

Indian Neutrino Observatory (INO)

July 5, 2026 • vajiramandravi.com

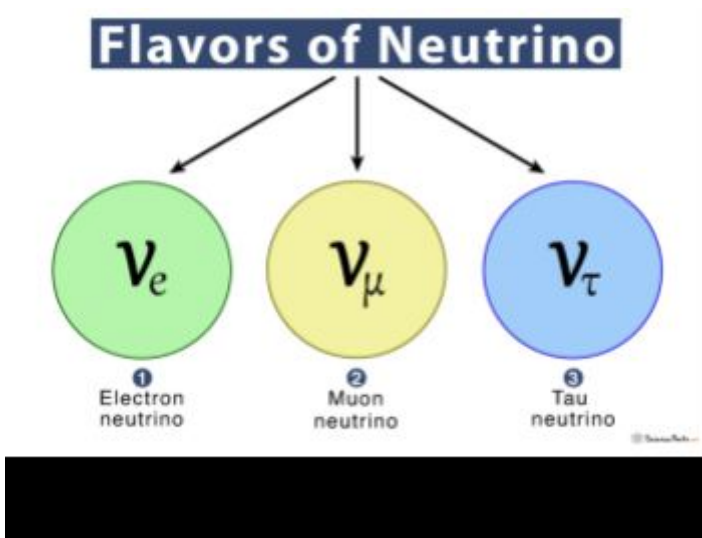


The Indian Neutrino Observatory (INO) is an initiative to create a state of the art underground laboratory to research fundamental scientific concepts. The mega-science project is to be jointly funded by the Department of Atomic Energy and the Department of Science and Technology. The INO Project is one of its kind in India due to the extensive collaboration of nearly 100 scientists and 26 institutes, of which **Tata Institute of Fundamental Research**, Mumbai, is the hosting institution.

The primary objective of the INO Project is to study neutrinos, **one of the most abundant fundamental particles**, coming from various sources and using an **underground Iron calorimeter (ICAL) detector**.

What are the Neutrinos?

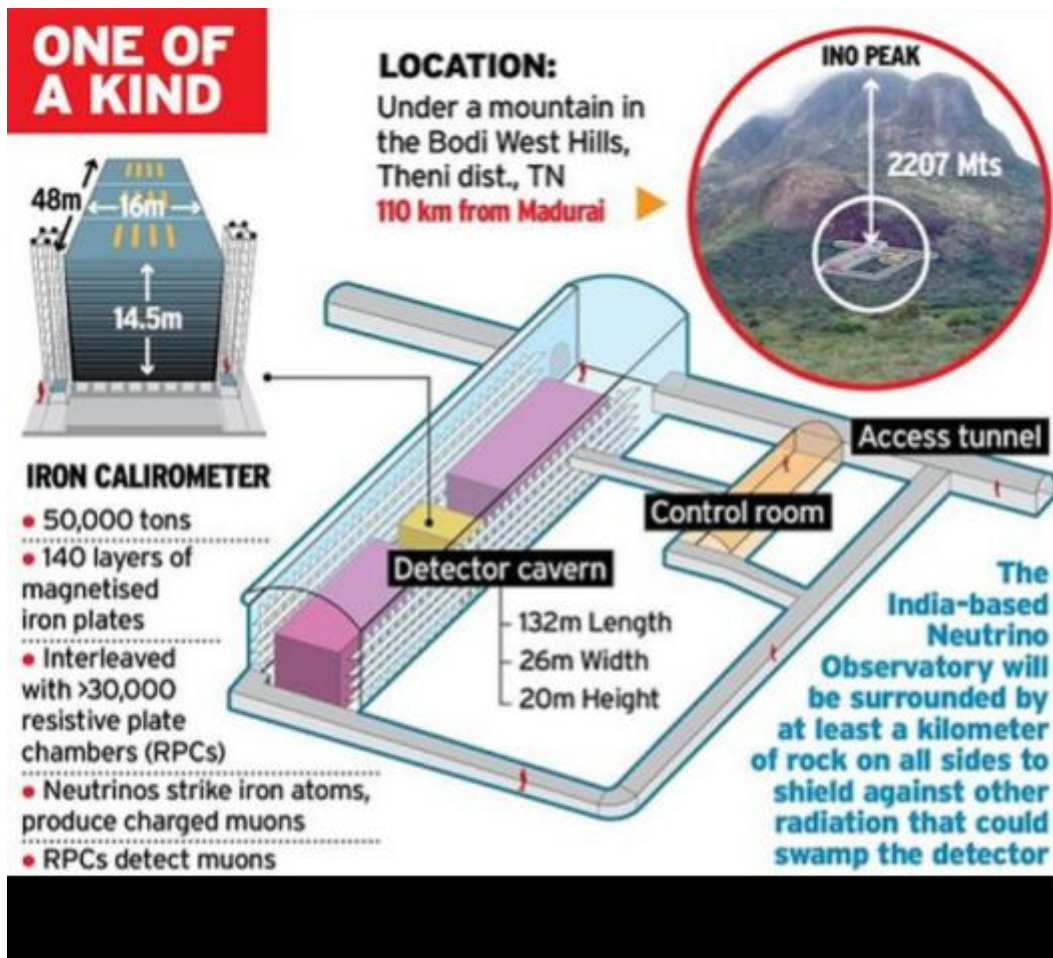
A neutrino is one of the fundamental particles, which means it isn't made of any known smaller particles.



- **Properties:** It is a Lepton and thus belongs to the same family as the electron, the most well-known fundamental particle.
 - Of all the subatomic particles that have mass, **neutrinos are the lightest**.
 - Unlike electrons, they are **electrically neutral**.
 - They interact with matter through the **weak force**. The property that matter is almost transparent to neutrinos is a result of this force's weakness.
 - Different species of neutrinos **mix and oscillate** into one another, in weak interactions, as they traverse through the cosmos.
- **Sources:** They are also the most prevalent massive particle in the universe, which makes them very common. They are produced both in fusion (as in Star) and **decay** (as in Reactor).
 - Neutrinos are produced by the **Sun and other stars** through nuclear fusion and decay processes in their core.
 - When heavy particles undergo a process known as "decay," they frequently produce neutrinos, which come from a variety of different sources.
 - Other sources include **exploding stars, relic neutrinos, natural radioactivity, and cosmic ray interactions**.

Need of INO

The INO project broadly aims to create an outstanding underground laboratory in India for non-accelerator-based high energy and nuclear physics research.



- **To study the physics of the little-understood particles:** Neutrino detectors around the world seem to see evidence that these weakly interacting particles are not really massless, as was thought so far.
 - This has a significant impact on a variety of fields, including nuclear and particle physics, astrophysics, and cosmology.
- **To detect masses of individual neutrino types:** Neutrinos are the most numerous particles in the universe (other than photons), and even a small mass can impact the **universe's evolution** through their gravitational effects, making it crucial to understand the size of the three individual neutrino types.
- **To study the evolution of the universe:** Recent astrophysical measurements offer insights into the universe's evolution, but it is crucial to explore neutrinos' masses and properties directly for complementary information.
- **To study the core of the Earth:** Neutrinos can be utilised in neutrino tomography, a detailed investigation of Earth's structure from the core, as they are the only particles capable of probing the deep interiors of the Earth.
- **Recapturing India's pioneering studies on neutrinos:** The planned Indian Neutrino Observatory is an attempt to recapture the pioneering studies on neutrinos at Kolar Gold Field (KGF), which detected the first atmospheric neutrinos in 1965. The closure of the mines forced the closure of this laboratory.

Importance of the Location of INO

The INO collaboration has decided on a site in the Bodi West Hills (BWH) region near Pottipuram village in Theni district of Tamil Nadu (110 km from the temple town of Madurai).

- **Why underground?**

- Because of their incredibly weak interaction with matter, neutrinos are very hard to detect in a laboratory.
- The background from cosmic rays and natural radioactivity will make it almost impossible to detect them on the surface of the Earth.
- The overburden provided by Earth matter is transparent to neutrinos, whereas **cosmic rays are substantially reduced** depending on the depth at which the detector is located.
- This is the reason most neutrino observatories are located deep inside the Earth's surface.
- **Bodi Hills** has been selected as the location because the Western Ghats' steep slopes offer ideal and stable rock conditions for creating a sizable underground cavern for long-term use.

- **Close to the equator:** Placing a neutrino detector close to the equator at an underground neutrino facility will **help study solar neutrinos and their oscillations**.

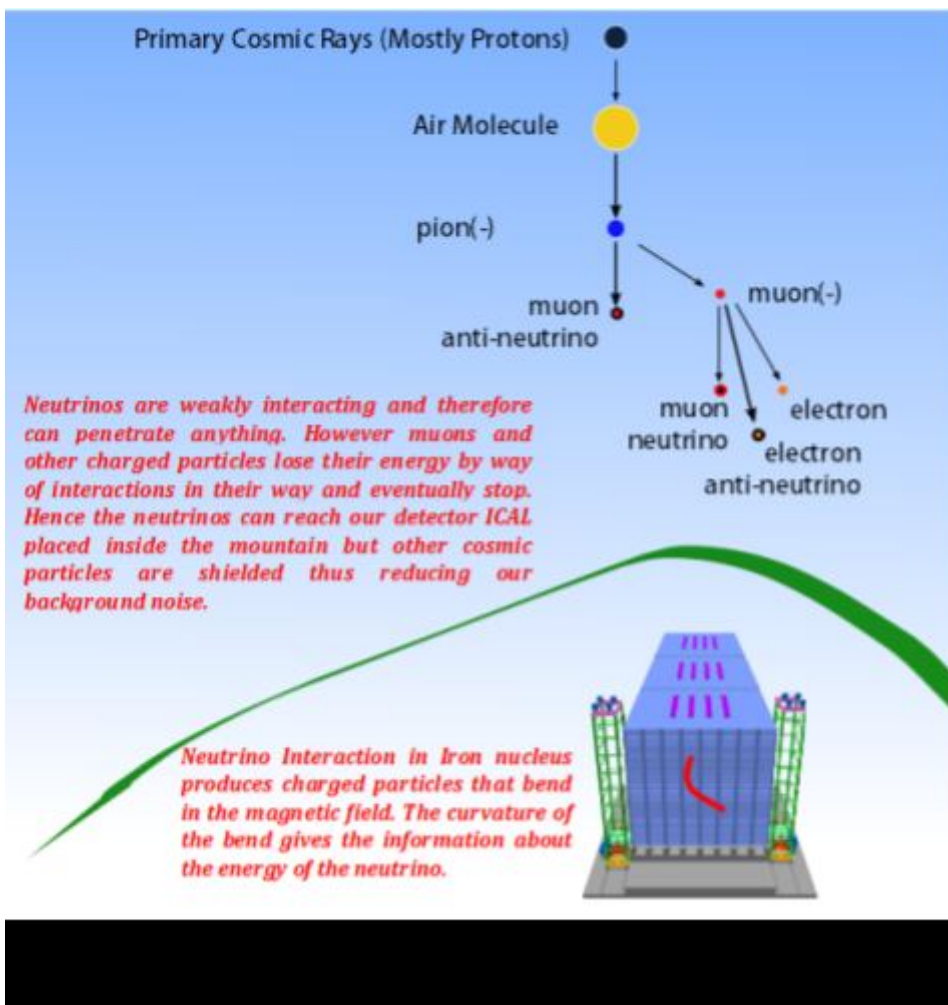
Iron Calorimeter Detector (ICAL)

The detector installed in the INO laboratory will be a magnetised iron calorimeter detector (**ICAL**). This non-moving static device will study the sky using neutrinos, much like a telescope studies the sky using visible light.

- Charged particles produced in the rare interactions of neutrinos with the iron (constituting the 50 kton, 1.3 Tesla magnet) will be detected in glass based detectors called RPCs sandwiched between successive iron layers.

What can the ICAL tell us about Neutrinos?

It appears from data gathered globally, particularly from the Super-Kamiokande and SNO experiments, that various neutrino flavours mix and oscillate into one another. But, all of these detectors have so far only detected a reduction in the expected spectrum.



- **Trough and peak effect:** The "trough and peak" effect can be established by studying the muon spectra from atmospheric neutrinos, which will allow ICAL to accurately determine the oscillation parameters.
- **Earth-matter effects:** Additionally, since ICAL can distinguish between neutrino and anti-neutrino events, it can also investigate the effects of Earth-matter. It will be able to study some unknown oscillation parameters as well.
- **Address the "neutrino-mass hierarchy":** The "neutrino-mass hierarchy," which is not currently well understood, is something that the INO team hopes to address using the detector.
- **Can be used as the far-detector:** The INO detector can also be used as the far detector of a long-baseline neutrino experiment, using a neutrino beam from a neutrino factory in Japan, Europe, or the USA.

Global Neutrino Observatories	Location
Sadbury	Canada
Super Kamiokande	Japan
Gran Sasso Mountains	Italy
Soudan mines	USA
KATRIN experiment	Germany
Daya Bay Reactor Neutrino Experiment	Honk Kong

Significance of INO Project

Despite being opposed by many ecologists and activists, the INO project is significant for India in many ways such as:

- INO is anticipated to eventually grow into a **premier underground science facility**, spanning numerous disciplines like physics, biology, geology, and related engineering fields - a true **Science and Technology Institution in India**, in essence.
 - Along with the LIGO **India** project, it is a dream project of **Indian physicists**.
- INO will contribute to other **high-energy and nuclear physics projects** worldwide.
- **Students** from science programmes across India will have the chance to take part in the creation of sophisticated particle detectors and electronic data-acquisition systems.
- Modern technologies are used in the design and development of INO. This would result in a generation that would strengthen the country's technological foundation.
- The detectors used in INO are also used in industries like medical imaging.

Current Status of INO Project

The proposed Indian Neutrino Observatory (INO) has been clouded by uncertainty since its very inception.

- The INO project was **conceived in 2005**, a site under the Bodi West Hills in Tamil Nadu's Theni district was identified by 2009 and a Rs 1,500 crore fund was proposed by 2015.
- In 2018, the environment ministry finally granted the Indian Neutrino Observatory (INO) the necessary approval.
- **Opposition to the Project:**
 - According to environmental experts, the project **site is within a tiger corridor** and poses a threat to its fragmentation.
 - Experts have also cited that **construction activities** like extensive blasting, excavation, tunneling, and transportation, etc. would impact **local ecology** as well as the local rock-system.
 - The **radiation-related myths** due to neutrinos have also been used as an argument against the project.
- As of today, due to opposition from ecologists and the state government, the **INO project's construction has not started yet.**

Source: <https://vajiramandravi.com/upsc-exam/indian-neutrino-observatory/>

© Vajiram & Ravi. For personal use only.