LA-UR-11-05923

Planning for Critical Assembly Experiments for Stockpile Stewardship and Global Security

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Summary: The United States Department of Energy's (USDOE) National Nuclear Security Administration and partner federal agencies are responsible for several key missions associated with nuclear weapons including stewardship of the U.S. nuclear weapons stockpile, nuclear counter terrorism, nuclear forensics, and emergency response. This paper will discuss our current plans for critical assembly experiments that constitute a key validation of the nuclear data and particle transport simulations necessary for these missions.

Introduction

After a hiatus of several years, the U.S. has recently re-constituted a general-purpose critical assembly experimental facility, NCERC (National Criticality Experiments Research Center) that was formerly known as CEF (Critical Experiments Facility). The NCERC is located at the Nevada National Security Site. As the NCERC project neared completion, we have been planning and prioritizing new experiments that could be performed at NCERC to meet requirements in the mission areas described above. This paper summarizes the status of those efforts. We note that the first critical operation at the NCERC was performed in June 2011 [1] and the first weapons programs experiment in September 2011 [2].

A substantial number of critical experiments were performed historically at the Los Alamos TA-18 Pajarito Site. Many of these experiments provided classic benchmark data that have been used to test nuclear data and transport codes. Machines such as Godiva, Jezebel, Flattop, and Big Ten have figured prominently in recent nuclear data testing, such as has been performed for ENDF/B-VII [for example, 3-8].

Eigenvalue simulations to compare calculated results with experimental critical configurations are very useful. In addition, we have used more detailed data from various critical experiments, such as reactionrate ratios, to more strenuously test modern nuclear-data libraries.

Discussion and Results

While historical data are crucial, it has become clear that new critical assembly data are required to meet the needs of stockpile stewardship and global security missions. Particularly, past experiments were often focused on goals other than nuclear data and particle transport simulation. In anticipation of the near completion of the NCERC project, a team from Los Alamos has worked to identify, prioritize, and propose new experiments supporting these missions. Several specific experiments have been proposed as a result of this work. There are several key objectives that are common to all of these proposals.

Benchmark Quality

The materials used in the assembly must be well characterized. The details of the assembly geometry, detector configuration, and surrounding environment must be well documented. Detailed models for simulations must undergo suitable peer review.

Focus on Uncertainties

For benchmarking purposes, the experimental uncertainties are as important as the nominal configuration. These integral experiments often provide key constraints on the use of nuclear data within simulations for a given application. It is important to focus on all uncertainties when planning, performing, and documenting the experiment.

Multiple Critical Configurations

It is important to be able to test nuclear data in various neutron spectra. Therefore, for a particular core material, we desire critical configurations with various reflectors to modify the driving neutron spectrum. It is also important to use multiple "identical" configurations to assess reproducibility.

Examine More than Critical Configuration

For a specific configuration, it is desirable to perform measurements in sub-critical, critical, and supercritical states. Measurements of external neutron and gamma spectra are valuable. In addition, differential measurements involving internal foils and detectors to determine reaction rates and reaction products provide further data to test and constrain our computational models.

Conclusions

As a result of our work, twelve (12) Integral Experiment Requests (IER) have been submitted to the USDOE Nuclear Criticality Safety Program (NCSP) for consideration [9]. These IERs include experimental proposals to study the following:

1. Reaction rate and fission-product yield data in various neutron spectra
2. High precision critical assembly data for fast U-235 and Pu-239 systems
3. Probability of initiation
4. Novel core materials
5. Specific reflector materials, for example Berylium
6. Threshold activation detectors to constrain the shape of the prompt fission neutron spectrum

The NCSP has developed a 5-year plan for experiments at NCERC. Several of the IERs described above have been given high enough priority that we expect they should be executed in the next two years; others are expected to be performed in the out years. Detailed planning for the near-term experiments is currently being performed using the NSCP Critical Subcritical Experiment Design Team (CEdT) process.

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Acknowlegments

This work has been jointly sponsored by the US DOE National Safety Criticality Program (NCSP), NNSA Science Campaign Program (SC), and NNSA Advanced Science and Computing Program (ASC).

Los Alamos National Laboratory is operated by the Los Alamos National Security, LLC, for the National Nuclear Security Administration of the U.S. Department of Energy under Contract DE-AC52-06NA25396.