SRF Accelerator Research & Development

Technologies developed at Fermilab will be used in the next generation of particle accelerators and will spur innovation to meet the challenges of America's future.

SRF acceleration cavities such as this one accelerate particle beams. Fermilab scientists and engineers conduct extensive research to make the cavities as efficient as possible.

Superconducting radio-frequency technology

Superconducting radio-frequency (SRF) systems are the technology of choice for the next generation of particle accelerators, and Fermilab is a world leader in their development and testing. Fermilab partners with U.S. industry and other institutions around the world to design and build SRF systems in cost-effective ways. The technology enables and is broadly used in different fields of discovery science, including nuclear and particle physics, materials science and medicine, as well as basic research and applications.

Test facilities for superconducting acceleration

Fermilab operates one of the most advanced complex of SRF science and technology research and test facilities in the United States, with broad capabilities ranging from basic materials science and superconductor characterization to accelerator cavity and cryomodule design, processing and testing. The infrastructure enables fundamental SRF research and allows developing and testing components for modern state-of-the-art and future accelerators.

SRF systems comprise accelerator cryomodules, high-power radio-frequency amplifiers, radio-frequency controls and cryogenic systems. At the heart of each SRF cryomodule is a string of SRF cavities operating at cryogenic temperatures that accelerate particle beams to the desired energy.

Currently, Fermilab is developing cryomodules for two major projects. One is a high-power superconducting proton accelerator for the Fermilab PIP-II project. The other is a next-generation X-ray laser, LCLS-II, being built at SLAC National Accelerator Laboratory.

Scientists and engineers have also developed a superconducting electron linear accelerator at Fermilab's FAST facility for advanced beam physics research.

A powerful accelerator for the future

Fermilab recently broke ground on an upgrade to its accelerator complex to produce the world's most intense beam of difficult-to-study neutrinos. Known as PIP-II, the project will deliver high-intensity beam for the upcoming international Deep Underground Neutrino Experiment, hosted by Fermilab, and Long-Baseline Neutrino Facility, based at Fermilab and Sanford Lab in South Dakota, to begin operations in the mid-2020s. The project involves the construction of a new, 800-million-electronvolt SRF linear accelerator, capable of delivering continuous particle beams to multiple experiments.

SRF for LCLS-II

Fermilab is involved in the design, assembly and delivery of SRF cryomodules for SLAC's Linac Coherent Light Source II. Fermilab is providing 22 of LCLS-II's 37 cryomodules. Fermilab is also responsible for 10 more cryomodules for its energy upgrade to LCLS-II HE. Both LCLS-II and LCLS-II HE aim at unprecedented cryomodule performance, enabled by nitrogen doping, a Fermilab-pioneered cavity treatment technique that drastically reduces the cryogenic consumption of this accelerator.

SRF for quantum science

The SRF technology developed for accelerators can also be applied to quantum science and technology. One of the biggest barriers to building a viable quantum computer relates to the amount of time that quantum bits, or qubits, can maintain information—coherence time. Fermilab scientists are using ultraefficient, superconducting cavities—the very same structures that are used to accelerate particles—to stretch a qubit's coherence time by orders of magnitude. The same technology will be used for experiments aimed at searching for dark photons.