Commissioning of the Neutral-Current Detector Array in the Sudbury Neutrino Observatory

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The Sudbury Neutrino Observatory (SNO) experiment has entered its third phase of physics production. Forty strings (thirty six strings of ^{3}He and four strings of ^{4}He proportional counters) were installed on a 1-m grid in the detector. The purpose of this "Neutral-Current Detector" (NCD) array is to provide event-by-event separation of charged-current (CC) and neutral-current (NC) $\nu - d$ interactions. This would significantly reduce the statistical correlation in the extraction of the CC and the NC signals [1–4], thereby improving the precision of the total active solar neutrino flux. The NC neutrons are detected via $^3\text{He}+n \rightarrow p+t$.

Extensive work have been done to characterize the performance of the NCD array and its associated electronic systems. Signals from each counter string are first amplified by a preamplifier, which would then be recorded by an ADC. Additionally, the pulses from the strings would be digitalized and recorded. This dual scheme allows the separation of NC and radioactive background signals in the NCD during neutrino running, while maintaining the capacity to handle situations when high event rates are expected (e.g. supernova or calibration). During the past year, the NCD electronic systems have been extensively calibrated, primarily by injecting pulses of various amplitudes and frequencies to each of the components.

One of the main activities is to remove instrumental backgrounds from the NCD data stream. These backgrounds are mostly induced by electronics noise. An example of such background events is shown in Fig. 1, whereas a neutron pulse is shown in Fig. 2. Cuts have been developed to remove these instrumental background events, and their efficiencies are being evaluated.

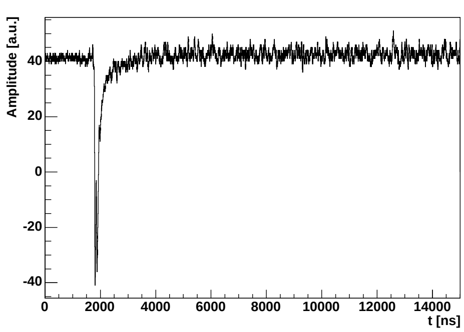

FIG. 1: An instrumental background event example. This is a micro-discharge event, which is characterized by the very fast rise time and the lack of a long ionization tail.

The overall performance of the array has been tested by deploying an AmBe and a ^{252}Cf source to various locations in the detector. Figure 3 shows the relative efficiency among different strings for a ^{252}Cf source deployed near the center of the detector. The measured efficiency is consistent with Monte Carlo predictions. Efforts are being devoted to understanding the systematics associated with determining the neutron capture efficiency.

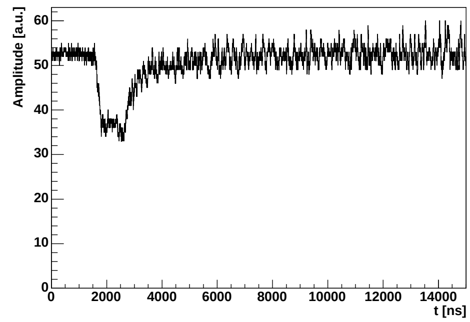

FIG. 2: A digitized pulse example. This is a neutron pulse, and the double peak structure contains information of the relative orientation of the proton and the triton counter.

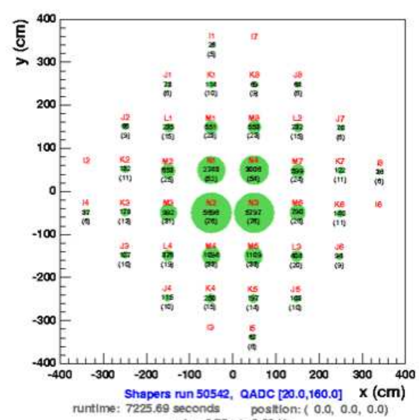

FIG. 3: Measured relative neutron capture efficiency for each of the NCD strings. The size of the circles is proportional to the fraction of the neutrons that wre captured by a particular string. The deployed position of the ^{252}Cf source was slightly off-centered, which explains the asymmetry seen in the relative efficiencies. The measured efficiencies shown here is consistent with Monte Carlo predictions.

[1] SNO Collaboration Phys. Rev. Lett. **87**, 071301 (2001).
[2] SNO Collaboration, Phys. Rev. Lett. **89**, 011301 (2002).
[3] SNO Collaboration, Phys. Rev. Lett. **92**, 181301 (2004).
[4] SNO Collaboration, arXiv:nucl-ex/0502021.