INDIA-BASED NEUTRINO OBSERVATORY

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About the Project

The existence of non-zero neutrino masses has profound implications on fields as varied as nuclear physics, geophysics, astrophysics and cosmology apart from being of fundamental interest to particle physics. The discovery of neutrino mass and oscillation is but a first step and there are several questions that may require different experiments spanning many decades to be resolved. We still do not know the scale of neutrino mass, we only partly know the extent of mixing and not even sure if the neutrino is its own antiparticle or not. The experimental field of neutrino physics is now moving into a phase where decisive and high precision experiments are needed. It was in this context that an initiative began to take shape a few years ago leading to the idea of the India-based Neutrino Observatory (INO).

Location and Structure

The detector will be placed inside a mountain at Theni near Madurai in South India. The rock burden of over 1 km on all the directions shields the detector from other cosmic rays. The geographical location is particularly interesting, as all the existing neutrino detectors are at latitudes larger than 35 degrees N or S. There is none close to the equator as yet.

Figure: INO site at West Bodi Hills near Theni.

Two caverns, one to house the detector and another to house the control systems will be built inside the mountain. A 2km long tunnel will connect these caverns to the portal outside the mountain.

Detector

Considering the physics possibilities and given the past experience of Indian scientists at the Kolar Gold Mines, it was decided to start with a modern Iron Calorimeter (ICAL) detector with Resistive Plate Chambers (RPC) as active detector elements. This massive detector (50 kton) has been designed to achieve a statistically significant number of neutrino interactions in a reasonable time frame with good energy and angular resolution to measure L/E with an accuracy better than half the modulation period. The magnetic field in the detector gives the possibility of distinguishing between neutrino and anti-neutrino interactions.

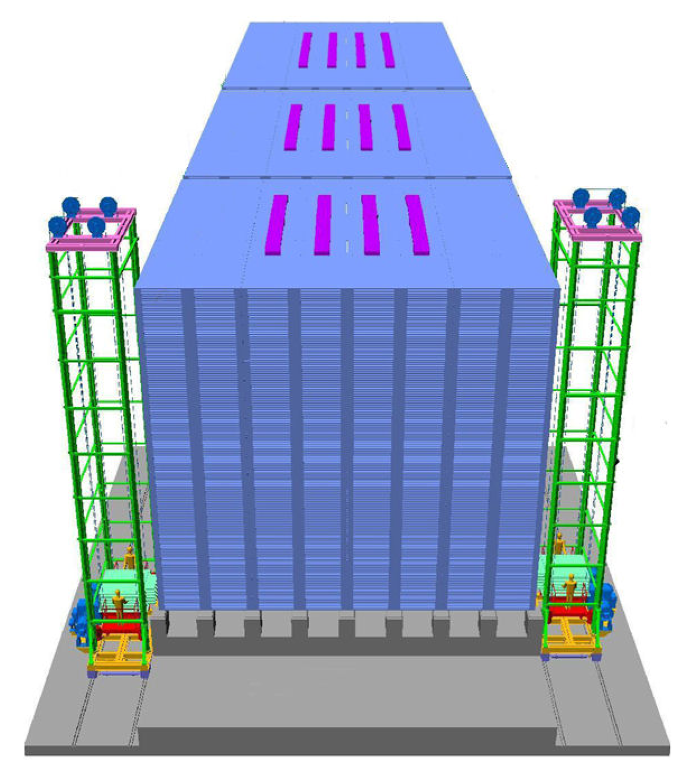

Figure: The Iron Calorimeter.

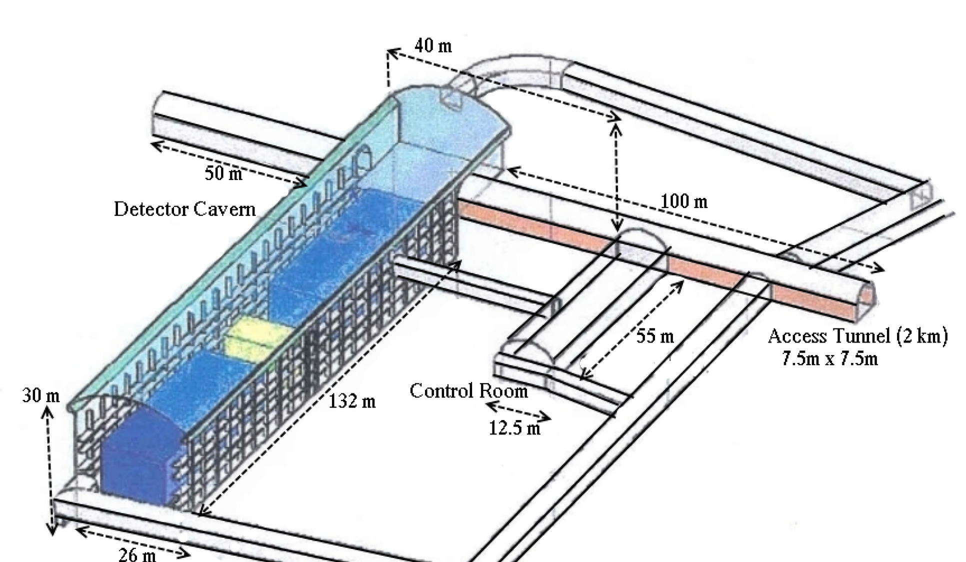

Figure: Schematic of detector caverns.

Figure: RPC fabrication in process at TIFR.

Detector Parameters

- 3 modules each of size 16m x 16m x 14.5m.
- 150 layers of RPCs interleaved by Iron plates of thickness 56mm.
- 64 (8 x8) RPCs per layer per module.
- Total of 28,800 RPCs of size 1.84m x 1.84m x 24mm, with 64 strips (30mm pitch) on either read-out planes.
- Magnetic field of 1.3 Tesla.
- Total of 3.6 million electronic channels.

Industrial Interaction and Collaborations

ICAL is an engineering intensive experiment and therefore requires state-of-the-art engineering inputs and expertise to design, fabricate and assemble. INO group has already tied up with a number of Indian industrial houses. Various jobs related to the preparation of a Detailed Project Report for the detector, cavern and the surface facilities are made by agencies having special expertise in those fields. Industries are also involved in the development of gas recirculation system, electrode paint and in the fabrication of large area RPCs. Other areas where we currently consulting local industries are machining of ICAL's iron plates, large scale production of RPCs, magnet design, large volume gas recycling systems, fabrication of high density VLSI circuit based modules etc.

Contact

Visit us at www.ino.tifr.res.in or write to nkm@tifr.res.in to know more about this project.

Main Goals

- Unambiguous and more precise determination of oscillation parameters using atmospheric neutrinos.
- Study of matter effects through electric charge identification, leading to determination of sign of δm^2_{23}.
- Study of CP violation in the leptonic sector and possible CPT violation studies.
- Study of very-high energy neutrinos and multi-muon events.

Graduate Training Program

A large number of well trained manpower is needed to lead the experimental activities of this project. In order to achieve this goal, a training program with strong emphasis on experimental high energy physics was started in August 2008.

Outreach and Awareness

As part of its responsibility toward the society, the INO team regularly organizes awareness meetings and outreach programs. Students from schools and colleges are invited to the labs at TIFR and are introduced to concepts in detecting high energy particles. Outreach programs to people near the site are conducted with the help of the district and village administrative bodies.

Other Experiments of INO

The INO project will also host other neutrino experiments like the Neutrino-less double beta decay (NDBD). NDBD experiments will reveal the nature of neutrinos (Majarona or Dirac). This experiment will be placed in the control room cavern. A crucial criterion for detector design for this experiment is high energy resolution for a precision measurement of the sum energy of two electrons emitted in the decay. The low temperature bolometric detectors are ideally suited for this purpose. The group focuses on the feasibility of a Sn cryogenic bolometric detector using ^{124}Sn.