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# Neutron Multiplicity Measurements for the AFCI Program Quarterly Progress Report April-June 2005

Denis Beller
*University of Nevada, Las Vegas*

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## Quarterly Progress Report
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UNLV Transmutation Research Project, Task 06
Principle Investigator: Denis Beller, Ph.D.

## Purpose and Problem Statement

The U.S. Advanced Fuel Cycle Initiative (AFCI) is a program to develop economic and environmental methods to reduce the impact of waste from commercial nuclear fuel cycles. One concept for near-complete destruction of waste isotopes from used nuclear fuel is accelerator-driven transmutation. High-power accelerators would be used to produce high-energy charged particles, which then collide with heavy metal targets to create a cascade of neutrons. These neutrons then cause a nuclear chain reaction in subcritical systems. Fission neutrons then transmute fissile waste isotopes as well as other problematic isotopes such as technetium-99 and iodine-129. To design these systems, complex reactor physics computer codes and highly detailed data libraries are used to compute the reactivity of systems, reaction rates, destruction rates, and nuclear-induced damage rates to materials. This project was developed to test a Russian-built Neutron Multiplicity Detector System (NMDS) for measuring neutrons generated in a central target by a variety of accelerators. To assist in experiment design and evaluation, we use the most advanced high-energy radiation transport code, MCNPX, to model experiments. Experimental results are compared to computational predictions and discrepancies are investigated. Initial plans were to conduct experiments using a 70-MeV proton cyclotron at the Crocker Nuclear Laboratory at the University of California at Davis and/or a 20 to 40 MeV electron linac (linear accelerator) at the Idaho Accelerator Center (IAC) at Idaho State University (ISU). Finally, we planned to use the 800-MeV linac at the Los Alamos Neutron Science Center at Los Alamos National Laboratory.

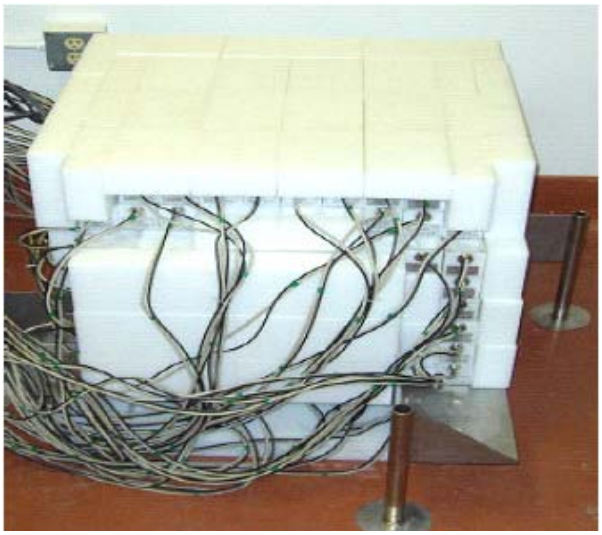

Figure 1. NMDS in the cubic configuration for cosmic radiation measurements.

## Personnel

**Principle Investigator**: Dr. Denis Beller (UNLV Mechanical Engineering)

**Students**: Ms. Shruti Patil, a graduate student, is working on her M.S. thesis to upgrade the NMDS and to plan and conduct an experiment with the NMDS at the Los Alamos Neutron Science Center (LANSCE) or at Brookhaven National Laboratory (BNL). Ms. Patil is majoring

in computer engineering at UNLV. She will also upgrade the capabilities of the NMDS and improve data acquisition and analysis software. Mr. Brice Howard, an undergraduate student (Mechanical Engineering), is using MCNPX to model detector performance. Mr. Timothy Beller, an undergraduate student (M.E.) with considerable experience with the NMDS, also consults with Mr. Howard and with Ms. Patil on the project. Tim was employed on TRP Task 27, RACE.

**UNLV Graduate Student Thesis Advisor**: Prof. Venkatesan Muthukmar, Electrical and Computer Engineering, UNLV, is Ms. Patil's thesis advisor.

**National Laboratory Collaborators**: Dr. Eric Pitcher (AFCI Experiments, LANSCE-12, Los Alamos National Laboratory); Dr. Stephen Wender (LANSCE-3 Group Leader, Los Alamos National Laboratory); and Dr. Michael Todosow (Brookhaven National Laboratory).

**DOE Collaborator**: Dr. Thomas Ward (UNLV Russian Collaboration Science Adviser, TechSource, Inc.)

## Issues:

**Budget:** The expenditure rate has been less than projected because we have not been able to travel to a national lab to conduct accelerator-driven testing. A request for a no-cost extension through the end of December will be submitted. This will allow for the completing modifications of the data acquisition system, testing, writing new control and data analysis software, and the completion of Ms. Patil's M.S. thesis.

**Management:** The laboratory space that the NMDS occupies in the Harry Reid Center was allocated to another PI, thus requiring the removal of the NMDS. We have decided to move the NMDS to a small room located on the second floor of the Harry Reid Center.

**Technical:** Dead time appears to be extremely high, with a resolving time constant for a single detector, many detectors, or the whole system on the order of 5 to 10 ms, which limits the count rate of the NMDS to less than 200 counts per second, and reduces its efficiency to a few percent when counting high-activity sources. It appears the problem is simply a limitation of the processing capability of the CPU in the "special computer." One CPU is simply trying to process too much information when count rates are high. Thus, the NMDS is only useful for sources between a few hundred to a thousand neutrons per second.

## Summary Report for Apr-Jun 2005

The NMDS, which was repaired and tested in the previous quarter, was determined to need a hardware and software upgrade to reduce data losses from count-rate limitations (dead time). Graduate student Ms. Shruti Patil gave a presentation at the ANS Student Conference based on experiments conducted to quantify the dead time. The title was "Neutron Detector Characteristics in Deadtime Measurements," by Shruti Patil, Timothy Beller, and Brice Howard, Annual Student Conference of the American Nuclear Society, Columbus, Ohio, April 15, 2005. Ms. Patil received a second place award in the Accelerator Applications track of the conference.

The NMDS was disassembled and placed into storage pending determination of a suitable laboratory space at UNLV.

During this quarter various solutions were investigated and a decision was made to purchase a digital data acquisition board and software. Much of the effort this quarter was dedicated to selecting the optimum combination of hardware and software to support the full 64-element NMDS while providing much faster detection capabilities. A new data acquisition system incorporating a multi-component digital input/output board and LabView® software was purchased. The new equipment was interfaced with one bank of eight detectors and testing was begun. When this system is successfully implemented on the NMDS it will eliminate the count-rate limitation, which will allow the NMDS to be used with a high-energy spallation source.

Other activities during the quarter included investigating a new method for measuring deadtime that is based on a LANL report on the Nuclear Weapons Inspection System. Undergraduate student Bryce Howard began modeling of the NMDS in alternate configurations, such as for monitoring actinides in separations processes for upcoming materials protection, control, and accounting research.