TaichuPix3 testbeam at DESY TB21

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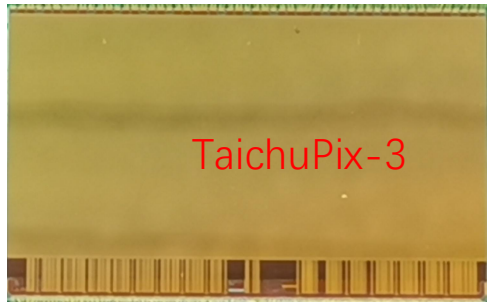
2023/01/10

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

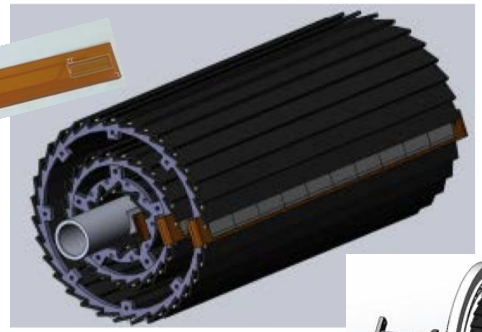
CMOS pixel sensor prototyping



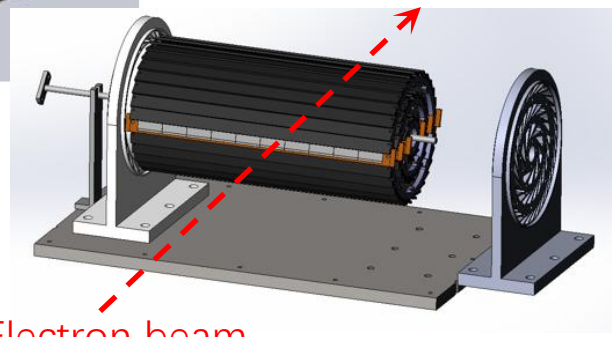
Detector module (ladder) prototyping

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

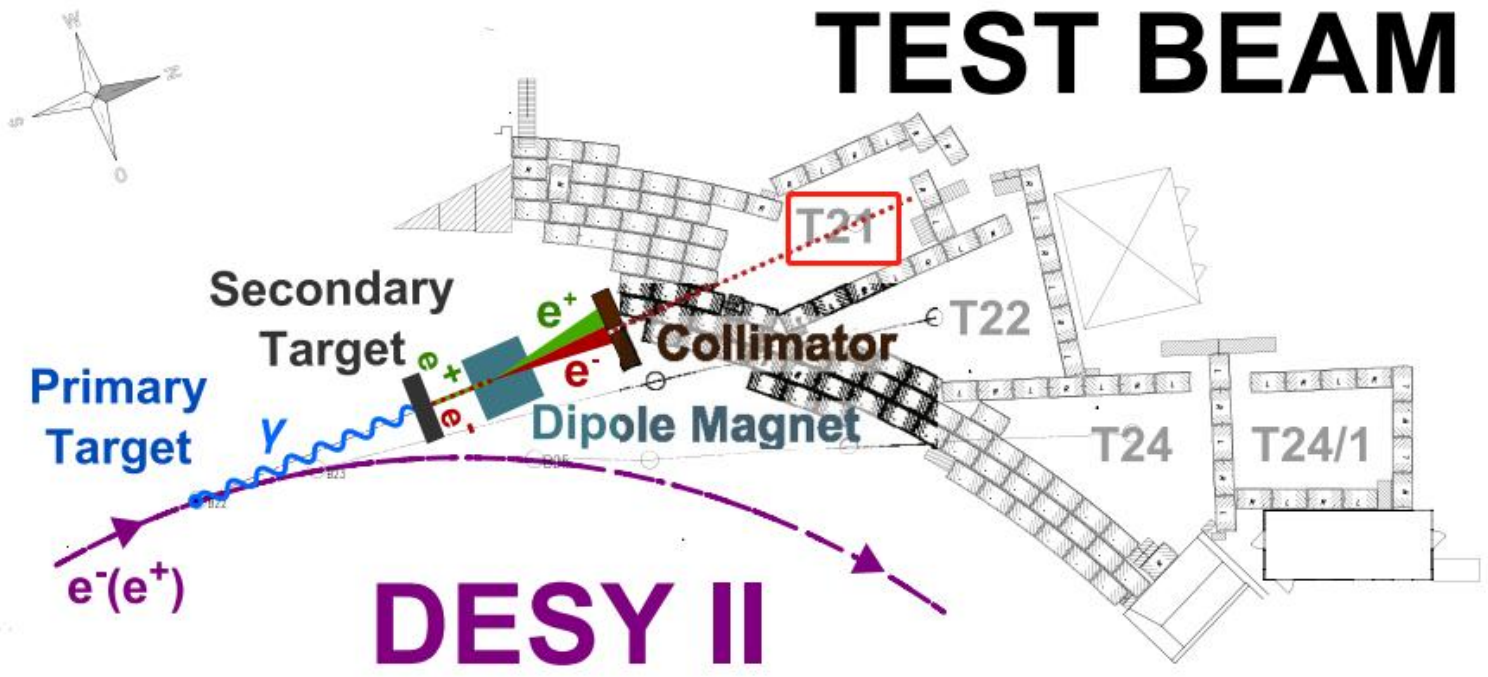
Full size vertex detector prototype



Beam test to verify its spatial resolution

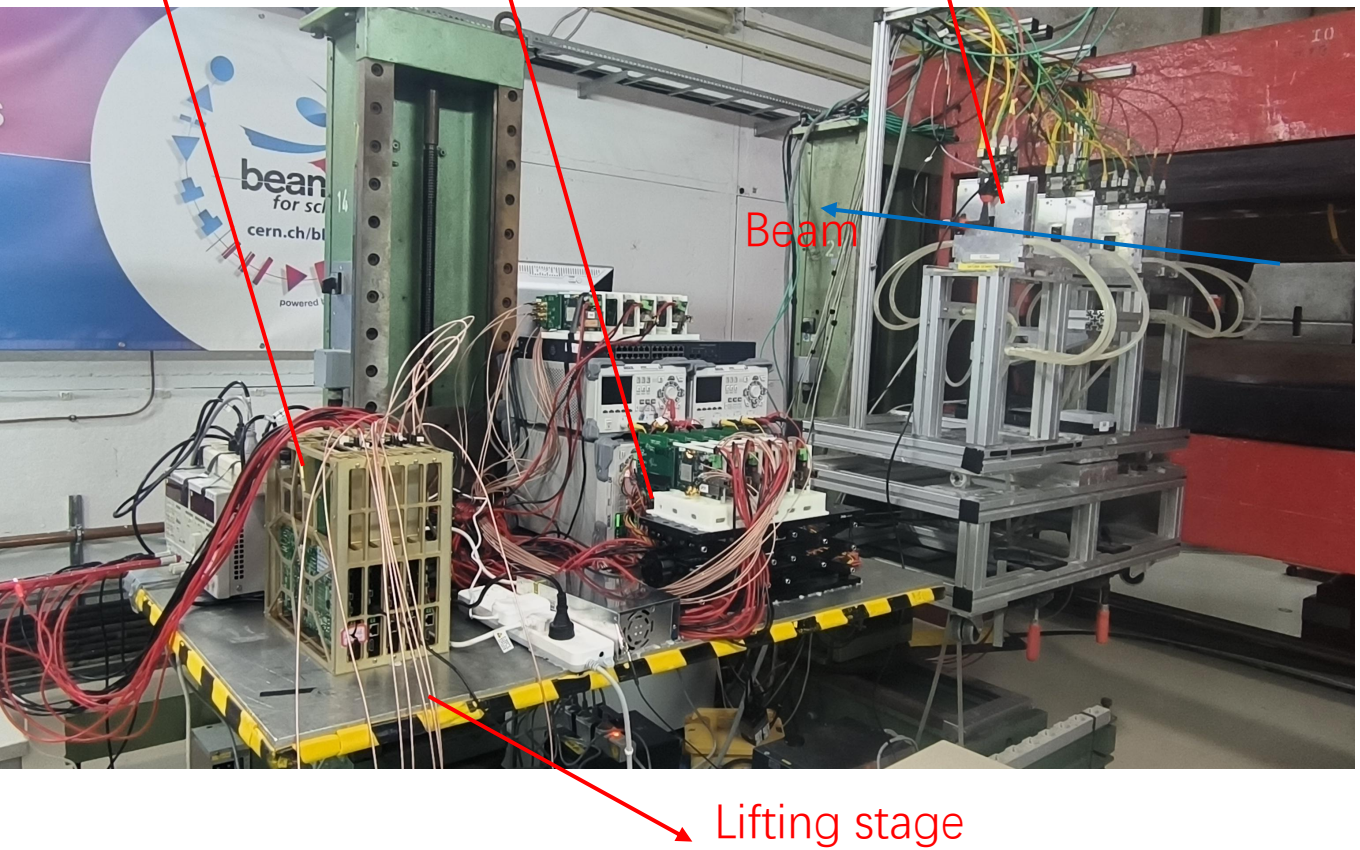


Introduction of DESY TB21



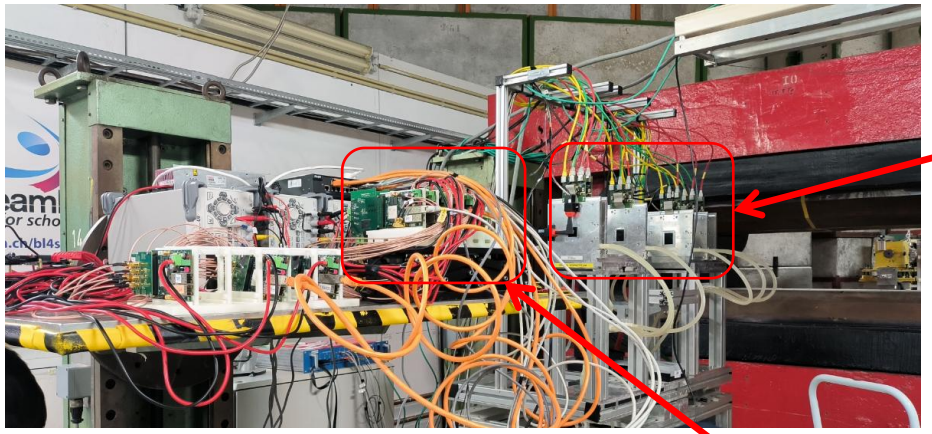
The electron or positron beams are converted bremsstrahlung beams from carbon fibre targets in the electron-positron synchrotron DESY II with up to 1000 particles per cm^2 and energies from 1 to 6 GeV, an energy spread of ~5% and a divergence of ~1mrad.

DESY Testbeam Setup

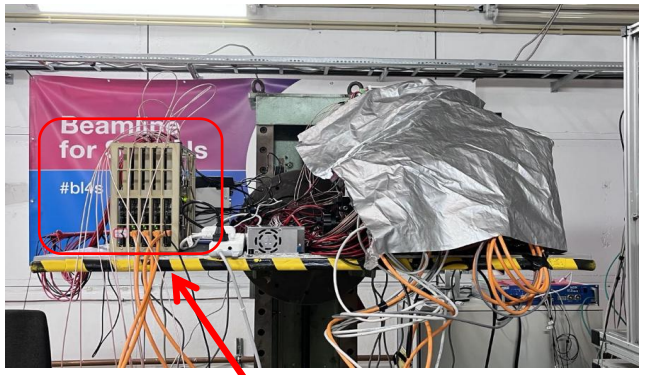


- The 6-layer of TaichuPix3 telescope was in the middle of the 5-layer MIMOSA and 4-layer JadePix telescope.
- MIMOSA is fixed there and cannot move. But it can be used to calibrate the position of the TaichuPix3 telescope

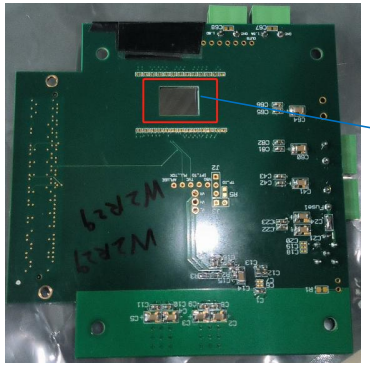
Setup of TaichuPix3



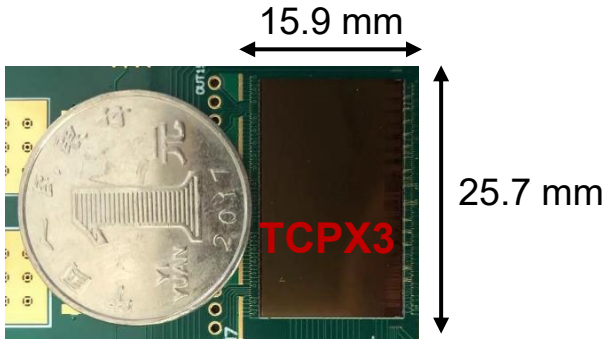
MIMOSA Telescope

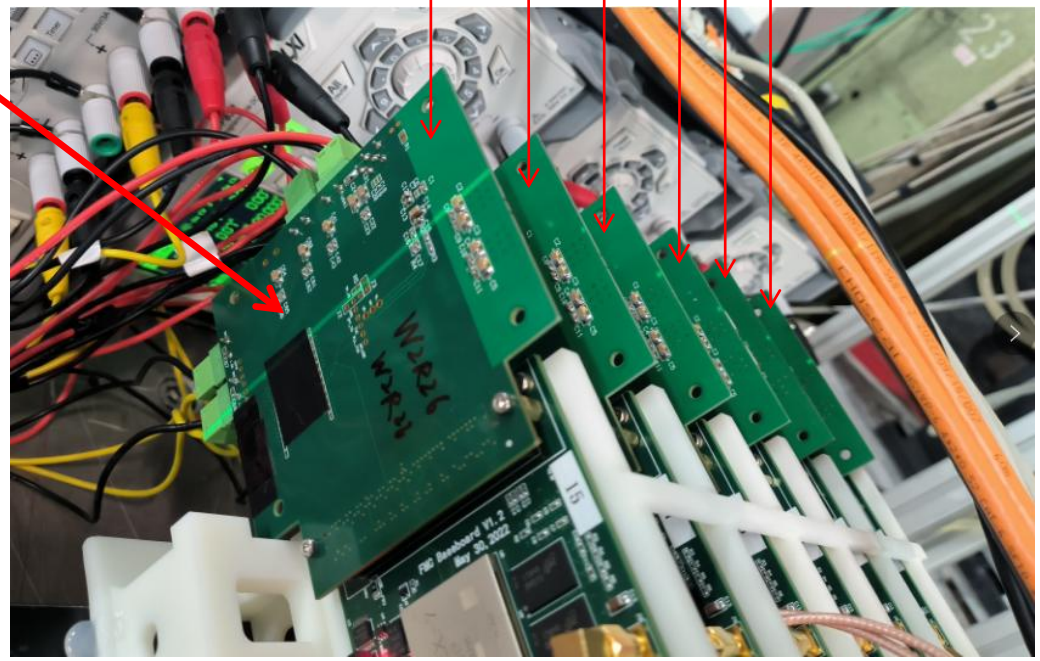


- Jadepix telescope



An open window in backside of PCB with a size of 12mm x 9mm





Overview of testbeam

Dec.12-Dec. 17:(SETUP 1)

- 1-6: W2R3, W2R11, W2R12, W2R10, W2R29, W2R26

Dec. 17:(SETUP 2)

- 1-6: W2R3, W9R3, W9R4, W9R6, W2R29, W2R12

Dec. 18-Dec.19(SETUP 3)

- 1-6: W2R3, W9R5, W9R4, W9R6, W2R29, W2R12

Dec. 20- Dec.22(SETUP 4)

- 1-6: W2R3, W9R5, W2R11, W9R6, W2R29, W2R12

Note: **W2:** No.2 Wafer by standard CMOS process;
R3: chip position on wafer is 3;
W9: No.9 Wafer by modified CMOS process;

The beam energy was tested from 3GeV 4GeV 5GeV 5.4GeV 6GeV

- W9R3 had a higher noisy pixels and replaced with W9R5
- W9R4 was easy to lose analog current and replaced with W2R11

Threshold scan

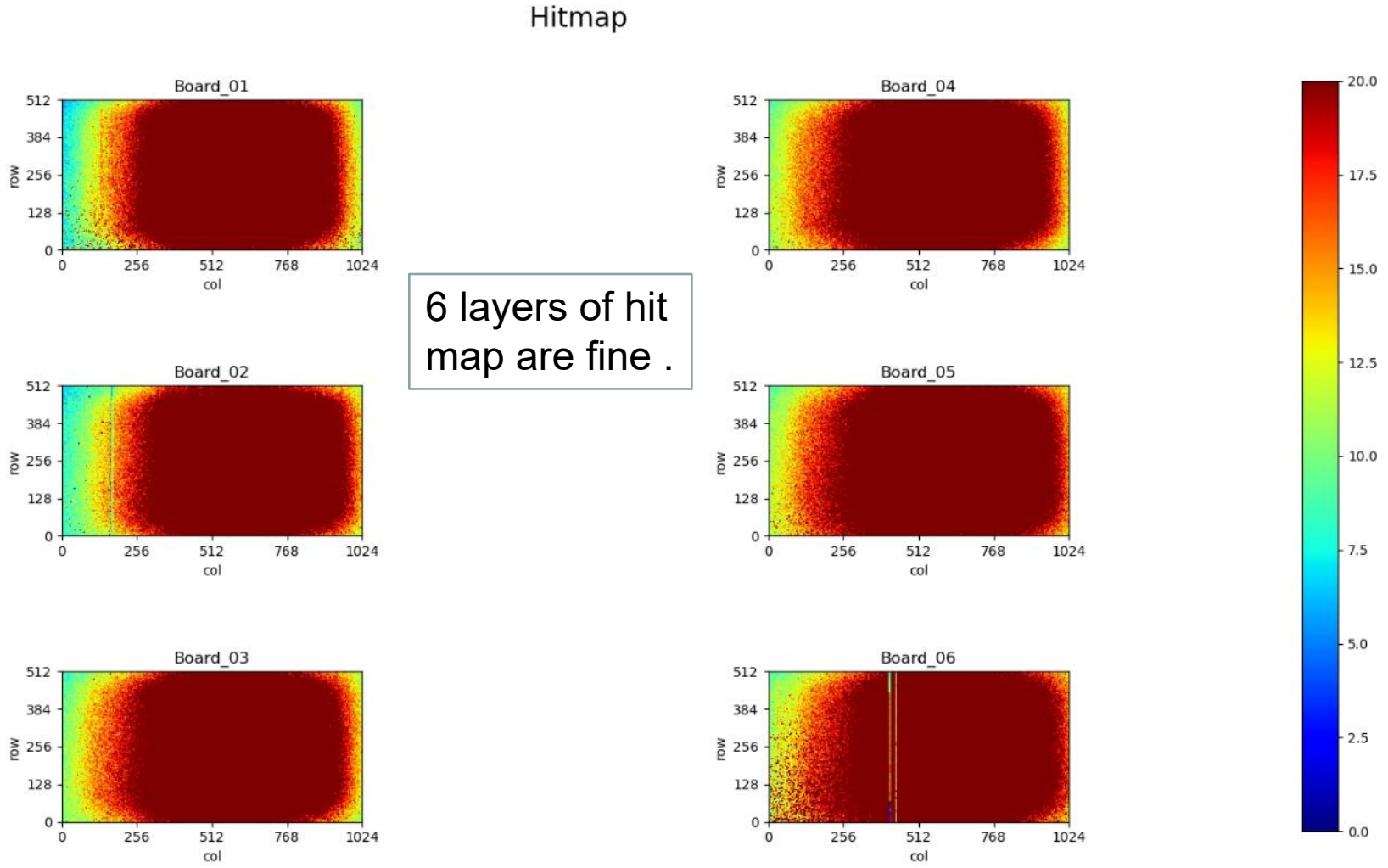
- With SETUP 4.（W2R3, W9R5, W2R11, W9R6, W2R29, W2R12)
- Scan ITHR of board 5（W2R29）with10 16 24 32 48 64 96; 4GeV ;30min for each run; keep the rest of boards unchanged
- Scan ITHR of board 2（W9R5）with16 24 32 48 64 96; 4GeV ;30min for each run; keep the rest of boards unchanged

➢ W9R5: the spatial resolution is 4.9 at ITHR16 when chi2 <2

➢ W2R29: the resolution goes to 5.09 at ITHR10 when chi2 < 2

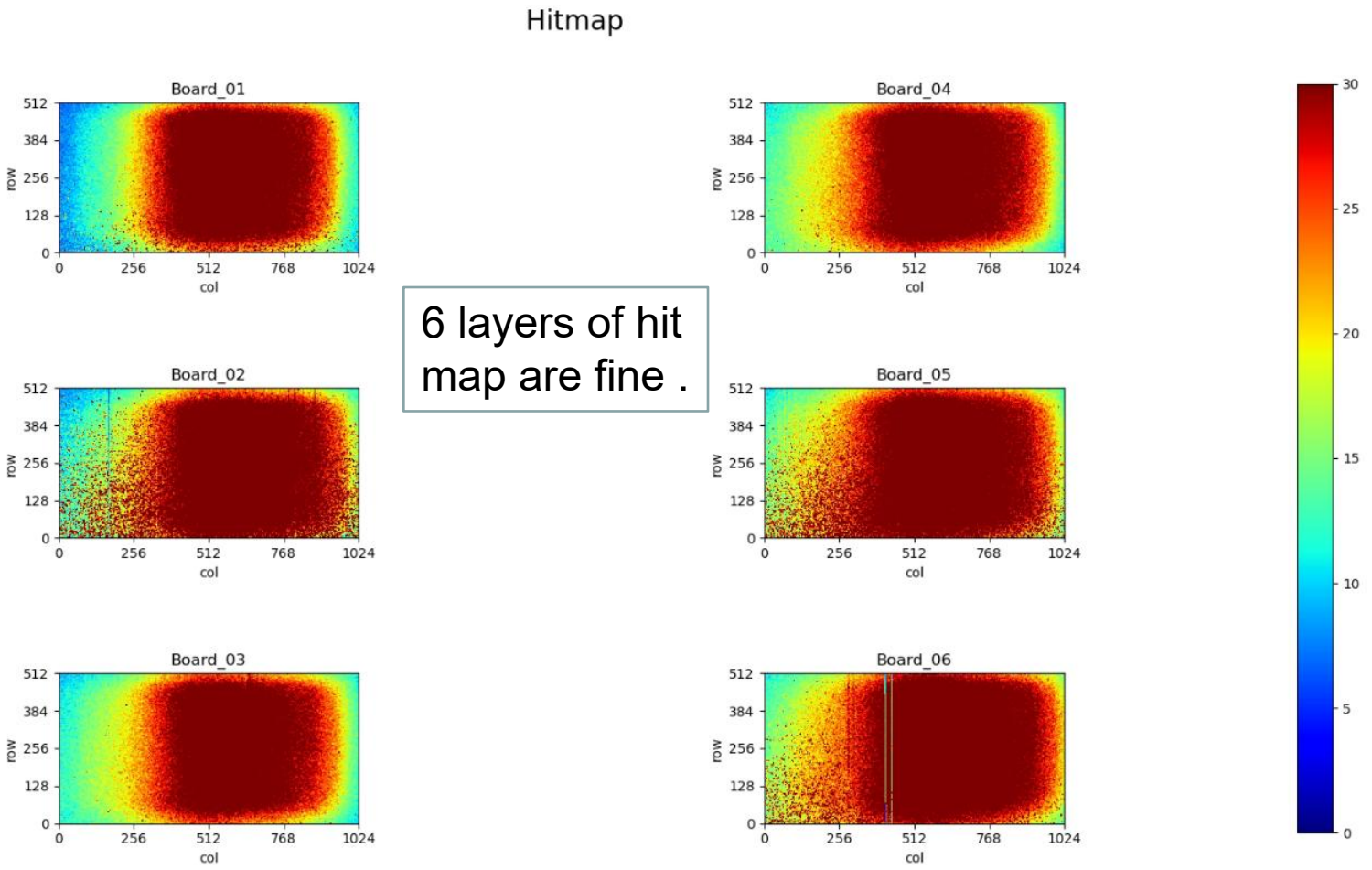
Chip	VBG[V]	ITHR16 Threshold[V]	ITHR32 Threshold[V]	ITHR64 Threshold[V]	ITHR96 Threshold[V]	ITHR16 mask pixels	ITHR32 mask pixels
W2R29	0.740	0.2654	0.3345	0.4468	0.5452	82	1
W9R5	0.737	0.1596	0.1983	0.2683	0.3113	26	4

Hitmap of 3 GeV beam



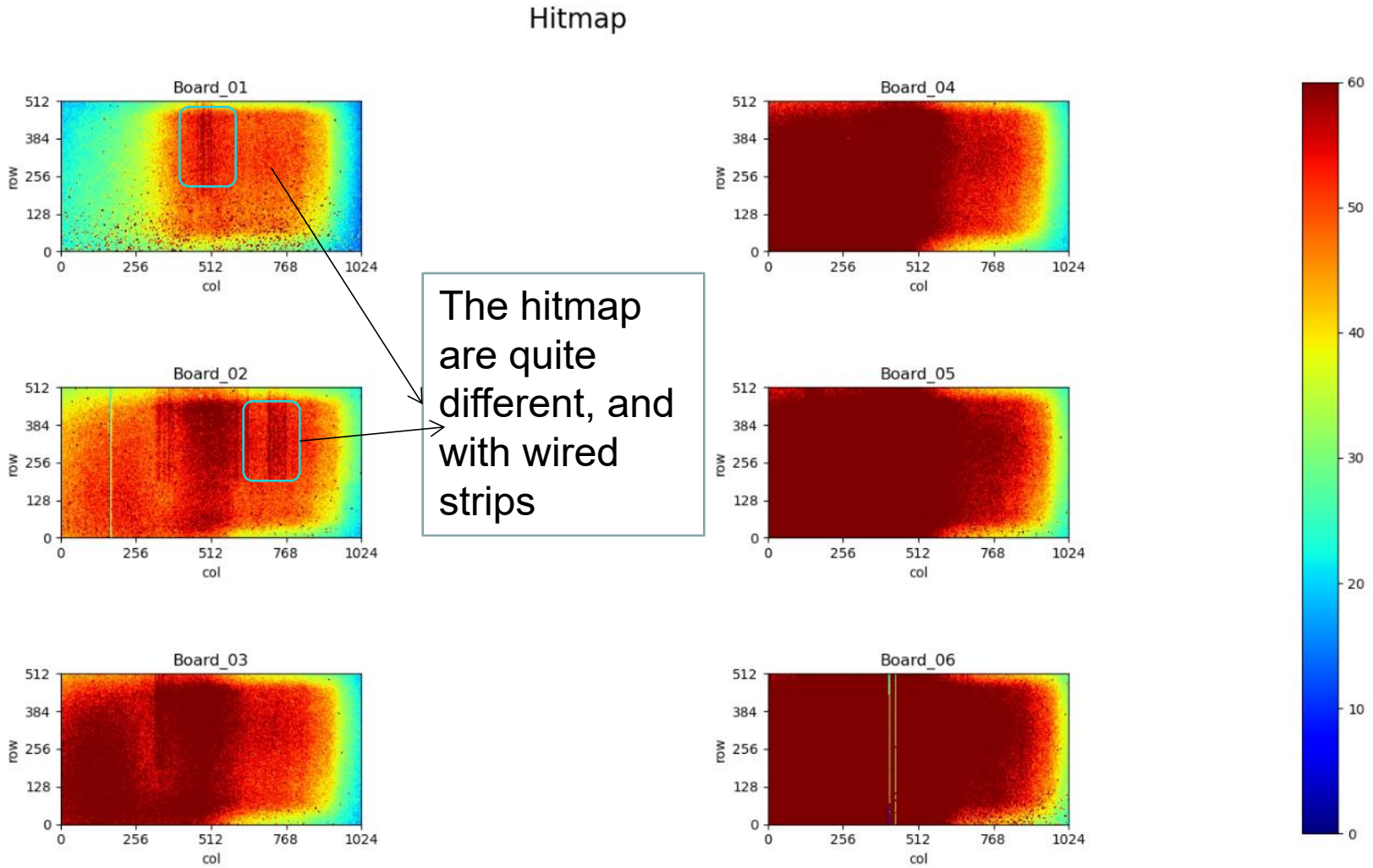
6 layers of hit map are fine .

Hitmap of 4 GeV beam

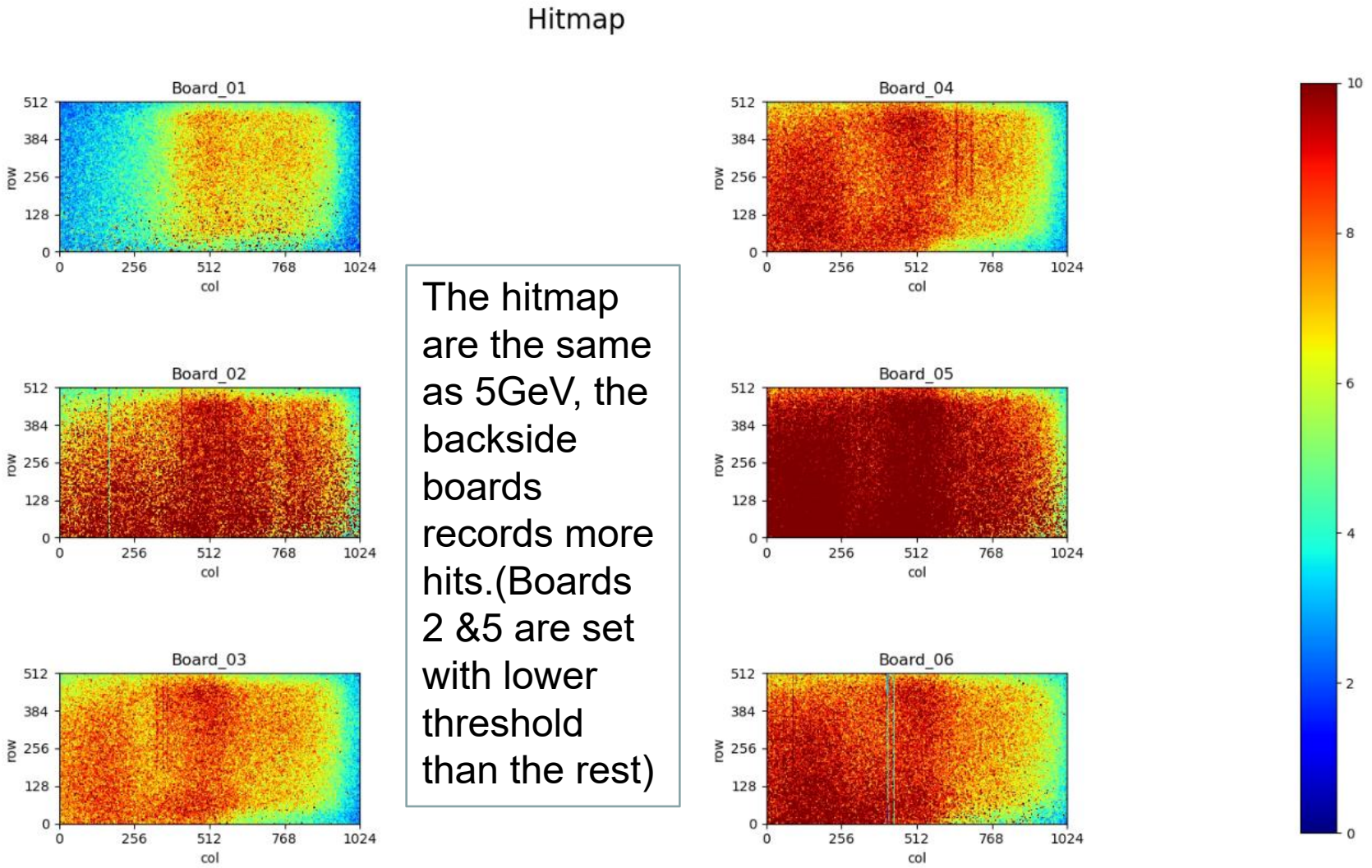


6 layers of hit map are fine .

Hitmap of 5 GeV beam

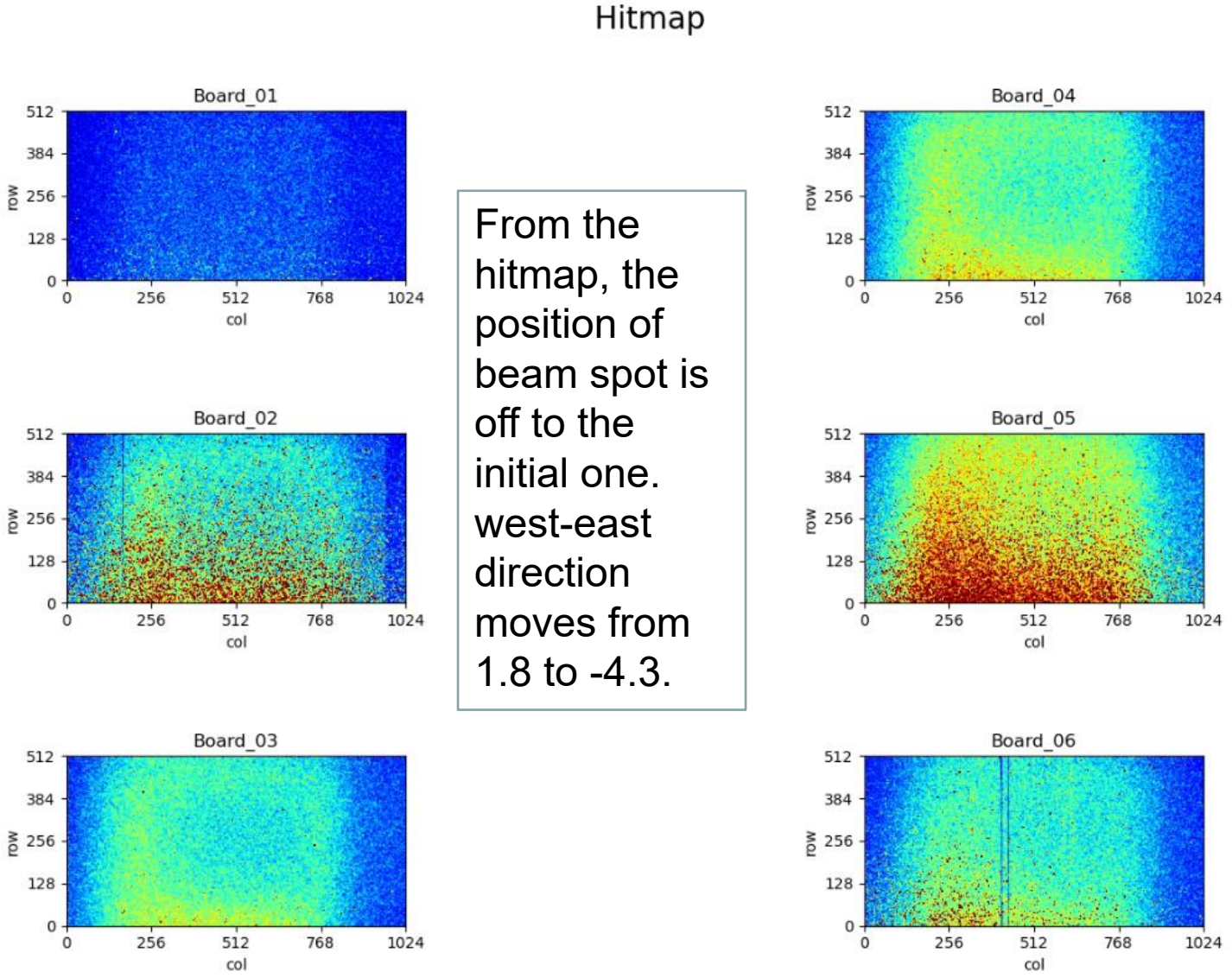


Hitmap of 5.4 GeV beam



The hitmap are the same as 5GeV, the backside boards records more hits.(Boards 2 &5 are set with lower threshold than the rest)

Hitmap of 6 GeV beam



From the hitmap, the position of beam spot is off to the initial one. west-east direction moves from 1.8 to -4.3.

Energy Option

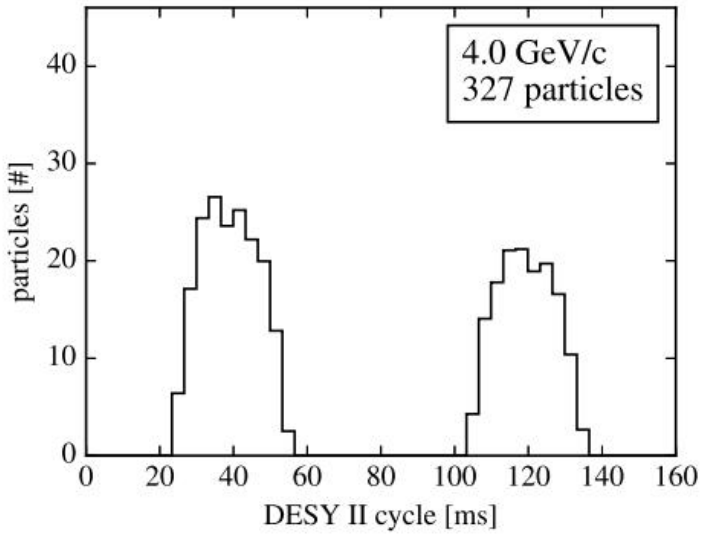
- From hit map, 4GeV is a moderate option.

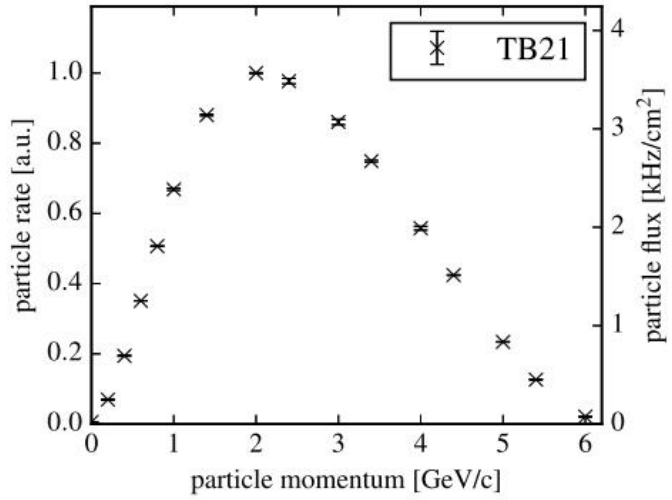
→ Enough data and higher energy

- 4 GeV is used for Threshold scan, the data rate is around 10K B/s for a standard CMOS chip and 67.4K B/s for modified process.

- The valid coincidence tracks are around 41 tracks/ s when chi2<2

- The sensors are working for the full beam time except for the chip replacement. Totally about 100GB valid data were recorded





(a) at TB21

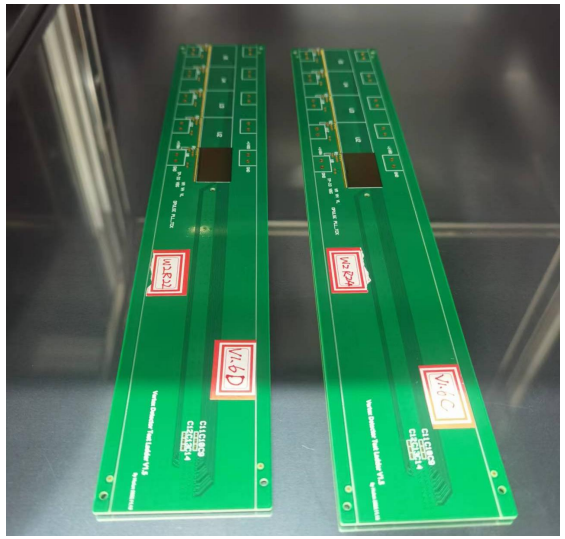
Refer from:The DESY II test beam facility"
https://doi.org/10.1016/j.nima.2018.11.133
NIMA, Volume 922, 1 April 2019, Pages 265-286

Progress for flex board

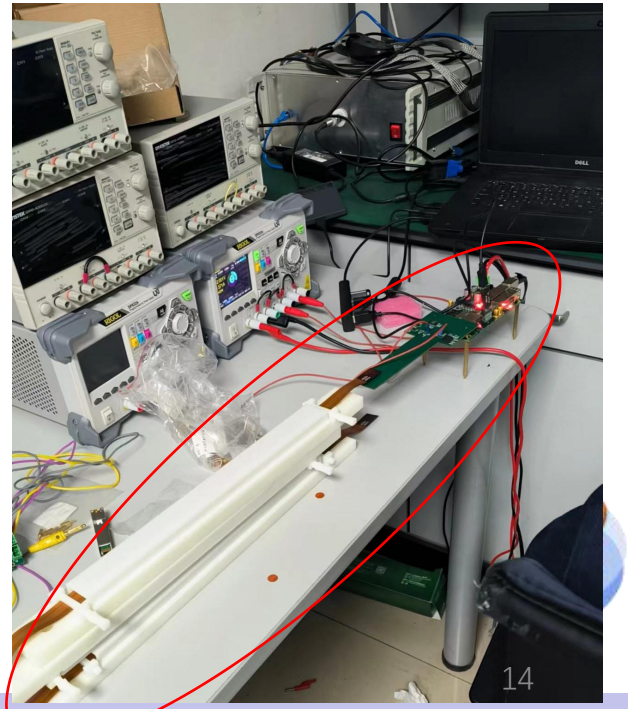
Jun Hu
Ying Zhang
Yiyue Yan

- 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 understand the issue,
    - The hard PCB is working correctly and a 4 layer flex board is under testing.

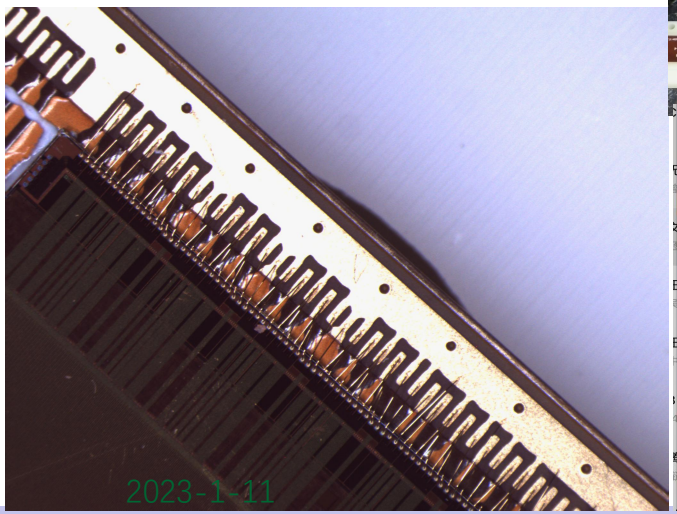
Hard PCB with test points

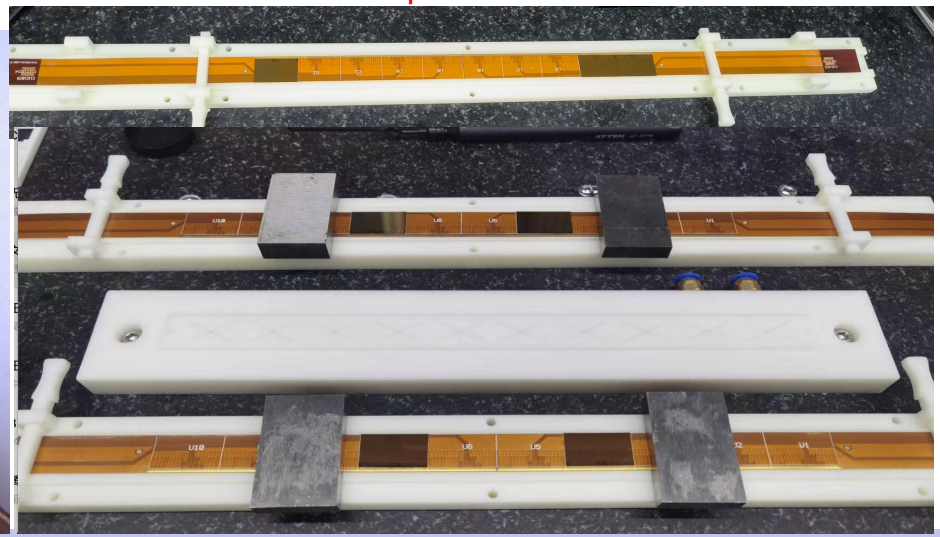


Electronics test bench



2~3 TaichuPix3 chips wire bonded on one flex

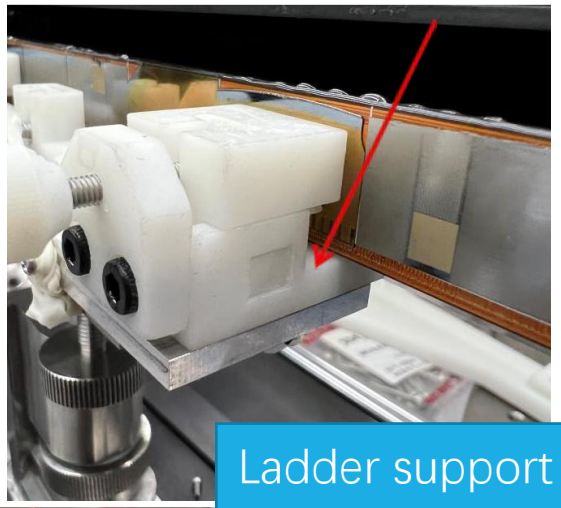




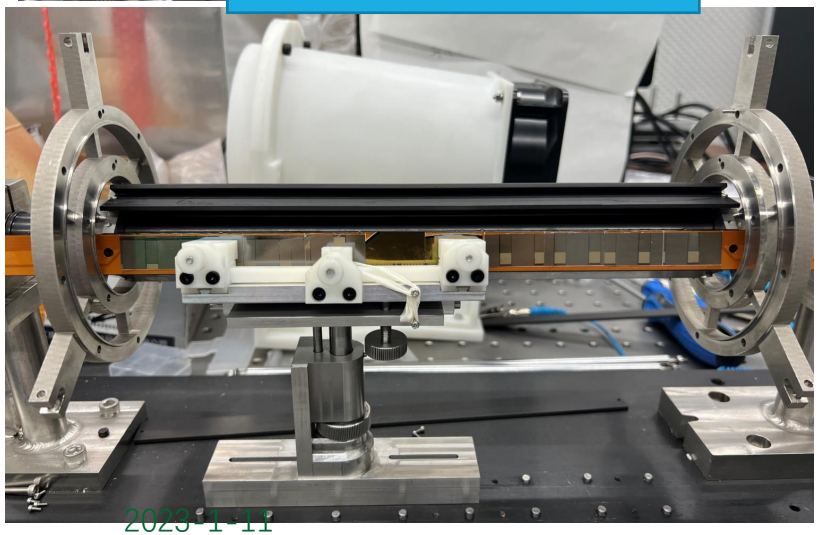
Ladder loading

- **Loading procedure of ladder on vertex detector has been tested**
- **Ladder with one TaichuPix3 chip with wirebonds and 9 dummy silicon chip**
- **Wire-bonding was protected during loading**

Wire-bonding

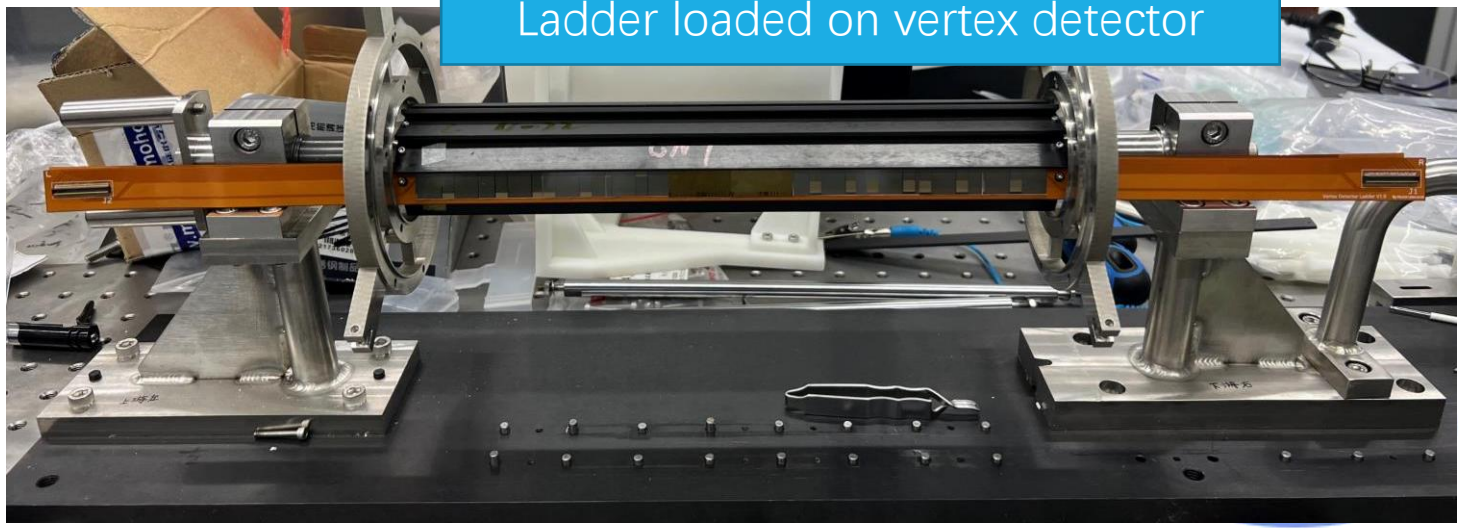


Ladder support tools



Jinyu Fu
Xinhui Huang
Wei Wang

Ladder loaded on vertex detector



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) Offline
  - Hao Zeng (IHEP) Offline
  - XueWei Jia (IHEP) Offline

Remote support

WeiWei, Ying Zhang (IHEP) ASIC

Jun Hu, Ziyue Yan (IHEP) firmware

Hongyu Zhang (IHEP) DAQ

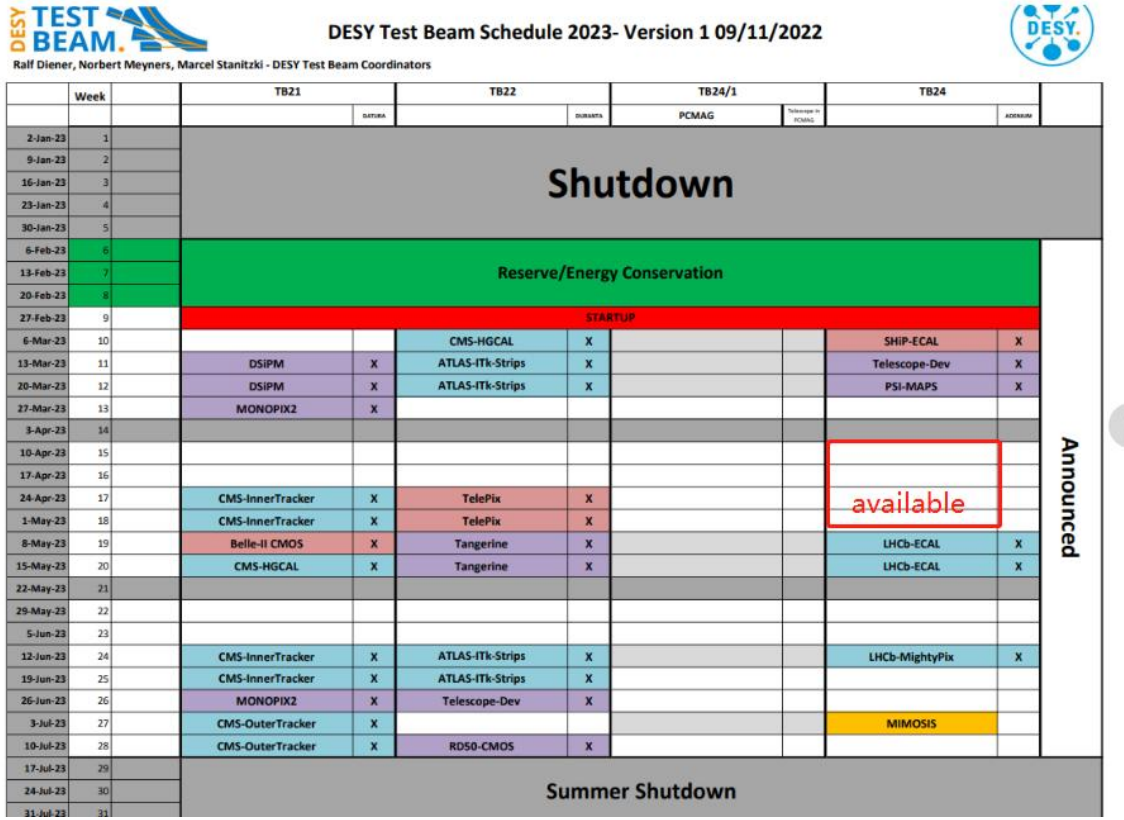
Jinyu Fu, Mingyi Dong (IHEP) Assembly

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

Yiming Hu, Xiaoxu Zhang (NJU)…

Summary

- 6 layers TaichuPix3 telescope basically works well. Enough data was acquired for offline analysis.
- The preliminary offline results shows a spatial resolution less than 5 μm, more analysis is going on.
- The publication is under preparation
- If possible, the baseline vertex detector is supposed to DESY again for testbeam in April 2023.



DESY TEST BEAM.

DESY Test Beam Schedule 2023- Version 1 09/11/2022

Ralf Diener, Norbert Meyners, Marcel Stanitzki - DESY Test Beam Coordinators

	Week		TB21		TB22		TB24/1		TB24		
				DATURA		DURANTA	PCMAG	Telescope in PCMAG		ADENIUM	
2-Jan-23	1		Shutdown								
9-Jan-23	2										
16-Jan-23	3										
23-Jan-23	4										
30-Jan-23	5										
6-Feb-23	6		Reserve/Energy Conservation								Announced
13-Feb-23	7										
20-Feb-23	8										
27-Feb-23	9		STARTUP								
6-Mar-23	10				CMS-HGCAL	X			SHiP-ECAL	X	
13-Mar-23	11		DSIPM	X	ATLAS-ITk-Strips	X			Telescope-Dev	X	
20-Mar-23	12		DSIPM	X	ATLAS-ITk-Strips	X			PSI-MAPS	X	
27-Mar-23	13		MONOPIX2	X							
3-Apr-23	14										
10-Apr-23	15										
17-Apr-23	16										
24-Apr-23	17		CMS-InnerTracker	X	TelePix	X			available		
1-May-23	18		CMS-InnerTracker	X	TelePix	X					
8-May-23	19		Belle-II CMOS	X	Tangerine	X			LHCb-ECAL	X	
15-May-23	20		CMS-HGCAL	X	Tangerine	X			LHCb-ECAL	X	
22-May-23	21										
29-May-23	22										
5-Jun-23	23										
12-Jun-23	24		CMS-InnerTracker	X	ATLAS-ITk-Strips	X			LHCb-MightyPix	X	
19-Jun-23	25		CMS-InnerTracker	X	ATLAS-ITk-Strips	X					
26-Jun-23	26		MONOPIX2	X	Telescope-Dev	X					
3-Jul-23	27		CMS-OuterTracker	X					MIMOSIS		
10-Jul-23	28		CMS-OuterTracker	X	RD50-CMOS	X					
17-Jul-23	29		Summer Shutdown								
24-Jul-23	30										
31-Jul-23	31										

Thanks for your attention!