Report from LBNF

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Fermilab PAC Meeting

23 June 2015

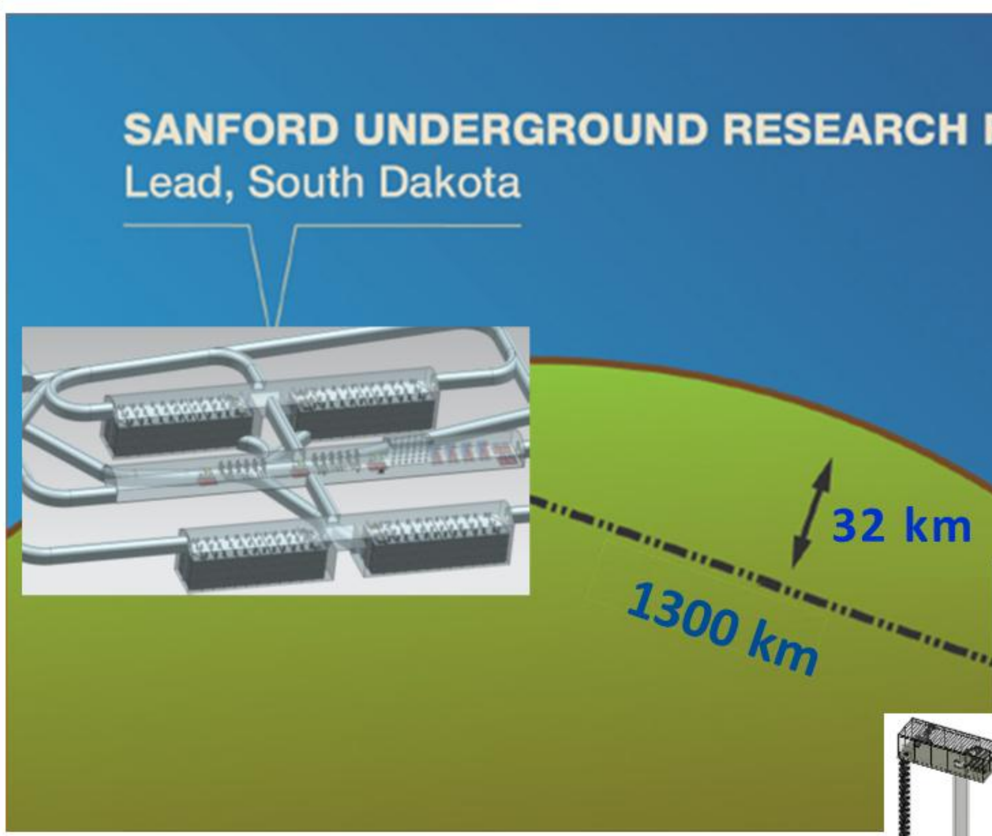
Outline

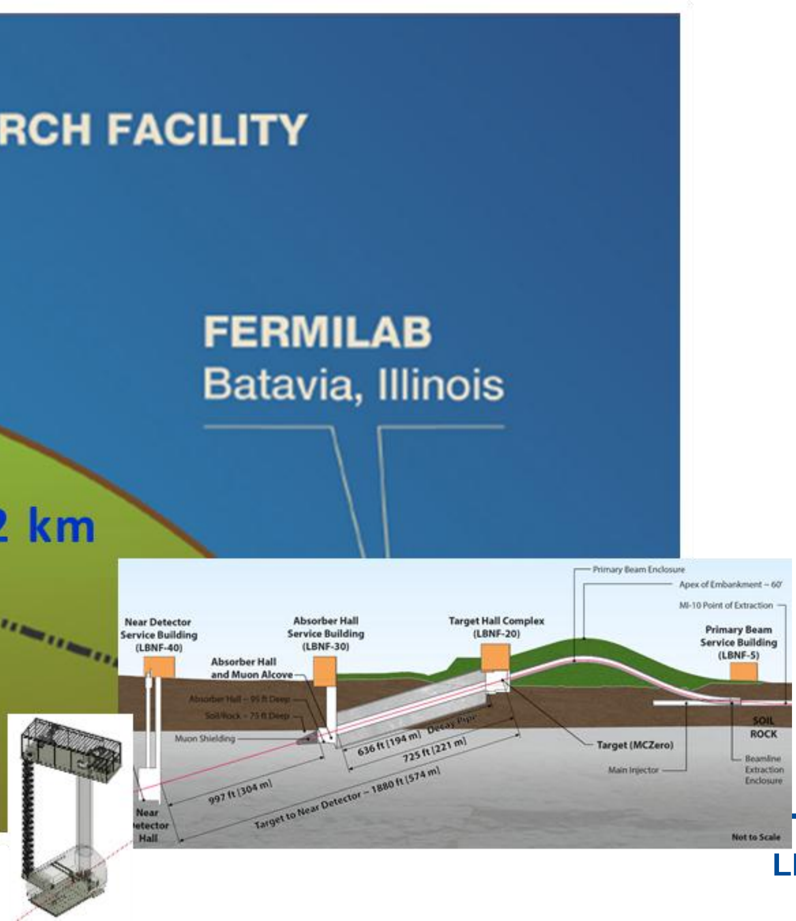
- LBNF scope at CD-1 Refresh
- The LBNF team
- Interfaces with DUNE
- LBNF/DUNE Project schedule
- LBNF/DUNE Reviews
- Near-term plan
- Summary and conclusions

The LBNF Project supports the DUNE Detectors

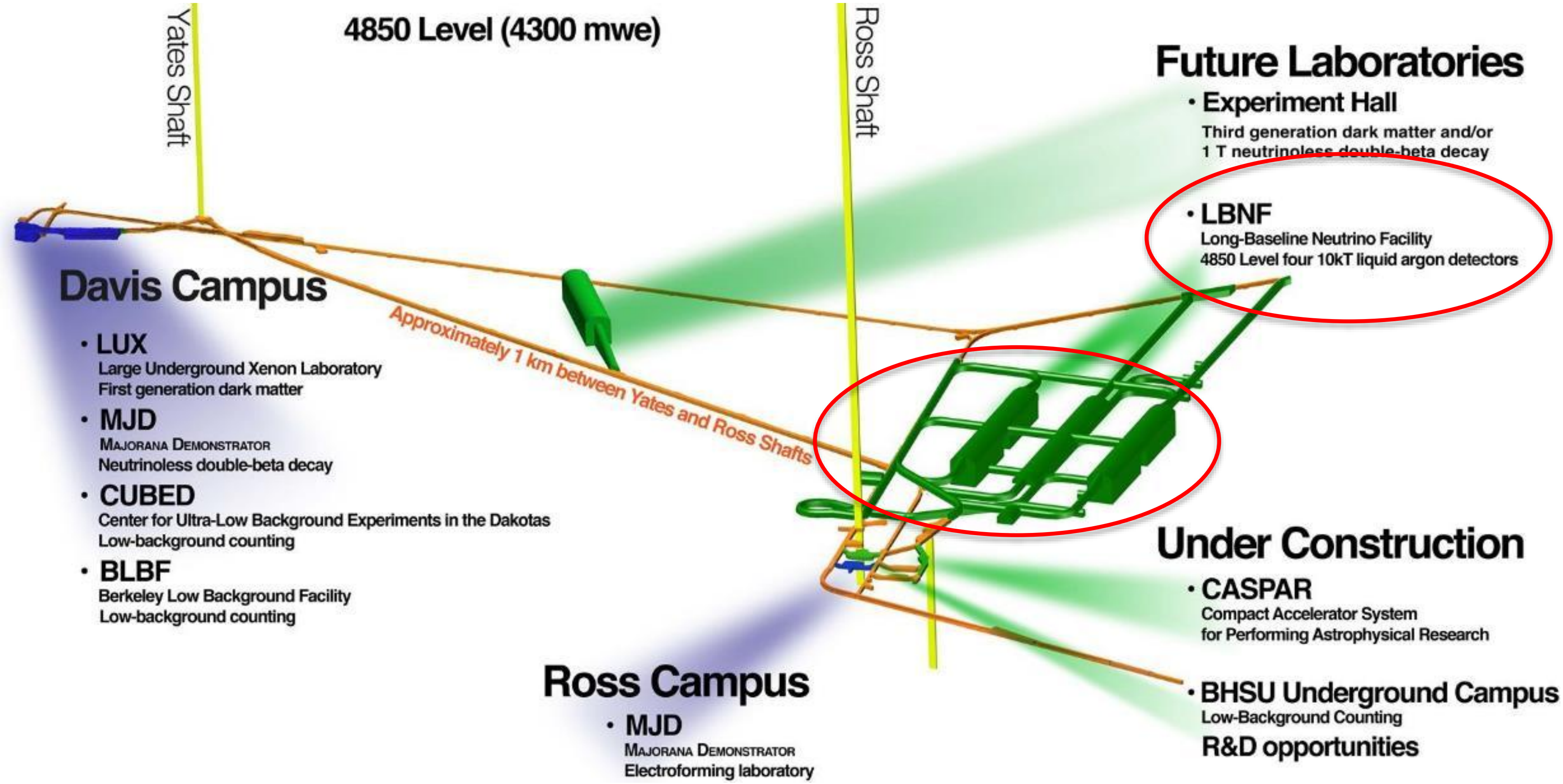
- conventional facilities at both the near and far sites
- cryogenics infrastructure to support the DUNE LAr-TPC detectors at SURF
- an intense neutrino beam aimed at the far site

LBNF is a Fermilab-hosted project with international participation





Sanford Underground Research Facility: at the 4850L



LBNF: Four cryostats in pits for 4-10kt detector modules, a central utility cavern with utilities & cryogenic equipment, access/egress drifts.

SURF – the Far Site

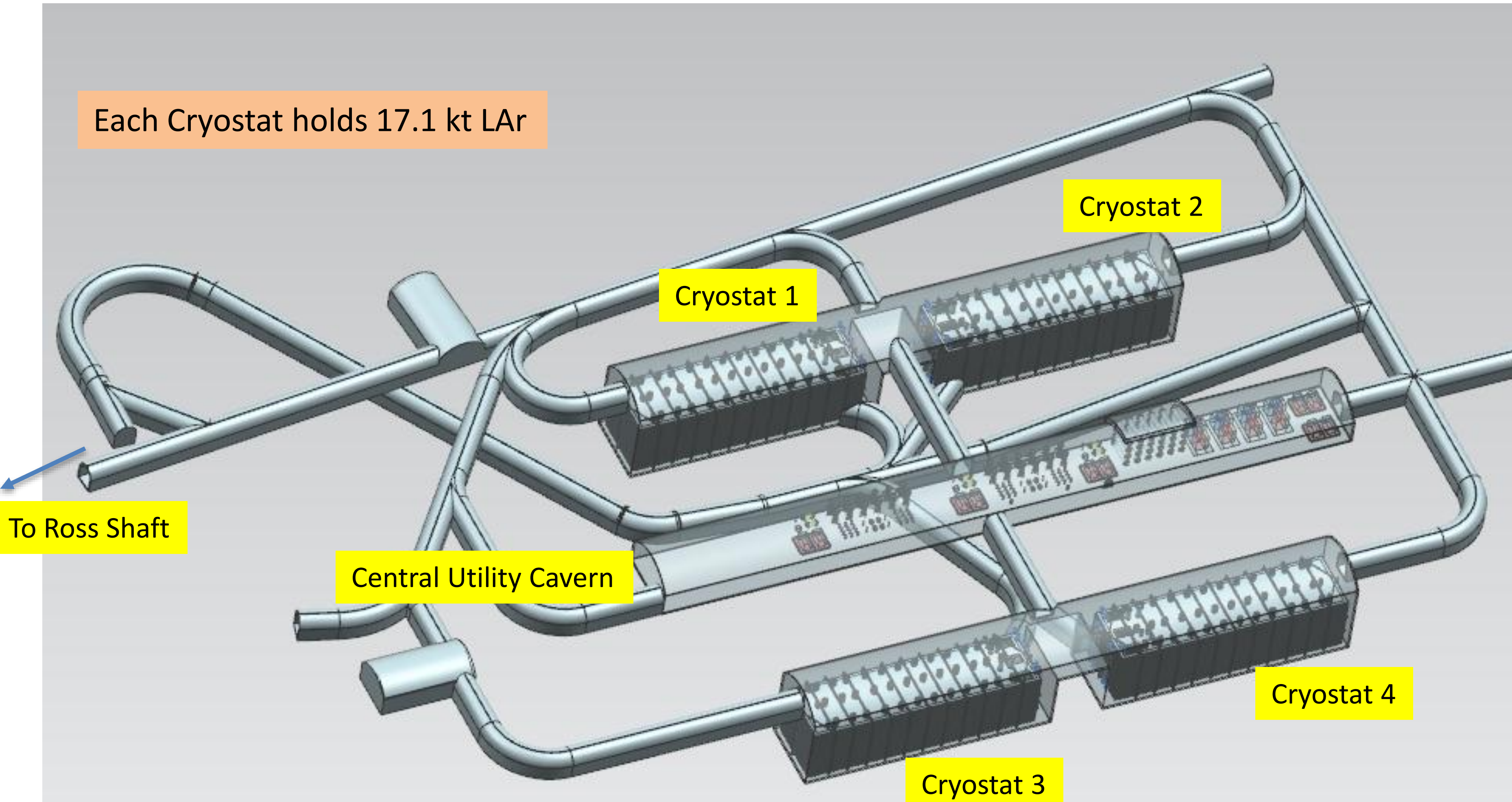
- Facility donated to the State of South Dakota for science in perpetuity
- Over $100M invested from private and state funds
- Experimental facilities at 4850 ft level
- Two vertical access shafts for safety
- Ross shaft refurbishment in process and is ~50% complete; working two 12 hour shifts/day in order to be done by 2017

Current underground physics program

- Large Underground Xenon (LUX)
- Future home of LZ
- Majorana Demonstrator
- Compact Accelerator System for Performing Astrophysical Research (CASPAR)
- Black Hills State Univ. Underground Campus – Low Background Assay and Measurement

Far Detector cavern configuration

- Two parallel caverns each have two 10 kt detector pits with a laydown space in between
- The CF utilities and cryogenics are in a separate parallel cavern, to alleviate conflicts with cryostat & detector install

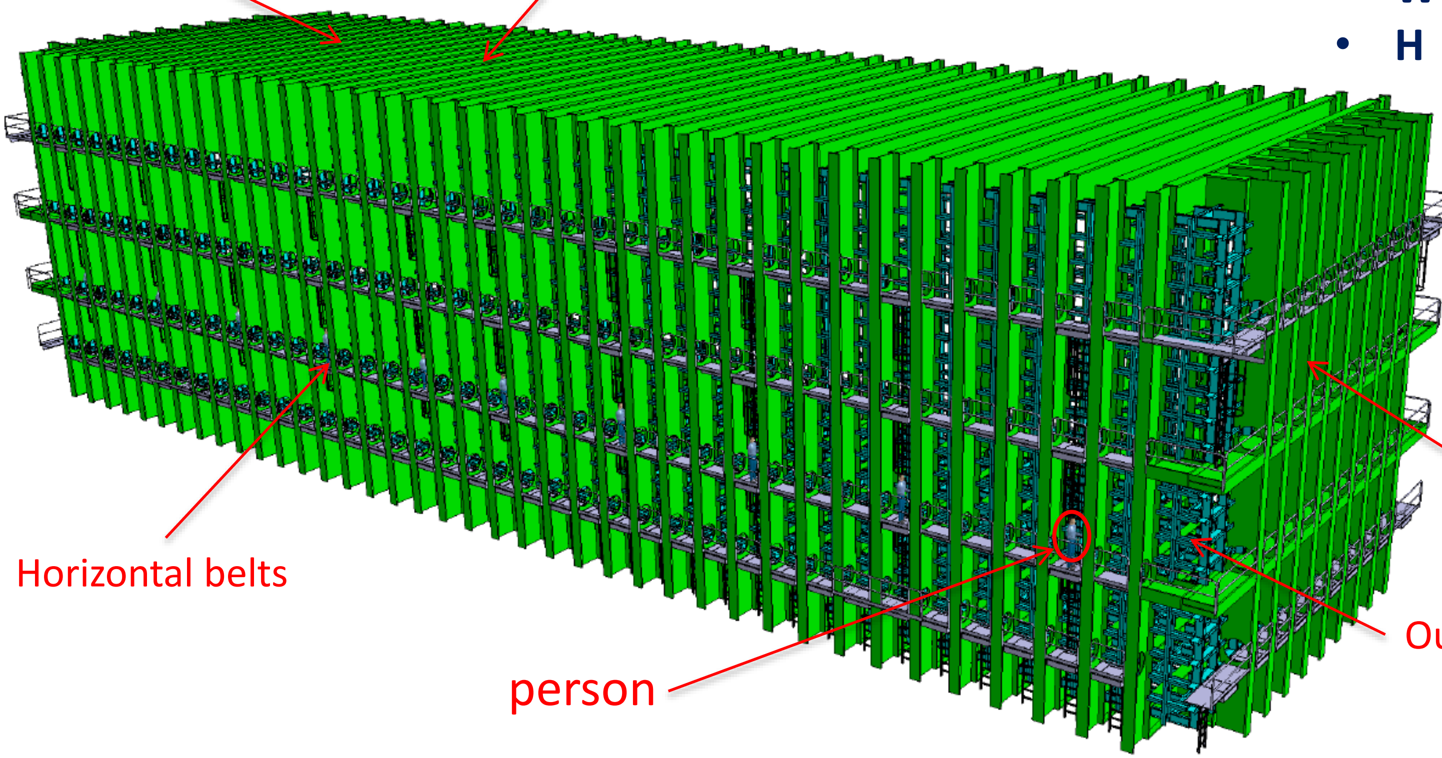


Central Utility Cavern holds cold boxes,
LN2 dewars, booster compressors, LAr/GAr filters, electrical/mechanical utilities

Free-standing cryostat steel frame support

Inner cryostat dimension:

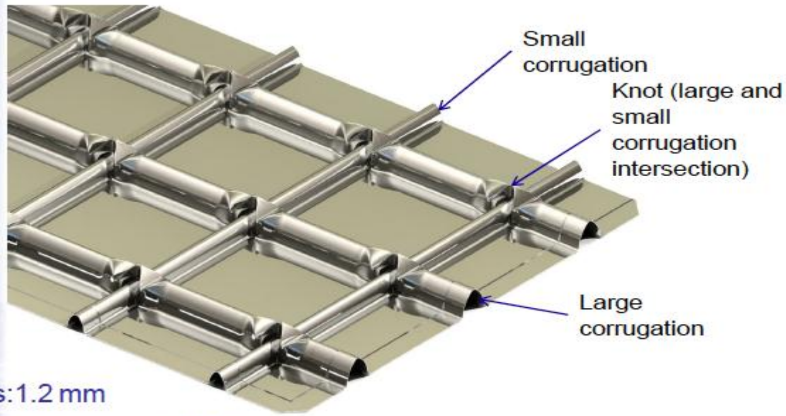
- **L = 62.00 m**
- **W = 15.10 m**
- **H = 14.00 m**



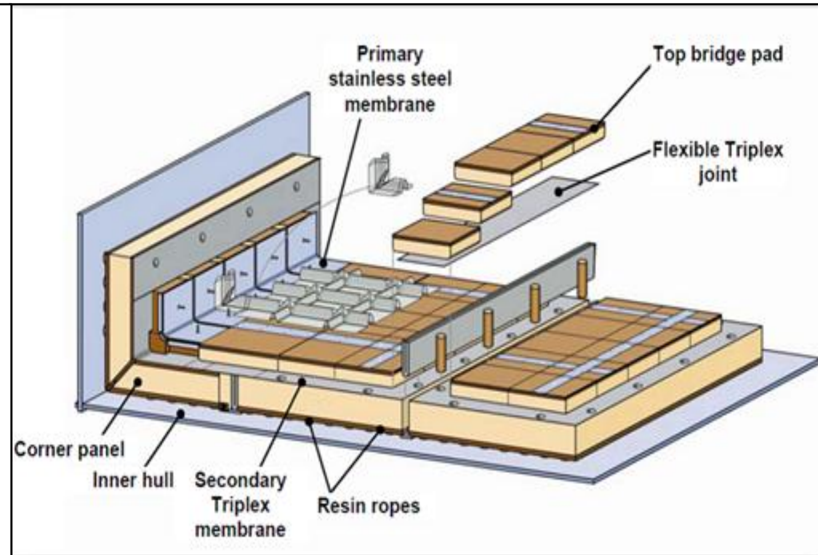
Design accommodates both single- and dual-phase detectors.
Similar designs are being used by the Short-Baseline Neutrino program and for LAr-TPC prototypes at CERN.

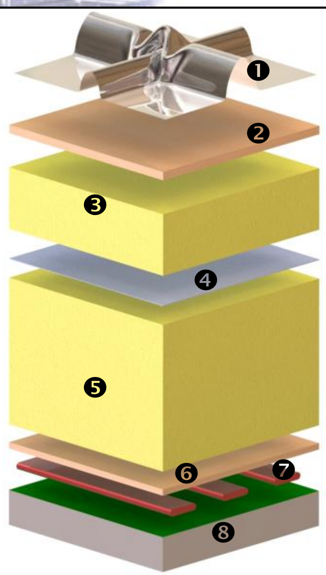
Membrane cryostat interior

The corrugated stainless steel primary barrier:



- Thickness: 1.2 mm
- Material: Stainless steel 304L





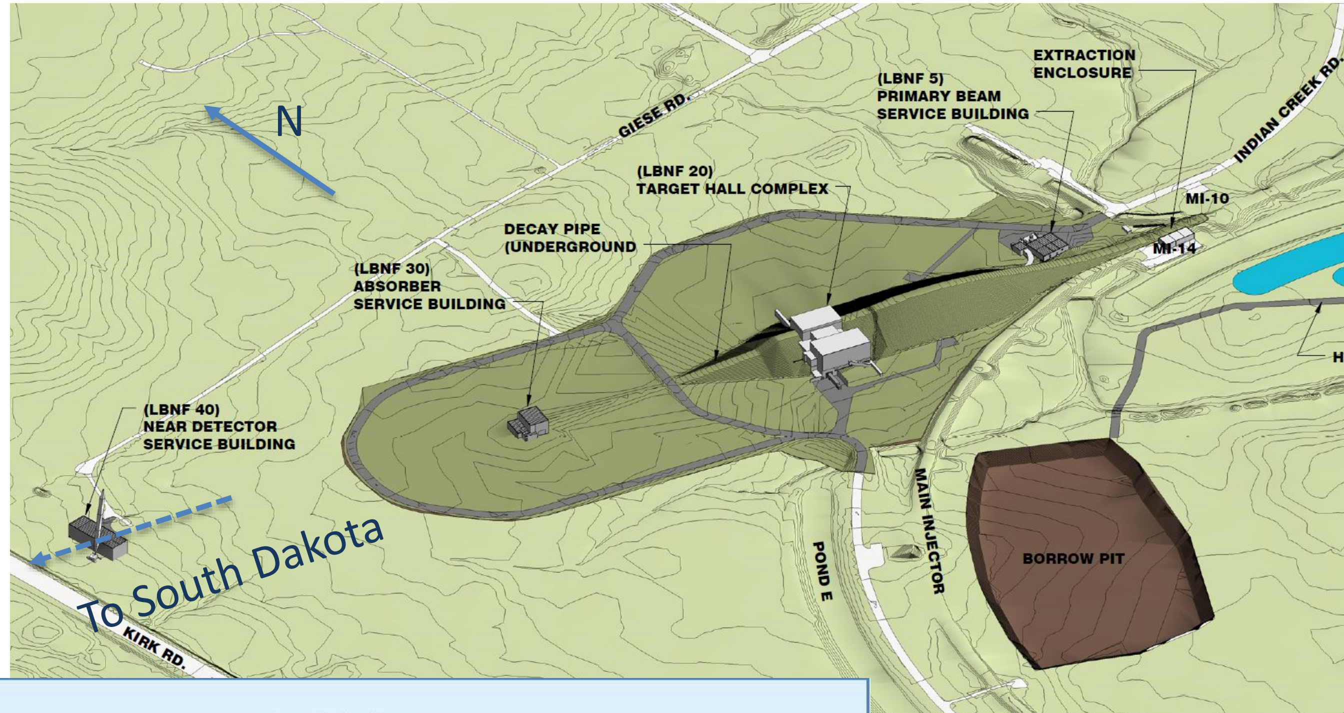
1. Stainless steel primary membrane
2. Plywood board
3. Reinforced polyurethane foam
4. Secondary barrier
5. Reinforced polyurethane foam
6. Plywood board
7. Bearing mastic
8. Steel structure with moisture barrier

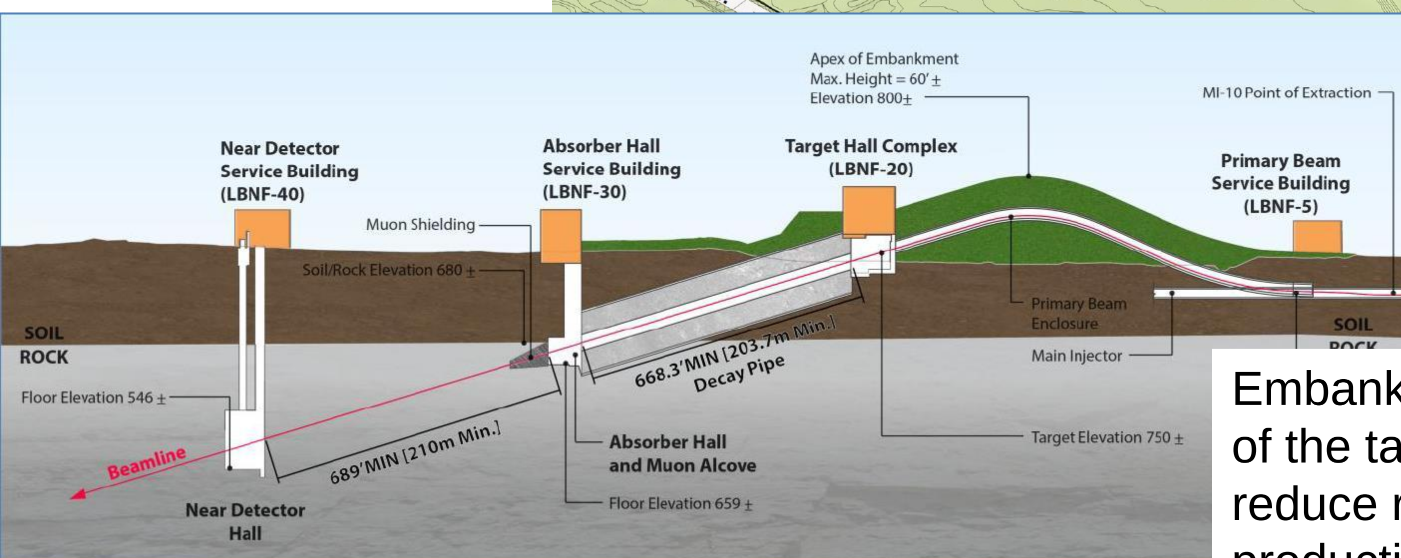
Fermilab – the Near Site

LBNF Project Area

North

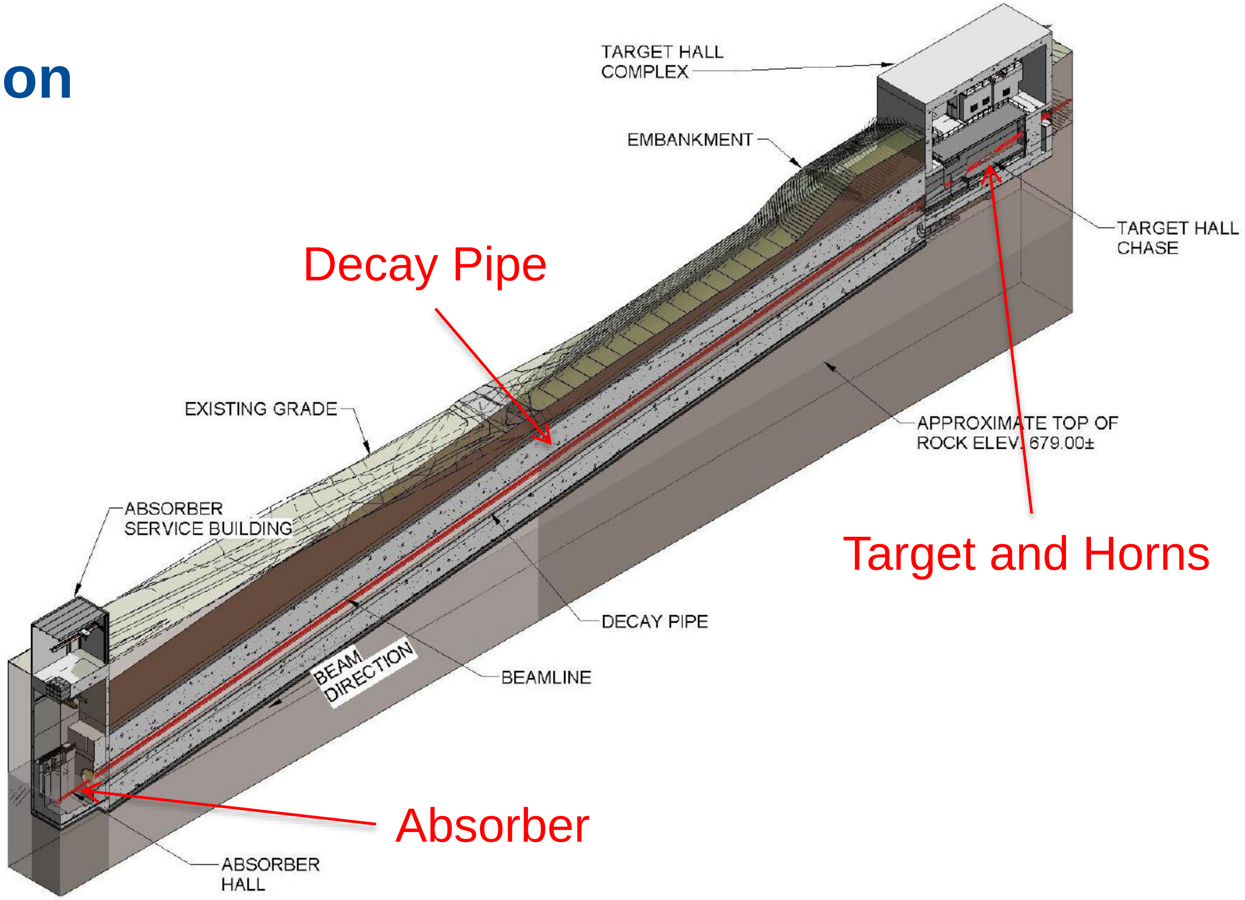
Neutrino Beam at Fermilab & the Near Detector Facility



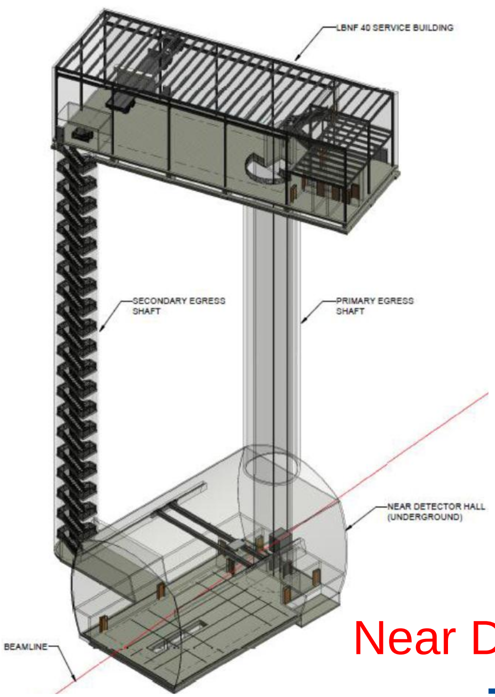


Embankment allows placement of the target close to grade to reduce risk of tritium production in the aquifer.

Near Site cross-section



Near Detector Surface Building



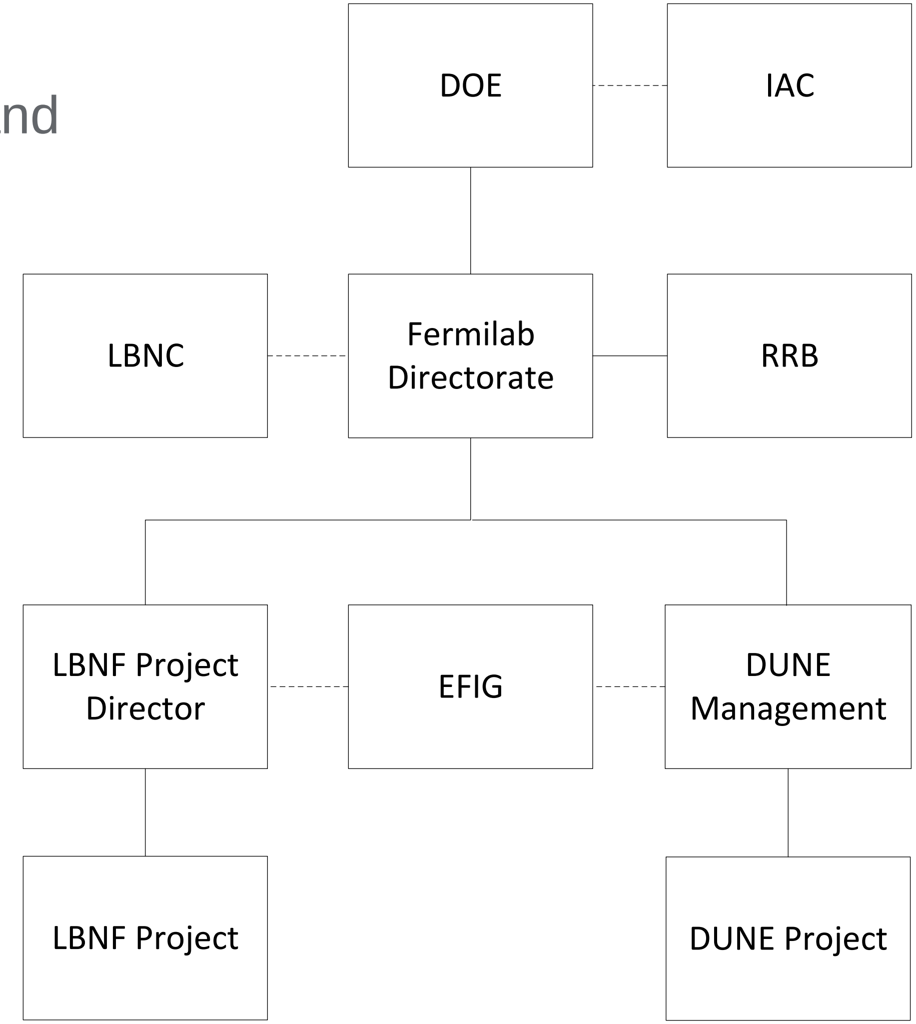
Near Detector Hall

- Beamline designed for initial 1.2 MW beam power with PIP-II, upgradable to 2.4 MW in the future.
- Decision in last month to increase target hall size to allow for future beam optimization & larger components.

LBNF/DUNE Organization

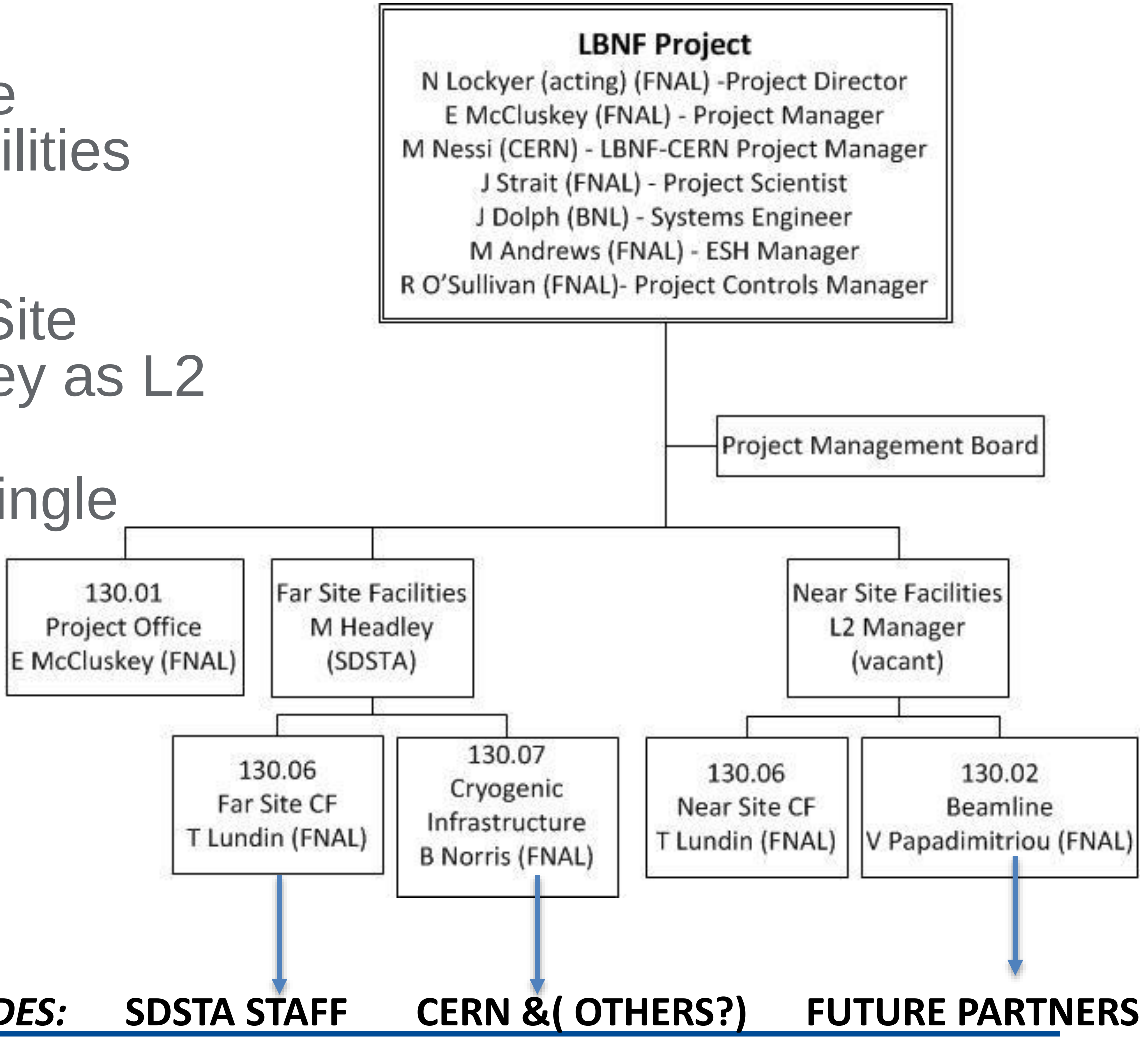
Based on LHC model

- Separates responsibility for facility and experiment
- International oversight and coordination provided by
  - IAC: International Advisory Council
  - RRB: Resources Review Boards
  - LBNC: Long-Baseline Neutrino Committee
- High level interfaces managed through EFIG: Experiment-Facility Interface Group, led by two Fermilab Deputy Directors
- Almost all groups functioning; RRB to start soon.



LBNF Project Organization

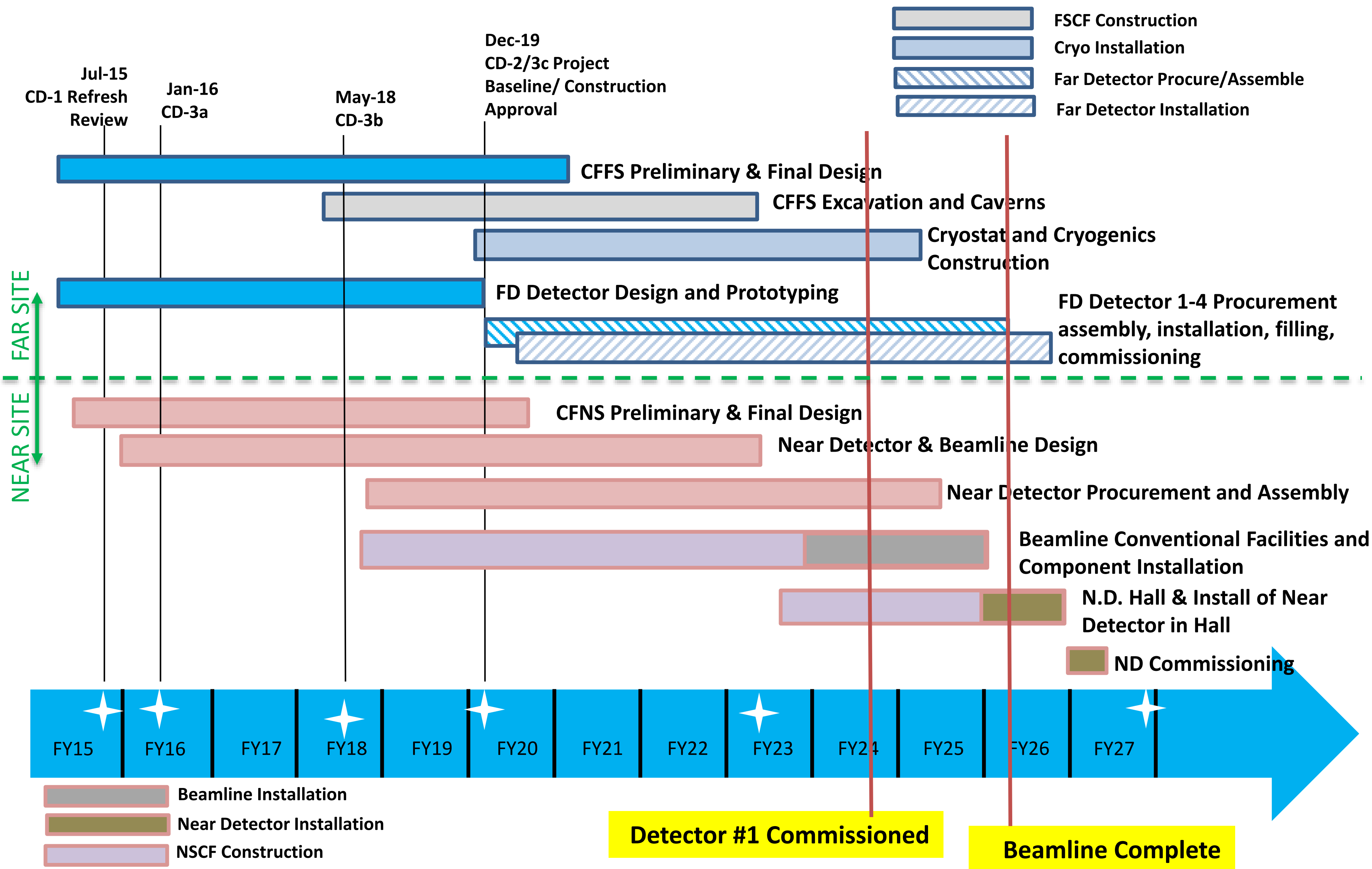
- Fermilab is the host laboratory with responsibility to execute the LBNF Project.
- New L2 Projects for Far Site Facilities and Near Site Facilities will be led by heads of new Fermilab LBNF divisions – integrates SDSTA into Far Site leadership with Mike Headley as L2 Manager
- Ensures coordination and single point of contact at each site
- Much of the project team worked on LBNE and has the background and experience for LBNF.



Requirements and interfaces

- LBNF manages requirements and interfaces internally between
  - the beamline and Near Site conventional facilities
  - the cryostat/cryogenic systems and Far Site conventional facilities
- LBNF must coordinate requirements for and interfaces with DUNE regarding
  - Cryostats & cryogenic systems for the Far Detector
  - Conventional facilities for the Far and Near Detectors
  - Beamline technical components to meet physics requirements
- Extensive work has been done through meetings between L2 and L3 subproject to be ready for CD-1 Refresh
- The Experiment-Facility Interface Group (EFIG) has also provided a formal means to come to consensus in many areas recently.
  - Modular, 4-cavern/cryostat layout with central utility cavern
  - Larger target hall to allow for potentially optimized neutrino beam components
  - Elimination of longer/wider decay pipes

LBNF/ DUNE Schedule Summary Overview



Conceptual Design Maturity & Reviews

- Designs for conventional facilities follow relatively standard engineering designs, and utilize outside engineering firms who also provide cost/schedule estimates.
  - ***Average design maturity ~ 20%***
- Designs of specialized beamline equipment and systems are largely developed by lab scientists and engineers based on past experience and similar designs (particularly from NuMI), and engineering standards.
  - ***Average design maturity ~ 50%***
- Technical systems such as cryogenic infrastructure are designed initially by lab engineers and scientists according to lab and industry standards with past experience on similar systems, and then may be contracted to industry for final design prior to fabrication.
  - ***Average design maturity ~ 30%***
- Designs for detector equipment and systems have largely been developed by lab or university engineers and scientists, utilizing prototyping or similar experiment experience.
  - ***Average design maturity ~ 20%***
- Independent design reviews charged by the Project to evaluate conceptual designs – all completed in May *find review pages here*
  - All reviews noted designs were at least at conceptual level or greater
  - Recommendations being addressed before DOE IPR

Recommendations from LBNF/DUNE Director's Review

- Review outcome was positive – ready for DOE CD-1R IPR. Final report publicly available.
- 30 recommendations with 16 needing to be addressed and closed before the review. Status provided here:

LBNF/DUNE CD1R Director's Review Recommendations		status
3	Refine the detector commissioning activities that will be included in CD4. This should be done for the CD-1 refresh review.	done - KPPs include commissioning
5	Clearly identify the "P5 recommendation" items in the requirements document as it flows down from the science requirements to the performance requirements. This should be done for the CD-1 refresh review.	in progress - draft document prepared
8	Address as much as possible all the technical review recommendations before the CD-1 refresh review	in progress - review recommendations being documented

LBNF/DUNE CD1R Director's Review Recommendations		status
9	Clearly state the assumptions used to define the DOE and non-DOE scope in the detector presentations. This should be done for the CD-1 refresh review.	in progress
12	Proceed to CD-1	done
14	Develop an end-of-life disposition concept for the LAr prior to CD-	done - in CDR
15	Address the Independent Design Review recommendations related to the conceptual design and cost prior to the July 2015 IPR.	done - review response spreadsheet, will be in talks
16	Incorporate the reconciled cost estimate from the A/E consultants prior to the July 2015 IPR and ensure the control account managers are familiar with the revised estimate.	done - cost/schedule updated and shared with CAMS
19	Prior to the DOE CD-1 Refresh Review, the project team needs to develop, articulate and be prepared to present a clear and coherent picture of how the LBNF/DUNE DOE project fits into the more comprehensive international effort.	in progress - graphics being developed
20	Prior to the DOE CD-1 Refresh Review, the project management team needs to work with the estimators (CAMs) to ensure that they understand, articulate and document how their lower level WBS element estimates roll up into the larger project estimate.	practices scheduled for this week

	LBNF/DUNE CD1R Director's Review Recommendations	status
23	[Pre-CD1] LBNF/DUNE Project needs to review and cleanup the risk register, as the risk register directly feeds the development of a proposed contingency level.	done - register reviewed, updated, revised contingency
24	[As part of the CD-1 approval] Several project management systems documents, such as the PPEP, PMP, and Acquisition Strategy need to be finalized and approved.	in progress - being finalized
27	[pre-CD1] Update and make consistent the required [PM] documents for CD-1.	in progress - being finalized
28	[pre-CD1] Formulate a strategy for procurement of liquid argon and establish its baseline cost implications in the event that this item is not supplied through the DUNE common fund.	done - 2 modules now in DOE cost
29	[pre-CD1] Complete the risk-based contingency estimate for the DUNE and LBNF projects based on the assumed US scope and reconcile this with the planned independent top-down contingency.	done - re-evaluation complete
30	[pre-CD1] Determine the changes to the DOE funding profile required to achieve a technically limited schedule.	in progress - using recent budget

Near Term Plan

- DOE CD-1 Refresh Independent Cost Review 7-8 July
  - Practicing for drill downs
- DOE CD-1 Refresh IPR
  - Applying information learned from Director's review
  - Engaging with subcommittee chairs in next 2 weeks to ensure they have what they need
- Recruiting for key open positions in both LBNF and DUNE
- In preparation for CD-3a, planned for November:
  - Planning for Far Site logistics meeting in August with consultants, conventional facilities (CF), cryo, and far detector participants, led by Far Site Facilities Manager, to ensure
  - Planning for decision-making meeting with key leaders in Aug/Sep to set Far Site CF interfaces and determine final design requirements

Summary

- LBNF will provide the facility and the neutrino beamline for the DUNE detectors.
  - conventional facilities at both the near and far sites
  - cryogenics infrastructure to support the DUNE detectors at SURF
  - an intense neutrino beam aimed at the far site
- Conventional facilities designs are advancing quickly, based on requirements from the beamline, cryogenics and detectors
- Modular cryostats based on designs similar to the short-baseline program and prototypes at CERN will be installed as excavated detector pits are completed with detector installation similarly executed one module at a time.
- The beamline design is based on NuMI experience and well understood and is designed to accept up to 2.4 MW beam

Conclusions

- Together, LBNF and DUNE will provide a world-leading facility and experiment for neutrino physics, nucleon decay and astroparticle physics.
- Aggressive schedule is planned:
  - Excavation at SURF to start late in 2017
  - Construction of first cryostat in early 2020
  - First far detector installation in late 2021, ready for filling in 2023
  - 2nd, 3rd and 4th detectors in following ~ 2 years
  - 1.2 MW beam by 2026
  - Precision near detector by 2027
- Significant progress has been made in the last 5 months and we are well positioned for CD-1 Refresh and know what is needed to do for CD-3a.