Building an International Flagship Neutrino Experiment

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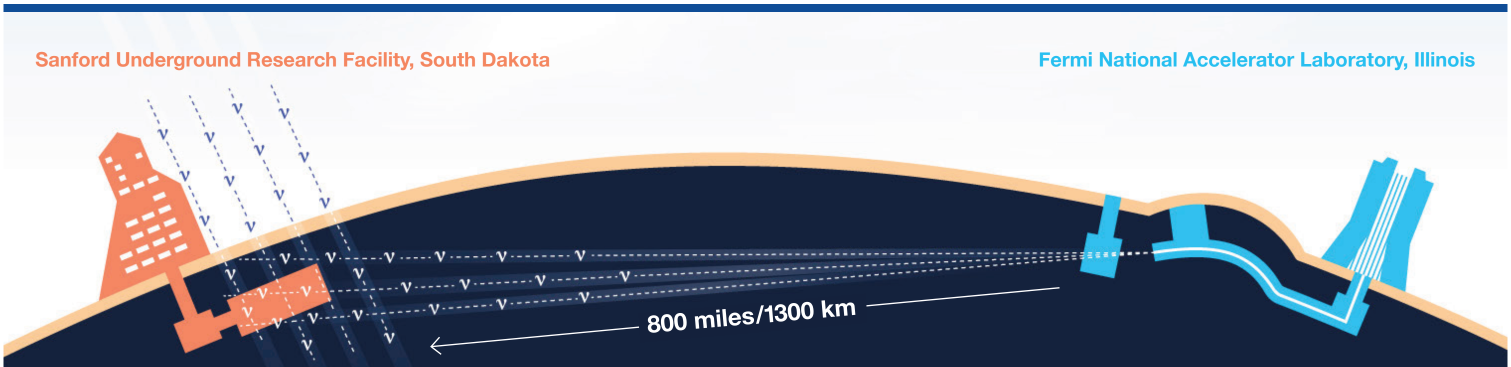
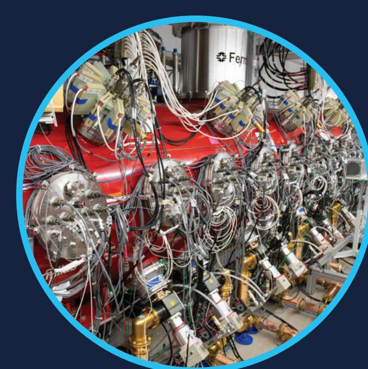
An international team of more than 1,500 scientists and engineers from over 35 countries is building the world's most advanced neutrino experiment. Hosted by the U.S. Department of Energy's Fermilab and supported by contributions from across the United States and around the globe, the Deep Underground Neutrino Experiment (DUNE) has the potential to transform our understanding of the universe. As the largest neutrino collaboration in history, DUNE has reached major milestones: excavation of the caverns in South Dakota is complete and partners worldwide are producing and testing detector components. Construction of the experiment in the mile-deep underground caverns will begin in 2026.





Deep Underground Neutrino Experiment (DUNE)

DUNE consists of two state-of-the-art particle detectors: a smaller one at Fermilab in Illinois 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. Collaborators around the world have begun the mass production of components for the first two of four huge particle detector modules for DUNE. Testing is taking place at CERN. DUNE collaborators also are working on components for the detector at Fermilab.

Long-Baseline Neutrino Facility (LBNF)

LBNF will house the DUNE far detector in South Dakota, as well as the smaller near detector at Fermilab. About 800,000 tons of rock has been moved from a mile underground at the Sanford Underground Research Facility and the excavation is now complete. The new space will be equipped with intricate cryogenic technology to keep the DUNE detector at its operating temperature of -300 degrees Fahrenheit. At Fermilab, a new beamline will be built to send the laboratory's intense high-energy beam of neutrinos 800 miles through the earth from Illinois to South Dakota. The neutrinos will travel straight through earth, no tunnel needed. Construction for the cryostat will begin in 2026.

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. A new, 700-foot-long particle accelerator, built with major contributions from partners around the world, will power the intense neutrino beam. The accelerator will be built with the latest superconducting radio-frequency technology developed at Fermilab. Tests at the PIP-II Injector Test Facility successfully concluded in 2021, including the acceleration of protons through a superconducting section. The PIP-II cryoplant building was completed in 2022. Construction of the complex that will house the accelerator has begun.

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.

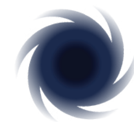
Three major discovery areas

Matter versus antimatter

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.

New physics

DUNE is on the lookout for the unexpected. This unique experiment will search for new physics beyond the Standard Model in exciting new ways.



Exploding stars

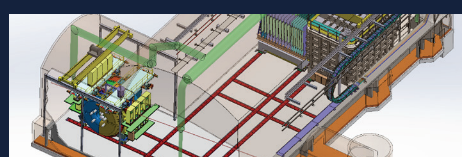
DUNE will look for the gigantic streams of neutrinos emitted by exploding supernovae to watch the formation of neutron stars and black holes in real time, and learn more about these mysterious objects in space.

What makes DUNE unique?

DUNE's distinctive innovations make it the only experiment capable of advancing neutrino physics to entirely new frontiers.

Beam source

- World's most powerful accelerator-produced neutrino beam in the world
- Broad-band, high-energy spectrum maximizing sensitivity to neutrino oscillations and enabling new physics
- Widest energy range of any accelerator neutrino beam



Moveable near detector

- Novel design enables millimeter-scale 3D imaging of dozens of neutrino interactions at once
- Gives most precise constraints on neutrino interactions with matter
- Enables precision neutrino oscillation physics in DUNE

Neutrino distance and energy

- Longest distance we have ever sent an accelerator neutrino beam
- The only experiment capable of a discovery level measurement of the ordering of the masses of the neutrinos
- Optimized for discovery science

Liquid argon technology

- Game-changing technology is a paradigm shift in the detection of neutrinos
- Can see details of neutrino interactions we have never been able to see before

Path to science

2017
Held groundbreaking for LBNF/DUNE

2018
First ProtoDUNE detector went online at CERN

2019
Began LBNF/DUNE-US site preparation at Fermilab

2021
Began main cavern excavation in South Dakota

2024
Completed main cavern excavation in South Dakota

2026
Begin installing the first DUNE detector

2029
Begin operating the first DUNE detector

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