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**Materials Research Pathway Lead**

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# **Materials Research Pathway**

**2024 LWRS Program Spring Review Meeting**

**April 30 – May 1, 2024**



# Objective

Provide data and methods to assess performance, damage, and mitigation options for systems, structures, and components that are essential to safe and sustainable operation of nuclear power plants



# Approaches

1. Measurement of degradation
2. Mechanisms of degradation
3. Modeling and simulation
4. Monitoring degradation
5. Mitigation strategies
6. Materials harvesting

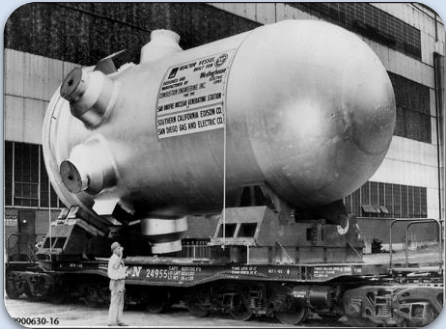


# Outcomes

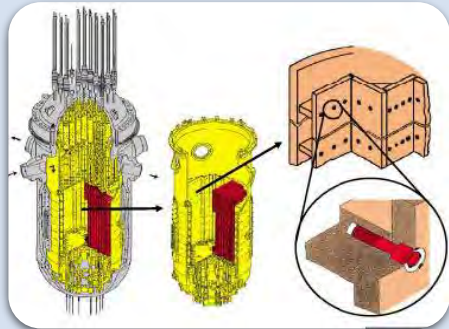
- Reduce uncertainty
- Increase operational efficiency
- Assess potential damage
- Reduce outage risk and inspection frequency
- Reduce operation costs and improve reliability



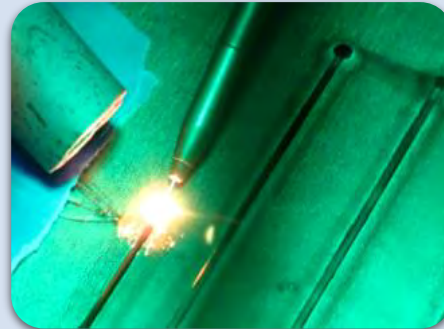
# Materials Research Areas



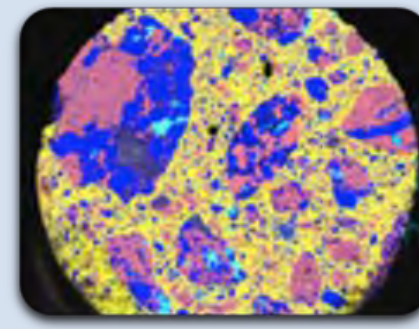
Reactor  
Pressure  
Vessel



Core  
Internals &  
Pressure  
Boundaries



Mitigation  
Technologies



Concrete  
Degradation



Cable  
Degradation

# Global Collaboration and Partnership



The Japan Concrete Aging Management Program (JCAMP) and more

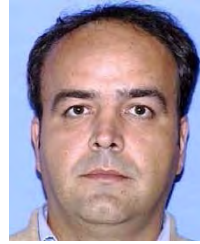
## Metals and mitigation



**M. Sokolov**  
RPV



**Z. Zhai**  
Ni-alloy SCC



**B. Alexandreanu**  
Ni-alloy SCC & EAF



**G. Was**  
IASCC



**M. Gushev**  
IASCC



**G. Sant**  
IASCC



**T. Lach**  
Baffle bolt PIE



**J. Chen**  
Weld repair



**X. Chen**  
Harvesting

## Concrete degradation



**Y. Le Pape**  
Concrete performance  
PRA of CBS



**E. Tajuelo**  
Irradiated concrete  
Harvesting



**S. Sabatino**  
Concrete NDE

## Cable degradation



**L. Fifield**  
Cable aging and gap analysis



**B. Glass**  
Cable NDE

## Emerging areas



**J. Jun**



**J. Keiser**

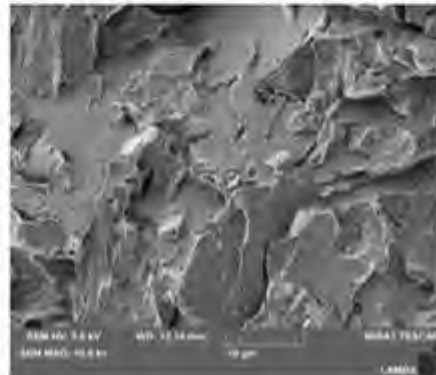
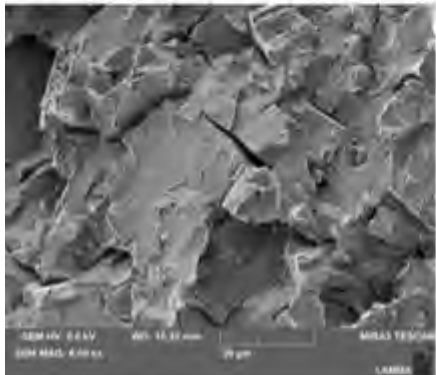
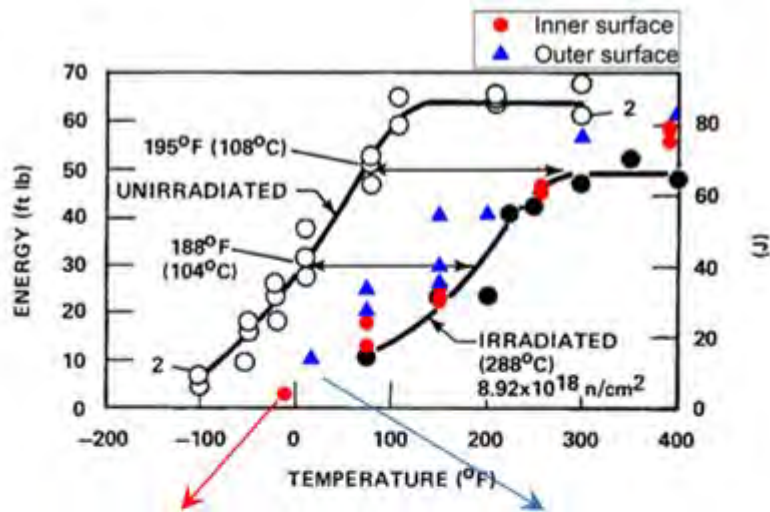
Selective leaching



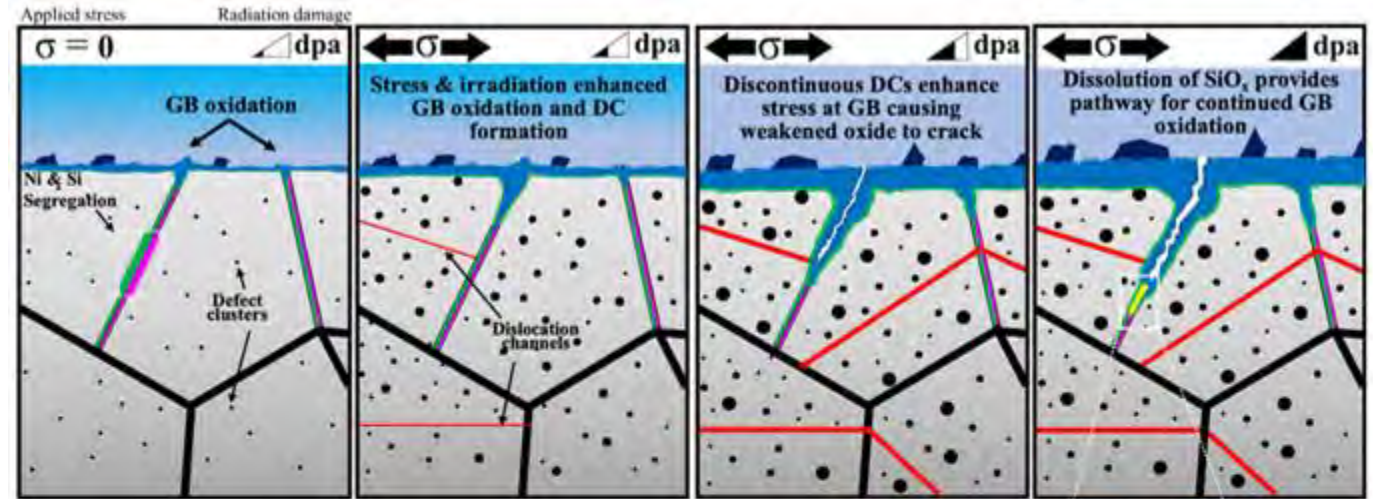
**X. Chen**

Ice condenser  
Operation beyond 80

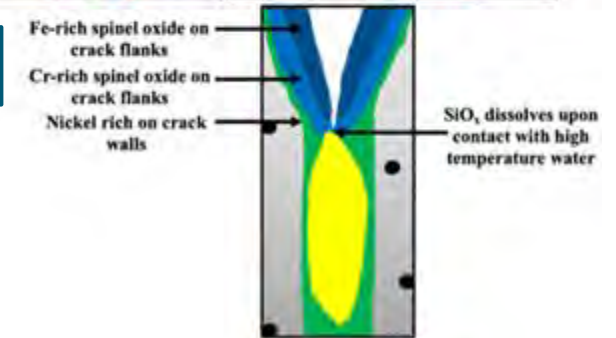
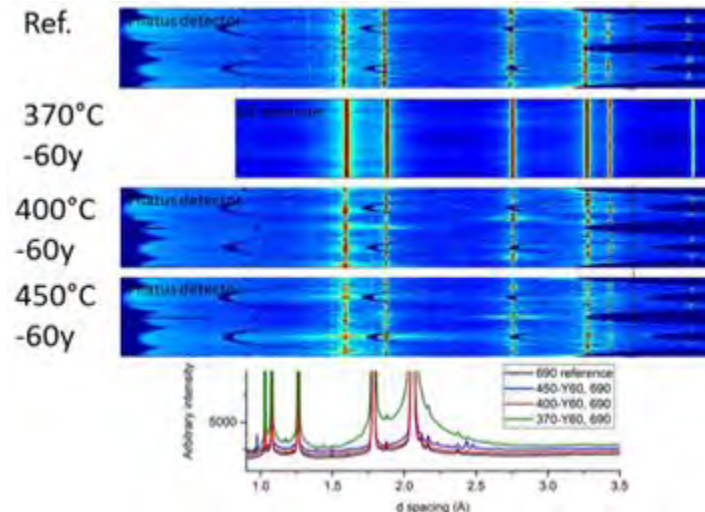
## High fluence effect on RPV



## Mechanism of irradiation-assisted stress corrosion cracking

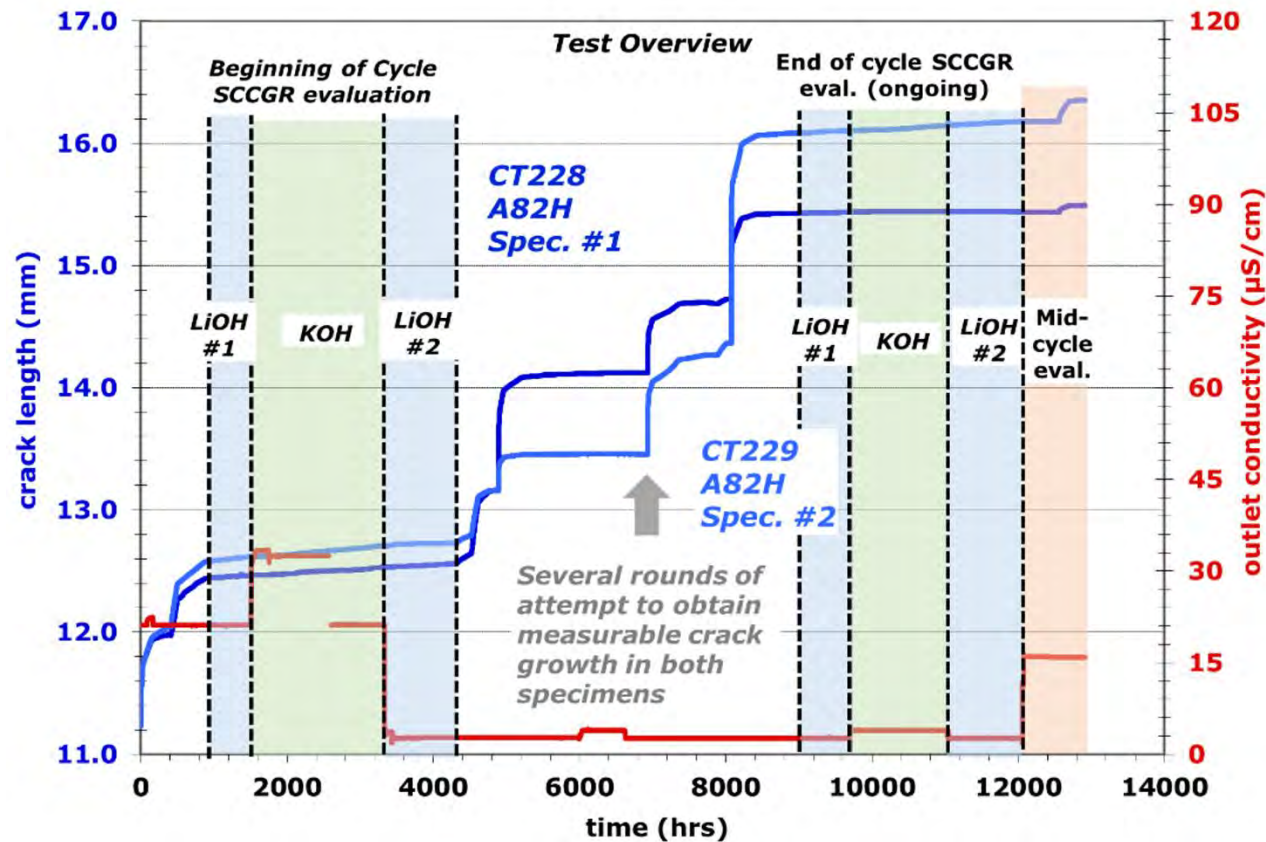


## Long-term thermal aging of alloy 690

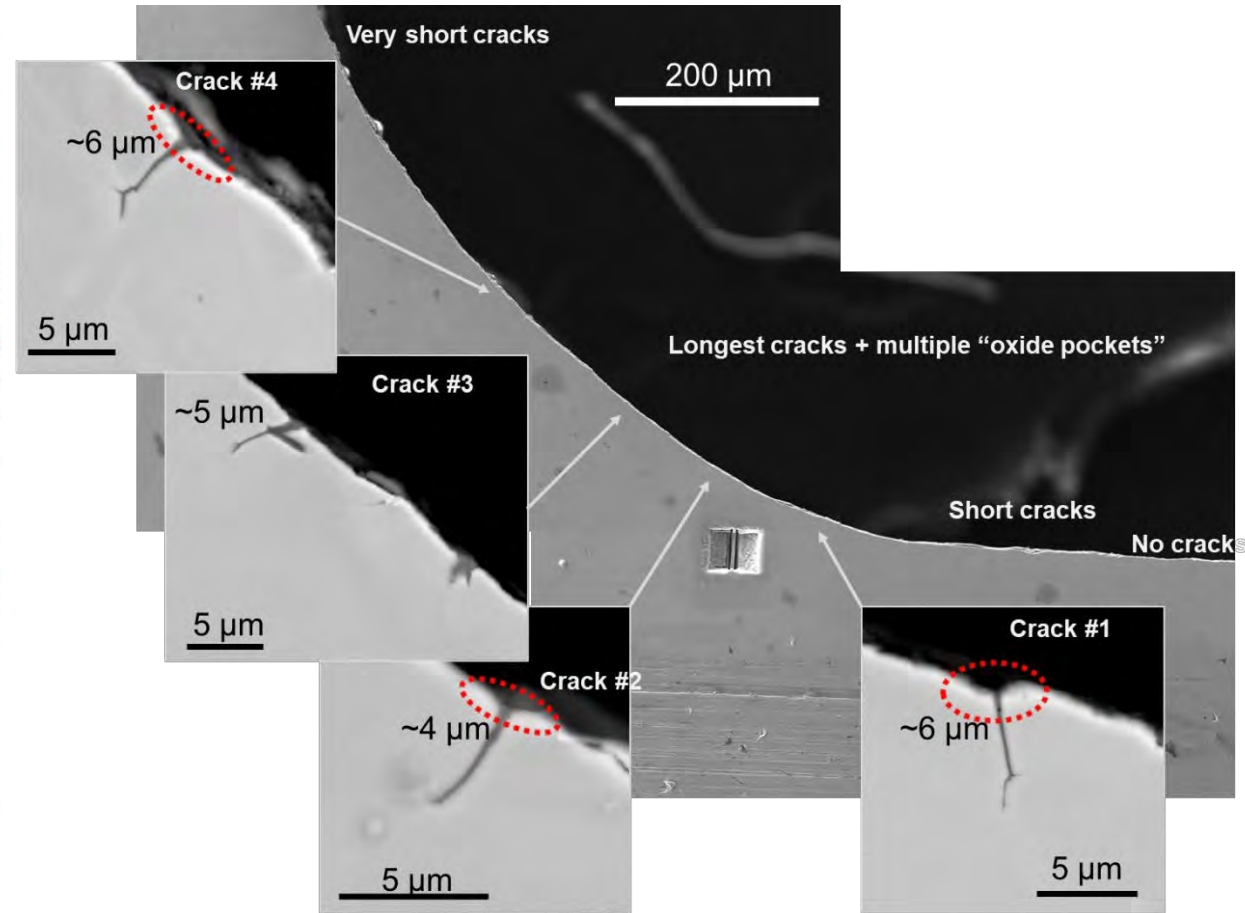




## Stress corrosion cracking of metal alloys



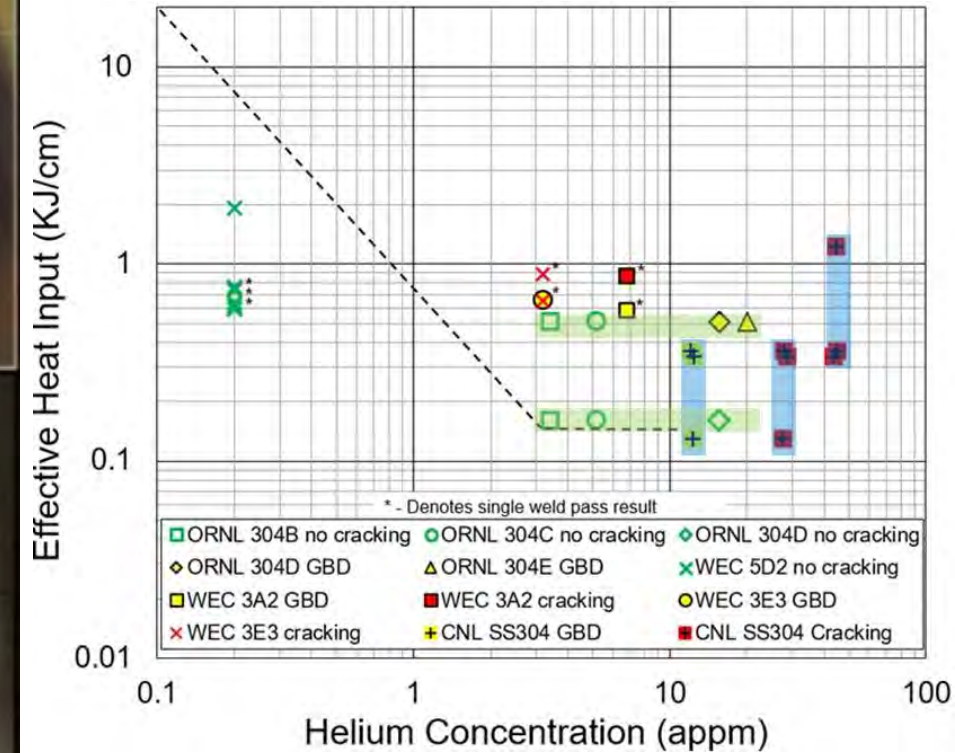
## Characterization of harvested baffle former bolts



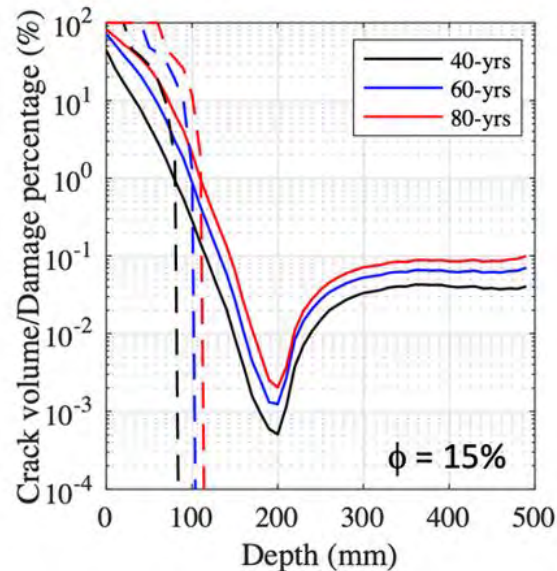
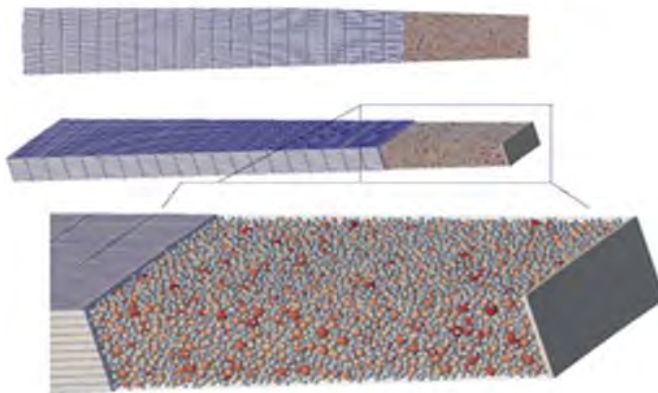
## RPV surveillance capsule harvesting



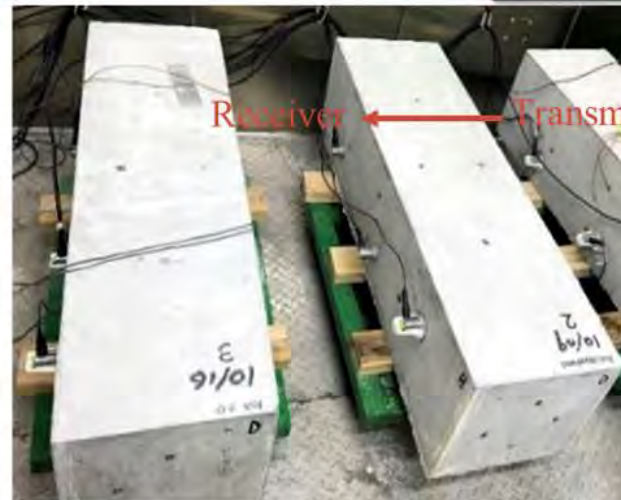
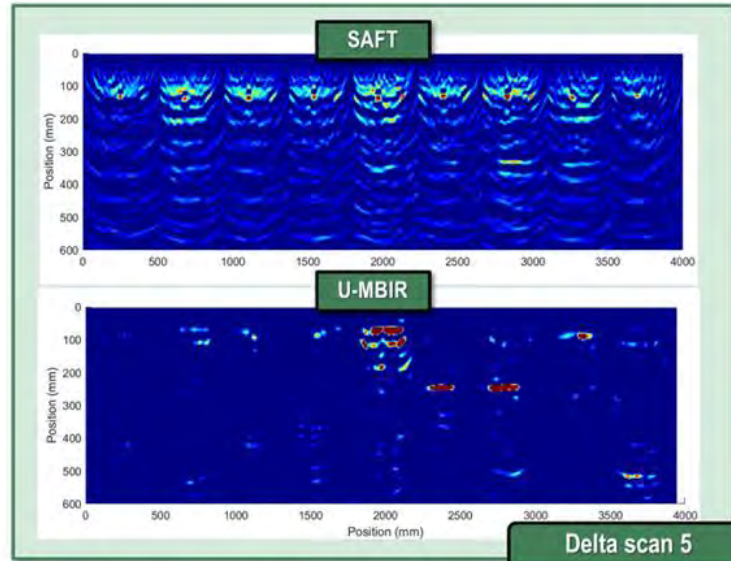
## Weld repair on irradiated stainless steels and Ni alloys



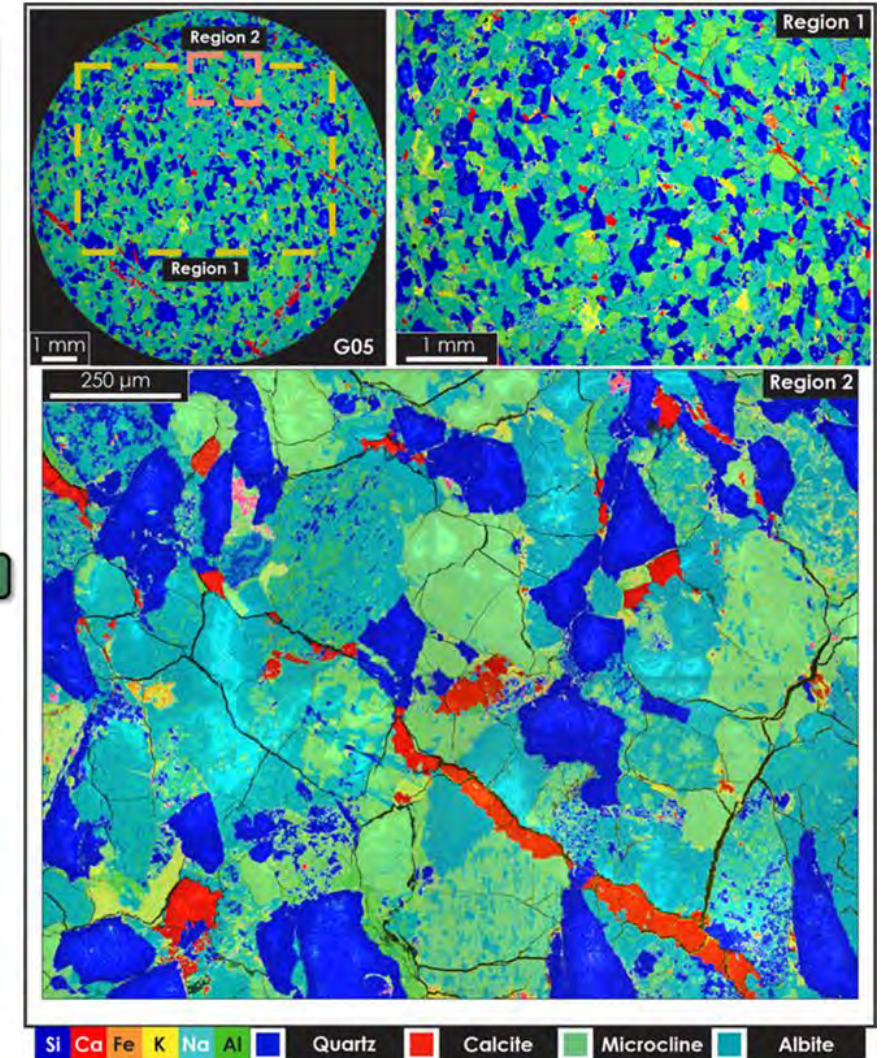
## Modeling and simulation of irradiated concrete



## Concrete NDE



## Irradiated concrete



## Cable aging research



**MAaD Science**  
Materials Aging and  
Detection Science  
@PNNL

- Accelerated Aging
- Polymer Testing & Characterization
- Advanced Data Analysis
- Performance Prediction

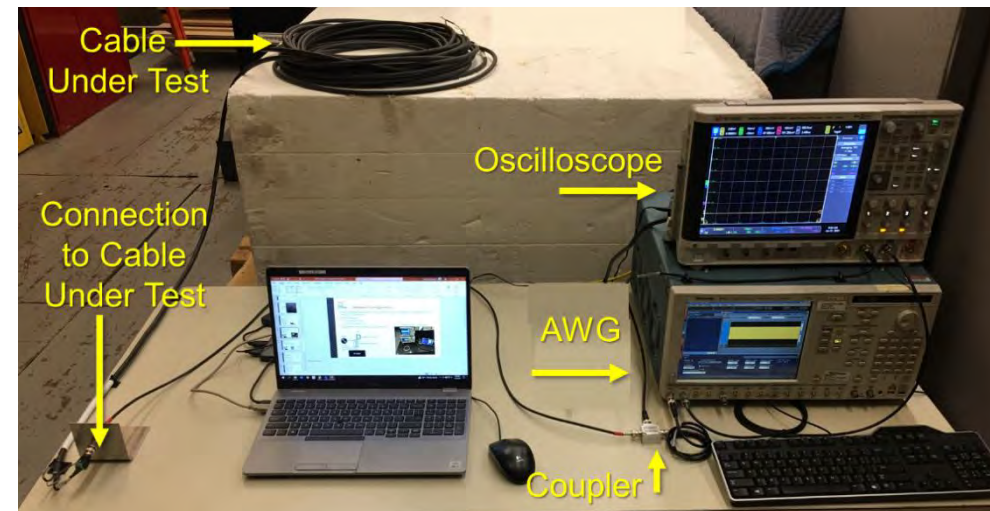


**ARENA**  
Accelerated and Real-Time  
Environmental Nodal Assessment  
@PNNL

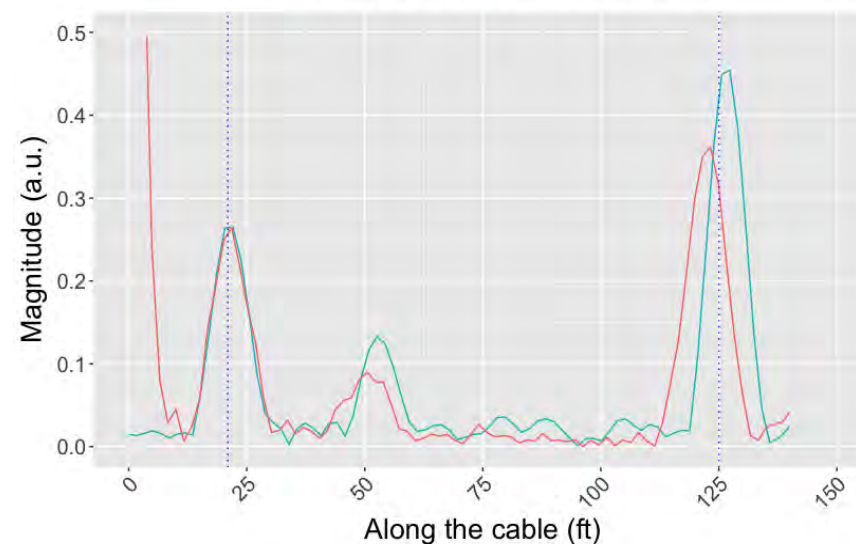
- Non-destructive Evaluation
- Condition Assessment
- Online Monitoring
- Digital & Physical Twins



## Cable NDE and online monitoring

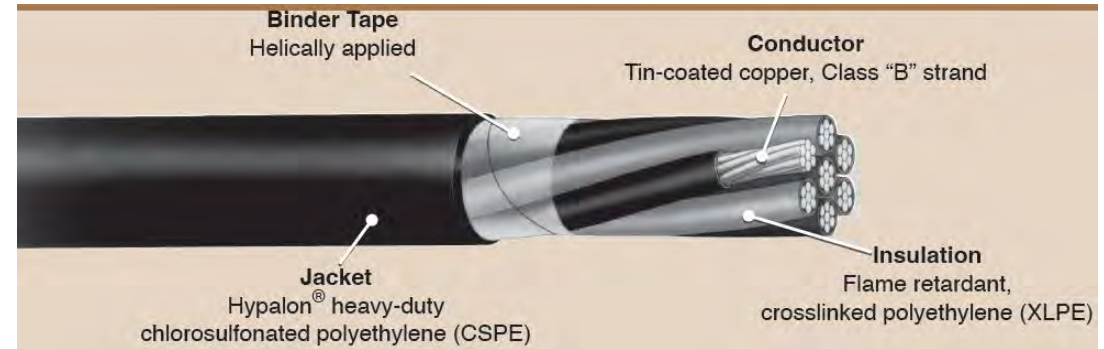


LiveWire, 48 MHz    PNNL SSTDR, 50 MHz



## DecaBDE Response Team received DOE Secretary's Honor Achievement Award

The team's efforts have been pivotal in navigating the complex challenges posed by environmental regulations on the nuclear industry. The Environmental Protection Agency's ruling on the manufacturing, processing, and distribution of DecaBDE, a flame retardant used in wire and cable insulation, necessitated a swift and effective response to ensure compliance while maintaining the integrity of critical infrastructure. The team's work underscores the importance of interdisciplinary collaboration in addressing environmental concerns within highly technical and regulated industries.



RSCC Firewall<sup>®</sup> III control cable



U.S. DEPARTMENT OF  
**ENERGY**



A. Hahn

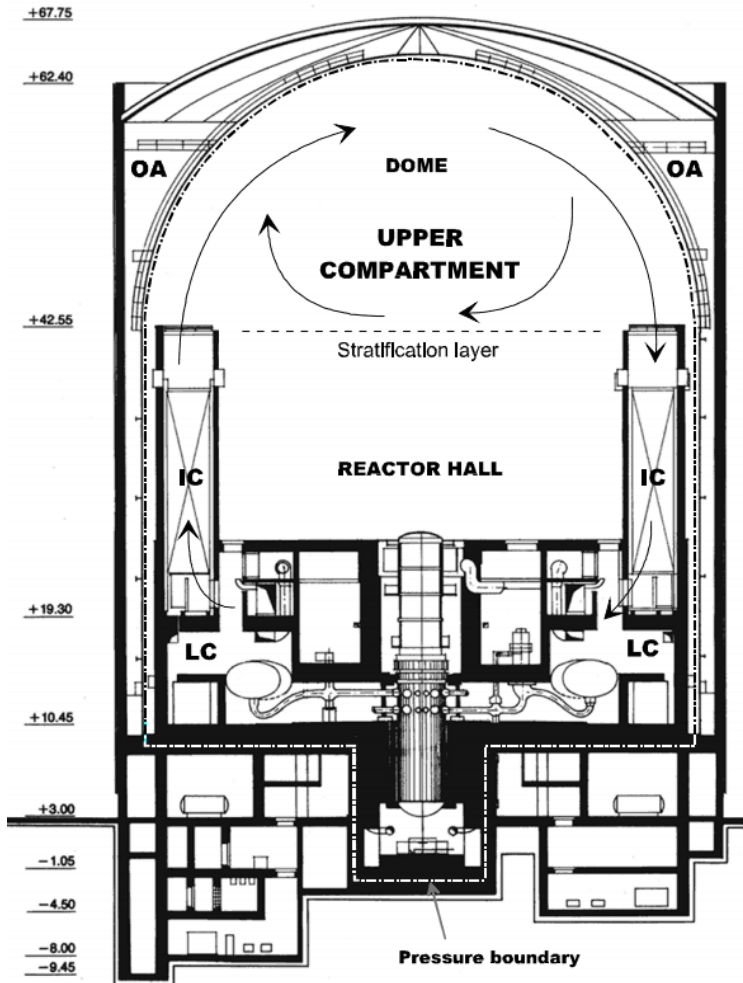


B. Hallbert



X. Chen

## PWR Ice condenser replacement



Schematic of the containment building

### Considerations for Replacement of Ice Condensers with Endothermic Materials

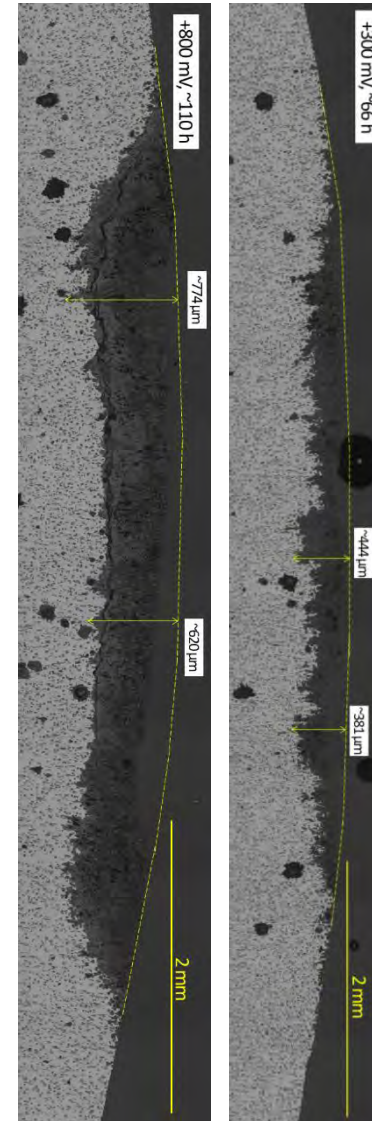
ORNL/TM-2023/3010



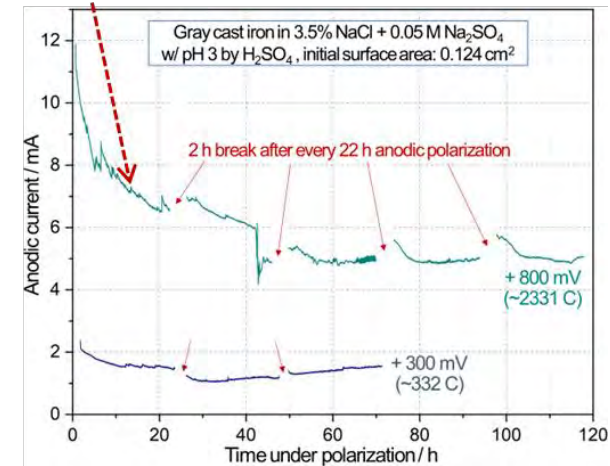
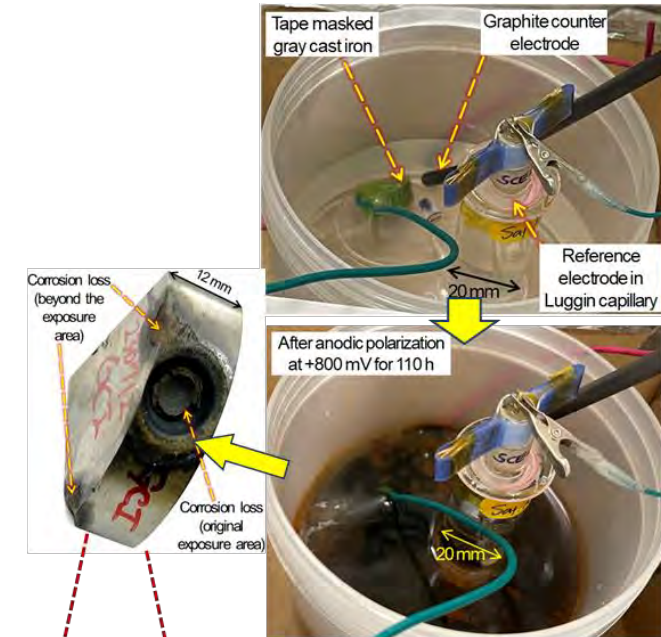
Adrian S. Sabau  
Jiheon Jun  
Xiao-Ying Yu  
Xiang (Frank) Chen  
September 2023

**OAK RIDGE**  
National Laboratory

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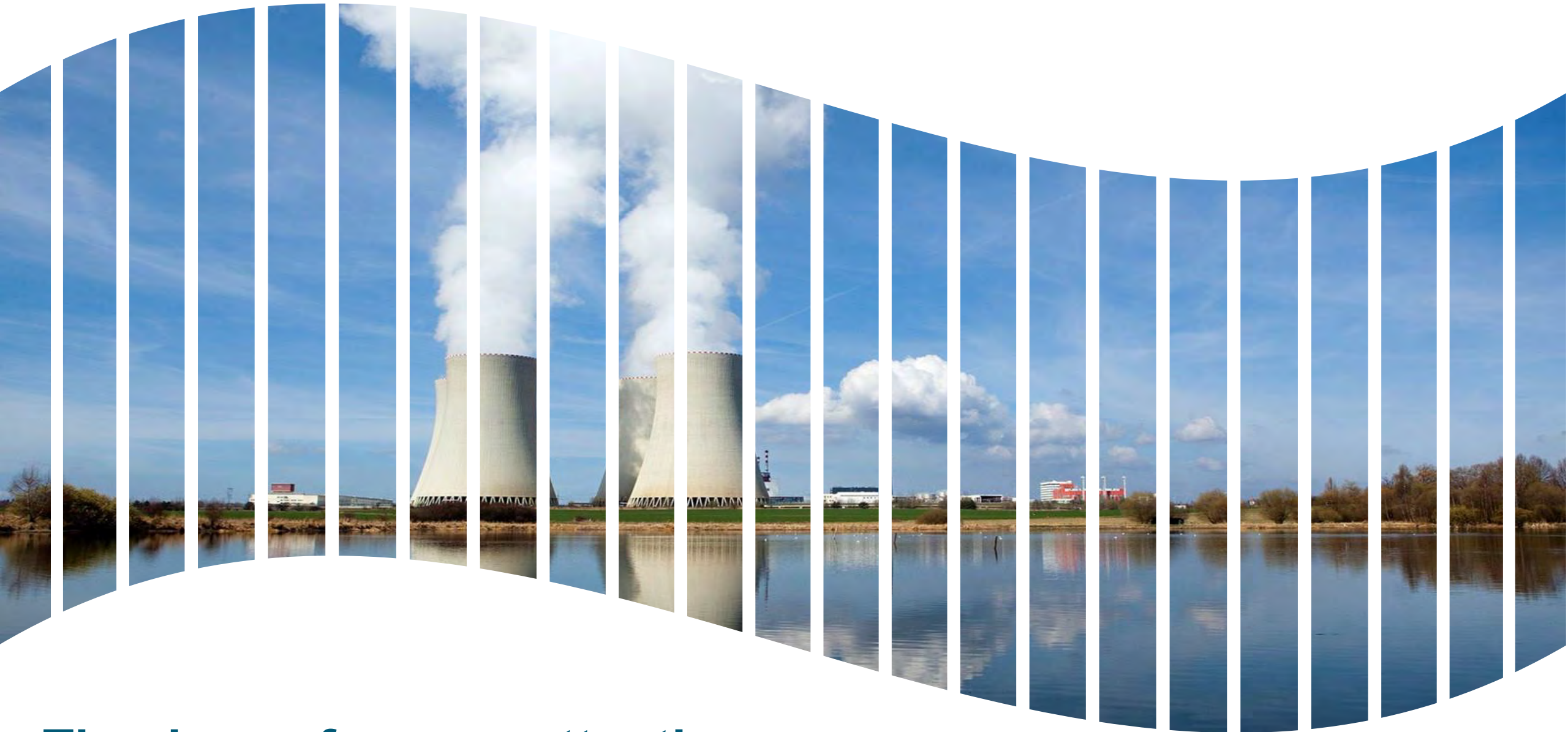
## Selective leaching



# Examples of Collaborative Activities

- **EPRI**
  - Repair welding of irradiated internals
  - Environmentally-assisted fatigue testing of additively manufactured 316L
  - Concrete NDE
  - Condition-based cable aging management
- **NRC**
  - Long-term SCC initiation testing on blunt notch high Cr Ni-based weld
  - Long-term thermal aging on performance of High-Cr Ni-based alloys
  - Concrete harvesting and testing
  - Condition-based cable aging management
- **PWROG**
  - RPV harvesting and archive material testing
  - Evaluation of ice condenser replacement
- **International**
  - Civil Nuclear Energy Research and Development Working Group (CNWG)
  - Canadian Nuclear Laboratories
  - EDF LTO





**Thank you for your attention  
Questions?**