

Water cooled Lead Ceramic Breeder blanket for fusion power plants

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#109

Introduction

- Recently, research activities on an innovative alternative blanket concept (a Water cooled Lead Ceramic Breeder), in which Lead / Lead-alloy is used as neutron multiplier, ceramic pebbles as tritium breeder, pressurized water as coolant, are on-going.
- This concept avoids the potential safety issue (Be-Water reaction in case of water leakage) when Beryllium is used as neutron multiplier in a water cooled blanket concept.
- After many iterations of nuclear, thermal hydraulic and thermal mechanical analysis, a sound configuration was selected.

Design Features

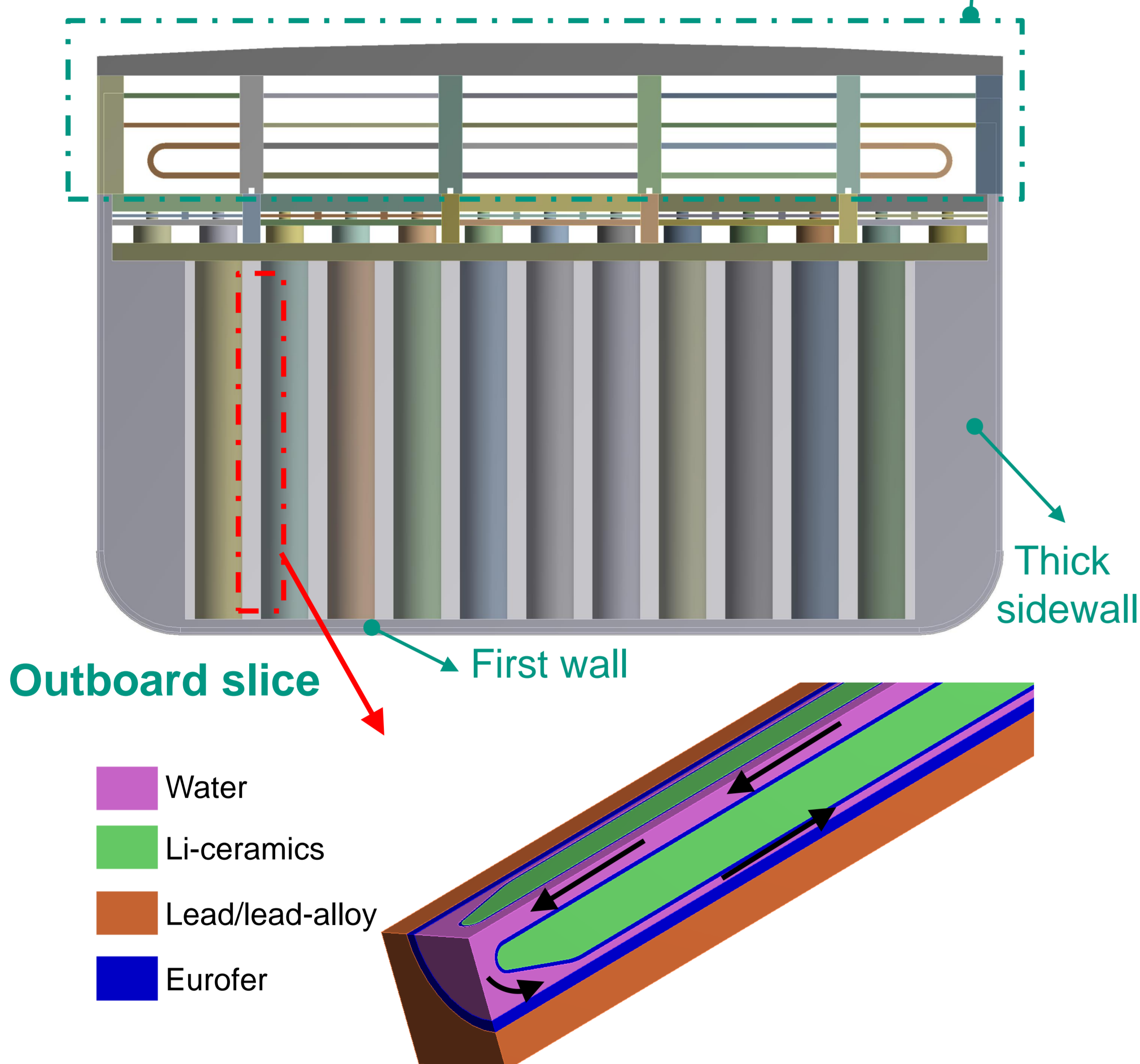
Coolant: 15.5 MPa water with $T_{inlet}/T_{outlet}=295/325$ °C

Structural material: EUROFER

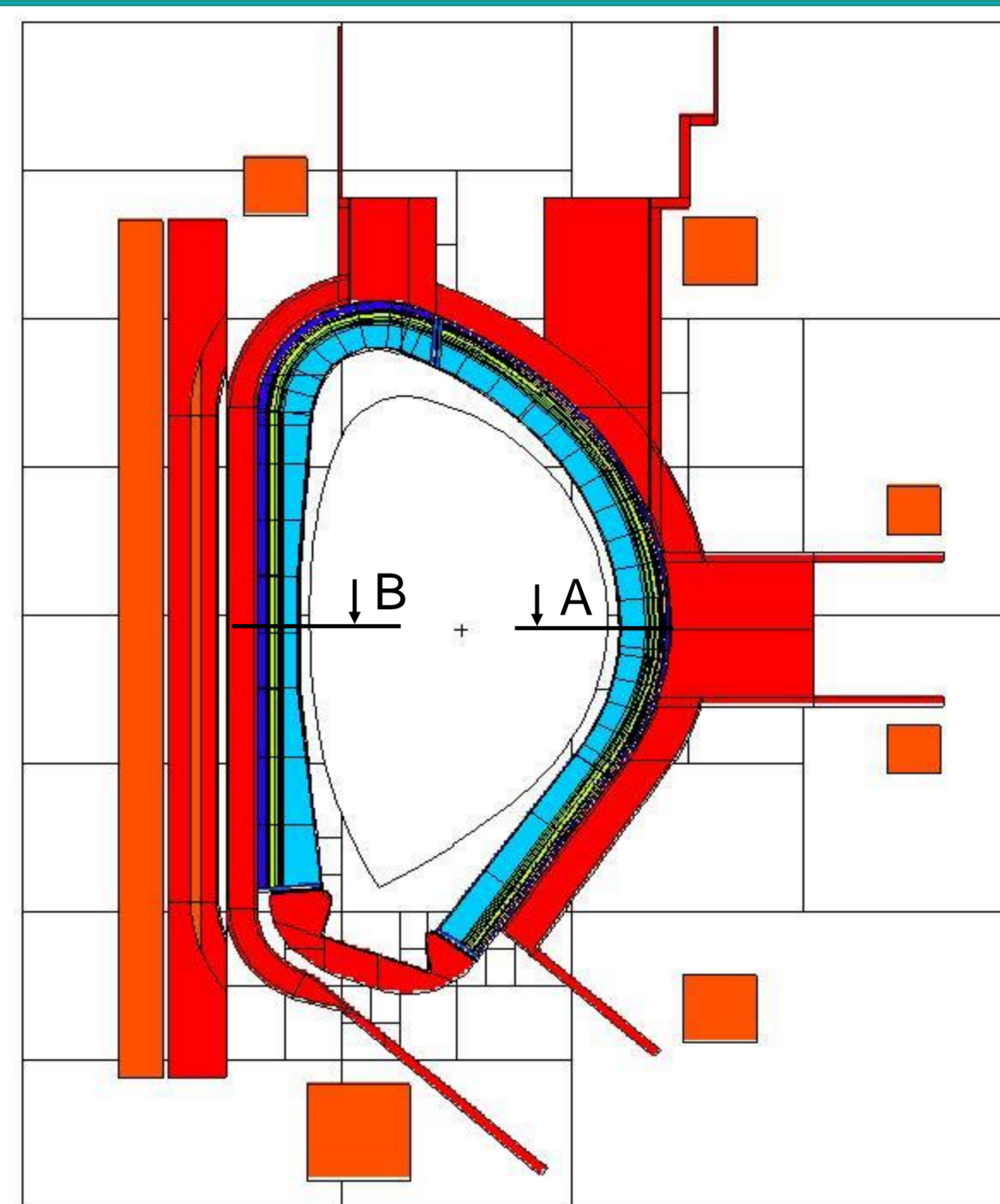
Neutron multiplier: Lead / Lead-alloy

Tritium breeder: Lithium Ceramic Pebbles

Back supporting structure



Neutronics Analysis

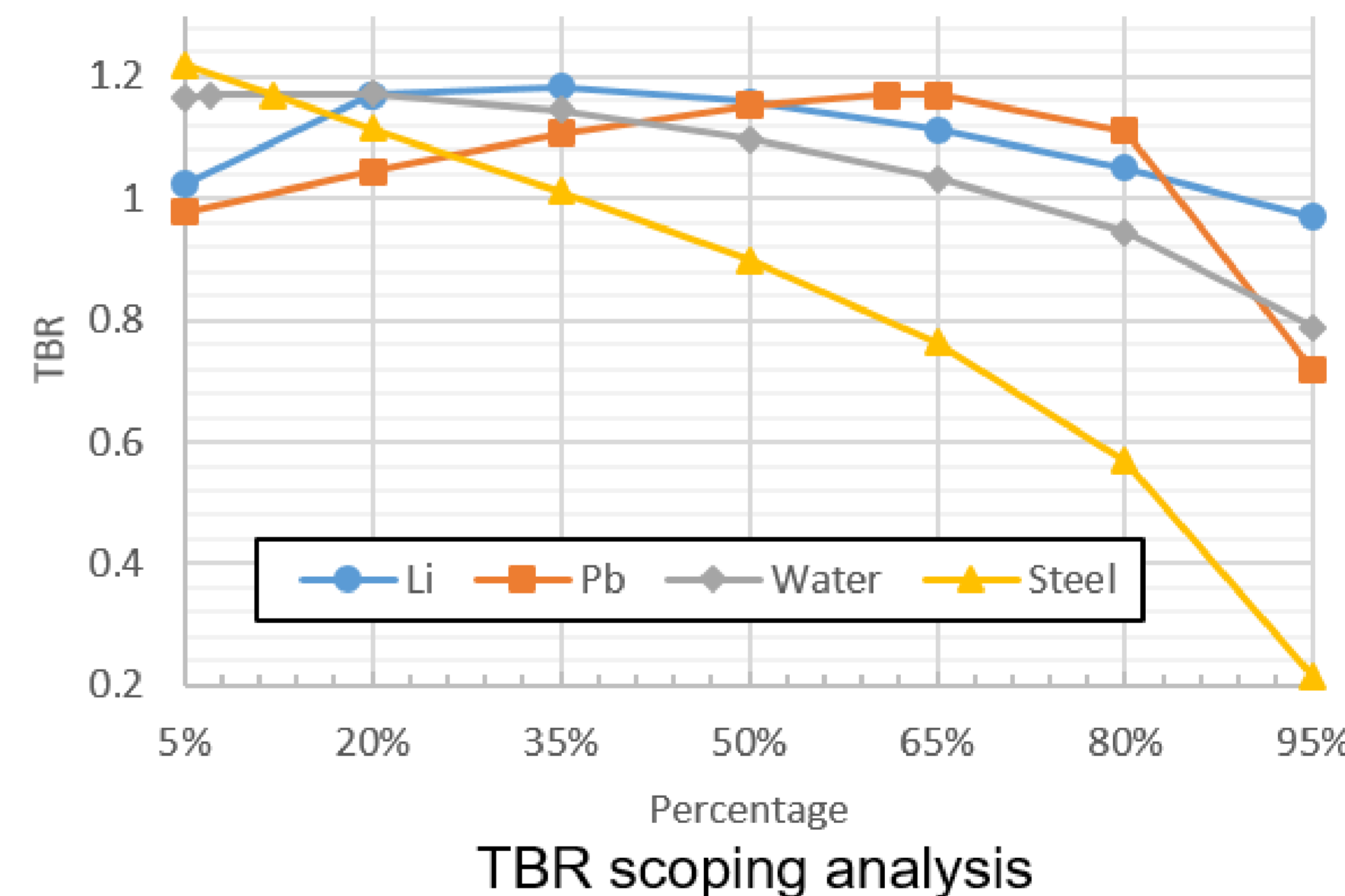


A-A

B-B

Homogenous model

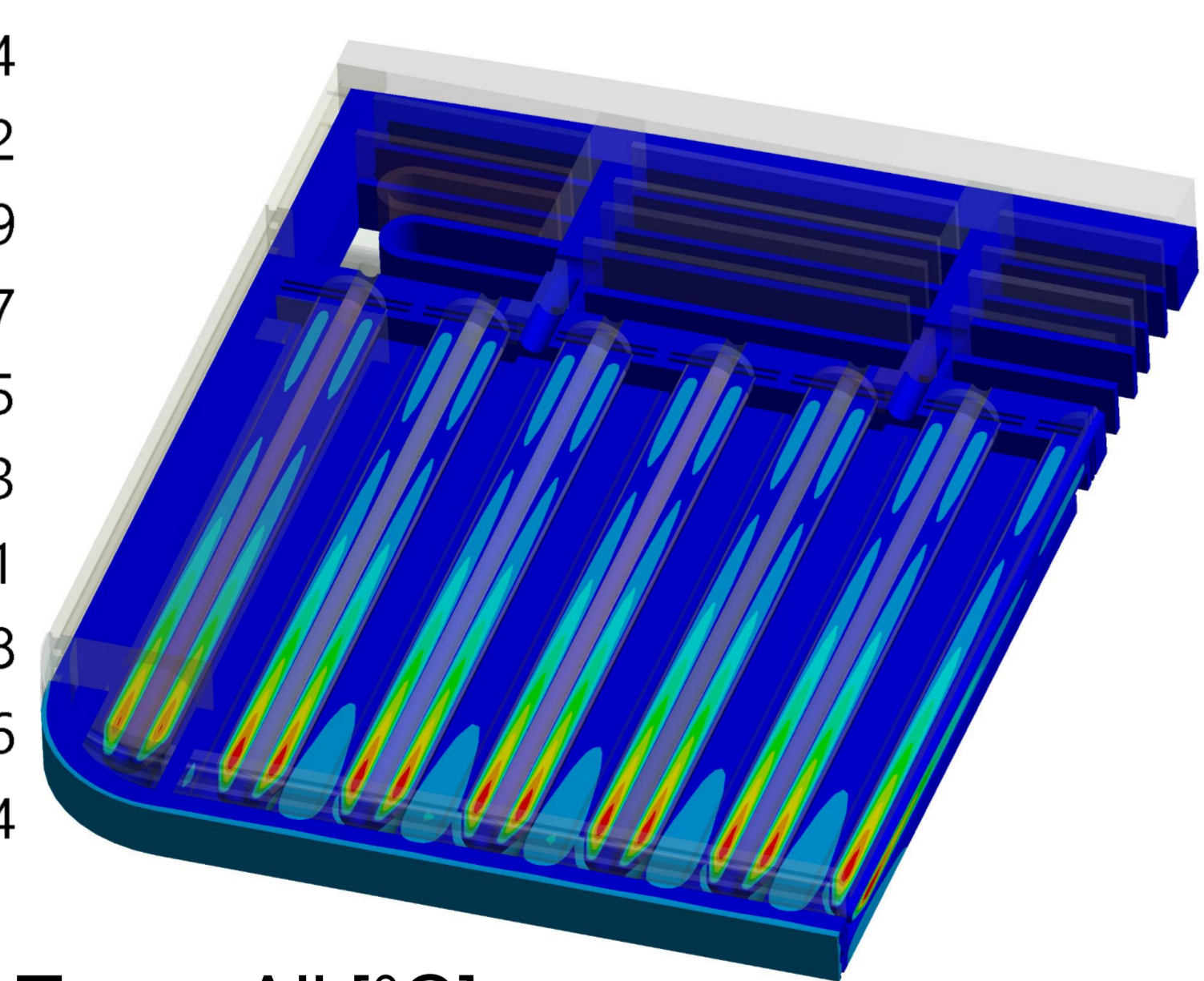
Neutronic model



After several design iterations with thermal, and thermomechanical analysis, a configuration with TBR of 1.17 is selected.

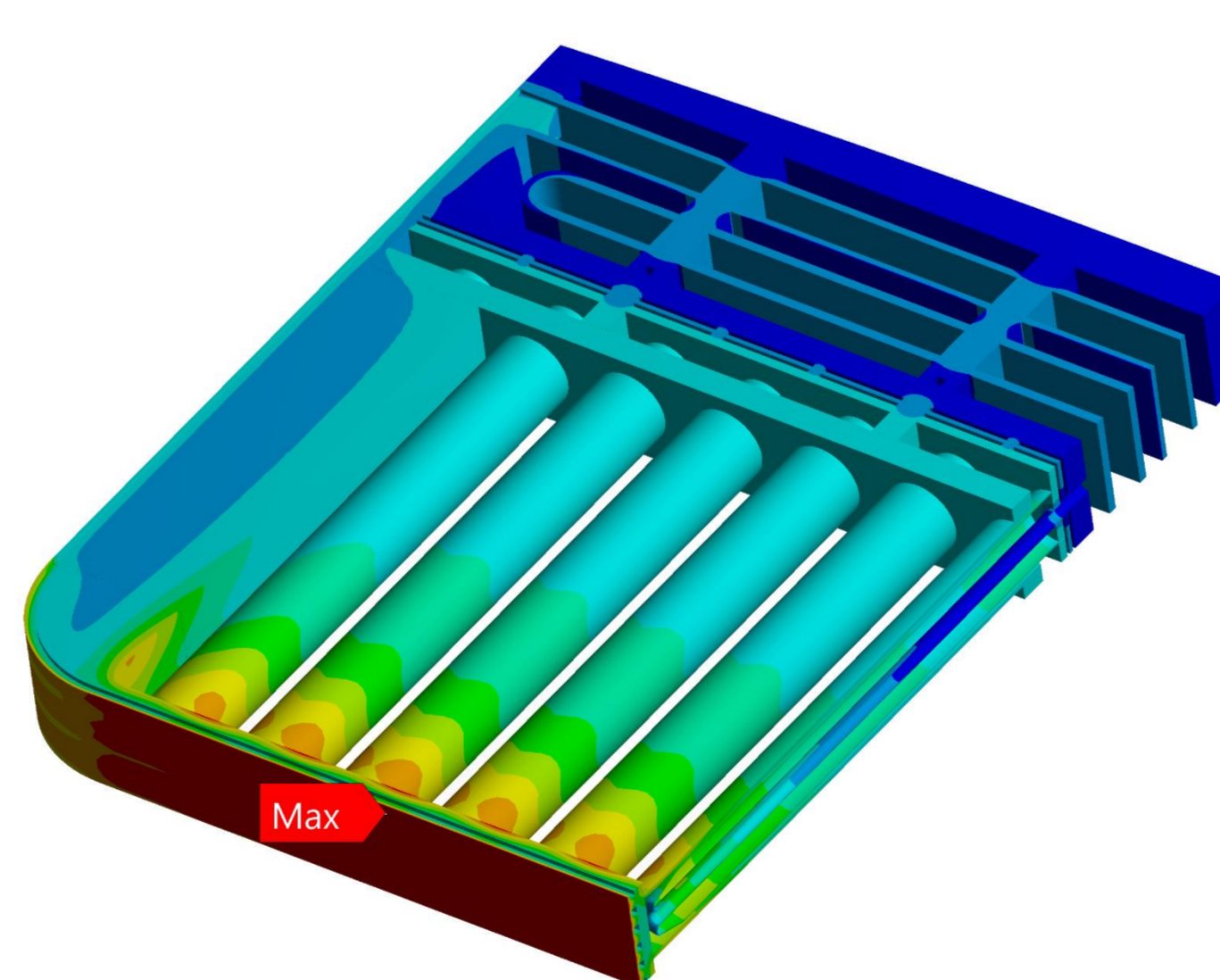
Thermal and Thermo-mechanical Analysis

890.44
824.32
758.19
692.07
625.95
559.83
493.71
427.58
361.46
295.34



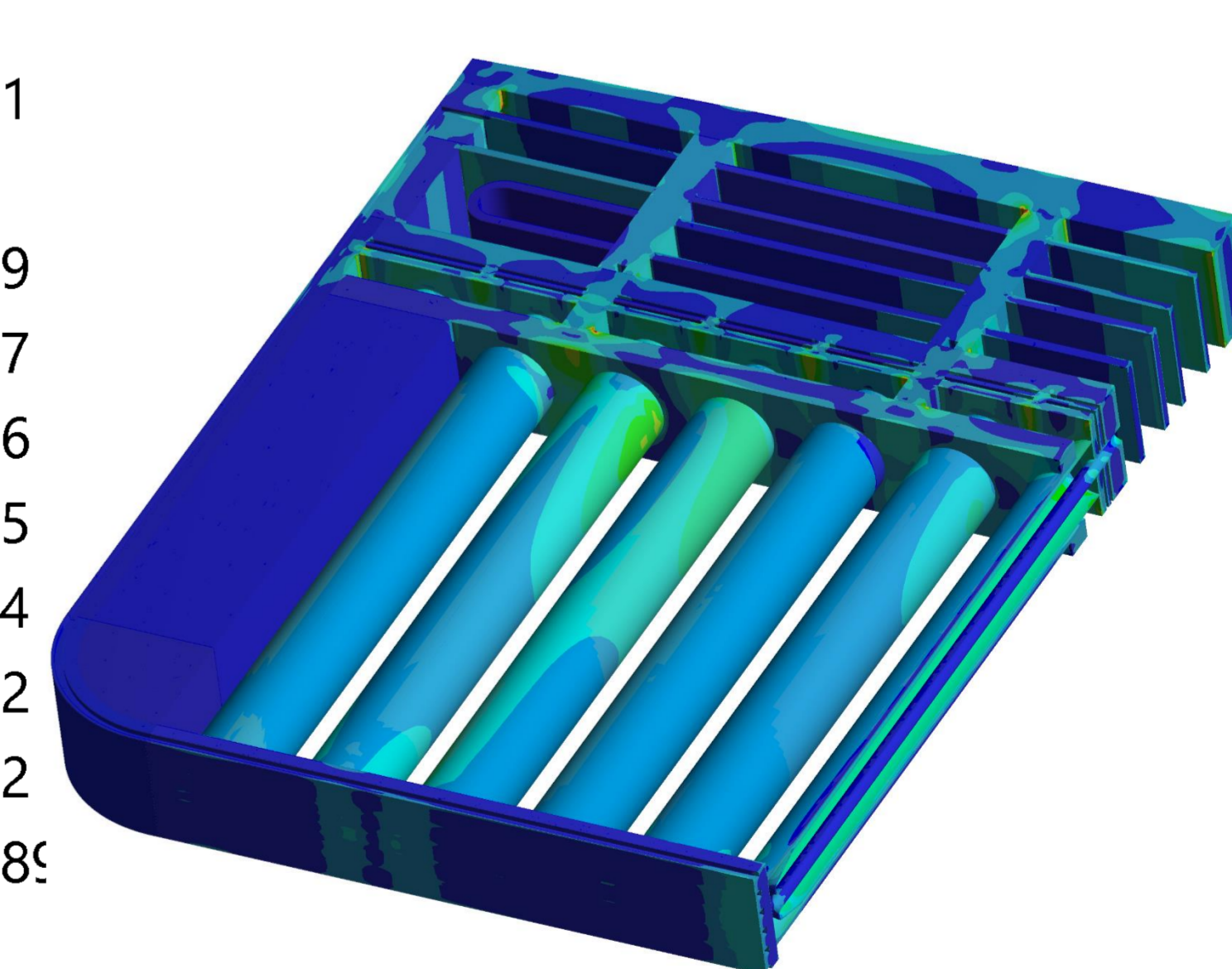
Temp. All [°C]

410.28
397.51
384.74
371.97
359.2
346.43
333.65
320.88
308.11
295.34



Temp. Eurofer [°C]

721.81
500
437.59
375.17
312.76
250.35
187.94
125.52
63.112
0.6998



Stress [MPa]

After several design iterations, temperature on materials are OK, stress level is acceptable.

Summary

- A water cooled lead ceramic breeder blanket was proposed to overcome the challenges, facing water-cooled blanket concept utilizing Beryllium.
- Nuclear, thermal-hydraulic and thermomechanical analysis iterations were performed, leading to a sound design with TBR 1.17 (temp. and stress level OK).

