Thermal dissipation test of MIMOSA sensor

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25.05.2018

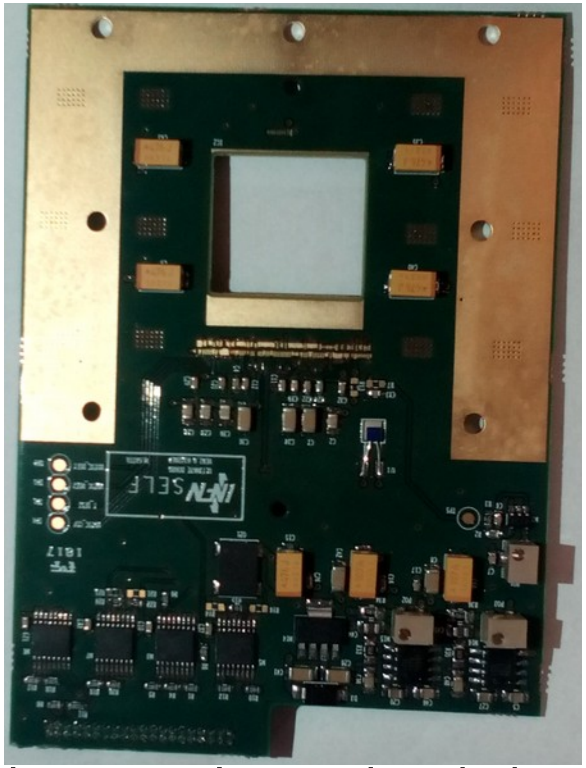
* partially supported by BG NSF, DN08-14/14.12.2016
& LNF-SU 70-06-497/07-10-2014

Recall from last week

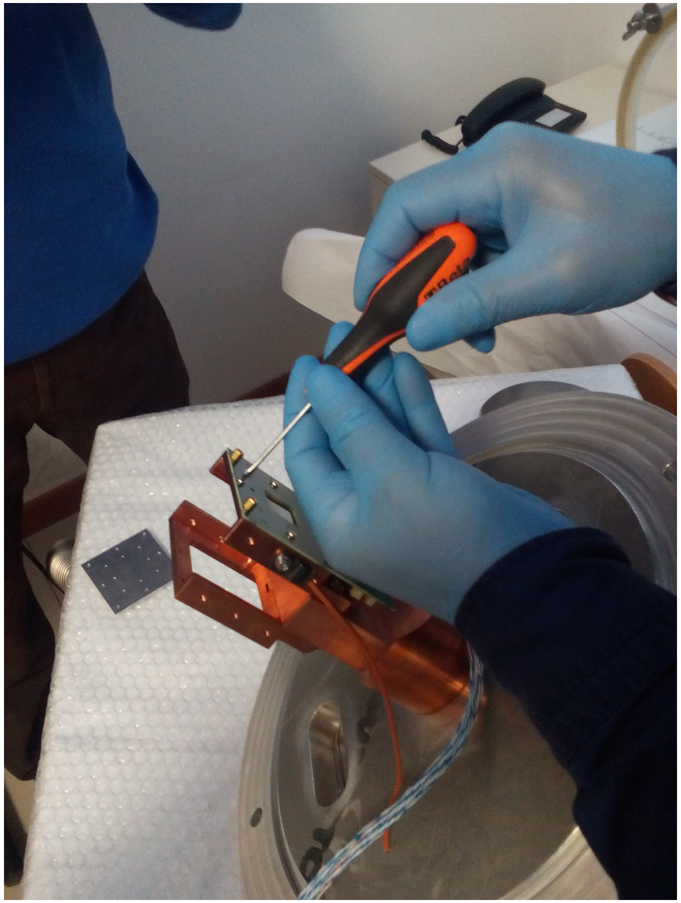
- MIMOSA initial thermal checks in air performed – sensor temperature ~37° C
- Using FLIR 335 IR camera, thanks to Fabio Ferrarotto and LABE, Roma 1
- Attempt to use the on-chip diode to monitor the temperature change - successful
  - Open anode diode realized in the Si substrate
  - However, cathode is connected to the “ground”
  - Measure the voltage, necessary to induce current of 100 μA
  - Dependence V-T observed, but influenced by the operational status of the chip (off, initialized, running)
    - Induced by the shift of the “ground” potential when changing the power state
- A manometer found and attached to the chamber (after some machining) for rough pressure control (~0.05 bar resolution)

Thermal dissipation

- MIMOSA chip power consumption – of the order of 0.7 W
- Three paths for thermal dissipation
  - Thermal conductance
  - Dissipation through air
  - Radiation
- Which one is the dominant for the MIMOSA chip?
- Radiation:
  - 2 cm x 2 cm surface (x 2, up and down)
  - Emission: $P = 2*S*\sigma T^4 = 0.4$ W @ 40° C
  - But also absorption from the nearby surroundings, so a better estimator is $\Delta(T^4)$ $\Rightarrow$ 140 – 180 mW, depending on temperature (0 – 10 degrees C)
  - Not bad as a start, but the thermal conductance is clearly necessary and **critical** for the MIMOSA cooling, or the chip will go above 100° C
    - Also because the radiative value would be for the two chips together, since they are looking at each other with one of the surfaces….



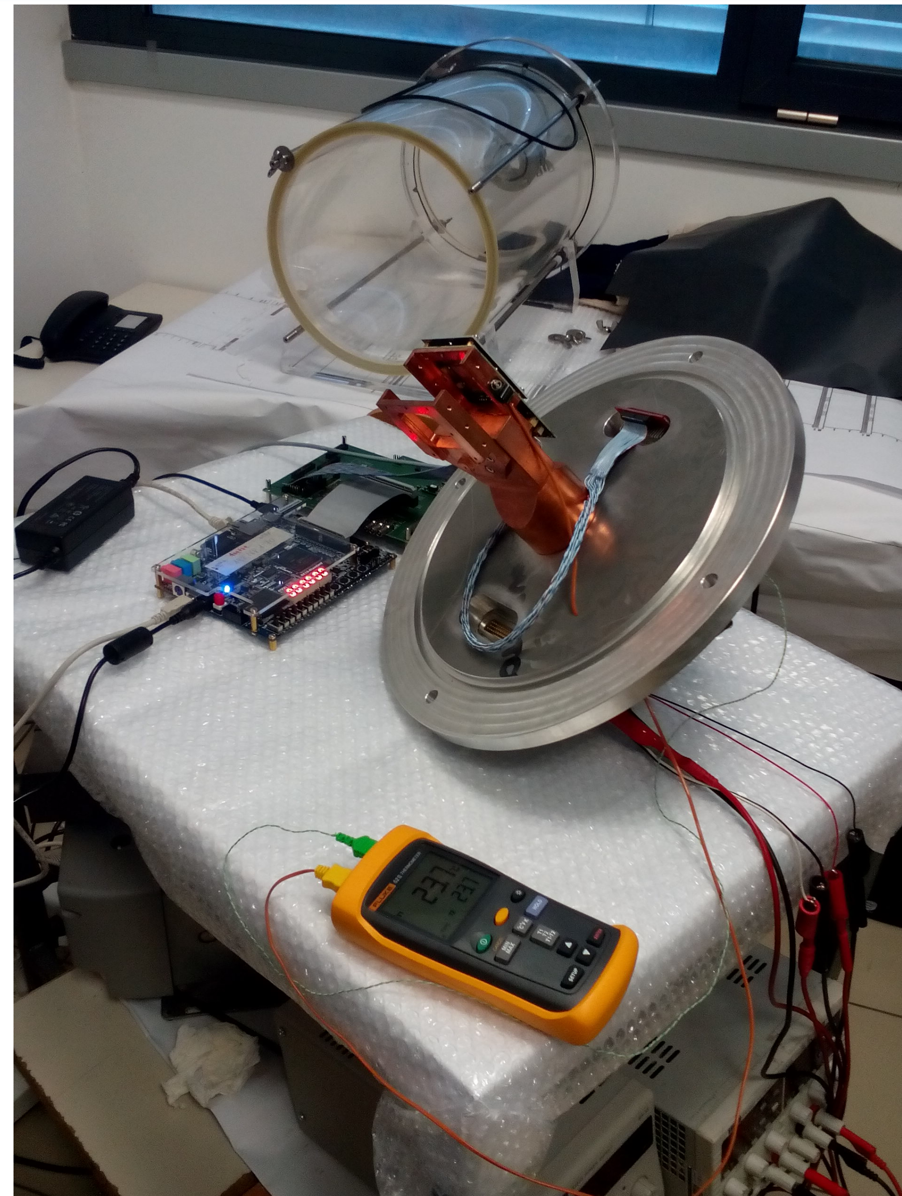
Mounting MIMOSA



- Carefully attached to the copper support frame
  - Note: chip is only 50 μm thick!
  - The protective metal plate was placed on top
  - Surfaces were cleaned with alcohol

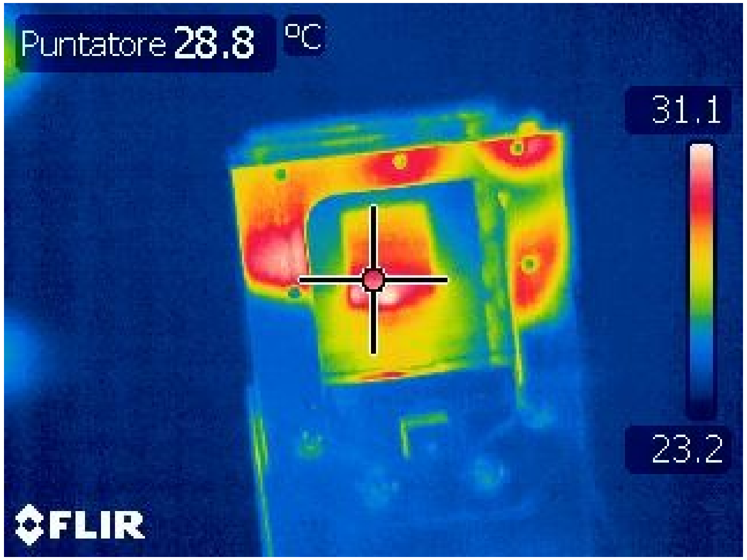
MIMOSA in air

- Using the Peltier cooler, attached to the copper arm
- Goal of the test: to see if and how the sensor follows the temperature on the copper arm
- Measuring:
  - Temperature on the inner part of the copper arm - $\mathbf{T_{IN}}$
  - Temperature of the outside part of the arm (close to the Peltier) - $\mathbf{T_{OUT}}$
  - Temperature of the hottest part of the sensor (using the thermocamera) - $\mathbf{T_{MIMOSA}}$
  - The voltage on the on-chip diode (100 μA current generator applied) - **U**

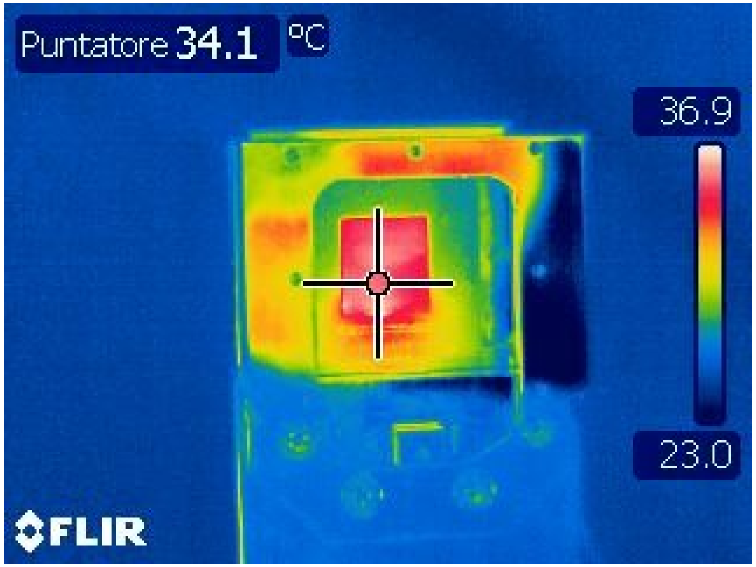


MIMOSA in air

MIMOSA initialized



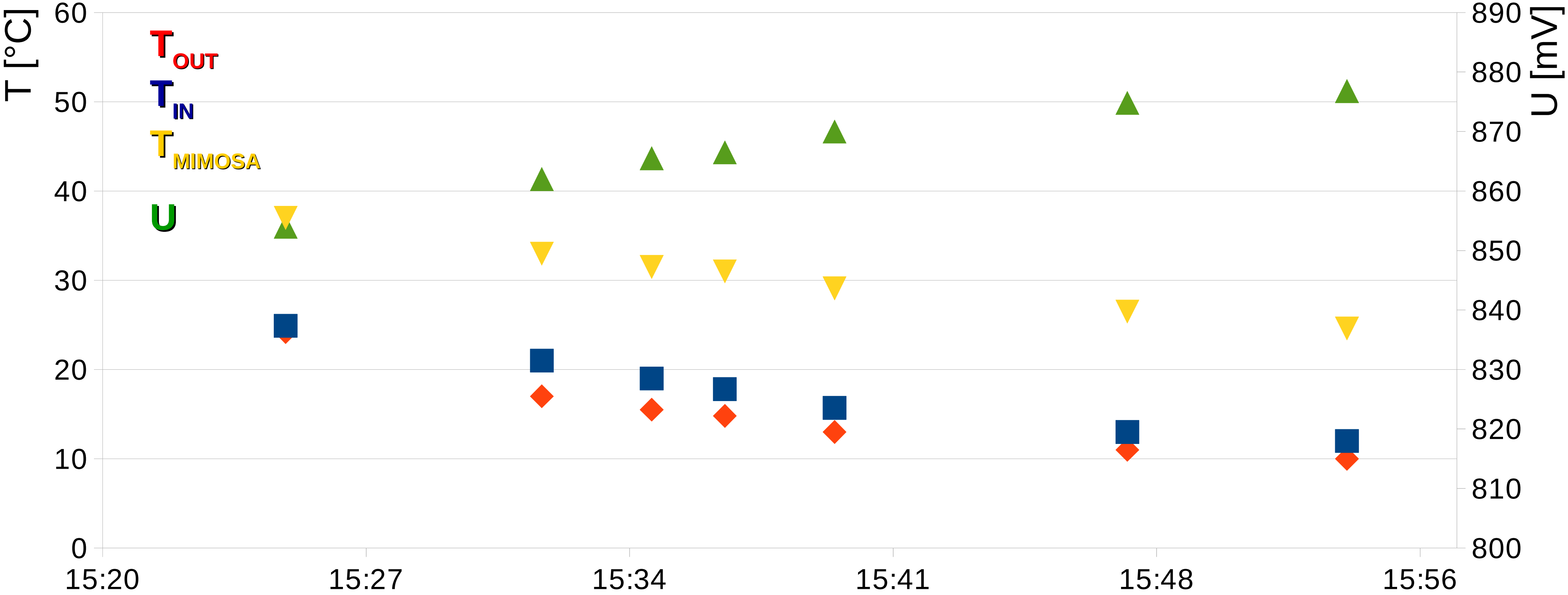
MIMOSA ON



- Reaching stable running condition (thermal equilibrium) @ 37° C
  - As expected
- Diode voltage: 854 mV
- Temperature in the room (and of the copper bar) ~24° C

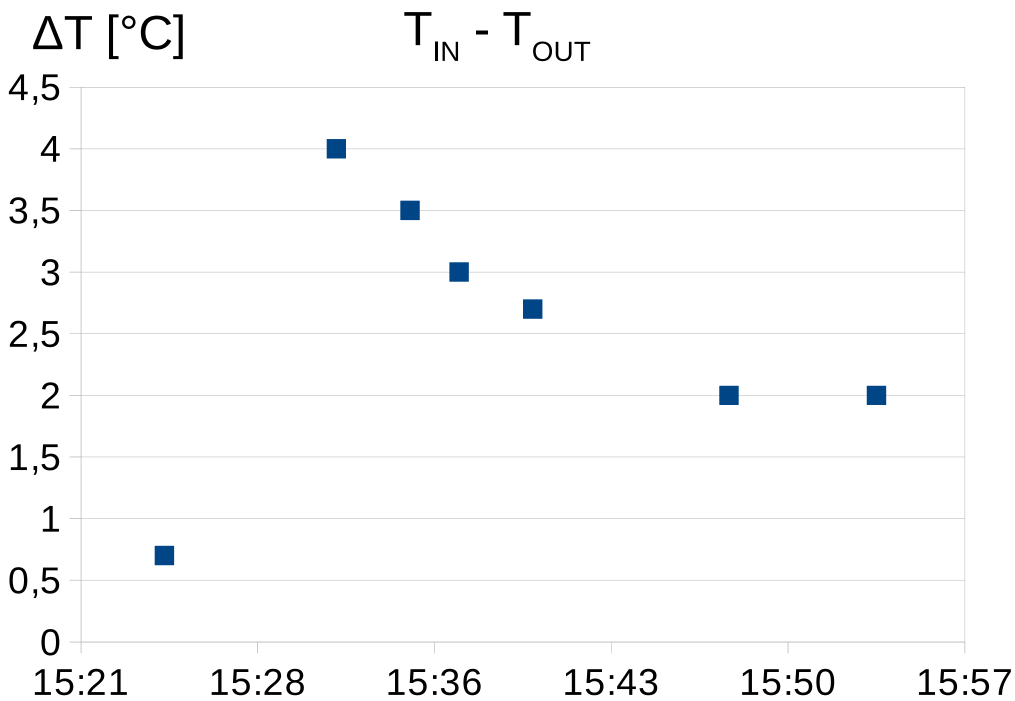
Next step: switch on the Peltier

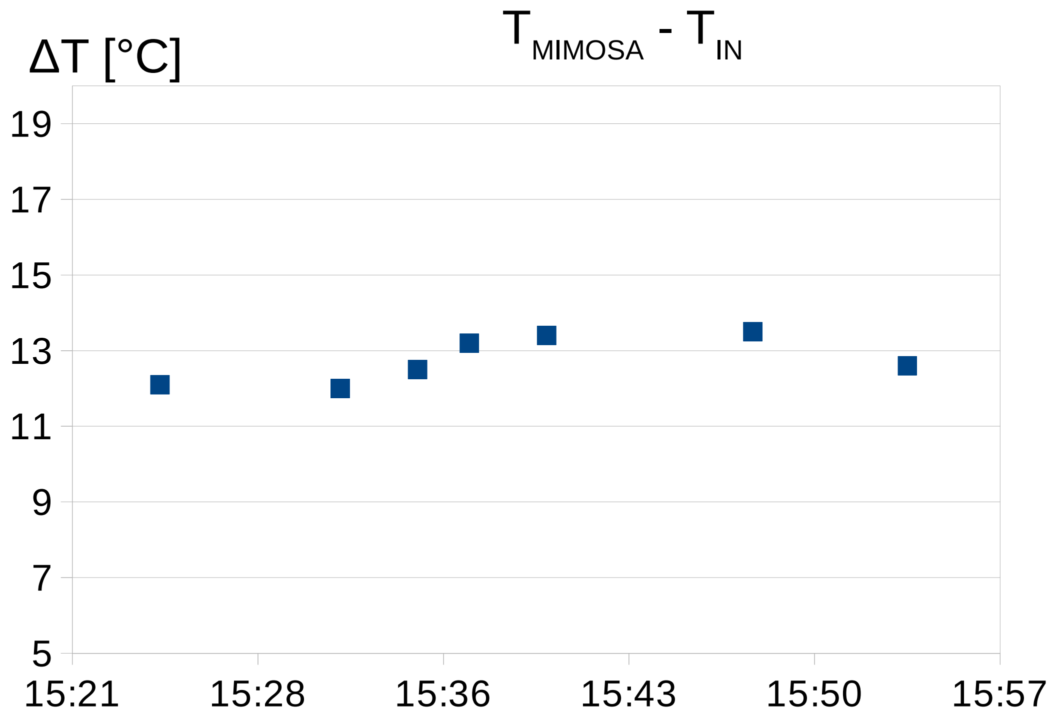
MIMOSA in air



- MIMOSA chip temperature followed the temperature on the copper bar!
- The copper bar went into equilibrium at about 12 degrees (and got condense…)
- About 30 min necessary for the system to stabilize
- Temperature of the chip equalized with the ambient air temperature (gas started to warm the chip)

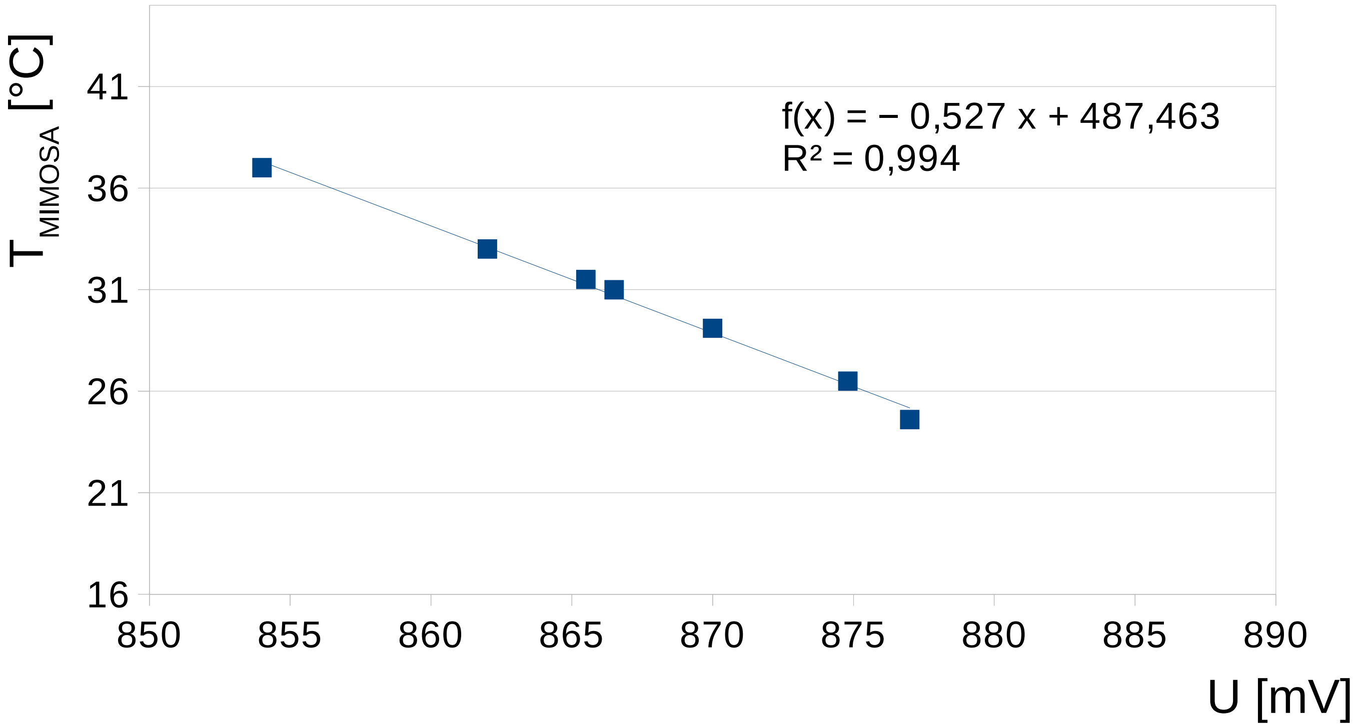
MIMOSA in air





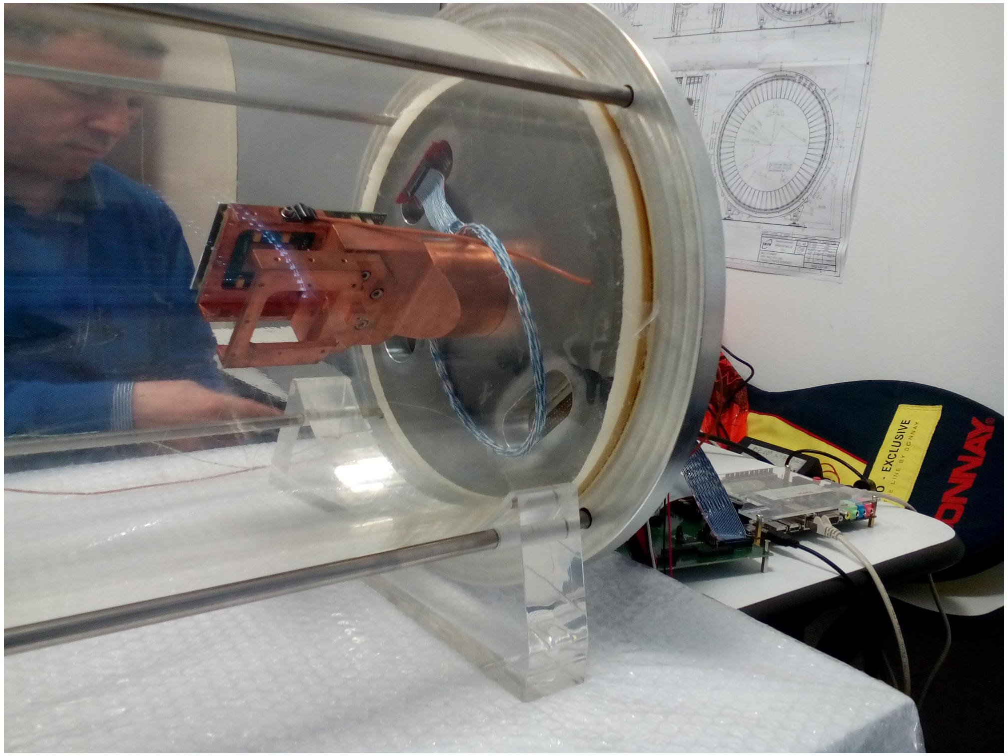
- After the initial jump (when switching on the Peltier) the temperature difference stabilized (indication of equilibrium)
- The MIMOSA temperature was within ~12-13 degrees above the copper temperature!

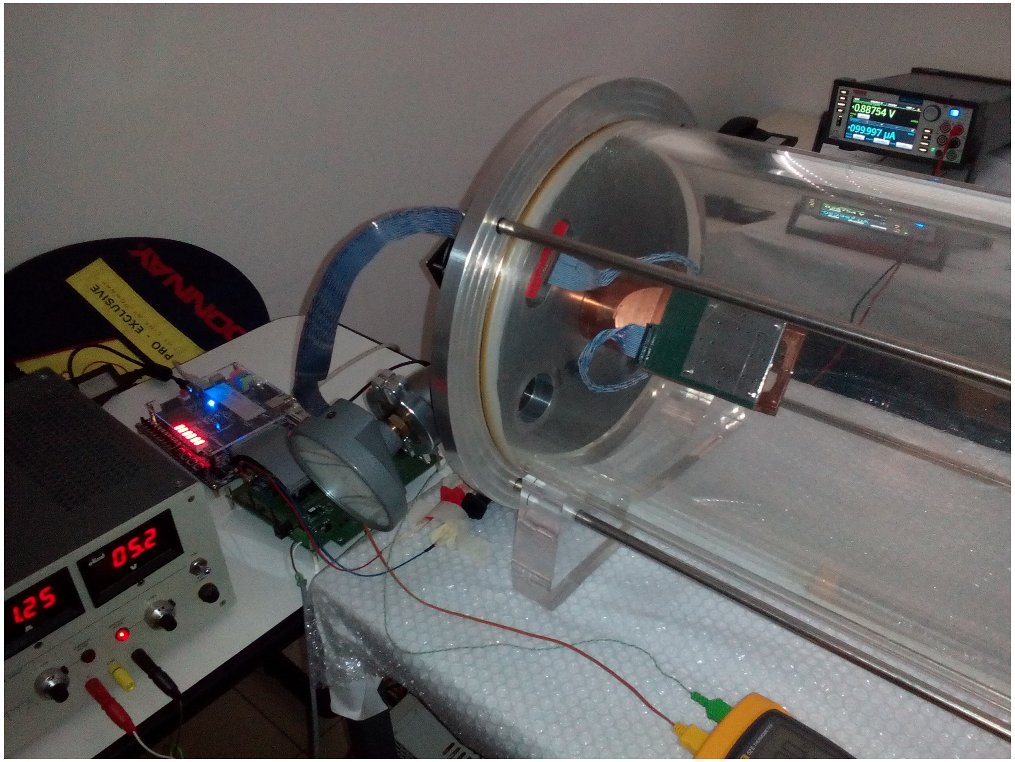
Temperature calibration



- The presence of IR camera allowed “precise” calibration of the Keitley voltage measurement → Chip temperature
- The curve is very much close to linear with slope of 0.53°C per mV
  - Gave optimism that we can actually have a temperature information for the MIMOSA chip in vacuum!
  - NOTE: calibration is unique to the setup, if something changes, the calibration should be repeated!

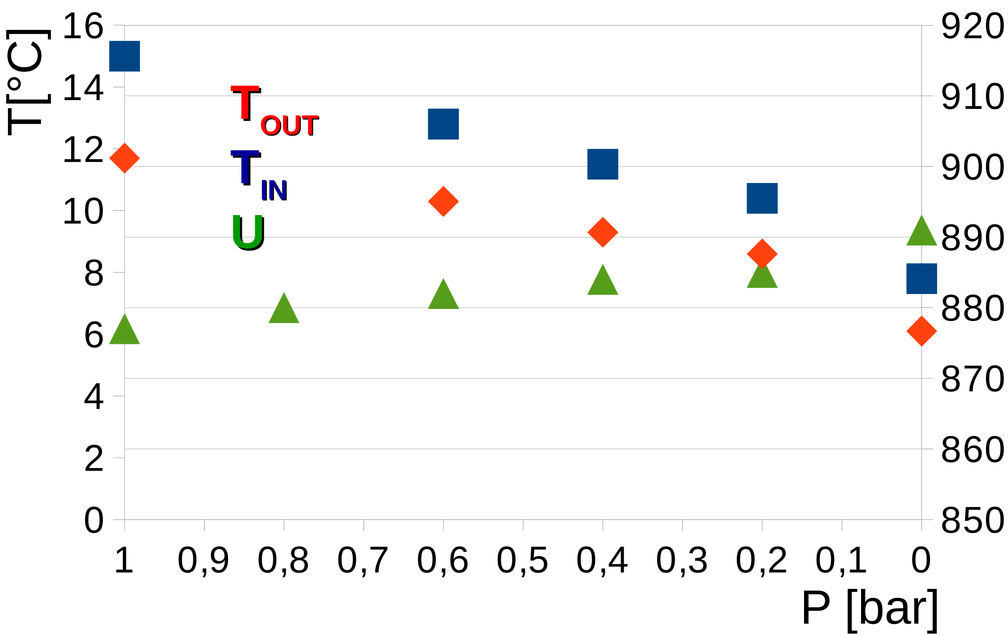
MIMOSA in vacuum

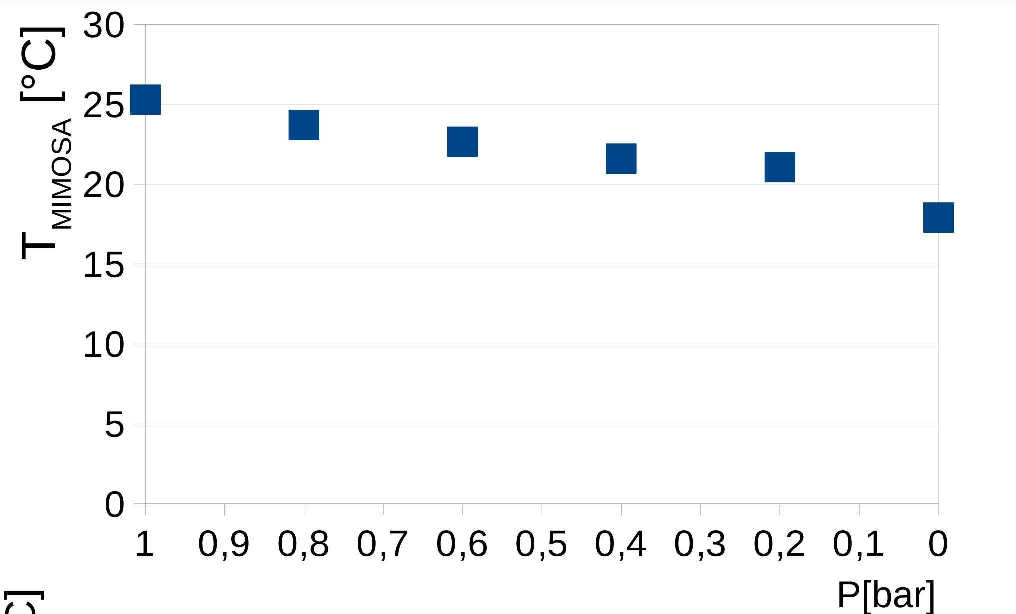


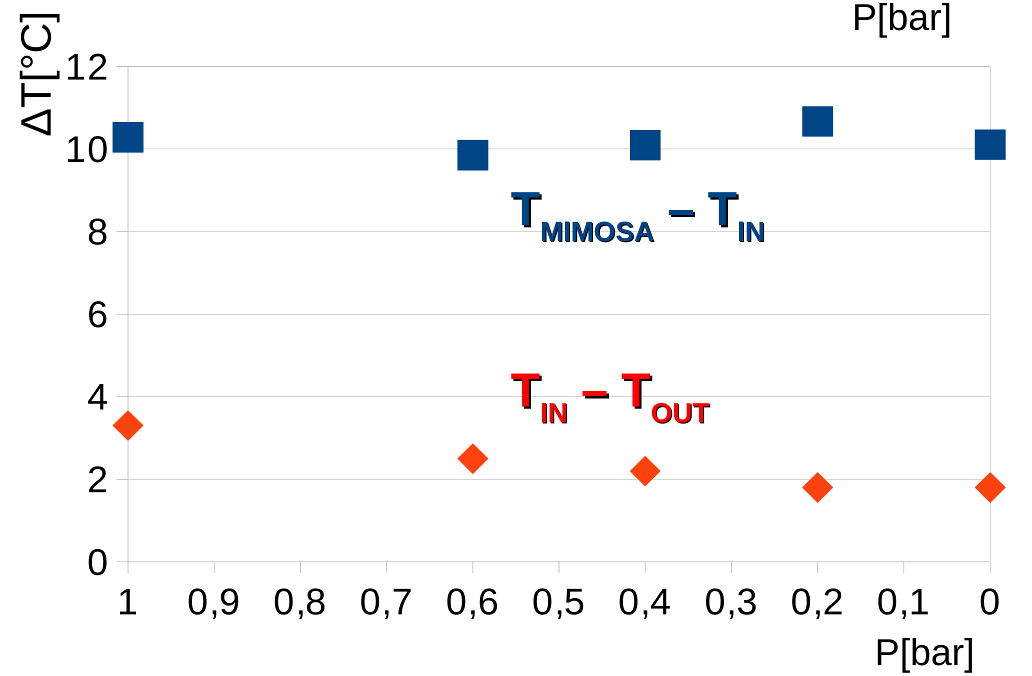


- Two rounds of evacuation of the chamber performed
  - First to remove the condensation from the in-air test
  - Second, step evacuation – the nominal test of MIMOSA
- With a lot of optimism due to the very good results from in-air test

MIMOSA in vacuum







- The calibration of the U_{DIOD} allowed to follow the temperature
  - The chip stayed cool during the tests
  - Difference chip – copper ~ 10°C
  - Difference IN – OUT: ~ 2°C (an indication of the thermal flow)

Conclusions

- The test of the MIMOSA thermal dissipation in vacuum performed
  - After the necessary and very important preparatory work
- The internal diode, if properly calibrated, is extremely useful for the knowledge of the operating conditions
- The thermal dissipation through the
  chip → 3 mm wide thermal contact with PCB → PCB metal strips →
  copper bar → Peltier
  is more than adequate solution for MIMOSA
- The work performed on the MIMOSA support and the PCB design and manufacturing is really wonderful
  - Congratulations to the mechanical and electronics services employed in the design of the system

MIMOSA works in vacuum and it works very very well :)

for the first time!