U.S. DEPARTMENT OF ENERGY | Nuclear Energy

Advanced Test Reactor National Scientific User Facility

J. Rory Kennedy, Ph.D.
Director, ATR NSUF
Idaho National Laboratory

Nuclear Academics Discussion Meeting
Leeds, United Kingdom
September 3, 2014

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Purpose of the ATR NSUF

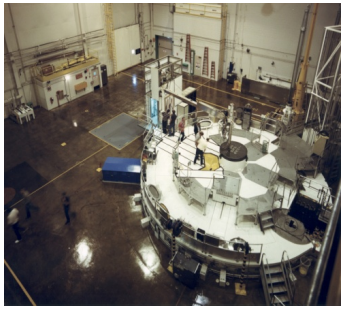
- **The research performed to support nuclear energy development requires specialized (expensive) and increasingly rare capabilities**
  - High flux reactors
  - Hot cells
  - Support infrastructure (shipping casks, test fabrication, etc.)
  - State-of-the-Art instrumentation
- **But also intellectual capital**
  - Universities
  - Nuclear industry
  - Innovative small businesses
  - National laboratories

- ***The ATR NSUF aims to merge the national nuclear research infrastructure with intellectual capital to pair the best ideas with needed capability***
- ***The ATR NSUF offers access to capabilities and expertise at no cost to the user. The NSUF can fund experiment design, fabrication, transport, irradiation, and post irradiation examination (PIE) activities.***
- ***The ATR NSUF does not fund user salaries, travel, or other underlying user costs.***

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

ATR NSUF Snapshot

- **Established 2007 under INL IFM funding**
- **DOE Office of Nuclear Energy first and only user facility**
- **4 types of projects:**
  - Irradiation + PIE
  - PIE only
  - "APS" (beamline at other user facilities)
  - Rapid Turnaround Experiments
- **Open competitive proposal process**
- **Non proprietary projects only**
- **University, National Laboratory, Industry, International**
- **Partner Facilities established starting in 2008 (self selection)**
  - 8 Universities
  - 3 National Laboratories (2 under consideration)
  - 1 Industrial



U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Current Partner Facilities

THE UNIVERSITY of WISCONSIN MADISON

PURDUE UNIVERSITY

ILLINOIS INSTITUTE OF TECHNOLOGY

Berkeley UNIVERSITY OF CALIFORNIA

OAK RIDGE National Laboratory

UNLV UNIVERSITY OF NEVADA LAS VEGAS

University of Michigan

Massachusetts Institute of Technology

Pacific Northwest NATIONAL LABORATORY

Westinghouse INNOVATION YOU CAN BE SURE OF

NC STATE UNIVERSITY

Partnerships bring additional capabilities to the ATR NSUF, offer collaborative opportunities beyond the INL and form a foundation for nuclear research that reaches across the U.S.

2013 and into 2014 has seen continued growth with the addition of our first industry partner.

Rapid Turnaround Experiments are an ideal venue for these kinds of collaborative endeavors.

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

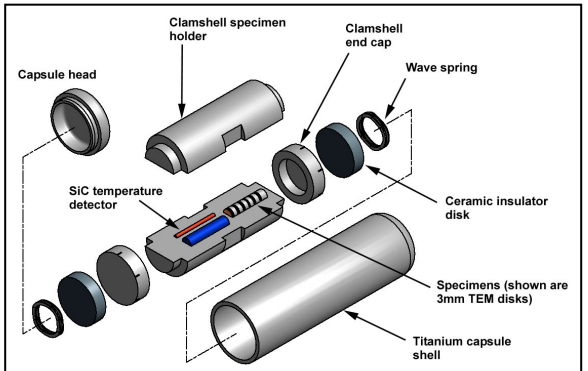
General Capabilities

- **Neutron Irradiations**
  - ATR (loop, rabbit), ATRC, HFIR (rabbit), MITR (loop), PULSTAR
- **Ion Irradiations**
  - Tandem Accelerator Ion Beam (U. Wisc), Ion Beam Lab (U. Mich)
- **Hot Cells**
  - INL(HFEF, FCF, AL, IASCC), ORNL (IFEL, IMET, REDC), PNNL (RPL), U. Mich (IMC), Westinghouse (MCOE)
- **High radiation level measurements/instrumentation**
  - Neutron radiography, elemental & isotopic analyses, gas sampling and analyses, profilometry, gamma scanning, mechanical testing, electron and optical microscopy, thermal analyses, eddy current, IASCC, EPMA, AES, XPS, SIMS, focused ion beam (FIB)
- **Low radiation level measurements/instrumentation**
  - SEM, TEM, APT, FIB, hardness, micro- & nano-indentation, tensile, thermal analyses, XRD, XPS, AES, SIMS, NMR, PAS
- **Beamlines**
  - X-ray (ANL APS: MRCAT, IIT)
  - Neutron, positron (PULSTAR, NCSU)
- **Visit atrnsuf.inl.gov under Research Capabilities tab for details at individual facilities**

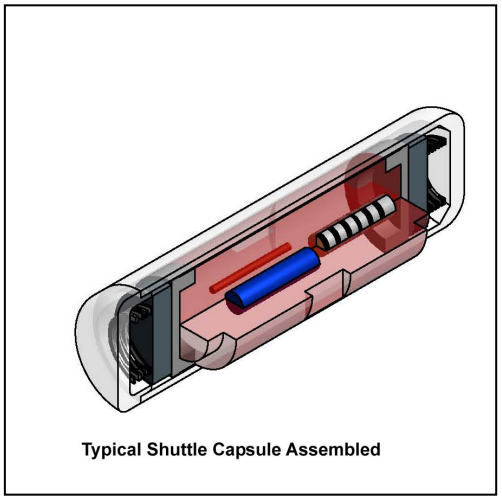
U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Specimen Library

- **Critical to reducing costs and taking advantage of new ideas and future analysis techniques and equipment.**
- **Current Library Materials**
  - ATR-NSUF reactor experiments excess samples
  - EBR-II reactor hardware
  - EBR-II surveillance samples
  - NE program samples that are no longer needed (FCRD Gas Fast Reactor (GFR) program)
  - Donated industry samples (EPRI-BOR 60 irradiated reactor structural materials)
  - FFTF core internals
  - Naval Reactors
  - LANSCE legacy accelerator production of tritium (APT) samples



Typical Shuttle Capsule - Exploded View


Typical Shuttle Capsule Assembled

U.S. DEPARTMENT OF ENERGY

Nuclear Energy

University of California, Santa Barbara 1 – Irradiation Experiment

"Characterization of the Microstructures and Mechanical Properties of Advanced Structural Alloys for Radiation Service"

Prof. G. Robert Odette, Dr. Jim Cole, INL

Scientific Goal:

- Large matrix or "Library" of samples (~1300) consisting of 39 advanced reactor structural materials. Testing conditions and sample geometries were selected to gain insight into a variety of outstanding questions on irradiation behavior in this important class of materials.

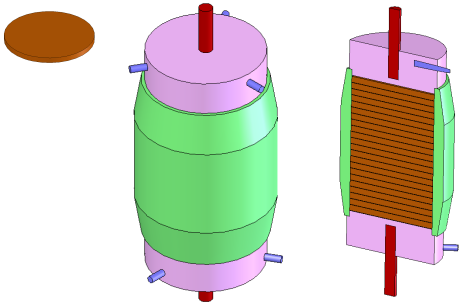
Facilities Used:

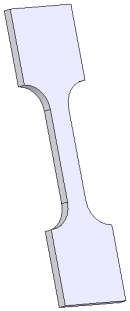
- ATR, MFC, CAES, LANL, ORNL, Oxford, UCSB, BNL

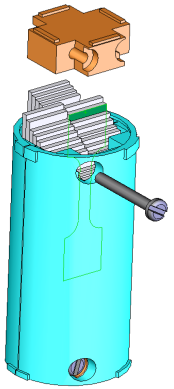
Significant Outcome:

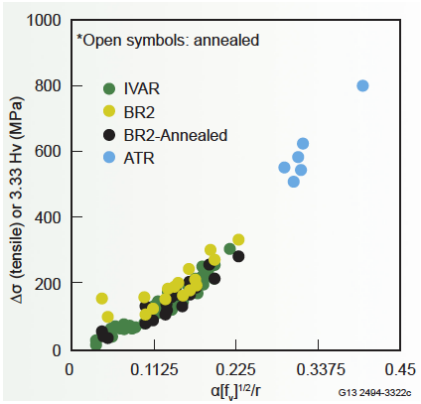
- Formation of late blooming phases in model RPV steels.
- High temperature strength and fracture behavior of SFR relevant F-M cladding alloys after irradiation.
- Radiation induced segregation behavior in model Fe-Cr alloys.
- Micromechanical behavior of FIB produced model Fe-Cr cantilevers.

Project participants also include LANL, ORNL, and PNNL

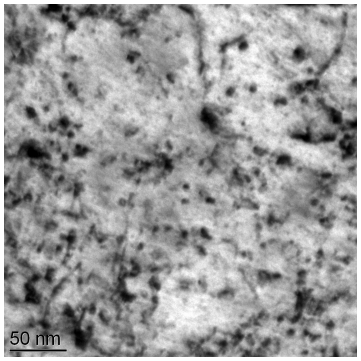








Model RPV Steels



U.S. DEPARTMENT OF ENERGY

Nuclear Energy

University of California, Berkeley – Irradiation Experiment

"Hydride LWR Fuel Rod Irradiation"

Prof. Don Olander, Prof. Mehdi Balooch, Dr. Mitch Meyer, Dr. Jim Cole, INL

Scientific Goal:

- Develop experimental U-Zr-Hydride LWR fuel with improved accident tolerance.

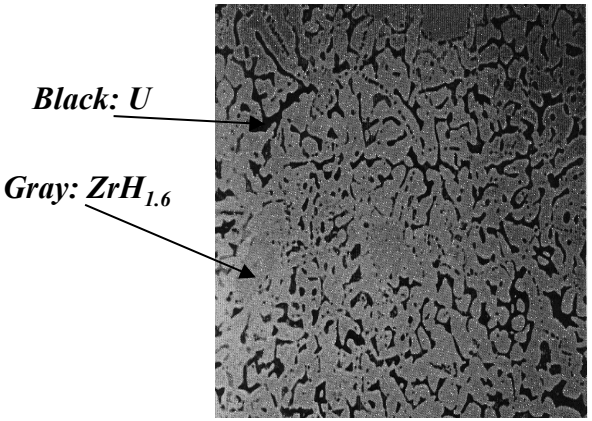
Facilities Used:

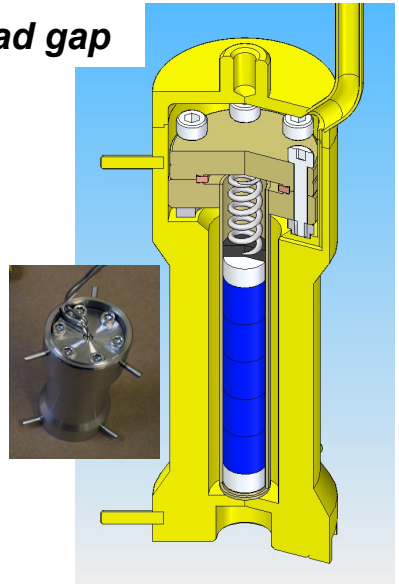
- MITR, PNNL

Significant Outcome:

- *Demonstration of partner facility concept to leverage underutilized irradiation and PIE capabilities.*
- *Achieve scientific insight into the fission gas behavior of a novel LWR fuel concept.*

Lead-bismuth eutectic in fuel clad gap





U.S. DEPARTMENT OF ENERGY

Nuclear Energy

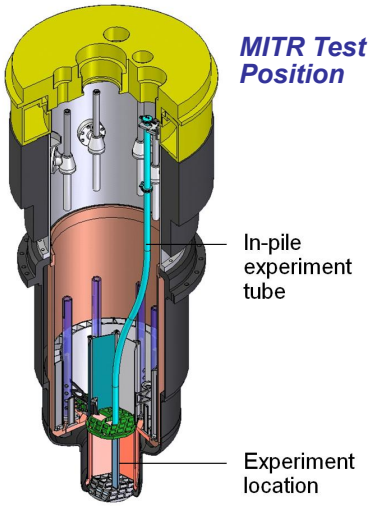
Pennsylvania State University – Irradiation Experiment

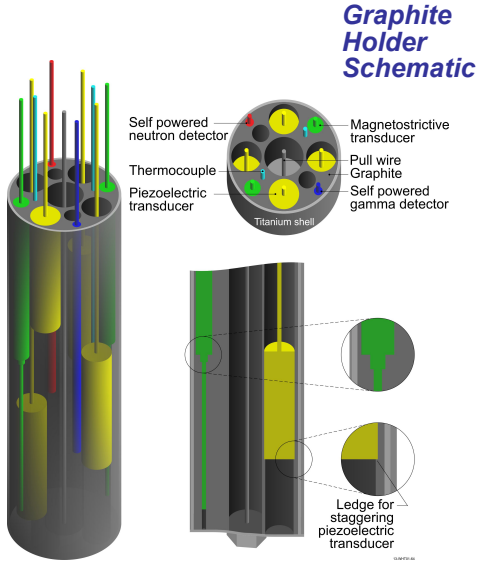
"Transducers for In-pile Ultrasonic Measurements of Fuels and Materials Evolution"

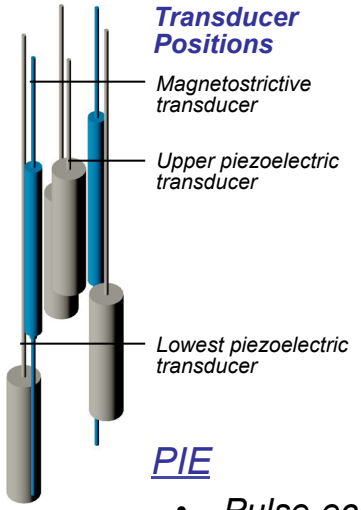
Professor Bernard Tittmann, Dr. Joy Rempe, INL

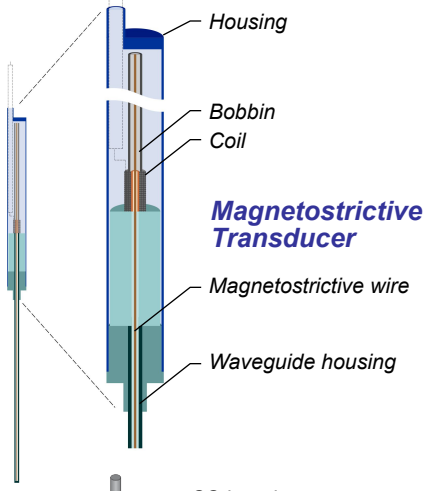
Scientific Goal:

- ***Enable in-pile use of ultrasonic sensor technologies for in-pile monitoring of wide range of parameters (temperature, fission gas composition and pressure, water level, coolant flow, dimensional changes, microstructure changes, etc.)***









Facility Used:

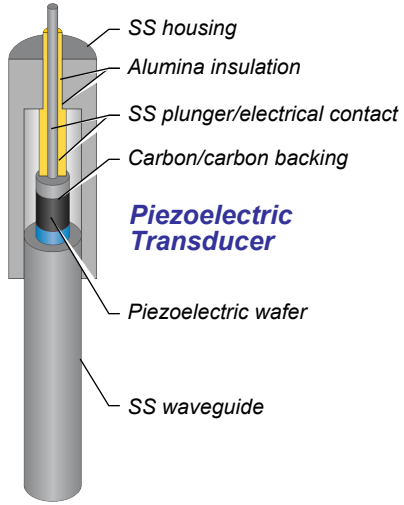
- **MIT Reactor**

Significant Outcome:

- **Development of a new class of in-pile sensors and detectors that will improve knowledge of in-reactor conditions for subsequent testing and modeling efforts.**

PIE

- *Pulse-echo*
- *Density*
- *Impedance*
- *Efficiency*
- *d_{33}*
- *Hysteresis*
- *Optical*
- *SEM*



U.S. DEPARTMENT OF ENERGY

Nuclear Energy

Idaho State University – ATR, ANL

"Measurement of Actinide Neutronic Transmutation Rates with Accelerator Mass Spectroscopy (MANTRA)"

Prof. George Imel, Dr. Gilles Youinou, INL

Scientific Goal:

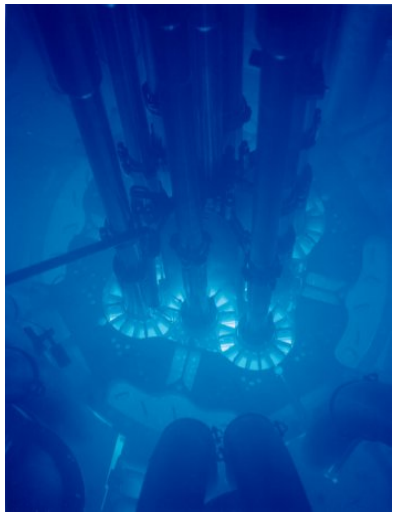
- **Infer effective neutron capture cross-sections of most actinides of interest for reactor physics in fast and epithermal neutron spectra.**

Facilities Used:

- **ATR, MFC, ATLAS AMS**

Significant Outcome:

- **First-of-a-kind nuclear data experiment for ATR which is generally used for material irradiations.**
- **First-of-a-kind PIE measurements at the ATLAS-AMS facility at ANL for this type of applications.**
- **The extreme sensitivity of the AMS should allow more information to be derived from each sample.**



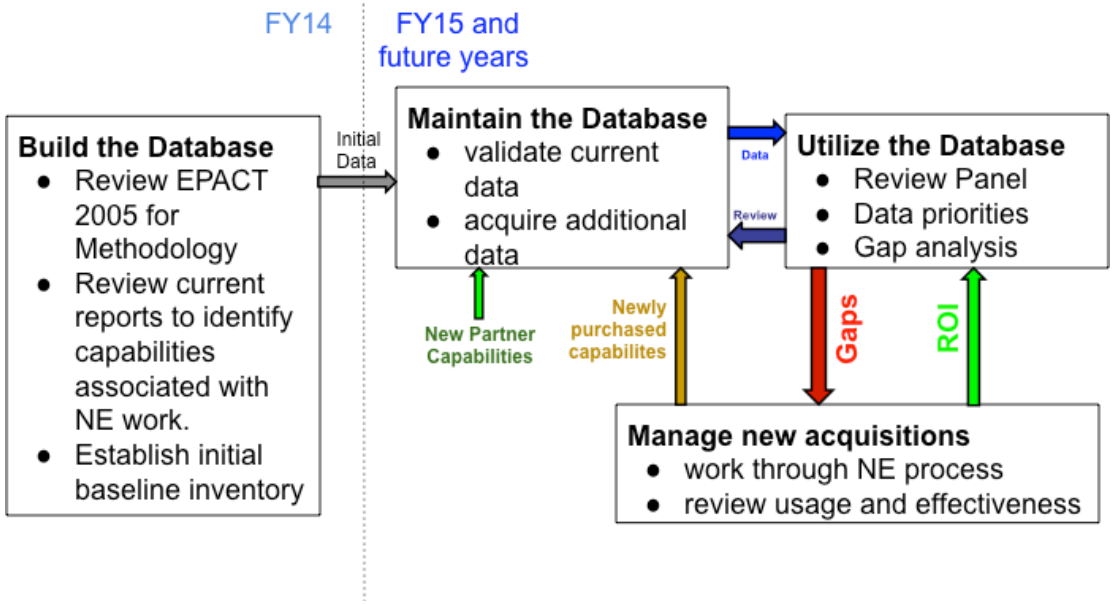
MANTRA will provide valuable information to nuclear data evaluators for years to come.

Improved nuclear data will benefit advanced modeling and simulation of future nuclear reactors and fuel cycles

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Infrastructure Initiative

- **New directive: catalogue, analyze, "manage" NE infrastructure**
- **NE has already established a formal program for managing infrastructure acquisitions with the NEUP/NEET infrastructure calls.**
  - NSUF will lead/manage this program and establish needs/priorities in call.
  - NSUF will continue to monitor acquisitions for effectiveness
- **NSUF will use database analysis to establish needs**
- **NSUF will take input from NE programs, Users Org, SRB, NEAC, ANIAC for**



- ***NSUF will collect and analyze international capabilities and perform feasibility/cost analysis of material transport vs national implementation.***

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Integrated Funding Initiative

- **Integration with NEUP/NEET funding base (effective for FY15 call)**
  - **The ATR NSUF will no longer fund user salaries, travel, or other underlying user costs (bridge funding)**
  - **NEUP/NEET will fund user salaries, travel, and other underlying user costs**
    - ***Restructure funding profile***
  - **1 call per year (with NEUP/NEET) for all but RTE projects**
  - **3 RTE calls per year**
  - **Pre-proposal stage of proposal process implemented**
  - **Single evaluation of entire scope of proposal and will include**
    - ***Letter of Intent***
    - ***Technical review***
    - ***Relevancy review***
    - ***Feasibility review***
      - **May require negotiation between proposer(s) and facilities**
      - **Will require communication and interaction with NSUF Technical Leads at earliest time (LOI)**
    - ***Firm cost estimate***

U.S. DEPARTMENT OF ENERGY

Nuclear Energy

Summary

- *ATR NSUF has the firm support of the DOE Office of Nuclear Energy.*
- *ATR NSUF continues to perform advanced studies on nuclear fuels and materials to support nuclear energy development.*
- *Variety of studies in topic, scope, complexity, cost*
- *Expanding partner facility utilization*
- *To enhance efficiency of utilization of NE invested infrastructure and advancement of nuclear energy development, NSUF will review infrastructure and potentially "manage" infrastructure.*
- *NSUF studies are integrated with NEUP/NEET studies through a single, unified proposal call and evaluation.*
- *Expansion of NSUF areas of study under consideration.*