Neutrino Project in India- An overview

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Abstract

The India-based Neutrino Observatory (INO) is a work focused on forming an elite underground lab to concentrate on essential issues in science. Utilizing an iron calorimeter (ICAL) detector, the primary objective of the laboratory is the investigation of neutrinos originating from a variety of natural and laboratory sources. The western ghats' steep slopes provide ideal and stable rock conditions for building a large underground cavern in safety for long-term use, so the laboratory will be in Tamil Nadu. It is hoped that this underground facility will also become a hub for other research in fields like physics, biology, geology, and so on. All of which will utilize the extraordinary circumstances that exist profound underground.

Introduction:

Particle physics has made a significant contribution to understanding the secrets of the cosmos by offering remarkable insights into the basic components of matter. The investigation of neutrinos has become an important field of study in this venture. India, a nation renowned for its scientific brilliance, has started the ambitious Neutrino Project to better understand about these elementary particles.

A Glimpse of Neutrinos:

The study of neutrinos has grown to be an exciting subject. India, a country well known for its scientific progress, has launched the ambitious Neutrino Project to learn more about these puzzling particles. Neutrino is a very small mass having no electric charge. Neutrinos are particles that can penetrate through very dense particles. The radioactive decay of primordial elements is the natural source of neutrino. They are "ghost particles" that barely reacts with anything else. The detection of neutrinos becomes difficult because of their tendency of not interacting with others. Sensitive detectors are required for the detection of neutrinos. Nearly all neutrino experiments depend on measuring the fraction of neutrinos that come in contact with the detectors (Dolgov, 2002).

The Neutrino Project in India:

The Indian initiative to conduct experiments on neutrino and cosmic ray physics dates back nearly 45 years. In fact, the KGF underground laboratory recorded the first atmospheric neutrino induced moon events nearly 347 years ago. The possibility of a neutrino Observatory in India was discussed as early as 1989.Several discussions were made during that year. During the initial meeting of the neutrino physics and cosmology working group at WHEPP-6 (Workshop on High Energy Physics Phenomenology), which was held in Chennai, the issue was brought up once more, and was decided then to gather specific ideas for such a detector. The Department of Atomic Energy (DAE) and a number of academic institutions, notably the Tata Institute of Fundamental Research (TIFR) and the Bhabha Atomic Research Centre (BARC), are working together on the Indian Neutrino Project. Nearly 50 scientists from the country joined hands to form National Neutrino Collaboration Group. They are engaged in detailing various aspects of India Based Neutrino Project (INO) and come up with the proposal for the construction of underground neutrino laboratory. Design and prototyping are being done for a magnetized tracking iron calorimeter. This detector will be used for atmospheric neutrino physics during the initial stages of operation. The objective is to perform accurate measurements of the parameter associated with neutrino oscillations

Scientific goals:

The main goal of India's neutrino project is to build a top-notch subterranean laboratory for studying neutrinos. The facility will hold a sizable detector that can record and examine neutrino interactions. Researchers intend to

solve the puzzles around neutrino masses, mixing angles, and flavour transformations by investigating neutrino oscillations. The initiative also aims to study cosmic phenomena including neutrinos emitted by celestial bodies (Mondal, 2012).

Location of the laboratory:

The essential necessities of a reasonable site for finding an underground lab separated from the physical science prerequisites, are the wellbeing and long haul strength of the lab. As a result, the quality of the rock, the availability of water and power for the project, low rainfall, ease of access, and minimal environmental impact and management were the primary factors in the search for an appropriate location for INO. Several sites were considered as potential INO locations in light of these criteria. The review included data from geologists, architects, biologists and physicists. It was based on data from available surveys, topographic sheets, multiple group site visits, and Google Earth images. It is important to note that the best rock medium for building safe and stable caverns is in peninsular India, south of 13°N lat. In order to create a stable and secure environment for such a long-term activity, the location of the laboratory cavern is primarily determined by the rock quality because the cavern must be more than 1000 meters underground. In terms of geology, the mountains in the southern part of India have the most dense and compact rock—mostly gneiss—while the Himalayas are mostly made of metamorphic sedimentary rock with gneiss in some places (Mondal, 2012).

In the southern state of Tamil Nadu, close to the town of Pottipuram, National Neutrino Collaboration Group seeks to build a cutting-edge neutrino observatory. The proposed site in Theni area was distinguished in light of the fact that the stone weight of more than 1 km every which way safeguards the locator from other enormous beams. The rock in the mountain will filter out the other particles, but neutrinos will reach the detector because they can easily pass through anything. The fact that all of the existing neutrino detectors in other nations are located at latitudes greater than 35 degrees North or South makes the location even more peculiar. At this time, none are close to the equator. With coordinates of 11.5°N and 76.6°E the location is in Singara. The southern peninsular shield provides one of the ideals tunneling environments for the construction of underground facility. If constructed here, the site will be the continuation of underground hydel project which is approximately 6.5kms from Masinagudi on the outskirts of Mudhumalai Wildlife Sanctuary close to the state borders between Tamil Nadu, Karnataka and Kerala. It is being executed by Tamil Nadu Electricity Board (TNEB) and is known as Pykara Ultimate Stage Hydro Electric Project (PUSHEP). The tunnel proposed for the neutrino project is located close to the PUSHEP acess tunnel. Hence the site is known as PUSHEP site. The generators for the PUSHEP are housed in an underground tunnel that is 70 meters long, 20 meters wide and 39 meters high. These dimensions are comparable to locate the Iron Calorimeter detector by INO which is a boon (Vivek et al. 200).

The bane of the site:

The state government stated that the undertaking falls precisely on the slope Inclines of this piece of the Western Ghats, which adjust inside it a critical tiger passage, to be specific the Mathikettan Periyar tiger hallway.The Mathikettan Shola National Park and the Periyar Tiger Reserve are connected by this corridor, which runs along the Kerala-Tamil Nadu border. Wild animals that make their seasonal migrations through the corridor will be disturbed by construction and quarrying activities. The region is a huge watershed and catchment zone for the waterways Sambhal and Kottakudi.

Even though the observatory's experiments would be carried out a kilometer underground, the ecological viability of the region deep in the Western Ghats would be jeopardized by massive blasting, transportation, excavation, and tunneling, among other activities. Since the Western Ghats are a global hotspot for biodiversity and a treasure trove of biological diversity, their protection was paramount. Apart from a large number of elephants and tigers, the specific region is home to numerous endemic species

of flowering plants, fish, amphibians, reptiles, birds, mammals, and invertebrates.

ICAL detector about neutrinos:

It appears from data gathered globally, particularly from the Super-Kamiokande and SNO investigations, that various neutrino flavours mix and oscillate into esch o detectors have only observed a decrease in their anticipated spectrum. This study has recently been enhanced by Super-Kamiokande, who excludes non-oscillation possibilities with a 98% confidence level (Murthy and Yajnik, 2000).

Technological Advancements:

The creation of cutting-edge technologies is required for the Indian Neutrino Project. To reduce ambient noise and cosmic ray interference, the proposed underground laboratory will be built at a depth of more than a kilometer. Low-energy neutrinos can be detected by the detector, which is made up of sensitive parts like photomultiplier tubes and advanced electronics. To extract useful information from the massive amount of data generated by the tests, advanced data analysis techniques, including machine learning algorithms, will be used.

Collaborations and International Significance:

Leading scientific organizations from all around the world have joined forces with India's Neutrino Project as a result of the attention it has received internationally. Collaboration increases the scientific potential of a project by encouraging knowledge sharing, resource pooling, and the use of a variety of expertise. India's involvement in the world's neutrino community also helps put the nation at the forefront of particle physics research, enhancing its scientific reputation on the worldwide arena.

Conclusion:

The Indian Neutrino Project has a great deal of potential to further our knowledge of the subatomic world and reveal the mysteries of the cosmos. This enormous project will allow researchers to study neutrinos with unprecedented precision by constructing a state-of-the-art underground laboratory and installing advanced detectors. By clearing out the enigmas surrounding the mass, flavour, and oscillations of neutrinos. The country's developing high energy physics scenario will be impacted by INO. In addition to participating in this project, those who get training at INO will also be qualified to contribute to other high energy and nuclear physics programmes worldwide. INO is anticipated to transform over time into a top-notch subterranean research laboratory that spans a variety of disciplines, including physics, biology, geology, and related engineering sectors. Students of science and technology across nation, particularly those from Tamil Nadu and its neighboring states, will be able to participate in cutting-edge science and technology research.

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