Building an International Flagship Neutrino Experiment

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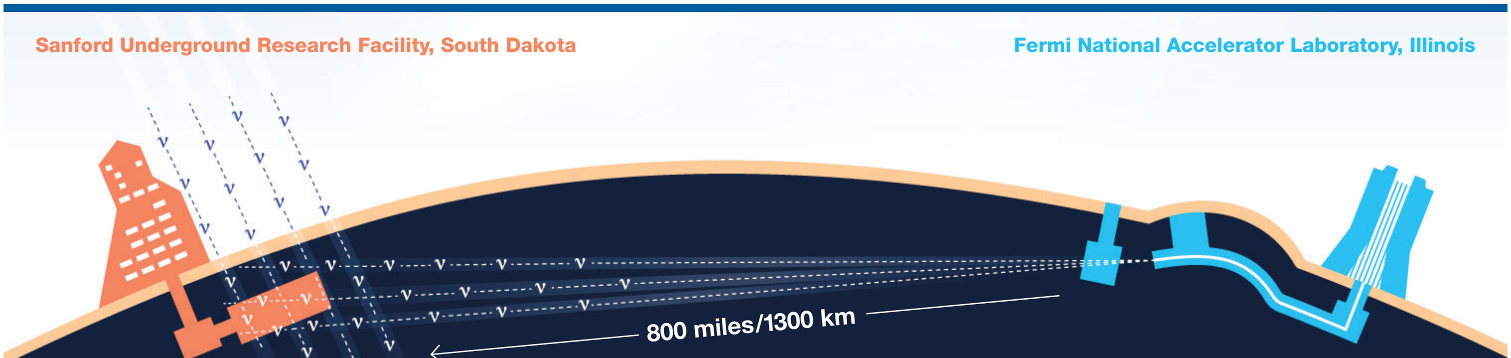
An international team of over 1,000 scientists and engineers from more than 30 countries is building the most advanced neutrino experiment in the world, which could change our understanding of the universe. Groundbreaking for this revolutionary endeavor—hosted by the U.S. Department of Energy's Fermilab with contributions from across the U.S. and around the globe—took place in July of 2017. A large prototype detector successfully recorded data at the European research center CERN from 2018 to 2020.



Deep Underground Neutrino Experiment (DUNE)

DUNE consists of two state-of-the-art particle detectors: a smaller one at Fermilab and a much larger one to be constructed a mile beneath the surface at the Sanford Underground Research Facility in South Dakota. The South Dakota detector will be the largest of its type ever built: It will use 70,000 tons of liquid argon and advanced technology to record neutrino interactions with unprecedented precision. In Feb. 2020, DUNE published the Far Detector Technical Design Report, which lays out everything needed to build the detector in South Dakota. Preparations for the construction of detector components are underway at institutions around the world.

Long-Baseline Neutrino Facility (LBNF)

Before the DUNE detectors can be built, they will need underground facilities equipped with intricate cryogenic technology to keep the detectors at their operating temperature of -300 degrees Fahrenheit. LBNF will house the DUNE far detector a mile underground in South Dakota, as well as the smaller near detector at Fermilab. About 800,000 tons of rock will be excavated from Sanford Lab's underground caverns, and a new scientific facility constructed. At Fermilab, a new beamline will be built to send the laboratory's intense high-energy beam of neutrinos 800 miles (1300 km) through the earth from Illinois to South Dakota, with no tunnel needed.

Proton Improvement Plan II (PIP-II)

The DUNE experiment requires the most particle-packed high-energy neutrino beam in the world, and that's exactly what Fermilab will deliver. Fermilab's high-energy neutrino beam is already the world's most intense, but a new particle accelerator, built with major contributions from partners around the world, will make that beam even more powerful. Groundbreaking for the PIP-II project took place in March 2019. The accelerator will be built with the latest superconducting radio-frequency technology developed at Fermilab. The PIP-II Injector Test Facility accelerated proton beam through its superconducting section for the first time in Oct. 2020.

Why neutrinos?

The Deep Underground Neutrino Experiment, powered by the Long-Baseline Neutrino Facility and Fermilab's PIP-II accelerator upgrades, will study elusive subatomic particles called neutrinos. They are the most abundant matter particles in the universe, and they are all around us, but we know very little about them. Each second a trillion neutrinos pass harmlessly through our bodies. In nature, they are produced in great quantities by the sun and other stars.

Scientists can create neutrinos in the laboratory with huge particle accelerators, and these neutrinos can be tracked with extremely sensitive detectors. Learning more about neutrinos, particularly the unique mechanism that allows them to change from one type to another over long distances, will tell us more about the universe and how it works. It may even give us the key to understanding why we live in a matter-dominated universe—in other words, why we are here.

Three major discovery areas

Origin of Matter

DUNE scientists will look at the differences in behavior between neutrinos and antineutrinos, aiming to find out whether neutrinos are the reason the universe is made of matter.

Unification of forces

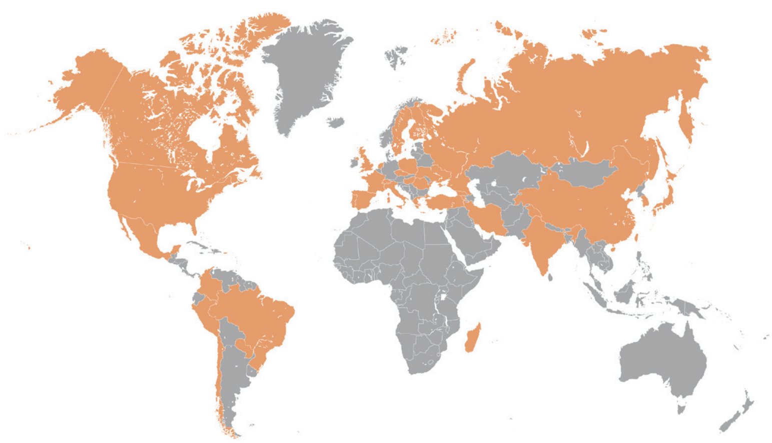
DUNE's search for the signal of proton decay—a signal so rare it has never been seen—will move scientists closer to realizing Einstein's dream of a unified theory of matter and energy.

Black hole formation

DUNE will look for the gigantic streams of neutrinos emitted by exploding stars to watch the formation of neutron stars and black holes in real time, and learn more about these mysterious objects in space.

An international effort

The Deep Underground Neutrino Experiment brings together over 1,000 scientists from more than 30 countries around the world.



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United States

Planned project timeline

July 2017
Groundbreaking for LBNF/DUNE

Sept. 2018
First ProtoDUNE detector online at CERN

Jan. 2019
Pre-excavation work begins in South Dakota

Nov. 2019
LBNF/DUNE site preparation starts at Fermilab

2021
Begin main cavern excavation in South Dakota

2024
Begin installing the first DUNE detector

For more information on the international collaboration and the institutions involved, please visit lbnf-dune.fnal.gov