A search for the extremely high energy cosmogenic neutrinos with the IceCube 2010-2011 data

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Search for Extremely High Energy Neutrino
- Extremely high energy (EHE) neutrinos (>10^17 GeV) generated from EHE cosmic rays (EHECRs)
- Can shed light on the origin of EHECRs
- The expected EHE neutrino rate is low: 1 event/year/km^3
- Major background is atmospheric muons

The IceCube Detector
- Deployed in the Antarctica glacier
- In-ice + IceTop + DeepCore
- 86 strings (completed at the end of 2010)
- ~5,000 Digital Optical Modules (DOM)
- Detector volume: ~1 km^3
- make the EHE cosmogenic neutrino search possible

The results based on data taken in 2010/5/31-2011/05/13 (319.2 days) with 79 strings configuration are presented here

Search Principle
The zenith angle and energy information is used in order to separate neutrino signals from backgrounds

- EHE cosmogenic neutrino (GZK) signal (all flavor)
- The integral number of photo-electrons (NPE) observed by each optical module for an event is used as the energy estimator in this analysis
- Correlated with energy
- Robust (low energy event can not produce high NPE)
- The NPE distributions are shown at right. As seen from the plot, the GZK signals have high NPE value compared to the background.

Energy estimator
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Zenith Angle Reconstruction
The zenith angle of events can be used to separate signal from background.
- Coincident events
- Corner clipping events
- In order to reconstruct / remove those events, several method were developed and performed.

- Isolated DOM cleaning
- Maximum log-likelihood reconstruction based on a track hypothesis (SPE with 12 iterations (SPE12))
- Quality of reduced log-likelihood value of SPE12

The isolated DOM cleaning removes DOMs that do not have additional hits within a certain radius (150m) and time range (1 µs). This cleaning is useful to keep the larger event in a coincident event.

Results and Outlook
The effective area and the sensitivity with the final selection criteria are shown below.

- The expected event rate for each model is listed in a right table.
- After the final selection criteria were optimized, the full data of year 2010-2011 was searched. There found no event above the selection criteria. However, a similar analysis conducted on data taken in 2011-2012 with the complete IceCube detector configuration found two events that passed all the selection. We are intensively investigating the two events. A talk for the analysis is scheduled today afternoon in session 19.

- The IceCube detector is capable of detecting EHE cosmogenic neutrinos and most of GZK models will be tested within a few years.

References