DUNE Project
Monthly Status Report
March 2017

ProtoDUNE-SP clean room roof beams installed in front of cryostat

Version 5: May 2, 2017

The 2017 DOE IPR for LBNF/DUNE was held at FNAL at the beginning of the month: February 28 – March 2. A LBNC review was held on March 23–25. Dates for design reviews and an installation workshop have been confirmed for mid-April. Production Readiness Reviews were held for ProtoDUNE-SP photon detector bars at Indiana and cold electronics mechanicals at BNL. A near detector workshop was held March 27–29.

Single-Phase ProtoDUNE Construction — G. Rameika

During March we completed the winding of the V-Plane and began winding the U-plane for APA#1. The V-plane took much longer than originally planned due to the need to better understand the results of tension measurements made both before and after the wires are placed and soldered. We now understand the measurements and can proceed. Tolerances look good. We now have a better understanding of how long each step of the winding process takes. We believe we can still meet the early June delivery date for APA#1; however we are considering whether or not to do cold testing before shipping.

During March the U.K. team made good progress on the winder, clean room and preparation for fabrication of the frames. Several technical people spent several weeks at PSL observing and learning the winding and soldering procedures.

Procurement of production parts for the CPAs has begun and ANL is ready to start fabrication.

A lot of progress on procurement of final prototypes for the Cold Electronic systems was made. The PRR for the mechanicals was held at BNL at the end of the month. Extensive studies of the ADC performance (statistics) continues. These results will be used to determine the acceptance criteria for the production order. We still have a problem with the packaging of the FE ASIC, as the yield from Quik-Pak was found to be unacceptable low. We think it was a QC problem which could likely be resolved, however we are still exploring possible other vendors as well.

In March we continued to study the problem of the SensL SIPMs cracking in the cold. It had been observed that they did not crack when installed on the PCB hoverboard. However, when tested on the final version, there were a small fraction that still cracked. Several options remain to be studied, including the possibility of removing older version units from test boards. We need a total of 720 to outfit the 60 bars to be installed in ProtoDUNE. Progress on the production of the bars themselves continued, including having the PRR for the Indiana bars.

In March the Electronics Test Stands at both FNAL and BNL went into operation. These will be very valuable for studying the system level performance of boards, feedthroughs and cables, with special attention being paid to grounding and shielding.

The PC4-35ton High Voltage test reached a major milestone at the end of the month. It is filled with liquid argon and holding voltage with 180kV on the cathode. The caveat is that the argon has not yet been purified. The real test is when we are operating at the design purity.

During March many aspects of installation continued to be practiced at the Ash River site. Much is being learned about handling components and assembling them together. We anticipate continuing the tests at Ash River through May. At that point we need to be ready to send the materials for the Detector Support Structure (DSS), trolleys and tooling to CERN for installation into the cryostat.

Work continued of the analysis of the DSS. We are working with CERN HSE to begin getting approvals for the designs and procedures of the equipment being built and sent.

Single-Phase ProtoDUNE Installation — F. Cavanna

A detailed ProtoDUNE-SP report has been presented at the March 22 LBNC Meeting. The next SPSC meeting will take place in early April: in preparation for this event the TDR revision was completed.

Activity on-site (EHN1):

The membrane insulation inside the cryostat structure is well advanced (but not completed yet), the clean room material is being delivered to CERN and the procurement for the material for the construction of the Cold Test Box is under way. The procedure for detector integration in the clean room is under development.

Instrumentation:

Beam Instrumentation: the H4 beam line simulation including concrete shielding (preliminary) and bending magnet geometry is in progress. Progress is reported on the CERN Tracking Fiber detectors, Cherenkov counter(s) and FNAL/ANL pLAPPD ToF (test in LArIAT test beam started). DAQ and data storage for all these detectors is under study.

Cryo-Instrumentation: The requirements for a gas analyzer system and its interfaces with the cryogenics and controls system is under evaluation. A map of sensors for cryogenics control inside the cryostat has been completed and technical solutions defined.

External Instrumentation: a successful mechanical test of the vertical positioning of the Muon tagging paddles has been carried out. The Design of a frame for (4) paddles — "CRT module" — has been completed, while the holding structure for the frames using new or existing rails is still to be defined. Shipment to CERN of the paddles from the Double Chooz experiment is expected by April or early May.

DAQ, Data Processing, Reconstruction & Analysis:

The DAQ Vertical Test Stand for the APA test in the Cold Box is well advanced; the plan for Prompt Processing and DQM is being updated. The path toward detector performance measurements and the definition of the ccalibration plan has been defined in detail. The focus is on the plan for calibrating space charge effects using CRT tracks.

A (new) MC challenge is in preparation using input from the H4 beam line simulation.

Comprehensive Plan document on ProtoDUNE computing is in preparation, including scope, organization and deliverables for DAQ, PromptProc and DataReco/Analysis.

Dual Phase ProtoDUNE — D. Autiero

As described in the February report, the cool-down of the 3x1x1 cryostat started on February 27 after having reached 0.2 ppm oxygen contamination. This cool-down procedure was expected to last for about one week before filling with liquid argon. On March 3 as filling of the cryostat with liquid argon was about to begin, the cool-down was interrupted due to the appearance of a cold spot with ice in the south east corner of the cryostat exoskeleton (see Figure 1).

Figure 1: Appearance of a cold spot with ice formation on the 3x1x1 cryostat exoskeleton during the cool-down procedure: details with visible light and infrared pictures

This unexpected problem needed further investigation to check the integrity of the internal cryostat membrane and understand whether the cold spot could be related to a membrane leak or not. CERN Neutrino Platform personnel decided to warm-up the cryostat for an inspection. This procedure took until March 12 and an access became possible on March 13. Visual inspection by GTT experts showed no membrane problems and a Helium leak test confirmed this. Given the absence of hints of an internal leak on March 21 a hole was drilled in the external tank at the point of lowest temperature (see Figure 2).

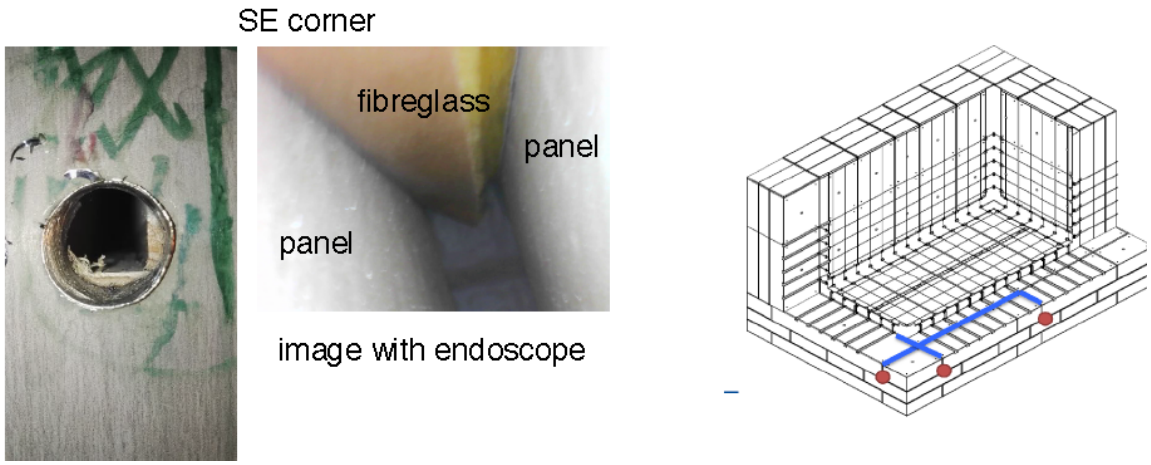


Figure 2: Investigation of the cold spot point on the 3x1x1 cryostat by drilling a hole in the steel plate of the exoskeleton structure: a gap in the insulation space was discovered.

The hole showed the presence of an open channel between insulation panels of 10x2 cm^2 cross section and 95 cm depth. This gap, due to an imperfection in the installation procedure of the insulation panels, was filled with expandable polyurethane foam. By the infrared camera survey performed at the moment of the appearance of the cold spot, five other cold points (without ice formation) had been identified. These points correspond to similar insulation panel overlaps at the bottom corners of the cryostat. Holes were drilled corresponding to these points and gaps in the insulation were identified at 3 of these points, which were filled with expandable foam. The instrumentation inside the cryostat was improved with additional temperature probes connected to the membrane; 4 probes were added to the insulation space at the cold spots before filling with foam. The nitrogen gas circulation in the insulation space was connected to a spectrometer in order to perform a continuous monitoring of the presence of argon from possible internal leaks. On March 28 the cryostat purge was restarted after these fixes and improved monitoring instrumentation.

In parallel, preparation for the 6x6x6 assembly continued smoothly. The installation schedule was updated by taking into account the availability of the clean room (used for ICARUS refurbishing) in hall 185, the planning to complete the 6x6x6 cryostat construction by the beginning of June and the precise installation procedures related to the finalization of the executive design of the CRP, field cage and cathode which was concluded by November 2016. A complete description of the progress of ProtoDUNE dual-phase during the last year and of the installation planning is contained in the SPSC annual report submitted in March 2017:
https://cds.cern.ch/record/2256436/files/SPSC-SR-206.pdf

Far Detector — J. Stewart

Cryostat Integration

A 3D model with initial placement of the primary roof penetrations needed for the first far detector was generated (see Fig. 1).

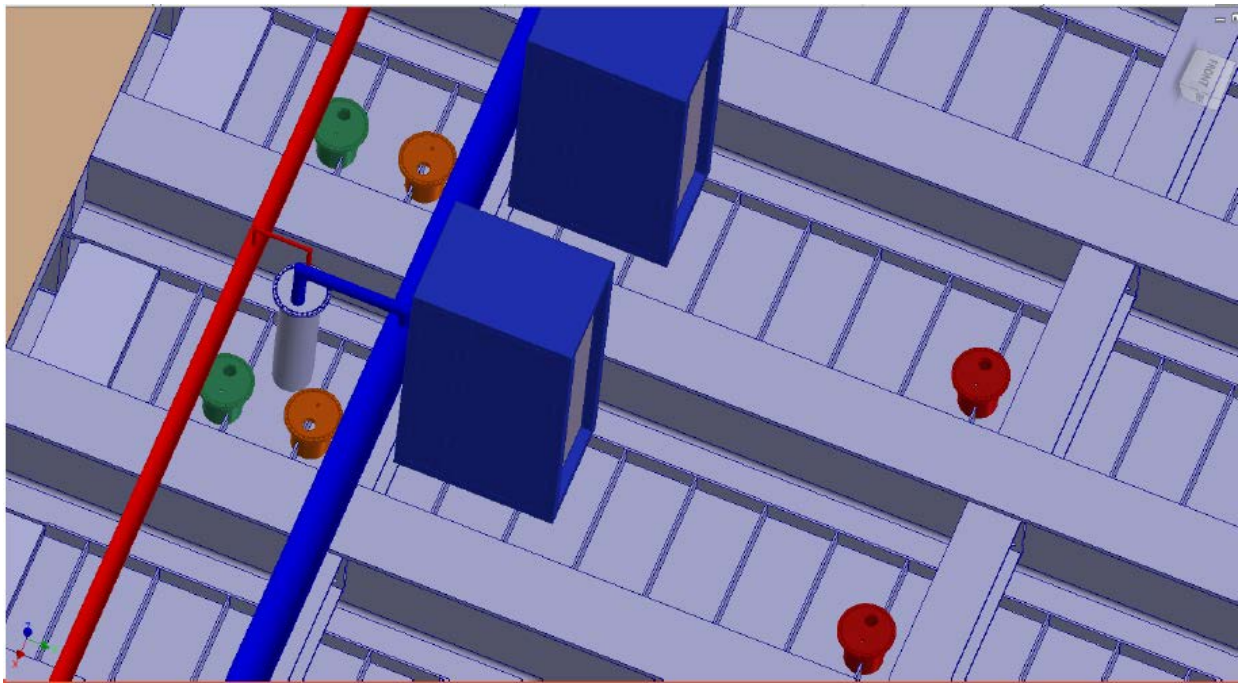


Figure 3: Roof penetration layout showing the APA support feedthrus (Green), the APA signal feedthrus (Orange), the CPA support feedthrus (Red), and the Cryogenic feedthrus for cooldown (Gray).

The model takes into account the I-Beam steel support structure of the cryostat and included initial placement of some of the cryogenic services. The central I-Beam needed to be shifted off-axis of the cryostat to allow placement of the supports for the CPA that is constrained to be along the center of the cryostat. In general the signal feedthru positions needed adjustment to adapt to the 1.6 m pitch of the beams which will translate into roughly 1m additional cable length (see Fig. 2).

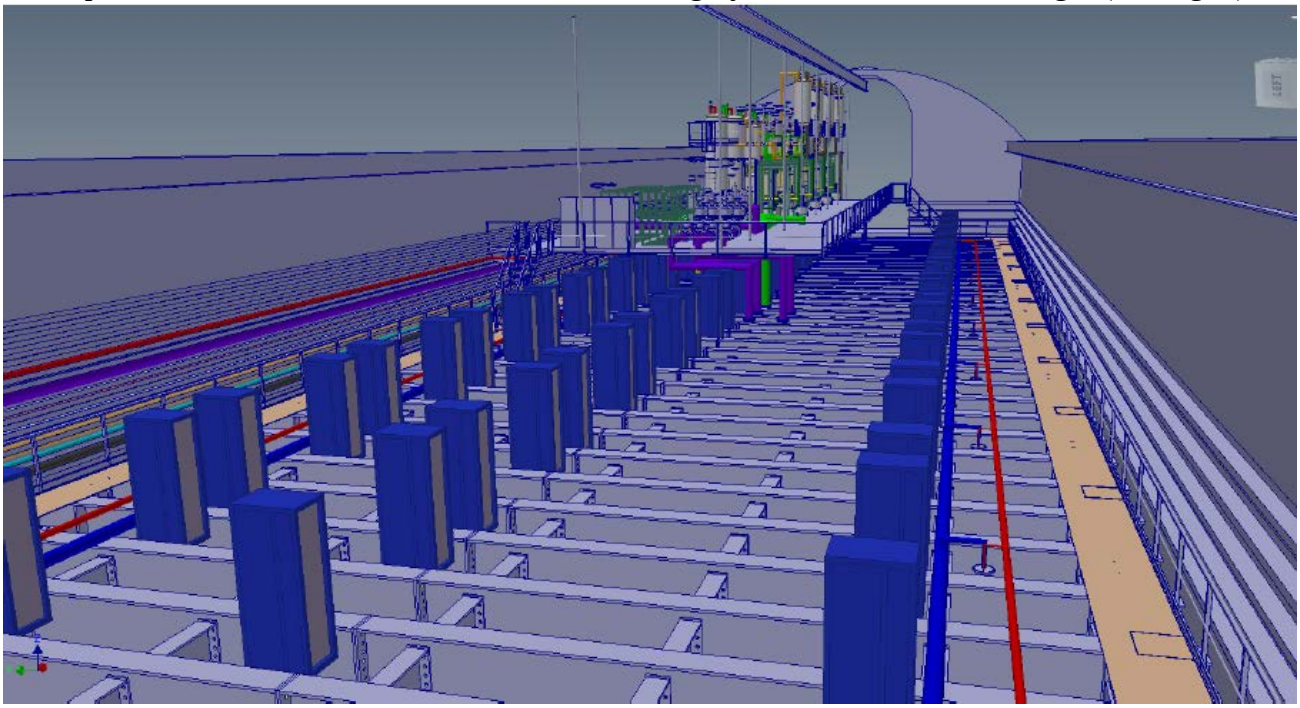


Figure 4: Top view of the Far Detector showing electronics racks placed near the signal feedthrus.

The penetrations for the spray nozzles are positioned close to the cryostat membrane wall, which is also where DUNE will want to monitor the argon temperature. It needs to be investigated

if the detector thermometers can be integrated into the sprayer feedthrus. The first look at the geometry of the penetration locations and the position of the APAs indicates that it will be very difficult to position a variable height thermometer array (spooler) behind the APAs so this instrumentation should be foreseen at the ends of the cryostat and not along the walls. Work started on an envelope model of the far detector that will include the main interface features but only the envelope dimensions for the parts. This will be the main model for defining the internal space requirements for the cryostat design.

Reviews

The DOE IPR took place at the start of March and the LBNC Review Late March. There were far detector sessions at both reviews with the goal of assessing progress.

Near Detector — K.-B. Luk

The major activity of the Near Detector Concept Study Team focused on the DUNE Near Detector Workshop that was held at Fermilab on Mar 27–29. The workshop was well attended, with a total of 85 people registered including a small number of non-DUNE members. There were 25 presentations, covering the timeline of the near detector task in 2017, scientific requirements for designing the near detector system, lessons learned in T2K and NOvA, status and outlook of the Near Detector Task Force, ideas and progress of detector R&D and how to move forward.

We learned that the uncertainty in normalization for exploring CP violation has to be ~2% or better. However, we still need to work backwards from this requirement to figure out what specifications should be imposed on the near detector.

In T2K, the background and signal events of electron-neutrino appearance are predominantly CCQE, with negligible muon-neutrino contamination and small amount of NC background. It is important to understand the differences between T2K and DUNE, identify challenges and figure out how the DUNE near detector can mitigate them.

Since NOvA has functionally identical near and far detectors, relative measurements of disappearance can significantly reduce many uncertainties. However, that is not the case for appearance analysis as there is no such signal observed in the near detector. Furthermore, background due to neutral-current interactions and intrinsic electron-neutrino contamination cannot be ignored. Thus, it is desirable to have a very capable near detector with full acceptance for containing hadronic showers and excellent lepton identification.

The Near Detector Task Force is in process of drafting its final report. Most of the team members plan to continue setting up software tools for connecting the near-detector measurements and their errors to those of the far detector for establishing a more realistic estimation of CP violation sensitivity.

It is essential to understand the flux, cross sections and detector efficiencies in order to reach high precision. There were a few talks on how one may use various kinds of neutrino interactions to measure each of these factors or using statistical method to determine the impact of each systematic uncertainty in the CP measurement. It is clear that these approaches are crucial for identifying the key parameters for designing the near detector in the near future.

There were several progress reports on detector R&D. Due to lack of support and manpower, progress on the Fine-grained Tracker and gaseous argon TPC was stagnant. However, R&D on liquid-argon TPC R&D is proceeding well. The goal is to have fully instrumented liquid-argon TPC modules with pixelated readout ready for test towards the end of 2017 or early 2018.

While the majority of the interested parties opted for a magnetic field, there was still skepticism on this requirement. Further work is needed to settle this issue.

Mark Thomson informed the participants that the plan is to have the collaboration to agree on a concept for the near detector system, including a plausible funding model, by January 2018.

Project Status — P. Novakova

The cost performance index dropped from 0.95 to 0.91. In general this is due to late cost reporting at Brookhaven. In February the university contract accruals have not been completed due to absence of the financial analyst for personal reasons. The accruals for both February and March have been recorded at the end of March. The CPA/FC negative cost variance of 86% is still worrisome; variance analysis from the system manager has been requested. The positive cost variance in the ProtoDUNE Cold Electronics dropped to 26% and will continue to decrease in the next few months, according to the L3 manager. The schedule performance index is 0.95.
The APA #1 wiring and tension tests have slipped again. In order for the project to recover, the team has discussed an option to eliminate the cold test at PSL. The frame fabrication of APA 2 has been delayed by more than a month and has now become a critical path activity, causing delays of the installation at CERN. The detector support structure (DSS) design and procurement has been delayed again and will be delivered at CERN in the beginning of July. Although this delay does not affect the TPC installation it has to be closely monitored since it can become a critical path activity soon.

UK APA Production

Many of the key winding machine components are received and being assembled in Daresbury APA production site. The commissioning of the winding machine is likely to be completed by May 5 (delayed by ~1 month). The winding of APA#4 is scheduled to start on May 17. The fabrication of the APA#4 frame is expected to finish on May 13. Good progress has been made even though some activities are behind schedule.

International Milestone Project Schedule

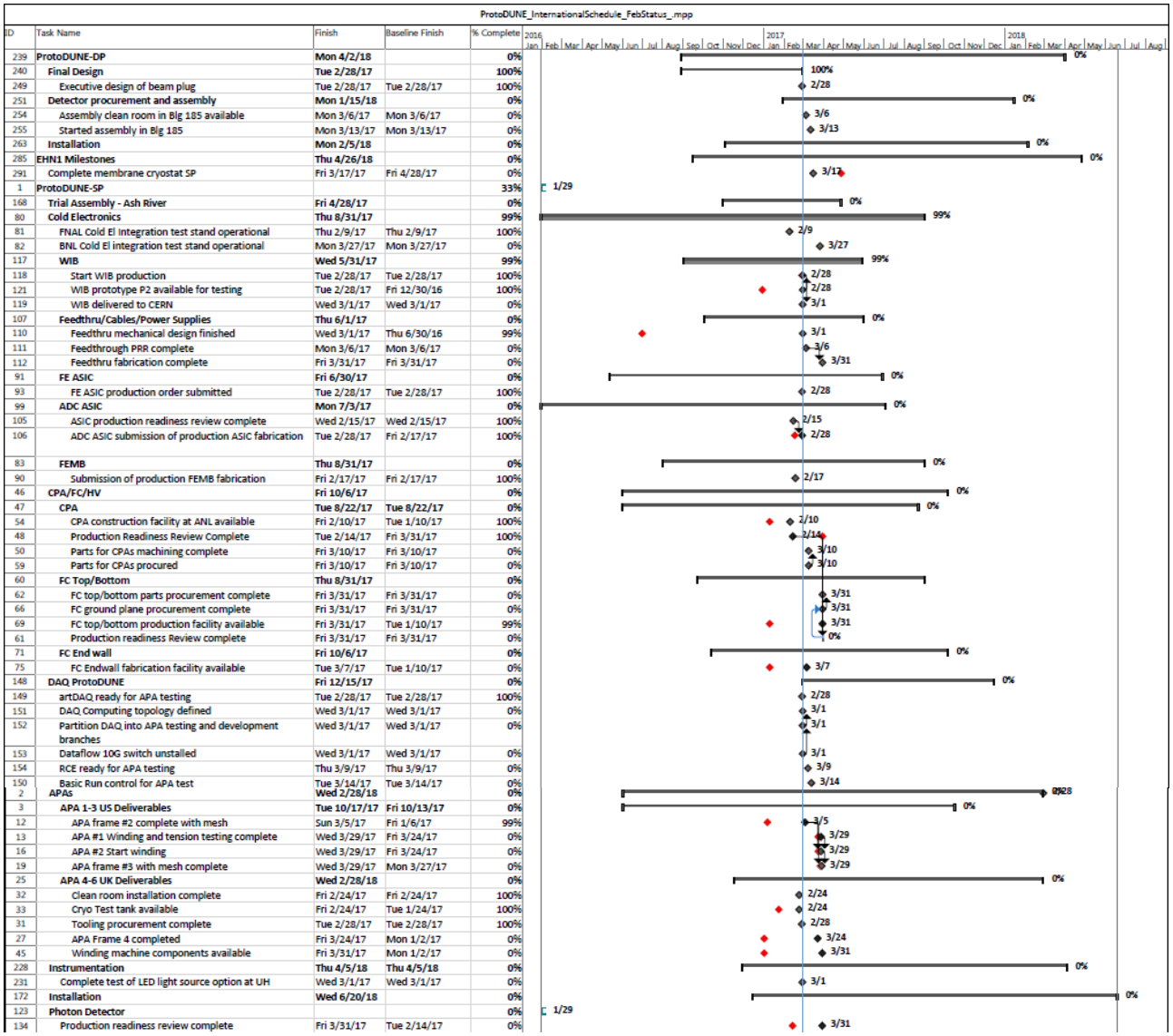
The main concern is how to keep the ProtoDUNE international schedule in synch with the Primavera schedule. A few options have been discussed; an effort to make the synchronization process automatic is still underway.

The DP team reported that the 1x1x3 prototype is cooling down. The team has revised the schedule and will provide the updated schedule to the project office on or after April 17.

Table 2 shows impact of the delays on key milestones

Milestone	Original Date	New Date	Impact on	
			UK APA#1 Ready to ship	Close TCO
APA #1 Winding and tension testing complete	24-Mar-17	12-May-17	N/A	10 days delay (5 April 2017)
APA #2 Fabrication Complete	31-Jan-17	5-May-17	N/A	10 days delay (5 April 2017)
UK Winding Machine Commissioning Complete	2-Jan-17	3-May-17	27 Sept 2017	1 May 2018

Table 2: Impact of milestones that slipped in February



ID	Task Name	Finish	Baseline Finish	% Complete
239	**ProtoDUNE-DP**	**Mon 4/2/18**		**0%**
240	**Final Design**	**Tue 2/28/17**		**100%**
249	Executive design of beam plug	Tue 2/28/17	Tue 2/28/17	100%
251	**Detector procurement and assembly**	**Mon 1/15/18**		**0%**
254	Assembly clean room in Blg 185 available	Mon 3/6/17	Mon 3/6/17	0%
255	Started assembly in Blg 185	Mon 3/13/17	Mon 3/13/17	0%
263	**Installation**	**Mon 2/5/18**		**0%**
285	**EHN1 Milestones**	**Thu 4/26/18**		**0%**
291	Complete membrane cryostat SP	Fri 3/17/17	Fri 4/28/17	0%
1	**ProtoDUNE-SP**			**33%**
168	**Trial Assembly - Ash River**	**Fri 4/28/17**		**0%**
80	**Cold Electronics**	**Thu 8/31/17**		**99%**
81	FNAL Cold El Integration test stand operational	Thu 2/9/17	Thu 2/9/17	100%
82	BNL Cold El integration test stand operational	Mon 3/27/17	Mon 3/27/17	0%
117	**WIB**	**Wed 5/31/17**		**99%**
118	Start WIB production	Tue 2/28/17	Tue 2/28/17	100%
121	WIB prototype P2 available for testing	Tue 2/28/17	Fri 12/30/16	100%
119	WIB delivered to CERN	Wed 3/1/17	Wed 3/1/17	0%
107	**Feedthru/Cables/Power Supplies**	**Thu 6/1/17**		**0%**
110	Feedthru mechanical design finished	Wed 3/1/17	Thu 6/30/16	99%
111	Feedthrough PRR complete	Mon 3/6/17	Mon 3/6/17	0%
112	Feedthru fabrication complete	Fri 3/31/17	Fri 3/31/17	0%
91	**FE ASIC**	**Fri 6/30/17**		**0%**
93	FE ASIC production order submitted	Tue 2/28/17	Tue 2/28/17	100%
99	**ADC ASIC**	**Mon 7/3/17**		**0%**
105	ASIC production readiness review complete	Wed 2/15/17	Wed 2/15/17	100%
106	ADC ASIC submission of production ASIC fabrication	Tue 2/28/17	Fri 2/17/17	100%
83	**FEMB**	**Thu 8/31/17**		**0%**
90	Submission of production FEMB fabrication	Fri 2/17/17	Fri 2/17/17	100%
46	**CPA/FC/HV**	**Fri 10/6/17**		**0%**
47	**CPA**	**Tue 8/22/17**	**Tue 8/22/17**	**0%**
54	CPA construction facility at ANL available	Fri 2/10/17	Tue 1/10/17	100%
48	Production Readiness Review Complete	Tue 2/14/17	Fri 3/31/17	100%
50	Parts for CPAs machining complete	Fri 3/10/17	Fri 3/10/17	0%
59	Parts for CPAs procured	Fri 3/10/17	Fri 3/10/17	0%
60	**FC Top/Bottom**	**Thu 8/31/17**		**0%**
62	FC top/bottom parts procurement complete	Fri 3/31/17	Fri 3/31/17	0%
66	FC ground plane procurement complete	Fri 3/31/17	Fri 3/31/17	0%
69	FC top/bottom production facility available	Fri 3/31/17	Tue 1/10/17	99%
61	Production readiness Review complete	Fri 3/31/17	Fri 3/31/17	0%
71	**FC End wall**	**Fri 10/6/17**		**0%**
75	FC Endwall fabrication facility available	Tue 3/7/17	Tue 1/10/17	0%
148	**DAQ ProtoDUNE**	**Fri 12/15/17**		**0%**
149	artDAQ ready for APA testing	Tue 2/28/17	Tue 2/28/17	100%
151	DAQ Computing topology defined	Wed 3/1/17	Wed 3/1/17	0%
152	Partition DAQ into APA testing and development branches	Wed 3/1/17	Wed 3/1/17	0%
153	Dataflow 10G switch unstalled	Wed 3/1/17	Wed 3/1/17	0%
154	RCE ready for APA testing	Thu 3/9/17	Thu 3/9/17	0%
150	Basic Run control for APA test	Tue 3/14/17	Tue 3/14/17	0%
2	**APAs**	**Wed 2/28/18**		**0%**
3	**APA 1-3 US Deliverables**	**Tue 10/17/17**	**Fri 10/13/17**	**0%**
12	APA frame #2 complete with mesh	Sun 3/5/17	Fri 1/6/17	99%
13	APA #1 Winding and tension testing complete	Wed 3/29/17	Fri 3/24/17	0%
16	APA #2 Start winding	Wed 3/29/17	Fri 3/24/17	0%
19	APA frame #3 with mesh complete	Wed 3/29/17	Mon 3/27/17	0%
25	**APA 4-6 UK Deliverables**	**Wed 2/28/18**		**0%**
32	Clean room installation complete	Fri 2/24/17	Fri 2/24/17	100%
33	Cryo Test tank available	Fri 2/24/17	Tue 1/24/17	100%
31	Tooling procurement complete	Tue 2/28/17	Tue 2/28/17	100%
27	APA Frame 4 completed	Fri 3/24/17	Mon 1/2/17	0%
45	Winding machine components available	Fri 3/31/17	Mon 1/2/17	0%
228	**Instrumentation**	**Thu 4/5/18**	**Thu 4/5/18**	**0%**
231	Complete test of LED light source option at UH	Wed 3/1/17	Wed 3/1/17	0%
172	**Installation**	**Wed 6/20/18**		**0%**
123	**Photon Detector**			**0%**
134	Production readiness review complete	Fri 3/31/17	Tue 2/14/17	0%

Figure 3: The March status of the DUNE Project schedule