EMUG

Update of the Iter MELCOR model for the validation of the cryostat design

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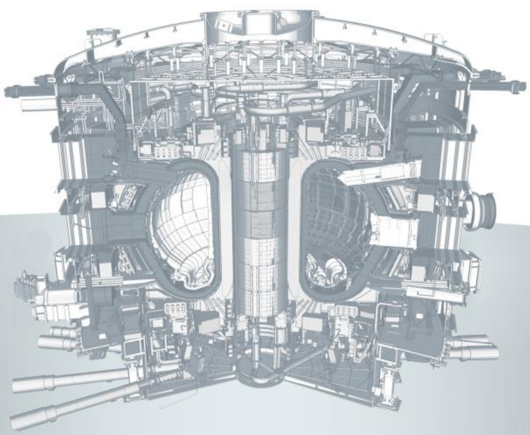

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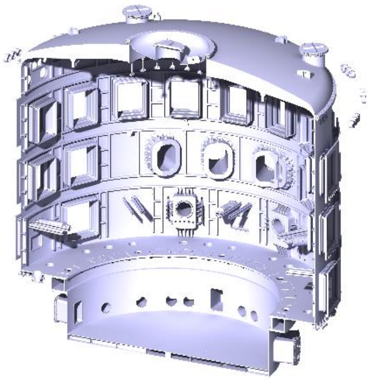
Scope of the task

- Inputs needed for thermomechanical analysis
- Updated geometry
- Generation of boundary conditions
  - Temperatures, pressures HTCs
- Assure traceability of all the values used in the model
- MELCOR 1.8.2 fusion

Scope of the task

The Iter cryostat:

- Maintain an internal vacuum to avoid excessive convective heat transfer between the Vacuum Vessel (VV) and the Magnet System (MS)
- Vacuum barrier (cryogenic temperatures and vacuum in one side, room pressure and temperature in the other)
- Strong thermal gradients, strong mechanical loads



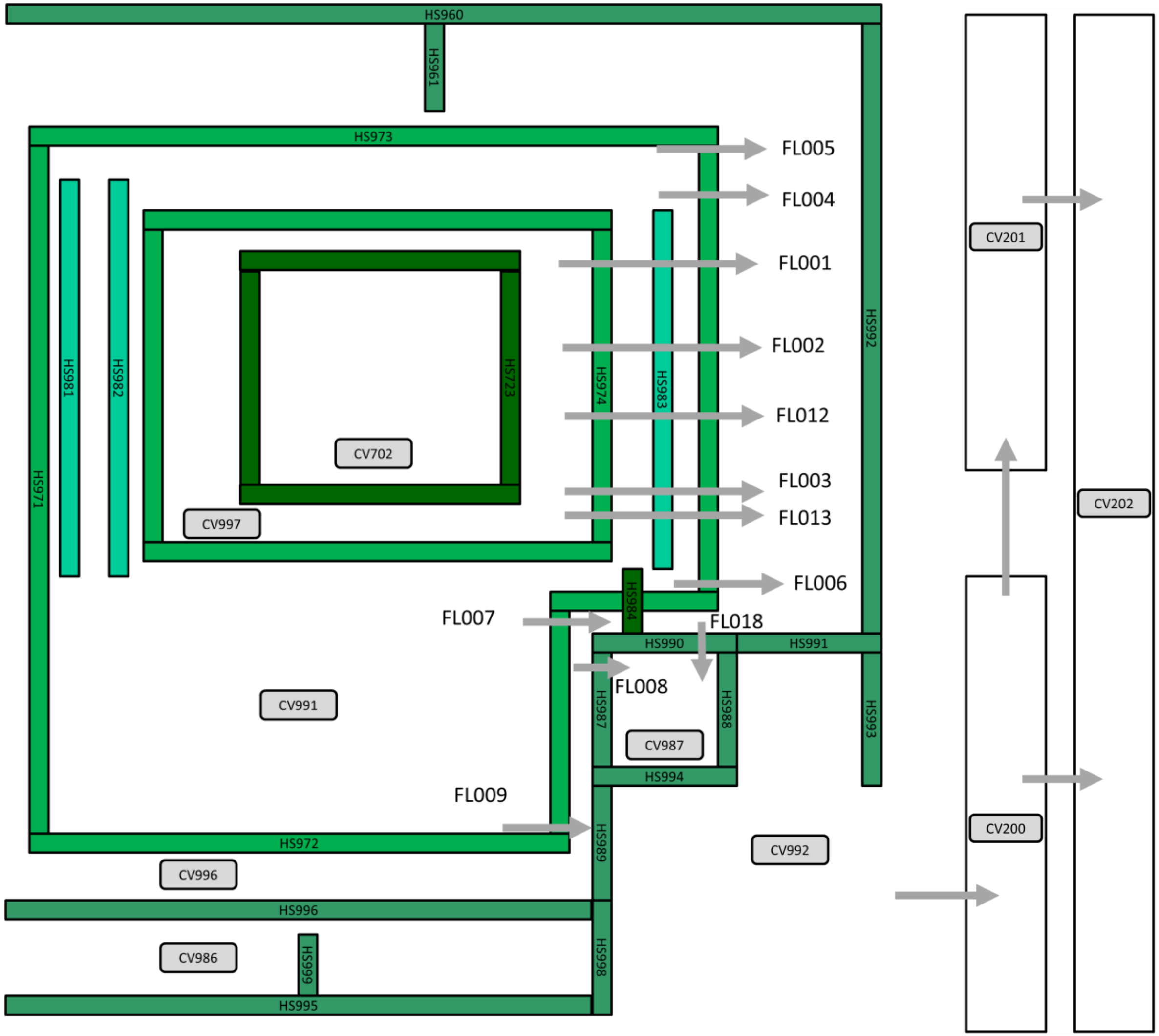
Model

- Scenarios to be simulated:
  - ICE: Ingress of Coolant event: 500 to 5200 kg of He at cryogenic temperatures injected into cryostat.
  - HiG: Helium ingress in Galleries: 2600 kg of He at cryogenic temperatures injected into galleries
  - LOVA: Loss Of Vacuum Accident: hole of $1 m^2$ in the cryostat wall and sudden depressurization.

Model

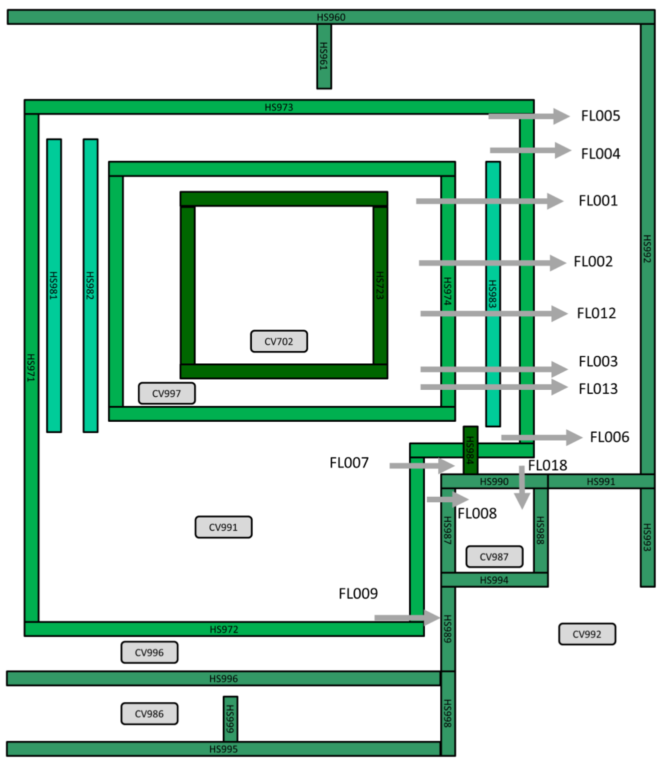
- ESC modelled:
  - Cryostat
  - Cryostat platforms
  - Magnet System: Surfaces at 4k and helium cooled. Includes feeders
  - VV: coolant and outer shell (constant temperature). Incudes supports
  - Thermal shield: Actively cooled at 80 k.
  - Building: rooms and leaks (CSR, B2 and galleries)

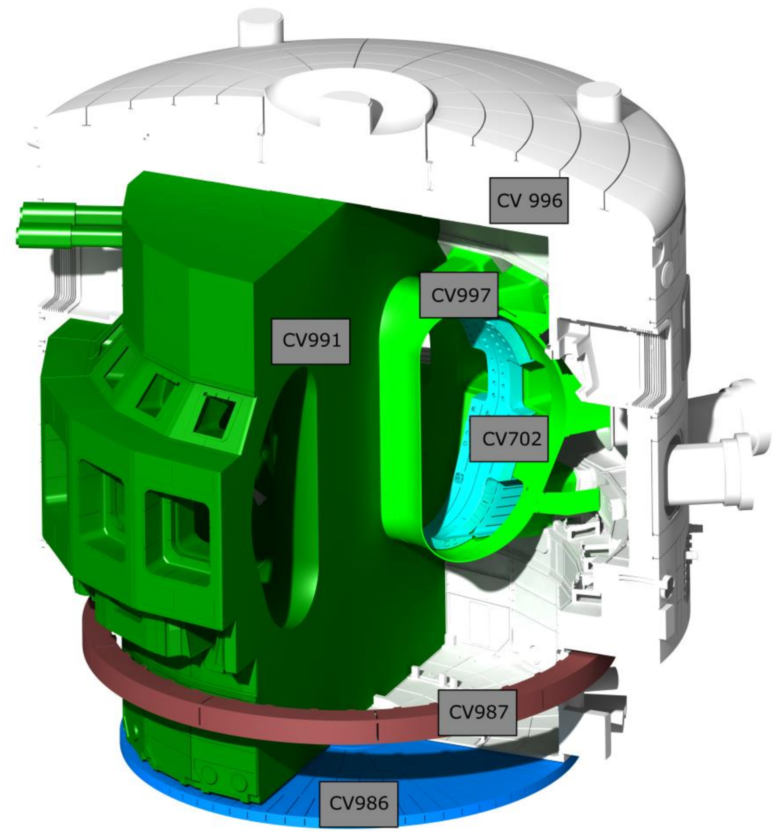
Model



New nodalization

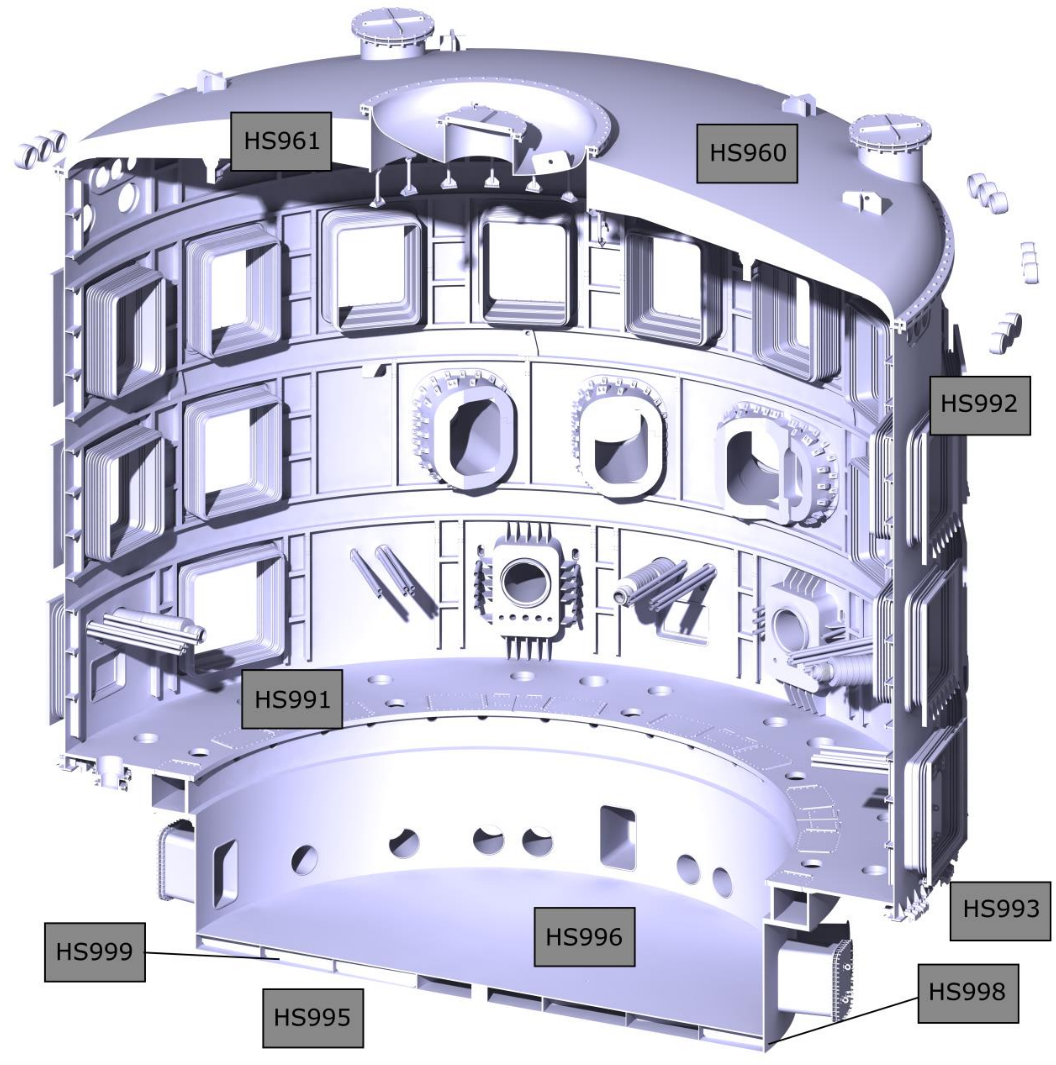
Model: Control volumes





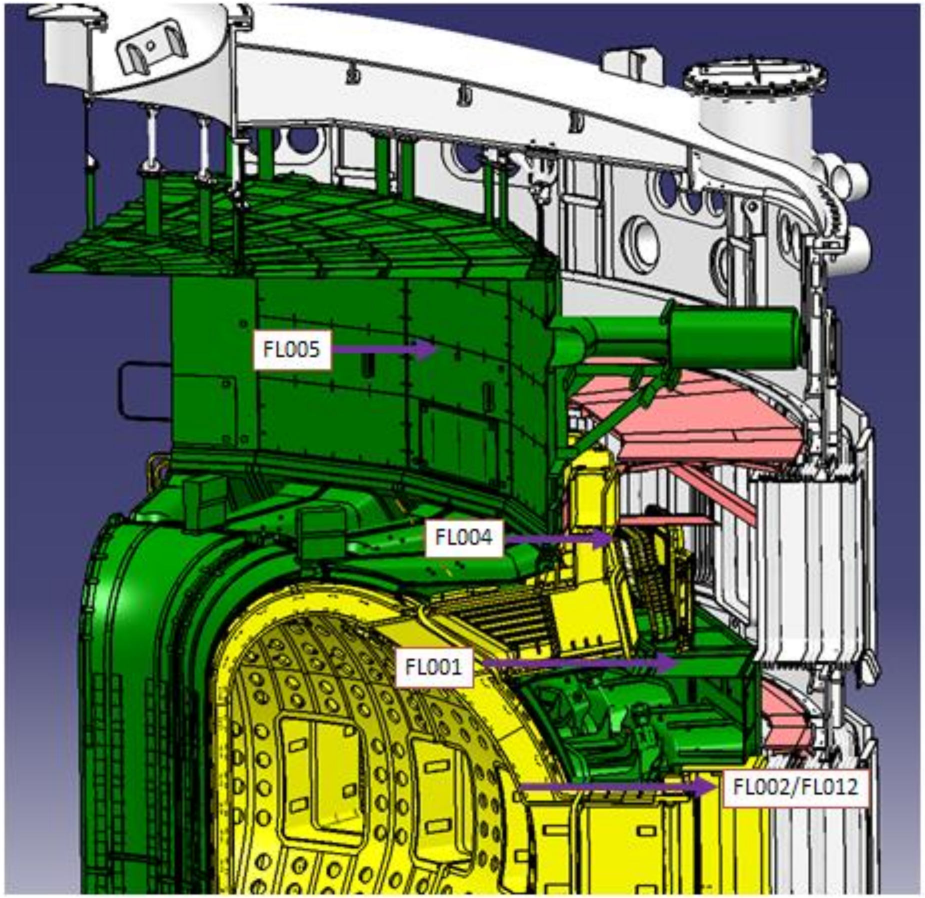
New nodalization control volumes

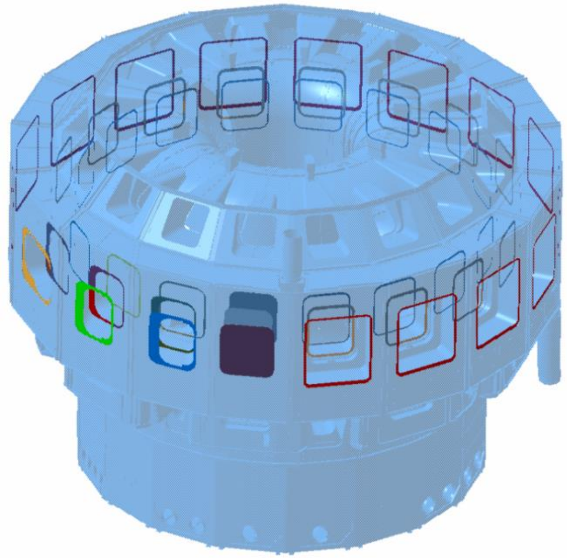
Model: Heat Structures



Cryostat heat structures

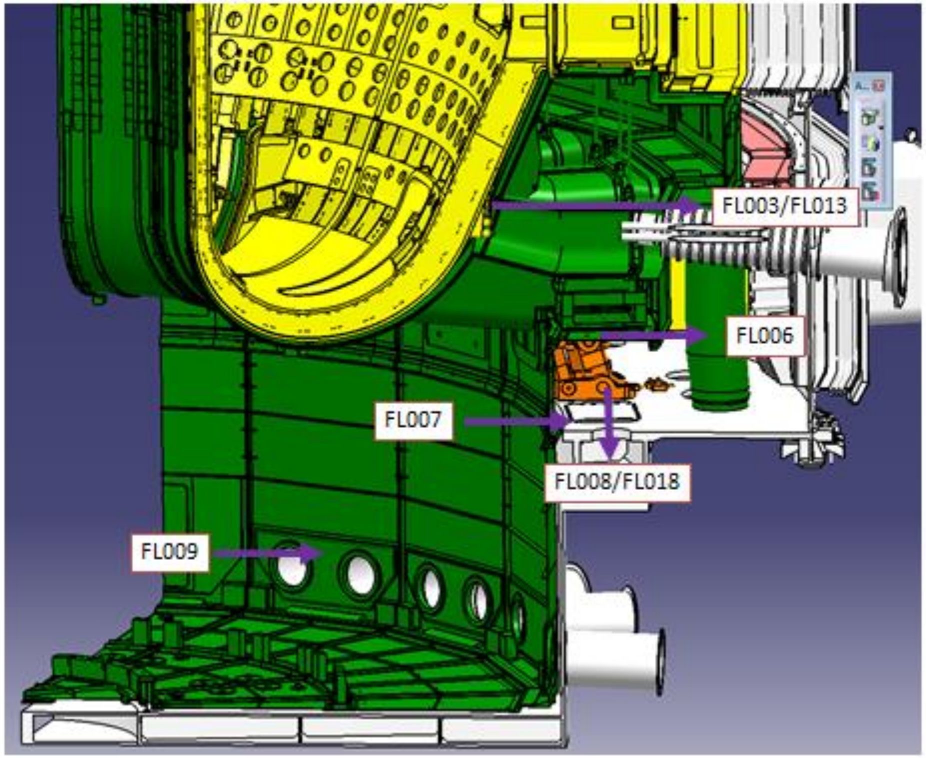
Model: Flow paths

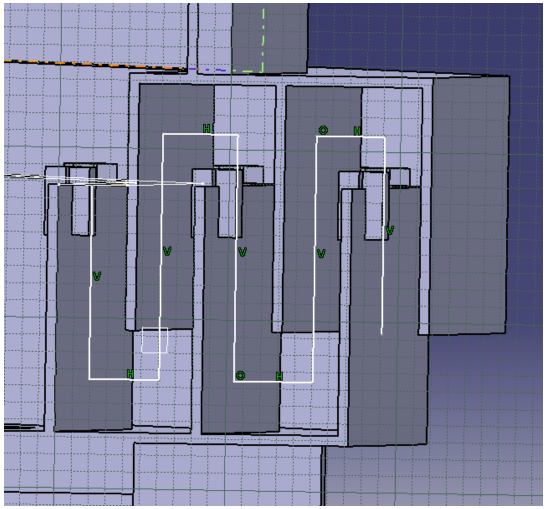




Cryostat flow lines

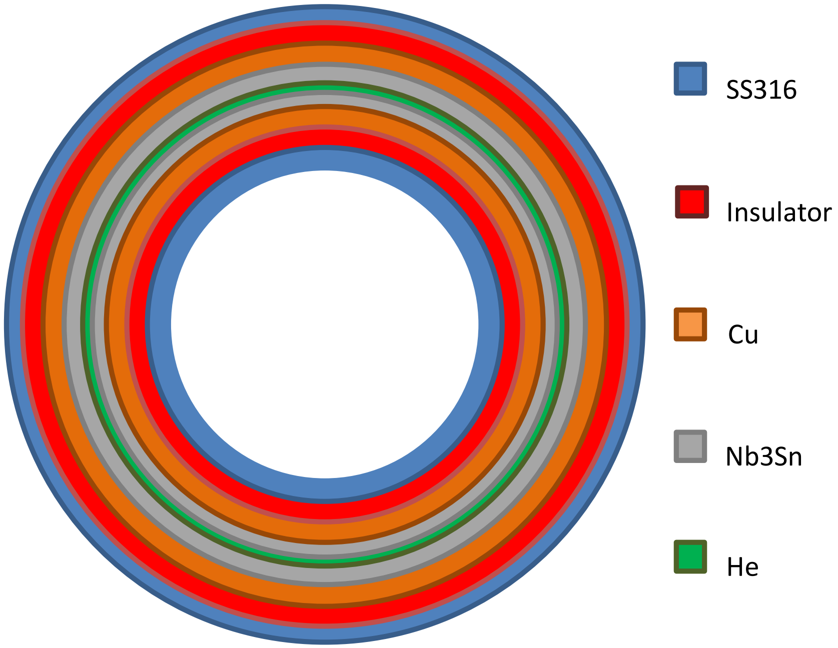
Model: Flow paths

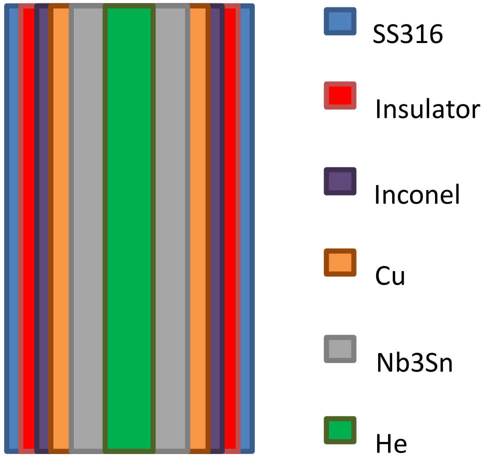




Cryostat flow lines

Model: Magnet system





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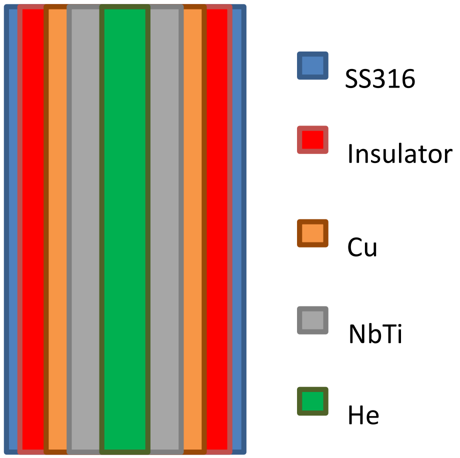
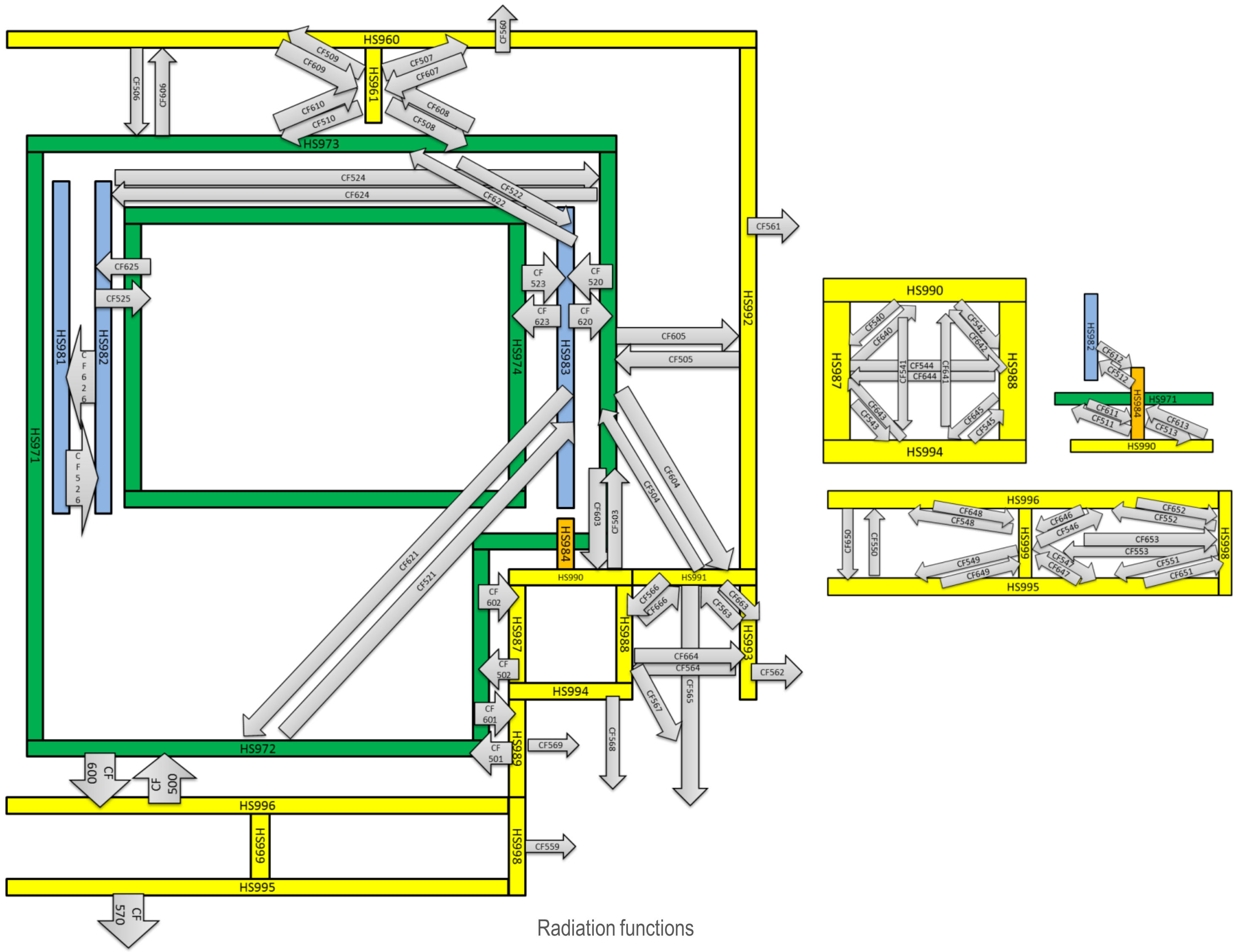


PFC

Model: Radiation Heat Transfer

- Radiation model through FUN1 radiation heat transfer functions
- VV fluid fixed temperature
- Concrete walls of bioshield at fixed temperature
- Once event starts, cooling is stopped and free convection drives heat exchange

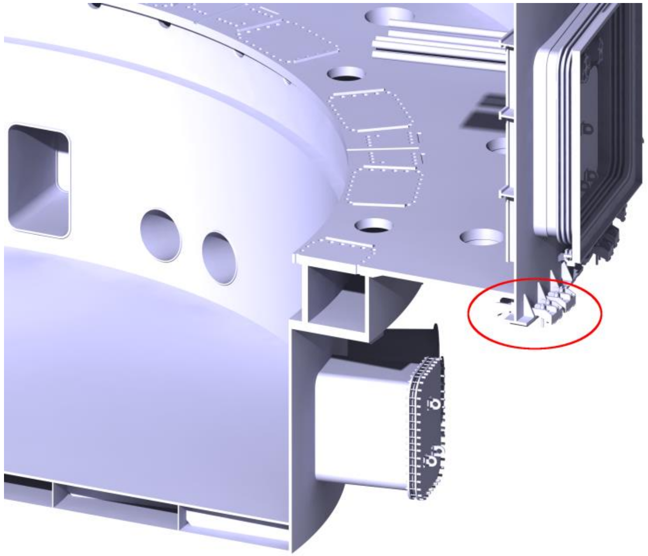
Model: Radiation Heat Transfer

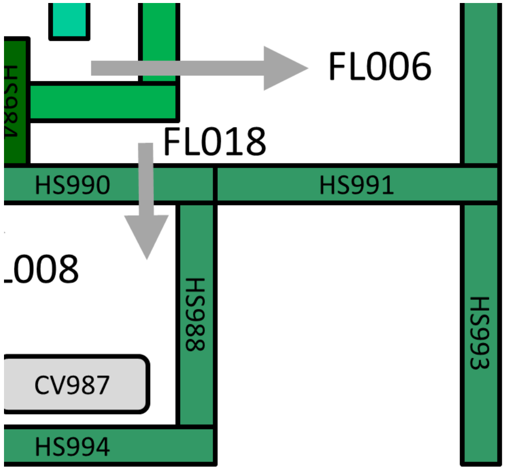


Radiation functions

Conduction assessment

- A conduction assessment was carried out in certain HS that could be specially affected by the temperature of their neighbours





Conduction assessment

- The MELCOR correlation for HTC calculation where implemented
- The surrounding HS temperature time evolution was used to calculate HS993 HTC
- In that way, all the temperature range is covered.
- Worst case was chosen

Conduction assessment

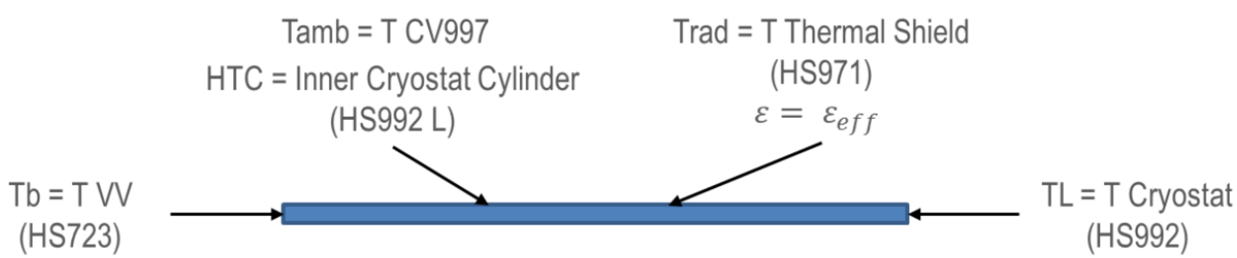
- Small disagreement due to gas properties and different molar fraction
- For the LOVA case, the HTC correlation implemented for natural convection turbulent regime showed a better agreement (evaluated at bulk temperature)

$$Nu^{1/2} = 0.825 + \frac{0.387 Ra^{1/6}}{[1 + (0.492/Pr)^{9/16}]^{8/27}}$$

Conduction assessment

- VV ports fin model to have a estimation of their contribution to in-cryostat heating
- 17 equatorial ports, 18 upper ports, 9 lower ports
- Result of estimation as a power source in CV

Parameter	Lower Ports	Equatorial Ports	Upper Ports
Length (m)	2.27	5.78	7.73
Perimeter (m)	11.14	10.99	9.49
Cross section (m^2)	0.85	0.55	0.36



Thank you!

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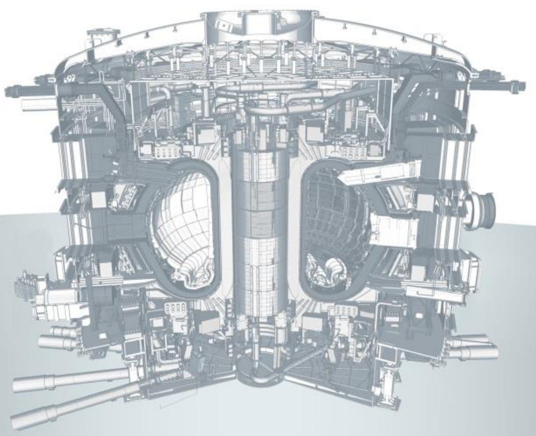

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