Nuclear Science User Facilities

Opportunities with NSUF for Nuclear Energy R&D

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National Technical Director, IRIS

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nsuf.inl.gov

Nuclear Science User Facilities

INL/EXT-17-43833

Outline

- NSUF Capabilities
- NSUF Information Management Tools
- NSUF CINR Workscopes

Nuclear Science User Facilities

NUCLEAR ENERGY R&D

NSUF: Pairing the best minds with the needed capability

- The Nuclear Science User Facilities (NSUF) offers unparalleled research opportunities for nuclear energy researchers.

- Users are provided access (at no cost to the researcher) to:
  - world-class nuclear research facilities,
  - technical expertise from experienced scientists and engineers, and
  - assistance with experiment design, assembly, safety analysis and examination.

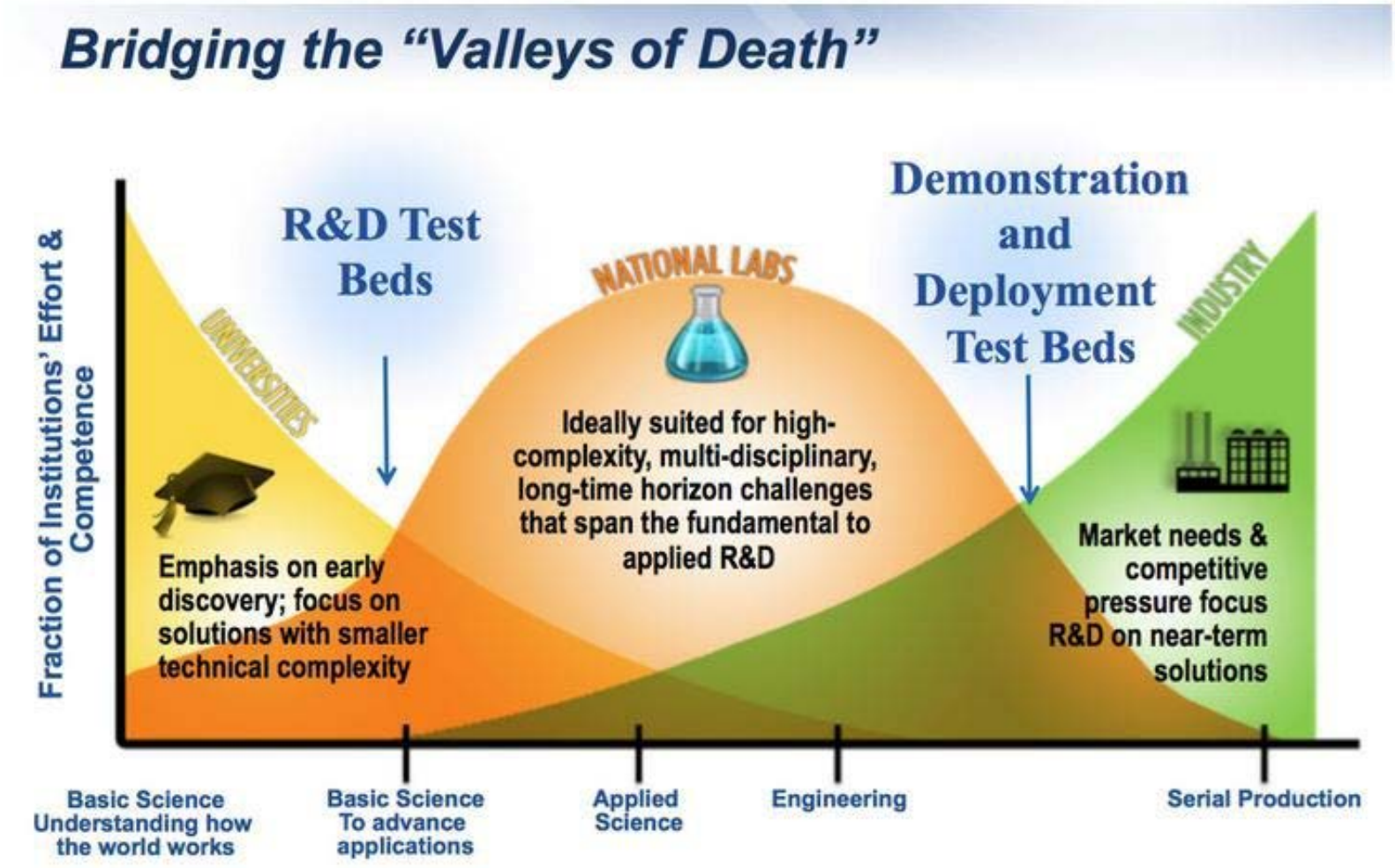
- Access is awarded through a competitive peer-reviewed process.

- Submitted proposals should be consistent with the DOE-NE mission and its programmatic interests.

NSUF supports all three of the **NE Mission Focus Areas** by offering access to capabilities that can provide the fundamental understanding to:

1. predict the long term stability of light water reactor structural materials and accident tolerant fuels to support the **existing fleet,**
2. determine the applicability of advanced materials for future reactor designs to better develop the **advanced reactor pipeline**, and
3. develop simplified materials recovery technologies, waste management, and proliferation risk reduction methods to the re-establish the **national fuel cycle infrastructure**.

Role of the National Laboratories in Nuclear Energy R&D



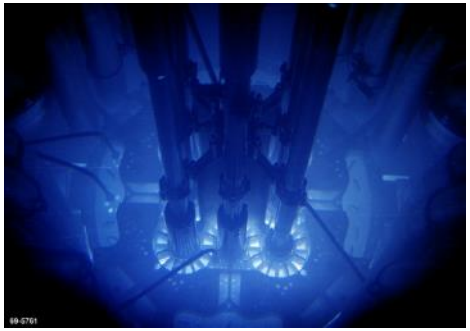
The US User Facility Model

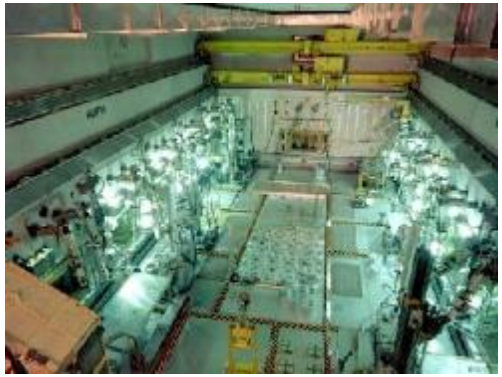
- The goal is to connect intellectual capital with investigative capabilities.
- Typically large single structure, government supported facilities with unique capabilities located at a single institution.
- Access is typically offered at no cost to the user through a competitive proposal process.
- Principle is to offer advanced, cutting edge capabilities to single investigators or teams.
- Generally the user facility offers a single type of capability to a broad range of technological or research areas.
- User facilities do not fund salaries or other user costs, such as travel.
  - They provide access and support with funding used at the user facility institution.
- Currently ~50 user facilities in US
  - Synchrotron X-ray sources (e.g. APS, NSLS-II)
  - Neutron spallation sources (e.g. SNS)
  - Advanced scientific computing
  - Nano-scale sciences
  - etc.

Advanced Photon Source, ANL

Nuclear Science User Facilities (NSUF)

- Established 2007 as US DOE Office of Nuclear Energy first & only user facility.
- Founded at Idaho National Laboratory initially intended as a single institution user facility. INL remains lead and primary institution.
- NSUF operates as typical US user facility (no cost to user, competitive proposal processes, no funding to users) but also some unique aspects.





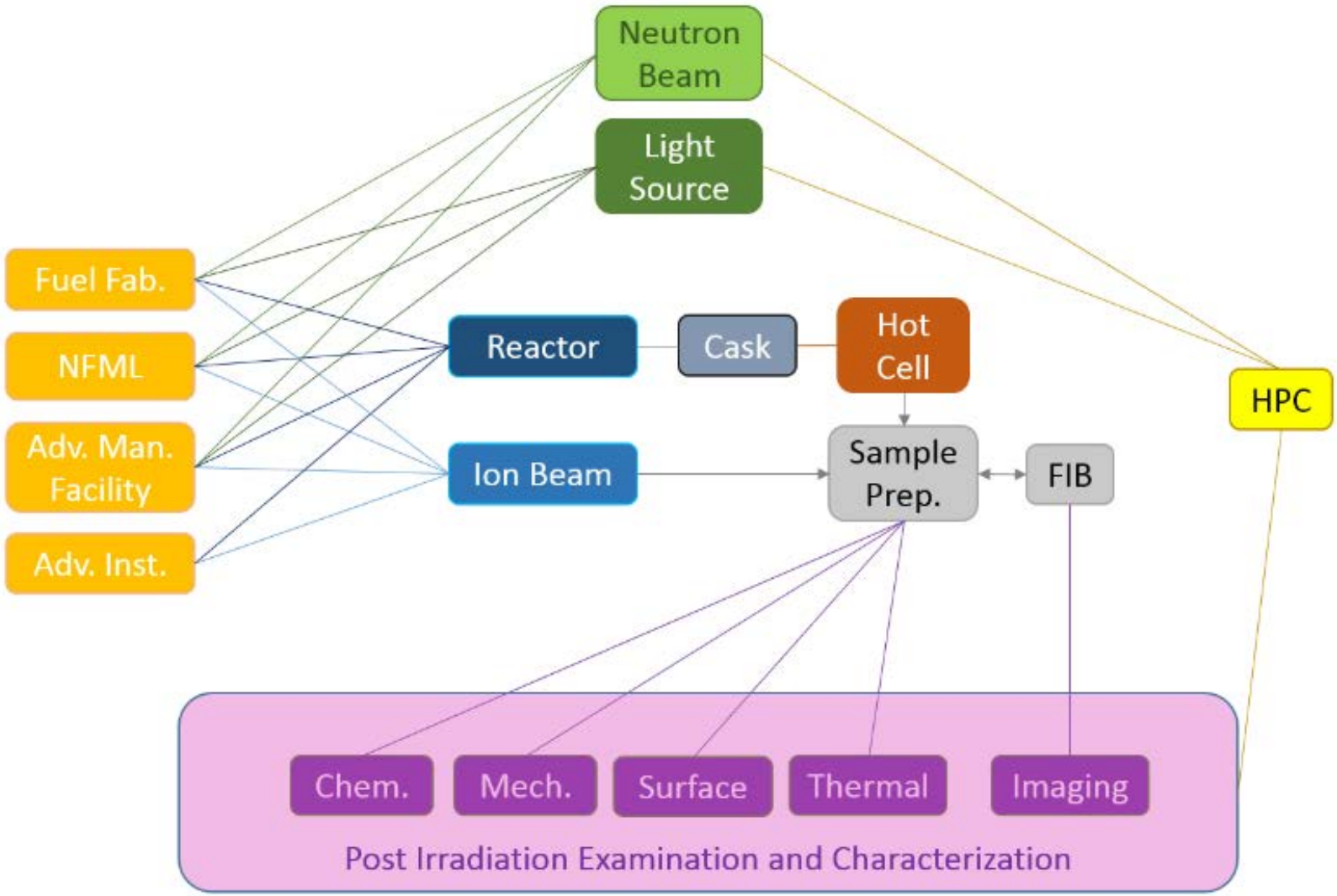
<u>Unique aspects of NSUF</u>

- **Consortium of facilities/capabilities, not single institution (currently 11 Universities + 4 Universities in CAES, 7 National Laboratories, 1 industry)**
- **NSUF offers multiple capabilities to a single scientific area:**
  - ***irradiation effects in nuclear fuels and materials*.**
- **Projects can last many years or be short duration.**
  - Largest projects include design, fabrication, transport, irradiation, PIE, and final disposition.
- **No base funding to facilities.**
  - Funding to facility is for project cost and is fully forward funded.
  - Excess capacity is generally utilized.

Nuclear Science User Facilities

CAPABILITIES

NSUF Experiment Pathways



NSUF Capabilities Offer Research Opportunities

Neutron Irradiations	Ion Irradiations	Gamma Irradiations	Hot Cells & Shielded Cells	Low Activity Laboratories	Beamlines	High Performance Computing
INL Idaho National Laboratory	Wisconsin University of Wisconsin-Madison	INL Idaho National Laboratory	INL Idaho National Laboratory	INL Idaho National Laboratory	125 Illinois Tech Since 1890	INL Idaho National Laboratory
Oak Ridge National Laboratory	University of Michigan	Oak Ridge National Laboratory	Oak Ridge National Laboratory	CAES Center for Advanced Energy Studies	Brookhaven National Laboratory	
MIT Massachusetts Institute of Technology	Argonne National Laboratory	Sandia National Laboratories	PNNL	Oak Ridge National Laboratory	Los Alamos National Laboratory	
NC State University	Sandia National Laboratories		Los Alamos National Laboratory	Cal		
Ohio State	A&M Texas A&M University		Westinghouse	PNNL		
Sandia National Laboratories	Lawrence Livermore National Laboratory		University of Michigan	Los Alamos National Laboratory		
SCK•CEN Studiecentrum voor Kernenergie Centre d'Etude de l'Energie Nucleaire			SCK•CEN Studiecentrum voor Kernenergie Centre d'Etude de l'Energie Nucleaire	Purdue University		
				University of Michigan		
				UNLV		
				University of Florida		
				SCK•CEN Studiecentrum voor Kernenergie Centre d'Etude de l'Energie Nucleaire		

11 Universities

CAES (4 Unis)

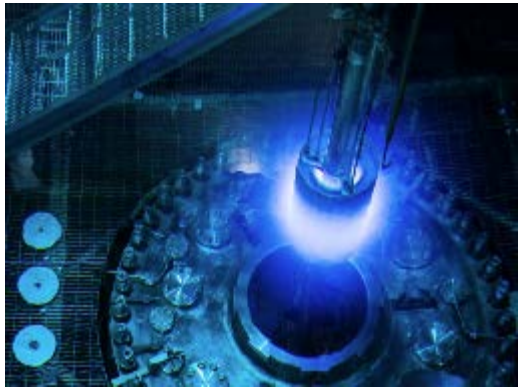
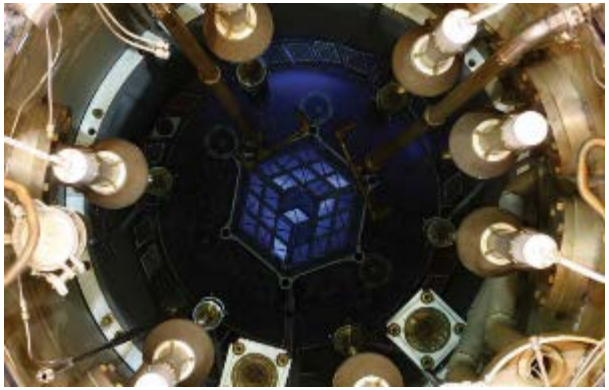
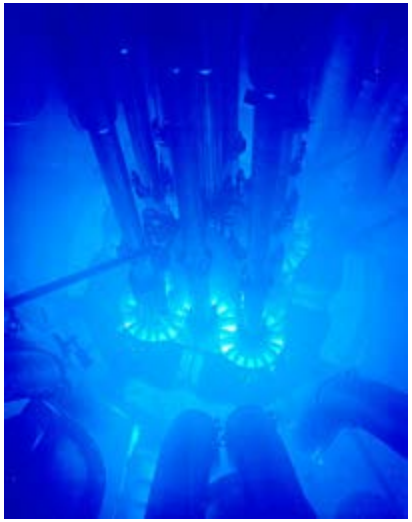
7 National Labs

1 Industry

Visit nsuf.inl.gov for details at individual facilities

NSUF

NSUF Neutron Irradiation Capabilities

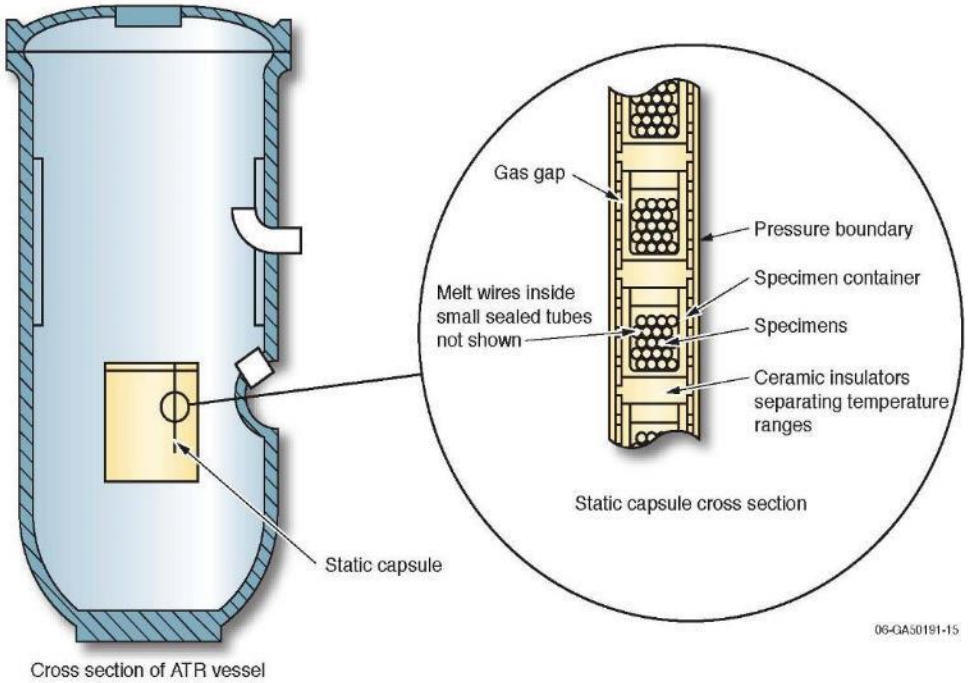


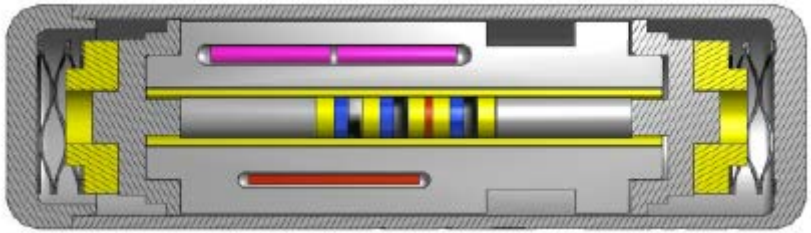




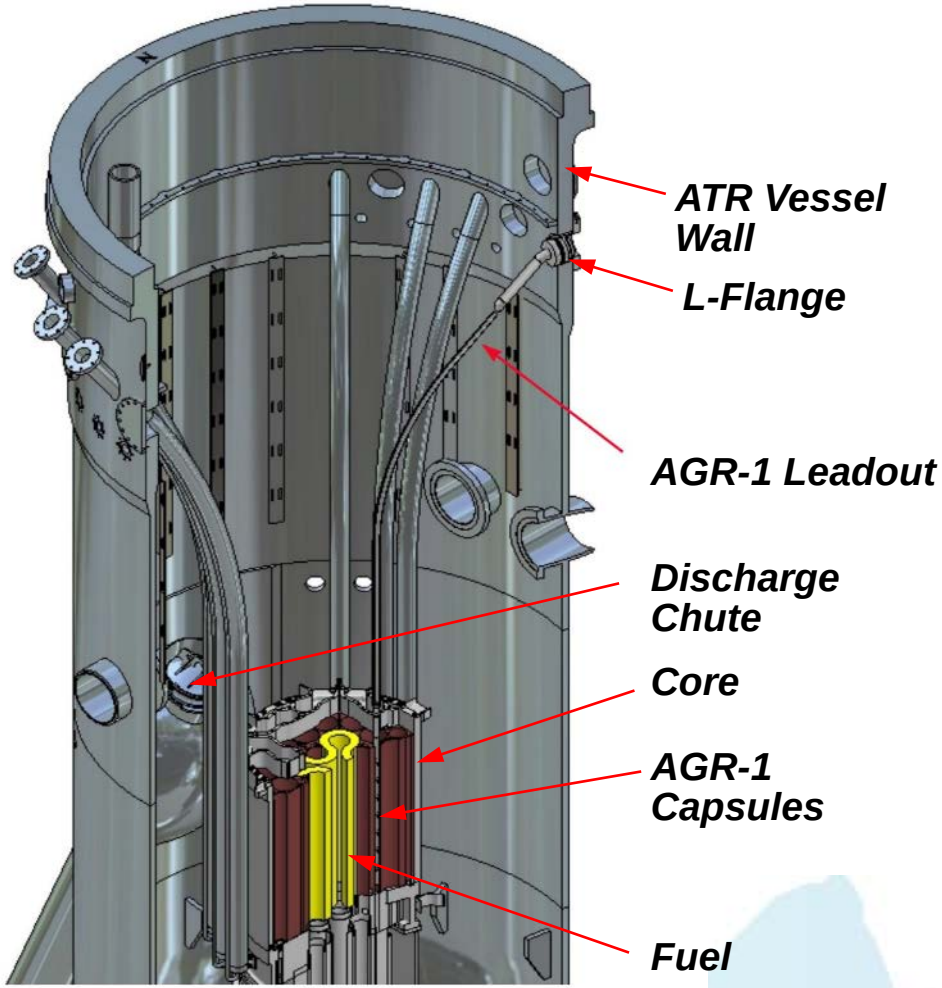
Simple Static Capsule Experiments

- Passive instrumentation (flux wires, melt wires)
- Enclosed in sealed tube, or fuel plates
- Temperature target controlled by varying gas mixture in conduction gap and with material selection
- Lengths up to 48”; diameter 0.5” – 5.0”
- Used for isotope production, fuel and material testing





Instrumented Lead Experiments



- On-line experiment measurements
- Temperature control range 250-1200°C, within +/- 5°C
- Monitoring of temperature control exhaust gases for experiment performance (e.g., fission products, leaking materials, etc.)
- Specialized gas environments (oxidizing, inert, etc.)

Hydraulic Shuttle Irradiation System

- 14 shuttle capsules
- Simultaneously irradiated

- <u>Flux, at 110 MW</u>:

  Thermal Flux: 2.5×10^{14} n/cm^2-s

  Fast (>1MeV): 8.1×10^{13} n/cm^2-s

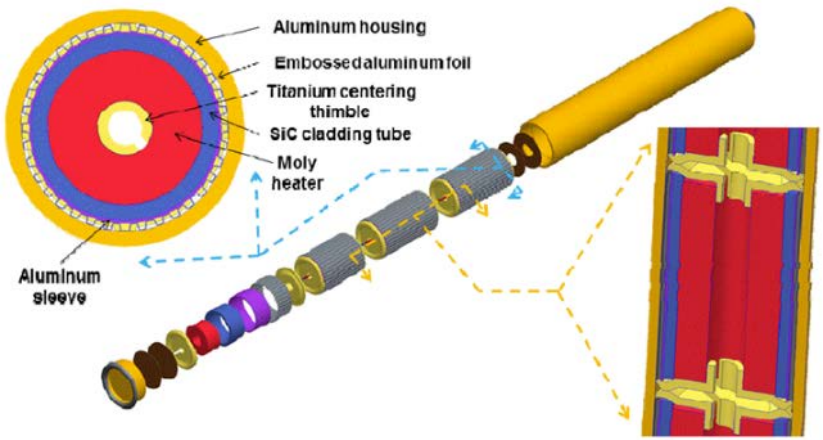
- <u>Dimensions</u>:

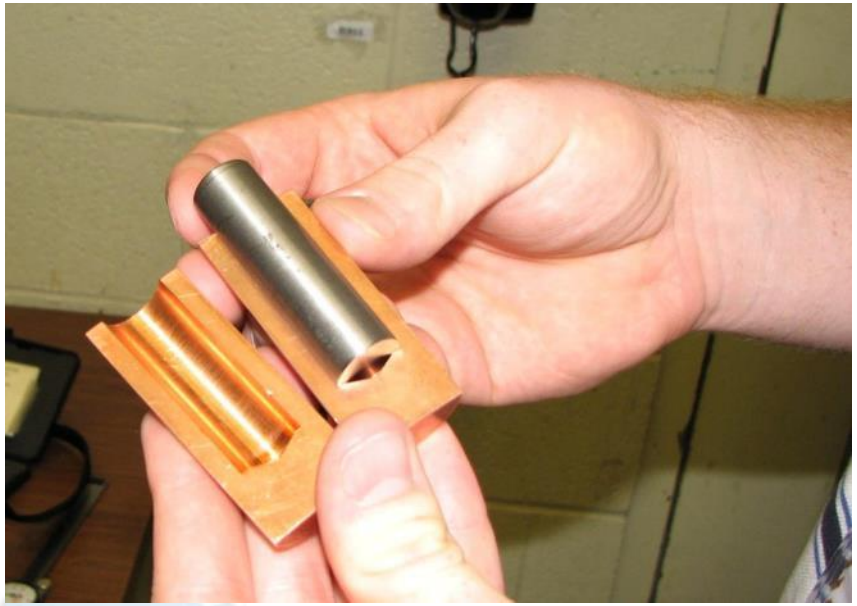
  ~ 0.55” ID, ~2.1” IL

  ~ 7 cc useable volume

  ~35 gm Contents

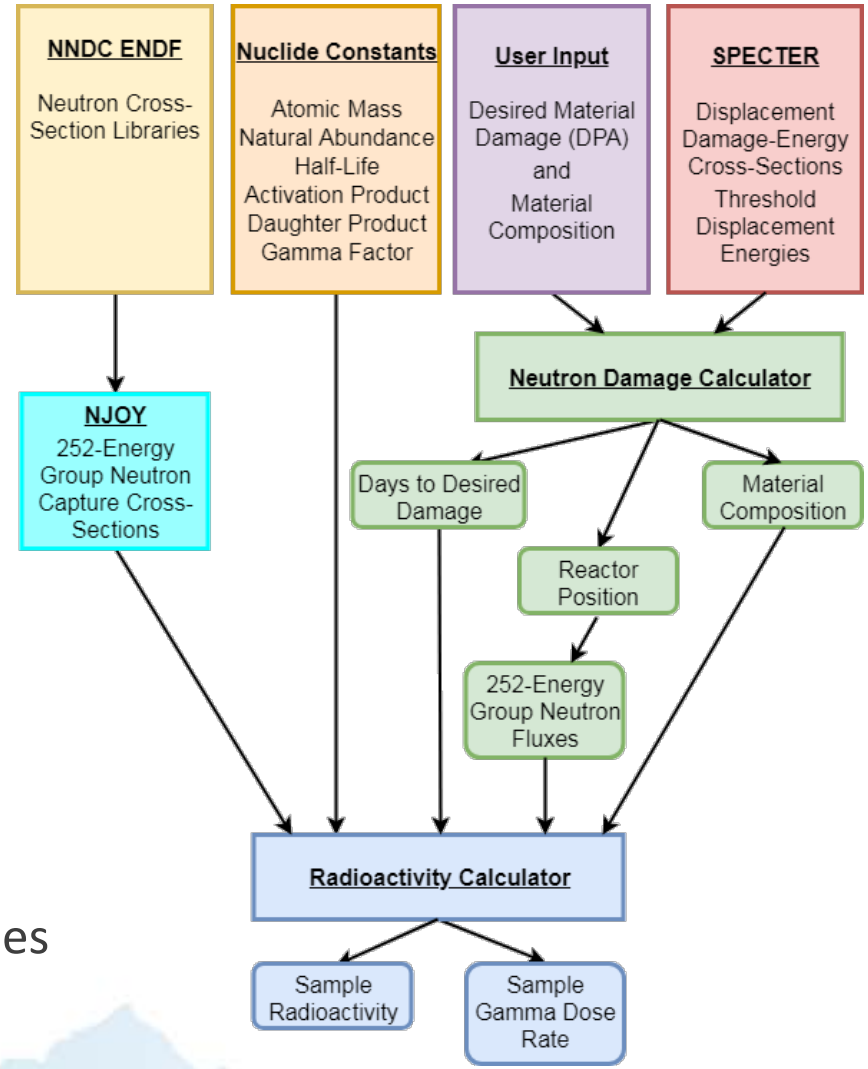
- Can irradiate small amounts of fissile material (10mg)





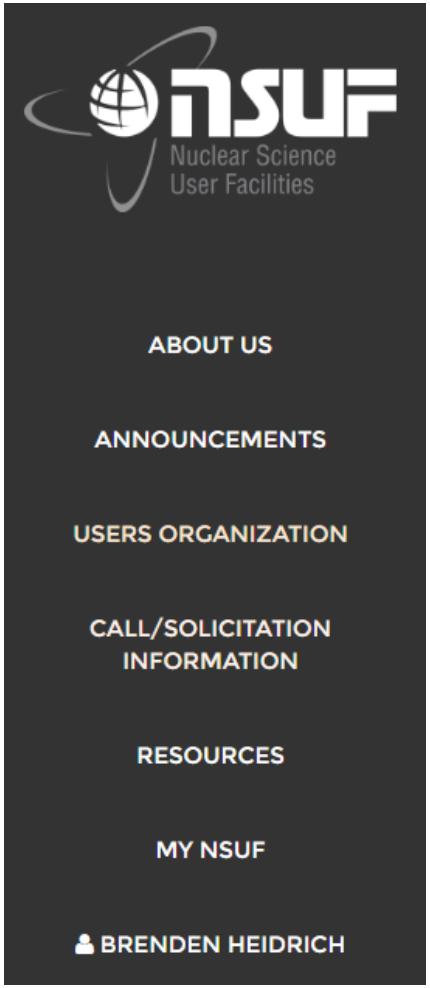
Irradiation Calculator Tool

- Neutron Damage Calculator
  - Input
    - Desired DPA
    - Material Composition
  - Output
    - Days to desired DPA
    - Reactor Positions
- Radioactivity Calculator
  - Input
    - Irradiation time
    - Material composition
  - Output
    - Radioactivity at set decay times
    - Gamma Dose Rate



Web Application Development

- Neutron Damage Calculator (Python) and Radioactivity Calculator (MATLAB) converted to C#
- Cross-sections and constant database created
- Calculators will be available on nsuf.inl.gov



Web Application – Position Selection

NSUF Calculator

Desired DPA

1

Material Composition

Fe-18Cr-8Ni-2Mn-0.75Si-0.1N-0.045P-0.03C-0.03S

Calculate

- Representative reactor positions for:
  - INL ATR
  - ORNL HFIR
  - MITR-II (coming soon!)
  - BR-2
  - OSURR
  - NCSU Pulstar

Select a row to calculate radioactivity and gamma dose rate:

Select	Reactor	Position	Diameter (cm)	Days	Cycles	Years	Thermal Fluence	Fast Fluence
○	ATR	A1	1.6	68.2	1.2	0.2	3.73e+020	3.10e+020
○	ATR	A13	1.6	77.9	1.4	0.2	3.55e+020	2.92e+020
○	ATR	B1	2.2	123.9	2.3	0.3	6.06e+020	3.16e+020
○	ATR	B9	3.8	402.5	7.3	1.1	8.35e+020	3.81e+020
○	ATR	I1	12.7	8024.7	145.9	22	1.26e+021	4.18e+020
○	ATR	I3	8.3	8227.6	149.6	22.5	1.75e+021	3.85e+020
○	ATR	I5	8.3	9833.6	178.8	26.9	1.76e+021	3.26e+020
○	ATR	I21	3.8	6699.3	121.8	18.4	3.96e+021	4.33e+020

Web Application – Final Results

Your sample contains **Fe-9.6Cr-0.03Y-0.01C-0.003N**

ATR

Position	B1
Diameter (cm)	2.2
Days	123.9
Cycle	2.3
Years	0.3
Thermal Fluence	6.06e+020
Fast Fluence	3.16e+020

The activity of your sample is as follows:

after 0 days: 2.47E+11 Bq/g or 6.66 Ci/g

after 30 days: 5.42E+10 Bq/g or 1.47 Ci/g

after 60 days: 2.64E+10 Bq/g or 0.714 Ci/g

after 90 days: 1.33E+10 Bq/g or 0.359 Ci/g

after 180 days: 2.67E+09 Bq/g or 0.0723 Ci/g

after 3098 days: 1.87E+08 Bq/g or 0.00505 Ci/g

The effective gamma dose rate of the sample at 30cm:

after 0 days: 882 mrem/hr/g

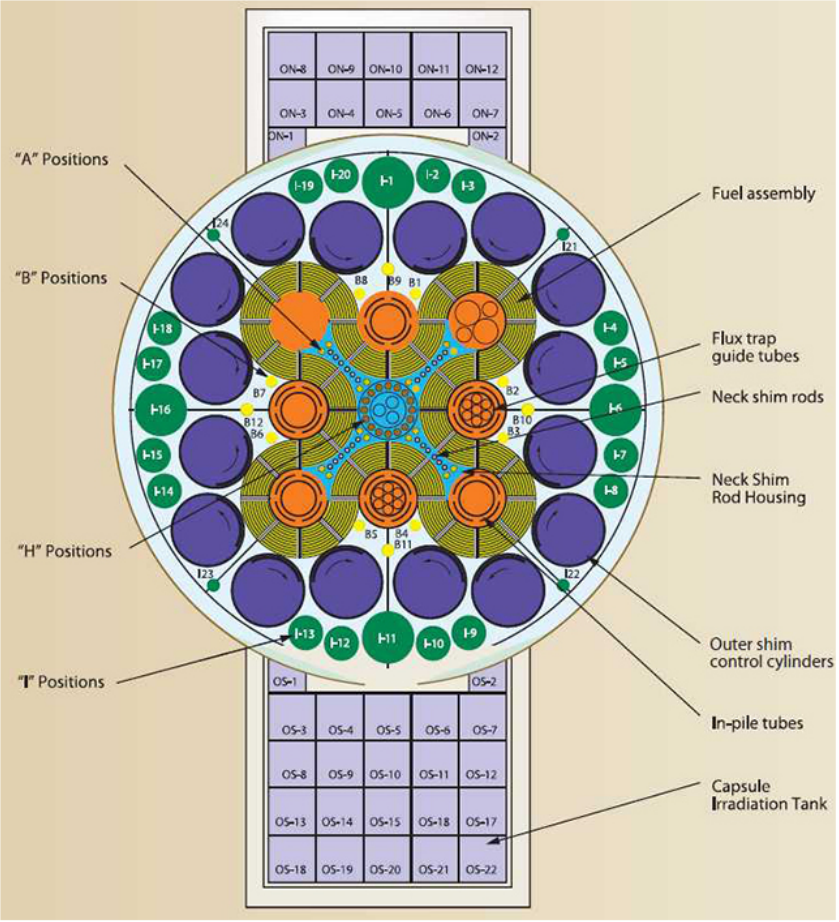
after 30 days: 431 mrem/hr/g

after 60 days: 213 mrem/hr/g

after 90 days: 107 mrem/hr/g

after 180 days: 14.8 mrem/hr/g

after 3098 days: 0.000901 mrem/hr/g



Select a different position

Testing Strategy for Novel Materials

Irradiation Testing Hierarchy

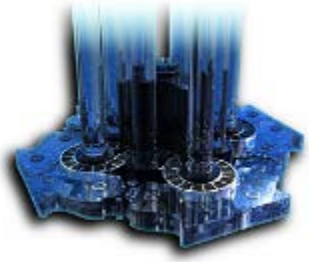
1. **Ion Beam Irradiation Facilities**
   - Allow immediate feedback of performance
   - Ease of instrumentation
   - Ease of environmental tuning
2. **Low-Power Research Reactors**
   - Proof-of-concept (First 1% and 10% testing)
   - Instrumentation development
   - Neutron and gamma testing
   - Experiment modeling & validation efforts
3. **High-Performance Test Reactors**
   - Proof-of-performance
   - Prototypical environment

THE UNIVERSITY of WISCONSIN MADISON

OHIO STATE

NC STATE UNIVERSITY

Massachusetts Institute of Technology



NSUF – Ion Beam Irradiation Facilities

University of Michigan

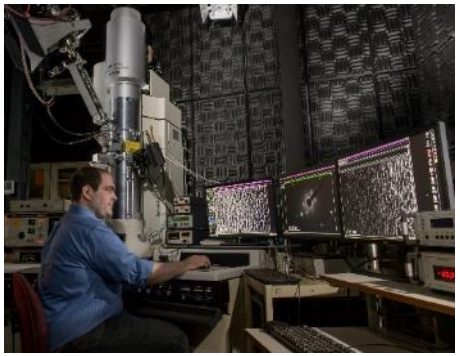
Ion Beam Laboratory

University of Wisconsin

Tandem Accelerator Ion Beam

Additional Partner Facilities:

- IVEM at the Argonne National Laboratory
- CMUXE at the Purdue University (surface science)
- Ion Beam Laboratory at the Texas A&M University
- I^3TEM Facility at the Sandia National Laboratory



Synchrotron Radiation

Illinois Institute of Technology
MRCAT Beamline
at Argonne National Laboratory's
Advanced Photon Source

National Synchrotron Light Source-II (NSLS-II)
radioactive materials beamline
at Brookhaven National Laboratory

Hot Cell Capabilities

Hot Fuel Examination Facility (INL)

MIT Reactor Hot Cells

Materials Center of Excellence Laboratories (Westinghouse)

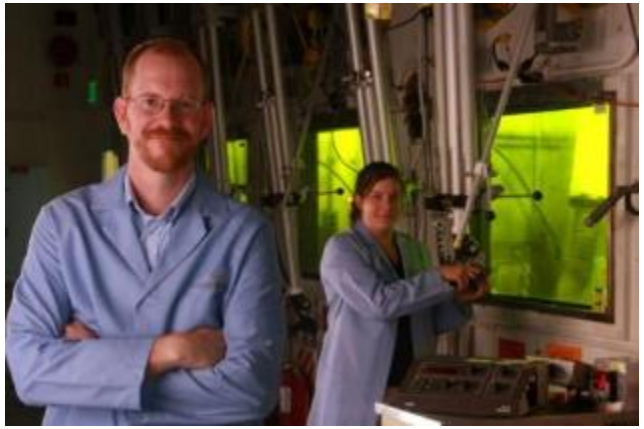
Radiochemical Engineering Development Center (ORNL)

Radiochemistry Processing Laboratory (PNNL)

NSUF Capabilities: high-rad

High radiation level measurements/instrumentation

- **Neutron Radiography**
- **Elemental & Isotopic Analyses**
- **Gas Sampling and Analyses**
- **Profilometry**
- **Gamma Scanning**
- **Mechanical Testing (tensile, punch, Charpy)**
- **Micro-focus X-ray Diffraction**
- **Thermal Analyses**
- **Eddy Current**
- **Irradiation Assisted Stress Corrosion Cracking**
- **Electron Probe Micro Analysis (EPMA)**
- **Electron and Optical Microscopy**
- **Focused ion Beam (FIB)**



NSUF Capabilities: low-rad

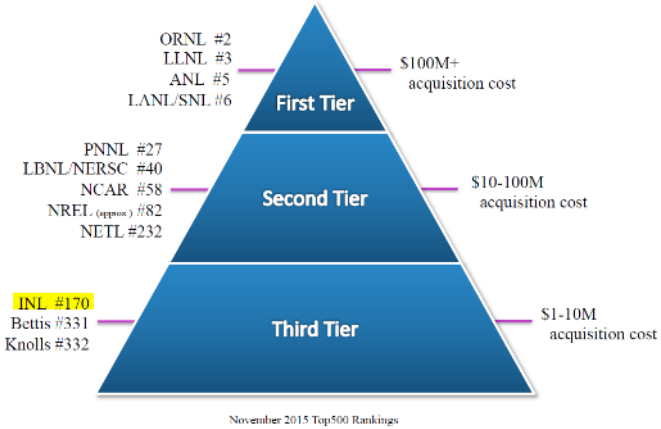
Low radiation level measurements/instrumentation

- **Electron and Optical Microscopy**
  - Scanning Electron Microscopy (SEM)
  - Transmission Electron Microscopy (TEM)
- **Focused Ion Beam (FIB)**
- **Mechanical Testing**
  - Tensile
  - Hardness
  - Micro- and Nano-Indentation
- **X-ray Diffraction**
- **Photo Electron Spectroscopy**
  - X-ray Photo Electron Spectroscopy (XPS)
  - UV Photo Electron Spectroscopy (UPS)
  - Auger Spectroscopy
- **Irradiation Assisted Stress Corrosion Cracking (IASCC)**
- **Positron Annihilation Spectroscopy**
- **Atomic Force Microscopy**
- **Secondary Ion Mass Spectrometry**
- **Thermal Analysis**
  - Thermal Conductivity
  - Heat Capacity
  - Thermal Expansion
- **Nuclear Magnetic Resonance**

NSUF High Performance Computing Resources

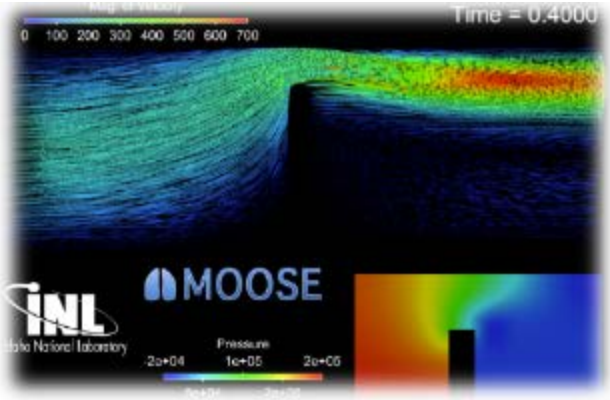
How does HPC enable DOE missions?

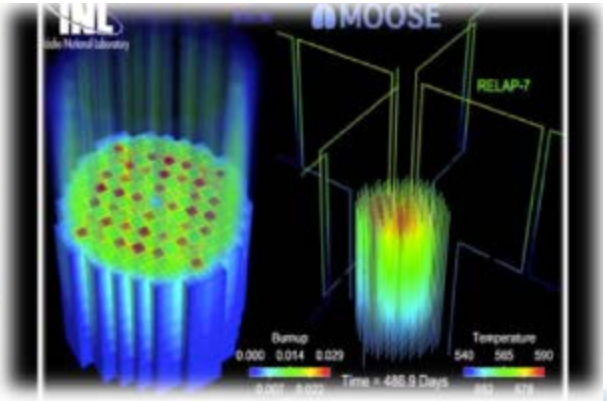
- High Performance Computing (HPC) compliments theory and informs experimental processes.
- HPC functions as a 'microscope' for researchers to better understand physics, chemistry, and engineering principles in ways not otherwise possible.
- HPC resources support NSUF, CASL, NEAMS, NEUP, and GAIN



NSUF Program Support

- System already in place for quickly granting user access and prioritizing work
- Reporting and accounting systems are being modified to better capture NSUF metrics and science impact
- Implementing tools to improve and simplify user experience
- Ensuring that NSUF and related programs have needed support
    - Priority scheduling for milestones upon request
    - Supporting as-run analysis, thermal analytics, neutronics analytics
    - MOOSE support





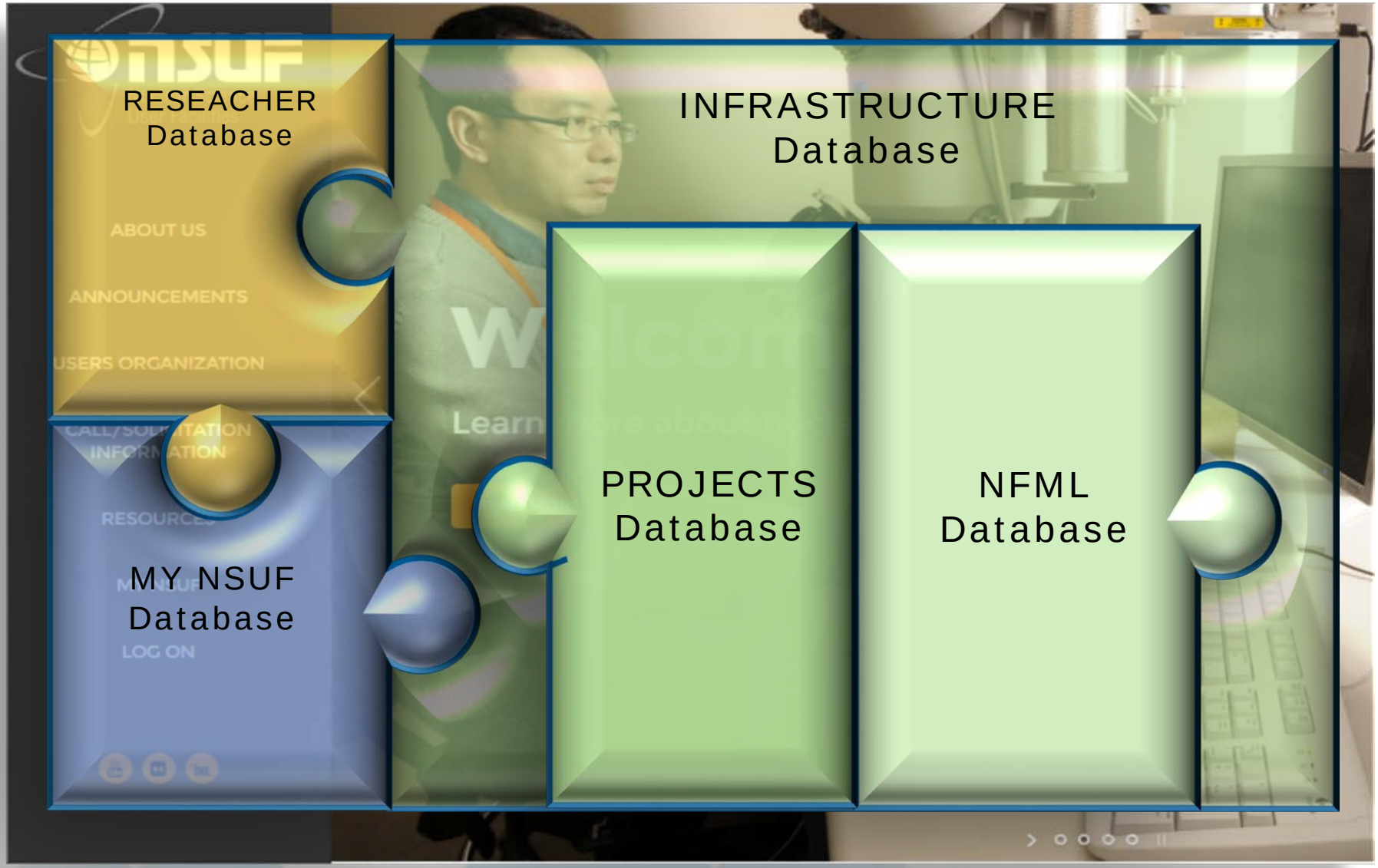
Courtesy of Eric Whiting, Director of Scientific Computing

Nuclear Science User Facilities

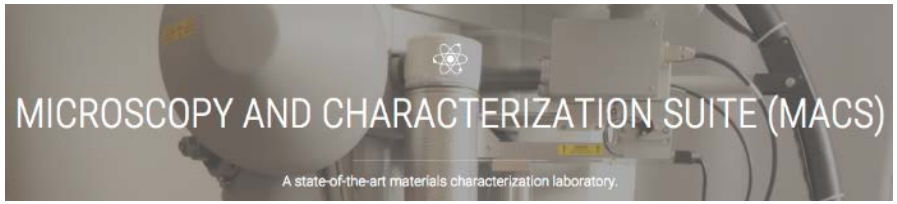
INFORMATION MANAGEMENT TOOLS

NSUF Webpage

NUCLEAR SCIENCE USER FACILITIES Website



Infrastructure Database (NEID)



FEI Quanta 3D FEG
Focused Ion Beam
SEM Microscope

Institutions

Facilities

Instruments

Database of world-wide nuclear energy R&D resources (NEID)

NSUF Resources

NSUF Resources

Reset NSUF Resources

- Select Institution Type -

The Nuclear Energy Infrastructure Database contains many institutions. Select a type of institution from the list above.

- Select Facility Type -

There are many different types of facilities in the NEID. Select a facility type from the list above to begin.

- Select Instrument Type -

If you are looking for a specific NSUF-partnered instrument in the NEID, choose a type of instrument to view all available instruments for that type.

PARTNERS

Quick Search

Other Searches

Nuclear Energy Infrastructure Database

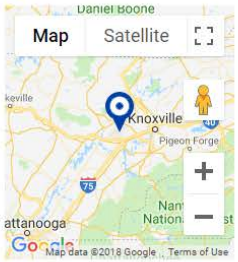
Nuclear Fuels and Materials Library

Featured Facility

Institution	Oak Ridge National Laboratory
Facility	Irradiated Materials Examination and Testing Facility (IMET)
Primary Type	Hot Cell
Core Functions	Irradiated Materials Examination and Testing.
Unique Functions	Testing of structural materials under simulated temperature and pressure. Hot Cells and solid state remote handling; Advanced in-cell materials testing
Website URL	http://www.ornl.gov/science-discovery/nuclear-science/facilities-and-capabilities/imet, \\CAESFS1\Home\HEIDBJ\Infrastructure Project\Database Files\NE...

View Facility

Featured Institution



Oak Ridge National Laboratory

Dept of Energy
Tennessee, United States

View Institution

NSUF

NSUF Partner Facilities

Facilities Search Result

Modify | Reset | Export to Excel

25

Search...

Facility	Institution	Owner Type	Primary Type	Materials Allowed	NSUF Partner	Website
Accelerator Laboratory	Texas A&M University	University	Ion Beam	beta/gamma only	PARTNER	Website
Advanced Materials Laboratory	Center for Advanced Energy Studies	University	Sample Preparation	alpha/beta/gamma	PARTNER	Website
Advanced Test Reactor	Idaho National Laboratory	Dept of Energy	Reactor	beta/gamma only	NSUF	Website
Analytical Chemistry Laboratory @ Churchill Laboratory Services	Westinghouse	Industry	Radiochemistry	beta/gamma only	PARTNER	Website
Analytical Laboratory	Idaho National Laboratory	Dept of Energy	Hot Cell	beta/gamma only	NSUF	Website
Analytical Support Operations at RPL	Pacific Northwest National Laboratory	Dept of Energy	Radiochemistry	beta/gamma only	PARTNER	Website
Annular Core Research Reactor	Sandia National Laboratory	Dept of Energy	Reactor	beta/gamma only	PARTNER	Website
ATR Critical Facility	Idaho National Laboratory	Dept of Energy	Reactor	beta/gamma only	NSUF	
ATR Gamma Facility	Idaho National Laboratory	Dept of Energy	Gamma Irradiator	beta/gamma only	NSUF	
Belgian Reactor 2	SCK/CEN	International Government	Reactor	beta/gamma only	PARTNER	Website

Showing 1 to 25 of 87 entries

Previous 1 2 3 4 Next

INL Information and Point of Contact

Institution	Contact	Reactor	PIE
Idaho National Laboratory	Simon Pimblott (208) 526-7499	ATR User Guide	INL PIE User Guide

NSUF Partner Institutions: Information and Points of Contact

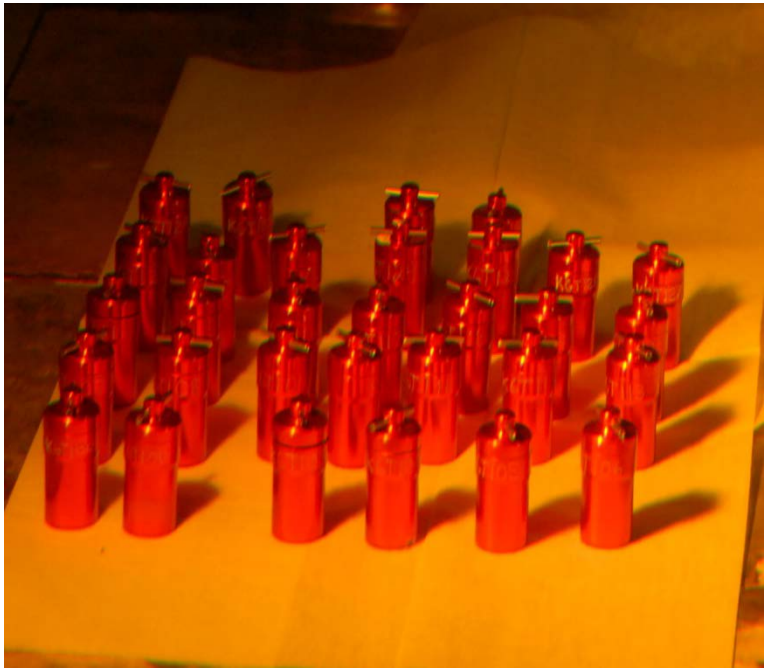
Partner Institution	Contact	Reactor	PIE	Gamma	Beamline
Argonne National Laboratory IVEM Tandem Facility	Meimei Li (630) 252-5111				User Guide
Brookhaven National Laboratory	Lynn Ecker (631) 344-2538				User Guide
Center for Advanced Energy Studies / MaCS	Joanna Taylor (208) 533-8178		Website		

Nuclear Fuels and Materials Library

- **Nuclear Science User Facilities**

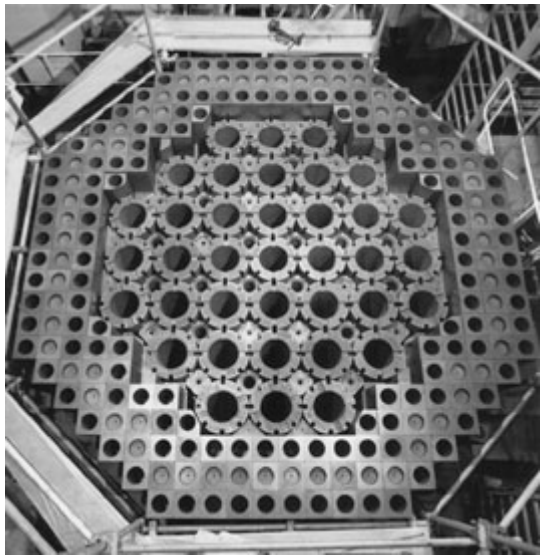
  Established in 2007 by DOE-NE to support nuclear energy R&D by providing researchers with no-cost-to-the-user access to unique facilities and **materials** through competitive processes.

- **The NSUF Nuclear Fuels and Materials Library**
  - Owned by DOE-NE and curated by the NSUF
  - Includes nuclear fuel and material samples from past and ongoing irradiation test campaigns, decommissioned power reactors, and donations from other sources.
  - contains >6000 searchable samples and corresponding information
    - Irradiation Conditions
    - Experiment information
    - Project reports



Nuclear Fuels and Materials Library

- Most samples in the library have been neutron irradiated:
  - **EBR-II** (Idaho National Laboratory)
  - **ATR** (Idaho National Laboratory)
  - **HFIR** (Oak Ridge National Laboratory)
  - **FFTF** (Hanford Site / Pacific Northwest National Laboratory)
  - José Cabrera Nuclear Power Station
  - Zion 1 & 2 NPS (in negotiation)
- A smaller number were proton irradiated:
  - LANSCE (Los Alamos National Laboratory)



NSUF Fuels and Materials Library

Steels	
17-4 PH SS	Fe-Cr Alloys
304 SS	HCM12-A
304 SS welds	HT-9
Super 304H	MA-956
316 SS	MA-957
347 SS	MAR-2008
416 SS	Mo-ODS
420 SS	nCr-YWT
9Cr ODS	NF616
Borated Steel	NF709
Carbon Steel	PM2000
Cast ASS	T-91
D9 ASS	Tool Steel T-1
Eurofer 97	XM-19
F82H-IEA	model alloys

Other Alloys	Ceramics	Pure Materials
Al_3Hf	Al_2O_3	Copper
Al1100	MgO	Iron
Al6061	$MgO\text{-}ZrO_2$	Ni/Cu/Nb (DC)
Aluminum Bronze	$Mg_2\text{-}SnO_4$	Nickel
Berylco #25	$Mg0_{1.5}Al_2O_3$	Niobium
C276 Hasteloy	$MgTiO_3$	Silver
Incoloy 800H	$Nd_2Zr_2O_7$	Tantalum
Inconel X/X-750	SiC	Tungsten
Stellite	Ti_2AlC	Zirconium
	Ti_3AlC_2	
	Ti_2AlN	
	TiO_2	
	Ti_3SiC_2	

Small amounts of purified actinides and fission products in liquid form.

NUCLEAR SCIENCE USER FACILITIES (*integrated*) Website

COLLABORATION Database

PI NAME
INSTITUTION
PROPOSALS
Expertise
Publications
Presentations
Personal Information

INFRASTRUCTURE Database

INSTITUTIONS
FACILITIES
EQUIPMENT
Google Maps

SEARCH
NEID
NFML
PEOPLE

PROJECTS Database

PROPOSAL/Project
PI NAME
Research Area
Material Type
INSTITUTION
FACILITY
PUBLICATIONS
PRESENTATIONS

NFML Database

Material Name
Reactor/Position
SAMPLE TYPE
DIMENSIONS
Storage Facility
Availability
Samples Remaining
Planned/As-Run Temp
Planned/As-Run Dose
Flux
Fluence
Environment
Documents

MY NSUF Database

PI NAME
PROPOSALS
INSTITUTION
FACILITY

Collaborators
Sample Info
Research Area
PUBLICATIONS
PRESENTATIONS

Nuclear Science User Facilities

PROJECTS & OPPORTUNITIES

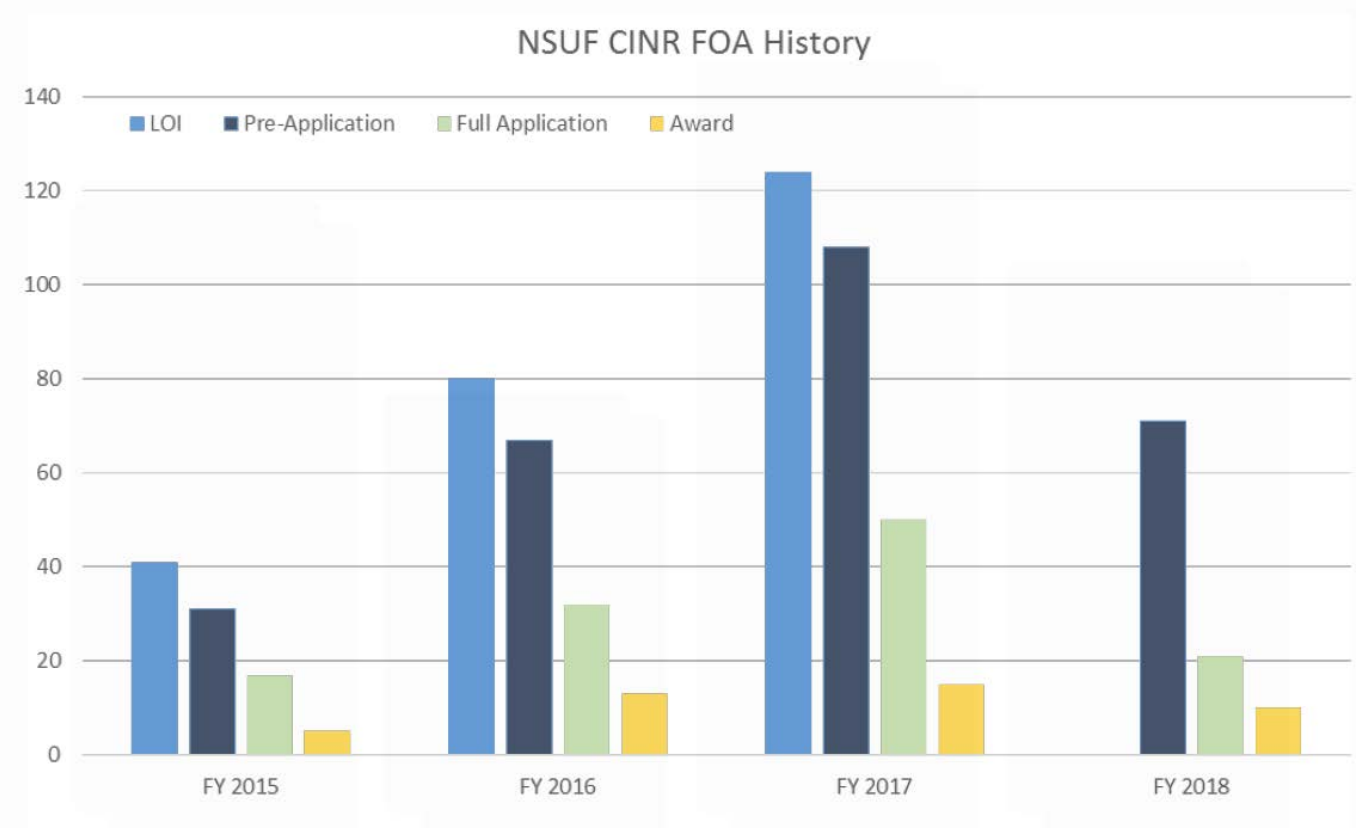
Accessing the NSUF

1. **Consolidated Innovative Nuclear Research FOA**
   - Kickoff in August, awarded the following June
   - R&D support funding can be requested
   - Irradiation + PIE ($500K -$4.0M, up to 7 years)
   - PIE only ($50K to $750K, up to 3 years)
   - Irradiation only ($500K -$1.5M)

2. **Rapid Turnaround Experiment calls**
   - For small examination or beam-line projects
   - Three calls per year
   - No R&D support funding
   - XPD at NSLS-II, IVEM and MRCAT at APS are available

3. **DOE-NE Infrastructure Programs**
   - Reactor Upgrades
   - General Scientific Infrastructure

History of CINR Projects



- FY 2015 -$14.1M, 41 LOIs, 31 pre-proposals, 17 full proposals, 5 awards
- FY 2016 -$10M, 80 LOIs, 67 pre-proposals, 13 awards
- FY 2017 -$10M, 124 LOIs, 108 pre-proposals, 50 full proposals, 15 awards
- FY 2018 -$10M, 71 access requests, 21 full proposals, 10 awards

NSUF Workscopes

University Led

- NEAMS-2:Separate Effects Irradiation Testing for Validation of Microstructural Models in Marmot
- FC-2.5: Separate Effects Testing in TREAT using Standard Test Capsules

University, National Laboratory, Industry Led

- NSUF 1.1: Testing of Advanced Materials or Advanced Sensors for Nuclear Applications
- NSUF 1.2: Irradiation Testing of Materials Produced by Innovative Manufacturing Techniques

Industry Led

- NSUF-2.1: Core and Structural Materials
- NSUF-2.2: Nuclear Fuel Behavior and Advanced Nuclear Fuel Development
- NSUF-2.3: Advanced In-reactor Instrumentation

NSUF Changes from FY 2018

- **Reinstated Letter of Intent and Pre-Application**
- **Submittal of Preliminary Statement of Work and Final Statement of Work**
- **IIT MRCAT Beamline at the Advanced Photon Source not offered this year**
  - Currently resolving challenges in handling radioactive material
- **NSUF-2 workscopes are open to industry leads only**
- **NSUF-2 2.4 workscope eliminated**
  - Synchrotron radiation available at NSLS-II X-ray Powder Diffraction Beamline
  - NSLS-II available in all NSUF workscopes
- **Declaration of Proprietary Data**
  - Data the Applicant wishes to protect during Irradiation or PIE phase
  - Such as chemical composition or physical properties
  - May negatively impact feasibility of the project

NSUF Reminders

- Uninvited full applications will not be reviewed for NSUF Access
- High Performance Computing Capability available through NSUF
- Source, Scope and Duration of R&D support must be identified for NSUF Access Only
- NSUF access process described in Appendix D
- Non negotiable User Agreement in Appendix E
- LOI due on August 30, 2018
- Pre-application due September 20, 2018
- Preliminary Statement of Work due on November 15, 2018
- Final Statement of Work due on February 12, 2019

NSUF-2: “Access Only” Workscopes

- **Objective**
  - Provide access to the capabilities of the NSUF for research projects supporting the DOE Office of Nuclear Energy mission
- **Types of Projects**
  - Irradiation only
  - Irradiation and PIE
  - PIE only
  - Beamline
- **Restrictions**
  - Open to Industry leads only
  - R&D support funding for Applicant not provided
  - Source, scope and duration of R&D funding must be identified
  - NSUF does not fund travel, salaries, or other user costs
  - Initial development effort should be complete and ready for irradiation

NSUF-2 Focus Areas

- **NSUF 2.1 Core and Structural Materials**
  - Understanding irradiation effects such as aging and material degradation (e.g. fatigue, embrittlement, void swelling)
  - Development of radiation resistant materials for current and future reactor applications
- **NSUF 2.2 Nuclear Fuel Behavior and Advanced Nuclear Fuel Development**
  - Increase fundamental understanding of the behavior of nuclear fuel
  - Improve performance of current fuels or develop advanced fuels
  - Irradiation and thermal effects on microstructure, thermophysical and thermomechanical properties and chemical interactions
  - Projects should aim at proposing simple irradiation experiments with post irradiation examination investigation of fundamental fuel performance aspects such as radiation damage, species diffusion or fission products
  - Coupling of experimental methods with modeling and simulation is encouraged

NSUF-2 Focus Areas

- **NSUF 2.3 Advanced In-reactor Instrumentation**
  - Support qualification of advanced in-reactor instrumentation
    - For characterization of materials under irradiation in test reactors
    - For on-line condition monitoring of power reactors
  - Advanced instrumentation, sensors, and measurement techniques for use in advanced reactors is encouraged

Contact Information

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- Technical Lead: J. Rory Kennedy
  Rory.Kennedy@inl.gov

DOE-NE Requests for Information

- Capabilities RFI (DE-SOL-0008318)
  - seeking information regarding capabilities needed by researchers to accomplish nuclear energy R&D
- CINR Workscope RFI (DE-SOL-0008246)
  - seeking ideas in the areas of research, information, comments, feedback, and recommendations from interested parties for future work scopes for the major NE-funded research programs.
- NFML RFI (DE-SOL-0010995)
  - seeking information regarding:
    - existing nuclear energy research materials and specimens that can, potentially, be added to the NFML, and
    - future needs for nuclear energy-related material to support ongoing nuclear energy challenges as well as future research advancements in nuclear energy.

Contact Information for NSUF

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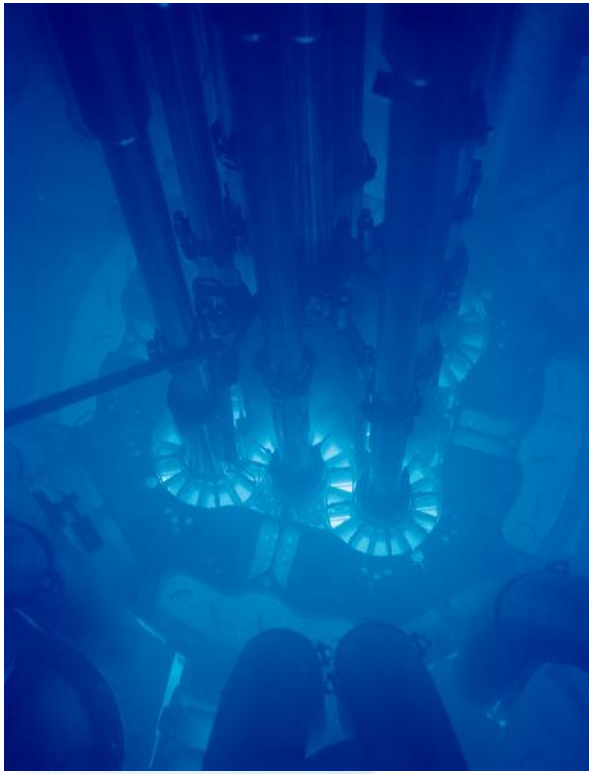

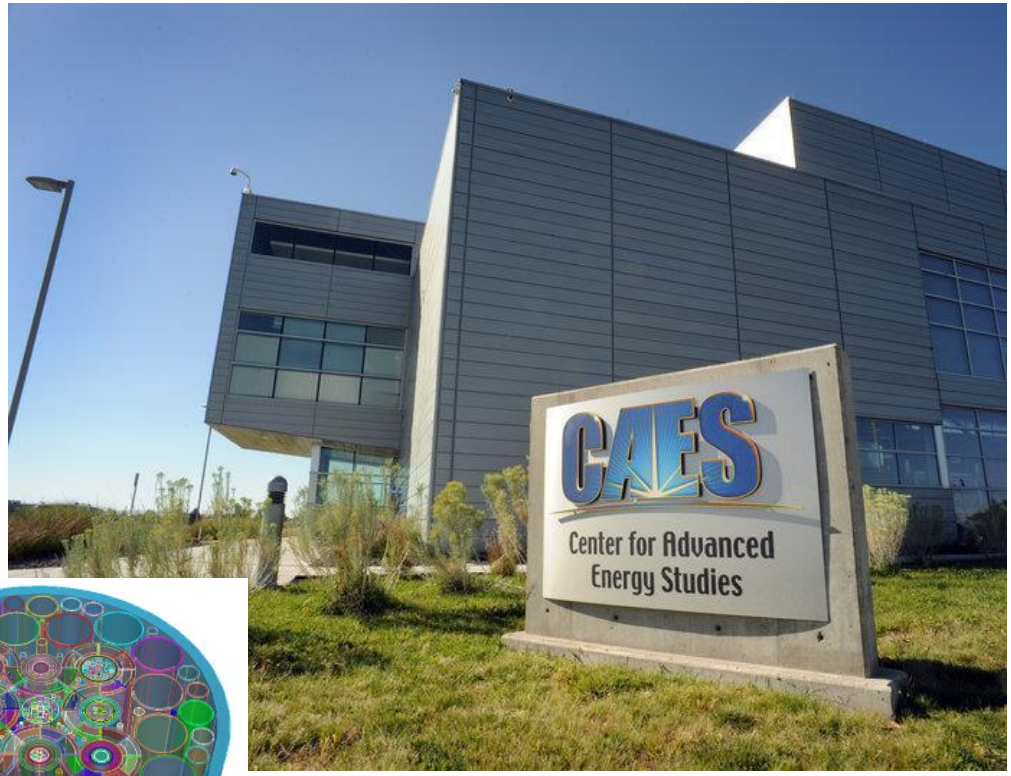

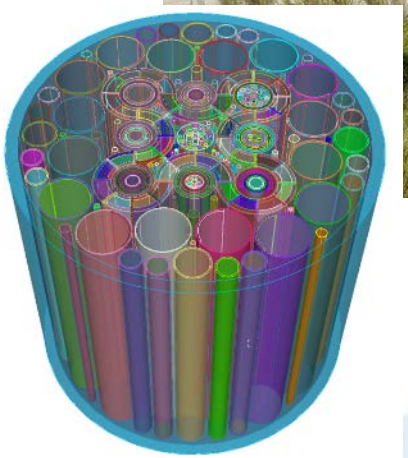

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NSUF

Nuclear Science
User Facilities

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