

PIP-II Particle Accelerator Project

Fermilab's Proton Improvement Plan II will power the long-term future of the U.S. accelerator-based particle physics program and enable the world's most powerful high-energy neutrino beam for the international Deep Underground Neutrino Experiment.



This architectural rendering shows the buildings that will house and support the new 700-foot-long PIP-II particle accelerator at Fermilab.

Abundant neutrinos, powerful protons

The PIP-II project is an essential upgrade of Fermilab's particle accelerator complex. Groundbreaking occurred in March 2019. The upgrade will enable Fermilab's accelerators to generate an unprecedented stream of neutrinos—subtle, subatomic particles that could hold the key to understanding the universe's evolution—by creating the world's most intense high-energy neutrino beams.

This capability positions Fermilab to be the world leader in accelerator-based neutrino research. It enables the scientific program for the international, Fermilab-hosted Deep Underground Neutrino Experiment (DUNE) and Long-Baseline Neutrino Facility (LBNF).

The key to PIP-II is power. When the PIP-II project is complete, Fermilab will be able to generate proton beams greater than 1 megawatt—60 percent higher than current capabilities. These powerful beams of protons will in turn create intense beams of neutrinos. Future PIP-II upgrades will triple the lab's current beam power.

PIP-II's high-intensity proton beams will provide a flexible platform for the long-term future of the Fermilab accelerator complex and the U.S. accelerator-based particle physics program.

An international project

PIP-II is the first particle accelerator on U.S. soil built with significant contributions from international partners. Institutions in France, India, Italy, Poland and the UK are contributing to the project, bringing specific expertise in accelerator technologies and established track records in contributing to international accelerator projects.

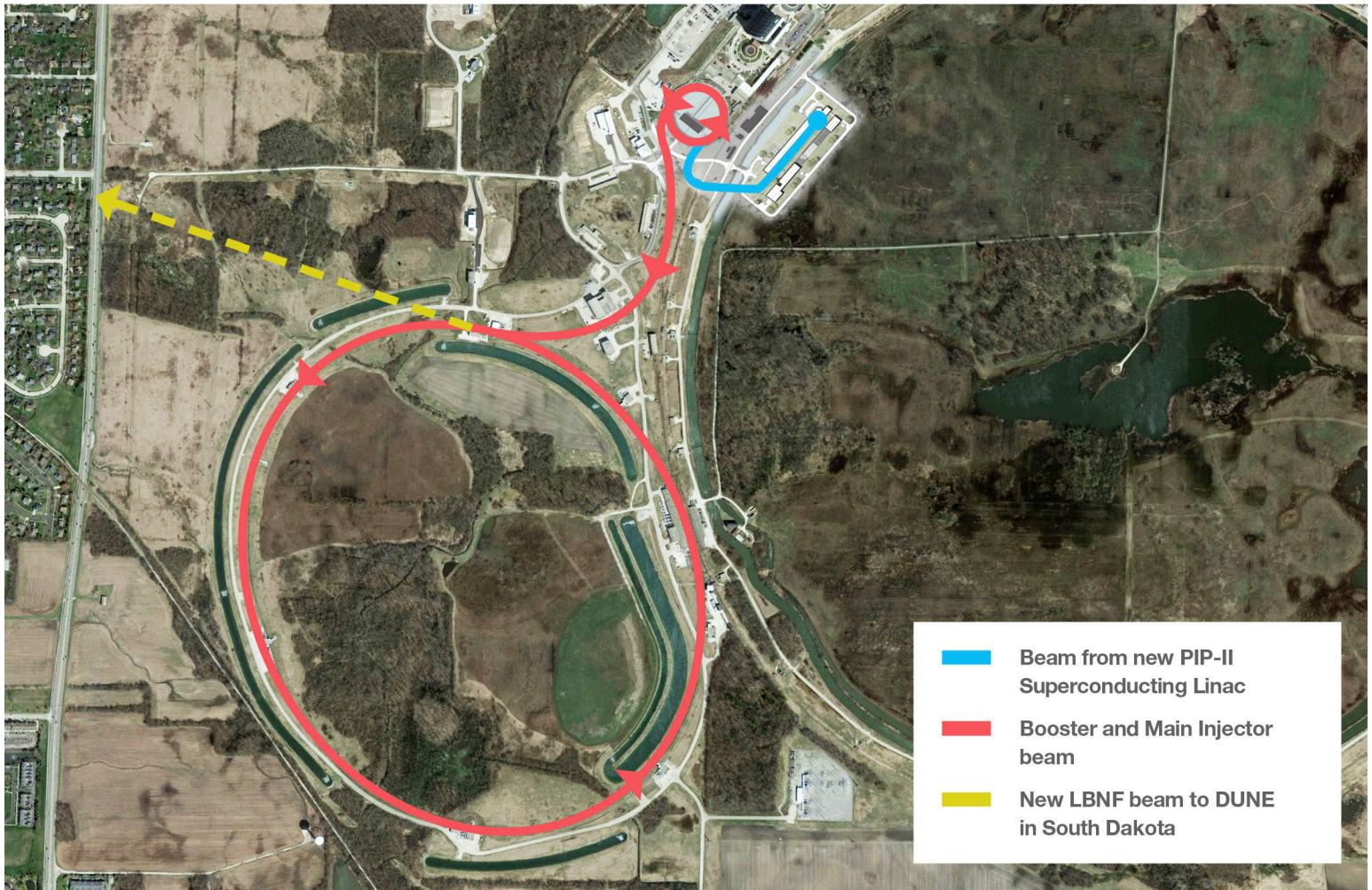


This photo shows the first PIP-II superconducting cryomodule, SSR1, built and successfully tested with beam at Fermilab, an example of the technology that will enable the Fermilab accelerator complex to generate powerful particle beams.

PIP-II and superconducting technology

Fermilab is a pioneer in the use of superconducting technology for particle acceleration, and PIP-II will use this forefront technology to accelerate protons efficiently. The project draws on Fermilab's world-class expertise in this research area, helping to raise the performance of the next generation of accelerators.

PIP-II's addition of a new superconducting accelerator to the laboratory's accelerator chain, together with the refurbishment of the lab's existing accelerators, will result in a cutting-edge accelerator complex, providing flexibility to send intense beams to multiple experiments, including LBNF/DUNE, over many decades. The cryoplat building that will house the facility's cryogenic equipment and single largest in-kind contribution was completed in Dec. 2022.



- Beam from new PIP-II Superconducting Linac
- Booster and Main Injector beam
- - - New LBNF beam to DUNE in South Dakota

The PIP-II project will supply powerful neutrino beams for the LBNF/DUNE experiment.

Neutrinos for LBNF/DUNE

The neutrinos generated by the powerful PIP-II-enabled accelerator complex will travel to the first of two DUNE particles detectors, located on the Fermilab site, and then continue to travel 800 miles (1,300 kilometers) through Earth's mantle to a second, much larger detector located a mile underground at the Sanford Underground Research Facility in Lead, South Dakota. Scientists will compare the data from the two detectors to understand how neutrinos change as they travel over long distances.

Benefits of PIP-II

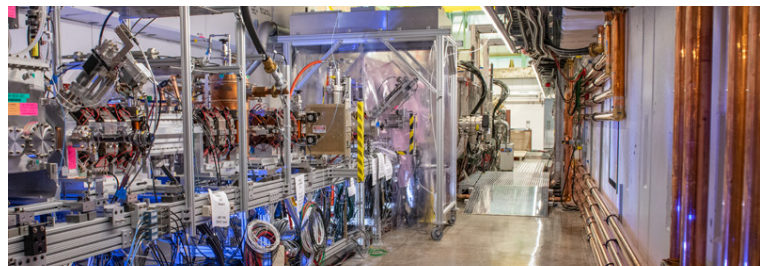
The development of PIP-II, LBNF and DUNE will have a multimillion dollar economic impact in Illinois and South Dakota, according to a recent study by Anderson Economic Group.

In addition, institutions from across the United States and around the globe contribute to these projects. The opportunity to build and test components for PIP-II also has multiplying effects for international collaborators, who will gain expertise in accelerator technology that can be applied in their home countries.

Scientists and engineers are developing the superconducting accelerator technology in PIP-II not only for fundamental science, but also for applications in industry, national security, medicine, computing and the environment.

Major Milestones achieved

The project received DOE CD-2 approval in Dec 2020, CD-3a approval in March 2021 and CD-3 approval in April 2022. Construction of the cryogenic plant building was completed in December 2022 and work began on the Linac Complex in January 2023. Successful beam tests were completed in PIP2IT in April 2020 and validated performance of the first two PIP-II cryomodules. A prototype of the high-beta 650 megahertz cryomodule was completed and underwent a successful cooldown in spring 2023. The PIP-II project will enable physics by the late 2020s.



PIP-II will maximize Fermilab's scientific potential by incorporating a unique first section for the lab's accelerator chain. This will allow scientists to customize beam parameters for multiple experiments operating simultaneously. Researchers will use the transforming potential of artificial intelligence and machine learning to deliver flexible beam patterns to users quickly, reliably and with minimal operational effort.