Strip-splitting method for ECAL clustering

K. Kawagoe (Kobe) for K. Kotera (Shinshu)

CALICE meeting, Casablanca

24th September, 2010

Introduction

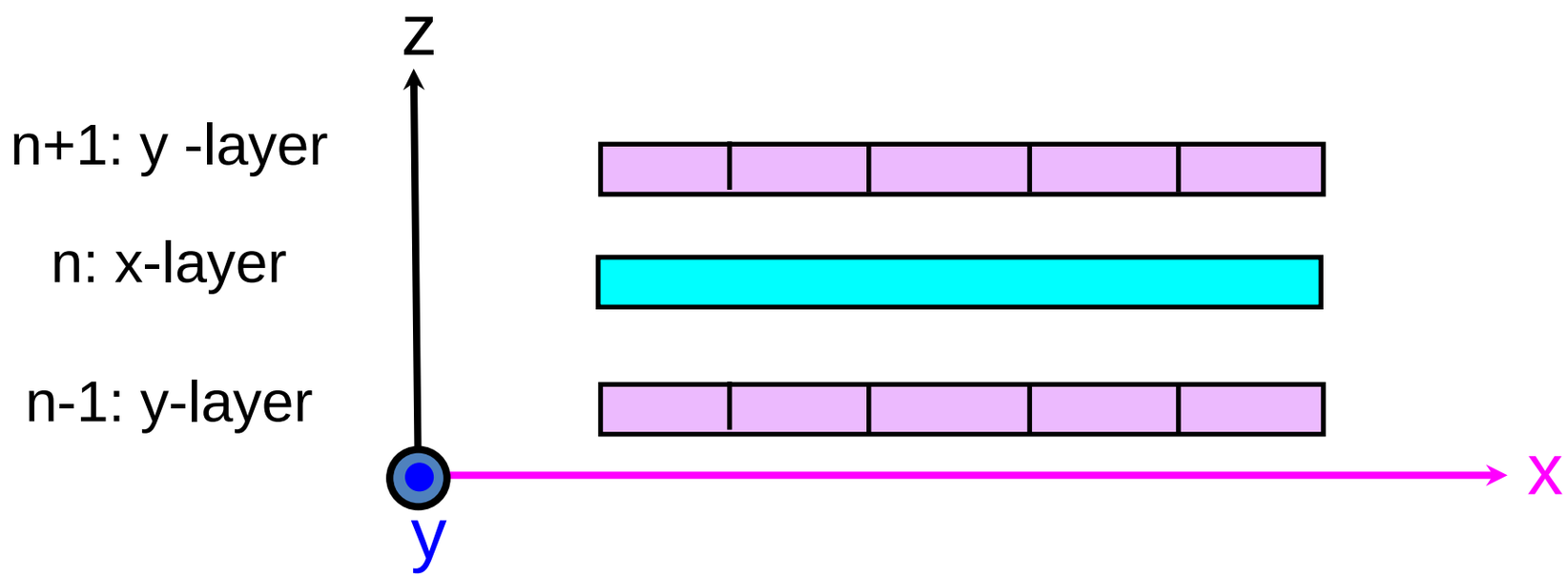
- ScECAL is aiming at “effective” w x w (w=5~10mm) granularity using orthogonal layers of scintillator strips with dimension w x l (l=45mm or longer).
- Possible problem
  - Ambiguity in hit-positions when multi-particles hit in a narrow region.

  ➔A special clustering algorithm must be developed and its performance must be demonstrated (ILD LOI).
- Previous approach: “Triplet method”
  - developed by Daniel: it was not so successful probably due to a problem in interface with PFA. The development is stopped.
- New approach: “Strip-splitting method”
  - A simple algorithm being developed by Katsu, to distribute energy deposit in a strip into virtually split square cells.
  - Energy deposits in the square cells are fed into PandraPFA i.e. clustering algorithm in PandraPFA is used.

– We used Mokka ILD_00_EcalSc01 with 27 layers of scintillator strips.

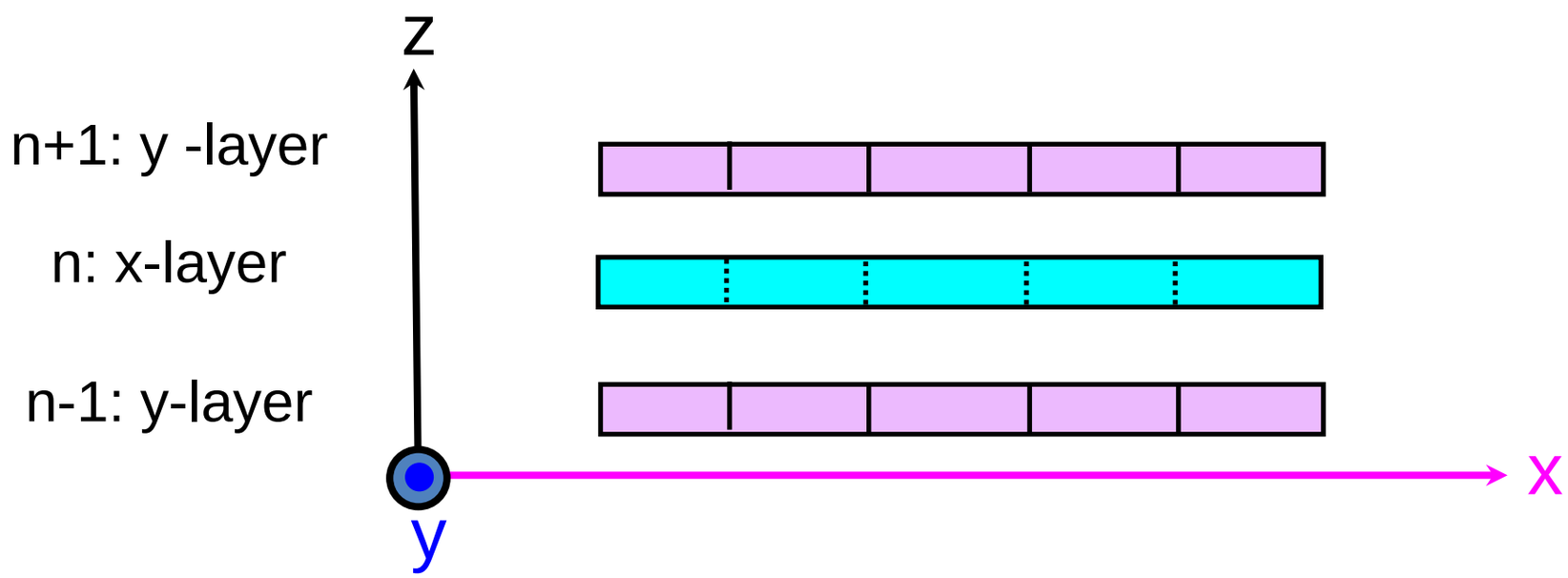
Strip-splitting method

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



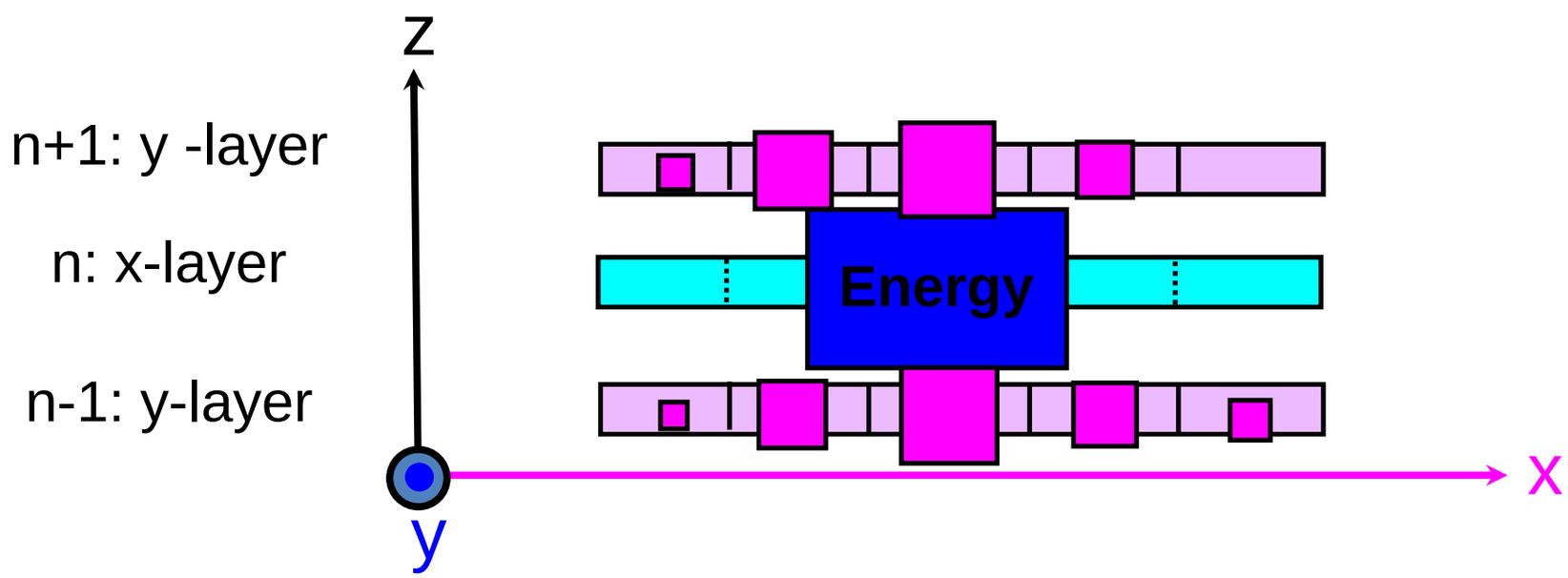
Strip-splitting method

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



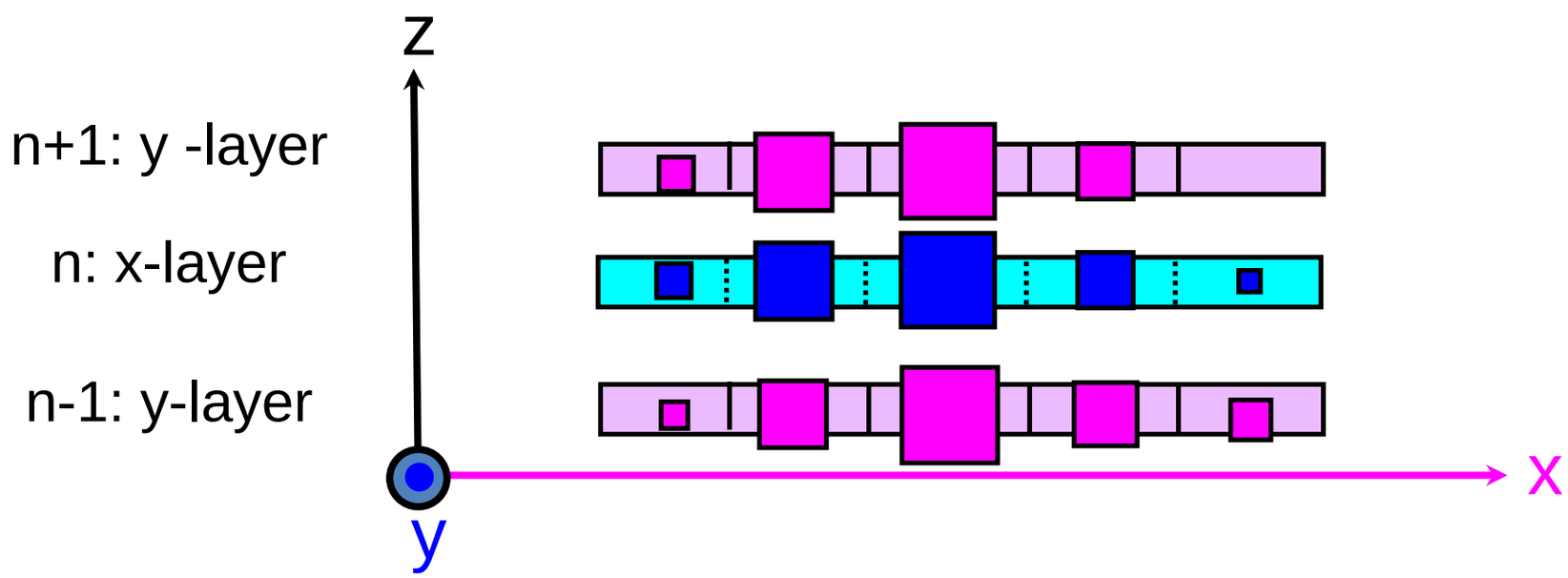
Strip-splitting method

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



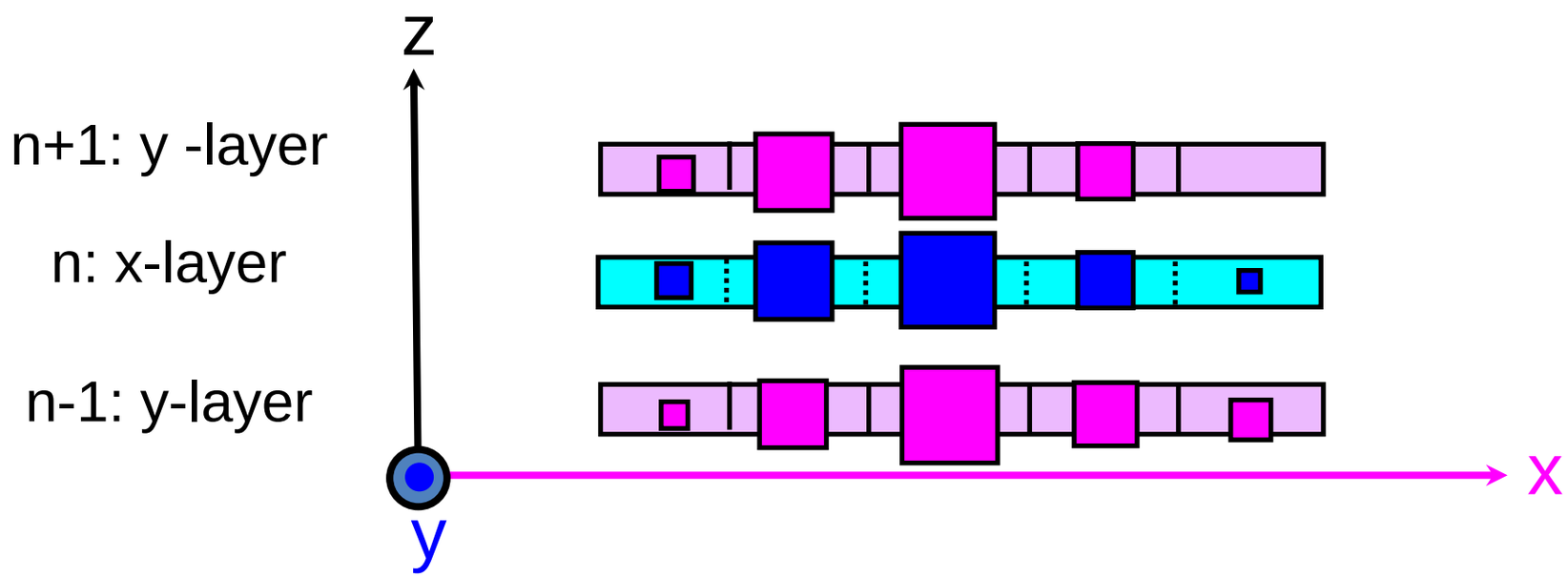
Strip-splitting method

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

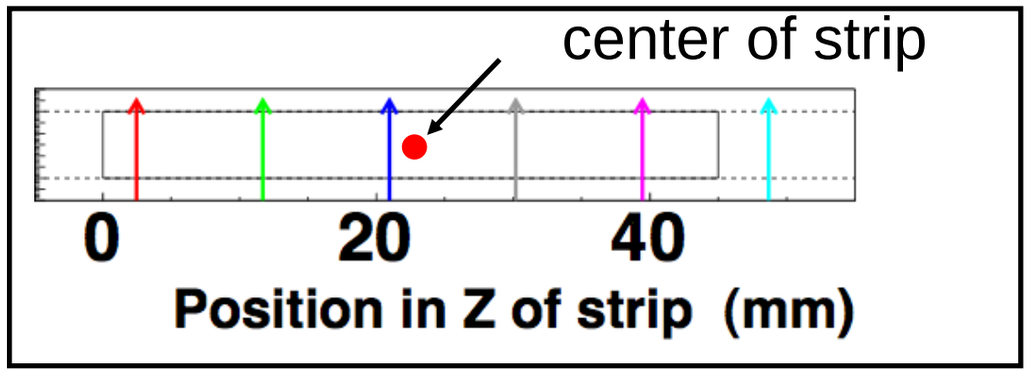


Strip-splitting method

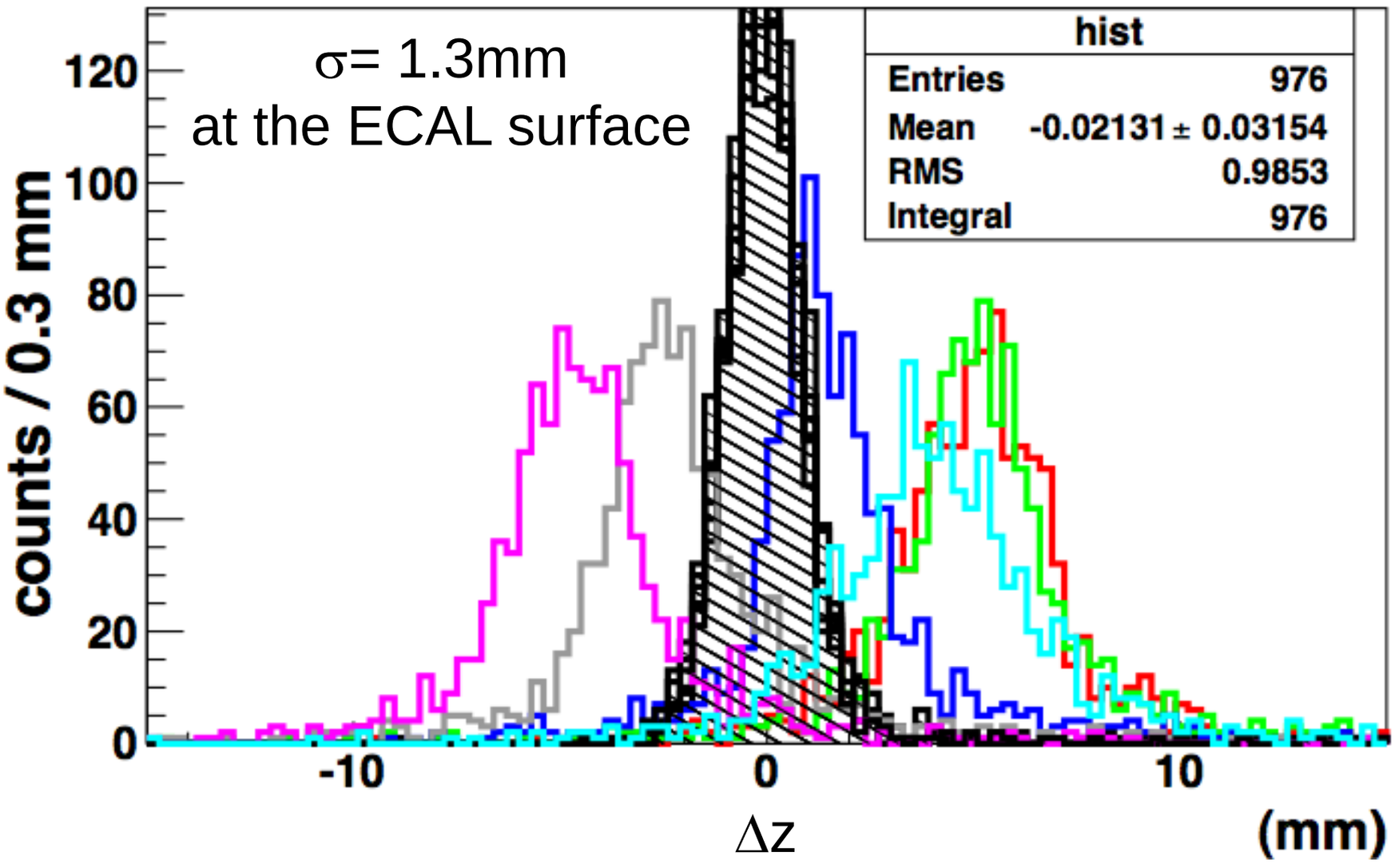
1. Assume that n-th is an x-layer, while (n-1)-th and (n+1)-th layers are y-layers.
2. Split each strip in n-th layer into virtual square cells.
3. Energy deposit in a strip in n-th layer
4. is distributed to the virtual square cells according to the energy deposits in the adjacent (n-1)-th and (n+1)-th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



Position resolution: Δz for 10 GeV photons



Position difference ($\Delta z = z_{rec} - z_{MC}$) between reconstructed position and MC true position at the ILD ECAL surface for 10 GeV photons with incident polar angles approximately 90 degrees.



For 45mm x 5mm strips:

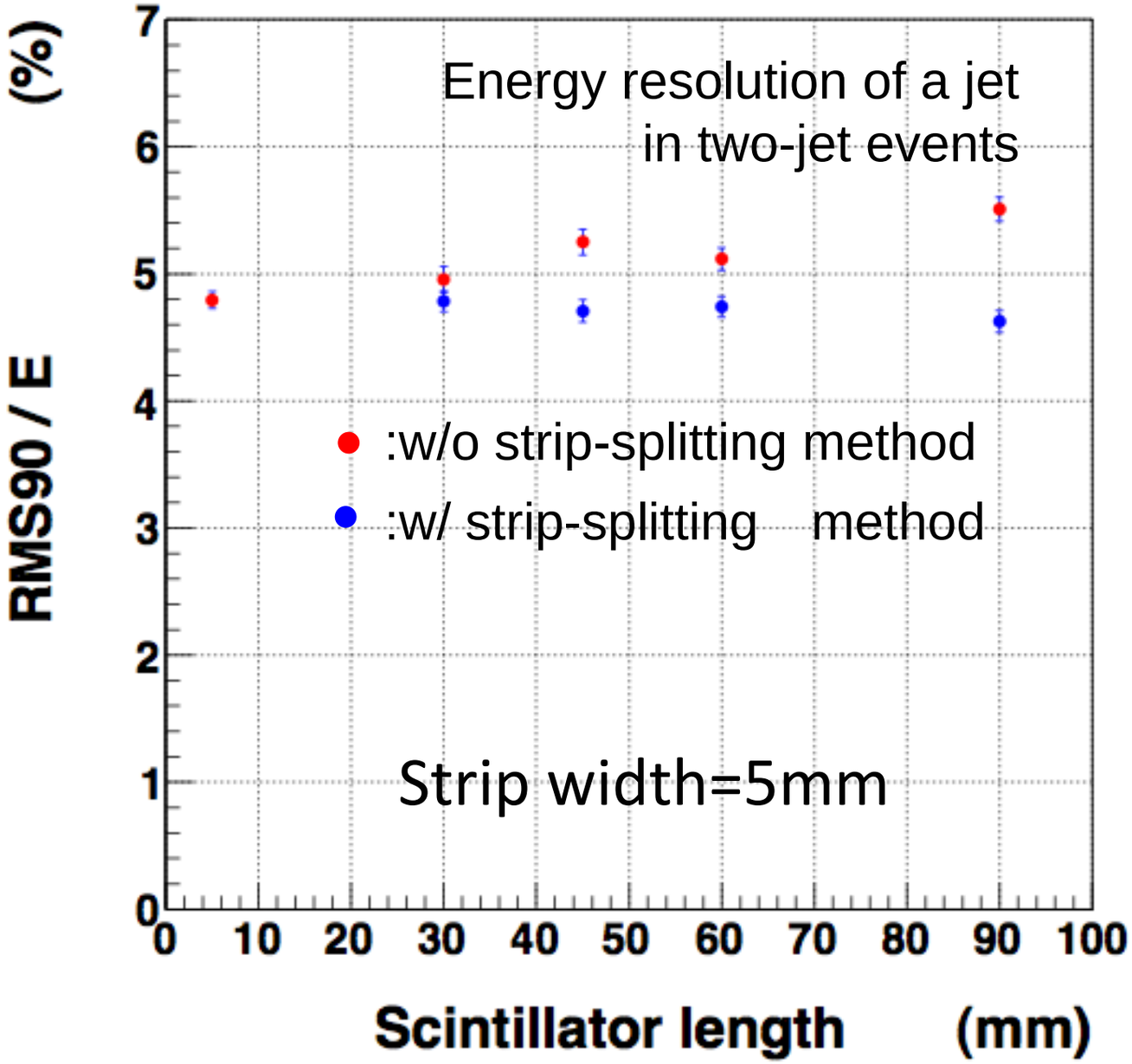
Black: Δz distribution of reconstructed PFO with strip-splitting method

Colored: Δz distributions of energy-weighted mean position without the strip-splitting method.

Systematic shift is removed by the strip-splitting method.

Jet energy resolution vs. scintillator strip length

√s = 91 GeV

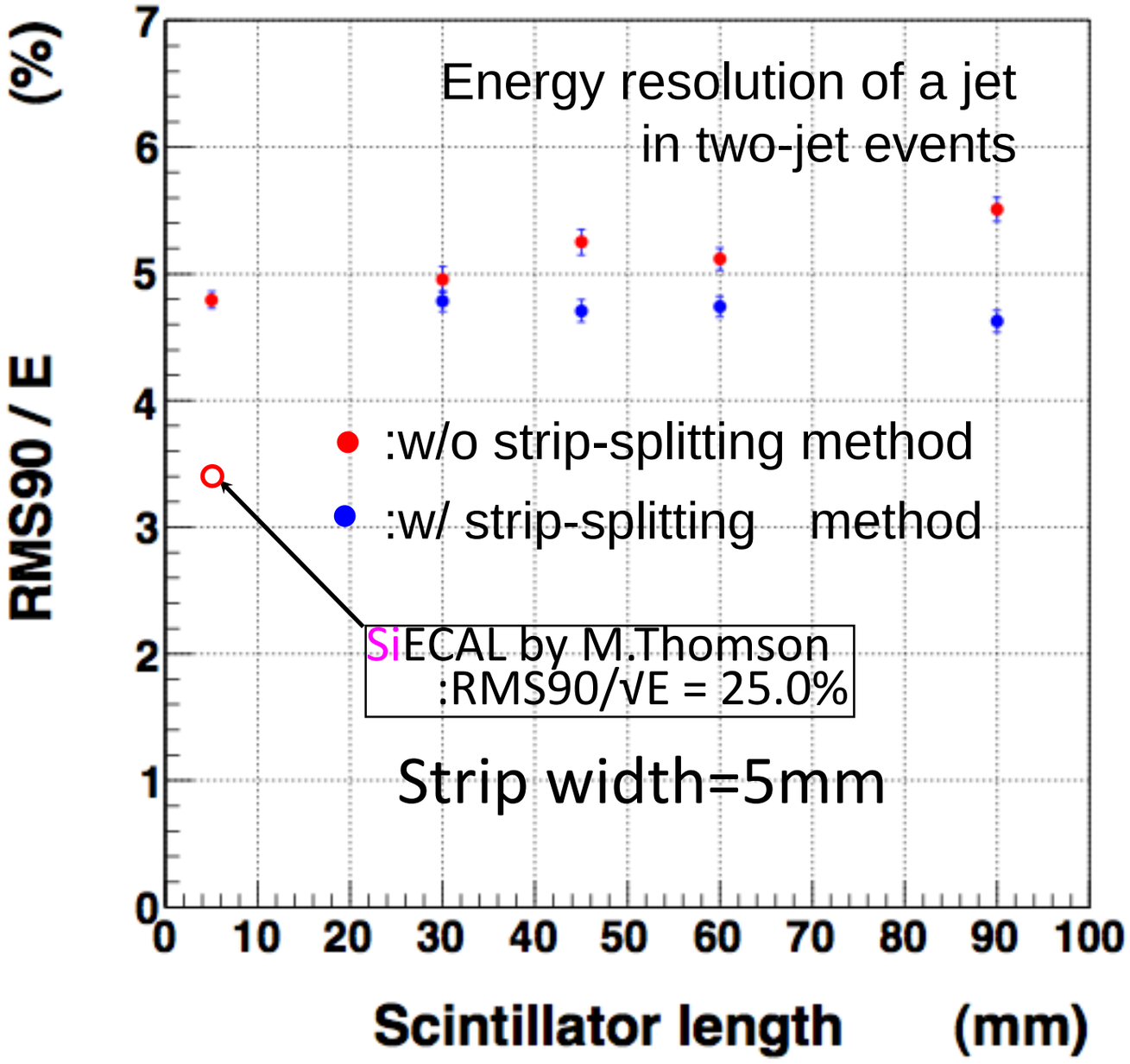


Performance for two-jet events with ScECAL with and without strip-splitting method with PandraPFA.

- $|\cos\theta_{thrust}| < 0.4$
- w/o strip-splitting method: the center positions of strips are fed into PndraPFA .

Jet energy resolution vs. scintillator strip length

√s = 91 GeV

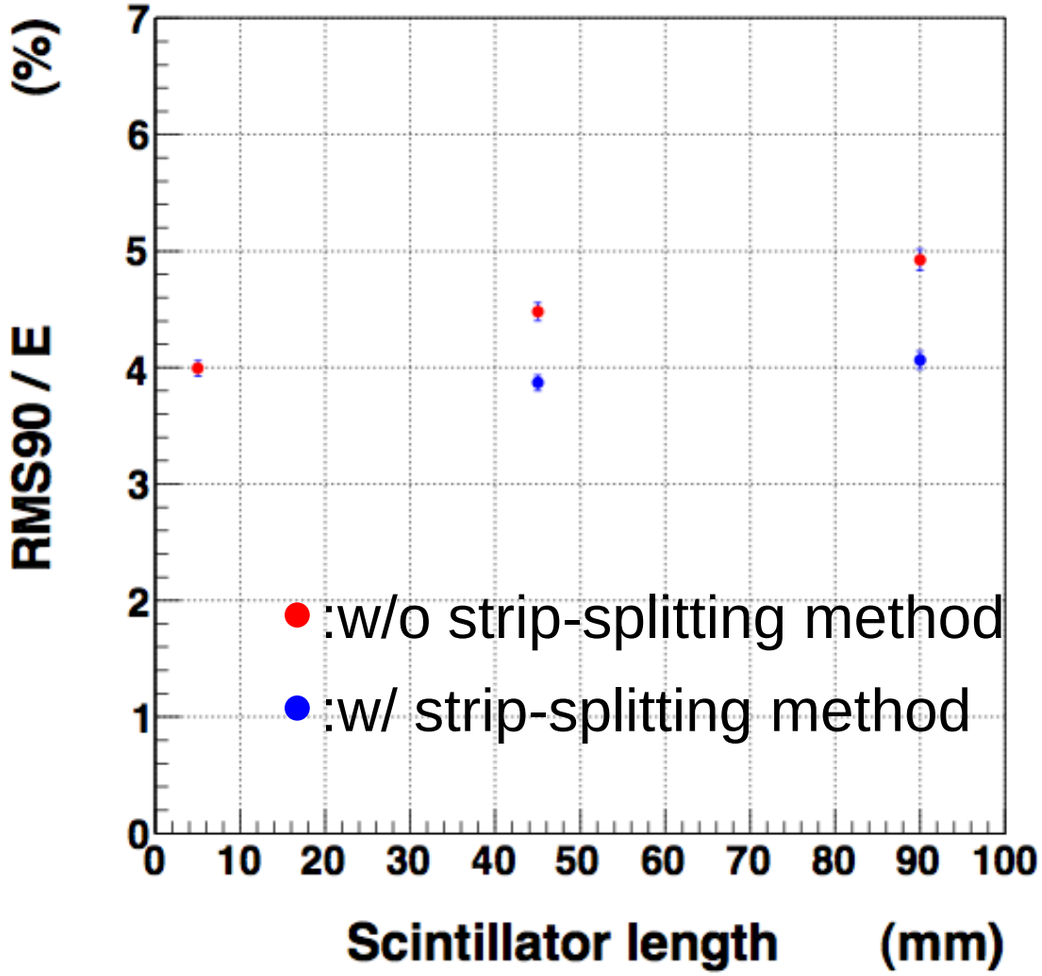


Performance for two-jet events with ScECAL with and without strip-splitting method with PandraPFA.

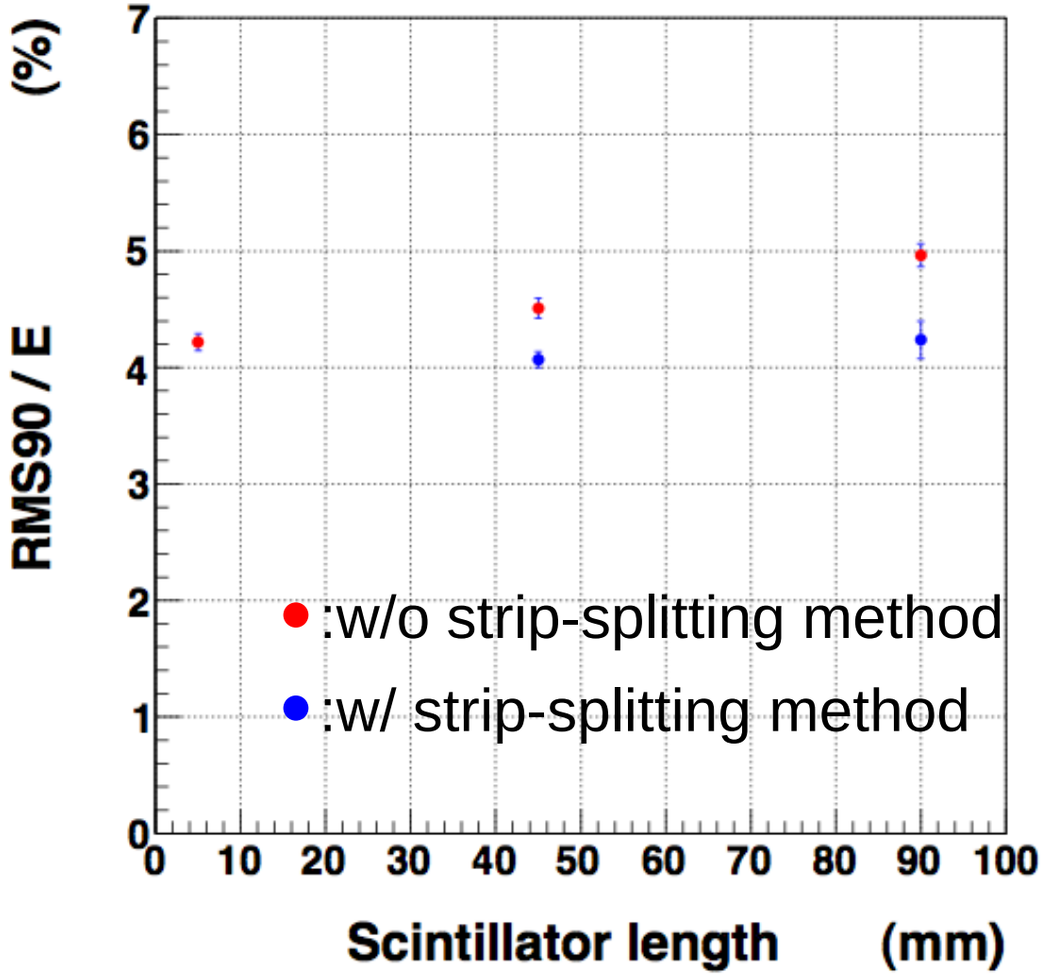
- $|\cos\theta_{thrust}| < 0.4$
- w/o strip-splitting method: the center positions of strips are fed into PndraPFA .
- The resolution (~32%/ √E) is a bit worse than Mark's resolution (25%/ √E) for 5mm x 5mm SiECAL. This is being understood mainly due to a possible problem in simulation process to make strip hits (mail from Katsu this morning).

Jet energy resolution vs. scintillator strip length at higher energies

√s = 360 GeV

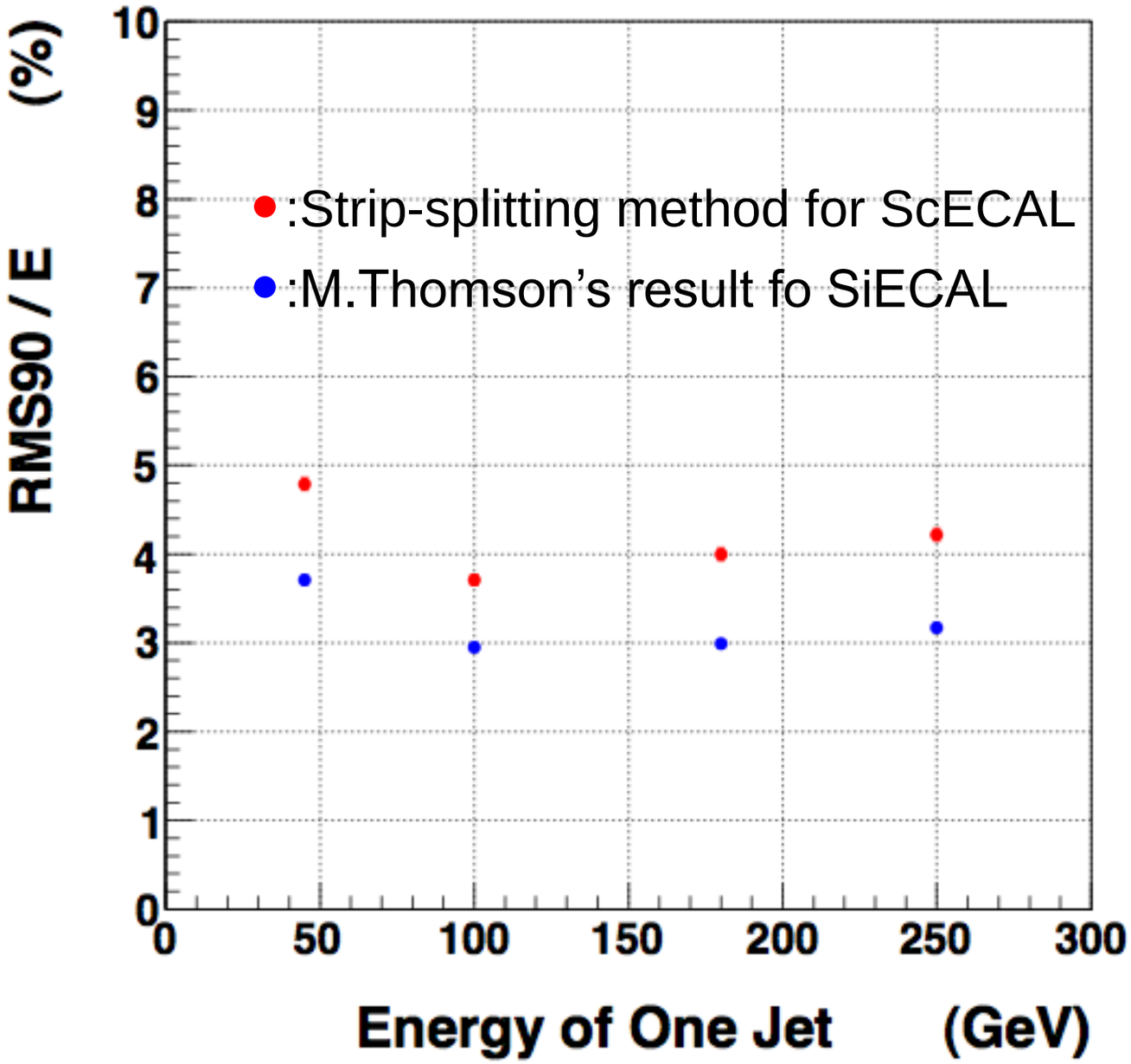


√s = 500 GeV



Even at √s = 500 GeV, 5mm x 90 mm strips show similar performance to that of 5 mm x 5mm square tiles.

Jet energy resolution vs. jet energy



- The tendency is the same as that of M. Thomson's result for SiECAL.
- The difference of the absolute resolutions is being understood.

Summary

- The strip-splitting method has been developed for strip clustering.
- Although fine tuning may be still necessary, this method seems promising: up to √s = 500 GeV, ECAL with 45 mm (or even 90 mm) x 5 mm scintillator strips shows similar performance to that of ECAL with 5mm x 5mm square tiles.

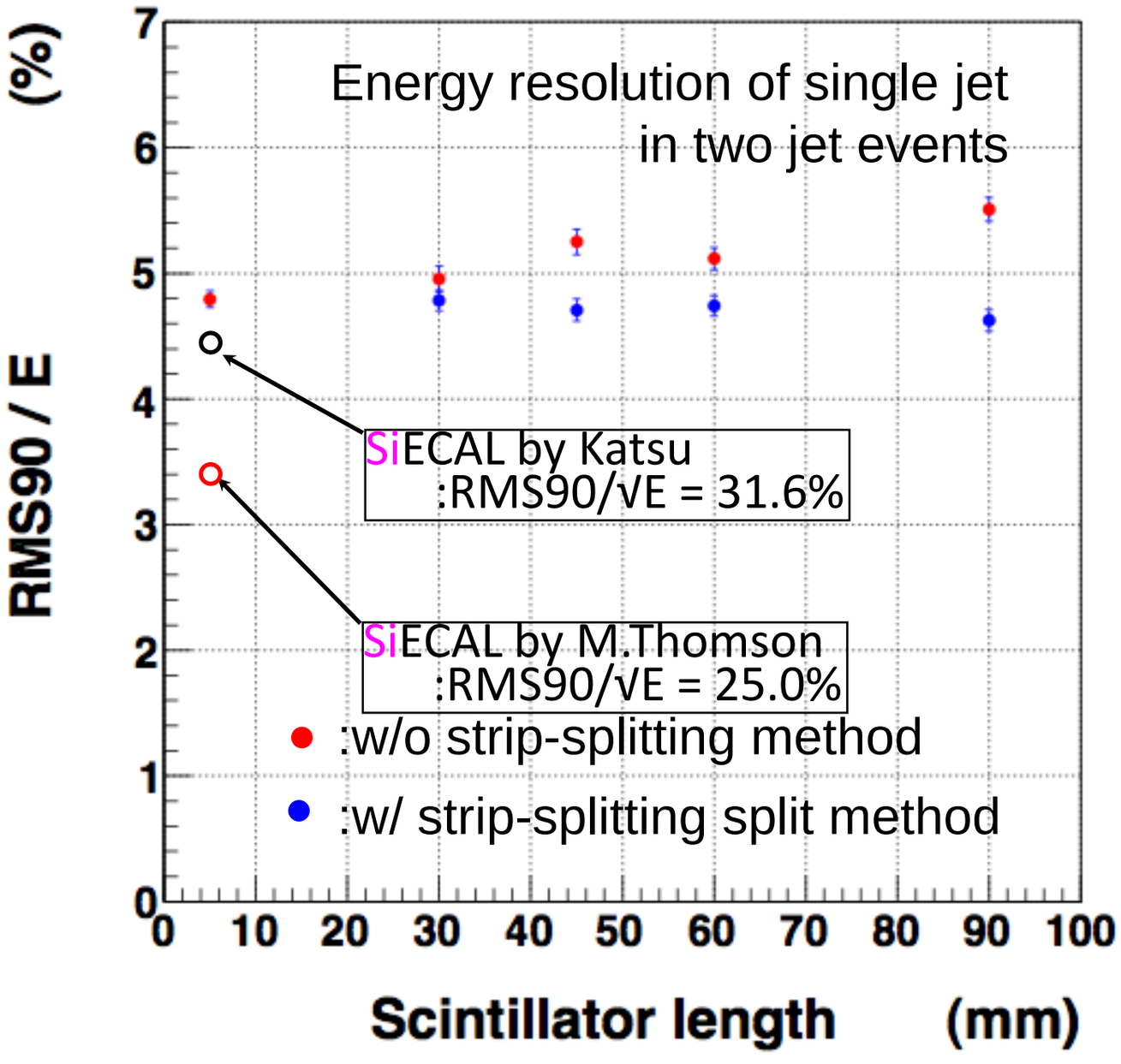
ToDos

- Performance issues
  - Performance at higher energies (up to √s = 1 TeV)
  - Studies of longer strips (>90mm) and wider strips (w=10mm)
  - understand the difference from Mark Thomson's result
  - Reconstruction of pi0
  - Reconstruction of multi-jet events (e.g. ttbar etc.)
  - Non-uniformity of response in a strip to be taken into account
- Technical issues
  - Write code for the Endcap hits
  - Boundary treatment
    - Stave - Stave, Module - Module, Endcap - Barrel
  - Use new Mokka (it intrinsically has strip shape in it, and HYBRID ECAL possible)
- The study of strip-splitting may be extended to
  - Hybrid ECAL (Scintillator and Silicon layers mixed)
  - Scintillator strip AHCAL

back up

Jet energy resolution vs. scintillator strip length

√s = 91 GeV



Comparison with 5mm x 5mm SiECAL:

- comparable resolution with default tune
- But worse than Mark Thomson's resolution:

being understood as a possible problem in making strip hits from 5mm x 5mm square cell hits in the simulation process (mail from Katsu this morning).

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

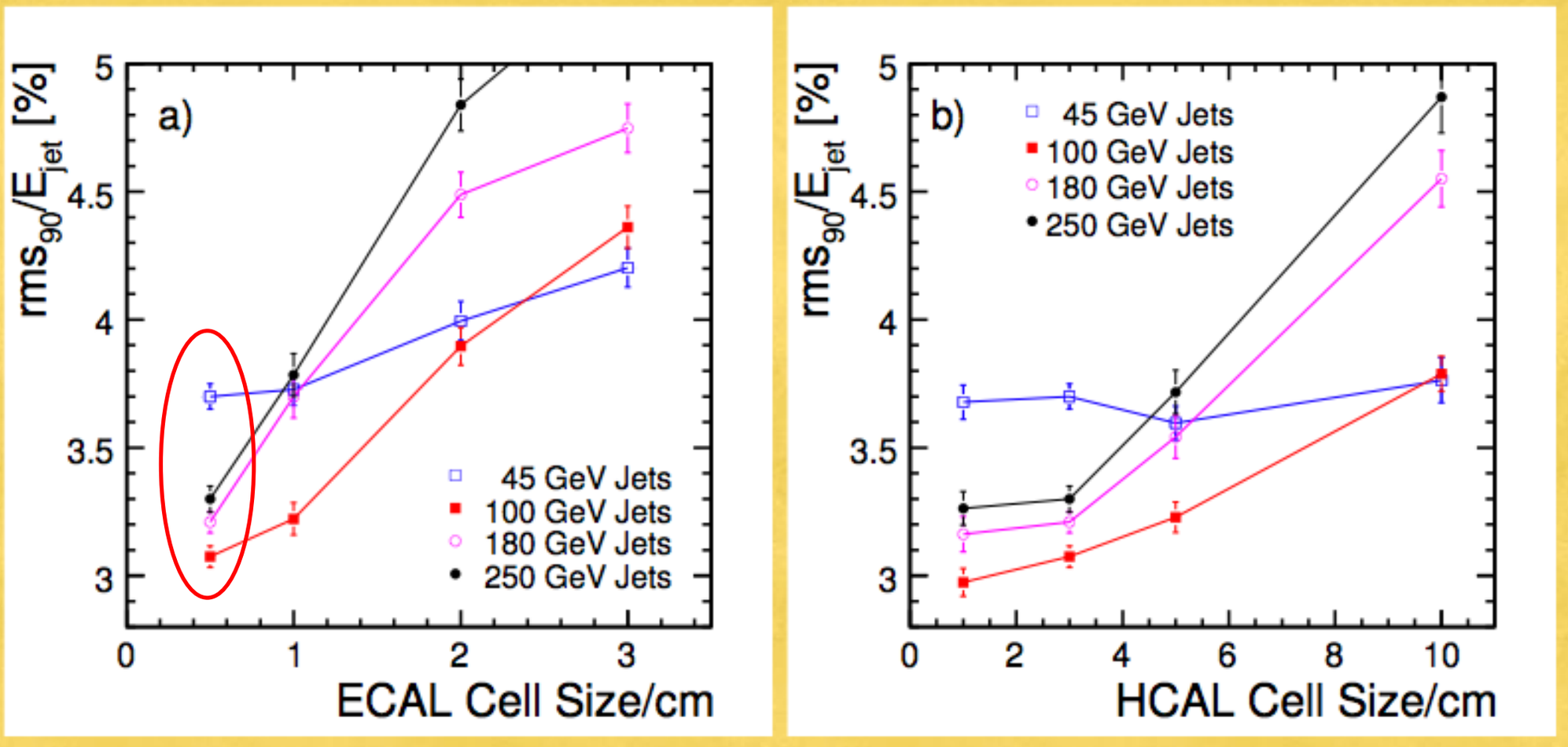


FIGURE 2.2-4. a) the dependence of the jet energy resolution (rms_{90}) on the ECAL transverse segmentation (Silicon pixel size) in the LDCPrime model. b) the dependence of the jet energy resolution (rms_{90}) on the HCAL transverse segmentation (scintillator tile size) in the LDCPrime model.