The DUNE Far Detector and ProtoDUNEs

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on behalf of the DUNE Collaboration

38th International Conference on High Energy Physics
Chicago, IL

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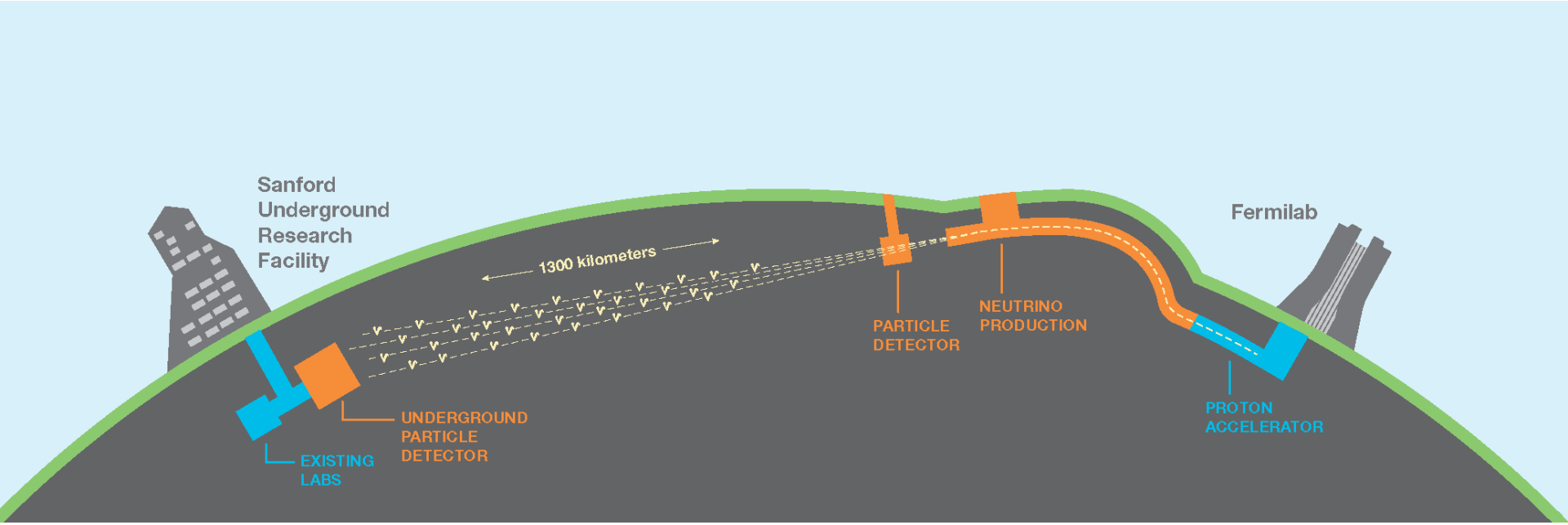
Fermilab DUNE

What is DUNE?



- The Deep Underground Neutrino Experiment will be:
  - a 40 kton fiducial liquid argon neutrino detector…
  - located 1.5 km underground…
  - 1300 km from Fermilab, which will host a 1.2 MW at 120 GeV neutrino beam…
  - and a highly-capable near detector.

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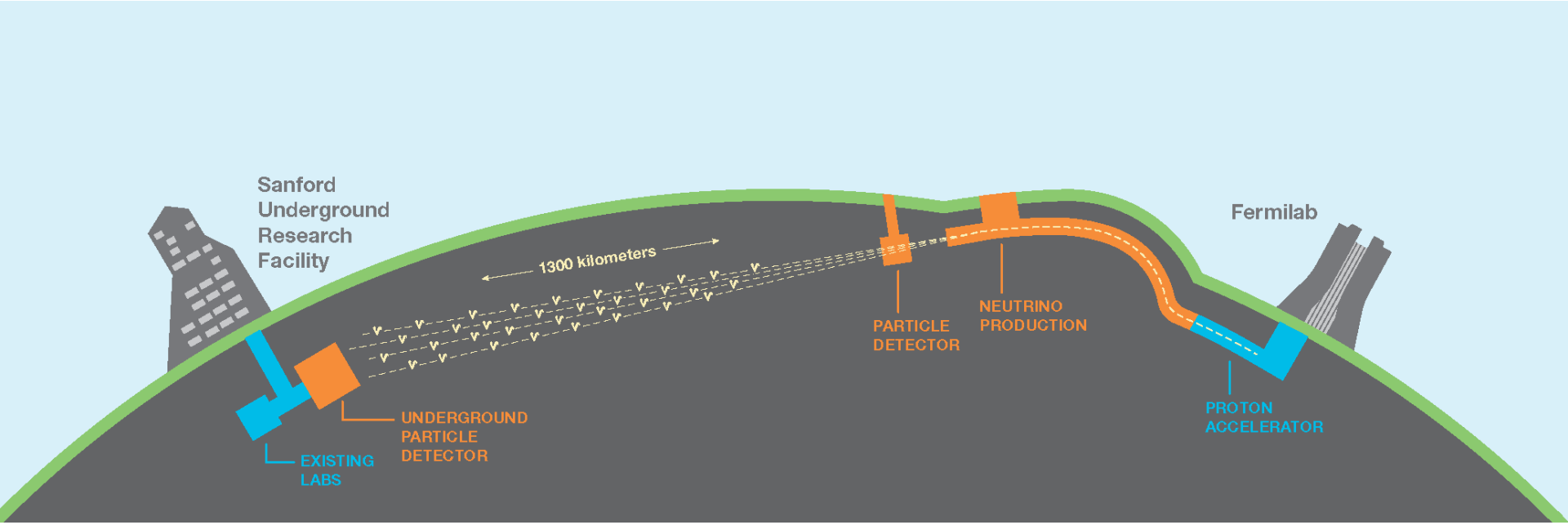

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Vaia Papadimitriou's talk tomorrow evening
Laura Field's poster tomorrow evening

We just heard from Sanjib Mishra
Bipul Bhuyan's talk yesterday

The DUNE Collaboration

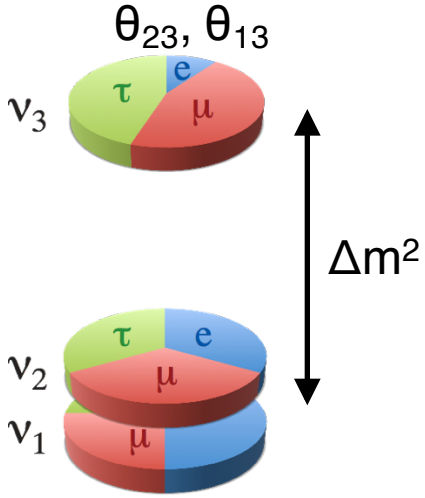
890 collaborators from 154 institutions in 28 countries.

DUNE Physics Goals Driving Design

- Make precise measurements of neutrino oscillations, including determining the mass hierarchy and the potential discovery of leptonic *CP* violation.

- Requires…
  - Large detector mass
  - Long baseline
  - Good energy resolution
    - At several GeV
  - Efficient electron neutrino identification

…liquid argon



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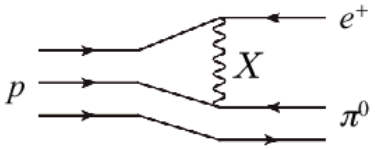

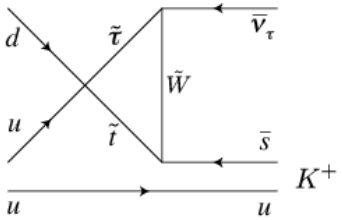

- Requires…
  - Low cosmic ray backgrounds

…deep underground

  - Timing for non-beam events

…photon detection

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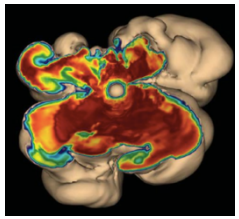
- Measure the spectrum and flavor composition of a supernova burst in our galaxy.



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    - Several MeV energy threshold

…good signal/noise

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Elizabeth's Worcester's talk tomorrow evening.

Posters on Monday from Luke Corwin, Gabriel Santucci, Karl Warburton

id argon

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ls

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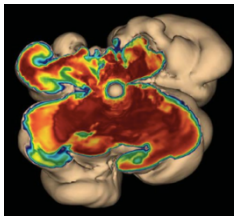

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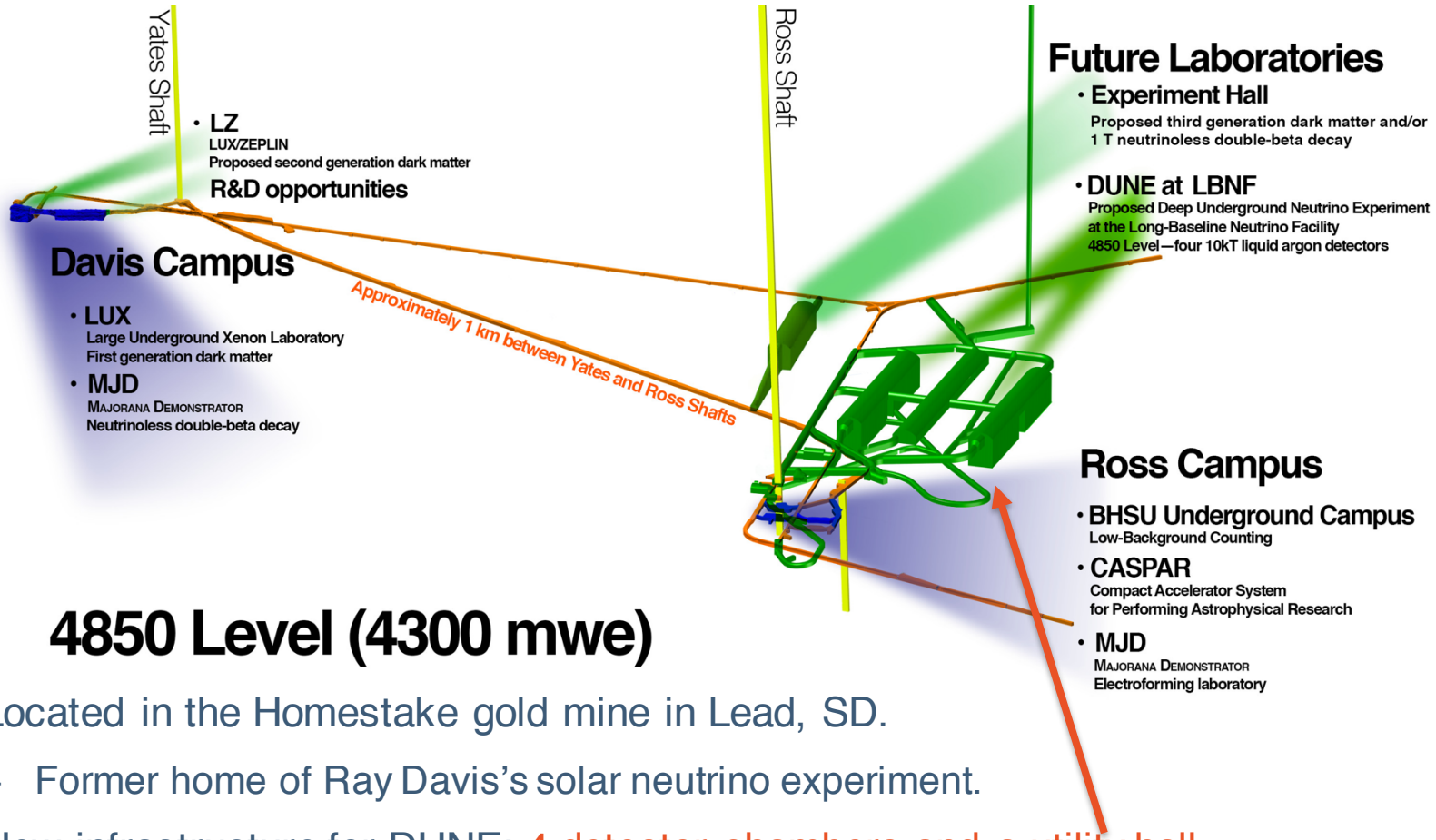
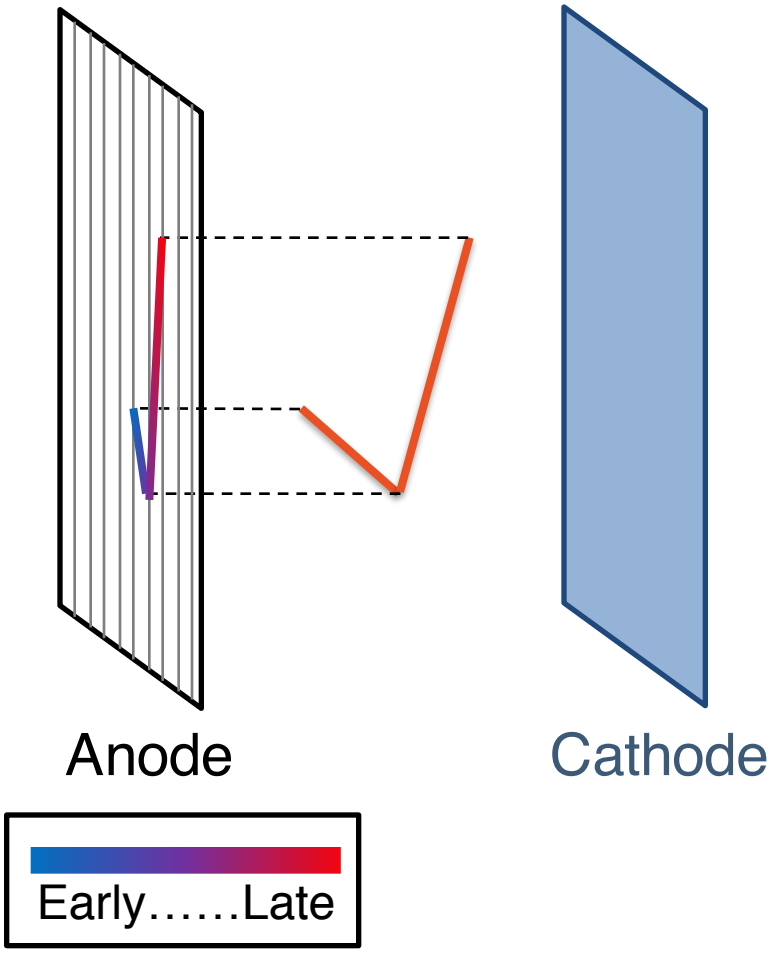
Sanford Underground Research Facility



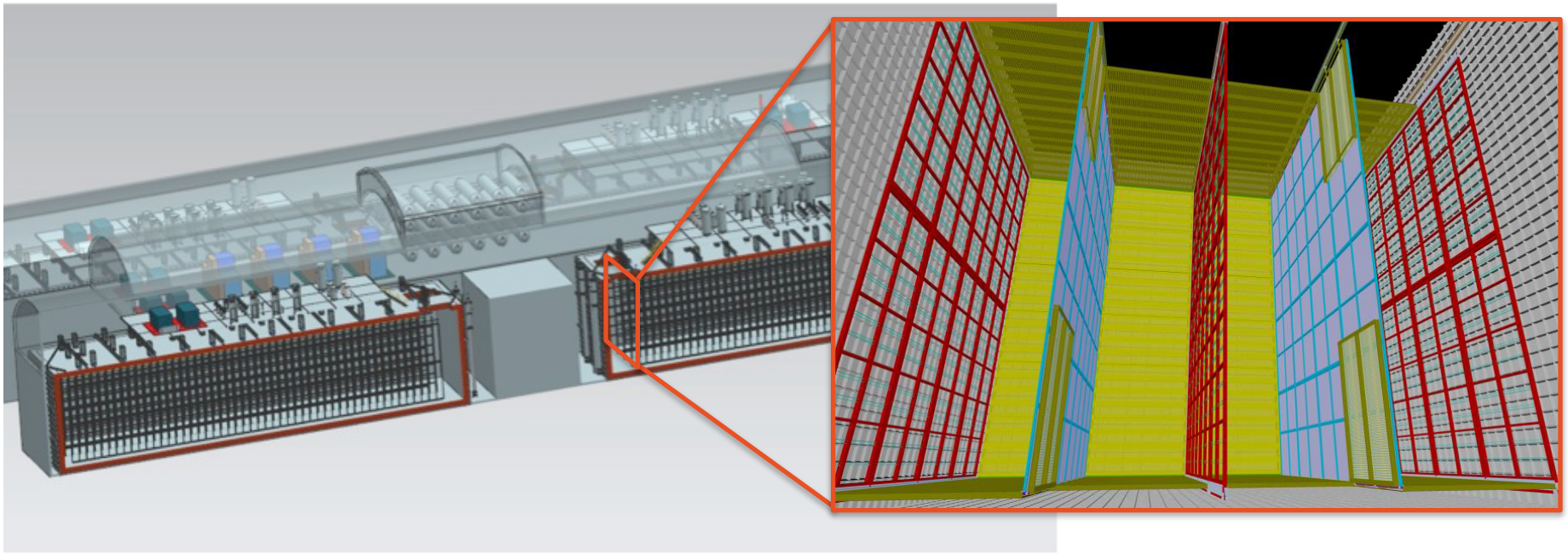
- Located in the Homestake gold mine in Lead, SD.
  - Former home of Ray Davis's solar neutrino experiment.
- New infrastructure for DUNE: 4 detector chambers and a utility hall.
- DOE approval pending to begin excavation.
  - Test blasts have already been conducted to measure vibrations.

A Time Projection Chamber

- Argon is an excellent scintillator
  - Charged particles ionize the argon atoms, which then recombine, emitting light.
- High electric field causes some (40%) of the charge to drift.
- The 2-dimensional projection of the event can be read out.
- The arrival time of the charge gives the third dimension.
- Produces high-resolution, 3-dimensional images of events.

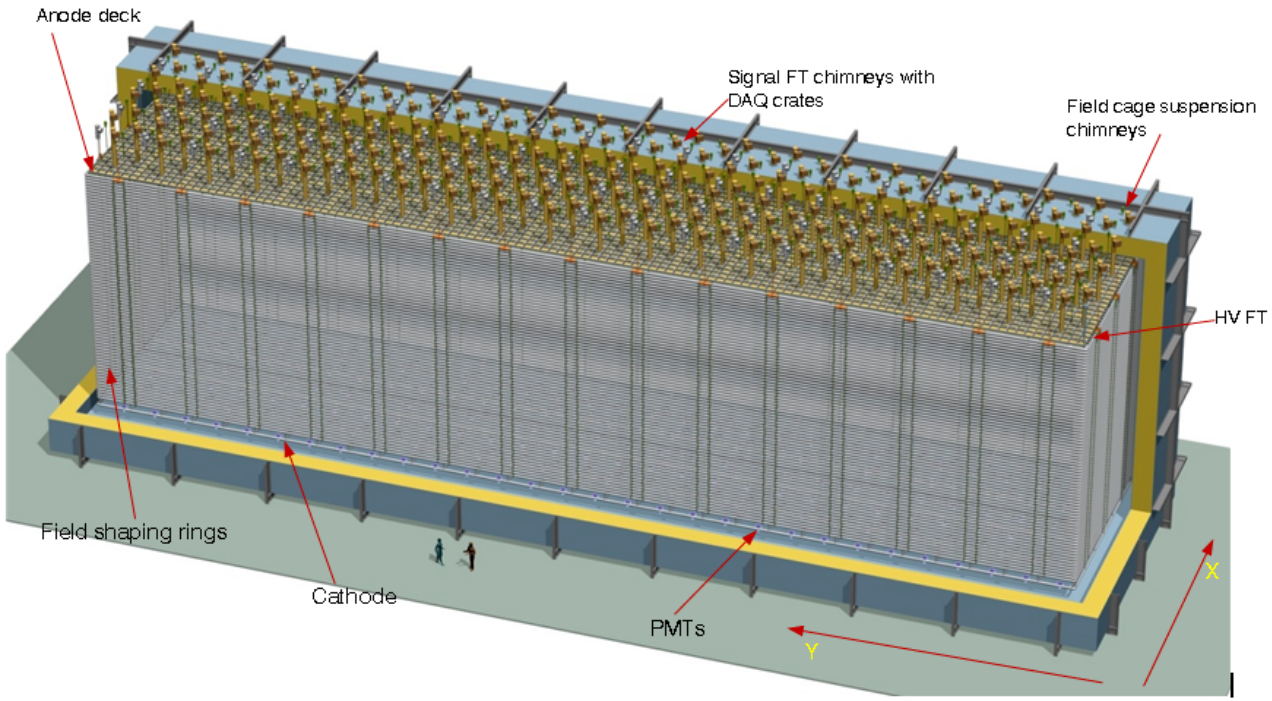


The DUNE Far Detector: Single Phase



- Single-phase TPC design based on LBNE modular drift cells.
  - Suspended Anode and Cathode Plane Assemblies (APAs & CPAs).
  - 3.6 m drift with a 500 V/cm E-field
  - Cold digital electronics reduce noise.
  - 3 views: collection wires vertical, induction wires at a 35.7° wrapped around APA.
    - Wrapping reduces the cold cable plant and number of readout channels.

The DUNE Far Detector: Dual Phase

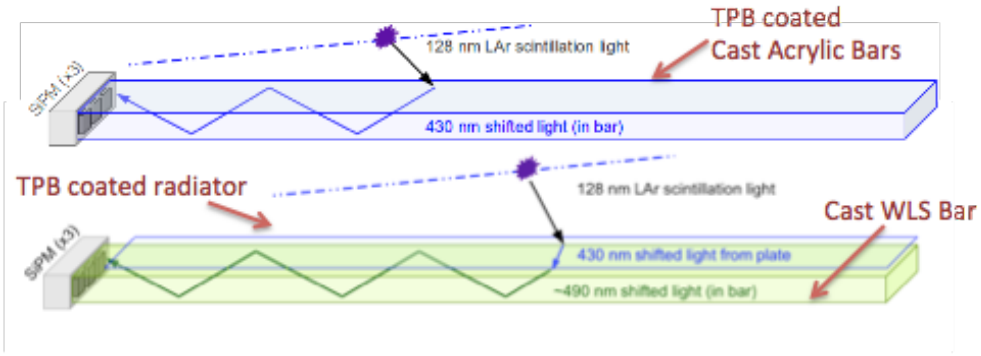


- Dual-phase TPC inspired by LBNO design.
  - 12 m vertical drift with a 500 V/cm in liquid, 1.5-4.5 kV/cm in gas.
  - Amplification via LEM = Large Electron Multiplier = a big GEM.
  - Readout in 2 orthogonal collection views from strips on the anode.
  - Partially cold electronics which are still accessible for maintenance.

DUNE Photon Detectors

- Scintillation light is detected ~instantly on the time-scale of the TPC.
  - Can set the absolute time, and hence position, of an event.
  - Copious scintillation light (24,000 γ/MeV), but at 128 nm

- Single-phase:
  - Light guides with SiPMs embedded in the APAs.
  - Multiple designs under consideration.



- Dual-phase:
  - PMTs coated in wavelength shifter sit below the cathode (floor).

The Path to DUNE

2014
- **P5 report:** Build on LBNE / LBNO-Laguna efforts to develop new international collaboration

2015
- LOI with 527 signatories
- New collaboration structure with LBNF and DUNE
  - Based on the LHC model
- Selection of name, spokespeople, new collaboration structure
- Conceptual Design Report, CD-1 refresh, CD3-a for LBNF

2016
- **Now**

The Path to DUNE

- 2016
- 2017 • Start of excavation at the far site
- 2018 • Two ProtoDUNE Detectors (SP & DP) operational at CERN
- 2019 • DUNE Technical Design Report for DOE and international organizations
- 2020
- 2021 • Start of FD installation: 1st module (single phase)
- 2022
- 2023 • Start FD installation: 2nd module (not necessarily the same design)
- 2024 • 20 kt operational
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- 2026 • Beam operations at 1.2 MW at 120 GeV

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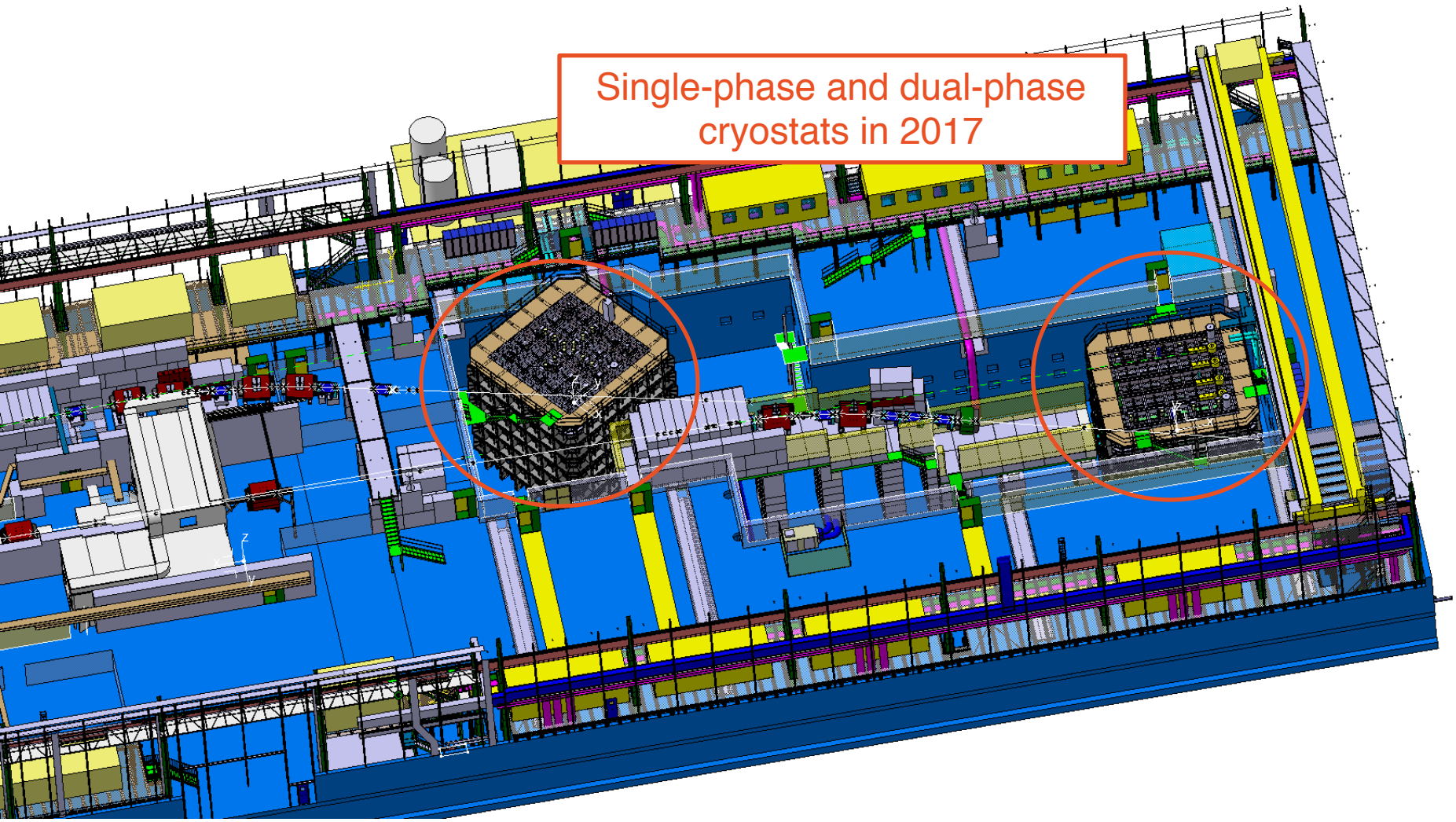
The CERN Neutrino Platform



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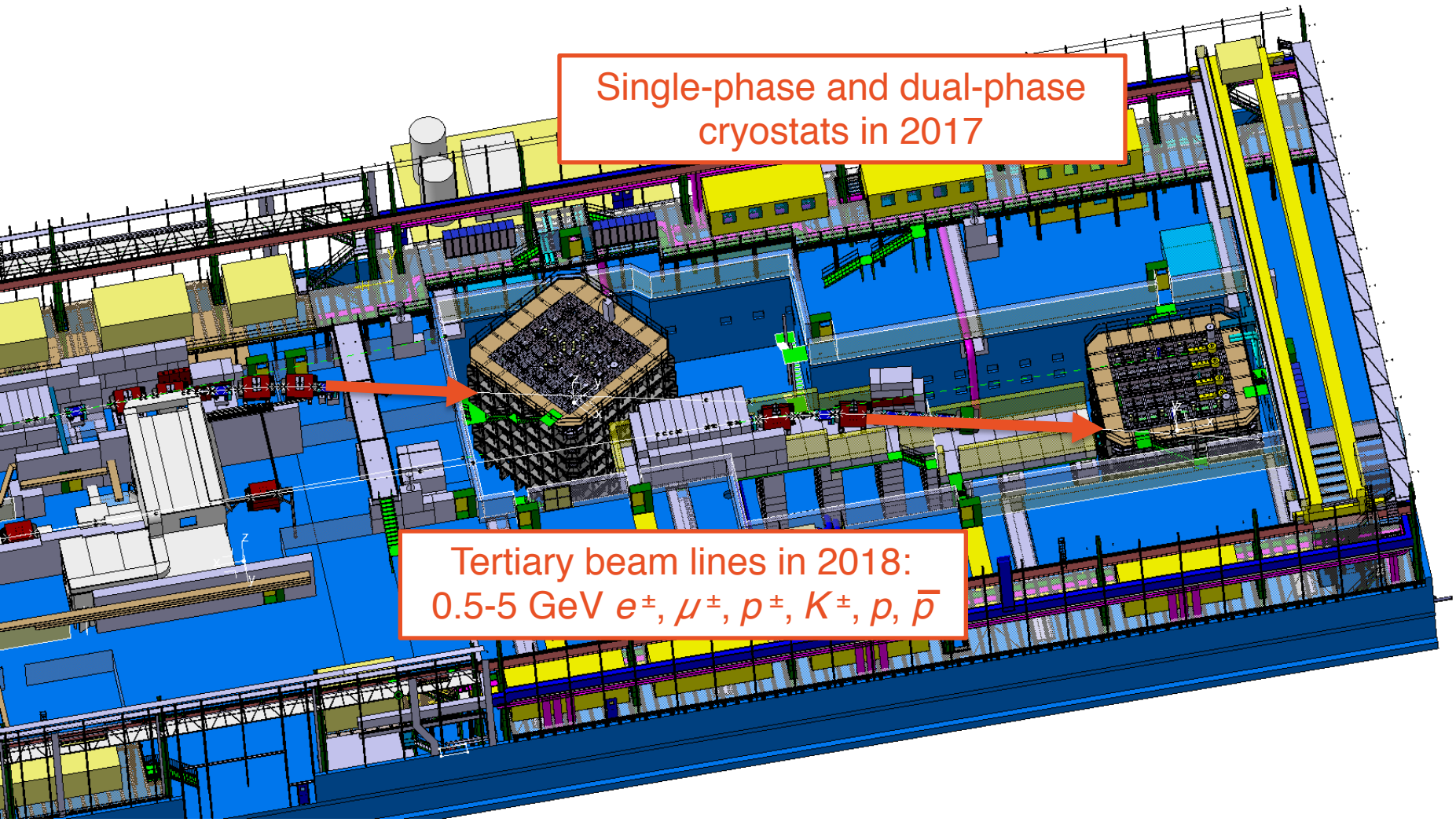
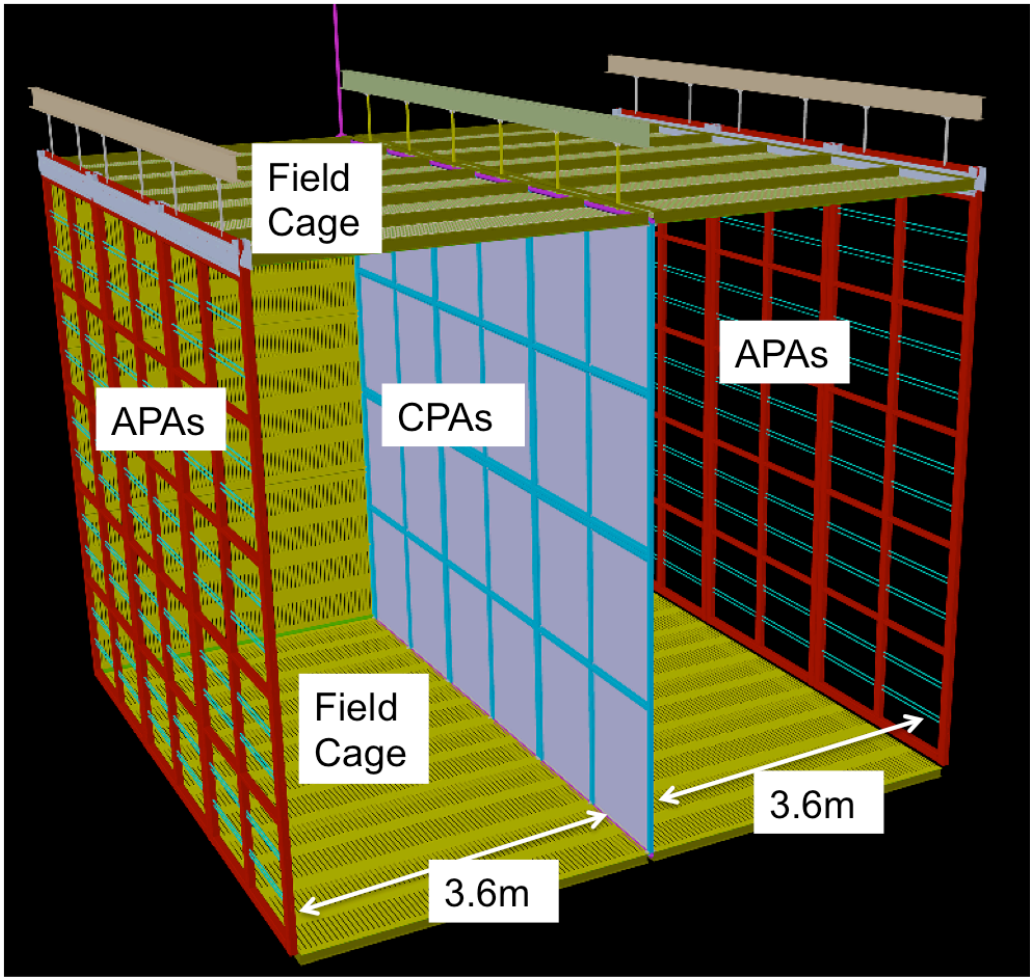


The CERN Neutrino Platform

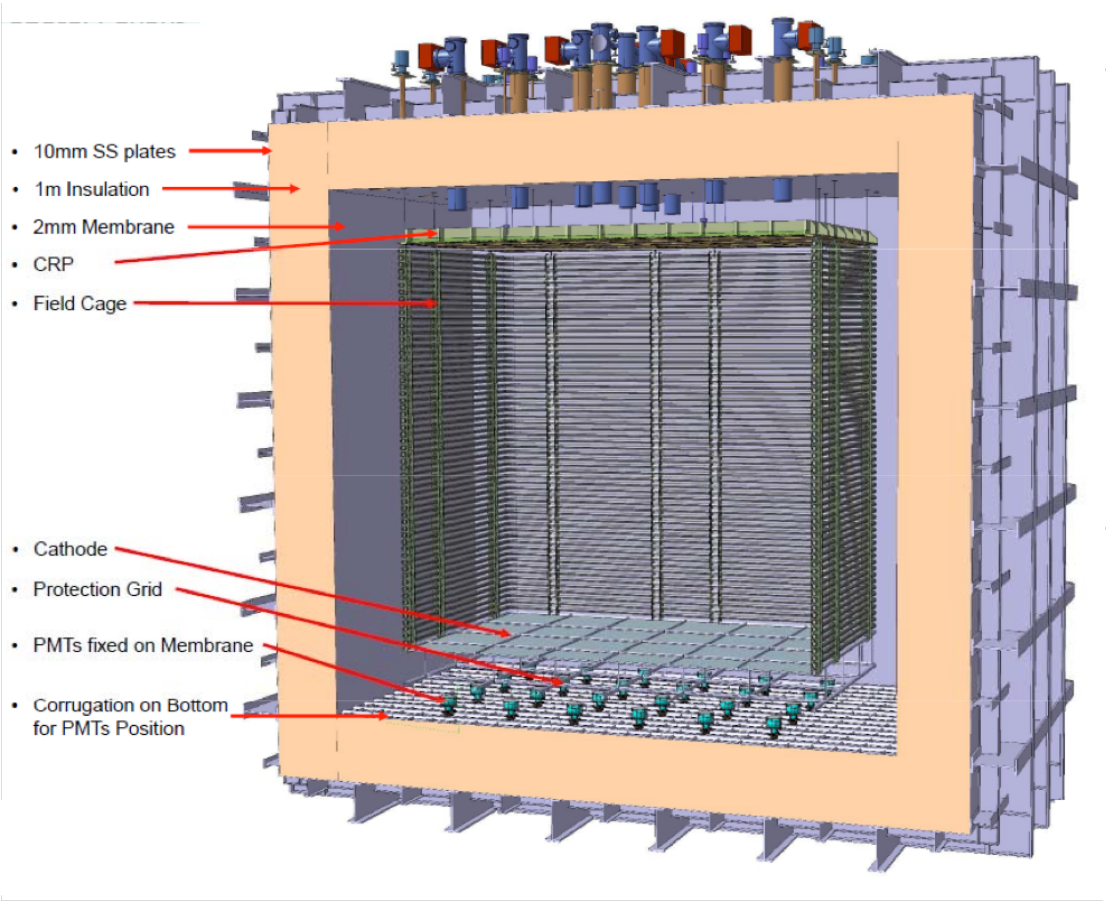
Under construction now, beneficial occupancy this Fall.

ProtoDUNE-Single Phase

- A full-scale engineering prototype.
  - Full-sized APAs and CPAs.
  - Full drift distance and field.
  - Comparing 2 photon detector designs.
  - Test of component construction, installation, commissioning, and performance.
- Charged particle beam experiment
  - Calibration for final detector
  - Charged particle σ measurements



ProtoDUNE-Dual Phase



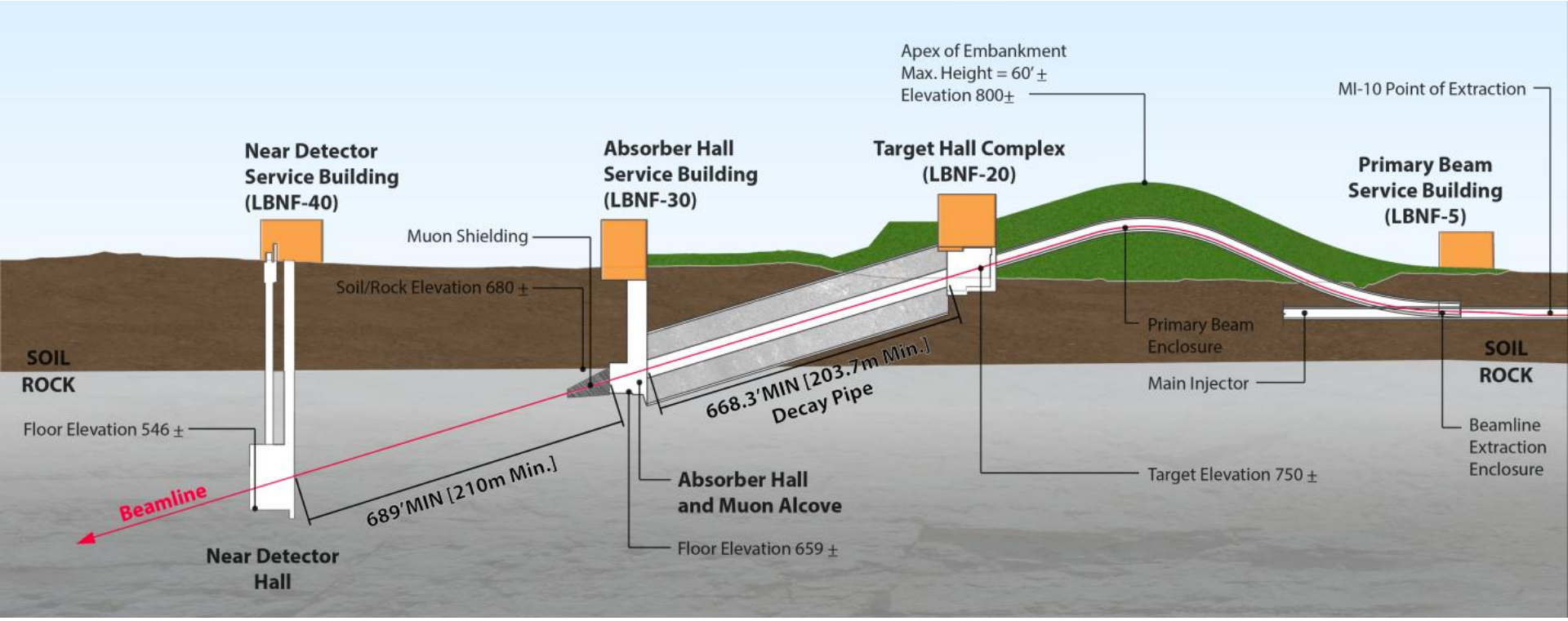
- A full-scale engineering prototype.
  - Full-sized readout planes, cathodes, and light collection.
  - Half of final drift distance, but will operate some time at double field.
- Charged particle beam experiment
  - Calibration for final detector
  - Charged particle σ measurements

Conclusions

- We are on the path to building 40 ktons of liquid argon detector underground at SURF.
- Liquid argon provides a fully-active target volume and the TPC gives us detailed views of interactions, enabling:
  - Long-baseline neutrino oscillation measurements.
  - Search for nucleon decay.
  - Observation of a galactic supernova.
- DUNE is a science priority in:
  - the US (P5 report) and
  - internationally (European Strategy for Particle Physics).
- The next step to DUNE: large protoDUNEs at CERN.

Backups

Long Baseline Neutrino Facility



- Conventional horn-focused neutrino beam using protons from the Main Injector.
- Horn and target design being optimized with a genetic algorithm developed LBNO.
  - Shows better sensitivity with a longer target and larger horns.
- Initially 1.2 MW, upgradeable to 2.4 MW