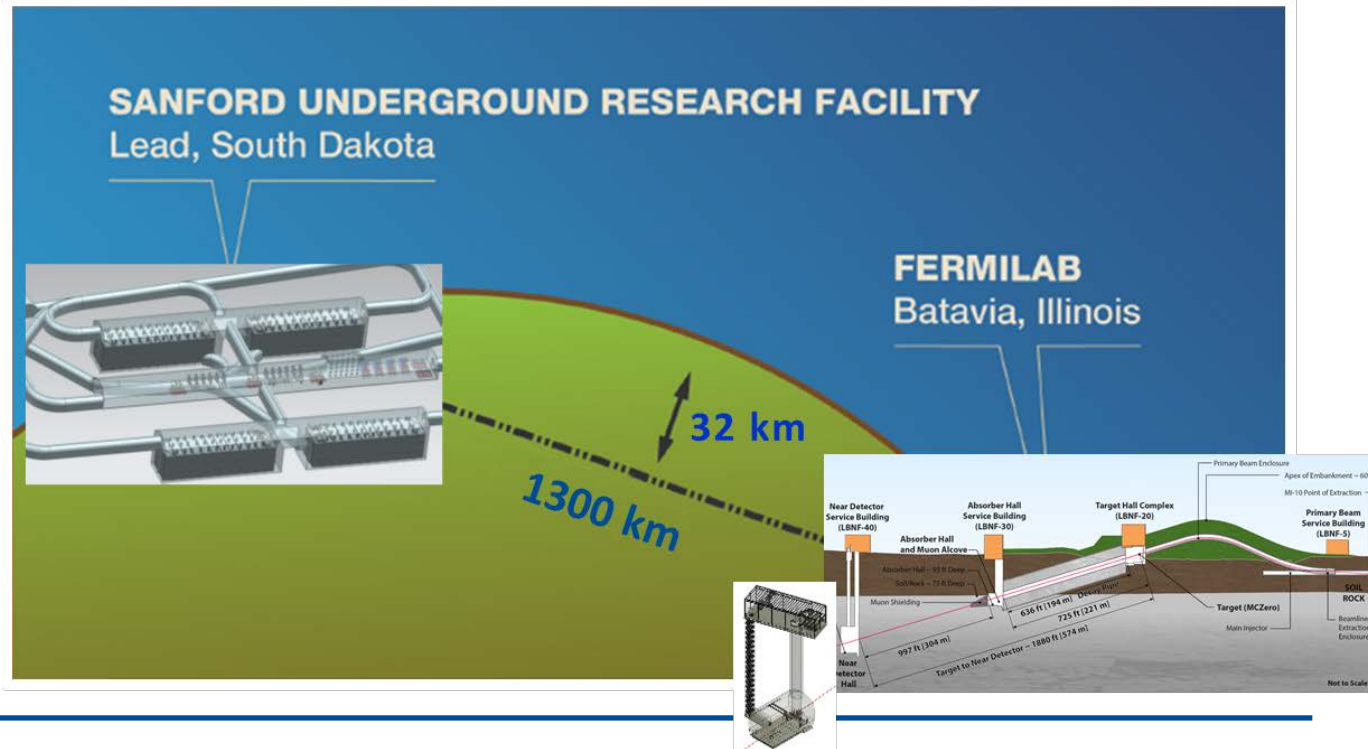


# Overview of DUNE and LBNF

*International from the start*

David MacFarlane,  
LBNC Chair

Report to HEPAP  
December 9, 2015



# 18 months ago: the P5 plan



- A strategic plan for U.S. particle physics maximizing opportunities for breakthrough science
  - Created in the context of global HEP
  - Explicit prioritization, hard choices made within realistic budget scenarios
- Particle physics community unified behind the plan: 2,331 signatures on letter sent to Secretary Moniz

# P5 Mandate: a new international neutrino collaboration

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## **P5 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 [of the report]. LBNF is the highest-priority large project in its timeframe”

- Asks Fermilab to do for neutrinos what CERN did for the Higgs, hosting and engaging the worldwide community
  - Implementation: Create the Long-Baseline Neutrino Facility (LBNF) and invite the world to do the science with the Deep Underground Neutrino Experiment (DUNE)
- The science from DUNE will be game changing for particle and astroparticle physics and will be in all the textbooks.

# Fermilab and the global community are moving fast to implement this recommendation!

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- All within the last year:
  - Formed a new international neutrino collaboration
  - Adopted a liquid argon detector 40 ktons fiducial deep underground for LBN, supernova and proton decay physics
  - Developed a completely new design for a deep underground facility at Sanford Lab
  - Optimized design of a 1.2MW beam complex growing to 2.4MW
  - Developed coherent short baseline program to further develop LArTPC and definitively address the sterile neutrino question
- A clear desire from international community to have a 10 kton fiducial detector being installed starting by 2021-2022
  - Working backwards, need underground construction start in FY2017, leading to CD-3a review December 2-4, 2015

# CERN & Fermilab: a key partnership

- Success of both CERN & Fermilab are highly intertwined
  - CERN is the world's leading high energy lab now that Fermilab has relinquished the energy frontier with closing of the Tevatron
  - Fermilab remains the only “single program” HEP laboratory in US
  - Both labs have tremendous technical depth



Signing new bilateral DOE-NSF-CERN agreement on May 7

- CERN is mandated to “steward” European particle physics
  - By engaging as a partner in a world-class long-baseline neutrino program in US, CERN is supporting & facilitating the European neutrino community
  - **CERN needs the US to execute the HL-LHC successfully and US needs CERN to help with LBNF: support outside Europe a first for CERN**
- Long-term interests & technology overlap on FCC



# Fermilab and South Dakota: a key partnership



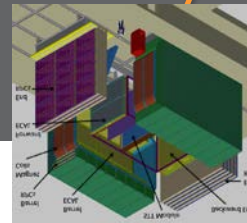
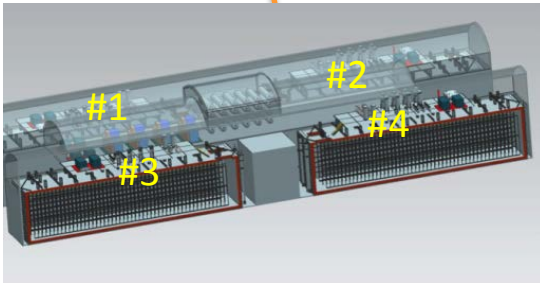
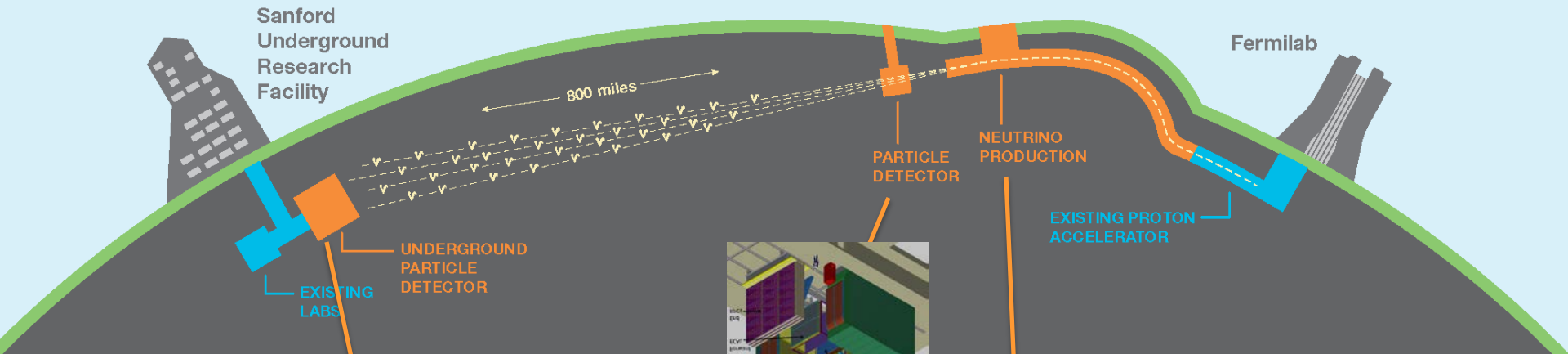
- Over \$145M invested in Sanford Lab from private and state funds
- Facility donated to the State of South Dakota for science in perpetuity
- Experimental Facilities at 4850 ft level
- Two vertical access shafts for safety and flexible logistics
- Ross shaft refurbishment in process and is ~65% complete
- Working two 12 hour shifts/day in order to be done by 2017

# Overall Experimental Layout for DUNE

More in Mark Thomson's DUNE talk



803 collaborators,  
27 nations,  
145 institutions



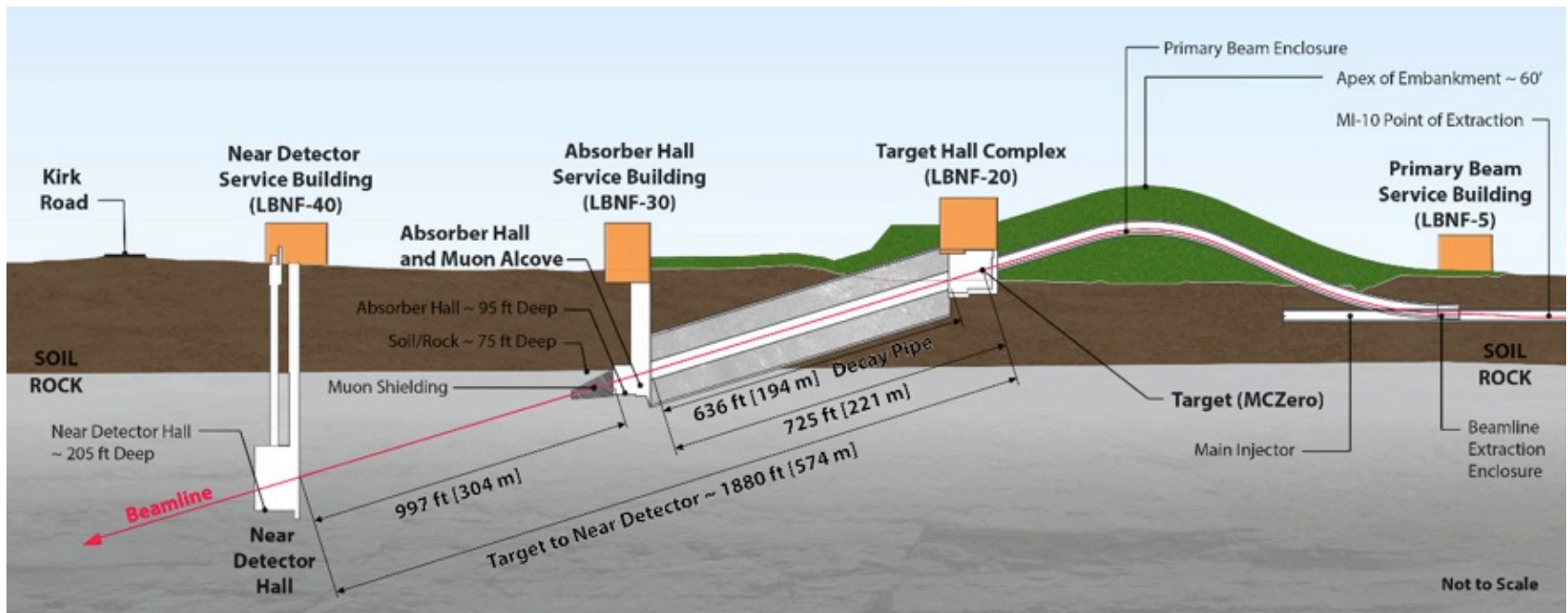
High-precision  
near detector

Wide-band, high-purity  $\nu_\mu$  beam with peak flux at  
2.5 GeV operating at  $\sim 1.2$  MW and upgradeable

- Four identical cryostats deep underground
- Staged approach to four independent 10 kt LAr detector modules
- Single-phase and dual-phase readout under consideration

# LBNF: Near-Site scope at Fermilab

- Proton beam @ 60-120 GeV extracted from the Main Injector
- Embankment allows Target Hall at grade and then neutrino beam directed downward towards SURF
- Target Hall, Decay Pipe, Absorber Hall, and Near IR Hall all located on Fermilab site
- Neutrino beamline completed 2026

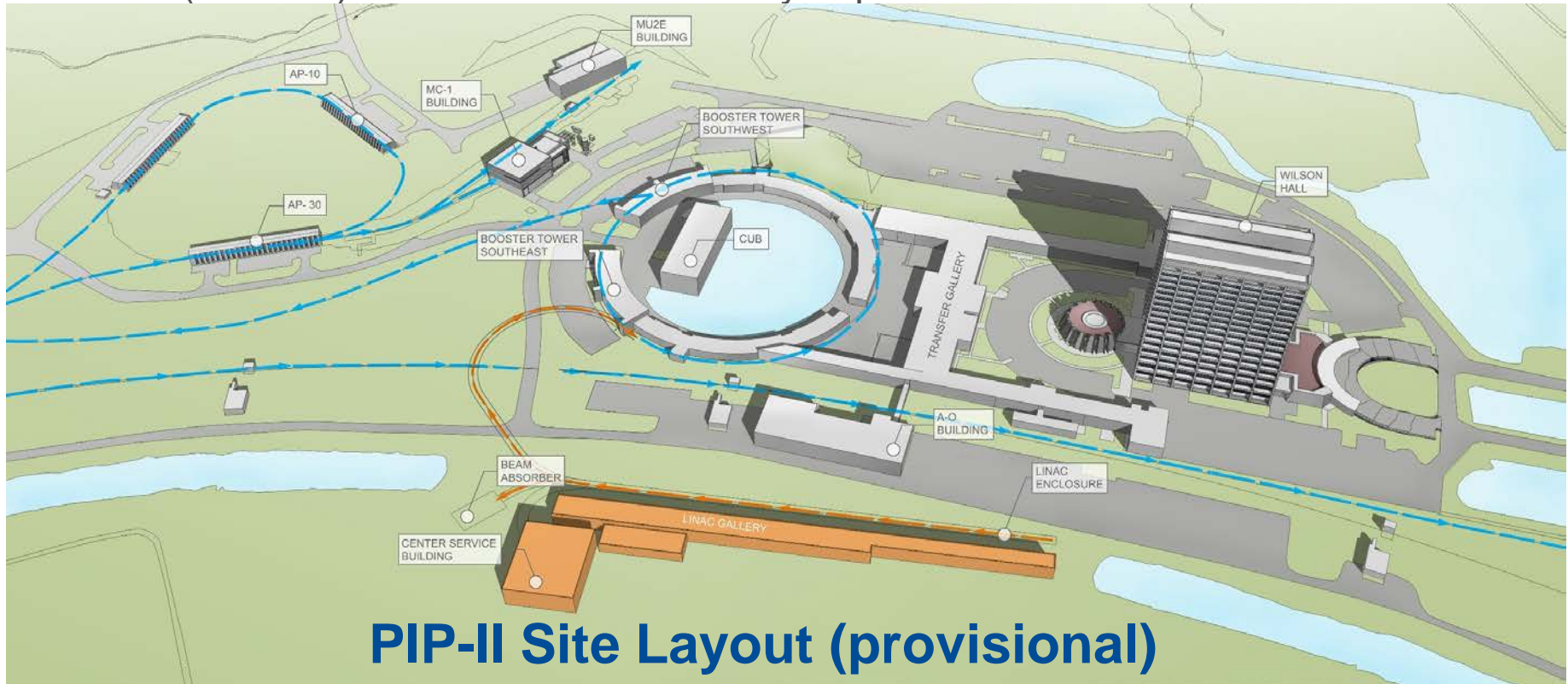




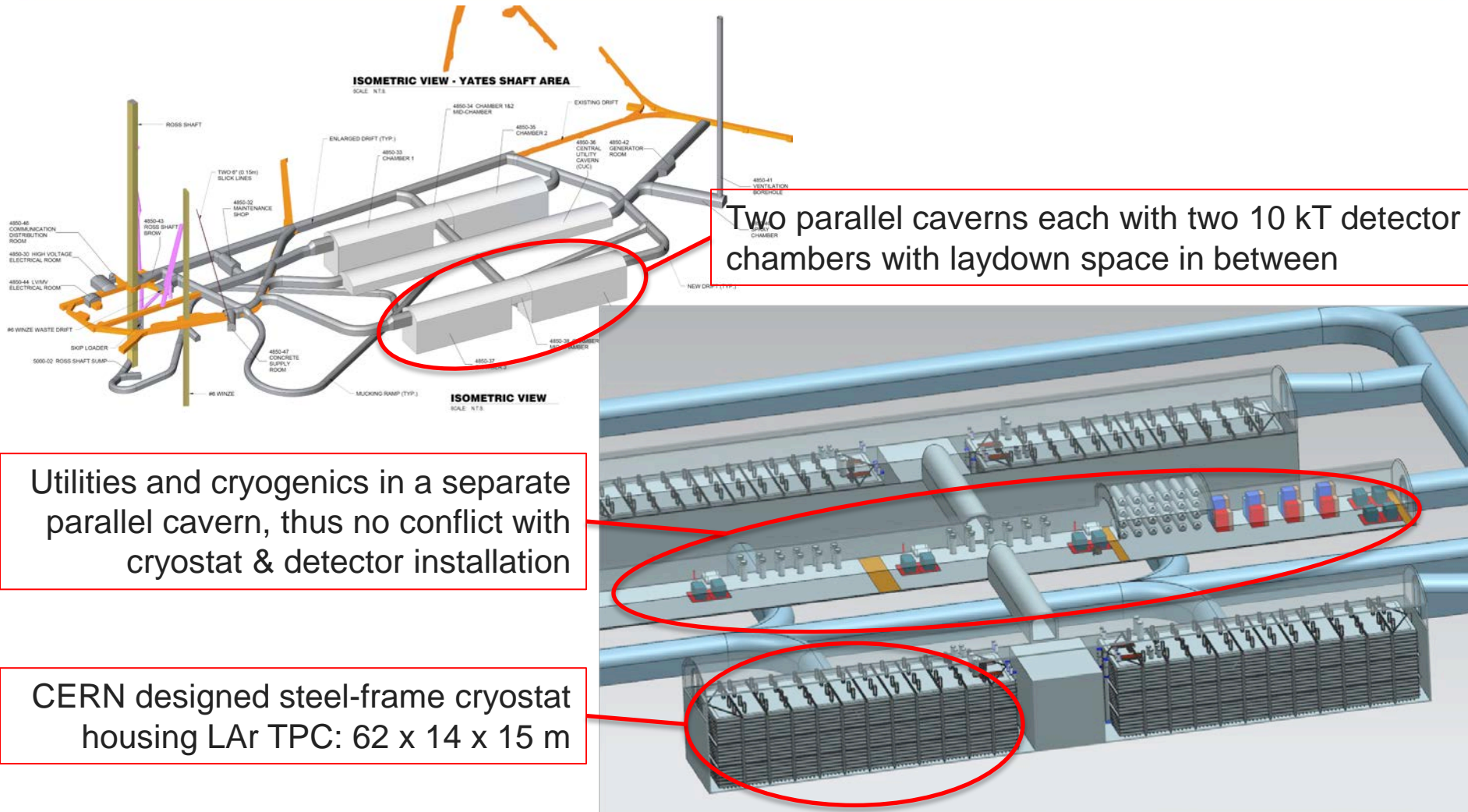
# Highest power beams for neutrinos

## Fermilab objectives: World-leading neutrino source

- PIP (700 kW), Booster (15 Hz): fully exploit the science opportunity of NOvA
- PIP-II (1.2 MW): new linac source received CD-0 approval on Nov 12
- PIP-III (2.4 MW): ultimate buildout to fully exploit the science of DUNE



# LBNF: Far Site scope at SURF 4850L



Two parallel caverns each with two 10 kT detector chambers with laydown space in between

Utilities and cryogenics in a separate parallel cavern, thus no conflict with cryostat & detector installation

CERN designed steel-frame cryostat housing LAr TPC: 62 x 14 x 15 m

More in Chris Mossey's Far Site Facilities talk

# LBNF/DUNE Critical Decision timeline

- **LBNF/DUNE held successful CD-1 Refresh Review July 14-16, 2015, at Fermilab**
  - Approved by ESAAB and signed by Lyn Orr on Nov. 5, 2015
- **LBNF CD-3a (initial far-site construction) Review conducted Dec. 2-4, 2015**
  - SC Management approval decision anticipated in February 2016

## **CD-3a commitment triggers international funding opportunities**

- **CD-3b (embankment start) Review currently anticipated in early 2018**
- **CD-2 (baseline) and CD-3c (construction start) Review anticipated in 2019**
  - Leads to Cryostat #1 installation start in Q3/2020, TPC #1 installation start in Q2/2022, Detector #1, 2 commissioning in Q1/2026, beam complete in Q4/2026
- **DOE considers PIP-II a separate project from LBNF/DUNE**
  - PIP-II will allow >1 MW beams on target for LBNF/DUNE and is planned on a similar timescale





# DUNE Reference Design meets P5 goals

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- P5 identified “minimum requirements to proceed”:
  - Reach an exposure of 120 kt-MW-years by 2035 ✓
  - Far detector underground cavern space for 40 kt LAr (fiducial) ✓
  - 1.2 MW beam upgradable to multi-MW power ✓
  - Demonstrated capability for supernova bursts ✓
  - Demonstrated capability for proton decay, providing a significant improvement over current searches ✓
- P5 “goal” is for  $3\sigma$  CPV coverage for  $> 75\%$  of  $\delta$  values ✓

*More in Mark Thomson's DUNE talk*



## Conclusion:

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- Fermilab committed to realizing the P5 vision of LBNF/DUNE as the flagship US-hosted world-class neutrino program
  - Unique opportunity for US to host a global program that leads to the discovery of CP violation in leptonic sector & beyond
  - International partnerships critical to success of LBNF/DUNE
- DUNE is a highly motivated, experienced and well organized international team that has assembled quickly
- LBNF moving quickly based on years of previous work at LBNE, LBNO, SURF, & elsewhere
  - CERN & Fermilab futures are intertwined....strong partnership
  - We know how to build the facility and deliver >1 MW beams
- Goal for start of construction in FY2017 (October 2016)

**Unique alignment within DOE to realize this project now**

## Next presentations

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- Mark Thomson, DUNE Co-Spokesperson
  - DUNE: A new collaboration for physics at LBNF
- Chris Mossey, Deputy Director and Project Director for LBNF at Fermilab
  - Status and plans for the LBNF far site project
- David MacFarlane, LBNC Chair
  - LBNC: oversight and assessment of LBNF and DUNE