LBNC Meeting Report

September 15-17, 2021

FNAL (Remote)

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Introduction

The LBNC met September 15-17, 2021 remotely. This is the second meeting of three planned for 2021.

The attendees at the meeting, shown in Appendix I, included LBNC members and consultants, DUNE Collaboration spokespeople, Gina Rameika and Stefan Soldner-Rembold, and members, Fermilab Director, Nigel Lockyer, and Fermilab CRO Kevin Pitts.

The activities of the LBNC are used to monitor the technical progress of the International DUNE collaboration and those aspects of the LBNF Project which have direct impact on the DUNE experiment. The latter is accomplished with a single presentation at the beginning of the meeting: at this meeting the discussion of progress with the beamline is also included in the LBNF report. The Fermilab Director requests assistance in this process from a number of experts, who supplement the expertise of the LBNC members in the scrutiny.

In the six months since the previous meeting, important changes to the project have been taking place. These changes, including a substantial rework of both the DOE Project and the DUNE organizations, were discussed in the plenary presentations. Sub-detector progress for the Near Detector, the Vertical Drift CDR, and the Horizontal Drift has been monitored during the course of the summer. The Horizontal Drift preparations for ProtoDUNE II and the detector component fabrication have been reviewed as described below. Also under review is the Conceptual Design Report for the vertical drift module. The Computing consortium preparation of its Conceptual Design Report has been delayed and we heard about its status at this meeting.

The charge for this meeting, prepared with guidance and approval from the Director is shown in Appendix II. For this meeting there was considerable emphasis on understanding the organization and management of the international DUNE collaboration and project.

For each meeting the LBNC is organized into small groups which concentrate on particular aspects of the presentations and the discussions. The makeup of the teams for this meeting is shown in an Appendix III. The committee as a whole discusses and concurs with both the Closeout Report and the Meeting Report.

In a slight departure from our usual practice, we have executed a review of the technical progress made on the preparations for the Horizontal Drift module. The charge for that review is provided in Appendix IV. The review was conducted over two days, the first on September 8, 2021 a week before this meeting and the second during the breakout session on September 16, 2021. Our Closeout Report contains the relevant comments from the Horizontal Drift Review and theis document contains the Review Report.

At each meeting the LBNC makes the Closeout Report open to all, and subsequently prepares this LBNC Meeting Report. The agenda and presentations used for the meeting, the Closeout Report, and this report can be accessed at**:** https://lbnc.fnal.gov/

The committee thanks the DUNE and LBNF participants, Fermilab, its Directorate and support staff, for their assistance and support.

Executive Summary

We heard an extensive report about the progress with the LBNF component of the project. We saw that LBNF continues to make enormous progress with its boots on and under the ground in South Dakota. Its challenges are dominated by establishing a viable and supportable project plan with a healthy funding profile and plan in order to support its continuing good performance.

LBNF/DUNE is a large project even by US DOE standards, and, with the full international scope of the experiment, it is structurally quite complex. It is important that LBNF/DUNE the project and DUNE the Collaboration work well together at many levels. Without the infrastructure, there is no place to put the detectors, without the detectors there is no experiment, and without the 1500 international physicists there will be no physics. We are therefore pleased that effort is being made to clarify the organizations and interfaces with the goal of improvement in both the organization and the decision-making process.

Nevertheless, as we follow the progress being made, we continue to be concerned whether as well as talking the talk, all partners are walking the walk. Communication early and often between all partners must prevail. The goal of the communication is, of course, to establish a common purpose. Achieving a shared vision of the strategy for project and experiment is imperative. Therefore, strategic decisions must involve all stakeholders.

Over the course of the past year, we have seen DUNE show excellent progress on maturing the components of the Horizontal Drift Far Detector and make enormous strides towards establishing the Vertical Drift design. There is also a clear understanding of the eventual scope of a fully performant Near Detector; a minimal day-1 detector has also been defined by the collaboration. This is all a pleasure to see.

Our major concern is predictably associated with the schedule which arises from the DOE guidance on the possible funding profile. This guidance falls considerably short of that needed to maintain a technically limited schedule. Managing this situation will be a challenge and the collaboration must provide guidance on the physics. We trust that the DOE understands the importance of improving the funding profile. Nevertheless, when establishing the ground rules for this initiative in the P5 process, DUNE was conceived as a “best in class” experiment. Nothing has changed that.

We have completed a thorough review of the technical status of the Horizontal Drift module. The relevant section of this report represents the Review Report. We found that the Horizontal Drift module work is in good shape. Especially pleasing is the efficient way the down-select on the electronics was made, the completion of the APA design adjustments, and the progress in staging ProtoDUNE II.

A year ago the Vertical Drift concept was a glint in a few people's eyes. We have observed an ambitious R&D program which is enjoying amazing success. We have reviewed the technical aspects in the Spring of the year and recently reviewed a complete Conceptual Design Report. DUNE has our comments, and we have discussed their path to what we anticipate will be a recommendation for approval of the CDR by the end of 2021.

Early in the year we reviewed and approved a Conceptual Design Report for a Near Detector which in our opinion would support the highest precision measurements of CP violation foreseen for DUNE. A key component of that suite is the SAND detector and a critical down-select of its tracker design was recently made. R&D on other elements is making progress and a Day-1 detector adequate for the first few years of operation has been clearly identified.

DUNE has established a very effective base computing capability which is ensuring accessibility to data and to analysis facilities appropriate to the current analysis and simulation need. The challenge is now to attack some of the more difficult aspects of the needed software infrastructure and to create a team capable of doing this work. A key example involves the choice and development of the software framework(s). We look forward to reviewing the CDR in early 2022.

An established benchmark for performance of an experiment is publications. In addition to publication of its design work, DUNE has hit the mark with its publication of ProtoDUNE TPC physics data. The analysis software teams are challenged by the increased scope and demands from the multiple technology variants coming into use. An example is the vertical drift cold box and ProtoDUNE work.

Once again, DUNE has impressed us with the work it does, and the progress it is making. We look forward eagerly to the achievement of CD1RR by the LBNF/US-DUNE Project and progress to CD2 for the Far Site facilities. This would provide a solid platform from which to launch the detector sub-project CD2 considerations.

LBNF Status

Substantial progress has been made in the previous months. Design development has advanced as per plan in most areas and some detailed designs have been completed fully. The far side construction project has been split successfully into two subprojects, which provides focus and manageable scope to the teams. A credible plan towards CD-1RR in Q2 2022 has been presented and preparations are well underway with a focus on finalizing the project scope, firming the international commitments and settling the funding profile. However, the current level of uncertainties in the funding makes planning challenging. Physics, staff profile, cash-flow constraints, and collaboration considerations went into a new top-level project sequencing to respond to the new "reference funding profile". The uncertainties in cash and schedule projections place strain on all stakeholders and can potentially compromise ultimate LBNF excellence.

The LBNC is pleased to see that the rate of safety-related issues has dropped back after several incidents have been reported in previous LBNC meetings. The issues in the Yates Shaft are being addressed and safe temporary access through the Ross Shaft has been established and reduces the impact to the schedule.

Changes of project sequencing and timeline might impact the tie-in schedule of LBNF/DUNE into the Main Injector within the long accelerator shutdown in 2027 - 2029. As the projections mature, this schedule interface to PIP-II should be addressed timely to avoid additional delays.

As before, the project team is technically very strong and capable. We were pleased to see progress being made in the gender balance at the management level and are interested in seeing, in the future, how diversity is progressing more broadly across the project, including at the technical level. At this time, no concrete plan has been presented as to how to manage staff turnover, which is already present, e.g. horn power supply expertise, and is to be expected to grow due to length and nature of the project.

Recommendations

- Help improve communication and decision-making processes between DOE, FNAL, LBNF/US DUNE, and the DUNE Collaboration.
- Clarification of the sequencing, including at the intermediate level, in response to the funding profile guidance is required as soon as possible.
- For the LBNF/DUNE project, provide a management plan document, which will be maintained to reflect any further changes in the organization.

DUNE Status

The LBNC commends DUNE for substantial progress made on several fronts, namely:

i) The finalization of the ND design with the selection of the STT inner tracker option for SAND.

ii) The advancement and continuing refinement of the plan for ProtoDUNE-II construction and operation in 2023.

iii) The rapid progress on the FD2 R&D and prototyping, and the completion of the FD2 CDR.

The LBNC is concerned about the new funding schedule resulting in rather significant delays in the starting date for oscillation physics, especially given the international competition. The LBNC strongly appreciates the uniqueness of the DUNE experiment, being capable of measuring both the neutrino mass hierarchy and the CP violating phase, which is retained despite the induced delays.

The LBNC would like to see an updated plan and timeline for CD2/CD3 for the ND, FD1 and FD2, with clear requirements and appropriate contingency. The plan should include pragmatic and realistic timelines for the construction and operation of the ProtoDUNE detectors.

DUNE Organization

The LBNC heard about the substantial reorganization of the LBNF/DUNE DOE project in the report of the Project Director, and separately of corresponding evolutions to the DUNE collaboration organization from the DUNE Spokespersons. The level of detail in these presentations was not sufficient to understand fully how the new organizations will interact with each other and with other partners. However, the LBNC noted some simplifications in the new organization which could be attractive. The committee was pleased to hear that two management plan documents, covering the DUNE Collaboration and the LBNF/DUNE DOE project, are being written, and would like to see them.

The committee is rather concerned that the mechanism of interaction of the DUNE Collaboration leadership with the LBNF/DUNE project is indicated in the organograms as rather indirect and limited in nature. This is not a workable organisation. In discussions during the LBNC meeting it was evident that, in practice, more direct and detailed interactions do take place frequently. This should be reflected in the org. charts: the crucial role of the international DUNE Collaboration must be evident, as it is the DUNE Collaboration that will deliver the science. Interactions between the DUNE Collaboration and the LBNF/DUNE-project need to be transparent and frequent at all levels, and lead to a shared vision of the strategy.

In terms of DUNE's internal organization, the LBNC notes that more consortia now span multiple detector modules. The LBNC would like to understand how this will be managed within the different consortia.

The LBNC further is concerned that because the readiness of the two far detector modules for US DOE CD-2 review is quite different, forcing a combination of the two into a single review is likely to result in a delay of the FD1 CD-2 approval.

Recommendations

- Provide an updated DUNE management plan document, which will be maintained to reflect any further changes in the organization.

FD Horizontal Drift

The LBNC conducted a mini-review of the FD1 HD subproject, with sessions on Sept. 8 as well as Sept. 16. The mini-review closeout is combined in this report with the closeout report of the regular LBNC Sept. 2021 meeting.

The LBNC commends the FD1 project on the excellent technical progress on all fronts, since the last LBNC meeting in March 2021.

The completion of the ASIC down-select completes a major milestone in the development of the cold electronics (CE). The fabrication runs needed for PD-II have been submitted for all 3 ASICs.

The team has prepared as well as they can against possible delays due to the global ASIC shortage. Such delays, however, remain a concern, particularly given that the CE lie on the critical path for PD-II and that the CE schedule to complete PD-II by end March 2022 is tight.

The launch of final ASIC production requires PD-II results. Given the tight CE schedule for PD-II, it was reassuring to hear that the PD-II schedule has several months of float before it would delay the ASIC production submission, and eventually the FD1 installation schedule.

APA progress is very good, with APA 1 for PD-II having been produced and soon to be shipped to CERN for Coldbox testing and eventual installation in PD-II. The decision to use PD-I electronics for the Coldbox test needed to launch the APA procurement orders is wise, given the CE development schedule.

The 5-year APA production schedule defines the critical path for FD1, the completion of which marks the beginning of physics for the overall project. The schedule shown ends with 4 months negative schedule float. While it was stated that some time savings are anticipated (for example due to a newer method of wire tension measurements that would be less time-consuming), and that such savings would provide some schedule float to cover the inevitable delays that arise during a 5-year production schedule, a baseline schedule with an appropriate schedule contingency will be needed to successfully navigate the CD baselining process.

The PDS is considering 2 different WLS materials. The current plan is to test both in PD-II and reach a decision based on the results. This approach seems reasonable. However, to ensure a timely transition to PDS production, caution should be exercised to avoid a situation where the R&D phase drags on.

For value engineering and other reasons, it is being considered to change from Dupont kapton laminated G10 sheets to carbon-doped resistive G10 sheets for the CPAs. The plan is to test both options (ie. 1 CPA each) in PD-II. Apart from the limited statistics, a concern is raised by the requirement of stable operation of the DUNE detector in cryogenic conditions over multiple decades. While there are many years of experience of cryogenic operation with the Dupont kapton in multiple HEP experiments, a testing program would be needed to gain confidence in the long-term stability of the carbon-doped option.

Plans for detector calibration systems are rather preliminary, and tests of various options will be done with PD-II. It was stated that these systems will be outside the scope of the US construction project, but related elements of the project (such as the cryostat design) will be performed to allow their eventual implementation. While this approach has obvious advantages in terms of cost and the schedule for decision making, it is rather unorthodox and the approach to identifying the needed resources should be agreed upon by all stakeholders.

Very good progress is being made on the installation and integration planning. The experience gained at Ash River with various mockups continues to be very valuable.

Recommendations

- Before the next steps in the CD process, determine and implement a schedule for FD1 that includes an appropriate level of schedule contingency.

- Develop and implement a plan for validation of stable longterm cryogenic performance of the various key elements going into the cryostat (eg. the possible use of carbon-doped G10 for the CPAs).

- Continue to develop the plan for detector calibration systems, allowing DUNE to progress on identifying the resources needed for their eventual implementation, and ensuring that the calibration systems are not limited unnecessarily by design decisions made in the scope of the US construction project.

FD2 Vertical Drift

The LBNC held an in-depth technical review of the vertical drift design for FD2 in April-May 2021. The committee commended the project on the rapid technical progress and in building an effective organization to support FD2.

As reported at that review, the R&D and design validation for FD2 is planned in two major phases:

1. Demonstration of the CRP design and PDS/Arapuca operation in an upgraded coldbox, and demonstration of a new field cage design and HV extender in a coldbox and in the NP02 cryostat.
2. Demonstration of full system performance with a protoDUNE run in NP02 in 2023 which will include "module-0", meaning final design assemblies.

While all three developments in the R&D program (CRP, PDS and HV) require new designs, R&D and demonstration, the electrical isolation of the PD Arapuca modules mounted on the cathode structure is considered the most challenging.

As reported at the review, the simulation and physics performance studies planned for FD2 will take 6-12 months to complete. They will support design decisions ahead of module-0 construction.

At the review, DUNE provided the LBNC with a set of 38 milestones covering the R&D and simulation studies to aid the committee's monitoring of progress. DUNE has done an excellent job keeping the committee abreast of progress in meeting these milestones by providing interim updates, and this is much appreciated by the committee.

The progress presented at this meeting confirms that DUNE continues to make excellent progress in vertical drift, with only minor slippage in the milestones, and the project is on-track with the plan presented at the Technical Review.

A full-scale CRP and initial PDS components are being prepared for the first coldbox test with installation planned for October. In total four development cycles are planned for the coldbox through 2022. Individual component tests for the new HV extender and feed-through led to design modifications that were incorporated in the NP02 system test. The NP02 cryostat was recently filled with LAr and the voltage ramped up to 300kV. This marks major progress and bodes well for this critical test of the full drift field.

The PD module design is progressing with parallel developments pursued for fiber powering and readout of the modules mounted on the cathode. The committee would appreciate a walk-through of the plans to demonstrate PDS operation at 300kV through the series of coldbox tests and suggested that this be presented as part of a dedicated meeting (see recommendations).

The configuration proposed for protoDUNE/module-0 will allow full demonstration of the top and bottom anode planes and the PDS mounted on the cryostat walls and on the cathode plane. To achieve this, the drift depth in protoDUNE will be limited to about 3m. However, the full 6m drift field is expected to be demonstrated in the NP02 HV test at the end of 2021. The committee endorses this approach.

While the R&D timeline remains challenging, with the goal of demonstrating the CRP, PDS and HV solutions by late 2022, the rate of progress continues to be very impressive.

DUNE provided the committee with the draft Conceptual Design Report for review on Aug 10. The committee completed a thorough review and sent an extensive set of comments and questions, including 10 high level comments of a general nature and more than 300 comments of a technical, editorial and typographical nature. At this meeting DUNE has provided the committee with initial responses to the 10 high level comments as well as several of the others. DUNE will address each point raised, and prepare a second version of the document. It is anticipated that, likely with a dedicated meeting to close loose ends, the committee will be able to conclude the review with a recommendation for CDR approval by the time of the next LBNC meeting in early December.

Recommendations

DUNE should:

- Work with the committee to complete the CDR review process, and release of the final document by December.
- Work with the LBNC to organize a half-day meeting to appraise the committee on R&D progress and to walk through the plans for the coldbox tests in 2022.
- Report on progress in the simulation work at the next LBNC meeting in December.

Near Detector

The LBNC notes that due to funding advice from the DOE, DUNE now plans to stage the installation of the beam and the near detector (ND), with the ND being the last element of DUNE to be installed. We caution that data taken without the ND is unlikely to be usable for oscillation analyses due to the impossibility of controlling for beam and cross-section systematics. While we understand the resource restrictions that necessitate this staging, all efforts must be made to minimize the interval between beam start and ND readiness. The likelihood that beam power will be small on Day 1 will mitigate the loss of usable data in the period between beam turn-on and ND readiness.

DUNE has chosen the straw tube tracker (STT) technology for the inner tracking of the SAND beam monitor. The LBNC welcomes this conclusive decision on the inner tracker, which will allow the SAND consortium to move forward, and agrees that STT can satisfy SAND's critical role as a beam monitor. The possibility of using the passive C/CH_2 layers in the STT to study neutrino interactions on free protons is a particularly interesting capability enabled by STT. Current neutrino interaction models factor the cross section into a component describing interactions on free nucleons and a component incorporating nuclear effects. While these nuclear effects can differ between nuclei (making extrapolation between different nuclei difficult), the free nucleon component is common to all nuclei and may be usefully constrained with data on free protons.

DUNE is considering the installation of a liquid argon target, called GRAIN, inside SAND and will organize an internal review of this component later this year. The LBNC has not yet been presented with design details or a compelling physics case for this component.

The 2x2 cryostat from the ND liquid argon TPCs (ND-LAr) has been delivered to FNAL, and is being prepared for operations in CY2022. Module 1 of the ND-LAr is in production. A preliminary design review of ND-LAr is planned for early 2022.

An updated cost estimate for the ND-GAr magnet is expected by the end of September. DUNE has made progress on optimizing a simple inner tracking configuration for ND-GAr-lite.

The Temporary Muon Spectrometer (TMS) consortium has adopted the LBNC's previous recommendation to plan on building a prototype module, to be known as Module One. We see steady progress in the TMS magnet design, which has settled on air cooling of the magnet. The TMS design has switched to single channel SiPMs due to the vendor discontinuing the favored multichannel device. This change happens to also simplify the mechanical design. There is ongoing effort on mechanical prototyping of the TMS. The simulation effort for the TMS is progressing nicely. There are concerns that the TMS effort is short on scientific technical personnel with detector design expertise. The LBNC notes that the current TMS consortium leader is also in the process of retiring.

DUNE must go into CD-1RR with a clear, crisp statement of its plan for the Day 1 ND. DUNE's plan, which we endorse, includes the TMS, SAND, and ND-LAr detectors, and the

PRISM movement system. Longer term, replacement of TMS by ND-GAr will be required for DUNE to reach its ultimate sensitivity. LBNC would like to see a clear strategy of how DUNE will ultimately transition from the Day 1 configuration to ND-GAr for Phase Two, and notes that ND-GAr-lite would provide one attractive path for this transition.

CD-1RR is currently planned in April 2022, with 3 pre-reviews in the January-March period. A tailored version of the ND conceptual design report with a focus on US scope will be required for these reviews, and DUNE would appreciate some endorsement from the LBNC of its contents. The LBNC anticipates that DUNE will send it a copy of this tailored CDR later this calendar year. DUNE has identified some small scope gaps in the ND that will need to be resolved before CD-1RR. CD-2 is likely pushed to 2023-2024, due to the new US funding profile.

Recommendations

- DUNE should find additional technical effort for TMS with the skill set to develop the detailed design.
- At the first LBNC meeting in 2022, present technical design details and elaborate the physics case for the LAr target in SAND.

Computing

The DUNE Computing Consortium continues operating a distributed data processing and storage system that serves the activities of the collaboration well. We commend DUNE for this. The current main activities are the pass4a production and data analysis. The DUNE workload management system and the underlying infrastructure have been demonstrated to be capable of absorbing bursts of activity. Following a suggestion from the previous meeting, DUNE invested effort understanding the impact of data locality in processing efficiency. In reconstruction jobs, the impact of remote data access is barely visible, while for analysis jobs it is more important. We consider the outcome of those studies very important for the definition of a future computing model. We invite them to be repeated regularly, whenever the conditions on the infrastructure or the application change.

DUNE continues engaging with the Research and Education networks, and particularly ESNET, to ensure its current and future needs will be met. We learned that some of the facilities are building experience with the DUNEONE overlay network. We would like to hear more at the next LBNC about this experience, the driving use cases, which part of the infrastructure is involved and what are the future plans. We would be interested also in an update of the planning of the SURF-FNAL link.

The hardware resource projections were updated based on the discussions on the LBNF schedule. Hardware resource contributions were identified and are being formalised. Sharing the infrastructure and many of the services with large HEP projects such as WLCG experiments continues to bring benefits to DUNE, in terms of flexibility and ease of operations.

DUNE made progress defining the needs of the future software framework and undertook a comprehensive review from the HEP Software Foundation. The review highlighted some novel challenges, particularly linked with the large event size and specific use cases like supernova signals. For example, the implementation of capabilities such as event-level MPI are very challenging to implement. Memory management will very likely require multithreading capabilities. Various scenarios were presented, including a progressive adaptation of the current framework, or the adoption of an existing one. Including capabilities to support user analysis in the framework brings an additional level of complexity if DUNE decides to do so. We appreciate that a conclusive decision about the architecture and implementation of the framework can not be defined in time for the CDR. We note that the DUNE requirements will imply considerable development work and time, regardless of the implementation chosen. We request that DUNE defines the process leading to this decision and presents it at the next meeting, with a timescale. We also invite the Computing Consortium to consider the effort needed across consortium boundaries, for example in the implementation of thread safe algorithms.

DUNE plans to produce the Computing CDR by the end of 2021. We support this plan.

Recommendation

- DUNE should produce a Computing CDR so that it can be reviewed for the March 2022 LBNC.

Simulation, Reconstruction and Data Analysis

The LBNC commends the DUNE collaboration for the excellent progress on producing and publishing high quality physics analyses using the ProtoDUNE data. In particular, we would like to congratulate DUNE on the publication of "First results on ProtoDUNE-SP liquid argon time projection chamber performance from a beam test at the CERN Neutrino Platform" in JINST and the submission of "Design, construction and operation of the ProtoDUNE-SP Liquid Argon TPC" also to JINST.

The LBNC looks forward to the publication of three results that are approaching maturity: the Michel electron energy resolution, Pandora performance and CNN performance. Michel electrons will be used to calibrate the detector response to low energy electrons. A purity of 96% and an energy resolution of 26% at 50 MeV was demonstrated using the ProtoDUNE data. Good agreement between data and simulation is shown for the particle identification efficiency with Pandora. The CNN algorithm distinguishes single tracks from showers. Although differences between the simulation and the data in the modelling of showers are observed, there is good agreement with the efficiency of the classification.

Good progress was shown for the hadron cross sections, seasonal variance of the cosmic ray muon rate, detector calibration, PID with dE/dx and the beam energy resolution. The LBNC notes that a number of the measurements are topics for PhD theses. The inclusive hadron cross sections are determined from measurements of the primary track length. For the energies accessible to ProtoDUNE, there is good agreement between the data and simulation. Furthermore, the proton and neutron inelastic cross sections are being extracted. We would be interested to see comparisons of the proton and neutron inelastic cross section measurements to existing results. The pion absorption and charge exchange cross sections broadly agree with G4, although discrepancies in the modelling of prior experiments compared to G4 are observed. The amplitude of the modulation between summer and winter in the cosmic ray muon rate is measured to be $3.6 \pm 0.8\%$ and agrees with previous measurements. A range of effects that impact the detector calibration were measured and corrected for. In general, the detector response is uniform in space and time after calibration. Good mu/gamma and e/gamma separation is found and the general features of the data are modelled by the simulation. The beam electron energy resolution is measured and the stochastic term is found to be 2% for the TPC and 9.9% for the PD, which exceeds the design requirements. Studies of detector stability showed that the LAr purity is good as long as there are no issues with the Ar circulation pumps. The charge response in the TPC was largely stable over the 22 months of operation except for a gas recirculation pump leakage in 2019. We were encouraged to see the successful results of the Xe doping. The neutron-based calibration was tested with a neutron source. In most cases, the agreement between the data and simulation is excellent.

Recommendations

- Report on progress in the simulation work at the next LBNC meeting in December. In particular, we wish to hear details about the photon simulation, and about the status and plans for the simulation for the FD2 Vertical Drift.

Appendix I: Attendees

Committee: Ties Behnke, Simone Campana, Dave Charlton, Francesco Forti, Cristiano Galbiati, Alexander Gottberg, Heather Gray, Joachim Kopp, Gobinda Majumder, Hugh Montgomery, Scott Oser, *Adam Para,* John Parsons, Tom Peterson, *Anna Pla-Dalmau*, Niki Saoulidou, Jeffrey Spalding, Eric Kajfasz, Darien Wood;

Scientific Secretary: Angela Fava

Fermilab PAC Chair: Hirohisa Tanaka

DUNE/LBNF (based mainly on registration)

Regina, Rameika, Stefan Soldner-Rembold, Chris Mossey, Elaine McCluskey, Alberto Marchionni, Andrew McNab, Cheng-Ju Lin, Chris Marshall Claudio Silverio Montanari, Dan Dwyer, Daniela Macina, Dario Autiero, Dominique Duchesneau, , Duane Newhart, Eric James, Ettore Segreto, Filippo Resnati, Flavio Cavanna, Francesco Pietropaolo, Gary Barker, Intikhab Alam, Inés Gil-Botella, Jack Fowler, Jaehoon Yu, Janet Bishop, Jolie Macier, José Maneira, Ken Herner, Leigh Whitehead, Luca Stanco, Marco Verzocchi, Marzio Nessi, Mathew Muether, Matthew Worcester, Maxine Hronek, Michael Kirby, Michele Weber, Mike Kordosky, Nadine Kurita, Paul Laycock, Russell Feder, Ryan Rivera, Sandro Palestini, Steve Kettell, Takuya Hasegawa, Theresa Shaw, Thomas Junk, Thomas LeCompte, Tim Bolton, Tingjun Yang.

FNAL Directorate/Management: Nigel Lockyer, Kevin Pitts, Doug Glenzinsky, Kayla Decker

DUNE RRB: Alison Markovitz

DOE: Adam Bihary, David Lissauer, Simona Rolli

Appendix II:
Charge Letter: LBNC September 2021 Review, September 15-17, 2021

18-Aug-2021

As usual, the LBNC should construct a report in which it acknowledges, comments on, and where appropriate, makes recommendations following the presentations and discussions during the meeting.

The LBNC should hear about the general status of LBNF and DUNE. Of continuing interest is the planning for a tailored approach to baselining following the recent DOE-IPR and the schedule for future DOE-IPRs. In addition, significant changes to the baseline funding profile has considerably modified the timeline for some aspects of the project. These modifications affect the US project, international partners, overall scope and the timeline to physics. The LBNC should hear about these issues and provide input and feedback.

The LBNC has regularly heard about the safety performance associated with the work at the Sanford lab. It would be interesting to understand how DUNE has more broadly addressed ES&H issues and integrated Lessons Learned from experience with the NP02 and NP04 experiments and other neutrino detector fabrication such as the SBND detectors,

As the definition of the technical plans for the major pieces of the DUNE detector progress, it is important for DUNE to ensure that all aspects of the endeavor enjoy an appropriate organizational structure and management coverage. DUNE is expected to discuss its management structures in the DUNE overview talk, in the Technical Coordination and to a greater or lesser extent in the main Sub-detector sections. These structures should allow convenient mapping to the US-DUNE DOE project. In its reports from this meeting, the LBNC should include commentary on the current management implementation within DUNE including how well the major sub-systems Far Detector Modules, and Near Detectors are integrated.

Prior to, and as part of, this meeting, the LBNC will undertake a "mini-review" of Far Detector 1 (FD-1, horizontal drift). The first part of the review will happen on September 8, in advance of the LBNC meeting, while the final portion of the review will occur during the LBNC meeting. The charge for the FD-1 mini-review is provided separately, closeout will be combined with the LBNC closeout.

The LBNC should hear about the progress with the FD-2 that utilizes Vertical Drift SP technology. Focus should be upon progress achieved since the dedicated vertical drift review in April/May 2021. The presentation(s) should cover:

a) Progress towards ProtoDUNE II VD (NP02).

b) Technical progress on the Vertical Drift Detector, HV, CRPs, photon detection, etc.

c) Progress on integration, documentation, including the ongoing review of the Vertical Drift CDR.

The LBNC should hear about status and plans for the Near Detector. This should include the "Phase 1" ("Day 1") Near Detector as well as planned evolution toward the ultimate DUNE ND. In light of the funding profile issues outlined above, the LBNC should hear about priorities, options and actions planned with the Near Detector.

The LBNC should also hear an update on safety issues related to LBNF and DUNE.

Appendix III: Assignments

Consultants shown in Italics

LBNF Status	**Gottberg,** Charlton, Fuerst, Peterson
DUNE Status	**Saoulidou,** Gray, Charlton, Kopp
Dune Organization	**Charlton**, Fuerst, Gottberg, Peterson, Spalding
FD1 Horizontal Drift	**Parsons**, Behnke, Fava, Majumder, Pla-Dalmau
FD2 Vertical Drift	**Spalding**, Galbiati, Kajfasz, *Para,* Wood
Near Detector	**Oser,** (Behnke), Kopp, Saoulidou
Computing	**Campana**, Charlton, Gray
FD1 Mini-Review	**Parsons**, Behnke, Fava, Majumder, Pla-Dalmau
FD2 Vertical Drift	**Spalding**, Galbiati, Kajfasz, *Para,* Wood
Near Detector (Breakout)	**Oser,** (Behnke), Kopp, Saoulidou
ProtoDUNE Analysis	**Gray**, Campana, Charlton
Computing (Breakout)	**Campana**, Charlton, Gray

Appendix IV: Horizontal Drift Review Charge Letter

10-Aug-2021

Charge Letter: LBNC Review of DUNE Far Detector 1 – Horizontal Drift

The DUNE Collaboration continues to move forward on three primary detector systems: Far Detector 1 (FD-1) using horizontal drift technology; Far Detector 2 (FD-2) using vertical drift technology; and the Near Detector (ND) consisting of multiple detector components. Of the three, FD-1 is the most mature, capitalizing on considerable R&D as well as a very successful ProtoDUNE detector. Based upon the successes and lessons learned to date, the Collaboration plans to move forward with a "Module 0" demonstrator in the ProtoDUNE cryostat. This Module 0 will utilize production-level components, and success will segue into full production of FD-1 components.

The LBNC has continued to monitor progress with FD-1, but has lacked the time necessary to perform a deeper dive into progress achieved over the last 12-18 months. As a consequence, we ask the LBNC to perform an in-depth review of all aspects of FD-1. This review will take place virtually on Wednesday, September 8, 2021 and also in a parallel session during the LBNC meeting on September 16, 2021.

The LBNC is asked to look at the overall status, progress and plan for FD-1. In particular, we ask the LBNC to consider the following questions:

- Please assess technical progress on FD-1 components since the completion of ProtoDUNE-I.
- What key challenges exist ahead of ProtoDUNE-II? Are they being adequately addressed?
- What additional lessons were learned through the decommissioning/disassembly of ProtoDUNE-I? Are those lessons informing future activity?
- Please consider the installation plan and timeline for the NP04 ProtoDUNE-II. Is the timeline and staffing credible?
- Is DUNE utilizing internal design and preproduction reviews adequately?
- Does DUNE have sufficient personnel actively working on FD-1 so that it can move forward on the anticipated timeline? Are there aspects of FD-1 that are currently uncovered?
- Is sufficient communication taking place between consortia to ensure successful system installation and integration within ProtoDUNE-II?
- Does the FD-1 effort have a good plan to move from ProtoDUNE-II to full production of final components?

Although this review is of the international DUNE FD-1 effort, some aspects of the findings and recommendations will be of direct relevance to the DUNE-US project, including the CD-1 "refresh" that is expected to take place in calendar year 2022. Also of relevance to DUNE-US project review and approval is timescale for "baselining" (CD-2).

The Committee should plan to deliver a closeout report as part of the LBNC meeting conclusion on September 17, 2021 and provide a full report by September 30, 2021.