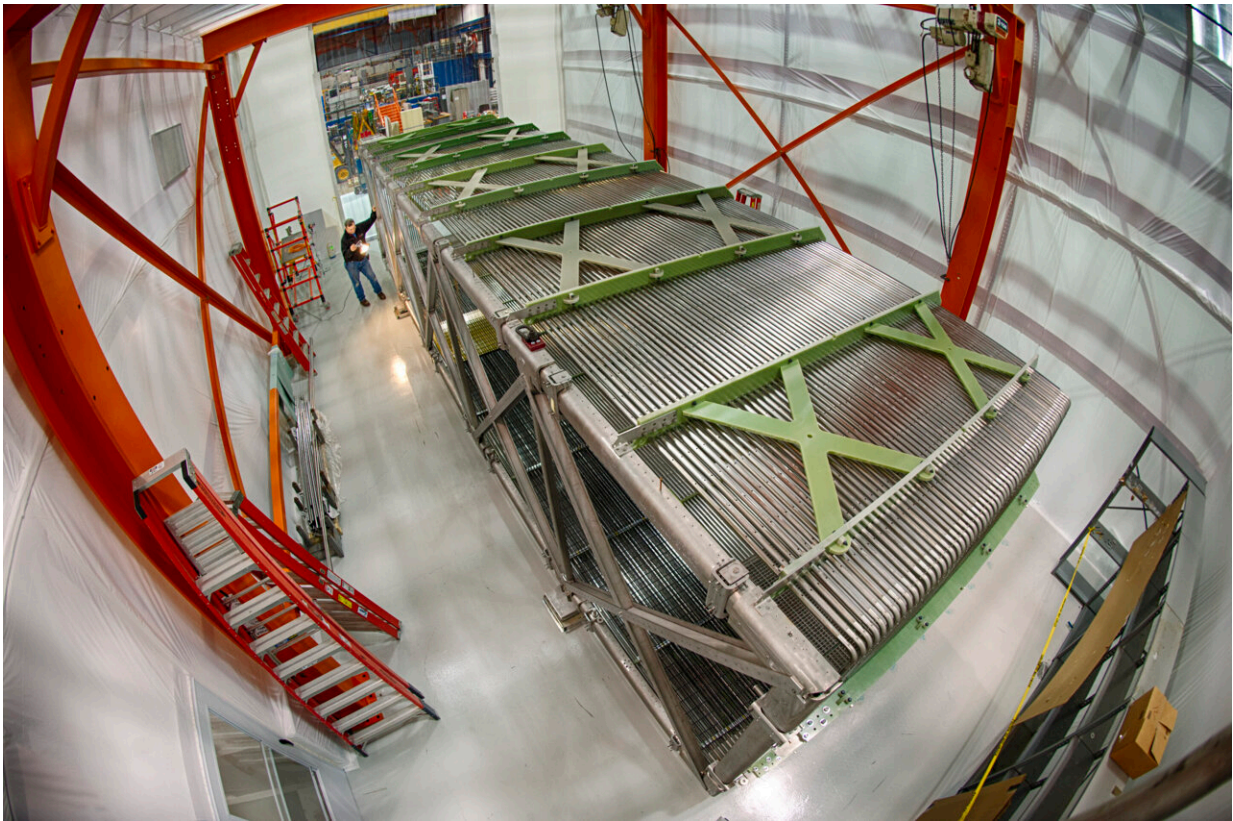


# New analysis takes a closer look at the sterile neutrino

November 1 2022, by Lauren Biron and Kurt Riesselmann

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MicroBooNE features state-of-the-art particle detection techniques and technology. The experiment studies neutrino interactions and is probing models of a theorized fourth neutrino called the sterile neutrino. Credit: Reidar Hahn, Fermilab.

A new result from the MicroBooNE experiment at the U.S. Department

of Energy's Fermi National Accelerator Laboratory probes the Standard Model—scientists' best theory of how the universe works. The model assumes there are three kinds of neutrinos. Yet for more than two decades, a proposed fourth kind of neutrino has remained a promising explanation for anomalies seen in earlier physics experiments. Finding the theorized sterile neutrino would be a major discovery and radical shift in our understanding of the universe.

The new analysis compares the experiment's data to a model with a fourth, [sterile neutrino](#) to test their compatibility. MicroBooNE scientists found no evidence of the long-sought sterile neutrino in the parameter range explored.

The possibility that sterile neutrinos caused the yet-unexplained anomalies reported by previous experiments still remains. These include measurements by the Liquid Scintillator Neutrino Detector at Los Alamos National Laboratory, the MiniBooNE experiment at Fermilab, and several radiochemical and nuclear reactor neutrino experiments.

"This is the first time we've checked whether our data fit a specific sterile-neutrino model," said Matt Toups, a Fermilab scientist and co-spokesperson for MicroBooNE. "We've excluded large sections of the sterile neutrino parameter space allowed by LSND. But there are still corners where a sterile neutrino could potentially be hiding."

While the most basic version of a sterile neutrino is becoming less likely, other, more subtle types of physics might be at play. For example, there could be a sterile neutrino working in combination with something else, such as dark matter. Or there could be completely different explanations for the anomalies. Unexplained physics related to the Higgs boson or other physics beyond the Standard Model could be the reason.

"In this work, we found an important interplay between the neutrino

appearance and disappearance, which was not considered in the previous experimental work. This has important consequences in the search result," said Xiangpan Ji, a postdoctoral researcher at DOE's Brookhaven National Laboratory, who is one of the co-leaders of this analysis.

Like the 2021 results, the new finding uses only half of MicroBooNE's dataset. Researchers will continue to look for potential sterile neutrino signals in future analyses. They also will expand their analyses to the full dataset.

The 170-ton MicroBooNE neutrino detector collected data from 2015 to 2021. It recorded hundreds of thousands of spectacularly detailed [3D images of neutrino events](#). Close to 200 collaborators from 39 institutions in five countries built and ran the experiment and are now working on the data analysis. The collaboration expects to release the first results from the full dataset in 2023.

MicroBooNE is one of three particle detectors that make up Fermilab's Short-Baseline Neutrino Program. ICARUS and the Short-Baseline Near Detector are the other two detectors. Together, they enable the detailed exploration of neutrino properties. In particular, they examine neutrino oscillations at low energies and short distances. Scientists hope that the combined measurements of these three detectors will completely resolve the anomalies in neutrino measurements seen by LSND and MiniBooNE.

Next year, MicroBooNE scientists also expect to report on sterile neutrino models using data from two beams of neutrinos with different energies, a unique feature of the Fermilab accelerator complex. So far, this MicroBooNE result has relied on neutrinos provided by Fermilab's Booster Neutrino Beam, produced by protons with energy of 8 billion electron volts (GeV). But the MicroBooNE detector also recorded interactions of neutrinos from Fermilab's Main Injector accelerator,

produced by 120-GeV protons.

"Our ability to explore [sterile neutrinos](#) and rare interactions will be enhanced when we add in the data from Fermilab's Main Injector neutrino beam," said Hanyu Wei, professor of physics at Louisiana State University and a co-leader of the sterile-neutrino analysis. "The interplay between the two beams' data will be interesting, not just more statistics."

In addition to weighing in on the sterile neutrino question, MicroBooNE will also search for other phenomena beyond the Standard Model and provide precision measurements of how neutrinos interact with matter.

"Neutrinos continue to be one of the strangest and most interesting particles out there. They are one of our best opportunities to study new physics beyond the Standard Model," said Justin Evans, scientist at the University of Manchester and MicroBooNE co-spokesperson. "There is so much incredible neutrino physics that MicroBooNE can do. We're excited to see what else is waiting for us in the data."

Provided by Brookhaven National Laboratory

Citation: New analysis takes a closer look at the sterile neutrino (2022, November 1) retrieved 24 April 2024 from <https://phys.org/news/2022-11-analysis-closer-sterile-neutrino.html>

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