Update of thermo-mechanical studies for TCTPs (Pb ions)

L. Puddu, F. Carra

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29/10/24

Outline

1. Introduction
2. Case 1a (halo heating)
3. Scraping
4. Conclusions

Introduction

Proposal: increase the Final TCT master thresholds from 2023 Pb run by a factor 3

(at 6.8 TeV)	Master threshold	Deposited power in jaw* at present master threshold
RS06 (10 ms)	0.11431 Gy/s	2.3-6.6kW
RS07 (82 ms)	0.02859 Gy/s	0.6-1.7 kW
RS08-12 (0.6s-82s)	0.01457 Gy/s	0.3-0.9 kW

Since, the thresholds for BPM are set on the impacting powers, the most conservative is case 1a (it maximizes the power deposition on the jaw for a set impacting power):

*Relative power deposition in TCT for the different scenarios (**per impacting ion**):*

	Case 1a	Case 1b	Case 2
Impacted jaw	65%	44%	7%
Opposite jaw	7%	14%	4%
Tank	3%	6%	2%
Total	75%	64%	13%

Introduction

- Case 1: halo leakage of ions from IR7 to the TCTP collimator (TCTPV)
  - A) impact of Gaussian beam ($\sigma_{x/y}$=0.425mm, 9mm impact parameter, half-gap=0.7mm)
  - B) with tracking input: similar operational scenario, but based on real tracking simulations
- Case 2: accidental case (direct beam **scraping** on the TCTP).

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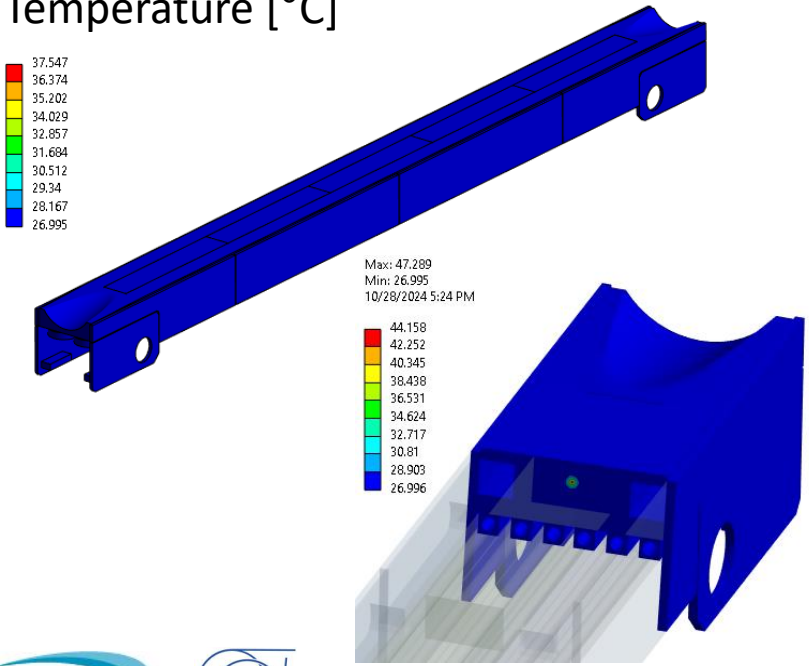
Time	Power deposited [kW]	Number of particles/second
10 ms	20	3.43E+08
82 ms	6	1.03E+08
82 s	3	5.15 e7

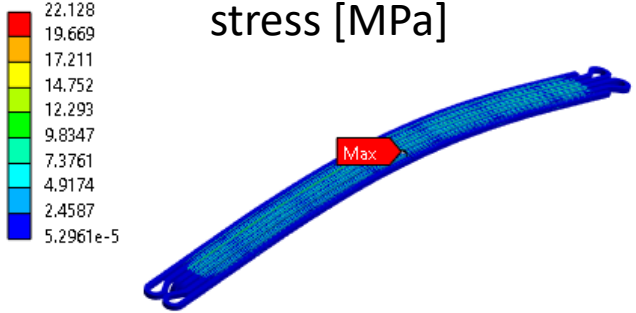
Results - Case 1a

20 kW – 10 ms

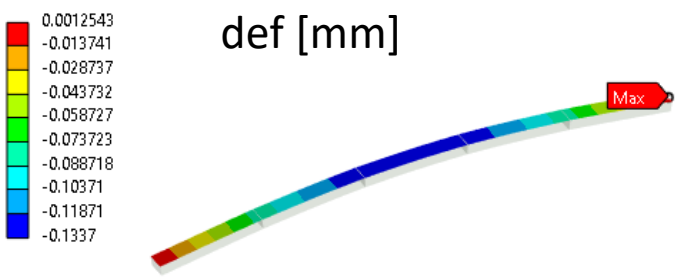
Temperature [°C]



Equivalent stress [MPa]



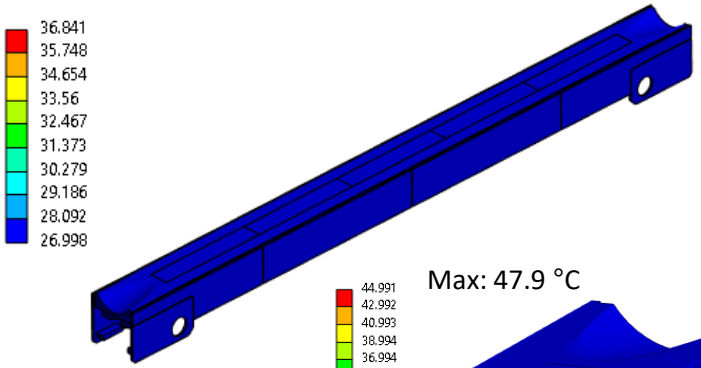
Directional def [mm]

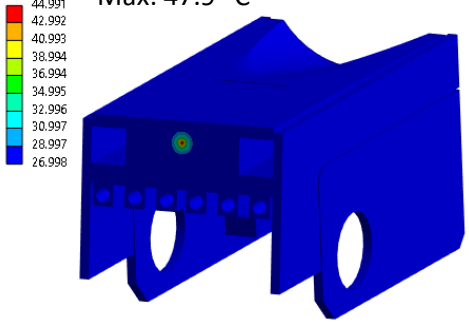


Results - Case 1a

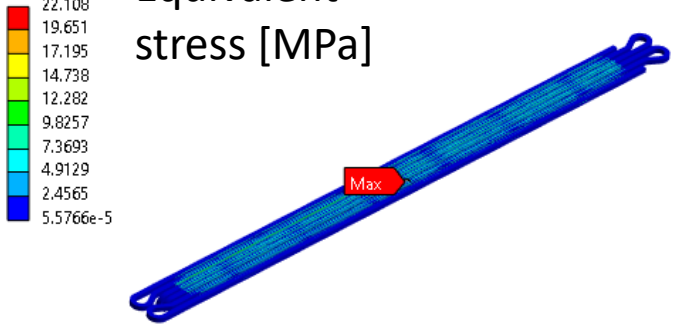
6 kW – 82 ms

Temperature [°C]

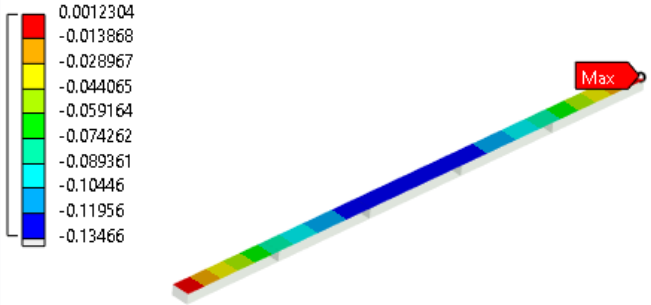




Equivalent stress [MPa]



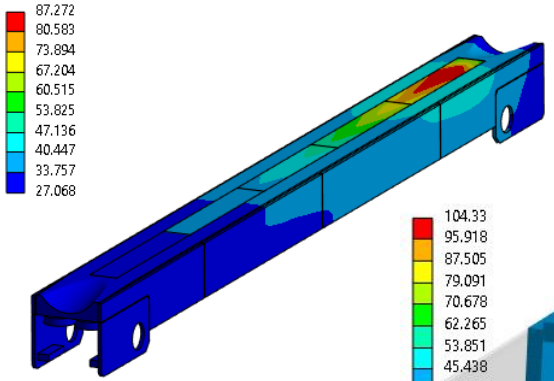
Directional def [mm]

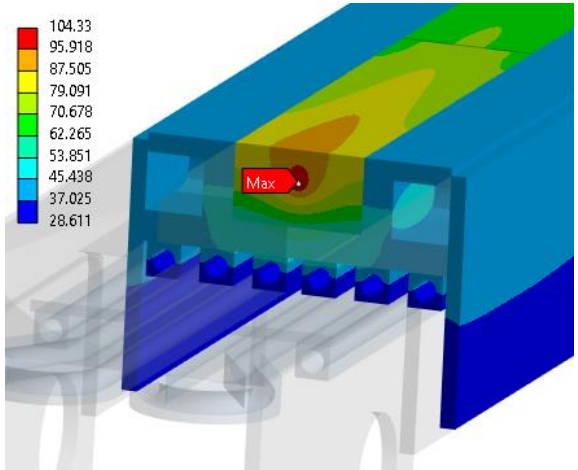


Results - Case 1a

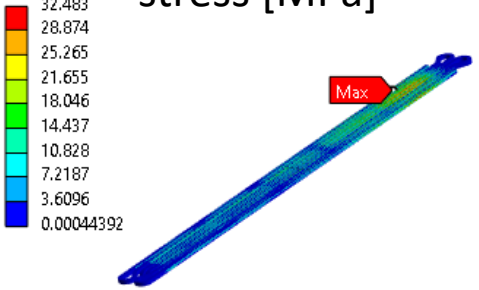
3 kW – 82 s

Temperature [°C]

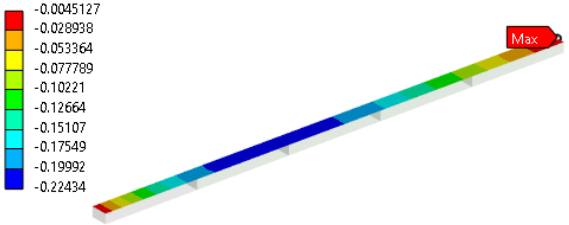




Equivalent stress [MPa]



Directional def [mm]



Results - Case 1a

Reminder:

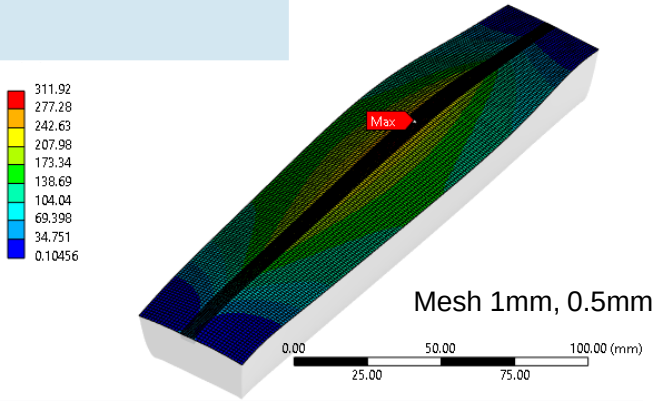
- Yield stress CuNi pipes = 120 MPa
- Yield stress Inermet180 = 640 MPa

Deposited Power [kW]	Time [s]	Tmax jaw [°C]	T probe [°C]		Max deflection jaw [um]	Max stress [MPa]	
						Pipes	Blocks
20	10 e-2	47.3	27.0	27.0	133	22.1	18.0
6	82 e-3	47.9	27.0	27.0	133	22.1	21.5
3	82	105.5	31.9	44.6	220	32.5	65

Scraping 3kW, 20 s – Results

Evaluation of stress on inermet:
Simplified (and conservative) sub-model

Map	Mesh size	Max Temp [°C]	Eq. Stress [MPa]
2	0.5 mm	121	
2 3	0.5mm (0.1mm)	163	312
2 3	0.5mm (0.05mm)	163	

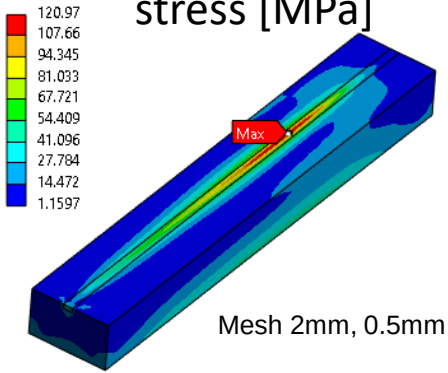


Mesh 1mm, 0.5mm

Scraping 3kW, 20 s – Results

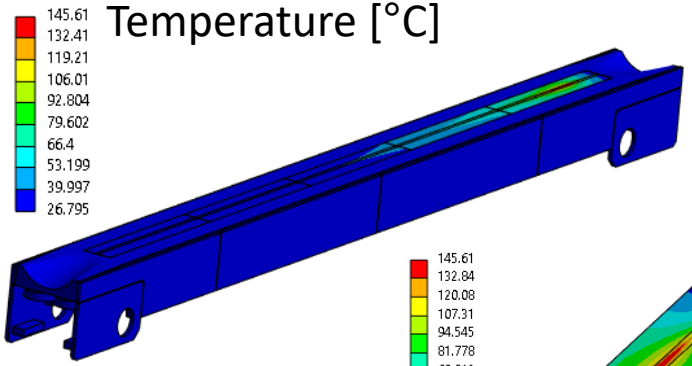
More accurate model:
Entire model with finer mesh at the power peak

Equivalent stress [MPa]

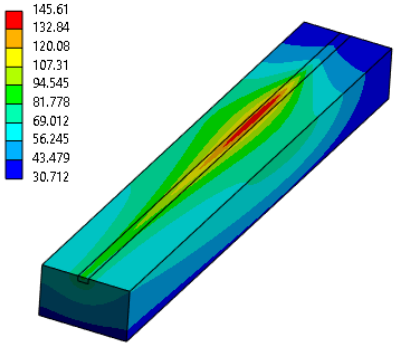


Mesh 2mm, 0.5mm

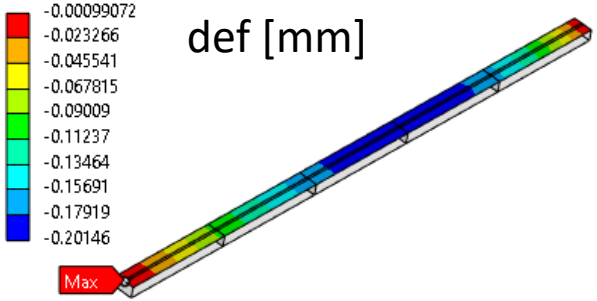
Temperature [°C]



Mesh: 0.5 mm, 0.05mm



Directional def [mm]



Scraping fast losses (0.1 s) – Results

Deposited Power [kW]	Time [s]	Tmax jaw [°C]	T probe [°C]		Max deflection jaw [um]	Max stress [MPa]	
						Pipes	Blocks
9	10 e-2	60.3	27.0	27.0	130	24.5	58.8
3	10 e-2	38.1	27.0	27.0			

Conclusions

- After the analysis of case 1a, an increase in BPM thresholds by a factor of 3 does not present any thermo-structural issues.
- For the scraping scenario, the stress analysis on the inermet, which was previously left incomplete, has now been concluded:
  - with a deposited power of 3 kW for 20 s, we reach approximately 50% of the yield strength of the inermet (with the conservative sub-model).
  - if the thresholds are set as discussed before, we actually dump at ~ 400W in the case of scraping, so almost 1/10 less than what was simulated

Thank you for your attention
Questions?