Contribution ID : **54** Type : **oral presentation**

A Fast Neutron Spectrometer for Underground Science

Wednesday, 10 April 2013 10:40 (20)

The University of Maryland and National Institute of Technology developed
the Fast Neutron Spectrometers (FaNS) as high efficiency, full-energy
reconstructing, neutron detectors. The first generation, FaNS-1, consisted of 18 liters of plastic scintillator, separated in six optically decoupled segments, and six ^{3}He proportional counters. The detector operated under the principle of capture-gated spectroscopy, a technique that demands a delayed coincidence between a neutron thermalizing in the scintillator and then capturing in a helium counter. FaNS-1 was calibrated at NIST using ^{252}Cf for efficiency and mono-energetic neutron generators, based on deuterium-deuterium and deuterium-tritium fusion, to test energy reconstruction. After measuring the surface fast neutron spectrum from 1 MeV to 150 MeV at NIST Gaithersburg, the detector was installed at the Kimballton Underground Research Facility in Ripplemead, VA, where it operated for two years. During this time FaNS-1 measured the fast neutron backgrounds from the surrounding rock, and placed a limit on the cosmic-ray spallation induced neutron flux. The fast neutron spectrum measured at KURF is presented along with the calibration and surface data.

An upgraded detector was designed to measure neutron energies from 250 keV to 2 GeV. FaNS-2 consists of sixteen segments of plastic scintillator, with total active volume of 73 liters, interspersed with 21 ^{3}He proportional counters for thermal neutron detection. FaNS-2 was calibrated at NIST using a variety of sources; ^{252}Cf spontaneous fission neutron sources, an AmBe (α, n) source, and two mono-energetic neutron generators. The absolute efficiency was also measured using the ^{252}Cf source at multiple distances from the detector. All calibration data types are compared to detailed Monte Carlo simulations using MCNP. We present the fast neutron fluence and spectrum measured at 100 m above sea level for neutrons from 250 keV to 2 GeV. We discuss installation of FaNS-2 in a shallow underground lab at 100 meter water equivalent overburden.

Summary

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Session Classification : Session 2 - Screening facilities and low background detectors

Track Classification : Screening facilities and low background detectors