Current Status and Future Plan of Hybrid ECAL Simulation

ILD ECAL Meeting @The Univ. of Tokyo

16th-17th November, 2013

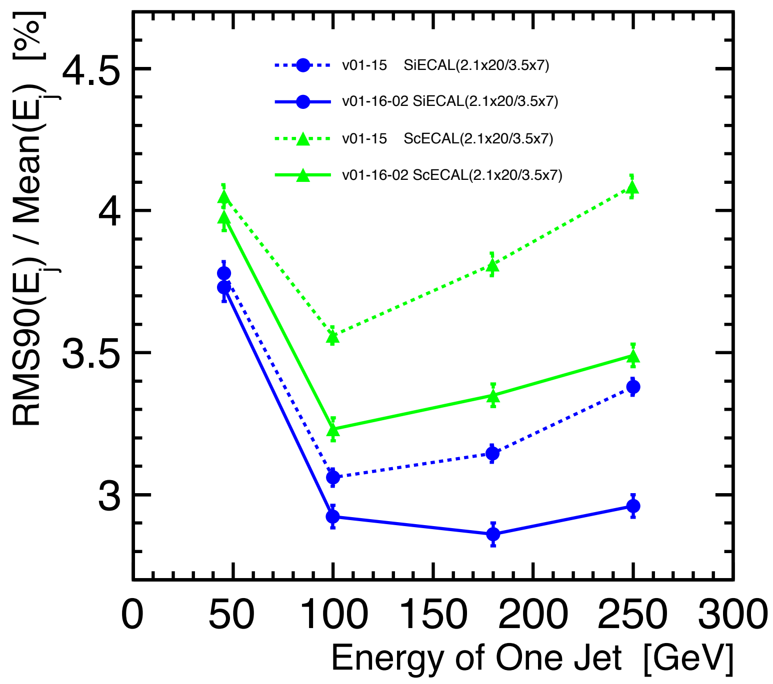
Hiraku Ueno (Kyushu University)

Current Status

- Jet Energy Resolution Evaluation
  - sensitive layer dependence
    - same absorber thickness
    - same module thickness
    - alternating structure
  - tungsten structure dependence
- understanding resolution by cheating

Updated Issues

- ilcsoft v01-16-02 (← v01-15)
    - with recent version of Pandora Processors
- switched new digitizer (includes time window) for Sc-layers
- Calibration of MIP threshold for virtual cells after SSA



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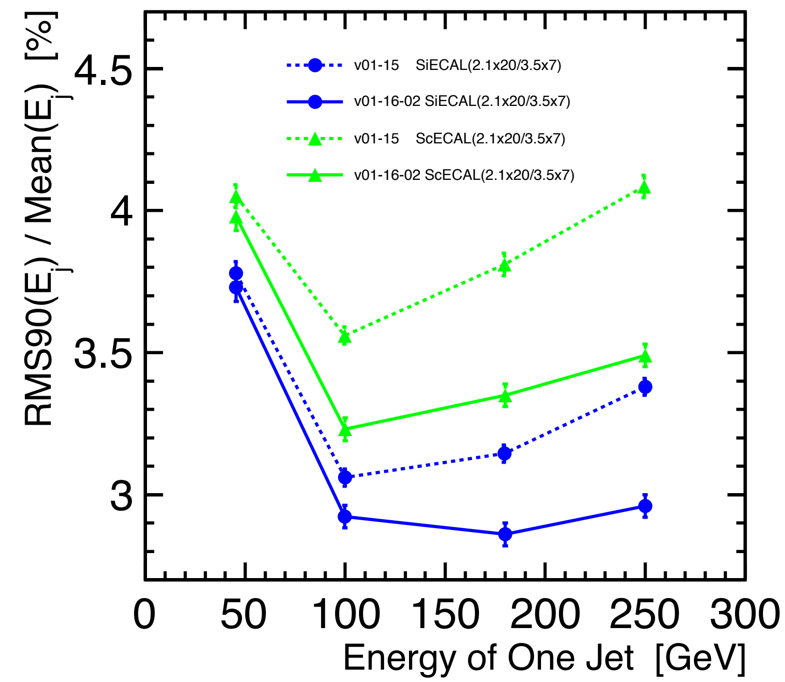

	W thickness (in20,out9)	Module thickness (mm)
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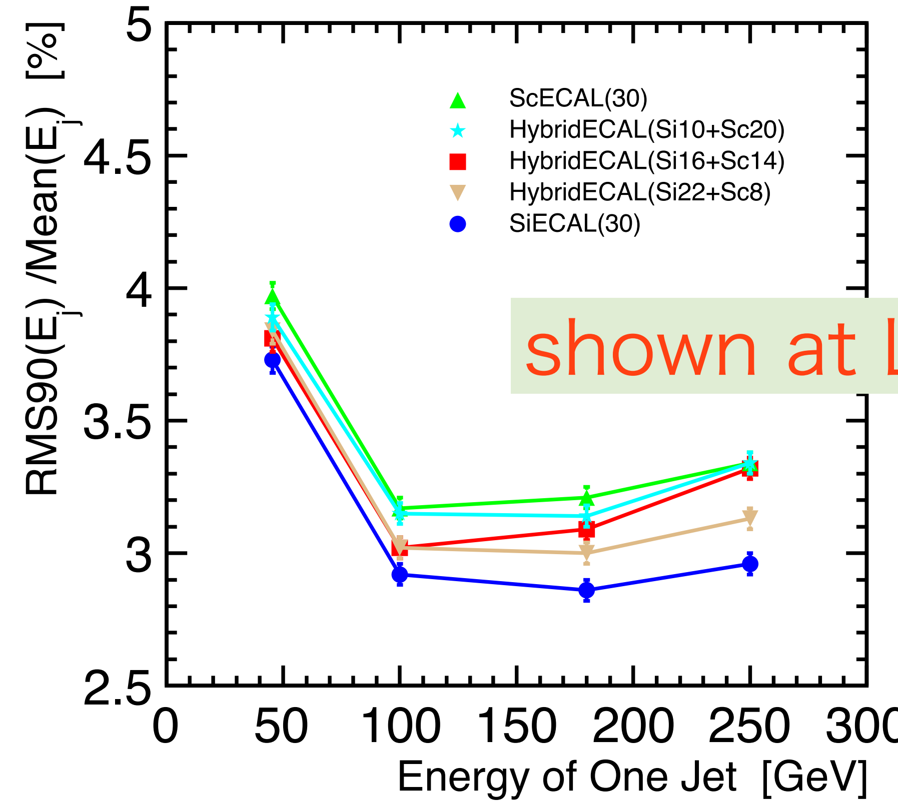
Hybrid(Si10Sc20)	2.1/3.3	185.2
ScECAL(30)	2.1/2.9	185.7



shown at LCWS13

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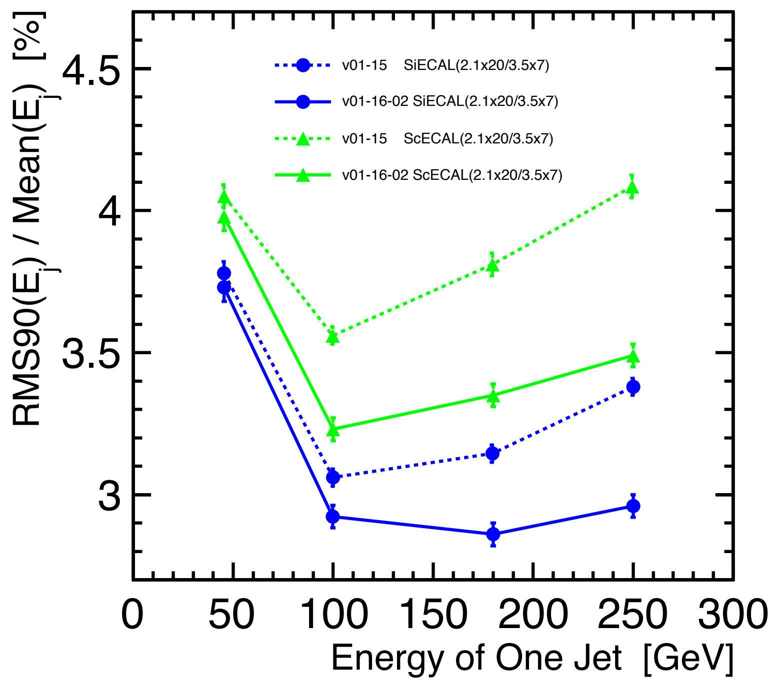

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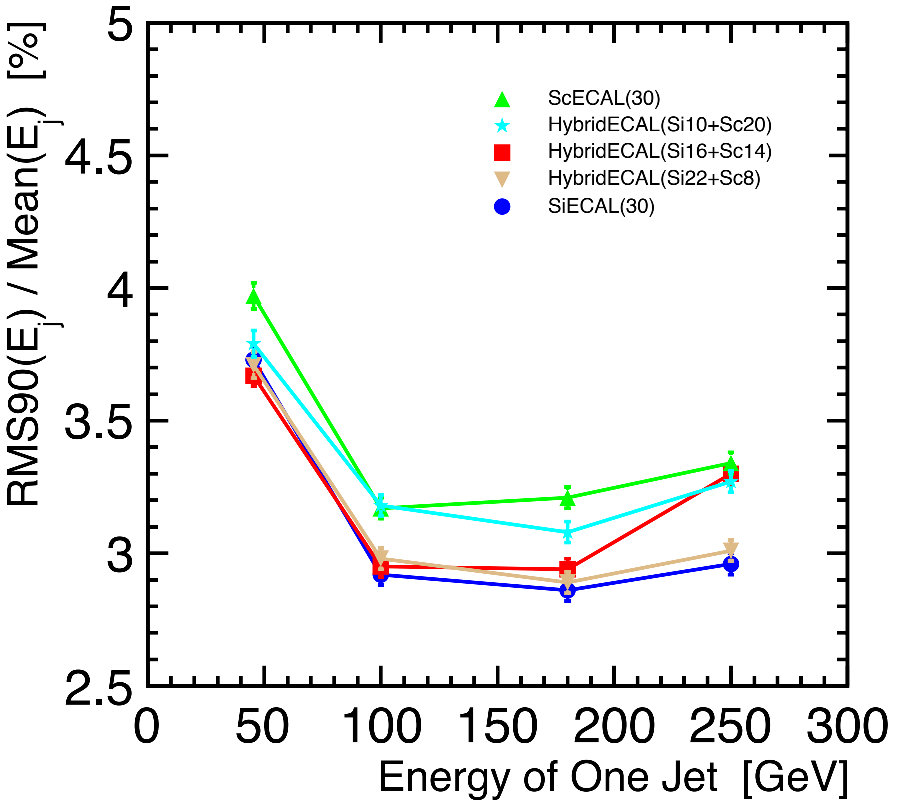


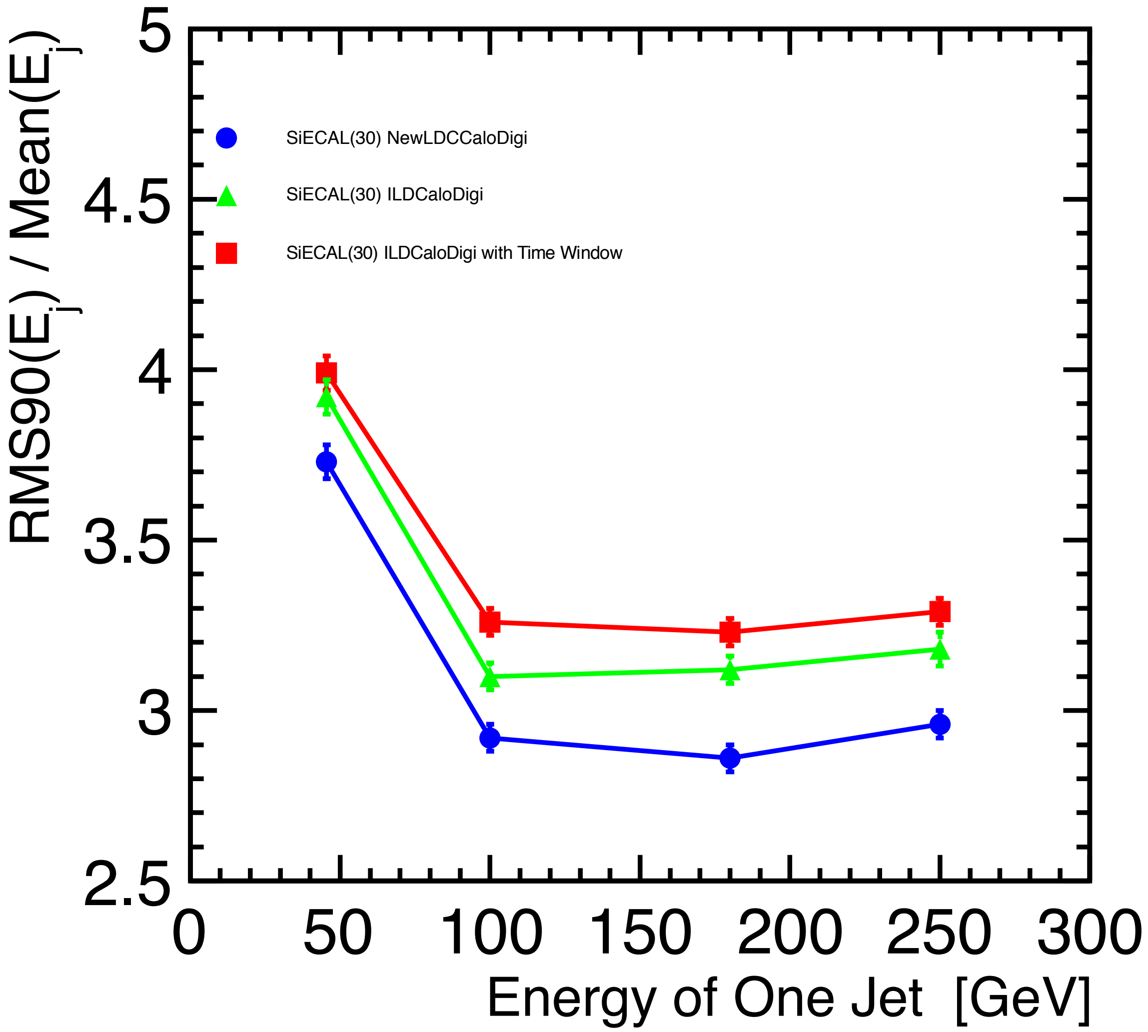
Future Plan

- evaluate more configurations
  - single layer alternating
  - two stacks tungsten structure
- inner radius dependence
- more realistic simulation
  - saturation
  - non-uniformity
  - dead strips
  - etc.

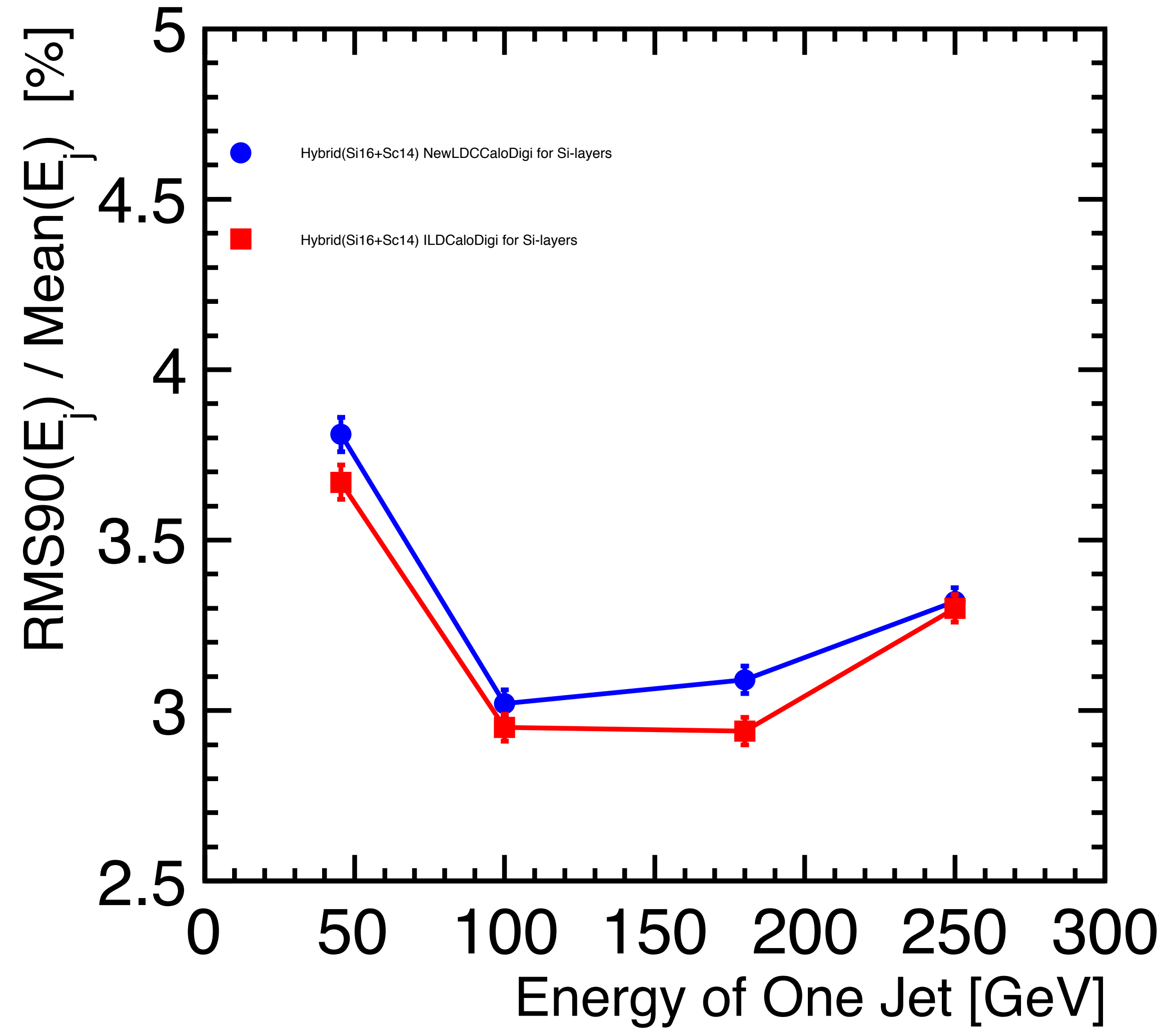
Backup

Transition to the New Digitizer

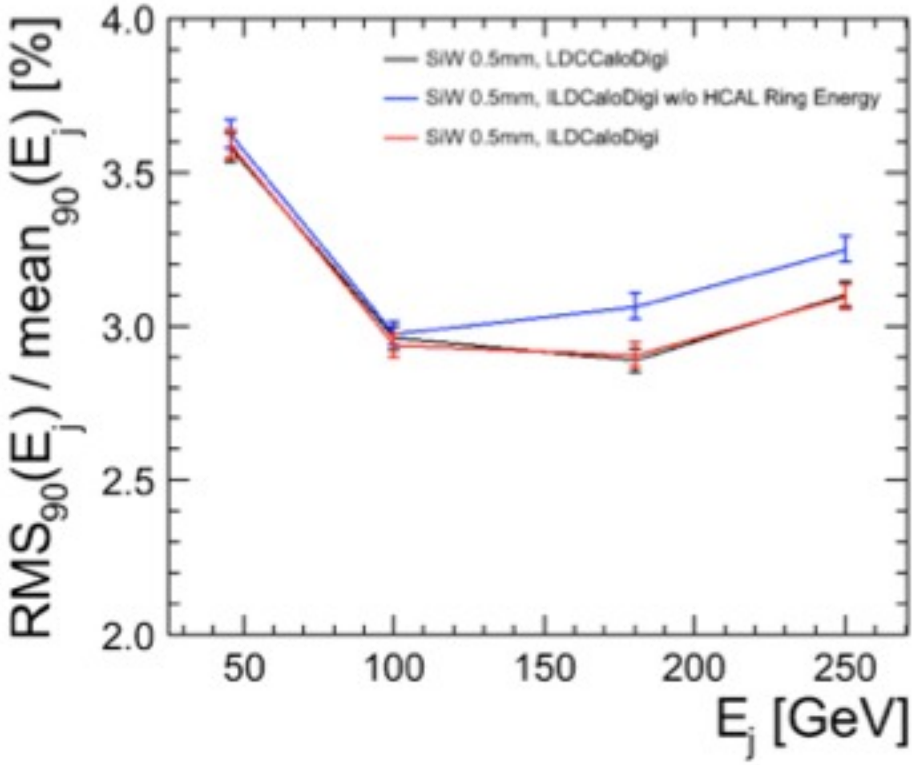
SiECAL(30)[2.1x20/4.2x9]
NewLDCCaloDigi vs ILDCaloDigi
(w/ or w/o time window)



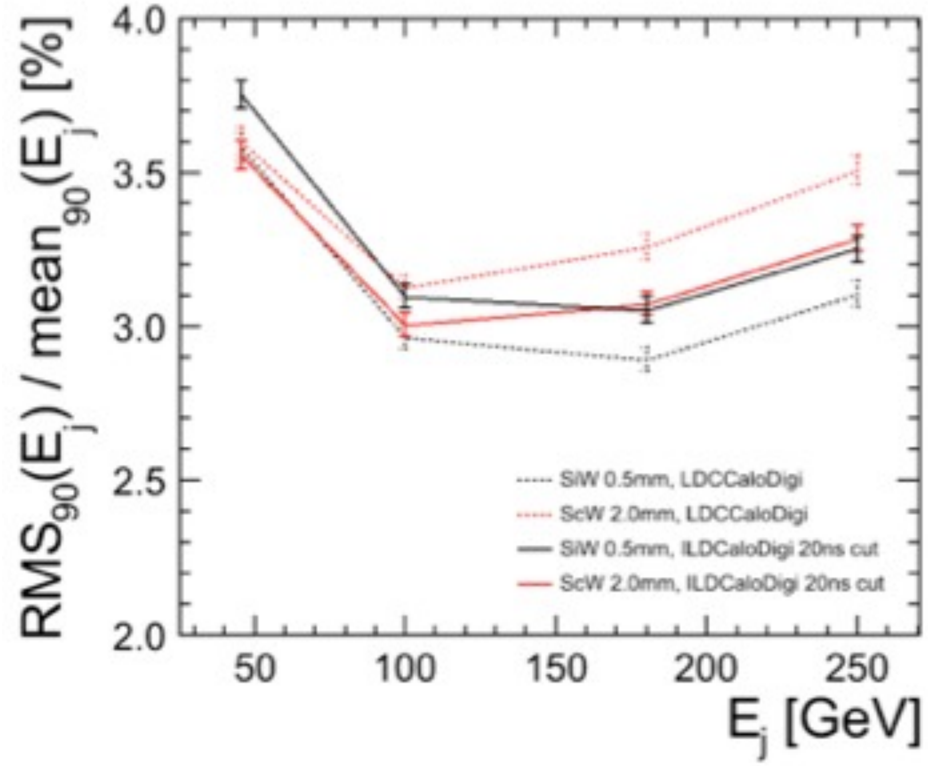
Hybrid(Si16+Sc14)[2.1x20/3.6x9]
NewLDCCaloDigi vs ILDCaloDigi



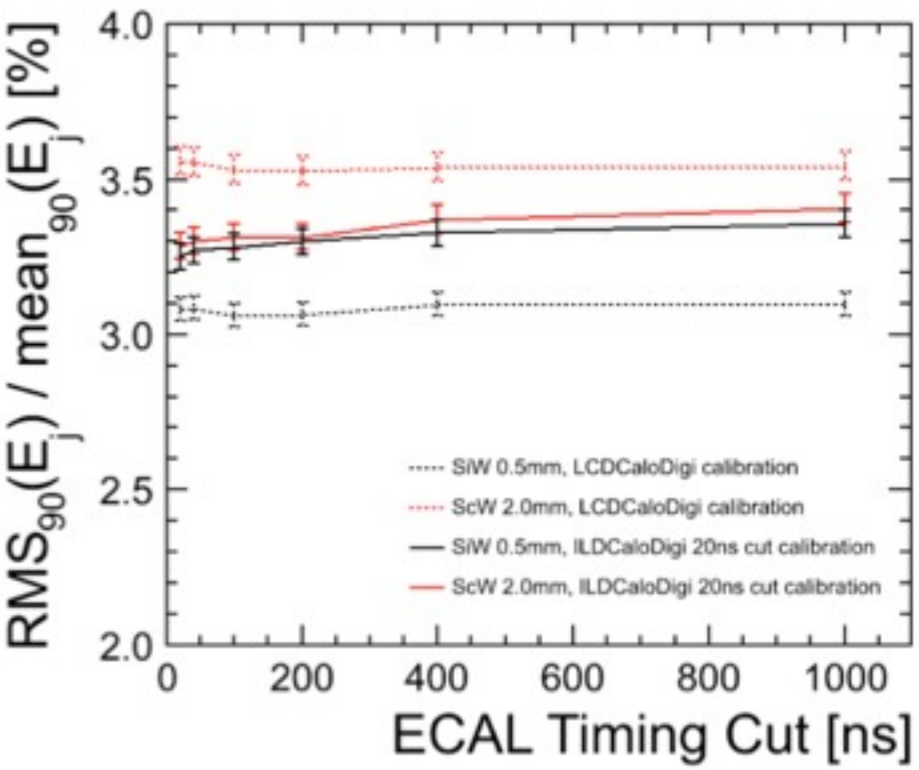
NewLDCCaloDigi vs ILDCaloDigi



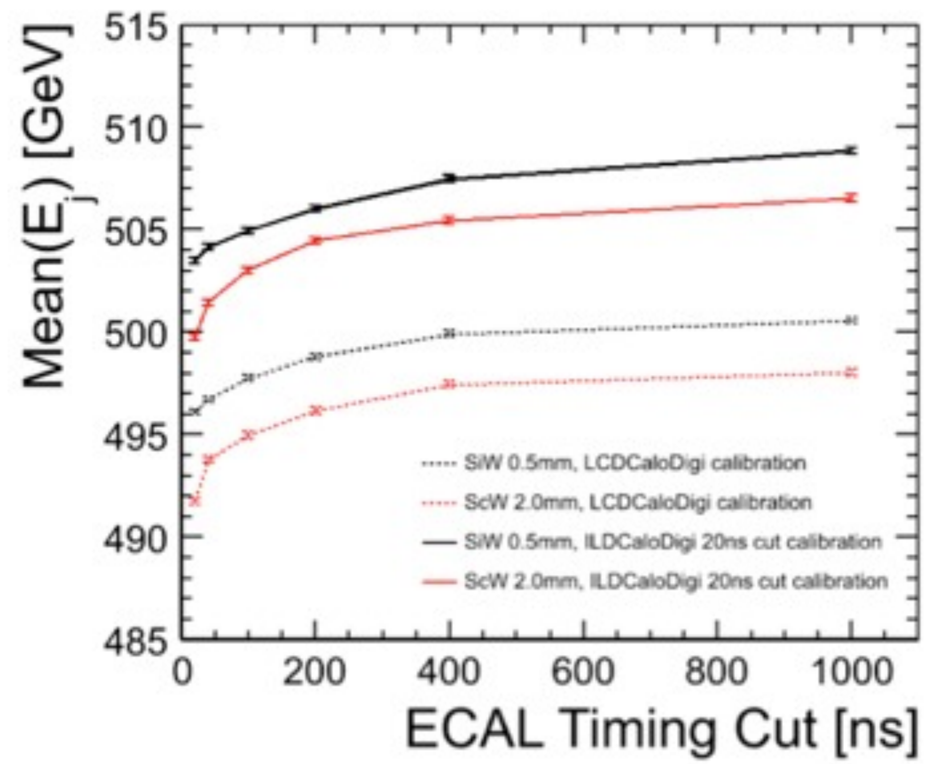
NewLDCCaloDigi vs ILDCaloDigi w/o Timing Cut



JER vs Timing Cut



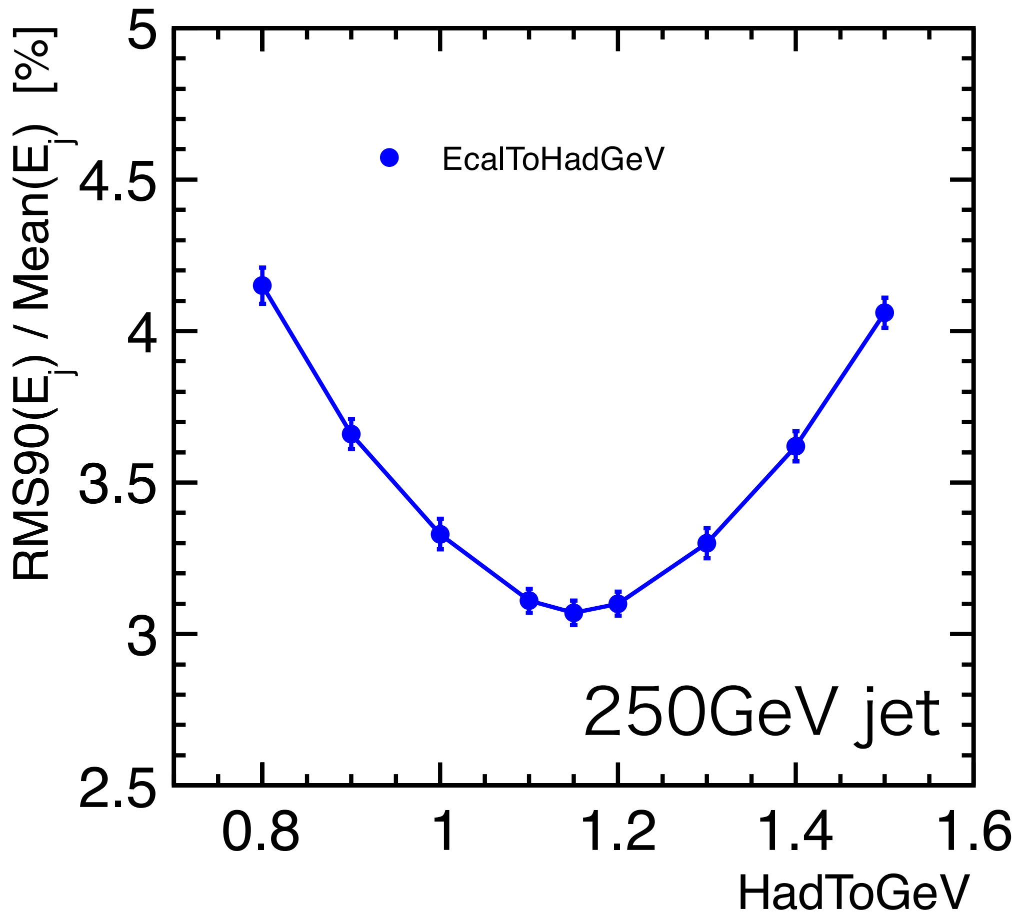
Mean vs Timing Cut

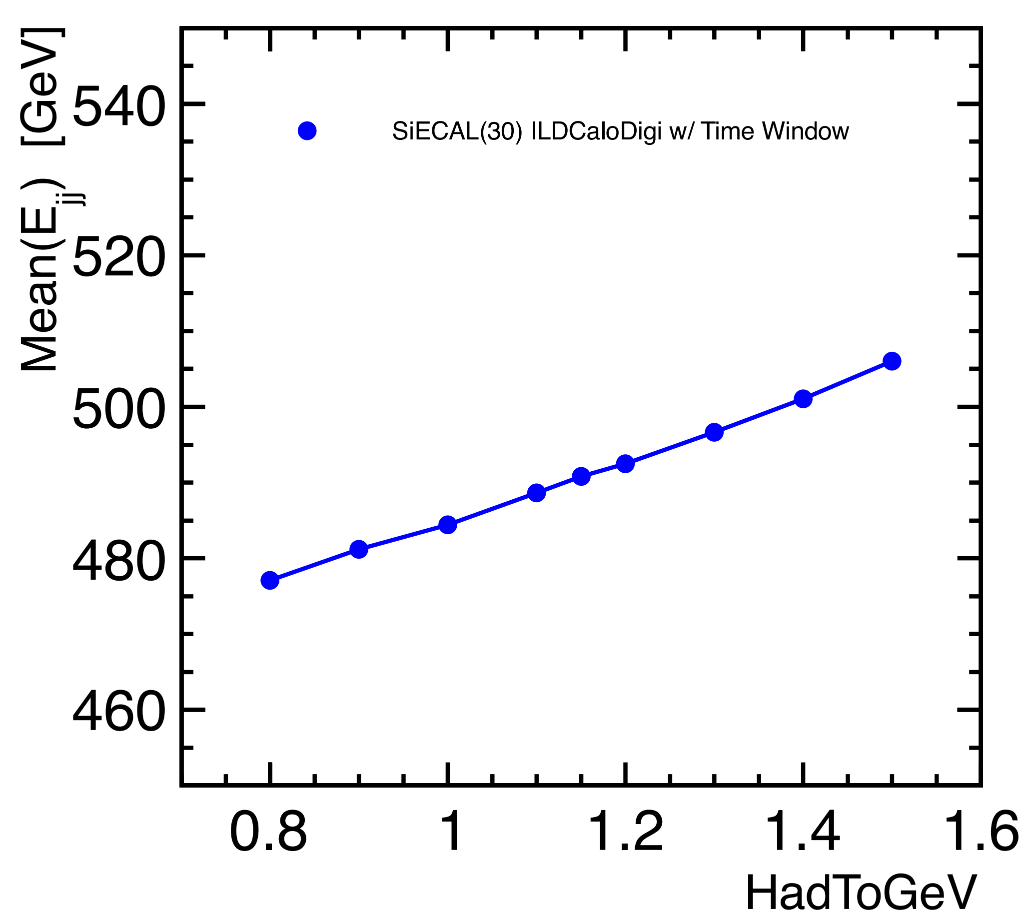


J.Marshall

EcalToHadGeV Calibration

SiECAL(30)[2.1x20/4.2x9]
with ILDCaloDigi, 20ns timing cut





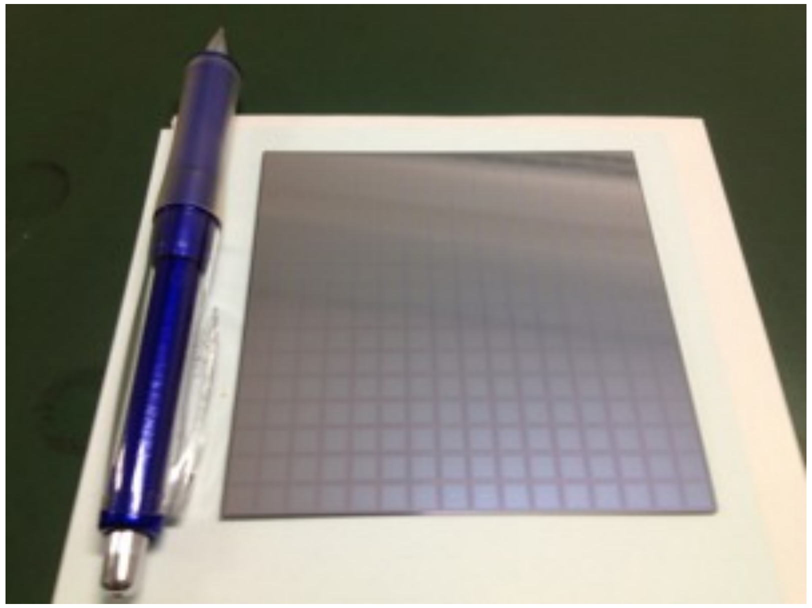
Calibration is done using 10GeV K_L

Contents

- Motivation for the Hybrid ECAL
- Calibration, Evaluation
- Jet Energy Resolution
    - Same Absorber Thickness
    - Same Module Thickness
    - Alternating Hybrid
- Understanding Jet Energy Resolution
- Summary

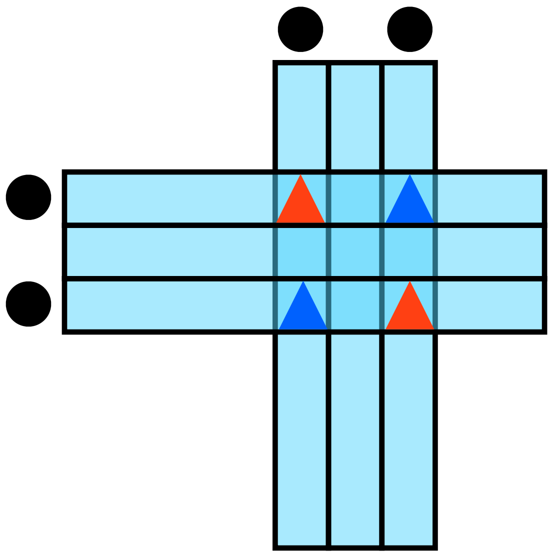
ILD ECAL Candidates

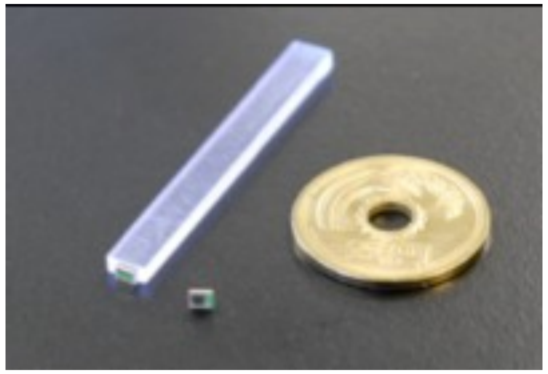
Silicon pads（Si ECAL）



- 5mm x 5mm cells
- good performance for PFA
- large fraction of detector cost

Scintillator strips +MPPC（Sc ECAL）



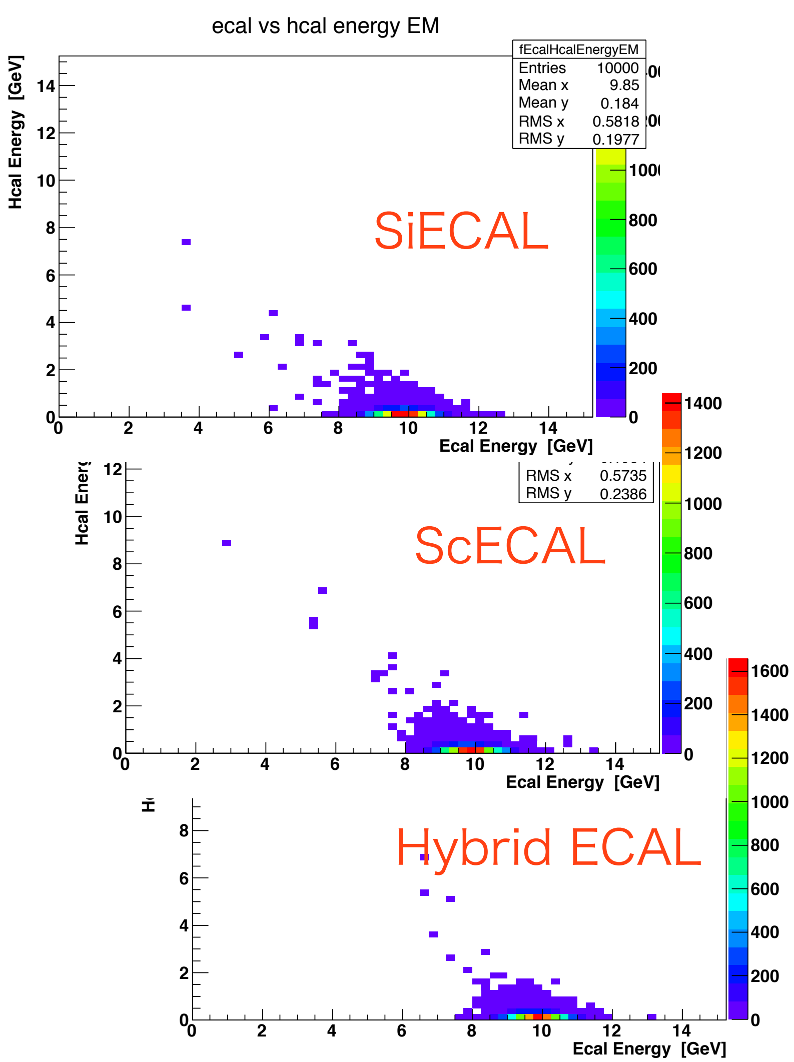


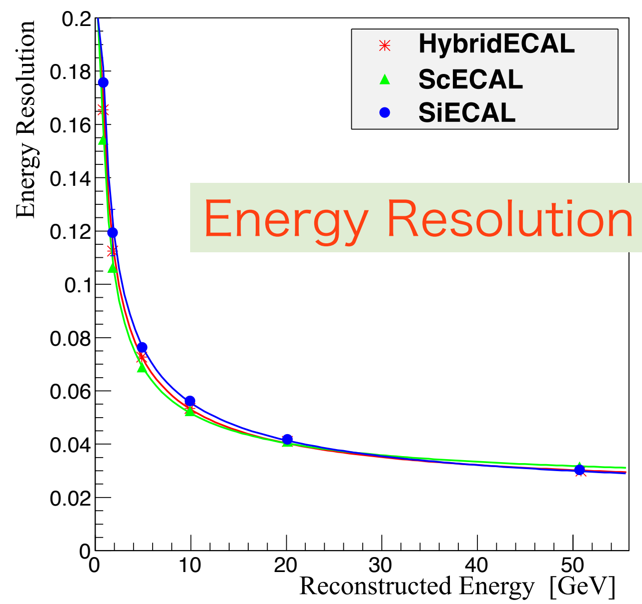
- 45mm x 5mm orthogonal & SSA
  --> 5mm x 5mm spatial resolution
- reasonable cost
- ghost hits

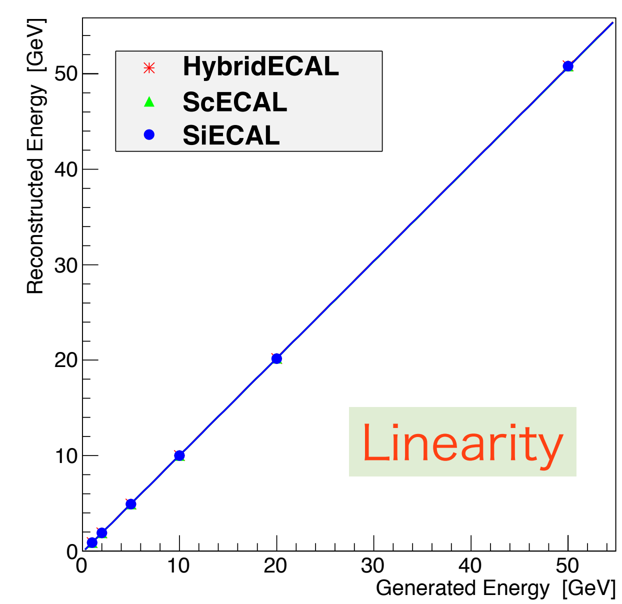
An option to make the ECAL at a lower cost while keeping performance as much as possible would be mixture of silicon and scintillator-strip layers.

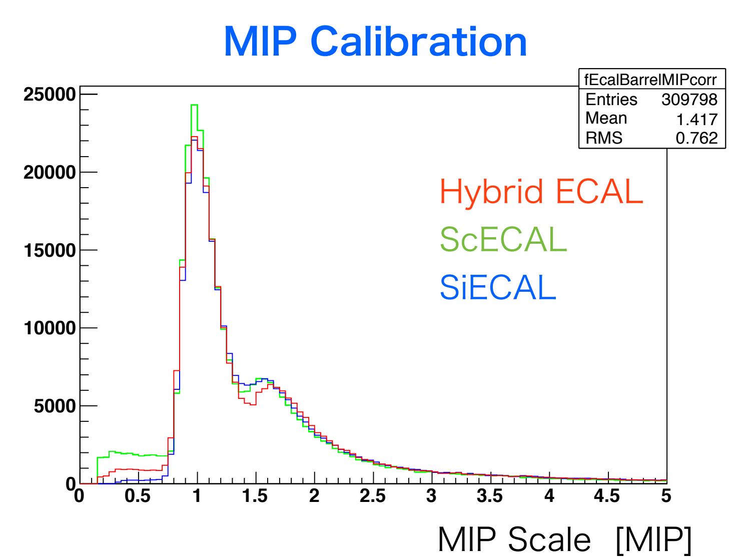
ECAL Calibration

- Calibration constants should be determined for silicon layers and scintillator layers respectively.
- calibrated using 10GeV photon, and confirmed our method.
- use 10GeV muon for MIP calibration.



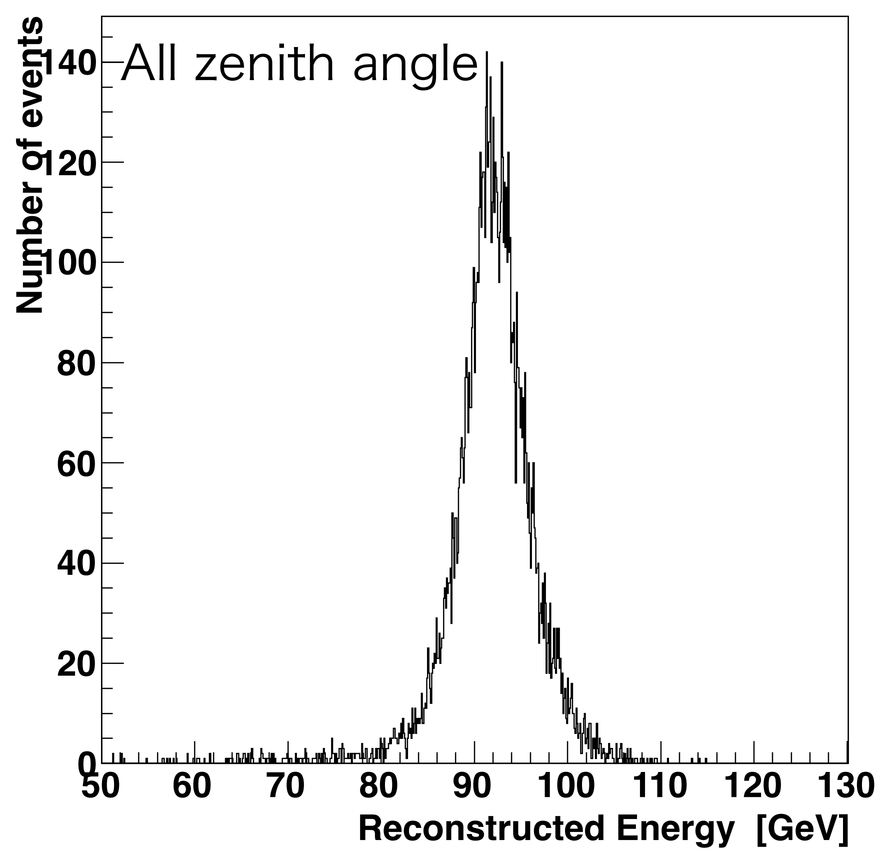


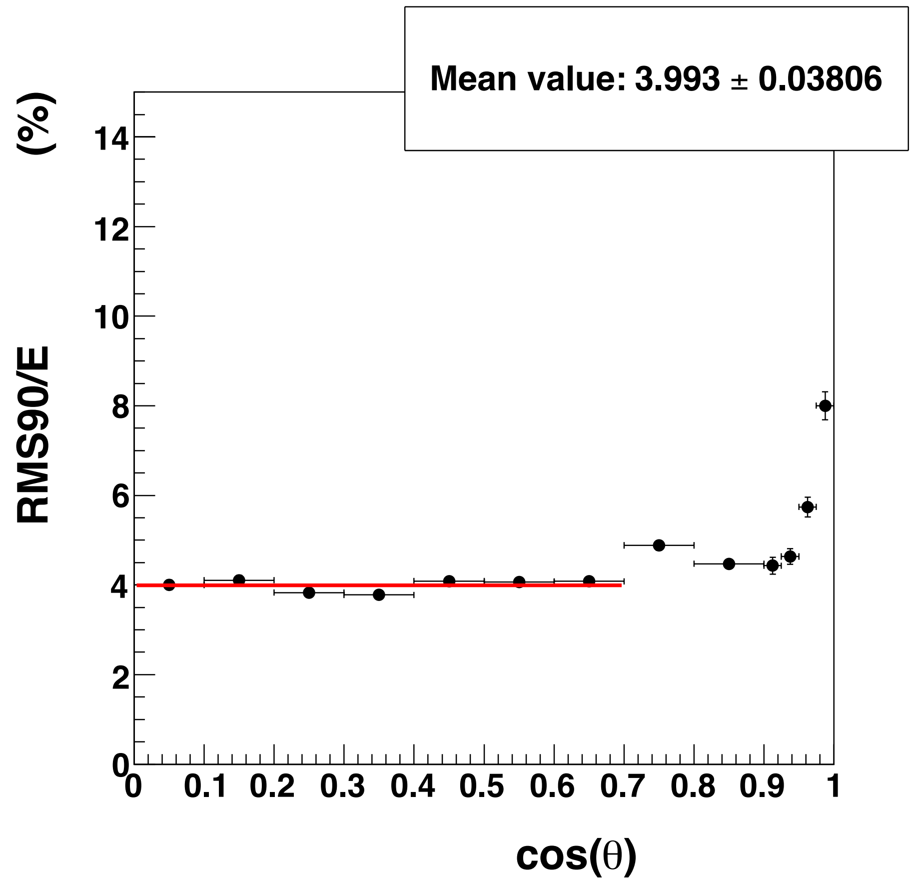




Hybrid ECAL Evaluation

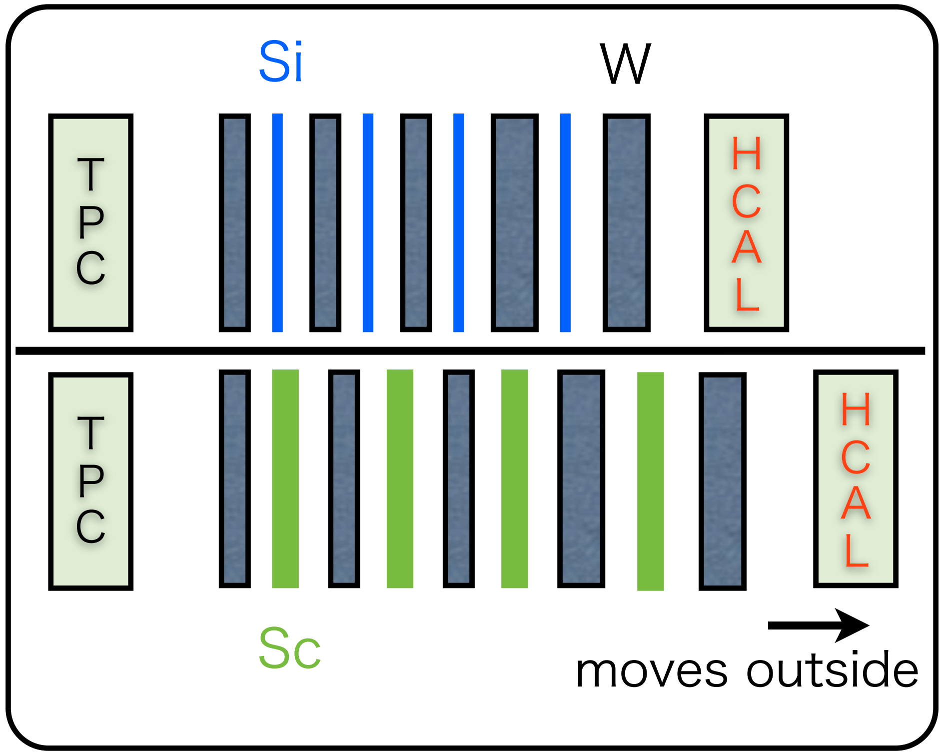
- We evaluated energy dependence and Sc:Si ratio dependence.
- software version : ilcsoft v01-16-02 with trunk version of some processors (Data were generated with old version of Mokka)
- $e^+e^- \rightarrow q\bar{q}$ (q=u,d,s, √s=91, 200, 360, 500GeV)
- only barrel region (cos(thrust angle)<0.7) for evaluation.



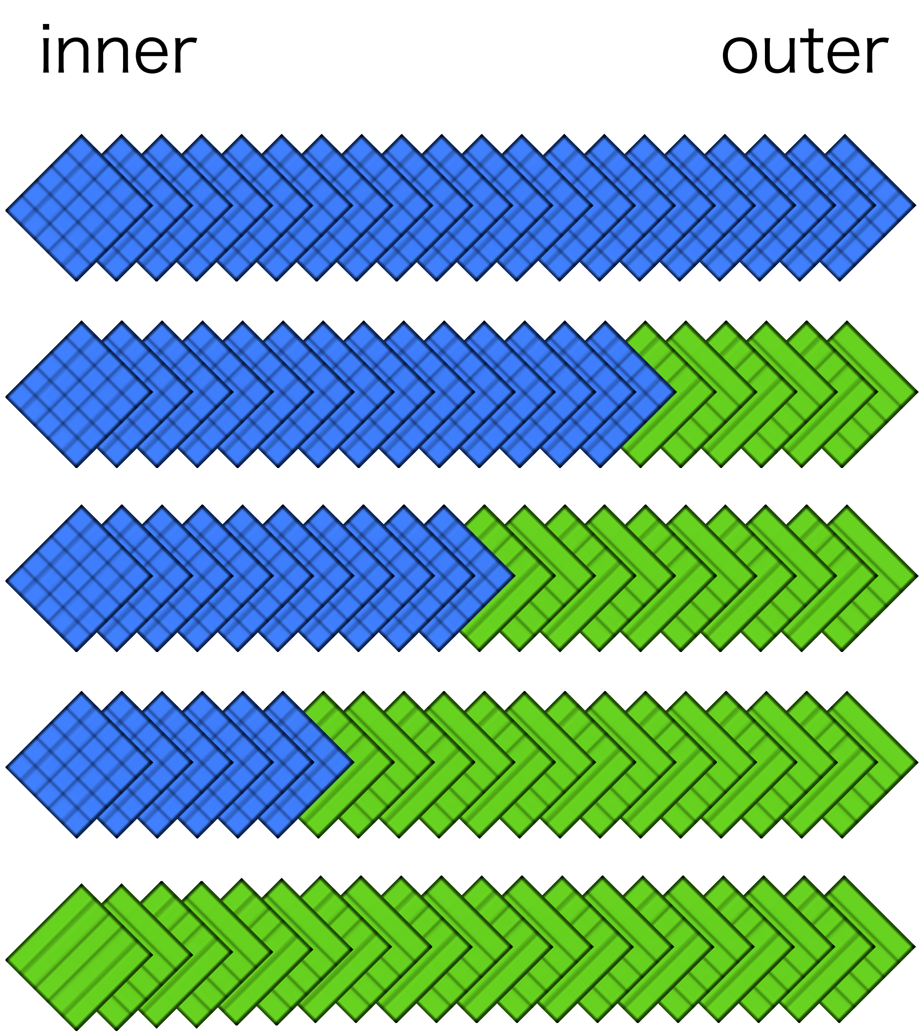


same absorber thickness

- performance difference between Si and Sc
- five configurations
- Sc thick = 2.0mm, Si thick = 0.5mm
- different module thickness

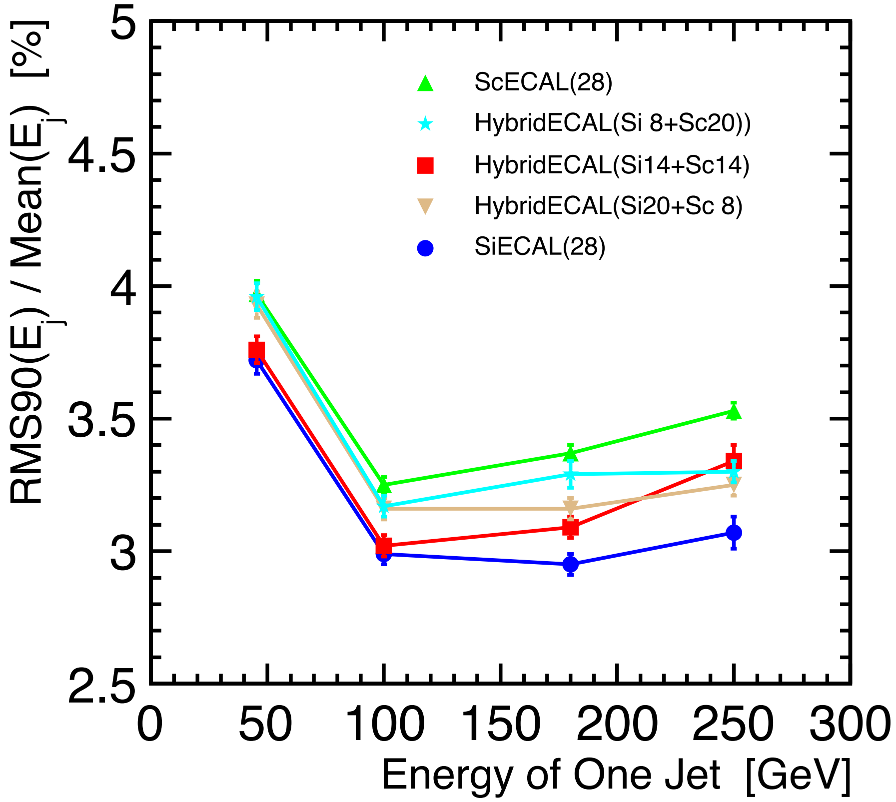


	W thickness (in20,out7)	Module thickness (mm)
SiECAL(28)	2.1/3.5	165.4
Hybrid(Si20Sc8)	2.1/3.5	176.7
Hybrid(Si14Sc14)	2.1/3.5	185.2
Hybrid(Si8Sc20)	2.1/3.5	193.7
ScECAL(28)	2.1/3.5	205.0

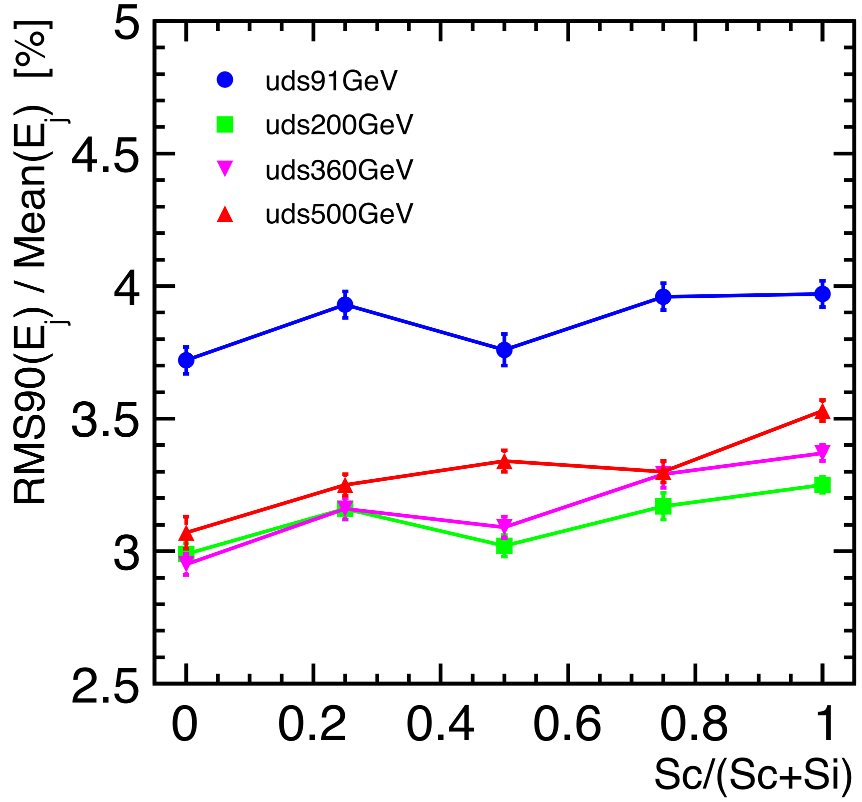


Jet Energy Resolution

Energy Dependence



Ratio Dependence



- JER difference between SiECAL and ScECAL is ~0.5% at 180, 250GeV.
- Hybrid(Si20+Sc8) is about medium between SiECAL and ScECAL.

- Scintillator performance becomes much better than that with old version
- JER becomes worse gradually.
- The performance doesn't degrade up to 50% of Scintillator layers up to 100GeV jet.

Jet Energy Resolution

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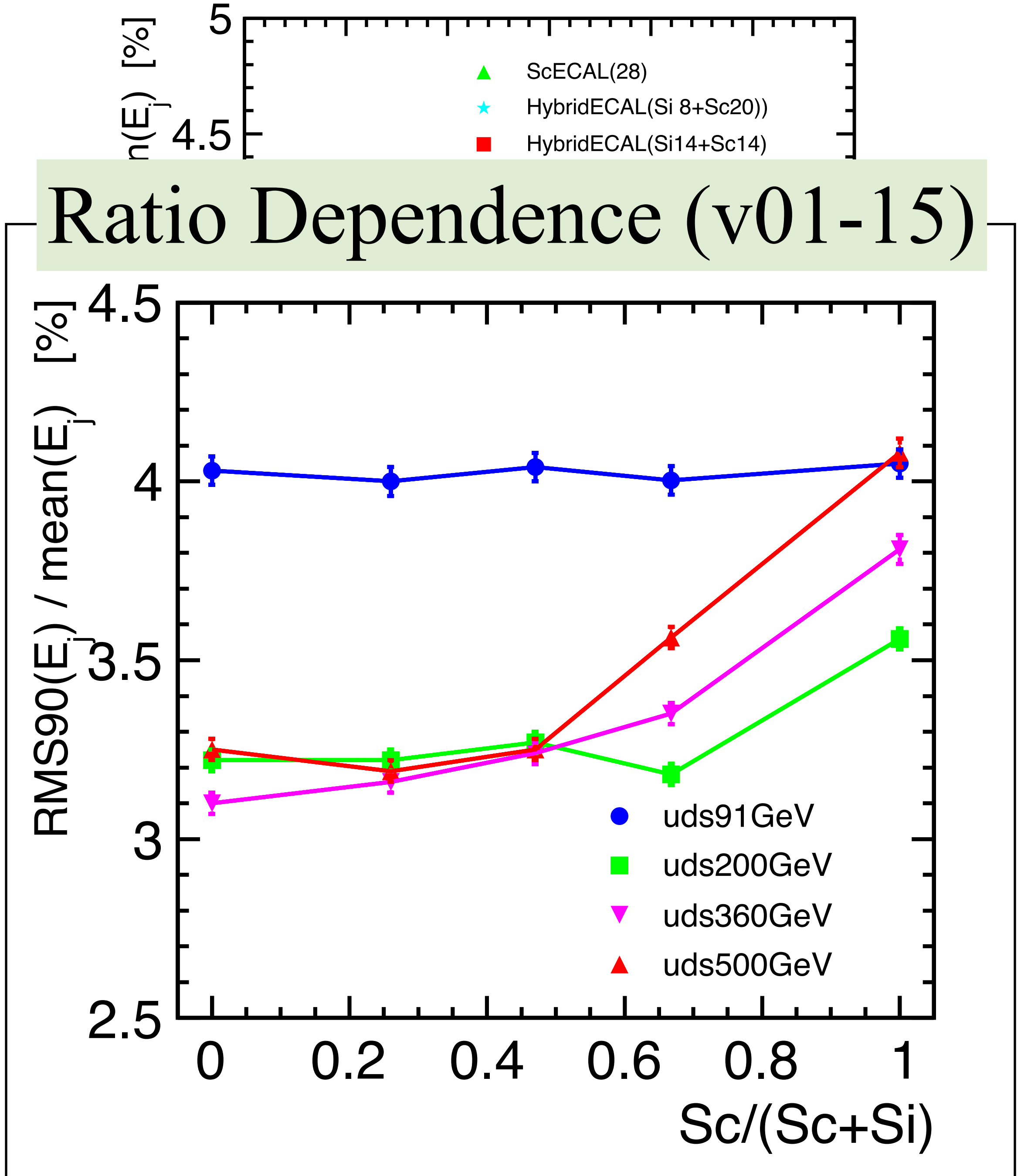

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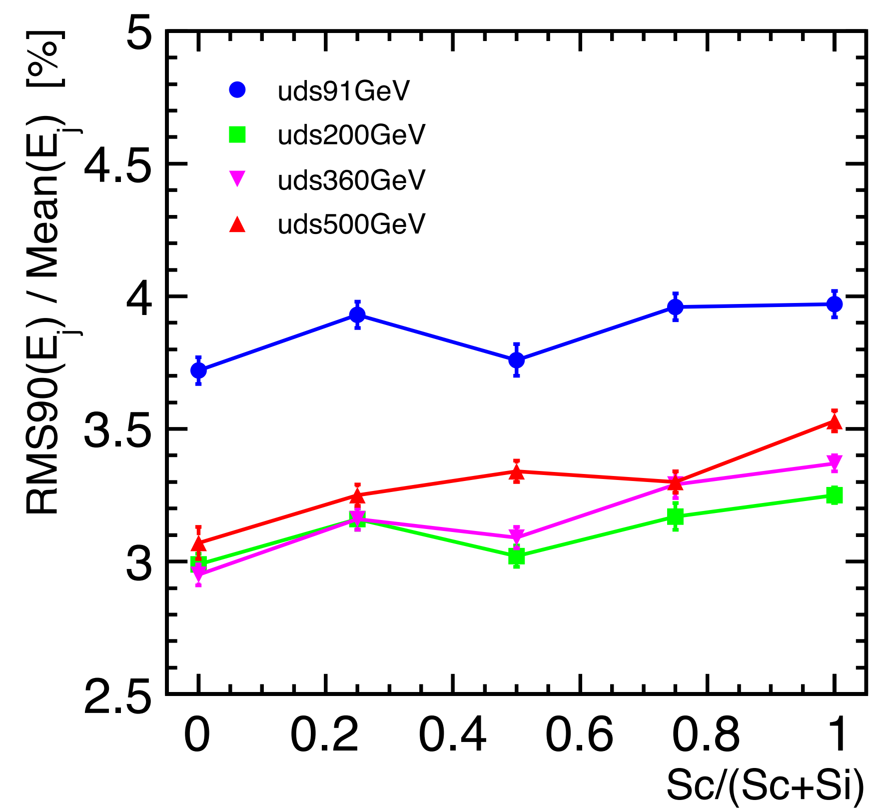

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- JER becomes worse gradually.
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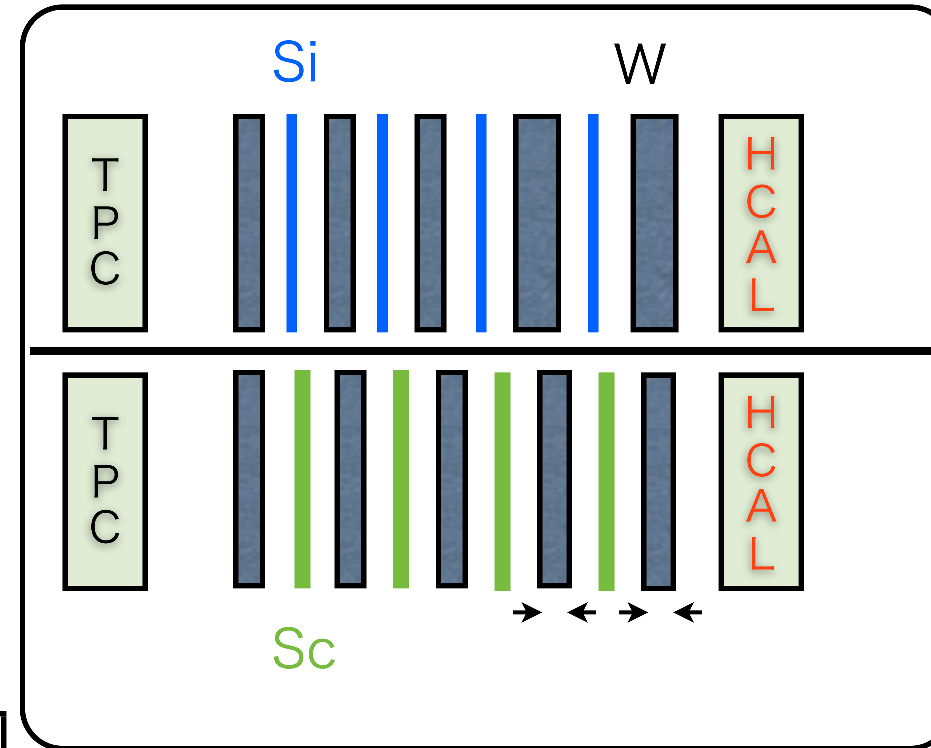
same module thickness

- to evaluate with official ECAL thickness
- five configurations
- Sc thick = 1.0mm, Si thick = 0.5mm
- change absorber thickness for outer layers



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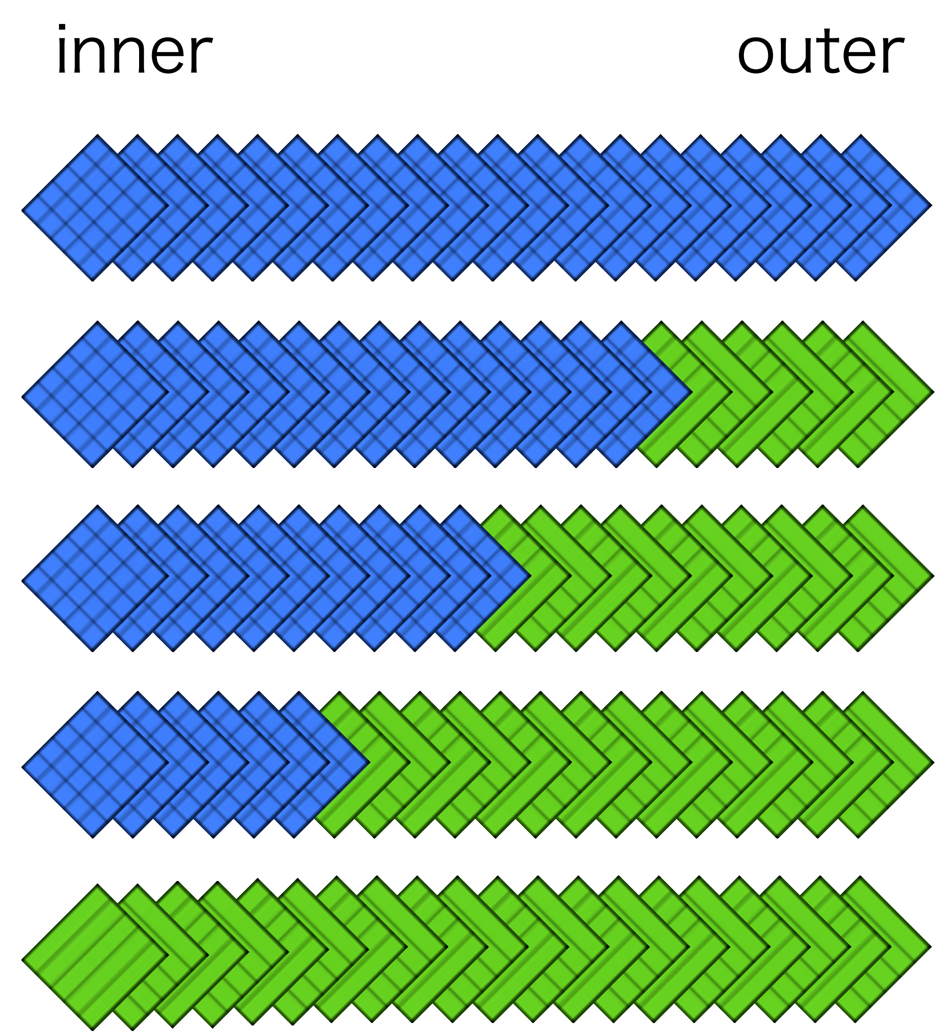
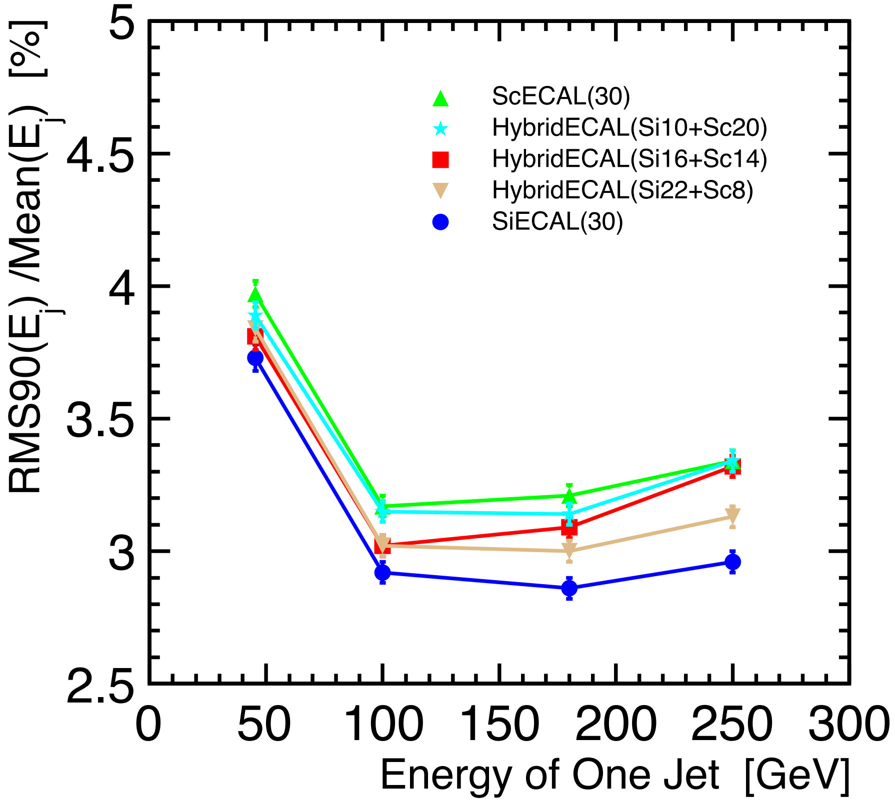


Jet Energy Resolution

Energy Dependence



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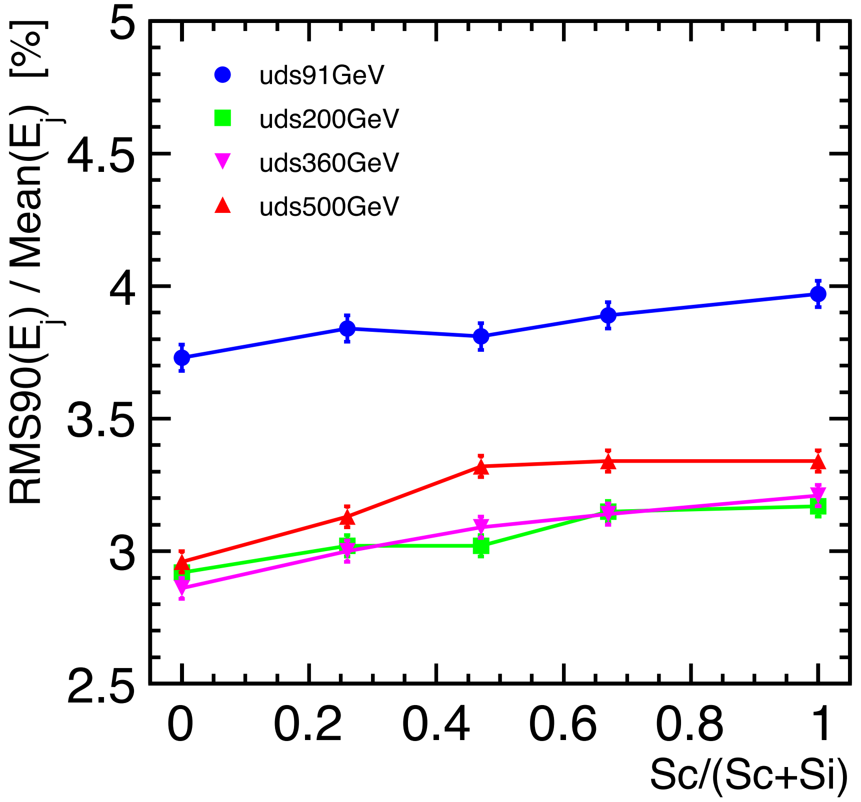
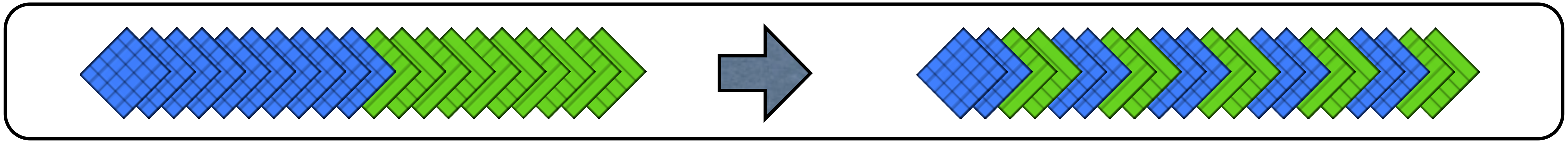


- JER difference between SiECAL and ScECAL is ~0.3% at 180, 250GeV
- The performances of ECALs contains Sc-layers more than half are same at 250GeV.
- Hybrid(Si22+Sc8) is about medium between SiECAL and ScECAL

- JER degrades not so much up to 180GeV jet.
- The difference between SiECAL and ScECAL or Hybrid(Si16+Sc14) is ~0.3% at 250GeV

alternating hybrid

- to help SSA and resolve ghost hits
- double layers alternate



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same module thickness

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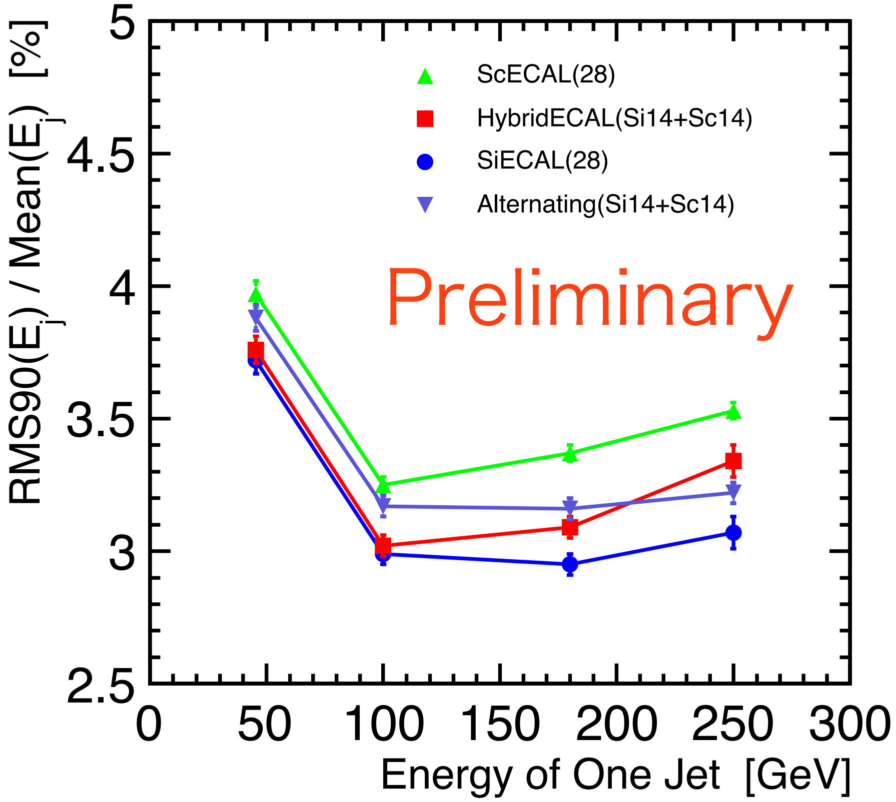
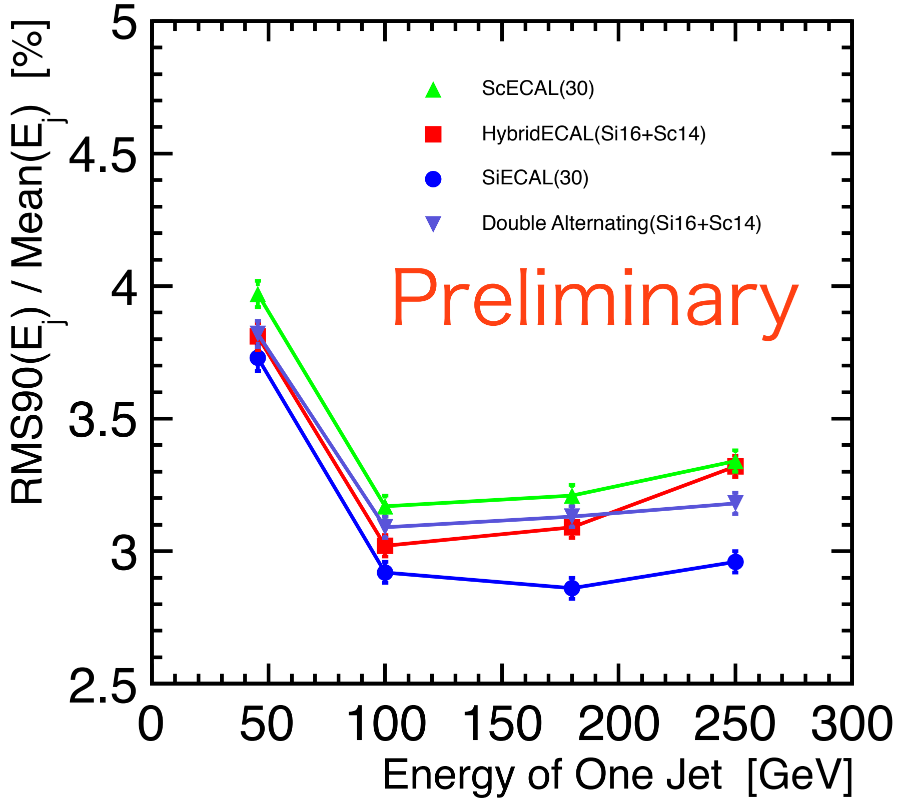
Performance of alternating hybrid

same absorber thickness



same module thickness

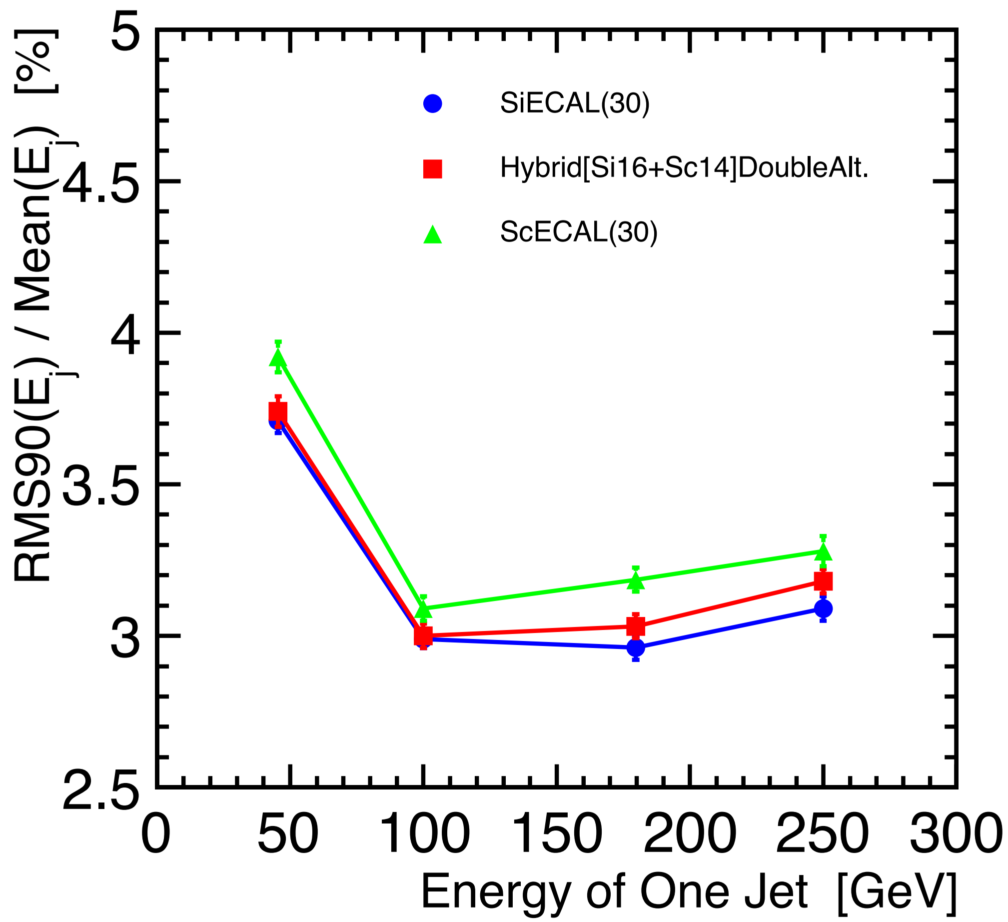


- For both case,
  - worse than half and half at low energies
  - a little bit better at high energies

Single layer alternating will be evaluated

Understanding ECAL Performance

- the contributions to JER by cheating MC information
- Data are generated with trunk version of Mokka

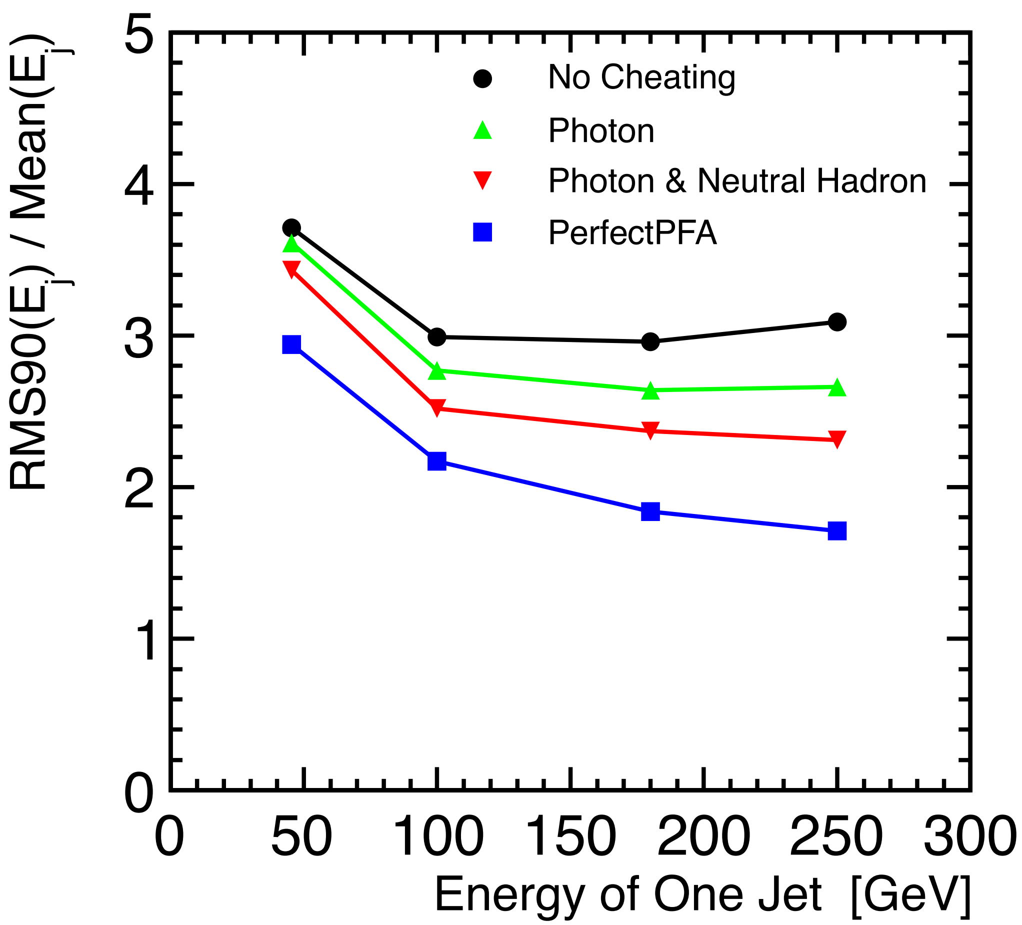


Sc = 1.0mm	W thickness (in20,out9)	Module thickness (mm)
SiECAL(30)	2.1/4.2	185.0
Hybrid[Si16+Sc14] Double Alternating	2.1/4.2	190.8
ScECAL(30)	2.1/4.2	197.4

Understanding ECAL Performance

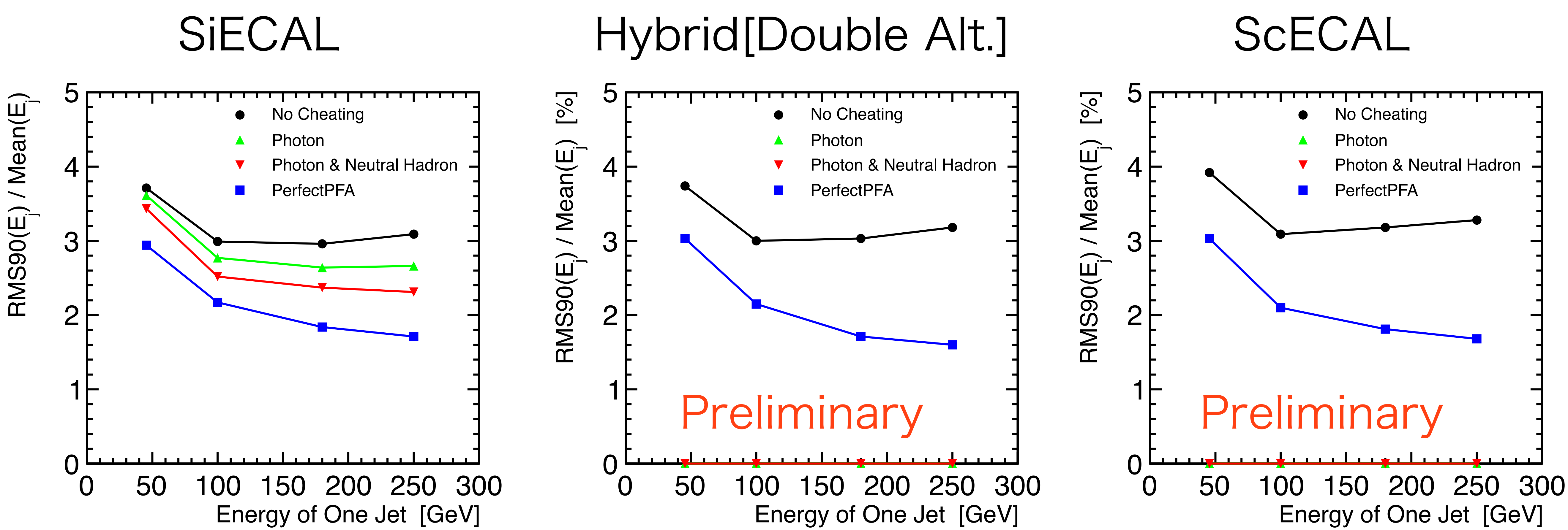
- switched standard PFA algorithm to MC cheating version
- We are evaluating three cases,
    - cheat photon
    - cheat photon & Neutral Hadron (neutron, K_L)
    - Perfect Pattern Recognition

SiECAL(30)



	45GeV	100GeV	180GeV	250GeV
Photon	0.10%	0.22%	0.32%	0.43%
Neutral Hadron	0.22%	0.25%	0.27%	0.35%
Others	0.49%	0.35%	0.53%	0.60%
Total Confusion	0.77%	0.82%	1.12%	1.68%

Understanding ECAL Performance

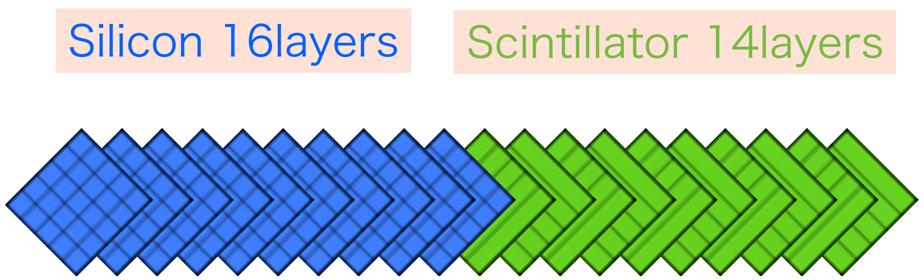


- Cheating with SSA has problem.
  - only PerfectPFA for Hybrid and ScECAL
- If pattern recognition is done completely, JERs are almost same.
- Each contribution to JER of Hybrid and ScECAL will be investigated.

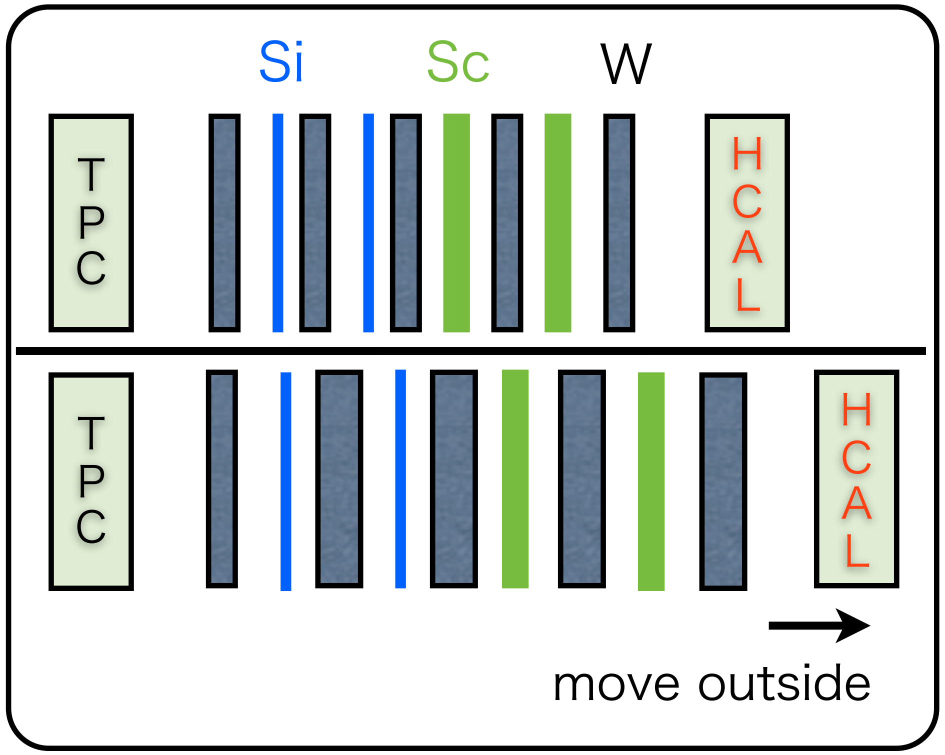
Absorber Thickness Dependence

- v01-15

Sc thickness = 1.0mm
Si thickness = 0.5mm

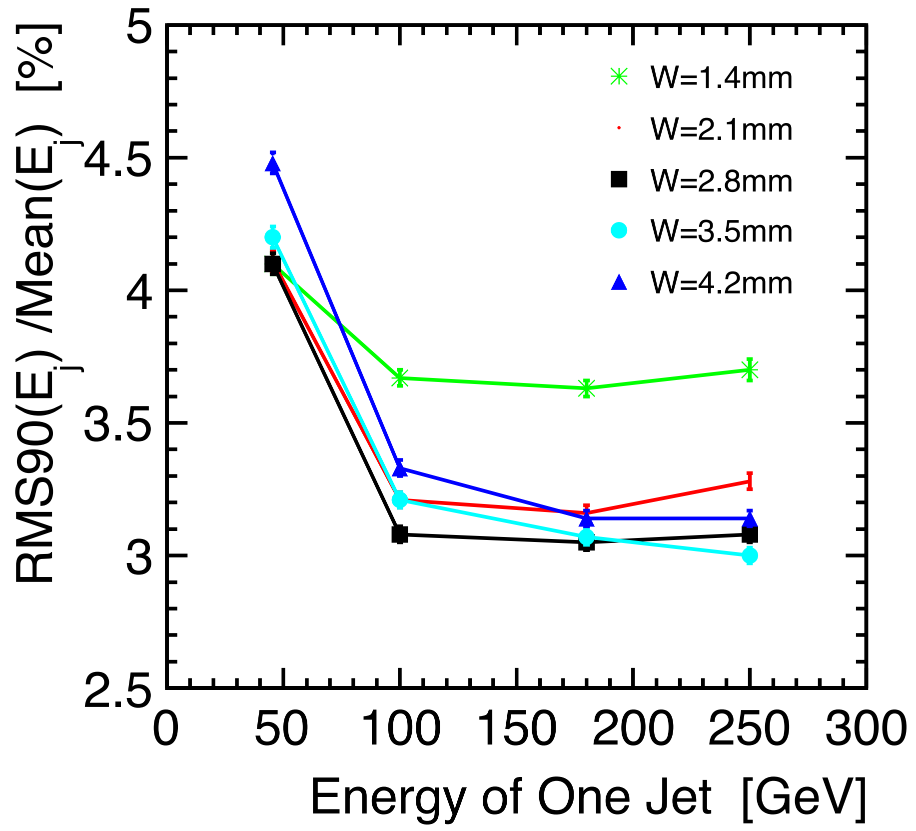


	W thickness (all 29 layers)	Total Radiation Length (X_0)
Hybrid(Si16Sc14)①	1.4	11.6
Hybrid(Si16Sc14)②	2.1	17.4
Hybrid(Si16Sc14)③	2.8	23.2
Hybrid(Si16Sc14)④	3.5	29.0
Hybrid(Si16Sc14)⑤	4.2	34.8

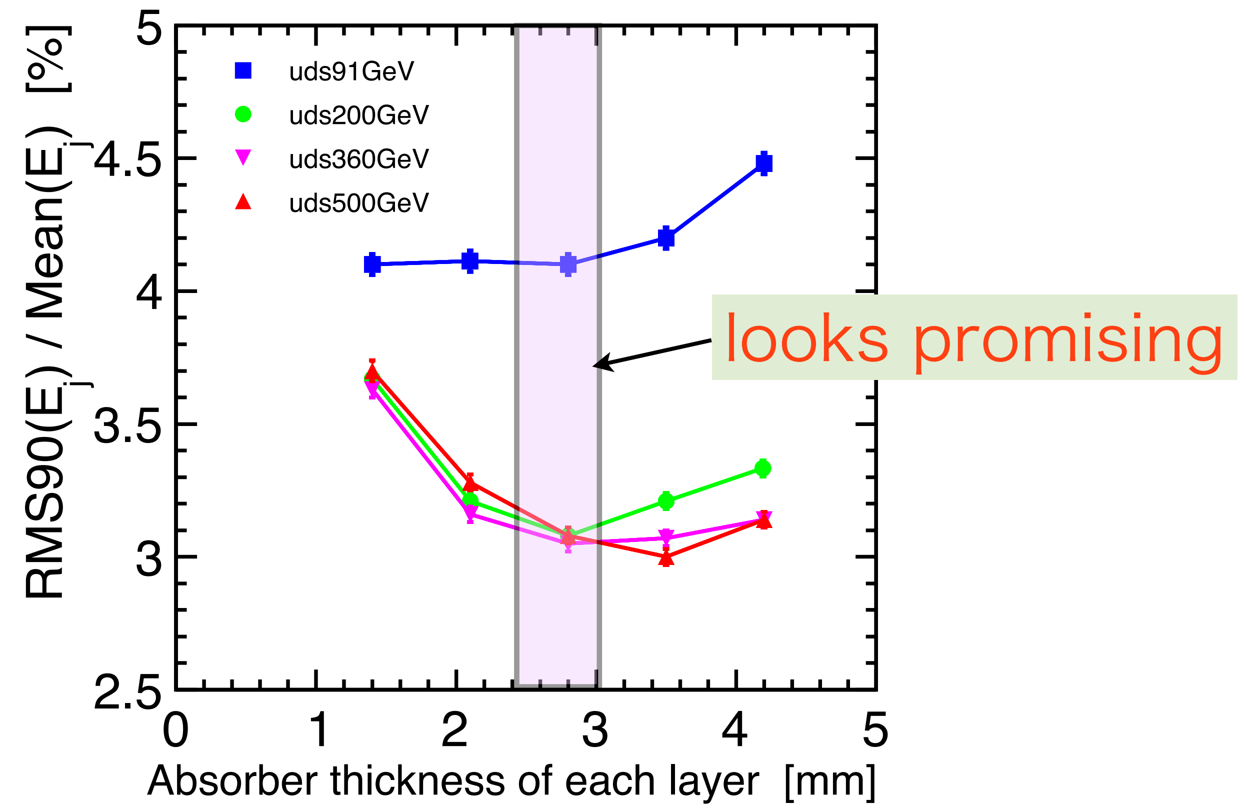


JER v01-15(Absorber thickness dependence)

Energy Dependence



W thickness Dependence



- 1.4mm is worse all over the energy
  - seems to be shower leakage
- 3.5mm seems enough to absorb EM showers

- performance becomes worse above 3.0mm at 45GeV
- ~2.8mm (~24X0) looks best for 100~250GeV jet