Idaho National Engineering and Environmental Laboratory

Task IV ARIES-AT FW/Blanket Design Safety Assessment

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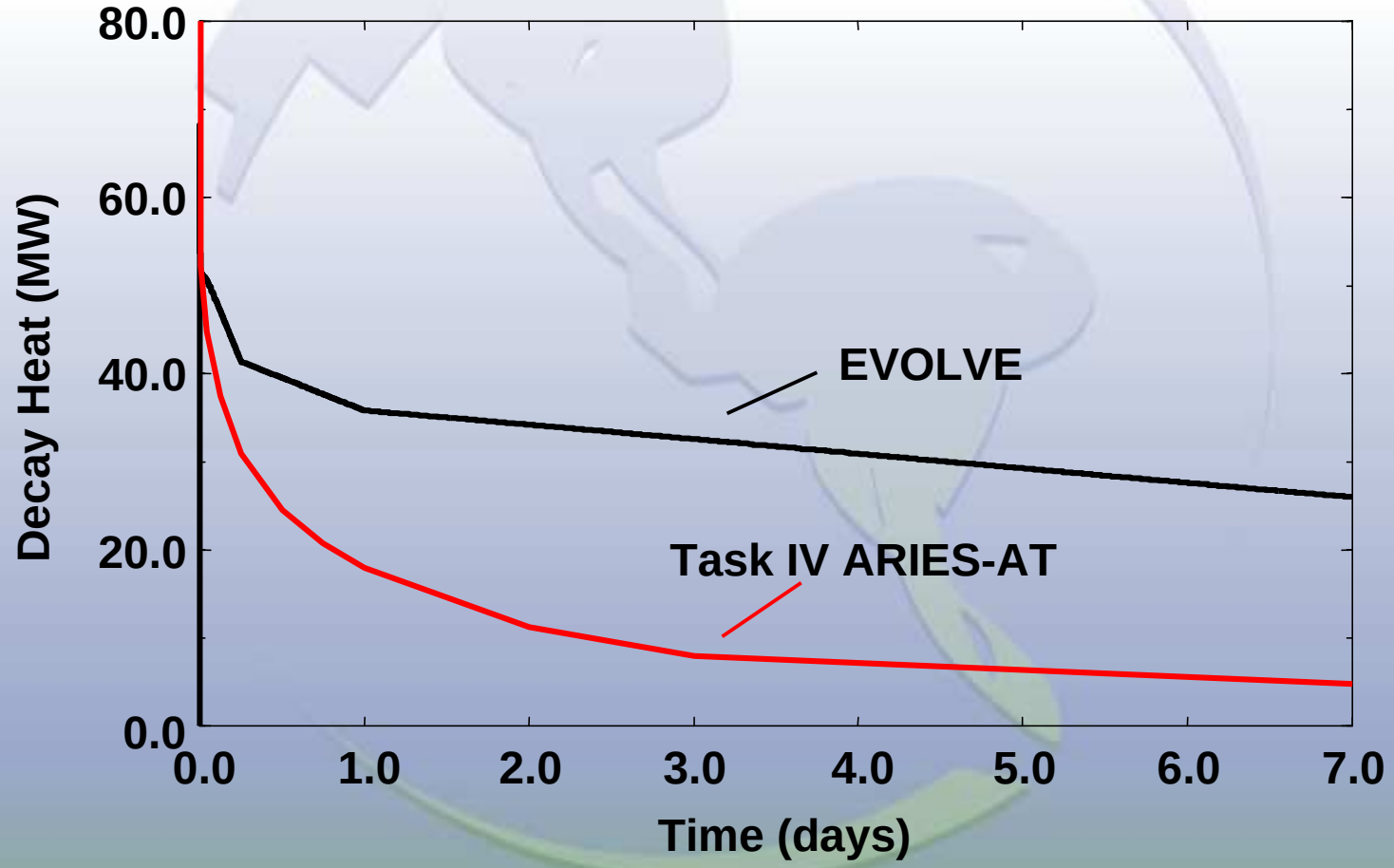
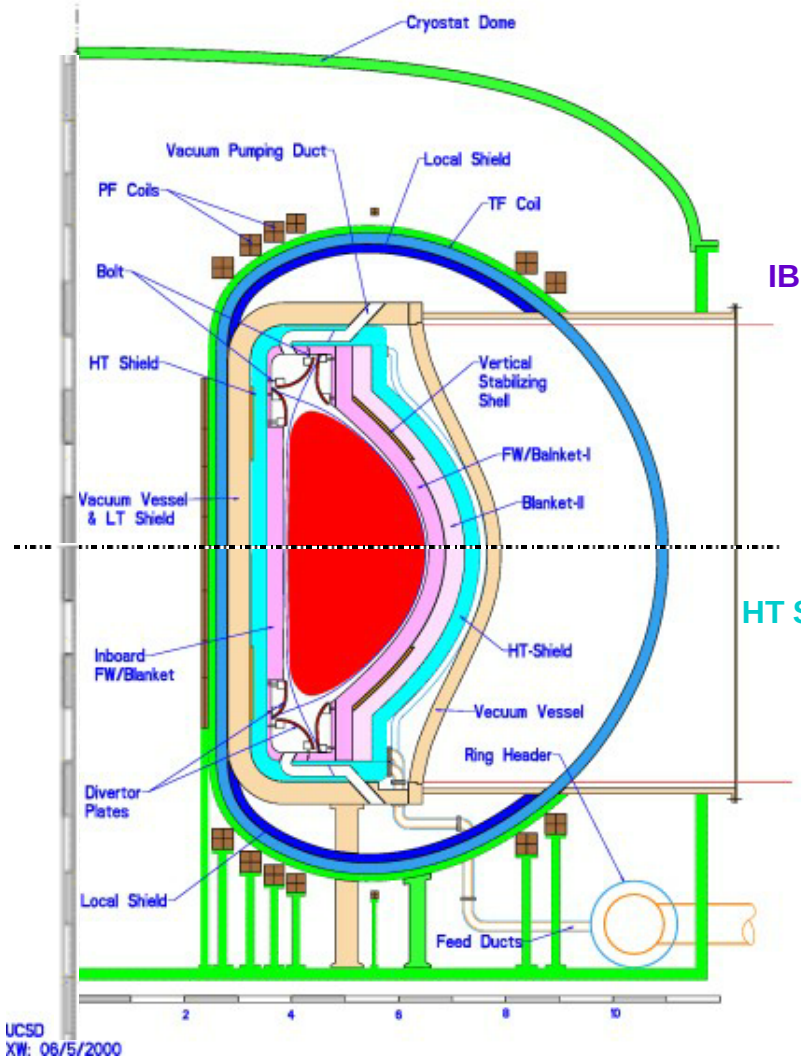
Introduction

- A preliminary safety assessment of the Task IV ARIES-AT FW/Blanket design has been completed
- Hesham Y. Khater performed the activation analysis with the DKR-PULSAR code (FENDL-2 activation cross section data) for 1 FPY operation at 10 MW/m^2 neutron wall loading
- Elsayed A. Mogahed performed decay heat-up calculations with ANSYS 5.5.1 finite element code for a loss-of-coolant accident (LOCA) and a loss-of-flow accident (LOFA)
- Information from both analyses was used to assess site boundary dose during two vacuum vessel (VV) bypass accident scenarios: loss-of-vacuum accident (LOVA) and an ex-vessel LOCA

Decay Heat Comparison



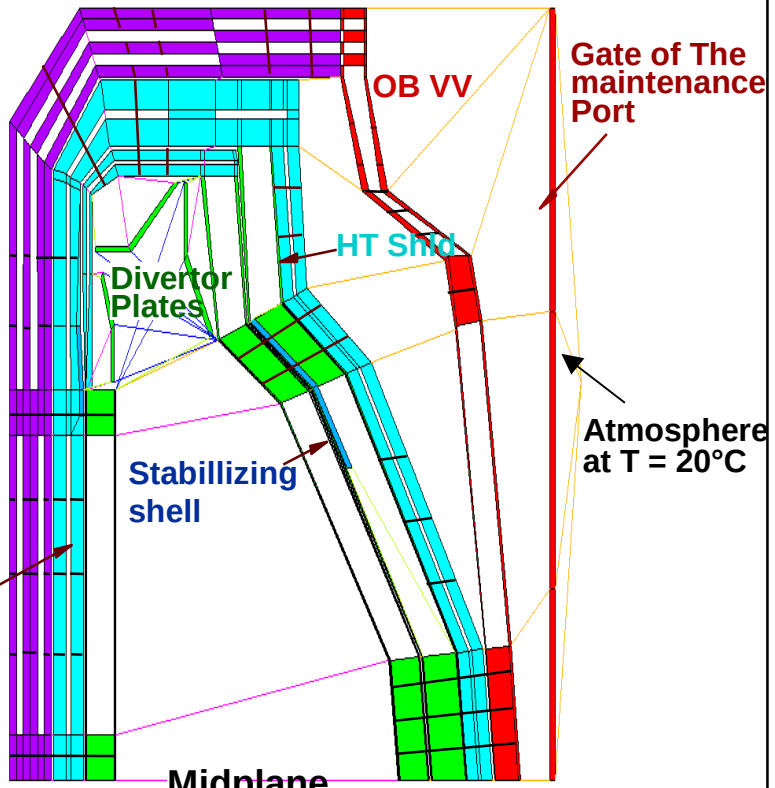
Cross Section of ARIES-AT Power Core Configuration



IB VV

HT Shld

Finite-Element Model



The Upper Half of the ARIES-AT Power Core is Considered

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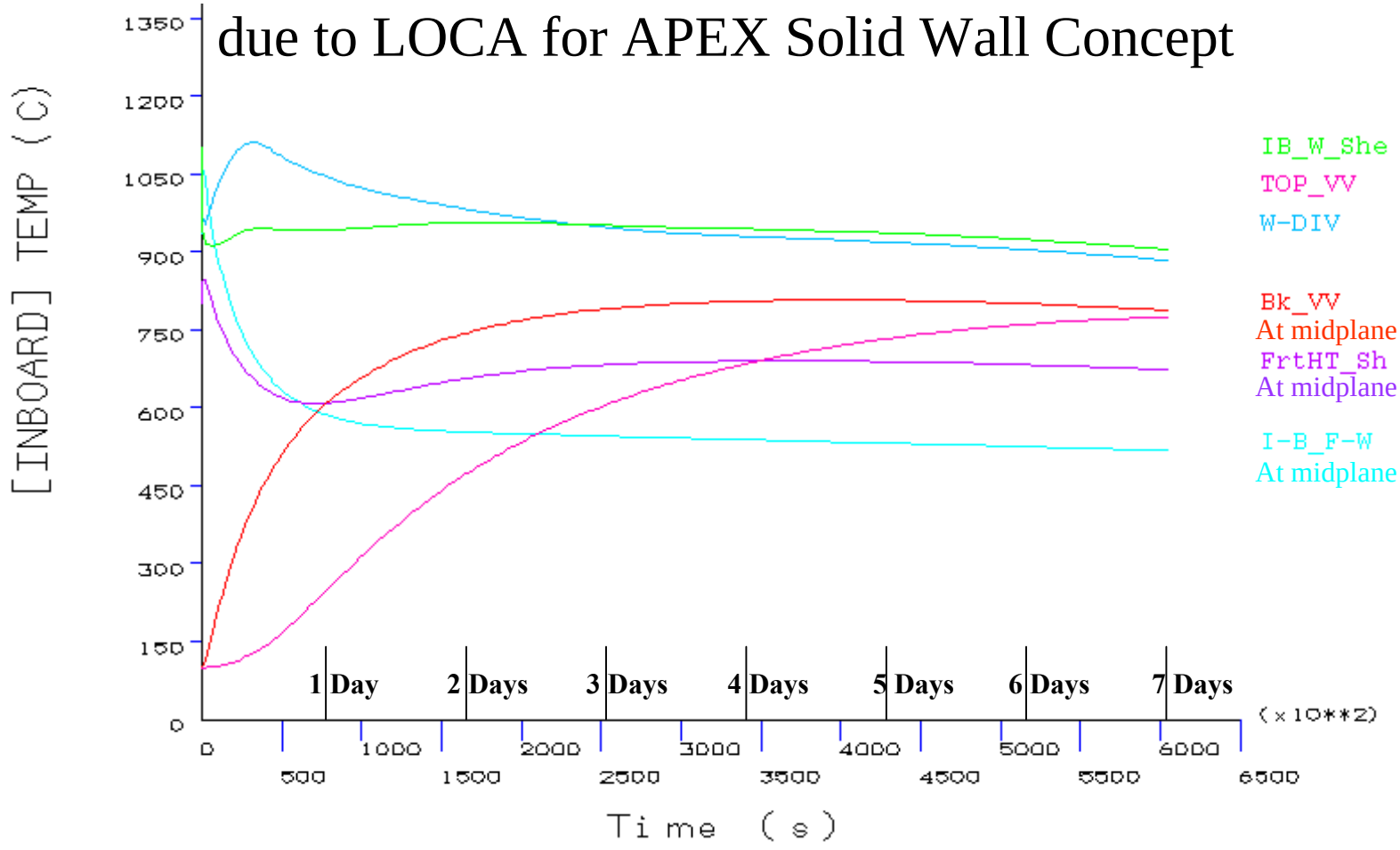
Inboard temperature history For One Week due to LOCA for APEX Solid Wall Concept



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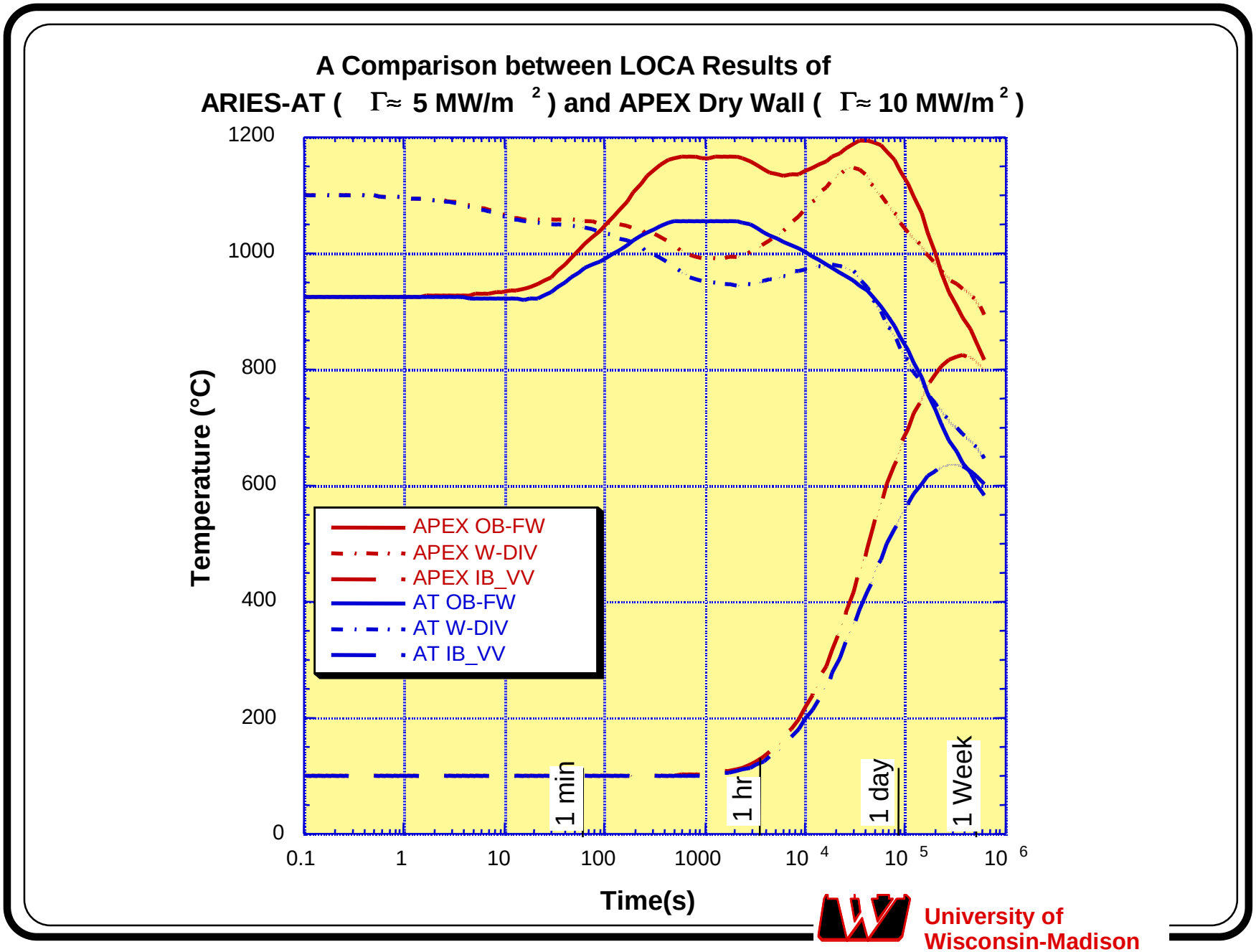

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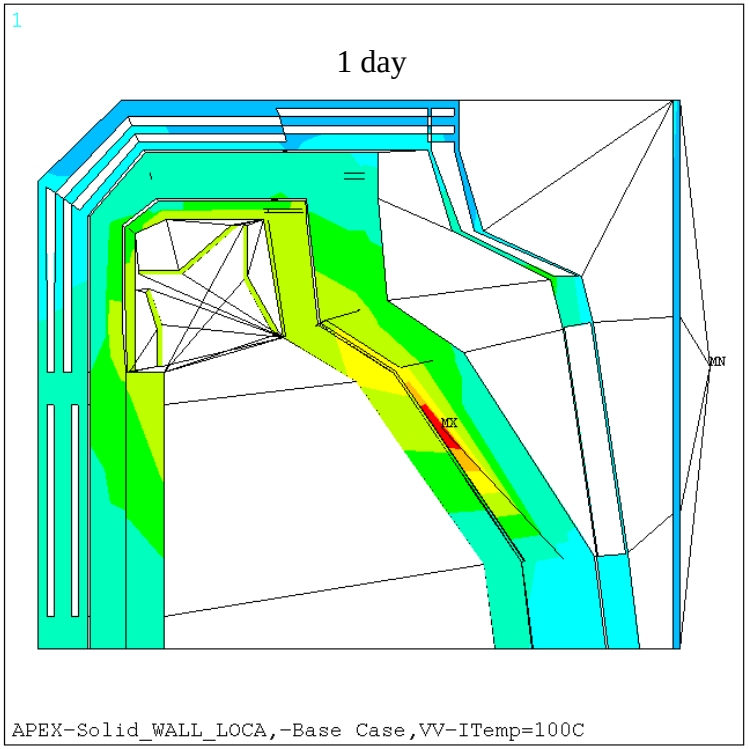
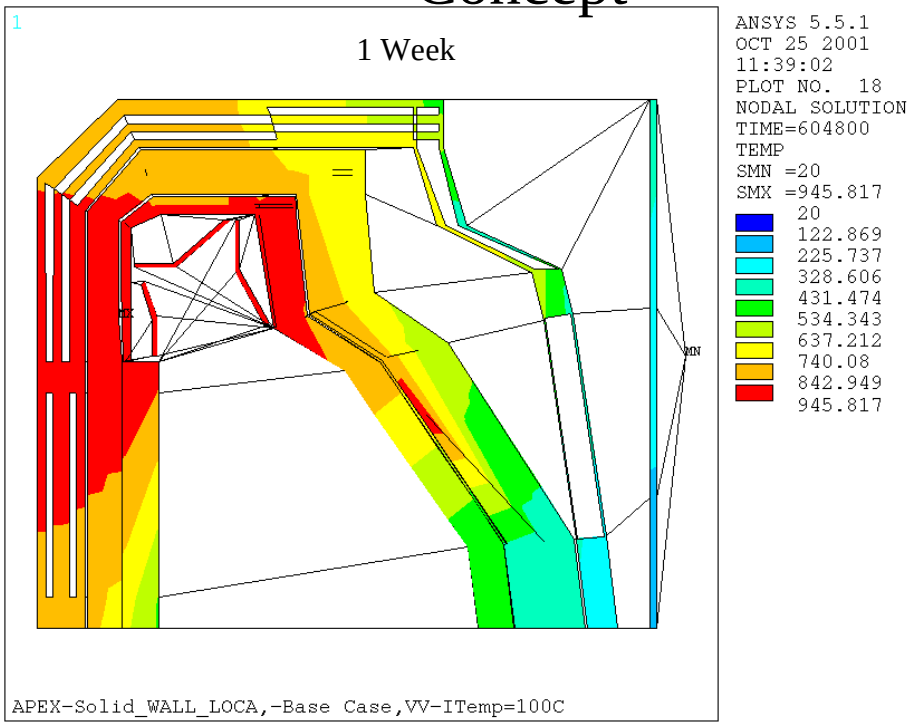
Temperature distribution

LOCA Analysis for APEX Dry Wall Concept





N. Wall Loading

10 MW/m2

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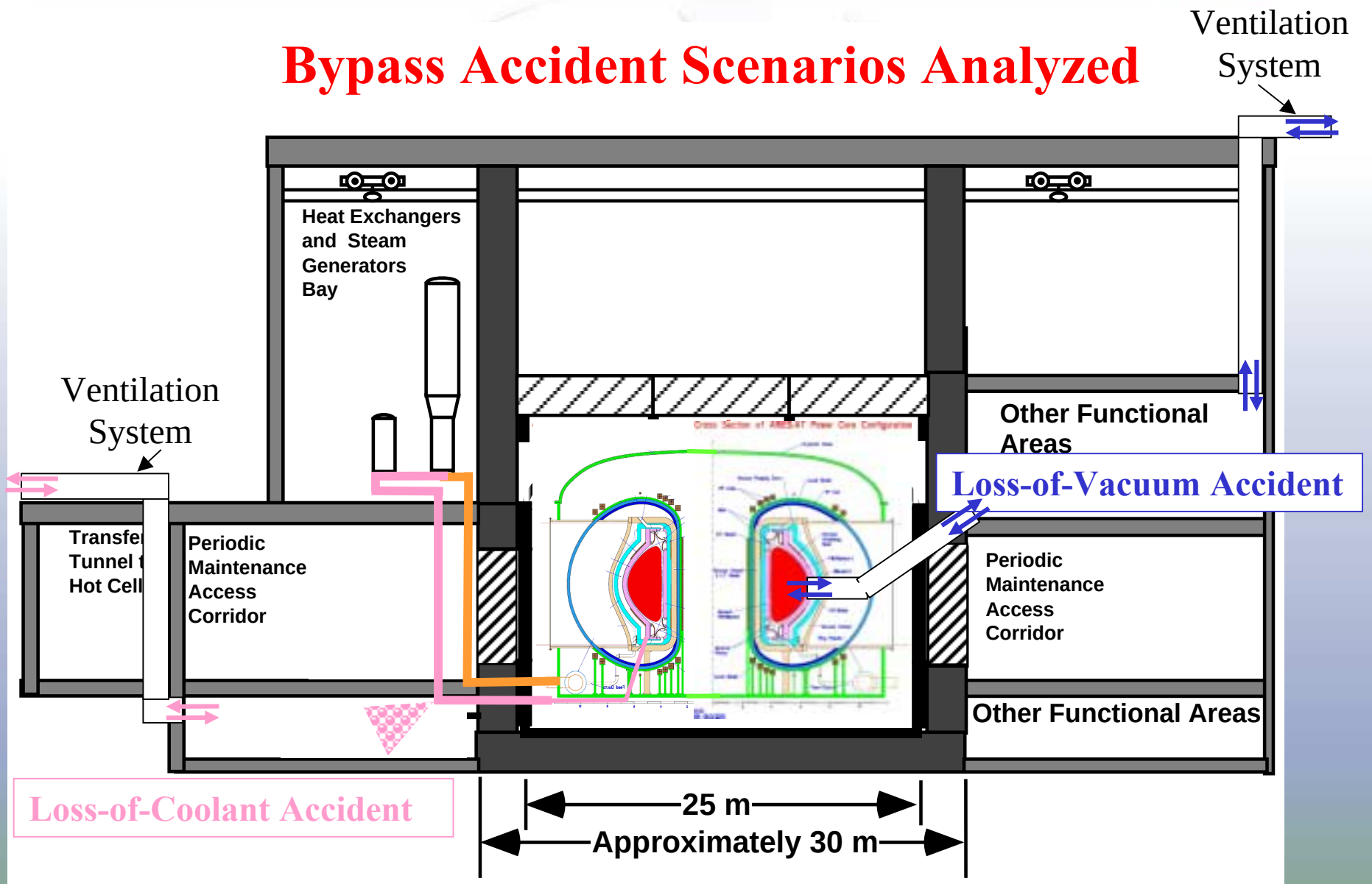
APEX Drywall Inventories and Allowable Releases

		Release Limit for 10 mSv at 1 km (worst case weather- F & 1m/s)	
Radionuclides	**Inventory**	**Ground Release**	**Elevated Release (100 m stack)**
Tritium as HTO	**180 g**	**15 g**	**130 g**
Activated W dust	**10-100 kg**	**300 g**	**3450 g**
Hg-203	**5100 Ci/m^3**	**2500 Ci (0.18 g)**	**25,000 Ci**
Po-210	**1380 Ci/m^3**	**2.5 Ci (0.03 g)**	**25 Ci**

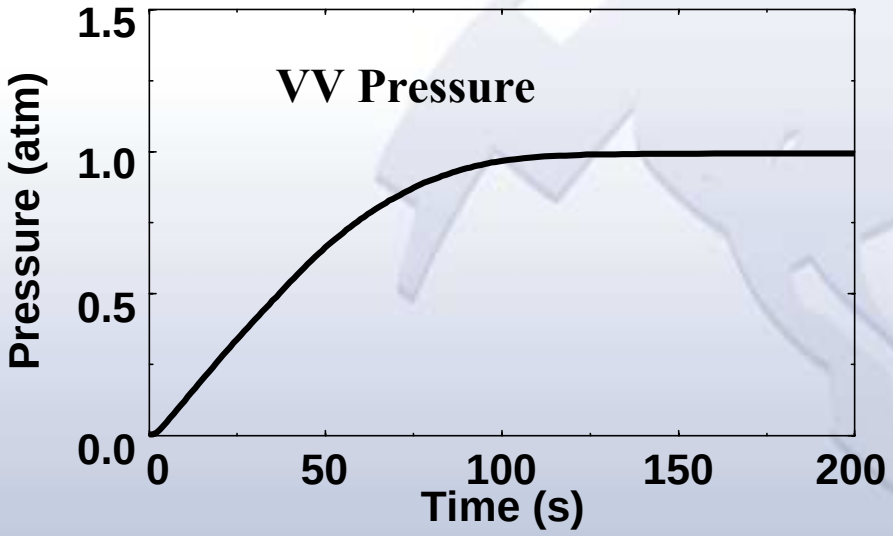
Two vacuum vessel bypass accident scenarios examined:

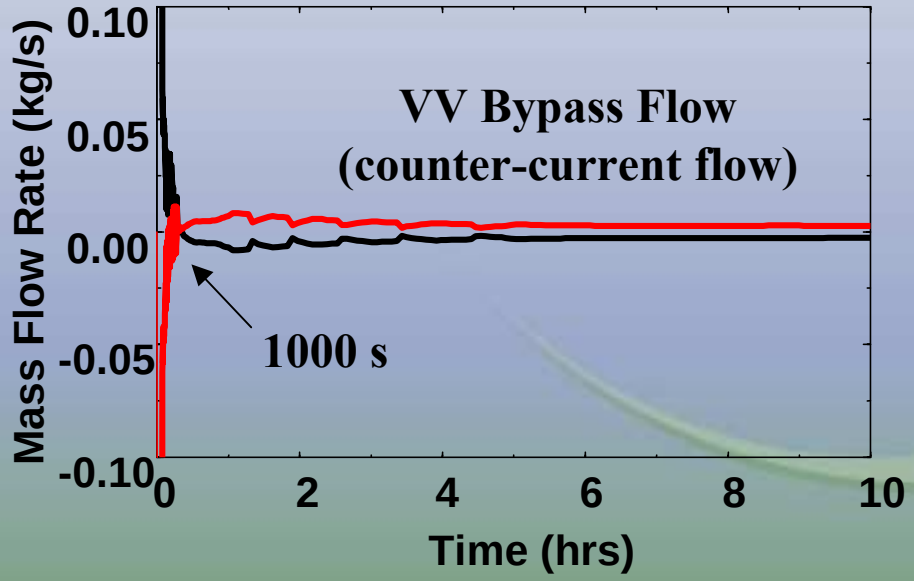
- **Complete-loss-of-power accident initiating a plasma disruption that fails VV creating loss-of-vacuum accident (LOVA)**
- **Ex-vessel loss-of-coolant accident (LOCA) creating a LiPb pool in a confinement building room**

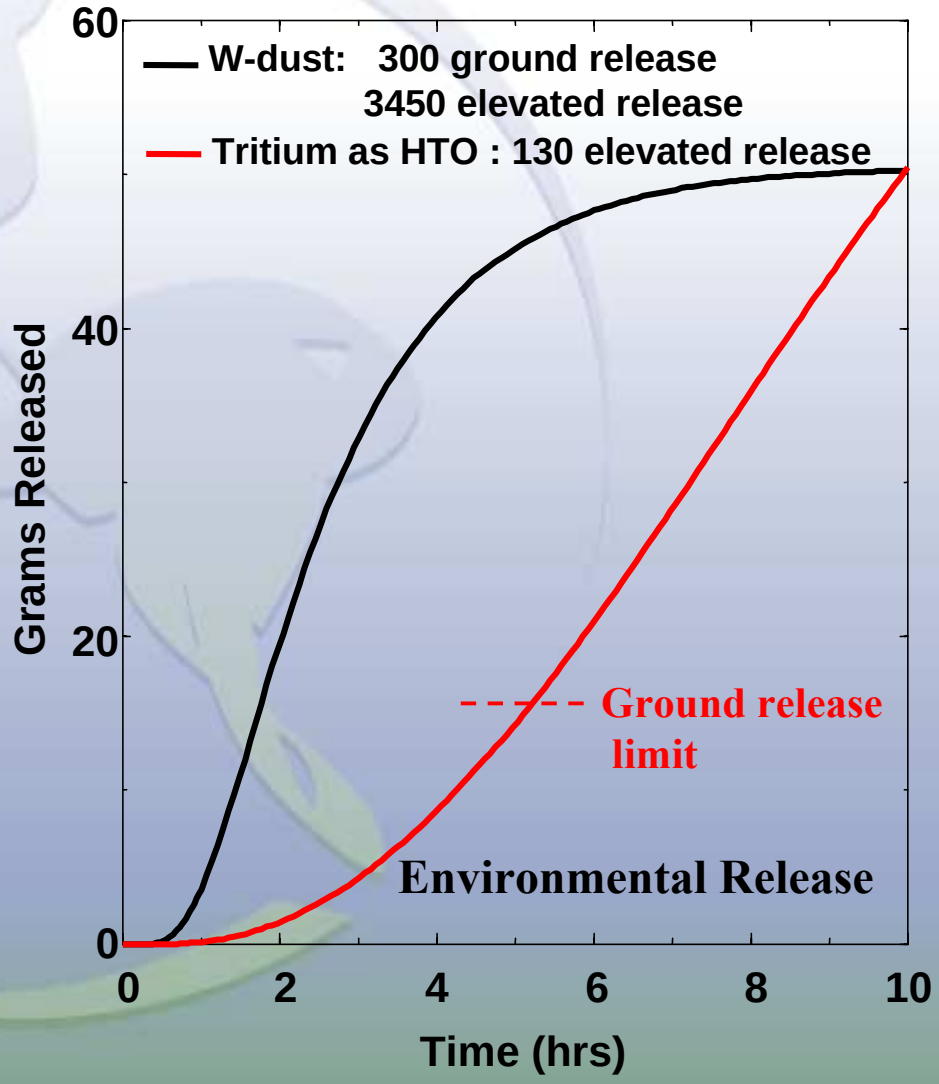
Bypass Accident Scenarios Analyzed



LOVA Bypass Accident Results







Ex-vessel LOCA Bypass Accident Results

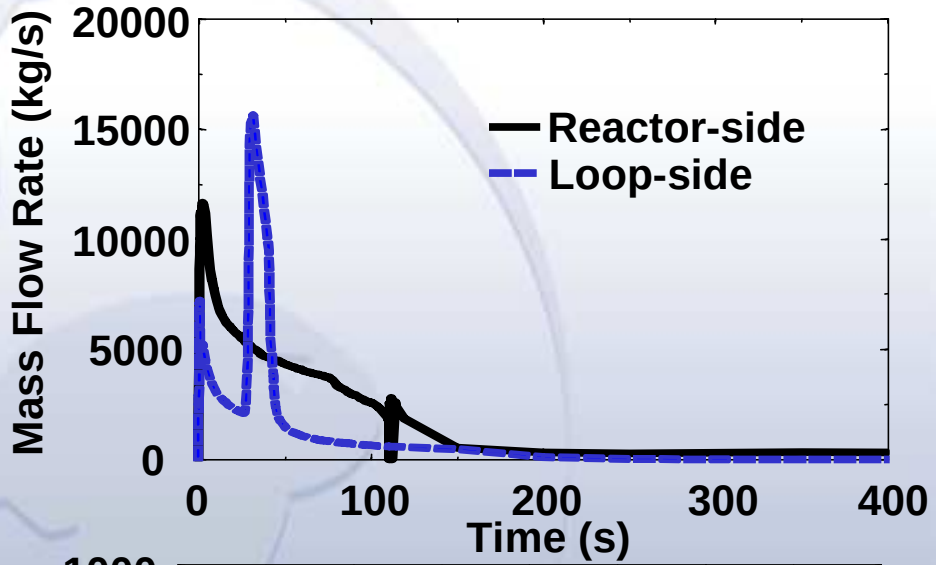
- Spill volume 125 m^3, surface area in lower function area (LFA) of 525 m^2
- Mobilization of Po-210 by surface evaporation of PbPo from Schipakin data (Psat(T) is vapor pressure of PbPo in mm of Hg, $y_{Po\text{-}210}$ is mole fraction)

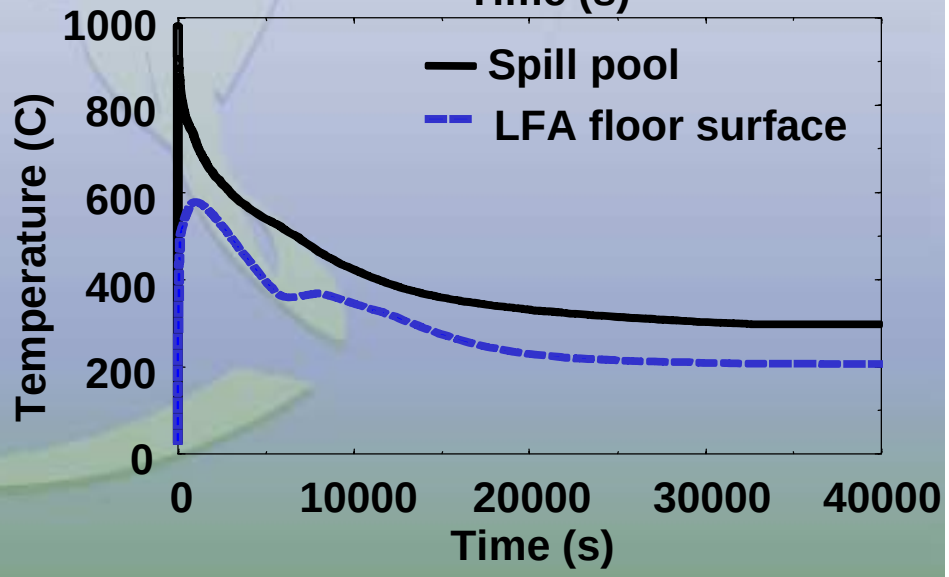
$$\Gamma(Ci/cm^2-hr) = y_{Po\text{-}210}\, 3.0 \times 10^5\, P_{sat}(T)\sqrt{1000/T}$$

- Mobilization of Hg-203 limited only by diffusion of Hg-203 to pool surface

$$\Gamma(\#/m^2\text{-}s) = -D_{Hg\text{-}203}\frac{\partial C_{Hg\text{-}203}}{\partial x}$$

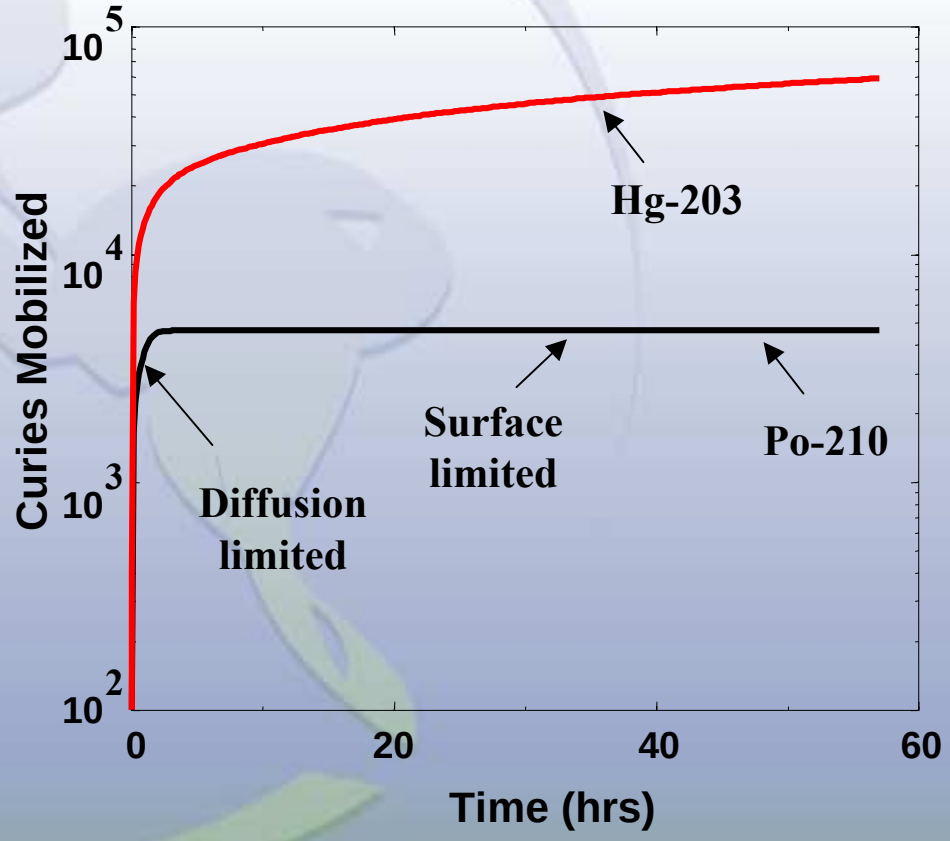
- Hg-203 surface concentration equals zero, Po-210 also limited by diffusion if surface evaporation is too large





Ex-vessel LOCA Bypass Accident Mobilization Results

- Hg-203 - confinement factors of 25 for ground release, 2.5 for elevated release or isolation in 1 hr, 5.5 hrs respectively
- Po-210 - confinement factors of 1650 for ground release, 165 for elevated release, or immediate isolation
- Online Po-210 cleanup from 30 PPB to 0.018 PPB (< 1 Ci/m^3)
- Online Hg-203 cleanup from 37 PPB to 1.5 PPB



Summary & Conclusions

- **Maximum temperatures are:**

Accident	IB-VV SS	IB-FW SiC	OB-FW SiC	Div W
LOCA	824	1063	1153	1148
LOFA	847	1083	1194	1100

- **Only concern may possibly be VV, but SS temperatures are less than ITER allowable ($0.7 \times T_{melt} = 960°C$)**
- **In-vessel inventory release (HTO, W dust) are not a concern regarding ground level release limit if isolation occurs within 5 hrs**
- **Ex-vessel inventory release (Po-210, Hg-203) is a concern and online cleanup (if possible) of isotopes should solve problem**