Cold electronics preparation for the protoDUNE experiment

Guang Yang, for the DUNE Collaboration

The main purpose of the DUNE experiment is to measure the CP-violation phase in long-baseline neutrino oscillations with a liquid-argon detector of unprecedented size. The DUNE detector will consist of a liquid-argon Time Projection Chamber. The protoDUNE detectors at CERN are prototypes of the full-scale DUNE experiment; their operation will provide important input for the success of DUNE. Cold electronics is one of the most challenging topics for DUNE and protoDUNE. The functionality of the front-end motherboard and warm interface board needs to be understood at a detailed level. In this talk, the integration test plan, as well as results of tests of the protoDUNE cold electronics will be presented.

Design and Fabrication of the ProtoDUNE Dual Phase LArTPC

Animesh Chatterjee, for the DUNE Collaboration

The WA105 protoDUNE Dual Phase Liquid-argon Time Projection Chamber (LArTPC) is a large demonstrator based on the GLACIER design, with a 6x6x6 m3 (appr. 300t) active volume. Dual-phase LArTPCs are one of the far detector technology options foreseen for the Deep Underground Neutrino Experiment (DUNE) at Fermilab. Dual Phase (DP) refers to the extraction of ionization electrons at the interface between liquid and gaseous argon and their amplification and collection in the gas phase. ProtoDUNE will be operating at the CERN neutrino platform test beam facility. It not only serves as the engineering prototype of the FD, but will also demonstrate the concept of a very large dual-phase LAr TPC and calibrate it with charged particle test beam. We will briefly discuss the actual dimension of the design, fabrication, testing, installation and commissioning of the detector components at CERN.

Design of the LBNF Beamline

Jim Hylen, for the DUNE Collaboration

The Long Baseline Neutrino Facility (LBNF) will utilize a beamline located at Fermilab to provide and aim a neutrino beam of sufficient intensity and appropriate energy range toward DUNE detectors, placed deep underground at the Sanford Underground Research Facility (SURF) in South Dakota. The primary proton beam (60-120 GeV) will be extracted from the MI-10 section of Fermilab's Main Injector. Neutrinos are produced after the protons hit a solid target and produce mesons which are subsequently focused by magnetic horns into a 194m long decay pipe where they decay into muons and neutrinos. The parameters of the facility were determined taking into account the physics goals, spacial and radiological constraints and the experience gained by operating the NuMI facility at Fermilab. The Beamline facility is designed for initial operation at a proton-beam power of 1.2 MW, with the capability to support an upgrade to about 2.4 MW. LBNF/DUNE obtained CD-1 approval in November 2015. We discuss here the design status and the associated challenges as well as the R&D and plans for improvements before baselining the facility.

A Flux Spectrometer for LBNF/DUNE

Laura Fields, for the DUNE Collaboration (poster)

The Long-Baseline Neutrino Facility (LBNF) will include a conventional neutrino beam made by colliding a high energy proton beam with a fixed target, focusing the resulting hadron using a set of magnetic horns and allowing them to decay to neutrinos. As with most conventional neutrino beams, uncertainties on the number of neutrinos in the beam as a function of energy are of order 10%. The Flux Spectrometer is a proposal to measure the LBNF hadron flux after the focusing horns and before the decay volume, substantially reducing uncertainties in the neutrino flux. Recent work on the Spectrometer, including potential locations, possible designs and preliminary simulations, will be presented.

Optimization of the LBNF Neutrino Beam

Rowan Zaki, for the DUNE Collaboration

The Long Baseline Neutrino Facility (LBNF) will use high energy protons impinging on a graphite target to produce kaons and pions, which will be focused by a set of magnetized focusing horns and directed into a decay pipe where they will decay, producing an intense neutrino beam. The neutrino energy spectrum can be tuned by changing a variety of parameters in the beamline such as horn and target shapes. Recent advances in computing power coupled with the development of complex optimization algorithms enable identification of parameters that are precisely tuned to optimize physics parameter sensitivity. An optimization of the LBNF beam parameters for sensitivity to CP violation has been performed. The resulting beam design and its physics performance will be discussed, as well as engineering modifications to that design and re-optimization incorporating these engineering constraints. For instance, the horn positions have been revisited and fine tuned, and the amount of material in the downstream target support has been carefully reviewed.

Using the PPFX package for the DUNE Experiment

Amit Bashyal, for the DUNE Collaboration

PPFX for the Deep Underground Neutrino Experiment (DUNE) is a project that aims to improve the prediction of DUNE's flux and the estimation of hadron production uncertainties using hadron production data. Currently, the DUNE flux relies on GEANT4 based physics model which large uncertainties from hadronic interactions in the beamline. We used PPFX, a package developed by the MINERvA experiment at Fermilab to add improved hadronic interaction data to the GEANT4 based flux prediction. We use PPFX to study the predicted flux uncertainties for several candidate beamline designs. In this talk, I will discuss the process of applying the PPFX package to DUNE's flux and the resulting flux uncertainties.

Neutrino energy reconstruction in the DUNE far detector

Nick Grant, for the DUNE Collaboration

A study is made of neutrino energy reconstruction in the DUNE far detector. This detector will consist of four modules of liquid argon time projection chambers (LArTPCs), each with a fiducial mass of 10kt; the study uses simulations of one of these modules. We have developed a method to reconstruct the neutrino energy taking advantage of the excellent spatial and energy resolutions of LArTPCs. For events selected as numu CC interactions, the reconstructed energy is estimated as the sum of the momentum of the longest reconstructed track and the reconstructed hadronic energy. If the longest track is contained in the detector, its momentum is estimated from its range, while its momentum is estimated using multi-Coulomb scattering if it exits the detector. The hadronic energy is estimated using the charges of the reconstructed hits not in the track. This gives an overall energy resolution of 18% for events with contained tracks and 20% for events with exiting tracks. For events selected as nue CC interactions, the reconstructed energy is estimated as the sum of the energy of the reconstructed shower with the highest total hit charge and the reconstructed hadronic energy. The hadronic energy is estimated from the charges of the reconstructed hits not in the shower. The overall energy resolution for these events is 13%. This method can be applied to other neutrino experiments that use the LArTPC technology.

Shower reconstruction performance studies for DUNE Far Detector

Reddy Pratap Gandrajula, for the DUNE Collaboration (poster)

Two of the flagship analyses at the DUNE far detector are to determne the neutrino mass hierarchy and to measure the CP violating phase, using the appearance of electron-neutrino signal events in the far detector. To efficiently select signal events, we require robust shower reconstruction tools to achieve the maximal electron/photon separation. We present a summary of existing shower reconstruction algorithms, and their efficiency and performance by calculating the shower purity and completeness, as well as the dE/dX distributions for electron and photon showers. We also explore possible areas of improvements for the electron shower reconstruction for better electron-neutrino signal reconstruction.

Selection of charged-current muon-neutrino and electron-neutrino interactions in the DUNE far detector

Dominic Brailsford, for the DUNE Collaboration

The Deep Underground Neutrino Experiment (DUNE) is a next generation long-baseline neutrino experiment whose primary physics goals include measurement of the charge-parity violating phase delta(CP) and determination of the neutrino mass ordering. The DUNE experiment's far site will house four 10 kt liquid argon time projection chambers which will measure the event rates of intrinsic muon-neutrino and oscillated electron-neutrino charged-current interactions from Fermilab's long-baseline neutrino facility beam to achieve these goals. This talk describes developments and characterisation of reconstruction-based multi-variate analyses to select such events.

Recent progress on wire-cell tomographic reconstruction for LArTPC

Hanyu Wei, for the DUNE Collaboration

The Deep Underground Neutrino Experiment (DUNE) will use the state-of-the-art massive Liquid Argon Time Projection Chambers (LArTPCs) to search for CP violation in the neutrino sector, proton decay, and supernova neutrinos. The 3D reconstruction of the particle trajectories in LArTPCs relies on multiple wire planes, which can be challenging due to the intrinsic ambiguity of identifying where along the wire the charge is deposited. In this talk, we present a novel 3D reconstruction method “Wire-Cell” inspired by the concept of tomography. Based on the independent measurements of the same charge from the three planes of wires, the 3D images of ionization charge can be efficiently reconstructed following the principle of compressed sensing utilizing mathematical techniques such as the L1 regularization. Current status and future prospects of the development will be reported.

Effects of Magnetic Horn Geometry Uncertainty on Neutrino Flux at DUNE

Eric Amador, for the DUNE Collaboration (Poster)

The goals of the Deep Underground Neutrino Experiment (DUNE) at Fermi Lab, is to precisely measure neutrino and antineutrino oscillation properties to determine if charge-parity (CP) symmetry is violated in the lepton sector, thus providing a possible explanation for the matter-antimatter asymmetry in the universe, and to measure the neutrino mass ordering. To maximize the neutrino flux in the desired energy range, the secondary charged mesons produced in the interactions of an intense proton beam with a target are focused using the magnetic field created by a set of horns. To ensure an accurate understanding of the beam line and the neutrino flux, it is essential o study uncertainties stemming from the geometry to these horns. In this study, two geometric parameters are considered, (i) the eccentricity and (ii) the ellipticity of the inner conductors. The effects of eccentricity and ellipticity of the inner conductor to the resulting neutrino flux are presented.