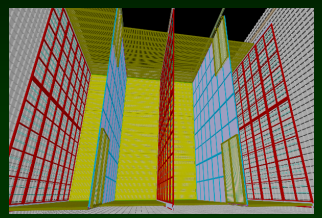
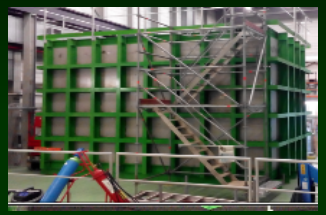
STATUS OF THE DUNE PROJECT

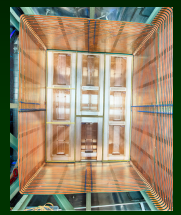
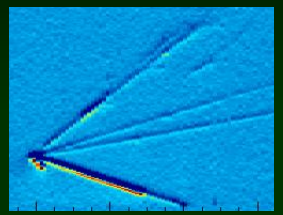
Norm Buchanan
On behalf of the DUNE collaboration

Colorado State University
Feb 12, 2016

Lake Louise Winter Institute



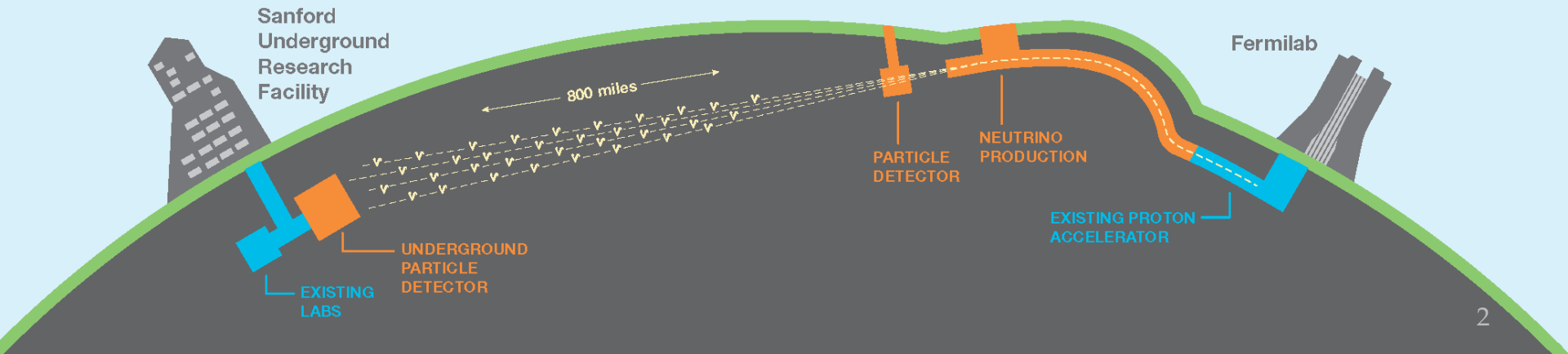



Deep Underground Neutrino Experiment

- Long-baseline oscillation physics
  - CP violation search (measurement)
  - Determination of mass hierarchy
  - Precision ν oscillation parameters
- Non-beam physics
  - Proton decay
  - Supernova burst neutrinos

Also

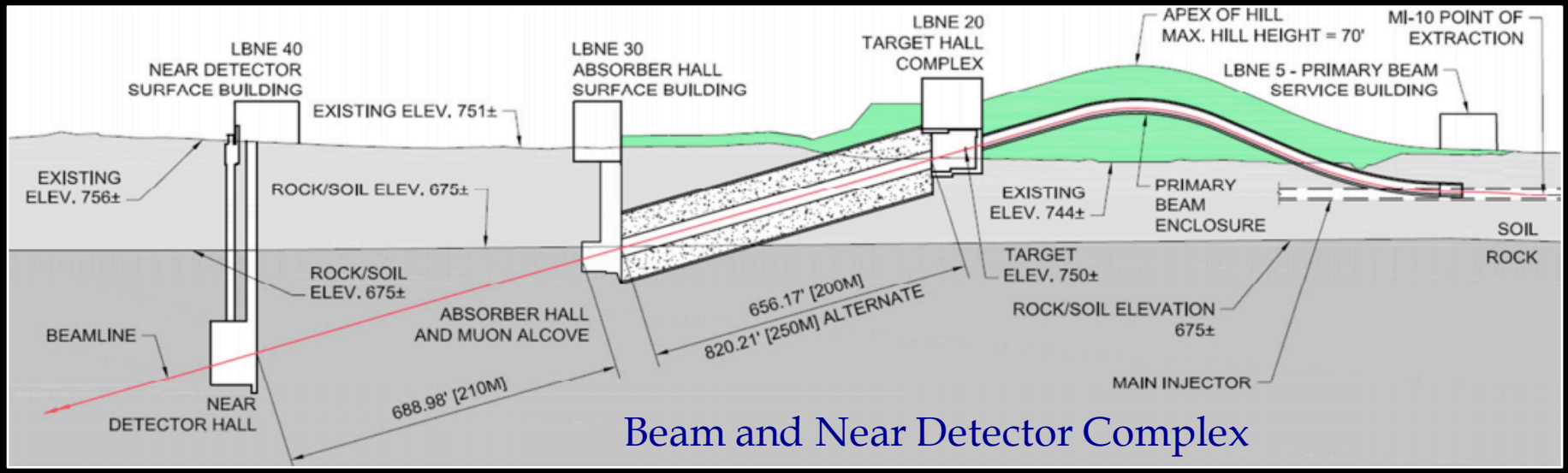
- Neutrino cross-sections
- Sterile neutrinos
- Atmospheric neutrinos
- Exotics



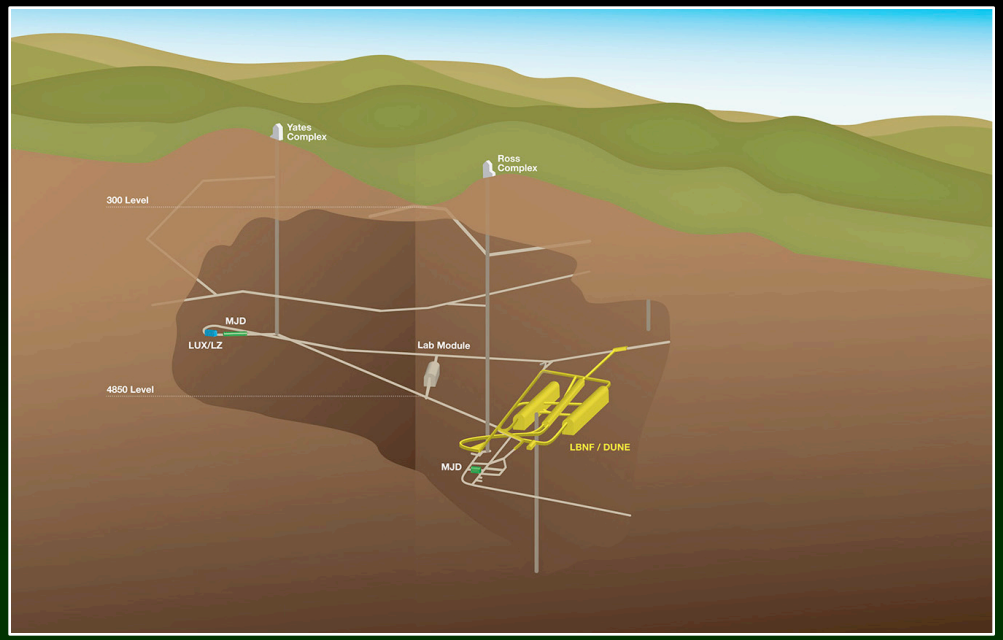
The DUNE Collaboration

Formed January 2015 from the previous LBNE and LBNO collaborations plus many new institutions (and growing)

DUNE Design



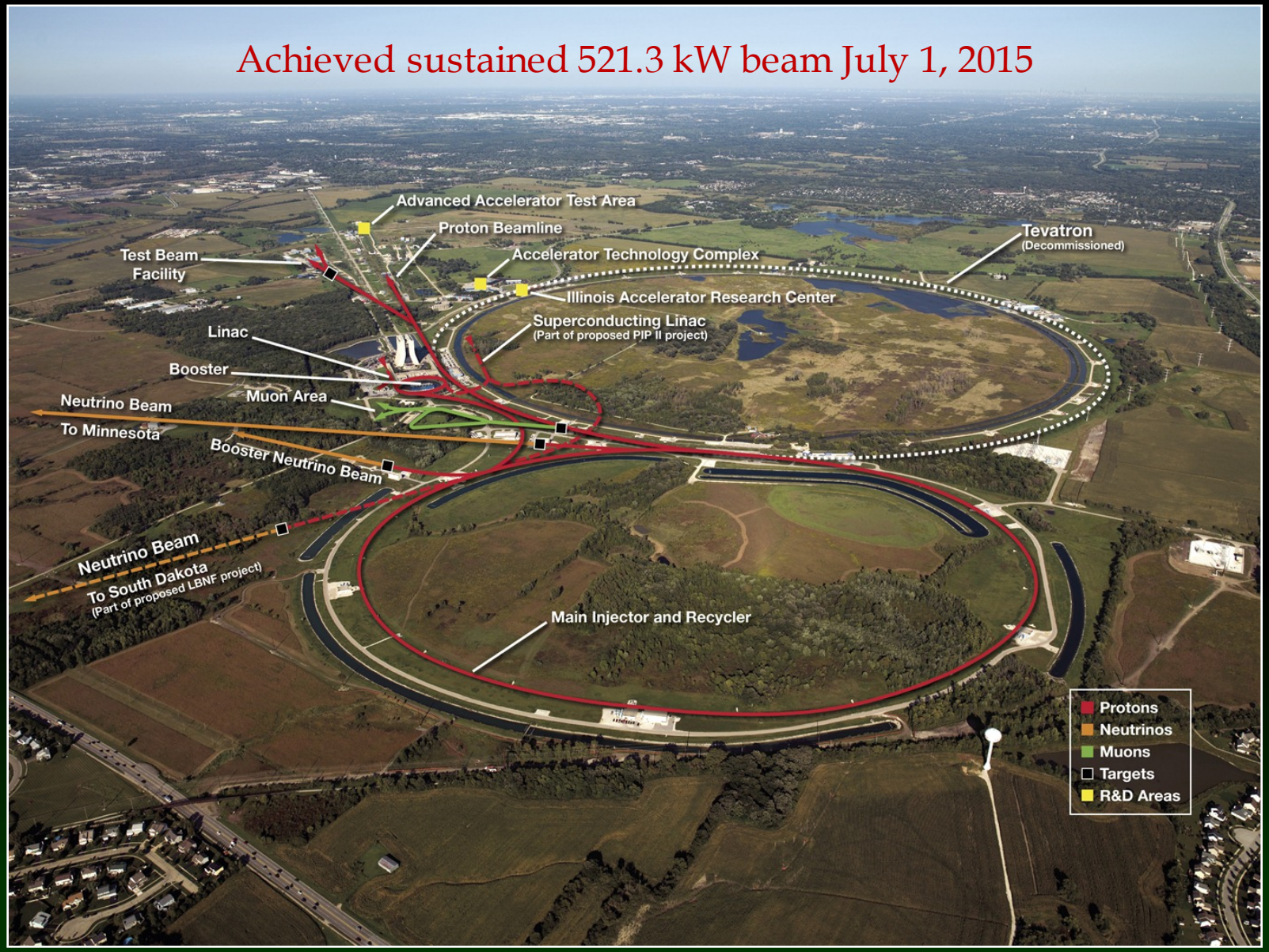
Beam and Near Detector Complex



Far Detector (SURF – Sanford Underground Research Facility)

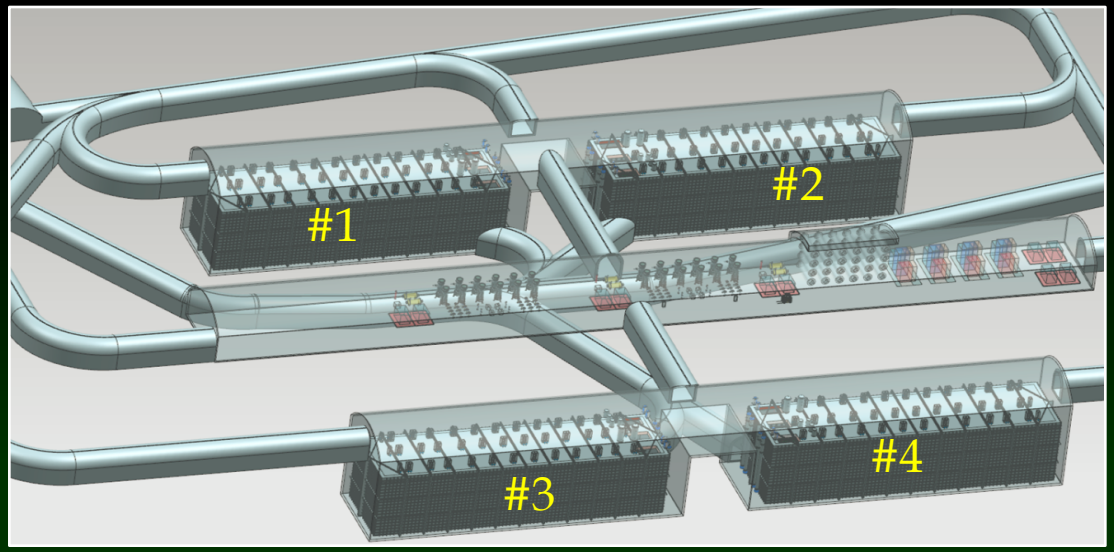
- Liquid argon-based designs
- Composed of time projection chambers and photon detectors
- 4 x 10 kt (fiducial) modules
- Employ staged approach to achieving full 40 kt mass

Neutrino Beam

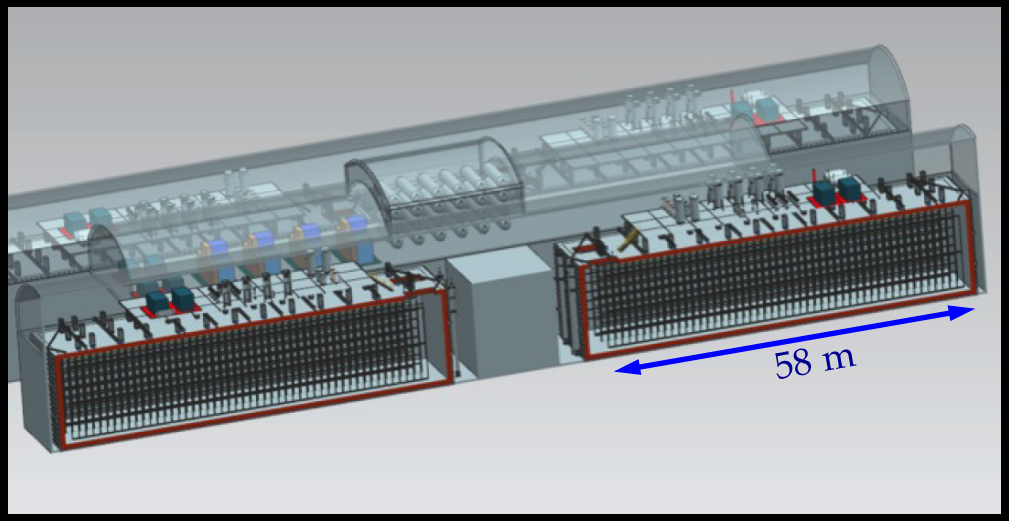


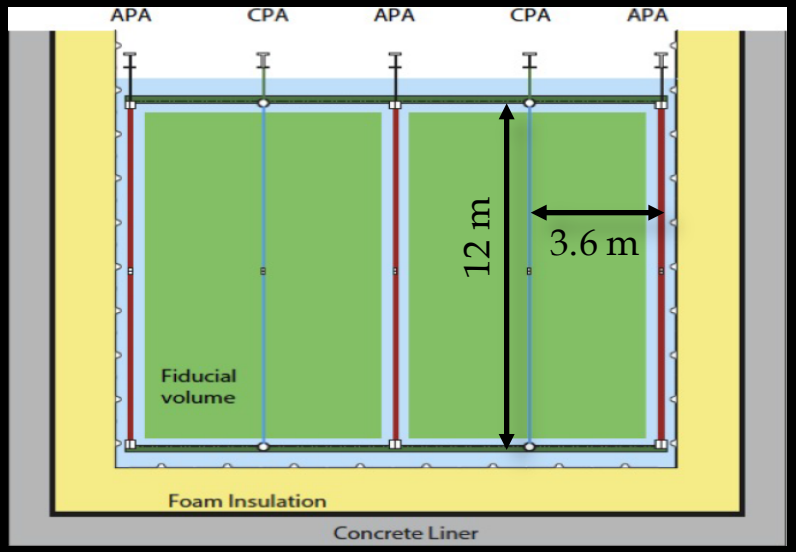
Getting to a 40 kt Far Detector

- Four separate cryostats located at 4850′ level of Homestake mine
  - Each with dimensions: 15 m (W) × 14 m (H) × 62 m (L)
  - Separate cavern for each of the cryostats
- Advantage is that a phased-in approach can be taken
  - Continue to learn as we go (LArTPC research is an evolving area)
  - Allows alternate designs – eg. dual phase LArTPC
- Installation of #1 (single-phase LArTPC) starts in 2022
  - Each of the remaining 3 detectors installed 18 months following the one before

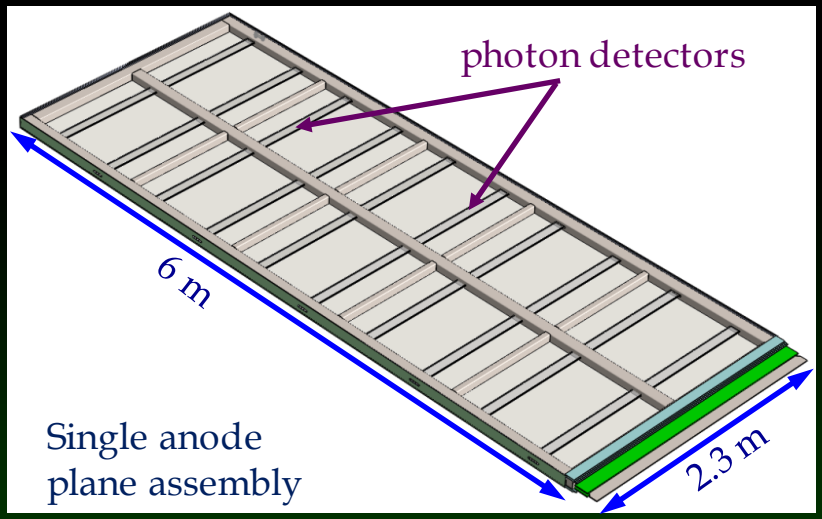


Reference Design Far Detector: Single-Phase LAr TPC





APA – anode plane assembly
CPA – cathode plane assembly

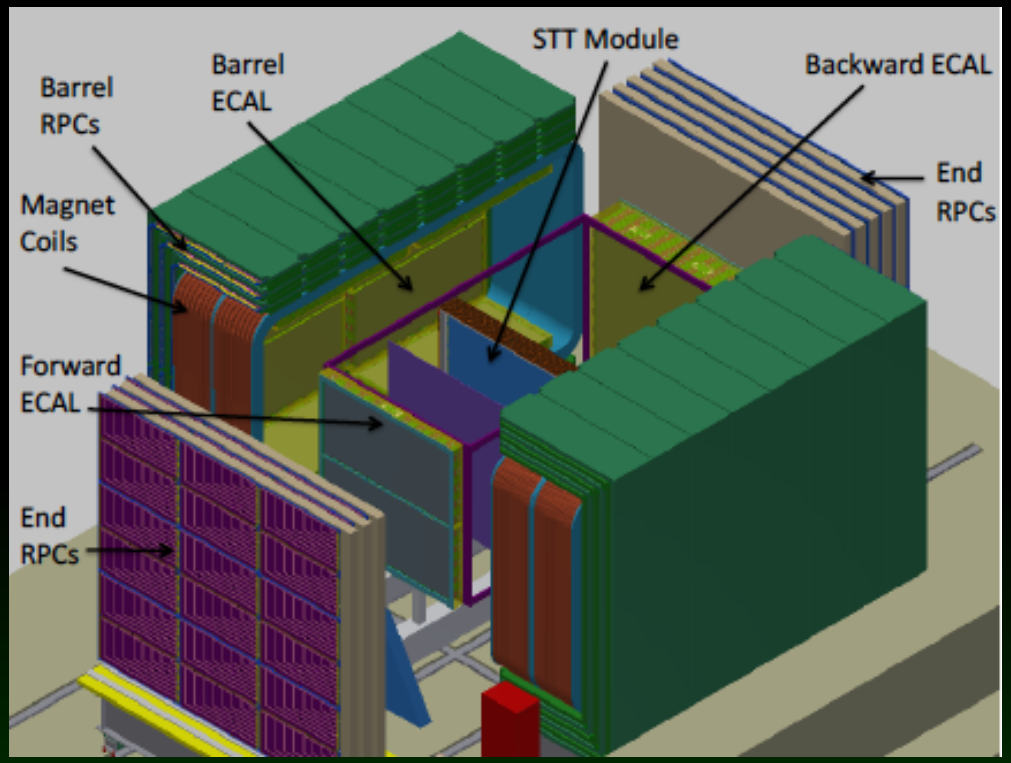


150 APAs per 10 kt module (ref. design)

Prototype TPC with 20″ photon detector

Near Detector Reference Design

Provides beam characterization and self-contained measurements



Design based on NOMAD-style fine grained tracker

- Central straw tube tracker
- Lead scintillator sampling ECAL
- Large-bore warm dipole magnet
- Resistive Plate Chamber (RPC)-based muon trackers

DUNE has appointed a task force to study the benefits of including a LAr TPC or high-pressure gaseous argon TPC to the ND

Prototyping and Testing

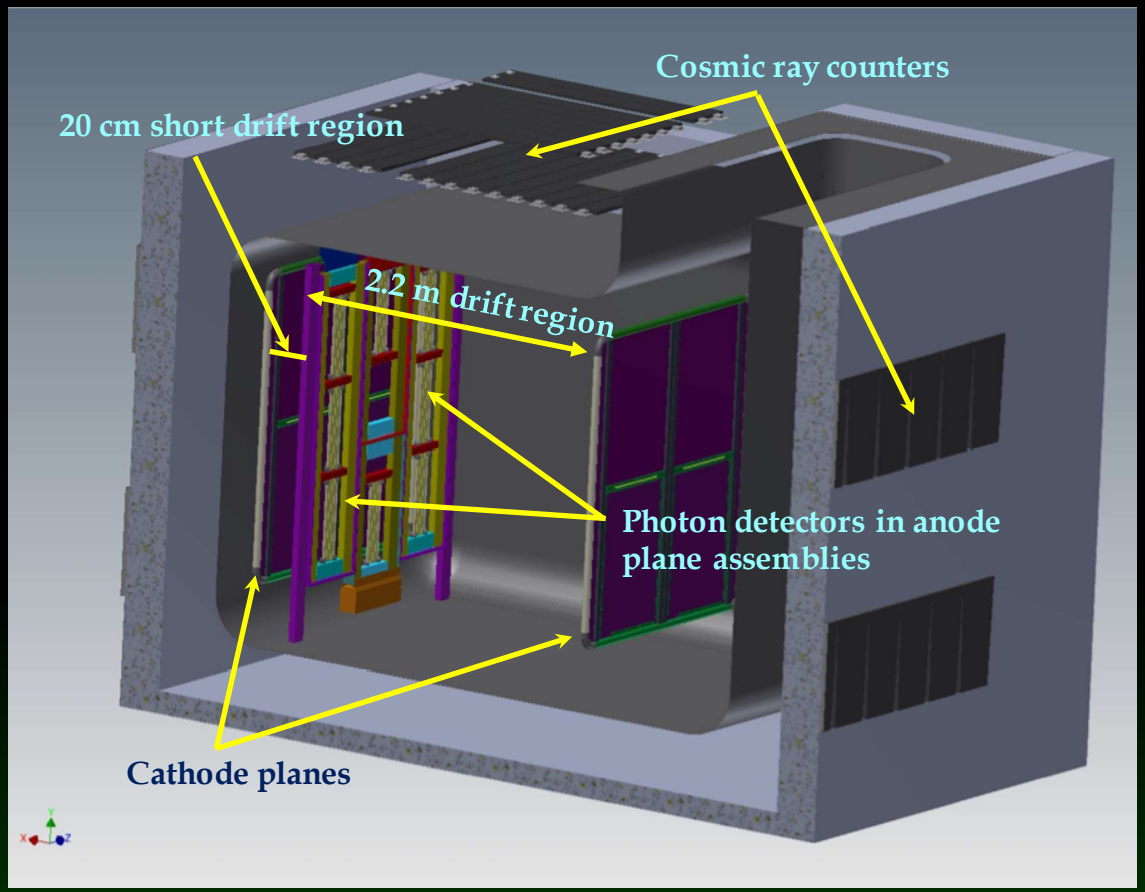
DUNE liquid argon TPCs will 10's of times larger than any built previously.

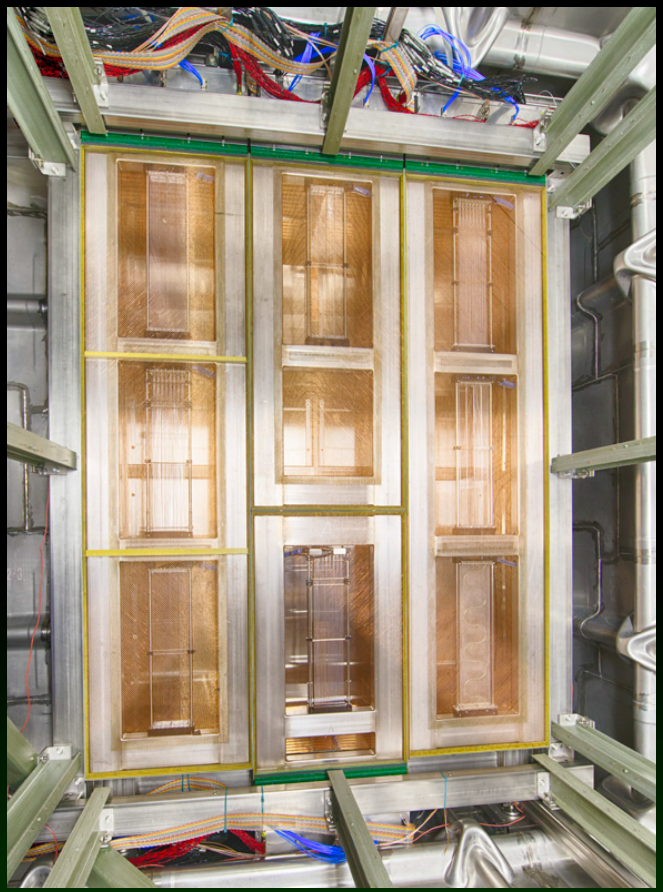
The project plan includes an extensive prototyping and testing program to ensure that all parts of the technology are thoroughly studied and tested.

Two key elements of this program are the 35t prototype at Fermilab and the protoDUNE prototypes at CERN.

35 t Prototype Cryostat

Prototype membrane cryostat with prototype TPC and photon detectors (2.5 x 1.5 x 2.0 m^3 active volume)





- DAQ operational (TPC, PDs, and CRCs read out together)
- **Filled with liquid argon Feb 2nd !**

35 t Prototype Cryostat

35 t prototype program goals

Engineering goals

- Construct TPC including interfaces
- Demonstrate low noise operation

Operation goals

- Exercise readout
- Characterize detector components
- Effect of wrapped wires and gaps between modules on reconstruction

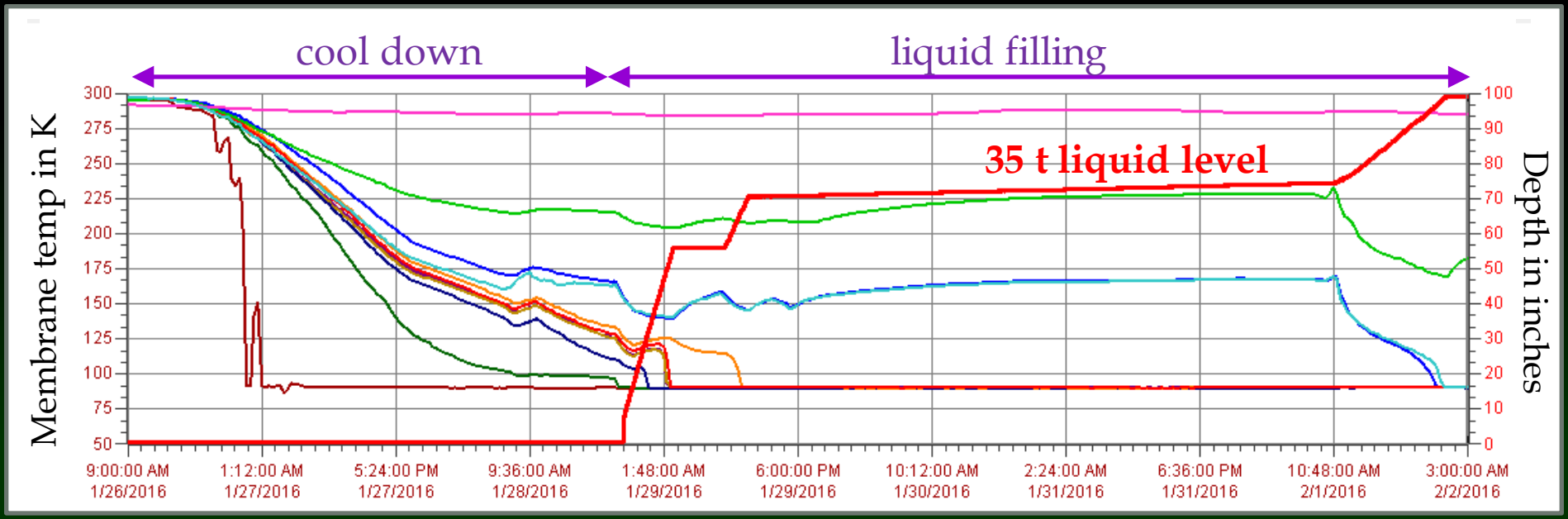
2-3 months for commissioning and data taking

Measurement goals

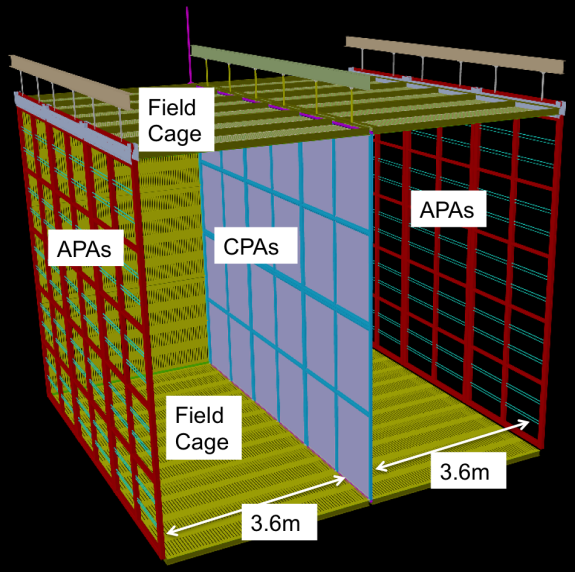
- S/N for MIPs
- Electron lifetime from cosmic muon tracks
- Event time from photon detectors
- Energy resolution and scale from Michel electrons
- Neutral pion reconstruction
- And more…

35 t Filling

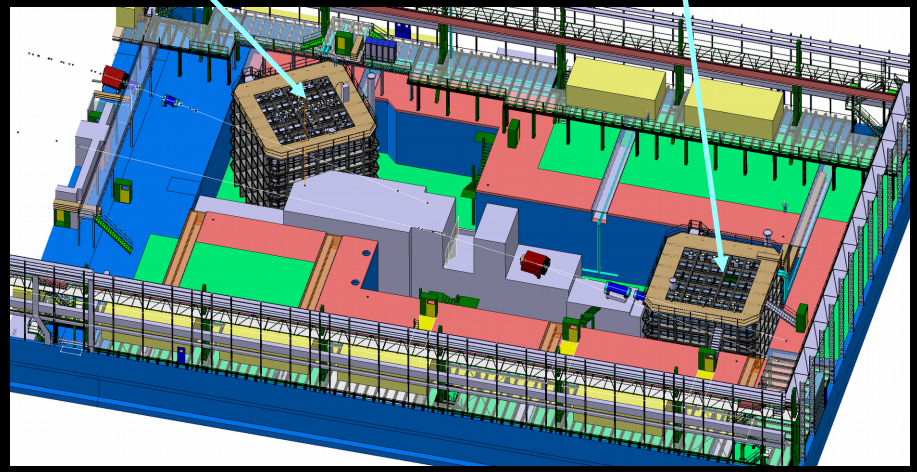
In situ digital camera and temperature monitors on the cryostat (inner) walls for level monitoring.



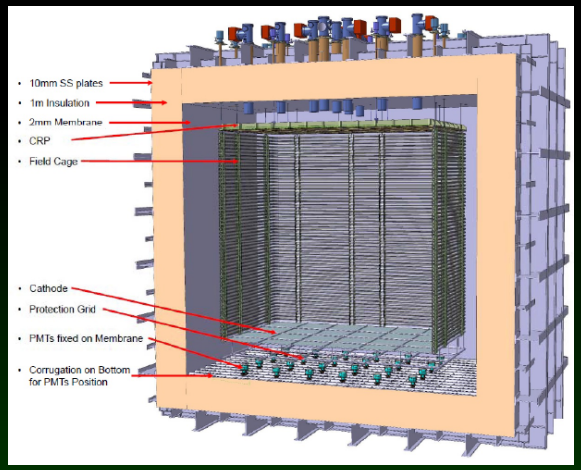
protoDUNE(s) - Single and Dual Phase



Single phase prototype



Prototypes located at the CERN Neutrino Platform (EHN1)



Dual phase prototype

Effort being incorporated into DUNE

Variety of particles and energies (μ, p, π, K, e^-/e^+) (200 MeV < E < 7 GeV)

- Testing of full scale integrated detector systems
- Gain experience with installation and commissioning
- Study systematics with well defined beam
- Provide inputs for modeling and MC studies
- Physics measurements – eg. hadron calorimetry, pion and kaon interactions, muon capture, …

Status and Plans

- DUNE collaboration formed (January 2015)
- 4-Volume Conceptual Design Report Delivered (June 2015)
  (ArXiv: 1512.06148, 1601.02984, 1601.05471, 1601.05823)
- Passed DOE CD-1 Review (July 2015)
- DOE CD-3a Review of LBNF far site initial construction (Dec 2015)
  - Feedback from reviewers was positive
- 35 t Cryostat filled for Phase 2 run (February 2016)
- 2-3 months of data taking with 35 t TPC and photon detectors
  - Analysis effort will continue through CY2016
- ProtoDUNE prototypes will take beam in 2018
  - Building completed in 2016
  - Single phase prototype TDR summer 2016 (dual phase already exists)

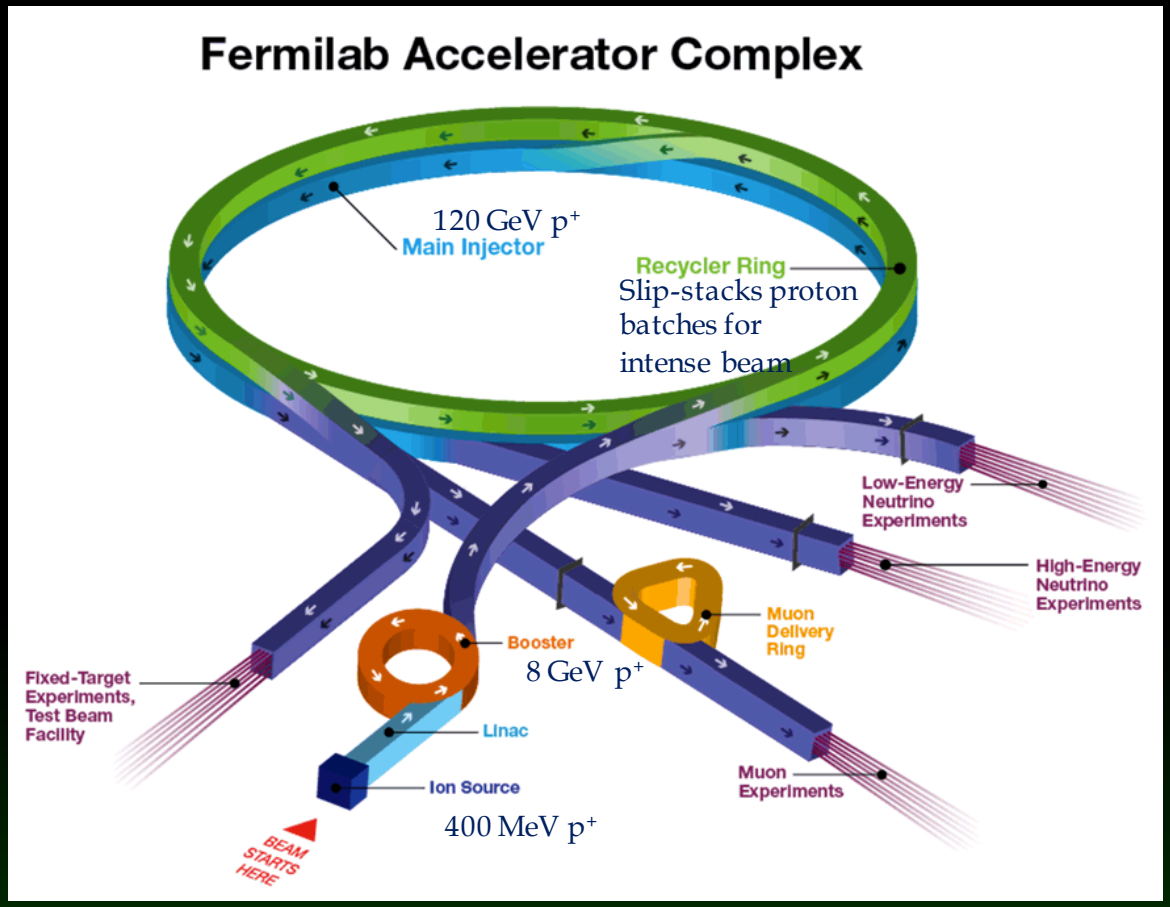
Summary

- Newly formed DUNE collaboration working toward next generation long-baseline neutrino experiment with diverse physics program
- Beam, near detector, and far detector designs have passed DOE CD-1 reviews (far site recently gone through CD-3a)
- Extensive prototyping program underway
  - 35 t prototype cryostat at Fermilab filled with LAr and beginning phase 2 operation with TPCs and photon detectors
  - protoDUNE single and dual phase prototypes will be operated in lepton and hadron beams at CERN in 2018

Exciting times ahead!

Supplementary

Proton Improvement Plan (PIP)



- **PIP** - current beam upgrades for NOVA (700 kW)
- **PIP-II – by 2026** replacing upstream portion of Linac feeding into 8 GeV Booster.
  - 1.03 MW at 60 GeV
  - 1.07 MW at 80 GeV
  - 1.20 MW at 120 GeV

- **PIP-III in R&D phase**: replace Booster with Rapid Cycling Synchrotron (RCS)

or

SC Linac.

- 2.0 MW at 60 GeV
- 2.4 MW at 120 GeV