Abstract

The broad band beam of neutrinos produced at the LHC provides an excellent target to look for spectral deviations in the neutrino spectrum. The simplest such scenario to consider is sterile neutrinos. I performed a Feldman-Cousins Asimov sensitivity parameter scan for sterile neutrinos at FASER and FLArE10 and found some parameter space where FLArE10 will be the most sensitive in the $|U_{\mu 4}|$ channel.

Neutrino Oscillations at FPF

Peter B. Denton

3rd FPF Meeting

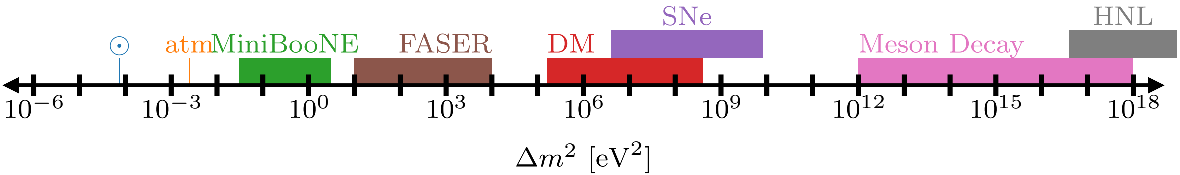
October 25, 2021

Brookhaven National Laboratory

Brookhaven NDI
Neutrino Discovery Initiative

Speaking from Setauket land

Sterile Neutrino Oscillations

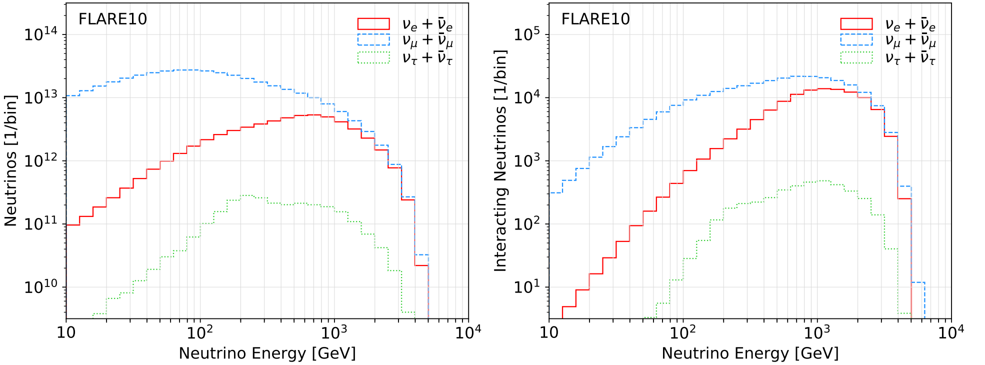


- Sterile neutrinos likely exist
- Most robust ways to detect them:
  - Oscillations: Best
  - Direct production: Good
- Knowing there are oscillations requires:
  - Seeing oscillations in space: Best
  - Seeing an oscillation signal in energy: Tough

    Broad band helps

Flux uncertainties

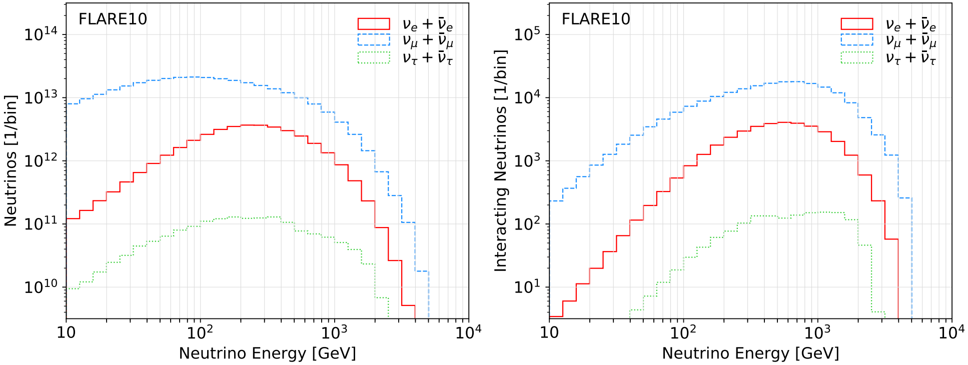
DPMJET



Courtesy of F. Kling

Flux uncertainties

SIBYLL



Courtesy of F. Kling

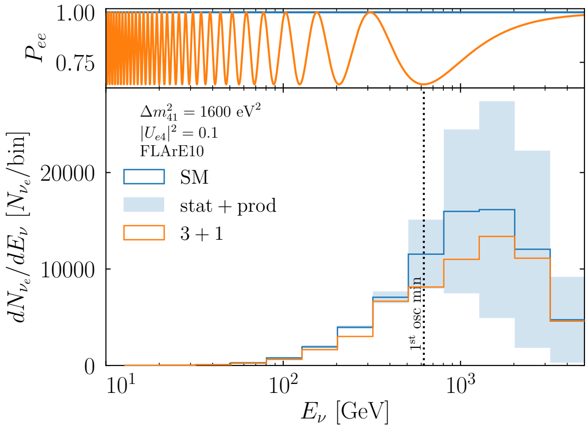
Flux uncertainties: my treatment

- Assume no charge identification: sum $\nu + \bar{\nu}$
- Assume flavor identification and no backgrounds
- Fiducial spectrum is the average:

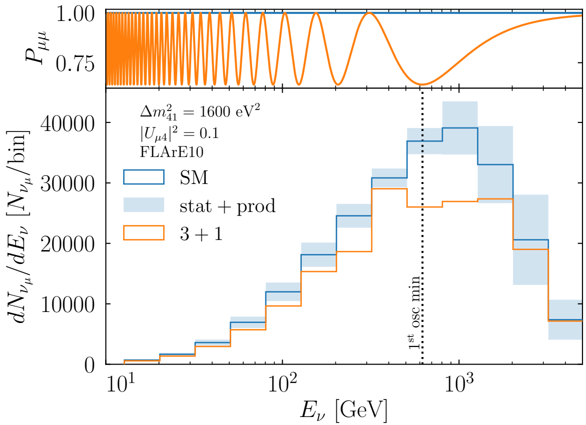
$$\left.\frac{dN}{dE}\right|_0 = \frac{1}{2}\left(\left.\frac{dN}{dE}\right|_{\rm DPMJET} + \left.\frac{dN}{dE}\right|_{\rm SIBYLL}\right)$$

- Range of model predictions provides 1σ pull term
  - Varies normalization and shape
  - Is conservative in range
  - Doesn't account for sub features in shape uncertainty

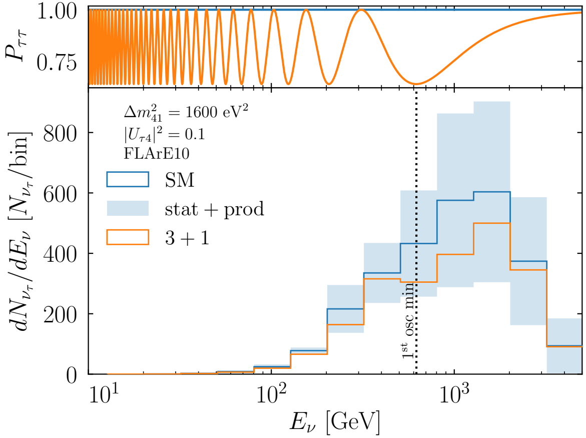
Spectra with ν_e oscillations



Spectra with ν_μ oscillations



Spectra with ν_τ oscillations



Feldman-Cousins

1. Log-likelihood test statistic for Poisson statistics
2. Generate an Asimov data set for no oscillations and calculate ΔTS between no oscillations and oscillations

I. Asimov, Franchise (1955)

Each TS calc includes a minimization over flux uncertainty

3. For a given pair: Δm_{41}^2, $|U_{\alpha 4}|^2$ generate a pseudo experiment and calculate ΔTS between no oscillations and oscillations

or $\sin^2 2\theta_{\alpha\beta}$ for appearance

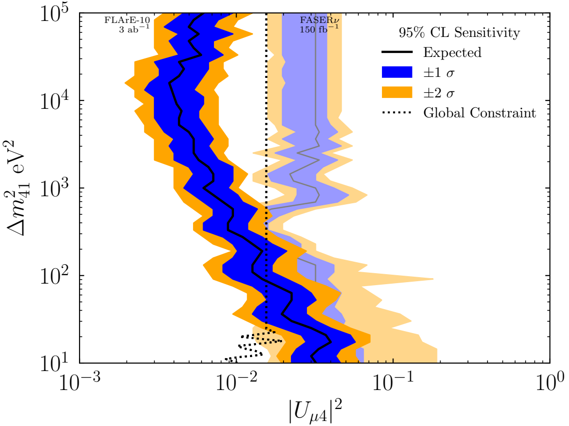
4. Repeat #3 many times and count how many ΔTS's are higher than in #2, compare to the desired CL, and generate an exclusion plot
5. Repeat #2-#4 many times to get an average sensitivity
6. Perform for three disappearance and four relevant appearance channels

$\nu_\tau \to \nu_\alpha$ will have no information

7. Compare to existing constraints on steriles: only ν_μ disappearance is competitive for FLArE10

Some are close

Sensitivity



Shape difference is because different baselines and fluxes used were different between FASER and FLArE10

Flux-sterile degeneracy

W. Bai et al 2002.03012

- Developed unique detailed flux prediction
- Included several scale parameters
- Indicated that varying these could make dip-hunting harder

Future work ideas

- Feldman-Cousins with full production uncertainties
- Consider relative importance of detector volume, energy resolution, and particle ID
- Consider the production position uncertainty

Thanks!