U.S. DEPARTMENT OF ENERGY | Nuclear Energy

Nuclear Science User Facilities

NSUF Overview
FY 2016 Consolidated Innovative Nuclear Research FOA
DE-FOA-0001281

Dan Ogden
NSUF Deputy Director
Idaho National Laboratory

NSUF Nuclear Science User Facilities

CINR Webinar
August 11, 2015

Outline

- Changes from FY 2015
- Overview of NSUF
- Requesting NSUF Access
- Workscope Consolidation
- NEET-NSUF-2 (Brenden Heidrich, INL)
- NEET-NSUF-1.2a (Janelle Zamore, DOE)
- NEET-NSUF-1.1a, 1.1b, 1.1c (Rich Reister, DOE)
- NEET-NSUF-1.1e (Scott Harlow)
- NEET-NSUF-1.1d (Madeline Feltus)
- NSUF Questions
- NEET-NSUF-1.3a, 1.3b,1.3c,1.d (Sue Lessica) (Wed. 10:30)

Changes from FY 2015

- Name Change: Evolved from "ATR National Scientific User Facility" to "Nuclear Science User Facilities"
- NSUF Access consolidated to two workscopes
- Uninvited applications will not be reviewed for NSUF Access
- DOE reserving option to decouple R&D request from NSUF Access and evaluate and fund either portion if feasible
  - Applicable in the NEET-NSUF-1 workscope only
- High Performance Computing Capability access through NSUF
- Source, Scope and Duration of R&D support must be identified for NSUF Access Only
- LOI due date August 27 - Pre application due date September 17

What is a User Facility?

Regional, national or international facility with unique experimental capabilities. Access is typically cost free through a competitive proposal process. The goal is to connect the best ideas with the capability regardless of geographical or institutional separation.

Advanced Photon Source (ANL)

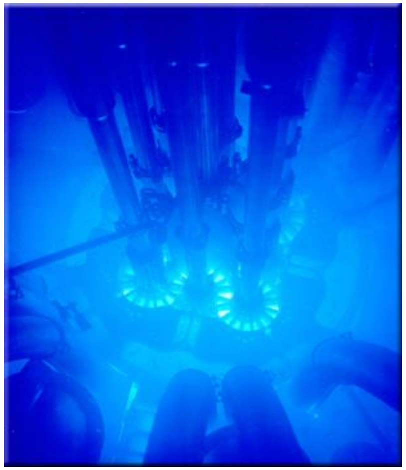
Spallation Neutron Source (ORNL)

There are currently 48 DOE user facilities in the U.S.

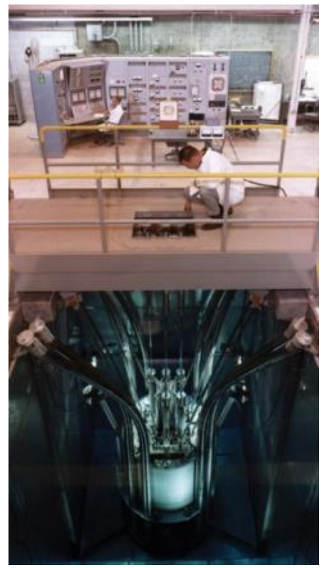
- Advanced scientific computing research
- High flux synchrotron and neutron sources
- Electron beam characterization
- Nano-scale science
- Biological and environmental research
- High energy and nuclear physics
- Fusion energy science

……But before 2007 there were no user facilities to address the unique challenges of nuclear energy. Then came the Advanced Test Reactor National Scientific User Facility!

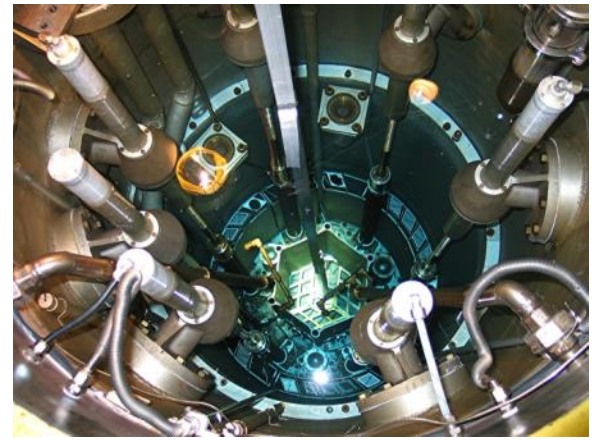
NSUF – Multiple Test Reactors



Advanced Test Reactor (INL)



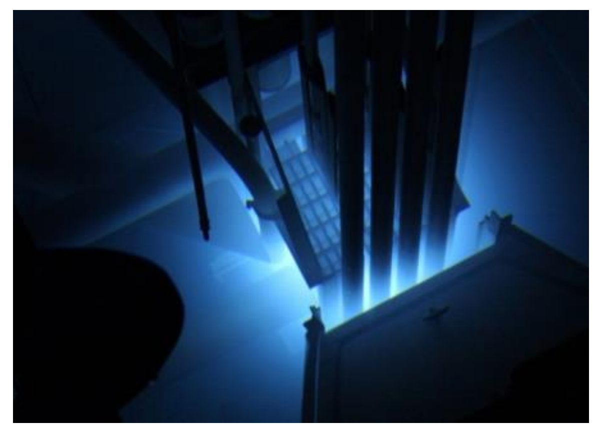
ATR Critical Facility (INL)



MIT Reactor

High Flux Isotope Reactor (ORNL)

NRAD Reactor (INL)



PULSTAR Reactor
(NCSU)

NSUF – Ion Beams

University of Michigan
Ion Beam Laboratory

University of Wisconsin
Tandem Accelerator Ion Beam

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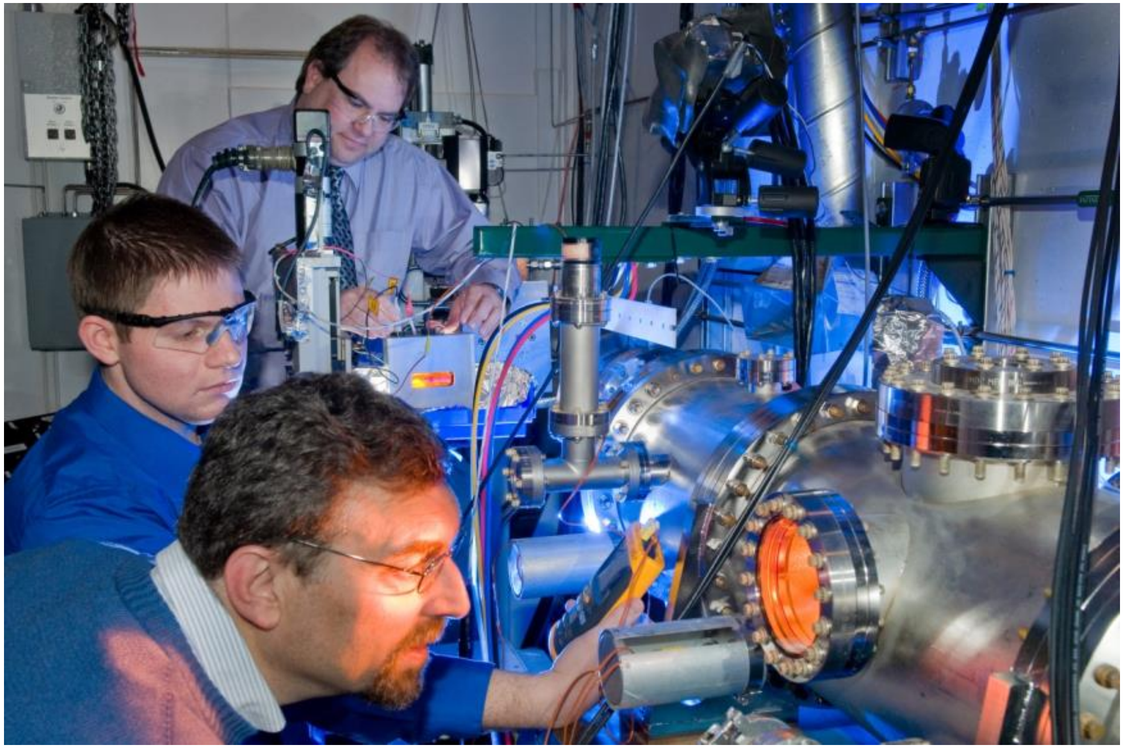
NSUF - Synchrotron Irradiation

NSUF Nuclear Science User Facilities



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

NSUF - Hot Cell Capabilities

Hot Fuel Examination Facility (INL)

Radiochemical Engineering Development Center (ORNL)

MIT Reactor Hot Cells

Materials Center of Excellence Laboratories (Westinghouse)

Radiochemistry Processing Laboratory (PNNL)

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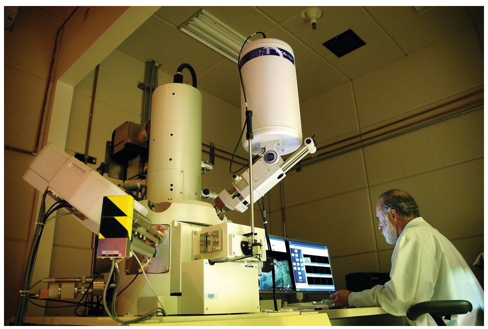
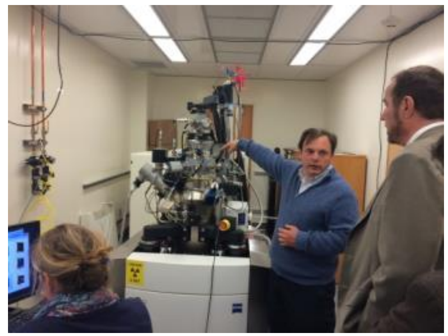
NSUF – Post Irradiation Examination

Nuclear Science User Facilities

(A sample to whet your appetite – visit nsuf.inl.gov for the full menu)

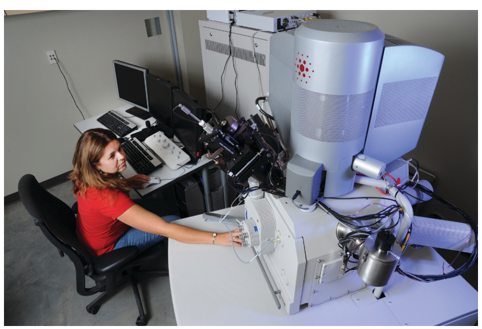


Electron Microscopy Laboratory (INL)



Nuclear Materials Laboratory (UCB)

Radiochemistry Processing Laboratory
Materials Science and Technology Laboratory
(PNNL)



Microscopy and Characterization Suite
Center for Advanced Energy Studies

Low Activation Materials Development
and Analysis Laboratory (ORNL)

NSUF – Sample Library

- A cache of irradiated material with pedigree
- Critical to reducing costs and taking advantage of new ideas and future analysis techniques and equipment
- A link is provided on our website: nsuf.inl.gov
- Questions? Ask Jim Cole (208) 526-8101 or james.cole@inl.gov

MOOSE

Multi-physics Object-Oriented Simulation Environment

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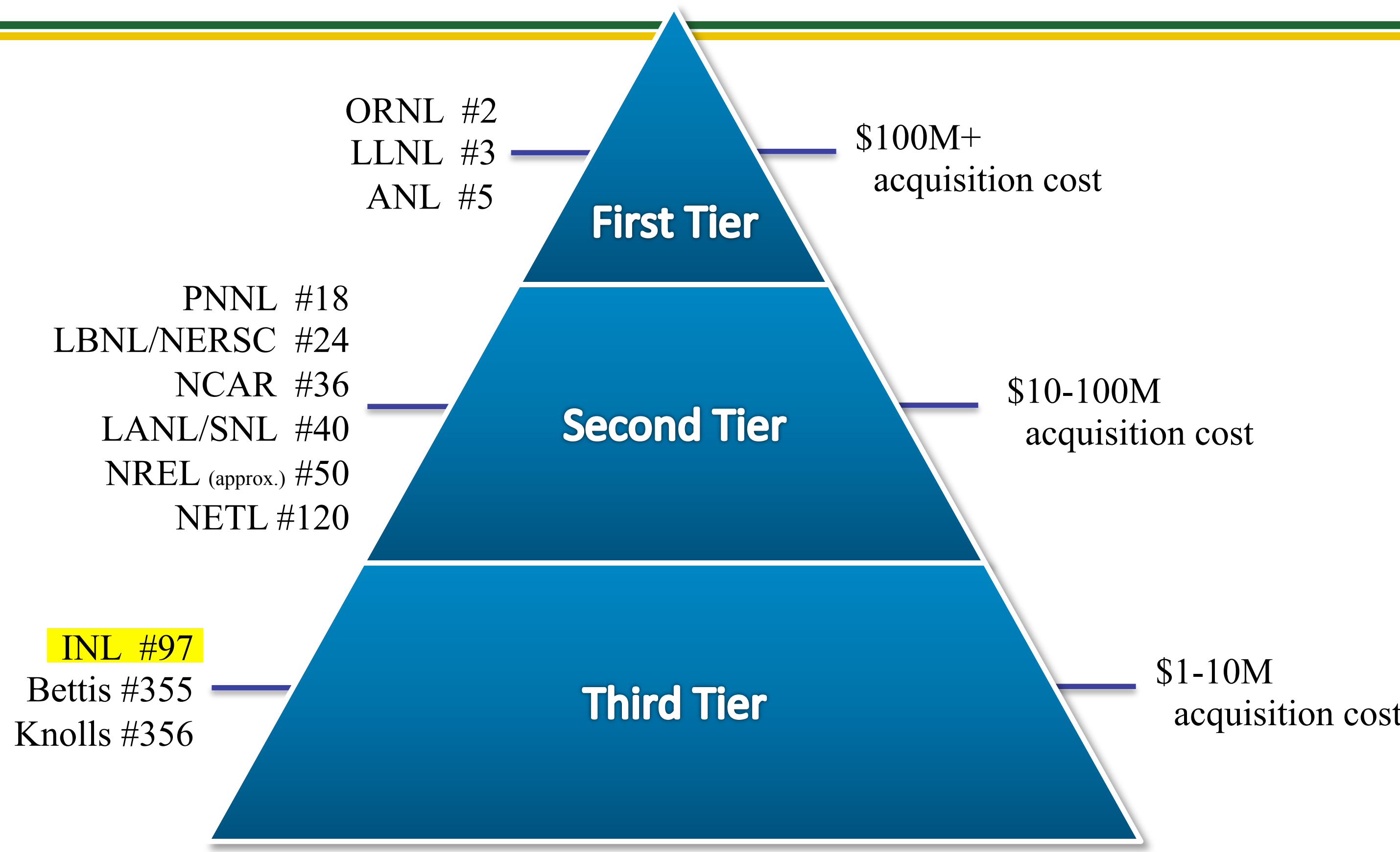
High Performance Computing

NSUF Nuclear Science User Facilities



November 2014 Top500 Rankings

Approximately five systems in the first tier

NSUF – A sample of our technical expertise

NSUF Staff (DOE)
Mr. Mike Worley
Ms. Alison Hahn
Mr. Brooks Weingartner

NSUF Staff (INL)
Dr. J. Rory Kennedy
Mr. Dan Ogden
Ms. Lindy Bean
Mr. Jeff Benson
Dr. James Cole
Dr. Brenden Heidrich
Dr. John Jackson
Mr. Collin Knight
Ms. Sarah Robertson
Ms. Renae Soelberg
Dr. Sebastien Teysseyre

Neutron Irradiation
Dr. Donna Guillen (INL)
Dr. Paul Murray (INL)
Dr. Lin-wen Hu (MIT)
Dr. Gordon Kohse (MIT)
Dr. Joseph Nielson (INL)
Dr. Randy Nanstad (ORNL)
Mr. Tom Maddock (INL)
Mr. Kevin Clayton (INL)
Mr. Dave Schoonen (INL)
Ms. Debra Utterbeck (INL)
Dr. Sean O'Kelly (INL)
Dr. David Senor (PNNL)
Mr. Mike Heighes (INL)
Mr. Brian Durtschi (INL)

Ion Beams
Dr. Gary Was (UM)
Dr. Beata Tyburska-Puchel (UW)

Examinations
Dr. Assel Aitkaliyeva (INL)
Dr. Brandon Miller (INL)
Dr. Jian Gan (INL)
Dr. Yaqiao Wu (CAES)
Ms. Joanna Taylor (CAES)
Dr. Andrew Casella (PNNL)
Dr. Maria Okuniewski (INL)
Dr. Peter Hoseman (UCB)
Mr. Ron Krone (INL)
Dr. Mitch Meyer (INL)
Dr. Dan Wachs (INL)
Ms. Katelyn Wachs (INL)

Synchrotron Irradiation
Dr. Jeff Terry (IIT)

And many more scientists, engineers and technical staff to help get things done - you are not alone!

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NSUF – A consortium

A group formed to undertake an enterprise beyond the resources of any one member

NSUF Nuclear Science User Facilities

CAES Center for Advanced Energy Studies

The University of Wisconsin Madison

Massachusetts Institute of Technology

INL Idaho National Laboratory

Illinois Institute of Technology

University of Michigan

Pacific Northwest National Laboratory

Oak Ridge National Laboratory

NC STATE UNIVERSITY

Berkeley University of California

UNLV University of Nevada Las Vegas

Westinghouse Innovation You Can Be Sure Of

Purdue University

Accessing the NSUF

Research Menu (A la carte)

- Neutron Irradiation
- Ion Irradiation
- Synchrotron Irradiation
- Post Irradiation Examination

Process Drivers

- Request for NSUF access must be feasible
- Determine cost of access (NSUF required to fully forward fund award)
- Applicant will need assistance from NSUF staff

Process

- Described in Detail in Appendix E
- Letter of Intent is a critical and mandatory first step (DUE August 27!)
- Visit our website at nsuf.inl.gov and contact us soon
- NSUF Technical Lead will be your new best friend

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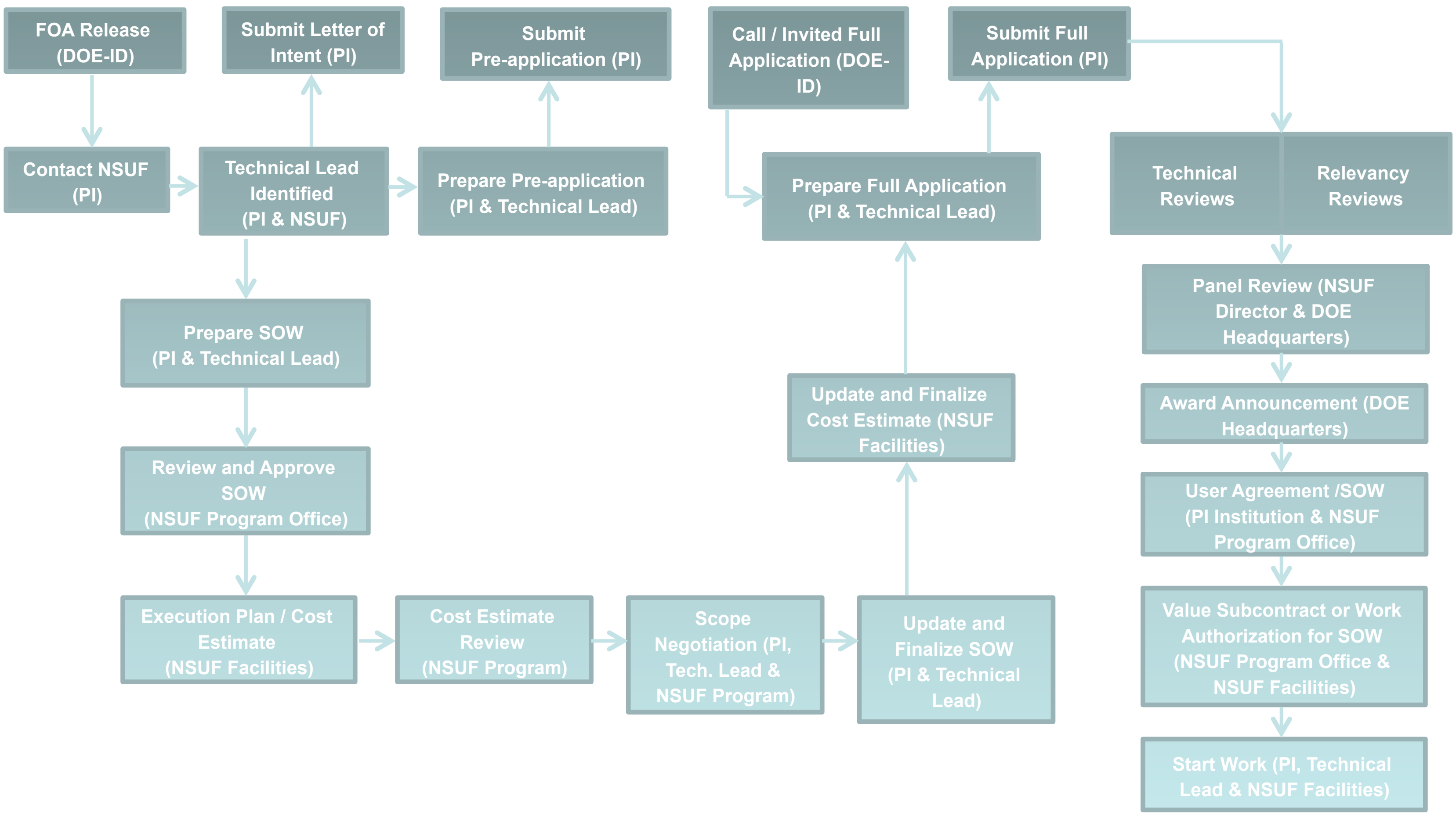
NSUF Access Process

NSUF Nuclear Science User Facilities



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Consolidation of NSUF Access to two workscopes

NSUF Nuclear Science User Facilities

- **In FY 2015, NSUF Access could be coupled to most R&D workscopes**
- **In FY 2016, NSUF Access will be available only through:**
  - NEET-NSUF-1 (for R&D support with NSUF Access)
  - NEET-NSUF-2 (for NSUF Access Only – No R&D support)
- **NEET-NSUF-1**
  - NE Mission/Program focus for direction connection with R&D support
- **NEET-NSUF-2**
  - NE Mission focus to provide broader opportunity for researcher's not needing R&D support

NEET-NSUF-2
NSUF Access Only

Dr. Brenden Heidrich
Idaho National Laboratory

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NEET-NSUF-2
NSUF Access Only

Nuclear Science User Facilities

- Objective
  - Provide cost-free 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
  - R&D support funding not provided
  - NSUF does not fund travel, salaries, or other user costs
  - Source, scope and duration of R&D funding must be identified
  - Preliminary development effort should be nearly complete

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NEET-NSUF-2 Focus Areas

NSUF Nuclear Science User Facilities

- **Core and Structural Materials**
  - Understanding material degradation mechanisms due to irradiation or irradiation combined with other environmental effects
  - Development of radiation resistant materials for current and future reactor applications
- **Nuclear Fuel Behavior and Advanced Nuclear Fuel Development**
  - Increase fundamental understanding of the behavior of nuclear fuel (including cladding)
  - Improve performance of current fuels
  - Research and 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

NEET-NSUF-2 Focus Areas

Advanced In-reactor Instrumentation

- Characterization of materials under irradiation in test reactors
  - Dimensional Changes
  - Crack Propagation
  - Internal Fission Gas Pressure
  - Non-intrusive to the specimen
- On-line condition monitoring of power reactors
- Non-traditional techniques (optical fibers, ultrasonics, wireless transmission)

Experiments with Synchrotron Radiation at the Advanced Photon Source

- Via the Illinois Institute of Technology and the MRCAT beamline
- X-ray diffraction, X-ray absorption, X-ray fluorescence, 5μm spot size fluorescence microscopy
- Fundamental aspects of radiation damage

NEET-NSUF-2
NSUF Access Only

Contact Information

- Federal Program Manager: Alison Hahn

  Alison.Hahn@nuclear.energy.gov

- Technical Lead: J. Rory Kennedy

  Rory.Kennedy@inl.gov

Questions?

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NEET-NSUF 1.2a Experimental Data and Models for Advanced Reactor Fuels and Cladding Materials using NSUF Facilities

Janelle Zamore
Federal POC

DOE-NEUP FY2015 Webinar
August 11, 2015

NSUF Nuclear Science User Facilities

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*The FCRD Advanced Fuel Campaign is tasked with development of near term **Accident Tolerant LWR fuel** technology and performing research and development of **long term resource enhancement** options.*

Advanced LWR fuels with enhanced performance, safety, and reduced waste generation

Transmutation fuels with enhanced proliferation resistance and resource utilization

Capabilities Development for Science-Based Approach to Fuel Development

- Advanced characterization and PIE techniques
- Advanced in-pile instrumentation
- Separate effects testing
- Transient testing infrastructure

ADVANCED FUELS CAMPAIGN

Multi-scale, multi-physics Fuel Performance M&S

NEAMS

Use of National Scientific User Facilities related call -

Experimental Data and Models for Advanced Reactor Fuels and Cladding Materials using National Scientific Users Facilities

The FCRD Advanced Fuel Campaign is developing advanced fast spectrum reactor metallic fuels and advanced LWR fuel technologies to improve performance of fuels and materials in Light Water Reactors during off-normal conditions. Proposals for separate effect experiments linking integral experimental data with microstructural-level material properties of candidate fuel system components are desired. Priority will be given to proposals that focus on metallic alloy fuels for advanced reactors and for technologies currently under investigation by the Accident Tolerant Fuel program. The experimental activities should produce data to be used in the validation of material property and fuel performance models. The model(s) supported and developed should be consistent and compatible with the NEAMS MBM fuel performance tools. Proposals focused on advancing LWR accident tolerant fuel and advanced recycle fuel concepts currently under study by the FCRD AFC will be given higher priority.

Proposals are sought that use the National Scientific Users Facilities (NSUF), e.g., Idaho National Laboratory (INL) hot cells, INL Advanced Test Reactor, etc., as well as applicant university facilities to provide sufficient separate effects data needed for development of high performance models of nuclear fuels and materials performance and behavior.

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Key Items to Consider

- **Apply to this call (NEET-NSUF) 1.2a if you intend to use NSUF capabilities such as the INL Advanced Test Reactor, hot cells etc.**
- **Apply to the mirror call NEUP FC-2.1 if you *do not* intend to use NSUF capabilities**
- **Must show relationship to elements of the Advanced Fuels program**
  - Priority given to LWR accident tolerant fuels and transmutation fuels
- **Models and Phenomena of interest include but are not limited to:**
  1) Metallic fuel swelling, fission gas behavior, and fuel-cladding chemical interaction (vs. FMS cladding materials)
  2) Creep and swelling of FMS cladding materials
  3) Nitride-silicide composite ATF fuel swelling, fission gas behavior
  4) Creep and corrosion resistance of FeCrAl cladding materials

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Contact Information

- **Federal Program Manager(s):**
  - Frank Goldner (Advanced LWR fuel lead) frank.goldner@nuclear.energy.gov
  - Janelle Zamore (Transmutation fuels lead) janelle.zamore@nuclear.energy.gov
  - Ken Kellar (Advanced Fuels Experimental Capabilities lead) kenneth.kellar@nuclear.energy.gov
- **AFC National Technical Director: Jon Carmack**
  - jon.carmack@inl.gov
- **Please review previous fuel related awards on www.neup.gov.**

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Back Up Slides

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Accident Tolerant Fuel (ATF) Goal: Enhanced "Grace Time"

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Fuels with **enhanced accident tolerance** are those that, in comparison with the standard UO_2 – Zr system, can **tolerate loss of active cooling** in the core for a **considerably longer time period** (depending on the LWR system and accident scenario) while maintaining or improving the fuel performance during normal operations.

Enhanced Tolerance to Loss of Active Core Cooling

Improved Reaction Kinetics with Steam
- Decreased heat of oxidation
- Lower oxidation rate
- Reduced hydrogen production (or other combustible gases)
- Reduced hydrogen embrittlement of cladding

Improved Fuel Properties
- Lower fuel operating temperatures
- Minimized cladding internal oxidation
- Minimized fuel relocation/dispersion
- Higher fuel melt temperature

Improved Cladding Properties
- Resilience to clad fracture
- Robust geometric stability
- Thermal shock resistance
- Higher cladding melt temperature
- Minimized fuel - cladding interactions

Enhanced Retention of Fission Products
- Gaseous fission products
- Solid/liquid fission products

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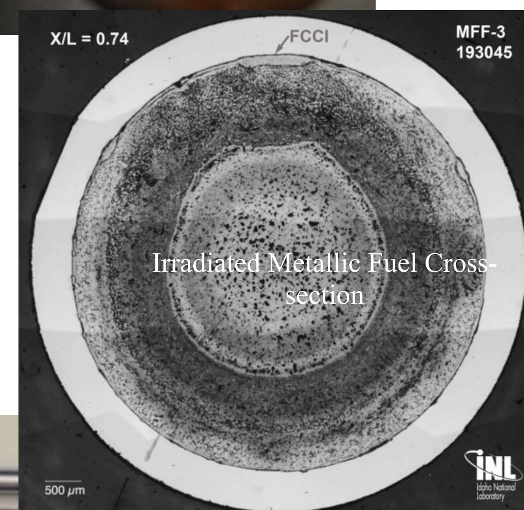
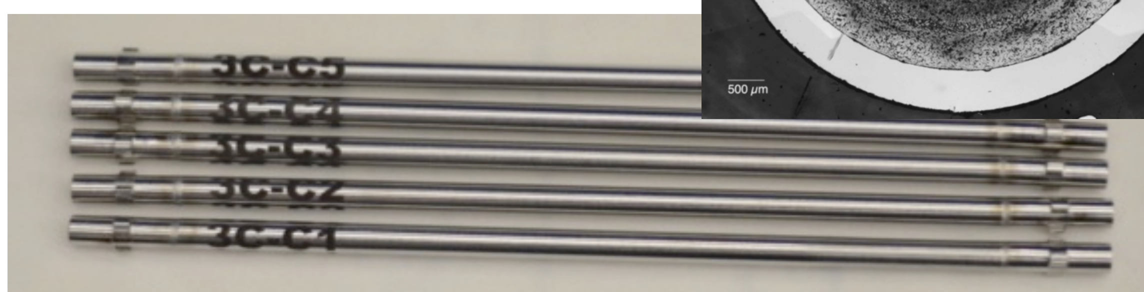
Advanced Fuel Technology Development for Actinide Management

Focus Priority on Metallic Fuels

- Advanced fabrication techniques
- Characterization of material properties of minor actinide bearing fuels
- Irradiation behavior of actinide bearing fuel compositions
- Development of advanced claddings having high burnup capability





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NEET NSUF 1.1: Materials Irradiations in support of LWRS

Richard Reister

NSUF Nuclear Science User Facilities

August 2015

NEET NSUF 1.1: Materials Irradiations in support of LWRS

1.1a: Targeted irradiations of LWR core internals

- Support research on irradiation induced phase transformations of materials used in core internal, such as 316 stainless steel.
- Under irradiation, large concentrations of radiation-induced defects will diffuse to defect sinks such as grain boundaries and free surfaces.
- This can lead to coupled-diffusion with particular atoms.
- This results in Radiation-Induced Segregation (RIS) of elements within the steel.
- Proposals are sought for irradiation and post-irradiation examination of LWRS core internal materials to provide validation data for phase transformation models under development in the LWRS program.

NEET NSUF 1.1: Materials Irradiations in support of LWRS

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1.1b: Gamma irradiation of LWR cables

- **Support research on aging related cable degradation in nuclear power plant environments.**
- **The insulation of Low and Medium voltage electric cables undergo aging due to a combination of factors such as temperature, radiation, moisture, vibration, chemical exposure, mechanical stress and the presents of oxygen.**
- **Proposals are sought to expose cables in the HFIR gamma irradiation facility followed by examinations to support the determinations of remaining useful life of cables.**

NEET NSUF 1.1: Materials Irradiations in support of LWRS

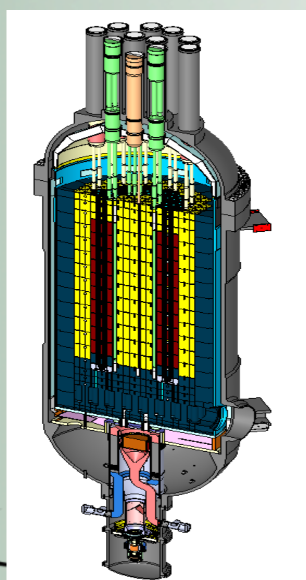
1.1c: Irradiation of LWR weld material

- Support the development of weld repair technologies for highly irradiated materials such as core internals.
- In a collaborative program with EPRI, advanced welding technologies are under development for highly irradiated materials that avoid helium-induced cracking.
- These weld repairs must be resistant to long-term degradation mechanisms.
- Demonstration of the long-term performance of these weld repairs is required before they can be used by industry.
- Proposals are sought for the examination of materials both pre- and post- irradiation as well as both pre- and post- welding.

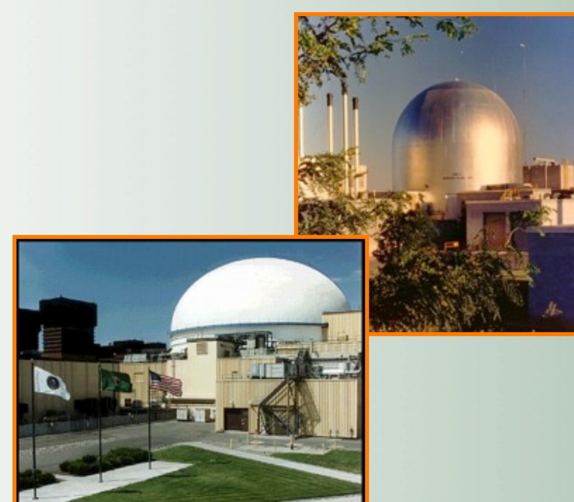
Nuclear Thermal Propulsion Fuels Testing

(NEET-NSUF 1.1E)

Scott Harlow



Nuclear Science User Facilities



Nuclear Thermal Propulsion Fuels Testing

NTP Fuels

- Coated composite fuels being developed within the DOE/NASA NTP program need to be irradiated under prototypic operating conditions to understand their response to neutron damage in the severe operational environment. The possibility of neutron irradiation damage being a significant contributor to the "mid-band" corrosion issue observed in the NERVA program needs to be investigated and understood.
- Initial irradiation tests would include small samples in low-cost non-instrumented capsules within HFIR or ATR. Specimen holder assemblies would be designed to stress the fuel samples under the elevated temperatures of irradiation. Specimens would be recovered and inspected for signs of stress corrosion cracking in their protective coating.

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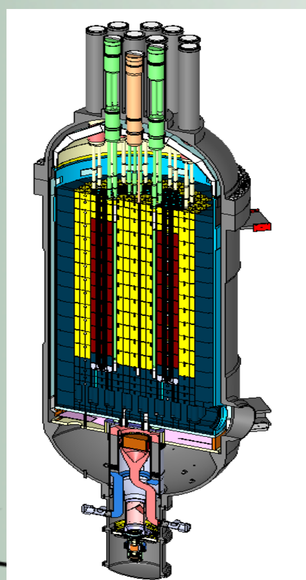
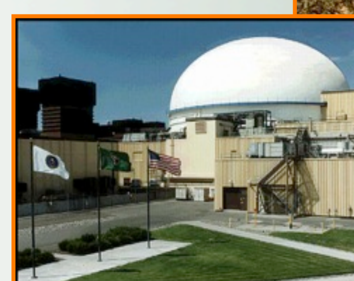
Experimental Data for Fission Product Retention, Diffusion, and Transport Properties for Gas-Cooled and Sodium Fast Reactors using NSUF Capabilities

(NEET-NSUF 1.1d)



Madeline Feltus

Office of Advanced Reactor Technology
Office of Nuclear Energy
U.S. Department of Energy



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Experimental Data for Fission Product Behavior using NSUF

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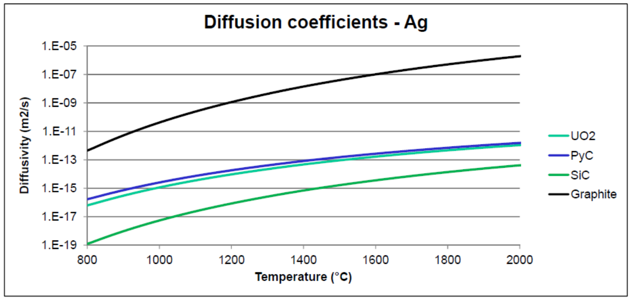
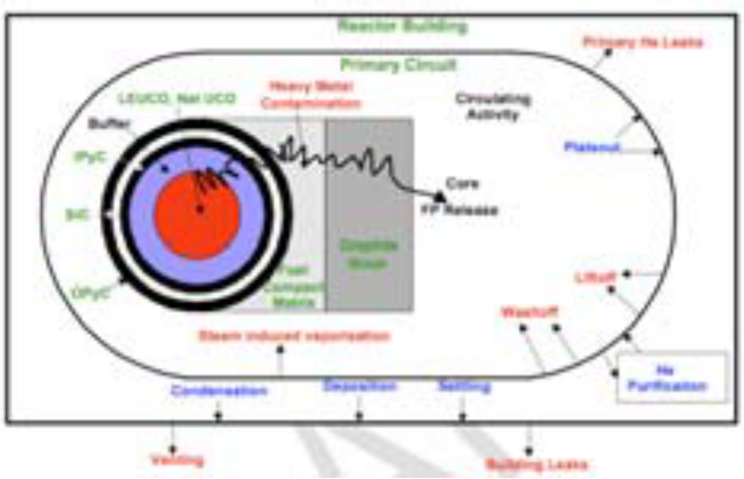
Motivation for getting experimental fission product data:

- High quality fission product behavior separate effects data is needed to data is needed for modelling TRISO particle fuel irradiation performance, and VHTR and SFR accident conditions.
- Fission product retention, temperature and time-dependent diffusion, sorption, and radionuclide transport information is needed for predicting fission product phenomena in VHTR TRISO fuel, matrix, graphite and sodium fast reactor fuel and coolant.

Diffusion Coefficients (IAEA Tec. Doc. 978)

D_0 (m^2/s) Q_0 (kJ/mol)	Kernel	Buffer	IPyC / OPyC	SiC	Graphite
D_0	6.7e-9	1.0e-8	5.3e-9	3.6e-9	1.6
Q_0	165	0	154	215	258





Experimental Data for Fission Product Behavior using NSUF

- **Focused on TRISO fuel Helium Gas-Cooled Reactors and/or Sodium-Cooled Fast Reactors:**

  - **Gas-cooled TRISO fuel reactors**: Fission product release test data is needed for microstructural and physical properties of the neutron irradiated TRISO fuel materials, fuel matrix and structural graphite materials, during reactor irradiation, decay, transport, sorption and diffusion during post-irradiation evaluations and during transient safety heat up tests.

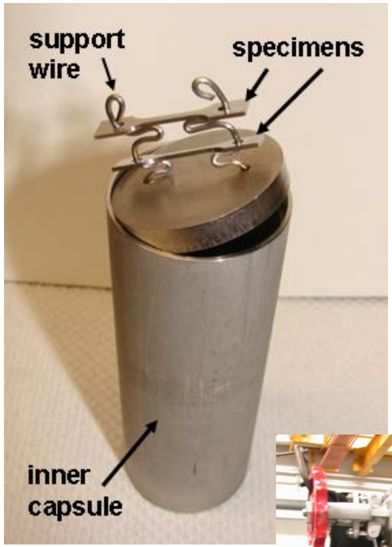
  - **Sodium-cooled Fast Reactors**: Fission product transport, diffusion and retention behavior data is needed sodium fast reactor fuel and reactor coolant system temperature and time-dependent conditions.

ORNL CCTF

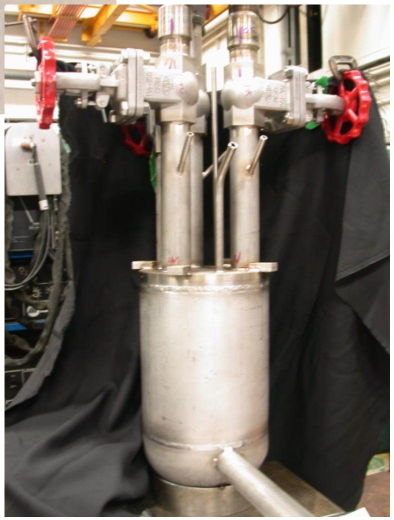
INL FACCS Furnace

Proposal Scope and Requirements

- **Proposals should include experiments and data measurements:**
  - **Separate effects tests focused on fission product transport mechanisms, diffusion, sorption and retention characteristics.**
  - **Individual chemical species of interest (Kr, I, Cs, Sr, Ru, Ag) using non-radioactive surrogates and/ or radioactive isotopes**
  - **Determine time- and temperature-dependent fission product diffusion, sorption, retention and transport behavior**
  - **Be performed at nominal reactor operating temperature ranges as well as high temperature transient accident conditions.**



Sodium capsules at ORNL

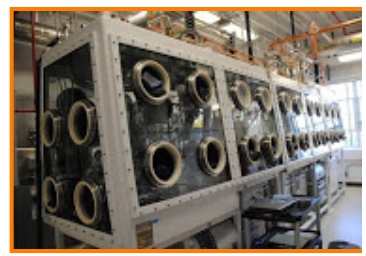


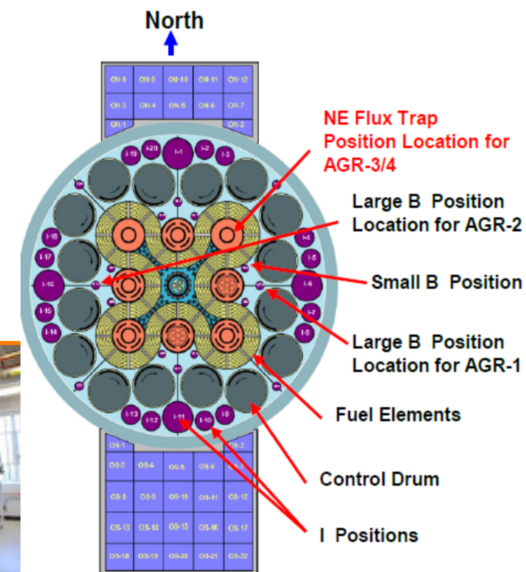
Flowing Sodium Loop at ANL

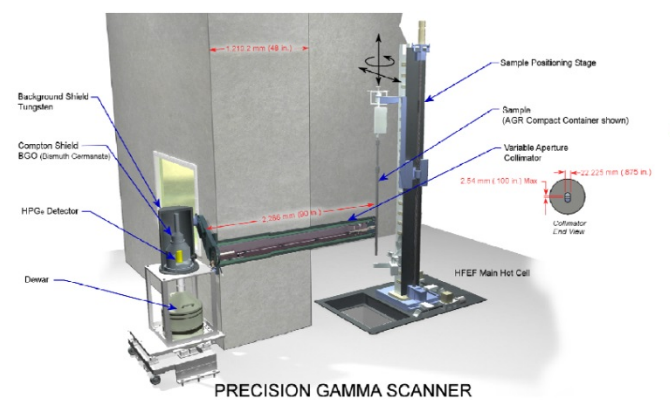
Proposal Scope and Requirements

- **Proposals are sought that:**

  - **Use NSUF capabilities** (e.g., INL ATR and hot cells, MFC, CAES, SEM/TEM/FIB microscopy, ORNL HFIR, NSUF partner reactors, facilities)
  - **Provide sufficient separate effects fission product data** needed for gas-cooled reactor TRISO fuel matrix and graphite and/or advanced sodium fast reactors using typical reactor operating temperature conditions.
  - **May use radioactive isotopes** or **surrogate non-radioactive species** (Kr, I, Cs, Sr, Ru, Ag)
  - **Tests should be performed on both un-irradiated and irradiated materials**, (e.g., VHTR TRISO fuel or surrogates, matrix and graphite and/or sodium fast reactor fuel or surrogates, sodium reactor coolant and structural materials)







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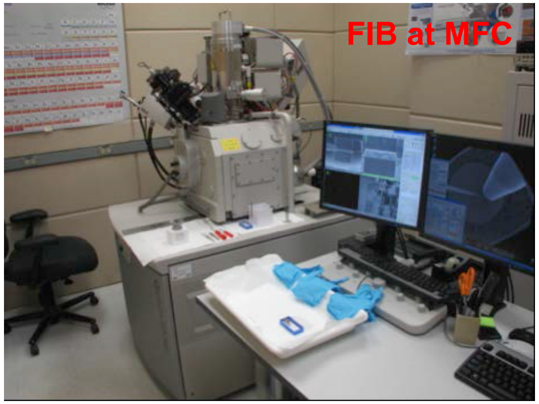
Nuclear Energy

Proposal Scope and Requirements

NSUF Nuclear Science User Facilities

■ Proposals may:

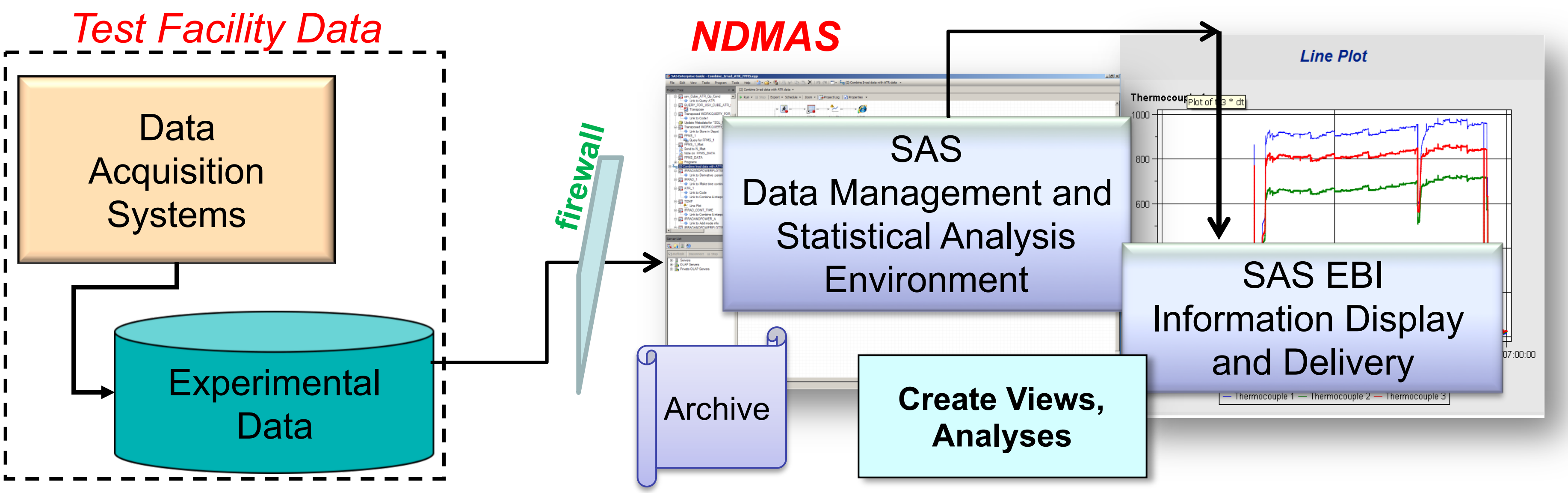
- Use in-situ university R&D laboratory facilities for non-radioactive specimen and material experiments.
- Demonstrate experiments and/or test rig configurations that may be feasible for using radioactive isotopes and materials at NSUF (e.g. hot cells, reactors, containment hoods, etc.).
- Use existing specimens from Advanced Graphite Creep tests, AGR TRISO fuel experiments, DOE fast reactor experiments, if available, at NSUF locations.
- Have NSUF-supported tasks up to 7 years for neutron irradiation testing, hot-cell PIE, microscopy, with a staggered 3 year R&D portion at home university.
- Use sodium loop test rigs with non-radioactive isotopes to develop fast reactor fission product (radioactive) source term experiments.



Quality Assurance Compliance

Quality Assurance and Data Retention:

- Data collection, experiments, data validation, and verification may require compliance with NQA-1 2009 and 2009 NRC accepted paragraphs.
- Archiving data and simulation results in the INL Nuclear Data Management and Analysis System (NDMAS) may be required.



Contact Information

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