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Engineering Department

STATUS of BBC DESIGN and ENGINEERING : PRELIMINARY RESULTS

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Outline

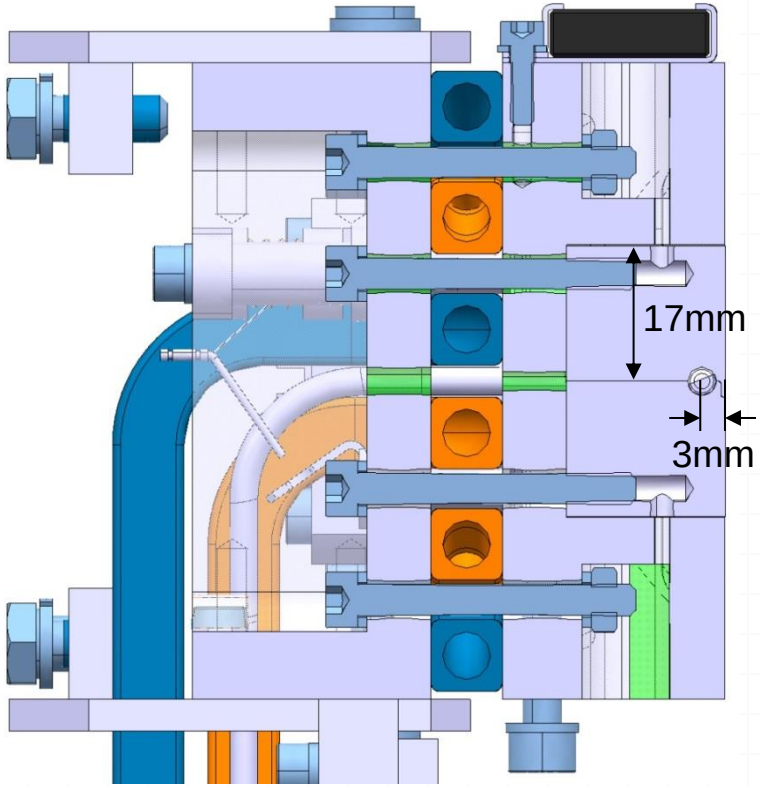
Beam-Beam compensator:

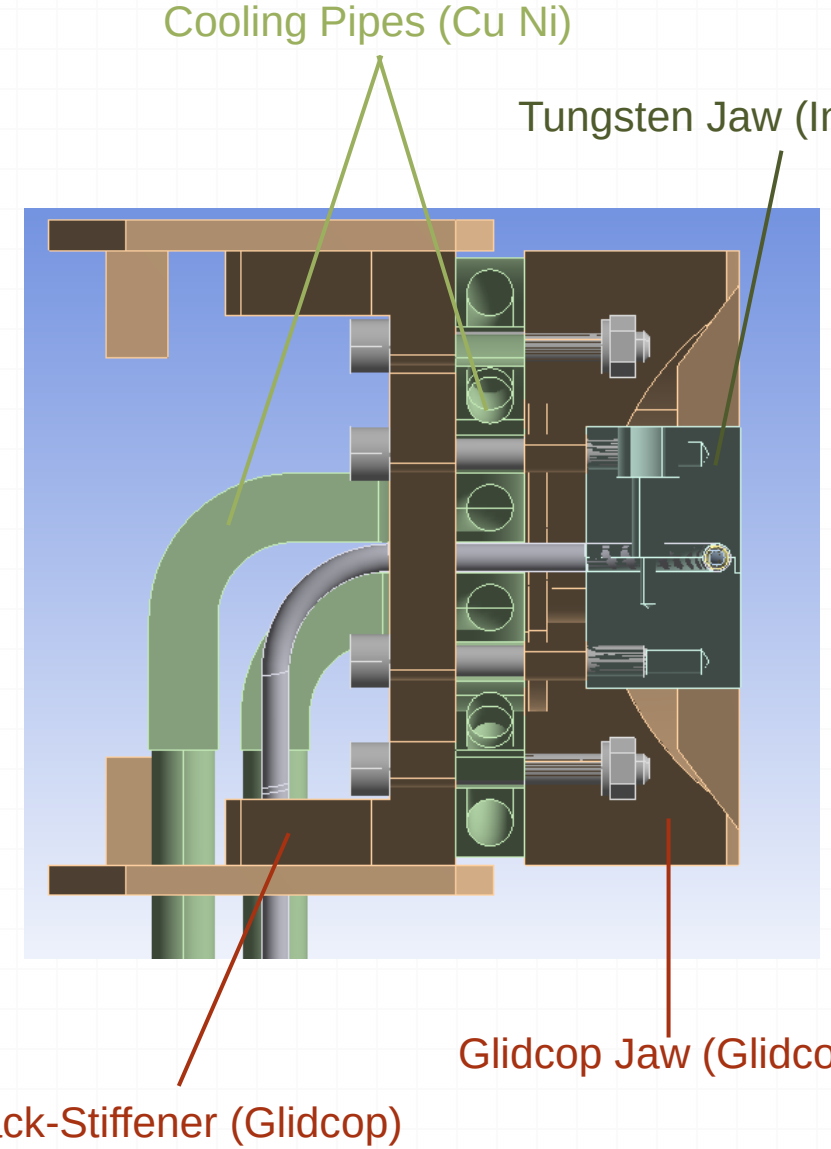
Decreasing the influence of a beam on the other using electrified wire in some TCTP collimators

Specifications:

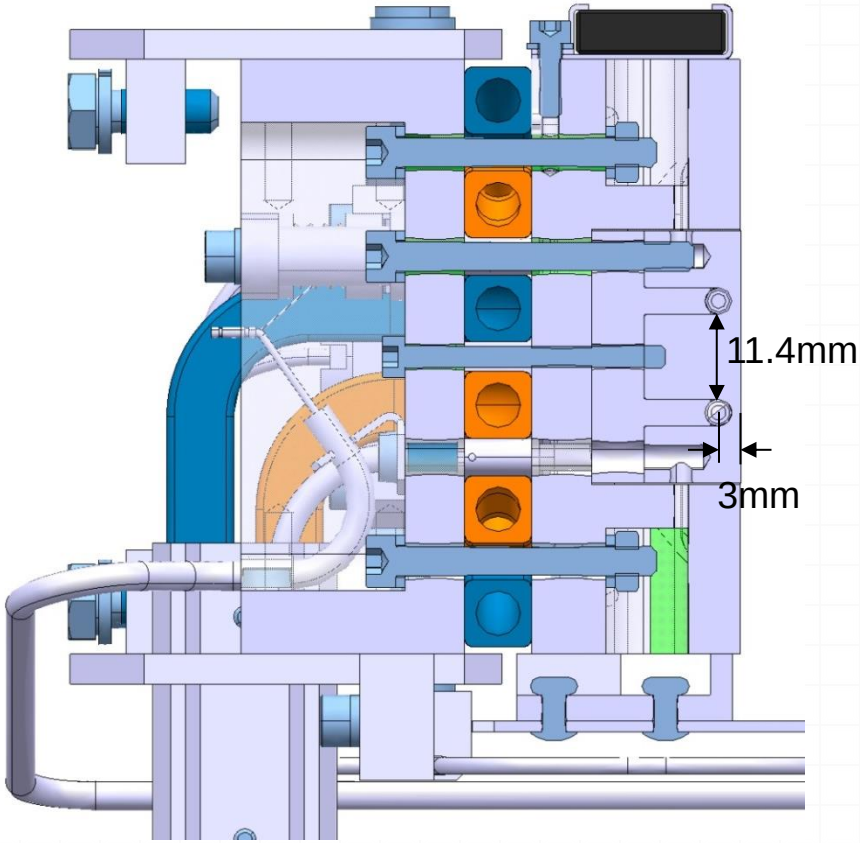
- Re-use **nearly 100%** of existing TCTP design
- Electrified wire as close as possible to the beam axis:
  distance the center of the wire - the surface of the jaw **<3mm**
- Maximum diameter of the copper **2mm**
- Maximum input current: **350A DC**
- If possible, **2 wires** (1 working – 1 spare)

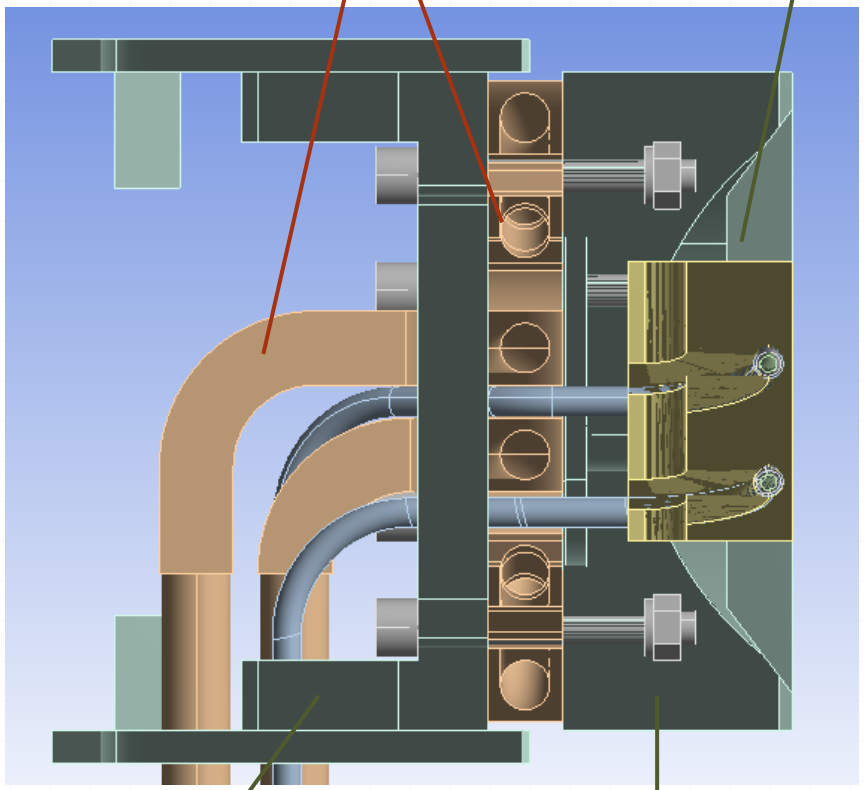
1 Wire Design





2 Wires Design





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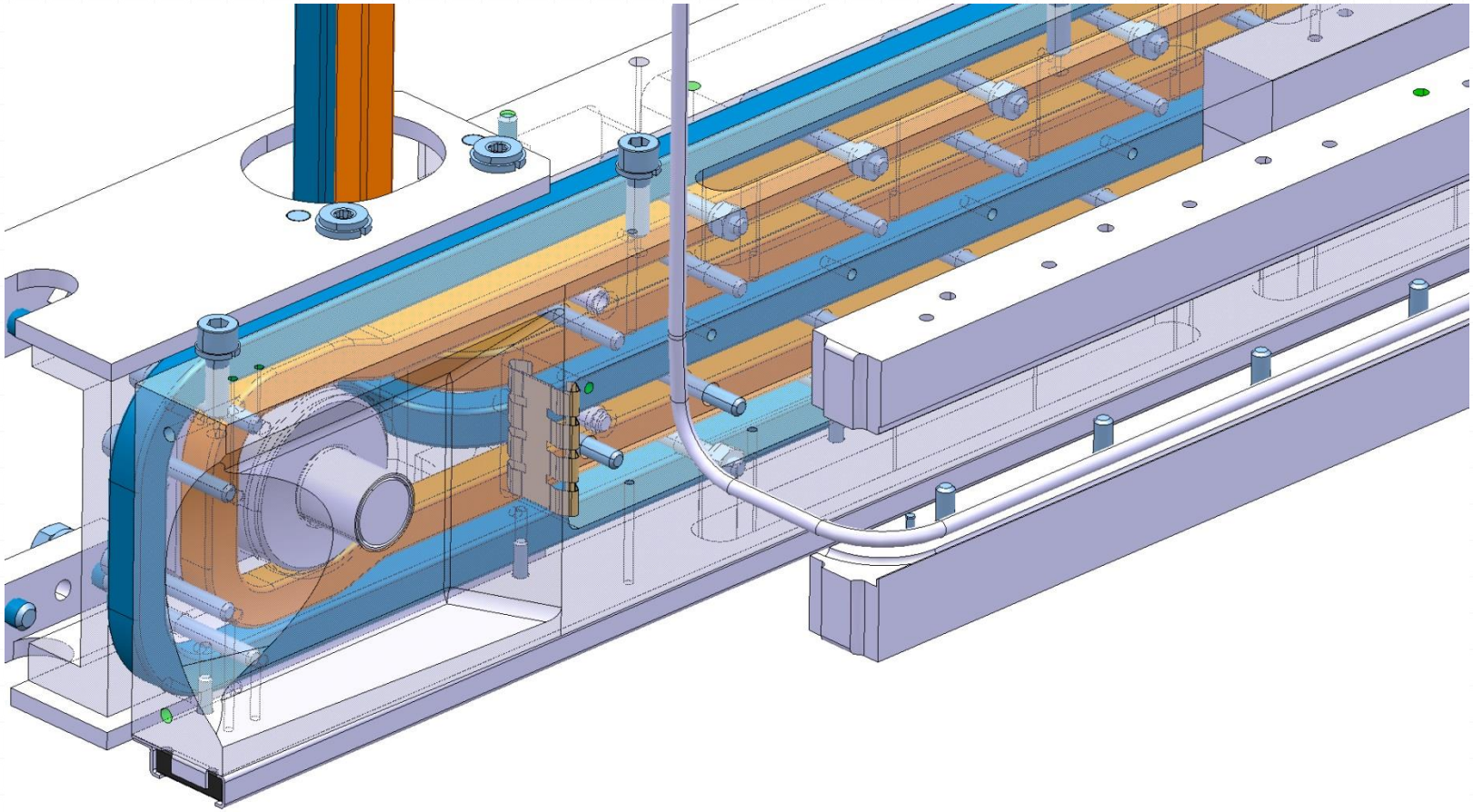
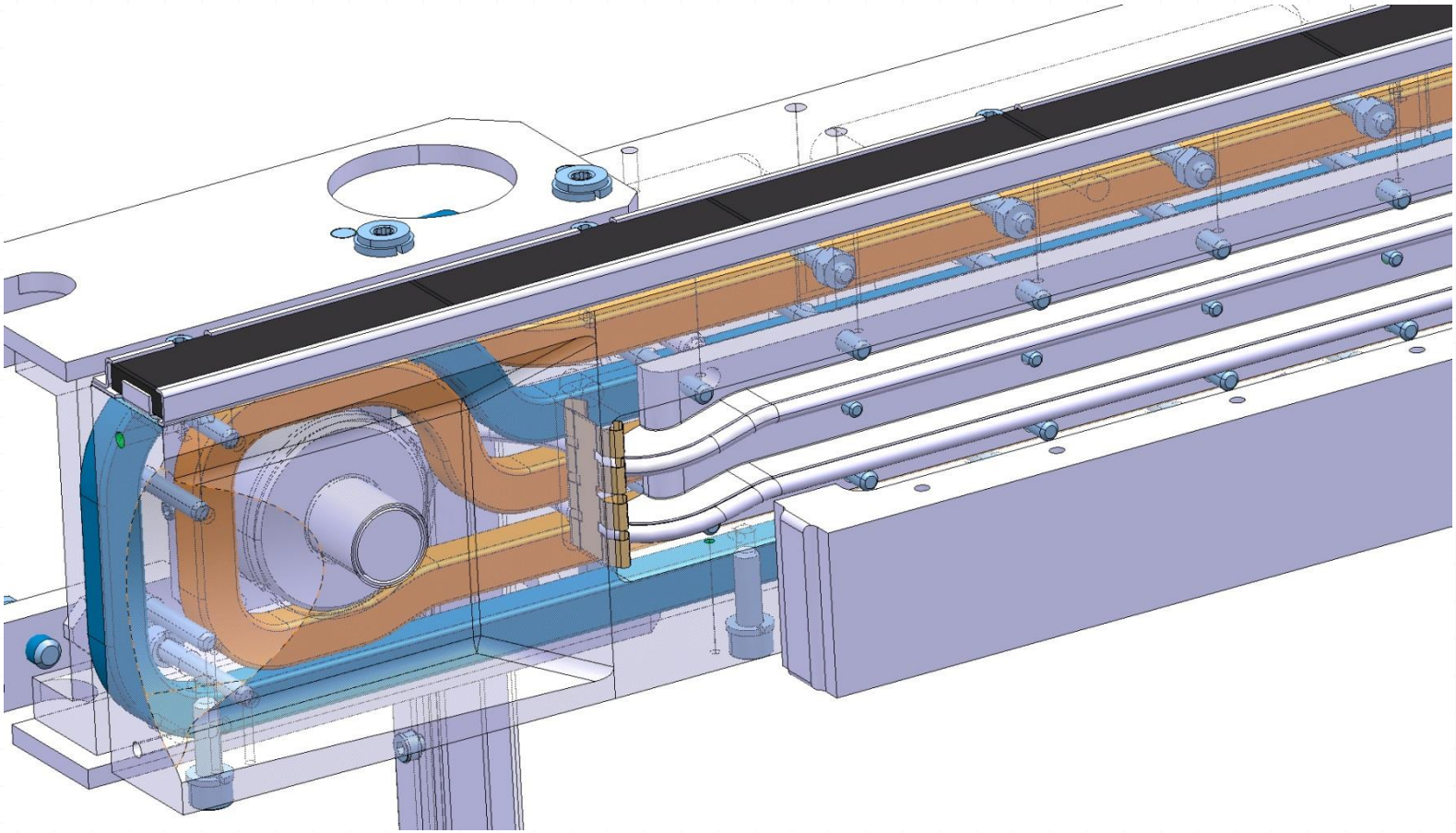
1 Wire Design



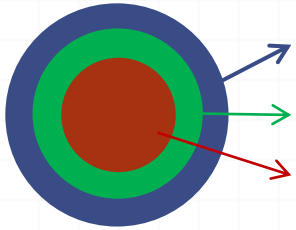
2 Wires Design



Wire

Thermocoax wire

3 Layers
Total diameter : 3.6mm



Stainless Steel – Thickness 0.3mm
Magnesium oxide – Thickness 0.5mm
Copper – Diameter 2mm

Electrical properties :

Magnesium Oxide layer → perfect electrical insulator
Copper → very good electrical conductor

Maximum admissible temperature (estimated by Thermocoax, not tested): ≈400ºC
(under testing by A. Ravni)

TCTP Thermal Load

TCTP without BBC

1h Beam Life Time (8.6e8 p/s) on each Jaw : 418.4W

TCTP with BBC

Heat generation due to Joule effect in the wire with 350 A :
2.11e8 W/m³ (at 300ºK)

Total thermal power dissipation:

1 Wire design at 300ºK : 940 W + *418W from beam*

2 Wires design at 300ºK : 986 W + *418W from beam*

BBC : adds more than twice the 1h BLT thermal load optimisticaly assuming RT Cu electric resistivity

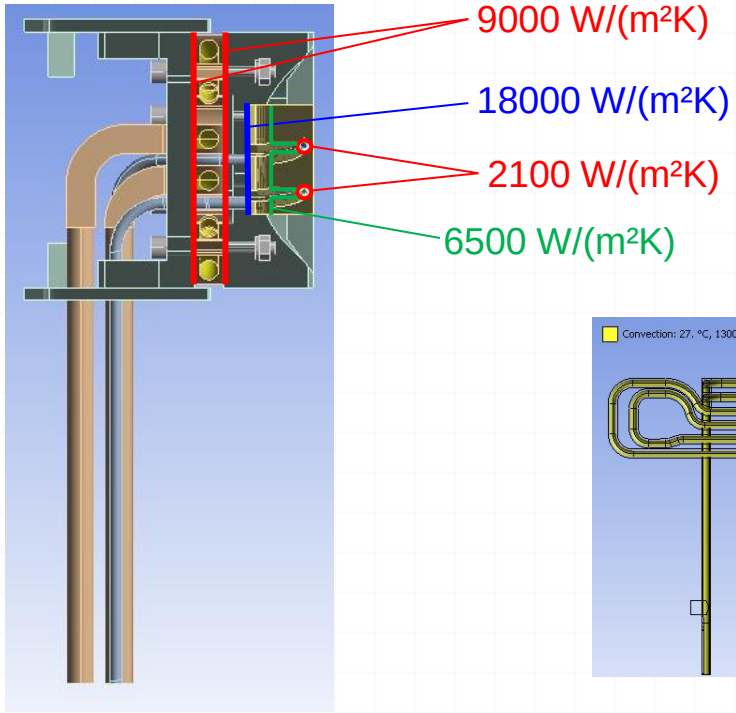
Thermal simulation : wire cooled only in Jaw

Calculation for both designs: 1 and 2 wires
Only electric load considered: 350A DC current

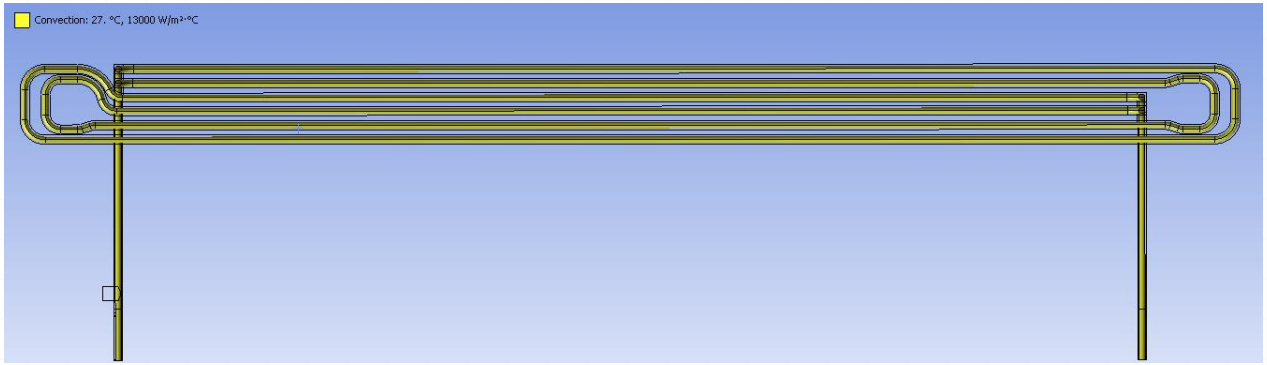
To achieve numerical convergence, electric load applied through internal heat generation

Power calculated from Joule heating 350A DC at 27ºC = 2.11e8 W/m³

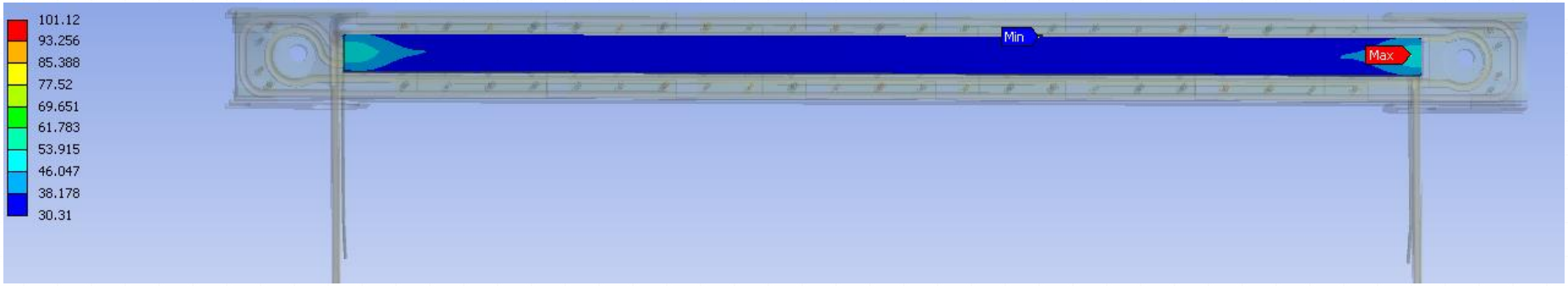
Thermal interfaces

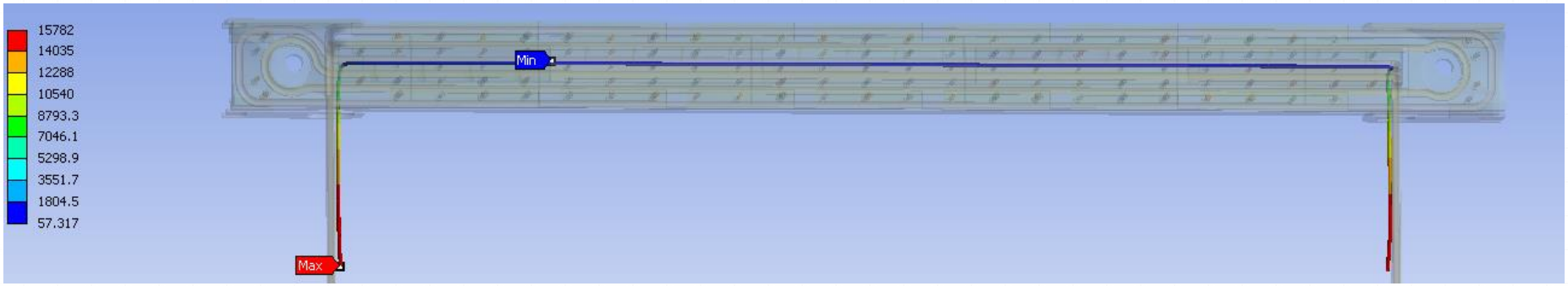


Heat sink : convection inside cooling pipes
13000 W/(m²K)



1 Wire





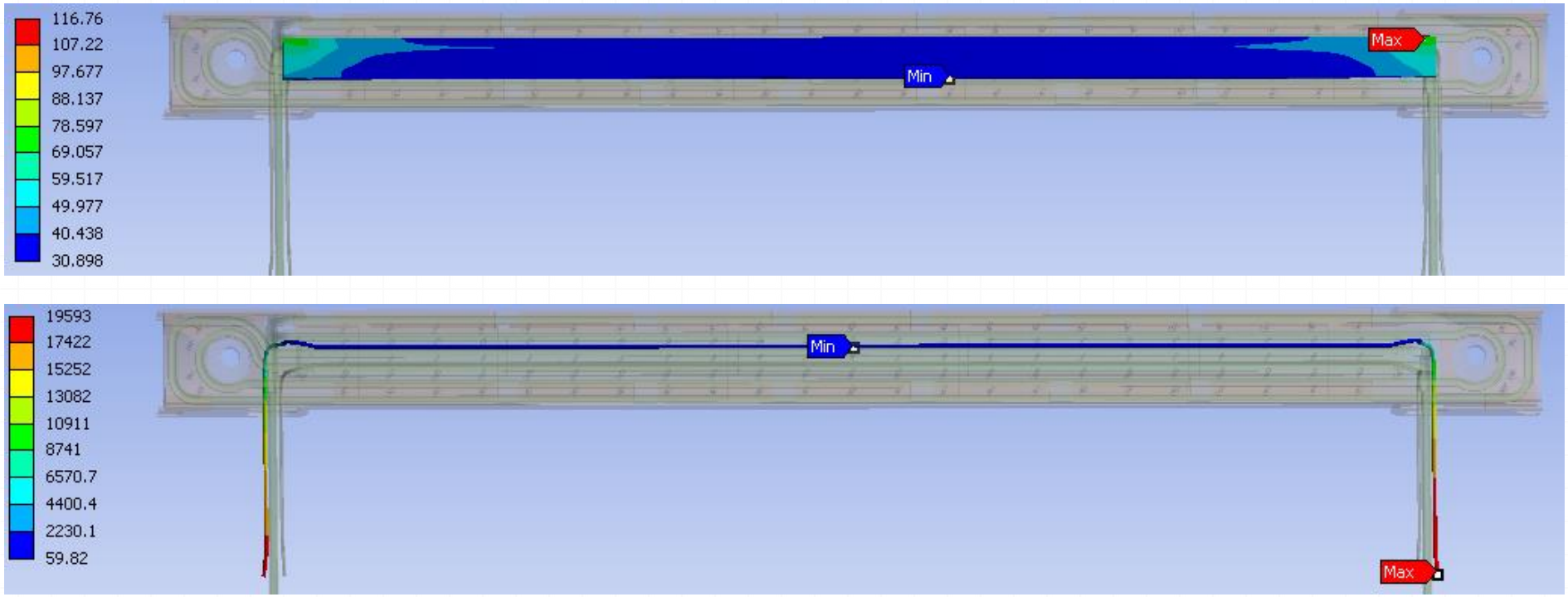
Temperature max

- Inermet Jaw: 101.1ºC
- **Wire: 15800ºC**

Average temperature

- Inermet Jaw : 34ºC
- Glidcop Jaw : 31.4ºC

2 Wires



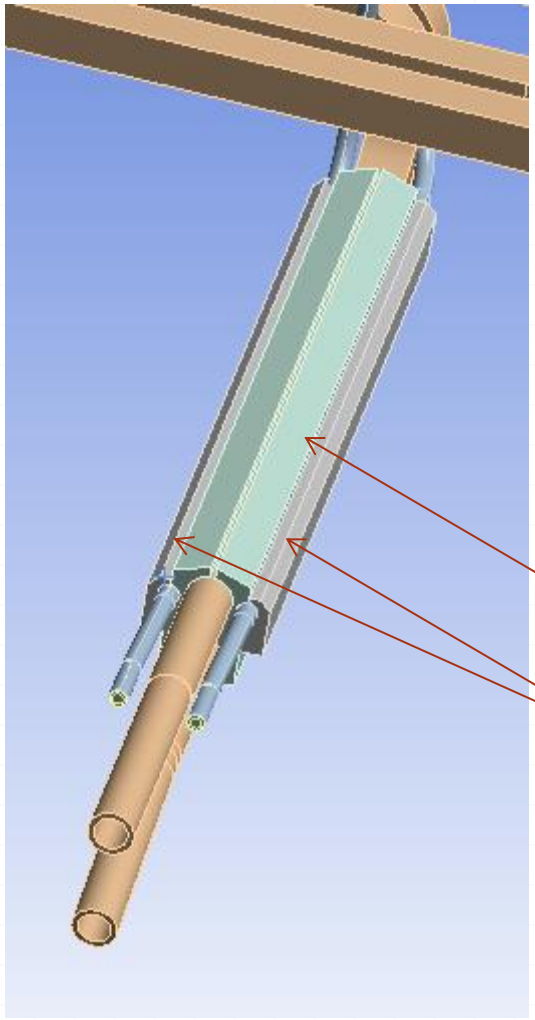
Temperature max

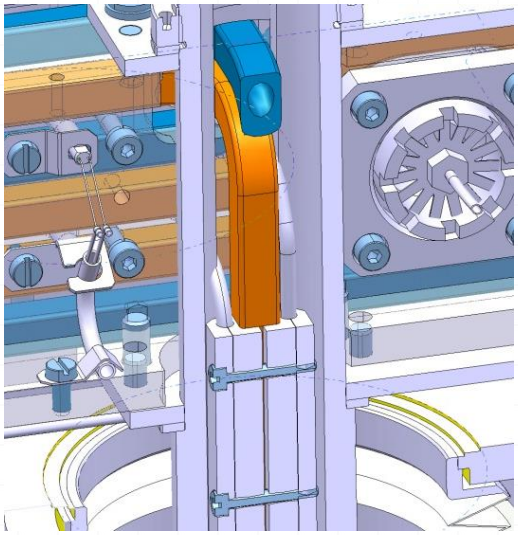
- Jaw: 116.8ºC
- **Wire: 19600ºC**

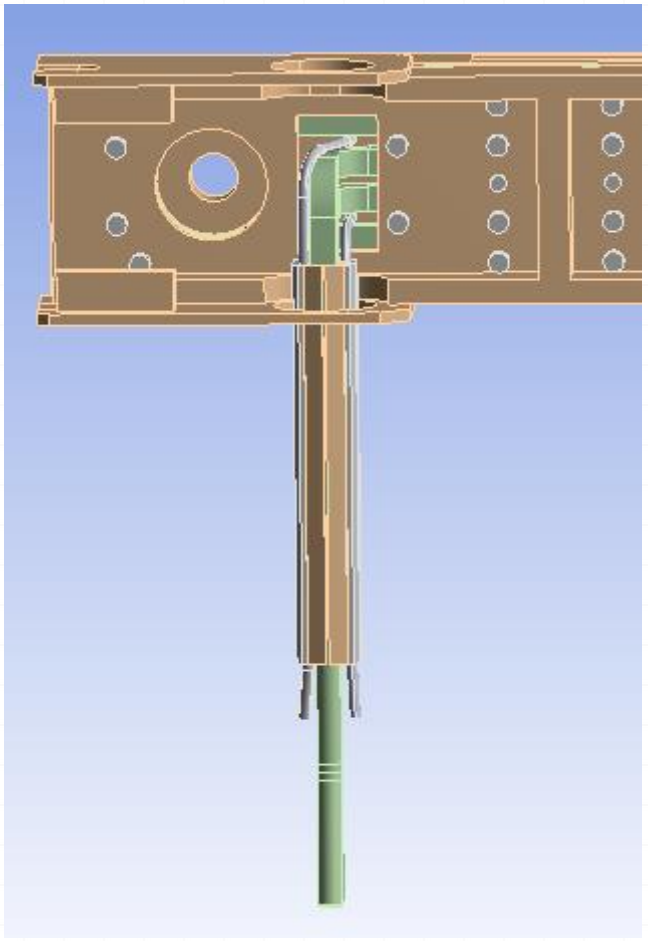
Average temperature

- Inermet Jaw : 36.6ºC
- Glidcop Jaw : 31ºC

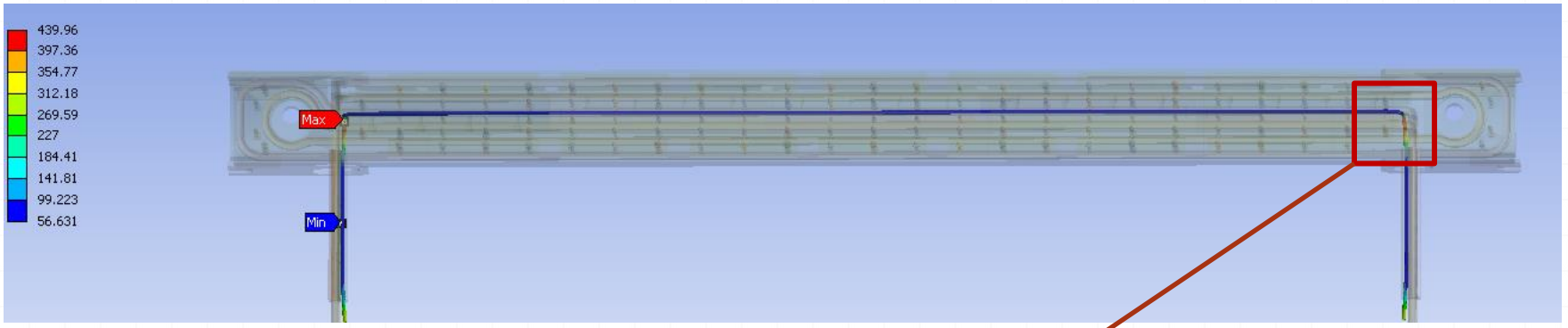
Additional thermal bridge system

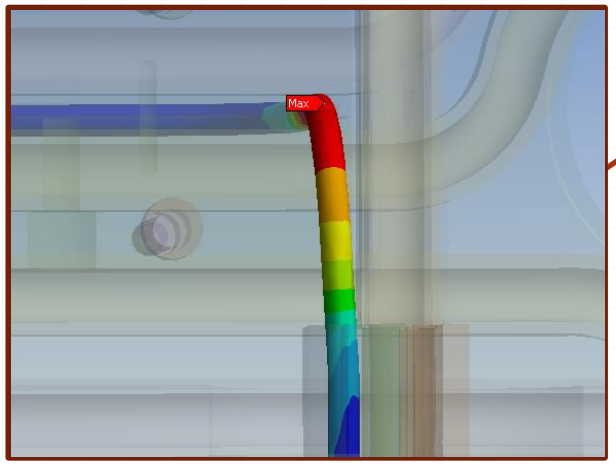






1 Wire – Optimized Cooling system





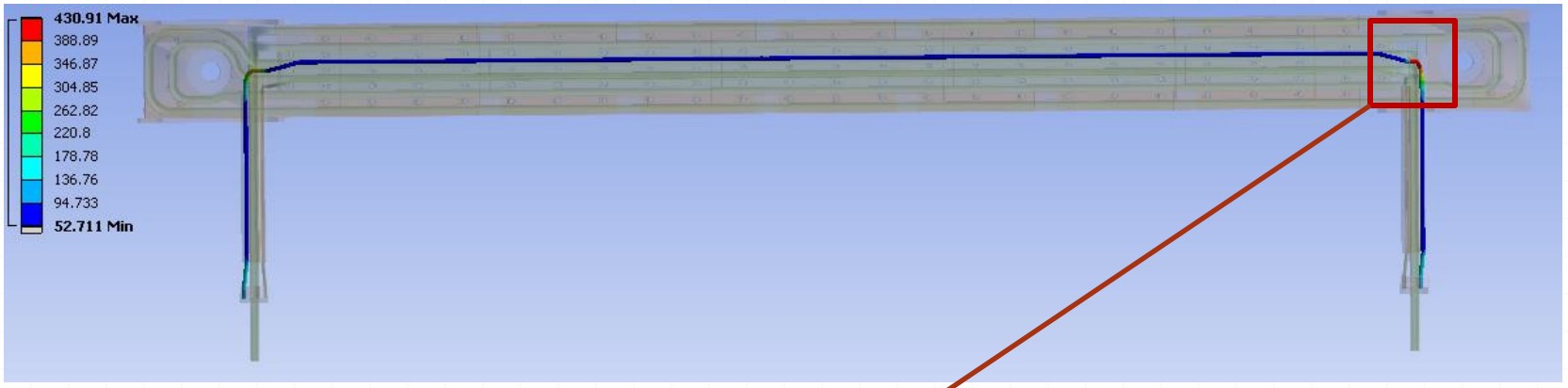
Temperature max

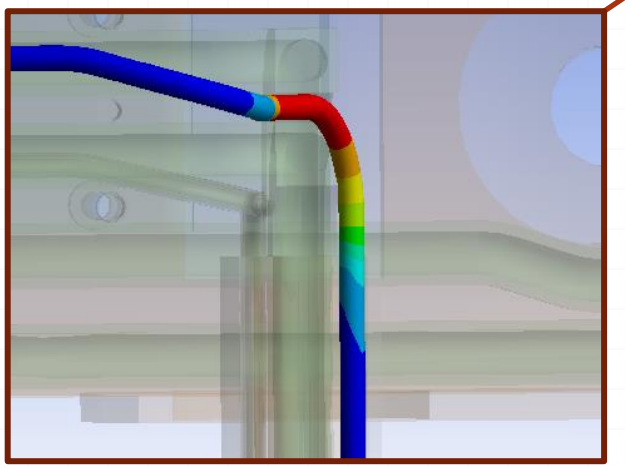
- Tungsten Jaw: 42.1ºC
- **Wire: 440ºC**

Average temperature

- Inermet Jaw : 32.5ºC
- Glidcop Jaw : 30ºC

2 Wires - Optimized Cooling system





Temperature max

- Tungsten Jaw: 49.2ºC
- **Wire: 431ºC**

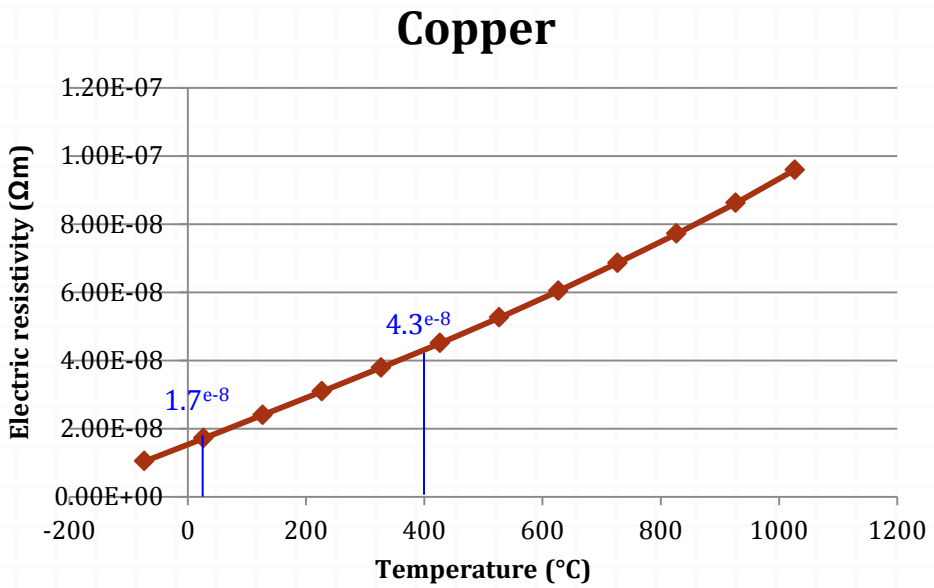
Average temperature

- Inermet Jaw : 34.6ºC
- Glidcop Jaw : 29.7ºC

350A DC not compatible with present design

Thermal issues

Electric resistivity not constant over temperature : the hotter, the higher the heat generation

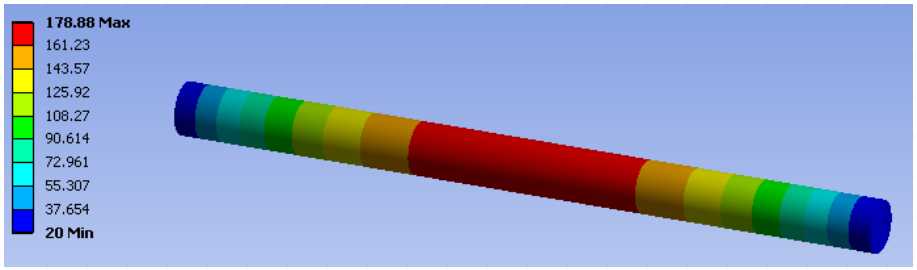


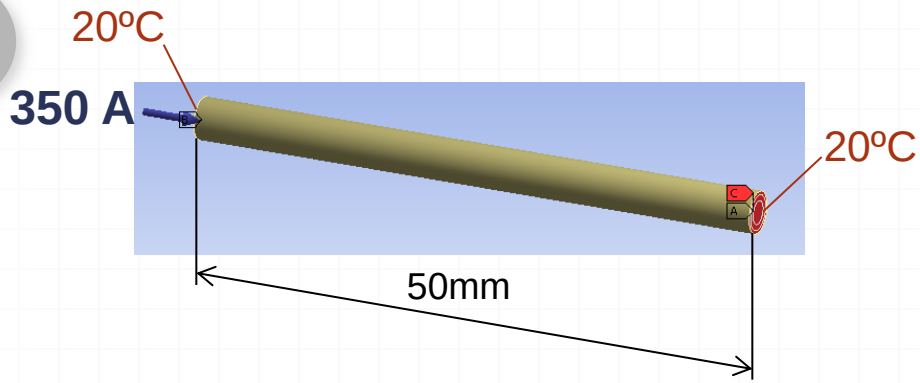
Electric resistivity at 400ºC = 2.5 times the one at 27ºC

Temperatures reached are clearly underestimated

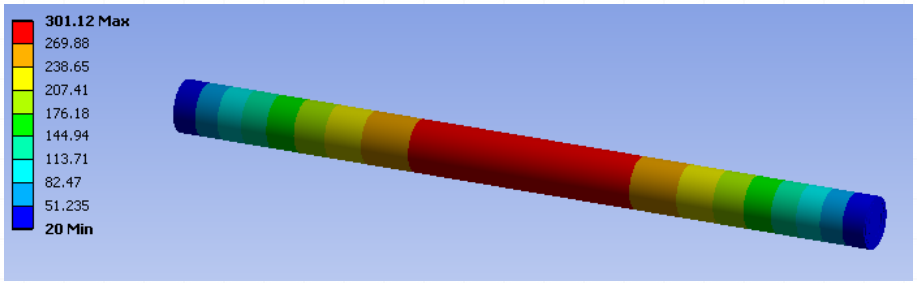
Preliminary conclusion : Thermal issues

350 A DC with constant electric resistivity at RT





350 A DC with T-dependant electric resistivity

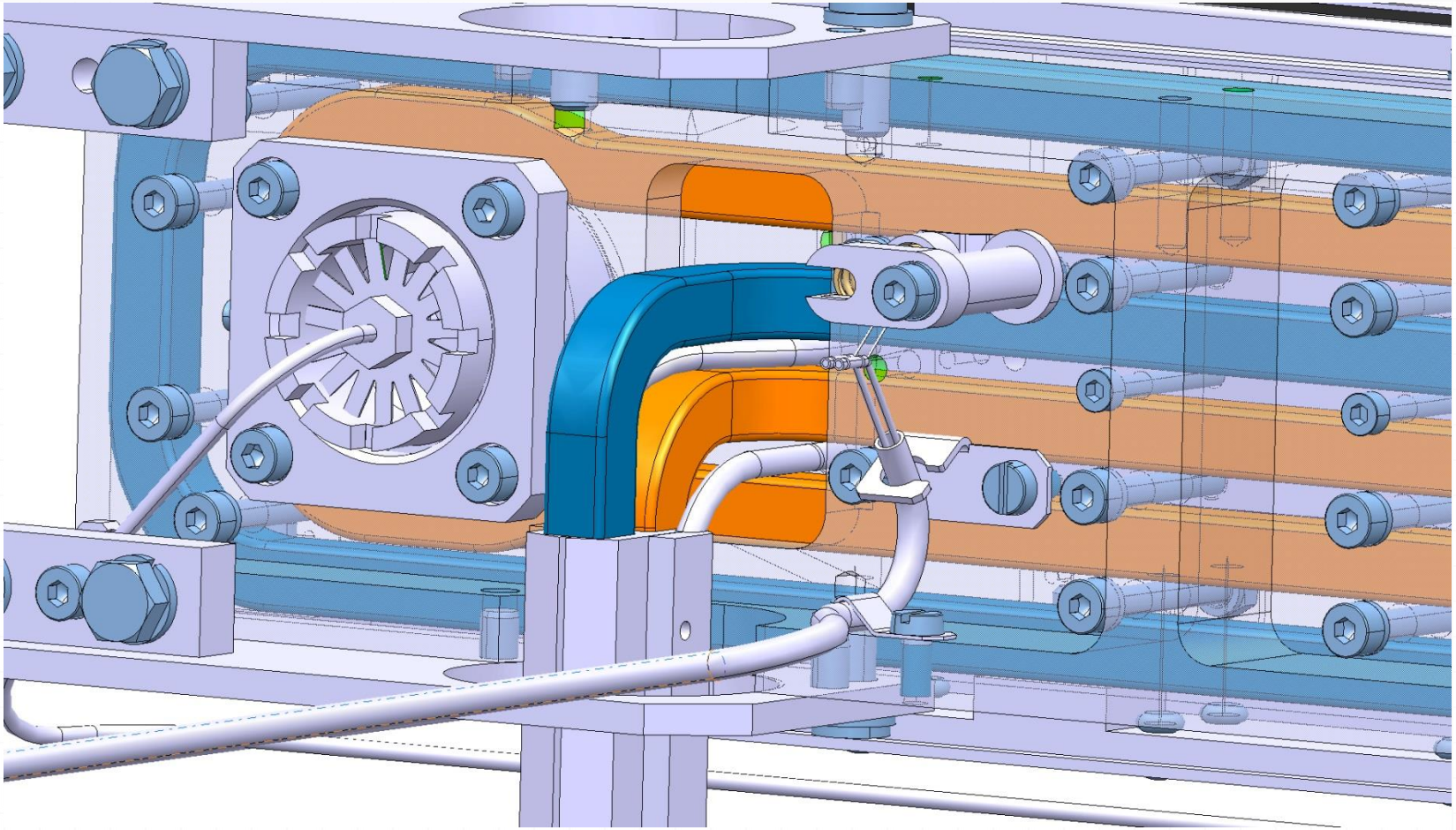


Taking into account dependancy in T :
Strong increase of the final temperature

Both designs not acceptable (yet !)

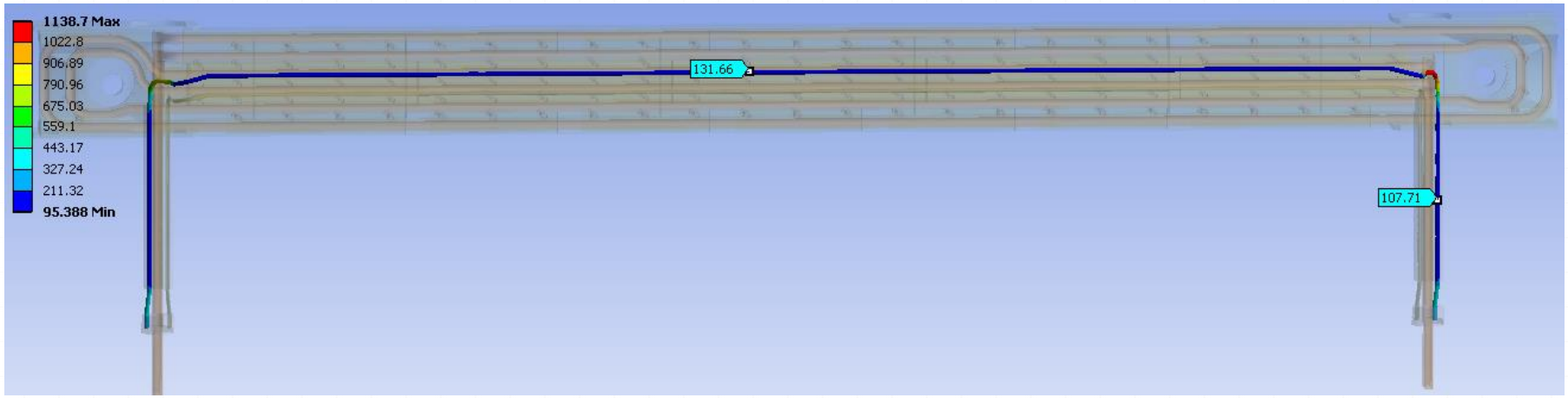
Challenge: must cool the wires in the hottest zones!

Back-up slide



Back-up slide

2 Wires design - Thermal load: 350 A with constant electric resistivity (at 400ºC)



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Back-up slide

2 Wires design - Thermal load: 300 A with constant electric resistivity (at 27ºC)