

# Sci-W ECAL Status for CEPC

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**On behalf of CEPC Calorimeter working group**



# Outline

- Brief review of Sci-W ECAL of CEPC
- CEPC ECAL Status
  - Super-layer assembly and test
  - Calorimeter trial assembly
  - Calorimeter cosmic ray test
- Summary and outlook



# PFA Calorimeter

## ➤ Challenges

### ➤ High granularity

➤ ECAL ~10 million channels

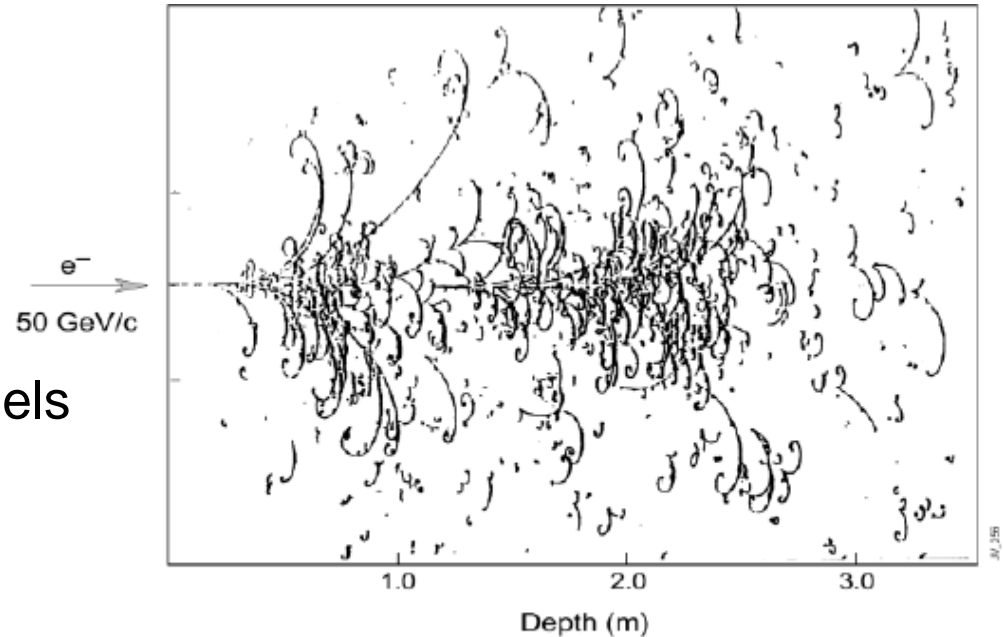
### ➤ Compact design

### ➤ High power

➤ ECAL about 100 kW

➤ EBU: 80 kW (without power pulsing)

➤ DIF: 20 kW

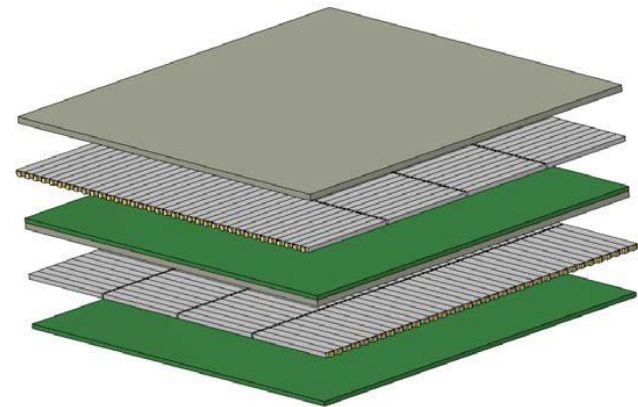
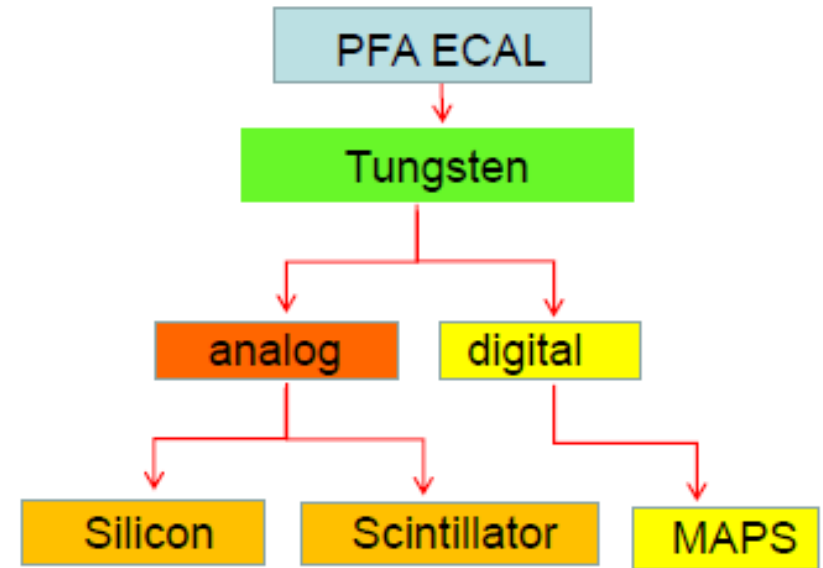


**Big European Bubble Chamber filled with Ne:H<sub>2</sub> = 70%:30%,  
3T Field, L=3.5 m, X<sub>0</sub>≈34 cm, 50 GeV incident electron**



# Sci-W PFA ECAL of CEPC

- **Sampling Calorimeter**
  - Sandwich structure
  - Absorber+SD+Electronics
- **Absorber**
  - Tungsten
- **Sensitive Detector**
  - Scintillator+SiPM
- **Electronics**
  - ASIC Chip



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# General Status

- All of the super-layers of the ECAL have been assembled
  - 16 super-layers were finished. 1 of them is for Japan group.
- The super-layers were tested by cosmic rays before installed into the ECAL structure
  - The 16 super-layers were divided into 5 groups and tested with cosmic rays.
- The prototype of calorimeter has been installed and tested
  - The first trial assembly of the prototype of the calorimeter was completed on August 3 in USTC



# Outline

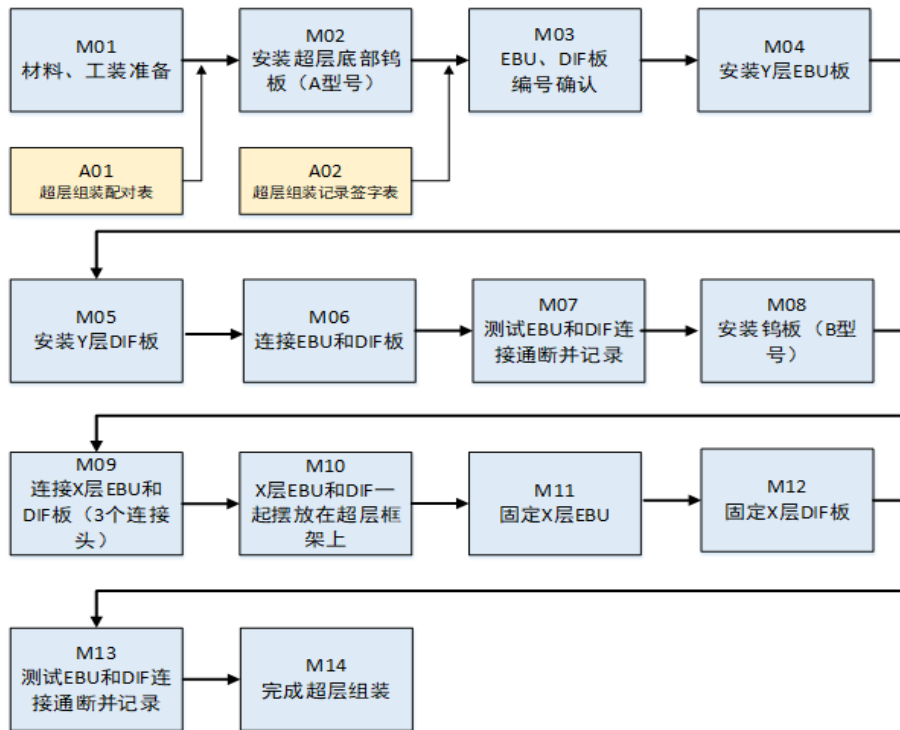
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# super-layer assembly

◆ An installation manual was prepared for the super-layer assembly



Installation process

## Installation manual

编号: \_\_\_\_\_  
密级: \_\_\_\_\_  
阶段标记: \_\_\_\_\_  
页数: \_\_\_\_\_

名称 CEPC Sci-W ECAL “超层” 组装指导书

签

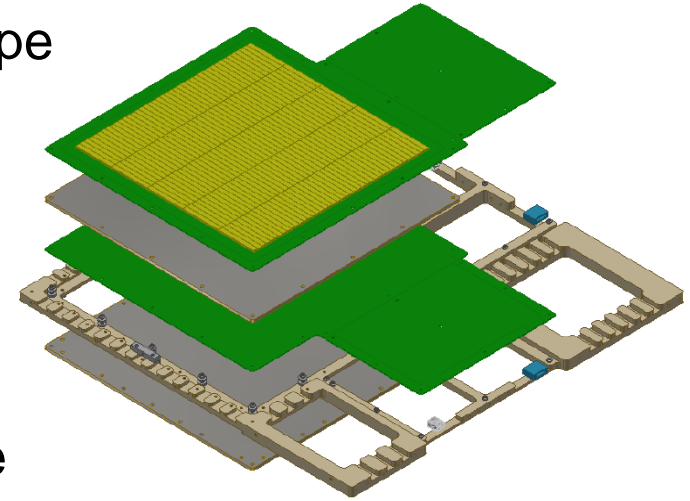
单位 中国科学技术大学  
编写 张云龙  
校对 沈仲茂  
审核 牛亚洲  
标审 周安顺  
批准 刘建北

中国科学技术大学  
2020年5月

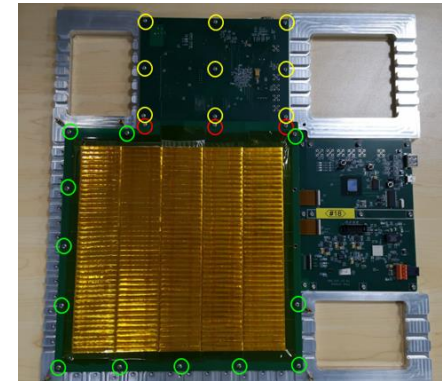
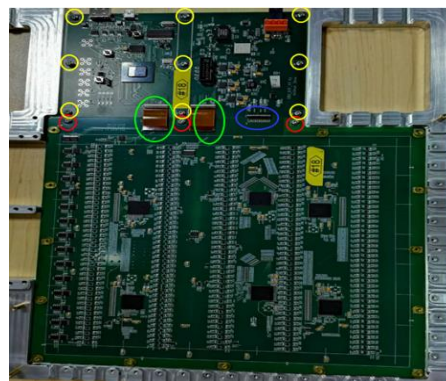
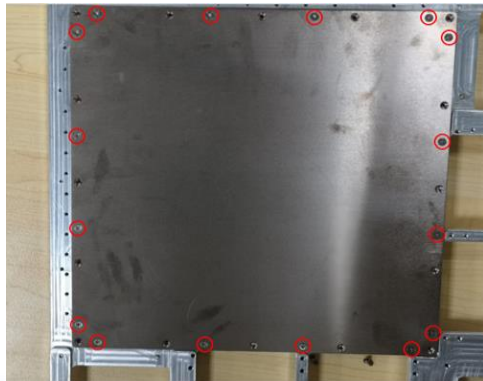


# super-layer assembly

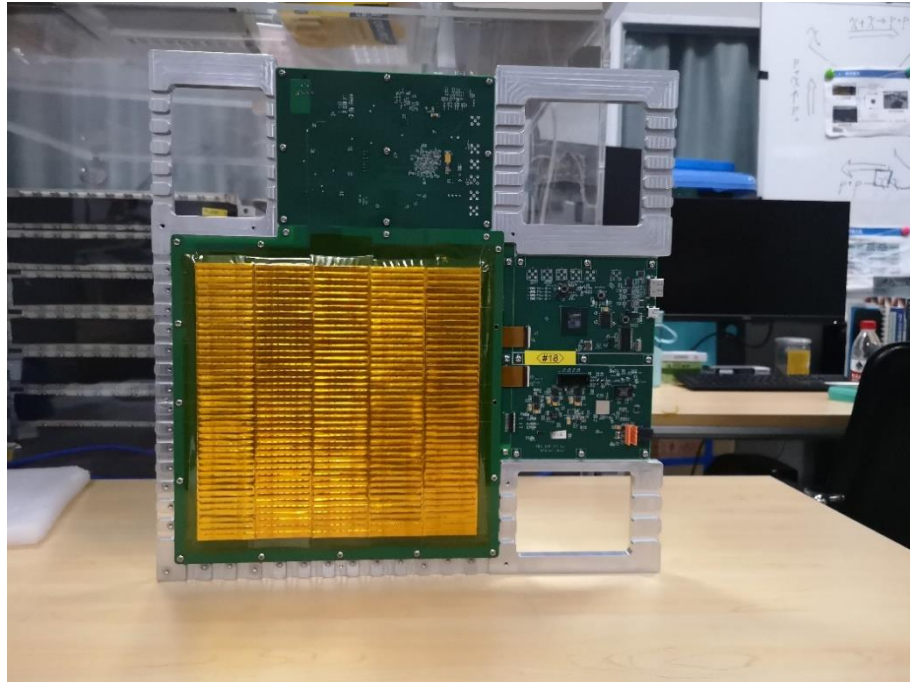
- ◆ There are 16 super-layers in ECAL prototype
- ◆ Each super-layer has 2 Ecal Board Units (EBU) and 2 Data InterFace boards (DIF)
- ◆ Also has 2 W-Cu alloy plates, W:Cu 85%:15%, thickness is 3.2 mm  $\sim 0.73 X_0$
- ◆ The aluminum frame is used to support the super-layer



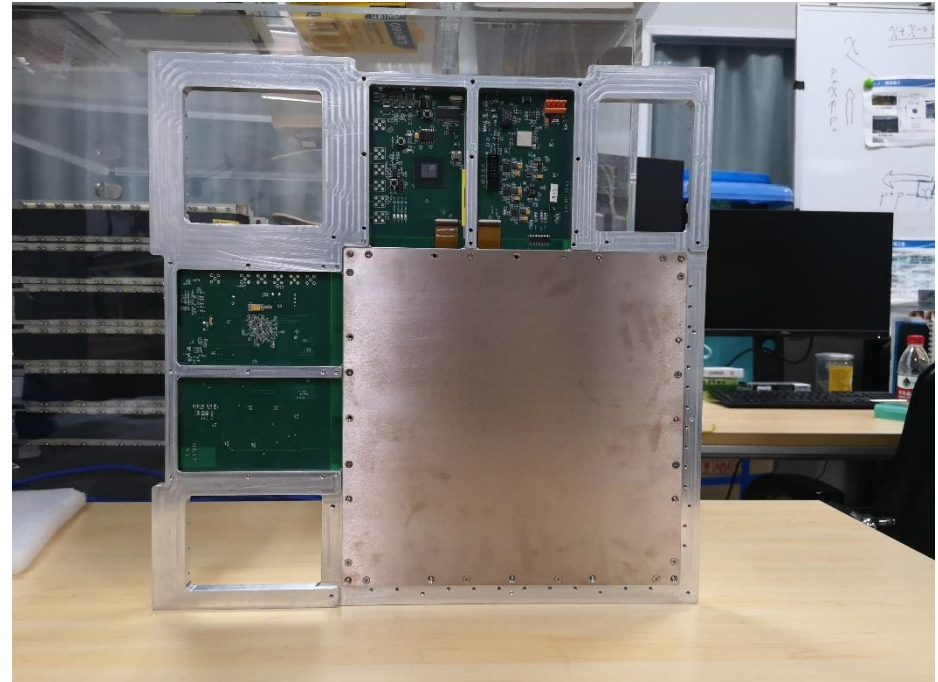
The structure of super-layer



# Super-layer assembly



A-side



B-side





# Super-layer assembly



Sci-W ECAL 样机超层组装记录表

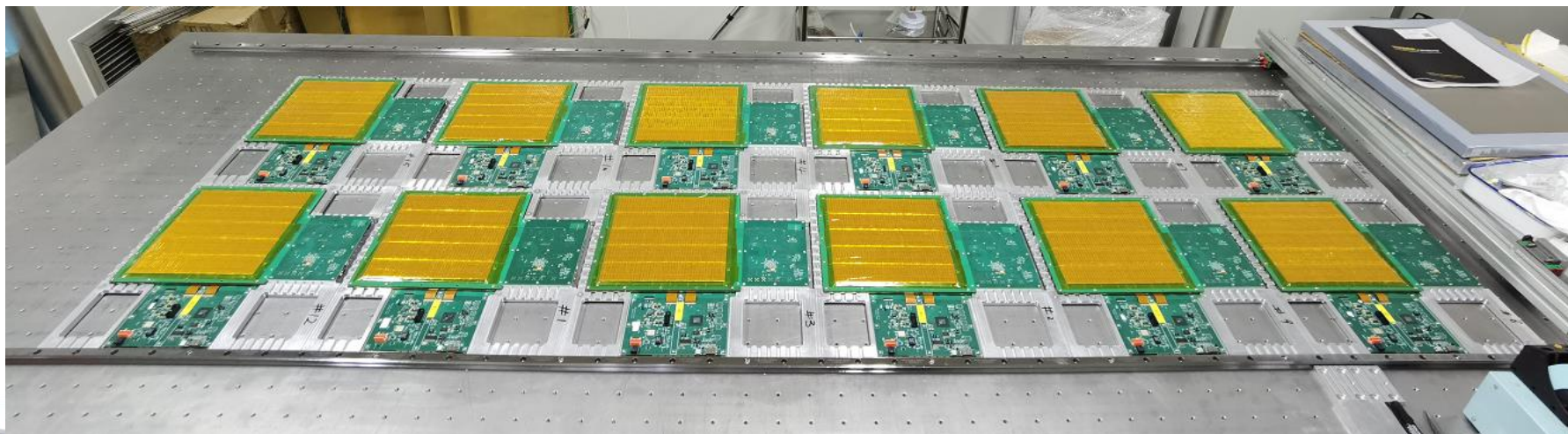
第十二层超层板板号确认:

类型	编号	编号确认	备注
超层	12	<input checked="" type="checkbox"/> <input type="checkbox"/> X	
Y 维度 ERU	24	<input checked="" type="checkbox"/> <input type="checkbox"/> X	
Y 维度 DF	24	<input checked="" type="checkbox"/> <input type="checkbox"/> X	
X 维度 ERU	23	<input checked="" type="checkbox"/> <input type="checkbox"/> X	
X 维度 DF	23	<input checked="" type="checkbox"/> <input type="checkbox"/> X	

第十二层超层板板号电压测试:

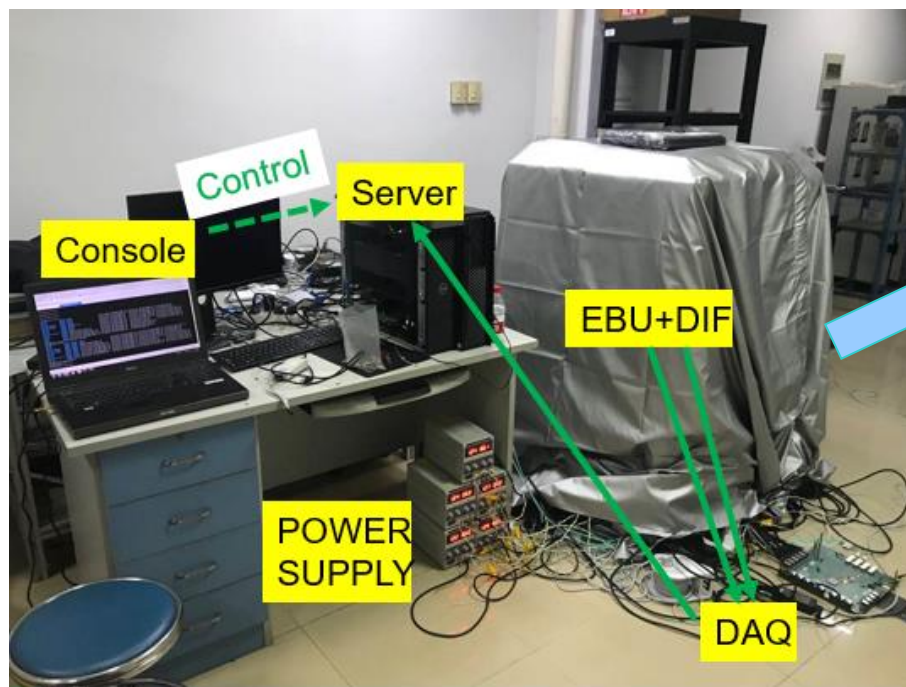
板号	管脚编号 1	管脚编号 2	阻值范围 (Ω)	实测阻值 (Ω)	是否正常	备注
Y 维度 ERU-DF	ERU J18 GND	DF GND 孔	<0.1	0.0	<input checked="" type="checkbox"/> <input type="checkbox"/> X	通
	ERU U17 C1223 正 (双线)	DF SV0 孔	<0.15	0.0	<input checked="" type="checkbox"/> <input type="checkbox"/> X	5V 电源 连通
	ERU C788 正	DF SV3_A 孔	<0.15	0.0	<input checked="" type="checkbox"/> <input type="checkbox"/> X	3V3A 连通
	ERU C760	DF SV3_IN			<input checked="" type="checkbox"/> <input type="checkbox"/> X	3V3B 连通

Record form

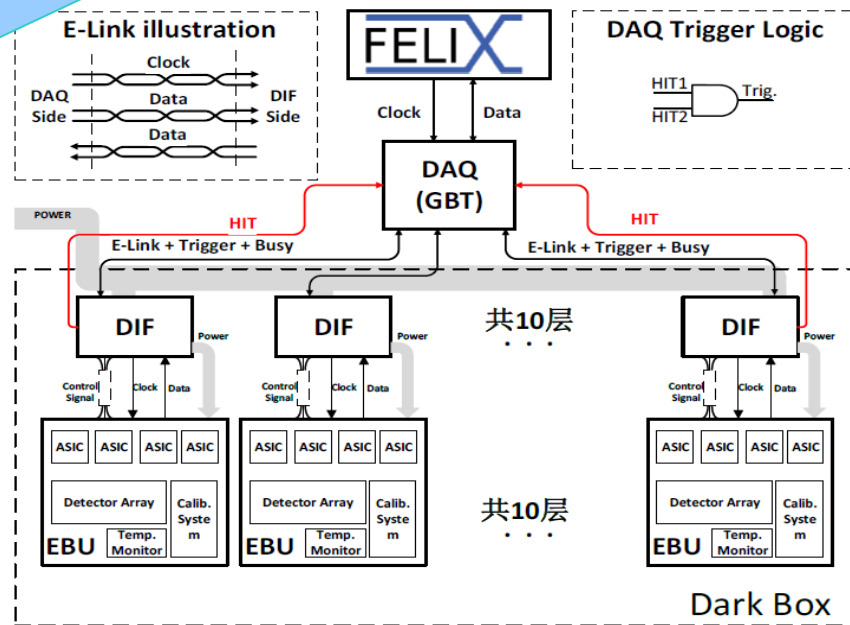
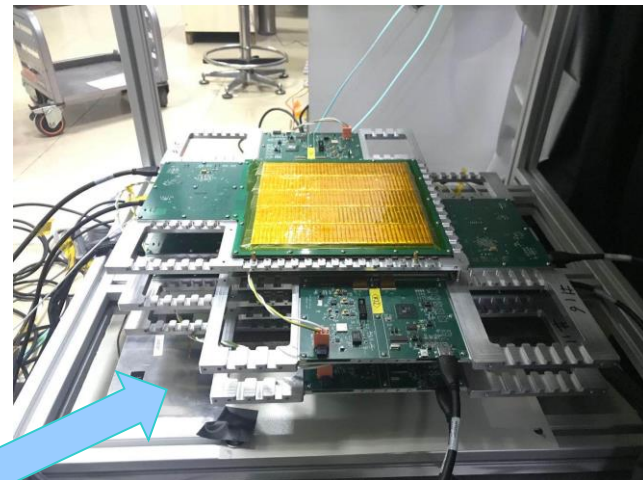


# Super-layer test

- The super-layer was tested with cosmic rays before installed into the calorimeter



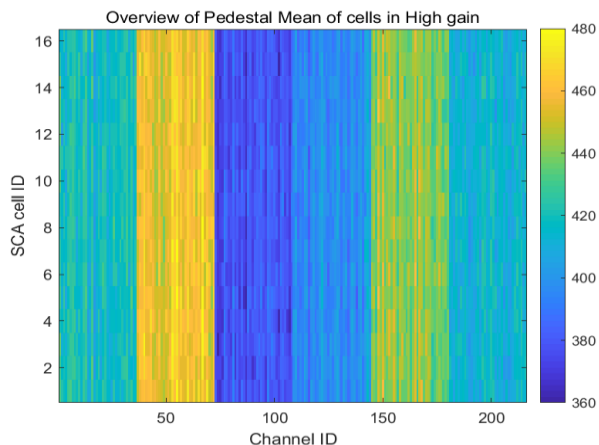
Multi Super-layers cosmic ray test



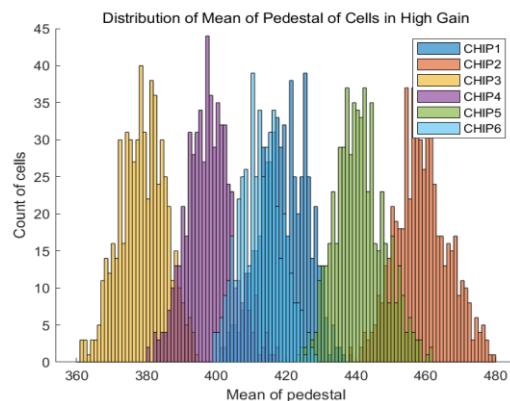


# Super-layer test

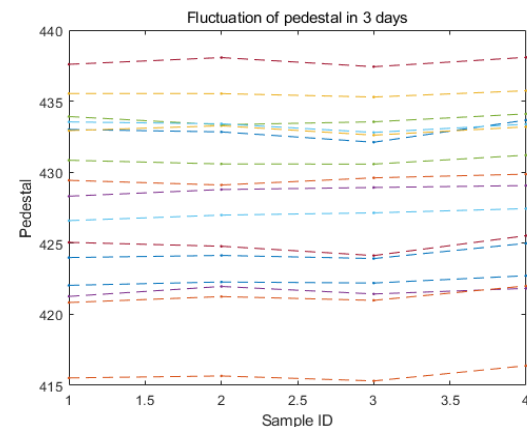
- The noise of each cell in each channel tested by random trigger from DIF boards
  - The pedestal position of different chips is a little different
  - The pedestal position of the same chip is more uniform
  - The pedestal position is very stable with the change of time



Pedestal position of each cell in each channel



Pedestal position distribution of each channel



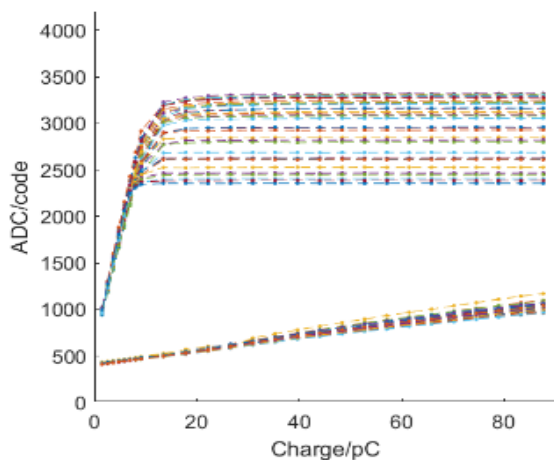
Pedestal position stability (3 days)



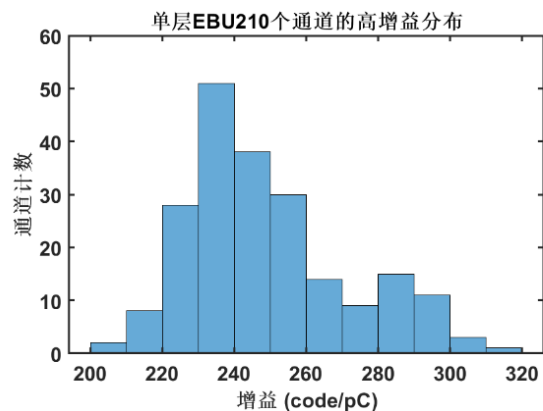
# Super-layer test

## ➤ The readout linearity

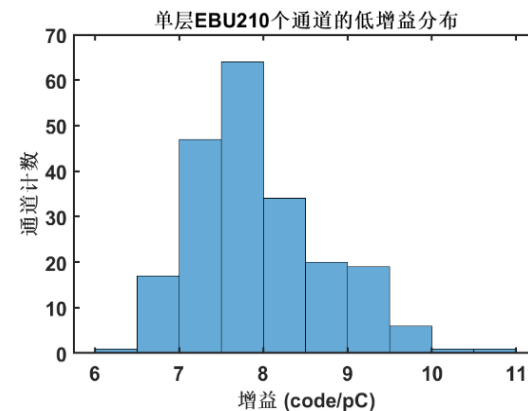
- The high and low gain channel could achieve the upper limit of 10 pC and 100 pC respectively
- The gain coefficients of high and low gain are about 240 and 8 code/pC respectively, and the ratio of high and low gain is about 30.



Linearity of the high/low gain channel



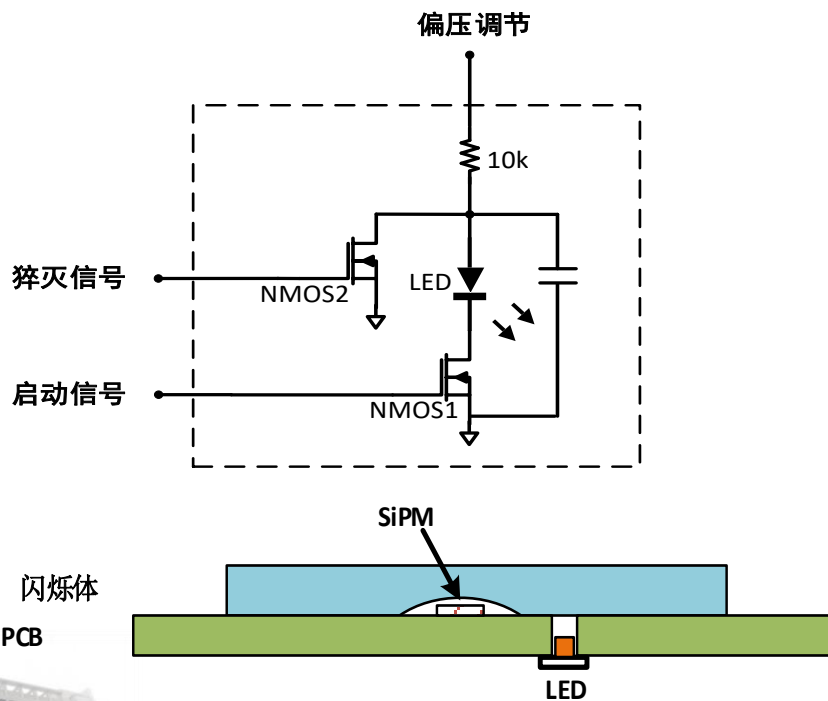
The high gain channel factor



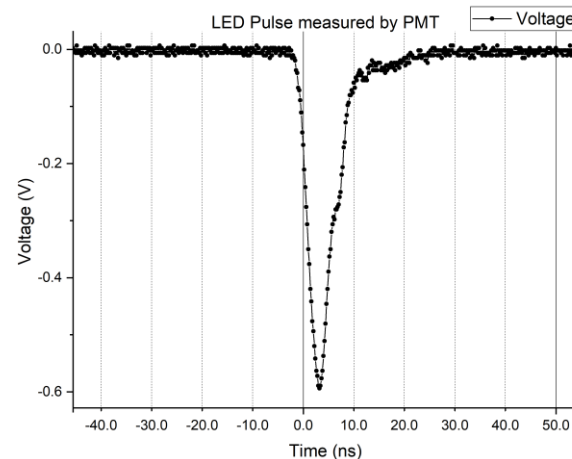
The low gain channel factor

# Super-layer test

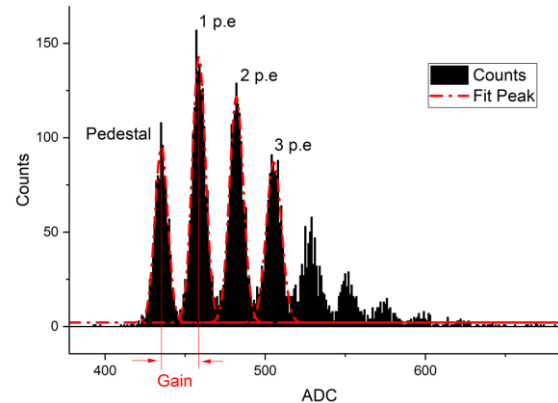
- LED calibration
  - The LED was put near the SiPM
  - A circuit was designed to drive LED to calibrate SiPM



## LED light spectrum



Single Photon Spectrum of SiPM generated by LED calibration

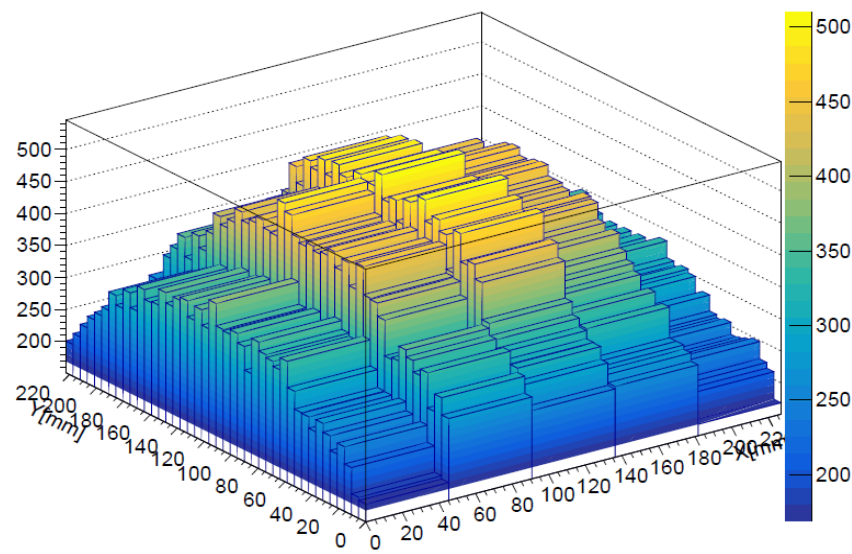


## SiPM photon electron peak

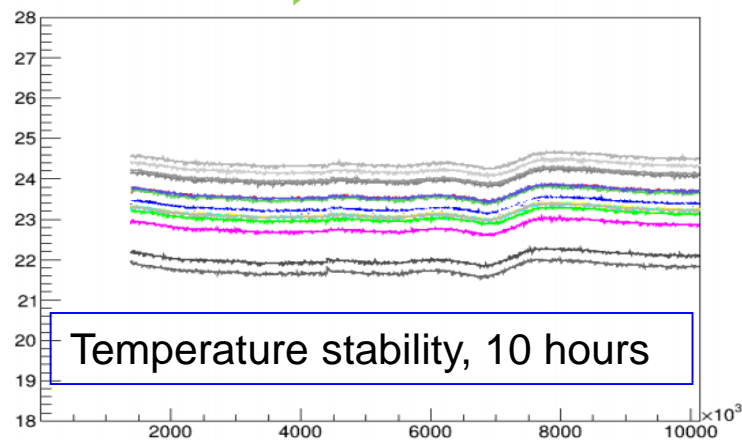
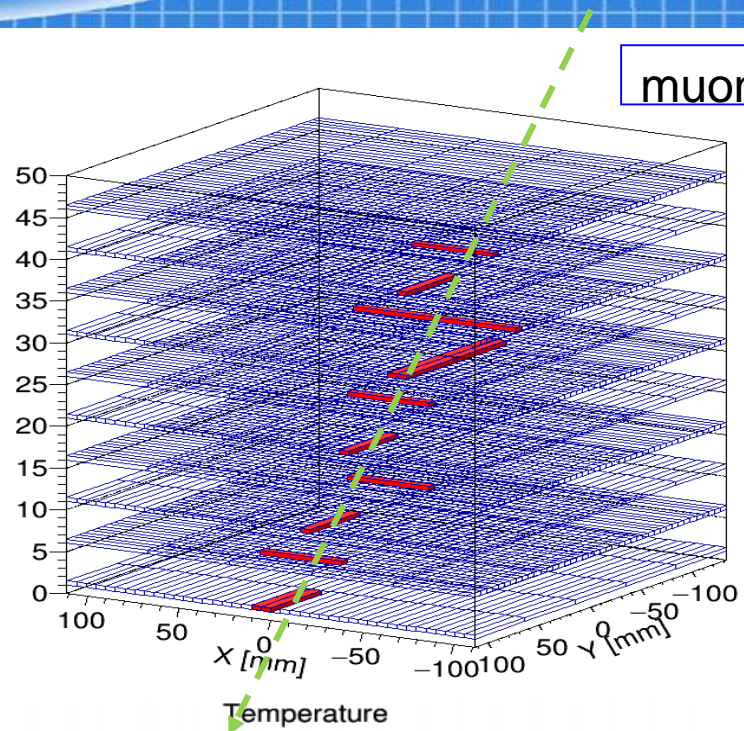


# Super-layer test

- Cosmic ray test
  - Validation mode
  - Evaluate the whole calorimeter system performance, and Prepare for the beam test.

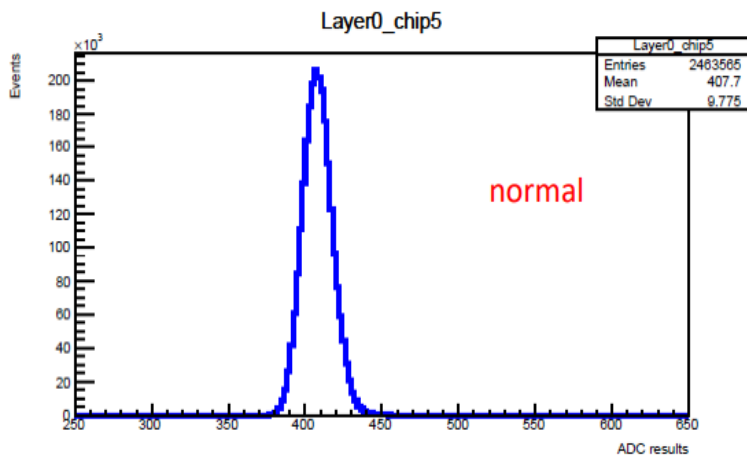


Hit number of each element

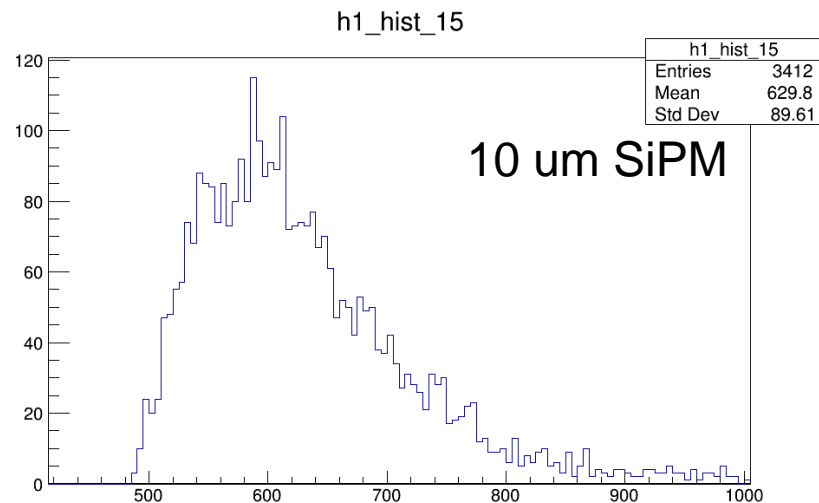
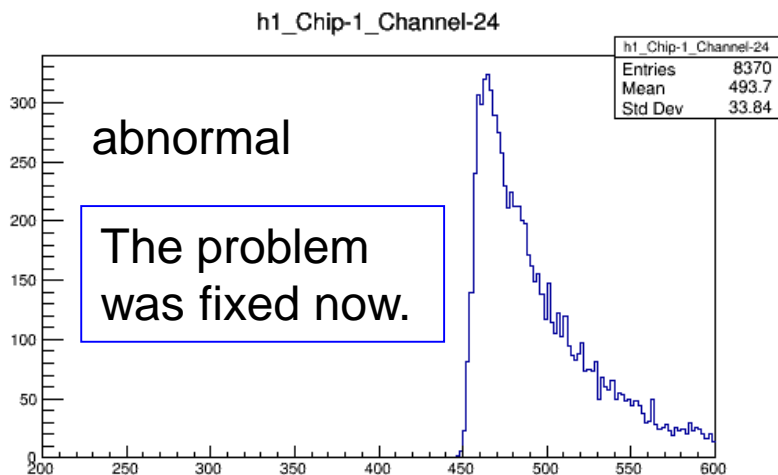
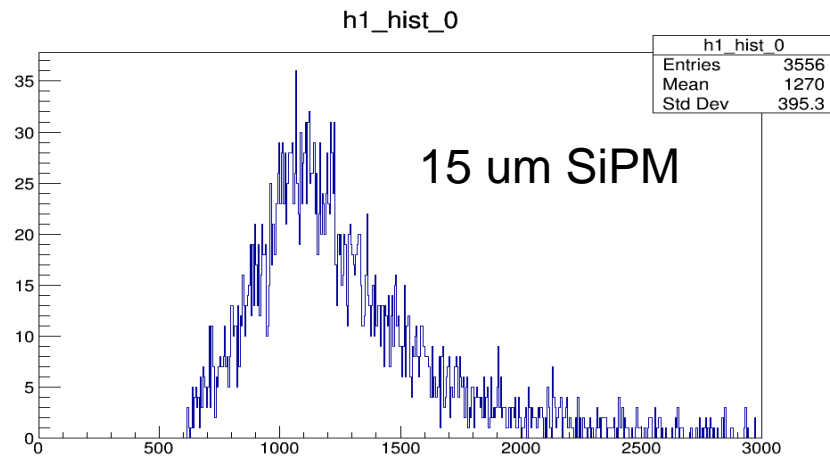


# Super-layer test

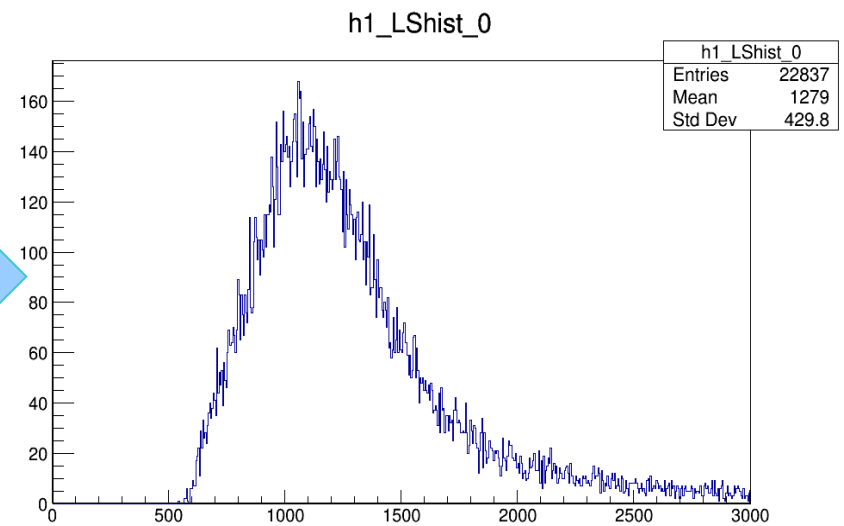
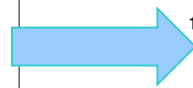
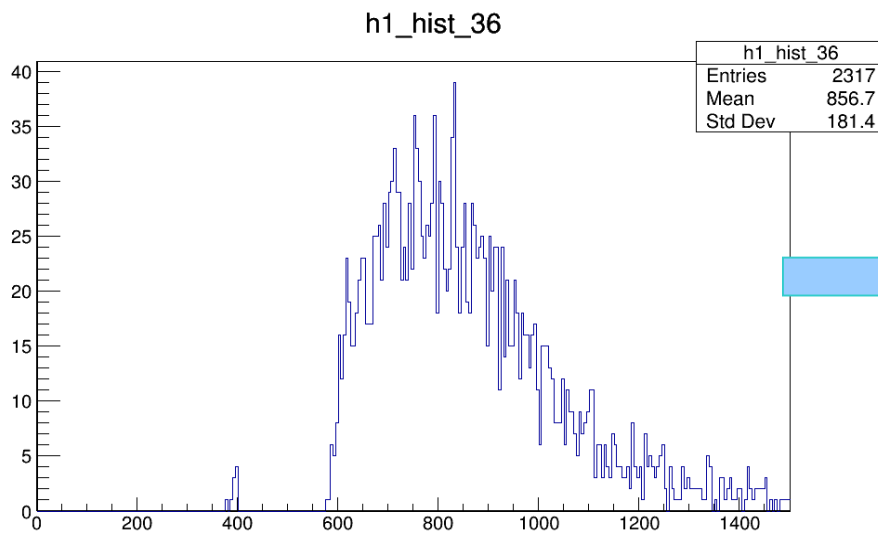
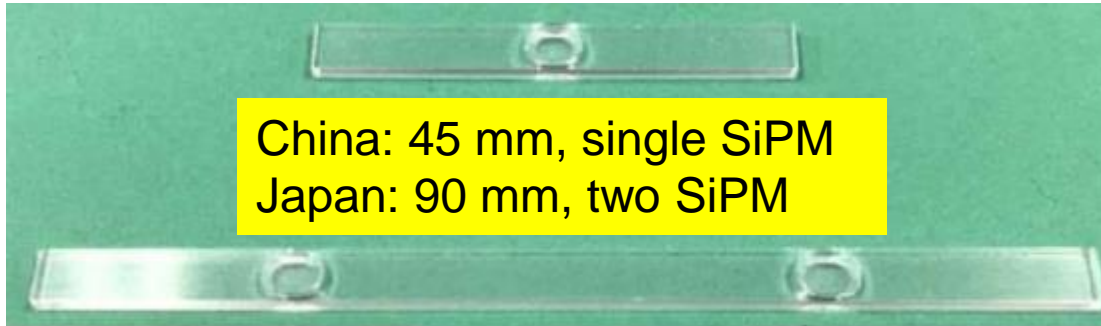
pedestal



MIPs amplitude



# Super-layer test



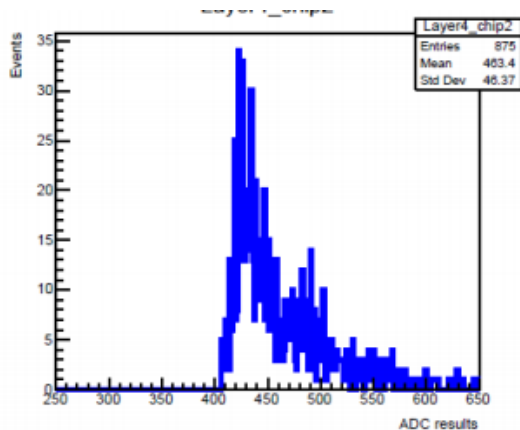
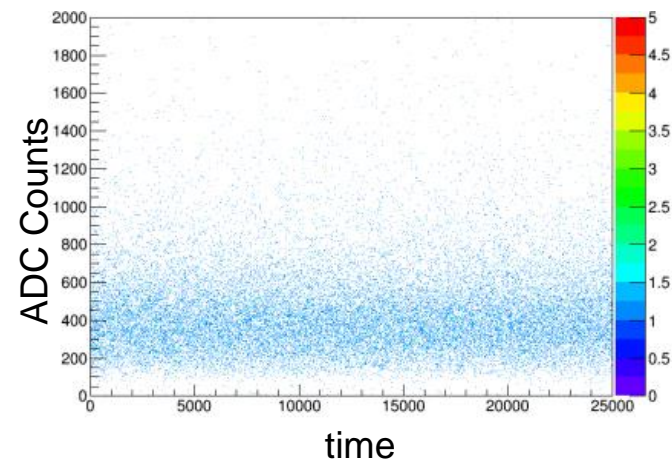
One SiPM amplitude

Sum of two SiPM amplitude

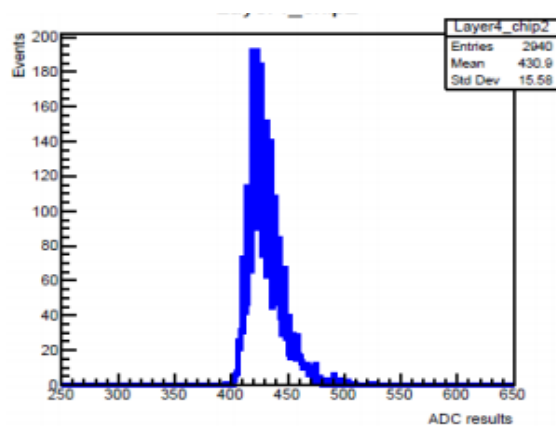


# Super-layer test

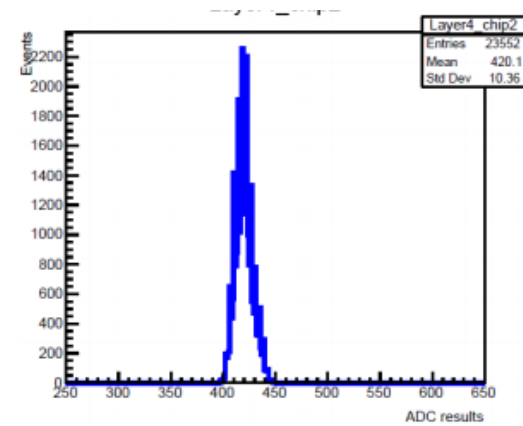
- Abnormal pedestal distribution
  - Some chips have the pedestal shift behavior, and there is no correlation between the pedestal position and time
  - It depends on the “refresh” rate of the chip.
  - We increase the external trigger rate, the pedestal distribution become normal.



20 HZ



100 HZ



660 HZ

# Outline

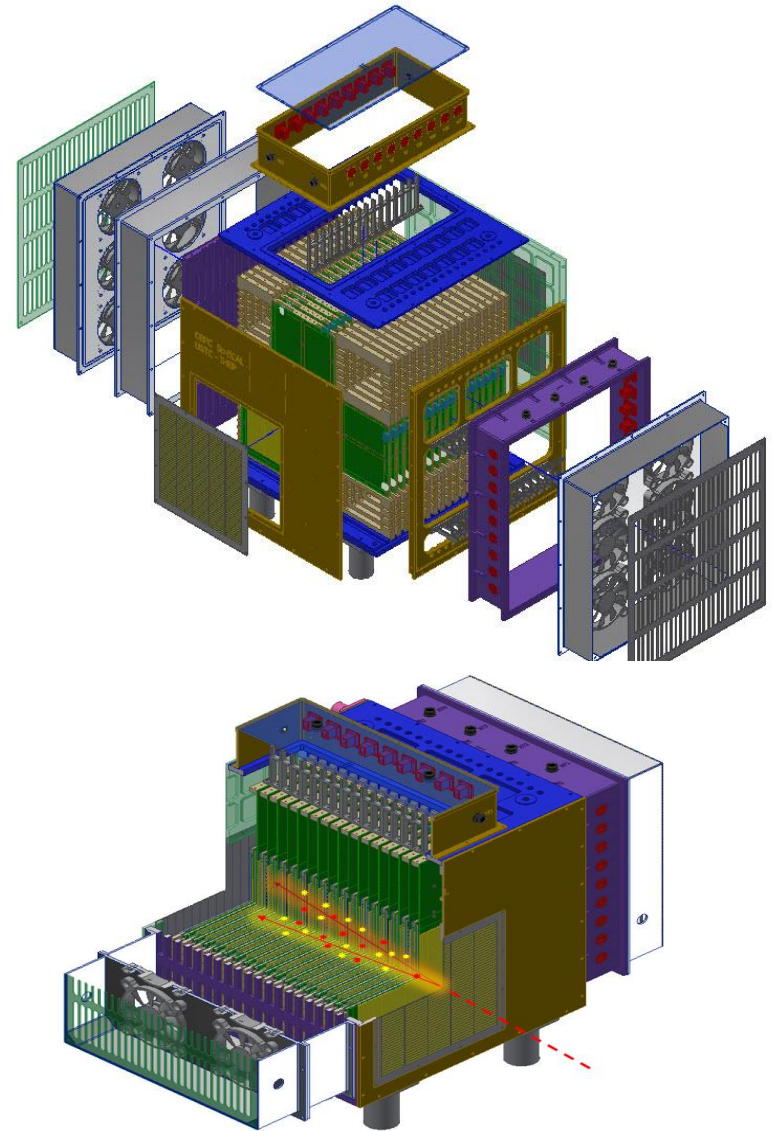
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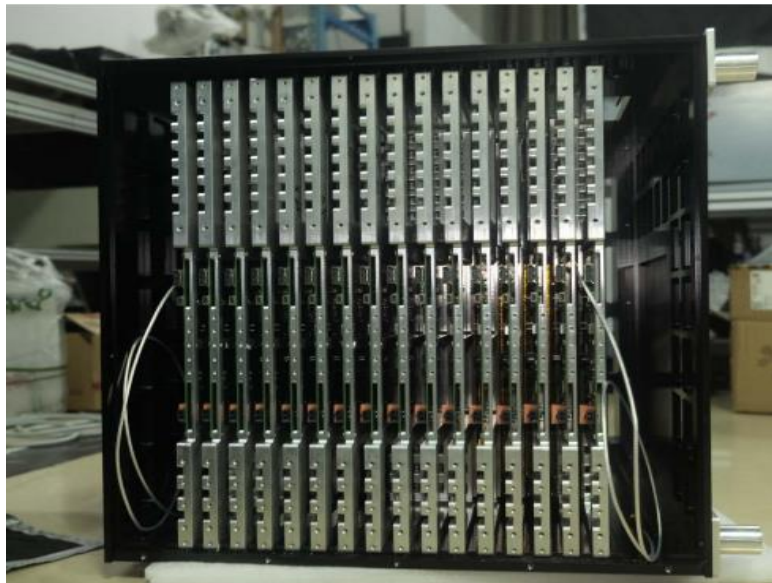


# Calorimeter Trail assembly

- The calorimeter prototype has 16 super-layers
- The total radiation length is about  $23.4 X_0$
- The adjacent layers are arranged in orthogonal order to ensure the 5 mm granularity
- The gap between two super-layers is smaller than 1 mm
- There are 12 fans on two sides to dissipate heat



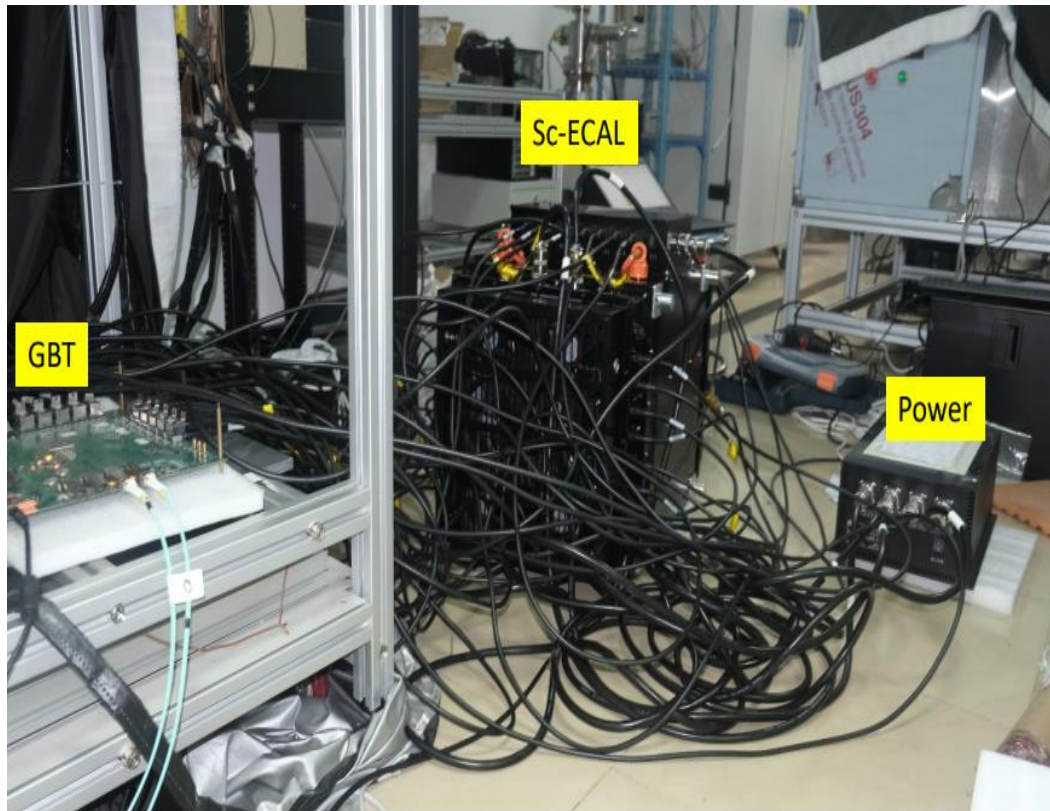
# Calorimeter Trail assembly



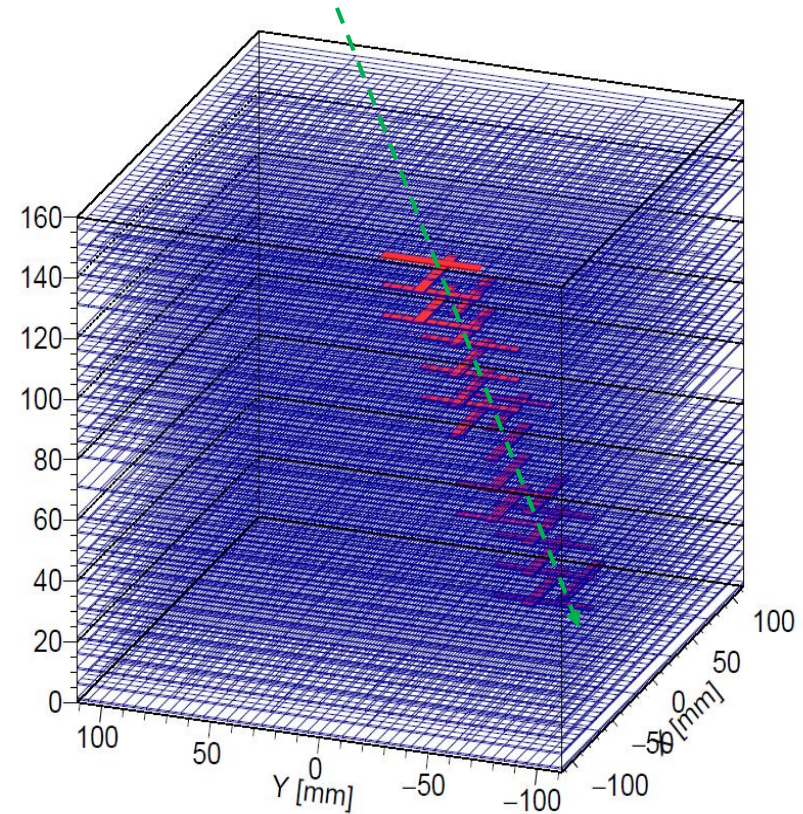


# Calorimeter test

First trial assembly and test

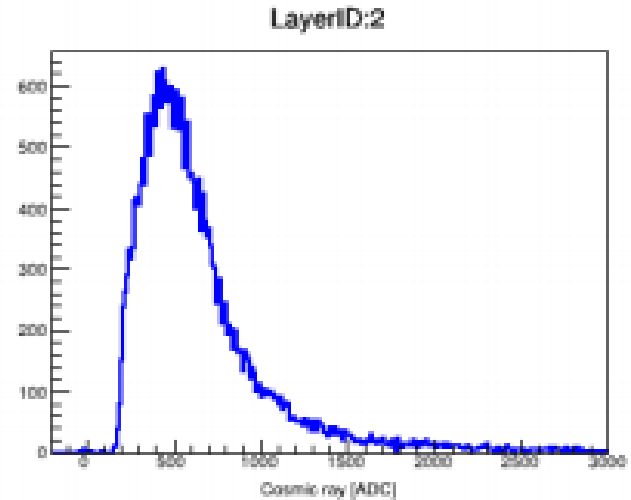
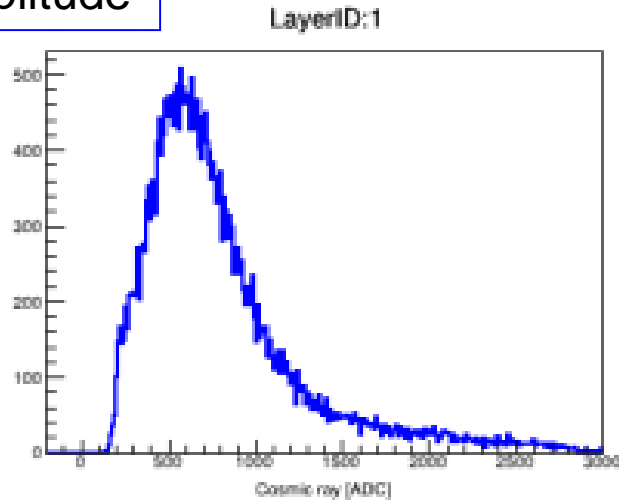


A muon track in the calorimeter

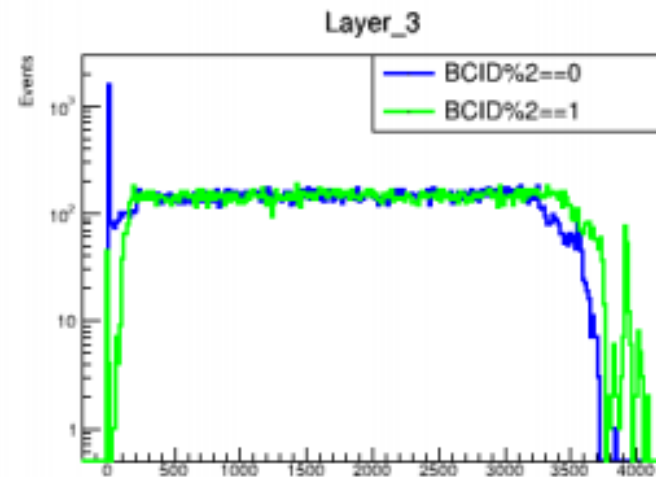
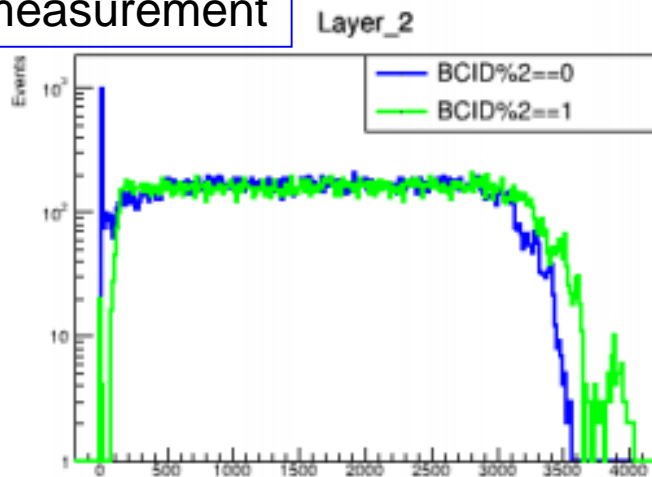


# Calorimeter test

## MIPs amplitude



## Time measurement



# Summary and outlook

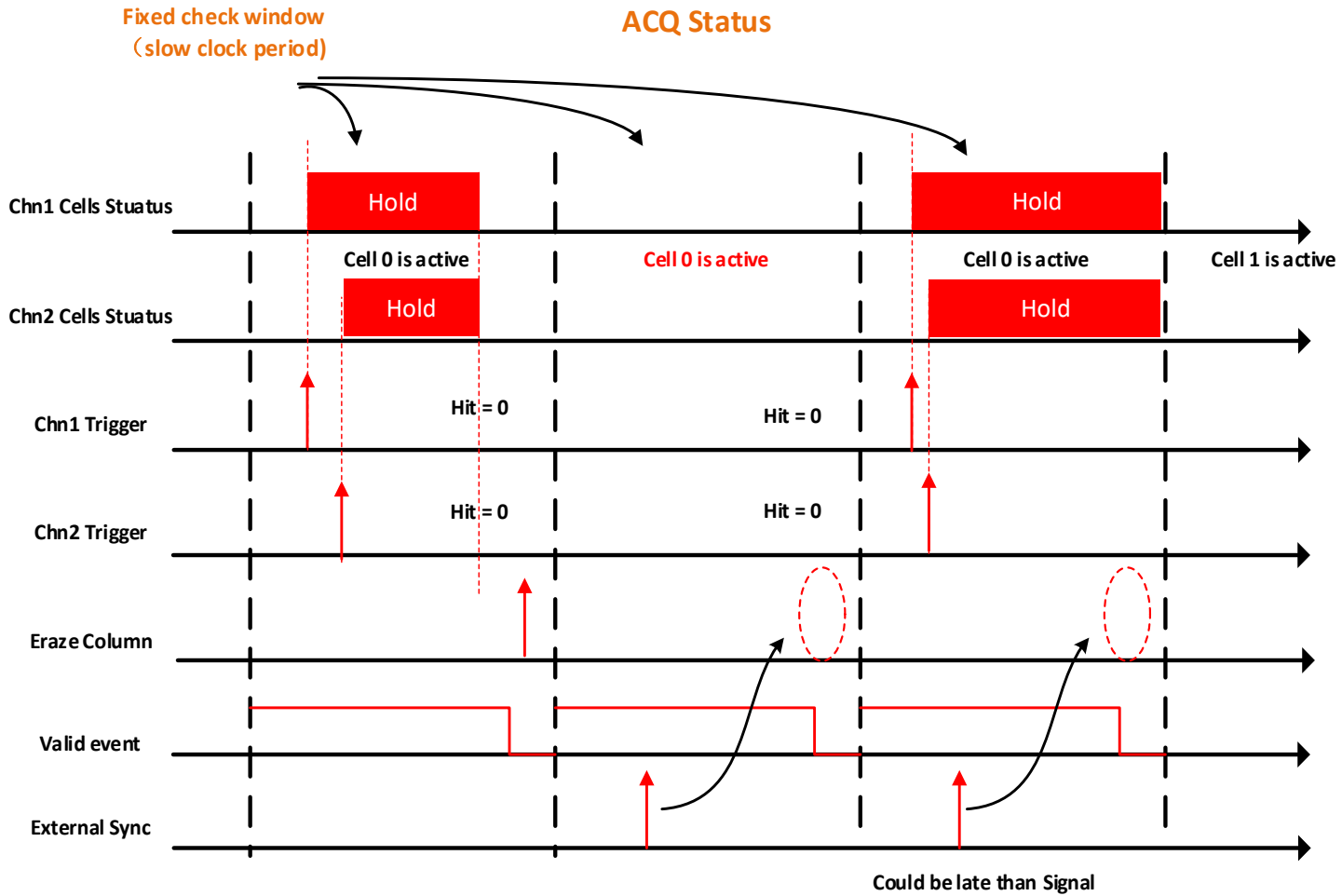
- All the super-layers (16) were assembled and tested using cosmic rays to check the performance
- Then, the prototype was trial assembled, and all the super-layers were installed.
- The preliminary test shows that the performance of the prototype is OK
  - The noise, MIPs amplitude, temperature...
- Next step, we will continue to carry out the commissioning of the calorimeter, and strive to carry out a long-term cosmic ray test at the end of this month.



# backup



# ECAL trigger



Validation Mode

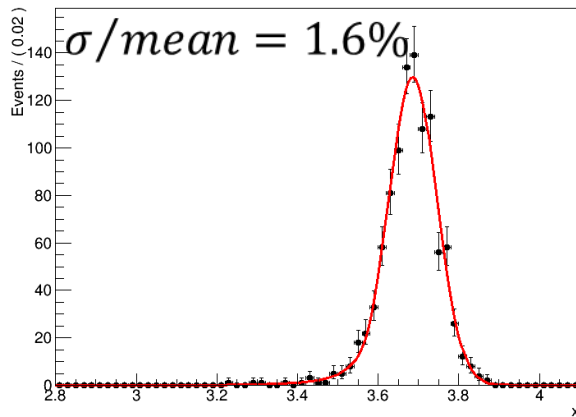




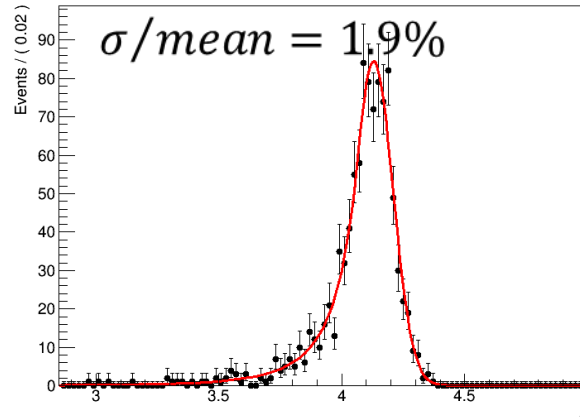
# Absorber parameter

Energy resolution @ 100 GeV  $\gamma$ . 30 layers, each layer is 2.8 mm

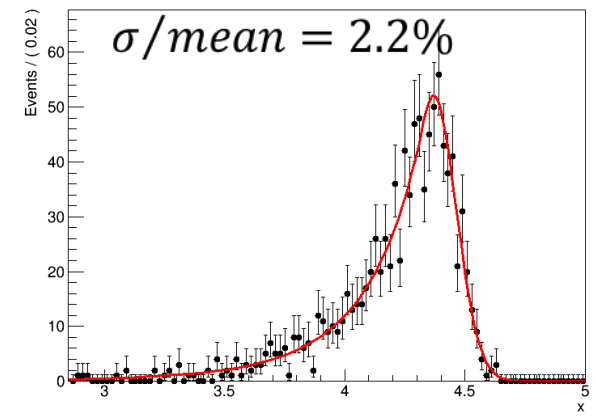
W:Cu 100:0



W:Cu 85:15

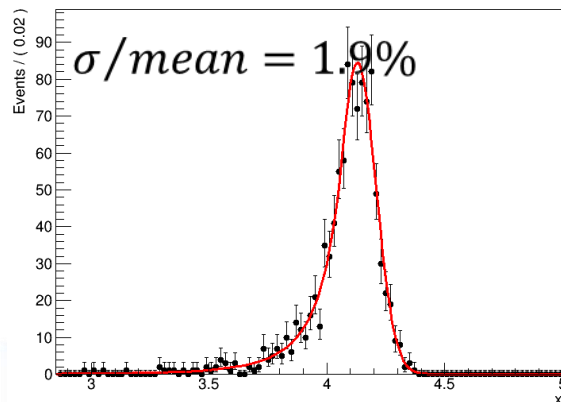


W:Cu 75:25

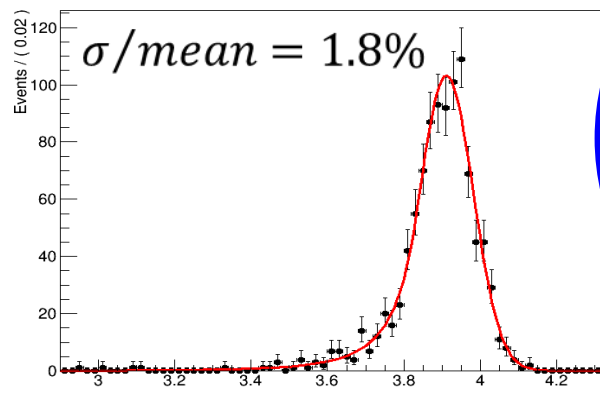


Energy resolution @ 100 GeV  $\gamma$ . 30 layers, W: Cu 85:15

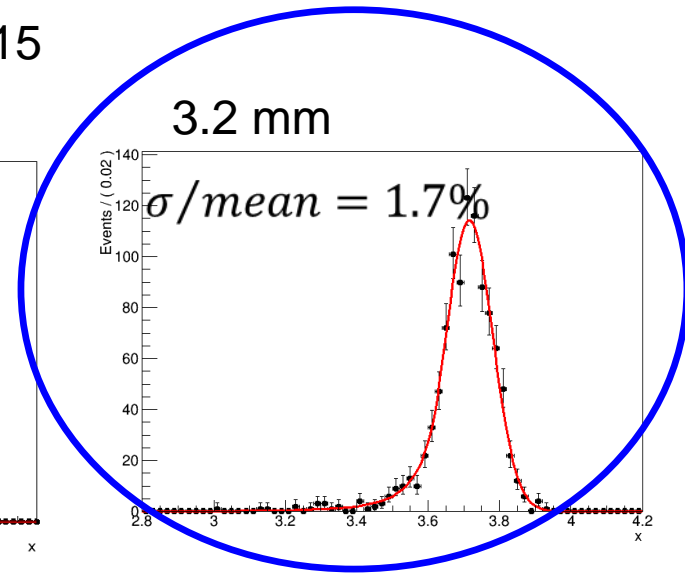
2.8 mm



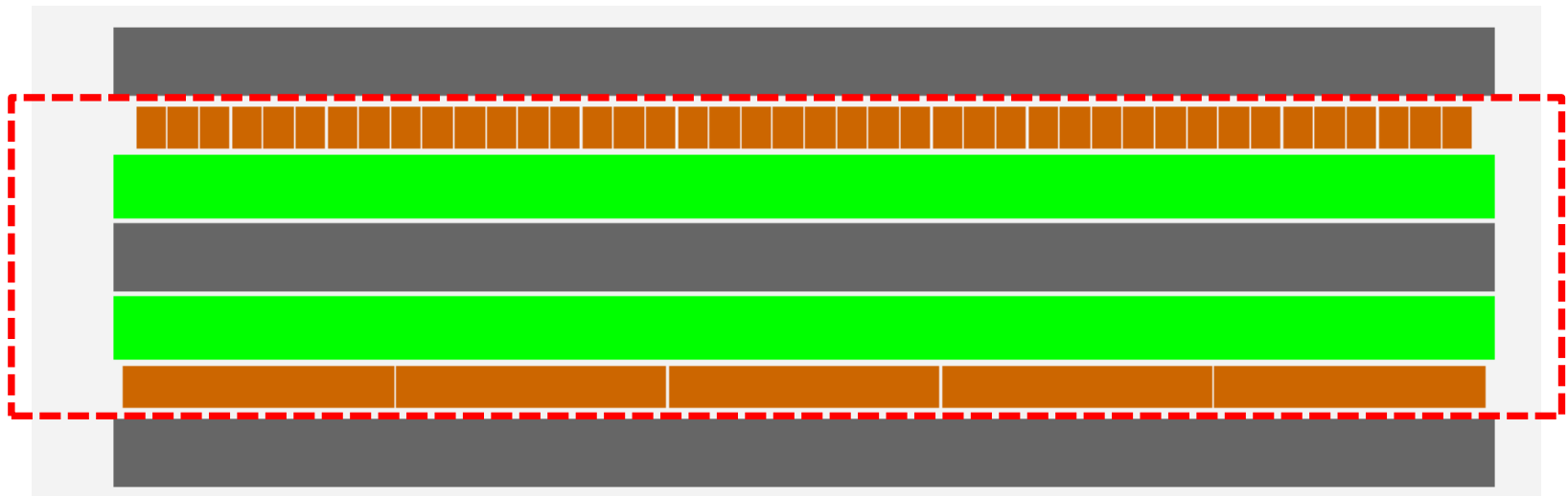
3.0 mm



3.2 mm



# ECAL prototype



tungsten



scintillator

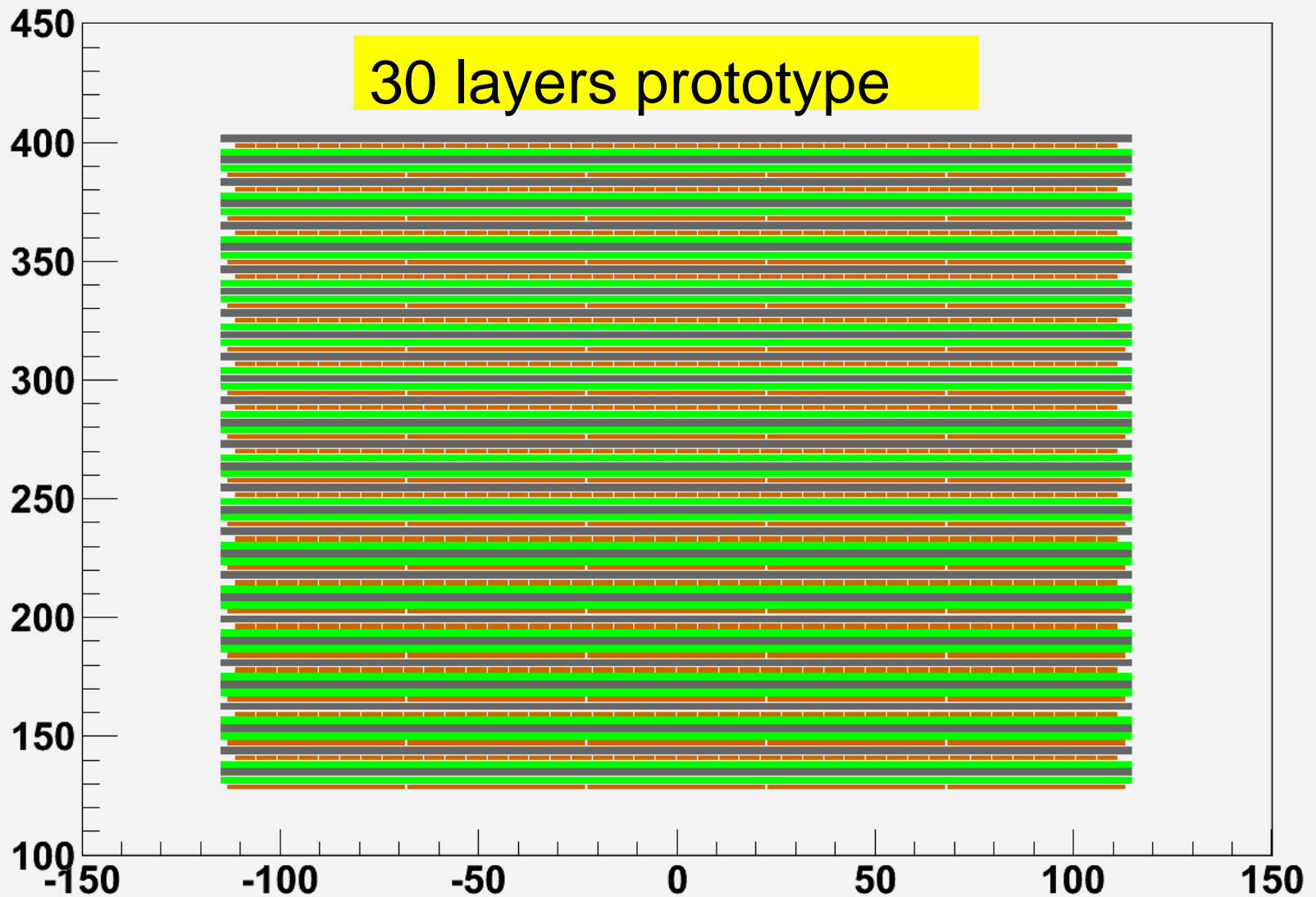


PCB





# ECAL prototype



# ECAL test trigger

