LA-UR-17-21834
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Title: Nuclear Criticality Experimental Research Center (NCERC) Overview

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Intended for: 2017 LANL Engineering Review

Issued: 2017-03-03

2017 Engineering Review Abstract

Abstract

Nuclear Criticality Experimental Research Center (NCERC) Overview

J. Goda, T. Grove, D. Hayes, B. Myers, R. Sanchez (NEN-2)

The mission of the National Criticality Experiments Research Center (NCERC) at the Device Assembly Facility (DAF) is to conduct experiments and training with critical assemblies and fissionable material at or near criticality in order to explore reactivity phenomena, and to operate the assemblies in the regions from subcritical through delayed critical. One critical assembly, Godiva-IV, is designed to operate above prompt critical. The Nuclear Criticality Experimental Research Center (NCERC) is our nation's only general-purpose critical experiments facility and is only one of a few that remain operational throughout the world.

This presentation discusses the history of NCERC, the general activities that makeup work at NCERC, and the various government programs and missions that NCERC supports. Recent activities at NCERC will be reviewed, with a focus on demonstrating how NCERC meets national security mission goals using engineering fundamentals. In particular, there will be a focus on engineering theory and design and applications of engineering fundamentals at NCERC. NCERC activities that relate to engineering education will also be examined.

Biographies

Joetta Goda

Advanced Nuclear Technology (NEN-2)
Program Manager

Joetta Goda first came to Los Alamos National Laboratory as a summer student in 1996. She returned in 1997 and has remained there ever since. Ms. Goda received a BS in Nuclear Engineering from the University of Illinois at Urbana-Champaign and an MS in Nuclear Engineering from the University of New Mexico. She has worked primarily in the area of nuclear criticality experiments both at the Los Alamos Critical Assembly Facility (LACEF) at TA-18 and now at the National Criticality Experiments Research Center (NCERC). Ms. Goda is the Program Manager for Material Management and Minimization (NA-23) as well as the current Principal Investigator for the Godiva IV critical assembly.

Travis Grove

Advanced Nuclear Technology (NEN-2)
Engineer

Travis is currently a nuclear experimentalist who has been working continuously on the Critical Experiments Team since 2006. He has extensive hands-on experience in performing both active and passive measurements on various quantities of special nuclear materials, designing and implementing experiments for specific scientific studies, analyzing results including list mode data analyses, and developing theoretical models from experimental and simulated data. Travis has programmed criticality safety analysis code, applying point reactor kinetics equations, improving power calculation and delayed neutron calculations and modeled neutron and delayed precursor concentrations for samples irradiated by a pulsed neutron source. Travis has served as test team member and technical field coordinator for DNDO detector testing campaigns and has

substantial field experience with both commercial and prototype experiments. His work has included support to nuclear nonproliferation, emergency response, and homeland defense. Travis has conducted research on the use of delayed neutrons to determine ^{235}U enrichment of bulk uranium samples developing a nuclear and thermodynamic model of a critical assembly. He has provided support to teams developing simulation tools for critical assemblies and determining uncertainty analysis for subcritical benchmark experiments using the Hage –Cifarelli formulism for active list mode data.

David Hayes

Advanced Nuclear Technology (NEN-2)
Group Leader

David K. Hayes is the Group Leader of the Advanced Nuclear Technology Group (NEN-2) at Los Alamos National Laboratory and is an expert in criticality and operational nuclear safety. In this capacity, Mr. Hayes manages a staff responsible for executing a wide variety of missions supporting a multitude of programs and agencies including the DOE Nuclear Criticality Safety Program (NCSP), DOE Emergency Response Programs, DOE Global Threat Reduction Programs, DOE Nuclear Counter Terrorism Programs, DHS Domestic Nuclear Detection Office, and Defense Threat Reduction Agency among others. NEN-2 is responsible for the operation of the National Criticality Experiments Research Center (NCERC) located at the Nevada National Security Site (NNSS). Prior to the decision (2004) to move LACEF to the Device Assembly Facility in Nevada, Mr. Hayes was certified as a crew chief on the five operational critical assembly machines: Comet, Flat-Top, Godiva-IV, Planet, and SHEBA. Since 2005, he has supported the transfer and re-establishment of general purpose nuclear material handling and criticality experiment capabilities. He assembled and led a core team of operators through the Criticality Experiments Facility (CEF) readiness review process from 2009 through the successful completion of the DOE Operational Readiness Review in 2010.

William Myers

Advanced Nuclear Technology (NEN-2)
Deputy Group Leader

Bill is the current programmatic team leader for criticality experiments and deputy group leader of the Advanced Nuclear Technology Group (NEN-2) of Los Alamos National Laboratory. Besides his current responsibilities, Bill had over 17 years' experience working at the Los Alamos National Laboratory's Critical Experiments Facility (LACEF) at Technical Area 18. His various responsibilities have included working with small teams to perform research and development in topic areas pertinent to nuclear criticality safety, dynamics and kinetics of nuclear reactor excursions, domestic nuclear materials safeguards, and nuclear emergency response efforts. Current work and interests include the use of passive and active techniques utilizing neutron measurements for detection and diagnostics of special nuclear materials. Bill has extensive experience designing and building radiation test objects using large quantities of special nuclear materials for experiments at the Los Alamos Critical Experiments Facility at Technical Area 18 and has actively participated in the development and writing of safety procedures for handling special nuclear materials, building radiation test objects, and operations of active sources (neutron generators and a RF Linear Electron accelerator).

Rene Sanchez

Advanced Nuclear Technology (NEN-2)
Engineer

Dr. Rene Sanchez is currently a Senior Technical Staff member at Los Alamos National Laboratory in the Nuclear Engineering & Nonproliferation Division Advanced Nuclear Technology Group (NEN-2). He obtained his Ph.D. in Nuclear Engineering from Massachusetts Institute of Technology. He has been with the Critical Experiments Team for over 20 years. Currently, he is the Principal Investigator (PI) for the PLANET and COMET Critical Assemblies.

Nuclear Criticality Experimental Research Center (NCERC) Overview

2017 Engineering Capability Review

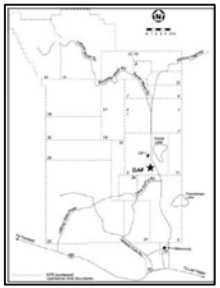
Travis Grove (NEN-2)

March 22, 2017

Operated by Los Alamos National Security, LLC for the U.S. Department of Energy's NNSA

What is NCERC?

- **NCERC: National Criticality Experiments Research Center**
- **Location: Device Assembly Facility (DAF) at the Nevada Nuclear Security Site (NNSS)**
- **Operated by: Los Alamos National Laboratory**
- **NCERC Mission Statement:**
  - The mission of the National Criticality Experiments Research Center (NCERC) is to conduct experiments and training with critical assemblies and fissionable material at or near criticality in order to explore reactivity phenomena, and to operate the assemblies in the regions from subcritical through delayed critical. One critical assembly, Godiva-IV, is designed to operate above prompt critical.

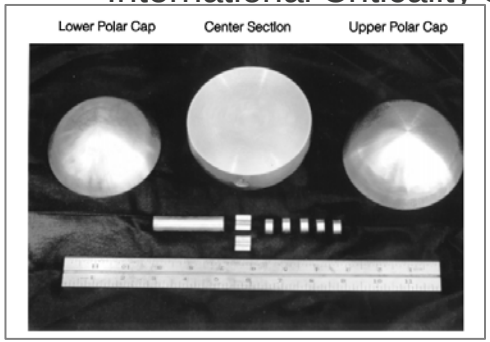


History of Los Alamos Critical Experiments

- **1943-1945: Dragon Experiment and Water Boilers at Omega Site (LOPO, HYPO)**
- **1945: Daghlian criticality accident at Omega Site**
- **1946: Los Alamos Critical Experiments Facility (CEF) founded at Pajarito Site (TA-18) at LANL**
- **1999: Decision made to move LACEF**
  - New Location: Eventually decided upon the DAF at NNSS (NTS)
- **2004: First material shipment to the DAF**
- **2005: Final shipment to reduce TA-18 below CAT II**
- **2007: Subcritical mass measurements started at DAF**
- **2011: Approved to start critical operations**
  - Two year start-up plan put into motion for four critical assembly machines
- **2013: First Godiva IV burst**
- **2016: Completed first operation on Flat-Top with Pu core**

NCERC General Activities: Subcritical Mass Measurements

- **NCERC is our nation's only general-purpose critical experiments facility and is only one of a few that remain operational throughout the world**
- **Subcritical Mass Measurements**
  - High neutron multiplication, static objects (bare, reflected, moderated, etc.)
  - Radiation Test Objects (RTOs)
  - Subcritical benchmarks for nuclear data/radiation transport code validation
    - International Criticality Safety Benchmark Evaluation Project (ICSBEP)



Thor core
9.6 kg delta-phase Pu-239

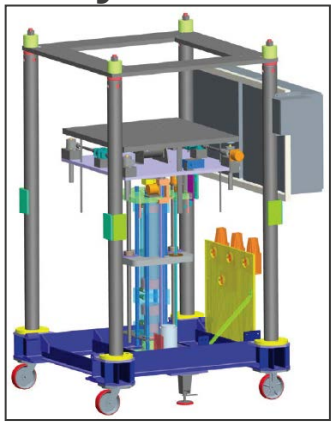
BERP Ball
4.5 kg alpha-phase Pu (94 wt% Pu-239)

Rocky Flats shells
Metal HEU nesting hemishells

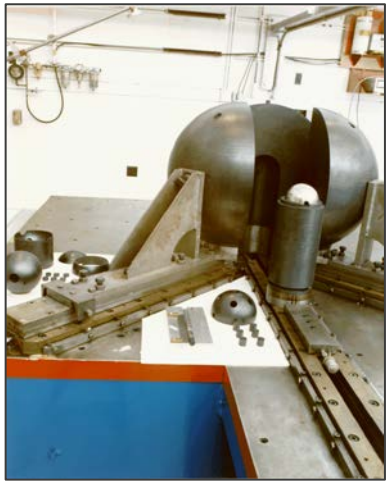
NCERC General Activities: Critical Mass Measurements

- **Four critical assembly machines**

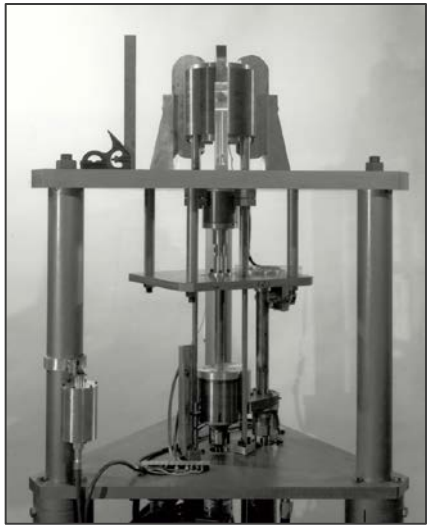
Comet: General purpose, heavy duty vertical lift assembly



Planet: General purpose, light duty vertical lift assembly



Flat-Top: Fast benchmark critical assembly



Godiva IV: Fast burst assembly

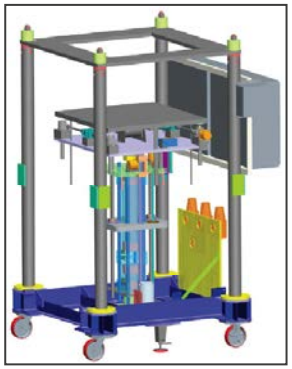
- **Critical Mass Measurements:**
  - Critical Benchmarks (ICSBEP)
  - Sample irradiations (foils, dosimetry, etc.) and reactivity worth measurements
  - Reactivity ranges from subcritical to prompt critical
  - Thermal, intermediate, and fast neutron energy spectrum
  - HEU, LEU, Pu, etc.

NCERC Supports Government Programs and Missions

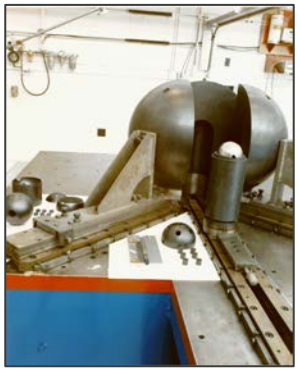
- Nuclear Criticality Safety Program (NCSP)
- National Technical Nuclear Forensics (NTNF)
- Nuclear Weapons Stockpile Stewardship Program
- Nuclear Material Management
- Nuclear Emergency Response
- Nuclear Counter-terrorism
- Nuclear Nonproliferation / Safeguards / Arms Control
- DHS/DNDO, DTRA, NASA, Naval Reactors
- Other collaborations: Universities, commercial partners
- International collaborations: AWE, IRSN, CEA, JAEA

NCERC General Activities: Recent Measurements

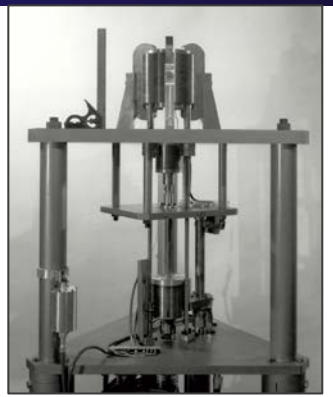
- **Comet**
  - JAEA U-Lead and Pu-Lead
  - NASA KRUSTY/KPR
  - NTNF irradiations
  - ICSBEP (Zeus, JAEA U-Lead and Pu-Lead)



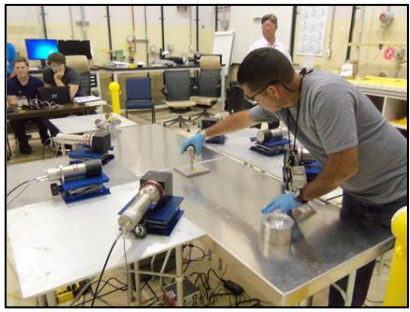
- **Planet**
  - NCSP training
  - NTNF irradiations
  - Alternative nuclear materials
  - ICSBEP (NCSP projects)



- **Flat-Top**
  - NCSP training
  - NTNF irradiations
  - NASA DUFF
  - ICSBEP (NCSP projects)



- **Godiva IV**
  - NCSP training
  - NTNF irradiations
  - NCSP projects
  - ICSBEP (NCSP projects)



- **Subcritical**
  - NCSP Training
  - DTRA, NA-84, NA-22 measurements
  - University consortia
  - IRSN and AWE measurements

Recent Work at NCERC: Theory

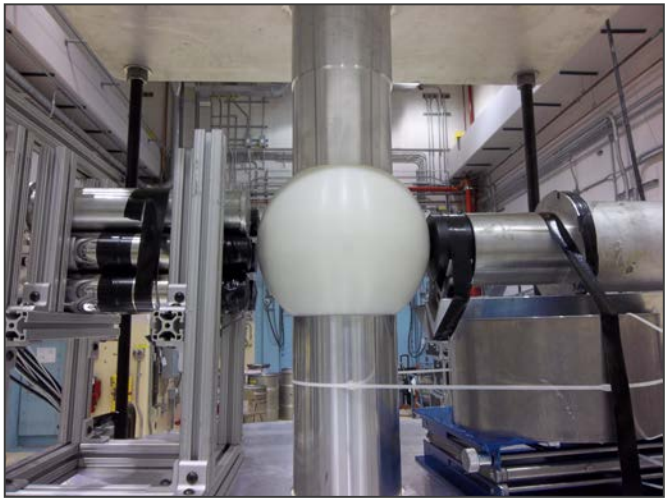
- **Subcritical time-correlation neutron measurement uncertainties**
  - Hage-Cifarelli formalism
  - Measurement uncertainties in singles, doubles count rate, leakage multiplication value
  - Methodology used to estimate uncertainties for upcoming subcritical experiments and to determine approximate measurement times to achieve desired uncertainties
- **MC-15: Multiplicity Counter-15 tubes**
  - Design of a next generation neutron multiplicity detector for emergency response activities
  - See poster by Mark Smith-Nelson for further information
- **Rossi-α and fission chamber measurements**
  - Pressure system engineered to charge the fission chambers
  - Measurement plates specifically engineered and experiments modified for these measurements

Recent Work at NCERC: Design and Application

- **Solution Reactor Modeling**
  - Fissile solution systems have existed for decades, but modeling these systems has been difficult (steady-state and dynamic evolution)
  - Process developed to model solution evolution (system components, operational modes, evolution, stability, etc.)
    - "Benchmark" versus historical systems (KEWB, SUPO, Silene, etc.)
  - Apply solution reactor modeling to accelerator-driven subcritical systems and critical system designs
    - Driver is Mo-99 supply: Simple designs indicate entire US Mo-99 need could be supplied by single solution reactor system
    - Software toolkits for design and LABView control simulator for training

Recent Work at NCERC: Design and Application

- **DUFF/KRUSTY/KPR with NASA**
  - Prototype space reactor for NASA, see presentation by Pat McClure and Dave Poston of NEN-5
- **Collaboration with JAEA**
  - Design and measurement of an intermediate neutron energy spectrum system to refine Lead neutron cross sections
  - Neutronic, mechanical design
  - Similar experiments for Pu-Lead currently in design
- **Neutron Diagnosed Subcritical Experiments (NDSE)**
  - NDSE supports Nuclear Weapons Stockpile Stewardship Program
  - Construction of RTO for subcritical mass measurements

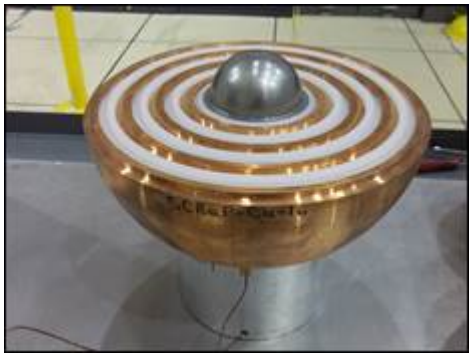


NDSE RTO Object Under Investigation at NCERC

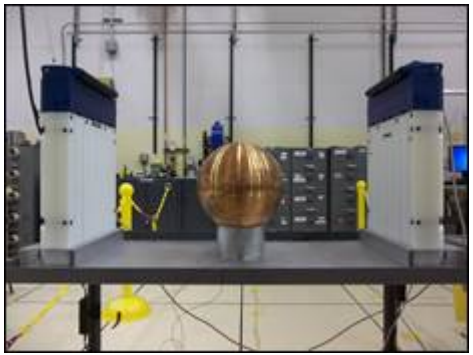
Recent Work at NCERC: Design and Application

- **Investigation of critical parameters and neutron spectra of alternative nuclear materials**
  - Hydride moderated high temperature reactors (see DV Rao's presentation)
  - Np-237 full critical experiment
- **Collaboration with IRSN**
  - Subcritical Copper-Reflected alpha-phase Pu (SCRaP)
  - Subcritical benchmark, will be included in the ICSBEP handbook

SCRaP Interstitial Materials



SCRaP Experiment with BeRP Pu Core



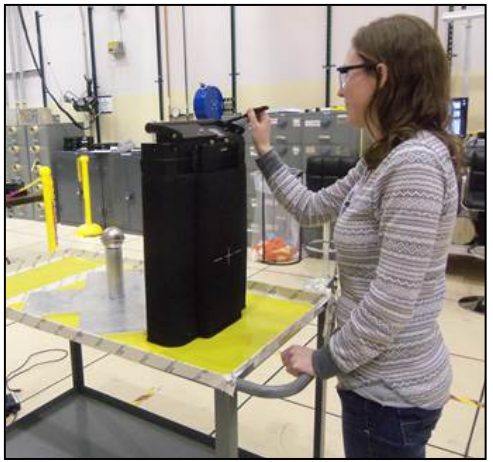
SCRaP Experiment Under Measurement

Recent Work at NCERC: Education

- **NCSP Two-Week Hands-On Criticality Safety Courses**
  - Multiple courses given per year, focus on DOE Criticality Safety Engineers, Officers, and Managers as well as Operators and Process Supervisors
    - Training supports activities across DOE complex, such as TA-55
  - One week in-class training, one week hands-on demonstrations at NCERC

Recent Work at NCERC: Education

- **University-Laboratory Consortium**
  - Consortium for Nonproliferation Enabling Capabilities (CNEC) and Consortium for Verification Technologies (CVT)
  - Collaborations between University research groups and Laboratory technical staff members
  - SNM detection system testing at NCERC on subcritical RTOs (Pu, HEU, Np)
  - See presentation by Rian Bahran, James Miller, and Jesson Hutchinson
- **Emergency Response (ER) training**
  - Oriented towards first responders
  - Search instruments, diagnostic instruments
  - Basic criticality safety for first responders and ER personnel



Nuclear Facility Investment and Pipelines

- **Measurement capability investment**
  - Fission chambers
  - Rossi-α measurement systems
  - Neutron generators
  - Automated radiation counting
- **Radiological safety investment**
  - Radiological contamination control
  - Quick retrieval sample plates plates
  - Rapid pneumatic transfer system (Rabbit)
- **Control room and system upgrades**
  - Reasons for upgrades
    - Obsolete and failing hardware
    - Lack of ability to procure spares
    - Operating systems no longer supported
    - Software that has no current version to run on modern operating systems
    - Integration of software, hardware and nuclear operations design requirements
    - Potential ramifications related to updated software quality standards
  - Upgrades completed in FY17
- **Investment in training and education for the next generation**
  - Many new Young Career staff, post-docs, and interns
  - From originally four qualified operators to seven, with five additional trainees in the pipeline

NCERC Key Points

- **NCERC is our nation's only general-purpose critical experiments facility and is only one of a few that remain operational throughout the world**
  - 70+ years of critical experiments and research
  - Capability to handle and conduct experiments with large quantities of SNM
- **Critical and Subcritical Experiments**
  - Four critical assembly machines
  - Subcritical RTOs, benchmarks, etc.
- **Theory, Design and Application, Education**
  - Time-correlation, solution reactor modeling, criticality safety training, university-laboratory consortia
- **Investment and Pipelines**
  - Personnel and Nuclear Facility Investment Vital to Current and Future Work
- **Important National and International Missions**
  - NCSP, NTNF, NASA
  - AWE, IRSN, CEA, JAEA

Acknowledgement

NCERC is supported by the DOE Nuclear Criticality Safety Program, funded and managed by the National Nuclear Security Administration for the Department of Energy.