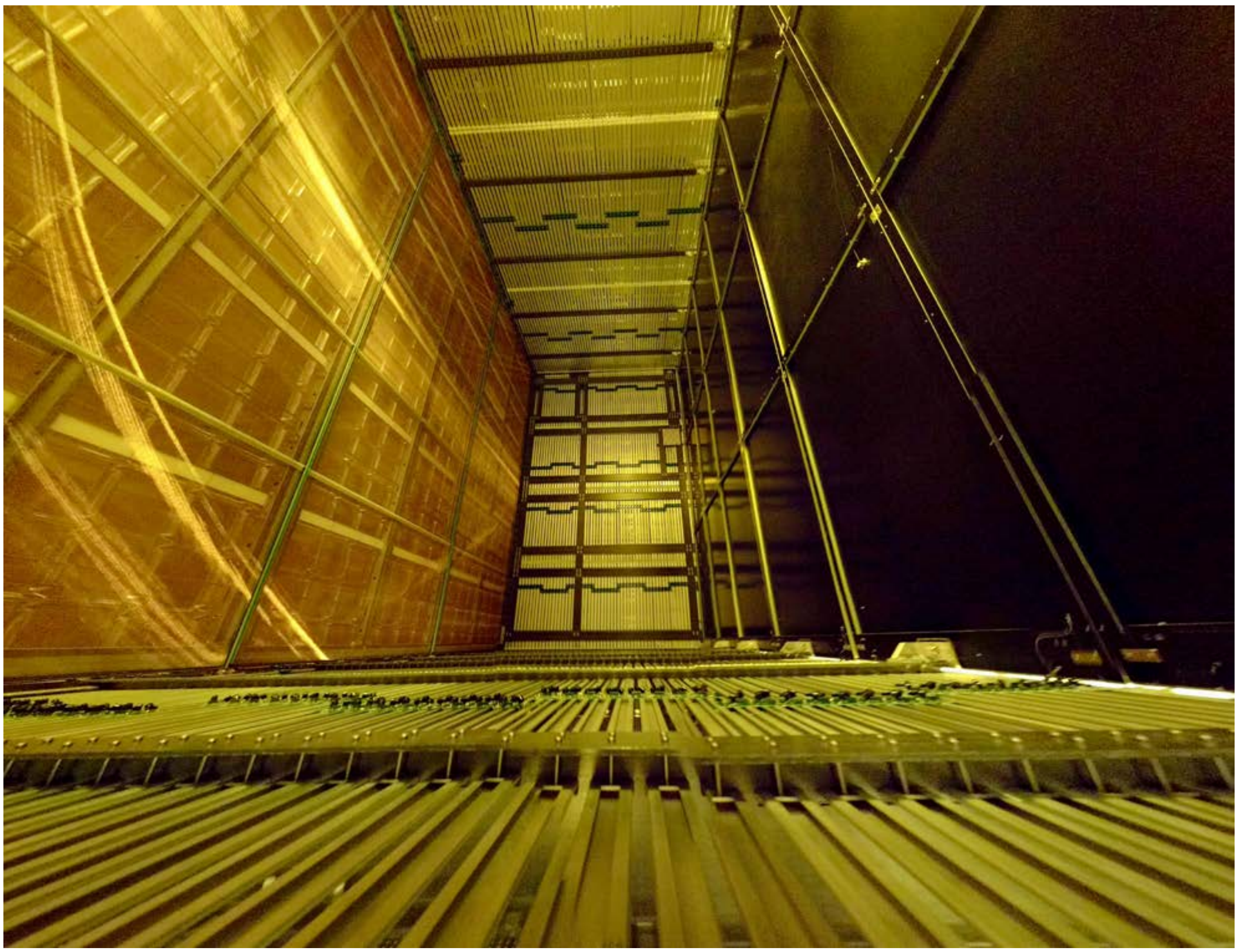
DUNE Project
Monthly Status Report
March 2018



ProtoDUNE-SP Saleve-side drift volume complete

Version 4: May 2, 2018

The beam-right or Saleve side of the ProtoDUNE-SP drift volume was completed; this represents more than half of the TPC and includes the beam plug. Warm and cold tests of APA#4 (US APA#3) were completed and it was moved into the cryostat. APA#5 (UK APA#2) arrived at CERN and was moved into the clean room. APA#6 (US APA#4) is expected to arrive on 6 April. APA#1–3 cabling on top of the cryostat continues. DAQ readout tests continue. The LAr cryogenic system, cryogenic instrumentation, muon tagger (CRT), beamline elements and beam instrumentation are being installed this spring in preparation for beam at the end of August.

The ProtoDUNE-DP technical coordination group continues. The ProtoDUNE-DP field cage is nearly complete inside the cryostat. The cold box for CRP testing was installed in Building 182. LEM production should be complete for CRP#1 in April and CRP#2 in June. Invar frames and anodes have been delivered to CERN. Installation of the two CRPs is expected this summer, followed by two frames (fake CRPs), with the ProtoDUNE-DP detector ready by October. A draft of the 3×1×1 paper has been distributed.

The DUNE far detector consortia have focused on WBS improvements and initial construction schedules in preparation for the RRB meeting on 10–11 April. Major effort is focused on the Technical Proposal. A risk registry has been developed.

The LBNF/DUNE interface workshop 22 March was very productive and discussed several key interface issues in advance of the final conventional facilities design. A successful calibration workshop was held 14–16 March. A successful near detector workshop was held 22–24 March. A kickoff meeting with ARUP conventional facilities design team is scheduled for 10–11 April. A review of the readiness for data exploitation by the ProtoDUNE-SP team has been rescheduled for 10–11 May. The next collaboration meeting is scheduled for 15–18 May. Installation workshops are planned for 14 May and 19 May. The next LBNC review is 22–24 May.

ProtoDUNE

EHN1 F. Resnati

NP02 (ProtoDUNE-DP)

- Mechanical construction of the cold box was completed
- The cold box was transported to building 182 and installed in its final position

Figure 1: *ProtoDUNE-DP cold box installation in Building 182*

- Final installation of the Protego valve on the outside of the cryostat was completed
- Installation of the warm piping on the roof of the detector started
- Production of all the field cage modules was completed
- Test installation of the entire field cage completed

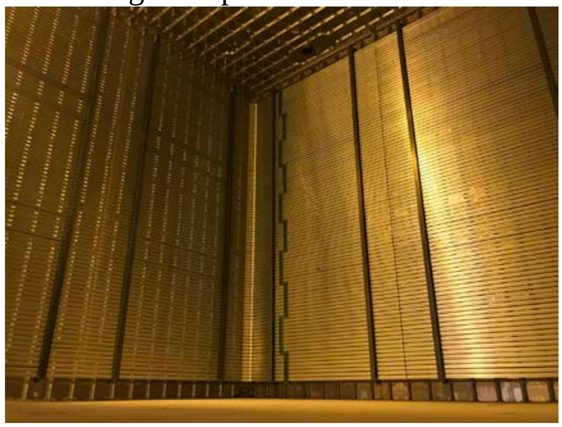


Figure 2: *Installation of ProtoDUNE-DP field cage*

NP04 (ProtoDUNE-SP)
- Operation of the cold box with APA#4
- Completion of the false-floor on the cryostat roof
- Leak testing all the penetration no longer accessible after deployment of first drift volume
- Arrival of APA#5, unpacking and insertion in the clean room

Figure 3: *APA#5 unloading in EHN1*

- Progressing with concrete block installation for H4 beam line extension
- Campaign of survey for the installation of magnets continued
- Cabling for magnets started

Figure 4: *H4 beamline magnet support blocks*

DUNE

Far Detector Consortia

Single Phase Anode Plane Assembly

Prof. Stefan Soldner-Rembold stepped down as APA Consortium leader after his election as DUNE co-spokesperson. Prof. Christos Touramanis (University of Liverpool) was elected APA Consortium leader.

The DUNE APA development Plan was presented at the LBNF/DUNE DOE IPR review on 20–22 March. The consortium continued preparation of the Technical Proposal. A second draft was submitted on 20 March.

While construction of the ProtoDUNE APAs is not directly part of the consortium, it has large overlap. The 2nd UK APA was shipped to CERN in mid-March; the 4th US APA was completed by the end of March. This concludes the production of APAs for ProtoDUNE-SP. An additional ProtoDUNE-style APA will be assembled at Daresbury Lab, to be delivered to CERN at the beginning of November 2018 for cold electronics studies.

The engineering resources becoming available after the completion of ProtoDUNE APA construction will focus on the design of an updated APA frame for the DUNE FD (led by PSL, University of Wisconsin), including the procedure for Cold Electronics (CE) and Photon Detector (PD) cable routing through the APA frame, and modifications to the winder machine to improve APA production time (led by Daresbury Lab., UK).

Single Phase TPC Cold Electronics

The BNL ASIC group submitted for fabrication a modified version of the front-end ASIC (LArASIC). This version is intended to make the baseline used for collection wires insensitive to strain caused by coefficient of thermal expansion mismatch between the silicon chip and the plastic surface mount package in which it is mounted. A second draft of the TPC electronics section of the Technical Proposal was completed. Select outside readers were asked for comments.

Single Phase Photon Detector

Consortium members continue to focus on the Technical Proposal Chapter, which is close to final. We have had several discussions on cabling of our system and in interactions with the APA consortium to develop a reasonable design for routing our cables. We have been also discussing about enlarging the size of the holes on the APA frames where the SPPD modules need to slide in. Some members of the consortium met with the representatives of the DarkSide experiment to discuss possible future collaboration on the photosensors (SiPM) and another meeting with the scientific lead of the FBK foundation about their possible involvement in the R&D effort of the Consortium in developing SiPMs which can operate at liquid argon temperature.

Dual Phase Charge Readout Plane

No report available.

Dual Phase TPC Cold Electronics

During March the dual-phase electronics consortium completed the Technical Proposal. The electronics installed on the 3x1x1 detector was recovered for ProtoDUNE-DP and for QC tests of the electronics cards produced for ProtoDUNE-DP. These QC tests are very useful to set-up and optimize the procedures which will be needed for the massive production for DUNE-DP and planning and logistics. The uTCA crates and MCH for ProtoDUNE-DP were delivered to CERN and configured and tested. The software environment for the DAQ back-end and storage servers at EHN1 with EOS integration was installed.

Dual Phase Photon Detector

The Dual Phase Photon Detection System Consortium (DPPD) has continued work on the Technical Proposal. A second draft was sent to editors on March 16th. Updated documents on the WBS and schedule of activities were prepared for the April RRB meeting. In addition, an initial high-level DPPD construction schedule was delivered. The consortium has participated at the DUNE FD Calibration Workshop presenting the plans for the DP photon detector calibration and discussing synergies with other calibration systems. The safety requirements were reviewed and progress on transportation and installation plans was made.

Progress in understanding the dual phase photon detector response for supernova neutrino interactions and nucleon decay events has continued during March 2018 via LArSoft fast optical simulations in the ProtoDUNE-DP geometry. A more systematic study to understand the expected light yield per MeV of deposited energy within the entire TPC active volume has also been carried out. From this study, a satisfactory average light yield of about 2 PEs/MeV was obtained. Finally, and in view of simulating the light response in the full far detector geometry in a sufficiently fast and accurate way, a preliminary study to parametrize the light response as a function of the source-PMT distance alone has been completed, with very promising results.

HV

HVS fabrication schedule for both the first (SP) and the second (DP) detectors was discussed and agreed within the consortium and transmitted to Technical Coordination. Short term R&D activities were reviewed and revised before submission for approval and funding. The second draft of Technical Proposal section (for the SP detector) was completed within the deadline. In agreement with the editors of the Technical Proposal, the editing of the HVS section of the DP detector was started this month.

The HV feed-through of ProtoDUNE-SP has arrived at CERN as well as the 300 kV power supply for ProtoDUNE-DP and the related HV cable rated for 350 kV. A HV test integrating all these elements (PS-cable-feedthrough) is in preparation at CERN building 182 in the dedicated 1-ton cryostat. The test will include a camera for visual inspection and ground plane monitoring.

Single Phase

The mini field cage was prepared and installed in the 50-liter LArTPC cryostat at CERN and was filled with ultrapure LAr with the aim of testing HV stability in the 10 cm gap defined by the ground planes and aluminum profiles. The detector is equipped with a camera in the gas phase looking downward into the detector. The ground planes are equipped with current pick off circuits; a single wire (acting as an antenna), protected in a cage, is located close to the field cage and is read-out with a charge sensitive preamplifier. All data are recorded on a LeCroy oscilloscope triggered by the charge sensitive preamplifier signal. Power supply current and voltage are recorded on the WA105 slow control system. Camera data is also recorded. The chamber was continuously operated at HV =100 kV (in term of electric field this is equivalent to 200 kV over the nominal 20 cm gap of ProtoDUNE) for several days without observing any instability or discharges in the Gap between profiles and ground planes. Attempts to increase the voltage to 120 kV were unsuccessful due to failure of the HV cable insulation. A new test will be done soon; if possible it will include a 150 kV HV feed through (e.g. SBND feedthrough that requires testing).

New higher resistivity Kapton (GOhm/square range) has been identified by Fermilab and prototypes were sent to CERN for lamination on FR4 boards. Cryogenic operation to test mechanical stability of lamination and resistivity at LAr temperature will follow shortly.

During March, the “beam right" TPC field cage was deployed: CPA-FC units rolled into final position with FCs folded up; once the CPAs and APAs for a given drift are in position, the FCs were deployed/unfolded and bridged the gap between; winch trollies were used to allow the bottom modules to be lowered in a controlled way and then to pull the top modules up; once horizontal, the mechanical connection between FC and APA was made; the electrical connection was made after all mechanical connections. A few alignment issues were found, which may be compensated when the “beam left" field cage is deployed. Ground plane filters were installed.

Figure 5: *deployed “beam right” Field cage of ProtoDUNE-SP.*

Dual Phase items

Activity focused on installation of the ProtoDUNE-DP Field cage. The assembly of all 24 submodules was completed by mid-March. A total of 17 out of 24 submodules were installed, leaving 7 to allow elevating platform access to the back of the field cage. Electrical connections for 60 installed profile gaps was completed (two sets of resistive divider boards, HVDB). Resistance measurement with one row of HVDB only and both the rows was performed and recorded. Full chain continuity was checked. Preparation of the HV test in air was pursued with the involvement of the CERN HSE officers.

Figure 6: Field cage details of ProtoDUNE-DP.

DAQ

DAQ activities in March have focused on finalization of the Technical Proposal and on planning for the next phase of the project leading up to the Technical Design Report. For the TP, consortium has produced a new version of its production and installation schedule up until 2025, which is commensurate with the DAQ needs of other consortia when building, testing and installing their hardware. Installation of the DAQ is expected to begin in Q2 2022, when the CUC counting room is handed over to the collaboration, with progressively more functionality available until Q2 2024, when the full system will be in operation. This is a tight schedule for the consortium, but necessary to make sure that detector installation and commissioning goes smoothly.

Planning for R&D activities in 2018/19 is now advanced, with five main areas of activity identified, each with participation by a strong team of institutes. These activities encompass both basic hardware and software development, and the definition, preparation and testing of algorithms for data filtering, compression and selection. The consortium plans to test all these elements in vertical slice tests at CERN and in the US in 2019. The experience gained will provide a good estimate of the resources and effort needed to deliver the final DAQ for the far detector, and will help us to optimize our technical strategy during the construction and commissioning periods.

Discussions are under way with a number of new institutes who will be joining the DAQ consortium in the coming months. The door is always open for new collaborators in this challenging project.

Cryogenic Instrumentation and Slow Controls

- The Technical Proposal continues to be the highest consortium priority. TP editors have produced a second draft o which is currently being reviewed by "external" reviewers.
- The Computational Fluid Dynamics (CFD) Steering group co-led by Jim Stewart and Alan Hahn held active discussions to produce a prioritized list of CFD tasks from the consortium side to meet the TDR deadline. The summary of tasks and timelines are listed in DUNE DocDB-7599. Consortium leadership will coordinate tasks between various groups to accomplish the needed work. Thanks to Jim, Alan and their team to finish the charge.
- Virginia Tech's petition to join the consortium was approved and we welcomed Virginia Tech to the CISC consortium.
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The key activities of the Near Detector Concept Study group centered around the workshop held at Fermilab on 22–24 March. The agenda of the workshop can be found at https://indico.fnal.gov/event/15649/. The goals of the workshop were to update progress on R&D tasks on instrumentation and findings of studies for assessing the capability of the liquid-argon TPC (LArTPC), high-pressure gaseous TPC (HPTPC), 3DST, and the PRISM concept for DUNE. This was the last workshop before making recommendations on the DUNE ND complex to the Executive Board (EB) via the spokespersons.

At the workshop, the participants agreed with the following recommendations:

1. The LArTPC should be optically partitioned, has short drift distance and pixelated readout. These features will significantly improve the capability of the LArTPC in handing the anticipated high-rate environment and efficiency of reconstructing events at the near site.
2. The LArTPC should be movable so that it can be positioned off-axis for implementing the PRISM concept.
3. The underground experimental hall should be rotated by 90 degrees to allow for moving the near detector off-axis.
4. The minimum experimental floor area must be at least 35 m (wide) by 17 m (beam direction). The hook height must be at least 13 m. if geotechnical condition of the near site is favorable, the length of the underground hall in the beam direction should be increased.

In addition, most of the study group preferred to have a new-build dipole magnet for the multi-purpose spectrometer downstream of the LAr TPC.

Impressive progress on pixelated readout for LAr TPC was presented at the workshop. On behalf of Pixel Liquid Argon Experiment (PixLAr) at Fermilab, Assadi reported that using 28k pixels, provided by the Bern group, multiplexed to 480 channels of the existing LArASIC electronics, they have observed beam tracks with very little background. However, due to multiplexing, some ghost tracks were present and need more sophisticated pattern recognition to reject them in offline analysis. Figure 1 shows an event with 19 tracks reconstructed, with only a few noise hits.

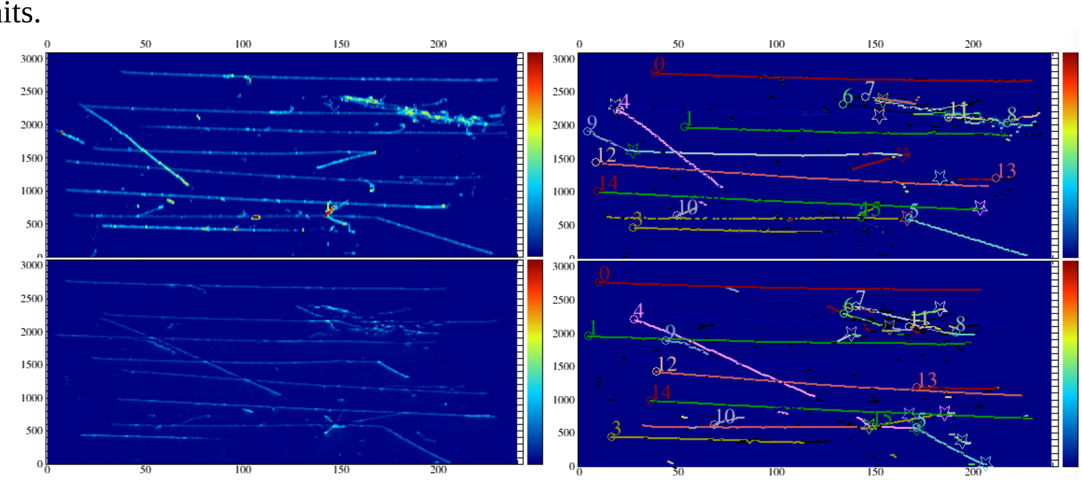

Figure 7: *(left) Raw hits of an event obtained with LArASIC, (right) Reconstructed 19 tracks of the event.*

Dwyer reported great progress on the first version of the LBNL low-power pixel readout ASIC (LArPix) since the DUNE collaboration meeting in late January. The LBNL team has now measured the total power consumption of 128 channels, about 6.7 W per square-meter, for the analog and digital circuits of the ASIC. This is on par with the heat flux through the cryostat walls, demonstrating its low-power capability. With some fine-tuning, power dissipation could be further reduced. By implementing four LArPix 32-channel chips on a pixel PCB installed in a prototype LArTPC with 10-cm drift, tracks of cosmic-ray muons were seen. As shown in Figure 2, each hit pixel collected about 10k electrons. Again, there was essentially no noise hit.

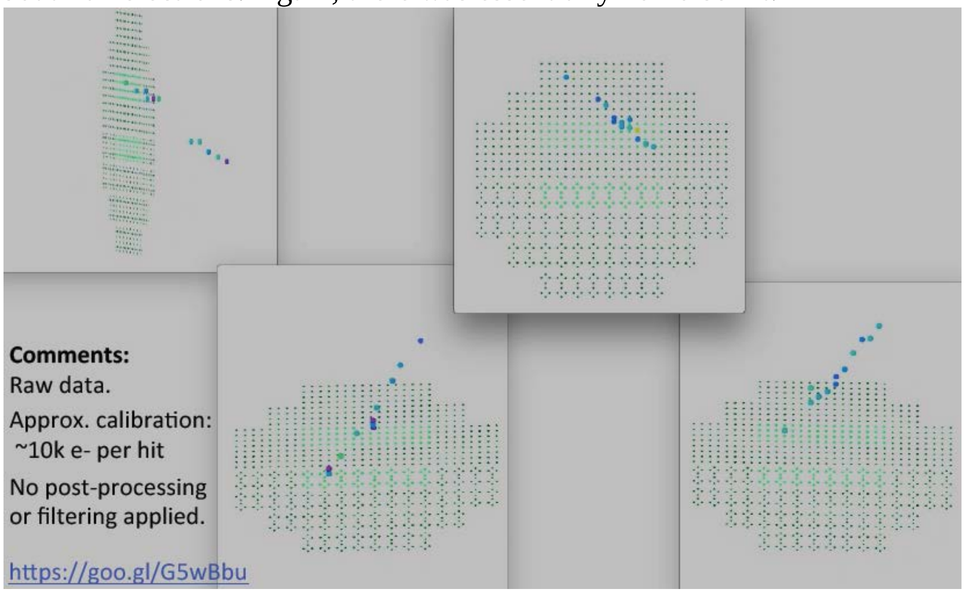

Figure 8: *Cosmic-ray muon tracks observed with the LBNL low-power LArPix ASIC.*

After the workshop, the ND coordinators and ND Physics convenors (Alfons Weber and Kam-Biu Luk, Mike Kordesky and Steve Manley) started to draft the report summarizing findings from the presentations given at the weekly meetings, workshops and written documents. This report will contain additional assessments and recommendation on tracking technology for the multi-purpose spectrometer. It will be submitted to the EB before the May DUNE collaboration meeting.

Technical Coordination — E. James

ProtoDUNE-SP APA#4 completed its cold box testing and was moved into the cryostat. The photon detectors were installed in APA#5 which will be inserted into the cold box in early April. APAs are still on the critical path, but cold electronics, photon detectors and installation work are all close to or on the critical path as well. Gabadi has been contracted to close the TCO starting in early May.

TC held meetings with consortium in preparation for the US IPR 20–22 March and the RRB meeting 10–11 April. Progress continues to define interfaces, deliverables and risks. WBS is being improved. Initial work on schedules is starting.

ProtoDUNE Milestones

Table #1 shows important ProtoDUNE milestones and current estimates.

Milestone	Original Date	New Date	Impact on Close SP TCO
PD ProtoDUNE system Installed at CERN	21-Feb-18	16-Apr-18	31-Jul-2018
ProtoDUNE UK APA #3 Start Winding	15-Nov-17	15-May-18	31-Jul-2018

Table 1: ProtoDUNE-SP key milestone watch for March

Installation

The installation plan and 3D Model of the gap between cryostats was refined based on planned removal of the rock septum with a 12m gap between the detectors. An installation plan for the single-phase detector that allows efficient installation was presented to management, who requested further work toward a design that no clean space above the 4850 level. Alternate configuration studies continued throughout March.

Alternate methods for routing detector cables with cable trays along the cryostat walls were developed. This study was performed to determine if the concept was mechanically viable and to define cable lengths. The cable length is critical as the signal attenuation is important. By defining the cable length clearly the electronics group can perform detailed signal transmission studies to determine if this alternate should be considered. This study required 3D modeling of all cable runs, due to the mismatch between the pitch of the cryostat support I-Beams (1.6m) and the pitch of the detector elements (2.3m). The 3-D models of the cable runs are shown in the figure below. Three cable lengths will be needed: 9m, 26.5m and 33m. If the cables are routed through the APA support frames then the required lengths are 9m and 23.5m. The difference in signal quality between the 33m and 23.5m cables may be significant.

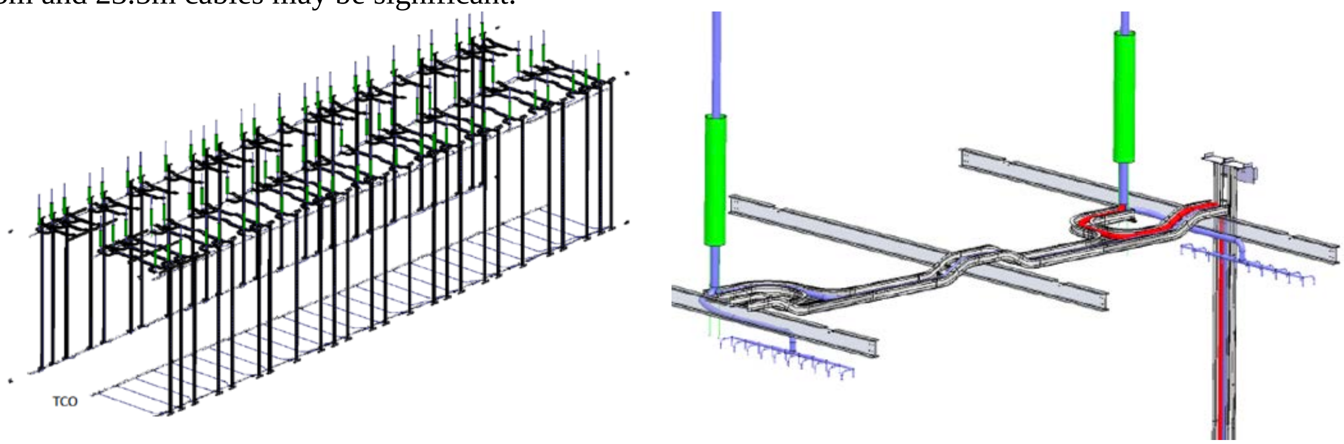

***Figure 7**: Left: Full 3D model of the cable routing with cable trays along the walls of the cryostat. Right: Detail view of one tray at the top of the detector (for 2 APAs). The top trays are supported from the DSS I-Beams and the cryostat wall trays are supported from M10 bolts in the edges of the cryostat.*

QA

Effort has focused on collecting lessons learned from ProtoDUNE and on review of QA sections of the Technical Proposal.