

Long Baseline Neutrino Committee

FERMILAB, October 2022

CLOSEOUT Report

October 7, 2022

Acknowledgements

The LBNC continues to enjoy examining the advances being made the LBNF project and by the DUNE Collaboration.

We appreciate interactions with DUNE over the course of the previous several months and the efforts made to prepare the presentations in both Plenary and Breakout sessions. They represent an impressive body of work.

The committee also thanks Fermilab, its new Directorate, and its staff, for their continuing support.

The LBNC would like to congratulate Gina Rameika on her appointment as Associate Director for High Energy Physics of the Department of Energy, Office of Science. During the past several years, in several leadership roles, Gina has been a key member of DUNE and has enormously facilitated the interactions between DUNE and the LBNC.

Charge Letter: LBNC March 2022 Review

The LBNC is charged by the Fermilab Director to review the scientific, technical, and managerial progress, plans and decisions associated with the Fermilab Long Baseline Neutrino Facility (LBNF) and the Deep Underground Neutrino Experiment (DUNE).

For the October 2022 meeting, the LBNC will meet in hybrid mode to review status and progress of LBNF and DUNE. As with other meetings, 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. In addition to updates on major detector systems: Far Detector 1, Far Detector 2, and Near Detector, the LBNC should also receive updates on activities towards ProtoDUNE-II and LBNF Beamline. Along with technical progress, staffing and plans, presentations should report on issues and concerns related to supply chains and availability of components.

Charge Letter: LBNC March 2022 Review

As design and construction decisions are made by partners contributing to this effort, the LBNC should comment on scope, timeline, and physics performance impacts of these decisions. Where appropriate, the LBNC should also comment on overall coherence of the international effort.

In considering the presentations and material provided for the meeting, attention should be given to prior LBNC recommendations and actions that have been undertaken to address these recommendations. For the DUNE detectors and computing, we would like to continue our work toward uniform and regular reporting and tracking of major DUNE technical milestones.

Other specific areas of review for this meeting should include:

- 1) Re-affirm scope and potential phasing of DUNE near detector complex. Follow up on the response to recommendations from the previous LBNC meeting.
- 2) Review and endorse as appropriate DUNE Computing CDR.

The LBNC should develop a Closeout Report which it should deliver at 12:15 CDT on October 7, 2022. Subsequently this should be refined into a LBNC Meeting report.

LBNC Meeting Assignments 10/5/2022

LBNE Status (Progress, Plans and Organization)

Gottberg, Aleksa, Ball, Champion

DUNE Status

Saoulidou, Kopp, Bortoletto

FD1 Horizontal Drift

Rumerio, Ball, Majumder, Wallny

FD2 Vertical Drift

Wood, Aleksa, Forti, Kajfasz, Para, Rescigno

Near Detector

Oser, Kopp, Saoulidou, Bortoletto

Computing (inc CDR Status)

Campana, Rusu

ProtoDUNE Analyses

Rusu, Campana, Rescigno

Oscillation Analysis Update

Kopp, Bortoletto, Oser, Para

LBNC Meeting Assignments 10/05/2021

Breakouts

Beamline Status & Progress

Gottberg, Ball, Champion

FD2- Vertical Drift Progress inc CDR

Wood, Aleksa, Forti, Kajfasz, Para, Rescigno

FD1- Horizontal Drift Progress

Rumerio, Ball, Majumder, Wallny

Near Detector Progress

Oser, Bortoletto, Kopp, Saoulidou

DUNE Computing Progress;

Campana, Rusu

LBNF Status (Progress, Plans and Organization)

Findings:

- The CD-1RR review was passed in July 2022.
- The CD-1RR Funding Profile had been announced shortly before the last LBNC meeting. This funding profile has now been fully integrated into the schedule, resulting in accelerating the start of beamline operation by nearly 2 years and the near detector installation by 7 month.
- LBNF/DUNE-US has received \$125M from the US Inflation Reduction Act (IRA) for 2023, this will not increase to total funding DOE envelope but will allow the project schedule to be maintained by offsetting near-term inflation impacts. However, this will not allow significant acceleration of near-site work.
- Preparations are made to issue a contract for the Far Detector and Cryogenics subproject nitrogen contract.
- The far-site excavation has been baselined and baselining of the far-site building and infrastructure is ongoing.
- 18.5 days of downtime in excavation work have been encountered due to a power outage at the Ross substation. The resulting costs will be absorbed from the contingency.
- A task force, lead by the CRO and the COO, has been put in place to finalize the planning of host lab support to the project and experiment.
- NSCF+B schedule is funding limited but the team is looking at early procurement authority for long-lead time items.
- The ND DOE cost cap remains at \$200M.

LBNF Status (Progress, Plans and Organization)

Comments 1/3:

- Congratulations for successfully passing CD-1RR. This reaffirmed selected alternatives, re-established the project point estimate and cost range, implemented subproject execution strategies, all important steps for setting the project on track.
- A key challenge for the project is how to respond to the rapidly changing external conditions. The LBNC is relieved to see that significant immediate risks posed by supply chain issues and inflation are being mitigated using the funding advancement available through the IRA. It is an important accomplishment that the excavation project was successfully baselined and that the previous top-level project timeline could be confirmed. The Committee is pleased to note that a full risk-based re-evaluation, taking current geopolitical constraints into account, is being prepared for ESAAB.
The advanced funds through the IRA are certainly mitigating the immediate effects of inflation, however, in the long term an increase of the total project costs due to inflation is very likely, should be evaluated and needs to be discussed in due time with DOE.
- Considering the growing lead times for some items, the LBNC endorses initiatives to gain early procurement authority, especially for those subprojects that are operating on a funding-limited schedule, like the NSCF+B.

LBNF Status (Progress, Plans and Organization)

Comments 2/3:

- The LBNC commends the massive progress that has been made on excavation while maintaining an above average safety performance. Excavation is now >40% complete bringing the overall subproject to >65% complete. LBNF/DUNE-US is providing a large fraction of cryogenic infrastructure and preparations are on track to issue a major contract in January, and an agreement has been signed with CERN to supply the second cryostat.
- The Project Executive Leadership Team structure had been presented at the previous LBNC meeting and is now fully established. The LBNC notes that this organization structure works well for all major stakeholders.
- Access to the Ross substation has been a continuing issue of the far-site excavation project. An investigation of the recent power outage has been conducted and actions are being integrated. The LBNC wonders if an in-depth evaluation of this old shaft and its infrastructure is warranted to reduce further issues.
- The Target Station Integration Building (TSIB) is critical to support the NSCF+B subproject, as well as the LBNF operation and power ramp-up. The commitment of the host lab has recently been demonstrated by the internal funding of TSIB to maintain the construction schedule

LBNF Status (Progress, Plans and Organization)

Comments 3/3:

- The \$200M cap on the Near Detector Subproject continues to be a concern in that it may limit the ultimate capabilities of the DUNE experiment unless cost mitigations can be developed.
- The planned Independent Project Reviews across the five subprojects are somewhat daunting, especially for the remainder of calendar year 2022. In addition, the project is being reviewed by the DOE Office of Inspector General and Office of Enterprise Assessment. There is a risk that the project office - and project team - will not be able to adequately support so many near-concurrent reviews.
- It's unclear if the potential impacts of inflation and supply chain disruption are fully appreciated. For example, electronics components are in short supply and have long lead times. It's quite uncertain when this situation will improve.
- It will be important to proactively prepare for procurements in advance of CD-3x approvals so that the procurements can be issued without delay when ESAAB approval is obtained.

No recommendations

Beamline Status & Progress

Findings

- A CD-3a review for the NSCF+B subproject will be conducted in December 2022. Beamline kicker and horn components will be procured with the resulting budget authorization.
- The CD-2/3 review for the NSCF+B subproject is planned in the fall of 2023.
- The magnet work at BARC is on hold.
- UKRI is conducting prototyping work that will lead to final design of a full-scale prototype target.
- The accelerator ramp-up schedule indicates beam to LBNF in Q1 FY 2032.
- There are approximately 45 FTEs supporting this subproject in FY 2022. This will drop off somewhat over the next couple years before ramping up for construction and installation.

Comments

- The NSCF+B presentation from the July 2022 CD-1RR review was shared with the subcommittee following the breakout session. The subcommittee would appreciate receiving this level of detail in future LBNC meetings.
- It would be appreciated if other members of the NSCF+B team attend the breakout session and present a few relevant and timely presentations along with the Deputy Project Director's overview presentation at future LBNC meetings.
- The subcommittee looks forward to the resumption of magnet work at BARC. Final designs for the magnets are needed in order to complete the designs for related components.
- The LBNC will continue to follow the interfaces between NSCF+B and other parts of the project, especially ND and DUNE and requests that the status of all major interfaces will be presented at the next meeting.

No recommendations

DUNE Status

- LBNC congratulates DUNE for significant, critical and in occasions impressive progress made on several fronts since the last LBNC meeting.
- Specifically, LBNC commends DUNE for :
 - Successfully completing the DOE IPR and CD1RR reviews, which signals the transition of the DUNE experiment into a new era.
 - Articulating a clear and strong physics message at Snowmass on both i) DUNE's unique, complementary and synergistic capabilities in the global context and in comparison to HYPER-K and other neutrino oscillation experiments, and ii) a well thought out phased approach for achieving its main physics goals.
 - Having successfully completed the Computing CDR which LBNC reviewed and proposes for approval.
 - Having improved the DUNE organization and management structure, as well as the interfaces with the DUNE-US project.

DUNE Status

- LBNC commends DUNE for :
 - Continuing to make excellent progress on all FD1 fronts : i) the APA production ii) the photon detection system iii) the Module-0 installation iv) preparations for the CD2/3 review in June 2023.
 - Continuing to make excellent progress on all FD2 fronts : i) R&D and prototyping ii) ProtoDUNE-VD installation ii) advancement and finalization of the design with a goal to deliver a first TDR draft to LBNC by mid-November 2022.
 - Having FD1 and FD2 scope clearly defined in multi-institutional MOUs.
 - Continuing to make very good progress on physics analysis with the ProtoDUNE-SP and ProtoDUNE-DP data-sets, and advancing on preparations for ProtoDUNE-HD and ProtoDUNE-VD.
 - Making significant progress on DUNE-ND concerning the ArgonCube 2X2, all ND Phase I sub-detector systems, and the DUNE-PRISM movement system.
 - The initiation of a new effort on a more integrated and comprehensive oscillation analysis, with realistic simulations and algorithmic reconstruction of all ND sub-detector systems, and improved statistical and systematics models for obtaining the final oscillation results.

DUNE Status

- LBNC fully endorses the DUNE overall phased approach in achieving its primary physics goals. As a key element of this phased approach, LBNC acknowledges the need and importance of a highly capable Near Detector Complex, for both Phase I and Phase II, as has been described and articulated by the Collaboration thus far, i.e. as a functionally “identical” smaller replica of the FD, with ND-LAr being a key and necessary component. This approach is well established, utilized by all previous long baseline neutrino oscillation experiments, and targets both the cancellation of systematic uncertainties with DUNE-PRISM, and minimizing their impact by providing strong constraints.
- LBNC acknowledges the extensive ND Phase I optimization studies that have been performed by DUNE, involving both ND-LAr and TMS. These clearly show that the current configuration of these two sub-detector systems is optimal, and cannot be descoped without seriously harming the physics performance.

DUNE Status

- LBNC welcomes and acknowledges the significant international partner contributions to the ND Complex from Bern (ND-LAr) and INFN (SAND), and strongly encourages the Collaboration to continue to develop a plan to best leverage these contributions given the overall cost constraints.
- LBNC urges DUNE to continue to improve and advance the overall ND plan, in terms of identifying the needed human and financial resources and securing international contributions, such that Phase I, and later Phase II, detector configurations can be build.
- LBNC urges DUNE to continue to systematically monitor and assess the impact of supply chain issues, and develop plans, as needed and when possible, to mitigate those.

FD1 Horizontal Drift

Findings and Comments:

- The LBNC commends the DUNE collaboration on the further excellent progress on FD1-HD.
- The Production Readiness Review for the 150 APAs was successfully signed off in July, and the UK production has started (3 APAs currently under construction), in line with the goal of starting FD1-HD installation in 2026.
- The project has maintained 4 months of float in the APA production schedule.
- To further optimize the APA production plan, a 5th winder will be added at the Daresbury factory, and a production site in Chicago, equipped with a 6th winder, is being prepared with the goal of producing about 10% of APAs. Explanations have been provided to motivate the investment in this second site even if the production capability is limited. Extra capacity at the Chicago site could account for a relatively limited gain in schedule.
- A key issue on availability of Cu-Be wire has arisen for APA production, due to Beryllium shortage. The amount of wire currently at hand is sufficient for only a very limited number of APAs. The project is actively consulting vendors in several countries to better understand the situation, and even started discussing possible alternative options and the many associated challenges that a change of plan would involve.
- Following the Production Readiness Review of the LArASIC chips in March, bridge funding was used to order enough LArASIC wafers for both FD1 and FD2 - addressing the risk of losing access to the 180nm CMOS process on which they are based. The first 50 of 250 wafers have been received.

FD1 Horizontal Drift

- The project will seek DOE CD3A approval to start production of ColdADC and COLDATA ASICs in 2023, as well as to procure FPGAs and all components for FEMB, WIB, and PTC boards. This is in line with the start of modules production in 2024, taking into account currently foreseen lead times. We commend the project for being proactive in taking preemptive measures to ensure that supply chain challenges will not negatively affect the production schedule. We encourage all areas of the project to adopt or continue with this approach.
- Progress continues on the integration of ProtoDUNE-HD-Module-0 (ProtoDUNE II), where 3 Module-0 APAs have been outfitted with electronics and photon detectors, and have been tested in the CERN cold box, with the 4th APA currently being operated in the cold box. The detector performance has been demonstrated to be better or equivalent to ProtoDUNE-SP.
- Liquid Argon suppliers cannot currently provide the amounts needed to fill the ProtoDUNE cryostats, due to reduced oxygen production in Europe. Therefore, it is possible that the cold run will be further postponed, even beyond the DOE CD 2/3 review for the FDC sub-project, currently scheduled for June 2023. The project is encouraged to critically evaluate and attempt to minimise any risks associated with continuing APA production despite delayed feedback from the ProtoDUNE II cold run. These risks will likely have to be accepted.
- We thank the project for expanding the milestone list to encompass all activities through the installation of the detector.

FD1 Horizontal Drift

Recommendations:

- Critically look at / evaluate any modifications made to the APA design of those used in ProtoDUNE-I to the production ones, in order to determine if any potential weakness could have been introduced that would only manifest itself during a cold run. Perform cold tests as soon as they become feasible while production is going on.
- Consider the possibility of securing enough parts for a second winder at Chicago which could further boost production / schedule contingency that could be commissioned at the same time as the first winder. The motivation and rationale for the second site at Chicago should be better articulated.
- Continue to proactively consult known and potential new vendors that could help solve the current shortage of Cu-Be wire for full production. If the prospects of solving this issue are found to be limited, the project should ramp up the investigation and evaluation of possible alternative wire materials and plan for qualification campaigns.

FD2 Vertical Drift

R&D highlights: The committee continues to be impressed with the rapid and thoughtful progress.

- **Photon Detection System (PDS):** Note that the FD2VD subcommittee had a meeting with the FD2VD team in September that was devoted to updates in the progress on the PDS. Significant advances included:
 - exercising xARAPUCAs in the cold box with Power over Fiber (PoF) and Signal over Fiber (SoF). A 50% power delivery efficiency was achieved with GaAS PoF in cold.
 - noise issues were studied, including light contamination from the PoF. Mitigation strategies are being implemented.
- **High Voltage:** The field cage design was updated to extend the 70% transparent region around the ends of the module volume; same configuration to be used in Module 0. Permits installation of xARAPUCAs on the end membrane, which give more uniform light coverage. Design of HV feedthrough updated based on previous NP02 experience.
- **Simulation and reconstruction:** The FD2VD simulation is running with updated CRP strip orientation, realistic field cage, not yet final PDS detector location. Technical advances made production much faster. Comparisons with HD produced for VD TDR. Studied low-energy physics efficiency, SNB triggering.
- **CRP assembly:** Anode design is nearly finalised and the same design has been used to produce the 4 CRPs (2 Top and 2 Bottom) for Module 0. New lighter framework for top modules under test at CERN. First bottom half-module assembled in US (Yale) and sent to BNL for testing. Technical problems with silver printing being addressed. Edge connectors revised based on previous coldbox tests

FD2 Vertical Drift

Comments:

- The final VD Module 0 tests may be delayed considerably by lack of argon availability. The project identified useful activities to carry out in advance of filling NP02 with LAr: assembly exercises, testing at warm temperatures. Given the expected delays and the relative maturity of the two FD designs, the optimal order of filling NP04 and NP02 is not obvious.
- The project team has been proactive in securing the components needed for Module 0. A few items, such as cold cables, have been identified as potential sources of delay, and these are being pursued actively.
- The simulation and reconstruction has had much less time for detailed study for VD than for HD, but it is showing comparable performance. There are outstanding items requiring deeper understanding
 - the lack of expected improvement in PDS resolution with higher visible energy
 - lower CVN efficiency than HD, especially for low-energy muon neutrino CC events
- Answers to follow-up questions from September meeting on PDS:
 - The optical component of the PDS noise from PoF IR photons leakage has been quantified in a dedicated setup. The electronics will be optically separated with an enclosure to mitigate the leakage.
 - Undershoot of the PDS electrical signal is about 2% of the peak with a long duration. It is not expected to be a source of bias from pile-up.
- The committee looks forward to receiving the Technical Design Report for review in November.

Recommendations:

- Plan for optimal use of time for Module 0 studies in the case of significant delays waiting for liquid argon
- Finalize the PDS electronics choices for fibers, optical connectors and leakage mitigation

Near Detector Status

General comments:

- After a round of cost scrubbing, the current cost estimate of US scope for the ND is \$249M — still \$49M above the cap imposed by DOE.
- DOE has imposed restrictive directives about the cost division between threshold scope vs. objective scope for ND. These constraints present difficulties for DUNE and preclude the threshold scope being sufficient to enable oscillation analyses. DUNE and DOE should revisit these constraints and ideally remove them.
- The LBNC reaffirms its support for DUNE's phased approach for its near detector. We emphasize that in order to do oscillation analyses DUNE requires all of the components of ND-LAr, TMS, DUNE-PRISM, and SAND. We see no descoping options that would save significant costs to the US project without dramatically impacting the physics performance of DUNE as a whole even during the early stages of running.
- We endorse ND-GAr as a future upgrade for DUNE to achieve its ultimate physics reach.

ND-LAr:

- Preliminary design for ND-LAr is complete. A preliminary design review was held in late June, resulting in a positive report.
- DUNE is preparing to operate the 2x2 demonstrator in the NuMI beam in 2023. The last two modules have been delayed due to supply chain issues with the charge readout electronics and cryosystems, and issues with delivery of light readout systems from Russia due to the war in Ukraine. DUNE still thinks it will be ready to begin operation in the NuMI beam by spring.
- DUNE has put significant effort towards developing analysis tools (simulation, reconstruction, integrated analyses with MINERvA). Many of these are becoming quite advanced.

Near Detector Status

TMS:

- The TMS Consortium has matured significantly, with an appropriate number of groups with relevant experience taking on defined responsibilities.
- A new “short stack” design for the steel plates could introduce some cost savings and simplify coil installation, and is under consideration.
- A new ASIC developed for CALICE is being considered for use in TMS’s analog front-end electronics.

PRISM:

- Some advances in the analysis status were discussed, although not in detail. Comparisons of oscillation contours from PRISM to those from traditional methods are underway. Some differences are seen and efforts are underway to understand these. DUNE hopes to be ready to show such comparisons at the January 2023 LBNC meeting. The LBNC eagerly anticipates seeing this work.
- Movable platforms for TMS and ND-LAr are at preliminary design stage.
- We were shown many details of the design for the movement system and cabling.
- Plans for a 4-roller prototype were descoped to a simpler Engineering Test Unit, with one powered and one non-powered roller.

Near Detector Status

SAND:

- The LBNC was shown proposed divisions/interfaces between the US project and SAND. Because the cost of the US scope for SAND is large (\$26.5M), these costs should be carefully scrubbed and scope swaps considered to reduce the cost to the US project.
- Refurbishment and repurposing work on KLOE magnet is ongoing. Shipment to FNAL is expected by the end of 2024.
- Three prototypes are planned for the Straw Tube Tracker. A preliminary design review is planned for Nov 2023. There are significant uncertainties due to the pandemic, supply chain, and the war in Ukraine. The LBNC would like to hear details about the expected impact and mitigation strategies for these issues.
- A prototype of GRAIN's internal vessel is planned for next year, while the outer vessel is still in preliminary design. A simulation for GRAIN is now being developed. A PDR is planned for Apr 2024.
- The physics case for GRAIN still seems weak to the LBNC, but we have been informed that its removal would result in little reduction of the US project cost.

Recommendations:

- All stakeholders should continue to work to ensure that sufficient resources are available to build ND-LAr, SAND, TMS, and PRISM in time for initial physics running.

Computing

- The priority of the Computing Consortium for the next two years should be the support of ProtoDUNE phase-2 activities. We would like to hear an update from the DAQ team at the next meeting. This update should include the interfaces with offline computing.
- The LBNC supports the DUNE data challenges plan as a program to commission new services and workflows. Good progress was presented at the meeting showing the newly developed components for workflow and data management working at scale. We are looking forward to hear the conclusions of the data challenges campaigns at the next LBNC. We believe the data distribution from FNAL to the other DUNE sites should also be challenged soon.
- DUNE computing builds on the existing HEP infrastructure and contributes evolving it according to its needs. The LBNC strongly supports this strategy. We suggest DUNE to discuss common data challenges with other HEP experiments, to exercise the effective use of shared resources and services.

Computing

- DUNE produced an extensive Conceptual Design Report that covers all the important areas of computing. The CDR was reviewed and the LBNC is very satisfied with the reactions to the comments and the final outcome. The LBNC recommends approval of the CDR.
- The CDR highlights some major challenges, driven by novel requirements of the DUNE experiment. The offline software framework and its need to deal with large event sizes is a clear example and the work on software parallelisation will require dedicated skills. We suggest DUNE plans the R&D activities around this and other major tasks early enough, finding the right balance with respect to supporting the ongoing operations.

Recommendation

- The LBNC recommends the approval of the CDR.

ProtoDUNE Physics Analysis and Publications

- ProtoDUNE SP and DP analyses continue and excellent progress has been made on several fronts. A ProtoDUNE-DP performance paper is in preparation.
 - 4 papers published
 - 1 paper submitted to journal
 - 22 analyses ongoing out of which 4 are under review/paper draft
- 20 students are working on ProtoDUNE analyses and 8 students graduated on ProtoDUNE data.
- A number of results here are being used to actively tune the DUNE simulations.
- Ramping up Offline preparation for data taking, simulation and processing for HD and VD.
- We encourage timely completion of the current analyses such that effort can move to ProtoDUNE phase-2

Recommendation

None

Oscillation Analysis Update

- We commend DUNE on the progress towards detailed simulations of all detector components. Important progress has been made in particular in the simulation of the Near Detector and in the modeling of systematic uncertainties.
- DUNE has presented a coherent plan for future development of the oscillation analysis, aiming for a combined analysis of simulated data from the far detector and on-axis near detectors, generated with mature detector simulations currently under development.
- The committee is pleased to see that, besides the main analysis pipeline, DUNE is mindful of the need for modularity of the simulation+analysis effort, allowing for comparison of event generators, cross-section models, statistical procedures, etc.
- Separately, the DUNE-PRISM analysis has been developed further.
- The establishment of a new Neutrino Interaction Uncertainties Physics Working Group is a welcome development.
- We are concerned that the people-power devoted to the analysis effort is limited, which will slow down the development of key aspects of the analysis.
- Given how essential PRISM is going to be for controlling systematic uncertainties, we are concerned that analyses fully exploiting DUNE-PRISM appear not to have high priority. Exploration of how detector systematics will impact this method is also critical. Notably, current plans do not foresee full integration of DUNE-PRISM even for the update planned for 2024.

Recommendation:

- DUNE should ensure that sufficient people-power is available to complete in a timely manner an oscillation analysis including DUNE-PRISM.

Executive Summary

- The LBNC is very impressed by the progress with LBNF which includes but is not limited to the excavation of the Far Detector caverns at SURF.
- The LBNC congratulates the LBNF/DUNE project on its successful completion of the CD1RR review and the anticipated ESAAB approval. This is an enormously important step forward.
- The LBNC notes that the sequence of reviews, involving CD2, CD2/3 and CD3 or international equivalents, for the various DUNE sub-detectors, will increasingly involve work scope, which is closely related to, or is even shared by the international partners. The partners, US and others, all have independent approval processes. The LBNC considers it important that all these independent review processes develop an awareness of and a sensitivity to their mutual requirements and contributions of the others.

Executive Summary

- The LBNC has explored, with the various levels of DUNE leadership, how the extant supply chain problems are being addressed. We found considerable awareness of the issues. For example, a sensitive electronics procurement was already facilitated by bridging funds, and a plan for DOE advanced procurement requests, is being developed. DUNE is to be congratulated on these efforts. However, the LBNC cannot avoid urging that a systematic exploration of the availability for all upcoming purchases be examined well in advance of procurement.

Executive Summary

- It is recognized that the most advanced DUNE component is the Far Detector 1 - Horizontal Drift module. It is close to completing its NP04 re-configuration in preparation for Module 0 operations. APA production at Daresbury has started. Overall, this detector continues to make excellent progress.
- The sister Vertical Drift module has enjoyed remarkable advances in its R&D. As an example, the operation of the photon detectors on the cathode using power over fibers is functioning and the CRP fabrication process is under control. Definition and preparation of the NP02 setup for the Vertical Drift Module 0 operation is underway. Importantly, while somewhat delayed, the Technical Design Report should be completed by Spring 2023.
- Technical progress with the multiple components of the Near Detector is good. It is important that DUNE has succeeded in creating a viable consortium of institutions capable of delivering the TMS detector.

Executive Summary

- We have endorsed the NDLAr-TMS-PRISM-SAND Near Detector configuration in the past and reaffirm that endorsement here.

As discussed in several sections of this report, the LBNC is concerned that a clear path to convergence of the resources needed for the DUNE Near Detector is not yet defined. There appears to be a funding mismatch, which is significant on the scale of the near detector, but relatively modest overall. During the discussions and presentations at this meeting, several possible options were advanced. These ranged from adjustment of DOE directives to re-partitioning of partner scope and contributions. The discussions also included the possibility of new participation. We suspect that the ultimate solution will involve a combination of all these ideas but feel that over the next several months, but well before the relevant CD2 review, resolution should be possible. A resolution is imperative.

Executive Summary

- The LBNC was very impressed by the quality of the Computing Conceptual Design Report. The review of the document which involved two passes was characterized by prompt response to recommendations. It clearly demonstrates that DUNE has taken an appropriate stance and position vis-à-vis the larger particle physics computing community. The LBNC is recommending that the Director approve the CDR.

Executive Summary

- DUNE presented analyses which are exploiting multiple sources, Single Phase, Dual Phase, and Cold Box, of data from the Neutrino Platform. As hoped it is proving to be a source of interesting original physics and detector knowledge, and is providing significant numbers of students with interesting projects.
- The goal for LBNF DUNE is excellent results in neutrino physics generally but especially in oscillation measurements. We heard a report on advances on the oscillation analysis front. The presentation generated considerable interest and discussion, lots of it positive. However, the committee is concerned about whether DUNE-PRISM, which the committee feels is a key component of the DUNE strategy, is receiving sufficient explicit attention. To achieve the goals of well developed analysis approaches at the time of data taking, it is also important that management encourages the appropriate level of collaboration effort.