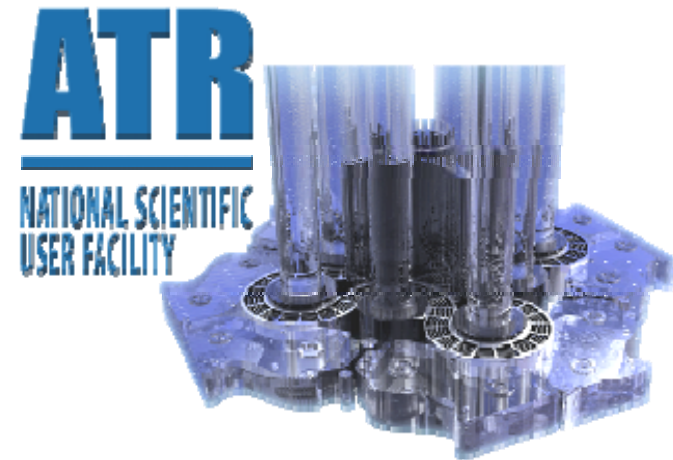


The Advanced Test Reactor National Scientific User Facility

**Mitch Meyer, Todd Allen, Frances
Marshall, Jeff Benson, Mary Catherine
Thelen**

IGORR 12, Beijing
October 2009

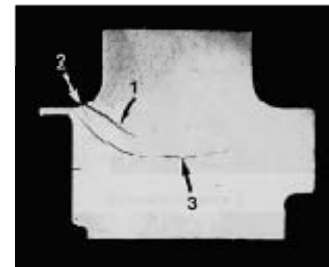
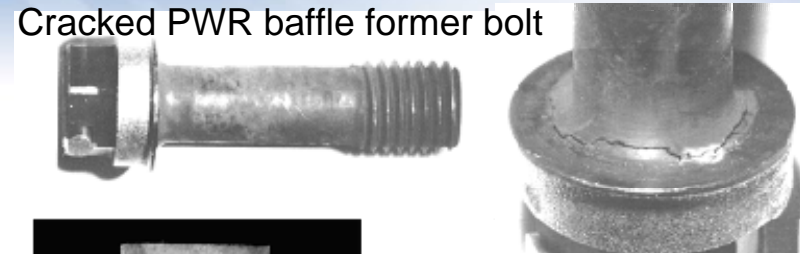
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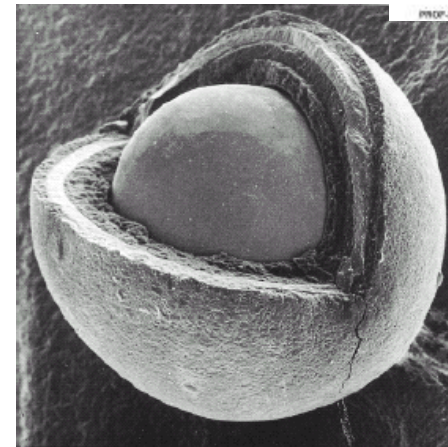
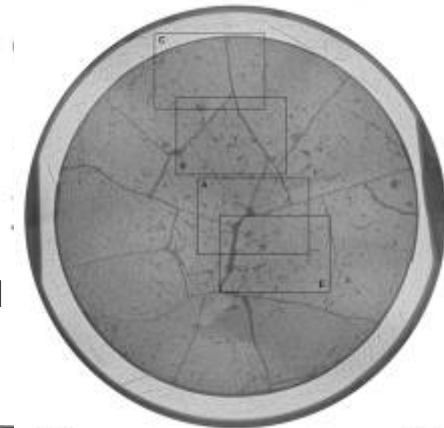
Nuclear Research Needs

- Advances in fuels/materials technology play a critical role in sustaining and advancing nuclear energy
- Life extension of current reactor fleet
 - The oldest operating reactors are now 40 years old
 - Most U.S. reactor licenses will be extended to 60 years
 - Is an 80 year life possible?
- Development of new fuels
 - Robust fuels for current LWRs
 - Transmutation of minor actinides
 - Proliferation resistant fuels
- Development of fuels and materials for next generation systems
 - **Very High Temperature Reactor (VHTR)**
 - **Sodium Fast Reactor (SFR)**
 - Supercritical Water-cooled Reactor (SCWR)
 - Gas-cooled Fast Reactor (GFR)
 - Lead Fast Reactor (LFR, SMR)
 - Molten Salt Reactor (MSR)
- **The infrastructure required to conduct nuclear energy research is not accessible to most researchers**

Cracked PWR baffle former bolt



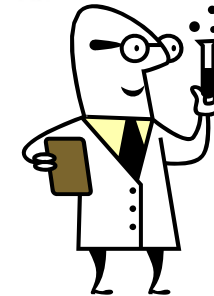
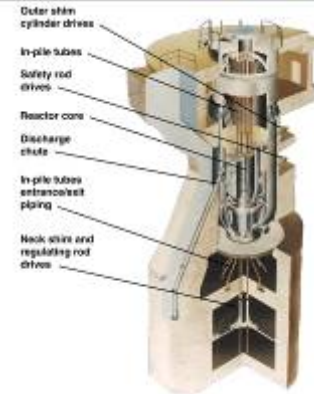
LWR Np- MOX fuel



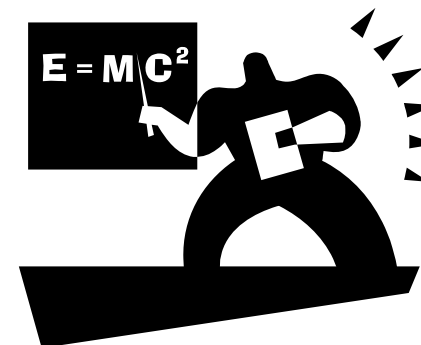
HTGR fuel

Nuclear Energy Research Infrastructure

- To perform the research required to support nuclear energy development requires specialized (expensive) capabilities
 - High flux reactor
 - Hot cells
 - Modern analytical tools applied to radioactive materials
 - Support infrastructure (shipping casks, test fabrication, etc.)
- But also intellectual capital
 - Universities
 - Nuclear industry
 - Innovative small businesses
 - National laboratories
- *User Facilities* are ideal for merging research infrastructure with intellectual capital



+



User Facilities

Regional, national or international facilities with unique experimental capabilities. Access is typically cost free through a competitive proposal process.



There are more than 60 major user facilities in the U.S.

- Advanced scientific computing research
- High flux synchrotron and neutron sources
- Electron beam characterization
- Nanoscale science
- Biological and environmental research
- High energy and nuclear physics
- Fusion energy science

.....***But there were no user facilities for radiation materials science!***

The ATR National Scientific User Facility

A means to provide the nuclear energy research community with access to the capability required to conduct cutting edge research and development

Test Reactors and Critical Facilities (ATR, ATRC, MITR, Pulstar)



Other National User Facilities (APS, SHaRE)



An Active and Engaged User Community

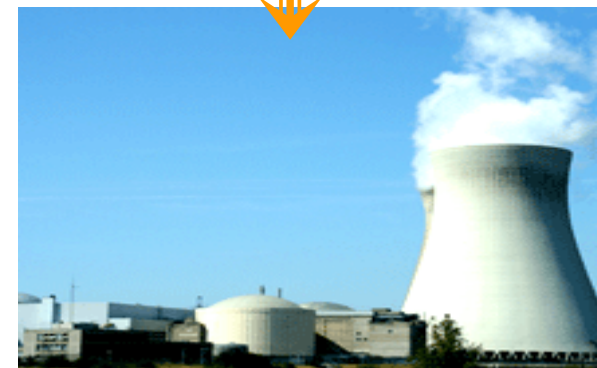
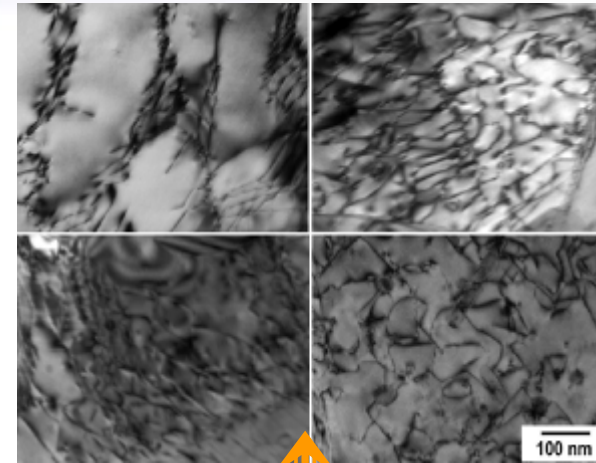


Examination Facilities (INL, MFC, UNLV, NCSU, Michigan, Wisconsin)



Key Objectives of ATR National Scientific User Facility

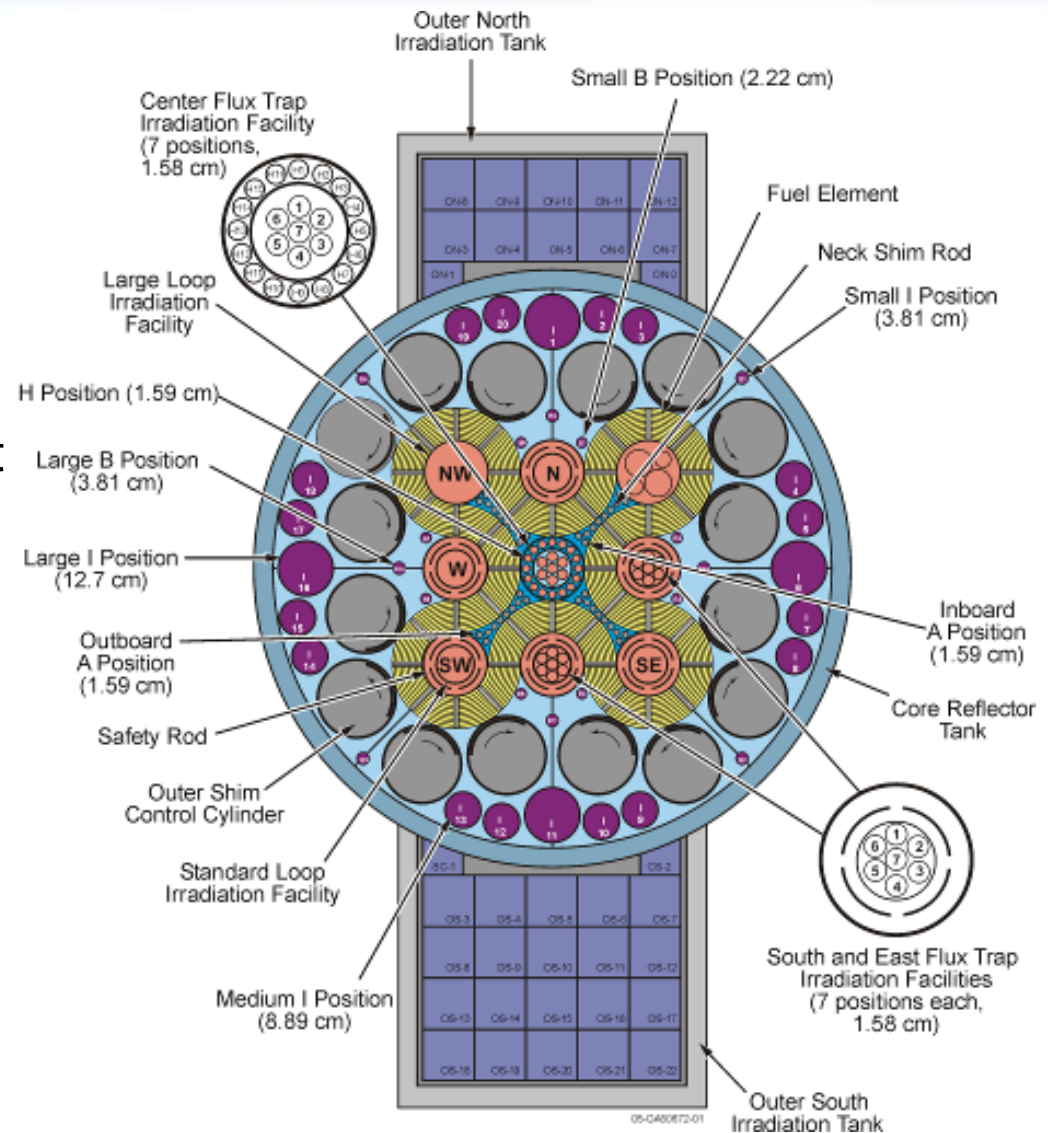
- Develop scientific understanding of irradiation behavior of new nuclear fuels and materials
- Stimulate collaborative research between user groups conducting basic and applied research
- Contribute to improved industry performance of current and future light water reactor fuels and materials
- Improve technical understanding of current and future nuclear technologies from a regulatory perspective
- Support advances in dynamic reactor modeling and simulation
- Provide essential radioisotopes for medical research and experimental treatments



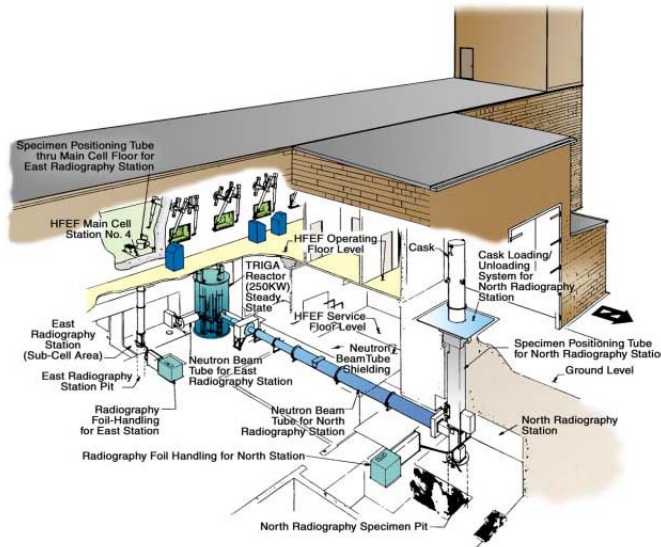
The ATR NSUF supports nuclear energy development at all levels

ATR Core Cross Section

- 250 MW_t peak power
- 77 irradiation positions:
 - 4 Flux Traps
 - 5 In-pile tubes (loops)
 - 68 in reflector
 - High flux positions in highest demand
- Approximate Peak Flux:
 - 1×10^{15} n/cm²-sec thermal
 - 5×10^{14} n/cm²-sec fast
- Test size - up to 5.0" Dia.



Hot Cell Facilities



- Partner facilities (UM, UNLV, MIT, NCSU - Google ATR NSUF for more information)
- Hot Fuel Examination Facility
 - Large argon and air cells
 - Non-destructive and destructive examination, metallography
 - Sample size reduction used for most SEM/TEM
 - Neutron radiography (TRIGA)
- Analytical Laboratory
 - Small cells set up for analytical sample prep and analysis

Access to ATR NSUF

- The ATR NSUF, like all other DOE user facilities, provides one-of-a-kind services to users whose proposals are based on technical merit
 - ***No-cost access to reactor and PIE capabilities for U.S. university-led, non-proprietary experiments***
 - ‘Basic’ irradiated material transportation services
- ATR NSUF does not approve developmental work for reactor insertion (user must “do their homework” first)
- The PIE and data reporting may be as much as 3-5 years removed from the proposal submission. The ATR NSUF works with the university to maintain adequate funding
 - “Bridge funding” for travel to the ATR NSUF and minimal on-site support at the home facility only
 - Amount of “bridge funding” is capped with exact amounts negotiated on a case-by-case basis

University Projects

- Twelve experiments in progress
 - U. Wisconsin pilot project inserted in 2008
 - Four university projects selected for ATR irradiation in 2008: University of Florida, North Carolina State, University of Illinois and University of California, Santa Barbara-1
 - First PIE-only experiment underway, University of Wisconsin
 - Two university projects selected for ATR irradiation in February 2009 (Utah State, University of California, Santa Barbara-2)
 - Two university projects selected in September 2009 (Drexel University, Idaho State University)
 - ***New User Experiment in 2010***
 - ***Offering ATR-C and Advanced Photon Source in FY2010***
- Partner Facilities
 - MIT (MIT Reactor): One 2008 (Colorado School of Mines) and one 2009 (MIT) experiment will be irradiated at MIT reactor.
 - University of Wisconsin (Characterization Lab for Irradiated Materials) University of Michigan (Irradiated Materials Testing Lab), NCSU (Pulstar Reactor), and UNLV (Electron Microscopy Laboratory).



Fifty project proposals were submitted as part of the first three solicitations

University Education Programs

- User's Week held each June
 - Fuels and materials performance course
 - Reactor experimenter's course
 - New user workshop
 - NSUF Research Forum
 - Facility tours
 - Advanced Photon Source workshop
- Next User's Week June 7-11, 2010
- Workshops at Conferences
- Summer internships, including scholarships to the Users Week and Faculty-student teams.
- Colloquium Series
- Reactor Testing Textbook

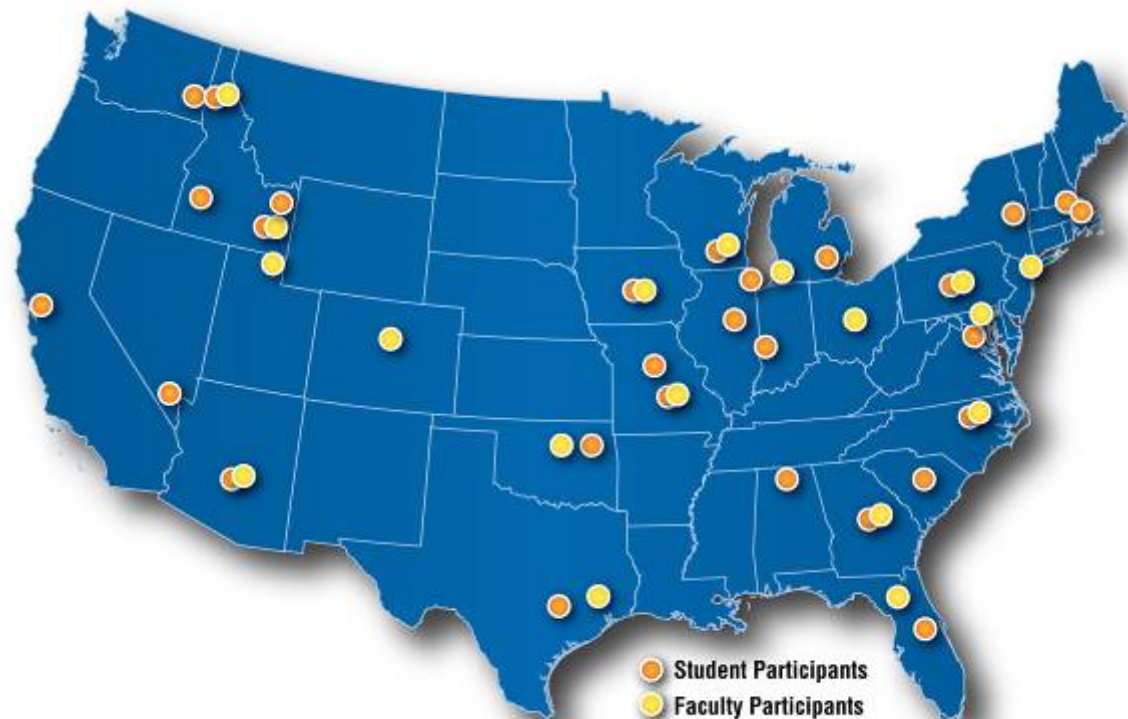


2009 User's Week Demographics

Total Attendees: 126

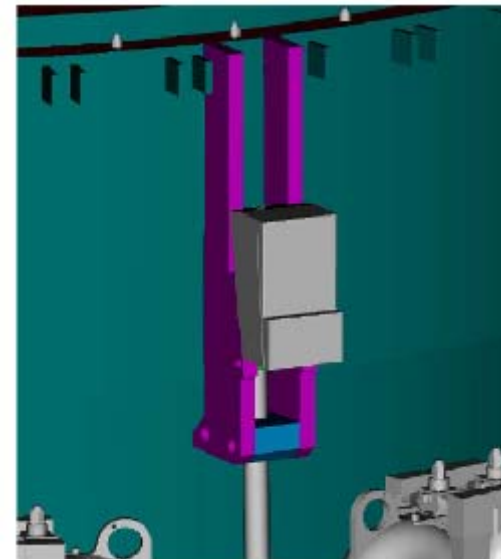
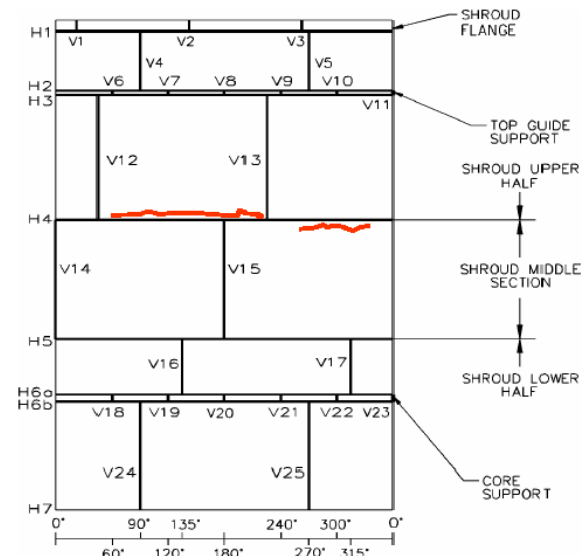
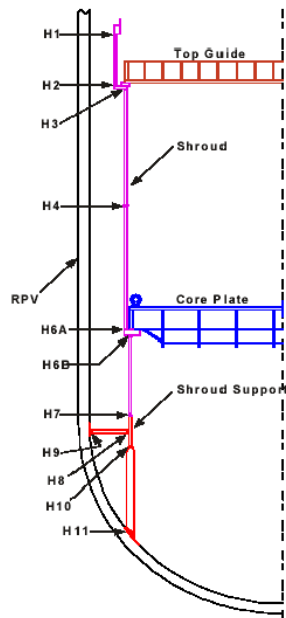
Universities: 37

- 52 students
- 24 faculty members
- 7 industry participants
- 43 other national laboratories, government and non-U.S. nuclear agencies



Industry Program Example

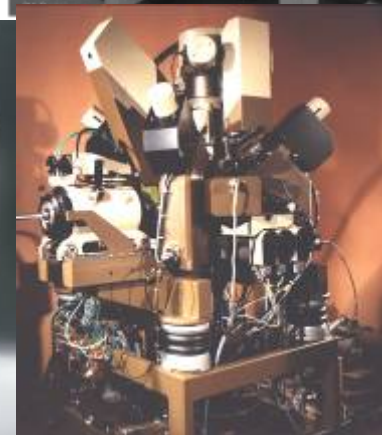
- Encourage industry led programs and industry university collaborations
- Joint experiment with EPRI
- Crack growth rates and fracture toughness of irradiated alloy X750 and XM-19 used in BWR core shroud repair brackets



Building Capability to Meet User Needs

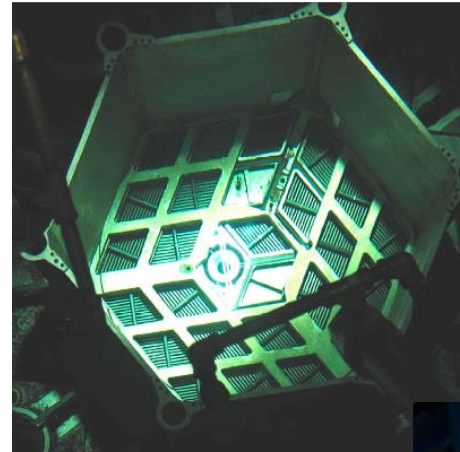
- **New reactor capabilities**
 - Hydraulic shuttle irradiation system (2009)
 - Pressurized water loop (2011)
 - Test Train Assembly Facility (2009)
- **New PIE capabilities**
 - Focused Ion Beam (FIB, 2009)
 - Micro x-ray diffraction (2009)
 - In-cell mechanical testing (2009)
 - Scanning thermal diffusivity (2009)
 - Electron probe micro-analyzer (EPMA, 2010)
 - Environmental crack growth rate testing (2011)
- **Partnerships**

Need for capability validated through industry advisory committee (ANIAC), user workshops and surveys, and Scientific Review Board (SRB)

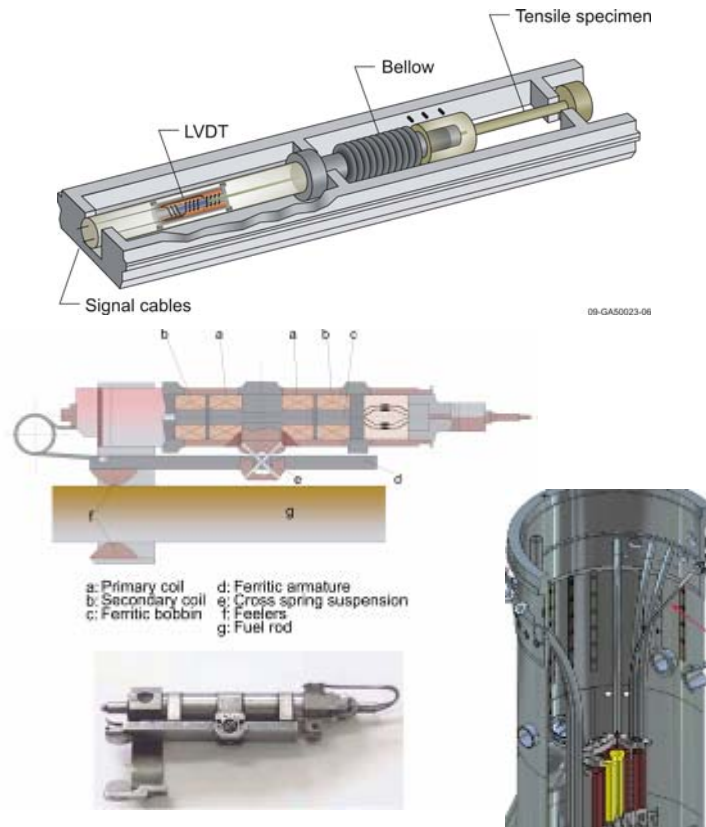


ATR NSUF Partnerships

- ATR NSUF partnerships function to meet customer needs
- ATR NSUF includes additional (on-INL) capability that benefits users
 - University research reactors (MITR, Pulstar)
 - Hot cells or hot laboratories (UM, UW)
 - Accelerator facilities (UW, UM)
 - Analytical capability (UNLV)
- Process
 - Potential university partners self-nominate
 - Expert group evaluates nominations
 - Capabilities added to next proposal solicitation

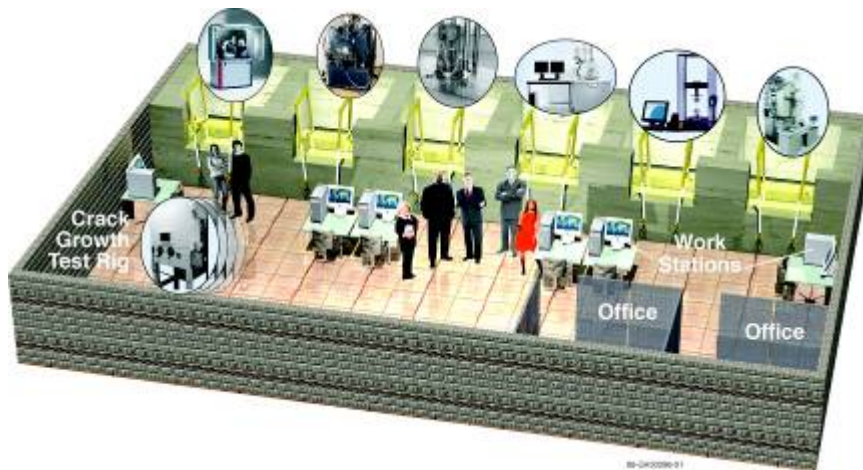


In-reactor Measurements



- **In-core methods currently available or being developed**
 - Dimensions (LVDT)
 - Thermal Conductivity (TCs)
 - Temperature (TCs)
 - Creep testing (bellows & LVDT)
 - On-line flux monitors
- **Potential New Technologies**
 - Ultrasonic techniques
 - Fiber optics
- **Potential future testing capability**
 - Tensile testing
 - Pressure measurements
 - Crack growth rate
 - Other capability driven by user community
- **Collaborations with CEA and Halden**

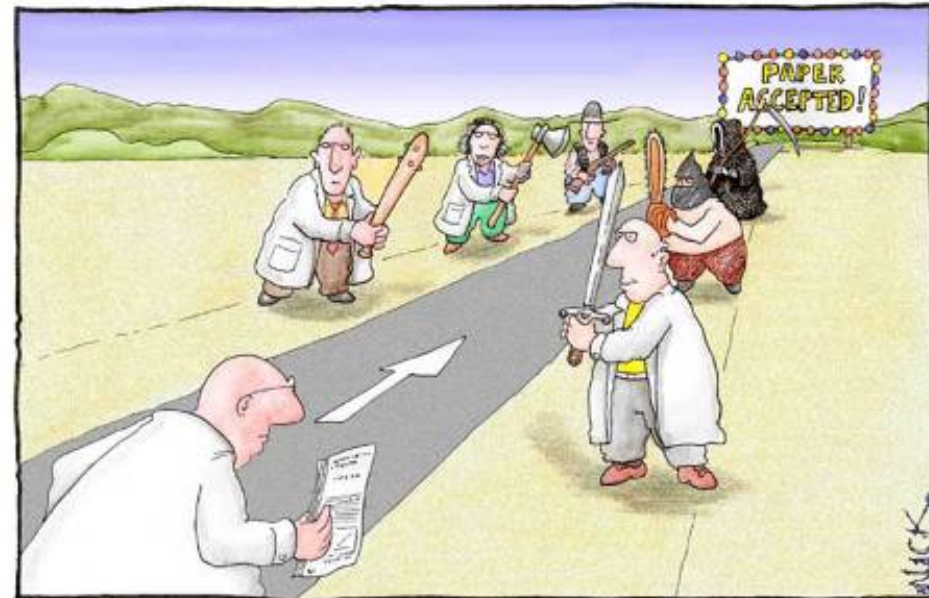
Future Development of ATR NSUF Research Capabilities



- **Goal: Apply state-of-the-art material science tools to irradiated materials and fuels**
 - Plan for and acquire state-of-the-art post-irradiation analytical and testing capabilities *based on user needs*
 - Develop partnerships to add capability that benefits the research community
 - Continue to develop in-reactor test and measurement methods
- **Integrate INL on-site capabilities into a new shielded Irradiated Materials Characterization Laboratory (2012)**

ATR NSUF Proposals

- Important to have a fair and transparent proposal review process in place (see picture)
- Proposal call open the majority of the year
 - Fall 2009 submission window opened: July 6, 2009
 - Last day to submit proposals to fall 2009 proposal call: October 15, 2009
 - Announcement of awards: January 4, 2010
 - Summer 2010 submission window opens: October 29, 2009
 - Last day to submit proposals: April 14, 2010
 - Announcement of awards: June 11, 2010
- ATR NSUF Partnership proposals can be submitted at any time



Most scientists regarded the new streamlined peer-review process as 'quite an improvement.'

We're Here to Help

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What distinguishes ATR NSUF from other user facilities?



Office of Science
U.S. Department of Energy

Office of Science User Facilities



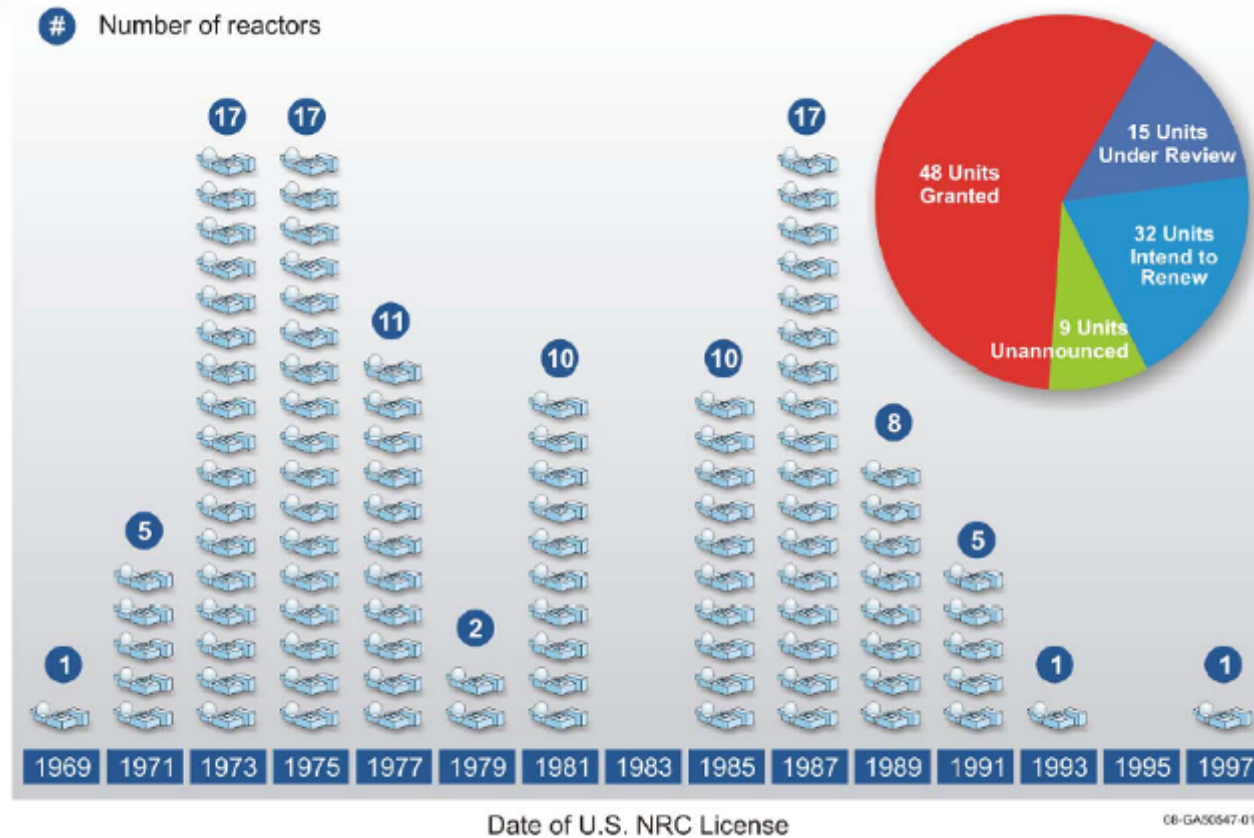
ATR
National Scientific User Facility

ATR/NSUF

	Office of Science User Facilities	ATR/NSUF
Applications	Neutron beam, light beam	In-reactor experiments - Static capsule, instrumented lead irradiations
Number of users each year	Hundreds	About 15 projects 100 users/year including summer session (40 percent of capacity is used by NR)
Duration of experiments	Short (days or weeks)	Long (one to five years, 3 years on average)
Complexity/lab resources needed to sponsor user experiments	Minimal	Extensive/significant costs associated with preparation and conduct of experiment

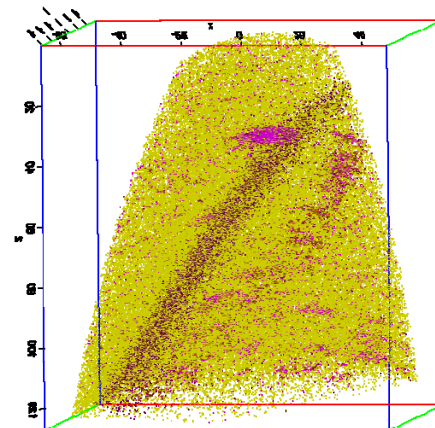
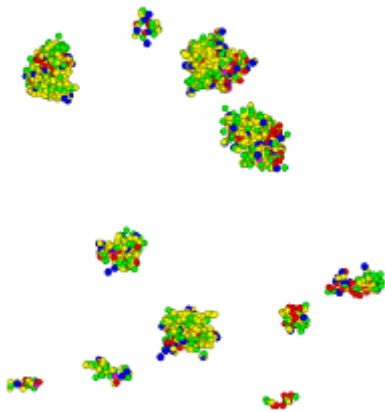
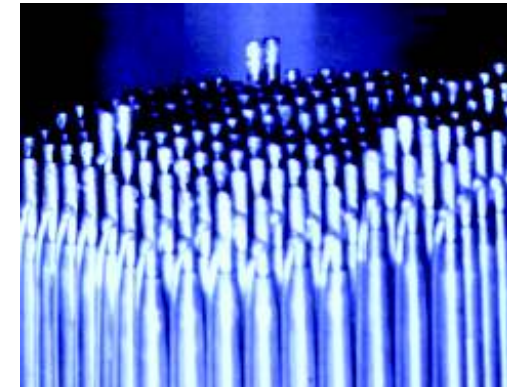
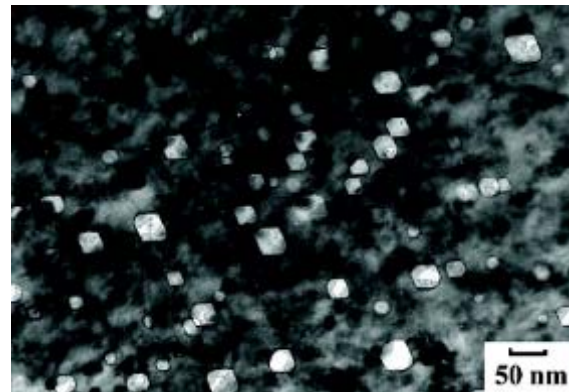
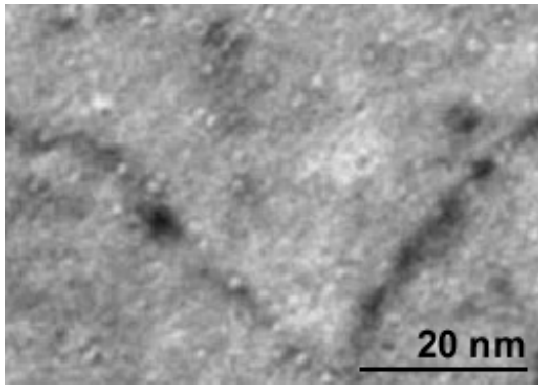
ATR NSUF is a comparable unique national asset, but does present unique management challenges

Aging Reactor Fleet



- Oldest reactors approaching 40 operating years
- Many reactor licenses extended to 60 years
- Currently investigating life extension to 80 years

IMCL - a window for looking at atomic-scale processes that lead to material degradation



CATASTROPHIC FAILURE OF PRESSURE VESSEL DURING HYDROSTATIC TESTING; DUE TO IMPROPER POSTWELD HEAT TREATMENT