Neutrinos detected in particle collider for first time at CERN

For the first time, neutrinos produced in a particle accelerator have been detected.

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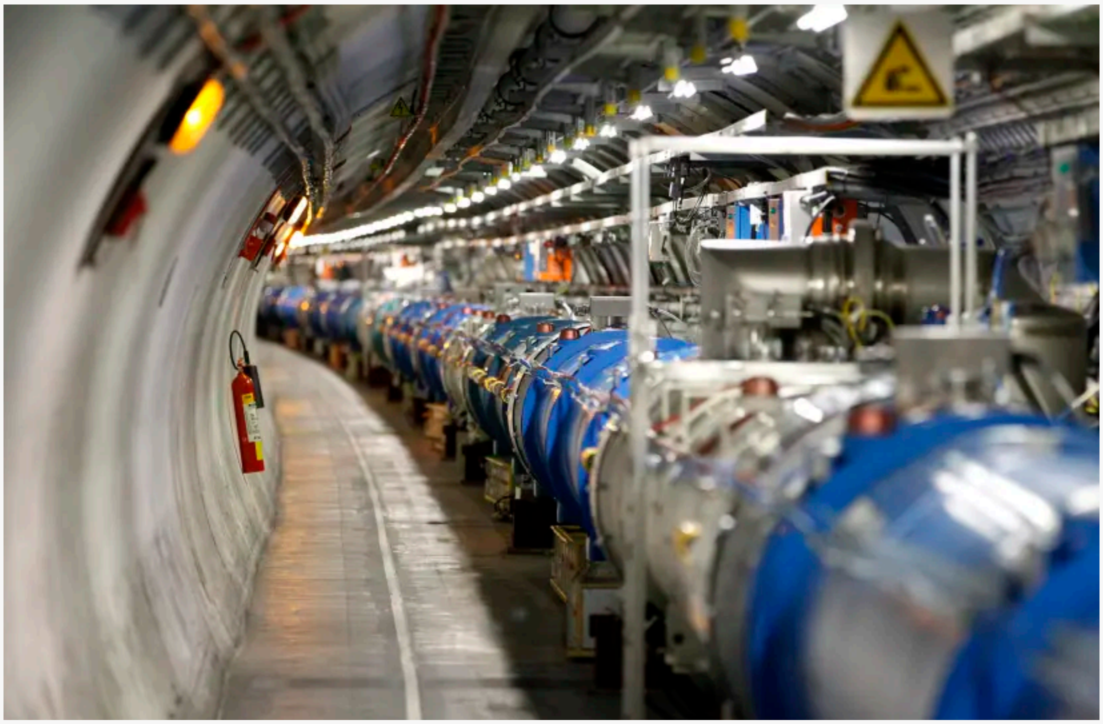

A general view of the Large Hadron Collider (LHC) experiment is seen during a media visit at the Organization for Nuclear Research (CERN) in the French village of Saint-Genis-Pouilly near Geneva in Switzerland, July 23, 2014
(photo credit: REUTERS/PIERRE ALBOUY)

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Researchers at the ForwArd Search ExpeRiment (FASER) at CERN have detected neutrino candidates in the first such detection in a particle accelerator, publishing a paper on the breakthrough in the peer-reviewed journal *Physical Review D* on Wednesday.

Neutrinos are the most abundant fundamental particles that have mass in the universe and have been detected from many sources, including the sun and cosmic-ray interactions. They are among the least understood particles in the standard model of particle physics, with neutrinos produced within a particle collider having never been directly detected.

Collider neutrinos are produced at high energies, at which neutrino interactions have not been well studied. Being able to detect and study collider neutrinos could shed light on the particles, as it would allow scientists to study the particles under highly controlled conditions.

"These neutrinos will have the highest energies yet of man-made neutrinos, and their detection and study at the LHC will be a milestone in particle physics, allowing researchers to make highly complementary measurements in neutrino physics," said Jamie Boyd, co-spokesperson for the FASER experiment, in 2019, according to CERN. "What's more, FASER may also pave the way for neutrino programs at future colliders, and the results of these programs could feed into discussions of proposals for much larger neutrino detectors."

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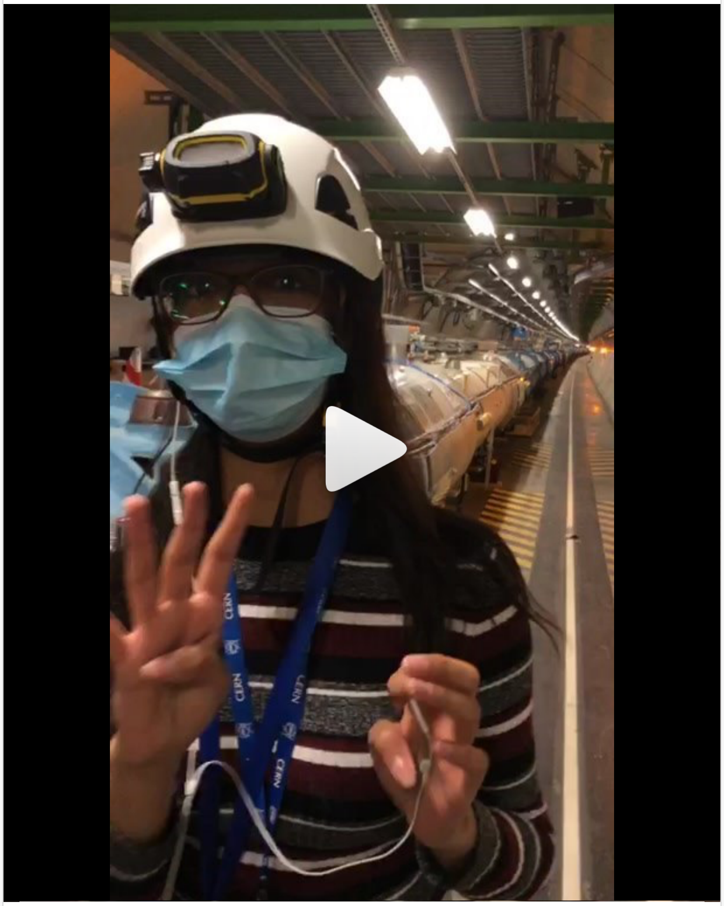

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The FASER researchers, led by physicists from the University of California, Irvine, observed six neutrino interactions during a pilot run of a compact emulsion detector at the Large Hadron Collider (LHC) at CERN in 2018, shortly before the LHC shut down for maintenance and upgrades, according to UC Irvine News.

The detector was made up of lead and tungsten plates alternated with layers of emulsion. During particle collisions at the LHC, some of the neutrinos produced smash into nuclei in the dense metals, creating particles that travel through the emulsion layers and create marks that can be seen following processing. The marks can provide information about the energies of the particles helping scientists understand what kind of particles they were.

Study co-author Jonathan Feng, UCI

Distinguished Professor of physics & astronomy and co-leader of the FASER Collaboration, explained to UC Irvine News that "this significant breakthrough is a step toward developing a deeper understanding of these elusive particles and the role they play in the universe."

The discovery gave the FASER team two crucial pieces of information, according to Feng: It verified that the position of the device in the LHC is the right location for detecting collider neutrinos and demonstrated that an emulsion detector is effective in observing neutrino interactions.

The result of the team's work has a statistical significance of 2.7 standard deviations, just below the three standard deviations required to claim evidence of a particle or process in particle physics.

"Having verified the effectiveness of the emulsion detector approach for observing the interactions of neutrinos produced at a particle collider, the FASER team is now preparing a new series of experiments with a full instrument that's much larger and significantly more sensitive," said Feng.

The device which led to the discovery is only a pilot version of a final much larger device that will begin operations once the LHC begins running again in 2022. The final device will weigh over 2,400 pounds, while the pilot detector weighs only about 64 pounds. The final device will also be much more reactive and able to differentiate among neutrino varieties.

According to CERN, the FASER team expects to observe about 20,000 collider neutrino interactions once the full-fledged detector becomes active in the next LHC run, from 2022 to 2024.

The final device will also be used to investigate the dark matter at the LHC, with researchers hoping to detect dark photons, which would help show how dark matter interacts with normal atoms and other matter in the universe through nongravitational forces.

The Scattering and Neutrino Detector (SND@LHC) will also work to detect and study neutrinos once the accelerator starts up again in 2022, but from a different angle than that of FASERν. The detector will also be able to search for new particles, very weakly interacting particles not predicted by the Standard Model which could make up dark matter.