PIP-II Project Update

Lia Merminga, Project Director
Fermilab Community Advisory Board
28 January 2021
• Build a world-class neutrino program
• Host it as a global project
• Upgrade Fermilab accelerator complex to provide >1 MW proton beam

**Recommendation 13:** Form a new international collaboration to design and execute a highly capable Long-Baseline Neutrino Facility (LBNF) hosted by the U.S. To proceed, a project plan and identified resources must exist to meet the minimum requirements in the text. LBNF is the highest priority large project in its timeframe.

**Recommendation 14:** Upgrade the Fermilab proton accelerator complex to produce higher intensity beams. R&D for the Proton Improvement Plan II (PIP-II) should proceed immediately, followed by construction, to provide proton beams of >1 MW by the time of first operation of the new long-baseline neutrino facility.
• **Proton Improvement Plan – II (PIP-II):** The upgrade of Fermilab accelerator complex to >1 MW proton beam

• **Long Baseline Neutrino Facility (LBNF):** Dual-site detector facility and neutrino beam

• **Deep-Underground Neutrino Experiment (DUNE):** The next generation neutrino experiment

The PIP-II/LBNF/DUNE project will be the first internationally conceived, constructed and operated mega-science project hosted by the Department of Energy in the United States.
PIP-II...a new accelerator to generate neutrinos
**PIP-II Mission & Scope**

**PIP-II** will enable the world’s most intense beam of neutrinos to the international LBNF/DUNE project, and a broad physics research program, powering new discoveries for decades to come.

- **800 MeV H− linac**
  - Warm Front End & SRF section
- **Linac-to-Booster transfer line**
  - 3-way beam split
- **Upgraded Booster**
  - 20 Hz, 800 MeV injection
  - New injection area
- **Upgraded Recycler, Main Injector**
  - RF in both rings
- **Conventional facilities, incl.**
  - Site preparation
  - Cryoplant Building
  - Linac Complex
  - Booster Connection
Indian Partners, Expertise and Capabilities

India, Department of Atomic Energy (DAE) (started 2009)
BARC, RRCAT, VECC; also IUAC
Substantial engineering / manufacturing experience; Superconducting magnets for LHC; 2 GeV synch light source

Italy, INFN (started 2016)
Internationally recognized leader in superconducting RF technologies
SRF cavity and cryomodule fabrication for XFEL; SRF cavities for ESS

UK, STFC UKRI (started 2017)
Substantial engineering and manufacturing experience; Construction, operation of synch light & neutron sources SRF cavity processing and testing for ESS

France, CEA, CNRS/IN2P3 (started 2017)
Internationally recognized leader in large-scale CM assembly
CM assembly for European XFEL and ESS; SSR2 cavities and couplers for ESS

Poland, WUST, WUT, TUL (started 2018)
Substantial engineering / manufacturing experience; CDS, LLRF, QC for XFEL, ESS

PIP-II Project benefits from world-leading expertise, facilities. "Timing is perfect"
PIP-II Superconducting RF CW Linac, 800 MeV Consists of Five Types of Cryomodules

- **Cryoplant**
- **CDS**
- **HWR**
- **RFQ**
- **Room Temperature**

**Cryomodules:**
- **Single Spoke** SSR1 X 2
  - 16 Cavities
  - 325 MHz
- **Single Spoke** SSR2 X 7
  - 35 Cavities
  - 325 MHz
- **Elliptical** HB650 X 4
  - 24 Cavities
  - 650 MHz
- **Elliptical** LB650 X 9
  - 36 Cavities
  - 650 MHz

**Energy Levels:**
- 2.1 MeV
- 10 MeV
- 32 MeV
- 177 MeV
- 516 MeV
- 833 MeV

**Linac** is technically complex, state of the art superconducting RF accelerator

**PIP-II Linac is the world’s highest energy and power CW proton linac, and the U.S. first accelerator project to be built with major international contributions**
The state-of-the-art PIP-II Superconducting RF Systems

Half Wave Resonator
- $\beta = 0.11$
- $Q_0 = 0.85 \times 10^{10}$
- Performance validated
- 2023

Single Spoke
- SSR1
- $\beta = 0.22$
- $Q_0 = 0.82 \times 10^{10}$
- 2022

Single Spoke
- SSR2
- $\beta = 0.47$
- $Q_0 = 0.82 \times 10^{10}$
- Testing in progress

Elliptical
- LB650
- $\beta = 0.61$
- $Q_0 = 2.4 \times 10^{10}$
- Dates: component built

Elliptical
- HB650
- $\beta = 0.92$
- $Q_0 = 3.3 \times 10^{10}$
- Unprecedented performance requirement

Dates:
- Component built
- Testing in progress
- Dates: component built

Lia Merminga | Community Advisory Board | PIP-II
Half-Wave Resonator (HWR) Fabrication by

HWR cryomodule successfully accelerated beam
Single Spoke prototype cryomodule fabricated by Fermilab; successfully accelerated beam
PIP-II Cryomodules accelerate beam to 17 MeV!

Significant Milestone: SRF cryomodules and accelerator systems demonstrate solid performance. International partners’ deliverables seamlessly integrated. New era of SRF proton acceleration at Fermilab
Cryogenic Plant Building Groundbreaking – July 2020
Cryoplant Building Construction

https://app.truelook.com/?u=fc1599677013#tl_live
https://app.truelook.com/?m=16002500832205566295043
PIP-II Site Status on 27 January 2021
Conventional Facilities

- Cryoplant Building Construction underway
  - Structural steel erection ongoing until mid-February 2021
  - Precast concrete wall panels installation scheduled for mid-February 2021
  - Completion in December 2021

- Site Work
  - Proposal docs underway; DOE review Feb 21

- Linac Complex Design integrated with technical systems
  - Final design underway
    - 90% review scheduled week of January 25th
    - On track for 100% in April 2021

- Booster Connection
  - Start design in March/April 2021
PIP-II baseline approved by DOE – December 2020

➢ Total Project Cost $978M (+$310M IKC)
➢ Completion date: Dec 2028

“This approval marks a significant milestone for the project and the start of a new era for Fermilab and the global HEP community.”
What does PIP-II mean to ....?

✓ Particle Physicists
  ➢ Competitive advantage to the U.S. neutrino program
  ➢ Enables broad research program for many decades

✓ Accelerator physicists/engineers/technicians
  ➢ State-of-the-art high-power SRF accelerator
  ➢ First SRF accelerator of the Fermilab complex and its first significant addition in 20 years

✓ Fermilab & our local community
  ➢ DOE investment of ~$1B plus international contributions
  ➢ Employment for >1000 FTEs over next 8 years

We are grateful to the lab, FSO, DOE/SC, partners and our community for unwavering support
Thank you!
We learned to work under Covid protocols