Improving reconstruction of GeV-scale neutrinos in IceCube-DeepCore by direct event simulation
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The IceCube Detector

- Instrumented cubic-km of deep glacier at South Pole Station, Antarctica
- Designed to detect ~TeV to PeV astrophysical neutrinos
- Denser infill array, DeepCore, extends high sensitivity down to ~5 to 100 GeV neutrinos

Digital Optical Module (DOM)

Event Reconstruction Challenges

- Detected charge amplitude and timing from Cherenkov photons form the signal

High energy event displays: ~1 PeV cascade-type (left) and ~ 340 TeV muon-type (right)

Low energy event displays: 30 GeV cascade-type (left) and 30 GeV muon-type (right)

- Often only O(10) photo-electrons (pe) for neutrinos of O(10) GeV, compared to O(10000) pe for the PeV-scale
- Modelling details are critical with so few photons available per low-energy event

Zenith resolution

Energy resolution

- Evaluation of ~4000 final level analysis MC events
- Energy range: generated from 1 GeV to 1 TeV, with most events in the 1 to 100 GeV range
- Mean time: O(100) seconds
- Significant potential to improve resolution
- Optimization is underway!

Motivation

- ‘Photon look-up tables’ characterize propagation through ice
- Currently rely on pre-generated templates describing photon detection probabilities in a given layer/region

Photon look-up tables for muon: 2D slice (left) and 1D slice (below)

- The most advanced ice models are too complex to be implemented via this method

- Key: replace look-up tables with real-time event simulation
- Event hypotheses are re-simulated to reduce statistical fluctuation
- Expected and observed charge are compared via a likelihood calculation
- A modified Poisson likelihood is used to account for limited statistics of the prediction

Summary: combines accurate photon prediction for choice of advanced ice models with highly optimized, existing software

DirectReco

References