

Hugh Montgomery, Chair
Long Baseline Neutrino Committee,
Steven Nahn, Chair
Neutrino Cost Group
October 14, 2019

Dr Nigel Lockyer, Director,
Fermi National Accelerator Laboratory,
Kirk Rd. & Pine St.,
Batavia, IL 60510

Dear Dr Lockyer,

We write to you in response to your request for an assessment of the status of the Deep Underground Neutrino Experiment (DUNE), which is being prepared, by an international collaboration, for operation at the Long Baseline Neutrino Facility. We address the status of the physics case and technical preparation, the health of the collaboration, and the development of the matrices of responsibility.

Slightly more than one year ago, the collaboration completed its Interim Design Report, a multivolume description of the goals and approaches to the development of the experiment. At the same time, they completed the installation of equipment for the NP04 “single phase” tests at the Neutrino Platform at CERN. During the course of the year which has passed, an extensive program of exploration has been completed with NP04, and installation of “dual phase” equipment in NP02 has been completed; testing has begun. Concurrently, approximately 2000 pages of Technical Design Report material have been delivered to and reviewed by the Long Baseline Neutrino Committee (LBNC). In addition responsibility matrices have been developed for the Far Detector Modules. We discuss these items in turn below.

Between August and December 2018 the NP04, ProtoDUNE SP detector was filled with LAr, purified, and full high voltage applied to the electrodes. The design high voltage was established. With the excellent purity obtained, electron lifetimes several times in excess of the baseline goal were measured. Data taken both with cosmic rays and with beams of different particle species and energies have been analyzed. The performance of the detector in terms of calorimetry, and in terms of particle identification, have been spectacularly demonstrated. The collaboration is now close to defining all of the operation parameters for the DUNE Single Phase detector. Some detailed improvements to the design will be made and the final construction designs demonstrated in a future ProtoDUNE experimental run. The Dual Phase equipment installation in NP02, ProtoDUNE DP has occupied much of 2019. Within the past couple of months, filling with LAr was successfully completed, and exploration of the characteristics of the installed equipment is underway.

DUNE will comprise four 17 kilotonne Far Detector Modules installed a mile underground at the Sanford Laboratory in South Dakota and a Near Detector complex at Fermilab. Two of the initial three Far Detector modules will be Single Phase and the third is intended to have a Dual Phase design. During the course of 2019, DUNE has completed four Technical Design Reports comprising an Executive Summary volume, a Physics volume, a Far Detector Single Phase volume and a Technical Coordination volume. Included in the Executive Summary volume is a discussion of a Near Detector complex, and the Computing plan. These are precursors of Conceptual Design and Technical Design Reports for those components, which will follow. In the report from its July/August meeting the LBNC wrote *“The delivery of draft chapters and volumes of the Technical Design Report to the LBNC for review has been impressive for most of the content, with little slippage in schedules. The DUNE TDR preparation team and the Collaboration as a whole are congratulated on this excellent progress. All of the Physics, Single Phase Far Detector, Near Detector and Computing parts are in good shape and converging.”*, and concluded *“The LBNC anticipates recommending for approval the Executive Summary TDR Volume, The Physics Volume, the Far Detector Single Phase Volume and the Technical Coordination Volume.”* These documents cover the scope included in the early 2019 baseline review of the DOE LBNE/US DUNE Project. The LBNC completed its reviews in mid-September 2019 and awaits the final versions before formally recommending that the Director approve these documents. Work has started on the TDR for the Far Detector Dual Phase design. In this case, precedence has, appropriately, been given to ProtoDUNE DP to demonstrate the viability of the technology before completion of the documents.

The DUNE Collaboration comprises 1031 members, from 184 institutions in 31 countries in addition to CERN. Over the course of the past two years, DUNE has demonstrated its strength by:

- Delivering the suite of Intermediate Design Reports,
- Delivering and operating the equipment, which has provided for the enormous success of the ProtoDUNE program at CERN. To date, this program has demonstrated that the Single Phase technology represents a technology baseline for the whole experiment. Further, the Dual Phase work is seeking to provide a flexible alternative. The single phase successes, in terms, for example, of LAr purity and electronic noise levels, open several possibilities for the fourth “opportunity” Far Detector module.
- Delivering the suite of Technical Design Reports, which
 - demonstrate the readiness for a baseline approval for the Single Phase modules,
 - demonstrate a physics performance based on fully developed simulation and analysis, and
 - provide a demonstration that the systematic uncertainties necessary for the ultimate precision are achievable with an appropriate Near Detector complex, and
 - describe the activities of the Computing consortium which has provided for the short term ProtoDUNE computing needs using international computing resources and has developed an organizational framework that

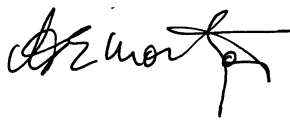
is establishing itself within the international computing field usually associated with the LHC collider experiments.

- Conducting a number of workshops to develop a supportable strategy for the Near Detector through a series of workshops. These have demonstrated a strong international desire to participate in this initiative and already work with the Liquid Argon Cube in Switzerland is active, and the possible use of the KLOE magnet from Italy is being explored.

The development of the resource responsibility matrix is led by the DUNE Resource Coordinator and DUNE has created a Finance Board from across the collaboration to assist in this work. The Technical Coordinator, Project Integration Director, and Resource Coordinator take the lead in the development of the multi-institutional Memorandum of Understanding, which is currently in the hands of the DOE. Primary oversight and scrutiny is provided by the Neutrino Cost Group. However, at its request a presentation describing the process was given to the LBNC, which then wrote in its report *"The LBNC judges that this process is well-organized, rigorous and effective."* With the completion of the LBNC review of the TDRs validating the design and science case, the NCG is initiating the detailed scrutiny of cost, schedule, and risk aspects, focusing on the two Single Phase modules. This is expected to conclude by the April RRB. The NCG has examined the resource matrices in some detail, particularly for the two Single Phase modules, for which 80% of the resources are committed or identified. There are also active prospects for most of the further 20%. The situation for the anticipated dual phase module has been started but is less well advanced. This reflects the fact that the technology is less mature and the ProtoDUNE DP operations are just beginning. For the Near Detector, the description provided in the Executive Summary volume of the TDR is the first validated design. DUNE is now developing Conceptual and Technical designs, which will benefit from active proposals to contribute as discussed in the above-mentioned series of workshops.

Over the course of the past two years, the advances made by the DUNE Collaboration have been impressive. They are appropriately oriented towards the establishment of rigorous and supportable designs from the physics through to the technical coordination. They understand the baseline requirements for both the Far and Near Detectors. They have largely established the resources for the first two Far Detector modules, have prospects for a third, and enthusiastic interest in the Near Detector. This represents convergence on a timescale appropriate to match the LBNF/US DUNE and PIP II project schedules.

Yours Sincerely,



Hugh Montgomery



Steven Nahn