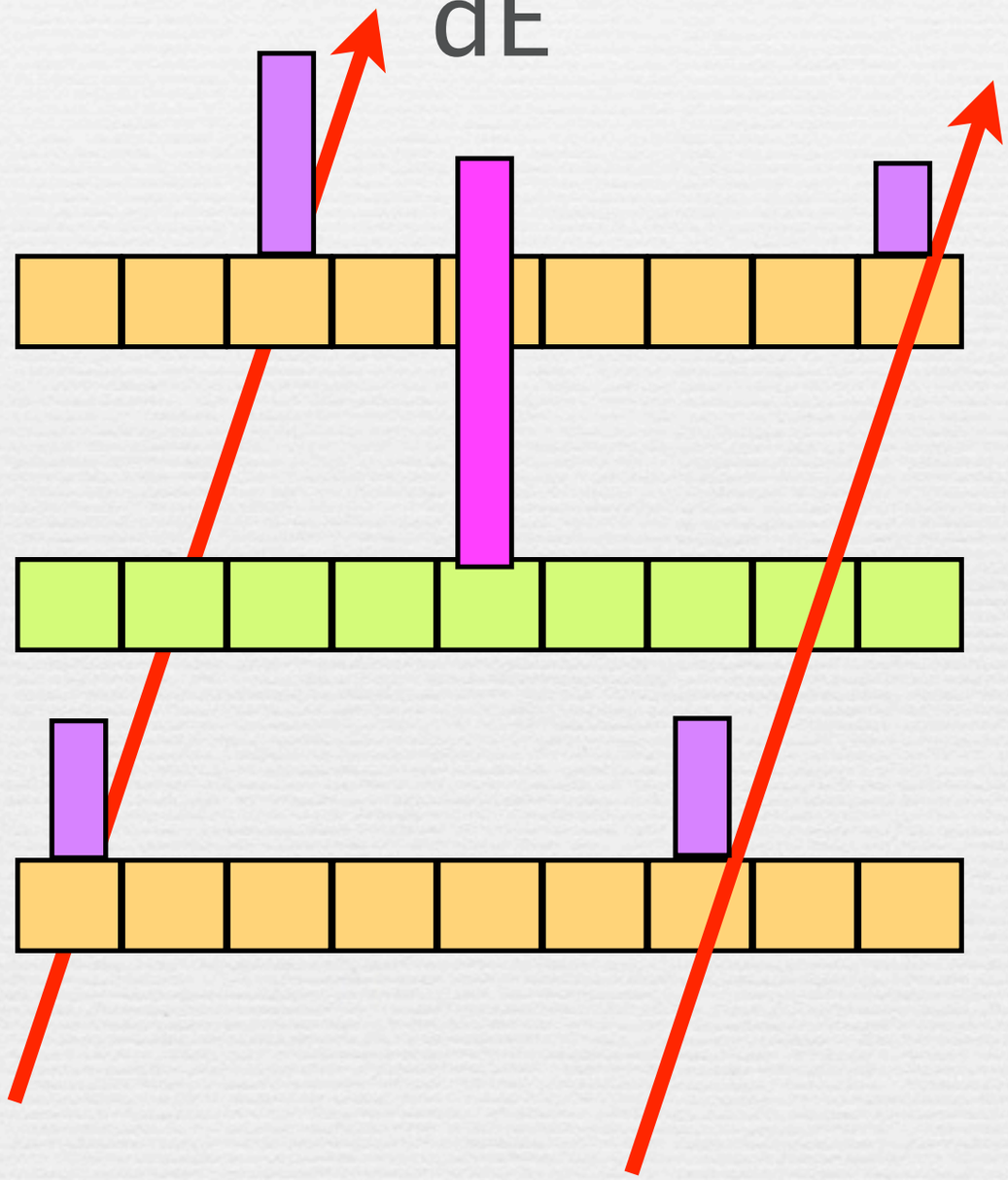
- Strip Splitting Algorithm



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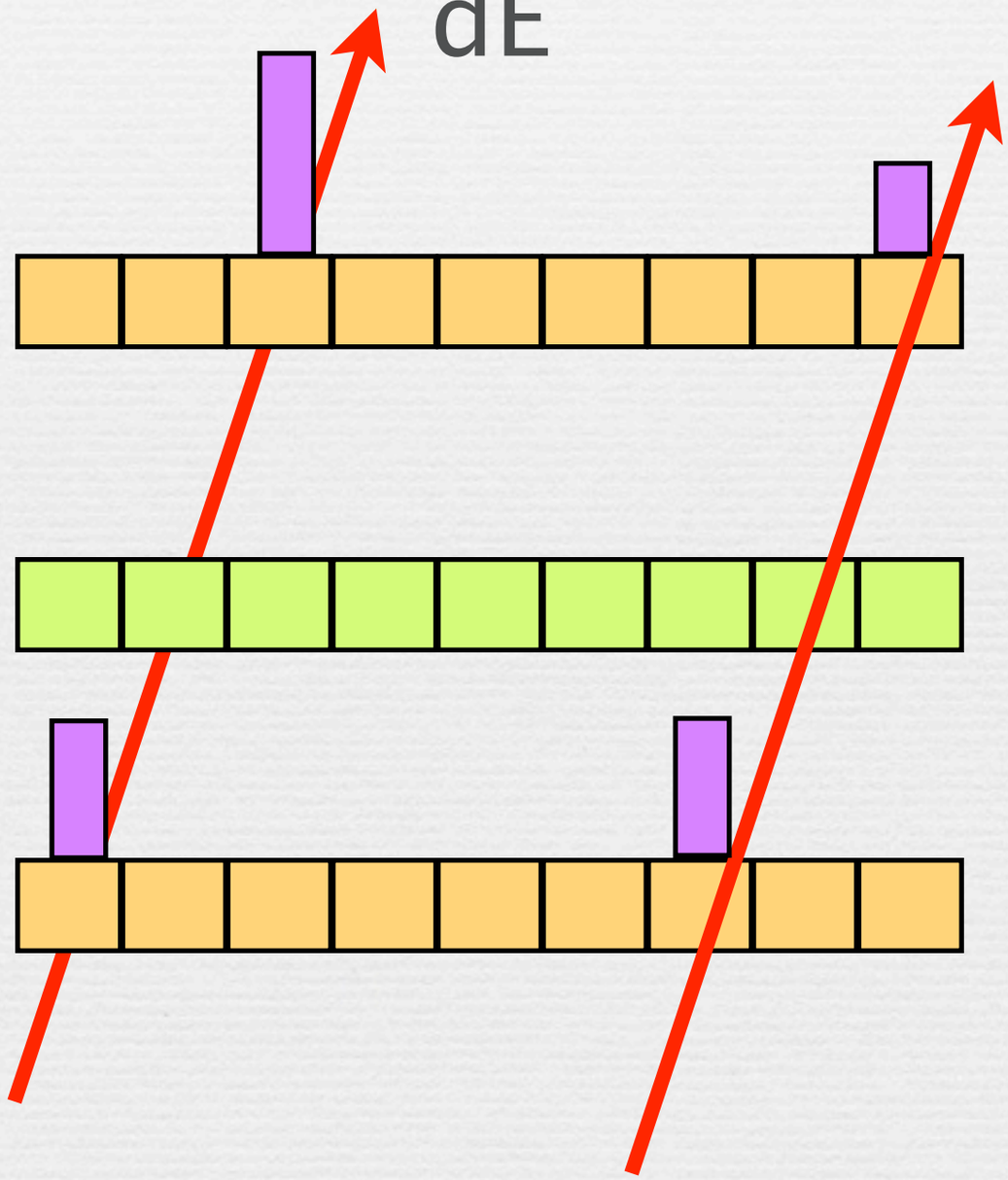
- Strip Splitting Algorithm



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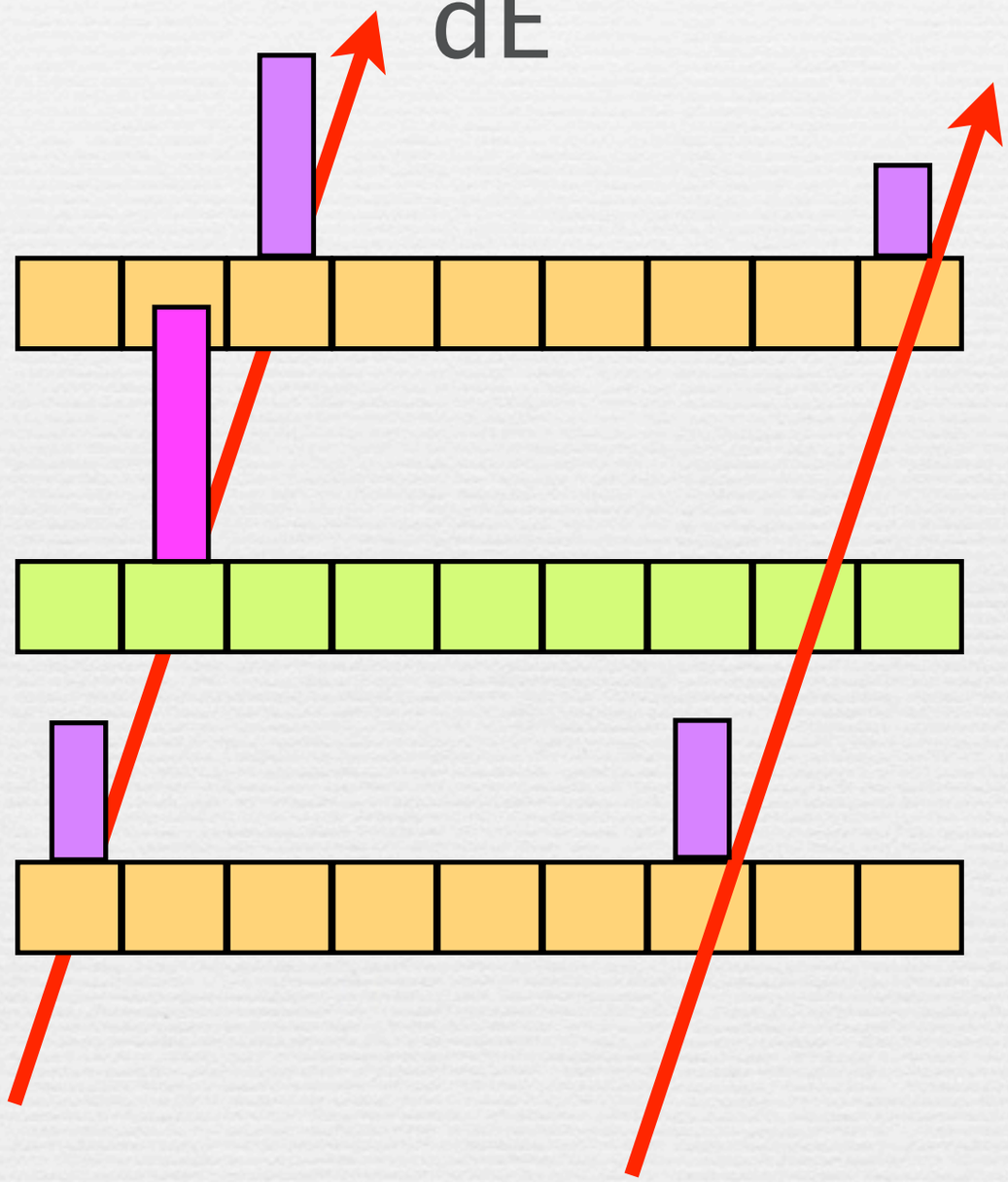
- Strip Splitting Algorithm



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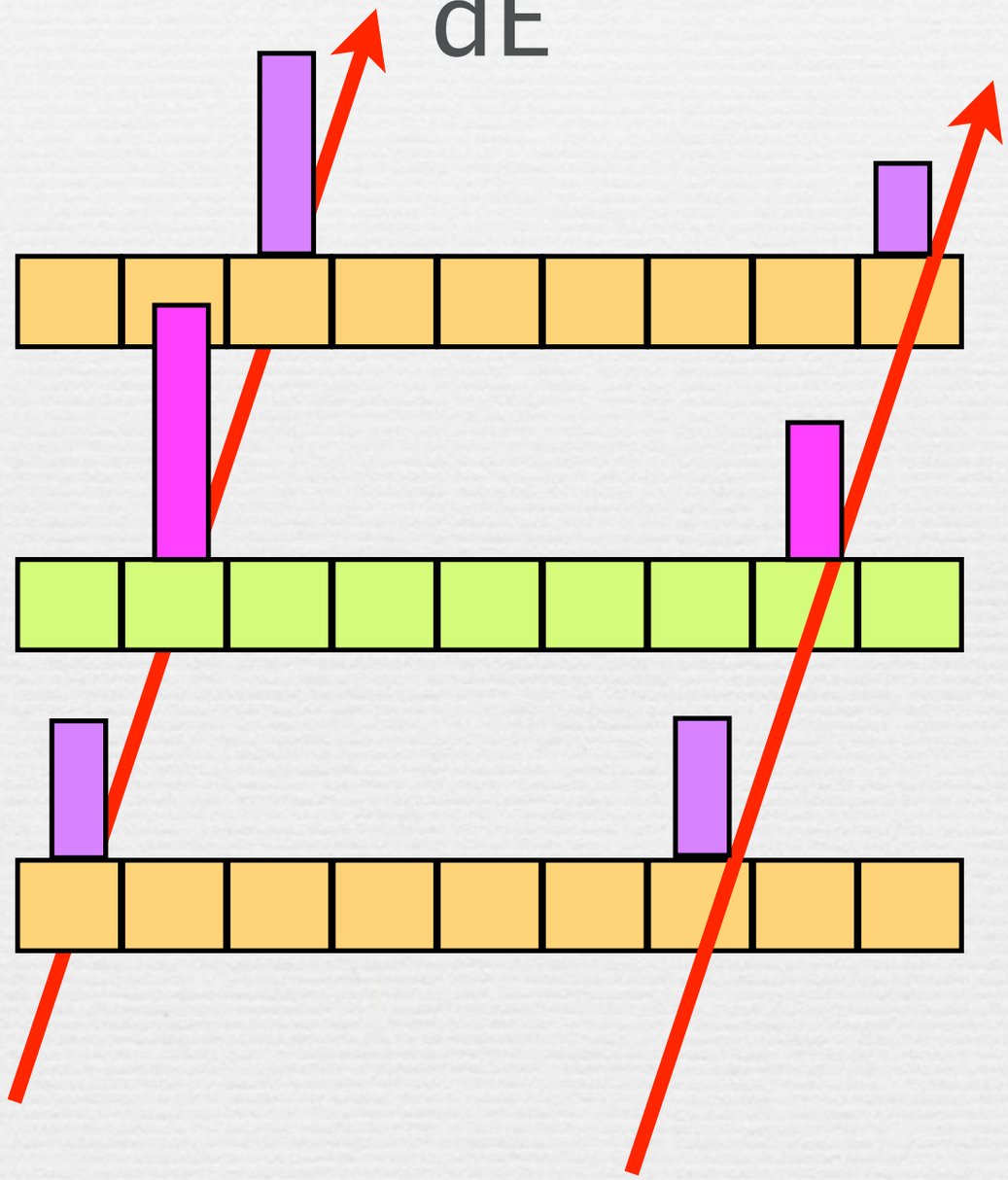
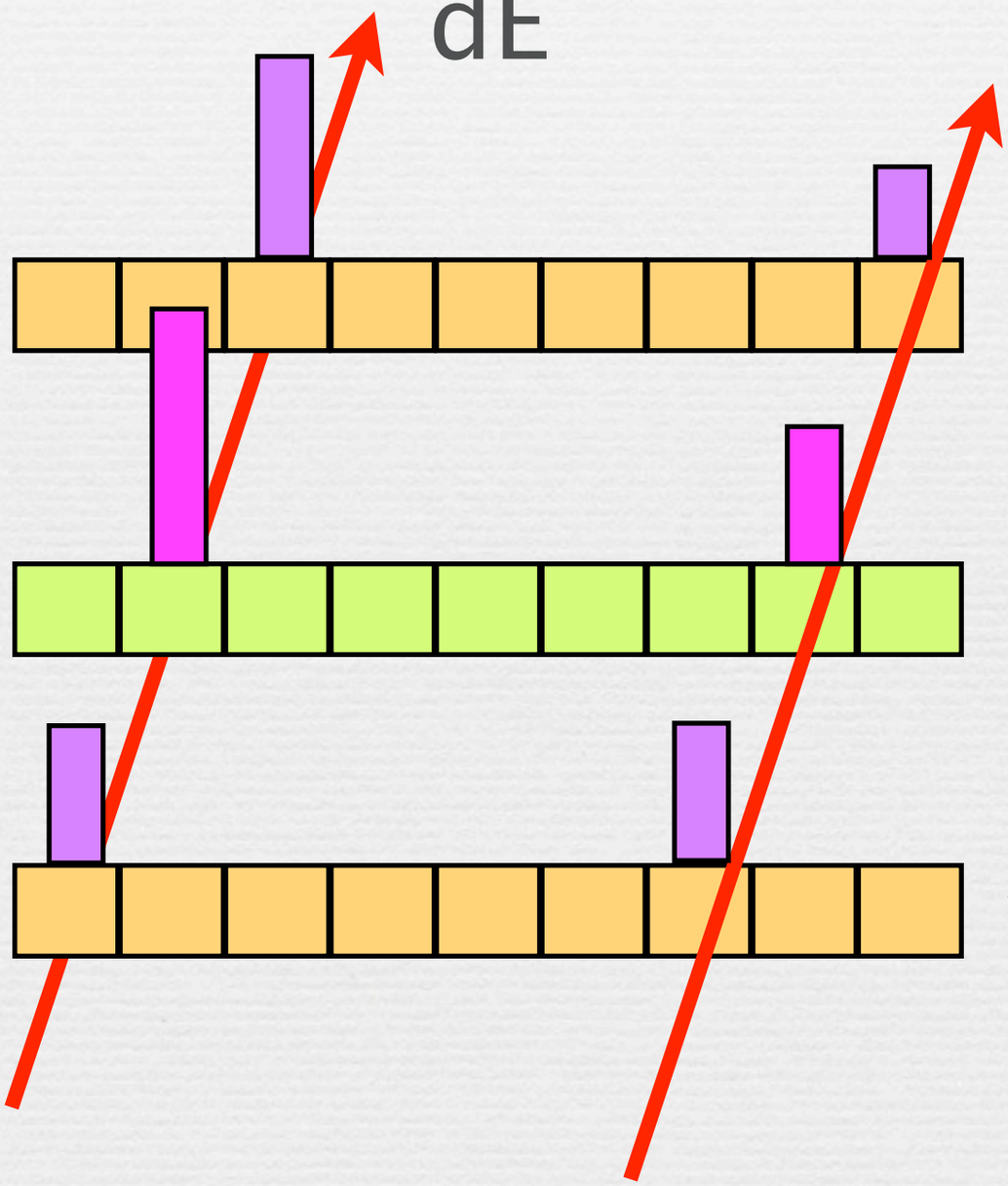
- Strip Splitting Algorithm



# SSA-II

- Strip Splitting Algorithm




back layer

scintillator strip layer

forward layer

virtually segmented

this info. will be passed to PANDORA