Status of ProtoDUNE-II

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for the DUNE collaboration

The Deep Underground Neutrino Experiment

DUNE is a neutrino oscillation experiment being constructed in the United States.

- A beam of neutrinos will be generated at the Fermi National Accelerator Laboratory (FNAL) and directed towards massive detectors.
- The detectors filled with liquid argon, will be situated in a mine 1300 km away at the Sanford Underground Research Facility (SURF) in South Dakota
- Near Detectors (ND) at FNAL will sample the ν beams near the production point
- Two, 770-ton prototypes at CERN, **ProtoDUNE Horizontal Drift (HD)** and **Vertical Drift (VD)**, are testbeds for full-scale DUNE technology.

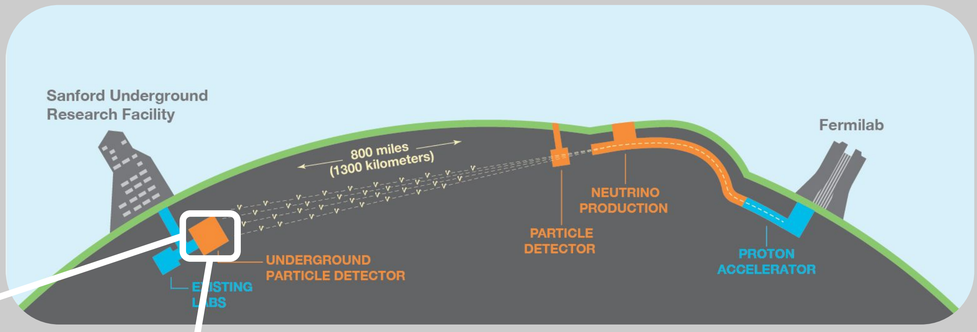


Fig. 1: Illustration of the DUNE experiment

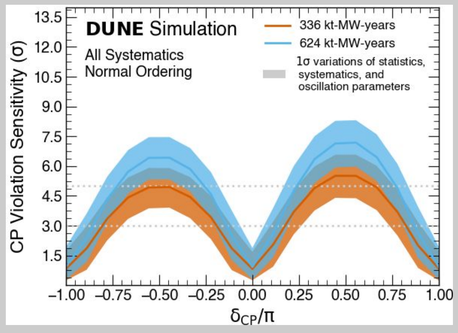


Fig. 2: DUNE CP sensitivity [1]

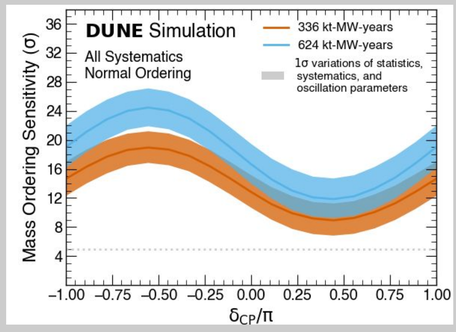


Fig. 3: DUNE mass ordering sensitivity [1]

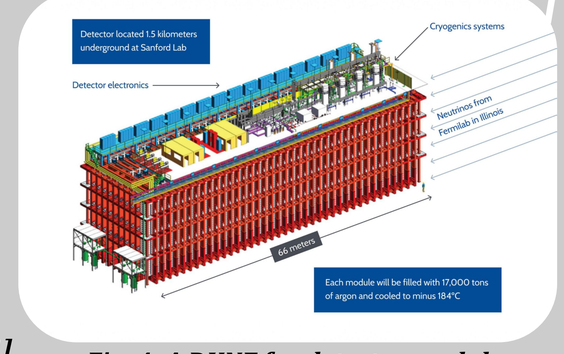


Fig. 4: A DUNE far detector module

DUNE physics program

- Measure δ_{CP} and determine if CP is violated
- Determine the neutrino mass ordering
- Determine the octant of θ_{23}
- Observe supernova burst neutrinos
- Measure solar and atmospheric neutrinos

ProtoDUNE-II at CERN

DUNE prototypes at the CERN neutrino platform

- The CERN Neutrino Platform R&D facility is located in a test-beam hall on CERN's Prévessin site
- It allows the global ν community to develop and prototype the next generation of ν detectors
- First successful operation of large scale DUNE prototypes at CERN Neutrino Platform in 2018
  - Led to improvements in the design, construction and assembly procedures of the liquid Argon TPCs foreseen for DUNE far detector modules.
  - The ProtoDUNE detectors have been updated and will take cosmic and beam data in 2024-2025
    - New calibration techniques including a laser calibration system and a pulsed neutron source
- **ProtoDUNE-HD** is equipped with the Horizontal Drift (HD) design
- **ProtoDUNE-VD** uses Vertical Drift (VD) design, an evolution of the 'Dual-Phase' design.

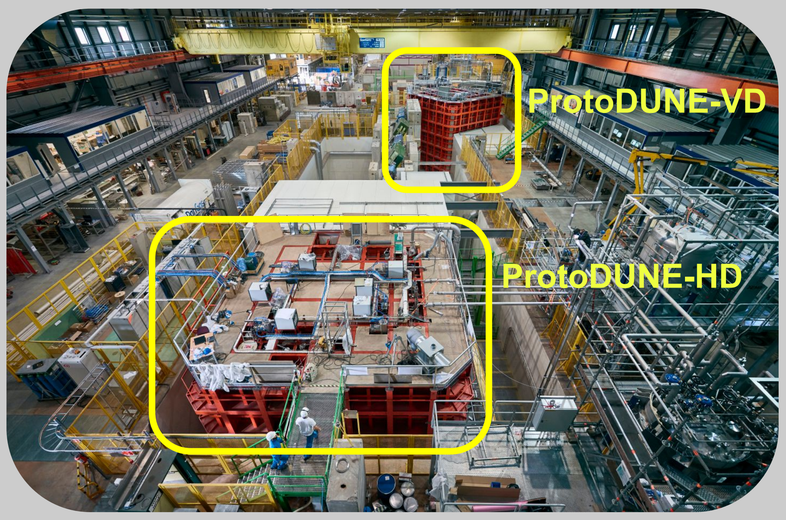


Fig. 5: The CERN neutrino platform

ProtoDUNE-HD

- Two drift volumes, 3.6 m drift distance each
- Completed LAr filling on April 30th 2024, running since May
- Beam turned on for commissioning and calibration on June 19th
  - 7 weeks of beam data in July/August 2024
  - Increase beam data statistics for cross section measurements, particle identification, calibration, reconstruction

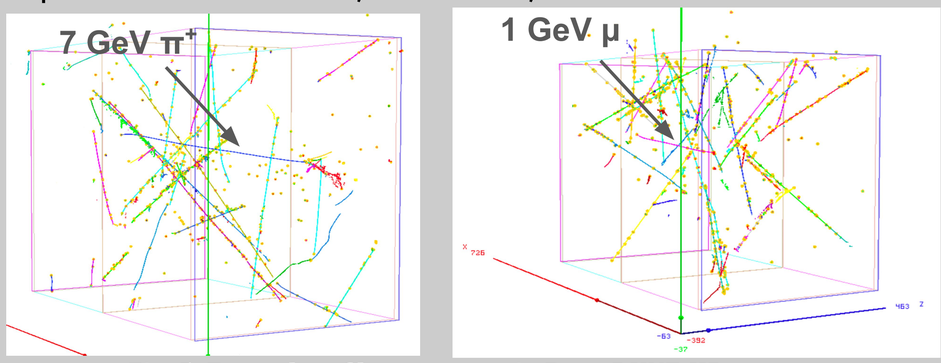


Fig. 5: Examples of beam events in ProtoDUNE-HD

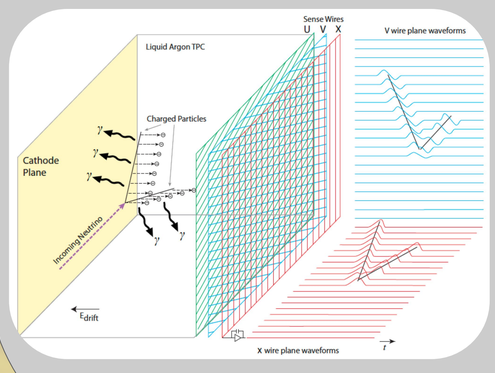


Fig. 6: The DUNE horizontal drift LArTPC technology

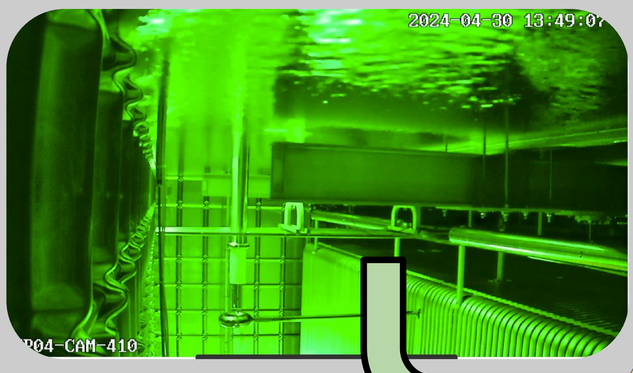
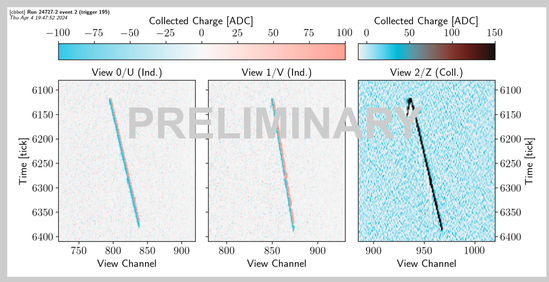


Fig. 7: ProtoDUNE-HD filled with LAr

ProtoDUNE-VD

- Made of four charge readout planes (CRPs): 2 top, 2 bottom and 16 upgraded X-ARAPUCAs : 8 cathode, 8 membrane
- Individual CRPs tested in cold box facility
- Active volume : 6.8 (W) × 3 (L) × 7 (H) m^3
- Transfer of LAr from protoDUNE-HD expected on October 2024
  - → Running starting in early 2025: Cosmics + beam data



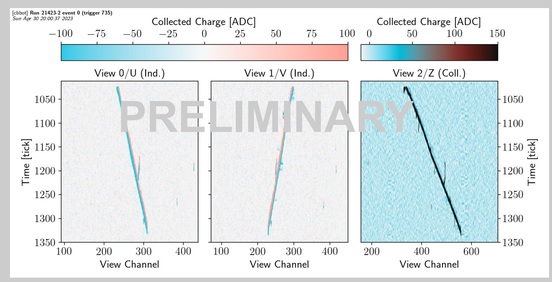


Fig. 8: Reconstructed muon tracks using VD technology in cold box facility

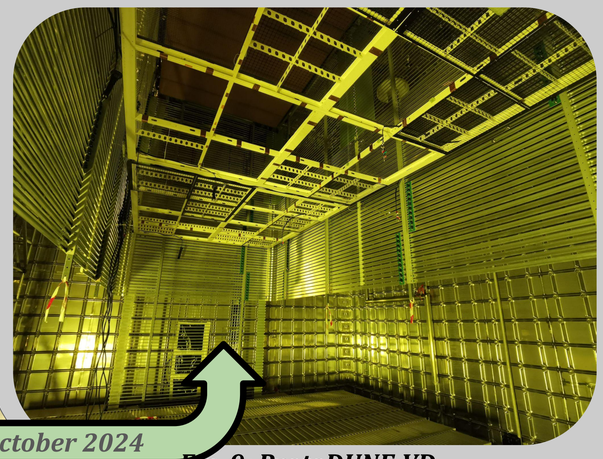


Fig. 9: ProtoDUNE-VD
Photo credit: D. Duchesneau

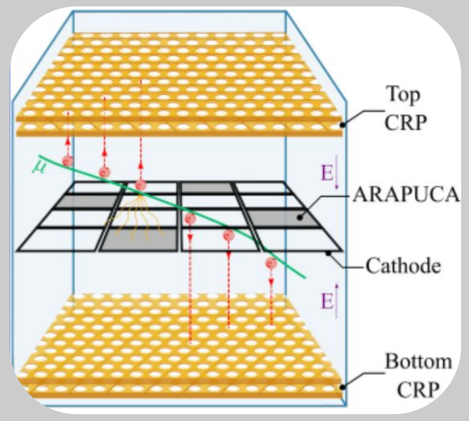


Fig. 10: The DUNE vertical drift LArTPC technology

Liquid Argon transfer on October 2024

Conclusions and perspectives

- Extensive R&D in last years at CERN neutrino platform to test, validate and optimize DUNE far detector technologies
  - Successful deployment and operation of large scale DUNE prototypes
- Implemented design optimizations in prototypes for ProtoDUNE-II
  - Additional beam data for cross section measurements, particle identification, calibration, reconstruction
- ProtoDUNE-HD filled with LAr and taking data since May 2024, ongoing data taking with beam
- LAr will be transferred from ProtoDUNE-HD to ProtoDUNE-VD in October of 2024 for data taking beginning of 2025

[1] Snowmass Neutrino Frontier: DUNE Physics Summary, DUNE Collaboration, FERMILAB-FN-1168-LBNF, Snowmass 2021 [2203.06100]