# The ePIC Silicon Vertex Tracker: design and development of the inner barrel

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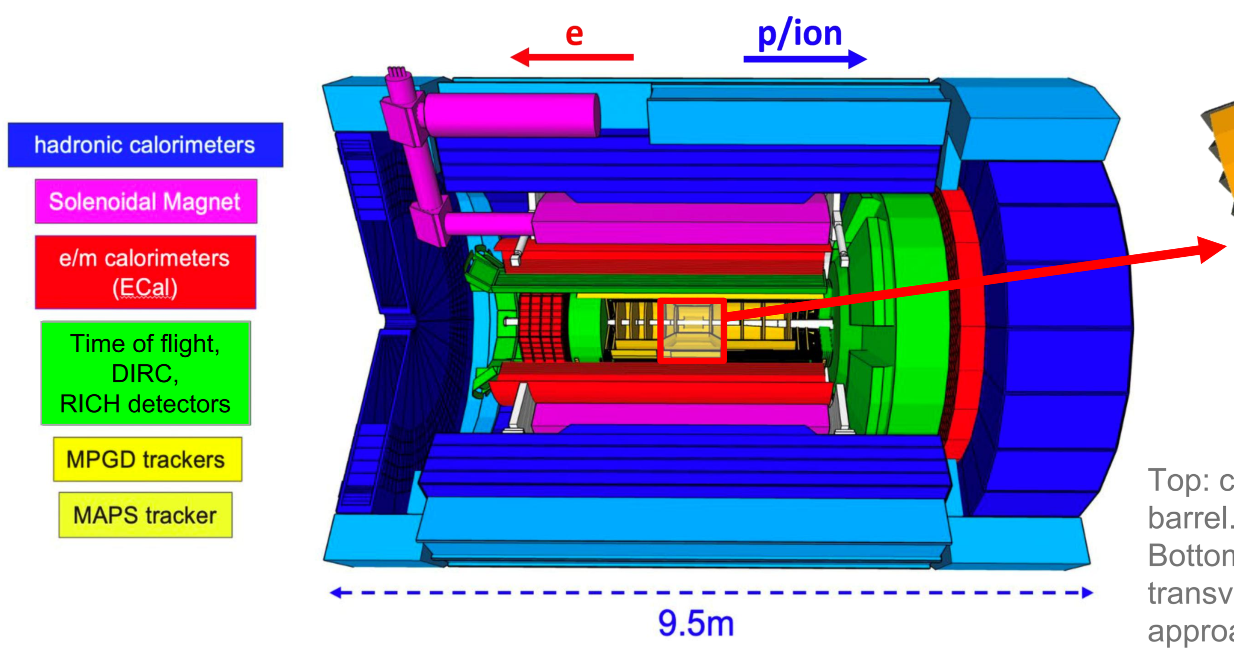
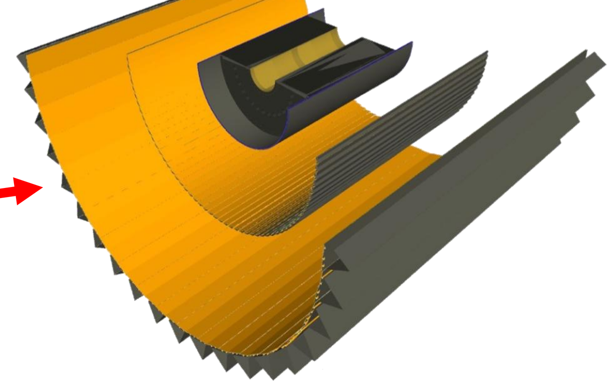
for the ePIC SVT detector subsystem collaboration

## Silicon Vertex Tracker

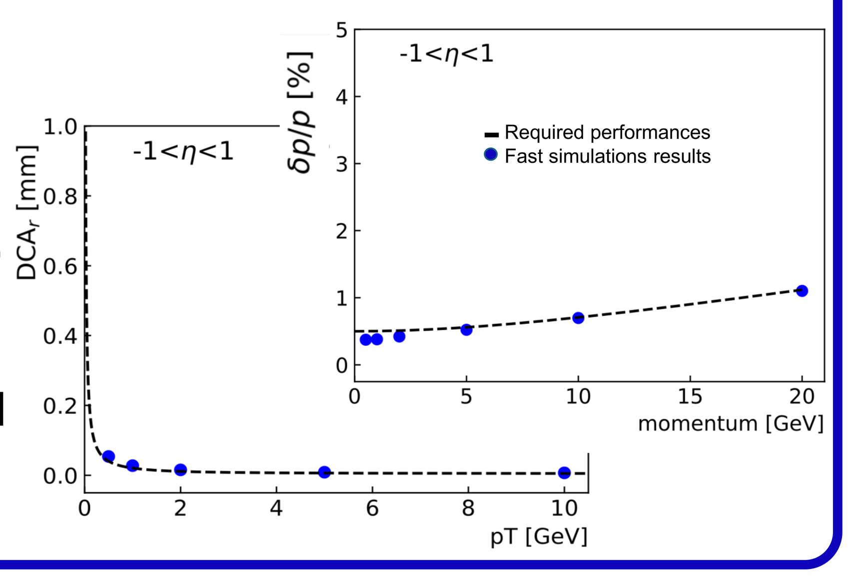
The ePIC (electron-Proton-Ion-Collider) detector [1] is designed to satisfy the performance requirements of the physics program at the EIC (Electron-Ion Collider), a new accelerator to be constructed at Brookhaven National Laboratory (USA) [2].



Top: conceptual design of the IB-OB half-barrel.
Bottom: physics required performances for transverse momentum and distance of closest approach compared to fast simulation.

The Silicon Vertex Tracker (SVT) [3] is the innermost subsystem of ePIC, having the role to perform teh tracking of charged particles and the localization of the primary collision vertexes and of the secondary micro-vertexes, key to identify weak decay. It is composed of an inner Barrel (IB) and an Outer Barrel (OB), covering the central pseudorapidity range, and two groups of endcaps disks, for a total active area of ~8,5 m².

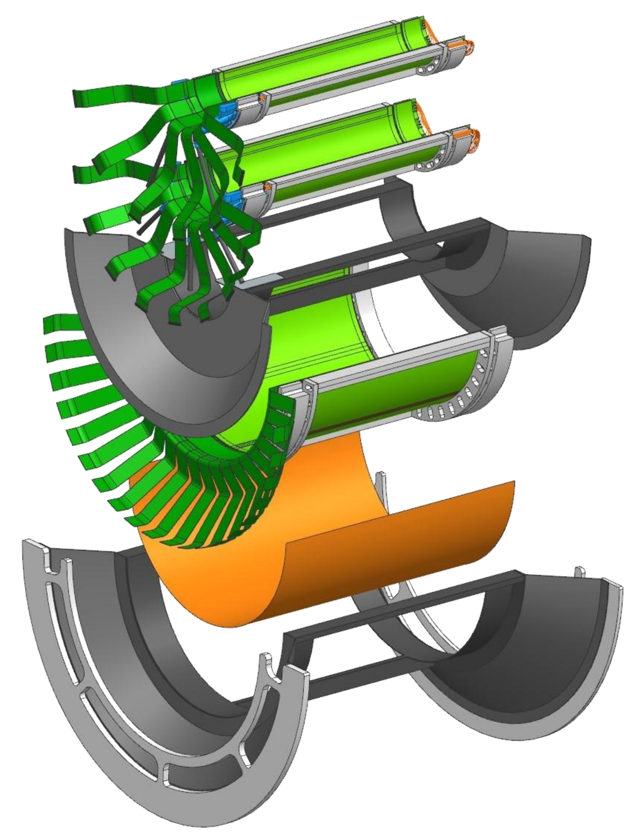



## Inner Barrel

The IB is designed to provide precise vertex reconstruction with asymptotic resolution better than 10 μm, and contributing to momentum measurement.

### IB structure

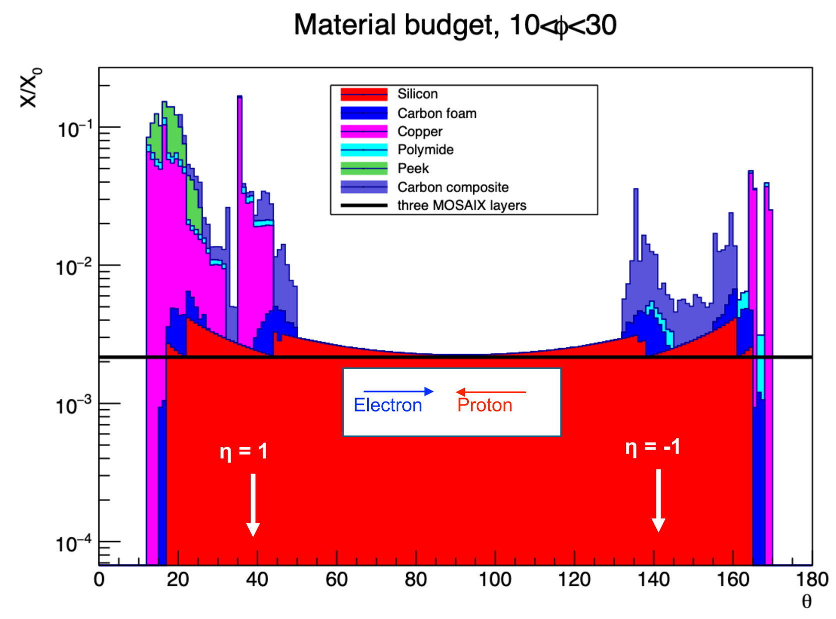
The IB is composed of three active layers (L0, L1, and L2) featuring a cylindrical design. Each half-layer integrates the sensors, two sets of FPCs/cables for power and data transmission, and an ultra-light support structure made of carbon foam and a carbon-fiber shell to maintain the required geometry.
The system utilizes ALICE ITS3 [4] MAPS sensors, fabricated in 65 nm commercial CMOS technology and thinned to 50 μm. These sensors feature a 20 μm pixel pitch and a power consumption of 40 mW/cm² in the pixel matrix. Arranged side-by-side, the sensors are bent to cylindrical radii of 36 mm (L0), 52 mm (L1), and 124 mm (L2).



CAD exploded view of IB support with cables and sensors.

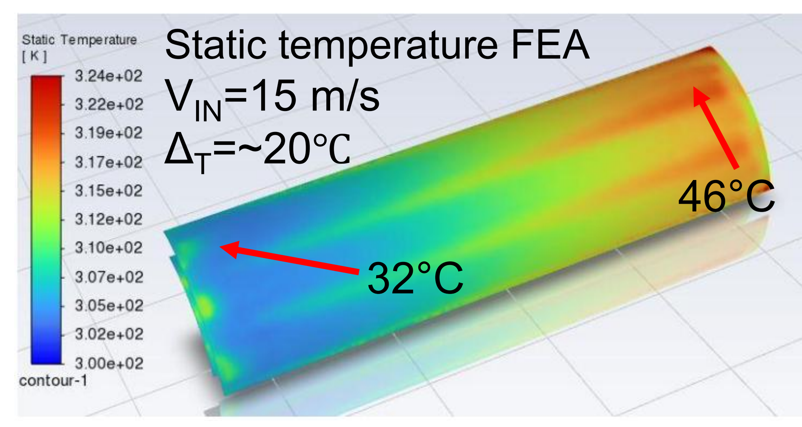
### Material budget

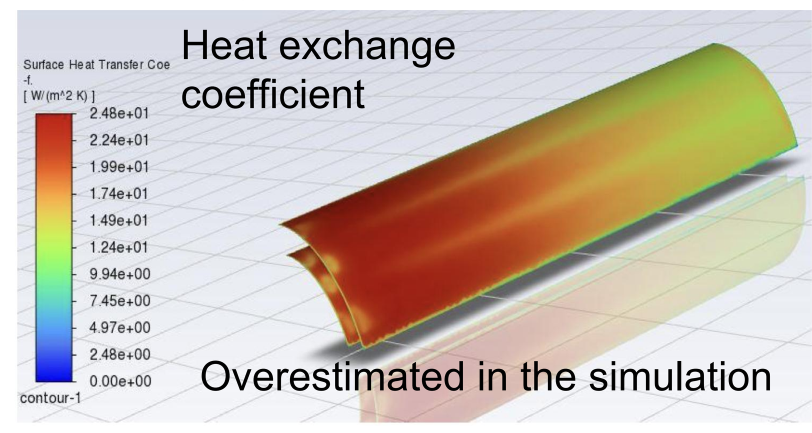
Material budget distribution as a function of pseudorapidity η, as obtained from simulation, is shown on the right. For η in range [-1,1] only sensors are present reaching 0.07%; elsewhere copper (likely to be replaced with aluminum) cables and services increase $X/X_0$. CFC thickness is kept at the upper safe estimate value of 1 mm.




### Thermal FEA

Preliminary simulations of the thermal load are ongoing for the quarter-barrel L0-L1 without the Left Endcap (power and data transfer) and support structures. Turbulence (critical for proper cooling) cannot be easily achieved.

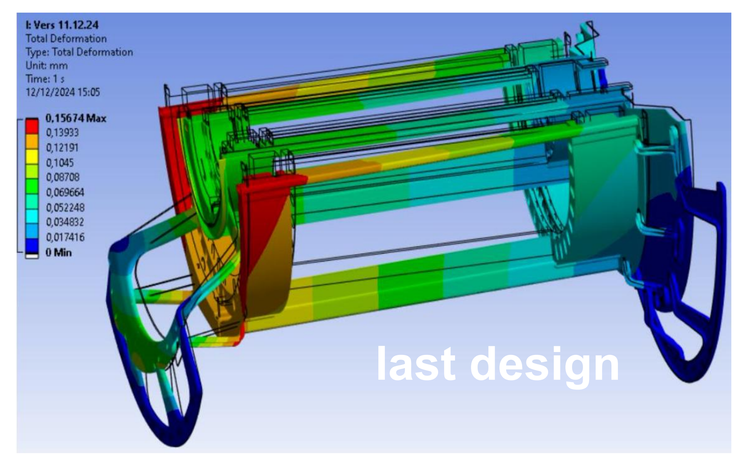


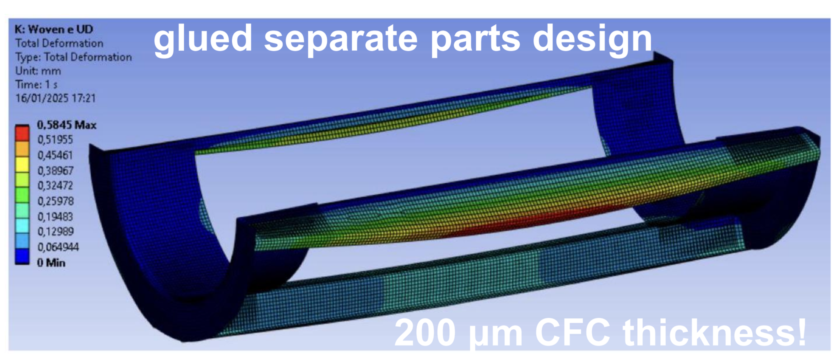




Air flow cooling and possible addition of other cooling elements are still under investigation. Measurements on mock-up with thermal load are needed to confirm the preliminary evaluation of cooling effectiveness.

### Mechanical FEA

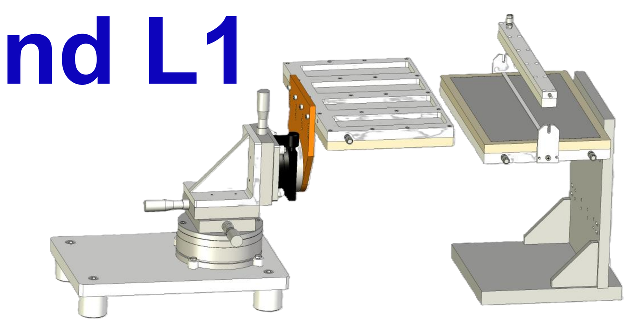
Mechanical load simulations with a load safety factor of 1.5 are ongoing.
L2 deformation results are extrapolated by L0-L1.
Results from last support design simulations show an enhanced deformation on e-side arms.



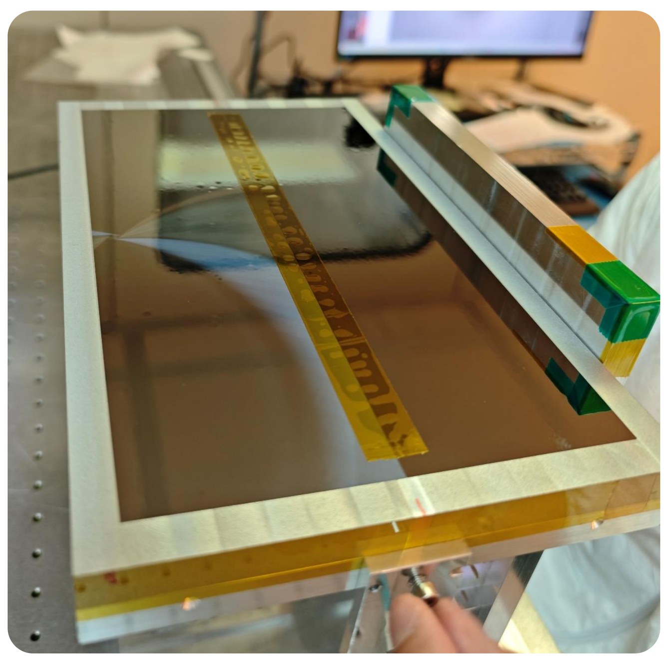




If support is made of separated parts glued together, the deformation is 600 μm on edges, due to copper cables, not affecting the sensor region. In this case CFC thickness of 200 μm is considered.

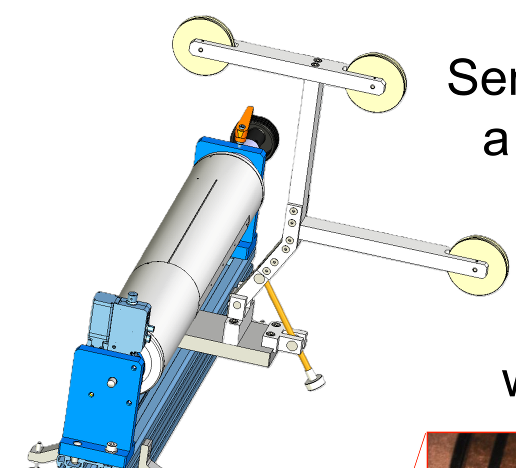
## Assembly of L0 and L1



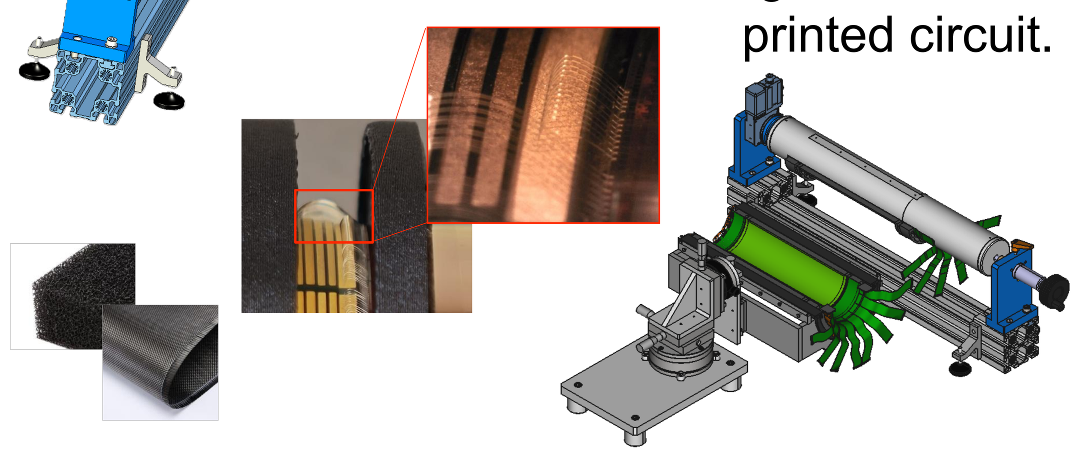
Two sensors for the innermost half-layers of the IB (266 mm × 59 mm and 78 mm, respectively) are aligned and joined before being bent into a half-cylindrical shape. The assembly procedure can be divided in three main steps.

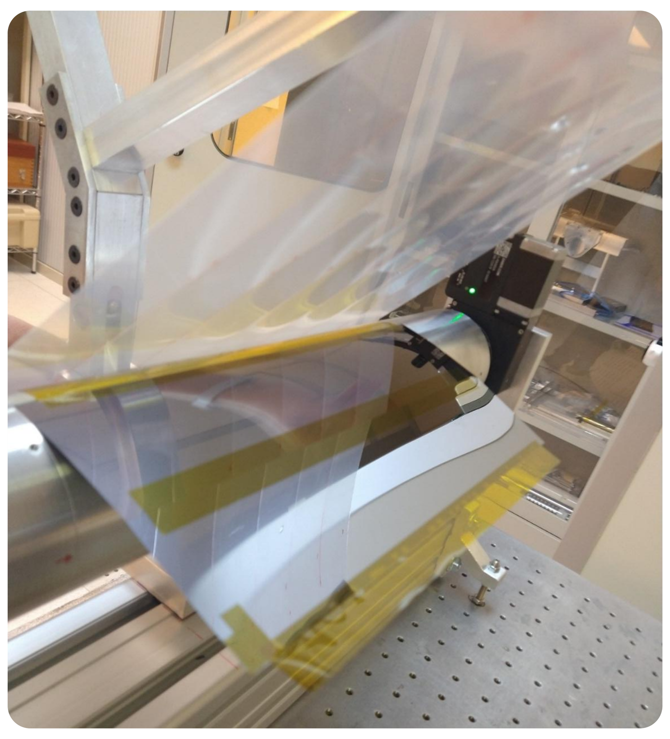


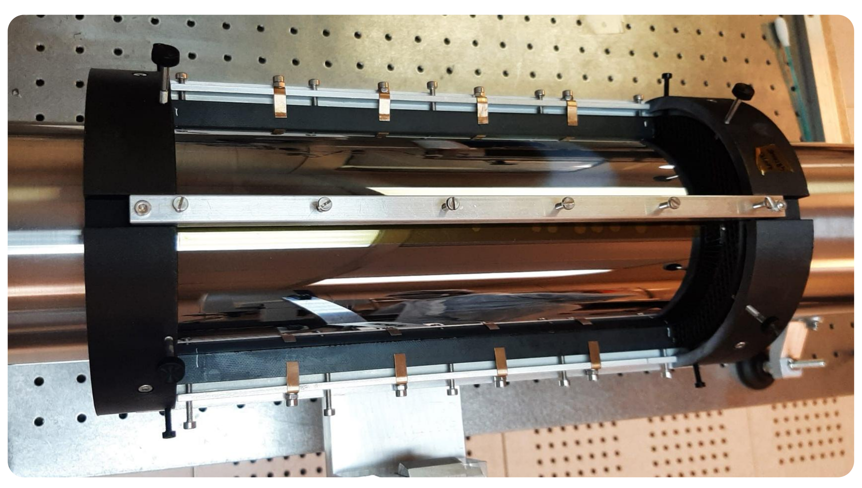
Sensors undergo **alignment and interconnection** on a planar tool with independent vacuum regions, leaving a 50 μm gap bridged by Kapton tape with minimal surface contact to ensure protection.



Sensor **bending** occurs via a tensioned Mylar foil and Kapton tape over a cylindrical mandrel, allowing for subsequent wire bonding to a flexible printed circuit.

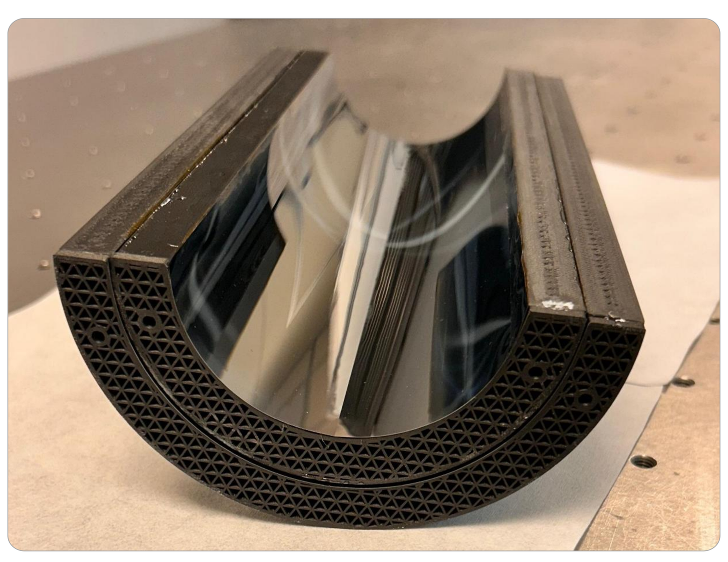






At last, the **gluing** of carbon-foam support structures (longitudinal bars and half-rings) and half-cylindrical carbon-fibre shell to the sensors surface is done. The layer is removed from the mandrel and glued to the complementary layer.

The pre-R&D campaign was completed in 2025, demonstrating the main procedure steps through the prototype. Given the fragility of the thin silicon sensors, the described process places particular emphasis on minimizing any operations that could pose a risk of mechanical damage.



## Outlook

- **Sensor**: Tests of sensors more ePIC-oriented.
- **Mechanical and thermal load simulation**: Implementation of design details and crosscheck of FEA on mock-up and first prototype with dummy thermal load.
- **Mechanical support**: Definition of materials and of design parameters to match required performances of mechanical stability and material budget. Production of prototypes by the end of the 2026
- **Cooling**: Heaters prototype foreseen by summer 2026, to be tested in wind tunnel set-up for studying air cooling efficiency.
- **Wire bonding**: Wire loop shape definition and relative pull-force estimation, evaluating any possible air-flow effects.
- **Vibrational measurements**: Investigation of sensor displacement caused by cooling airflow, which could affect tracking performance.
- **Aging tests**: Ongoing tests in climate chamber of adhesive power of Kapton tape. Then tests on half-layers prototype are foreseen, studying the overall thermal effect on silicon and the various components.

[1] Dalla Torre S., "The ePIC detector at the EIC", CERN Detector Seminar 2024, https://indico.cern.ch/event/1418391/
[2] Khalek Abdul R. et al., "Science requirements and detector concepts for the electron-ion collider: EIC yellow report", Nuclear Physics A 1026 (2022): 122447.
[3] Gonella L., "Development of a Silicon Vertex and Tracking Detector for the Electron-Ion Collider.", The 32nd International Workshop on Vertex Detectors.
[4] ALICE collaboration, "Technical Design report for the ALICE Inner Tracking System 3 - ITS3. A bent wafer-scale monolithic pixel detector", CERN-LHCC-2024-003, https://cds.cern.ch/record/2890181