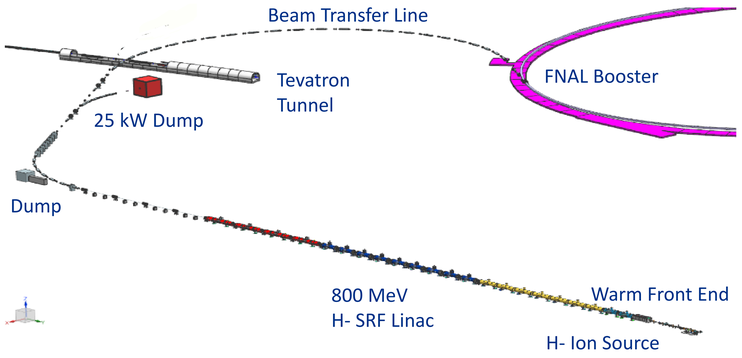
FERMILAB-POSTER-24-0020-PIP2

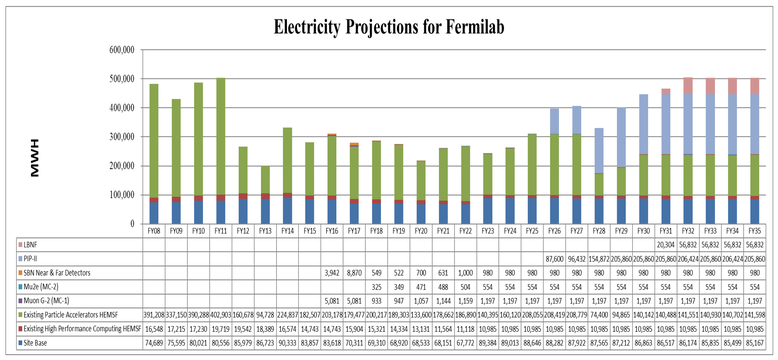
Sustainability in Proton Improvement Plan – II

PIP-II Project Overview

PIP-II is an essential enhancement to the accelerator complex and will enable the world's most intense beam of neutrinos to the international LBNF/DUNE project. PIP-II will use the latest advances in superconducting radio frequency (SRF) technology to produce a 1.2 MW, upgradable and efficient, proton beam.



PIP-II scope including a new SRF linac and upgrades to existing accelerator complex.



	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	FY35
LBNF																								20,304	56,832	56,832	56,832	56,832
PIP-II																			87,600	96,432	154,872	205,860	205,860	205,860	206,424	205,860	206,424	205,860
SBN Near & Far Detectors									3,942	8,870	549	522	700	631	1,000	980	980	980	980	980	980	980	980	980	980	980	980	980
Muze (MC-2)											325	349	471	488	504	554	554	554	554	554	554	554	554	554	554	554	554	554
Muon G-2 (MC-1)									5,081	5,081	933	947	1,057	1,144	1,159	1,197	1,197	1,197	1,197	1,197	1,197	1,197	1,197	1,197	1,197	1,197	1,197	1,197
Existing Particle Accelerators HEMSF	391,208	337,150	390,288	402,903	160,678	94,728	224,837	182,507	203,178	179,477	200,217	189,303	133,600	178,662	186,890	140,395	160,120	208,055	208,419	208,779	74,400	94,865	140,142	140,488	141,551	140,930	140,702	141,598
Existing High Performance Computing HEMSF	16,548	17,215	17,230	19,719	19,542	18,389	16,574	14,743	14,743	15,904	15,321	14,334	13,131	11,564	11,118	10,985	10,985	10,985	10,985	10,985	10,985	10,985	10,985	10,985	10,985	10,985	10,985	10,985
Site Base	74,689	75,595	80,021	80,556	85,979	86,723	90,333	83,857	83,618	70,311	69,310	68,920	68,533	68,151	67,772	89,384	89,013	88,646	88,282	87,922	87,565	87,212	86,863	86,517	86,174	85,835	85,499	85,167

Electricity projections for Fermilab categorized by project (as of Feb 2024). PIP-II and LBNF will drastically increase electricity consumption when they begin operating.

PIP-II Sustainability Workshop

Held in December 2021, the workshop's purpose was to brainstorm ideas, explore strategies, and to develop executable plans to improve sustainability features for PIP-II. Over 28 opportunities were identified ranging across multiple disciplines. The primary themes were:

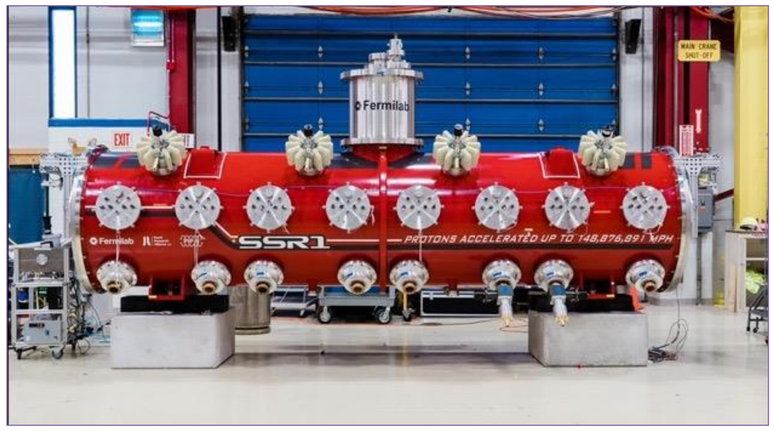
1. Energy management at accelerator facilities
2. Energy efficient technologies
3. Campus and building management
4. Energy recovery
5. Waste heat recovery

SRF vs Normal Conducting Technology

For linear accelerators, there are two options for the type of accelerating technology to use: superconducting or normal conducting (room-temperature) cavities. There are benefits and drawbacks to each type.[1]

Superconducting Cavities	Normal Conducting Cavities
➢ No thermal problems ➢ Less RF power ➢ Smaller amplifiers ➢ Continuous wave (CW) operation	➢ Less infrastructure required ➢ Simpler technology (if pulsed) ➢ Less expensive cavities (copper)
➢ Less tolerant against beam loss ➢ Cryogenic system required ➢ Complicated cavity fabrication (expensive)	➢ Higher RF power required ➢ Expensive amplifiers ➢ Thermal problems (if high duty factor [DF])

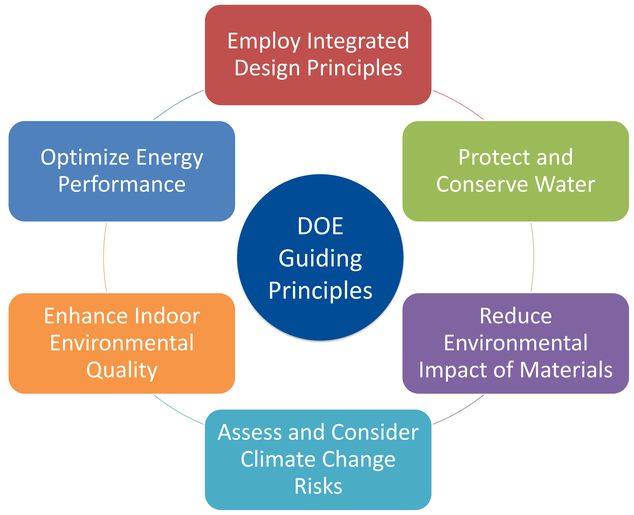
SRF technology was chosen for PIP-II because it is more flexible (pulsed and CW operation), scalable (higher power), and "future-proof" than normal conduction. In addition, SRF technology is still advancing, and its efficiency can still be improved while normal conducting cavities have reached their design maturity. Ultimately SRF technology will allow PIP-II to run more efficiently and use less power, resulting in operational cost savings for the lab.



Prototype SSR1 cryomodule built for PIP-II. Implements current cutting edge SRF technology to accelerate proton beam in 800 MeV Linac.

Sustainable Buildings

All PIP-II buildings will meet DOE Guiding Principles for Sustainable Federal Buildings and Fermilab sustainability goals.



PIP-II site showing the buildings that must comply with Guiding Principles for Sustainable Federal Buildings. Solar panels shown were considered but will not be implemented.

Case Study: Solar PV on Linac Complex

The project investigated the possibility of covering the roof of the Linac Complex (~ 1 acre) with solar panels.

Linac Complex Roof		PIP-II Load
1 acre	Space	55 acres
0.475 MW	Power	26 MW
$1.4 Million	Cost	$77 Million

1. Podlech, H. (2013). Superconducting versus normal conducting cavities. CERN Yellow Report CERN-2013-001, pp.151-170