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NSUF 2018 SRB - Overview of NSUF Research Portfolio

Simon M. Pimblott

August 2018

The INL is a U.S. Department of Energy National Laboratory
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Overview of NSUF Research Portfolio

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NSUF Nuclear Science User Facilities

NSUF Ten Year Impact Assessment

Review of NSUF research portfolio

- Purpose of research project
- Relevance to DOE-NE mission
- Topics of DOE-NE interest
- NSUF capability utilization
- Science and Technology gaps
- Accomplishments and success stories

NSUF Projects

Focused on irradiation effects on nuclear fuels and materials

Use multiple and varied capabilities

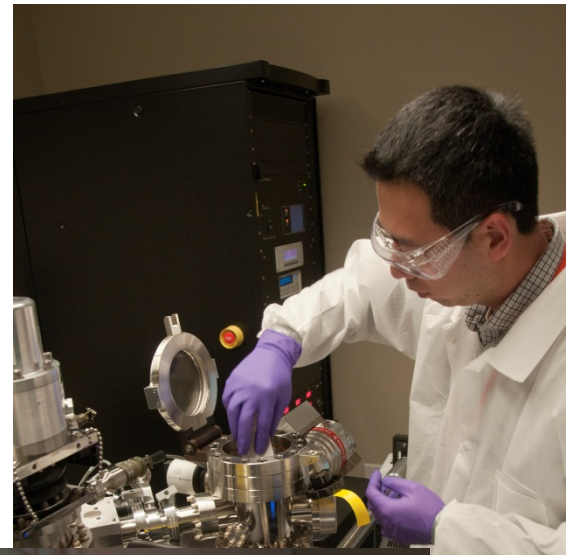
Projects can

- last for many years (CINR)
- be of short duration (RTE)

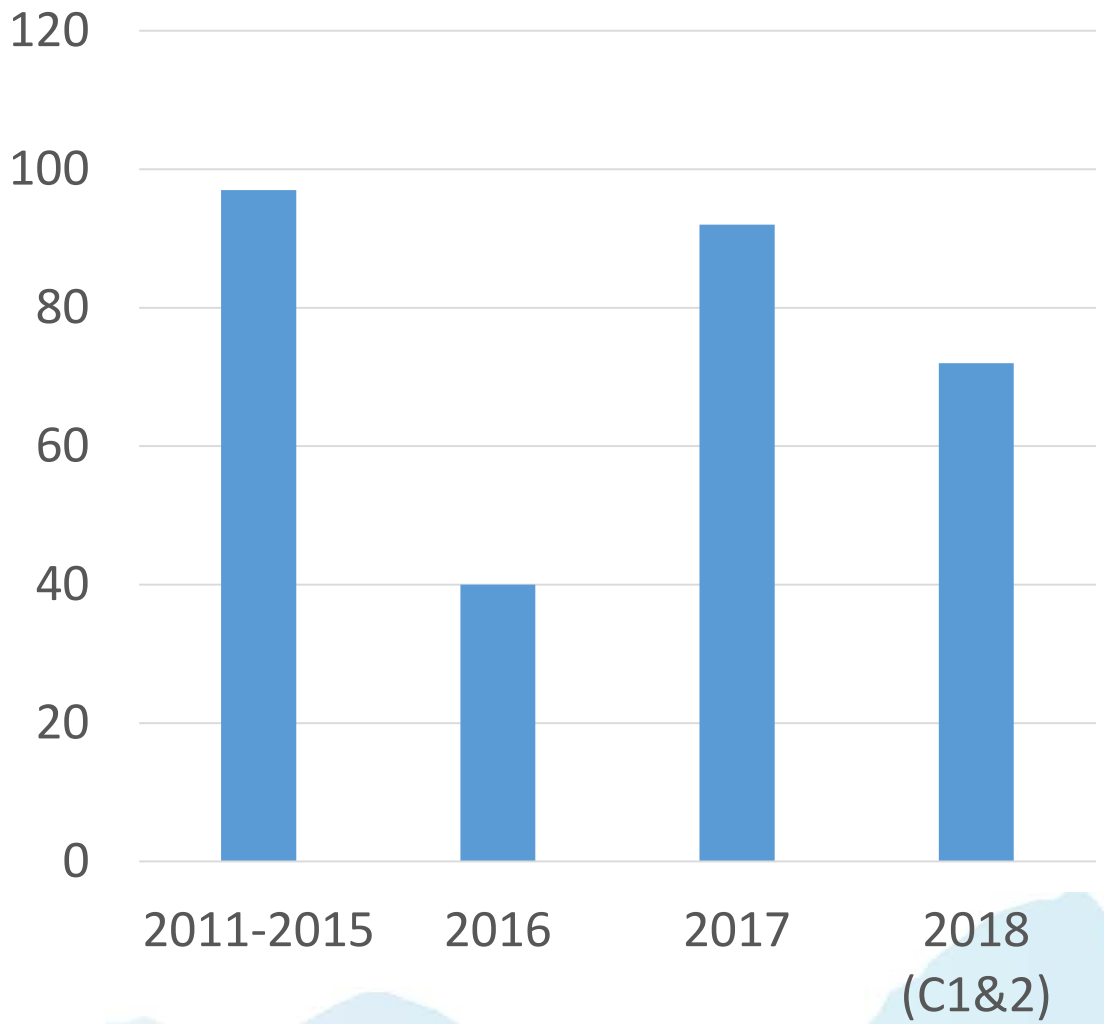
Projects can include

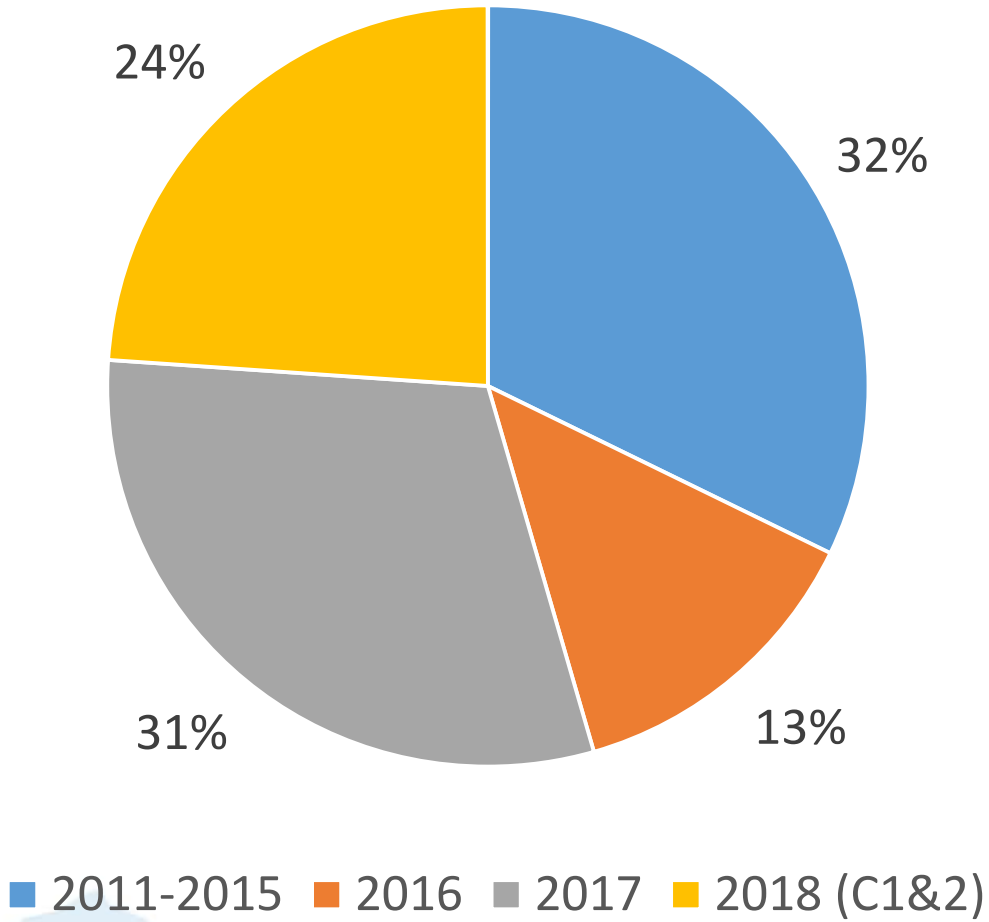
- design
- fabrication,
- transport,
- Irradiation
- PIE

Portfolio covers near- and long-term goals of DOE-NE



RTE Experiments





Purpose of Research & Relevance to DOE-NE Mission

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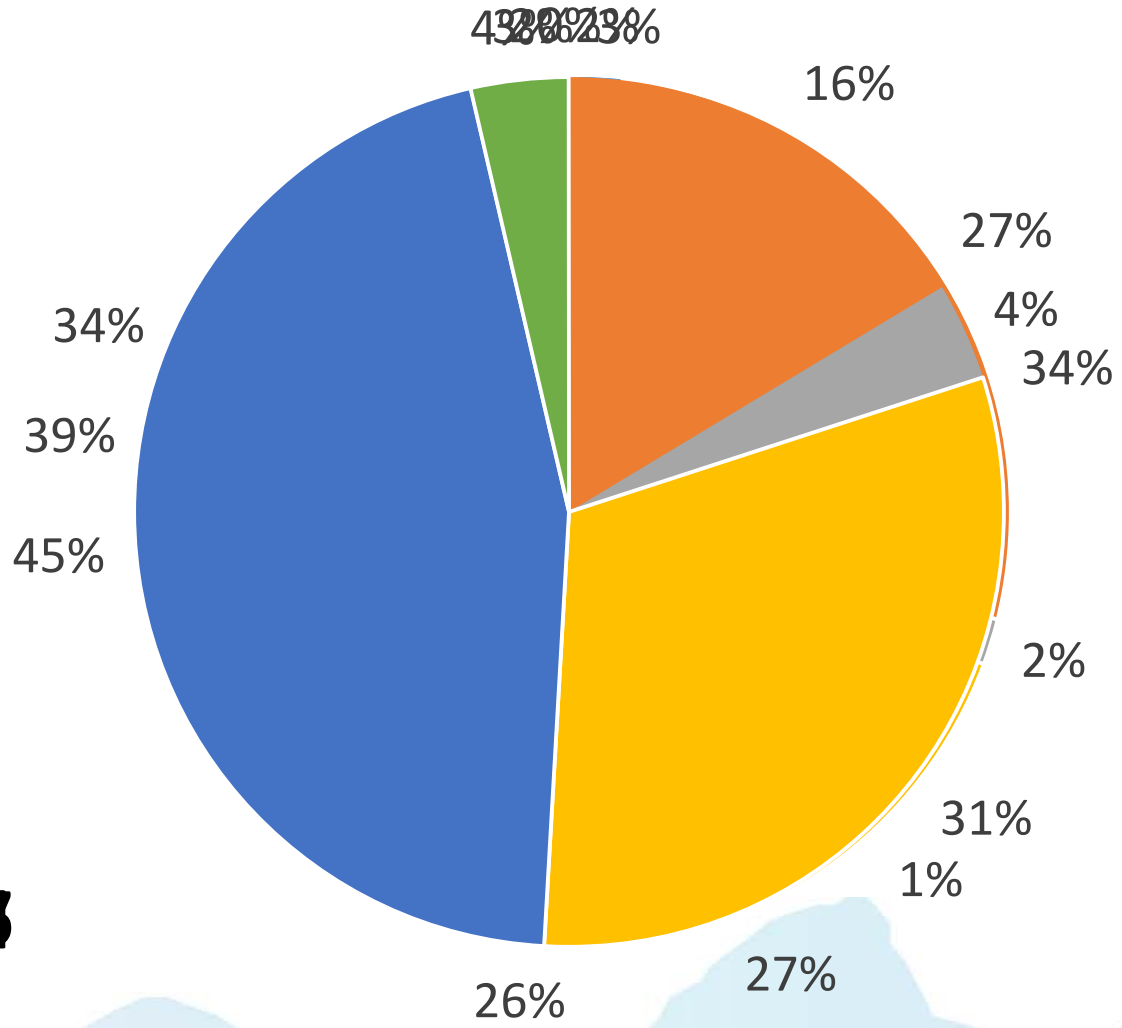
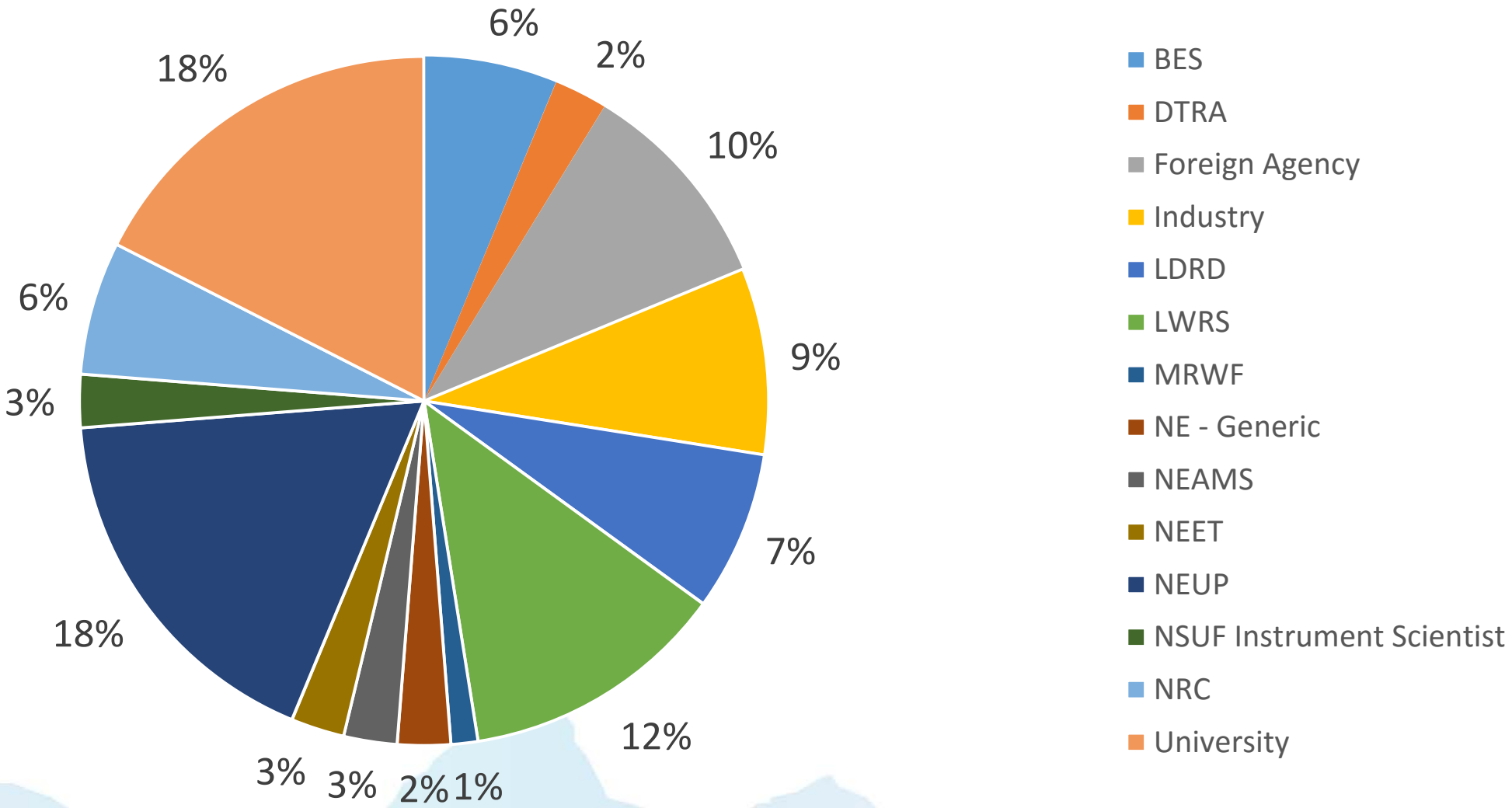
NSUF Nuclear Science User Facilities

DOE-NE Research Area



- Used Fuel Disposition
- LWR Sustainability
- Advanced Innovation for Nuclear Energy
- Accident Tolerant Fuels + Fuel Cycle R&D
- Advanced Reactor Technologies
- NNSA

Research Funding



2017

Topics of DOE-NE Interest

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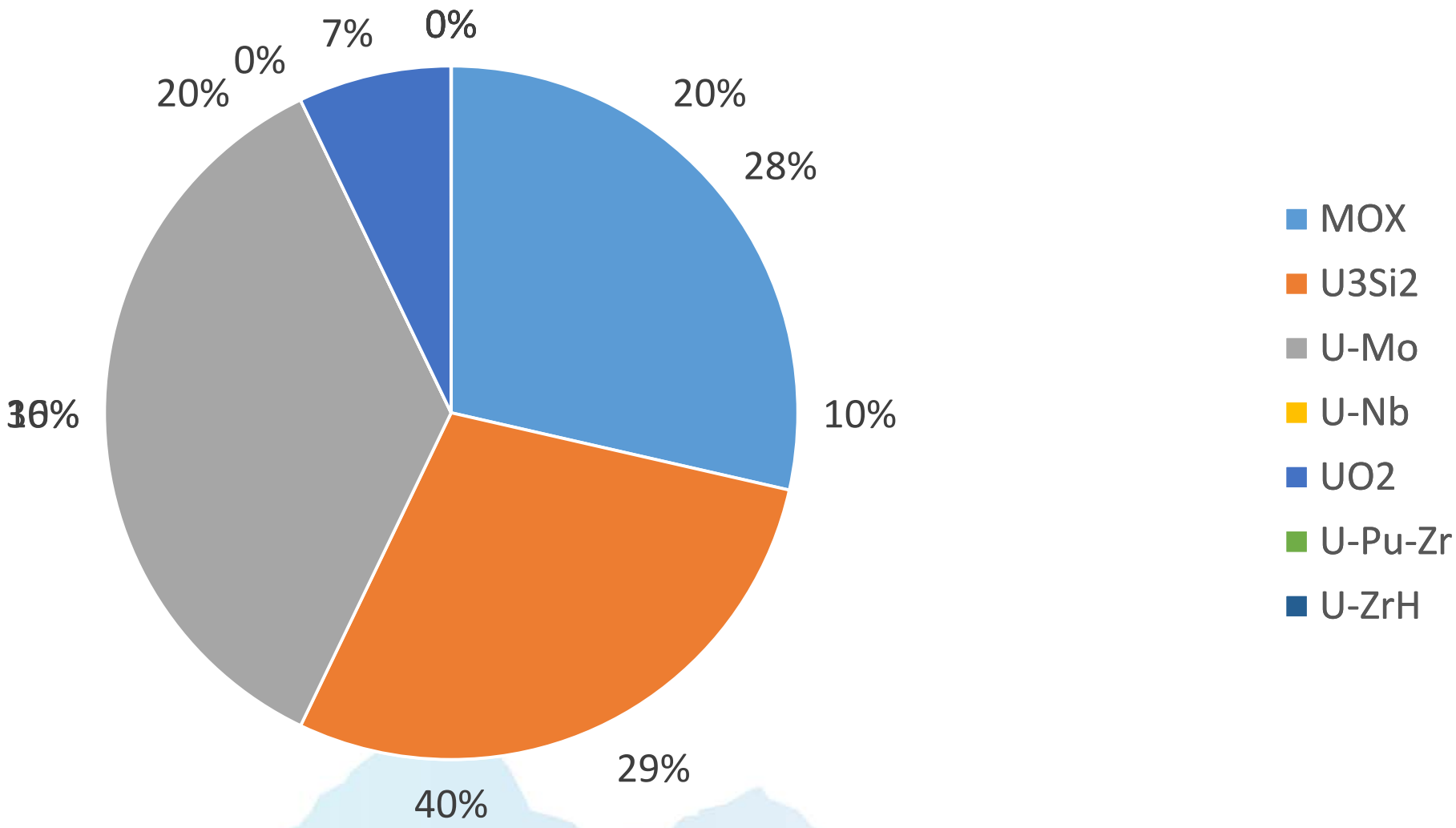
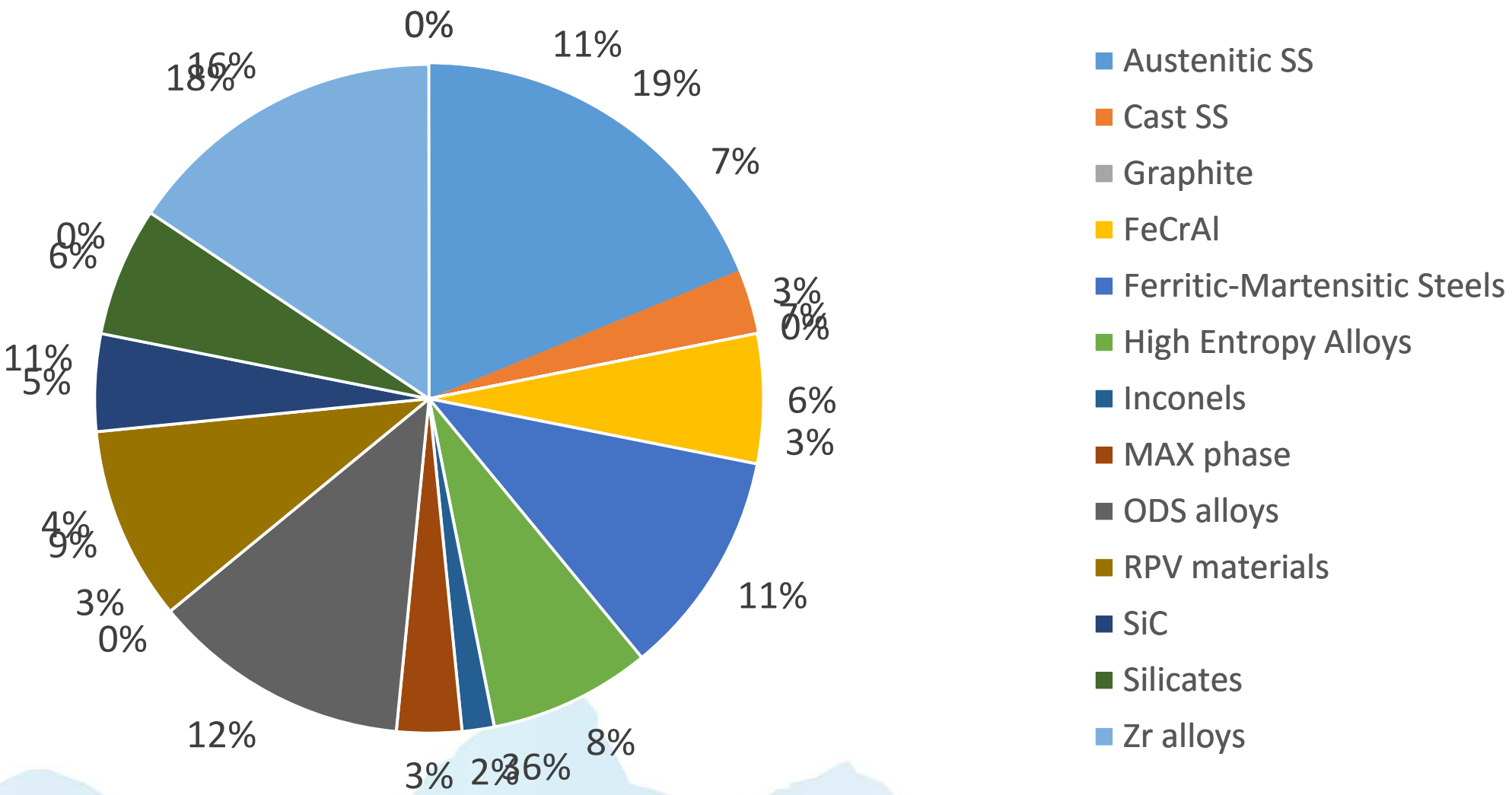
NSUF Nuclear Science User Facilities

Fuel Samples



Structural and Clad Material Samples



2017

NSUF Capability Utilization

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NSUF
Nuclear Science
User Facilities

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	NC State University	
NC State University	Sandia National Laboratories		Los Alamos National Laboratory Est. 1943	Cal	Los Alamos National Laboratory Est. 1943	
Ohio State	Texas A&M University		Westinghouse	PNNL		
Sandia National Laboratories	Lawrence Livermore National Laboratory		University of Michigan	Los Alamos National Laboratory Est. 1943		
SCK•CEN Studiecentrum voor Kernenergie Centre d'Etude de l'Energie Nucleaire			SCK•CEN Studiecentrum voor Kernenergie Centre d'Etude de l'Energie Nucleaire	NC State University; University of Michigan; Purdue University; UNLV University of Nevada Las Vegas; University of Florida; SCK•CEN Studiecentrum voor Kernenergie Centre d'Etude de l'Energie Nucleaire; Wisconsin University of Wisconsin-Madison		

11 Universities

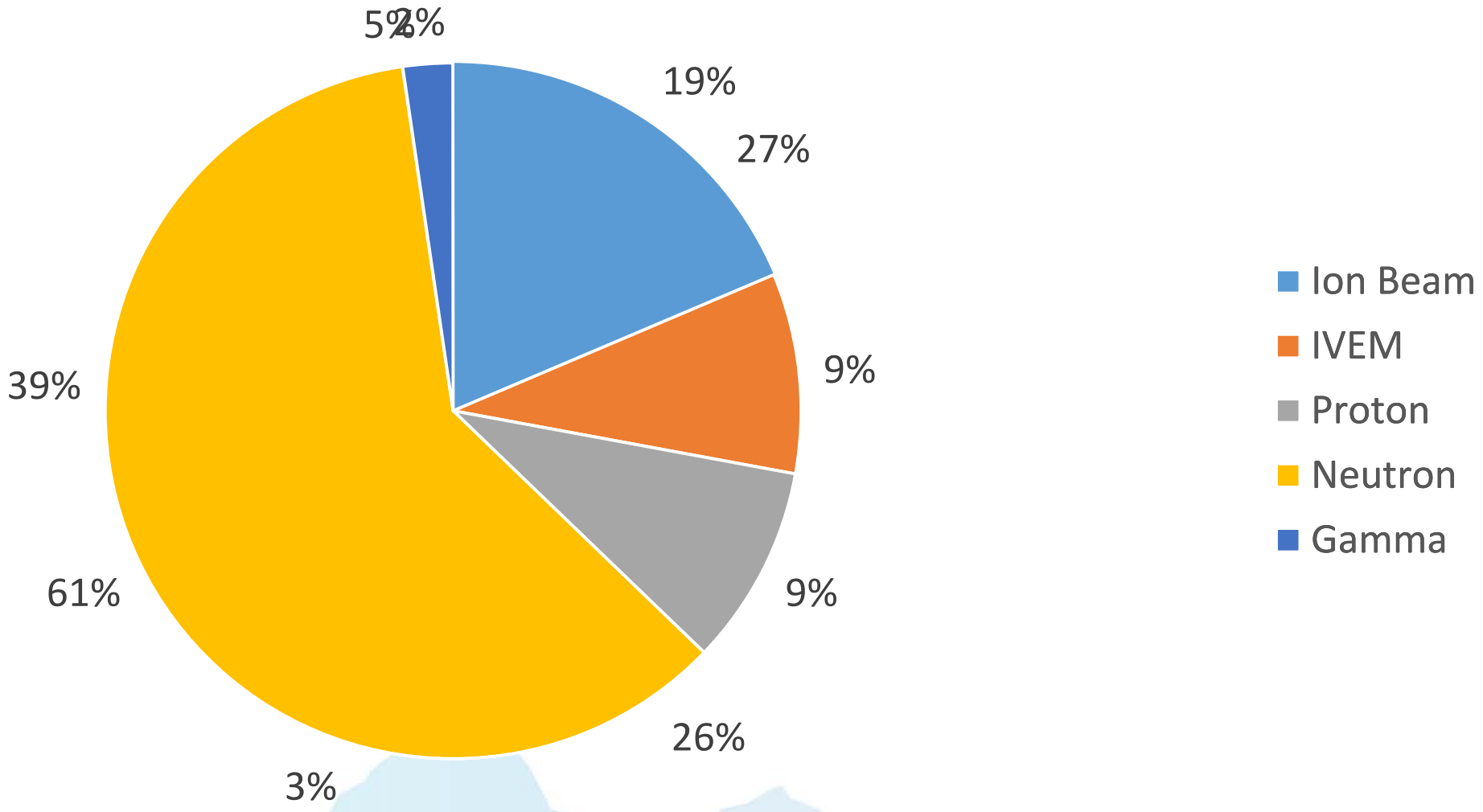
CAES (4 Unis)

7 National Labs

1 Industry

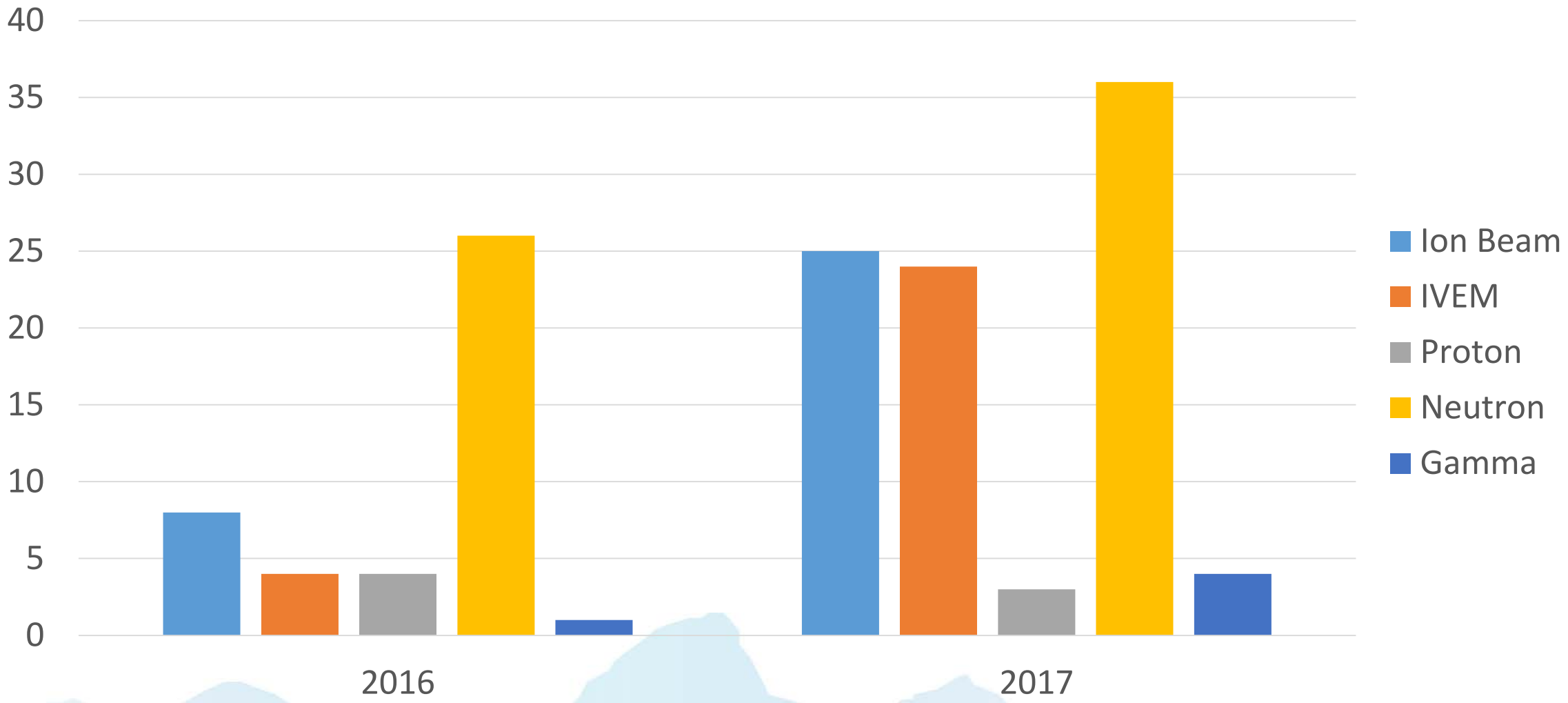
NSUF

Sample Irradiation Mode

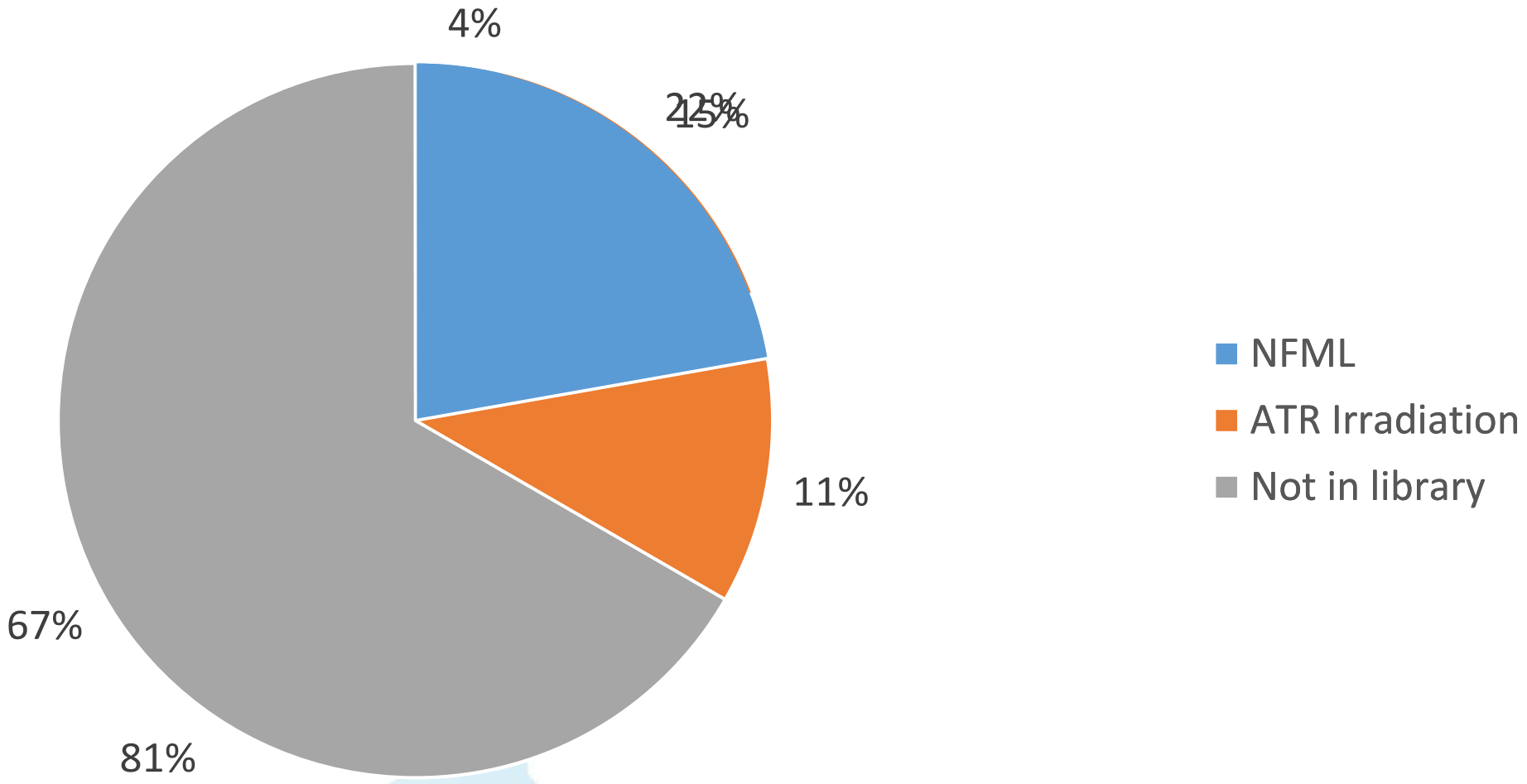


2017

Ion Beams as a Surrogate for Neutrons



NFML Utilization



2016

Science and Technology Gaps

Measuring Technology Maturity

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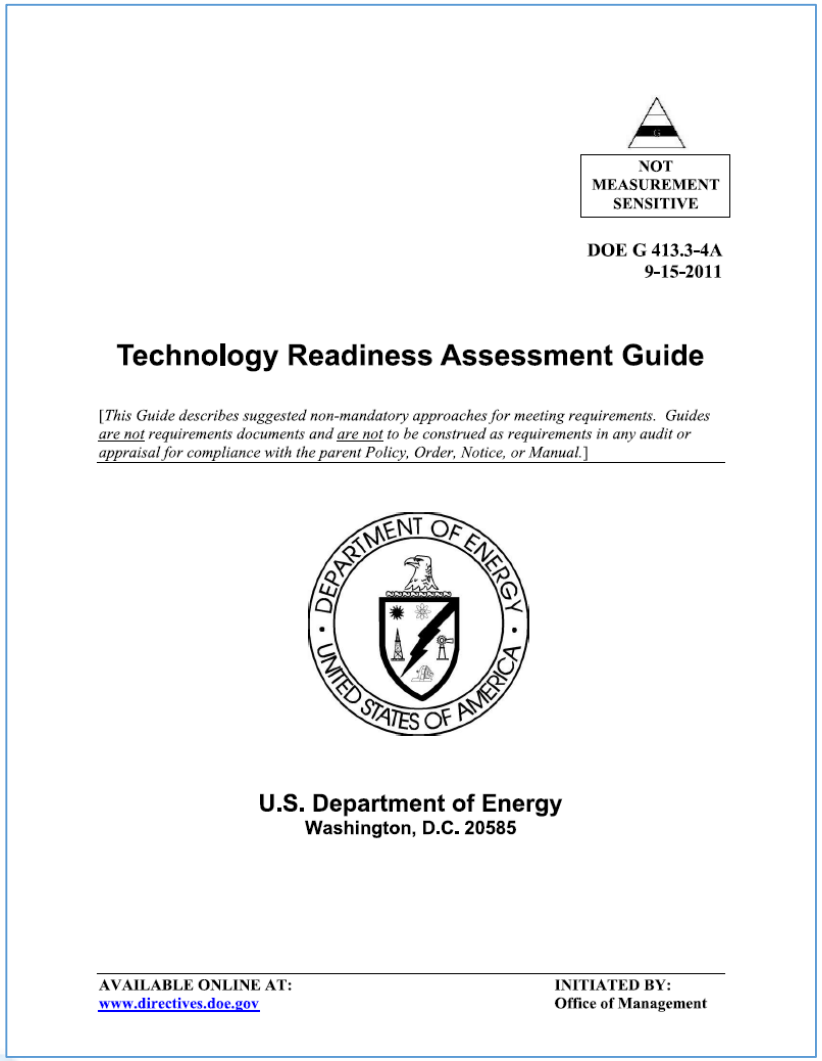
NSUF Nuclear Science User Facilities

Technology Readiness Levels for Advanced Materials

- DOE G 413.3-4A “Technology Readiness Assessment Guide”
- Process pioneered by NASA and DOD
- TRA provides
  - snapshot of the maturity of a technology and allows judgement of potential,
  - guide to steps needed for development and deployment

but is not a pass/fail test.



NOT MEASUREMENT SENSITIVE

DOE G 413.3-4A
9-15-2011

Technology Readiness Assessment Guide

[*This Guide describes suggested non-mandatory approaches for meeting requirements. Guides are not requirements documents and are not to be construed as requirements in any audit or appraisal for compliance with the parent Policy, Order, Notice, or Manual.*]

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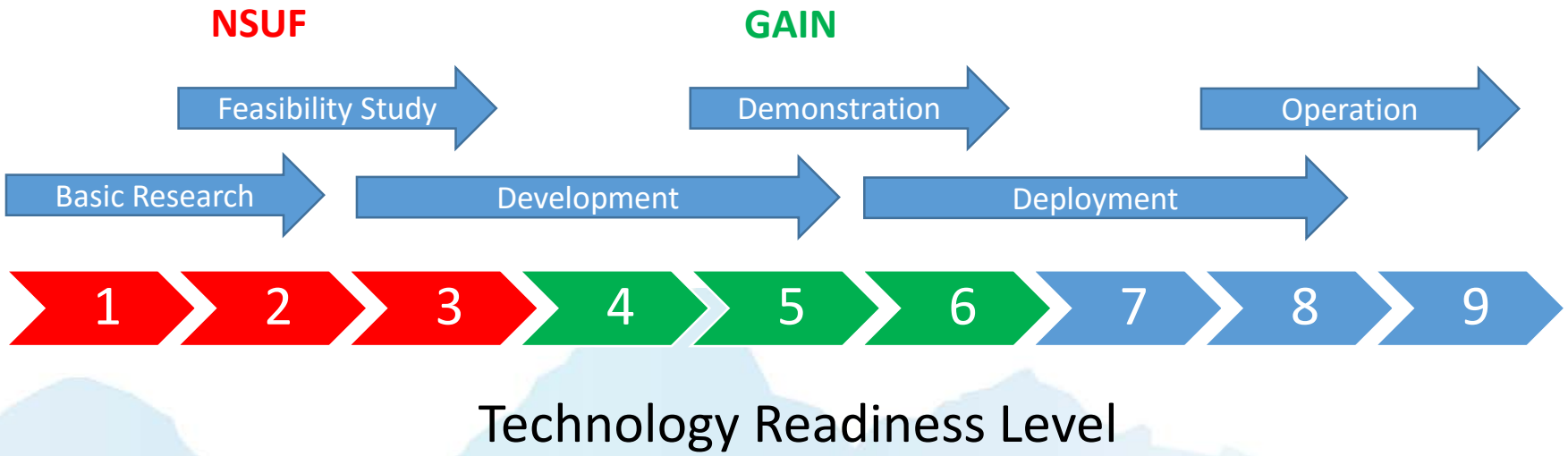
Technology Readiness Levels

- Way of assessing the maturity of a technology
- Based on analysis of
  - concepts,
  - requirements, and
  - demonstrated capabilities
- Range from 1 to 9 representing scientific concept to technical maturity



Critical TRL Evaluation

- Detailed questions tailored to the particular challenge, specific for each TRL.

- The TRL is the level at which all questions are answered positively.

- Objective:
  - Identify gaps in testing, demonstration and knowledge
  - Increase attention and direct resources
  - Increase transparency

TRL Calculator

TRL 9	Has the material been successfully deployed in an operational environment?
TRL 8	Has the material been successfully deployed in a limited operational environment?
TRL 7	Has the material been successfully deployed in a relevant operational environment?
TRL 6	Has engineering scale testing been demonstrated in a relevant environment?
TRL 5	Has lab scale testing been demonstrated in relevant environment?
TRL 4	Has lab scale testing been completed in a simulated environment?
TRL 3	Has proof of concept demonstration been performed in a simulated environment?
TRL 2	Has a fabrication technology been formulated?
TRL 1	Have the basic properties of the material been observed and reported?

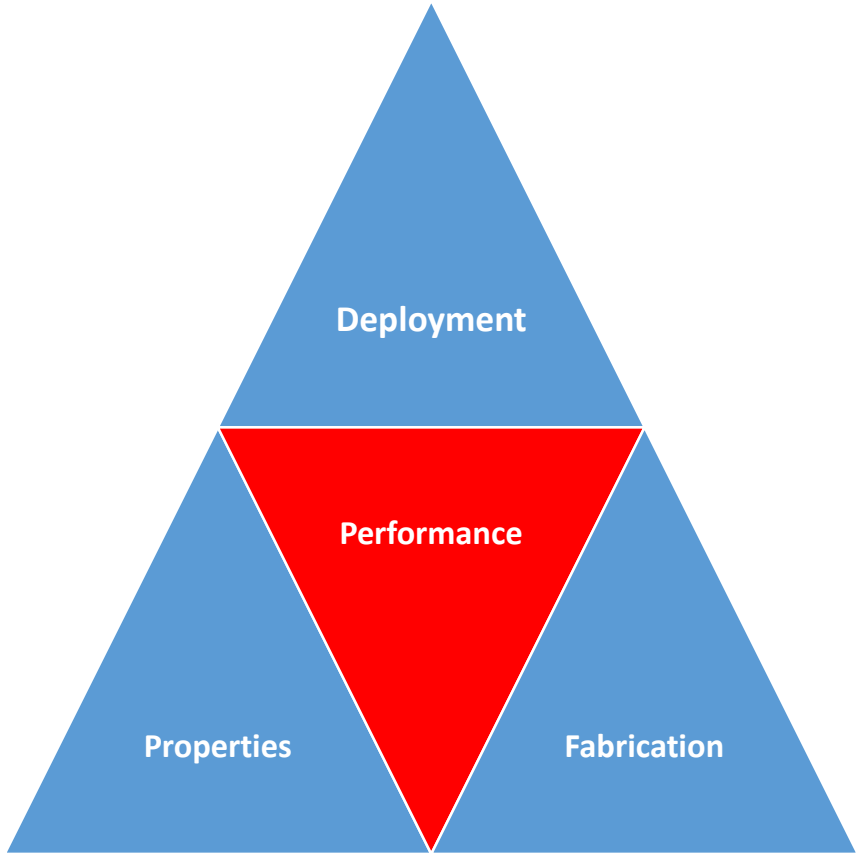
Technology Readiness Levels

- Advantages
  - common understanding
  - common judgement for funding
  - common judgement for transition of technology

- GAO has recommended DOE adopt TRA using TRL

  "premature application of technologies by DOE was the reason for cost growth"

- System needs to be broken down into a number of sub-systems



TRL Development Workshop

- Scheduled for w/c 14th January 2018
- Panel comprising:

Peter Andresen – GE retired	Stu Malloy - LANL
Mike Burke – EPRI	Simon Pimblott
Jim Cole	Lance Snead – Stony Brook
Rory Kennedy	Steve Zinkle - Tennessee

- Objectives:
  - TRL definitions, descriptions and supporting information needs
  - Top level questions to determine anticipated TRL (work down from TRL 9).
  - TRL Assessment tools – TRL calculator criteria, TRL checklists, TRL testing definitions (scale, system, and environment)
  - Template for TRA Report

Materials Understanding and Development

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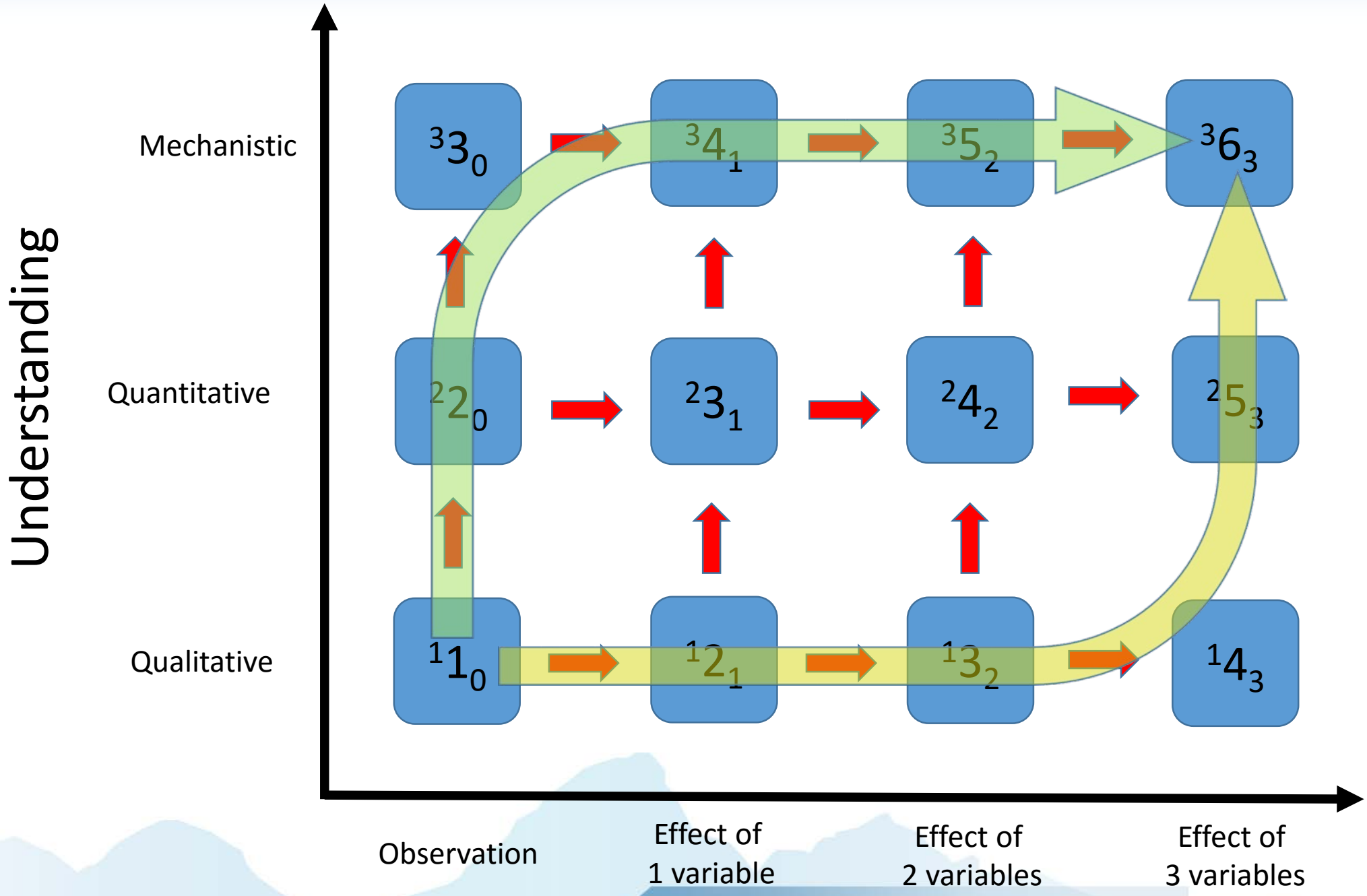
NSUF
Nuclear Science
User Facilities


Understanding
Mechanistic
Quantitative
Qualitative
$^{3}3_{0}$
$^{3}4_{1}$
$^{3}5_{2}$
$^{3}6_{3}$
$^{2}2_{0}$
$^{2}3_{1}$
$^{2}4_{2}$
$^{2}5_{3}$
$^{1}1_{0}$
$^{1}2_{1}$
$^{1}3_{2}$
$^{1}4_{3}$
Observation
Effect of 1 variable
Effect of 2 variables
Effect of 3 variables

Material Assessment Exercise

Goal:

- To allow judgement of where the NSUF has added value to nuclear fuel or material development and deployment.

Approach:

- To look at the change in the term symbols for a particular fuel or material.

Example:

- The increased understanding of a radiation induced effect due to a series of RTEs and subsequent analysis might be described by the path:

$$^{2}3_{1} \rightarrow {}^{2}4_{2} \rightarrow {}^{2}5_{3} \rightarrow {}^{3}6_{3}$$

  - The starting point, $^{2}3_{1}$, is a phenomenon that has been experimentally observed as a function of one variable, displacement dose, and has been measured quantitatively allowing empirical prediction/extrapolation.
  - The first step, $^{2}3_{1} \rightarrow {}^{2}4_{2}$, reflects an experimental study quantifying the effect of a second variable such as dose rate.
  - The second step, $^{2}4_{2} \rightarrow {}^{2}5_{3}$, represents a further experimental study quantifying the effect of a third experimental variable such as temperature.
  - The third step, $^{2}5_{3} \rightarrow {}^{3}6_{3}$, the development of a mechanistic understanding of the effect of the three experimental parameters on the observed phenomenon.

The Future of Nuclear

Portfolio Gap Analysis

- Strengths, Weaknesses, Opportunities & Threats
- Utilization of Facilities – INL, CAES, & Partners
- Utilization of Nuclear Fuels and Materials Library (NFML)
- Additions to the NFML – SAM experiments
- Value for money

Capability Management

- Balancing Capability
  - To reflect DOE-NE and NSUF Strategic Plan
- Goal
  - To align portfolio to areas of strength and national importance and to maintain international standing
- Research Areas
  - Emphasize & Enhance – strategic intervention
  - Maintain – active monitoring
  - Encourage Excellence – reduce without affecting impact vision and goals
- Balancing
  - Based on evidence such as:
    - Publications
    - Potential future needs
    - Community engagement
    - Portfolio
- Themes determined by DOE-NE mission