NCSP
NUCLEAR CRITICALITY SAFETY PROGRAM

NEWSLETTER

Fall 2019

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Please contact **Lori Scott** for information or contributions: lori.scott@nnsa.doe.gov

DATES TO REMEMBER

- Feb 11-12 2020 — Technical Program Review at LANL

Two-week Practitioner Course Dates:

Jan 27–Feb 7, 2020 Aug 10–21, 2020

One-week Manager's Course Dates:

Mar 30–Apr 3, 2020 Jun 15–19, 2020

Course Registration: https://ncsp.llnl.gov/trng_apply.php

LINKS TO REMEMBER

- NCSP WEBSITE
- NCSP HISTORY & PROGRAM OVERVIEW
- NCSP ORGANIZATION CHART
- NCSP MISSION AND VISION
- NCSP FIVE-YEAR EXECUTION PLAN
- NCSP PLANNING CALENDAR
- PREVIOUS NCSP NEWSLETTERS
- CSSG TASKINGS

A MESSAGE FROM THE NCSP MANAGER

Thank you, everybody, for a great year! We successfully met 17 Integral Experiment milestones in FY19. In addition to conducting our IE mission, we trained 77 students in our NCSP courses, 139 students in our MCNP criticality courses, and 117 in our SCALE KENO courses.

With the help of the CSCG, we developed a pilot course for Criticality Safety Officers. We have added additional detail to our Five Year Plan and task spreadsheets in order to better track our deliverables and provide more program transparency. We continue to improve our codes. Last year, we moved our IE database over into NA-50's G2 system, and this year, we modernized the database and are in the beta test phase of its release. We submitted several critical experiments to the ICSBEP, including TEX Pu-baselines, KRUSTY, and a new Sandia thermal 0.855 cm pitch LEU experiment (see photo below of the recent ICSBEP meeting). We presented ~40 papers and posters at ICNC. NCERC continues its role in providing a diverse set of critical experiments to the NCSP and other areas, including completing 18 weeks of experiments in support of NA-20 and the JAEA by evaluating lead and void reactivity values in support of recovery efforts in Japan. The NCSP continues as a leader in the field of nuclear data (see photo below of the recent CSEWG meeting). We continue working on RPI accelerator refurbishment. We've got a lot to look forward to this year. NCERC is going to complete the TEX HEU baselines using the Jemima fuel plates this year. We are going to continue our evaluation of Ce-142 and begin taking new measurements of zirconium isotopes. We are going to offer our first pilot CSO course.

Thank you, again, and congratulations on a job well done.

Participants at the October 2019 ICSBEP Meeting in Paris, France

Participants at the November 2019 CSEWG Meeting at BNL

National Nuclear Security Administration

U.S. DEPARTMENT OF ENERGY

A MESSAGE FROM THE CSSG

It has been a while since the last CSSG newsletter input, and while we have not been as busy in the last year as in prior years, we have still had plenty to do. In the last year, or so, the following Taskings have been completed.

Tasking 2017-05: Starting in late '17 and finishing in early '18 the CSSG completed a review of the SRNS criticality safety program. This was needed by SRNS to meet a commitment to have an external review of the program after some issues that occurred several years earlier.

Tasking 2018-01: The CSSG was tasked with identifying a scope of training to support an improved interfacing between NCS and operations/production. This information is being utilized by the NCSP to develop training for the position that is commonly referred to as a Criticality Safety Officer.

Finally, with Tasking 2019-01 the CSSG performed their usual review and prioritization of the FY20 NCSP Proposals. This was utilized by NCSP Management to develop the FY20 5-Year plan.

Several members of the CSSG have also been utilized to support assessments/reviews at a couple of NNSA sites. Of particular note from these assessments, there is a lack of Operations Line Management ownership of criticality safety. This will be a focus of the CSSG in the near term.

The CSSG and CSCT will hold a joint meeting in Washington, D.C. after the ANS Winter Meeting. Two key topics for discussion are 1.) Consistency of Criticality Safety in DOE Rules, Orders, and Standards, and 2.) Short and Long Term Actions Necessary to Address Inexperienced Criticality Safety Engineers and Inexperienced Federal Oversight.

As always, we look for additional opportunities to support the NCSP and the DOE Criticality Safety Community. Just let the NCSP Manager, or any CSSG member, know if you believe that something requires our attention.

David Erickson, CSSG Chair

Welcome NCSP Newcomers

John Miller

Sandia National Laboratories

NCSP Management Team,
C_EDT Manager,
Team Lead, Integral Experiments

John Miller has a B.S. and M.S. in Nuclear Engineering from the University of New Mexico (UNM) and over 20 years of experience providing support for nuclear criticality safety (NCS), radiation dose and shielding, and the lifecycle planning and management of nuclear materials. He has supported activities at multiple Department of Energy (DOE) facilities in the USA, as well as at the Sellafield Nuclear Facility in the UK. John has been involved in training criticality safety professionals through DOE hands-on NCS classes, UNM NCS Short Courses, UNM NCS Manager's Workshops, UNM/UK NCS Workshops, etc. He is active in the American Nuclear Society (ANS) NCS Division and has served in leadership roles and on various committees. He is also active in the development of NCS Standards (i.e., NCSCC, Chair of ANSI/ANS-8.19, and member of ANSI/ANS-8.1 and -8.6).

Brian Bluhm

Los Alamos National Laboratory

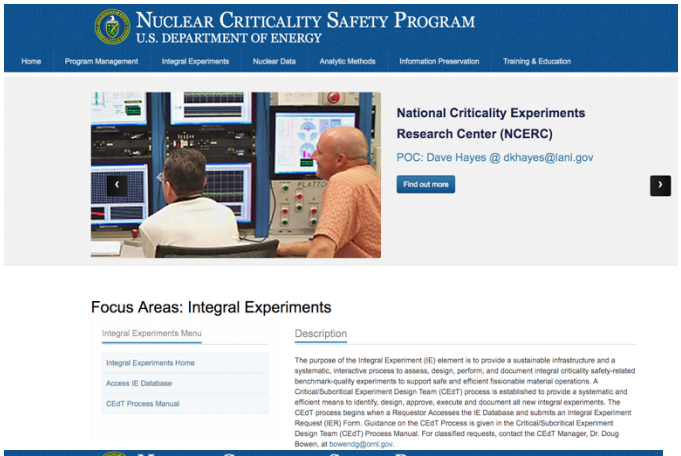
NCSP Task Manager

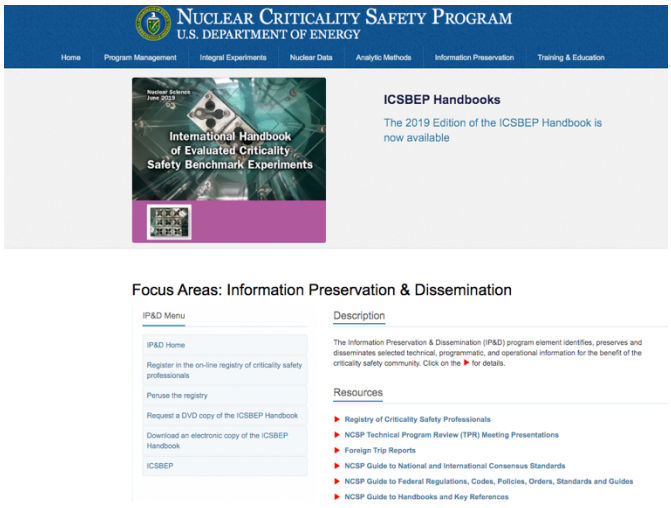
Brian Bluhm is the Deputy Division Leader for Nuclear Engineering and Nonproliferation (NEN) at the Los Alamos National Laboratory (LANL). NEN Division and its predecessors pioneered nuclear safeguards concepts, develops instruments and techniques used to monitor and measure nuclear materials, and operates the Nation's only capability for nuclear criticality experiments.
NEN Division is comprised of for groups –Safeguards Science and Technology (NEN-1), Advanced Nuclear Technology (NEN-2), International Threat Reduction (NEN-3), Systems Design and Analysis (NEN-5), but also works extensively with the National Criticality Experiments Research Center – Facility Operations (NCERC-FO) group which is the permanent-party resident at the National Nuclear Security Site in Nevada. The Division includes about 200 staff, including students and contractors, and executes budget of approximately $130M.
Brian's responsibilities include assisting in managing the nuclear operations within NEN division both onsite in Los Alamos and at the Design Assembly Facility (DAF) located at the Nevada National Security Site (NNSS). Brian also works with division and program management to set strategic areas for program development. Prior to coming to NEN, Brian served as a program manager within the Intelligence and Emerging Threats (IET) program office, where he worked with government sponsors to develop and deliver solutions relevant to national security problems. Brian's technical background is in the area of Physical/Analytical Chemistry; however, while at LANL he has expanded that to include nuclear processing/detection and various remote sensing methodologies. Brian received his Ph.D. from Texas A&M University in Analytical Chemistry, and his B.S. in Chemistry from North Carolina State University.

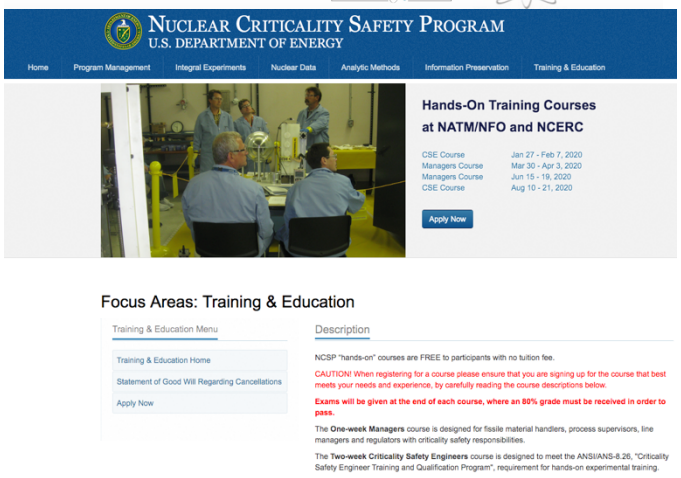
INFORMATION PRESERVATION & DISSEMINATION

Check out our Website!!!

https://ncsp.llnl.gov







National Nuclear Security Administration

U.S. Department of Energy

INFORMATION PRESERVATION & DISSEMINATION (cont'd)

NCSP Annual Technical Program Review (TPR)

This year, the 2019 NCSP annual TPR was held in Amarillo TX at PANTEX at the John C. Drummond Center, on March 26-27, 2019.

The review was another great success, with just under 90 participants from ANL, AWE, BNL, CNS, CS Engineering, DNFSB, DOE, IRSN, LANL, LLNL, NCSU, NNL, NNSS, ORNL, RPI, Sigma Science, SNL and SRS.

Each year at the TPR NCSP Task Managers present their technical results and accomplishments from the previous fiscal year. The TPR is an excellent opportunity for NCSP to showcase their outstanding achievements to the Crit Safety community. Feedback from our previous TPRs has been that this has also been an outstanding professional development/training opportunity for all who participate.

Best papers from the TPR are selected by the NCSP Management Team and presenters are invited to present at the winter ANS meeting, with travel funded by the NCSP Manager.

Best Papers selected from the 2019 TPR and being presented at the winter ANS meeting are listed below. Congratulations to all presenters!

IRSN	Benchmark Intercomparison (IRSN-LANL-LLNL-ORNL Collaboration)	Isabelle Duhamel
ORNL	Recent Developments in SCALE	Will Wieselquist
LANL	AMPX Status Report and ENDF/B-VII.0 Data Testing	Forrest Brown
LLNL	Inherently Safe Subcritical Assembly (ISSA) Benchmark Evaluation	Tony Nelson
SNL	Sandia BUCCX Titanium and Aluminum Sleeve Experiments	David Ames
RPI	Benchmarking Unresolved Resonance Region Total Cross Section	Jesse Brown

The full TPR agenda, with links to all presentations can be found at:
https://ncsp.llnl.gov/TPRAgendas/2019/NCSP_2019_TPR_Agenda.html

Thanks to everyone who participated and to those who made it all happen.

INFORMATION PRESERVATION & DISSEMINATION (cont'd)

International Conference of Nuclear Criticality (ICNC)

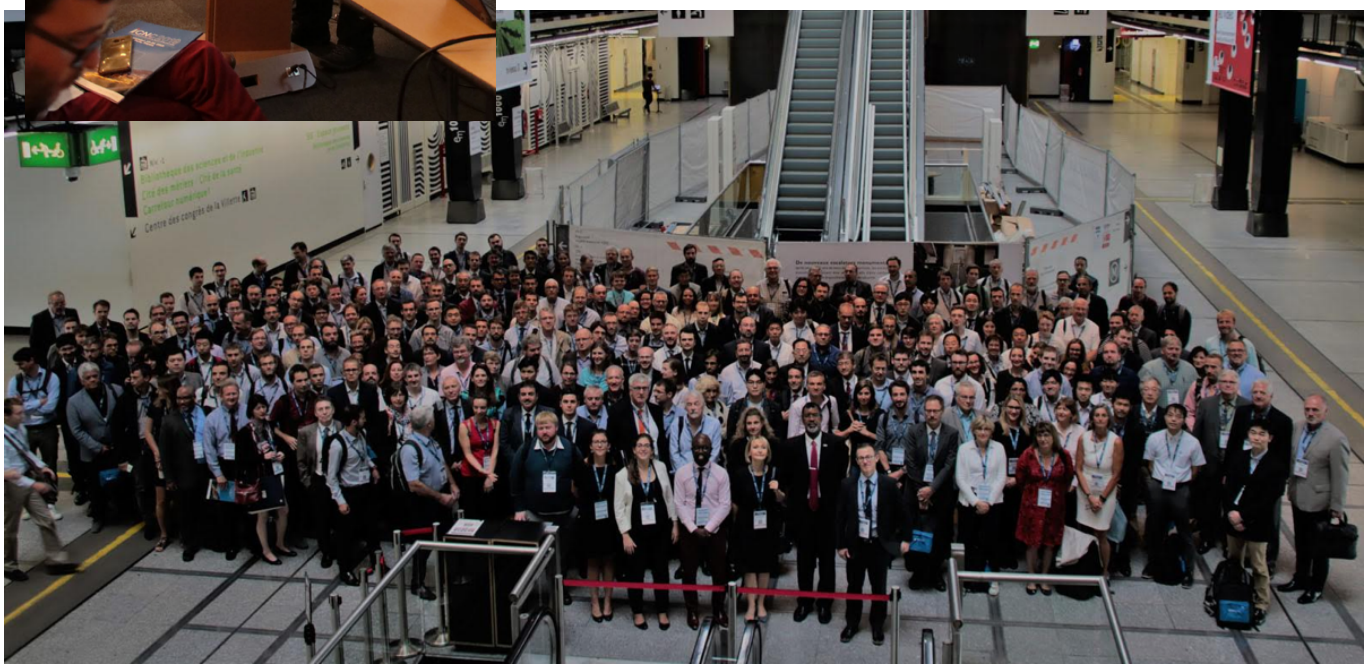
The 11th International Conference of Nuclear Criticality safety was held in Paris, France, September 15-20, 2019. Many NCSP sites were present at the conference to share their research with the international NCS community. Papers presented for NCSP-funded work is listed in the ICNC publications list in this newsletter and are available via the ICNC proceedings.

Angela Chambers, Leader of Track 11, "Future Challenges," discussing the papers and key points of her track on the last day of the conference.

Track 11 involved the following topics for discussion:

- New reactors and fuel types, etc.
- New processes
- Identification and solution to past and current difficulties.
- Future experimental needs

Forrest Brown, LANL, presenting his paper in Track 1, "Codes and other calculation methods," Session 3, "Automated Acceleration and Convergence Testing for Monte Carlo Nuclear Criticality Safety Calculations."



Participants at the September 2019 ICNC Meeting in Paris, France

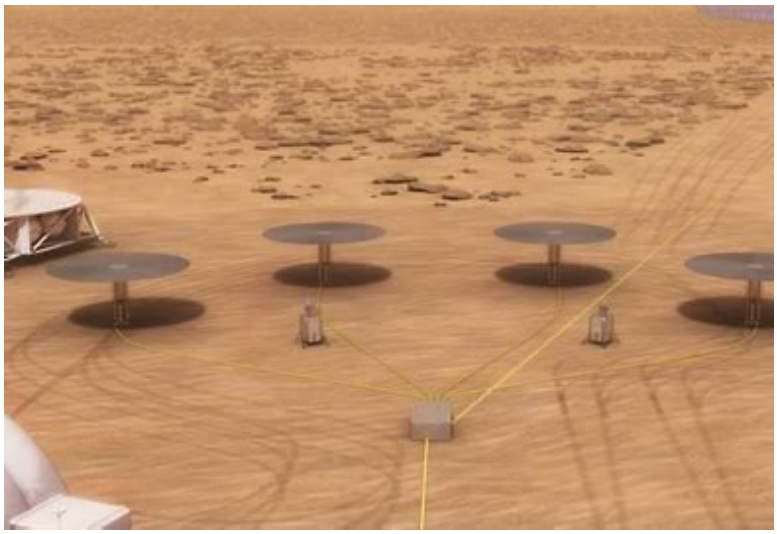
INTEGRAL EXPERIMENTS

KRUSTY (Kilowatt Reactor Using Stirling TechnologY) *A Joint NNSA/NASA Project*

In 2018, NNSA, along with the National Aeronautics and Space Administration (NASA), completed testing a prototype fission reactor coupled to a Stirling engine in an experiment entitled KRUSTY (Kilowatt Reactor Using Stirling TechnologY).

This design of this experiment was dual purposed: NNSA needed beryllium oxide experimental benchmark nuclear data, and NASA was looking for a small fission power source to provide approximately one kilowatt of power.

For NASA, the experiment is part of the NASA Kilopower project aimed at developing small fission reactors as a potential power source for manned missions to the moon and Mars as well as deep space missions where currently utilized power sources may not be adequate.



Conceptual Drawing of 4 Kilopower Reactors on Mars' Surface

The DOE Nuclear Criticality Safety Program partnered with NASA's Space Technology Mission Directorate to develop and test the KRUSTY reactor at NNSA's National Criticality Experiments Research Center (NCERC) in the Device Assembly Facility (DAF) at the Nevada National Security Site (NNSS).

The KRUSTY Experimental Assembly

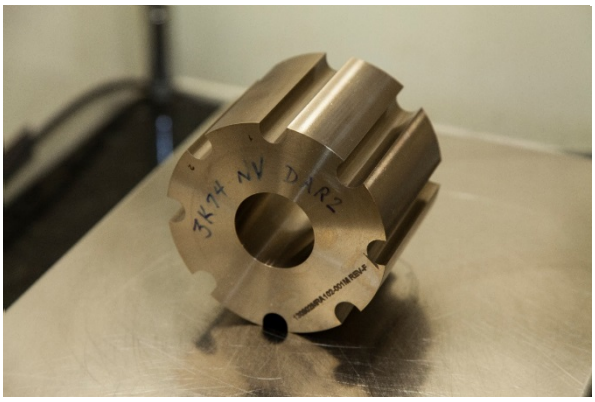
Los Alamos National Laboratory (LANL), along with NASA's Glenn Research Center in Cleveland, Ohio, designed and performed initial testing of the KRUSTY reactor design with contributions from NASA's Marshall Space Flight Center in Huntsville, Alabama. Initial testing was conducted in December 2016 using a surrogate (non-fissile) reactor core and resistive heating elements at the NASA Glenn Research Center.

NNSS, the Nevada Field Office, the NNSA Production Office, the Y-12 National Security Complex, LANL, Lawrence Livermore National Laboratory, and Sandia National Laboratories all contributed to completion of the design, safety analysis, fabrication, and final testing of the KRUSTY experiment.

The Y-12 National Security Complex in Oak Ridge, Tennessee, cast and machined the reactor core, which was delivered to the DAF early in the fall of 2017.

INTEGRAL EXPERIMENTS (cont'd)

KRUSTY (Kilowat Reactor Using Stirling TechnologY) ***A Joint NNSA/NASA Project (cont'd)***



Y-12 Manufactured Uranium Core Piece for KRUSTY Experiment

Assembly of the KRUSTY experiment began at DAF shortly after the arrival of the Y-12 fabricated core and the NASA components, including the Stirling converters, shielding materials, sodium heat pipes, and beryllium oxide reflector. The uranium core is subcritical in air, but once surrounded by the beryllium oxide (BeO) reflector, it becomes critical, which means it maintains a self-sustaining reaction of splitting uranium atoms until the reflector is removed.

LANL's Advanced Nuclear Technology Group and Advanced Nuclear Experiments Group, along with support from NNSS Mission Support and Test Services staff, conducted the KRUSTY experiments at NCERC.

LANL experimenters at NCERC achieved initial criticality on November 16, 2017. In the following months, a series of critical experiments to characterize the assembly and obtain BeO experimental benchmark data were completed, culminating in a 28 hour continuous full power demonstration in March of this year. The full power run demonstrated the feasibility of small fission reactors for deep space and manned Mars missions.

LANL is currently using the nuclear data obtained to develop an experimental benchmark which can then be used for a variety of applications including those in nuclear criticality safety, emergency response, and non-proliferation.

The KRUSTY Team Completes the Final Assembly Steps

In May of this year, KRUSTY was recognized as one of eight of the prestigious government-wide Gears of Government President's Award at a ceremony at the Eisenhower Executive Building.

KRUSTY Team with the NNSA Administrator and Deputy Secretary of Energy at Gears of Government Presidential Awards' Ceremony

The Gears of Government Awards recognize individuals and teams across the Federal workforce whose dedication supports exceptional delivery of key outcomes for the American people in the areas of mission results, customer services, and accountable stewardship. Each May, the Executive Office of the President presents exemplary Agency and Council Award recipients with the Gears of Government President's Award.

The NNSA NCSP Manager and the NASA technical and project leads attended the ceremony along with NNSA Administrator Lisa Gordon-Hagerty and Deputy Secretary of Energy Dan Brouillette.

INTEGRAL EXPERIMENTS (cont'd)

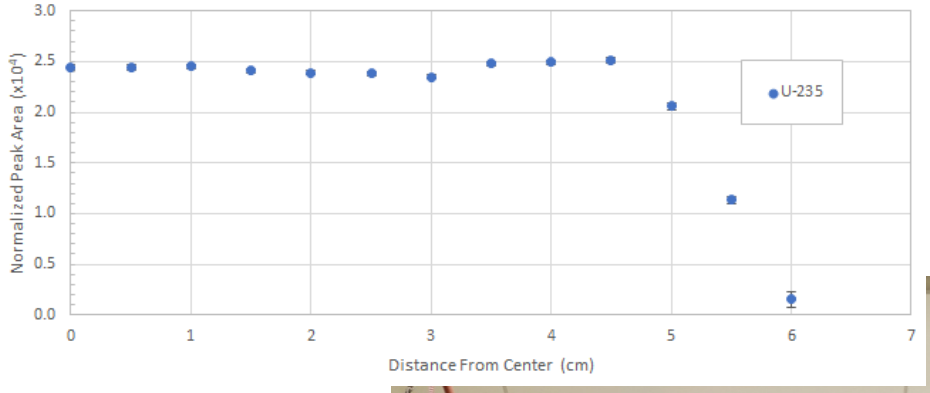
Characterization of UNM's AGN-201M U(19.75)O_2-Polyethyelene Fuel

(John Miller, Sandia National Laboratories)

The AGN-201M fuel characterization effort at University of New Mexico (UNM) is in support of the generation of a high-fidelity benchmark integral experiment for the NEA/OECD International Handbook of Evaluated Criticality Safety Benchmark Experiments (ICSBEP Handbook). These measurements will ultimately support a DOE Nuclear Criticality Safety Program (NCSP)-funded feasibility study for use of AGN-201 fuel plates as an NCS training tool at Oak Ridge National Laboratory in a subcritical assembly. The effort required collaboration between DOE and NRC license facilities and required approval and hazard analysis documentation from both worlds, which was not exactly a trivial exercise. Sandia National Laboratories (Sandia) NCS staff were involved in the various approvals and procedure development necessary to support this work and the NCS staff benefited by gaining professional development associated with the characterization and re-assembly activities. A final report of the activities and characterization will be made available to the NCSP.

During the week of May 13th, the characterization of UNM's AGN-201M fuel was conducted as task number 1 under a CRADA (SC19/01942.01.00) between Sandia and UNM. Radiation protection sample diagnosis staff from Sandia National Laboratories used two portable High Purity Germanium detectors to measure the activity of all present nuclides and uranium enrichment. Preliminary results show an average enrichment ^{235}U of 19.3 wt.%, which represents a fairly accurate measurement of the known 19.75 wt.%, especially given the interference of fission product chains.

A set of radial measurements of the upper most fuel disk using a pin hole collimator attempted to see any radial ^{235}U burn-up profile. There is an apparent reduced activity of ^{235}U at an approximate radial position of 3cm (small dip in figure below) that might be indicative of reflector return. The large drop starting at 5 cm is associated with reduced solid angle as the disk edge passes outside of the viewing angle of collimator.



Radial Measurements of the Upper Most Fuel Disk using a Pin Hole Collimator

Photograph showing Essentially all of the Reactor Pieces Laid Out

National Nuclear Security Administration
U.S. DEPARTMENT OF ENERGY

TRAINING AND EDUCATION

NCSP Hands-on Training and Education Courses

Two-week Practitioner Course Dates:

Jan 28 – Feb 8, 2019 Aug 12 – 23, 2019

The NCS Practitioners Courses were held at the National Atomic Testing Museum (NATM), the National Criticality Experiments Research Center (NCERC) and Sandia National Laboratories in Las Vegas, Nevada. The courses are designed to meet the ANSI/ANS-8.26, "Criticality Safety Engineer Training and Qualification Program," requirement for hands-on experimental training.

Then NATM portion of the course involves classroom lectures and workshops for NCS Evaluation development and the NCERC and SNL portions of the course involve experiments with the critical assemblies.

NNSS, LANL, ORNL, LLNL, SNL, Y12 and NFO staff participated in the course execution.

One-week Manager's Course Dates:

Apr 15 – 19, 2019 Jun 3 – 7, 2019

The Managers courses were held at both NCERC and SNL. THE courses are designed for fissile material handlers, process supervisors, line managers and regulators with criticality safety responsibilities.

NNSS, LANL, ORNL, LLNL, SNL, Y12 and NFO staff participated in the course execution.

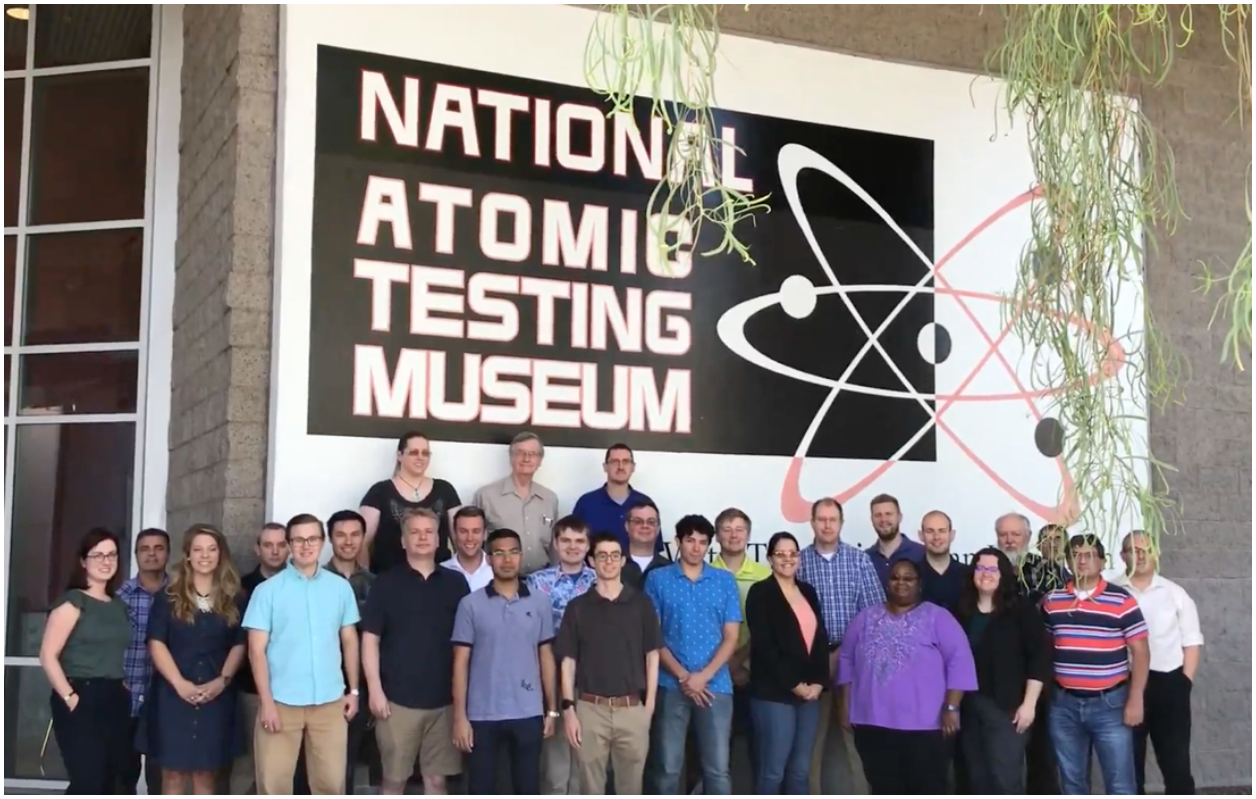


Photo from the August 2019 2-week Hands-on Course at the National Atomic Testing Museum

TRAINING AND EDUCATION (cont'd)

NCSP Hands-on Training and Education Courses *(cont'd)*

Photo from the classroom portion of the August 2019 2-week Hands-on Course. Matt Windsor (Sandia) is leading the Human Factors Module.

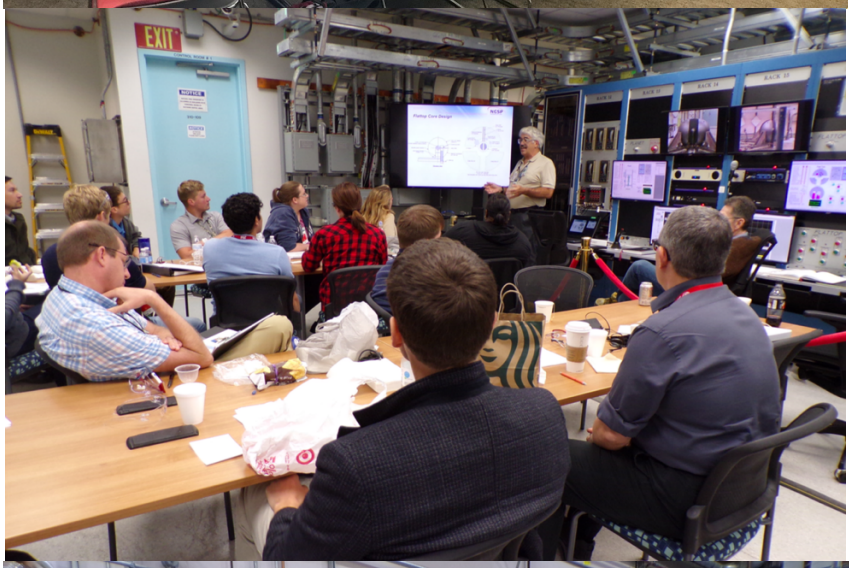
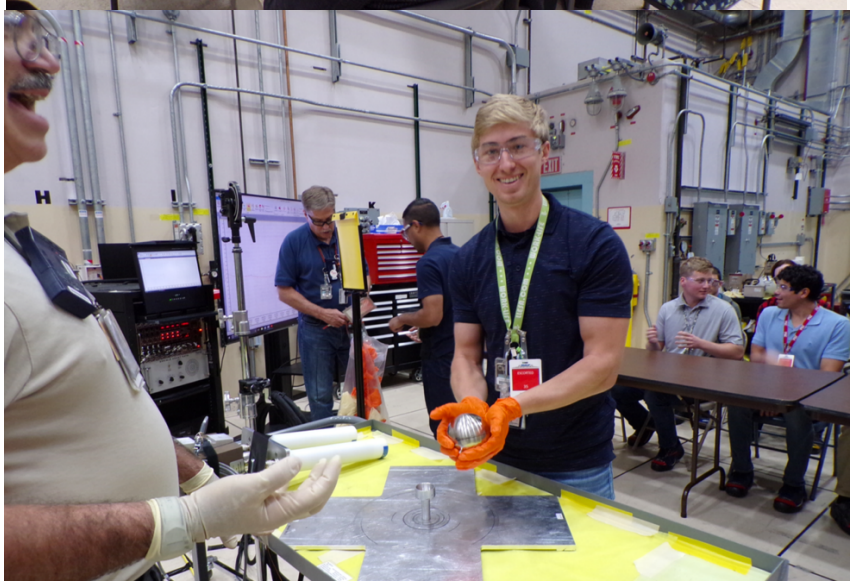


Photo from the NCERC portion of the August 2019 2-week Hands-on Course.



Jesse Norris (LLNL) holding the Np-237 ball at NCERC during the NCERC portion of the 2-week Hands-on Course.

TRAINING AND EDUCATION (cont'd)

Class Information:
https://mcnp.lanl.gov/classes/classinformation.shtml

Fees and Registration Information:
https://laws.lanl.gov/vhosts/mcnp.lanl.gov/classes/CostsRegistrationInfo.shtml

MCNP6 Class Schedule for 2019 - 2020

Nov 5-8, 2019 Los Alamos, NM	Unstructured Mesh with Attila4MC Non-US citizens must register by 2019-08-09 | Tues 12:30 - Fri 4:30
March 2-6, 2020 Los Alamos, NM	Introduction to MCNP6 Non-US citizens must register by 2019-12-06 | Mon 10:00 - Fri 12:00
March 9-13, 2020 Los Alamos, NM	Criticality Calculations with MCNP6 Non-US citizens must register by 2019-12-13 | Mon 10:00 - Fri 12:00
April 20-24, 2020 Los Alamos, NM	Practical MCNP for Health Physics (Link to LANL Radiation Protection website) See the RP website for class information & registration. Non-US citizens must register by 2020-01-24.
June 1-5, 2020 Los Alamos, NM	Introduction to MCNP6 Non-US citizens must register by 2020-03-06 | Mon 10:00 - Fri 12:00
June 16-18, 2020 Los Alamos, NM	Using NJOY to Create MCNP ACE Files & Visualize Nuclear Data Non-US citizens must register by 2020-03-20 | Tues 10:00 - Thurs 5:00
July 6-10, 2020 Los Alamos, NM	Introduction to MCNP6 Non-US citizens must register by 2020-04-10 | Mon 10:00 - Fri 12:00
July 13-17, 2020 Los Alamos, NM	Unstructured Mesh with Attila4MC Non-US citizens must register by 2020-04-17 | Mon 10:00 - Fri 4:30
July 20-24, 2020 Los Alamos, NM	Intermediate MCNP6 Non-US citizens must register by 2020-04-24 | Mon 10:00 - Fri 12:00
July 27-31, 2020 Los Alamos, NM	Variance Reduction with MCNP6 Non-US citizens must register by 2020-05-01 | Mon 10:00 - Fri 12:00
Aug 3-7, 2020 Los Alamos, NM	Criticality Calculations with MCNP6 Non-US citizens must register by 2020-05-08 | Mon 10:00 - Fri 12:00
Sept 28 - Oct 2, 2020 Los Alamos, NM	Intermediate MCNP6 Non-US citizens must register by 2020-07-06 | Mon 10:00 - Fri 12:00
Oct 5-9, 2020 Los Alamos, NM	Introduction to MCNP6 Non-US citizens must register by 2020-07-10 | Mon 10:00 - Fri 12:00
Oct 26-30, 2020 Los Alamos, NM	Introduction to MCNP6 Non-US citizens must register by 2020-07-31 | Mon 10:00 - Fri 12:00
Nov 2-6, 2020 Los Alamos, NM	Unstructured Mesh with Attila4MC Non-US citizens must register by 2020-08-07 | Mon 10:00 - Fri 4:30

TRAINING AND EDUCATION (cont'd)

Class Information:
https://www.ornl.gov/scale/scale-training

Fees and Registration Information:
https://utconferences.eventsair.com/scale-fall-2019-oak-ridge-training-course/register/Site/Register

Course Dates and Descriptions

The next training block at Oak Ridge National Laboratory will be held February 3 - 28, 2020. The course schedule is listed below.

February 3 - 7, 2020 (Mon - Thurs: 8am-5pm; Fri: 8am-noon)
SCALE Criticality Safety and Radiation Shielding Course

February 10 - 14, 2020 (Mon - Thurs: 8am-5pm; Fri: 8am-noon)
SCALE/ORIGEN Standalone Fuel Depletion, Activation, and Source Term Analysis Course

February 17 - 21, 2020 (Mon - Thurs: 8am-5pm; Fri: 8am-noon)
SCALE Sensitivity and Uncertainty Analysis for Criticality Safety Assessment and Validation Course

February 24 - 28, 2020 (Mon - Thurs: 8am-5pm; Fri: 8am-noon)
SCALE/Polaris Lattice Physics, Depletion, and Uncertainty Analysis

NCSP FUTURE CHALLENGES

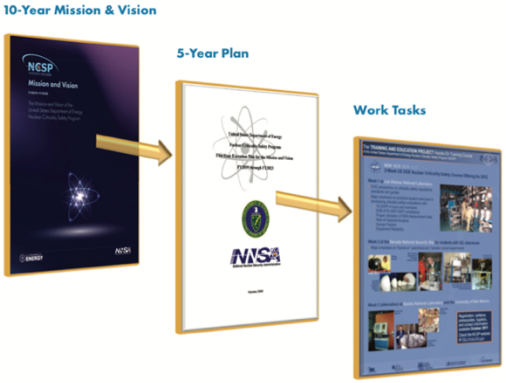
An Overview Of The United States Department Of Energy's Nuclear Criticality Safety Program And Future Challenges

(Presented at ICNC 2019 - 11th International Conference on Nuclear Criticality Safety
September 15–20, 2019 – Paris, France – Doug Bowen and Angela Chambers)

NCSP OVERVIEW

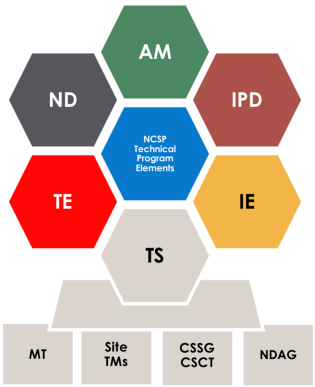
Organizational Structure, Work Sites, and Collaborators

NCSP serves primarily as a capability maintenance program aimed at preserving a unique skill set and associated infrastructural assets for the United States. Skills and infrastructure are preserved and maintained by performing mission-related work in each of the Technical Program Elements (TPEs). The results of this work significantly enhance criticality safety throughout DOE. In addition to maintaining the infrastructure or base program, NCSP resources are routinely employed to solve DOE problems. NCSP is organized around the five TPEs defined in the NCSP Mission and Vision (M&V), which defines the program's 5- and 10-year attributes and goals within each of the five TPEs. Based on the attributes and goals outlined in the M&V, a 5-year plan is generated annually to define tasks, collaborations, budget and milestones for each site based on available funding.



Implementation of NCSP Attributes and Goals into Site Work Tasks

The NCSP manager, Dr. Angela Chambers, relies on technical advice from the CSSG, CSCT, and NDAG to assist with technical NCS and nuclear data matters as they arise. The NCSP manager has nine task managers who manage site funding, tasks, and milestones, as well as a management team to assist with daily execution of NCSP at the manager's direction.



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

NCSP Organizational Structure

NCSP FUTURE CHALLENGES (cont'd)

NCSP funds work activities at many sites across the United States, as shown below.

- Argonne National Laboratory
- Brookhaven National Laboratory
- Oak Ridge National Laboratory
- Lawrence Livermore National Laboratory
- Los Alamos National Laboratory
- Mission Support and Test Services, LLC
- National Criticality Experiments Research Center
- National Nuclear Security Administration, NA-30, Naval Reactors
- Savannah River Site
- Sandia National Laboratories

NCSP Work Sites

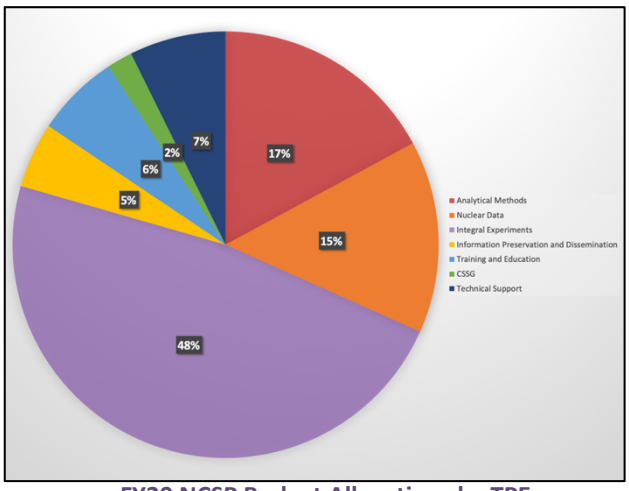
NCSP also collaborates with international and university partners to support program objectives, as shown below. These organizations are listed below:

- **International Partners**
  - Institut de radioprotection et de sûreté Nucléaire (IRSN), France
  - Atomic Weapons Establishment (AWE), United Kingdom
  - European Atomic Energy Community (Euratom) Joint Research Center, JRC-G2 facility (Geel Electron Linear Accelerator – GELINA)
- **Universities**
  - Georgia Institute of Technology
  - Massachusetts Institute of Technology
  - North Carolina State University
  - Rensselaer Polytechnic Institute
  - University of Tennessee, Knoxville
  - University of Florida, Gainesville

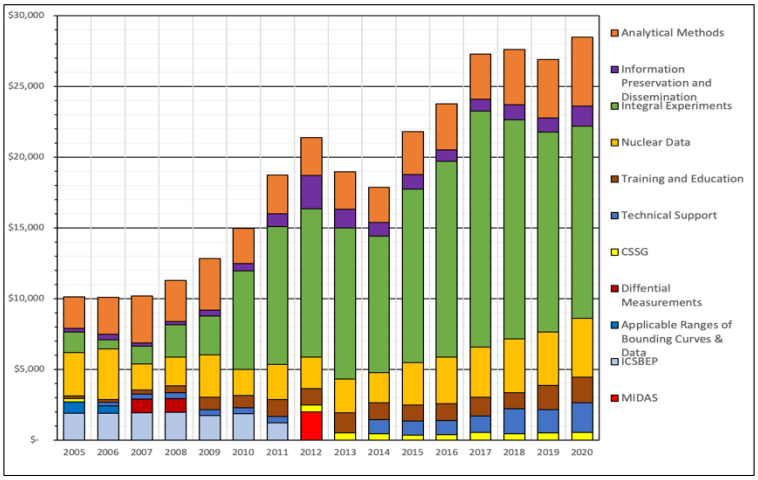
NCSP Budget

The NCSP budget is organized around the five TPEs: Analytical Methods, Information Preservation and Dissemination, Integral Experiments, Nuclear Data, and Training and Education. NCSP's administrative functions are assigned to the Technical Support (TS) element, and they include the Criticality Safety Support Group (CSSG). In the past, NCSP had different program elements such as Differential Measurements (now Nuclear Data), Applicable Ranges of Bounding Curves and Data (now Analytical Methods), International Criticality Safety Benchmark Evaluation Project (ICSBEP), and MIDAS (US-France collaboration on the Valduc Criticality Safety Facility Refurbishment). The NCSP budget has grown and evolved since the earlier days of the organization. The NCSP budget, shown in the figure below, is over a 15-year period. Since fiscal year (FY) 2005, the NCSP budget has grown significantly, from approximately $10M to more than $28M in FY 2020 (estimated). For FY 2019, the NCSP budget is $26.8M, as shown in the figure below, and the funding is distributed among the five TPEs. Also as shown in in the figure below, almost half of the projected FY 2020 budget will be spent on the integral experiment TPE, And the other half budget is dominated by the Analytical Methods and Nuclear Data TPEs.

NCSP FUTURE CHALLENGES (cont'd)



FY20 NCSP Budget Allocations by TPE



NCSP Budget Fiscal Year 2005–2020 (2020 Estimated)

NCSP FUTURE CHALLENGES

NCSP site task managers were asked what they considered to be the biggest future challenges for the program. Each site has various areas of expertise in one or more TPEs, so the future challenges have been grouped under each of the five TPEs, and the Technical Support element is also included. These goals and challenges have been taken from the NCSP M&V [2] document and are significant for meeting important NCSP objectives, extending as far as 10 years into the future.

Each year, the NCSP management team generates a status report of work completed and proposed work and compares that to the attributes and goals in the NCSP M&V. The priorities listed above are those with a high budget or technical priority for the NCSP and are typically funded and tracked to completion. Some of these tasks, such as succession planning, are ongoing tasks that need to be adapted to needs at the various sites. Other tasks, such as design and development of a solution, ^{237}Np, or Jezebel-like critical assembly, will likely require funding beyond what the NCSP can support with its modest budget. Regardless, the NCSP manager has many challenges in the future to meet the growing demands of the NCS community, and she works with her technical support teams (CSSG and CSCT) and site task managers to ensure that high priority tasks are adequately funded, supported, and tracked to closure. The NCSP manager also works diligently with her management and the rest of DOE to ensure that the nuclear safety goals of the NCSP are met. This requires constant feedback to DOE management that NCSP attributes and goals are important to the NCS community. NCSP has recently updated its website to communicate with end users and has started to produce periodic newsletters to convey important news to the DOE and NCS communities.

CONCLUSIONS

This paper summarizes NCSP organization, structure, and high-priority M&V attributes and goals. NCSP is a highly adaptable to addressing mission critical needs. The site task managers have indicated which of these high priorities need additional focus based on issues at their sites. Future challenges involve aging of human resources and training needs for the next generation of code developers to address analytic methods and nuclear data, integral and differential measurement experimenters, maintenance staff, and nuclear data analysts. Aging issues with critical assemblies are also a significant issue, as costs to operate critical assemblies continue to be high. It is always a challenge to keep the critical assemblies operational. NCSP makes large investments in modernizing and maintaining numerous code packages such as MCNP/SCALE and NJOY/AMPX and will consider making significant investments in new capabilities such hot and cold machine shops and a rad chem laboratory at NCERC to support the integral experiment mission. These challenges must be managed along with all the other program priorities to ensure that all NCSP M&V objectives are met.

National Nuclear Security Administration
U.S. DEPARTMENT OF ENERGY

PUBLICATIONS - FY2019

INTERNAL REPORTS AND JOURNALS

J.L. Alwin, F.B. Brown, M.E. Rising, "Excluding Benchmark Statistical Outliers in Nuclear Criticality Safety Validation: A Comparison Study of Upper Subcritical Limits for Plutonium Systems using Whisper-1.1", LA-UR-18-27731

M.E. Rising, "MCNP6 Code Developments and CGMF/FREYA Integration and Validation", LA-UR-18-26533

C.J. Solomon, M.E. Rising, "(U) Modernization of the Monte Carlo N-Particle Transport Code", LA-CP-18-00110

S.R. Bolding, C.J. Josey, M.E. Rising, C.J. Solomon, J.S. Bull, "Release Testing for MCNP 6.2.1", LA-UR-18-30577

Jeremy Lloyd Conlin, "Development and Maintenance of NJOY (2018 Revision)

B. Merryman, F.B. Brown, J.L. Alwin, "Investigating Region-wise Sensitivities for Nuclear Criticality Safety Validation", LA-UR-18-31601

J.L. Alwin, F.B. Brown, M.E. Rising, "Verification of MCNP6.2 with ENDF/B-VIII.0 Nuclear Data for Nuclear Criticality Safety Applications", LA-UR-19-23348

F.B. Brown, "Doppler Broadening Resonance Correction for Free-gas Scattering in MCNP6.2", LA-UR-19-24824

J.L. Alwin, J.B. Spencer, "Critical Experiment Benchmark Results using UM and Mesh Quality Recommendations", LA-UR-19-26393

J.L. Alwin, J.B. Spencer, G. Failla, "Criticality Accident Alarm System (CAAS) CSG-UM Hybrid Example", LA-UR-19-27007

J.B. Spencer, J.L. Alwin, "Big Ten MCNP6 Unstructured Mesh Benchmark", LA-UR-19-25731

A. Sood, M.E. Rising, "MCNP Modernization Execution Plan for 2019", LA-CP-19-20317

A. Sood, M.E. Rising, "MCNP Modernization Plan", LA-CP-19-20318

CONFERENCES AND JOURNALS

ANS Winter Meeting, Orlando, FL

F.B. Brown, M.E. Rising, J.L. Alwin, "Verification of MCNP6.2 for Nuclear Criticality Safety Applications", presentation at 2018 ANS Winter Meeting, Orlando FL, LA-UR-18-30510

C.J. Josey, F.B. Brown, "Fitting Nuclear Data with Chebyshev Polynomials", presentation at 2018 ANS Winter Meeting, Orlando FL, LA-UR-18-30509

C.J. Josey, F.B. Brown, "Bias in Monte Carlo Alpha-Eigenvalue Calculations", presentation at 2018 ANS Winter Meeting, Orlando FL, LA-UR-18-30508

T.P. Burke, F.B. Brown, "Development of a Library for Computing Monte Carlo Tallies on Heterogeneous Systems", presentation at 2018 ANS Winter Meeting, Orlando FL, LA-UR-18-30498

D.H. Timmons, M.E. Rising, A.K. Prinja, "Evaluating the MCNP6.2 Correlated Fission Multiplicity Models for Criticality Calculations", presentation at 2018 ANS Winter Meeting, Orlando FL, LA-UR-18-30763

ANS Summer Meeting, Minneapolis MN

J.L. Alwin, F.B. Brown, "Excluding Benchmark Statistical Outliers in Nuclear Criticality Safety Validation: A Comparison Study of Upper Subcritical Limits for Highly Enriched Uranium Systems", submitted to ANS Annual Meeting 2019, Minneapolis MN, LA-UR-19-20048

B. Merryman, F.B. Brown. J.L. Alwin, C.Perfetti, "Investigating Region-wise Sensitivities for Nuclear Criticality Safety Validation", ANS 2019 Summer meeting, LA-UR-19-20297

J.L. Alwin, F.B. Brown, "Excluding Benchmark Statistical Outliers in Nuclear Criticality Safety Validation", for ANS Minneapolis, LA-UR-19-25267

J.L. Alwin, "Sharing of Good Industry Practices and/or Lessons Learned in Nuclear Criticality Safety: Using Sensitivity-Uncertainty Methods to Improve Traditional Validation", ANS Minneapolis, LA-UR-19-25296

J.A. Alwin, F.B. Brown, "Excluding Statistical Outliers in Nuclear Criticality Safety", submitted to ANS Annual Meeting 2019, Minneapolis MN, LA-UR-19-20084

ANS Winter Meeting, Washington, DC

F.B. Brown, "Automated Acceleration and Convergence Testing for Monte Carlo Nuclear Criticality Safety Calculations", for ANS Winter 2019, LA-UR-19-25527

Nuclear Data 2019, Beijing, China

P.A. Grechanuk, M.J. Grosskopf, W. Haeck, et al., "Can machine learning techniques help us to solve nuclear data problems?", Prepared for Nuclear Data 2019, Beijing, China LA-UR-18-30087

P.A. Grechanuk, M.J. Grosskopf, W. Haeck, et al., "Finding Outliers in Differential and Integral experiments using Machine Learning Techniques", Prepared for Nuclear Data 2019, Beijing, China LA-UR-18-30086

ORNL - Modernization of SAMMY: An R-matrix Bayesian Nuclear Data Evaluation Code, for the 2019 International Conference on Nuclear Data for Science and Technology, Beijing, China

PUBLICATIONS - FY2019 (cont'd)

CONFERENCES AND JOURNALS

ICNC 2019 - 11th International conference on Nuclear Criticality Safety

J.L. Alwin, J.B. Spencer, G. Failla, "Criticality Accident Alarm System Analysis Using MCNP6.2 Constructive Solid Geometry/Unstructured Mesh Hybrid", LANL, ICNC 2019 - 11th International conference on Nuclear Criticality Safety, Sept. 15-19, 2019.

D. G. Bowen, "Current Status of the DOE/NNSA Nuclear Criticality Safety Program Hands-on Criticality Safety Training Courses," ORNL, ICNC 2019 - 11th International conference on Nuclear Criticality Safety, Sept. 15-19, 2019.

D. G. Bowen, "An Overview of the United States Department of Energy's Nuclear Criticality Safety Program and Future Challenges," ORNL, ICNC 2019 - 11th International conference on Nuclear Criticality Safety, Sept. 15-19, 2019.

D. G. Bowen, "Overview and Status of Domestic and International Standards for Nuclear Criticality Safety," ORNL, ICNC 2019 - 11th International conference on Nuclear Criticality Safety, Sept. 15-19, 2019.

F.B. Brown, C.J. Josey, S.Henderson, W.R. Martin, "Automated Acceleration and Convergence Testing for Monte Carlo NCS Calculations", LANL, ICNC 2019 - 11th International conference on Nuclear Criticality Safety, Sept. 15-19, 2019.

F.B. Brown, C.J. Josey, S. Henderson, W.R. Martin, "Automated Acceleration and Convergence Testing for Monte Carlo Nuclear Criticality Safety Calculations", LANL, ICNC 2019 - 11th International conference on Nuclear Criticality Safety, Sept. 15-19, 2019.

C.W. Chapman, M.T. Pigni, K. Guber, "Progress on ^{140,142}Ce Neutron Cross Section Resolved Resonance Region Evaluations," ORNL, ICNC 2019 - 11th International conference on Nuclear Criticality Safety, Sept. 15-19, 2019.

J. Clarity, T. Miller, W. Marshall, D. Mueller, "Detailed Design of an Epithermal/Intermediate Critical Experiment Using the Sandia National Laboratories Critical Facility," ORNL, ICNC 2019 - 11th International conference on Nuclear Criticality Safety, Sept. 15-19, 2019.

T. Cutler, J. Hutchinson, W. Meyers, R. Bahran, "CURIE Experiment: An Experiment to Validate and Test Updated URR Information", LANL, ICNC 2019 - 11th International conference on Nuclear Criticality Safety, Sept. 15-19, 2019.

G.A. Harms, D. E. Ames, J. T. Ford, R. D. Campbell, "The Sandia Critical Experiments Program – What Are We Doing for You Now?," SNL, ICNC 2019 - 11th International conference on Nuclear Criticality Safety, Sept. 15-19, 2019.

D.K. Hayes, "Nuclear Criticality Safety Training at the National Criticality Experiment Research Center," LANL, ICNC 2019 - 11th International conference on Nuclear Criticality Safety, Sept. 15-19, 2019.

D.K. Hayes, "Nuclear Criticality Safety Beyond 2019 ," LANL, ICNC 2019 - 11th International conference on Nuclear Criticality Safety, Sept. 15-19, 2019.

C. A. Manring, A. I. Hawari, "Development and Implementation of an Improved Liquid TSL Treatment in the FLASSH Code", NCSU, ICNC 2019 - 11th International conference on Nuclear Criticality Safety, Sept. 15-19, 2019.

D. P. Heinrichs and S. S. Kim, "Results of a Newly Expanded COG Criticality Validation Suite", LLNL, ICNC 2019 - 11th International conference on Nuclear Criticality Safety, Sept. 15-19, 2019.

C.M. Percher, A.J. Nelson, W.J. Zywiec, S.S. Kim, D. P. Heinrichs, LLNL, "Thermal Epithermal Experiments (TEX): Test Bed Assemblies for Efficient Generation of Integral Benchmarks," ICNC 2019 - 11th International conference on Nuclear Criticality Safety, Sept. 15-19, 2019.

C. M. Percher, D. P. Heinrichs, S. Bates, D. Biswas, "Future Challenges in Re-Establishing a Solution Critical Capability in the United States", LLNL, ICNC 2019 - 11th International conference on Nuclear Criticality Safety, Sept. 15-19, 2019.

M.E. Rising, "Evaluating Sensitivity-Based Similarity Metrics Between Application and Benchmarks", LANL, ICNC 2019 - 11th International conference on Nuclear Criticality Safety, Sept. 15-19, 2019.

M.E. Rising, "Evaluating Sensitivity-Based Similarity Metrics Between Applications And Benchmarks", LANL, ICNC 2019 - 11th International conference on Nuclear Criticality Safety, Sept. 15-19, 2019.

N.C. Sorrell, A.I. Hawari, "Development of a Generalized Lattice Symmetry Formulation for Thermal Scattering Law Analysis", NCSU, ICNC 2019 - 11th International conference on Nuclear Criticality Safety, Sept. 15-19, 2019.

PUBLICATIONS - FY2019 (cont'd)

CONFERENCES AND JOURNALS

M&C 2019

Submitted LLNL-ABS-763661, Expanded COG Criticality Validation Suite, to the International Conference on Mathematics and Computational Methods applied to Nuclear Science and Engineering

C.J. Josey, F.B. Brown, "Computing Alpha Eigenvalues Using the Fission Matrix", submitted to ANS Mathematics & Computations 2019, Portland OR, LA-UR-18-31280

C.J. Josey, F.B. Brown, "Stabilizing the K-Alpha Iteration Algorithm in Very Subcritical Regimes", submitted to ANS Mathematics & Computations 2019, Portland OR, LA-UR-18-31279

F.B. Brown, C.J. Josey, S. Henderson, W.R. Martin, "Automated Acceleration and Convergence Testing for Monte Carlo Criticality Calculations", ANS Mathematics & Computation, MCD 2019, Portland OR, LA-UR-19-23887

P. Grechanuk, M.E. Rising, T.S. Palmer, "Identifying Sources of Bias from Nuclear Data in MCNP6 Calculations using Machine Learning Algorithms", ANS Mathematics & Computation, MCD 2019, Portland OR, LA-UR-19-20421

D. Timmons, M.E. Rising, C. Perfetti, "The Use of MCNP 6.2 KCODE for High Fidelity, Near Critical Benchmarks", ANS Mathematics & Computation, MCD 2019, Portland OR, LA-UR-19-20522

C.J. Josey, F.B. Brown, "Computing Alpha Eigenvalues Using the Fission Matrix", for MCD 2019, LA-UR-19-23543

C.J. Josey, F.B. Brown, "Stabilizing the K-Alpha Iteration Algorithm in Very Subcritical Regimes", for MCD 2019, LA-UR-19-23527

Nuclear Science And Engineering

M.A. Gonzales, B.C. Kiedrowski, A.K. Prinja, F.B. Brown, "Analytical, Semi-Analytical, and Numerical Heavy-Gas Verification Benchmarks of the Effective Multiplication Factor and Temperature Coefficient", NUCLEAR SCIENCE AND ENGINEERING, Vol.191, issue 1, pp. 1-45 (2018)

OTHER

M.E. Rising, et al., "Correlated Fission Physics, Transport and Applications", for INMM Annual meeting, LA-UR-19-20757, LA-UR-19-25670 (2019)

F.B. Brown, C.J. Josey, S.Henderson, W.R. Martin, "Fission Matrix Application to Acceleration and Convergence Testing for Monte Carlo Criticality Calculations", for ICTT-26, LA-UR-19-24563 (2019)

P. Grechanuk, M.E. Rising, T.S. Palmer, "Using Machine Learning Methods to Predict Bias in Nuclear Criticality Safety", Journal of Computational and Theoretical Transport, 47:4-6, 552-565 (2019), DOI: 10.1080/23324309.2019.1585877

J.L. Alwin, J.B. Spencer, "Criticality Accident Alarm System (CAAS) CSG-UM Hybrid Example", presentation at ANS RPSD 2018, Santa Fe NM, LA-UR-18-28060

J.L. Alwin, "MCNP6 Unstructured Mesh (UM) for Criticality Accident Alarm System (CAAS) Analysis", presentation at ANS RPSD 2018, Santa Fe NM, LA-UR-18-28059

K.L. Currie, M.E. Rising, "MCNP6 Source Primer: Release 1.0", ANS RPSD 2018, Santa Fe, NM, LA-UR-18-28441

PUBLICATIONS - FY2018

INTERNAL REPORTS AND JOURNALS

F.B. Brown, Monte Carlo Techniques for Nuclear Systems, LA-UR-16-29043

F. B. Brown, Advanced Computational Methods for Monte Carlo Calculations, LA-UR-18-20247

C.J. Werner, et al., MCNP User's Manual – Code Version 6.2, LA-UR-17-29981

F.B. Brown, et al., Status Report on the MCNP 2020 Initiative, LA-UR-17-28985

D.A. Brown, et al., ENDF/B-VIII.0: The 8th Major Release of the Nuclear Reaction Data Library with CIELO-project Cross Sections, New Standards and Thermal Scattering Data, submitted to Nuclear Data Sheets, LA-UR-17-30870

P.A. Grechanuk, Semi-Analytic Benchmarks for MCNP6, LA-UR-16-28568

P. Grechanuk, et al., Semi-Analytical Benchmarks for MCNP6, Trans. Am. Nuc. Soc., Vol.116, p.709-711, LA-UR-17-20668

P.A. Grechanuk, Using Machine Learning to Predict MCNP Bias, LA-UR-18-20175

Ed Lent, A Comparative Study of the COG Thermal Libraries II, including the latest thermal scattering law data from NCSU, LLNL-TR-743341

D.A. Brown, et al., ENDF/B-VIII.0: The 8th Major Release of the Nuclear Reaction Data Library with CIELO-project Cross Sections, New Standards and Thermal Scattering Data, Nuclear Data Sheets 148, 1

D. Heinrichs, Integral Experiment Needs, showing discrepancies for Cd radiative capture gamma lines in EGAF, CapGam, and JEFF3.2 libraries, LLNL-PRES-740584

J.L. Conlin, et al., Release of ENDF/B-VIII.0-Based ACE Data Files, LA-UR-18-24034

D.K. Parsons, NJOY Processing of ENDF/B-VIII.0 Thermal Scattering Files, LAUR-18-25096

C.J. Josey, General Improvements to the MCNP Alpha-Eigenvalue Solver, LA-UR-18-22738

J.A. Arthur, et al., Validating the Performance of Correlated Fission Multiplicity Implementation in Radiation Transport Codes with Subcritical Neutron Multiplication Benchmark Experiments, Annals of Nuclear Energy , Vol.120, p.348-366, LA-UR-17-31332

CONFERENCES

International Conference on Transport Theory, Monterey CA

F.B. Brown, Investigation of Clustering in Monte Carlo Criticality Calculations, LANL

P Grechanuk, et al., Using Machine Learning Methods to Predict Bias in Nuclear Criticality Safety Simulations, LANL

IEEE Nuclear Science Symposium, Atlanta GA

C.R. Bates, et. al., Verification and Validation of MCNP6.2, LANL

ANS Winter Meeting, Washington, DC

J. Arthur, et. al., Improved Figure of Merit for Feynman Histograms, LANL

T. Cutler, et al., Experimental Design To Study Criticality Effects of Plutonium Aging, LANL

R. Bahran, et. al., Neptunium Subcritical Observation (NeSO) Integral Benchmark Experiment Design, LANL

V. Hagopian, et. al., Design of a Highly-Enriched Uranium (HEU) Metal Fast Burst Supercritical Assembly, LANL

D.K. Hayes, Flat-top Startup at the National Criticality Experiments Research Center, LANL

J. Hutchinson, et. al., Prompt Neutron Decay Constant Fitting Using the Rossi-alpha and Feynman Variance-to-Mean Methods, LANL

J. Hutchinson, et. al., Measurements on a Subcritical Copper-Reflected α-Phase Plutonium (SCRαP) Sphere, LANL

K.L. Klain, Determination of the Optimal Time Bin Width for the Rossi-Alpha Analysis of Highly Subcritical Fast Metal Systems, LANL

G. McKenzie, et. al., Prompt Neutron Decay Constant Measurements on a Polyethylene-Reflected Sphere of Highly Enriched Uranium, LANL

A. McSpaden, et. al., Eliminating Detector Response in Neutron Multiplicity Measurements for Model Evaluation, LANL

W. Myers, et. al., Using Fast Burst Assembly Designs to Demonstrate Safe Assembly of KRUSTY Core Components, LANL

R. Sanchez et al, Kilowatt Reactor Using Stirling TechnologY (KRUSTY) Experiment Update, LANL

PUBLICATIONS – FY2018 (cont'd)

INTERNAL REPORTS AND JOURNALS

P.T. Grechanuk, et al., Using Machine Learning Methods to Predict Bias in Nuclear Criticality Safety, Prepared for Journal of Computational and Theoretical Transport, LA-UR-18-24800

F.B. Brown, et al, Diagnostics for Undersampling and Clustering in Monte Carlo Criticality Calculations, LA-UR-18-27656

F.B. Brown, et al, Statistical Tests for Convergence in Monte Carlo Criticality Calculations, LA-UR-18-28764

F.B. Brown, et al, State-of-the-art Advances in Monte Carlo Criticality Methods, Contribution to DOE-NCSP newsletter, 2018-08-21

B. Merryman, et al, Investigation of Region-wise Sensitivities for Nuclear Criticality Safety Validation, LA-UR-18-29058

M.E. Rising, et al, Methods to Predict Bias in Criticality Safety Applications using MCNP6 and Whisper, LA-UR-18-26230

J.A. Alwin, et al, Case Studies of Baseline Upper Subcritical Limits using Whisper-1.1: HEU-MET-FAST-013-001, HEU-SOL-THERM-001-008, PU-MET-FAST-022-001, and PU-SOL-THERM-001-001", LA-UR-18-28704.

F.B. Brown, et al, Verification of the MCNP6.2 Release for Nuclear Criticality Safety Applications, LA-UR-18-25535

C.J. Josey, et al, Fitting Nuclear Data with Chebyshev Polynomials, LA-UR-18-24669

T.P. Burke, et al, Development of a Library for Computing Monte Carlo Tallies on Heterogeneous Systems, LA-UR-18-24970

F.B. Brown, Advances & Challenges of Monte Carlo Simulation, LA-UR-18-26714

M.E. Rising, et al, MCNP Version 6.2: New Features and Tools for RPSD Applications, LA-UR-18-22358

J.A. Arthur, et al, Validating the Performance of Correlated Fission Multiplicity Implementation in Radiation Transport Codes with Subcritical Neutron Multiplication Benchmark Experiments, Annals of Nuclear Energy, Vol.120, p.348-366, LA-UR-17-31332

J.A. Arthur, et al, Validation of MCNP6 Using Subcritical Benchmark Experiments, LA-UR-18-24470

M.E. Rising, MCNP(R) Version 6.2 Correlated Fission Capabilities, LA-UR-18-28545

CONFERENCES

ANS Winter Meeting, Washington, DC

K. Smith, et al., Cold Critical Pre-Experiment Simulations of KRUSTy, LANL

D. Heinrichs, DOE Nuclear Criticality Safety Program Website Modernization, LLNL

Cole Manring, Evaluation of the Thermal Neutron Scattering Law for a Heavy Paraffinic Molecular Material, NCSU

C.J. Josey, et al., Bias in Monte Carlo Alpha-Eigenvalue Calculations, LANL

F.B. Brown, et al., Verification of MCNP6.2 for Nuclear Criticality Safety Applications, LANL

C.J. Josey, et al., Fitting Nuclear Data with Chebyshev Polynomials, LANL

Development of a First-Principles Hydrogen Vibrational Spectrum in Liquid H2O, NCSU

ANS Summer Meeting, Philadelphia, PA

C.J. Josey, et al., A New Monte Carlo Alpha-Eigenvalue Estimator with Delayed Neutrons, LANL

Advances in Nuclear Nonproliferation Technology and Policy, Wilmington, NC

J.A. Arthur, et al., Validation of MCNP6 Using Subcritical Benchmark Experiments, LANL

M.T. Andrews, et al., MCNP6.2 Correlated Fission Capabilities and Associated Packages: MCNPTools, Intrinsic Source Constructor, and Detector Response Function Toolkit, LANL

PHYSOR, Cancun, MX

Assessment of Thermal Neutron Scattering in A Heavy Paraffinic Molecular Material, NCSU

C. Percher, Comparison of Experimental and Predicted Temperature Results for TEX, LLNL