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Neutrino absorption tomography with IceCube detector

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The neutrino absorption tomography, using neutrino as a probe of Earth's density profile, has been expected to give an independent observation of core density and core-mantle boundary.

Neutrinos are elementary particles that rarely interact with materials. Due to their small cross section, most of them penetrate through the Earth without leaving any trace of existence.

However, since the cross section increases as the neutrino energy increase, some of high-energy neutrinos are absorbed inside the Earth. This absorption probability directly depends on number of target nucleons, thus it is also sensitive to density profiles of targets.

The advantage of the neutrino tomography is direct measurement of matter density: while other geophysics techniques depend on convoluted effect of density, temperature and chemical structure.

Nevertheless, the neutrino absorption tomography had been a future project due to following reasons.

1) It requires high-intensity neutrino beam with energy over ~10TeV.

2) Must use large volume neutrino telescope(s) in order to detect reasonable amount of neutrinos which rarely interact inside the telescope volume.

For 1), using atmospheric neutrino is one of the practical solutions. It is challenging, however, because the energy flux over a few ten TeV is not measured well yet. Also the event rate at the required energy is much less than the one of energy below TeV, which results in a long-term measurement.

For 2), the project needs to use at least a kilometer scale telescope. Now we have only one solution: using IceCube detector completed in January 2011.

The IceCube neutrino telescope, deployed in the depths between 1500m and 2500m at the South Pole glacier ice, started operation from 2005 with 60 optical sensors attached on 1 detector-string.

The deployment carried out within summer season at South Pole and 15~20 strings are deployed in each season. Meanwhile at north hemi-sphere, obtained neutrino data were analyzed for searching extraterrestrial neutrinos or measuring atmospheric neutrino spectrum.

From season 2007 to 2008, with 22 strings and 40 strings respectively, approximately 20000 neutrinos were observed.

In this study, we analyzed the 2007 and 2008 neutrino data and compared them with Monte-Carlo simulations based on several Earth models.

Our simulation with the Preliminary Reference Earth Model represents the data within statistic errors. It is the first indication of neutrino deficit due to the Earth's core with neutrino absorption tomography.

We also present future expectation of this analysis with 10 years operation of full-size IceCube.

Systematic uncertainty from atmospheric neutrino flux, energy reconstruction, detector calibration, and bed-rock density will be discussed as well as ongoing plans to reduce these systematics.

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