DUNE Project
Monthly Status Report
July 2018

DEEP UNDERGROUND
NEUTRINO EXPERIMENT

Cold Box test of ProtoDUNE-DP CRP#1

Version 3: September 14, 2018

Final ProtoDUNE-SP instrumentation was installed and checked out at the beginning of the month. Additional cryogenics trainings were added for access to EHN1 as preparations for filling advance. A short between building and detector ground that first appeared during welding of the cryogenic piping was traced to an insulating pipe support that conducts under compression. Purging of the cryostat started at the end of the month, with gaseous argon at the 20ppm level (quite good). Purity monitors successfully checked out; DAQ studies ongoing; photon tests ongoing; temperature sensors and cameras tested; cold electronics noise tests continuing; beam plug under vacuum. ProtoDUNE-SP commissioning plans continue to develop. ProtoDUNE-SP shift signup has been implemented, with several groups signed up. Shift training is being developed.

ProtoDUNE-DP CRP#1 was tested in the cold box. Extensive analysis of the CRP was conducted during a quick “cold removal”. A second cold test of CRP#1 is being setup for early next month. LEM and anode production for CRP#2 is well underway. A paper on the 3x1x1 was submitted to JINST.

Extensive discussions between Technical Coordination and consortia were held this month, with internal review planned for early August leading to the submission of the initial cost book information to the Neutrino Cost Group in mid-August. The NCG will evaluate this for the RRB meeting in September.

Consortia are updating interface documents, WBS, risks and schedules. We received the report from the 22–24 May LBNC review. A proposed set of high level detector related requirements was provided to the Executive Board on 19 July. The Interim Design Report was published to arXiv on 26 July (1807.10334 Strategy, 1807.10327 Single Phase, 1807.10340 Dual Phase). Extensive preparations were involved for the August LBNC review.

A cold electronics workshop was held 16–18 July at BNL. A DAQ workshop was held 19–21 July at BNL. The next LBNC review is 1–3 August. A Data Selection workshop is scheduled 13–14 August at Penn. An LBNF and DUNE far site integration meeting is scheduled for 22–24 August at CERN. A review of the DUNE-SP DSS is planned for 20–21 August at CERN. Other reviews are being prepared in advance of the TDR.

ProtoDUNE

EHN1 — F. Resnati

NP02 (ProtoDUNE-DP)

CRP

- Modification of the grid wire tensioning of the CRP#1.

Cold Box

- Completion of the first cryogenic test of the CRP#1.
- Started the second cold box test of the CRP#1.

Field cage

- Completion of the HV tests.
- Field cage set in its final position (Two sub-modules not installed to allow installation of the rest of the detector components).

PMTs

- 30% of the TPB coating of the PMT is completed

NP04 (ProtoDUNE-SP)

Cryostat

- Building and detector ground separation established.
- Completion of the installation of the stress sensors on the cryostat.
- Successful pressure tests of the cryostat.

CRT

- Commissioning of the downstream modules completed 100%.
- Cabling and commissioning of the upstream modules mostly finished.

Cryo

- Cryogenic installation and commissioning completed.
- Formal approval of the ‘Cryogenic Permit’.
- Completion of the purging of the cryostat.
- Start regeneration of the purification cartridge.

Beam

- Testing of the magnets ongoing (voltage/current and cooling).
- Fine-tuning of the alignment of the magnets.
- Installation of the beam pipe and beam instrumentation support inside the NP04 clean room.

DUNE

Far Detector Consortia

Single Phase Anode Plane Assembly

No report available.

Single Phase TPC Cold Electronics

The highlight of the SP TPC Electronics Consortium activities in July was a two and one-half day workshop held at Brookhaven. The goal of the workshop was to review the status of ASIC designs underway, to consider lessons learned from preparations for ProtoDUNE and to solidify planning for the work to be done in the next two years. Based on ProtoDUNE experience, we expect to qualify every ASIC used in DUNE cold electronics with tests at liquid nitrogen temperature. Initial discussions were held on how this should be done.

Single Phase Photon Detector

During July the SPPD Consortium continued working on development of the requirements through a close interaction between the Physics and Simulations WG and the Physics group involved in Supernova neutrino detection.

Important progress has been made on active ganging of SiPMs. The group led by Gustavo Cancelo demonstrated that it is possible to actively gang up to 72 Hamamatsu SiPM while preserving detection of single photon pulses. The baseline design foresees active ganging of 48.

A working group has been formed to study doping LAr with Xe to shift the scintillation emission wavelength to 174 nm and significantly increase the Rayleigh scattering length. This would improve uniformity of light collection inside the active volume.

Dual Phase Charge Readout Plane

CRP activities in July focused on cold box tests in CERN building 182. These allow high voltage and mechanical behaviour checks in cold operating conditions.

CRP#1 assembly and instrumentation was completed in June before installation in the cold box. Figure 1 shows the sequence of CRP insertion steps from its garage position where it is attached to the cold box roof up to the closure of the cold box before the first test in July.

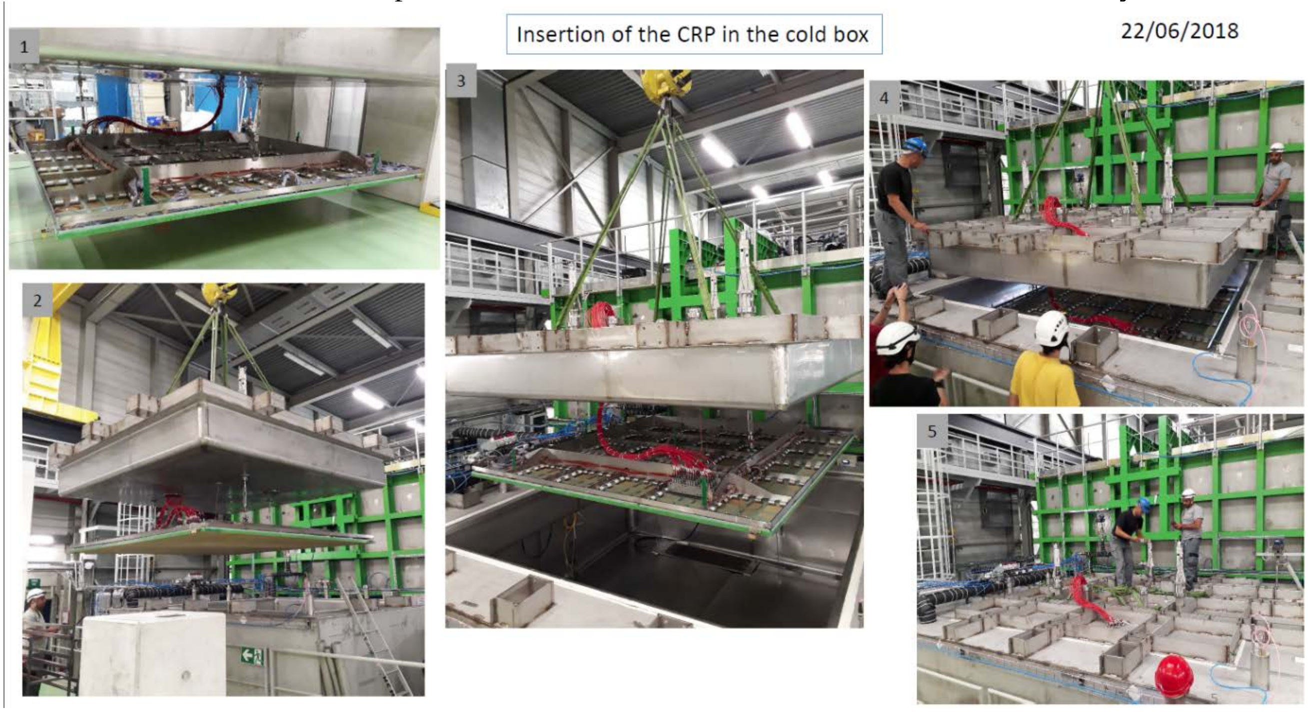

***Figure 1:** CRP insertion steps into the cold box.*

Test results showed good behaviour of LEM high voltage, allowing stable operations up to a LEM voltage of ~32 kV/cm. However, it was difficult to maintain high voltage on the grid and contact was measured between some LEMs and the grid. After extracting the CRP from the cold box, modifications to the grid and its HV connection have been implemented.

Dual Phase TPC Cold Electronics

No report available.

Dual Phase Photon Detector

The main activities of the Dual Phase Photon Detection System (DPPD) consortium in July focused on development of initial system cost estimates and optical simulations. The initial cost estimates are based on the cost of the ProtoDUNE-DP photon detection system.

July has been a month of rapid progress for DPPD optical simulations. A new photon library for fast optical simulations created in LArSoft for a ProtoDUNE-DP geometry has been compared for the first time with the reference photon library created with the LightSim code. The agreement in photon visibility between the two libraries is satisfactory for most (LAr voxel, PMT) combinations, typically within a factor of 2. Hybrid libraries have also been created in LArSoft to reduce the very large memory usage of standard photon libraries. Code development for simulation of S2 light in gaseous argon has been completed and validated as planned. Simulation of PMT response has greatly advanced, starting from existing implementation used for the single-phase photon detectors. PMT response simulation includes pulse shaping from 3x1x1 experimental data, as well as realistic dark count rates and electronics noise.

HV

Purging and cool-down of ProtoDUNE-SP took place in July. During this critical period, the HV system was continuously monitored. The Heinzinger PS was replaced by a Wiener MPOD channels for better monitoring the current in the FC. Up to 1.2kV was applied on the CPA. At 1kV an estimated current of 7nA is expected at room temperature (the total resistance of the field cage is ~1.39GΩ). Both the voltage and the total current in the FC resistive boards were recorded by DCS slow control monitoring system.

During cool down, the FC current was observed to decrease as expected (the resistors mounted on the resistive boards are known the increase their value by ~8% when the temperature is decreased from ambient to LAr). The current behavior can be followed at the NP04 slow control web site: https://np04-slow-control.web.cern.ch/np04-slow-control/app/#!/comissioning. The ground plane monitoring system has been tested and fully integrated into DCS slow control.

The ProtoDUNE DP NP02 Field Cage was raised to nominal position with dedicated winches and was connected to the final suspension wires. The two bottom FC panels in front of the TCO were removed for future insertion and installation of the CRP modules. The HV was ramped to 150kV at the new FC position; results are compatible with previous tests. The cathode and ground plane designs were finalized and all stainless-steel components and assembly jig were produced. Welding of the cathode structure started.

Additional HVS consortium activities were devoted to completion of the Preliminary Cost Estimate for both the SP and DP far detectors. Basis of Estimate documents, prepared by the main sub-systems were reviewed and perfected down to the design level presented in the WBS spread-sheet: R&D/design optimization, CPA, FC top/bottom, EndWalls, HVS distribution, shipping/integration/installation. Detailed studies on Packaging, Shipping to ITF, Transport underground and Installation have progressed significantly and have been discussed within the consortium. Design optimization of the SP CPA/FC and related R&D activities have started. This includes:

- ground plane decoupling
- possible use on bent profiles for the corned FC panels
- possible replacement insulating PE with resistive plastic as material of the endcaps
- possible use of higher resistivity Kapton foils
- Design of the Cathode/FieldCage of the DP detector scaling for ProtoDUNE has started.
- R&D on the 750-kV power supply with Heinzinger will restart in September.

DAQ

During July the DAQ project advanced on several fronts, in parallel with ongoing work on ProtoDUNE-SP DAQ in anticipation of first beam. A revised WBS for the construction project for the first two modules has now been put in place, with full resource loading in preparation for the September RRB meeting. A clear picture of the scope and scale of the project is now in place.

In preparation for the LBNC, we conducted an internal review of data volume and trigger rate estimates, taking into account the FD calibration strategy. This review indicated that our assumption of <30PB/year of raw data is still an upper bound, but that some work may be needed to define our onsite data processing needs for calibration.

A workshop was held at Brookhaven to discuss the use of the FELIX readout system in the final DAQ design and the interfaces between FELIX and the upstream processing elements for TPC data. A range of design possibilities were identified, which will be explored further in preparation for the TDR.

Finally, work progresses on prototype hardware, firmware and software components for the pre-TDR DAQ demonstrator. As first data from ProtoDUNE-SP begins to arrive, we will be ready to compare performance of data selection and compression algorithms against estimates from simulation. Towards the end of the year, we hope to use ProtoDUNE data to test realistic firmware and software implementations of these steps, validating the technology prior to finalizing the TDR.

A new institute, Imperial College London, has joined the DAQ team; there remain many interesting and open tasks for future new collaborators.

Cryogenic Instrumentation and Slow Controls

Cost estimating for the upcoming RRB meeting has been the main focus in July. Individual cost estimates for each system (including basis of estimates or BOEs) have been produced and integrated into the SP and DP WBS. The cost estimates are going through internal review by technical coordination before submission to the NCG in mid-August. Meanwhile, consortium working groups have been optimizing activities to meet the goals for the TDR.

Following the LBNC meeting early August, the consortium will work with ProtoDUNE cryogenic instrumentation group to develop a plan for validating the fluid flow model using ProtoDUNE data. A dedicated meeting is scheduled for 15 August to discuss this. A document is under preparation summarizing the plans and will be submitted to the LBNC soon. The temperature sensors in ProtoDUNE-SP are reading out temperatures nicely as can be seen through the web-based slow controls interface (np04-slow-control-web.cern.ch).

Near Detector — K.-B. Luk

Coordinators and physics conveners completed revision of the report and recommendations for the DUNE Near Detector based on comments and suggestions received. A summary of changes was presented to the Concept Study group before the final report (along with dissents on recommendations) were submitted to the EB for decision. The EB appointed two members to review the recommendations. Towards the end of July, the EB discussed the recommendations and generally accepted all of them. However, they want to revise a couple before making a decision.

Mike Wilking (Stony Brook) continued discussion with technical support of the Fermilab Neutrino Division on requirements and impacts for implementing the PRISM concept.

Based on the outcome of the first EB meeting addressing the recommendations, the DUNE Near Detector Concept Study has accomplished its mission. The Concept Study group will be dissolved in the near future. Although there is a concept in place, there are many questions remaining to be addressed. There is a need to understand interaction between the high-pressure gaseous TPC (HPgTPC) and 3D scintillator tracker (3DST). The presence of the 3DST will reduce the active volume of the HPgTPC. The geometry of the proposed new magnet has not been specified. The relative merits of a warm magnet versus a superconducting one need to be spelled out. The design of the electromagnetic calorimeter and the muon detector coupled to the HPgTPC is still open. The pros and cons of using side muon detectors versus a wider liquid argon TPC for catching the large-angle muons needs further studies. Clearly, this list is just the tip of an iceberg.

Technical Coordination — E. James

Progress continues to define DUNE cost, schedule, interfaces, deliverables and risks. A cost book was assembled for the Neutrino Cost Group and will be reviewed internally before delivery in mid-August. The RRB meeting is 13 September. LBNC review will be 1–3 August. A Detector Support System conceptual design review (30% design) will be held at CERN 20–21 August. Planning is underway for conceptual design reviews of the photon system and the DAQ.

Installation

Effort in July focused on collecting cost information for the Neutrino Cost Group review in August. Where possible quotes were solicited for material and the installation group worked with consortia to understand the necessary labor effort and possible schedule.

The design of the DSS progressed in preparation for a 20 August design review. Drawings were produced and technical design note revised.

Following the integration workshop at the collaboration meeting the design of the ITF building was revised. All truck access was moved to the east end of the building and the footprint was expanded to 50,000 sq. ft. This footprint fits on the lot available at a possible site near the South Dakota School of Mines and Technology. The number of workstations was reduced from 4 to 3 to match consortia needs. Finally, the configuration was revised to consider the decision not to have an overhead crane. The revised plan view is shown in Fig 2.

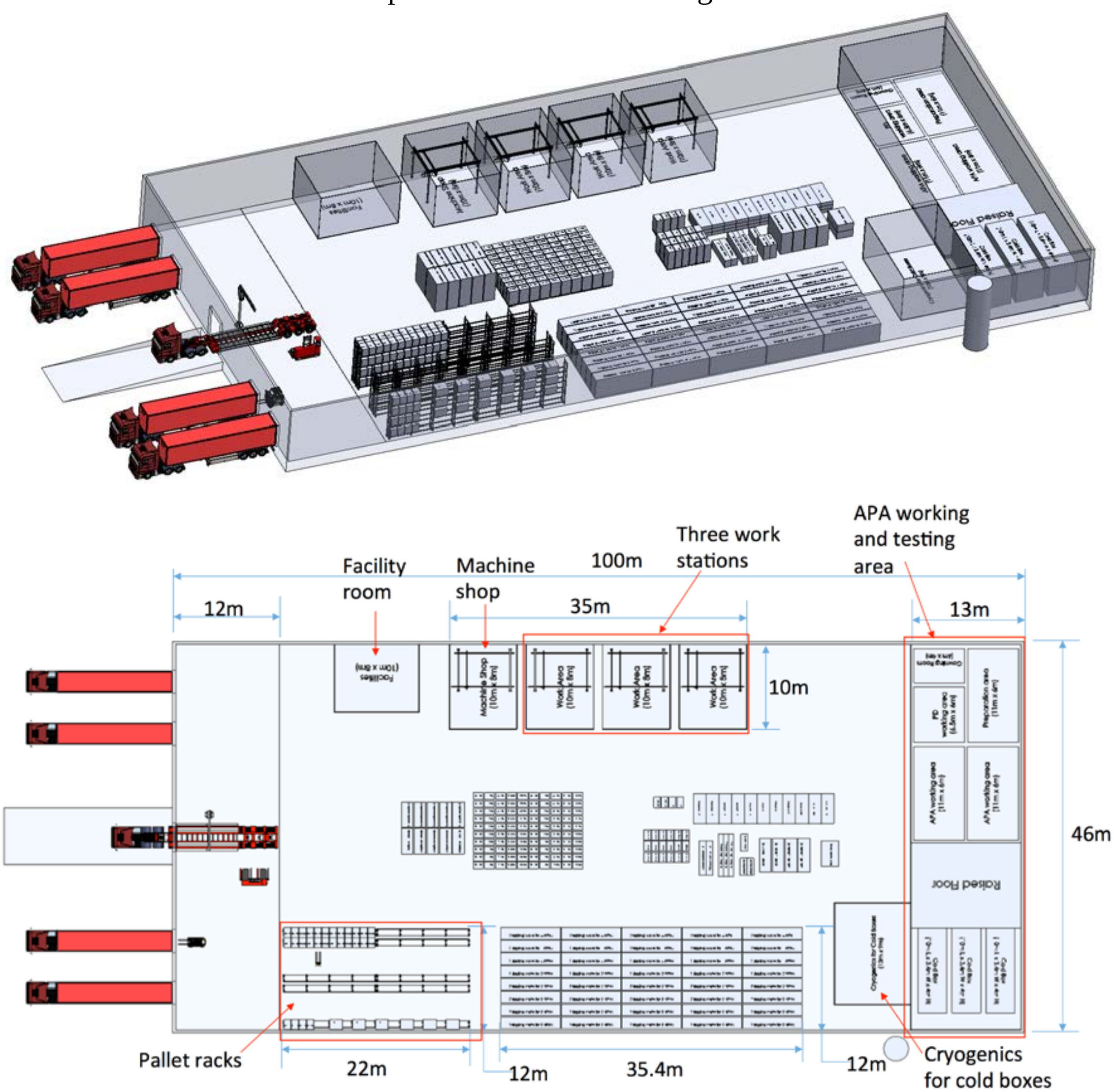

Figure 2: *Top panel —isometric view of the ITF building. Bottom Panel —plan view of the revised building layout.*

The collaboration meeting brought together CERN engineers and the Minnesota installation team to develop an initial conceptual design of the equipment at Ash River for prototyping the installation process. By re-using steel from the ProtoDUNE-SP installation testing a first setup to test APA cabling looks fairly simple. A more involved test setup that allows full prototyping of the installation was also sketched. The general layout is shown in Figure 3.

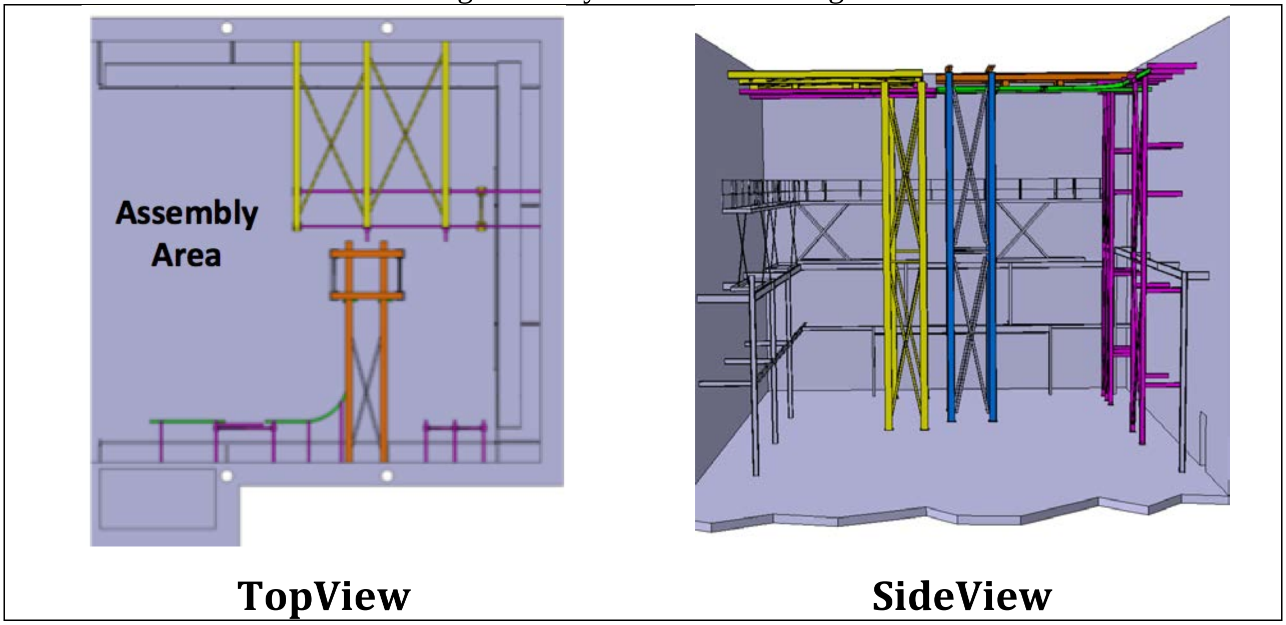

Figure 3: *Conceptual layout for full scale DUNE installation prototyping at Ash River.*