



# Activity 1.a: Lightweight mechanics for future Trackers



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On behalf of WP4

## Outline:

Carbon foam for tracker **gas cooling** and **support**:

- ALICE Inner Tracking System 3 (ITS3)



Low mass cold plate for tracker **liquid cooling** and **support**:

- 3D printed modular cold plate with mini/microchannel
- High thermal conductivity carbon cold plate:
  - with embedded polyimide pipes
  - with microvascular network, pipe-less

**Air cooling**

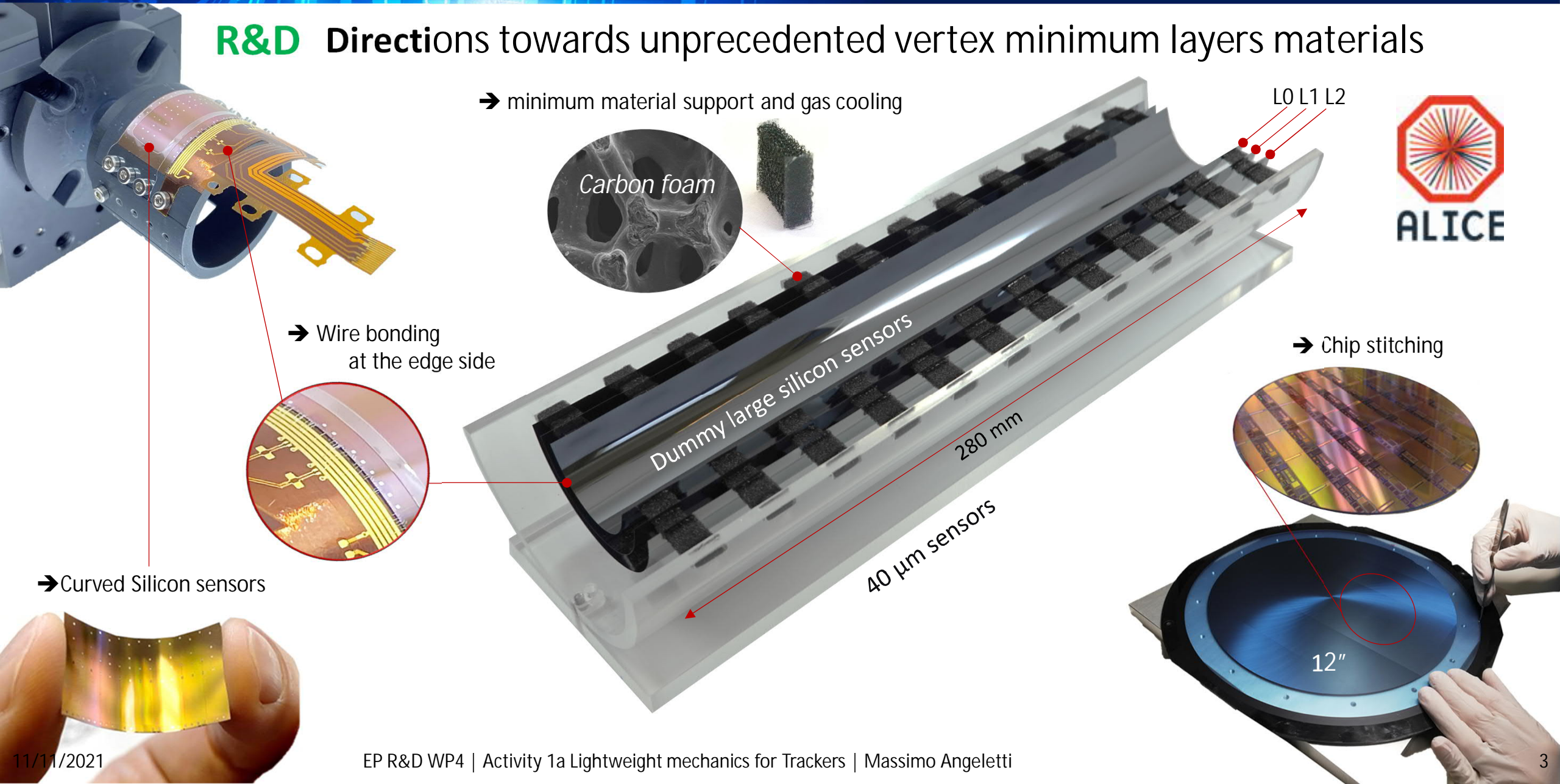
sensor

sensor

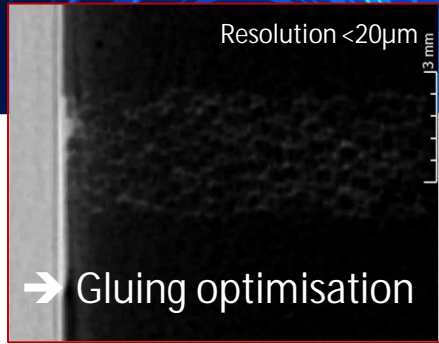
cold plate



## R&D Directions towards unprecedented vertex minimum layers materials

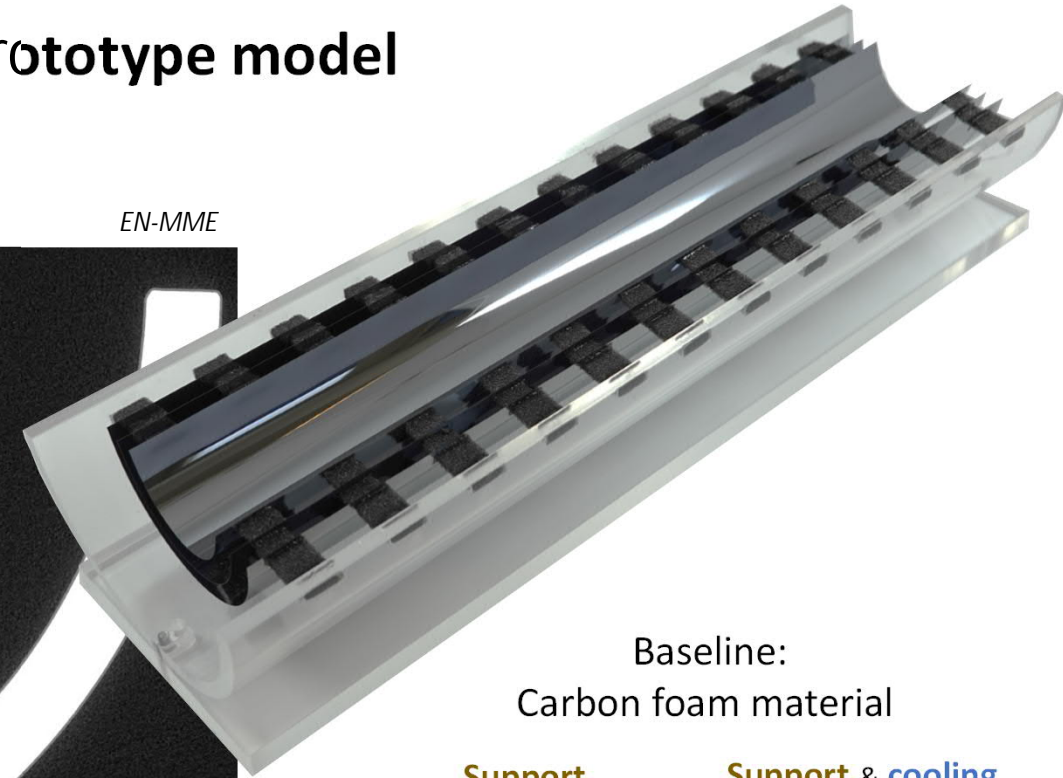
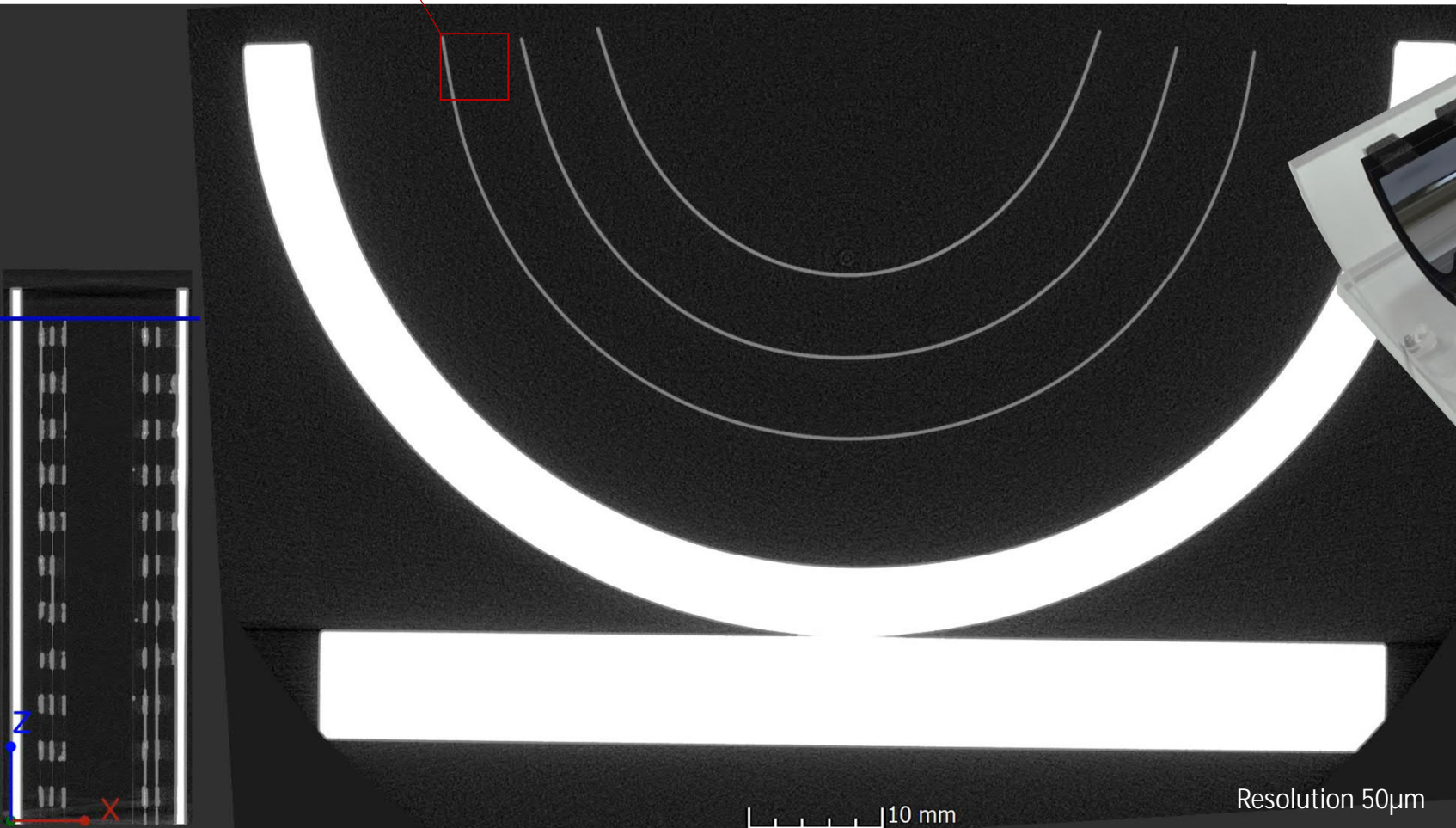


## Metrology assessment on first prototype model



X-ray computed tomography

EN-MME



Baseline:  
Carbon foam material

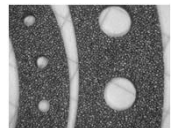
Support



ERG Carbon  
@Duocel

$\rho = 0.06 \text{ kg/dm}^3$   
 $K = 0.033 \text{ W/m}\cdot\text{K}$

Support & cooling



Allcomp K9  
Standard Density

$\rho = 0.2\text{-}0.26 \text{ kg/dm}^3$   
 $K = >17 \text{ W/m}\cdot\text{K}$

## NEXT: wind tunnel thermal test of new dummy model with carbon foam radiators

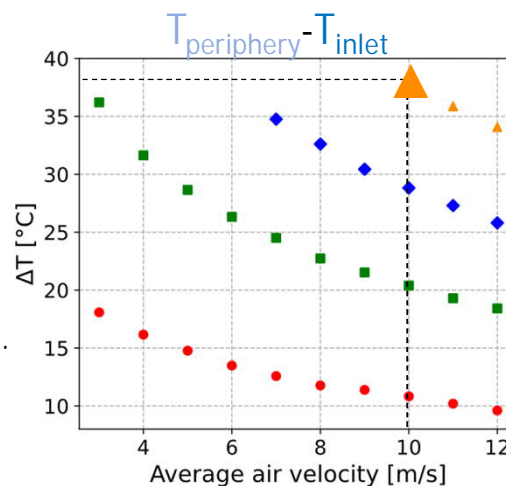
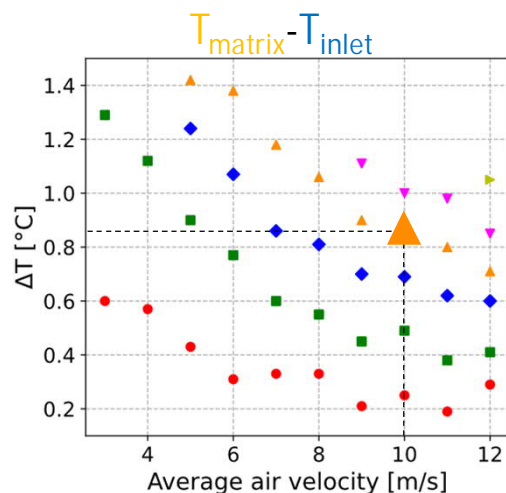
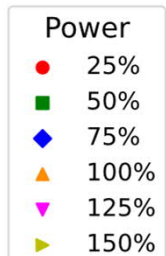
### Previous test on a prototype No radiators

Only Layer 0 integrated  
with heaters

$T_{\text{inlet}} = 23^\circ\text{C}$  (air)

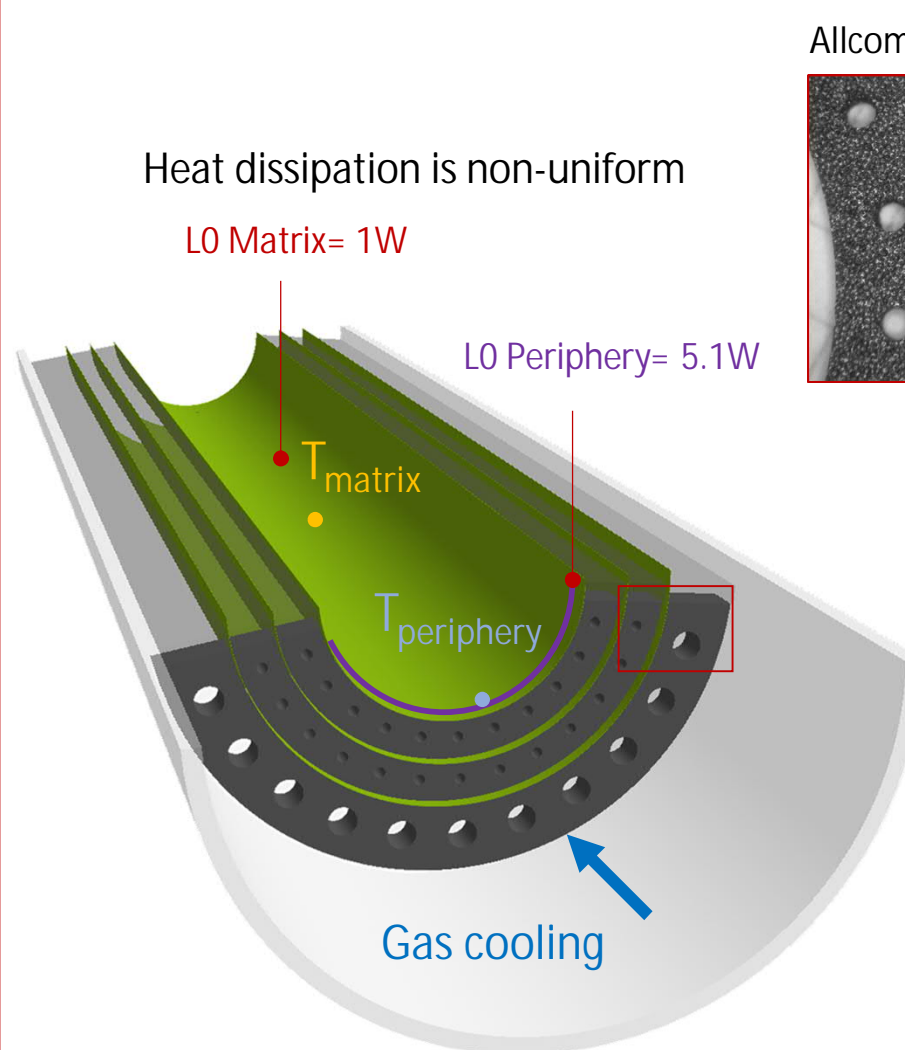
Layer 0  
Nominal power  
(100%)

Matrix= 1W  
Periphery= 5.1W

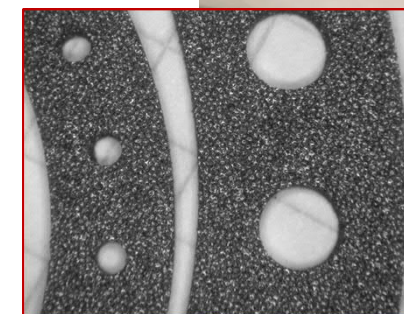


Outcome:

- Matrix region can be cooled by air convection.
- Temperature of the periphery region increase considerably.



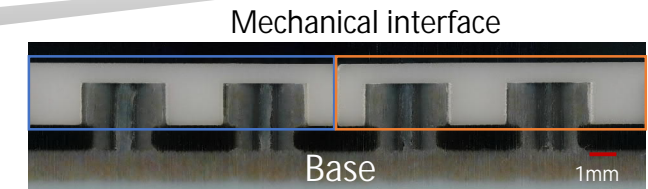
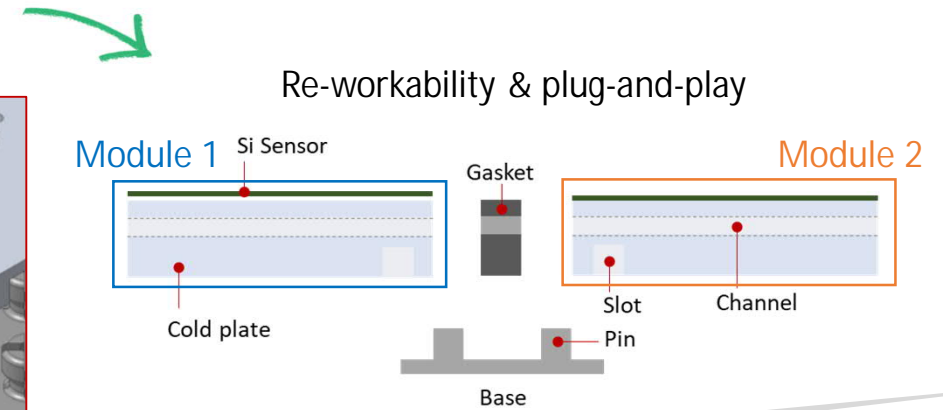
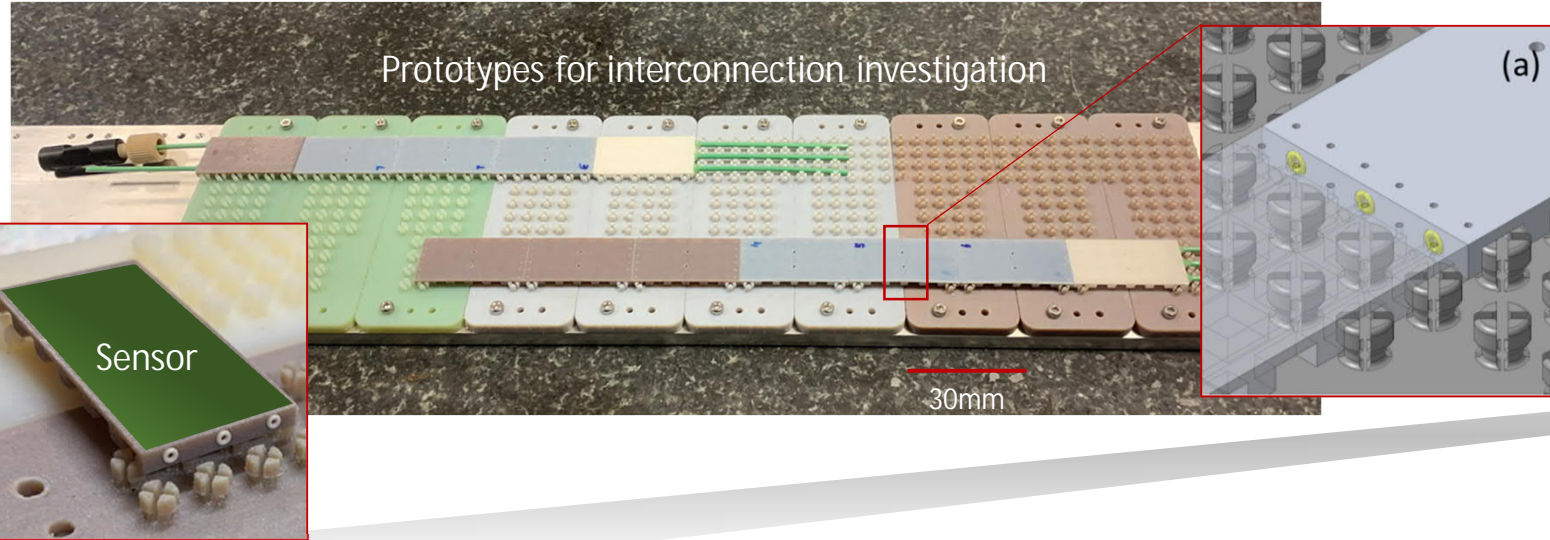
Allcomp K9 standard density



All dummy sensors (G10 material)  
are integrated with heaters

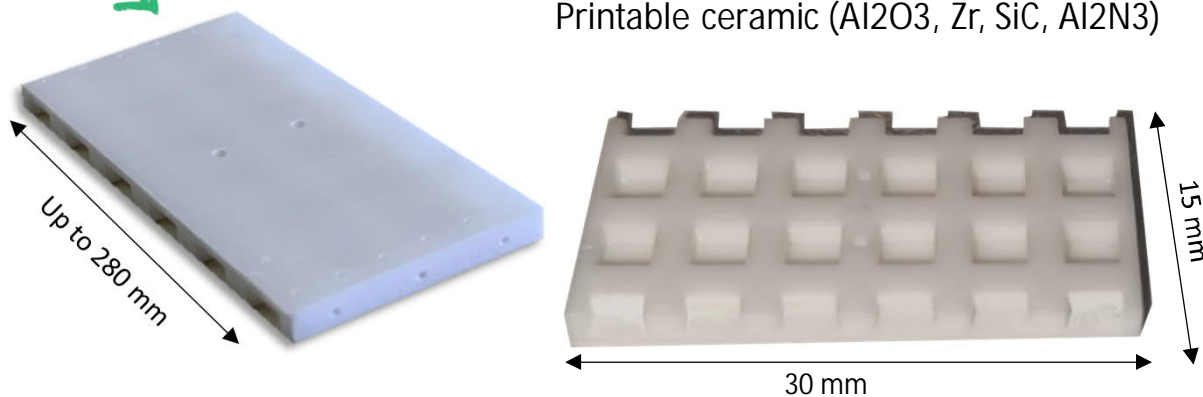
Utrecht, CERN

## R&D Interlocking modular coldplate (NEW concept)

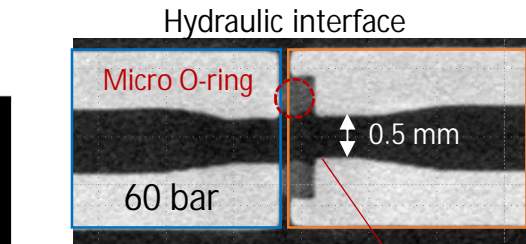
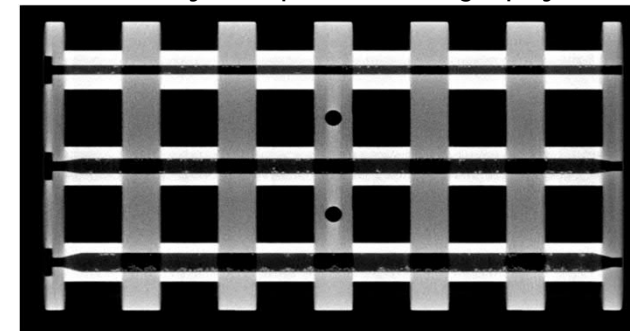


## 3D printed Ceramic modular Coldplate (NEW material)

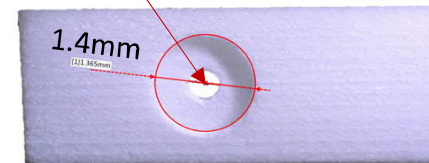
Printable ceramic ( $\text{Al}_2\text{O}_3$ , Zr, SiC,  $\text{Al}_2\text{N}_3$ )



X-ray computed tomography



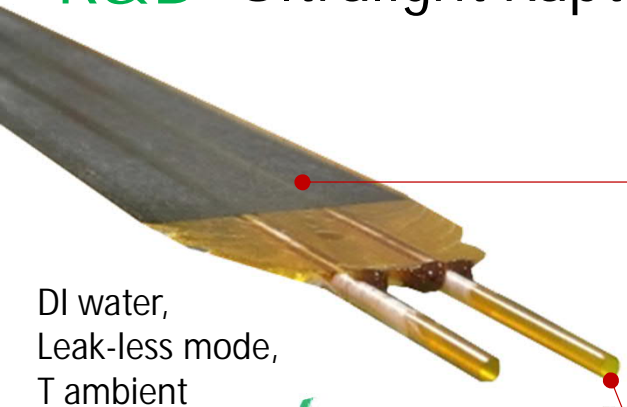
EN-MME-MA/MM



**NEXT:** Implementation on a detector layout

# Low-Mass cold plate: Carbon cold plate with embedded Kapton pipes

## R&D Ultralight Kapton pipe from water to CO<sub>2</sub>



Developed by

Used in ALICE in 2 detectors:  
ITS and MFT (LS2)

Also used by

ALICE

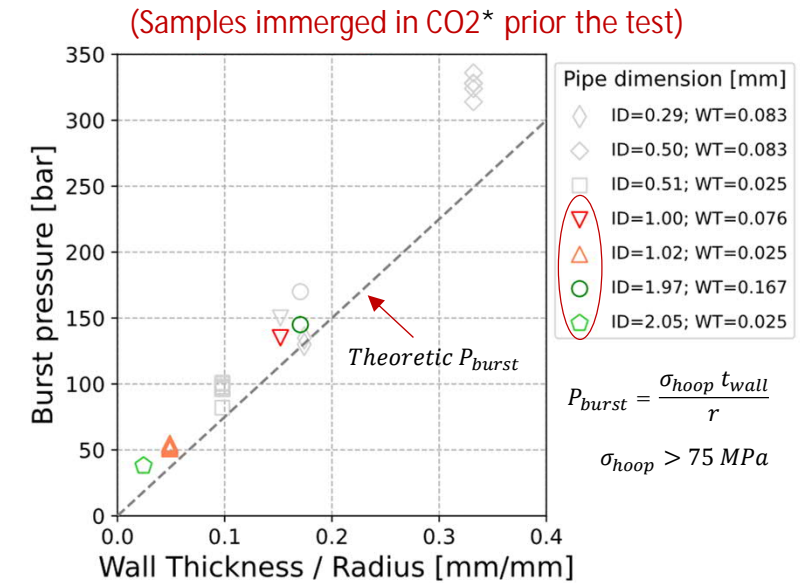
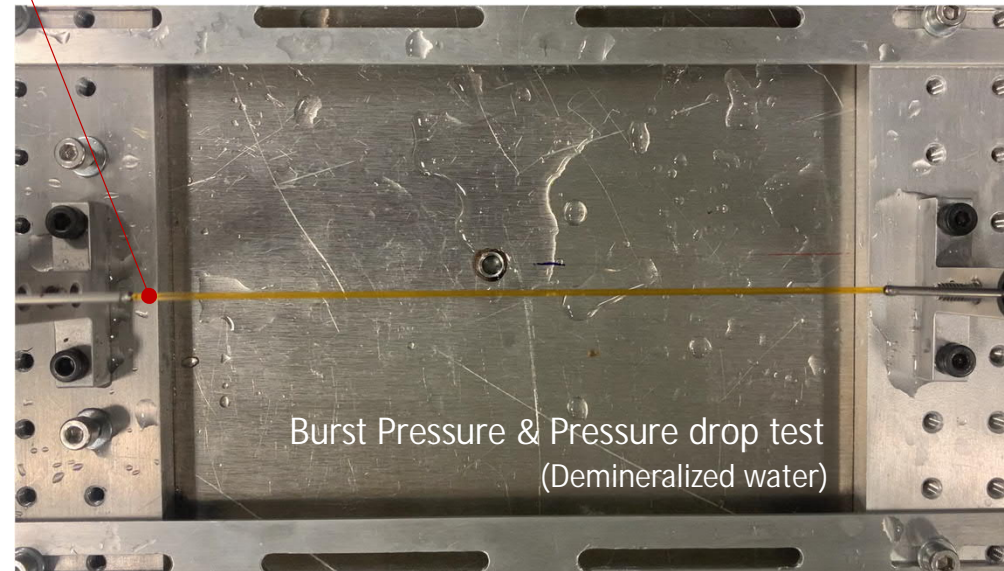
NICA  
MPD, IT (JINR)

SPHENIX

S-INE  
NA61



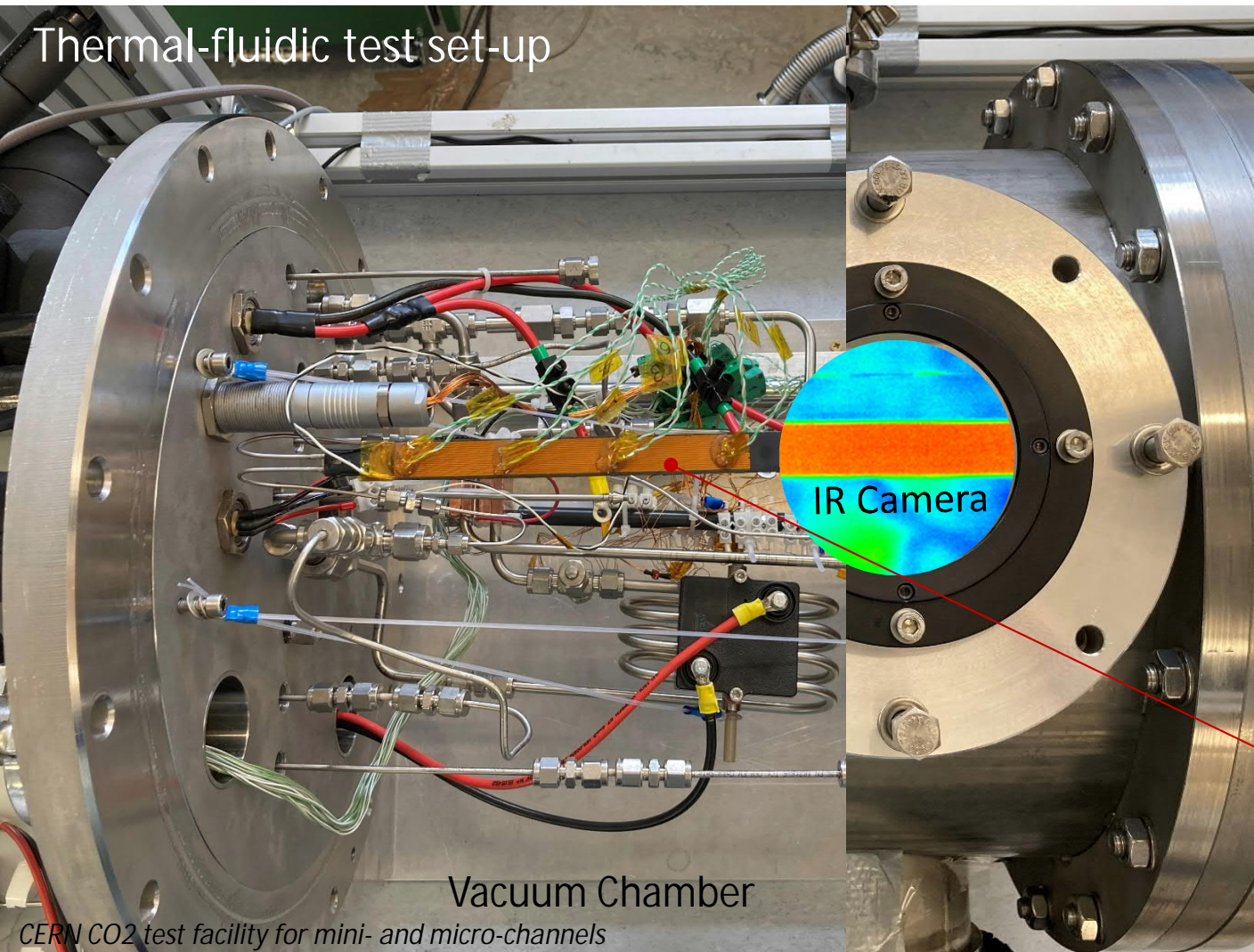
Kapton Pipe  
CO<sub>2</sub> compatibility and  
high pressure



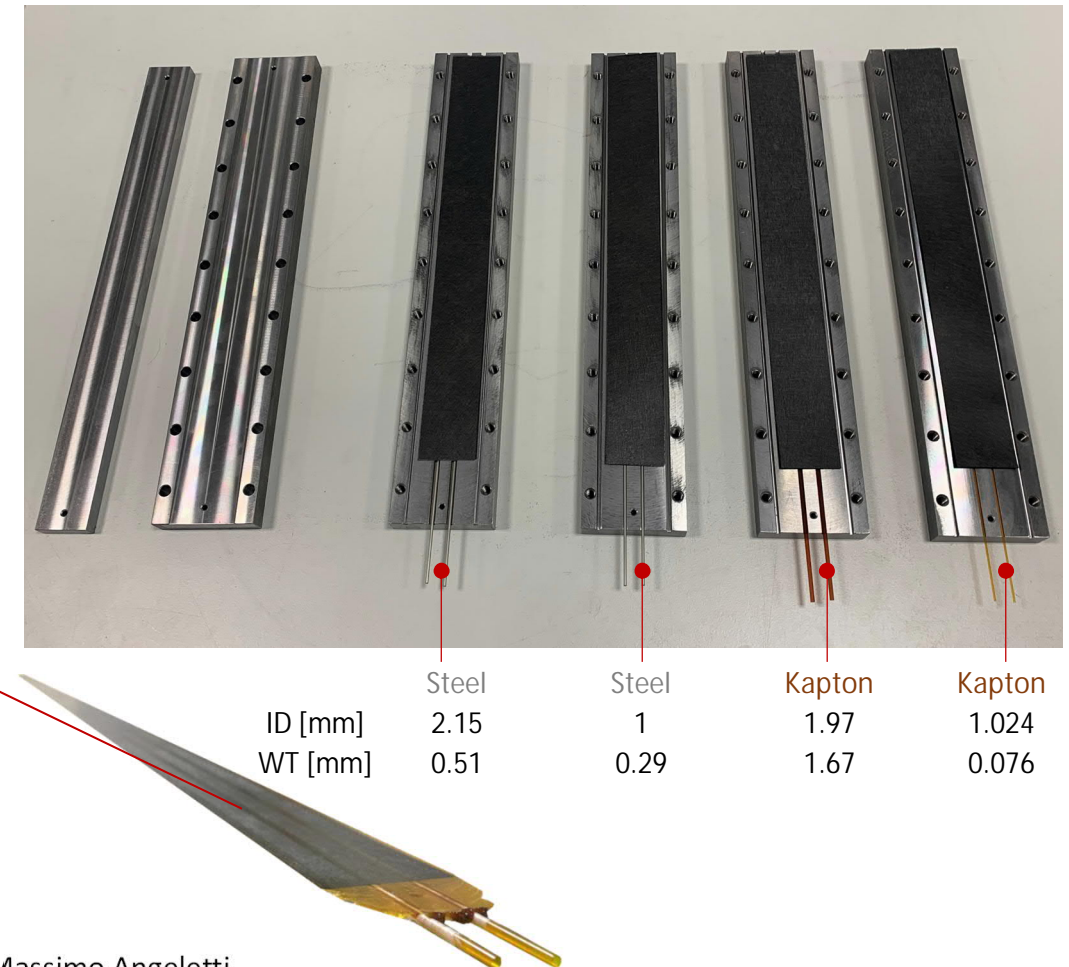
\*3 weeks (2 weeks at T=22°C, p=45 bar; 1 week at T=-28°C, p=15bar, v.quality=0.3)

## NEXT: Kapton material under permeability test

**NEXT:** ALICE ITS2 IB Cold plate test with two-phase CO<sub>2</sub>



**NEXT:** High Pressure CPs production  
for CO<sub>2</sub> comparison test



## R&D with microvascular network, pipe-less (NEW concept)

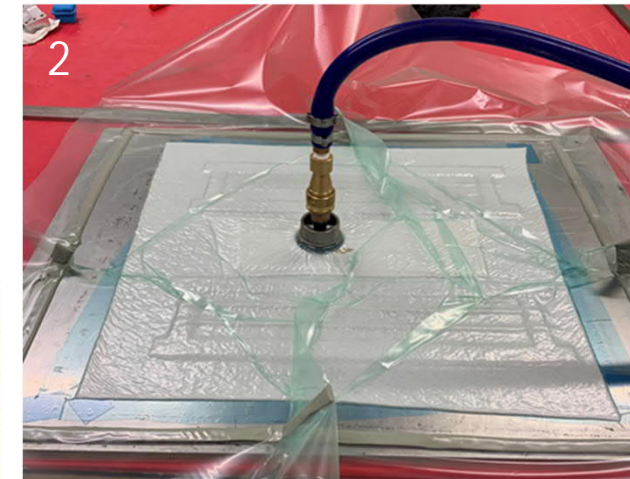
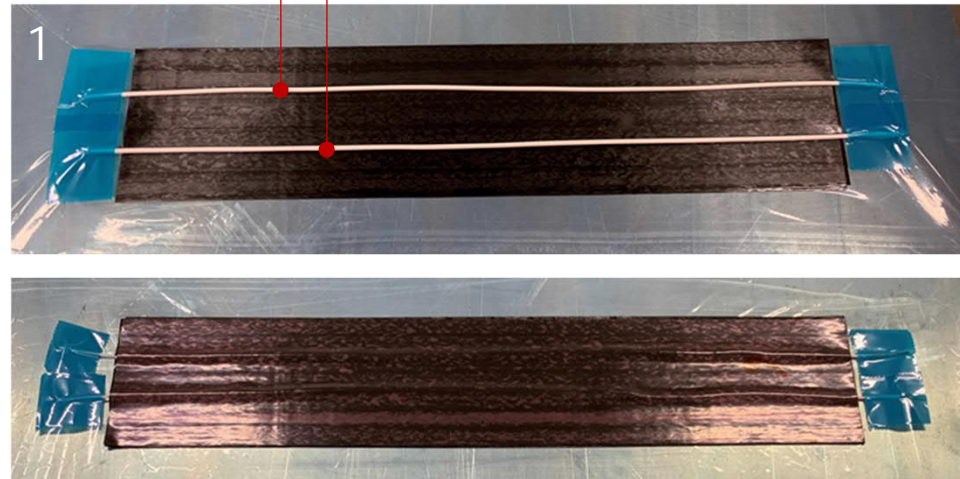
### VaSC (Vaporization of Sacrificial Components)

1. Modified PLA embedded in CFRP preform
2. CO-cured with CFRP part
3. Vaporization step after curing (Vacuum oven 200°C for 15h)

Different methods to produce PLA preform  
(Filaments, Pre-cut sheets, 3D printed network)

Thermo-plastic (PLA) sacrificial material , removed after curing

EP-DT-Composite lab

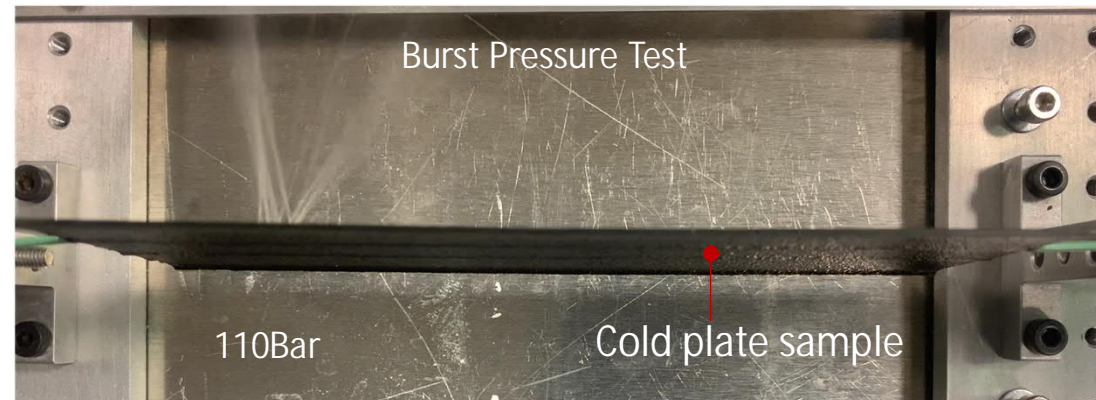


Laminate: 6 plies T800/ER450 : [0,90,0, PLA, 0,90,0], 0.5 mm channel diameter, 300 mm length

X-ray computed tomography



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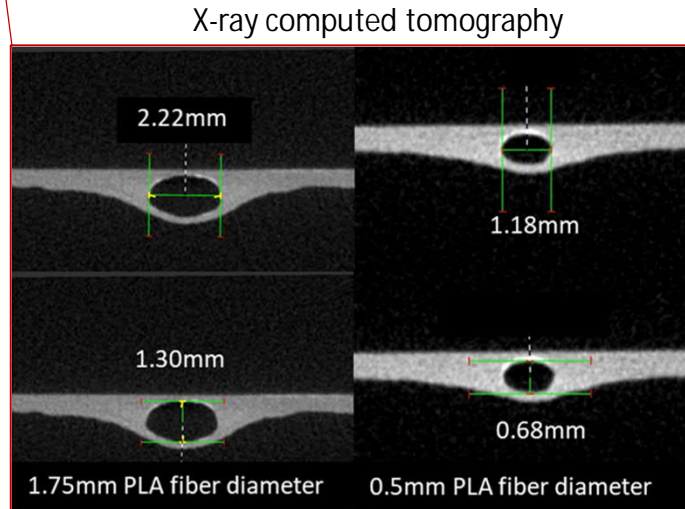


**NEXT:** New samples production for systematic pressure test campaign

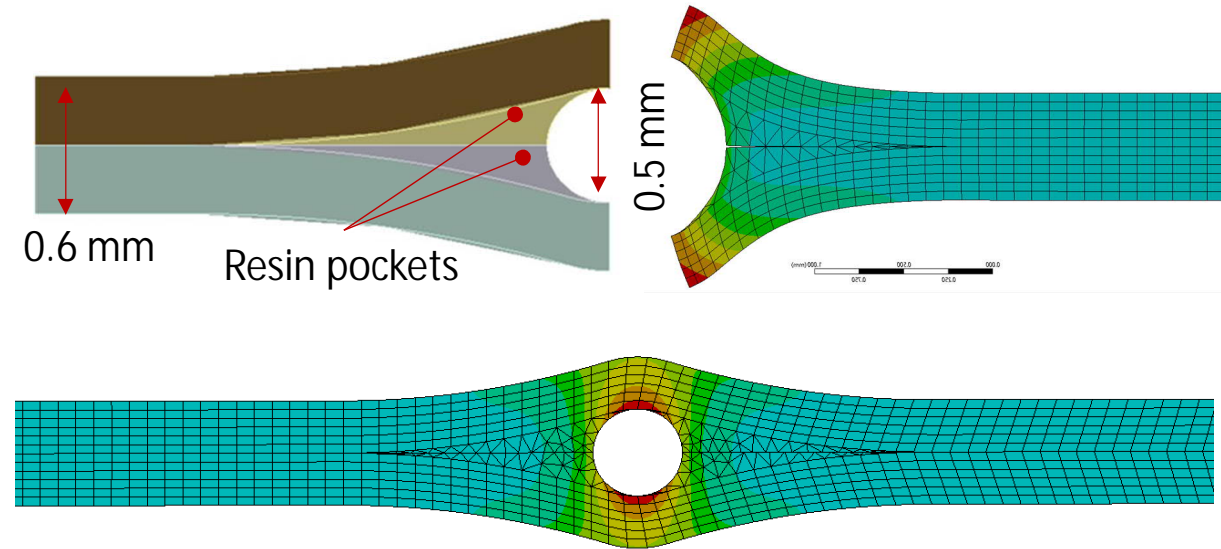


different channel widths and carbon laminates

**NEXT:** Fracture mechanics simulation are being performed



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Optimize the channel shape and minimize the risk of interface failure

**NEXT:** Permeability test with different fluids



Thank you

For your attention