# Long Baseline Neutrino Committee Report

***Fermilab PAC***
***July, 2019***
***Chicago***

**Montgomery**

**July 19, 2019**

# Outline

- LBNC Scope and Process
- DUNE TDR Review
  - Process
  - Review Teams
- LBNC April 2019 Meeting
  - Agenda
  - Executive Summary
- Dune TDR Review Progress/Status
  - Near Detector
  - TDR Status Summary
  - TDR Timetable
- Conclusions

# Scope of LBNC

- LBNC is used by the Director for oversight of the international experiment DUNE.

- Oversight of LBNF is limited to those aspects of DUNE which feed directly into DUNE activities. (Below was discussed between LBNC and LBNF leadership and agreed by Fermilab Director.)
  - Cryostat and Cryogenic Systems
  - Beamline Implementation for DUNE and Facility for Near Detector
  - Management of LBNF-DUNE Interfaces
  - Monitoring of Risks to Milestones
  - Regular Plenary Status Report, (subgroup as needed.)

( The initial scope of LBNC was extremely broad, this is a clarification.)

# Membership

- **New Members added at beginning of 2019.**

- Chair, Hugh Montgomery (Jefferson Lab)
- Sampa Bhadra (York)
- Ties Behnke (DESY)
- David Charlton (Birmingham)
- Amber Boehnlein (JLab)
- Joel Fuerst (ANL)
- Cristiano Galbiati (Princeton)
- Beate Heinemann (DESY)
- Patrick Huber (Virginia Tech)
- Bob Laxdal (TRIUMF)
- Ted Lui (FNAL)
- Naba Mondal (TIFR)
- Jocelyn Monroe (Royal Holloway)
- Scott Oser (U. British Columbia))
- Marco Pallavicini (Genova)
- John Parsons (Columbia)
- Tom Peterson (SLAC)
- Kevin Pitts (UIUC)
- Jimmy Proudfoot (ANL)
- Jeff Spalding (FNAL- ret)
- Bob Tschirhart (FNAL)

# Process

- **LBNC 3-4 face-to-face meetings per year:**
  - August 2018 at Fermilab
  - December 2018 at CERN
  - April 2019 at Fermilab
  - July 2019 at Fermilab: "Final Review of TDRs"
  - December 2019

- **Report to Director**
- **Report to DUNE RRB**
- **Report to FNAL PAC**
- **Report to DOE Independent Project Review (Jan 2019)**

# Intended Outcomes for RRB

- **Provide credible validation of TDR and monitoring of project for RRB and sponsoring agencies.**
  - Gateway for international agencies to move forward with their funding decisions with confidence that the whole project has a valid and credible plan
  - Neutrino Cost Group (NCG) is separate panel working in parallel but coordinated with the LBNC on cost/risk/schedule.
  - NCG Chair is Steve Nahn

# TDR Review Process

- **Dedicated Reviews of TDR Volumes**
  - Executive Summary
  - Physics
  - Far Detector – Single Phase
  - Far Detector – Dual Phase
  - Technical Coordination
- **TDR Review Teams**
  - LBNC Members
  - Consultants

# TDR Review Teams

## Executive Summary

- David Charlton (Chair)
- Amber Boehnlein
- Joel Fuerst
- Bob Laxdal

## Physics

- Beate Heinemann (Chair)
- Sampa Bhadra
- Patrick Huber
- Joachim Kopp (CERN)
- Naba Mondal
- Scott Oser
- Vadim Rusu (FNAL)

Consultant

# TDR Review Teams

## Far Detector – Single Phase

- Kevin Pitts
- Philippe Farthouat (CERN)
- Hugh Lippincott (FNAL)
- Ted Liu
- Jocelyn Monroe
- John Parsons
- Anna Pla-Dalmau (FNAL)
- Jimmy Proudfoot

## Far Detector – Dual Phase

- Jeff Spalding (Chair)
- Ties Behnke
- Philippe Farthouat (CERN)
- Cristiano Galbiati
- Adam Para (FNAL)
- Jimmy Proudfoot
- Darien Wood (Northeastern)

Consultant

# TDR Review Teams

## Near Detector

- Scott Oser (Chair)
- Ties Behnke
- Patrick Huber
- Eric Kajfasz (CPPMarseille)
- Dean Karlen (U. Victoria)
- Naba Mondal
- Beate Heinemann (ex-officio)

## Technical Coordination

- Austin Ball (CERN, Chair)
- David Charlton
- John Osborne (CERN)
- Tom Peterson
- Jeff Spalding

Consultant

# LBNC Meeting Agenda: April 1-3, 2019

- LBNF Status
- DUNE Status

- ProtoDUNE SP: Status analysis, 2019 Operations
- Dual Phase: ProtoDUNE DP, R&D Progress, TDR Status

- Near Detector: Description, Status
- Computing: Consortium Progress, planning

- TDR Status
  - from DUNE
  - From LBNC Review Teams

# DUNE Executive Summary I

- The issues associated with working underground, especially SAFETY were evident in both the planning work for LBNF, but also the installation and commissioning of DUNE. The LBNC considers that:
  - Integration of a strong SAFETY culture and sense of responsibility in the line management is essential for DUNE:
  - Narratives and charts should explicitly place SAFETY “up front and central”
- ProtoDUNE-SP continues to impress as we see more and more analysis demonstrations. It provides a strong basis for a successful DUNE experiment. Nevertheless there are performance issues and long term stability which should be addressed with the 2019 operations.
- The design and expected performance of the Near Detector, and its impact on systematic uncertainties in the primary measurements of DUNE, need to be clearly articulated with an eye to the anticipated resource constraints.
- The Dual Phase program has made enormous strides and demonstrated responsive approach to the December recommendations. These are reflected also in improvements in the LEM understanding and in the preparation for ProtoDUNE-DP. We look forward to the operations of ProtoDUNE-DP already this year.

# DUNE Executive Summary II

- There is significant progress in establishing the DUNE Computing Consortium, short term resource needs have been met. However, the path to support for sufficient dedicated professional effort is not yet established. This lack appears to lead to critical gaps in core capability. Further, it may lead to an unadventurous approach to a rich menu of modern computing challenges.
- The TDR review program/plan has demonstrated qualified success:
  - Chapters of the FD-SP have been delivered on time, but the time pressures have led to a product which would have benefited from a stronger participation from non-authors. The quality of the chapters was uneven.
  - The Technical Coordination documentation was inhibited by a complete reorganization of the TC aspects of DUNE. This resulted in a complete rewrite of the document, but with the goal to strengthen the management.
  - The Physics TDR has had intensive interaction with the review team and progress is both evident and convergent.
  - LBNC and DUNE understand that there are challenges involved in this process. The timescales involved generate “less than ideal” situations. Nevertheless progress is real and the goal of a thorough assessment of the DUNE technical status for the Fall 2019 RRB is achievable.

# DUNE Executive Summary III

- Dune should be congratulated on the progress it has made on numerous fronts, even in the short time since the previous meeting in December 2018.
  - This demonstrable progress augurs well for the establishment of technical baselines, which would support a strong DUNE physics program during the upcoming decades.
  - Careful articulation of the critical performance requirements is required.

# Near Detector Review Report, June 2019 I

Note that this review asked the question “Can the goals be achieved with this plan?” It did not ask questions such as “Is the design optimal? Is the design the most cost effective? Are the resources identified?” We anticipate that such questions will be addressed along the path to a full Conceptual Design Report and a Technical Design.

**1. Essential Aspects of the Near Detector**

Dune has convincingly demonstrated that a capable near detector is required in order to achieve its physics goals.

The primary target mass for the ND should therefore consist of liquid argon TPCs.

Accordingly, a magnetized detector capable of determining the sign and momentum of charged particles is required downstream of the liquid argon TPCs.

Detector data taken solely in the on-axis location is not sufficient for DUNE to achieve its physics goals.

The committee found the DUNE-PRISM concept compelling and strongly endorses the necessity for a movable near detector.

An on-axis beam monitor is required that is capable of accurately measuring the beam center, lateral profile, and rates on a few days’ timescale.

The movable detector concept should be implemented from the start of DUNE’s physics data-taking.

# Near Detector Review Report, June 2019 II

**2. Comments on the Movable Components of the Near Detector**

When placed in a suitable magnetic field, the MPD readily provides the needed sign selection and spectrometry while providing a host of complementary capabilities that address weaknesses of the DUNE ND design:

1. The gaseous argon TPC
2. The gaseous argon target,
3. Electron neutrino and antineutrino interactions in the gaseous target

We agree that some kind of ECAL is needed for a detector of this sort, but this may be an area where optimization in terms of channel count is possible.

We recommend that more study be done (or at least presented) of the robustness with which the MPD can determine the $t_0$ for its TPC.

It is desirable to minimize the amount of material between the liquid argon TPCs and the following magnetized detector, whatever its design.

The review committee felt that the unique capacities of a high-pressure gaseous argon TPC provide an exceptional opportunity to achieve additional physics in a way that alternate magnetic spectrometers could not.

Because beam conditions will change over time, it is advisable to return the movable components of the near detector to the on-axis position regularly and to distribute the data-taking at each off-axis location as evenly in time as possible.

# Near Detector Review Report, June 2019 III

**3. Concerns About Beam Monitoring**

The review committee had several concerns about this detector concept and was not convinced that this particular design was well motivated, although we agree that some kind of on-axis beam monitor is required. Particular concerns were: …….

We were therefore concerned that the proposed 3DST lacks a strong physics motivation, especially for the aspects of it that rely on a carbon target. Given its complexity, we urge DUNE to explore simpler alternatives for on-axis beam monitoring, and in particular recommend looking at something like T2K's on-axis INGRID array as a simpler concept that may provide better monitoring of beam pointing.

**Does the ND Concept Allow DUNE to Achieve its Physics Sensitivity Goals?**

**In the judgment of the review committee, the proposed movable liquid argon TPCs and MPD, when combined with the DUNE-PRISM technique and a suitable on-axis beam monitor, will allow DUNE to reach its physics goals.**

# TDR Status Summary

**Note:** this commentary is based on the status at approximately the beginning of July. I have taken into account the varying levels of expectations for different volumes and chapters. Final submission is still to come and so updates are expected of all documents, which will also benefit from more extensive collaboration review.

- **Executive Summary "TDR" Volume**
  - Several chapters are in good shape. Those needing work are the Near Detector, the Computing and Technical Coordination. As planned, overall Executive Summary and the Dual Phase Exec Summary have not yet been delivered.

- **Physics TDR Volume**
  - The seven chapters received and reviewed are in good shape. Two chapters, a description of DUNE and the Scientific Landscape, as planned, have not yet been delivered.

# TDR Status Summary

- **Far Detector Single Phase TDR volume**
  - All nine chapters have been received and five are in good shape. One chapter has not yet received adequate review and three chapters require varying amounts of further work.

- **Far Detector Dual Phase TDR volume**
  - As planned five chapters have been delivered and reviewed and three are in good shape. Two chapters need more work and, also as planned, four chapters are yet to be delivered.

- **Technical Coordination TDR volume**
  - The Technical Coordination organization underwent a major change in early 2019. This resulted in an immature first submission in February. A second submission in May, was complete. The recently completed review of this version was very positive. All chapters need some work in response to the review.

# Schedule Update

| DUNE Far Detector Technical Design Report | Drafts 1 | Drafts 2 | Drafts 3 | Reviews LBNC-1 | Reviews LBNC-2 | Reviews Collaboration | Submission Target 26-Jul | Submission Target 1-Nov |
|---|---|---|---|---|---|---|---|---|
| **Volume I: DUNE** | | | | | | | | |
| Executive Summary | | | | | | | FINAL | |
| Physics Summary | | | | | | | FINAL | |
| Technical Coordination Summary | | | | | | | FINAL | |
| Single Phase Module Summary | | | | | | | FINAL | |
| Dual Phase Module Summary | | | | | | | FINAL | |
| Near Detector Summary | | | | | | | FINAL | |
| Computing Summary | | | | | | | FINAL | |
| Appendix: DUNE Near Detector Reference Design | | | | | | | FINAL | |
| Appendix: DUNE Computing Model | | | | | | | FINAL | |
| **Volume II: DUNE Physics** | | | | | | | | |
| Executive summary | | | | | | | FINAL | |
| LBNF and DUNE | | | | | | | FINAL | |
| Scientific Landscape | | | | | | | FINAL | |
| Tools and Methods | | | | | | | FINAL | |
| Standard neutrino oscillation physics program | | | | | | | FINAL | |
| GeV-Scale Non-accelerator Physics Program | | | | | | | FINAL | |
| Supernova neutrino bursts and physics with low-energy neutrinos | | | | | | | FINAL | |
| Beyond the Standard Model Physics Program | | | | | | | FINAL | |
| Summary and Conclusions | | | | | | | FINAL | |
| **Volume III: DUNE Single Phase Module** | | | | | | | | |
| Executive Summary | | | | | | | FINAL | |
| Anode Plane Arrays | | | | | | | FINAL | |
| High Voltage | | | | | | | FINAL | |
| TPC Electronics | | | | | | | FINAL | |
| Photon Detector System | | | | | | | FINAL | |
| Data Acquisition | | | | | | | FINAL | |
| Cryogenic Instrumentation/ Slow Controls | | | | | | | FINAL | |
| Calibration | | | | | | | FINAL | |
| Integration and Installation | | | | | | | FINAL | |

# Schedule Update

| **DUNE Far Detector Technical Design Report** | | Drafts | | | | Reviews | | | Submission Target | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | | LBNC-1 | LBNC-2 | Collaboration | | 26-Jul | 1-Nov |
| | | | | | | | | | | |
| | | | | | | | | | | |
| **Volume IV: DUNE Dual Phase Module** | | | | | | | | | | |
| Executive Summary | | | | | | | | | INTERIM | FINAL |
| Charge Readout Planes | | | | | | | | | INTERIM | FINAL |
| High Voltage | | | | | | | | | INTERIM | FINAL |
| Electronics | | | | | | | | | INTERIM | FINAL |
| Photon Detector System | | | | | | | | | INTERIM | FINAL |
| Data Acquisition | | | | | | | | | | FINAL |
| Cryogenic Instrumentation/ Slow Controls | | | | | | | | | INTERIM | FINAL |
| Calibration | | | | | | | | | | FINAL |
| Integration and Installation | | | | | | | | | | FINAL |
| | | | | | | | | | | |
| **Volume V: Technical Coordination** | | | | | | | | | | |
| Executive Summary | | | | | | | | | FINAL | |
| Global Project Organization | | | | | | | | | FINAL | |
| Detector Design and Construction Organization | | | | | | | | | FINAL | |
| Detector Installation and Commissioning Organization | | | | | | | | | FINAL | |
| Facility Description | | | | | | | | | FINAL | |
| DUNE Detector Description | | | | | | | | | FINAL | |
| Integration Engineering | | | | | | | | | FINAL | |
| Reviews | | | | | | | | | FINAL | |
| Quality Assurance | | | | | | | | | FINAL | |
| Environment, Health, and Safety | | | | | | | | | FINAL | |
| Appendix:  Project Documents | | | | | | | | | FINAL | |

# Summary

- **LBNC continues to track the progress of DUNE, most recently it met in April 2019.**
  - Note that, although we have not had a formal report, we know that the ProtoDUNE-DP is filling with Liquid Argon

- **LBNC primary activities concerned review of the five TDR volumes being prepared by DUNE**
  - Face-to-Face one-day reviews of the Physics TDR, the Far Detector Single Phase, the Technical Coordination, and the Near Detector plan were conducted. Other teleconferences were used to follow-up and toe discuss the Computing.
  - Progress of the documents has been good.
  - Final Submission is expected before the July 31 LBNC Meeting.

- **The LBNC will:**
  - Assist with the work of the Neutrino Cost Group
  - Prepare a report from to the Director and to the DUNE RRB by September.

- **Backups Follow**

# DUNE Science Program

## Neutrino Oscillation Physics

**Search for leptonic (neutrino) CP Violation**

Resolve the mass hierarchy ($m_3 > m_{1,2}$ or $m_{1,2} > m_3$)

Precision oscillation physics

Parameter measurements, $\theta_{23}$ octant

**Testing the current three-neutrino model, non-standard interactions, …**

## Nucleon Decay

Particularly sensitive to channels with kaons

## Supernova burst physics and astrophysics

3000 $\nu_e$ events in 10 sec from SN at 10 kpc

+ many other topics (ν interaction physics with near detector, atmospheric neutrinos, sterile neutrinos, WIMP searches, Lorentz invariance tests, etc.)