Neutrino flavor composition using High Energy Starting Events with IceCube

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The IceCube Neutrino Observatory

- Km^3 telescope that detects high-energy neutrinos via Cherenkov light at the South Pole [1]

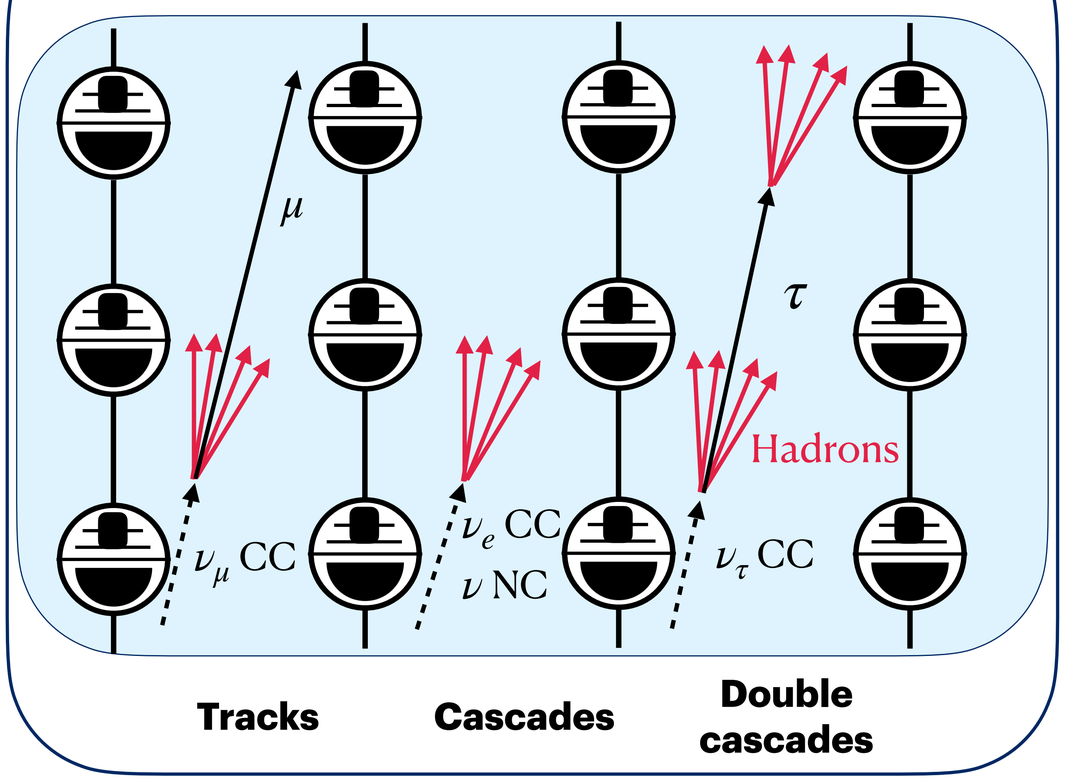
High Energy Starting Event Sample

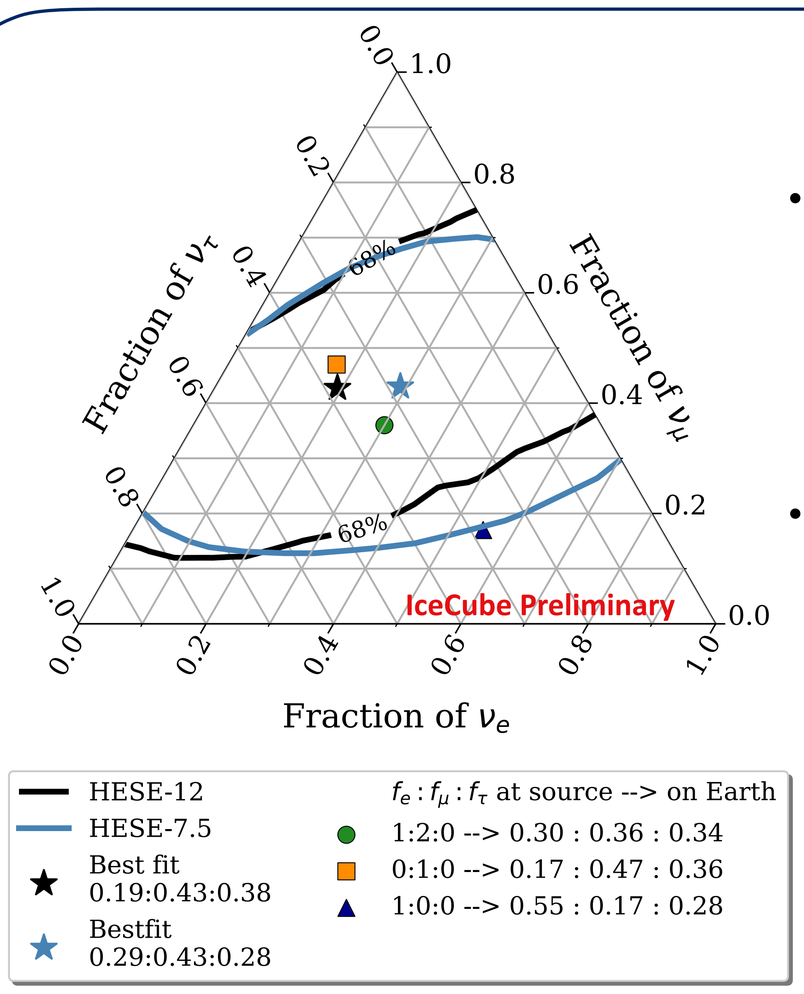
- Events with $E_{\mathrm{tot}} > 60$ TeV and interaction vertex inside the detector [2]
- Sensitive to all neutrino flavors via tracks, cascades and double cascades

Flavour composition

- Constrains neutrino production mechanism
- Probe for new physics

Detection signatures



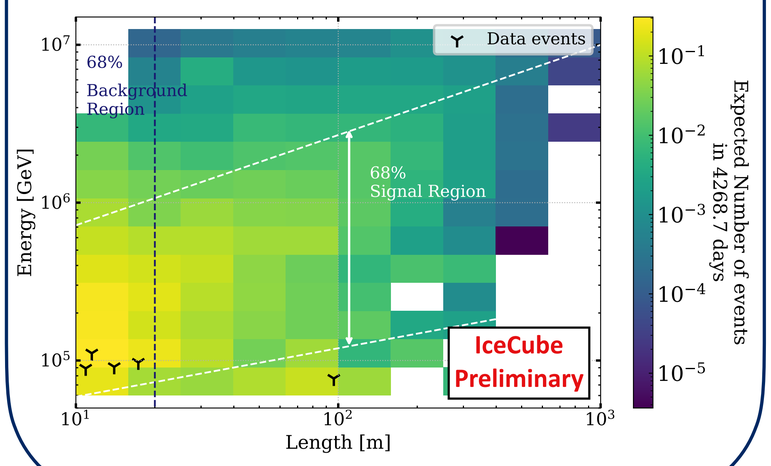


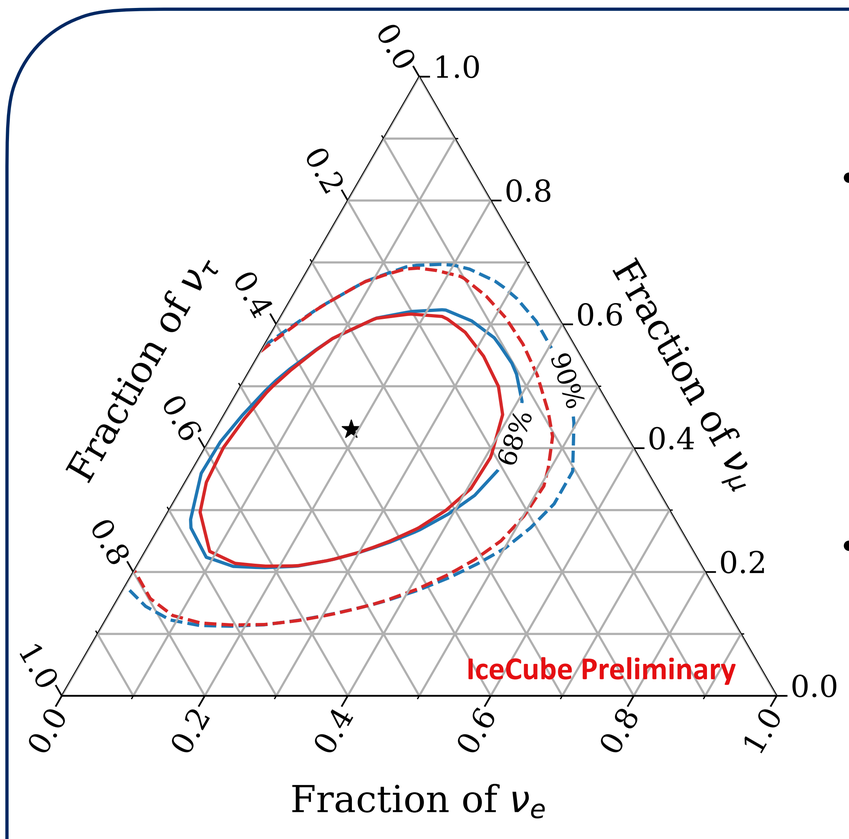
Flavor composition measurement

- 12 years of HESE data
  - 64 cascades
  - 28 tracks
  - 5 double cascades
- Flavor composition, flux normalization and spectral index consistent with previous results [3]

Double cascade candidates

- 4 of 5 events reconstructed length < 17 m
  —> 68% background region
- Event with 96 m length consistent with misclassified muon



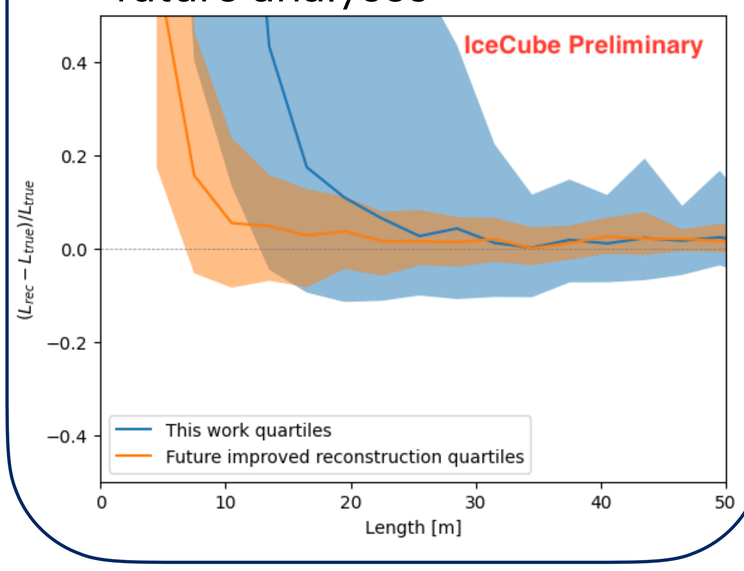


Analysis improvements

- Sensitivity improved by 10% using fewer bins in a summary statistic optimized by a neural network [4]
- Further improvements from new particle identification using BDT [5], and combining HESE sample with cascade [6] and track [7] sample

Tau reconstruction improvements

- Optimized fit starting point led to improved tau length resolution
  —> Enhance flavor composition sensitivity in future analyses



References

[1] IceCube Coll., JINST 12, P03012 (2017), [arXiv:1612.05093]
[2] IceCube Coll., Phys. Rev. D 104, 022002 (2021), [arXiv:2011.03545]
[3] IceCube Coll., Eur. Phys. J. C 82, 1031 (2022), [arXiv:2203.07915]
[4] O. Janik (IceCube Coll.), PoS ICRC (2025) 1132
[5] Z. Chen (IceCube Coll.), PoS ICRC (2025) 1011
[6] IceCube Coll., Phys. Rev. Lett. 125, 121104 (2020), [arXiv:2001.09520]
[7] IceCube Coll., Astrophys. J. 928, 50 (2022), [arXiv:2111.10299]

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