# ENHANCING SAFETY DURING THE GLOBAL NUCLEAR RENAISSANCE



#### MELCOR Developed At Sandia National Laboratories For The U.S. NRC

- Started in 1982
- Ongoing development of new capabilities
- MELCOR is now viewed as a state-of-the-art tool for source term calculations
- Evolving as a repository of our knowledge of severe accident phenomenology
- Modular architecture, portable to new systems

#### Major MELCOR "Packages"

- Basic physical phenomena
- Hydrodynamics, heat and mass transfer to structures, gas combustion,
- aerosol and vapor physics
- Reactor-specific phenomena
- Core degradation, core concrete interactions
- Support functions
  - Thermodynamics, material properties, data-handling utilities

# **WORLDWIDE USER COMMUNITY**

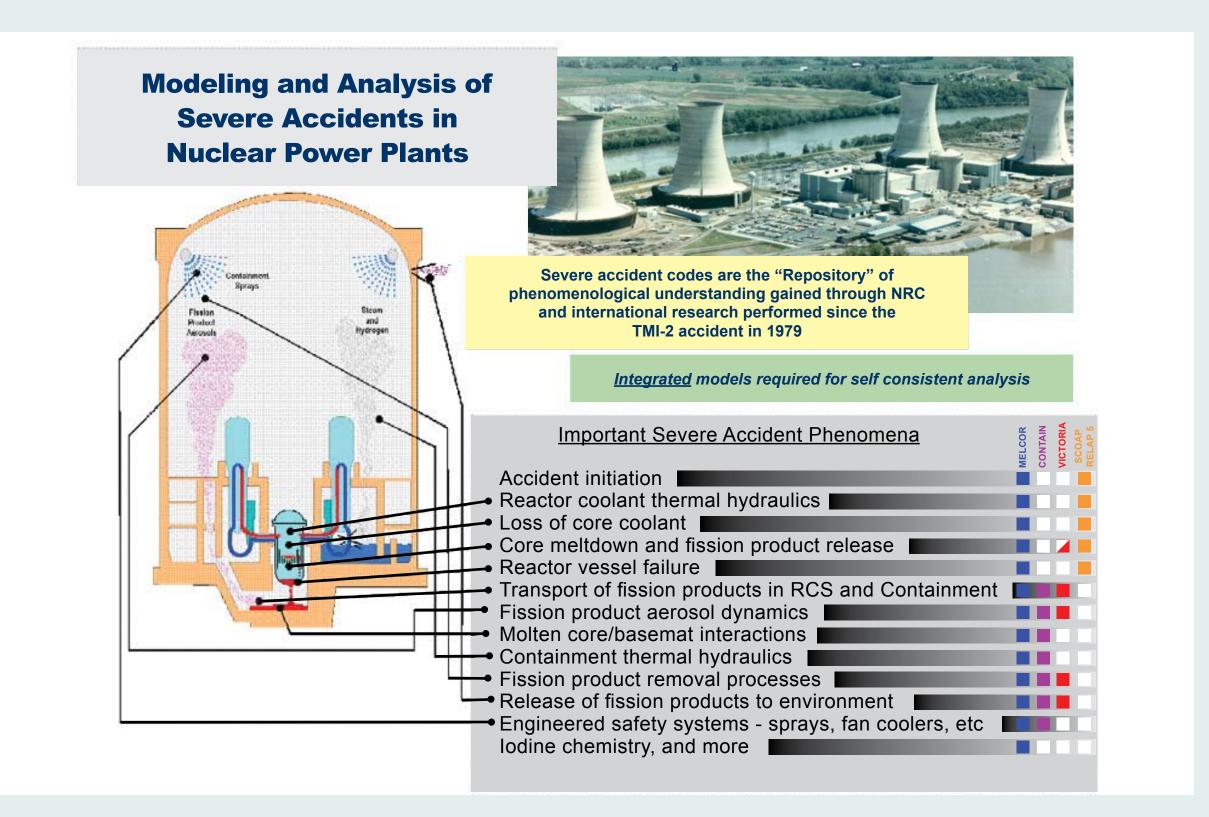
#### Participation of International Partners Through The U.S. NRC Cooperative Severe Accident Research Program (CSARP) and MELCOR Code Assessment Program (MCAP)

• Development Contributions (new models), Suggestions, and Applications

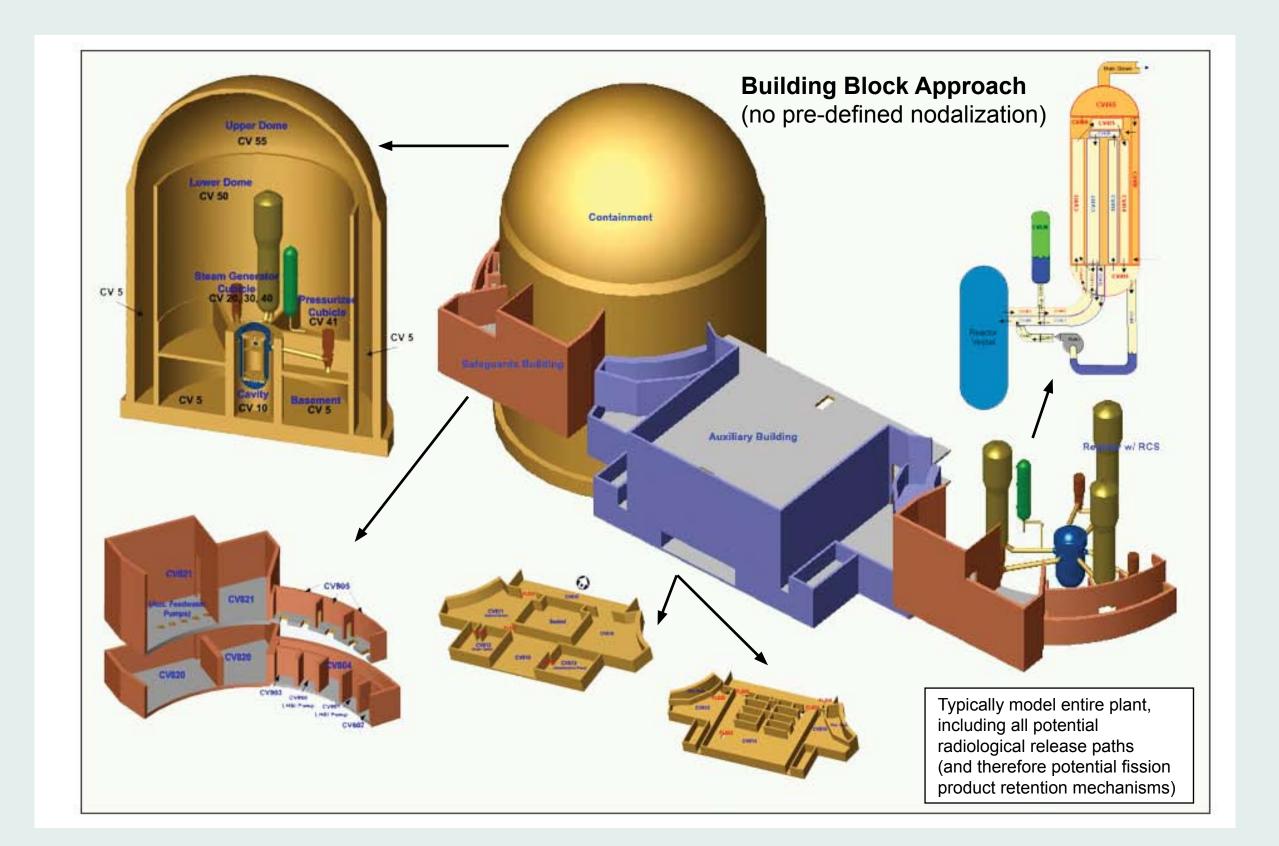


# MELCOR ANALYSIS FOR REGULATORY APPLICATIONS

# **SEVERE ACCIDENT MODELING**

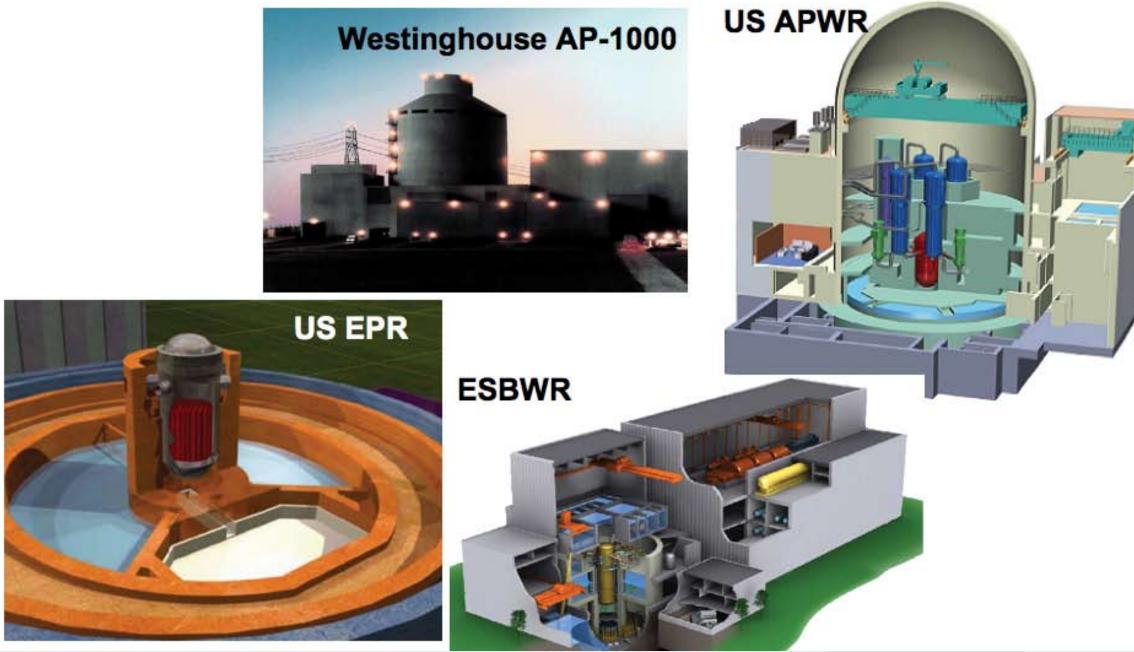


# **MELCOR MODELING APPROACH**



## **DESIGN CERTIFICATION**

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

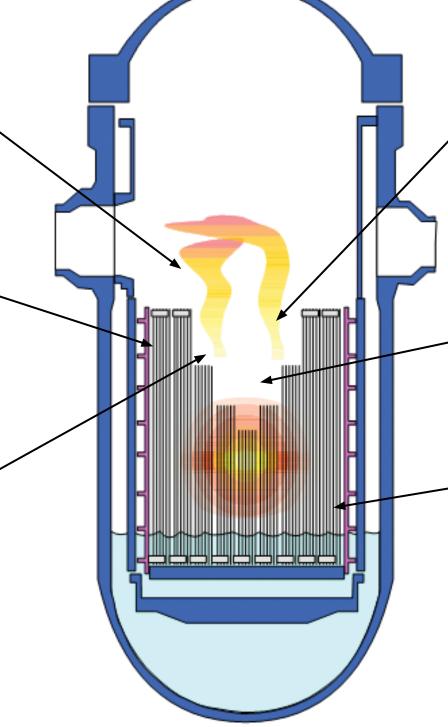


# **CORE HEATUP/ FISSION PRODUCT RELEASE PHENOMENA IN MELCOR**

Fission product species/volatility modified (Cs<sub>2</sub>MoO<sub>4</sub>) -Phebus Tests – affects deposition in the reactor coolant system

Radionuclide modeling allows analysis of fission product release from . mixed MOX/LEU core (French VERCORS and RT tests)

Fuel failure criteria expanded via control function – Phebus tests – affects hydrogen generation and melt progression

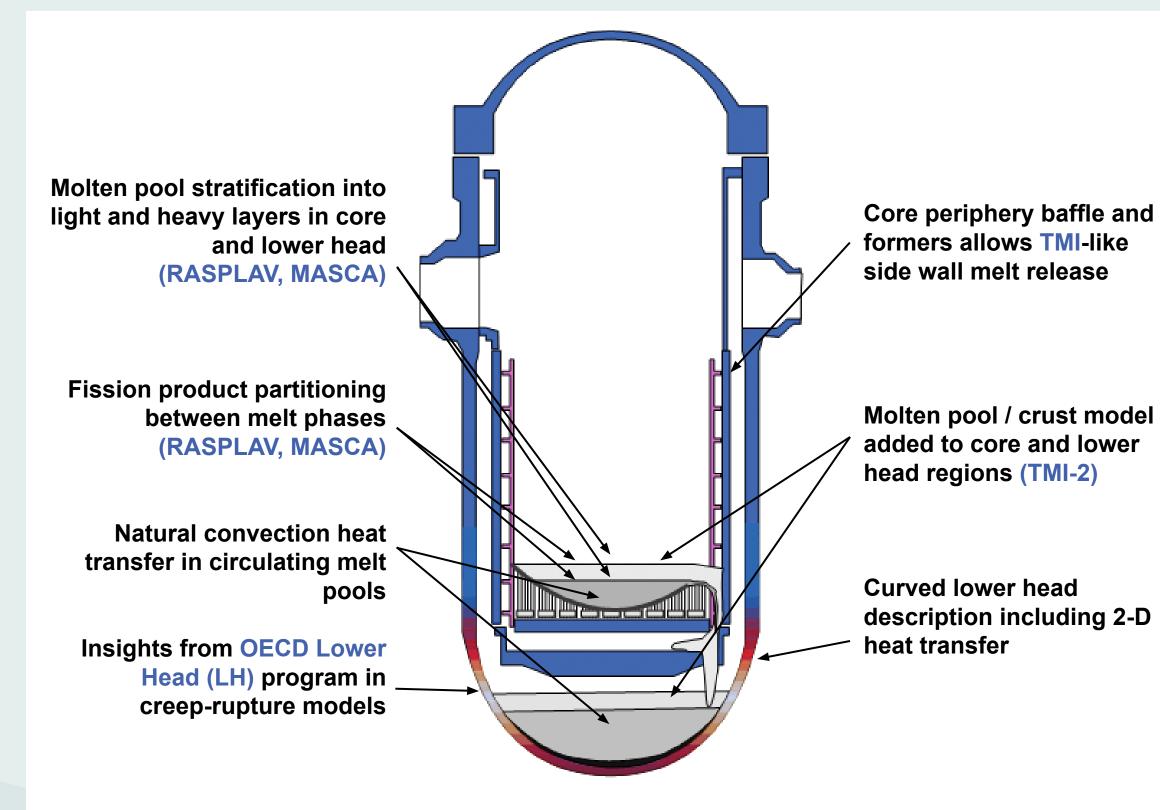


Ag release mode added – Phebus Tests – important fo iodine chemistry Important to aeroso agglomeration and

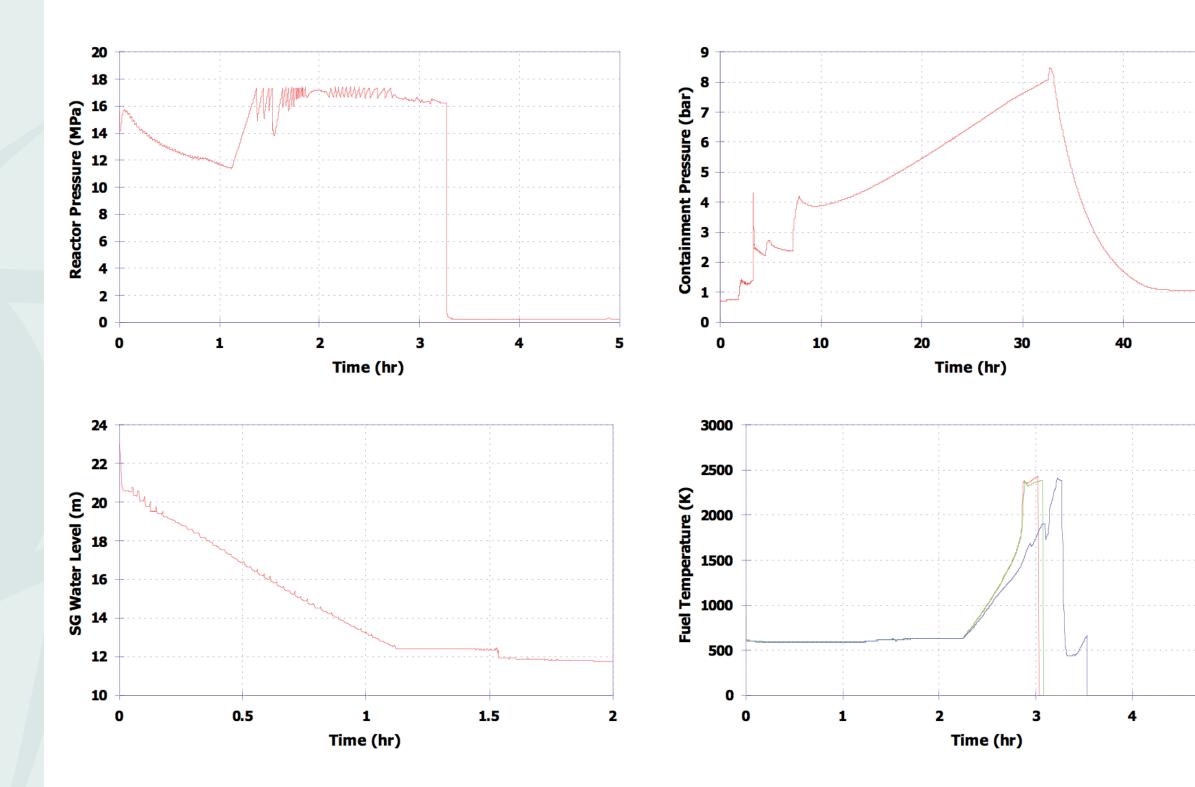
B₄C oxidation model (PWR) – **QUENCH** Tests Phebus FPT-3

Quench-reflood modeling – QUENCH tests - quench front not necessarily wate

## LATE PHASE MELT PROGRESSION PHENOMENA IN MELCOR



**TYPICAL SEVERE ACCIDENT RESPONSE** 



- Severe accident codes can assist in the assessment of fission product transport to leakage location
- Account for natural deposition processes • Assist in refinement of regulatory guides and licensing reviews

- Evaluation of regulation concerning hydrogen control (risk informed 10 CFR 50.44 combustible gas control)
- Code approach provides objective estimates with greater certainty





# OFFICE OF NUCLEAR **REGULATORY RESEARCH**

# **MELCOR APPLICATIONS**

#### Main Steam Isolation Valve (MSIV) Leakage for Boiling Water Reactors

Account for transport processes

#### **Revised Source Term**

 Revised NUREG-1465 for high burnup ( > 40 MWD/MTU) and mixed-oxide fuel in pressurized water reactors

# Risk Informed H, Rulemaking

- H2 uncertainty range in Sequoyah supporting hydrogen rulemaking
- MELCOR produces narrower distribution compared to subjective expert elicitation

#### State-of-the-Art Reactor Consequence Analysis (SOARCA)

- State-of-the-Art Modeling and Simulation
- MELCOR accident progression and source term analysis
- MACCS2 off-site consequence analysis
- Detailed, integrated, and realistic simulations (avoid excessive conservatism and bounding estimates)
- External technical reviews (independent experts from industry and national laboratories)
- Best modeling practices (panel recommendations)
- Code enhancements