The 4th Korea-China Workshop for Rare Isotope Physics

Development and Performance of Muti-wire Drift Chambers of the CSR External-target Experiment(CEE)

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- Detector Design and Technologies
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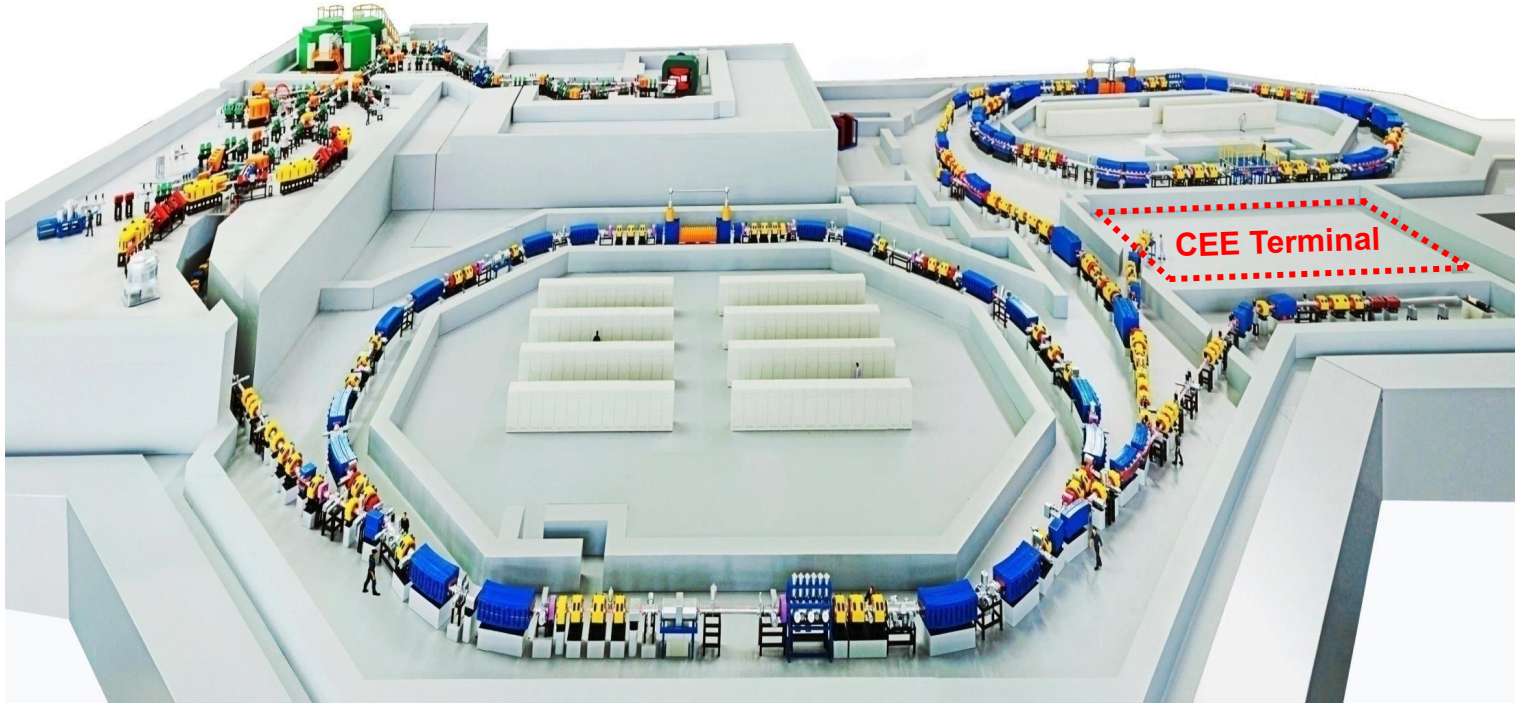
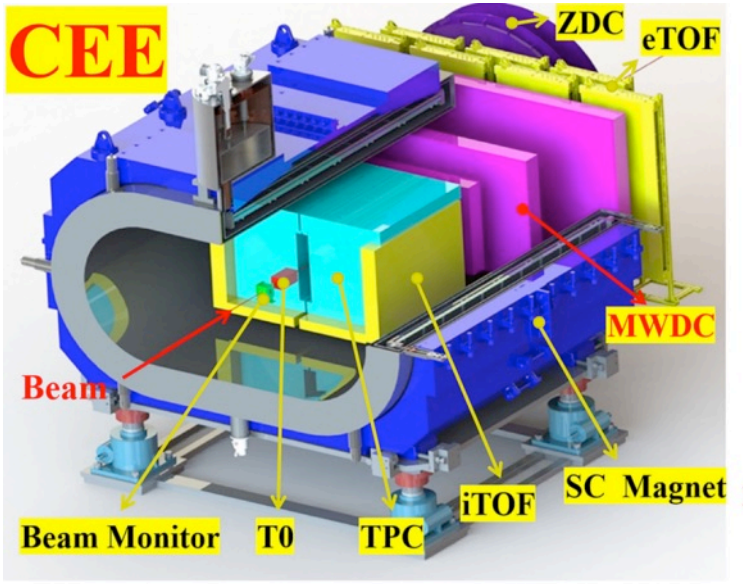
Research Background



Overview of the Cooling Storage Ring (CSR)

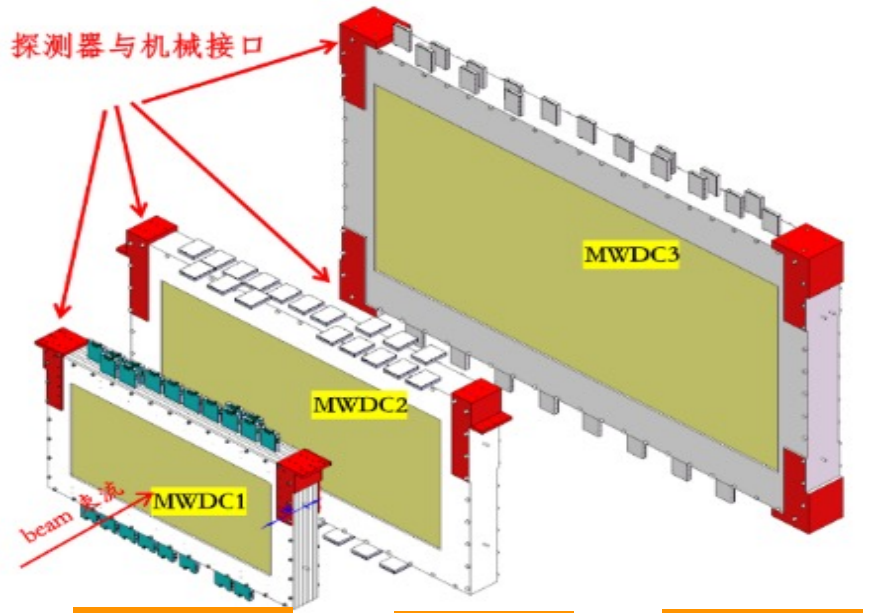


(a)

Schematic layout of the CEE spectrometer

- The Cooling Storage Ring (CSR) at HIRFL provide beams for studying nuclear matter properties.
- The CSR External- target Experiment (CEE) aims to measure lightly charged particles over a wide solid angle.

Research Background

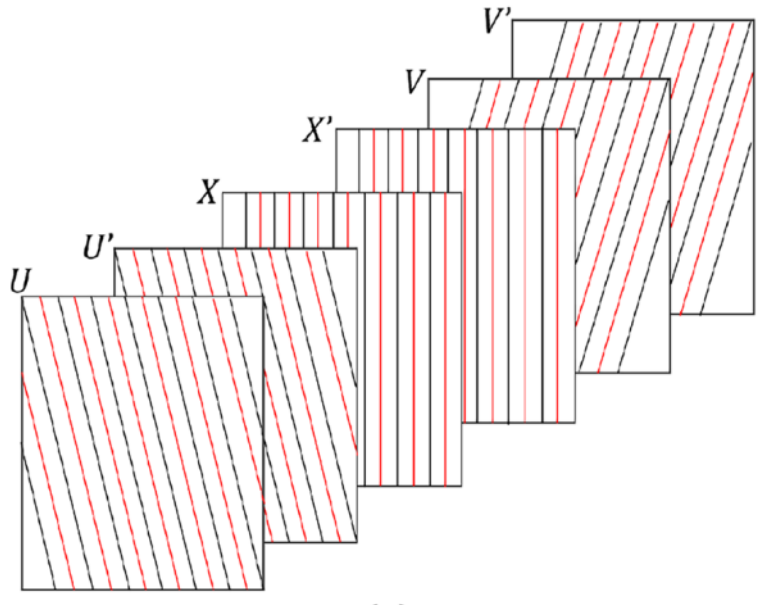


Technical challenges

- Extremely large sensitive area
  - ✓ Wire spacing accuracy
  - ✓ Layer spacing accuracy
  - ✓ Mechanical stability and precision
- Shielding/avoiding beam current

	SX/cm	SY/cm	S/m²	θ_x/°	θ_y/°	Drift unit size/mm	Number of electronic channels
MWDC1	136	63	0.8568	30.6	15.32	8×8	**960**
MWDC2	190	88	1.6720	30.70	15.38	10×10	**1152**
MWDC3	274	126	3.4524	30.78	15.31	15×15	**1152**

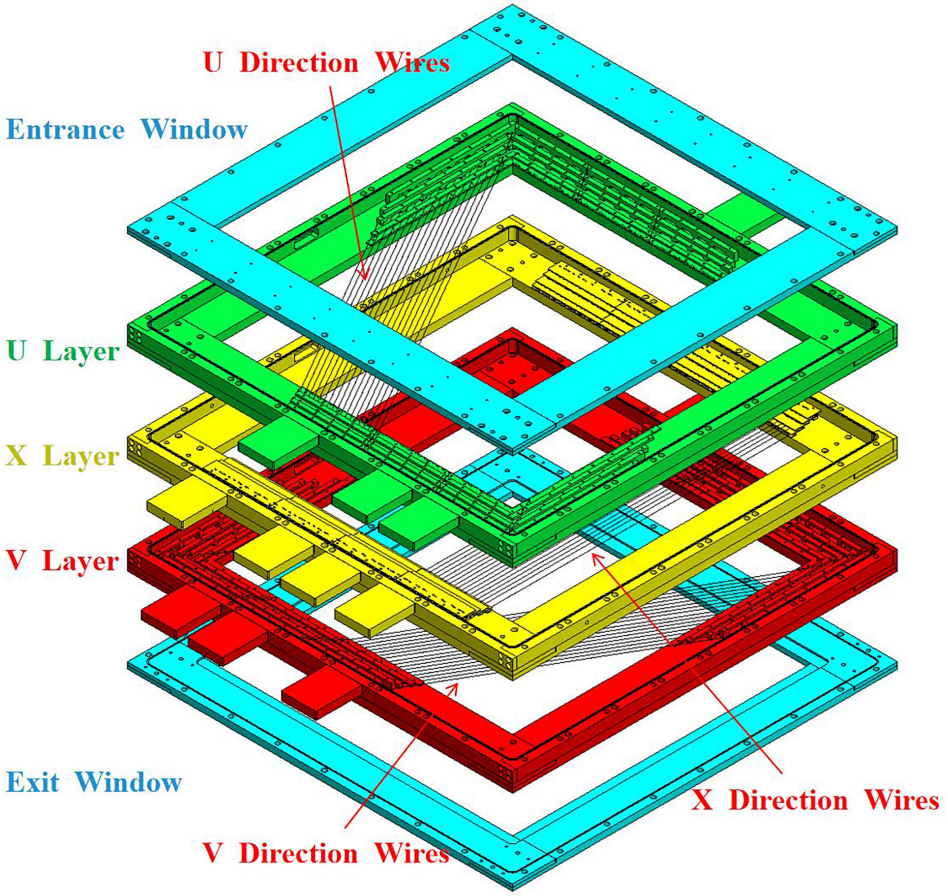
Detector Design and Technologies



Schematic view of the sense wire orientation

- Each MWDC consists of six sense wire layers that are stretched in three directions, namely, X, U, and V, meeting 0 °, 30 ° , and −30 ° , respectively, with respect to the vertical axis.
- For each direction of the wires, to discriminate between the left and right positions, the anode wires mounted in two adjacent layers were displaced by half drift unit size.

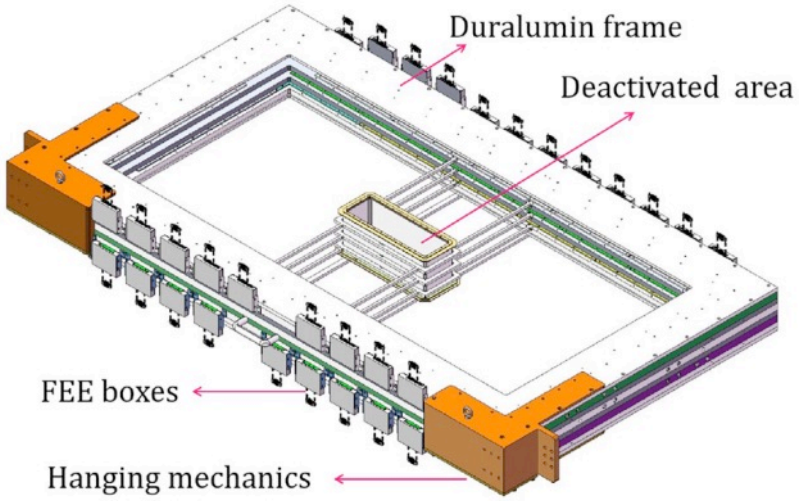
Detector Design and Technologies



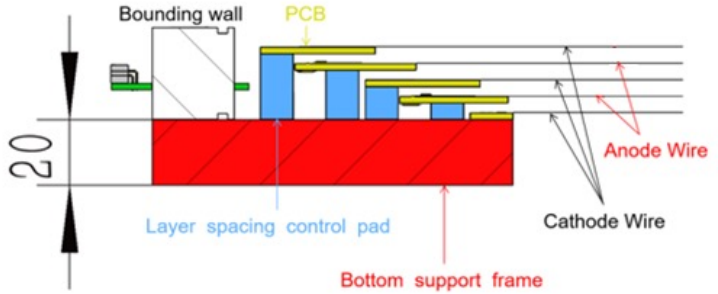
Schematic diagram of the MWDC

- For the ease of fabrication and maintenance, the X, U, and V layers were completely independent.
- Each measurement layer included two layers of anode wires and three layers of cathode wires.
- In addition to the X, U, and V measurement layers, each detector includes an entrance window and an exit window with Kapton film to hold working gas mixture.

Detector Design and Technologies



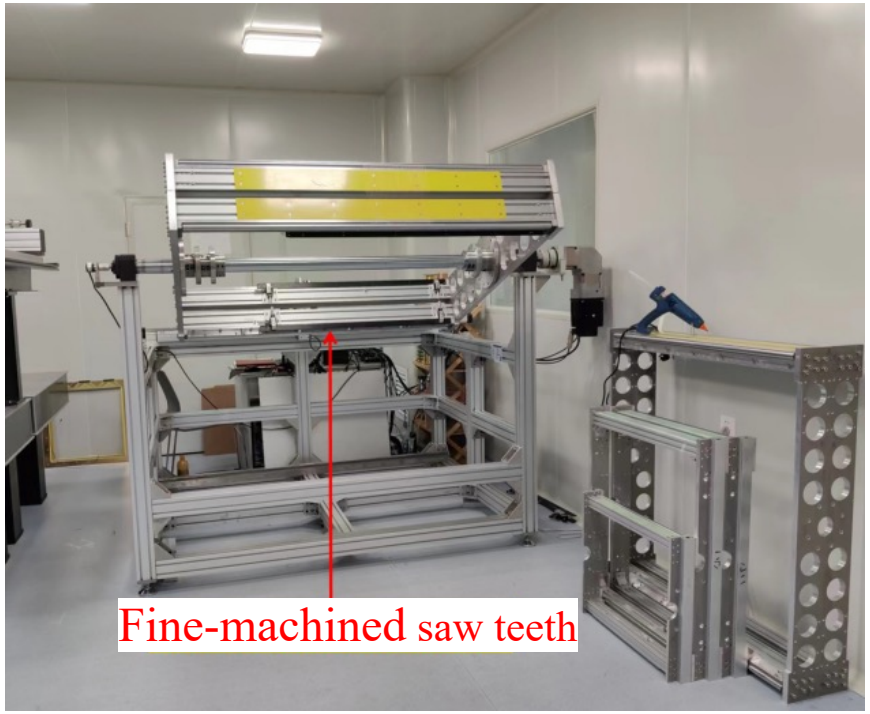
Schematic diagram of the MWDC



Cross-section of the internal structure of the X-measurement layer

- For the convenience of maintenance, the sensitive area is divided into 4-6 zones for each layer.
- To avoids a significant reduction in the wire tension, a 20-mm thick duralumin frame was used as the support frame.
- The bottom support frame contains high-precision peg holes for PCB-positioning.
- Layer-spacing control pads were used to ensure the spacing accuracy of each wire layer.

Automatic wire winding machine



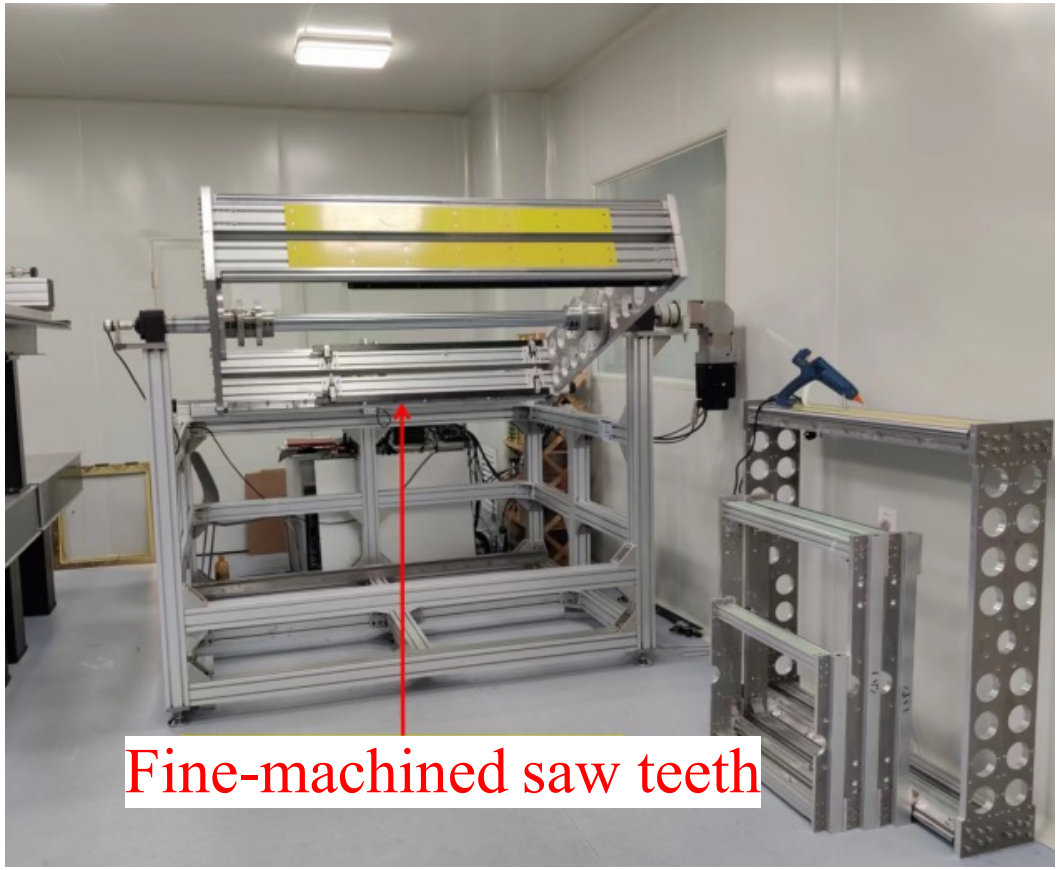
Automatic wire winding machine

Function:

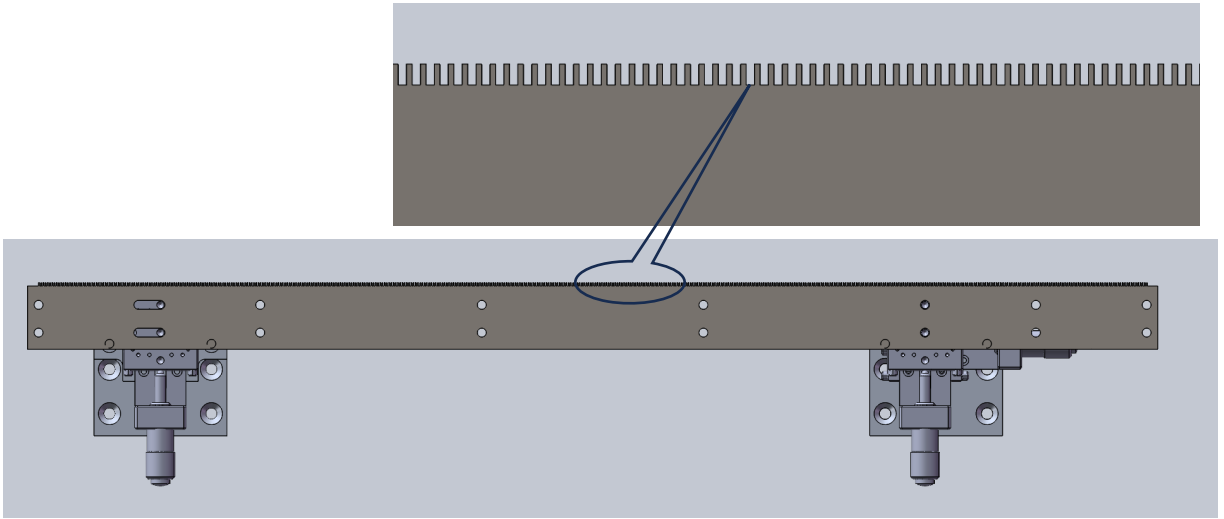
- adjustable of wire spacing
- adjustable of wire tension

Wire alignment and welding operation platform

Fine-machined saw teeth



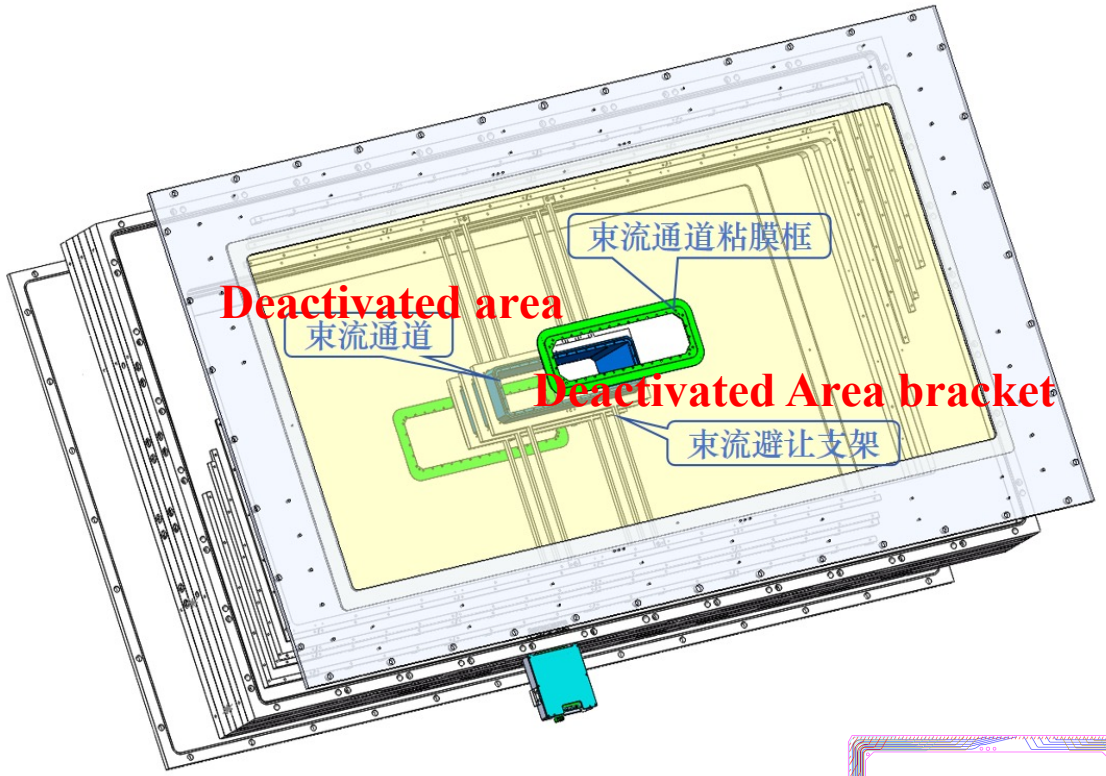
Automatic wire winding machine

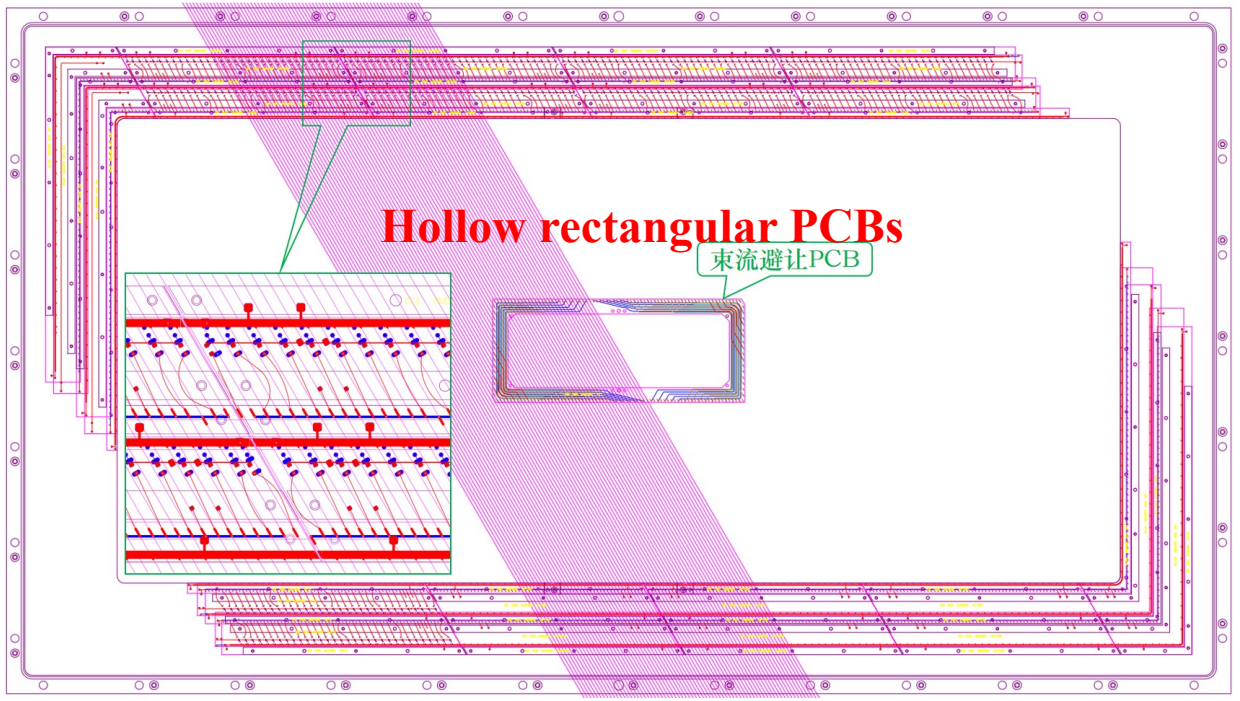


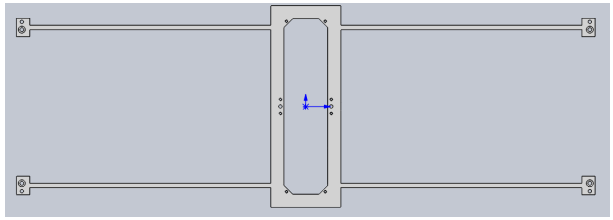
Fine-machined saw teeth

- benefit from fine-machined saw teeth, wire spacing accuracy < 20 μm

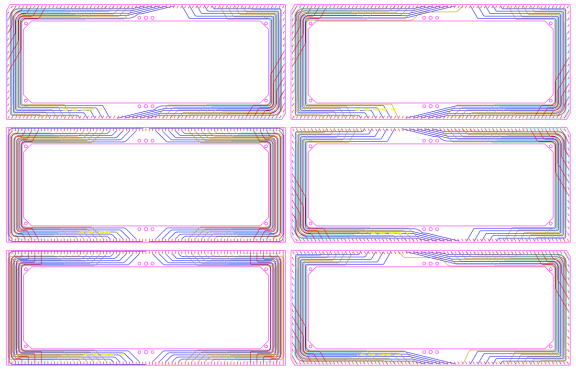
Deactivated area design







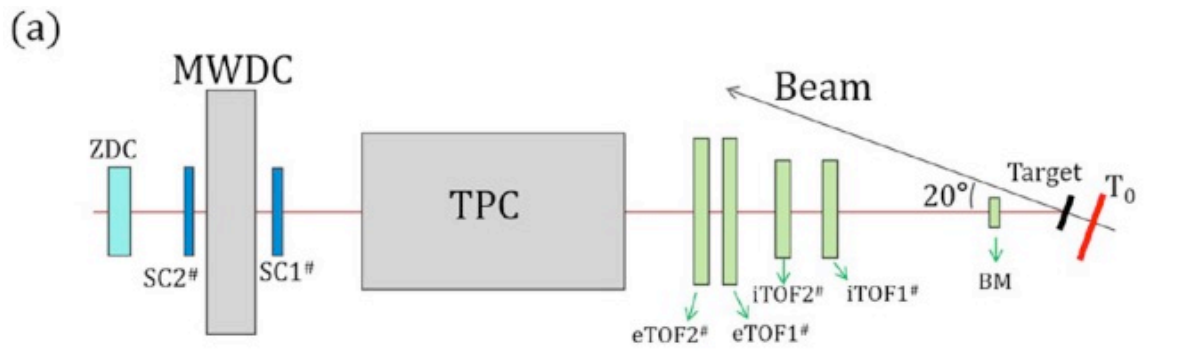
Deactivated area bracket

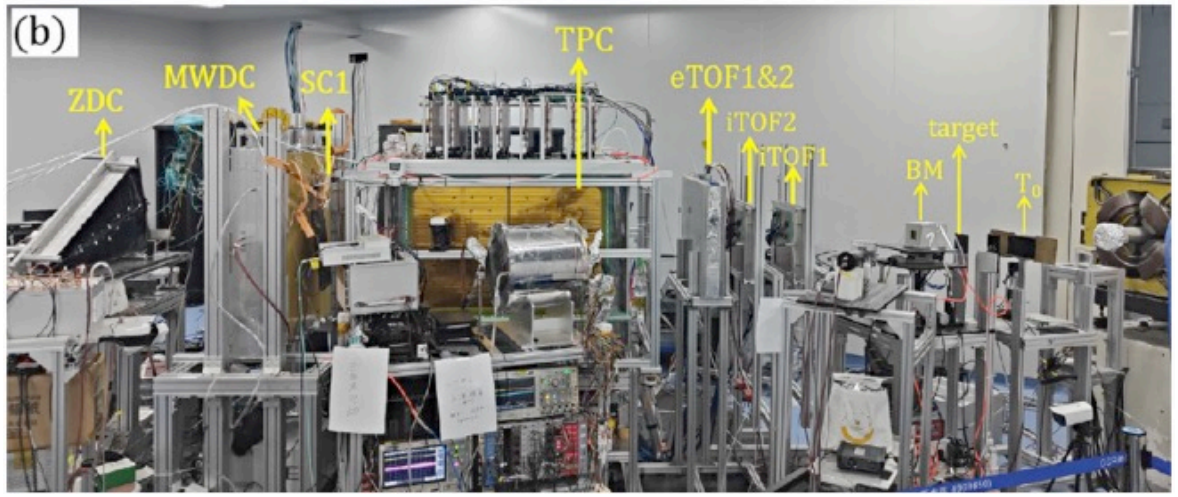


Hollow rectangular PCBs

	Size of of deactivated area
MWDC1	30cm×10cmm
MWDC2	40cm×14cm
MWDC3	60cm×20cm

Experimental setup of the beam test





The detector setup in the test beam experiment performed at the CEE location on HIRFL-CSR.
(a) A schematicview (b) a real photograph

Beam Conditions:

- **Beam Type**: 350 MeV/u Kr →Fe
- **Beam Direction**: Approximately 20° with respect to the detector setup

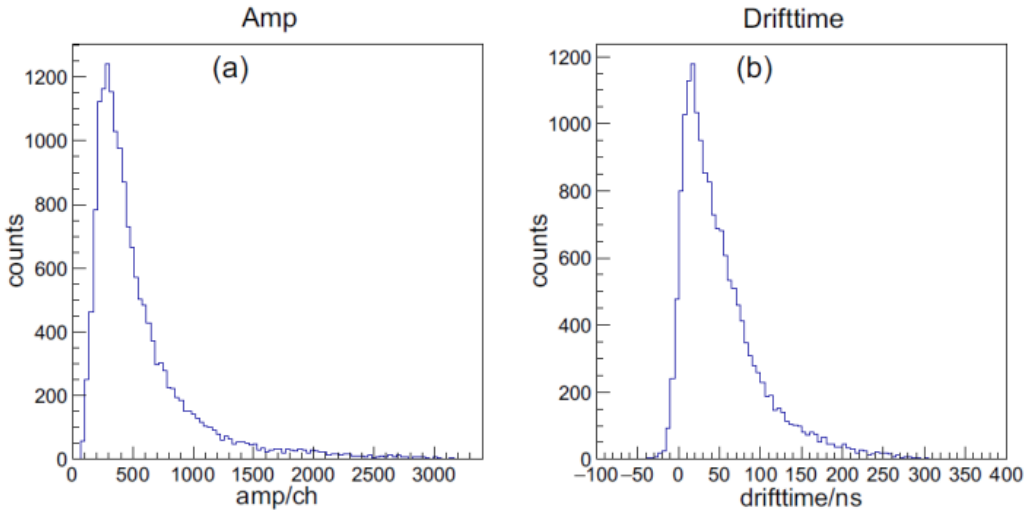
Detector Configuration:

- Start-Timing Detector (T0)
- Inner Time-of-Flight Detectors (iTOF1, iTOF2)
- Outer Time-of-Flight Detectors (eTOF1, eTOF2)
- Time Projection Chamber (TPC) Prototype
- MWDC Prototype
- Scintillators (SC1, SC2)
- Zero-Degree Counter (ZDC) Prototype

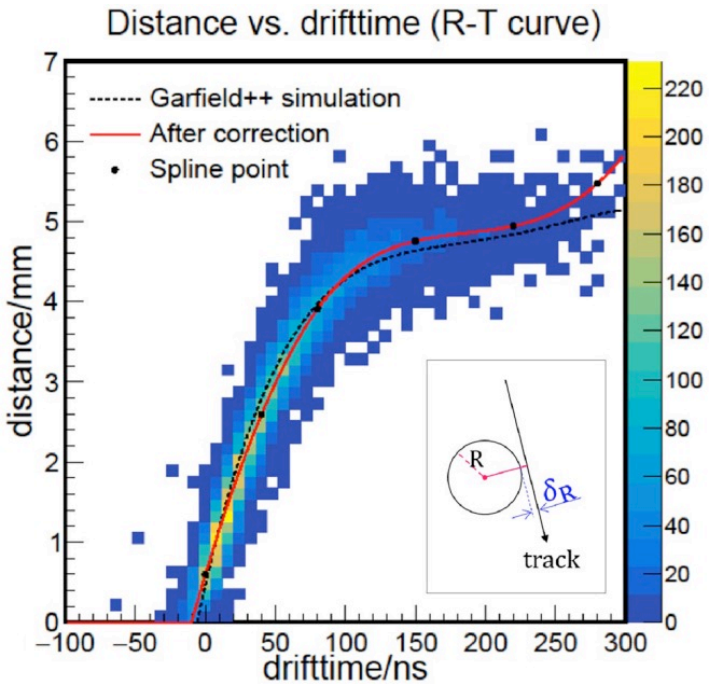
High Voltage: 1500 V on anode wires

Working Gas: 80% Argon + 20% CO_2

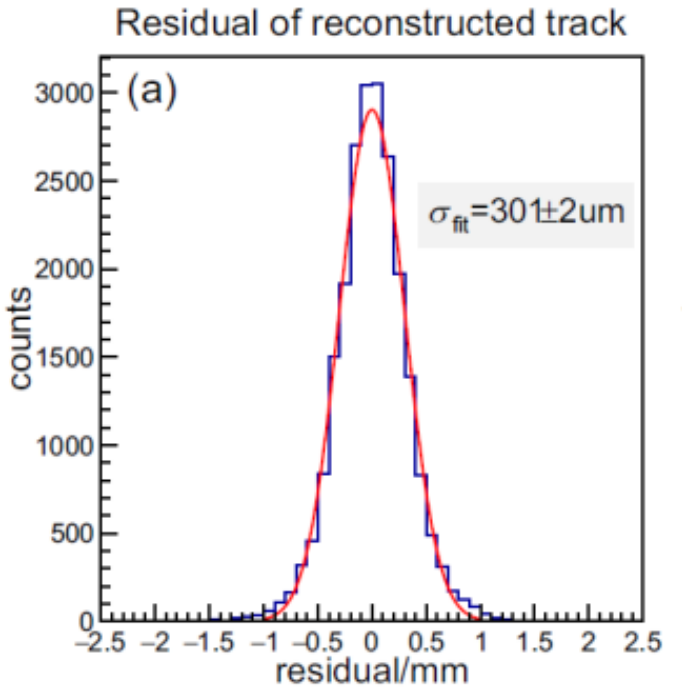
Beam test results: MWDC Prototype Performance



The distribution of the energy loss(a) and drift time with respect to the timing provided by SC1 and SC2 (b)



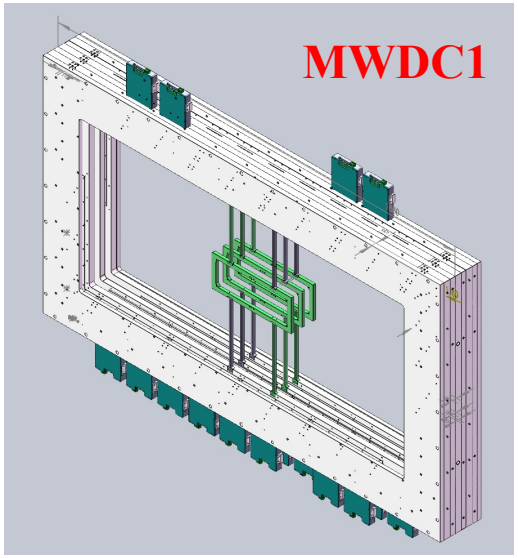
The R–T curve calibration. The inset shows the definition of the tracking residue R

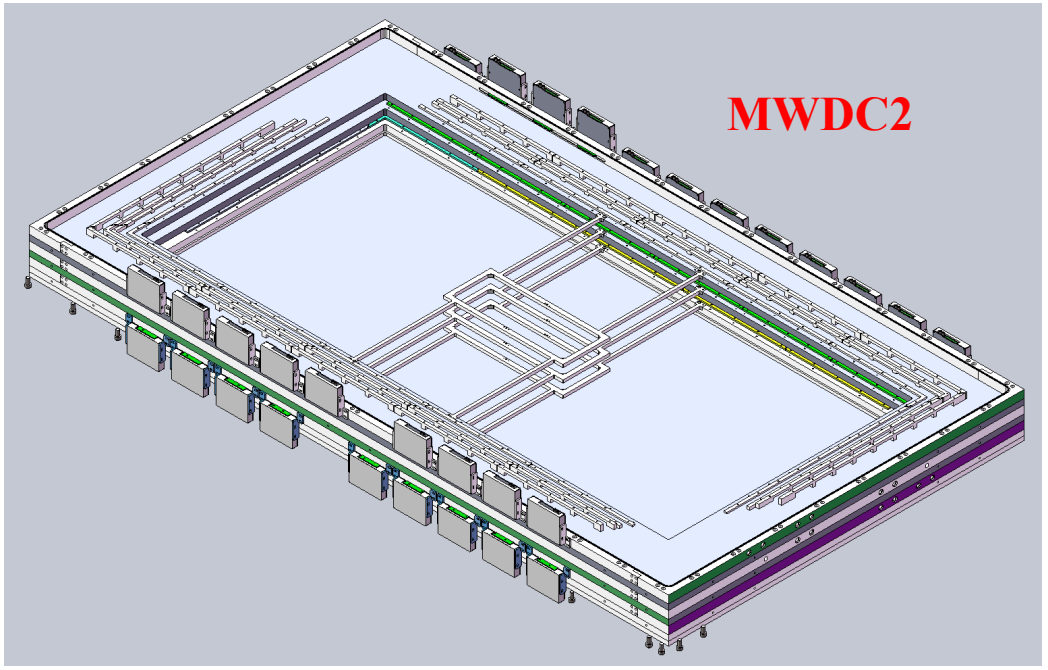


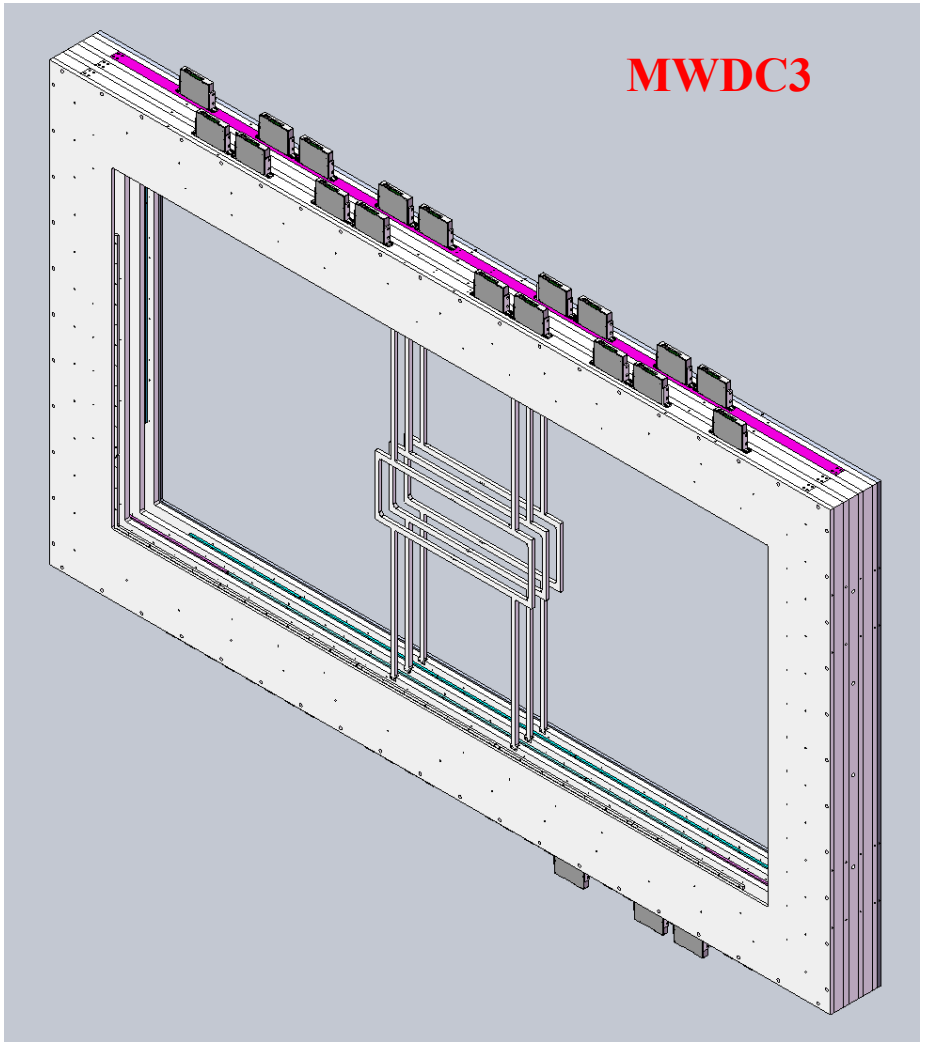
The distribution of the tracking residue. The curve is the fitting using Gaussian function

- **The tracking residual, was measured to be approximately 300 μm. This result meets the CEE design requirement.**

Design of MWDC1~3



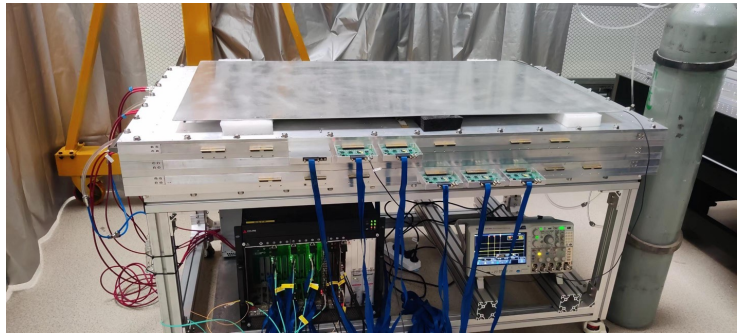


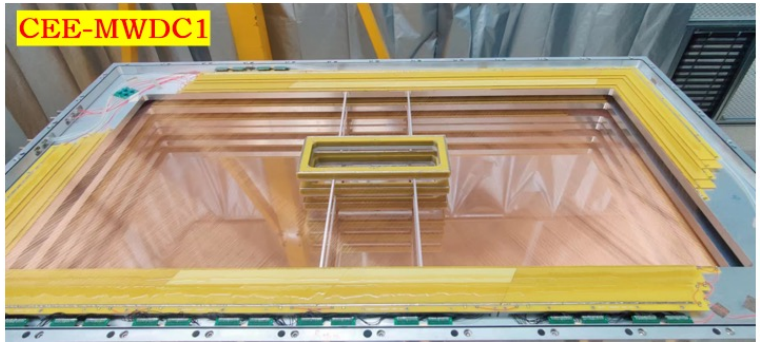


Design drawings of MWDC1-3

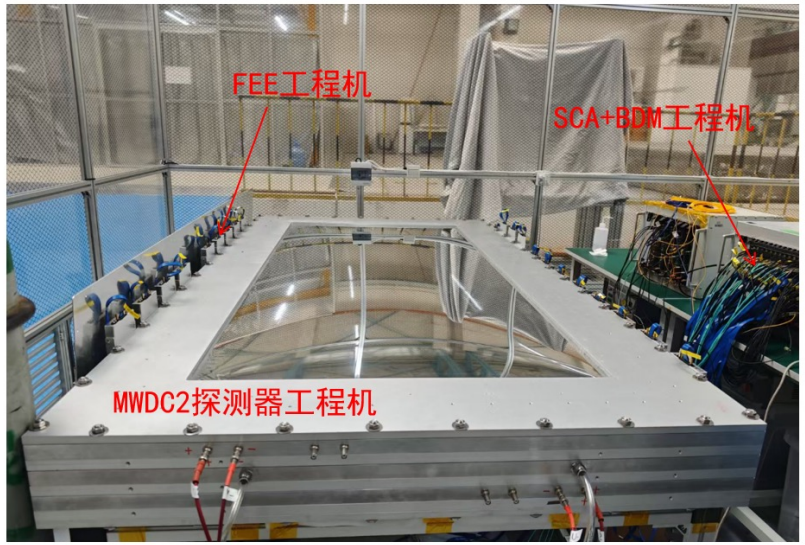
Fabrication and Assembly of MWDC1~3

MWDC1

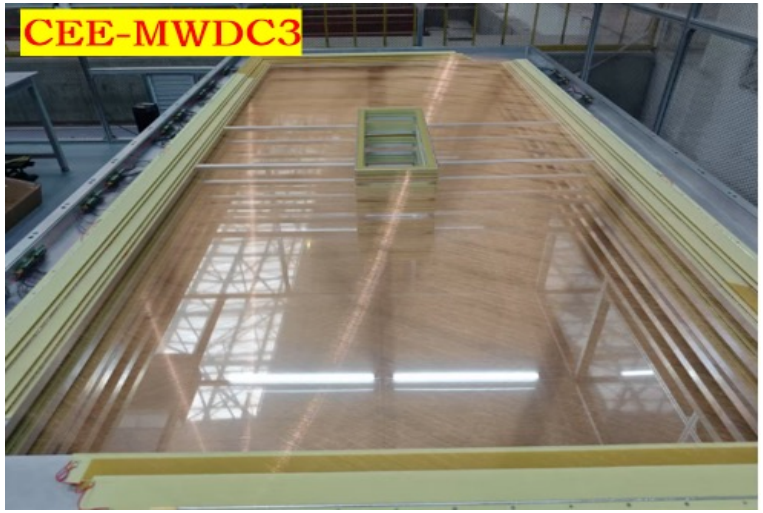




MWDC2

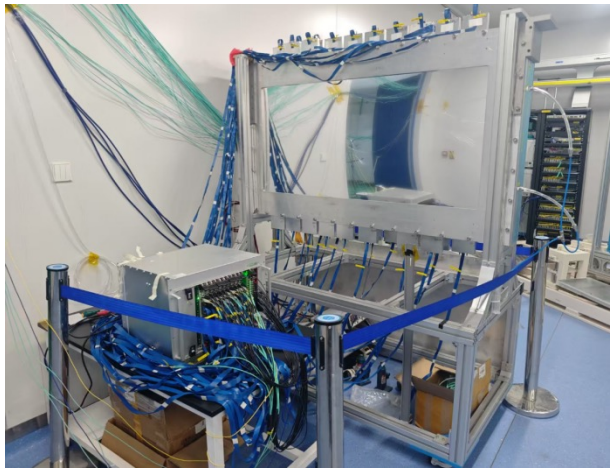


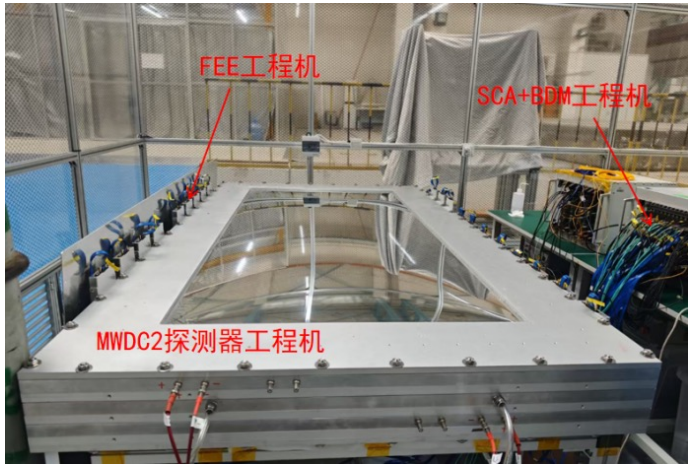
MWDC3

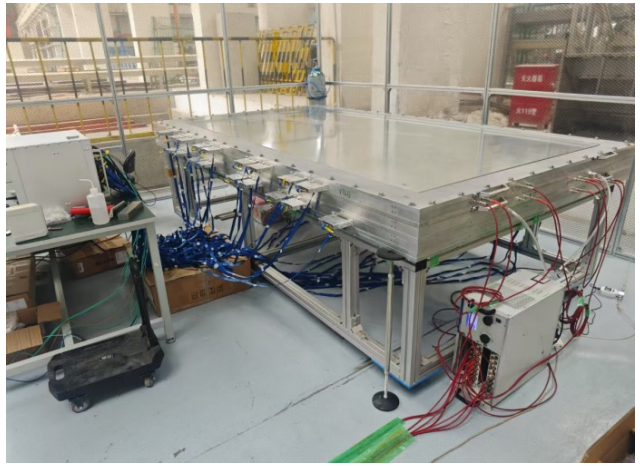


Real photograph and images of the inside of MWDC1-3

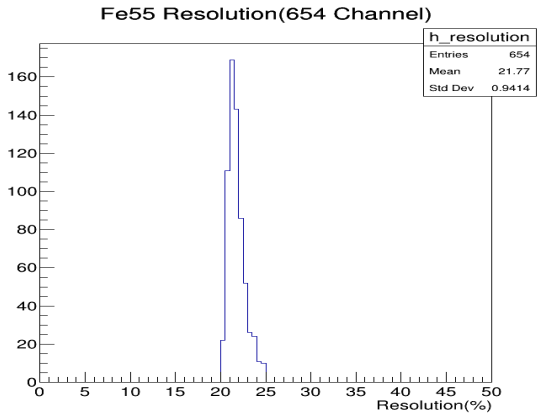
Performance of MWDC1~3

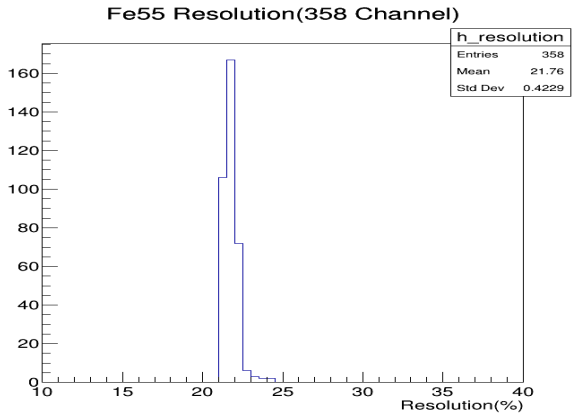


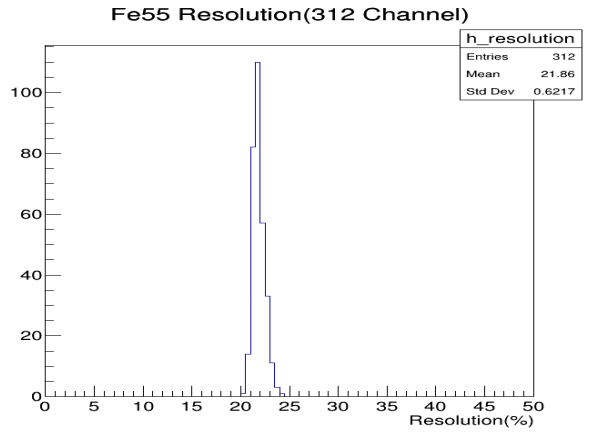




On-site test images of the ^{55}Fe X-ray source for MWDC1-3.

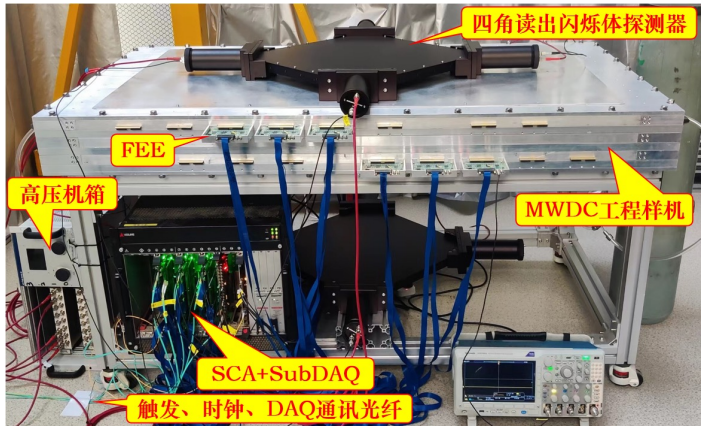


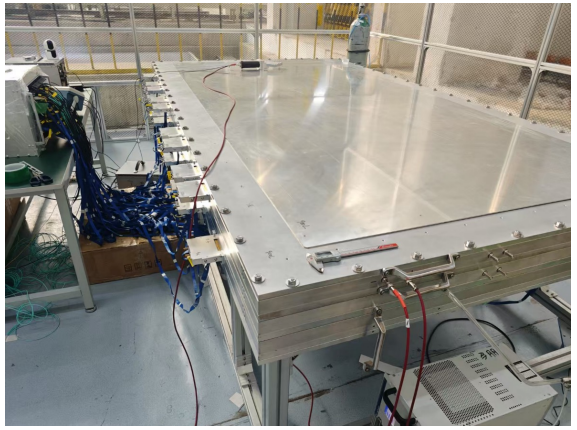




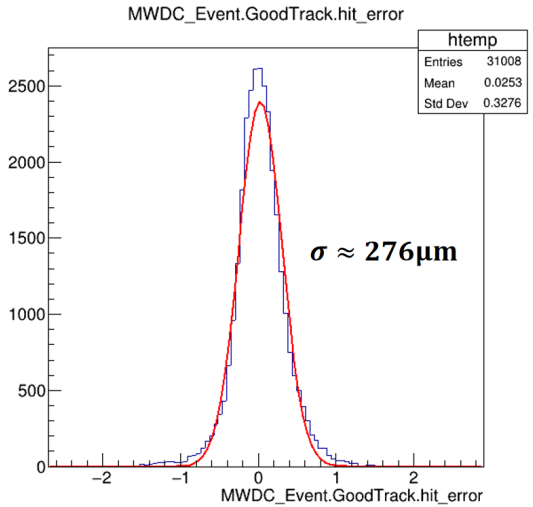
The average ^{55}Fe X-ray source energy resolution of MWDC1-3.

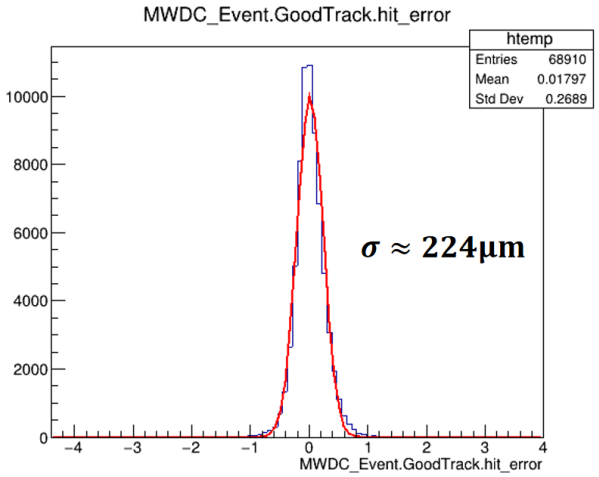
Performance of MWDC1~3

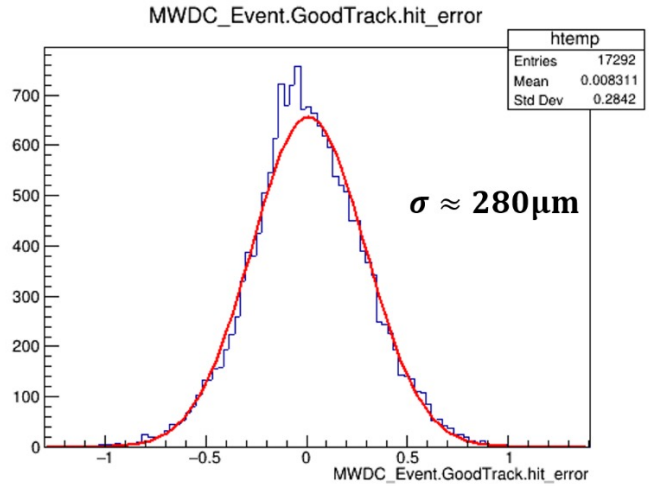




On-site test image of CEE-MWDC1-3 with cosmic rays





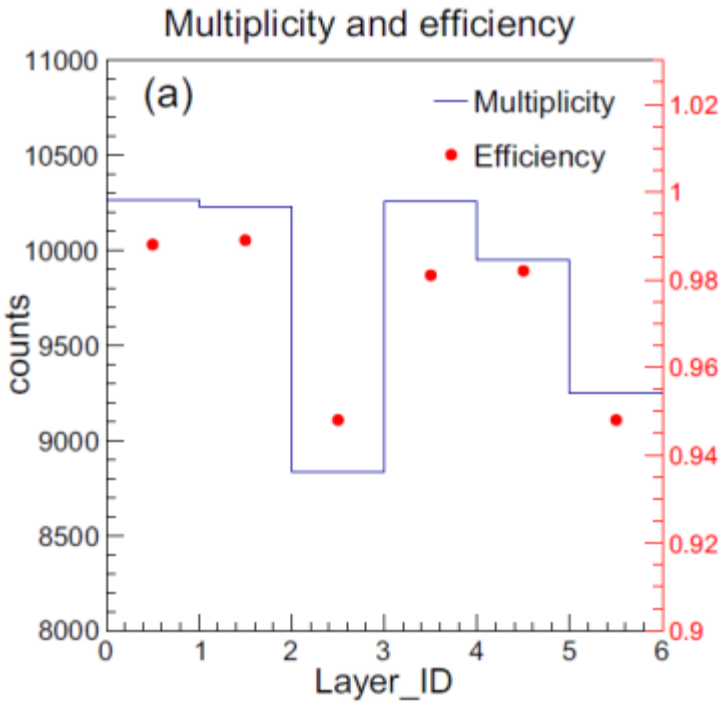


The tracking residual of MWDC1-3.

Summary

- **A prototype of the MWDC detector at CEE was assembled and operated in a beam test experiment of 350 MeV/u Kr + Fe.**
- **The tracking residual of the MWDC prototype, was measured to be approximately 300 μm.**
- **The MWDC engineering machine was tested for iron source and cosmic ray.**
- **The energy resolution of the MWDC engineering machine typically stands at 22% for ^{55}Fe X-rays, with a tracking residual of less than 300 μm for cosmic rays.**
- **The experimental results demonstrate that the MWDC satisfied the requirements of the CEE experiment.**

Thanks for your attention!


Multiplicity and efficiency
(a)
Multiplicity
Efficiency
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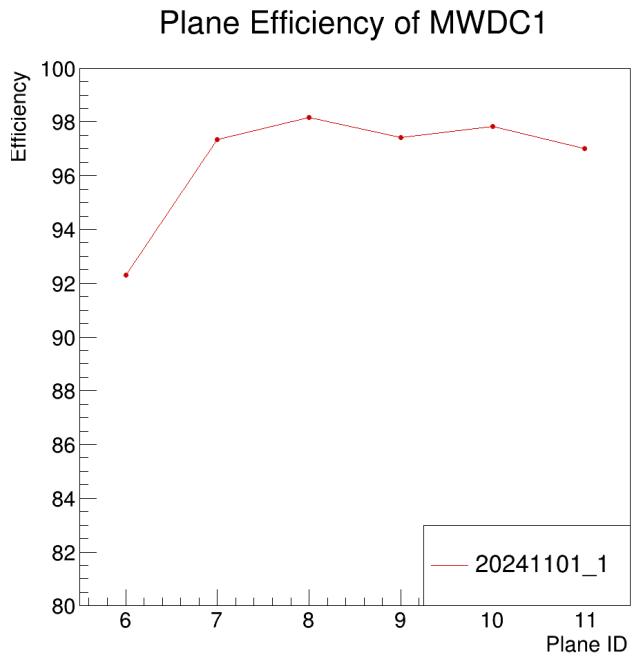
Plane Efficiency of MWDC1
Efficiency
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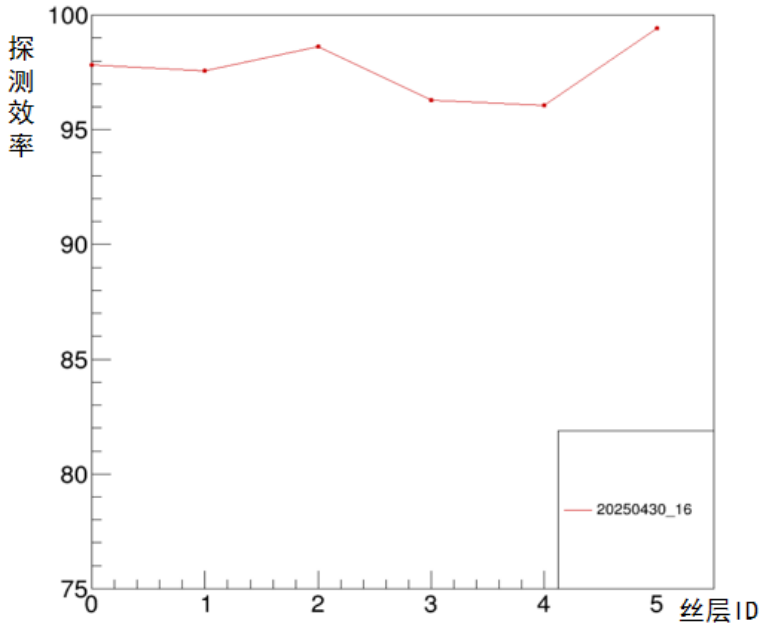
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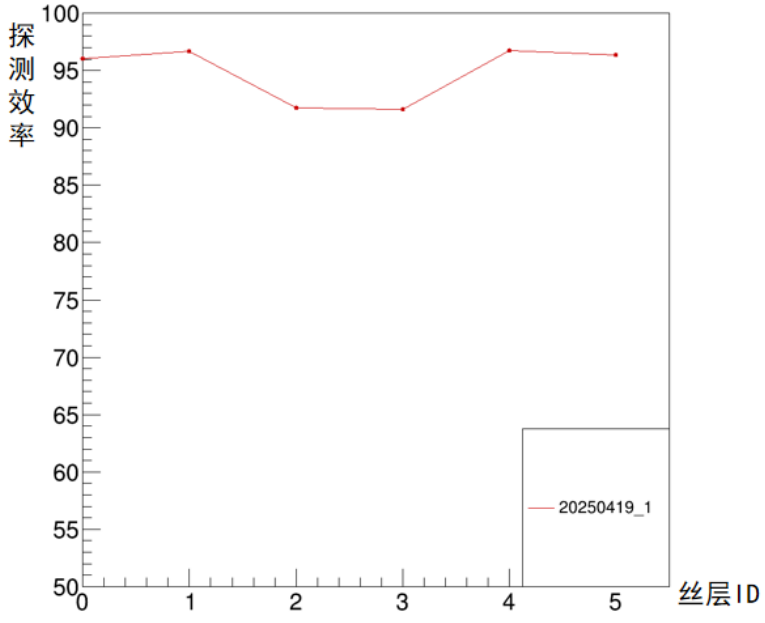
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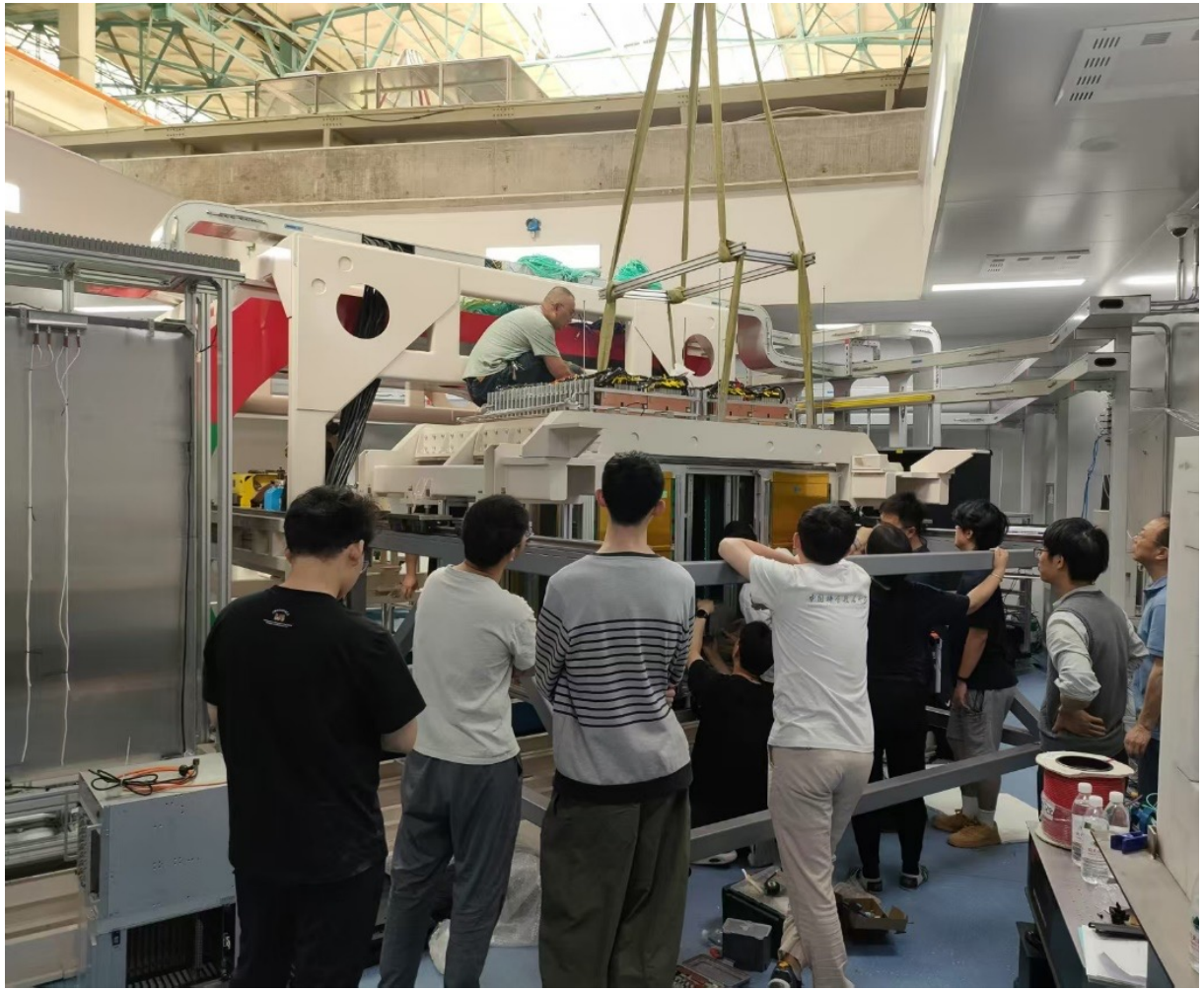
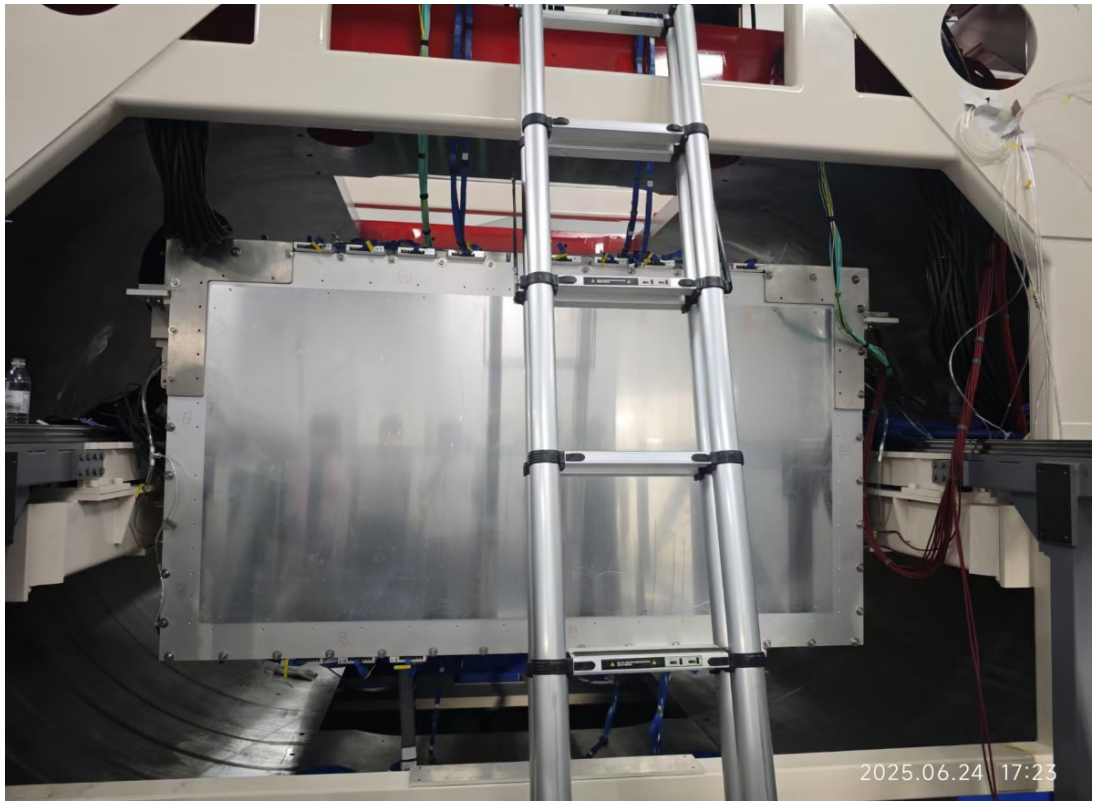
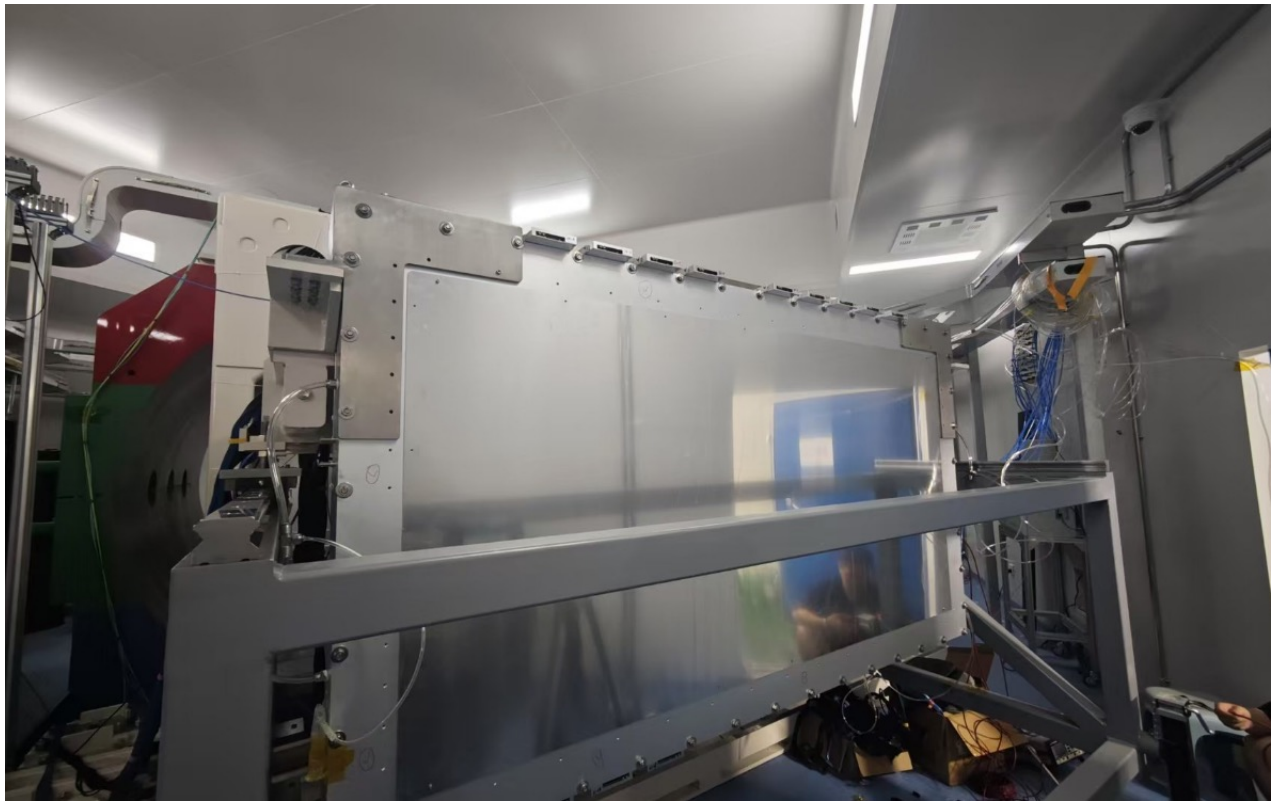
Detector System installation



Detector System installation





CEE detector without magnet