Simulation Study for the Hybrid ECAL for ILD

ECFA2013 @DESY

27th-31st May, 2013

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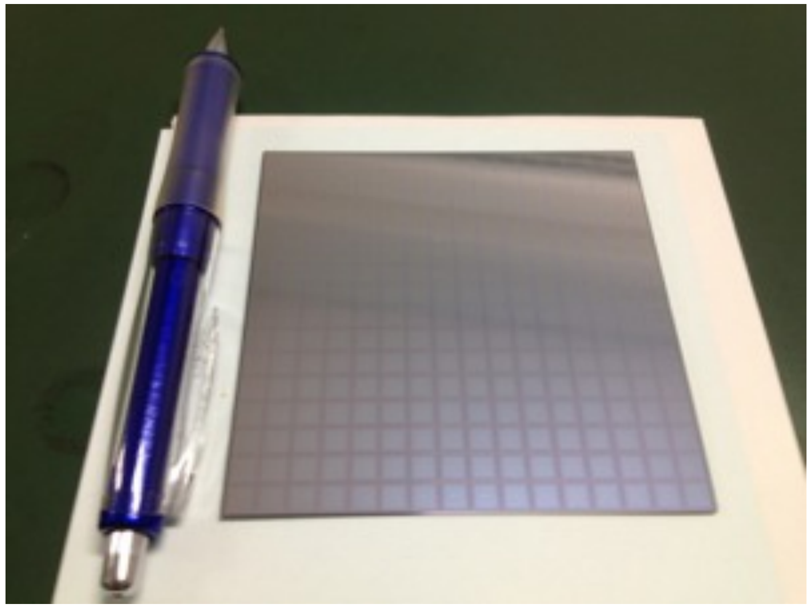
On behalf of ILD ECAL group

Contents

- Motivation for the Hybrid ECAL
- Calibration
- Jet Energy Resolution
    - same absorber thickness
    - same module thickness
    - alternating hybrid
- Summary

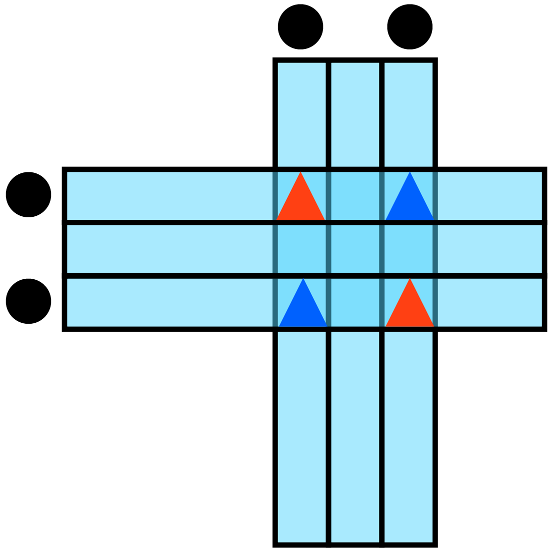
ILD ECAL Candidates

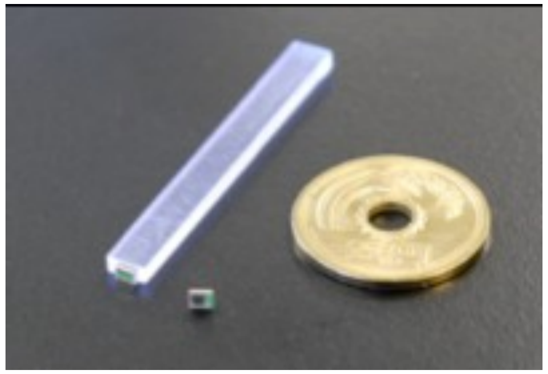
Silicon pads（Si ECAL）



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

Scintillator strips +MPPC（Sc ECAL）



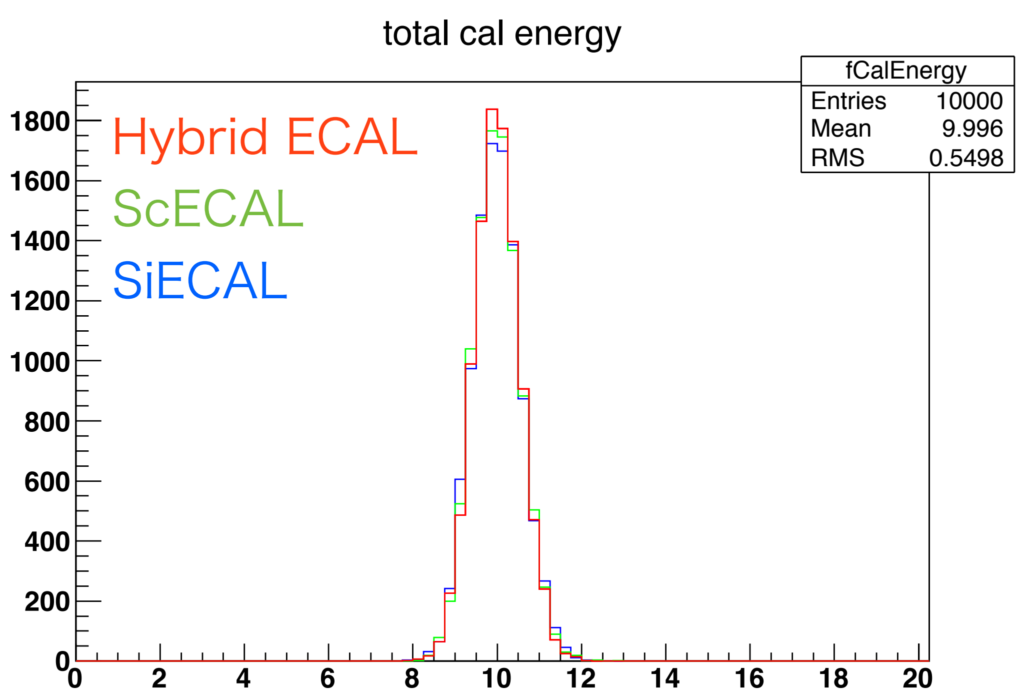


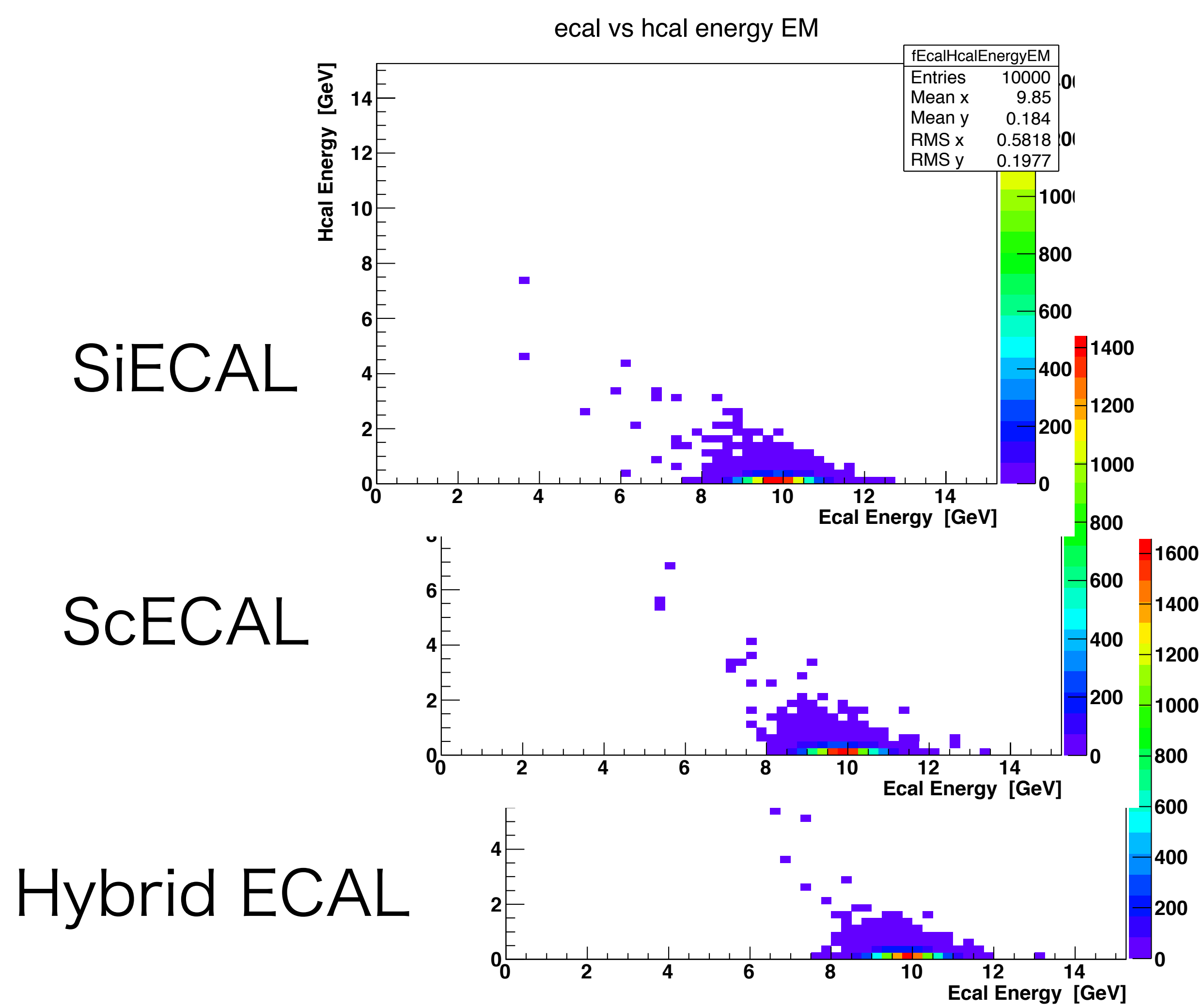
- ✻ 45mm x 5mm orthogonal & SSA
  --> 5mm x 5mm spatial resolution
- ✻ reasonable cost
- ✻ ghost hits
- ✻ thicker than silicon

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 separately (Sc, Si)
  - determined using 10GeV photons

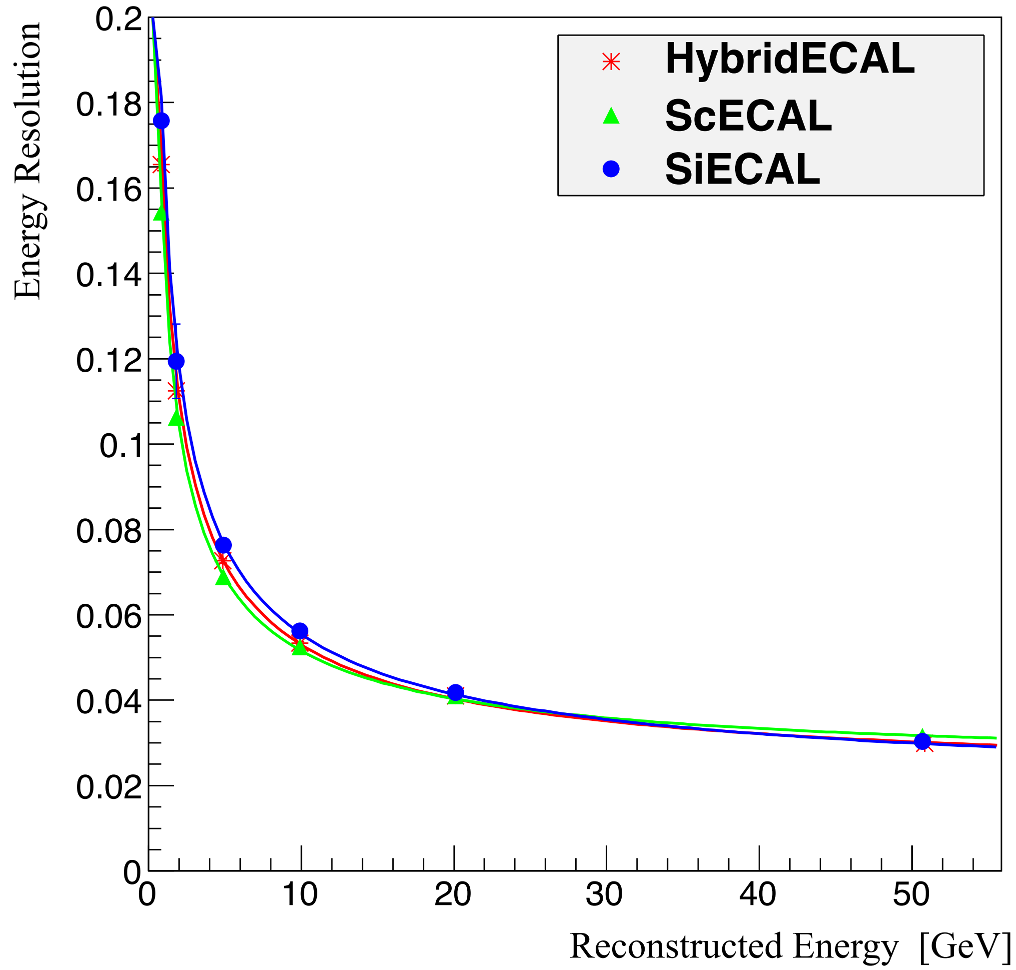




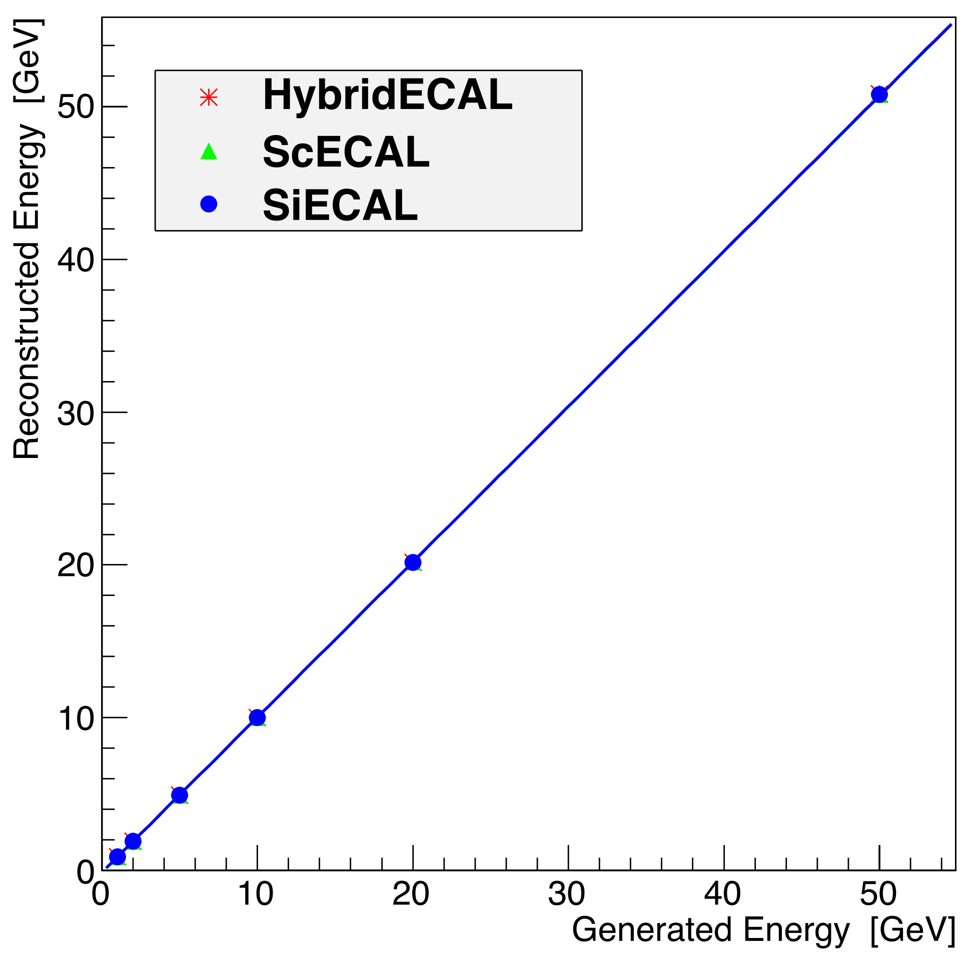
ECAL Performance

- photon energy resolution and linearity using 1~50GeV photons.

Photon Energy Resolution



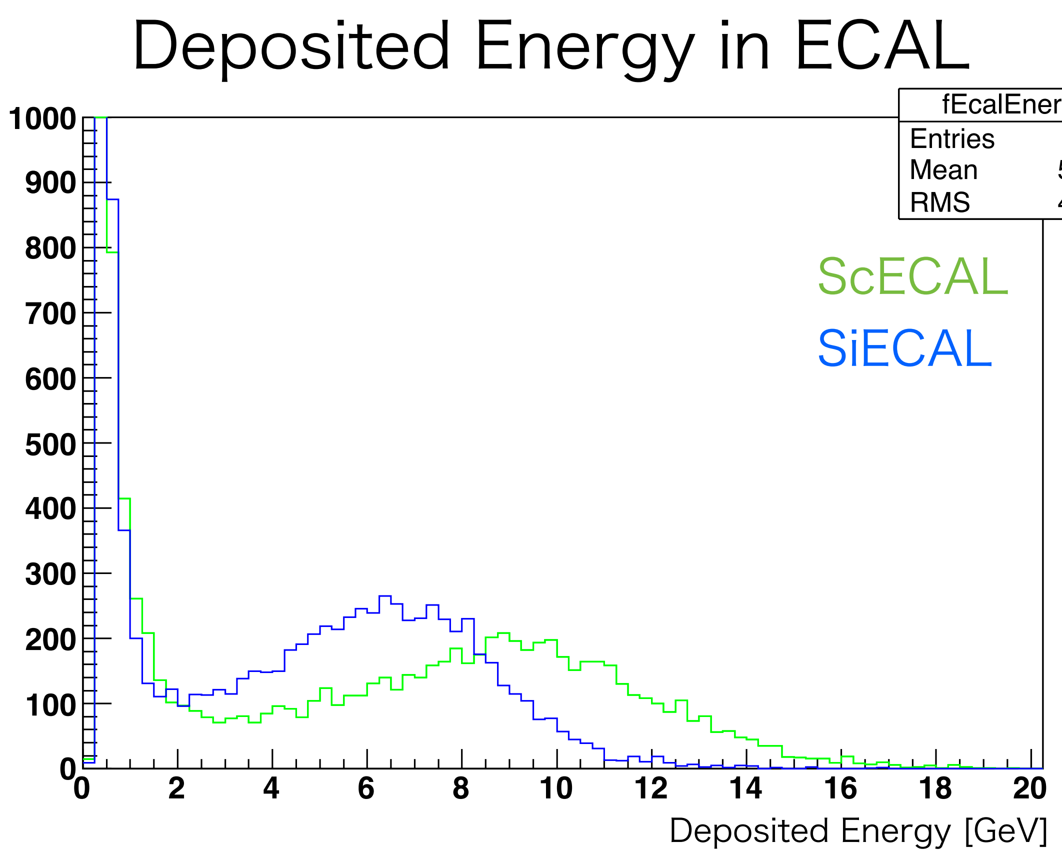
Linearity

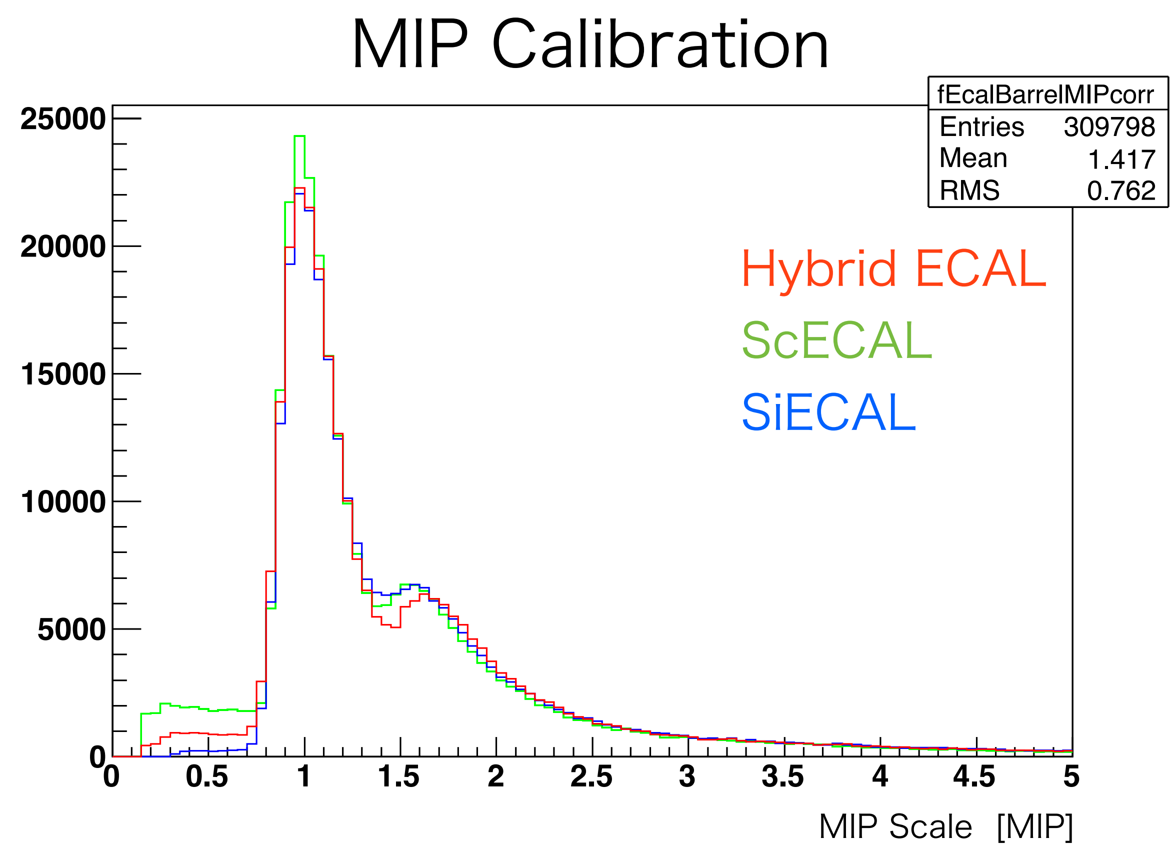


The calibration method works well.

ECAL Calibration

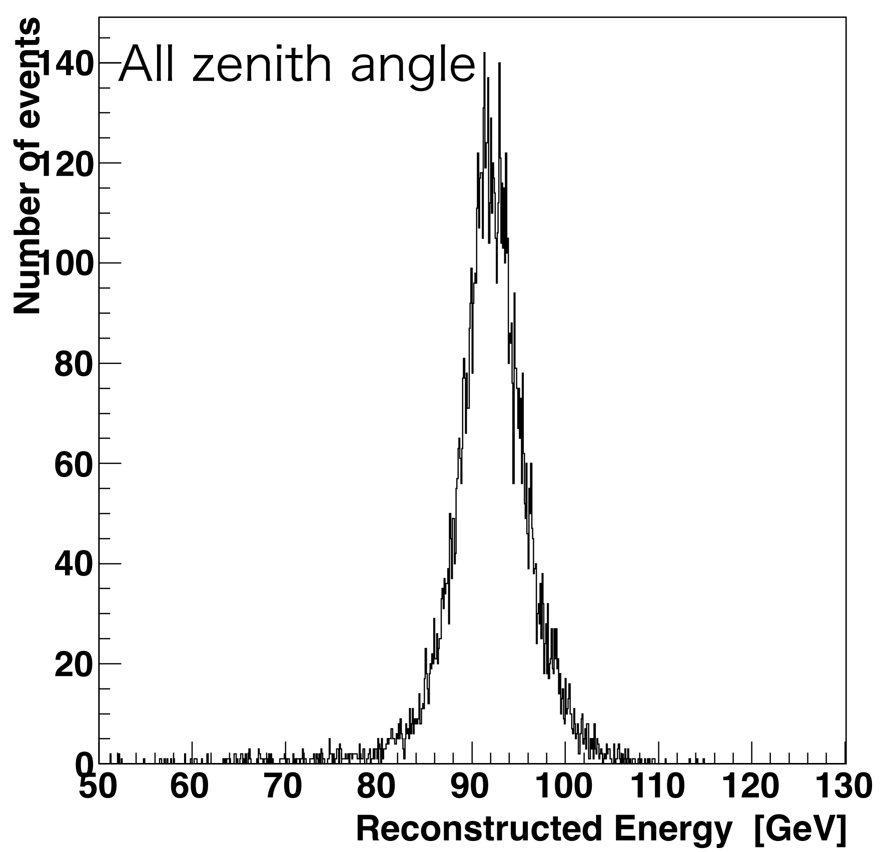
- e/h compensation in ECAL : 10GeV π^+
- MIP calibration : 10GeV muons

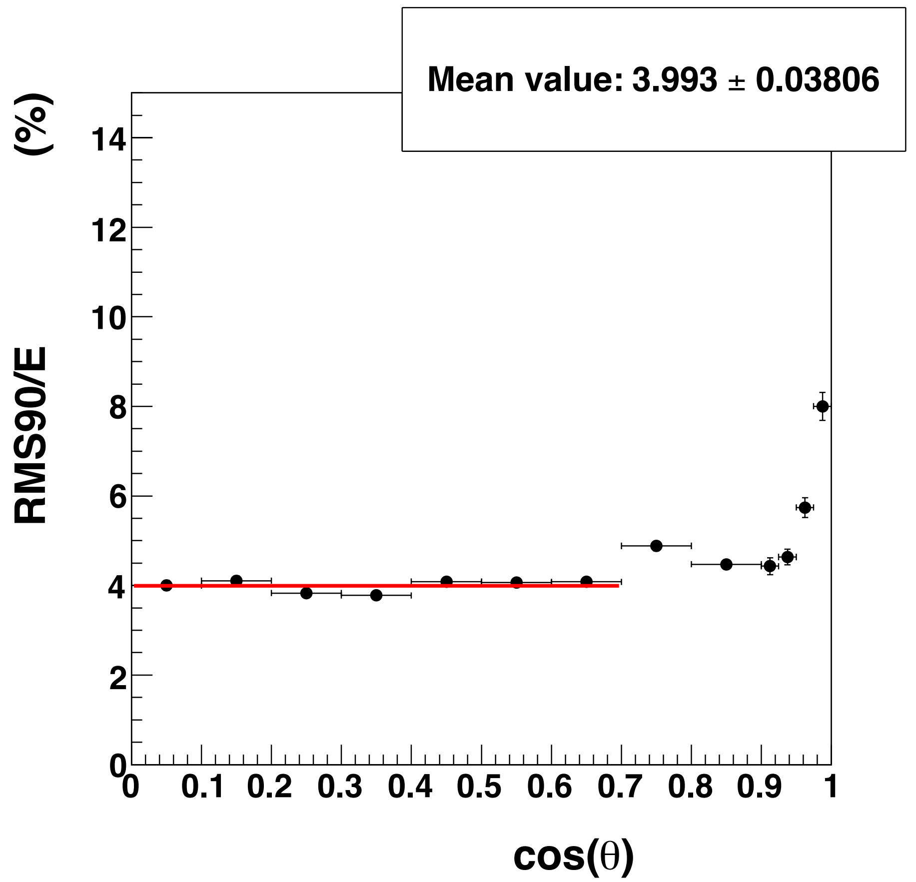




Hybrid ECAL Evaluation

- We evaluated energy dependence and Sc:Si ratio dependence.
- software version : ilcsoft v01-15
- Used events are $e^+e^- \rightarrow q\bar{q}$ (q=u,d,s, √s=91, 200, 360, 500GeV)
- We use only barrel region (cos(thrust angle)<0.7) for evaluation.





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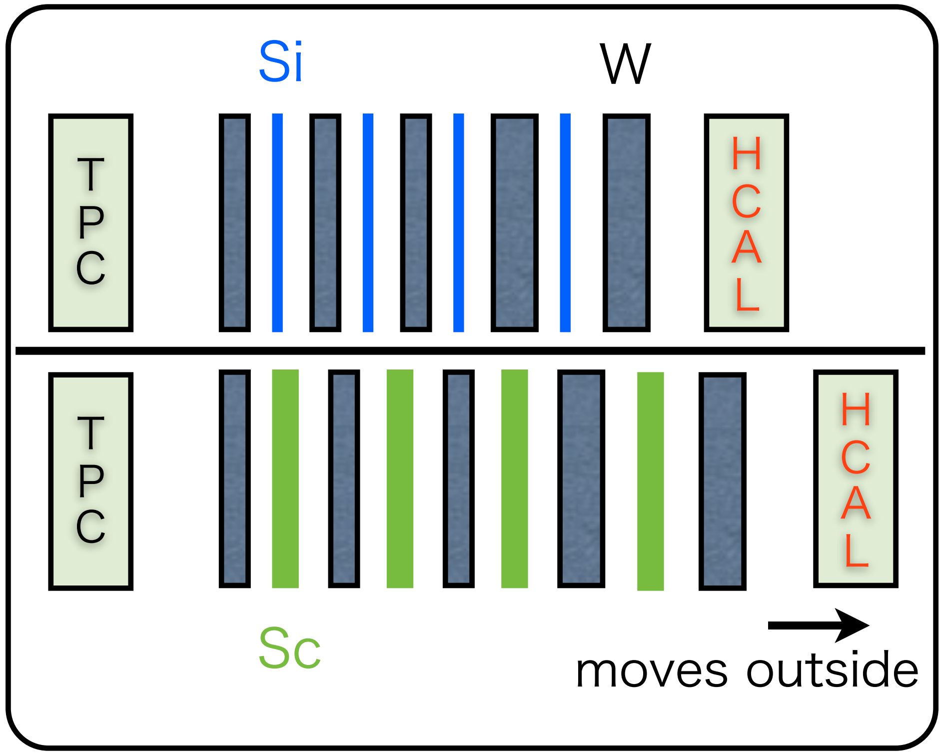
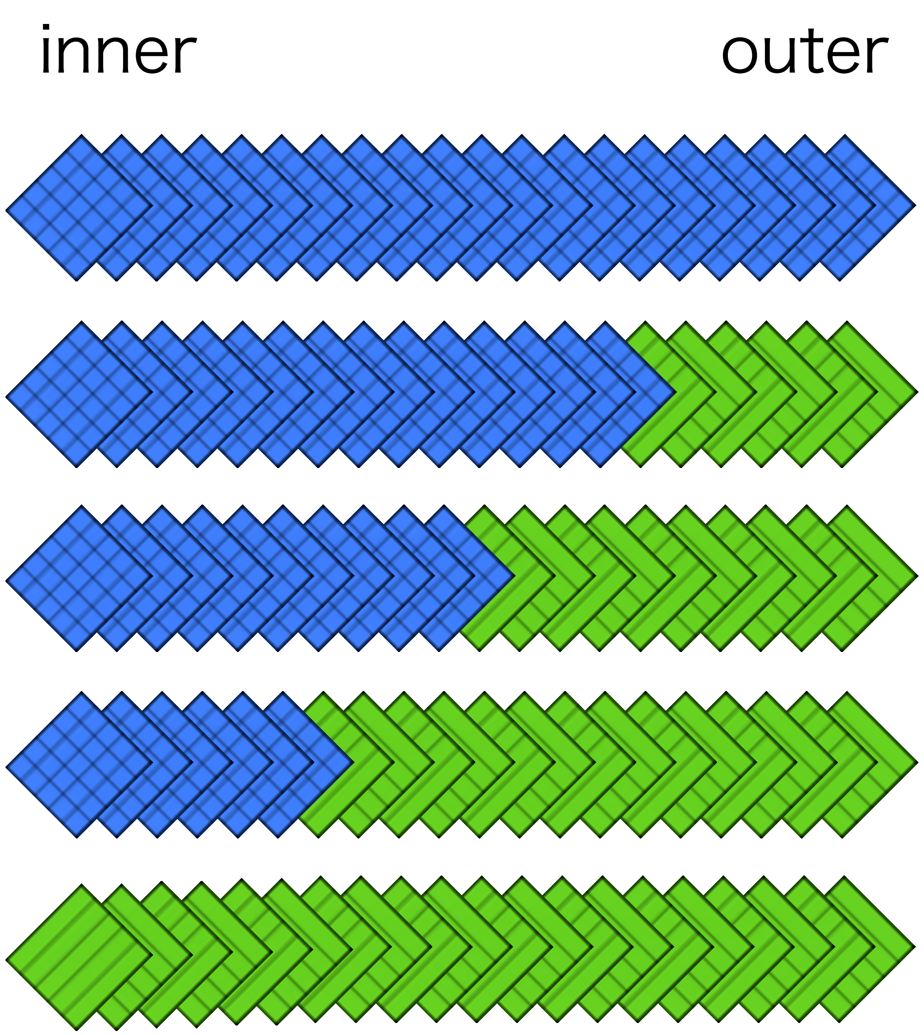
- Jet Energy Resolution
  - same absorber thickness
  - same module thickness
  - alternating hybrid
- Summary

same absorber thickness

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

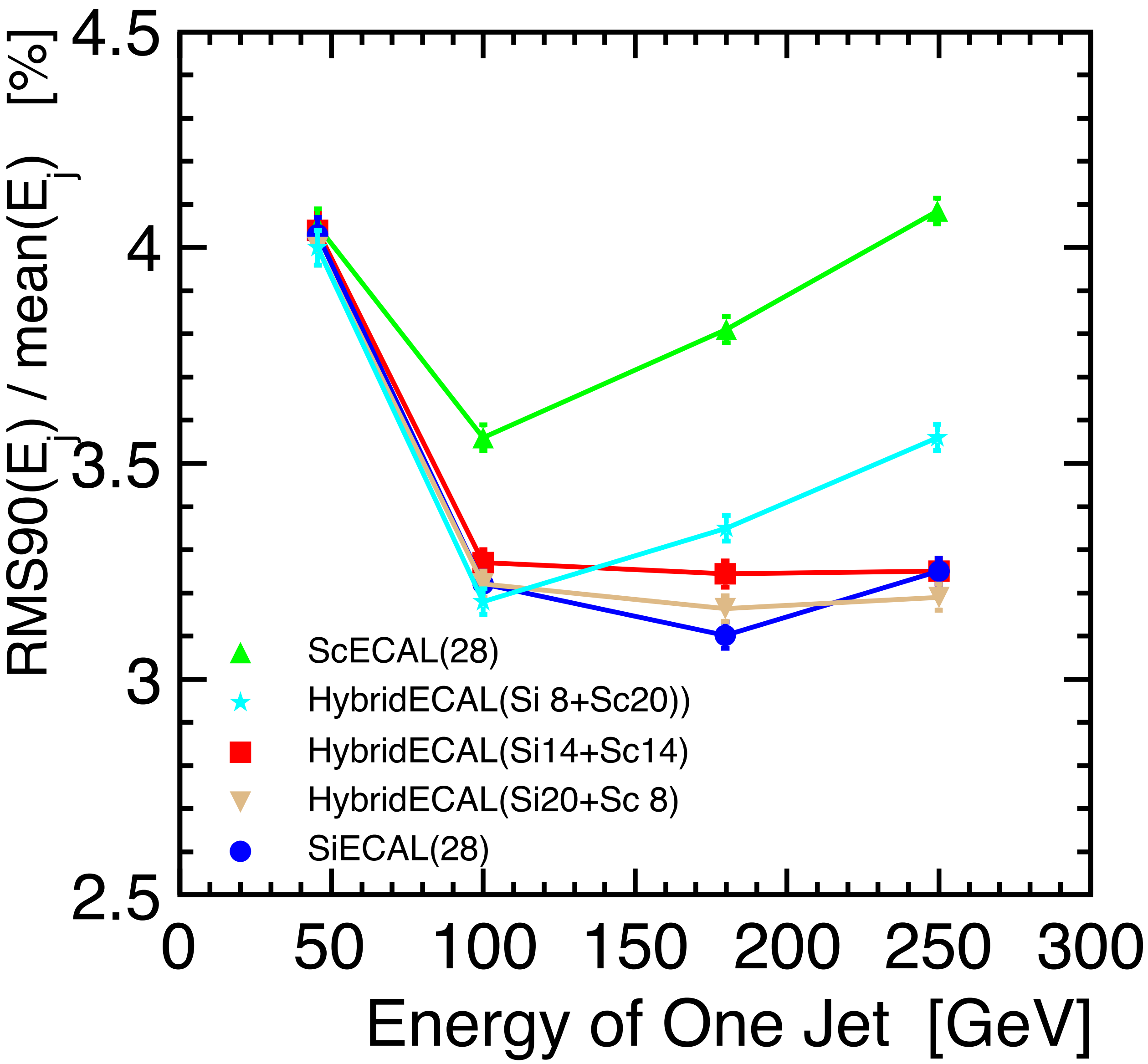


	W thickness (in20,out7)	Module thickness (mm)
SiECAL(28)	2.1/3.5	165.4
Hybrid(Si20Sc8)	2.1/3.5	176.7
Hybrid(Si14Sc14)	2.1/3.5	185.2
Hybrid(Si8Sc20)	2.1/3.5	193.7
ScECAL(28)	2.1/3.5	205.0



Jet Energy Resolution

Energy Dependence

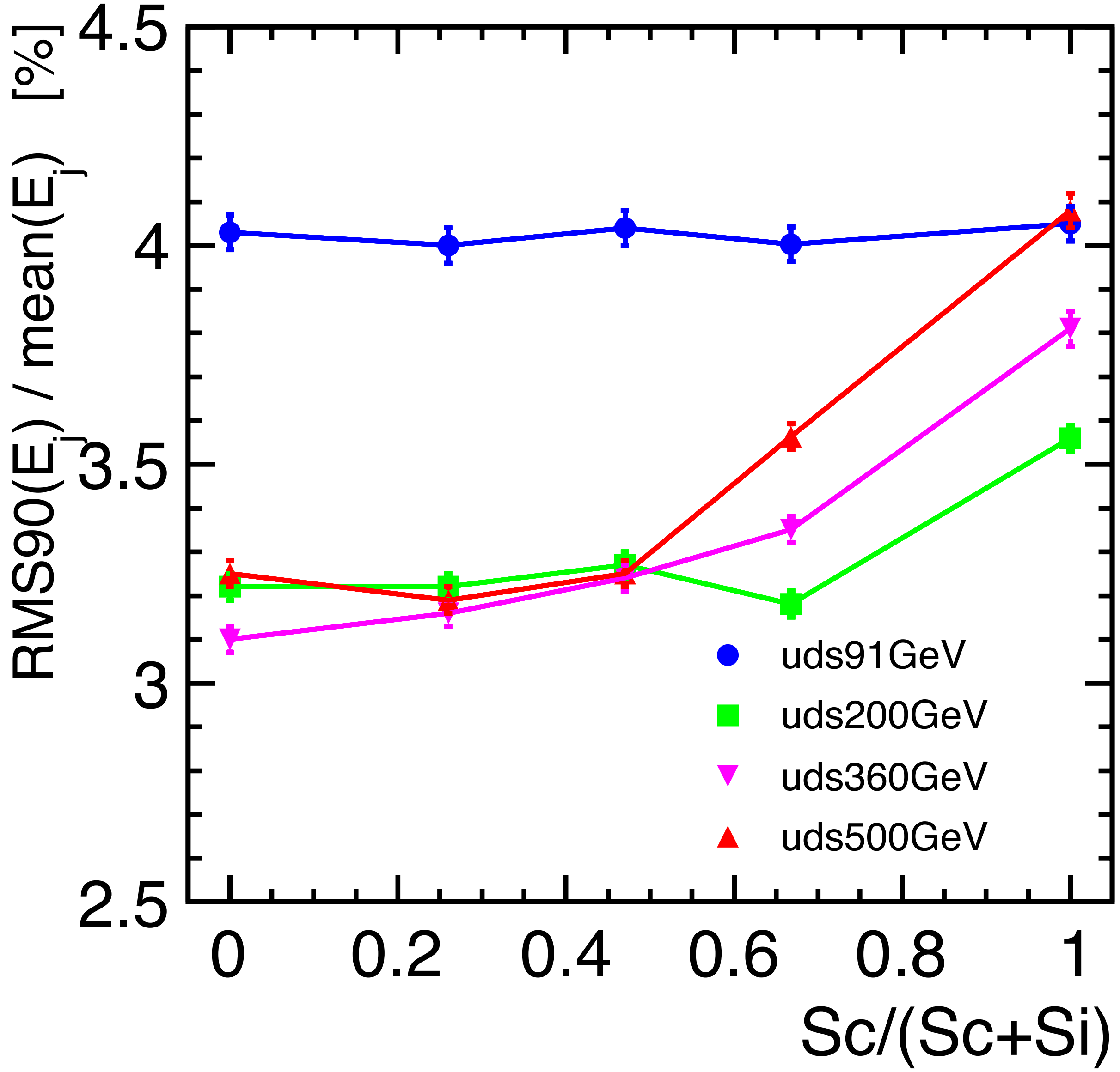


- no big difference between SiECAL, Hybrid(Si14+Sc14), Hybrid(Si20+Sc8)

- We can keep performance with less silicon layers at low energies.

Jet Energy Resolution

Ratio Dependence



- almost same performance at low energies
- the more scintillator, the worse performance at high energies
- not degrade so much up to 50% of scintillator layers

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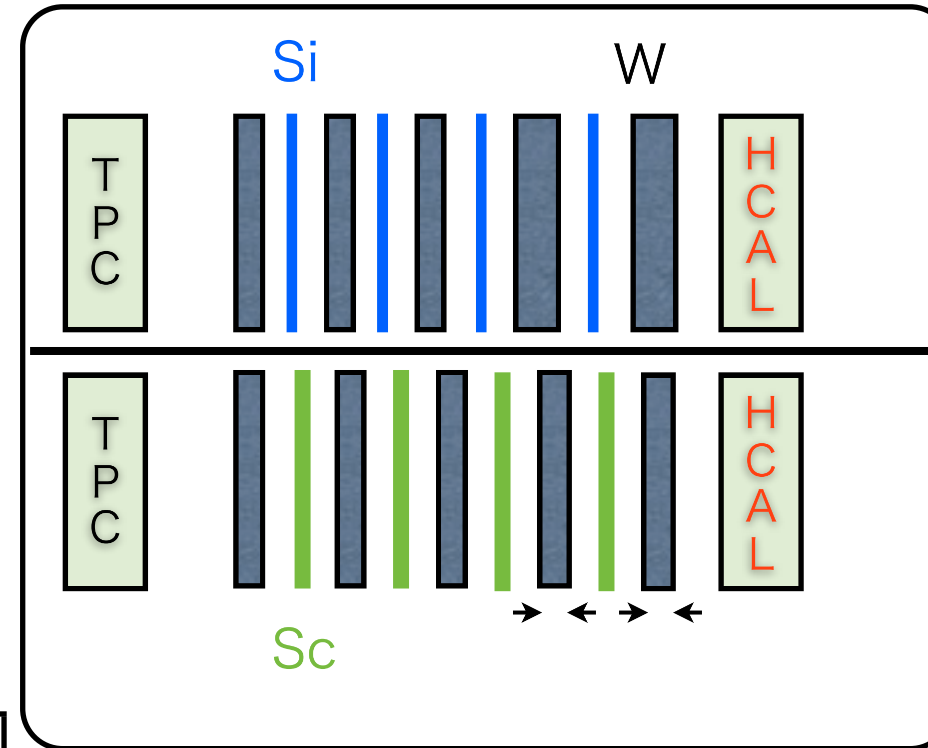
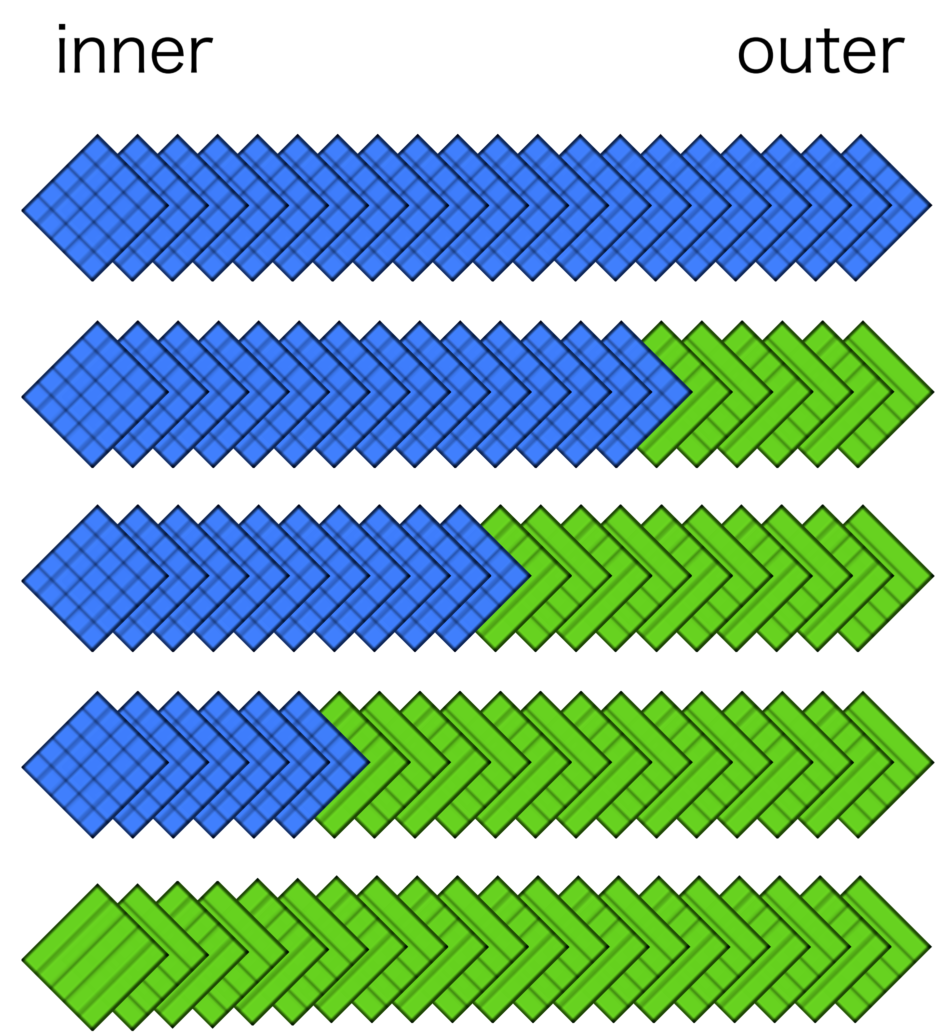
same module thickness

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

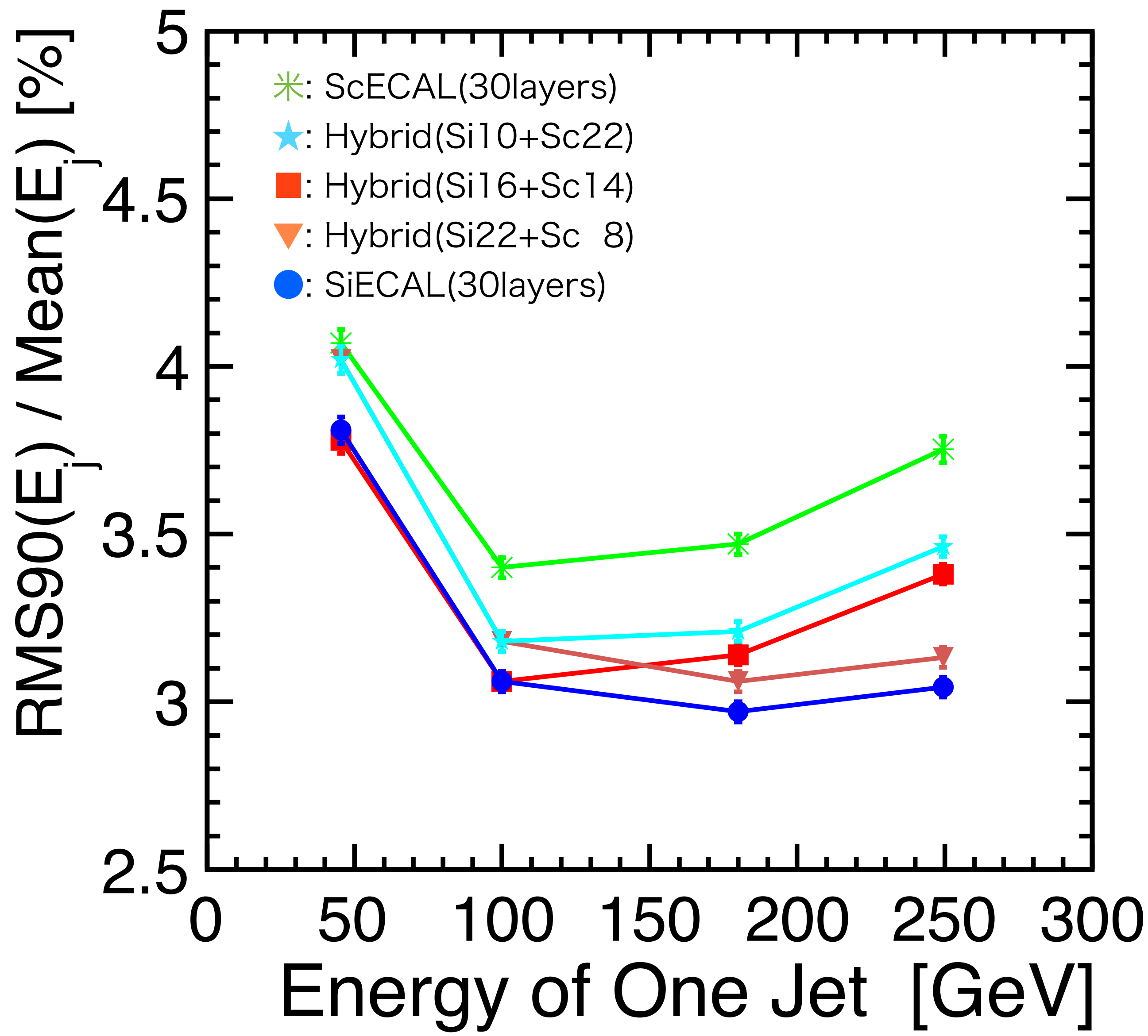


	W thickness (in20,out9)	Module thickness (mm)
SiECAL(30)	2.1/4.2	185.0
Hybrid(Si22Sc8)	2.1/3.9	185.6
Hybrid(Si16Sc14)	2.1/3.6	185.4
Hybrid(Si10Sc20)	2.1/3.3	185.2
ScECAL(30)	2.1/2.9	185.7



Jet Energy Resolution

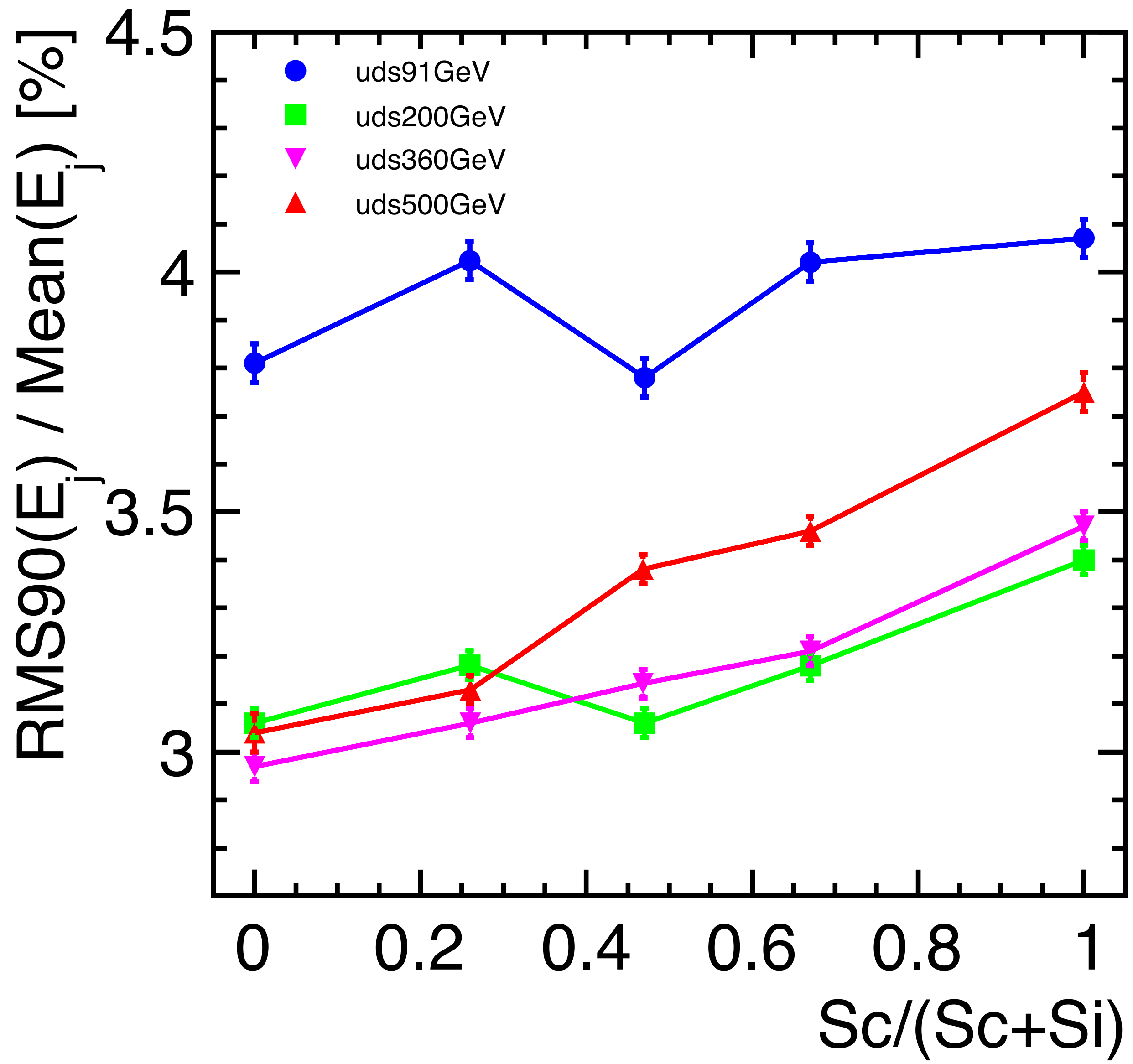
Energy Dependence



- performance looks to depend on the number of silicon layers all over the energies
- Hybrid(Si16+Sc14) is about medium between SiECAL and ScECAL at high energies.

Jet Energy Resolution

Ratio Dependence



- Performance becomes worse almost linearly as scintillator layers increase

- Hybrid(Si16+Si14) is better than other hybrid at low energies.

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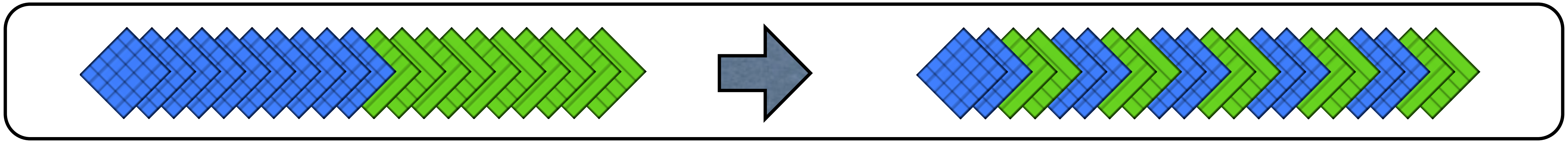
alternating hybrid

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



same absorber thickness

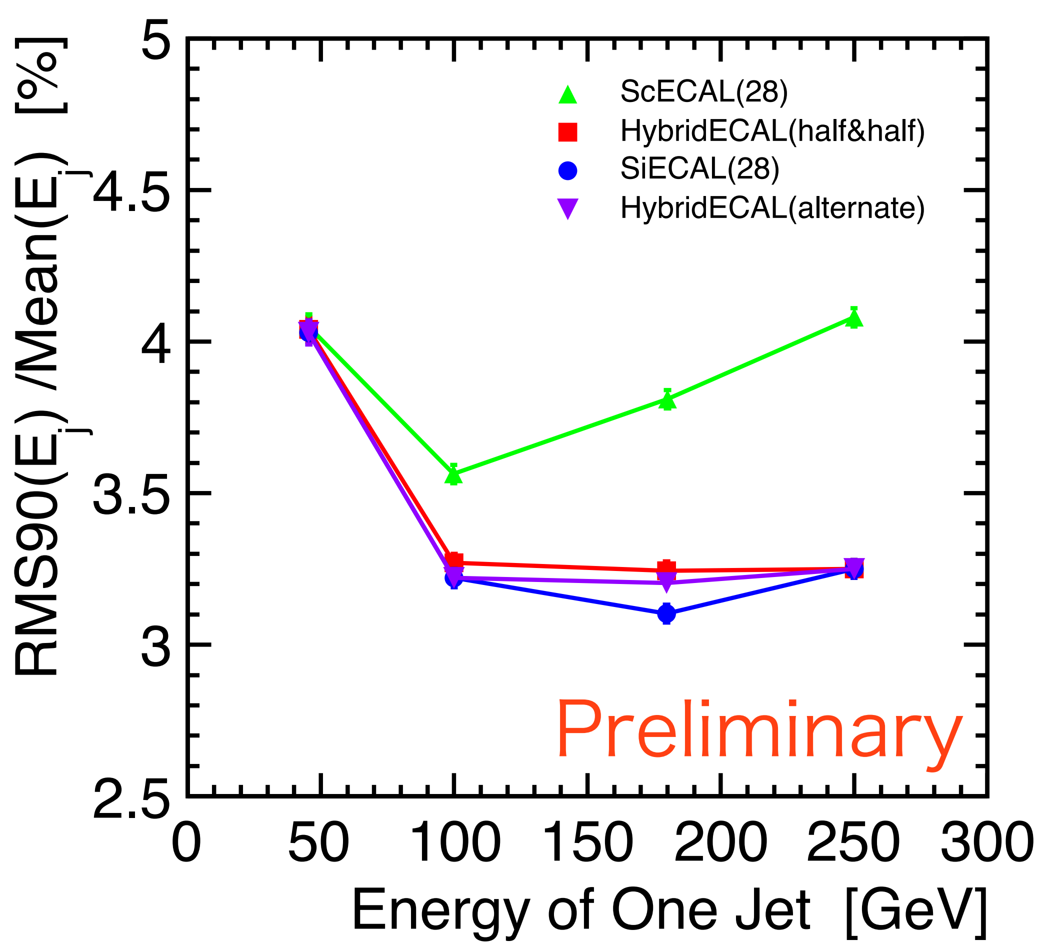
	W thickness (in20,out9)	Module thickness (mm)
SiECAL(30)	2.1/3.5	165.4
Hybrid(Si16Sc14) [not alternate]	2.1/3.5	185.2
Double layers Alternate(Si16Sc14)	2.1/3.5	185.2
ScECAL(30)	2.1/3.5	205.0

same module thickness

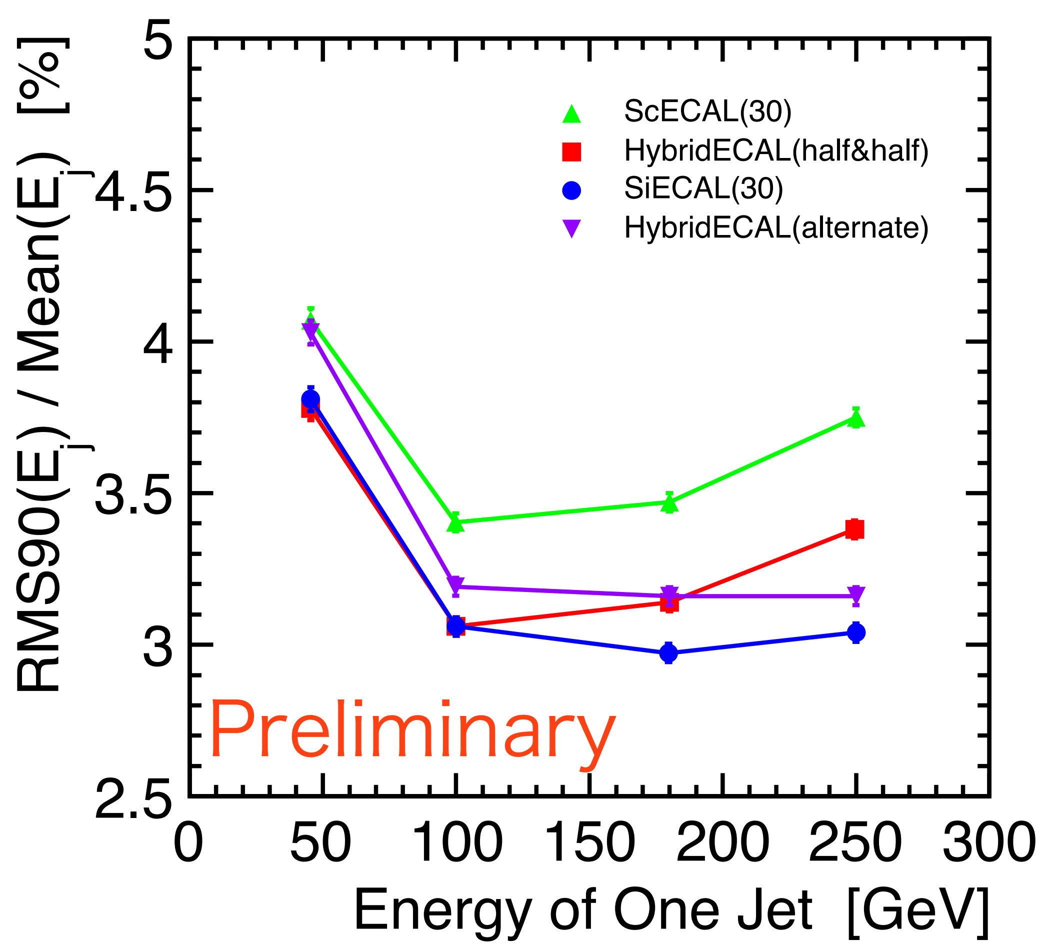
	W thickness (in20,out9)	Module thickness (mm)
SiECAL(30)	2.1/4.2	185.0
Hybrid(Si16Sc14) [not alternate]	2.1/3.6	185.4
Double layers Alternate(Si16Sc14)	2.1/3.6	185.4
ScECAL(30)	2.1/2.9	185.7

Performance of alternating hybrid

same absorber thickness



same module thickness



Summary

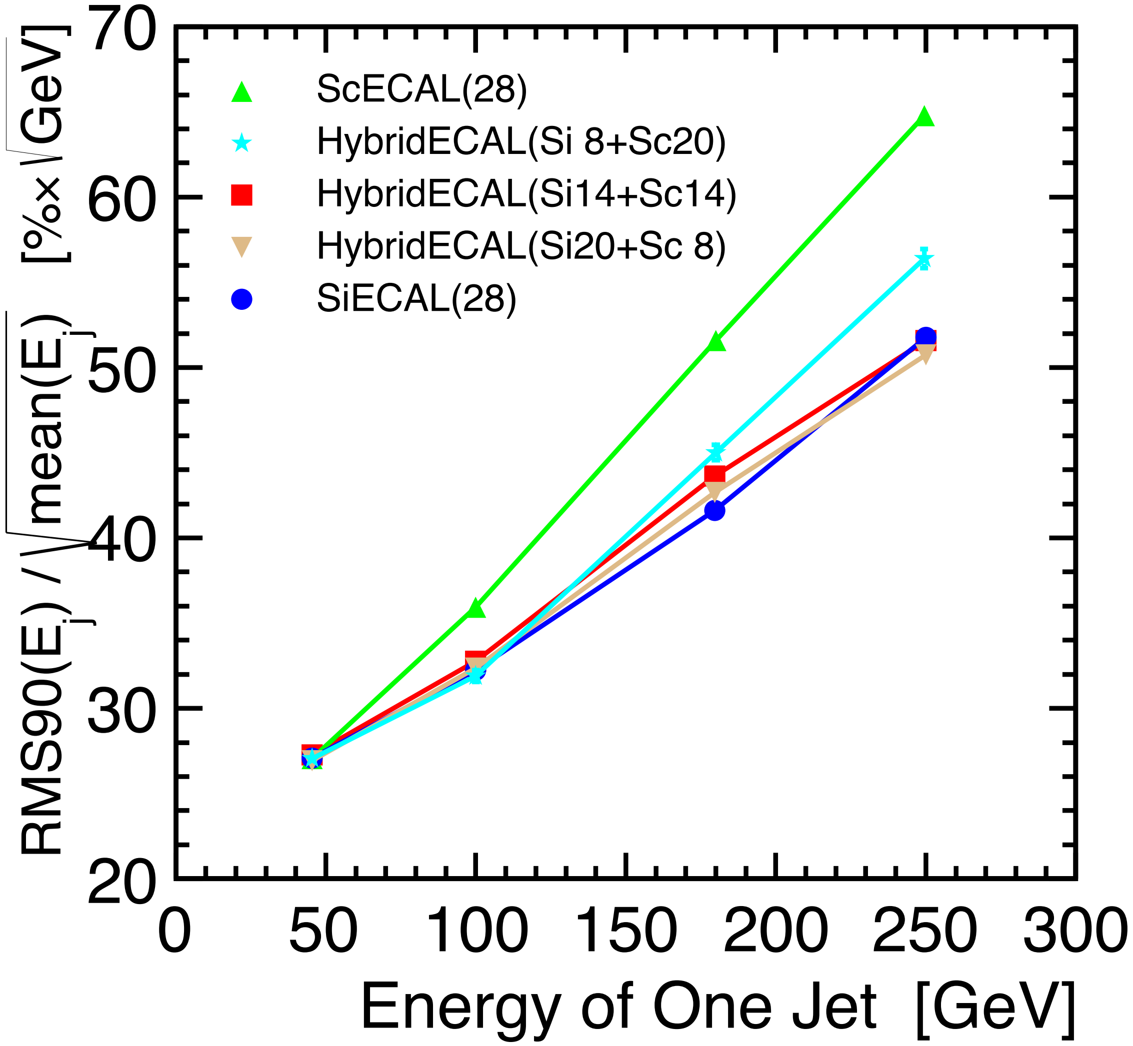
- Hybrid ECAL is an option to make ILD ECAL with a lower cost while keeping performance as much as possible.
- We evaluated Jet Energy Resolution for 3 types of Hybrid ECALs.
  - same absorber thickness ... performance of Hybrid ECAL doesn’t degrade so much up to 50% of scintillator layers.
  - same module thickness ... performance becomes worse almost linearly as scintillator ratio increase.
  - alternating hybrid ... looks good for the case of same absorber thickness, and at high energy in the case of same module thickness.

Backup

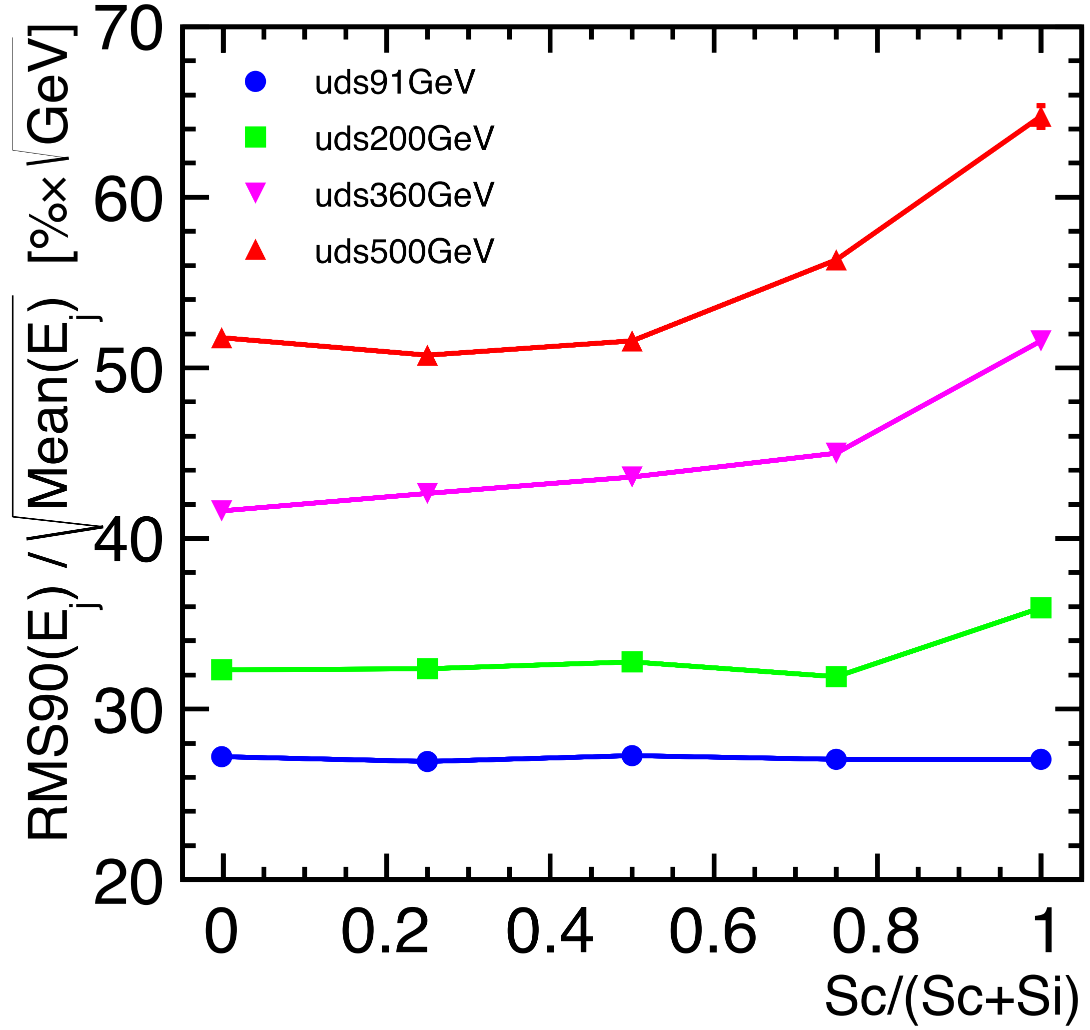
RMS90(E_j) / √mean(E_j)

same absorber thickness

Energy Dependence

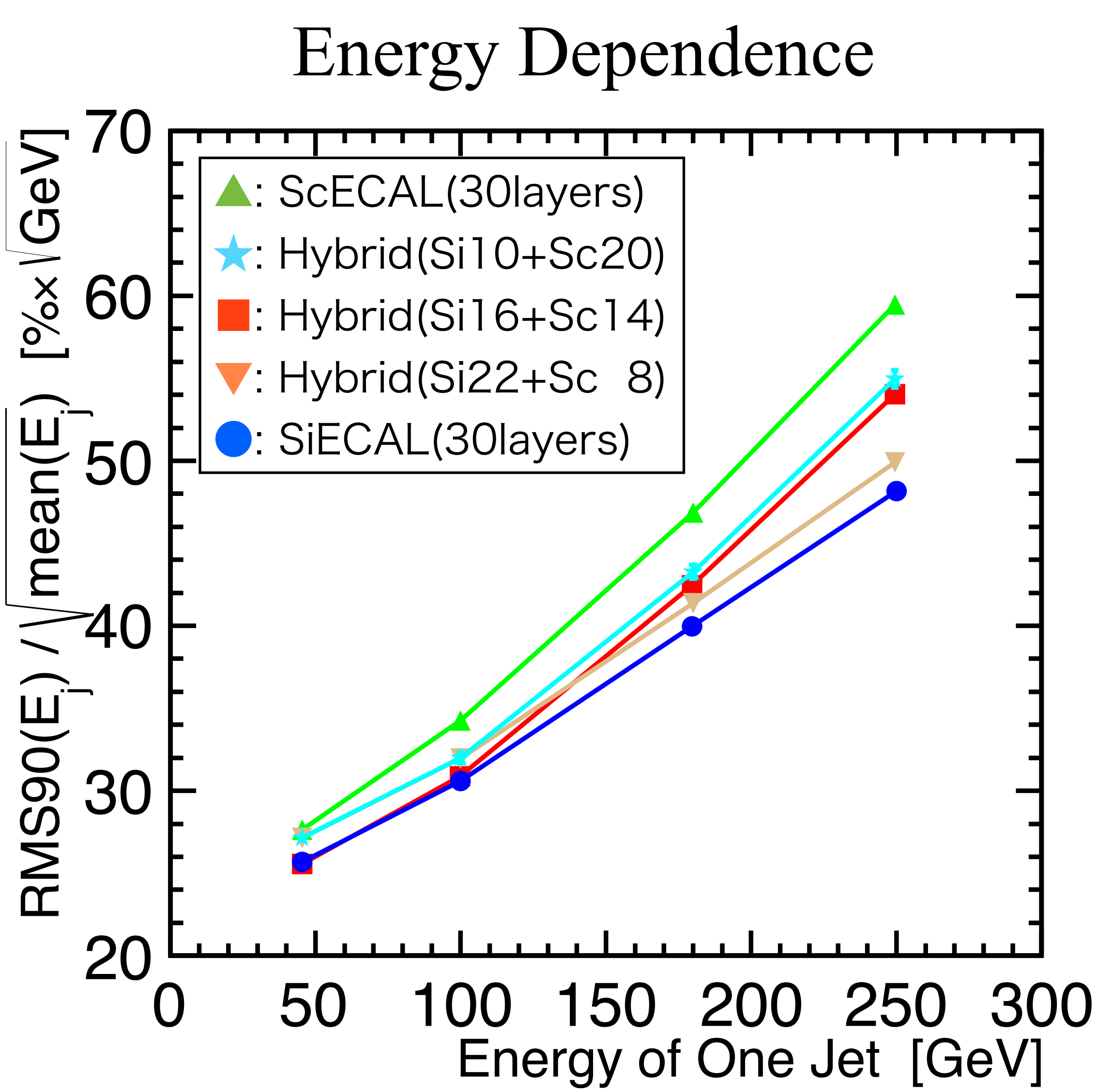


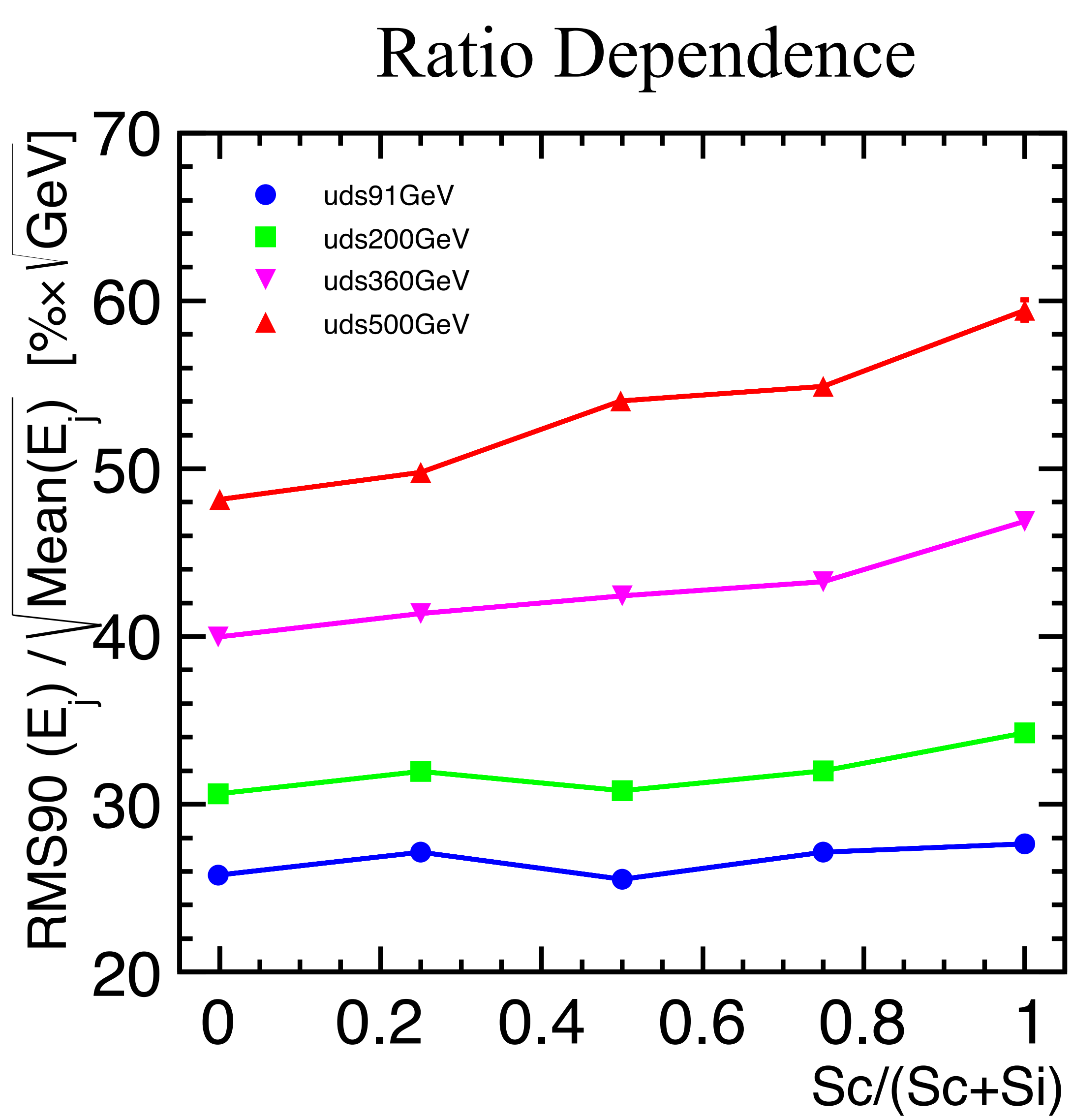
Ratio Dependence



RMS90(E_j) / √mean(E_j)

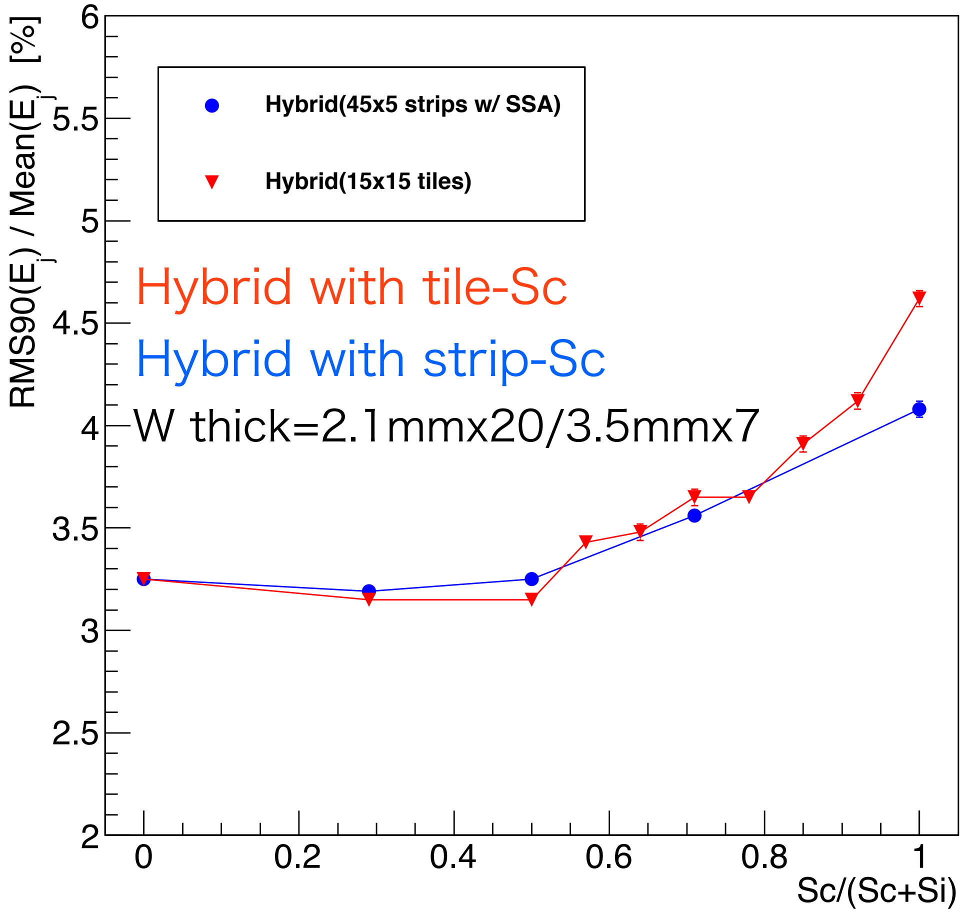
same absorber thickness



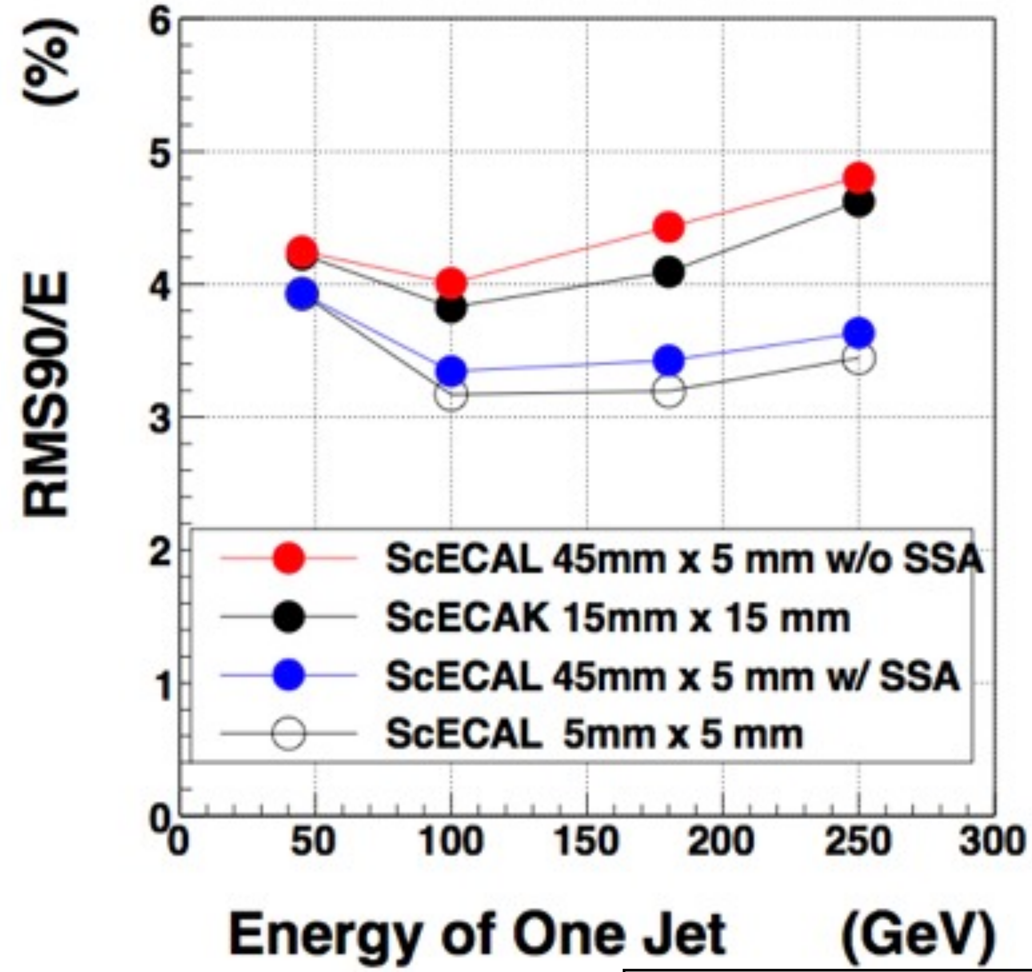


hybrid with Sc-tiles(15x15mm)

Hybrid with tile-Sc



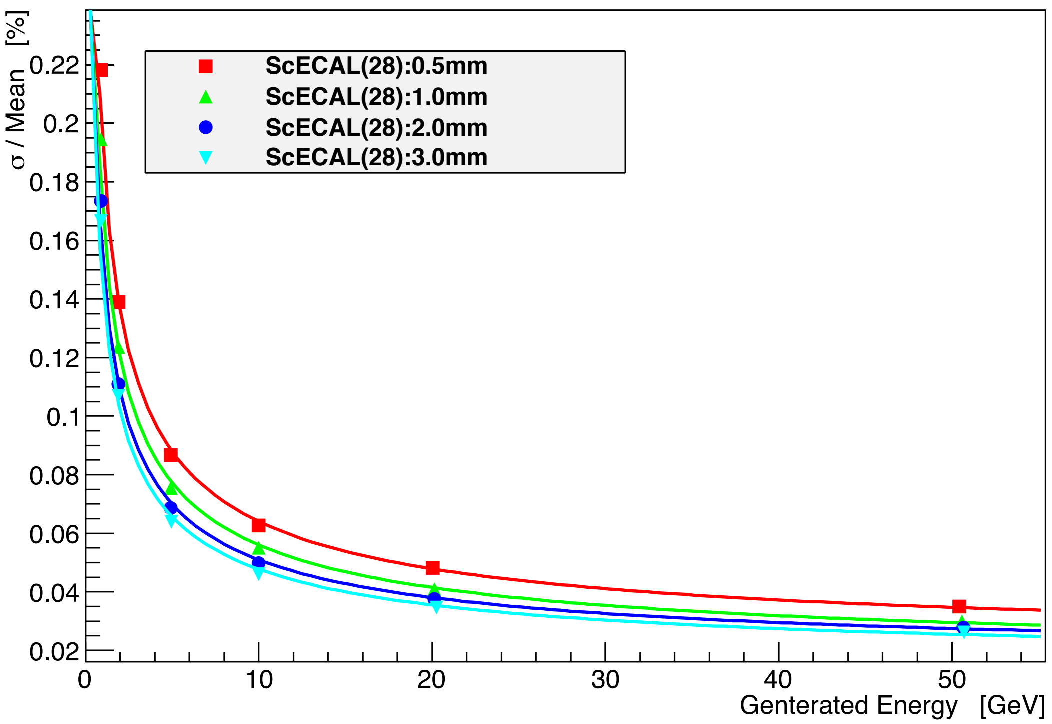
tile ScECAL



by K.Kotera

Scintillator Thickness Difference

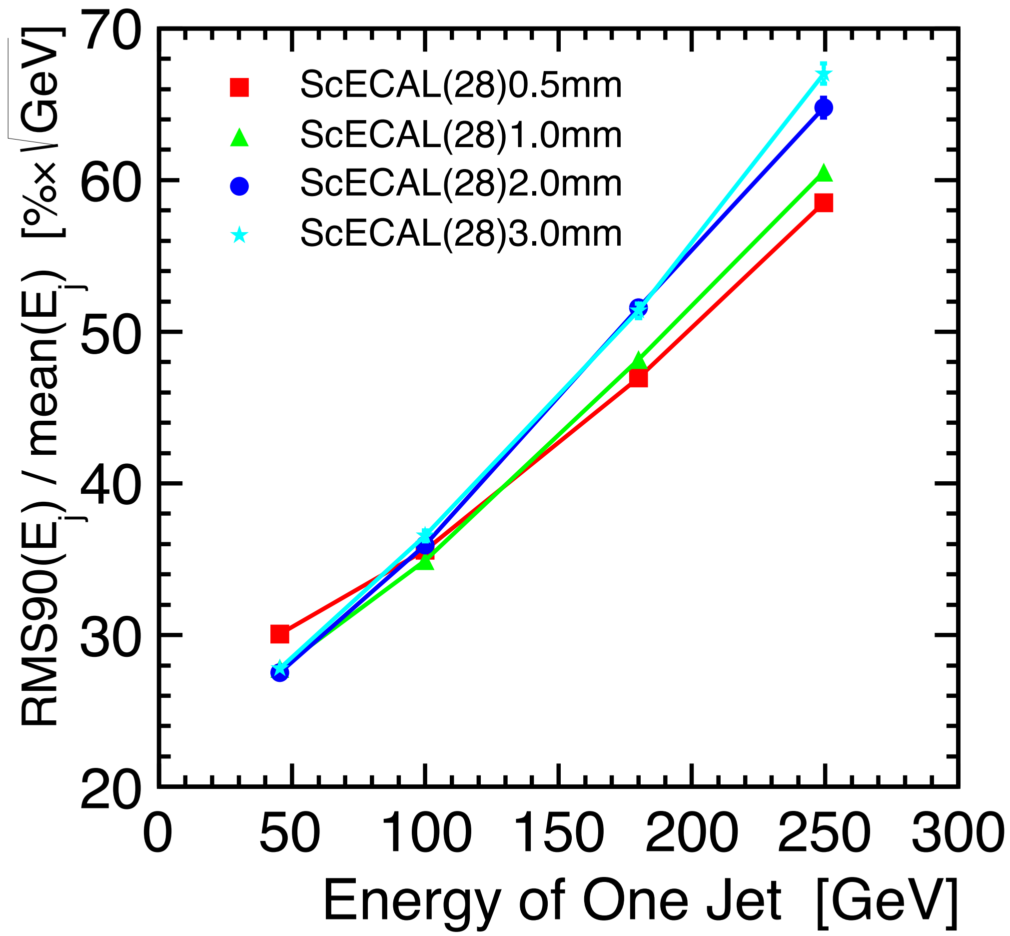
Photon Energy Resolution



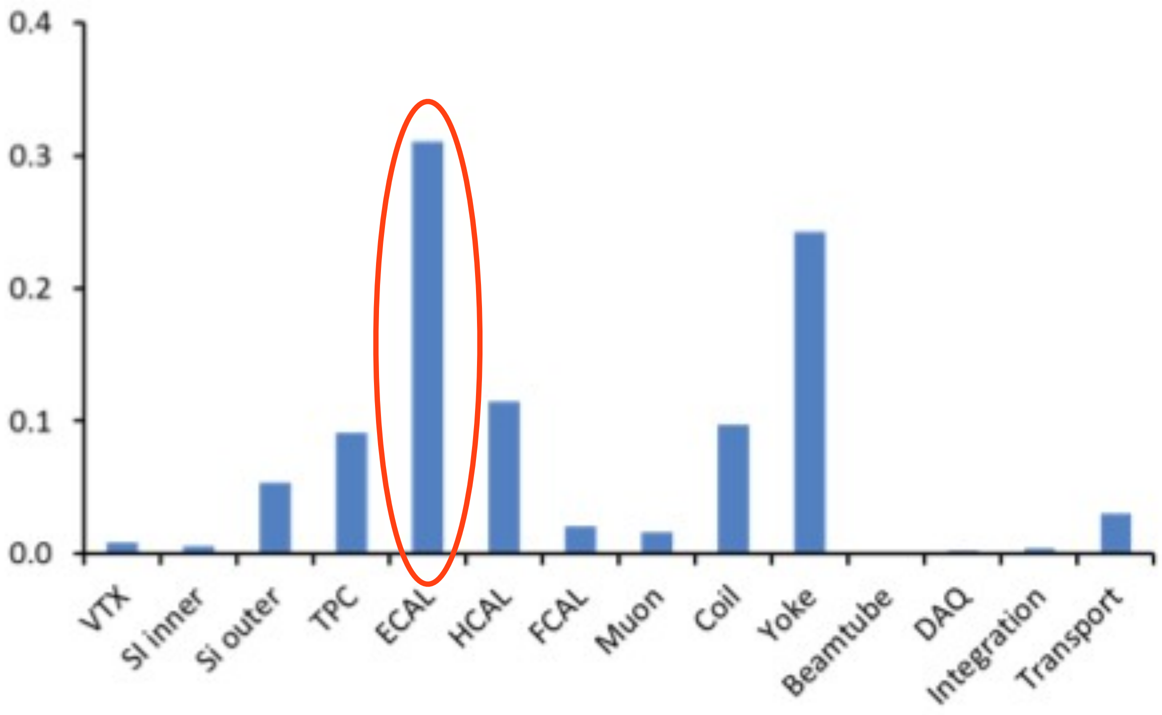
ECAL Performance (photon 1~50GeV)

ScThick	σ stat	σ const
0.5mm	19.04%	2.19%
1.0mm	16.84%	1.71%
2.0mm	15.17%	1.72%
3.0mm	14.26%	1.56%

Jet Energy Resolution



Costing



System	Option	Cost [MILCU]	Mean Cost [MILCU]
Vertex			3.4
Silicon tracking	inner	2.3	2.3
Silicon tracking	outer	21.0	21.0
TPC		35.9	35.9
ECAL			116.9
	SiECAL	157.7	
	ScECAL	74.0	
HCAL			44.9
	AHCAL	44.9	
	SDHCAL	44.8	
FCAL		8.1	8.1
Muon		6.5	6.5
Coil, incl anciliaries		38.0	38.0
Yoke		95.0	95.0
Beamtube		0.5	0.5
Global DAQ		1.1	1.1
Integration		1.5	1.5
Global Transportation		12.0	12.0
Sum ILD			391.8

Hybrid(Si16+Sc14) W2.1x20/3.6x9

Reconstructed Energy