PROCEEDINGS OF SCIENCE

Search for heavy neutral lepton production and decay with the IceCube Neutrino Observatory

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Searching for HNLs with IceCube is soooooo much fun..

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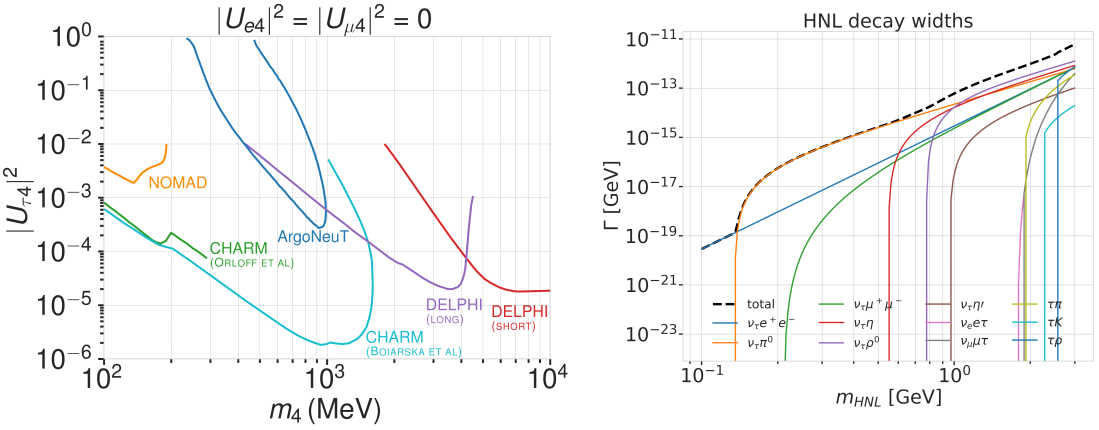

Figure 1: Current $|U^2_{\tau 4}|$ limits (left) from NOMAD [1], ArgoNeut [2], CHARM [3, 4], and DELPHI [5] and decay widths of visible decay modes in IceCube (right) calculated based on the results from [6].

1. Introduction

- Motivate the search for (heavy) sterile neutrinos
- Cite the relevant papers

2. IceCube DeepCore

The IceCube Neutrino Observatory [7] is located at the geographic South Pole and consists of 5160 Digital Optical Modules (DOMs), deployed into the antarctic glacial ice at depths between 1.45 km and 2.45 km. It is an ice Cherenkov telescope instrumenting a volume of about 1 km^3. The ice is used as interaction and detection medium, simultaneously, where interacting neutrinos can produce charged secondary particles, which themselves can emit Cherenkov photons detectable by the DOMs. The DOMs are arranged on a nearly-hexagonal array, as shown in Figure 2, with 125 m horizontal and 17 m vertical spacing in IceCube and a closer 42-72 m horizontal of 7 m vertical spacing in the denser, bottom-center part of the array, called DeepCore [8]. While IceCube targets the detection of astrophysical neutrinos with energies above ~100 GeV, DeepCore can measure neutrino interactions down to a few GeV, due to its closer spacing in regions with very good optical properties of the ice. This allows the measurement of atmospheric neutrino oscillations that occur mainly occur in the 10-50 GeV region. The location of DeepCore is also indicated in Figure 2, which also shows the absorption properties of the ice with respect to depth.

The two observable, low energy event topologies in IceCube DeepCore are *tracks* and *cascades*. Tracks are elongated light emission patterns, produced by long-lived muons, mainly originating from ν_μ CC interactions or cosmic ray air showers, with a subdominant component from ν_τ CC interactions (BR of $\tau \to \mu \sim 17\%$ [9]). Cascades are roughly point-like, spherical light emissions, produced by electromagnetic and hadronic showers. They are produced by ν_e and most ν_τ CC interactions, as well as NC interactions of all flavours.

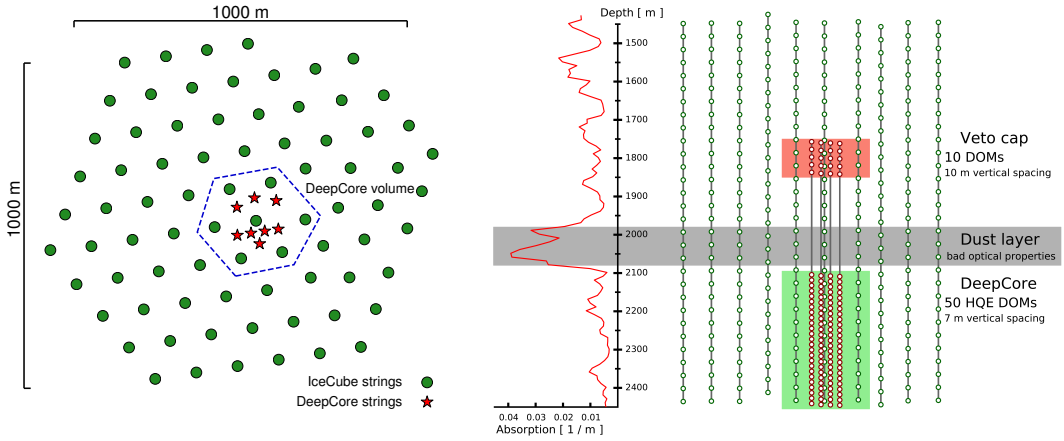

Figure 2: Top (left) and side (right) view of the IceCube and DeepCore array. The side view also shows the ice absorption at different depths.

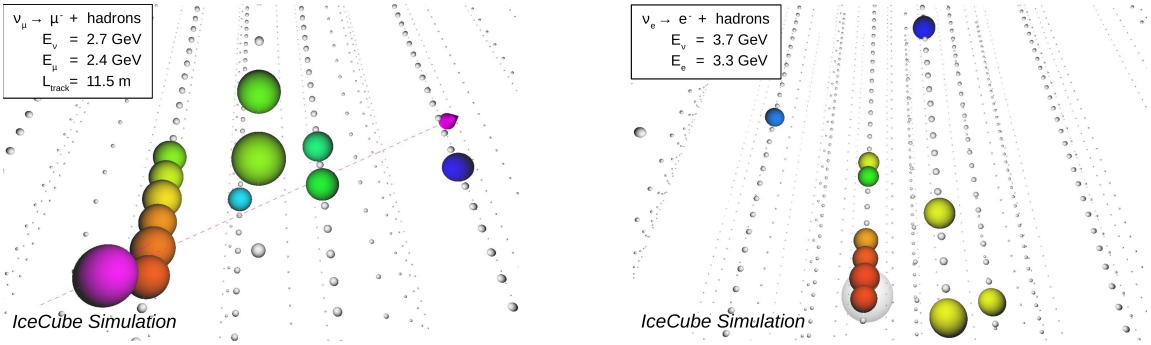

Figure 3: Example of low energy event topologies in IceCube DeepCore. The color of the spheres indicates the arrival time of the photons while its size is relative to the number of photons that were detected.

3. Neutrino Oscillations

- mass/flavor mixing
- testable phase space (ennergy/zenith)
- 10 year data sample + rates
- IC/DC oscillation results (OVS, hight stats prediction)

4. Heavy neutral lepton search

- model details
- double cascade signatures (up scattering, decay (decay modes))
- low energy event signature (double cascade)

- nutau detection channel (mass-energy-mixing-decay length relation)
- issues/takeaways
- envisioned analysis principle

References

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[8] IceCube collaboration, *The Design and Performance of IceCube DeepCore*, *Astropart. Phys.* **35** (2012) 615 [1109.6096].

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