Atmospheric neutrinos analysis in SNO

C.A. Currat, Y.D. Chan, K.T. Lesko, A.W. Poon, G. Prior, N.R. Tolich, and R.G. Stokstad for the SNO Collaboration

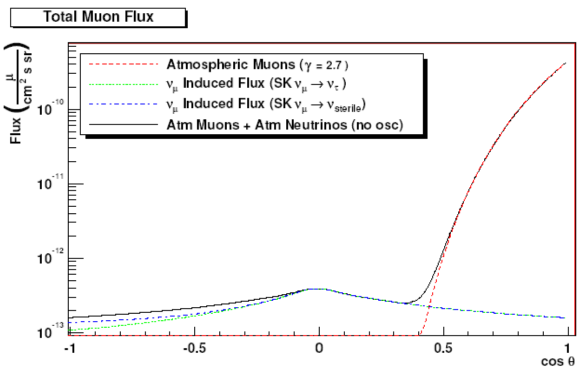

FIG. 1: Simulated zenith dependence of the flux for both down-going cosmic muons and neutrino induced muons as expected at SNO. The effect of various oscillation scenarios is visible below the horizon.

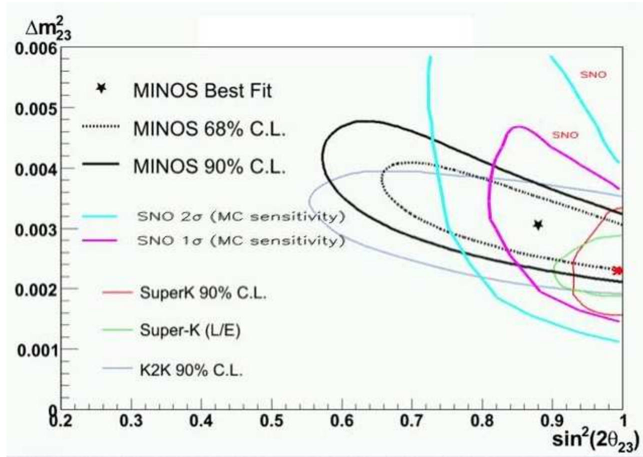

FIG. 2: *Projected* sensitivity contours for a $\nu_\mu \to \nu_\tau$ oscillation at SNO with $(\Delta m^2, \sin^2 2\theta) = (2.5 \times 10^{-3}, 1)$ compared to current measurements by other collaborations. The curves represent confidence levels of 68% and 90% for stopping and trough-going muons combined. Statistical study only.

Although it serves primarily as a solar neutrino experiment, the Sudbury Neutrino Observatory can also observe atmospheric neutrinos. SNO's location under a flat overburden will allow a measurement of the absolute atmospheric neutrino flux by observing the rate of neutrino-induced muons above and below the horizon. While the neutrino flux is symmetric about the horizon, only events coming from below the horizon have a significant probability of having oscillated as illustrated on Figure 1. SNO's measurement allows an independent check of the atmospheric neutrino oscillation parameters.

Located in Sudbury, ON, Canada, SNO is the deepest underground laboratory currently in operation. Having a depth of 2092 m (or 6 km water equivalent) reduces the number of cosmic ray activity seen within the detector to ~70 events/day. The low cosmic ray activity allows SNO to be highly sensitive to solar neutrinos, high-energy cosmic rays and neutrino-induced muons.

The principal analysis topics currently being pursued are:

- Determination of the atmospheric neutrino flux above the horizon
- Measurement of atmospheric neutrino oscillations
- Precision measurement of the cosmic ray flux at 6010 mwe depth
- Precision measurement of the neutron production/spallation rates from cosmic ray muons

The analysis is based on a 800-days data set and uses both the heavy and light water volumes in SNO as target for a total of approximately 2.7 ktonnes. Two types of events are used separately to best constrain the oscillation parameters space. Muons traversing the detector provide a broad scan of the high energy part of the neutrino spectrum. There is a roughly equal number of muons stopping inside the detector with energies up to 3–4 GeV.

Signal extraction techniques are based on a maximum likelihood analysis with both simultaneous fit to systematic parameters and with fixed systematic errors. Figure 2 shows SNO's projected fits on the oscillation parameters where the sensitivity combines both the through-going and stopping muons. Also shown are the results of the latest measurements by the Super-Kamiokande and K2K collaborations [1],[2],[3], and in particular the newly released result by the MINOS collaboration [4]. Despite SNO's modest size compared to other Cherenkov detectors, the perspective of performing virtually model-independent measurements on atmospheric neutrinos makes it particularly competitive.

Blindness constraints on our dataset are expected to be lifted later this year in view of the final phase of the analysis.

[1] Y. Fukuda et al., Phys. Rev. Lett. 82 p. 2644 (1999).
[2] Y. Ashie et al., Phys. Rev.D 71 p. 112005 (2005).
[3] E. Aliu et al., Phys. Rev. Lett. 94 p. 081802 (2005).
[4] N. Tagg et al., hep-ex/0605058 (2006).