

BACKGROUND INFORMATION / SUDBURY NEUTRINO OBSERVATORY

The Sudbury Neutrino Observatory is a unique neutrino telescope, the size of a ten-story building, two kilometers underground in Inco's Creighton Mine near Sudbury, Ontario. It was planned, constructed and operated by more than 200 scientists from Canada, the United States and the United Kingdom. Through its use of heavy water, the SNO detector provides unique ways to detect neutrinos from the Sun and other astrophysical objects and measure their properties.

For many years, the number of solar neutrinos measured by other underground detectors had been found to be smaller than expected from theories of energy generation in the sun. This had led scientists to infer that either the understanding of the Sun was incomplete, or that the neutrinos were changing from one type to another in transit from the core of the Sun.

In results presented in 2002, SNO scientists compared the number of electron-type neutrinos reaching the SNO detector to the number of neutrinos seen by a second reaction, which measured independently the total rate of all of the three known types of neutrinos. The observed difference in these two numbers showed conclusively that neutrinos change their type en route to Earth, and arrive as a mixture of electron neutrinos and the other two types. This change in type implies that neutrinos have a mass greater than zero and requires additions to the Standard Model for elementary particles at the most fundamental level. It also confirms models for energy generation in the sun with high accuracy.

The SNO detector consists of 1,000 tonnes of ultrapure heavy water enclosed in a 12-meter diameter acrylic plastic vessel, which in turn is surrounded by ultrapure ordinary water in a giant 22-meter diameter by 34-meter high cavity. Outside the acrylic vessel is a 17-meter diameter geodesic sphere containing 9,600 light sensors or photomultiplier tubes, which detect tiny flashes of light emitted as neutrinos are stopped or scattered in the heavy water. The flashes are recorded and analyzed to extract information about the neutrinos causing them. At a detection rate of about one neutrino per hour, many days of operation are required to provide sufficient data for a complete analysis. The laboratory includes electronics and computer facilities, a control room, and water purification systems for both heavy and regular water.

The construction of the SNO Laboratory began in 1990 and was completed in 1998 at a cost of \$80 million (Canadian) with support from the Natural Sciences and Engineering Research Council of Canada, the National Research Council of Canada, the Northern Ontario Heritage Foundation, Industry, Science and Technology Canada, Inco Limited, the United States Department of Energy, and the Particle Physics and Astronomy Research Council of the UK. The heavy water was on loan from Canada's federal agency AECL with the cooperation of Ontario Power Generation, and the unique underground location is provided through the cooperation and support of Inco Limited, now Vale. Measurements at the SNO Laboratory began in 1999, and the detector was in almost continuous operation until November 2006.

In June 2001, the second phase of measurements with the SNO detector was begun, in which ultra pure sodium chloride (salt) was added to the heavy water core of the detector, to enhance signals for some of SNO's neutrino reactions and add further to the accuracy of SNO's neutrino determinations. In 2003, a further phase began in which the salt was removed and an array of neutron detectors were installed to make an independent measurement of the reaction

sensitive to all neutrino types. These latter two phases added to the accuracy of the measurements of neutrino properties and of the properties of the sun.

Further background information can be found on the SNO website:
www.sno.phy.queensu.ca .

SNO Participating Institutions

Canada

Queen's University
Carleton University
Laurentian University
University of Guelph
University of British Columbia
TRIUMF
Chalk River Laboratories (to 1996)
University of Alberta (since 2007)

United States

Lawrence Berkeley National Laboratory
Los Alamos National Laboratory
University of Pennsylvania
University of Texas at Austin (2002-2008)
University of Washington
Brookhaven National Laboratory
Princeton University (to 1992)
University of California at Irvine (to 1989)
Louisiana State University (since 2004)
Massachusetts Institute of Technology (since 2005)

United Kingdom

Oxford University

Portugal

LIP Lisbon (from 2005)

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