

次世代電子陽電子コライダー用 高精細シンチレータカロリメータの大型試作機の ビーム試験による性能評価

東京大学 M1 高津大誠

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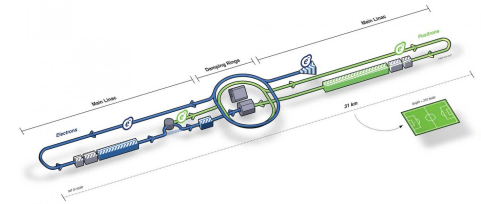
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- **Introduction**
 - Motivation
 - PFA
 - Sc-ECAL technological prototype
 - AHCAL technological prototype
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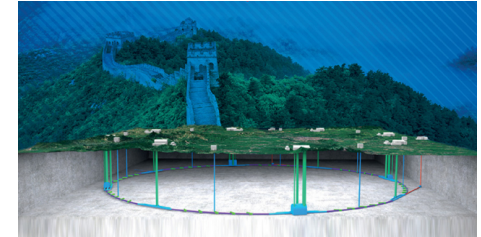
Motivation

- **The necessity of a Higgs factory**
 - Completeness and Verification of the Standard Model
 - Exploration of New Physics
- **Proposed Higgs Particle Measurement at $e^+ e^-$ Colliders**
 - International Linear Collider (ILC)
 - Circular Electron Positron Collider (CEPC)
 - Etc..
- **Requirement**
 - A high granularity calorimeter
- **Our study**
 - Performance analysis of the large prototype beam test experiment for a high granularity scintillator calorimeter

ILC in Japan



CEPC in China

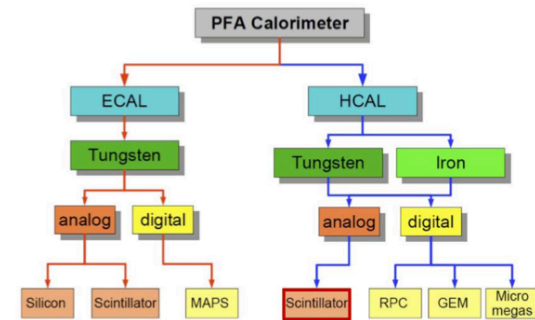
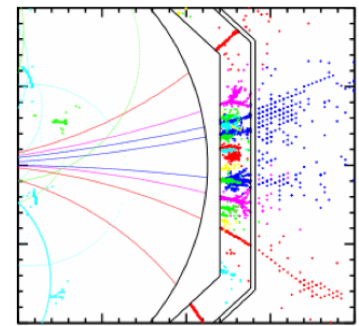


FCC at CERN

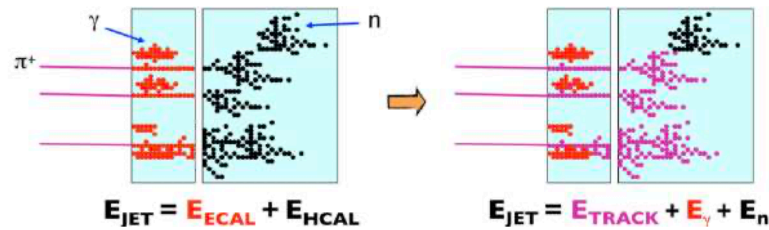


Particle Flow Calorimetry

- **Particle Flow Algorithm (PFA)**
 - Choose sub-detector best suited for each particle type
 - Reduce the role of hadron calorimetry for energy measurements
 - Require good separation power of close-by particles in calorimeters to match with tracker
- **High-granularity calorimetry for PFA**
 - Hardware challenge: readout channels on the order of 10~100 million
 - Integration challenges: compact (fully inside coil), hermetic, limited space for instrumentation



→ A high granularity calorimeter is required



ECAL (Electromagnetic Calorimeter)

- **Sc-ECAL (Scintillator-based Electromagnetic Calorimeter)**

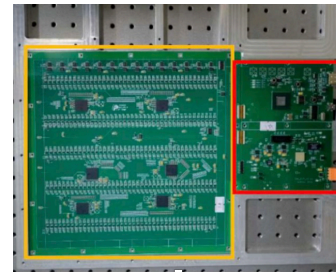
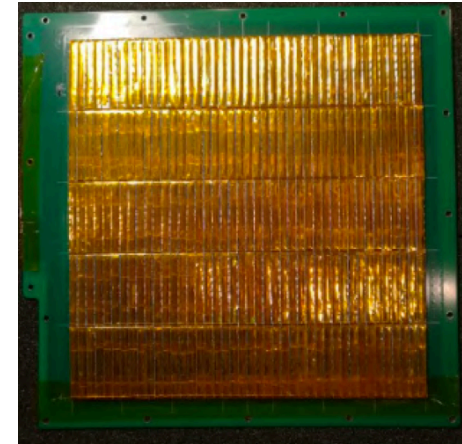
- based on strip-shaped plastic scintillator readout by SiPM
- Center dimpled readout based on scintillator strip
- Virtual segmentation of $5\text{mm} \times 5\text{mm}$ cell can be achieved by x-y configuration of strips

- **Sc-ECAL prototype**

- Dimensions: Transverse size of approximately 20×20 cm
- Sampling layers: 32 layers
- Channels: 6,720 channels
- Weight: Approximately 350 kg
- Chips used: SPIROC2E
 - Number of chips: 192 chips
- Two types of SiPM are implemented
 - S12571-010P
 - S12571-015P
- Development years: 2016-2020

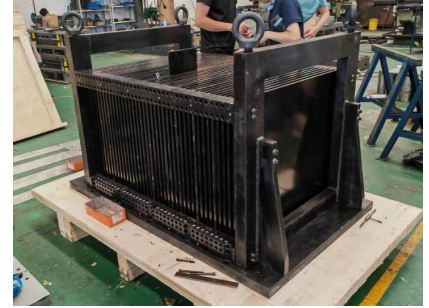


Sc-ECAL



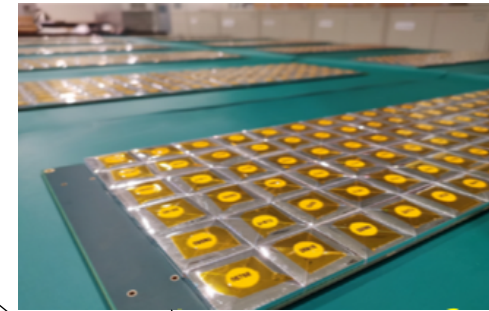
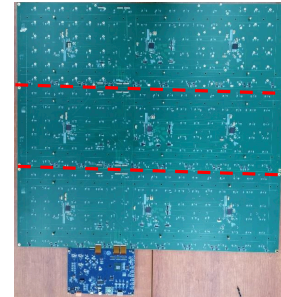
EBU

HCAL (Hadron Calorimeter)



CEPC-AHCAL

- **CEPC-AHCAL (Analogue Hadron Calorimeter)**
 - based on scintillator cell read out by SiPM with center dimple
- **CEPC-AHCAL prototype**
 - Dimensions: Transverse size of approximately 72x72 cm
 - Sampling layers: 40 layers
 - Channels: 12,960 channels
 - Weight: Approximately 5 tons
 - Chips used: SPIROC2E
 - Number of chips: 360 chips
 - Tile size : 40 * 40 * 3 mm³
 - Two types of SiPM are implemented
 - MPPC S14160-1315PS
 - NDL 22-1313-15-S
 - Development years: 2018-2022



HBU

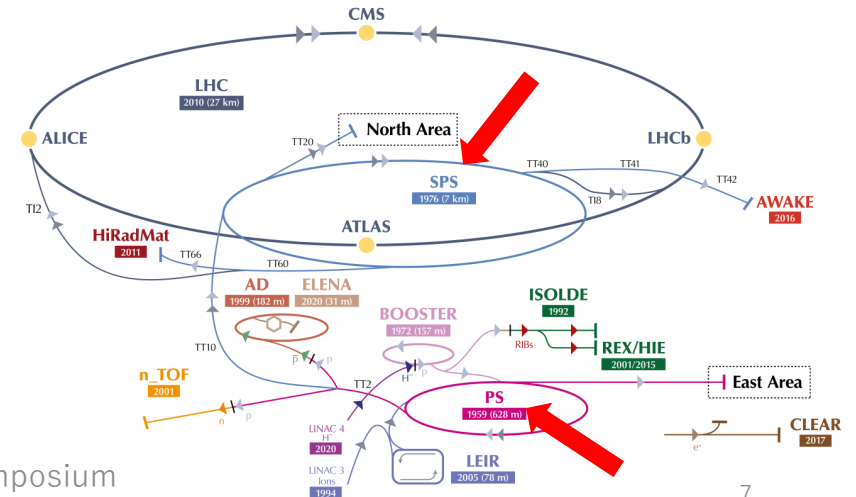
Beam Test Experiment

beamline



Combined system

- **Demonstrate the performance of Sc-ECAL and AHCAL combined system at CERN**
→ Examine the detector's response in the entire calorimeter
- **First successful beam test at CERN SPS H8: Oct-Nov, 2022**
 - High energy particle beams: muons, positrons and pions (10 - 120 GeV)
 - Collected data sets for detector performance and detailed shower studies
 - Found beam purity issue at H8: mixture of positrons and pions/protons
→we conducted beam test again last year
- **Second successful beam test at CERN, 2023**
 - SPS: Site 887, H2 beamline
 - muons, electrons and pions(10 – 350 GeV)
 - April 26th to May 10th
 - PS: Site 157, T9 beamline
 - muons, electrons and pion(0.5 – 15 GeV)
 - May 17th to 31st

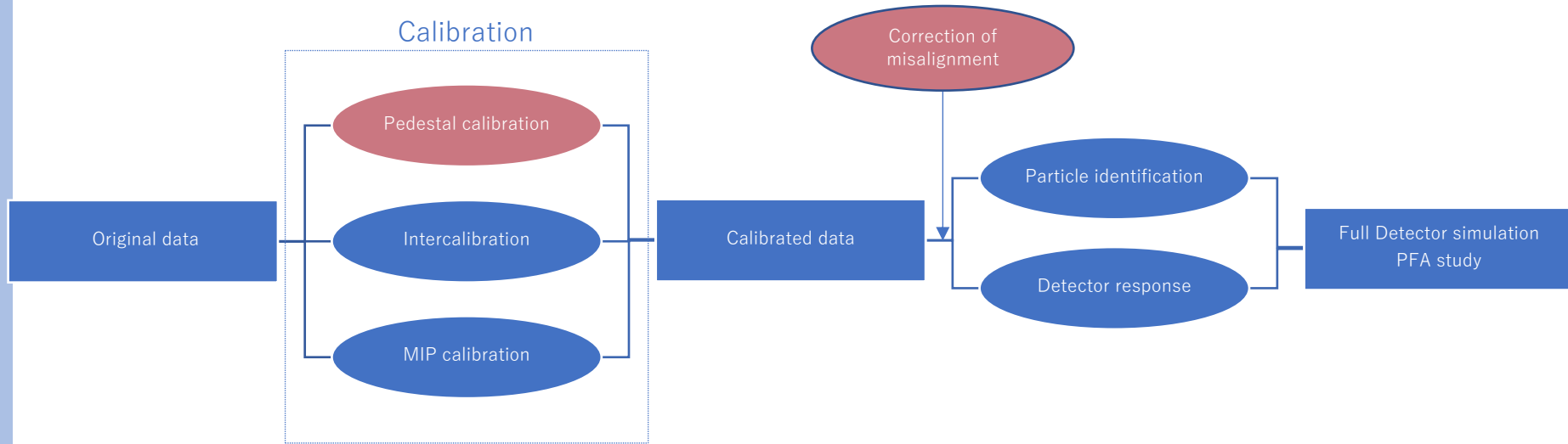


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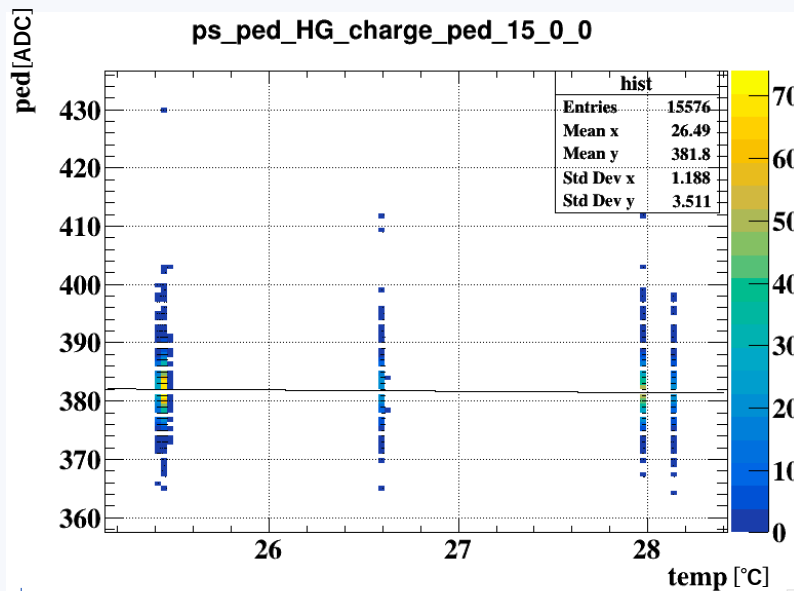
Analysis Flow

Full detector simulation and PFA study is planned



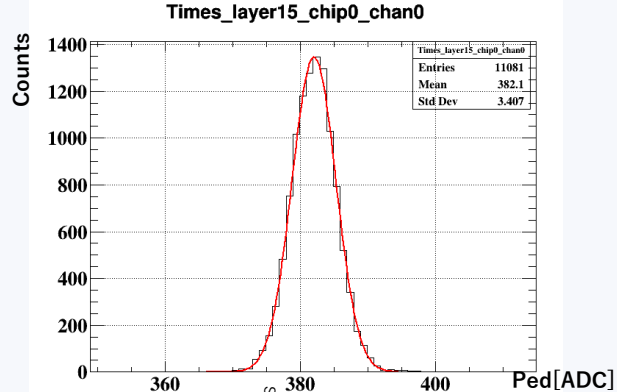
Pedestal Calibration(ECAL)

- A pedestal-run was conducted, and pedestal obtained through a random trigger.
- Stable pedestal values were observed across all channels

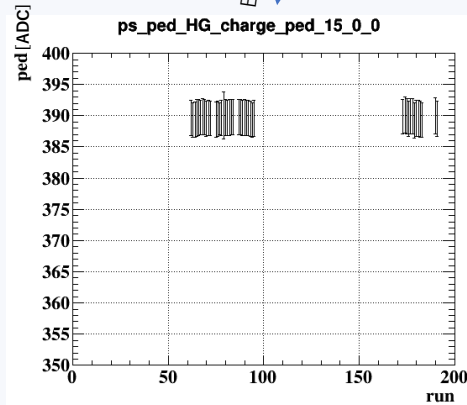


Extract the slope of the fitting function

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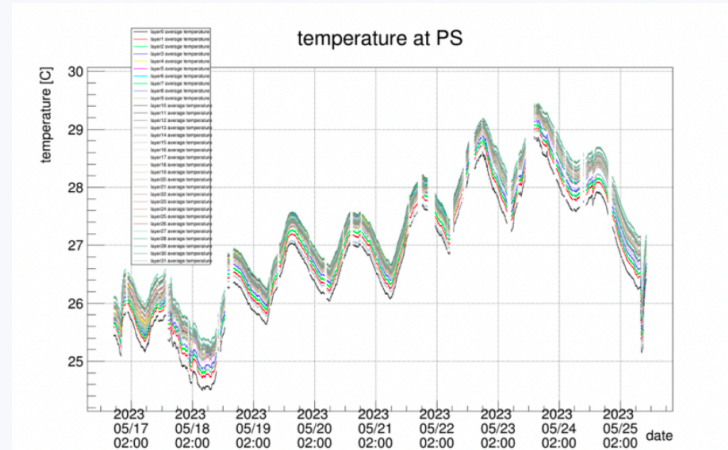
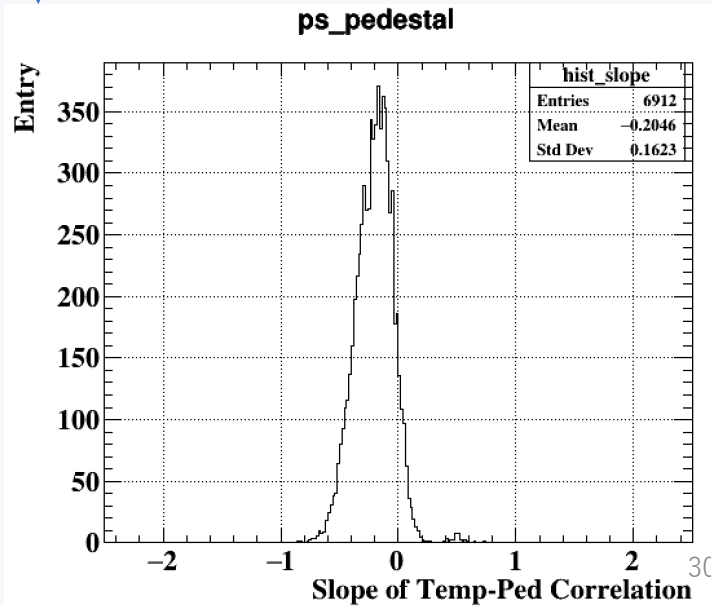


Extract peaks for all runs

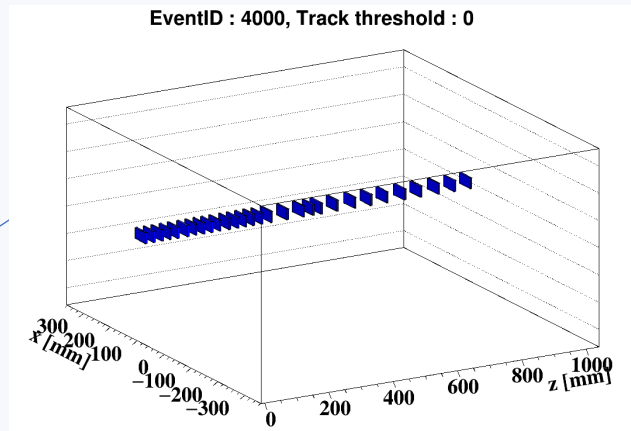
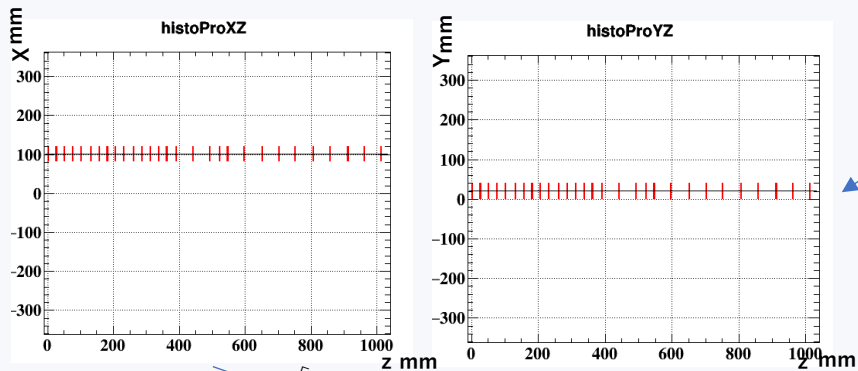


Pedestal Calibration

- The pedestal shows slight temperature dependence, but it's at a level that can be ignored under experimental conditions



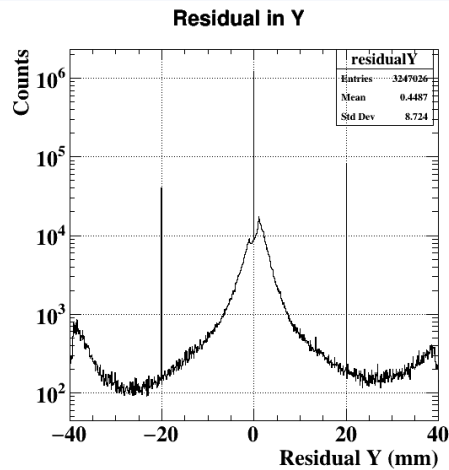
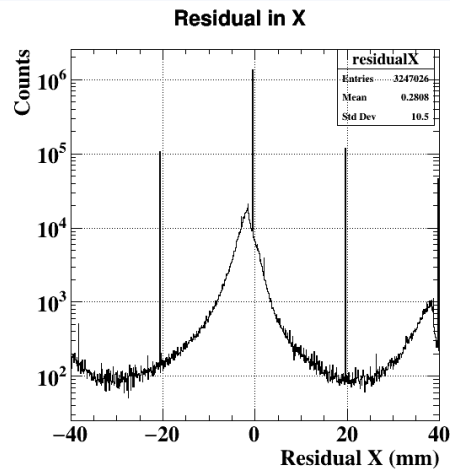
Alignment(Residual)



projection

Extract the residuals between the fitting function and the hit cells of all layer

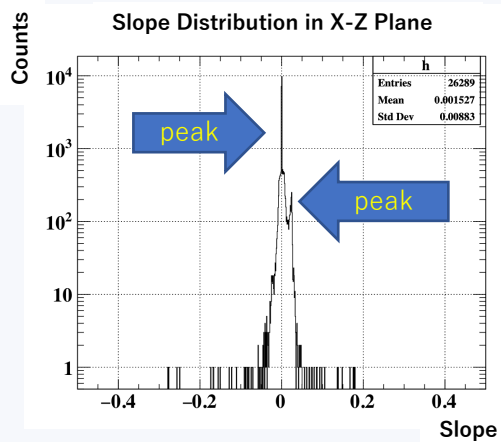
Residual :the residual with the muon track.



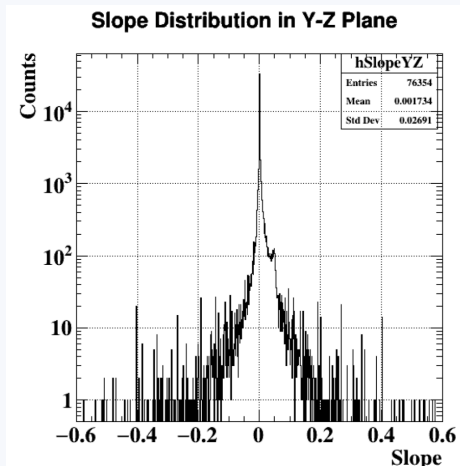
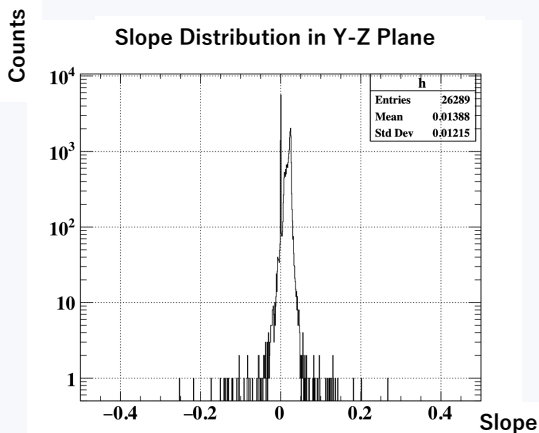
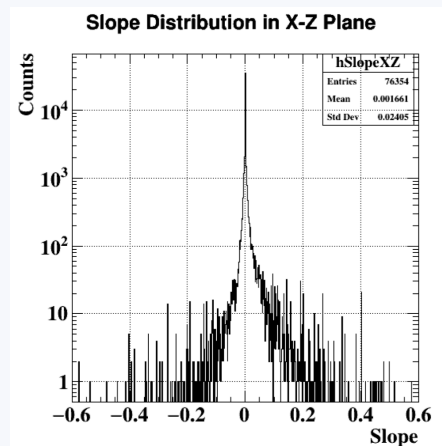
Alignment (Slope)

There are two peaks!!

Sc-ECAL



AHCAL



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Summary

- **Sc-ECAL and AHCAL combined beam test experiment was conducted at CERN**
 - Beam test campaigns at SPS-H2 and PS-T9
 - Collected decent statistics of data samples in the wide energy range
- **The pedestal shows slight temperature dependence, but it's at a level that can be ignored under experimental conditions.**
- **The combined system likely tilted along to beam direction**
 - Quantitative evaluation will be conducted
 - Angle correction will be necessary

Back ups

MPPC

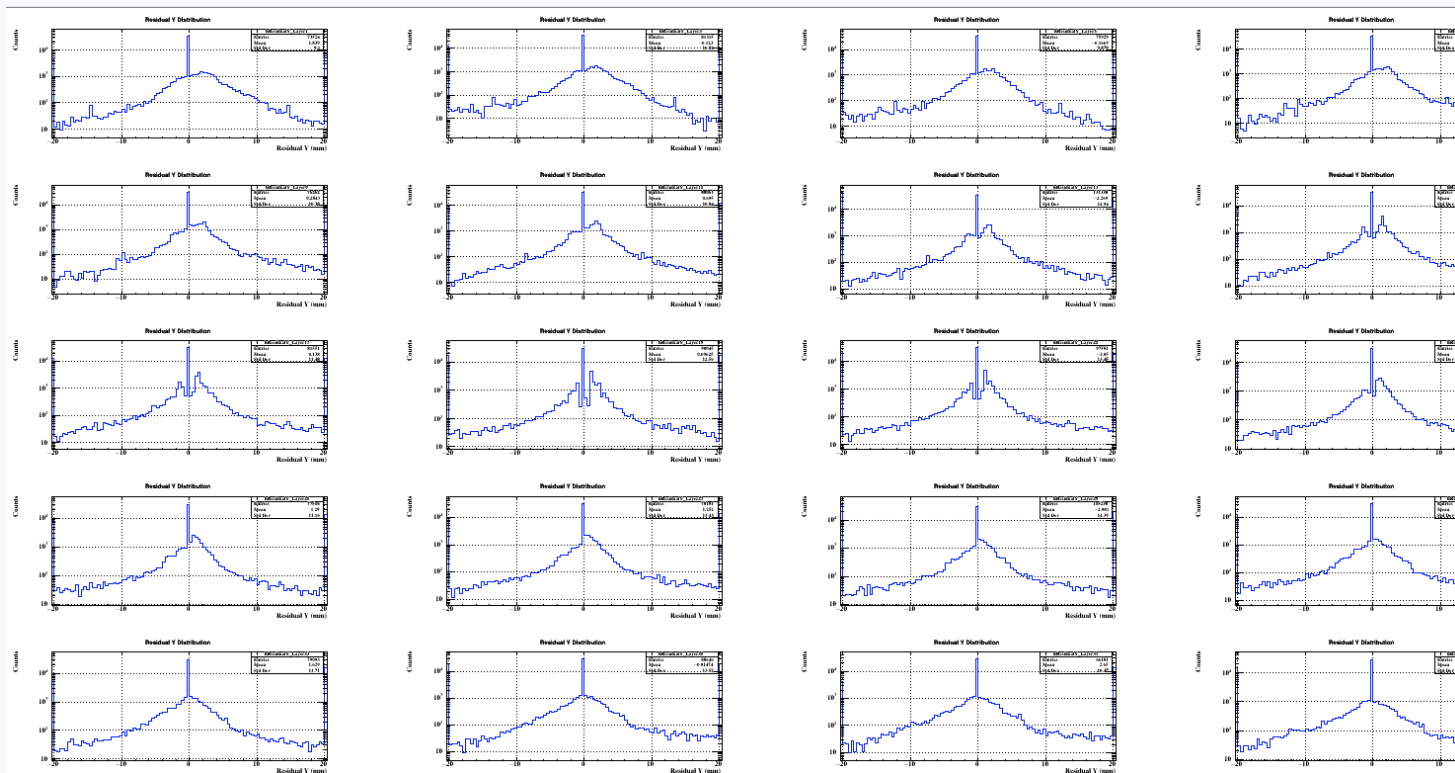
ECAL

	Pixel size	# of pixel
S12571-010P	10 um	10,000
S12571-015P	15 um	4,489

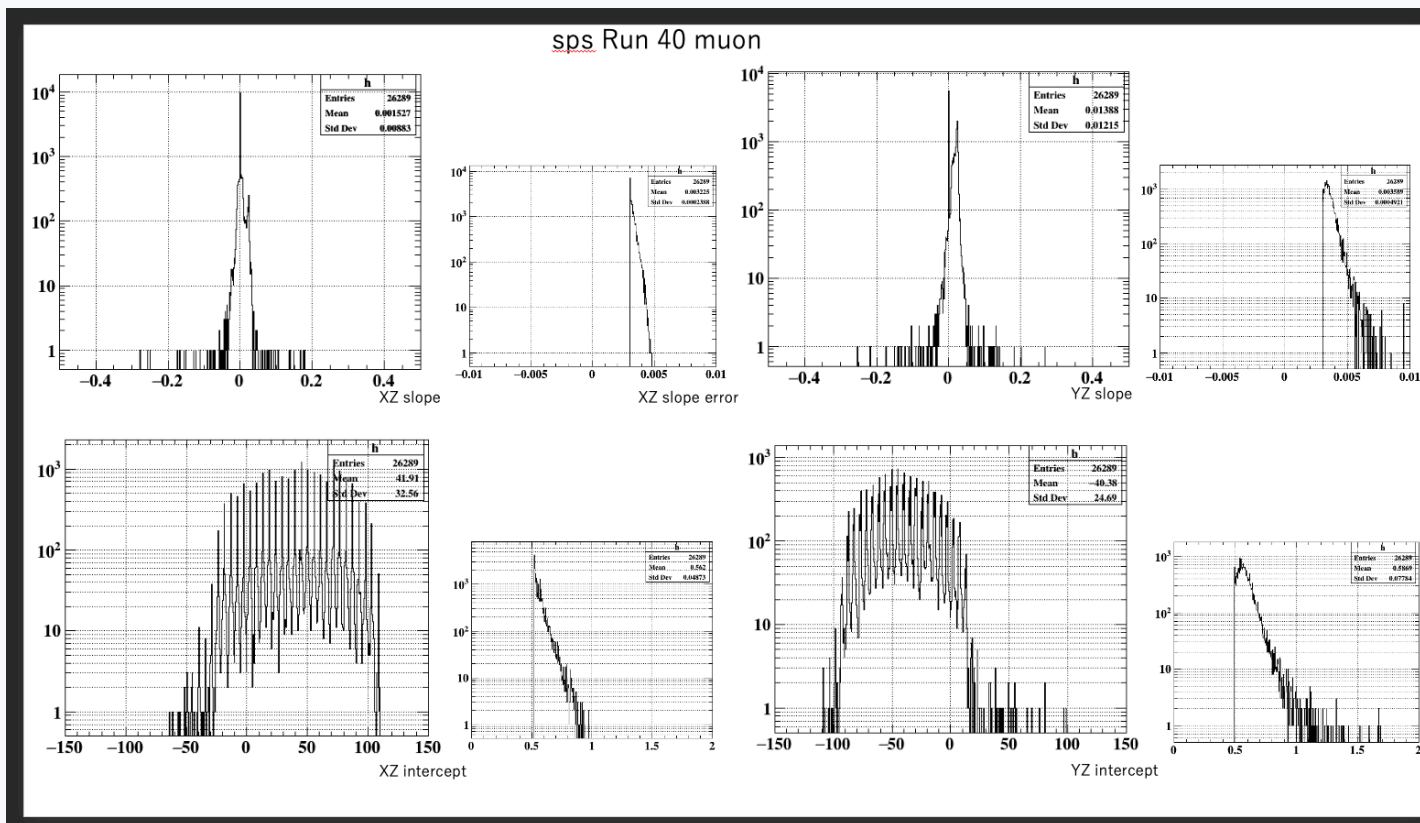
HCAL

	pixel size	npx
S14160-1315PS	15 um	7,284
NDL 22-1313-15-S	15 um	7,396 * 4

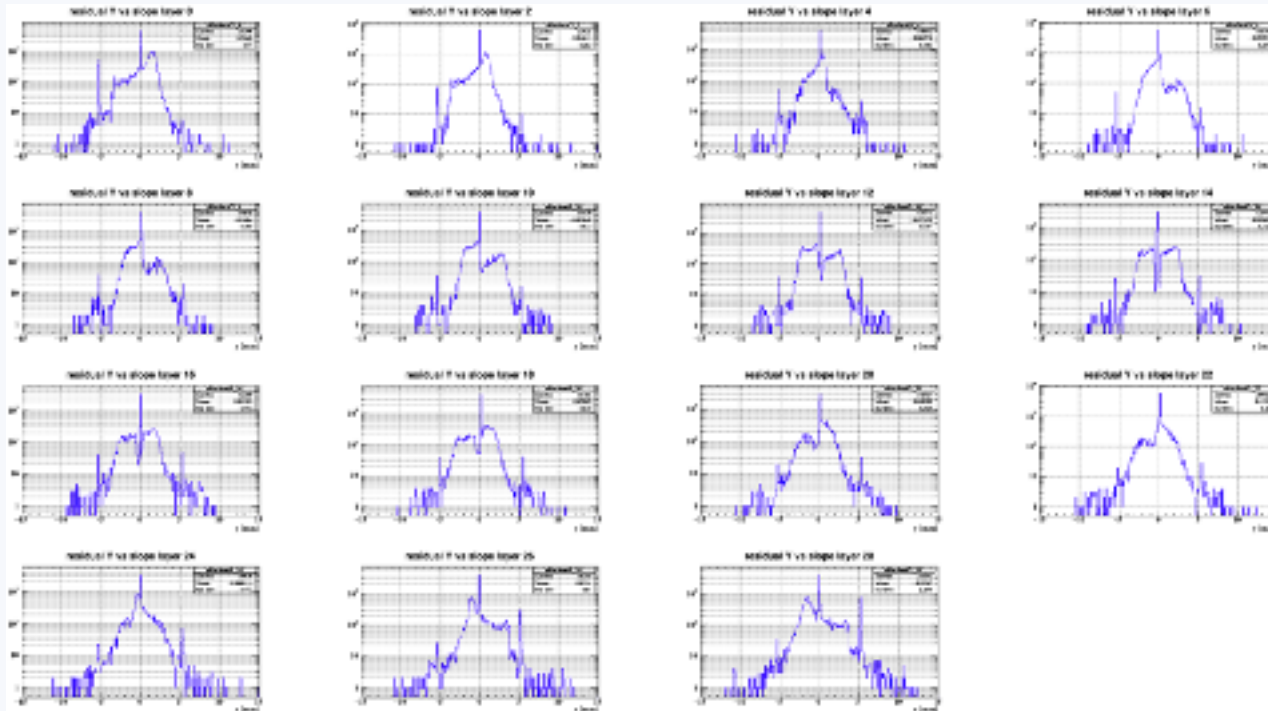
HCAL Residual



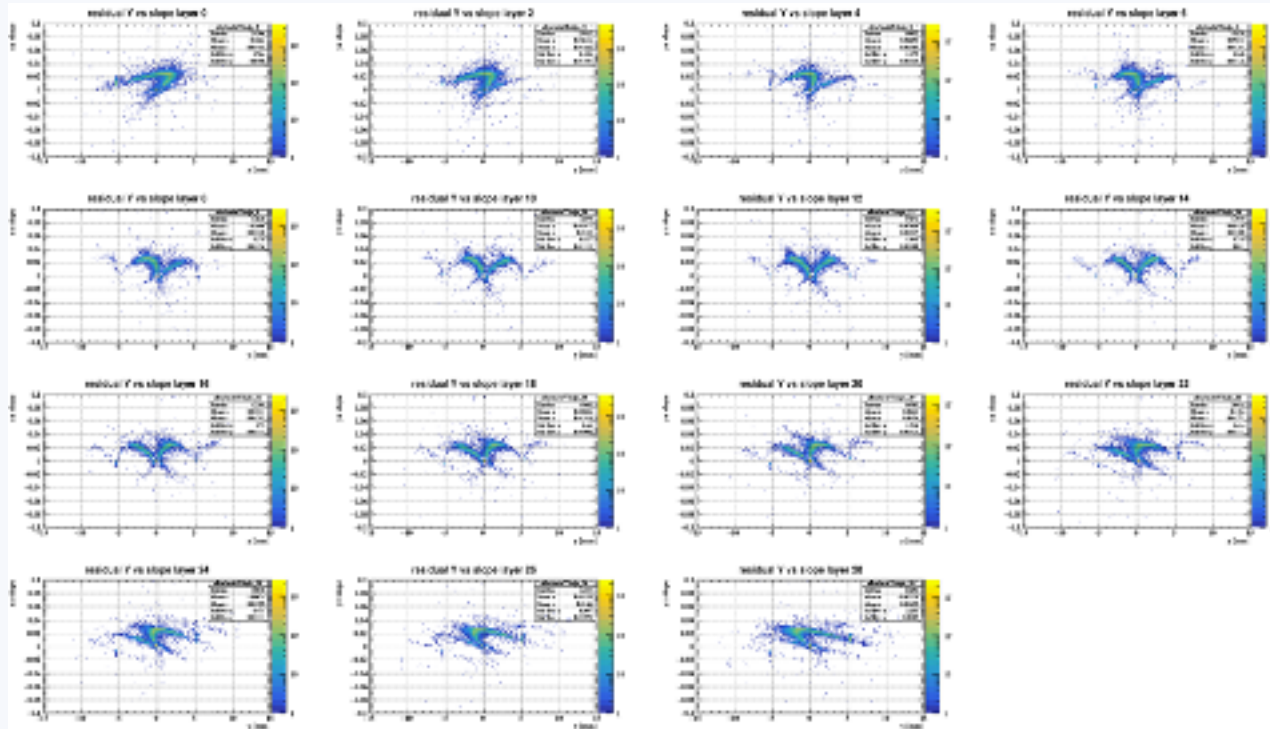
ECAL Residual



ECAL Residual

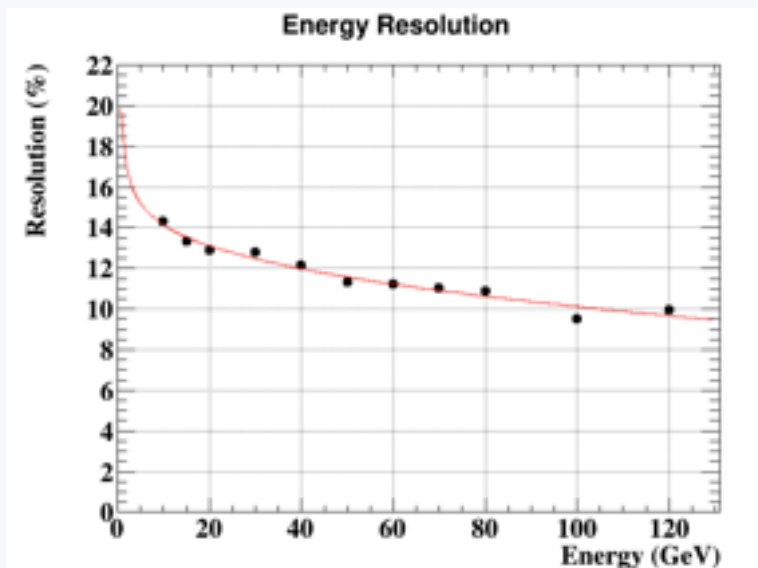


ECAL Residual



Energy Resolution

Simulation



2022

