SAND2022-15035C

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Spent Fuel and Waste Science and Technology (SFWST)

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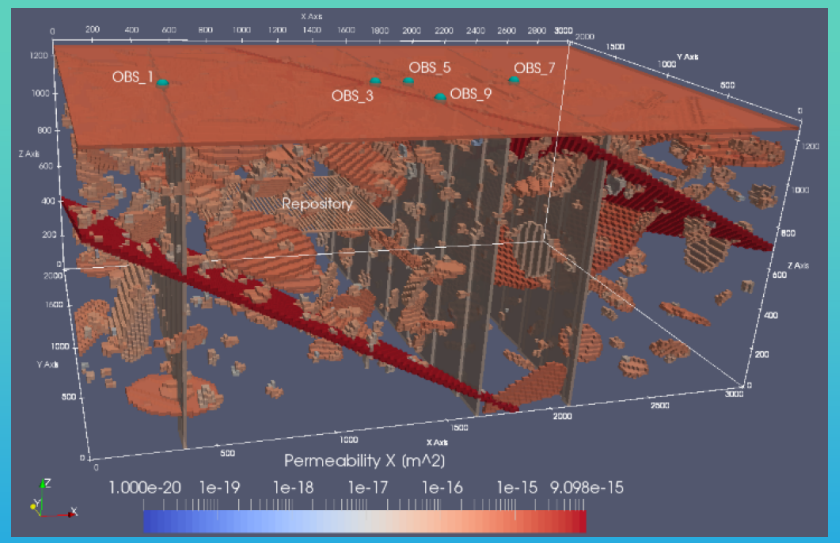

Canister Deposition Field Demonstration (CDFD) Progress

SAND2022-****

Electric Power Research Institute

Extended Storage Collaboration Program

November 9, 2022

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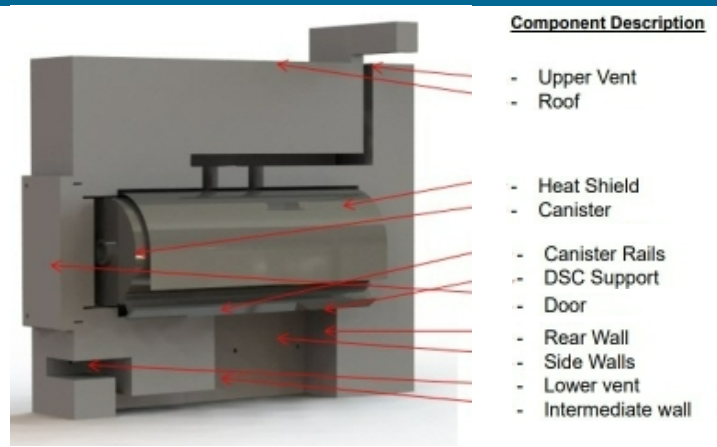
General Plan



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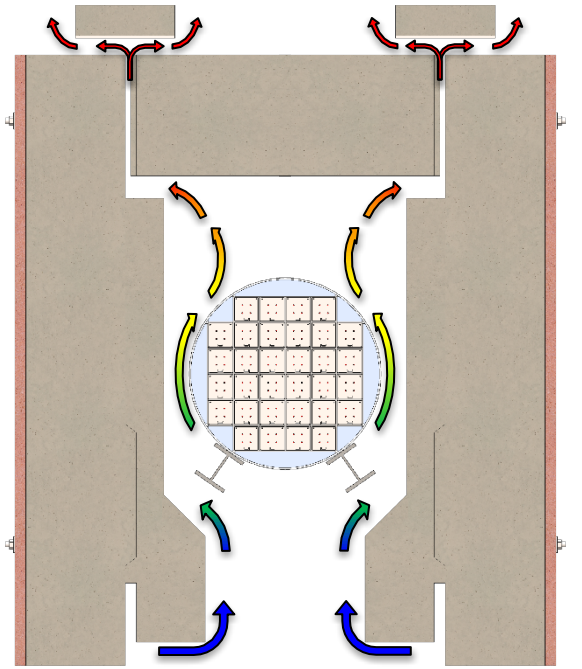
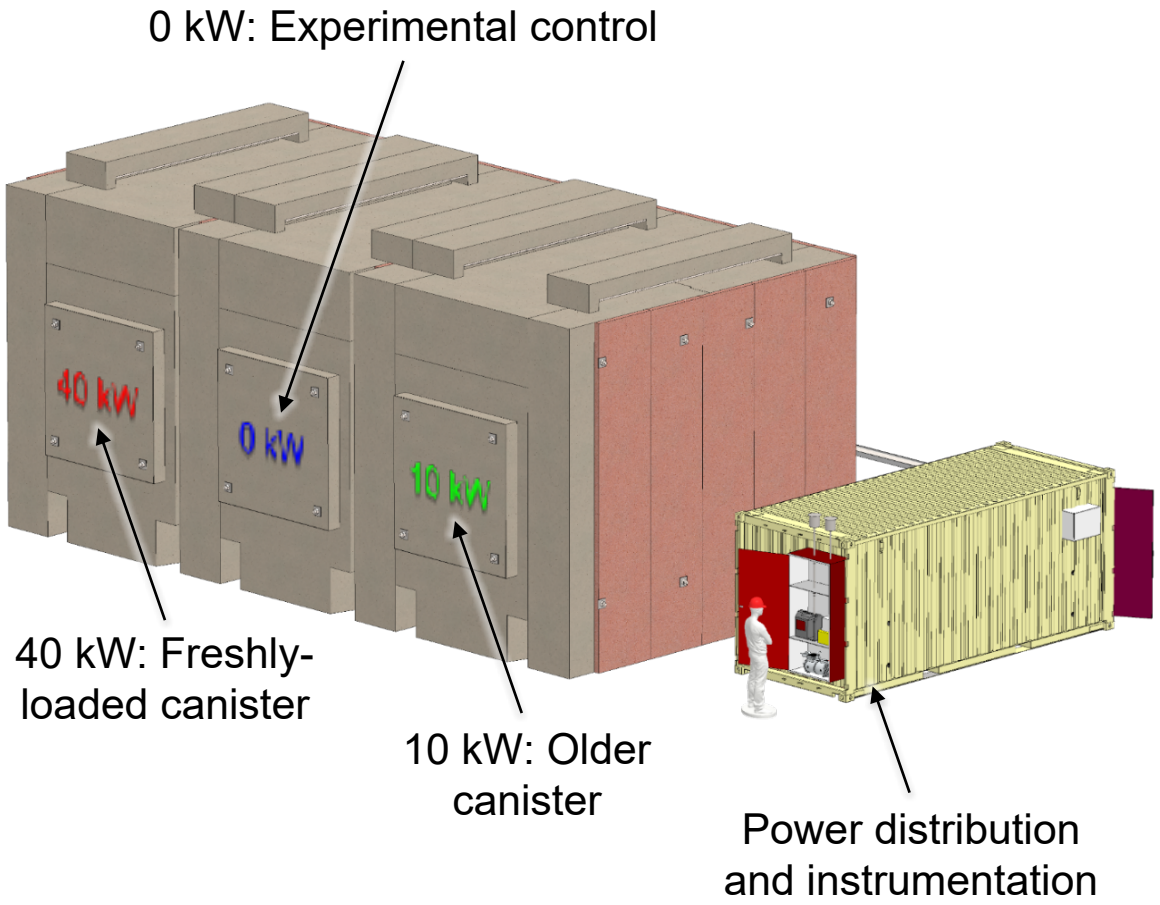


Loaded Advanced Horizontal Storage Module Cross-Section

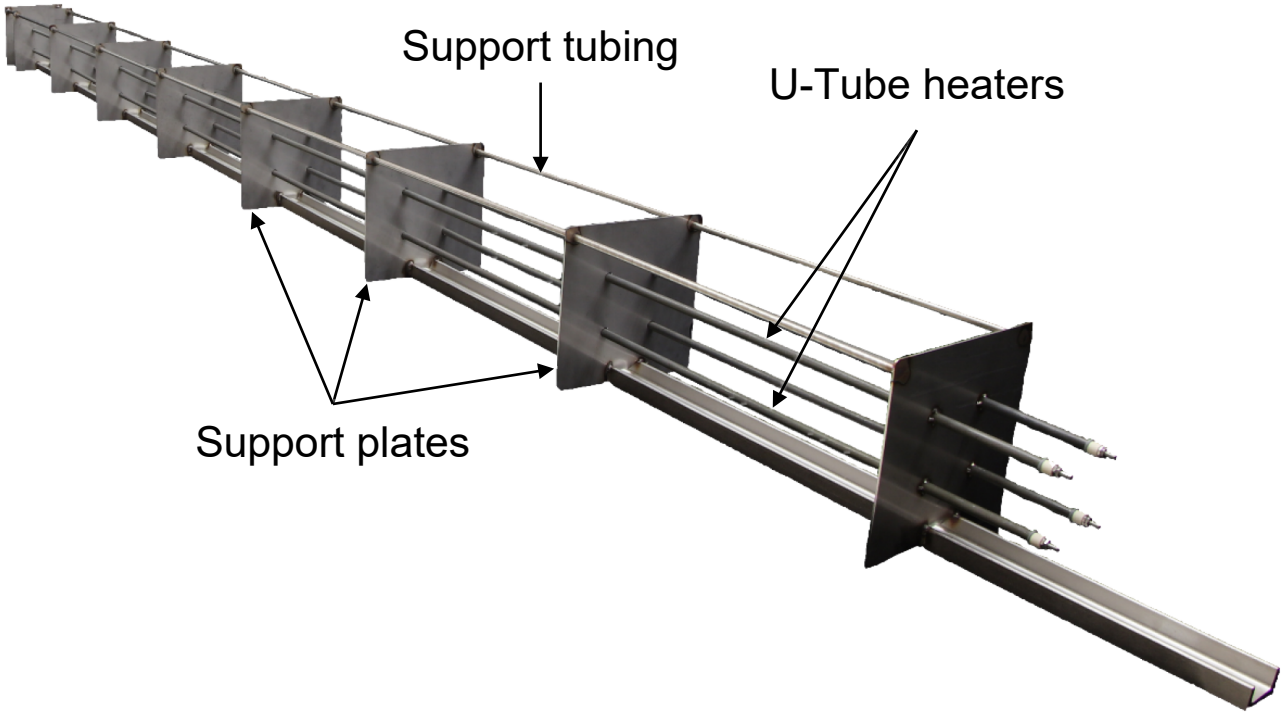
- Horizontal Interim Storage Systems
  - Weld-sealed stainless steel canister
  - Shielding concrete enclosure
  - Passively cooled by induced ambient air flow
    - Ambient air contains dust that collects on the canister
    - Dust contains salts that may deliquesce in humid air
- Resulting concentrated brines cause pitting
  - With sufficient stresses, pits evolve into Chloride-Induced Stress Corrosion Cracks (CISCCs)
    - Canister welds produce residual stresses
    - SCCs could penetrate through the canister wall

CDFD Overview

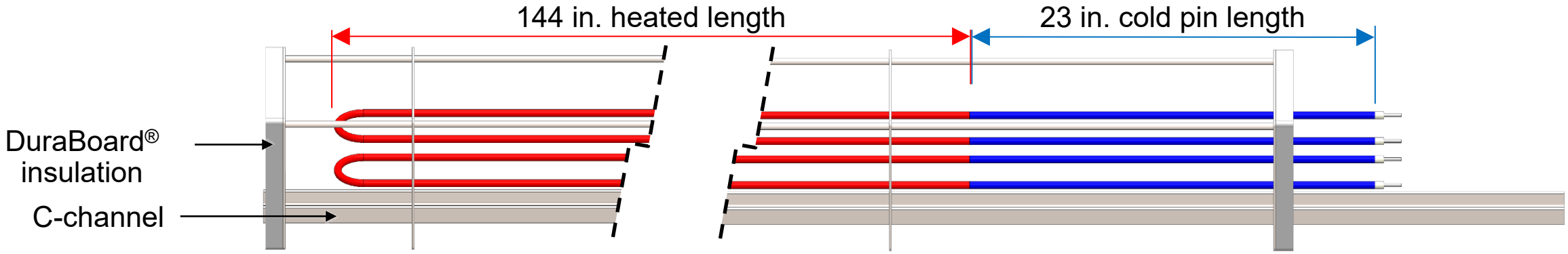


- 3× NUHOMS® 32PTH2 canisters
  - Furnished by Department of Energy (NE-8)
  - Electric heaters simulate decay heat
  - Each canister inside Advanced Horizontal Storage Modules (AHSMs)
  - Test located at site of interest
- Canister surface sampling to collect dust deposition, composition, and evolution
  - Monitoring for weather conditions
  - Ambient particulate characterization
    - Chemical composition and size distribution
  - Provide realistic data
    - Bounding conditions for SCC experiments and modeling at SNL and PNNL
    - Validation data for thermal/deposition modeling at PNNL

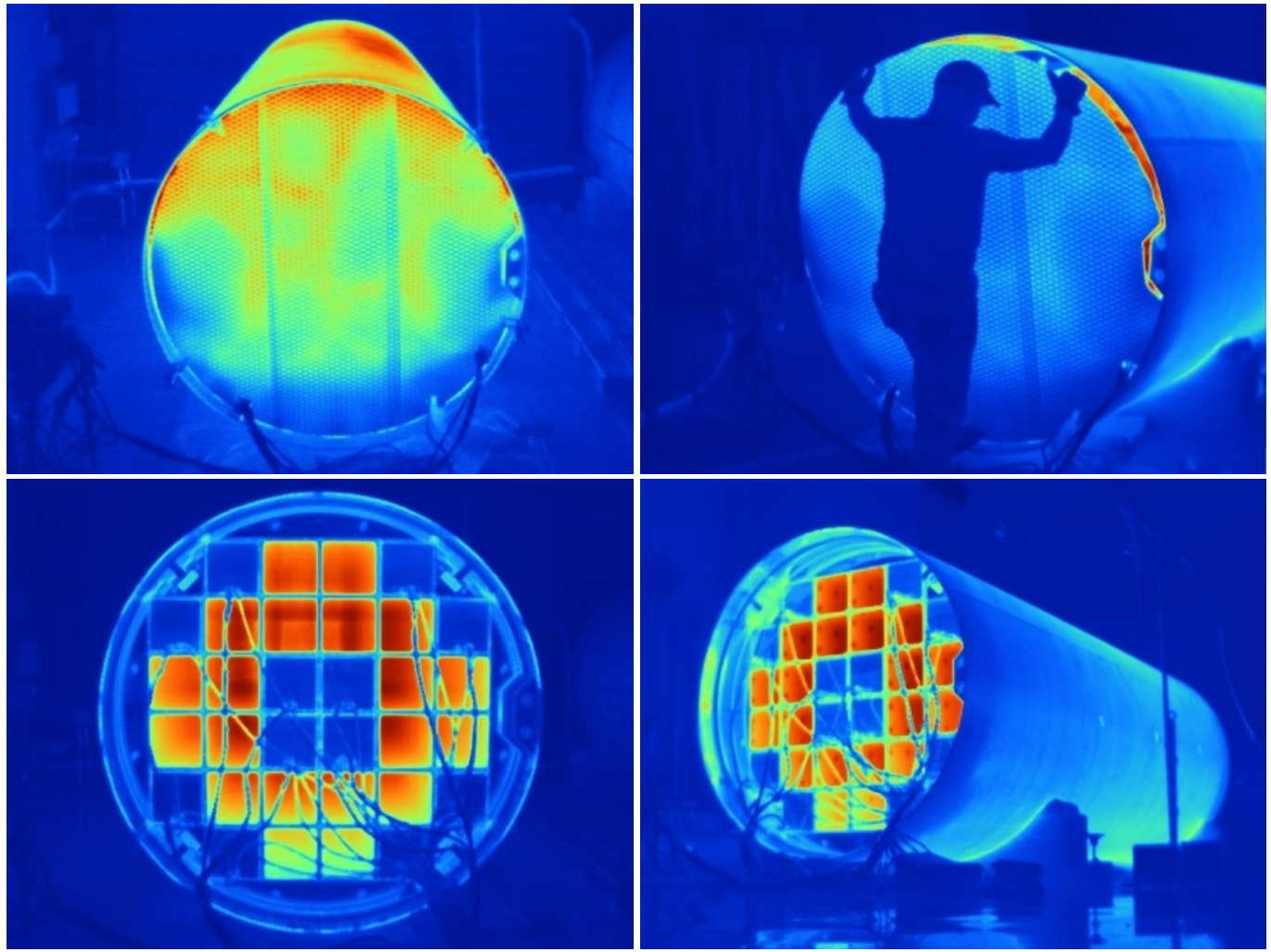
Heater Assemblies



- Robust design with two independent heater elements
  - One heater assembly for every SNF assembly
  - Incoloy 800 heater cladding
    - 144 in. heated region like SNF
  - 316/316L stainless steel support materials
    - Support plates center assemblies and restrict transverse movement during transport
  - C-channel forms backbone of assembly
    - Restricts axial movement during transport
  - Insulation added at ends of assembly
    - Shapes heat profile to be like SNF

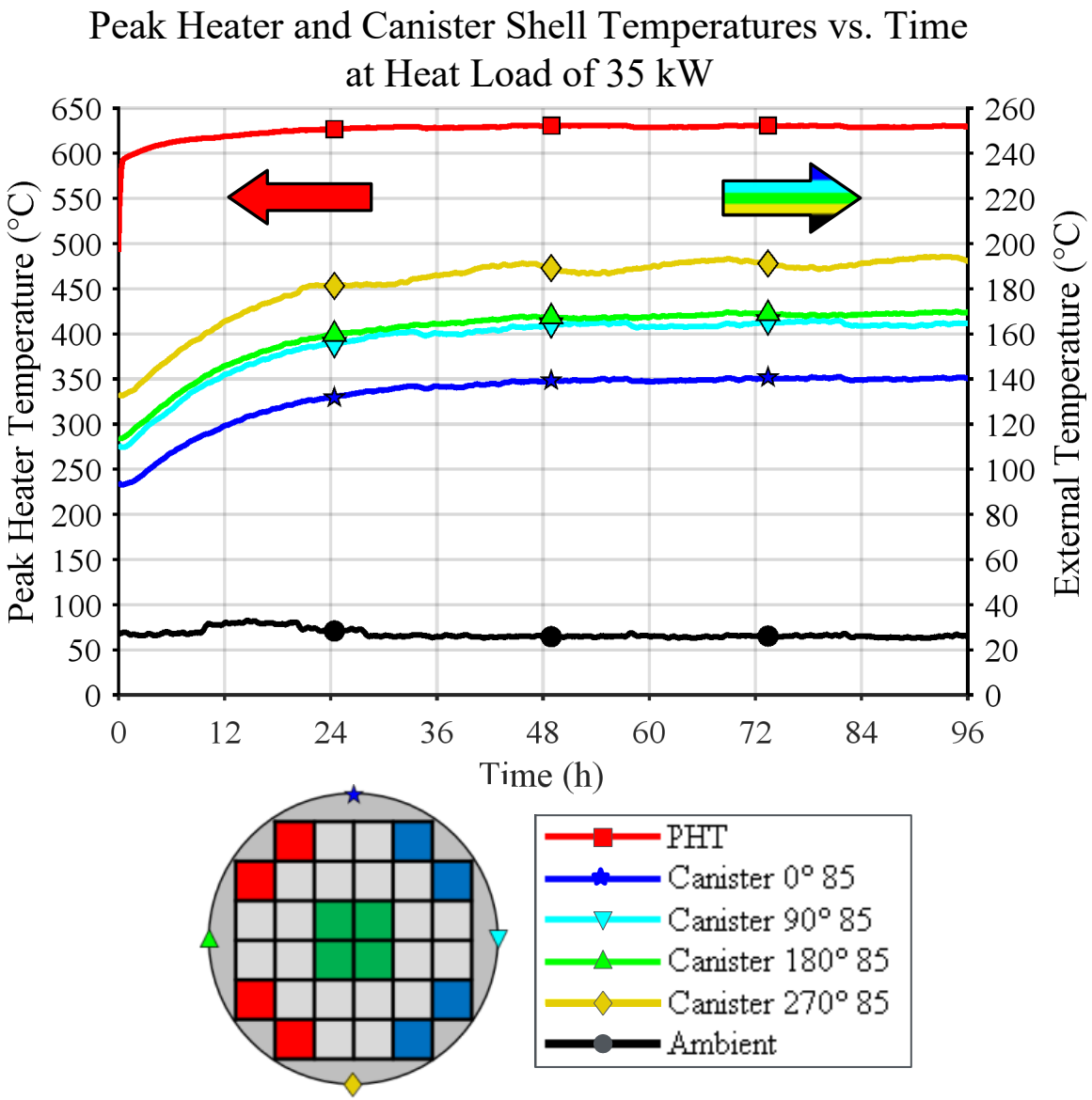


Preliminary Heater Tests



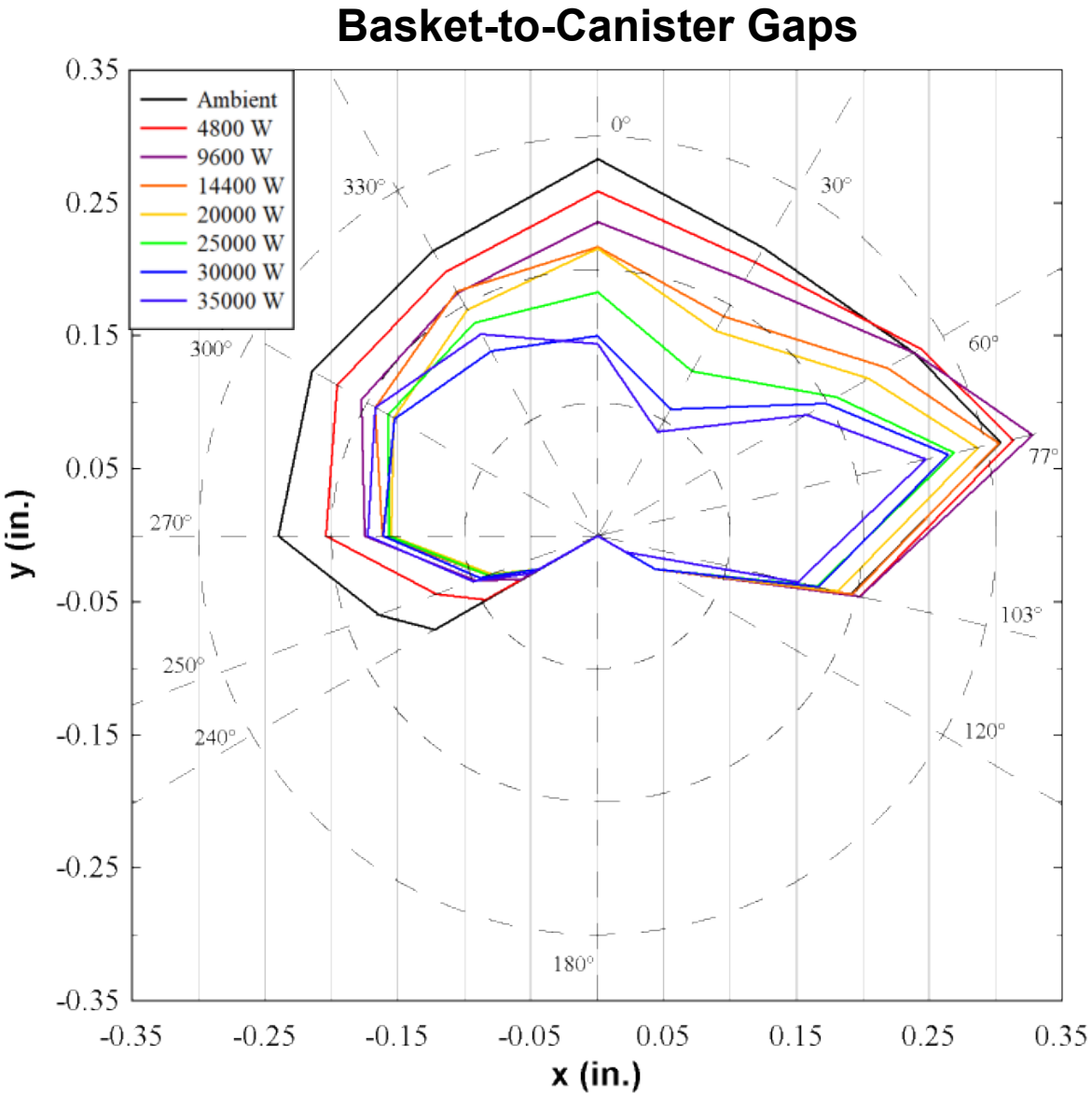
- In situ heated testing
  - Generate validation data for model refinements
    - Twelve (12) prototype heater assemblies
    - Heater tests from 4.8 to 35 kW
  - Boundary conditions significantly different than AHSM
    - Natural convection into open room
    - Separation to floor by wooden cradles

Preliminary Heater Tests



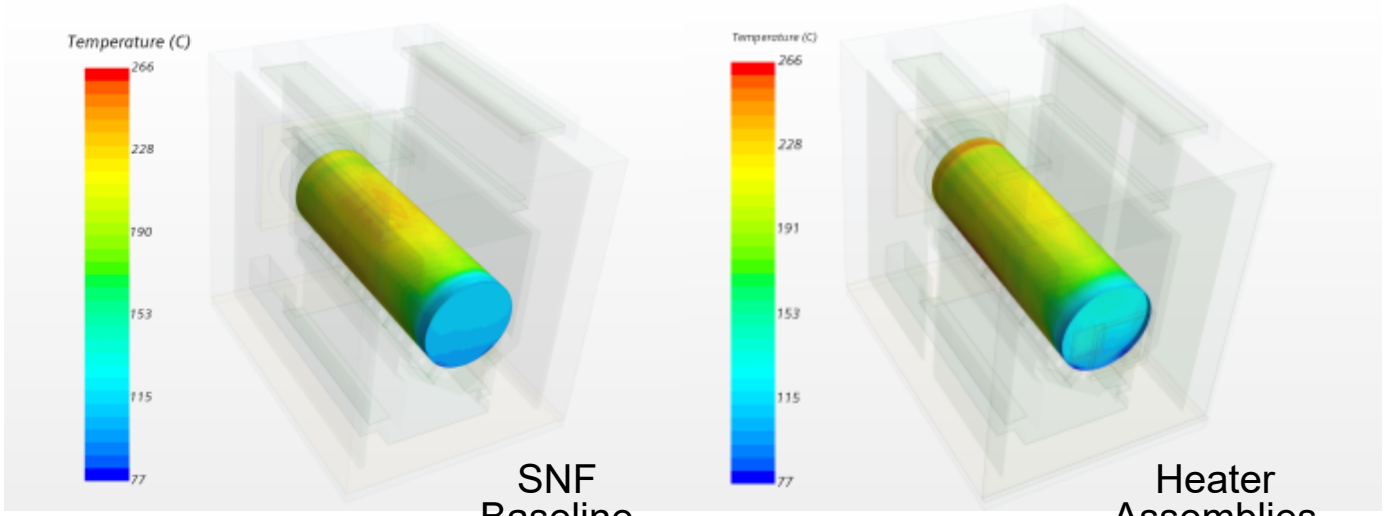
- Results shown for heat load of 35 kW
  - Heat applied in basket center and corners
- Thermocouples (TCs) on canister shell exterior
  - Maximum temperature 195 °C at bottom-middle of canister
- Heater assemblies instrumented with TCs
  - Heater cladding, C-channel, and thermal radiation shields
  - Peak heater temperature of 633 °C
- Steady-state temperature data
  - Improve agreement with thermal modeling at PNNL

Thermal Model Support



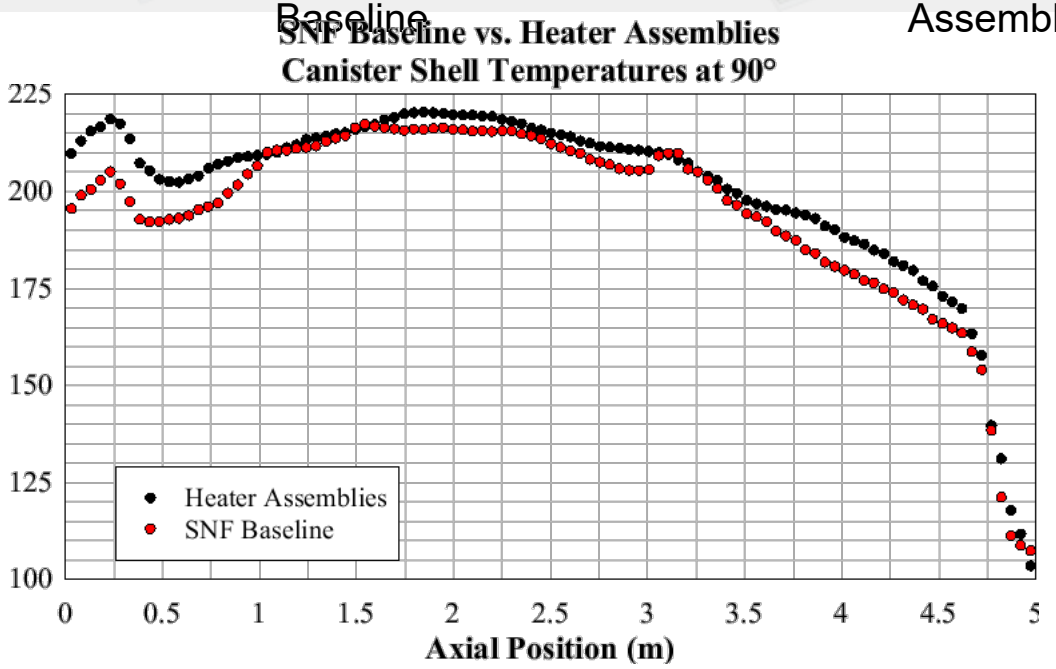
- Canister gap and inner diameter measurements
  - Recorded for different heat loads
- Basket-to-canister gaps decrease due to thermal-driven expansion of basket
  - Changes basket-to-canister gap thermal resistance
- PNNL thermal modeling incorporating measured gaps

Thermal Modeling



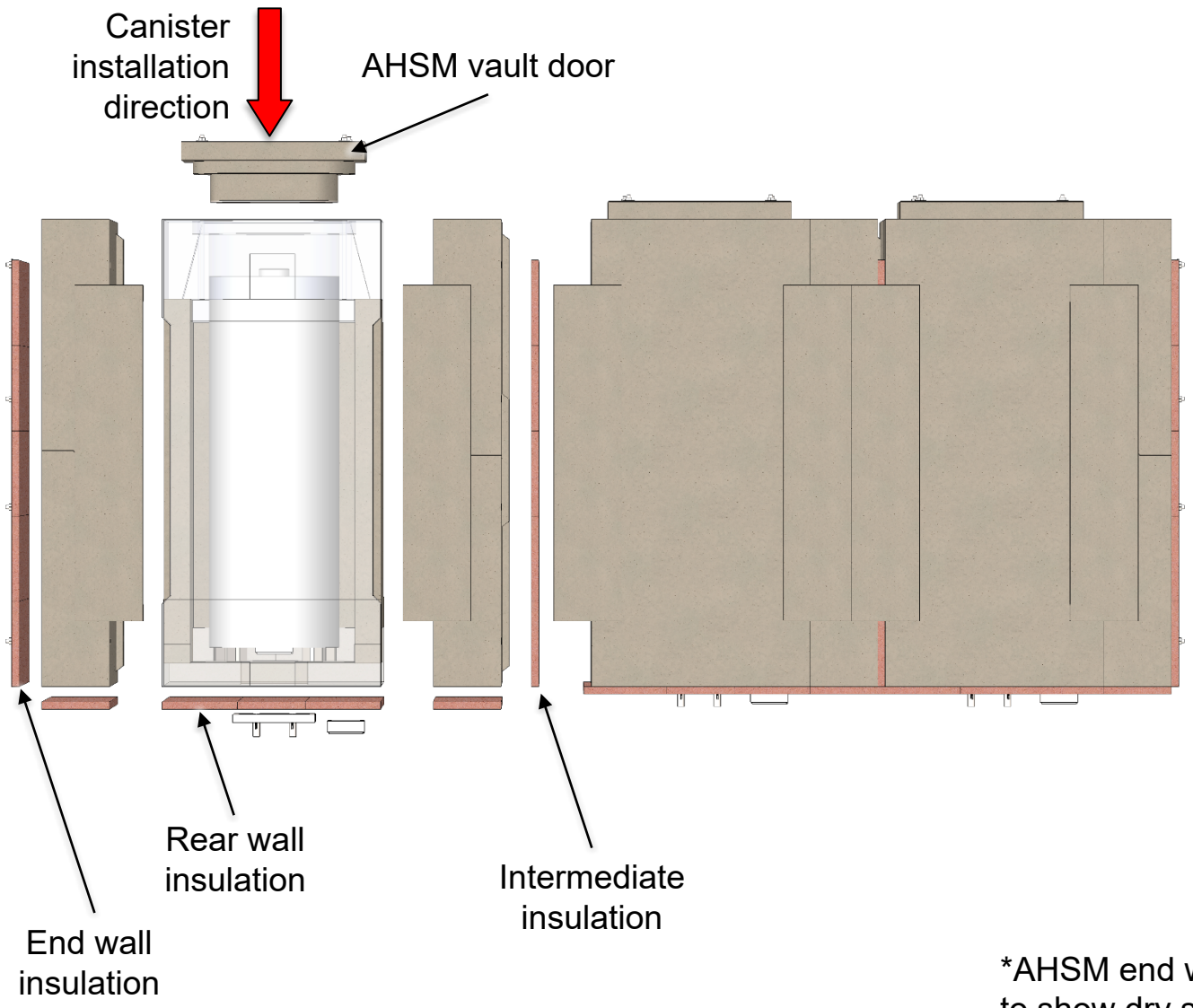
SNF Baseline

Heater Assemblies

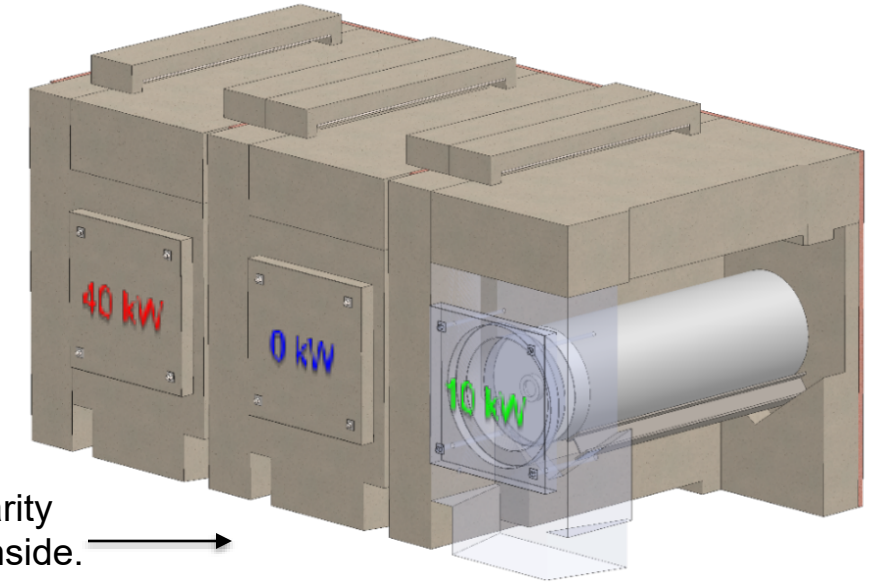


- Benchmark electrically heated canister to baseline
  - Baseline: Canister loaded with spent nuclear fuel (SNF)
- Model informed with experimental data
  - Surface emissivities and canister gaps
- Current models are steady state
  - Future work for diurnal transient effects and realistic thermal masses
- All thermal modeling performed at PNNL
  - Sarah Suffield, Ben Jensen, and Jim Fort

Insulative Boundary Conditions

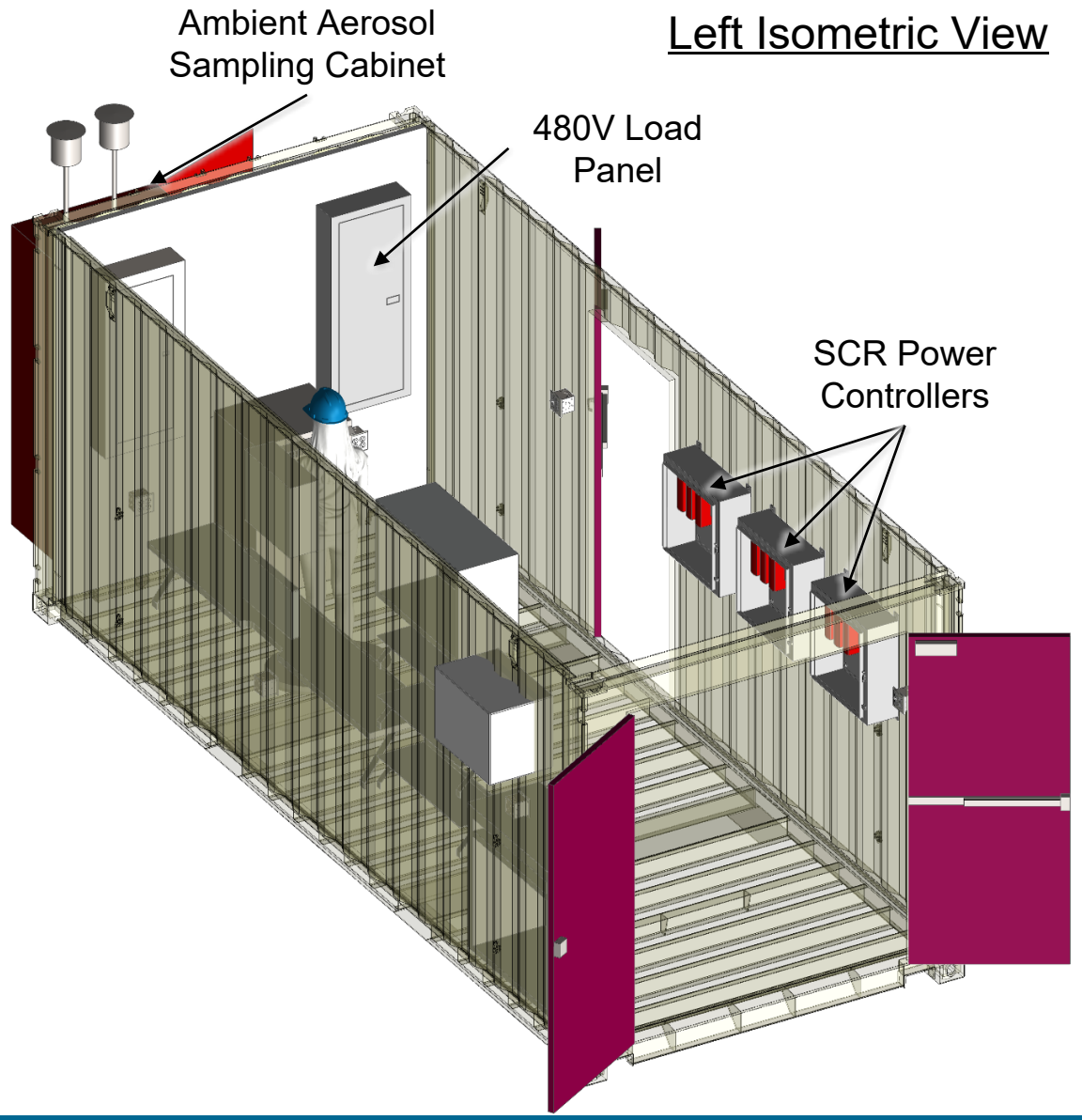


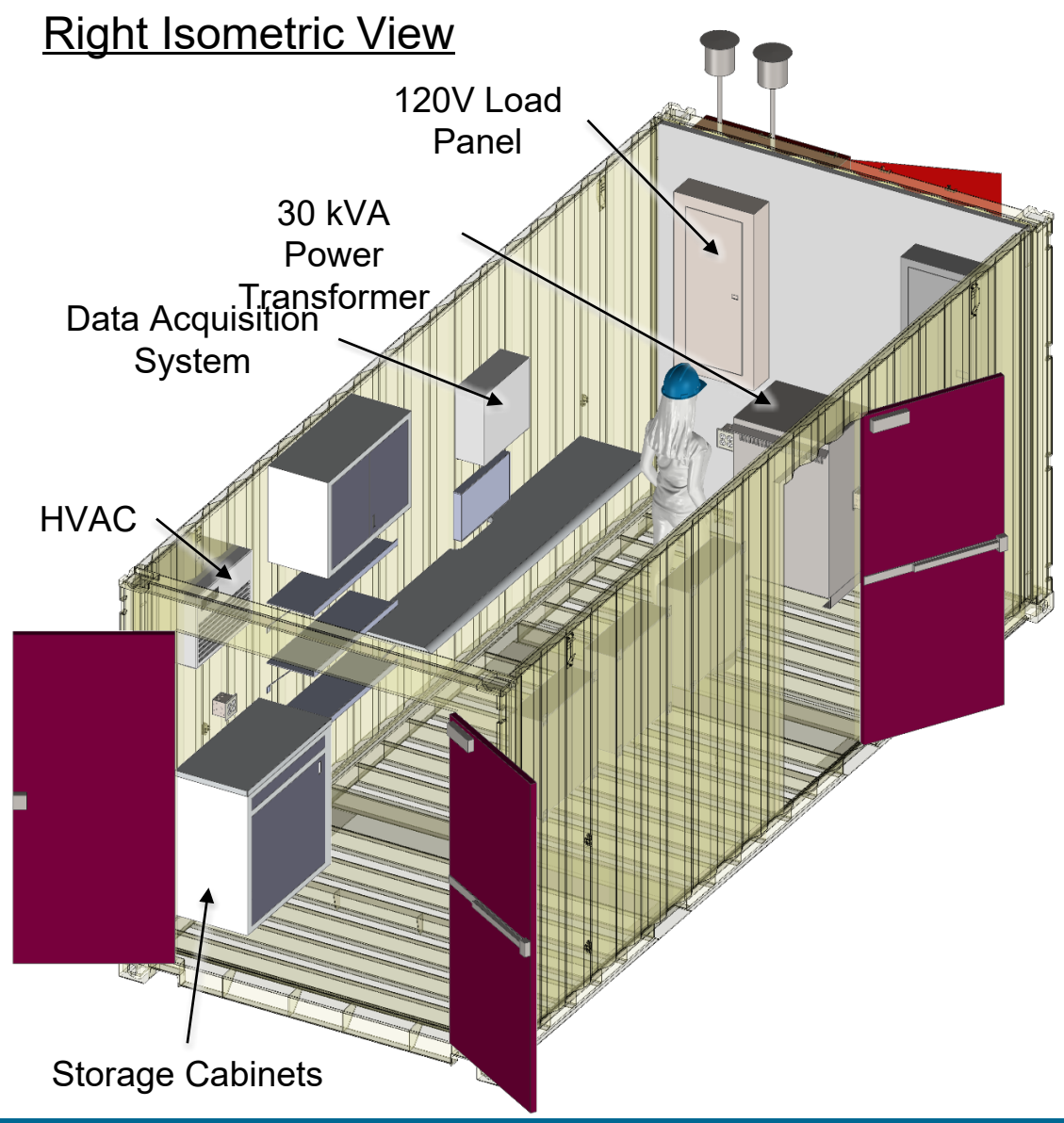
- Exterior insulation on side and back walls of AHSMs
  - Near-adiabatic boundary conditions
  - Improved modeling validation
- Insulation between adjacent modules serves as a thermal break
  - Minimizes influence of neighboring canisters



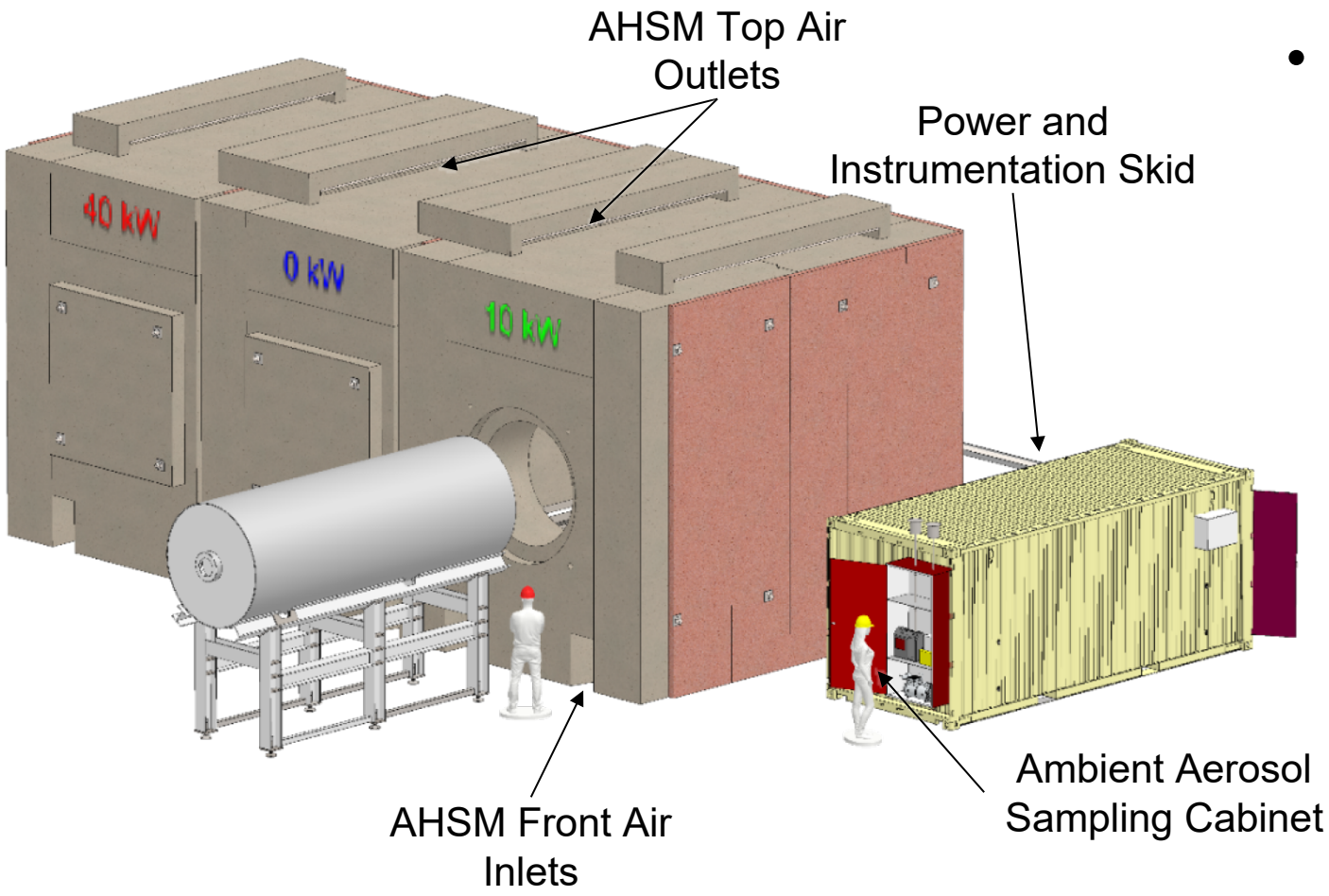
*AHSM end wall hidden for clarity to show dry storage canister inside.

Power & Instrumentation Skid





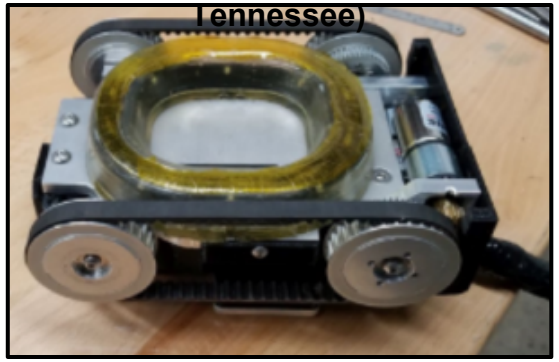
CDFD Test Layout

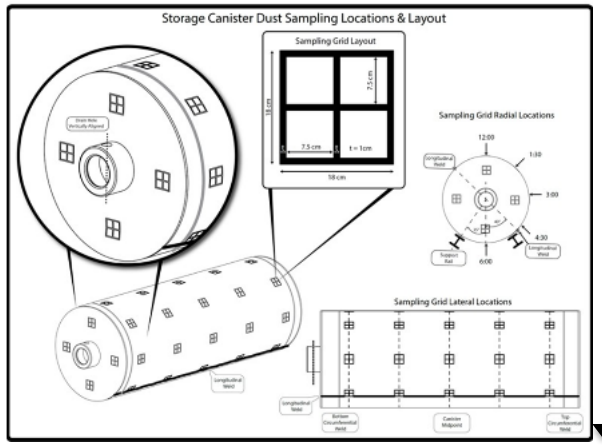


- Periodic hand sampling of canister surface
- Ambient aerosol sampling cabinet placed on the same side as the AHSM air inlets
  - Cascade impactor and laser particle spectrometer
    - Provide data for particle densities, size distributions, and compositions

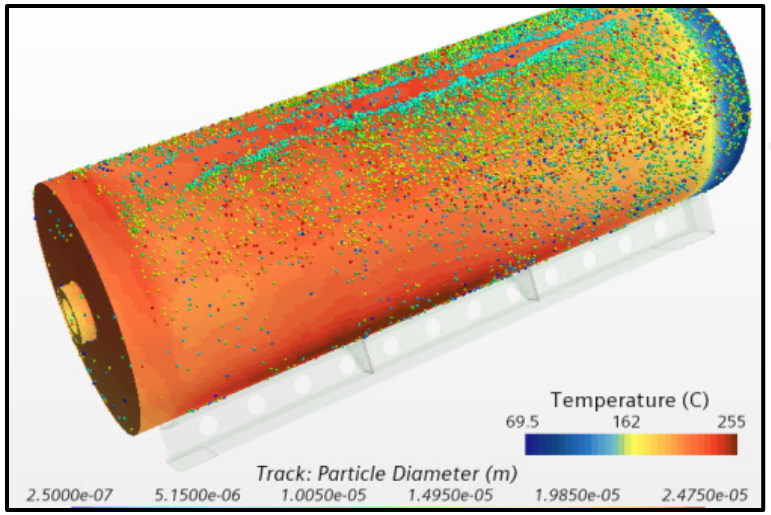
Deposition Sampling

Canister Inspection Robot (Robotic Technologies of Tennessee)





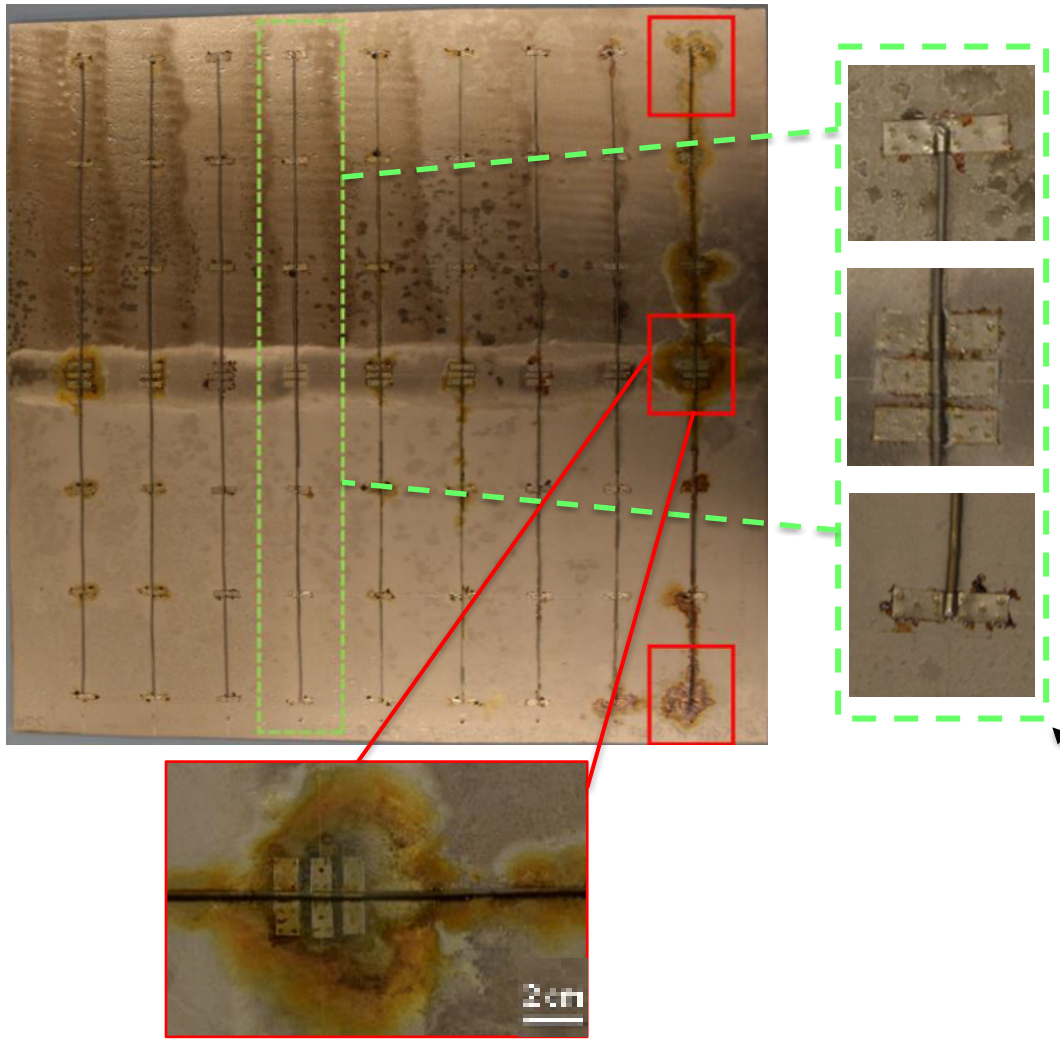
Deposition Model of 40 kW Canister
S. Suffield (PNNL)



- Current canister deposition sampling conducted remotely
  - Efficiency of robotic sampling is unknown
- CDFD sampling to use manual sampling
  - Ensures quantitative salt collection
  - Impossible for canisters loaded with SNF
  - Identified 29* sample locations
  - Support deposition modeling being performed at PNNL
  - Bounding conditions for SCC experiments

*Some locations may not be accessible

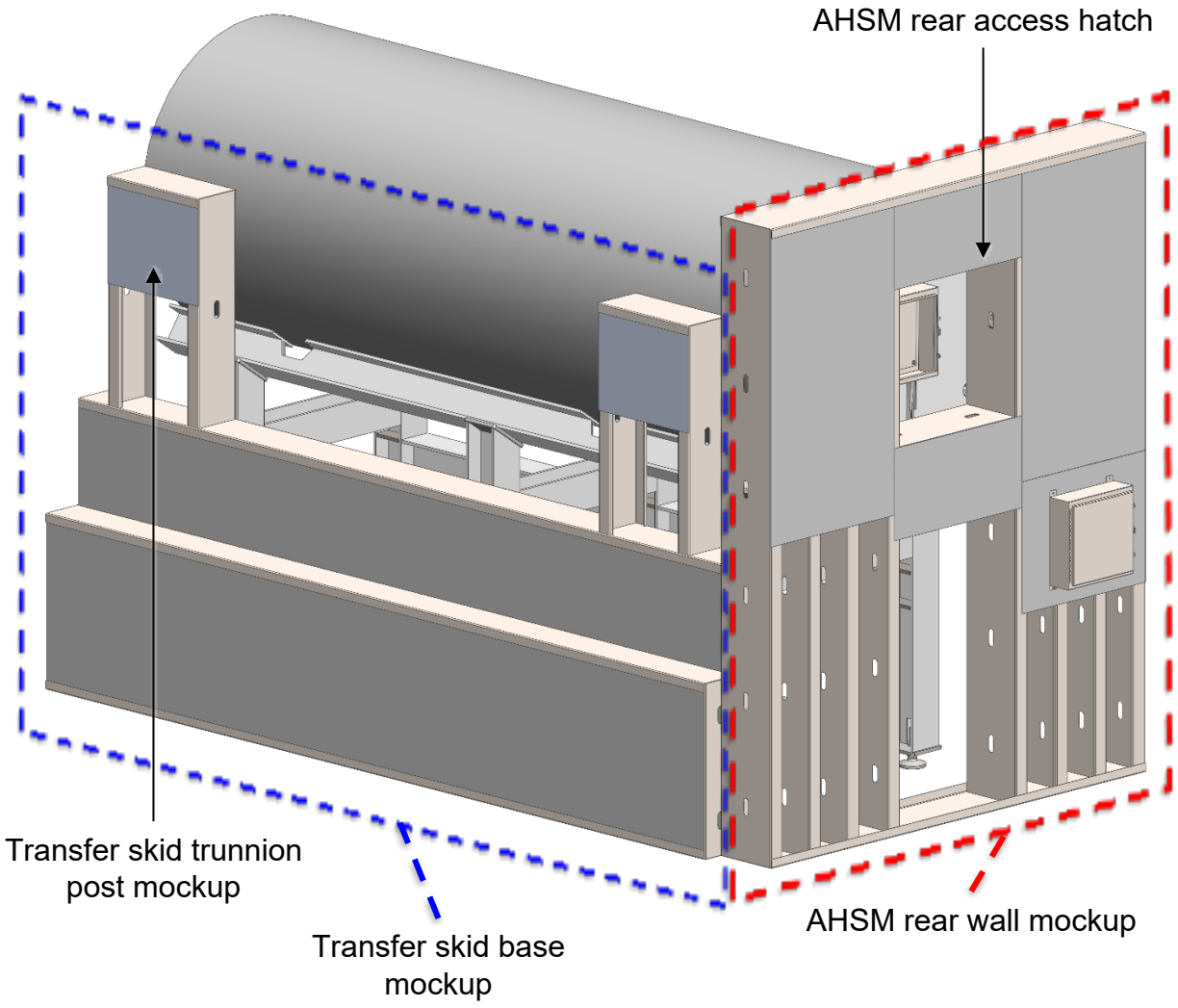
Thermocouples for Marking Sampling Locations



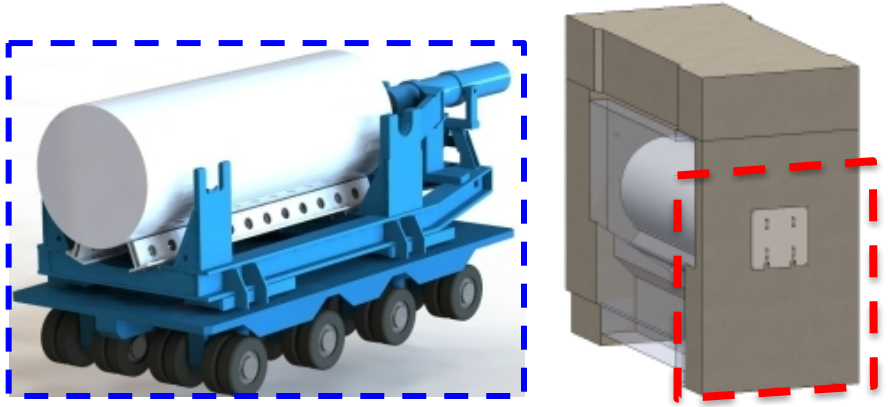
- Thermocouples for surface temperatures and as indicators for deposition sampling regions
  - Surface scribing, enamels, and blackening agents also considered
- Currently under investigation for corrosion resistance
  - Mockup plate designed to test TC wires, shims, and spot welds
    - Various materials, cutting techniques, and surface roughness
  - Accelerated corrosion testing with high relative humidity (RH) and salt concentrations
    - Stainless steel shims and TCs had the least severe corrosion response

Schaller, R. *et al.*, *FY22 Status Update: SNF Interim Storage Canister Corrosion and Surface Environment Investigations*. 2022, Sandia National Laboratories: Albuquerque, NM. p. 66-67.

AHSM and Transfer Skid Mockups



- Gain working experience and develop operating procedures
  - Sampling: Canister on transfer skid
  - Transition from Insertion/Extraction: Canister inside AHSM
- Equipment and procedures to be finalized for the testing team
- Sampling team working at actual height with realistic obstacles
  - Sample locations will be assessed to determine feasibility



Summary

- 3× NUHOMS® 32PTH2 canisters furnished by DOE/NE-8
  - 35 heater assemblies received
    - Instrumentation and loading started
  - Preliminary heater tests from 4.8 to 35 kW
    - Data and measurements incorporated into steady state thermal modeling
      - Ongoing efforts for transient modeling at PNNL
- Test layout designed for AHSMs and dry storage canisters
  - Located at site of interest
- AHSM and transfer skid mockups under construction
  - Equipment and operating procedures to be finalized
    - Hand sampling and insertion/extraction