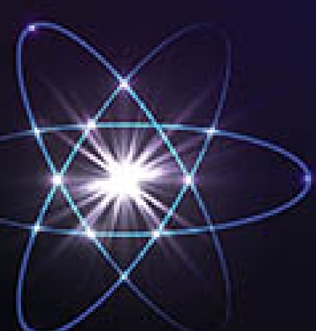
NCSP
NUCLEAR CRITICALITY SAFETY PROGRAM

NEWSLETTER

SPRING 2021

IN THIS ISSUE



Please contact Marsha Henley
for information or contributions:
henleym@ornl.gov

DATES TO REMEMBER

Hands-On Training & Education Course Dates:
Two-week Practitioner Course Dates:
Jan 25-Feb 5, 2021 Aug 9-20, 2021

One-week Manager's Course Dates:
Apr 5-9, 2021 Jun 7-11, 2021

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

LINKS TO REMEMBER

NCSP Website
NCSP Program Management
NCSP Mission and Vision
NCSP Five-Year Execution Plan
NCSP Planning Calendar
Previous NCSP Newsletters
CSSG Taskings
Nondestructive Assay Program

A Message from the NCSP Manager

We are off to a great 2021. We had a first ever virtual NCSP two-week Hands-On Course and our first ever NCSP nuclear data measurement at LANSCE. We've completed several experiments at NCERC along with CAAS testing for UPF. We also just completed our annual Technical Program Review with over 180 registered attendees. Our analytical methods groups have adopted to the challenges of COVID-19 and have successfully conducted online MCNP and SCALE courses. Thank you for all that you do, and please enjoy this latest newsletter that describes some of the recent NCSP accomplishments.

FY22 Proposals

Proposals submitted to the NCSP for consideration for FY2022 are currently being vetted by the NCSP Manager. Feedback is expected to be provided to the proposers in the next couple of months as the NCSP budget for FY2022 begins to solidify. Funding for accepted proposals will arrive sometime after October 2021. The NCSP 5-year plans are due to NNSA in mid-August.

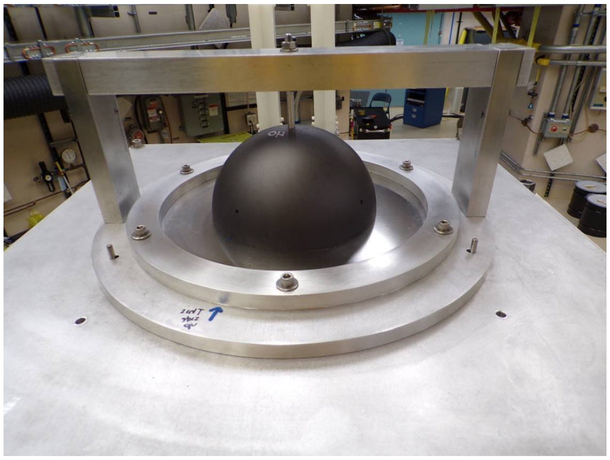
NCSP Technical Program Review and Joint Meetings

This year's NCSP Technical Review Program (TPR) was hosted virtually by Oak Ridge National Lab (ORNL), February 23 – 25, 2021. This was the first year the annual TPR was held over a three-day period. The agenda accommodated a total of 68 presentations from international collaborators, NCSP task managers, and technical principal investigators. More than 180 people registered for the TPR and the meeting averaged about 110 attendees over the three-day period. The attendees represented foreign institutions (24 people from AWE plc, European Commission – Joint Research Centre, French Alternative Energies and Atomic Energy Commission (CEA), Institut de Radioprotection et de Surete Nucleaire (IRSN), and the OECD NEA), 11 from industry (Amentum, CS Engineering and Spectra Tech), 119 from national labs (Argonne, Brookhaven, Y12, Idaho, Lawrence Livermore, Los Alamos, Mission Support and Test Services, Naval Nuclear, Oak Ridge, Sandia, Pacific Northwest, and Savannah River , 11 from universities (Massachusetts Institute of Technology, North Carolina State, Rensselaer Polytechnic Institute, University of Michigan, University of New Mexico and University of Tennessee) and 16 from the US government (Army Test and Evaluation Command, Department of Energy, and National Nuclear Security

Administration. Over 60 attended the virtual Analytical Methods Working Group (AMWG) meeting held on February 22 and hosted and chaired by Jennifer Alwin, Los Alamos National Laboratory. The Nuclear Data Advisory Group (NDAG) meeting was also held on February 22 and led by Mike Zerkle, Naval Nuclear Laboratory with over 70 in attendance. The Critical Safety Support Group (CSSG) met on Friday to discuss and evaluate the FY22 proposals. We are in the process of having the presentations added to the NCSP website and will announce availability.

MUSiC: Measurement of Uranium Subcritical and Critical

The Measurement of Uranium Subcritical and Critical (MUSiC) experiment began December 7-17 at the National Criticality Experiments Research Center (NCERC). The experiment consists of benchmark measurements of highly enriched uranium (HEU) systems that span a wide range of reactivities from deeply subcritical through slightly above delayed critical. The Rocky Flats shells (93.16% U-235 enriched hemishells) are used to achieve ten configurations of increasing mass. One configuration is shown in Figure 1. The experiment was divided into two phases, the first phase, which was just completed, established achievable configurations. The second phase, which will be executed during February and March of 2021, will consist of measurements by a variety of detector systems on each of the chosen configurations.



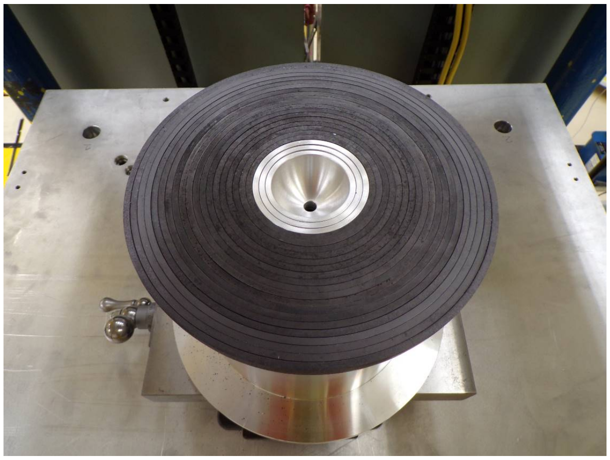


Figure 1. Left – assembled Rock Flats hemishells (top). Right – assembled Rocky Flats hemishells (bottom)

The use of multiple detector systems will provide detector-independent results and can be used for cross validation. Data collected over such a wide span of reactivities provides a unique opportunity to determine the range over which neutron noise techniques such as Feynman variance-to-mean, Rossi-alpha, and pulsed source can be accurately employed for a bare HEU system. The detector systems that will be deployed include a NoMAD detector, an array of four small volume He-3 detectors, and an array of eight 5.08 cm × 5.08 cm cylindrical EJ-309 liquid organic scintillators. In addition, IRSN will utilize a new He-3 detector system with a goal of looking at spatial correlations in near-critical systems in addition to multiplicity analysis.

The first phase of experiments provides baseline critical configurations to be used in the benchmark evaluation. The reactivity worth as a function of separation distance and the reactivity worth of aluminum hemishells (shown in the center of photo on the right in Figure 1) were also measured.

The detector systems for the second phase include a new capability for NCERC--an organic scintillator array named the Rossi Alpha Measurements – Rapid Organic (n, γ) Discrimination Detector (RAM-RODD). While the title includes the "Rossi-alpha", the detector system can also be used for other neutron noise analysis methods. Organic scintillators are of particular interest for neutron noise measurements because of their exceptional time resolution when compared to other commonly used detectors such as He-3 based detectors. RAM-RODD has an experimentally measured time resolution of ~ 900 ps. The excellent time resolution makes the system ideal for neutron noise measurements of fast, bare systems. In addition, the liquid organic scintillator (EJ-309) is capable of discriminating between gammas and neutrons via pulse shape discrimination for neutron energies above ~400 keV. The results from MUSiC will demonstrate the advantages of using organic scintillator systems in future benchmark measurements.

The Planet vertical lift machine is used to remotely assembly of the upper and lower portion of the hemisphere shells. A CAD drawing of the detector setup for MUSiC is shown on the left side of Figure 1. The RAM-RODD organic scintillators (bot shown) will be deployed in an arc at the same height and approximately 70 cm from the center of the assembly, just beyond Planet's top plate. Due to the low fission rate of HEU, fissions will be induced via two different sources: (1) a DT generator and (2) a Cf-252 source.

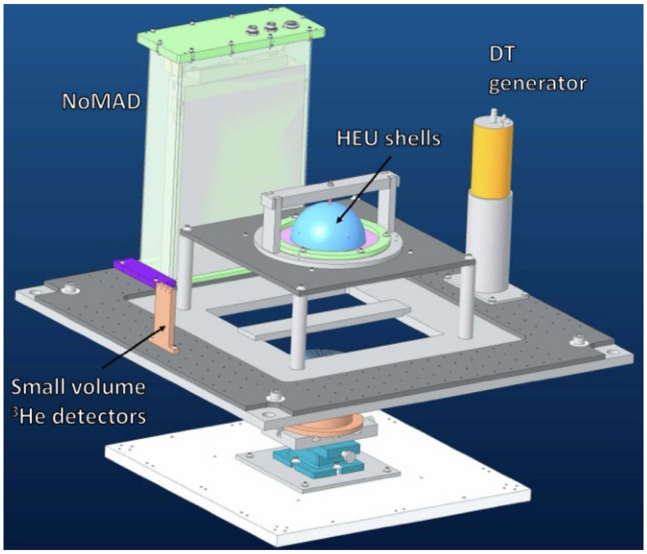


Figure 2. Left – CAD drawing of the proposed measurement setup. Right – Planet remote operation.

MUSiC is a very simple HEU system, and therefore, will provide valuable data for nuclear validation. It is, in essence, a new Lady Godiva (HMF-001). Some additional applications for the measurements include validating (1) correlated fission physics packages such as CGMF and FREYA using the subcritical measurements and (2) alpha-eigenvalue calculations currently included in codes such as MCNP.

U-233 Capture Measurement Project

Uranium-233 has played an important role in solution critical experiments going back to the 50's and 60's, including experiments from the Falstaff Program. More recently, management of legacy ^{233}U material across the DOE complex has led to a requirement for improved nuclear cross sections.

To meet the goals of the NCSP, initial measurements of the 233U(n,γ) reaction data were made during December 2020 at the Los Alamos Neutron Science Center (LANSCE) at Los Alamos National Laboratory (LANL) using the Detector for Advanced Neutron Capture Experiments (DANCE) combined with the NEUtron detector array at dANCE (NEUANCE).

Because ^{233}U fission is around one order of magnitude more likely than capture, accurate measurement of the ^{233}U capture cross section relies on the discrimination between the gammas produced in capture and fission reactions. This discrimination method requires the use of an experimental setup combining capture and fission detectors. In this measurement, NEUANCE tagged fission neutrons while DANCE detected both capture and fission gammas. Coincidences between NEUANCE and DANCE are reconstructed during analysis.

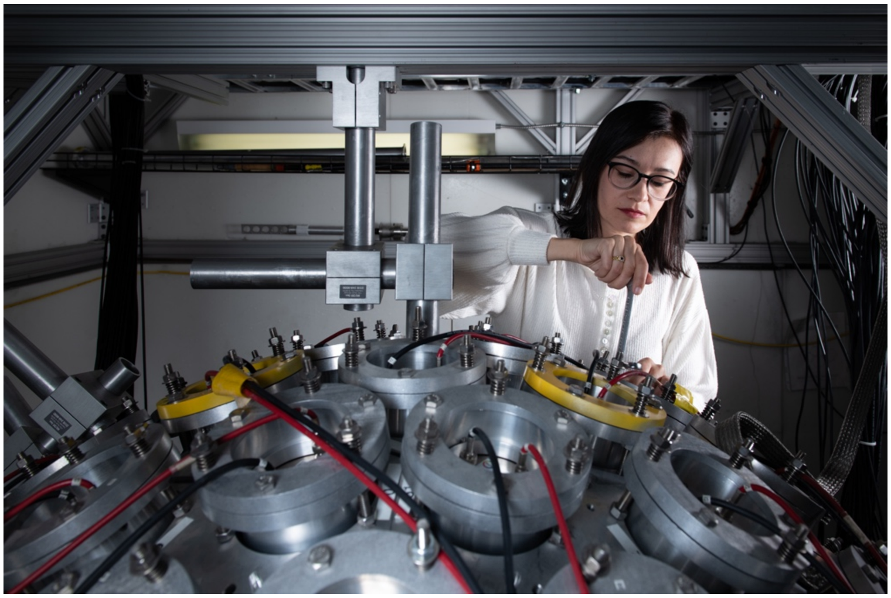
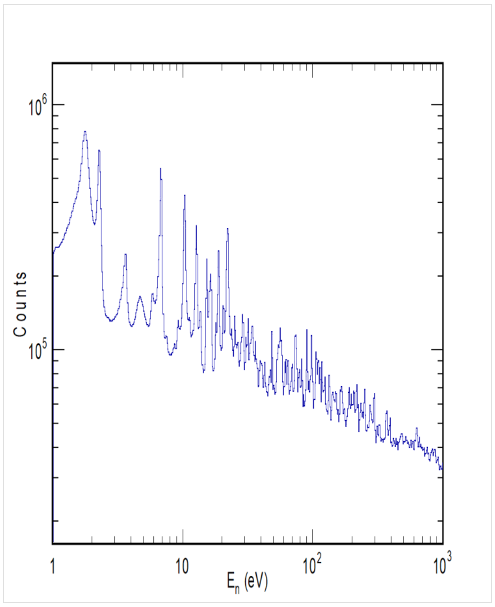


Figure 1: Esther Leal Cidoncha (NCSP-funded postdoctoral fellow in P-3) working on DANCE.

This measurement will provide cross section data in the Resonance Region (RR), with a focus in the keV neutron energy Unresolved Resonance Region (URR). NEUANCE offers excellent separation between fission neutrons and gamma-rays via pulse shape discrimination. A major advantage of this neutron tagging technique is that it allows use of relatively thick samples (>50 mg/cm2). While the fission products are trapped in the sample, the fission neutrons escape to the NEUANCE detectors unimpeded. As a result, the measurement time is greatly reduced. Thirty milligrams of high purity (99.98 %) 233U was purchased from the National Isotope Development Center (NIDC) for the measurement. The material was fabricated into two samples, one of 20 mg and one of 10 mg.

Analysis of the data from the December experiments is in process. The preliminary raw counts before subtraction of the fission gammas is shown in Figure 2 for a small percentage of the total counts obtained. In order to achieve enough statistics in the keV region the measurements will continue in June and July of 2021.



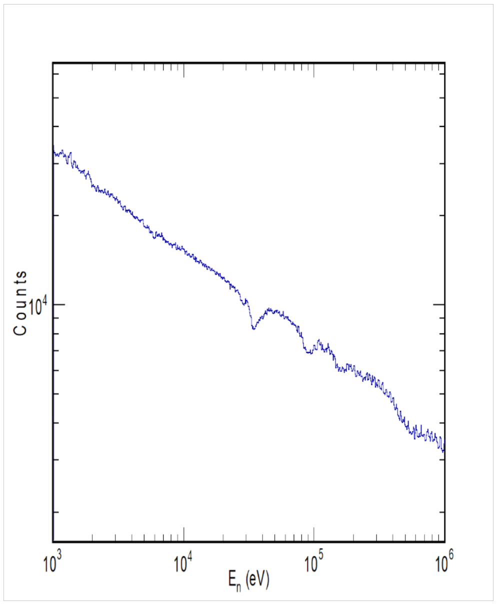


Figure 2: Preliminary raw ^{233}U counts before subtraction of the fission gammas. The Resolved Resonance Region (RRR) is shown in the figure on the left, and the Unresolved Resonance Region (URR) is shown in the figure on the right.

Y-12 Builds a New Neutron Production Target for GELINA for NCSP Nuclear Data Measurements

For more than one decade the Nuclear Criticality Safety Program (NCSP) performs neutron induced cross section experiments at the Geel Electron Linear Accelerator (GELINA) at the European Joint Research Center (JRC) in Geel, Belgium. The experiments at GELINA (Figure 1) are performed under the DOE-Euratom agreement and described in action sheet number 66. The GELINA produces neutrons via Bremsstrahlung from a pulsed electron beam accelerated to 150 MeV. The electrons are striking a rotating depleted uranium target (Figure 2) and produce high energy γ-rays when stopped. The neutrons are released from the uranium target via (γ,n) and (γ,fission) reactions. Two beryllium canned water containers mounted above and below the uranium target serve as moderator for the neutrons. This produces a neutron spectrum with energies ranging from 10 to 20 MeV.

Figure 1: Areal view of the GELINA facility at the JRC-Geel. The neutron flight tubes go in direction north and south from the neutron production target.

In the direction south and north of the GELINA facility at various distance from the neutron production target, flight stations are located to house different experiments. The neutron travel from the neutron target hall to these experimental station in evacuated flight tubes, with flight path length ranging from 10 to 400 m length. The neutron energy is determined by the time-of-flight (TOF) method, i.e., the flight time of the neutron is recorded and with the flight path length the energy can be calculated. Due to the combination of long flight path on short electron burst, hence short neutron pulse, the GELINA has a neutron energy resolution unsurpassed worldwide. This makes GELEINA the premier facility to perform neutron induced cross section experiments in the resolve neutron resonance range (RRR). Therefore, GELINA is ideally suited for neutron induced cross section measurements in the RRR. Typical transmission data for Vanadium are shown in Figure 3, where the experimental data are compared with the existing resonance data from the Evaluated Nuclear Data File (ENDF) library use by most simulation codes.

Figure 2: GELINA neutron production target. The combination of a rotating depleted Uranium disk with two Beryllium canned water moderators above and below the disk produce the neutrons.

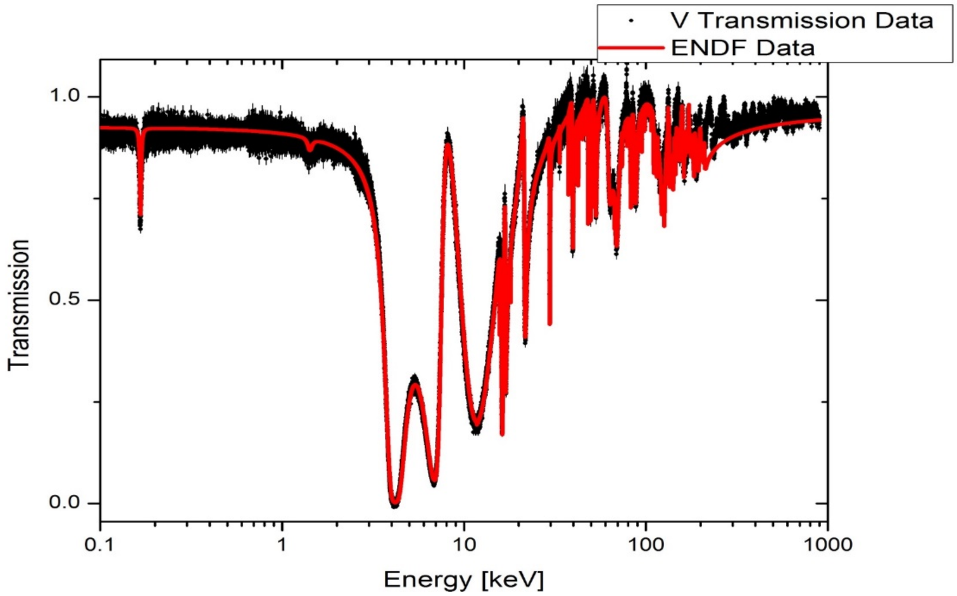


Figure 3: Vanadium neutron transmission data obtained with a 50 m flight path. Resonances are well resolved beyond the ENDF library data.

The GELINA neutron production target is a highly complex, critical part of the facility and is considered a single point of failure for the facility. In case of a failure no replacement was available since the European companies are no longer in business. Thus, the NCSP stepped in and offered to use the expertise in uranium processing to build a new target at the Y-12 National Security Complex in Oak Ridge to show the appreciation for the long-standing collaboration. In a first step, Y-12 had the existing old paper drawings translated from French to English and converted to modern electronic standard format. This was achieved in the course of several months in close collaboration with GELINA personnel. From the final electronic drawing a 3D model was built on the computer to check for inconsistencies. In the next step the depleted Uranium part (Figure 4) was cast and machined to specifications by Manufacturing Sciences

Corporation, Inc. (MSC) in Oak Ridge. Currently, government approval for export of special nuclear material has been obtained and all parts for the target have been manufactured and are being assembled/tested prior to shipment to the GELINA facility.

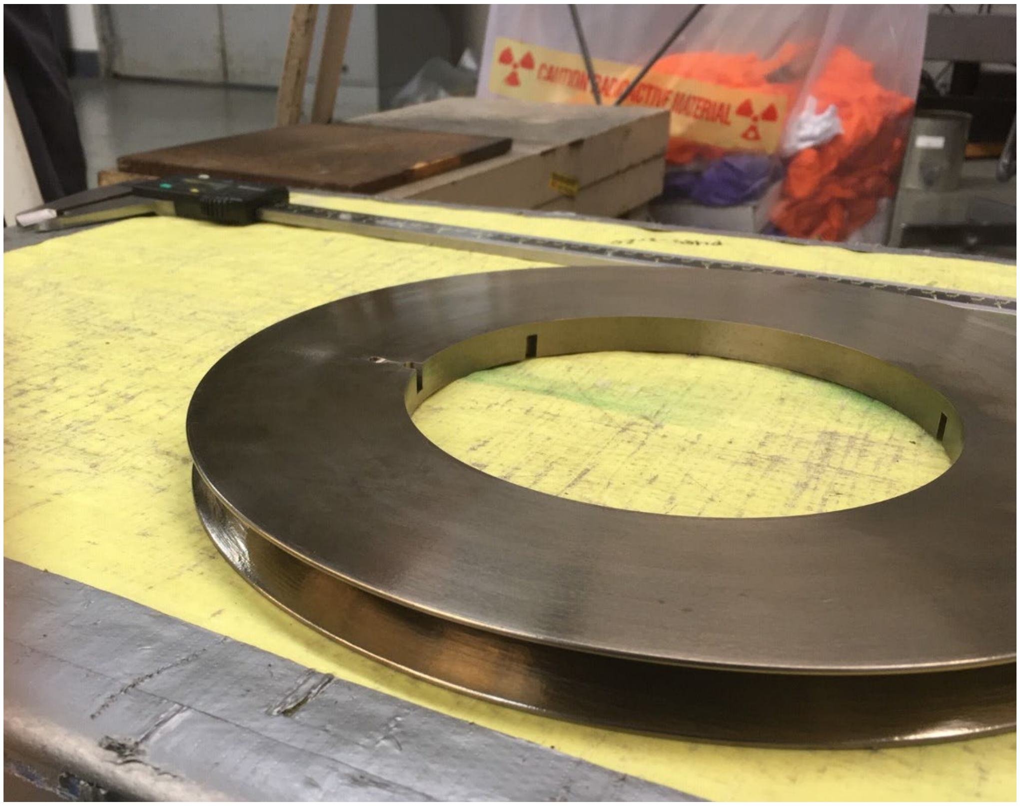


Figure 4: The core of the GELINA target, a depleted uranium disk. The neutrons are released from the uranium by (γ,n) and (γ,fission) reactions.

Hypatia Experiment Performed at the DOE's National Criticality Experiments Research Center (NCERC)

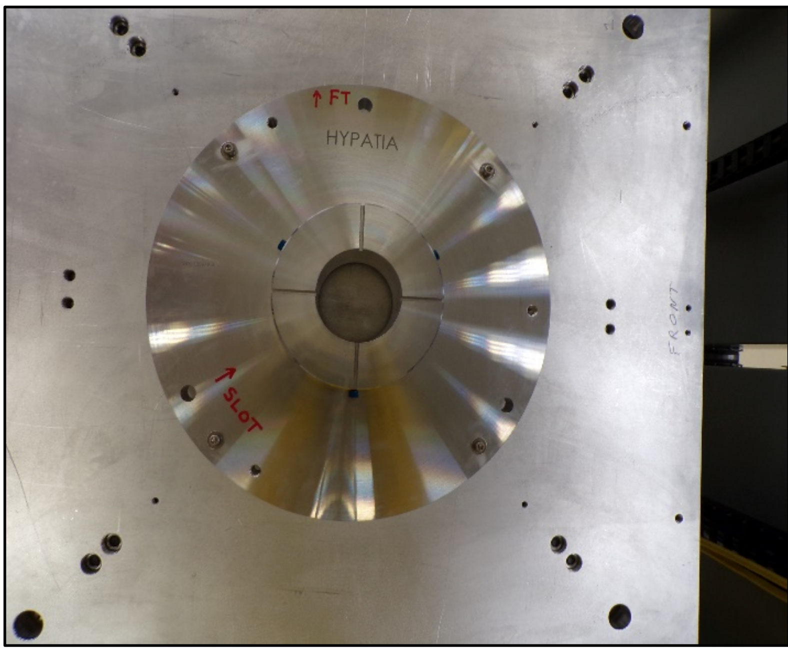
LA-UR-21-20837
Theresa Cutler, Travis Grove, Holly Trellue

The Hypatia measurement campaign was completed in January 2021 at the DOE's National Criticality Experiments Research Center (NCERC) at the Nevada National Security Site (NNSS). This measurement campaign provides 15 unique integral experiments investigating the temperature effects upon the cross sections of yttrium hydride ($YH_{x=1.7-1.9}$) in a critical reactor system.

YH_X is being investigated as a potential high temperature moderator material by the DOE-NE Microreactor Program for microreactor designs. While materials development of this material occurred decades ago, there is a need for more recent testing to validate modern and rapidly improving thermal scattering laws, differential cross section measurements, temperature effects upon reactivity, and other neutronic properties of yttrium hydride. The Hypatia experiment has been proposed, designed, and executed to complete the data set and test all the modern data in a single experiment.

The Hypatia experiment consists of a fuel column comprised of HEU discs, cans of YH_X, aluminum oxide heater plates, and other moderator and reflector materials (beryllium, depleted uranium, and graphite) that is inserted into a thick beryllium reflector. The cans of YH_X have been manufactured at the Sigma facility at Los Alamos National Laboratory (LANL) and consist of discs of YH_X that are canned in molybdenum and welded shut. Aluminum oxide spacers are also used to thermally isolate the central portion of the fuel column and provide fine reactivity control. Numerous Resistance Temperature Detectors (RTDs) are situated in the fuel column to track and record temperatures.

During the Hypatia experiment baseline measurements were taken at room temperature. Aluminum oxide heater plates were specially designed and utilized for this project to increase the central core temperature to a range of temperatures, after which additional reactivity measurements were taken. Thermal and neutronic calculations have indicated that YH_X is a unique material that can exhibit a positive temperature coefficient of reactivity – i.e., reactivity can increase as the temperature in the YH_X increases. Reactors using YH_x need to account for this unique feature during the design process, and the Hypatia experimental results will significantly aid that process.



Shown above are photos taken during the measurement campaign. The photo on the left shows a horizontal view of the fuel column support plate and the photo on the right shows the fuel column being instrumented with RTDs and the heater controller wiring in preparation for the temperature-heated measurements.

For configuration 1, six different temperature reactivity measurements were taken with four YH_X cans in the fuel column. For configuration 2, six different temperature reactivity measurements were taken with two YH_X cans in the fuel column. These two sets of data will be utilized to separate out the reactivity coefficients of the fuel and other materials in the fuel column.

Table 1. Configuration 1 Preliminary Data.

Experiment Heater Temperature (°C)	Measured Reactivity Change (cents)
15.00	0.00
85.0	3.05
140.5	6.66
200.0	10.50
260.0	13.71
310.0	23.0

Table 2. Configuration 2 Preliminary Data.

Experiment Heater Temperature (°C)	Measured Reactivity Change (cents)
15.0	0.00
90.0	1.35
145.0	2.91
200.0	4.80
260.0	5.87
320.0	6.33

Tables 1 and 2 gives preliminary results for the twelve measured configurations with the YH_X cans. The temperature of the heater for each configuration is given in the left column, while the measured reactivity change (from a baseline configuration) is given in the right column. It can be seen that as the temperature of the system increases, the overall reactivity of the system increases as well, as calculations have predicted, with approximately half the reactivity increase in the configuration with half the YH_x. Further investigation of this data will be performed in the future as the studies of YH_X as a potential high temperature moderator material continue.

Shown above are photos taken during the measurement campaign. The image on the left shows an image of the YH_X discs before being canned in molybdenum, and the photo on the right shows the work in the NCERC experimental building preparing for critical operations.

Acknowledgement

This work was supported by the DOE Office of Nuclear Energy, Microreactor Project under Advanced Reactor Technologies and based upon work supported by the DOE Nuclear Criticality Safety Program, funded and managed by the National Nuclear Security Administration for the Department of Energy. The YH_X discs were manufactured at the SIGMA facility at LANL and are excess material from a project supported under the LANL LDRD-DR “Multi-Scale Kinetics of Self-Regulating Nuclear Reactors”.

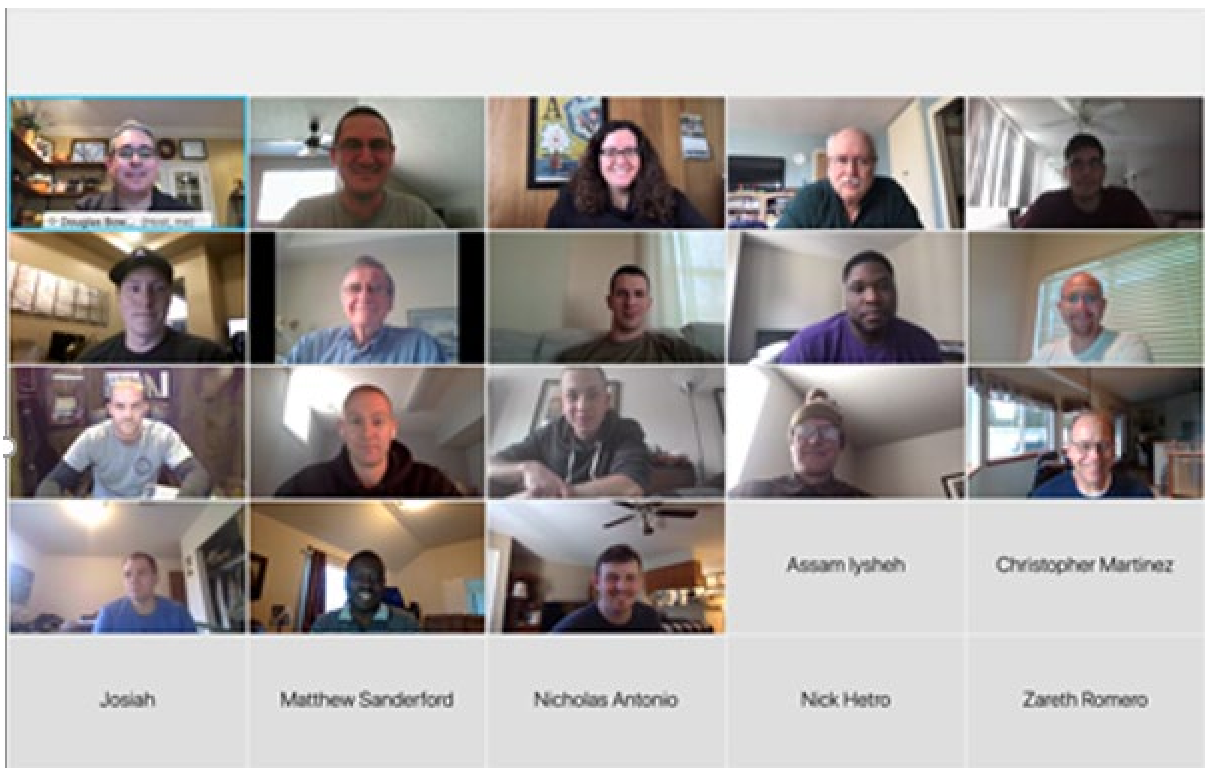
Workshop for Applied Nuclear Data Activities (WANDA 2021)

The 2021 Workshop for Applied Nuclear Data Activities (WANDA) was held virtually Jan 25 – Feb 3, 2021. WANDA 2021 is an annual meeting that addresses the wide-ranging impact of nuclear data. The workshop included many different topics with representation by nuclear criticality safety staff from several different laboratories and universities. The full agenda is found here and links to the presentation are at this location. Many NCSP contributors provided meeting support.

Training and Education

NCSP Two-week Practitioner Course Completed in Winter 2021

The first week of the DOE NCSP Two-week Hands-on Course was conducted January 25 - 29. 21 students attended the course which was held virtually. 9 students were scheduled to attend the second week of the course in-person at NCERC. However, an NCERC employee tested positive for COVID, therefore, all NCERC employees were required to quarantine resulting in the course having to be postponed. Fortunately, the students were advised of the cancellation prior to beginning travel. The NCSP management team apologized for the inconvenience caused by this delay. Students will attend the second week of the course either at NCERC or Sandia National Laboratory (SNL) once the facilities and state restrictions allow it.



Two-week Practitioner Course Dates:

Aug 9-20, 2021

The first week (lectures and workshops) will held at the National Atomic Testing Museum (NATM) while the second week (hands-on portion) will be held at the National Criticality

Experiments Research Center (NCERC) and Sandia National Laboratories. The courses are designed to meet the ANSI/ANS-8.26, "Criticality Safety Engineer Training and Qualification Program," requirement for hands-on experimental training. The NATM portion of the course involves virtual classroom lectures and workshops for NCS Evaluation development and the NCERC and SNL portions of the course involve hands-on experiments with the critical assemblies. Due to COVID-19, there will be limits on the number of students attending the course. MSTS, LANL, ORNL, LLNL, SNL, Y12 and NFO staff participate in the course execution. Due to COVID-19, the first week of the 2-week course may be held virtually.

One-week Manager's Course Dates:

Sandia Manager Course – Apr 5-9, 2021 – postponed – New date to be determined
NCERC Manager Course – Jun 7-11, 2021 (course to be held in person)

The NCERC Manager Course in June is slated to be the course pilot for a new content applicable to Criticality Safety Officers (CSOs) in addition to process supervisors, NCS managers, regulators, and others with NCS program responsibilities.

The courses are designed for fissile material handlers, process supervisors, line managers and regulators with criticality safety responsibilities. Mission Support and Test Services (MSTS), LANL, ORNL, LLNL, SNL, Y12 and Nuclear Facility Operator (NFO) staff participate in the course execution.

MCNP® Courses

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

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

Apr 5 – 9, 2021	Intermediate MCNP6 (online)
Apr 19 – 23, 2021	Unstructured Mesh with Attila4MC (online)
May 24 – 28, 2021	Introduction to MCNP6 (online)
June 7 – 9, 2021	Criticality Calculations with MCNP6 (online)

MCNP® 2021 User Symposium

The symposium will be held virtually via Webex during the week of July 12th. There will be no registration fee. The symposium will include presentations from the MCNP® development team and from MCNP® users internal and external to Los Alamos. There will be interactive opportunities for questions, feedback, and discussion. If you have suggestions for the structure, schedule and content of the symposium, please send them to msc_exec@lanl.gov.

SCALE Users' Group Workshop

Please save the date for the 5th SCALE Users' Group Workshop to be hosted virtually by Oak Ridge National Laboratory (ORNL) on August 4 – 6, 2021. The workshop will provide a highly interactive forum for a fruitful exchange between SCALE users and developers and will include a mix of presentations, open discussions, and tutorial sessions. End users are invited to participate in the meeting and contribute with presentations on impactful and innovative applications of SCALE.

If you are not a licensed user of SCALE and would like to order the software, please visit: https://www.ornl.gov/content/how-order-scale.

Please find more information about the event at https://scalemeetings.ornl.gov/.