Users Meeting – Day 1 Talks Session 4 PIP-II

Lidija Kokoska – PIP-II Project Engineer

53rd Annual Users Meeting

August 10, 2020

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

Proton Improvement Plan – II (PIP-II)

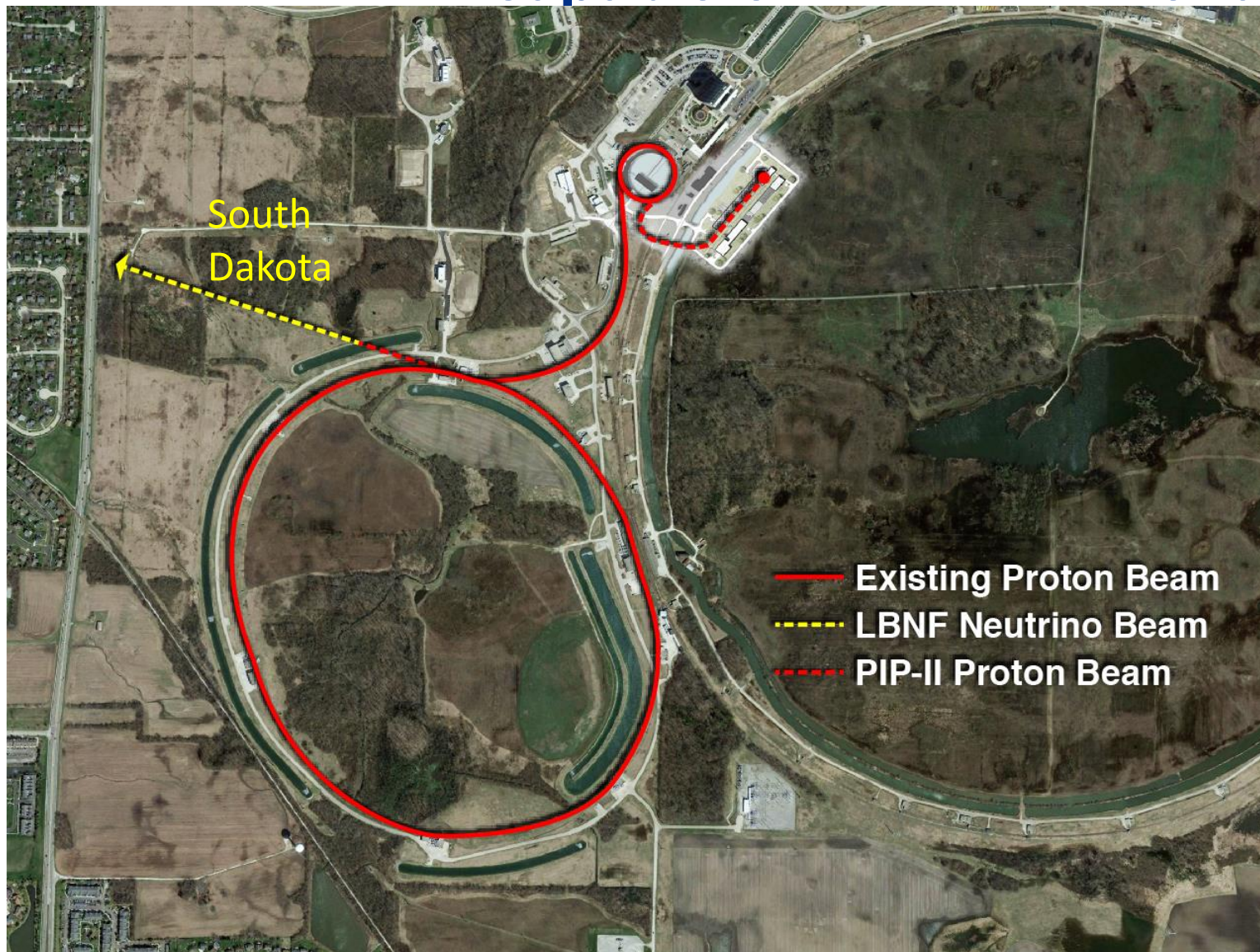# "Defining the Decade" with PIP-II

- PIP-II Mission

- PIP-II Recent Highlights

- PIP-II World Class Engagement

- PIP-II Enables new Science

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PIP-II MISSION

Present Fermilab accelerator complex & beamlines

Minnesota

Proton Beam
Neutrino Beam
Muon Beam

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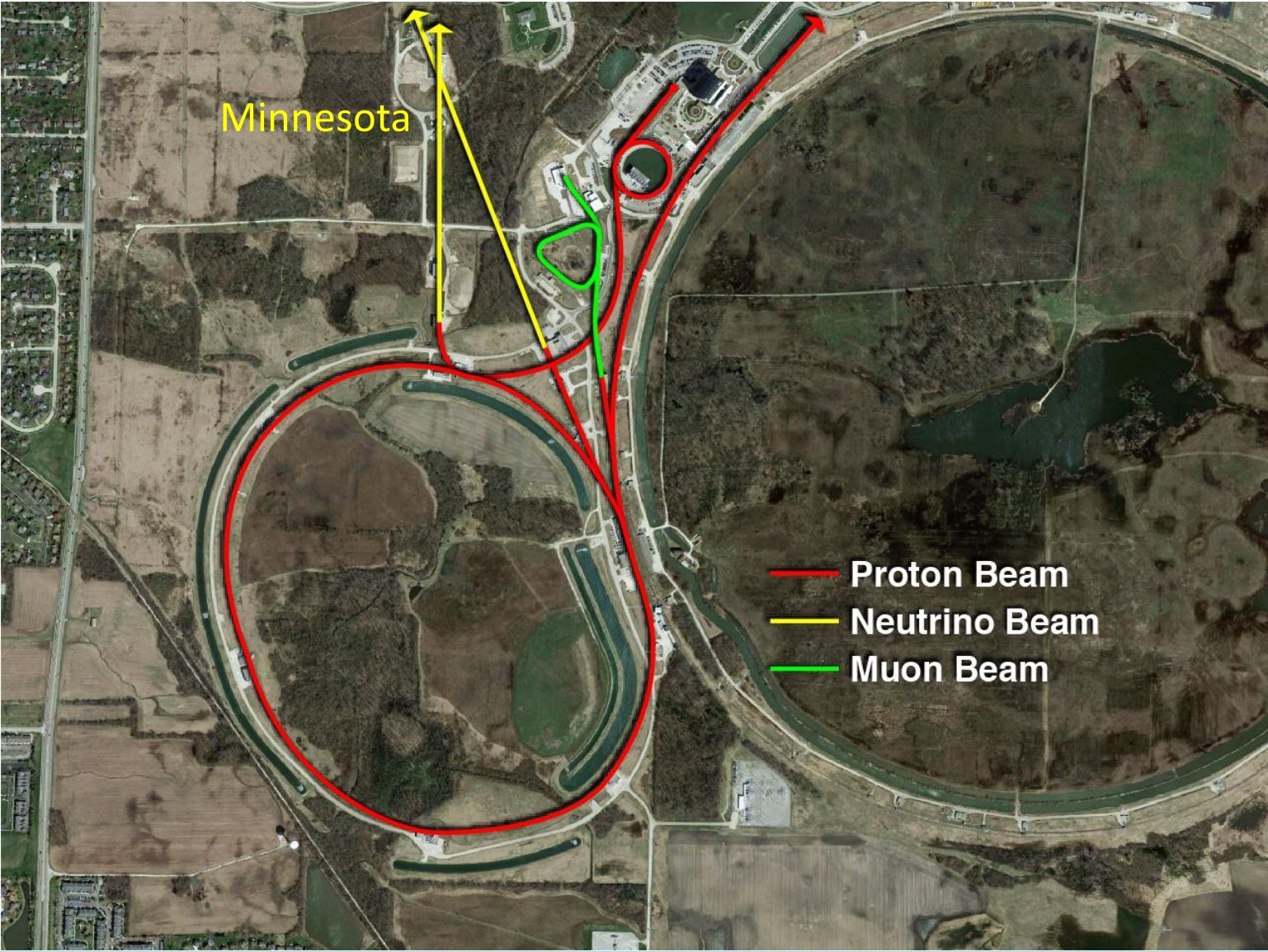
PIP-II

PIP-II Accelerator and LBNF Beamline – capable of >2 MW in the future

South Dakota

Existing Proton Beam
LBNF Neutrino Beam
PIP-II Proton Beam

PIP-II

P5 Report defines PIP-II Mission

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.

PIP-II linac will provide:

Beam Power
- ➢ 1.2 MW proton beam at the start of DUNE
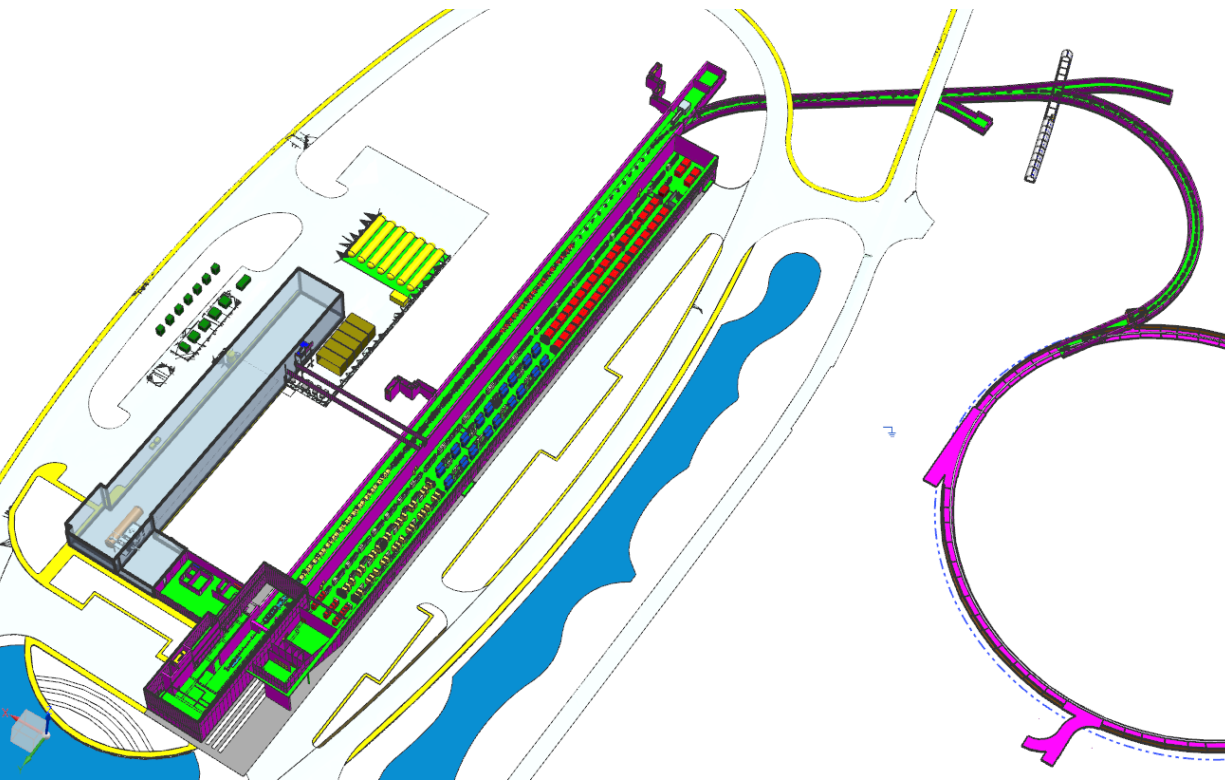- ➢ Upgradeable to multi-MW capability

Flexibility and multi-user capability
- ➢ Compatible with CW-operations
- ➢ Customized beams for specific science needs
- ➢ High-power beam to multiple users simultaneously

Reliability
- ➢ Fully modernizing the front-end of the Fermilab accelerator complex

PIP-II Scope

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

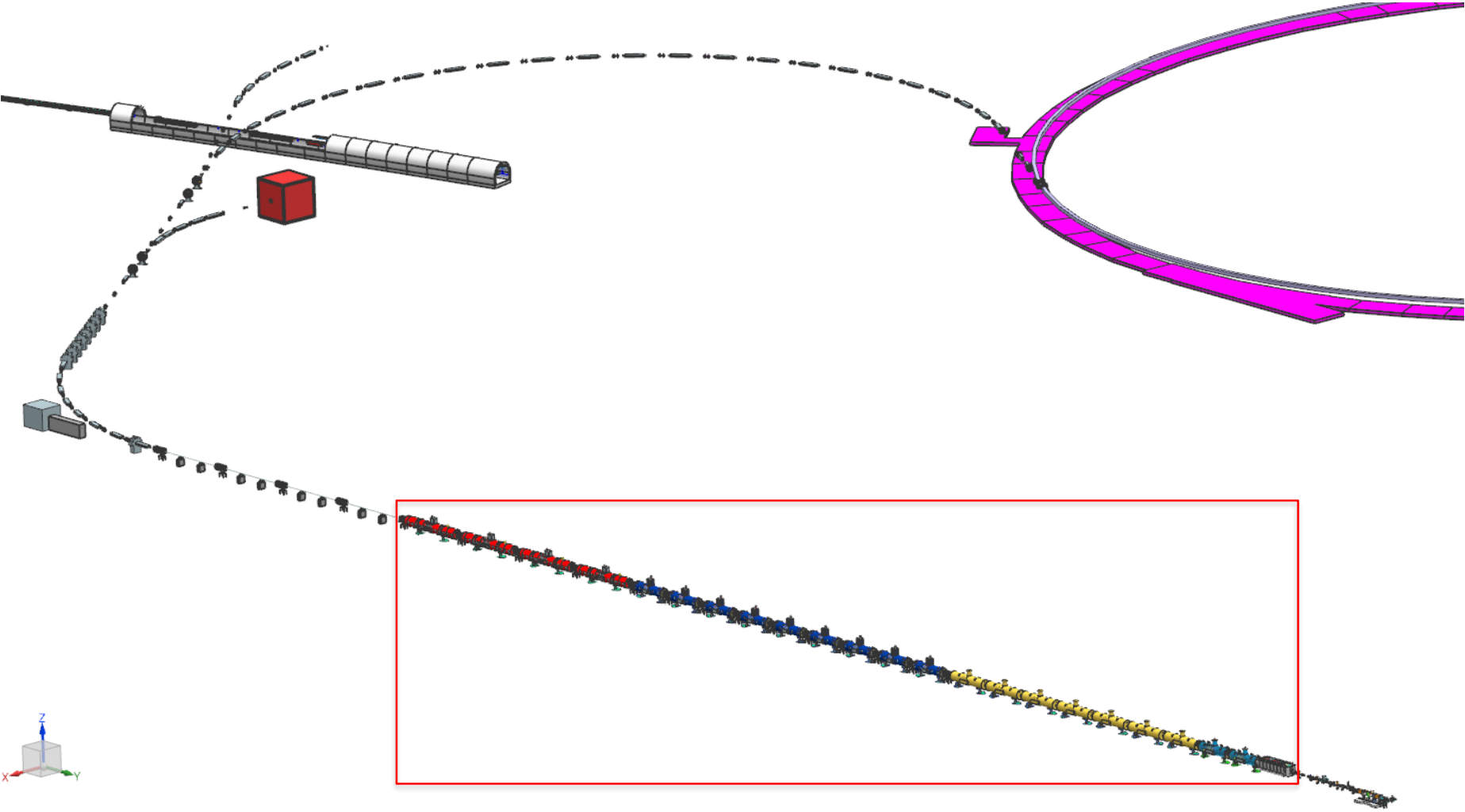**Upgraded Recycler & Main Injector**
- RF in both rings

Conventional facilities
- Site preparation
- Cryoplant Building
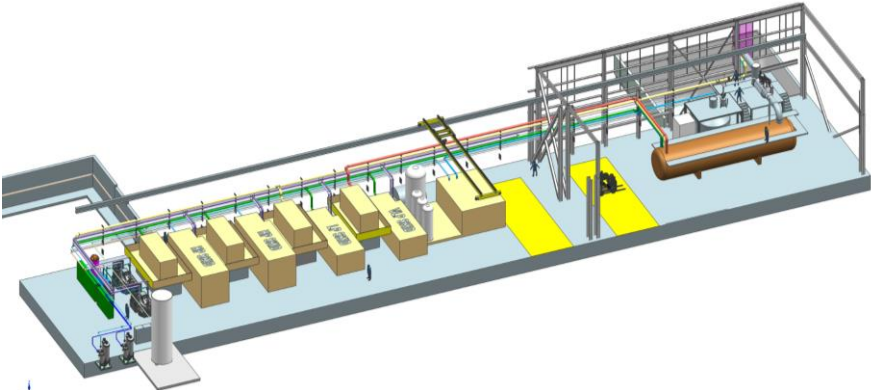- Linac Complex
- Booster Connection

The PIP-II scope enables the accelerator complex to reach 1.2 MW proton beam on LBNF target.

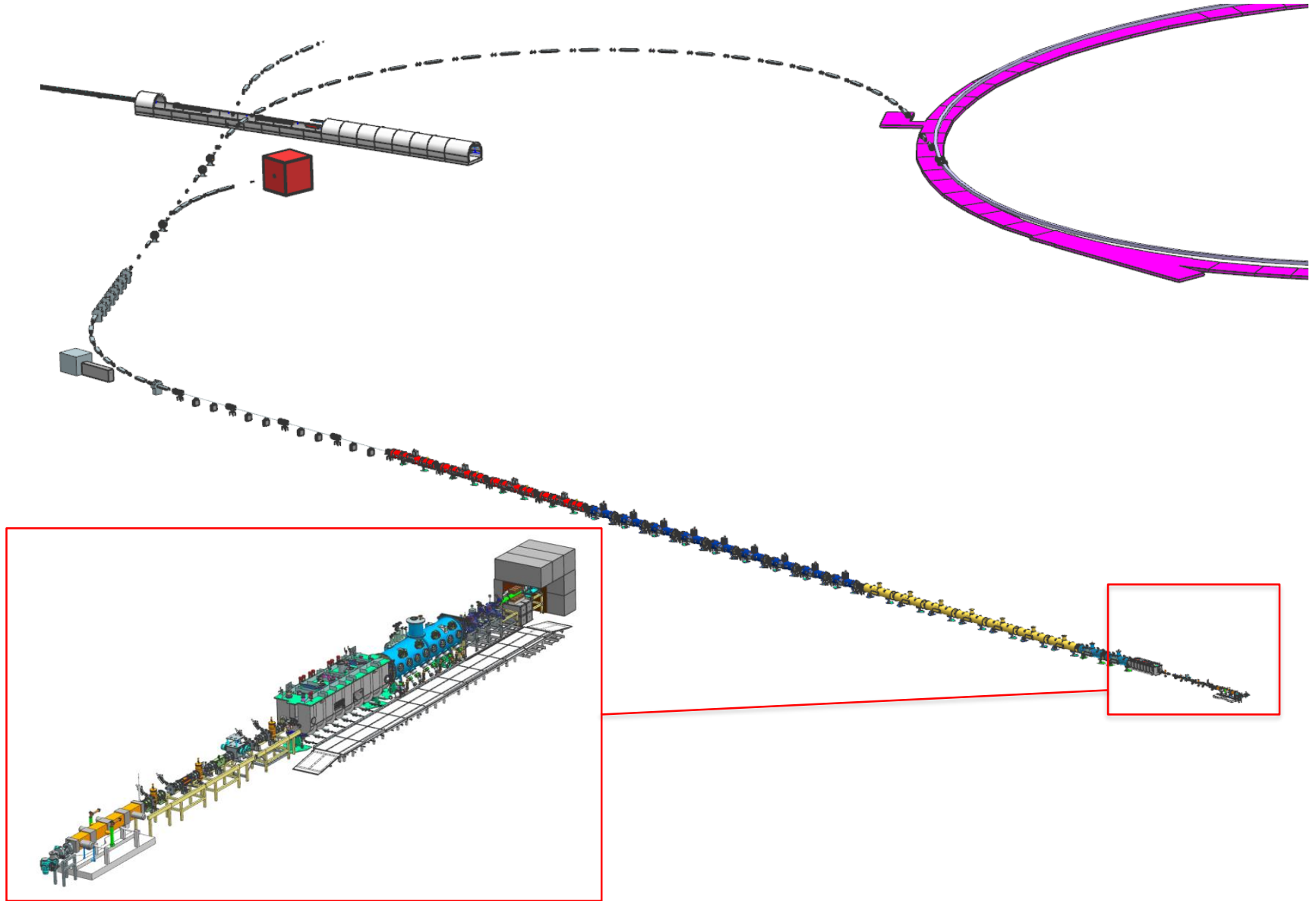# PIP-II Superconducting Linac

PIP-II RECENT HIGHLIGHTS

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Cryoplant Building Groundbreaking

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PIP-II Front-End and Injector Test Facility

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Half-Wave Resonator (HWR) Fabrication by ![Argonne NATIONAL LABORATORY]
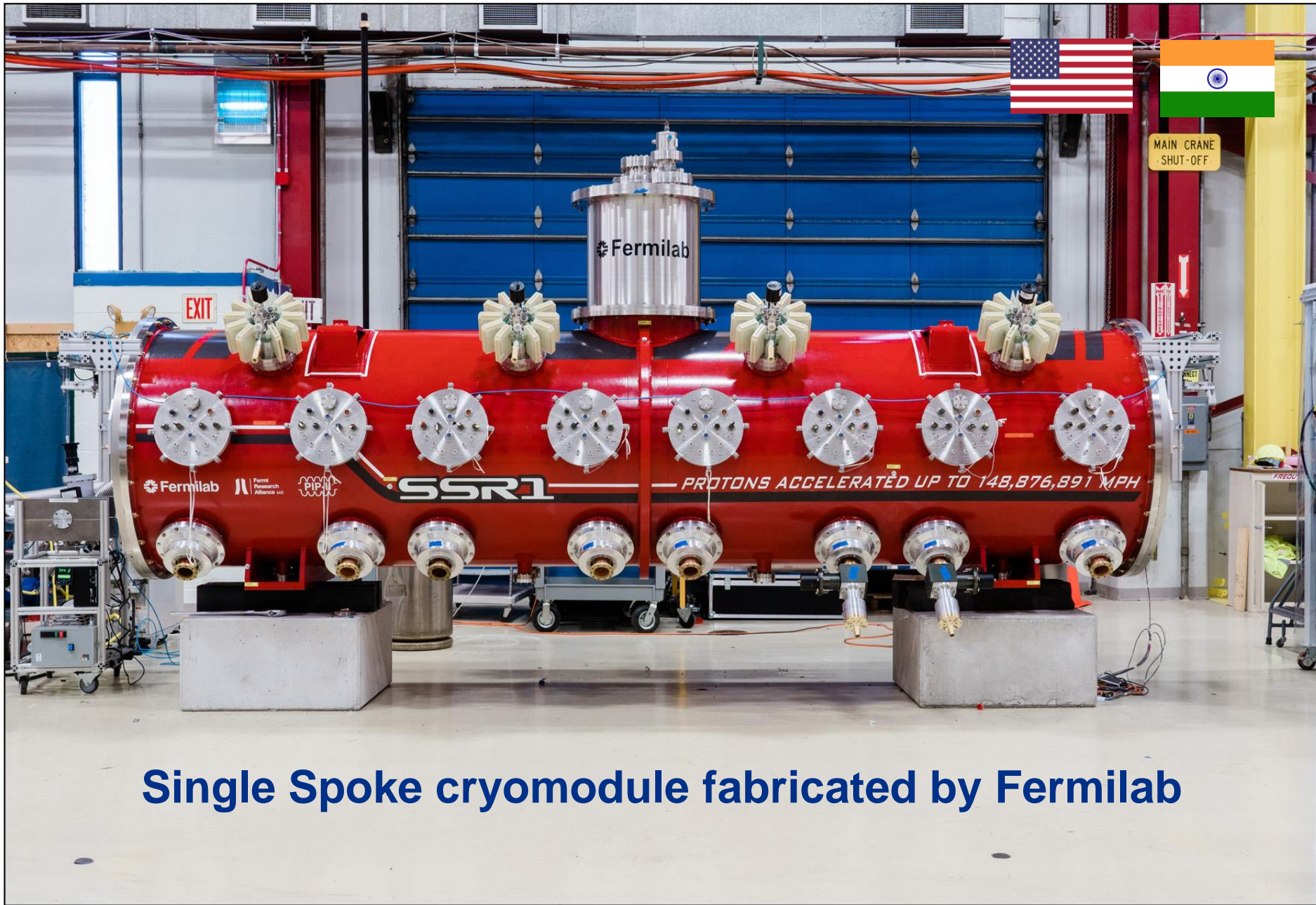
Single Spoke cryomodule fabricated by Fermilab

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PIP2IT Installation Progress

PIP-II WORLD CLASS ENGAGEMENT

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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, 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
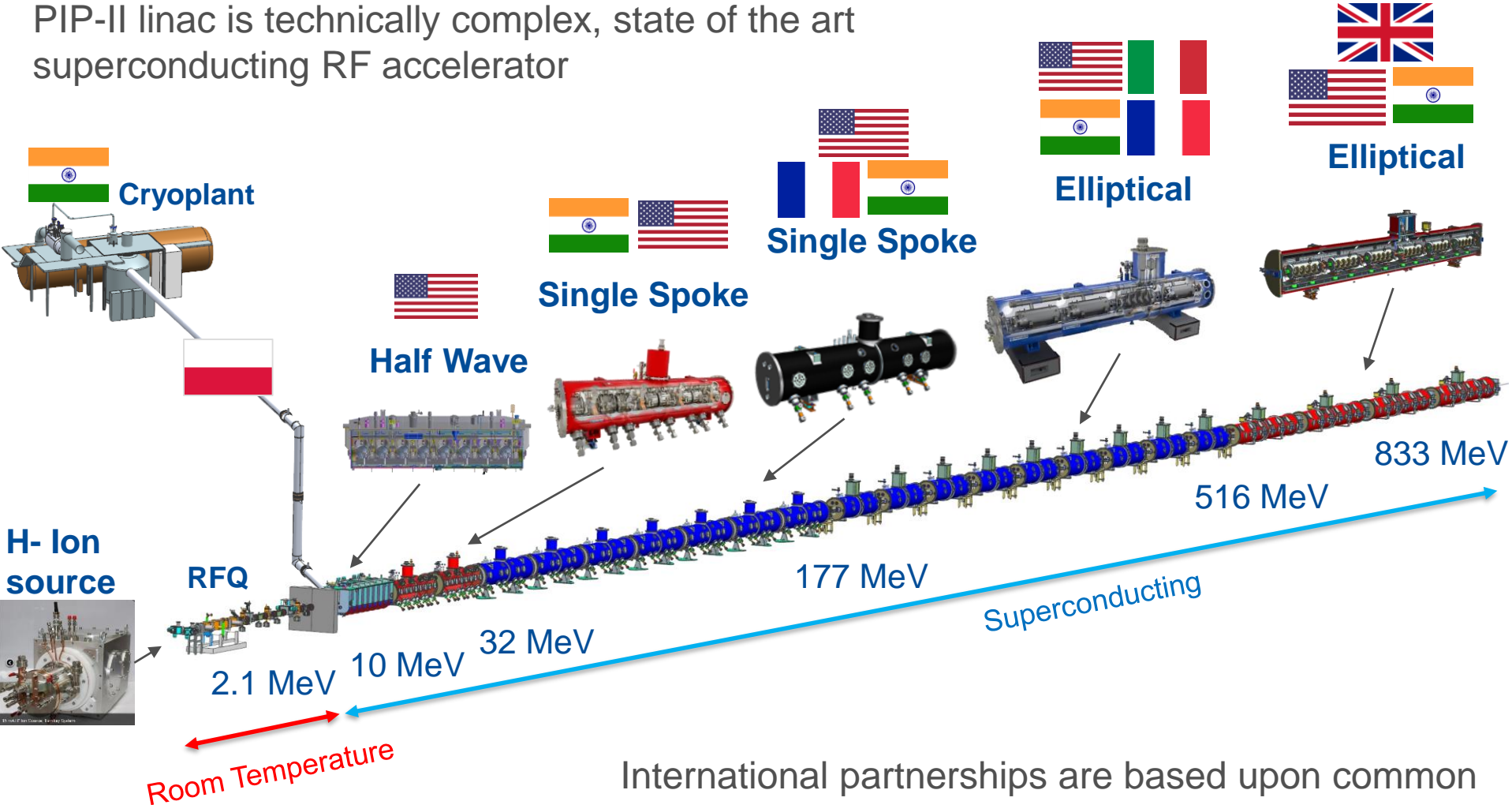SSR2 cavities and couplers for ESS

Poland, WUST (started 2018)

Substantial engineering and manufacturing experience
CDS, LLRF, QC for XFEL and ESS

PIP-II Project benefits from world-leading expertise, facilities.
"Timing is perfect"

PIP-II 800 MeV Linac & International Contributions

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

Cryoplant

Elliptical

Elliptical

Single Spoke

Single Spoke

Half Wave

H- Ion source

RFQ

2.1 MeV

10 MeV

32 MeV

177 MeV

516 MeV

833 MeV

Superconducting

Room Temperature

International partnerships are based upon common interests in science & technology

PIP-II Project benefits from world-leading expertise and capabilities. No scope gaps.

PIP-II ENABLES NEW SCIENCE

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PIP-II Design Is Compatible With Future Science-Driven Upgrades

- PIP-II is designed for >1 MW over 60 – 120 GeV and 1.2 MW at 120 GeV
- Provides platform for upgrade to >2 MW
- Linac beam power of 1.6 MW (CW), programmable bunch patterns
- Facility enables simultaneous, multi-user, high beam power operations
  - Switch yard to provide beams to Muon Campus in multiuser mode with LBNF
  - **Upgrades to mu2e (in conjustion with LBNF/DUNE), truly requires PIP-II's CW capability.**
- Linac tunnel includes space and infrastructure to reach 1 GeV
- Tunnel extension (by 120 m) compatible with energy 2–2.5 GeV
- Beam current can be increased by a factor of a few by upgrading amplifiers

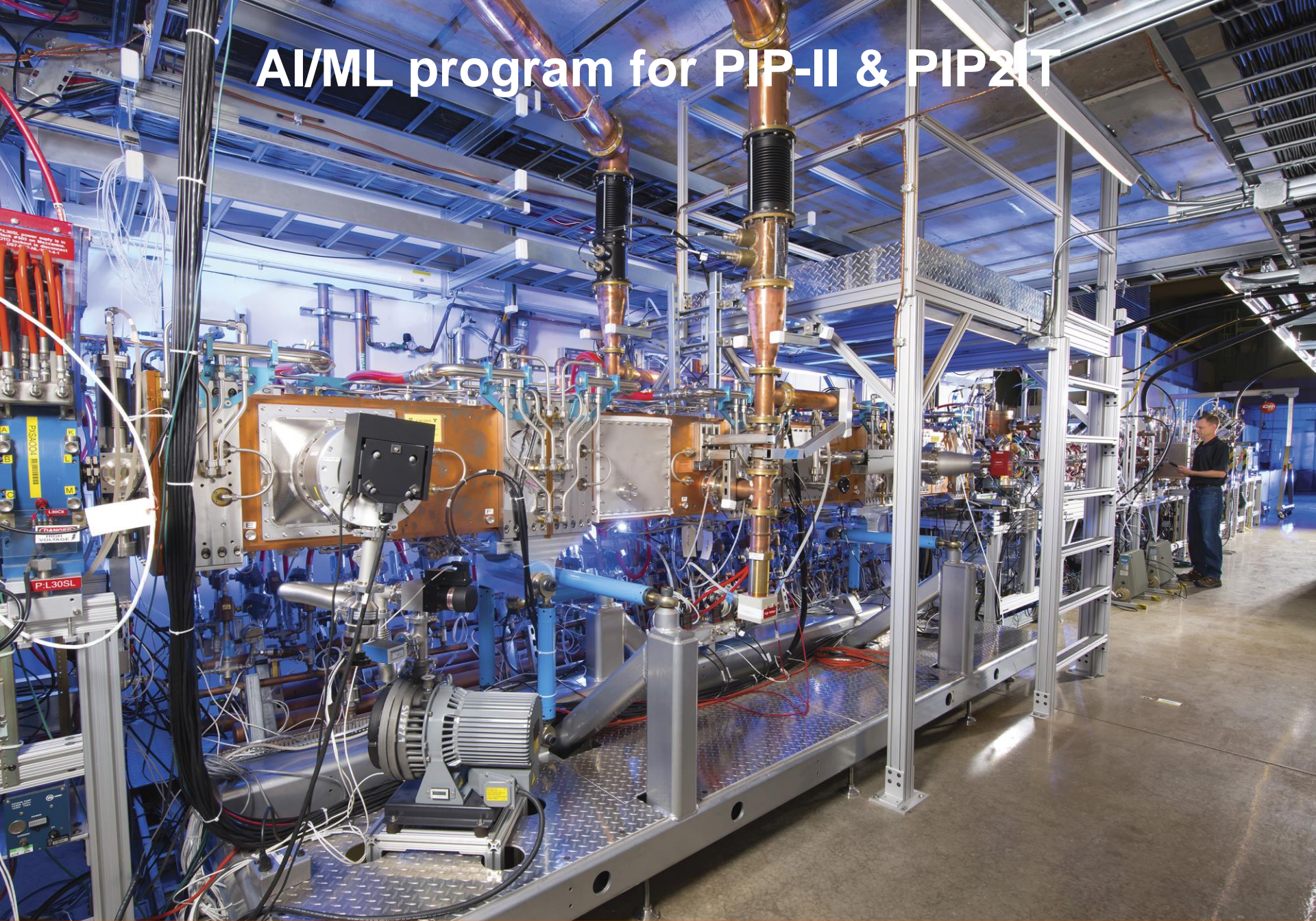Lidija Kokoska | Project Engineer | 53rd Users Meeting
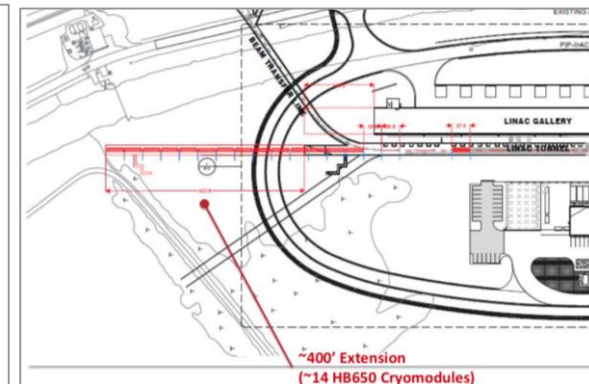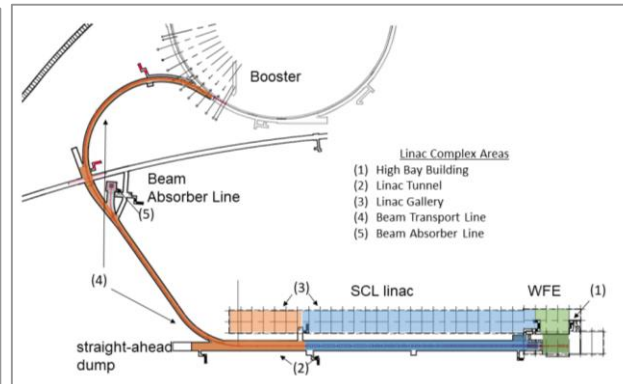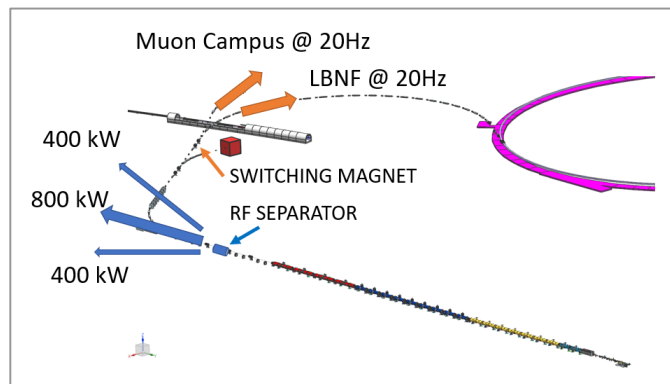
PIP-II Major Milestones

- Successfully completed DOE baseline review (2020)
- PIP-II cryogenics plant: Major in-kind contribution awarded
- Cryoplant Building: Planning for August construction start
- Linac Complex final design in progress, complete Dec 2020
- **Enable physics by late 2020's**

PIP-II

AI/ML program for PIP-II & PIP2IT

Testing components for the PIP-II particle accelerator

🐝 Fermilab · U.S. DEPARTMENT OF ENERGY | Office of Science

Excellent progress on all fronts: AI/ML

✓ PIP-II will utilize transforming potential of Artificial Intelligence and Machine Learning to deliver flexible beam patterns to users quickly, reliably, and with minimal operational effort.

✓ Developing AI/ML program for PIP-II and PIP2IT
- PIP-II: Accelerator Empowered by AI/ML
- PIP2IT: Testbed for AI/ML Methods

✓ Partnering with experts in the field of AI/ML
- Collaboration with SLAC AI/ML accelerator group
- Bayesian Optimization (BO) with Gaussian Processes (GP) Model successfully applied to tuning LCLS FEL; gains nearly two orders of magnitude
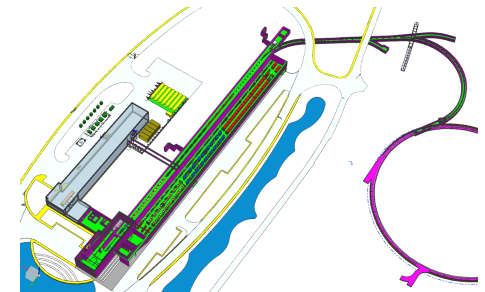
LCLS Laser Power Tuning Results
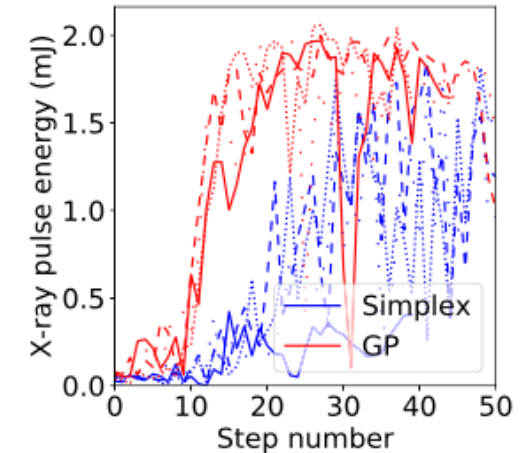
1. BO with GP – 1 minute
2. Simplex – 5 minutes
3. Operator (human) – 10's of mins

ARTIFICIAL INTELLIGENCE and MACHINE LEARNING at PIP2IT and PIP-II

Thank you!