Preliminary Thermal Test for IB

SVT Padova Team

Outline

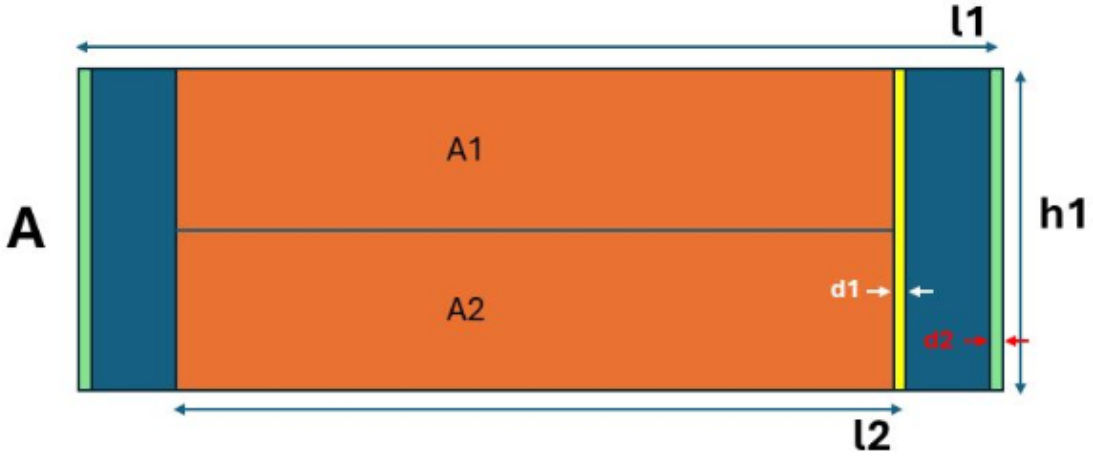
1) Preliminary test of air cooling system
2) Thermal simulations
3) Conclusions and future steps

Preliminary test of air cooling system

Preliminary air cooling test for IB

- L0 and L1 thermal prototypes
  - 2 heat load diffusers of L0 size
  - Deposition of copper trace to mimic sensors and LEC
  - 12 pt1000 attached to each fiber glass
- Compressed air passing through a 20m pipe
  - Flow meter to measure the volumetric flow rate
  - 2 air diffusers
- Aluminum heat sinks 3D printed
  - Variability of heat dissipation associated to different geometric shapes
  - Silicone thermal interface grease

Sensor and LEC

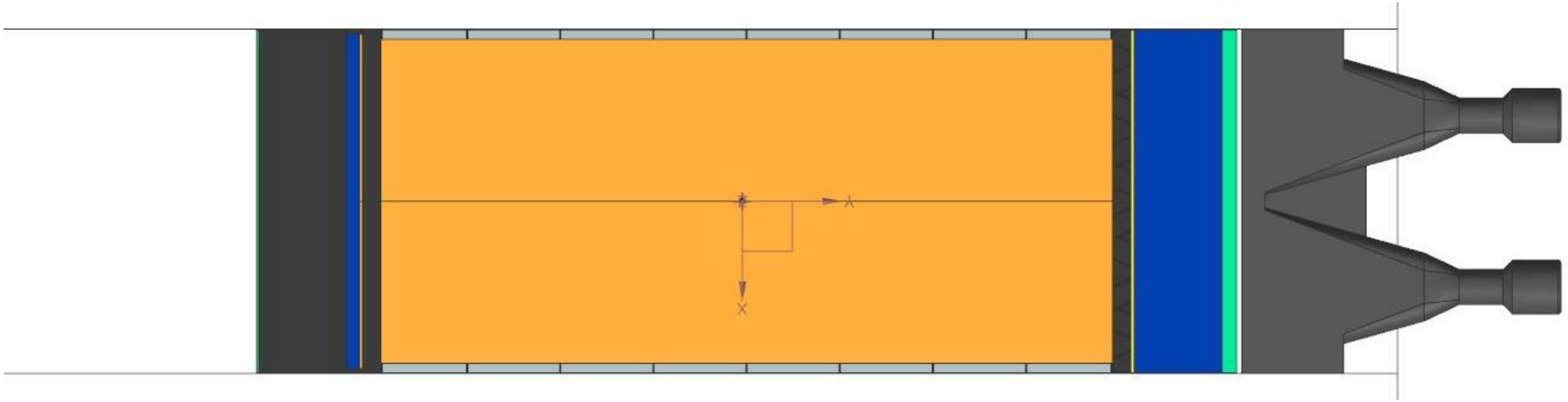


Size [mm]:

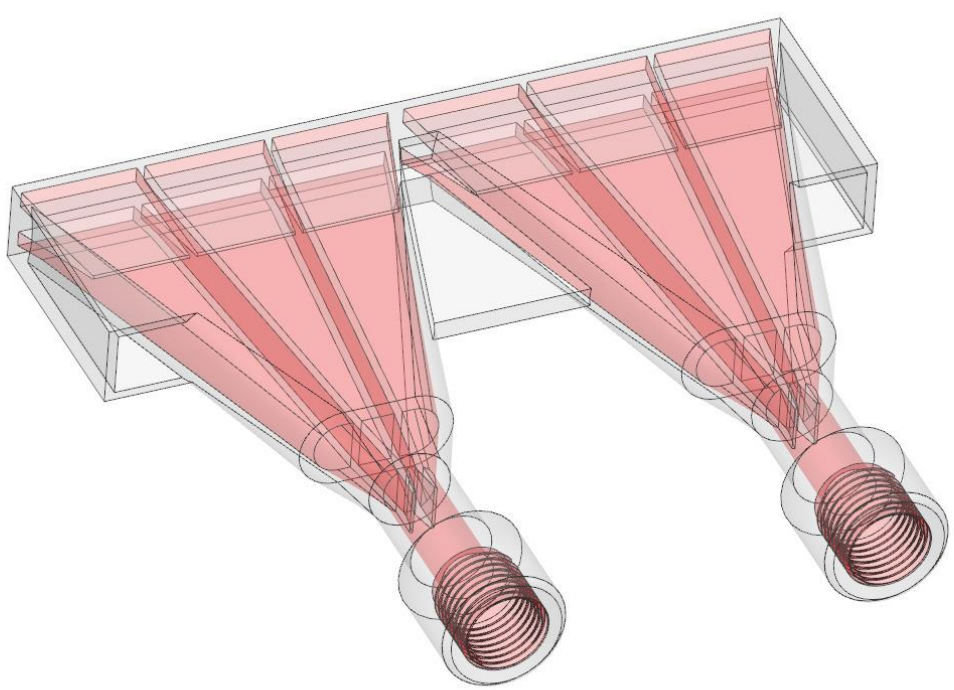
l1=336.5
l2=266
h1=117.5
h2=156.7
d1=4.5
d2=5

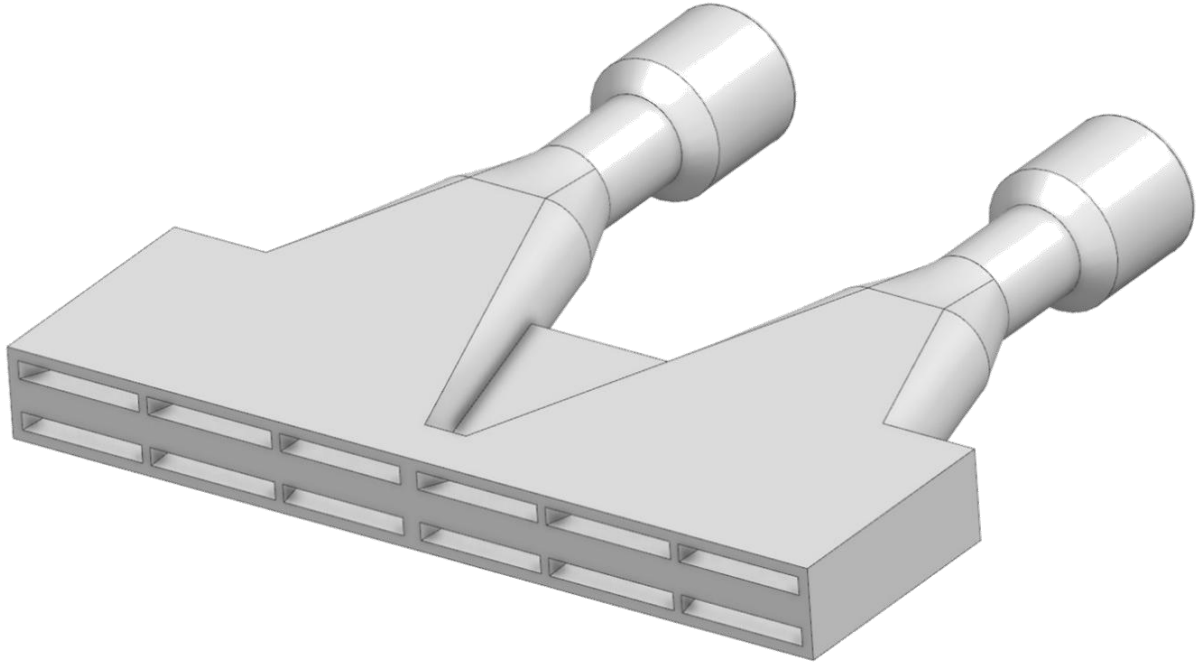
Power density

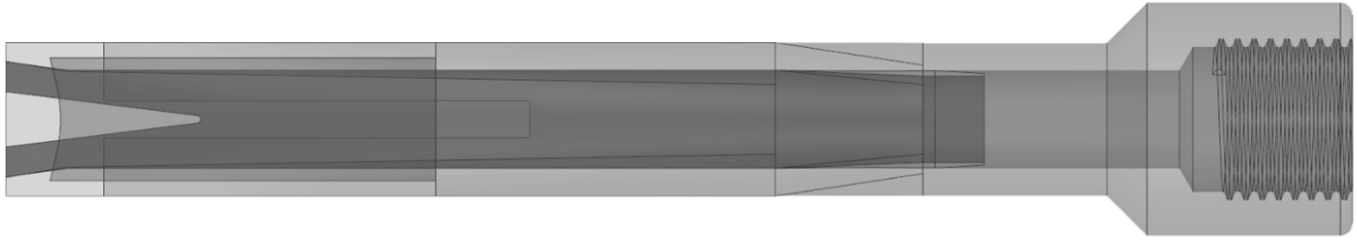
0
40 mW/cm²
1600 mW/cm²



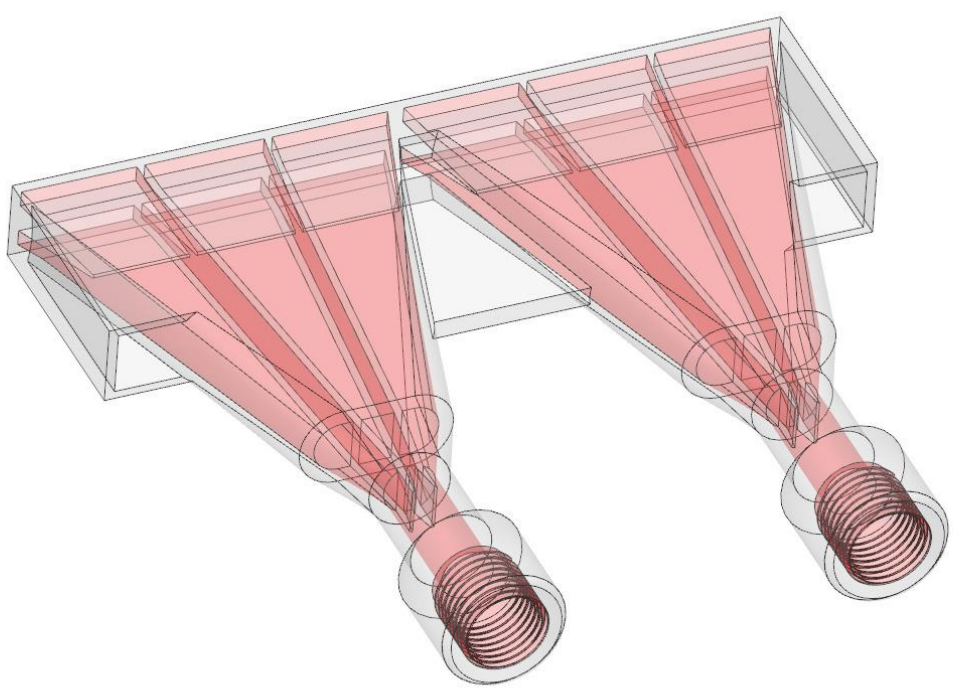
Air diffusers

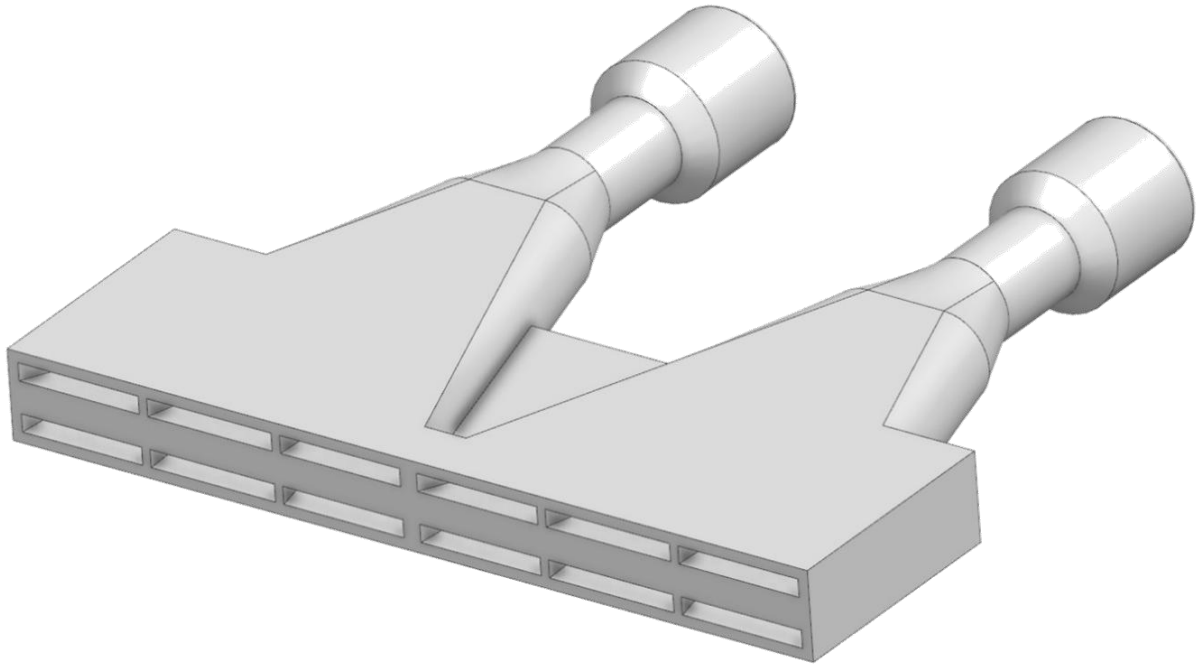


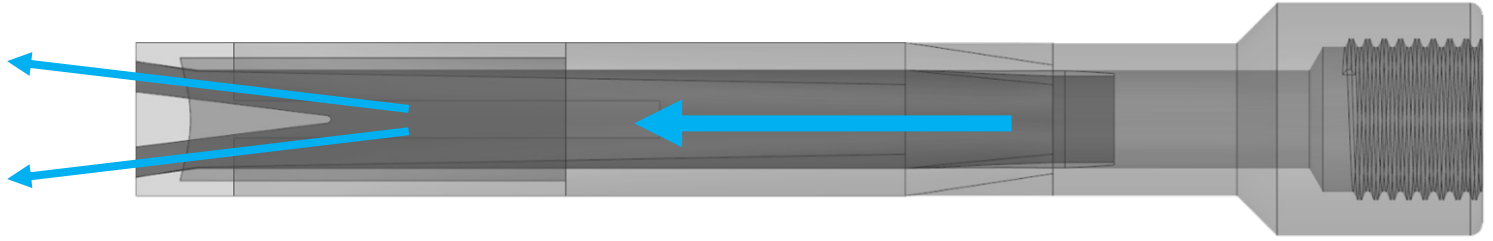




Air diffusers



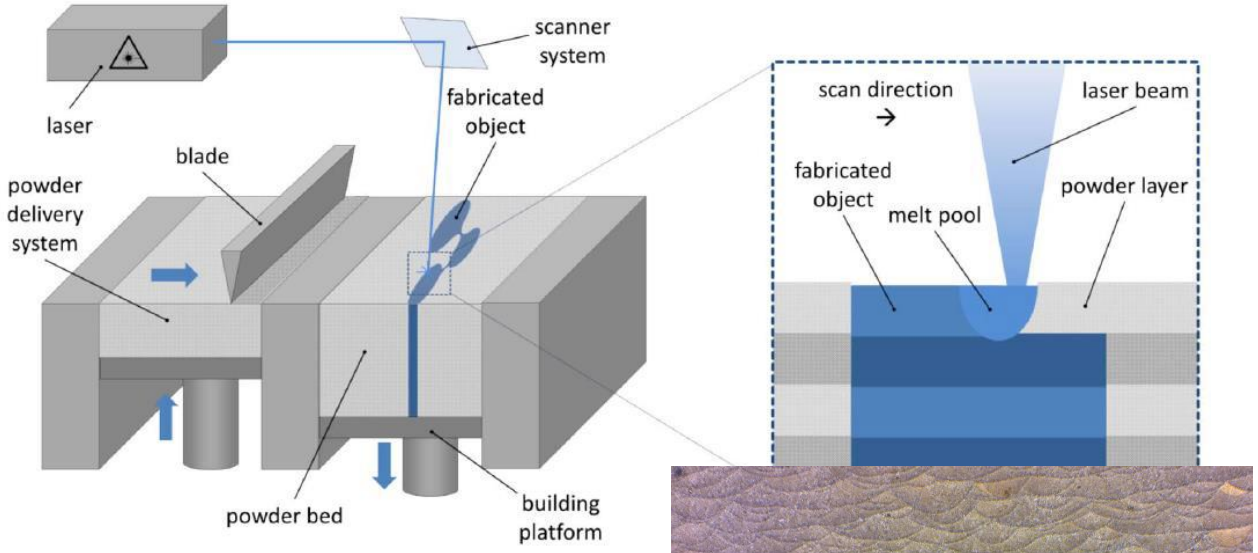




Heat sink shapes

Heat sink shapes – How it's made

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



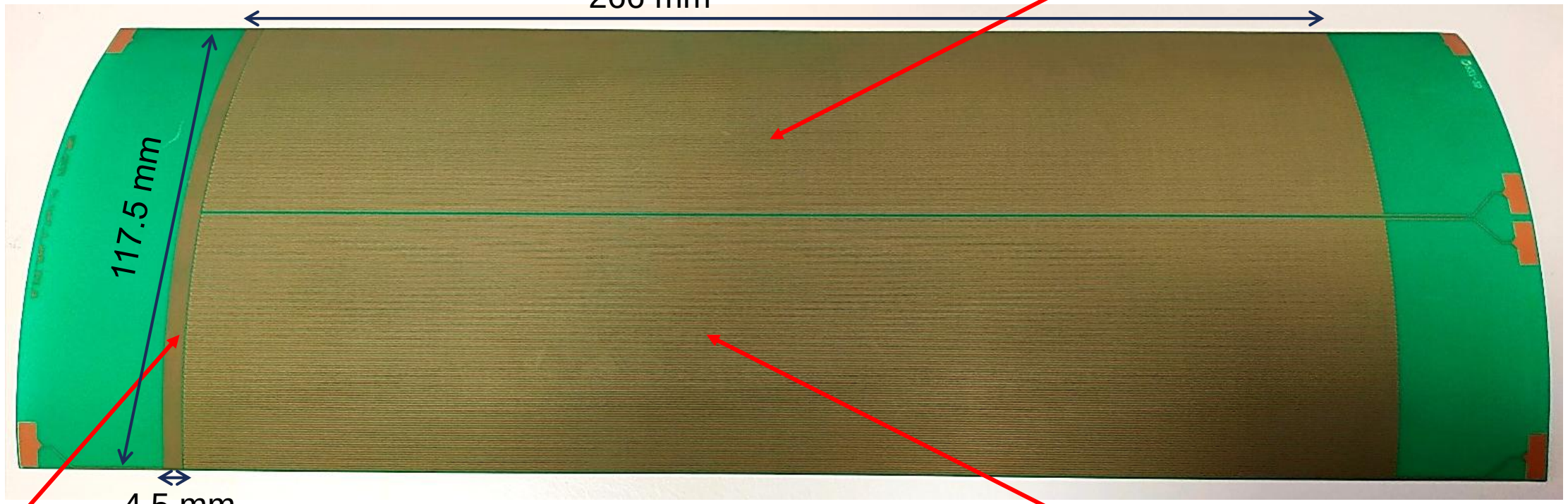
Al-Si10-Mg

Main Process Parameters:

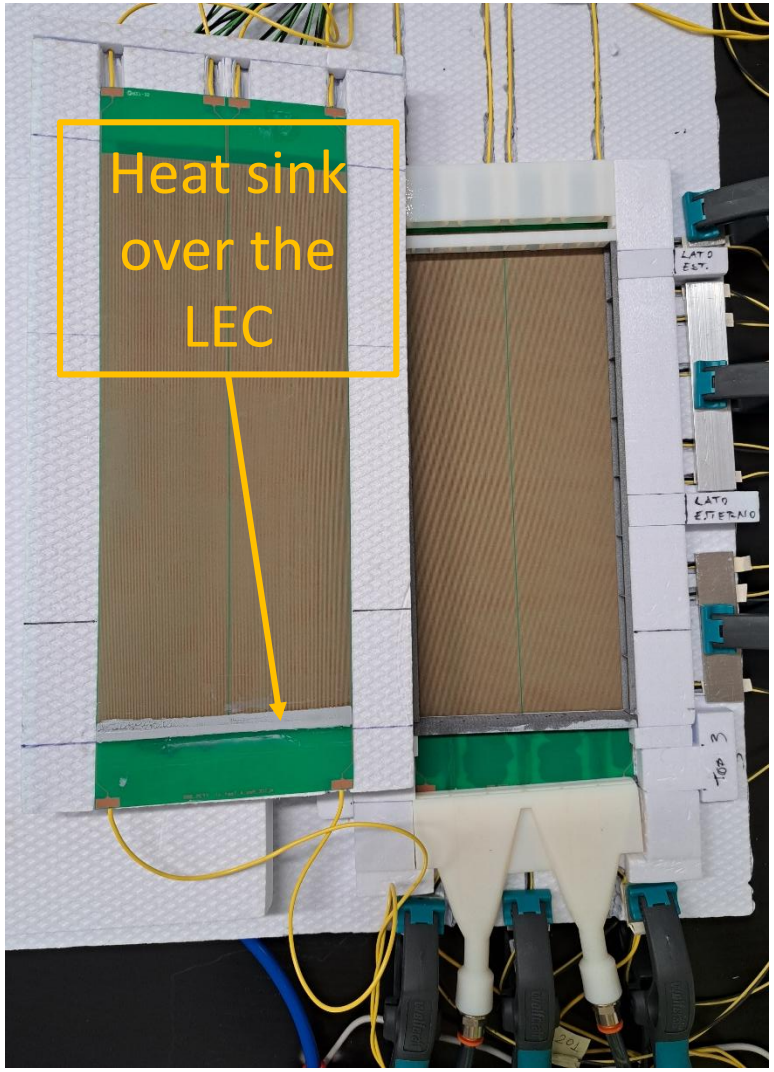
- LASER POWER (W)
- LAYER THICKNESS (t)
- SCAN SPEED (v)
- HATCHING (h)
- SPOT SIZE
- SCANNING STRATEGY
- PARTICLE SIZE DISTRIBUTION
- MATERIAL PROPERTIES

P. Rebesan (INFN Padova)

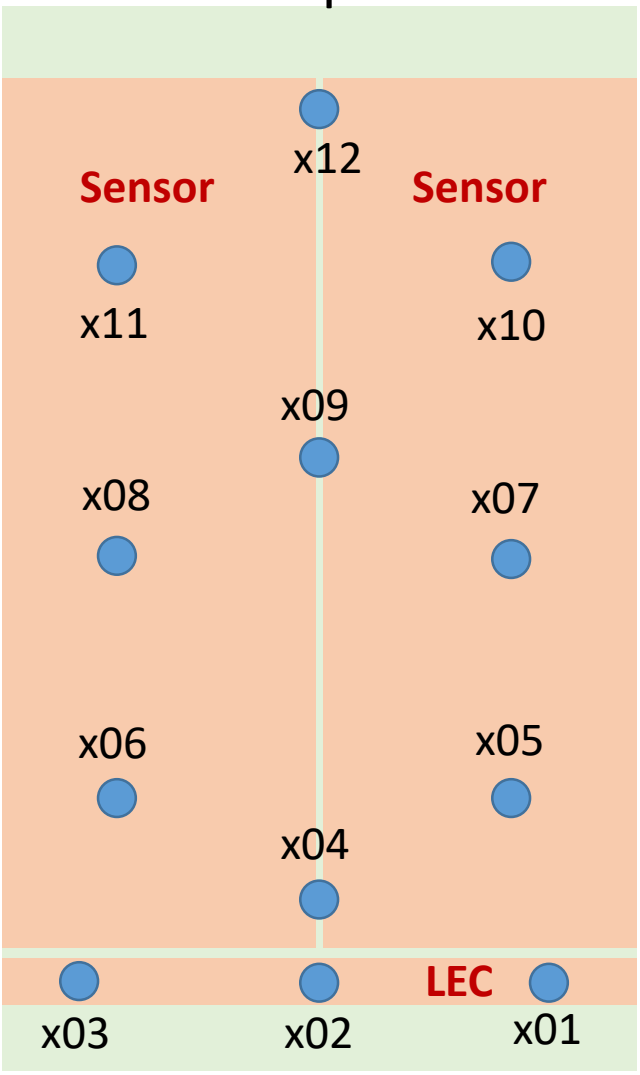
Setup – Heat load diffuser with copper trace



Setup



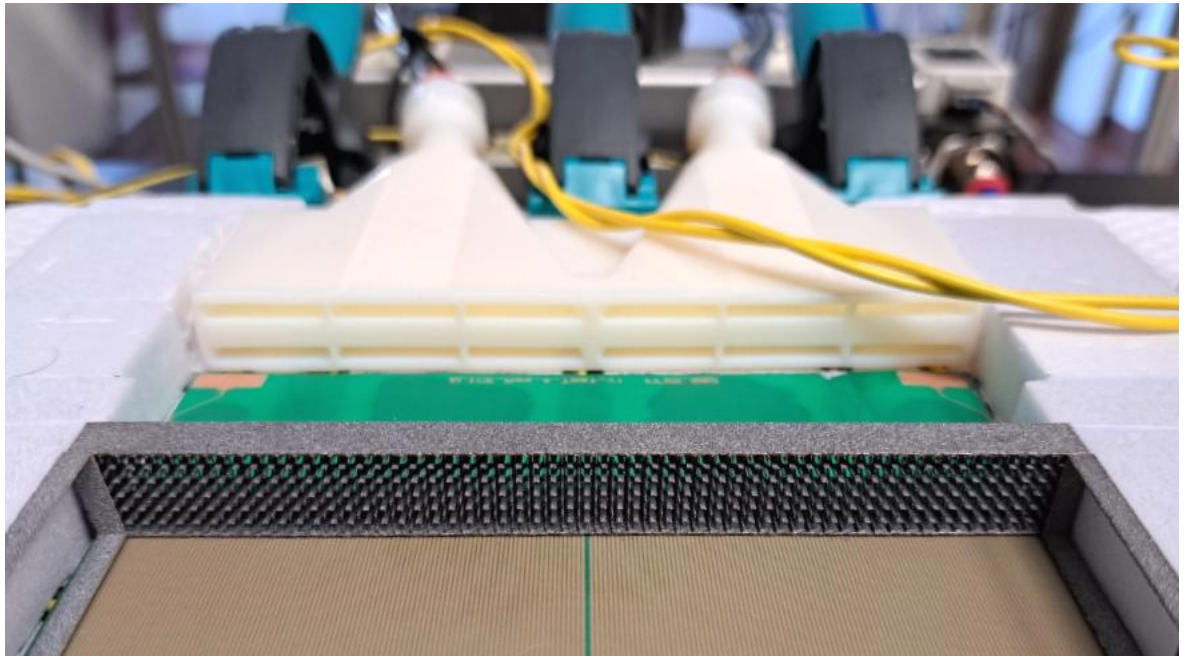
PT 1000 position



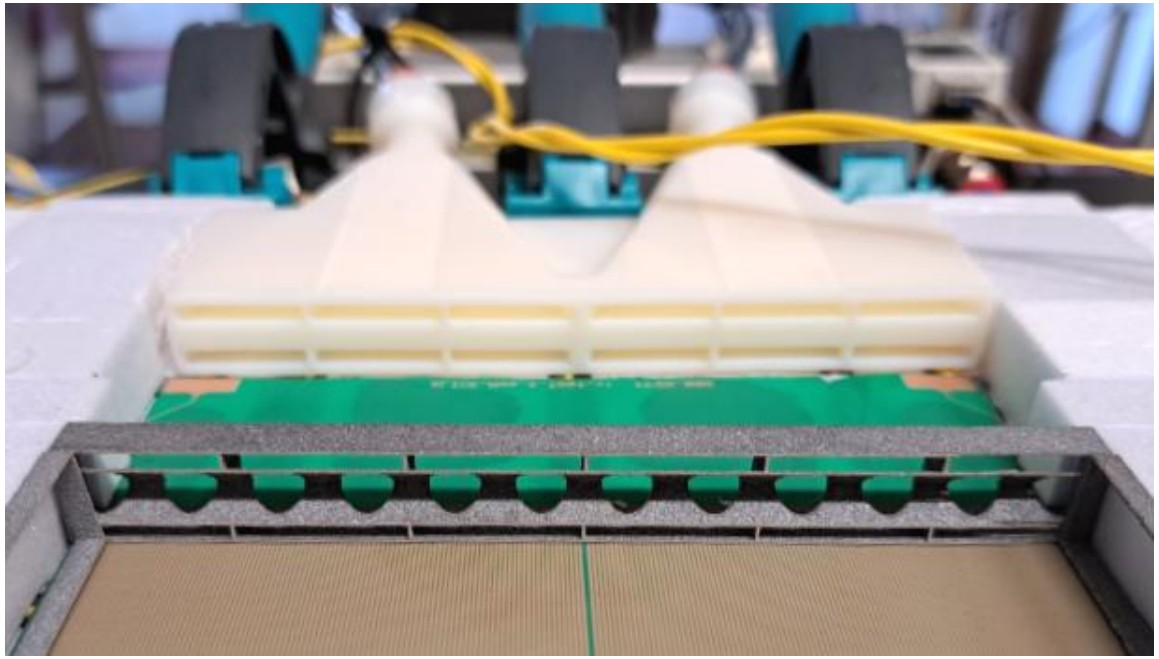
Setup

2 heat sink shapes tested

Heat sink 01

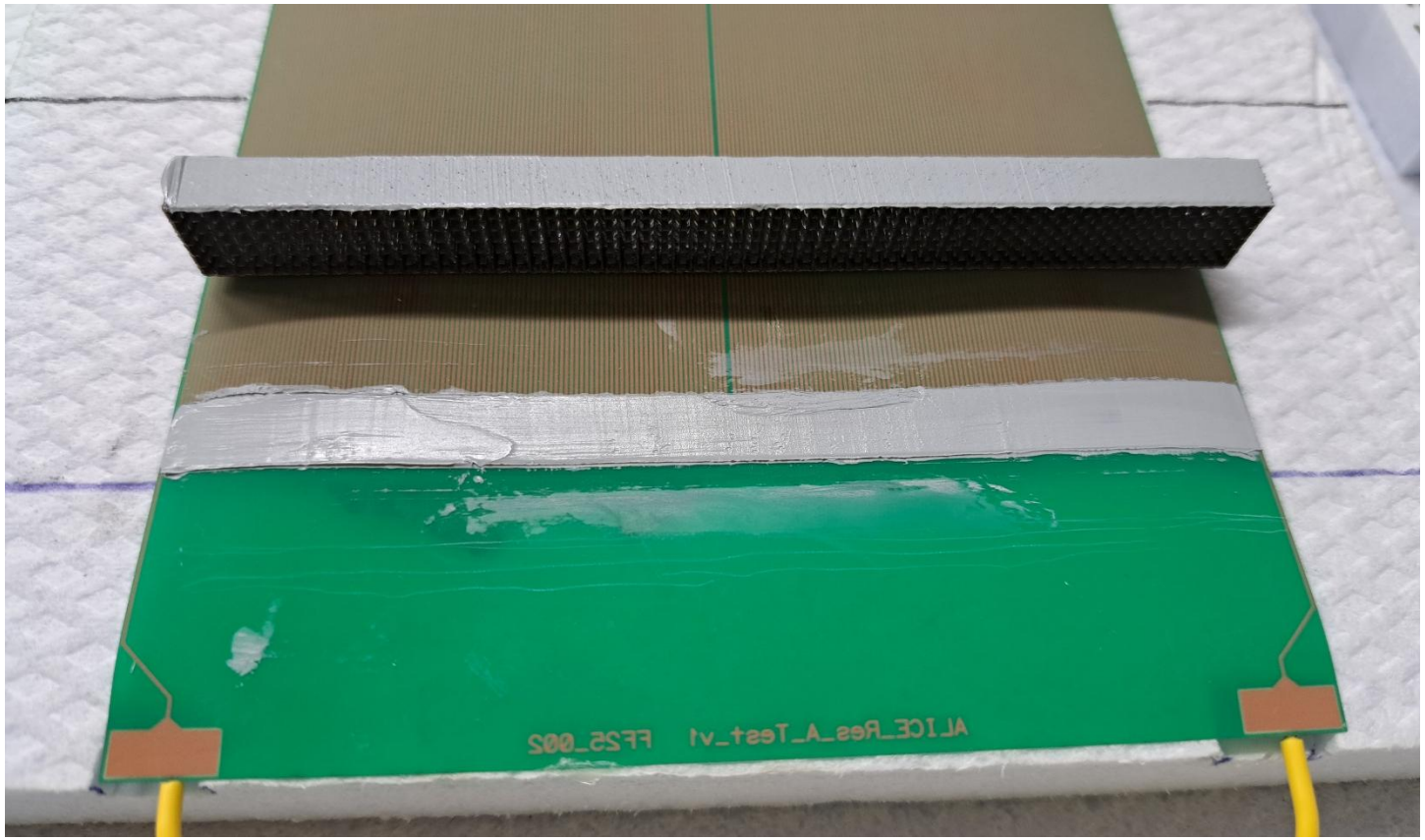


Heat sink 02



Setup

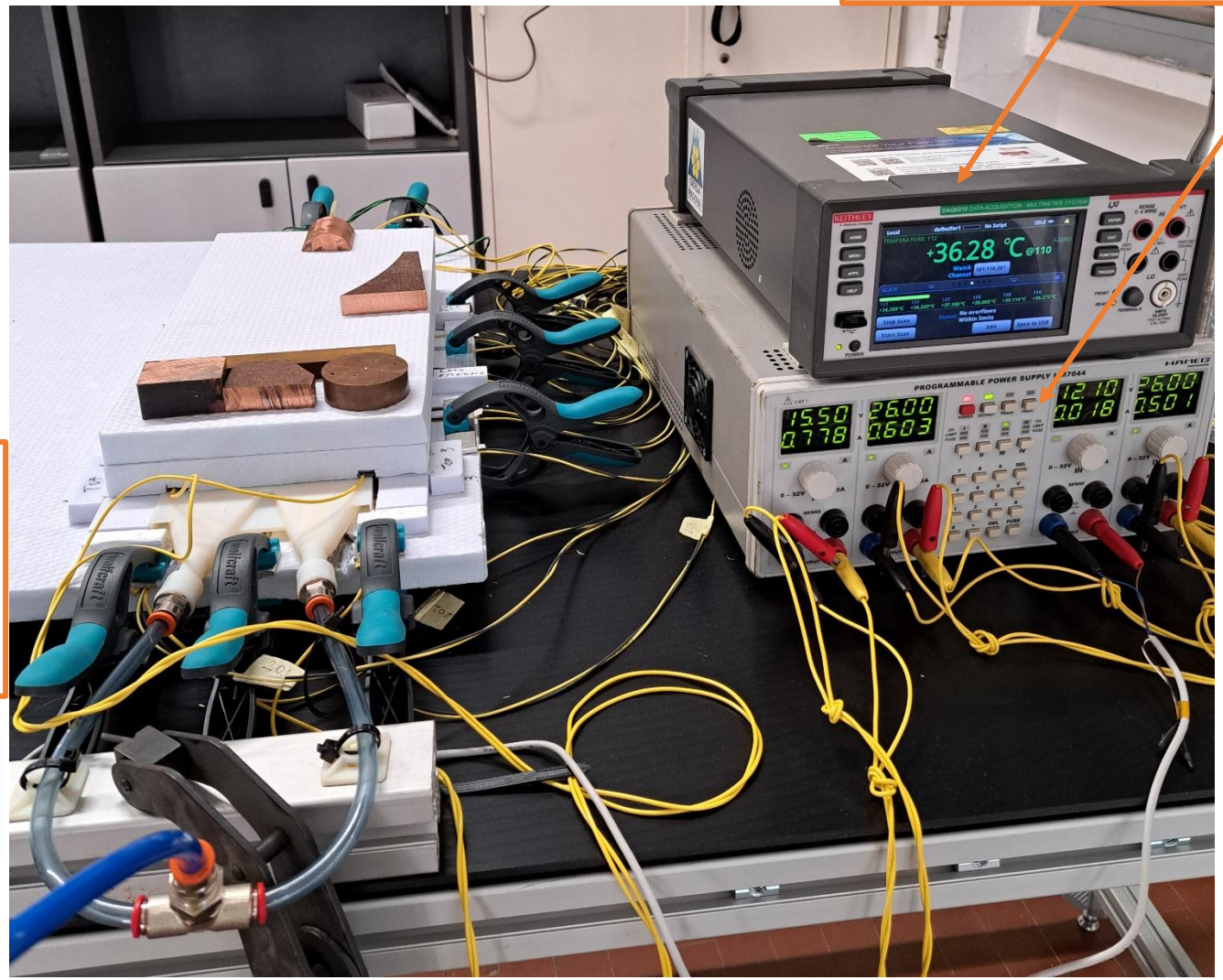
Use of silicone thermal grease only with heat sink 01



Complete Setup

DAQ6510 Keithley
Data Acquisition

HM7044 Hameg
Power Supply

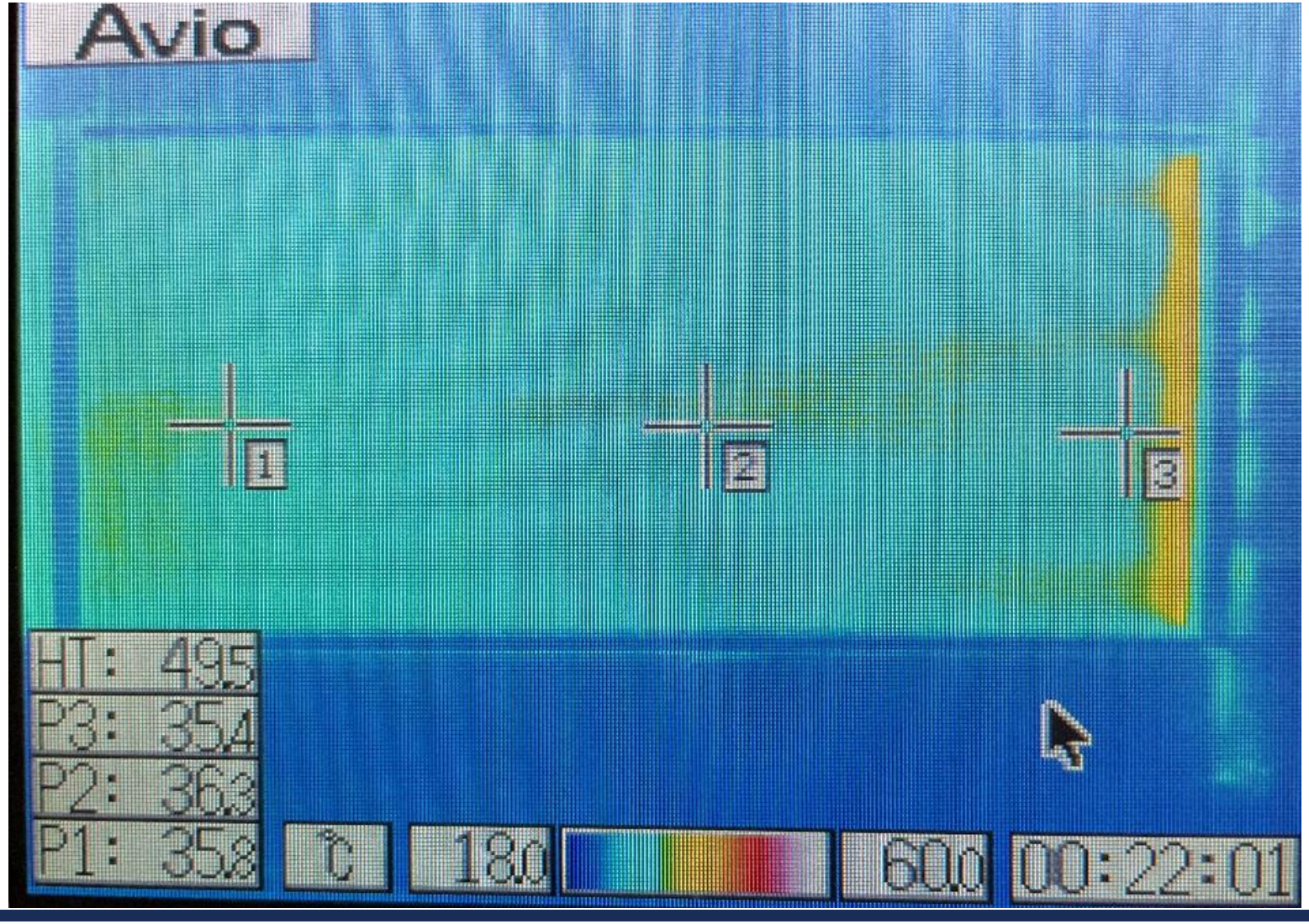


Digital flow
switch
SMC
PFMB7102

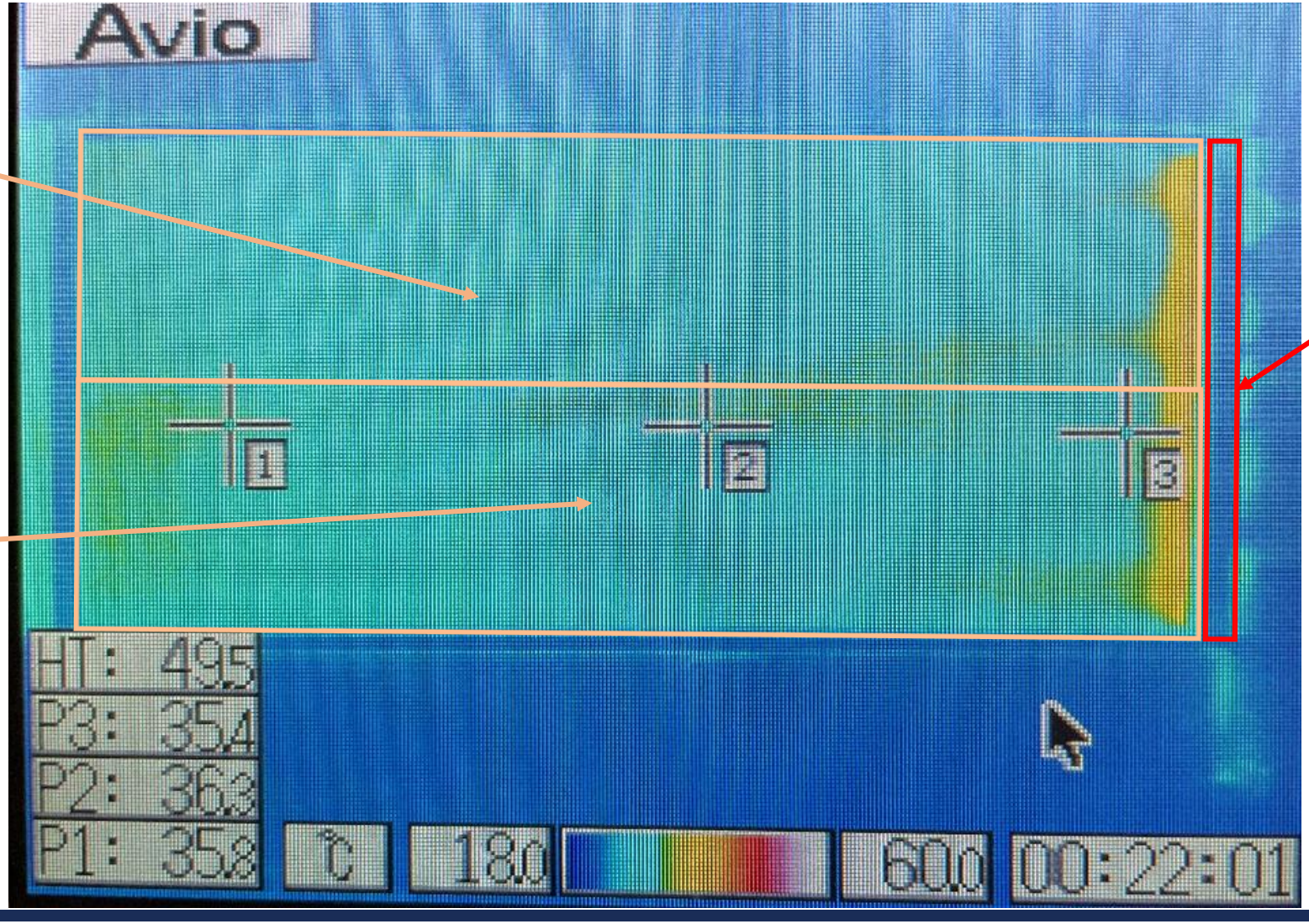
LEC: 4.23 W each
Sensor: 6.25 W each
corresponding to
nominal power of
1.6W/cm^2 for LEC and
40mW/cm^2 for sensor

Air: 378 L/m
corresponds to about
12 m/s in this setup

Thermal Measure



Thermal Measure

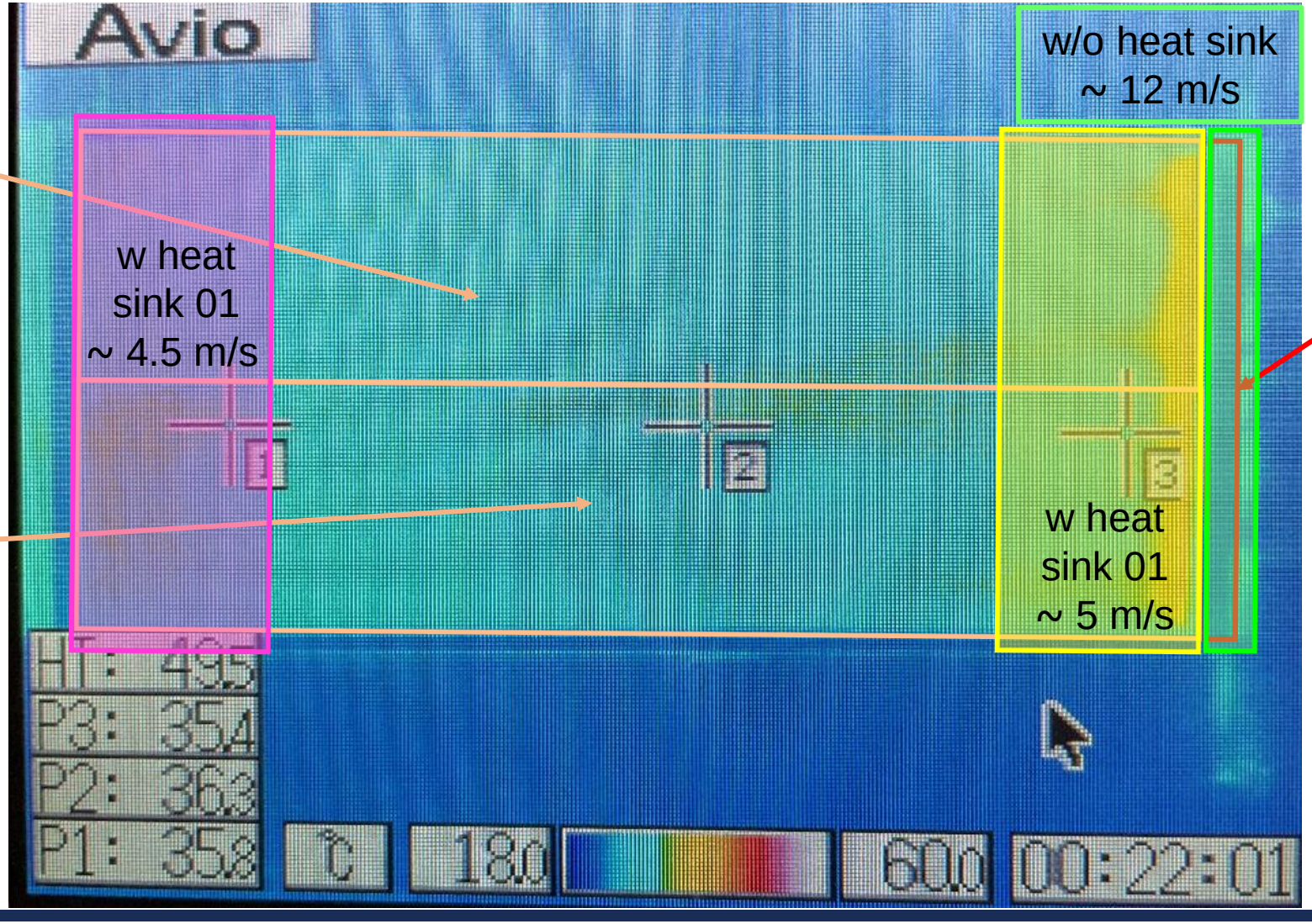


Sensor 2

Sensor 1

LEC

Thermal Measure

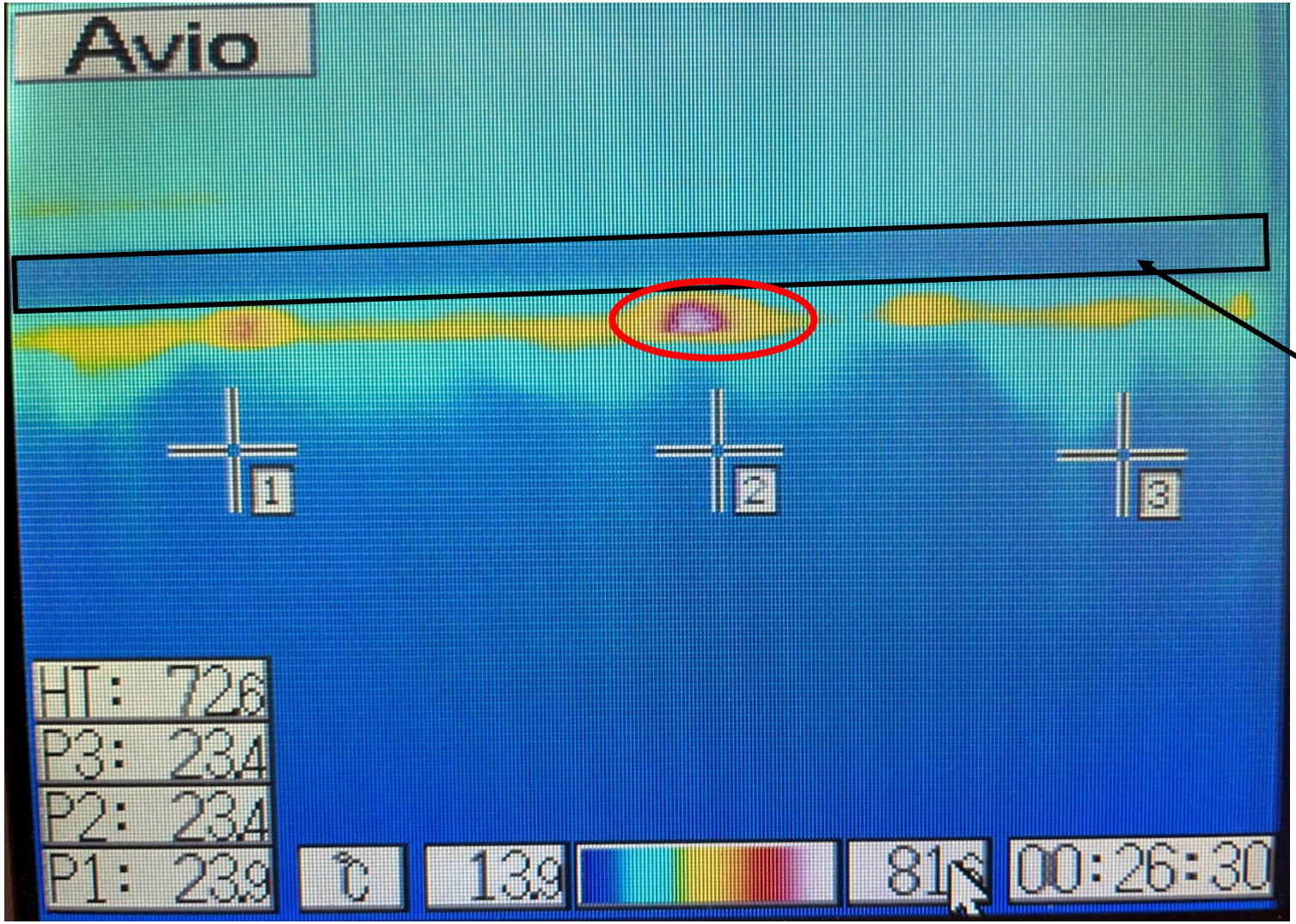


Sensor 2

Sensor 1

LEC

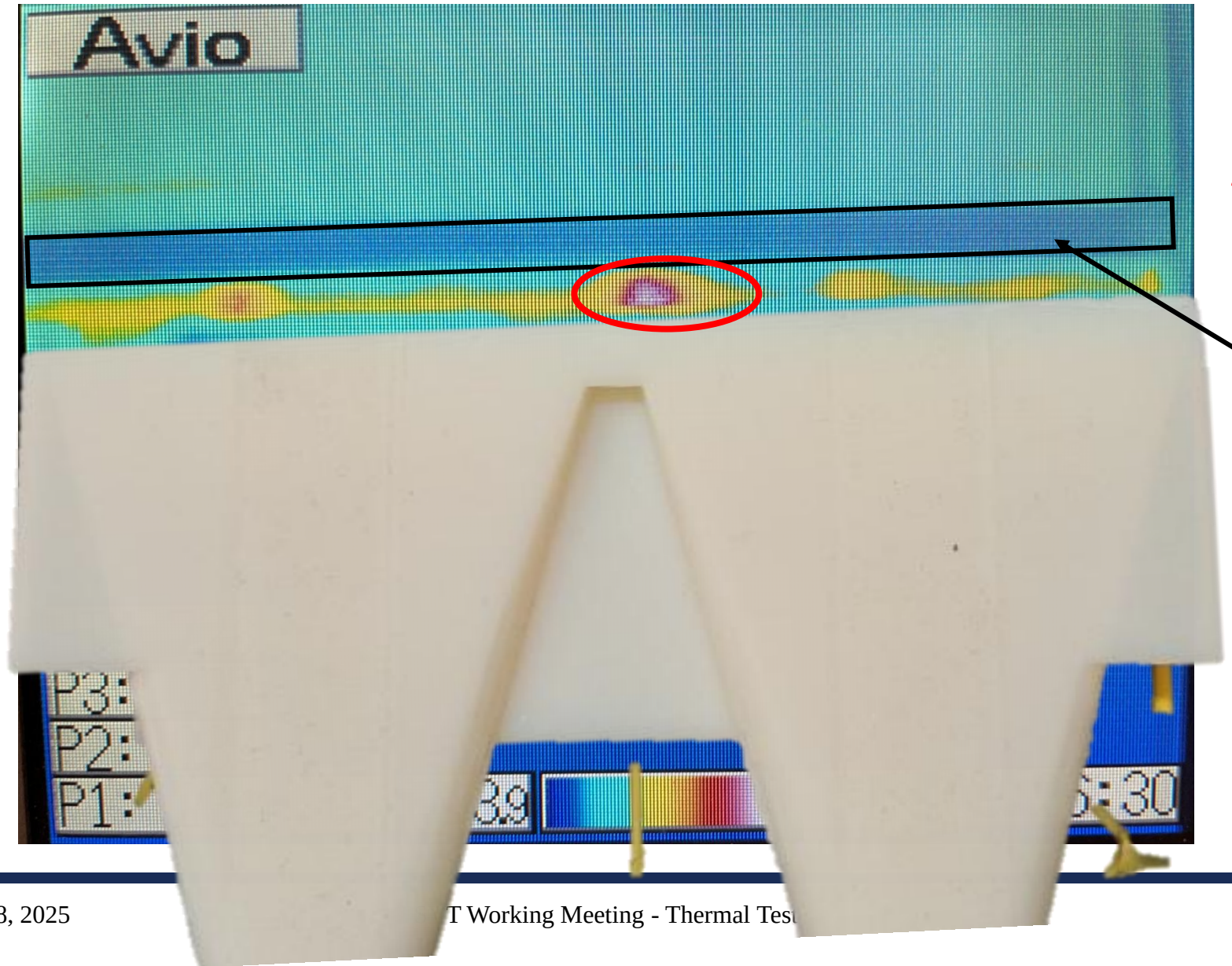
Thermal Measure



HOT SPOT
~80°C

LEC

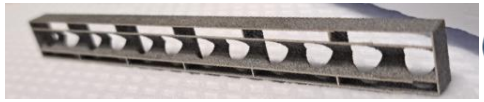
Thermal Measure

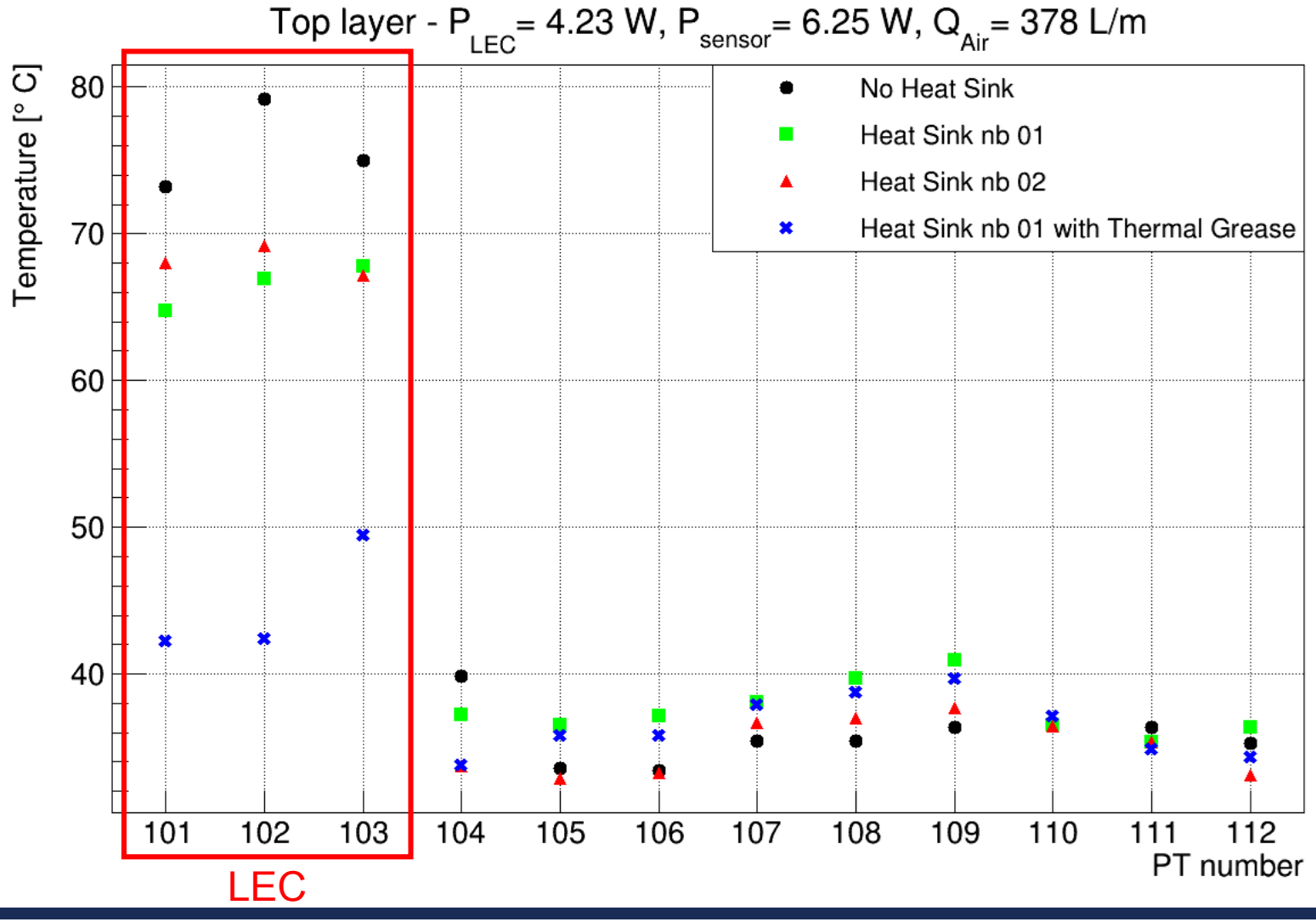


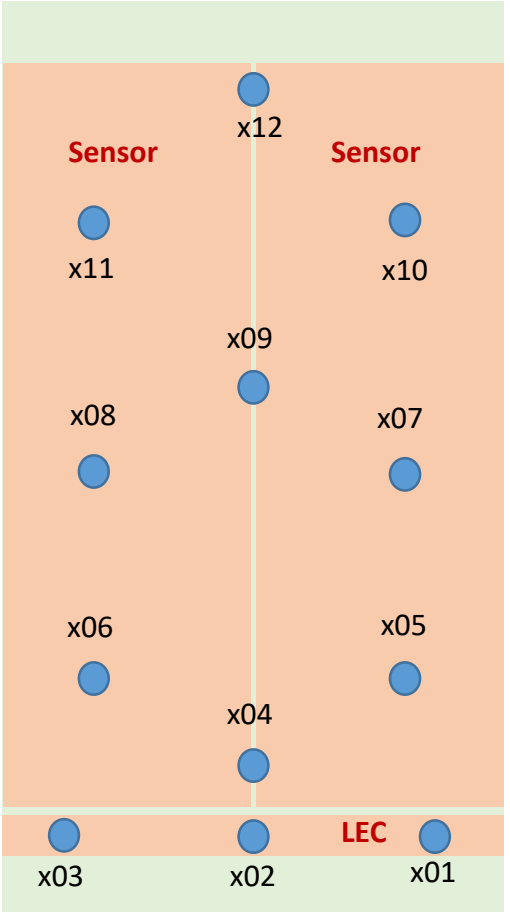
Preliminary results

Heat sink nb 01

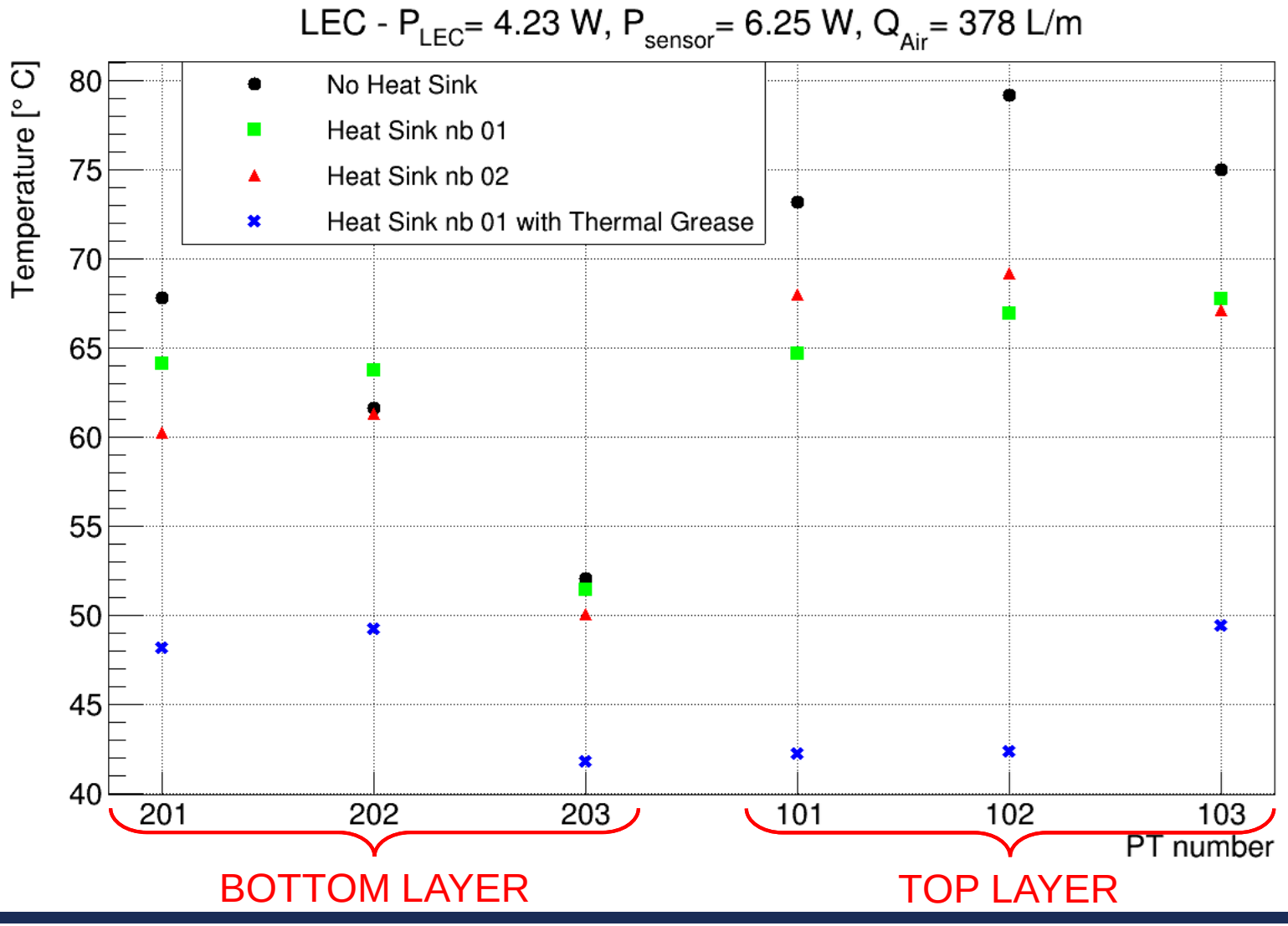
Heat sink nb 02

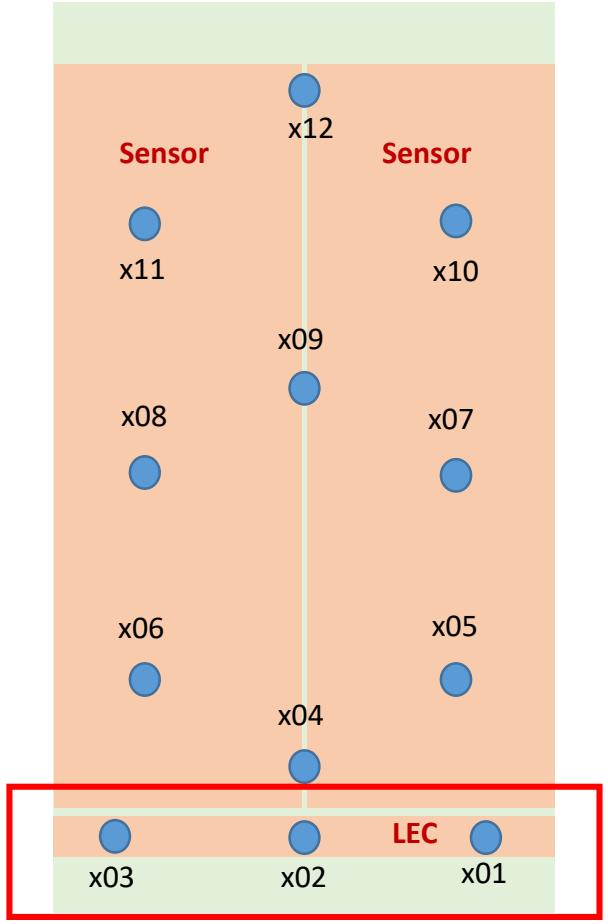




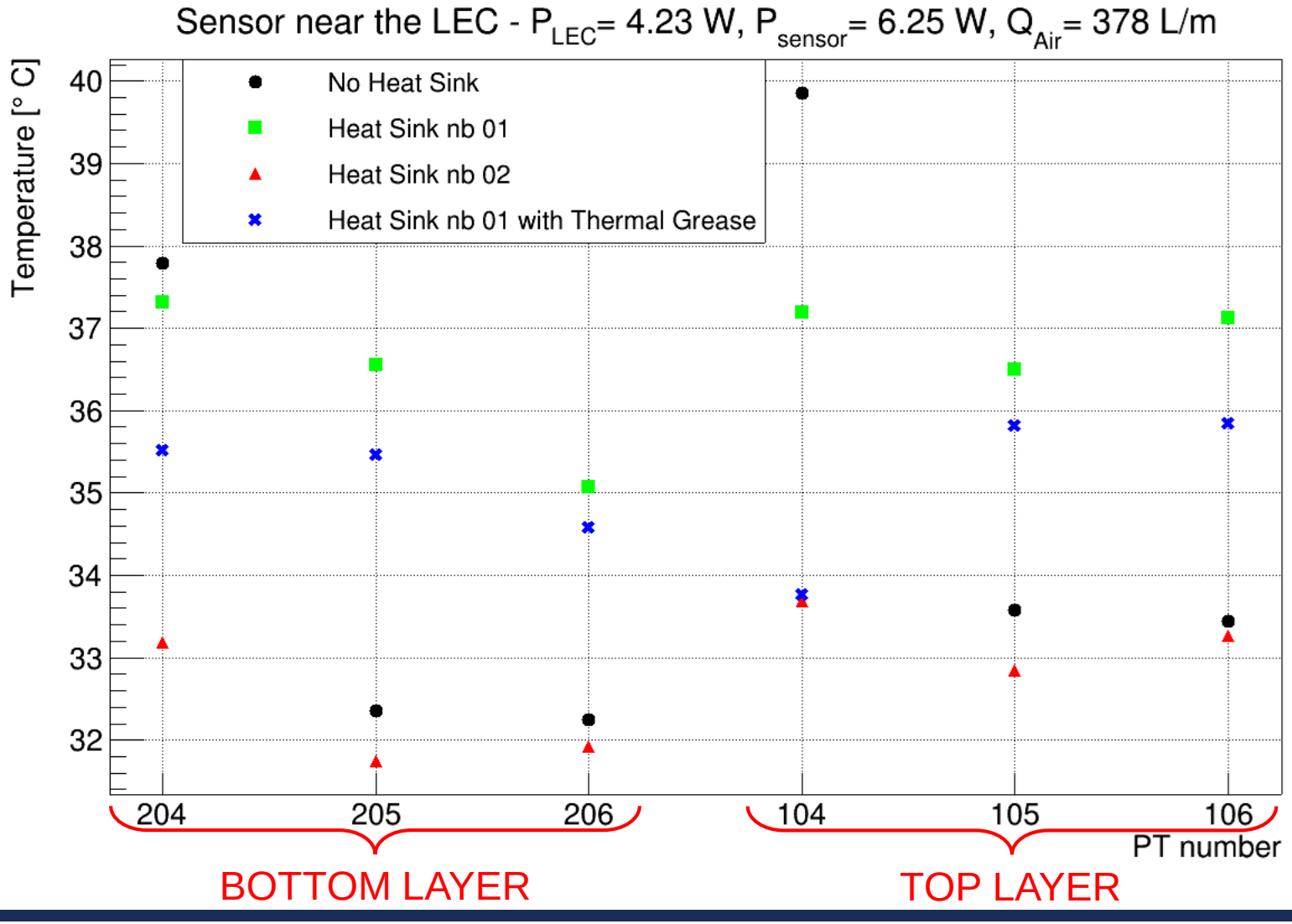


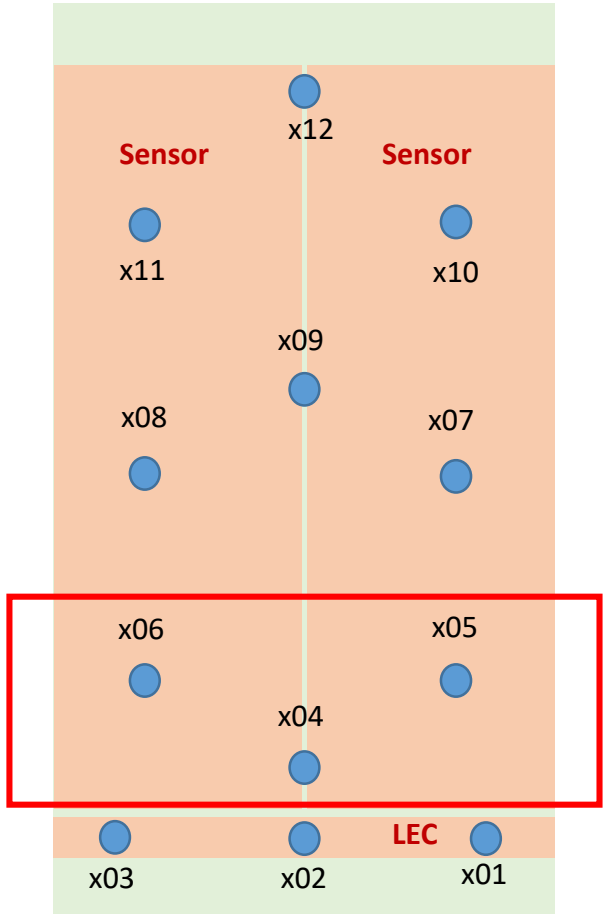
Preliminary results – Only LEC





Preliminary results – On the sensor, near LEC





Thermal simulations

Aluminum 3D printed radiator for LEC

Power dissipated on LEC through radiatior for L0+L1: ~20W
Study to optimize geometry of 3D printed aluminum radiator: main parameters

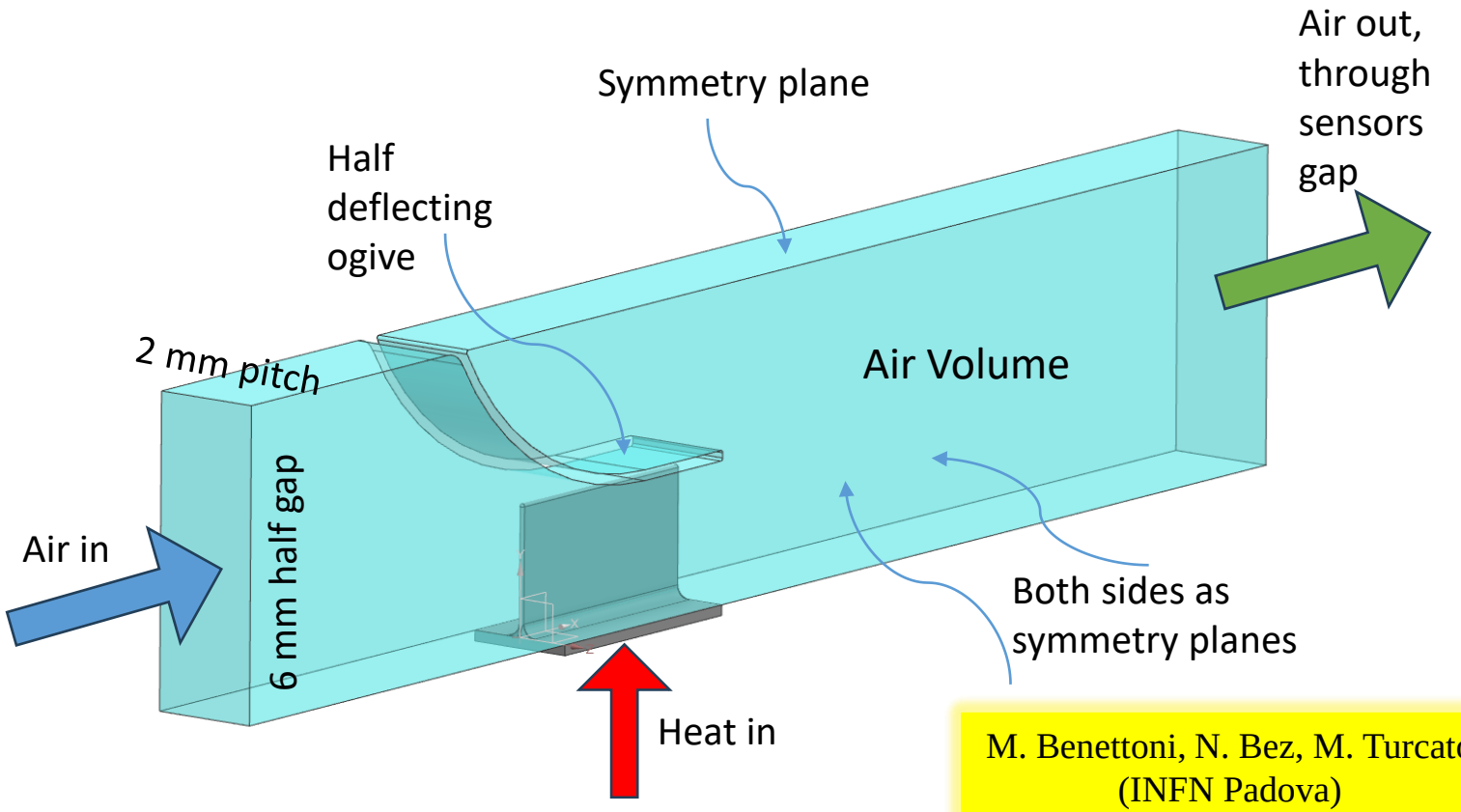
- Air flow/speed at inlet
- Fins height
- Fins - and LEC contact surfaces - thickness
- Fins pitch
- Partialization of the flow section by means of ogive / wings to concentrate flux near to LEC cooling surfaces
- Overall admissible mass of radiator (now ~ 1.1 – 1.8 cm^3 ~ 3 – 5g depending on walls thicknesses and fins pitch)

Few prototypes already produced by AM (Additive Manufacturing), ready for test (straight version).
Material: Al-Si alloy, bulk thermal conductivity ~140 ± 20 W/mK

M. Benettoni, N. Bez, M. Turcato (INFN Padova)

Aluminum fin cooled by air flow

- Simple preliminary simulations of a single fin of radiator
- Heat inlet at fin bottom face 1.6 W/cm^2 (0.144 W on the 0.09 cm^2 surface of simulation)
- Air flux at inlet: 10 m/s, 290K (~17 °C)
- Feasible thickness from nominal 0.1 mm up, considering 0.1, 0.2 and 0.3 mm
- Fin pitch 2 mm
- Sensor power neglected for now

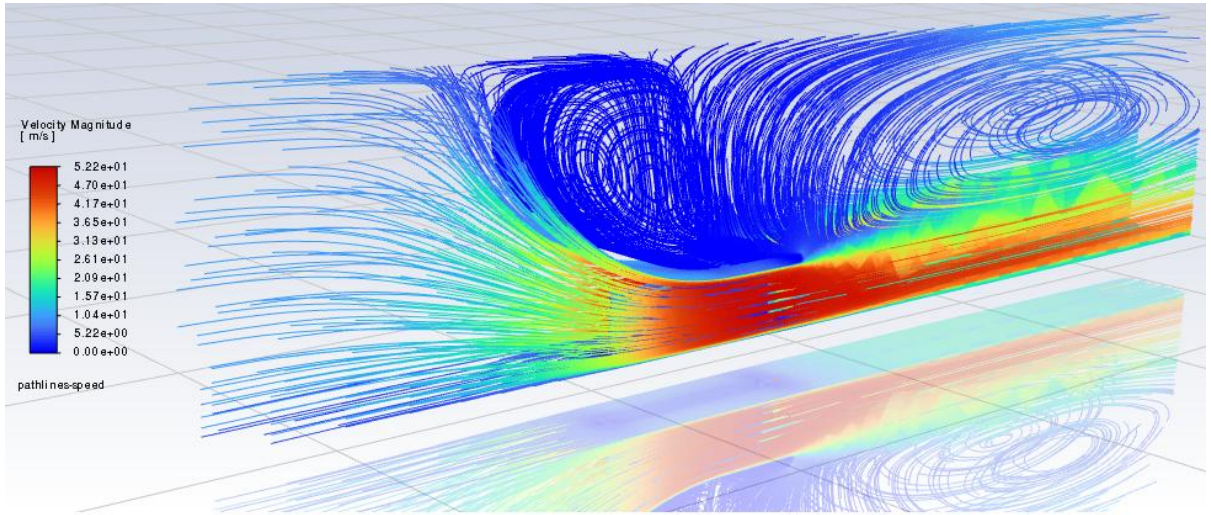


M. Benettoni, N. Bez, M. Turcato (INFN Padova)

Aluminum fin cooled by air flow

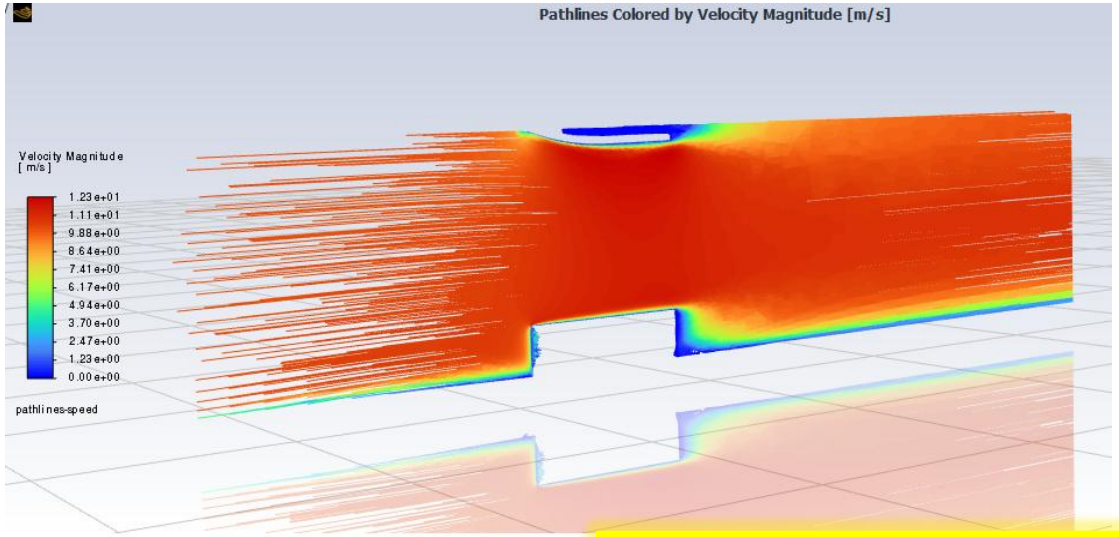
- Large ogive: tight air passage
- High speed: ~52 m/s

Vortex



- Thin ogive: almost full passage
- Lower speed: ~12 m/s

Laminar



M. Benettoni, N. Bez, M. Turcato
(INFN Padova)

Conclusions and future steps

Conclusions

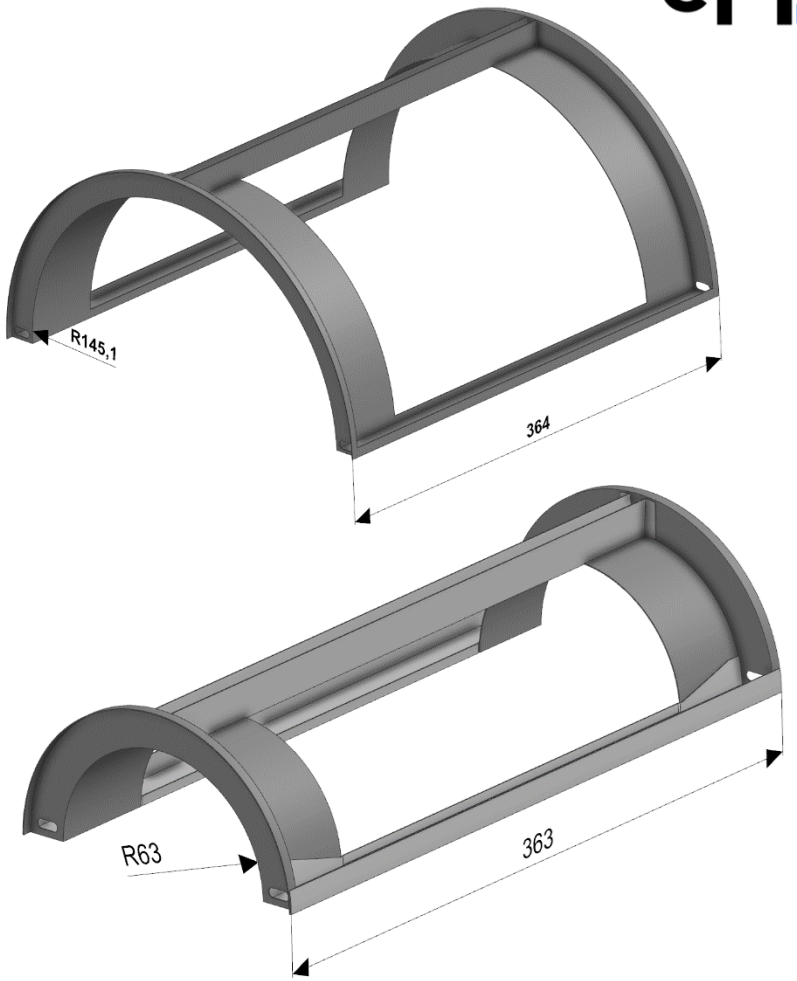
Preliminary test of air cooling system:

- Heat sink decreses the temperature measured on the LEC
  - The use of silicone thermal grease improves the results
- On the sensor, instead, the use of a heat sink provides thermal issues in the area close to the LEC
  - Changing the geometric shape improves the results → it is necessary to design a heat sink that allows for better airflow
- Hot spot around 80°C detected at the outlet of the air diffusers
  - Improvement of air diffusion both considering geometry and number of diffusers

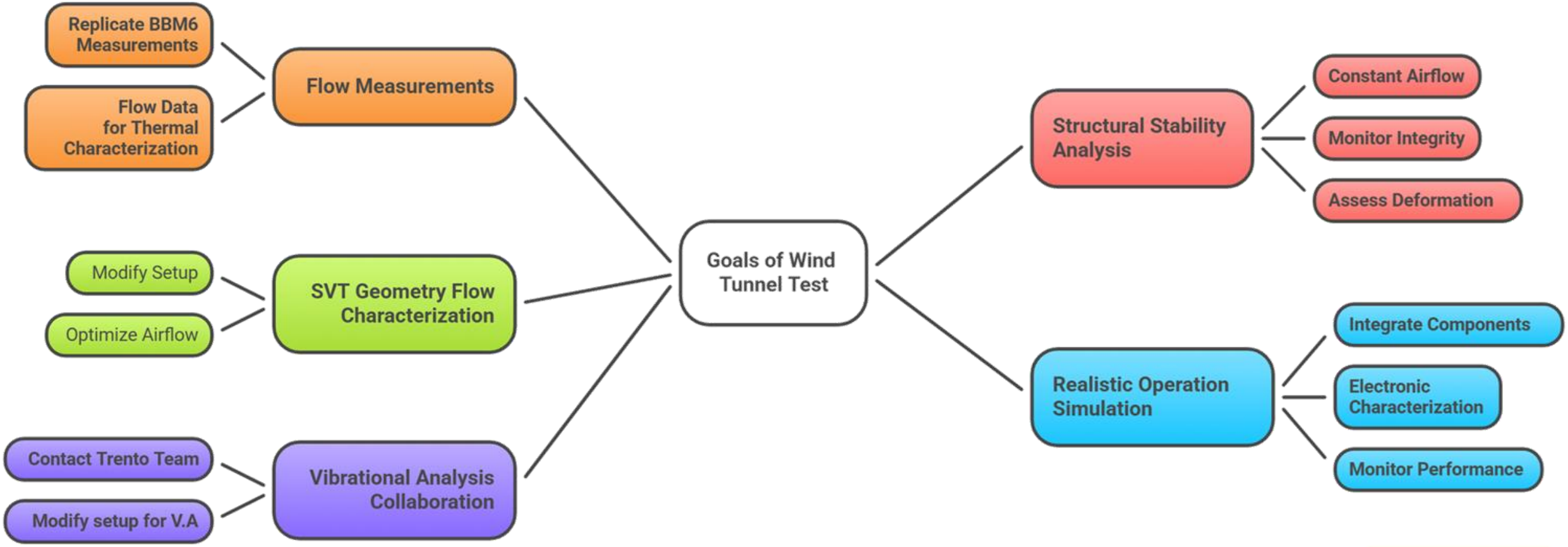
Future steps

New thermal tests with:

- The support prototype that Padova will receive available at the end of the year
- Real sensor sizes for L0, L1, L2
- Use of appropriate material like kapton or kapton + silicon
- Optimizing the air flow
- Test on wind tunnel



Wind tunnel test

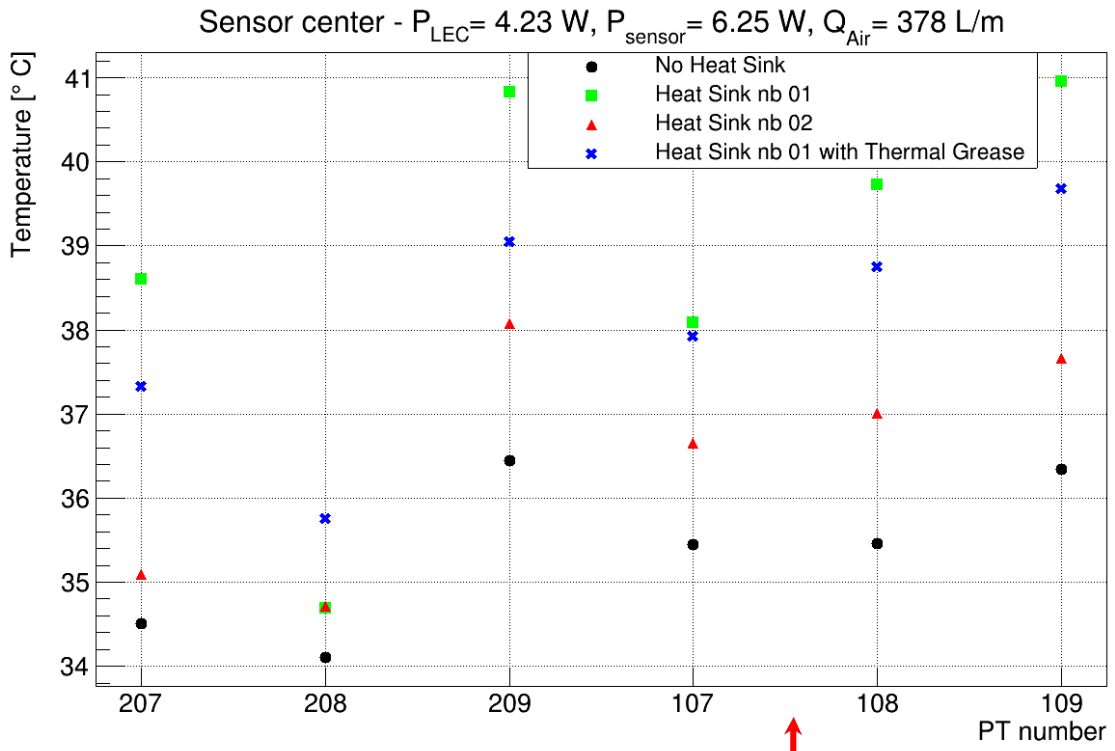


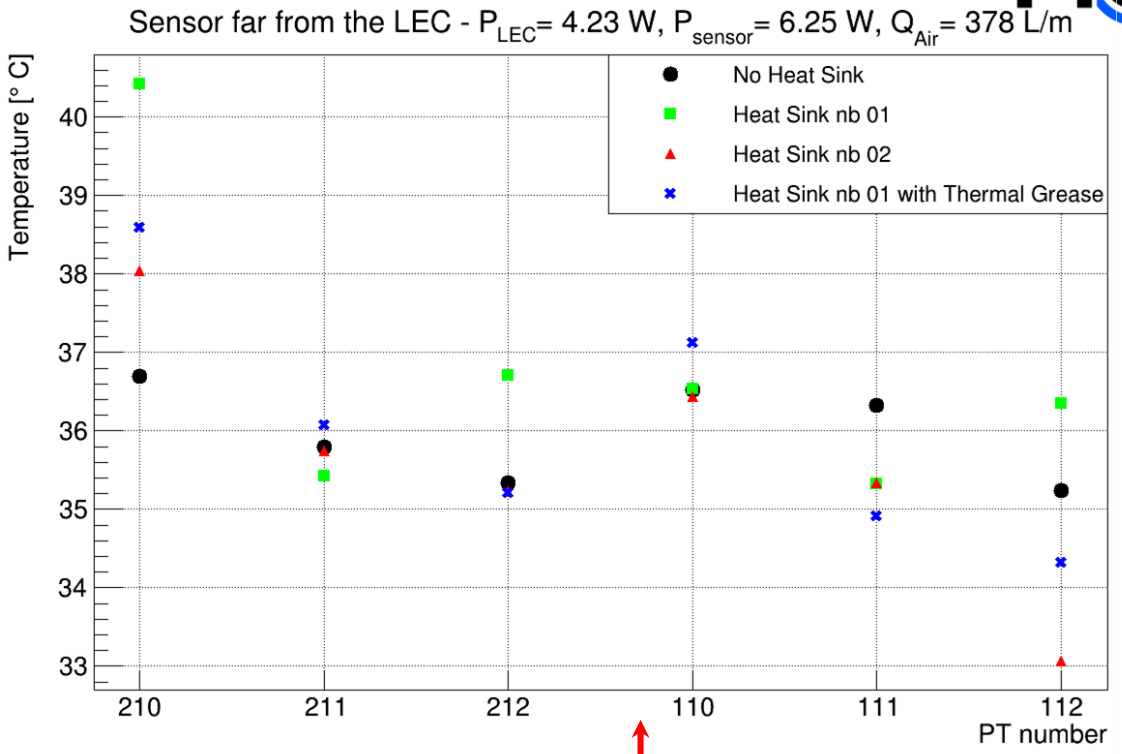
V. Patel
(INFN Bari)

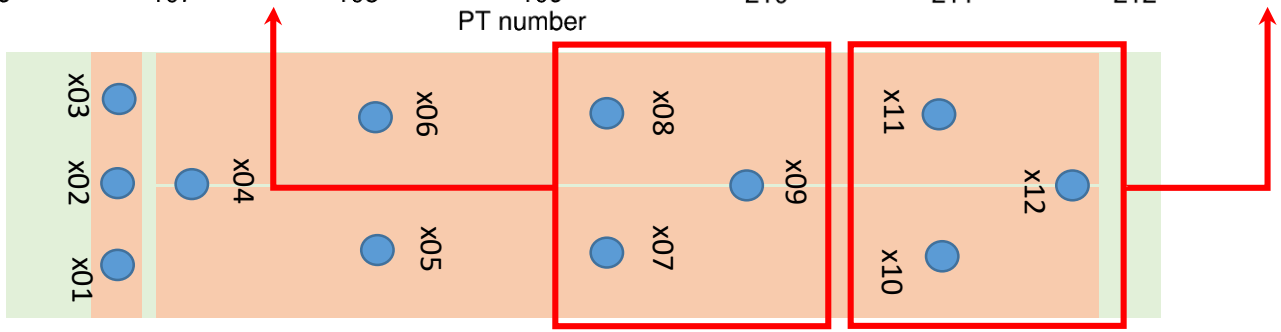
Thank you for the attention

Backup

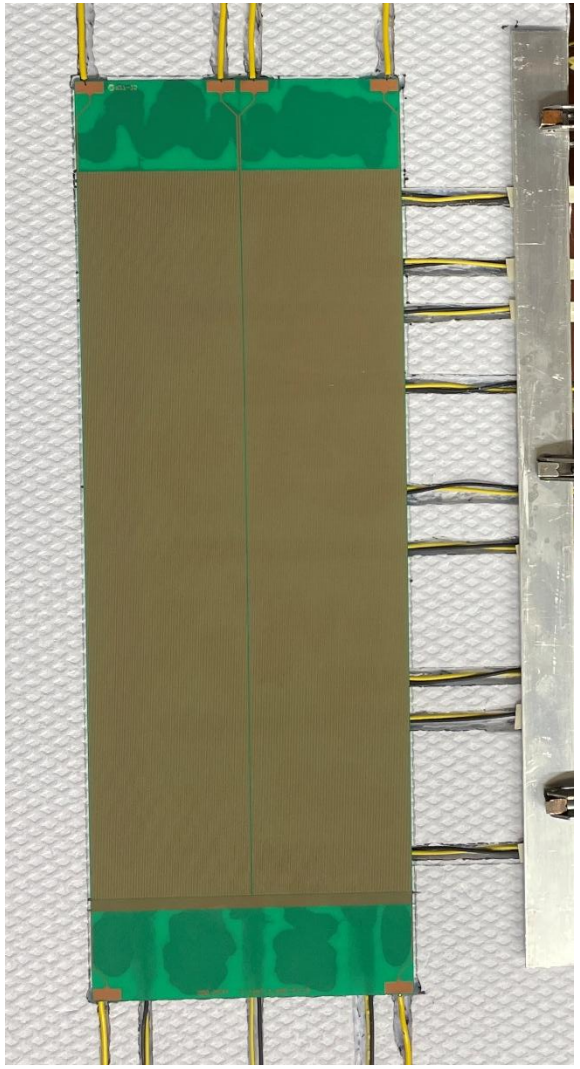
Preliminary results – Far from LEC



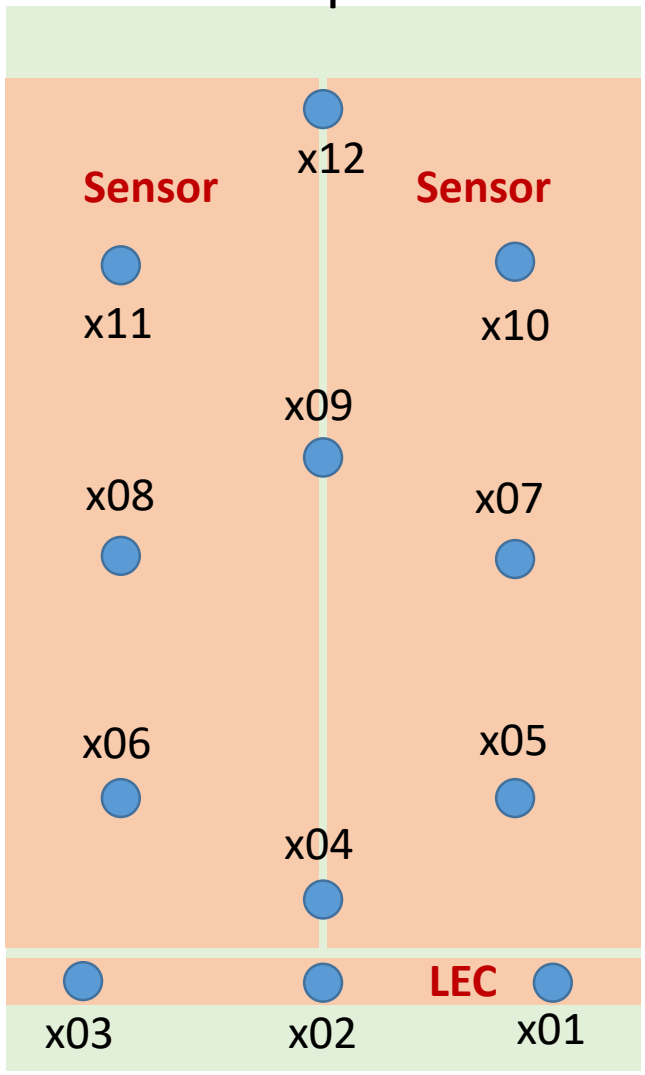




Setup – Bottom layer

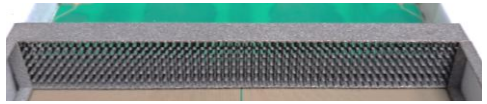


PT 1000 position

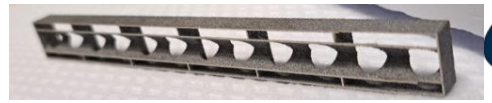


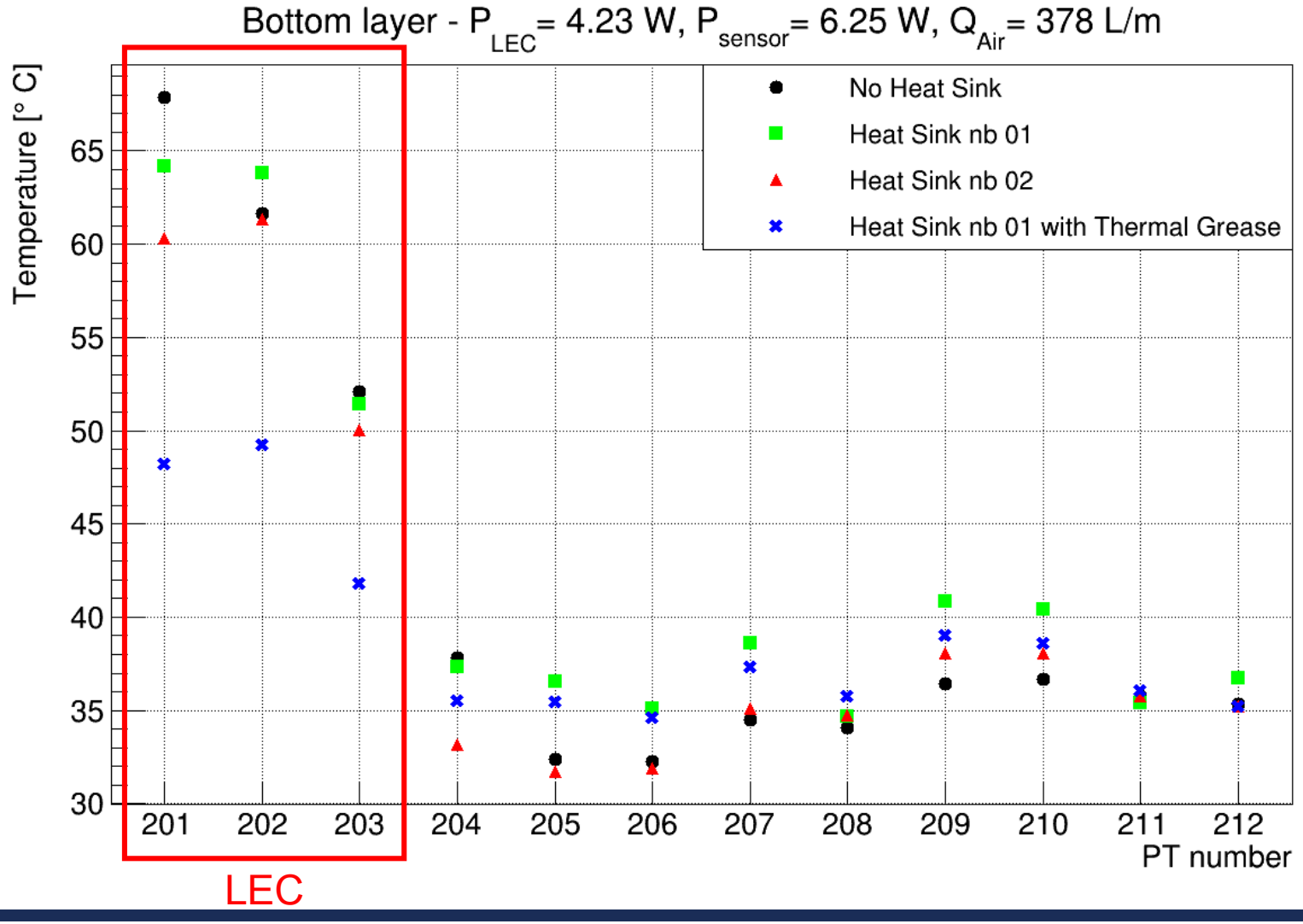
Preliminary results

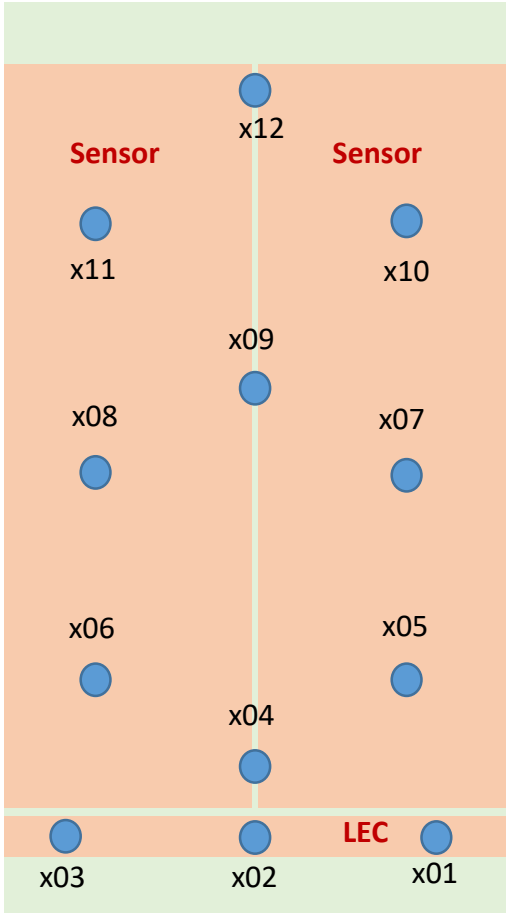
Heat sink nb 01



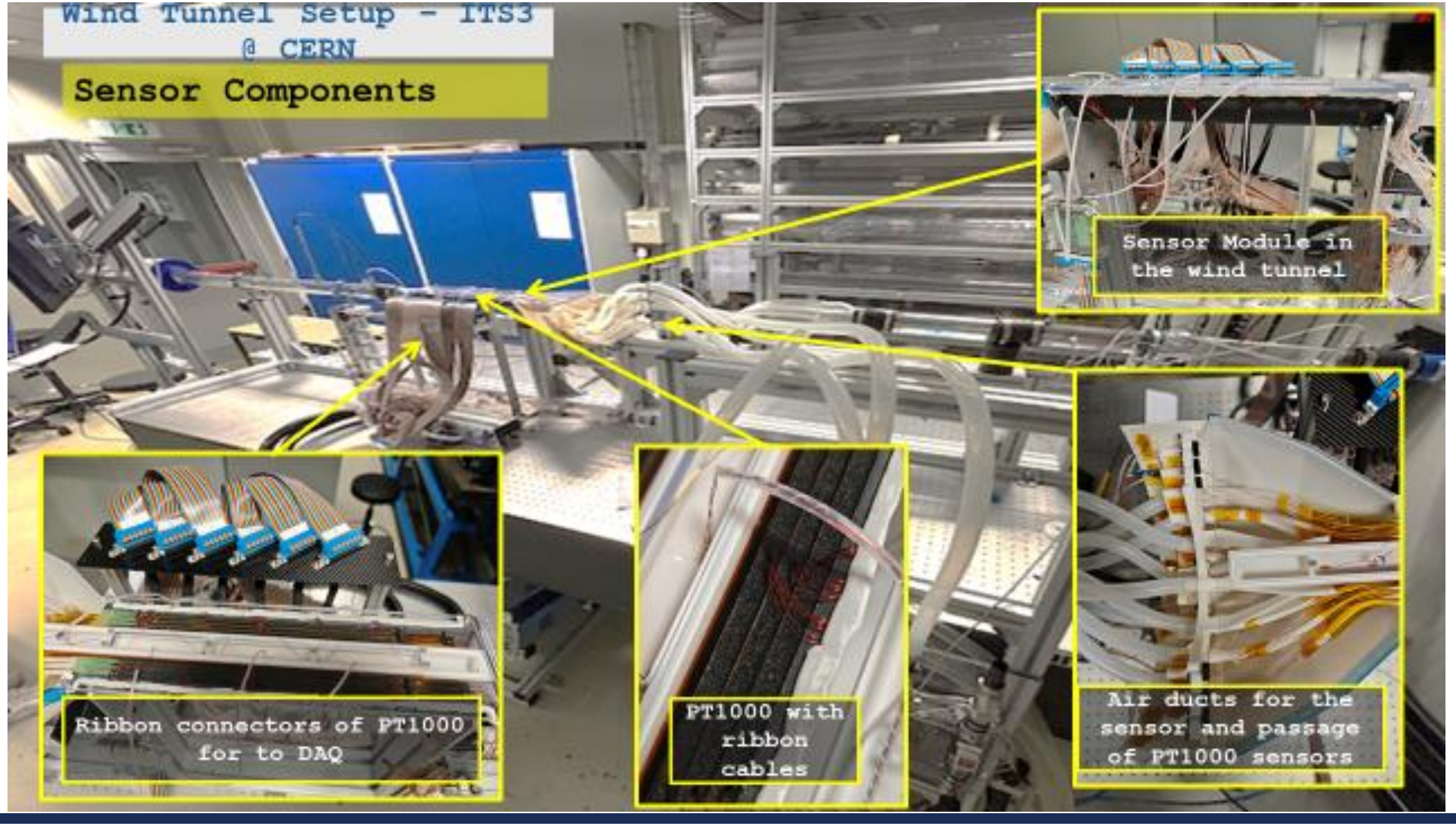
Heat sink nb 02



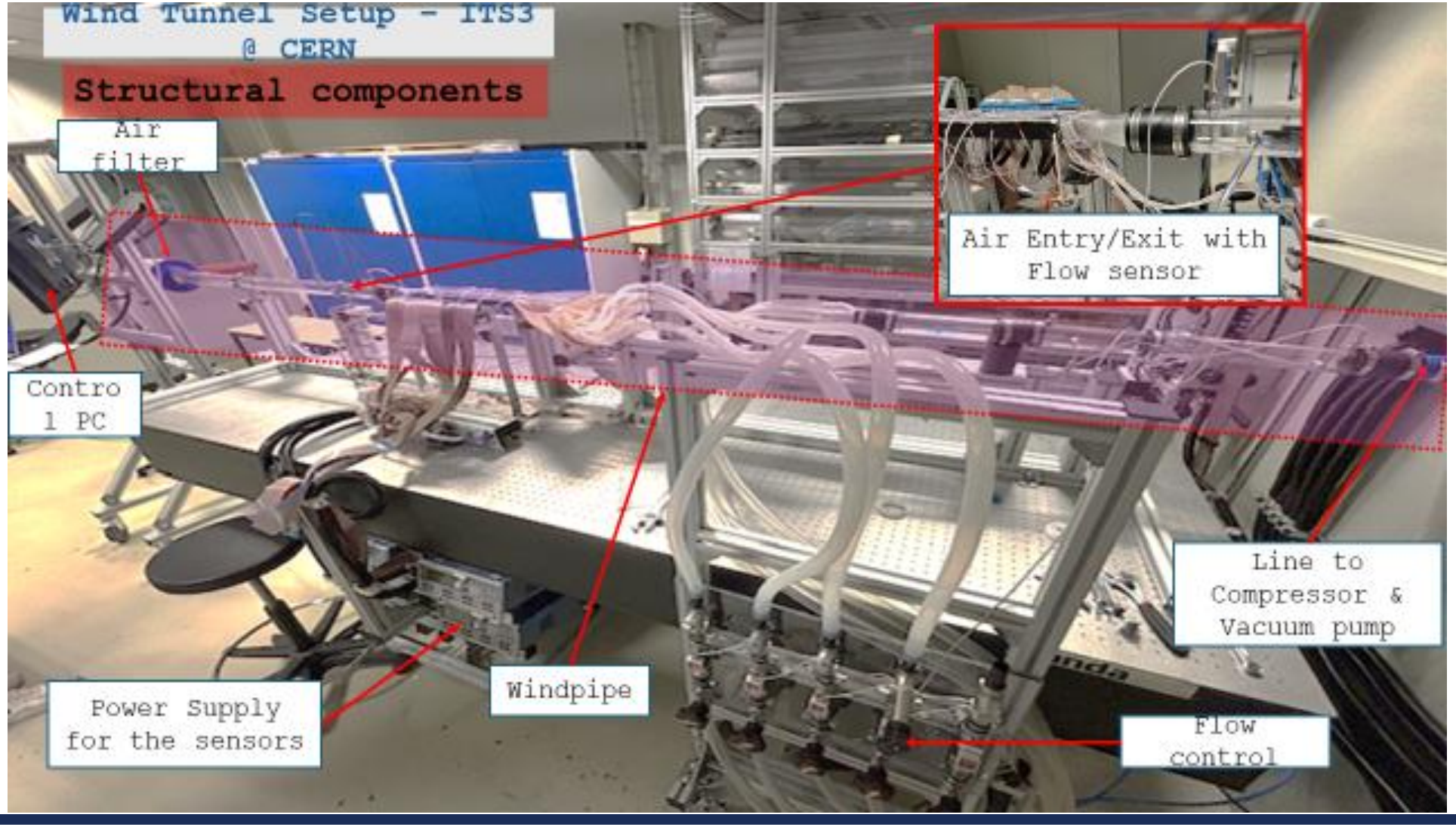




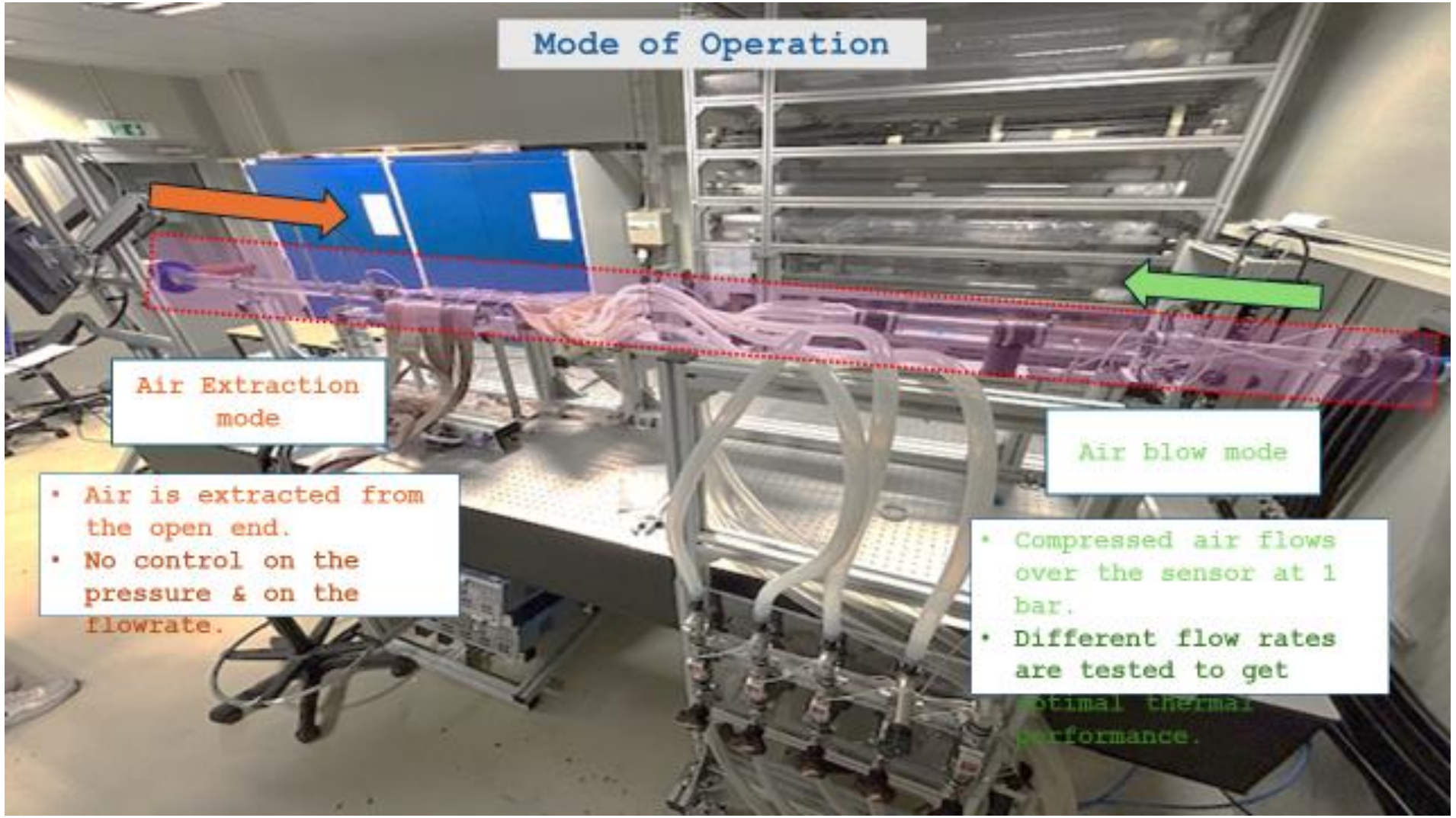
Wind tunnel setup – Sensor components



Wind tunnel setup – Structural components



Wind tunnel setup – Operation mode



Air Flow Rate