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DOE/NNSA Nuclear Criticality Safety Program – Brief Overview

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2020 SCALE Users' Group Workshop

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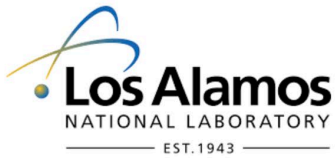
ORNL is managed by UT-Battelle, LLC for the US Department of Energy

U.S. DEPARTMENT OF ENERGY

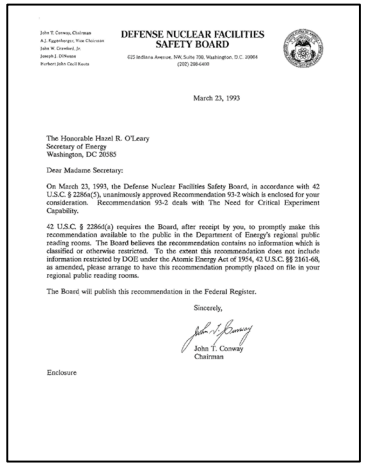
Agenda

- Nuclear Criticality Safety Program (NCSP) history and organization
- NCSP work in the DOE complex organized around 5 technical program elements
- Budget summary
- Future of NCSP SCALE support



Background / History

- Defense Nuclear Facilities Safety Board (DNFSB) Recommendations 93-2 and 97-2:
  - 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.
- 97-2 encompassed ongoing DOE activities of 93-2 while broadening scope to address important cross-cutting safety activities needed to ensure NCS throughout the Complex.
- DOE Implementation Plan for Board Recommendation 93-2 and 97-2 resulted in establishment of the US Nuclear Criticality Safety Program (NCSP)



DEFENSE NUCLEAR FACILITIES SAFETY BOARD

March 23, 1993

The Honorable Hazel R. O'Leary
Secretary of Energy
Washington, DC 20585

Dear Madame Secretary:

On March 23, 1993, the Defense Nuclear Facilities Safety Board, in accordance with 42 U.S.C. § 2286a(5), unanimously approved Recommendation 93-2 which is enclosed for your consideration. Recommendation 93-2 deals with The Need for Critical Experiment Capability.

42 U.S.C. § 2286d(a) requires the Board, after receipt by you, to promptly make this recommendation available to the public in the Department of Energy's regional public reading rooms. The Board believes the recommendation contains no information which is classified or otherwise restricted. To the extent this recommendation does not include information restricted by DOE under the Atomic Energy Act of 1954, 42 U.S.C. §§ 2161-68, as amended, please arrange to have this recommendation promptly placed on file in your regional public reading rooms.

The Board will publish this recommendation in the Federal Register.

Sincerely,

John T. Conway
Chairman

Enclosure

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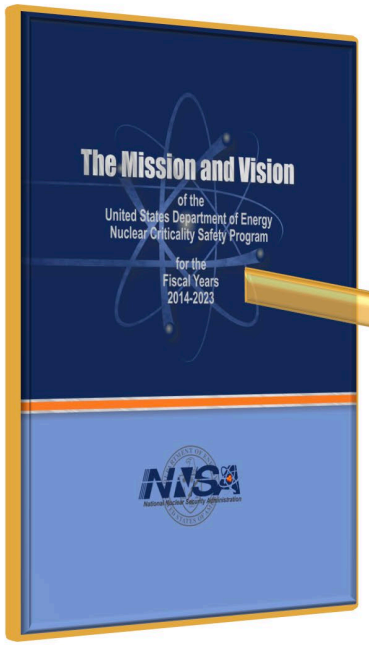
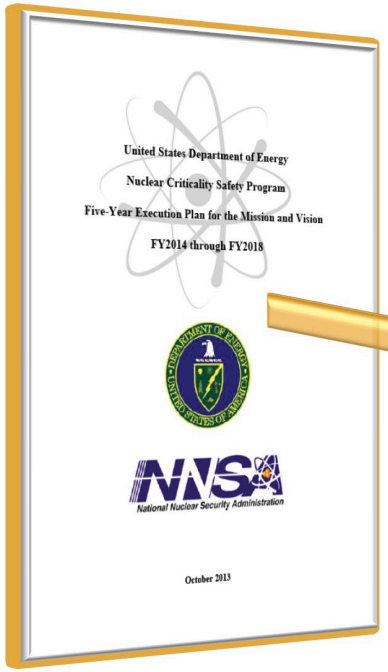
NNSA Nuclear Criticality Safety Program

10 Year Mission & Vision

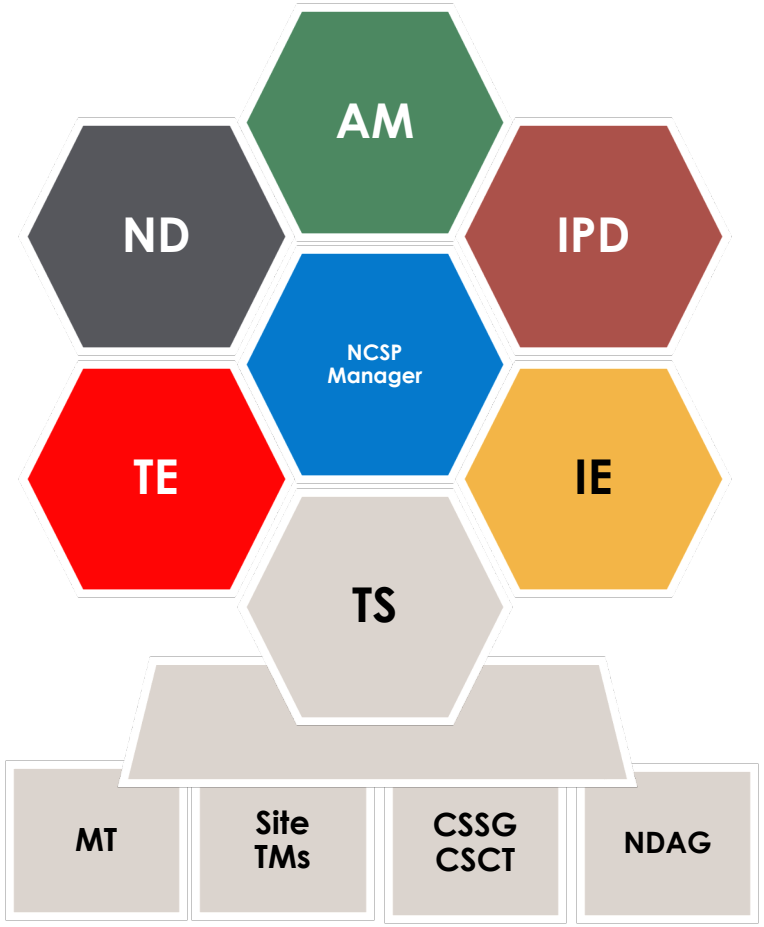


5 Year Plan



Work Tasks

NCSP Technical Program Elements



AM = Analytical Methods
IPD = Information Preservation and Dissemination
IE = Integral Experiments
ND = Nuclear Data
TE = Training and Education
TS = Technical Support
CSSG = Criticality Safety Support Group
CSCT = Criticality Safety Coordinating Team
MT = Management Team
NDAG = Nuclear Data Advisory Group
TM = Task Managers

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Nuclear Data Measurements & Evaluation Work for NCSP

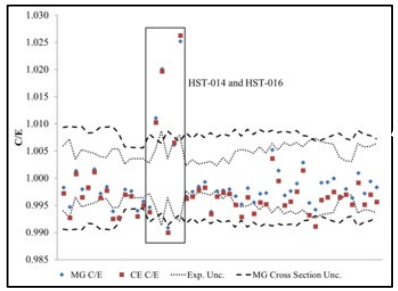
- **Objective**: Provide measured and evaluated thermal, resonance, unresolved resonance, and fast region cross section data to address the priority NCSP nuclear data needs
- **Vision**: Addresses multiple Nuclear Data 5- and 10-year goals and attributes identified in the NCSP Vision
- **Final product**: Rigorous ENDF/B evaluations produced from cross section measurements and analyses.
- Measurement work effort focused on NCSP priorities by NCSP Nuclear Data Advisory Group (NDAG)
- NCSP 5-year plan provides a listing of Nuclear Data measurement and evaluation priorities for the program

Appendix B
Nuclear Data Priorities, Basis Statements, and Milestones

Nuclear Data Measurements

Materials	Pre-FY2019	FY2019	FY2020	FY2021	FY2022	FY2023	Post-FY2023
Cerium (^{142}Ce)							
Basis	Neutron transmission and capture of ^{142}Ce in the resonance range. Cerium is an element that is predominately ^{140}Ce (88.450 a/o) and ^{142}Ce (11.114 a/o) and can be found in chemical processing streams because it is commercially used as a catalyst or additive for chemical applications (e.g., glass polishing powder). As a result, cerium appears as an admixed material in process streams. ^{142}Ce is also a stable fission product. The primary interest for cerium cross sections is for poison credit in NCS analyses. The need for improved cerium cross sections has been specifically identified for the Hanford Plutonium Finishing Plant and other similar operations. Isotopically enriched sample required.						
Chlorine (^{35}Cl)							
Basis	Measurement of the ^{35}Cl (n,p) cross section in the resonance range. Chlorine is present in fuel cycle facilities in Pu solutions, electrorefining processes, chloride salts, and as brine/drift in some repository environments. Improved ^{35}Cl (n,p) cross sections needed for poison credit in these in these environments. A need for improved ^{35}Cl cross sections has been specifically identified at LANL and Y-12.						
Lanthanum (^{nat}La)							
Basis	Measurement of neutron transmission and yield of ^{140}La in the resonance range. Lanthanum is an element that is predominately ^{139}La (99.910 a/o) and a stable fission product. The primary NCS interest is for fission product credit. In the latest edition of the ENDF nuclear data library, the resonance analysis is based on parameters obtain with an experimental set up which is known to have certain problems. Currently, ENDF/B-VIII evaluations for La do not have adequate covariance data based on experimental data. Improved covariance data are needed to support sensitivity/uncertainty analyses for fission product credit applications. Natural samples can be used.						
Molybdenum (^{95}Mo)							
Basis	Measurement of neutron capture in ^{95}Mo in resonance range, URR. Neutron transmission measurements previously completed at RPI. ^{95}Mo is a stable fission product and the primary absorbing nuclide in natural Molybdenum. Molybdenum isotopes are currently encountered in irradiated fuel as fission products or in molybdenum alloys in research reactors and space reactors. The current primary interest in NCS is for fission product credit for transport casks, irradiated fuel storage, and reprocessing plants (UPu-MoZr deposits in French reprocessing plant equipment for example). Needs identified by NR and IRSN for fission product credit and Y-12 for U-Mo applications (lower priority). Isotopically enriched sample required.						
Neptunium (^{237}Np)							
Basis	Measurement of ^{237}Np fission cross section in fast energy range. ^{237}Np is an actinide of interest in nuclear criticality safety for applications at ORNL and other sites. Applications include ^{238}Pu production w/ HFIR at ORNL (low NCSP priority) and fast burst reactor for LANL. Nuclear data improvements will improve critical mass estimates. On the HPRL there is a request for fission cross section in the energy range from 200 keV to 20 MeV. The application list was fast systems, and the required accuracy is 1.5-4%. This requirement comes from the desire to improve the current low accuracy in the covariance matrix (6-8%).						
Tantalum (^{181}Ta)							

NCSP Nuclear Data Program



Nuclear Data Gaps/Needs

Integral Measurements (Critical Experiments)

Differential Nuclear Data Measurements

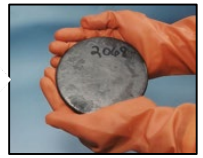
Publish Critical Benchmark (ICSBEP Handbook)

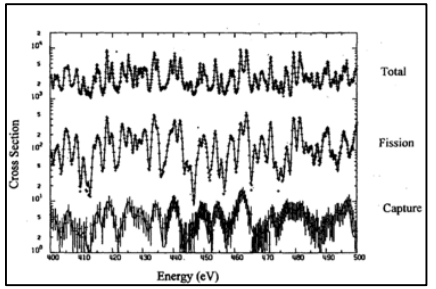
Measurement Data Processing (SAMMY)

Nuclear Data Testing

Generate ENDF Libraries & new Cross Sections (AMPX, NJOY)

Nuclear Criticality Safety Applications





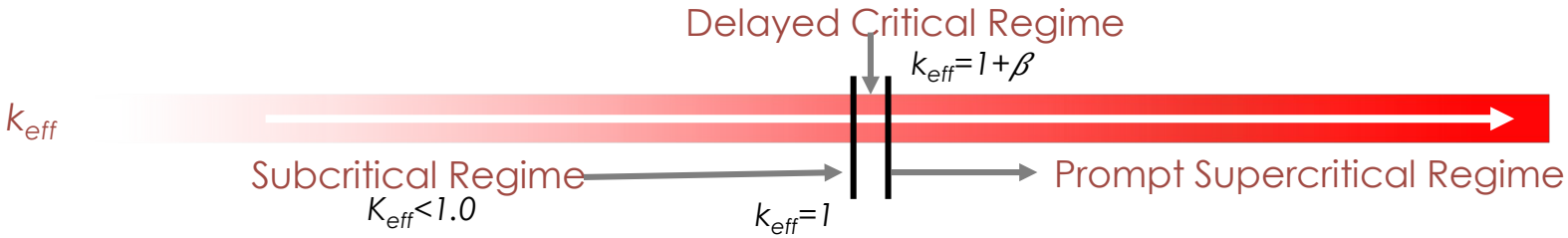
ENDF B-VIII.0

NCSP 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

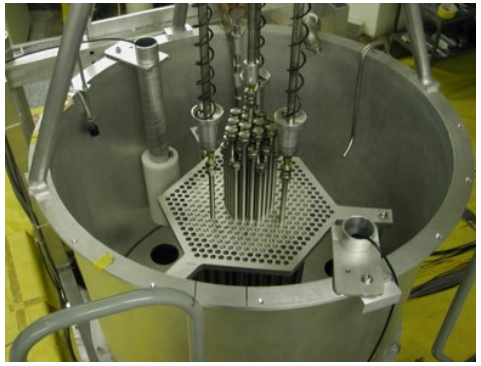
SNL/TA-V/SPR Facility

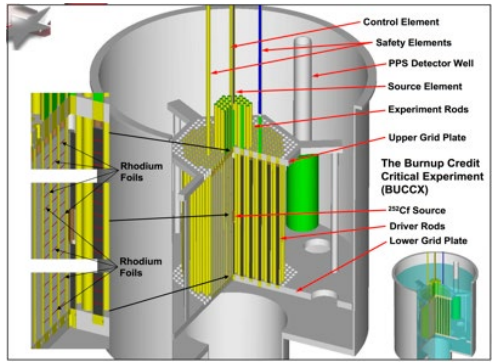


NCSP Critical Assemblies

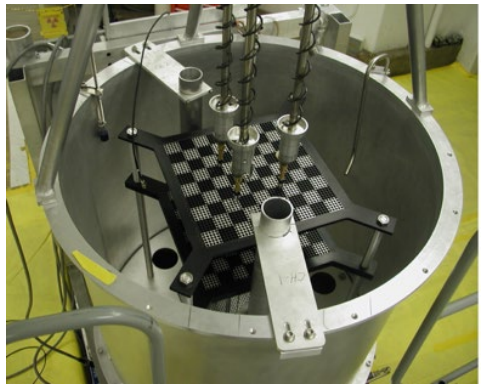
Sandia National Laboratory

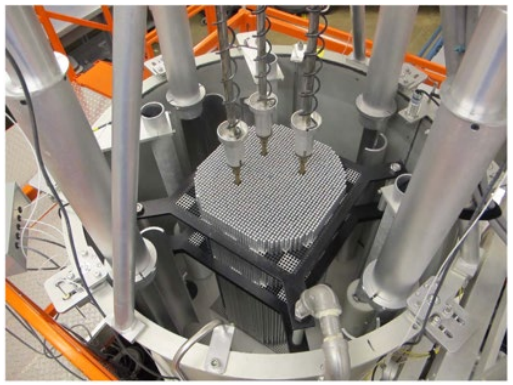
SNL – BUCCX – U(4.31)/Fission Product Experiments



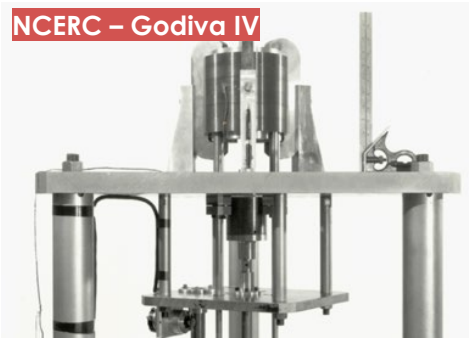


SNL – 7uPCX – U(6.9) UO_2 rods





NCERC/DAF

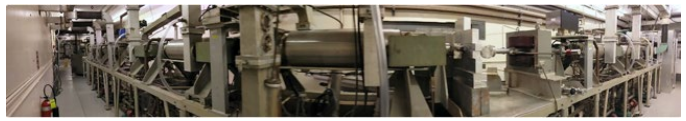


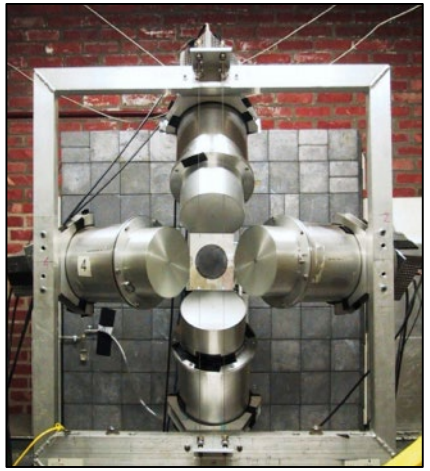
NCSP Differential Experiments

- NCSP integral measurements are performed at
  - JRC-Geel GELINA Facility (Geel, Belgium)
  - RPI LINAC (Troy, NY)
- Types of experiments that are performed
  - Total cross section/Transmission measurements
  - Capture measurements

JRC-Geel (GELINA)

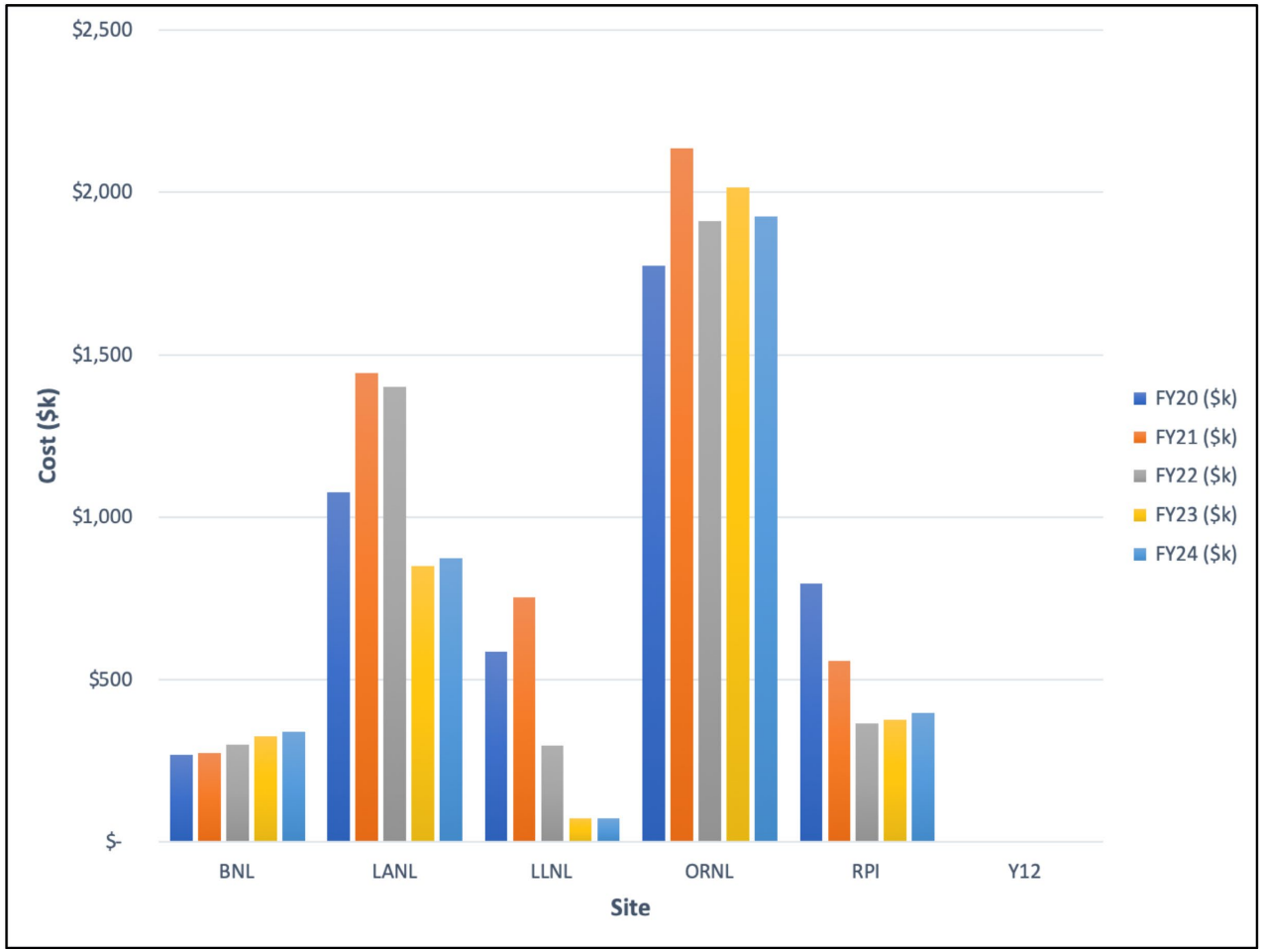
RPI LINAC

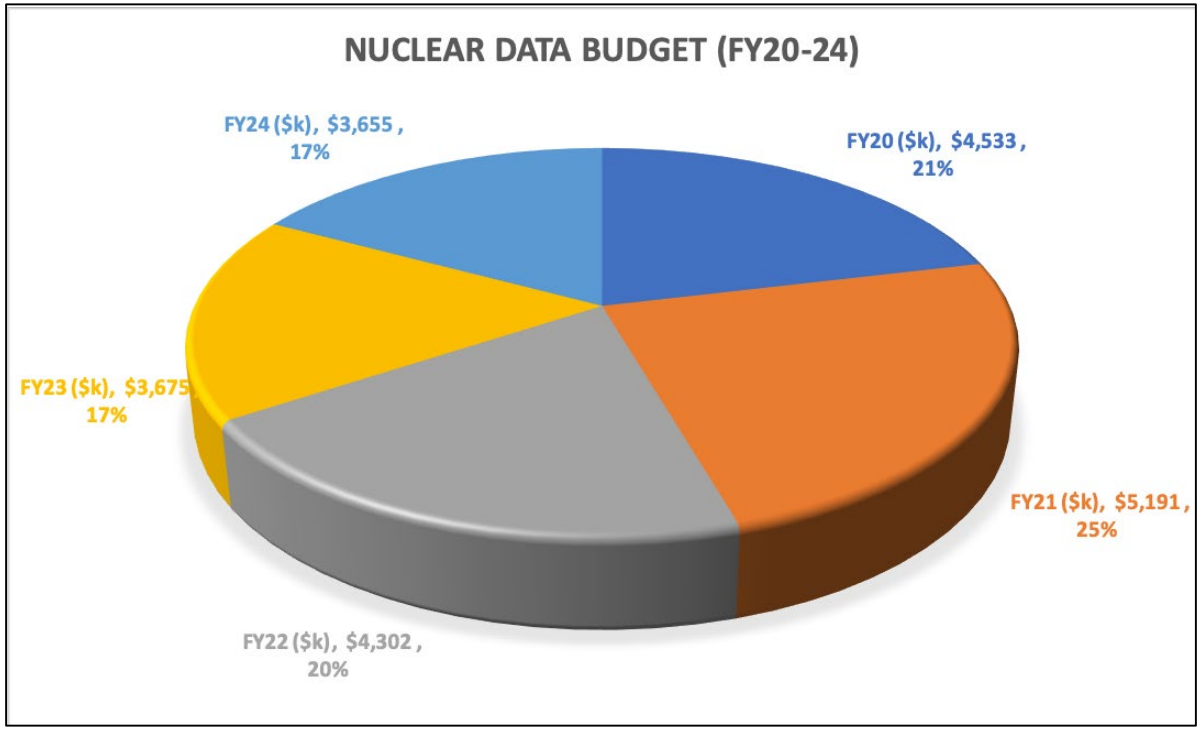




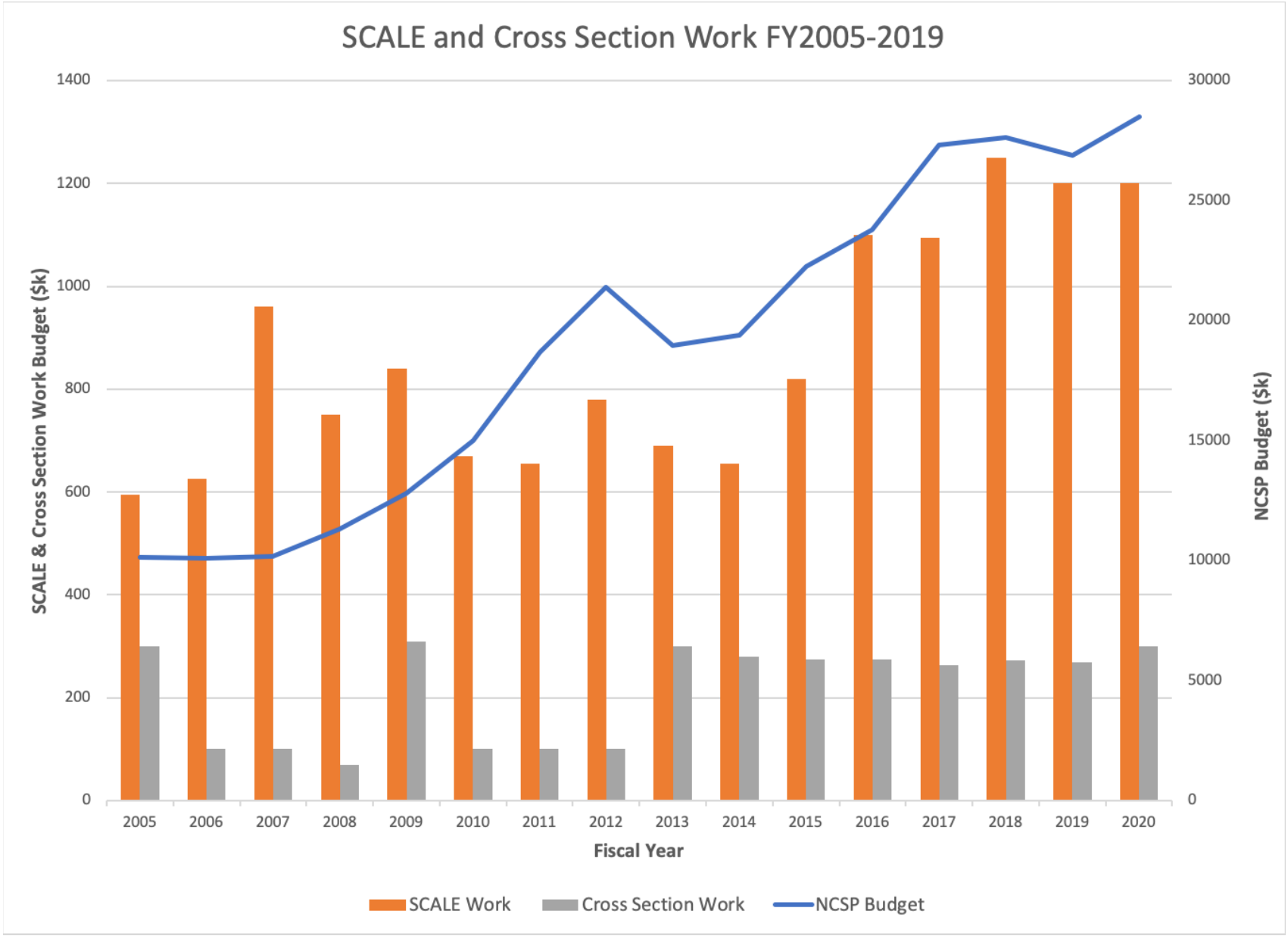
Photos referenced from:
https://ec.europa.eu/jrc/en/research-facility/linear-electron-accelerator-facility
http://www.linac.rpi.edu/public_html/accelerator.html

NCSP Nuclear Data Budget – by site and by year (FY20-24)

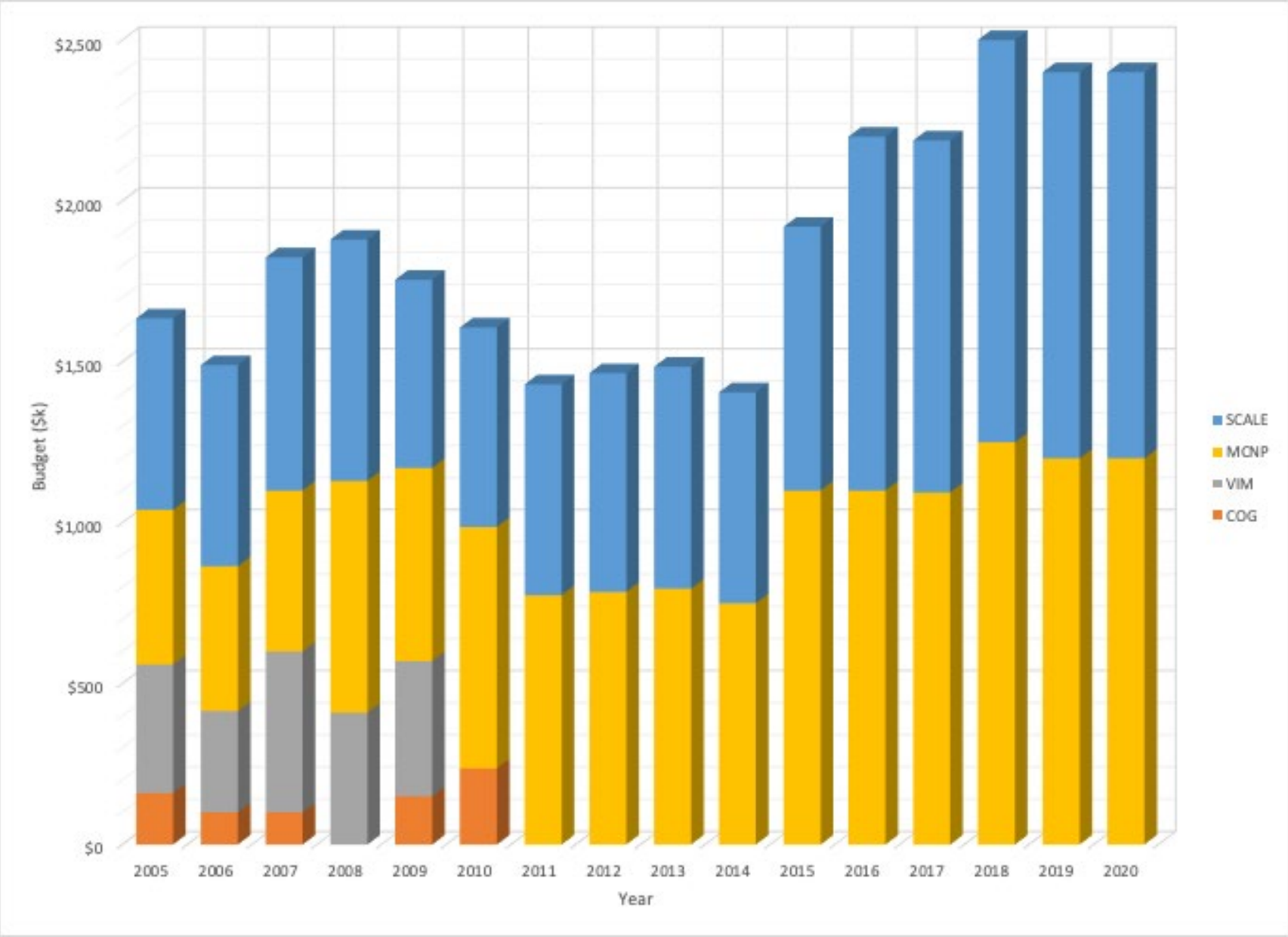




SCALE Support by the NCSP – FY2005 through FY2020



NCSP-funded Code Packages 2005-2020



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NCSP Support of SCALE in the Future

- NCSP support tends to follow trends in the DOE/NNSA NCS community
  - SCALE/MCNP maintenance, modernization, and development funding has grown over the years with the NCSP budget, but this trend may not continue into the future
    - CSSG tends to recommend funding for tasks that more directly support facility staff
    - TE and IE elements are receiving much of the focus these days
- NCS staff are trained to preclude criticality accidents via NCS evaluations and implementing and maintaining process criticality safety limits for facility staff
    - Applying analytical methods to this goal is about ~10% of their job
- **Challenge**: continuously enhance ORNL AM tools for those supporting NCSP missions
  - ORNL SCALE work directly competes with comparable work at other sites

2019 Technical Program Review @ Pantex

Questions