The neutrino mass ordering and atmospheric neutrinos at DUNE

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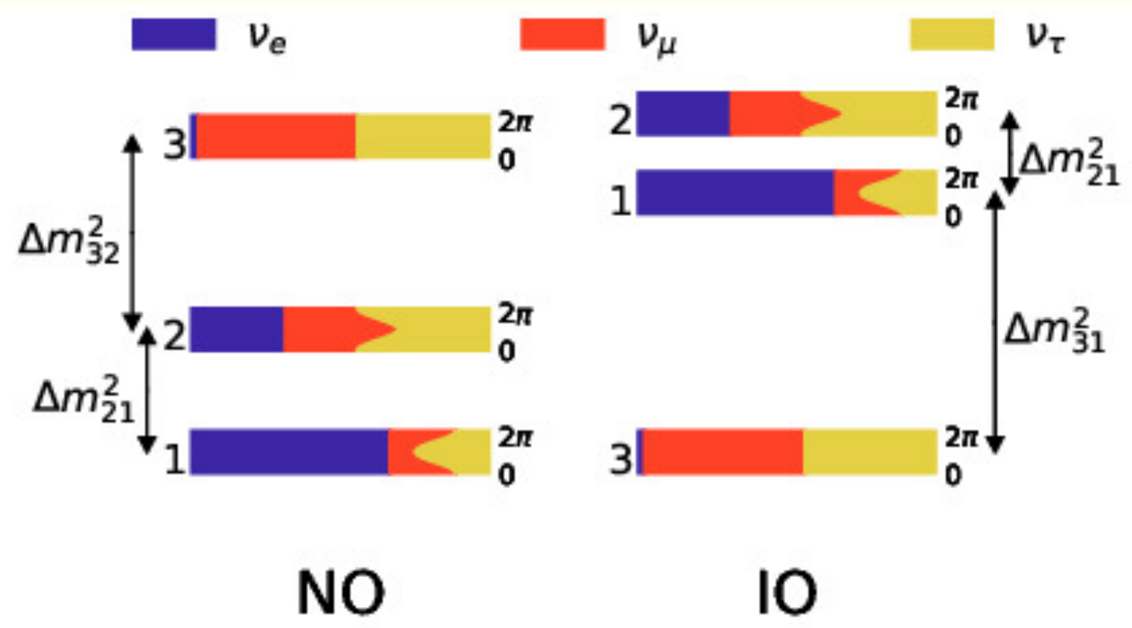
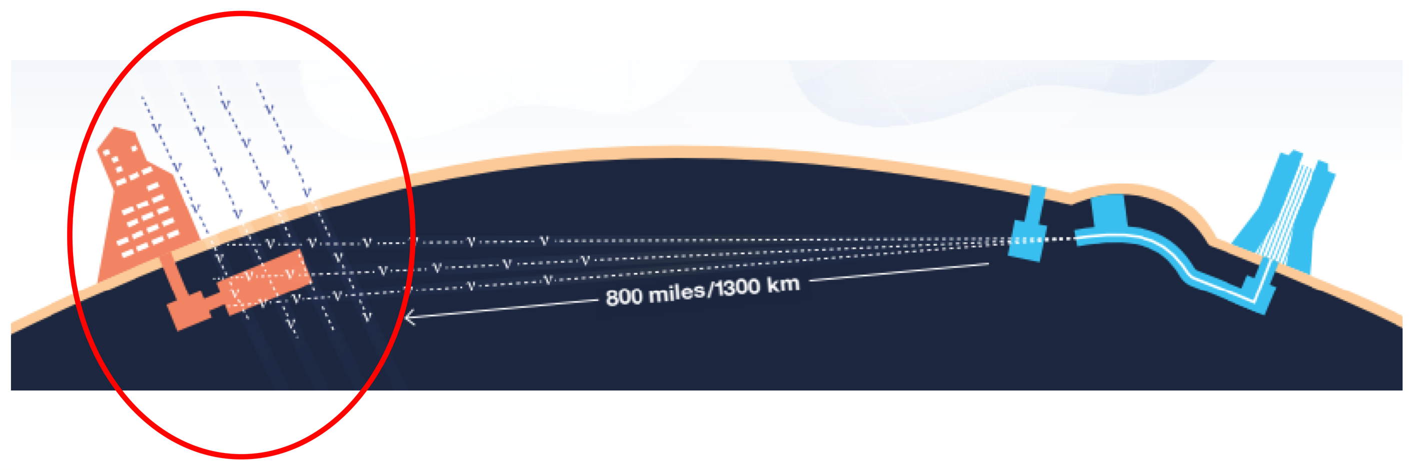
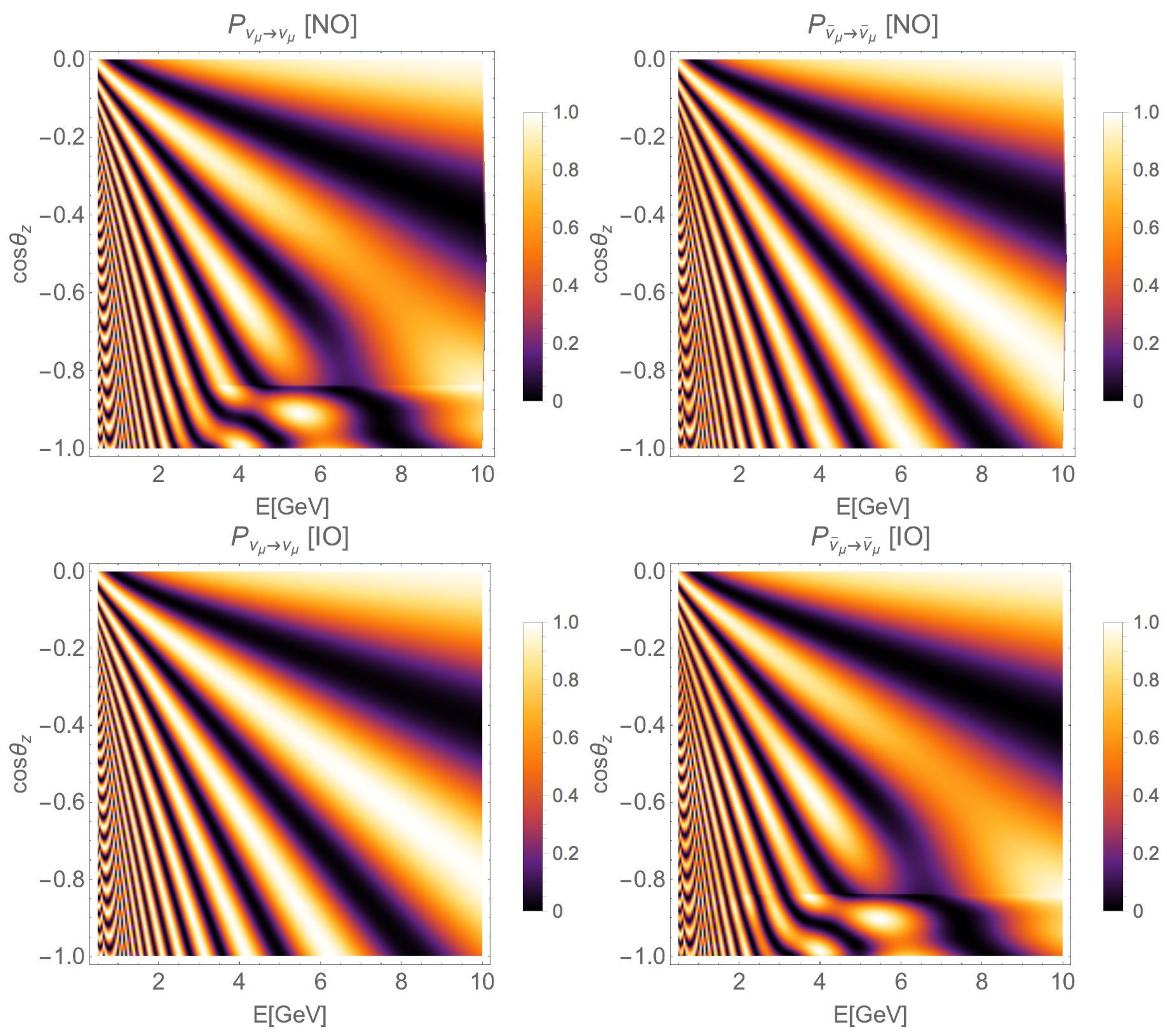


Nowadays neutrino oscillation parameters are being precisely measured [1,2]. However, there are some remaining unknowns as the octant of the atmospheric mixing angle, the value of the CP-phase and the **neutrino mass ordering**, which can be normal or inverted.

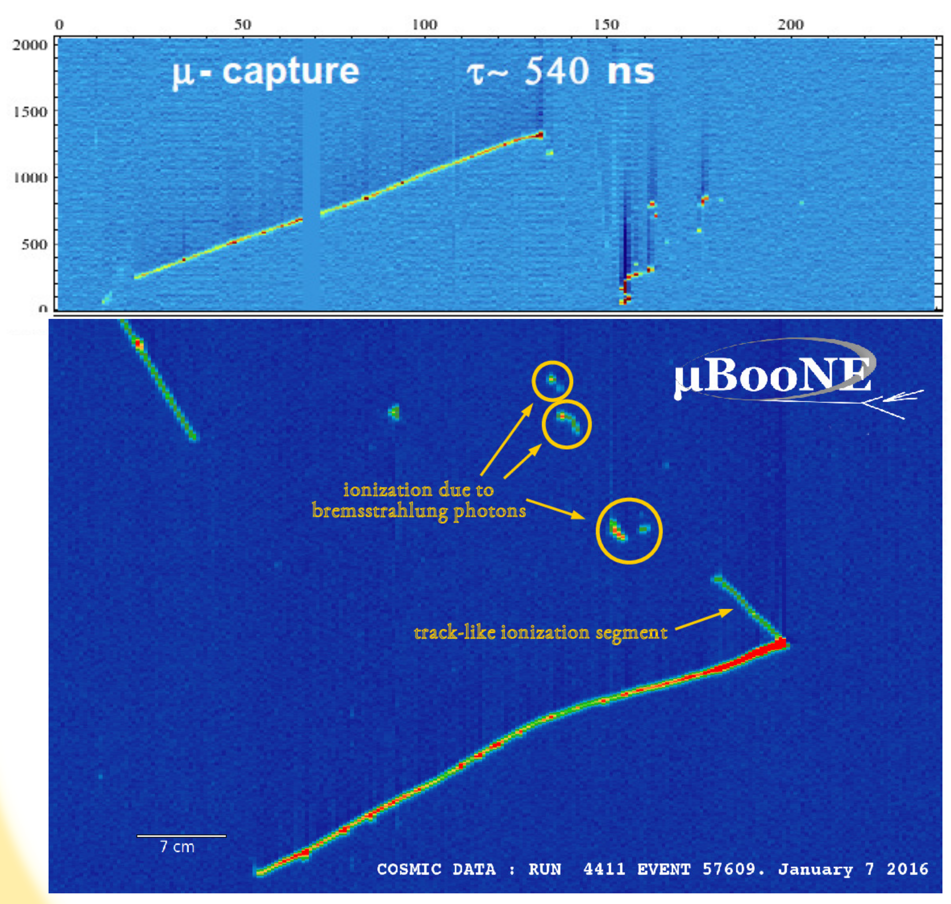
It is possible to extract the neutrino mass ordering at DUNE using atmospheric neutrinos. This will give an extra bonus to the overall sensitivity of the experiment. Additionally, one can use **muon capture** as a method of charge tagging to improve the sensitivity further considerably.



We use the less sensitive, but statistically much more relevant disappearance channel to get a bonus to the measurement of the neutrino mass ordering at DUNE. In this case the probabilities get suppressed (enhanced) for normal (inverted) ordering.



In principle, one needs a magnetized detector to distinguish particles from antiparticles. This would enhance importantly the sensitivity to the mass ordering at an experiment. DUNE is not magnetized, but can however use the **capture of muons in Argon** to tag the charge in roughly 75% of the events. Below we show the two event topologies, **muon capture** in ArgoNeuT [3] and **muon decay** in MicroBooNE [4].



neutrino: $\nu_\mu + n \to \mu^- + p$

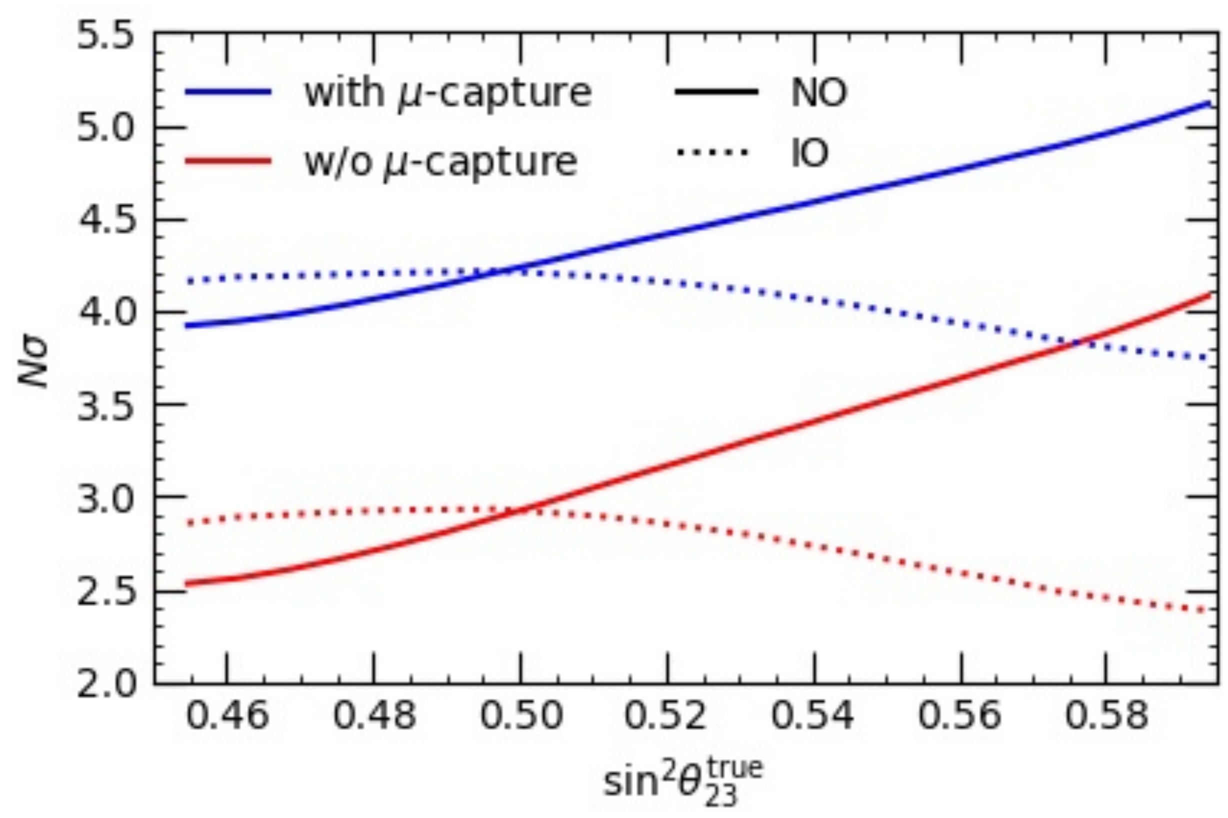
75% ↳ capture

25% ↳ $e^- + \bar\nu_e + \nu_\mu$

antineutrino: $\bar\nu_\mu + p \to \mu^+ + n$

100% ↳ $e^+ + \nu_e + \bar\nu_\mu$

We perform a dedicated simulation of the atmospheric neutrino signal at the DUNE far detector, carefully taking into account fluxes, interactions and detector geometry. In the statistical analysis we try to reproduce this signal using the opposite mass ordering. We take several sources of possible systematic errors into account, varying also the relevant oscillation parameters. For comparison, we use two methods for the analysis, with and without charge identification via muon capture. We find a great improvement in sensitivity using muon capture [3].



References

[1] P.F. de Salas et al, Phys.Lett. B782 (2018) 633-640

[2] P.F. de Salas et al, Front.Astron.Space Sci. 5 (2018) 36

[3] LArIAT Collaboration, arXiv:1406.5560

[4] MicroBooNE Collaboration, JINST 12 (2017) no.09

[5] C.A. Ternes et al, arXiv:1905.03589