The DOE Nuclear Criticality Safety Program (NCSP)

Angela Chambers, PhD, NA-511
ANS NCSD Meeting
June 13, 2022

NCERC
OAK RIDGE National Laboratory
Sandia National Laboratories
Lawrence Livermore National Laboratory
Los Alamos NATIONAL LABORATORY

Background / History–Mission Vision–Organization

Early history

- Defense Nuclear Facilities Safety Board (DNFSB) Recommendations:
  - 93-2 (3/23/1993): Need for a general-purpose critical experiment capability that will ensure safety in handling and storage of fissionable material.
  - 97-2 (5/19/1997): Need for improved criticality safety practices and programs to alleviate potential adverse impacts on safety and productivity of DOE operations.
- DOE Implementation Plan for 93-2 and 97-2 recommendations resulted in establishment of the US NCSP

Defense Nuclear Facilities Safety Board

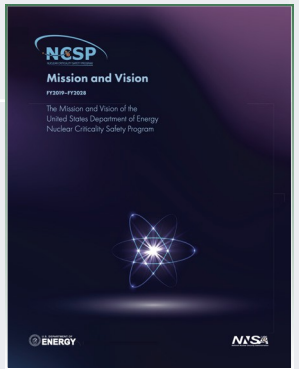
NCSP 5-year plan

Mission

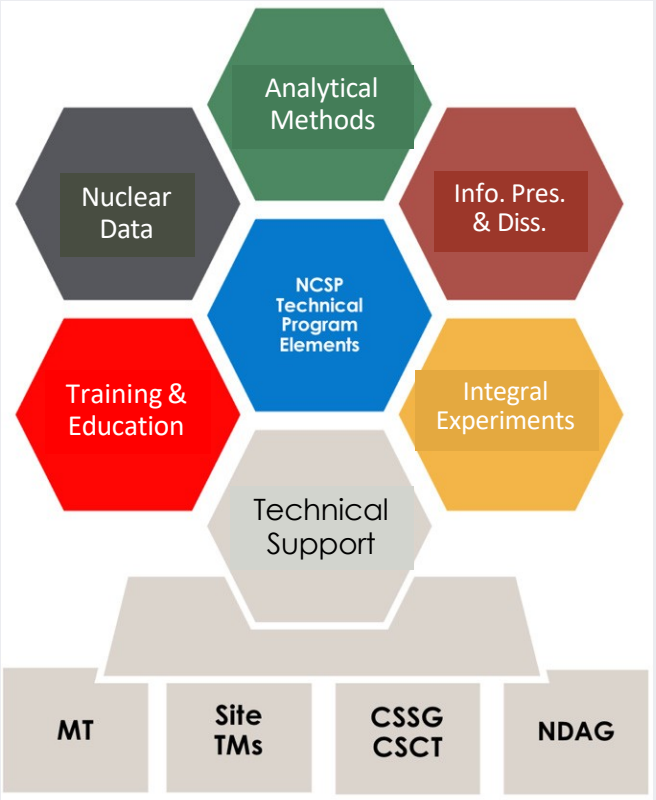
Provide sustainable expert leadership, direction and the technical infrastructure necessary to develop, maintain, and disseminate the essential technical tools, training, and data required to support safe, efficient fissionable material operations within DOE.

Vision

Continually improving, adaptable, and transparent program that communicates and collaborates globally to incorporate technology, practices, and programs to be responsive to the essential technical needs of those responsible for developing, implementing, and maintaining nuclear criticality safety.



NCSP organization



TS – Technical Support
MT – Management team
TMs – Task managers
CSSG – Criticality Safety Support Group
CSCT – Criticality Safety Coordinating Team
NDAG – Nuclear Data Advisory Group

Technical Program Element Activities

SCALE
AMPX
MCNP6
NJOY

AM

NNDC

ND

SAMMY

GELINA

linac The Gaerttner LINAC Center

IPD

ICSBEP

NCS Handbooks & Reports

NCSP Website
https://ncsp.llnl.gov

NCSP Goals

TE

IE

TS

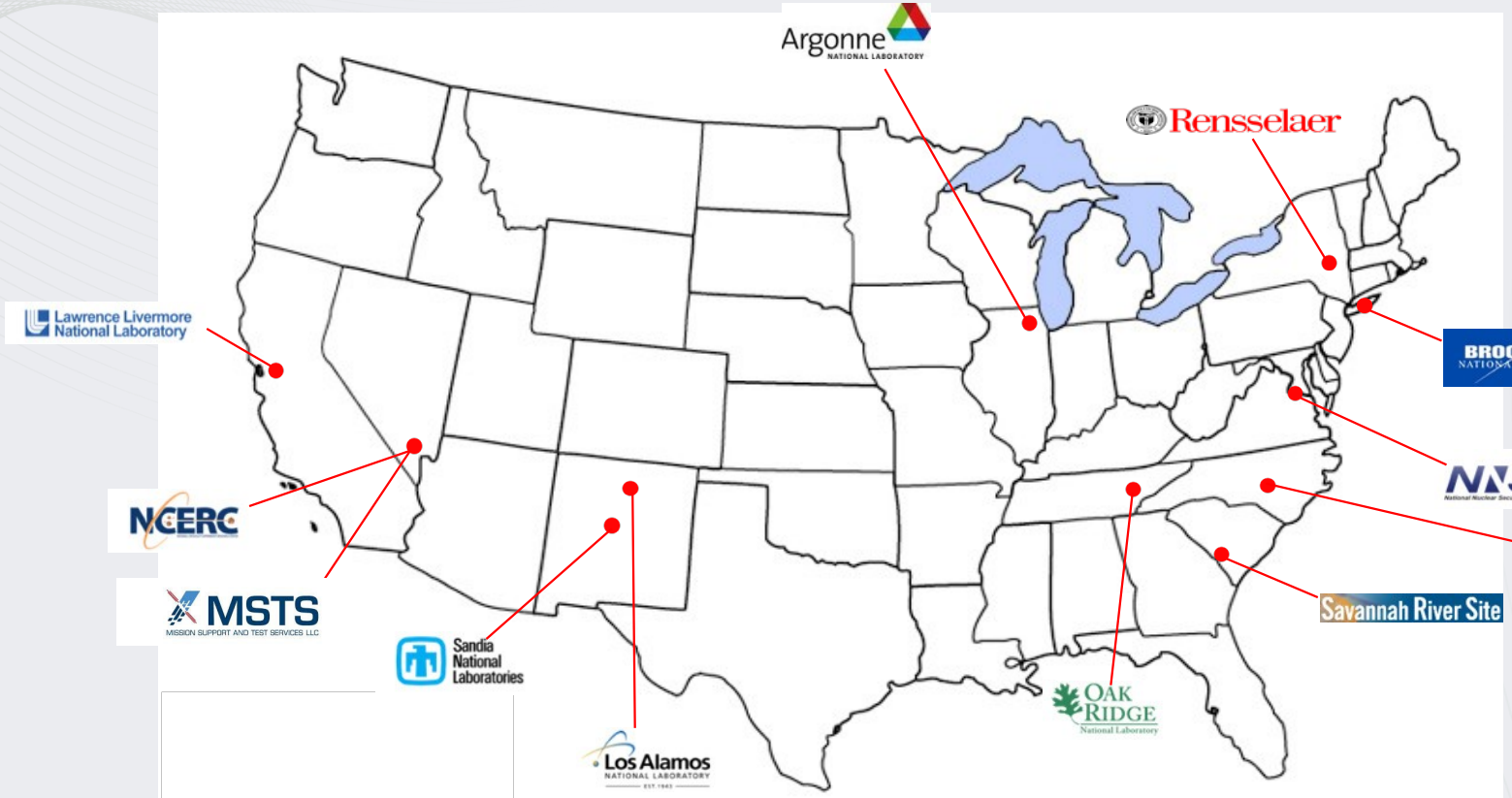
Succession Planning

NDA Program

Program Execution

OAK RIDGE National Laboratory

Current NCSP Work Sites



DOE NNSA Office of the Chief of Defense Nuclear Safety (NA-511)

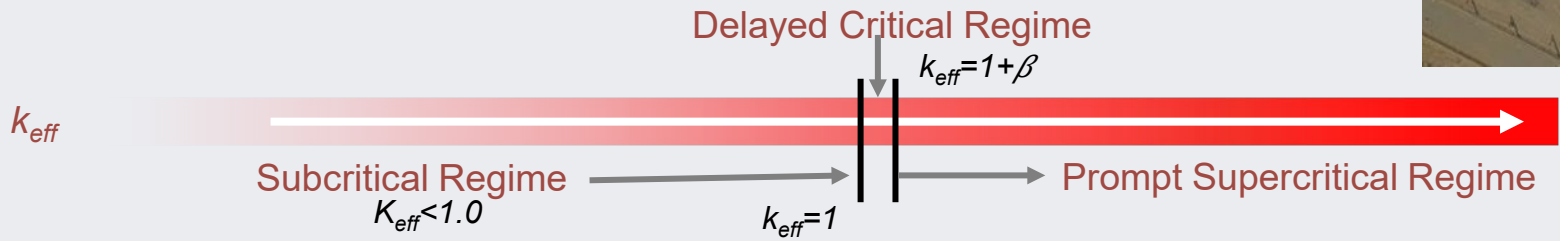
UNM
IRSN
INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE
NNSA
NUCLEAR CRITICAL
NCERC
GEORGIA TECH
SRNS
Massachusetts Institute of Technology
Los Alamos
NATIONAL LABORATORY
EST. 1943
Y-12
BROOKHAVEN
NATIONAL LABORATORY
NAVAL NUCLEAR LABORATORY
AWE
NEVADA NATIONAL
NNSS
SECURITY SITE
Rensselaer
THE UNIVERSITY OF ARIZONA
UF UNIVERSITY of FLORIDA
THE UNIVERSITY OF TENNESSEE
European Commission
Joint Research Centre
OAK RIDGE
National Laboratory
Sandia
National
Laboratories
Lawrence Livermore
National Laboratory
OAK RIDGE
National Laboratory

Integral Experiments

- NCSP integral measurements are performed at
  - Sandia National Laboratories (SNL) and
  - National Criticality Experiments Research Center (NCERC), currently operated by Los Alamos National Laboratory
    - NCERC is located at the Nevada National Security Site (NNSS) inside the Device Assembly Facility (DAF)
- Types of experiments that can be performed
  - Subcritical
    - Rocky Flats shells, BeRP ball, Np-237 sphere, TACS shells, etc.
  - Critical/Delayed Supercritical
    - NCERC: Planet, Comet, Godiva IV, Flattop
    - Sandia: Sandia Pulse Reactor critical assembly (2 fuel types, currently)
  - Prompt Supercritical
    - NCERC: Godiva IV (< 300 deg. C pulse)

DAF/NCERC

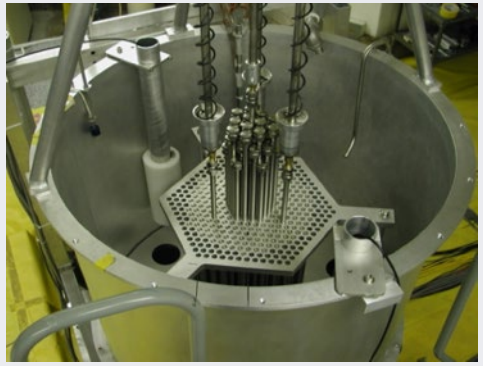
SNL/TA-V/SPR Facility

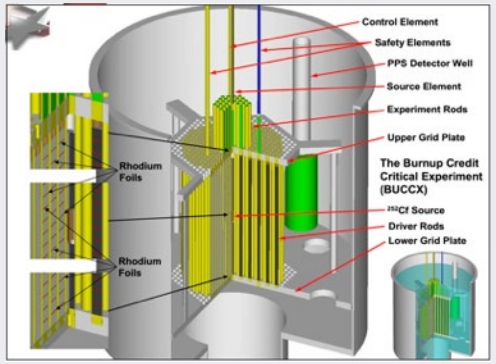


Critical Experiments Facilities

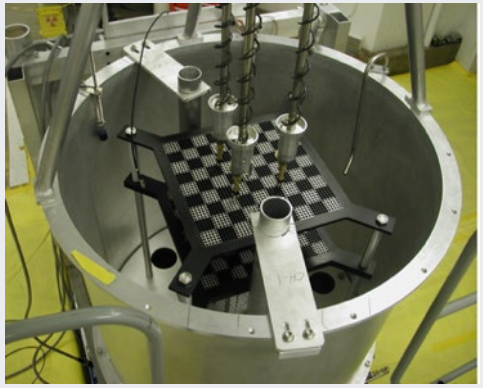
Sandia National Laboratories (NM)

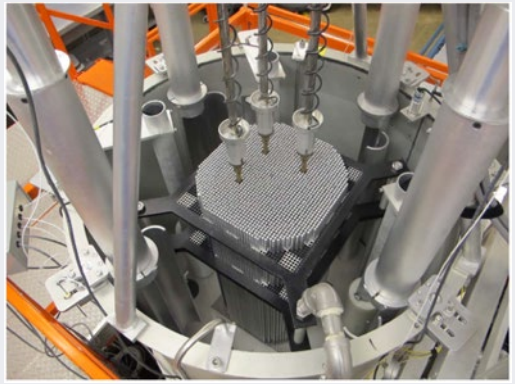
SNL – BUCCX – U(4.31)/Fission Product Experiments





SNL – 7uPCX – U(6.9) UO_2 rods





NCERC/DAF

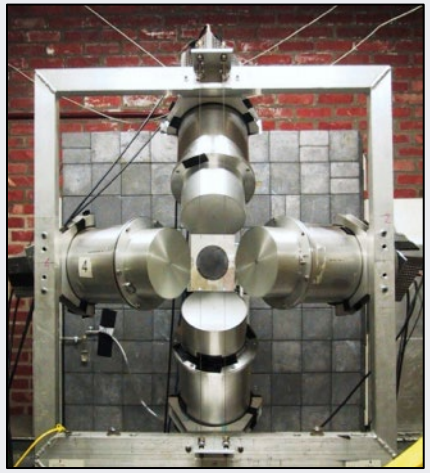
Differential Experiments

- NCSP differential nuclear data measurements are performed at
  - JRC-Geel GELINA Facility (Geel, Belgium)
  - RPI LINAC (Troy, NY)
  - LANL (Los Alamos, NM) LANSCE/Lujan Neutron Scattering Center

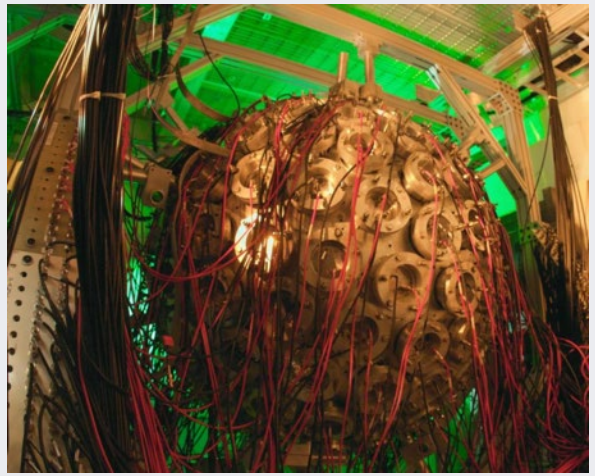
JRC-Geel (GELINA)

RPI LINAC

GELINA

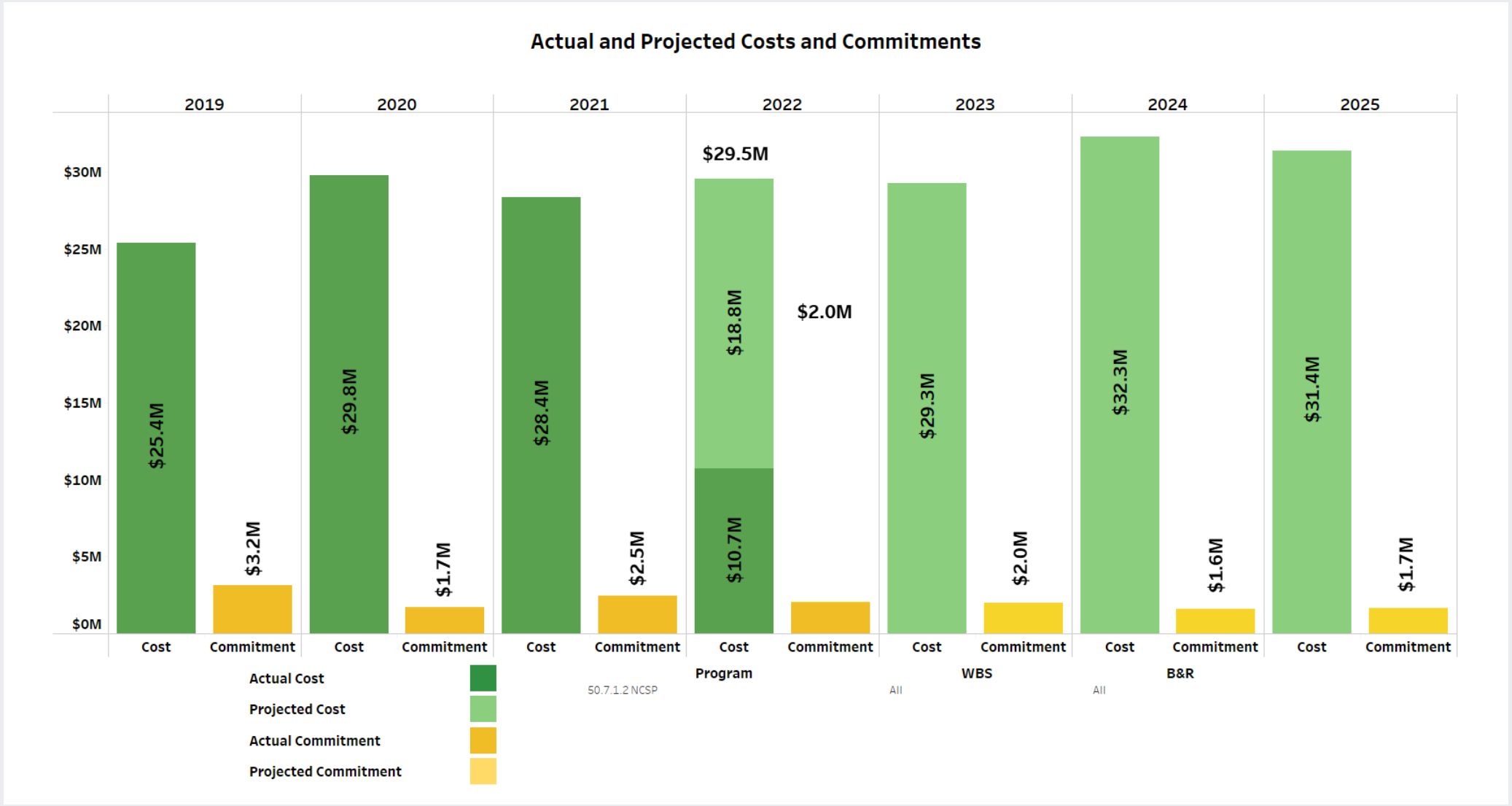


GELINA

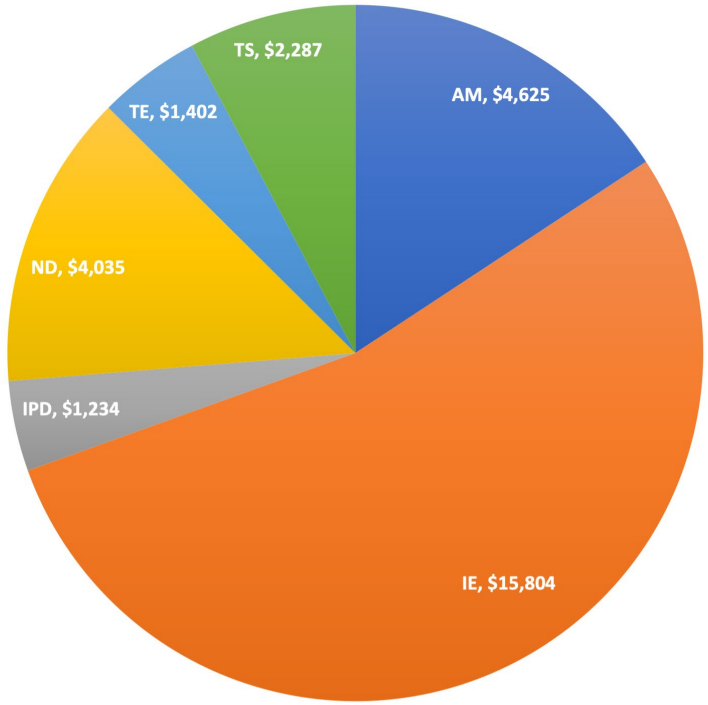


LANL - DANCE

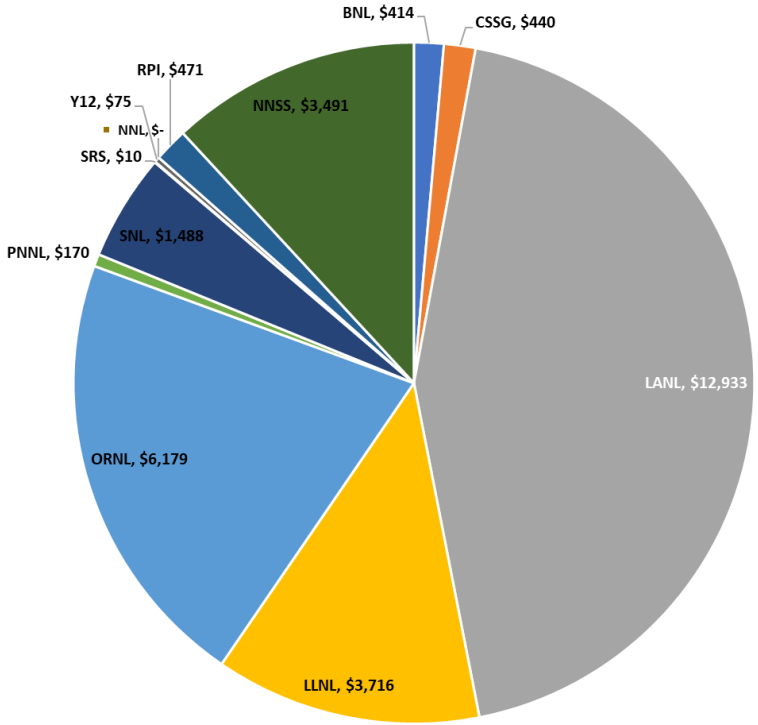
Annual NCSP Budget



FY22 NCSP Funding

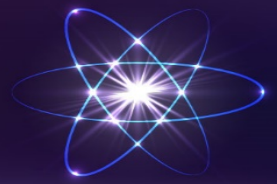


Funding by Technical Element ($k)



Funding by Site ($k)

Recent Accomplishments



- 7 Critical Experiment Campaigns Executed (CED 3b completed during FY21)
- 5 Critical Experiment Benchmark Reports Completed for ICSBEP Handbook
- 9 NCSP Criticality Safety Classes
- 94 Hands-on NCS students
- 391 MCNP students (all virtual)
- 173 SCALE students (all virtual)
- 1st Ever MCNP Users' Group Workshop (500+ attendees)
- 5th Annual SCALE Users' Group Workshop (173 attendees)
- 1st ever NCSP ND measurement at LANSCE (U-233)
- Chlorine worth experiments at NCERC in support of PF4 operations
- NCSP IE Managers using G2 for IER process
- Completion of DU target for use at Gelina accelerator

FY22 NCSP Make It Happen List

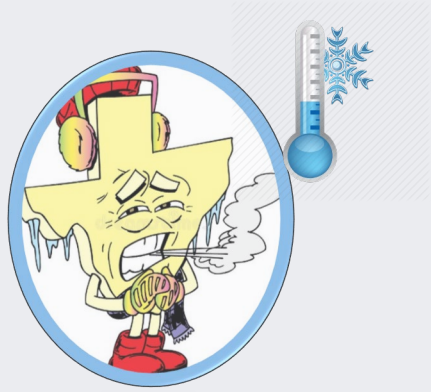
1. ✓ Production and delivery of hafnium to NCERC in support of TEX-Hf (IER 532) – NNL – March 2022
2. Conduct nuclear accident dosimetry exercise (IER 538) – LLNL – August 2022
3. Complete TEX low temperature DU surrogate testing (IER 547) – LLNL – in Nevada September 2022
4. Submit TEX HEU benchmark report to the International Criticality Safety Benchmark Experiment Program (IER 297) – LLNL – 4A approved, comments on draft report received and being incorporated – September 2022
5. Complete critical experiments with UO_2 Rods and molybdenum foils (IER 305) – SNL – September 2022
6. Complete measurements for the Flattop benchmark (IER 423) – LANL – June 2022
7. Complete fabrication of lithium for critical experiment (IER 499) – Y-12 – design change – September 2022*
8. Complete high multiplication neutron subcritical measurements (IER 518) – LLNL – June 2022
9. Measure the fission neutron spectrum shape using threshold activation detectors (IER 153) – LANL – July 2022
10. Promote use of MCNP Version 6.3 at DOE sites – LANL – September 2022
11. Complete prompt fission neutron spectrum (PFNS) measurement of Plutonium-240 at LANSCE – LANL – June 2022
12. Complete Zr-91 measurements at GELINA – ORNL – June 2022
13. Complete site acceptance tests for accelerator section #1 at RPI – NNL – **September 2022**
14. ✓ Complete GELINA neutron production target – Y-12 – Received at GELINA – November 2021
15. ✓ Complete Sandia CSO/Manager course pilot course – SNL – April 2022
16. Complete revision to CEDT Manual – NCSP Management Team – August 2022

TEX Background

- There is a wide data gap in validation experiments in the intermediate (epithermal) neutron energy range
- The series of **T**hermal/**E**pithermal e**X**periments (TEX) are designed to investigate the effect of various interstitial materials and conditions on critical mass.

  - TEX – Pu-239
  - TEX – Tantalum
  - TEX – HEU
  - TEX – Hafnium
  - TEX – Low temperature
  - TEX – mixed U and Pu
  - TEX – Pu-240
  - TEX – Lithium and Chlorine
  - TEX – U-233

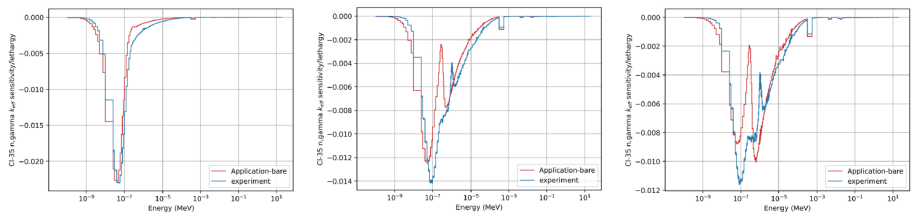
No low temperature experiments in ICSBEP Handbook!



Chlorine Worth Experiments

- Aqueous Chloride Operations at PF-4 are important:
  - Recover Pu from pyrochemical residues
  - Reduces waste sent to WIPP
- Aqueous Chloride Operations have very conservative mass limits
  - Significant amounts of Chlorine but calculations not crediting Cl-35 neutron absorption
  - Accounting for Cl-35 absorption leads to higher mass limits
- Experiments funded by Material Recycle and Recovery Program, NNSA Plutonium Program Office (NA-191)
- Development and evaluation of criticality safety benchmark for inclusion in the ICSBEP handbook is funded by NCSP

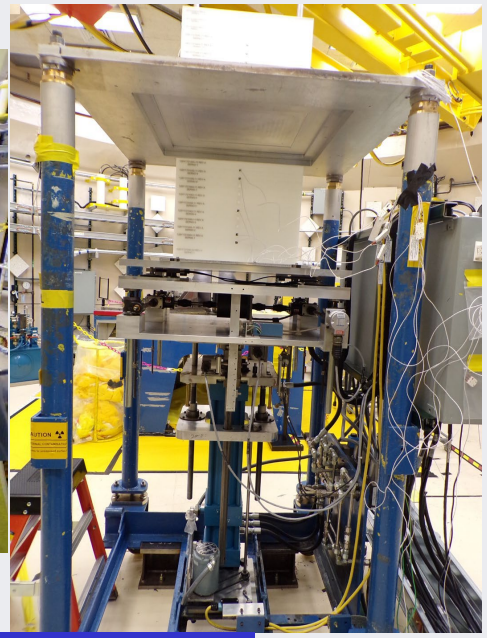
Sensitivity Plots: Cl-35 (n,γ)



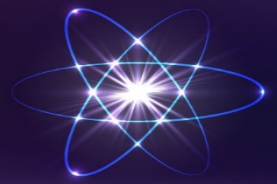
Configuration 1
20-100 g/L

Configuration 2
300-400 g/L

Configuration 3
500-600 g/L



Directly supports NNSA's mission



NCSP
NUCLEAR CRITICALITY SAFETY PROGRAM

Questions?

https://ncsp.llnl.gov