



中国科学技术大学

University of Science and Technology of China



IGFAE  
Instituto Galego de Física de Altas Enerxías



XUNTA  
DE GALICIA

XVII Conference on Resistive Plate Chambers and Related Detectors

# Mass production and quality control of CEE iTOF-MRPC

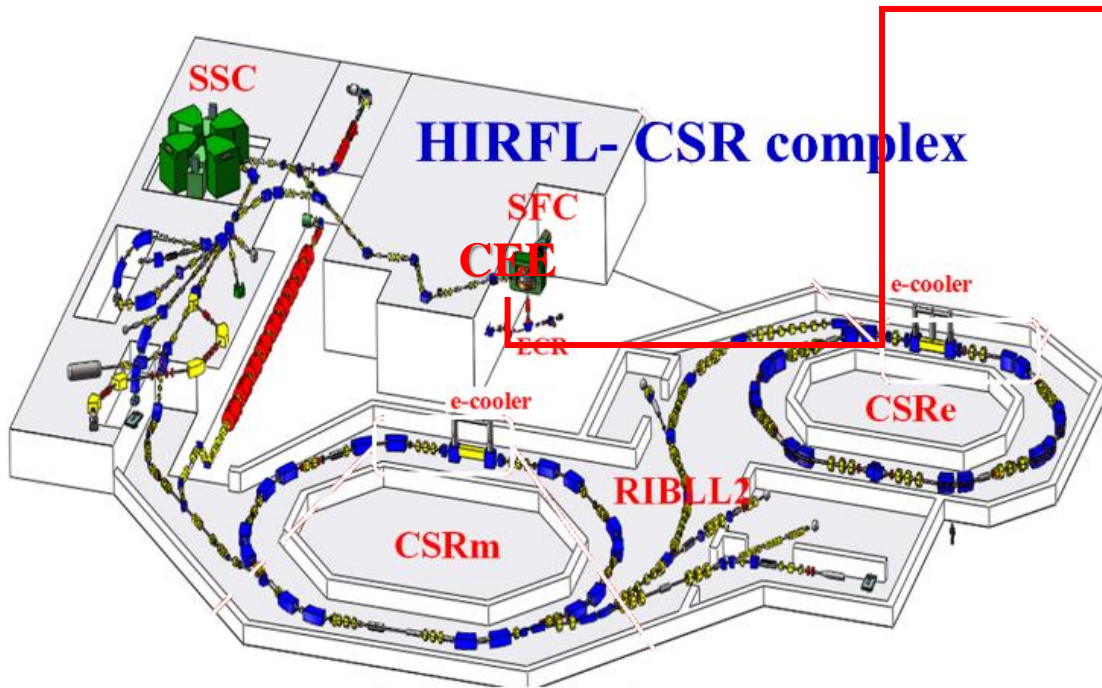
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Department of Modern Physics, USTC

# Outline

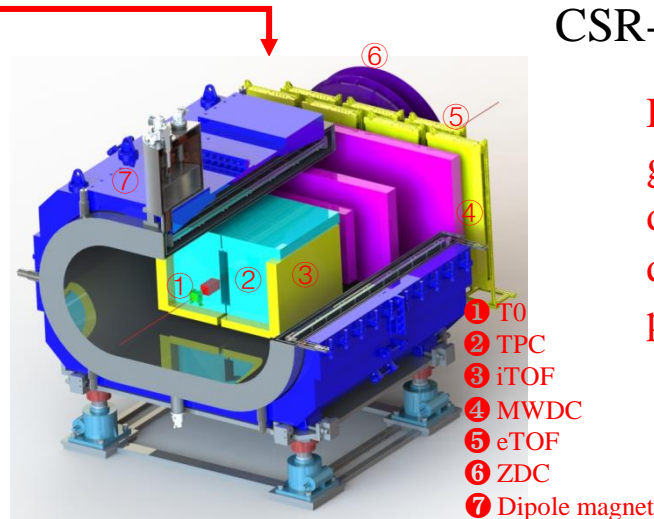
- **Motivation**
- **iTOF-MRPC**
- **QC on MRPC production**
  - **Production environment**
  - **QC on material preparation**
  - **QC on MRPC assembling**
  - **Finish check**
- **HV test**
- **Summary**

# Motivation



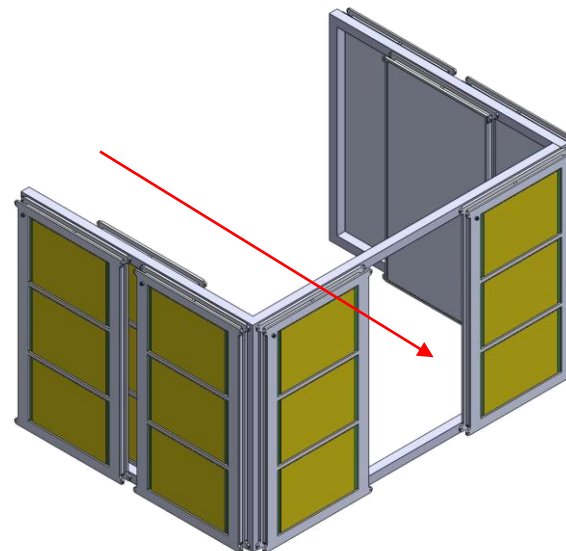
Heavy-Ion Research Facility at Lanzhou (HIRFL-CSR)

- ✓ Provides various ion beam with incident energy in the range of 0.5~1.2GeV/u (can be as heavy as uranium)



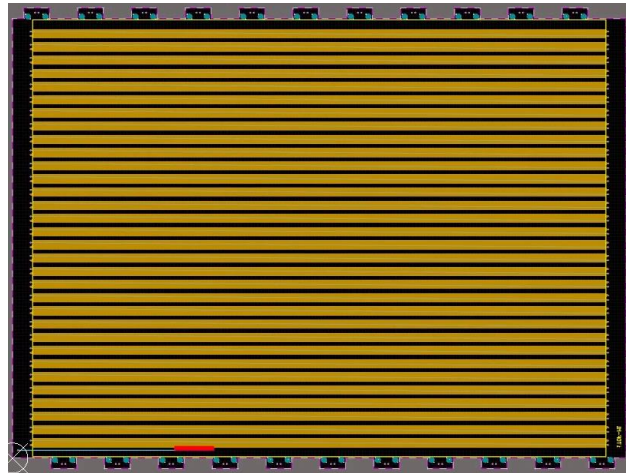
CSR-external Target Experiment, CEE

Fix target  
goals to study the bulk properties of dense matter and to understand the quantum chromo-dynamic (QCD) phase diagram



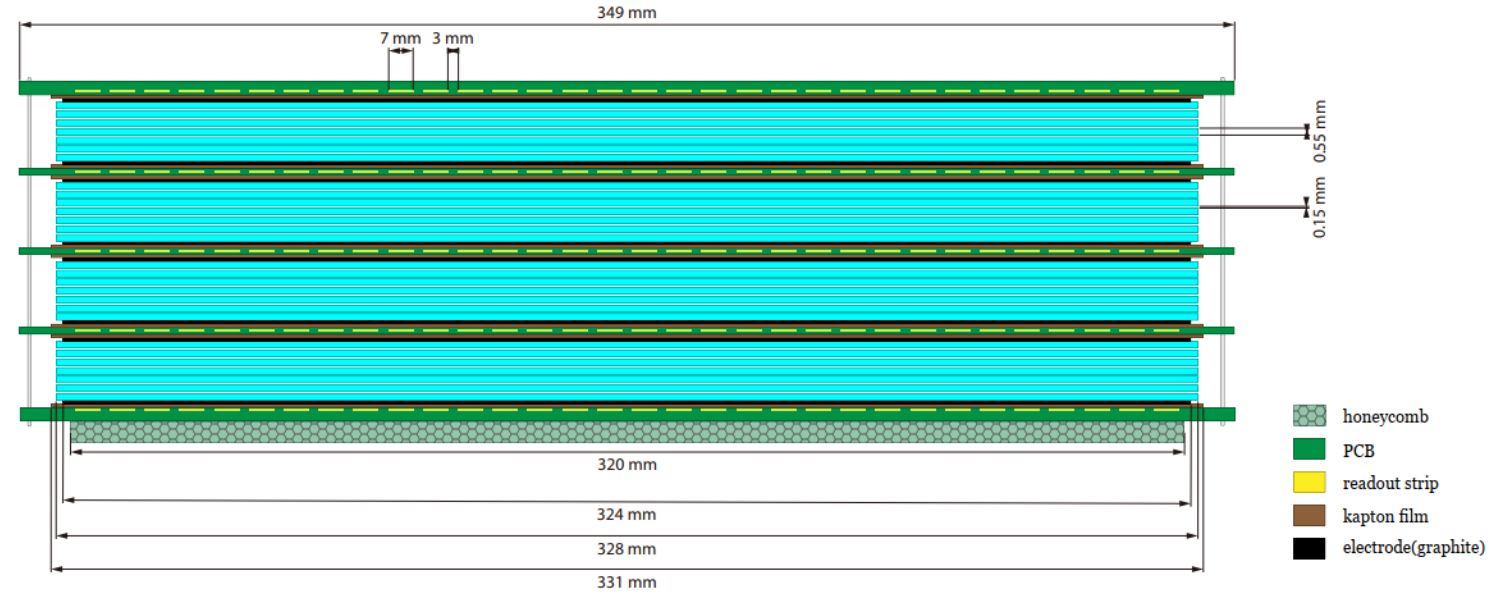
iTOF system	
Number of modules	24
Area	3.4 m <sup>2</sup>
Number of Channels	1536

Gap	width	0.150 mm
	quantity	4 × 6
Glass thickness		0.55 mm
Readout strip	width	7 mm × 32 Double end readout
	length	426 mm
Strip interval		3 mm

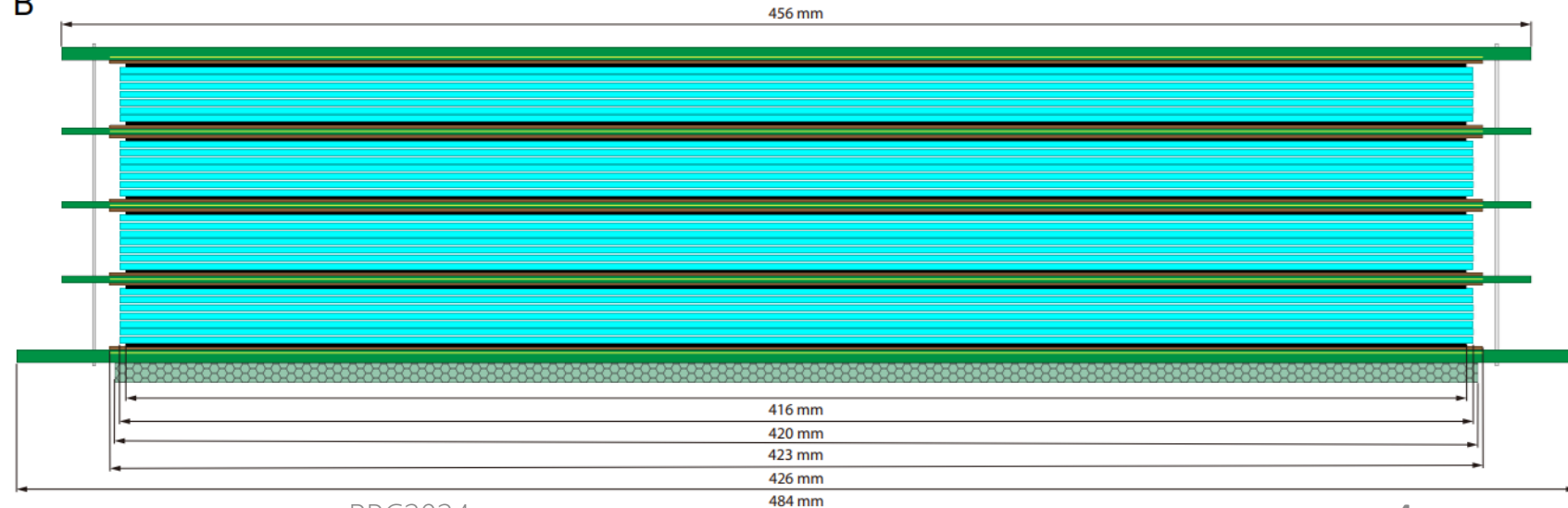


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A



B



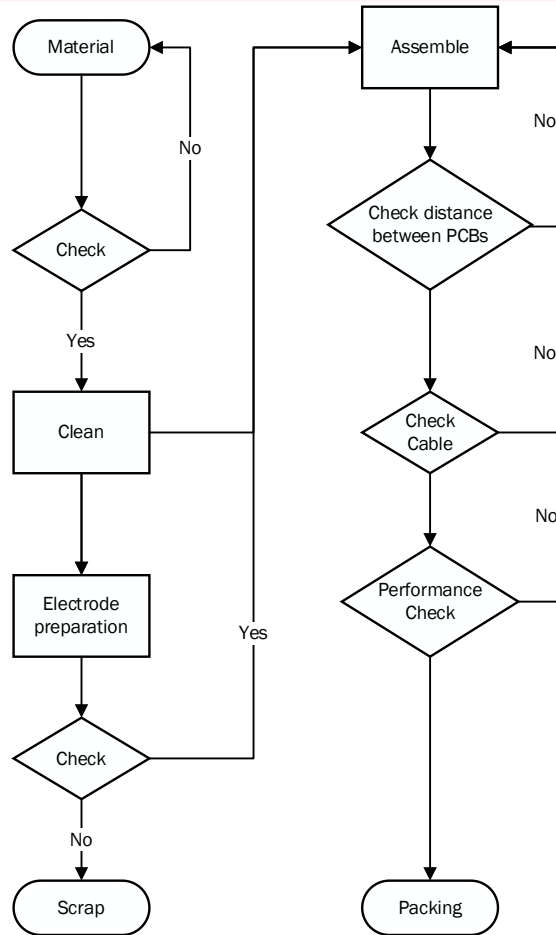
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# QC on MRPC production



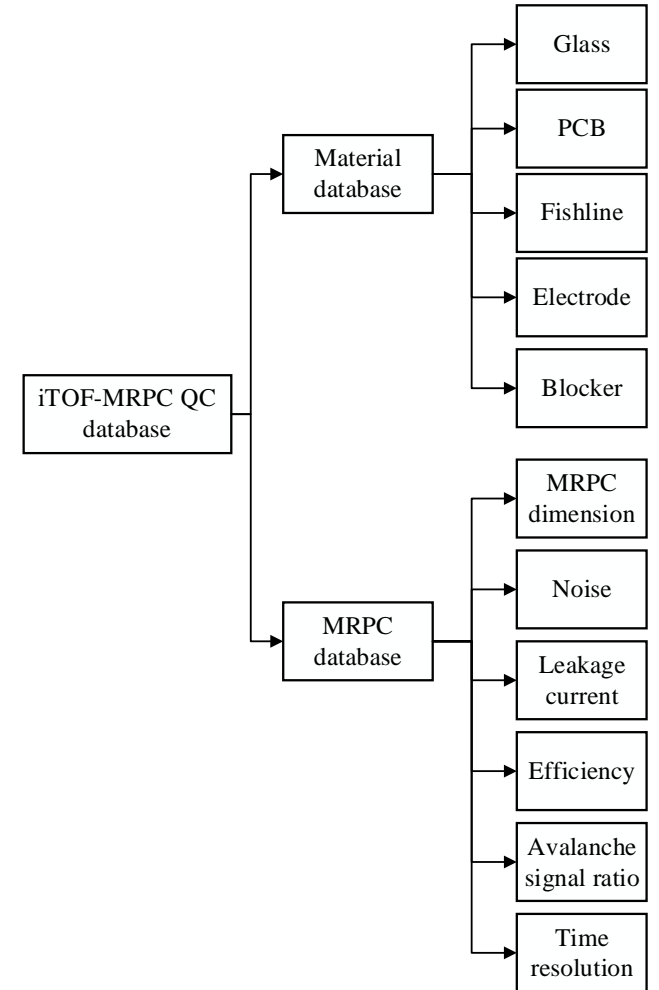
## Technological process of production



## Production information website :

<https://pnp.ustc.edu.cn/detdb/?tbname=mrpc>

MRPC	UID	Program	Type	Stage	Module ID	QA	Test
CBM-TOF	1018	CBM-TOF	MRPC3b	Mass Production	18	NONE	NONE
STAR-EPD	1119	CBM-ToF	MRPC3b	Test	119	PASS	PASS
FEE Board	1017	CBM-ToF	MRPC3b	Mass Production	17	PASS	PASS
RX Board	1016	CBM-ToF	MRPC3b	Mass Production	16	PASS	PASS
SiPM	1020	CBM-ToF	MRPC3b	Mass Production	20	PASS	PASS
	1019	CBM-ToF	MRPC3b	Mass Production	19	PASS	PASS
	1026	CBM-ToF	MRPC3b	Mass Production	26	PASS	PASS
	1021	CBM-ToF	MRPC3b	Mass Production	21	PASS	PASS
	1039	CBM-ToF	MRPC3b	Mass Production	39	PASS	PASS
	1040	CBM-ToF	MRPC3b	Mass Production	40	PASS	PASS
	1041	CBM-ToF	MRPC3b	Mass Production	41	PASS	PASS
	1042	CBM-ToF	MRPC3b	Mass Production	42	PASS	PASS
	1048	CBM-ToF	MRPC3b	Mass Production	48	PASS	PASS





# Production environment



Cleaning Room



Bechtop



Environment	
Area	90 m <sup>2</sup>
Cleanness level	Class 10000
Bechtop	Class 1000
Temperature	22 ± 1°C
Humidity	< 40%



Ultrasonic cleaning machine

9/9/2024



Ultrapure water machine

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Graphite electrode spraying machine

# Material preparation



**Main materials for one iTOF-MRPC module**

Material	Dimension(mm)	Tolerance	Quantity
Graphite	416 × 324 × 0.13	Length/width: -0.5 mm	8
Glass	420 × 328 × 0.55	Length/width: ±0.2 mm, thickness: ±0.02 mm uniformity: < 0.01 mm	28
Kapton	426 × 331 × 0.125	Length/width: ±0.1 mm	8
Honeycomb board	423 × 320 × 6	Warpage: < 0.02%	1
PCB_B	484 × 349 × 4	Length/width: ±0.1 mm, uniformity: < 0.15 mm Warpage: < 0.75%	1
PCB_M1	456 × 349 × 1.1		1
PCB_M2	456 × 349 × 1.2		1
PCB_M3	456 × 349 × 1.1		1
PCB_T	456 × 349 × 4		1
Blocker_L	Height: 5		-0.5 mm
Blocker_I		80	
Fishing line	Diameter: 0.151	±0.005 mm	200 m
pin	0.6 × 0.6 × 30		172
HV lead	Diameter: 3		2 m
High-density connector	Height: 6		8

# QC on material preparation



Material main test items		
Material	testing tool	Inspection item
Graphite	multimeter	Surface resistivity between 1-10 MΩ/sq
	visual inspection	No scratches or defects
Glass	visual inspection	No scratches or defects
Kapton	visual inspection	No scratches or defects
Honeycomb board	feeler gauge	Warpage: < 0.02%
PCB	spiral micrometer	Uniformity: < 0.15 mm
Blocker	spiral micrometer	Height: 4.5 – 5 mm
Fishing line	spiral micrometer	Diameter: ±0.005 mm
High-density connector	multimeter	Connect to the readout strip

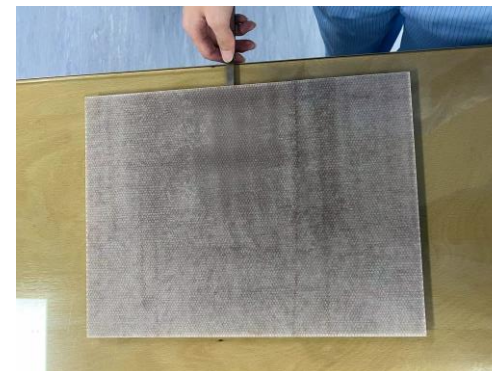
Measure fishing line diameter



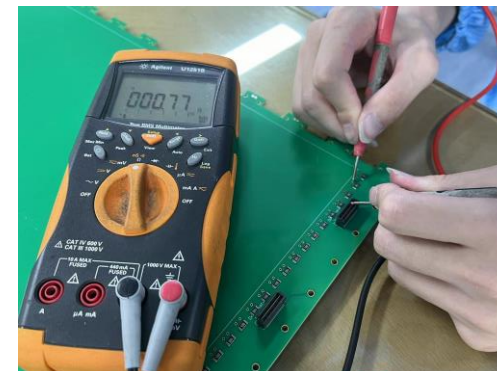
Measure PCB thickness



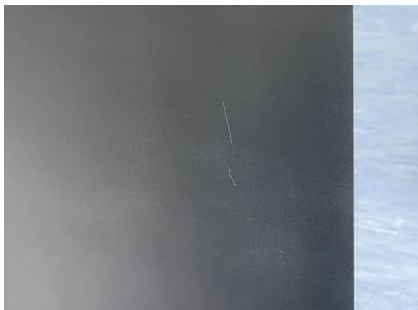
Measure the warpage of honeycomb board



Measure whether the High-density connector is connected



scratches or defects



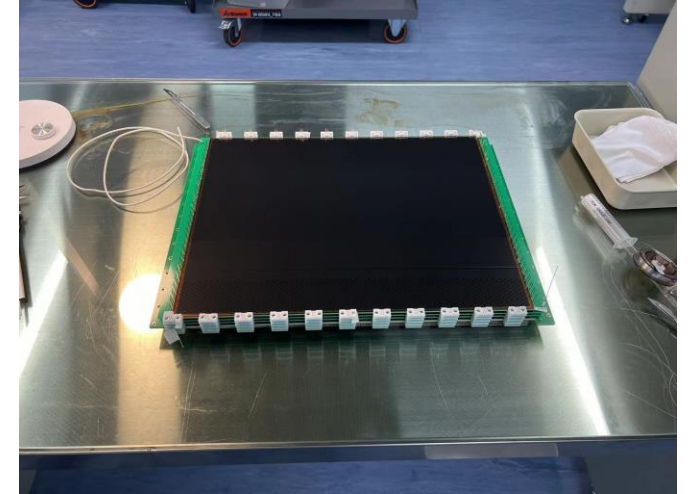


# QC on MRPC assembling

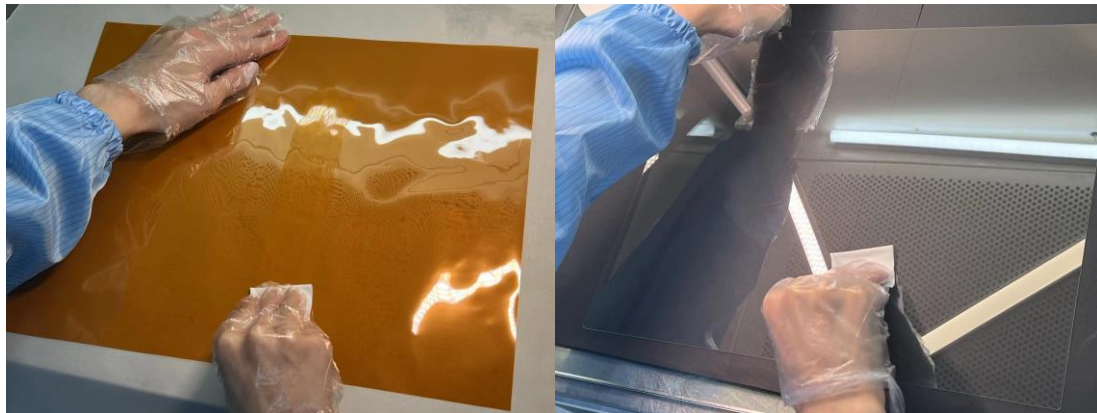


Cleaning of materials		
Material	Cleaning method	Cleanliness standard
Glass	Use non-woven fabric dampened with alcohol to clean	Observation under light, no oil or dust
Kapton		
Honeycomb board		
PCB		
Fishing line		No stain on the wiped non-woven fabric
Blocker	Ultrasonic cleaning	No dust

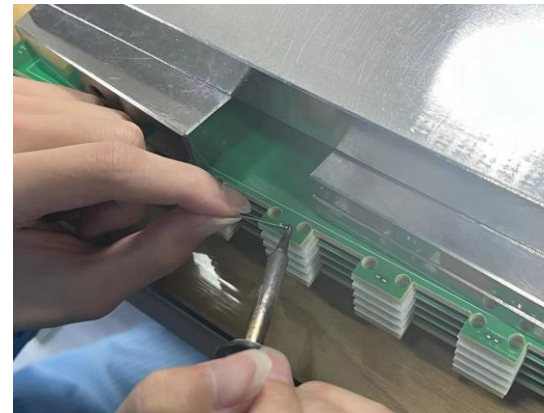
The fourth stack of iTOF-MRPC is being assembling



Clean kapton film and glass



Soldering



Use fishing line to create gas gaps



## MRPC dimension check

- Distance between PCB to PCB  
This indicates the uniformity of the gas gap.
- Total detector thickness  
Due to the compact space of the spectrometer, it is essential that each detector meets the required dimensions..

Check distance between PCB to PCB



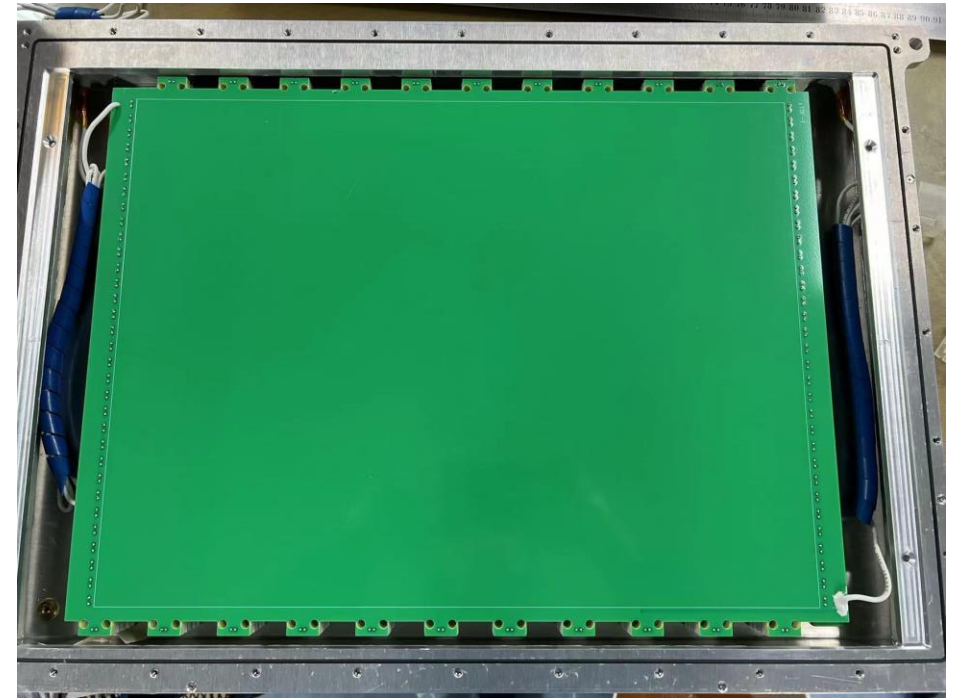
Check total detector thickness



## HV cable check

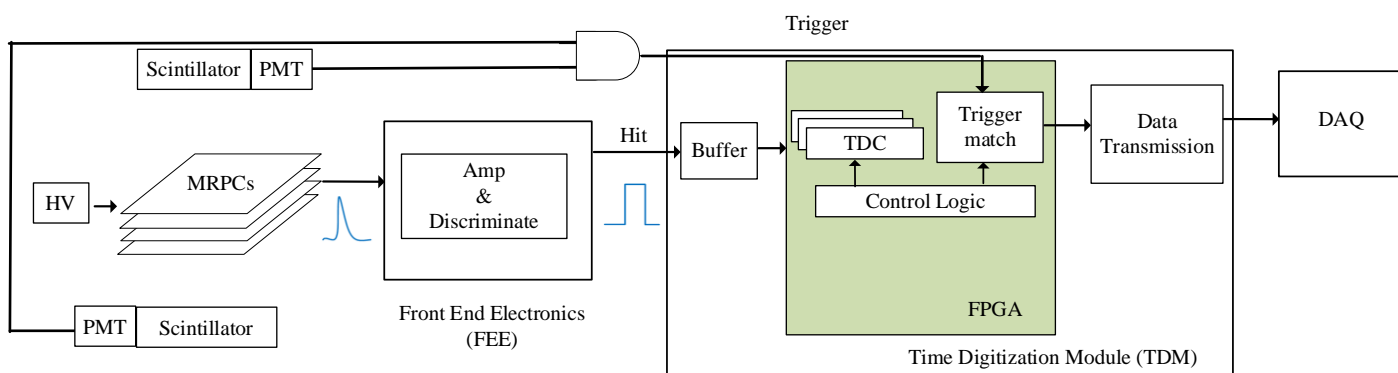
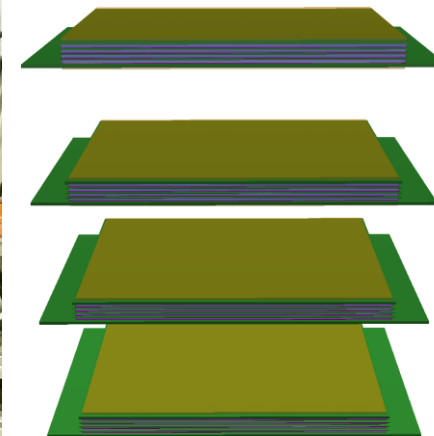
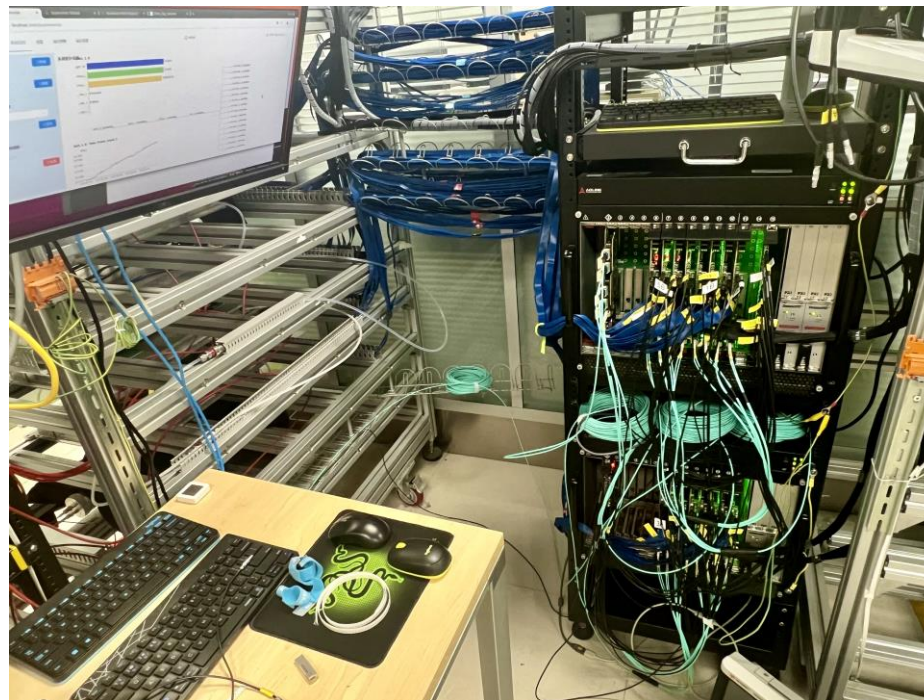
- Check whether the connection is secure and properly connected

The iTOF-MRPC, which has passed the test, is being loaded into the gas box for HV testing





# HV test system



Working gas:

90% Freon + 5% Sulfur hexafluoride + 5% isobutene

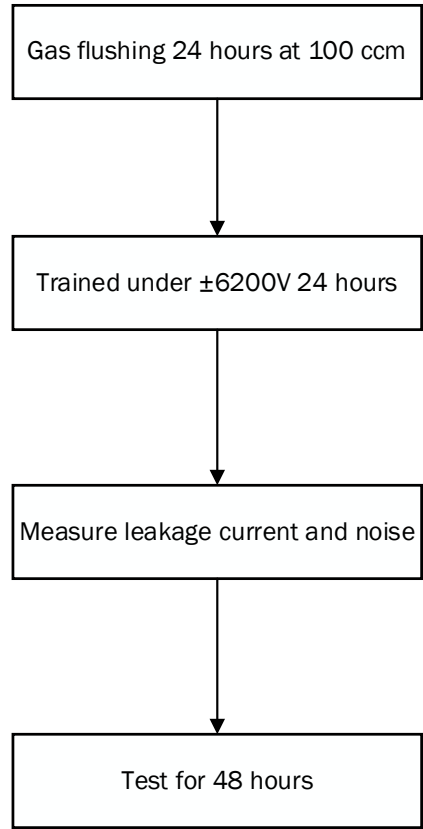
Trigger:

Plastic scintillator + PMT

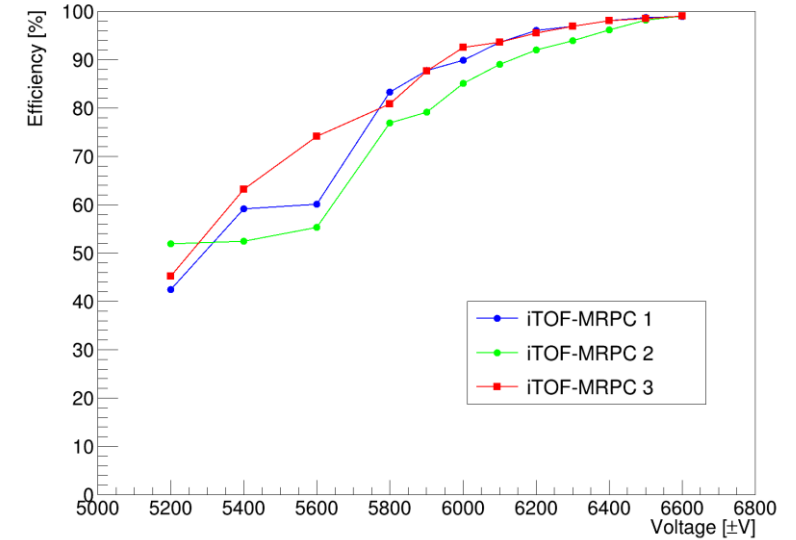
Electronics:

NINO FEE + FPGA TDC, with time resolution of 9 ps

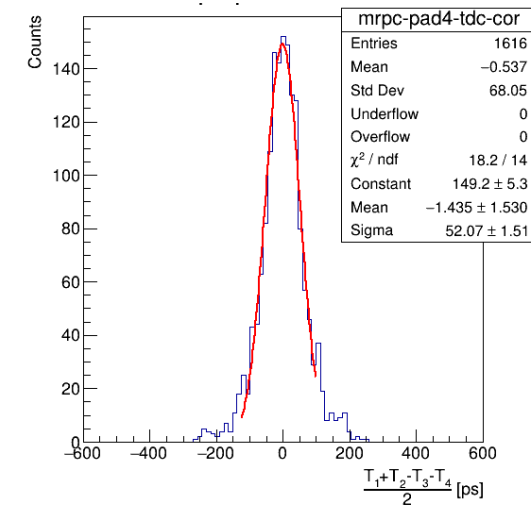
Criteria of MRPC performance in cosmic ray test	
Test conditions	Criteria
HV	$\pm 6200$ V
Threshold	200 mV
Mixture gas	90% Freon + 5% Sulfur hexafluoride + 5% isobutene
Leakage current	< 10 nA
Noise rate	< 300 Hz
Efficiency	> 95%
Time resolution	< 40 ps



### Efficiency



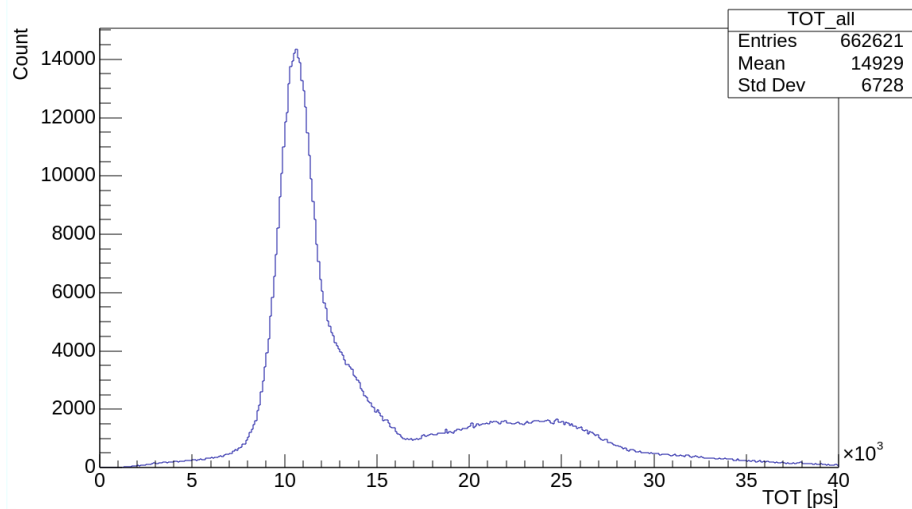
### Time resolution



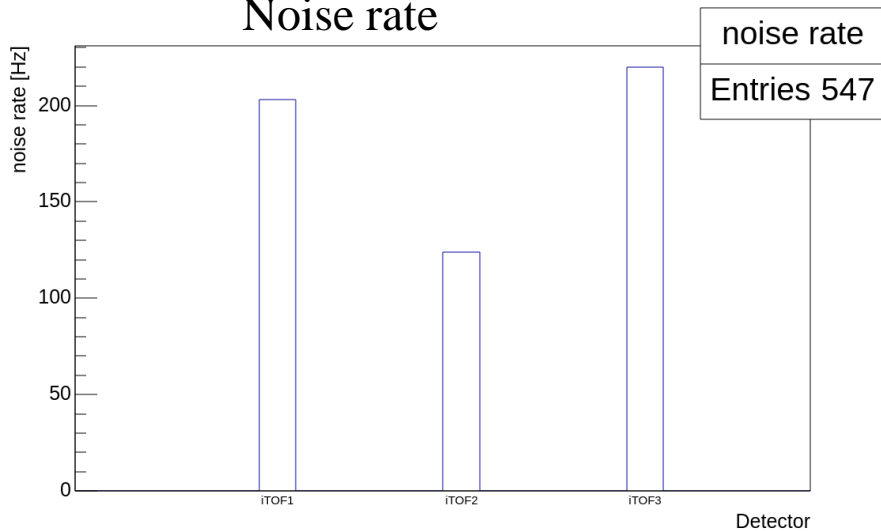
$$\sigma_t = \text{Sigma} / \sqrt{2}$$



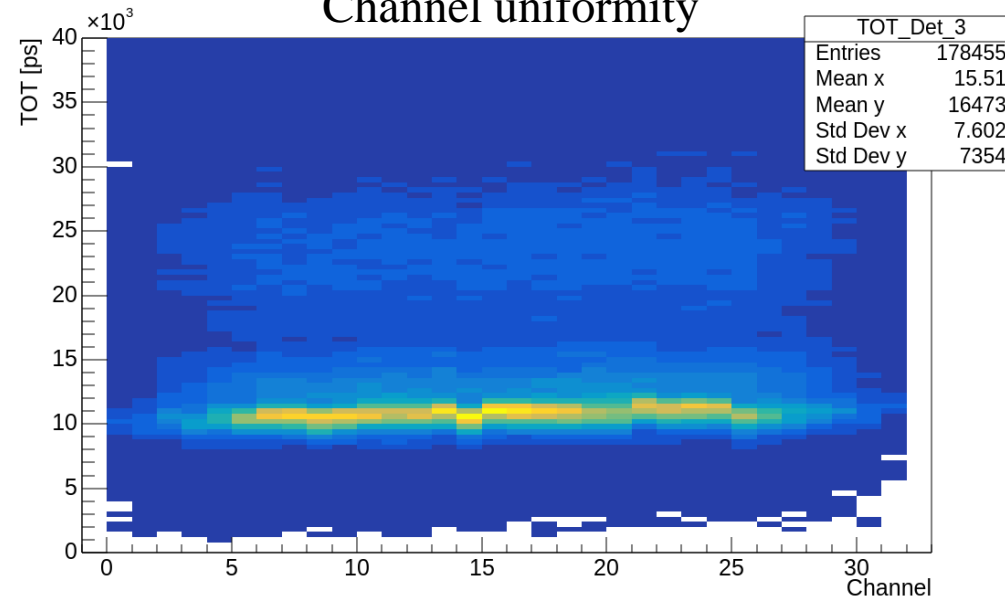
### Typical TOT spectrum of iTOF-MRPC



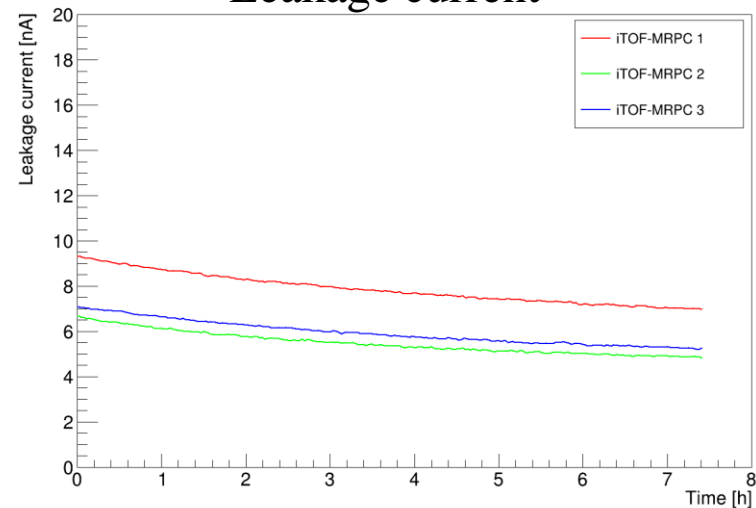
### Noise rate



### Channel uniformity



### Leakage current



- **iTOF-MRPC Overview:**

4 × 6 × 0.15 mm gas gap double-end readout MRPC, sensitive area 420 × 328 mm

- **Material Preparation:**

The preparation of key materials for iTOF-MRPC production was covered, with specific focus on dimensions, tolerances, and quality assurance methods.

- **QC in Production:**

We provided a detailed breakdown of QC processes during MRPC production, covering material inspection (e.g., graphite, glass, Kapton, and PCBs), using tools like multimeters and spiral micrometers.

- **Assembly and Final Checks:**

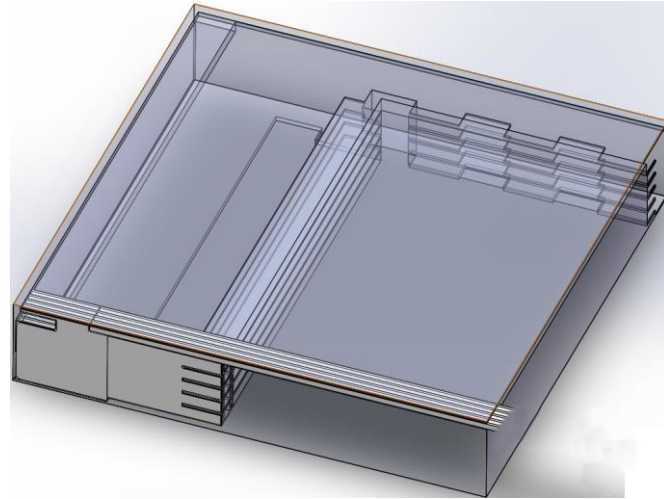
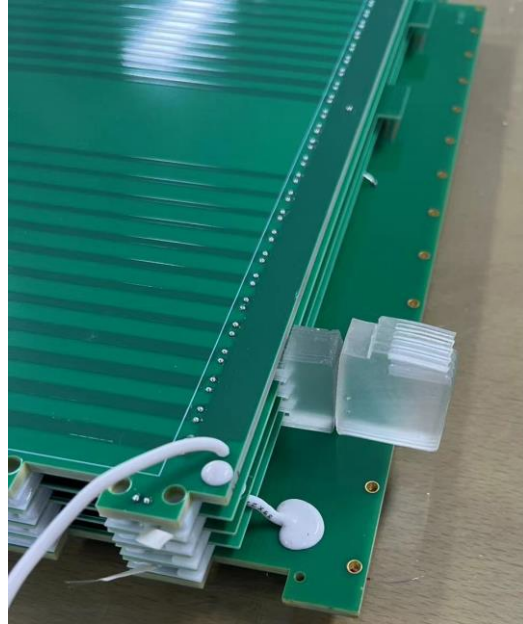
QC during assembly included material cleaning, ensuring uniform gas gaps. It also covered final checks on module dimensions, thickness, and connections.

- **HV Testing:**

High-voltage tests were conducted using a specific gas mixture and trigger system. Key performance criteria included leakage current of less than 10nA, noise rate below 300Hz, efficiency greater than 95%, and time resolution under 40ps, ensuring the high-quality performance of the modules.

*Thank you!*

# Backup



Gas seal blocker