LOCA and LOFA Analysis for ARIES-AT

E. A. Mogahed, L. El-Guebaly, A. Abdou, and P. Wilson

Fusion Technology Institute
University of Wisconsin-Madison

With input from
M. Sawan and D. Henderson

June 19-21, 2000 - ARIES Project Meeting
UW-Madison

http://fti.neep.wisc.edu/FTI/ARIES/JUN2000/loca_eam.pdf

University of Wisconsin-Madison

CONTENTS:

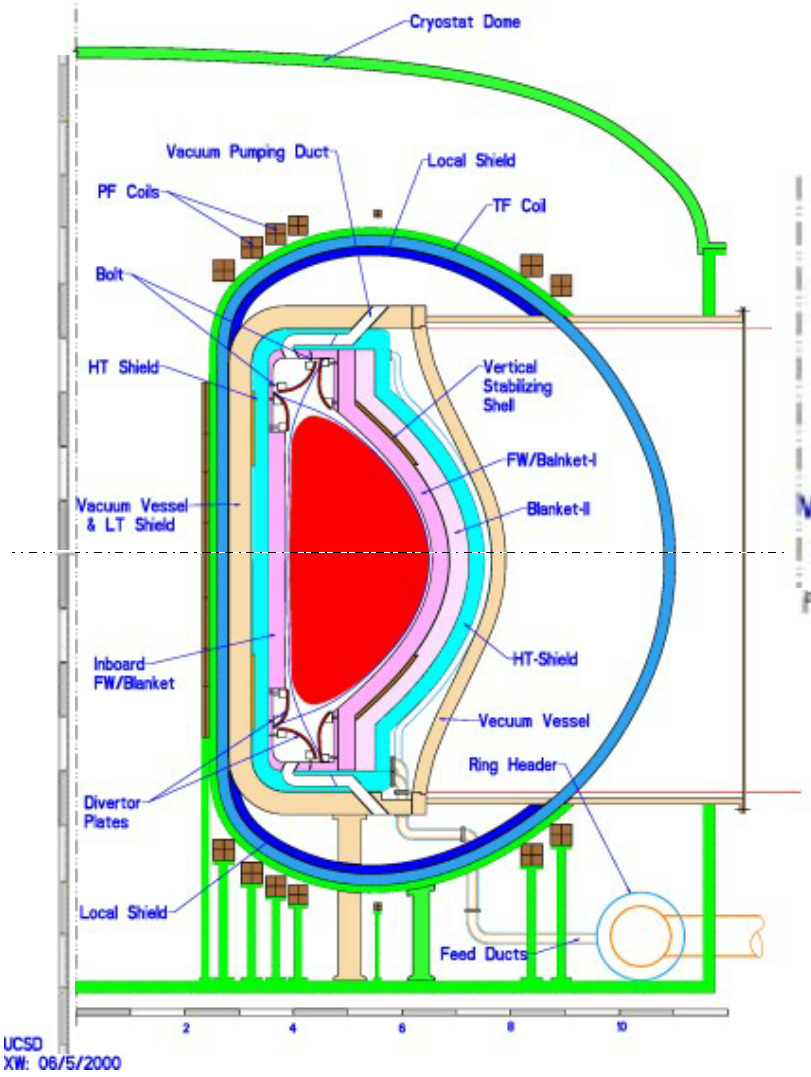
University of
Wisconsin-Madison

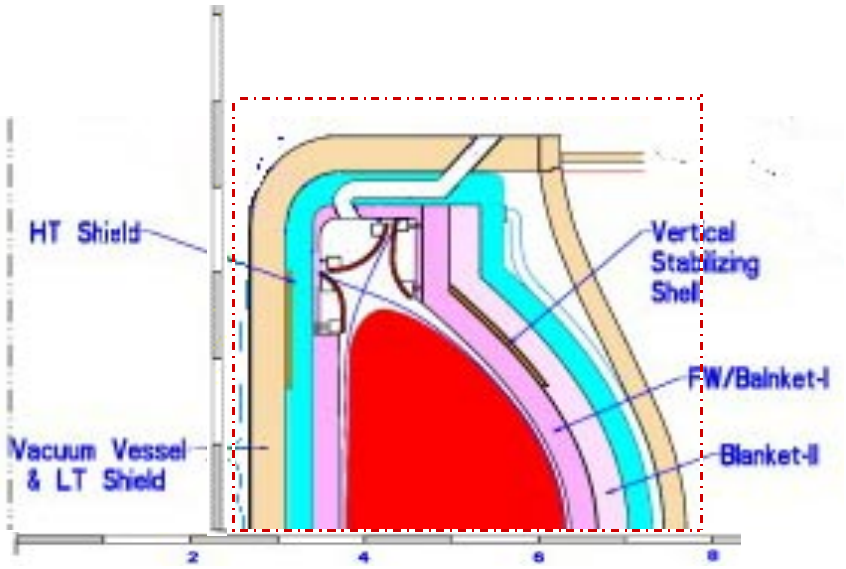
Introduction

- 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.

Cross Section of ARIES-AT Power Core Configuration





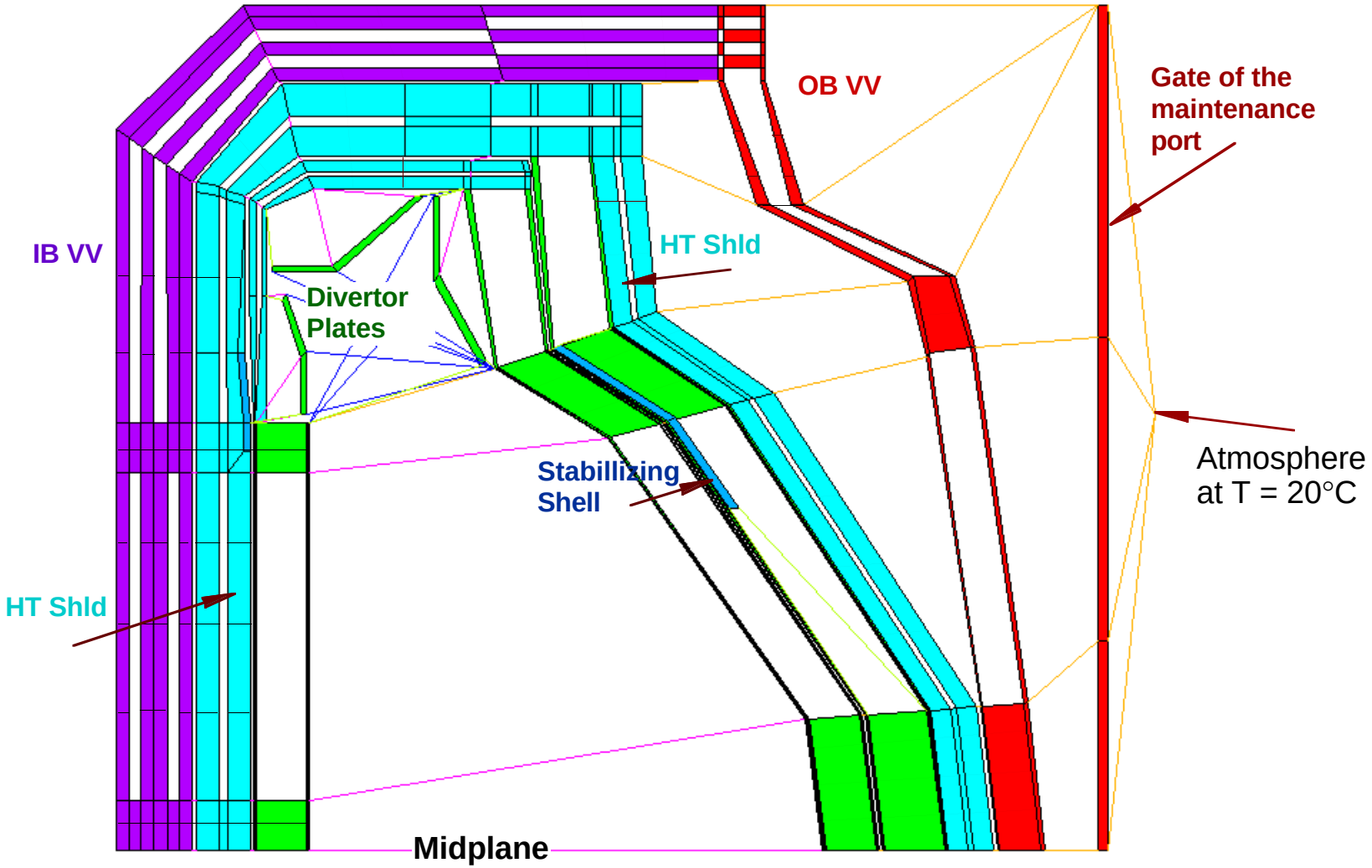
- The Upper Half of the ARIES-AT Power Core is Considered for the Thermal Finite Element Model.

University of Wisconsin-Madison

Finite-Element Model

- A transient axisymmetric finite-element model in r-z plane is constructed to study ARIES-AT LOCA/LOFA events.
- The analysis was done for the upper half only, the divertor plates and 4 cm W vertical stabilizing shells are included.
- ANSYS 5.4 code is used to perform this analysis.

Finite-Element Model



University of Wisconsin-Madison

Assumptions, Initial and Boundary Conditions

Due to the large difference between the time scale of plasma shutdown (10-20 s) and the loss of coolant or flow loss (several minutes-hours), it is assumed that the plasma is immediately quenched at the onset of the LOCA/LOFA and the chamber components' temperature begins to increase due to the decay heat generated (worst case scenario).

University of Wisconsin-Madison

* The base case assumes:

1- Adiabatic boundary conditions at the inner surface of the I/B VV.

2- The outer surface of the O/B VV radiates to the gate of the maintenance port.

3- The maintenance port convects (naturally) to the atmosphere at 20°C.

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

University of Wisconsin-Madison

Average Temperature at Onset of LOCA/LOFA in °C

	Coolant	Structure
Inboard Components:		

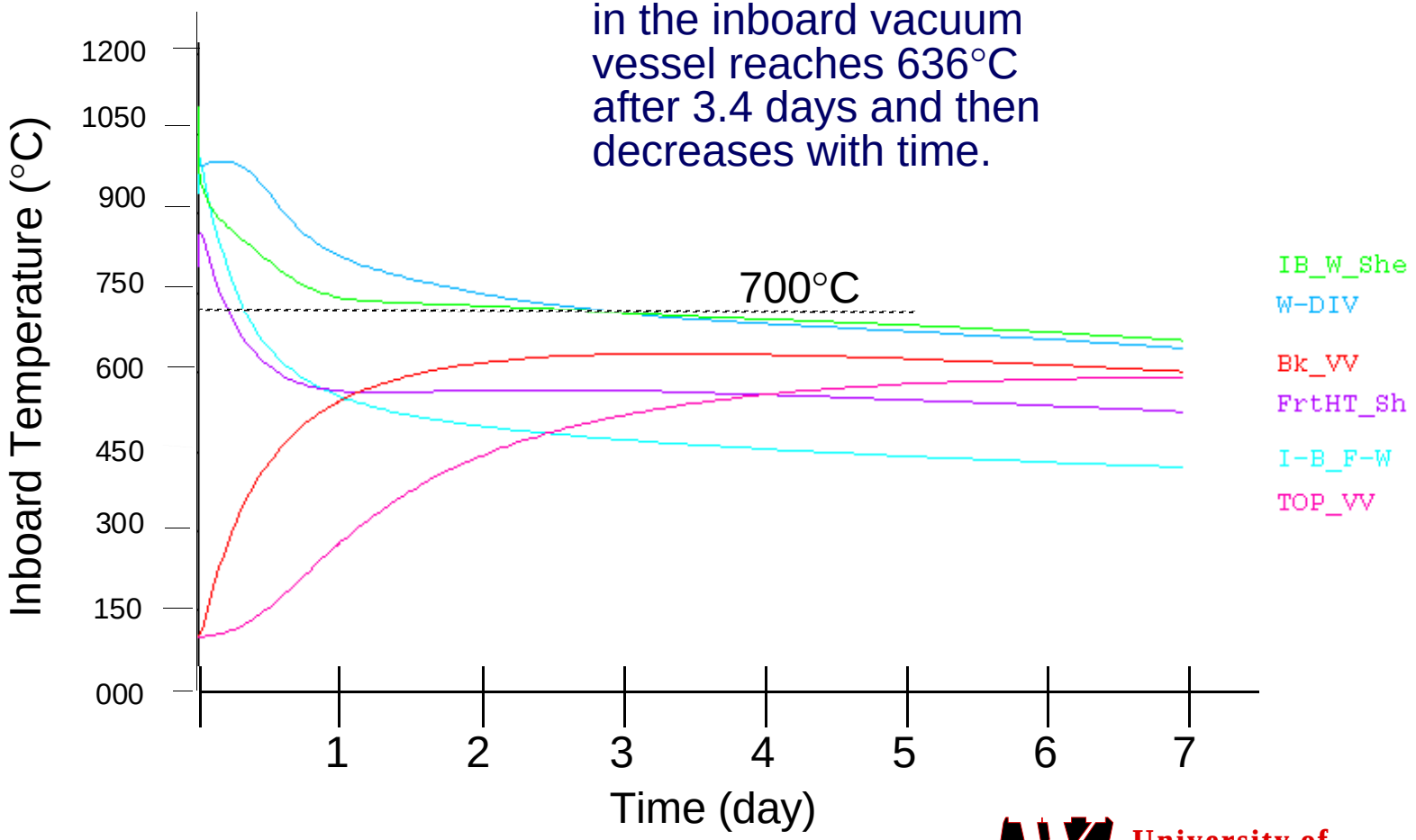
LT shield & V.V.	75	100
HT shield	759	806
Blanket	968	925 for side SiC walls
First wall	800	960 for front wall 925 for back wall
Outboard components:		

Blanket-I:		
Wall	787	950 for front wall 925 for back wall
Blanket-I	965	925 for side SiC walls
Blanket-II:		
Wall/blanket	709	800 for front/back wall
Blanket-II	932	800 for side SiC walls
HT shield	725	800
V.V.	75	100

University of Wisconsin-Madison

Inboard LOCA
Temperature History of Some Key Components

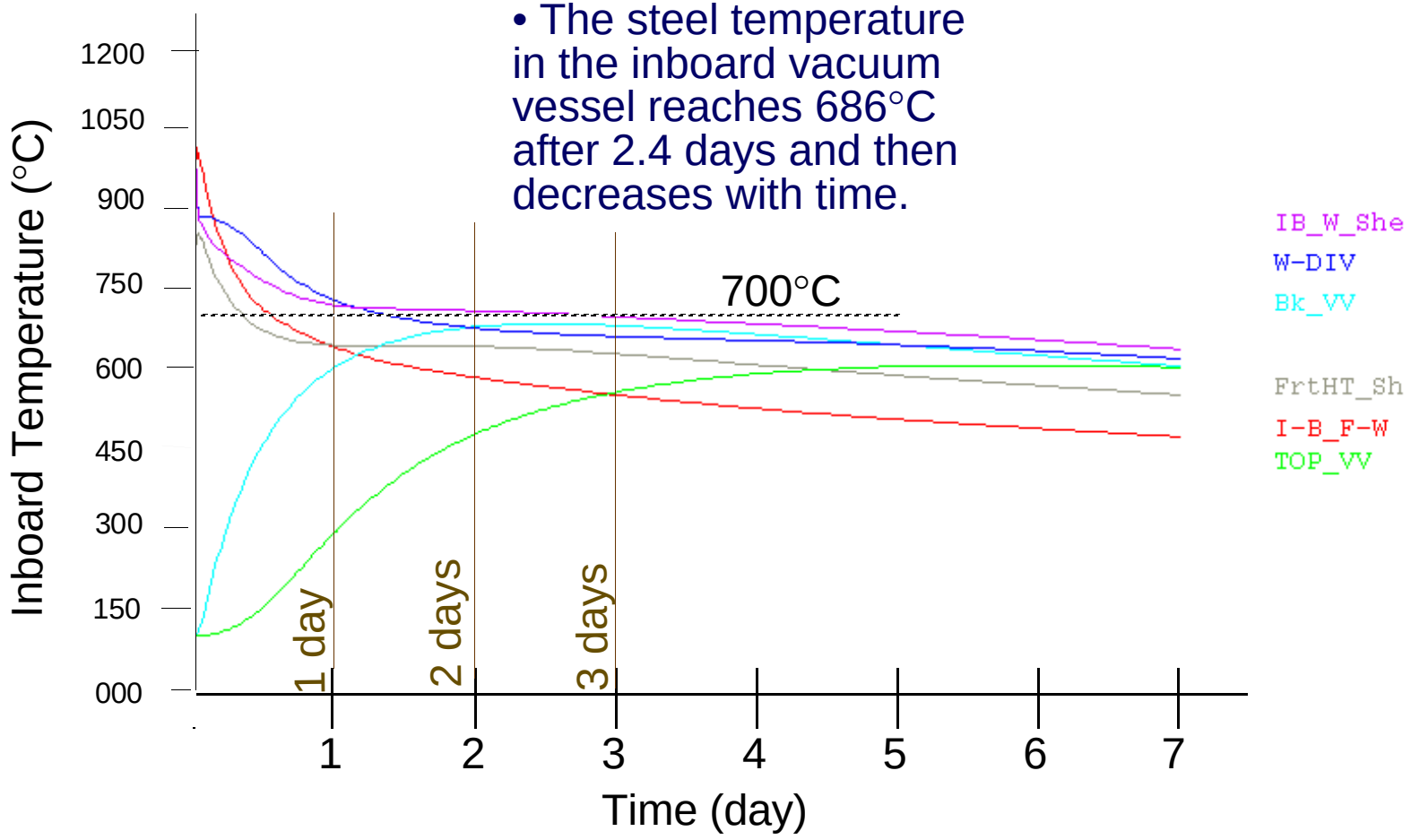
- The steel temperature in the inboard vacuum vessel reaches 636°C after 3.4 days and then decreases with time.



University of Wisconsin-Madison

Inboard LOFA
Temperature History of Some Key Components

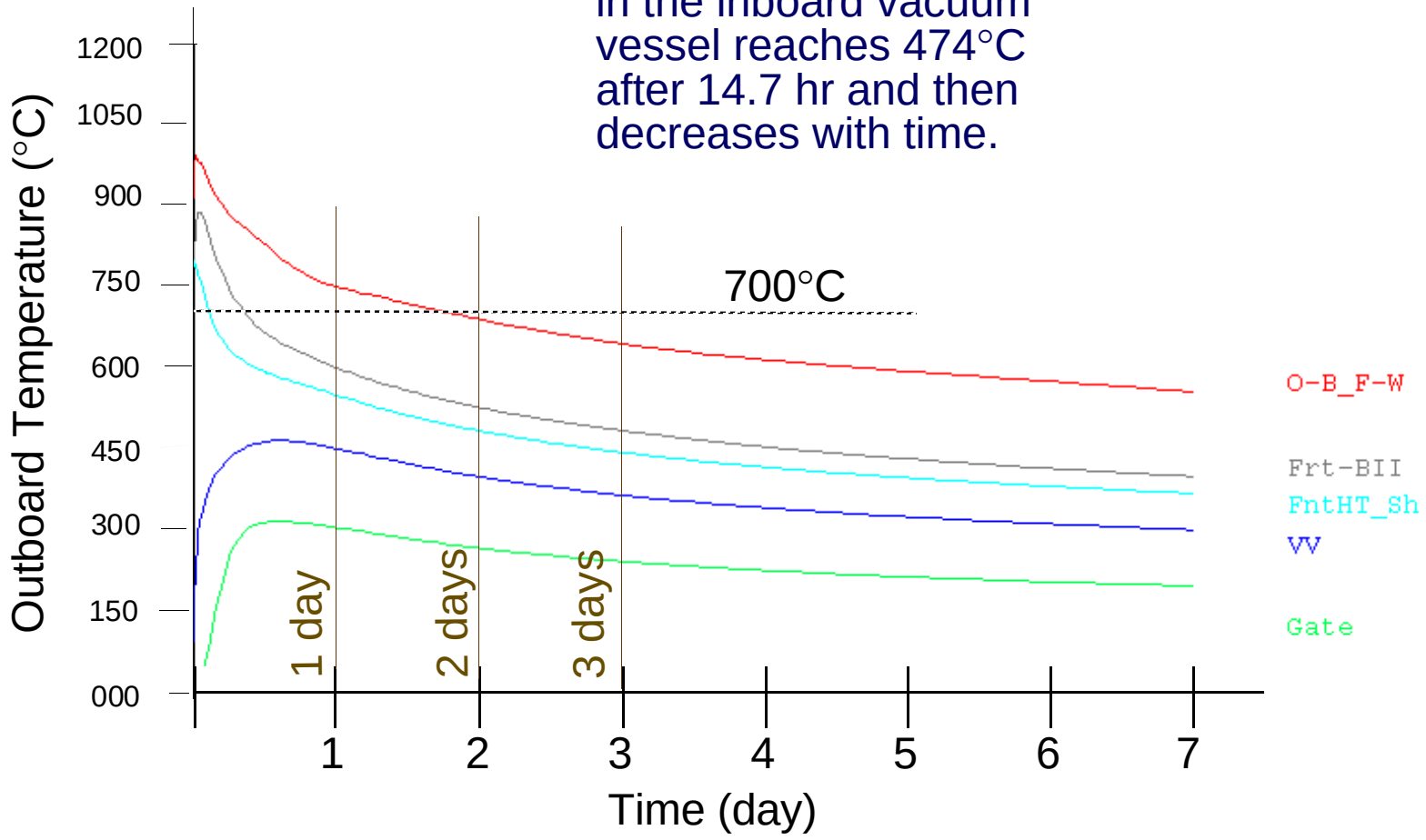
- The steel temperature in the inboard vacuum vessel reaches 686°C after 2.4 days and then decreases with time.



University of Wisconsin-Madison

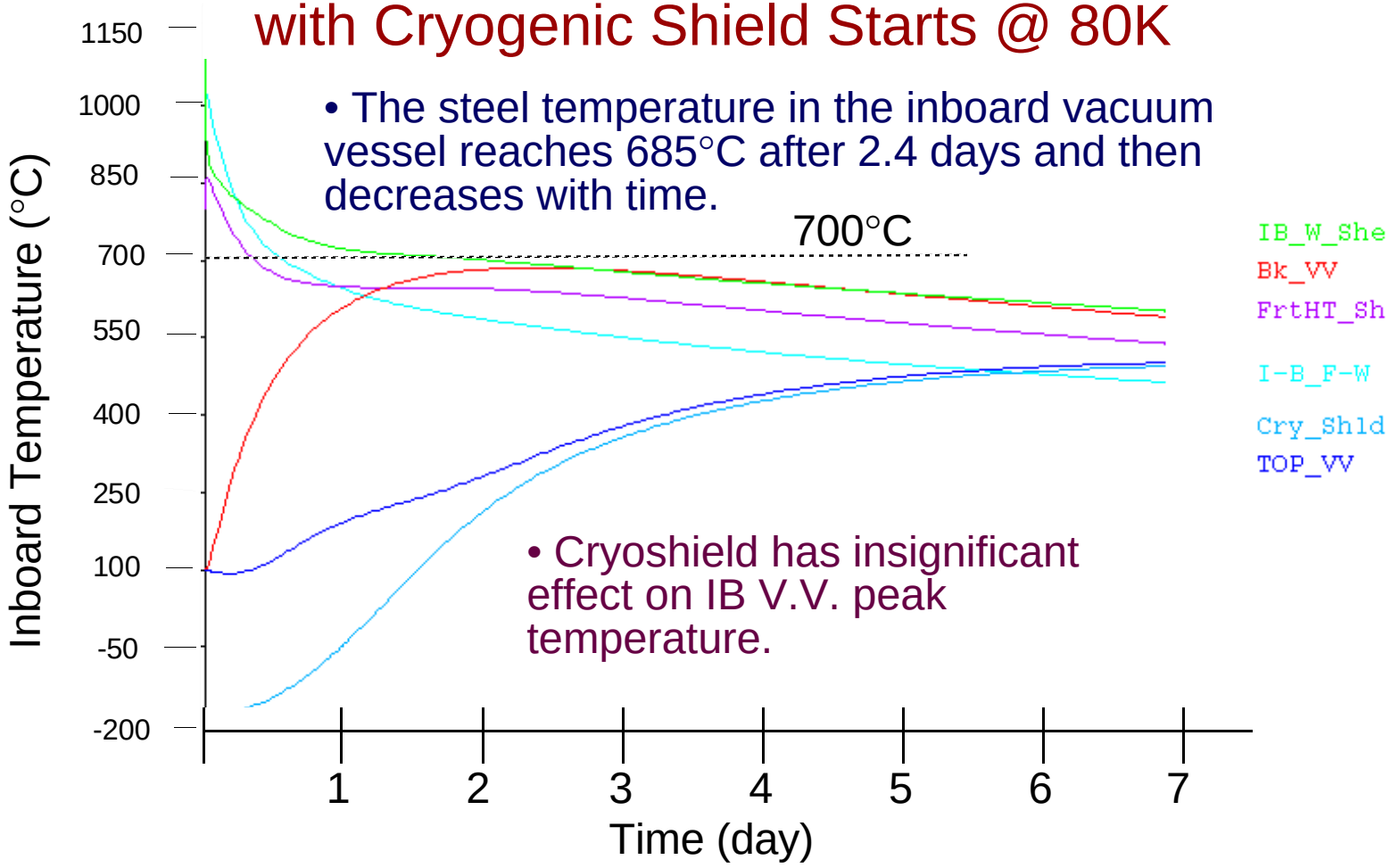
Outboard LOFA
Temperature History of Some Key Components

- The steel temperature in the inboard vacuum vessel reaches 474°C after 14.7 hr and then decreases with time.



University of Wisconsin-Madison

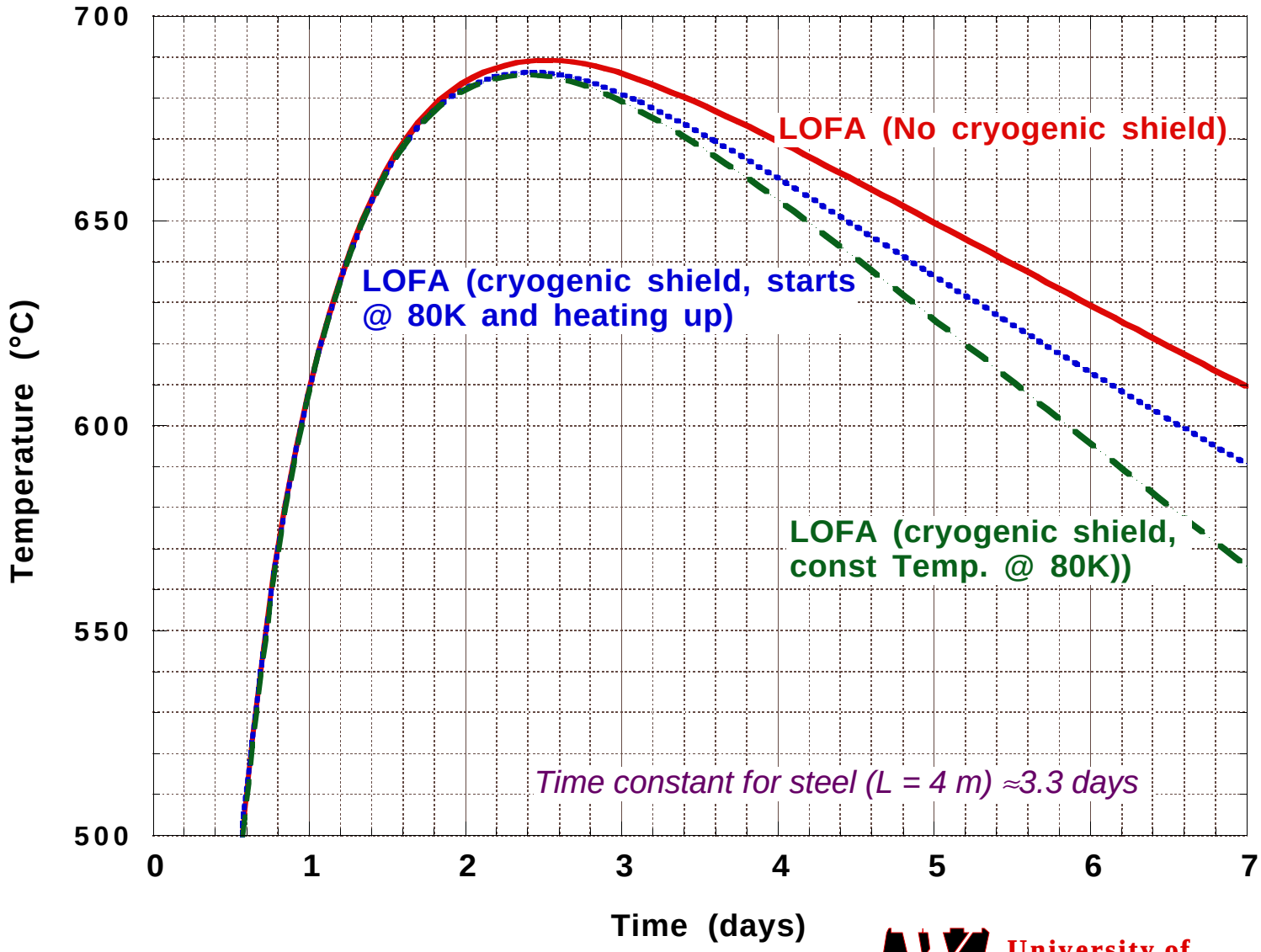
Inboard LOFA
Temperature History of Some Key Components with Cryogenic Shield Starts @ 80K



- The steel temperature in the inboard vacuum vessel reaches 685°C after 2.4 days and then decreases with time.
- Cryoshield has insignificant effect on IB V.V. peak temperature.

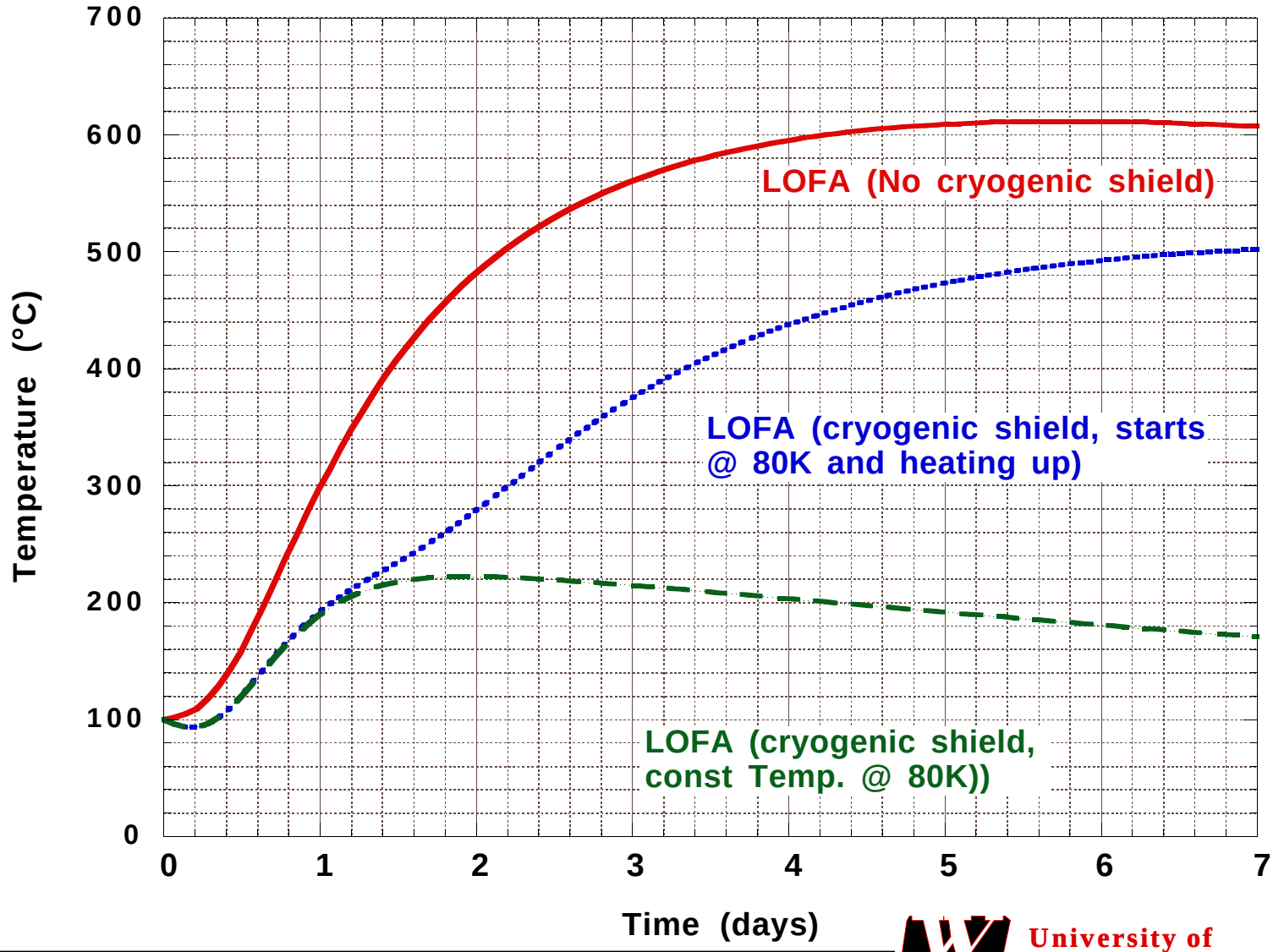
University of Wisconsin-Madison

Temperature Comparison of the Back of VV at the Midplane



University of Wisconsin-Madison

Temperature Comparison of the Top of VV



University of Wisconsin-Madison

Summary of the Results

Temperature (°C) in the I/B vacuum vessel at the midplane ($T_{initial}$ = 100°C)

Case	*1 day*	*2 days*	*3 days*	*7 days*
1 - Complete LOCA (in LiPb & Water)	543.8°C	617.4°C	**634.6°C**	601.5°C
2 - LOFA in LiPb & LOCA in Water	608°C	683.9°C	**685.9°C**	669.4°C
3 - LOFA in LiPb & LOCA in Water (with Cryogenic Shield)	607.9°C	**682.2°C**	680.9°C	590.5°C

Temperature (°C) in the I/B vacuum vessel at the midplane ($T_{initial}$ = 50 °C)

1 - Complete LOCA (in LiPb & Water)	512.3°C	591.2°C	**611.5°C**	586.3°C
2 - LOFA in LiPb & LOCA in Water	581°C	665.5°C	**671.9°C**	601.7°C

University of Wisconsin-Madison

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 (T_{max} < 700°C).
- With no heat sink on IB side, maximum IB V.V. LOCA/LOFA temperature reaches 689°C in ~ 2.5 days.
- Partial LOCA/LOFA (in one loop or more) will result in lower temperatures.
- No need for a special procedure to deal with LOCA/LOFA