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Nuclear Energy

US Nuclear Science User Facilities (NSUF) Status and Update



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Nuclear Academics Discussion Meeting (NADM)
Lancaster University
September 4-5, 2017



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- **Established 2007 as DOE Office of Nuclear Energy first and only user facility**
 - Idaho National Laboratory is lead institution
 - Irradiation effects in nuclear fuels and materials
 - Provide access to capabilities and expertise at no cost to user
 - Support design, fabrication, transport, irradiation, PIE, disposition
 - Link intellectual capital with nuclear research infrastructure to fulfill mission of DOE-NE
- **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, Small Business, Int'l researchers



- Recognized early that needs of community exceed capacity at INL
- Partner Facilities program started in 2008
- Name changed to Nuclear Science User Facilities in 2014
- 11 Universities + 4 Universities in CAES, 7 National Laboratories, 1 industry

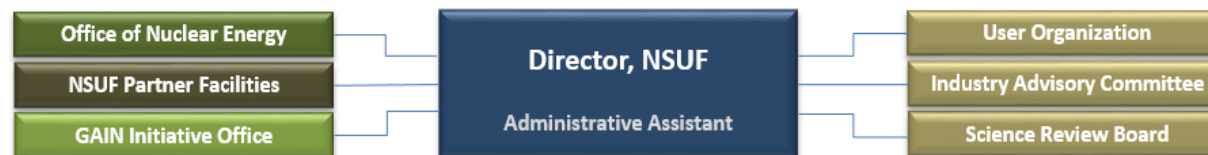




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NSUF Organization Chart

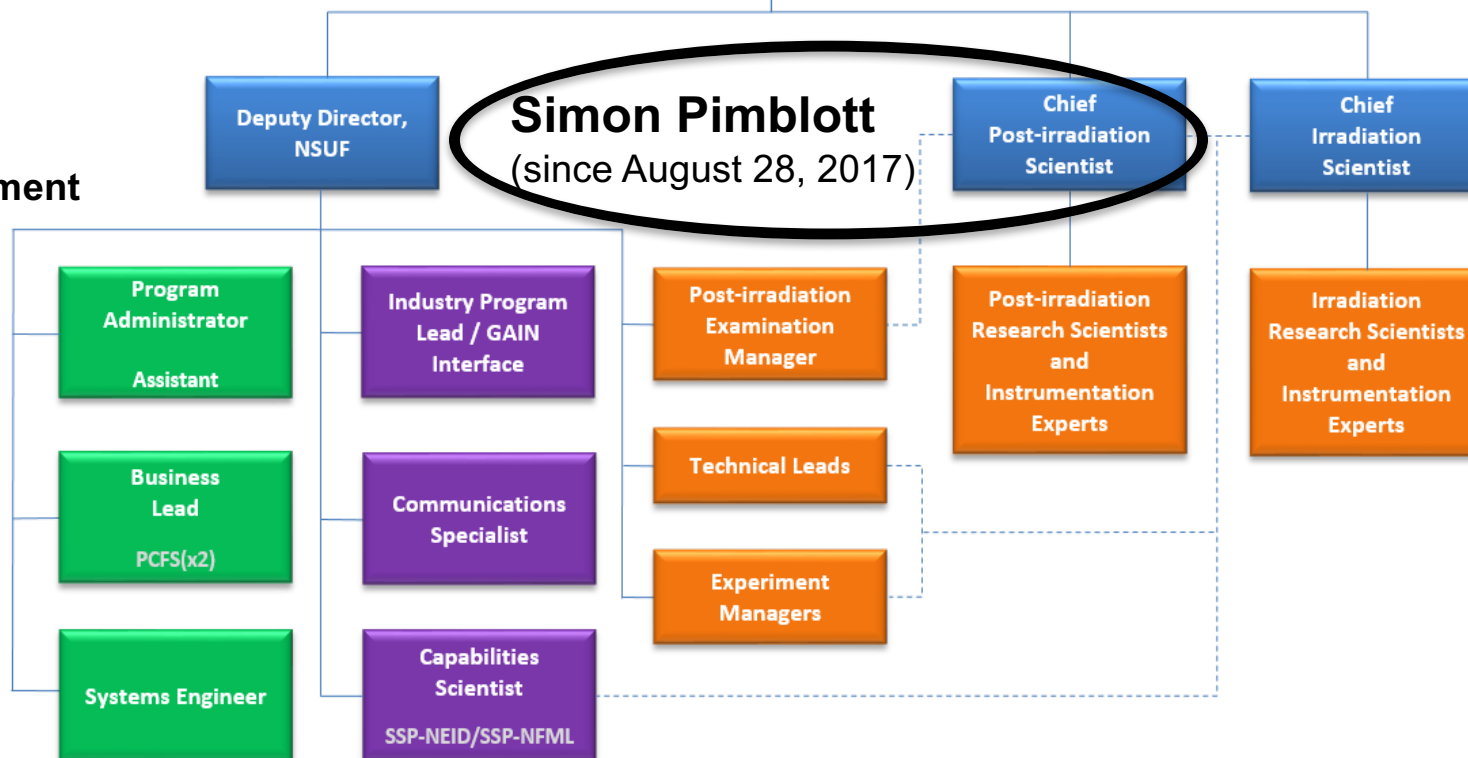


Added Staff in 2017:

Project Scheduler

Information Management
Specialist

Financial & Controls
Specialist



Mission
Administration

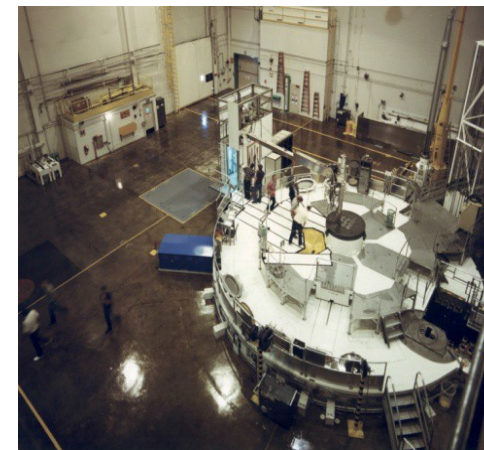
Mission
Support

Mission
Execution

NSUF Projects Summary

FY 2007 – FY2017

- Total of ~\$182M in DOE support (2007-2017)
- Total of 32 CINR type projects executed
- Total of 33 CINR type projects currently ongoing
- Total of 136 RTEs executed
- Total of 92 RTEs ongoing
- 293 total projects awarded
 - >21 US universities
 - 5 national laboratories
 - 4 industry
 - 4 international (Oxford U., Manchester U., Liverpool U., ANSTO)



FY 2017

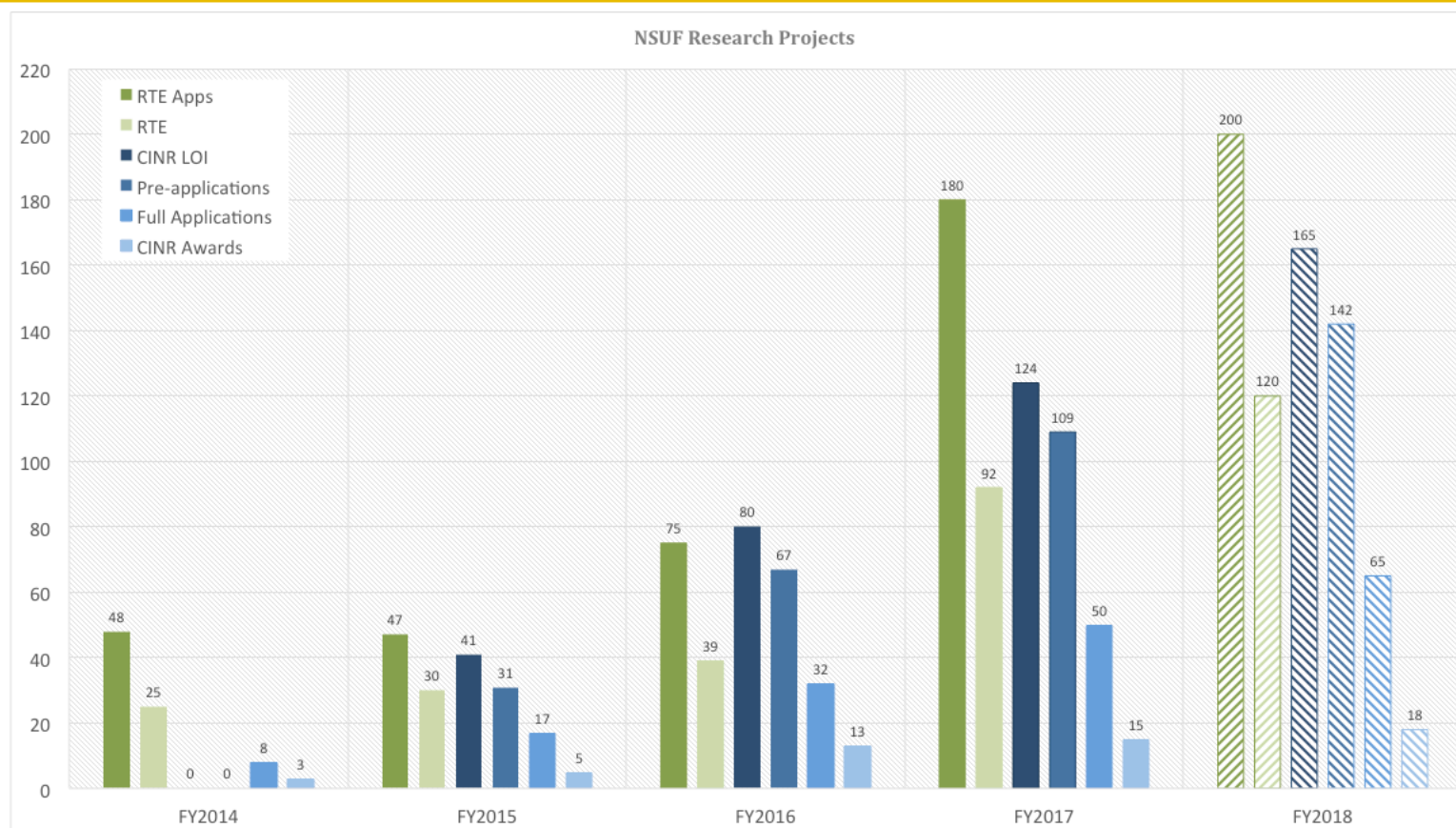
- Effective FY2017 budget: ~\$29M (same as FY16)
- Total effective FY 2017 budget allocated to projects: \$14.7M direct (CINR + RTE) + \$3.4M supporting (PIE coordination, experiment managers, experiment analyses, shipping, SCK-CEN pilot projects)



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Historical and Projected Growth



■ CINR type projects support

- FY 2014 – \$400K, 8 full proposals, 3 awards
- FY 2015 – \$4.1M, 41 LOIs, 31 pre-proposals, 17 full proposals, 5 awards
- FY 2016 – \$10M, 80 LOIs, 67 pre-proposals, 32 full proposals, 13 awards
- FY 2017 - ~\$11M, 124 LOIs, 109 pre-proposals, 50 full proposals, 15 awards

Graphics created by
Brenden Heidrich



■ Computational Model Development and Validation

- In-Situ Ion Irradiation to Add Irradiation Assisted Grain Growth to the MARMOT Tool (NEAMS, \$125K)
- Simulation of Radiation and Thermal Effects in Advanced Cladding Materials (NSUF-2, \$45K)
- HPC Access to Advance Understanding of Fission Gas Behavior in Nuclear Fuel (NSUF-2, \$890K)
- Study of the Irradiation Behavior of Fast Reactor Mixed Oxide Annular Fuel with Modern Microstructural Characterization to Support Science Based Model Validation (NSUF-2, \$773K)

■ Advanced Fuel Development

- Irradiation, Transient Testing and Post Irradiation Examination of Ultra High Burnup Fuel (NSUF-2, \$3600K)
- Irradiation of Advanced Neutron Absorbing Material to Support Accident Tolerant Fuel (NSUF-2, \$630K)



- **Sensor Development / Additive Manufacturing**
 - Additive manufacturing of thermal sensors for in-pile thermal conductivity measurement (NSUF-1.2a, \$536K)
 - Radiation Effects on Optical Fiber Sensor Fused Smart Alloy Parts with Graded Alloy Composition Manufactured by Additive Manufacturing Processes (NSUF-1.2b, \$775K)
 - Radiation Effects on Zirconium Alloys Produced by Powder Bed Fusion Additive Manufacturing Processes (NSUF-2, \$830K)
- **Welding and Joining Advanced Cladding**
 - Performance of SiC-SiC Cladding and Endplug Joints Under Neutron Irradiation with a Thermal Gradient (NSUF-1.2c, \$985K)
 - Capacitive Discharge Resistance Welding of 14YWT for Cladding Applications (NSUF-1.3, \$59K)



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FY2017 CINR Awarded Projects Focus on Key Technologies & Understanding



■ **Fundamentals for Reactor Materials**

- **Correlation between Microstructure and Mechanical Properties of Neutron-Irradiated Ferritic-Martensitic and Austenitic Steels (NSUF-1.1a, \$652K)**
- **X-ray Characterization of Atomistic Defects Causing Irradiation Creep of SiC (NSUF-2, \$150K)**
- **Positron Annihilation Studies of Neutron Irradiated Ferritic Alloys (NSUF-2, \$203K)**
- **Improved Understanding of Zircaloy-2 Hydrogen Pickup Mechanism in BWRs (NSUF-2, \$817K)**



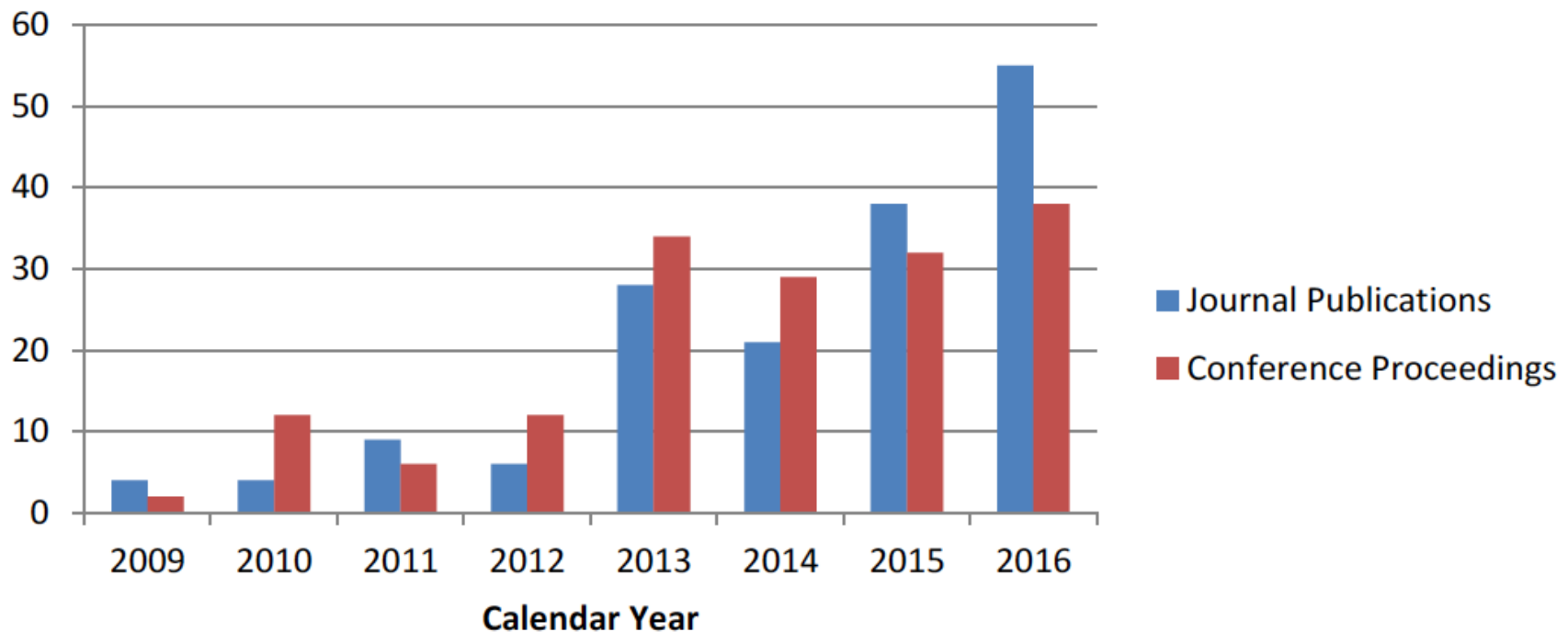
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NSUF Publications



NSUF Publications/Conference Proceedings



- Beginning to see results from early irradiation tests
- Increase in RTE awards.
- Journal of Nuclear Materials is by far the most published in journal.

■ 2016

- Ion Beam Investment Options Workshop

■ 2017

- Ion Beam Irradiation Roadmap
- NSUF/GAIN Nuclear Thermal Hydraulics Workshop

■ 2018

- Nuclear Materials Technical Readiness Level (TRL) Definitions Workshop



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Nuclear Fuels and Materials Library (NFML)



- 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.
- Web-based searchable database through nsuf.inl.gov (public launch Sept 14, 2016).
- Interest in collaboration on international efforts.
- Materials Include:
 - Steels
 - Other alloys
 - Ceramics
 - Pure materials
 - Actinides
 - Fission products



INL
Legacy
materials

Volunteered
materials
from outside
the INL

Supporting
documentation
related to
samples



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Nuclear Fuels and Materials Library (NFML)



■ New additions to NFML

- Contact with Savannah River Site on host of irradiated fuel materials in the National Nuclear Materials Archive (NNMA) (jointly sponsored by the Office of Materials Integration, Office of Nuclear Forensics, and DOE-IN). Includes MOX, carbides, and alloys.
- Type 347 commercial reactor baffle bolts (EPRI and Westinghouse)
- Zorita 304 SS (EPRI) located at Studsvik (Sweden) – on hold
- X-750 samples (AECL) – awaiting provenance confirmation

■ Sample Requests and Awards in 2017

	Total Proposals & Pre-Apps Received	2017 Requests	2017 Awards
RTE	180	23	10
CINR	109	8	2



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Nuclear Fuels and Materials Library (NFML)



■ NFML On-line Database Update

- Keyword Search
- Filter by Organizations, Dimensions, Material Names, Material Descriptions, and Specimen Types
- Logarithmic sliders to query by As-Run Dose, Total Dose, Temp and Fluence
- Results limited to only the projects that have Sample and Cycle data
- Improvements to the tracking system

- **NSUF created a searchable and interactive database of all pertinent infrastructure supported by, or related to, the DOE Office of Nuclear Energy (DOE-NE).**
- **Database known as the Nuclear Energy Infrastructure Database (NEID) and is located at nsuf-infrastructure.inl.gov (public launch Nov 2015)**
- **Used for analyses to identify needs, redundancies, efficiencies, distributions, etc., to best understand the utility of DOE-NE's available infrastructure, inform the content of infrastructure calls, and provide information to NSUF users.**
- **Infrastructure information collected can be combined with information on R&D needs as part of infrastructure gap analysis**
- **NSUF now coordinates the infrastructure investment programs for DOE-NE**

