Measuring the Cross-Section of Charged-Current Neutrino Interactions in Sodium Iodide

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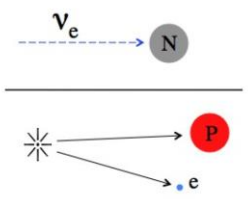
Abstract

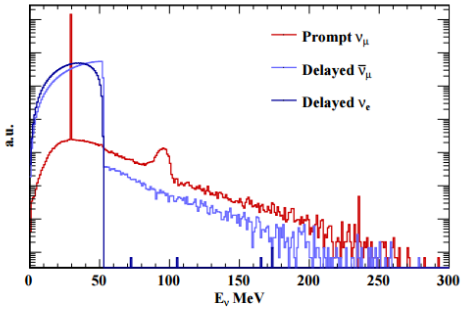
An array of twenty-four 7.7 kg sodium iodide (NaI[Tl]) scintillating detectors has been deployed to the basement of the Spallation Neutron Source at Oak Ridge National Laboratory in order to observe and measure the cross-section of charged-current neutrino interactions on ^{127}I. Preliminary results and testing of these detectors will be presented herein. In addition, potential applications for observing coherent elastic neutrino-nucleus scattering (CEvNS) will be discussed. This work was conducted at the Spallation Neutron Source which is a DOE Office of Science User Facility and supported by the Office of High Energy Physics.

Introduction

- The cross-section of the charged-current neutrino interaction on ^{127}I has been measured before by the Liquid Scintillator Neutrino Detector Experiment.
- Using an array of Sodium Iodide scintillating crystals doped with thallium iodide, in conjunction with neutrinos from the SNS, we hope to improve upon these measurements.
- The charged-current interaction, which is shown below, is sensitive to neutrinos with energy as low as .789 MeV.
- Whereas the LSND was sensitive to ^{127}Xe, NaI scintillating crystals are sensitive to electrons, which gives additional information about path length and energy of the incident neutrino.

$$\nu_e + {}^{127}I \rightarrow {}^{127}Xe$$



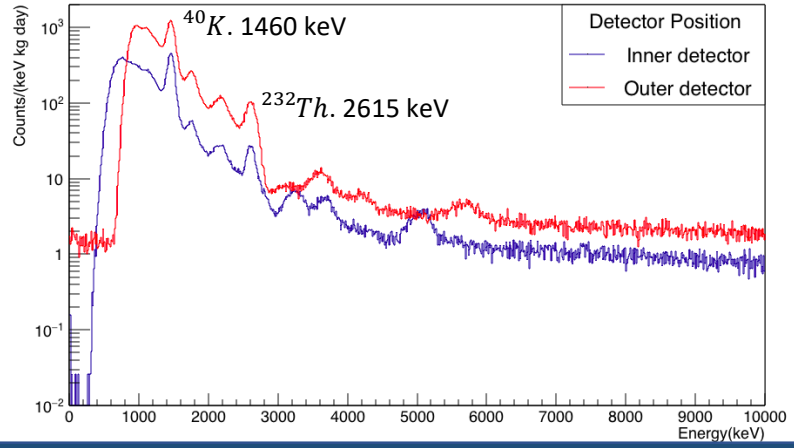


SNS neutrino energy spectrum

Expected Rates and Preliminary Results

- In 1994, Dr. Engel et al. reported a theoretical charged-current cross-section of 210-310 $\times 10^{-42} cm^2$ for a quasiparticle neutrino.
- The SNS reports a total neutrino flux of 4.4x10^7 $cm^2 s^{-1}$, one-third of which are electron neutrinos. Combined with the theoretical rate by Dr. Engel et al., we have an expected event rate of .24 events per crystal month.
- Able to calibrate spectra using ^{40}K and ^{232}Th gamma peaks.
- Currently testing methods to reduce noise including vetoing events which pass through multiple detectors.
- SNS provides a 60Hz pulsed beam, which allows the use of the timing signal as a coincidence requirement.

Sample spectra from two detectors



CEvNS Applications

- Coherent elastic neutrino-nucleus scattering was predicted in 1974, but hasn't been observed.
- In this interaction, a neutrino with low energy transfers momentum to a target nucleus, producing recoil energies on the scale of tens of KeV.
- ^{22}Na is a possible candidate for observing CEvNS interaction.
- Currently designing a multi-ton NaI array and associated infrastructure to observe CEvNS in ^{22}Na in conjunction with charged-current neutrino interactions on ^{127}I.

Array Details

- The array, which occupies a 16"x16" footprint, consists of 24 NaI[Tl] crystals for a target mass of 185kg.
- Each detector is fitted with a ScintiTech base.
- A layer of water shielding is currently in place, but options for a steel shell with muon veto panels are being explored.

Array without any shielding at Duke University.

Array with water shielding at ORNL.

References

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