Abstract

Most models predict neutrinos to be produced in astrophysical sources such as Active Galactic Nuclei and Gamma Ray Bursts. Because of the very long baselines from these sources to the Earth a 1:1:1 flavor ratio is expected at the Earth. The IceCube Neutrino Observatory is a cubic kilometer Cherenkov detector, located deep within the Antarctic ice, built to detect all flavors of neutrinos. Unlike the two other neutrino flavors, tau neutrino background from atmospheric origin is negligible. The identification of a tau neutrino in IceCube would therefore be strong evidence for the existence of an astrophysical neutrino flux. From ca. the PeV energies, the tau lepton generated (in a charged current interaction) by the incoming tau neutrino can travel far enough before decaying for it to be distinguished from the other flavors. Depending on the energy and decay mode of the tau lepton and the interaction positions, tau neutrinos can lead to several different signatures in the detector. In 63% of tau neutrino charged current interactions, both the primary interaction and the subsequent tau lepton decay create two distinctive hadronic and/or electromagnetic cascades connected by the tau track. The case where both cascades occur within the detection volume is nicknamed a “Double Bang”. Recent results from the IceCube Collaboration show evidence of the presence of a flux of extraterrestrial neutrinos up to energies where tau neutrino detection via this signature would become feasible [1].

The distance between the two cascades versus the primary neutrino energy:

The energy range available for detecting a via this signature is determined by:

• Lower energy limit by the minimum distance between the two cascades to be able to separate them. As an initial guess this is taken to be 50 m.
• Upper energy limit by the detector dimensions.

Detection of Tau Neutrinos

Motivation: A 1:1:1 neutrino flavor ratio is expected at the Earth for astrophysical neutrinos. While the other two neutrino flavors suffer from background from atmospheric neutrinos, tau neutrino production in the atmosphere is negligible.

The charged current interaction of a with a nucleon leads to a hadronic cascade and the creation of a lepton (and equivalent for ):

\[
\nu_\tau + N \rightarrow \pi^+ + X
\]

After travelling a certain distance the lepton then decays, producing a second cascade or a muon:

\[
\pi^- \rightarrow \mu^- + \nu_\mu
\]

\[
\mu^- \rightarrow \nu_\mu + X
\]

Depending on the position of the interaction and the position and mode of the decay, the interaction of a can lead to several different signatures in the detector [3].

Conclusions

• Longer livetime and larger detector compared to previous tau neutrino results with IceCube [7].
• Expecting of the order of 1 “Double Bang” signal event per year with the assumed flux.
• A first series of cuts provide efficient background reduction, with about 7 order of magnitude for atmospheric muons.

Preliminary Results

On Monte Carlo simulations the remaining fluxes after these cuts are estimated for the signal and different backgrounds.

The following flux models were used:

- Atmospheric neutrinos (per flavor):
  - 1.2 \cdot 10^{-8} \text{E}^{-2} \text{GeV}^{-1} \text{cm}^{-2} \text{s}^{-1} \text{sr}^{-1} [1]
- Astrophysical neutrinos:
  - Gaisser H3a model [4]
- Atmospheric neutrinos:

References