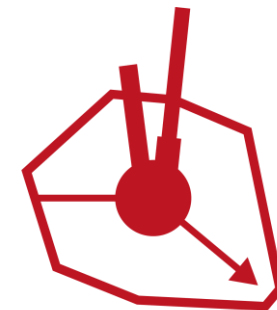


Preliminary cooling tests for the ePIC Silicon Vertex Tracker Inner Barrel



DIS2026

S. Ciarlantini, C. Bonini
on behalf of ePIC Padova Team

University of Padova, Centro di ateneo di Studi e Attività Spaziali CISAS Giuseppe Colombo, Padova, Italy
Istituto Nazionale di Fisica Nucleare, Sezione di Padova, Padova, Italy

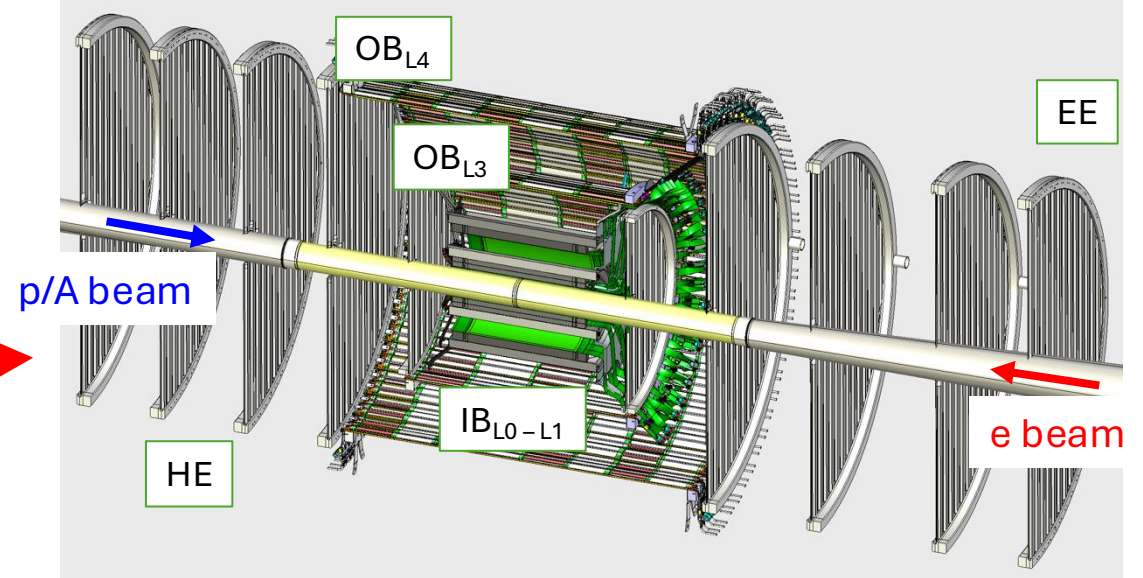
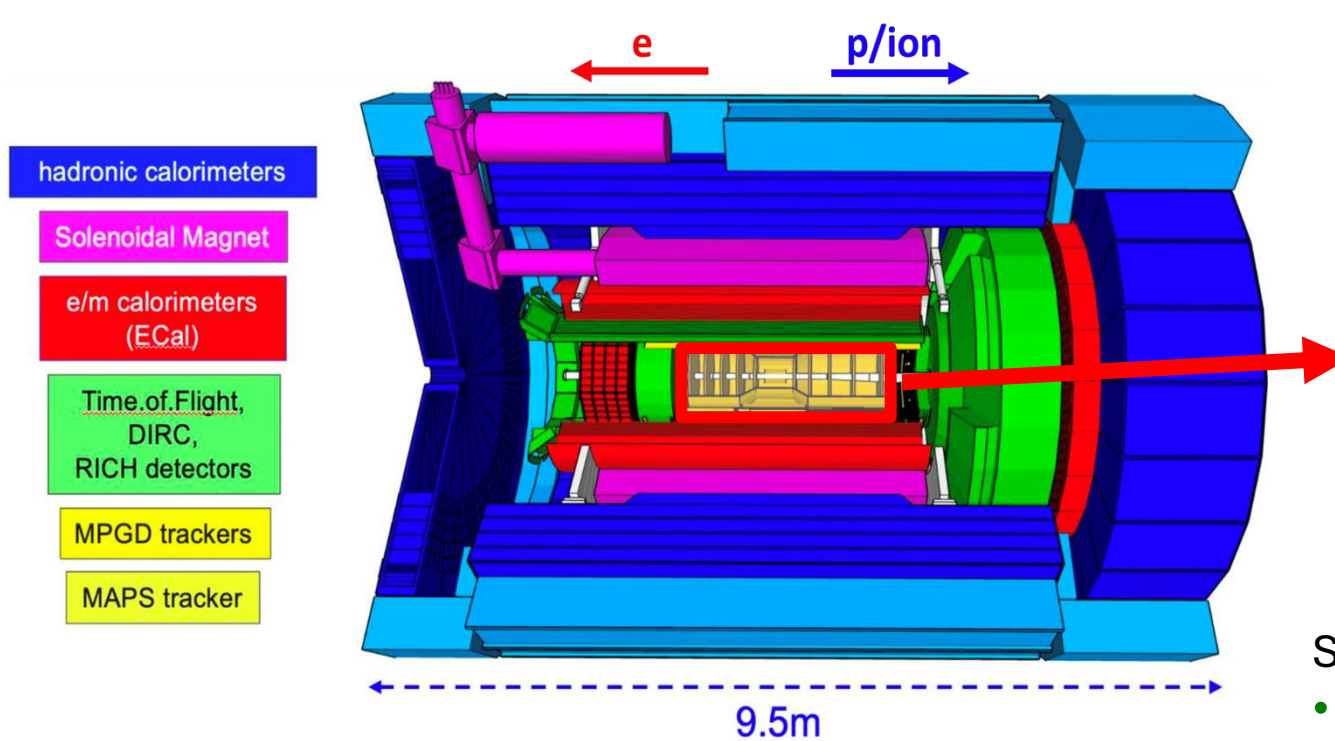
33rd INTERNATIONAL WORKSHOP ON DEEP INELASTIC SCATTERING
AND RELATED SUBJECTS
Bologna, 4-8 May 2026



UNIVERSITÀ
DEGLI STUDI
DI PADOVA



The **Silicon Vertex Tracker (SVT)** is the innermost subsystem of the future ePIC (electron-Proton-Ion Collider collaboration) detector. It is designed to meet the performance required by the physics program at EIC (Electron-Ion Collider), the new accelerator facility that will be built at the Brookhaven National Laboratory (Upton, NY, USA).



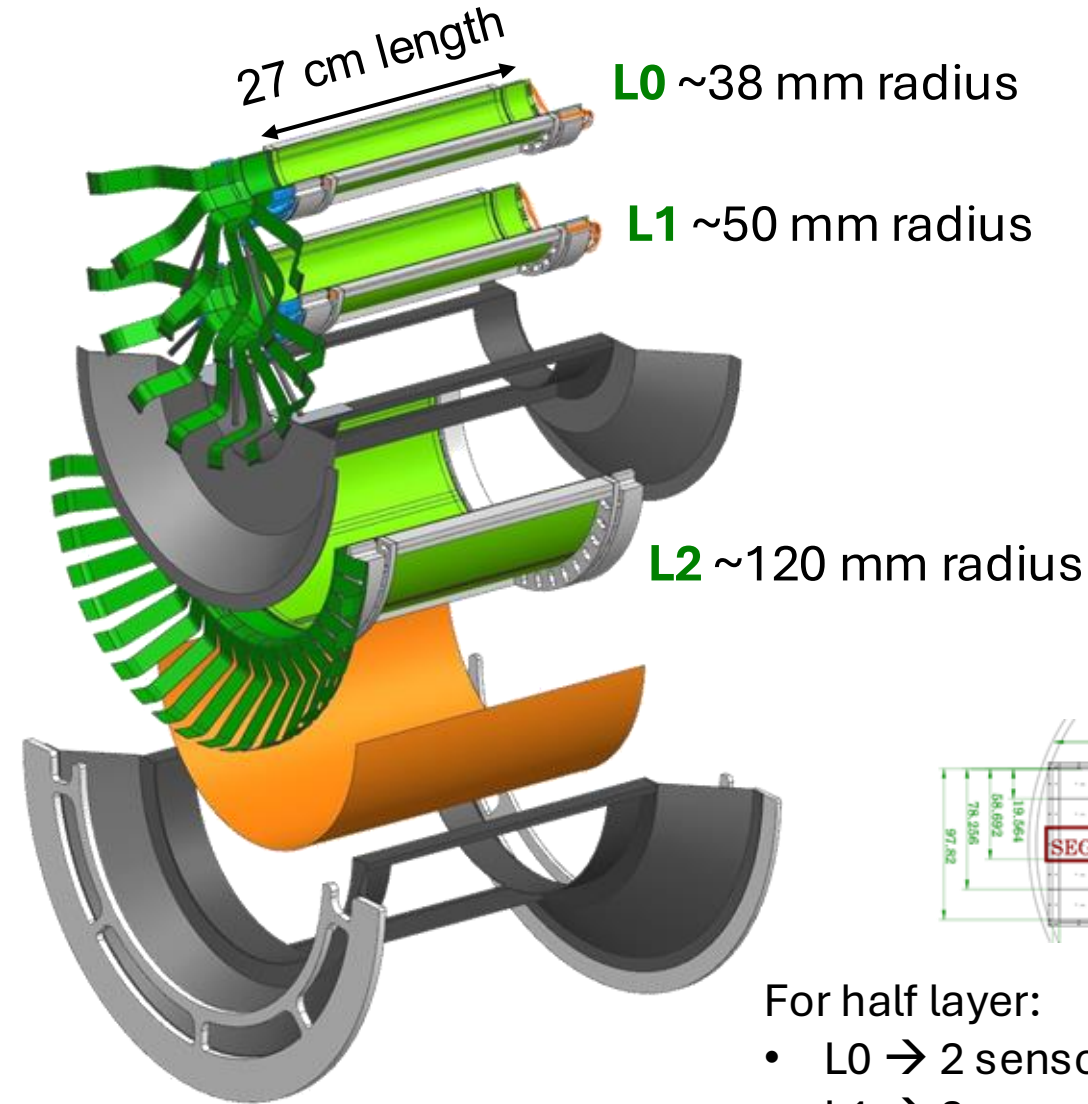
SVT detector is composed of:

- **Inner Barrel (IB)** → three layers L0 – L1 – L2
- **Outer Barrel (OB)** → two layers L3 – L4
- **Electron/Hadron Endcaps** → 2 arrays with 5 disks each

More info on ePIC detector and SVT :

- ePIC website: <https://www.epic-eic.org>
- in D. Colella talk <https://agenda.infn.it/event/47074/contributions/289192/>

ePIC SVT Inner Barrel: structure and sensors



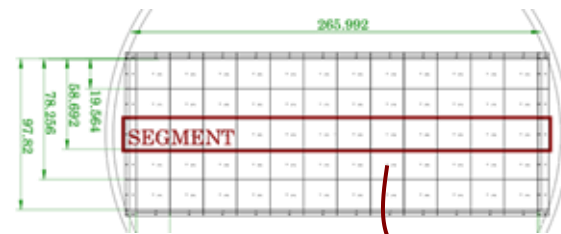
The IB is designed to provide precise vertex reconstruction and contribution to momentum measurement.

Therefore, the requirements:

- low material budget $\rightarrow X/X_0 \sim 0.07\%$ per layer
- high hermeticity and light structure \rightarrow made in carbon fiber composite, carbon foam

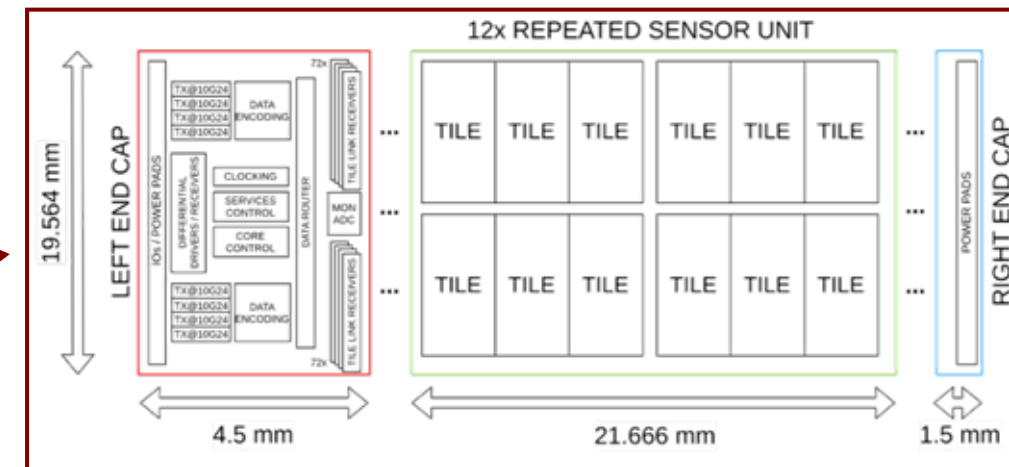
IB will use MOSAIX sensors developed by ALICE collaboration for ITS3 detector:

- MAPS in 65 nm CMOS imaging technology.
- Thinned down to $\leq 50 \mu\text{m}$ to bend in cylindrical shape
- Low power consumption: $40\text{mW}/\text{cm}^2$

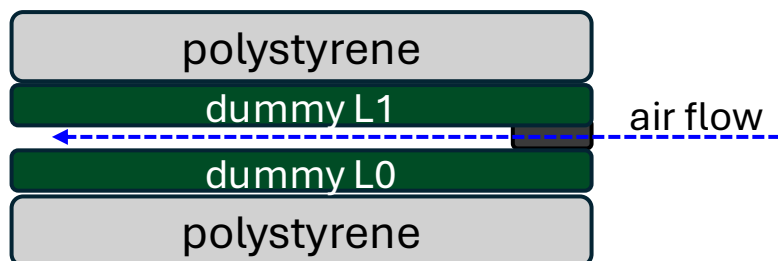
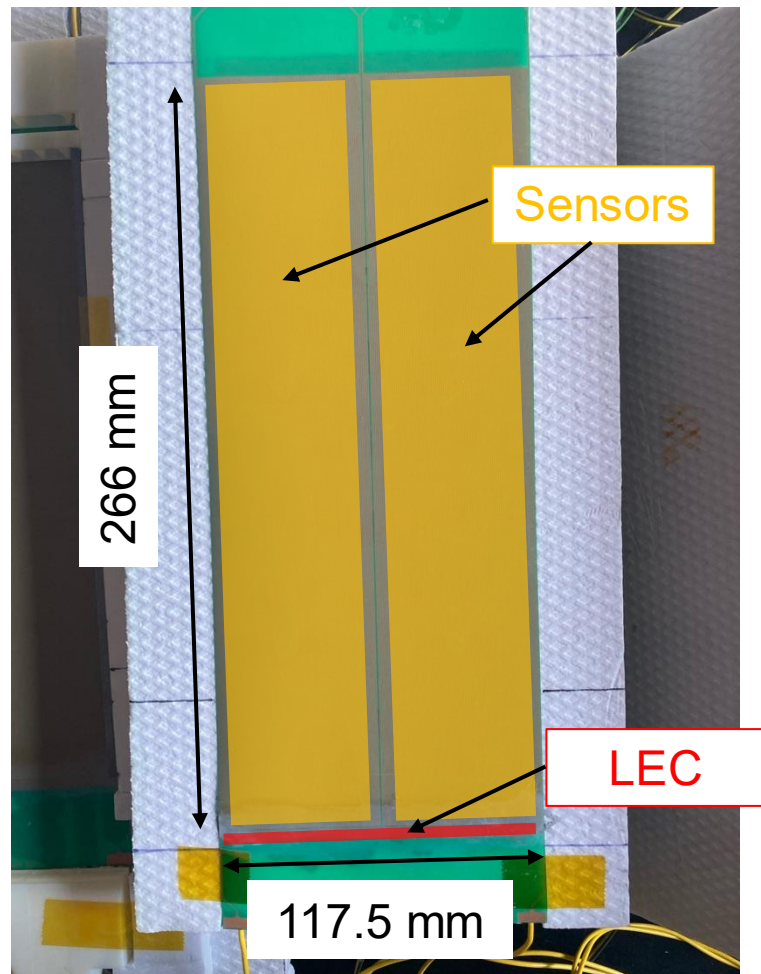


For half layer:

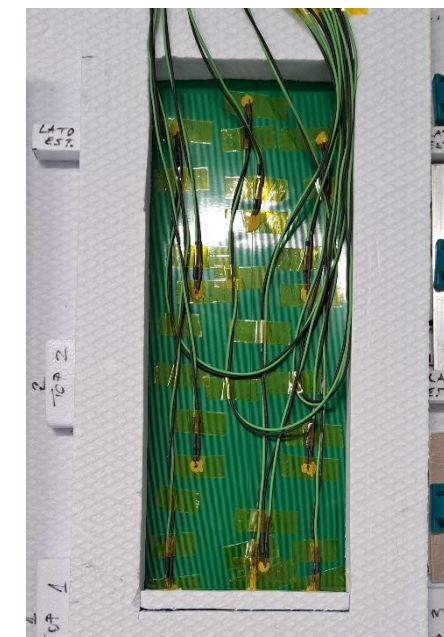
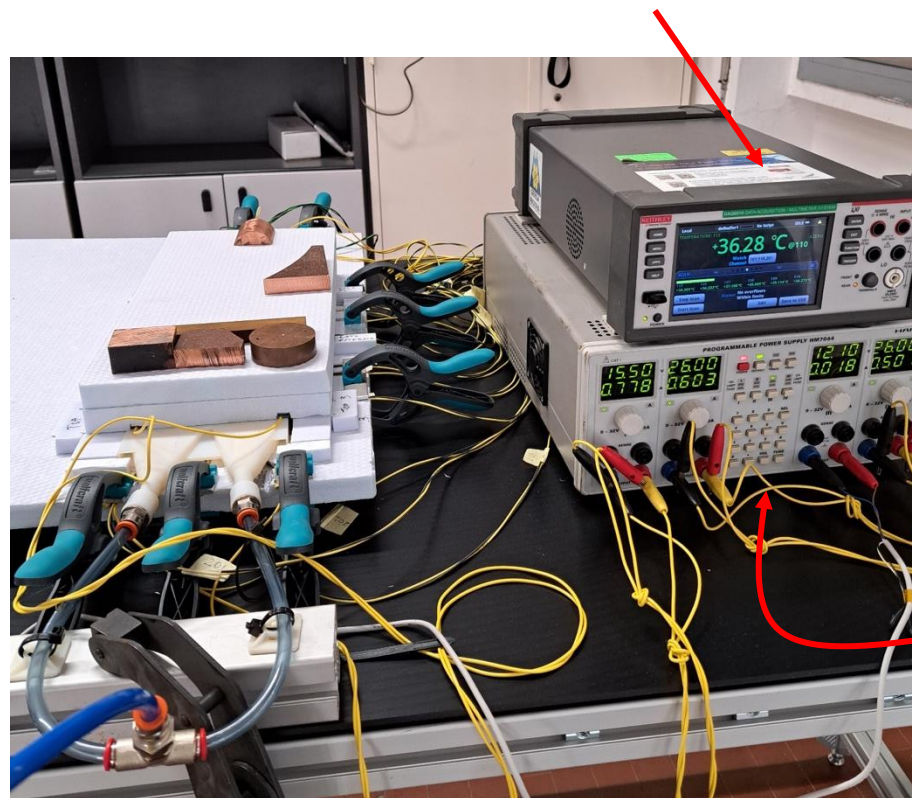
- L0 \rightarrow 2 sensors of 3 segments
- L1 \rightarrow 2 sensors of 4 segments
- L2 \rightarrow 4 sensors of 5 segments



Temperature measurements setup



2 dummy heat load L1 sized (fiberglass+copper)
Temperature measured with PT1000 probes read by
DAQ6510 Keithley Data Acquisition



HM7044 Hameg Power Supply
Nominal power of

- **1.6W/cm² for LEC**
- **40mW/cm² for sensor**

Total power of one dummy layer: 8.4 W
for LEC + 2 × 6.2 W for sensors

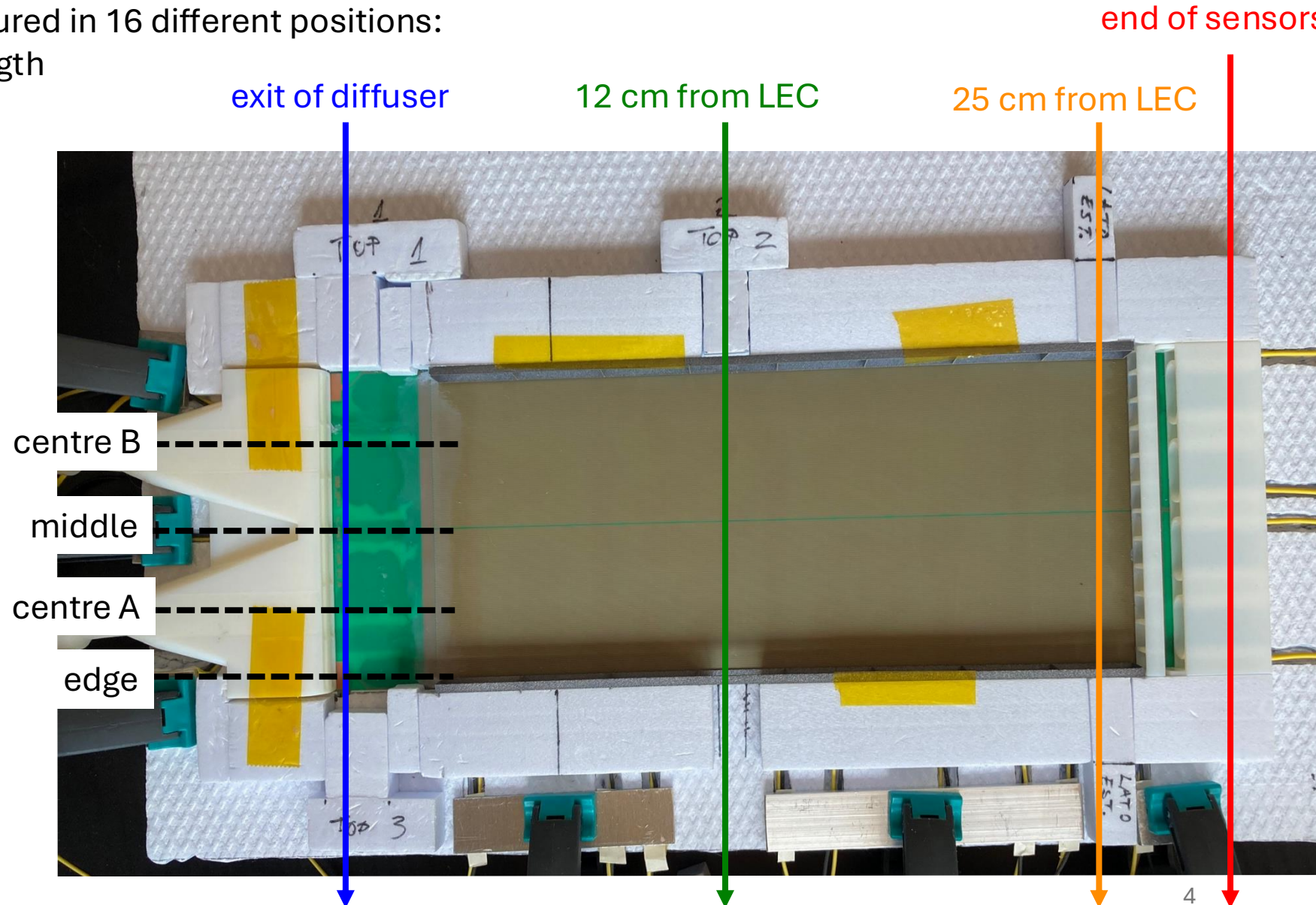


Flow meter
3 different flows tested: 212 L/min, 265 L/min, 311 L/min

Air parameters measurements setup

Air temperature and velocity measured in 16 different positions:

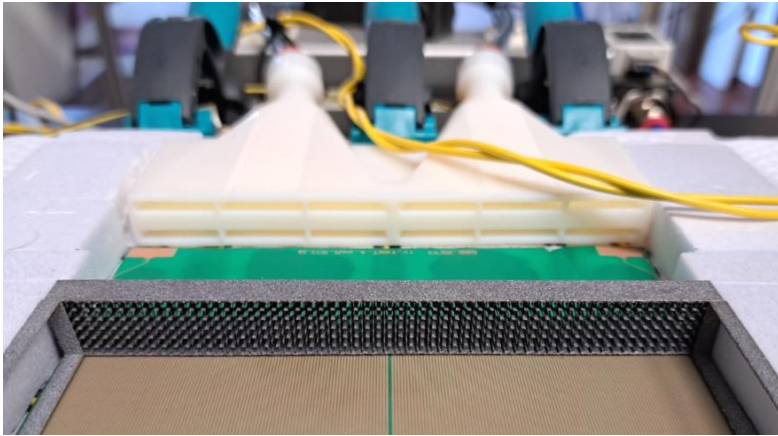
- 4 positions along the sensor length
- 4 positions along diffuser one



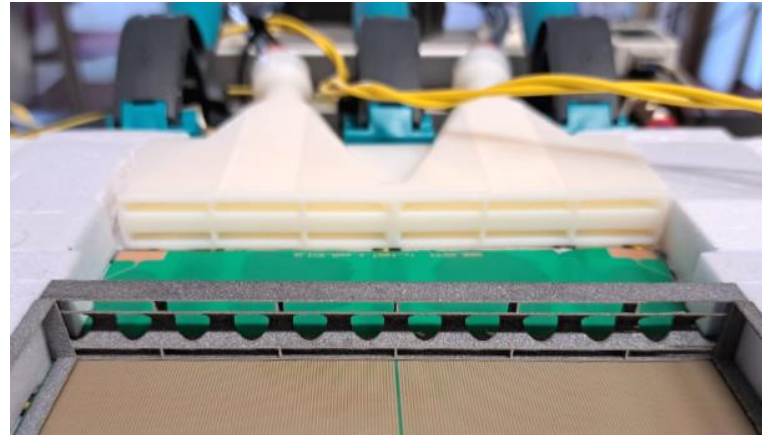
Heat sinks tested

Alternative solution with respect to the project baseline (carbon foam)
Aluminum heat skinks directly placed on the LEC, using silicon thermal grease to increase thermal conductivity.

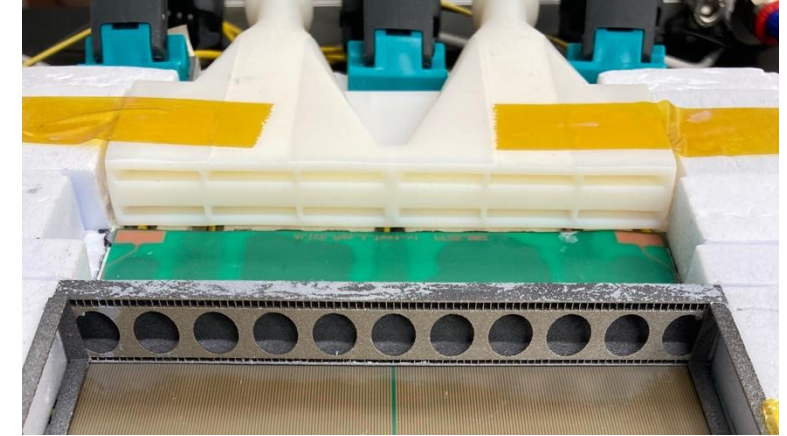
Heat sink 1



Heat sink 2



Heat sink 3



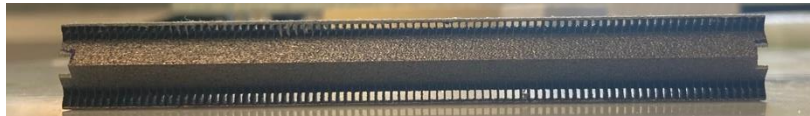
Heat sink 1



Heat sink 2



Heat sink 3



Few prototypes produced by Additive Manufacturing in aluminum (bulk thermal conductivity $\sim 140 \pm 20$ W/mK)

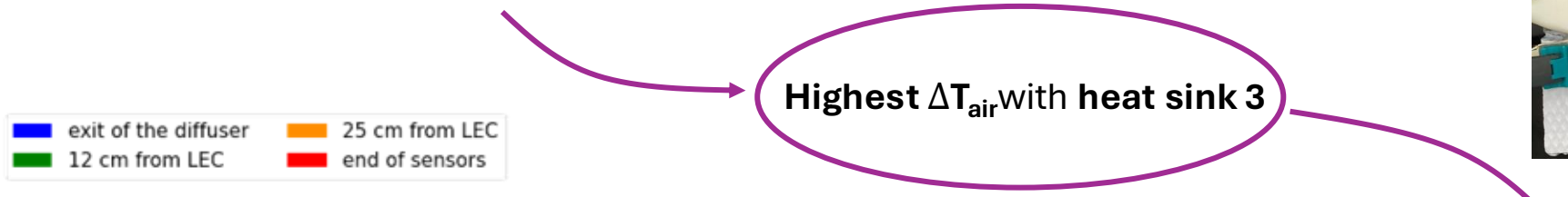
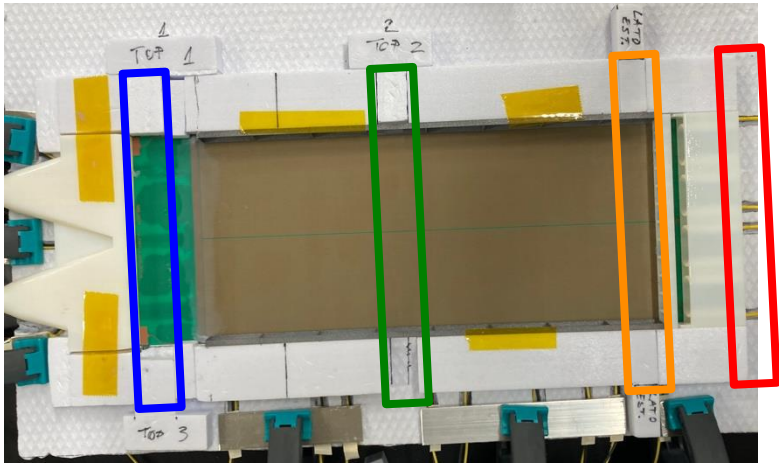
Equivalent density of $0.4-0.6 \text{ g/cm}^{-3}$, comparable with carbon foam one

Work by Servizio Tecnologie Avanzate from Padova INFN

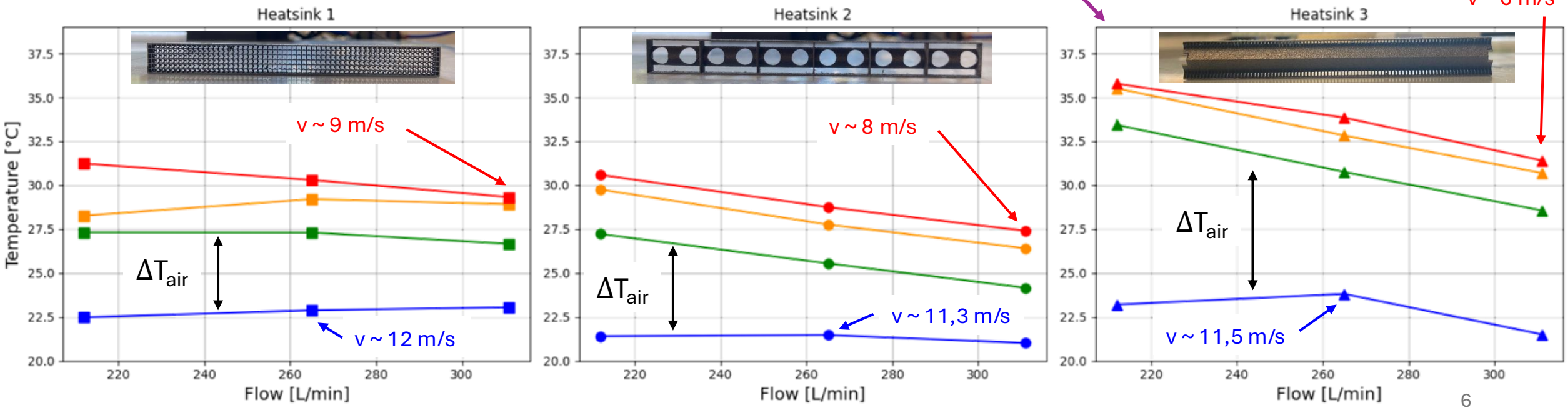
Thermal measurements: air

Key information: relative temperature difference ΔT_{air} with respect to the offset (blue curve)

The LEC area is the primary source of heat: heat sinks effectiveness is indicated by ΔT_{air}
 Higher ΔT_{air} \longrightarrow more effective heat sink



- exit of the diffuser
- 25 cm from LEC
- 12 cm from LEC
- end of sensors

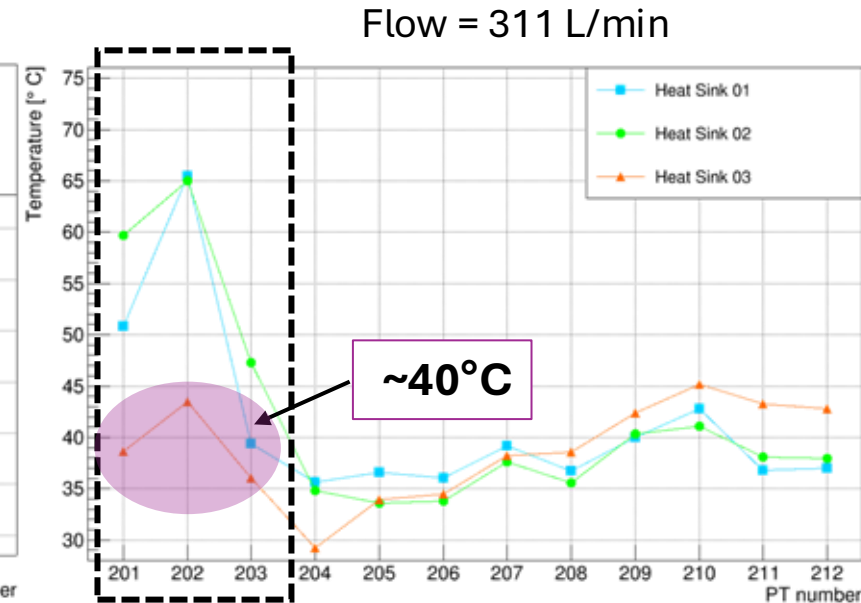
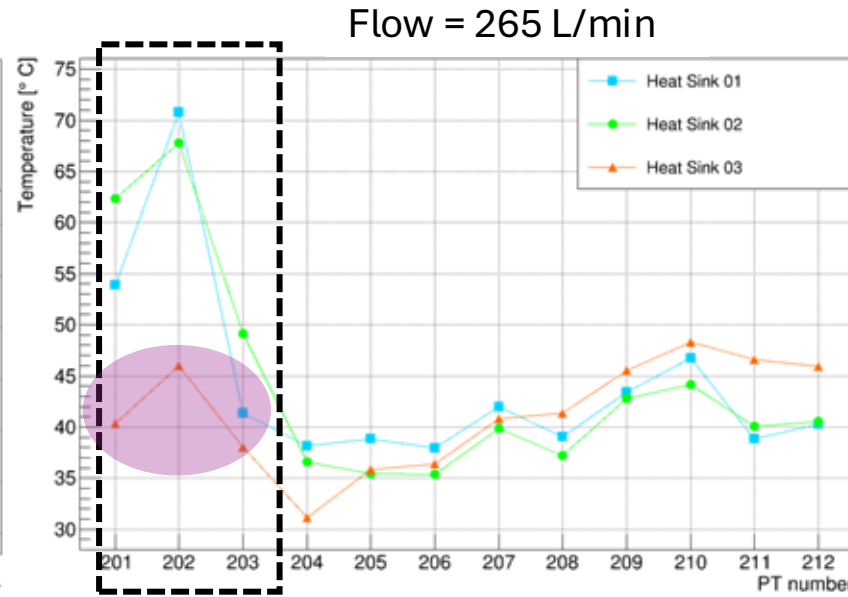
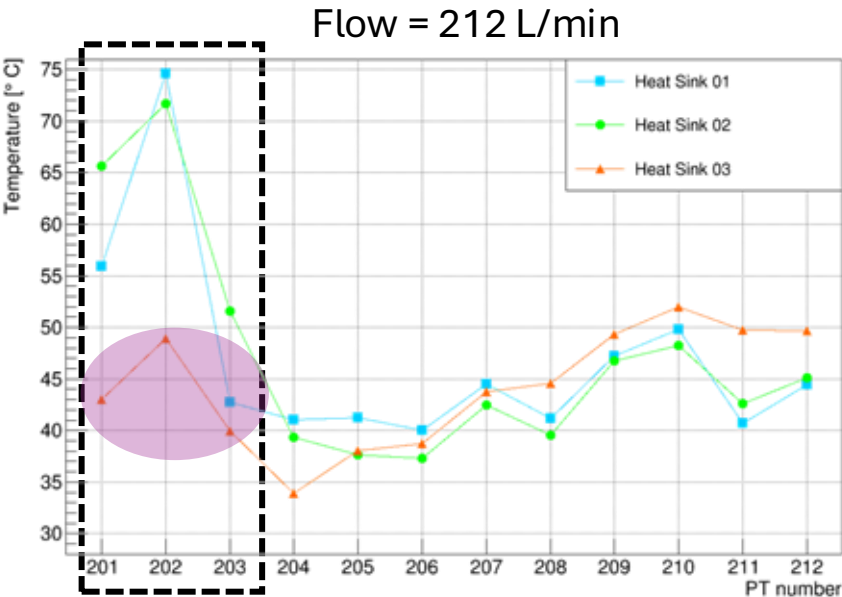
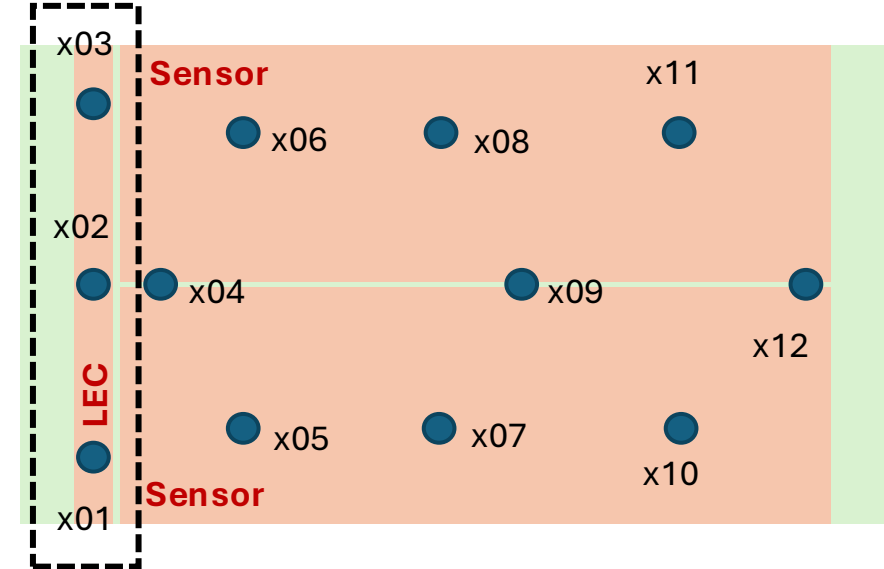


Thermal measurements: sensor

Temperature from PT probes placed at different sensor positions

- Temperature decreases with increasing air flow
- Sensor region: equivalent effect for the three designs
- LEC region: **lowest temperature values** with **heat sink 3**

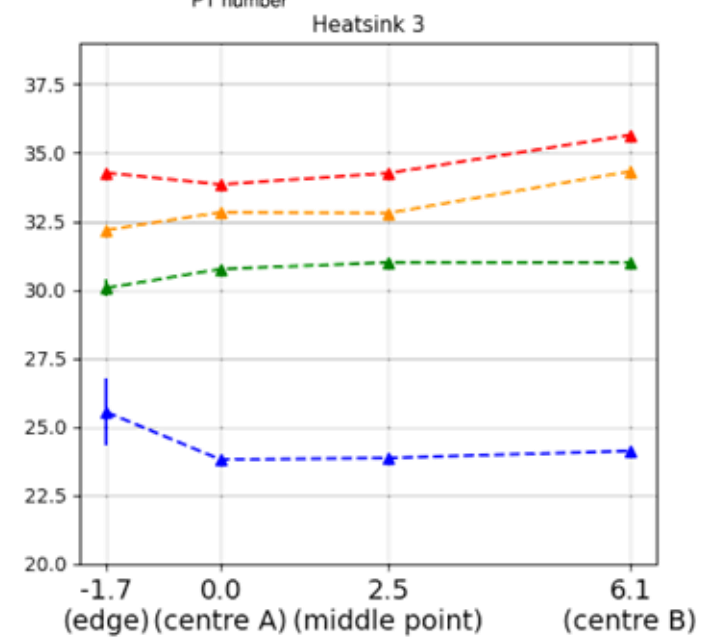
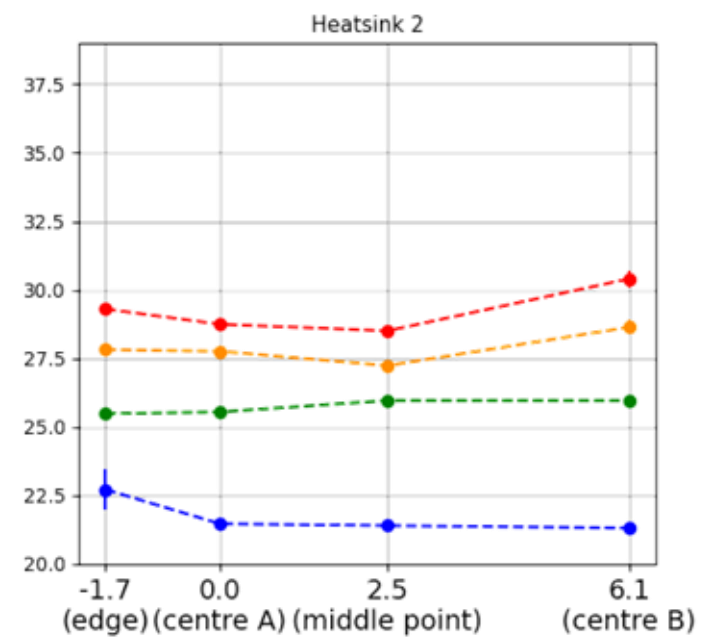
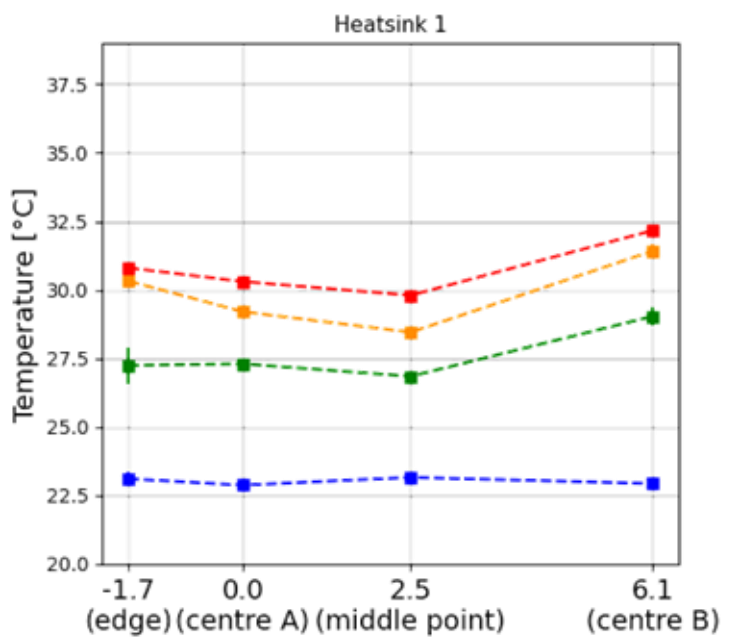
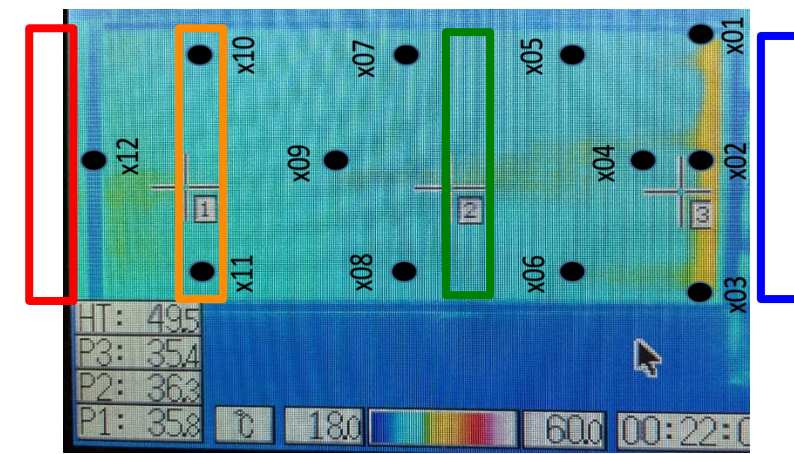
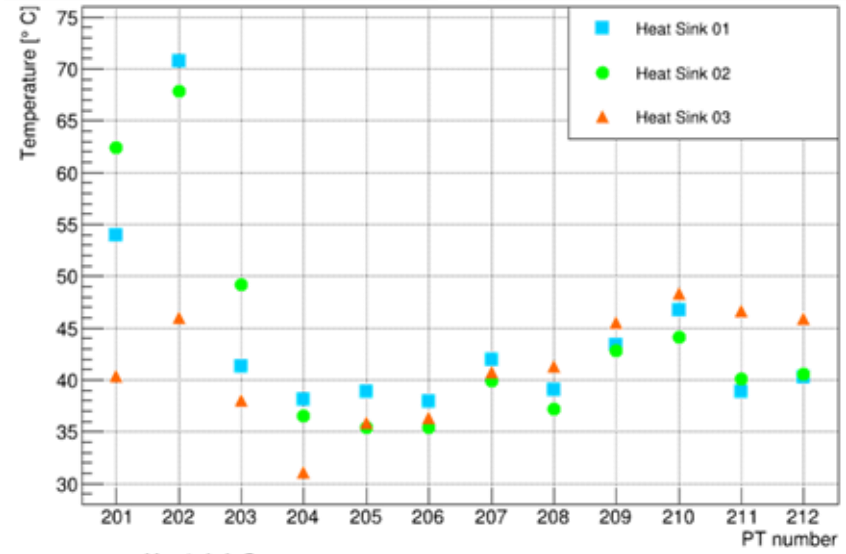
it is the heat sink with the highest ΔT_{air} measured



Thermal measurements: 265 L/min

Comparison between sensors and air temperature @ 265L/min flow

- Homogeneous results for different positions along the diffuser
- T_{air} at exit of diffuser is the same for all diffuser positions: reliable offset



T_{air} measured positions
 exit of diffuser
 12 cm from LEC
 25 cm from LEC
 end of sensors



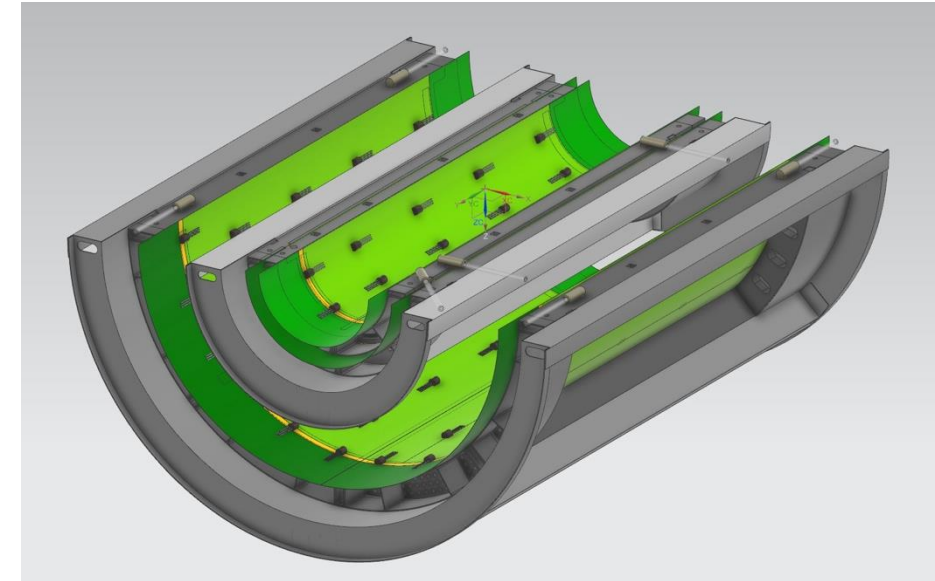
Positions along diffuser

Preliminary test of air cooling system:

- Simplified thermal mockup L0+L1 half barrel has been used to prove feasibility of air cooling in ePIC SVT case
- 3D printed Al heatsinks have been exploited as alternative to the main technical choice (carbon foam)
- Three different shapes have been explored with clear indication of improved effectiveness on heat sink 3
- First indication of thermal behaviour in presence of LEC
- Homogeneous results for different positions along the diffuser

Outlook:

- Tuning of thermal FEA for better design of heatsinks and air manifolds
- Realization of the half barrel thermal mockup close to final materials for the support and real dummy sensor sizes

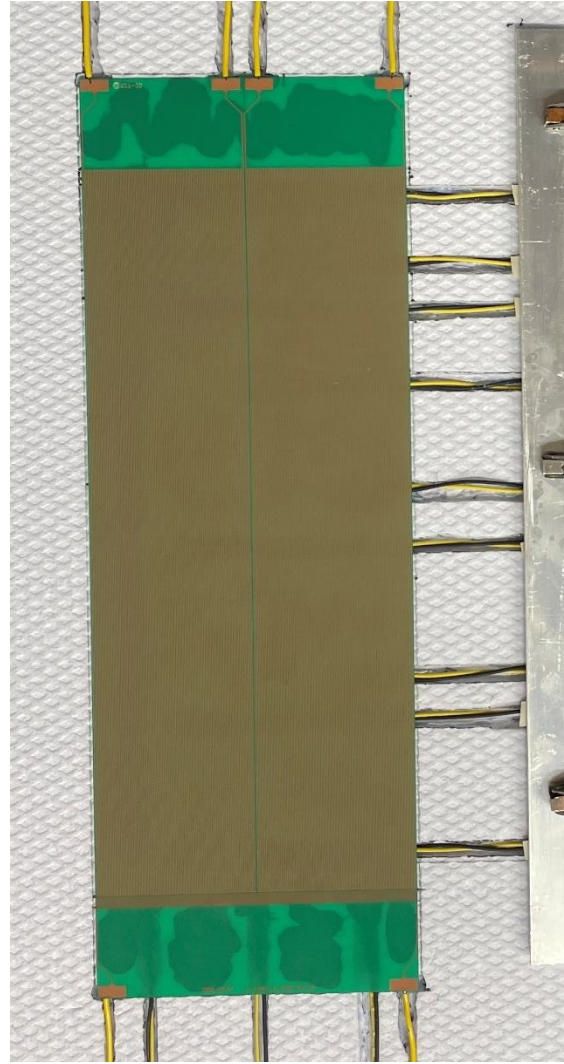


CAD project of the half barrel

Thank you for the attention

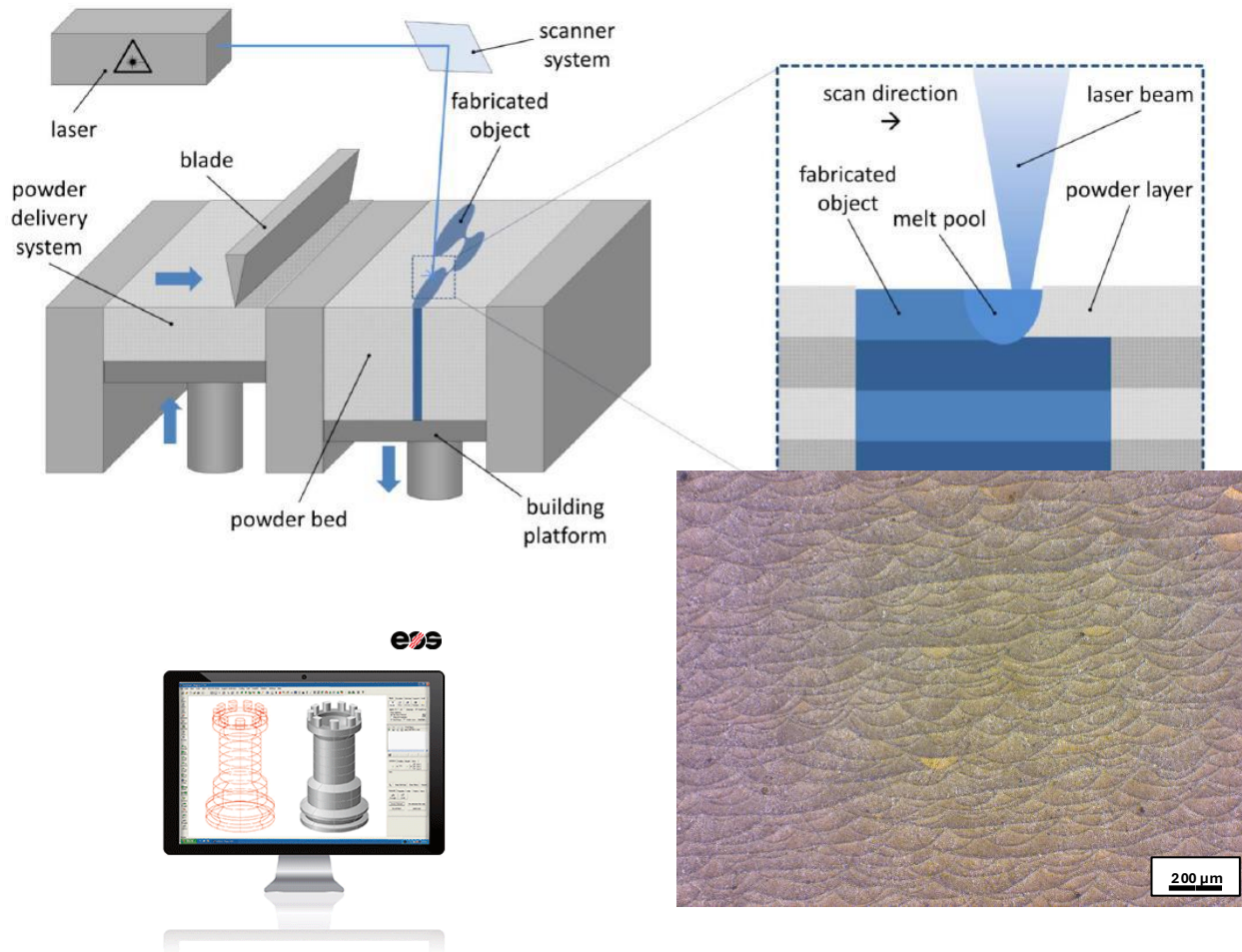
BACK UP

Setup PT1000 probes bottom layer



Heat sink shape – How it is made

Process where focused energy (laser beam) is used to selectively melt a layer of a powder bed.

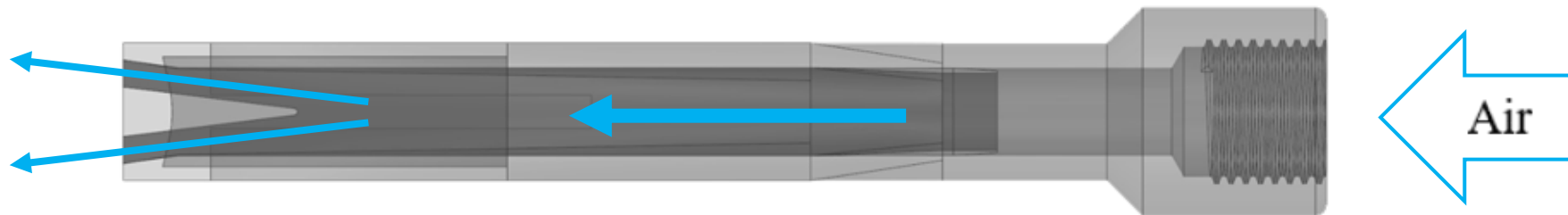
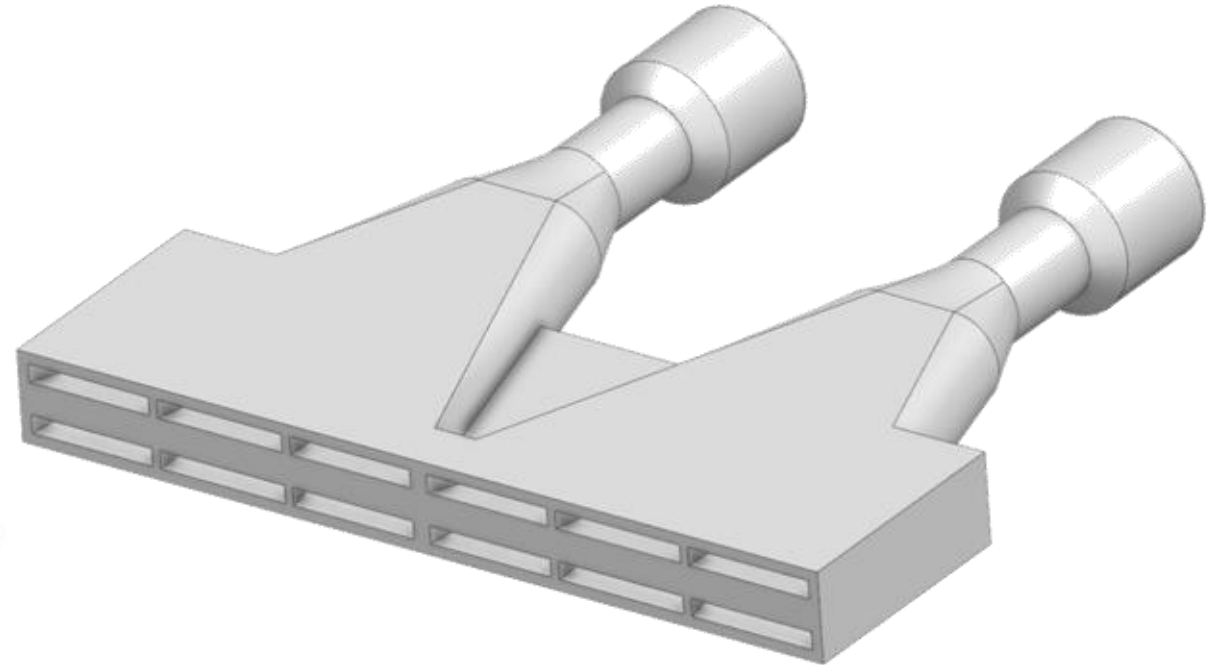
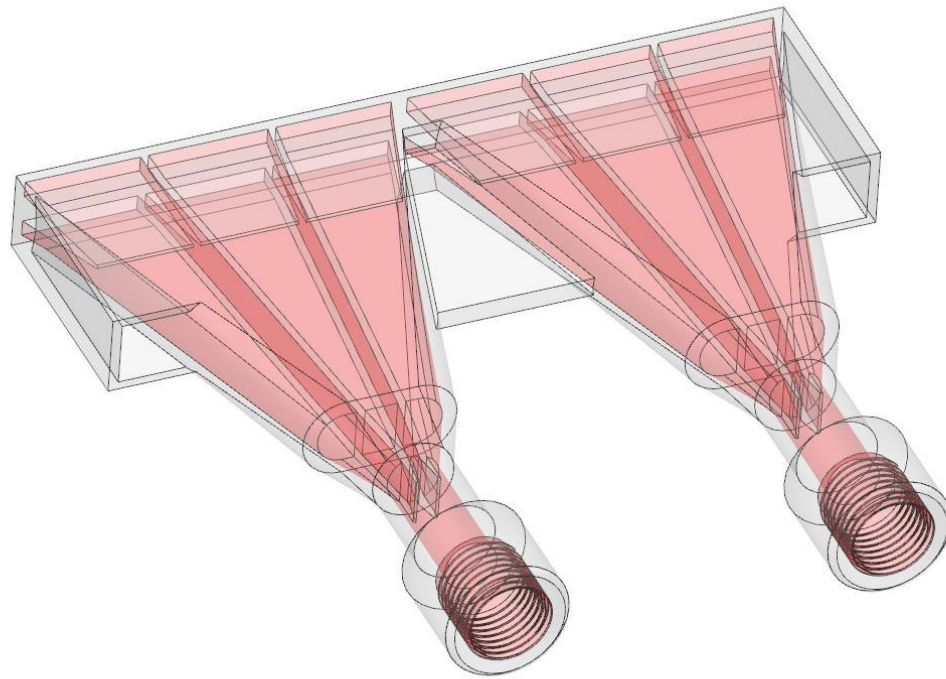


Main Process Parameters:

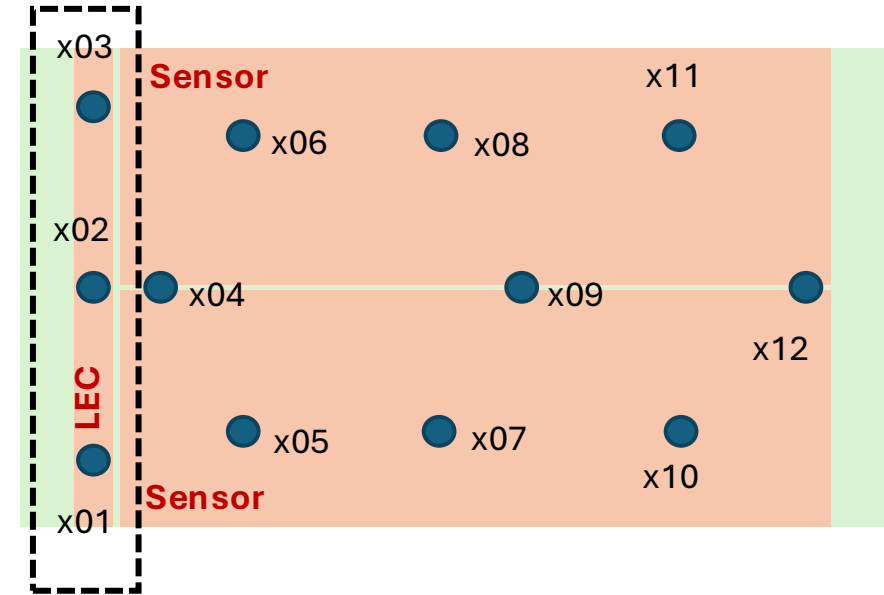
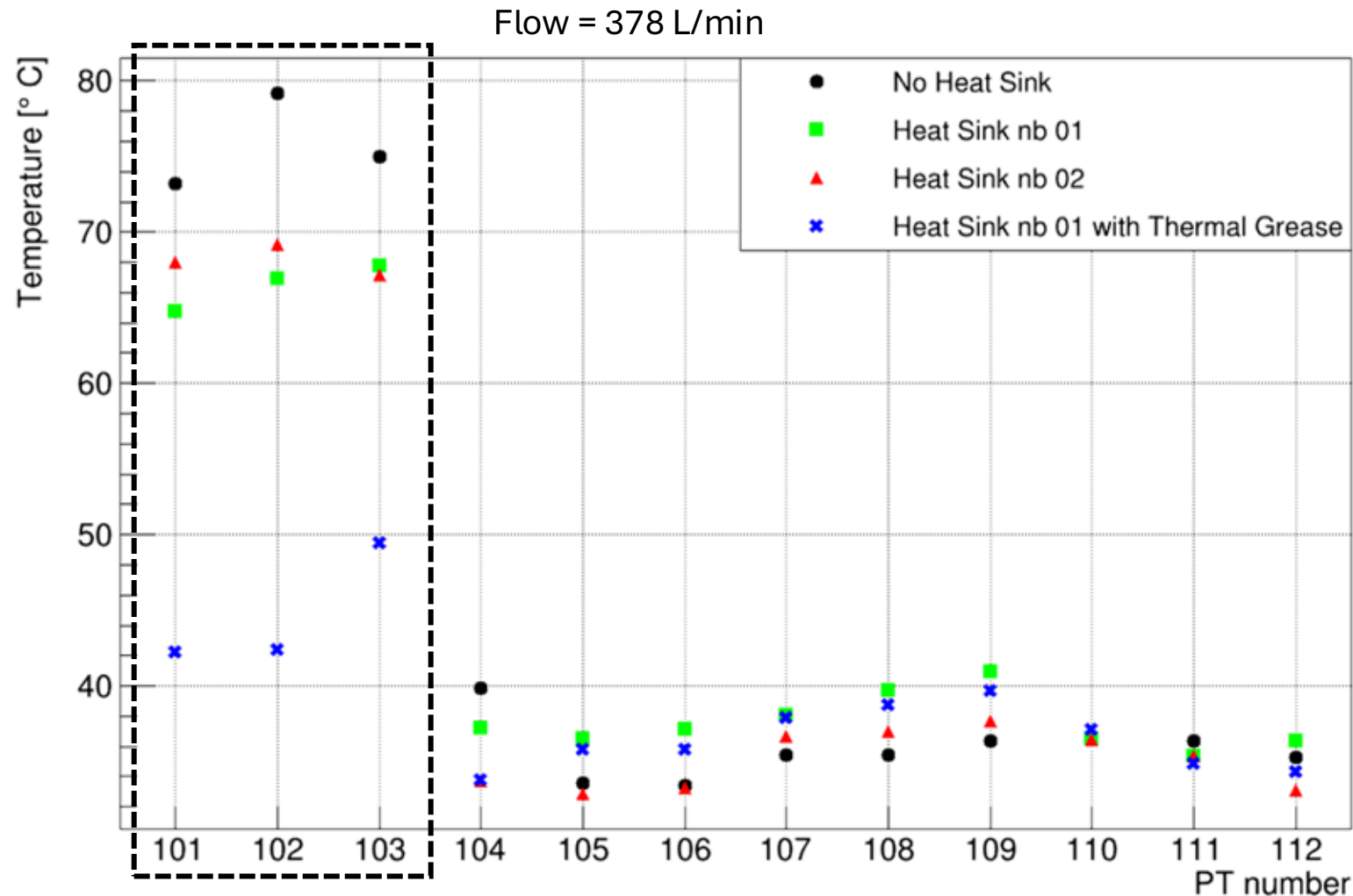
- LASER POWER (W)
- SPOT SIZE
- LAYER THICKNESS (t)
- SCANNING STRATEGY
- SCAN SPEED (v)
- PARTICLE SIZE DISTRIBUTION
- HATCHING (h)
- MATERIAL PROPERTIES

P. Rebesan
(INFN Padova)

Air Diffuser shape



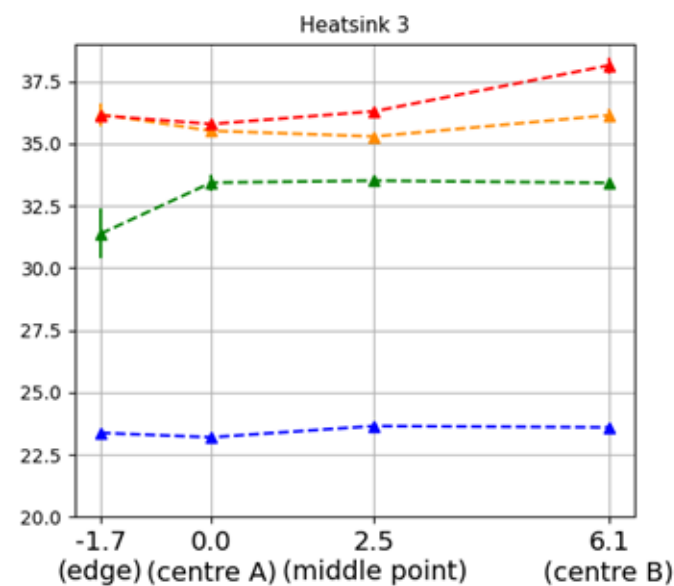
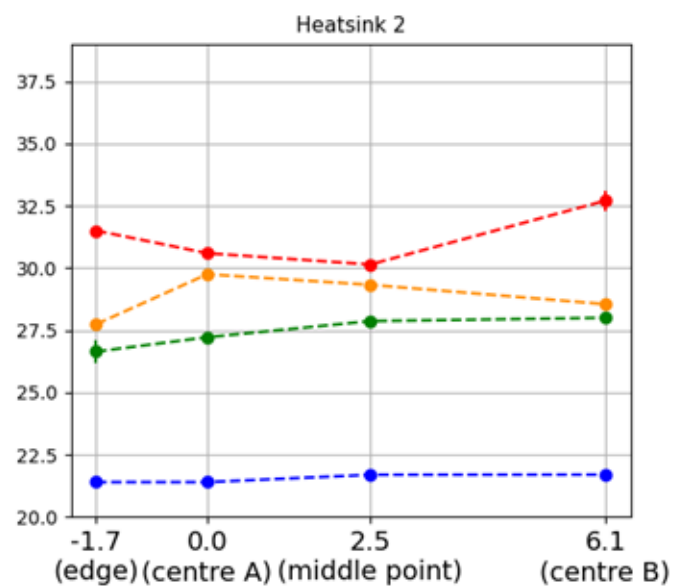
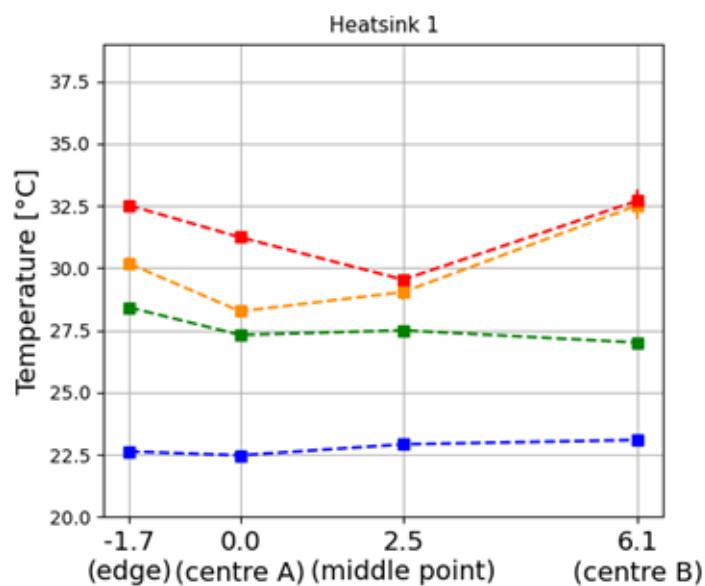
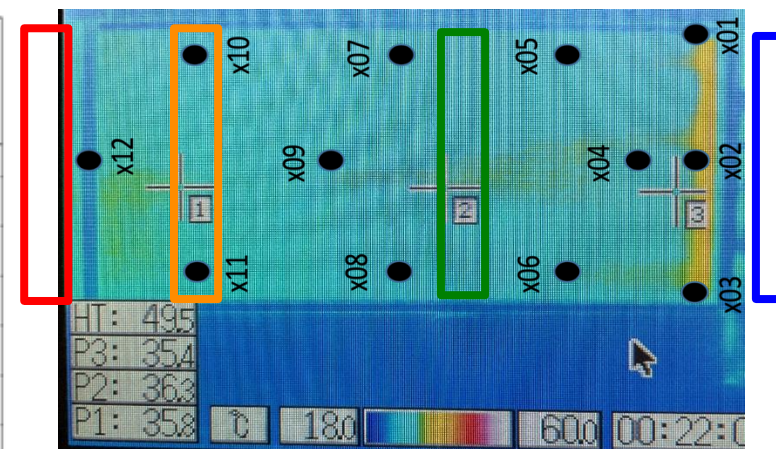
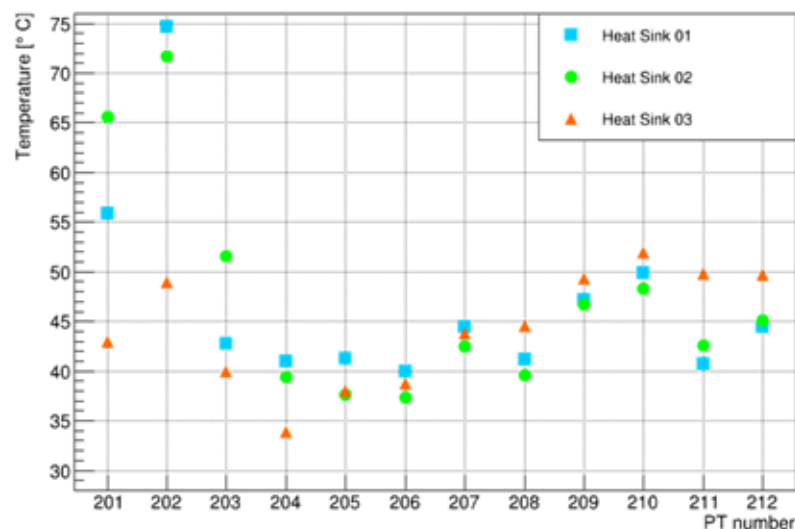
Comparison with and without thermal grease



- ~20°C temperature reduction with thermal grease
- ~10°C temperature reduction using heat sink

Thermal measurements: 212 L/min

Comparison between sensors and air temperature @ 212L/min flow

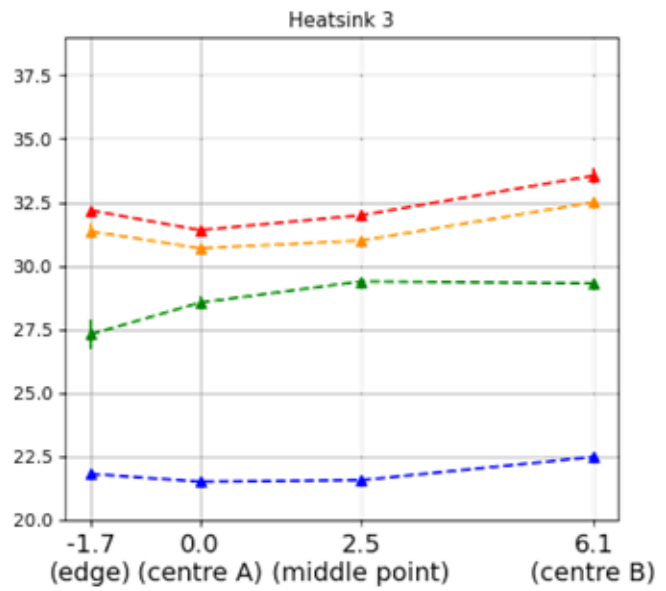
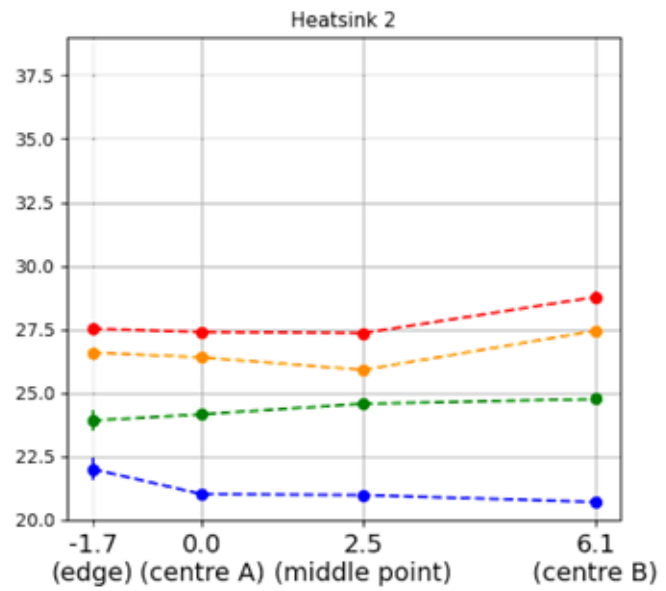
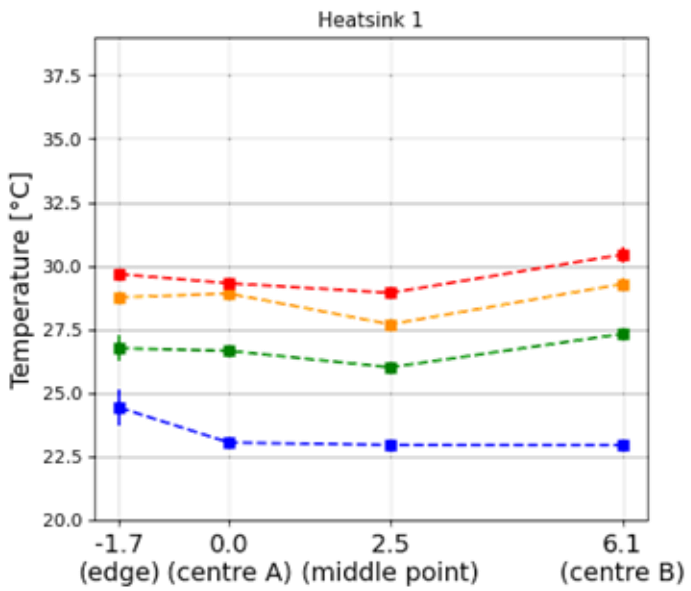
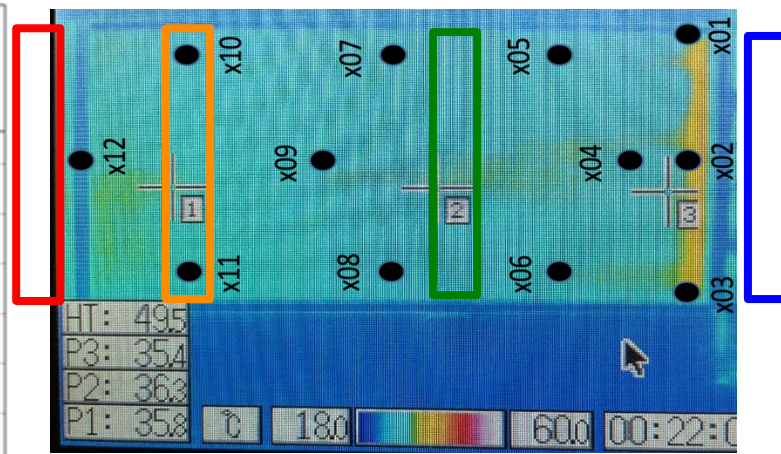
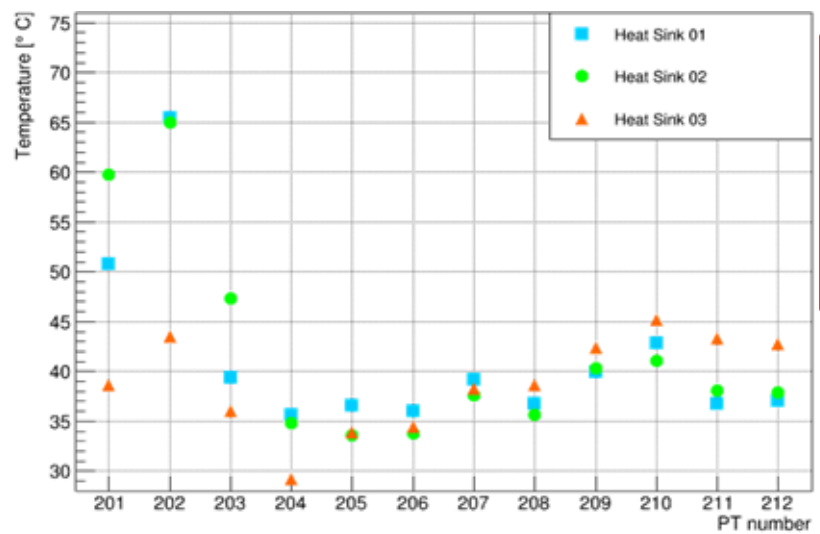


T_{air} measured positions
 exit of diffuser
 12 cm from LEC
 25 cm from LEC
 end of sensors

Positions along diffuser

Thermal measurements: 311 L/min

Comparison between sensors and air temperature @ 311L/min flow

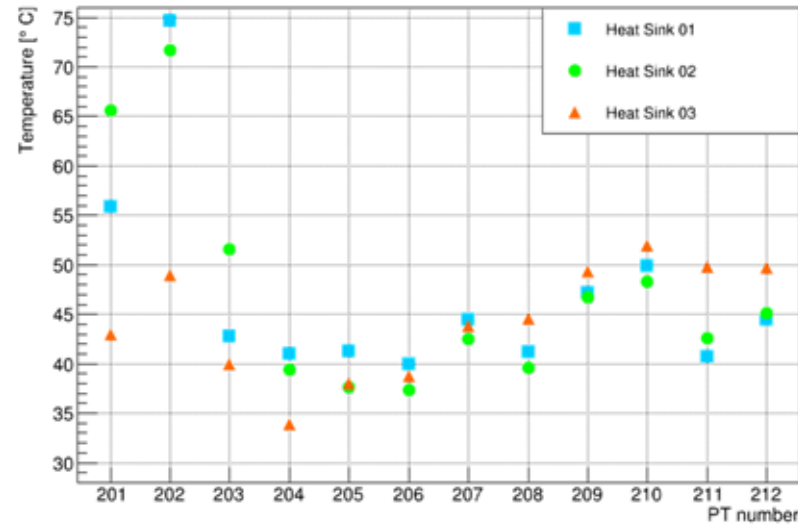


T_{air} measured positions
 exit of diffuser
 12 cm from LEC
 25 cm from LEC
 end of sensors

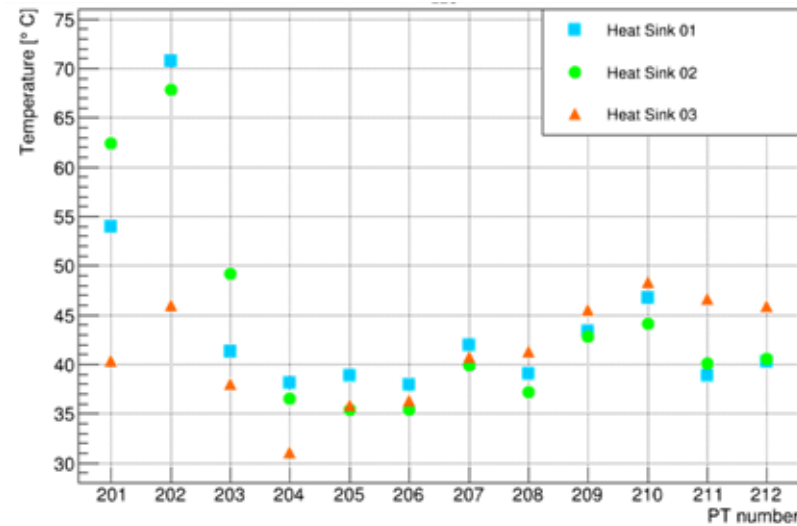
Positions along diffuser

Thermal measurements

Flow = 212 L/min



Flow = 265 L/min



Flow = 311 L/min

