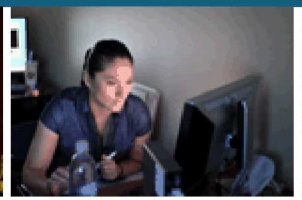
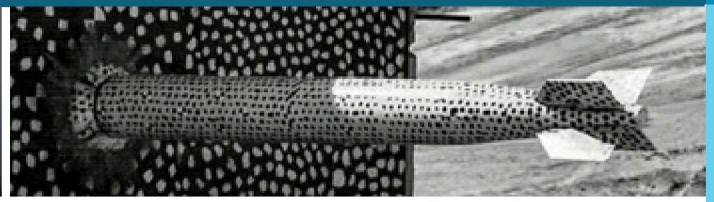
SAND2020-7328PE

MELCOR and Integral Reactor Safety Assessment





David L. Luxat

Severe Accident Modeling/Analysis Department

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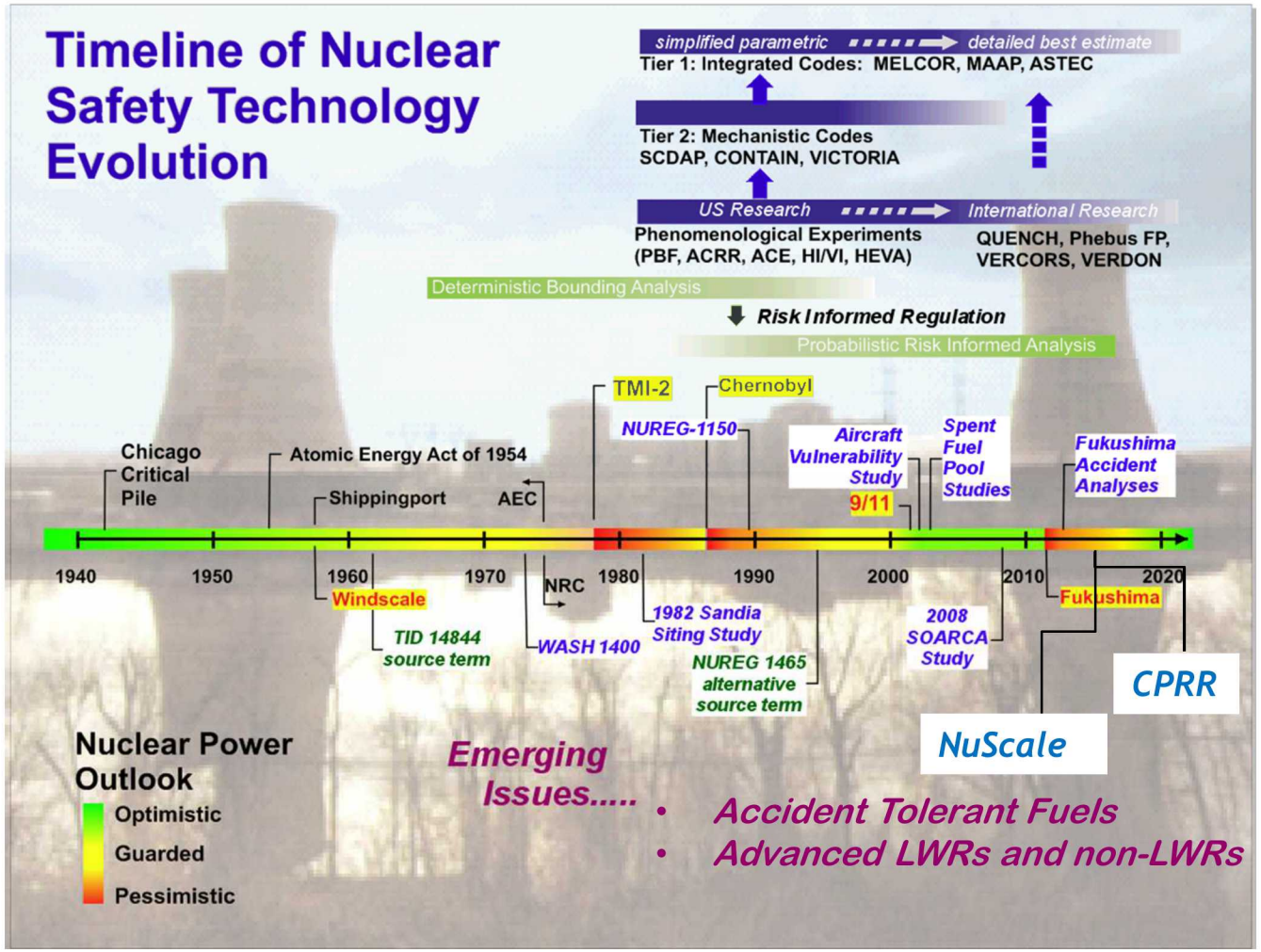
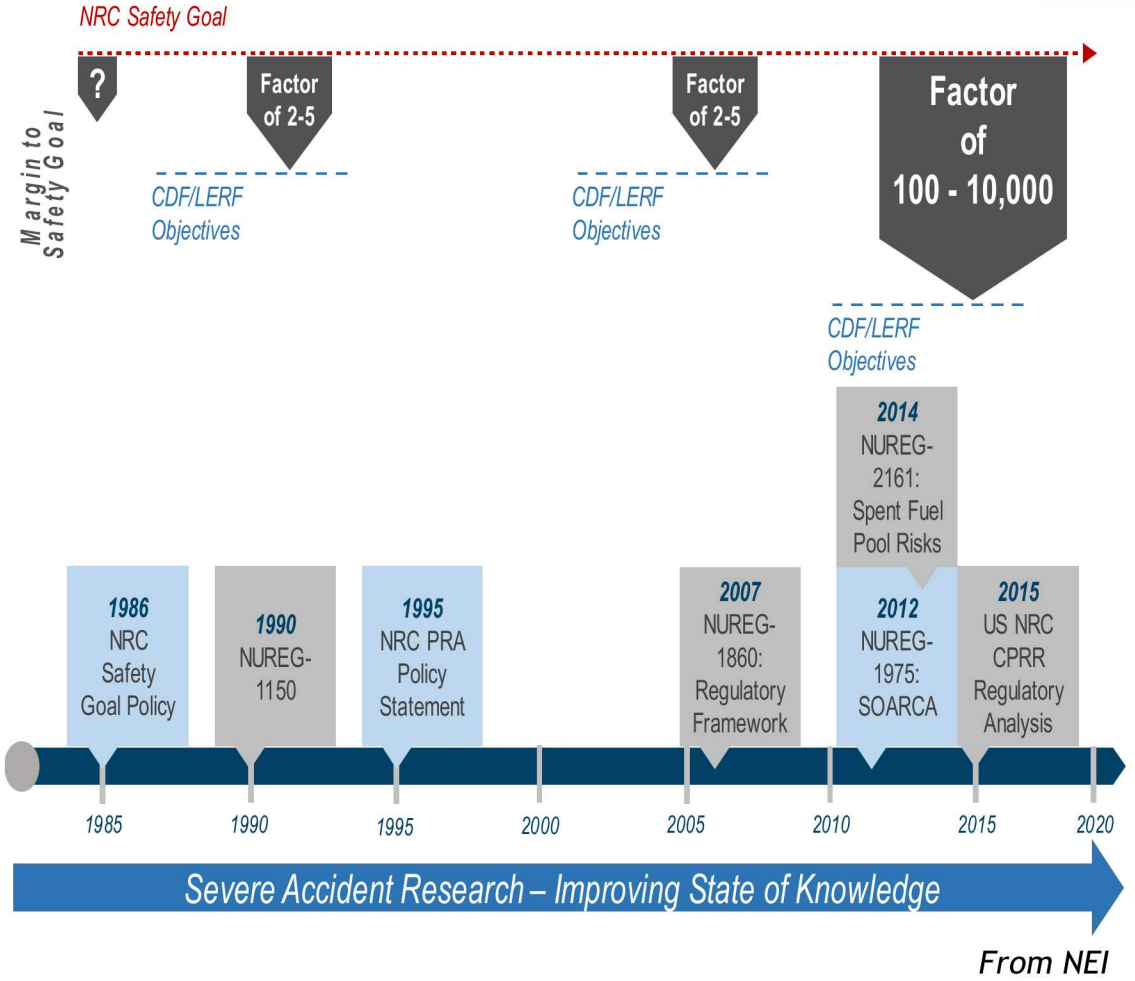


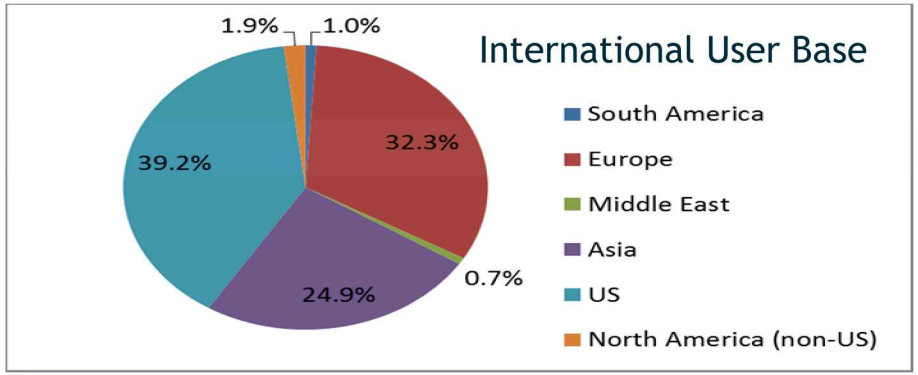


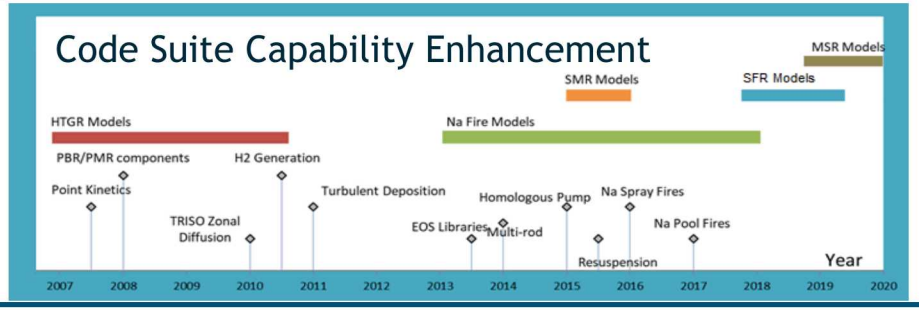
Sandia nuclear safety research

MELCOR/MACCS – Technology-Neutral Safety Analysis Code Suite

MELCOR
Integrated Accident and Source Term Modeling
- Hydrodynamics for range of working fluids
- Accident response of plant structures, systems and components
- Generalized fission product transport modeling inside facilities

MACCS
Consequence Assessment
- Near- and far-field atmospheric transport and deposition
- Assessment of health and economic impacts of radiological accidents





Nuclear Reactor System Applications

Safety/Risk Assessment
- Technology-neutral
  - Experimental
  - Naval
  - Advanced LWRs
  - Advanced Non-LWRs
- Accident forensics (Fukushima, TMI)
- Probabilistic risk assessment

Regulatory
- License amendments
- Risk-informed regulation
- Design certification (e.g., NuScale)
- Vulnerability studies
- Emergency preparedness
- Emergency Planning Zone Analysis

Design/Operational Support
- Design analysis scoping calculations
- Training simulators

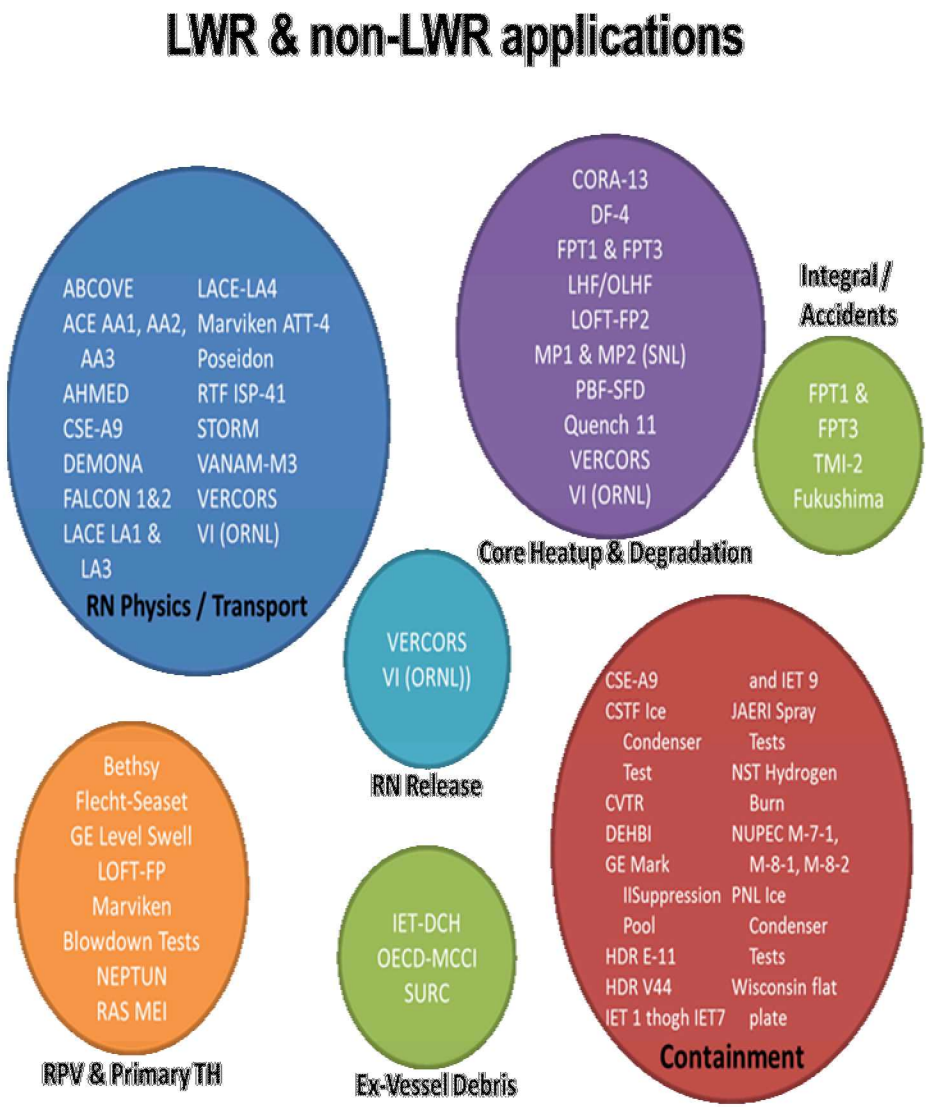
Non-Reactor Applications

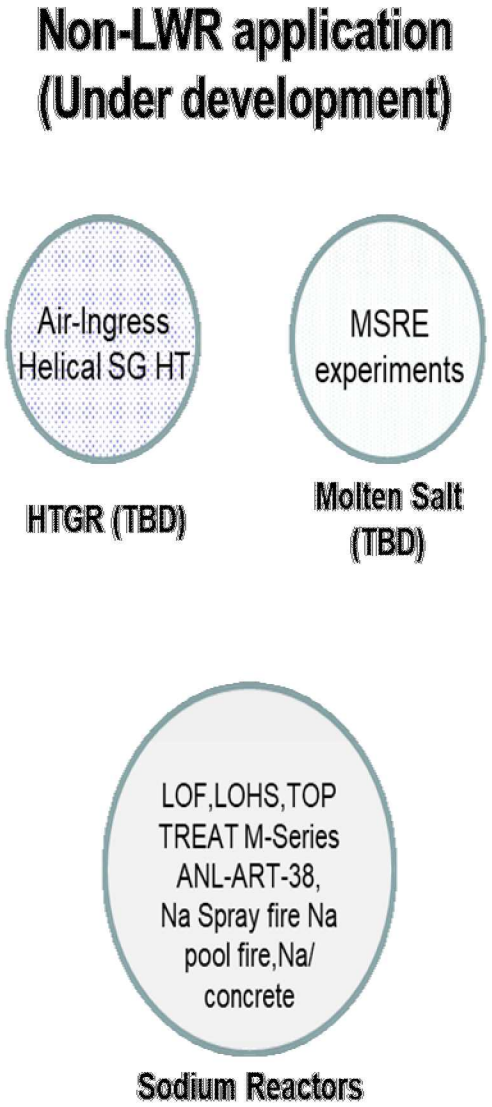
Fusion
- Neutron beam injectors
- Li loop LOFA transient analysis
- ITER cryostat modeling
- He-cooled pebble test blanket (H^3)

Spent Fuel
- Risk studies
- Multi-unit accidents
- Dry storage

Facility Safety
- Leak path factor calculations
- DOE safety toolbox codes
- DOE nuclear facilities (Pantex, Hanford, Los Alamos, Savannah River Site)

MELCOR Capabilities and Validation





Integral plant response accident analysis code

Multi-physics modeling
- Thermal-hydraulic response
- Core heat-up, degradation, and relocation
- Core-concrete interactions
- Hydrogen production, transport, combustion
- Fission product release and transport

Extensively validated
- Separate effects tests
- Integral tests
- International Standard Problems
- Actual reactor accidents

Facilitates uncertainty assessment
- Fast-running
- Reliable and robust
- User access to modeling parameters'

Non-LWR development since 2005

Non-LWR Accident Progression and Source Term Analysis

HTGR development including
- Model testing
- Critical assessment

SFR (Heat pipe reactor) development including
- Model testing
- Core modeling
- Containment modeling
- Thermochemistry

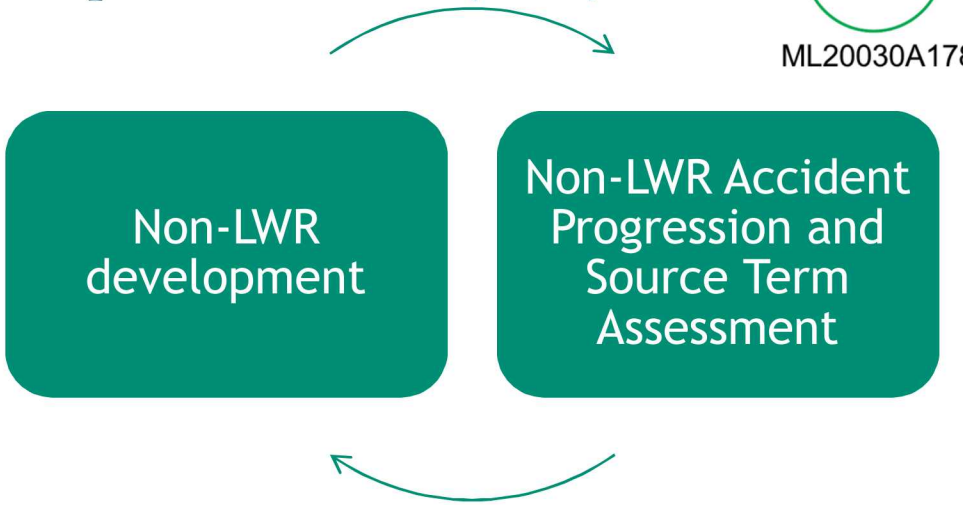
MSR/FHR development including
- Model testing
- Thermochemistry
- Core modeling

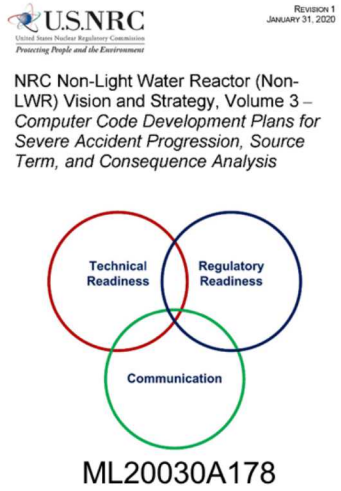
High-Temperature Gas-cooled Reactor (HTGR)

Sodium Fast Reactor (SFR)

Molten Salt Reactor (MSR)

Fluoride salt-cooled High temperature Reactor (FHR)





MELCOR

Sandia National Laboratories

OAK RIDGE National Laboratory

SCALE

Full-plant demonstration calculations
- NRR source term assessment
- Accident progression insights

Plant models developed from publicly available information

Three non-LWR concepts
- High-Temperature Gas-cooled Reactor (HTGR)
  - Pebble bed design
- Fluoride salt-cooled High temperature Reactor (FHR)
  - UC Berkley design
- Megapower heat pipe reactor

Internal NRC training

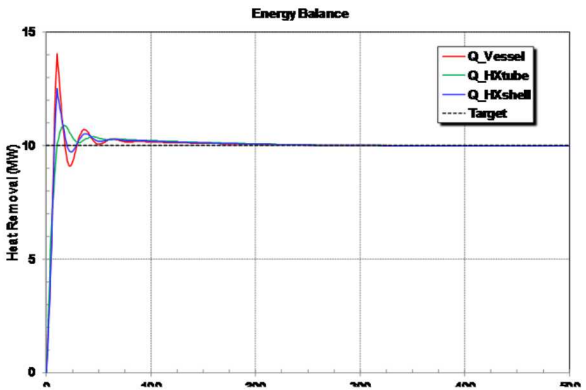
Public meetings to demonstrate capabilities and methodology

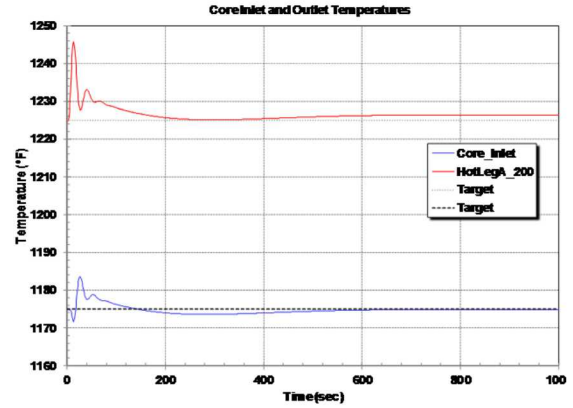
Molten Salt Reactor Source Term Modeling – MSRE Simulation Model

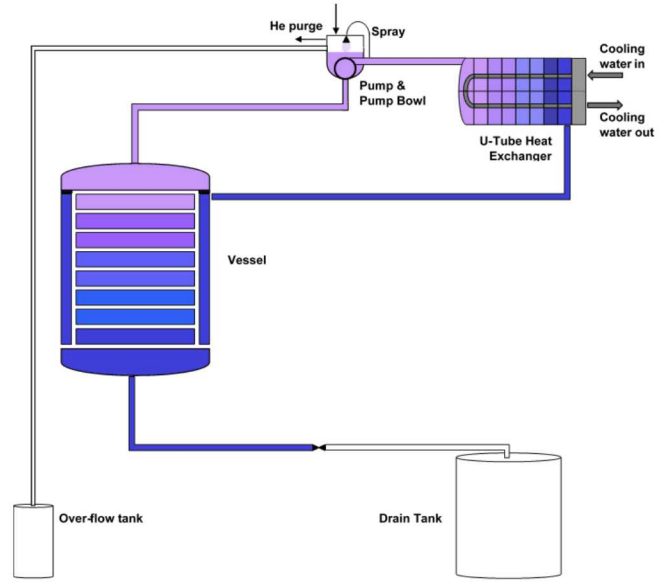
MSRE model based on available ORNL-TM-0728
- Currently available MELCOR version
- Could be used as demonstration of the MSR EM

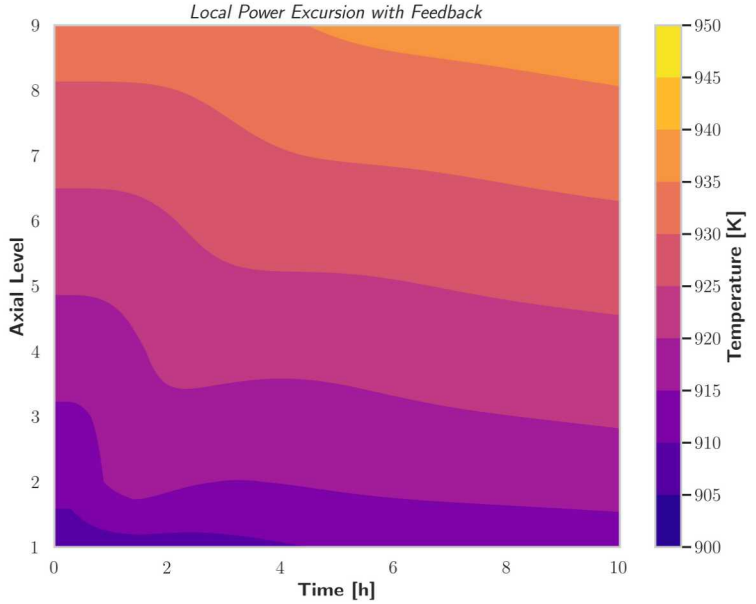
System represented using generic MELCOR elements
- 1D core for now with 2D extension straightforward
  - 8 control volumes
  - No traditional solid core structures represented
- Graphite blocks (heat structures)
- Diversion and drain tanks connected to primary loop
- Core bypass (leakage flow)
- Primary loop (with heat structures for pipe walls)
- Fuel pump and pump bowl
  - Overflow tank
  - Pump spray with helium gas purge for salt clean-up
- Horizontal u-tube heat exchanger

Initial efforts for FHR-type non-LWR underway
- Sample analysis based on PBR-400 (HTGR) with FLiBe as the working fluid
- Error-free execution
- Physically sensible plant response
- Will expand validation efforts









Thanks for your attention