A High-Sensitivity Fast Neutron Imager

SL10-IM-NSC-PD2Jc

John Goldsmith (PI), James Brennan, Erik Brubaker, Belkis Cabrera-Palmer, Mark Gerling, Peter Marleau, Nick Mascarenhas, and David Reyna

1. INTRODUCTION

A wide range of NSC (Neutron Scatter Camera) activities were conducted under this lifecycle plan. This document outlines the highlights of those activities, broadly characterized as system improvements, laboratory measurements, and deployments, and presents sample results in these areas. Additional information can be found in the documents that reside in WebPMIS.

2. SYSTEM IMPROVEMENTS

Several improvements were made to the NSC over the course of this project. The liquid-scintillator-cell configuration was changed from nine cells in each plane to 16 cells in each plane (2" deep, 5" diameter cells in the front plane, 5" deep, 5" diameter cells in the rear plane). The cells were mounted in a new shock-proof frame that also provided motorized adjustment of the spacing between the two planes. To simplify transporting the system, the liquid scintillator material itself was changed from EJ-301 to the less-hazardous EJ-309 (higher flashpoint, more benign chemical content). Dual-mode imaging capabilities were implemented in software, enabling simultaneous Compton-camera gamma imaging in addition to the neutron imaging. Data acquisition was converted to an all-digital system using a newly available VME digitizer system, leading to both enhanced data analysis capabilities, and to a much more portable configuration (with a large separate electronics rack replaced by a single VME crate attached to the scatter-camera frame, as shown in Fig. 1). Maximum-Likelihood Expectation-Maximization (MLEM) methods were added to our image reconstruction toolkit.

Fig. 1. Neutron Scatter Camera

3. LABORATORY MEASUREMENTS

A variety of laboratory measurements were conducted over the course of the project. After implementing the variable-plane-spacing capability, the trade-offs between sensitivity, spatial resolution, and spectral resolution as a function of plane spacing were explored. A careful measurement of the AmBe neutron spectrum quantified the spectral capabilities of double-scatter measurements. Moving into the application space of treaty verification and warhead monitoring, a wide variety of measurements were made with multiple- and/or extended-source configurations, including imaging a W87 RV with mock neutron sources, and a demonstration "warhead counting exercise" conducted with LLNL and BNL with various configurations of multiple neutron sources.

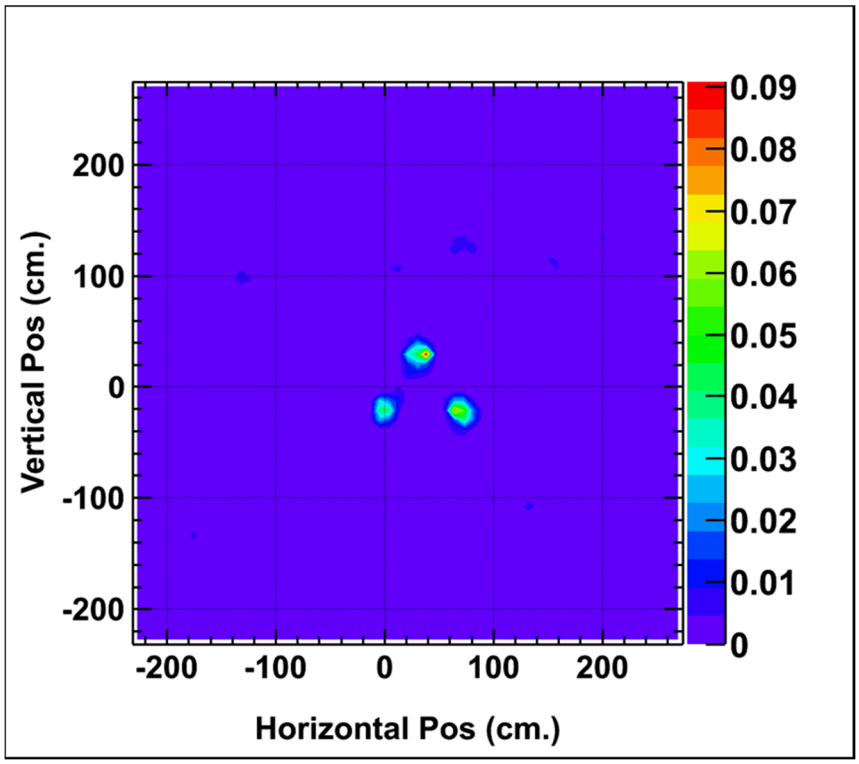

Fig. 2. MLEM image of three neutron sources obtained during the three-laboratory warhead counting exercise.

4. DEPLOYMENTS

Neutron scatter cameras also participated in a variety of measurements at other sites. These include imaging a neutron source located inside the cargo hold of a docked freighter from the pier, pier-side imaging of the motion of neutron and gamma sources on a ship, and through-the-wall observations of SNM movement at the LLNL Superblock facility. Our compact version of the NSC (MINER, Mobile Imager of Neutrons for Emergency Responders) made through-the-wall observations of SNM movement at the Baker facility of the Nevada Nuclear Security Site, and high-rise-to-high-rise localization of neutron sources in downtown Chicago, which also provided an opportunity to compare liquid-scintillator and ^{3}He measurements. Over the past year, the NSC has been operating at the Spallation Neutron Source (SNS) at Oak Ridge National

Laboratory. It made measurements at beamline 14a (and more recently, a basement location) to characterize the neutron background for a potential future coherent neutrino scattering experiment. Sixteen 5" diameter, 5" deep liquid scintillator neutron detection cells have been removed from a previous incarnation of the NSC and temporarily deployed in the RadMAP vehicle detection system operated by Lawrence Berkeley National Laboratory (LBNL). Over the past year, the detectors have been present and functioning for all background runs collected by the RadMAP team.

Fig. 3. Neutron Scatter Camera deployed at Alameda Point, California

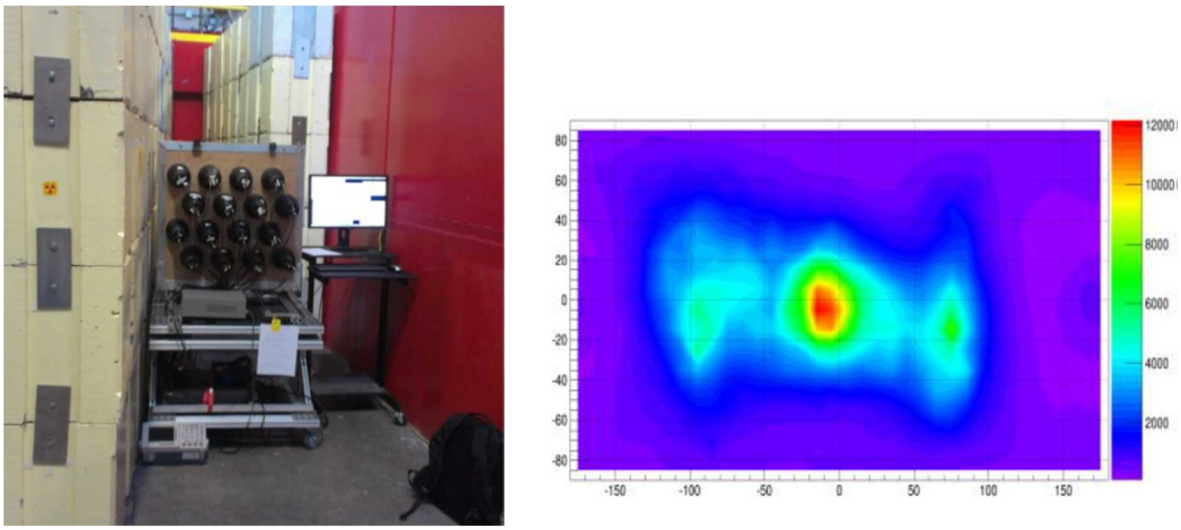

Fig. 4. The NSC located between two beamlines at the Oak Ridge National Laboratory Spallation Neutron Source (left), and image of the fast-neutron distribution (right).

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.