DUNE Project
Monthly Status Report
April 2017

Assembled ProtoDUNE-SP Field Cage, CPA and APA for Ash River Workshop

Version 6: May 26, 2017

The annual SPSC review was held April 4–5 and the final ProtoDUNE-SP TDR was produced. Many internal DUNE reviews were held, including production readiness reviews (PRR) for the Endwall Field Cages and APAs as well as design reviews for the Cryogenic and Beam Instrumentation and a design review for ProtoDUNE-DP. A ProtoDUNE-SP installation workshop was held at CERN. An internal committee to review ASIC design options for DUNE was formed. Much progress and many lessons have been learned from the dual phase 3x1x1 cryostat. A budget for the rest of USFY2017 was passed at the end of the month that doubles the LBNF/DUNE funding for this year.

Single-Phase ProtoDUNE Construction — G. Rameika

In April, the winding of the U plane and the first half of the final G plane for PSL APA#1 was completed. Good progress was made on the U.K. APA winder, clean room and frames.

CPA frame production started at Argonne and good progress was made.

Acceptance criteria for ADC ASICs were developed and new packaging vendors were pursued. The first batch of production chips (due at the end of May) will be packaged by MOSIS. The PRR for the CE mechanicals was held. Lots of progress was made on the mechanical elements of the system.

Testing mounted SiPMs (both new and old versions) on the new hoverboard continued. We believe we will have enough of the old version on the new hoverboard in time for APA#1.

The 35ton was filled with liquid argon, purified and many tests were performed. There is an issue with current draw, sometimes for extended periods, other times, just periodic spikes. By the end of the month it was decided to conclude the test, drain the argon and make some modification to a potential problem near the cathode related to a field shaping strip.

Noise studies using the 35-ton electronics cards were on-going at DAB. Progress continued on getting the isolation transformer installed at the DAB electronics teststand,

Much work continued on DSS analysis and documentation and procurement of the long-lead time beams was initiated. At the current time the idea is that the beams will be fabricated in Switzerland by a company related to our original vendor in Texas.

Trial assembly and development of procedures continued at Ash River. A trial run of the photon detector modules into the APA frame took place at Ash River. The tooling was deemed to work well but the fit was tight. However, the Ash River APA frame was not built with the proper APA slotting. The tooling was sent to PSL and the test will be repeated there.

Single-Phase ProtoDUNE Installation — F. Cavanna

A detailed report on ProtoDUNE-SP has been presented at the annual SPSC meeting on April 5 at CERN. The SPSC recognized the progress by the ProtoDUNE-SP collaboration towards completing the first anode plane assembly and achieving the high voltage feedthrough requirements. The Committee was also pleased to note the achievement by the ProtoDUNE-SP collaboration in defining the organization of the project. Operation extending beyond the start of LS2 was proposed and favorably viewed; the SPSC Committee now expects an official request to continue operations in EHN1 as well as a run plan proposal for 2018.

An “Installation Workshop” and two Instrumentation Readiness reviews took place at CERN in April. Closeout reports were, in general, positive with valuable suggestions and recommendations mostly addressing interconnections among various activities or sub-systems.

Activity on-site (EHN1):

The Membrane insulation inside the cryostat structure is well advanced (but not completed yet), the material for the clean room is delivered at CERN and the procurement of the material for the construction of the Cold Test Box is under way.

The procedures for APA acceptance upon arrival at CERN and detector integration (PD and CE) inside the clean room are being finalized.

Instrumentation:

Beam Line and Instrumentation: the G4 beam line simulation for H4 beam line including concrete shielding (preliminary) and exact bending magnet geometry is completed. Optimization of the shielding layout through detailed FLUKA simulation is in progress.

Cryo-Instrumentation: Two different solutions for the LAr Vertical T-gradient monitor at high precision (10 mK) have been proposed and fully developed by the Hawaii U. and Valencia IFIC Groups and both included in the ProtoDUNE-SP Cryo Instrumentation layout.

The Purity Monitor System developed by the U. of Huston and UC Irvine has achieved an important milestone: a very successful test in LAr was performed in the TallBo cryostat at the PAB cryogenic facility at FNAL showing clean cathode-anode signals collected with the first ProtoDUNE Purity Monitor.

DAQ, Data Processing, Reconstruction &Analysis:

A 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 March report, the 3x1x1 cryostat purge procedure was restarted on March 28 after having introduced some fixes to the cryostat insulation related to the appearance of a cold spot with ice occurred during the first cool-down attempt at the beginning of March. A second cool-down procedure was eventually started on April 6. Since April 12 it was observed the

formation of new cold spots. On April 13 the number of cold spots had reached the number of 12. The cold spots did not affect the point where the first cold spot formed in March, showing that the fix performed at that time by drilling a hole and filling and expandable foam the cavity where the glass-wool was missing had worked correctly. The mass spectrometer connected to the exhaust of nitrogen circulating in the insulation space also proved the absence of argon contamination in the insulation space, indicating that the membrane integrity was not compromised. The cryostat was then warmed up again but by keeping pure argon inside since no access was needed and allowing to restart more quickly the cool-down after new fixes to the insulation. No cold spots had formed on the bottom face of the cryostat but they were distributed only on the side faces, in their bottom sections. During the week of April 24 GTT organized a massive campaign of fixes by drilling about 60 holes at the bottom of the side faces of the cryostat corresponding to the points of the gaps among the insulation blocks filled with glass-wool. In a minority of the holes it was seen that the glass-wool was missing. For all holes it was performed the injection of expandable foam. GTT also started performing some more detailed simulations to check how convective motions of nitrogen could be established in the gaps were glass-wool is missing. A new cool-down procedure was then restarted at the end of the month.

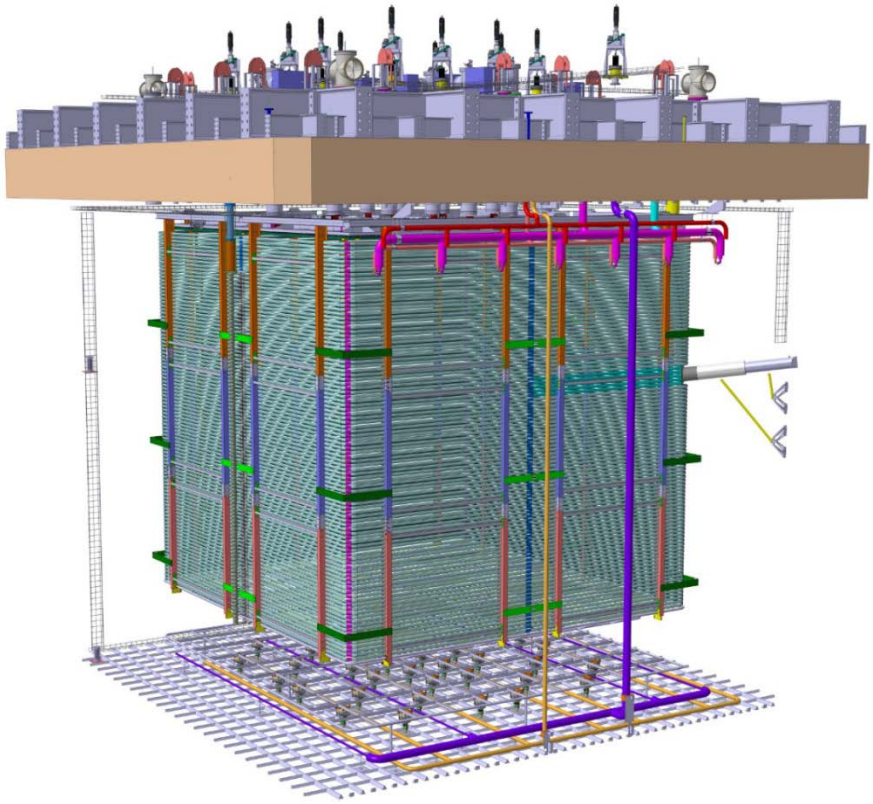


Figure 1: Picture from the ProtoDUNE-DP design review. 3D view of the ProtoDUNE dual-phase detector integrated in the cryostat, including the penetrations in the cryostat roof, the cryogenic piping the cable trays in the cryostat corners and the corrugated membrane on the floor

The ProtoDUNE dual-phase Technical Design Review took place at CERN on April 24–25. The agenda and the slides of the review can be accessed at: https://indico.cern.ch/event/617300/. The review scrutinized the overall project status and the installation procedures. Dedicated sessions were organized on three main sub-systems of the detector: 1) CRP, electronics and DAQ; 2) light readout and slow control; 3) Cathode, drift cage and high voltage. Each session was subdivided in two parts dealing respectively with the design and with the production readiness and QA/QC aspects. The discussions at the review were quite lively and constructive. In the report written by

the review committee it was mentioned that: “The committee appreciated the impressive amount of work done by the ProtoDUNE-DP team in preparation for this Review. The Team has nearly completed the final design of all TPC and PDS components. Procurement of the most urgent parts has already started and vendors have been properly identified. The Technical Design is well advanced and the Committee supports proceeding toward construction”. During the week of the design review the construction of the sub-module zero of the Field Cage was also ongoing at UTA (see Fig. 2). It had as major goal the qualification of the companies producing and machining the FRP I-beams which provides the supporting structure in which the extruded aluminum profiles, constituting the equipotential rings of the race-track are inserted.

Figure 2: Construction of the sub-module zero of the field cage for the qualification of the FRP I-beams production companies.

Far Detector — J. Stewart

Progress has been made on updating the Interface Control Documents (ICDs) for the far detector. The revised ICDs will be review at the joint LBNF/DUNE workshop on May 18. The cryogenic monitoring plan has made progress and a draft should be available soon. Work on understanding space requirements has been slow due to lack of engineering resources. The critical regions of the far site CF model have been extracted from the integrated LBNF/DUNE model and imported into a local model at ANL. Work on inserting detector components into this model and studying the motion of components during installation has started. The goal of this exercise is both the improve the installation planning and also to provide stay clear regions to the far site CF. A good understanding of the space needed for detector installation is required for the final CF design which will start in the June-July timeframe. Figure 1 shows the reduced far site model and an APA transport box being moved into position for installation. There has been no progress on the detector support structure due to lack of resources.

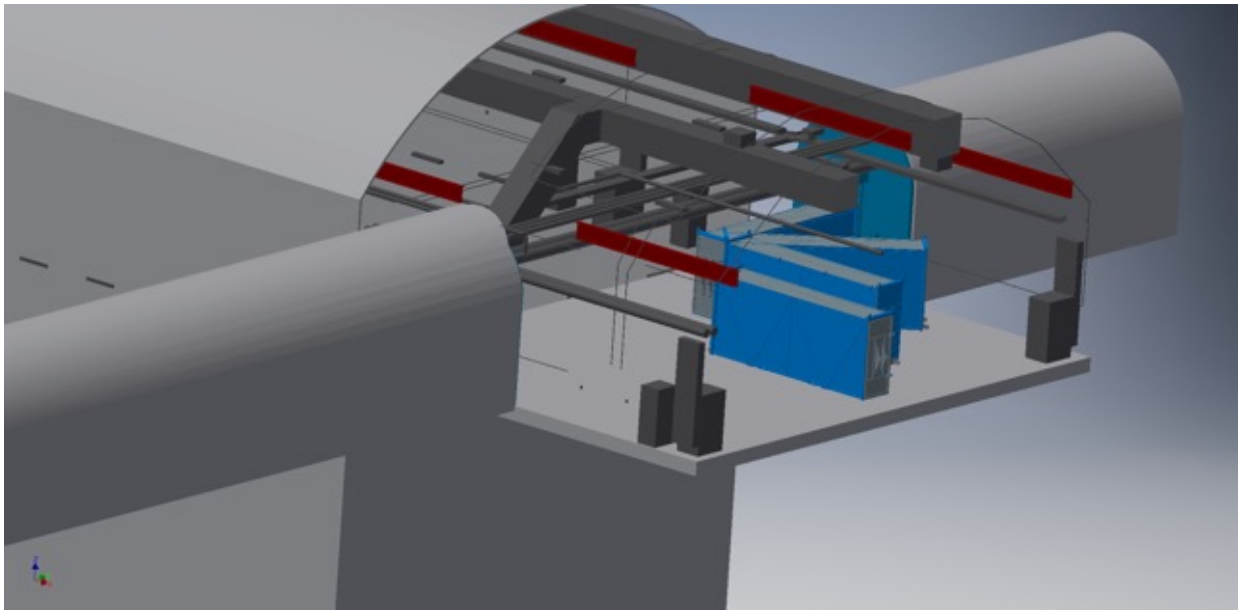


Figure 3: Extraction of the current cavern model (exported from NX) containing ducting, piping and rails, which is then imported into AutoCAD Inventor. The APA transport boxes are added from the Far Detector models and work on understanding the installation motions has started

Near Detector K.-B. Luk

As the Near Detector Task Force winds down, the Near Detector Physics Working Group is taking over the task. They began to work with the Long Baseline Working Group in identifying the remaining issues to establish requirements for designing the near detector system. This joint effort meets on Friday weekly, focusing on technical detail. The other weekly meeting on Monday is used for discussing scientific progress.

The joint effort agreed to have only two fitters using the near and far detector measurements to determine the CP reach. One fitter is Valor which is being ported from T2K to DUNE. The other one is CAFAna, a fitter developed by Caltech for the NOvA analysis. Apparently, the latter one is relatively easy to get adopted. Caltech and Berkeley have teamed up to modify CAFAna for DUNE.

In parallel with this long-term effort, Stony Brook and BNL are adopting some T2K software packages for doing quick studies of different near-detector configurations. The output of this modified package coupled with a neutrino-interaction generator can be input to GEANT4 for detailed simulation. The general feeling is that this effort would be useful for comparing the performance of different near-detector designs in 2017.

Chris Marshall reported his follow-up study on ν_e elastic scattering after the March ND Workshop. He concluded that the divergence of the neutrino beam will be significantly worse than the angular resolution of any of the three detector technologies (Fine-grained Tracker, Gaseous-argon TPC and Liquid-argon TPC). As a result, it is unlikely that we can extract precise enough spectral information of the neutrino events from ν_e elastic scattering for DUNE.

In response to the findings of Chris Marshall, Sanjib Mishra reported on the possibility of using coherent charged-pion charged-current events to pin down the incident neutrino beam direction. However, there were concerns about various kinds of background that would compromise this promising process. Further work is needed to clarify how serious the background would be in DUNE.

Alan Bross presented a fairly detailed talk on his thoughts on gaseous-argon TPC. He pointed out that this technology is mature. Thus, no R&D on this option is needed. With a total

argon mass of 0.9t, there would be about 10 million charged-current events collected in 3 years of running. He also roughly cost out a superconducting solenoid for the TPC. With a field of 1T, inner diameter of 3m and 5m in length, the cost of the magnet would be less than $20M. He has been talking to ALICE colleagues to see if the ALICE TPC could be moved to Fermilab for beam studies after it is replaced with an upgrade in the future.

Alfons Weber (Oxford and RAL) has been appointed as the co-coordinator of the DUNE Near Detector Design Study group. He and Kam-Biu Luk will work together in guiding the effort until the final concept of the near detector system is adopted by the DUNE collaboration in January 2018.

Project Office — P. Novakova

The cost performance index changed from 0.91 to 0.93. There is slight improvement in the cost variances in APAs, CPAs and Photon detector. The CPA/FC negative cost performance index also improved from negative 86% to negative 70%. The positive cost variance in the ProtoDUNE Cold Electronics dropped from 26% to 22%. It would have dropped even more but some of the cold electronics purchases were stopped due to insufficient funds in April. The schedule performance index is almost constant at 0.96 which is very important having in mind the tight ProtoDUNE schedule.

The APA #1 wiring and tension tests stay unchanged mostly due to eliminating the 20-day cryo test at PSL. The APA#2 frame fabrication has been delayed by more than a month and has now become a critical path activity; however, it does not delay the installation at CERN since the cryo tests have been eliminated. The detector support structure (DSS) design and procurement has been delayed again and will be delivered at CERN in 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.

The UK winding machine components have been assembled in Daresbury. The commissioning of the winding machine is likely to be completed in mid-May — delayed by ~1 month. The winding of UK APA#1 is scheduled to start on May 17. The fabrication and testing of the APA#1 frame is expected to finish on May 13. Good progress has been made even though some activities are behind schedule.

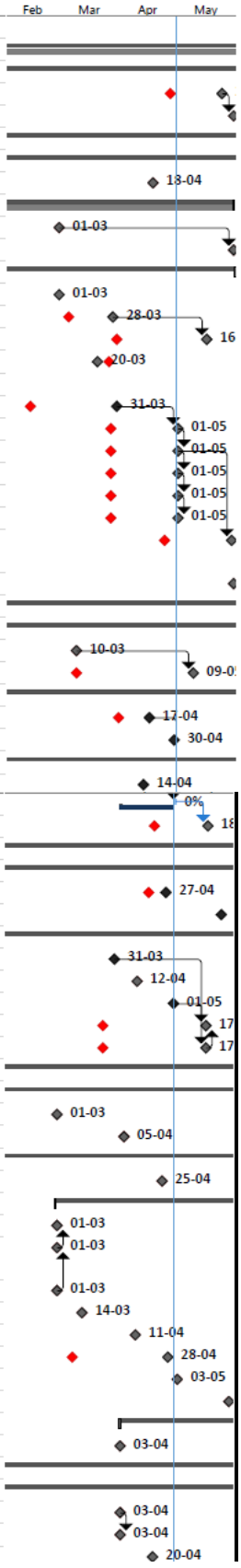
One concern is how to keep the ProtoDUNE international schedule in synch with the Primavera schedule. A few options have been discussed; effort to make the synchronization process automatic continues. The DP team reported that the 1x1x3 had to be warmed up to evaluate an area that was frozen, and then cooled down again. The team is in a process of revising the schedule and will provide an updated schedule as soon as the revision is complete. Table #1 below shows the impact on our two 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-Jun-17	N/A	24 April 2018
APA#2 Frame Fabrication Complete	31-Jan-17	2-Jun-17	N/A	24 April 2018
UK Winding Machine Commissioning Complete	2-Jan-17	17-May-17	27 Sept 2017	1 May 2018

Table 1: Key milestone watch for April

ProtoDUNE_InternationalSchedule_AprilStatus_v.1.mpp

ID	Task Name	Finish	Baseline Finish	% Complete	Predecessors
1	**ProtoDUNE-SP**			**50%**	
80	**Cold Electronics**	**Thu 31-08-17**		**99%**	
99	**ADC ASIC**	**Mon 03-07-17**		**0%**	
102	ADC ASIC production complete	Wed 24-05-17	Fri 28-04-17	0%	106
100	ADC ASIC for APA 1-3 testing complete	Wed 31-05-17	Wed 31-05-17	0%	102
91	**FE ASIC**	**Fri 30-06-17**		**0%**	
83	**FEMB**	**Thu 31-08-17**		**0%**	
84	FEMB PRR complete	Tue 18-04-17	Tue 18-04-17	100%	90FS+42 days
117	**WIB**	**Wed 31-05-17**		**99%**	
119	WIB delivered to CERN	Wed 01-03-17	Wed 01-03-17	100%	118
122	WIB testing complete	Wed 31-05-17	Wed 31-05-17	0%	119
107	**Feedthru/Cables/Power Supplies**	**Thu 01-06-17**		**0%**	
110	Feedthru mechanical design finished	Wed 01-03-17	Thu 30-06-16	100%	
111	Feedthrough PRR complete	Tue 28-03-17	Mon 06-03-17	100%	
112	Feedthru fabrication complete	Tue 16-05-17	Fri 31-03-17	0%	111FS+35 days
82	BNL Cold El integration test stand operational	Mon 20-03-17	Mon 27-03-17	100%	
123	**Photon Detector**			**0%**	
134	Production readiness review complete	Fri 31-03-17	Tue 14-02-17	50%	
130	Begin ProtoDUNE PD module assembly	Mon 01-05-17	Mon 27-03-17	0%	134
133	Dip Coated Bar production complete	Mon 01-05-17	Mon 27-03-17	0%	130
137	WLS plates fabrication/test complete	Mon 01-05-17	Mon 27-03-17	0%	133
138	PD cables ready to ship	Mon 01-05-17	Mon 27-03-17	0%	137
142	Light guide bars procure/test complete	Mon 01-05-17	Mon 27-03-17	0%	138
136	Dip Coated Bar testing complete and shipped to CSU	Mon 29-05-17	Mon 24-04-17	0%	133FS+20 days
144	SSPs ready to ship	Wed 31-05-17	Wed 31-05-17	0%	
46	**CPA/FC/HV**	**Fri 17-11-17**		**0%**	
47	**CPA**	**Thu 24-08-17**	**Tue 22-08-17**	**0%**	
59	Parts for CPAs procured	Fri 10-03-17	Fri 10-03-17	100%	
50	Parts for CPAs machining complete	Tue 09-05-17	Fri 10-03-17	0%	59
60	**FC Top/Bottom**	**Thu 31-08-17**		**0%**	
61	Production readiness Review complete	Mon 17-04-17	Fri 31-03-17	100%	48
69	FC top/bottom production facility available	Sun 30-04-17	Tue 10-01-17	100%	
71	**FC End wall**	**Fri 03-11-17**		**0%**	
75	FC Endwall production facility available	Fri 14-04-17	Tue 10-01-17	0%	
72	Production readiness review Complete	Mon 01-05-17	Mon 03-04-17	0%	61
79	Procurement of FC EndWall FC materials complet	Thu 18-05-17	Thu 20-04-17	0%	72FS+13 days
2	**APAs**	**Thu 04-01-18**		**0%**	
3	**APA 1-3 US Deliverables**	**Thu 04-01-18**	**Fri 13-10-17**	**0%**	
14	APA Production Readiness Review	Thu 27-04-17	Tue 18-04-17	100%	
12	APA frame #2 complete with mesh	Fri 26-05-17	Fri 06-01-17	99%	10FS+5 days
25	**APA 4-6 UK Deliverables**	**Wed 22-11-17**		**0%**	
45	Winding machine components available	Fri 31-03-17	Mon 02-01-17	100%	
34	Transport containers ready	Wed 12-04-17	Wed 12-04-17	0%	
27	APA Frame 4 completed	Mon 01-05-17	Mon 02-01-17	0%	
35	APA #4 Start winding	Wed 17-05-17	Fri 24-03-17	0%	44,27
44	Winding machine commissioning complete	Wed 17-05-17	Fri 24-03-17	0%	45FS+34 days
168	**Trial Assembly - Ash River**	**Fri 09-06-17**		**0%**	
228	**Instrumentation**	**Thu 05-04-18**	**Thu 05-04-18**	**0%**	
231	Complete test of LED light source option at UH	Wed 01-03-17	Wed 01-03-17	100%	
232	Complete tests at Fermilab using large cryostat	Wed 05-04-17	Wed 05-04-17	0%	
172	**Installation**	**Thu 29-03-18**		**0%**	
174	Installation review complete	Tue 25-04-17	Tue 25-04-17	100%	
148	**DAQ ProtoDUNE**	**Fri 15-12-17**		**0%**	
151	DAQ Computing topology defined	Wed 01-03-17	Wed 01-03-17	100%	152
152	Partition DAQ into APA testing and development branches	Wed 01-03-17	Wed 01-03-17	100%	153
153	Dataflow 10G switch installed	Wed 01-03-17	Wed 01-03-17	100%	
150	Basic Run control for APA test	Tue 14-03-17	Tue 14-03-17	100%	
155	Computing hardware validated	Tue 11-04-17	Tue 11-04-17	100%	
154	RCE ready for APA testing	Fri 28-04-17	Thu 09-03-17	100%	
156	SSP Board Reader ready	Wed 03-05-17	Wed 03-05-17	0%	
157	DQ monitoring v.2 ready	Tue 30-05-17	Tue 30-05-17	0%	
145	**HV Test**	**Tue 25-07-17**	**Tue 25-07-17**	**0%**	
146	HV Test Phase 1 Complete	Mon 03-04-17	Mon 03-04-17	0%	
239	**ProtoDUNE-DP**	**Mon 02-04-18**		**0%**	
295	**EHN1 Milestones**	**Fri 27-07-18**		**0%**	
299	Complete membrane cryostat DP	Mon 03-04-17	Mon 03-04-17	0%	
300	Clean room available DP	Mon 03-04-17	Mon 03-04-17	0%	299
298	Clean Room Installation Complete SP	Thu 20-04-17	Fri 13-01-17	0%	



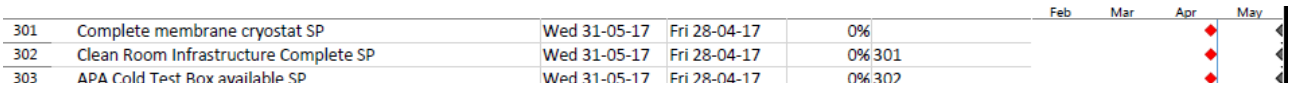


Figure 4: April status of the DUNE Project schedule