# PIP-II Project Update

Lia Merminga, Project Director

Fermilab Community Advisory Board

28 January 2021

A Partnership of:

US/DOE
India/DAE
Italy/INFN
UK/UKRI-STFC
France/CEA, CNRS/IN2P3
Poland/WUST

# Building for Discovery

## Strategic Plan for U.S. Particle Physics in the Global Context

- 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.

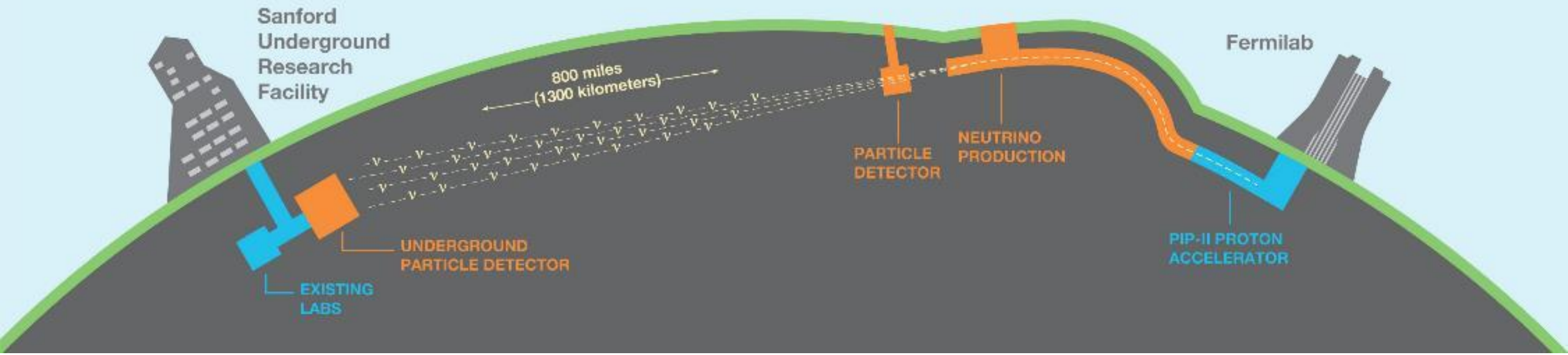
**Recommendation 14:** Upgrade the Fermilab proton accelerator complex to produce higher intensity beams. R&D for the Proton Improvement Plan II (PIP-II) should proceed immediately, followed by construction, to provide proton beams of >1 MW by the time of first operation of the new long-baseline neutrino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



PIP-II

# PIP-II / LBNF / DUNE

~1,214 collaborators from 202 institutions in 33 countries (including CERN)




- **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.***

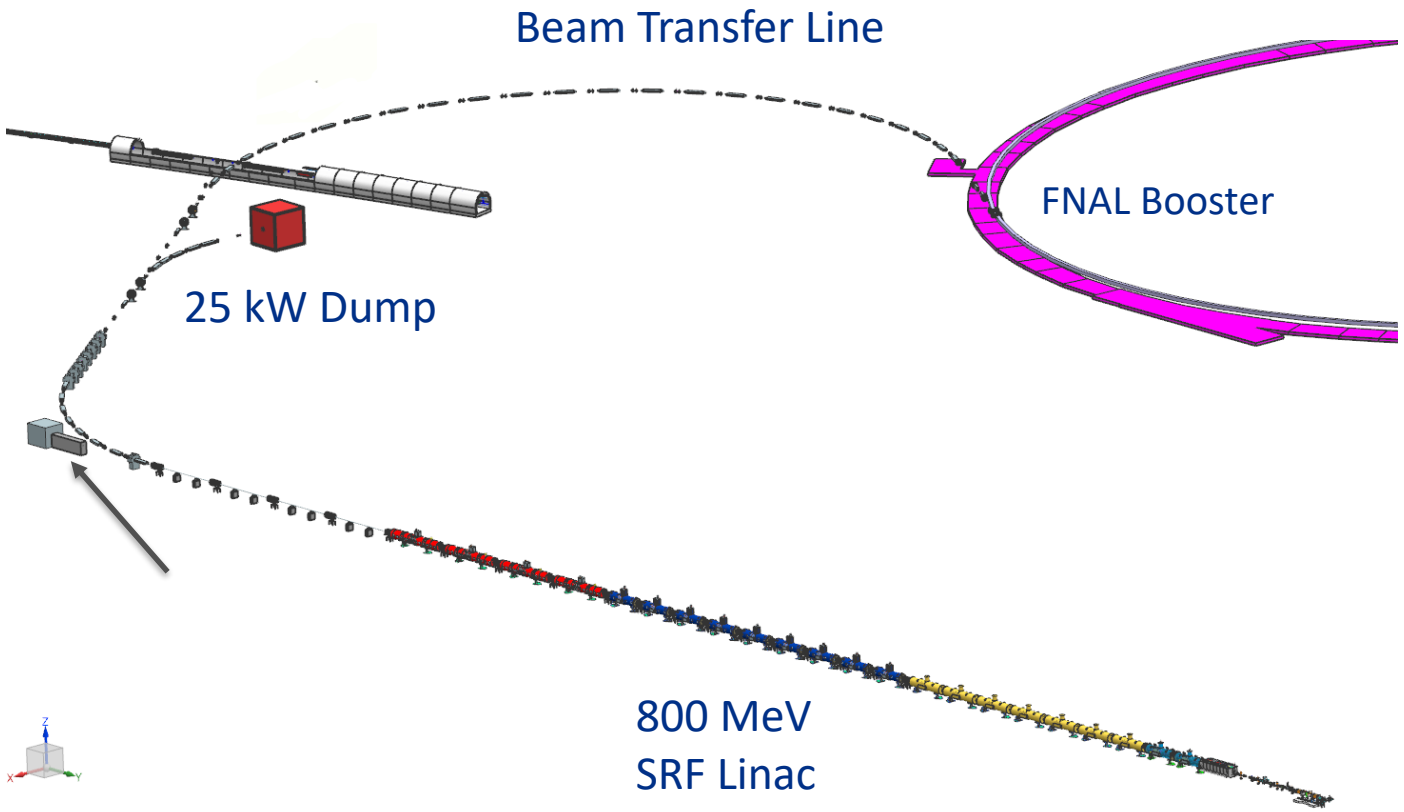
# PIP-II….a new accelerator to generate neutrinos






# 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


Main Injector
Transfer Line
PIP-II
SRF Linac
Booster

# PIP-II International 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)

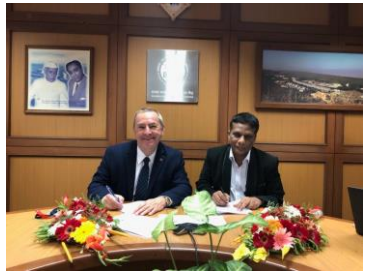
Substantial engineering and manufacturing experience; Construction, operation of synch light & neutron sources SRF cavity processing and testing for ESS

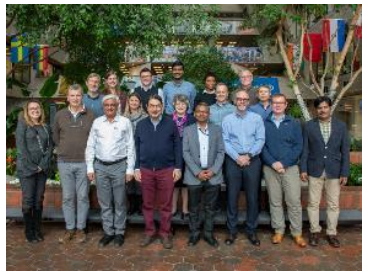
## France, CEA, CNRS/IN2P3 (started 2017)

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)

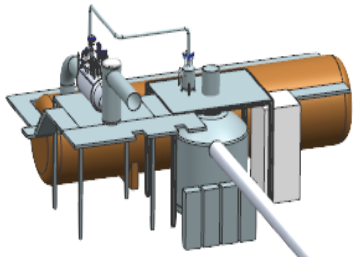
Substantial engineering / manufacturing experience; CDS, LLRF, QC for XFEL, ESS





***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

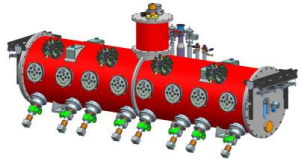


Cryoplant

CDS

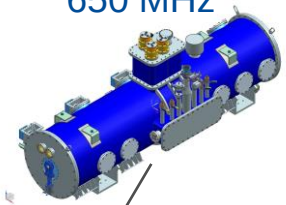
**HWR**
8 Cavities
162.5 MHz

**Single Spoke**
SSR1 X 2
16 Cavities
325 MHz

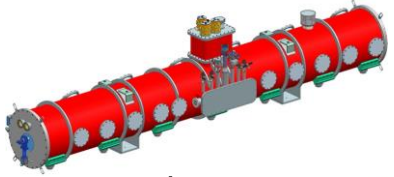


**Single Spoke**
SSR2 X 7
35 Cavities
325 MHz

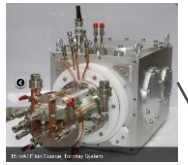
**Elliptical**
LB650 X 9
36 Cavities
650 MHz



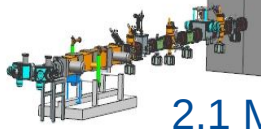
**Elliptical**
HB650 X 4
24 Cavities
650 MHz



**H- Ion source**



**RFQ**



2.1 MeV

10 MeV

32 MeV

177 MeV

516 MeV

833 MeV

Room Temperature

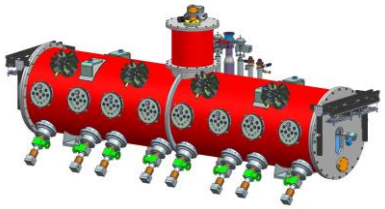
Superconducting

PIP-II Linac is technically complex, state of the art superconducting RF accelerator

***PIP-II 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

5.9 m

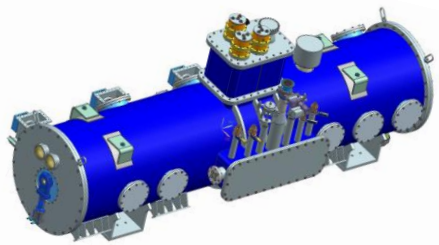


5.3 m

2023

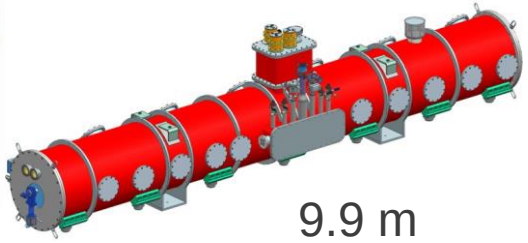
6.5 m

2023

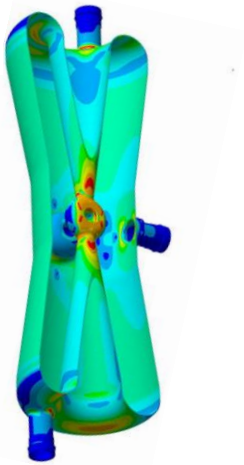


5.5 m

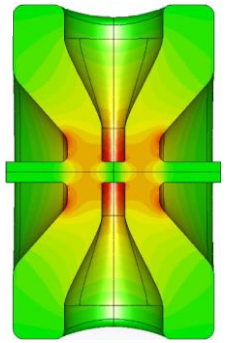
2021-22



9.9 m

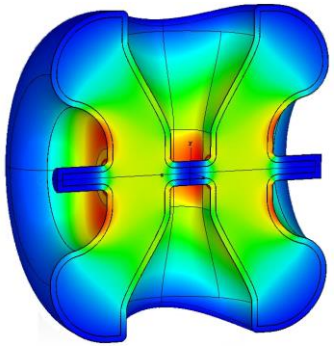


**Half Wave Resonator**
β=0.11 $Q_0$ =0.85x10$^{10}$

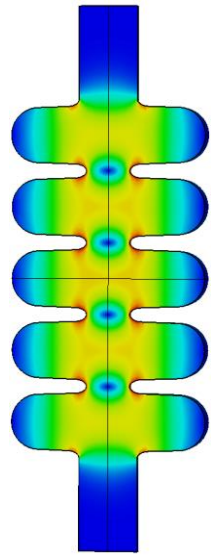


**Single Spoke**
SSR1
β=0.22 $Q_0$ =0.82x10$^{10}$

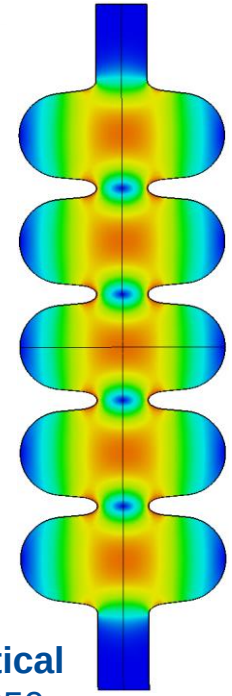
2022



**Single Spoke**
SSR2
β=0.47 $Q_0$ =0.82x10$^{10}$



**Elliptical**
LB650
β=0.61 *$Q_0$ =2.4x10$^{10}$

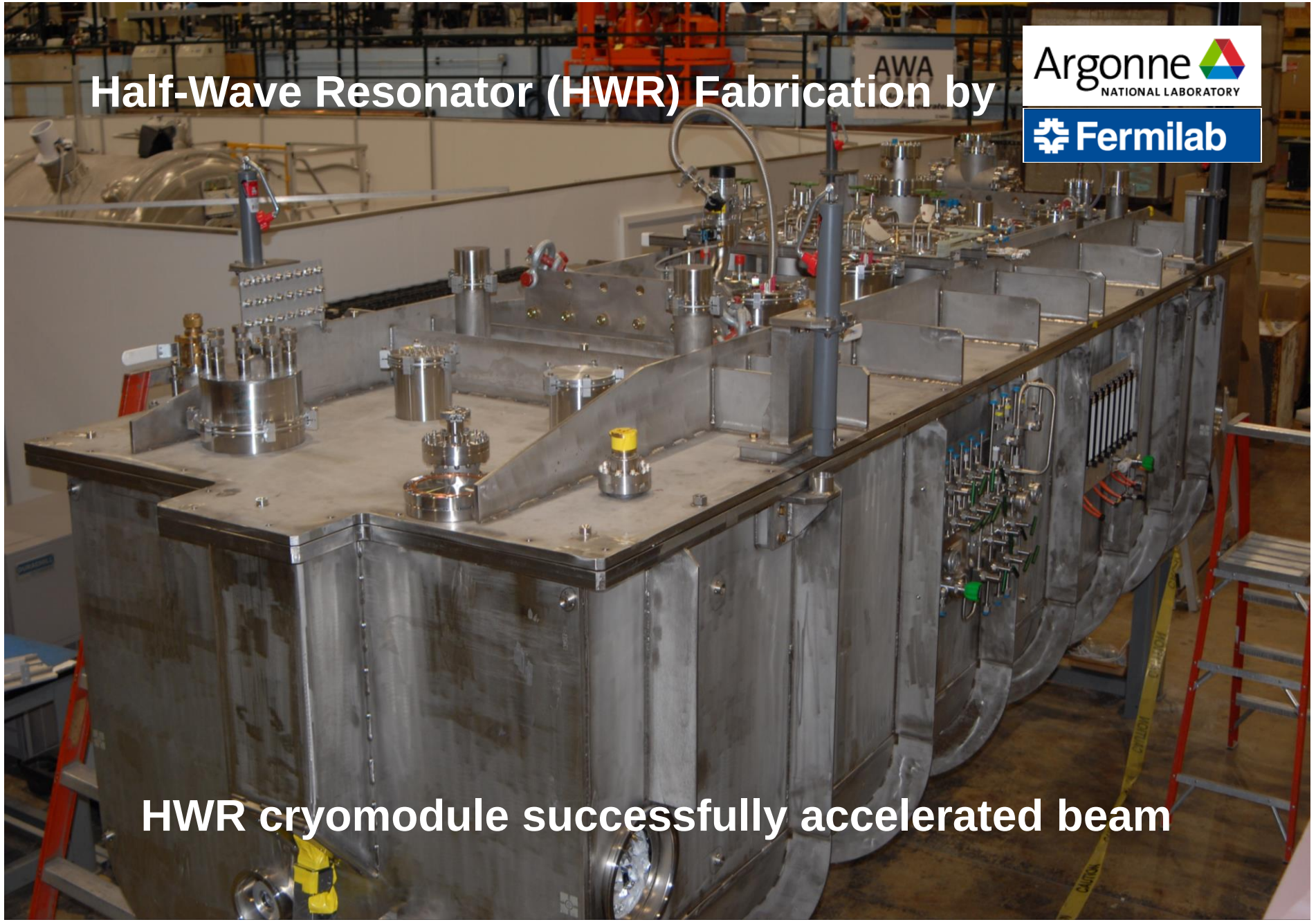


**Elliptical**
HB650
β=0.92 *$Q_0$ =3.3x10$^{10}$

✓ Performance validated ✓ Testing in progress Dates: component built

*unprecedented performance requirement

# Half-Wave Resonator (HWR) Fabrication by



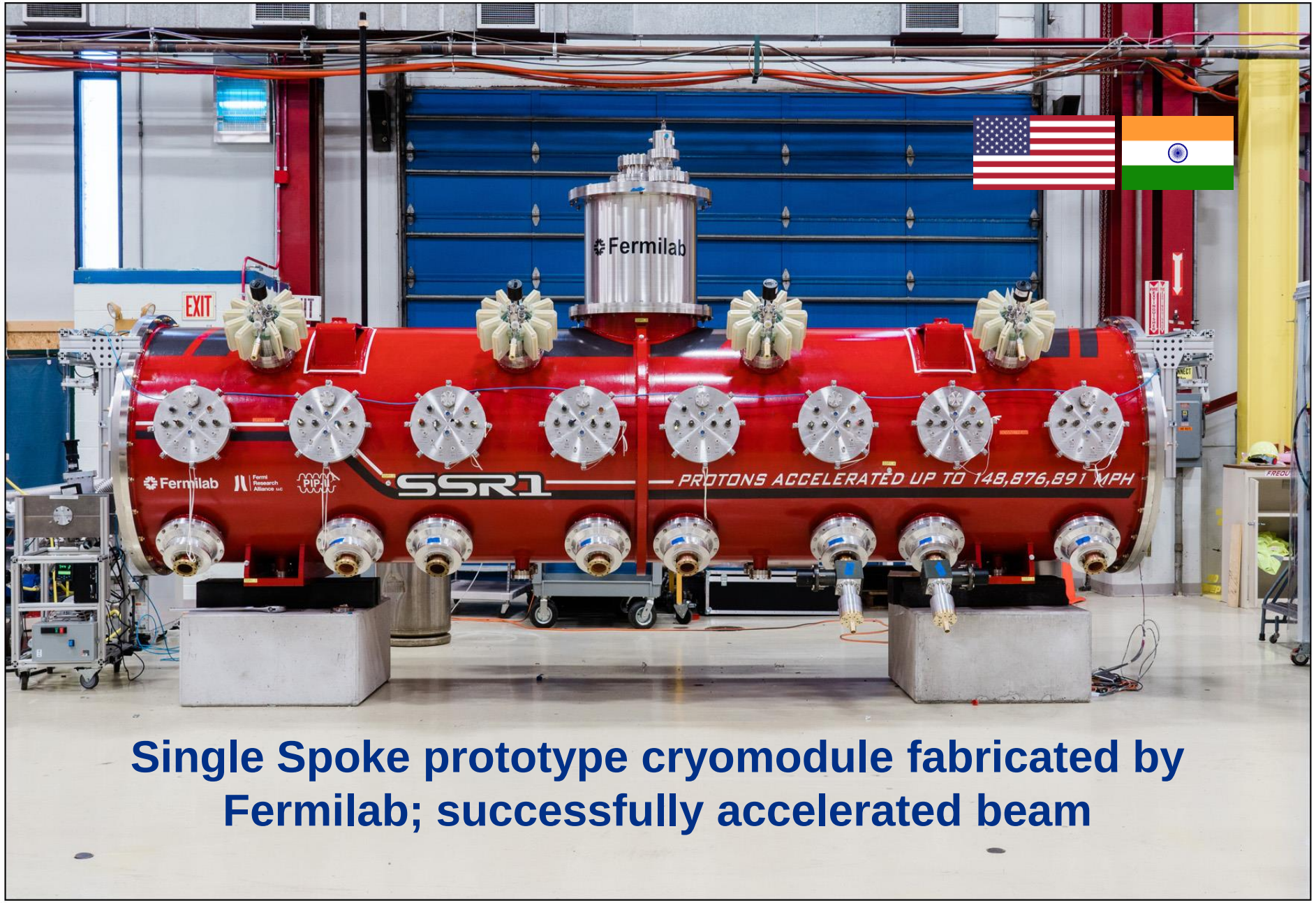

Argonne NATIONAL LABORATORY

Fermilab

**HWR cryomodule successfully accelerated beam**

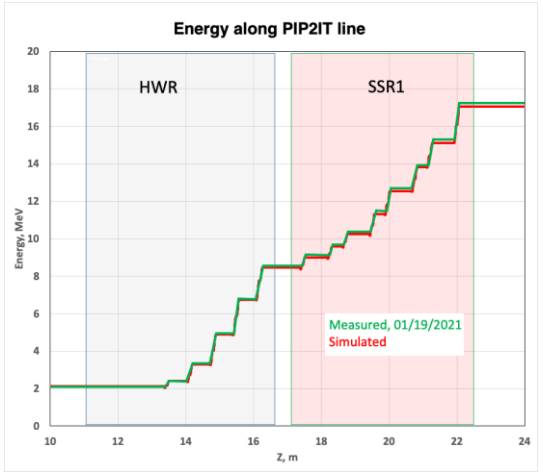


PIP-II




**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

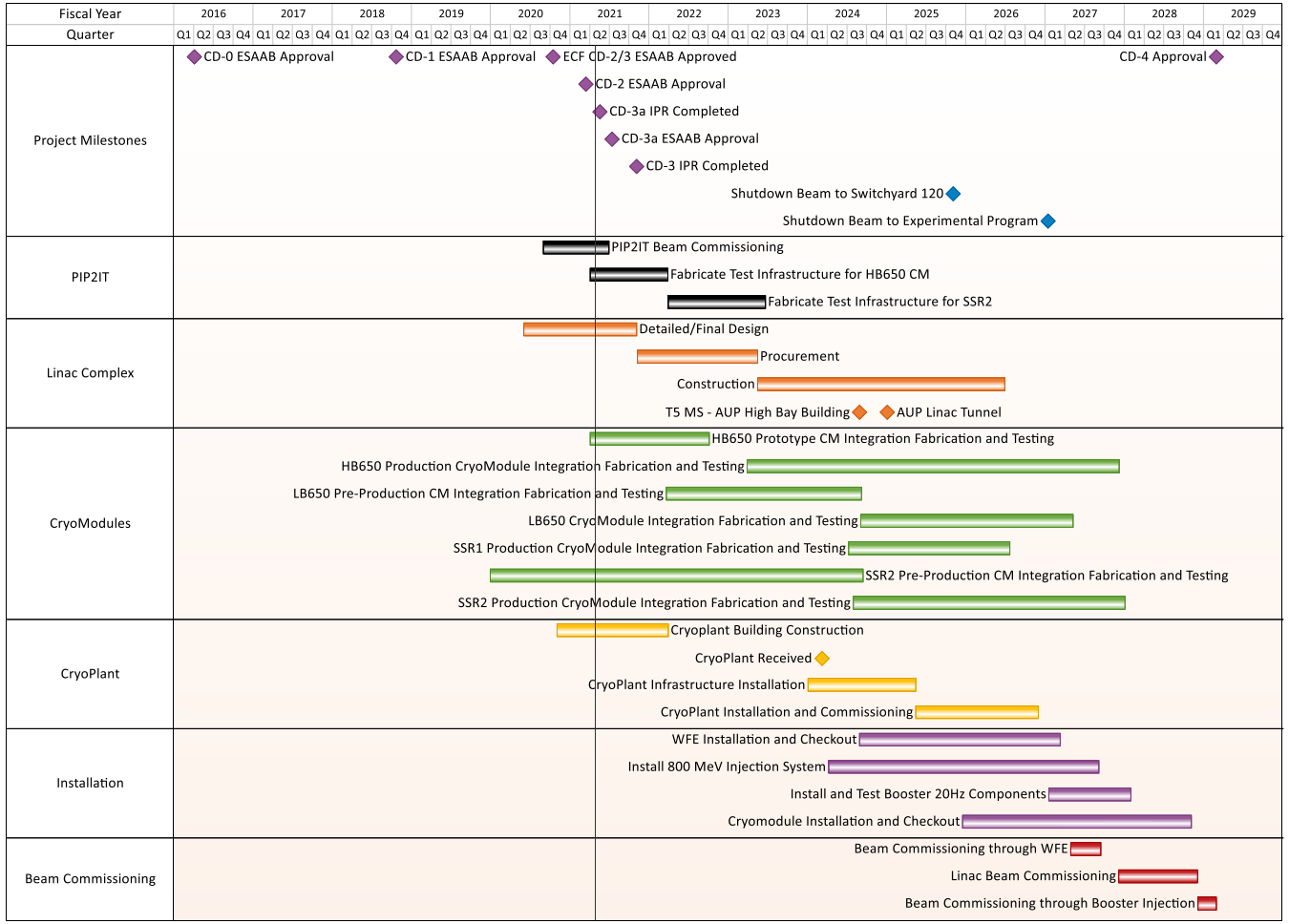
https://app.truelook.com/?m=160025008322055662950 43

# 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**

News

Major upgrade to Fermilab accelerator complex gets green light

December 16, 2020

Media contact

- Leah Hesla, Fermilab, media@fnal.gov, 630-840-3351

The U.S. Department of Energy has formally approved the scope, schedule and cost of the PIP-II project at DOE's Fermilab.

The approval, known as Critical Decision 2 or CD-2, is an endorsement of Fermilab's detailed, formal plan for building the PIP-II accelerator, a high-power, superconducting machine that will become the heart of the laboratory accelerator complex.

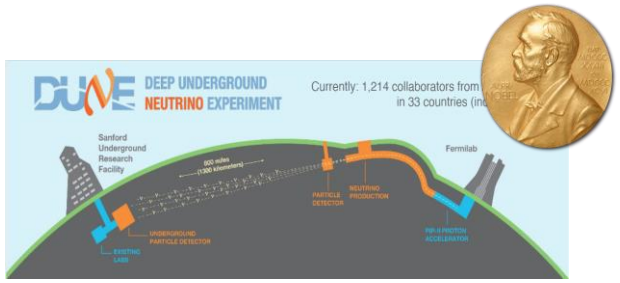
PIP-II, the only particle accelerator project in the United States with significant contributions from international partners, will send megawatt-scale proton beams — 60% higher than what Fermilab currently provides — to the lab's experiments. The high beam power is especially important for the international Deep Underground Neutrino Experiment, hosted by Fermilab, where scientists will study difficult-to-detect subatomic particles called neutrinos, which could provide clues about the evolution of the universe. PIP-II's powerful beams will provide researchers with an abundance of these mysterious particles to study for decades to come.

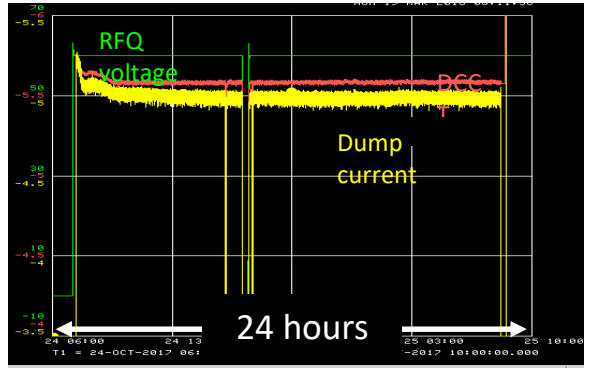
The PIP-II project received CD-2 approval from the U.S. Department of Energy this month. When complete, it will provide more powerful beams of protons to Fermilab experiments. This rendering shows the site of the PIP-II complex, just above and to the left of the 15-story Wilson Hall. Image: Fermilab

***"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