Updated MiniBooNE Neutrino Oscillation Results within the Context of Global Fits to Short-Baseline Neutrino Data

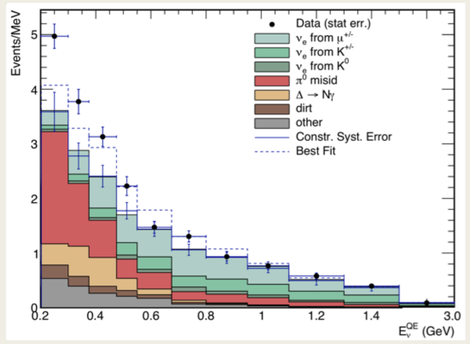
Alejandro Diaz, Carlos Argüelles, Janet Conrad, Zander Moss, Michael Shaevitz
Massachusetts Institute of Technology

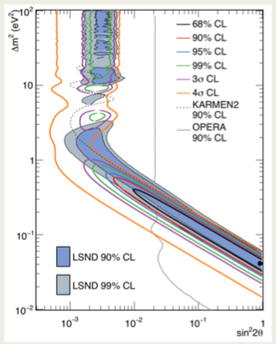
MiniBooNE Excess and Sterile Neutrinos

With the newly released dataset, MiniBooNE reports an anomalous excess of 460.5 ± 95.8 events (4.8σ) ν_e-like events at low energies [1].

If fit to a two neutrino oscillation hypothesis, the best fit oscillation parameters are found to be at $(\Delta m^2, \sin^2 2\theta) = (0.037\ eV^2, 0.958)$, with the 90% CL extending up to $(\Delta m^2, \sin^2 2\theta) \approx (0.01\ eV^2, 0.4)$.

For this to be due to neutrino oscillation, at least one sterile neutrino ν_4 would need to be added.

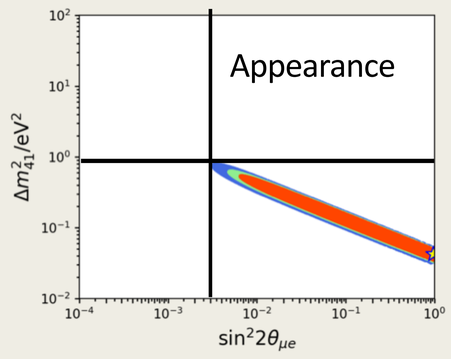


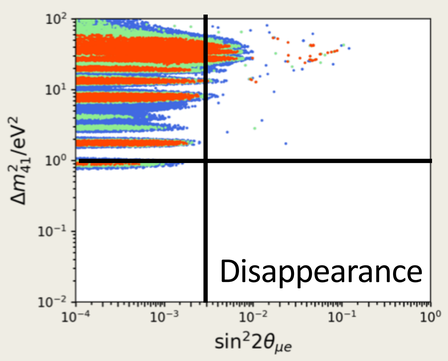


Tensions and ν_4 Decay

While several experiments have seen anomalies that are consistent with a third mass splitting with $\Delta m^2 \sim 1\ eV^2$, other experiments have seen null results which give rise to tensions in the allowed parameter space. An example is given below where global fits done on appearance and disappearance oscillation experiments are shown separately.

We wish to consider how expanding the 3+1 sterile model by allowing the ν_4 sterile mass state to decay into invisible BSM particles affects the global fits and tensions.



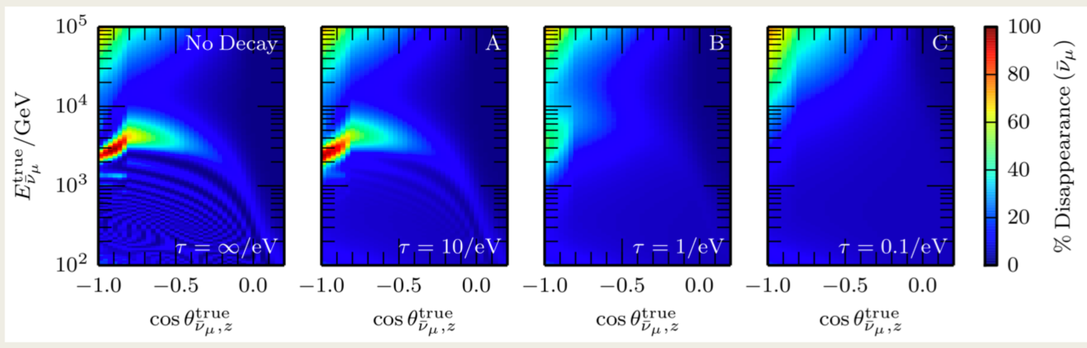


IceCube Sterile Neutrino Search

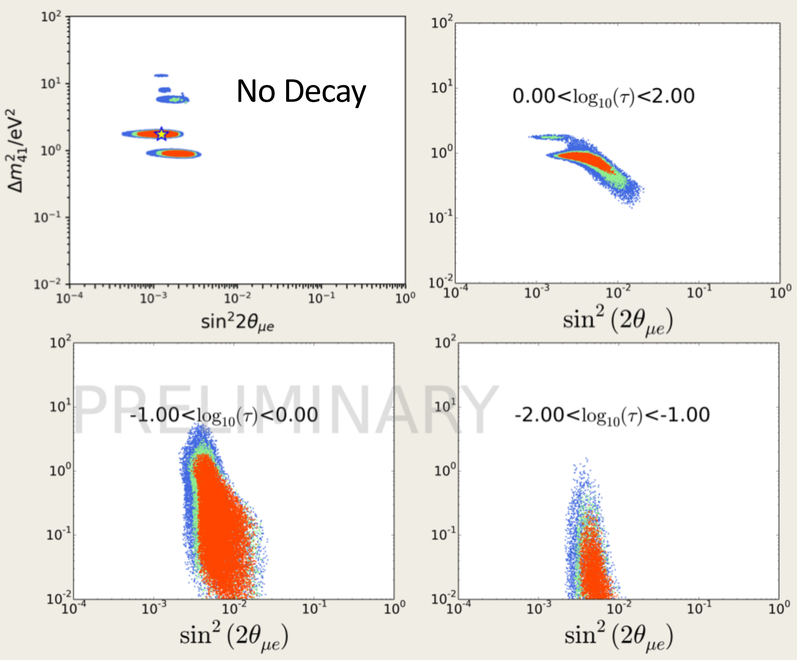
As an example, consider how neutrino decay would affect observed oscillations at IceCube.

Due to matter effects, a stable sterile neutrino would lead to resonant effects that would strengthen atmospheric ν_μ disappearance in the TeV range at low zenith angles.

IceCube did not observe this resonance, placing constraints on a minimal 3+1 sterile model [2]. But, as can be seen in the figure below, a finite lifetime for ν_4 would result in decoherence resulting in no enhancement of ν_μ disappearance [3].



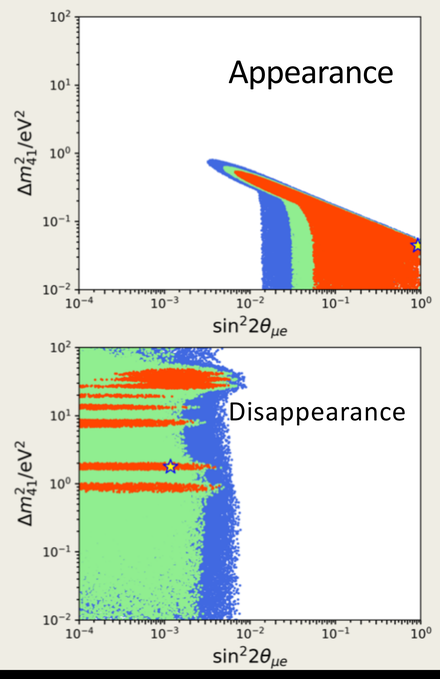
Global Fit: 3+1+Decay



To the left, we see how the best fit regions change with the lifetime of ν_4.

To the right, we again plot the best fit regions for appearance and disappearance experiments separately. We see that, even with decay, the tension remains.

Best Fit	Δm^2(eV^2)	$\lvert U_{e4}\rvert$	$\lvert U_{\mu 4}\rvert$	τ (eV^{-1})	Min. χ^2(dof)	$\Delta\chi^2$(dof)
Null	---	---	---	---	328.8 (315)	---
3+1	1.75	0.16	0.11	---	297.1 (312)	31.7 (3)
3+1+Decay	0.89	0.21	0.14	5.3	290.6 (311)	38.2 (4)



References:
[1] A. A. Aguilar-Arevalo et al. (MiniBooNE), (2018), arXiv:1805.12028 [hep-ex].
[2]Aartsen, M. G. et al (IceCube), Phys. Rev. Lett. 117, 071801 (2016), arXiv:1605.01990
[3] Zander Moss, Marjon H. Moulai, Carlos A. Argelles, Janet M. Conrad, arXiv:1711.05921 [hep-ph] (2017).

Massachusetts Institute of Technology