SNO Data Taking and Discoveries

The SNO detector is located in a huge rock cavern - 22 meters in diameter and 30 meters high, 2 kilometers underground at the Inco Creighton Mine, 20 minutes west of Sudbury Ontario. The rock above the detector filters out Cosmic Rays which would otherwise produce light photons in the detector, masking the tiny signals from neutrinos (seen only about 15 times per day). Neutrinos (symbol $\nu$ - Greek letter nu) are detected in the clear plastic spherical tank at the centre of the detector, filled with 1000 tonnes of Heavy Water borrowed from AECL with the cooperation of Ontario Power Generation. Three types of reactions for neutrinos are seen in the heavy water which consists of D$_2$O or deuterium oxide instead of the normal H$_2$O, where D stands for deuterium - a heavy form of hydrogen with a proton (p) and an additional neutron (n) in its core (d). Each of these three reactions releases characteristic light photons (see the diagrams at right) which are detected by the 9600 ultrasensitive phototubes, surrounding the plastic tank. The outer part of the detector is filled with ultrapure normal water, which supports the central plastic tank and shields the core against tiny amounts of radioactivity in the surrounding rock. Any dust from the mine which enters the detector water can interfere with neutrino measurements, so SNO has been operated as a cleanroom laboratory from the time of its construction. Ultrapure materials are also used throughout the detector to minimize interferences.

In close to 7 years of data taking beginning in 1999, SNO has seen thousands of neutrinos through all three reactions. Careful modeling of each neutrino “event” allows the reaction type, energy, location and neutrino direction to be found with high probability. By comparing neutrino reaction rates, SNO announced in May 2001 that it had strong evidence that neutrinos (which start out as electron neutrinos in the Sun’s core) oscillate from this original type to other types as they travel from the sun to the detector. Two thirds of the neutrinos from the sun have changed from their original type to one of the other two types.

Since these other neutrinos could not be identified by earlier experiments, SNO’s total neutrino numbers are much higher than those reported earlier, and now are in excellent agreement with the predictions of solar theories – the Solar Neutrino Problem has been solved. SNO’s papers detailing these results were the most cited papers in the world wide Physics literature in 2002 with more than 1000 references each. The SNO experiment completed its data-taking phases in November 2006 and final analyses are approaching completion in 2009. The detector is being converted to the SNO+ experiment which will measure lower energy solar and geo neutrinos and search for rare nuclear decays to obtain more information about neutrinos.