Search for Light Sterile Neutrinos With Eight Years of IceCube Data

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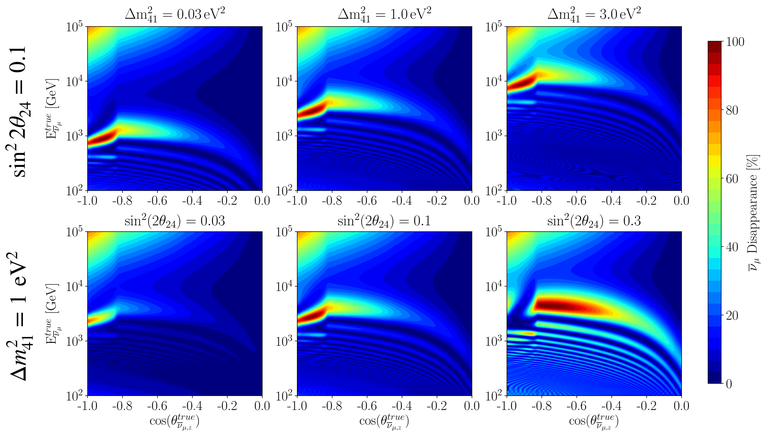
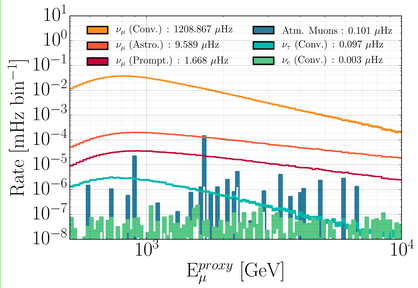
Sterile neutrino signature: flavor change at TeV energies



In the presence of an eV scale sterile, neutrino matter effects will induce large sterile to active transitions for antineutrinos at TeV energies.

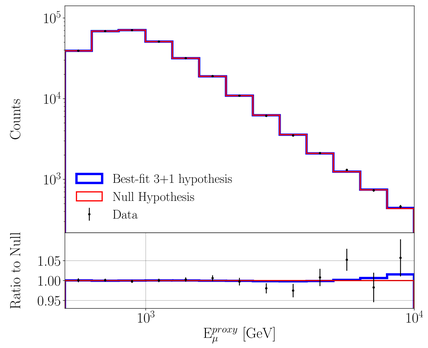
Event selection: ~ 300 000 muon neutrinos!



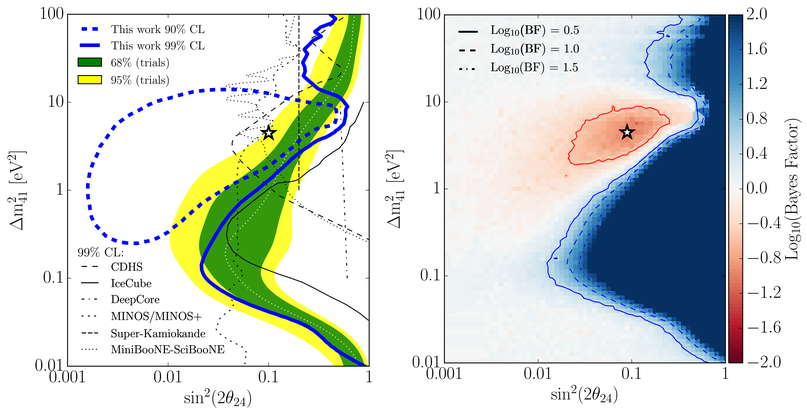
Component	Full Sample Composition
Conv. ν_μ	315,214±561
Astro ν_μ	2,350±48
Prompt. ν_μ	481±22
All ν_τ	23±5
All ν_e	1±1
Atmospheric μ	18±4
Purity	>99.9%

Expected composition of the sample.

High-purity event selection contains more than 99% muon neutrino deep inelastic scattering events.



Parameter constraints: Frequentist and Bayesian



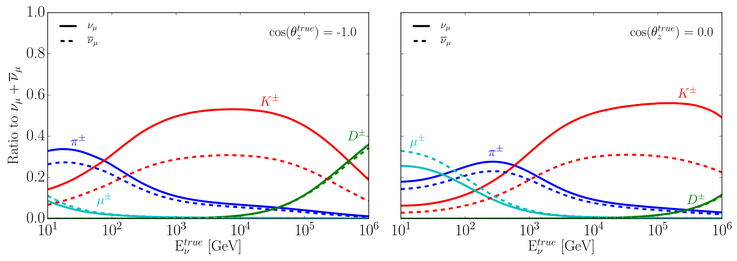
Improved constraints for mass squared differences below 1eV^2. Preferred region at higher masses, but not significant.

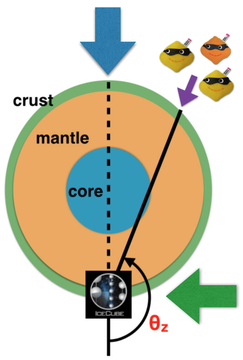
The null hypothesis is rejected with an 8% p-value.

Connection to the mixing angles: terms in **red** are constrained by this analysis, those in **green** by ν_e disappearance experiments, *e.g.* reactor, & **blue** is appearance, *e.g.* LSND/MB:

$$\sin^2 2\theta_{ee} = \sin^2 2\theta_{14}$$
$$\sin^2 2\theta_{\mu\mu} = 4\cos^2\theta_{14}\sin^2\theta_{24}(1-\cos^2\theta_{14}\sin^2\theta_{24})$$
$$\sin^2 2\theta_{\mu e} = \sin^2 2\theta_{14}\sin^2\theta_{24}$$
$$\sin^2 2\theta_{e\tau} = \sin^2 2\theta_{14}\cos^2 2\theta_{24}\sin^2\theta_{34}$$
$$\sin^2 2\theta_{\mu\tau} = \sin^2 2\theta_{24}\cos^4\theta_{14}\sin^2\theta_{34}$$

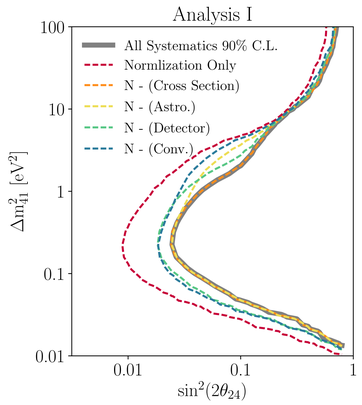
Atmospheric neutrinos





Neutrinos are produced in cosmic-rays showers throughout the Earth's atmosphere. They travel through the Earth layers on their way to IceCube they can experience flavors conversion.

Sources of uncertainty



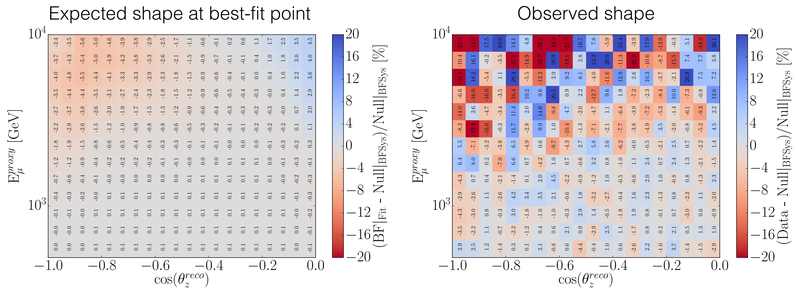
Impact on the analysis sensitivity when removing any of the systematic categories one at a time.

Five different sources of uncertainty considered in this analysis:

- Atmospheric neutrino fluxes: considered uncertainties in the cosmic-ray spectrum and hadronic interaction models that produce relevant mesons.
- Astrophysical neutrino fluxes: assume a single unbroken power-law compatible with other IceCube measurements.
- Bulk ice: allow for variations of ice layers within in-situ measurements
- Detector response and local ice effects: incorporates new parameterization of PMT response.
- Neutrino cross sections: study impact in detection and Earth transport.

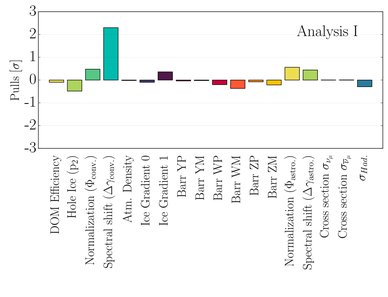
Statistical analysis uses a binned likelihood with nuisance parameters. Likelihood used is a modified Poisson likelihood to account for Monte Carlo errors.

A closer look at the best-fit point



- Best-fit point found at $\Delta m^2_{41} = 4.5\ \mathrm{eV}^2$ and $\sin^2 2\theta_{24} = 0.1$.
- Robust feature under the removal of:
  - Any year of data and
  - Any group of systematics.
- Similar parameter point found when studying any year independently

Nuisance parameters pulls at best-fit point



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References

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