Fermilab Proton Program

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Mission Need

PIP-II’s Mission Need was derived from P5 Recommendations, “Building for Discovery, Strategic Plan for U.S. Particle Physics in a Global Context” (May 2014):

“... provide proton beams of >1 MW by the time of first operation of the new long-baseline neutrino facility.”

“The PIP-II project at Fermilab is a necessary investment in physics capability, enabling the world’s most intense neutrino beam, providing the wideband capability for LBNF, as well as high proton intensities for other opportunities…”

1. **Deliver high beam power** to LBNF/DUNE to meet the science requirements of this international mega-experiment

2. **Ensure sustained high reliability** of the Fermilab accelerator complex (the existing accelerator complex is ~50 years old)

3. **Provide upgrade potential** to meet the future needs of science

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1) P5 = Particle Physics Project Prioritization Panel
The Neutrino Program (2027 ?)

PIP II (Proton Improvement Project II, a.k.a. the accelerator) + LBNF (long baseline neutrino facility - the neutrino beam) + DUNE (deep underground neutrino experiment - the detector)
PIP-II: replace existing 400 Mev linac with a new 800 Mev one using SRF technology
design is a new 800 MeV CW-compatible Linac that integrates into the existing Fermilab accelerator complex

Summary of Key Performance Parameters
• 800 MeV Linac & other upgrades to power a 1.2 MW neutrino beam for LBNF/DUNE
• Upgradable to CW-beam operation for future science opportunities
• Conventional Facilities flexible for incremental enhancements in the future
The PIP-II 800 MeV Linac Technologies

Room Temperature Technology

Superconducting Radio Frequency Technology

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<th>IS</th>
<th>LEBT</th>
<th>RFQ</th>
<th>MEBT</th>
<th>$\beta=0.11$</th>
<th>$\beta=0.22$</th>
<th>$\beta=0.47$</th>
<th>$\beta=0.61$</th>
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PIP-II Injector Test Facility (PIP2IT)
1st US International Accelerator Project

Powering the next generation of discoveries in High Energy Physics

Cryogenic System

WARM SECTION

SUPERCONDUCTING SECTION

IS LEBT RFQ MEBT 

β=0.11 β=0.22 β=0.47 β=0.61 β=0.92

SSIP-II Linac

HWR x 1

SSR1 x 2

SSR2 x 7

LB650 x 11

HB650 x 4
Driven by DOE Policy 485.1 and DOE Order 142.4:

- DOE requires legally binding agreements be in place to accept hardware contribution from a foreign partner as well as define: IP rights, ownership, disposition of property, and other details—typically executed through a CRADA or S&T
  - **DOE expectation is that these binding agreements are preferred by CD-2, but the PME can approve CD-2 if “good faith efforts” are leading to signed agreements by CD-3**

Driven by DOE Order 413.3B:

- Joint project planning and close coordination with the international partners is needed “to ensure the highest quality final product is delivered on mutually agreed need dates”
  - **DOE expectation is that planning documents between the host lab and each partner institution are required by the CD-2 review and must be bilaterally signed by the ESAAB**
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**PIP-II Schedule Summary**

- **HWR Fab/Assembly**
- **SSR1 1st Cryomodule Fab/Assembly**
- **PIP2IT Program**
- **Cryoplant Final Design & Fabrication**
- **HWR Fab/Assembly**
- **SSR1 Production**
- **SSR2 Production**
- **LB650 Production**
- **HB650 Production**
- **Installation & Commissioning**
- **Remaining Conventional Facilities Construction**

**Yearly Milestones**

- **FY17**: PDR Complete
- **FY18**: Receipt of largest single in-kind contribution
- **FY19**: Retirement of several high technical risks
- **FY20**: Beneficial Occupancy of the Linac Tunnel
- **FY21**: Production
- **FY22**: Engineering/Development
- **FY23**: DOE Activity
- **FY24**: DOE and/or International Partners
Congress support demonstrated

From CD-1:
DOE TPC: $888M
$653→$928M range
41% Contingency on ETC

New cost profile and TPC update under development
What’s next - PIP III (??, 2030+, initial thoughts)

**Assumptions**

- PIP-II complete with following performance:
  - 800 MeV, 2 mA, 100% duty factor
- Booster has reached end of service with following performance:
  - 6.4E12 ppp x 20 Hz = 164 kW
- LBNE is running at 1.2 MW @ 120 GeV
- A suite of short baseline neutrino experiments is in place and operating at 80 kW @ 8 GeV
- Mu2e has been reconfigured for 800 MeV and is operating at 100 kW

**Goals for the Next Decade**

- Increase LBNE beam power beyond 2 MW
- Support short baseline experimental program at several x 100 kW
- Support next generation muon experimental program at several x 100 kW
  (Provide protons at 3 GeV or above for a kaon program at few x MW)
  (Provide protons at 7 GeV or above for muon-facility at few x MW)

**Constraints**

- Neutrino experiments require low duty factor
- Muon experiments require high duty factor
- Slip-stacking is not an option at these intensities
- Space-charge at injection into circular accelerators should be limited to <0.15
Booster replacement:
➢ Booster is as old as the linac being replaced
   – already ~50 yrs old
➢ Replacement of the booster would fully modernize the accelerator complex
   – Options for replacement would increase the accelerator complex’s capability by a factor of up to 5

Booster replacement options would appear to be a new RCS or an 8 Gev linac. There is no official Fermilab position yet. They have been asked to say something for the upcoming P5.