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Weekly Update - LANSCE Neutron Spectrum Characterization

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Weekly Update – LANSCE Neutron Spectrum Characterization
Andrew Ratkiewicz and Micah Johnson 12/18/2018

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Progress Summary: Preparations for characterizing the energy spectrum of the LANSCE neutron source have been made.

Motivation: The spallation neutron source at the Los Alamos Neutron Science Center (LANSCE) produces a white spectrum of neutrons with energies between about 100 keV to greater than 600 MeV. Recently, an effort to radiograph dense objects has been stood up at the Weapons Neutron Research (WNR) facility at LANSCE. However, the spallation process as well as some target-cooling techniques can create high gamma fluxes. The gamma- and neutron-energy spectrum of the source influence the quality of the radiographs that can be made with the source. Additionally, models of the source are essential to interpreting radiographs made with it, and experimental constraints on the gamma- and neutron-energy spectrum of the source will greatly increase the fidelity of these models.

Technique: The gamma- and neutron-energy spectrum of the LANSCE source can be constrained in the ~10-MeV to ~100-MeV range through measurements of threshold reactions on bismuth foils. The decay of the activation products of the (n,Xn) and (γ,Xn) reactions can be measured, and, using the known cross sections for these reactions, the spectral content of the beam can be inferred. Many of these activation products decay via γ-ray emission, so measuring these decays requires High-Purity Germanium (HPGe) detectors.

Progress: Preparations for a measurement intended to constrain the spectral content of the LANSCE source were conducted at Lawrence Livermore National Laboratory (LLNL). Existing resources at LLNL were leveraged to execute the measurement in a cost-effective way. First, a data acquisition system (DAQ) was borrowed from the LLNL Nuclear Counting Facility (NCF), which saved the Neutron Imaging (NI) project on order $40,000. Since the half-lives of the radioactive isotopes of bismuth of interest to this measurement range from about a week to about 10 minutes, the data acquisition system must be stable over a long period of time. Stability tests were conducted at the NCF in which a signal from a single HPGe detector was fed into all five units of the DAQ. The decay of an ^{152}Eu source was measured over the course of two weeks, and the gain of each unit of the DAQ was determined to be stable to better than 0.1%. Additionally, it was determined that each unit of the DAQ responded to the signal from the HPGe detector in a consistent way. Conducting these tests at LLNL rather than at LANSCE saved the NI project at least an FTE week in travel time. A subset of the results from these tests are shown in Fig. 1.

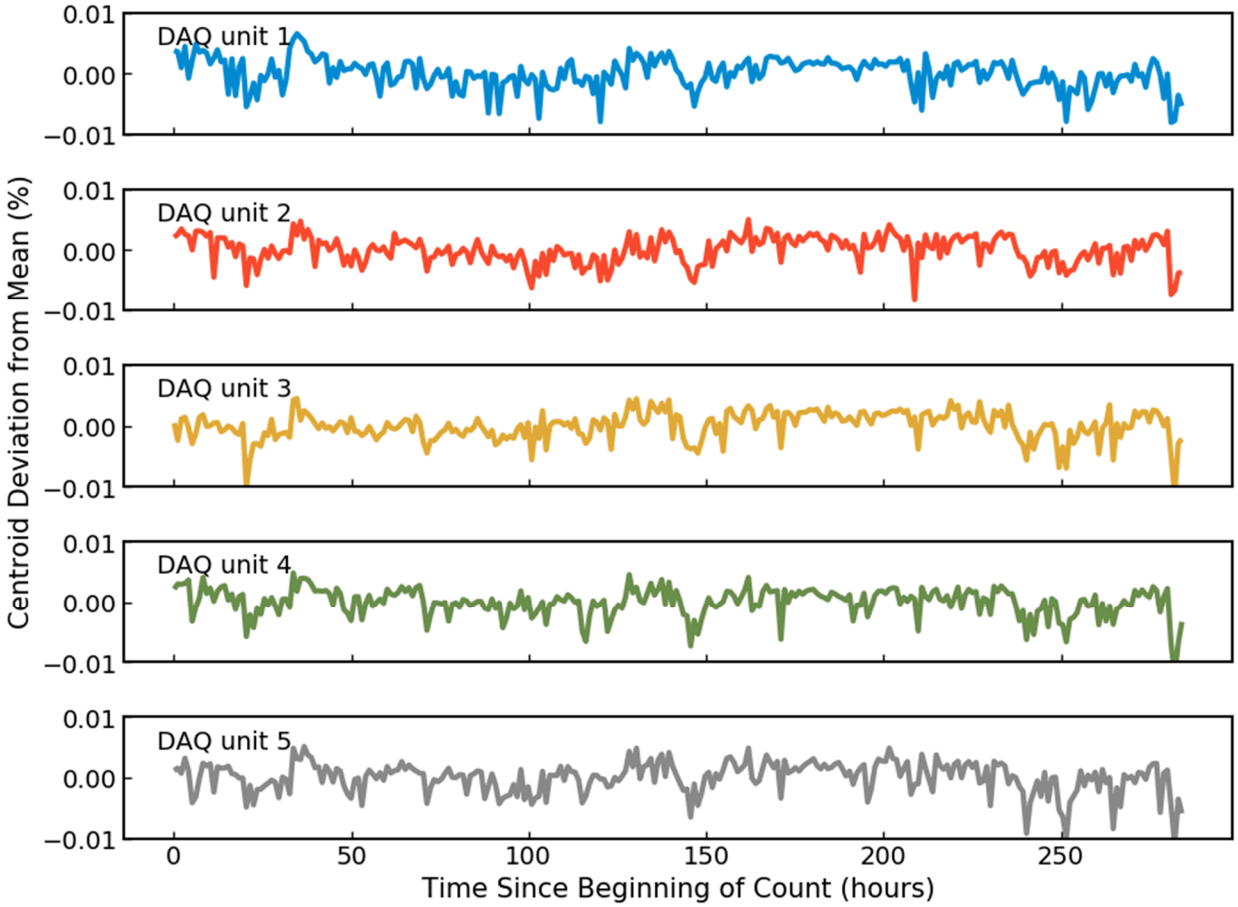

Figure 1. A plot showing the stability of the response of the DAQ to the signal from the detection of a 1112.1-keV γ-ray emitted in the decay of 152Eu. The gamma spectra were fit, and the peak centroids were extracted and normalized to the mean centroid. The DAQ demonstrates good stability over a period of time longer than that needed to reliably measure the decay of the radioactive isotopes of bismuth of interest to this measurement.