US Nuclear Science User Facilities (NSUF)
Overview and Status

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Director, NSUF
Idaho National Laboratory

HotLab 2016
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The research performed to support nuclear energy development requires specialized and increasingly rare capabilities:
- Test and research reactors
- Hot cells
- Ion beams
- Support infrastructure (shipping casks, test fabrication, etc.)
- State-of-the-Art instrumentation & Expertise

But also intellectual capital:
- Universities
- Nuclear Industry
- Innovative Small Businesses
- National Laboratories

The NSUF aims to merge the national nuclear research infrastructure with intellectual capital to pair the best ideas with needed capability:
- Focus area of NSUF is irradiation effects in nuclear fuels and materials. Expanded scope is intended.
- The 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 NSUF core purpose is to provide an avenue for innovative ideas that address NE mission needs to be realized.
Established 2007 as DOE Office of Nuclear Energy first and only user facility
- Idaho National Laboratory is lead institution

Generally select projects through open competitive proposal processes
- Consolidated Innovative Nuclear Research (CINR FOA, 1 call/year)
  - Irradiation + PIE ($1.0M - $4.0M, up to 7 years)
  - PIE only (~$500K, up to 3 years)
  - Irradiation only ($500K - $3.5M)
  - Beamlines at other user facilities
- Rapid Turnaround Experiments (RTE, 3 calls/year, limited $$, executed within 9 months)
- Proposals welcome from University, National Laboratory, Industry, Int’l researchers

Partner Facilities established starting in 2008 (self selection)
- 8 Universities + 3 universities in CAES (3 expressed interest)
- 4 National Laboratories (3 expressed interest)
- 1 Industrial
NSUF – A consortium
A group formed to undertake an enterprise beyond the resources of any one member
Neutron Irradiations
- ATR (loop, rabbit), ATRC, HFIR (rabbit), MITR (loop), PULSTAR, NRAD (Future: BR2 – SCK-CEN Belgium), Halden – Norway ?

Ion Irradiations
- Tandem Accelerator Ion Beam (U. Wisc), Michigan Ion Beam Lab (U. Mich), IVEM (ANL) (Future: TAMU, SNL, LANL)

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; BNL NSLS-II: XPD, NST Dept)
- Neutron, positron (PULSTAR, NCSU)

Visit nsuf.inl.gov under Research Capabilities tab for details at individual facilities
Total of 28 awarded CINR type projects executed
Total of 21 awarded projects currently ongoing (excluding RTEs)
Total of 97 RTEs executed
Total of 30 RTEs ongoing
176 total projects awarded
- 122 projects to 33 US universities
- 49 projects to 5 national laboratories
- 4 projects to 3 international (Oxford U., Manchester U., ANSTO)
- 1 project to industry (GE-Hitachi)
172 total projects across 22 states
Interest and support levels
- FY 2014 – $400K, 8 full proposals, 3 awards
- FY 2015 – $4.1M, 41 LOIs, 31 pre-proposals, 17 full proposals, 5 awards (1 R&D coupled, 4 NSUF only)
- FY 2016 – $9.7M, 80 LOIs, 67 pre-proposals, 32 full proposals, 12 awards (8 R&D coupled, 4 NSUF only)
- FY 2017 – 124 LOIs, 109 pre-proposals
High Impact Nuclear R&D

Project portfolio spans a variety of research objectives that are ultimately focused on both near and long-term technology development goals:

- Understanding atomic level phenomena in fuels that affect thermal transport, elemental migration/diffusion, interface interaction, etc. as complex microstructures develop under irradiation
  - ceramic, metallic, TRISO, ATF

- Understanding fundamental defect evolution in irradiated structural materials across multiple length scales as they affect mechanical properties.
  - RPV, austenitic, F/M, Zr alloys, ATF

- Development of innovative radiation resistant materials for advanced reactor systems

- Development of radiation resistant sensors for collecting high fidelity on-line irradiation test data

- Providing fundamental actinide nuclear data that can help inform advanced reactor and fuel cycle modeling and simulation campaign.

J. Cole contributed to content of slide
1. Gather Data on Nuclear Energy R&D Capabilities

2. Estimate Near, Mid and Long-term R&D Directions

3. Use these to perform gap analyses for Nuclear Energy R&D needs.

4. Assist funding decisions and incorporate the results into the NEID.
Infrastructure / Capabilities

- Nuclear Energy Infrastructure Database (NEID) public web-based searchable tool launched in November 2015 (nsuf-infrastructure.inl.gov)
- Over 125 institutions operating over 450 facilities housing almost 900 instruments
- Current NEID users include researchers from 75 Federal Government and National Laboratories, 38 Universities and NGOs, and 25 Industry organizations.
- Used to complete infrastructure gap analyses
Nuclear Fuels and Materials Library (NFML)

B. Heidrich

- Provides irradiated samples for users to access for experimentation through one of the competitively reviewed proposal processes.
- Critical to reducing costs and taking advantage of new ideas and future analysis techniques and equipment.
- The library includes over 3500 specimens as part of the NSUF awarded research. 6K – 7K additional specimens by year end.
- Most materials in NFML neutron irradiated with small number ion irradiated.
- SAM irradiation series to stock library moving forward
- Effort to consolidate materials into easily accessible locations to reduce costs of retrieval.
- Interest in collaboration on international efforts.

- Materials Include:
  - Steels
  - Other alloys
  - Ceramics
  - Pure materials
  - Actinides
  - Fission products
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<th>Other Alloys</th>
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<td>MgO</td>
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<td>various model alloys</td>
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Nuclear Fuels and Materials Library
B. Heidrich

Materials from NSUF projects, EBR-II, ATR, FFTF, HFIR, José Cabrera Nuclear Power Station, Zion 1 & 2 NPS (in negotiation).
1. We can connect **facilities and instruments** as parts of a **process** to accomplish a research method or process, such as:
   - Microstructural characterization of irradiated fuel.
   - Irradiation experiment (through design, fabrication, irradiation, etc.)

2. We can include **fuels and materials**:  
   - Nuclear Fuels and Materials Library  
   - Link to facilities utilized  
   - Link to researchers

3. We can connect **research**:  
   - Subject matter  
   - Facilities utilized  
   - PIs & collaborators

4. We can include **expertise**:  

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**Future Initiatives:**

**Integrating Databases**
NSUF Vision

Building sustainable value over the long term

- High Impact Results
  - Establish processes and activities to focus research on high-impact, NE-relevant challenges. Increase program awareness.

- Projects
  - Award and execute competitive (CINR and RTE scopes) and non-competitive projects (NE programs, CRADAs).

- NFML

- HPC
  - Identify and analyze capability status and needs. Support V&V and M&S through coupling experiment to computation.

- Capability Development
  - Acquire cutting edge, state-of-the-art instrumentation, internationally recognized expertise, and other user facility leveraging.

- Capability Enhancement

- Infrastructure Management/NEID

- Human Capital

- Capability Maintenance/Replacement
UK National Nuclear User Facility (NNUF)
- Ongoing for ~3 years
- Strong interest in linked NFML
- Access to NSUF facilities provided to UK researchers

SCK-CEN BR-2 Reactor (Belgium)
- Initiated in 5/2016
- In process of establishing CRADA (4 projects with in-kind contributions)
- Strong potential for NSUF access to BR-2 reactor space

Halden Research Project (Norway, OECD)
- Potential for NSUF access to Halden reactor space