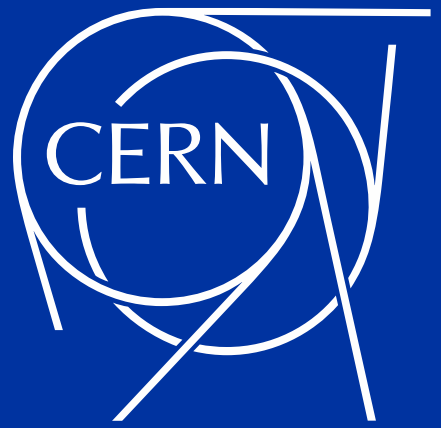


Review of TCLM studies

G. Cattenoz, L. Puddu
WP5.2 – Technical meeting

2025-03-24

Outline

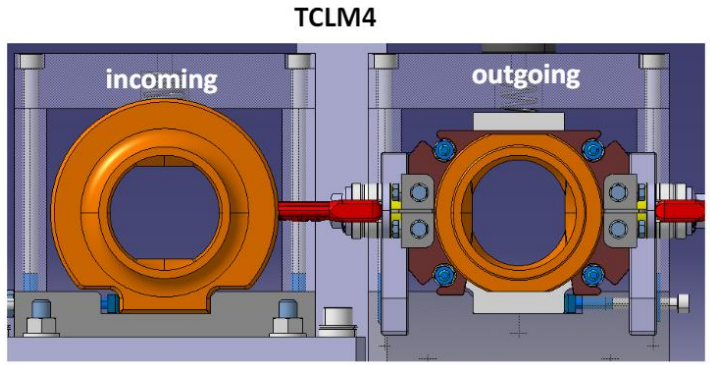
- **Introduction**
- **Thermal cycles to be done at CERN**
- **First proposal for thermal isolations for TT at CERN**
- **Results from simulations**
  - TCLM4 outgoing
  - TCLM5/6 + TCLM4 incoming
- **Next step: experimental test with prototypes**
- **Conclusions**

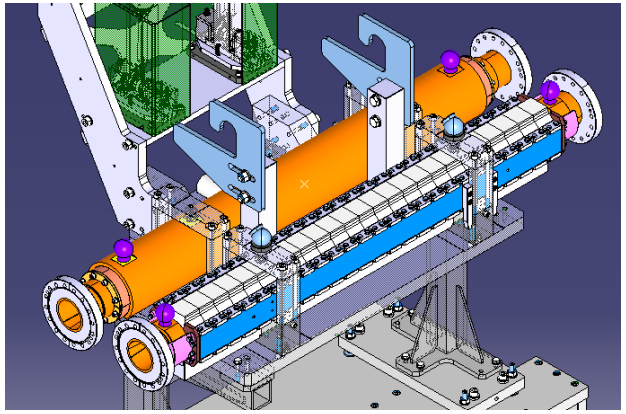
Introduction

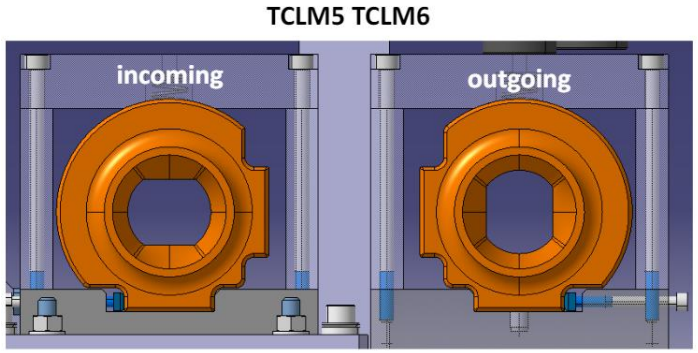
Different design:

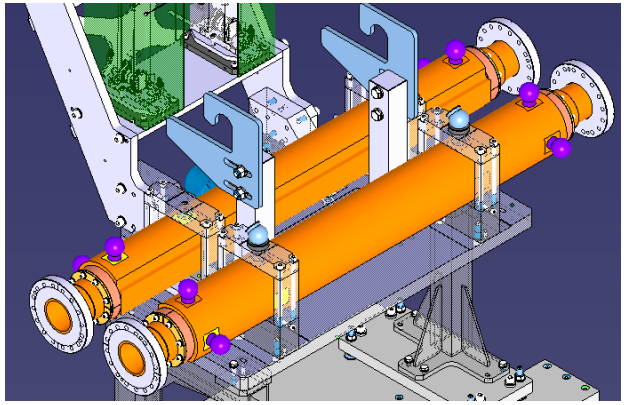
- **TCLM4 outgoing:**
  - Most loaded
  - Made of copper and inermet

- **TCLM5/6 + TCLM4 incoming:**
  - Less loaded
  - Made of copper only
  - Easier design







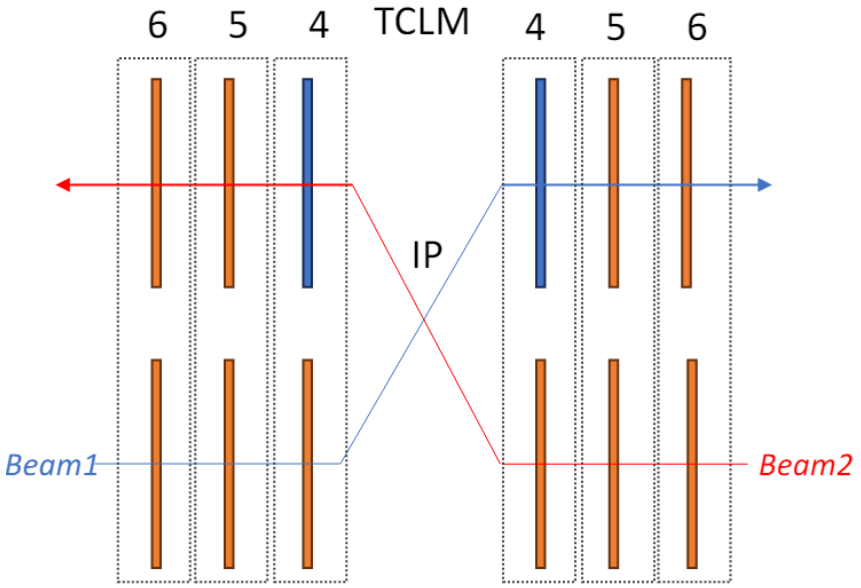


Introduction

- **New TCLM masks design analyzed (EDMS n. 3221866, 3221867)**
- **Scenarios simulated:**
  - Bake out (250 °C)
  - Operational conditions

Load from Fluka simulations [Watt]	Incoming	Outgoing
TCLM4	1	40
TCLM5	2.4	8.6
TCLM6	0.12	1.6

+ 3 Watt (impedance)



Thermal cycles to be done at CERN

Cycles for NEG and SS parts:

- 1st step:

  Bakeout of Stainless-Steel parts at 250°C

  NEG part (TCLM) remains at 120°C, for 48h00

- 2nd step:

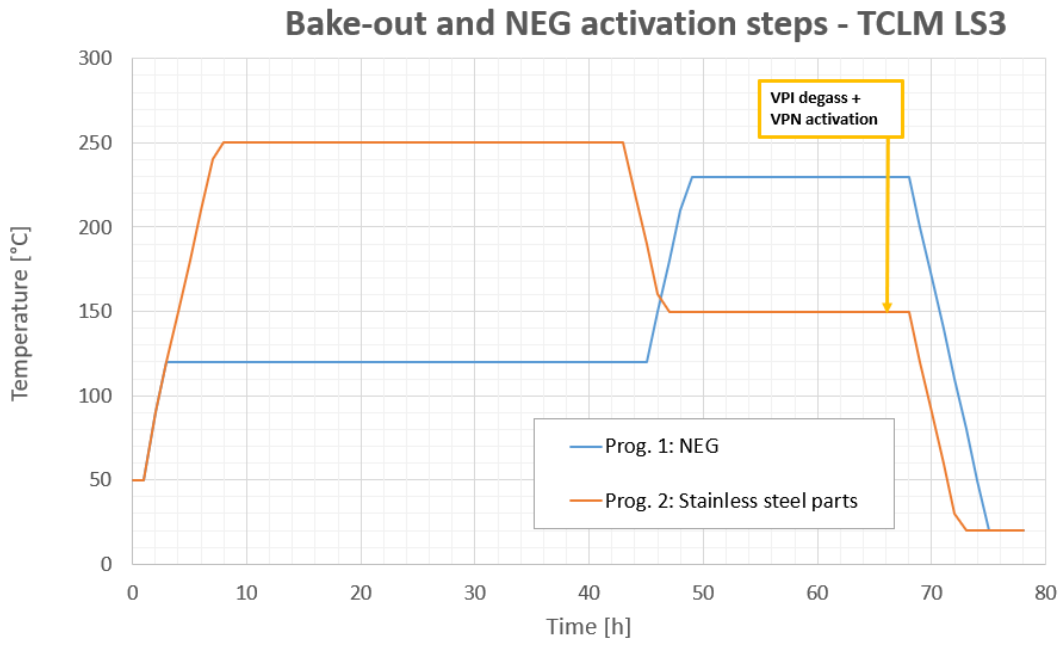
  SS parts are cooled to 150°C

  NEG part (TCLM) is increased to NEG activation temp (230°C), for 24h00

- 3rd step:

  cool down to RT

➢ During the TCLM prototype UHV test we will verify that we can reached the 230°C or not.



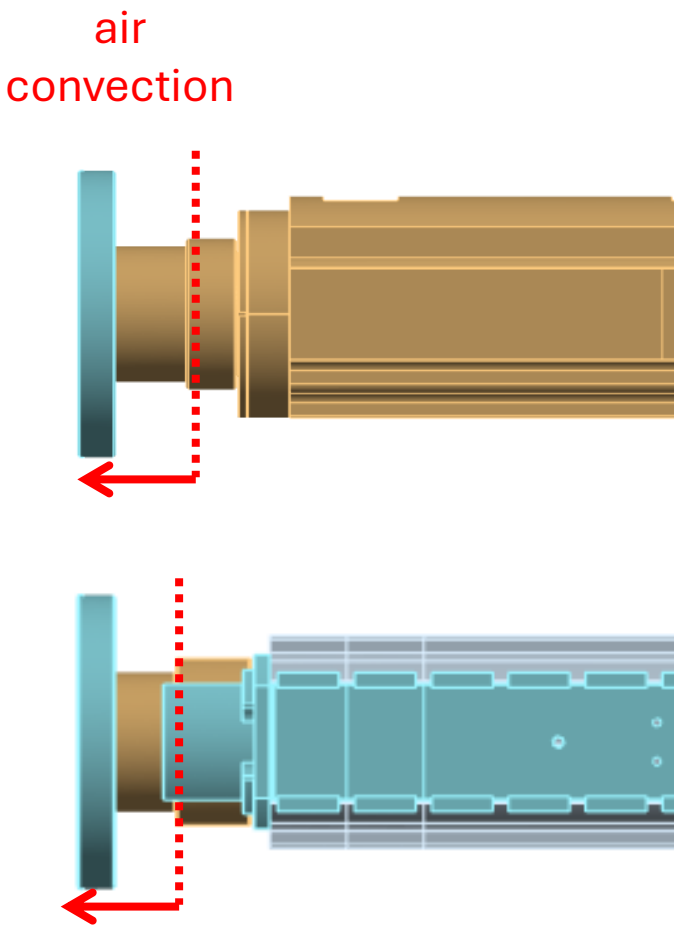
1st proposal for TT at CERN

TCLM5 and 6

- Heating tape in direct contact (wrapped) on the external surface (tape length 3 or 4 m)
- Insulation cover as close as possible to the flanges and all over the tape.
- Glass fibres, 10 mm thick (1 layer) attached with aluminium tape): until 2.5 cm from the end flanges
- Flanges covered with heating collars (which don't really have insulation properties)
- Threads for lifting, survey target interface with the mask and supports of the masks below remain accessible.

TCLM 4

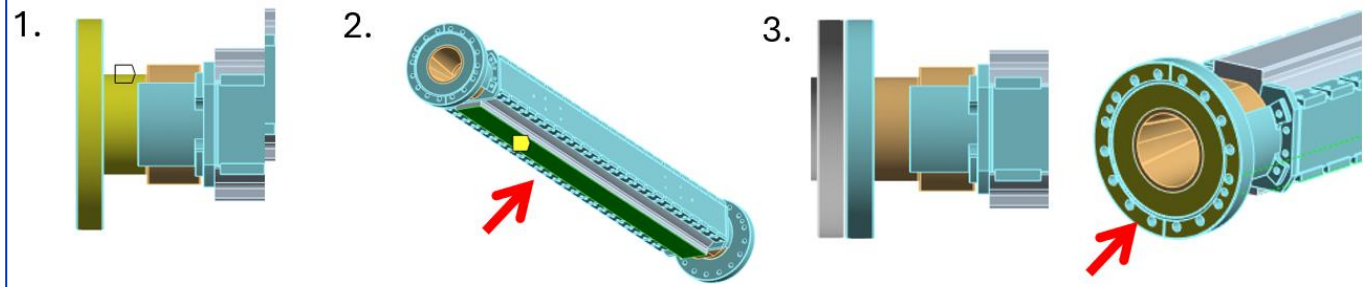
- Same as TCLM5/6
- **Alternative: bakeout jackets like collimator**



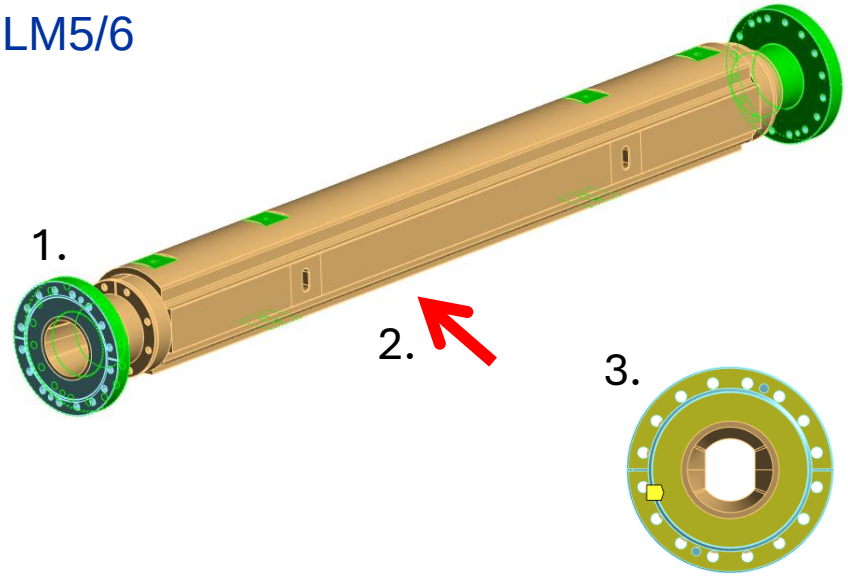
1st proposal for TT at CERN
Themo-mechanical simulations in ANSYS: BC

1. Air convection (extremities): 5 W/m^2/K
2. Contact with the beam + supports at the bottom: 2 W/m^2/K
3. At the extremities, the contribution of the thermal resistance given by the contact with the second flange (16xM8)+, by the flange itself and the air: 4.5 W/m^2/K

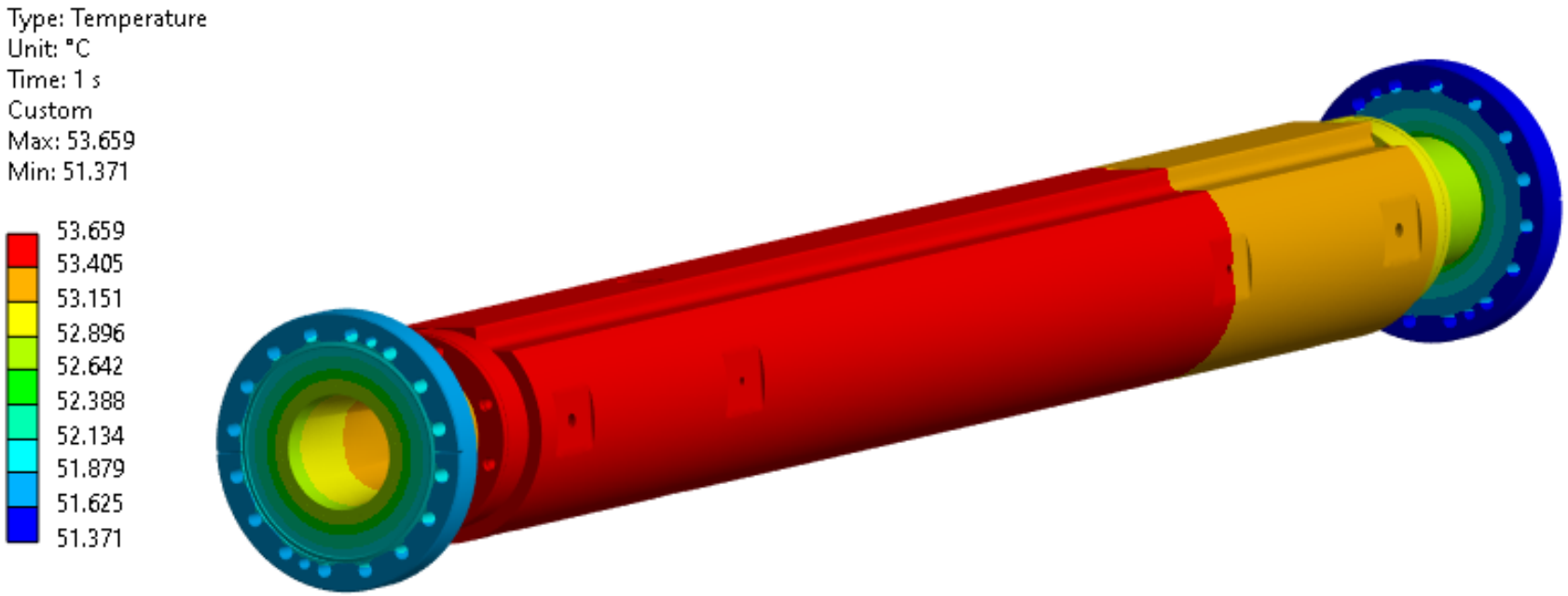
TCLM4



TCLM5/6



Results from simulations
TCLM5/6 – operational scenario

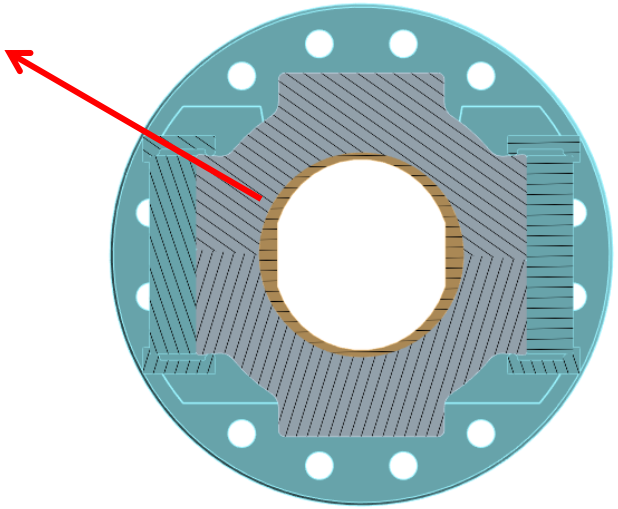


TCLM	Power [Watt]	Tmax [°C]	Taverage [°C]
5OUT	11.3	53.7	52.8
5IN	5.4	37.3	36.9

Results from simulations
TCLM4 – operational scenario

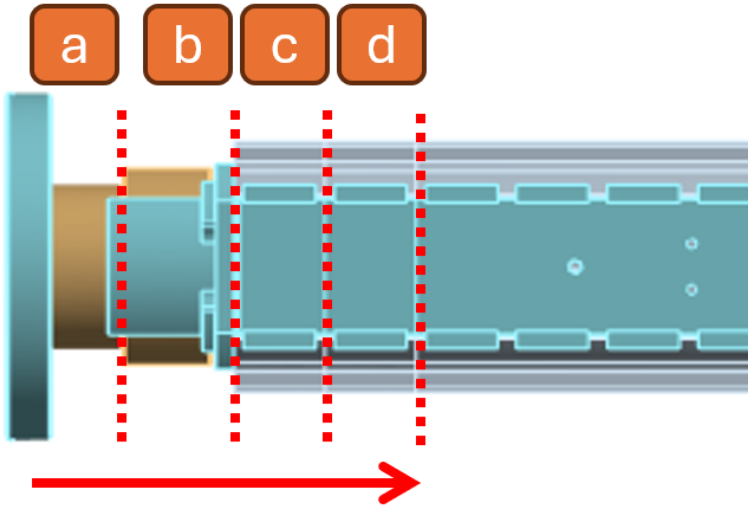
Power [Watt]	In-Cu thermal contact	Entire model		Copper	
		Taverage [°C]	Tmax [°C]	Taverage [°C]	Tmax [°C]
43	No	115.4	121.8	115.8	120.2
	Perfect	114.9	120.6	115.8	120.6

Inermet-Cu interface: Perfect contact **or** no contact



120 °C doesn't represent a problem from the structural point of view (bake-out is more critical), but it can be a problem for degassing

Results from simulations
TCLM4 – operational scenario



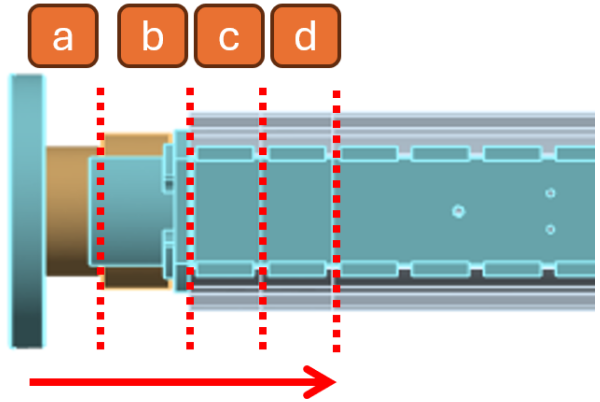
Surface with free air convection	In-Cu thermal contact	Entire model		Copper	
		Taverage [°C]	Tmax [°C]	Taverage [°C]	Tmax [°C]
a	No	115.4	121.8	115.8	120.2
	Perfect	114.9	120.6	115.8	120.6
b	No	81.3	87.4	81.3	85.5
	Perfect	80.8	86.2	81.6	86.2
c	No	70.5	76.1	70.7	74.8
	Perfect	70.3	75.4	70.9	75.4
d	No	**62.9**	**68.1**	**63.4**	**67.5**
	Perfect	**62.8**	**67.7**	**63.4**	**67.7**

Results from simulations

- **TCLM4: T<70°C if first 2 clamps are not covered**
  - First proposal (A): not acceptable
  - Problem:
    - Can we reach the temperature required during bake out with configuration D?
      - Other simulations

- **TCLM5/6: max temperature slightly higher than 50°C**

Results from simulations
TCLM4 – Bake out scenario



What power do we need to keep the bake out temperature in the entire model?

Steady state thermal simulations:

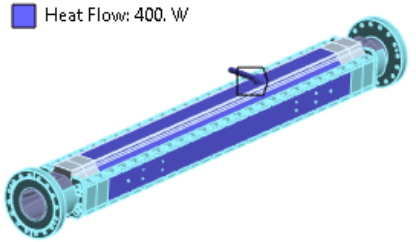
- Input: 250 °C

Surface with free air convection (up to)	Power [Watt]
A	107.7
B	171.2
C	209.1
D	247.3

How much time do we need to reach bake out temperature in the copper pipe?

Transient thermal simulations:

- Input: 400W



Surface with free air convection (up to)	Time	
	Perfect contact	No contact
B	4.6 h	5 h
D	5.6 h	7.7 h

Results from simulations

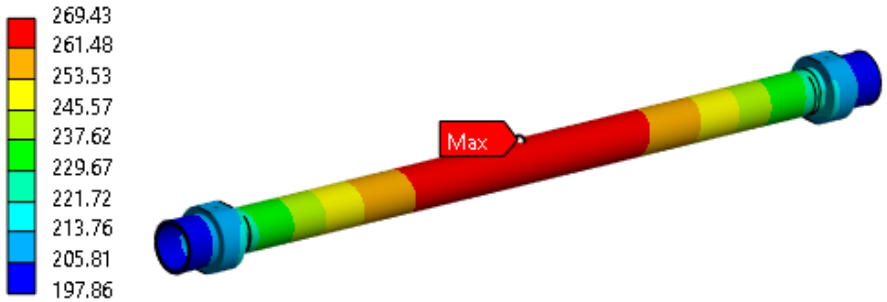
TCLM4 – Bake out scenario

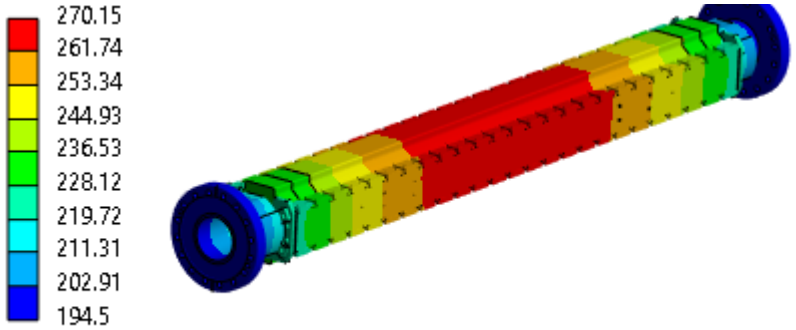
Temperature distribution – Case D

Input: 400 Watt

Perfect contact

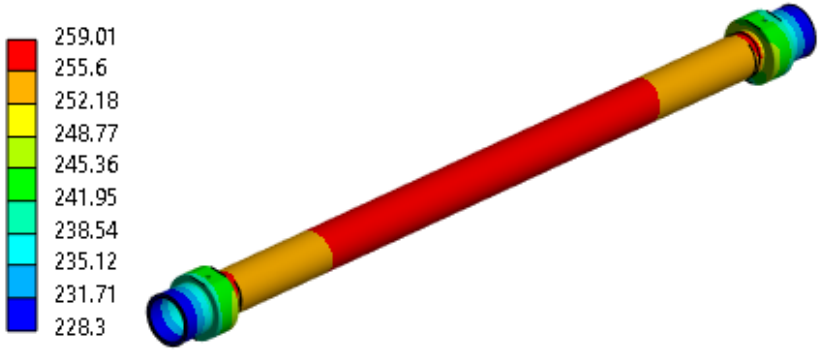
After 5.6 h

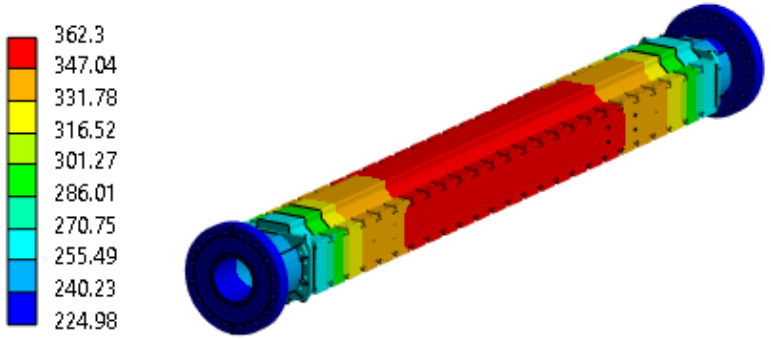




No contact

After 7.7 h





From a structural point of view, the bake-out is a very critical condition and the design validation is based on certain **assumptions**, including **250°C** being **uniform** in both copper and Inermet (if Inermet is at higher temperature, that would be even better)

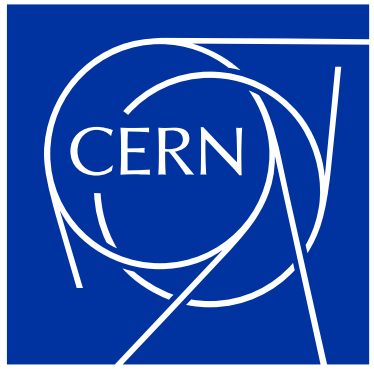
Next step

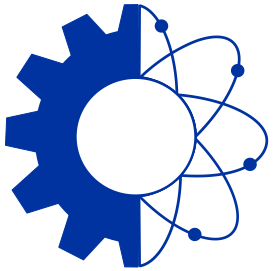
- **Experimental set-up for bake out once we have the prototypes at CERN**
- **When: May 2025**
  - TCLM5/6:
    - we do not expect problems: completely covered
  - TCLM4:
    - **Plan A: thermal isolation on TCLM4 from the center up to the second clamping system (configuration D)**

    Alternatives (to be discussed)
    - Plan B: active cooling system
    - Plan C: thermal jackets to be removed after bake out like for collimators

Conclusions

- **The results from the simulations show different scenarios for:**
  - TCLM5/6 + TCLM4 incoming: masks in copper
  - TCLM4 outgoing: masks in inermet and copper
- **The first proposed thermal insulation during the operational scenario cannot be implemented for TCLM4 outgoing masks (T>120 °C)**
- **Several solutions have been investigated though FEA that must be tested while the prototype will be available at CERN**
  - 2 alternatives have been already identified





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