

Safety Analysis of LOCA Accident for the DEMO HCPB Blanket

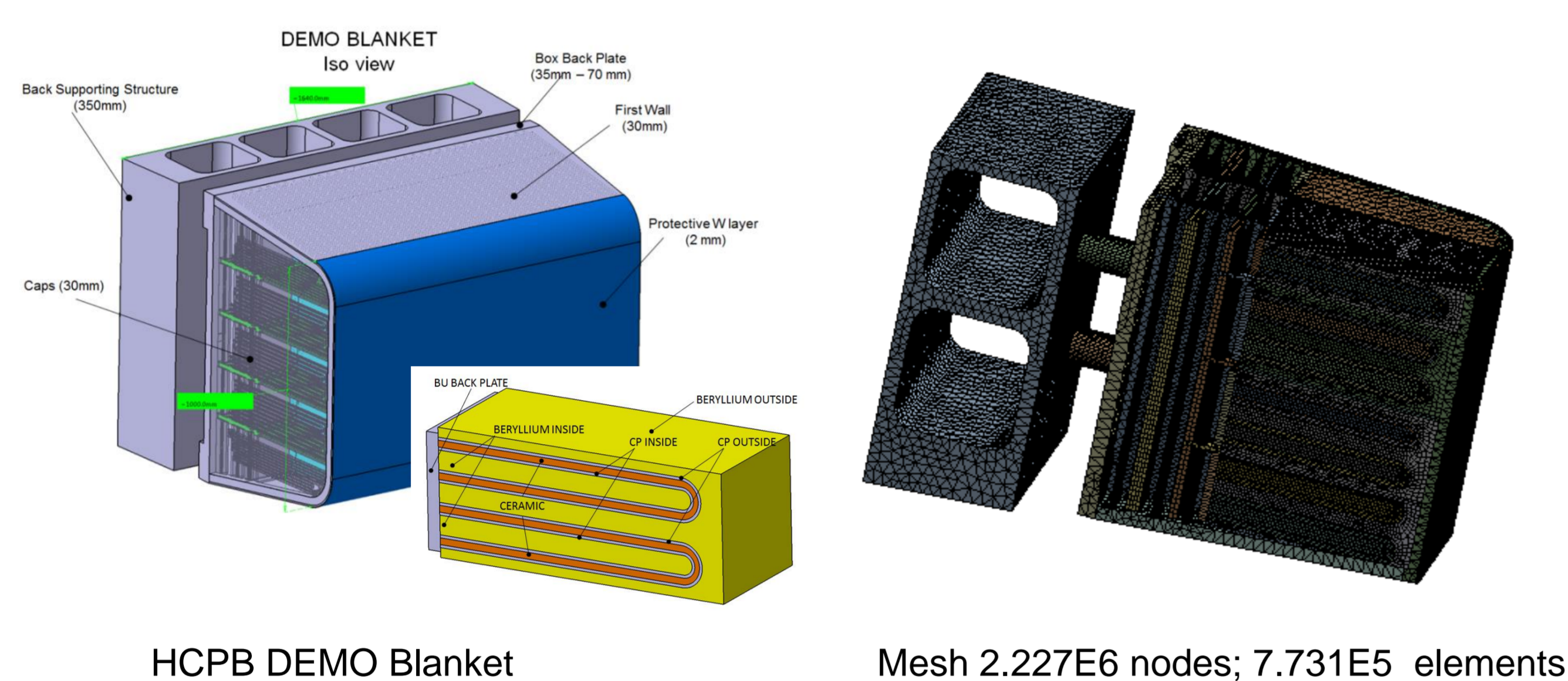
Q. Kang, D. Carloni, Sz. Kecskés

Introduction

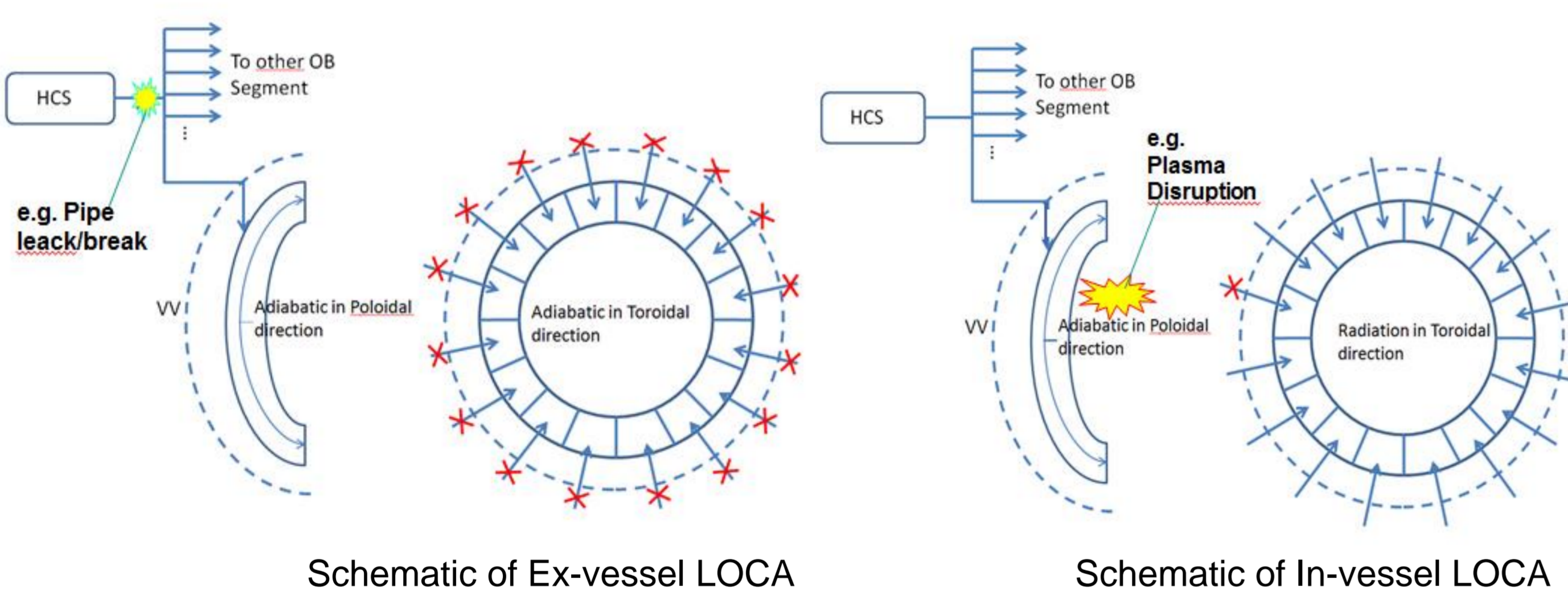
- The Loss of Coolant Accident (LOCA) caused by a pipe break of Helium Coolant System (HCS) in Helium Cooled Pebble Beds Blanket system (HCPB) has been analyzed.
- Six cases have been studied taking into account both ex-vessel and in-vessel LOCAs.
- Thermal expansion behaviour of Back Supporting Structure (BSS) with the most severe LOCA temperature has been studied.

Finite element model

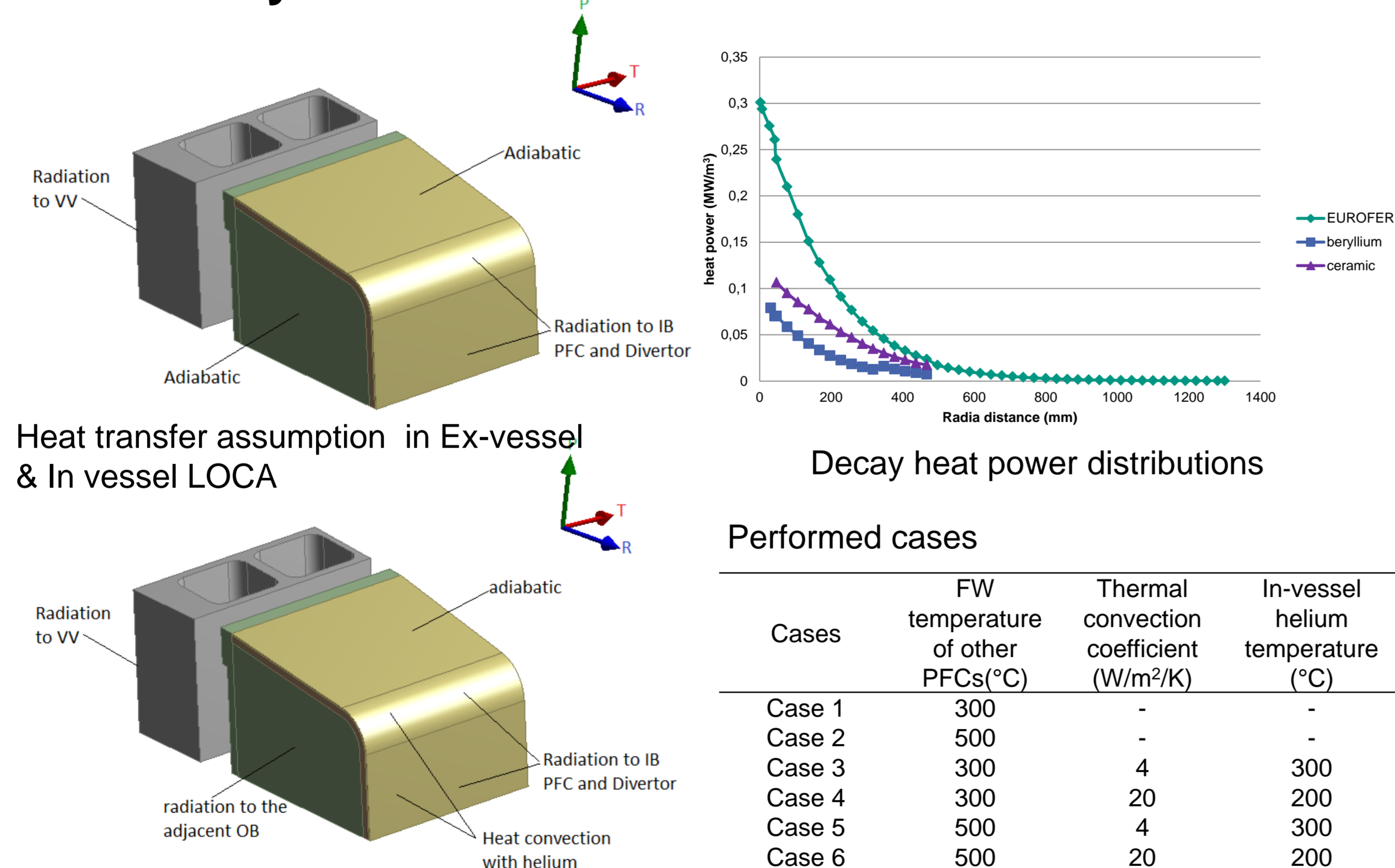
Geometry and mesh



Accidental scenario



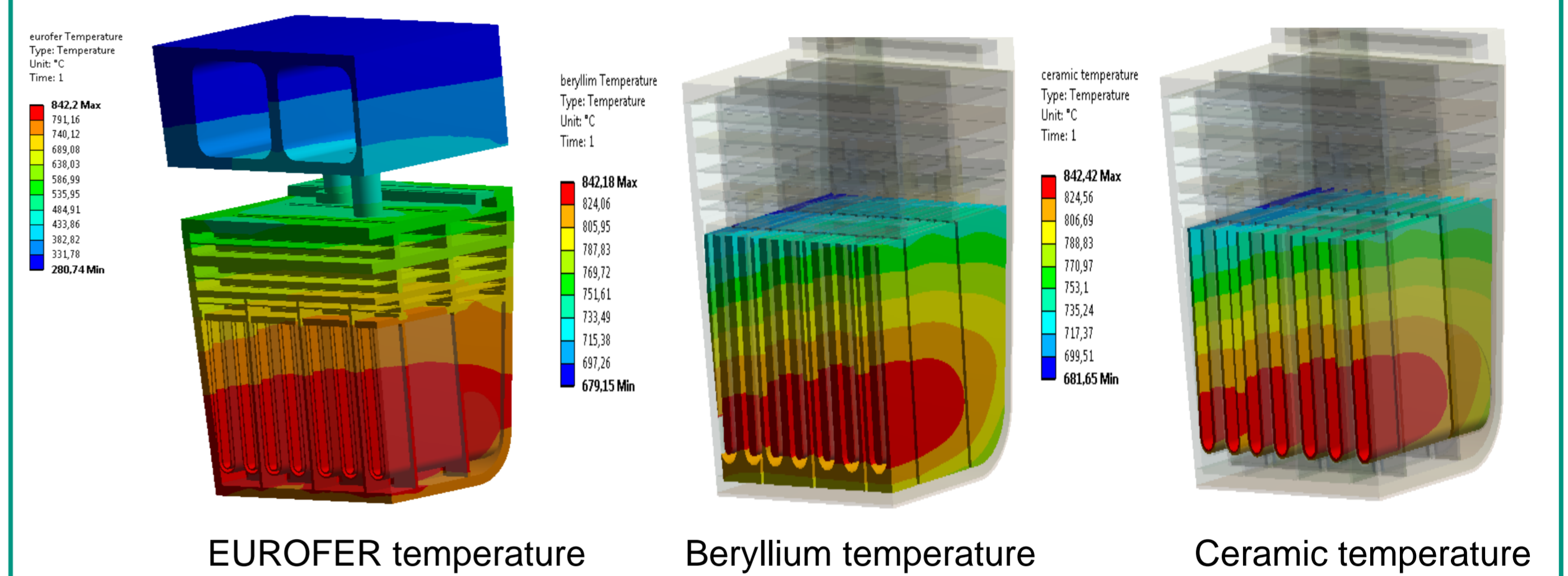
Boundary condition



Results and analyses

Thermal simulation: Steady-state analysis

- The most severe accident is Ex-vessel LOCA with PFCs at 500 °C (Case 2)
- The maximum temperature 842 °C occurs within the breeding zone



Summary of temperature results

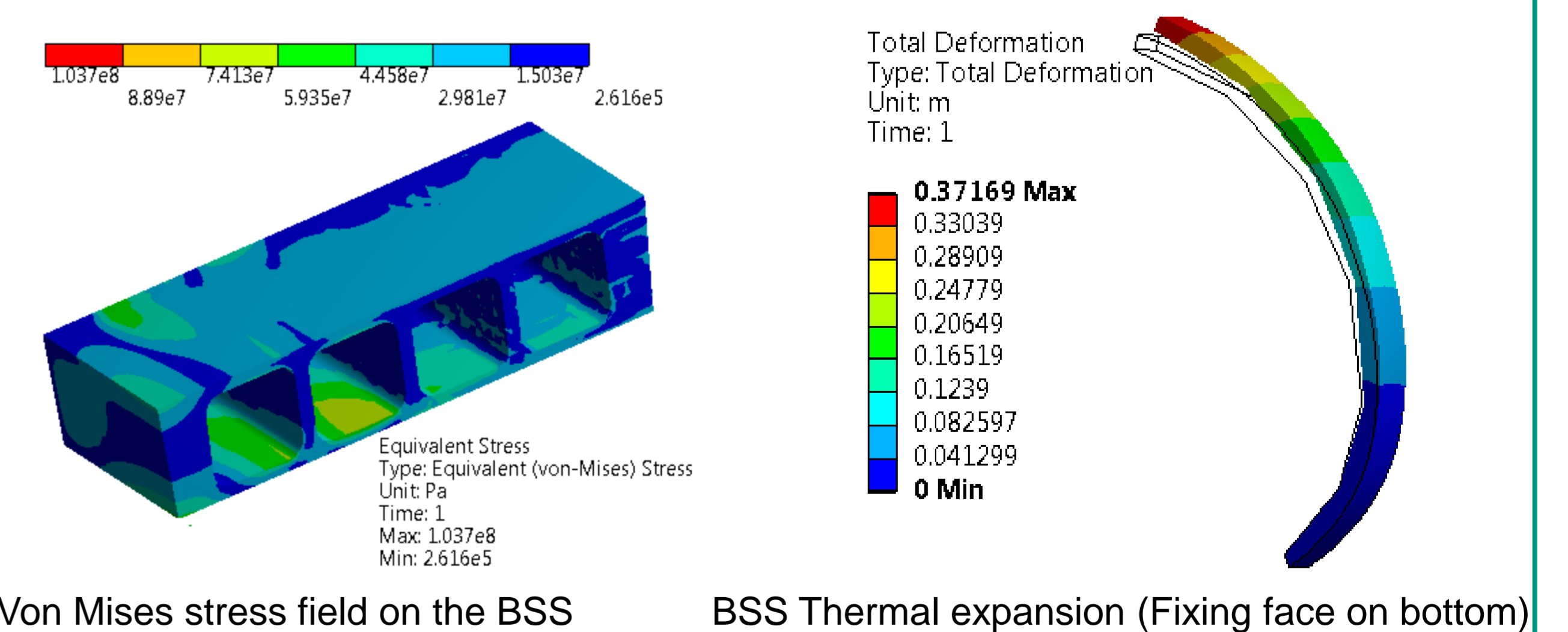
	EUROFER (°C)	Beryllium (°C)	Ceramic (°C)	BSS (°C)
Case 1	277.1-808.2	664.0-808.2	666.4-808.7	277.1-409.7
Case 2	280.7-842.2	679.2-842.2	681.7-842.4	280.7-418.2
Case 3	261.2-777.4	534.4-777.4	543.0-777.8	261.2-375.0
Case 4	257.2-724.8	519.3-724.7	526.8-725.2	257.2-365.6
Case 5	289.6-818.6	596.5-818.6	604.4-818.9	289.6-415.0
Case 6	280.5-763.6	582.9-763.6	589.1-764.2	286.5-408.4

Structure mechanical simulation

- Using temperature field from thermal simulation
- Thermal stresses in FW, BP and BSS are admissible
- 37.2 mm displacement in poloidal and radial direction in one BSS segment

Verify stress compliance with limits defined by RCC-MR

Path	FW	BSS	BP
$\bar{P}_L + \bar{Q}_L$ [MPa]	73.3	141.4	421.0
$\bar{P}_L + \bar{P}_B + \bar{Q} + \bar{F}$ [MPa]	159.2	364.5	541.4
$\bar{P}_L + \bar{P}_B + \bar{Q}$ [MPa]	148.5	240.6	477.2
T_m [°C]	625.2	376.9	402.2
$S_{\sigma^D}(T_m)$ [MPa]	-	470	470
$S_{\sigma^D}(T_m)$ with F [MPa]	793.3	786.8	784.4
$S_{\sigma^D}(T_m)$ without F [MPa]	231.9	786.8	784.4
1 (IPFL) SF	-	0.3	0.89
2 (ILF) SF	0.2	0.46	0.69
3 (ILF) SF	0.64	0.31	0.61



Summary

- Steady-state thermal analyses for the assumed ex-vessel and in-vessel LOCA accidents have been performed to study the temperature behavior of HCPB blanket module.
- The thermal expansion behaviour of BSS in most severe accident has been evaluated as it is critical to design the attachment between blanket and VV.