



中国科学技术大学
University of Science and Technology of China



中国科学院高能物理研究所
Institute of High Energy Physics Chinese Academy of Sciences

PFA ScECAL prototype update

Yazhou Niu (USTC)

On behalf of the CEPC Calorimeter working group

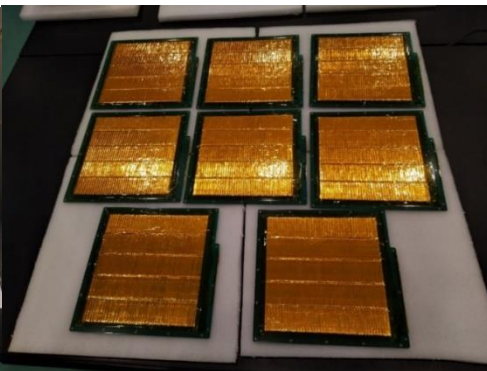
CEPC DAY, 22 Jan. 2021

CEPC Sc-ECAL prototype

scintillator strips



Ecal Basic Unit (EBU)



Super-layer: two EBU and absorber layers integrated



- Energy resolution $< 16\%/\sqrt{E}$, position resolution $< 10\text{mm} \times 10\text{mm}$
- One EBU: 210 sensitive cells of scintillator strip coupling with SiPM
 - Scintillator strips : $2\text{mm} \times 5\text{mm} \times 45\text{mm}$
 - SiPM (HPK) : S12571-010P (24 layers) and S12571-015P (8 layers)
- Super-layers: two alternate of EBU and absorber layers integrated
- Complete Sc-ECAL prototype has been fabricated
 - Transverse dimension : $226\text{mm} \times 222\text{mm}$
 - Radiation length : $22 X_0$



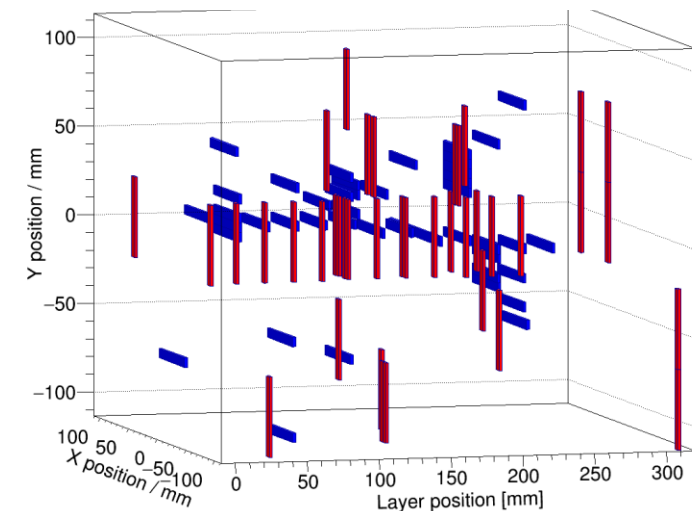
Sc-ECAL prototype

First beam test at IHEP E3

- IHEP E3 beam line: secondary particle beam
 - Mixed with proton/pion: **proton dominate**
 - Momentum : **300MeV-1.2GeV**
 - Event rate: less than **100 per minute**
- Task : learn to do beam test
 - Combined test with other detector
 - Event build through triggerID
 - “rehearsal” for future more beam test
- Data collection
 - 500 MeV, 800 MeV, 1 GeV momentum measured
 - Total 12 thousands events collected
 - **More detailed analysis are ongoing**

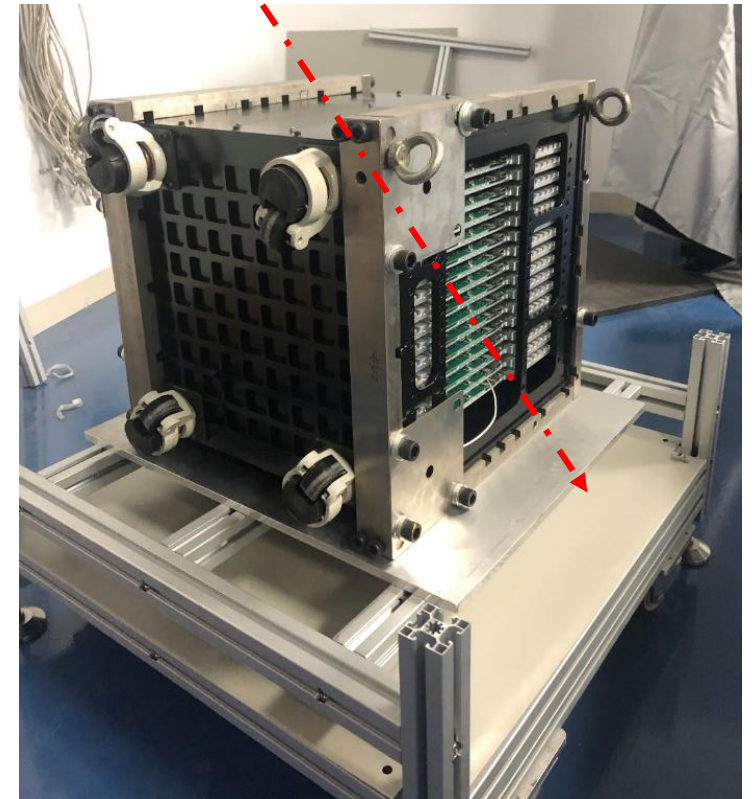
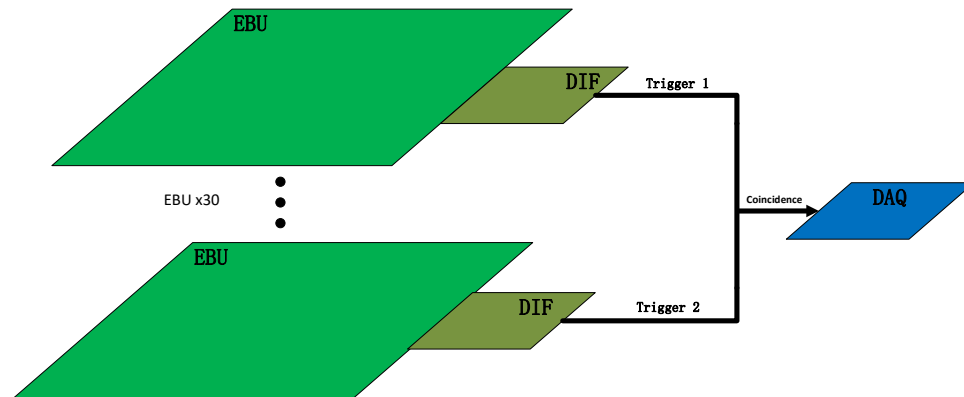


proton@1GeV candidate

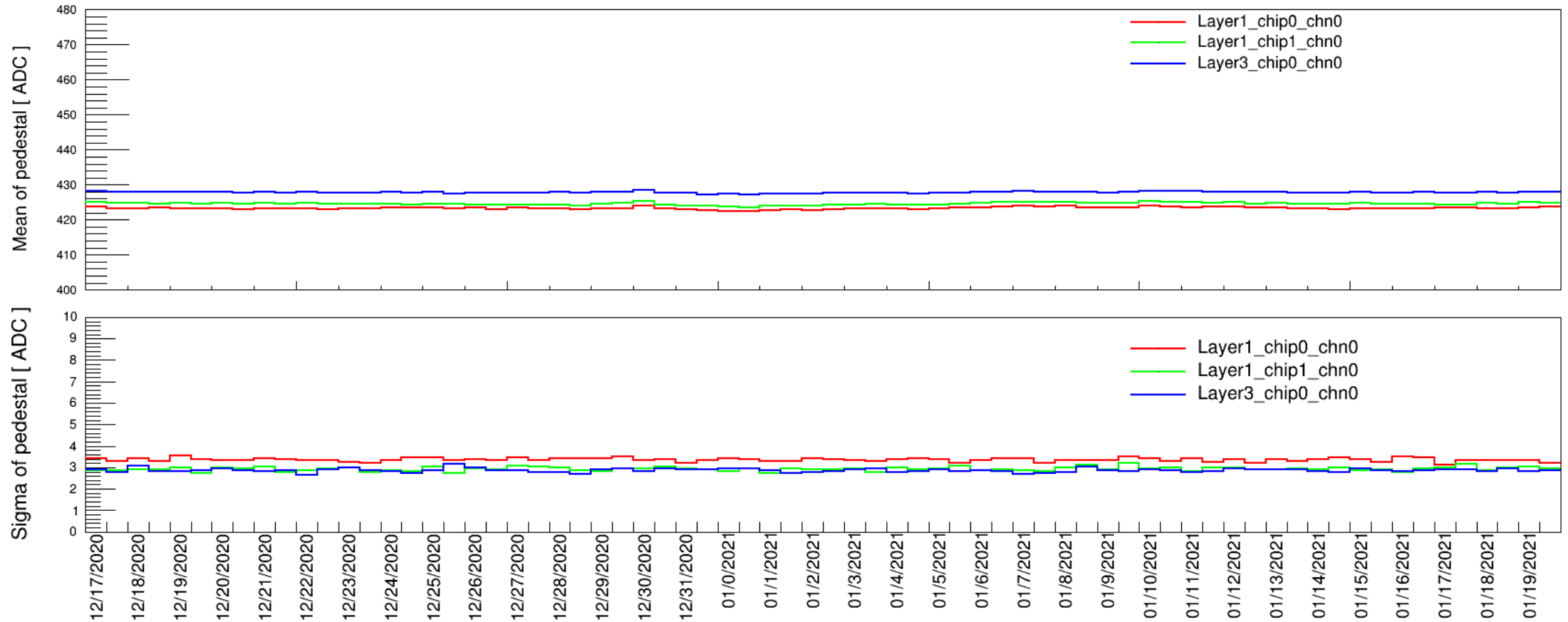


Long-term cosmic ray test

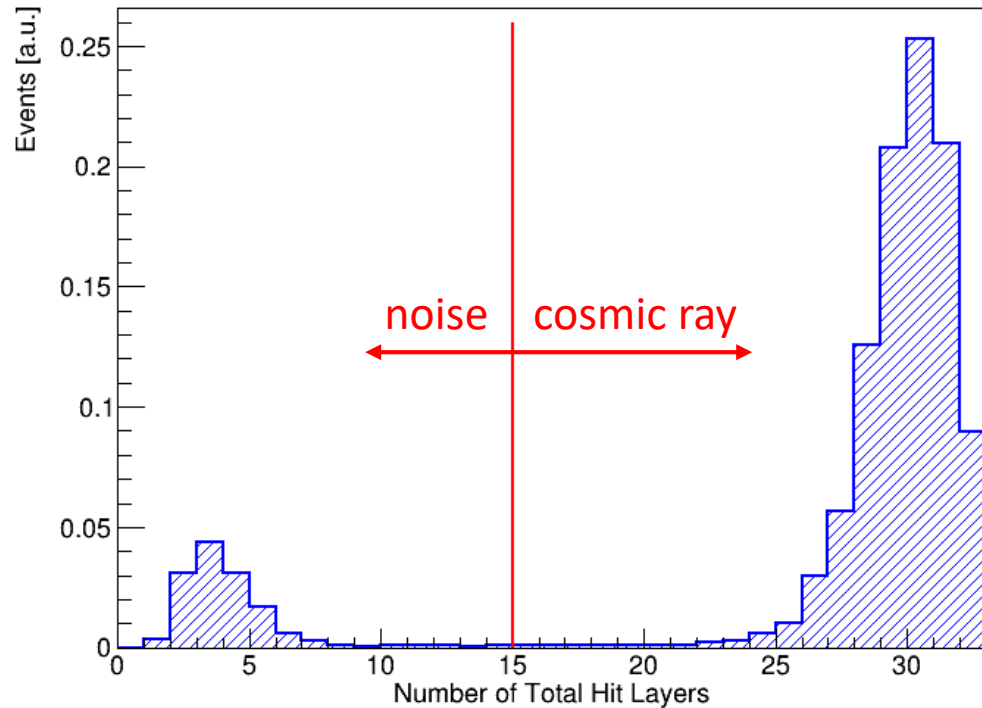
- ScECAL has been rotated by 90 degree
 - Coincidence trigger of Layer1 & Layer29
 - Event rate : ~ 16 per minute
 - Target to collect ~ 400 thousands
- **Position resolution** (track fitting)
- **Cell-to-cell MIP calibration** (track correction)



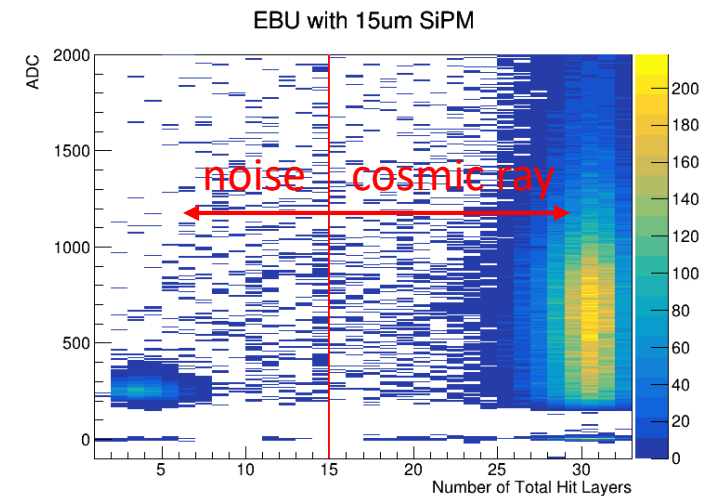
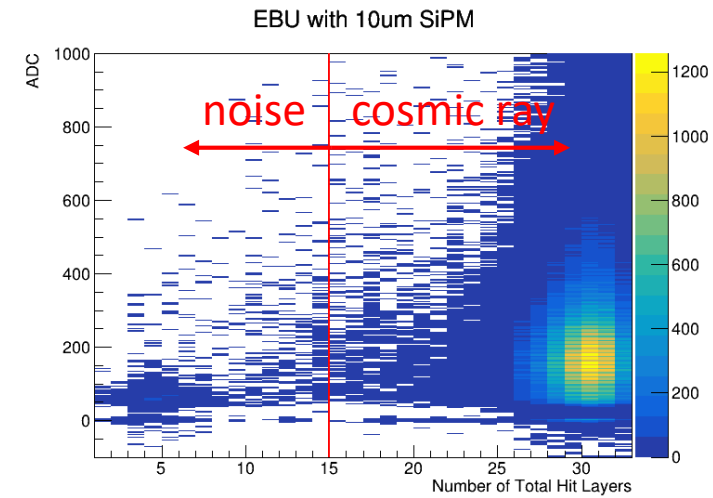
Pedestal stability



Cosmic ray test result



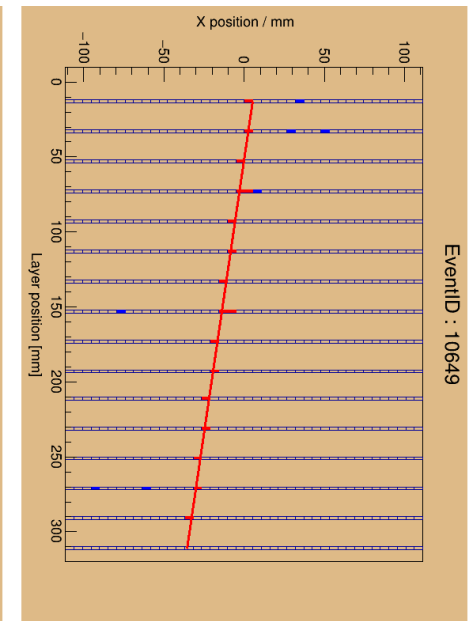
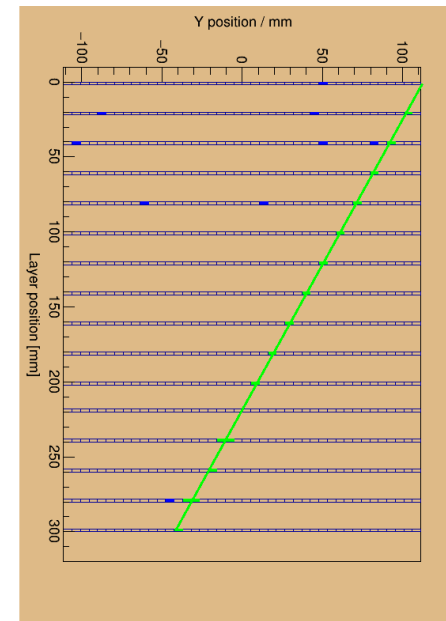
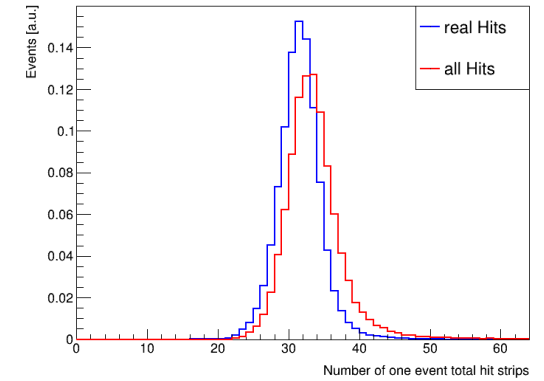
- Some pre-selections are needed



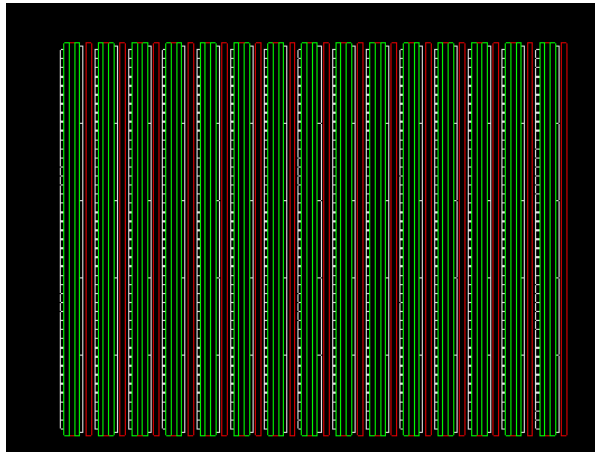
Cosmic ray track finding and fitting

- A preliminary algorithm has been performed

	Cut	Efficiency
preSelections	$TotalHitLayer \geq 22$	92%
	$TotalHitStrips \leq 64$	99.6%
	$ADC \geq 5\sigma$	99%
Iteration Fitting	All hits	
	$ Pos_{x/y} - tracking \leq (47.5, 5, 7.5)$	
Track Selections	$ Intercept_{x/y} \leq 114$ $ \varphi_{x/y} \leq 0.7$	98.2%
	$\sigma_{x/y}^2 \leq 9.6$	98.3%
	$TotalHitLayer_{x/y} > 6$	99.8%
Alignment	$Pos_{x/y} - track fitting$	

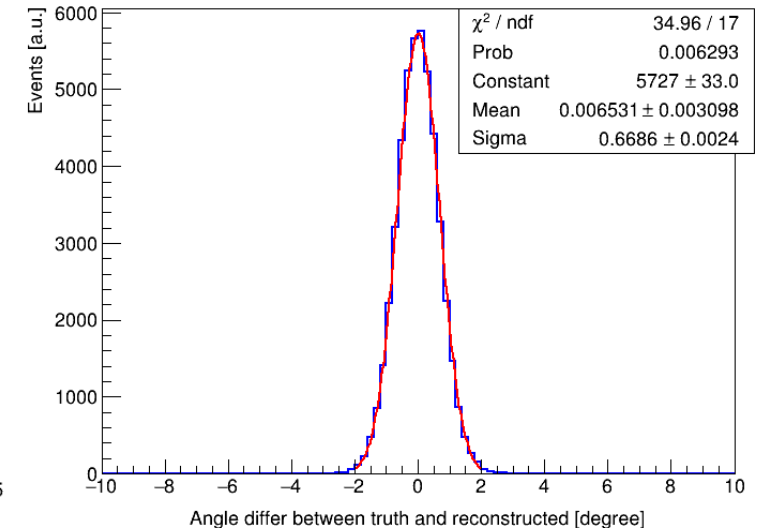
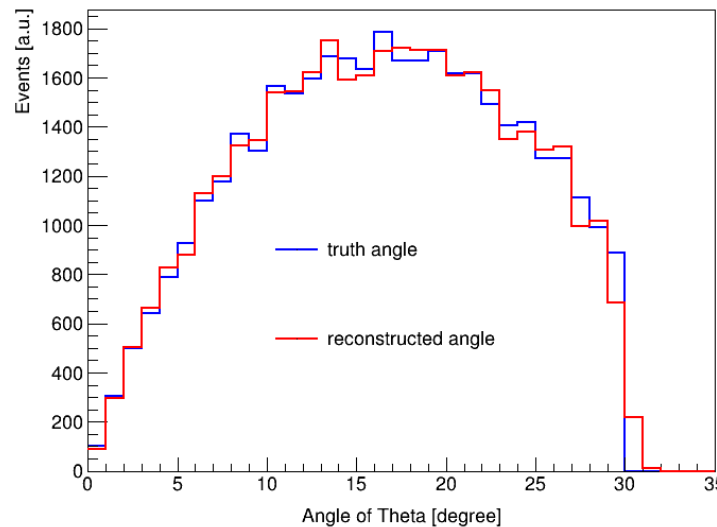


Geant4 simulation



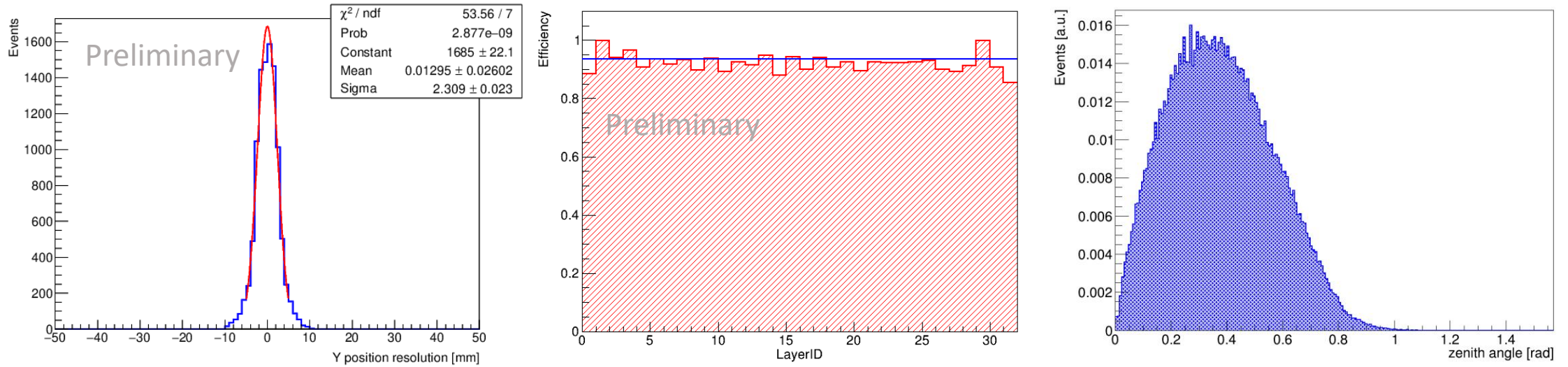
- A standalone package based on GEANT4 developed
- The track finding and fitting algorithm works fine
- The intrinsic angle resolution is about 0.7 degree
- Cosmic ray generator would be performed

- CEPC Sc-ECAL prototype
 - 30 layers
 - Absorber: WCu (85:15) 3.2 mm
- Version: Geant4-10.2.1
- Physics List: QGSP_BERT
- Cut: > 0.5 MIP



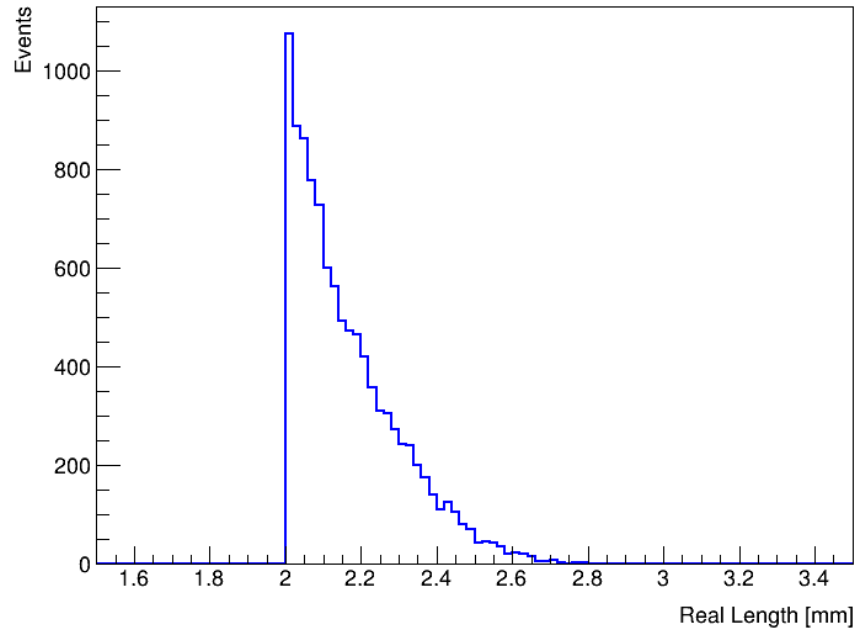
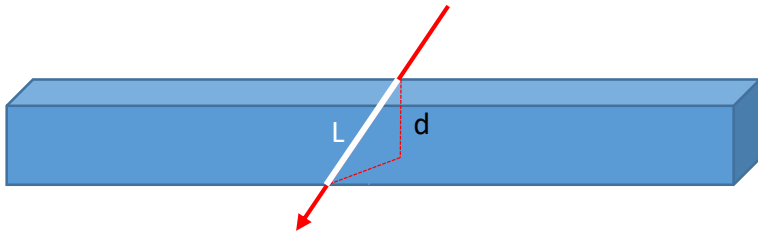
mu-@ 4GeV, plane, iso 0-30 degree

Cosmic ray test results

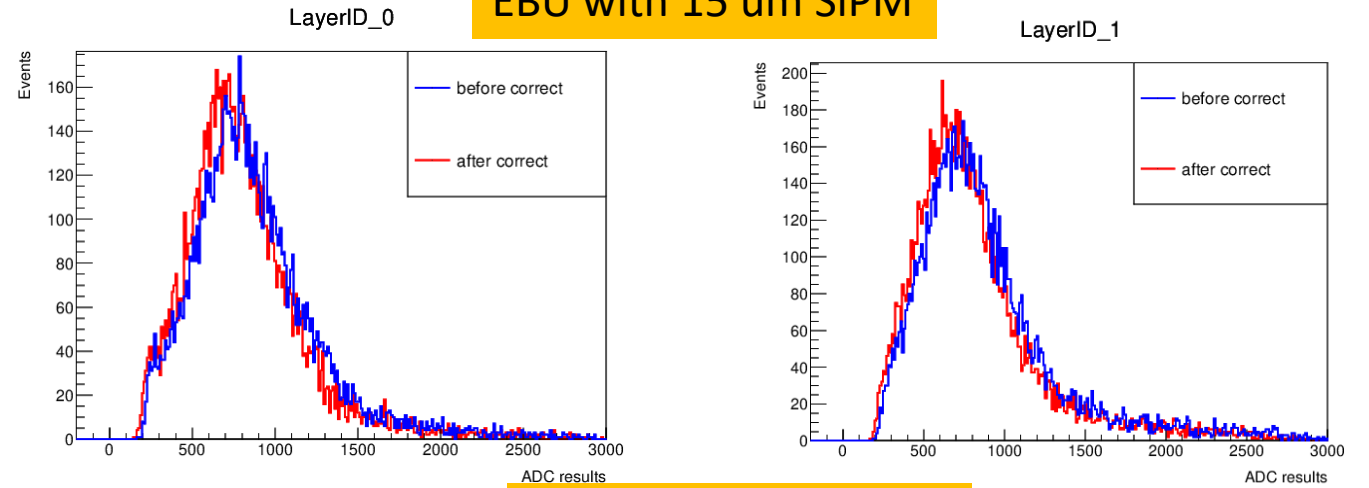


- Position resolution better than 3 mm - **Achieve the requirement for ScECAL**
 - Strongly affected by large angle scattering
- Efficiency achieve about 90% for all layers
 - Layer 1 & 29 are trigger layers
 - Sensitive area is about 93.5%

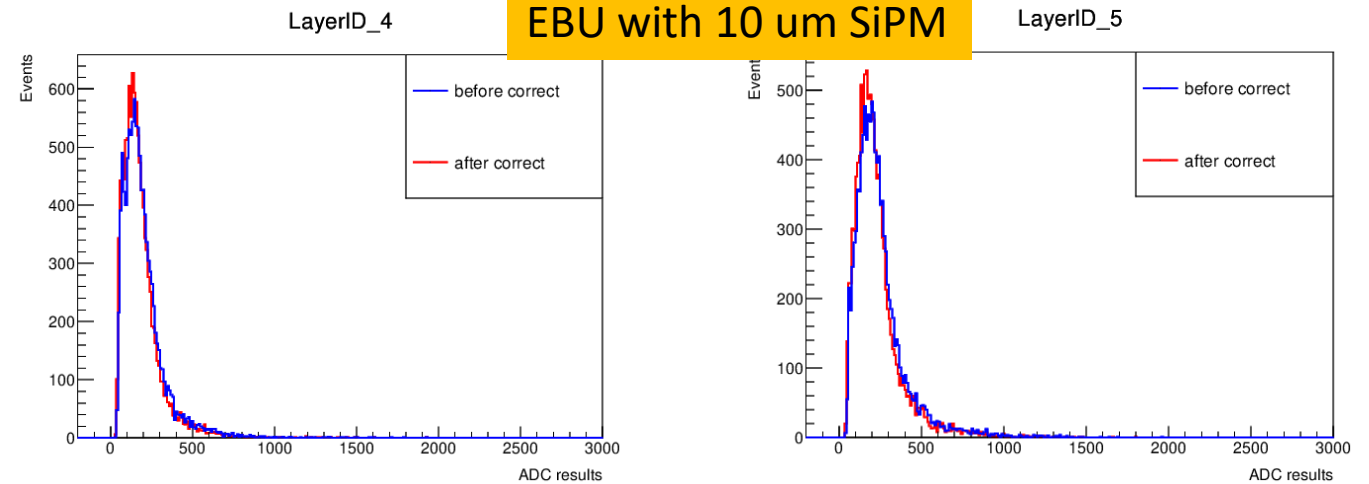
ADC correction



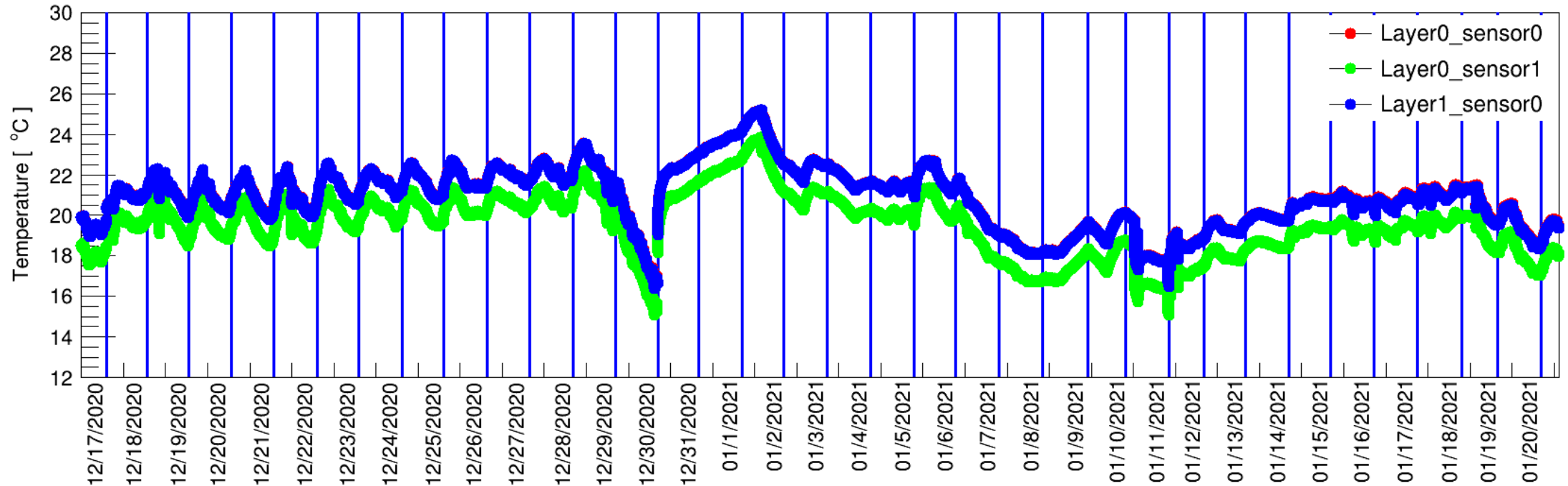
EBU with 15 μm SiPM



EBU with 10 μm SiPM



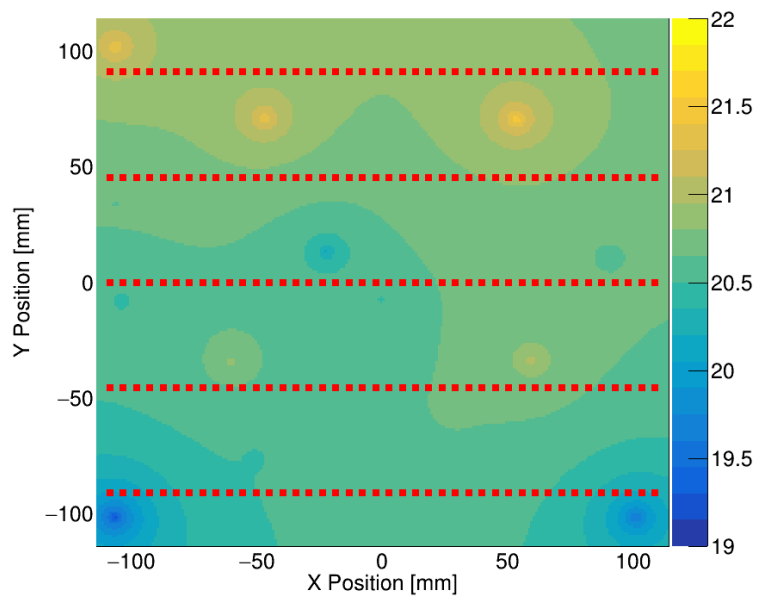
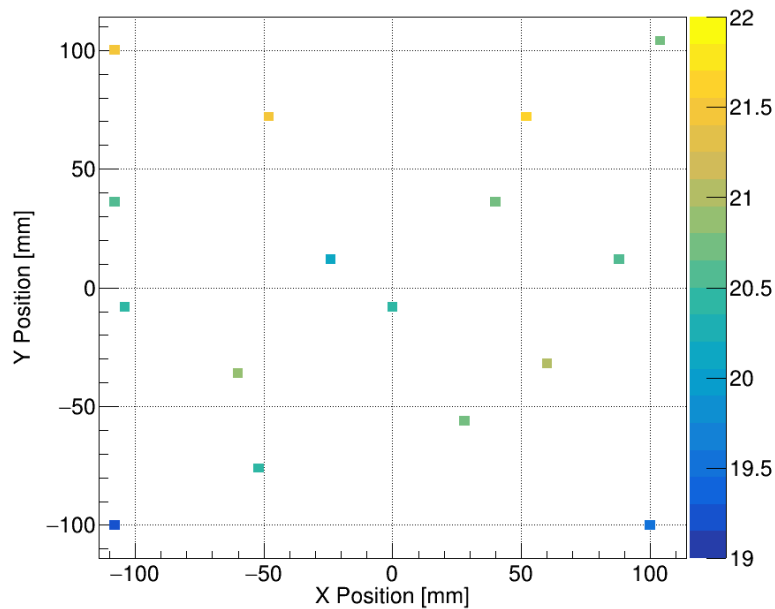
Temperature monitor



- Each layers equipped 16 temperature sensors ($0^{\circ}\text{C} \sim 85^{\circ}\text{C}$, $\pm 0.1^{\circ}\text{C}$)

Temperature reconstruction

- The temperature difference in one layer about 3°C
- Reconstruction algorithm : **Inverse Distance Weighted**
- The temperature reconstructed of each SiPM location

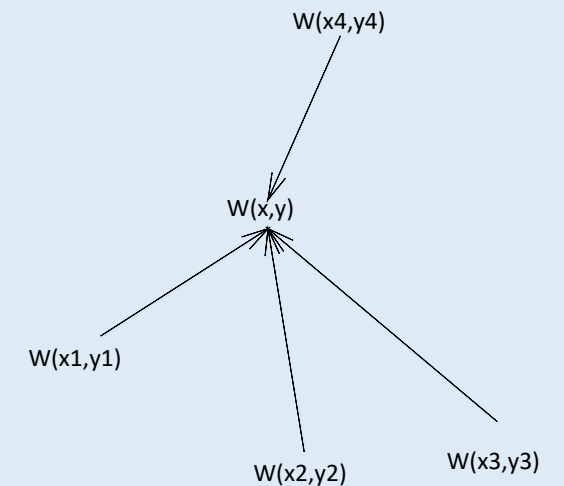


- Inverse Distance Weighted

$$W(x, y) = \sum_{i=1}^n Q_i W_i$$

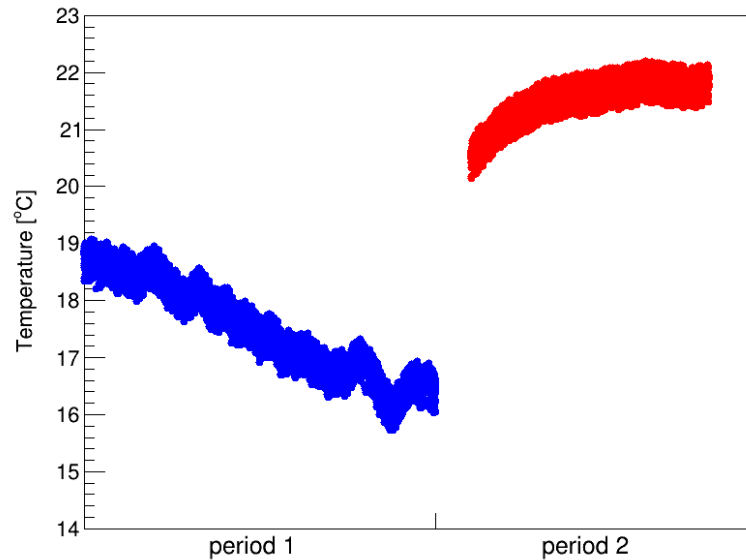
$$Q_i = \frac{1}{\sum \frac{1}{L_i}}$$

(W: temperature, Q: weight, L: length)

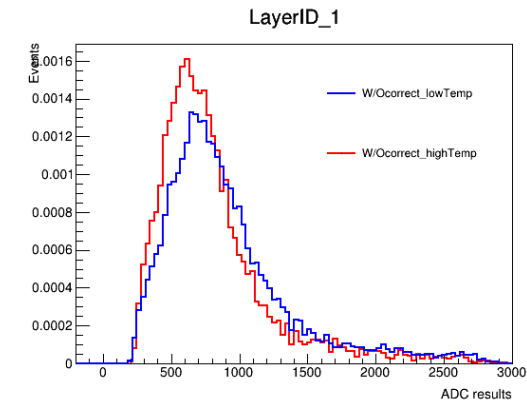
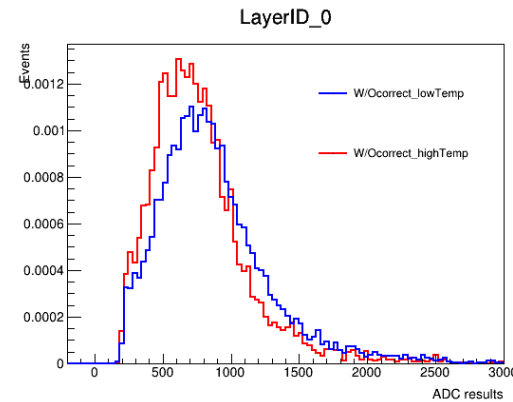


SiPM gain correction

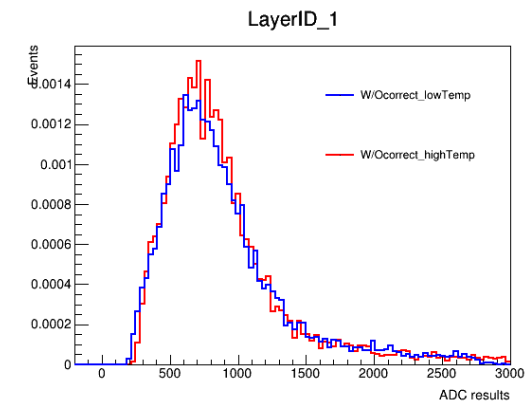
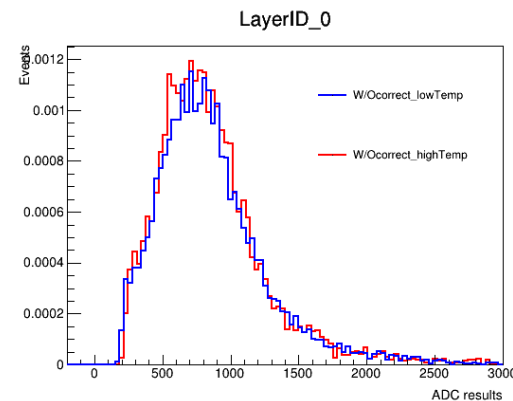
- SiPM gain temperature dependence $-2\% / ^\circ\text{C}$
- Setting $18\ ^\circ\text{C}$ as reference temperature



Two periods with large temperature difference



Before correction



After correction

Summary and plan

- A long term cosmic ray test is ongoing
- Position resolution better than $3mm$, required $5mm \times 5mm$ granularity by MOST project for CEPC ScECAL
- Correction of incident angle and temperature effect on the ADC measurement have been implemented
- Cell-to-cell MIP response calibration is ongoing
- Postpone the March 2021 beam test at DESY and applying reserve a latter time slot

Thank you!