DUNE Project
Monthly Status Report
February 2017

Version 6: March 21, 2017

A ProtoDUNE-SP risk workshop was held 3 February at FNAL. A ProtoDUNE-DP risk workshop is tentatively planned for April 25 at CERN. The 2017 DOE IPR for LBNF/DUNE was held at FNAL at the end of the month: February 28 – March 2. Dates for design reviews and an installation workshop have been confirmed for mid-April. Production Readiness Reviews for ProtoDUNE-SP have started. There has been good technical progress this month.

Single-Phase ProtoDUNE Construction — G. Rameika

Winding APA#1wires continued throughout the month. The X-planes were completed without incident, but problems with tensioning tolerances developed when winding the first half of the V-plane. This introduced a delay in order to repair the under tensioned wires and as of the end of the month, we had not yet completed this first half plane. (Management visited PSL on March 7 and discussed a mitigation plan to try and get back on schedule. Final measurements of the V-plane tension will indicate whether the problem is solved.)

The cold box for testing the U.K. APAs arrived at Lancaster and work on preparing it has begun.

The first Production Readiness Review (PRR) was conducted for the CPAs. Following this, materials for the CPA frames were ordered and drawings and documentation were updated. Two CPA panels were assembled for a cold test in LN_2 at BNL and surveyed for variation in shape after cooldown and warmup.

Materials have been ordered for the Module 0 field cage panels.

Test boards and front end ASICs were sent to Michigan State. A quantity of 40 P1ADCs is at BNL undergoing testing to determine the statistical yield of chips that would be acceptable to use in the detector.

Good progress was made on the dipping station for the photon detection dipped acrylic bars. The question of SiPM tolerance for cold operation remains open. We are trying to procure enough of the old production type as well as determine if the new ones are actually robust from cracking when mounted on the production hover-board.

Much work continued on design and calculations for the Detector Support Structure as well as design of trolleys, hinges and latches. As materials become available they are tested at Ash River.

During the month of February good progress was made on both the DAB (electronics) and PC4 (high voltage) test stands. DAB is at the state that preliminary measurements can be made. The first customers are 35-ton following up on some of the noise problems encountered during the short run. Both SBND and ProtoDUNE electronics will be set-up here and tested over the coming months. We are still waiting on the installation of an isolation transformer so that the tests can be conducted with grounding the same as will be in the real detectors.

The PC4 test installation was completed and nearly ready for buttoning up the cryostat. The voltage was raised to 40kV in air with no problems observed. The cool down should start in early March and we anticipate being ready to start the real test by about the third week of March.

Single-Phase ProtoDUNE Installation — F. Cavanna

A DOE LBNF/DUNE Independent Project Review took place at FNAL February 28 – March 1. ProtoDUNE-SP was reviewed in the Detector Session — Main Question was: *Are ProtoDUNE goals and schedule realistic?* [from the IPR Close Out] “Yes, the schedule to inform the TDR, LBNC review and CD-2 is tight but realistic.”

The next CERN SPSC meeting will take place in early April: answers to questions from the SPSC were submitted and a TDR revision is under way.

Activity onsite (EHN1):

Half of the membrane insulation installation is complete, clean room material procurement in progress, cold test box design is complete and material procurements is ready to start, grounding and electrical layout is progressing (safety document nearly completed) and the procedure for the integrated APA tests in Cold Box and data read-out is actively under ddevelopment.

Instrumentation:

Beam Instrumentation: progress is reported on the CERN Tracking Fiber detectors (also possibly used for ToF), Cherenkov counter(s) and FNAL/ANL pLAPPD ToF (test in LArIAT test beam started). DAQ and data storage for all these beam detectors is under study.

Cryo-Instrumentation: two vertical temperature gradient monitors are planned, based on designs developed at U-Hawaii and IFIC-Valencia. Progress with the internal Webcam Monitors (W&M) was reported based on development for the 35-ton HV-test installation.

External Instrumentation: mechanical tests of the muon tagging paddles are underway. Design of the frame for (4) paddles to make a "CRT module" is in progress at U-Chicago, the support structure is under discussion. Shipment of the paddles (from Strasbourg, Double Chooz experiment, to CERN) is delayed until April due to the temporary unavailability of storage at CERN

DAQ and Data Reconstruction & Analysis:

The DAQ Vertical Test Stand for the APA test in the Cold Box is progressing, a detailed plan with prioritized Calibration tasks, Detector Performance Measurements and first Physics Measurements: is almost completed, the (new) MC production is not started yet (input beam fluxes are being further optimized).

Great progress is reported with EM and hadron shower reconstruction by new CNN-based algorithms for EM component identification, combined with efficient (traditional) algorithms (TrajCluster+PMA, Pandora...) for hadron track reconstruction and primary vertex identification.

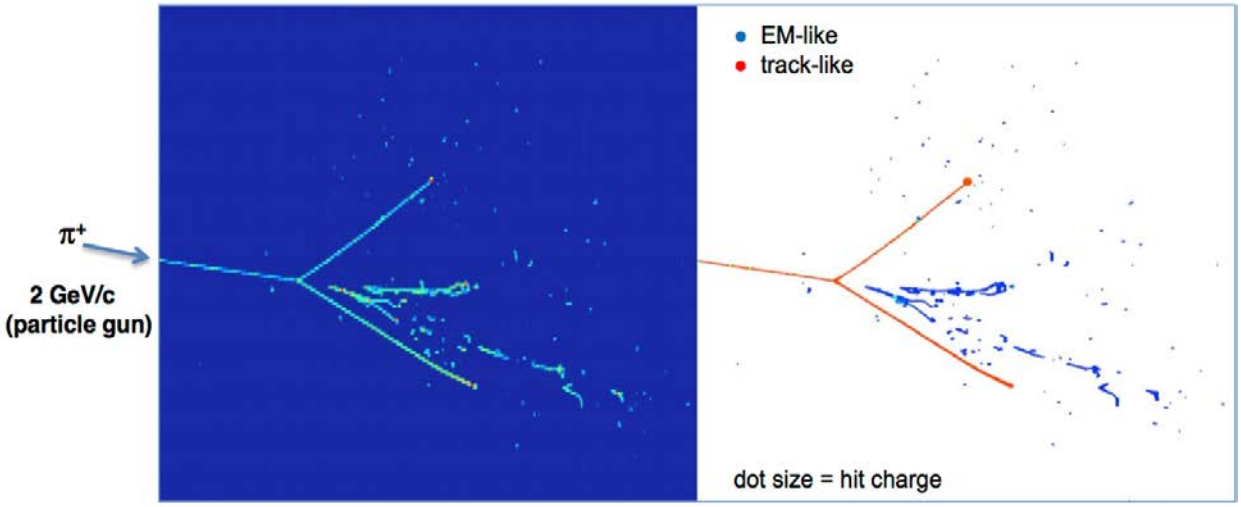

Figure 1 ProtoDUNE-SP Monte Carlo beam pion interaction with Convolutional Neural Network reconstruction overlaid.

Figure 1 shows a ProtoDUNE MC event with a beam pion entering the TPC active volume and undergoing a hadronic interaction is displayed together with the corresponding CNN output showing the recognized EM-like component in the event (blue) from π^0 conversion.

The open loop purge of the 3x1x1 detector reached a level of 1.5 ppm oxygen, 5 ppm nitrogen and 50 ppm water (similar to the 35 ton open loop purge) by the end of January and the closed loop purge (February 8–15 corresponding to 80 volume changes) reached 0.2 ppm oxygen, compatible with the sensitivity of the measurement. The cool-down phase started on February 15 but some gas pockets in the liquid nitrogen line prevented stable liquid nitrogen flow in the condenser. The line had to be modified by adding a purging valve at the input of the condenser. This delayed the cryogenic system commissioning by ~1.5 weeks. The cryostat cool-down started on February 27 and was expected to last about one week before filling with liquid argon.

Impurities in the gas were constantly monitored during the open-loop purge, closed-loop purge and during the LN_2 line repair and cool-down as can be seen in Figure 2.

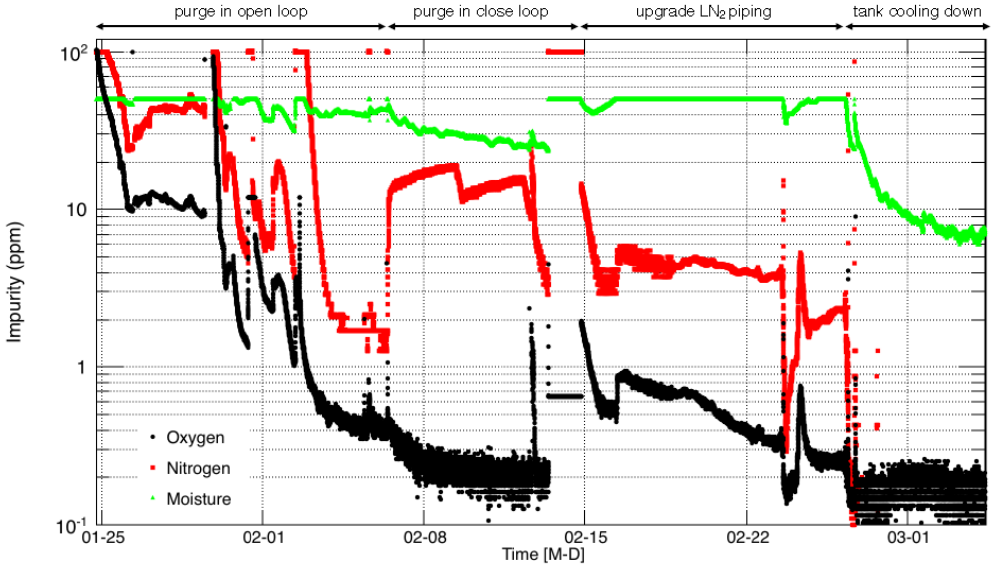

Figure 2: Evolution of the gas argon purity conditions from the start of the cryostat purge until cool-down

The good purity of the Ar gas was confirmed by measurements of the slow component of the scintillation light with the photomultipliers mounted below the cathode (see Fig. 3)

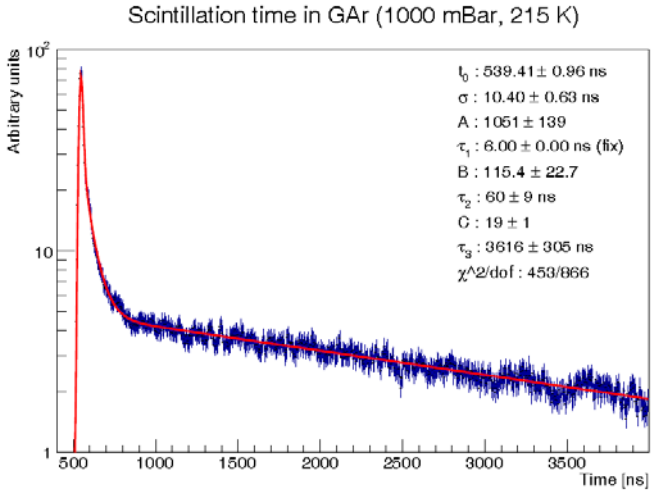

Figure 3: Fit of the slow component of the scintillation light produced in gas argon corresponding to a measurement performed at the end of closed-loop recirculation

Additional work on cabling and grounding further reduced noise levels on all connected sub-systems with respect to that reported in January. The RMS noise averaged on all channels with all systems active was 1.7 ADC counts, compared to 2.4 ADC counts of the previous report. Figure 4 shows the RMS noise per channel with and without the slow control and HV systems connected.

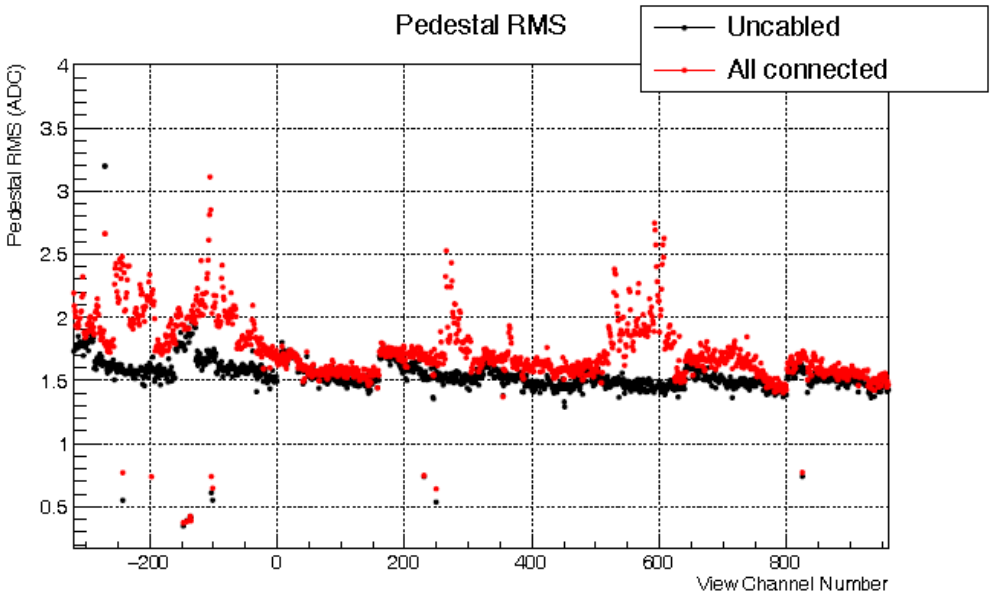

Figure 4: 3x1x1Noise measurements with and without the slow control and high voltage connected.

Preparation of the 6x6x6 cryostat continued smoothly with the installation of the roof penetration pipes and completion of the assembly of the steel exoskeleton (see Fig. 5)

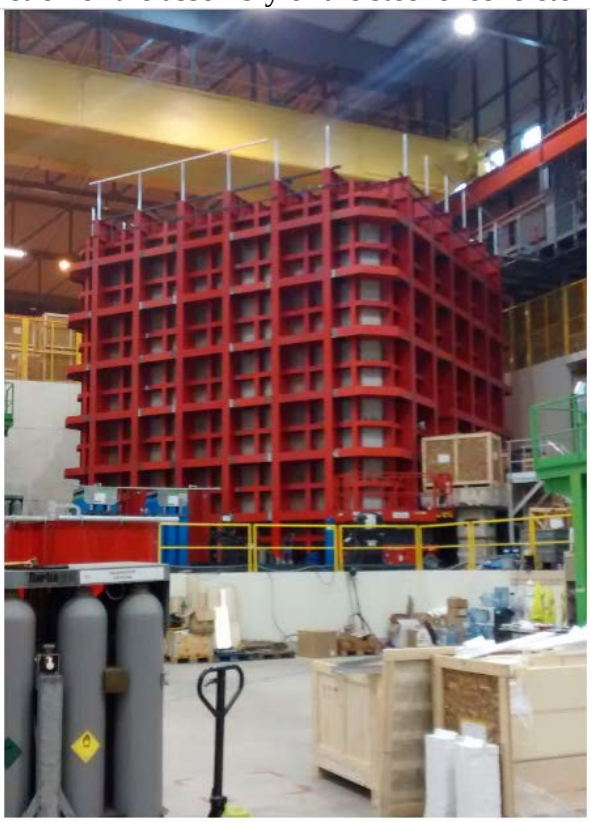

Fig.5: Completion of ProtoDUNE-DP cryostat exoskeleton assembly.

Ross Cage Design

An alternate design for the Ross Cage is being considered. As all dual-phase components and most single-phase components will fit in a 3.5 m high cage there is an advantage to having the cage at least this high. Investigation of a 4m high cage to accommodate the single phase top/bottom field cage units is planned. An alternate, which preserves the 3.5 m option, is to make special provision to connect the top/bottom field cages to the work deck above the new cage. The dimension of the field cage transport boxes match well to the space available on the work deck platform and can be connected so the hoist rope is unimpeded. The general configuration is shown in Fig. 6. Details of the work deck and how one will load the boxes on the deck need to be worked out.

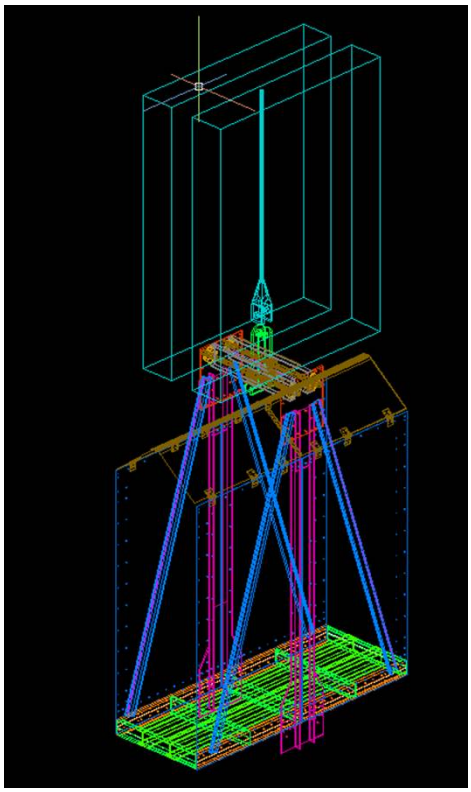

Figure 6: Sketch of the 3.5 m high Ross cage with the top/bottom field cage transport boxes mounted where the work deck will be.

Studies for routing the lower single-phase APA cables

Investigations have continued on the optimum concept to route the lower APA cables to the cryostat roof flanges. A prototype of the cable routing through the end of the APA was constructed using a rapid prototype of the APA corner and the planned cables. The conclusion of this test was that it will not be possible to route all the APA and photon detector cables through the side tubes of the APA. A photo of the cable test is shown in Figure 7. Tests were performed to determine if cables long enough to run along the cryostat floor and up the cryostat wall are adequate to transmit the data from the cold electronics at the bottom of the cryostat to the warm interface crate above the roof. The cable length was estimated to be less than 35 m. The cable tests were performed at room temperature on 35m cable samples from Samtec, Hitachi, and Paralink (see Table 1) using an FPGA for data transmission, which was set to maximize the cable compensation. If required one could

possibly use the higher gage gore Twinax cables for the lower central APA but this would require testing and 35 m gore cables were not available and are known to be expensive. Given the poor results from the data transmission test it was decided to focus in the short term on determine if it will be possible to route part of the cables through the central APA tube and a fraction through the side tube.

Figure 7: Photograph shows the cable bundle needed for the lower APA running through the corner of the APA side tube. It was not possible to fit all the photon detector cables through the opening and still have space for the link connecting lower and upper APA.

Maker	Gauge		Test frequency (GHz)	Temperature	Pre-emphasis(PE)	Active Equalization used	Result
Samtec	26 stranded	35m	1.3	R.T.	17	Yes	Multiple errors in 10^{13} bits
Leoni Paralink	24	35m	1.3	R.T.	17	Yes	Multiple errors in 10^{13} bits
Hitachi	26	35m	1.3	R.T.	17	Yes	Multiple errors in 10^{13} bits
Hitachi	23	35m	1.3	R.T.	17	Yes	Multiple errors in 10^{13} bits

Table 1: The table summarizes the results of the 35m cable tests. Bit errors were seen in tests where 10^{31} bits were transmitted.

Cryostat Integration

Work progresses slowly on the definition of the cryostat roof penetrations due to insufficient engineering. The focus has been on working with scientists to clarify issues in advance of the start of engineering. In order to facilitate this, the biweekly Far Detector Meeting will be used as a Single-Phase Far detector meeting which will concentrate on topics related to the cryostat design.

The first meeting had presentations summarizing the work needed for the cryostat interfaces and a presentation on calibration concepts.

Near Detector — K.-B. Luk

The Near Detector Task Force has completed the last run-throughs of the analysis chain. These results, the most sophisticated so far, are applied to the simulated far detector data to determine the CPV sensitivity. In addition, these results can be used to guide the design of the near detector. The Task Force is on track to release their final report to the collaboration in March 2017.

The Near Detector and Near Detector Physics working groups held several phone meetings to discuss how to specify the scientific requirements for designing the near detector system. The interested parties narrowed down to five key physical processes that should serve as 'standard candles' for evaluating different conceptual designs of the near detector.

The Gaseous Argon TPC working group continued to work on developing a new GEANT4-based simulation package called GArSoft that can be used for studying different detector configurations. The simulation can now provide a toy digitization of ionization signals in the TPC. The reconstruction effort is progressing nicely and TREX should be ready to provide reconstruction algorithms soon.

The Near Detector working group is preparing an agenda for the upcoming Near Detector workshop at Fermilab on March 27–29.

Project Status — P. Novakova

The performance trend in the last months is almost constant. The cost performance index changed from 0.94 to 0.95. The negative cost variance in CPA/FC has a minor improvement; the positive cost variance in the ProtoDUNE Cold Electronics is slightly neutralized. The schedule performance index has changed from 0.95 to 0.96. The wiring of the V plane on APA#1 has slipped a few days; the tension test will start on March 6. This is causing a 3 day delay in the final installation at CERN. The frame fabrication of APA#2 has been delayed by a few weeks but this will not cause delays of the installation if the wiring starts right after the APA#1 wiring is completed. The detector support structure (DSS) design and procurement has been delayed again and will be delivered at CERN in the end of June. Although this delay does not affect the TPC installation it has to be closely monitored since it can become a critical path activity soon.

Many of the key winding machine components have been received and are being assembled in Daresbury. The commissioning of the winding machine is likely to be completed by March 31. This will cause delay in the APA#4 wiring start date which now has slipped to April 3. Fabrication of the APA#4 frame is expected to finish on March 24. The cryo test tank has been assembled and is available for testing. Clean room installation has been completed. Good progress has been made even though some activities are behind schedule. The DP team found a problem in the 1x1x3 cryogenics which has caused a delay in cooling down the detector. The team is working on schedule revisions. Table 2 shows the impact that the delays will have on two important milestones.

The ProtoDUNE international schedule has been reviewed by the DOE Independent Project Review in February although it was not the main focus of the review. The schedule committee members expressed concerns about maintaining two separate schedules and synchronizing them. This is also the concern of the project office; however, discussions are still underway to implement an automatic synchronization process that will eliminate these concerns.

Milestone	Original Date	New Date	Impact on	
			UK APA 1 Delivered	Close TCO
APA #1 Winding and tension testing complete	24-Mar-17	29-Mar-17	N/A	3 days delay (20 Mar 2017)
UK Winding Machine Components Available	2-Jan-17	31-Mar-17	2 months delay (13 Oct 2017)	2 months delay (23 May 2017)

Table 2: Impact of milestones that slipped in February

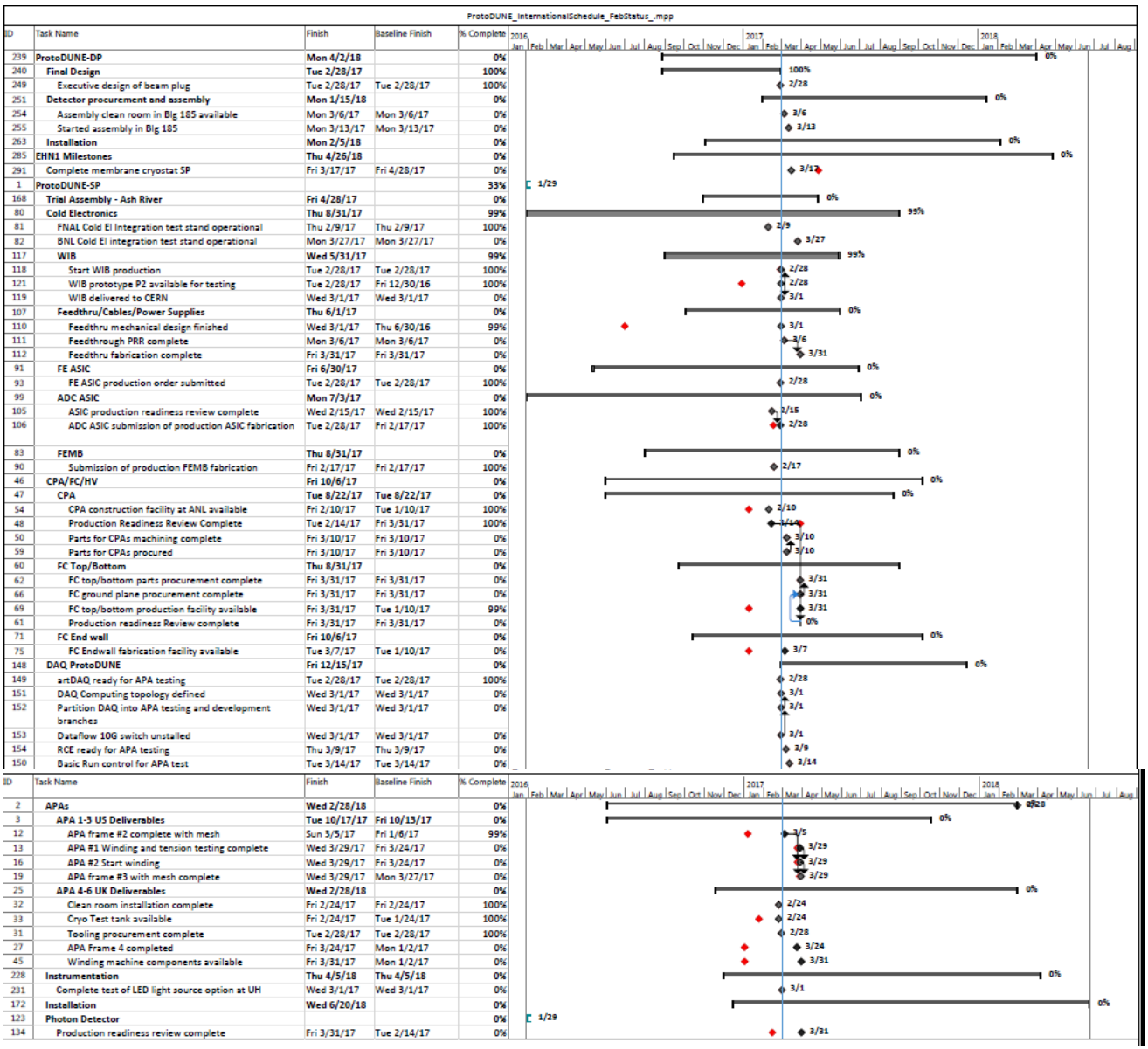

Figure 8: The February status of the DUNE Project schedule