ILD simulation for Sc-ECAL

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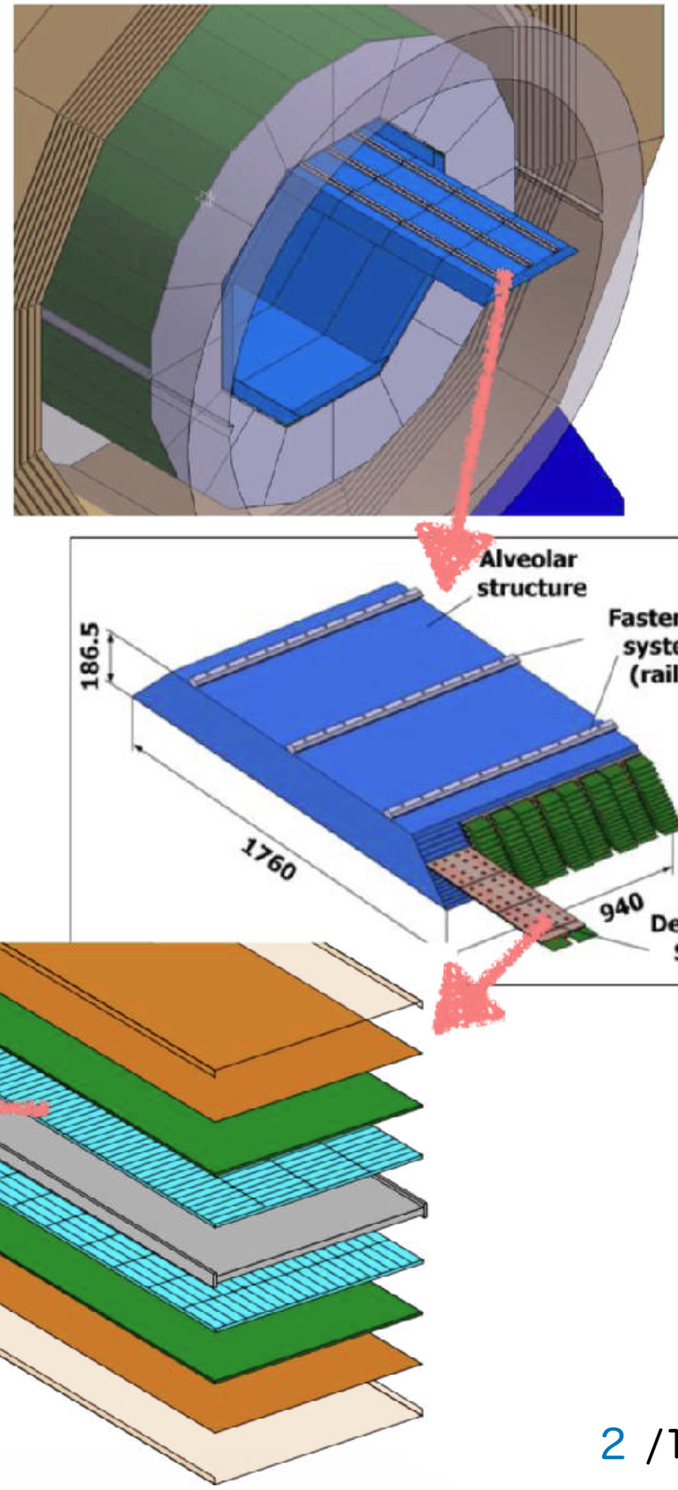
Sc-ECAL

- Scintillator Electromagnetic CALorimeter (Sc-ECAL)
  - Technology option of EM calorimeter for ILC and CEPC
- Based on scintillator strips readout by SiPM
  - 5 × 45 × 2 mm^3 scintillator strip
- Virtual segmentation : 5 × 5 mm^2 with strips in x-y configuration
  - # readout channels significantly reduced ($10^8 \rightarrow 10^7$)
    →Low cost
  - Retaining performance comparable to real 5 × 5 mm^2 segmentation
- Timing resolution < 1 ns



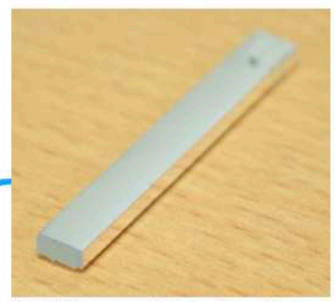
Previous study

- R. Terada done ILD simulation for Sc-ECAL
  - ILD version is old one: v01-19
  - Calibration parameter is different from the latest result
    - 7 MipPe is small
- The objective of this talk is to calibrate the parameters for Sc-ECAL using the latest ILD model
  - Final goal of this study is to evaluate the Sc-ECAL performance with the latest ILD version

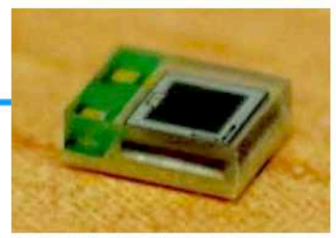
Sensor type	ScECAL	SiECAL
Collection	ECal*ScHits	ECal*SiHits
CaloDigi	RealisticCaloDigiScinPpd	RealisticCaloDigiSilicon
ppd_mipPe (p.e)	7	-
ppd_npix (pixel)	10,000	
calibration_mip (GeV)	0.0002407 (at Barrel) 0.0002472 (at Endcaps)	0.0001575
calibration_factorsMipGev	0.006729 (at Barrel) 0.007256 (at Endcaps)	0.00641222630095

Device parameters

Calibration Data



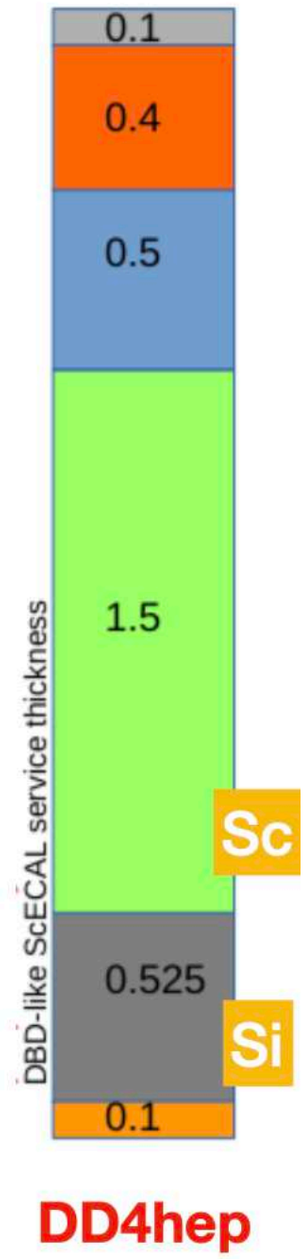
Scintillator (45 x 5 x 2 mm²)



MPPC (10k pixel)

Simulation Parameter

- DD4hep
  - Both Sc and Si sensor
  - Compare two models with same events
- ILD version: v02-01
- Detector model: ILD_l5_03_v02
- Use default Pandora PFA parameters

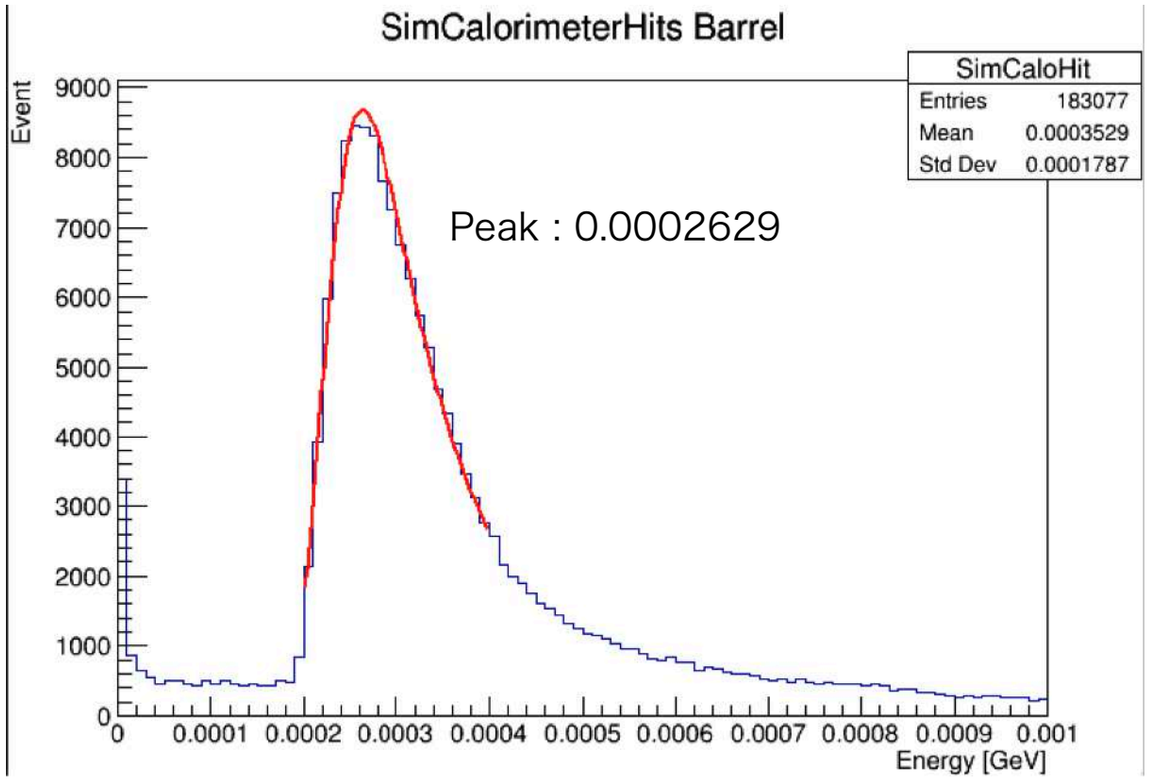


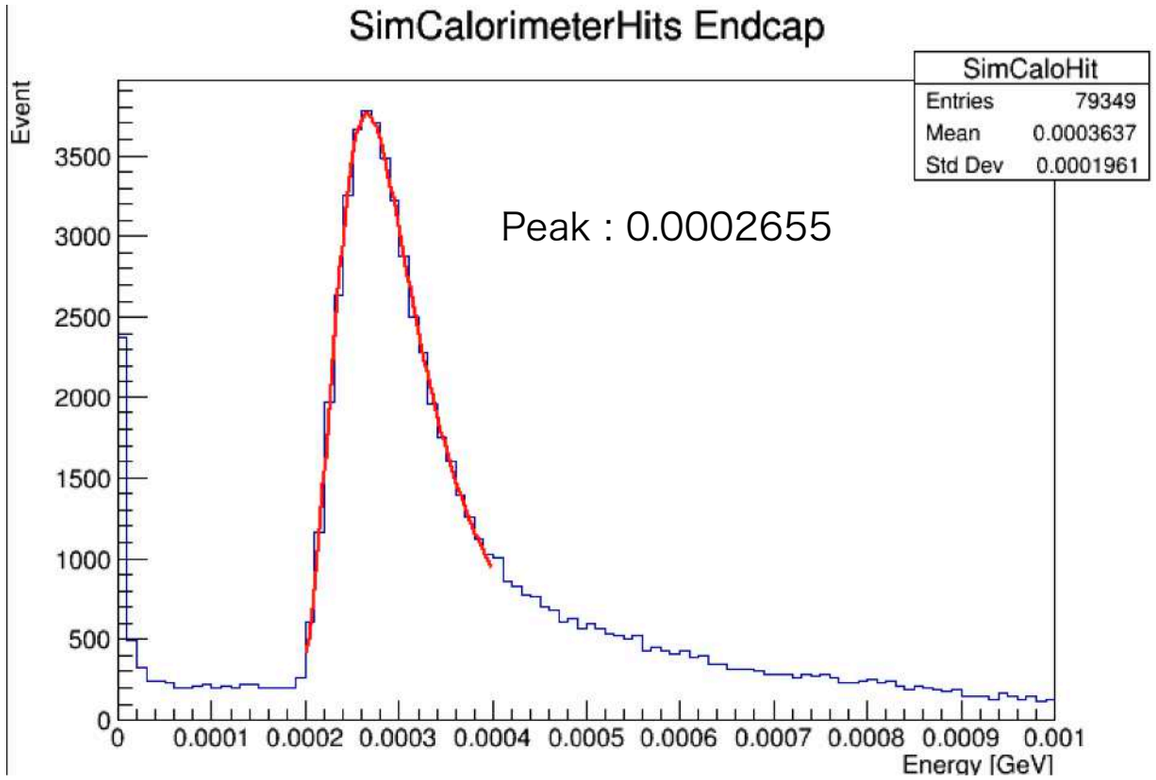
- Calibration parameters decided as below at new ILD model

ppd_mipPe (p.e.)	10
ppd_npix (pixel)	10000
EcalBarrel/EndcapMip	0.0002629 0.0002655
EcalBarrel/ EndcapEnergyFactors	0.00758 0.01515 0.00810 0.01619
PandoraEcalToEMScale	1.031

MIP calibration

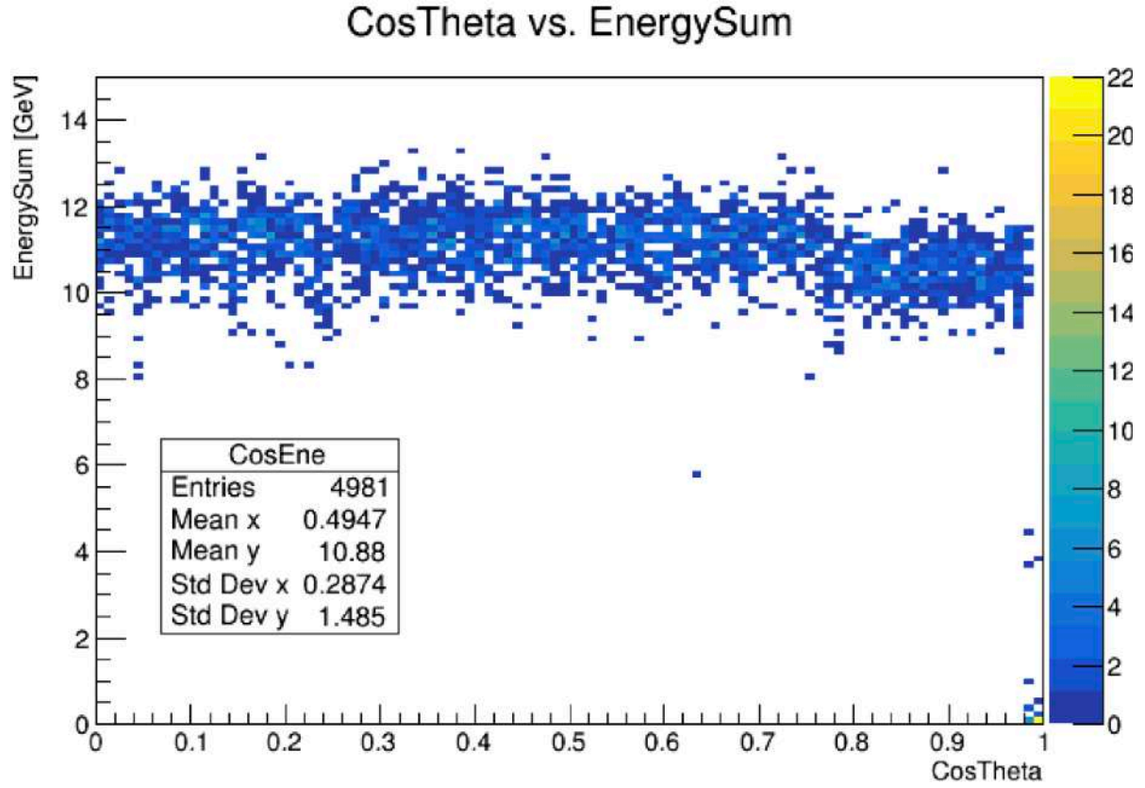
- EcalBarrel/EndcapMip calibration done
  - Data: 10 GeV muon
  - Collection: EcalBarrel/EndcapCollection
  - Fit: langaus function
- The peak of hit energy is the value of MipPe.
- Independent calibration with barrel and endcap

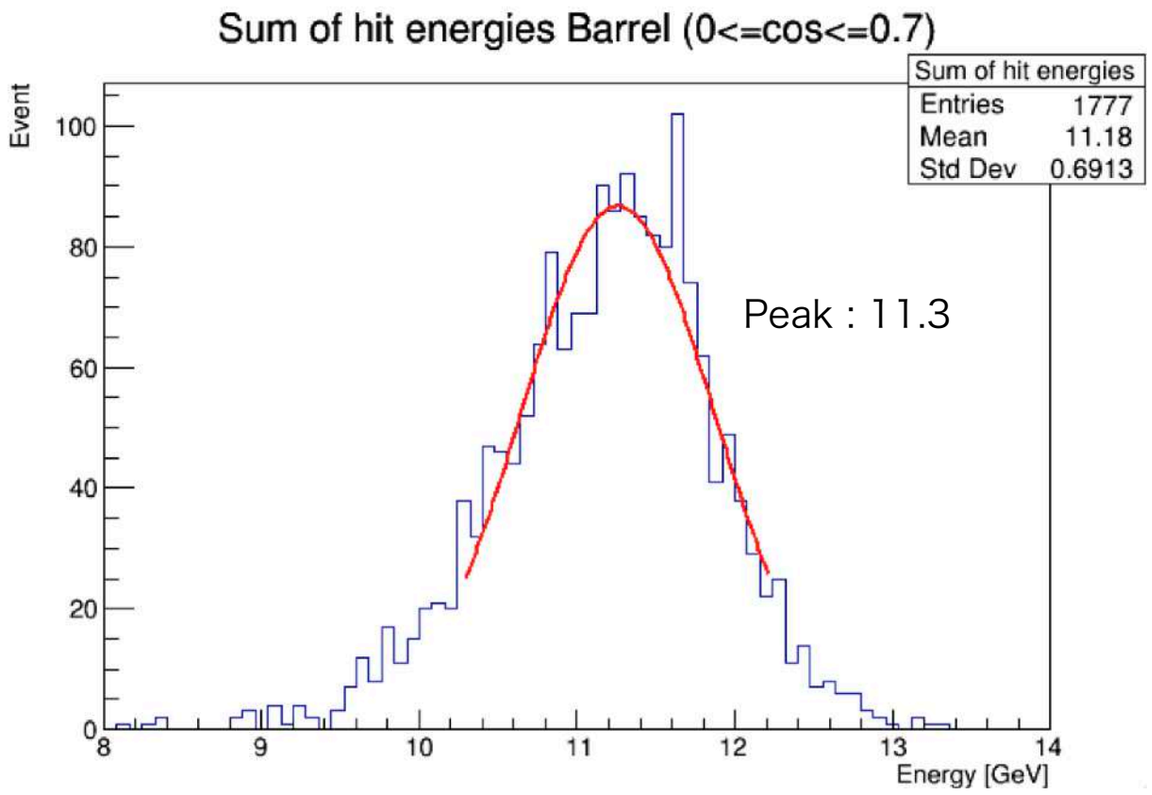


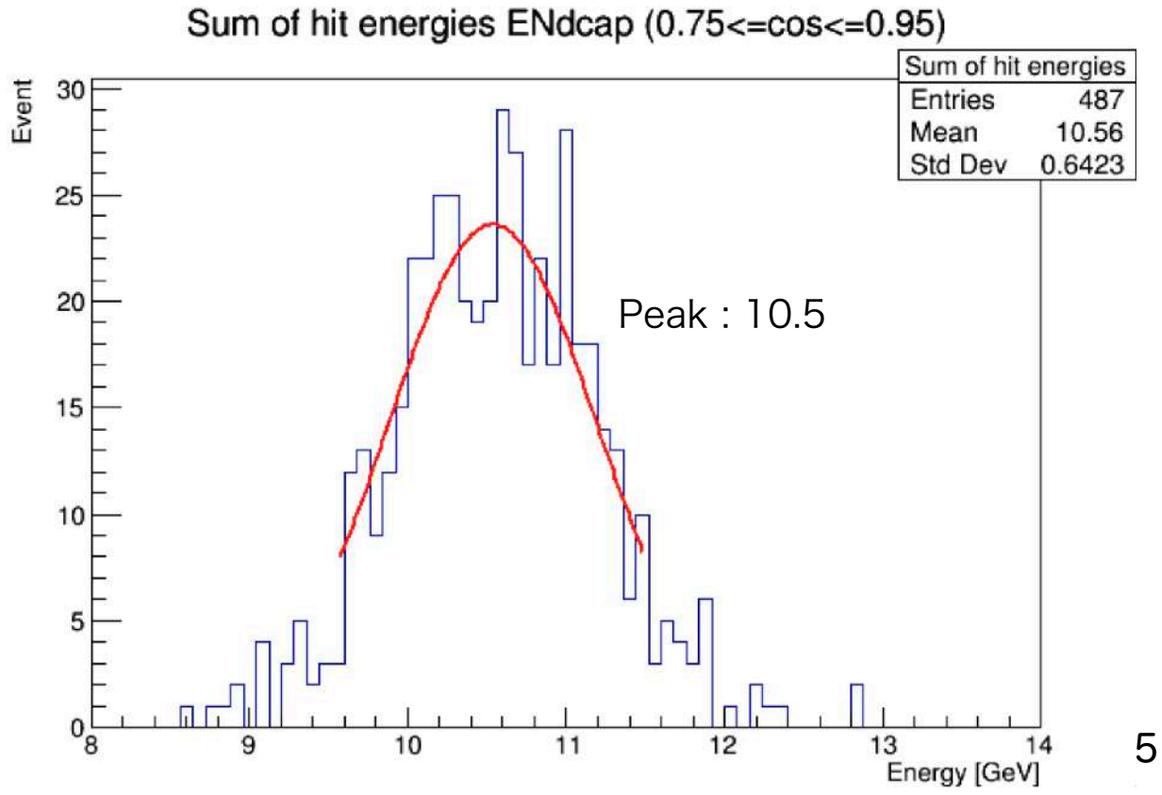


Energy Factors calibration

- Energy factors calibration done
  - Data: 10 GeV gamma
  - Collection: MCParticle, EcalBarrel/EndcapCollectionRec
  - Fit: gaussian
    - Range: ±1.5 × sigma
- Multiply the factors by 10/peak

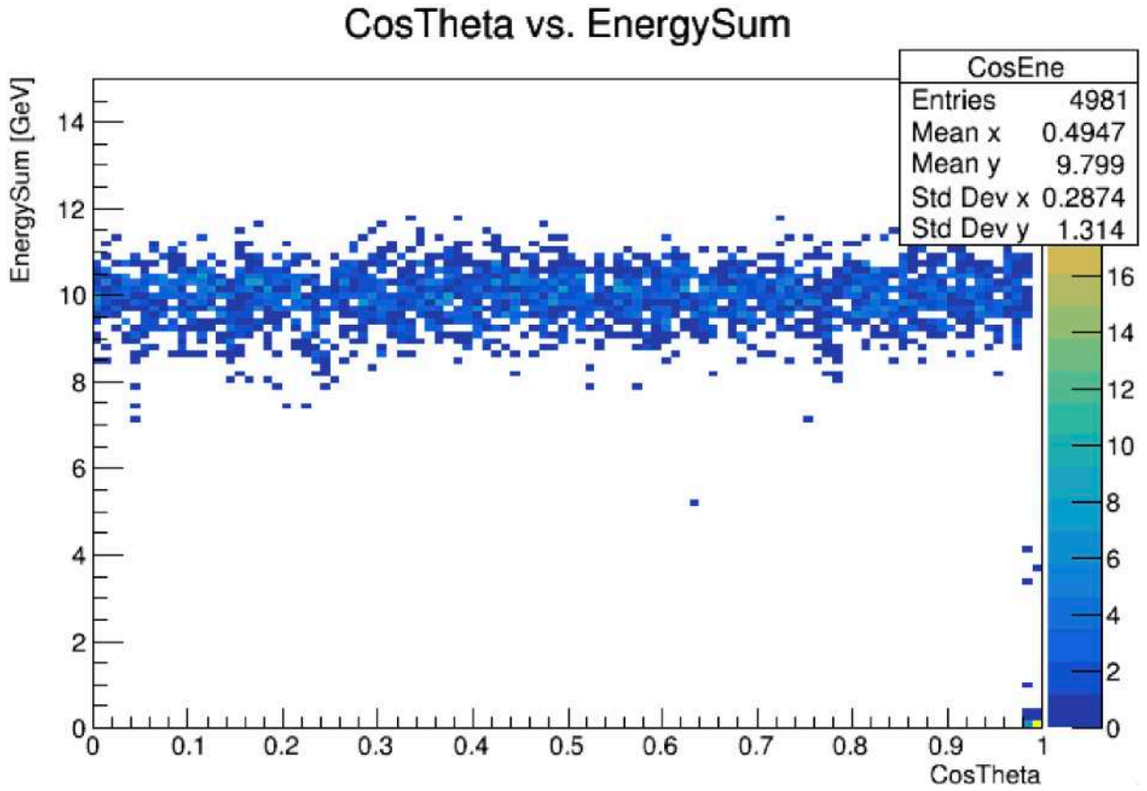


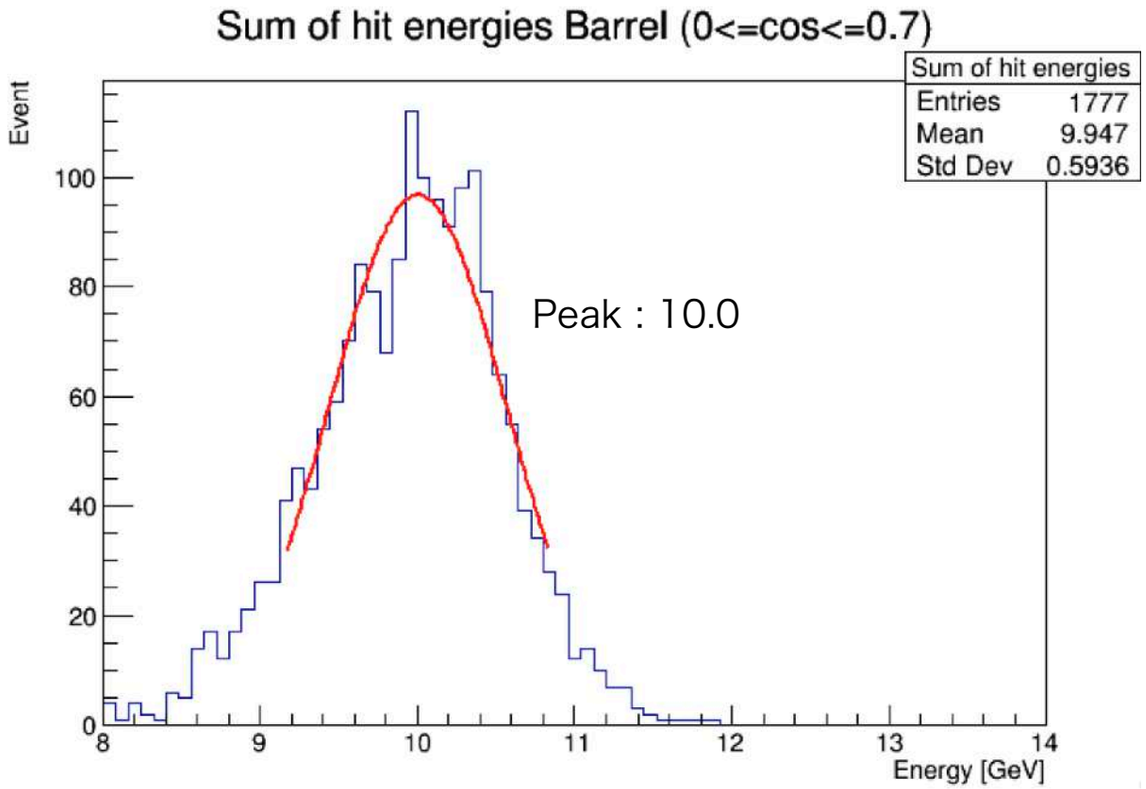


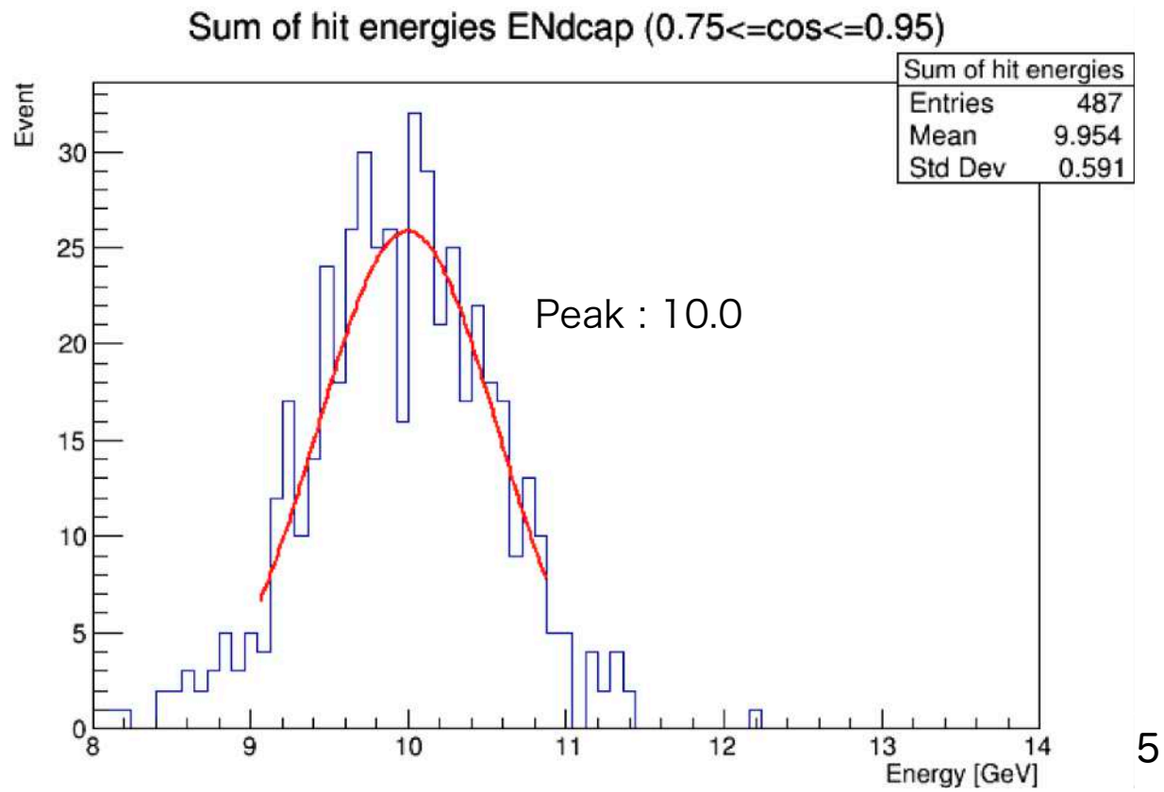


Energy Factors calibration

- Sum of hit energies are located 10 GeV accurately
  - Both at barrel and endcap

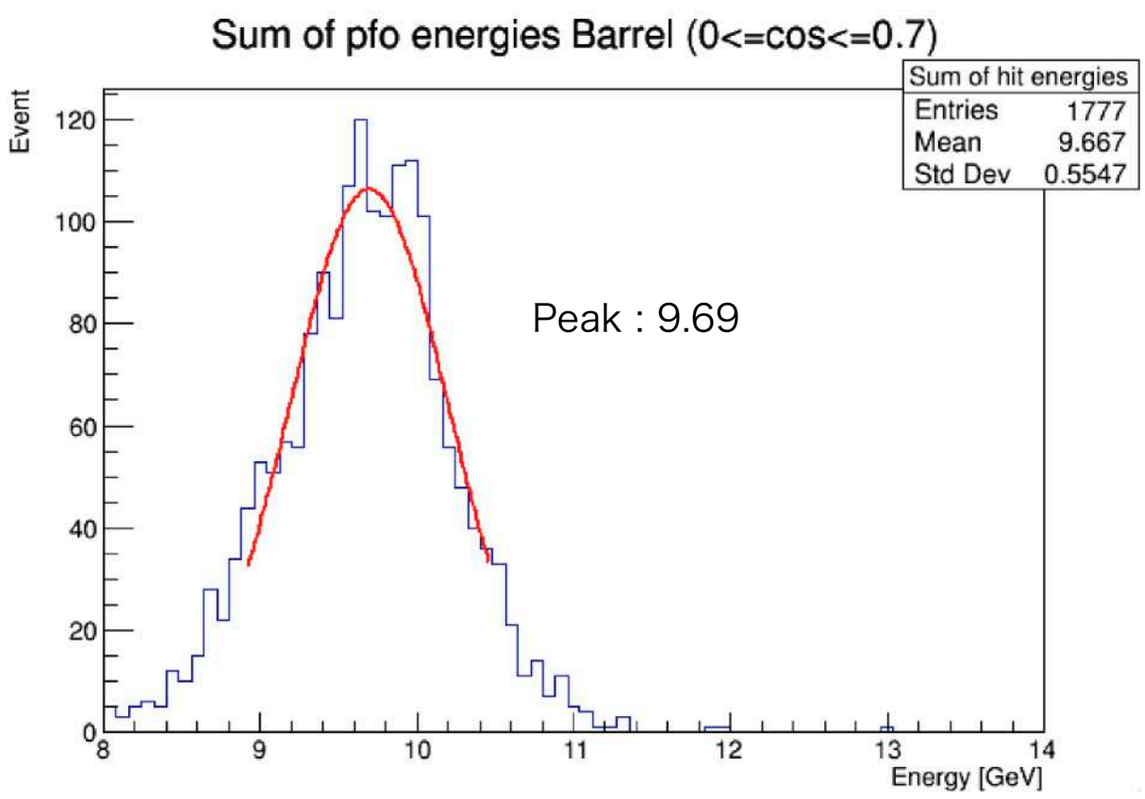


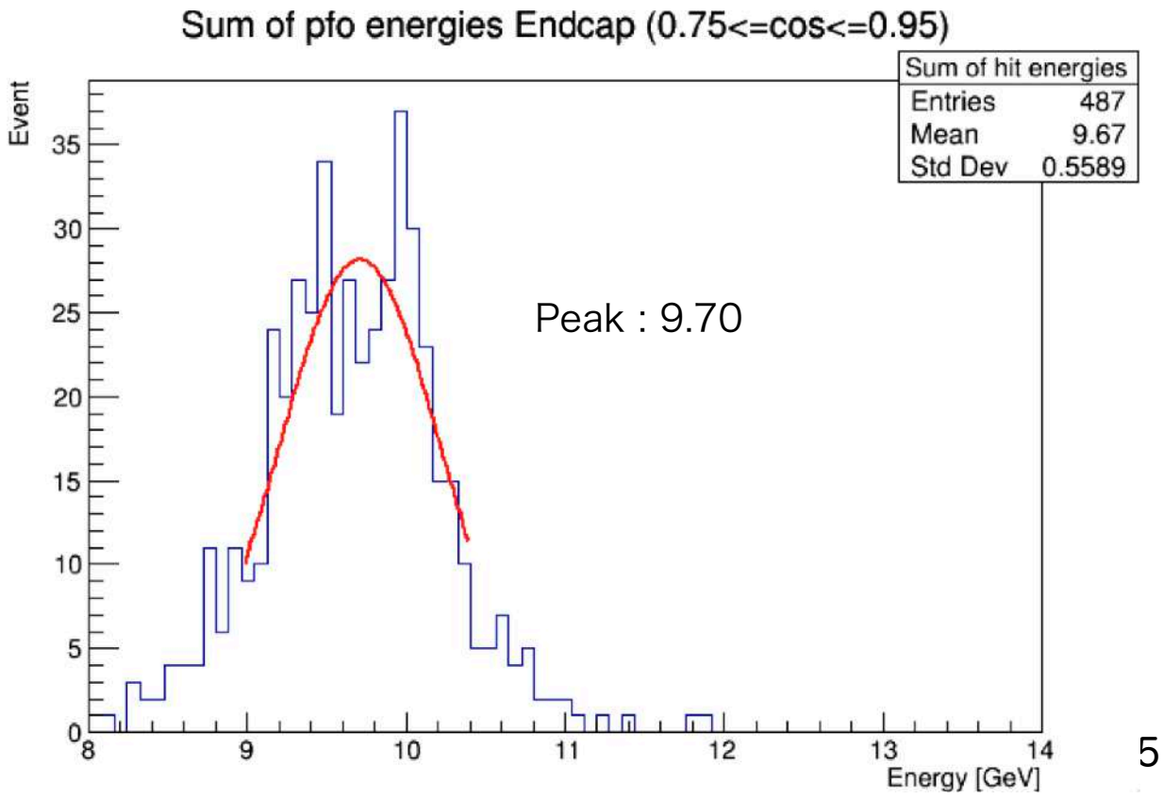




EM scale calibration

- PandoraEcalToEMScale calibration done
  - Data: 10 GeV gamma
  - Collection: MCParticle, PandoraPFOs
  - Fit: gaussian
    - Range: ±1.5 × sigma
- Multiply the factors by 10/peak

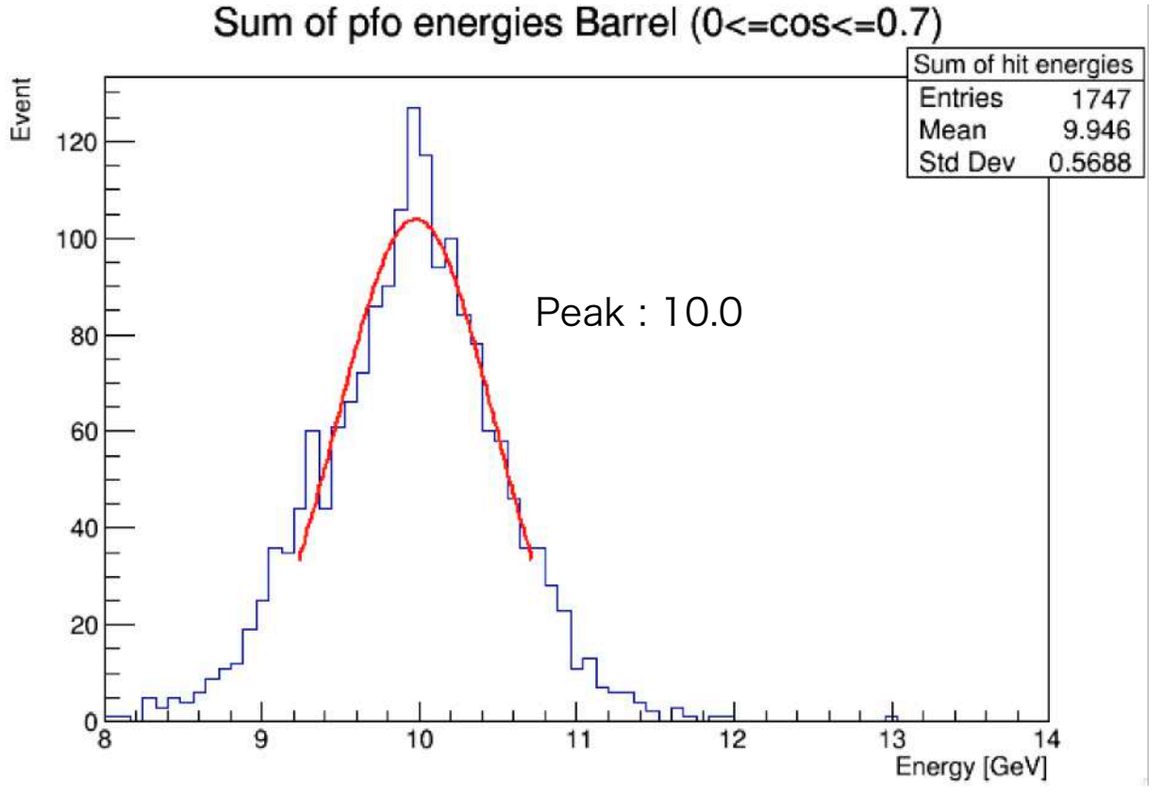


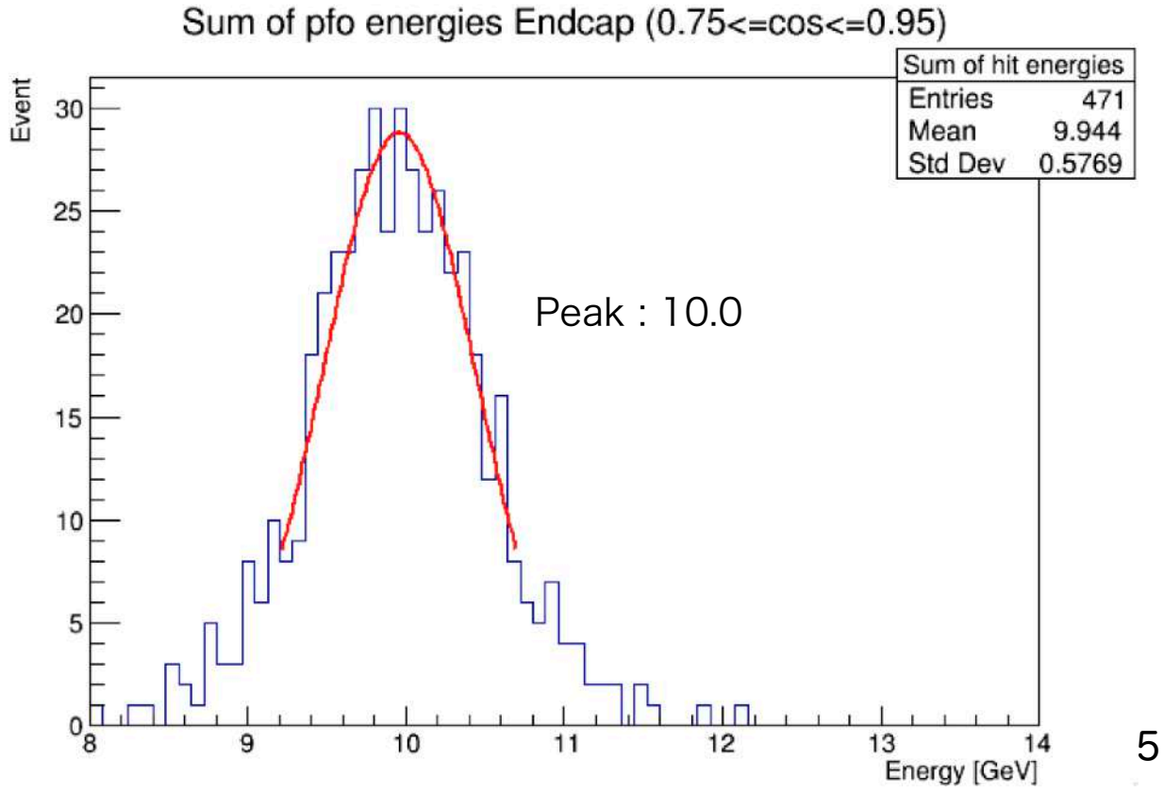


EM scale calibration

- Sum of PFO energies are located 10 GeV
  - Both at barrel and endcap
- Calibration completed

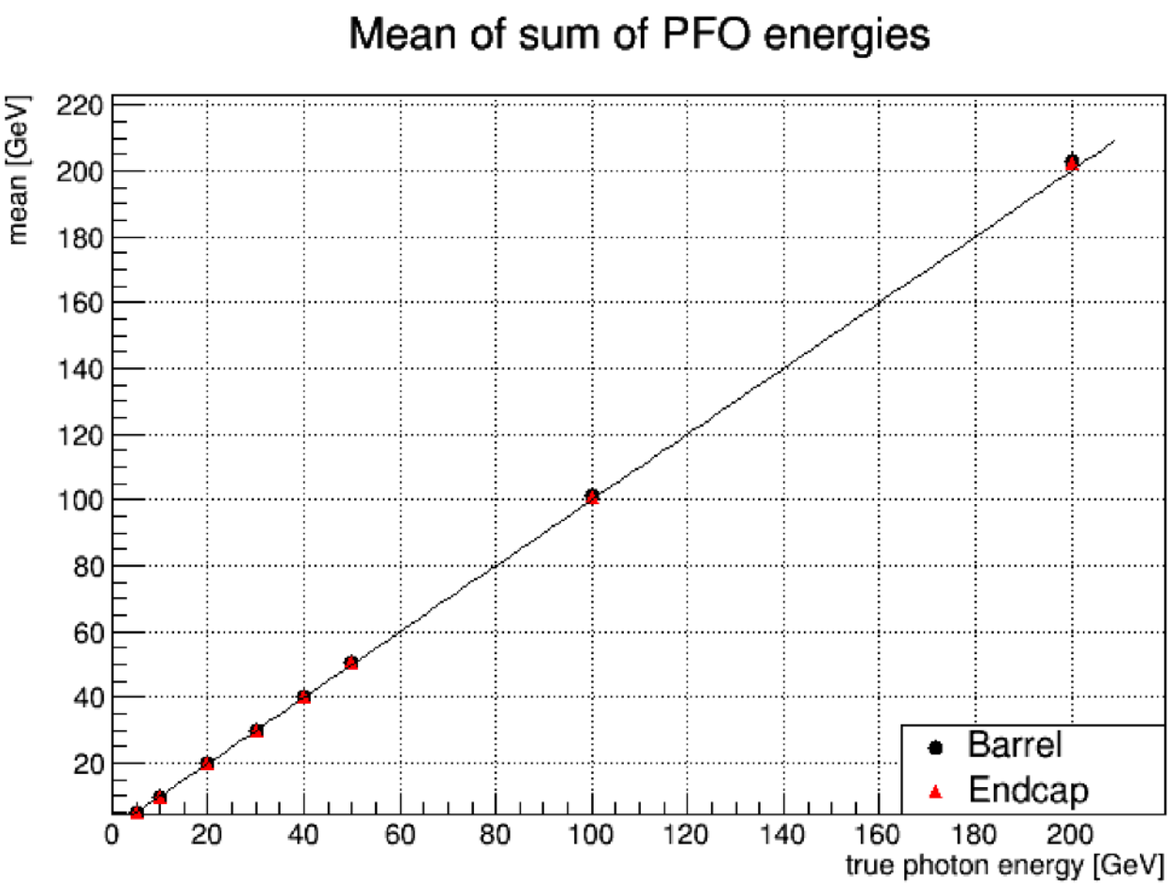
ppd_mipPe (p.e.)	10	
ppd_npix (pixel)	10000	
EcalBarrel/EndcapMip	0.0002629	0.0002655
EcalBarrel/ EndcapEnergyFactors	0.00758	0.01515
	0.00810	0.01619
PandoraEcalToEMScale	1.031	

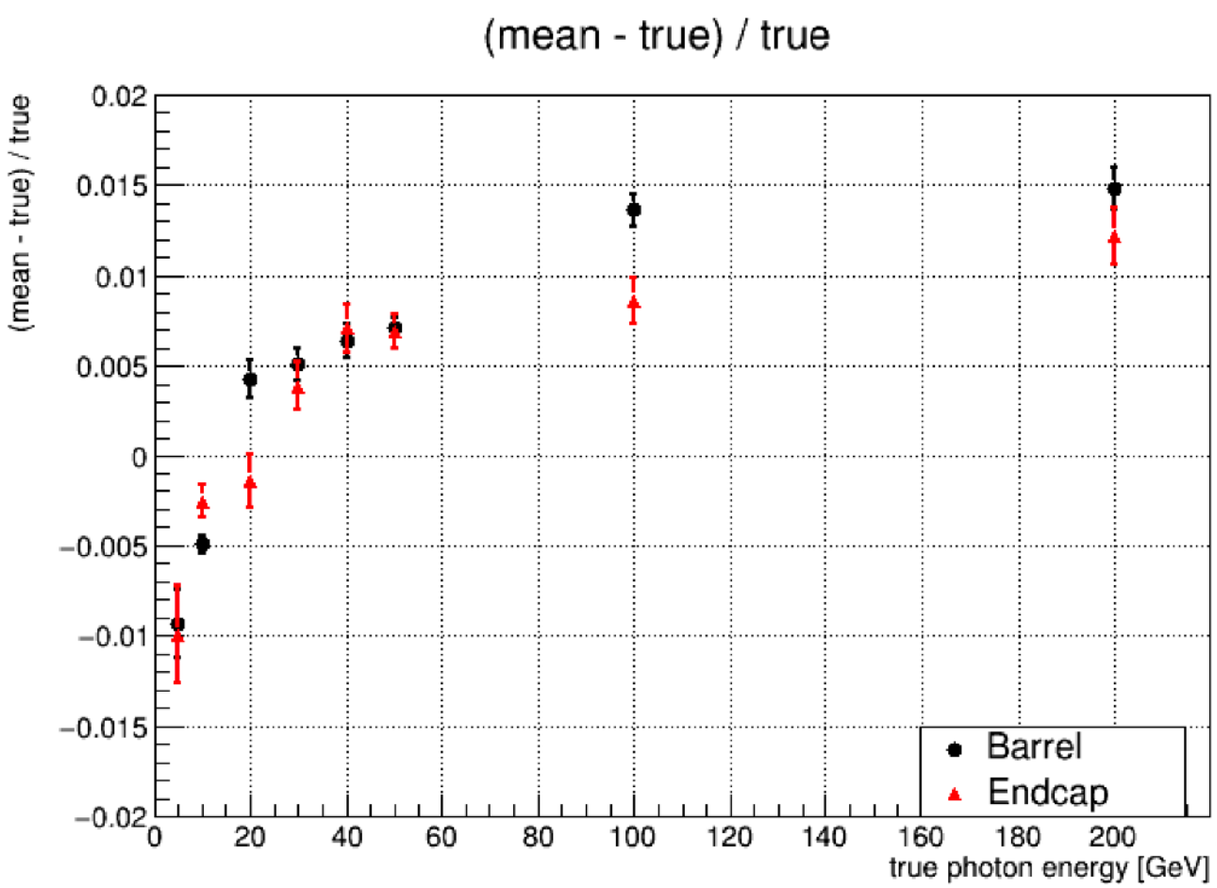




Energy linearity

- Injection gamma at different energies
  - 5, 10, 20, 30, 40, 50, 100, 200 GeV
  - Check the peak of PFO energy
- Energy linearity is good
  - A bit shift to large at the large energy injection
  - Gap filter for Si-ECAL is implemented, but not working properly



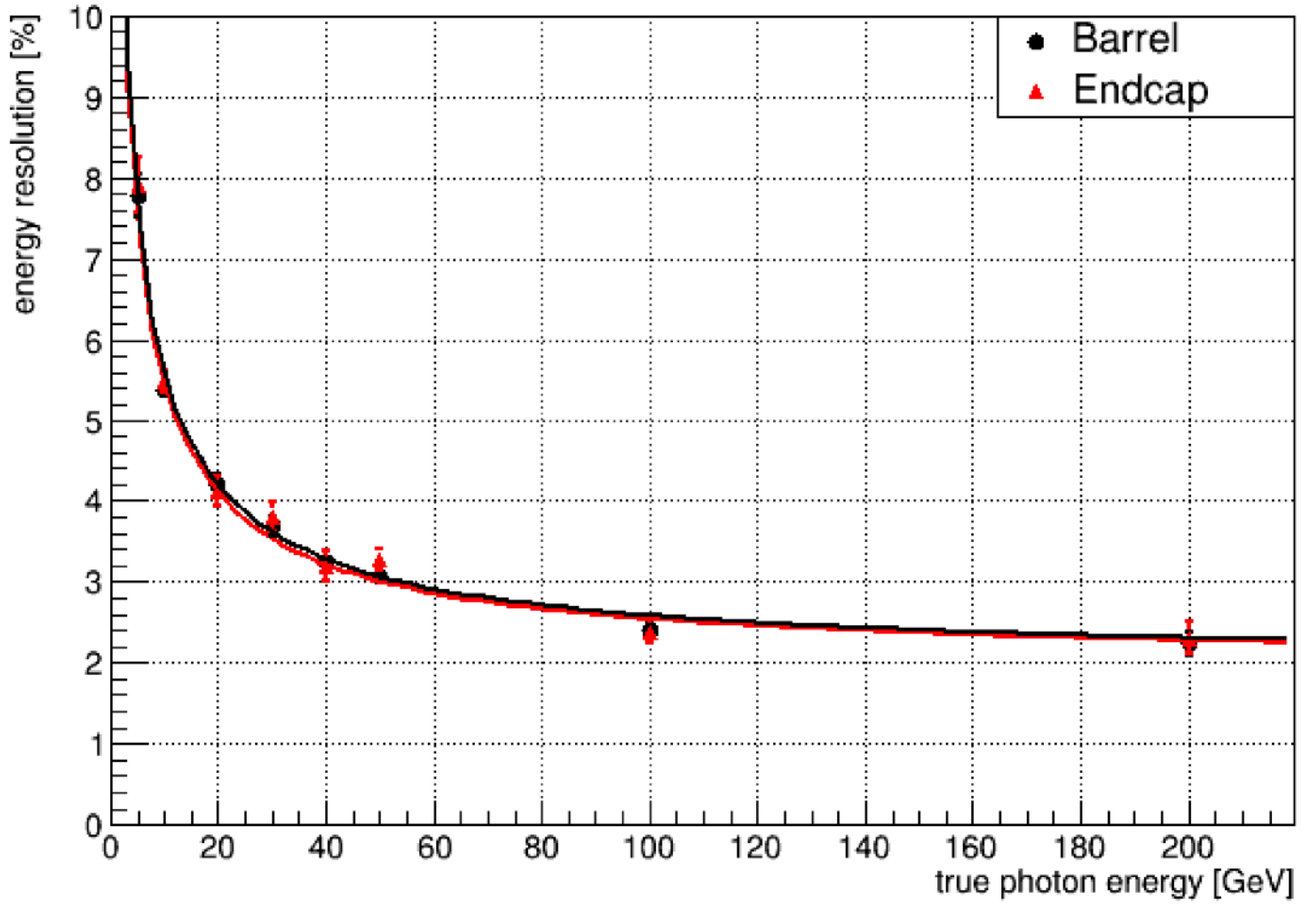


Energy resolution

- Energy resolution is calculated using PFO
  - Fit : $(\frac{\sigma_E}{E})^2 = (\frac{a}{\sqrt{E}})^2 + (b)^2$
- 16% resolution achieved
  - Reasonable result for Sc-ECAL
  - Comparison with Si-ECAL will be done

	Barrel	Endcap
Stochastic a	16.1	16.5
Constant b	1.97	1.99

energy resolution vs. true photon energy



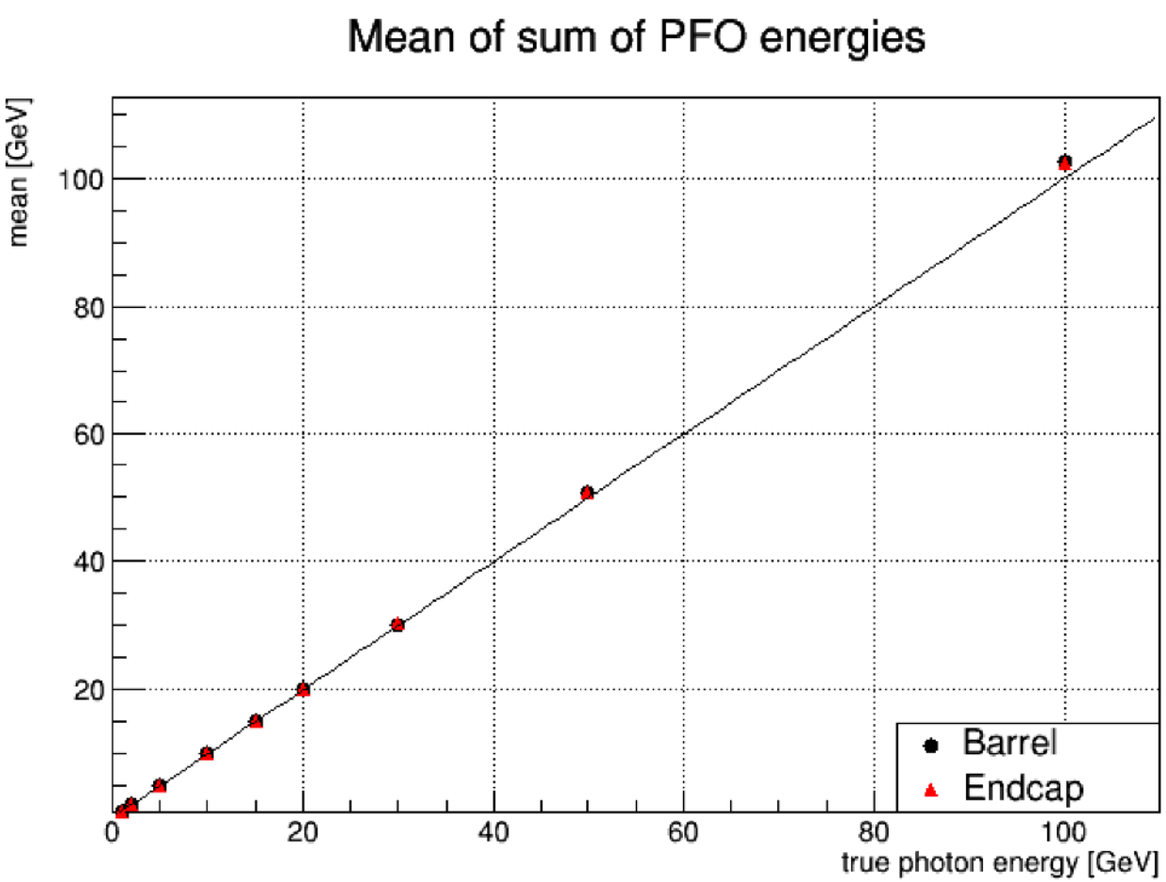
New sample with v02-01-02

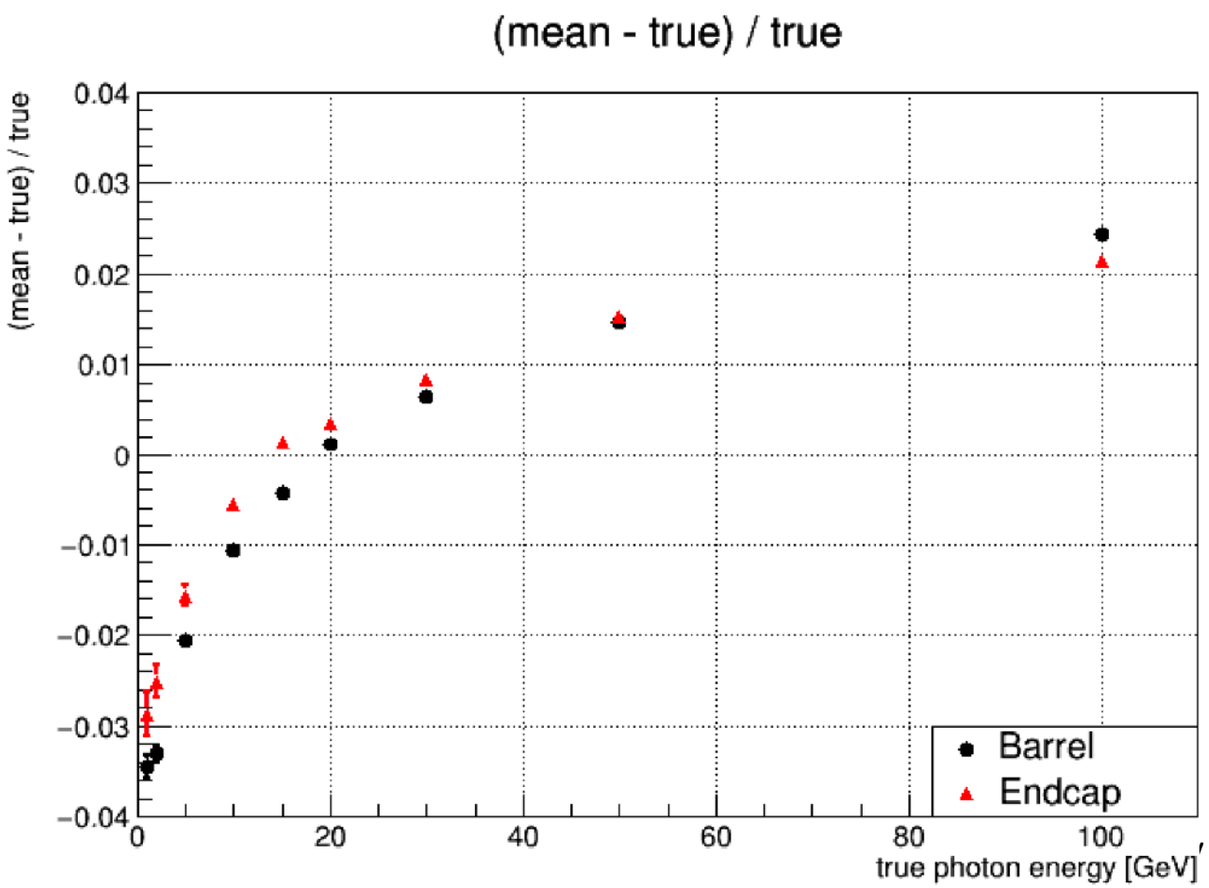
- New test production sample with ILCSoft v02-01-02
  - Created by H. Ono, A. Miyamoto
- Detector model
  - ILD_l5_o1_v02 (AHCAL + Si-ECAL)
  - ILD_l5_o3_v02 (AHCAL + Sc-ECAL)
- Contents at ILD_l5_o3_v02:
  - Single muon and single photons
  - 2f-JER (di-samples)

- Check the performance of single photon event
  - Energy linearity
  - Energy resolution

Energy linearity with new sample

- The linearity is a bit worse compared to previous sample
  - Gap filter not implemented
  - Now preparing gap filter for Sc-ECAL

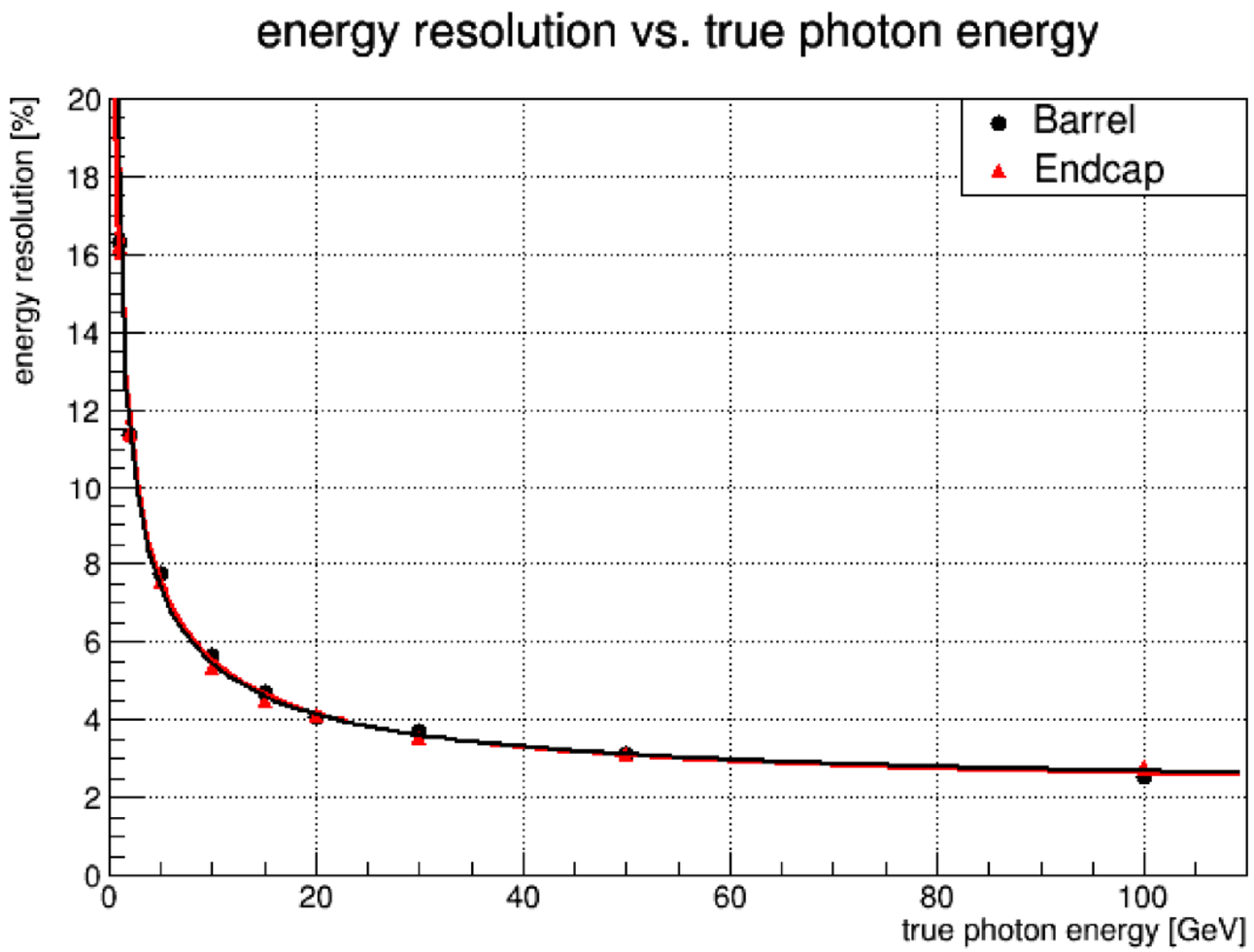




Energy resolution with new sample

- 16% resolution with 2% constant
  - Almost the same as the previous sample

	Barrel	Endcap
Stochastic a	16.3	15.8
Constant b	2.05	2.16

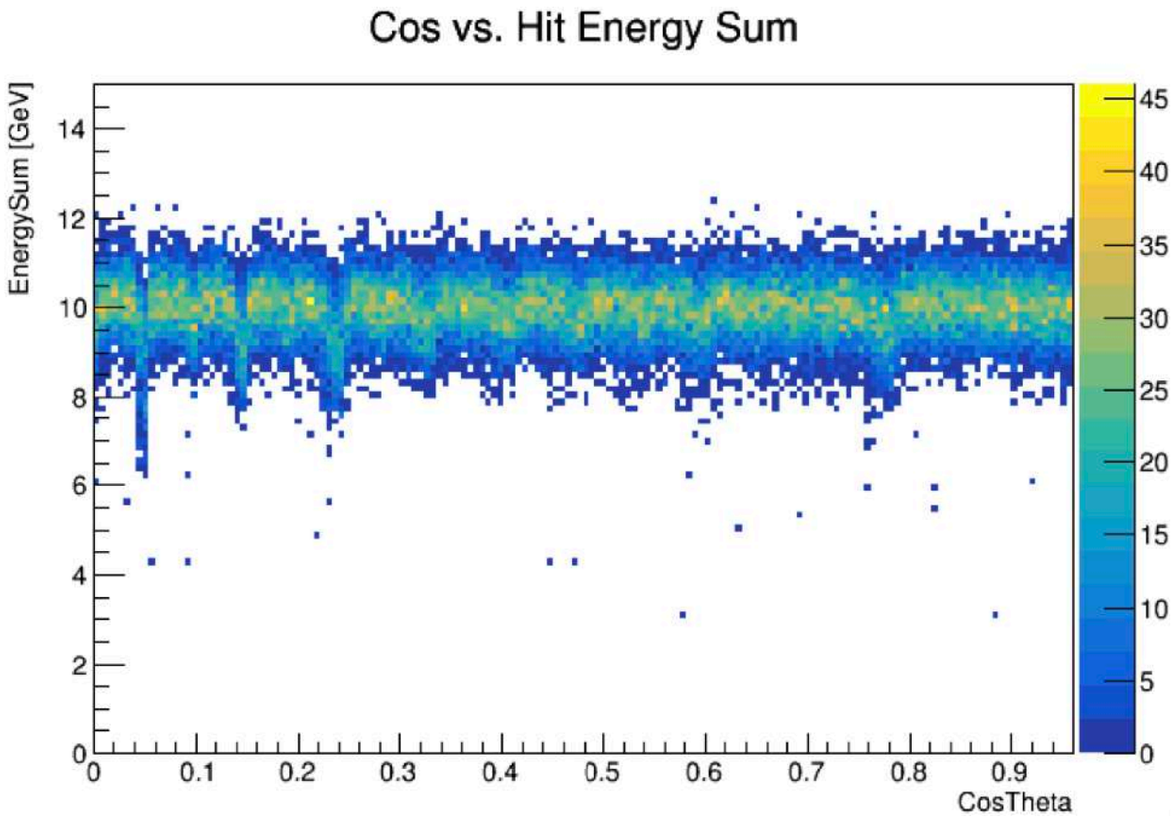


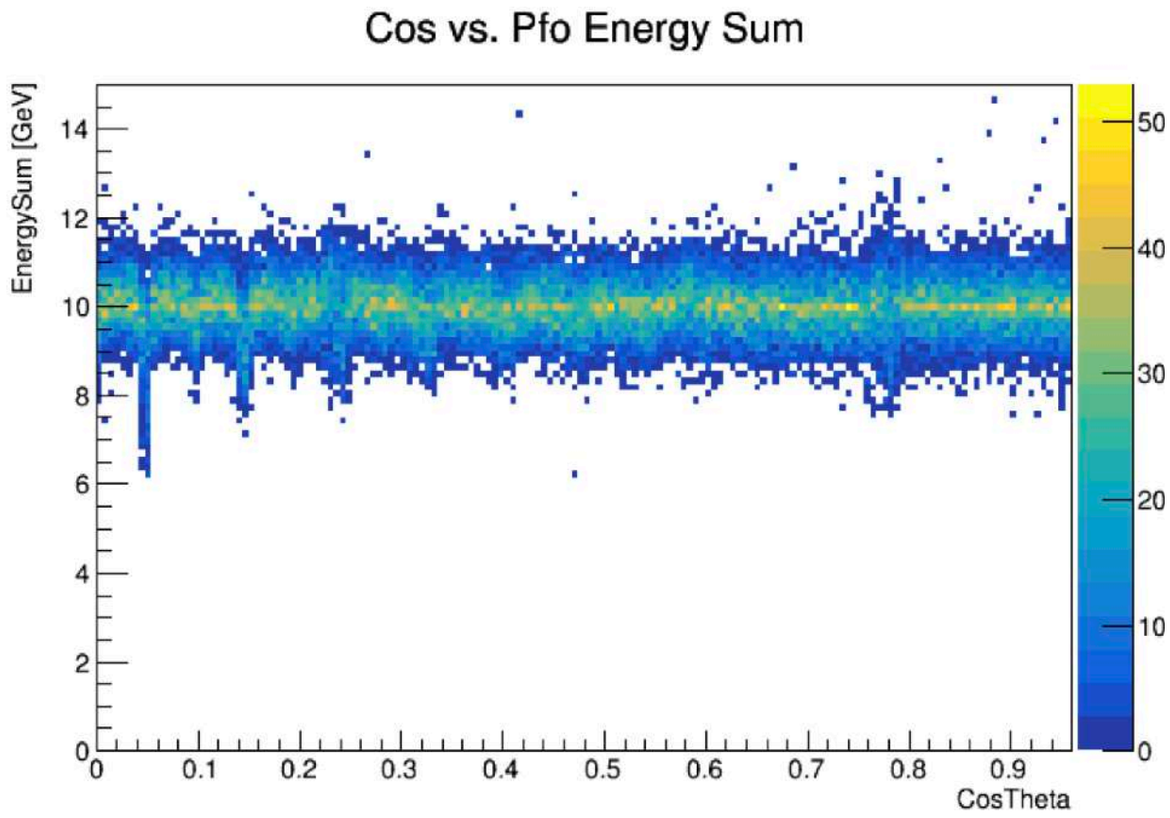
Summary and prospects

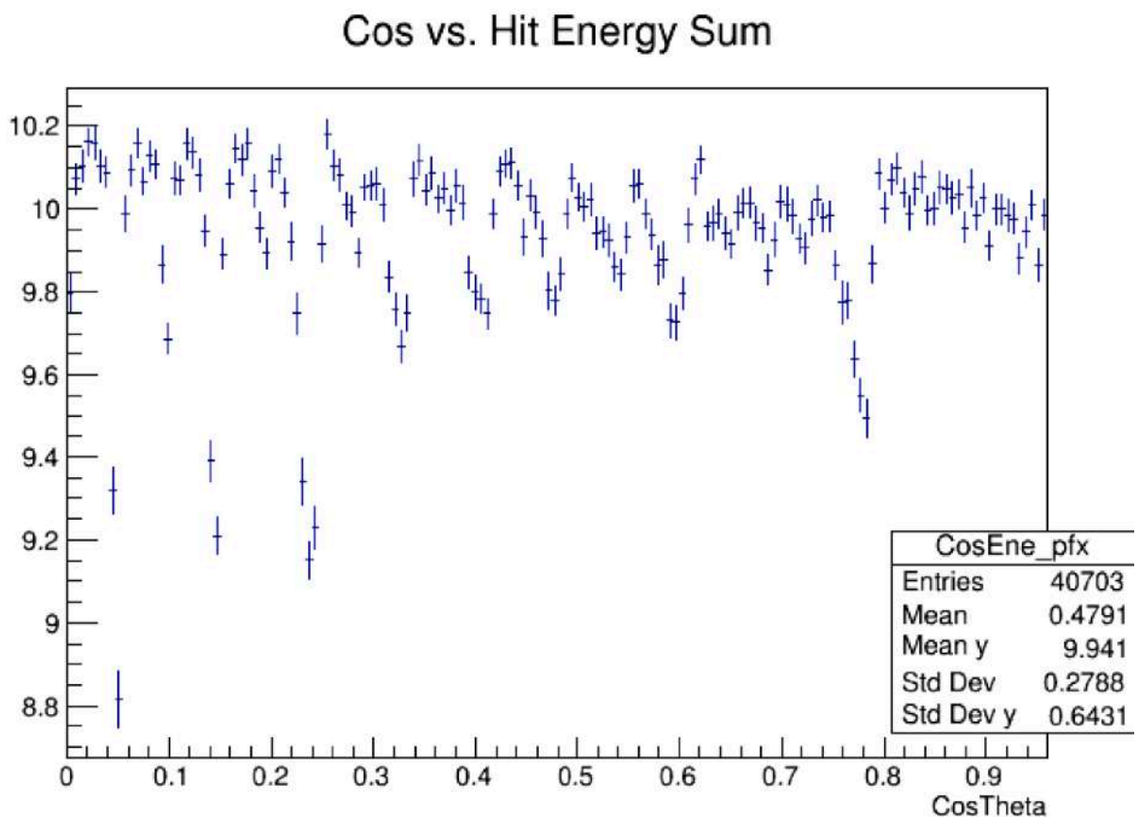
- ILD simulation for Sc-ECAL
  - Parameter calibration for Sc-ECAL with new detector model
- Calibration completed
  - MIP, energy factors, EM scale
  - Energy linearity is good
    - Gap filter for Sc-ECAL is needed
  - Energy resolution is reasonable

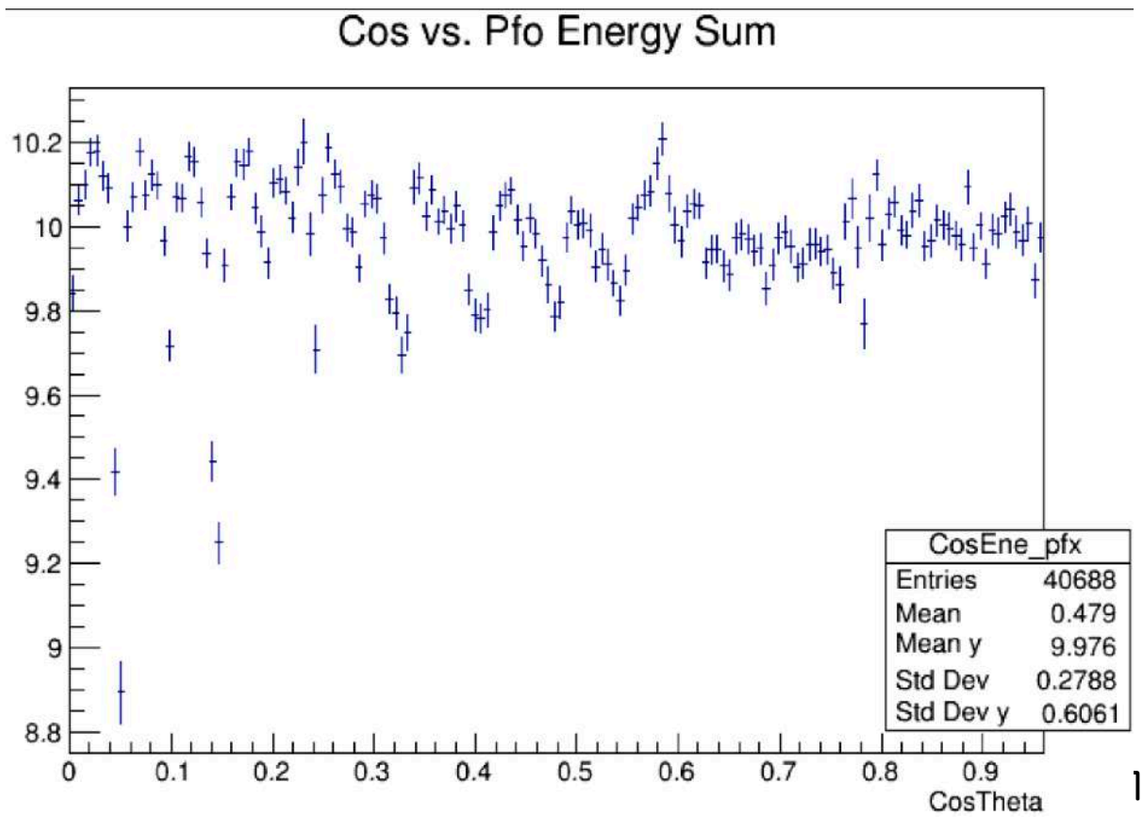
- Preparing the gap filter for Sc-ECAL
  - Set different parameters according to x-y strip orientation
- Evaluate the saturation effect
  - Apply real saturation curve measured by UV laser
    - See my talk about saturation study at the CALICE meeting last year
  - Preparing new setup for more accurate measurement
- Evaluate the performance of jet sample

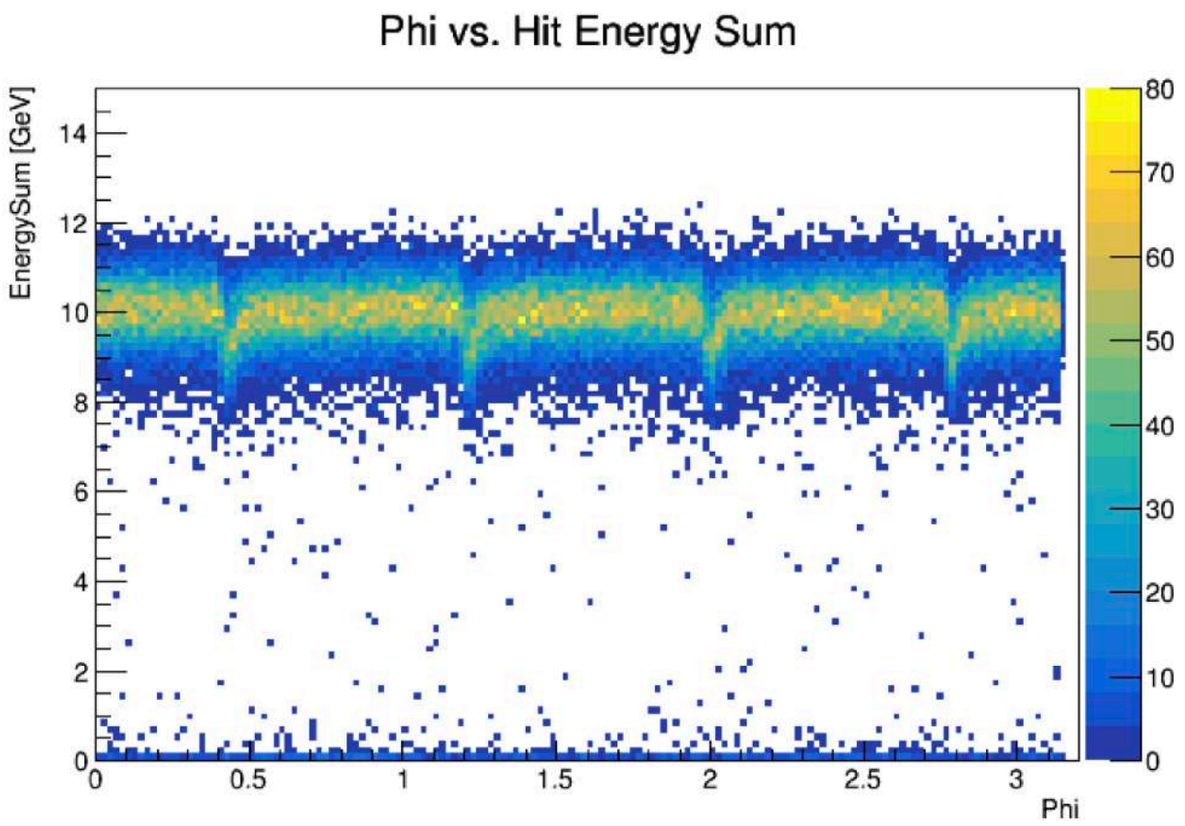
Backup

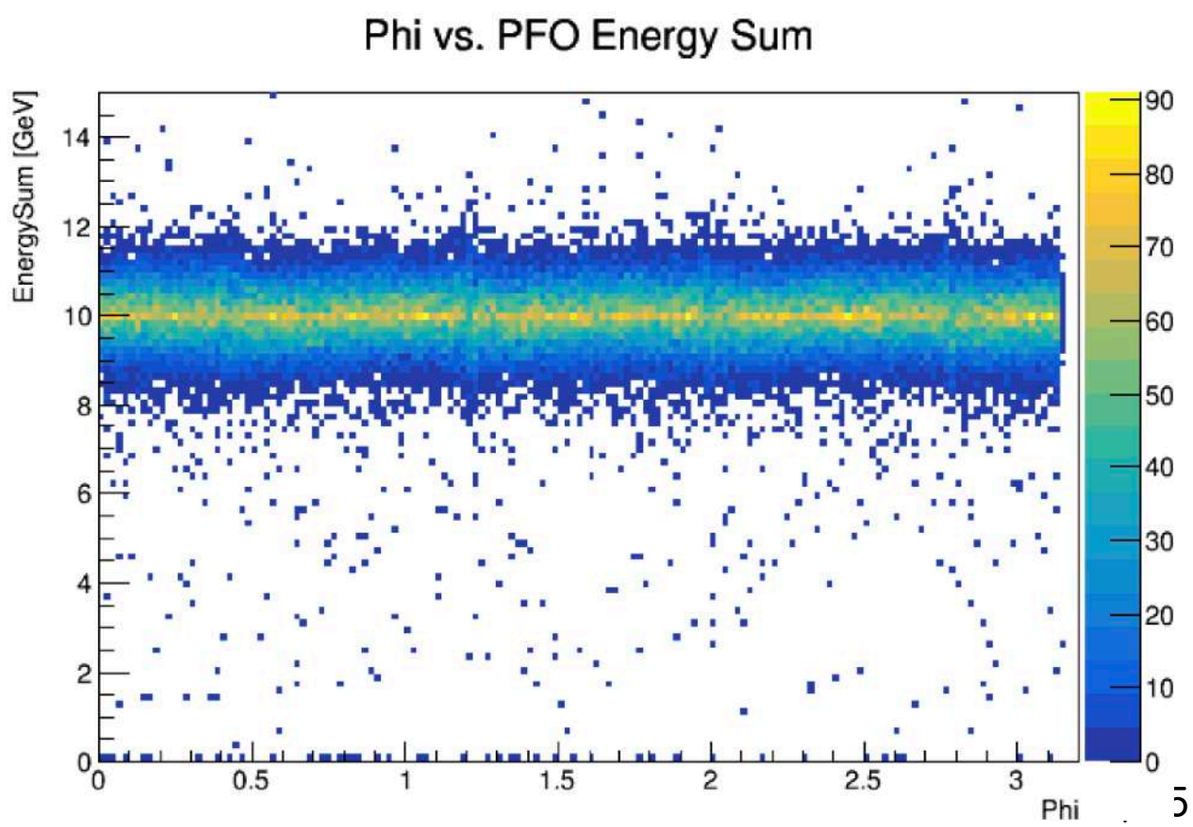

Cos vs. Hit Energy Sum
EnergySum [GeV]
CosTheta


Cos vs. Pfo Energy Sum
EnergySum [GeV]
CosTheta


Cos vs. Hit Energy Sum
CosEne_pfx
Entries 40703
Mean 0.4791
Mean y 9.941
Std Dev 0.2788
Std Dev y 0.6431
CosTheta


Cos vs. Pfo Energy Sum
CosEne_pfx
Entries 40688
Mean 0.479
Mean y 9.976
Std Dev 0.2788
Std Dev y 0.6061
CosTheta


Phi vs. Hit Energy Sum
EnergySum [GeV]
Phi
0
2
4
6
8
10
12
14
0.5
1
1.5
2
2.5
3
80
70
60
50
40
30
20
10
0


Phi vs. PFO Energy Sum
EnergySum [GeV]
Phi
0
2
4
6
8
10
12
14
0.5
1
1.5
2
2.5
3
90
80
70
60
50
40
30
20
10
0