CONNOR AWE

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Project Title

Coded Aperture Imaging of Charged Current Induced Leptons

Project Objective

I investigated the possibility of using a coded aperture imaging system with bulk scintillator for the detection of neutrino charged current interactions.

Project Description

Neutrinos have historically been a fruitful area of physics research and show promise for applications in nuclear security. However, any effort to utilize neutrino detectors in real world applications must contend with low signal rates and large backgrounds if the detector is to remain compact enough to be practical. Track reconstruction offers an efficient means of rejecting backgrounds in experiments where the particle of interest is non-isotropic. One application that track reconstruction might prove particularly useful for is reactor monitoring. Many proposed reactor monitoring schemes involve detection of reactor neutrinos via the charged current interaction, in which a neutrino and a proton interact to form a neutron and a lepton. Because leptons can travel a macroscopic distance in crystal scintillator at modest energies, there is reason to believe that a kinematic reconstruction of a neutrino's momentum from the products of a charged current interaction is possible. However, the light produced in scintillating material is not always compatible with standard optics. We investigated a method of imaging lepton tracks with a coded aperture system to circumvent this problem using a detector that had been part of previous work at ORNL. While we demonstrated that reconstruction of an electron track in the detector should be technically possible to within ~30 degrees, at SNS energies that track is not well correlated with the incident neutrino momentum.

Project Relevance to Nuclear Nonproliferation

Neutrinos have long been proposed as a tool for reactor monitoring as part of a non-proliferation program, with inverse beta decay as the primary measurement channel. The addition of track reconstruction to standard crystal scintillator could reduce the backgrounds involved in most neutrino based measurements without dramatically increasing hardware costs.

Products and Outcomes of Project

After conducting several simulations with GEANT 4 and investigating some of the theory involved, we concluded that the project would not work as envisioned at ORNL's Spallation Neutron Source (SNS). Unfortunately, this indicates that the tracks produced in NaI[Tl] at reactor neutrino energies would be effectively meaningless.

I spent the rest of my summer working on experiments searching for coherent neutrino nucleus scattering at the SNS.

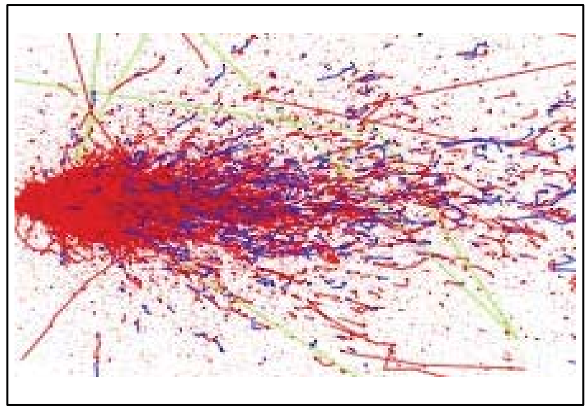

FIGURE 2 - 1000 ELECTRONS AT 50 MEV SIMULATED IN 20 CM OF NAI[TL] WITH GEANT 4. ELECTRONS ARE IN RED, PROTONS ARE BLUE, AND PHOTONS ARE GREEN.