LOCA and LOFA Analysis for ARIES-AT

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http://fti.neep.wisc.edu/FTI/ARIES/MAR2000/loca_eam.pdf

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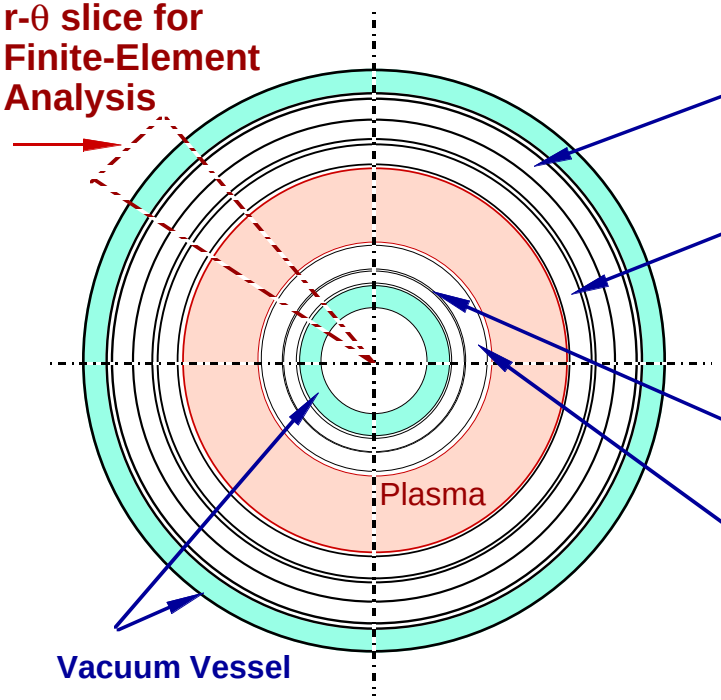
Introduction

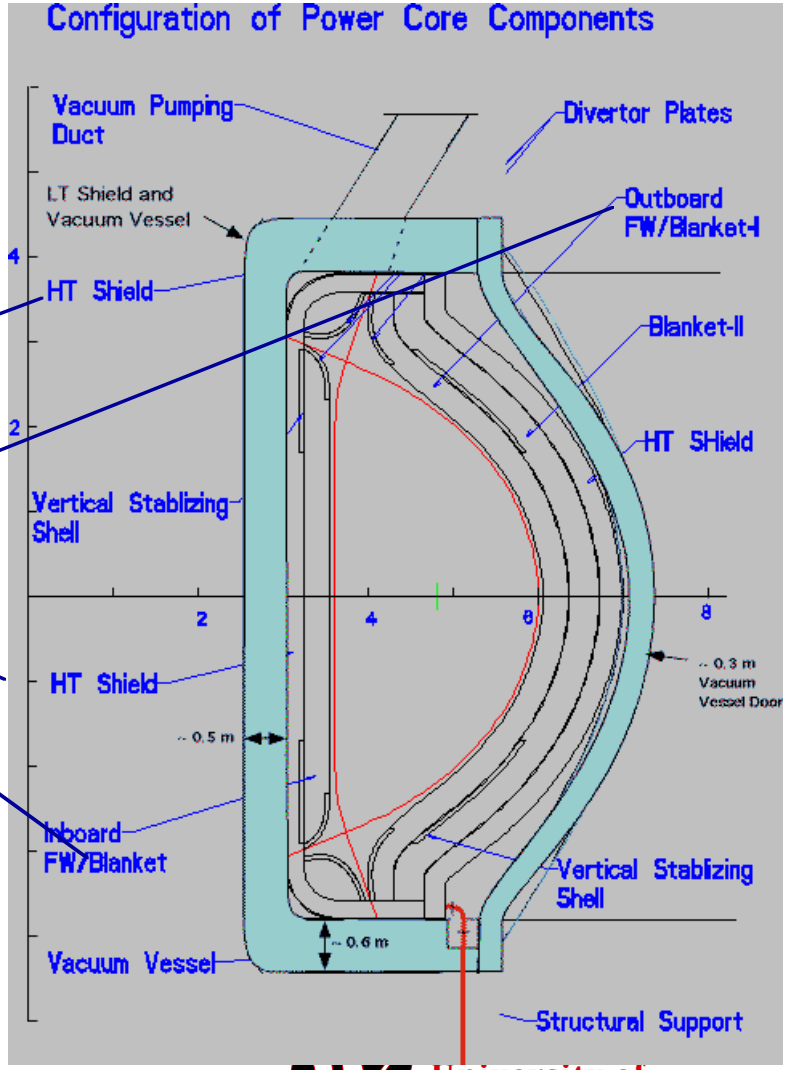
- This analysis addresses the rare events of loss of coolant accident (LOCA) and loss of flow accident (LOFA) during the first week following the accident.

- The analysis is performed for a base configuration specific to ARIES-AT.

• ARIES-AT Power Core

Cross-Section at Mid-Plane





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Finite-Element Model

- A transient 2-D finite-element model in r-θ plane is constructed to study ARIES-AT LOCA/LOFA events.
- The analysis was done for IB & OB sides only, and stabilizing shells are not included.
- ANSYS 5.4 code is used to perform this analysis.

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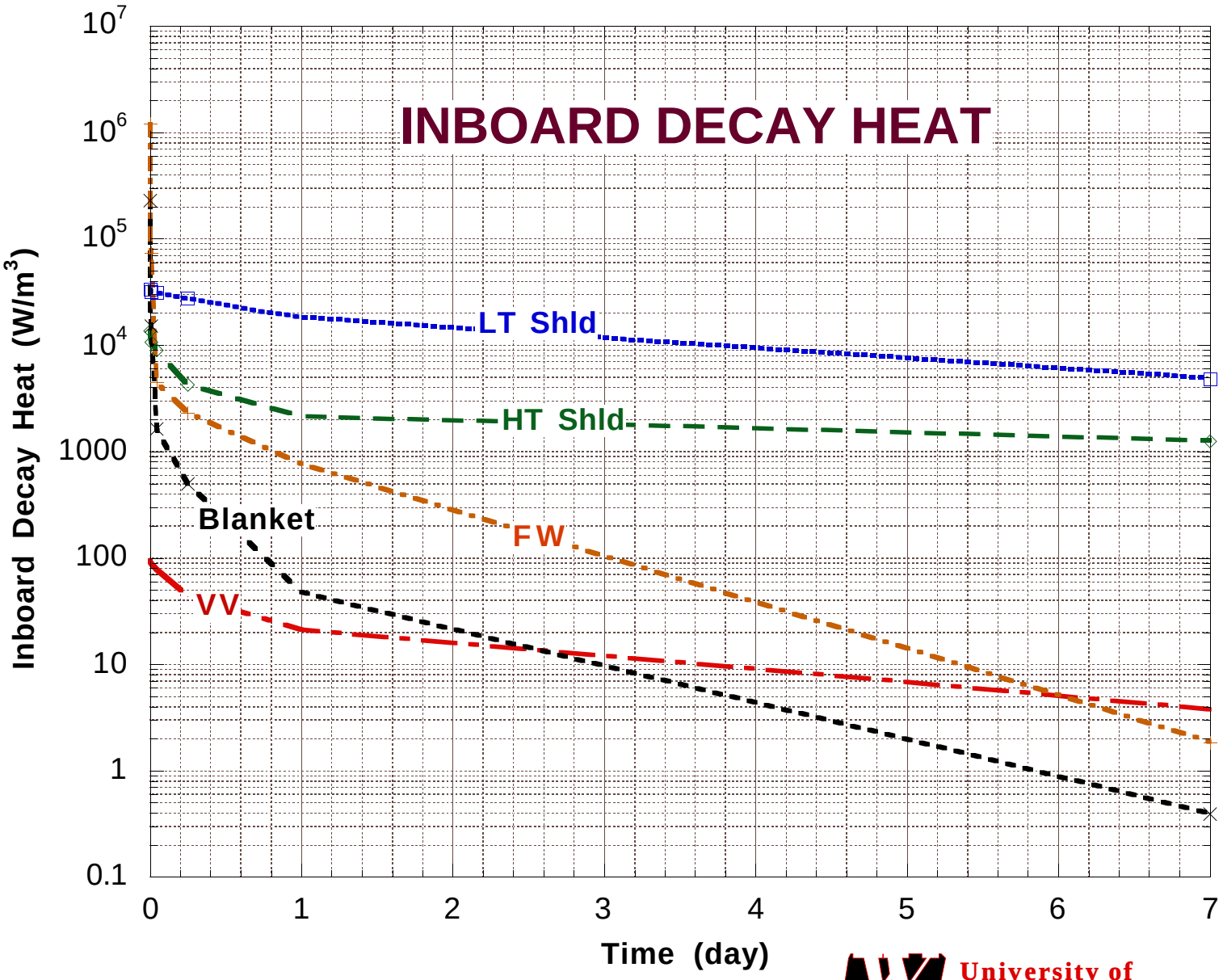
Assumptions, Initial and Boundary Conditions

- The base case assumes:
  1- Adiabatic boundary conditions at the inner surface of the I/B VV.

  2- Radiative boundary conditions at the outer surface of the O/B VV.

  3- Thermal radiation is allowed in the gaps between surfaces .



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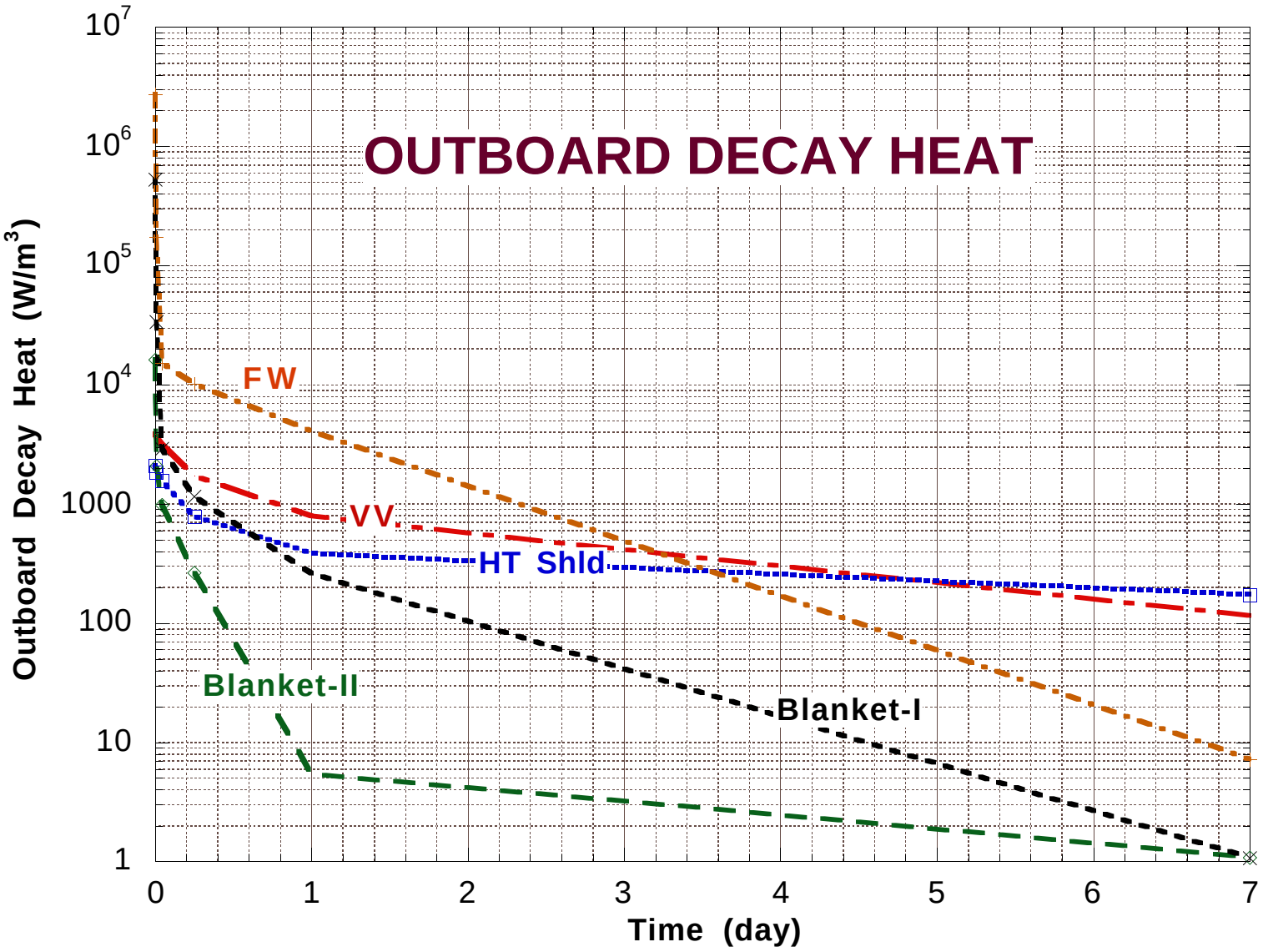

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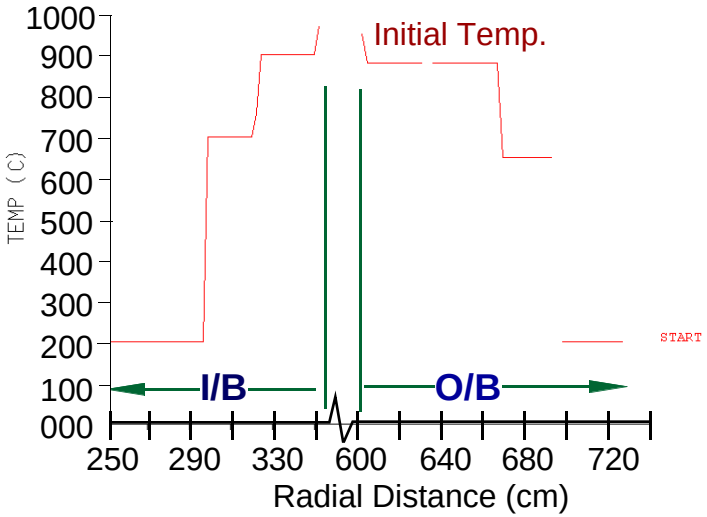
Average Temperature at Onset of LOCA/LOFA in °C

	Coolant	Structure
Inboard Components:		

LT shield and V.V.	175	200
HT shield	~750	SiC/FS/LiPb 800/900/700
Blanket	1020	1000/900 for side SiC walls
First wall	851	1000/970 for front wall 1000/840 for back wall
Outboard components:		

Blanket-I:		
Wall	777	1000/950 for front wall 1000/820 for back wall
Blanket	1020	1000/880 for side SiC walls
Blanket-II:		
Wall/blanket	same as for Blanket-I	
HT shield	~650	SiC/FS/LiPb 750/850/650
V.V.	175	200



Initial temperature distribution

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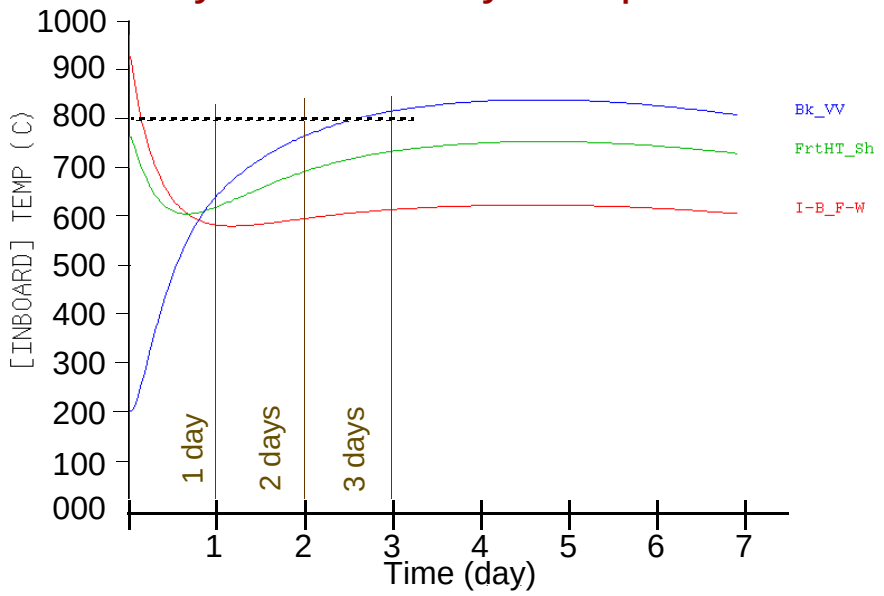
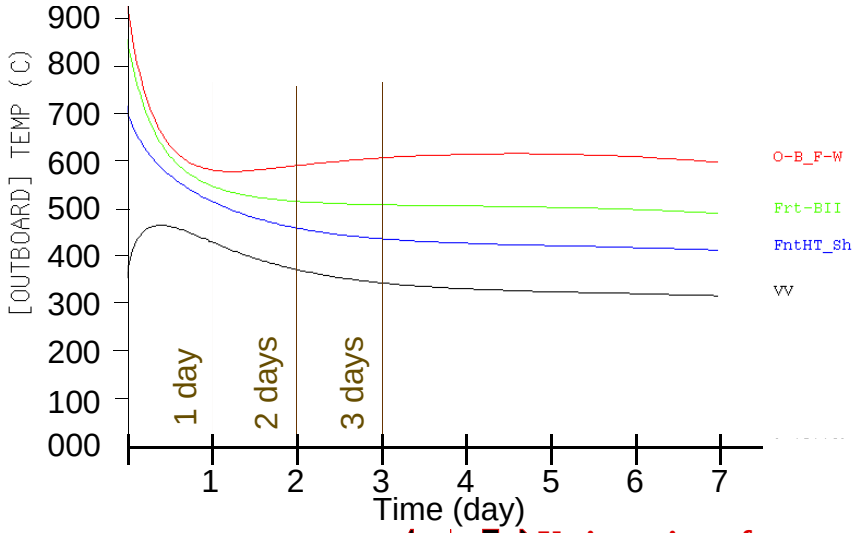
O/B & I/B LOCA Temperature History of Some Key Components

- The steel temperature in the inboard vacuum vessel exceeds 800°C after 2.7 days.



- The steel temperature in the outboard vacuum vessel reaches 462°C after 10 hr and then decreases with time.



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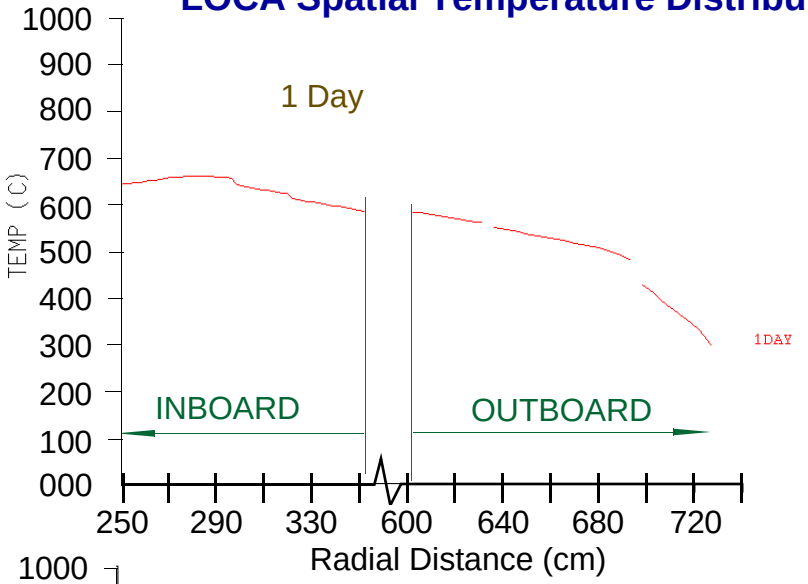
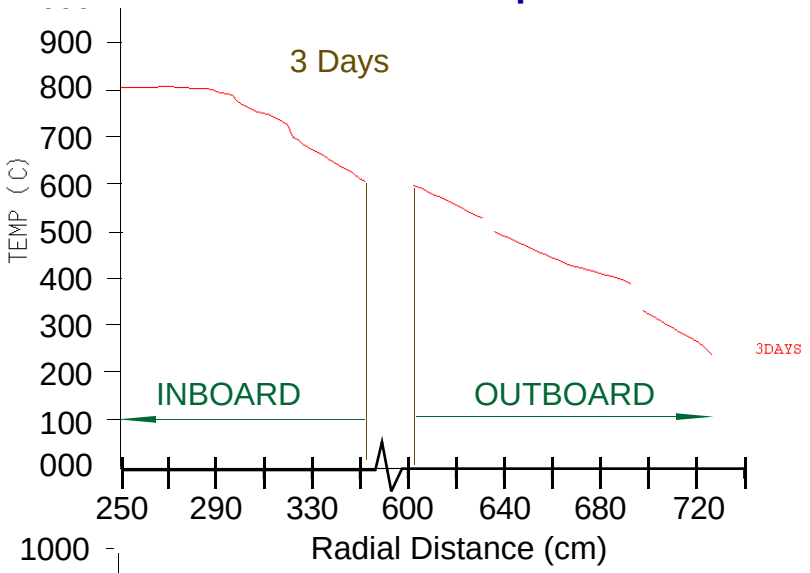
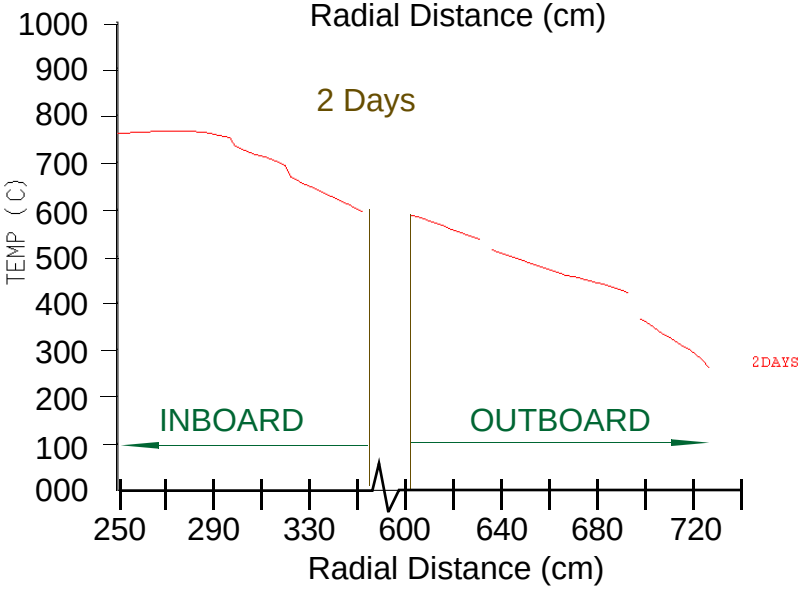
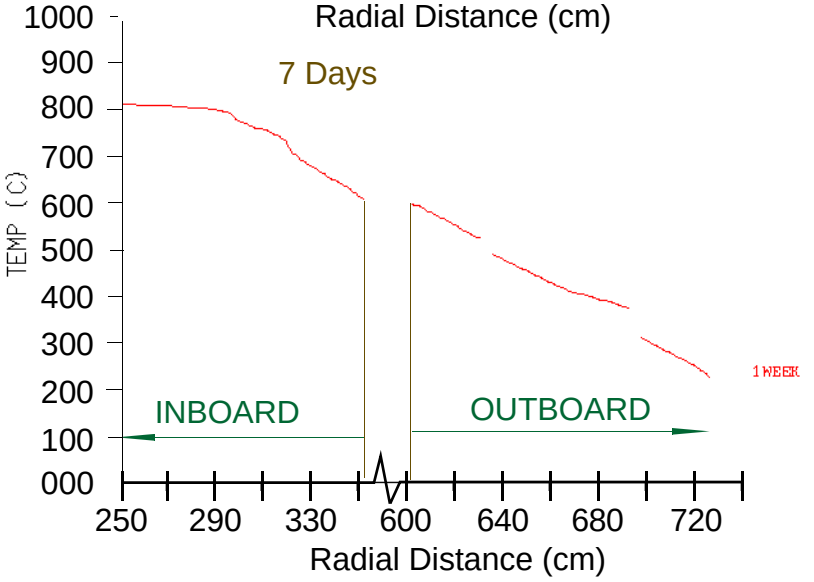
LOCA Spatial Temperature Distribution in the I/B & O/B at the Mid-plane









LOCA-Base case

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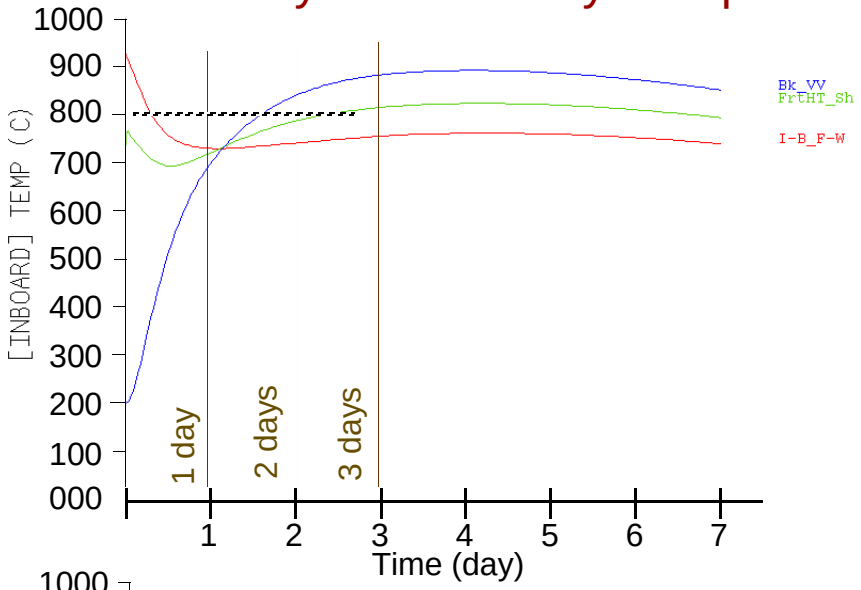
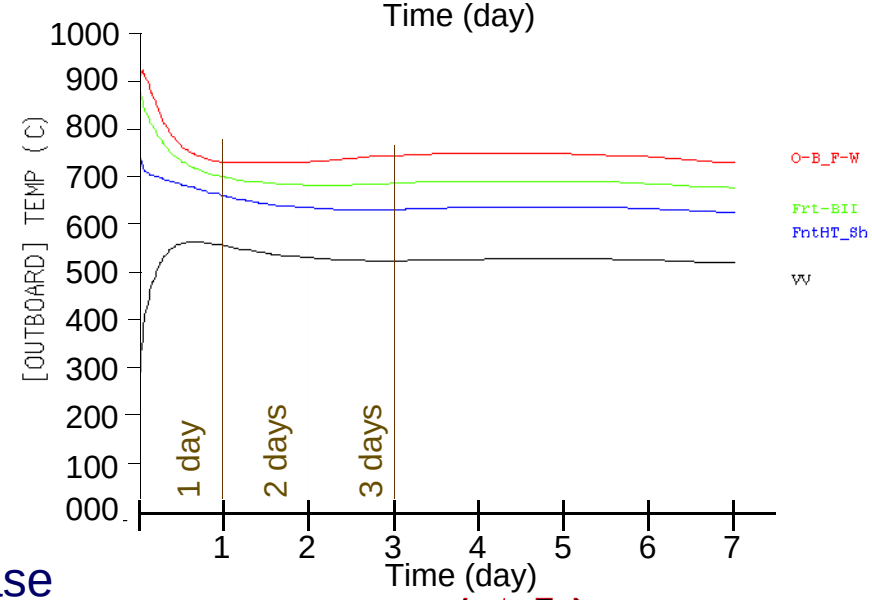
O/B & I/B LOFA Temperature History of Some Key Components

- The steel temperature in the inboard vacuum vessel exceeds 800°C after 1.5 days.



- The steel temperature in the outboard vacuum vessel reaches 565°C after 15.5 hr and then decreases with time.



LOFA-Base case

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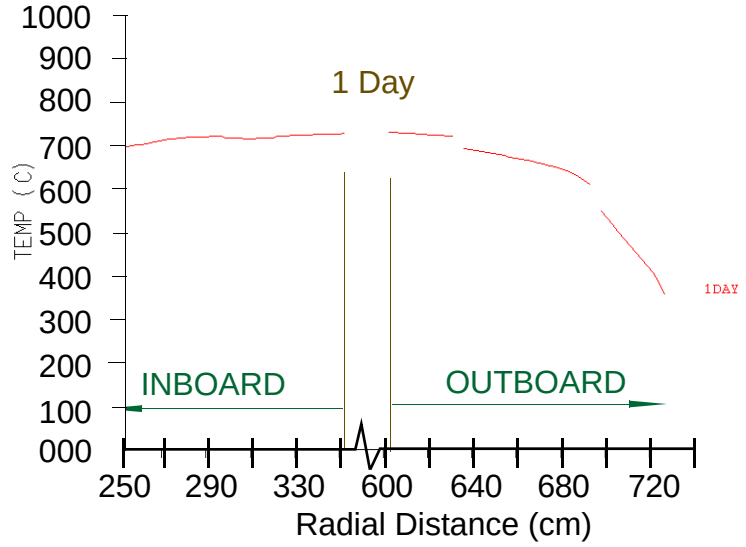
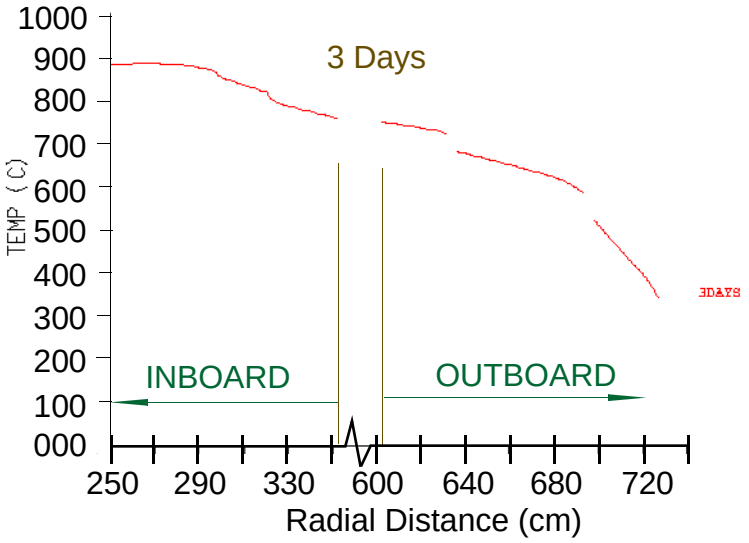
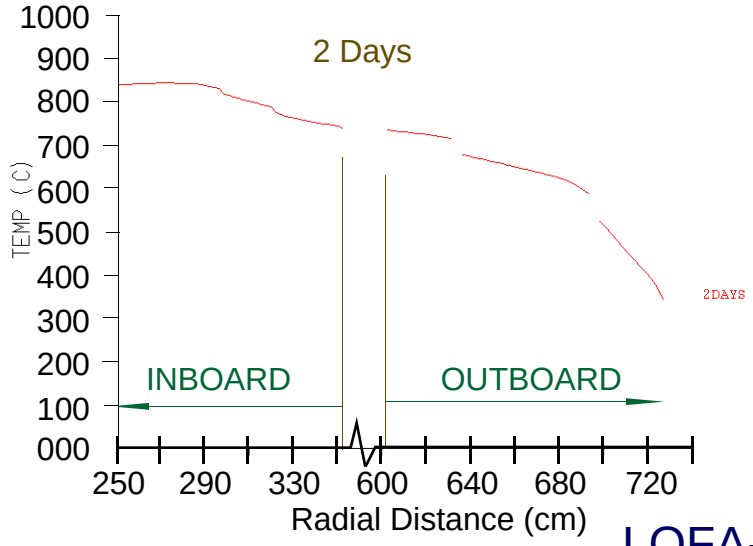
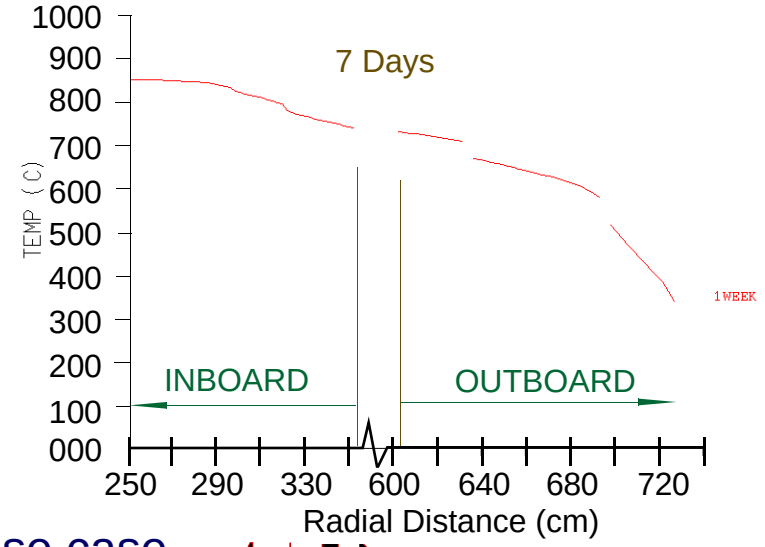
LOFA Spatial Temperature Distribution in the I/B & O/B at the Mid-plane









LOFA-Base case

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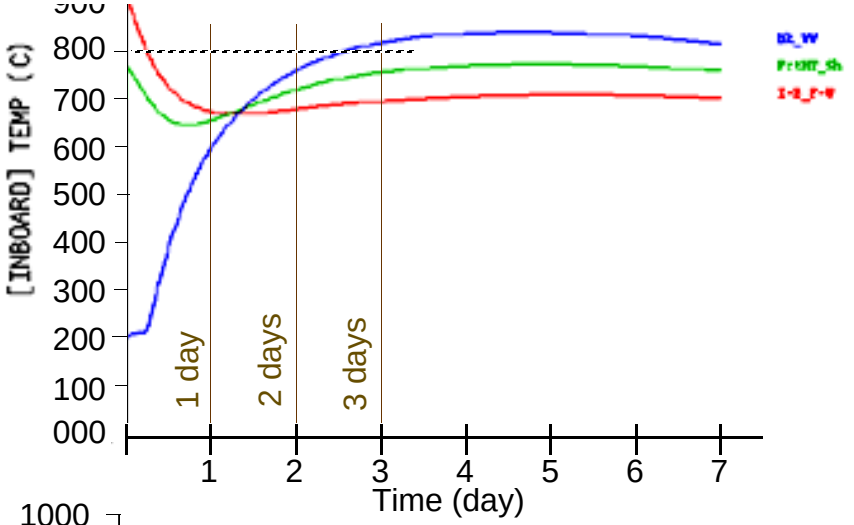
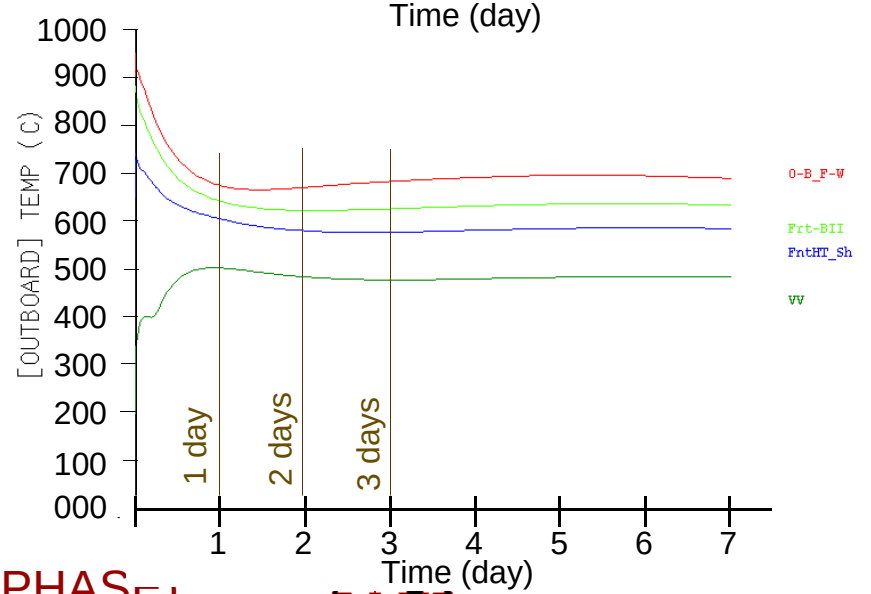
O/B & I/B LOFA (WATER CHANGES PHASE)
Temperature History of Some Key Components

- The steel temperature in the inboard vacuum vessel exceeds 800°C after 2.6 days.



- The steel temperature in the outboard vacuum vessel reaches 503°C after one day and then decreases with time.



LOFA (WATER CHANGES PHASE)

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Summary of the Results

Maximumm temperature (°C) in the I/B vacuum vessel

Case	*1 day*	*2 days*	*3 days*	*7 days*
1 - Compelete LOCA (in LiPb & Water)	685°C	768°C	816°C	807°C
2 - LOFA in LiPb & LOFA in Water	698°C	840°C	884°C	852°C
3 - Compelete LOFA (in LiPb & Water)	593°C	756°C	815°C	813°C

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Important Issues

Safety issues:

1 - The time to take action (for example: 24 hr after onset of LOCA/LOFA).

2 - The release of water vapor during LOCA/LOFA.

Material issues:

1 - The maximum steel temperature in the inboard vacuum vessel.

2 - Duration of this temperature.

Design issue:

1 - Heat sink in the inboard side.

Conclusions

- Worst case scenario is total LOFA in LiPb and total LOCA in water
- SiC components have an acceptable temperature during full LOCA/LOFA ($T_{max} < 1100°C$).
- IB V.V. exhibits the highest LOCA/LOFA temperature among all FS components.
- With no heat sink on IB side, maximum IB V.V. LOCA/LOFA temperature reaches 840°C in 2 days.
- Partial LOCA/LOFA (in one loop or more) will result in lower temperatures.

Suggestions

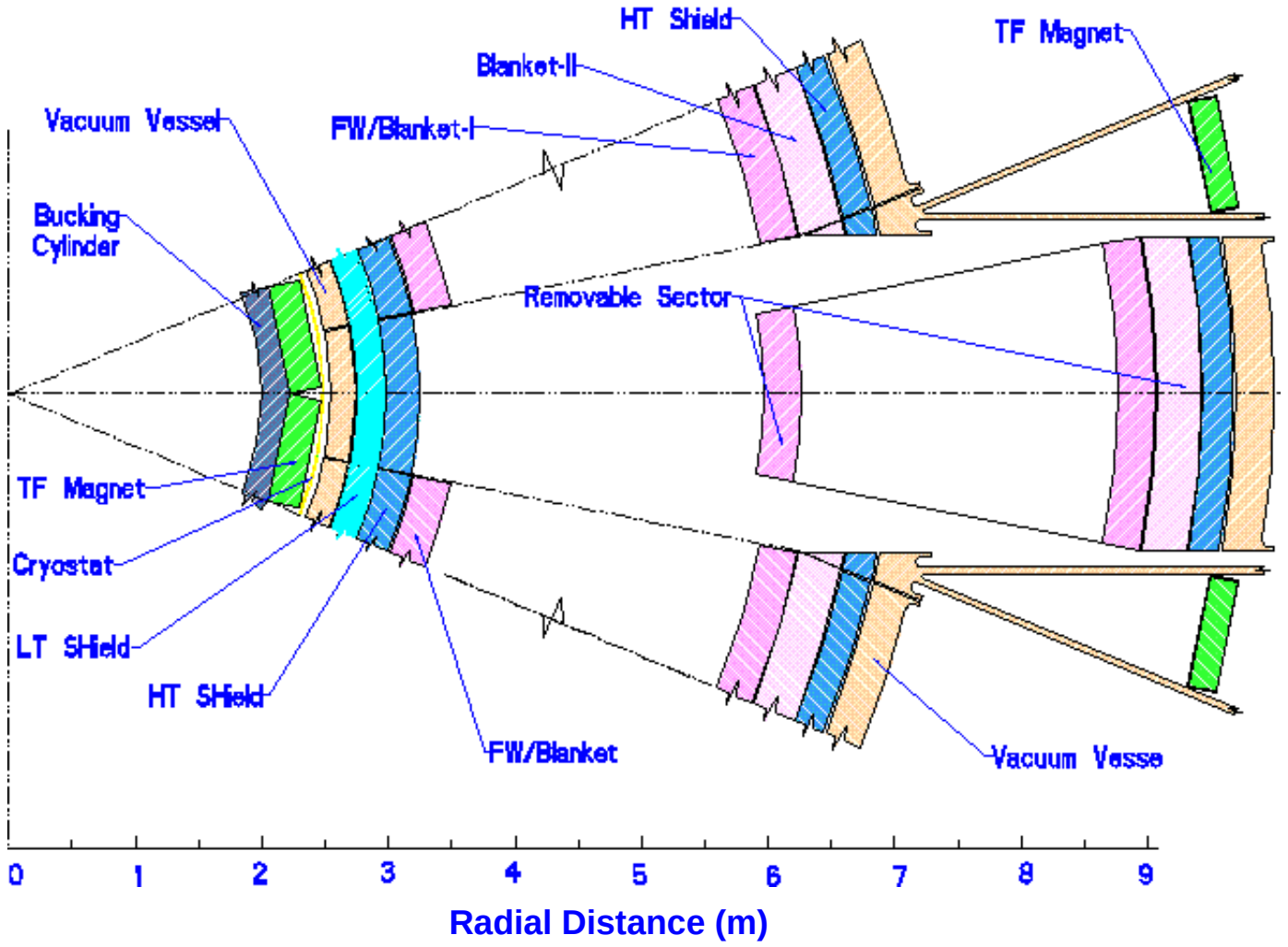
• If temperature of FS components exceeds the limit, one or more of the following solutions may be considered:

- Take action before 2 days (e. g., flow helium gas in chamber to remove decay heat).
- Install heat pipes that activate at 500°C on the IB VV.

Suggestions (Cont.)

- Incorporate LiPb heat removal loop (like that of ARIES-RS) using natural convection to transfer heat from IB side to OB side.
- Provide a rupture disk mechanism that will release the water vapor from the VV and LT shield during LOCA/ LOFA.
- The water vapor released during LOCA/LOFA should continuously be collected, then condensed and returned back to the VV and LT Shield. That could act as a passive heat sink (like a heat pipe).

Plan View of Showing Removable Sector Being Withdrawn



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