FCC secondary collimator – 1hBLT FEA

G. Gobbi, F. Carra

FCC collimation design meeting #19

CERN | EN ENGINEERING DEPARTMENT

25/6/2018

TCSP case study

- TCSP most loaded jaw of the first secondary collimator (**TCSGA6L**)
- **Thicker jaw** (**4.5 cm** instead of 2.5 cm)
- Skew TCP removed and thickness of primary collimator jaws (30cm long) increased from 2.5 cm to 3.5 cm
- Slow losses
  - Nominal operation: 1h BLT
  - Accidental case: 0.2h BLT (10s)

  Already presented at FCC meeting #15 on 08/12/2017

- TCSP design with stiffer structure than the current one, simulated with bonded contacts between CFC and Glidcop housing

Collimator Jaws	TCP 60cm	TCP 30cm	TCP 30cm Thicker Jaw, w/o TCPB	
Primaries (kW)				
TCP.D6L	14.7	7.7	6.5	-16% ▼
TCP.C6L	158.7	99.2	79.7	-20% ▼
TCP.B6L	260.8	153.7	NA	
Secondaries (kW)				
TCSG.A6L	220.9	226.6	92.4	-59% ▼
TCSG.B5L	10.6	13.9	9.8	-29% ▼

M. Varasteh | *Energy deposition studies: 30cm TCPs with thicker jaws and no skew*
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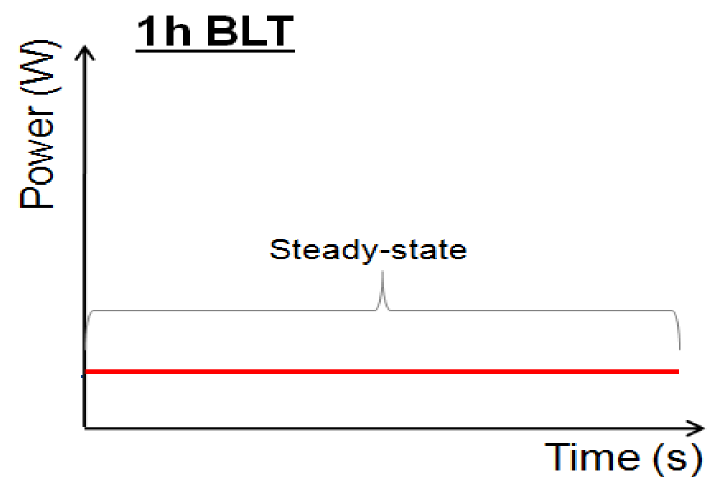
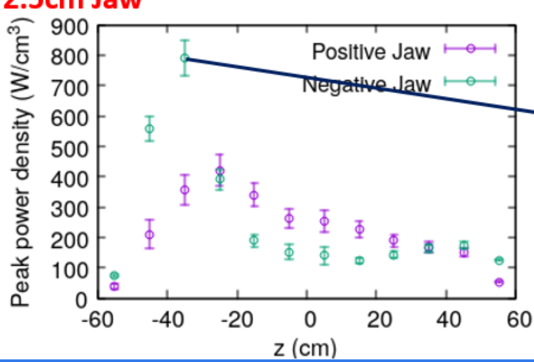
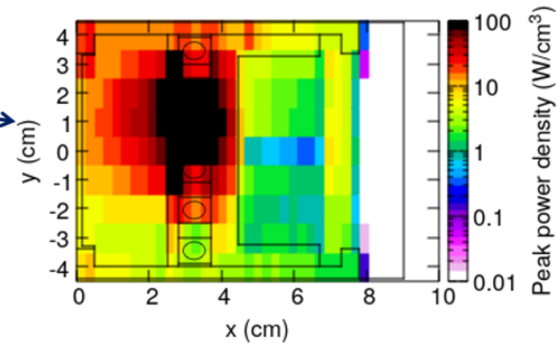


TCSP – FCC thermal load

Power density on the First Secondary

2.5cm Jaw

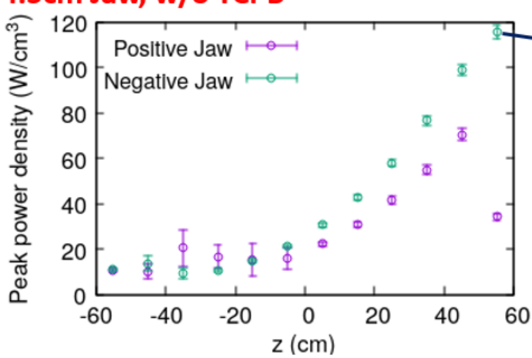


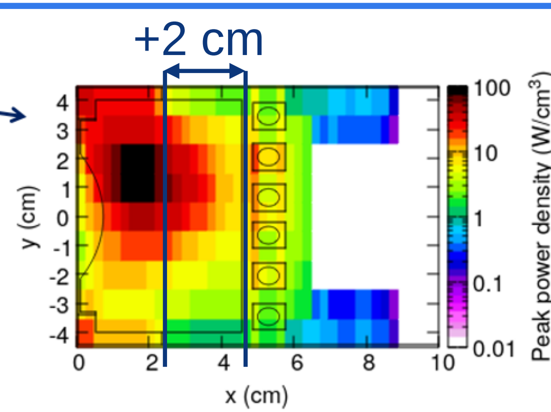


x-y-z resolution: ***0.24cm, 1cm, 10cm***

- TCSG.A6L → **800 Wcm^{-3}**
- TCSG.A5L → 90 Wcm^{-3}
- TCSG.D4L → 33 Wcm^{-3}

4.5cm Jaw, w/o TCPB





- TCSG.A6L → **115 Wcm^{-3}**
- TCSG.A5L → 85 Wcm^{-3}
- TCSG.D4L → 30 Wcm^{-3}

60cmTCP, v-halo, Thicker TCS:

- TCSG.A6L → **130 Wcm^{-3}**

in LHC:

- Secondary → 10 Wcm^{-3}

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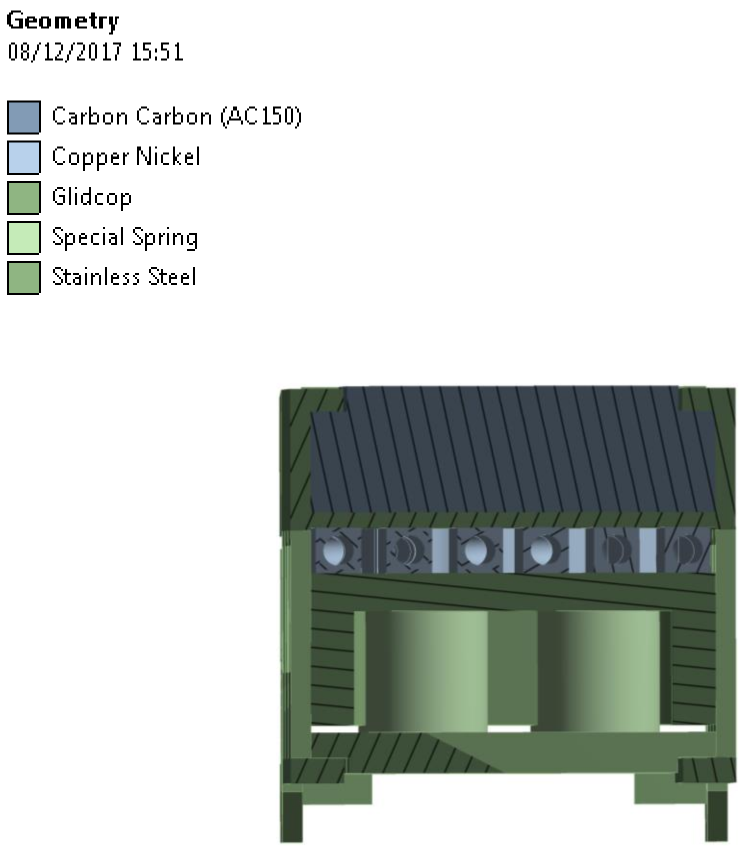
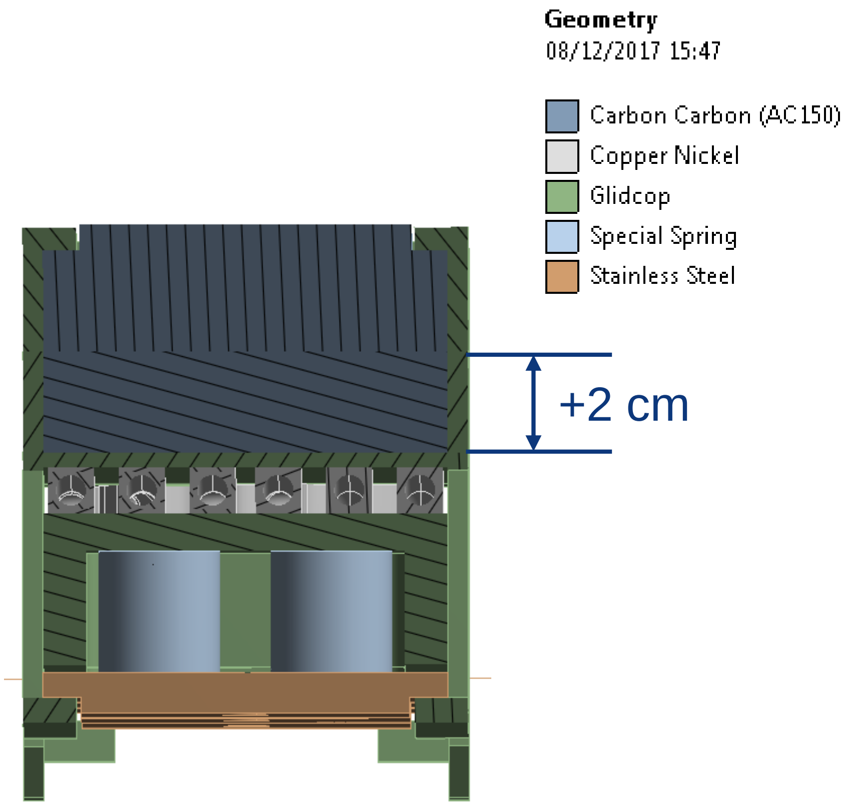
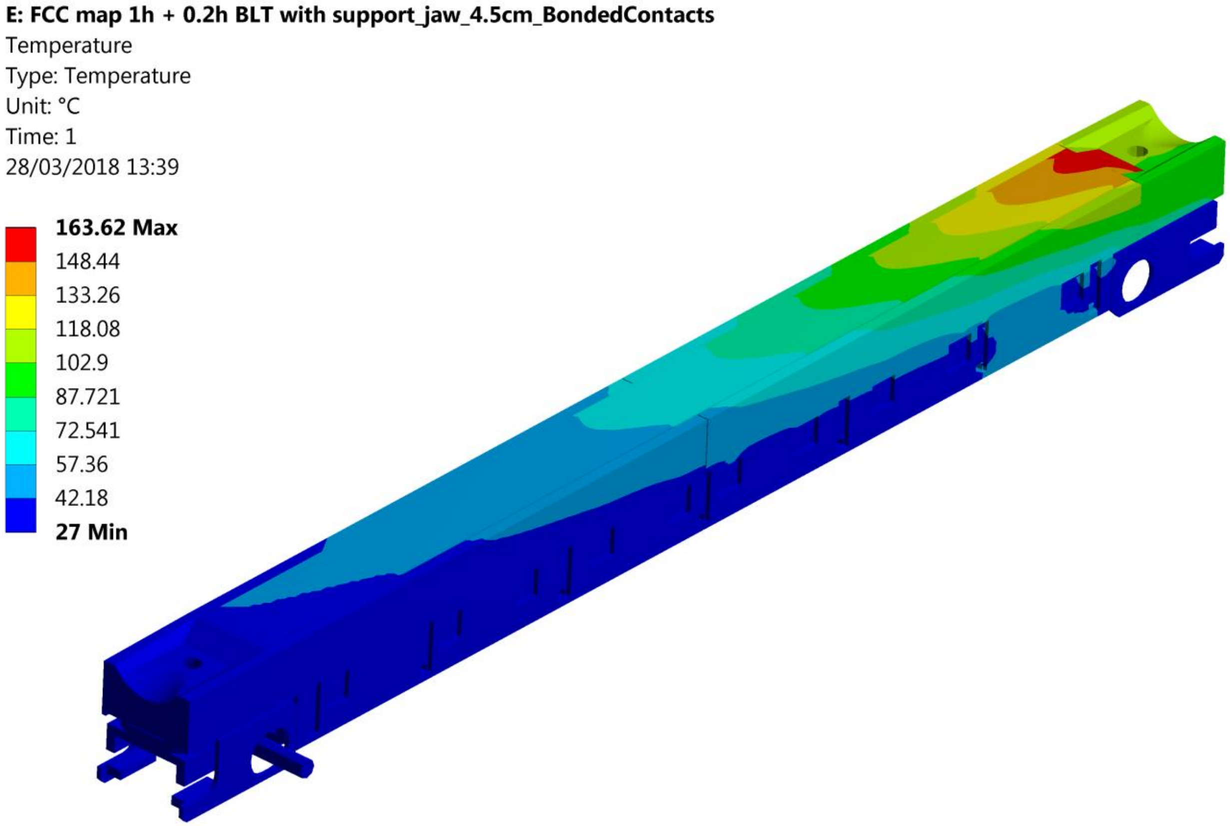
TSCP case study





Thermal analysis – results 1hBLT

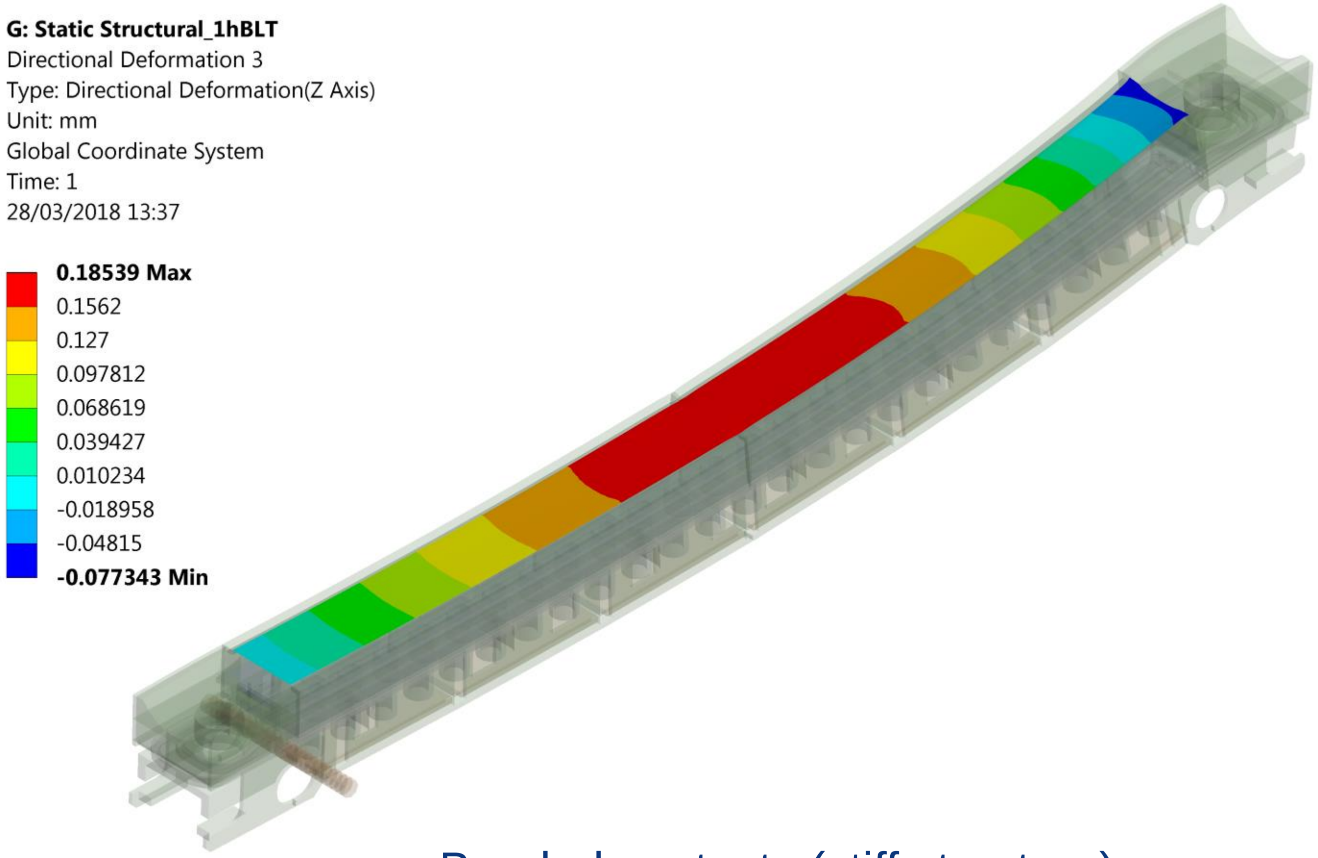


Cooling water at T = 27 ºC (constant)

T_{max} = 164 ºC (4.5 cm jaw)

T_{max} = 330 °C for **0.2hBLT**

Structural analysis - results

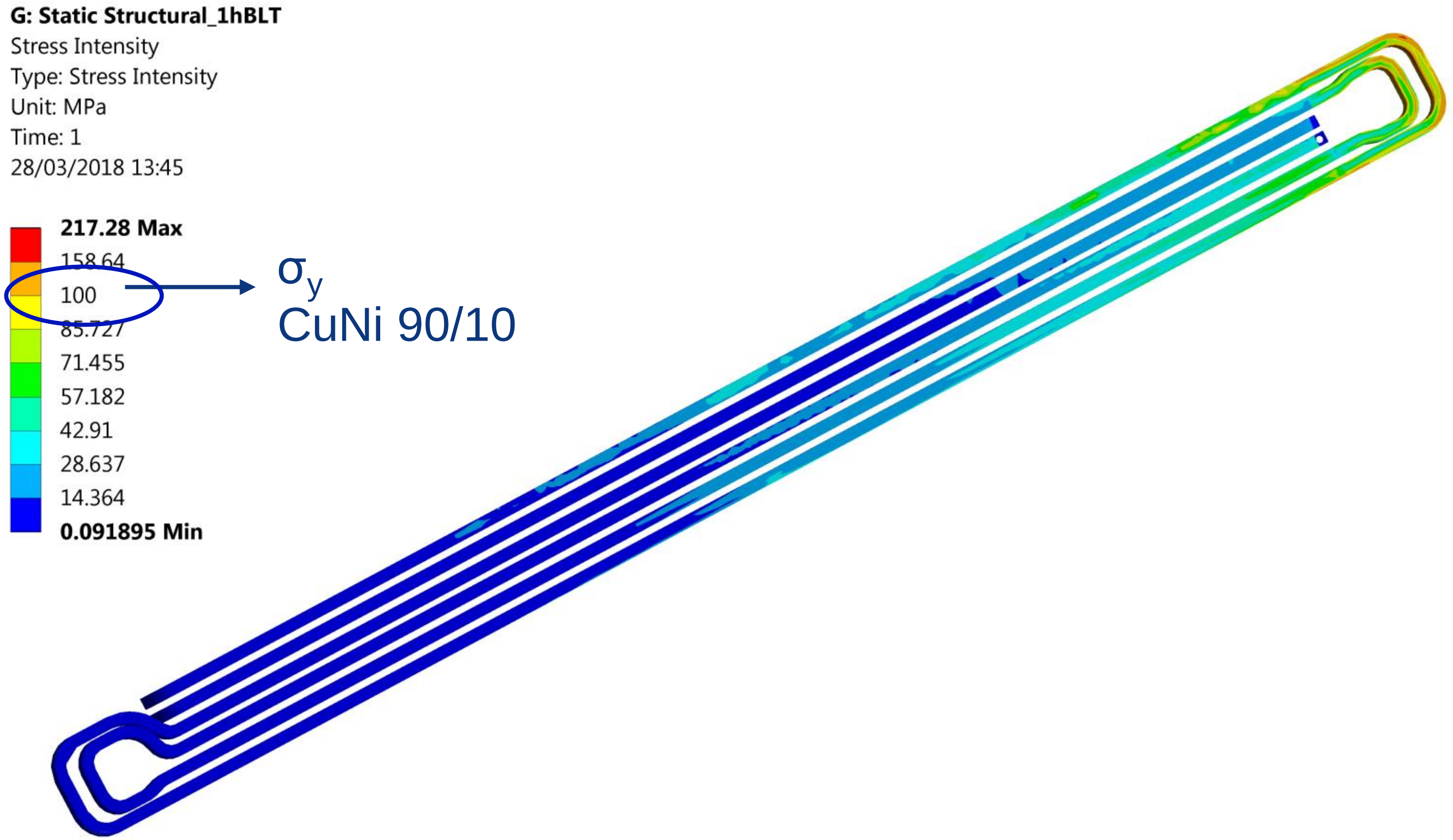


Bonded contacts (stiff structure)

Thermal induced deflection (4.5 cm jaw) = 262 µm

Thermal induced deflection = 375 µm for **0.2hBLT**

Structural analysis - results



σ_y
CuNi 90/10

Plasticity on downstream region of cooling pipes

Summary

- 1h BLT scenario was simulated for a thicker TCSP collimator jaw (4.5 cm) with FCC load →conceptual study
- Maximum T = 164ºC →1/2 with respect to 0.2h BLT (330 ºC)
- Thermal induced deflection 262 µm vs 375 µm of 0.2h BLT, obtained with bonded contacts between CFC and housing (structure much stiffer than the current one)
- Plasticity on the cooling pipes still present even if in a smaller region → can be addressed with different cooling pipes material

FCC primary collimator – 0.2hBLT FEA

M. Pasquali, G. Gobbi, F. Carra and A. Bertarelli

FCC collimation design meeting #19

25/6/2018

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TCP case study

- Vertical primary collimator (**TCPD6L**)
- **Thicker jaw→3.5 cm** instead of 2.5 cm
- **Active length 30 cm**
- Slow losses
  - Nominal operation: 1h BLT
  - Accidental case: 0.2h BLT (10s)

Collimator Jaws	TCP 60cm	TCP 30cm	TCP 30cm Thicker Jaw, w/o TCPB	
Primaries (kW)				
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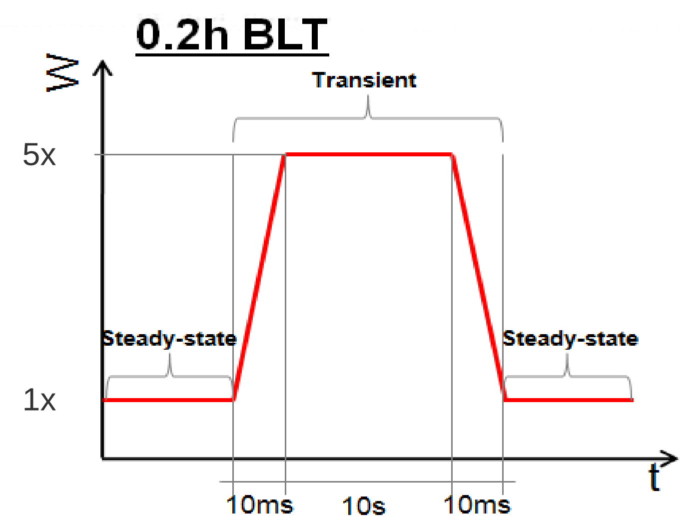
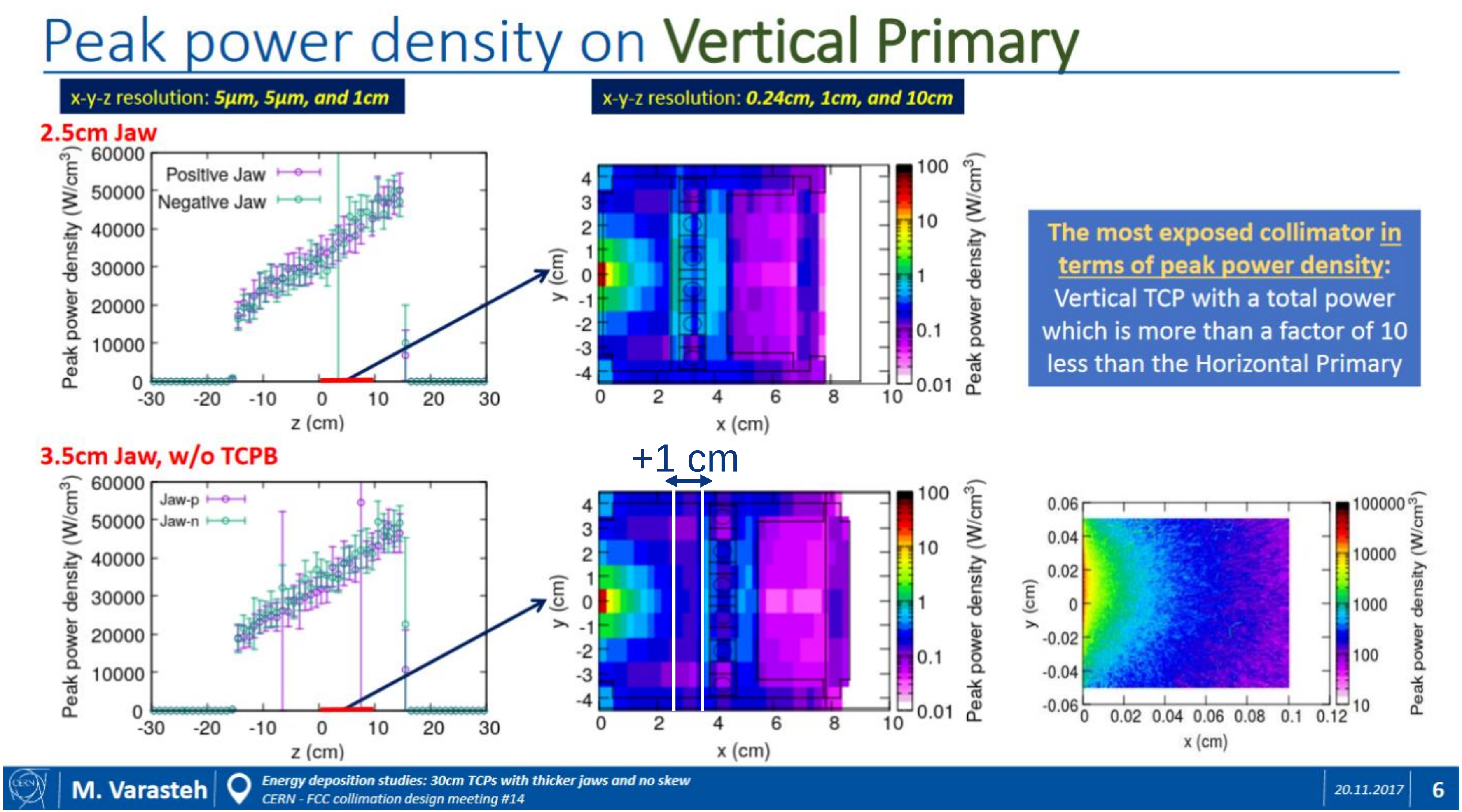
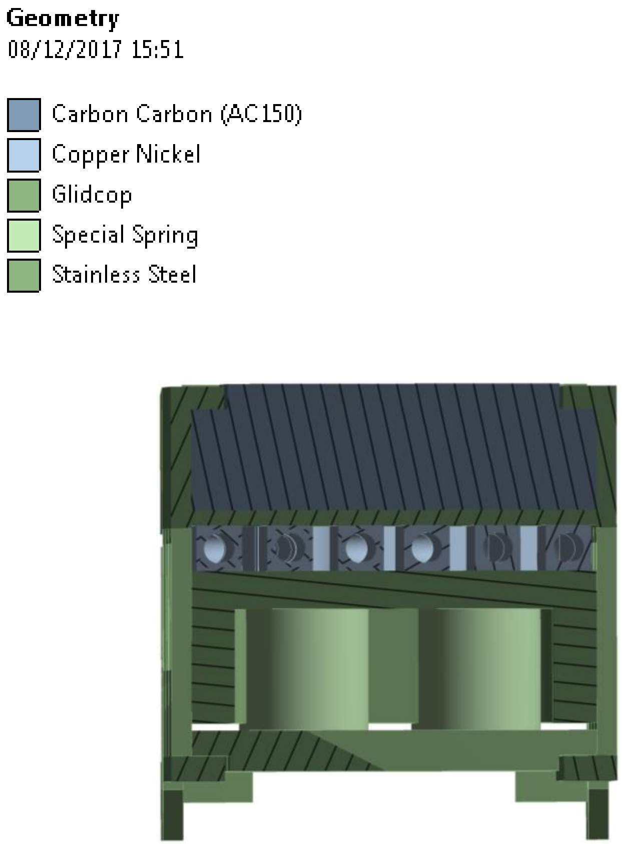
- TCP design with stiffer structure than the current one, simulated with bonded contacts between CFC and Glidcop housing

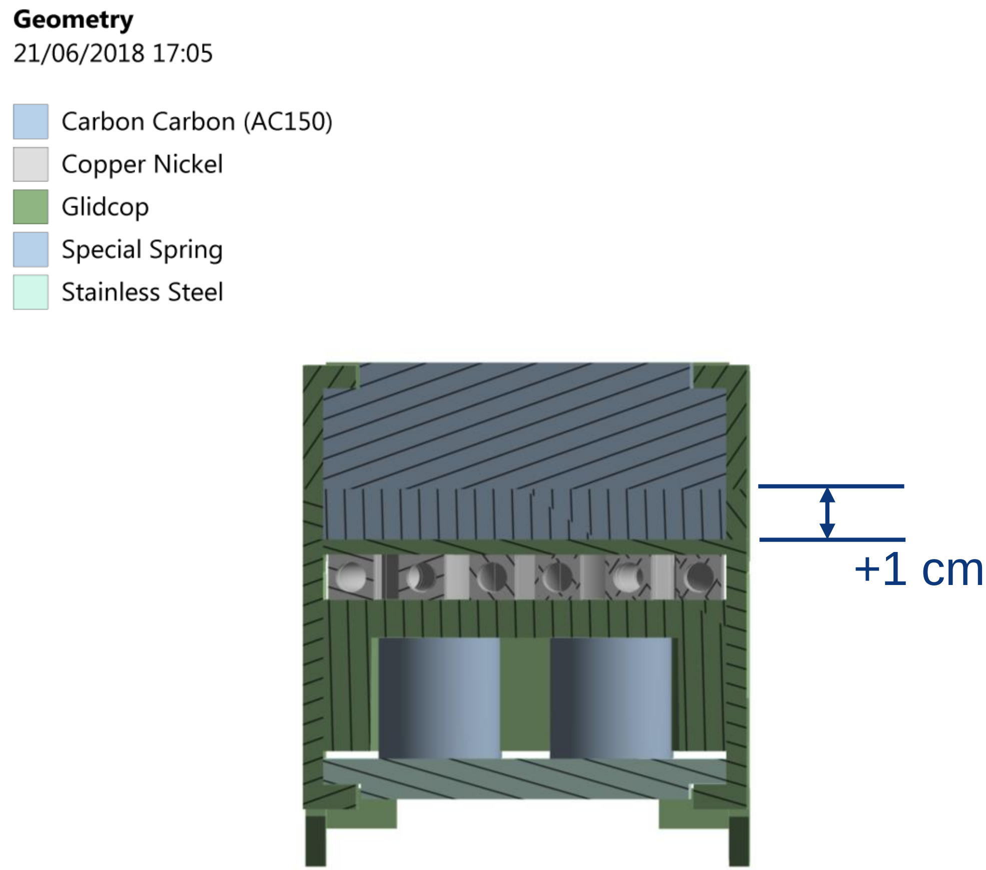


TCP – FCC thermal load



TCP case study

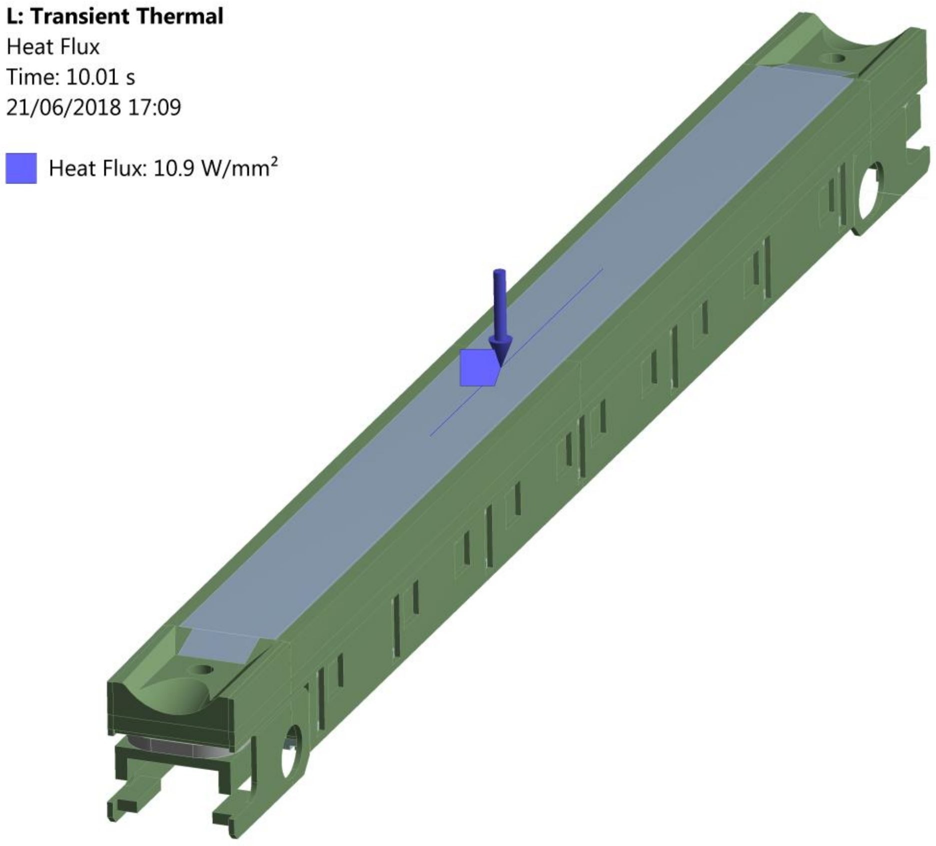




2 approaches:

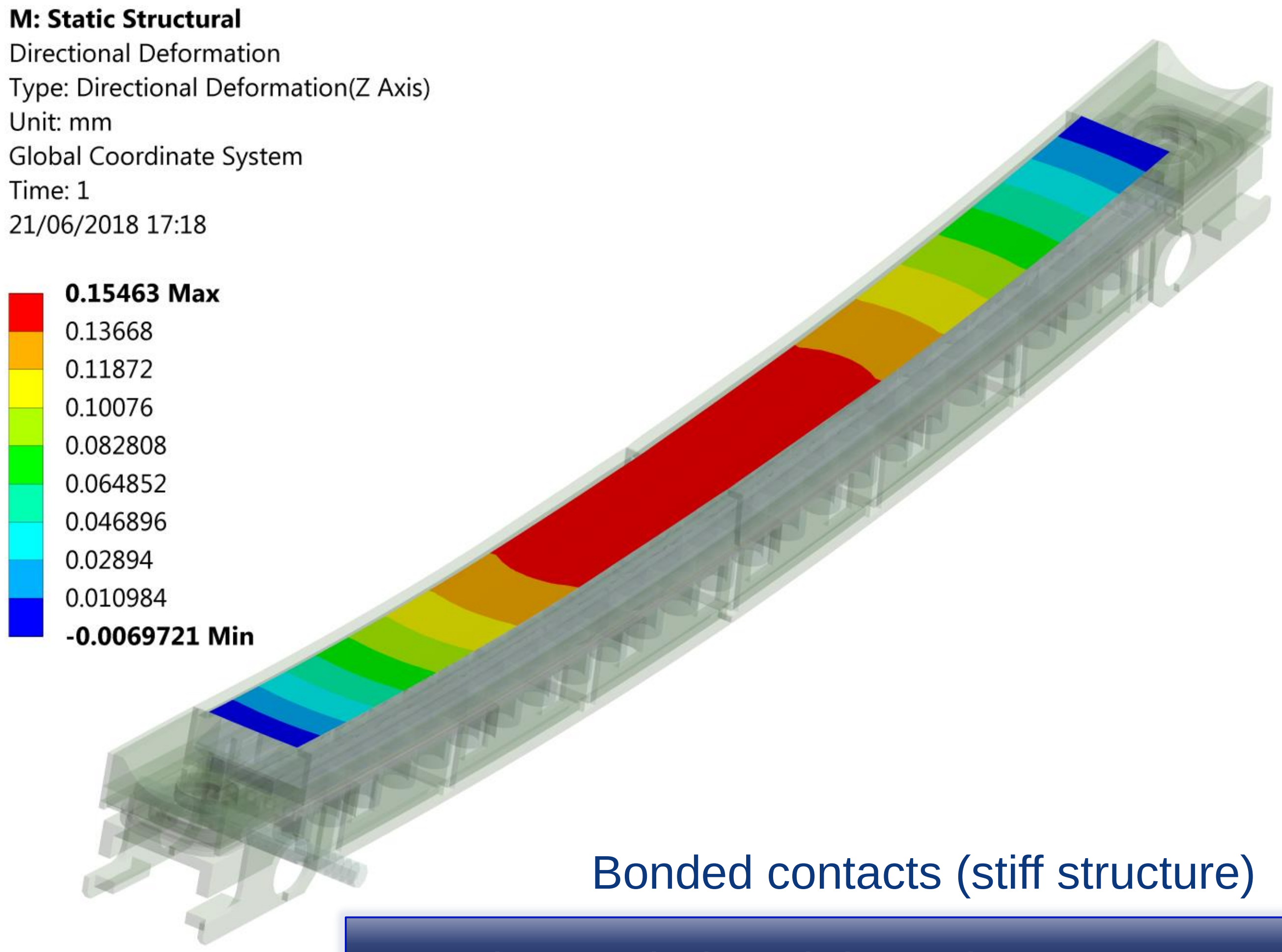
1. Check collimator structure
2. Focus on CFC absorber

Thermal load – Approach 1



- Surface 300x1 mm
- Heat flux equivalent to 3.27 kW (total thermal load on the absorber)
- t = 10 s

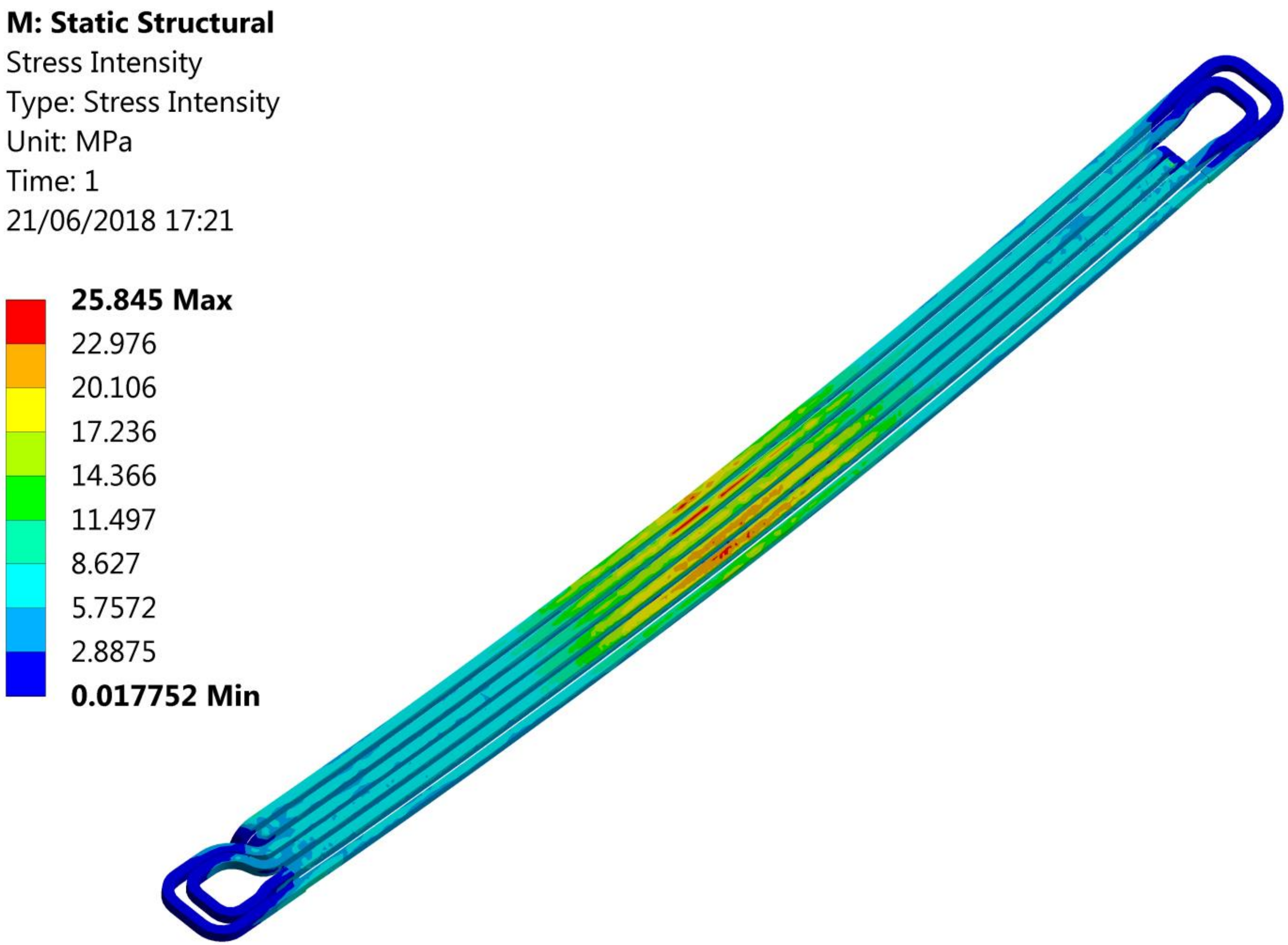
Structural analysis - results



Bonded contacts (stiff structure)

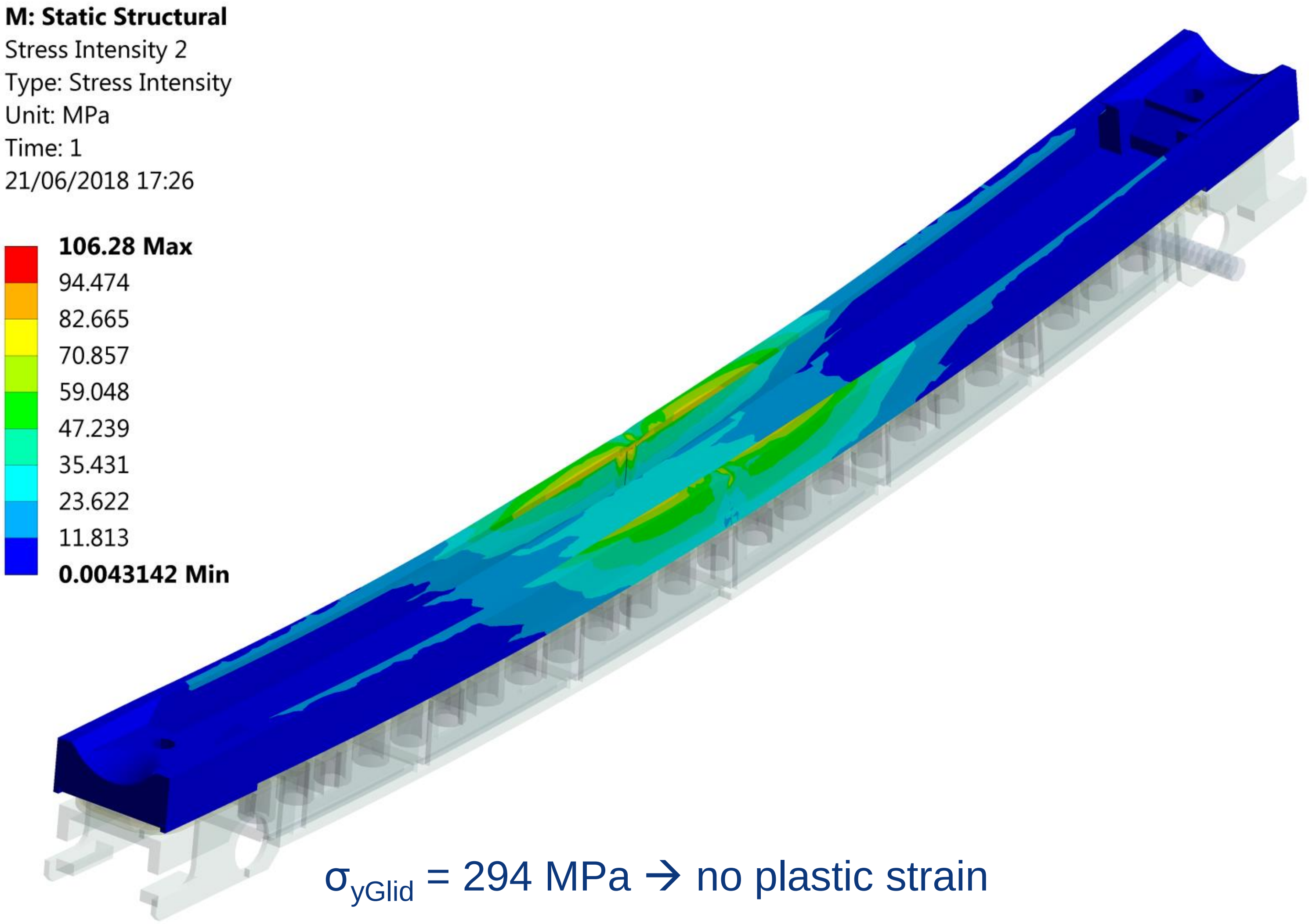
Thermal induced deflection = 162 µm

Structural analysis - results



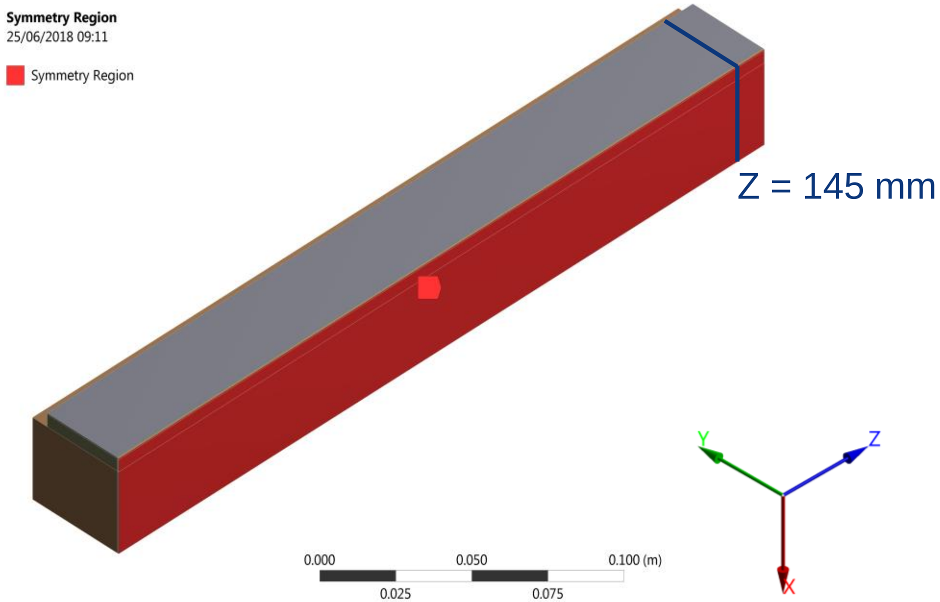
σ_{yCuNi} = 100 MPa → no plastic strain

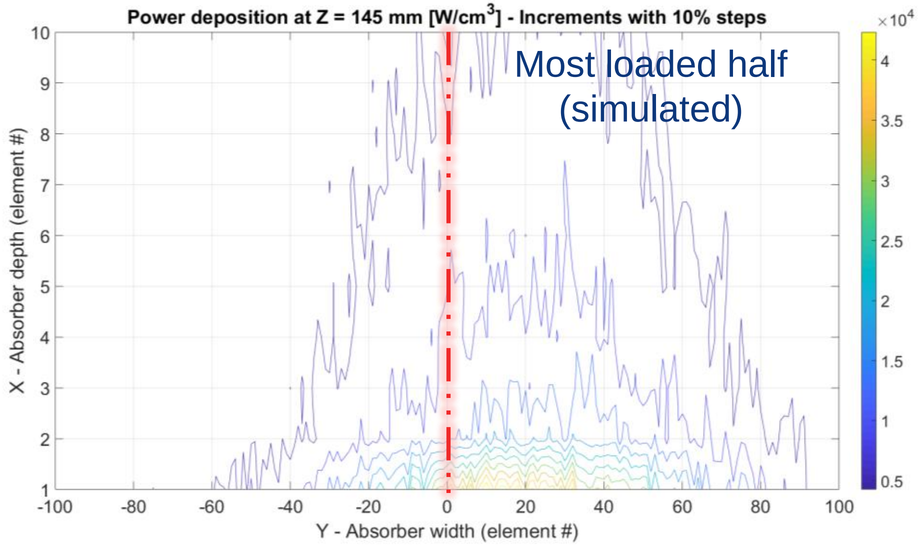
Structural analysis - results



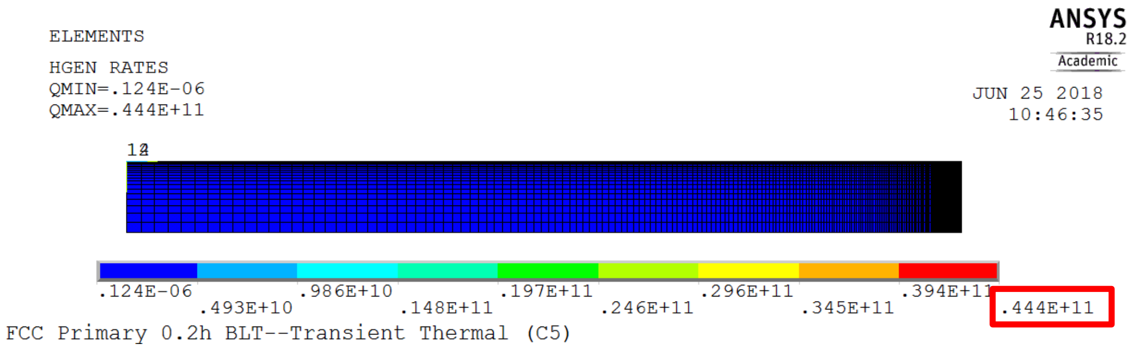
σ_{yGlid} = 294 MPa → no plastic strain

Thermal load – Approach 2

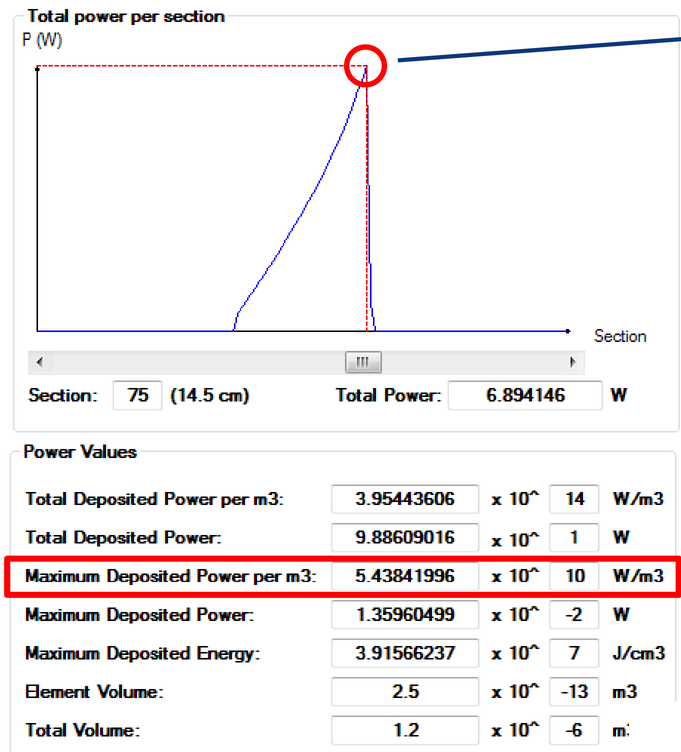


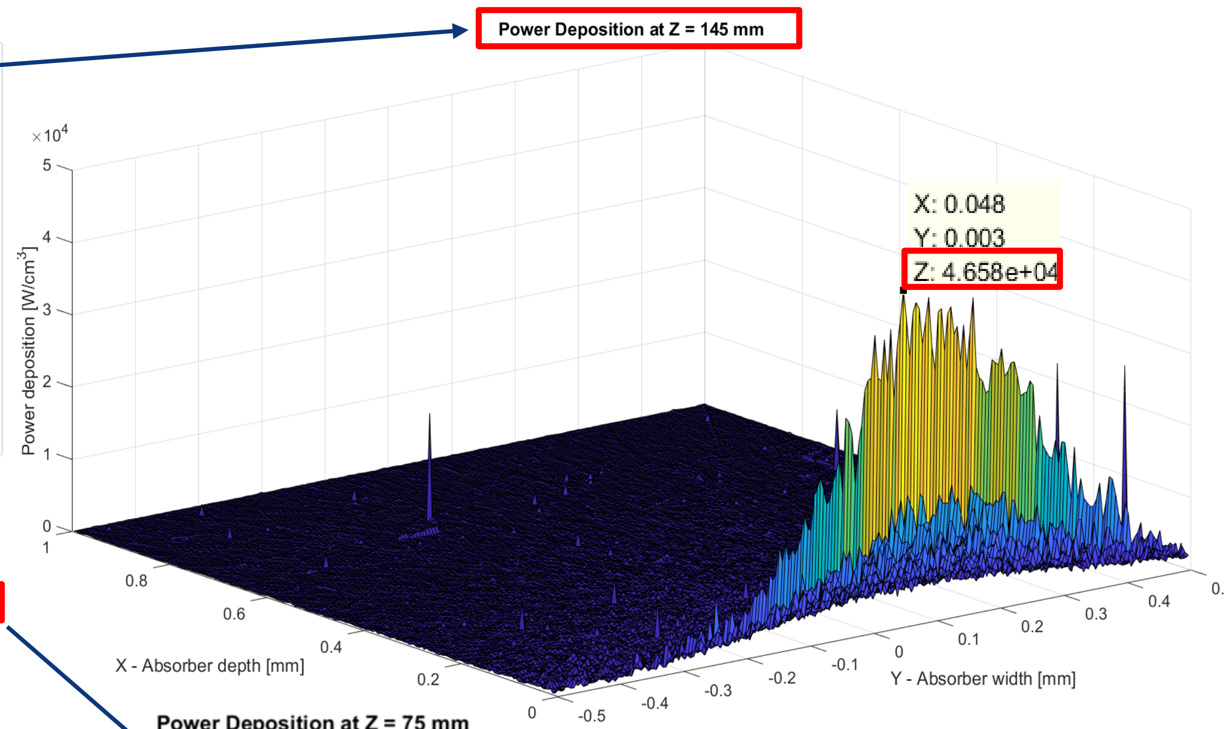


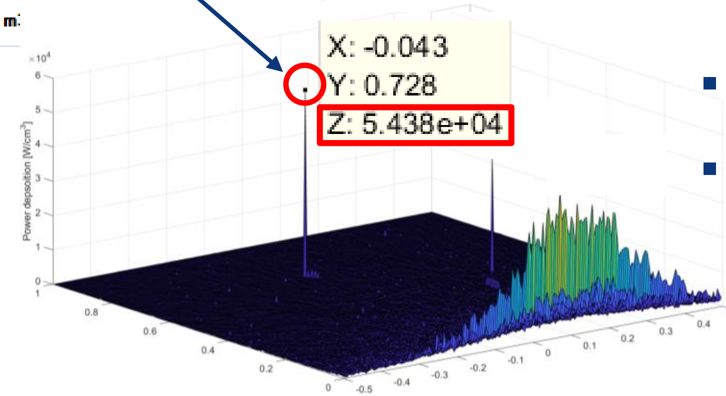
- Simulation of half absorber (most loaded one)
- Biased mesh (5 x 5 x 5 µm at highest refinement point)
- 44400 W/cm^3 as max resolved thermal load



TCP – FCC thermal load

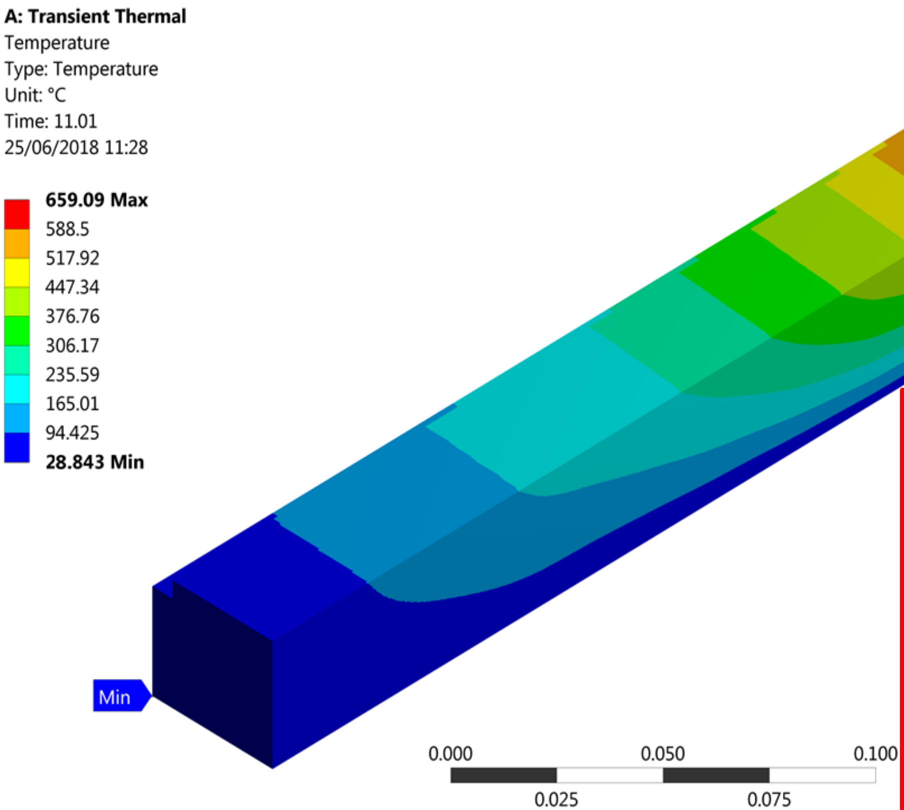






- Isolated max = 54380 W/cm^3
- Max on most loaded section = 46580 W/cm^3 (it was 44400 W/cm^3 resolved by the mesh)

Thermal analysis – results 0.2hBLT

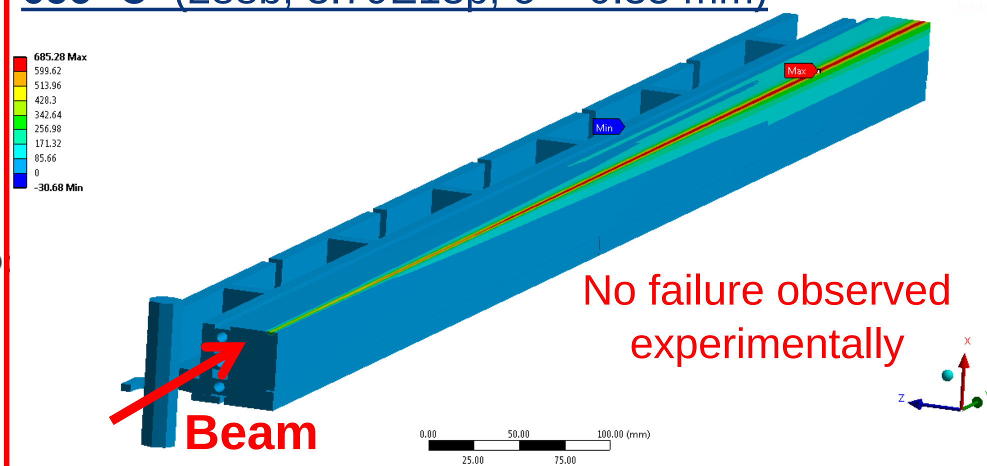


T_{water} = 27 ºC (constant)

$$h_{eq} = \frac{k_{Glid}}{l_{Glid}} + \frac{k_{CuNi}}{l_{CuNi}}$$

T_{max} = 659 ºC

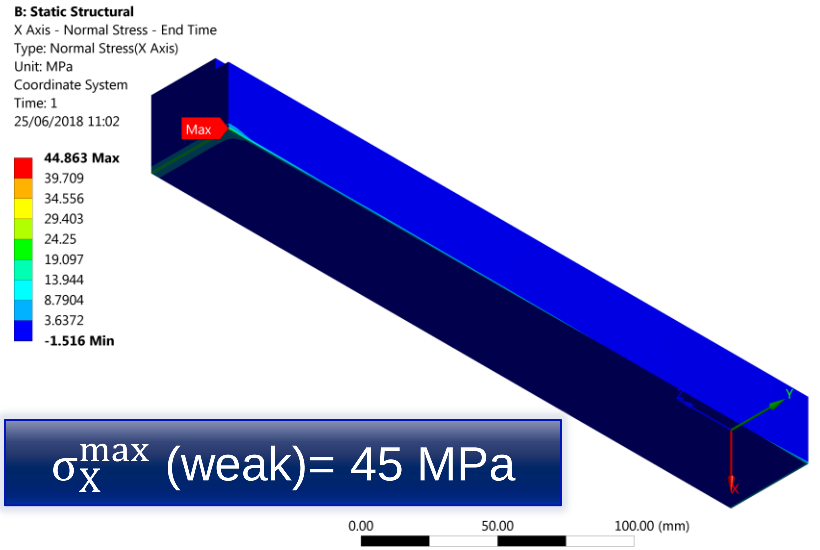
The HRMT-23 case: max simulated T on CFC jaw: **685 ˚C** (288b, 3.79E13p, σ = 0.35 mm)



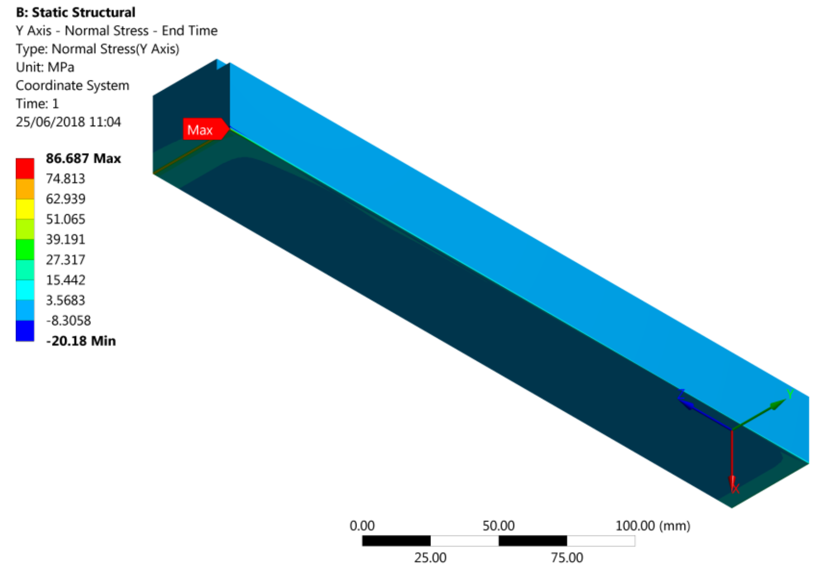
No failure observed experimentally

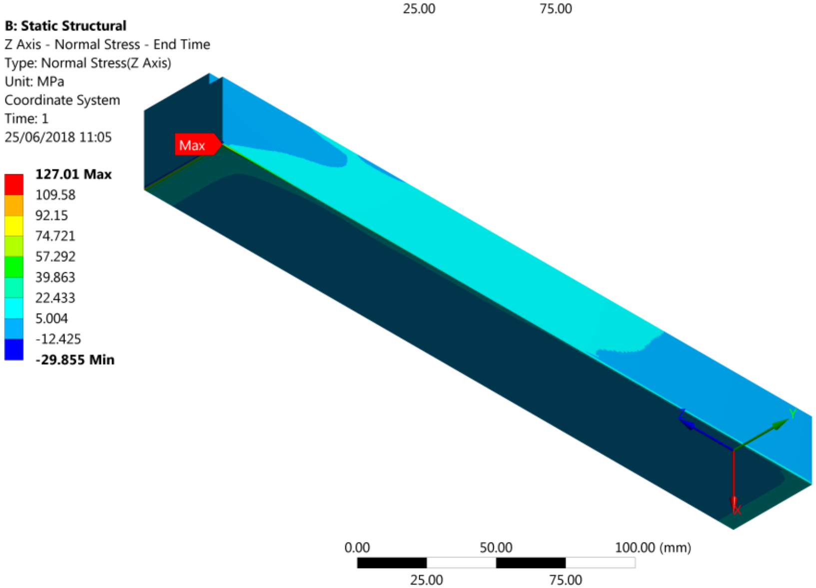
The HRMT-36 case: grazing shot at 288b, 3.72E13p, σ = 0.25 mm => No failure observed

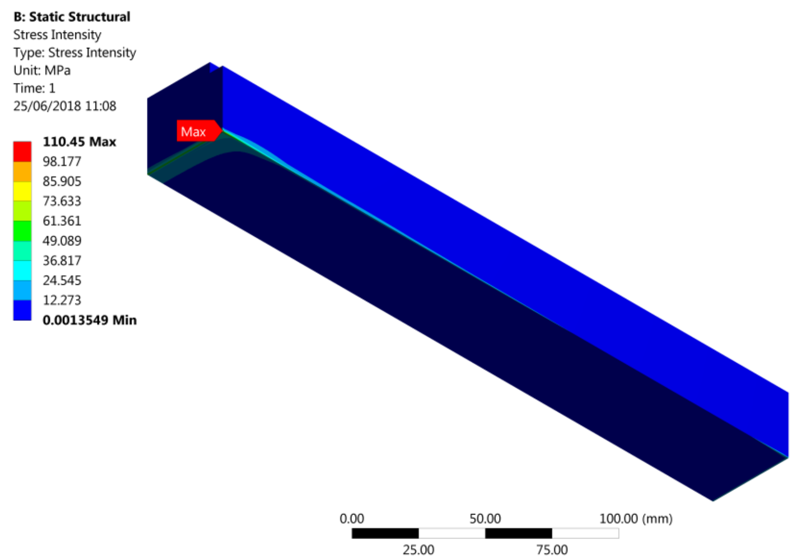
Structural analysis - results



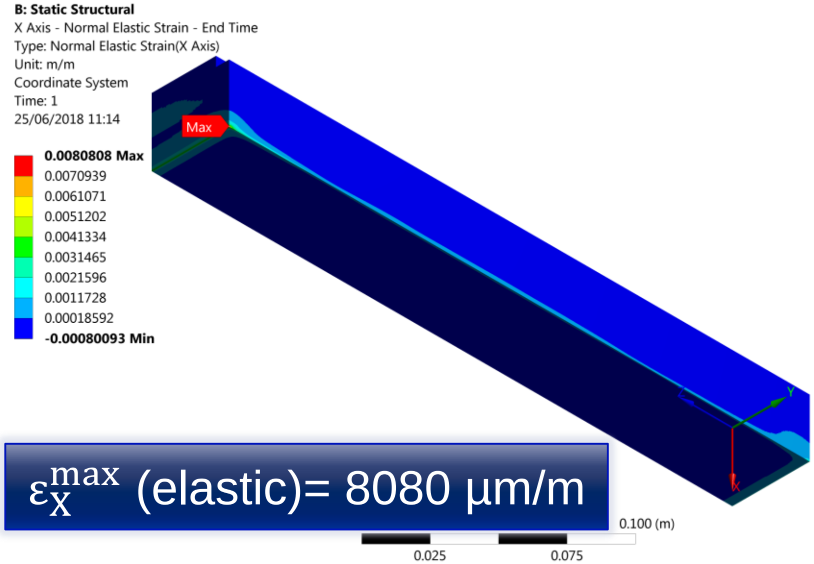
σ_X^{max} (weak)= 45 MPa



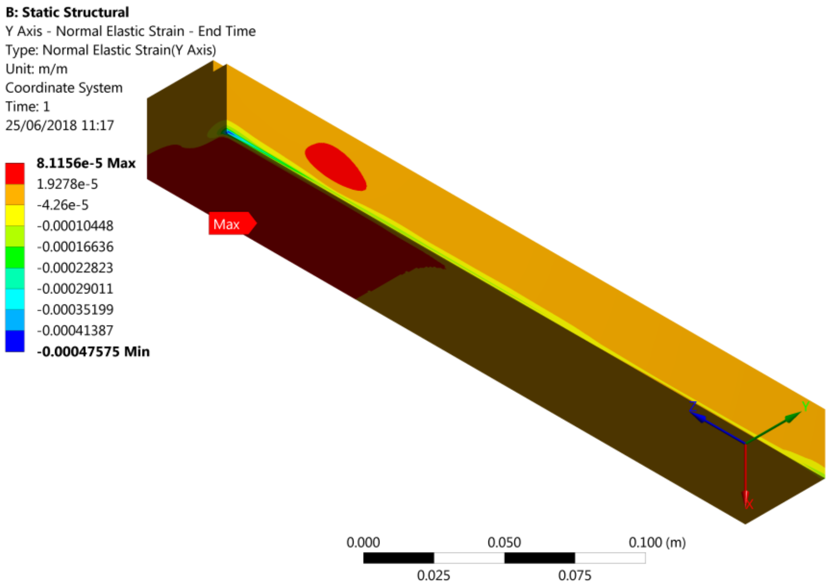


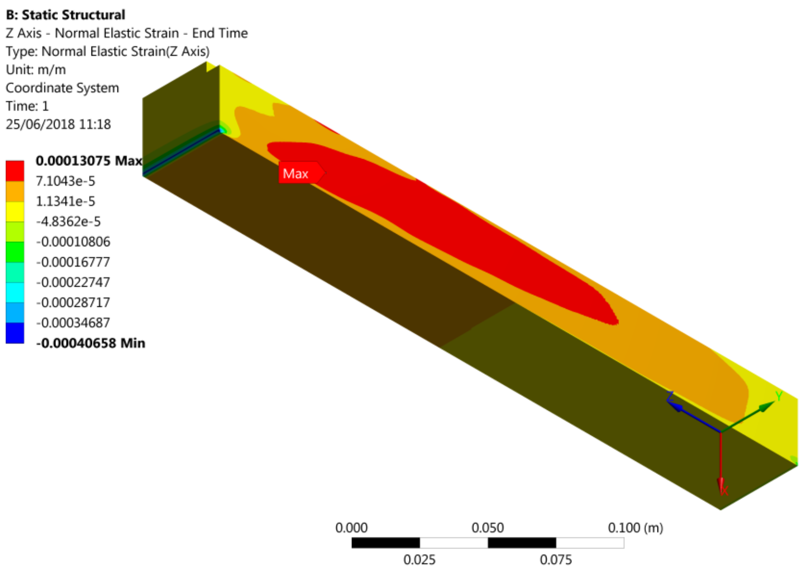


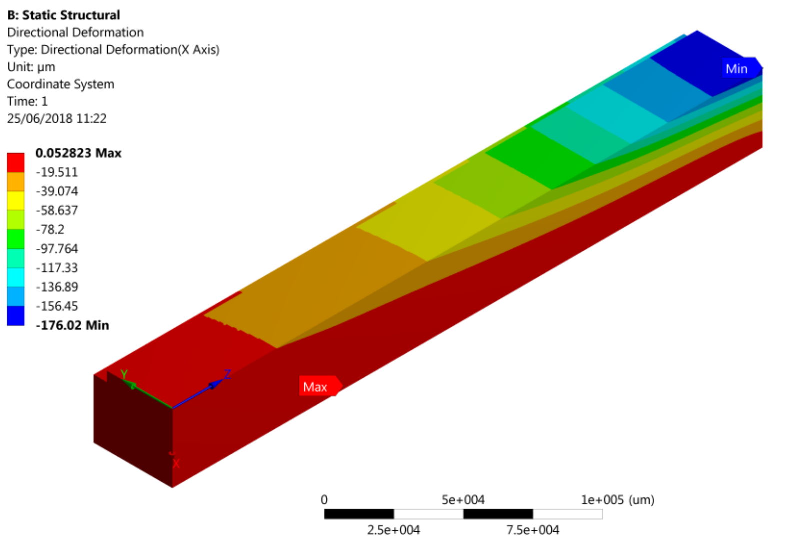
Structural analysis - results



ε_X^{max} (elastic)= 8080 µm/m





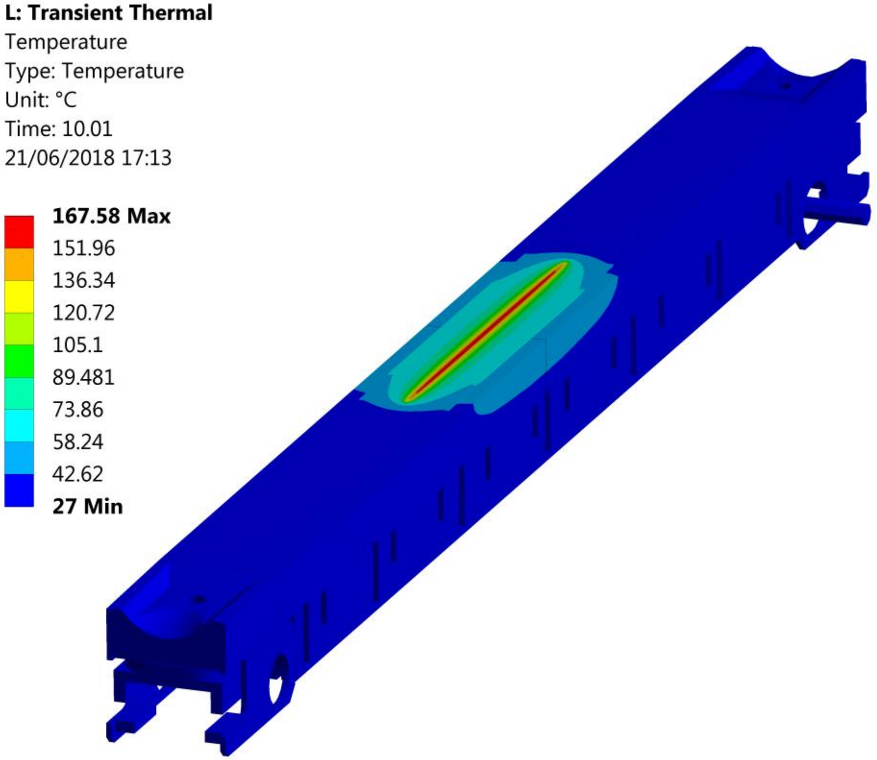


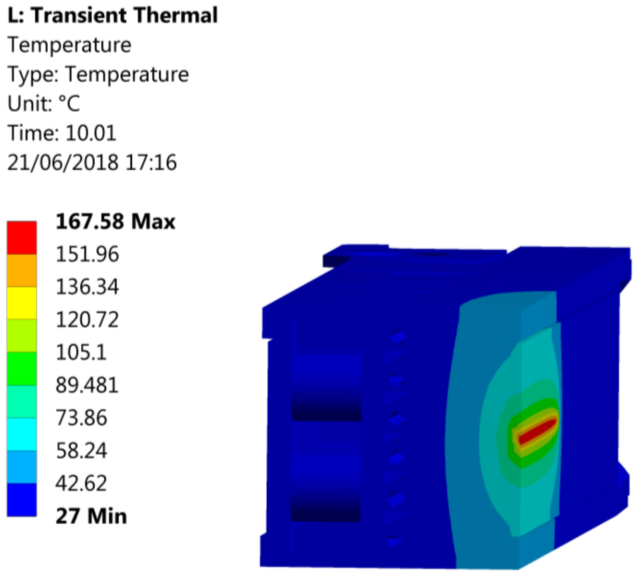
Summary

- 0.2 h BLT scenario was simulated for a thicker TCSP collimator jaw (3.5 cm) with FCC load → conceptual study
- Global structure: thermal induced deflection of 162 µm
- No plasticity arising on the housing or the cooling pipes
- Maximum T = 659 ºC on CFC absorber. Previous experimental tests featuring similar peak temperatures showed no failure on CFC absorbers
- Max thermal induced stress along X (weak direction) 45 MPa corresponding to 8000 µm/m (elastic equivalent) →
  - Glidcop-CFC bonding simulated as an infinitely rigid fixed bc
  - Numerical analyses have shown to over predict stress/strain values (e.g. HRMT-23, HRMT-36);

Thanks for your attention

Thermal analysis – results 0.2hBLT





Cooling water at T = 27 ºC (constant)

T_{max} = 167 ºC

Structural analysis - results