Search for Solar Atmospheric Neutrinos with 9 Years of IceCube Data

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for the IceCube Collaboration

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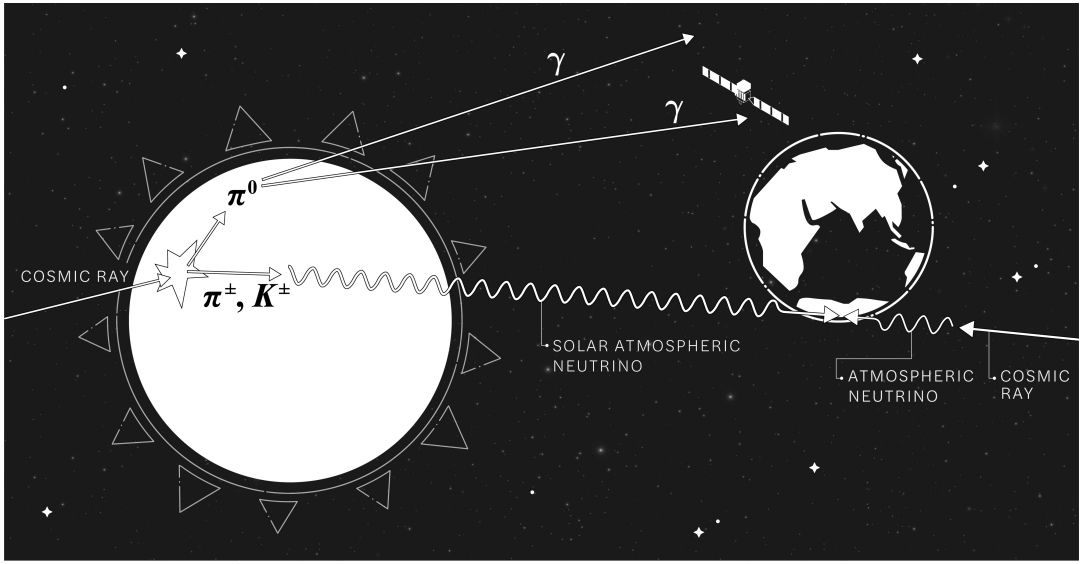
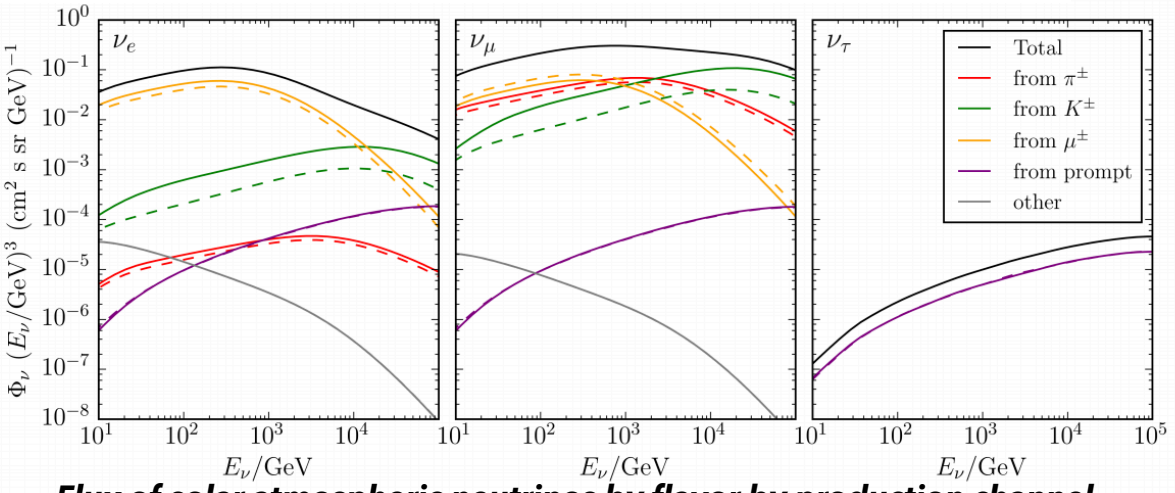
Motivation

- Solar atmospheric neutrinos are produced by cosmic-rays interacting with solar matter
- Energy spectrum falls off with $\sim E^{-3}$
- Previous IceCube analysis (https://arxiv.org/abs/1912.13135) set limits on normalization of nominal spectrum at 12.6 × nominal value



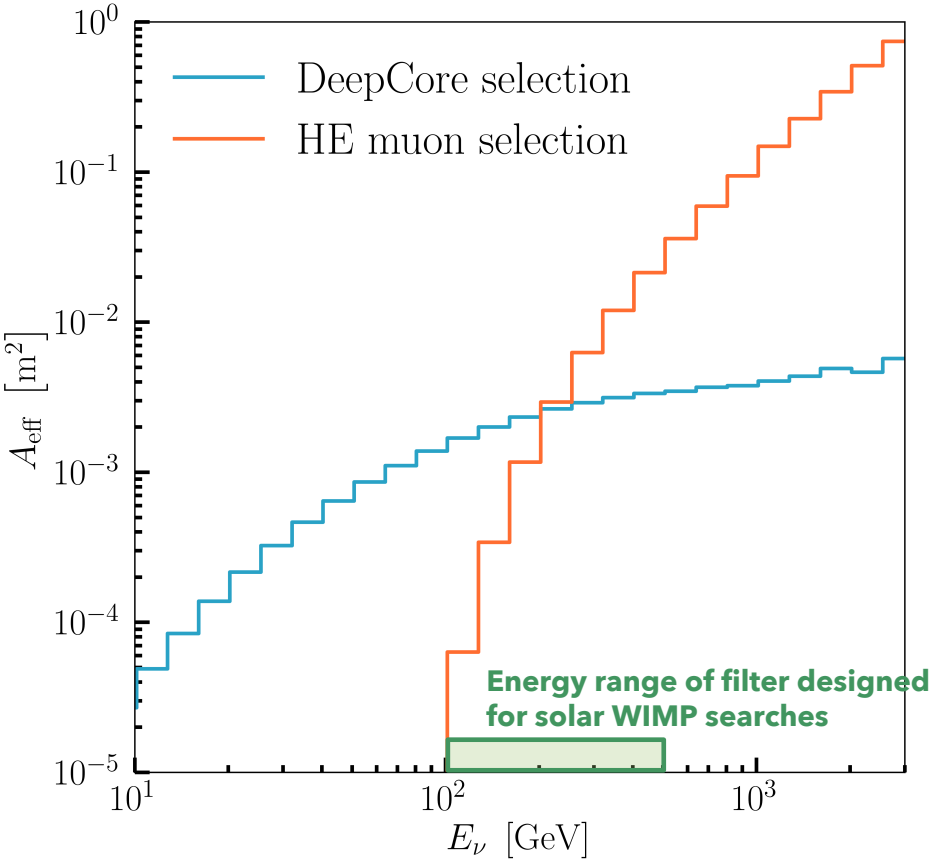
• CARTOON OF SOLAR ATMOSPHERIC NEUTRINO PRODUCTION •

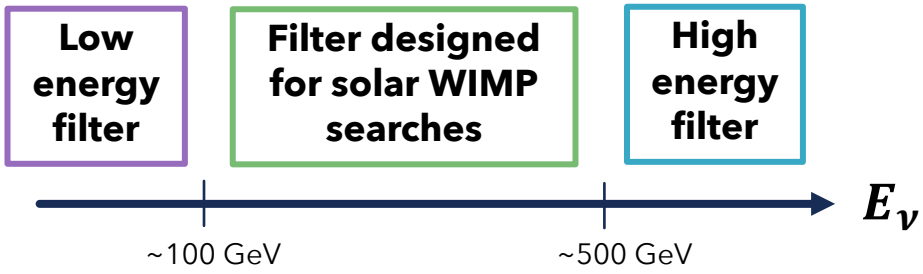


Flux of solar atmospheric neutrinos by flavor by production channel. https://arxiv.org/pdf/1703.07798.pdf.

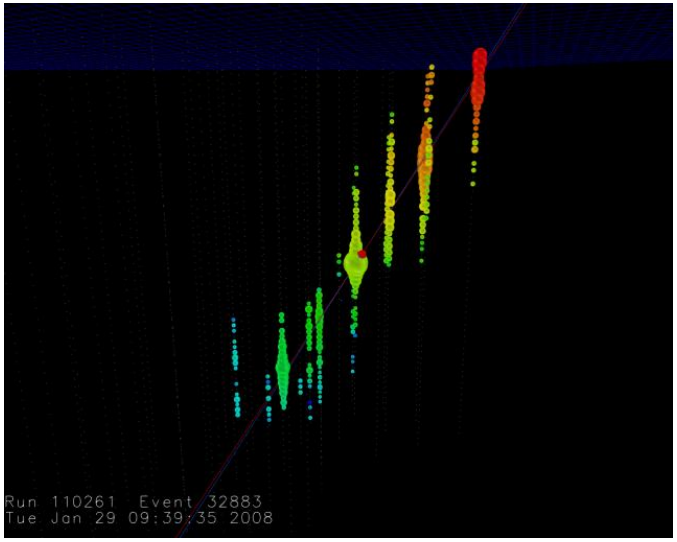
Optimized event selection

- Soft spectrum of solar atmospheric neutrinos (a background for solar WIMP searches) means event selection must account for this energy range
- **Our new event selection allows us to probe this mid-energy range, an improvement on existing event selections**

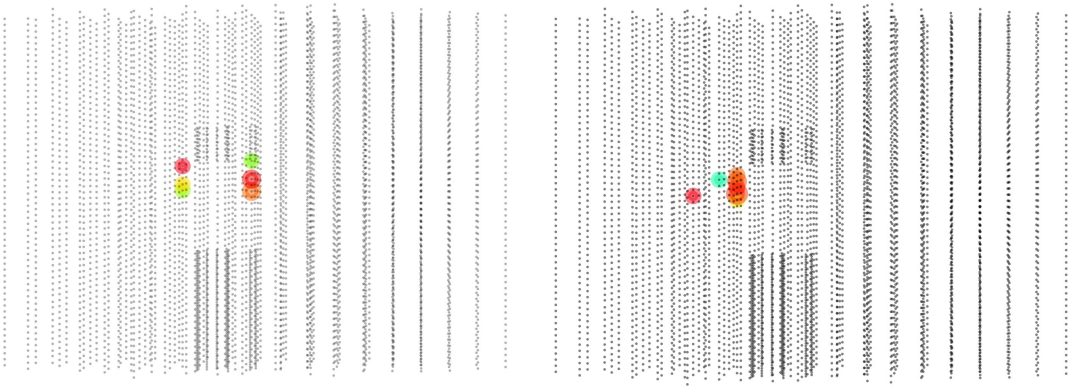




Challenges of low-energy optimization



Example of a high-energy track.
Source: *IceCube Gallery.*



Example of a 200 GeV muon track.

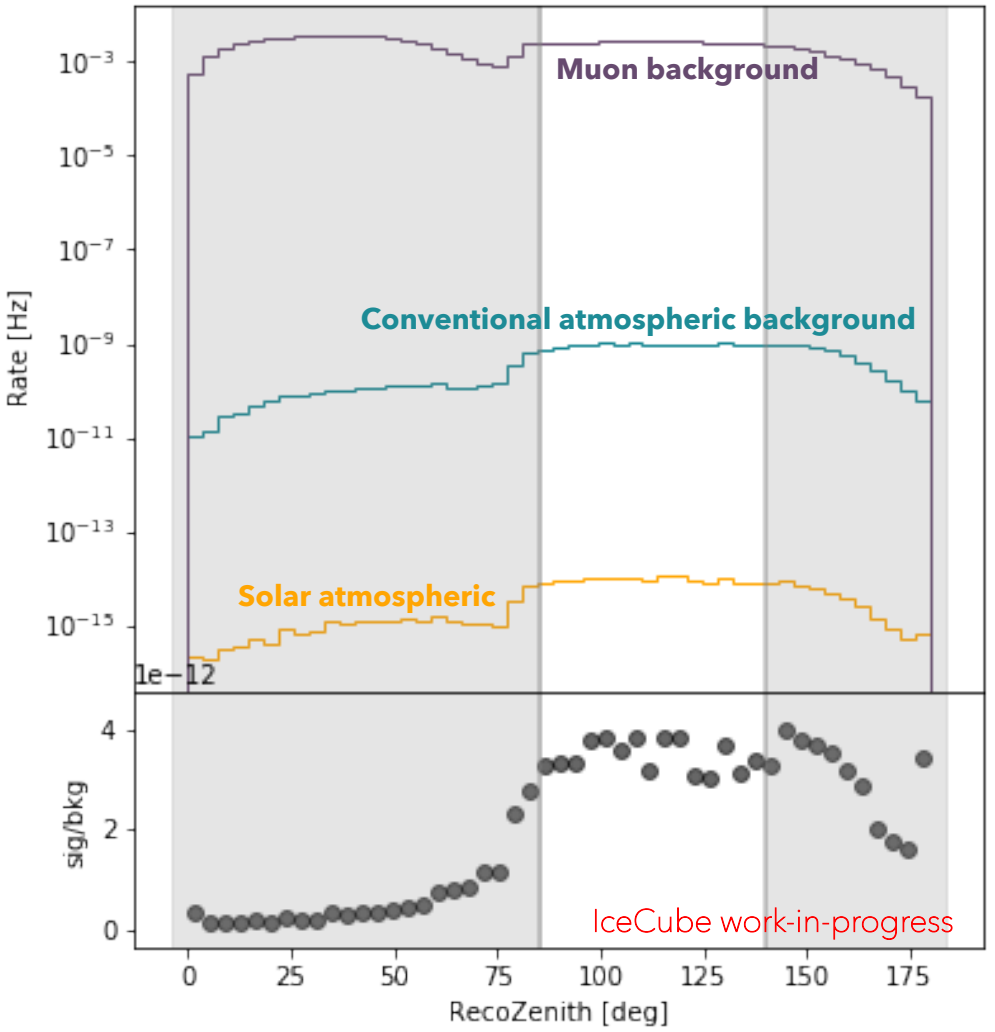
Example of a 200 GeV electron cascade.

- Previous analysis only used high-energy tracks (muon neutrino dominated)
- Our MC simulations include:
  - High-energy tracks (~1 TeV) and are track-like
  - Low- and mid-range energy tracks/low energy cascades **which include all flavors**
    - Angular resolution is poorer anyway, so might as well include all flavors
    - Cascade background 10x lower than tracks

Status of event selection

- We've combined low- and high-energy Monte Carlo samples from previously existing simulation toolkits
- Currently verifying low-level background exclusion cuts by investigating cuts from previous analysis

Example low-level cut: Reconstructed Zenith Angle between 85° and 140°.



Need to reduce background by 10^{12}

Next steps and acknowledgements

- Low-level cuts:
  - Tune cuts to numbers optimized for this new event selection
  - Investigate how cuts effect signal purity
- Beyond:
  - Build a Boosted Decision Tree capable of filtering out additional background to further purify solar atmospheric signal
  - Optimize BDT through appropriate choices of boosting methods/hyperparameters

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