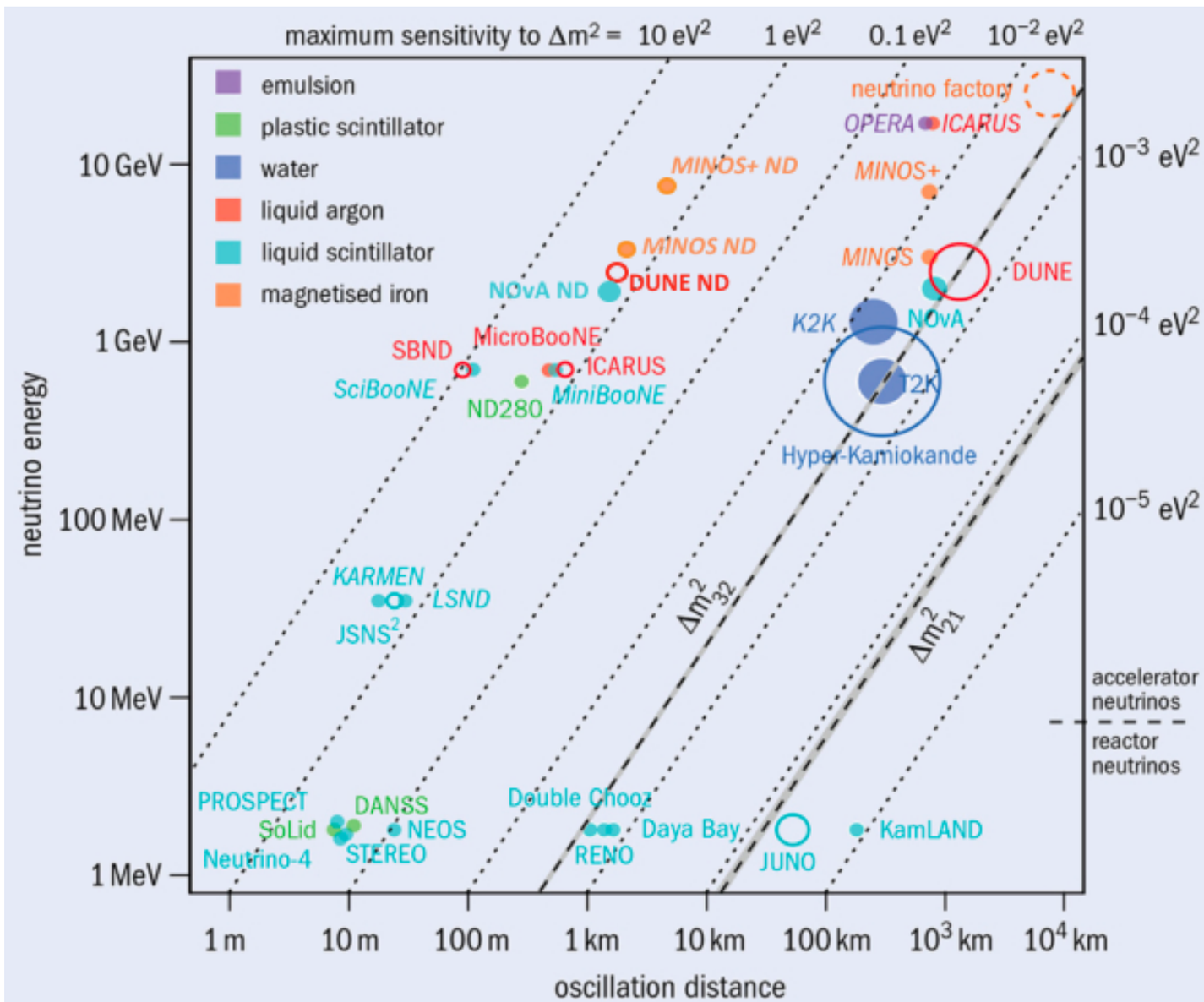
NF02 Workshop Introduction

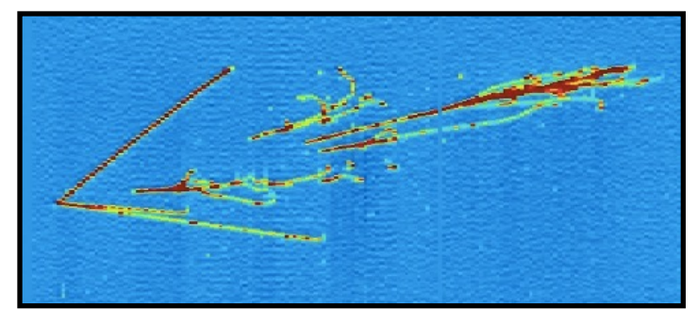
Georgia Karagiorgi, **Bryce Littlejohn**, Pedro Machado, Alex Sousa

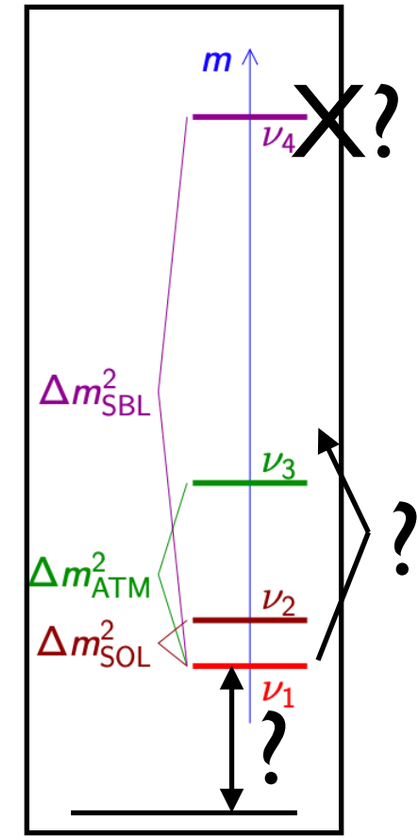
September 25, 2020

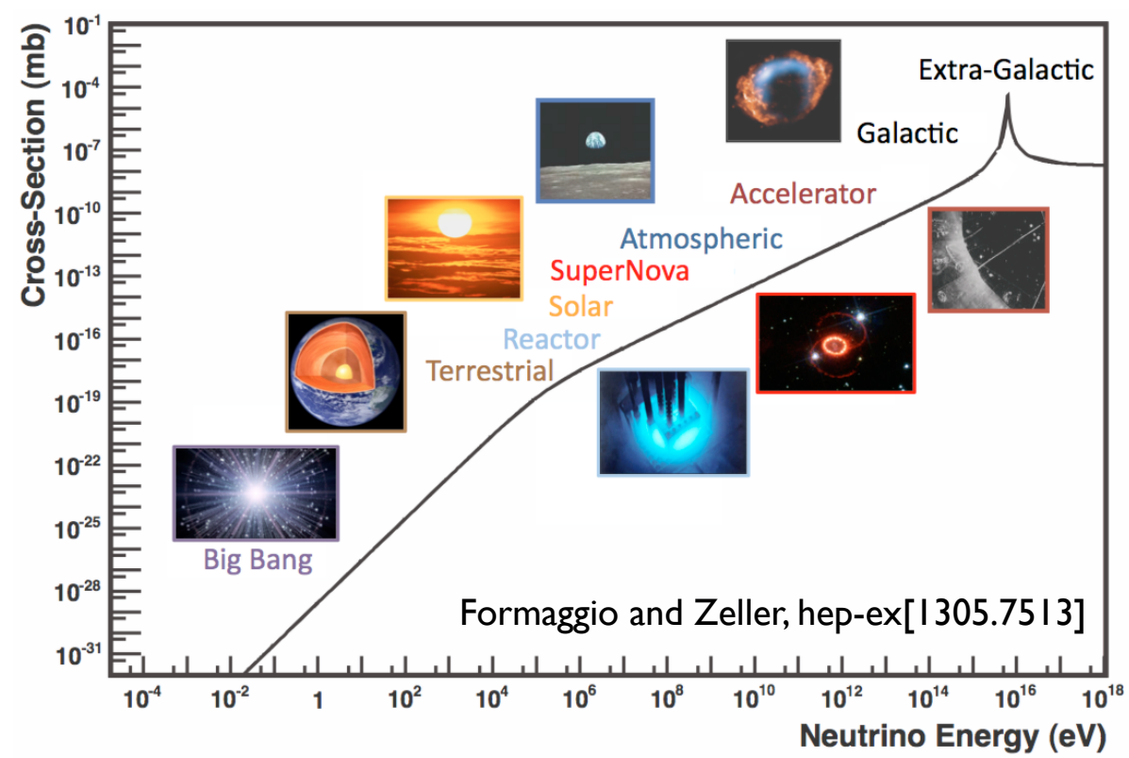
Neutrino Frontier in One Slide

- Fundamental neutrino properties: mass, oscillation, interactions, portals to new physics
- Understanding neutrino sources, interaction targets, and detector technologies







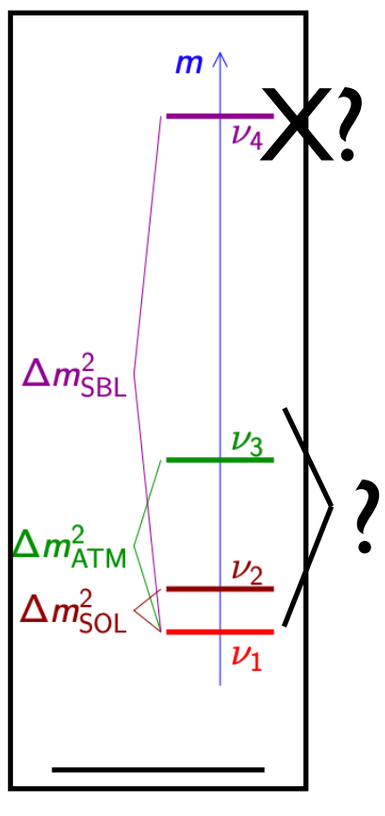


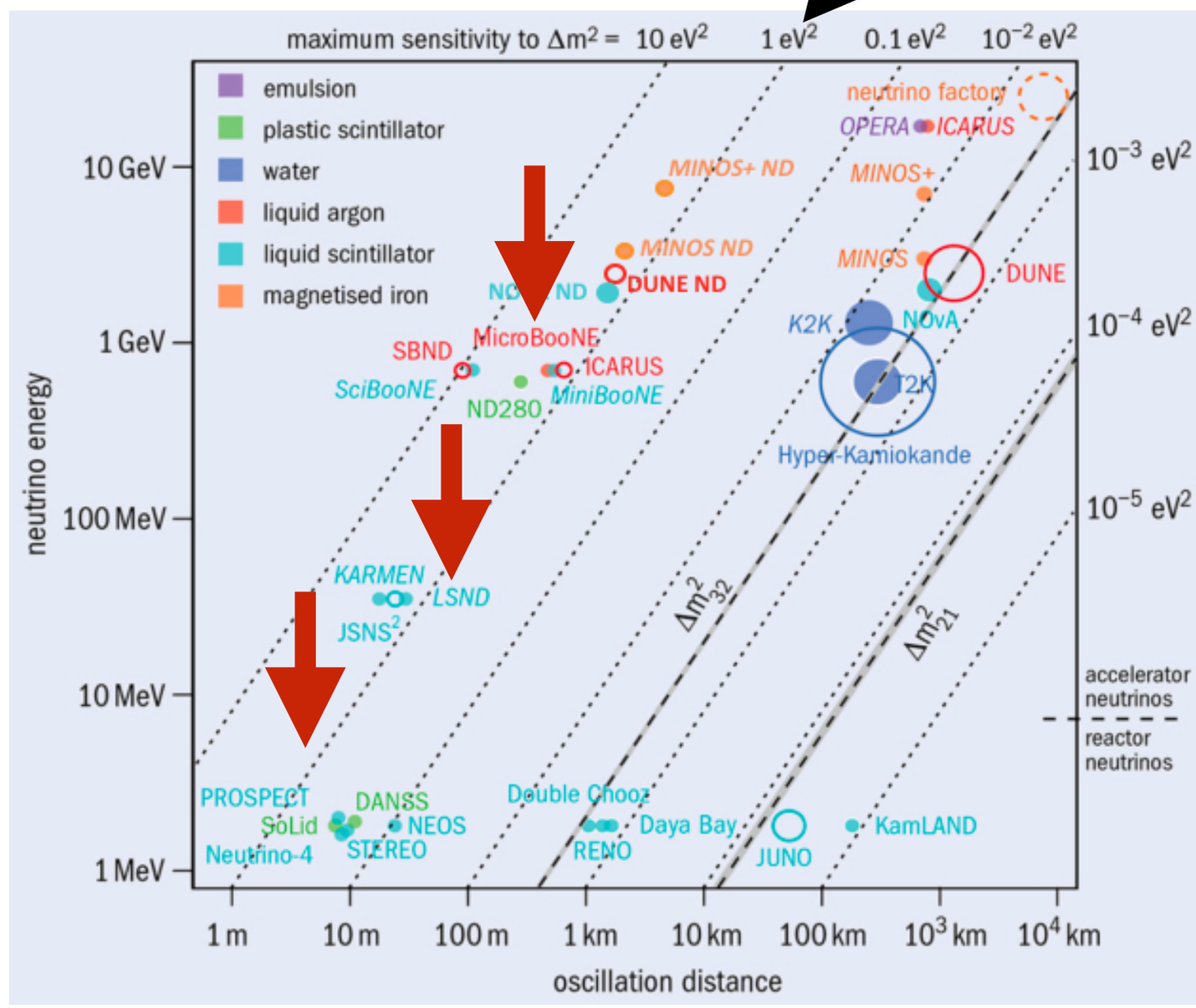
Altered from https://cerncourier.com/a/tuning-in-to-neutrinos/

NF02

- NF02: Look for non-standard oscillations: specifically sterile neutrinos, or whatever is causing odd results along this line
  - Could look for a straight diagonal line (3+1)
  - Could be some other line shape: maybe curved? Maybe multiple lines? etc. 'Non-vanilla scenarios'
  - Maybe Lvs.E is just totally the wrong phase space to be looking at to understand the anomalies

$$P_{\rm dis} = \sin^2 2\theta \sin^2\left(1.27\Delta m^2({\rm eV}^2)\frac{L({\rm m})}{E_\nu({\rm MeV})}\right)$$

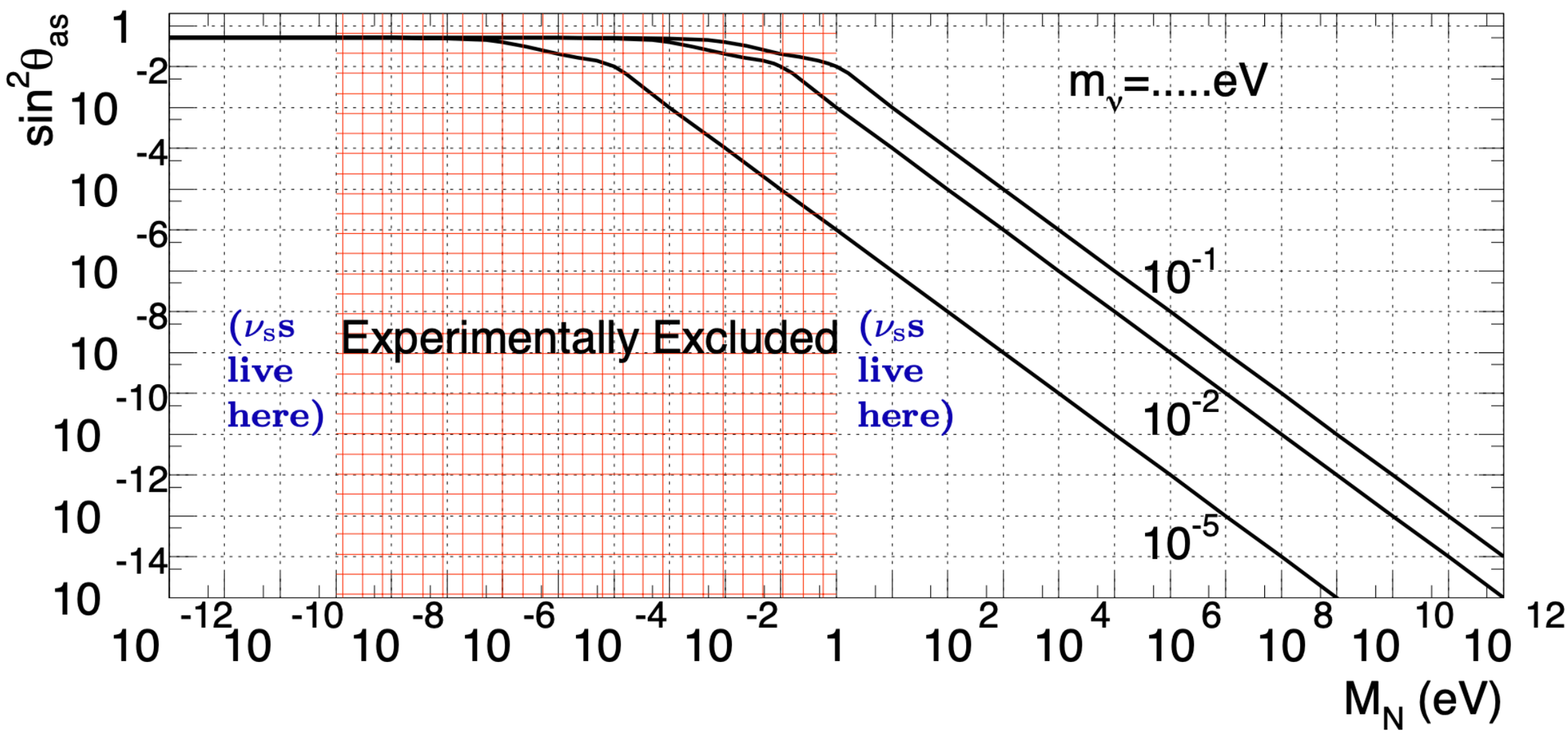




NF02: What's a Sterile Neutrino?

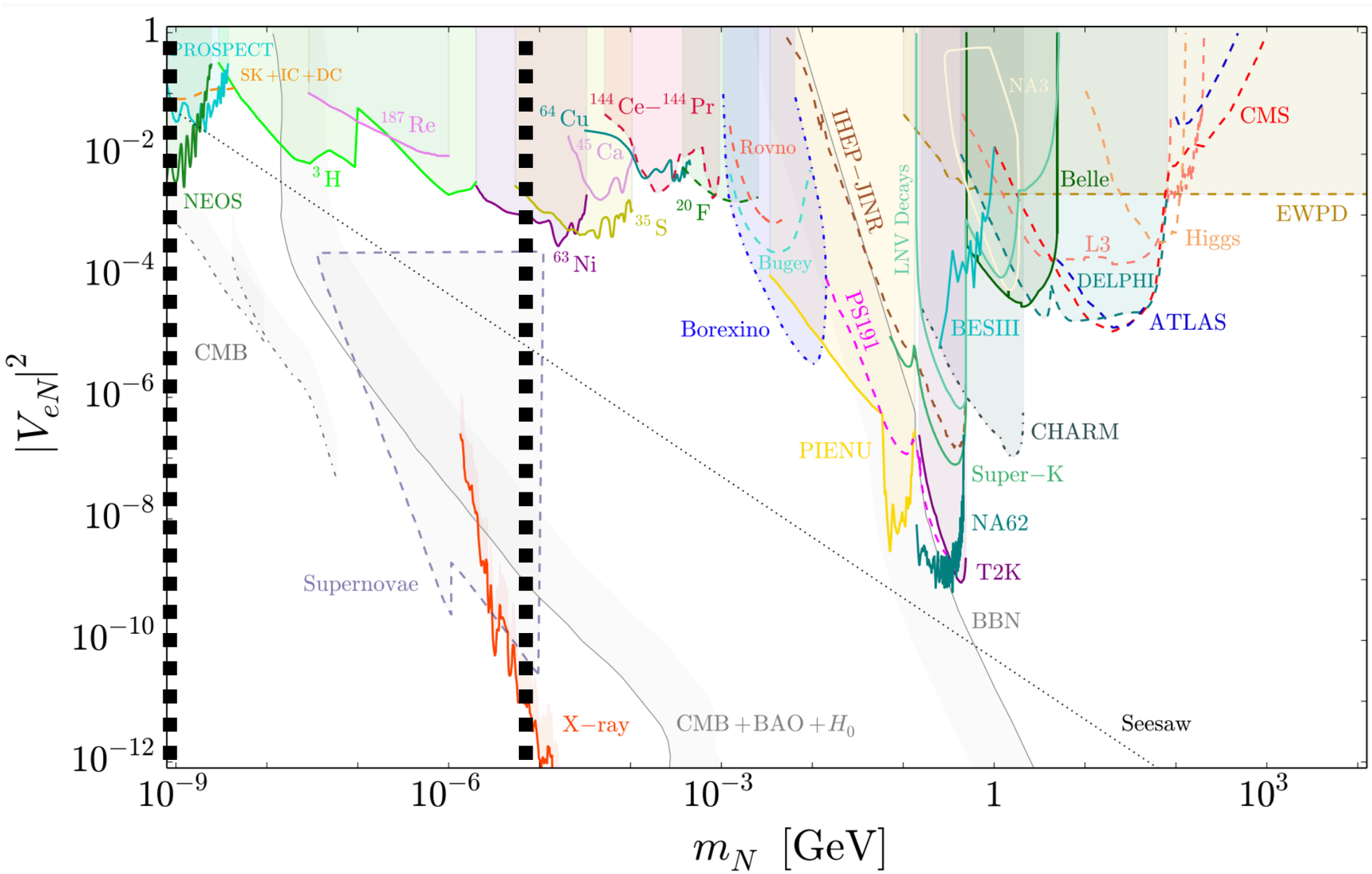
- There are many possible descriptions
  - They could be right-handed neutrinos; could be the Seesaw partner of our SM active neutrinos; could be some other phenomenology behind them
- SO I guess they could be MANY THINGS
  - Huge range of possible masses and couplings to consider

[AdG, Huang, Jenkins, arXiv:0906.1611]



NF02: Light Sterile Neutrinos

- Diverse experimental searches try to span this space
- In NF02: a lot of focus on the lower-mass region, as active-sterile oscillation in this range can be used to try to explain neutrino-sector anomalies



NF02: What Anomalies?

- Meson Decay-At-Rest Anomaly (LSND):
  - Excess of $\overline{\nu}_e$-like events detected in a nearly-$\overline{\nu}_e$-free flux
- Meson Decay-In-Flight Anomaly (MiniBooNE):
  - Excess of low-energy ν_e ($\overline{\nu}_e$)-like events detected in a ~pure ν_μ ($\overline{\nu}_\mu$) flux
- Radioactive Source (Gallium) Anomaly:
  - ~10% deficit in measured ν_e WRT predictions at meter-scale baselines
- Reactor Flux Anomaly:
  - ~6% deficit in measured $\overline{\nu}_e$ WRT predictions at <1km baselines
- These anomalous results seem like fluxes of one flavor either disappearing or transitioning to another flavor
  - At surface level, they seem to fit the profile of neutrino oscillations
  - At an L/E that is not consistent with the active neutrino flavors

NF02 Present and Future

- Probe anomalous results in more precise / more diverse ways
- Direct-search experimental side:
  - Can we reproduce anomalies with better experimental setups (better resolution, lower backgrounds, more optimized baseline/energy)?
  - Can we verify/test other possible explanations for these anomalies? (bad reactor flux predictions? bad GeV-scale cross-section predictions?)
  - Can we probe the sterile oscillation hypothesis in other channels or sources (with atmospherics? beta spectra? numu disappearance? NC disappearance?)
- From theory and indirect-experimental side:
  - Can we constrain the 'standard 3+1' or 'non-vanilla' sterile oscillation hypotheses with cosmological measurements?
  - Can we unite all measurements to find a sterile neutrino phenomenology that is consistent with all existing dataset?
  - Can we develop alternate models that better describe the data, or that help link sterile neutrino anomalies to other interesting puzzles in the universe? Scenarios need not involve oscillations at all, BTW…

Categorizing NF02

- The last two slides lead us to the following categorization:
- Astrophysical/Cosmology
- LBL Accelerator / Atmospheric
- Reactors / Radioactive Sources
- SBL Accelerator / Decay-at-rest
- Theory / Non-Vanilla-3+1 Scenarios
- Today, we'll have one talk on each subject above.

NF02-Adjacent LOIs

- We have received O(75) NF02-adjacent LOIs
  - Actually more, but overlap in some experiments' content in different LOIs, or some are better directed elsewhere (i.e. NF10 for a detector overview)
- Generally sorted into five categories:
  - Astrophysical/Cosmology : 11 LOIs
    - Cosmo light relic bounds, X-ray searches for steriles, astrophysical neutrino flavor physics, …
  - LBL Accelerator / Atmospheric: 15 LOIs
    - ND oscillation, ND/FD oscillation, tau neutrinos, atmospheric oscillations from acc/non-acc
  - Reactors / Radioactive Sources: 19 LOIs
    - SBL reactor, radioactive neutrino source measurements, beta spectrum measurements
  - SBL Accelerator / Decay-at-rest: 16 LOIs
    - Pretty self-explanatory…
  - Theory / Non-Vanilla-3+1 Scenarios: 15 LOIs
    - Global sterile fits, non-osc solutions to anomalies, oscillation pheno beyond simple 3+1

Today: NF02 Workshop Goals

- Goals:
  - Categorize/summarize received NF02-adjacent LOIs
  - Have discussion about emphasis, missed efforts/opportunities/connections
  - Start narrative-building process based on talks and feedback
- Five speakers, one for each category
  - 15 min for speaker to present a summary of their category
  - 10 min for feedback from audience and conveners
- End with 45 minute speaker panel Q&A and discussion
  - Big picture: What have we missed or mis-categorized?
  - Transition to discussion of White paper related Qs and organization

Questions