LBNC Closeout Report: June Review (February 18-21, 2018)

Contents

Executive Summary [All]

The LBNC met at Fermilab, February 18-21, 2018, primarily to assess progress and planning for the DUNE Technical Proposal and to review progress with the protoDUNE projects at CERN. In addition to plenary presentations by consortium leaders and related discussion, the meeting included "referee subgroup" breakout sessions to focus in more detail on preparation for the Technical Proposal. For this purpose the LBNC referee subgroups were re-organized to provide better coverage of technical systems: (1) DUNE-SP, (2) DUNE-DP, (3) DUNE Physics and Reconstruction, (4) DUNE Computing, (5) LBNF/DUNE Cyrogenics, (6) LBNF management, schedule, and planning, (7) LBNF/DUNE Interfaces, and (8) DUNE management, schedule, and planning. For the next meeting two other subgroups will be established to cover (9) Beamline design and optimization and (10) Near Detector. Further details on the composition of the subgroups are provided in Appendix 1. In addition, while the protoDUNE projects are still active, the DUNE-SP and DUNE-DP subgroups will continue to monitor their progress, while also covering the relevant consortia for the far detector design and planning.

LBNF:

Overall, the Committee was very impressed by the significant progress achieved by both LBNF and DUNE since the last LBNC review in October 2017. Of particular note for LBNF, following signing the CM/GC contract, Kiewit/Albicini Joint Venture (KAJV) has conducted site surveys in anticipation of final design kickoff with the A/E firm ARUP. The CM/GC is also packaging work requirements for the pre-excavation work at the far site. A number of issues have arisen in moving the ARUP contract from SDSTA to FRA, most recently in the area of liability and insurance which are now close to resolution. The project anticipates resuming design work in March 2018. Ross shaft refurbishment is currently focusing on rock handling infrastructure between the 4850 and 5000 foot levels, but this work was recently stopped as a result of a working platform safety incident in January 2018. CERN has also developing a design contract with the membrane cryostat manufacturer, GTT for the far site cryostats, based on a common steel frame design and detailed specification of the top surface penetrations for the single and dual phase TPC designs.

There are a number of new and unusual procurement, liability, real estate, and tax issues that have been and will continue to be worked by LBNF, FSO, and DOE HQ. These problems are well recognized and continue to be addressed, but the resulting accumulated delays in resolving paths forward are worrisome. The committee welcomes the creation of a Host Laboratory Working Group to identify and discuss the requirements of operating an international laboratory across several sites (SURF and Fermilab) and stakeholders. Five sub-groups have been struck: Business and Liability, Fermilab-SURF relationships, International Laboratory, LBNF/DUNE Project Support and User Interactions. Business continuity plans, tax issues, and SURF costing model are being developed within the context of the Host Laboratory Working Group and sub-groups. A new business model for SURF operations has been developed by FRA, SDSTA and DOE, based around direct costs, direct and indirect cost pools. Pool costs are based on ultimate area utilization. This model will be adopted in FY 2019.

LBNF management presented a schedule of major tasks that must be completed prior to the start of excavation. The schedule has 7 critical or near-critical task sequences and every one of these task sequences depends on major contracts being placed in a timely manner. A further complication is

Fermilab's procurement authority is presently at $5M, and raising this authority with FSO would require a focused effort on demonstrating the integrity of and improving procurement systems and controls. The performance issues include quality, competency, and capacity, and Fermilab states that they are actively looking to increase procurement resources. The safety incident with the Ross shaft is a timely reminder of the risks and hazards associated with mine operations and underground construction, particularly given the complexity of Fermilab-managed activities at a non-DOE site The committee considers the following to be the key short-term risks to LBNF. Addressing these risks will be key in meeting the start of excavations (Dec. 2019) and Near-Site scope by CD-2/3B.

- The ability to successfully place contracts in a timely fashion;
- The development of international partners for near-site work; and
- The complete formalization of Far-Site command, control, safety oversight and regulatory structures

The LBNC therefore expressed the following concerns:

> *[Comment] The committee is deeply concerned about the ability to conclude procurement actions. It continues to be clearly suboptimal and impacting schedule. We note that LBNF, FNAL, FSO, IRB and DOE-SC are working together and communicating on a biweekly basis, and look forward to progress in reducing the project schedule and cost risk to procurements. We note that within the year there are several million dollars of separate key contracts that must be placed in a timely manner to avoid delay of construction start.*
>
> *[Comment] As a consequence, the committee believes there is only a small probability of meeting the schedule for start of excavation as presented. This small probability is completely dependent on the ability to execute timely contracting. A determined effort by Fermilab to address this, which will likely include actively engaging outside contract support, is critical for increasing the probability of meeting this schedule.*

DUNE:

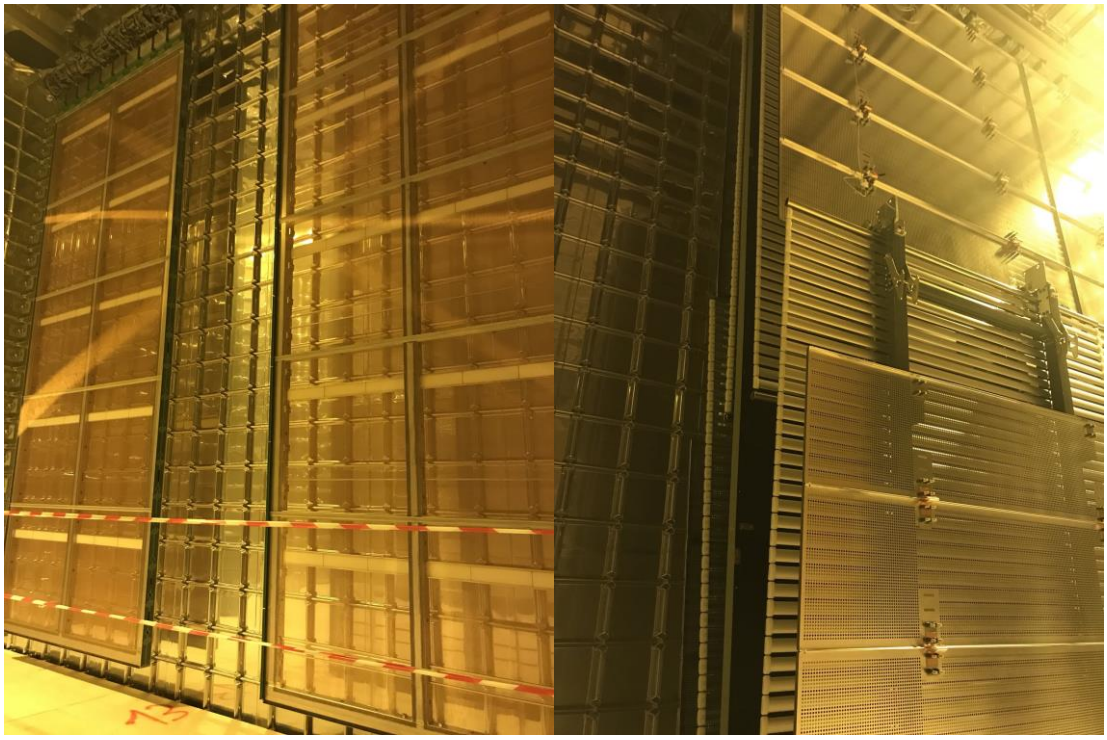
Equally impressive was the successful completion of the two protoDUNE cryostats at the Neutrino Platform at CERN, as well as the delivery to CERN of four out of six APA planes for protoDUNE-SP produced by PSL and the UK, along with readout electronics and photon sensors. Installation of photon detectors, testing of the DAQ system with full APA assemblies installed in the cold box has also proceeded well. While there have been unfortunate delays in commissioning the full DAQ system at CERN due to interface issues between the cold electronics and DAQ systems, these seem to be largely resolved at this point. Likewise field cage and cathode plane components have been assembled into modules and inserted into the cryostats.

The LBNC is also pleased to hear about the revised plans for protoDUNE-DP, which conservatively incorporates lessons learned from the 1x1x6 into the LEM, CRP and grid designs for the 6x6x6 in a way that appears to make possible cosmic ray running and validation in protoDUNE-DP in time to support the TDR. Further optimization of these designs, including the CRPs, will be possible now that a separate cold

cryo tank has been constructed for this purpose. Altogether this appears to be a sound strategy for incorporating experience from the 1x1x6 into future dual phase designs.

While there is thus good progress on assembling the elements of the protoDUNE TPCs at CERN, the committee did not hear about the organization of commissioning, testing, and beam operations and their organization, and so was unable to form a clear impression of planning in these areas. There is an overall concern about the critical nature of the protoDUNEs to the long-term strategy of DUNE and the Technical Design Report, particularly given the relatively short time between now and the production of the TDR. This places an emphasis on validating many of the engineering and systems performance features of the protoDUNEs, including the cryostat and cryogenic operations at scale. Therefore, the committee recommended:

- *[Recommendation] Clarify and communicate to all stakeholders the lead person for the ProtoDUNE integrated test. Establish and document ProtoDUNE test goals as a prioritized list integrated into a comprehensive test plan in the next six weeks and present to the Dune collaboration and the LBNC.*
- *[Previous recommendation from Oct 2017] "Ensure that the cryogenics performance testing is given priority on Proto-DUNE and sufficient attention to collect data, baseline simulations, and iterate as needed."*
    - *Assessment: should not be closed until a comprehensive integrated test plan is written and agreed upon within the collaboration. This plan should be presented at the next LBNC meeting and made available within the next 6 weeks*



Anode Plane Assemblies (APAs) (left) and field cage modules (right) stored and ready for assembly in place inside the protoDUNE-SP cryostat at CERN.

The DUNE Collaboration has continued to grow by attracting new Institutions (totaling now 1061 collaborators from 175 Institutions in 31 Nations) with about 300 FTE working on the project, including a healthy fraction of PhD students. Although there are no firm commitments, there is significant progress in negotiations with new prospective partners in Europe, South America and Asia, with particular interest for the Near Detector from Italy, Germany and JINR/Russia. The new organizational structure based on Far Detector consortia has been established in a timely manner for 8 out of the total 9 planned subsystems, including the appointment of leadership for them. These groups have now been operational for several months, with a focus at this point on the steps needed to produce a Technical Proposal by May. The recent Collaboration meeting at CERN (Jan 29 to Feb 2, 2018) was an important part of this process and an opportunity for consortium leadership to present their plans including a decision pathway and milestones. Consortia for the Near Detector will be defined at a future stage when appropriate. A new management structure has been proposed to the Institutional Board, which will see the evolution of the Executive Committee by May 2018 into a management and decision-making body bringing together the consortia leaders with DUNE top management. An Advisory Group will also be formed including 4-6 elected members as well as representatives from younger members of the DUNE collaboration. The LBNC recognizes that an extended transition period to this new structure is needed, but we would not want to see this completion date slip in light of many forthcoming important decisions.

The LBNC discussed proposed plans for the Technical Proposal as presented by DUNE management, the TP Editors, and the consortium leaders. While the committee still views these plans as very ambitious, it also agrees that the TP will allow the Collaboration to maintain full momentum for developing the project in a focused and timely fashion, including the detailed construction strategies and schedules for the various components. High level risks and mitigation strategies will also be identified and incorporated in these documents. As part of these efforts, the LBNC continues to recommend maintenance of a clear line of sight between physics and technical requirements:

> *[Recommendation from Oct 2017] At our next meeting, the LBNC would like to hear a proposed mechanism for documenting the flow down from physics to technical requirements in DUNE, as well as how this will be addressed in the TDR and be demonstrated with the protoDUNE test plan.*

In general, the committee is concerned that plans for systematically constructing these physics arguments do not appear credible or viable, nor do they appear high in priority with the consortia and physics groups. Very few of the detector consortia appear to have a clear interface to the relevant DUNE physics groups for example. Demonstration of the physics capability of the proposed DUNE detector will depend on consistent simulations with documented and understood performance capabilities. Therefore, the LBNC also recommends:

> *[Recommendation] For the next meeting, present a plan for detector studies for key parameters (e.g. higher noise, dead channels, lower operating voltage…) that are being considered from the flow down from physics to technical requirements to be included for Physics TDR. For those that will not be studied for the TDR a qualitative reasoning should be provided.*

The LBNC was also somewhat concerned by the reliance on overlapping personnel on protoDUNE and DUNE instead of more formal documentation in the transfer of knowledge and lessons-learned from the design, construction, and commissioning of the protoDUNEs. One particular lessons-learned is the critical importance of understanding interfaces and devising formal approaches and change controls for their management. This led to a recommendation:

> *[Recommendation] Present a plan at the next LBNC meeting that outlines the integration framework, roles and responsibilities of the DUNE Technical Coordinator, DUNE-US Project Director and consortia, and how they will recognize and resolve technical choices and interface issues.*

One area of ongoing concern for the LBNC is the planning for the computing model to support data reduction and analysis at DUNE. We note that the collaboration decided not to set up a computing consortium at this time as part of its recent re-organization for construction of the far detector. However, at the time of the TP and certainly by the TDR, there are several aspects of the computing model with significant cost implications, which will require definition. The current outline for the Software and Computing volume for the Technical Proposal is extremely detailed in terms of topics and seems too ambitious for the TP. A strong focus in the TP should be maintained on identifying strategic collaboration-level decisions that will impact the computing model such as overall organization, connection to physics requirements and the degree to which computing, software and infrastructure will be in-kind contributions from collaborating institutions. Additionally, there will be considerations based on the changes in the computing landscape and software development model.

> *[Recommendation] By February, 2018, develop a list of questions and factors that will influence the computing model, with prioritization of those factors in terms of likely cost and schedule impact.*

In our view, the S&C outline of the TP, intended as a response to this recommendation, is not sufficiently incorporated into TP planning. Some open questions with respect to the data volume, driven by DAQ considerations have been settled, and should be documented. We continue to urge the development of the list of questions and factors that will influence the computing model and document them for the TP.

Overall, we previously commented that *"Given the number of open issues, it seems prudent to extend the development time of the Computing "Technical Proposal" (TP) to August 2019."* and we continue to stand by this advice.

The LBNC has been concerned for some time about the design and technical status of the cold electronics system for DUNE, which is first deployed as a prototype system in protoDUNE-SP. The protoDUNE-SP implementation utilizes an ADC ASIC in the LAr at cold temperatures that has known flaws and does not meet requirements. The LBNC has therefore requested that the DUNE Collaboration develop a long-term robust strategy (potentially multi-pronged) for developing and testing at scale a system that meets requirements. DUNE has been working over the last few months to put in place such a strategy and a plan was presented at the October meeting. The plan includes development of a new standalone ADC ASIC in 65 nm CMOS through a multilab collaboration (BNL, FNAL and LBNL) as a part of the present three chip

design approach, as well as pursuit of a second system-on-chip pathway building on development for the future nEXO experiment to produce a single combined function ADC (incorporating front-end (FE) amplification, ADC, digitization and serialization of the output data stream (COLDATA), and optical line drivers with a design team at SLAC). In the case of the 3-chip development, the Design Group has delineated responsibilities across laboratories along with a plan to carry out internal "deep reviews" of the design. The baseline design is the three ASIC approach with separate FE, ADC, and COLDATA chips, but it is expected that the alternative combined function approach will also be presented in the Technical Proposal. A third approach based on commercial off-the-shelf (COTS) ADC solutions are being evaluated for SBND and are considered only as a backup plan for DUNE. While the LBNC continues to monitor this situation closely, we have no new recommendations at this time and instead offer the following comments:

[Comment] Having a 12-bit ADC with noise and linearity performance that meets the requirements defined by the DUNE physics program – and works reliably at cold temperature – is of the utmost importance to the experiment.

[Comment] While development for the 3-ASIC solution as the primary option is the top priority, and initial progress on this effort is positive, it is important to continue efforts on all of the options outlined.

[Comment] It is unlikely that a single solution will be identified at the time of the TDR, so it is important to establish selection criteria that are based upon physics priorities, cost and reliability.

[Comment] The multi-stage testing plan outlined makes sense. We encourage the collaboration to investigate ways to carry out additional "system level" tests, such as the planned use of a spare APA plane in the CERN cold box.

Finally, we note and welcome the formation of a calibration and monitoring task force for the far detector TPCs and look forward to hearing their report at our next meeting, as well as the impact of their advice on the TPC and cryostat design.

Section 1: LBNF Management, Schedule and Planning [Smith, Robinson, MacFarlane]

Findings:

- Ross shaft refurbishment now focusing on rock handling infrastructure between 4850 and 5000, but stopped as a result of working platform safety incident during January 2018
    - Work platform became jammed while descending
    - Hoist rope became slack, operator noticed and stopped movement quickly
    - Work platform became unjammed and moved ~20 feet down with slack rope; minor injuries sustained to the three workers on the platform
- The Continuing Resolution in FY2018 is still throttling available funds. The project expects between $80M – $82M, which are the House/Senate markup figures. Project is working to increase FY2018 funding to $95M. Cash flow is being managed.
- Remaining issues involved in moving the Arup contract from SDSTA to FRA are still to be resolved. Project anticipates resuming design work in March 2018.
- CM/GC contract has been let (Kiewit/Albicini Joint Venture); CM/GC has conducted site surveys in anticipation of final design kickoff. CM/GC is packaging work requirements for the pre-excavation work at the far site, prior to formally engaging with the A/E firm Arup.
- LBNF rejected the 90% Final Design submittal of waste rock conveyor engineering and fabrication, and is working with the Procurement and Legal on the path forward.
- LBNF management presented a schedule of major tasks that must be completed prior to the start of excavation. The schedule has 7 critical/near-critical task sequences and everyone of these task sequence depends on major contracts being placed in a timely manner.
- Fermilab's procurement authority is presently at $5M, Fermilab management stated that as a result of recent past performance, they cannot hope to increase this authorization from DOE any time in the near future. The performance has been both a quality, competency, and capacity issue, and Fermilab states that they are actively looking to increase procurement resources.
- CERN has initiated design contract with membrane cryostat manufacturer, GTT.
- Refining the convergence of the Single Phase and Dual Phase cryostat designs continue
    - Minimizing the differences between the roof penetrations between the SP and DP
    - Other 5 sides of the cryostat are expected to be identical (declared as "essentially" common at this time).
- The Far-Site Construction Coordinator has been hired, and the committee was pleased to hear that a Senior Procurement Administrator had accepted (one more procurement position is open)

- The near-site A/E contract will require rebidding.
- Acquisition plans for near site CM/GC contract is in development.
- The committee welcomes the creation of a Host Laboratory Working Group to identify and discuss the requirements of operating an international laboratory across several sites and stakeholders. Five sub-groups have been struck: Business and Liability, Fermilab-SURF relationships, International Laboratory, LBNF/DUNE Project Support and User Interactions
- Business continuity plans, tax issues, and SURF costing model are being developed within the context of the Host Laboratory Working Group and sub-groups.
- A new business model for SURF operations has been developed by FRA, SDSTA and DOE, based around direct costs, direct and indirect cost pools. Pool costs are based on ultimate area utilisation. This model will be adopted in FY 2019.
- The project has received a broad exemption for work in project scope from the DOE Senior Realty Officer, resolving transfer of property from DOE to SDSTA.
- LBNF has chosen to go with the optimized 3-horn / 4 interaction-length design for the beamline and absorb the added cost and complexity.
- LBNF is actively anticipating an additional partner for the optimized beamline configuration.
    - IHEP is engaged
    - Discussions are underway with KEK
    - High-Power Beam Workshop at CERN being planned
- Attempting to understand and clearly decide on Near Detector (ND) facility requirements in advance of planned CD-2 (Oct. 2019)
- The beamline design will likely only be at a early preliminary design stage at the expected time of CD-2. DOE understands and accepts this as being the result of the limited funding profile.
- In light of the considerable increase in electrical power consumption for LBNF/DUNE, the project is assessing the possibility of new rates with the local authority.

Comments:

- Root-cause analysis of work platform incident did not yield a single specific cause. Several factors were deemed to be in play, operations suspended until dogging system designed and installed on work platform. Prompt action by the hoist controller to limit the rope spill is highly commended, noting that the hoist control reliability project will remove the reliance on human control in these operations in the future.
- The committee is extremely concerned about the ability to conclude procurement actions. It continues to be clearly suboptimal and impacting schedule. We note that LBNF, FNAL, FSO, IRB and DOE-SC are working together and communicating on a biweekly basis, and

look forward to progress in reducing the project schedule and cost risk to procurements. We note that within the year there are several million dollars of separate key contracts that must be placed in a timely manner to avoid delay of construction start.

- The committee is deeply concerned by the small probability of meeting the schedule for start of excavation as presented. This small probability is completely dependent on the ability to execute timely contracting. A determined effort to address this, which will likely include actively engaging outside contract support, is critical for increasing the probability of meeting this schedule.
- The relevant tax situation between South Dakota and the project is better understood, and is being actively managed.
- The committee would like to see the charter, definition of the top priority items and drivers/timelines that each subgroup of the Host Laboratory Working Group is pursuing.
- The committee commends LBNF, FNAL, and FSO in getting a clean determination and delegation of authority for improvements to non-DOE assets at SURF.
- The committee considers the following to be the key short-term risks to LBNF. Addressing these risks will be key in meeting the start of excavations (Dec. 2019) and Near-Site scope by CD-2/3B.
    - The ability to successfully place contracts in a timely fashion;
    - The development of international partners for near-site work;
    - The complete formalization of Far-Site command, control, safety oversight and regulatory structures

Recommendations:

- Fermilab and LBNF, please prepare a breakout briefing for the next meeting which clearly addresses progress and plans towards mitigating the project schedule and cost risks resulting from the inability to place contracts in a timely manner. This briefing should focus on those areas where Fermilab and the project can make specific progress (capacity, quality and/or competency, and process).

Previous Recommendations:

One recommendation from October 2017 meeting:

"*The host lab and DOE efforts to resolve numerous legal and procurement challenges at the far site need to further evolve in order to allow timely resolution and achievement of the defined International Project Milestones.*"

Response: Progress has been made against this recommendation, through engagement with DOE and the creation of the Host Laboratory Working Group, to address legal issues related to far site

development, and biweekly calls to facilitate communications in procurement. However, substantial work remains to be completed to resolve all challenges related to procurement for the numerous remaining large contracts. Based on the seven near-critical path items, the resolution of these procurement challenges will be essential to deliver the project on time.

Section 2: LBNF/DUNE Planning for Cryogenics [Klebaner, Fuerst, Robinson, Monroe, Laxdal]

Findings:

- Work on proximity cryogenics on the mezzanine has been a collaborative effort between FNAL and CERN.
- Cryogenic work packages are being developed – there is still unassigned cryogenic scope.
- The mezzanine on the top of the cryostat has been extended in length since the last meeting to accommodate a local meeting area.
- The neutrino platform (NP) group is working on a p-Dune cryogenic and cryostat commissioning and test plan to be available for the next LBNC meeting - an integrated p-Dune test plan including cryogenic testing, detector testing, electronics testing, beam based measurements was not presented.
- LBNF & DUNE have established penetrations needed for FD-SP and cryo systems.
- FD-SP cryostat lid penetrations were settled in Dec. 2017 as part of the calibration task force activity. Work is continuing towards harmonizing penetration design for both SP and DP designs – the goal is to have 5 walls the same with the only differences being in the lid. CERN has initiated a design contract for the cryostat engineering design with GTT.
- LBNF is working on solicitation for a design-fab-install contract for the LN2 system: they are iterating with DOE on the acquisition plan, reviewing the Scope Of Work and established a Source Evaluation Board. The procurement value requires DOE MA approval, which adds time to the procurement cycle. LN2 cryoplant RFP goes to DOE by end of Feb. 2018.
- ProtoDUNE Cryogenic system commissioning is scheduled for June-August 2018.
- Recommendation #2 from the Oct. 2017 review ("Ensure that the cryogenics performance testing is given priority on ProtoDUNE and sufficient attention to collect data, baseline simulations, and iterate as needed.") and #5 from the Jun. 2017 review ("Identify ways to test the ProtoDUNE cryostat designs with the goal to converge to a common design and report finding.") have been closed.
- The 3x1x1 (WA105) cryostat ran for over six months, ending operation in Nov. 2017 and retiring many of the PD-DP risks. The cryostat is presently warm and ready for internal visual inspection.
- The ProtoDUNE-DP cryostat is clean, leak checked, and ready for detector installation.
- The ProtoDUNE-DP schedule is being reviewed in an effort to make it compatible with a Nov. 2018 LAr fill.
- The new NP02 coldbox will allow tests of individual CRPs. The box should be available in Mar. 2018 and is considered a key element in the strategy to minimize risk.
- Cryogenic Instrumentation and Slow Controls (CISC) is a joint SP/DP consortium with broad scope including LAr CFD analysis, cryogenic instrumentation and feedthroughs (both LBNF and DUNE/LAr-specific) and slow control systems. The consortium will use

data from ProtoDUNE to validate CFD simulations and provide calibration information. The stated Temperature sensors calibration requirement of less than 5mK (+/- 2.5 mK) is driven by the cryostat CFD model.

Comments:

- The NP, LBNF and Dune teams are commended for the continued progress of blending the SP and DP cryostat design for the far detector.
- We congratulate the NP team for developing a commissioning and test plan for the protoDUNE cryostat and cryogenic system. Documentation and communication of this plan should be presented to the DUNE collaboration and the LBNC within 6-weeks to allow timely completion of an integrated ProtoDUNE test plan that includes the input from all stakeholders (cryogenics, electronics, detector technology, etc). The integrated test plan should include a prioritized set of goals for the full p-Dune test. Such an integrated and prioritized plan would allow for timely critical decisions and conflict resolution in the likely event that hardware or logistic issues arise.
    - The prioritized list should consider what technical qualifications are needed for the CD-2 TDR
    - There does not seem to be a single point of contact (owner) for the integrated protoDUNE test – given that there are a number of important potential outputs from the test (including cryogenics) and given the importance of test results for DUNE/LBNF and the fixed time window for a beam based test it is critical that there is a well defined decision making process for day to day activities.
    - During cryostat testing consider avoiding dye penetrant testing.
- Given the mid term goal of completing the TP and working towards the TDR and CD-2, nailing down owners for at least some of the unassigned cryogenic scope is becoming critical. It may be easier to `sell' unassigned scope if installation is excluded.
- It is not clear how changes in scope (i.e. DUNE cryostat mezzanine modifications) during this conceptual design phase are reviewed and communicated.
- It is not clear how the CISC consortium is interacting with the cryogenic technical team – there is clearly an overlap of interest and it is clear that some discussions are taking place but it is not clear that there is an overarching body setting priorities and defining scope to minimize overlap.
    - Keeping an industrial platinum sensor to within 2.5 mK at 82 K in practice would be difficult. Typical commercial RTDs are calibrated to above +/- 10 mK. A trade-off analysis of cost associated with high calibration accuracy for thermometers and associated benefits from the CFD model may be beneficial. Additionally a relative temperature measurement may be acceptable for the CFD model validation.
- The GTT contract is not a standard contract between CERN and a vendor. It has special provisions associated with intellectual property (IP). It would be beneficial to have

provisions that allow cost effective modifications during the engineering phase based on p-DUNE lessons learned.

Recommendations:

- Complete the commissioning and test plan for the ProtoDUNE cryostat and cryogenic system within 6-weeks and present to the Dune collaboration and LBNC.
- Clarify and communicate to all stakeholders the lead person for the ProtoDUNE integrated test. Establish and document ProtoDUNE test goals as a prioritized list integrated into a comprehensive test plan in the next six weeks and present to the Dune collaboration and the LBNC.
- Define and document a mechanism to assess priorities for LBNF/DUNE unassigned cryogenics work packages based on impact to TDR and CD-2 prior to the next LBNC meeting.
- Establish and document a process to review and communicate new scope in the pre-CD2 period prior to the next LBNC meeting.

Previous Recommendations:

- "*Ensure that the cryogenics performance testing is given priority on Proto-DUNE and sufficient attention to collect data, baseline simulations, and iterate as needed.*"
    - Assessment: should not be closed until a comprehensive integrated test plan is written and agreed upon within the collaboration. This plan should be presented at the next LBNC meeting and made available within the next 6 weeks.

Section 3: LBNF/DUNE Interfaces [Lindgren, Smith, Klebaner, Fuerst]

Findings:

- An update was presented on the status of the LBNF/DUNE Configuration Management Plan (CMP)
- Conventional Facilities and LN2 system are under configuration management and using BCR tool/CCB.
- CMP in draft form available
- DUNE will go under change control post-TDR approval
- Mezzanine and proximity cryogenic work will go under configuration control at CD2
- An ICD matrix for LBNF, cryogenics, cryostat and DUNE has been defined
- DUNE far detector consortia at initial ICD draft stage
- FD Mezzanine platform extended by 9.6 m to almost 50 m in length
- GTT doing design study on cryostat
- Adjustments to layout will be communicated back in the spring for iteration and finalization
- LBNF/DUNE integration meetings were held four times in 2017, and there will be two in February 2018
- Project is evaluating configuration management tools
- Current plans for ullage and internal cryostat clearances were presented
- Design work to understand minimum ullage needs is now happening at two places, FNAL and SDSU

Comments:

- Development of the CMP should continue
    - DUNE consortia leaders serving on CCB is a good step
    - Selecting a CM tool should be a priority and the CMP should be revised to reflect that
    - The draft version of the CMP is a good start
- The team has done a good job to get CF, Cryo, Cryostat, and DUNE draft ICD's for each element. Building on those as planning continues will be critical.
- For DUNE, key consortia interface development needs to be a priority.
    - Getting the matrix cleaned up, so unneeded ICD's are dropped, and continued effort on the documents themselves is needed
- ICD's at the "textual description" stage is a good start. The format/template of the ICD's needs continued development

    - The template should include preparers, checkers, owners, revision history, WBS (level 3-ish) assignments and owners, drawing reference numbers, etc., to maximize it's usefulness
    - Progess to date is good, just needs to continue
- The increased focus on integration, and the hiring of an experienced system engineering lead are positive steps. With the large number of consortia, a very strong systems approach will be needed to ensure that what they build fits together and works as intended.
- The CISC cryogenic modeling plan is a good start, with reasonable goals.
    - CFD work plan that has calculations done in two places using different tools is a good way to check for errors.
    - The instrumentation plan needs refinement, the committee was not convinced that the choices for things like the needed temperature precision were optimized, or what the requirements were based on.
    - This consortia touches many others, development of clear scope ...
- The concurrent scheduling of installation, commissioning and operations for the various aspects of LBNF and DUNE within the chambers will require careful control and management to ensure all EH&S requirements are met for all tasks. Removal of the rock septum may exacerbate this situation.
- Although the consortia are aware of the interface issues and have an established interface matrix, the technical proposal should further outline the integration framework, roles and responsibilities of the Technical Coordinator and consortia, and how they will recognize and resolve technical choices and interface issues.

Recommendations:

- The DUNE system engineering lead will need a team to support the large number of consortia and develop a very strong systems approach. Present a plan for that at the next LBNC meeting
- Present a plan at the next LBNC meeting that outlines the integration framework, roles and responsibilities of the DUNE Technical Coordinator, DUNE-US Project Director and consortia, and how they will recognize and resolve technical choices and interface issues.

Previous Recommendations:

- None

Section 4: DUNE Management, Schedule and Planning [Charlton, MacFarlane, Proudfoot]

Findings:

- The DUNE Collaboration has continued to grow by attracting new collaborators (totaling now 1061 collaborators from 175 Institutions in 31 Nations). Although there are no firm commitments, there is significant progress in negotiations with new prospective partners in Europe, South America and Asia, with particular interest for the Near Detector from Italy, Germany and JINR/Russia.
- A new management structure, including consortia leaders, aimed at streamlining decision making and insuring uniform communication of information to national funding agency representatives has been proposed.
- An Advisory Group has been formed which will include 4-6 elected members as well as representatives from younger members of the DUNE collaboration.
- The new management structure and Advisory Board is expected to be ratified by the Executive Committee and put in place by May 2018.
- The calibration task force has prepared a timeline for work to be done leading up to the TDR. A calibration workshop is to be held in March 2018. The task force leaders have worked closely with Technical Coordination to define a set of dedicated penetrations for the top of the cryostat that will provide sufficient coverage for the various calibration systems under consideration.
- Milestones are being maintained for: protoDUNE's, Far detector, Near Detector, Management, TP/TDR, Reviews. The set of recently completed milestones was presented. Milestones with significant delay comprise: update of the strategy document, and finalization of the CRP consortium (the leadership is now in place).
- The Far Detector strategy was presented. The full detector requires 4 FD modules following a "2 + 1 + 1 model": 2 Single-phase FD modules, one of which will be the first module; 1 Dual-phase FD module; 1 [As yet] uncovered "Opportunity" FD module. For the TDR in 2019, DUNE will seek approval of (at least) two FD modules, dependent on technical readiness and funding model
- Consortia leaders have been appointed for Single Phase (APA, Photon Detection System and TPC Electronics), Dual Phase (CRP, Photon Detection System, TPC Electronics) and Joint (HV, DAQ and Slow Controls). The consortia are now ~6 months into existence and working well.
- The DUNE International Project Office contains project documentation covering a number of DUNE far detector requirements: Technical Coordination DocDB-6413, APA DocDB-

6416, SP-ELE DocDB-6419, SP-PD DocDB-6422, CRP DocDB-6425, DP-ELE DocDB-6428, DP-PD DocDB-6431, HV DocDB-6434, DAQ DocDB-6437, CISC DocDB-6440

Comments:

- The LBNC acknowledges the continued successful efforts of DUNE to attract new collaboration members, and with positive negotiations with several potential international contributors that would increase non-DOE resources.
- The LBNC commends DUNE management for its plans to further streamline the consortia organizational structure and a newly proposed Advisory Committee allowing a broader representation of the collaboration to communicate with DUNE management and to provide a more transparent decision-making process.
- The LBNC commends the DUNE collaboration on the speed with which the consortia have taken ownership of their systems
- The DUNE management is commended for preparing a DUNE Project Office with a web page giving links to requirements documents. Though incomplete, this shows good awareness of the importance of such a site in providing open and transparent communication of requirements, schedules and reviews.
- No status report was presented on the November near-detector (ND) workshop, and the plan for the ND decision; the LBNC would like to hear a report on progress and status of the ND conceptual design development at its next meeting.
- Plenary presentations were improved and more directed towards the charge. Speakers may want to carefully consider the message they intend to convey with any given slide. It is common with many other collaborations to provide practice sessions in advance of major reviews.
- We anticipate that reports from individual consortia will become a normal feature in the future. Our interactions with consortia leadership were much more effective when leadership was present at Fermilab. Given the nature of the May review (review of the TP), we strongly suggest that consortia leaders attend this review in person.

Recommendations:

- **Present a** report on progress and status of the ND conceptual design development at the May 2018 LBNC meeting

Previous Recommendations:

- "*A report on the calibration issues, including implications for the cryostat, should be presented at the next LBNC meeting.*"

Response: Since the last LBNC meeting, responsibility for developing calibration plans has been transferred from the APA consortium to the Calibration Task Force, which sits within the DUNE physics organization. The leaders of this task force (Kendall Mahn (MSU) and Sowjanya Gollapinni (UTK)) have worked closely with Technical Coordination to define a set of dedicated penetrations for the top of the cryostat that will provide sufficient coverage for the various calibration systems under consideration. With these now in place and agreed upon, the task force will continue to work on physics based studies with the goal of defining an optimized, comprehensive calibration plan for the far detector. The Technical proposal will have a dedicated section outlining calibration strategy for far detector

- "*Lessons learned: A formal process to aggregate the lessons learned from previous detector prototypes, commissioning and operation of relevant LAr TPCs into the DUNE/LBNF design should be developed. The LBNC would like to hear a presentation at its next meeting on any cross-cutting system design issues that emerge from lessons learned, over and above the existing calibration task force.*"

  Response: As part of the close out for the construction and installation phases for the ProtoDUNE detectors, we will require all project and subsystem managers to contribute to a lessons-learned document detailing issues encountered. We would expect to have a draft document in place by the time of the next LBNC review in May.

- "*At our next meeting, the LBNC would like to hear a proposed mechanism for documenting the flow down from physics to technical requirements in DUNE, as well as how this will be addressed in the TDR and demonstrated with the protoDUNE test plan.*"

  Response: Technical Proposals will include the documented flow down and this will be presented at the May LBNC meeting.

Section 5: DUNE Physics and Reconstruction [Mondale, Boehnlein, Bhadra, Huber, Heinemann]

Findings:

- An outline and a schedule for the physics TDR has been presented.
- A calibration task force for the FD has been setup, spanning a wide range of activities
- At present Monte Carlo event generation, reconstruction and physics analysis is not limited by computing resources.
- For the TDR, the plan is that most physics results will be based on full reconstruction. Example results have been presented.

Comments:

- LArSoft is supported by community efforts at present, and this is enough for the DUNE physics input for the TDR.
- In order to relate the low-level detector performance and physics results (as required for the TDR) there is a continued need for bi-directional and close communication between the physics & reconstruction groups and the various detector consortia.
- Two important individuals who have been leading the ProtoDUNE data reconstruction have left, leaving a void in leadership. It is not clear to us what is the plan for the ProtoDUNE analysis, and how this will be used as input for the DUNE Physics TDR.
- For future meetings, we should measure reconstruction progress relative to reconstruction metrics defined in response to a previous recommendation by this committee (reference needed)
- In general, the LBNC would very much appreciate a summary of the main worries and challenges in this area in future meetings.

Recommendations:

- For the next meeting, present a plan for detector studies for key parameters (e.g. higher noise, dead channels, lower operating voltage…) that are being considered from the flow down from physics to technical requirements to be included for Physics TDR. For those that will not be studied for the TDR a qualitative reasoning should be provided.
- For the next meeting, present a plan for ProtoDUNE data analysis, including calibration and quality assessment of the data, the main performance measures that will be extracted for the TDR, the manpower available and any other important aspects.

Previous Recommendations:

- "*The Physics group and Reconstruction groups need close communication with the Computing group. This is essential in order to complete various physics studies required for the Physics TDR in a timely manner and to ensure that necessary computing resources are available. In particular, different reconstruction techniques may require resources that are currently not in any plan.*"

  Response: Groups are meeting regularly and keeping a close communication.

- "*DUNE DP simulation and reconstruction under LArSoft framework should be brought at par with that of DUNE SP in order to make the physics cases for both the detectors on equal footing.*"

  Response: While DP reconstruction is making progress, the view of physics group is "we do not anticipate making precise relative statements between the performances of the SP and DP technologies, as the levels of sophistication will differ at the time of the TDR".

- "*The effect of detector imperfections such as design parameters, as well as imperfections such wire breakage, LAr impurity, dead electronics, nonlinearities, calibrations, operational degradation as realized in operations, and any related detector conditions on key physics performance parameters should be discussed initially in the TP and in full detail in the TDR using either simulation, or experience from other closely related and relevant experiments, or both.*"

  Response: Established an initial set of top priority detector variations to study. We have made another recommendation on this issue in this meeting.

- "*There are various algorithms and tools that are being developed for SP and DP. A freeze date for a reference algorithm should be established for producing various physics plots as input for the TDR.*"

  The final freeze date is Jan 2019, but several milestones over the coming year are related to this, including a checkpoint of algorithms and their performances in May 2018.

Section 6: DUNE Computing [Boehnlein, Bhadra, Mondal, Huber, Heinemann]

Findings:

- DUNE Computing has successfully recruited technical effort from the DUNE collaboration and has rotated some leadership.
- Most major milestones through Q4/17 directly under the control of Dune Computing have been met, with Q1/18 milestones completed or largely on track. The missed or delayed milestones are being addressed.
- Progress has been made in addressing computing for the ProtoDUNEs. The offline beam instrumentation database has been tested with mock devices and is ready for large scale testing. Calibration and hardware database efforts are being led by new leadership.
- Planning for computing resources to support the Physics TDR and the ProtoDUNE reconstruction is in hand. A ticket-based requesting system has been introduced to facilitate production requests.
- A decision was taken to include Software and Computing in the on-going Technical Proposal. An outline listing possible topics has been provided, and the first draft is due Feb 23.

Comments:

- The LBNC compliments DUNE Computing on continued progress in meeting milestones in a timely manner and addressing operational issues. We note continuing progress in the area of databases, tutorials and on the successful recruitment of additional contributors to S&C.
- The Physics and Reconstruction Group has stated that computing resources are not a limiting factor for the TDR. We commend DUNE Computing on meeting the operational needs of DUNE.
- The current outline for the Software and Computing volume for the Technical Proposal is extremely detailed in terms of topics and seems too ambitious for the TP. A strong focus in the TP should be maintained on identifying strategic collaboration-level decisions that will impact the computing model. These considerations include overall organization, connection to physics requirements and the degree to which the collaboration will make in-kind contributions to computing. Additionally, changes in the computing hardware architectures and software development model.
- The TP outline includes many legitimate operational and/or low level infrastructure decisions to be made. This list is valuable for forming work plans and for internal documentation. However, the Technical Proposal is a strategic document.
- In our judgement, maintaining focus on a strategic vision for DUNE computing is more important than converging on a S&C TP volume as implied by the presented outline by May.

Recommendations:

- *On the timescale of the TP, S&C must develop a list of questions and factors that will influence the computing model*

Previous Recommendations:

"A combined set of milestones that includes computing and reconstruction for the TDR should be developed such that appropriate Monte Carlo samples can be generated and that validated production releases are available that are appropriate for the TRD and for protoDUNE reconstruction."

Response: This recommendation was met

"By February, 2018, develop a list of questions and factors that will influence the computing model, prioritize of those factors in terms of likely cost and schedule impact."

Response: The S&C outline of the TP does not address the recommendation. Some open questions with respect to the data volume, driven by DAQ considerations have been settled, and should be documented. We continue to urge the development of the list of questions and factors that will influence the computing model and document them for the TP.

Additionally, we commented: "Given the number of open issues, it seems prudent to extend the development time of the Computing "Technical Proposal" (TP) to August 2019."

Response: We stand by this advice.

Section 7: DUNE-SP []

Subsection 7.1: DAQ Consortium [Liu, Boehnlein, Pitts, Bhadra, Pallavicini]

Findings:

- New DAQ Consortium formed over the past six month. A growing DAQ consortium with about 30 institutes and two workshops so far
- Presented at review: overall DAQ scope, general top-level requirements, top level conceptual dataflow, agreed-upon design principles/guidelines, with key interfaces listed, as well as key decisions to be made before TDR, and a tentative schedule towards TDR with milestones, along with a list of risks and concerns. Responses to previous recommendation also presented towards the end of presentation
    - The new DAQ design is very different from ProtoDUNE-SP
    - No details presented/referenced
- ProtoDUNE-SP DAQ is technically outside DAQ consortium
- A Technical Proposal draft is imminent (by March 2018), with first prototype HW/FW/SF for new DAQ available by Oct 2018
- A fully documented design, based on ProtoDUNE, also basis for cost are said to be in place, with a draft WBS and schedule established.
- A demonstrator program (with new DAQ prototypes) was mentioned. The DAQ consortium assumes that ProtoDUNE facilities will continue to be available beyond 2018 for testing the new DAQ prototypes.
    - No details presented/referenced
- It was clearly stated in the Pre-TDR milestones that the interface documents, functional specifications as well as costing and infrastructure requirements are all completed

Comments:

- With very limited time available for the DAQ presentation/discussion, the committee is unable to review the details of the progress made by the new DAQ consortium
- Good progress made developing the new DAQ Consortium
    - In time to carefully design the DAQ system for DUNE
    - Overall DAQ scope, top-level requirements, as well as design principles have been identified and agreed upon

- While a conceptual system dataflow was presented at the review, no details were shown beyond top level diagram.
- We did not have the opportunity to review the interface documents, functional specifications as well as costing and infrastructure requirements.
- First new DAQ prototype HW/FW/SF is scheduled to become available by Oct 2018
  - This seems to be rather aggressive, even if all design specifications are in place
  - A demonstrator program (with new DAQ prototypes) was mentioned, which requires the continuation of ProtoDUNE facilities beyond 2018, with the demonstrator complete by Jan 2019
  - This seems to be a good idea, but without seeing the details, the committee is unable to evaluate its feasibility
    - This seems very aggressive, if recent history is a guide
  - The committee is told that ProtoDUNE-SP DAQ is technically outside DAQ consortium. This is a surprise to the committee
  - It is stated that new DAQ collaborators are strongly motivated to learn from ProtoDUNE, though not clear how many of them have actually joined the effort for ProtoDUNE DAQ commissioning
  - Large overlap between active ProtoDUNE and DUNE FD DAQ personnel does not automatically mean lessons learned will be formally documented in real time and incorporated in DUNE DAQ design and for future reference.

Recommendations:

- Before May review, make available the documentations mentioned in the presentation to the LBNC committee, such as interface documents, performance and functional specifications, cost and infrastructure requirements, and the full design documentation of the new DAQ system.
- Lessons learned from commissioning and operation of protoDUNE should be formally documented in real time for incorporation in DUNE DAQ design and future reference.

Subsection 7.2: ElectronicsSP Consortium [Pitts, Liu, Pallavicini, Monroe, Proudfoot, Mondal, Galbiati]

Findings:

- The consortium has recently produced both a "strategy" and "decision process document".
- Highest consortium priority is to complete the ASIC plan outlined at the October meeting. The plan continues to be based upon a 3 chip design (amplifier/shaper, ADC, COLDATA) with members of the ADC Design Group from BNL/FNAL/LBNL collaborating on a new ADC chip that will be done in 65nm CMOS. The Design Group has delineated responsibilities across laboratories along with a plan to carry out internal "deep reviews" of the design. Initial submission of the cold ADC chip is anticipated for June 2018.
- In parallel, work will continue on the SLAC Cryo system-on-chip design that was originally developed for nEXO. Submission of that chip will occur in Feb/Mar 2018.
- The new COLDATA chip is progressing and submission will occur in June 2018.
- The ADC developed at Columbia for ATLAS and a commercial off-the-shelf (COTS) ADC solutions are under evaluation and are considered only as a backup plan for DUNE.
- Coldbox tests of the protoDUNE electronics show good results.
- Options for routing cables from the lower APA remain under consideration. Mock up work will be undertaken at Ash River.

Comments:

- Having a 12-bit ADC with noise and linearity performance that meets the requirements defined by the DUNE physics program – and works reliably at cold temperature – is of the utmost importance to the experiment. The current plan has a single primary option (new, three-lab ADC design) with an aggressive timeline. Initial progress on this effort is positive.
- While development for the 3-ASIC solution is the top priority, it is important to continue efforts on all of the options outlined.
- It is unlikely that a single solution will be identified at the time of the TDR, so it is important to establish selection criteria that are based upon physics priorities, cost and reliability.
- The multi-stage testing plan outlined makes sense. We encourage the collaboration to investigate ways to carry out additional "system level" tests, such as the planned use of a spare APA plane in the CERN cold box.
- We support the integration effort to finalize the cable routing for DUNE-SP and encourage the development of an interface document and decision strategy in collaboration with the APA consortium.

Recommendations:

- None

Subsection 7.3: PhotonSP Consortium [Tschirhart]

Findings:

- Science requirements are established and presented in terms of measuring (i) the magnitude and arrival time of energy deposits greater than 200 MeV and (ii) for SuperNova burst events, the arrival time of energy deposits less than 200 MeV.
- Several technical solutions are under study now that may meet the science requirements.
- An initial analysis of interfaces to other consortia and other systems was presented.
- A list of milestones up to and beyond generation of the TDR was presented.
- An initial list of risks and mitigations was presented.

Comments:

- Proponents are appealing to the physics and simulation teams to work with them on validating and refining science requirements informed by the performance and limitations of candidate technical solutions. This key iteration must be completed in advance of the TDR.
- The most mature light collection technologies (bars) presently do not clearly satisfy the technical performance requirements. The proponents have identified mitigation strategies to increase light collection that will directly impact APA design and performance (e.g. fractional area of light collection embedded into the APA planes.) Proponents are also pursuing R&D for less mature technologies that may hold the promise of improved light collection and detection (e.g. Arapuca).
- The science requirements of the Single Phase (SP) consortium and the "science goals" identified by the Dual Phase (DP) consortium are not identical or even similar. We see no reason why the scientific requirements for the SP and DP detector systems would be different. If this is not the case, then a clear explanation should be incorporated into the TP.
- The MicroSoft Project (MSP) schedule identifies technology choice down-selects based on Proto-DUNE performance, but there is no discussion in the narrative on how this process would occur.
- The proponents noted interest within the consortium to continue R&D on pulse-shape discrimination techniques although there presently is no clear motivation to pursue this vigorously in the context of science requirements. Proponents should consider pursuing this instrumentation opportunity as scope contingency.

Recommendations:

- Pursue a compact linkage of science requirements to technical performance requirements.
- Determine if SP and DP science requirements can be identical or largely similar. If not, the associated narrative should succinctly describe why not.

Subsection 7.4: protoDUNE-SP CE & TPC [Pitts, Liu, Pallavicini, Monroe, Proudfoot, Mondal]

Findings:

- Considerable progress has been made since October on many aspects of the protoDUNE-SP TPC and CE.
- Four APAs are now at CERN, two more are currently under construction. A total of 7 APAs are planned, 6 for protoDUNE-SP, 1 for system-level testing in the CERN cold box.
- Two more APAs under construction (1 PSL, 1 UK) are anticipated to arrive at CERN in late March/ early April. Time for testing will be short, but the schedule currently allows for 6 APAs installed into protoDUNE-SP.
- The cryostat has been cleaned and leak-checked, the Detector Support Structure has been installed.
- Field cages and cathode planes have been assembled and installed in the cryostat.
- Electronics production and testing has continued to progress over the last several months.
- Testing of 3 APAs has been completed in the cold box, all 3 are now in the cryostat.
- Approximately 1500 front end chips have been tested to date, and about 2500 ADC chips have been tested to date (out of 5000 produced) and the best chips are being selected for protoDUNE.
- Cold box testing of instrumented APAs shows good noise performance, consistent with results from the 40% APA test stand at BNL.
- Efforts are underway to document “lessons learned” from protoDUNE-SP construction.
- Progress has continued on the 35-ton HV tests. Testing with and without the beamplug showed no difference in performance, the decision has been made to install the beam plug into protoDUNE-SP.

Comments:

- We congratulate the protoDUNE-SP team on the significant progress that has been made on many fronts since the October LBNC meeting.
- System level performance of ProtoDUNE-SP will provide crucial information ahead of the 2019 TDR. Heroic efforts by a number of individuals have put protoDUNE-SP in a position where it can deliver on this important information with cosmics and with beam. It is absolutely crucial that the collaboration provide the attention and personpower to successfully complete and commission protoDUNE-SP and extract the results over the next several months.
- With 4 APAs at CERN and 2 more in production, the effort is on track to successfully button-up the cryostat and hand activities over to the cryo team on schedule. The schedule to receive and install the final two APAs is tight, and it is very likely that time

available for testing will be extremely limited. Given that a successful protoDUNE-SP can be operated successfully with 4 or 5 APAs, we suggest that the collaboration consider holding the 6th APA out of protoDUNE in order for it to be used as a second integration test plane for the electronics effort. If it is possible to allow additional schedule contingency for final assembly (TCO activities), cryogenics and commissioning ahead of beam, this is more important than a 6th APA in protoDUNE. In addition, a second APA outside of protoDUNE could be extremely valuable in electronics testing for years to come.

- In addition to having protoDUNE as a basis for cost, labor and schedule estimates, it is also important to document "lessons learned" from the protoDUNE experience, e.g., in winding APAs so that every production site does not have to re-learn the lessons that have already been learned. This "lessons learned" documentation needs to happen in "almost real time" so items are not forgotten.

Recommendations:

- None

Subsection 7.5: protoDUNE-SP DAQ [Liu, Boehnlein, Pitts, Bhadra, Pallavicini]

Findings:

- DAQ system is now able to get data from cold-box from WIBs and FEMBs, together with photon detector SSPs, with first data taken with cold electronics during APA#3 cool down using RCE readout
    - Low rate with no data compression
    - Still in the process of making sense of the data
    - Work in progress to stabilize the RCE readout to allow for higher rates
- First tests with FELIX readout still have problems, WIB firmware not optimal yet

Comments:

- The DAQ system appears to be ready for testing with the Cold Box with the RCE path, though we are unable to assess in details. The WIB firmware issue and the long (few months) debugging time was not anticipated. Clearly much more still remains to be done, in particular, making sure the coldbox data is correct.
- Before the detector components are fully operational, it is important to use simulated data (such as cosmics) to test all aspects of the DAQ chain.
- Still a lot of work ahead beyond Cold Box testing, which is necessary to bring a working system ready for beam.
- Strong support with appropriate number of personnel is crucial to the success of the DAQ system development, from commission to operation.

Recommendations:

- Use simulated data (such as cosmics) to independently test and verify all aspects of the DAQ chain and further improve the monitoring capabilities

Past Recommendations:

- *"Lessons learned from the integration, commissioning and operation of the Proto-DUNE should be documented in real time and incorporated into DUNE DAQ design*
    - *Recommendation not implemented yet, there is plan to do so, we are looking forward hearing about lessons learned in May"*

Response: DUNE management should continue to work closely with the DAQ group to identify any additional need in the effort, tasks and expertise leading up to data-taking

Subsection 7.6: DUNE-SP schedule & planning [Proudfoot, Charlton, Heinemann, Huber, Tschirhart]

Findings:

- APA-1,2 and -3 have been installed in the DUNE-SP cryostat, APA-4 was delivered at CERN from PSL on Feb 16th 2018, approximately 2 weeks ahead of schedule.
- The APA construction teams in the UK and the US have moved to a 7 day work schedule to improve the efficiency of operations and to accelerate construction of APA-5 and APA-6, which are now expected to be delivered to CERN in the first 2 weeks of April.
- Tests of the beam plug in the 35 ton are concluded and have indicated that the unexpected current rise and HV trips are independent of whether the plug is installed or not. The decision has been made to install the beam plug in the protoDUNE-SP cryostat.
- APA-4 is on schedule to be installed in the cold box and will be tested both with the standalone DAQ and the protoDUNE-DAQ to provide a cross check between the two systems. Some challenges remain with firmware for WIBs, associated with inconsistent data structures.
- Selection of the cold ASICs is proceeding well. Chips for APA-5 and APA-6 will be selected at the beginning of March to allow delivery of readout boards to CERN ahead of the expected delivery of APA-5 and APA-6
- Work on additional activities including cryogenics, slow control, instrumentation and monitoring is ramping up as work on TPC installation ramps down
- An outline for the test beam run plan was presented

Comments:

- Some challenges remain with firmware for WIBs; these are associated with inconsistent data structures.
- An outline for the test beam run plan was presented, with a general indication of run periods and priorities. Personnel availability may be a concern and the protoDUNE-SP management should consider, for example, assembling a small team of “professional shifters”.
- A tightly integrated plan for TCO closing, completing work in the cryostat and handing the system to cryo team was presented. The LBNC has some concerns that the TCO closing date at the end of April may not allow sufficient margin for the remaining work to be completed prior to initiating cryogenic operations

- We are encouraged to hear the plans to document lessons learned during DUNE-SP construction and integration and communicate these to the DUNE consortia. This is an important outcome for the protoDUNE-SP program and should not be delayed.

Recommendations:

- Review APA5 and 6 construction status, the TCO closing schedule and the implications for beam readiness; the status should be followed up with the LBNC POC in ~1 month
- Present a draft test beam run plan including priorities, resources needed, and contingencies at the May 2018 LBNC meeting
- The situation with respect to WIB firmware is fluid and the protoDUNE-SP management should provide a status update to the LBNC POC in ~ 1 month
- Prepare a draft document describing lessons learned and present at the May 2018 LBNC meeting

Previous recommendations:

"*The ProtoDUNE management should engage the DUNE collaboration and Executive Committee in a timely way, informing them of the key issues concerning the number of APAs to be installed and the concerns surrounding the beam plug and the high voltage behavior observed in the 35ton test. The consequences should be discussed with the collaboration: what they give up by not installing the beam plug and the potential risk to protoDUNE should they decide to install the beam plug.*"

Response: ProtoDUNE-SP have agreed to a plan which provides for the installation of 6 APAs on a schedule which is consistent with the required schedule for TCO closing. The decision is to install the beam plug

Section 8: DUNE-DP []

Subsection 8.1: DAQ Consortium [Liu, Boehnlein, Pitts, Bhadra, Pallavicini]

Findings:

- ProtoDUNE-DP DAQ is based on the same system design as in 1x1x3. See Section 7.2 for findings, comments, and recommendations.

Comments:

- ProtoDUNE-DP DAQ should be ready for commissioning and data taking, as long as adequate person-power is available to commission and operate the system

Recommendations:

- None

Subsection 8.2: ElectronicsDP Consortium [Pitts, Liu, Pallavicini, Monroe, Proudfoot, Mondal, Galbiati]

Findings:

- The DUNE-DP Electronics Consortium takes advantage of considerable R&D work and experience going back more than a decade.
- A requirements document exists, as well as multiple interface documents.
- The protoDUNE-DP Electronics system was constructed in 2016 and has been successfully utilized in the 3x1x1 detector.

Comments:

- The baseline design for DUNE-DP electronics is well-defined.
- We commend the work done to date and the successful establishment of this consortium.
- This effort is well-positioned to produce a detailed TDR.
- We look forward to results from protoDUNE-DP.

Recommendations:

- None

Subsection 8.4: PhotonDP Consortium [Tschirhart]

Findings:

- Science goals/requirements are established in terms of triggering, time stamping and the possible use in Particle ID and calorimetry.
- Technical solutions explored in the 1x1x3 prototype are planned to be further studied in Dual Phase Proto DUNE.
- An initial analysis of interfaces to other consortia and other systems was presented.
- A list of milestones up to and beyond generation of the TDR was presented.
- An initial list of risks and mitigations was presented.

Comments:

- Proponents are appealing to the physics and simulation teams to work with them on validating and refining science requirements informed by the performance and limitations of candidate technical solutions. This key iteration must be completed in advance of the TDR.
- The interface summary slide succinctly and clearly describes interfaces and provides clear links to definitive documentation.
- The science goals/requirements of the Dual Phase (DP) consortium and the science requirements identified by the Single Phase (SP) consortium are not identical or even similar. We see no reason why the scientific requirements for the SP and DP detector systems would be different. If this is not the case, then a clear explanation should be incorporated into the TP.

Recommendations:

- Pursue a compact linkage of science requirements to technical performance requirements.
- Determine if SP and DP science requirements can be identical or largely similar. If not, the associated narrative should succinctly describe why not.

Subsection 8.5: protoDUNE-DP technical, schedule, and planning [Galbiati, Tschirhart, Monroe, MacFarlane]

Findings:

- Based on experience from the WA105 1x1x3 experience, a number of changes are underway in the design of the LEMs, CRPs and grids for the 6x6x6 protoDUNE-DP, which will address HV issues in a conservative fashion
- Investigations of some of the HV issues on the 1x1x3 are ongoing according to a plan developed in Nov 2017
- Procurements of components for the 6x6x6 appear to be the limiting factor in determining the schedule for assembly of protoDUNE-DP
- An important collaborative program has been initiated by CERN to develop a solution for delivering 600 kV HV to DUNE-DP
- A cold cyro tank has been designed to allow ongoing investigation and optimization of the CRP design

Comments:

- The plan for constructing protoDUNE-DP appears to be a sound strategy for demonstrating the dual phase technology in time for the DUNE TDR, although it appears likely this will not be completed in time for beam this year.
- The cold cryo tank will allow testing CRPs before insertion in the 6x6x6.
- The approach of optimizing the CRP standoff design with the cold cryo tank appears sound.

Recommendations:

- None

Appendix 1: Subgroup organization and membership

Number	Topic	Subtopics & Consortia	Referee group	POC
1	DUNE-SP	APA	Monroe	Stefan Soldner-Rembold, Alberto Marchionni
		DAQ	Liu, Boehnlein, Pitts, Bhadra, Pallavicini	Dave Newbold, Georgia Karagiorgi
		ElectronicsSP	Pitts, Liu, Pallavicini, Proudfoot, Galbiati	David Christian, Marco Verzocchi
		HV	Monroe, Galbiati	Francesco Pietropaolo, Bo Yu
		PhotonSP	Tschirhart, Galbiati	Ettore Segreto, Dave Warner
		Slow Controls and Cryo Instumentation	Klebaner, Fuerst, Robinson, Monroe, Laxdal	Sowjanya Gollapinni, Anselmo Cervera
		Calibration & Monitoring	Bhadra, Mondal	Kendall Mahn, Sowjanya Gollapinni
		protoDUNE-SP CE & TPC	Pitts, Liu, Pallavicini, Proudfoot, Galbiati	Gina Rameika
		protoDUNE-SP DAQ	Liu, Boehnlein, Pitts, Bhadra, Pallavicini	Giovanna Lehmann Miotto & Karol Hennessy
		DUNE-SP schedule & planning	Proudfoot, Charlton, Heinemann, Huber, Tschirhart	Eric James
		protoDUNE-SP TPC systems, schedule & planning	Proudfoot, Charlton, Heinemann, Huber, Tschirhart	Eric James

Number	Topic	Subtopics & Consortia	Referee group	POC
2	DUNE-DP	CRP & TPC systems	Monroe, Galbiati	D. Duchesneau
		DAQ	Liu, Boehnlein, Pitts, Bhadra, Pallavicini	Dave Newbold, Georgia Karagiorgi
		ElectronicsDP	Pitts, Liu, Pallavicini, Proudfoot	Dario Autiero, Takuya Hasegawa
		HV	Monroe, Galbiati	Francesco Pietropaolo, Bo Yu
		PhotonDP	Tschirhart	Ines Gil-Botella, Ettore Segreto, Dominique Duchesneau
		Slow Controls and Cryo Instumentation	Klebaner, Fuerst, Robinson, Laxdal	Sowjanya Gollapinni, Anselmo Cervera
		Calibration & Monitoring	Bhadra, Mondal	Kendall Mahn, Sowjanya Gollapinni
		protoDUNE-DP technical, schedule and planning	Tschirhart, Monroe, MacFarlane	Dario Autiero
3	DUNE physics, simulation & reconstruction		Boehnlein, Bhadra, Mondal, Huber, Heinemann	Ryan Patterson
4	DUNE Computing		Boehnlein, Bhadra, Mondal, Huber, Heinemann	Andrew Norman
5	LBNF/DUNE cryogenics		Klebaner, Fuerst, Robinson, Laxdal, Galbiati	David Montanari, Stephen Pordes
6	LBNF management, schedule and planning		Smith, Robinson, MacFarlane	Elaine McCluskey

Number	Topic	Subtopics & Consortia	Referee group	POC
7	LBNF/DUNE interfaces		Tschirhart, Smith, Klebaner, Fuerst	Nandhini Dhanaraj, Steve Kettell
8	DUNE management, schedule and planning		Charlton, MacFarlane, Proudfoot	Mark Thomson, Ed Blucher
9	Beamline design and optimization		Laxdal	
10	DUNE Near Detector		Bhadra, Huber, Heinemann, Monroe	