The Custom PCB cooling system for Magnet Box design

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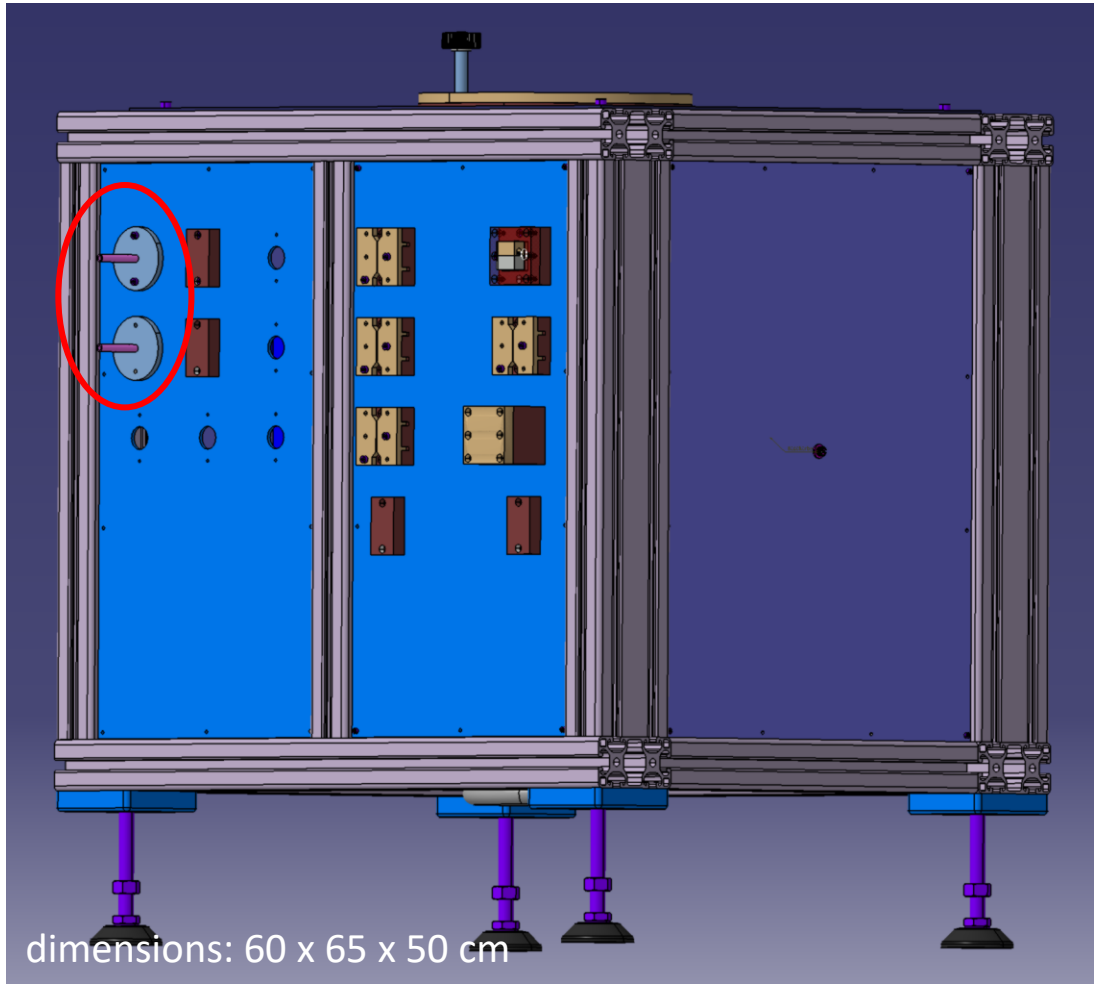
Magnet Box

- Test stand for new custom PCB design
  - Initial function checks, reliability, cooling, etc.
  - Main purpose study of magnetic field effects on PCB
- Light-tight system with a laser feedthrough
- Cooling :
  - Construction with liquid cooling and heat pipes
  - DC driven ventilation systems not preferred (electrical noise)



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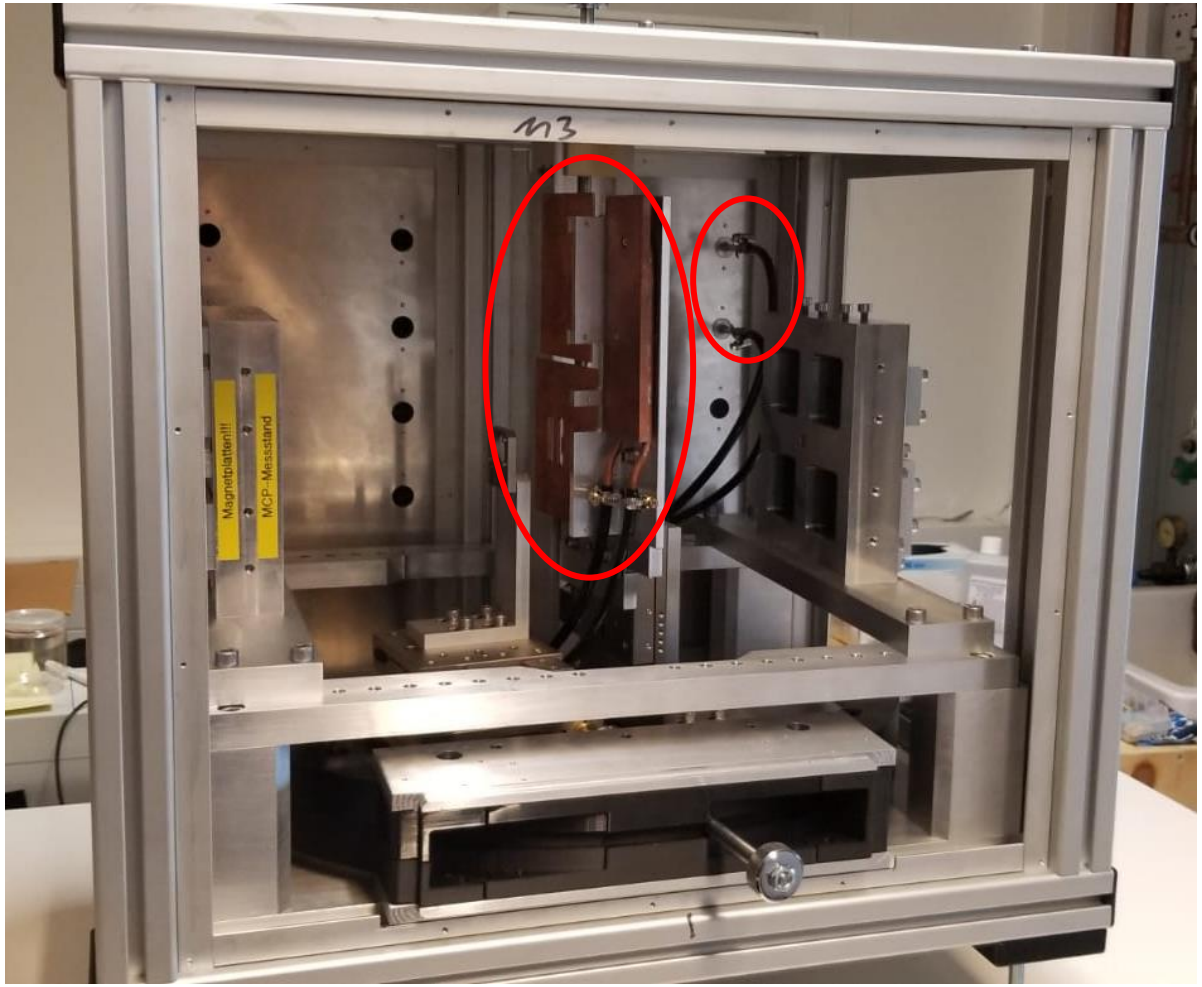
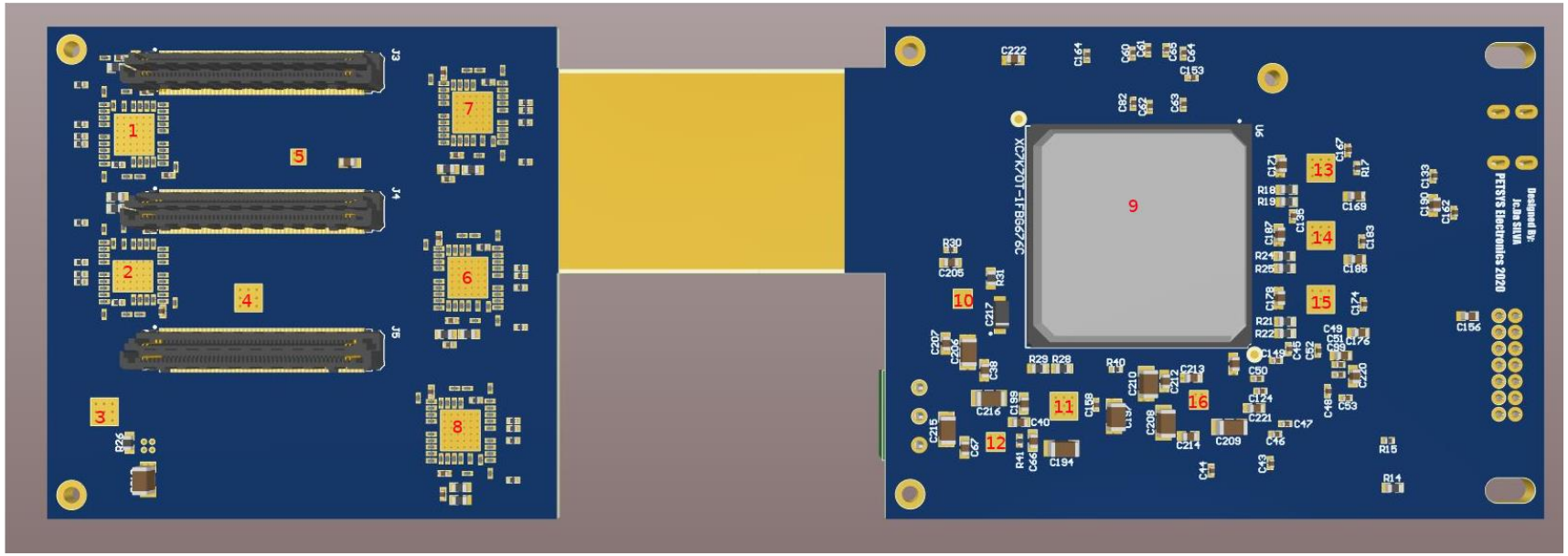


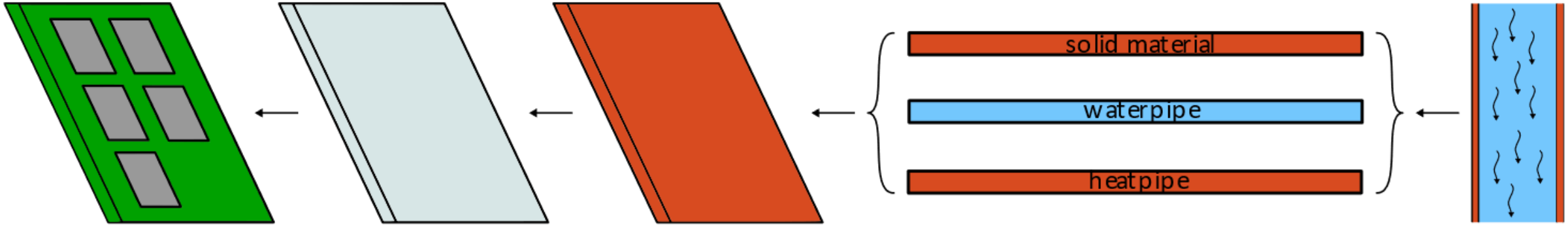
Custom PCB requirements

- Two rigid parts and FEASTMP dc/dc modules
- Target temperature around 18–20 °C
- Important:
  - Minimal risk for leakage of coolant
  - Prevention of short circuit

- 16 hot spots that need to be cooled down
- Total heat generation ~40 W



Cooling



circuit board with heat sources

soft thermal pad

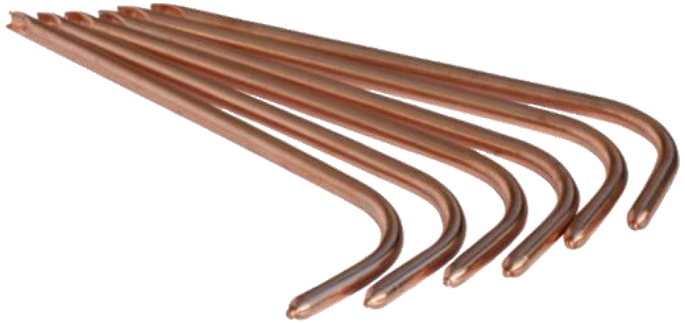
copper plate

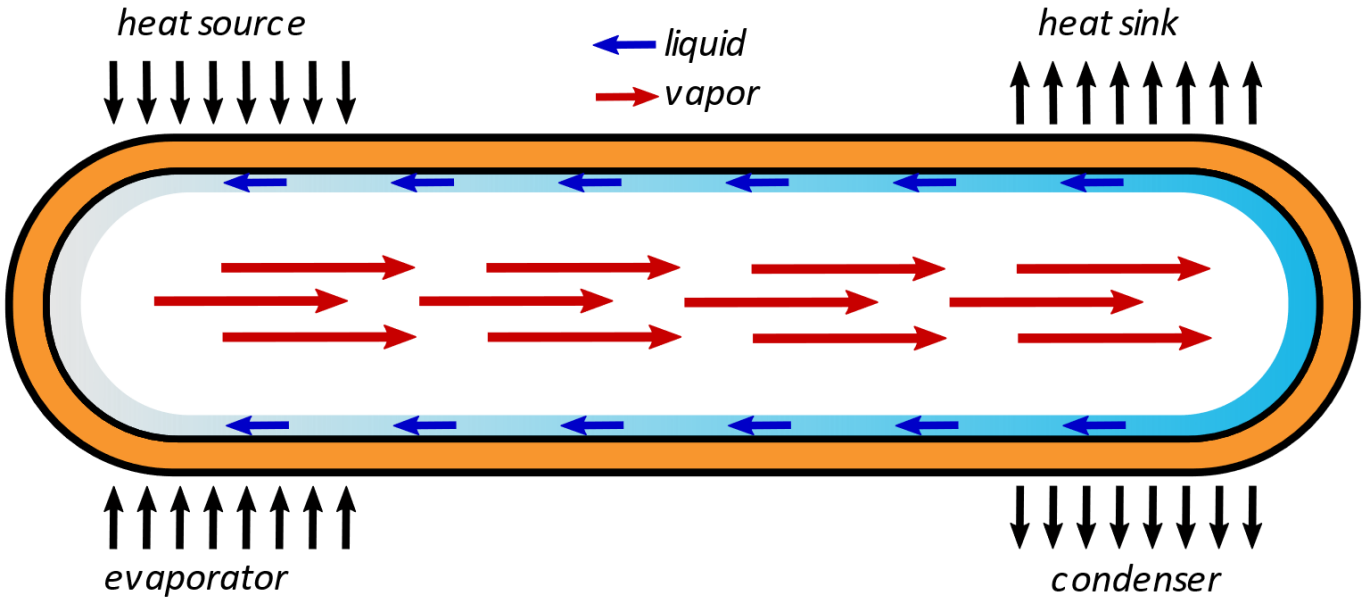
3 methods for connection and heat transfer

main water cycle

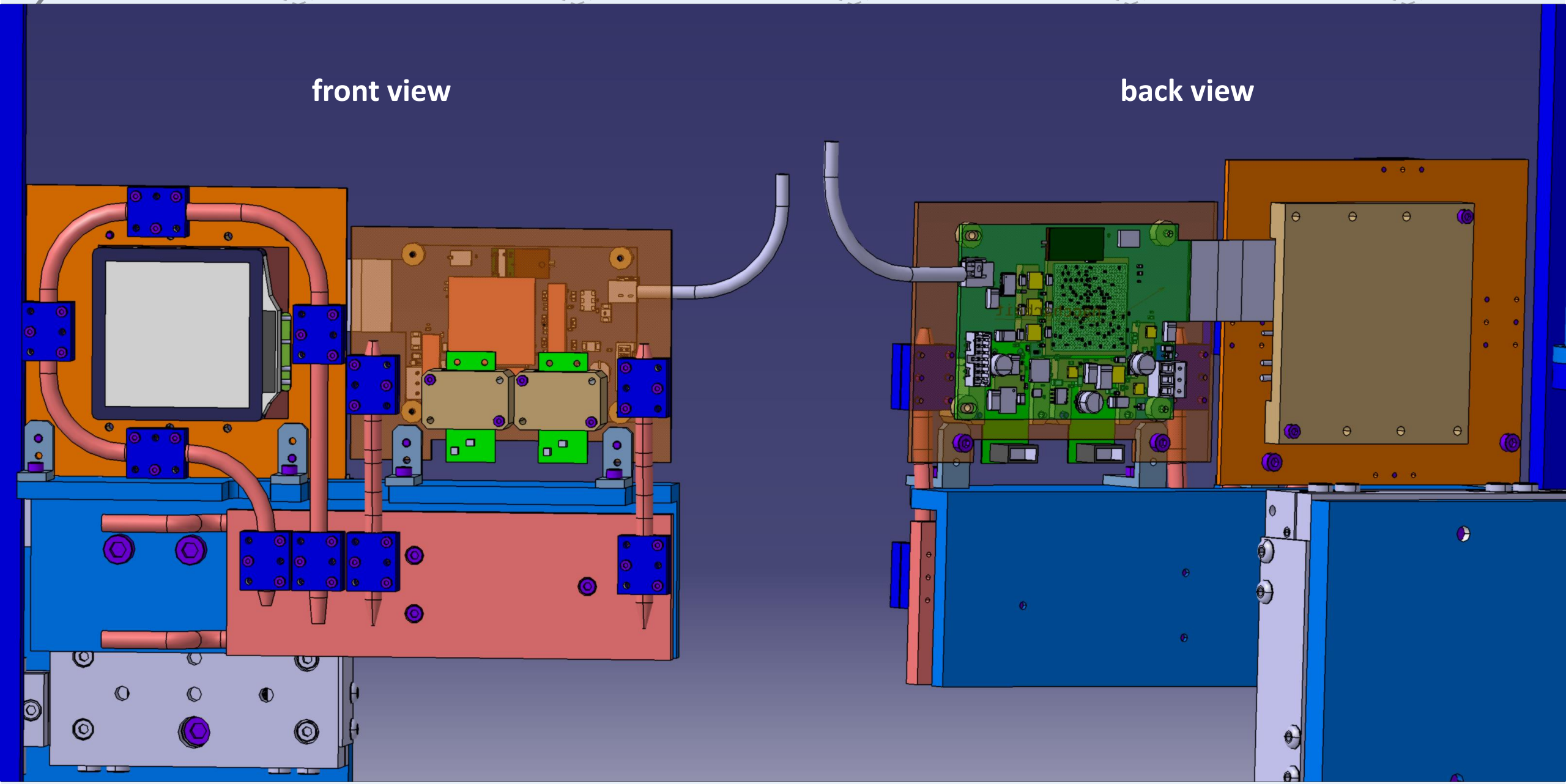
Heat pipe

- Effective and flexible device for heat transfer
- Uses thermal conductivity and phase transition

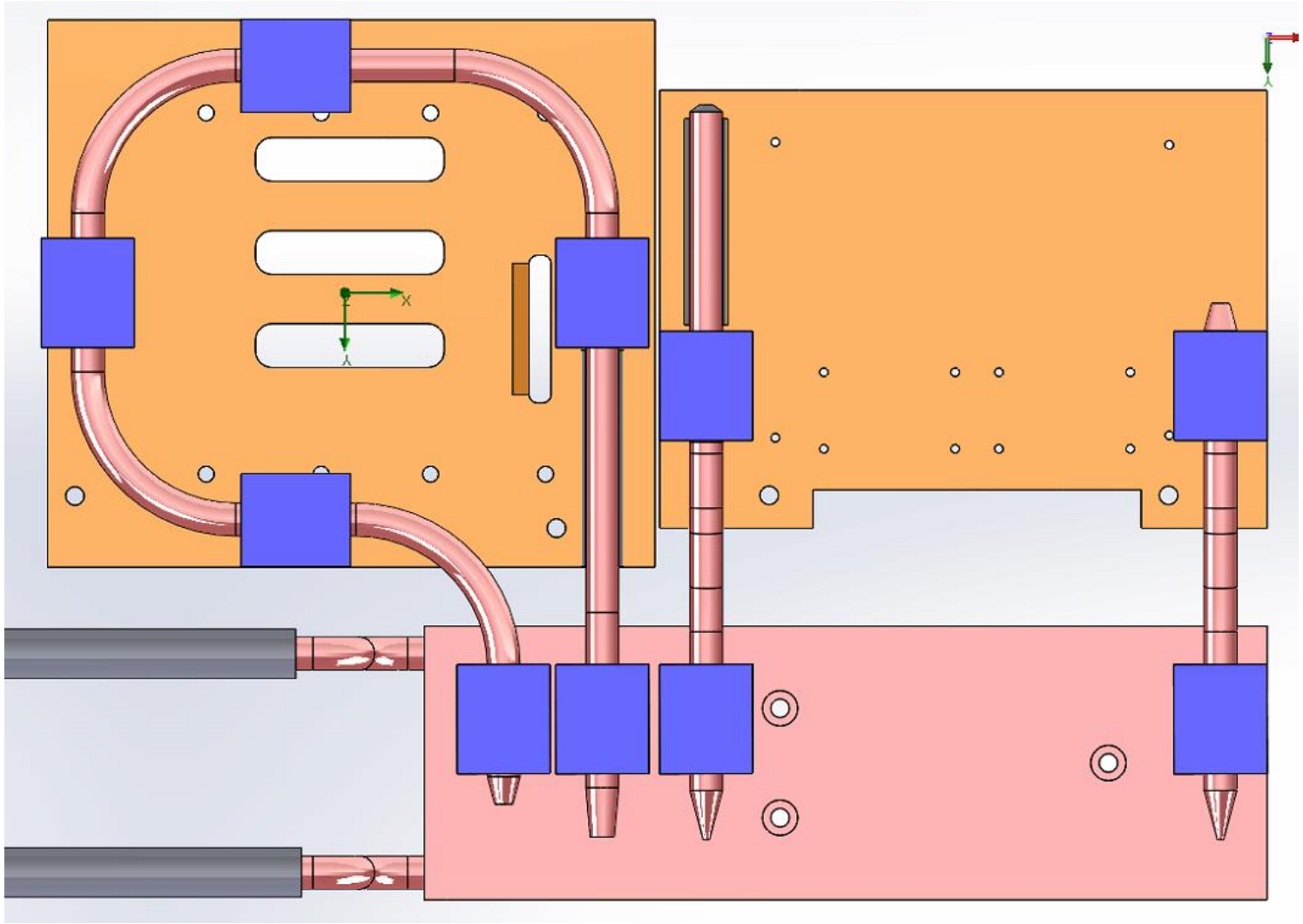




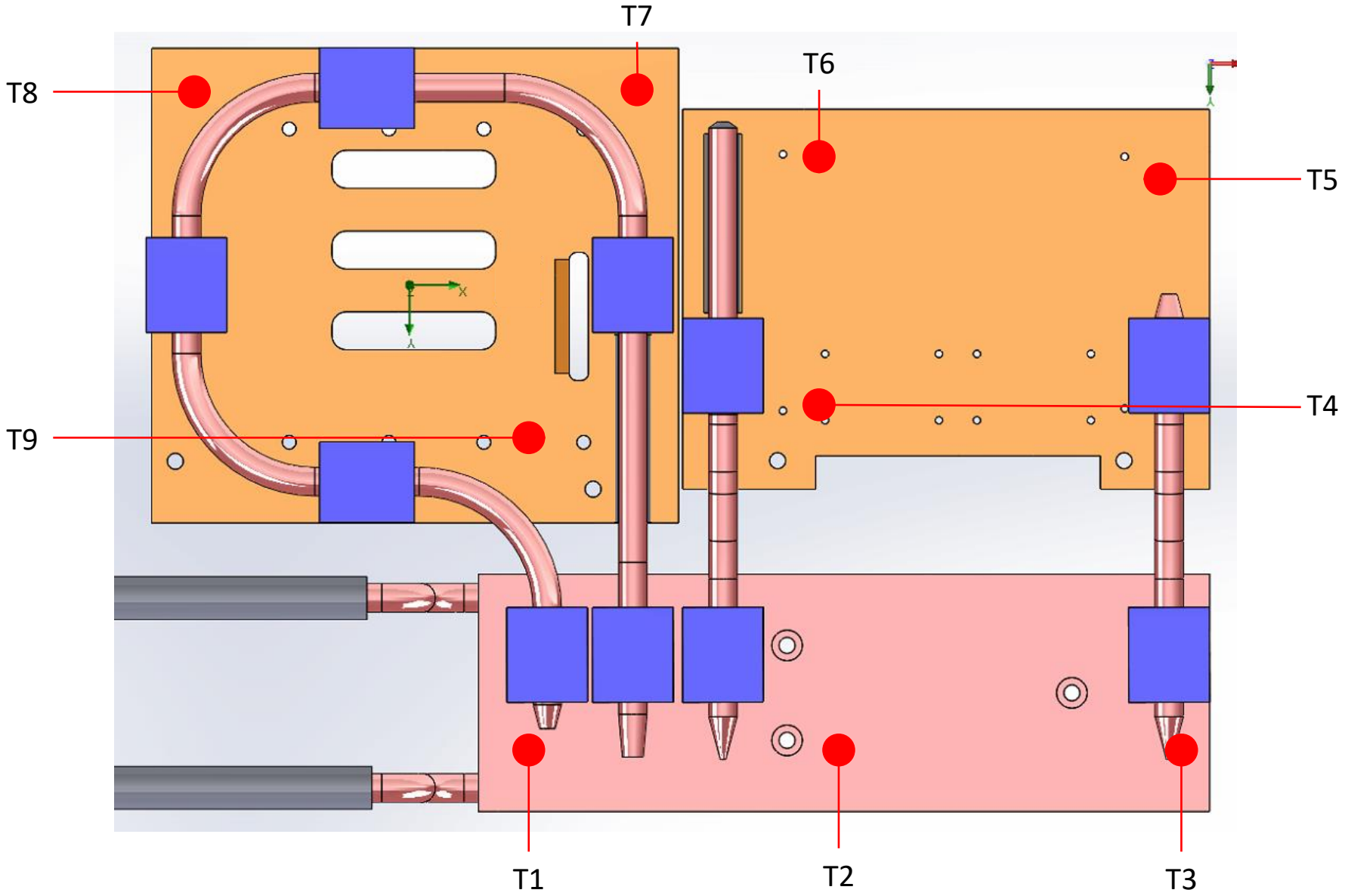
Magnet Box cooling design



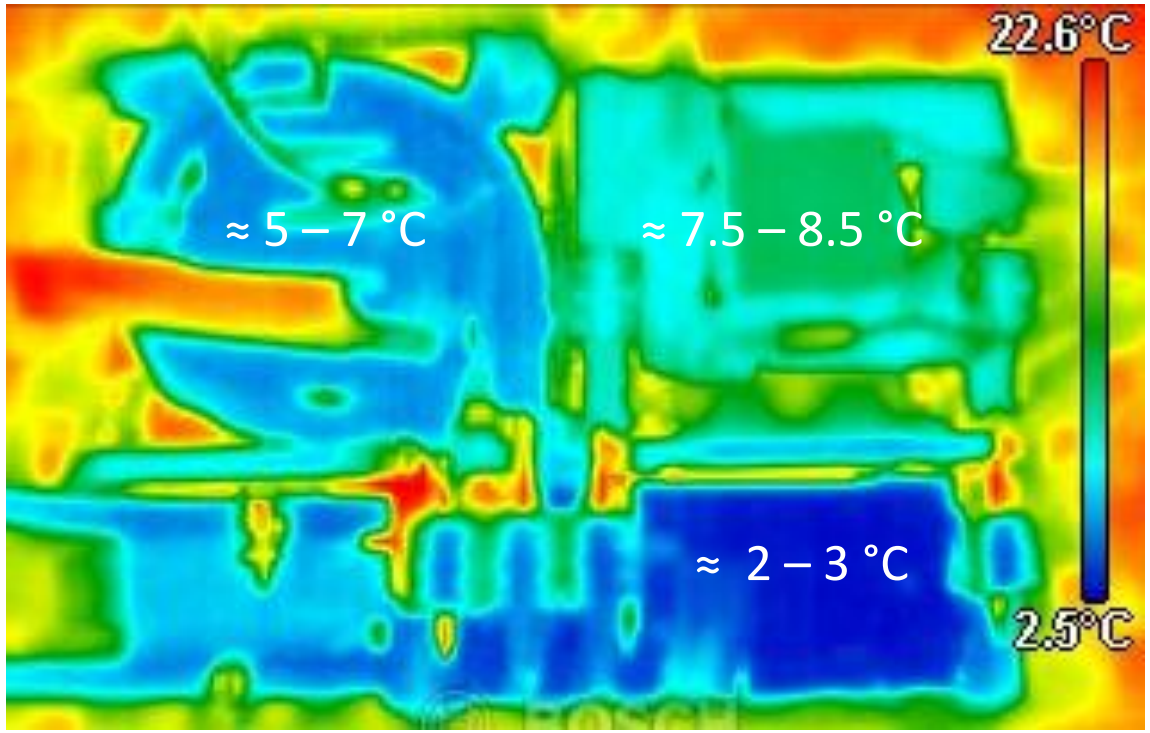
SolidWorks implementation

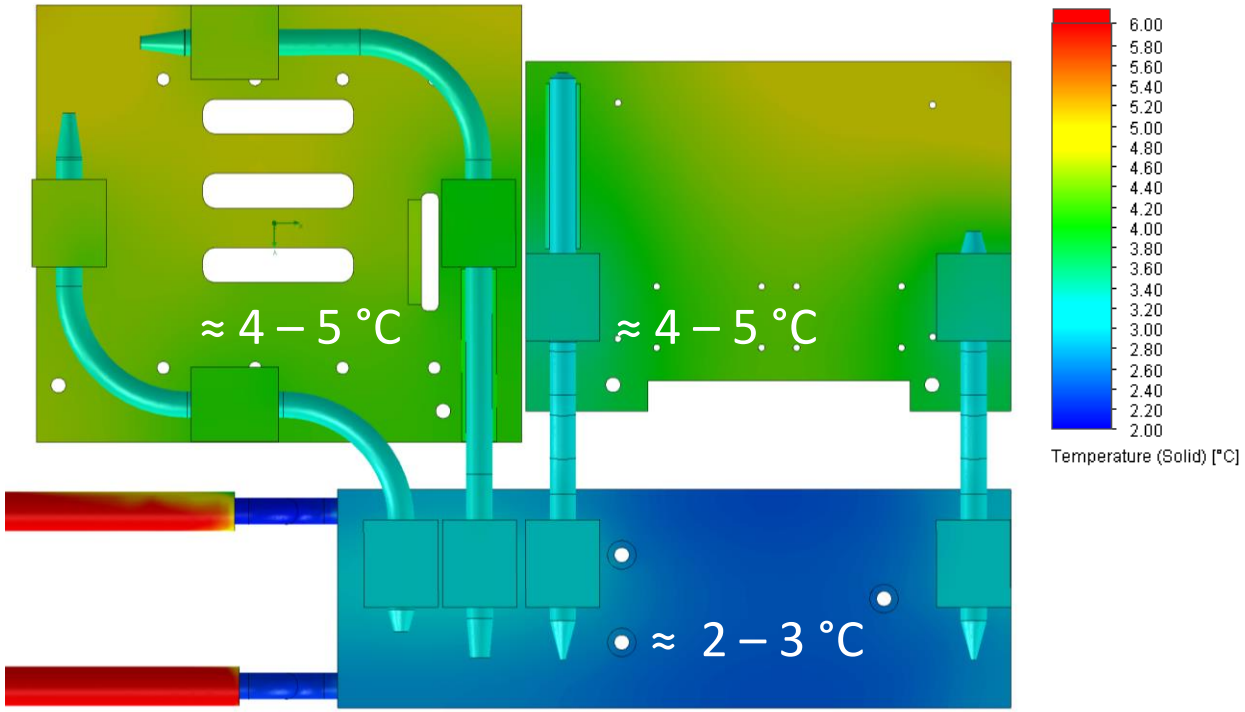


Temperature measurement points



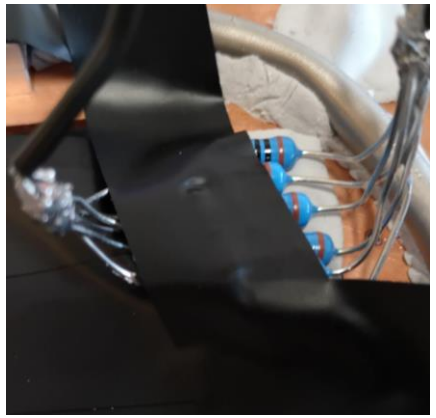
Comparison of measurement and simulation at room temperature without additional heat





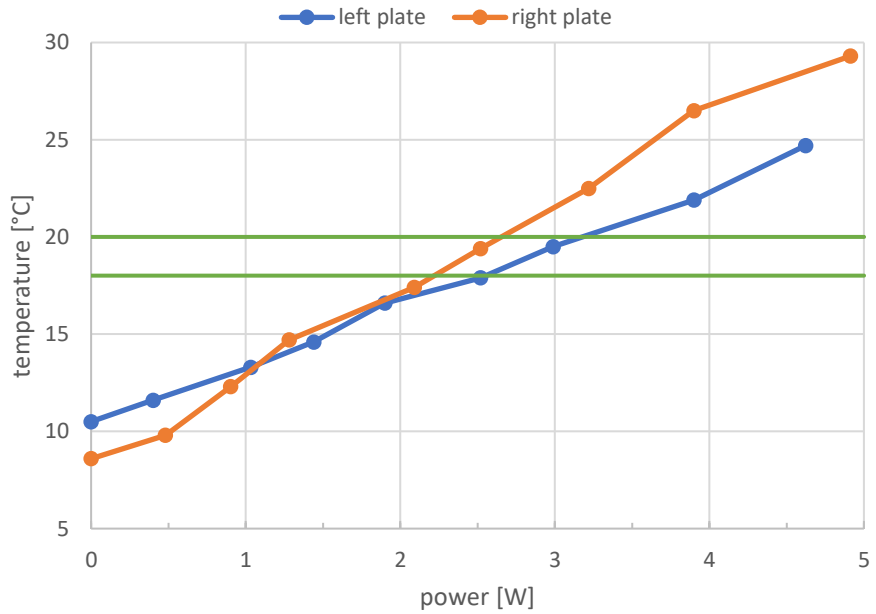
Heating experiment

- Heat generation with soldered resistors
- 5 W heat generation on one plate
  - Left plate max temperature at heat source 29.3 °C
  - Right plate max temperature at heat source 24.7 °C
- No influence on the respective other plate

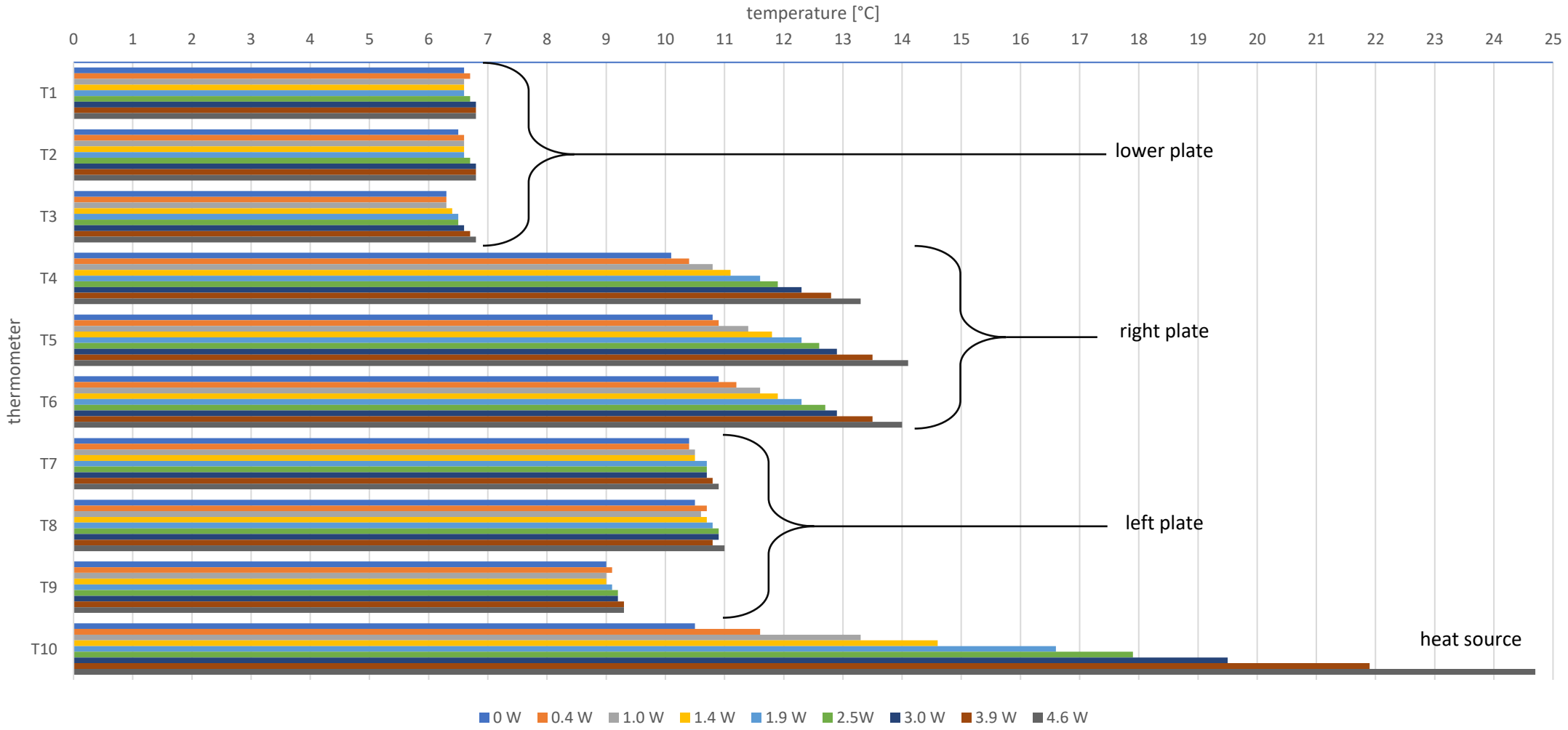


- 6–11 °C above target temperature

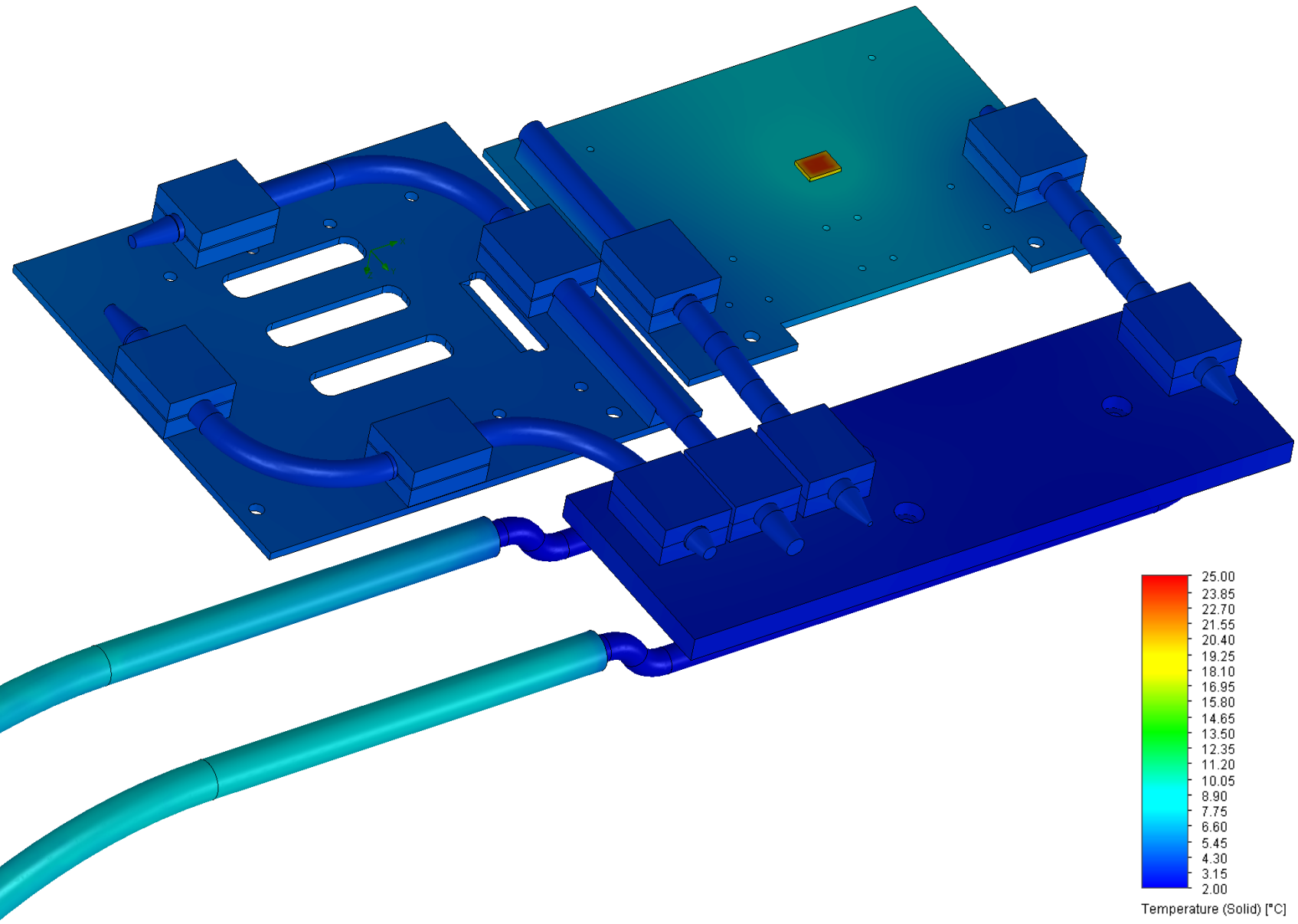
  → cooling still has to be improved!

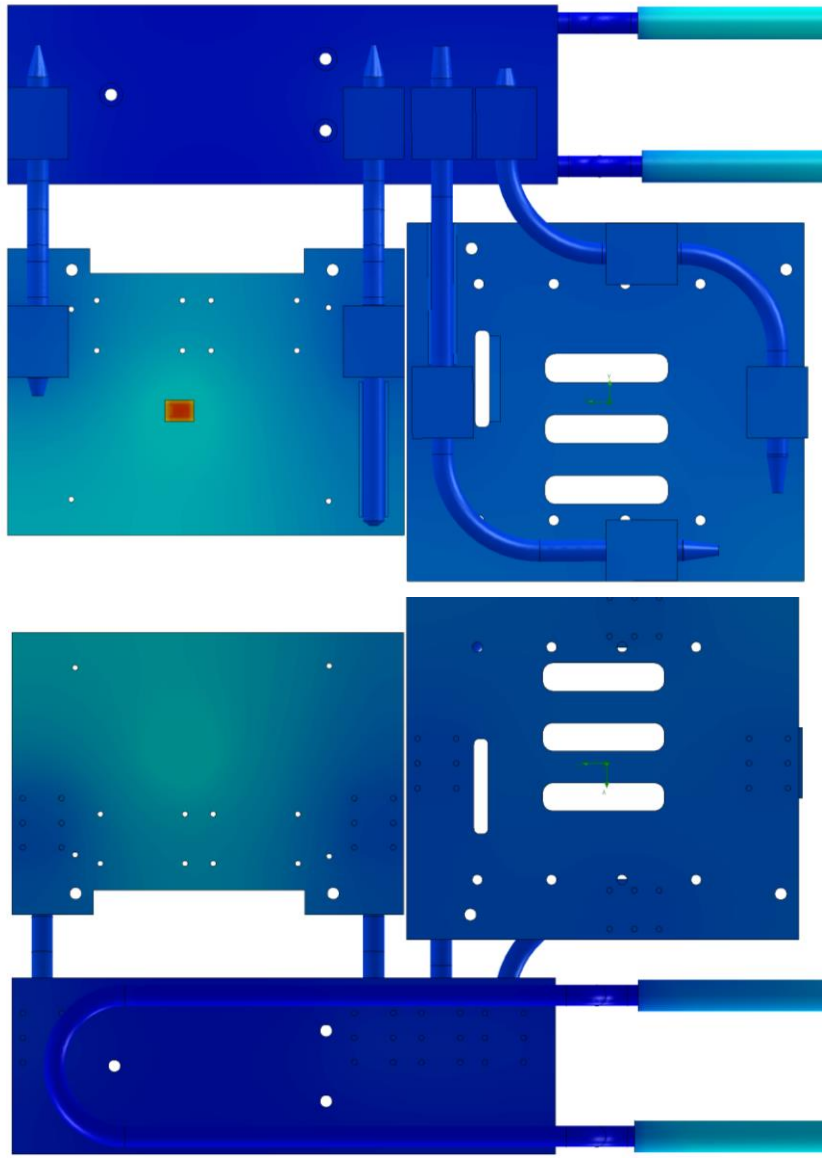


Impact of heat on measurement points (heat generation on right plate)

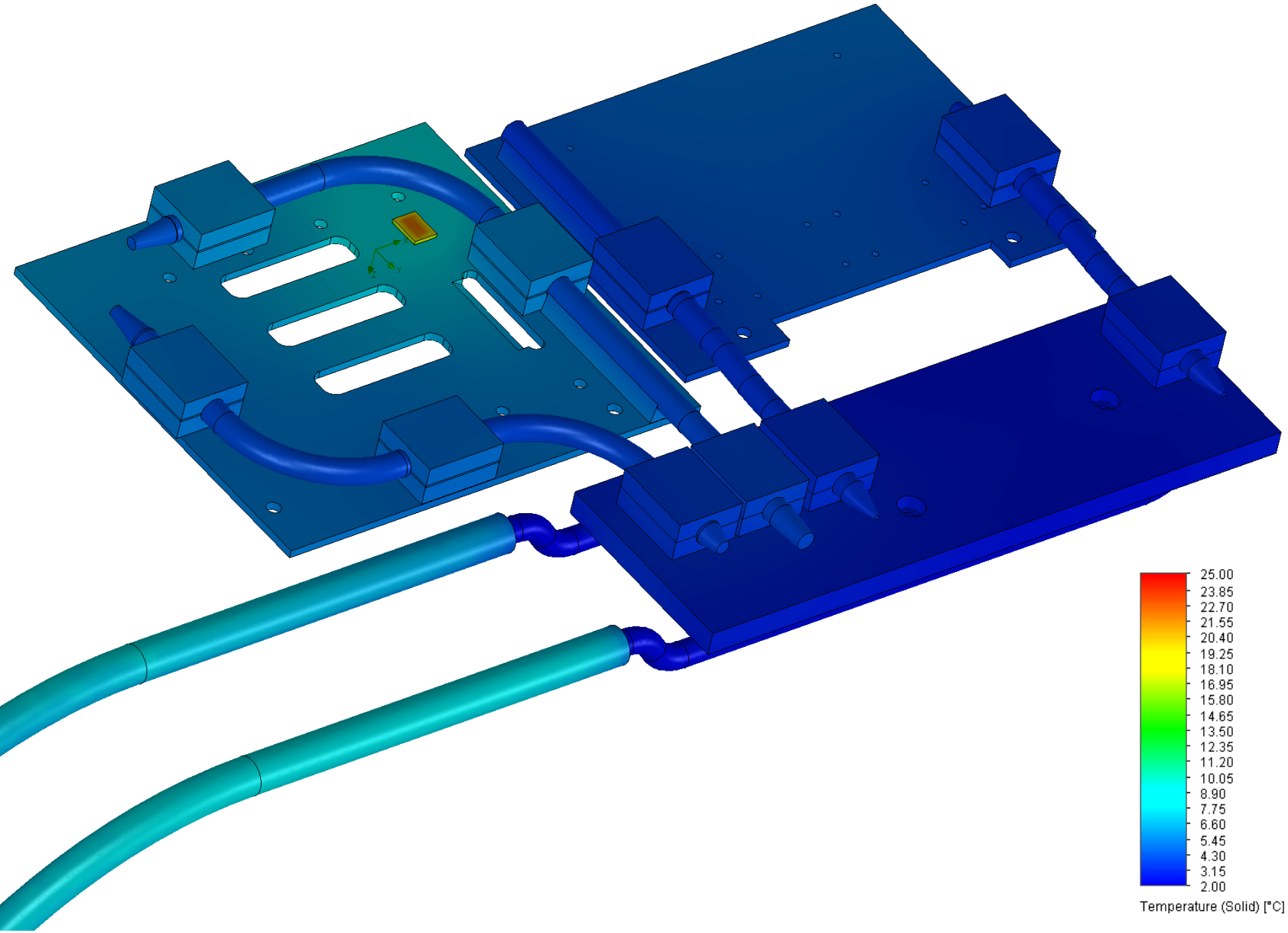


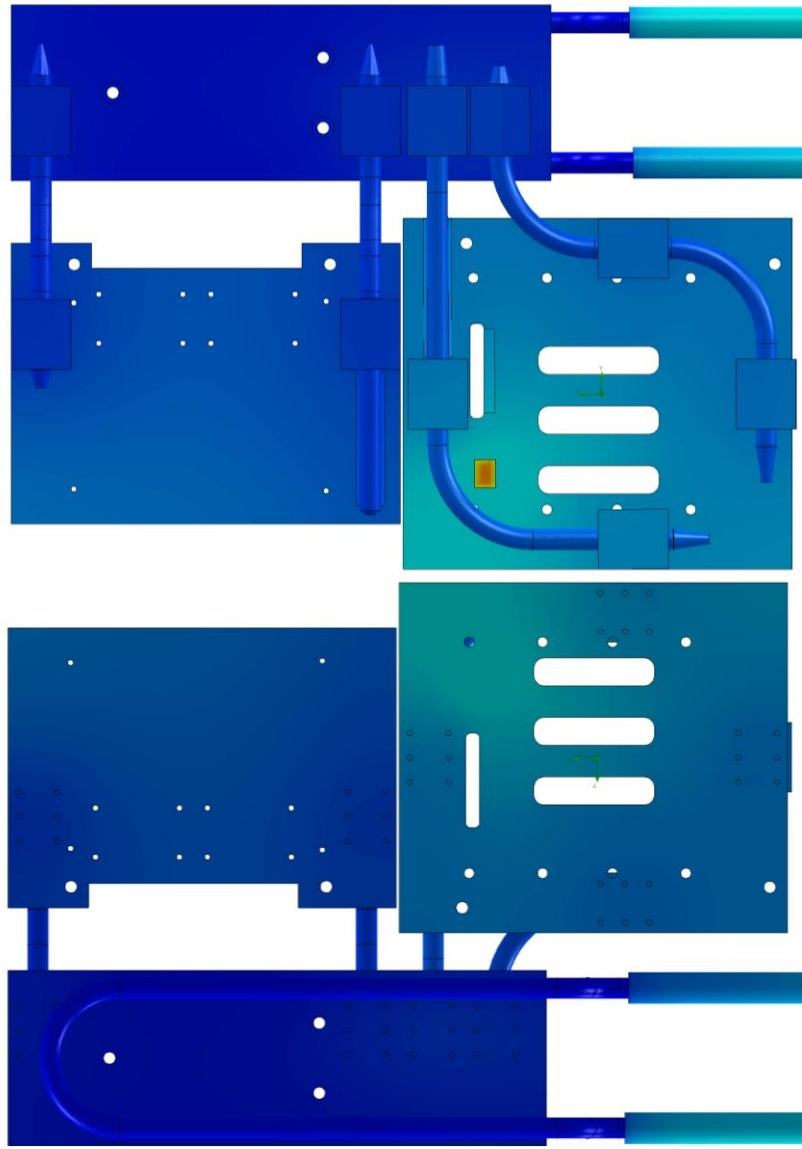
Heat Simulation – 5 W right plate



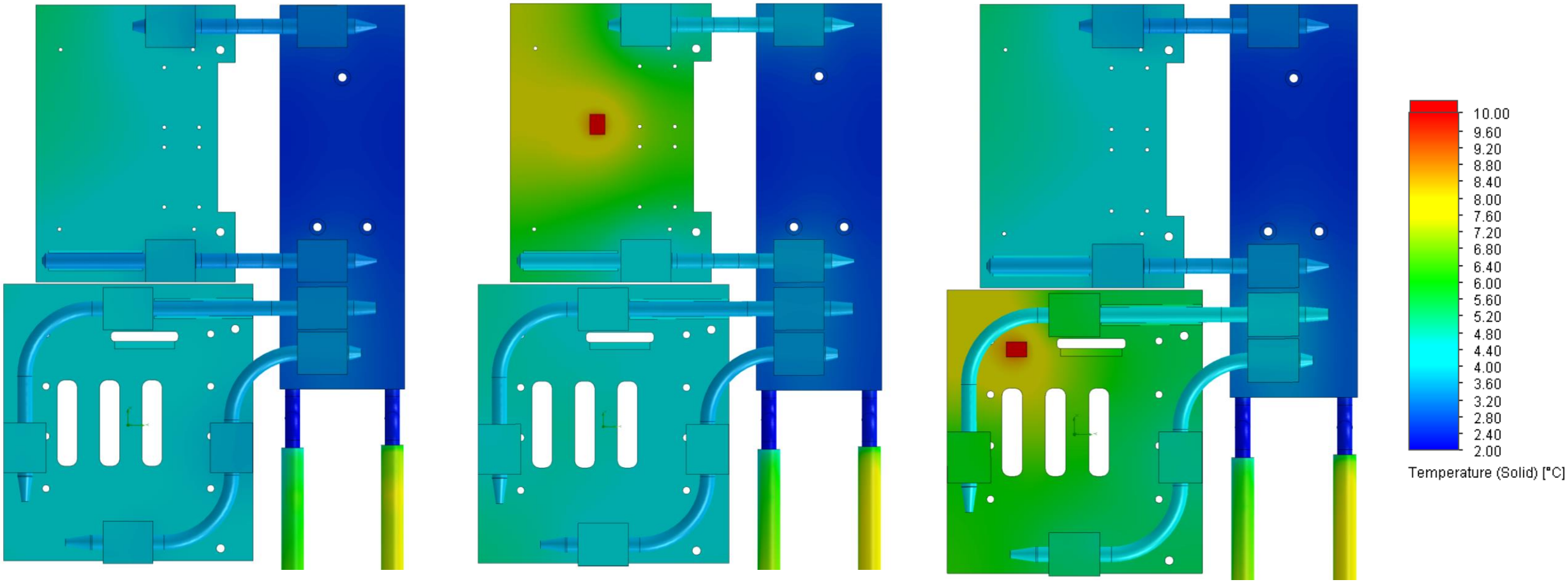


Heat Simulation – 5 W left plate

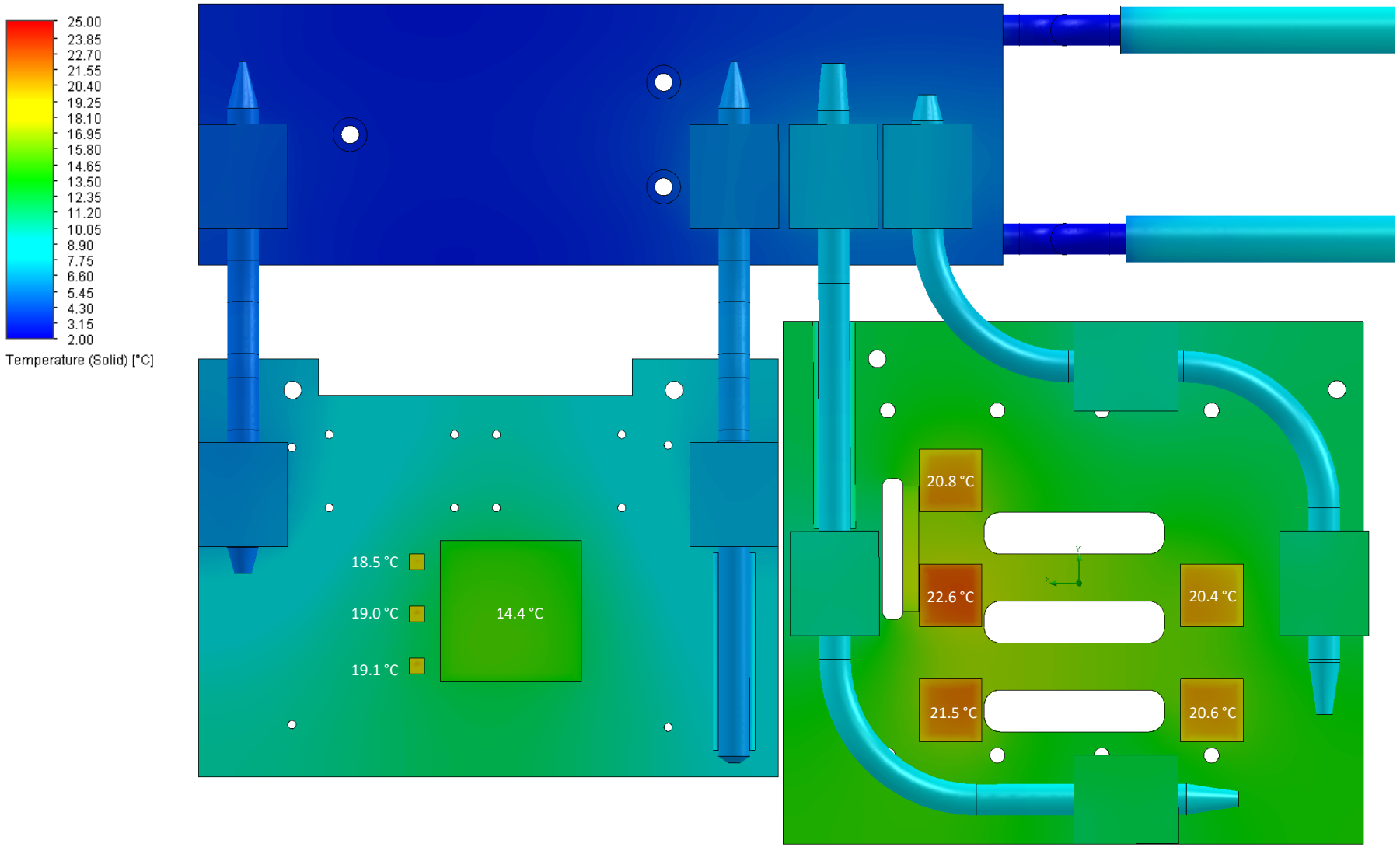




Comparison of heat distribution

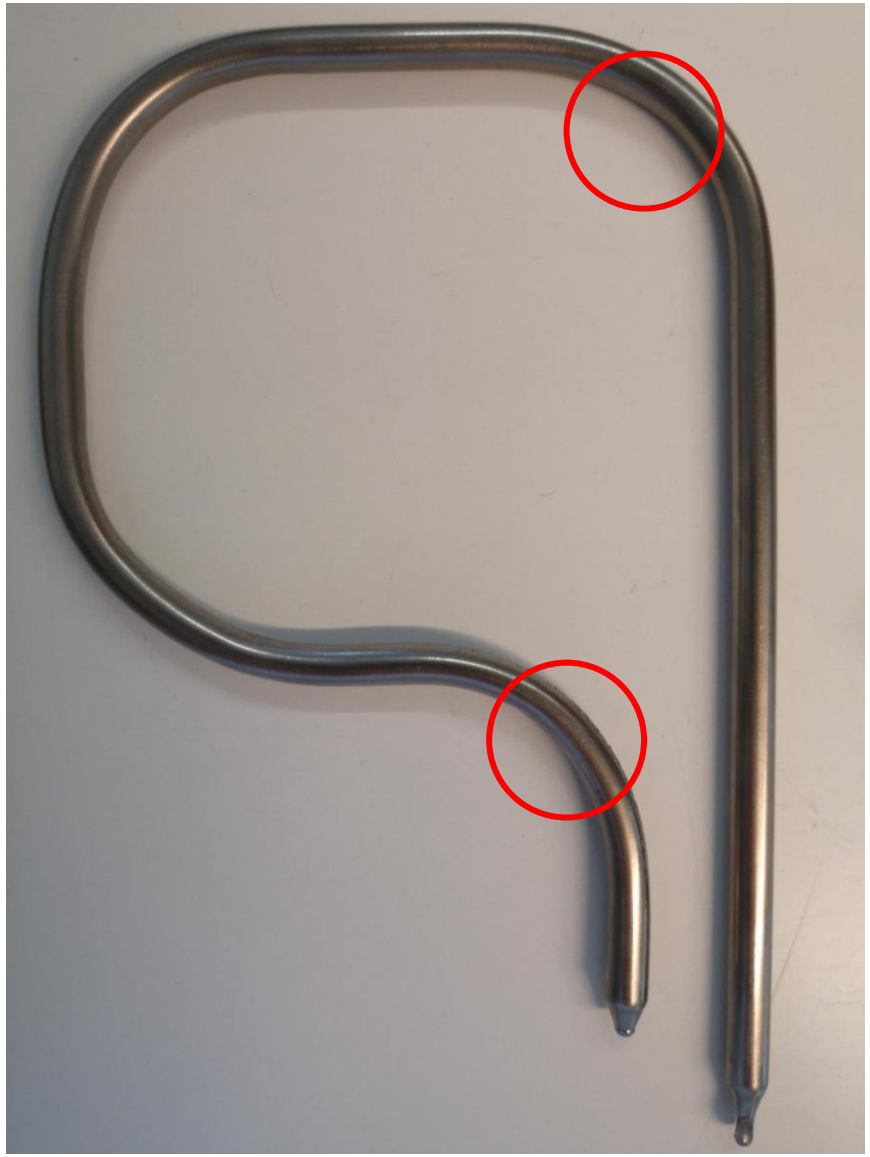


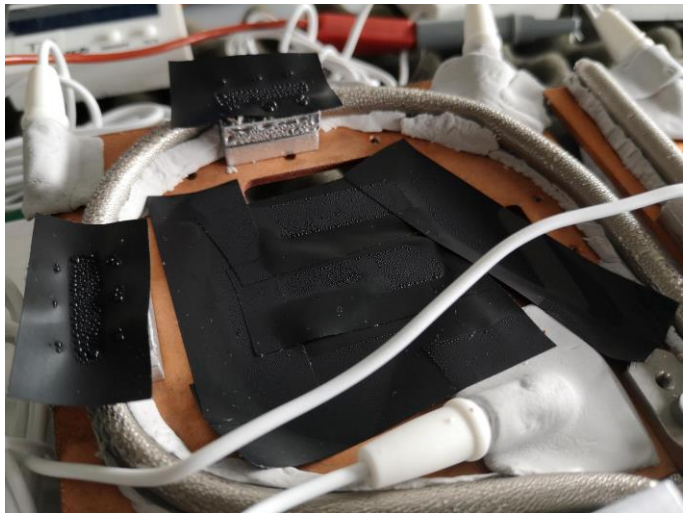
Predicted heat distribution



Difficulties and problems

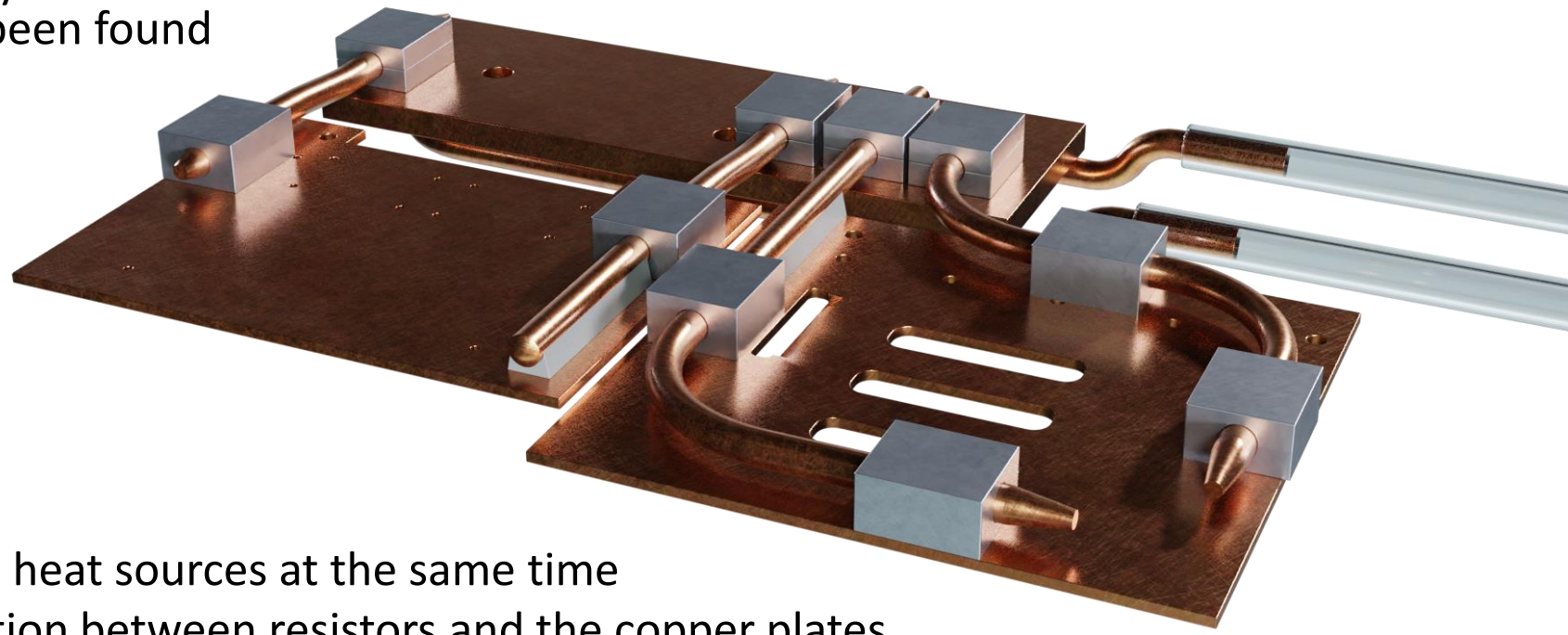
- Measurement accuracy (±1 °C)
- Heat pipe bending
  - Affects efficiency
  - Special tool required
- Unstable external conditions
  - Room temperature → air conditioning
  - Severe condensation → dehumidifier





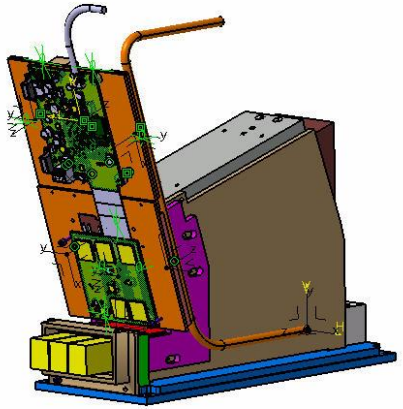
Summary and outlook

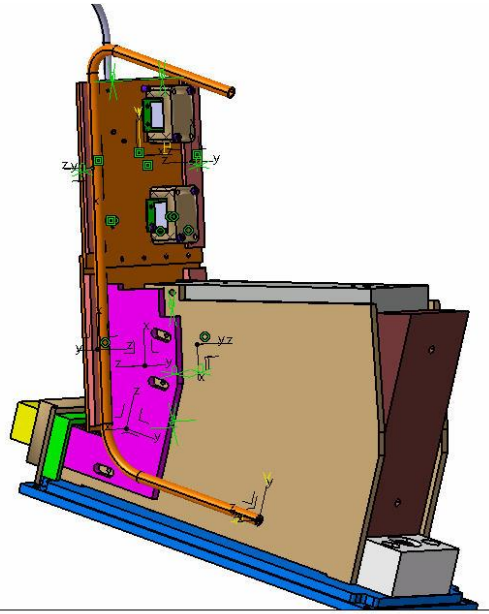
- Basic simulation is working properly
- Lab results mostly in good agreement
- Some difficulties have already been identified and possible solutions have been found
  - Heat pipe bending
  - Condensation issue

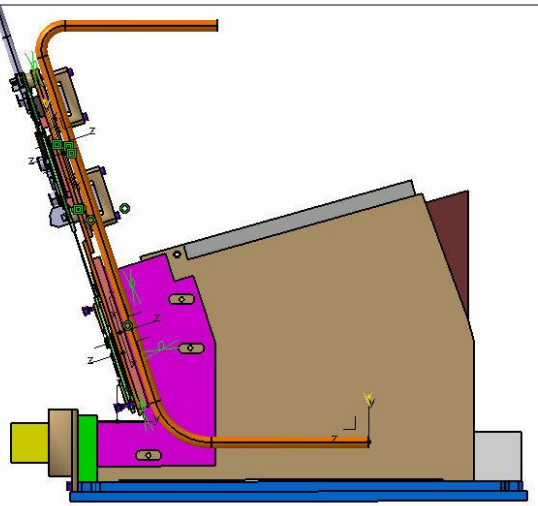


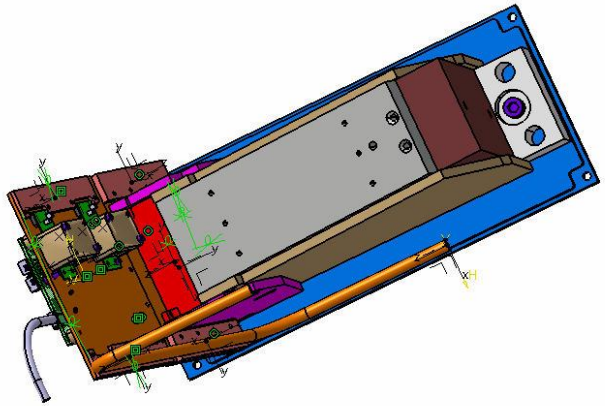
- Outlook
  - Implementation of more heat sources at the same time
  - Improvement of connection between resistors and the copper plates
  - Test of new professionally bent heat pipe (done)
  - Test setup with stable room conditions

Outlook – Custom-design PCB together with MCP-PMT integrated into GCS









Thank you for your attention!

If you have any questions, feel free to ask them now.