

# **Status of the MOST2 vertex detector prototype R & D (preliminary result on DESY test beam )**

**Zhijun Liang**

On behalf of the CEPC MOST2 Vertex detector study group

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Circular Electron Positron Collider

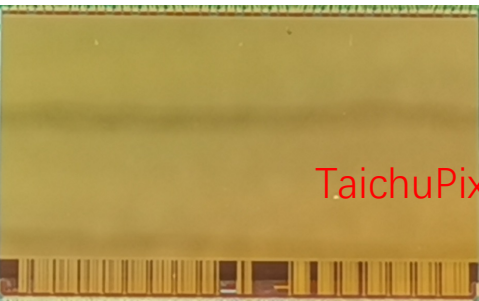


# Overview of MOST2 vertex detector R&D

- **Can break down into sub-tasks**

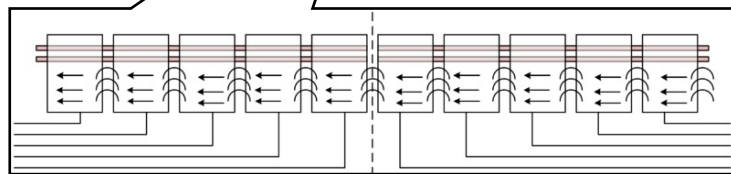
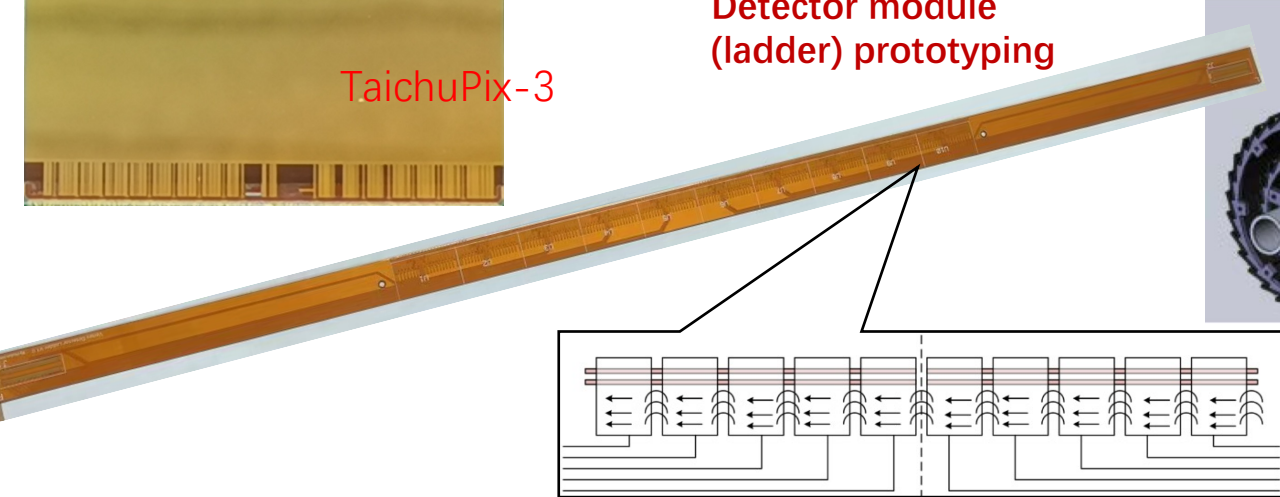
- CMOS Pixel Sensor chip R&D
- Detector layout optimization, ladder and vertex detector support structure R&D
- Detector assembly
- Data acquisition system R&D

CMOS pixel sensor  
prototyping



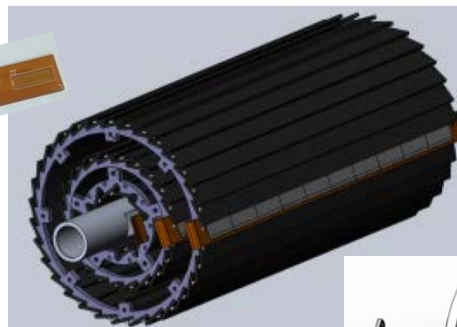
TaichuPix-3

Detector module  
(ladder) prototyping

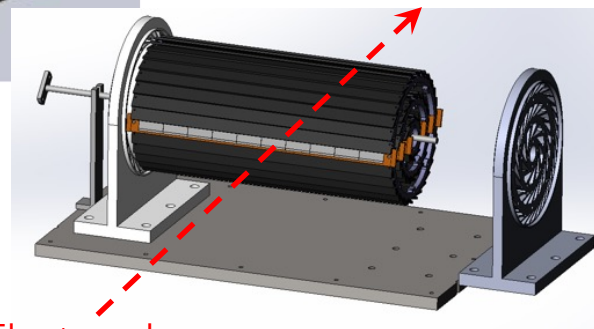


Double sided ladder  
10 sensors/ladder side, read out from both ends

Full size vertex detector prototype



Beam test to verify its  
spatial resolution



Electron beam

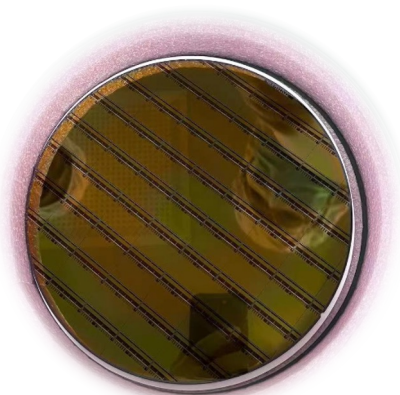




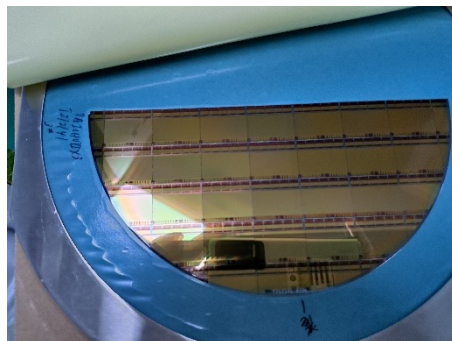
# Large-scale sensor TaichuPix-3

Chip size :  $26 \times 16$  mm  
Pixel size :  $25\mu\text{m} \times 25\mu\text{m}$

- 6 TaichuPix-3 wafers arrived at IHEP in July
  - All wafer thinned down to  $150\mu\text{m}$  and diced



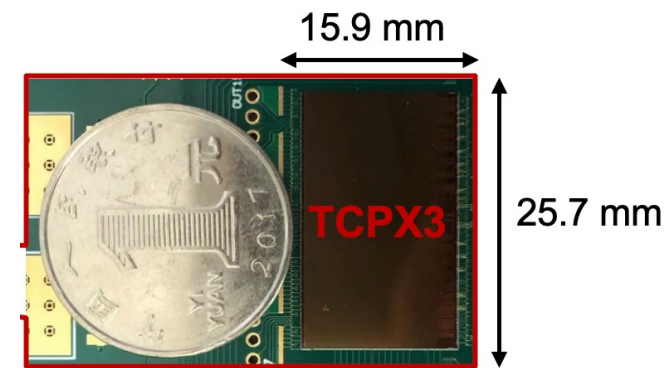
8-inch wafer



Wafer after thinning and dicing



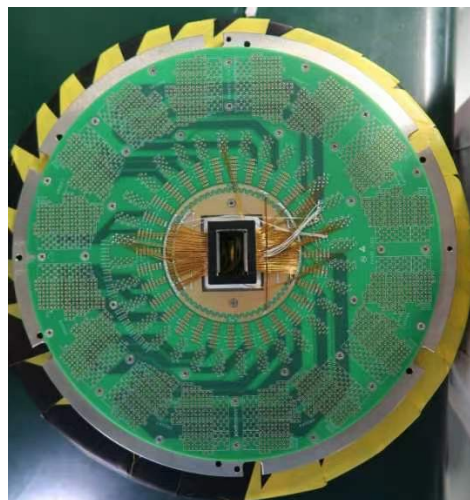
Thickness after thinning



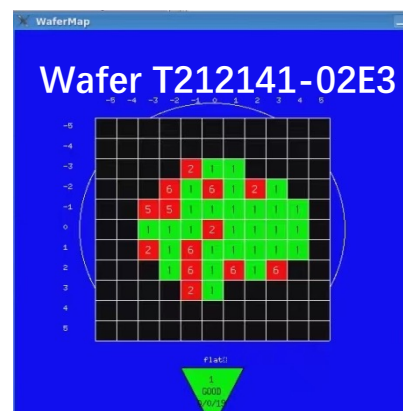
TaichuPix-3 chip vs. coin

- Complete wafer testing on probe-station → chip selecting & yield evaluation

Wei Wei, Ying Zhang



Probe card for wafer test



An example of wafer test result

## 5 wafers tested

- 2 wafer based on standard process
  - Reasonable yield achieved
- 3 wafer based on modified process
  - lower yield than the std. process







# Testbeam on DESY

## • On Site team (DESY)

- Joao (IHEP) Project leader
- Zhijun Liang (IHEP) test beam coordinator
- Tianya Wu (IHEP) Shift leader , ASIC expert
- Ming Qi (NJU) Shift leader
- Lei Zhang (NJU) Shift leader
- Xiaomin Wei (NWPU) ASIC experts
- Jia Zhou (IHEP) DAQ
- Xinhui Huang (IHEP) Assembly
- Shuqi Li (IHEP)
- Hao Zeng (IHEP) 机动
- XueWei Jia (IHEP)



## Romate support

WeiWei, Ying Zhang (IHEP) ASIC

Jun Hu, Ziyue Yan (IHEP) firmware

Hongyu Zhang (IHEP) DAQ

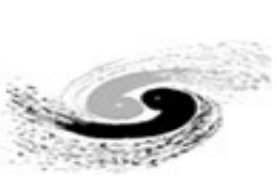
Jinyu Fu, Mingyi Dong (IHEP) Assembly

Wei Wang, Gang Li, Linhui Wu (IHEP) Offline

Yiming Hu, Xiaoxu Zhang (NJU)...





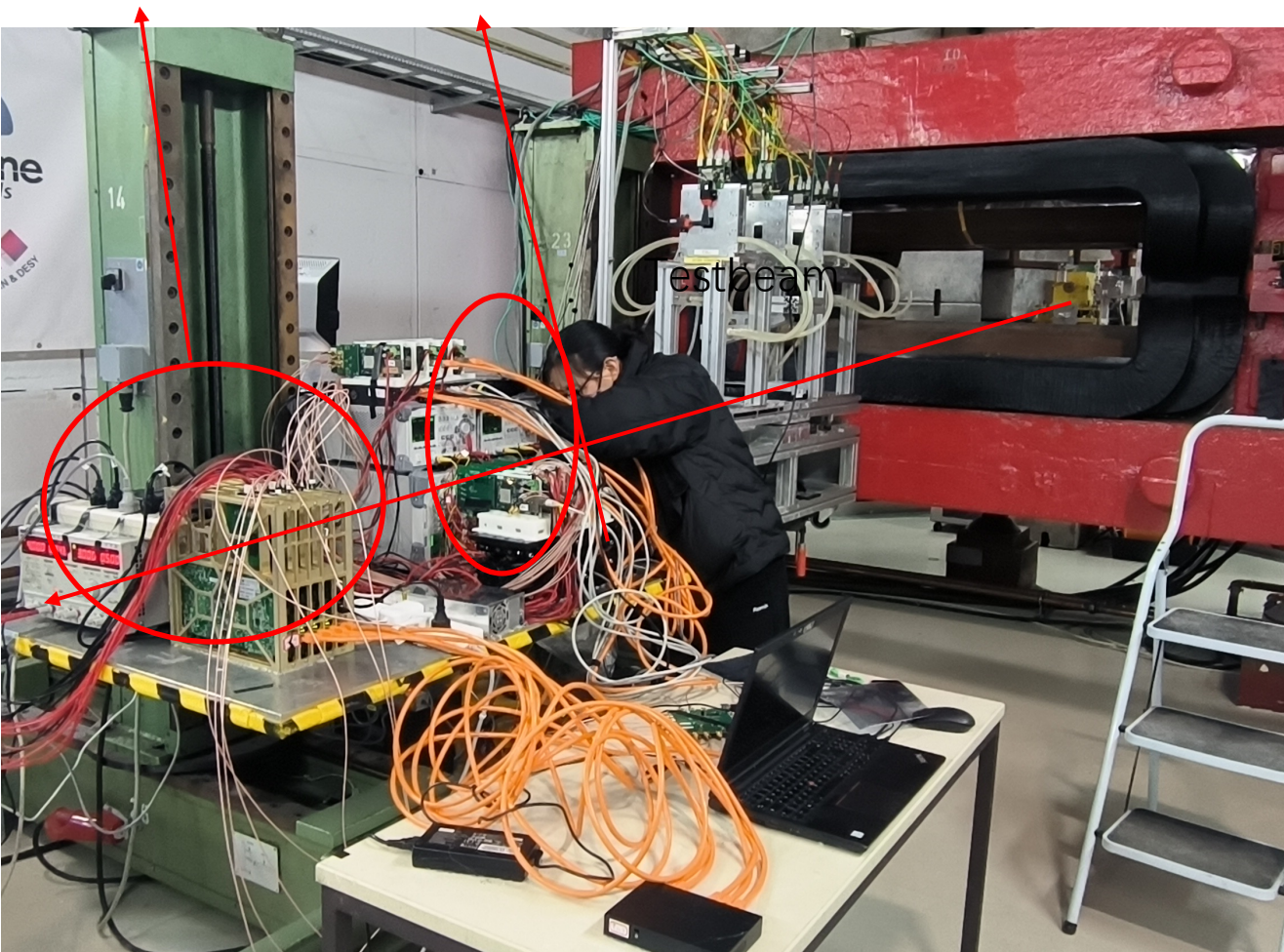


# DESY Testbeam setup

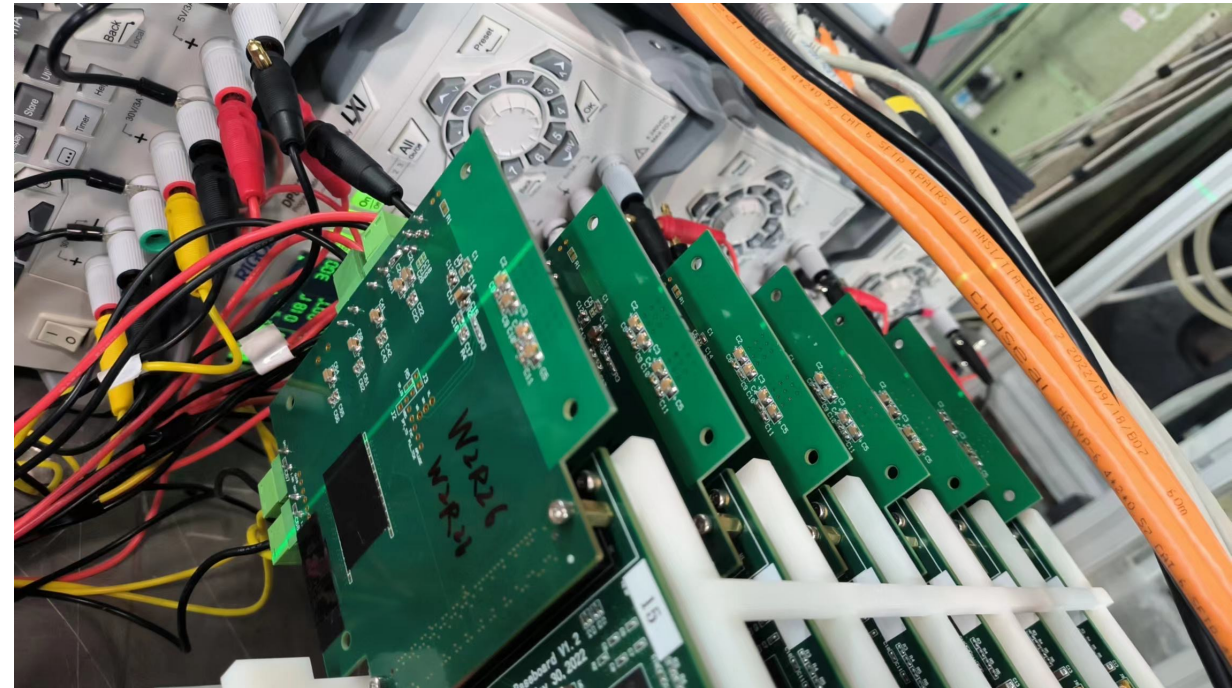
- Using 4~5GeV electrons beam at DESY
  - Taichu telescope ( 6 layer of pixel detector )
  - Jadepix telescope (4 layer of pixel detector)

Jadepix  
telescope

Taichu  
telescope



Taichu telescope ( 6 layer of pixel detectors)



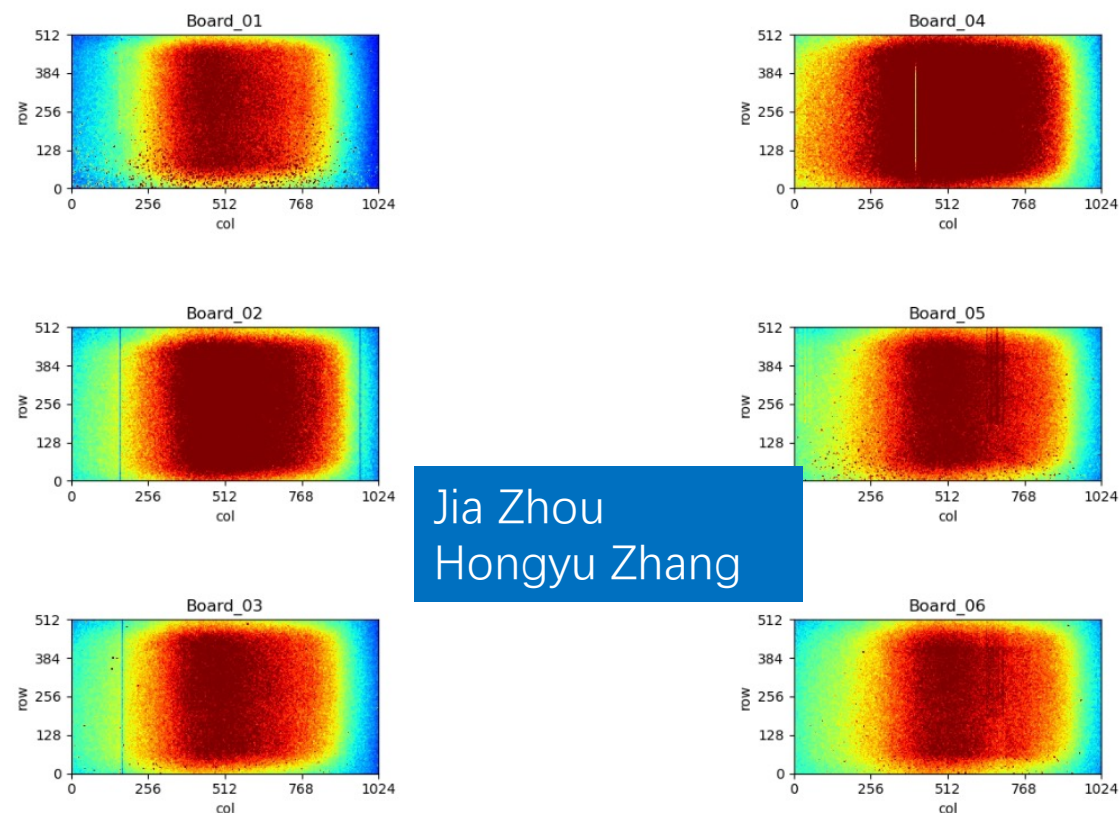




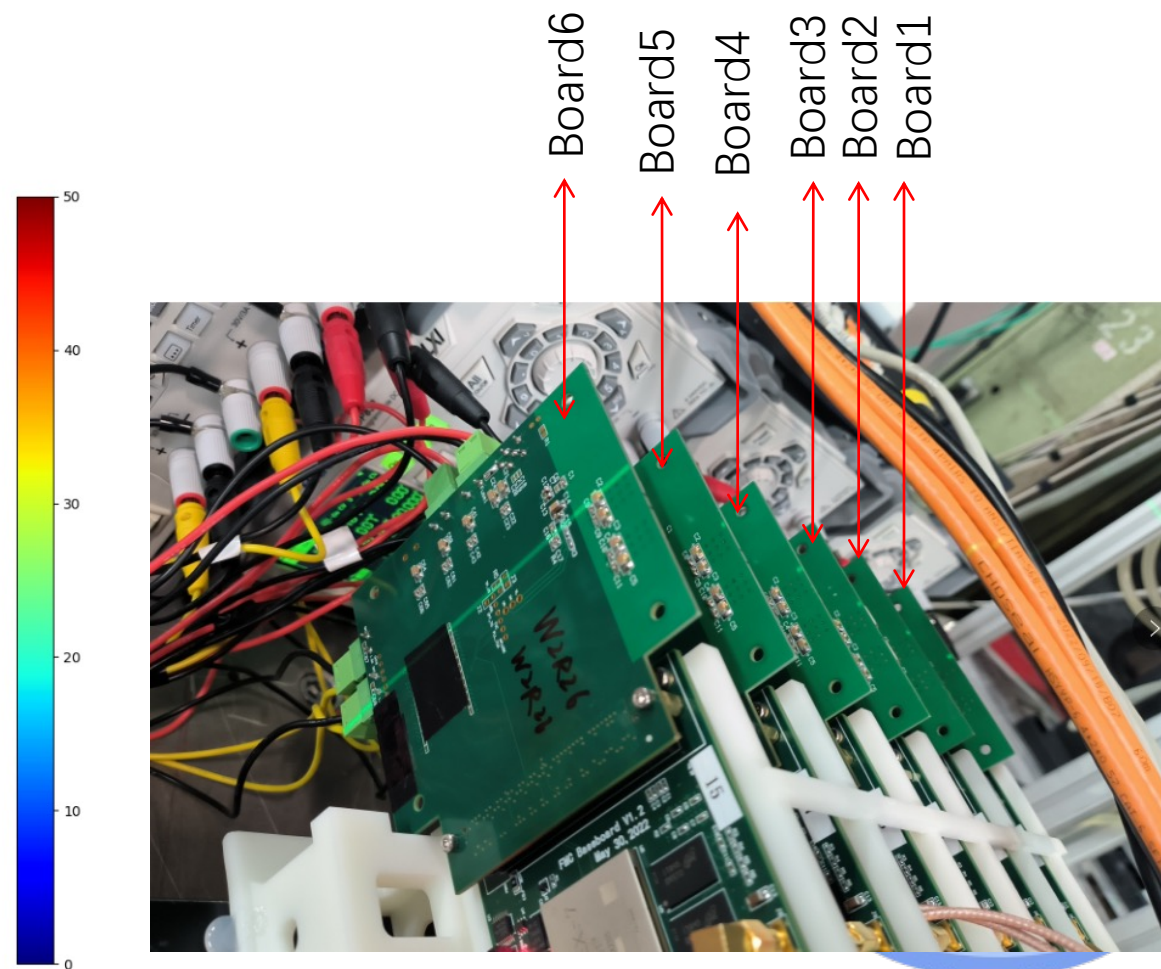
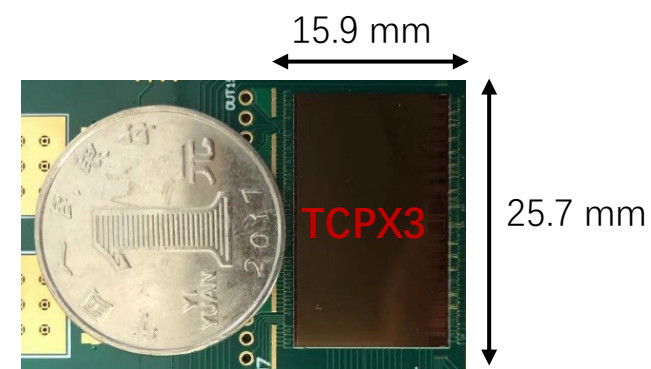
# Hit maps

- TaichuPix is full-size vertex detector prototype chip
  - Beam spot of DESY testbeam ( $\sim 1.5\text{cm} * 1.2\text{ cm}$ ) is fully captured in Taichupix telescope.

Taichupix telescope on-line monitoring



Jia Zhou  
Hongyu Zhang





# Timestamp calibration

- For timestamp calibration, a chip self-test is necessary before the beam test. The chip level timestamp (time1) is normalized
- Clock of timestamp is running with 20MHz
- The coincidence data will be figured out by the same chip level timestamp, which is recognized by a range of  $3 \text{ time1}(\pm 1 \text{ time1})$

Run0651-Rundata-analyze-01.txt - 记事本

row	col	time1	time2	chip_id	valid
520	310	29	236	13	1
520	307	29	236	13	1
520	308	29	236	13	1
520	301	29	236	13	1
520	302	29	236	13	1
520	303	29	236	13	1
520	300	29	236	13	1
520	305	29	236	13	1
520	306	29	236	13	1
519	307	29	236	13	1
520	304	29	236	13	1
519	301	30	236	13	1
519	302	30	236	13	1
519	303	30	236	13	1
519	300	30	236	13	1
520	309	30	236	13	1
519	310	30	236	13	1
518	307	30	236	13	1
519	308	30	236	13	1
518	301	30	236	13	1
518	302	30	236	13	1

Run0651-Rundata-analyze-02.txt - 记事本

row	col	time1	time2	chip_id	valid
110	107	29	3	13	1
110	110	29	3	13	1
110	109	29	3	13	1
110	108	29	3	13	1
110	103	29	3	13	1
110	102	29	3	13	1
110	101	29	3	13	1
110	100	29	3	13	1
109	107	29	3	13	1
110	106	29	3	13	1
110	105	29	3	13	1
110	104	30	3	13	1
109	103	30	3	13	1
109	102	30	3	13	1
109	101	30	3	13	1
109	100	30	3	13	1
108	107	30	3	13	1
109	110	30	3	13	1
109	109	30	3	13	1
109	108	30	3	13	1

Run0651-Rundata-analyze-03.txt - 记事本

row	col	time1	time2	chip_id	valid
520	303	29	131	13	1
519	303	29	131	13	1
518	303	29	131	13	1
517	303	29	131	13	1
516	303	29	131	13	1
515	303	29	131	13	1
514	303	29	131	13	1
513	303	29	131	13	1
512	303	29	131	13	1
511	303	29	131	13	1
510	303	29	131	13	1
520	310	30	132	13	1
520	309	30	132	13	1
520	300	30	132	13	1
520	307	30	132	13	1

Run0651-Rundata-analyze-04.txt - 记事本

row	col	time1	time2	chip_id	valid
520	307	29	52	13	1
520	310	29	52	13	1
520	309	29	52	13	1
520	300	29	52	13	1
520	303	29	52	13	1
520	302	29	52	13	1
520	301	29	52	13	1
520	304	29	52	13	1
519	307	29	52	13	1

Run0651-Rundata-analyze-05.txt - 记事本

row	col	time1	time2	chip_id	valid
110	107	29	66	13	1
110	110	29	66	13	1
110	109	29	66	13	1
110	100	29	66	13	1

Ziyue Yan, Tianya Wu, Jia Zhou





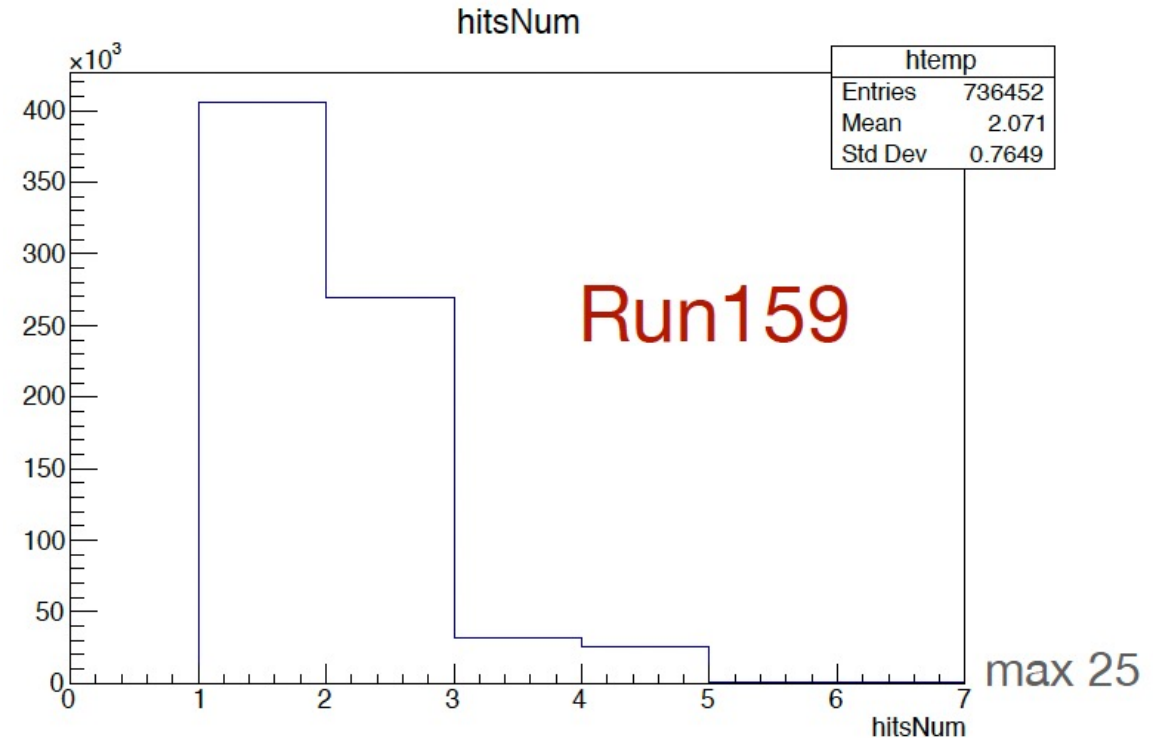
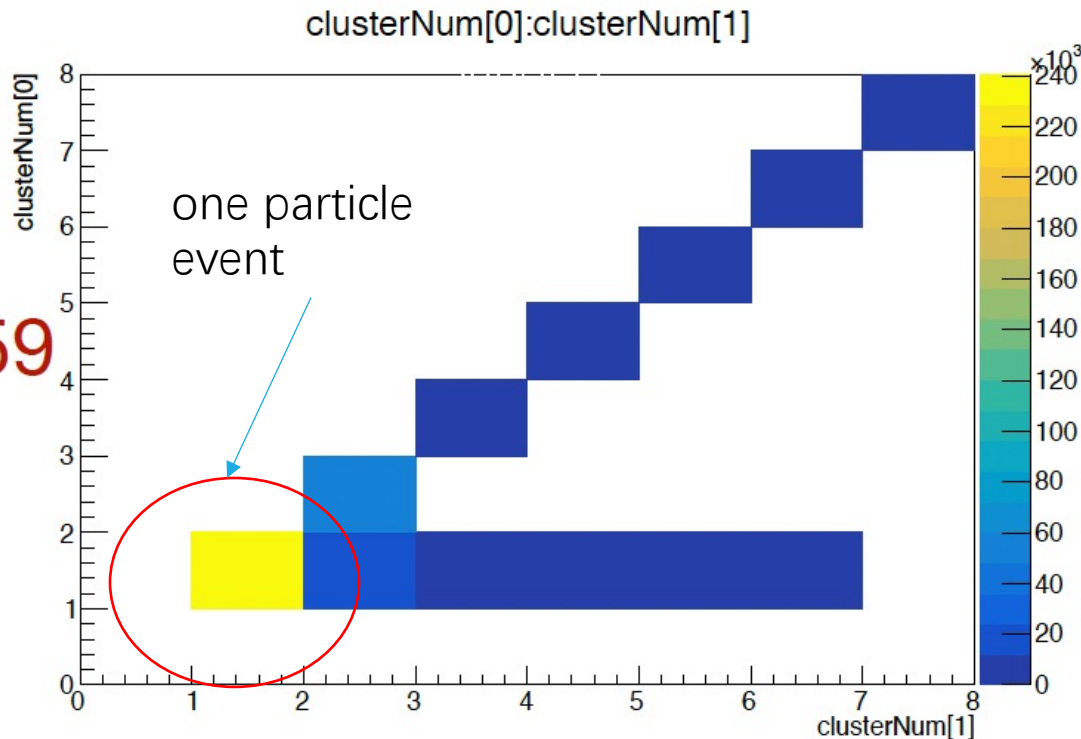
# Cluster size

- Most of the events has one particle ( one cluster per layer )
  - There is small fractions of events with more than one particles
- Average cluster size is about 2

Shuqi Li

Number of cluster per layer  
layer 0 Vs layer 1

Run159







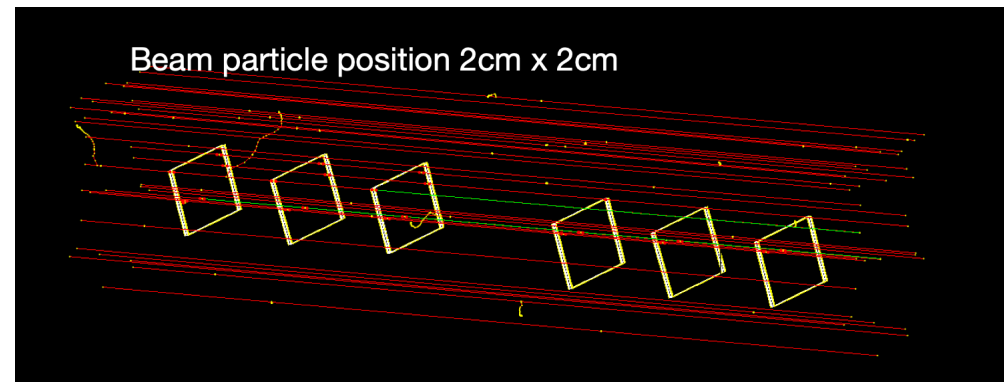
# MOST2 offline reconstruction and alignment

## Track Reconstruction

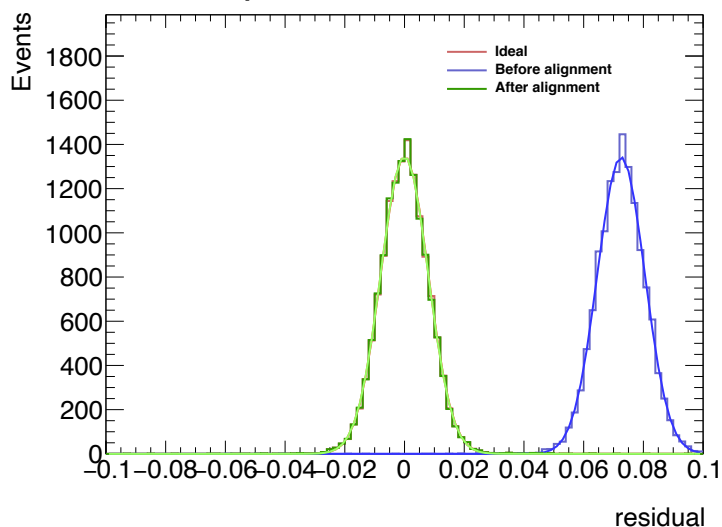
- No magnetic field
- Least squares fitting (Straight line fit)
- No considering multi-scattering now

## Alignment

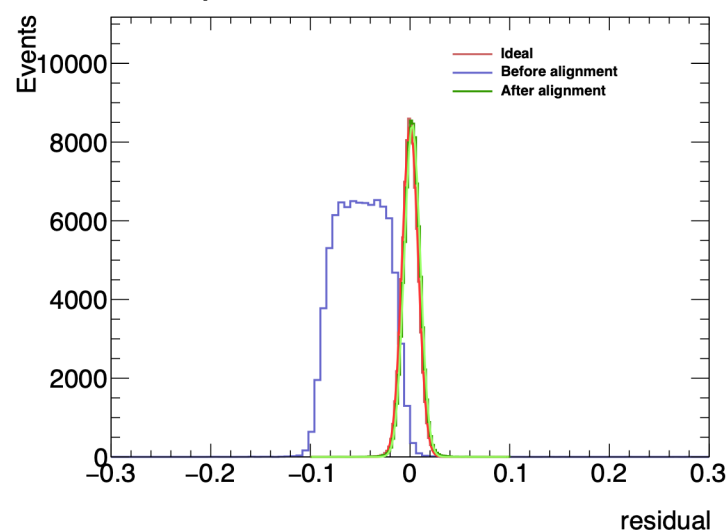
- Using Millepede (c++ version) matrix method
- Correct for the misalignment chip position
- Evaluate the influence of different alignment parameters on spatial resolution



- If the chip translation on X and Y



- If the chip rotation around beam direction



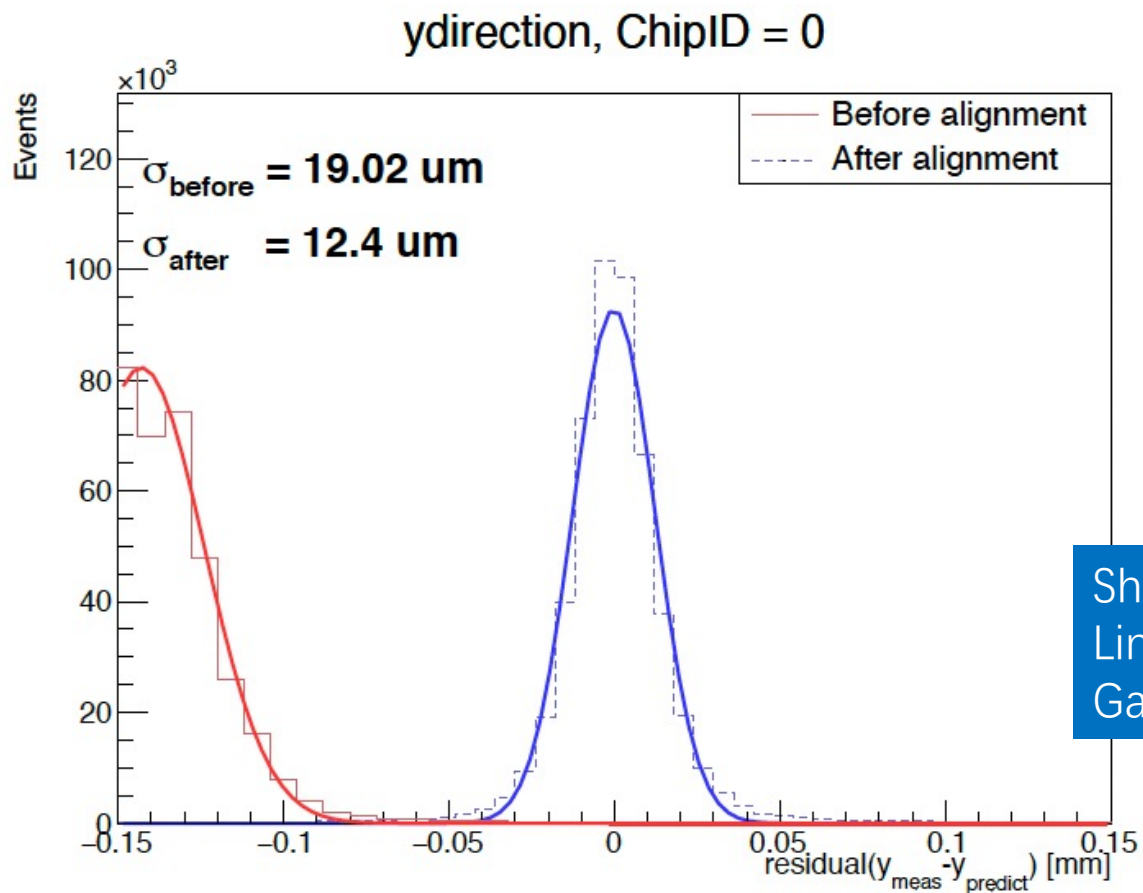
Shuqi Li  
Linhui Wu  
Gang Li



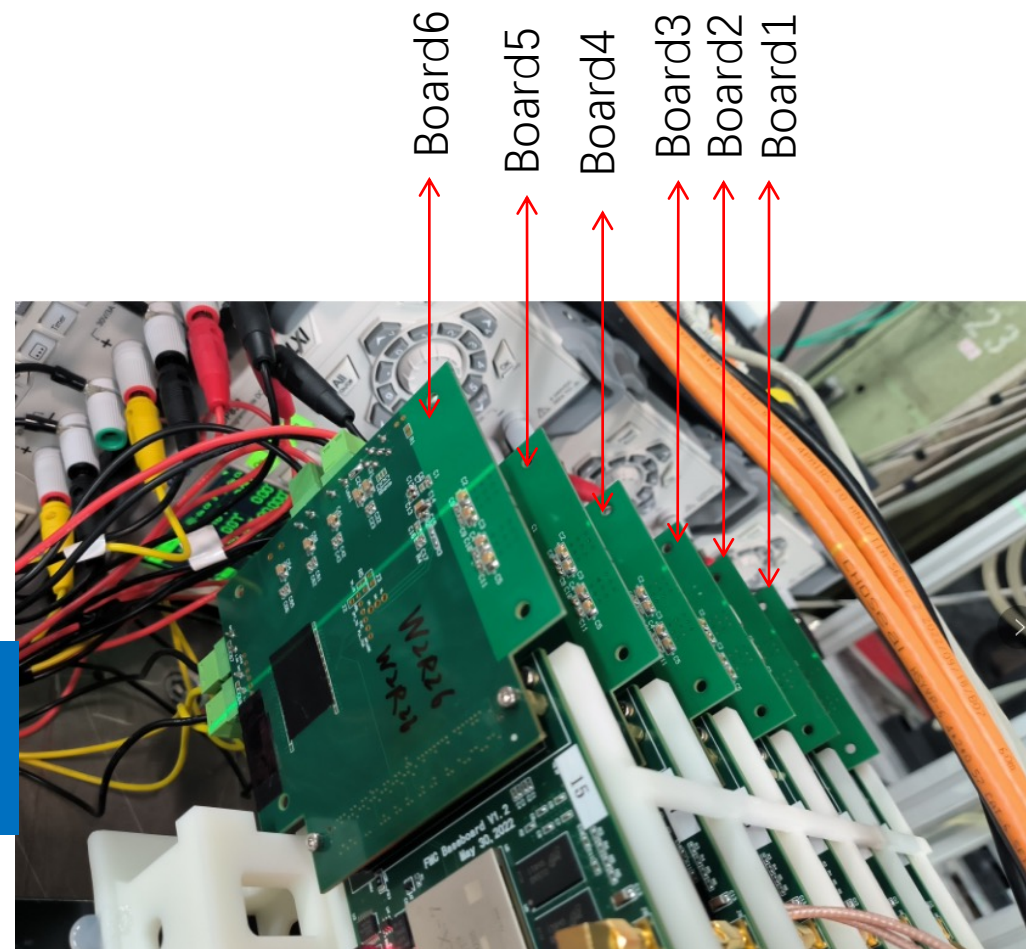


# Track Alignment

- Detector alignment using tracks has been setup



Shuqi Li  
Linhui Wu  
Gang Li

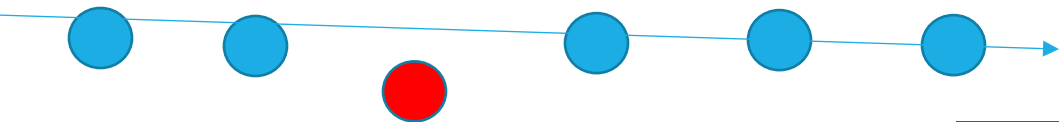






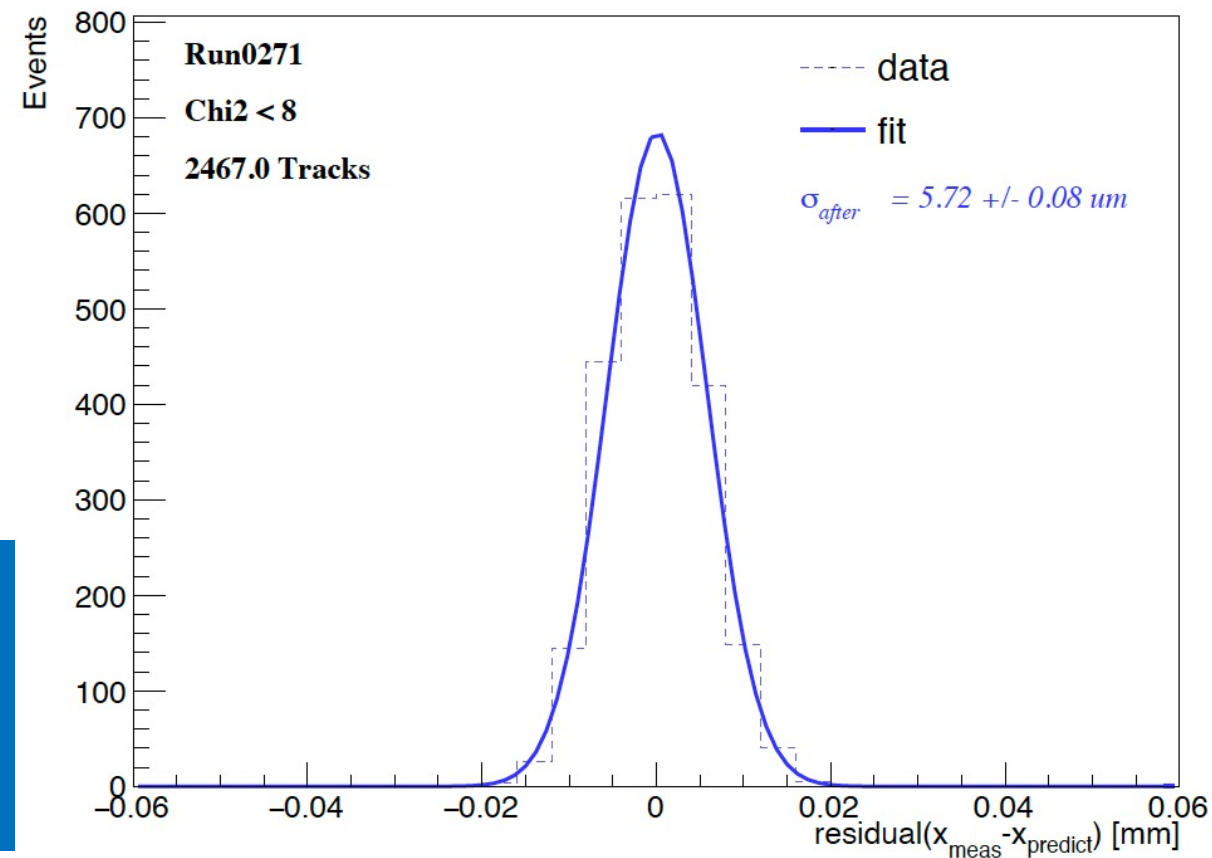
# Spatial Resolution and efficiency (Preliminary)

- After alignments, Using 5 pixel layers to fit a track
  - Measure unbiased residual (resolution)
  - 5  $\mu\text{m}$  ~6  $\mu\text{m}$  resolution from Preliminary study
- Efficiency
  - Using 5 pixel layers to fit a track
  - Using 6<sup>th</sup> layer (unbias layer) to calculate efficiency
  - Hit Efficiency >99% from Preliminary study



Shuqi Li  
Joao  
Linhui Wu  
Gang Li  
YiMing Hu(NJU)

xdirection, ChipID = 1

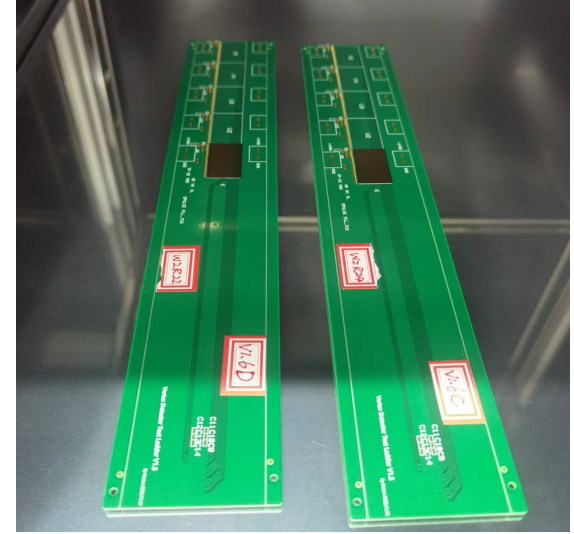


# Electronics test in ladder

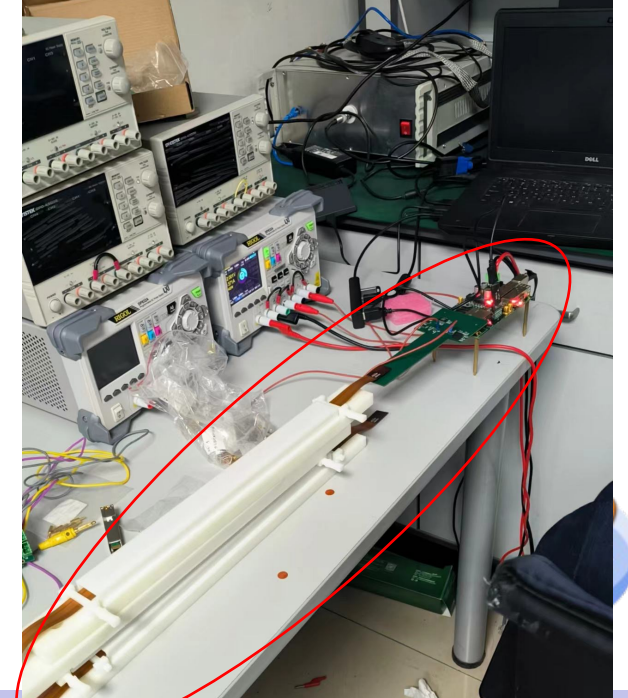
- Testbench setup: 2~3 chips wire bonded on one flex
  - Can communicate with TaichuPix in OCT mode (self-checking mode)
  - **Issue:** Readout lots noise in charge injection mode
  - **Challenge:**
    - Long flex cable (~70cm) → some issue with power distribution and delay
    - Missing test point to debug the communication issue
  - **News**
    - Made a hard PCB with test point, try to under the issue
    - Understood the grounding issue in digital injection

Jun Hu  
Ying Zhang  
Yiyue Yan

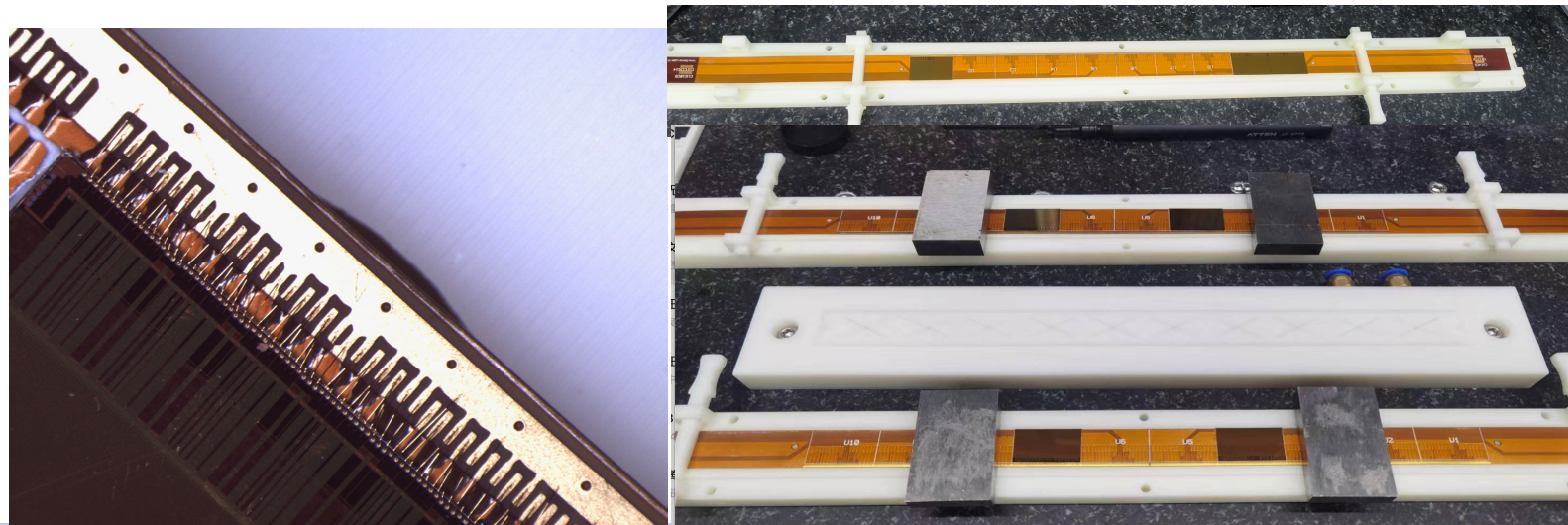
Hard PCB with test points



Electronics test bench



2~3 Taichu chips wire bonded on one flex



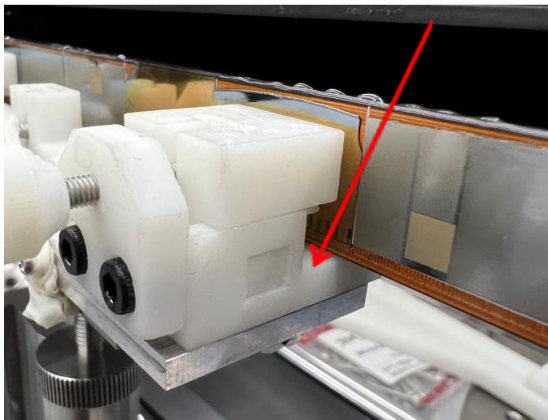




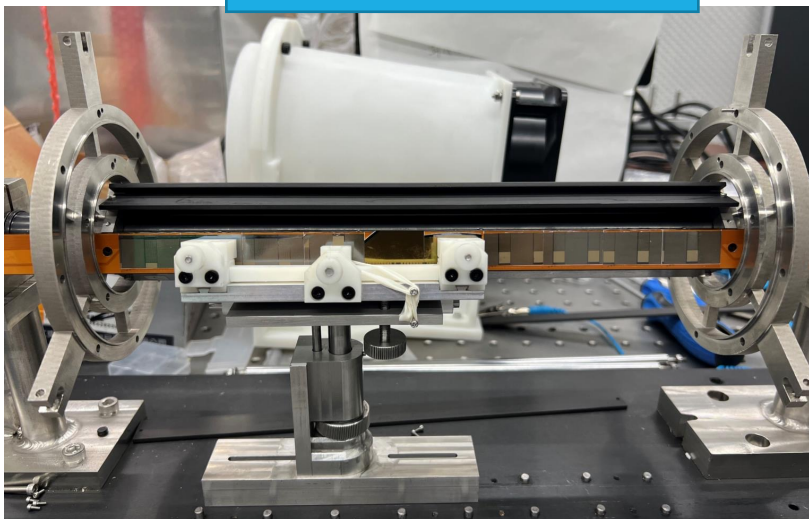
# Ladder loading

- Loading procedure of ladder on vertex detector has been tested
- Ladder with one Taichu3 chip with wirebonds and 9 dummy silicon chip
- Wire-bonding was protected during loading

Wire-bonding



Ladder support tools



Ladder loaded on vertex detector

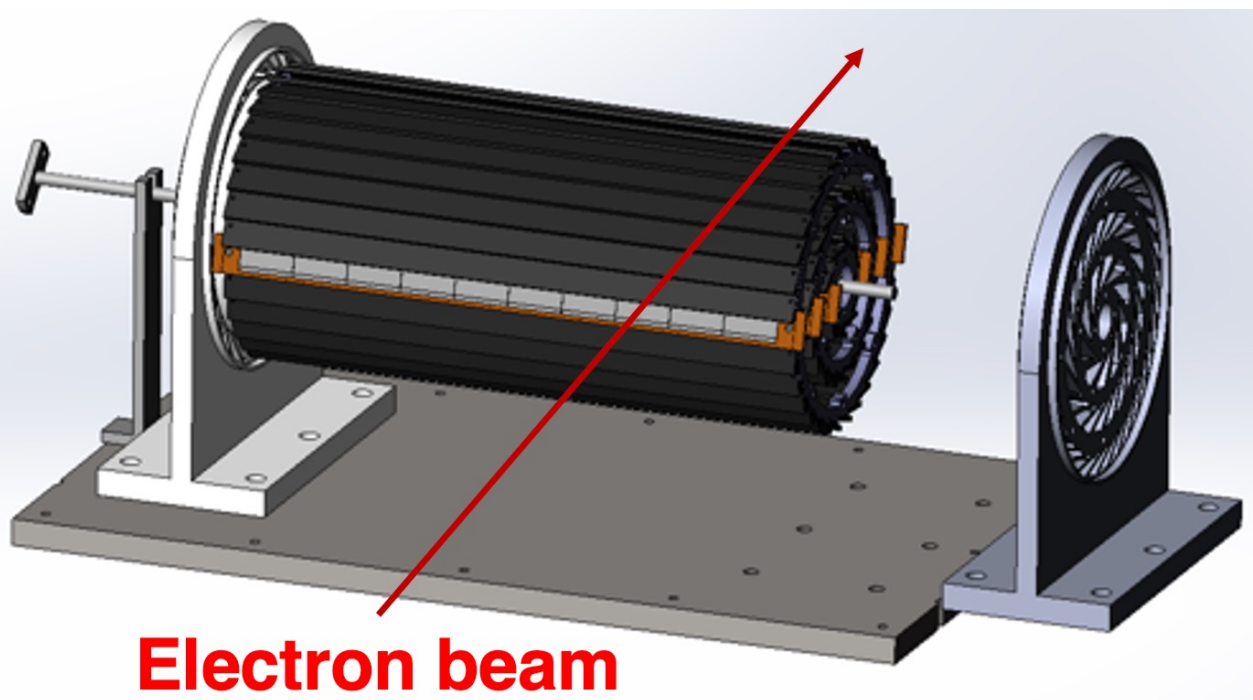


Jinyu Fu  
Xinhui Huang



# Plan for next test beam

- Plan to perform beam test at DESY in April 2023
  - Plan to install 6 real ladders on prototype, Plan to install all the carbon fiber support structure detector



DESY testbeam : Apr, 2023

**st Beam Schedule 2023**

	TB21	TB22	TB24/1	TB24
	Caltech	University	POWAG	University
1	Shutdown			
2	Shutdown			
3	Shutdown			
4	Shutdown			
5	Shutdown			
6	Shutdown			
7	Shutdown			
8	Shutdown			
9	Shutdown			
10	Shutdown			
11	DSBM	QMSHGAL	X	SHIP-ECAL
12	DSBM	ATLASITk Strips	X	Telescope-Dev
13	MONOPX2	ATLASITk Strips	X	PS-MAPS
14				
15				
16				
17	QMSInnerTracker	TeleRx	X	
18	QMSInnerTracker	TeleRx	X	
19	Belle-II QMOS	Tangerine	X	UHD-ECAL
20	QMSHGAL	Tangerine	X	UHD-ECAL
21				
22				
23				
24	QMSInnerTracker	ATLASITk Strips	X	
25	QMSInnerTracker	ATLASITk Strips	X	
26	MONOPX2	Telescope-Dev	X	
27	QMSOuterTracker			UHD-Muon-GK
28	QMSOuterTracker	RD60-QMOS	X	MMQSS
29				



# Summary



- Large-scale sensor chip (TaichuPix-3) from engineering run ready
- Detector module (ladder) assembly in progress
- Full vertex detector prototype assembly in process
- Rehearsal test beam using Taichu3 telescope at DESY is on-going
  - Preliminary results looks promising
- To Do
  - Next DESY Test beam in middle of 2023
    - Test beam with vertex detector prototype

