

# 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

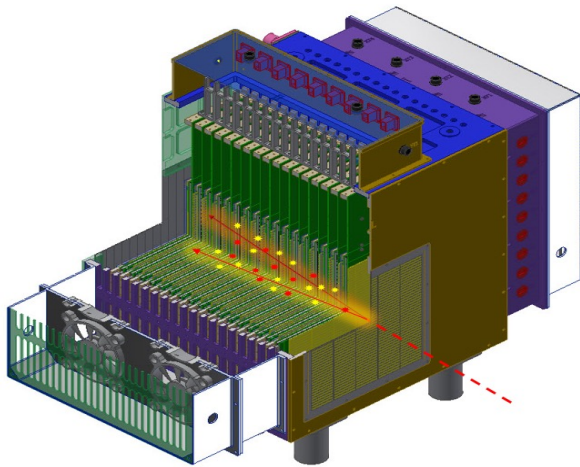
- CEPC PFA Calorimeter Prototypes  
Brief Introduction
- Beam test at CERN
- Summary



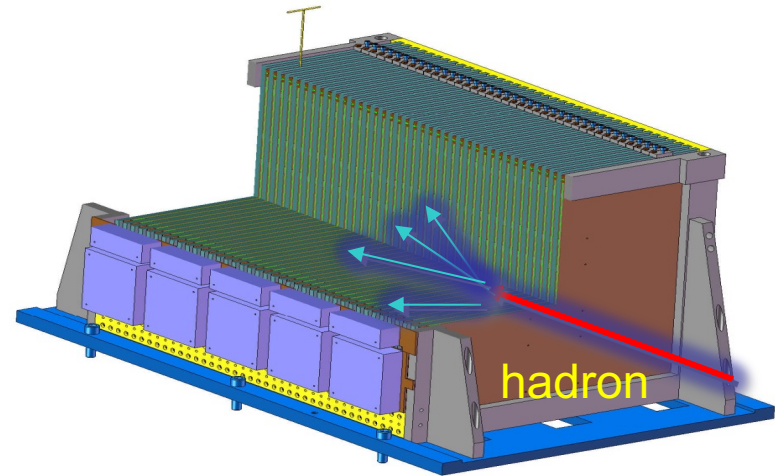
# PFA Calorimeter

## 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

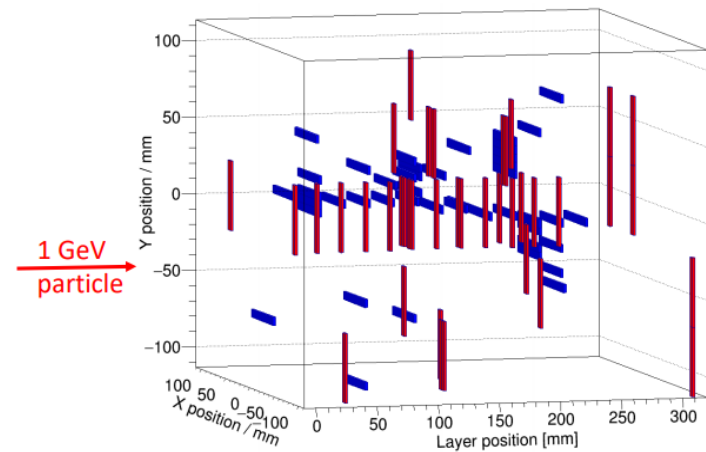
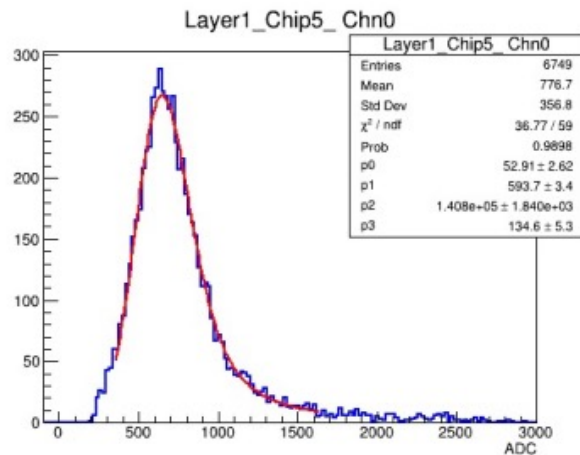


AHCAL



# Sci-W ECAL

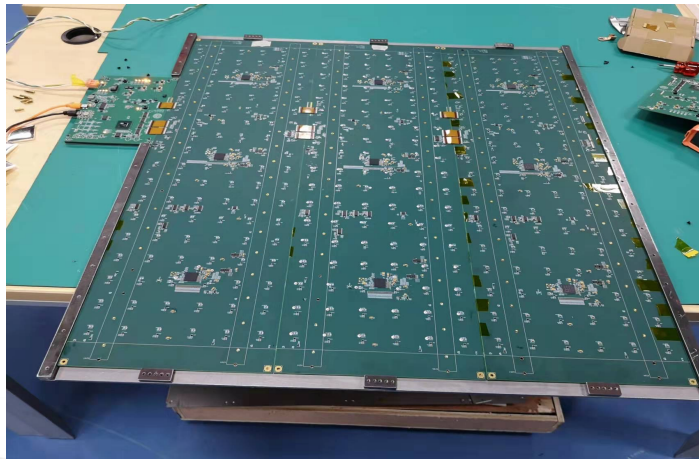
- Sci-W ECAL has been developed two years ago.
- It has been verified by long-term cosmic ray test in laboratory, and has been tested in IHEP in October 2020
- Its performance is stable.



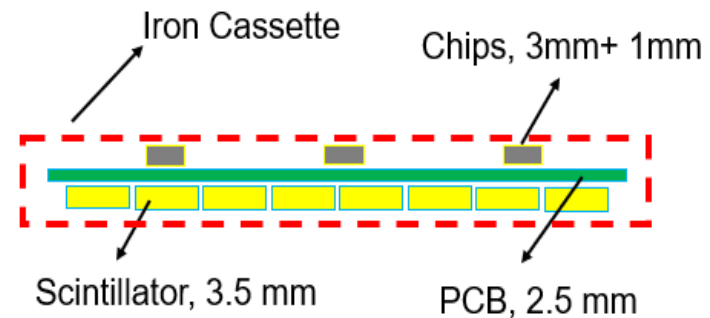


# AHCAL

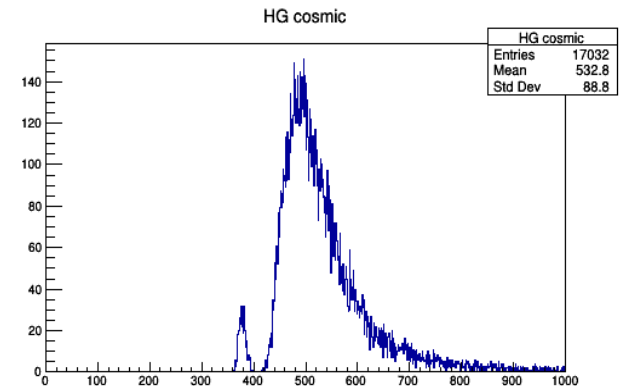
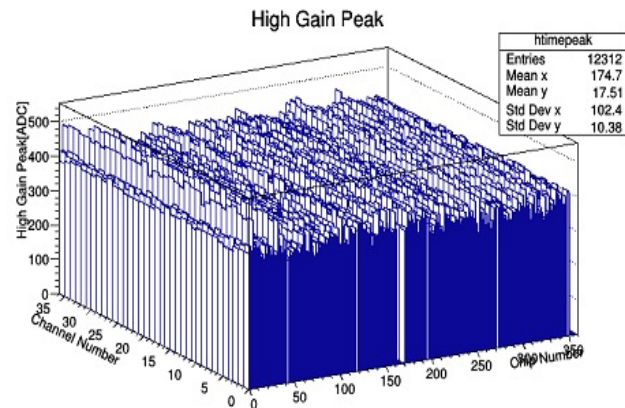
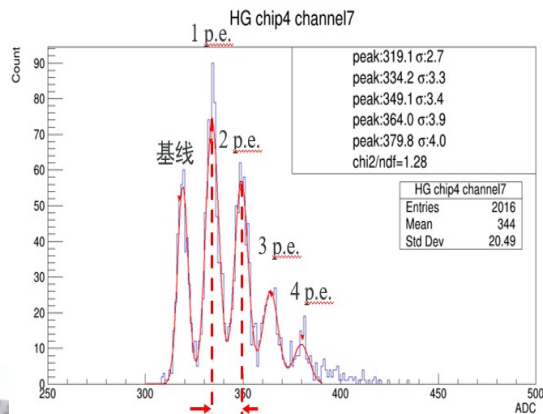
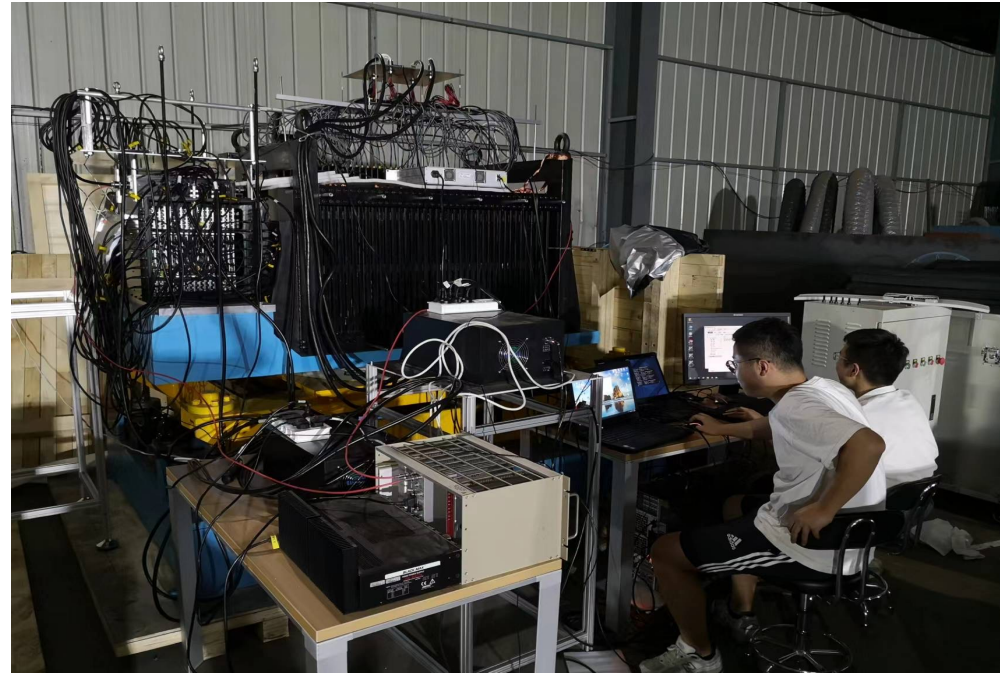
- ◆ The AHCAL was assembled this summer
  - ◆ It has 39 iron absorbers
    - ◆ Absorber: 20 mm iron
  - ◆ 40 sensitive layers, and sensitive area is  $\sim 72 \text{ cm} \times 72 \text{ cm}$ 
    - ◆ Each layer has 324 sensitive cells
    - ◆ Cell size is 40 mm x 40 mm



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  $\pm 20$  cm, and the up and down movement distance is  $\pm 15$  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

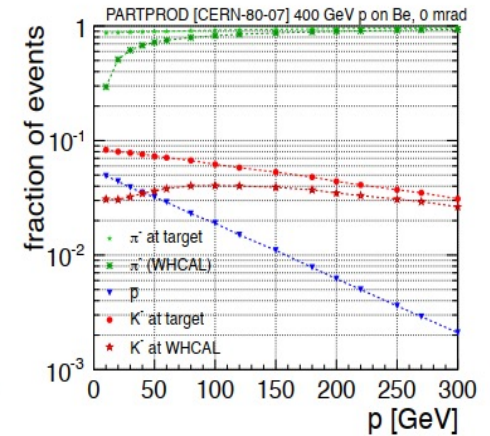
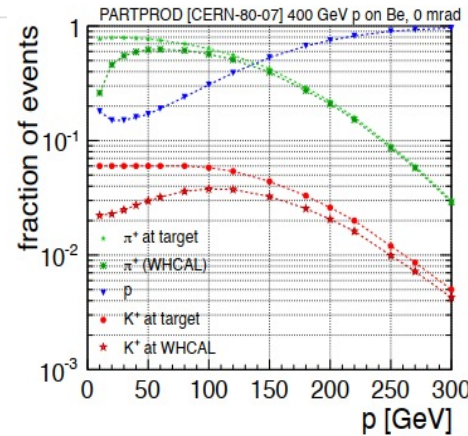
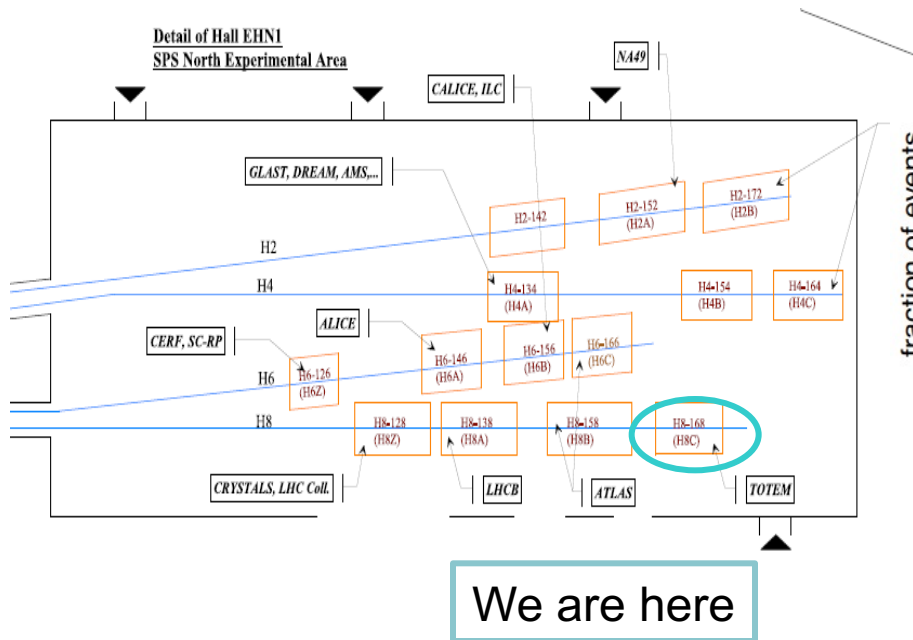
Version: 1.10

	Mon 26 Sep	Tue 27 Sep	Wed 28 Sep	Thu 29 Sep	Fri 30 Sep	Sat 1 Oct	Sun 2 Oct	Mon 3 Oct	Tue 4 Oct	Wed 5 Oct	Thu 6 Oct	Fri 7 Oct	Sat 8 Oct	Sun 9 Oct	Mon 10 Oct	Tue 11 Oct	Wed 12 Oct	Thu 13 Oct	Fri 14 Oct	Sat 15 Oct	Sun 16 Oct	Mon 17 Oct	Tue 18 Oct	Wed 19 Oct	Thu 20 Oct	Fri 21 Oct	Sat 22 Oct	Sun 23 Oct	Mon 24 Oct	Tue 25 Oct	Wed 26 Oct	Thu 27 Oct	Fri 28 Oct	Sat 29 Oct	Sun 30 Oct
Week	39							40							41							42							43						
Machine																																			
North Area	T2 - H2	Calice Sdhcal	NA65							CMS HGCal							LHCf							LHCb ECAL											
			A. Ariga PPE172							D. Lazic PPE172							Y. Itow PPE172							H. Schindler PPE172											
	T2 - H4	V. Gninenko PPE134+PPE144	NA64e							EB. Holzer							Place-holder							M.R. Jäkel, E. Oliveri PPE134, PPE154											
	T4 - H6 main user	CMS PIXELS	ATLAS ITK PIXEL							ATLAS AFP							MONO LITH							RD50											
			A. Rummler PPE146							A. Rummler PPE156							Dannheim Dao PPE156							E. Figueras											
	T4 - H6 parallel use	EP hybrid	ATLAS AFP BCM							ATLAS ITK PIXEL							ATLAS MALTA EP PIXEL							NA62 ATLAS HGTD											
			A. Rummler PPE146							A. Rummler PPE146							V. DaoD. Dannheim PPE146, PPE156							H. Danielsson PPE136											
	T4 - H8	UA9 Totem	UA9							LHCb CMS MTD (SLEDOM)							Calice ScW ECAL							NA60+											
			W. Scandale PPE128							H. Schindler, N. Neri PPE128, PPE138, PPE158, PPE168							J. Liu, E. Scomparin 158 or 168, PPE138							EP hybrid ATLAS HGTD E. Gkoukousis PPE136, PPE146											

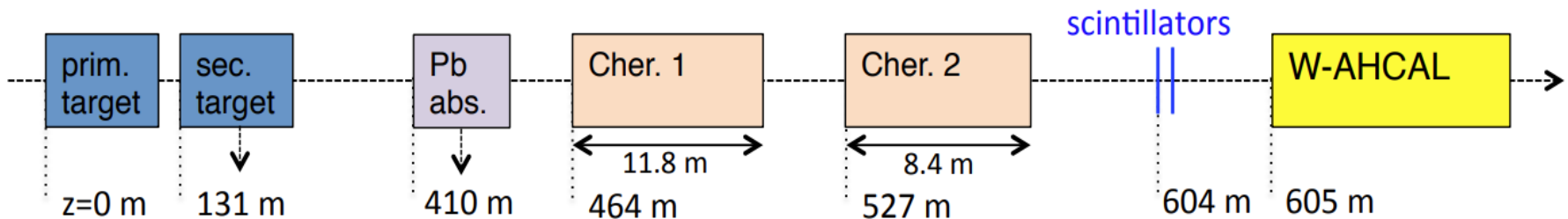




# H8 Beam Line



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.



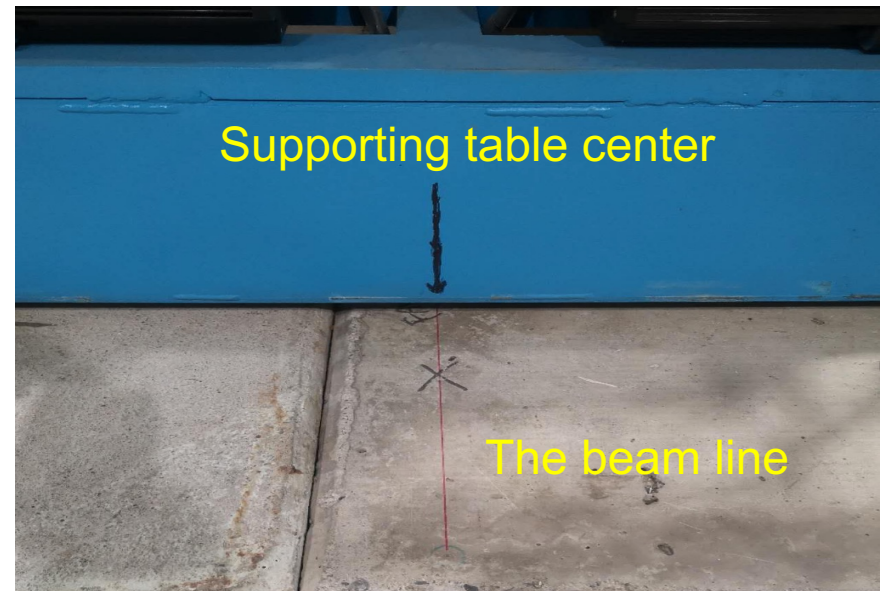
Hefei, 15/9



CERN, 14/10

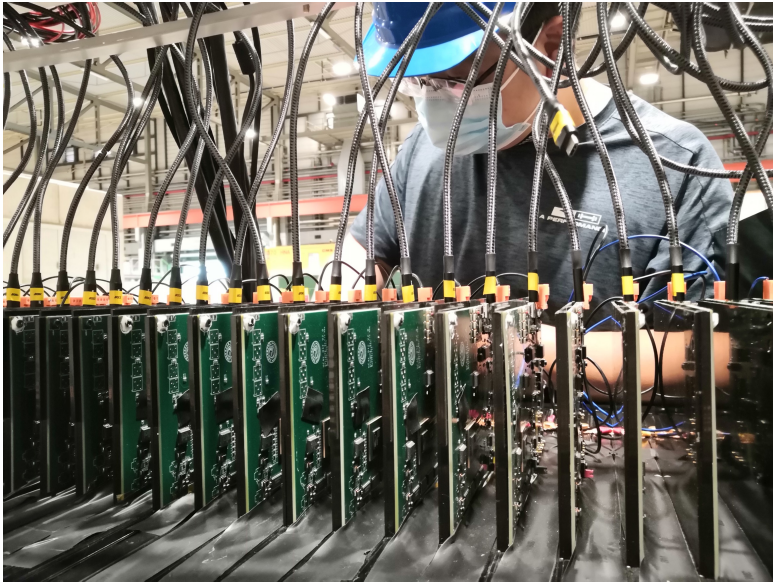


# Install the detectors in beam area





# Install the detectors in beam area



2022/10/24

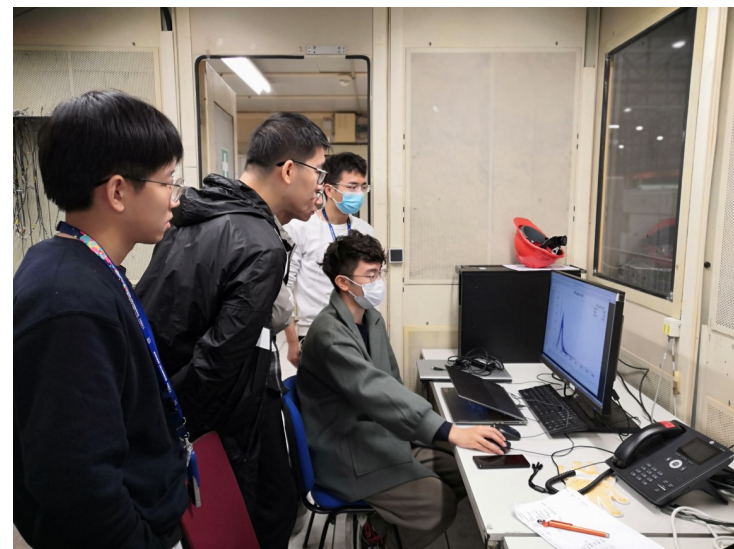
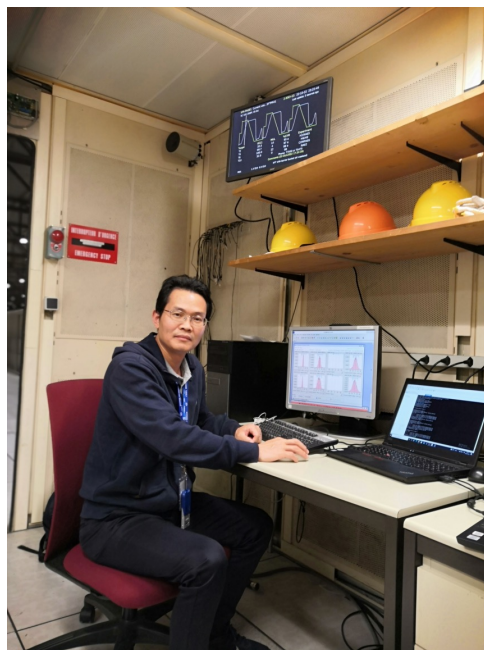


# Beam Test

◆ The calorimeters has been calibrated in H8

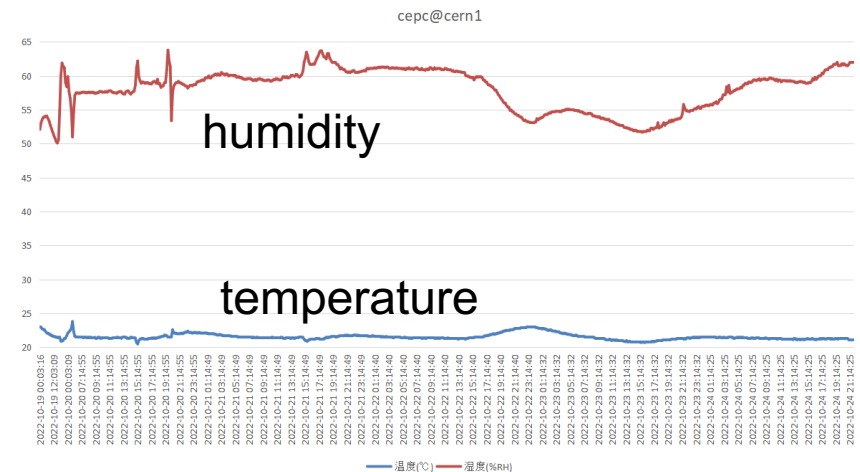
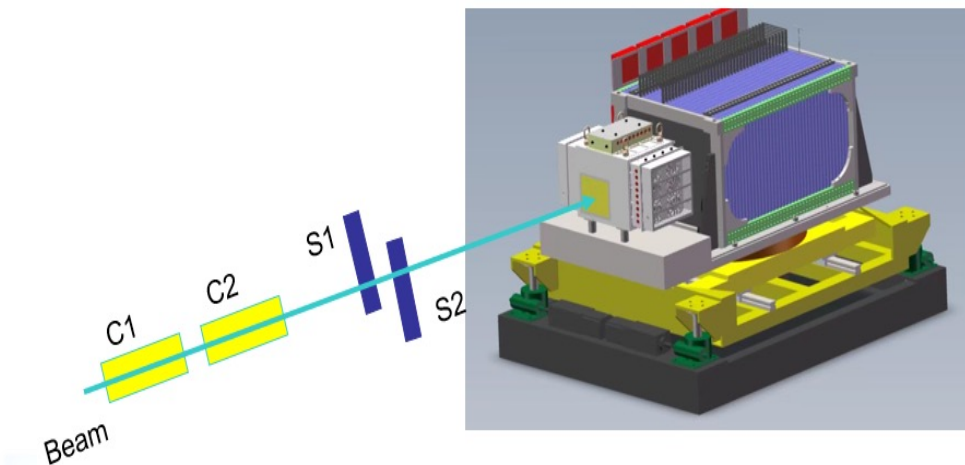
◆ 10 – 120 GeV/c pions

◆ 10 – 40 GeV/c positrons



# Beam test

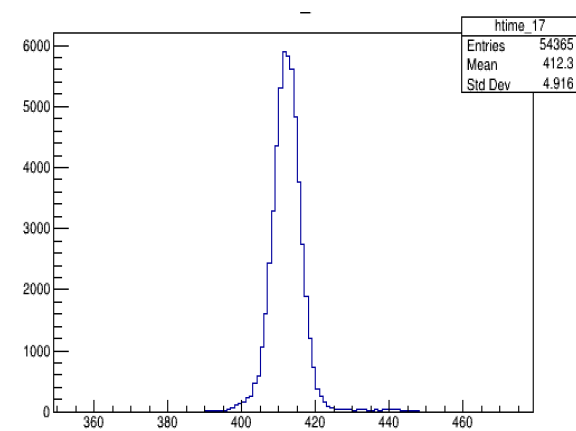
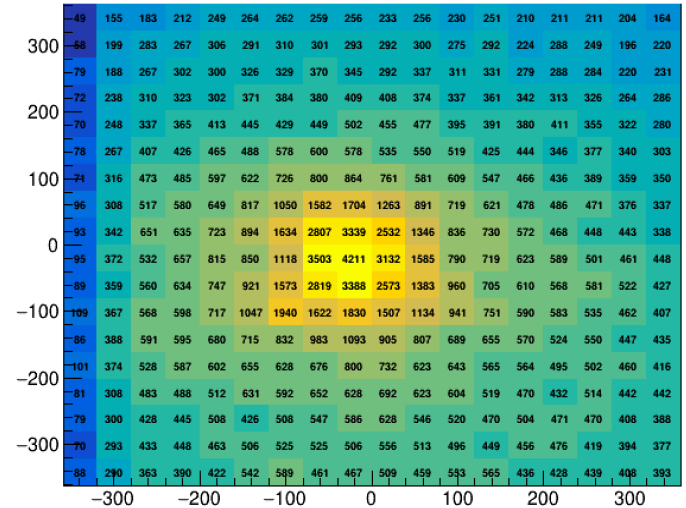
- We collected data until today
  - Muon+
    - 160 GeV/c
  - Pion+
    - 20, 30, 40, 50, 60, 70, 80, 90, 100, 120 GeV/c, one million per point
  - Electron
    - 10, 20, 30, 40 GeV/c, 10 thousand per energy point



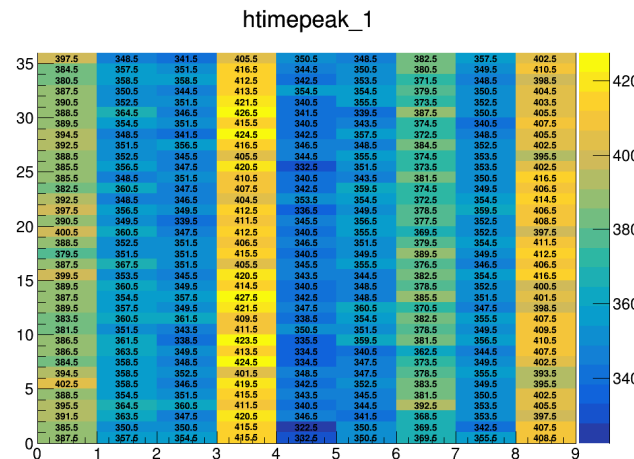
# Mu+ test

- 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

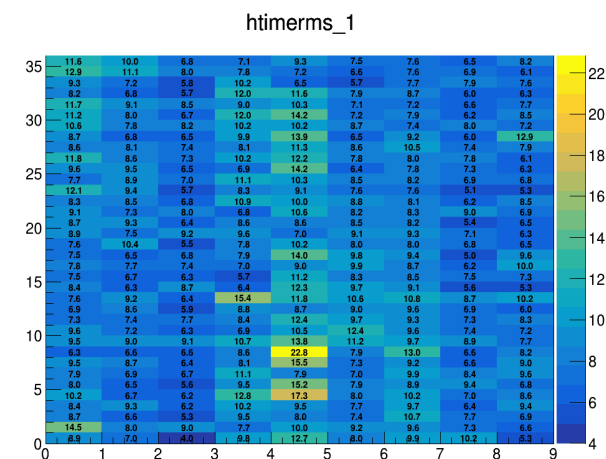
## Hitting map



Pedestal



Pedestal Position

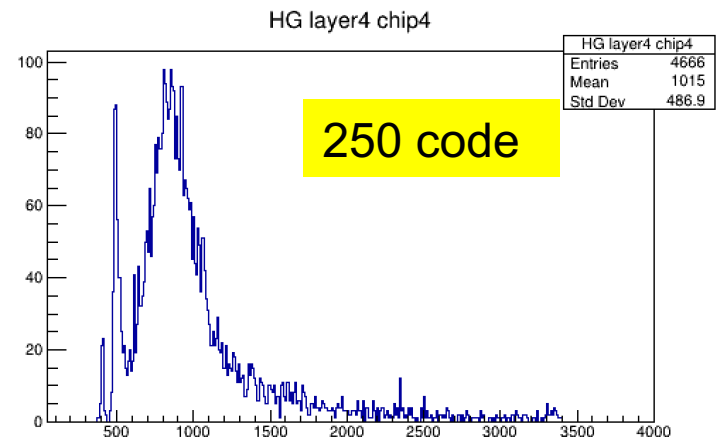
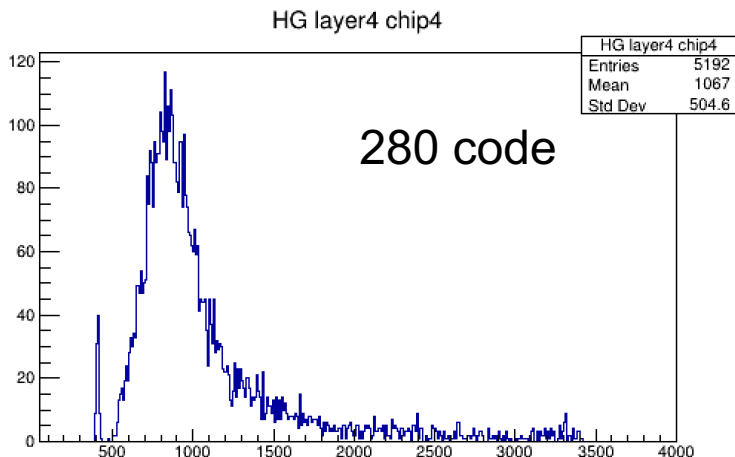
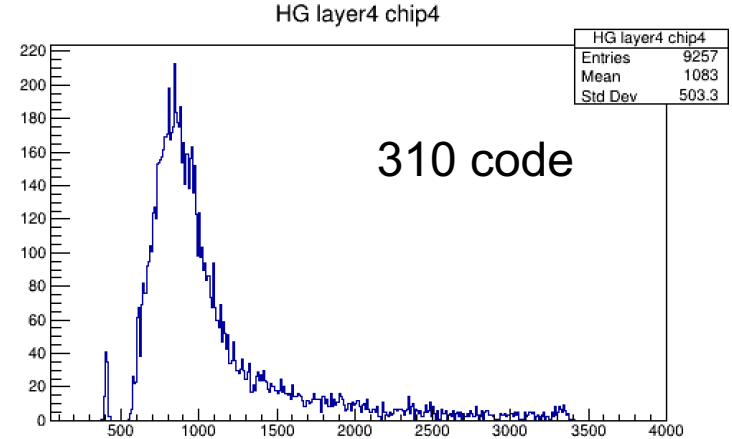
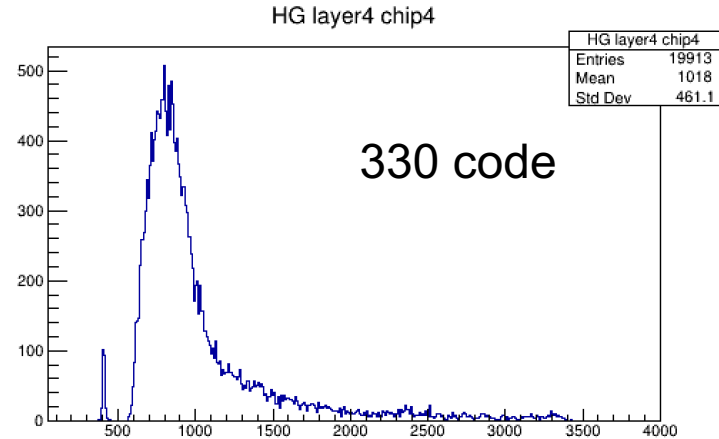


Pedestal rms



# Mu+ test

- The thresholds were calibrated using muon beam

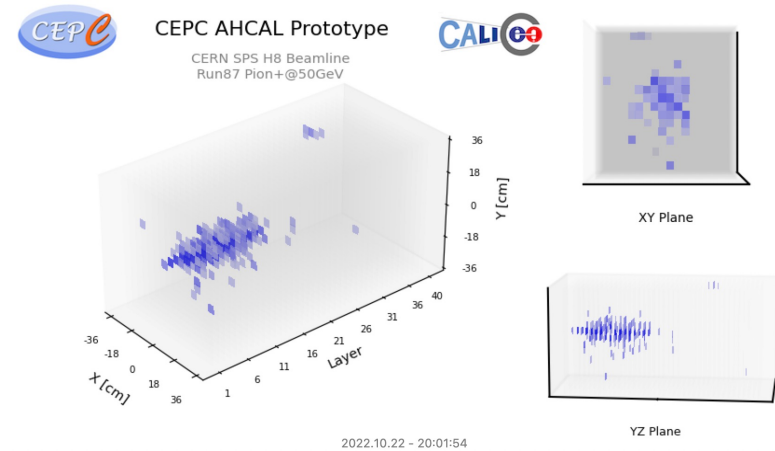




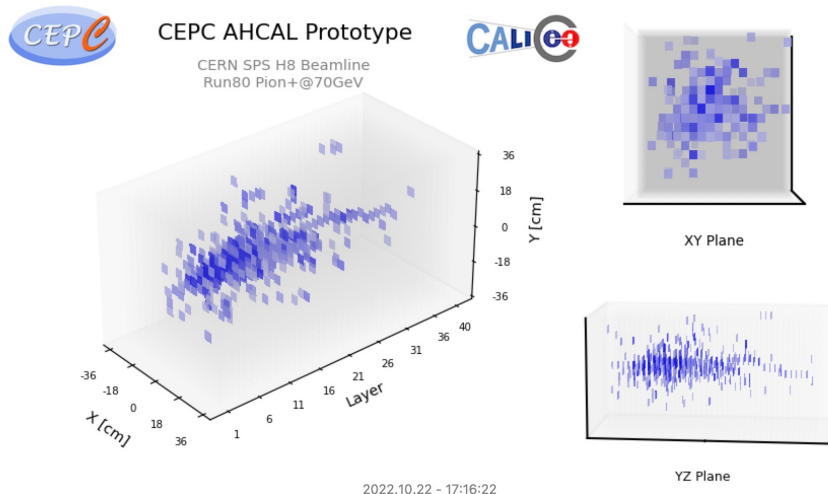
# pion+ test

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

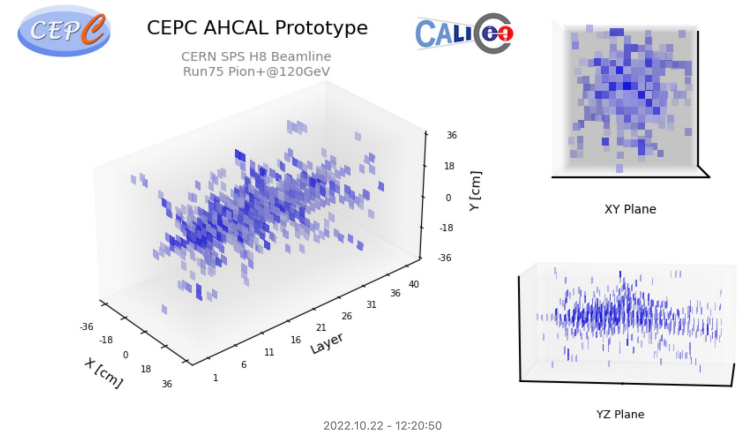
50 GeV



70 GeV

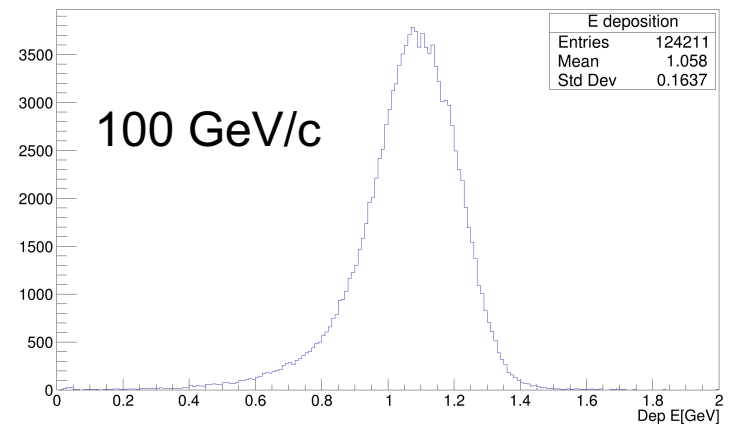
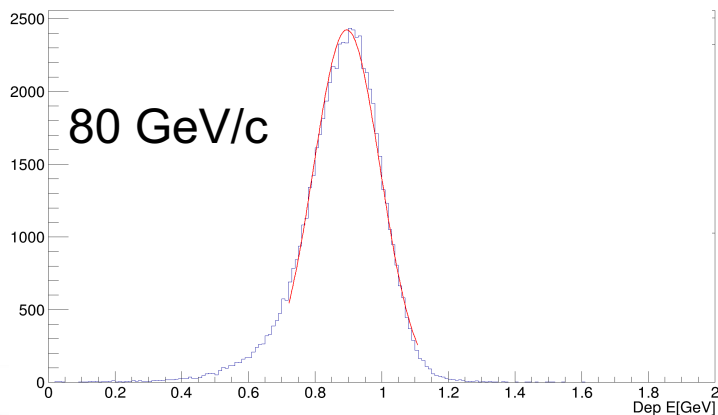
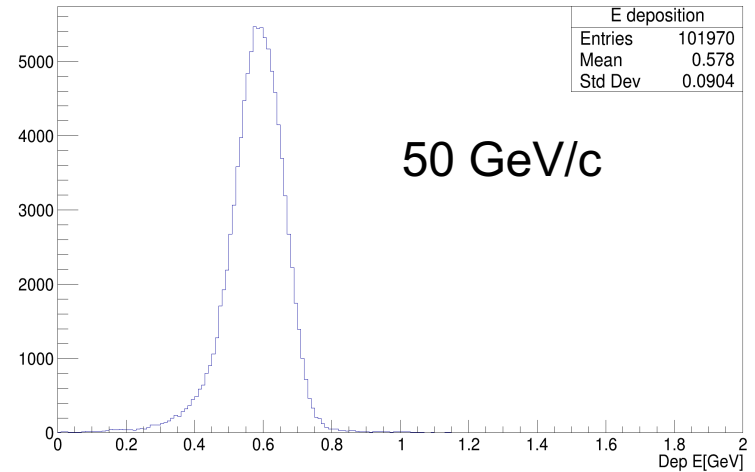
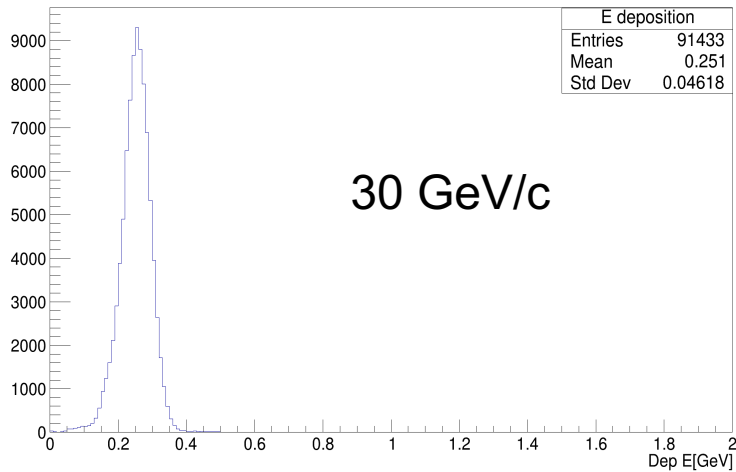


120 GeV



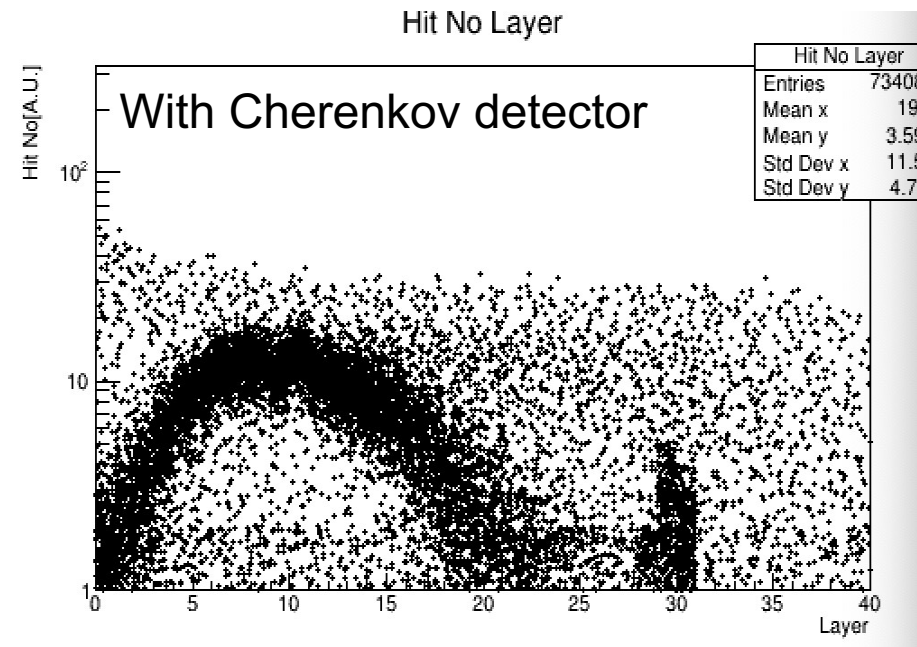
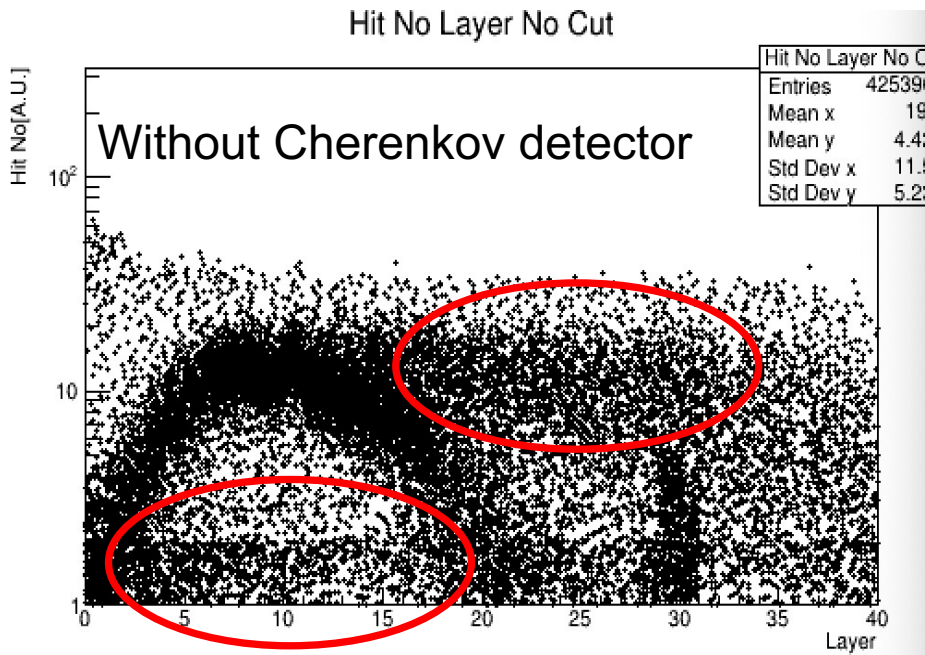
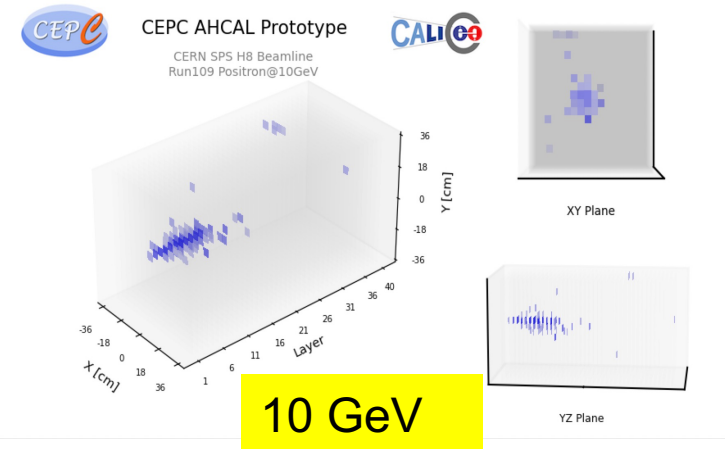
# pion+ test

- 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







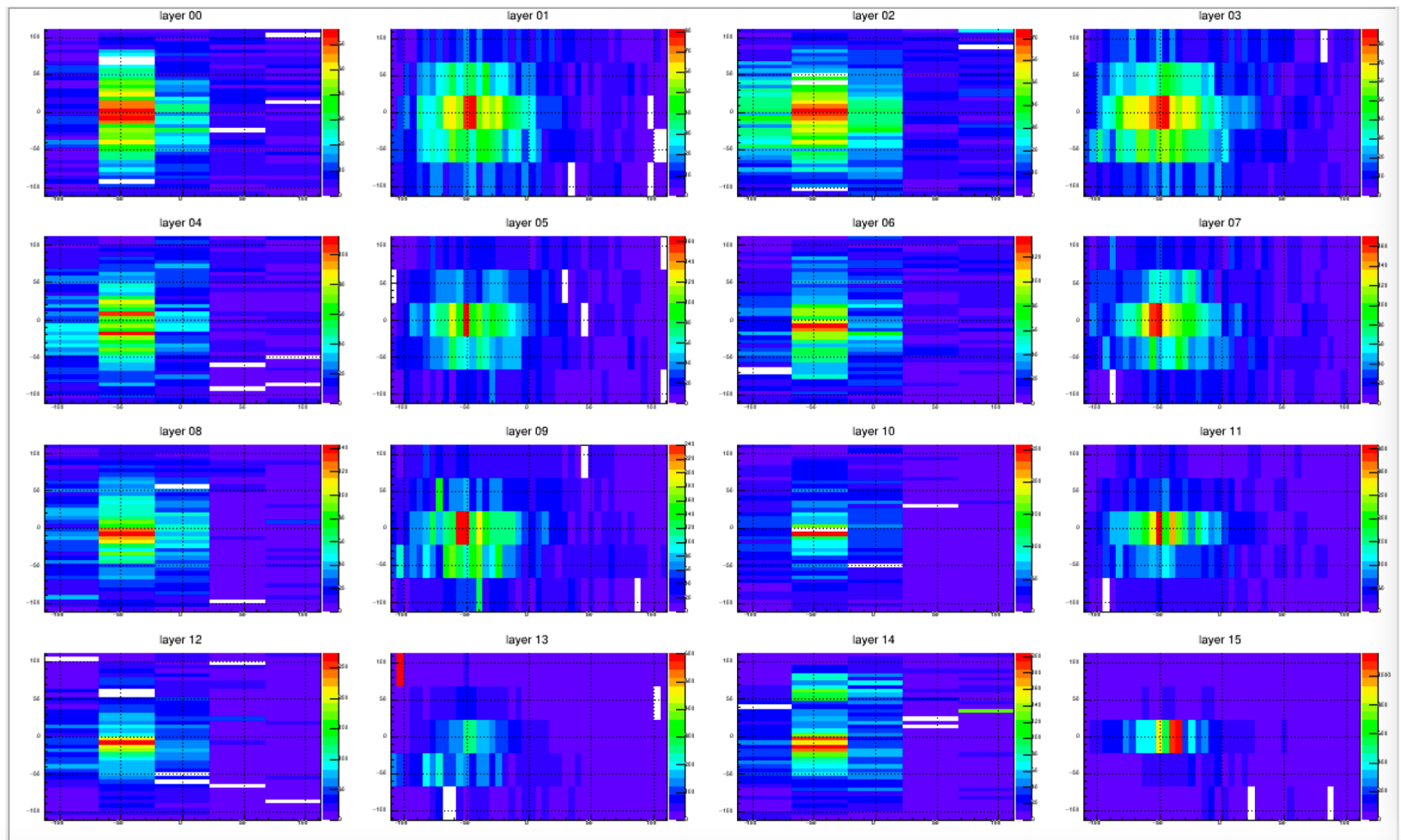
THANKS



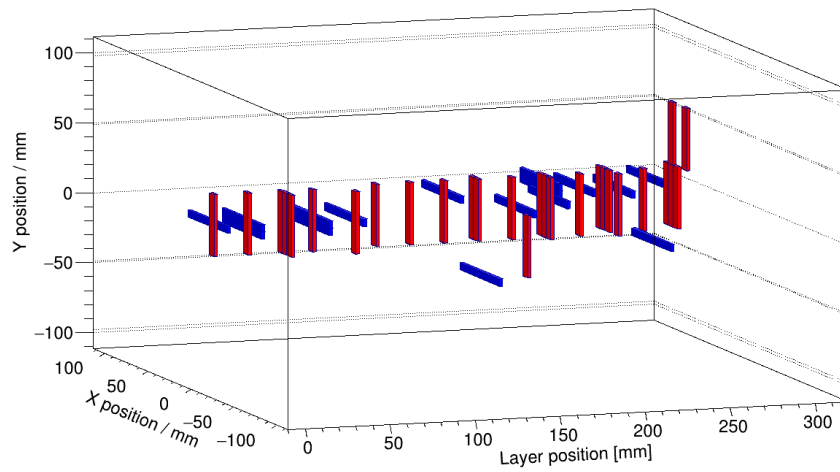
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# PFA Calorimeter



EventID : 0



moun+ 160GeV

