Snowmass2021 - Letter of Interest

Sensitive Tests for Sterile Neutrino Oscillations at the Short-Baseline Neutrino Program at Fermilab

NF Topical Groups: (check all that apply ☐/■)

☐ (NF1) Neutrino oscillations
■ (NF2) Sterile neutrinos
☐ (NF3) Beyond the Standard Model
☐ (NF4) Neutrinos from natural sources
☐ (NF5) Neutrino properties
☐ (NF6) Neutrino cross sections
☐ (NF7) Applications
☐ (TF11) Theory of neutrino physics
☐ (NF9) Artificial neutrino sources
☐ (NF10) Neutrino detectors
☐ (Other) *[Please specify frontier/topical group(s)]*

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On behalf of the ICARUS[1] and SBND[2] Collaborations

Abstract: The Short-Baseline Neutrino (SBN) program presents an exciting opportunity in experimental neutrino physics. SBN is primarily designed to address the possible existence of 1 eV mass-scale sterile neutrinos through sensitive searches for both electron neutrino appearance and muon neutrino disappearance in a primarily muon neutrino beam at Fermilab. The SBN detectors will be completed soon, beginning an exciting period of operations and new physics results over the next ∼5 years.

[1] https://icarus.fnal.gov/collaboration/
[2] https://sbn-nd.fnal.gov/collaboration.html

The Short-Baseline Neutrino (SBN) program consists of multiple LArTPC neutrino detectors positioned along the Booster Neutrino Beam (BNB) at Fermilab. The MicroBooNE detector, an 89 ton active mass LArTPC located 470 m along the beam, has been collecting data in the BNB since October 2015. Earlier in that same year, a proposal [1] was presented and approved to augment the MicroBooNE detector with two additional LArTPCs – a near detector close to the source that can characterize the neutrino beam before any substantial oscillation can occur and, thereby, greatly reduce systematic uncertainties in a search for oscillation signals downstream, and a larger far detector to be installed just downstream of MicroBooNE to increase the statistics of a potential signal. The near detector, SBND (or the Short-Baseline Near Detector), is a 112 ton active mass LArTPC sited only 110 m from the neutrino production target. The far detector, located 600 m from the target, is the existing 476 ton active mass ICARUS-T600 detector. After being refurbished and upgraded for optimal performance in SBN, the ICARUS-T600 has been installed and is now in a commissioning phase. The SBND detector is being assembled at Fermilab and will begin operations in early 2022. The addition of SBND and ICARUS enables a diverse and exciting physics program [2], including a world-leading sterile neutrino search that can cover the parameters allowed by past anomalies at $\geq 5\sigma$ significance. Figure 1 shows the sterile neutrino parameter sensitivities in both the electron neutrino appearance and muon neutrino disappearance channels at SBN [1].

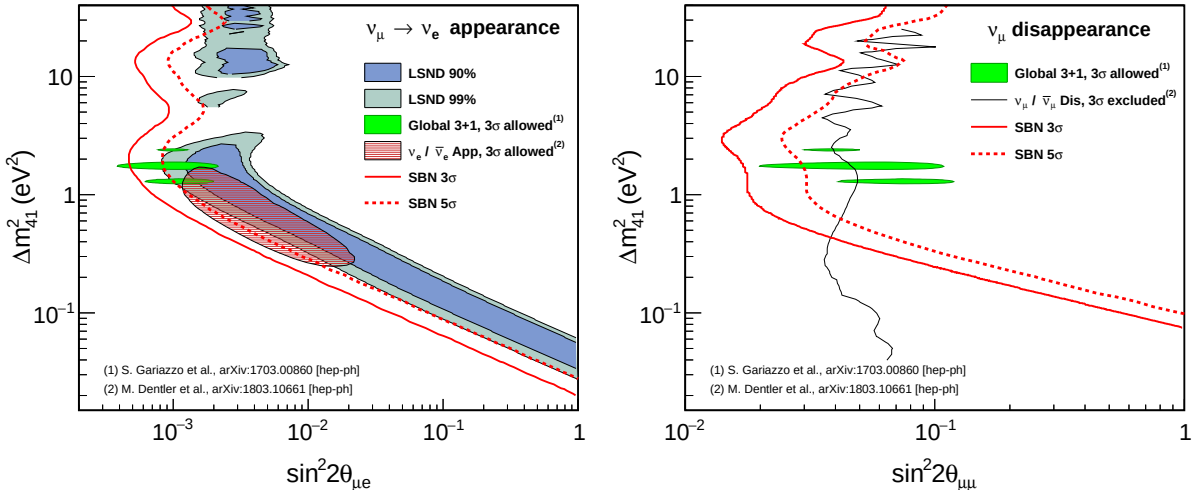

Figure 1: SBN 3σ (solid red line) and 5σ (dotted red line) sensitivities to a light sterile neutrino in the $\nu_\mu \rightarrow \nu_e$ appearance channel *(left)* and $\nu_\mu \rightarrow \nu_\mu$ disappearance channel *(right)*. For comparison, the LSND preferred region at 90% C.L. (shaded blue) and 99% C.L. (shaded gray) is presented [3]. Moreover, global ν_e appearance (shaded red) and global ν_μ disappearance (black line) 3σ regions [4] are also included. Finally, 3σ global best fit regions [5] are shown in green. The sensitivities are reproduced from the SBN proposal [1].

The development of the Short-Baseline Neutrino program is strongly coupled to multiple recommendations of the last P5 Report in 2014, including the pursuit of experiments capable of resolving the light sterile neutrino hypothesis as an explanation of past anomalies, and the creation of new opportunities to advance the development of the liquid argon TPC detector technology for neutrino physics. The SBN program is now well along in its construction. In the next few years, the SBN program at Fermilab will provide powerful new input to the question of light sterile neutrinos. SBN will also be a valuable opportunity for the large international neutrino physics community, which is developing the challenging techniques needed to extract physics information from LArTPC data and is making plans to construct and operate such detectors at enormous scales for the DUNE neutrino program.

References

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[3] LSND Collaboration, A. Aguilar-Arevalo *et al.*, "Evidence for neutrino oscillations from the observation of anti-neutrino(electron) appearance in a anti-neutrino(muon) beam," *Phys. Rev.*, vol. D64, p. 112007, arXiv:0104049 [hep-ex].

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