11 T Heat Load Withstand Levels

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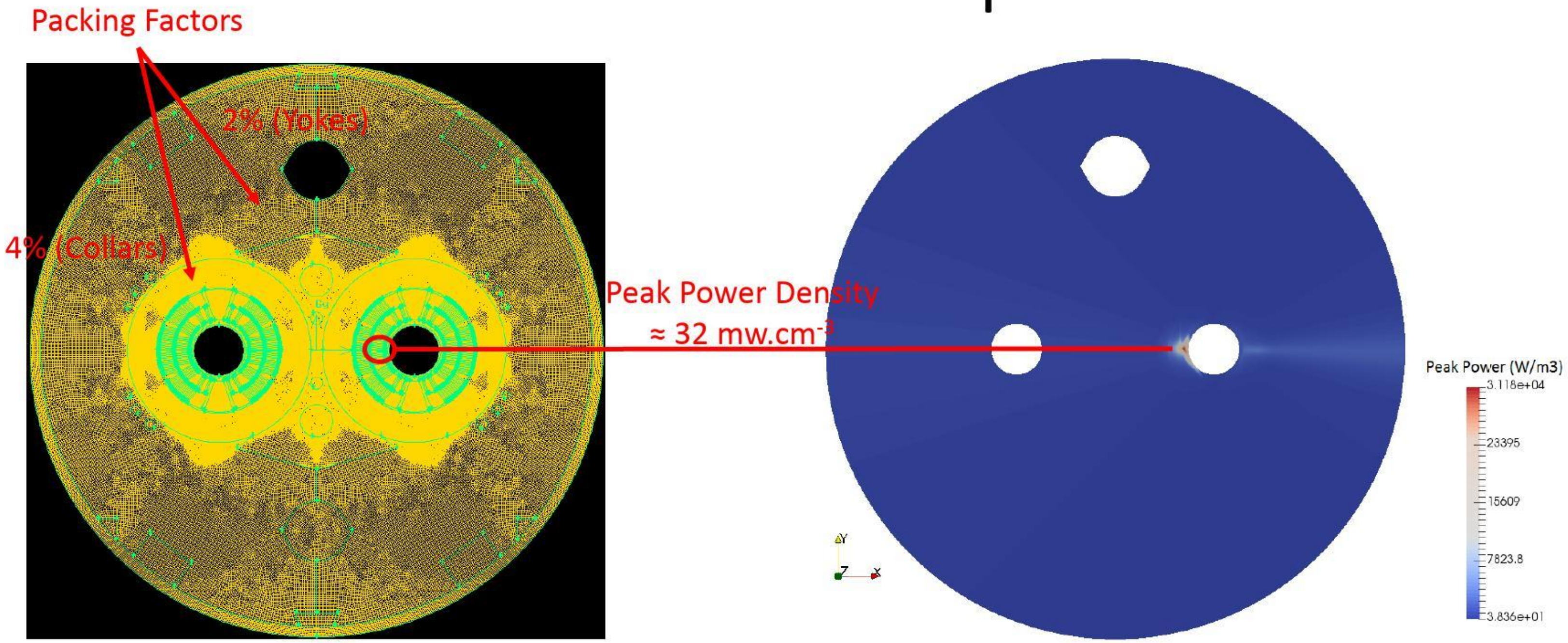
4th WP11+11 Technical machine interfaces WG 05/06/2018

Overview

- Steady state modelisation results
- Static cooling limits
- Current ramps

Steady state modelisation results
(by former fellow *Fouad Aabid*)

11-Tesla Dipole



<u>Mesh Quality</u>:

Numerical Mesh: 375196 cells (hexahedral)

Min. cell volume: 6.2e-12 m^3 – Max. cell volume: 8.8e-9 m^3

99% of Mesh Cells < 0.5 in Equisize Skewness, worst element at 0.83

<u>Boundary Conditions</u>:

Constant Temperature T=1.9K at the Cold Source

Adiabatic Walls (No heat exchange) on the walls of the External Shell

Uniform heat flux from the Coldbore (where peak power density is): 3.31 $W.m^{-3}$

Steady state modelisation results 11T-dipole
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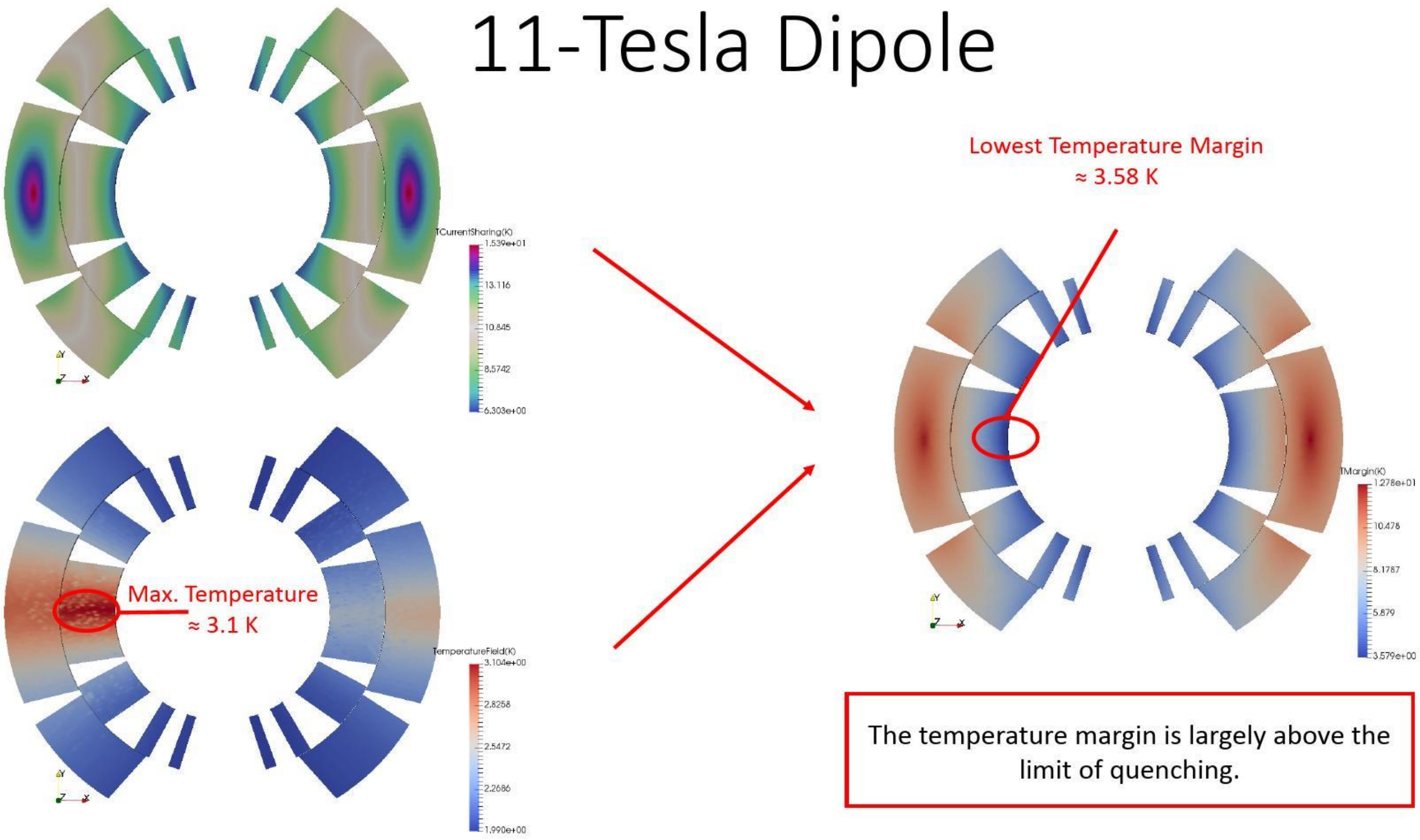

Steady state modelisation results 11T-dipole
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The configurations featuring peak power densities of 50mW/cm^{-3} and 100mW/cm^{-3} are also tested. The aim is to verify that the cooling is sufficient for the coils to sustain such levels of energy while maintaining their superconductivity. The results reported in Figs. 14-15 show that the temperature margin is > 3K with a peak power density of 50mW/cm^{-3}. When the energy deposited in the coils climbs up to 100mW/cm^{-3} however, the temperature margin remains positive in the coils but the helium in the annular gap largely warms up to T_λ and slightly above, which could indicate a failure in cooling.

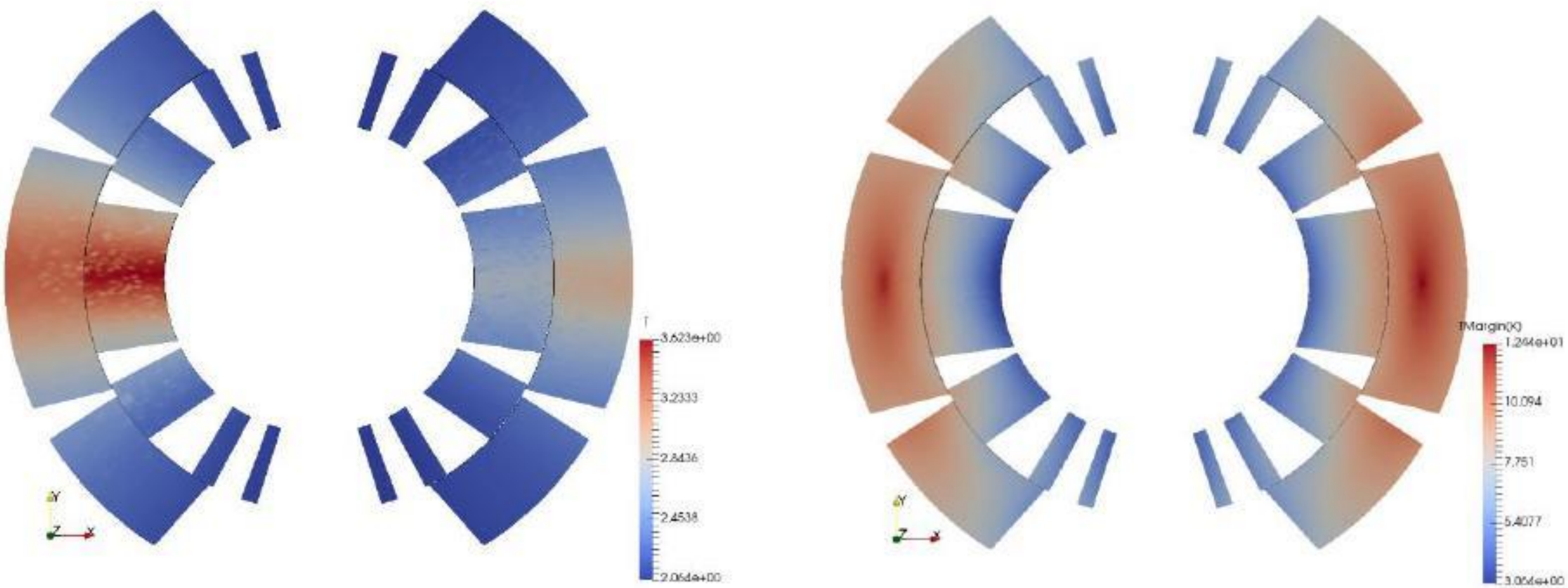

Fig. 14: The operating temperature reaches a maximum value of approximately T = 3.62K, which leads to a temperature margin T_{Margin} > 3.0K when the peak power density is of 50mW/cm^{-3}.

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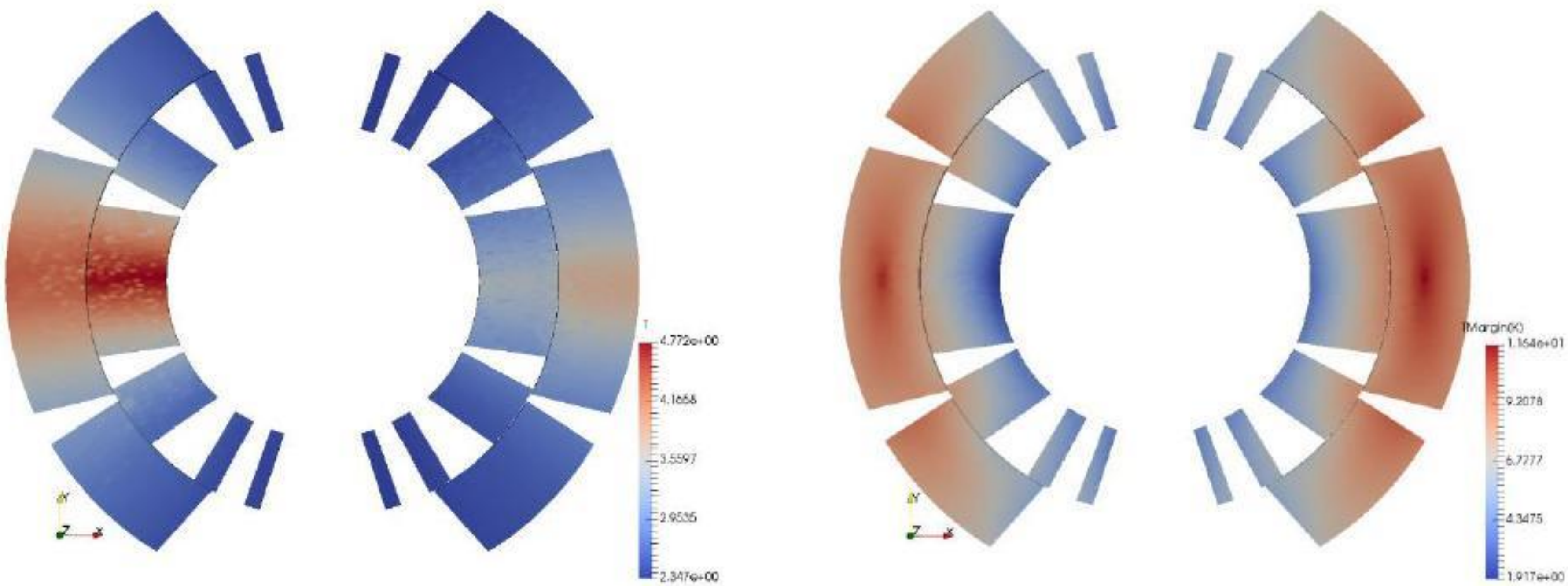

Fig. 15: The operating temperature reaches a maximum value of approximately T = 4.77K, which leads to a temperature margin $T_{Margin} \approx 1.9K$ when the peak power density is of $100mW/cm^{-3}$.

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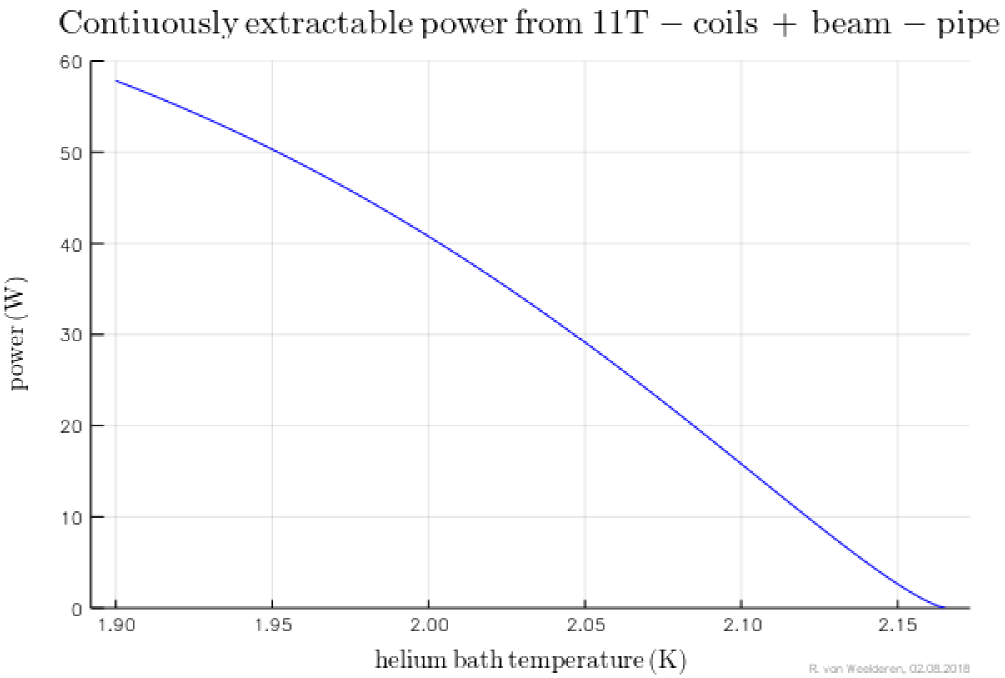
Recap:

At 32 mW/cm^3 → Tmargin 3.58 K
At 50 mW/cm^3 → Tmargin ~ 3.0 K
At 100 mW/cm^3 → Tmargin ~1.9 K

Static cooling limits

No radial cooling holes → conduction cooling through beam-pipe – coil annular space

Total continuous extraction capacity (both apertures combined) goes from 58 W at 1.9 K to ~ 15 W at 2.1 K



Updated 06.08.2018
With extended graph covering
1.9 K – 2.17 K T-range

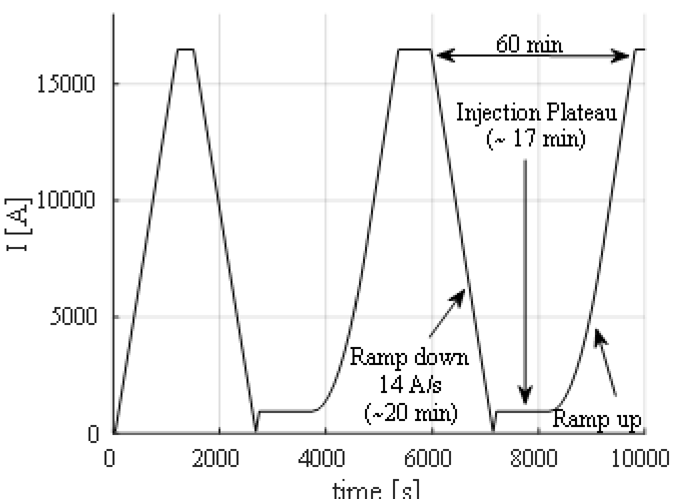
Curent ramps

Updated 06.08.2018

- Current ramp is estimated to dissipate ~ 4 W/m

  (~ 2207 J/m/aperture in 20 min x 2 apertures + 0.5 W/m static losses)
- Allowing the losses to heat up the magnet to Tλ (2.17 K) needs ~ 15 ℓ/m cold-mass inventory

→ Helium buffer is sufficient for current-ramp *no need for continuous cooling*.



Courtesy Susanna Izquierido Bermudez