Microreactor Program Review

Technology Maturation Technical Area

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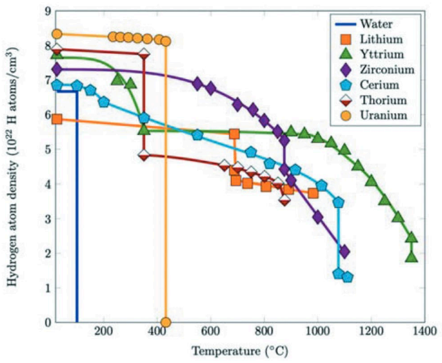
How Technology Maturation Meets Program Objectives

- Through cross-cutting research and development and technology demonstration support, achieve technological breakthroughs for key features of microreactors, examine:
  - Moderation to reduce required fuel mass
  - Microreactor Automated Control System to move control material in response to reactivity changes
  - Advanced heat transfer to remove heat from a microreactor core
- Meet critical R&D needs of existing developers that require national lab or university expertise or capabilities.
  - Develop containment mechanism to keep hydrogen within moderating material for reactivity purposes
  - Design state-of-the-art heat exchangers to transfer heat from the core to thermal energy or power production
  - Build and test non-nuclear test articles
- Develop advanced technologies and concepts for next-generation microreactor applications and systems.
  - Design and test state-of-the-art technology for the above
  - Understand structural health concerns and performance of systems using instrumentation
- Enable future microreactor applications through:
  - Coupling of the above components
  - Developing technology that vendors can eventually use

MRP Microreactor Program

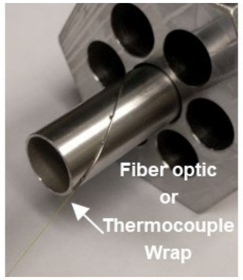
Three control areas supported

- High Temperature Moderator Material – hydrides
  - LANL (Caitlin Kohnert)
  - ANL (Latif Yacout/Sumit Bhattacharya)
  - ORNL (Kory Linton/Nedim Cinbiz)



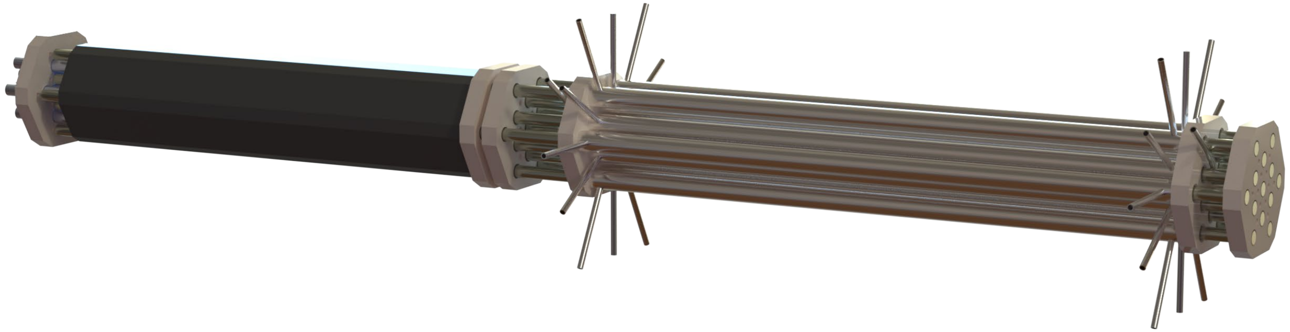
* Technical Report, ANL/CFCT-20/19 (2020)

- Instrumentation and Sensors – Microreactor Automated Control System and structural health monitoring
  - INL (Tony Crawford)
  - ORNL (Chris Petrie)
  - LANL (Paul Geimer)



(Started with stainless steel, now looking at graphite)

- Heat Transfer – graphite test article generation
  - LANL (Martin Ward)



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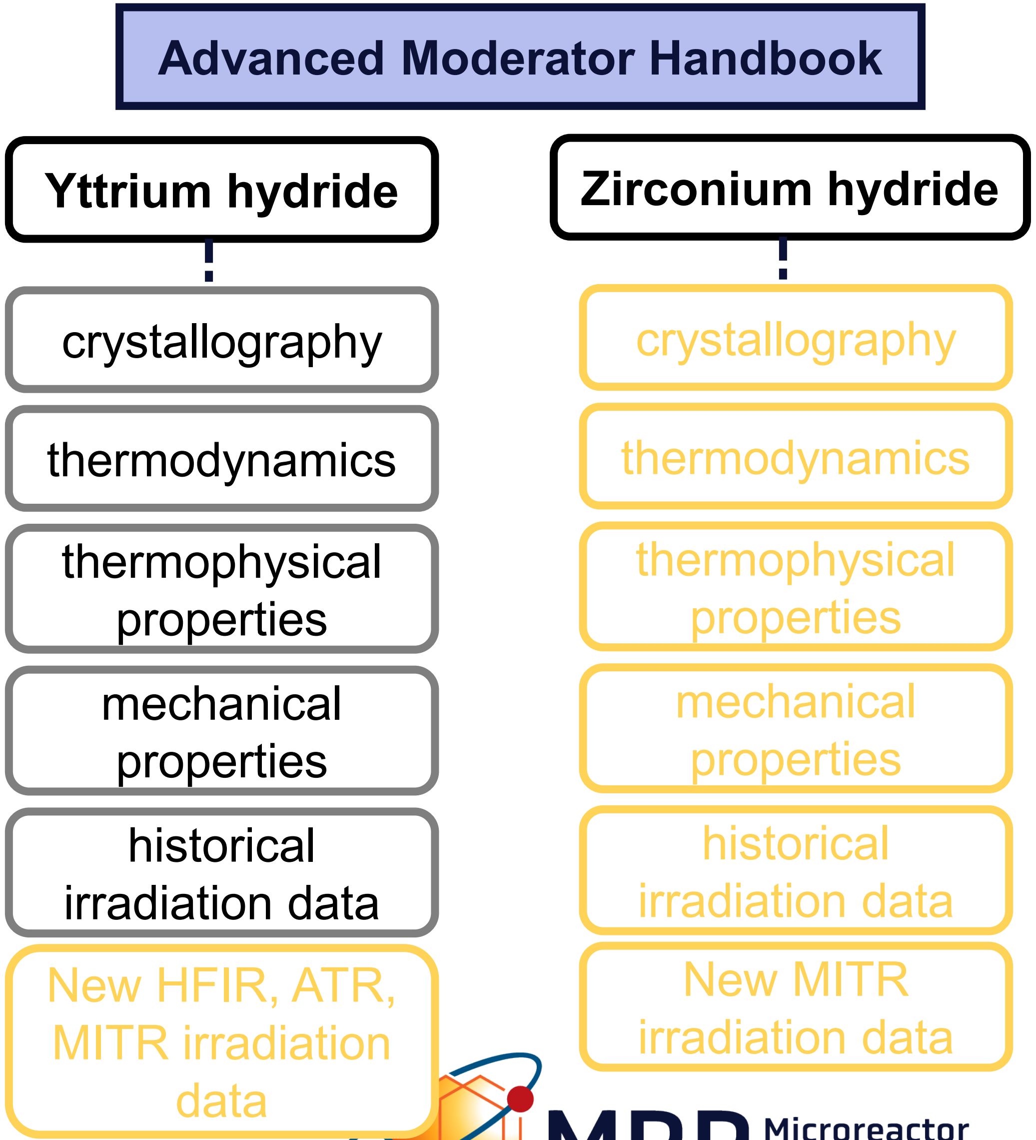
Advanced Moderator Handbook for Hydride moderators produced by LANL is being enhanced

- The goal of the Handbook is to provide scientists and reactor designers with a set of physical and thermal property data for metal hydride moderators.
- Topics included are summarized in the flow chart to the right.
- Neutronic properties included.
- Initial post-irradiation examination performance is included and more is being added.



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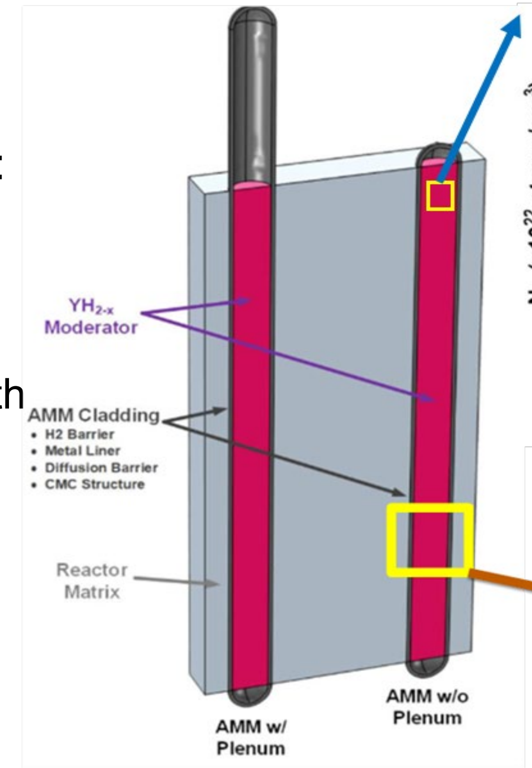
ADVANCED MODERATOR MODULE (AMM) CONCEPT

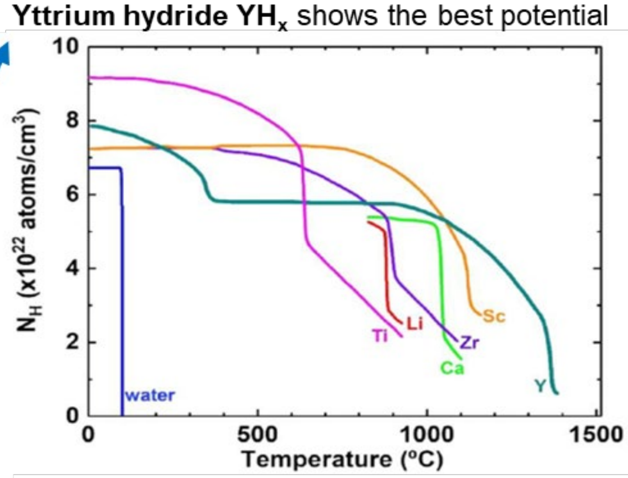
Objective: Argonne National Laboratory is developing an AMM featuring a YH_{2-x} metal hydride, encased in a niobium (Nb) liner with a permeation barrier to contain hydrogen at high temperatures, and a silicon carbide (SiC) composite cladding for structural integrity.

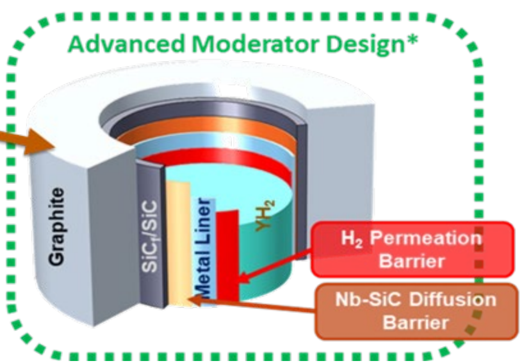
Advantages of the AMM design:

- Utilizing metal hydrides, like YH_{2-x}, allows optimal moderation
- AMM's encapsulation method promises improved performance:
  - Improved H_2 retention.
  - Reduced thermal neutron absorption compared to other approaches (e.g., SS, high temp. alloys, ..).
  - Successful deployment will support small microreactor cores with extended operational lifetimes.



AMM technology with Plenum description [1]





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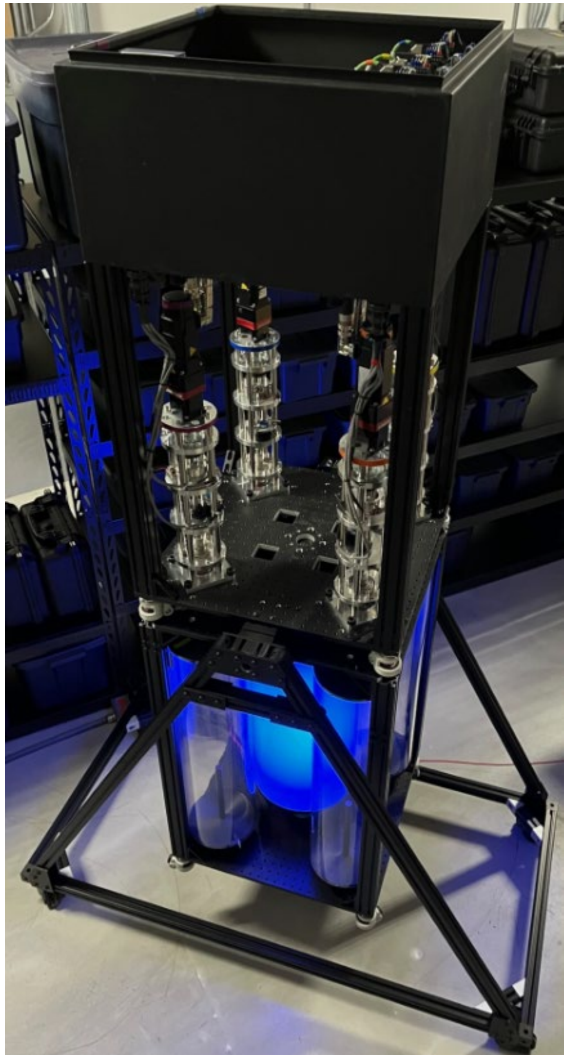
Instrumentation and Sensors - Microreactor Automatic Control System (MACS)

- **A robust, adaptable, interchangeable, hardware in the loop control platform that enables graded automation**
- Mature Microreactor control technologies to pave the way toward autonomous operation of microreactors, which is key to improve:
  - Performance
  - Operational efficiency
  - Cost competitiveness
- MACS helps advance microreactor instrumentation technology by enabling one to optimize:
  - Parameter, and thus sensor, selection
  - Communication architectures and
  - Optimize placement
- Visual Benign Reactor as Analog for Nuclear Testing (ViBRANT) is used as an example

MACS/ViBRANT's agile development and reactor surrogate processes produce high quality project faster



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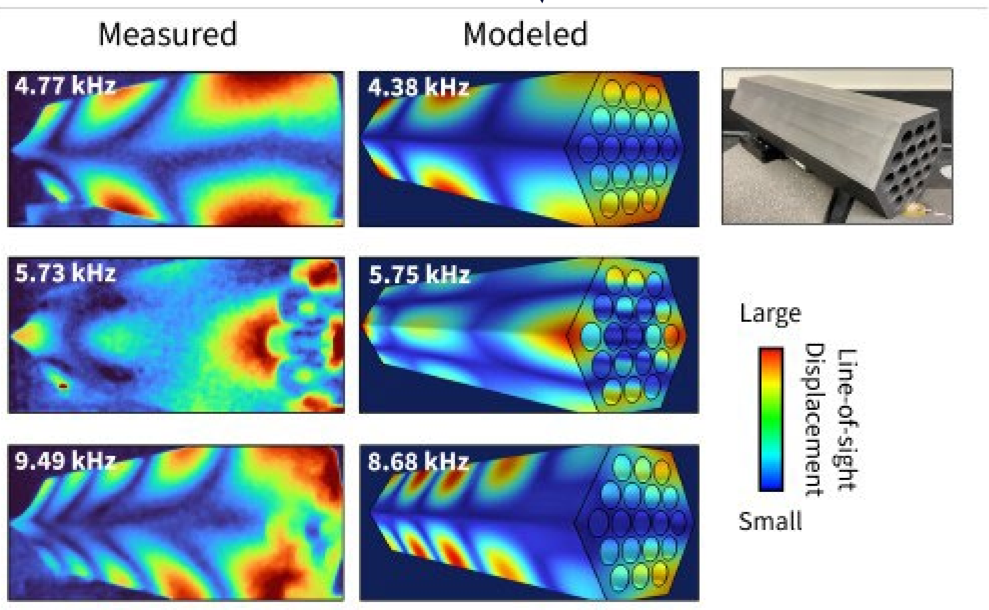
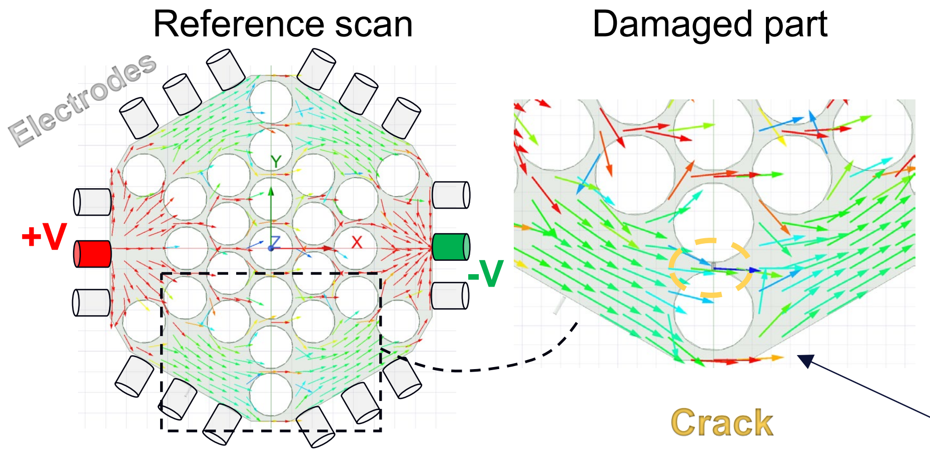
Structural Health Monitoring

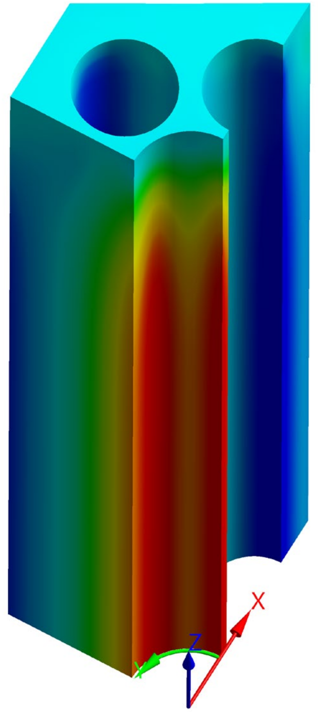
- Electrical impedance tomography (EIT) used for measuring graphite stresses and damage localization in graphite microreactor components.
- Laser Doppler Vibrometer measurements can determine defects in structural materials (see graphite test article below).





Current paths during measurements of impedances between electrode pairs

Graphite stresses



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