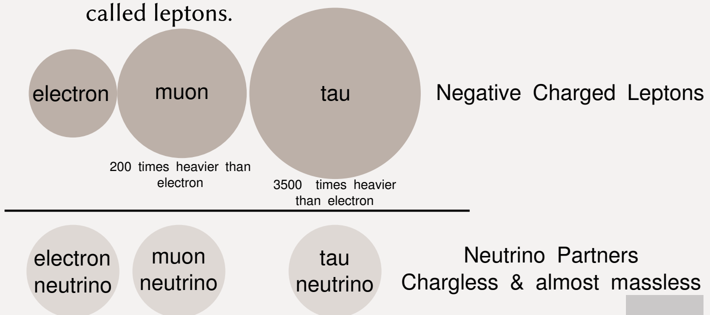
What are Neutrinos ?

We know that all things in this world are made of atoms. An atom has a nucleus in its centre around which electrons go around. Inside the nucleus there are protons and neutrons.

Neutrinos are tiny elementary particles like the electron but not part of the Atom. An elementary particle is one which cannot be broken into further smaller pieces. Though the words neutron and neutrino almost sound similar, they are entirely different particles. Neutrinos are represented by the greek letter ν (nu).

Scientific discoveries in the past have found out that there are two more particles similar to the electron called as the muon and the tau. The muon is 200 times heavier than an electron and the tau is 3500 times heavier than the electron. Each of these three particles have a neutrino partner called the electron neutrino, muon neutrino and the tau neutrino. The electron, muon and the tau are all negatively charged particles but all the neutrinos are chargless (neutral) and are almost massless. The group of these six particles is called leptons.



Where are they Produced ?

Neutrinos are abundantly found in nature. The Sun, the stars and the atmosphere produce millions of neutrinos every second.
Most of these neutrinos pass through our body and we do not realize it. They can even pass through the earth and come out on the other side. The reason they can do this is because they interact very less with anything that come in their path. In simple words, an interaction is something that changes the property of the particle like its speed, direction etc. For example, light rays from a torch cannot penetrate a wall because particles of light interact with the wall and get scattered before they can get to the other side of the wall.

Since neutrinos interact very weakly, they are harmless.

Neutrinos can also be made artificially. They are produced in radioactive decays and in nuclear reactors.

What is Neutrino Oscillation ?

Though neutrinos are found in abundance, due to their weakly interacting nature, studying these particles in the laboratory is extremely difficult. In spite of it, Scientists have devised methods to detect these particles and to study them.Neutrinos were initially thought to be massless particles but recent experiments suggest that they indeed have a very small mass.

These experiments found an important discovery about neutrinos. They discovered that neutrinos change from one type to another as they travel. For example, an electron neutrino that is produced in the Sun converts itself into a muon neutrino or a tau neutrino on its flight to the earth. This conversion is called as neutrino oscillation.

It was the discovery of this property of neutrino oscillation that suggested that neutrinos have mass.

Neutrino oscillation not only happens in neutrinos produced in the Sun, they happen in all the neutrinos irrespective of where they are produced.

The fact that neutrinos have mass has implications on the current understanding we have about the Universe and in sciences like Nuclear Physics, Particle Physics, Astro Physics and Cosmology. This makes the study of neutrinos a very interesting domain in scientific research. The 2002 Nobel Prize for physics was awarded to research related to Neutrinos.

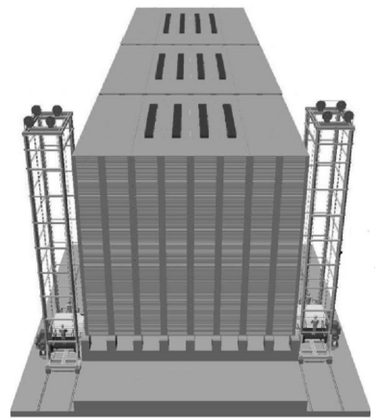
India-Based Neutrino Observatory

The discovery of neutrino oscillations is just a first step and there are several questions that are still unanswered. The field of neutrino physics has attracted world-wide attention and there is a need to understand many questions put forth by the phenomena of neutrino oscillations.

The Super-Kamiokande neutrino observatory in Japan, Sudbury Neutrino Observatory in Canada, Gran-Sasso Lab in Italy, IceCube Neutrino Observatory in the South Pole are some of the existing neutrino laboratories.

A few years ago an initiative began to take shape leading to the idea of the India-based Neutrino Observatory (INO), a modern world class laboratory in India for studying neutrinos.

The India-based Neutrino Observatory, shortly INO, was proposed to be a particle physics research project to primarily study atmospheric neutrino oscillations. This project is notable in that it will provide a precise measurement of neutrino parameters and will also address the neutrino mass hierarchy problem. It is also unique in that it can distinguish between neutrino and anti-neutrino interactions. The project will also host other neutrino experiments like the Neutrino-less double beta decay which would shed light on the nature of neutrinos. The project is a multi-institute collaboration and one of the biggest experimental particle physics projects undertaken in India.



The ICAL Detector

The INO project has been marked as a Mega Science Project in the 11th 5 years plan.

In the first phase INO will construct a detector to detect neutrinos that are naturally produced in the atmosphere. Since there are particles other than neutrinos that are produced in the atmosphere, it would be difficult to identify and separate signals produced by neutrinos from the signals produced by the other particles. One way to avoid the other particles from reaching the detector is to keep the detector inside a mountain. Since neutrinos can easily pass through anything, they will reach the detector while the other particles will be filtered out by the rock in the mountain.

The Neutrino Detector

The detector is called Iron Calorimeter (ICAL). It will consist of detectors called Resistive Plate Chamber (RPC) arranged in a stack of about 150 layers. Iron plates will fill the spaces between the layers. Over 30,000 RPCs will be used in this detector. A total of over 3.6 million channels will carry the electronic signals from these RPCs to be finally stored in a computer.

Current carrying coils through the detector will produce a magnetic field, magnetizing the entire detector. This is a massive detector weighing 50 ktons and would be the world's largest electromagnet.Just as a telescope observes the sky through visible light, the ICAL will observe the sky through neutrinos.