Investigation and improvements of the mechanical structure of Cylindrical GEMs for the BESIII experiment

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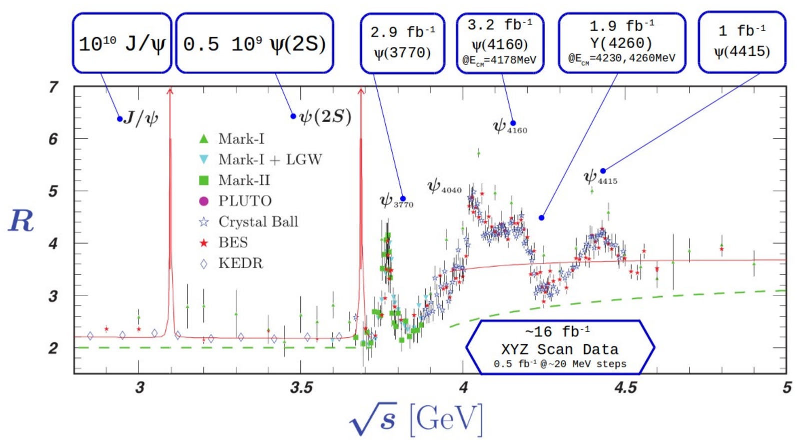
BESIII Experiment

Beijing Spectrometer III @ Beijing Electron Positron Collider II

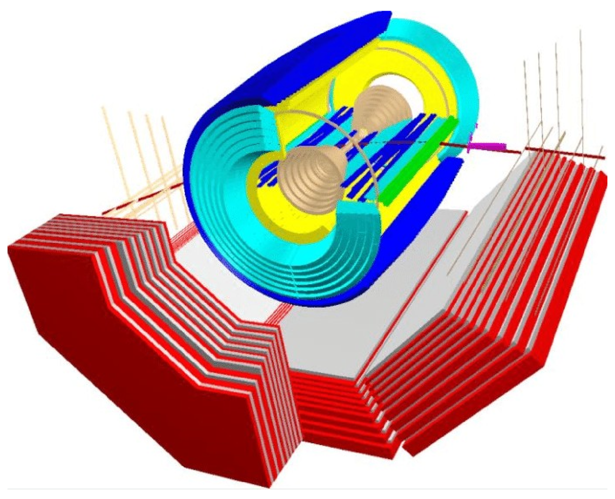


τ-charm

$$2\text{ GeV} \leq \sqrt{s} \leq 4.6\text{ GeV}$$

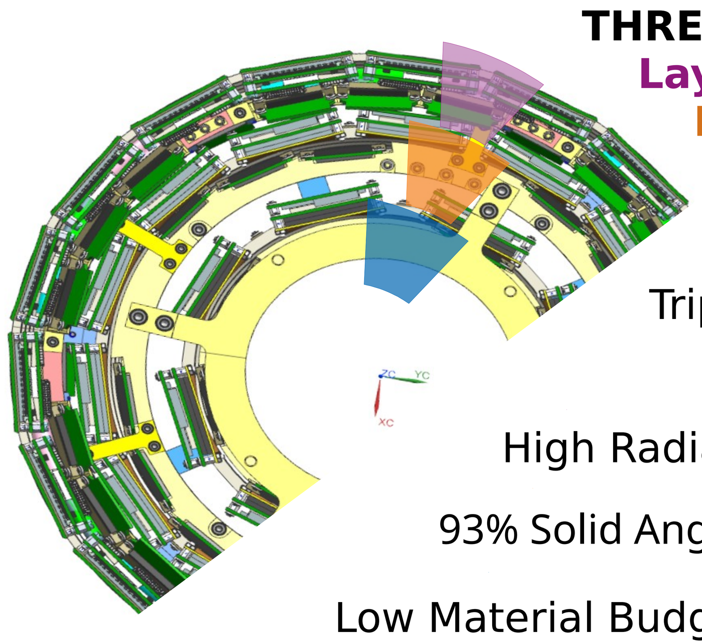
$$\mathscr{L}_{design}(\sqrt{s} = 3.77\text{ GeV}) = 10^{33}/cm^2 s$$

J/ψ world largest single data sample at e^+e^- collider 02/2019



- Muon Chamber
- Solenoidal Magnet 1T
- Electromagnetic Caloremeter
- Time of Flight
- Multi Layer Drift Chambers

NEW Cylindrical GEM – INNER TRACKER



THREE LAYER DETECTOR
Layer 3 – Outer
Layer 2 – Middle
Layer 1 - Inner

Triple Cylindrical GEM

High Rate

High Radiation Hardness

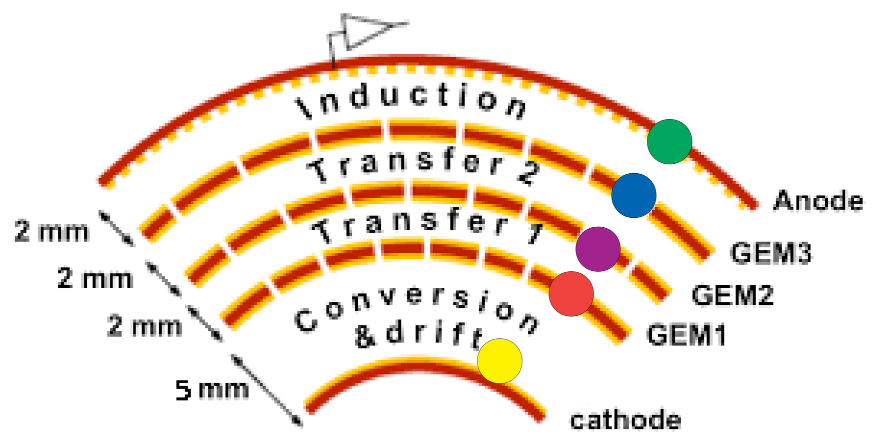
93% Solid Angle Coverage

Low Material Budget ≤ 1.5 X_0

Time and Charge Analogue Readout

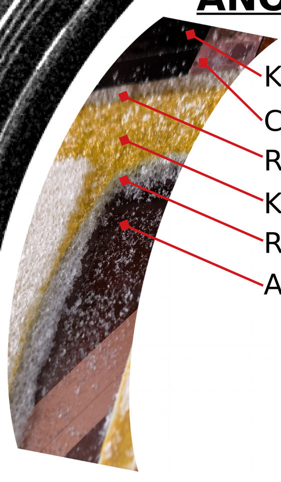
Better Resolution along the beam axis

$\sigma_z < 1$ mm - $\sigma_{xy} \sim 130$ μm $\sigma_{pt} \sim 0.5\%$ @ 1 GeV/c



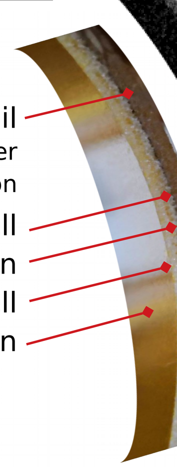
Mechanics of the prototypes

ANODE



Kapton 50 μm
Copper 5 μm
Rohacell 2 mm
Kapton 12.5 μm
Rohacell 2 mm
Anode Foil
Kapton 25 μm
Copper 5 μm
Kapton 50 μm
Copper 5 μm

CATHODE



Cathode Foil
5 μm Copper
50 μm Kapton
1 mm Rohacell
12.5 μm Kapton
1 mm Rohacell
2.5 μm Kapton

Cylindrical Simulations

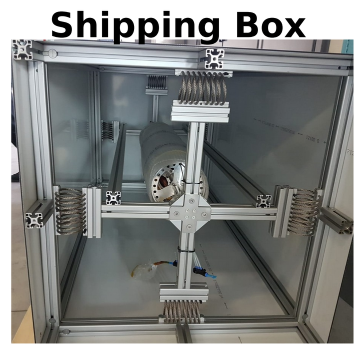
Maximum Deformation = 230 um
Total Radiation Lenght = 0.50985

L2

THE DETECTOR IS CONSTRUCTED IN ITALY AND THEN SHIPPED TO BEIJING FOR COMMISSIONING

Shipping Box

The detector is held from a central axis connected to its permaglass rings



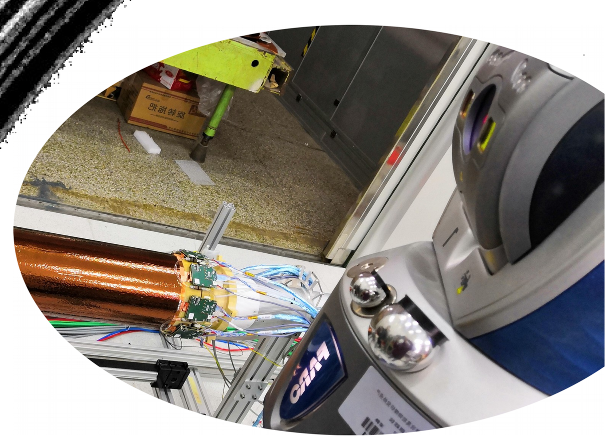
The axial support is connected with 4 springs on each side to the external part of the box

After every movement of any layer the QUALITY ASSURANCE and QUALITY CONTROL protocol is applied to check its status

- **Gas Leakage**
- **Capacitance Measurements**
- **Resistance Measurements**
- **High Voltage Distribution**

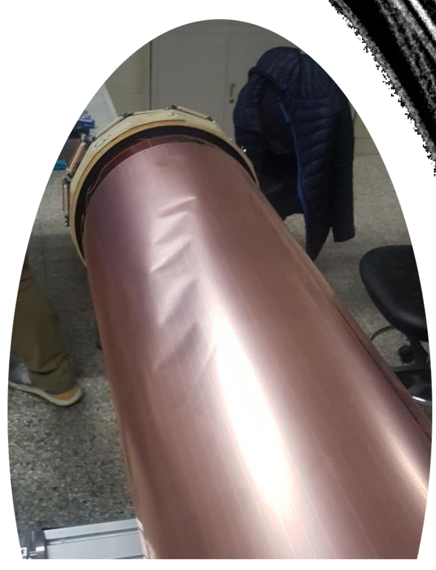
These tests pointed out some malfunctions

A campaign of different tests started to deeply investigate the problems



Laser Surface's Measurements

The external structure of each detector has been examinated and no major issues were found



Computed Tomography Scan

Thanks to an industrial machine (450 kV) in the IHEP laboratory the scan allowed us to look inside the detector and reconstruct the position of each foils in different points of the detector. Few defects has been spotted and confirmed the Quality Protocol results.

Mechanical Opening

Foil by foil the detector was opened and each detail of the mechanical structure and of the foils have been visually investigated.

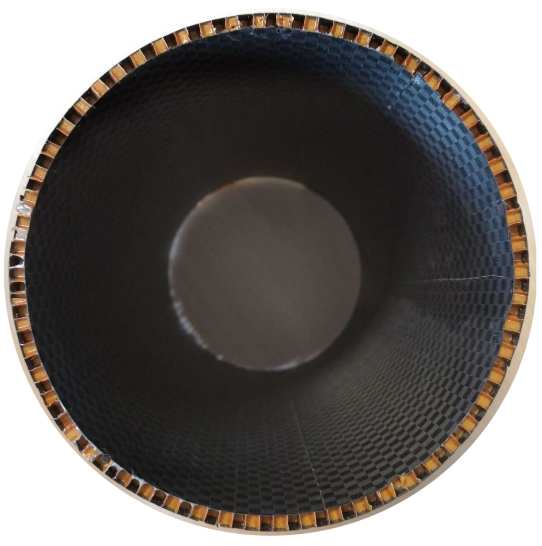
Few issues were spotted first with the CT and then with the opening:
the gaps size were not the fullfilling the request.
This kind of problems was compatible with the HV issues.
These problems were due to an excess of vibrations during shipping:
the Kapton-Rohacell sandwich was not rigid enough
to prevent inner damage from unexpected events

L3

To assure the proper rigidity of the detector during the assembly operations and transportations, the mechanical robusteness was improved on the final detectors:

ANODE

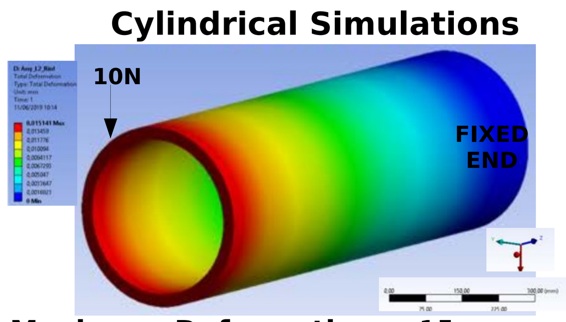
Kapton 50 μm
Copper 5 μm
Carbon Fiber 70 μm
Honeycomb 3.8 mm
Anode Foil
Kapton 25 μm
Copper 5 μm
Kapton 50 μm
Copper 5 μm



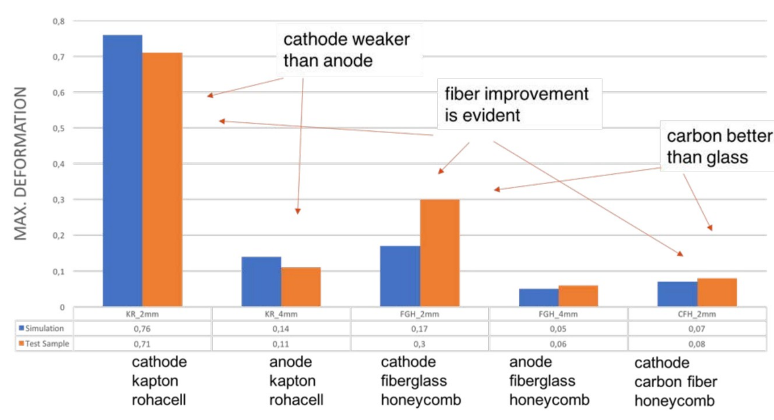
CATHODE

Cathode Foil
Copper 3 μm
Kapton 50 μm
1.8 mm Honeycomb
50 μm Kapton
3 mm Copper

Cylindrical Simulations



Maximum Deformation = 15 um
Total Radiation Lenght = 0.5173



This choice, despite increasing the radiation length of the detector, was chosen because:

- INCREASES THE MECHANICAL ROBUSTENESS CONSIDERING THE NECESSARY HANDLING TO OPERATE THE WHOLE DETECTOR
- REMAINS IN THE REQUESTED LIMITS OF THE MATERIAL BUDGET.

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INFN Istituto Nazionale di Fisica Nucleare

Institute of High Energy Physics
Chinese Academy of Sciences