# The Sudbury Neutrino Observatory Experiment

A.W.P. Poon, M. Bergevin, Y.-D. Chan, C.A. Currat, R. Henning, K.T. Lesko, G. Prior, and N.R. Tolich
*Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720*

The Sudbury Neutrino Observatory (SNO) experiment [1] has now entered the third phase of its physics program. Forty strings of proportional counters, of which 36 are filled with $^3$He and 4 are filled with $^4$He gas, have been deployed on a square grid in the central $D_2O$ detector volume. The experiment has been acquiring production data with this "Neutral-Current Detection" (NCD) array since November 2004, and will continue until the end of 2006.

The two principal solar neutrino detection channels in SNO are the charged-current (CC) $\nu_e d$ and the neutral-current (NC) $\nu_{e,\mu,\tau} d$ interactions. Because the CC channel is sensitive exclusively to $\nu_e$ while the NC channel has equal sensitivity to all active neutrinos, a discrepancy in the measured flux through these two channels would indicate leptonic flavor transformation. This new physics was observed in previous phases of the SNO experiment [2–5]. SNO is primarily sensitive to neutrinos from $^8$B decays in the Sun.

In previous phases of the SNO experiment, neutrons from the NC reaction were detected by their radiative captures in deuterons (Phase I) and in $^{35}$Cl (Phase II), resulting in Cherenkov light signal from the Compton-scattered electrons. In the current phase, a significant fraction of the neutrons are captured by the NCD array. This separation of the CC signal (Cherenkov light) and the NC signal (pulses in the NCD) would reduce the statistical correlation, and hence improving the statistical uncertainty, in the extraction of the total active solar neutrino flux. SNO is the only detector that has this neutral-current capability to measure the total $^8$B solar neutrino flux in the foreseeable future, and the precision in measuring the ratio of the $\nu_e$ flux to the total active flux dictates our knowledge of the neutrino mixing angle $\theta_{12}$.

The SNO physics analysis program is now focused on the data from this array of proportional counters. Efforts have been devoted to the calibration of the signal pulses, removal of instrumental backgrounds and reconstruction of the pulses. These are also the main focuses of the SNO group at LBNL.

In 2005, the SNO collaboration published an updated analysis of the Phase II data [5] and a search for periodicity in the solar neutrino flux [6]. In [5], the $\nu_e$ and total active neutrino fluxes and their day-night asymmetry were measured. The energy spectrum of the electron in the CC reaction was also measured. No statistically significant spectral distortion was observed. Figure 1 shows the extracted CC electron effective kinetic energy spectrum with statistical error bars compared to predictions for an undistorted $^8$B shape with combined systematic uncertainties.

There have been recent claims that the solar neutrino data from the Super-Kamiokande experiment exhibited a 7% amplitude modulation at a frequency of 9.43 $y^{-1}$ [7]. Searches for this periodic signal were performed using a Lomb-Scargle periodogram and a unbinned maximum likelihood technique on the SNO Phases I and II data [6]. The best-fit amplitude for

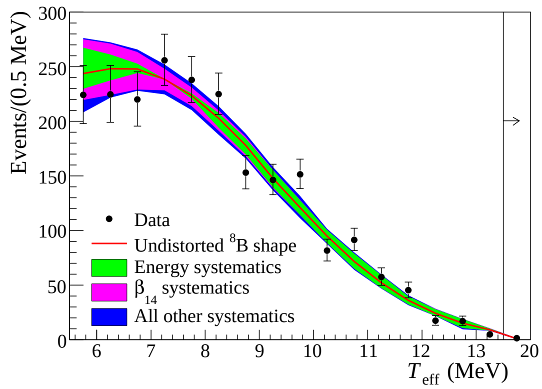


FIG. 1: Extracted CC $T_{\rm eff}$ spectrum with statistical error bars compared to predictions for an undistorted $^8$B shape with combined systematic uncertainties, including both shape and acceptance components. The systematic error bands represent the fraction of the total uncertainty attributable to the given quantity.

a periodic signal in the frequency range of 9.33 to 9.53 $y^{-1}$ was found to be $(1.3\pm1.6)$%, which disagrees with the claim of a 7% modulation in the Super-Kamiokande by 3.6$\sigma$.

After the end of data taking at the end of 2006, the SNO experiment will take two additional years to complete its analysis program. The main focus of the analysis program will be a precision measurement of $\theta_{12}$ (from CC to NC flux ratio measurement) and searches for signatures in matter-enhanced neutrino oscillation (through searches for day-night asymmetry of neutrino flux and spectral distortion in the measured CC electron spectrum).

[1] SNO Collaboration, Nucl. Instr. and Meth. **A449**, 172 (2000).
[2] SNO Collaboration, Phys. Rev. Lett. **87**, 071301 (2001).
[3] SNO Collaboration, Phys. Rev. Lett. **89**, 011301 (2002).
[4] SNO Collaboration, Phys. Rev. Lett. **92**, 181301 (2004).
[5] SNO Collaboration, Phys. Rev. C **72**, 055502 (2005).
[6] SNO Collaboration, Phys. Rev. D **72**, 052010 (2005).
[7] P.A. Sturrock, hep-ph/0501205, and references therein.