Nuclear Science User Facilities

Opportunities with NSUF for Nuclear Energy R&D

Brenden Heidrich, Ph.D.
Chief Irradiation Scientist, NSUF
National Technical Director, IRIS

CINR Workshop
Idaho Falls, ID
August 22, 2018
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

Bridging the “Valleys of Death”

- **R&D Test Beds**: Emphasis on early discovery; focus on solutions with smaller technical complexity.
- **NATIONAL LABS**: Ideally suited for high-complexity, multi-disciplinary, long-time horizon challenges that span the fundamental to applied R&D.
- **Demonstration and Deployment Test Beds**: Market needs & competitive pressure focus R&D on near-term solutions.

Basic Science: Understanding how the world works
Basic Science: To advance applications
Applied Science
Engineering
Serial Production
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.
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.

Unique aspects of NSUF

- 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
<table>
<thead>
<tr>
<th>Neutron Irradiations</th>
<th>Ion Irradiations</th>
<th>Gamma Irradiations</th>
<th>Hot Cells &amp; Shielded Cells</th>
<th>Low Activity Laboratories</th>
<th>Beamlines</th>
<th>High Performance Computing</th>
</tr>
</thead>
<tbody>
<tr>
<td>INL Idaho National Laboratory</td>
<td>WISC Wisconsin</td>
<td>OAK Ridge National Laboratory</td>
<td>INL Idaho National Laboratory</td>
<td>INL Idaho National Laboratory</td>
<td>CAES Center for Advanced Energy Studies</td>
<td>ILLINOIS TECH SINCE 1890</td>
</tr>
<tr>
<td>Oak Ridge National Laboratory</td>
<td>MIT Massachusetts Institute of Technology</td>
<td>Argonne National Laboratory</td>
<td>Sandia National Laboratories</td>
<td>PNNL Pacific Northwest National Laboratory</td>
<td>Oak Ridge National Laboratory</td>
<td>ILLINOIS TECH SINCE 1890</td>
</tr>
<tr>
<td>NC State University</td>
<td>MIT Massachusetts Institute of Technology</td>
<td>Argonne National Laboratory</td>
<td>Sandia National Laboratories</td>
<td>PNNL Pacific Northwest National Laboratory</td>
<td>Oak Ridge National Laboratory</td>
<td>ILLINOIS TECH SINCE 1890</td>
</tr>
<tr>
<td>Ohio State University</td>
<td>MIT Massachusetts Institute of Technology</td>
<td>Argonne National Laboratory</td>
<td>Sandia National Laboratories</td>
<td>PNNL Pacific Northwest National Laboratory</td>
<td>Oak Ridge National Laboratory</td>
<td>ILLINOIS TECH SINCE 1890</td>
</tr>
<tr>
<td>Texas A&amp;M University</td>
<td>Oak Ridge National Laboratory</td>
<td>Argonne National Laboratory</td>
<td>Sandia National Laboratories</td>
<td>PNNL Pacific Northwest National Laboratory</td>
<td>Oak Ridge National Laboratory</td>
<td>ILLINOIS TECH SINCE 1890</td>
</tr>
<tr>
<td>Lawrence Livermore National Laboratory</td>
<td>Oak Ridge National Laboratory</td>
<td>Argonne National Laboratory</td>
<td>Sandia National Laboratories</td>
<td>PNNL Pacific Northwest National Laboratory</td>
<td>Oak Ridge National Laboratory</td>
<td>ILLINOIS TECH SINCE 1890</td>
</tr>
<tr>
<td>SCK•CEN</td>
<td>Oak Ridge National Laboratory</td>
<td>Argonne National Laboratory</td>
<td>Sandia National Laboratories</td>
<td>PNNL Pacific Northwest National Laboratory</td>
<td>Oak Ridge National Laboratory</td>
<td>ILLINOIS TECH SINCE 1890</td>
</tr>
</tbody>
</table>

Visit nsuf.inl.gov for details at individual facilities

11 Universities
CAES (4 Unis)
7 National Labs
1 Industry
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

Flux, at 110 MW:
Thermal Flux: $2.5 \times 10^{14}$ n/cm$^2$-s
Fast (>1 MeV): $8.1 \times 10^{13}$ n/cm$^2$-s

Dimensions:
~ 0.55” ID, ~2.1” IL
~ 7 cc useable volume
~35 gm Contents

Can irradiate small amounts of fissile material (10 mg)
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

- 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:

<table>
<thead>
<tr>
<th>Select</th>
<th>Reactor</th>
<th>Position</th>
<th>Diameter (cm)</th>
<th>Days</th>
<th>Cycles</th>
<th>Years</th>
<th>Thermal Fluence</th>
<th>Fast Fluence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ATR</td>
<td>A1</td>
<td>1.6</td>
<td>68.2</td>
<td>1.2</td>
<td>0.2</td>
<td>3.73e+020</td>
<td>3.10e+020</td>
</tr>
<tr>
<td></td>
<td>ATR</td>
<td>A13</td>
<td>1.6</td>
<td>77.9</td>
<td>1.4</td>
<td>0.2</td>
<td>3.55e+020</td>
<td>2.92e+020</td>
</tr>
<tr>
<td></td>
<td>ATR</td>
<td>B1</td>
<td>2.2</td>
<td>123.9</td>
<td>2.3</td>
<td>0.3</td>
<td>6.06e+020</td>
<td>3.16e+020</td>
</tr>
<tr>
<td></td>
<td>ATR</td>
<td>B9</td>
<td>3.8</td>
<td>402.5</td>
<td>7.3</td>
<td>1.1</td>
<td>8.36e+020</td>
<td>3.81e+020</td>
</tr>
<tr>
<td></td>
<td>ATR</td>
<td>I1</td>
<td>12.7</td>
<td>8024.7</td>
<td>145.9</td>
<td>22</td>
<td>1.26e+021</td>
<td>4.13e+020</td>
</tr>
<tr>
<td></td>
<td>ATR</td>
<td>I3</td>
<td>8.3</td>
<td>8227.6</td>
<td>149.6</td>
<td>22.5</td>
<td>1.75e+021</td>
<td>3.85e+020</td>
</tr>
<tr>
<td></td>
<td>ATR</td>
<td>I5</td>
<td>8.3</td>
<td>9833.6</td>
<td>178.8</td>
<td>26.9</td>
<td>1.76e+021</td>
<td>3.26e+020</td>
</tr>
<tr>
<td></td>
<td>ATR</td>
<td>I21</td>
<td>3.8</td>
<td>6699.3</td>
<td>121.8</td>
<td>18.4</td>
<td>3.96e+021</td>
<td>4.33e+020</td>
</tr>
</tbody>
</table>
Web Application – Final Results

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

Position: B1
Diameter (cm): 2.2
Days: 123.9
Cycle: 2.3
Years: 0.3
Thermal Fluence: 6.06e+020
Fast Fluence: 3.15e+020

The activity of your sample is as follows:
- after 0 days: 2.47E+11 Bq/g or 5.66 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: 2.57E+09 Bq/g or 0.0723 Ci/g
- after 300 days: 1.87E+08 Bq/g or 0.00605 Ci/g

The effective gamma dose rate of the sample at 30cm:
- after 0 days: 862 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 300 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
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
• I³TEM 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?
- 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

![Diagram of HPC priorities and costs]

Courtesy of Eric Whiting, Director of Scientific Computing
Nuclear Science User Facilities

INFORMATION MANAGEMENT TOOLS
DOE releases workscopes
For the FY19 CiNR webinars
READ MORE & REGISTER →
Infrastructure Database (NEID)

Institutions

Facilities

Instruments

FEI Quanta 3D FEG
Focused Ion Beam
SEM Microscope
Database of world-wide nuclear energy R&D resources (NEID)
NSUF Resources

What would you like to research?

Capabilities

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: [Link]

Featured Institution

Oak Ridge National Laboratory
Dept of Energy
Tennessee, United States

Quick Search

Other Searches

Nuclear Energy Infrastructure Database
Nuclear Fuels and Materials Library
## NSUF Partner Facilities

### Facilities Search Result

<table>
<thead>
<tr>
<th>Facility</th>
<th>Institution</th>
<th>Owner Type</th>
<th>Primary Type</th>
<th>Materials Allowed</th>
<th>NSUF Partner</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accelerator Laboratory</td>
<td>Texas A&amp;M University</td>
<td>University</td>
<td>Ion Beam</td>
<td>betas/gammas only</td>
<td>PARTNER</td>
<td>Website</td>
</tr>
<tr>
<td>Advanced Materials Laboratory</td>
<td>Center for Advanced Energy Studies</td>
<td>University</td>
<td>Sample Preparation</td>
<td>alphas/betas/gammas only</td>
<td>PARTNER</td>
<td>Website</td>
</tr>
<tr>
<td>Advanced Test Reactor</td>
<td>Idaho National Laboratory</td>
<td>Dept of Energy</td>
<td>Reactor</td>
<td>betas/gammas only</td>
<td>NSUF</td>
<td>Website</td>
</tr>
<tr>
<td>Analytical Chemistry Laboratory</td>
<td>Westinghouse</td>
<td>Industry</td>
<td>Radiochemistry</td>
<td>betas/gammas only</td>
<td>PARTNER</td>
<td>Website</td>
</tr>
<tr>
<td>Analytical Laboratory</td>
<td>Idaho National Laboratory</td>
<td>Dept of Energy</td>
<td>Hot Cell</td>
<td>betas/gammas only</td>
<td>NSUF</td>
<td>Website</td>
</tr>
<tr>
<td>Analytical Support Operations at RPL</td>
<td>Pacific Northwest National Laboratory</td>
<td>Dept of Energy</td>
<td>Radiochemistry</td>
<td>betas/gammas only</td>
<td>PARTNER</td>
<td>Website</td>
</tr>
<tr>
<td>Annular Core Research Reactor</td>
<td>Sandia National Laboratory</td>
<td>Dept of Energy</td>
<td>Reactor</td>
<td>betas/gammas only</td>
<td>PARTNER</td>
<td>Website</td>
</tr>
<tr>
<td>ATR Critical Facility</td>
<td>Idaho National Laboratory</td>
<td>Dept of Energy</td>
<td>Reactor</td>
<td>betas/gammas only</td>
<td>NSUF</td>
<td>Website</td>
</tr>
<tr>
<td>ATR Gamma Facility</td>
<td>Idaho National Laboratory</td>
<td>Dept of Energy</td>
<td>Gamma Irradiator</td>
<td>betas/gammas only</td>
<td>NSUF</td>
<td>Website</td>
</tr>
<tr>
<td>Betelne Reactor 2</td>
<td>SCKCEN</td>
<td>International Government</td>
<td>Reactor</td>
<td>betas/gammas only</td>
<td>PARTNER</td>
<td>Website</td>
</tr>
</tbody>
</table>

Showing 1 to 25 of 67 entries

## INL Information and Point of Contact

<table>
<thead>
<tr>
<th>Institution</th>
<th>Contact</th>
<th>Reactor</th>
<th>PIE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idaho National Laboratory</td>
<td>Simon Pimbloff</td>
<td>ATR User Guide</td>
<td>INL PIE User Guide</td>
</tr>
<tr>
<td></td>
<td>(208) 326-7499</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## NSUF Partner Institutions: Information and Points of Contact

<table>
<thead>
<tr>
<th>Partner Institution</th>
<th>Contact</th>
<th>Reactor</th>
<th>PIE</th>
<th>Gamma</th>
<th>Beamline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argonne National Laboratory</td>
<td>Meiwei Li</td>
<td>Reactor</td>
<td>PIE</td>
<td>User Guide</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(630) 232-5111</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IVEM Tandem Facility</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brookhaven National Laboratory</td>
<td>Lynn Eckert</td>
<td>Reactor</td>
<td>PIE</td>
<td>User Guide</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(631) 344-2538</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Center for Advanced Energy Studies / MaCS</td>
<td>Joanna Taylor</td>
<td>Website</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(208) 533-8170</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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
- Al₃Hf: Al₂O₃
- Al1100: MgO
- Al6061: MgO-ZrO₂
- Aluminum Bronze: Ni/Cu/Nb (DC)
- Beryco #25: Mg₂-SnO₄
- C276 Hasteloy: Mg₀.₁₅Al₂O₃
- Incoloy 800H: MgTiO₃
- Inconel X/X-750: Mg₂AlC
- Stellite: Ti₃AlC₂
- 17-4 PH SS: Fe-Cr Alloys
- 304 SS: HCM12-A
- 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

### Ceramics
- Mg₂-SnO₄
- Mg₀.₁₅Al₂O₃
- MgTiO₃
- Mg₂AlC
- Ti₃AlC₂
- Ti₃SiC₂

### Pure Materials
- Copper
- Iron
- Nickel
- Niobium
- Silver
- Tantalum
- Tungsten
- Zirconium

Small amounts of purified actinides and fission products in liquid form.
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**
- Federal Program Manager: Tansel Selekler
  TanselSelekler@nuclear.energy.gov

- 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

Brenden Heidrich
(208) 526-8117
Brenden.Heidrich@INL.gov

NSUF@INL.gov
NSUF.INL.gov
NSUF-Infrastructure.INL.gov
DISCLAIMER

• This information was prepared as an account of work sponsored by an agency of the U.S. Government.

• Neither the U.S. Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.

• References herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the U.S. Government or any agency thereof.

• The views and opinions of authors expressed herein do not necessarily state or reflect those of the U.S. Government or any agency thereof.