Progress of the Strip Clustering

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IWLC at CERN

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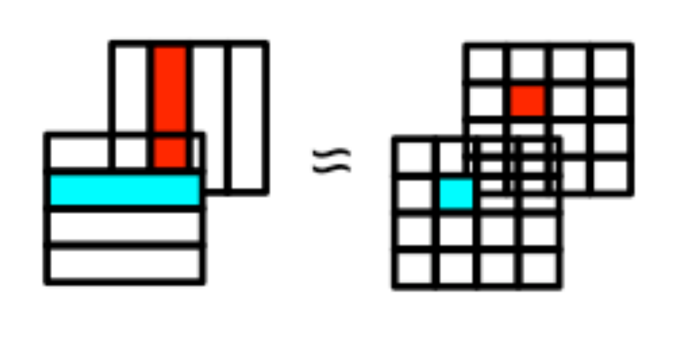
Introduction



- ScECAL is aiming at “effective” W x W (W=5~10 mm) granularity using alternately put orthogonal layers of scinitllatr strips with demention W x L(L=45 mm or longer).

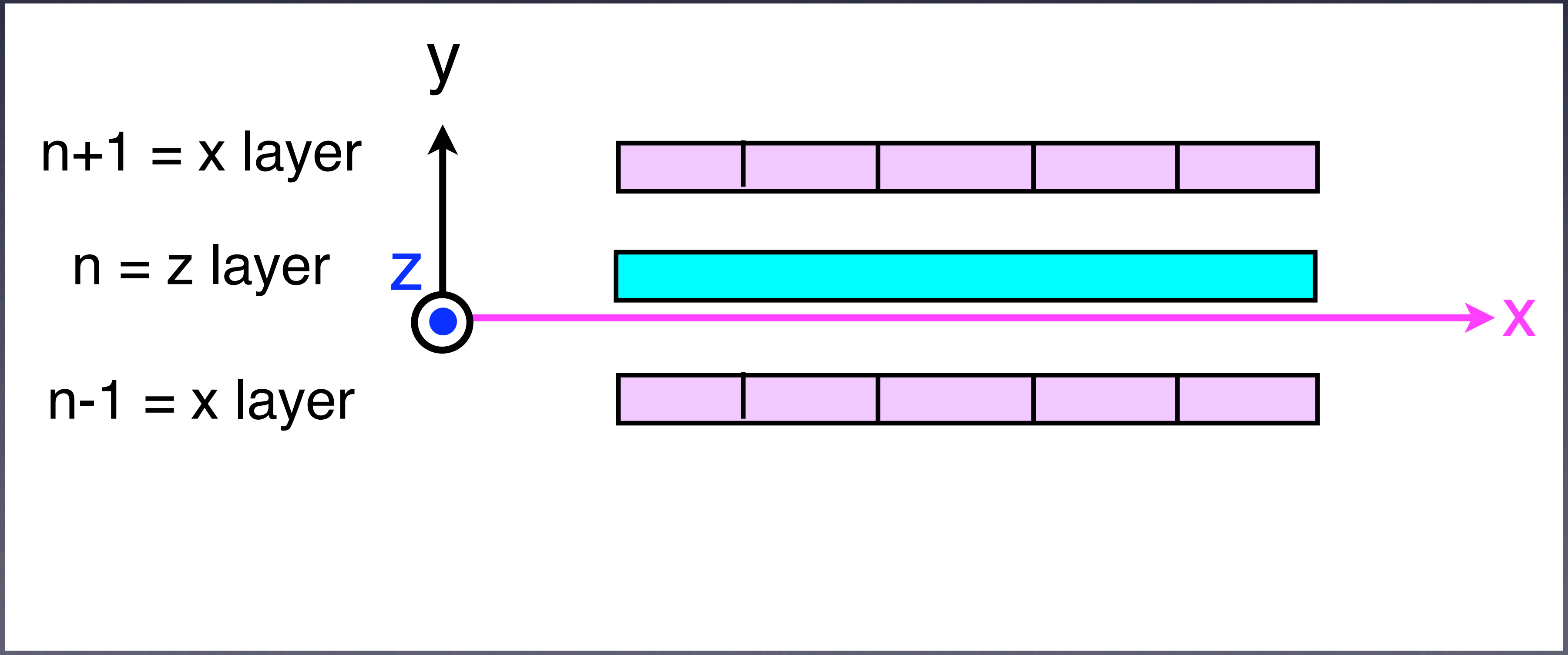
- Possible problem
  - Ambiguity in hit-positions when multi-particles hit in a narrow region. ▶A special algorithm must be developed and its performance must be demonstrated (ILD LOI)

- Previous approach: “Triplet method”
  - It was developed aiming to be able to independently reconstruct jets ▶ interface to PandoraPFA is difficult.

- New approach: “Strip-splitting method”
  - A simple algorithm to distribute energy deposit in a strip into virtually split square cells.
  - Energy deposit in the square cells are fed into PandoraPFA i.e. clustering algorithm in PandoraPFA is used.

Strip-splitting method

1. Assume that n-th is a z-layer (fine segmentation in z direction), while n±1 layers are x-layers (fine segmentation in x direction).
2. Split each strip in n-th layer into virtual square cells.
3. Energy deposit in n-th layer
4. is distributed in virtual square cells according to the energy deposits in adjacent (n-1)th and (n+1)th layers.
5. The position and energy of virtual square cells are fed into PandoraPFA.



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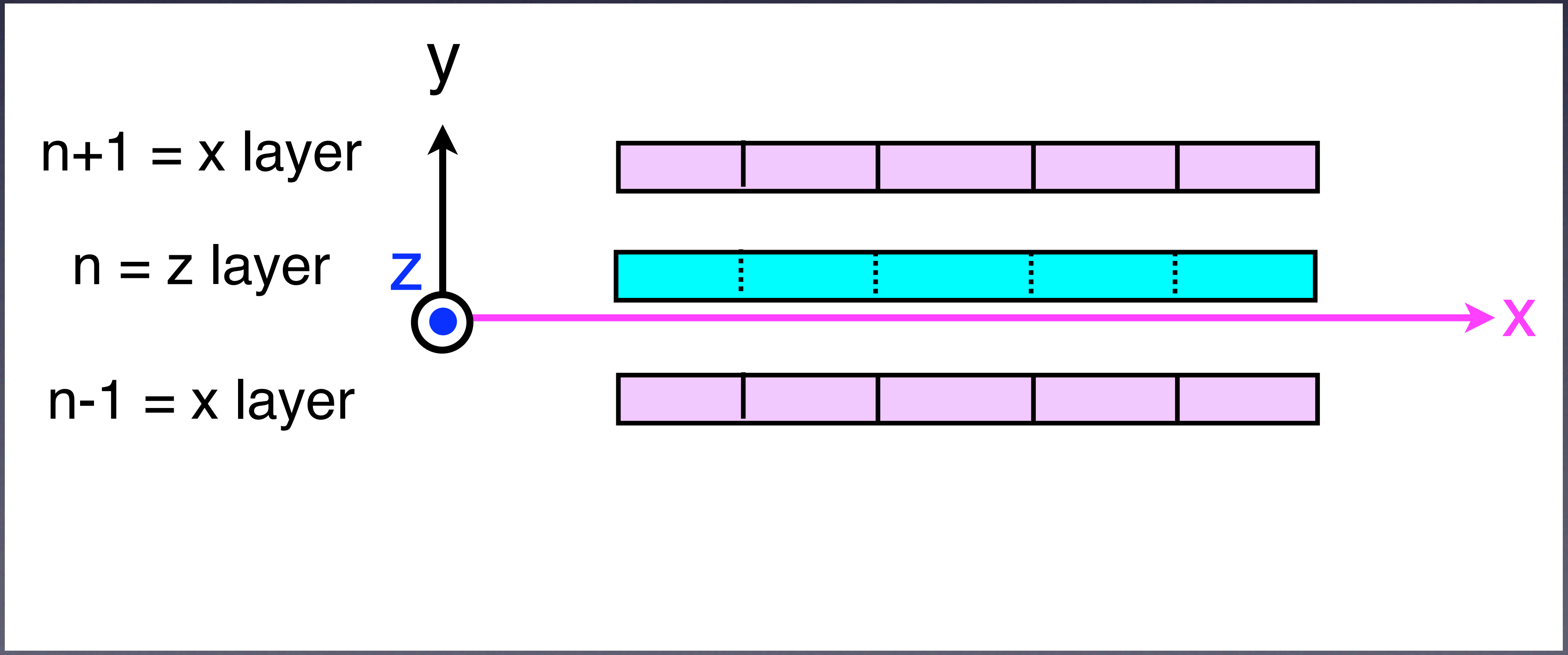

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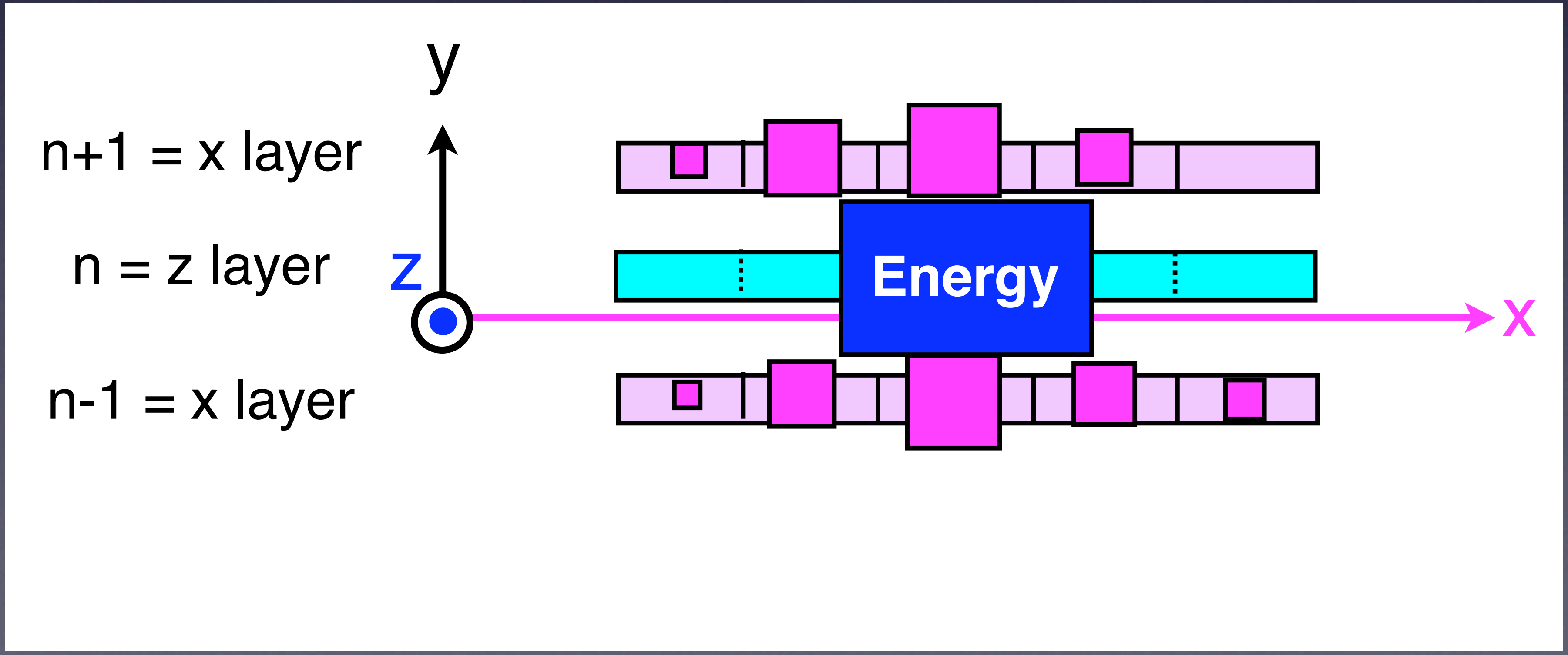

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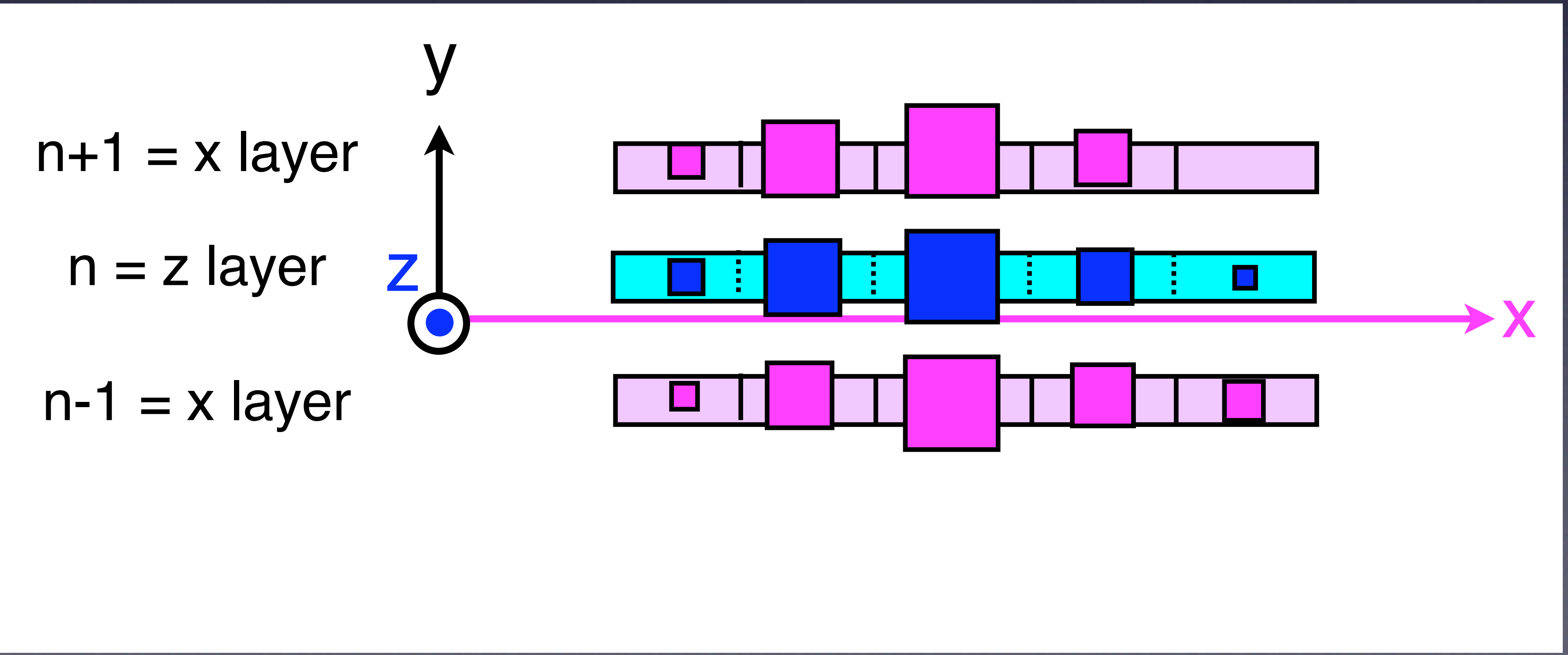

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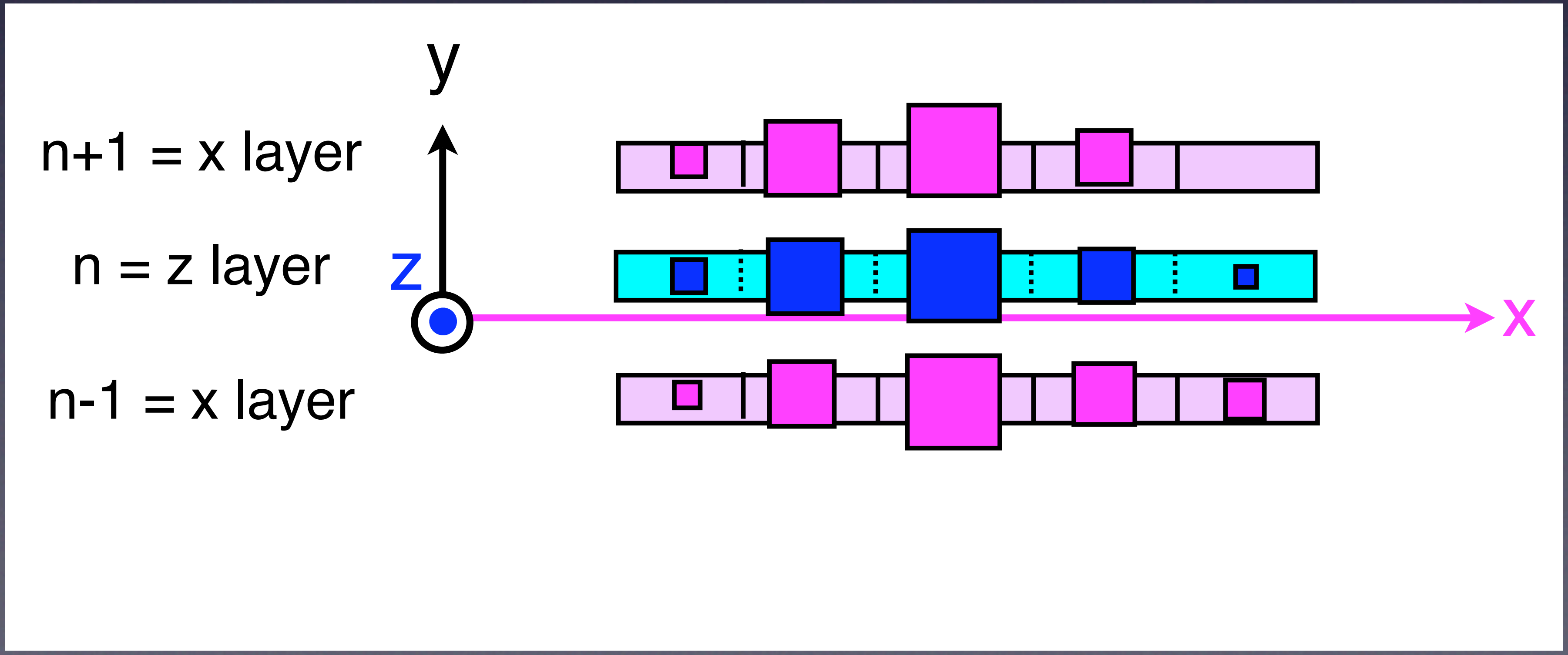
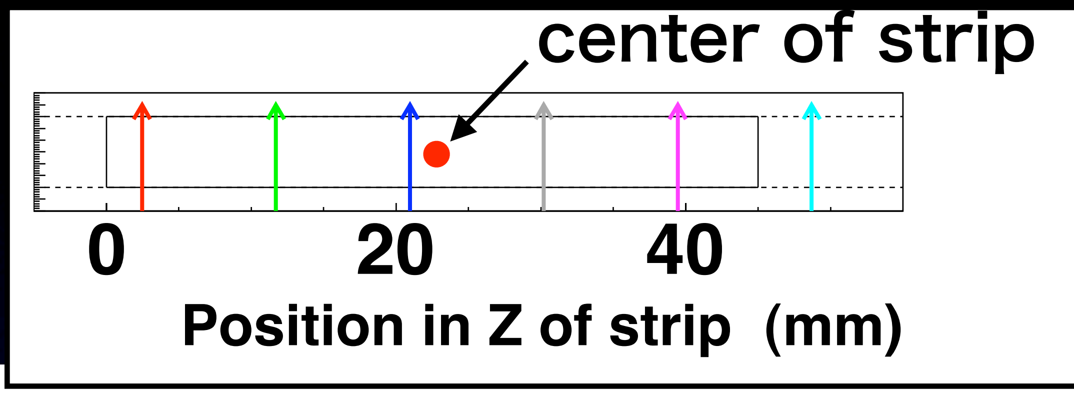
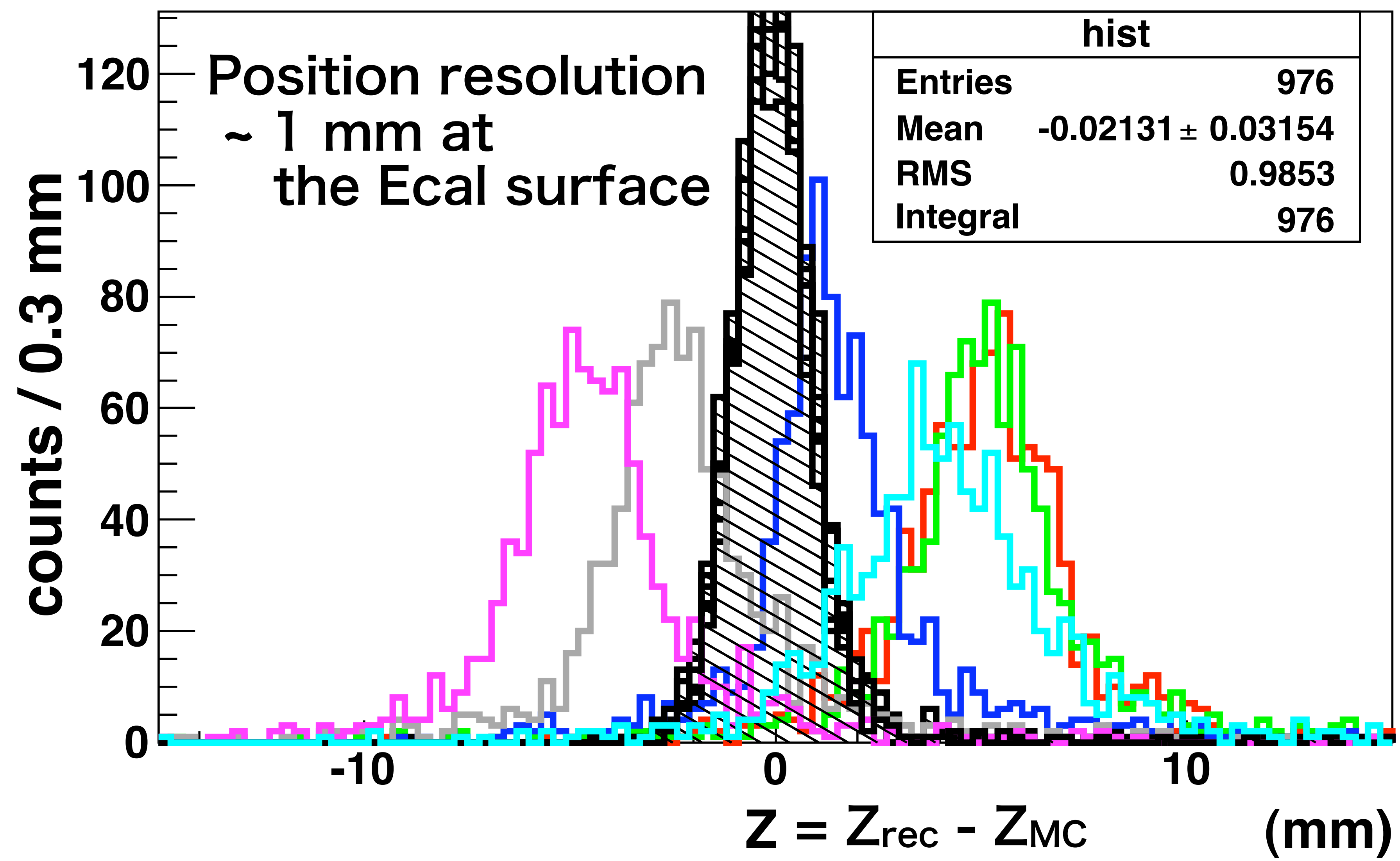


Position resolution: in z for 10 GeV photons



Position difference between reconstructed position and MC true ($z = z_{rec} - z_{MC}$) at the ILD ECAL surface. 10 GeV photons was injected at 6 positions with incident polar angles approximately 90°.



For 45 mm x 5 mm strips:

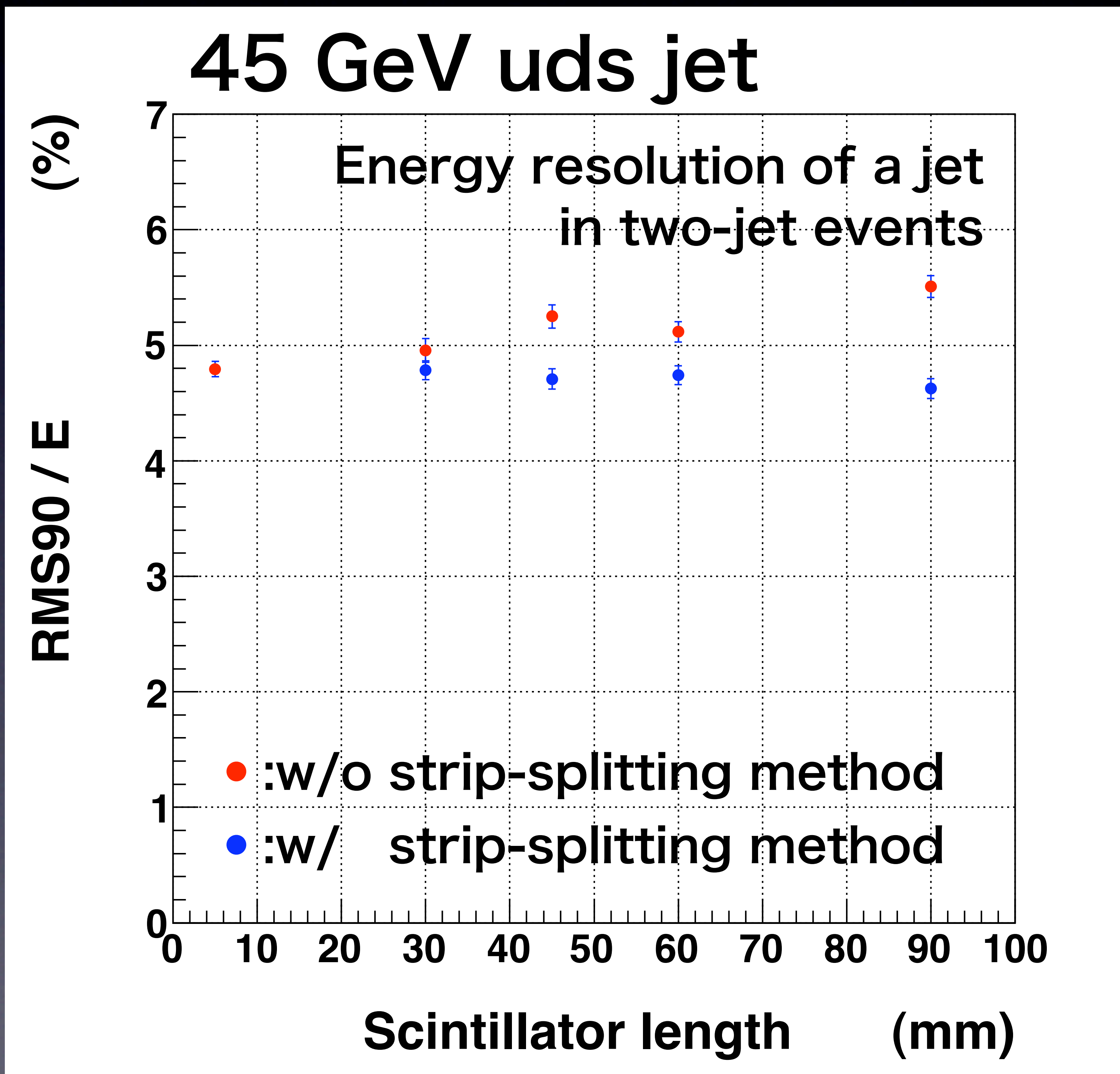
colored: z distributions of energy-weighted mean position without the strip-splitting method

Black: z distributions of reconstructed PFO with strip-splitting method

Systematic shift is removed by the strip-splitting method.

Jet energy resolution vs. scintillator strip length

$\sqrt{s}$ = 91 GeV, Scintillator width = 5 mm



Performance for uds two-jet events with ScECAL with and without strip-splitting method

w/o strip-splitting method: the center positions of strips are fed into PandoraPFA

cos(thrust angle) < 0.4

No degradation of JER with strip-splitting method even with long scintillator strips

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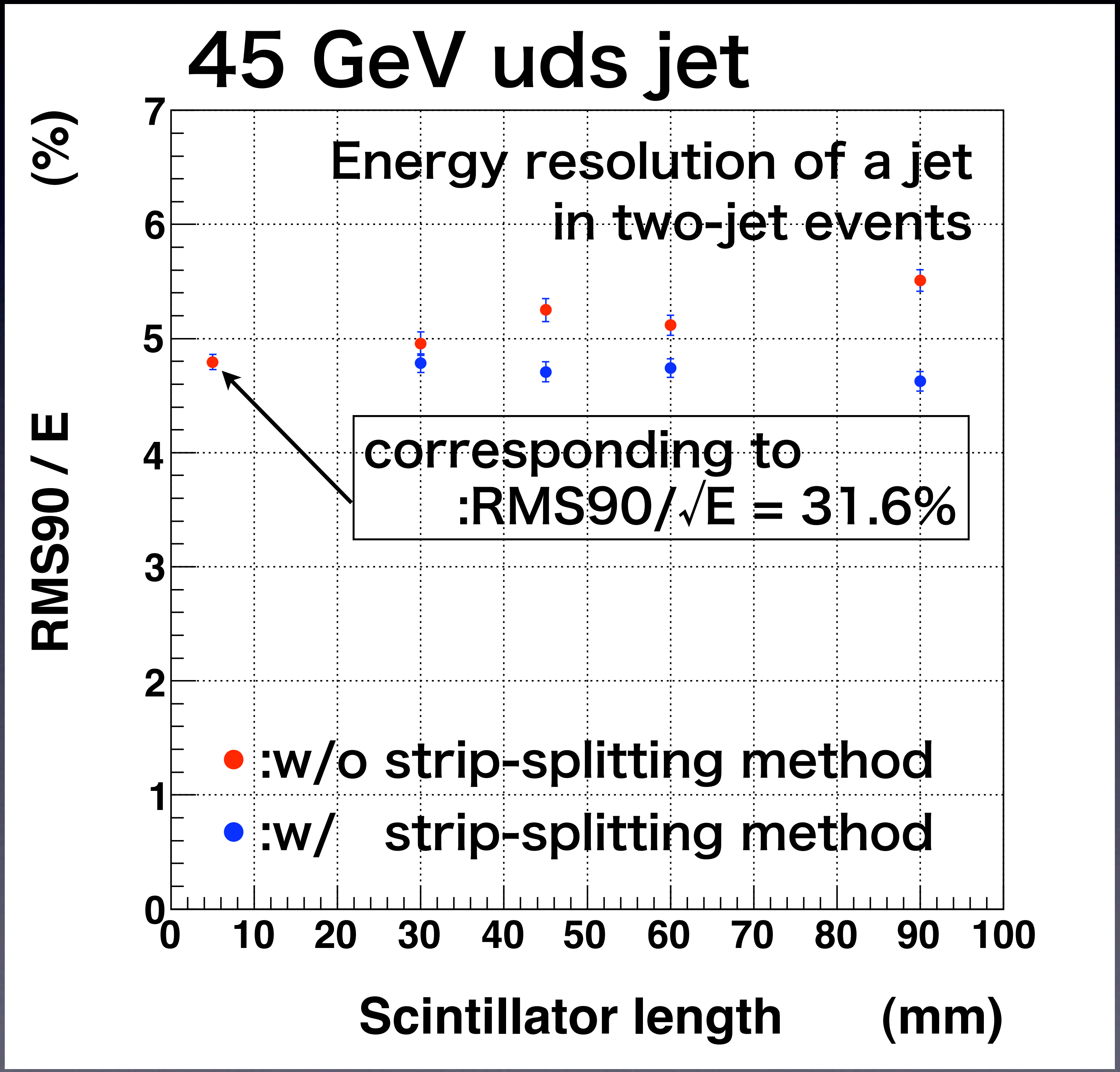

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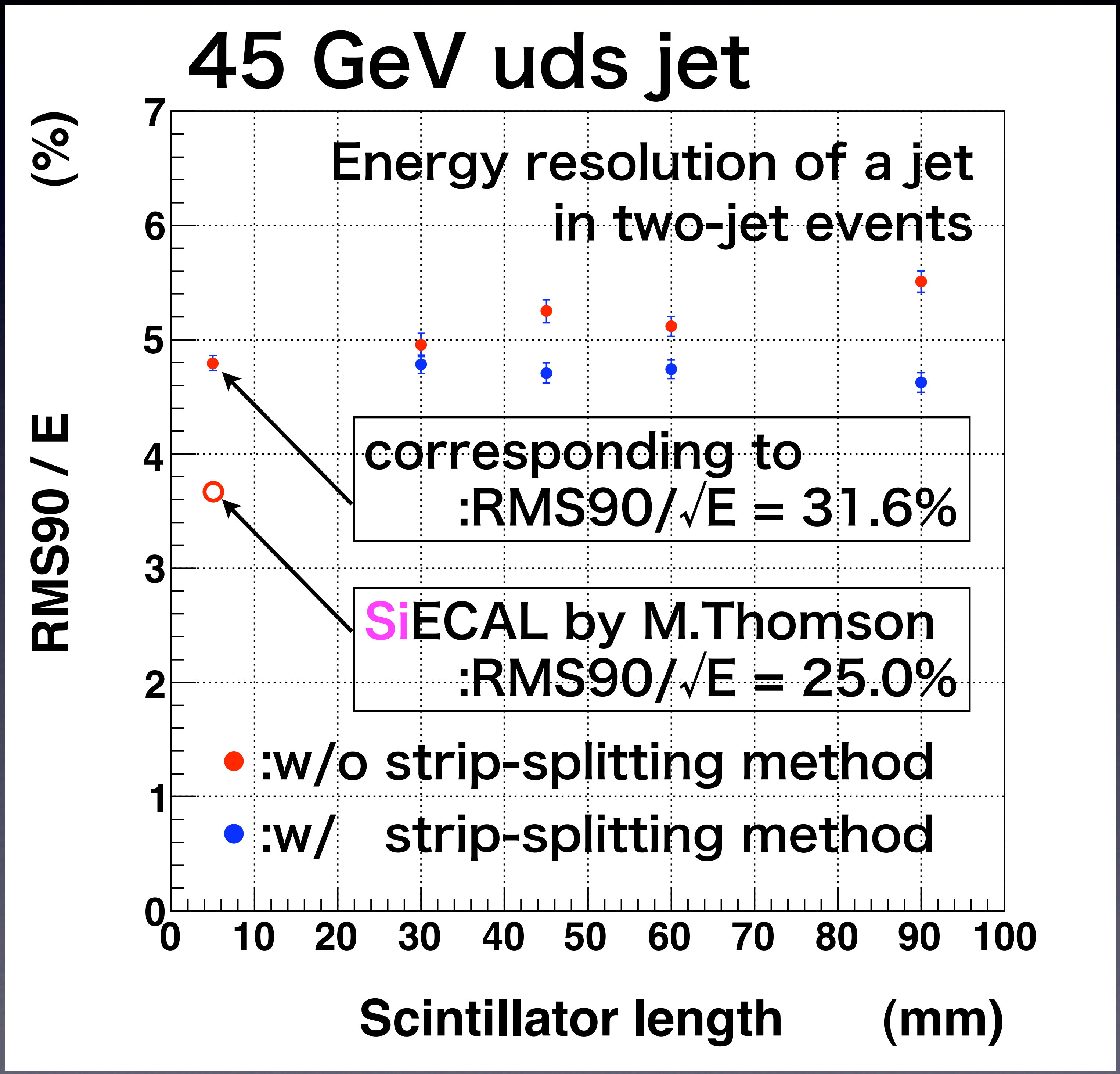

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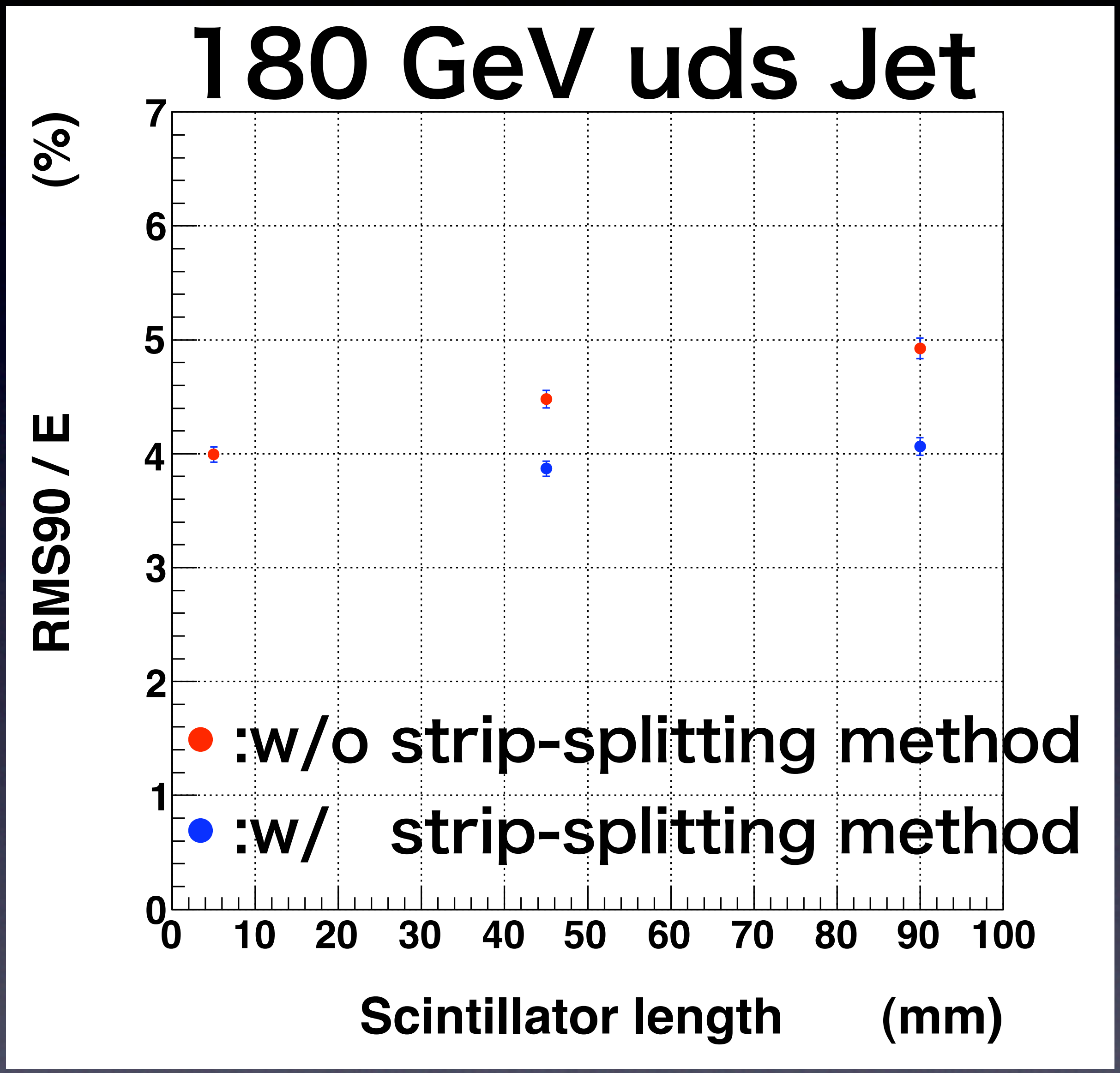
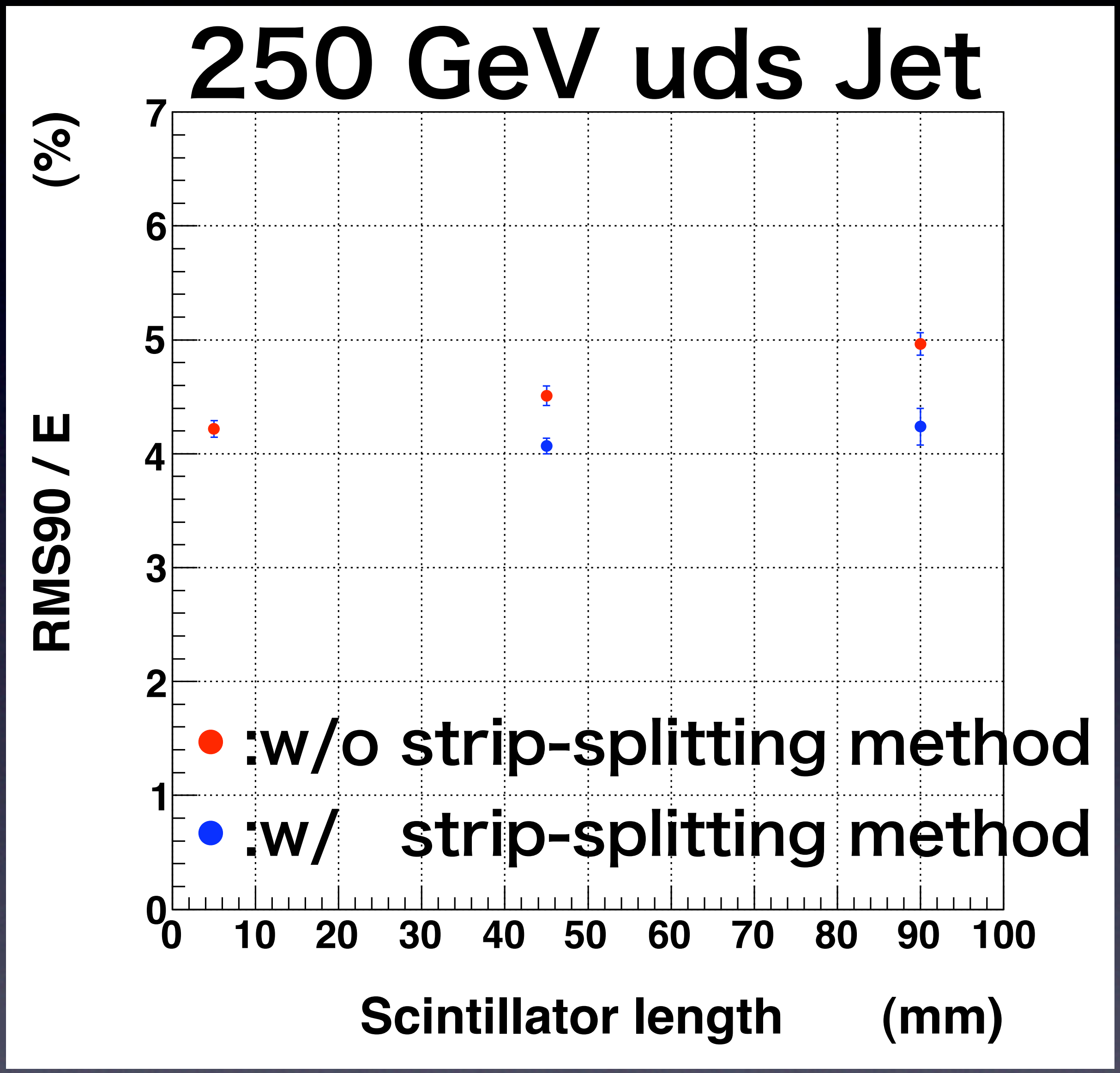
The resolution 31.6%/√E is a bit worse than Mark's resolution for 5 mm x 5 mm SiECAL. We will come back to this problem later.

Jet energy resolution vs. scintillator strip length at higher energy

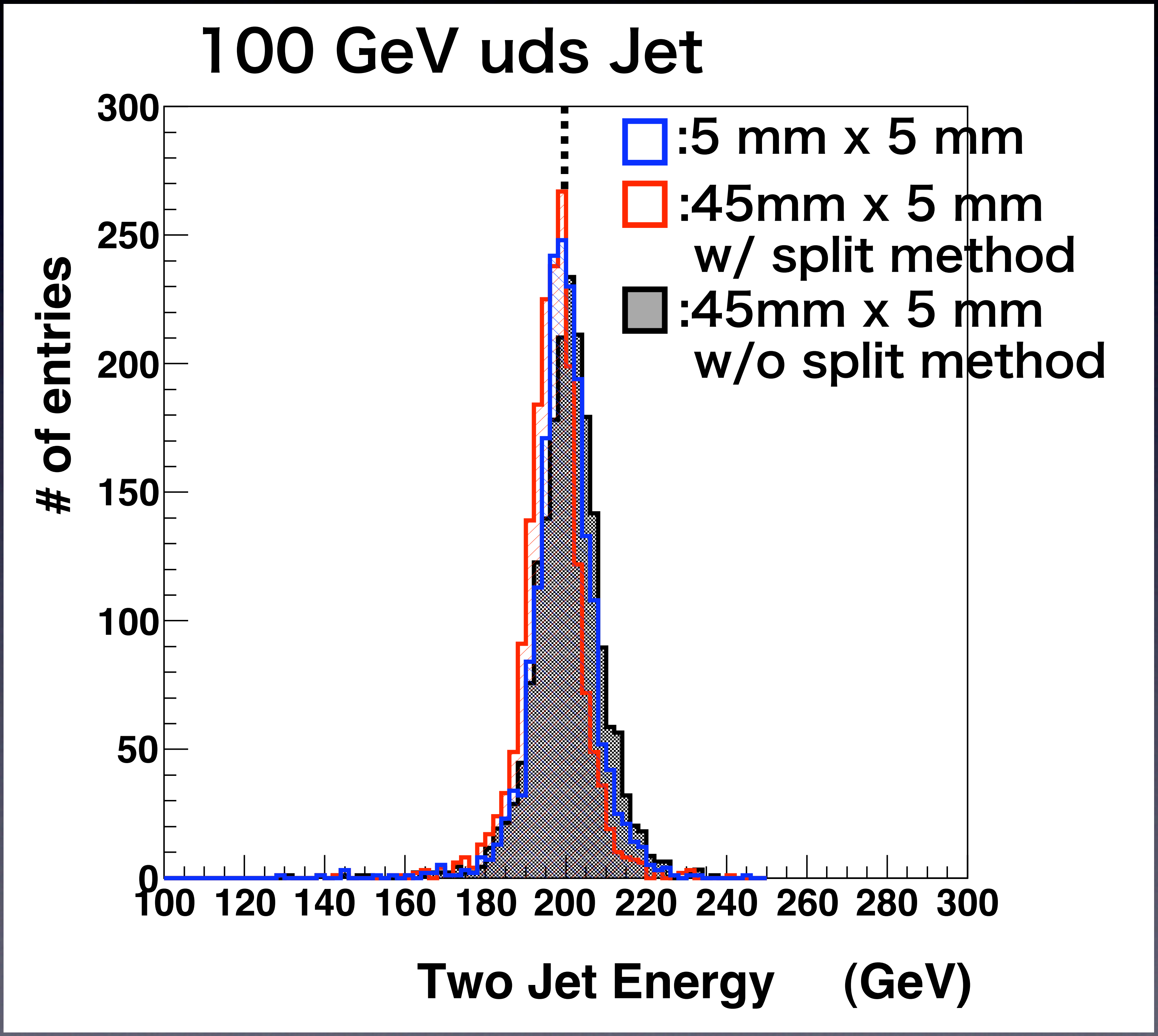




Even at √s = 500 GeV (250 GeV jet), ScECAL 90 mm x 5 mm strips shows similar performance to that of 5 mm x 5 mm square tile ScECAL.

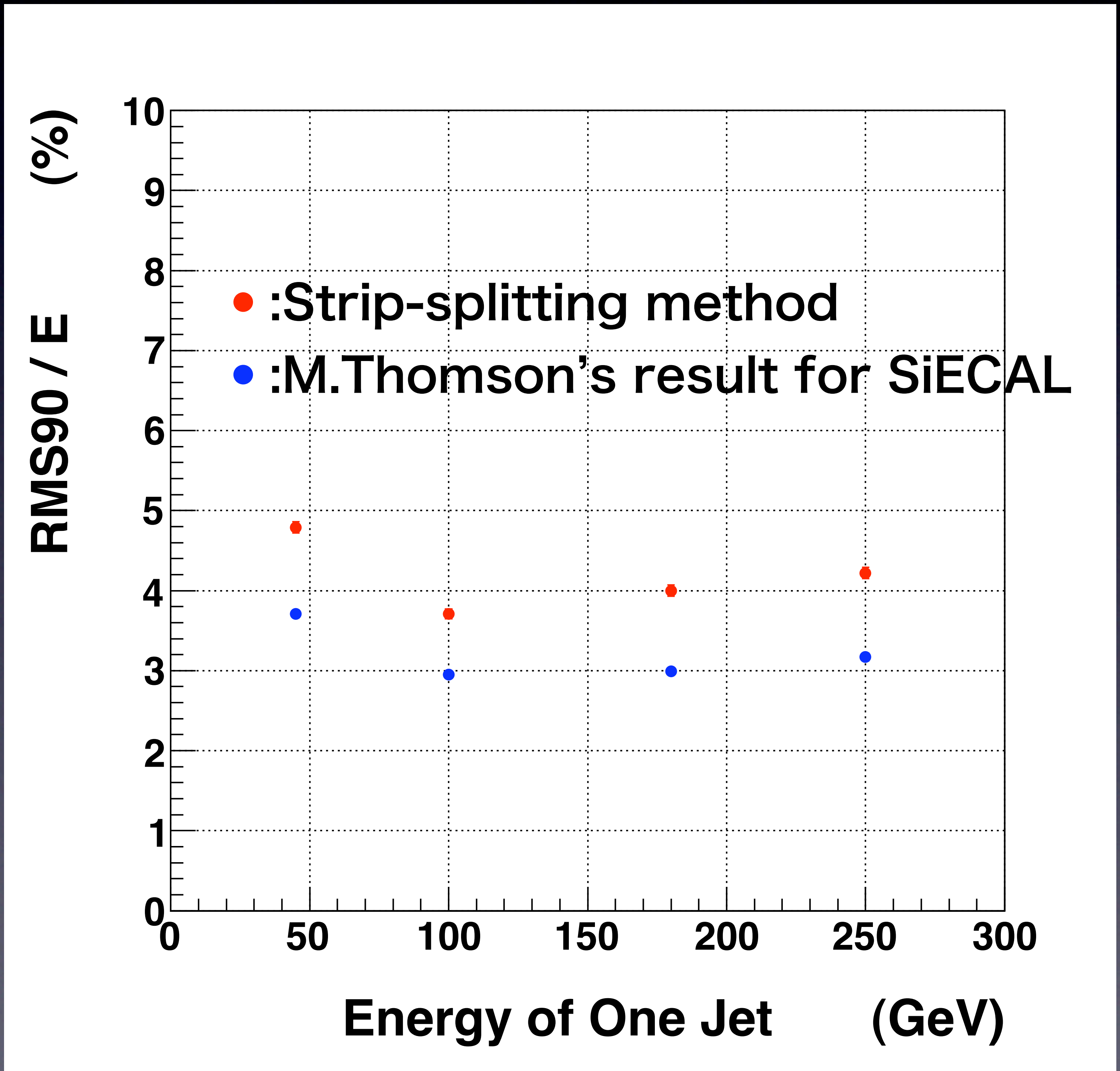
Distribution of jet energy

√s = 200 GeV, Scintillator width = 5 mm



Hatched histogram, with 45 mm x 5 mm ScECAL without Split method, has broader shape than others

Jet energy resolution vs. jet energy



The energy dependence is the similar to that of M.Thomson's result for SiECAL

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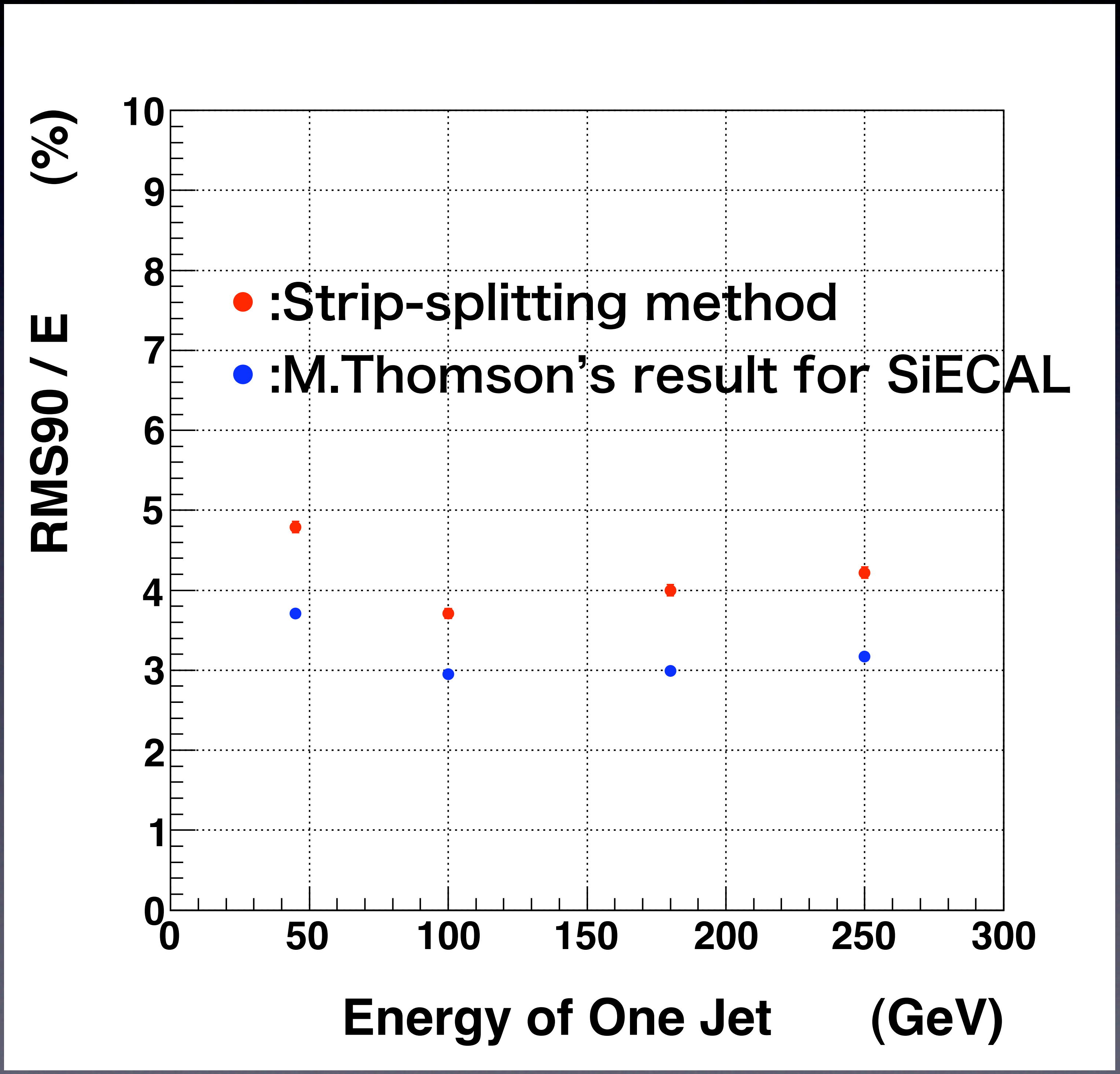

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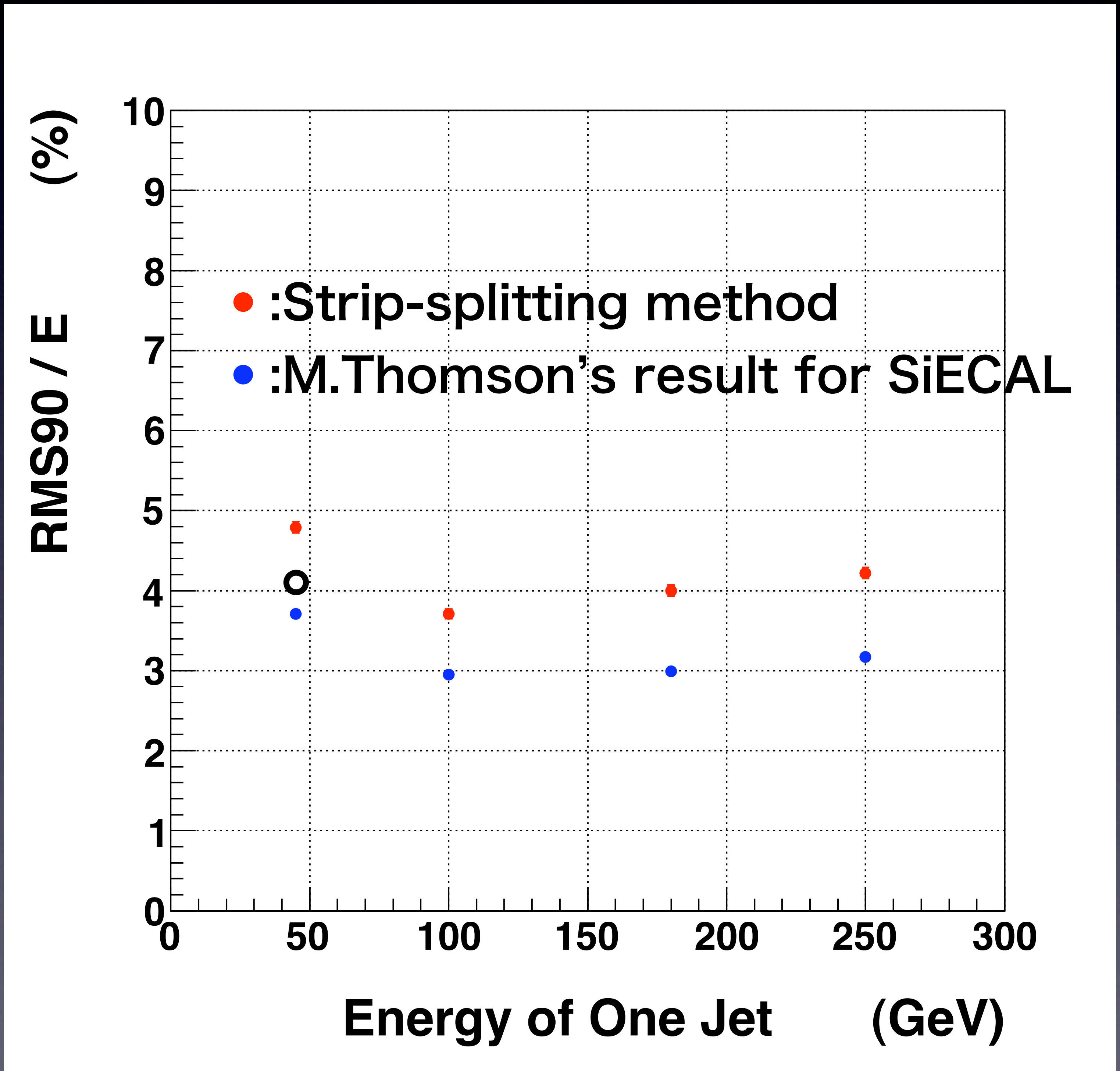
Difference is possibly from some problems in the merge process in which scintillator strip hits are made by merged 5 mm x 5 mm Mokka events

Jet energy resolution vs. jet energy



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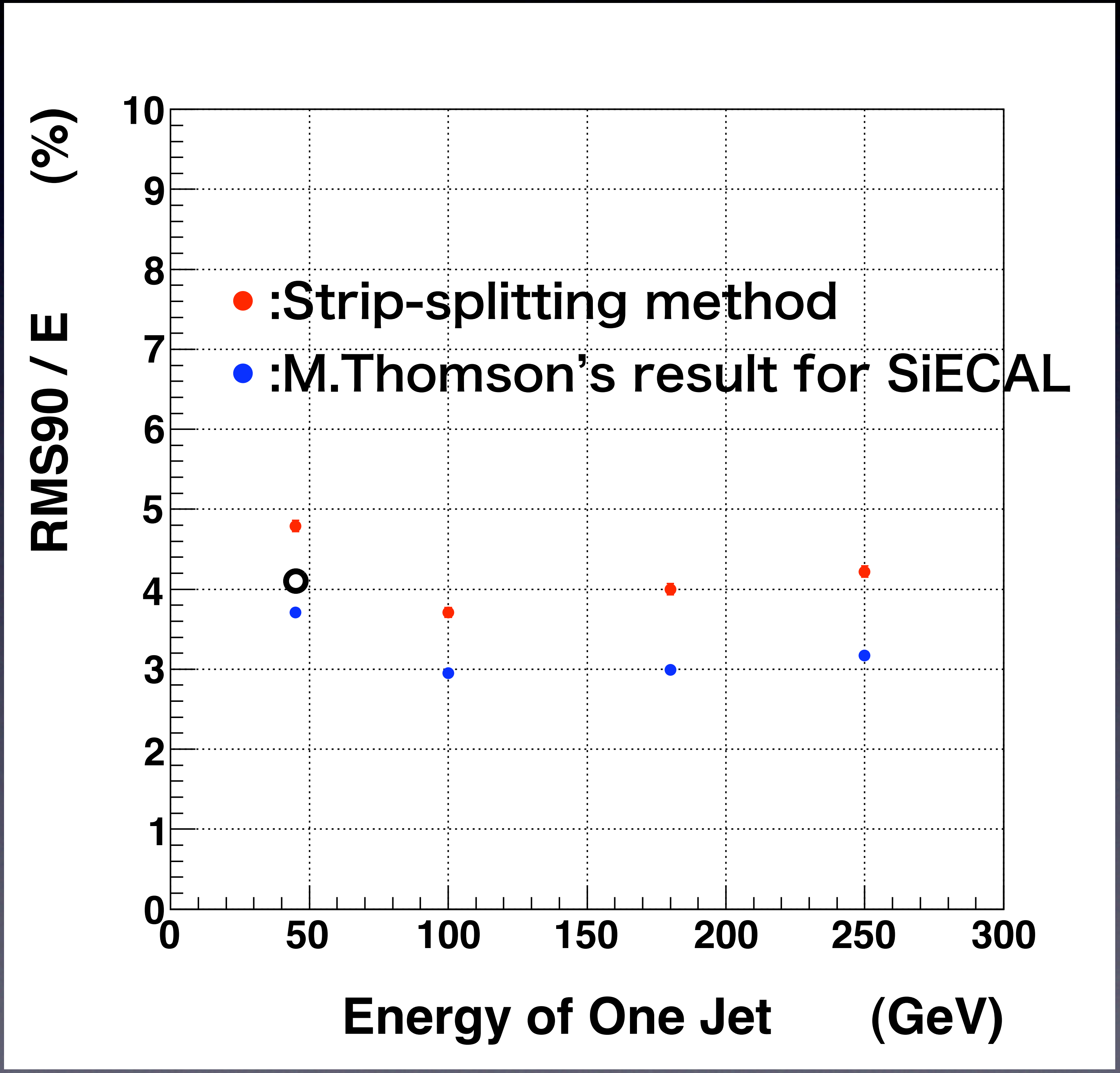

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◀ w/o this process, 5 x 5 mm scintillator Ecal has the performance close to SiECAL

▶ Using Latest Mokka which intrinsically generates events in scintillator strips.

Mokka v07-05 and NewPandoraPFA with new module SplitStrip: status

I began to study ScECAL performance with these tools combination.

with instruction by Daniel Jeans, “SplitStrip” module was made and installed ▶ easy to set parameters.

Feature of v07-05(04) by Gabriel.

- More realistic simulation for Si and Sc ECAL.
  - MPPC dead volume, reflector film ...(size tunable)
- Scintillator strip events are directly generated (minimum unit of strip length is 5 mm).
- Hybrid ECAL (Si or Sc layers can be selected for each alveolus i.e. each two layers).

Some residual problems make ScECAL performance be degrade so far ▶ investigation of causes is ongoing.

Summary

The Strip-splitting method has been developed for strip clustering.

Although fine tuning may be still necessary, this method seems promising : up to $\sqrt{s}$ = 500 GeV, ScECAL with 45x5 mm scintillator strip shows the similar performance to that 5 x 5 mm scintillator ECAL has.

Study with latest version of Mokka is ongoing, in which strip hits events are directly generated.

To do

Performance issues;

- understand the difference from Mark Tomson's result,
- performance at higher energy (up to √s = 1 TeV),
- Studies of longer strips (> 90 mm)and wider strips (10 mm),
- Reconstruction of π^0,
- Reconstruction of multi jets events (e.g. ttbar etc),
- Non-uniformity of response in strip to be taken into account.

Technical issues;

- Write code for the endcap hits,
- Boundary treatments:

  Stave-Stave, module-module, Endcap-barrel.

The study of strip-splitting method maybe extended to;

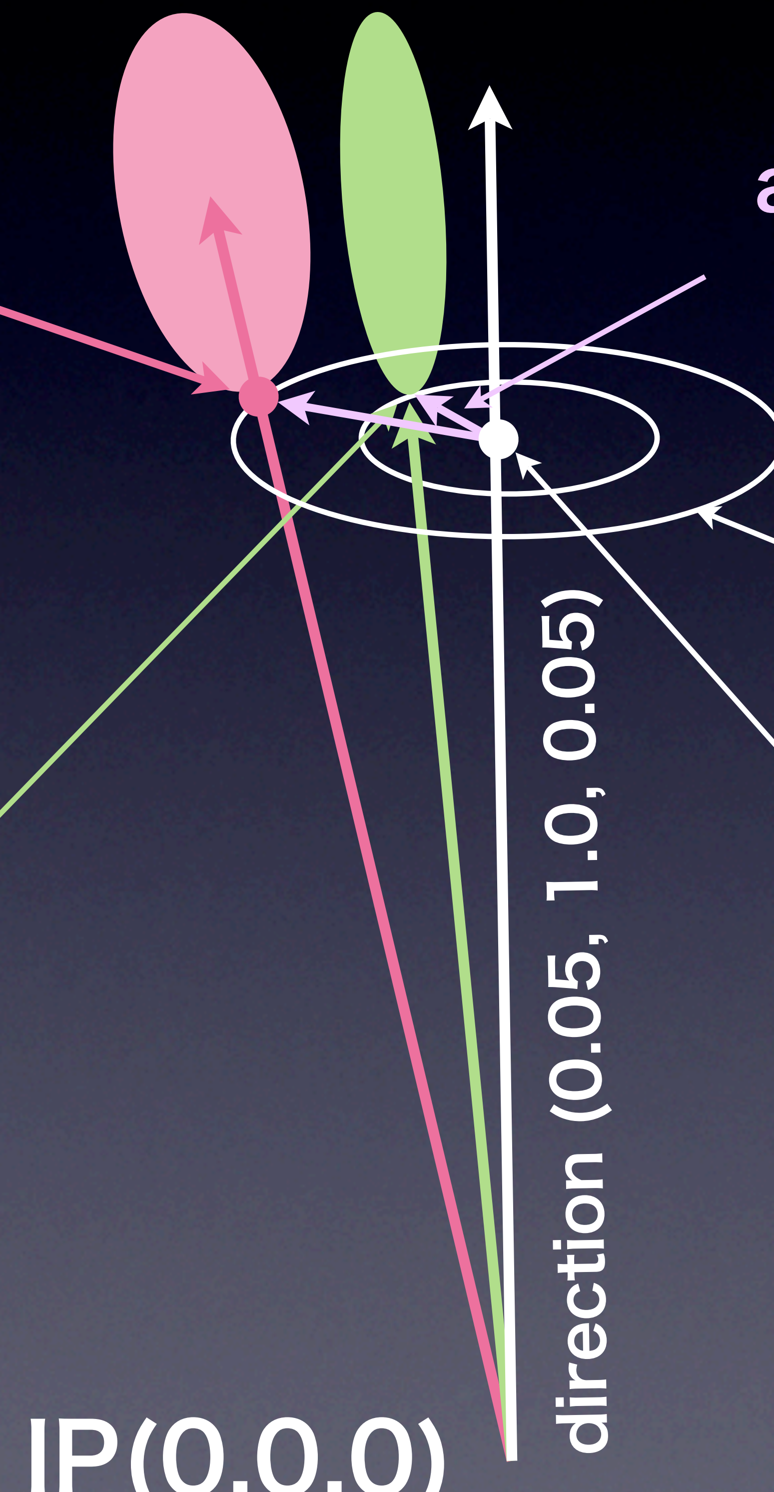
- Hybrid ECAL,
- Scintillator strip AHCAL.

back up

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 truth on the Ecal innter surface.

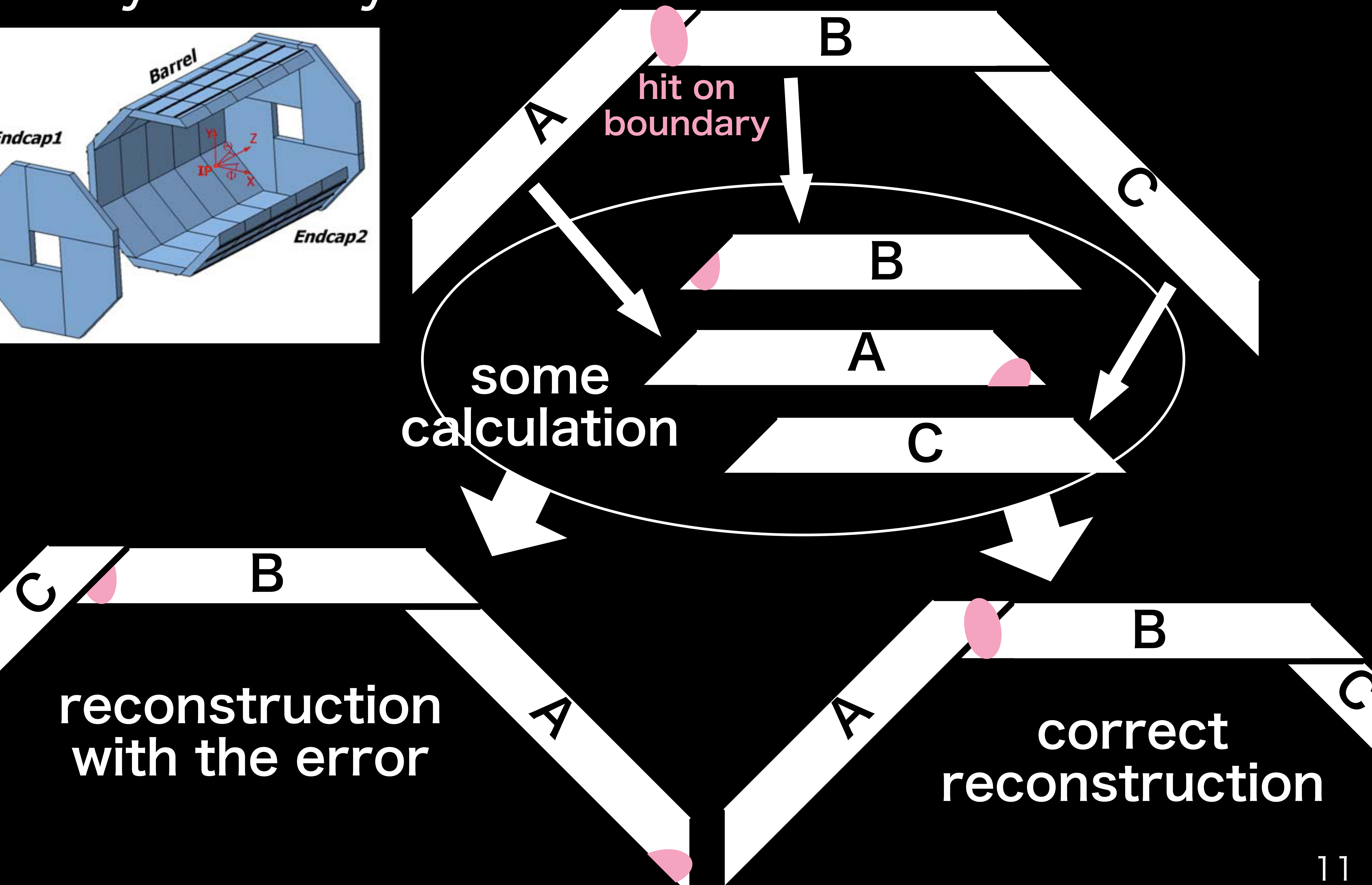


Ecal inner surface.

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

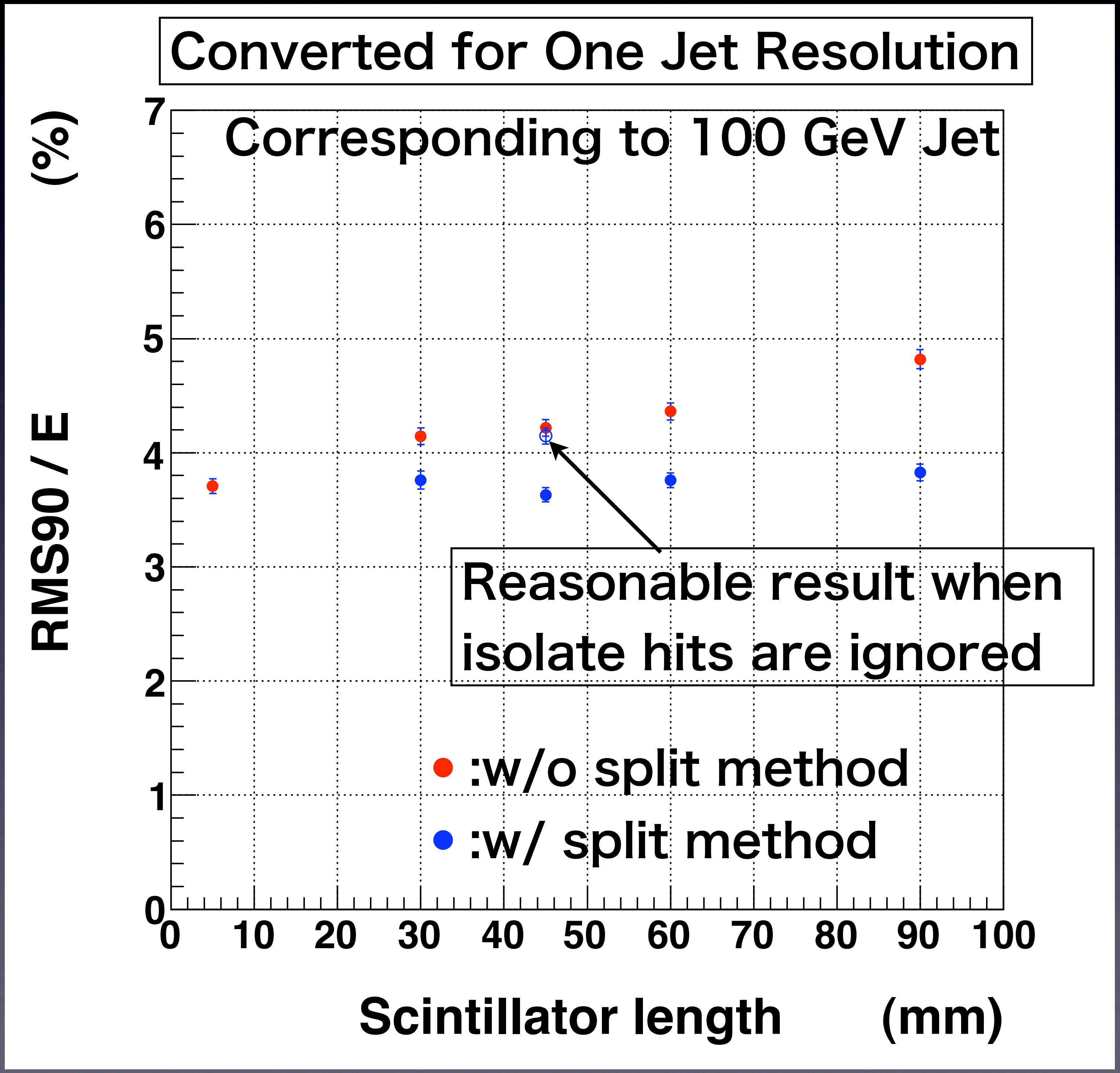
Position which MC true momentum points on the Ecal inner surface (x, y=1850 mm, z).

In Mokka simulation Octagonal symmetry of barrel is used to calculate



Sc. length dependence of the Jet energy resol.n

√s = 200 GeV, Scintillator width = 5 mm



Split method still works for √s = 200 GeV events.

In the case of Isolate hits (there is no hit above and bellow neighbor scintillators), the energy is put on the center cell of split cells in this split method (also in previous and following slides).

When such isolate hits are ignored (not added their energy) JER degrades.

2.2.6 ECAL and HCAL detector technology

The ILD concept incorporates two different technology options for both the ECAL and HCAL. The two ECAL technologies are: i) a Silicon-Tungsten (SiW) calorimeter where the baseline

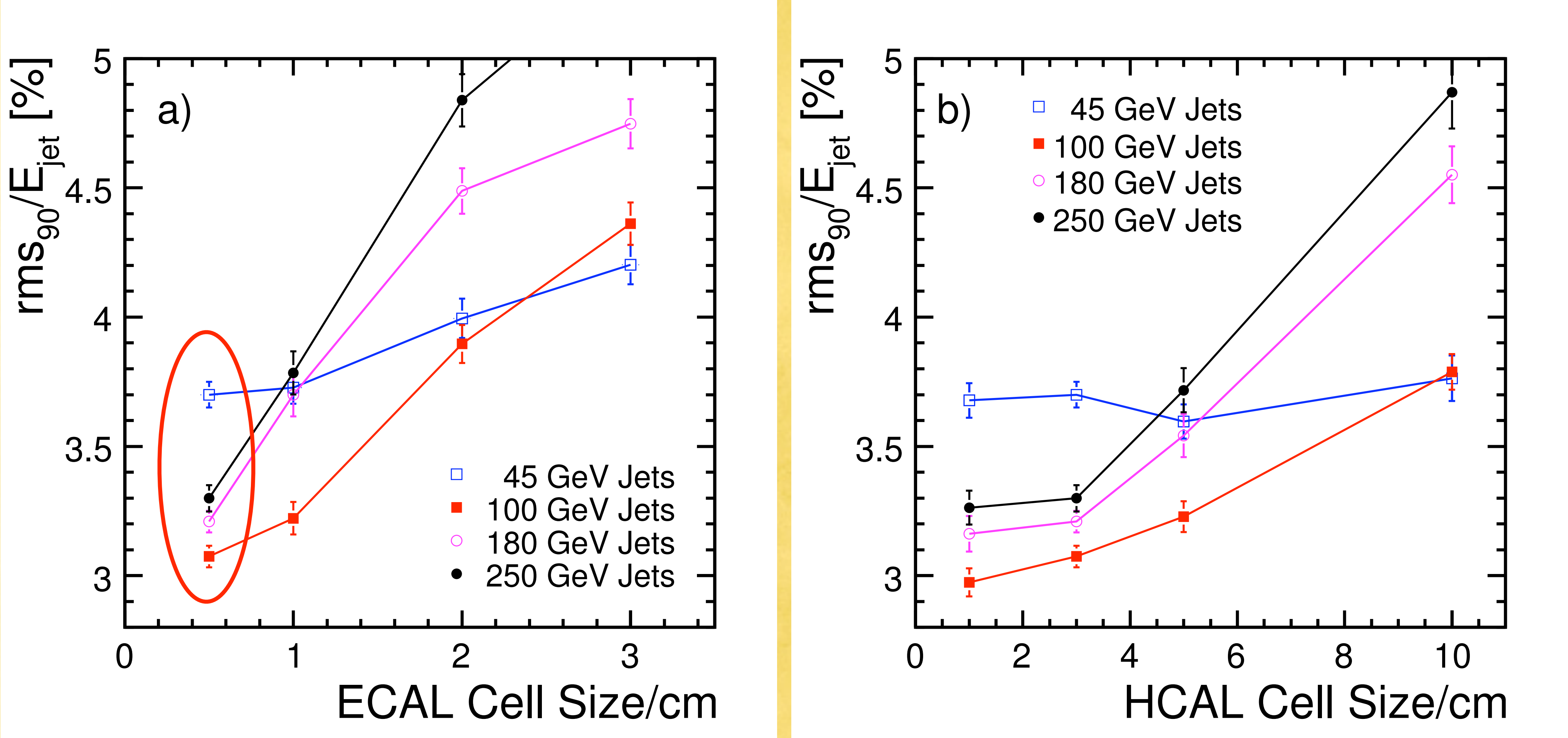
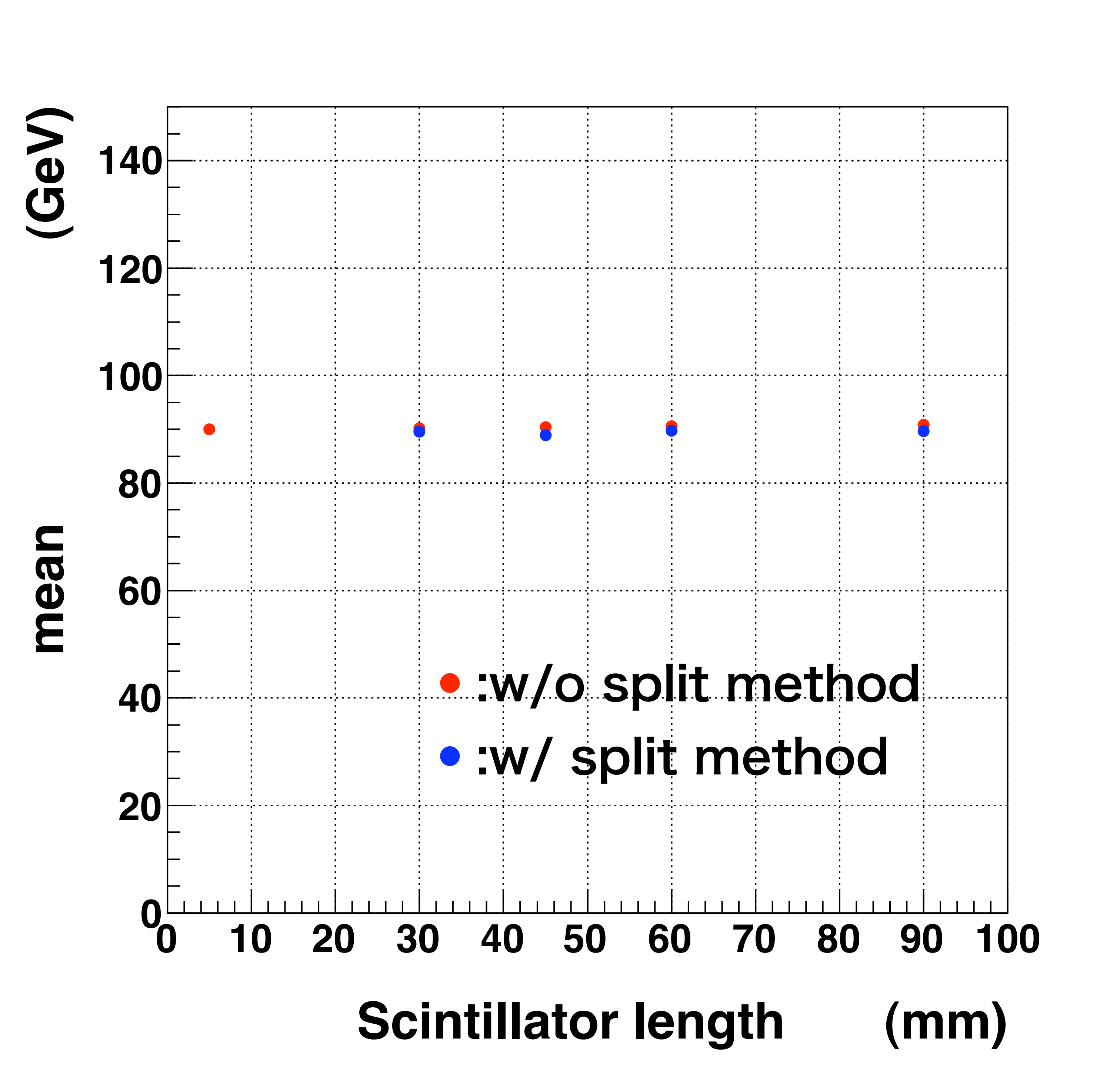


FIGURE 2.2-4. a) the dependence of the jet energy resolution (rms_{90}) on the ECAL transverse segmentation (Silicon pixel size) in the LDCPrime model. b) the dependence of the jet energy resolution (rms_{90}) on the HCAL transverse segmentation (scintillator tile size) in the LDCPrime model.

Sc. length dependence of the Jet energy

$\sqrt{s}$ = 91 GeV, Scintillator width = 5 mm



I will make 5 mm x5 mm tile scintillator data soon. Already we can expect that split method still work well for $\sqrt{s}$ = 500 GeV

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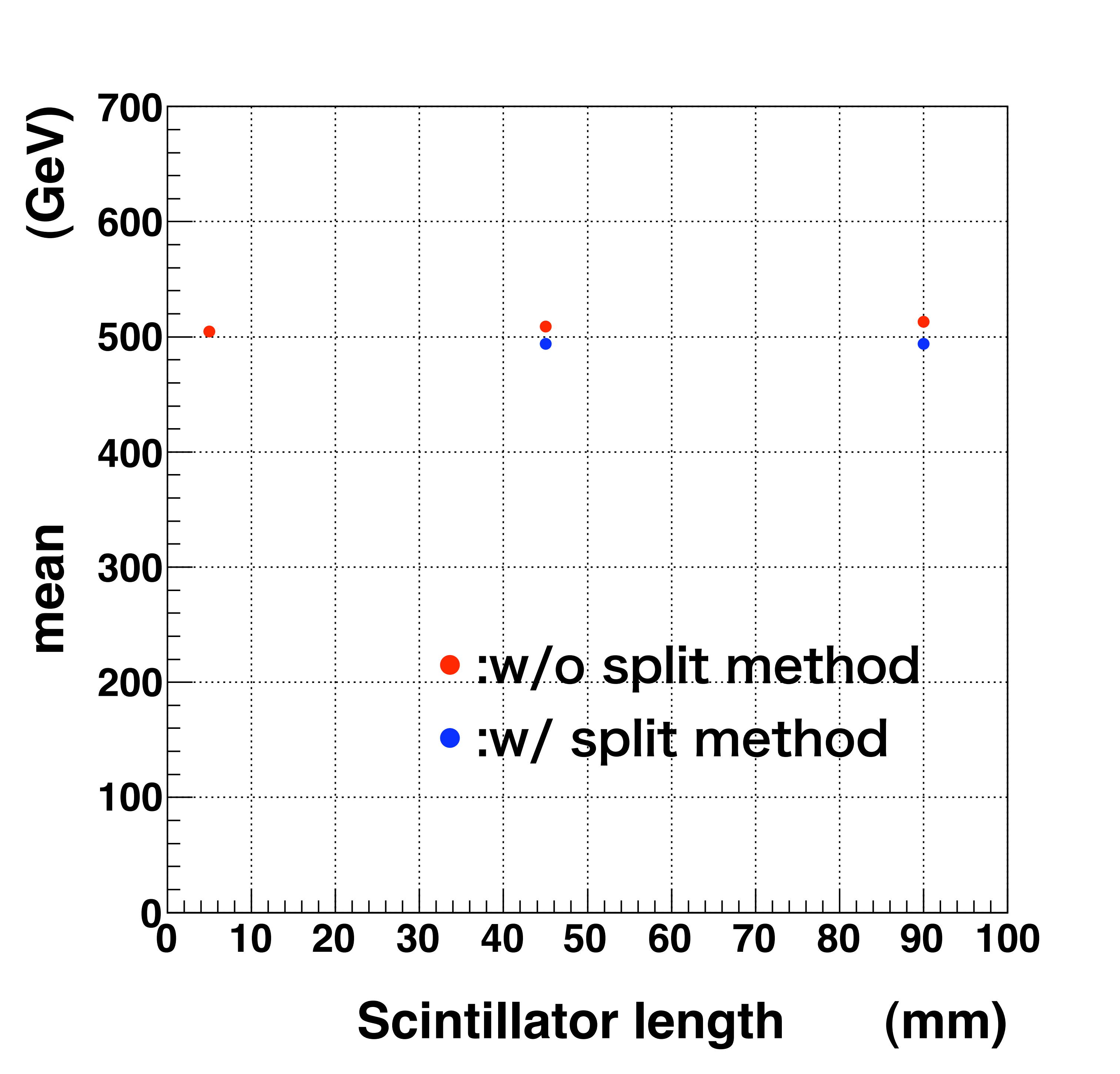

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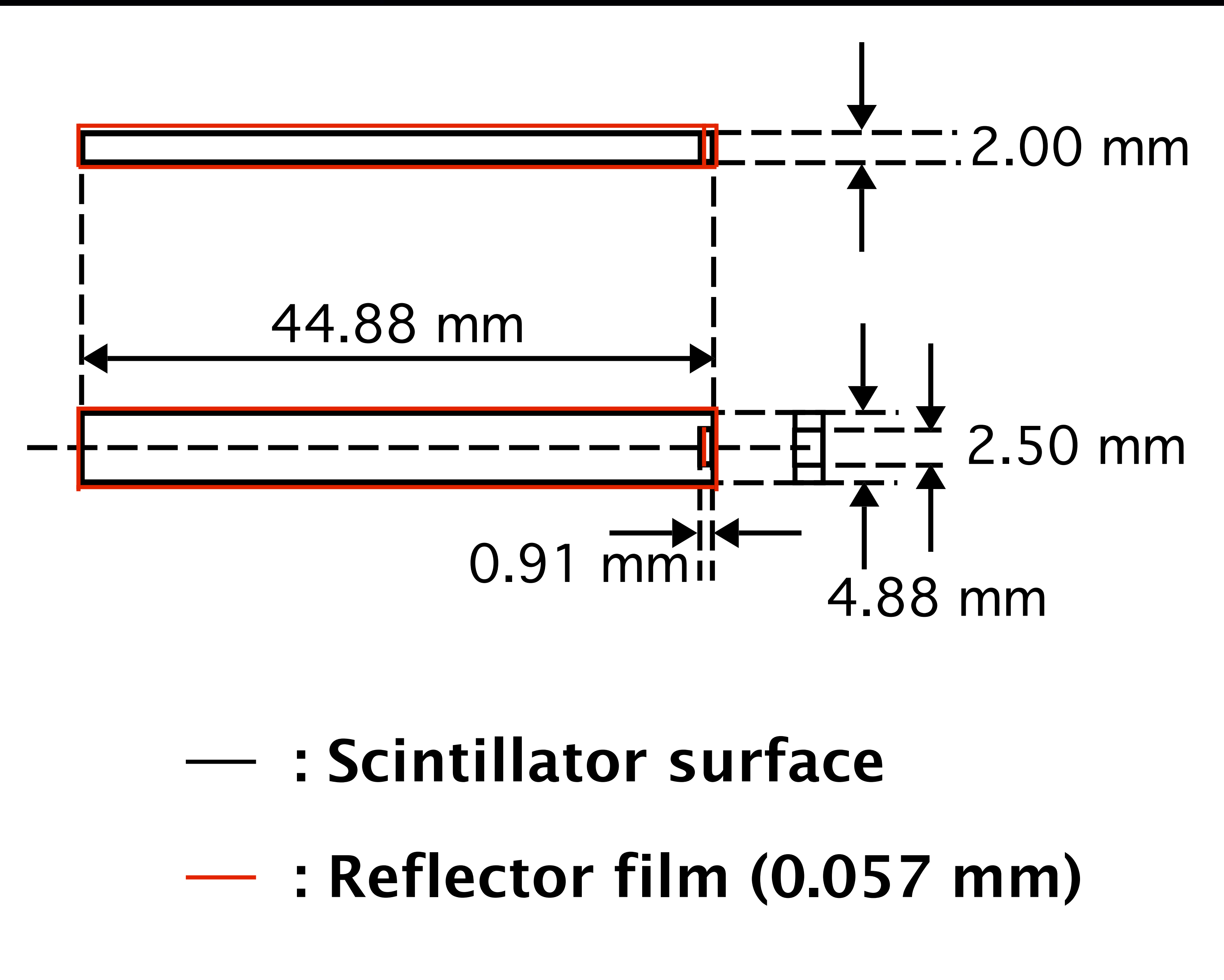
Merge in MerlinReco → Strip implemented in Mokka

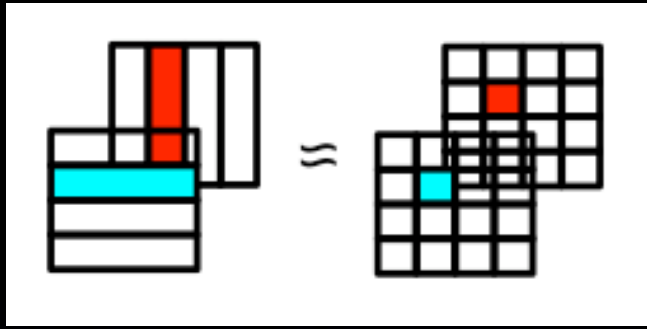


Strip directly implemented method

- Reflector film is implemented.
- The currently smallest MPPC package is implemented.
- position dependence of response is achieved as a function.

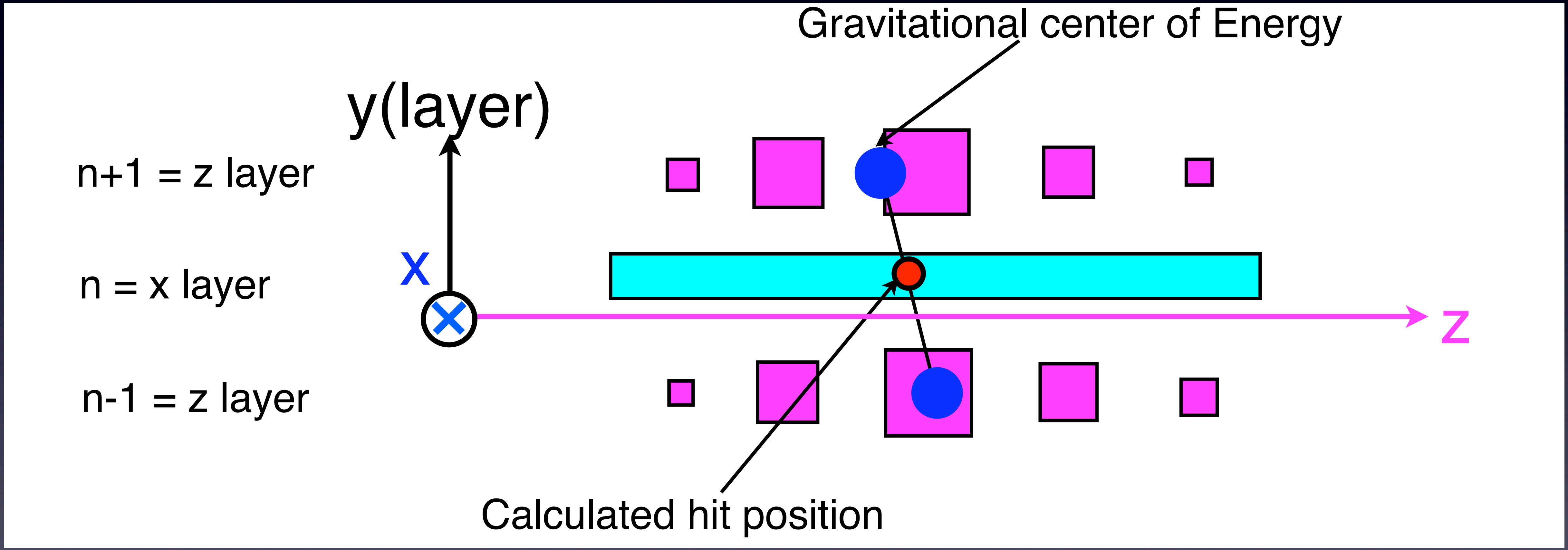
←empirical

Strip clustering: Triplet method



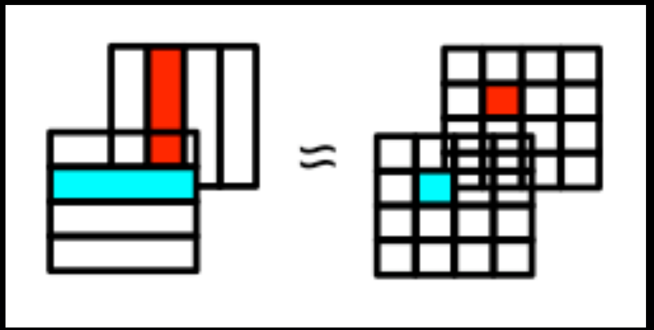
by Daniel Jeans

2) Making triplets: three 2d clusters in successive layers



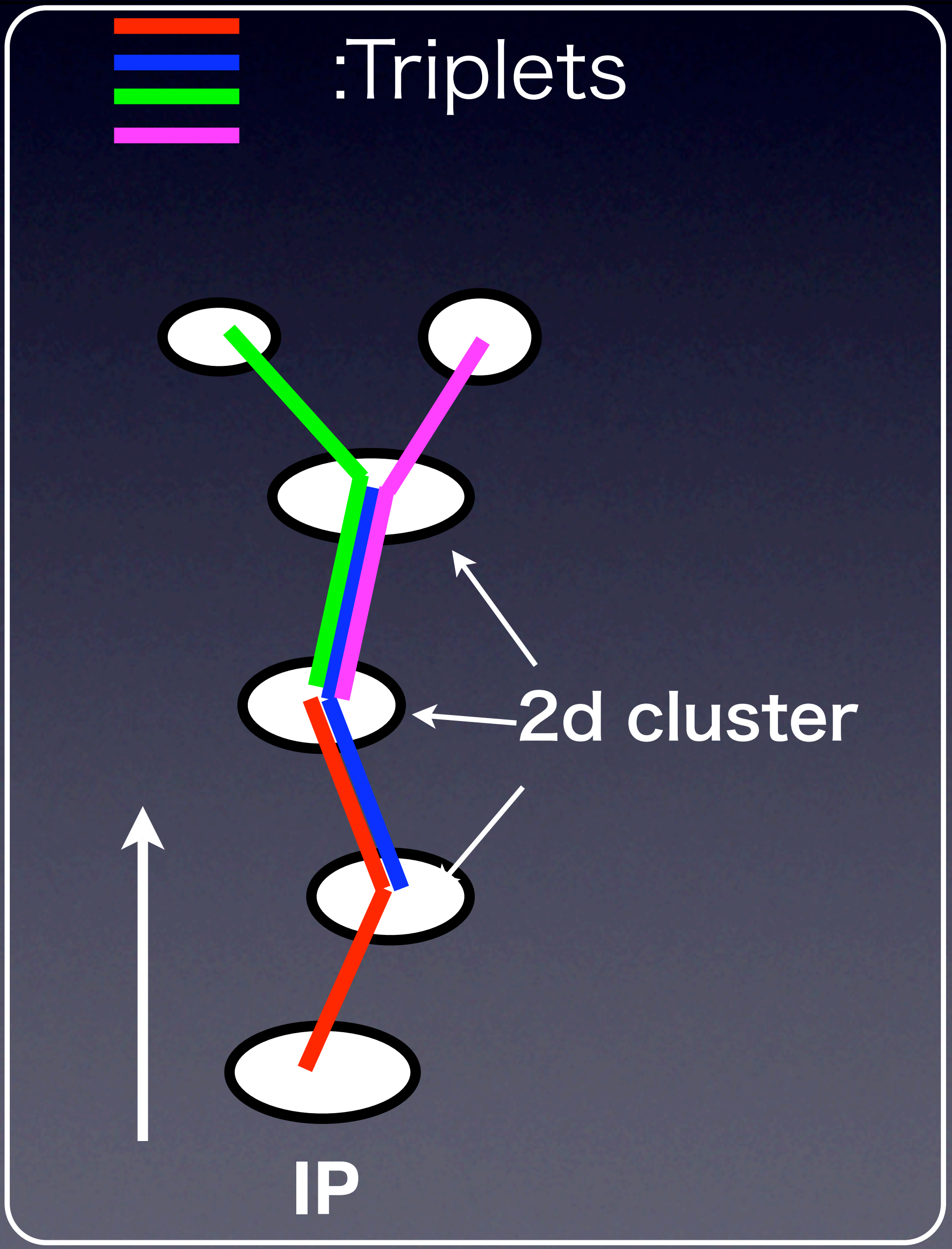
- Requiring cluster overlap with adjacent layers in a Triplet,
- the hit position of n = x(z) layer is determined with n-1 layer and n+1 layer → new position
- make Triplets for all layers.

Strip clustering: Triplet method



by Daniel Jeans

An example of clustering from four triplets



3) Make Calorimeter tracks connecting Triples (left cartoon)
  - Start from the inner layer
  - gather Triplets which has the common cluster in each
4) Matching with TPC tracks
  - gather calorimeter tracks if they have merit reducing the difference from the energy by the tracker
5) Pass the new hit positions to the PandoraPFA Processor → (need to optimize PandoraPFA).