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Constraints on Sterile Neutrino Mixing from IceCube

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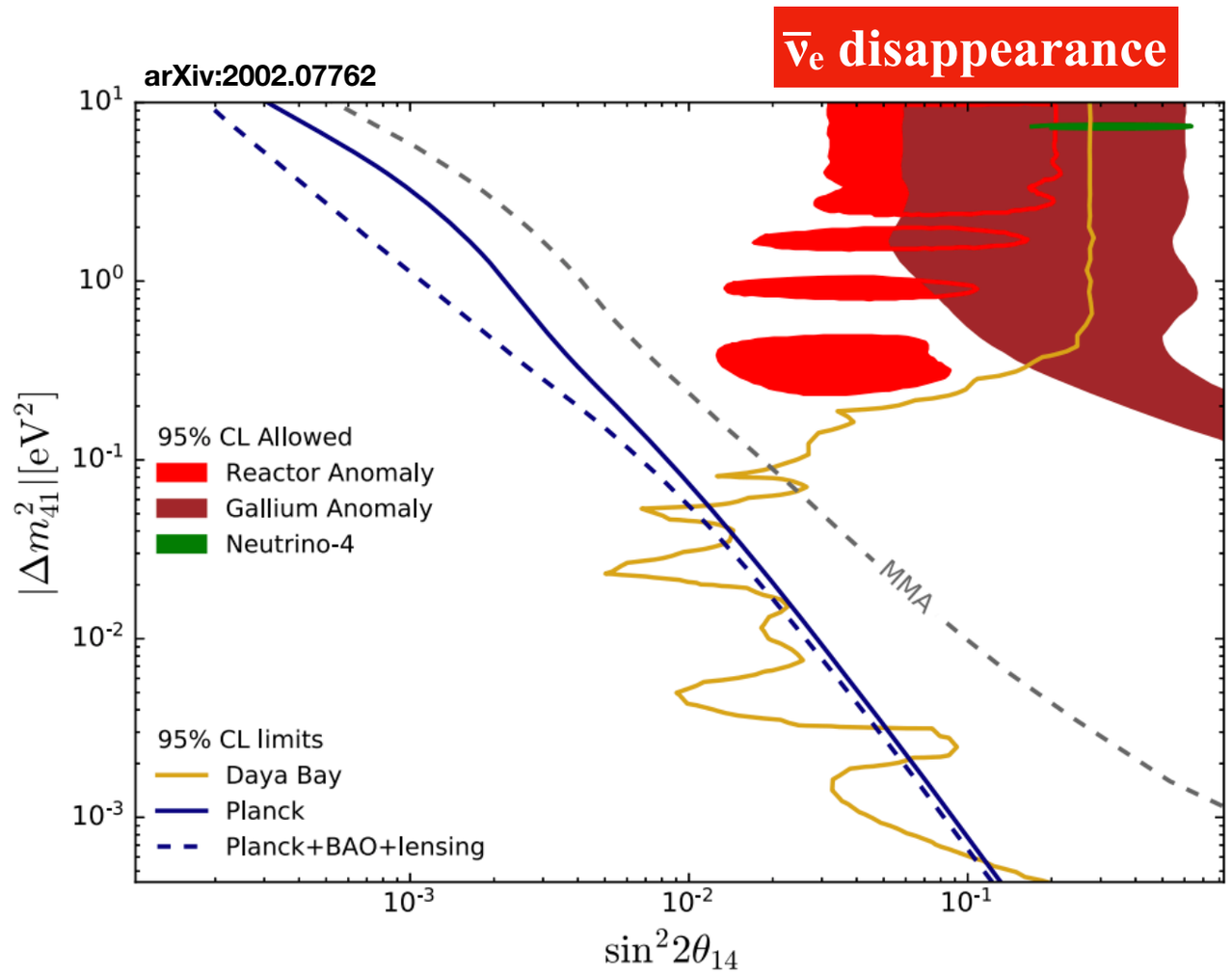
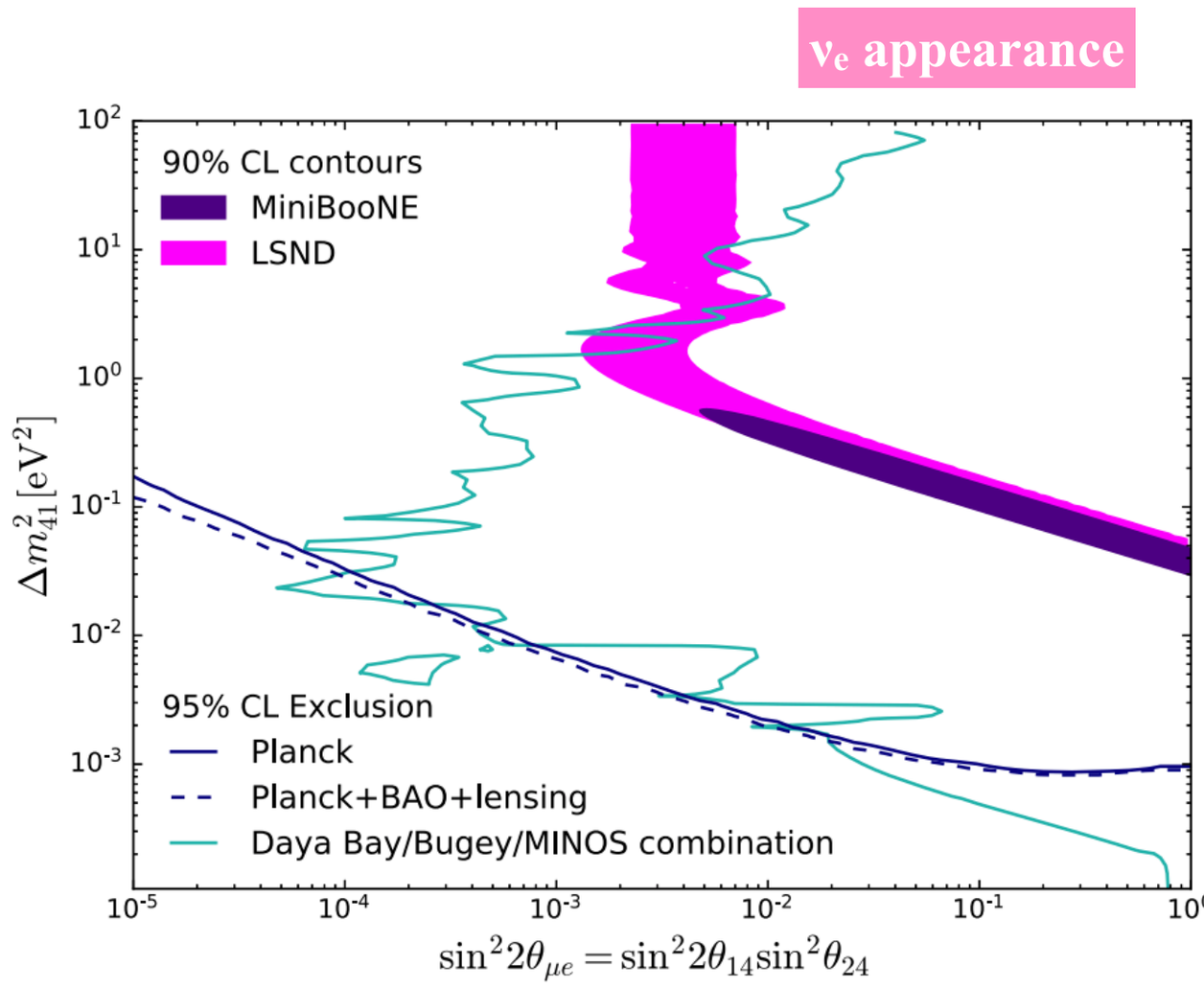
3+1 puzzle

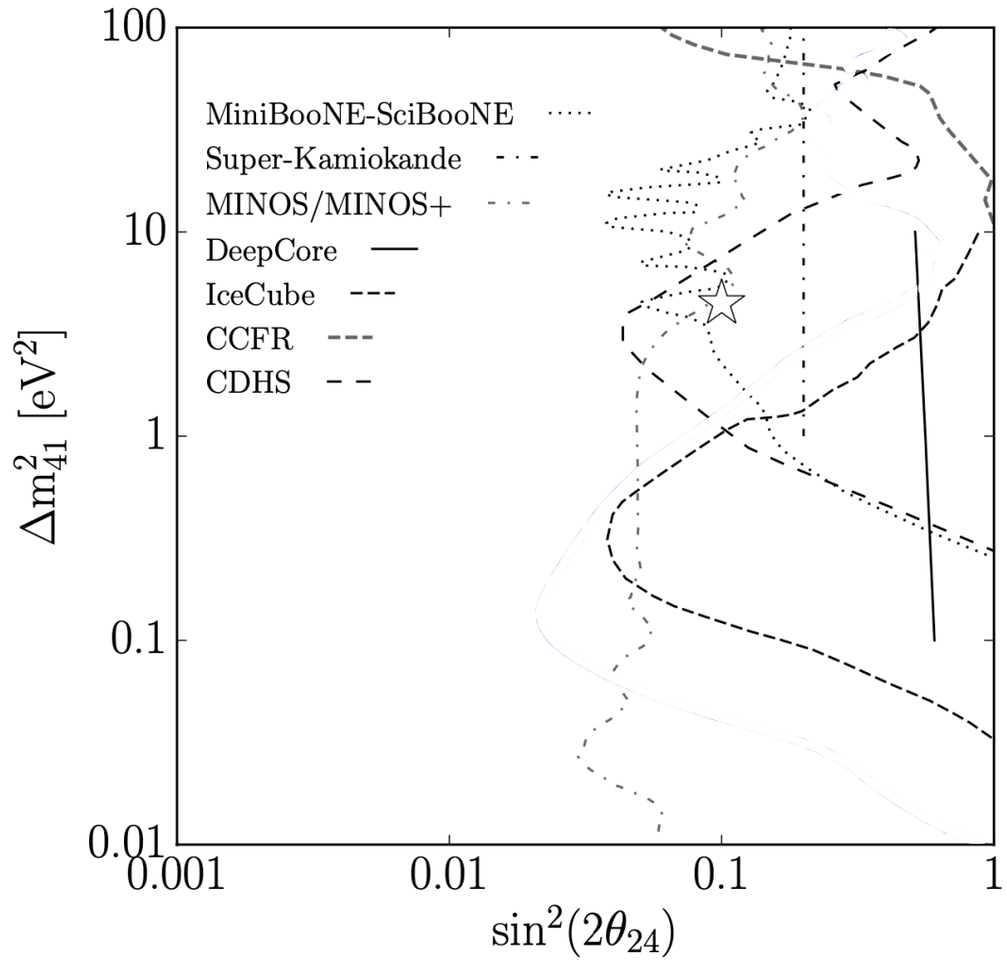
- Appearance and disappearance anomalies not explain with SM oscillations.
- 3+1 model fits well but point to different regions of the phase space.
- Other measurements are in tension with results from anomalies.





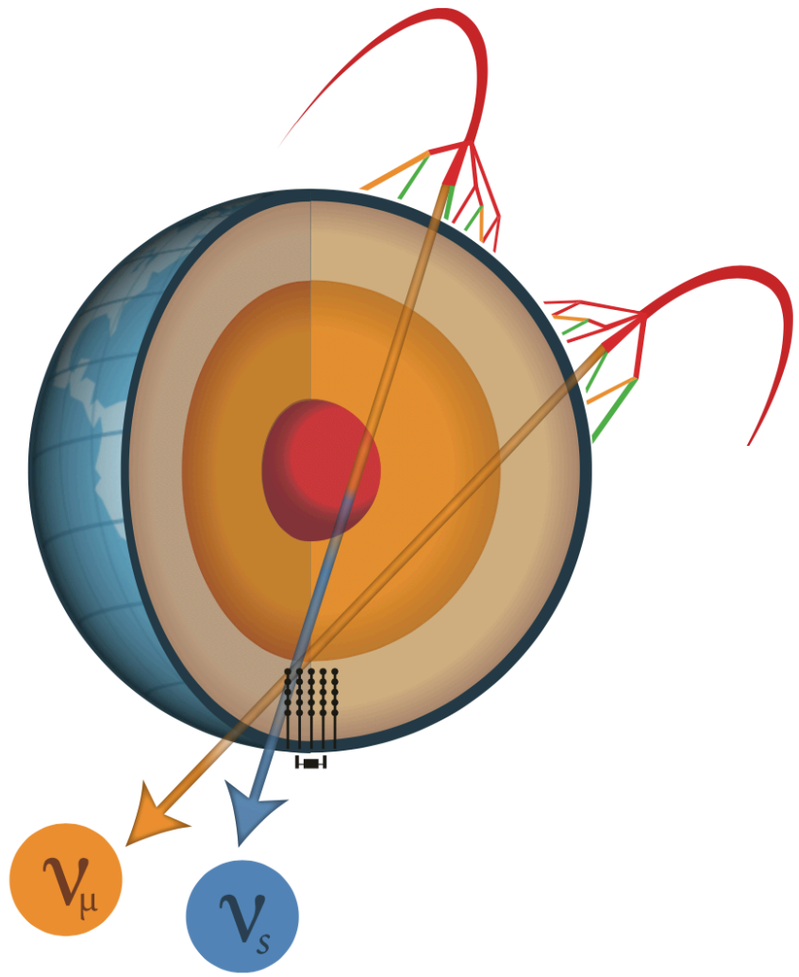
ν_μ disappearance in 3+1 model

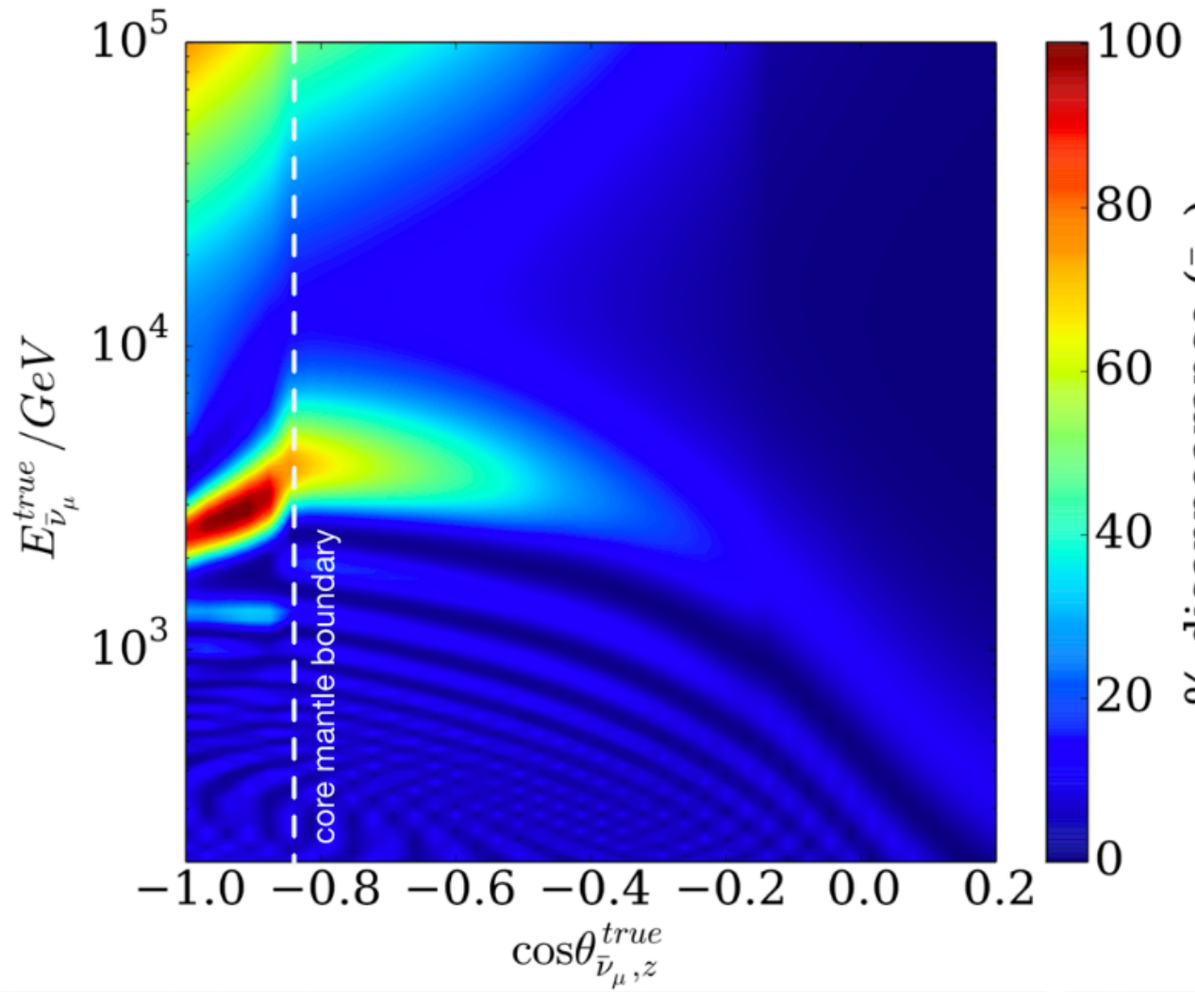
- Atmospheric neutrinos:
  - Oscillation pattern change at few GeV for neutrinos crossing the Core.
- Accelerators:
  - Event rate deficits expected in the near and far detectors.
- No anomalies have been observed in this channel.



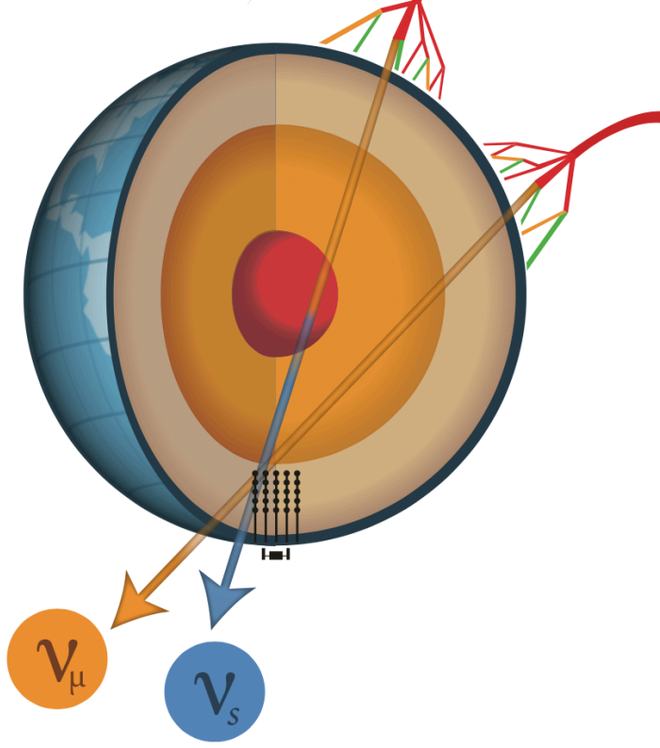
Where can we improve?

- Novel analysis from IceCube using ν_μ at ~TeV energies.
- Resonant disappearance is expected for $\bar{\nu}_\mu$ crossing the Earth core when sterile neutrino is present.

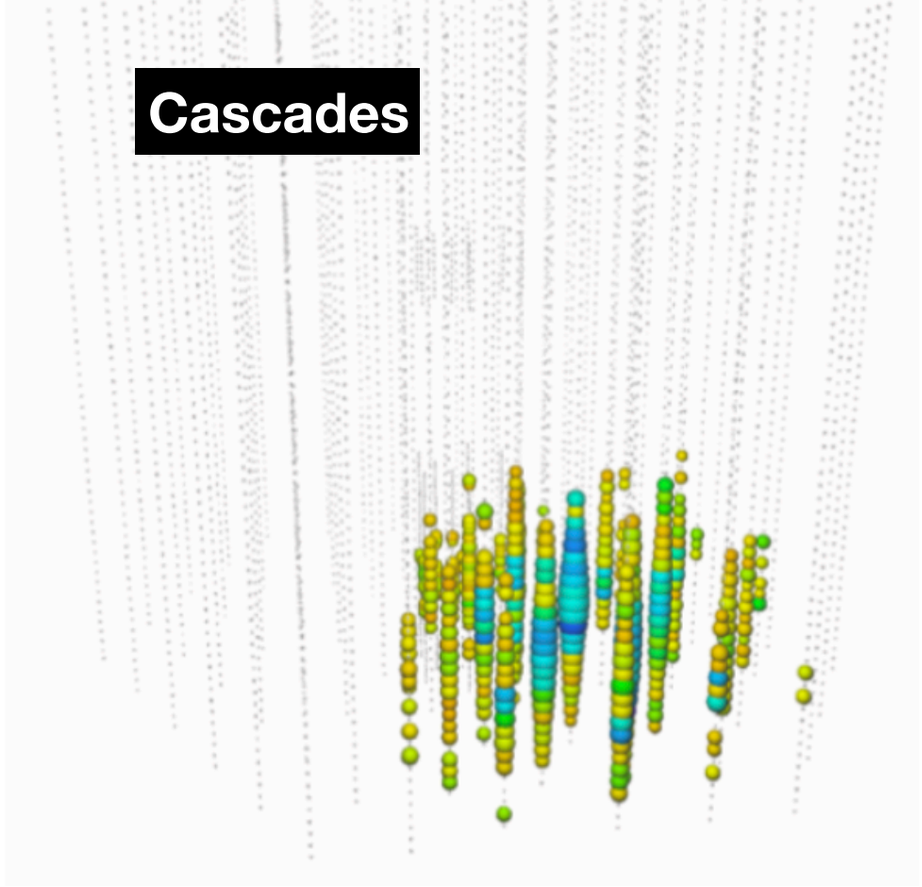


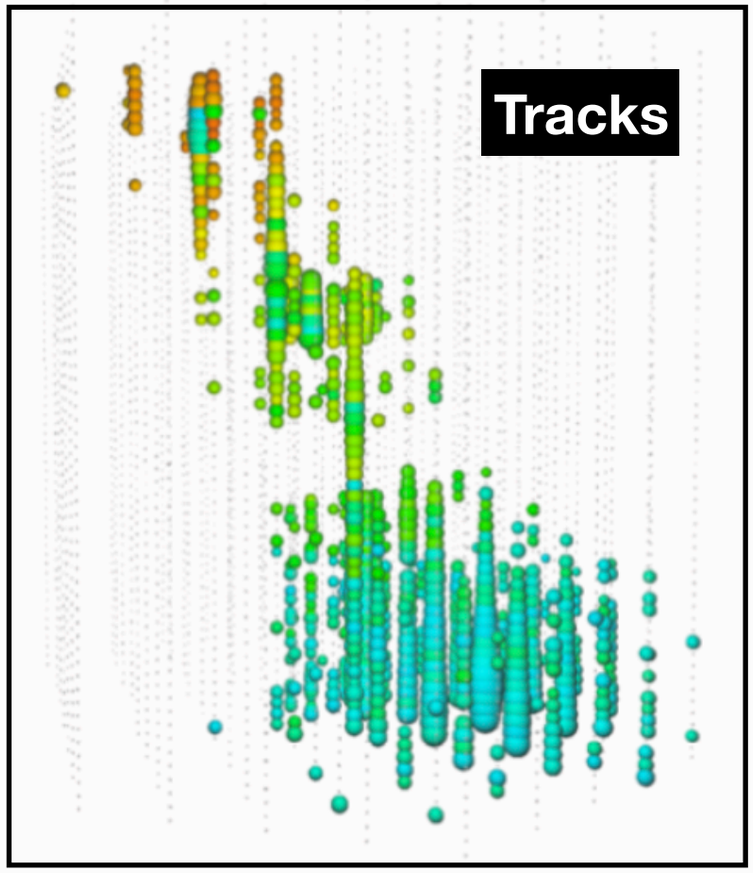


Analysis strategy



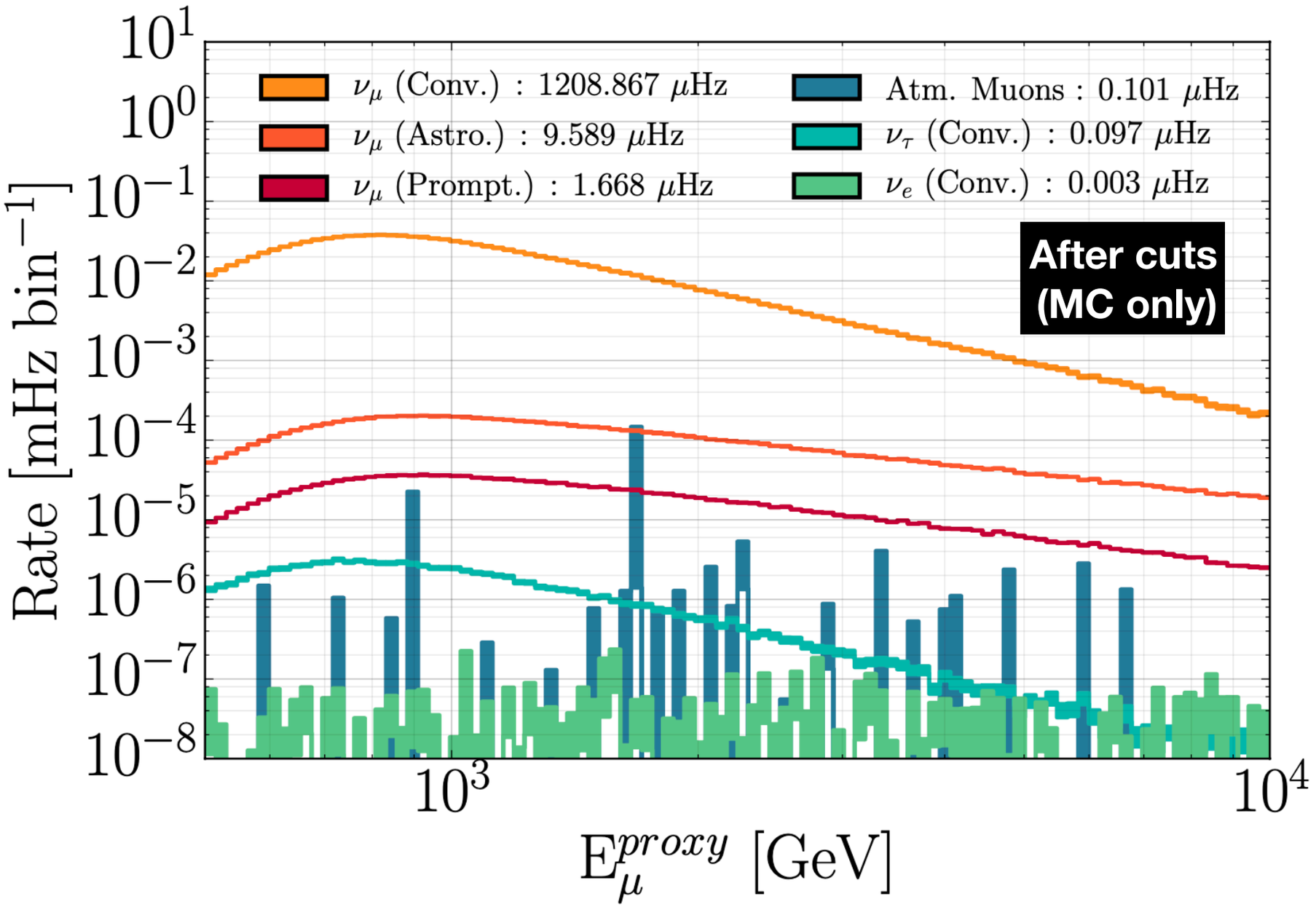
- ν_μ crossing the core of the Earth in the TeV regime.
  - Look for up-going track-like patterns.
  - The earth acts as a shield to block atmospheric muons.
  - Other neutrinos look very different in the interaction volume.





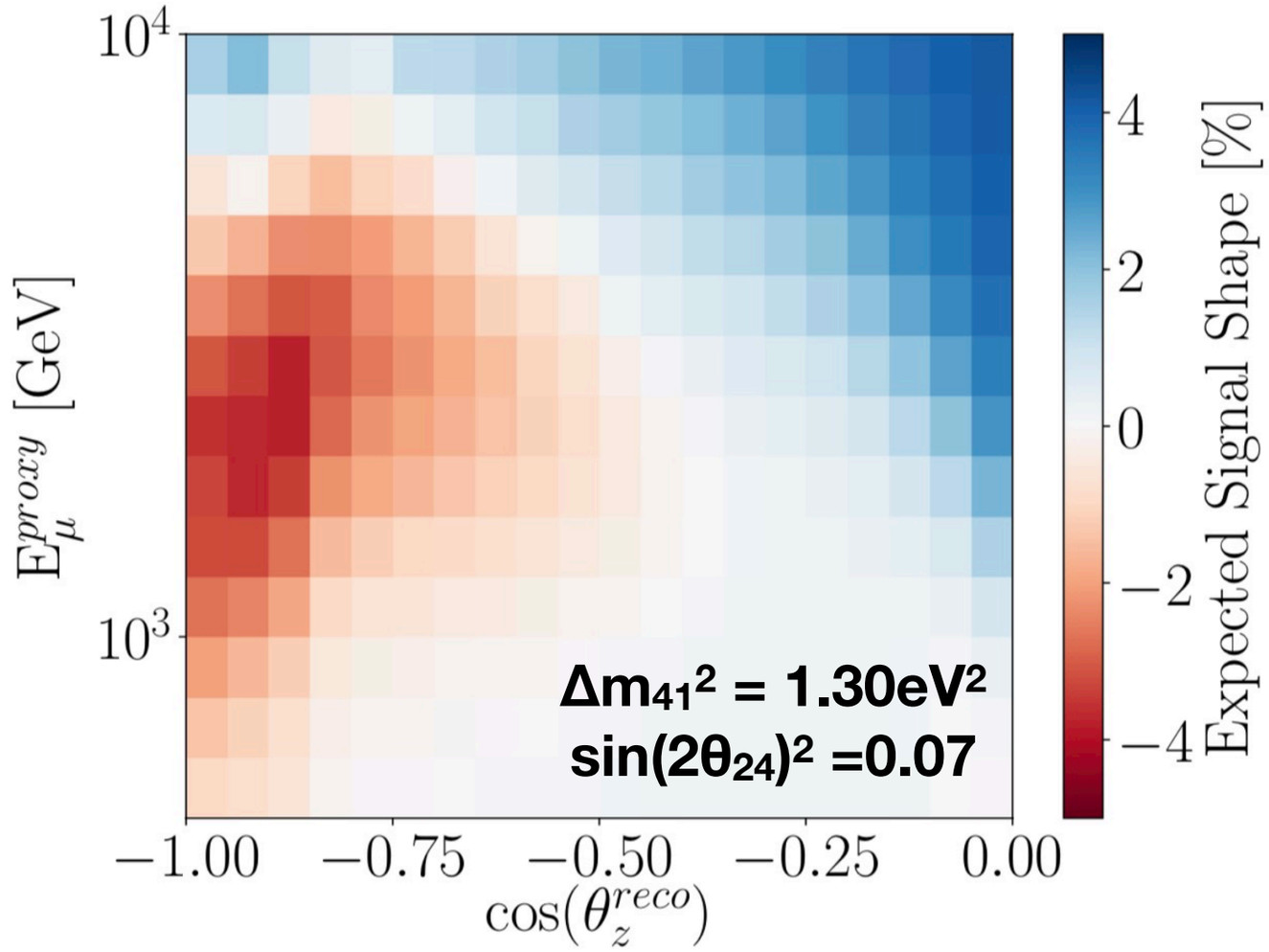
Event selection

- Tight cuts to reduce atmospheric muon contamination.
- Thousands of tracks every year with $\nu_\mu/\bar{\nu}_\mu$ purity >99.9%!



Main limitations

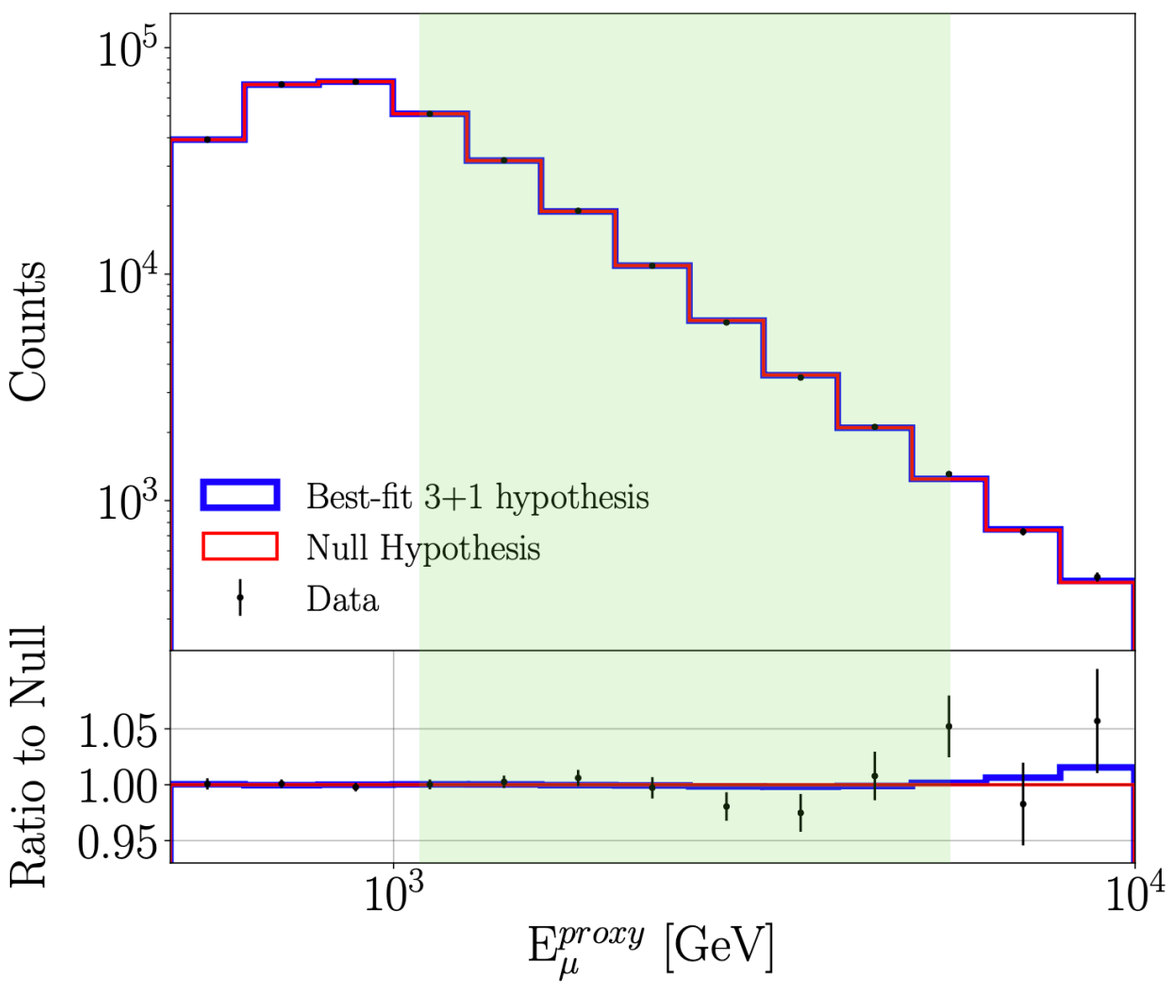
- Can not distinguish $\nu_\mu/\bar{\nu}_\mu$ -> resonant effect is reduced.
- Energy of the neutrino is not directly observable (most of events outside volume).
- Many systematics (atm+cosmic neutrino flux, detector eff., cross sections).

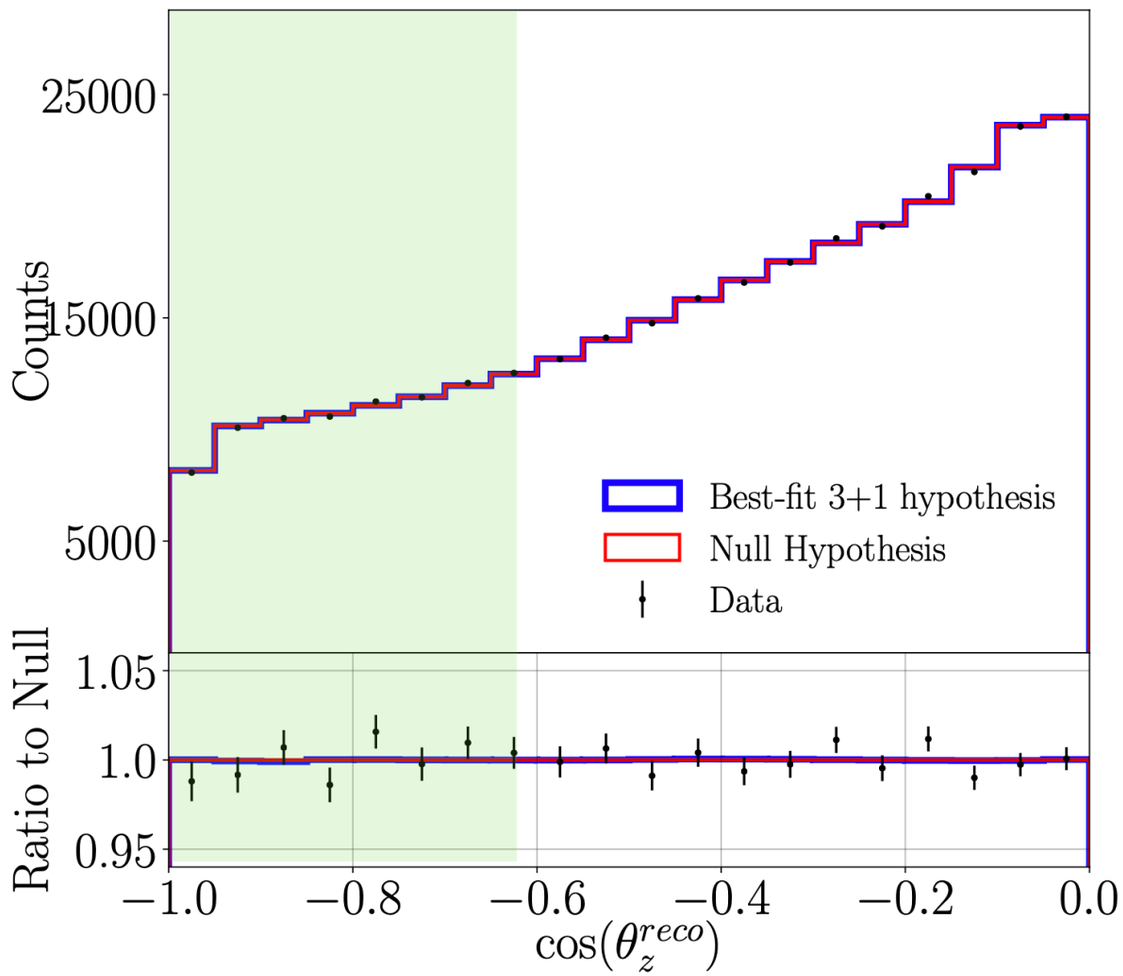


Oscillation pattern still clear for some 3+1 parameters!

Results

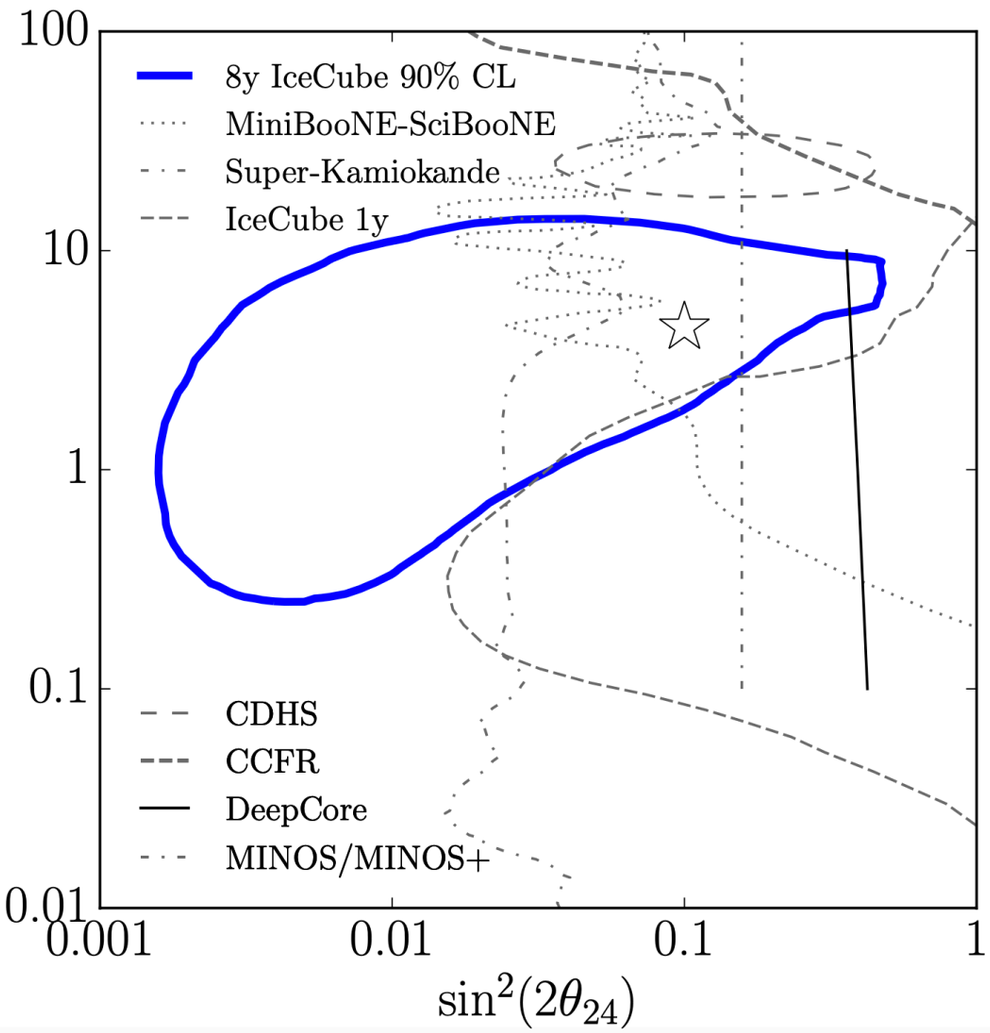
- Using 8 years of data -> 300k $\nu_\mu + \bar{\nu}_\mu$ events!!!
  - Look for a dip in the shaded area.

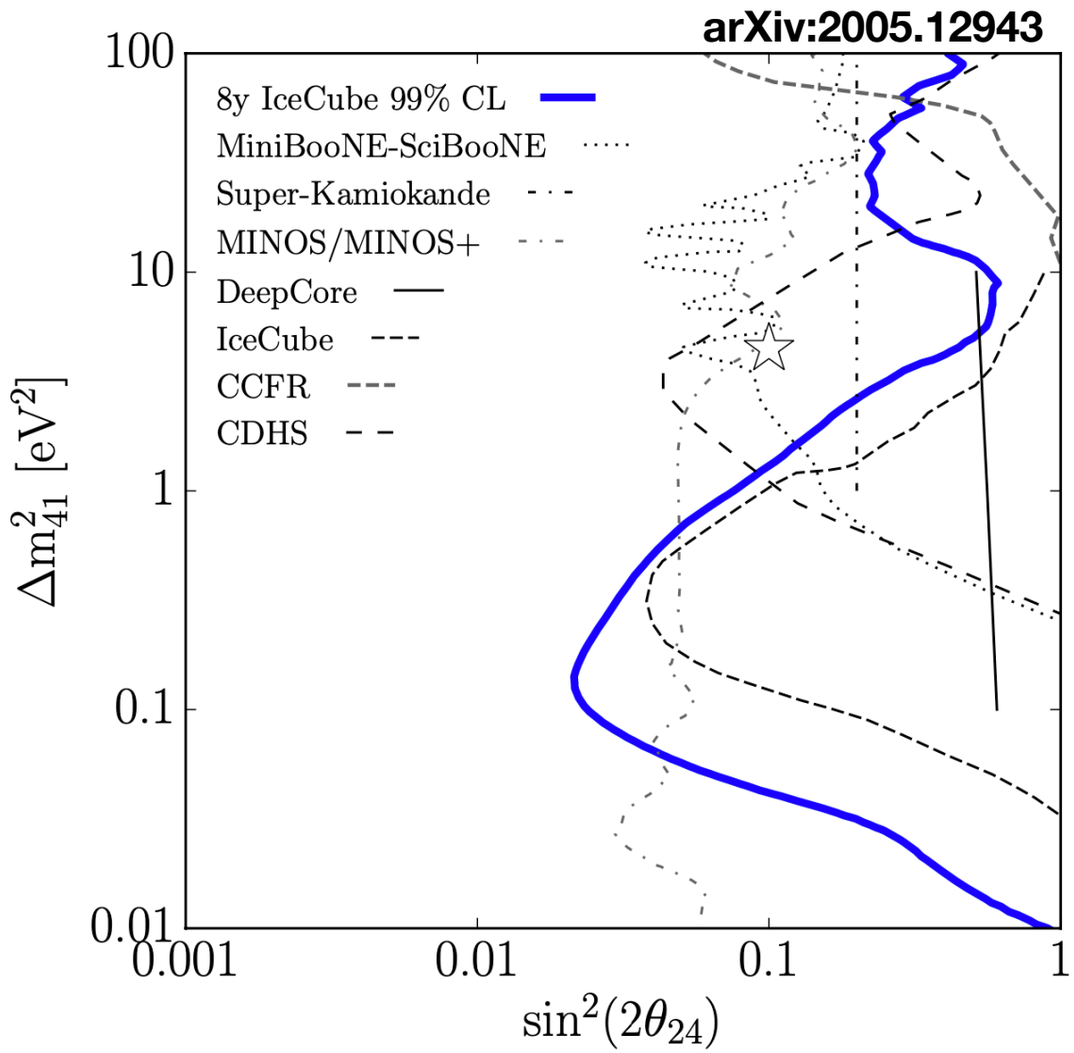




How it compares to others?

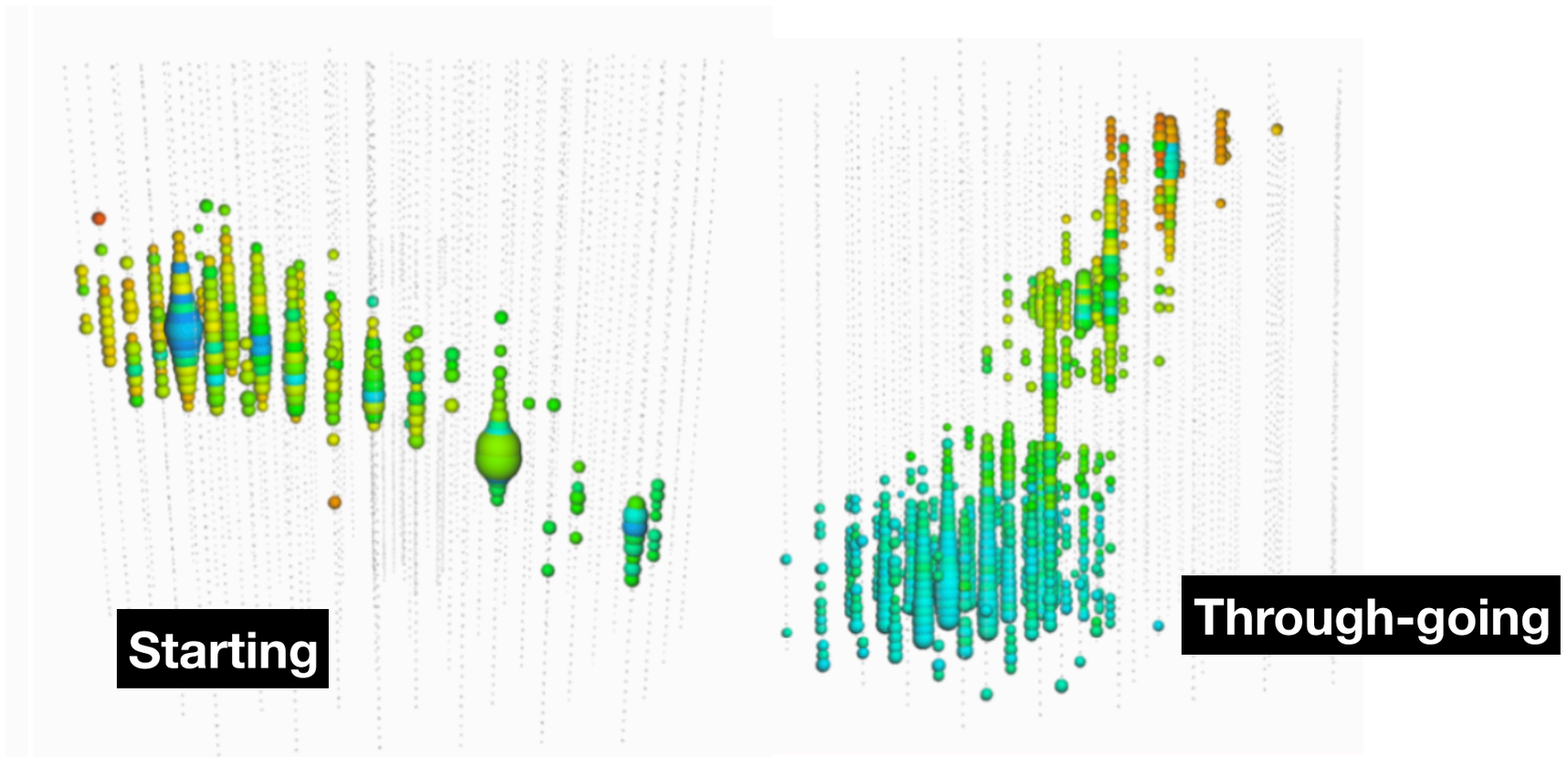
- Leading constraints in some regions of the phase space!
  - Sensitivity studies show that the analysis is still statistically limited.
  - Best fit point remains stable for different time periods.





Prospects

- Main limitation -> poor energy resolution
  - Energy reconstruction algorithm not optimised for this specific search.
  - Through-going muons are not the best proxy to reconstruct neutrino energy.
- How can we improve our energy estimator?
  - New energy reconstruction using NN.
  - Dedicated event selection for starting events -> better proxy from neutrino energy.



Conclusions

- Sterile neutrinos are one of the hot topics in the neutrino community.
  - Several results still not understood.

- IceCube can study 3+1 models using neutrinos energies never explored before.
  - First analyses have shown very competitive constraints.
  - New ideas undergoing to further improve this measurement.

Acknowledgements

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