

MELCOR accident analysis for ARIES-ACT

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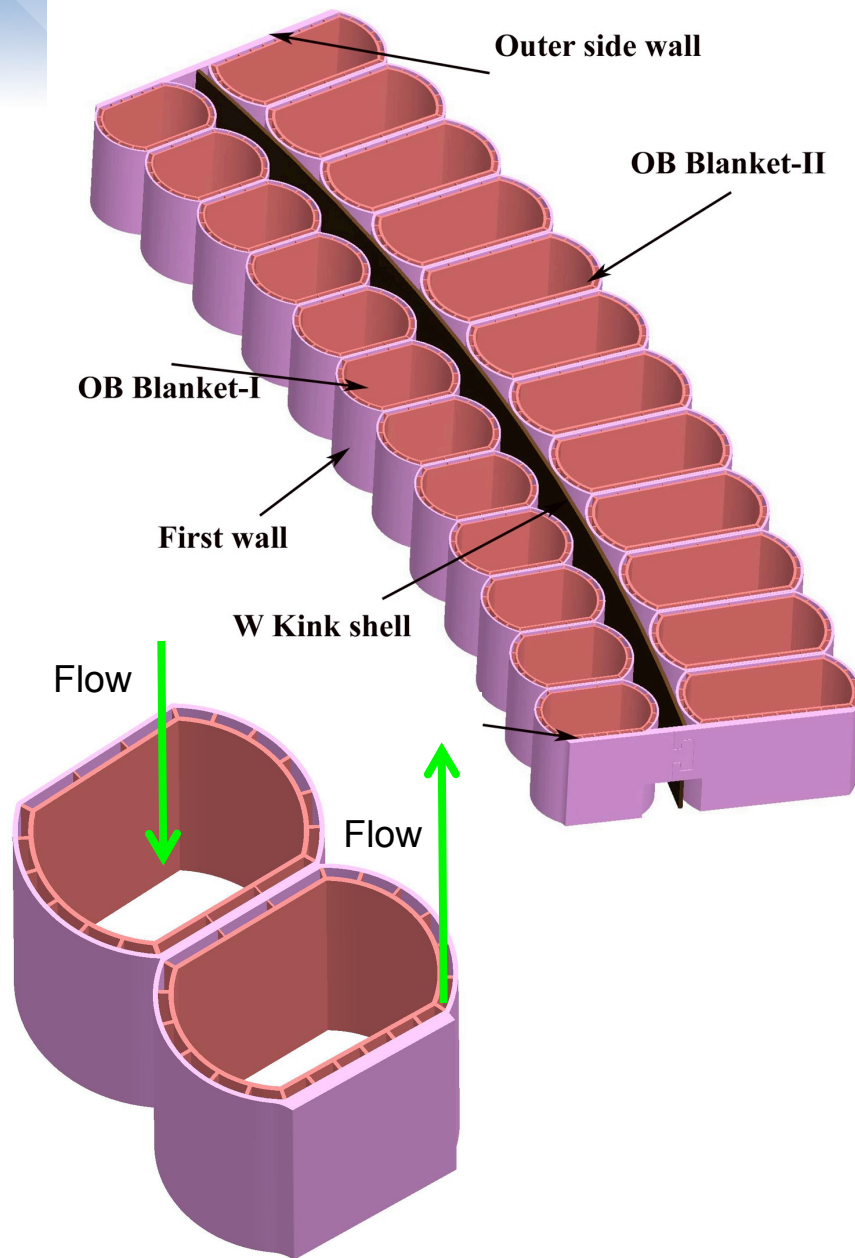
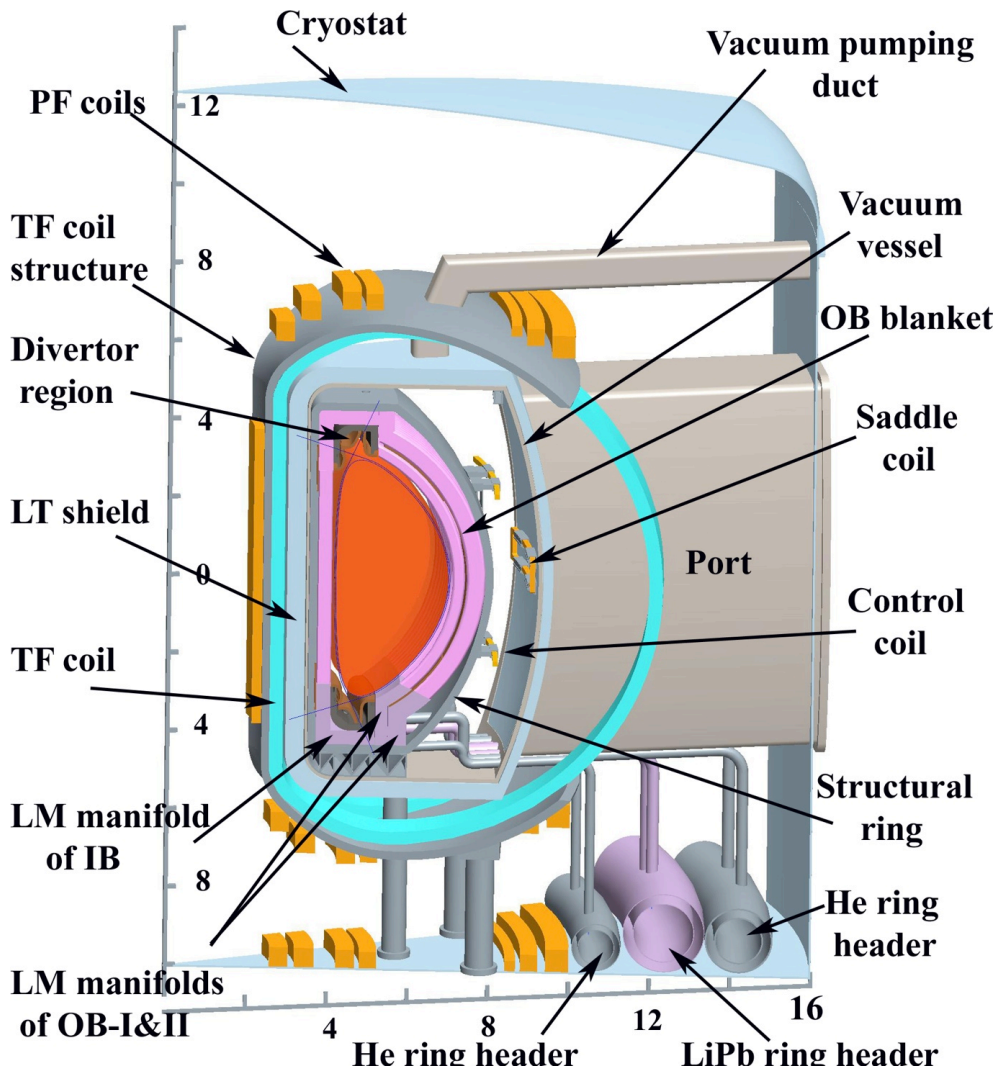
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ARIES-ACT

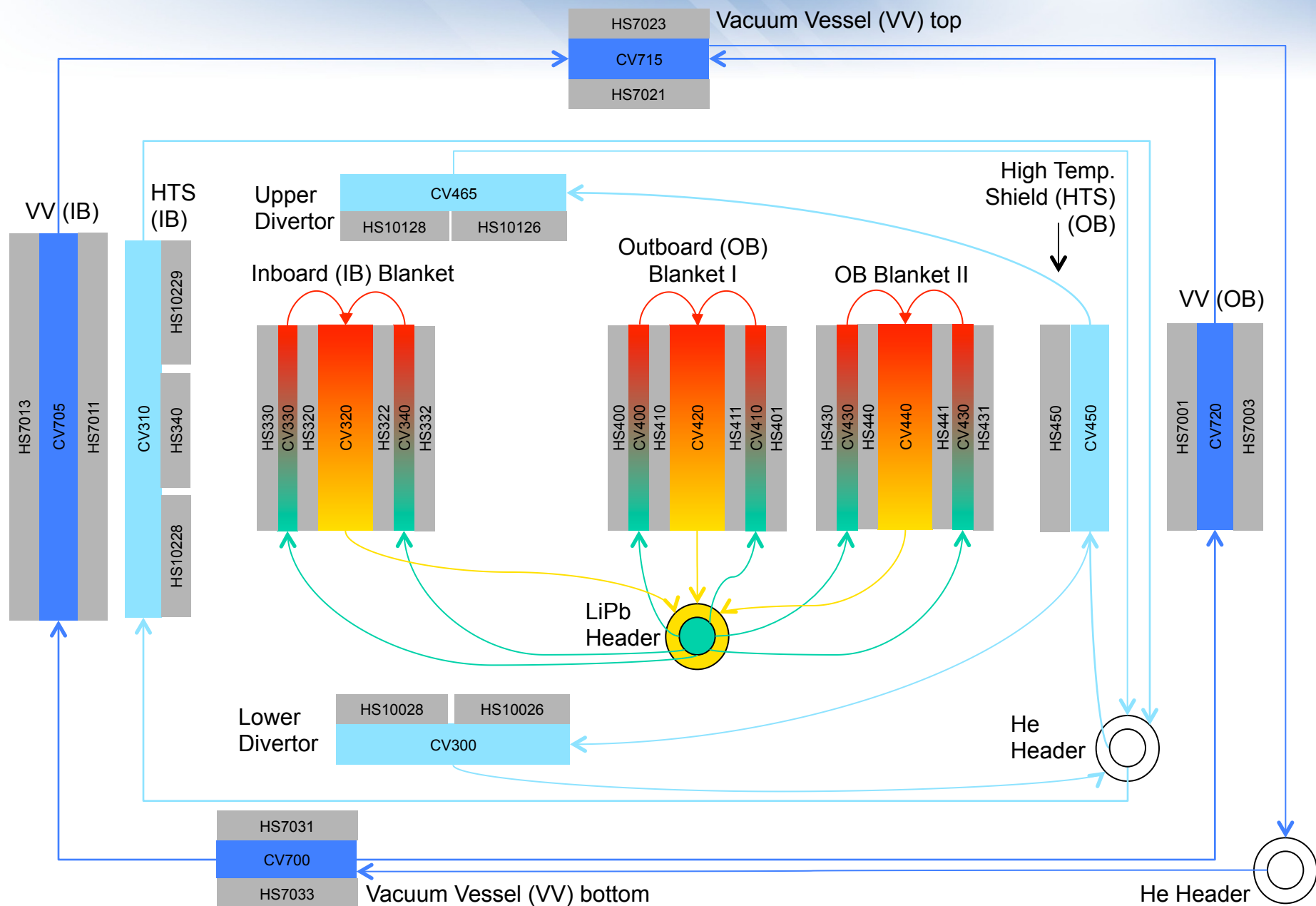
- The ARIES design analyzed here is one of four planned ARIES-ACT design points
- It features LiPb cooled, SiC blankets (1 inboard and 2 outboard)
- In contrast with previous ARIES designs (e.g. ARIES-AT) it has a high temperature shield and divertors that are cooled by helium
- Previous ARIES vacuum vessel designs were water cooled and as such had a dual purpose as vacuum vessel and shield for the magnets
- A desire to avoid large amounts of tritiated water in the VV due to permeation at high temperature has split these functions in the present design:
 - A thin walled, He-cooled vacuum vessel that runs hot (400-500 °C)
 - A low (~room) temperature water cooled shield outside the VV
 - This component is not intended to take pressure or vacuum stresses
- Ultimate decay heat removal in an accident is removed via natural circulation in the water loop, which runs to the roof of the building and exchanges heat with the atmosphere

ACT-1 Schematics



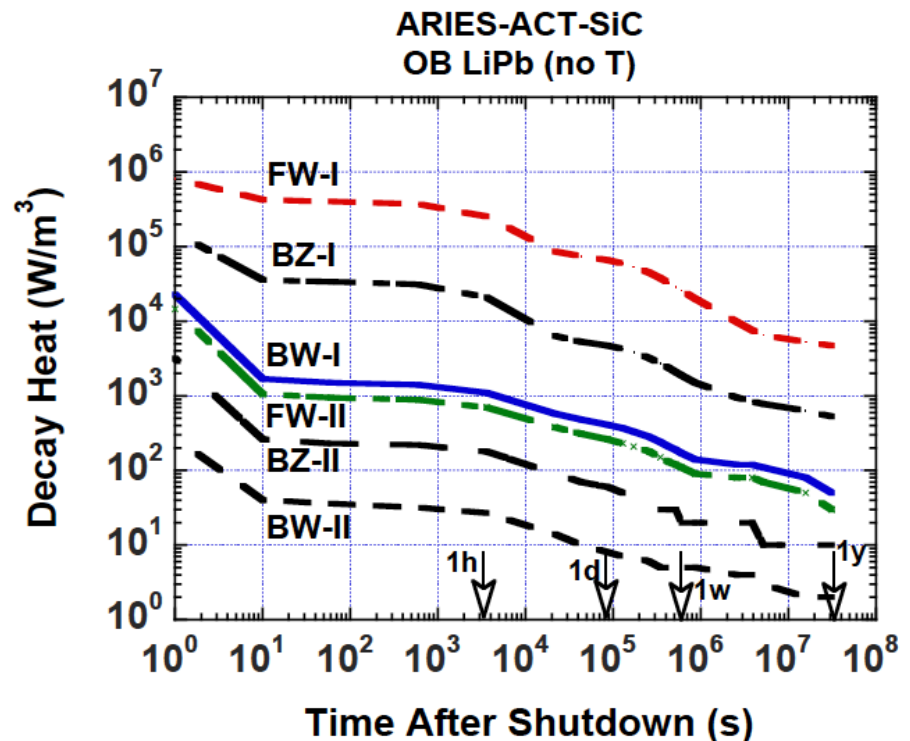
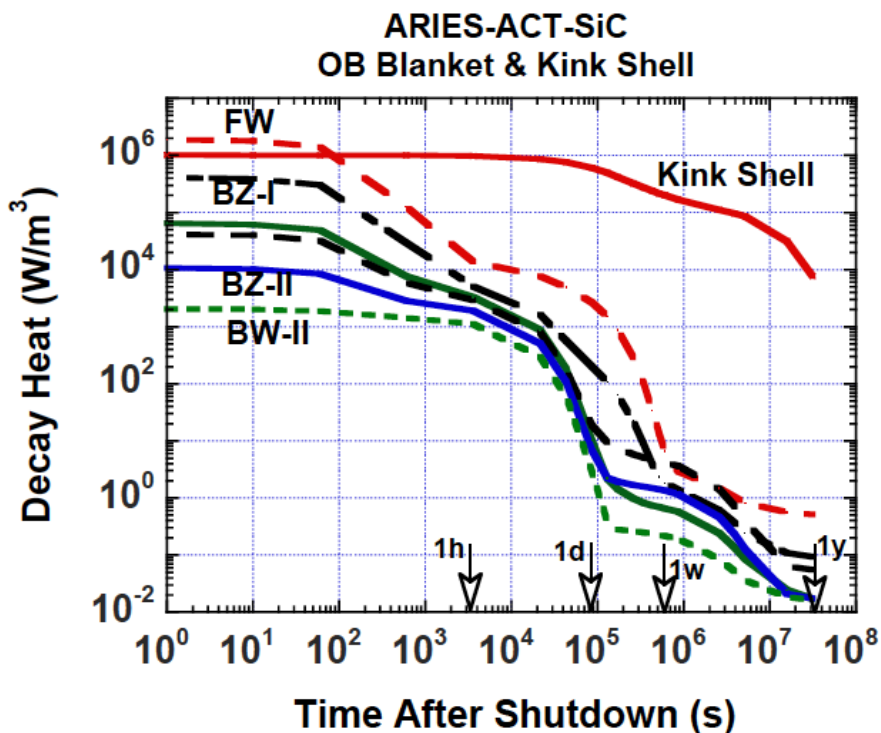
MELCOR Model of ARIES-ACT

- MELCOR is a code originally designed to model severe accident progression in water-cooled fission reactors
- INL has modified it for fusion; MELCOR 1.8.5 for fusion has the unique capability of using multi-phase fluids other than water
 - However, it cannot use *different* working fluids within the same input model
 - Because we need PbLi, He, and H₂O for ARIES-ACT, we employed a scripted coupling of two different models running concurrently: one modeling the LiPb and He loops, the other modeling H₂O
 - They pass heat flux and temperature information between each other
- We have chosen to analyze a loss of flow accident (LOFA) caused by a complete loss of site power (or long term station blackout), in which only natural convection in the water cooled shield provides decay heat removal
 - The low-temperature (water-cooled) shield is covered with superinsulation, which we treat as an adiabatic boundary (conservative)
- The following slide shows portions of the actual MELCOR model schematic; note that it excludes the low temperature water-cooled shield



Accident initiation

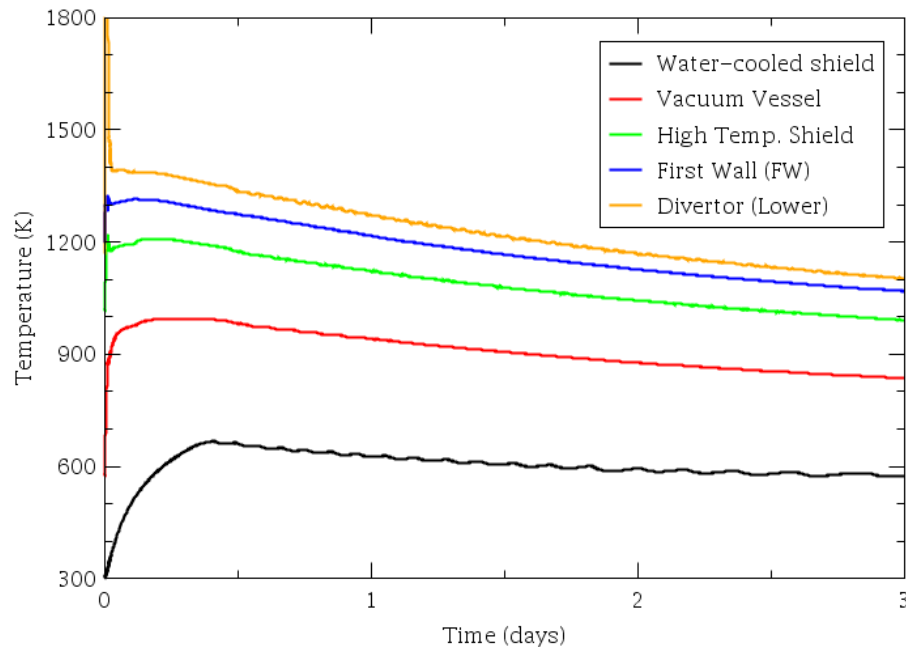
- Beginning from steady state, operational conditions, power is terminated and only decay heat remains
- Decay heat is based on 1-D activation analysis (see Dr. El-Guebaly's paper in session OS13), and is given for each component as a function of time:



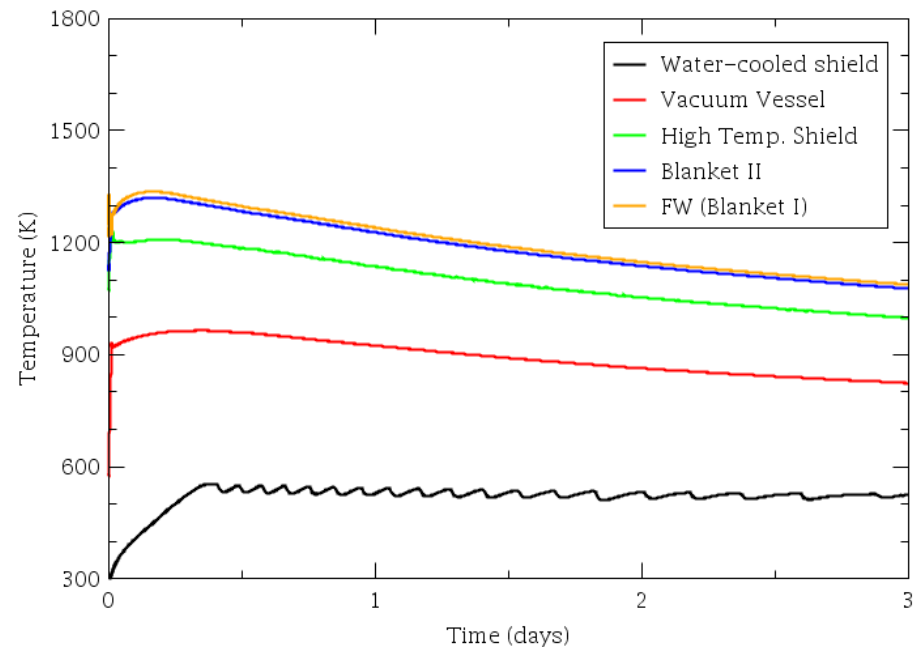
Structure temperatures during LOFA

- Divertor, first wall, and high temperature shield temperatures essentially decrease throughout accident
- Vacuum vessel and low temperature shield temperatures increase for ~0.5 days, then slowly decrease
 - Low temperature shield oscillates due to water boiling

Inboard Structures
and Divertor



Outboard Structures



Conclusions and Future Work

- ARIES-ACT is able to withstand a loss of flow accident
 - Natural convection in the water loop of the low temperature shield is able to transfer adequate heat to the environment to cool the system via a heat exchanger on the roof of the building
 - Boiling of water occurs in the low temperature shield; consideration of resulting stresses on this structure from increased water pressure (which is otherwise not intended to be a pressure vessel) may be necessary
- Some other accident scenarios will be considered
 - Loss of water coolant
 - The heat exchanger in this system is the link to the ultimate heat sink
 - Loss of this water may require use of gas injection to the cryostat
 - This will need to overcome the barrier to heat transfer provided by superinsulation even in the absence of vacuum
 - Possibly an in-vessel break that results in pressure relief to the cryostat to show that this confinement boundary does not breach