Preliminary Results from CONNIE-100

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Abstract

CONNIE-100 currently sits 30 meters from a 3.8 GW nuclear reactor in Angra dos Reis, Rio de Janeiro, Brazil with the expectation of detecting coherent-elastic neutrino-nucleus scattering. To do this, there must be a solid understanding of the background radiation. This article presents some of the first results of the experiment regarding background radiation rates. X-rays and muons are counted in each of the 14 CCDs in order to better recognize the background radiation of the system. The results seem favorable since the radiation doses of the CONNIE-100 CCDs are lower than those measured in the engineering run of the CONNIE detector. The success of the current exposures at 100 K creates new expectations for 80 K exposures.

1 Introduction

The growing interest in neutrino physics has allowed researchers at FNAL to investigate technologies that will allow the detection of coherent-elastic neutrino-nucleus scattering (CENNS). The greatest challenge faced currently regards the possible detection of events at low energies and low probability of occurrence.

CONNIE-100 builds on the results of CONNIE. The goal of both detectors is to find coherent-elastic neutrino-nucleus interactions using charge coupled devices (CCDs). CCDs have proven to be a suitable candidate to detect neutrino interactions thanks to their low readout noise ($2e^-$ readout noise has been established for CONNIE detector at 130 K), good spatial resolution and low energy threshold.

A charge coupled device (CCD) is a device that transfers electrical charge within itself. A charge can be generated by the interactions of photons, or other radiation source, with the silicon atoms; the intensity of the charge per pixel is proportional to the intensity of the radiation. Scientific grade CCDs are commonly cooled (¡150K) to reduce dark current and noise in the data. CCDs are typically thin silicon wafers (microns in thickness) and are commonly used in cosmological and medical applications thanks to their high quality image data.

The discovery of CENNS would lead to better understanding of neutrino oscillations, energy transport in supernovas, nuclear reactor monitoring, and potential new physics.

The article is organized as such: Sec. II the design and function of the CONNIE-100 detector is described and compared to the CONNIE detector; Sec. III the results obtained at Angra are analyzed; Sec IV. discusses the conclusion and future of the experiment; Appreciations in Sec. V.; Sec. VI. references.

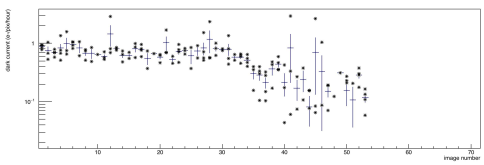

Figure 1: The noise for the CCDs drops after lowering the array temperature to 80 K.

2 CONNIE-100 Detector

The detector array used in the experiment consists of 14 science grade CCDs stored in a copper box. Each CCD has a mass of 5.7 grams and dimensions of 3cm x 6cm, 2,000 pixels x 4,000 pixels, and 675 μm thickness. The array and copper box are cooled to 100 K to reduce dark current from the silicon and infrared radiation from the copper box. CONNIE-100 also uses a detector that is 2.7x thicker than the one used in CONNIE and allows particles to deposit more of their energy as they pass through the CCD.

The array is shielded by 30 cm of polyethylene, 15 cm of lead, and then again 30 cm of polyethylene. Lead is intended to shield from gamma radiation. On the other hand, polyethylene shields form neutrons. Occasionally, cosmic muons can interact with the lead and produce neutrons, hence the second layer of polyethylene. The new detector also lacks ceramic in its packaging. The previous iteration contained this material and it became a considerable source of radiation thanks to its U and Th contents.

3 Results

Understanding the noise of the experiment is crucial to later discriminate noise from a CENNS event. Dark current and background radiation are the greatest contributors of noise to the detectors. At 100 K, the CCDs experience about 1 e^{-}/pixel/hour (Fig. 1). The noise at 80 K is inconclusive but early measurements point to 0.1 e^{-}/pixel/hour.

Fig. 2 & Fig. 4 show the radiation rates for CONNIE. One can see peaks at 8 KeV and another starting at 150 KeV. These peaks correspond to X-rays

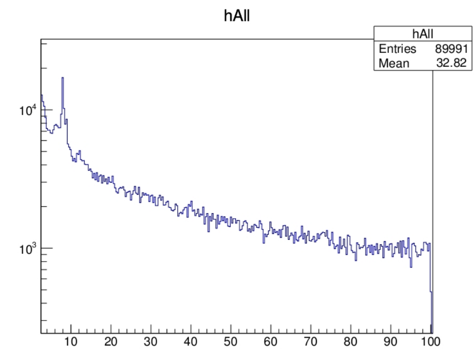

Figure 2: Radiation rate observed at 100 K. The results are about 10x less than the results from CONNIE. Units of events/gram/day/KeV

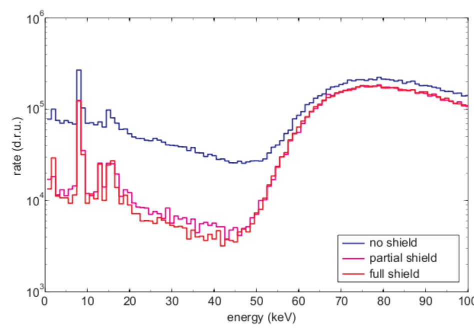

Figure 3: Original radiation rate for CONNIE

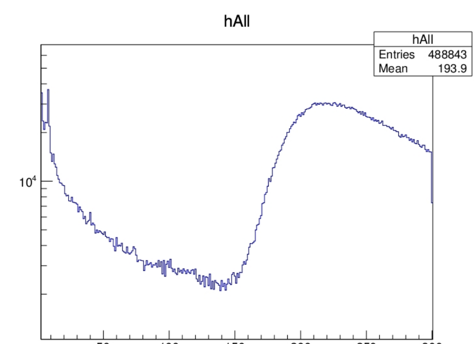

Figure 4: The energy for muon events has shifted from about 50 KeV to about 150 KeV when compared to CONNIE. Units of events/gram/day/KeV.

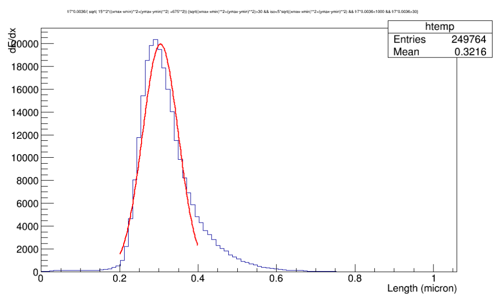

Figure 5: The original calculated value for energy loss was 0.35 KeV$//mu$m

due to the copper and muons respectively. The new values for CONNIE-100 show that the rates are about an order of magnitude less than the previous experiment. The figure also lacks a peak at about 16 KeV which was present in the previous results. This is thanks to the change of the CCDs packaging; the bump was attributed to the U and Th present in the original packaging. The thicker CCDs are also able to receive more of the muons' energy; therefore shifting the second peak to higher energies.

4 Conclusion

It is interesting to see that the array is receiving less radiation than expected. The thicker CCDs also allow better readings of muon radiation. Further work must be done to understand why each of the CCDs have different number of events and what is the optimal exposure time according to occupancy. Noise at 80 K must be well defined to continue taking data at this temperature.

5 Acknowledgments

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6 References

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