MAG-S.01.03-T020-D003

Analysis of new baseline and partial- or non-insulated coils

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Outline

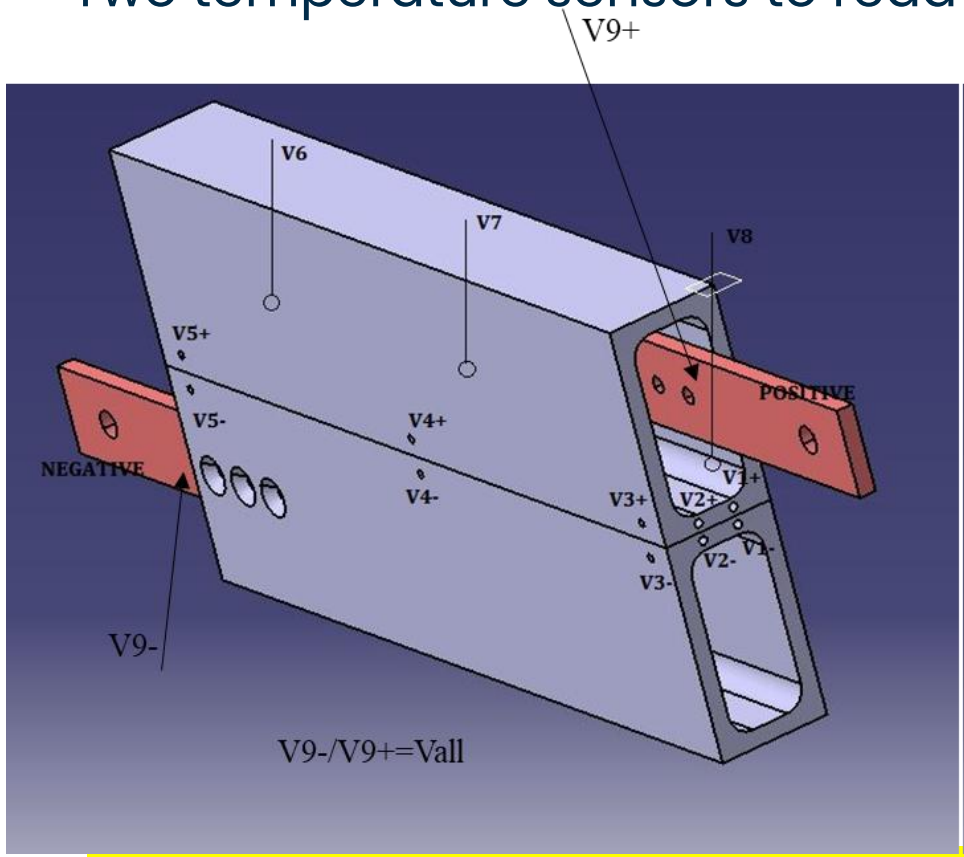
- 2025 tests on jacket sample
  - Summary of new thermal results

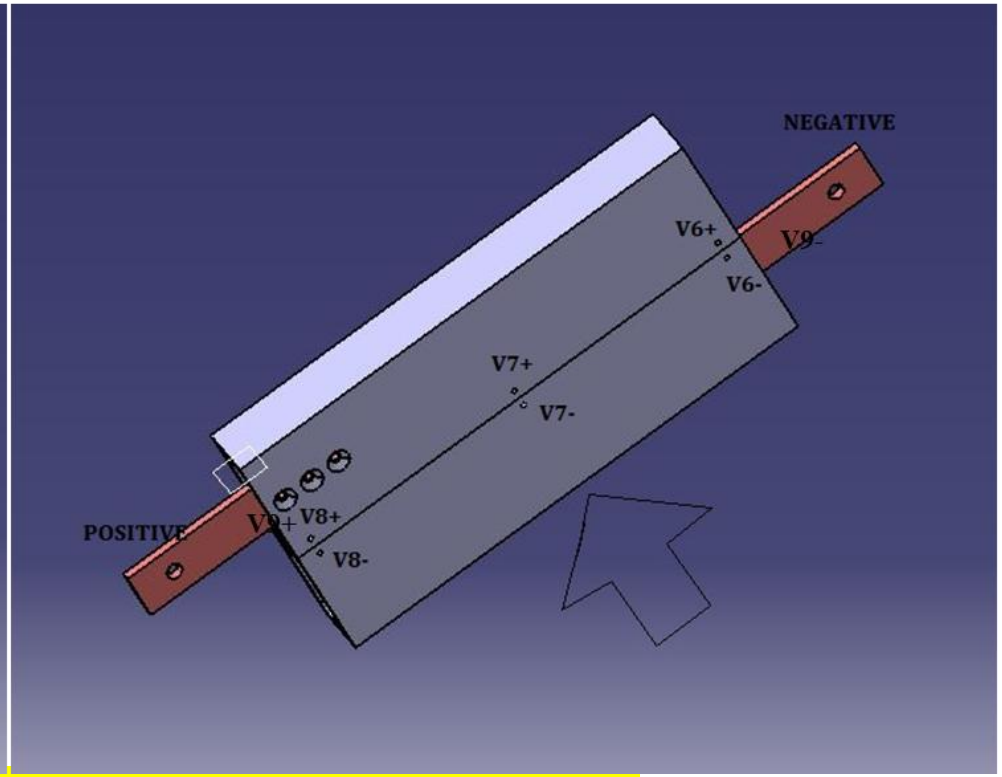
- Co-simulation for non-insulated coils electrical and thermal-hydraulic analysis

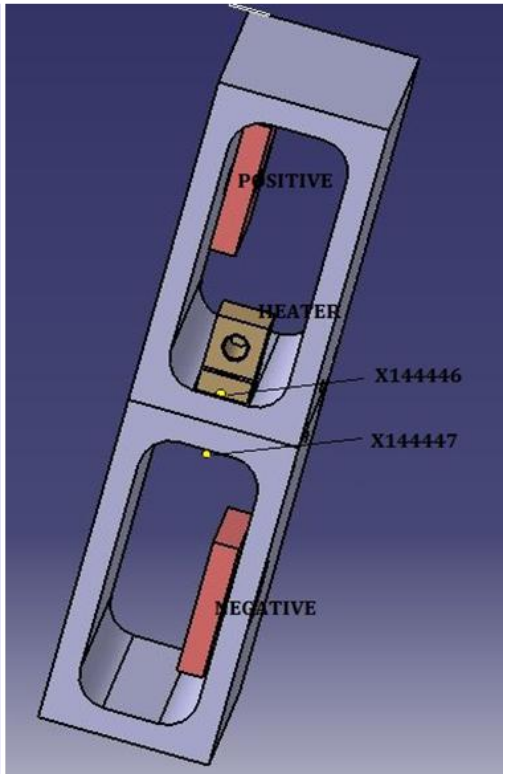
Aim of the tests on jacket sample

Measure the electric (and thermal) resistance across the jacket

- Nine voltage taps pairs to monitor contact resistance.
- Two temperature sensors to read the temperature (difference ΔT between two jackets)



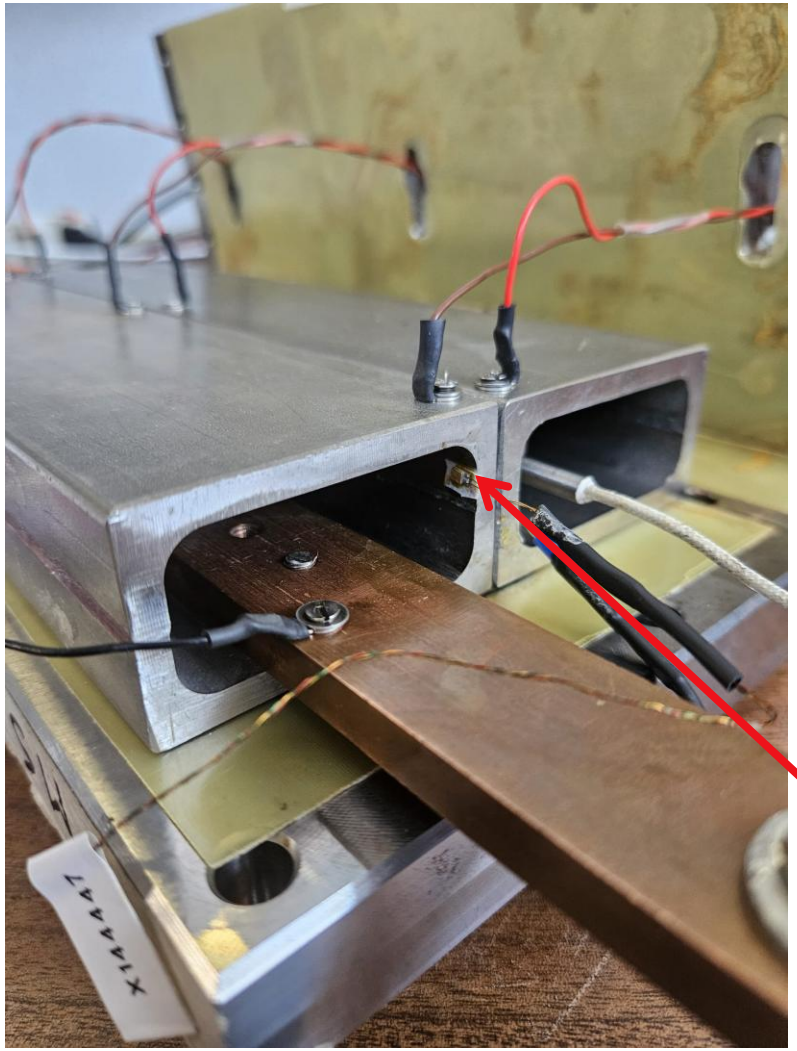


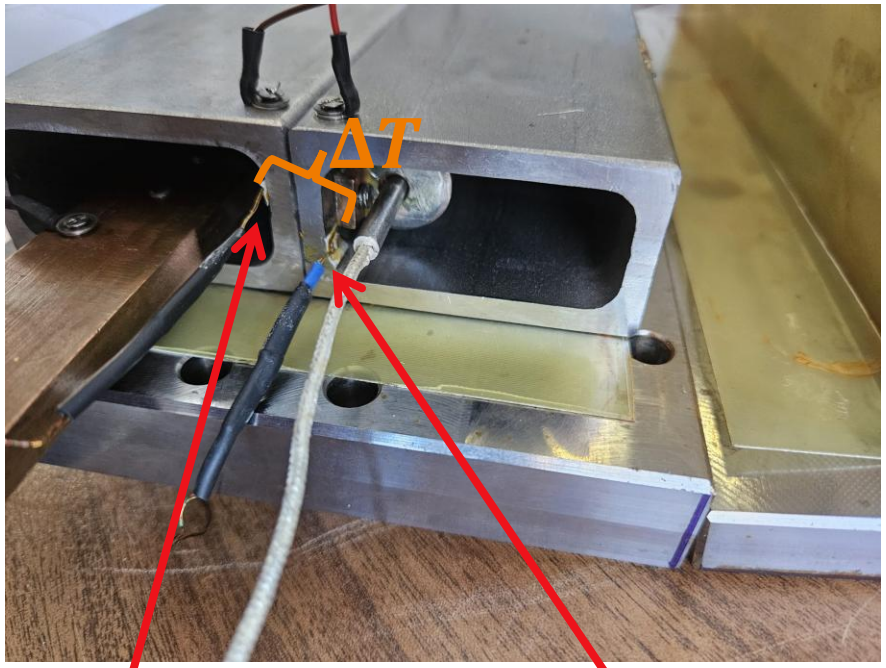


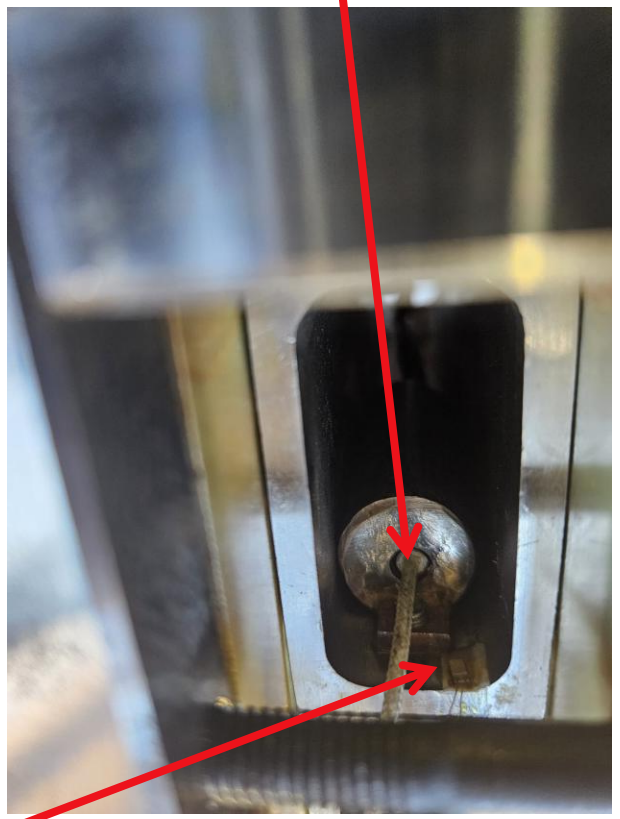
- First tests in 2024: unreliable temperature results at low T

New sample

Heater **under vacuum**





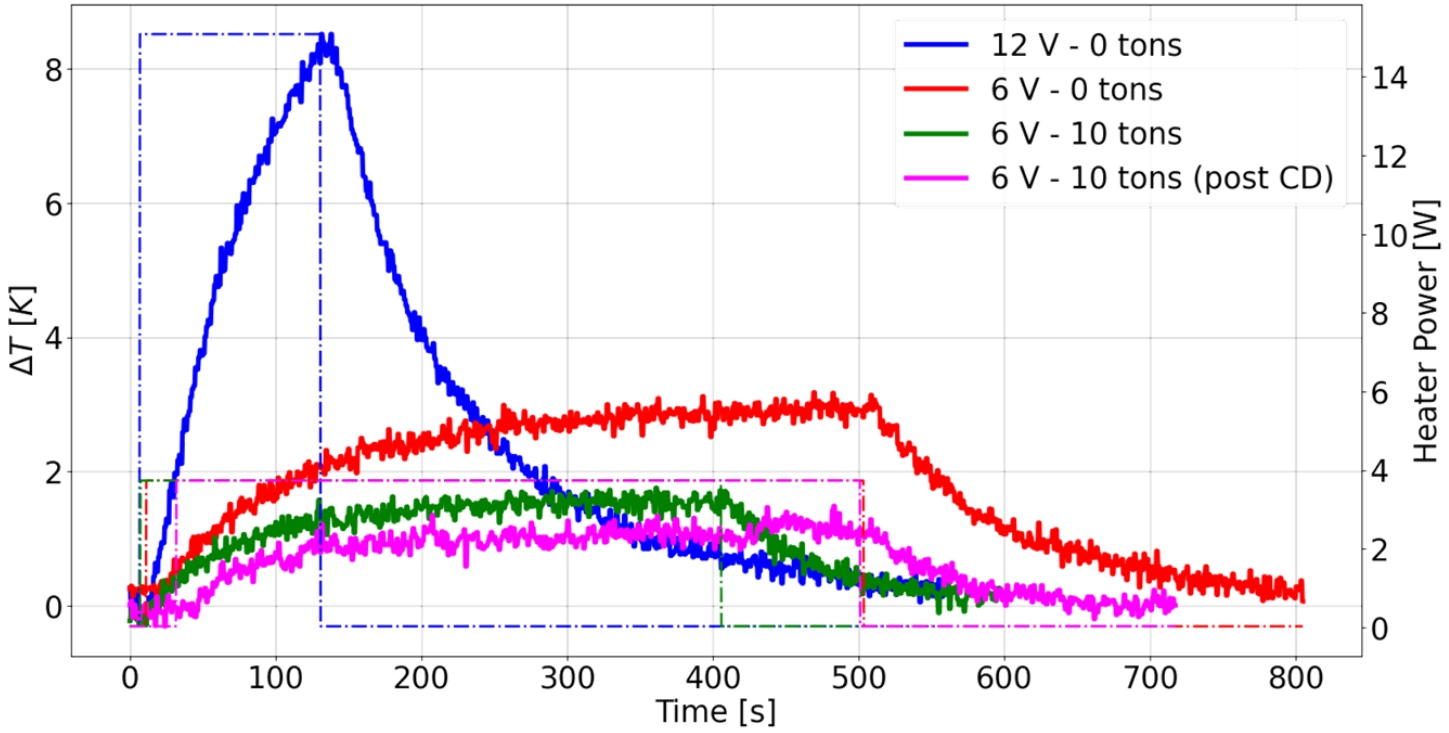


T1 (“lower” sensor)

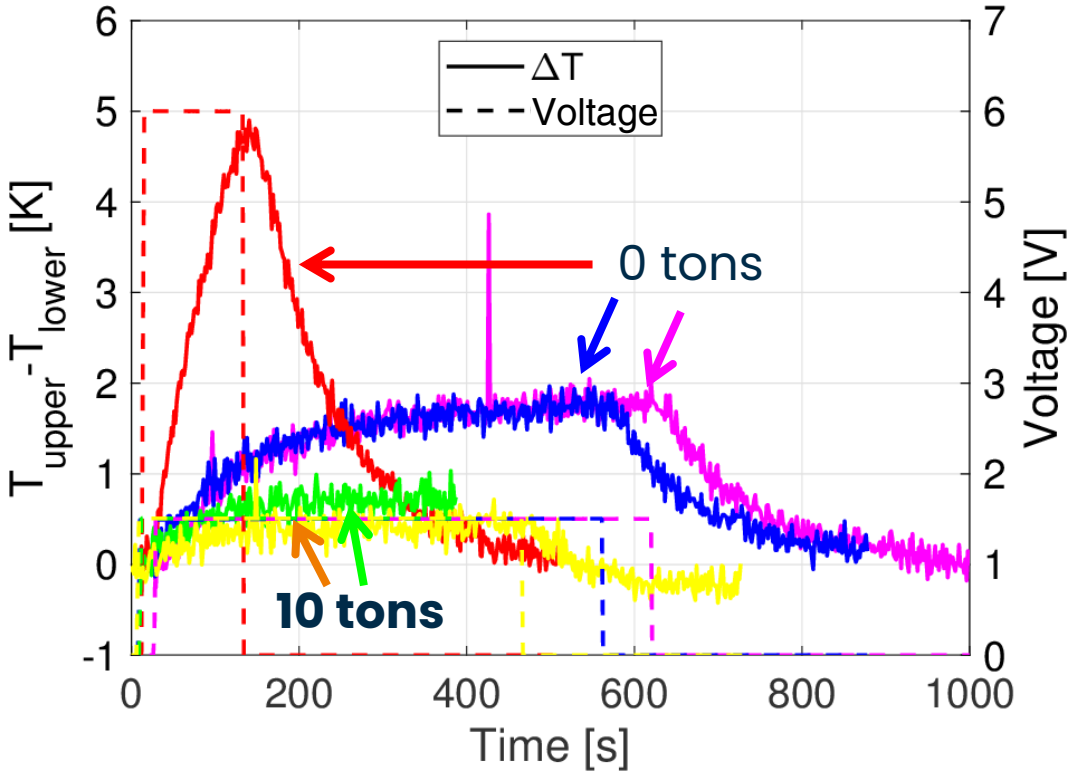
T2 (“upper” sensor)

Summary of the new thermal results: room T (295 K)

First campaign



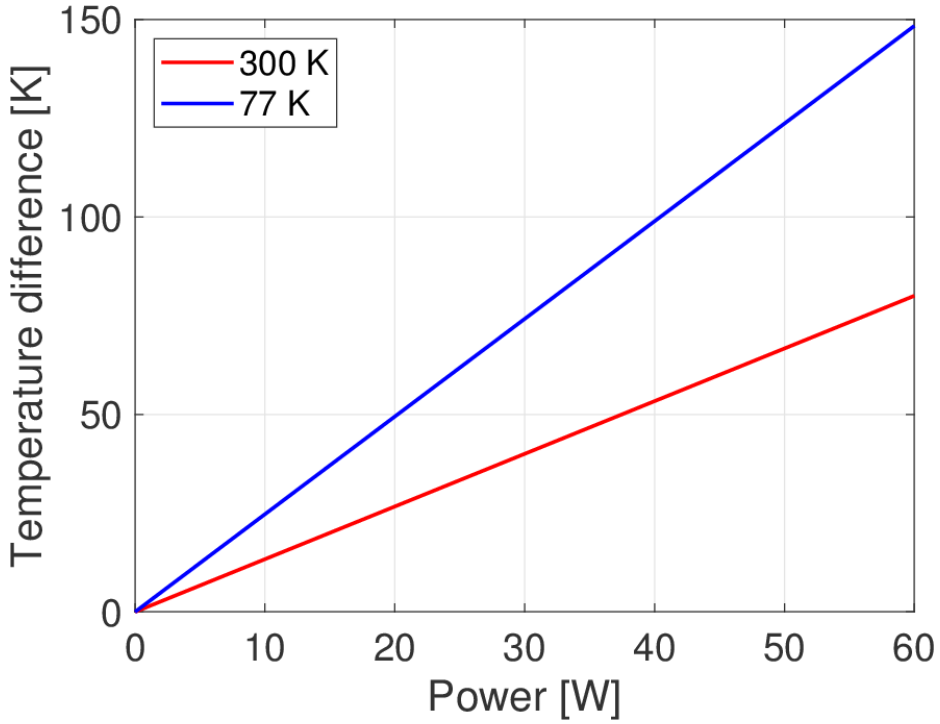
Second campaign



In the new campaign

- Smaller ΔT for higher pressure, as in the first campaign
- ΔT smaller wrt first campaign, for the same power → better thermal cupling for the sand-blasted sample
- At 1.2 V, the ΔT across the jacket should be ~5 K, *without any contact resistance*) → a non-negligible fraction of the power is dispersed

Comparison with theoretical ΔT



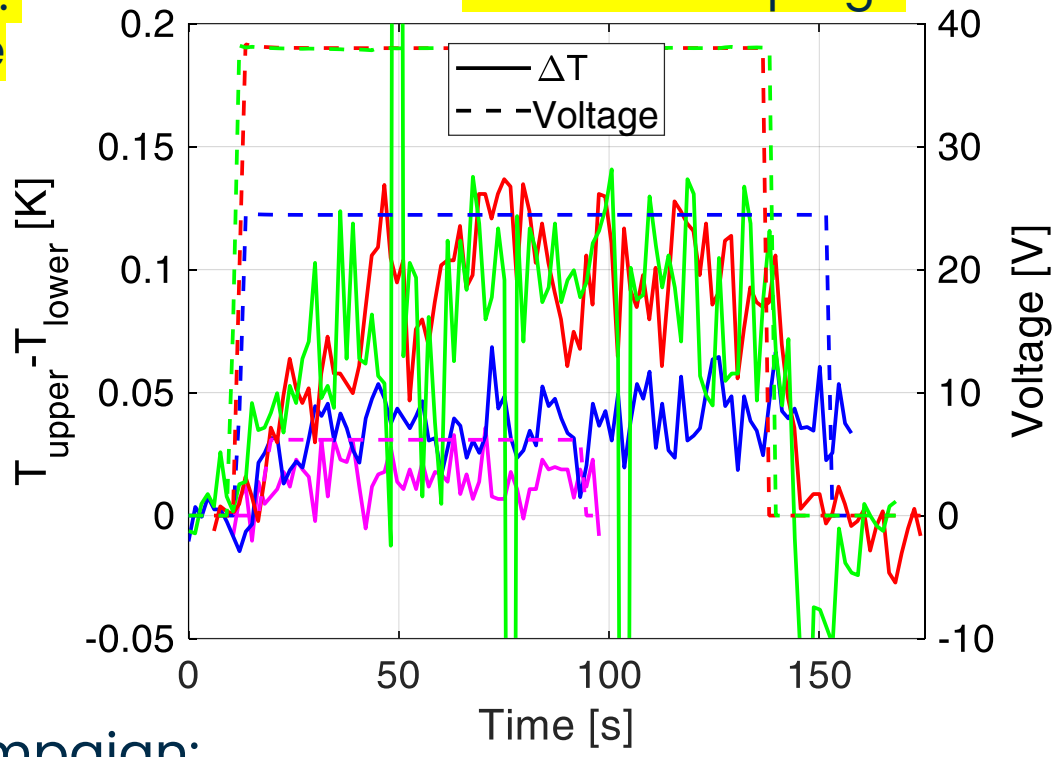
- At 1.2 V (~4 W), the ΔT across 1 cm jacket should be ~5 K, *without any contact resistance*

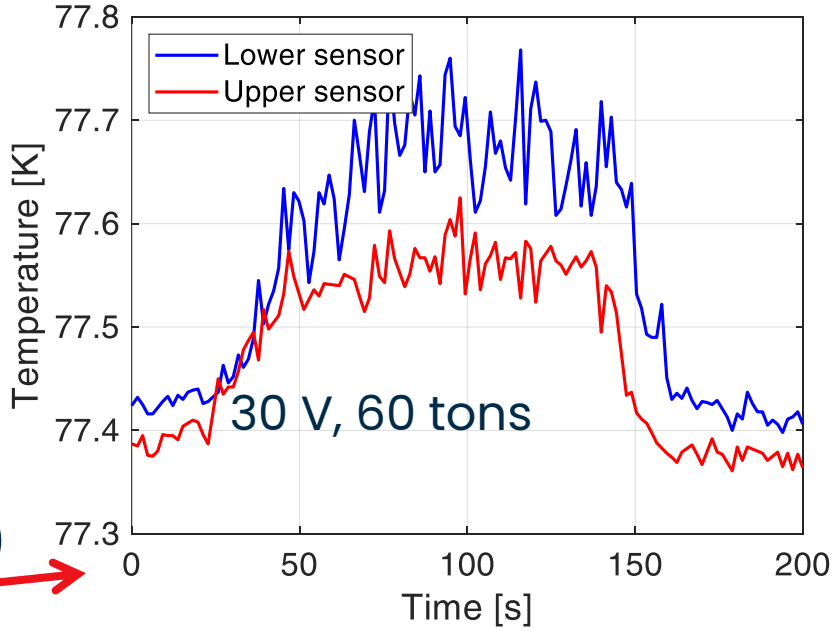
  → a non-negligible fraction of the power is «dispersed»

Summary of the new thermal results: cryogenic T (77 K)

First campaign: data unreliable

Second campaign



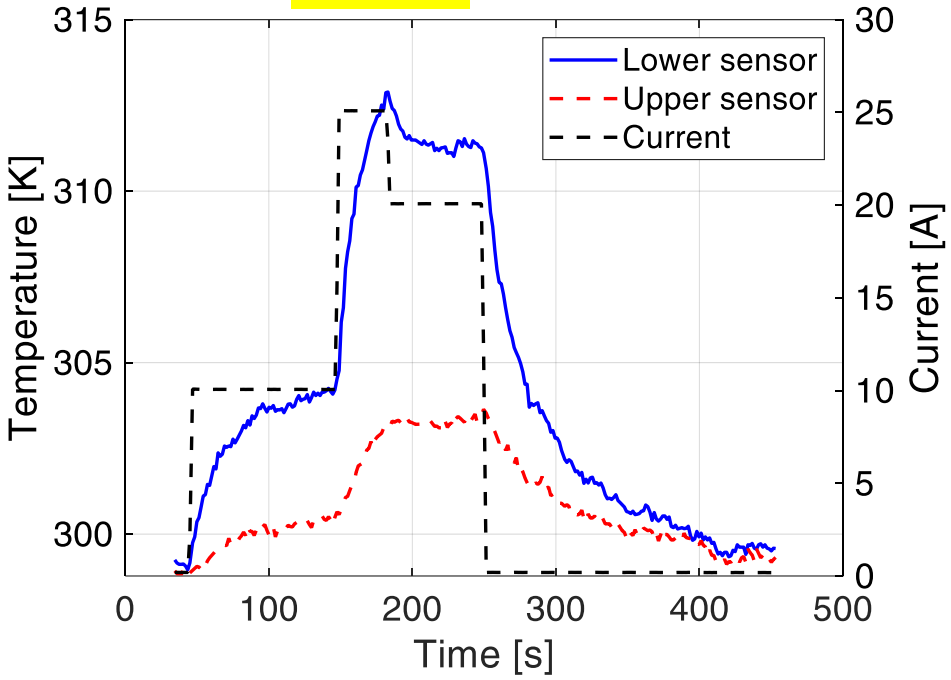


In the new campaign:

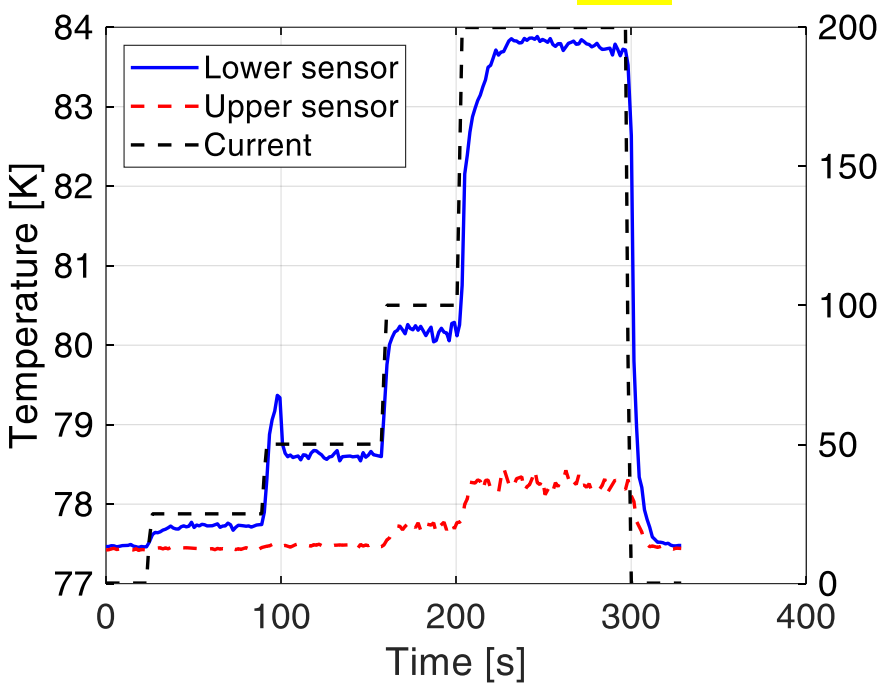
- measured ΔT at 0 t is consistent with power (scaled ~V^2)
- ΔT <0 for 60 t → data unreliable

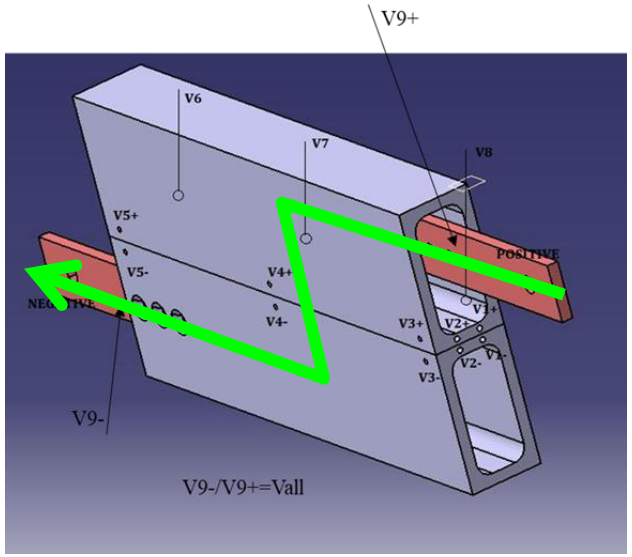
Effect of current

Room T



77 K



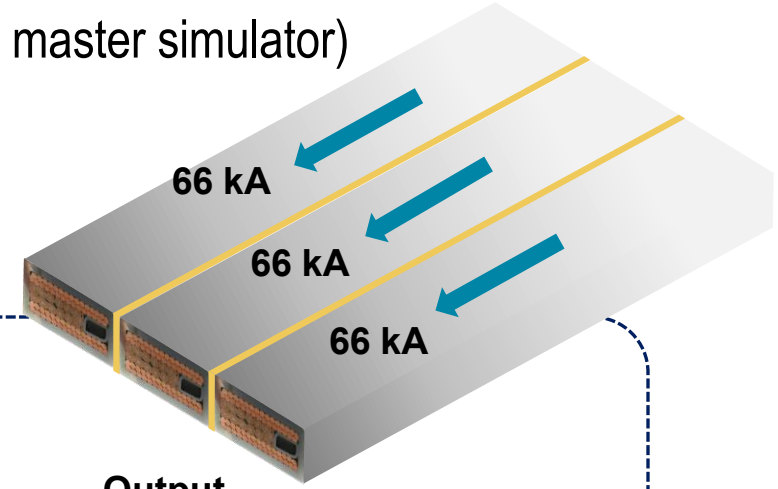


- Higher Joule power (← current) in the lower jacket, where the (-) lead is installed
- → Possibility to exploit temperature measurements to assess the uniformity of the contact

Preliminary TH-EM Coupled Analysis – Straight Cables

In collaboration with Seoul National University

- Co-simulation interface (using FMI standard 2.0)
  - <1> Each numerical model is calculated for a designated time step (controlled by the master simulator)
  - <2> Calculated outputs are exchanged between the two models.
  - <3> The master simulator determines the time step (Δt) and mesh size.
  - <4> Repeat <1> ~ <3>



Master Simulator

- time step (Δt) control
- mesh size control

Output
- Joule heat dissipation
- Transport current
- Voltage

Input
- time step (Δt)
- mesh size (Δt)
- Superconductor resistance (Rsc)

Input
- time step (Δt)
- mesh size (Δt)
- Joule heat dissipation
- Transport current

Output
- Superconductor resistance (Rsc)
- Temperature

Slave 1 (Circuit model)

Slave 2 (Thermal-Hydraulic)

fmi Functional Mock-up Interface
The leading standard to exchange dynamic simulation models

Preliminary TH-EM Coupled Analysis – Straight Cables: status (I)

Proceed by furtherly reduced steps:

1) **Test 0**: Prepare a python script that calls *an* fmu
2) Transform it into a python wrapper
3) Embed this wrapper in a library to be linked in the fortran project
4) Develop the fortran project that interacts with the model in the fmu

Preliminary TH-EM Coupled Analysis – Straight Cables: status (II)

Test 1: connect a simple fortran script (not the 4C code) to the circuit model developed by SNU in the .fmu file to artificially increase Rsc (expectation: current sharing among conductors)

1) Write a python wrapper that calls the fmu
2) Embed this wrapper in a library to be linked in the fortran project
3) Develop the fortran project that interacts with the model in the fmu

Conclusions

- New tests on jacket sample show consistent temperature measurements, but still not usable for *quantification* of the thermal contact resistance (further steps will be the use of some 3D model)
- Co-simulation for non-insulated coils electrical and thermal-hydraulic analysis is progressing with Seoul National University

Thank you for your kind attention

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