Building DUNE on the Grid.

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Fermilab

DUNE

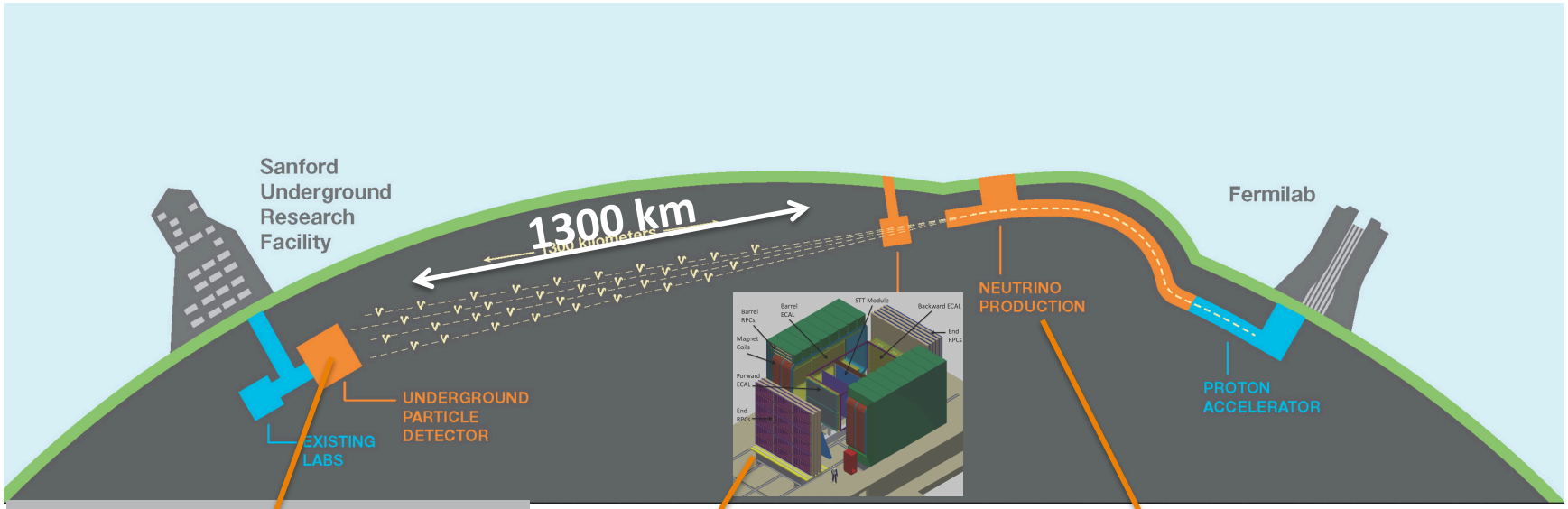
Introduction

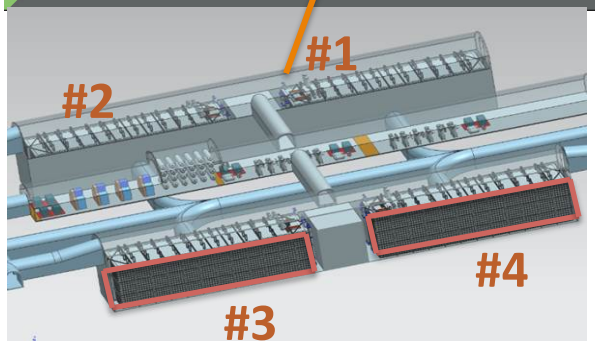
- Talk is given from my perspective as administrator of DUNE virtual organization and scientific collaborator
- Goal is to give a general overview of the computing challenges DUNE is expected to face in the next 3 years, with an eye to the next decade.
- Also to give some overview of the exciting technology and science that is expected
- Much thanks to Tom Junk of Fermilab, DUNE Software and Computing Coordinator, for material for this talk, and others on the computing team (Amir Farbin, Stu Fuess, Eileen Berman).

What is DUNE: Deep Underground Neutrino Experiment

- In early 2015, LBNE experiment at Fermilab and LBNO experiment at CERN, plus other interested long-baseline neutrino experiments, formed a unified collaboration, DUNE name was picked in April of 2015.
- As of Jan 2016, 802 individuals, 146 institutions, 26 countries
- Fermilab is host lab and is responsible for building the Long Baseline Neutrino Facility (LBNF) which will host the experiment
- Detector construction under leadership of international collaboration.
- Three main physics goals
  - Long Baseline Neutrino Oscillation measurements
  - Supernova neutrino observation
  - Nucleon decay measurements

DUNE experimental strategy





High precision near detector at 574 m

Wide band, high purity nm beam with peak flux at 2.5 GeV operating at ~1.2 MW and upgradable

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

LBNF / DUNE – An International mega-science project

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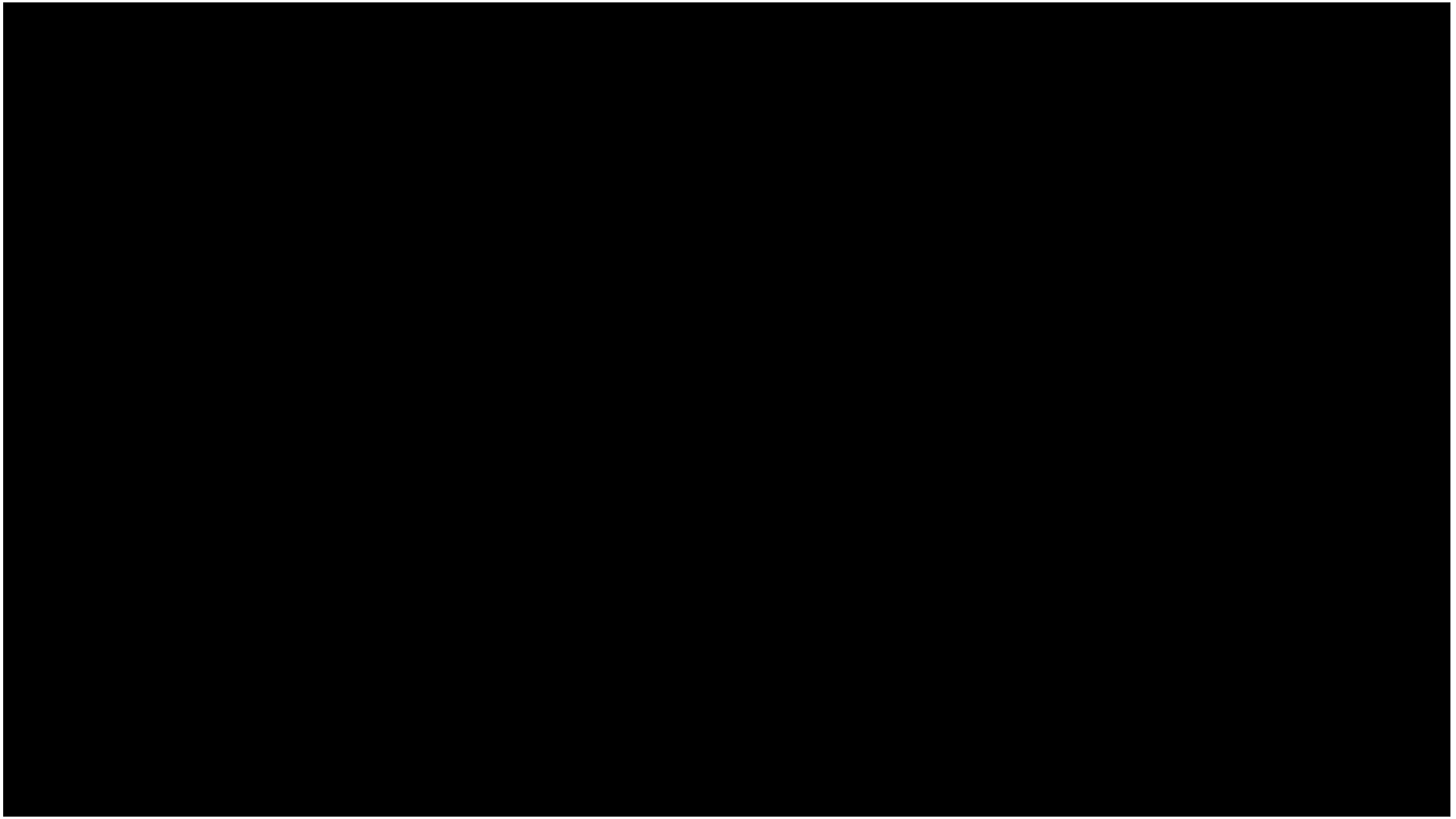
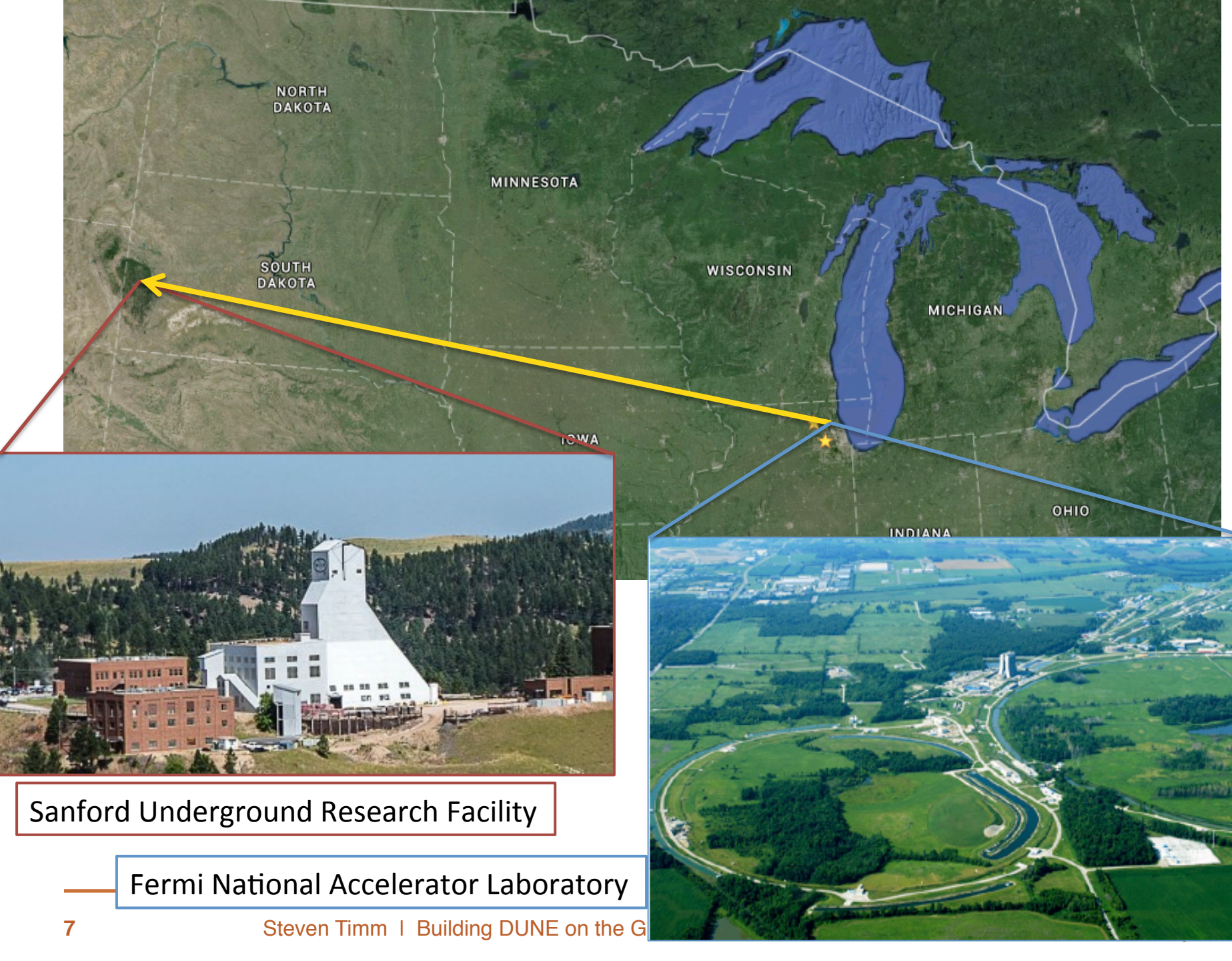


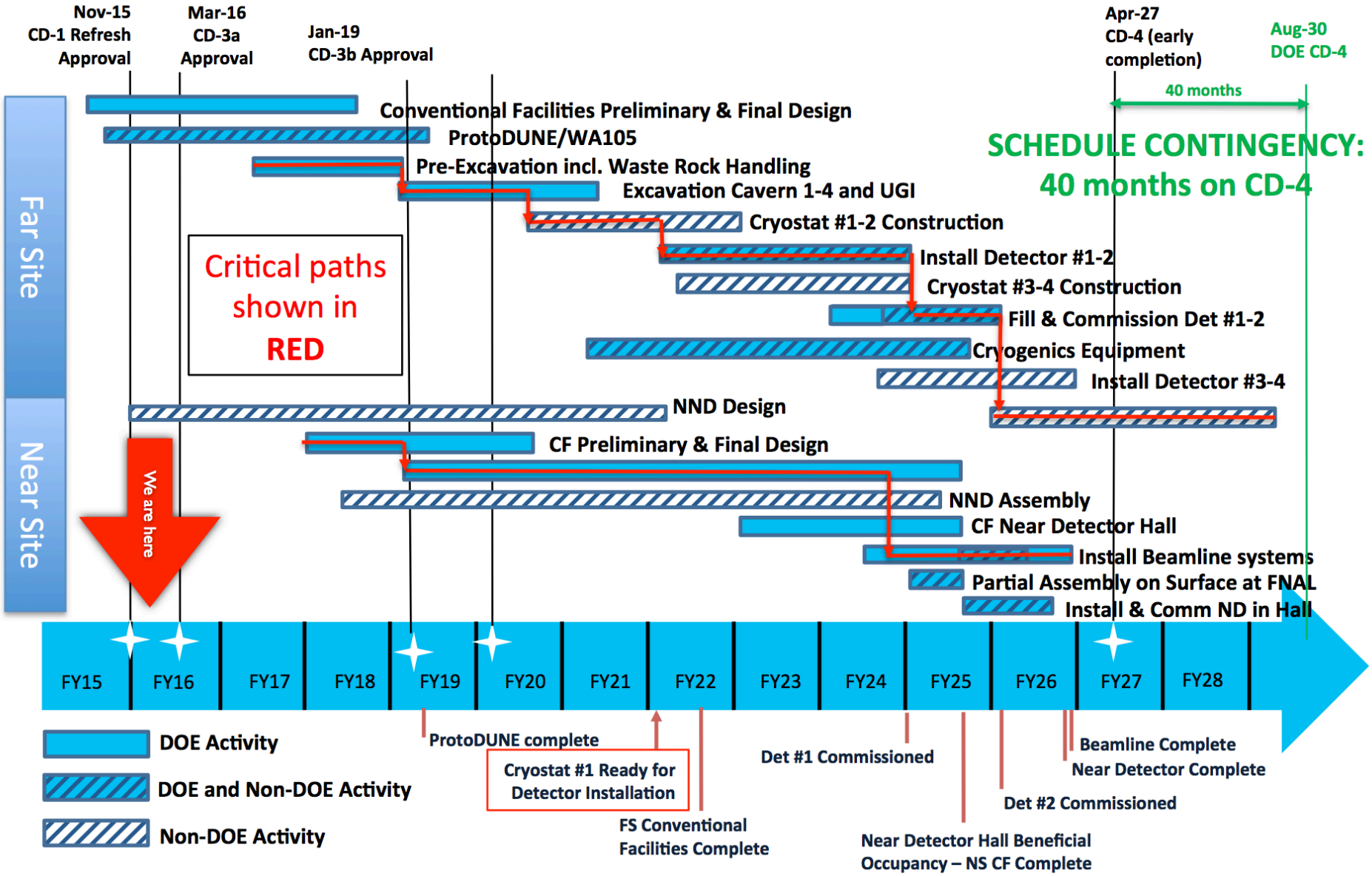


Sanford Underground Research Facility

Fermi National Accelerator Laboratory

DUNE/LBNF schedule

A resource-loaded schedule, practically technically driven.



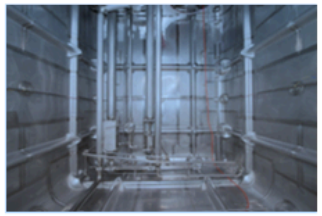
Scientific Goals for FY16 Through FY18

- 35-ton prototype
  - Operations in FY16, finishing in Summer.
  - Analysis proceeds in FY17 and FY18.
  - Multiple NIM/JINST articles on detector characterization. Student Ph.D.'s.
    Signal and background
    Effects of unique DUNE APA geometry
    Electron Lifetime and Diffusion
- Run TWO ProtoDUNE Detectors – single phase and dual phase in CY18
  - Tight schedule driven by LHC Long Shutdown 2 (need accelerators for beam)
  - Detector characterization and response calibration
  - Prep work in FY16 and FY17
- Support CD-2 (~FY19)
  - Detector optimization (including technology downselect e.g. for Near Detector)
  - Deliver Technical Design Report
- Beamline optimization
- Physics Sensitivity Calculations: Beam, Atmos, SNB, NDK, Exotics, ND Physics

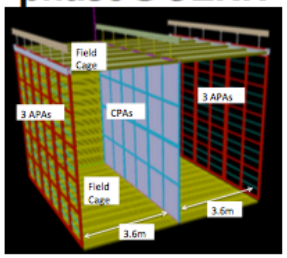
ProtoDUNE detectors

- ProtoDUNE single- and dual-phase 300 tons prototypes to operate in 2018.

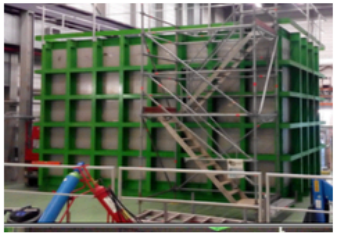
35T @ FNAL



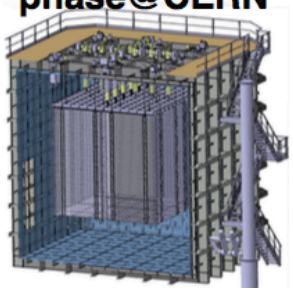
protoDUNE single phase@CERN



WA105 3x1x1@CERN



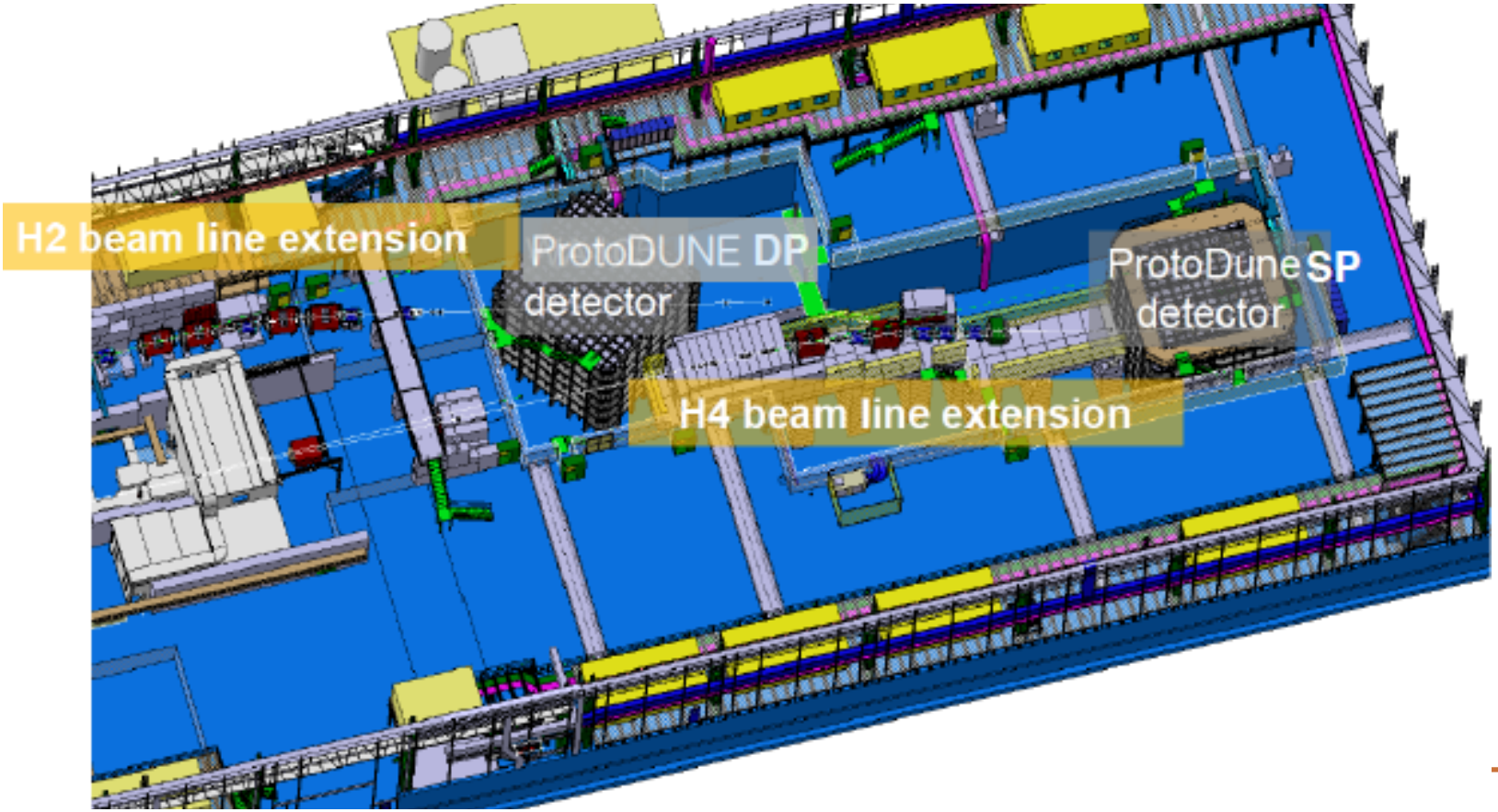
protoDUNE dual phase@CERN



- *Mitigation of risks associated with current detector designs*
- *Establishment of construction facilities required for full-scale production of detector components*
- *Early detection of potential issues with construction methods and detector performance*
- *Provide required calibration of detector response to particle interactions in charged particle test beams*

ProtoDUNE Experimental Layout

Single-Phase and Dual-Phase Detectors with test beams at CERN. Run in 2018.



DUNE Expected Near-Term Computing Resourcs

- From DUNE's recent presentation to Fermilab Scientific Computing Portfolio Management Team

Year	CPU Hr	Disk	Tape	Peak Slots
2016	11M	220TB	1PB	4000
2017	11M	220TB	1PB	4000
2018	24M	230TB	11PB	5000

- In 2016,2017 biggest line item is 35Ton analysis
- In 2018 biggest line item is ProtoDUNE analysis.

Main Computing Activities

- Beamline and target simulation
  - GEANT 4
  - MARS for expected radioactivity
- Detector Simulation

- Physics simulation
  - How do we get the physics effects out.
- Reco/analysis of test data
  - Mainly LArSoft, known to be very thirsty for RAM.
  - 35-Ton prototype running now in cosmics at Fermilab
  - ProtoDUNE coming at CERN 2017/2018
    - Both single-phase and dual-phase liquid argon TPC in test beam (300T)
    - Petabytes of raw data reduce to 1 PB if zero suppression works correctly

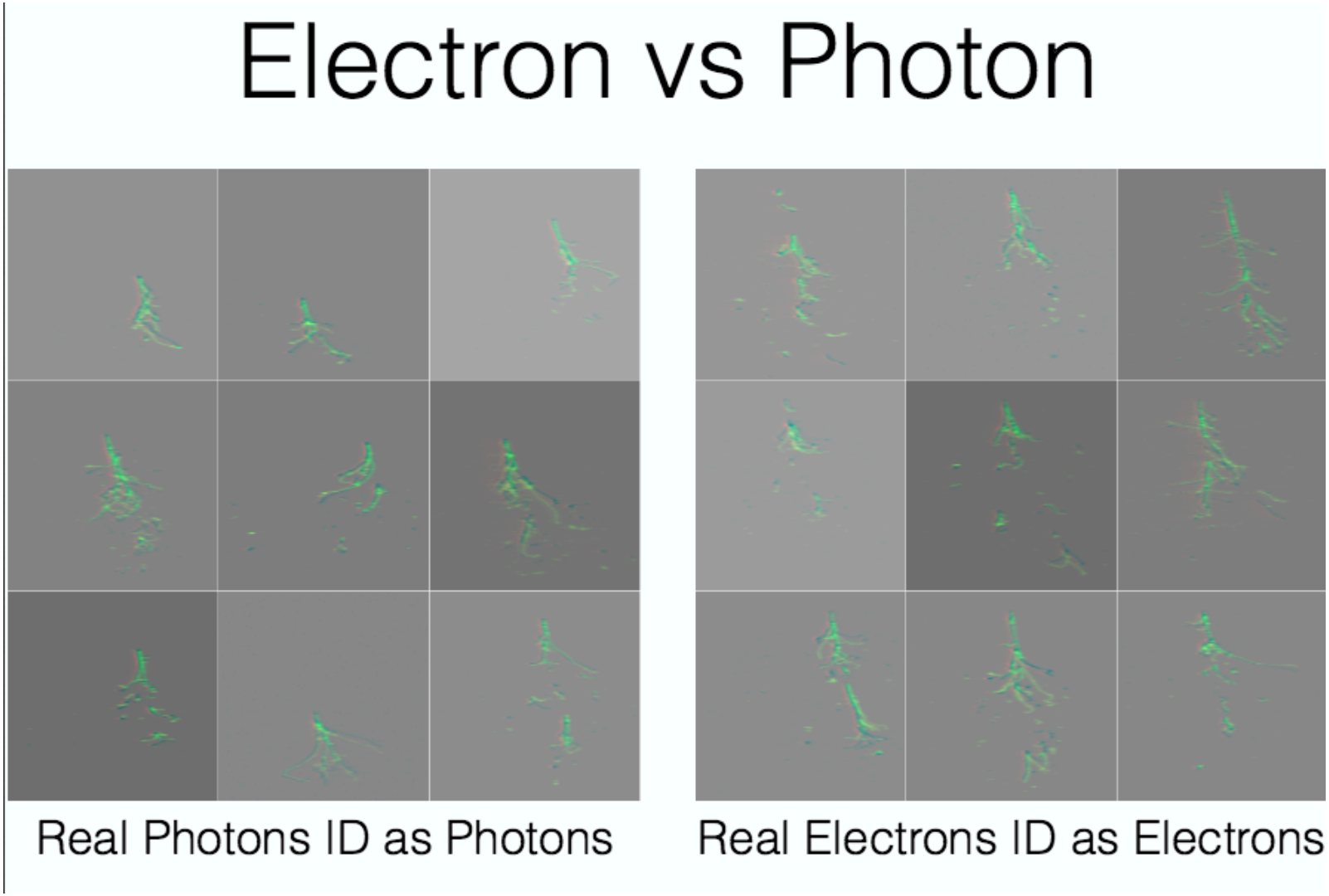
Keys to Current Computing Program at Fermilab

- SAM for data and metadata management
- FTS for file transfer
- dCache/Enstore for Data Storage
- *art* for analysis framework
- *artdaq* for data acquisition
- LArSoft for general Liquid Argon calorimeter reconstruction
- Dunetpc layer above LArSoft for DUNE-specific detector geometry

Plans in preparation for ProtoDUNE @ CERN

- Workflow management system
- Data distribution system
- Network bandwidth—how to get test beam data out of hall to CERN and then to rest of world
- Storage—Tiered system similar to LHC experiments
- DUNE collaborators come from wide range of collaborations in US, Europe, and Asia and all possibilities are on the table.

Deep Learning: Coming soon?



Deep Learning

- From Amir Farbin's Computing Techniques Seminar at Fermilab
  - (DUNE Deputy S+C Coordinator)
- DUNE has requested GPU hardware to build small training Deep Learning system
  - 2 Machines, 8 GPU's each, Infiniband
- Deep learning efforts already in other neutrino experiments, NOvA, LAriaT (photos shown on previous page), MicroBooNe.

Summary

- We have to plan a bit differently for an experiment that will last past the end of the UNIX epoch.
- Nominal start of data taking is 10 years away but thanks to large test data, DUNE has to get computing house in order now.
- Fermilab management is encouraging all Fermilab-based experiments to use the Open Science Grid extensively.
- International nature of collaboration means that DUNE also will run on European grids.
- Thanks to Open Science Grid for the cycles thus far, hopefully many more to come.