



Status of DUNE

Jianning Bian for the DUNE collaboration

University of California, Irvine

NNNG REE Baijing

DEEP UNDERGROUND NEUTRINO EXPERIMENT



- New beam at Fermilab (1.2 MW@120 GeV protons, upgradeable to 2.4 MW), 1300 km baseline
- On-Axis 40 kton Liquid Argon Time Projection Chamber (LArTPC) Far Detector at Sanford Underground Research Facility, South Dakota, 1.5 km underground
- Highly-capable near detector at Fermilab
- v_e appearance and v_{μ} disappearance \rightarrow Measure MH, CPV and mixing angles
- Large detector, deep underground \rightarrow Nucleon decay and supernova burst neutrinos

DUNE Collaboration



946 collaborators from 161 institutions in 30 nations



ROBERT RATHBUN WILSON

Long Baseline Neutrino Facility (LBNF)



- 60-120 GeV protons from Fermilab Main Injector
- Wide energy spectrum covers the 1st and 2nd oscillation maxima
- Initial upward pitch, 101 mrad pitch to get to S. Dakota
- Near Detector Hall at edge of Fermilab site
- Initially 1.2 MW, upgradeable to 2.4 MW
- Reference design similar to NuMI, optimized to improve sensitivity to oscillation measurements

The LBNF/DUNE Project

- High-level recommendations
 - US "Snowmass" community study (2012-13) & Particle Physics Project Prioritization Panel (P5) Report (2014)
 - European Strategy for Particle Physics Update (2013)
- Neutrino Protocol signed between DOE and CERN
- Highest priority in Fermilab
- Follows the CERN LHC management model: Collaboration (DUNE) and Facility (LBNF) managed separately
 - LBNF(Long-Baseline Neutrino Facility): Neutrino beamline, Far/Near detector halls and facilities
 - DUNE(Deep Underground Neutrino Experiment): Far/Near detectors, Scientific program

Sanford Underground Research Facility, Lead, S. Dakota



- 4 caverns for detector and one utility hall for DUNE
- DOE has approved to begin excavation for the first two caverns in FY2017 budget (CD-3a)

Blast Vibration Study, March 2016



experiments

Studied the blast energy moves through

the rock and the air in existing spaces

MAJORANA DEMONSTRATOR Electroforming laboratory

Far Detectors: Liquid Argon Time Projection Chamber (LArTPC)



• High resolution 3D track reconstruction

Event display in LArTPC (MicroBooNE MC)

- Charged particle tracks ionize Argon atoms
- Ionized electrons drift to anode wires (~ms) for XY-coordinate
- Electron drift time projected for Z-coordinate
- Argon scintillation light (~ns) detected by photon detectors, providing t_0

Far Detector: Single-Phase LArTPC



- Anode wires immersed in LAr
- Anode and Cathode Plane Assemblies (APA, CPA) suspended from ceiling
- Drift distance: 3.6 m, wire pitch: 5 mm
- Induction wires +-37.7° to collection wires, wrapped around APA
- Photon detectors: light guides+SiPMs, embedded in APAs



Jianming Bian - UCI

Far Detector: Dual-Phase LArTPC

- Electrons extracted from LAr to a gaseous volume
- Signal amplified by LEM in the gas phase
- The charge is collected and recorded on a two-dimensional and segmented anode.
- Drift distance: 12 m (vertical)

Cathode

PMTs

Signal/Noise: 100/1

Anode deck

Field shaping rings

Photon detectors: PMT below cathode



Near Detector

- Constrain systematic error for FD oscillation measurements
- High-precision cross-section/shortbaseline measurements
- Reference design inspired by NOMAD
 - Magnetized straw-tube based tracking
 - Pb-scintillator sampling ECAL
 - RPC-based muon tracker
 - Multiple Targets (incl. Argon)
- Other designs being investigated
 - High-pressure Ar Gas TPC
 - LArTPC
 - Hybrid detector



Neutrino Oscillation at DUNE



- Measure Mass Hierarchy, CP violation and mixing angles with neutrino and anti-neutrino beam
- 1300km baseline: large matter effect to solve MH
- Wide band beam covers 1st and 2nd oscillation maxima

MH & CPV Sensitivity



300 kt-MW-yrs 3.5+3.5 years x 40kt @ 1.07 MW, 80GeV protons

CPV & MH Sensitivity vs. Exposure



14

Proton Decay

- Measurements of proton decay can test baryon number conservation
- GUTs predict proton decay modes and rates
- DUNE FD for proton decay: Large volume, deep underground, superior K reconstruction, sensitive to p→vK



Year



Supernova Neutrino Burst

- High-statistics observation of SNB neutrinos for astrophysics and neutrino physics
- Dominant process in LAr: $v_e^{+40}Ar \rightarrow e^{+40}K^*$, sensitive to neutronization
- Elastic scattering could provide directionality



DUNE Plan and Strategy

- 2018: Start to operate full-scale ProtoDUNE-SP/DP at CERN
- 2019: DUNE Technical Design Report (TDR) ready for funding agencies:
 - 1st 10 kTon FD module engineering design
 - 2nd 10 kTon FD module decision and engineering design
 - ND Engineering design
 - Physics TDR, funding matrix ...
- 2020: Far Detector fabrication facilities ready
- 2021: Start to install 1st FD module
- 2023: Start to install 2st FD module
- 2024: 20kt Far Detector operational
- 2026: Deliver neutrino beam at 1.2 MW

DUNE 35-ton Single-Phase Prototype

- 35-ton membrane cryostat at Fermilab, operated Feb-Mar 2016 ☺
- Achieved required LAr purity without initial evacuation ⁽²⁾
- TPC/Photon detection operated successfully ⁽²⁾
- High noise ⊗





DUNE WA105 Dual-Phase 3x1x1m³ Prototype

- First large scale dual-phase LArTPC
- Assembled in Bldg 182 @ CERN
- Data taking is about to begin
- First results expected by the end of 2016





ProtoDUNEs at the CERN Neutrino Platform



- Single-phase and dual-phase ProtoDUNEs
- CERN Neutrino Platform in construction
- Beneficial occupancy Sept 16
- Cryostats complete April 17

Lange and Lange

 Test-Beam operations in 2018: 0.4-12GeV, e,μ,π,K,p

CERN Neutrino Platform

CERN Accelerating science

Camera NP02



*Images updated every 30 minutes.

Welcome to EHN1-Neutrino Platform Facility

Camera NP04



*Images updated every 30 minutes.

External structures of the cryostats in place!

CENF-Homepage Project Description

Useful Links Contact Us Multimedia

The 5th of September 2016 the new EHN1 extension dedicated to the Neutrino Platform has been handed over from Civil Engineering (SMB) to the final users, in order to start the installation of the detectors and the related infrastructures.

ProtoDUNE-SP

- Single-phase LArTPC prototype
- Full-sized APA-CPA
- Full drift distances (3.6m)
- Comparing 2 photon detector designs
- Plan for operation in 2018
- Test components, construction/installation/ commissioning
- Use H4 beamline to test LAr response to charged particles



ProtoDUNE-DP

- Dual-phase LArTPC prototype
- Size: 6 m x 6m x 6m
- Full-sized readout planes, cathodes, and light collection
- Half of final drift distance (6m)
- Reuse elements and infrastructure from the 3x1x1 prototype
- Use H2 beamline





- DUNE/LBNF project: detailed plan for the 40 kt LArTPC FD, the fine grained ND and the 1.2 MW@120 GeV beam
- Strong scientific program: neutrino oscillation, nucleon decays, supernova neutrino, • cross-sections ...
- DUNE has been established as an international scientific priority: Fermilab
 - DUNE/LBNF is Fermilab's first priority
 - Synergy with the short baseline program (SBN)
 - **US** Government
 - DOE has approved for LBNF construction in FY2017 budget (\$45M-\$55M) CERN
 - Constructing Neutrino Platform and ProtoDUNEs for DUNE at CERN
 - Playing a key role in LBNF and SBN program
- It is an exciting time for neutrino physics and DUNE, welcome to join! Thank you! 24

