Silicon Detector R&D Meeting

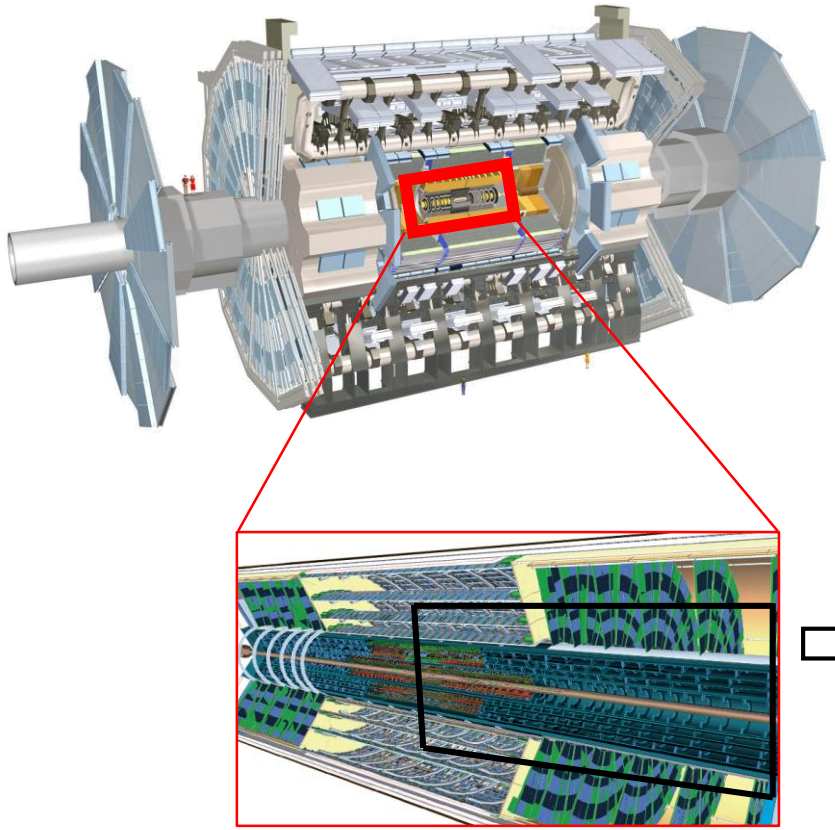
Atlas-ITK activities at DESY on carbon-fibre support structures

Dario Ariza on behalf of the Desy Atlas group

Hamburg, 13.04.2022

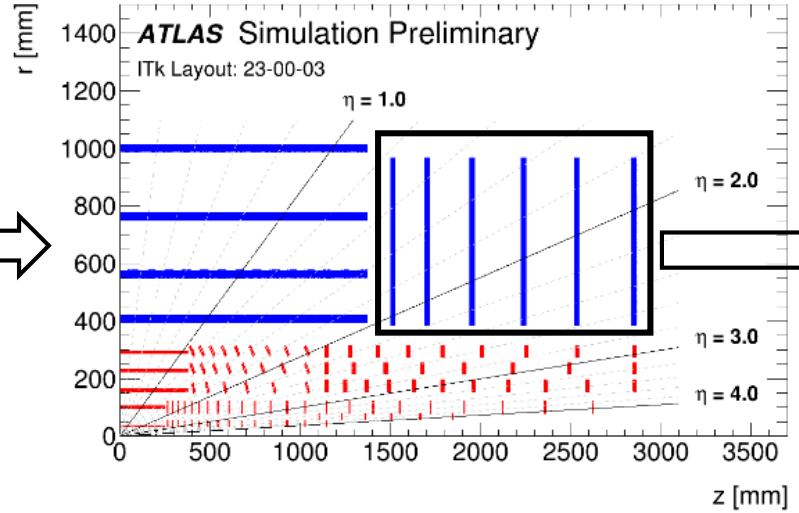
HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

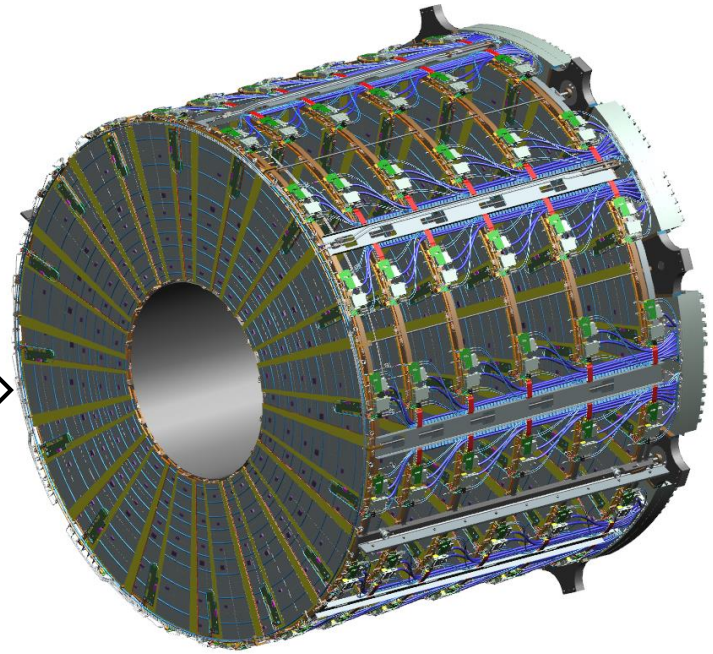
Atlas Inner Tracker for HL-LCH



ATLAS phase II upgrade with a completely new Inner Tracker:

- Increased luminosity and pile-up
- Higher granularity
- Increased radiation tolerance required



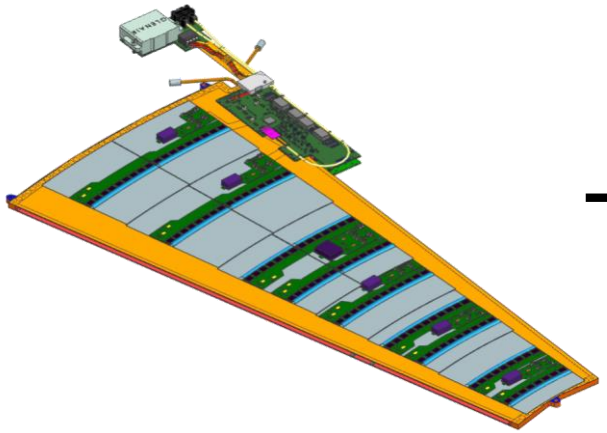


The new Atlas strip Endcap

Local Support

Global Support

Endcap



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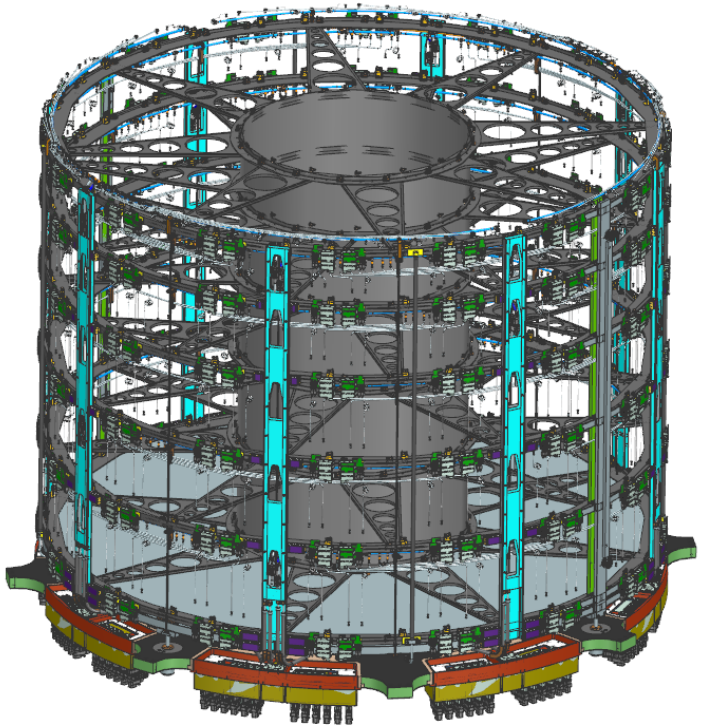

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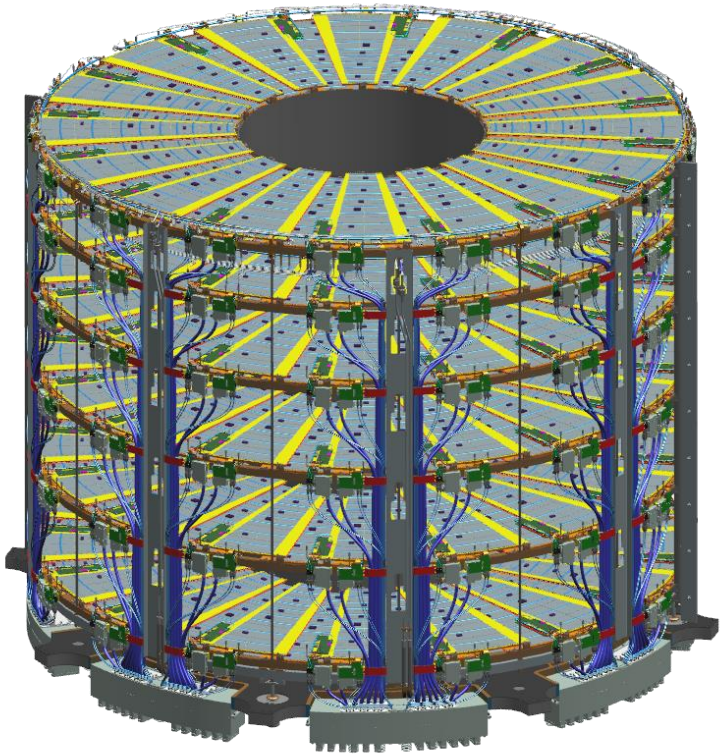
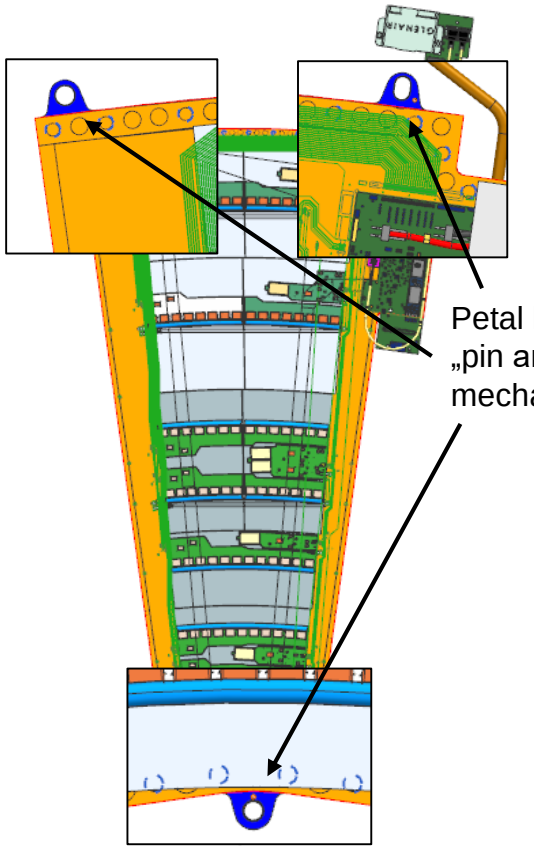


Local support

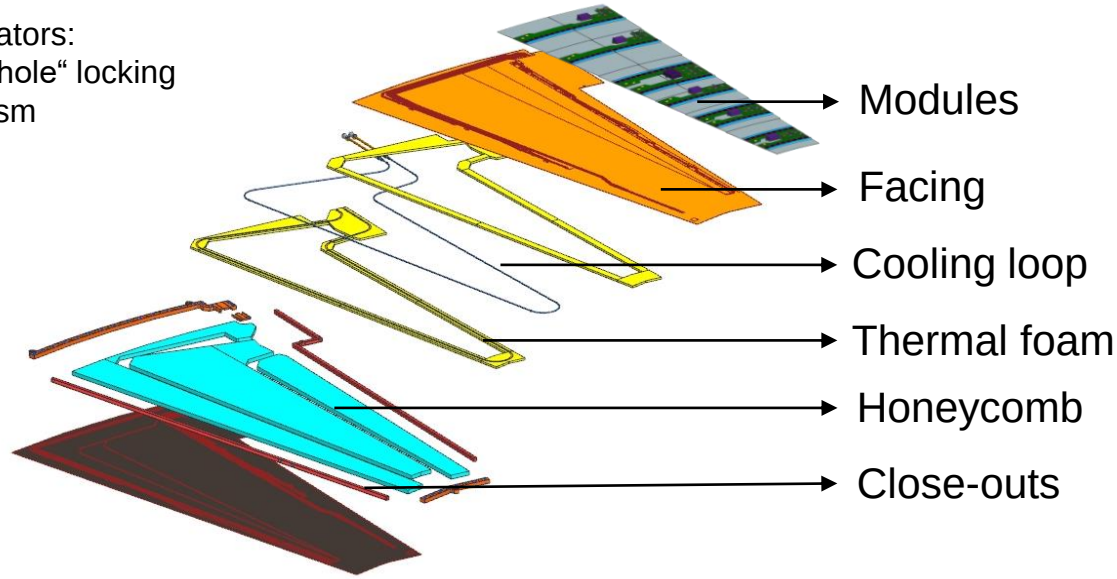
Petal core

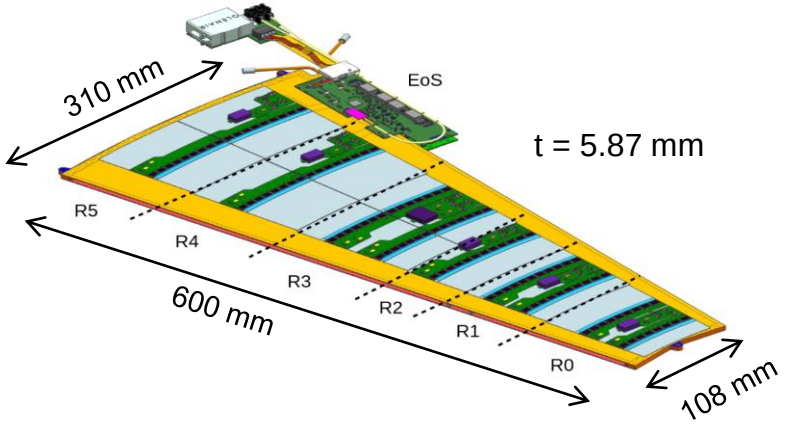
Low mass sandwich structure with an embedded cooling lopp that holds the Si-modules and electronics.

Key elements:
Thermal foam for efficient heat dissipation
Honeycomb for structural rigidity
Embedded „flex-circuit-board“ (bustape/facing)
High precision positioning
Weight: 250 g



Petal locators:
„pin and hole“ locking mechanism



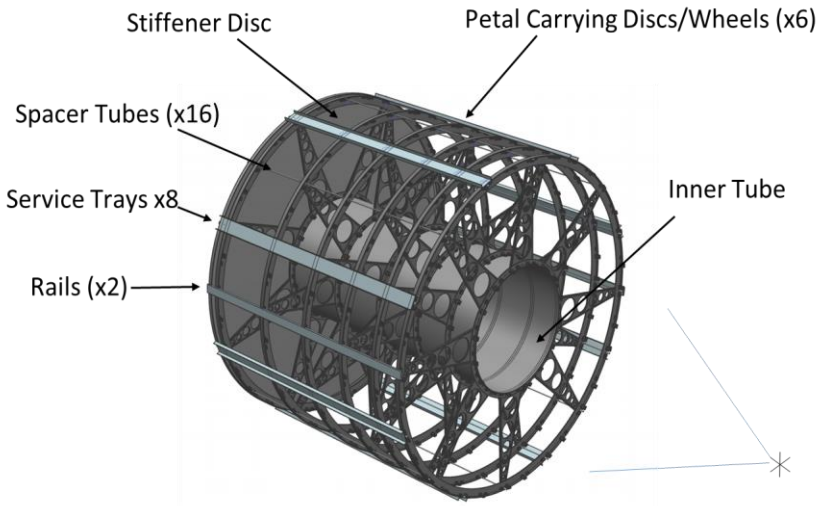


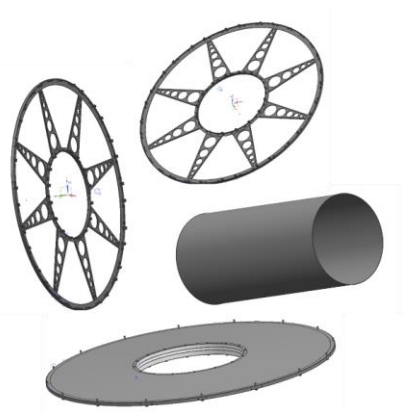
Global support

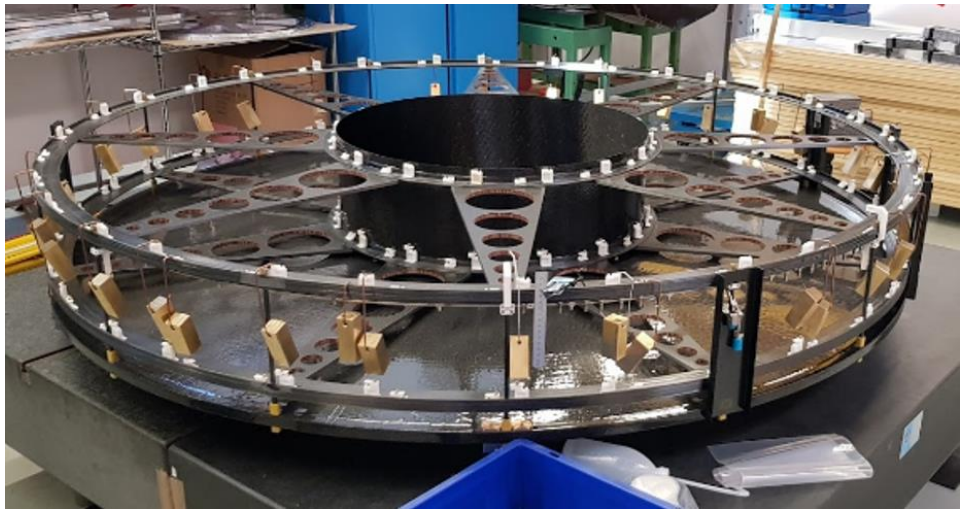
The Endcap structure

Low material structure while ensuring thermal and mechanical stabilitiy for the supported subcomponents and maintaining high precision.

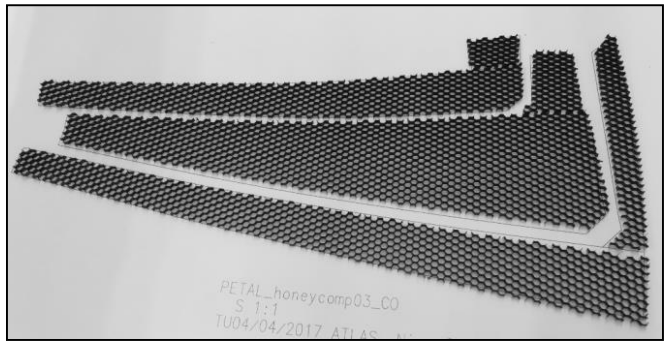
- Discs (holds the 32 petals in place and connect them to the rest of the structure)
- Inner Disc (connects the Discs on the inner radius)
- Service Trays (connects the Discs on the outer radius and carries electrical cables and cooling pipes from the petals to the back of the EC)
- Rails (connects kinematically the EC to the outer world)
- Stiffener Disc (provides Z-stiffness at the back of the EC)

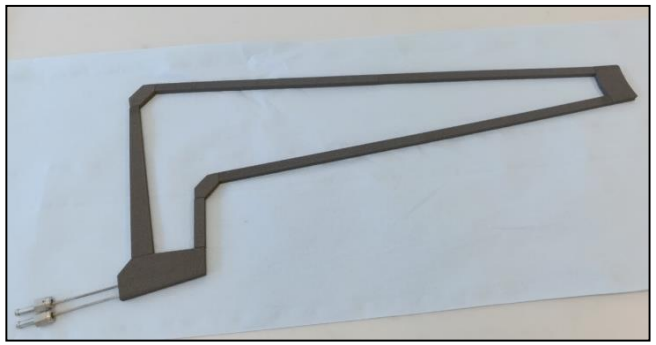


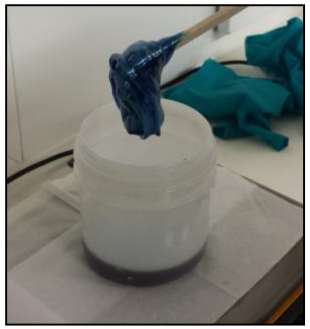




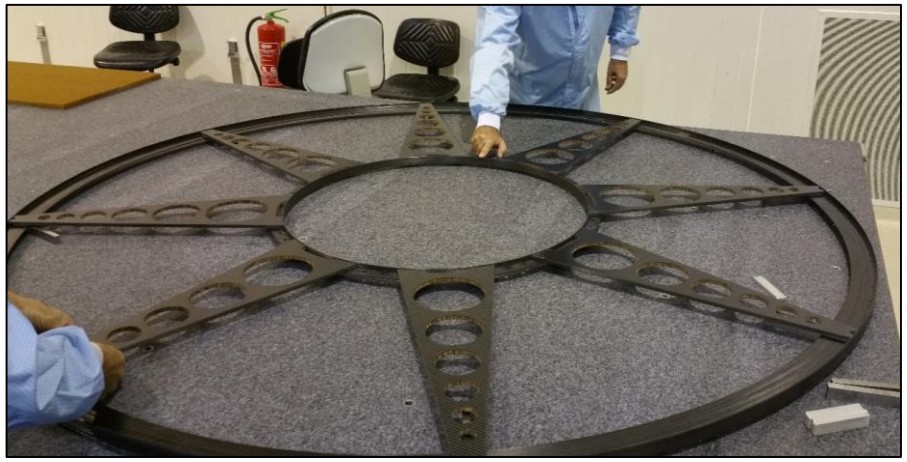
Carbon fibre Structures







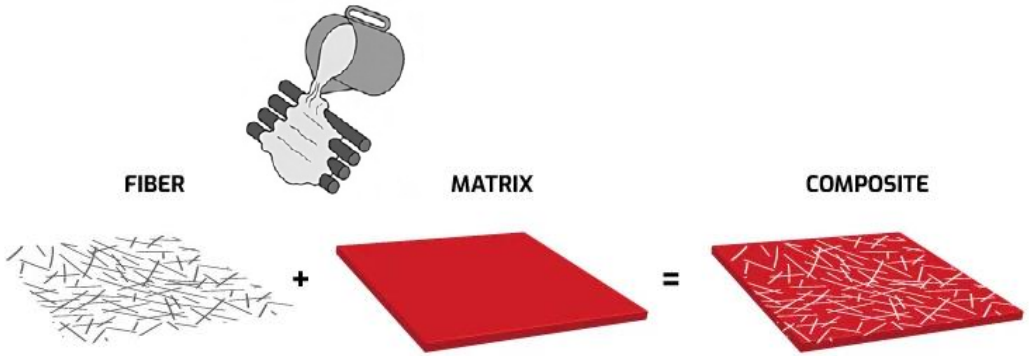
Everywhere in detector



Composites materials

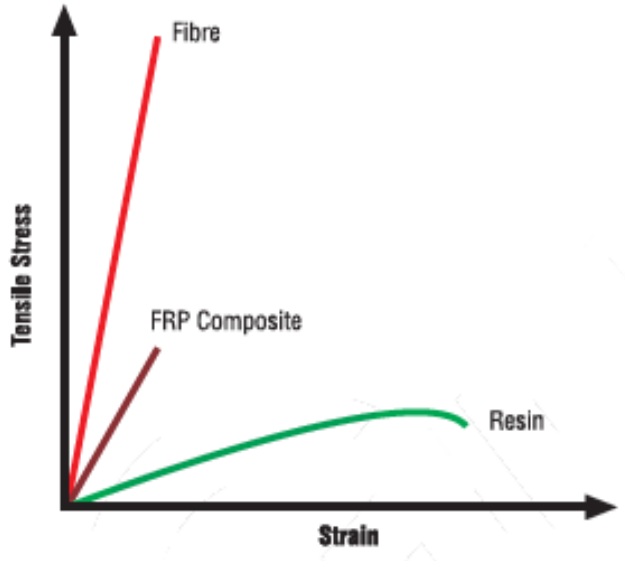
What is it?

A composite material is a combination of two materials with different physical and chemical properties. When they are combined they create a material that is specialized to do a certain job, for instance, to become stronger or just lighter.



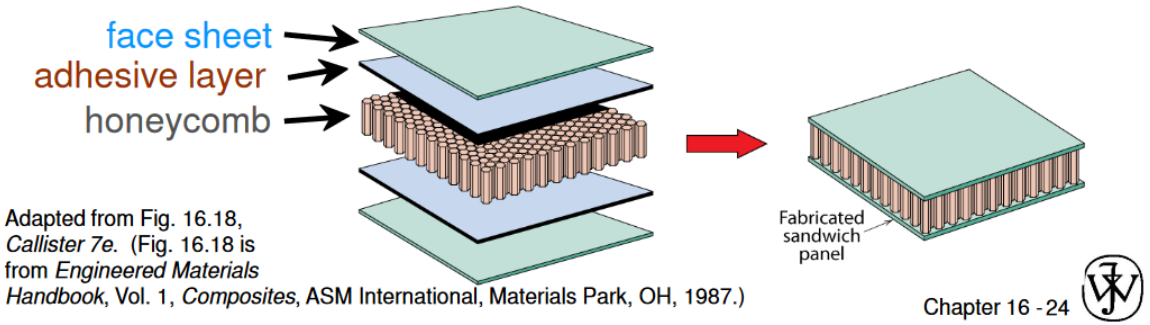
Why composites?

Excellent mass/strengh ratio, as well as a very low coefficient of thermal (CTE) and moisture expansion (CME) and its radiation hardness and length.



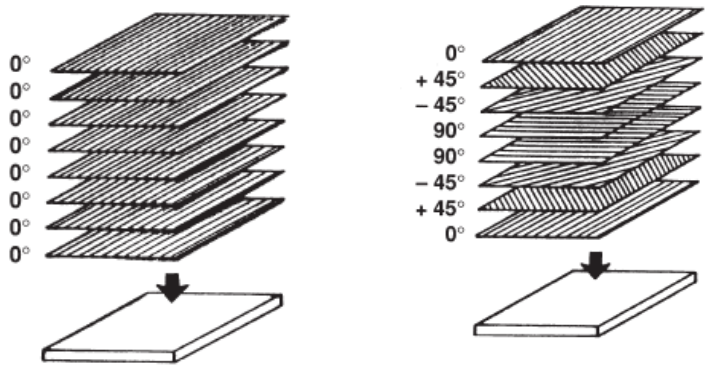
Sandwich structures?

Low mass due to the core and increase greatly the bending stiffness



Composites materials

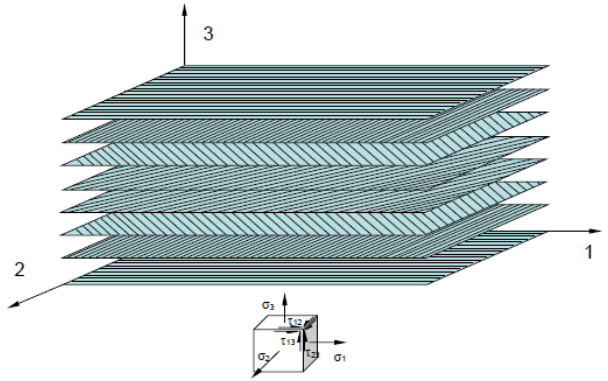
- As in any other material there are different types of fibers as well as different types of resin to choose from.
- Composite materials are anisotropic (different properties in different orientation)
- Design to match required load expectation (add material only where is needed)
- „Fibers are strong but brittle and polimers are weak but flexible“



Defining properties:
E – young's modulus
G – shear modulus
V – poisson's ratio

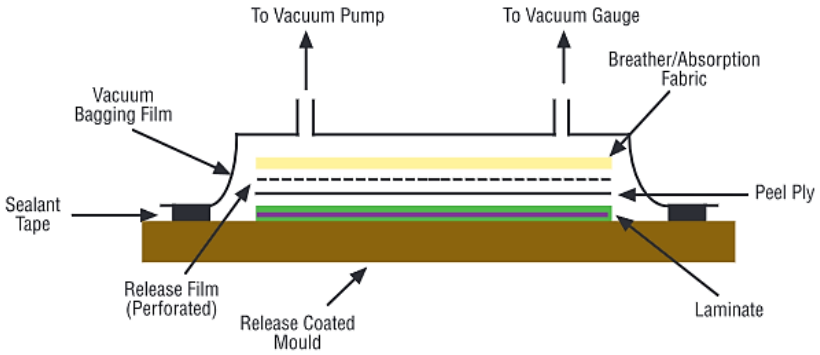
Fiber orientation determines the properties of the laminate

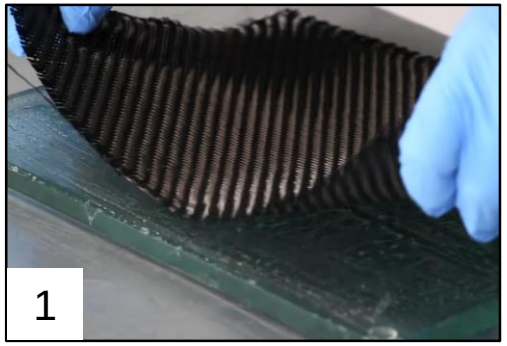
Align the fibers to counteract expected loads

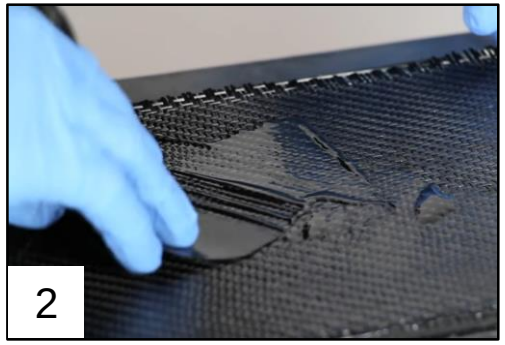


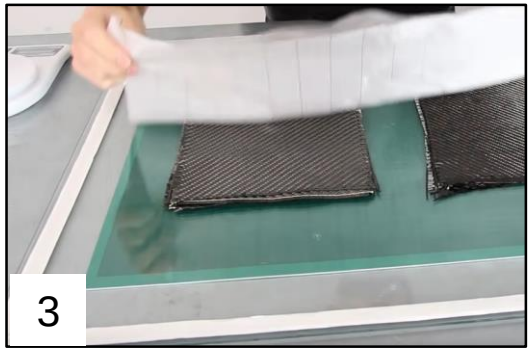
CFRP manufacturing methods

- Hand lay-up
- Vaccum press moulding
- Autoclave moulding
- Injection moulding
- Winding
- Press Moulding







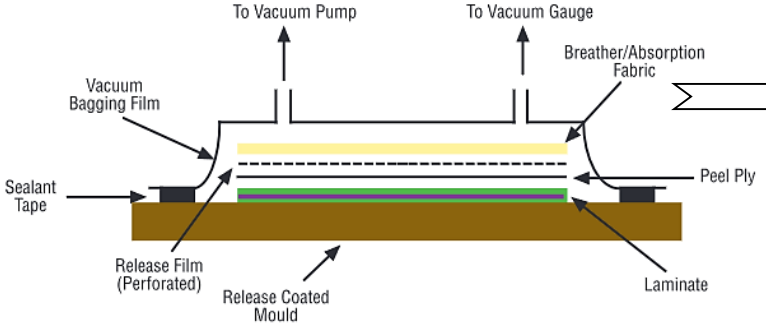


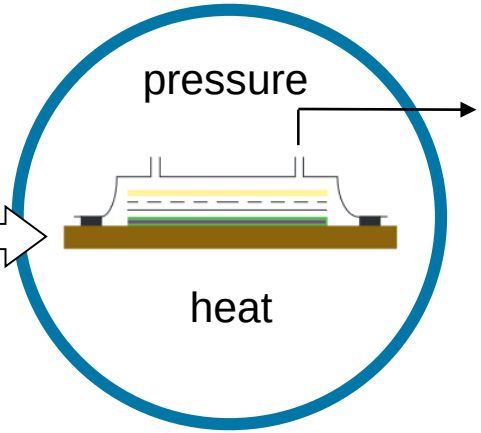
Facing co-curing in the autoclave

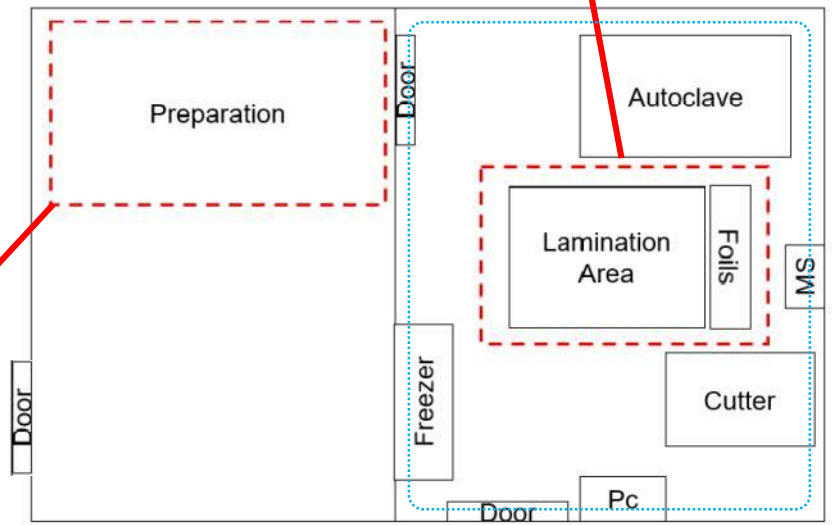
- Autoclave purchased by Atlas & CMS
- 2 Areas (mechanical processing area, clean area) in the production hall bld. 43a
- Desy deliverable for both strip Endcaps (ca 800 tapes)
- QC on bustapes before and after co-curing, as well as implementation on the Cern database
- Long process to finally produce parts for the detector (e.g pdr, fdr, sq, prr….)

Our blue friend!

Clean area



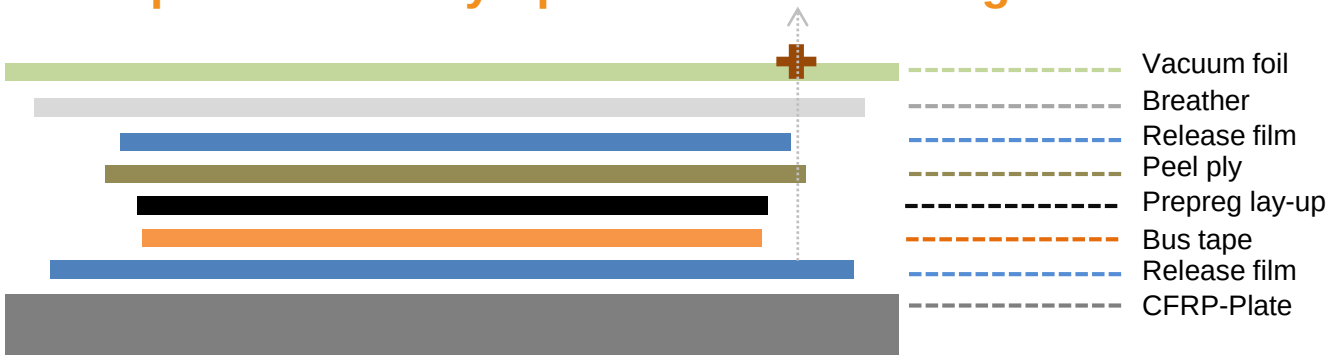


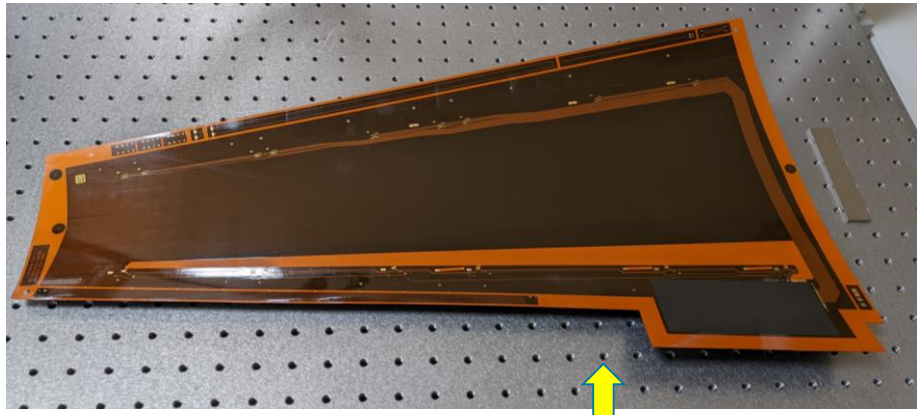


Production hall 43a

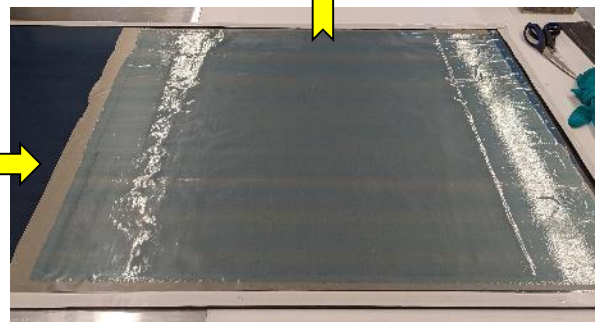
Bustape + facing co-curing

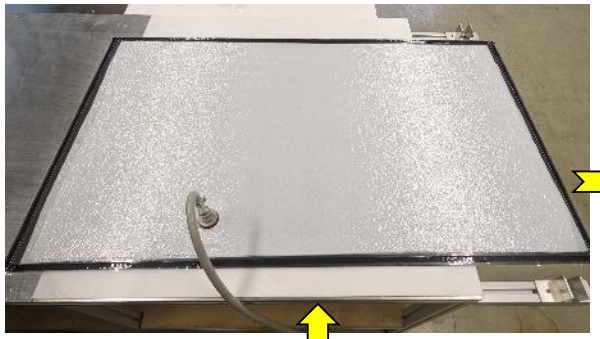
Description of the lay-up for the Petal facing

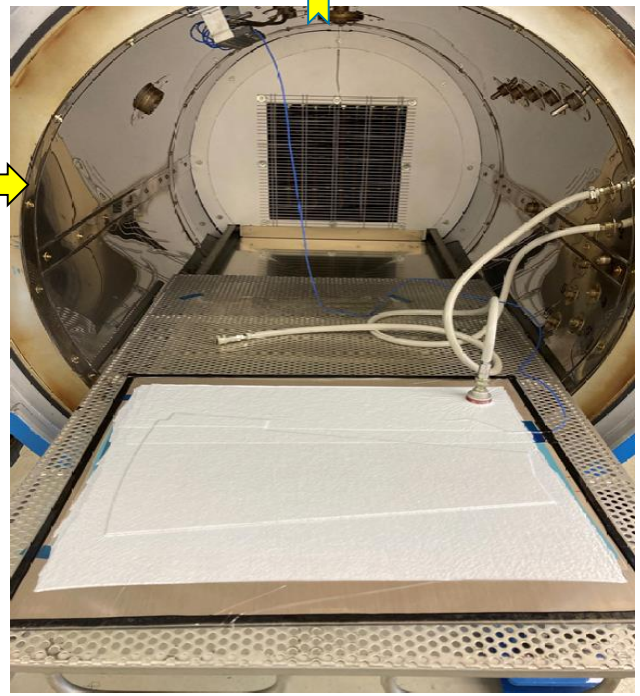




- CFRP-Plate (4 mm)
- Release film (Wrightlon 5200B)
- Bus tape
- Prepreg lay-up [0°/90°/0°]
- Peel ply (Ease 234 TFP-1)
- Breather (Airweave N10)
- Vacuum foil (Wrightlon-7400)



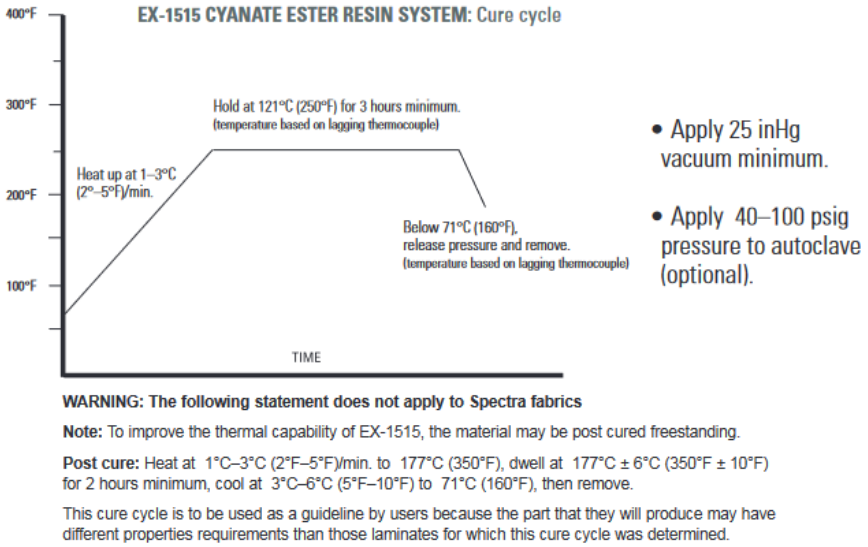




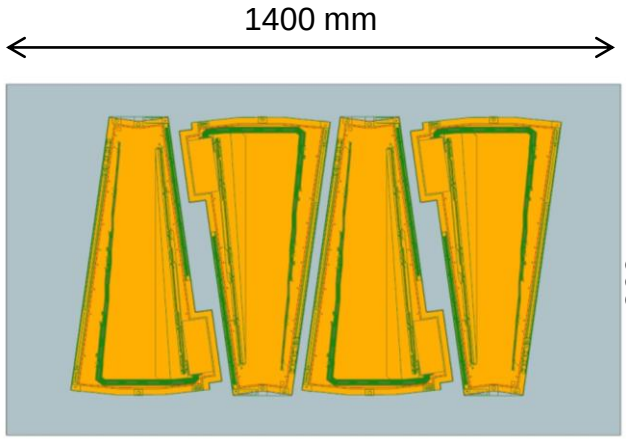
Bustape + facing co-curing

autoclave co-curing cycle

- Heat up with ca. 1,7°C/min to 80°C .
- Hold temperature for 20 min.
- Ramp up to 121°C with ca. 1,2°C/min with 3 bar.
- Hold at 121°C for 205 min.
- Cool down to 50°C and reduce pressure proportionally.



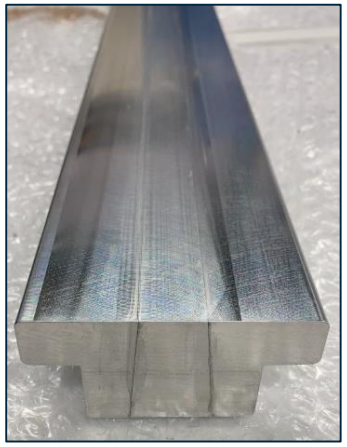
- Apply 25 inHg vacuum minimum.
- Apply 40–100 psig pressure to autoclave (optional).



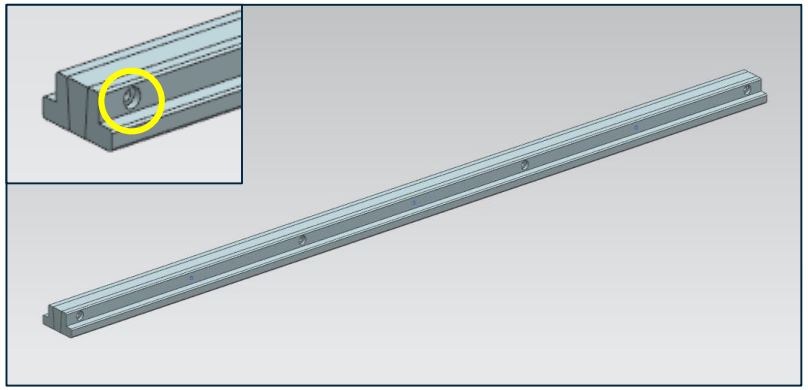
Service tray

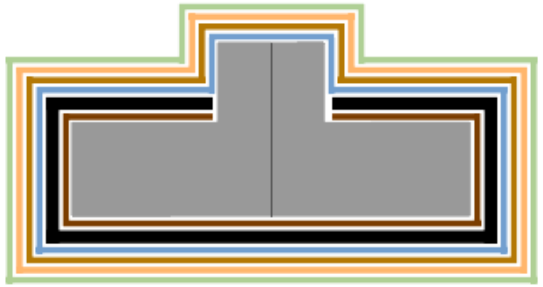
The service trays host some of the electrical Type-I services as well as the piping for the cooling of the local support structures for the strips end-caps (Petals). They provide a low inductance path for the end-cap wheels, stiffener disk, and cooling pipes to the Faraday cage comprised by the Outer Cylinder (OC) and the Structural Bulkhead (SB) of the Inner Tracker (ITk). They also provide additional stiffness to the end-cap global structure.

- A Desy derivable object
- 1400 mm long x 80 mm wide
- 17 trays in total + 1 for the System test
- Similar procedure as before but with the need of a mold to achieve the desired shape
- Post-machining required for final form and precision



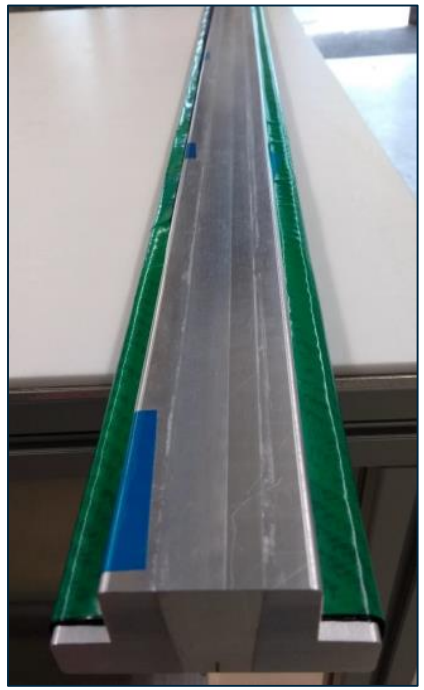
elec. connection (Cu)



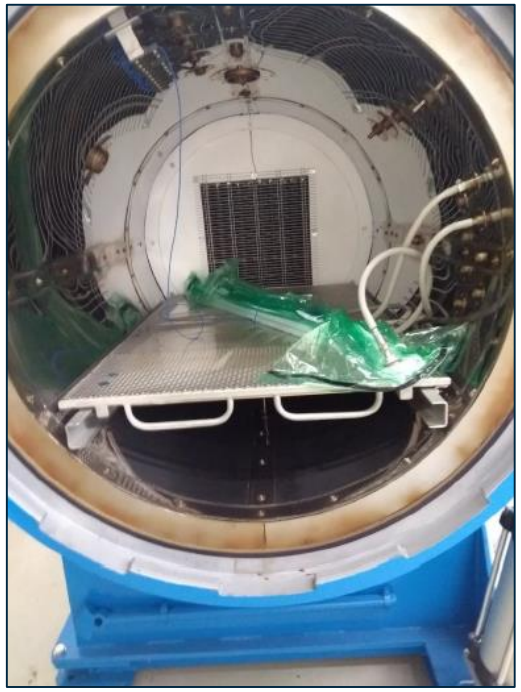


Service tray co-curing

Lay-up



Bagging



De-bagging

Post-processing

Delivery

THE END

Back up