



U.S. NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

**RIC2010
MELCOR DEVELOPMENT ACTIVITIES
AND RECENT APPLICATIONS**

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USNRC

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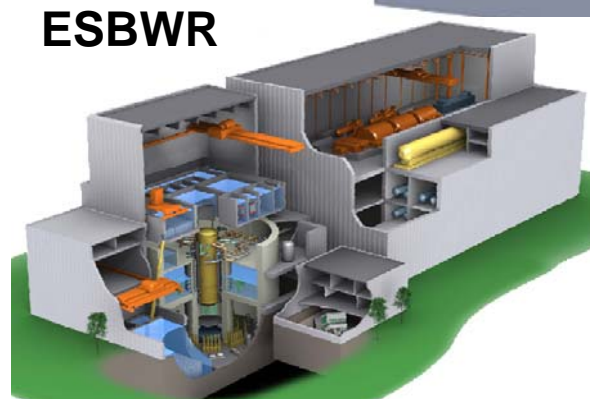
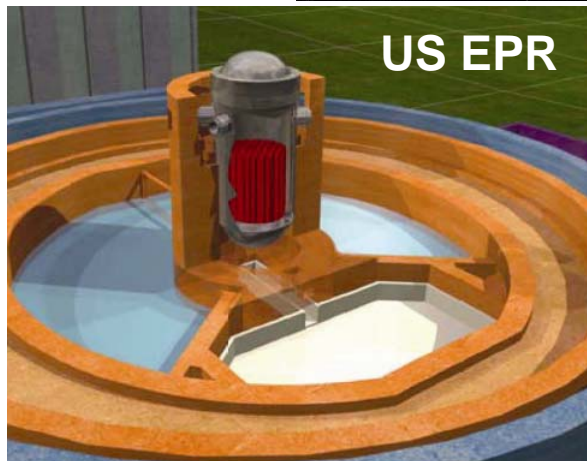
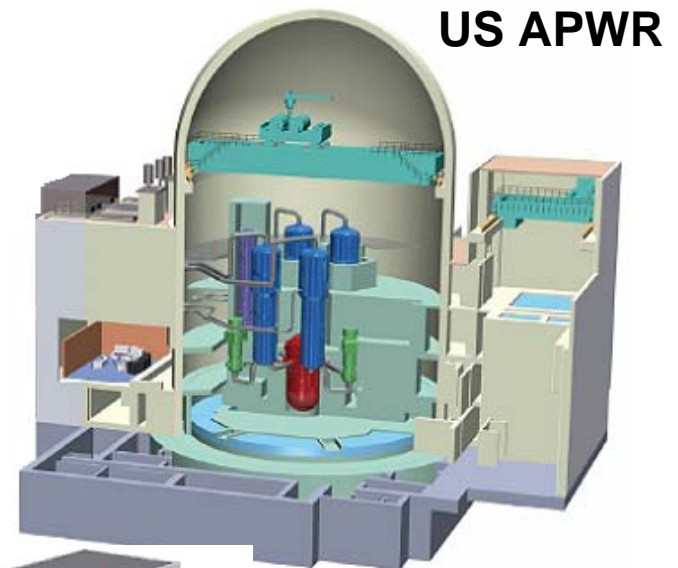
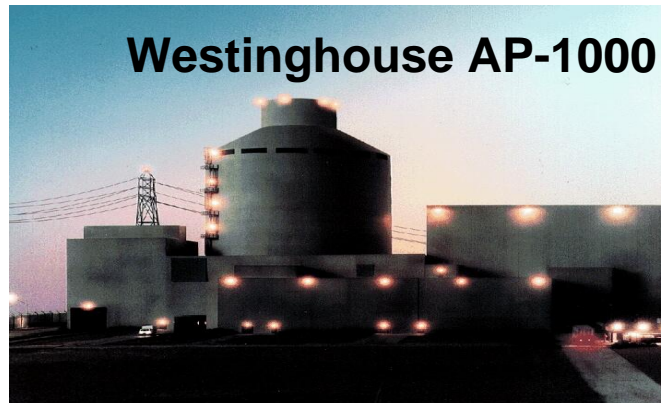


OUTLINE

- Application of MELCOR to Design Certification for New Reactors
- Development of MELCOR Fission Product Release Models for Gas Cooled Reactors
- Application of MELCOR to Evaluation of System Success Criteria
- Development and Application of MELCOR Accident Simulation Using SNAP

Design Certification

- Severe accident response and source term
- Containment response to design basis accident



Design Certification

ESBWR Long Term Cooling

First 3 days (Passive Period)

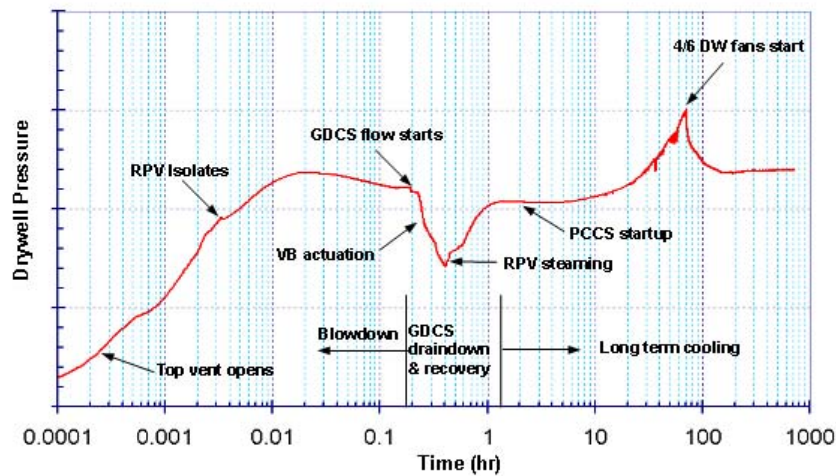
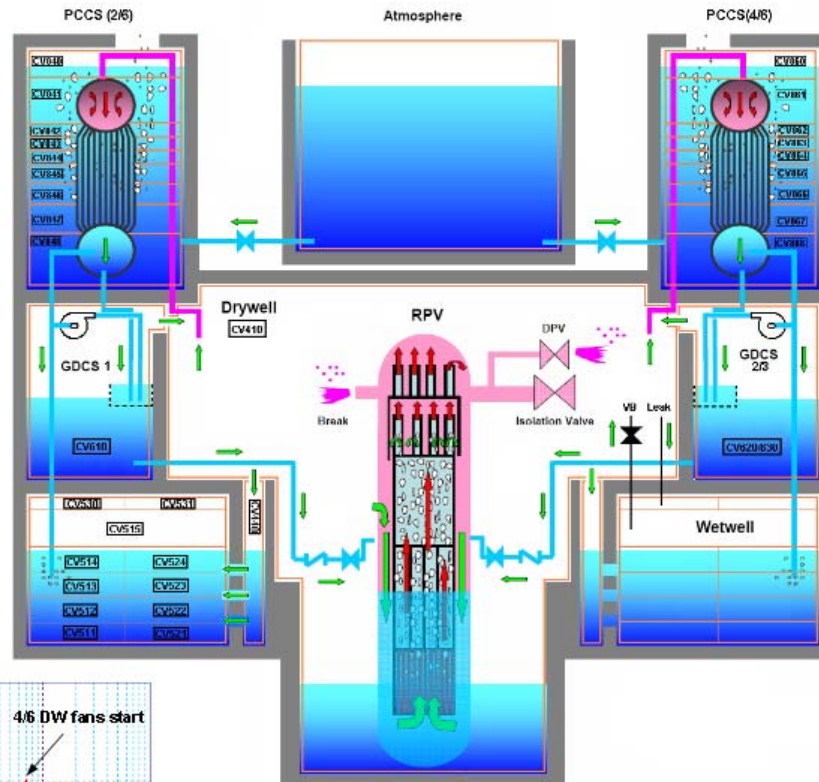
Dominant phenomena include core radiolysis causing PCCS non-condensable gas bounding and bypass leakage of steam from drywell to wetwell

Post 3 days (Intervention Period)

Drywell recirculation fans

PCCS pool refill

PARs credited



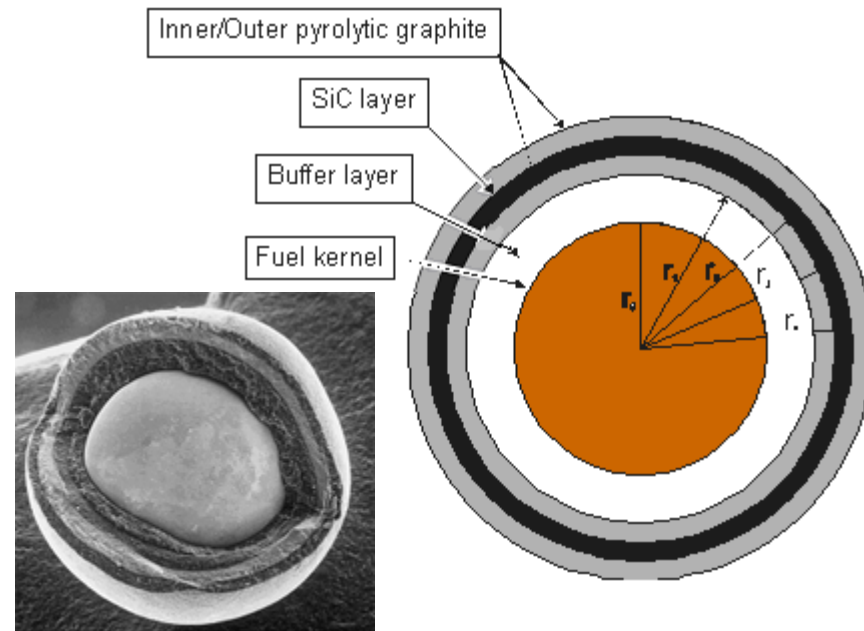


HTGR FP Release

- Develop HTGR specific fission product release and transport models for MELCOR
 - Use existing MELCOR models for fission product transport and deposition in the primary system and containment
 - Implement diffusional release models for both intact and failed TRISO fuel particles
 - Implement diffusional release model for matrix and graphite block
 - Applicable to both pebble bed and prismatic designs
 - Calculate releases for both normal operation and accident conditions
- Basic approach similar to LWRs
 - Code used for independent confirmatory (audit) calculations

TRISO Particle FP Release

- FP release from kernel involves both diffusion and recoil
- For failed particles, release from kernel
- For intact particles, release is controlled by SiC layer



$$\frac{\partial C}{\partial t} = \frac{1}{r^2} \frac{\partial}{\partial r} \left(r^2 D \frac{\partial C}{\partial r} \right) - \lambda C + \beta$$

$$\frac{\partial C}{\partial r} = 0; (r = 0)$$

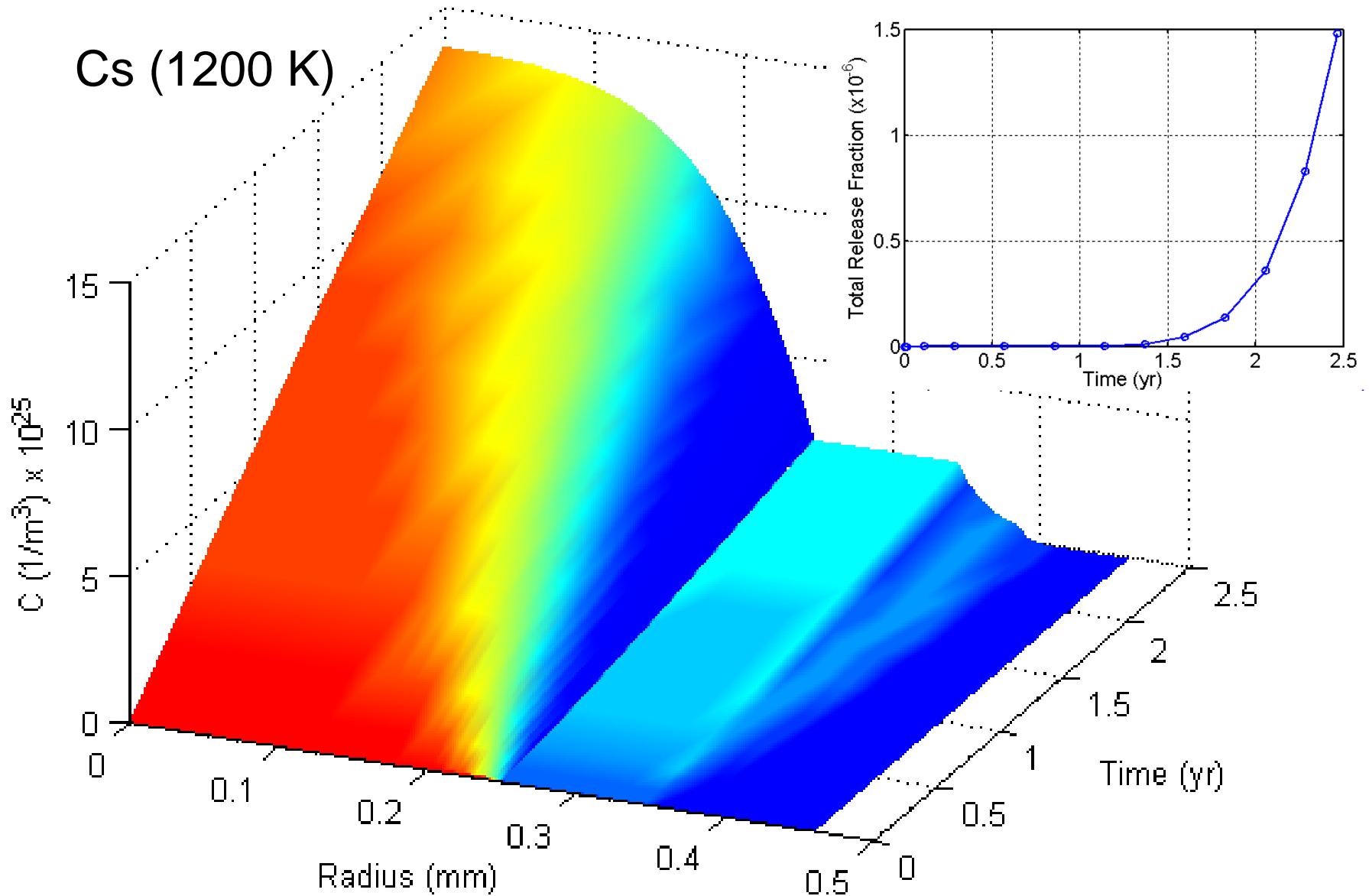
$$C = 0; (r = R)$$

C = Concentration ($1/m^3$)
 D = Diffusion coefficient (m^2/s)
 λ = Decay constant ($1/s$)
 β = Generation rate ($1/m^3 \cdot s$)

Kernel generation \sim yield x power
 Buffer generation due to recoil \propto kernel generation

Intact TRISO Particles

Cs (1200 K)





MELCOR Steady State

- Perform “Accelerated” Steady State Run with MELCOR to Get FP and Dust Distribution in the System
 - Dust and FP release during normal operation
 - Use existing models in MELCOR for FP transport and deposition on surfaces
 - Need to be run long enough to establish trends and/or equilibrium
 - Scale to desired operating time
 - Use as initial condition for accident analysis



Success Criteria Application

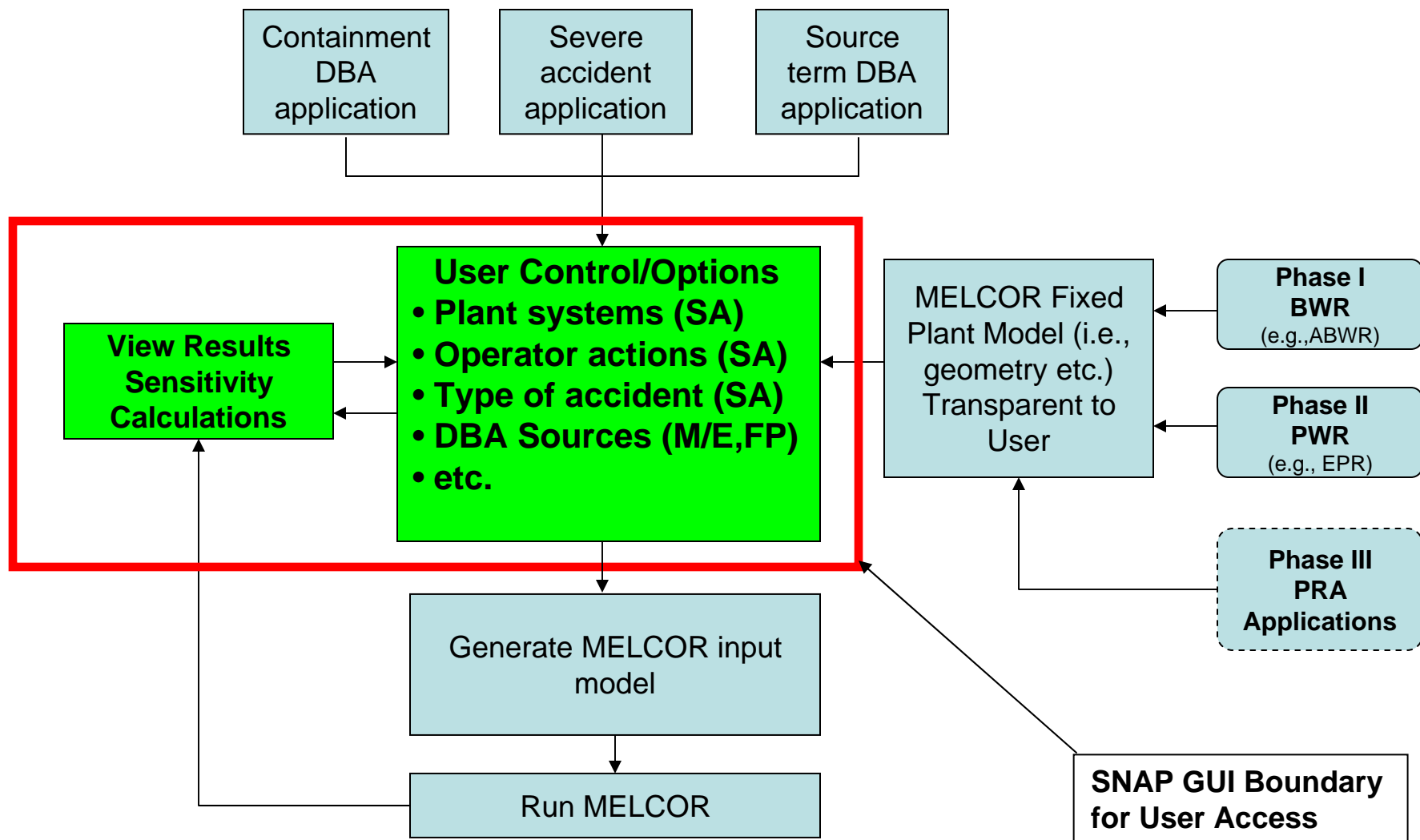
- Application of MELCOR to update basis for PRA treatment of specific operator timing and mitigation system effectiveness issues of interest
- Detailed SOARCA MELCOR 1.8.6 models for Surry and Peach Bottom used
- Many calculations intentionally assume minimal operator action and are allowed to proceed to core damage to:
 - Establish minimal equipment configurations
 - Establish timings for human error probability (HEP) evaluations
 - Establish time window for AC power recovery
- For the above reason, many results do not correspond to the best-estimate integrated plant response to a given initiator; they do correspond to the best-estimate simulation given the prescribed boundary conditions



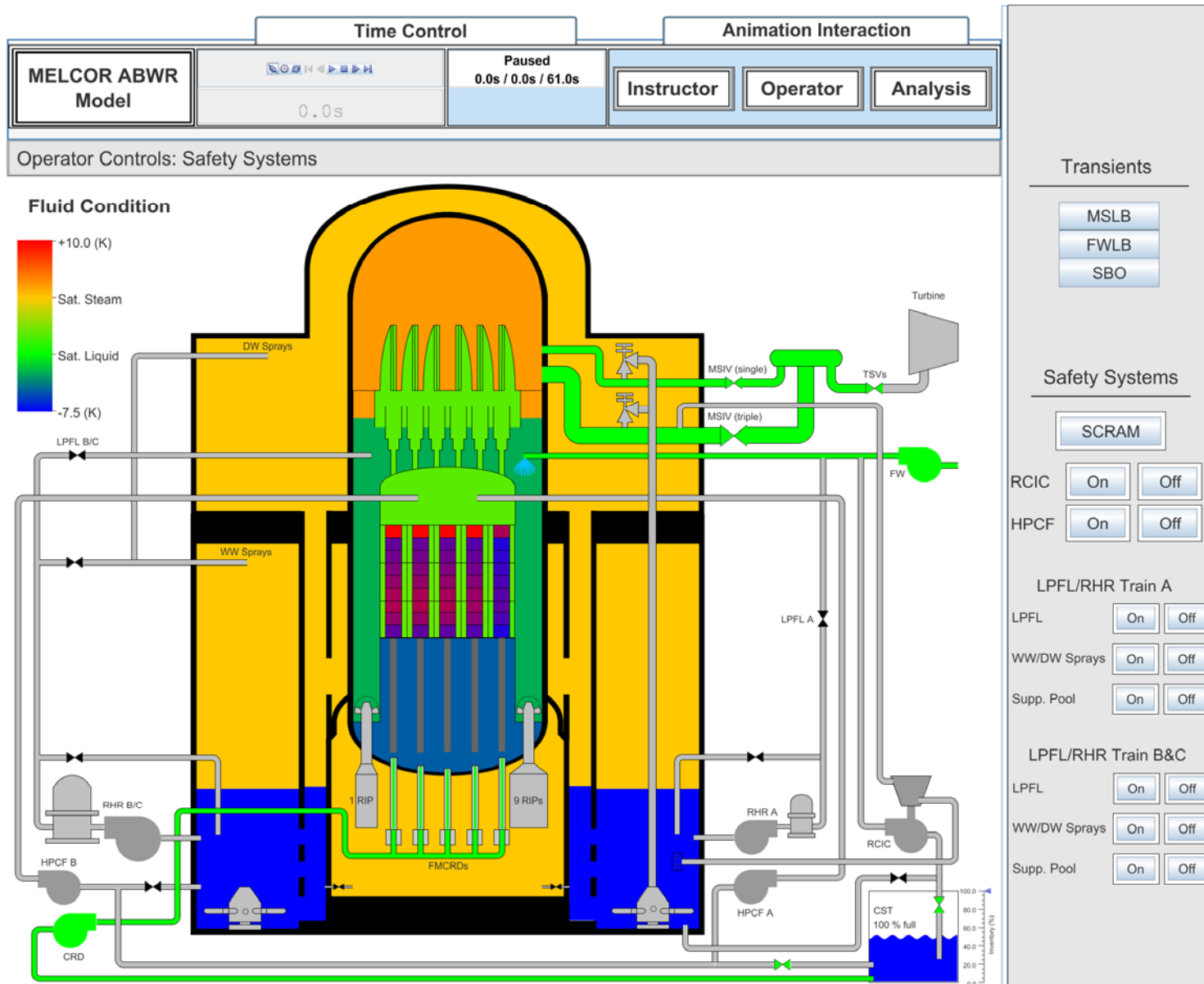
Success Criteria Application

- Results are documented in an August 2009 report available in the NRC's Agencywide Document Accession and Management System (ADAMS) at accession number ML091890792
- Additional analysis and documentation enhancement planned
- Work commenced at Sandia National Labs to look at additional aspects (e.g., core damage surrogates)
- Extension to other plants planned (e.g., 4-loop large, dry)
- Possible future information exchanges with industry

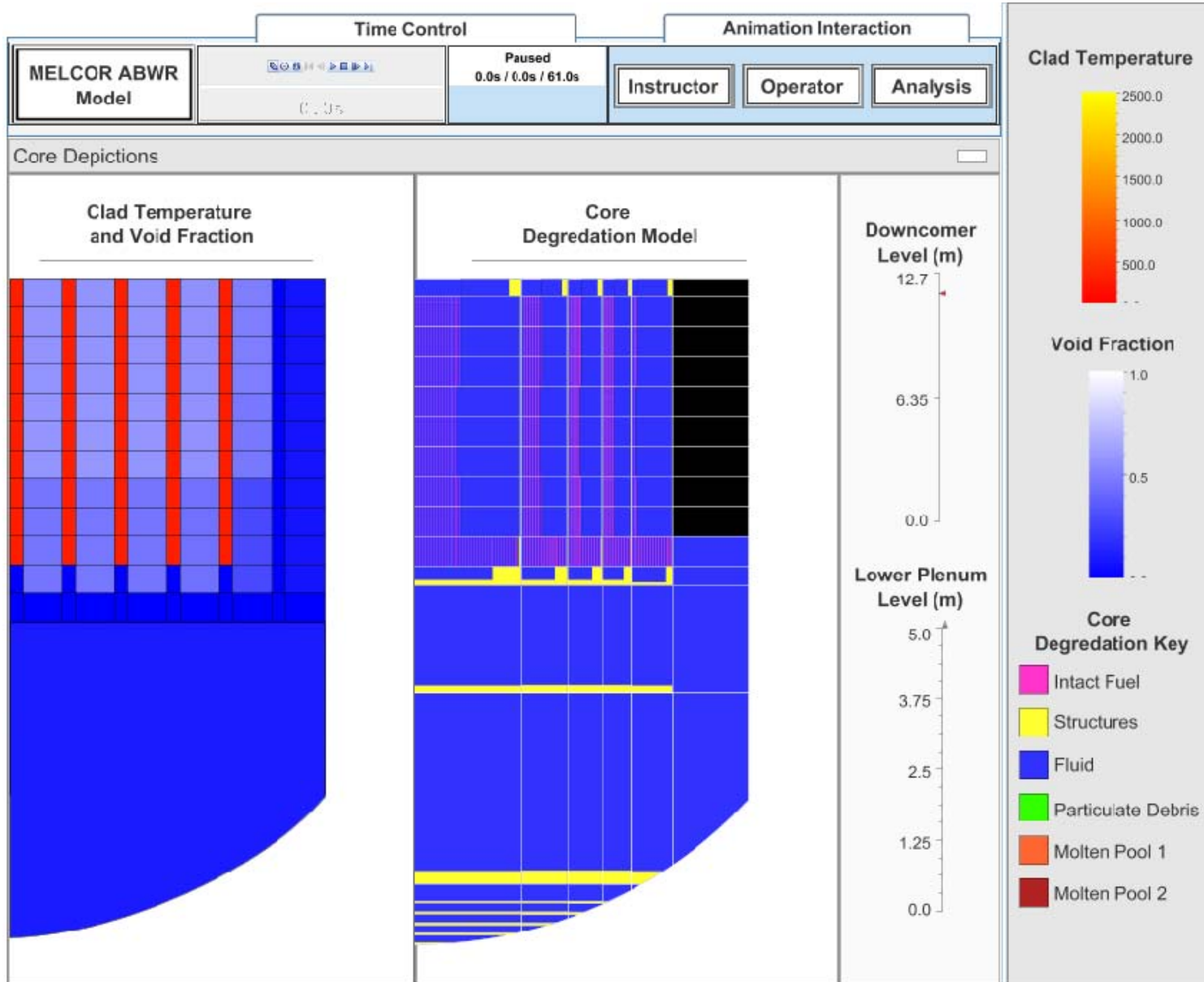
Accident Simulation Using SNAP



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Accident Simulation Using SNAP





Acronyms

- BWR Boiling Water Reactor
- DBA Design Basis Accident
- FP Fission Product
- HTGR High Temperature Gas Reactor
- PAR Passive Autocatalytic Recombiner
- PBR Pebble Bed Reactor
- PCCS Passive Containment Cooling System
- PMR Prismatic Modular Reactor
- PRA Probabilistic Risk Assessment
- PWR Pressurized Water Reactor
- SA Severe Accident
- SNAP Symbolic Nuclear Analyzer Package
- SOARCA State-of-the-art Reactor Consequence Analysis
- SPAR Standardized Plant Analysis Risk