Muons and muon-spallation neutrons at the Sudbury Neutrino Observatory

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The depth of the Sudbury Neutrino Observatory (SNO), its northerly location, and its use of heavy water make it unique in terms of muon and muon-spallation neutron studies.

The detection of the neutral-current(NC) breakup of the deuteron by solar neutrinos is one of the primary goals of SNO. In order to determine the NC rate accurately, one needs to account for the various backgrounds properly. The largest source of background neutrons comes from nuclear spallation of the ^{16}O and ^{2}H nuclei in the heavy water by muons. The higher energy signal of muons allows for easy separation of the muons from neutrinos. This ability to separate out the muons permits the selection and/or removal of muon spallation products that produce subsequent events [1].

The capture of a neutron on deuteron, $d(n,\gamma)t$, produces a mono-energetic gamma ray with an energy of 6.25 MeV. This mono-energetic gamma can be used as a calibration source. Furthermore, spallation neutrons provide a constant, uniformly distributed, and containerless calibration source that has been used to study SNO's response for both energy scale and temporal variations. Unlike deployable devices, these neutrons do not disrupt normal data taking [2].

One use of this spallation neutron data set is as a "blindness" tool. Once the spallation neutrons are flagged, they can be reinserted into the neutrino data set. This has the effect of increasing the apparent NC component of the solar neutrino flux. This blindness scheme was instituted for the current salt phase of SNO as one way of hiding the true NC number from the analyzers.

Muons and muon spallation neutrons have also been studied in support of a Day *vs.* Night neutrino analysis. We checked day-night asymmetries in the rate of muons and muon induced spallation neutrons and found these are consistent with zero [1] as expected.

SNO is also capable of the extraction of a clean sample of atmospheric neutrino-induced muons over a uniquely large range of zenith angles, which will allow an accurate measurement of the unoscillated neutrino-induced muon signal from above the horizon. Taken as a whole, the angular distribution gives an almost model-independent neutrino oscillation test.

References

[1]arXiv.org pre-prints: nucl-ex/0204008, nucl-ex/0204009.
[2]Q. R. Ahmad et al., Phys. Rev. Lett. **87** (2001) 071301