Reconstruction of the Granular Scintillator Strip Electromagnetic Calorimeter in ILD

LCWS2012@Texas

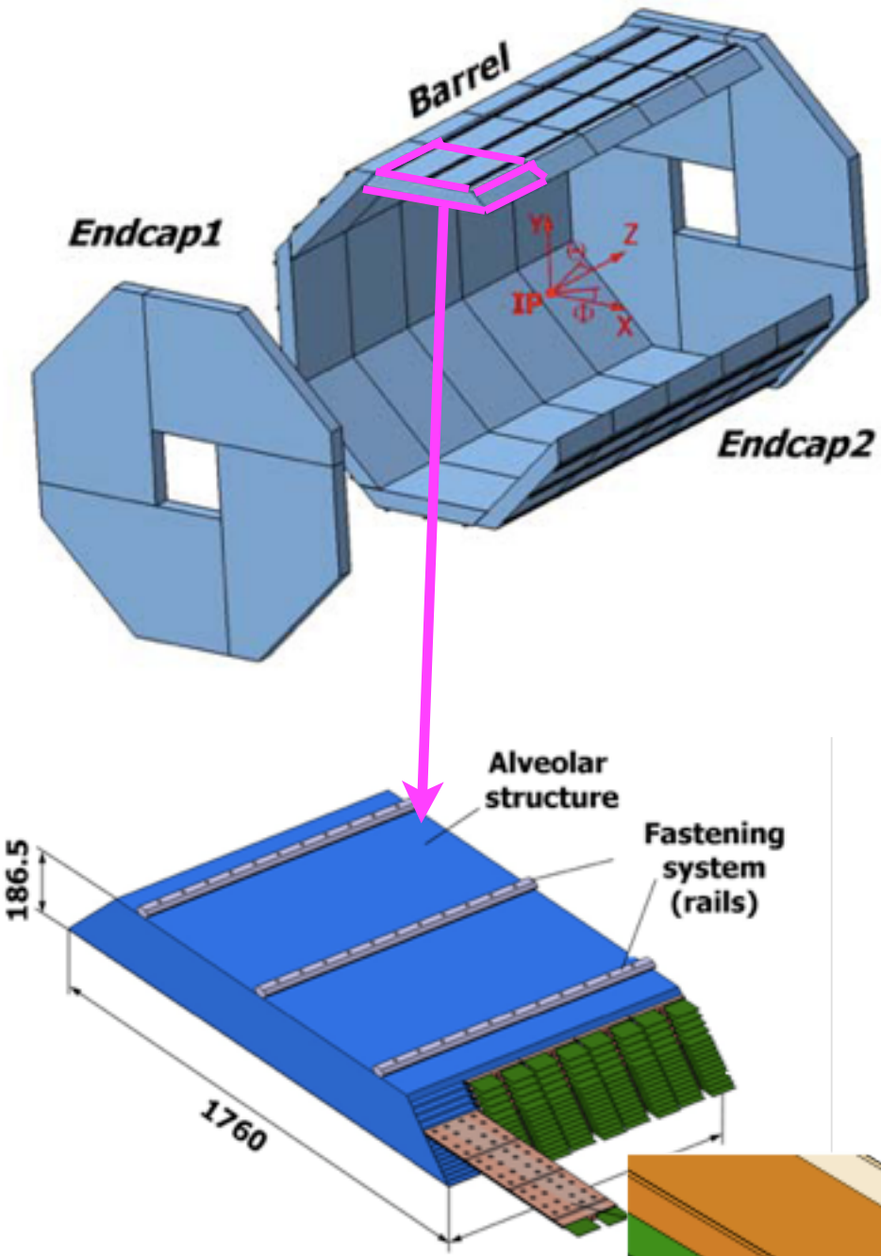
K.Kotera & T. Takeshita

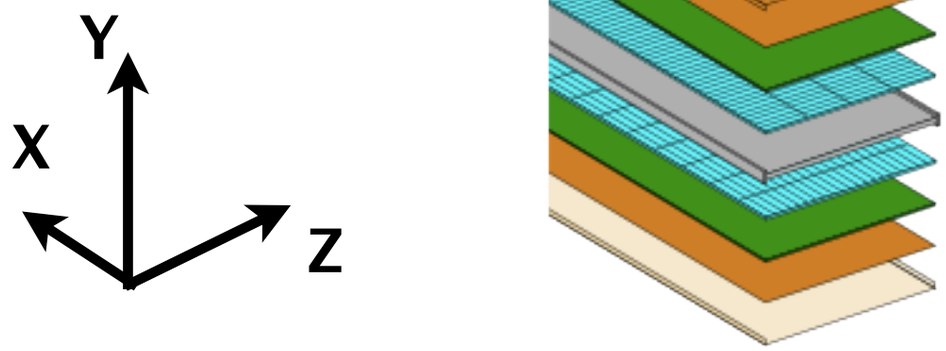
Shinshu University

Contents

They are simulation studies by using Mokka-Marlin/ PandoraPFANew.

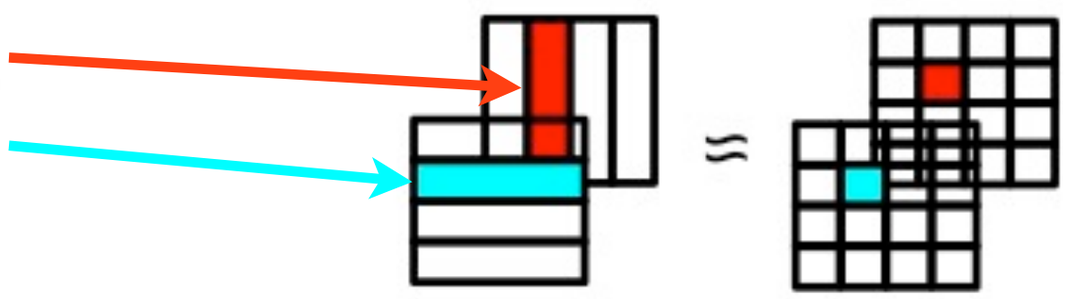
Scintillator strip ECAL for ILD

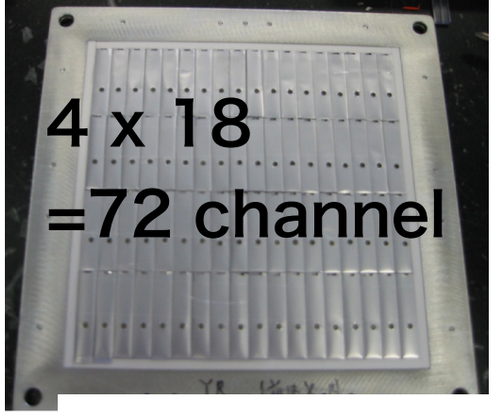




- Simulation Model
  - 25 absorber layers
    - 3 mm thick W ➡ 21.5X_0
  - plastic scintillator
    - 5 mm wide
    - 45 mm length
    - 2 mm thick
- JER/√E < 30% @ √s =91 GeV necessary.

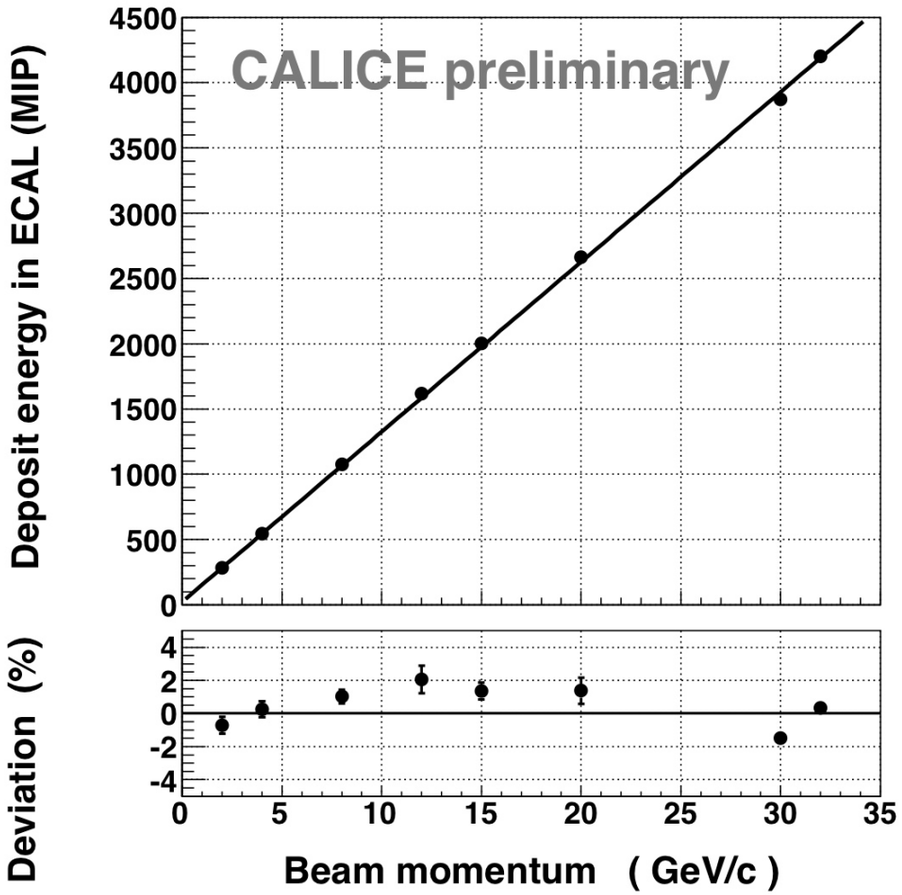
strips in odd layers are orthogonal with respect to those in even layers.

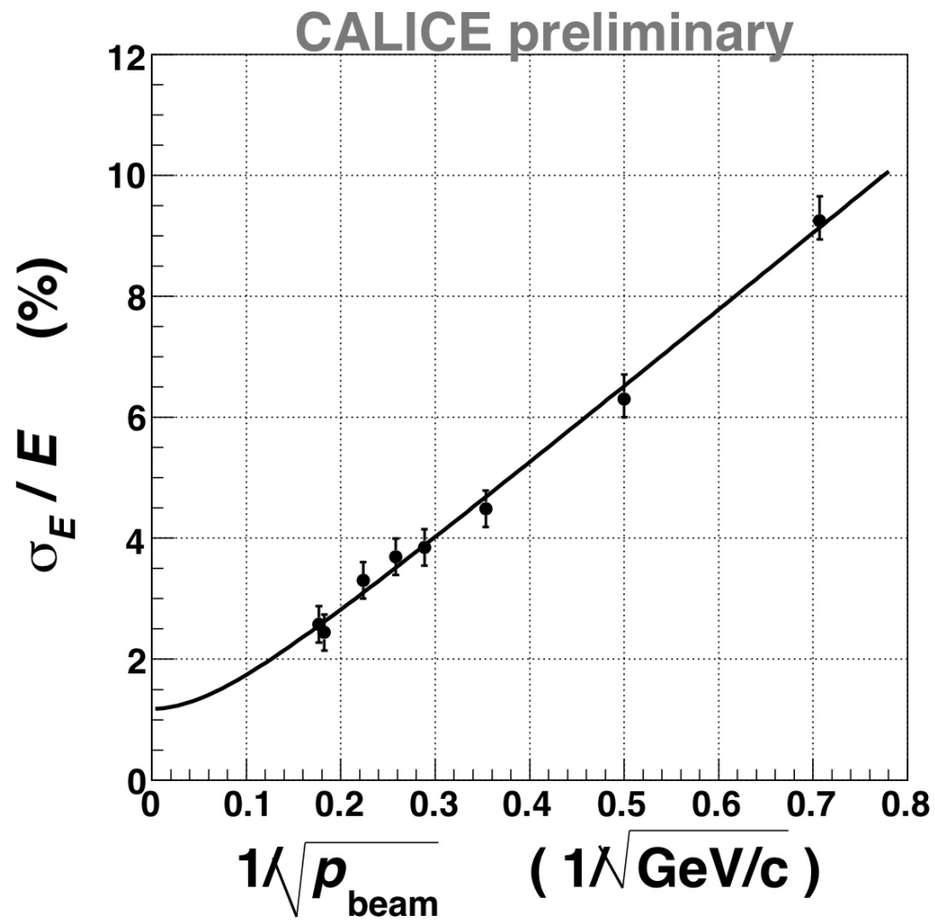




Prototype performance

Electron beam @ FNAL 2009





- 2160 channel prototype (10 x 45 x 3 mm²) 2009 at FNAL,
- deviation from linear fit : < 2.0%,
- Energy resolution for electron (2-32 GeV) :

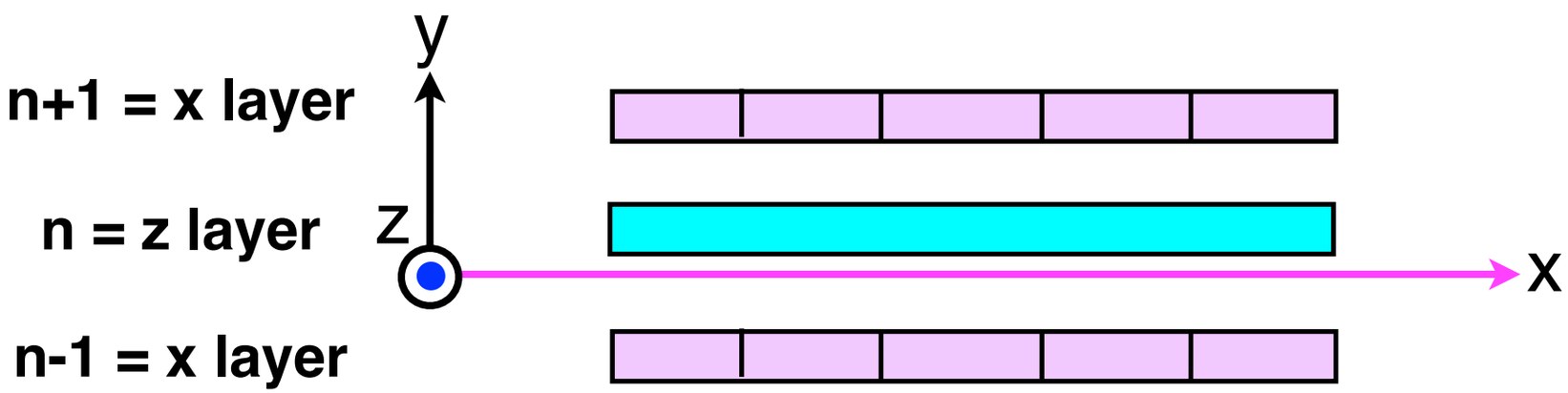
$\delta_E / E = [12.9 \pm 0.1(\text{stat.}) \pm 0.4(\text{syst.})]\%/\sqrt{E}$
$+ [(1.2 \pm 0.1(\text{stat.})^{+0.4}/_{-1.2}(\text{syst.})]\%$
(intrinsic beam spread is subtracted)

good basic performance

granularity is more important for PFA

1. Assume that n-th is an z-layer (fine segmented in z direction), while n±1 layers are x-layers (fine segmented in x direction).
2. a shower comes from the bottom
3. split each strip in n-th layer into pseudo-square cells

Split method

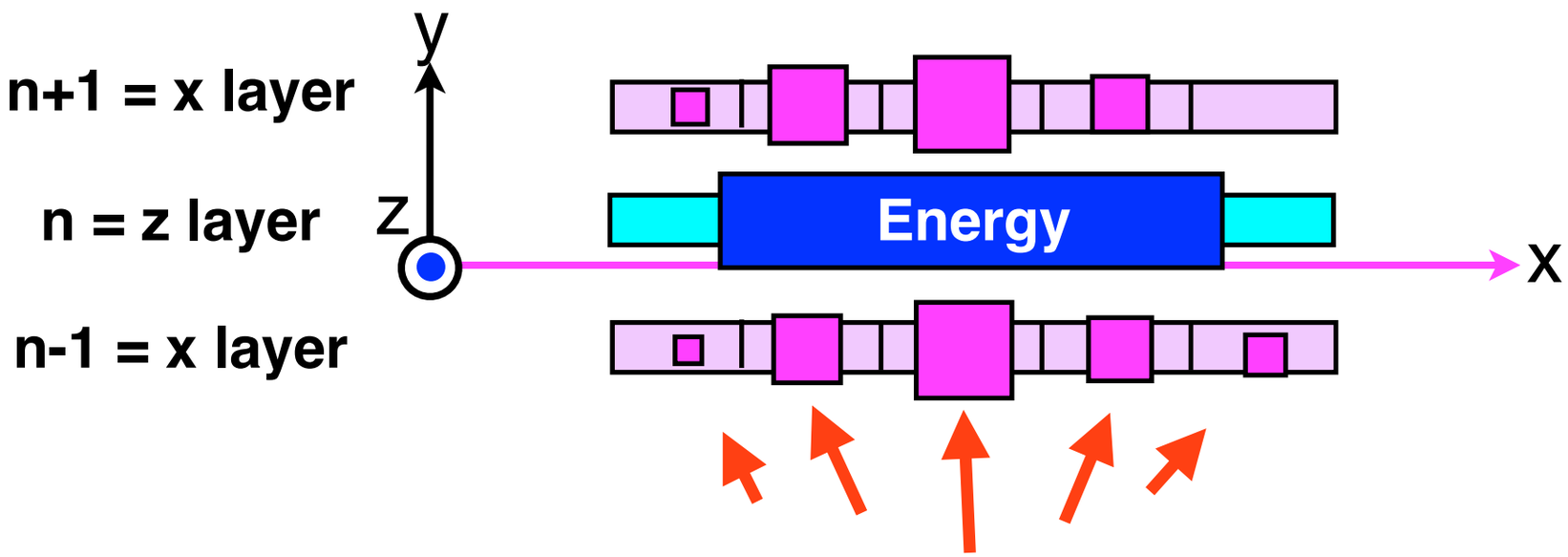


4. energy deposit in n-th layer is distributed in pseudo cells referring adjacent n±1th layers.
5. The position and energy of pseudo square cells are fed into PandoraPFA.

granularity is more important!
for PFA

1. Assume that n-th is an z-layer (fine segmented in z direction), while n±1 layers are x-layers (fine segmented in x direction).
2. a shower comes from the bottom.
3. split each strip in n-th layer into pseudo-square cells

Split method

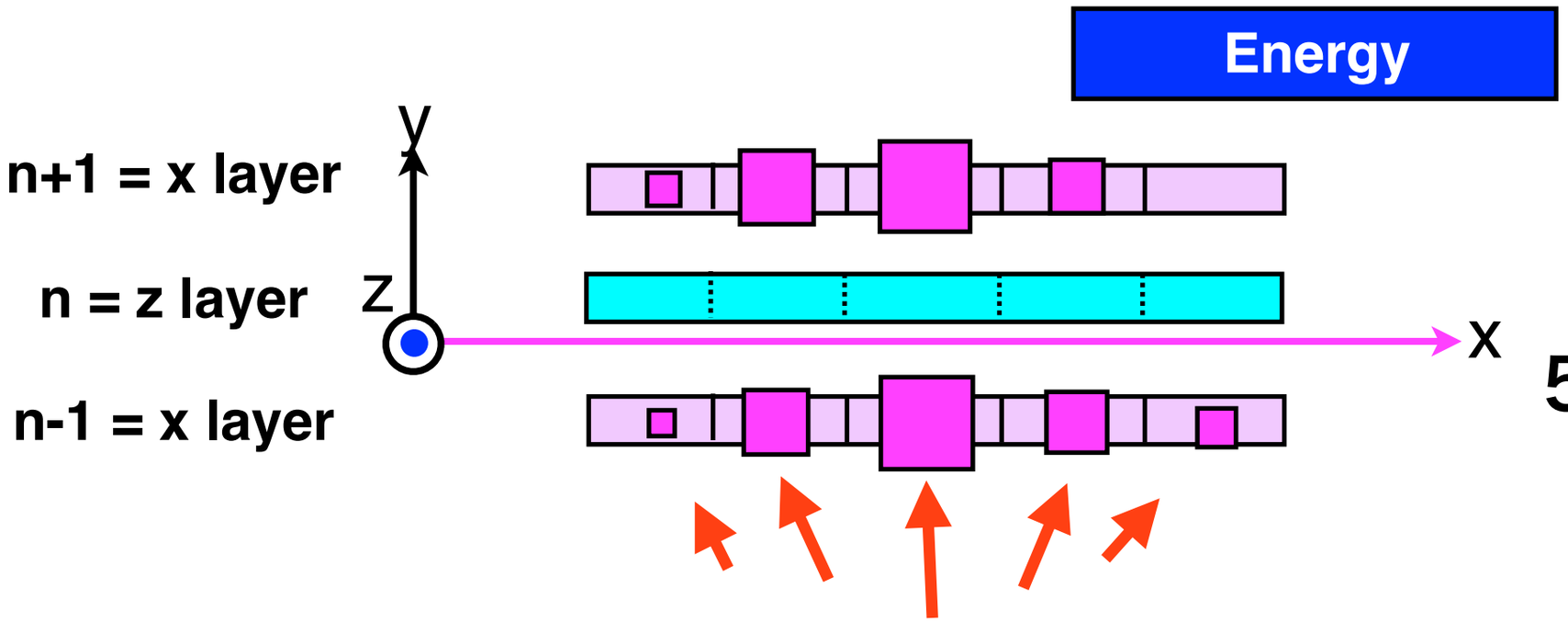


4. energy deposit in n-th layer is distributed in pseudo cells referring adjacent n±1th layers.
5. The position and energy of pseudo square cells are fed into PandoraPFA.

granularity is more important!
for PFA

1. Assume that n-th is an z-layer (fine segmented in z direction), while n±1 layers are x-layers (fine segmented in x direction).
2. a shower comes from the bottom
3. split each strip in n-th layer into pseudo-square cells

Split method

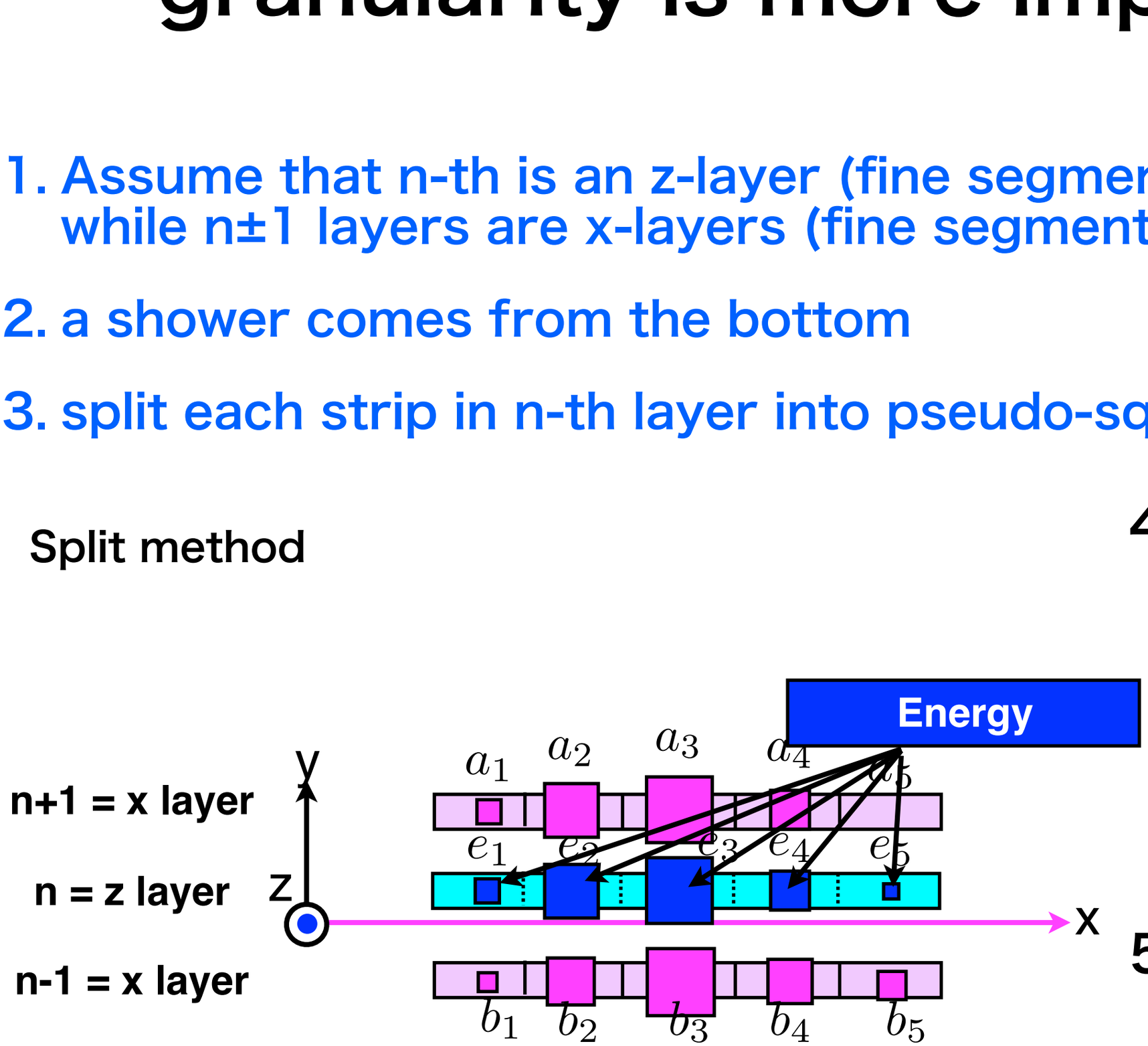


4. energy deposit in n-th layer is distributed in pseudo cells referring adjacent n±1th layers.
5. The position and energy of pseudo square cells are fed into PandoraPFA.

granularity is more important!
for PFA

1. Assume that n-th is an z-layer (fine segmented in z direction), while n±1 layers are x-layers (fine segmented in x direction).
2. a shower comes from the bottom
3. split each strip in n-th layer into pseudo-square cells

Split method



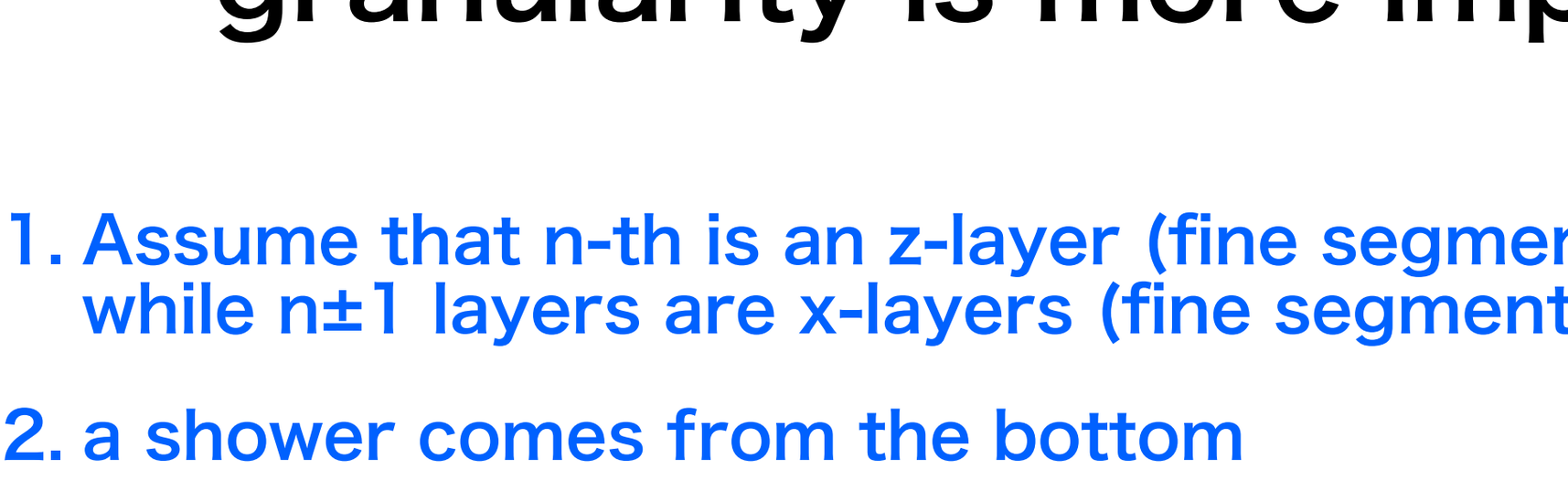
$$e_i = E_{\mathrm{n}} \cdot \frac{a_i + b_i}{\sum a_i + \sum b_i}$$

4. energy deposit in n-th layer is distributed in pseudo cells referring adjacent n±1th layers.
5. position and energy of pseudo square cells are fed into PandoraPFA.

granularity is more important!
for PFA

1. Assume that n-th is an z-layer (fine segmented in z direction), while n±1 layers are x-layers (fine segmented in x direction).
2. a shower comes from the bottom
3. split each strip in n-th layer into pseudo-square cells

Split method

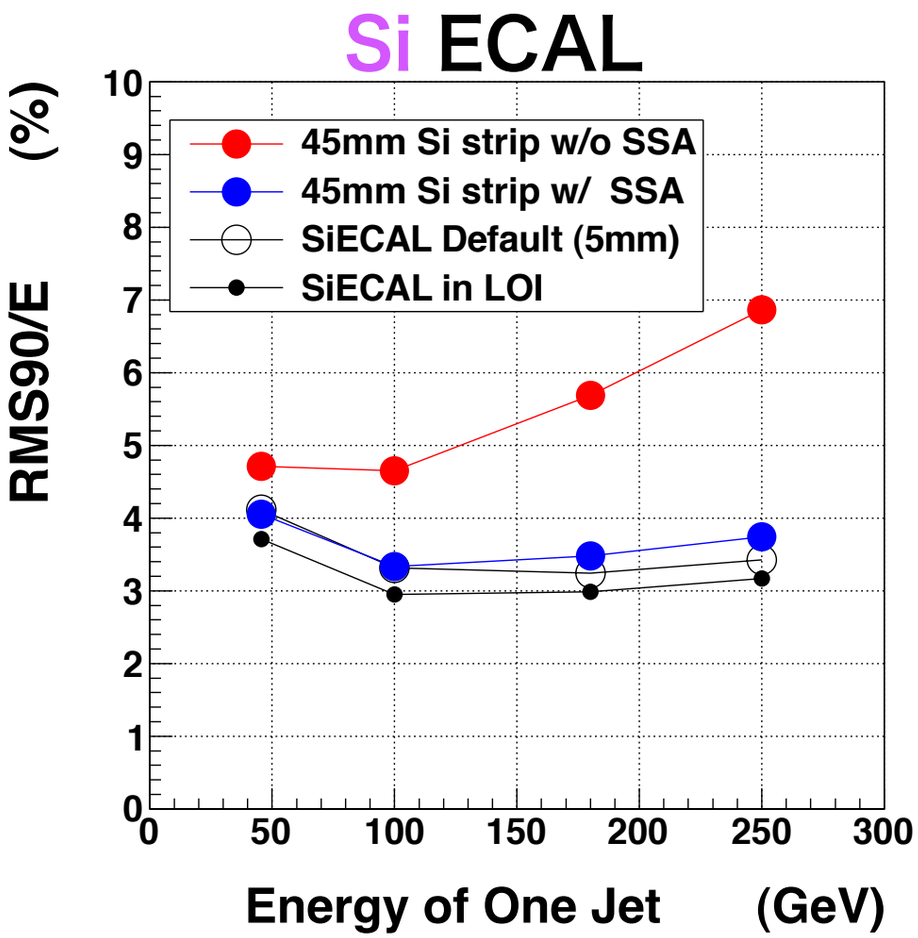


4. energy deposit in n-th layer is distributed in pseudo cells referring adjacent n±1th layers.
5. position and energy of pseudo square cells are fed into PandoraPFA.

Strip Splitting Algorithm

Previous results

ILD Kyushu May2012

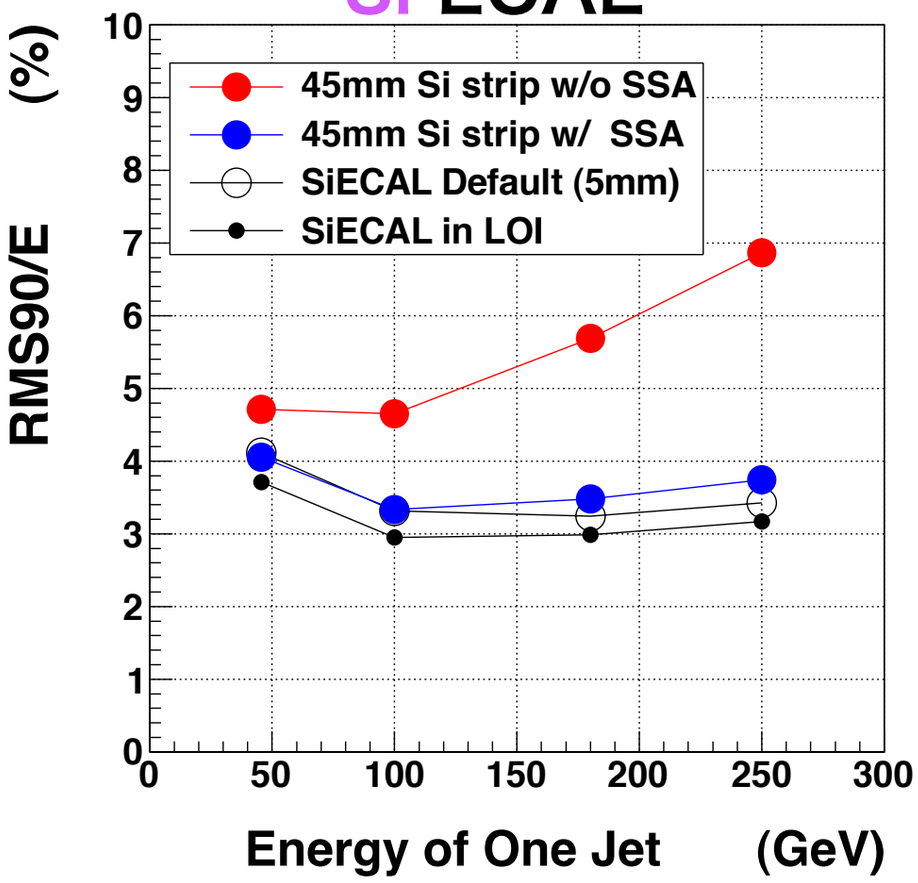


2.1 mm x 20 tungsten,
4.2 mm x 19 tungsten,
0.5 mm x 30 silicon ,
total 185 mm with other materials

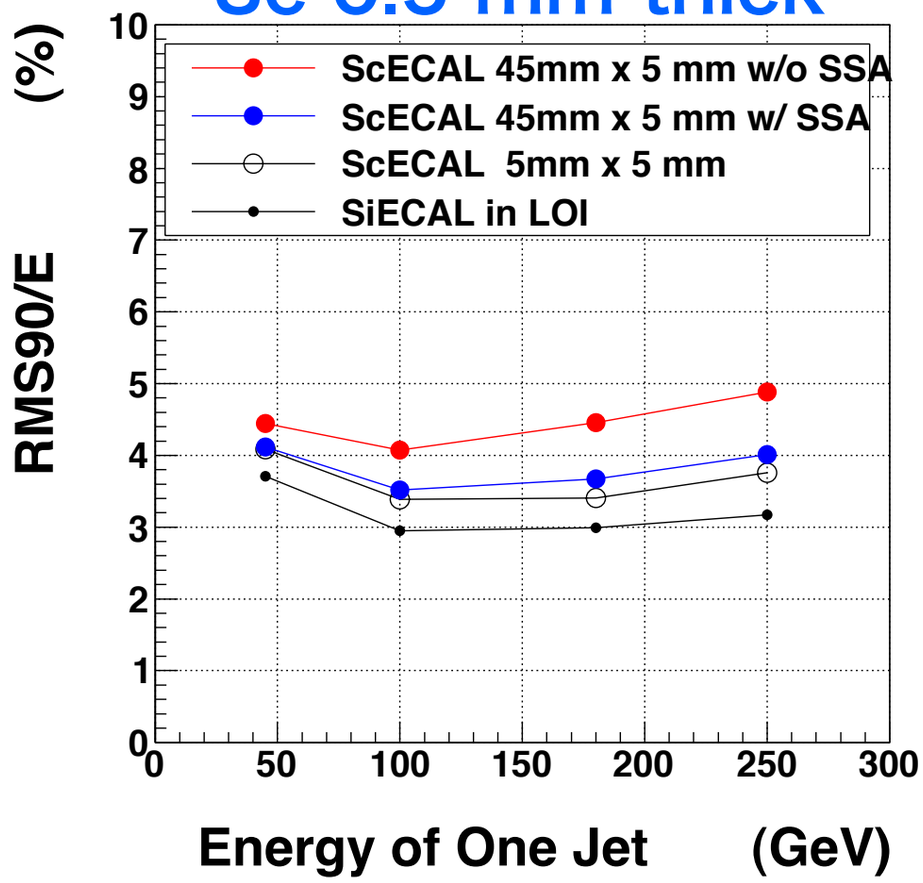
- Strip Splitting Algorithm was tested by using a special ECAL model with Si-Strip readout in order to minimize effects of calibration in PandoraPFA,
- JER improves significantly, by SSA (● → ●) especially H.E.
- A little degradation of strip ECAL is seen at H.E (● →○).
- Systematic difference between LOI and this ECAL exists (● → •).
- JER of ScECAL at 45 GeV is 4%. Hope to be improved by tunings.
- Next step is to see Sc-strip ECAL

Scintillator strip ECAL

Si ECAL

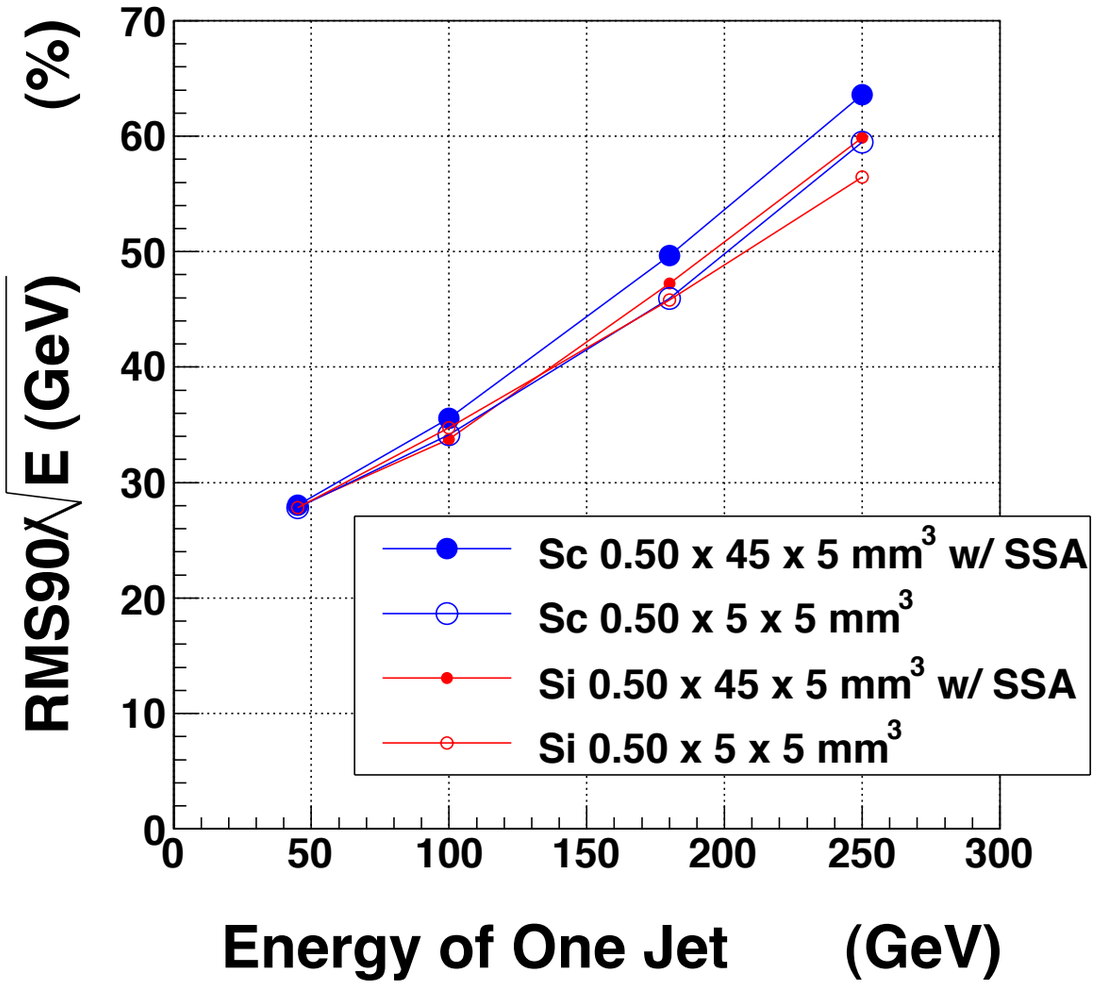


Sc 0.5 mm thick



- SSA works well also for Sc-Strip ECAL (right blue).
- Sc-Strip w/o SSA is better than Si-Strip w/o SSA (Why?).
- Systematic difference between LOI and ScEACl increased, we expect that the detail tuning for hadronic interaction in ECAL (explain in later page).

Comparing in RMS/√E(GeV) between Sc and Si 0.5 mm thick strip ECAL

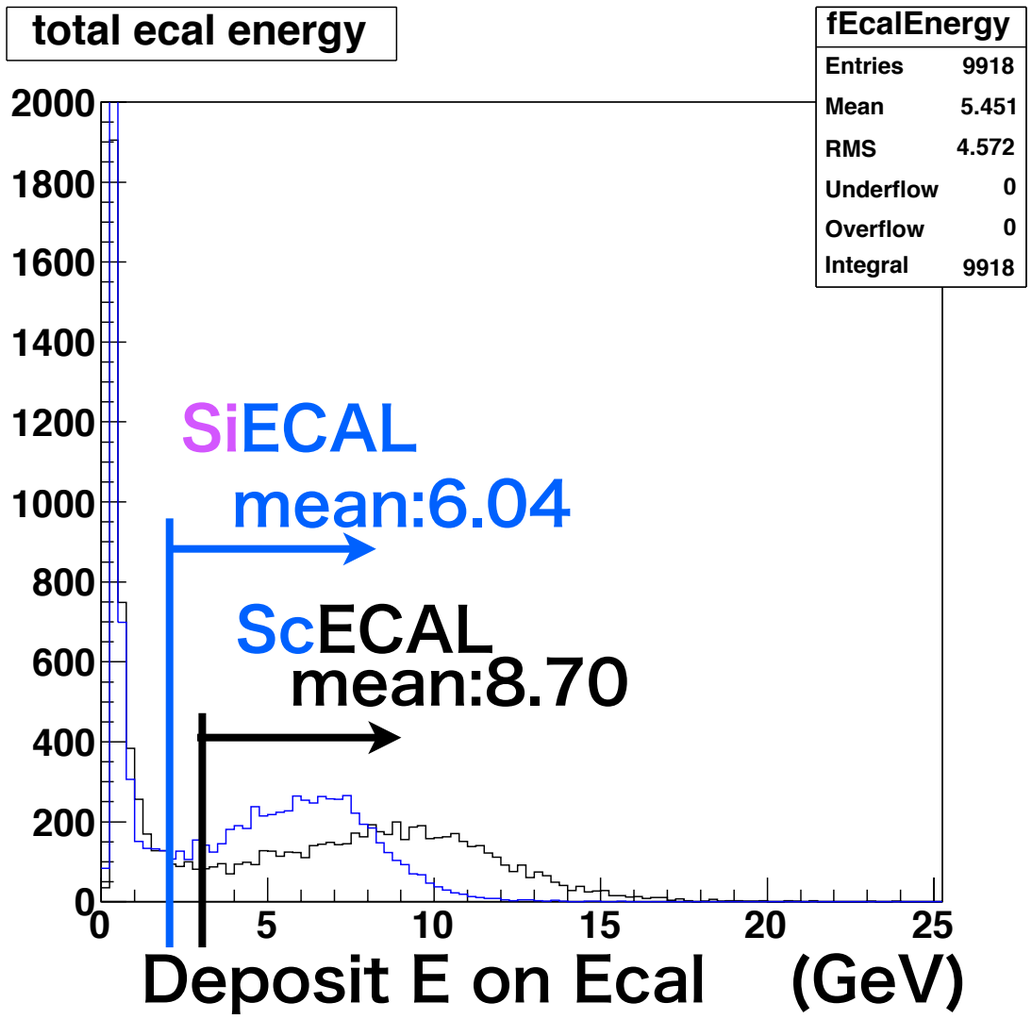


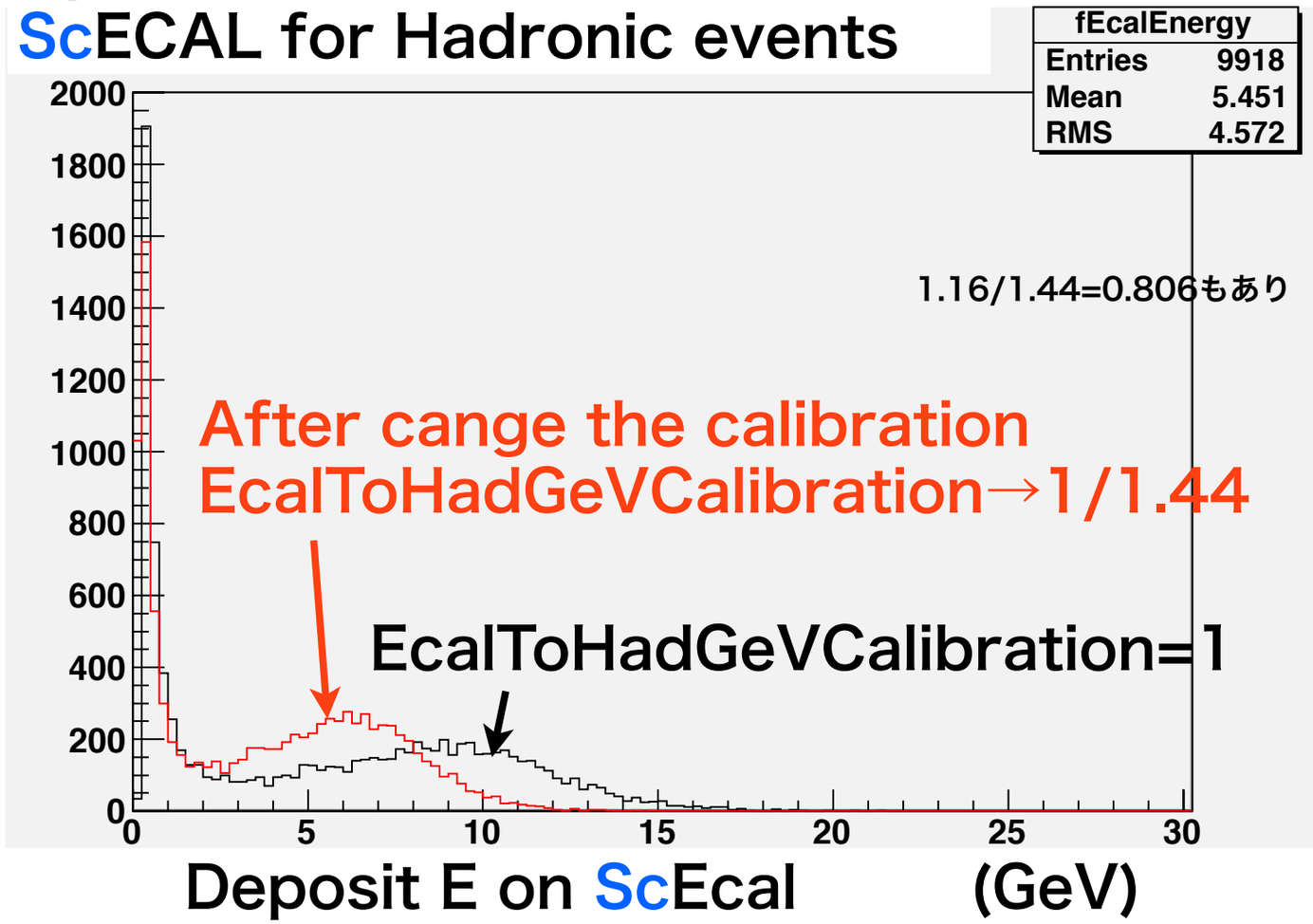
- RMS/√E(GeV) shows up difference of JER at high energy.
- Strip 45 mm ECALs have also good JER with SSA for both Si and Sc 0.5 mm thick strip ECAL.
- a little degradation appears than tile ECAL and it increases as the jet energy increases.
- The degradation is rather larger for Sc strip ECAL than Si strip ECAL for High energy.
- Differences come from the difference of the hadronic interaction in ECAL (→next page).

Ecal calibration for Hadronic events

Results of ScECAL in previous slides required large change of calibration of ScECAL for Hadronic events.

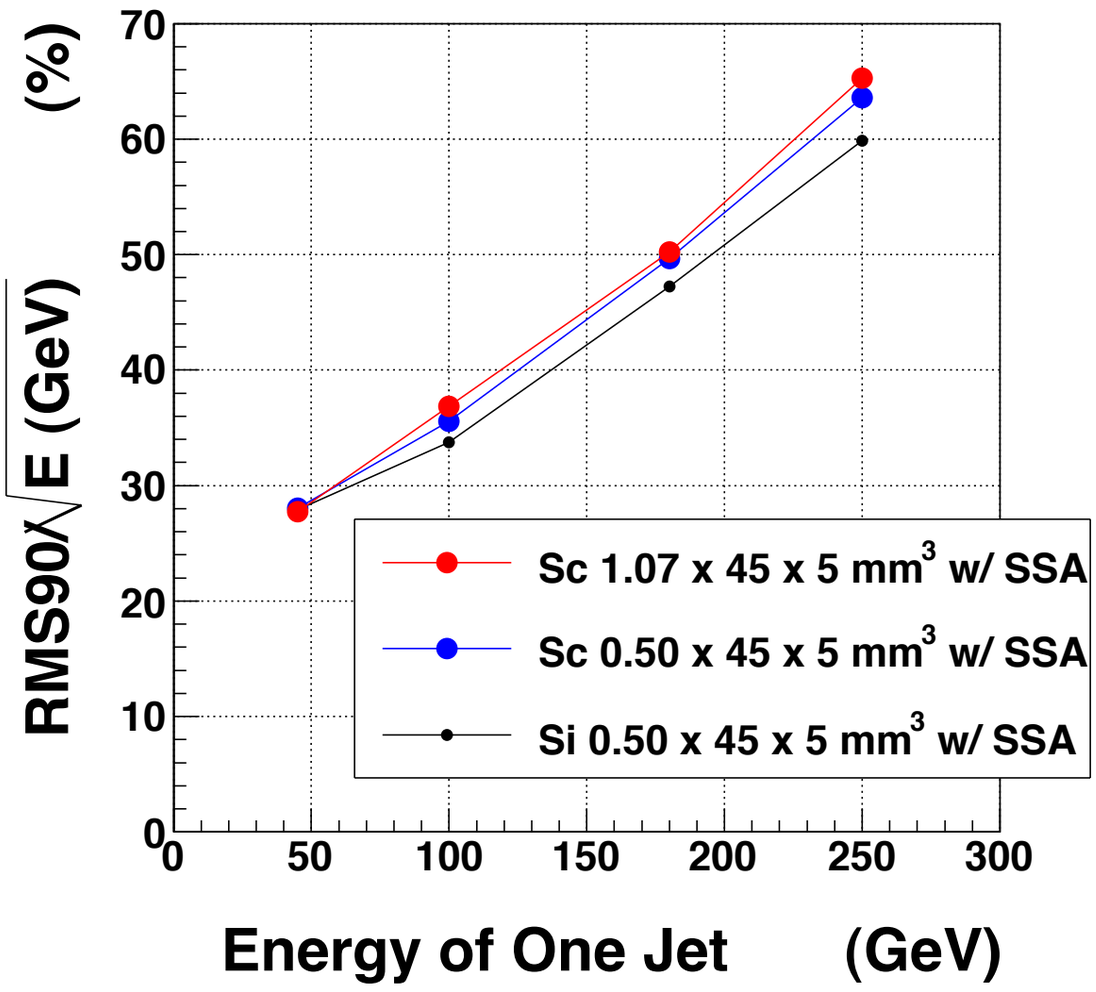
- After tune with 10 GeV photon
- π^+ 10 GeV





- This tune makes 10 GeV K_L energy mean worse , but improve JER.
- This means there are rooms to improve the tuning about hadronic interaction in ScECAL.

1 mm thick scintillator

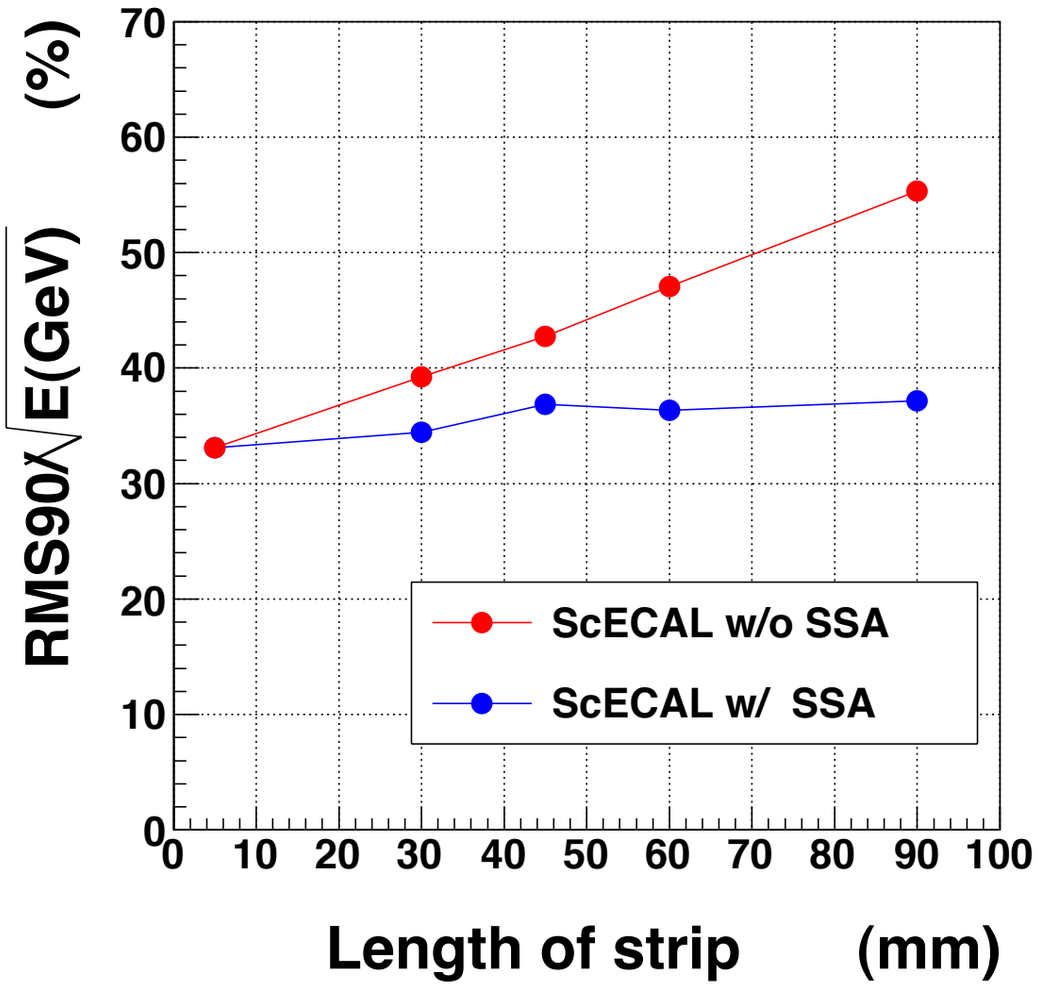


- Making 0.5 mm thick scintillator strip ECAL is not realistic.

Therefore;

- 1 mm thick scintillator has been tested in Mokka-Marlin.
- JER with 1 mm thick scintillator is comparable with 0.5 mm sc.
- Energy deposit in 1 mm thick scintillator is close to one in 0.5 mm silicon.
- Total module thickness of Ecal becomes only 1.5 cm greater than default Si ECAL of 18.5 cm.

100 GeV JER depending on strip length



- 1 mm thick scintillator strip Ecal is tested with uds two jet events with 200 GeV of center of energy
- For two-100 GeV jet events, 90 mm strip ScECAL still keep the performance.

Summary

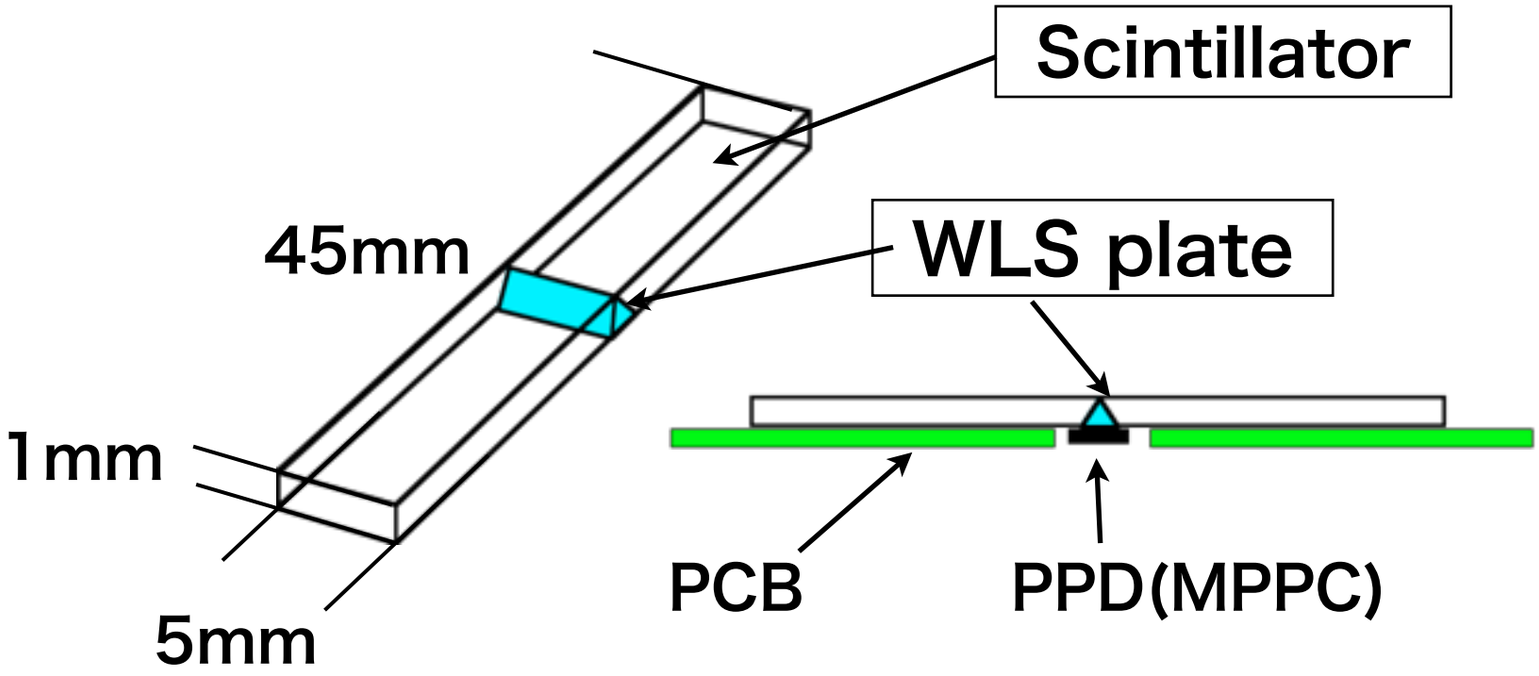
- Strip 45 mm ECALs have good JER with Strip Split Algorithm for both Si and Sc 0.5 mm thick and Sc 1 mm thick strip ECAL.
- 1 mm thick scintillator strip ECAL is feasible.

  → we are moving to developing 1 mm thick scintillator ECAL from 2 mm thick scintillator ECAL.

To do

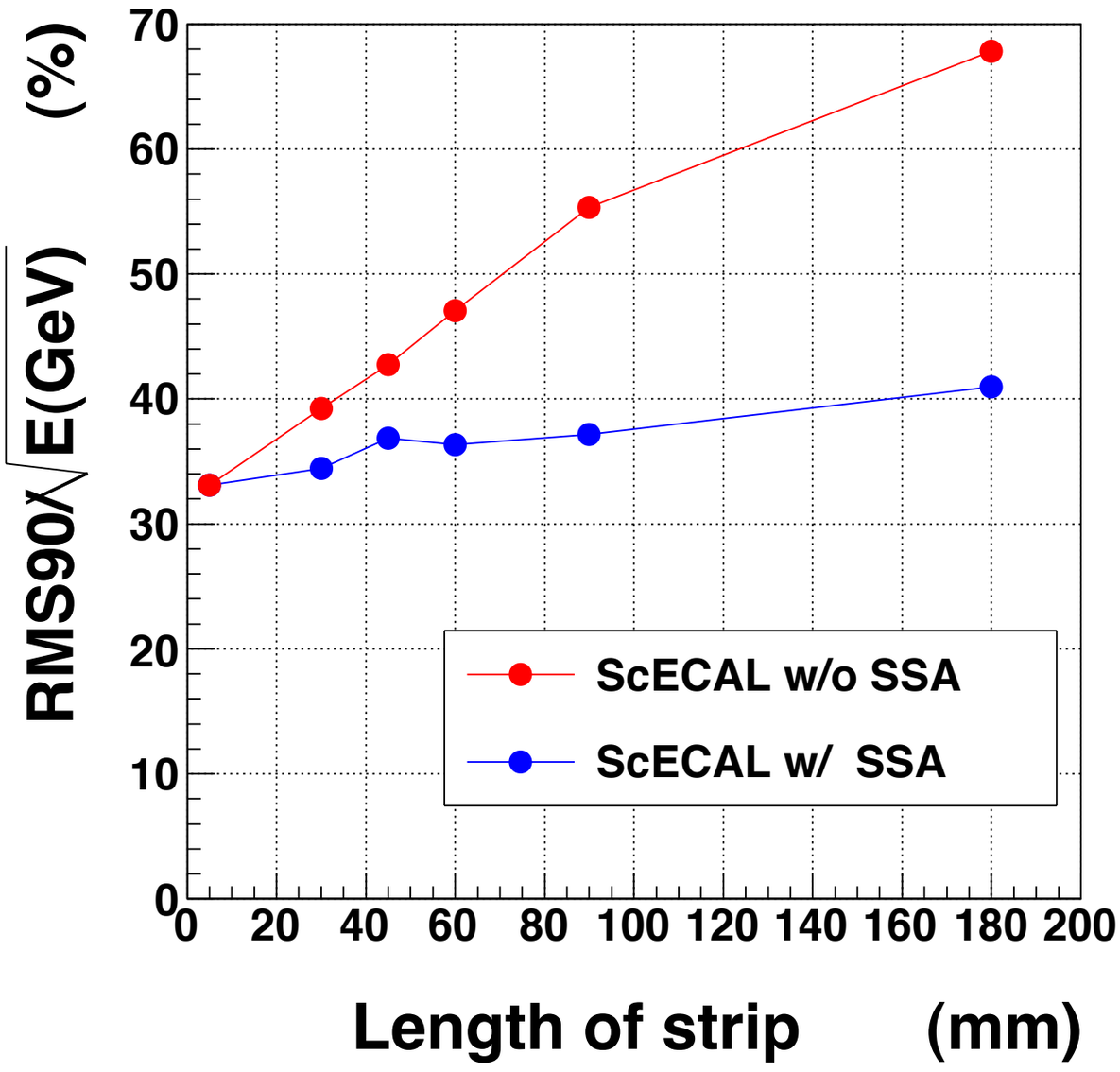
- Difference of Hadronic interaction between in ScECAL and in SiECAL is pretty large.→ to understand what is happening and to care properly for that.
- To show performance of separation of particles.
- To show performance with some Physics mode.
- ILC soft v01-09-02 was used in this study→now moving to DBD version v01-15.
- To fix technological problem in Endcap

Feasibility of 1mm thick Scintillator ECAL



- This is one of the various ideas to make 1 mm thick scintillator / PPD unit.
- We preparing to test this.
- We are developing various possible ways to make 1 mm thick scintillator/PPD unit be feasible.

Backup


RMS90/√E(GeV) (%)
70
60
50
40
30
20
10
0
0 20 40 60 80 100 120 140 160 180 200
Length of strip (mm)
ScECAL w/o SSA
ScECAL w/ SSA