

Development and beam test of the CEPC PFA Calorimeter prototypes

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On behalf of CEPC Calorimeter working group

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Outline

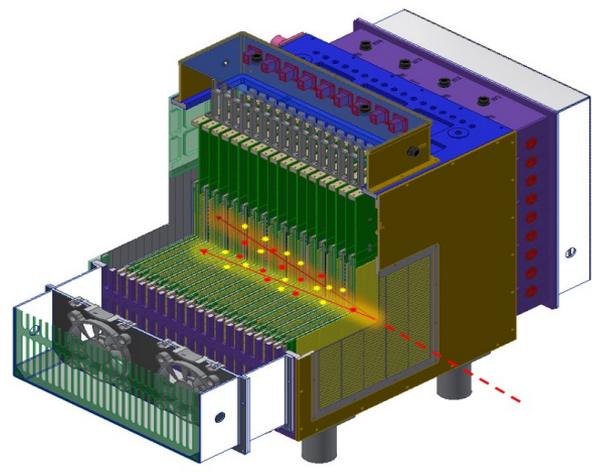
- CEPC PFA Calorimeter Prototypes
Brief Introduction
- Beam test at CERN
- Summary



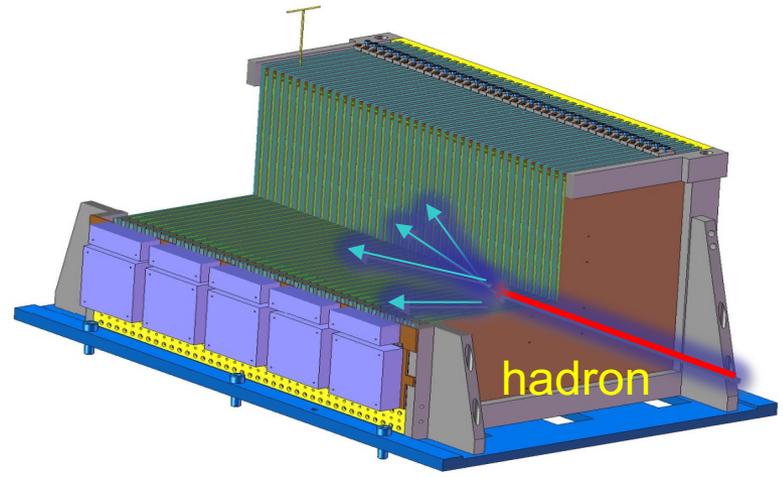
PFA Calorimeter

Sampling Calorimeter

Calo	Sampling No.	Sensitive detector	Absorber	Granularity	Electronics	Absorb length	Energy Resolution	weight
Sci-W ECAL	30	PSD+SiPM	W-Cu	5mm×5mm	SP-2E	22 X ₀	16%@ 1 GeV	0.3 T
AHCAL	40	PSD+SiPM	Fe	40mm×40mm	SP-2E	4.6 NIL	60%@ 1 GeV	5.0 T



Sci-W ECAL

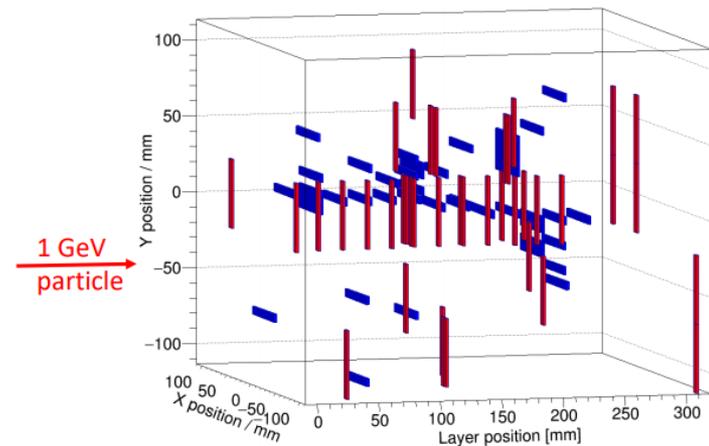
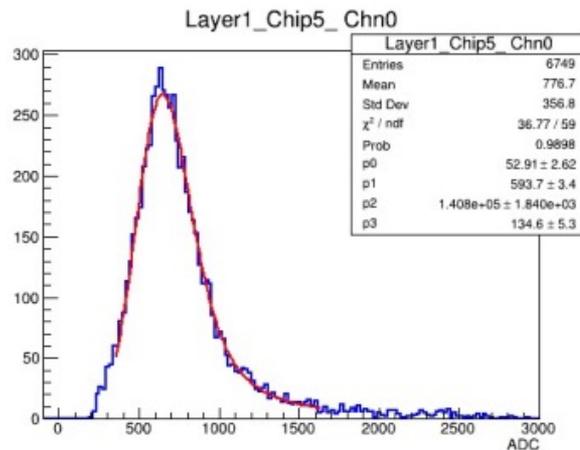


AHCAL



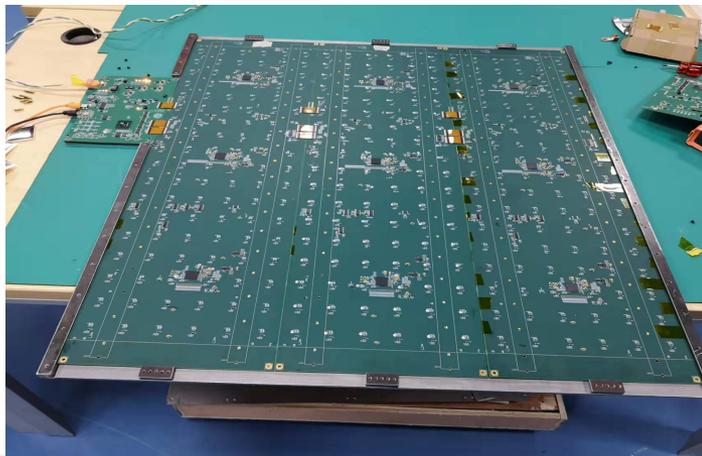
Sci-W ECAL

- Sci-W ECAL has been developed two years ago.
- It has been verified by long-term cosmic ray test in laboratory, and has been tested in IHEP in October 2020
- Its performance is stable.

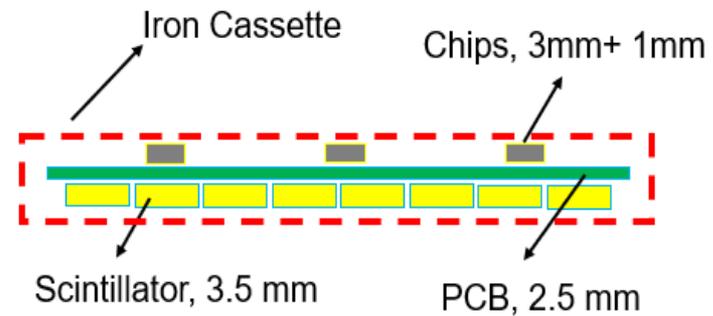


AHCAL

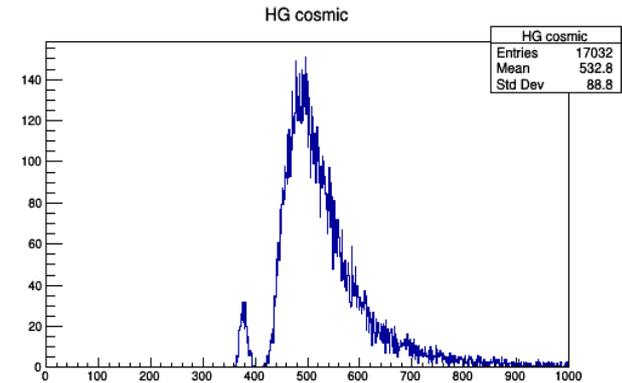
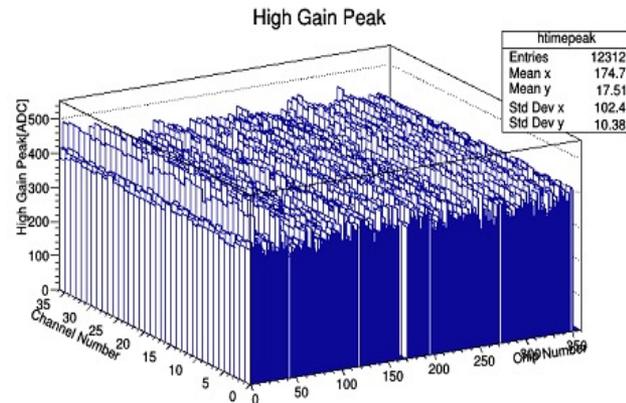
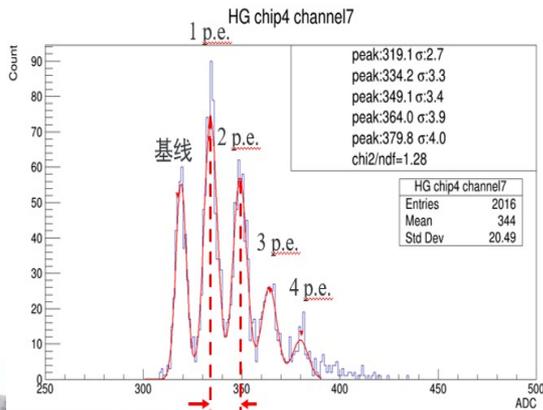
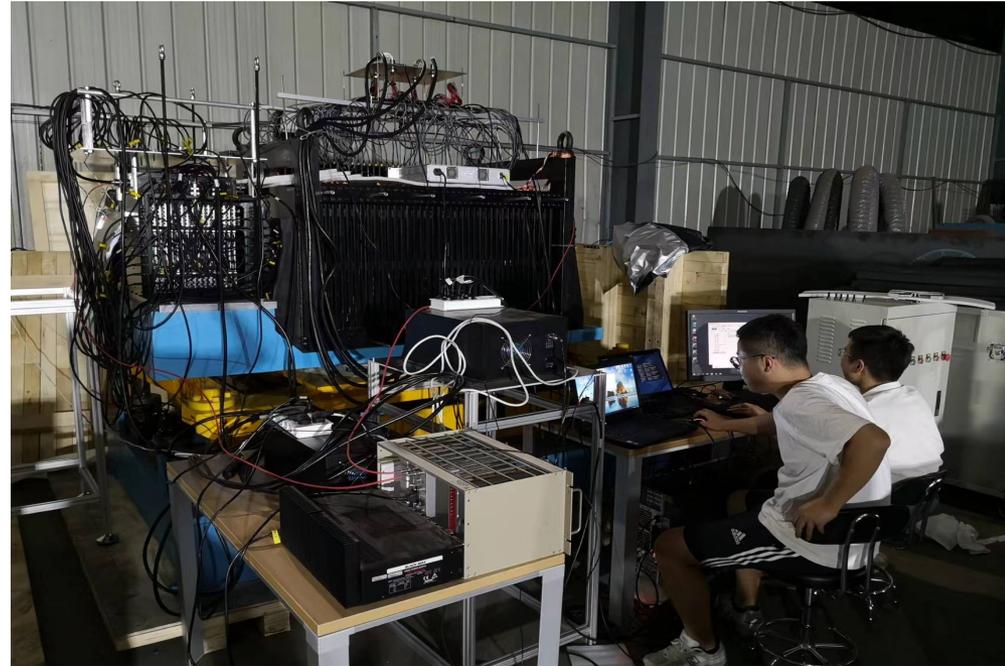
- ◆ The AHCAL was assembled this summer
 - ◆ It has 39 iron absorbers
 - ◆ Absorber: 20 mm iron
 - ◆ 40 sensitive layers, and sensitive area is $\sim 72 \text{ cm} \times 72 \text{ cm}$
 - ◆ Each layer has 324 sensitive cells
 - ◆ Cell size is 40 mm x 40 mm



sensitive layer



- ◆ We also tested the two calorimeters using cosmic ray in laboratory
 - ◆ Pedestal, MIPs, low/high gain ratio...



Supporting Table

- ◆ The supporting table for calorimeter beam testing
 - ◆ The table can support ECAL and AHCAL at the same time
 - ◆ The horizontal movement distance is ± 20 cm, and the up and down movement distance is ± 15 cm



Supporting table



AHCAL on this platform

Beam test

- Two weeks of high-energy particle beam test at H8 of SPS
 - The H8 beam line is a high-energy, high-resolution secondary beam line.
 - The maximum momentum that can be transported in the experiments is 400 GeV/c protons or secondary mixed hadron beams within the range 10-360 GeV/c.
 - the electron beams with variable purity (10 – 99 %) are also possible. The maximum $\Delta p/p$ acceptance of the line is 1.5%.

SPS: October 2022



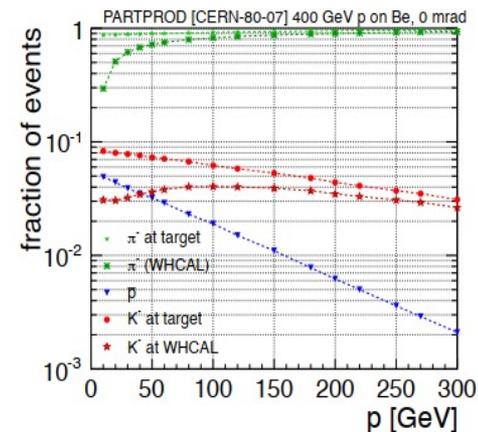
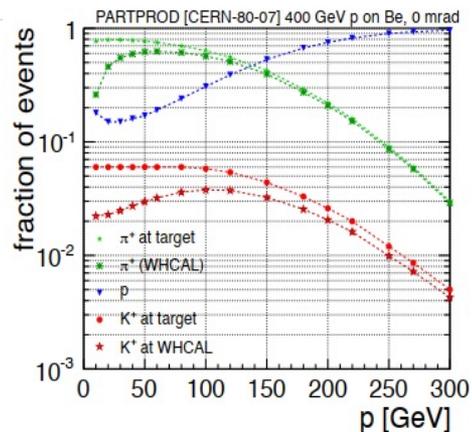
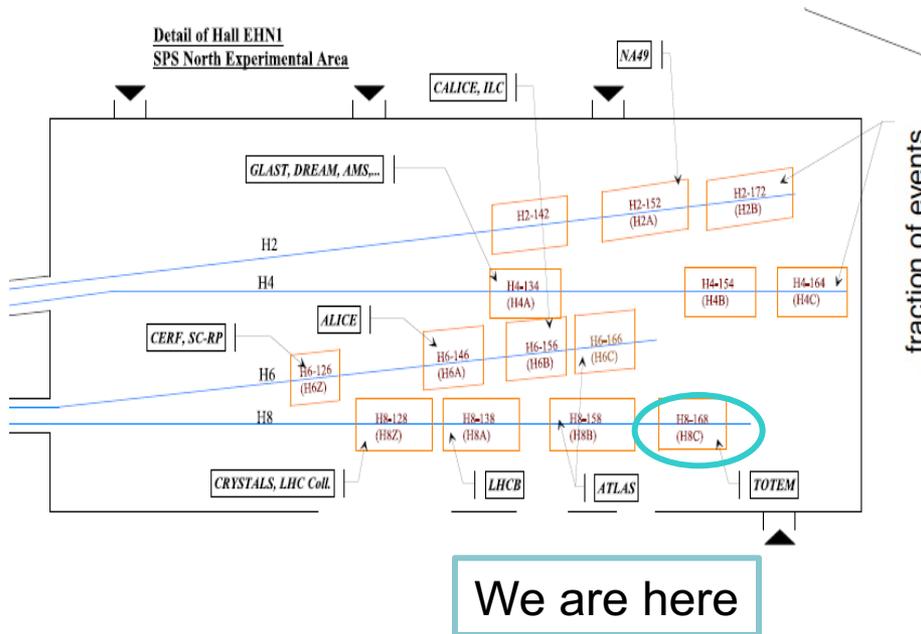
schedule issue date: 30-May-2022

Version: 1.10

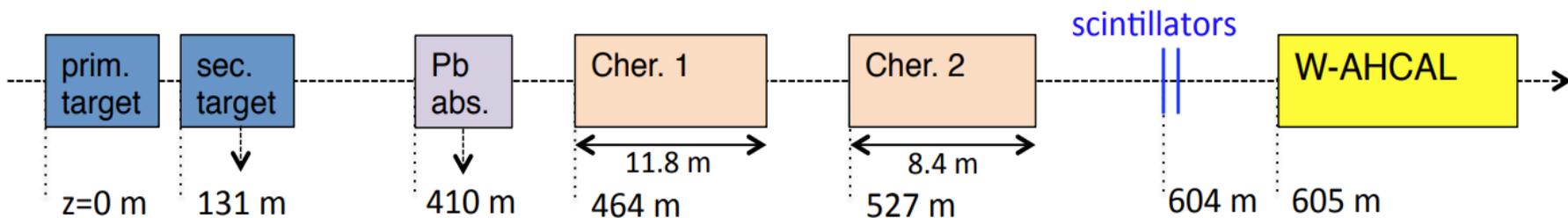
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Week		39							40							41							42							43																											
Machine																																																									
North Area	T2 - H2	Calice Scd			A. Ariga PPE172				NA65							CMS HGCAL							D. Lazic PPE172							Y. Itow PPE172							LHCf							H. Schindler PPE172							LHCb ECAL						
	T2 - H4	V. Gninenko PPE134+PPE144							NA64e							EB. Holzer							Place-holder							M.R. Jäkel, E. Oliveri PPE134, PPE154							GIF RD51																				
	T4 - H6 main user	CMS PIXELS			A. Rummler PPE146				ATLAS ITK PIXEL							ATLAS AFP							MONO LITH							Dannheim Dao PPE156							E. Figueras							RD50							NA62						
	T4 - H6 parallel use	EP hybrid			A. Rummler PPE146				ATLAS AFP BCM							ATLAS ITK PIXEL							ATLAS MALTA EP PIXEL							V. DaoD. Dannheim PPE146, PPE156							NA62 ATLAS HGTD							EP hybrid ATLAS HGTD E. Gkoukousis													
	T4 - H8	UA9 Totem			W. Scandale PPE128				UA9							H. Schindler, N. Neri PPE128, PPE138, PPE158, PPE168							LHCb CMS MTD (SEEDOM)							J. Liu, E. Scomparin 158 or 168, PPE138							Calice Scw ECAL NA60+																				



H8 Beam Line



The secondary particles in the beam



Optional



Transport

- ◆ In the middle of Sep. The detectors were sent to CERN from Hefei. The total weight is 10.6 tons.
- ◆ On Oct. 14, the detectors were arrived at CERN.

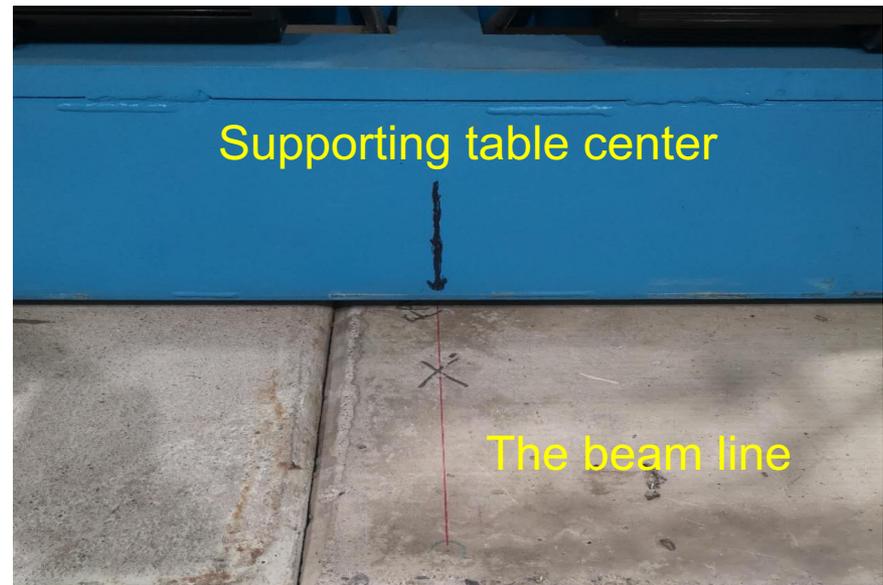


Hefei, 15/9

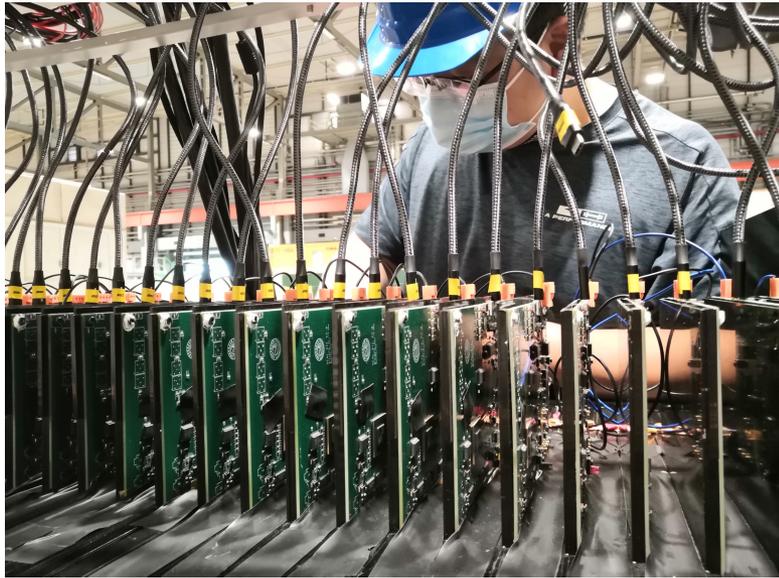


CERN, 14/10

Install the detectors in beam area



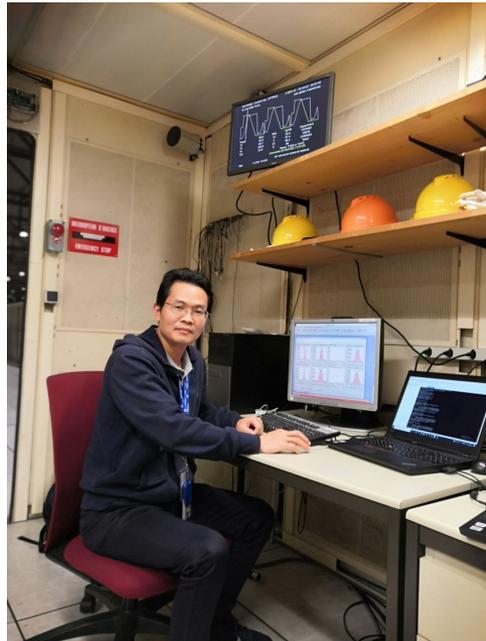
Install the detectors in beam area



2022/10/24

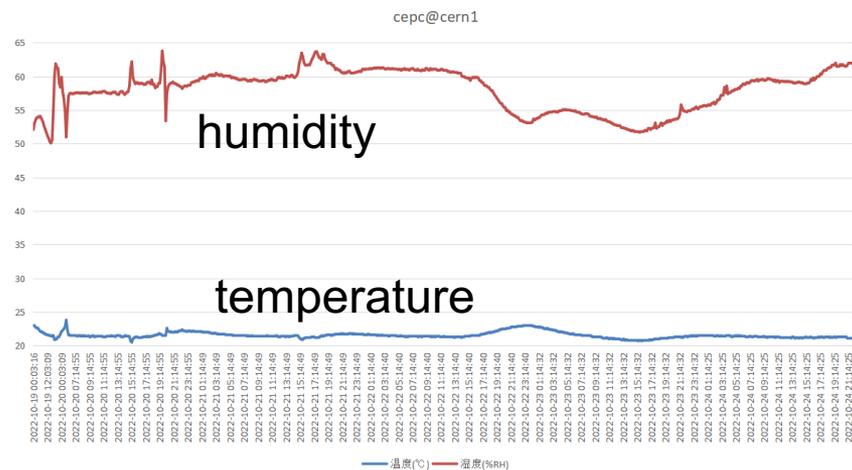
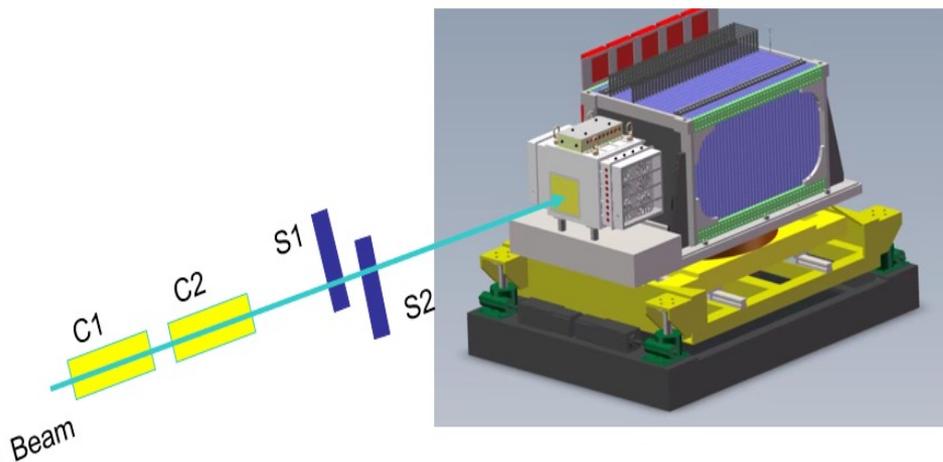
Beam Test

- ◆ The calorimeters has been calibrated in H8
 - ◆ 10 – 120 GeV/c pions
 - ◆ 10 – 40 GeV/c positrons



Beam test

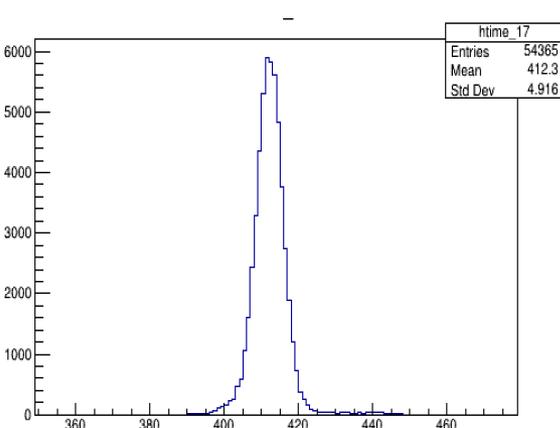
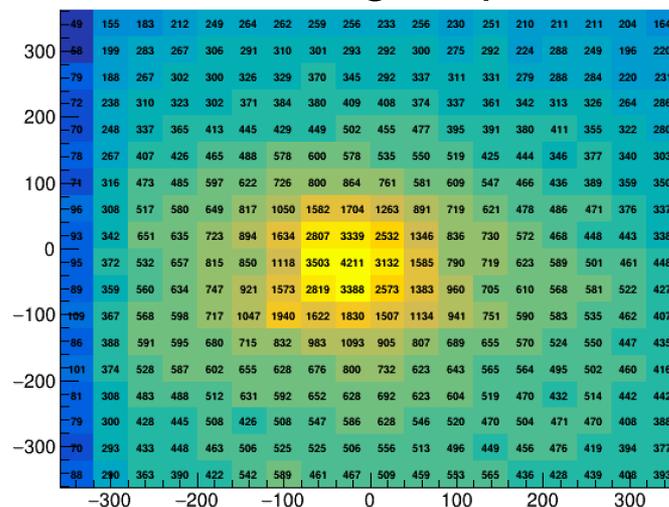
- We collected data until today
 - Muon+
 - 160 GeV/c
 - Pion+
 - 20, 30, 40, 50, 60, 70, 80, 90, 100, 120 GeV/c, one million per point
 - Electron
 - 10, 20, 30, 40 GeV/c, 10 thousand per energy point



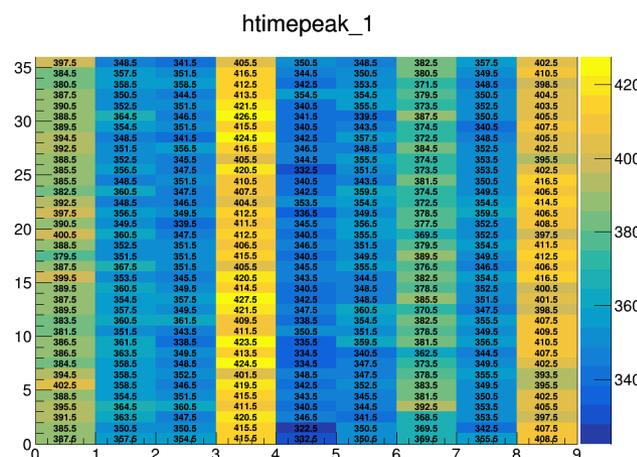
Mu+ test

- The energy reference should be taken from MIPs which could be calibrated using high energy muons
- Muon halo mode with 160 GeV/c
- The halo size is about 70 cm x 70 cm, close to the size of AHCAL sensitive area

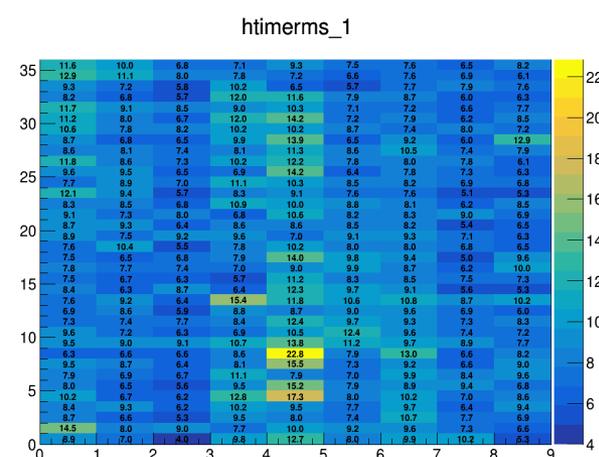
Hitting map



Pedestal



Pedestal Position

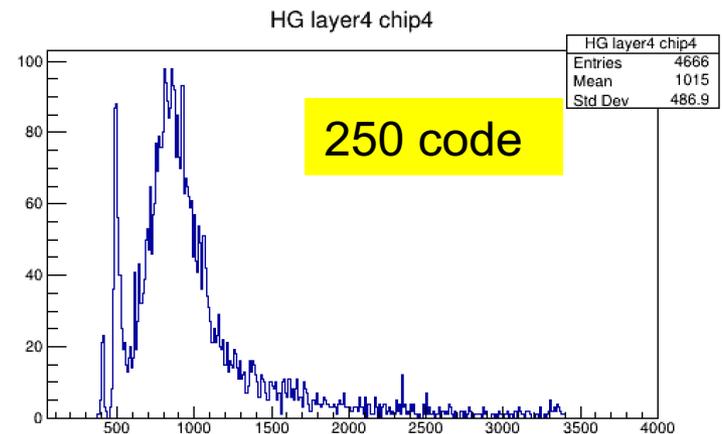
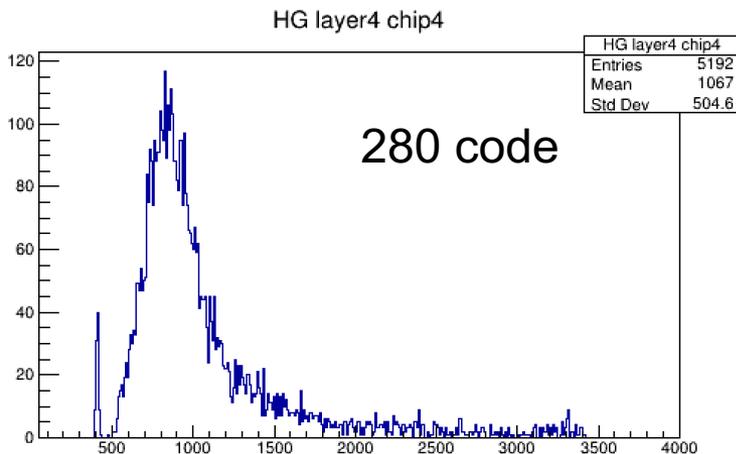
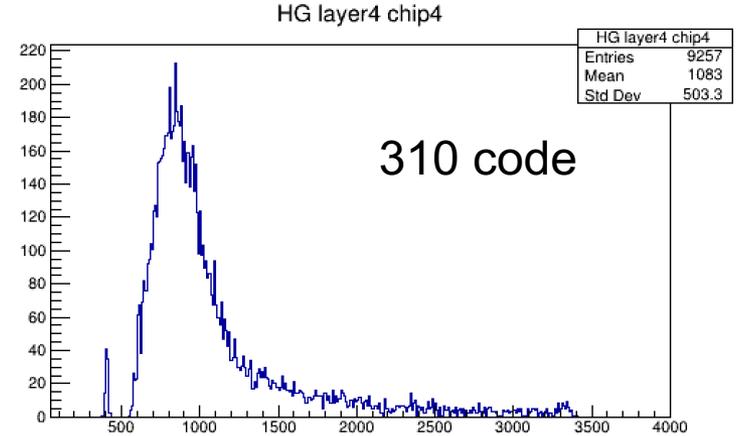
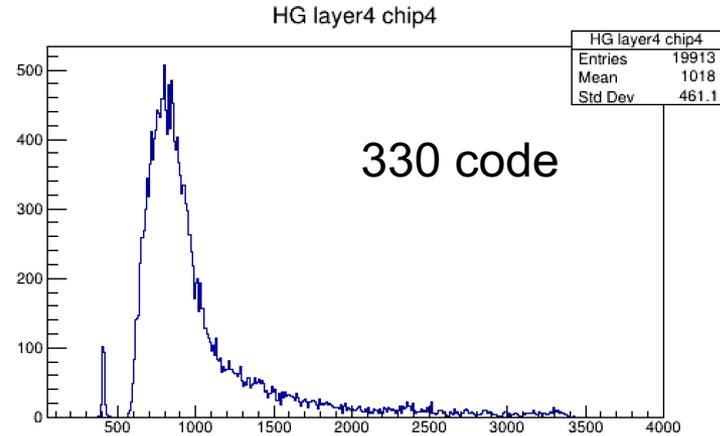


Pedestal rms



Mu+ test

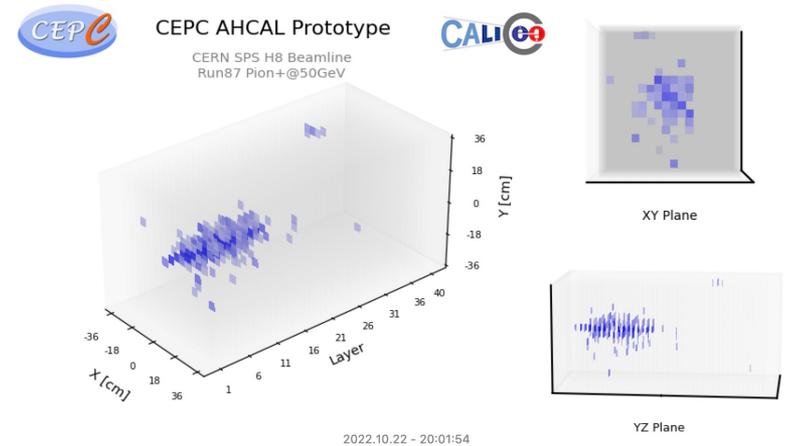
- The thresholds were calibrated using muon beam



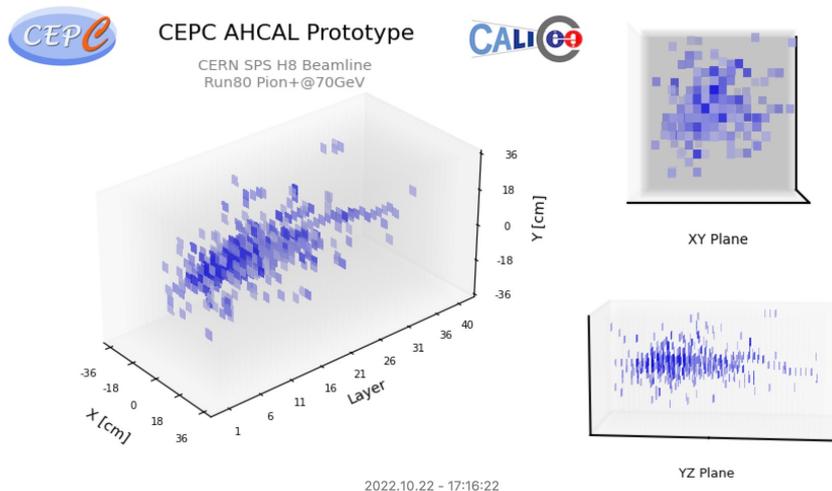
pion+ test

- The energy response of AHCAL was studied by pions
- In the past week, we tested AHCAL independently by pion beams

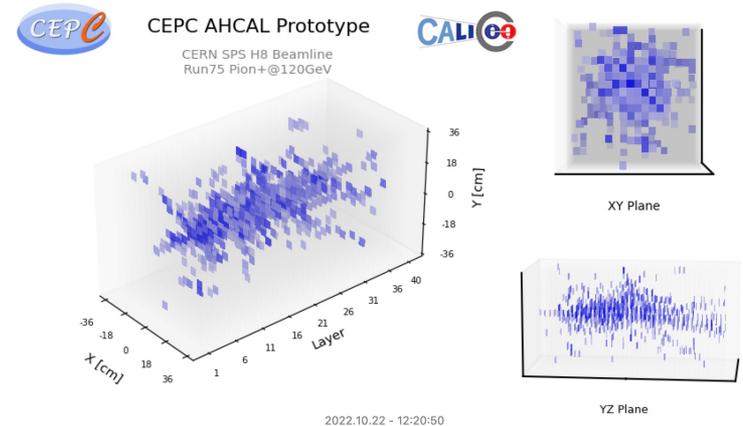
50 GeV



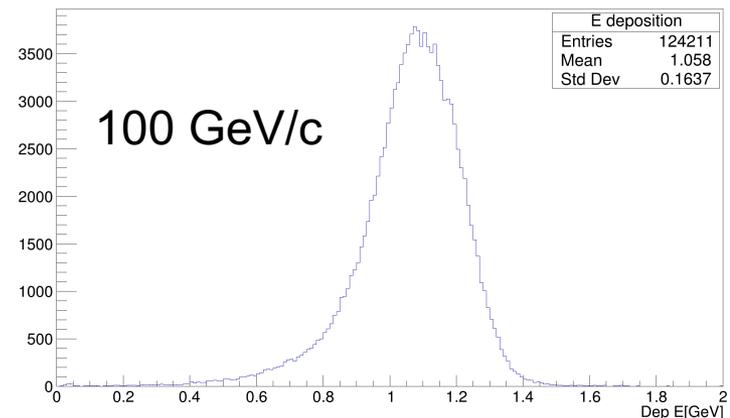
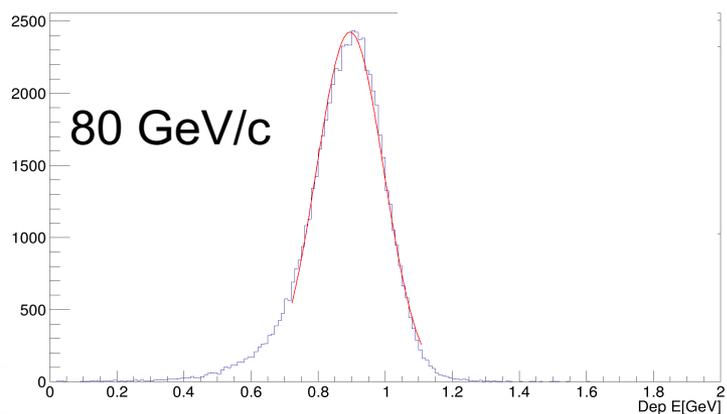
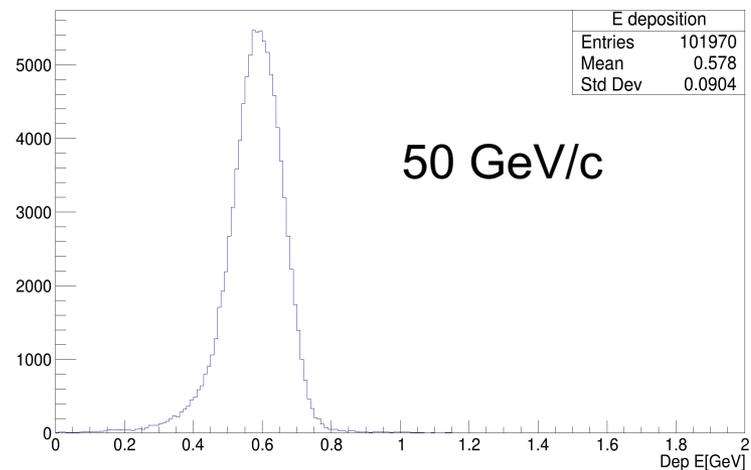
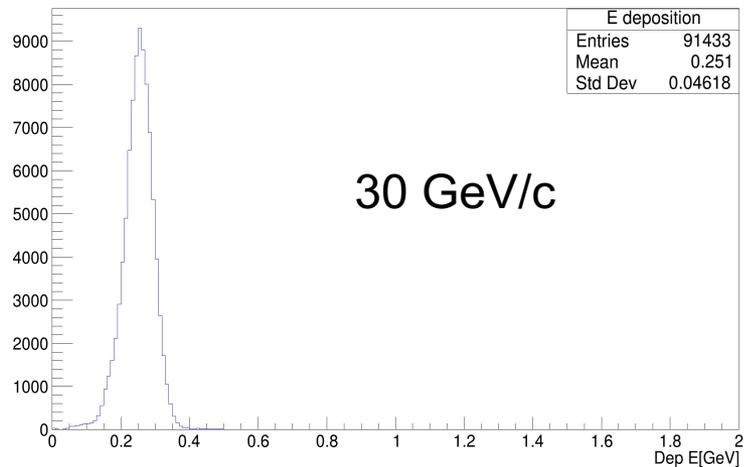
70 GeV



120 GeV

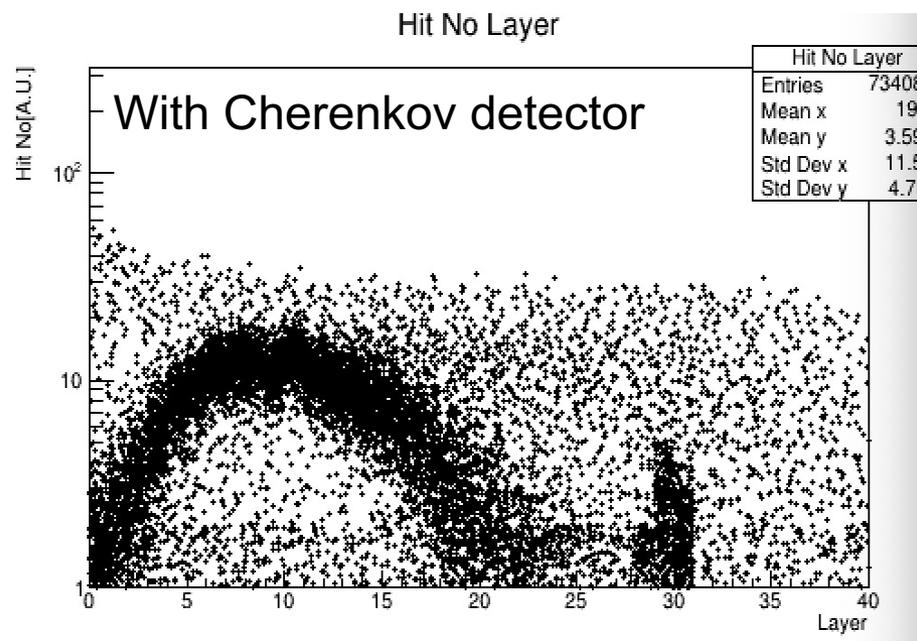
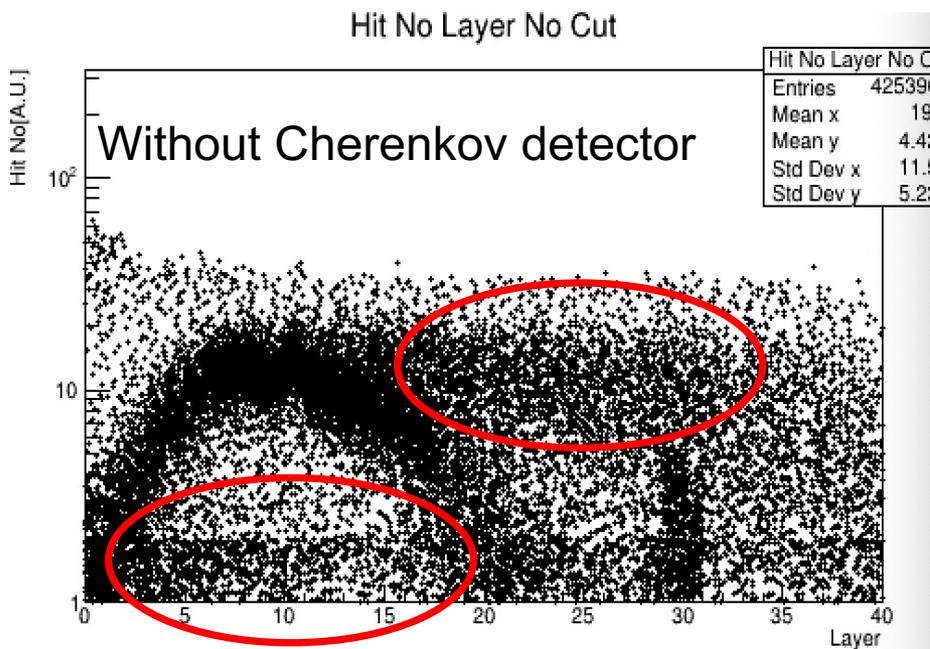
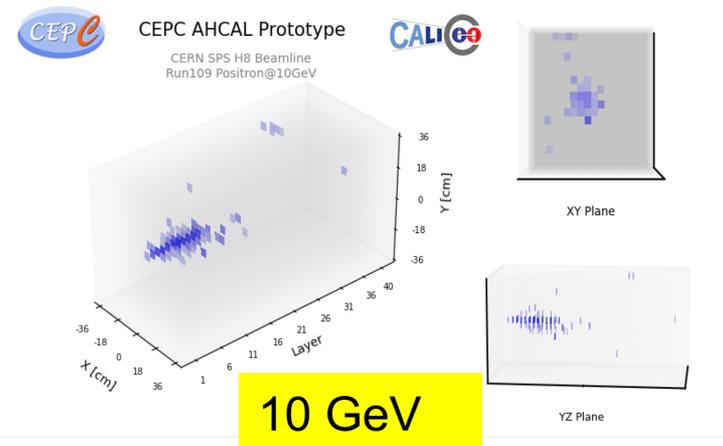


- The energy deposition in sensitive cells



positron test

- In order to study the AHCAL response to EM shower, the positron were used to calibrate AHCAL



Summary

- Both the Sci-W ECAL and AHCAL were assembled, and sent to CERN in early Oct.
- The two calorimeters has been taking beam test since Oct. 19, the preliminary results show the calorimeters work very well
 - The AHCAL were tested with pions and positrons from 10 GeV/c to 120 GeV/c
 - Next, we will switch to ECAL test using electrons, and to do the two calorimeters combination test





Bonfanti

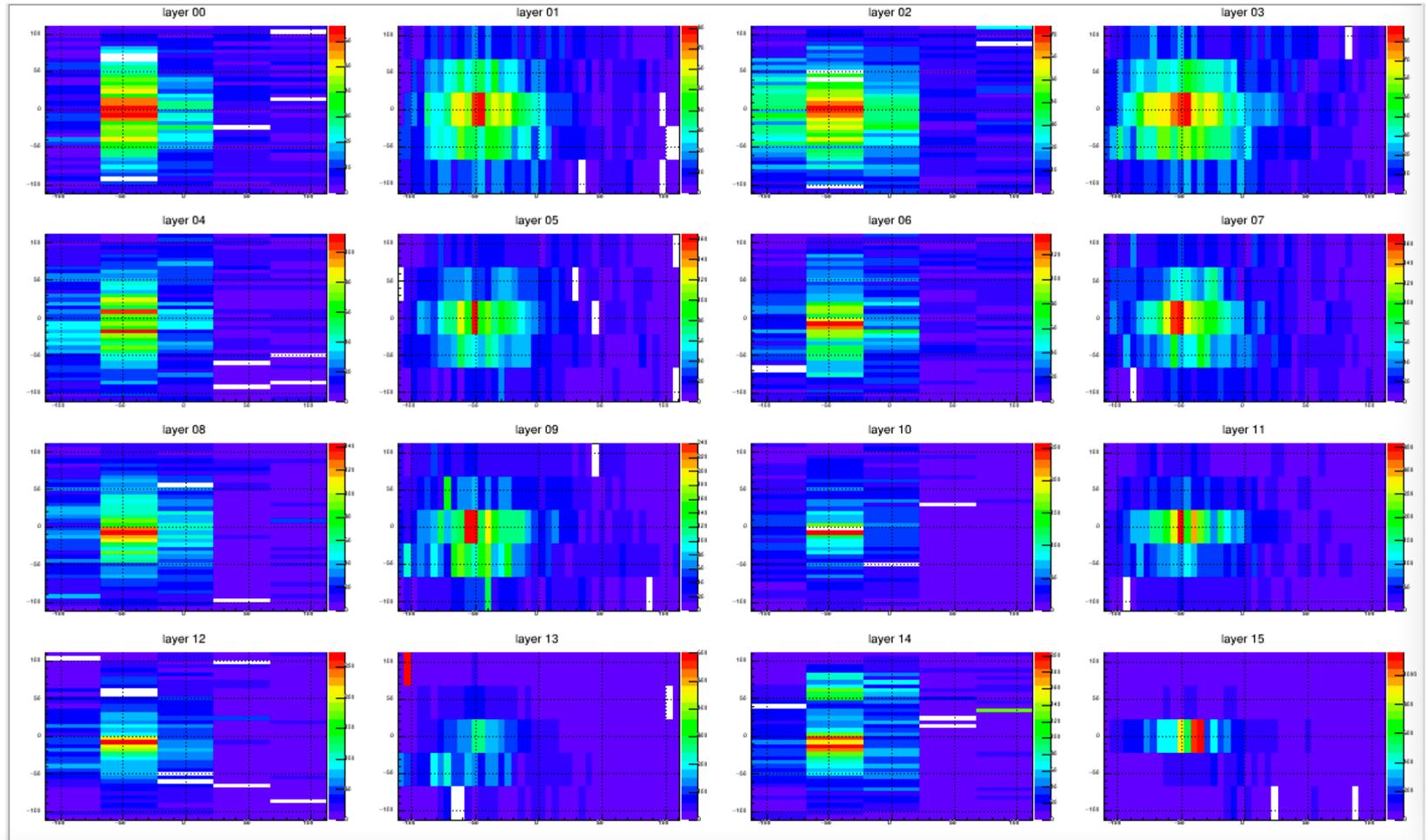
CALICO

THANKS

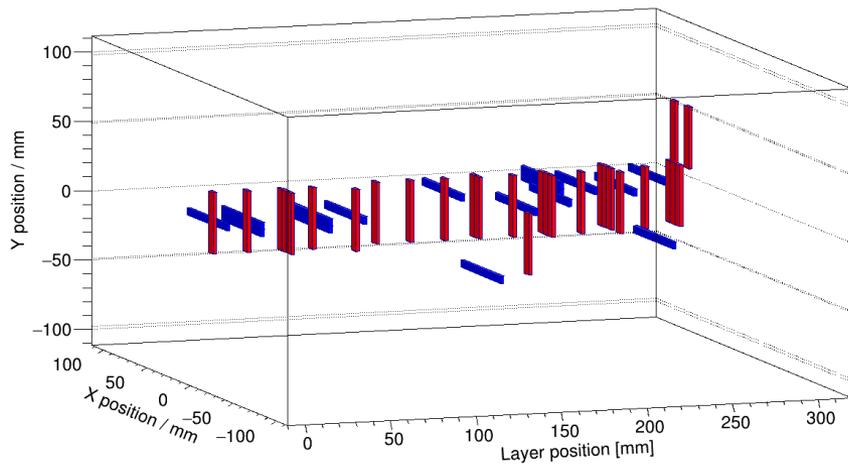
backup



PFA Calorimeter



EventID : 0



moun+ 160GeV

