

Long Baseline Neutrino Committee

December 2019 CERN

CLOSEOUT Report

December 7

Acknowledgements

The LBNC appreciates the opportunity to see the progress being made by the DUNE Collaboration. In particular, after the appetizer from the Single Phase ProtoDUNE a year ago, we were able to see the progress made with both technologies in the ProtoDUNE environment. The responses to questions and queries were transparent and helpful.

The committee thanks Fermilab and CERN, for their support and hospitality.

LBNC Meeting Charge Draft 7/31/2019

- The LBNC would like to hear about the general status of LBNF and the principle outcomes of the recent IPR meeting. Time is devoted on the second afternoon to a report on the progress with the beamline in a parallel session. (The time is chosen such that it could be remote.)**
- The LBNC would like to hear from DUNE its overall status and progress from a high level, providing a within which to consider the details which follow.**
- The LBNC would like to hear about the progress with ProtoDUNE SP, addressing both the analyses, including results from the photo-detection and progress towards defining the operating parameters, which was seen as a primary goal for 2019. Time has been reserved on the second afternoon for breakout discussions which we suggest could be used for discussion of progress with installation and tests thereof (eg at Ash River)**

LBNC Meeting Charge Draft 7/31/2019

- The primary goal of this meeting is to understand the progress made with the Dual Phase technology. We have therefore devoted the whole of the first afternoon. Our hope would be to hear in detail of the installation and the operations thus far of ProtoDUNE DP. This should describe both the successes and the difficulties, for example the ion build-up, the bubbling, and the purity. This can be divided among several speakers. The LBNC imagines that each of the issues is likely to require significant future R&D and would like to hear about those plans including their schedules. Of particular interest may be the 600kV Power Supply design issues. Finally, we expect that this discussion leads to an understanding of a path forward towards a Dual Phase detector. The LBNC would like to hear how this path would lead to a future verification program likely including a second phase of ProtoDUNE DP operation, and to a TDR at an appropriate time.

LBNC Meeting Charge Draft 7/31/2019

- **Considerable progress was made in the first half of 2019 with understanding the needs and concepts for the Near Detector. We would like now to hear about progress towards a Conceptual Design and a CDR. In addition to a report on the recent DESY workshop, we could imagine several talks addressing key components. These should address: (ND time allocation 2 hrs)**
- **the current concept overall,**
- **the Argon Cube,**
- **the MPD including magnet designs for the Helmholtz or double dipole coils, and the reuse of ALICE TPC components,**
- **the Beam Monitor, including use of KLOE magnet, simulations, infrastructure and logistics,**
- **any plans for fall back systems and staging including the rationales and the way they support the goals for systematic uncertainties.**

LBNC Meeting Charge Draft 7/31/2019

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LBNC Meeting Charge Draft 7/31/2019

- **The LBNC is aware of substantial ongoing progress made by the Computing Consortium and would like to hear an update. It would be interested in any progress to co-involve those seeking and organizing the resources and those concentrating thus far, primarily on algorithm development and analysis.**
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- **The LBNC will develop a Closeout Report which it will deliver on Saturday morning at 11:00 am. Subsequently this will be refined into a LBNC Meeting report.**

LBNC Meeting Assignments 12/07/2019

Agenda Thursday December 5

LBNF Status

LBNF Review/writing Team: **Bob Laxdal**, Austin Ball, Angela Fava, Hugh Montgomery, Tom Peterson

DUNE Overall Status + Exec Summary

DUNE Review/writing Team: **Dave Charlton**, Austin Ball, Simone Campana, Hugh Montgomery

ProtoDUNE SP Status, Analysis and Ops parameters

Single Phase Review/writing Team: **Kevin Pitts**, Angela Fava, Tiehui Liu, John Parsons

DP Computing and Analysis Status:

Computing Review/writing Team: **Simone Campana**, Dave Charlton, Hugh Montgomery

LBNC Meeting Assignments 12/07/2019

ProtoDUNE DP detailed Progress; Install, Operation Results.

Dual Phase R&D Plans

Dual Phase Review/writing Team: **Jeff Spalding**, Cristiano Galbiati, Eric Kajfasz, , Adam Para, Jim Proudfoot, Darien Wood

Near Detector Conceptual Design

Near Detector Review/writing Team: **Scott Oser**, Ties Behnke, Joachim Kopp, Naba Mondal, Niki Saoulidou

Software & Computing

Computing Review/writing Team: **Simone Campana**, Dave Charlton, Hugh Montgomery

LBNC Meeting Assignments 12/07/2019

Technical Breakouts

LBNF Beamline “LBNF Review/writing Team: **Bob Laxdal**, Dave Charlton, Hugh Montgomery, Tom Peterson

Single Phase Breakout: Single Phase Review/writing Team: **Kevin Pitts**, Angela Fava, Tiehui Liu, John Parsons.

Dual Phase Breakout: Dual Phase Review/writing Team: **Jeff Spalding**, Cristiano Galbiati, Eric Kajfasz, , Adam Para, Jim Proudfoot, Darien Wood

Executive Summary: **Hugh Montgomery**, all

LBNF Status: Bob Laxdal, Austin Ball, Angela Fava, Hugh Montgomery, Tom Peterson

- Findings:
 - Nine reliability projects total 36M\$ - all on track to be completed before start of excavation
 - Three reliability projects completed: replacement of the Oro Hondo fan VFD, an upgrade to the refuge chamber and completion of rock transport skips
 - Other reliability projects in progress - Ross shaft construction continues (305 new steel sets installed) and is scheduled to complete in the first quarter 2020 – involves rehab of the hoist motor, replacement of the hoist drives, brakes and clutches, cage replacement, ...)
 - All 31 work packages totaling 92M\$ for pre-excavation are awarded to KAJV. The contractor has 90 people on site and completion is expected in DEC2020.
 - As of 41% contract duration 28% of work has been billed.
 - The phase I Ross head frame reinforcement is completed and rock conveyor design at 90% complete.
 - KAJV has lost 0 days to injury so far - currently showing 0 days of float
 - Excavation and Building and Site Infrastructure tasks are launched with 100% final design now complete and 25% of contracts let.
 - 5 work packages at 23M\$ awarded to KAJV for early excavation –
 - Expected to save 6.5 months and 21M\$
 - goal is to get bids return in Feb2020 and award remaining contracts by July 2020
 - In previous LBNC, cavern turn-over phases were delayed to OCT2022 and JUL2023 for the North and South caverns respectively and last meeting were reported as further delayed by >1 year. Attempts are being made to compress the schedule (eg. with parallel activities, 24x7 excavation). Oct 2022 for North cavern is being kept as the working date until CD-2 baselining.

LBNF Status: Bob Laxdal, Austin Ball, Angela Fava, Hugh Montgomery, Tom Peterson

- Findings (cont'd):
 - Cryogenics – Detector #1 – warm structure and membrane design complete
 - nitrogen system procurement in progress - turn-key contract – working through contract terms with vendor – schedule requires contract let before Sept 2022
 - Still missing scope in Argon cryogenics
 - Near site: A/E design services awarded (>25M\$) – PDR goal is March 2020
 - Cost and schedule data based on PDR expected May 2020
 - Finalized ND facility requirements and excavation bounds
 - Awarded 15M\$ site preparation contract
 - Developing 3D models of systems
 - Near detector presentation stated that the present hall is big enough
 - Beamline
 - PD progressing - Continuing with 3D CAD integration models and securing engineering team
 - Completed high level interface specifications between beamlines and CF
 - Plan to define >90% interfaces in beamline systems in 2019
 - Integrated design maturity at 52%
 - Target conceptual design approved Aug. 21, 2019 – RAL
 - Advancing Horn A and module design including target interface and exchange mechanism

LBNF Status: Bob Laxdal, Austin Ball, Angela Fava, Hugh Montgomery, Tom Peterson

- Findings (cont'd):
 - Management
 - Added new position – LBNF Deputy project director at 0.5FTE level for LBNF/DUNE support
 - Hired Assoc. General Counsel for Construction
 - Filled 4 FS construction coordinator positions and one safety pos'n
 - Presented resources show ~50FTEs each month over last 6 months with an expected increase of 10% in next 6 months
 - DOE review in Oct. 2019
 - Did not support baselining until TPC better defined including definitive FS excavation costs, closing of international contribution gaps, mature LBNF/DUNE-US NS cost estimates
 - Wanted a clearer leadership accountability for LBNF/DUNEUS and dedicated responsibility for DOE scope +DUNE
 - Directed more attention to procurement organization
 - Goal is still to have excavation work under contract with the CM/GC in July 2020 – reworking CD-2 date
 - Far site system engineering release of version 5 imminent – developing 4-D model for installation planning
 - SURF and FNAL updated MOU for far site management
 - LBNF notes that there is still ~100M\$ in unidentified scope

LBNF Status: Bob Laxdal, Austin Ball, Angela Fava, Hugh Montgomery, Tom Peterson

- Comments:
 - Far Site
 - LBNF is to be congratulated for continuing to make steady progress at the far site on reliability projects and pre-excavation work. The report that KAJV contract billing is low with respect to contract duration needs careful scrutiny as it hints at delay. Also the reported contract disputes are concerning as they can impact schedule milestones - plus the effort required to settle those disputes can be non-negligible.
 - LBNC supports LBNF in their push towards a July 2020 contract award date for far site excavation. The efforts to address DOE concerns following the October review are encouraged to avoid delays in excavation that would further delay the availability of the North cavern and increase project costs. The awarding of 5 early excavation contracts to help pull back the delay in North cavern completion by 6 months is very positive news.
 - Given the analysis that the North Hall completion date of Oct. 2022 will almost certainly be delayed by ≥ 6 months, LBNC cautions that the decision not to rebaseline before CD-2 may negatively impact or misinform other deliverables that have schedule dependencies. The impact should be analyzed.
 - The Far Site teams and LBNF should be congratulated on the excellent safety record

LBNF Status: Bob Laxdal, Austin Ball, Angela Fava, Hugh Montgomery, Tom Peterson

- Comments (cont'd):
 - Far site (cont'd)
 - The project has shown good progress in the area of systems engineering. The Far Site integrated model has matured (V5 to be released this month) and will be a useful tool for coordinating and communicating installation schedules, interfaces and potential interferences. Such models will be essential to better define the resources that will be required underground during the staging and installation phase.
 - The plan for early handover of the North Cavern while excavation continues on the South needs careful scrutiny for hidden coactivity issues. The extent to which the logistic pathways for the cryostat installation and continued excavation works can be separated will be a key indicator of how easily this coactivity can be controlled.
 - Near Site
 - The A/E design phase and pre-excavation work are moving towards meaningful milestones. The LBNF strategy regarding establishing costs and effort associated with the near detector is receiving appropriate attention with the goal to help refine Total Project Cost as requested in the Oct. DOE review.
 - The beamlines continues to make good progress with an integrated design maturity at the 50% level - the successful conceptual design review of the target with RAL is a major milestone

LBNF Status: **Bob Laxdal, Austin Ball, Angela Fava, Hugh Montgomery, Tom Peterson**

- Comments (cont'd):
 - Management:
 - The addition of a LBNF Deputy Project Director for Enterprise Coordination at 50% will help facilitate manpower mobilization throughout the project and should bolster the search for international contributions – it would be good to establish a metric for the top management positions to monitor if the 50% level is sufficient
 - Kudos to LBNF for presenting a backward looking resource actuals vs scheduled and forward looking projected resources – the step jump in forward looking projections vs past means that some work is being pushed out and may keep being pushed out until more resources are found – the information should be broken down into skill set to inform potential shortfalls in technical or engineering skills.
 - The LN2 contract is taking a long time to converge. While LBNF notes that the contract does not need to be signed until 2022 the project should note the issues and methodology used to date as lessons learned that can guide future large procurements to avoid future bottlenecks. There is concern that given the complexity demanded by both scale and environment, 'turn key' cryogenic solutions may be too great a challenge for private companies.
 - Recommendations:
 - none

LBNF Beamline Breakout: **Bob Laxdal, Dave Charlton, Hugh Montgomery, Tom Peterson**

- Findings (cont'd):
 - Near site:
 - Awarded 15M\$ site preparation contract
 - Developing 3D models of systems including CF, beamline and target complex
 - Beamline
 - PD progressing - Continuing with 3D CAD integration models and securing engineering team
 - Completed high level interface specifications between beamlines and CF
 - Plan to define >90% interfaces in beamline systems in 2019
 - Integrated design maturity at 52%
 - Target conceptual design approved Aug. 21, 2019 – RAL
 - Advancing Horn A and module design including target interface and exchange mechanism
 - International collaborations on corrector magnets (IHEP), main dipole and quadrupoles (BARC), target and target systems (RAL) and high current feedthrough and hatch covers (KEK)
 - designed to transport high intensity protons in the energy range of 60-120 GeV to the LBNF target.
 - systems that are prone to failure, such as water-cooled systems, are designed to be repairable and/or replaceable.
 - Implemented new organization – 5 L3 systems (CAMs) and 21 L4 systems (Technical Managers) - Filled management and added mechanical engineering resources
 - Working with professional estimator to update BOEs for all procurements

LBNF Beamline Breakout: Bob Laxdal, Dave Charlton, Hugh Montgomery, Tom Peterson

- Findings (cont'd):
 - Beamline
 - Prototype development and testing underway for several subsystems:
 - Target Shield Pile Cooling Panel prototype
 - Target Shield Pile Hatch Cover prototype being vacuum and pressure tested
 - Horn Stripline Feedthrough prototype being pressure tested at J-PARC
 - Three others planned for the next three years – Target, Horn A and stripline for Horn B,C
 - Resources
 - Engineering need is reasonably uniform over the next 10 years at ~7-10FTEs
 - technical support grows from 5 in 2019 up to 23 in 2027
 - Given that majority of Beamline resources are from Accelerator Division, an MOU is being developed between Beamline and AD.
 - Competing programmatic priorities (PIP-II, Mu2e, Operations) noted as being a challenge for some key engineering resources.
 - EH&S
 - The LBNF radiological design goal is to contribute to less than 30% of the limits of the environmental radiological quantities specified by the Fermilab policies and implement ALARA in all aspects of the design.
 - QA
 - Following standard FNAL and DOE protocols

LBNF Beamline Breakout: Bob Laxdal, Dave Charlton, Hugh Montgomery, Tom Peterson

- Comments:
 - The beamlines report presented in the break-out gave good confidence that the effort and planning towards the LBNF beamline and target complex are in good shape for this stage of the project
 - The project staffing and organizational structure look reasonable – the pull on engineering resources from PIP-II and mu2e was noted but seems to be manageable – a potential concern are the significant technical resources required for the build portion of the project with technical resource needs growing from 5FTEs to 20FTEs in a time frame where PIP-II will also be installing
 - ES&H and QA plan look to be receiving appropriate attention
 - Preparations toward CD-2 are advancing well with a credible plan with the proviso that international partners for non-DOE scope are still to be defined
 - The beamlines continues to make good progress with an integrated design maturity at the 50% level - the successful conceptual design review of the target with RAL is a major milestone of the last period – in general LBNF has a good experienced partner in RAL

LBNF Beamline Breakout: Bob Laxdal, Dave Charlton, Hugh Montgomery, Tom Peterson

- Comments (cont'd):
 - The presented schedule calls for first beam on target in April 2029 with CD-4 early completion Aug. 2031 – this is several years after the first DUNE detector would be ready for neutrinos – there seems like a real science opportunity available if the LBNF near site schedule could be pulled forward by a few years – the bottlenecks in cash flow, resources, logistics should be analyzed now to determine whether such a schedule adjustment is feasible as long lead technical items will make this less possible as time goes on

- Recommendations:
 - Explore the bottlenecks towards pulling ahead LBNF first beam milestones by 2-3 years

DUNE Overall Status: Dave Charlton, Austin Ball, Simone Campana, Hugh Montgomery

The LBNC

- Congratulates DUNE on the approval of four TDR volumes
- Notes positively the continuing gradual growth of the collaboration, and requests that institutional membership changes, including the contributions expected from new groups, be included in the Spokepersons' reports to future LBNCs
- Is pleased to see the progress with some funding applications (US-NSF, France, Brazil)
- Requests to see a summary of the expected construction responsibility commitments included in the Spokespersons' reports in future
- With regard to the change in consortium structure, agrees that it makes sense to include cryogenic instrumentation relevant to detector status and operation with other detector instrumentation. The collaboration is urged to proceed cautiously and to ensure that all aspects of the work in the rearranged consortia receive sufficient attention.
- Is impressed by the strong progress across many areas of SP and ND preparations
- Commends the collaboration on the startup of ProtoDUNE-DP operation, and notes the various challenges being addressed, discussed later in these slides
- Notes the recent MOOD workshop and the possibility that this can help grow the collaboration, but cautions that diversion of effort into R&D towards that module must not detract key expertise, or effort, from higher-priority work. Higher priorities include the essential work towards the milestones for the first two FD modules, the ND, and in fully establishing the DP technology.

Recommendations

- Develop a strategy and timeline for modules 3 and 4, beyond the first two modules

ProtoDUNE SP Status: Kevin Pitts, Angela Fava, Tiehui Liu, John Parsons

• Findings

- Results and “lessons learned” from a year of ProtoDUNE-SP running were presented.
- HV system uptime is now >99%, the streamer rate has been reduced after periods of running with auto-recovery off.
- Using tracks, a very high (40msec) electron lifetime is measured. This result varies significantly from the lifetime inferred via purity monitoring.
- A post-mortem on the pump failure was presented and corrective action has been identified. The system recovered quickly.
- Xe doping was observed to compensate for light yield loss from residual N₂ contamination.
- Calorimetric reconstruction of multiple particles was presented for the first time, from which the resolution is better than expectation. It is hypothesized that the diffusion and/or flow model is incomplete or inaccurate in simulation.
- Initial results on the characterization of the performance of the photon detection systems were presented, confirming the expectations on Arapuca performing better than the alternatives.

• Comments

- We congratulate the Collaboration on successful construction, assembly, commissioning and operation of ProtoDUNE-SP.
- Considerable lessons have been learned from the HV system. Uptime is high, and the streamer rate is reduced.
- We appreciate the progress made on analyzing ProtoDUNE-SP data and understanding performance. The Collaboration should continue this work, including the items previously recommended.
- It is important to publish paper(s) sooner rather than later on the detector, performance and results.
- It would help to present an “apples to apples” comparison of the ProtoDUNE-SP Arapuca results compared to TDR projections.
- We agree and support plans for the conclusion of ProtoDUNE-SP phase 1 (including ending with testing at higher voltage) and agree with the importance of phase 2 to verify preproduction modifications, including field cages, APA and cold electronics.

• Recommendations

- None.

Single Phase Breakout, APA: Kevin Pitts, Angela Fava, Tiehui Liu, John Parsons.

- Findings

- Based upon ProtoDUNE and extensive installation/assembly prototyping, the detailed APA frame design is in its final stages
- Cold electronics cable routing testing successfully completed. Work continues on photon detector mounting and cable routing, but sufficiently complete to finalize frame design.
- Dual APA frame mounting and assembly, including cable routing has been successfully tested several times.
- Progress has been made on shipping frames, winding apparatus and production sites. Reviews scheduled for early 2020.
- On schedule to produce pre-production modules for phase 2 of ProtoDUNE-SP and production schedule compatible with first two modules being single phase.

- Comments

- We congratulate the Collaboration on considerable progress in prototyping and evaluating APA production, quality control, transport and installation.
- It is important to continue to work closely with industry so that the APA boards can be produced with the proper thickness and tolerance.

- Recommendations

- None

Single Phase Breakout, cold electronics: Kevin Pitts, Angela Fava, Tiehui Liu, John Parsons.

• Findings

- Progress has been made on understanding the LArASIC ledge effect. Further investigation and mitigation strategy in progress.
- Noise in ColdADC is very good. Kickback effect from pipeline to sample-and-hold identified as a reason that linearity is worse-than-expected.
- COLDATA is working well, with only minor modifications foreseen..
- Most recent CRYO submission (Nov 2019) optimized for nEXO, will be used in ICEBERG test chamber. A new test board is being made to mitigate noise sources.
- Next iterations of all 4 ASICs will be submitted in spring/summer 2020.
- Considerable test stand work continues, including APA7 coldbox and a high pressure setup at BNL.
- A discharge in ICEBERG killed the front-end ASICs on all boards.
- The COTS ADC solution will undergo a coldbox test but is no longer considered as an option for DUNE.
- Timeline calls for a downselect in early 2021, a preproduction submission in spring 2021, mount boards on APAs Fall 2021, ProtoDUNE-SP phase 2 run in early 2022.

• Comments

- We congratulate the Collaboration on considerable progress in multiple dimensions. Progress continues on multiple approaches, problems are being identified and studied.
- The timeline is aggressive to downselect the ASICs in January 2021.
- Results from the BNL high pressure test chamber indicate that possible bubble production at the bottom of the DUNE cryostat may not be a concern. Measurements will be repeated with actual FEMB prototypes when these are available, which is important.
- The ICEBERG “event” that killed the FE ASICs appears to be a consequence of HV being applied to the chamber without LV on the readout boards, therefore frontend protection was not active. Although likely an anomaly with a new setup, a series of even unlikely events can pose a risk to long term success of DUNE.

• Recommendations

- A full postmortem on the ICEBERG “event” should be completed and lessons learned be incorporated into procedures associated with cold electronics and chambers.

Dual Phase: ProtoDUNE DP Progress and R&D Plans

Jeff Spalding, Ties Behnke, Cristiano Galbiati, Eric Kajfasz, Jim Proudfoot, Darien Wood

Findings:

- NP02 cryostat filling completed in early August. Extensive progress commissioning the various systems (CRP alignment and tracking, LEMs and grids, PMTs, electronics and DAQ), but several issues have limited periods of stable operation:
 - A short in HV extender connection limits the HV to <150kV, providing a uniform field for ~1.5m drift (1/4 of full depth). Within this region, track reconstruction performs well. Plans are under development for surgery that severs the shorted connection to allow deeper drift region.
 - Purity: several gas filter regeneration cycles have been needed – filter clogging with “dust” (chemical analysis in process). e-lifetime is improving slowly, but currently purity monitors and TPC measurement from tracks indicate still below minimum requirement.
 - LAr surface bubbles (seen at two particular locations: HV feedthrough and FC clips – mechanism not understood) and development of surface waves(~1mm peak to trough) limit stable CRP operation (no discharging). Work-around developed with pressure cycles to provide limited periods of more stable operation, while also supporting studies of the bubble/wave phenomena.

Dual Phase: ProtoDUNE DP Progress and R&D Plans

Jeff Spalding, Ties Behnke, Cristiano Galbiati, Eric Kajfasz, Jim Proudfoot, Darien Wood

Findings continued:

- The stable operating margin is compounded by reduced planarity of CRP at LAr temperature - design change needed to improve “stiffness”
- Ion trapping at liquid surface reduces signal –needs further study (expected to be much less of an issue below ground)
- Systems commissioning
 - CRP alignment and HV commissioning: progressing, but limited by stable operating periods
 - Electronics: common mode noise from pickup in slow controls cables partially mitigated. Discharge in a CRP without LEMs damaged the electronics – successfully accessed and replaced (an advantage of the DP design)
 - PD system: 6/36 PMTs with TPB, 30 with PEN sheets for WLS. Calibration established, Comparison TPB/PEN ongoing. No WLS reflector panels in protoDUNE-I
- DUNE discussed initial planning and goals for further operation over next few months
 - An extensive set of potential tasks and goals to (a) develop and document CRP performance, and (b) develop understanding of the purity and liquid surface issues. A campaign.
- LEM/CRP improvement plan
 - Improvements to LEM and CRP are in place to address spark rate (hole rim quality, guard rings) and planarity – plan to install 2 new-design CRPs in ProtoDUNE-II
- LBNC informed of ideas in internal discussions for sharing the NP02 cryostat for DP protoDUNE-II and for validating technology for the 4th “Module of Opportunity”

Dual Phase: ProtoDUNE DP Progress and R&D Plans

Jeff Spalding, Ties Behnke, Cristiano Galbiati, Eric Kajfasz, Jim Proudfoot, Darien Wood

Comments:

- The committee appreciates the detailed set of presentations, and the discussions in the breakout session on protoDUNE-DP.
- And would like to extend congratulations to the cryogenic and DP teams on the hard work and significant progress made.
- **It is essential that proto-DP issues are either solved or addressed in the design, with validation in a future protoDUNE demo using near-final components.**
 - Purity – has to be understood and solved
 - Waves and bubbles – may have to modify the design to manage / live with such disturbance. If source not under control, design needs to be robust.
 - Ion trapping at liquid surface – need to fully understand scale and impact on performance – although we note that this expected to be much improved with zero cosmic rate at SURF
- DP should develop and provide a specification for the surface quality necessary for stable CRP/LEM operation. We note that the spec can be developed using the cold box setup.
- We consider the intervention surgery on the HV extender to be high risk – even with development of special tooling and practice mockups. This needs strong justification (need for data with longer drift), and if carried out, should be deferred until after high priority studies are concluded.

Dual Phase: ProtoDUNE DP Progress and R&D Plans

Jeff Spalding, Ties Behnke, Cristiano Galbiati, Eric Kajfasz, Jim Proudfoot, Darien Wood

Comments continued:

- Critical R&D and design work towards close-to-final design for successful ProtoDUNE-DP-II will require well defined interim test steps – needs detailed planning and realistic timeline to protoDUNE-II
- eg. for WLS, protoDUNE-II will include the reflective panels and validate final material choice and application method, following R&D with smaller scale pre-testing.
- The plans to develop the 600 kV HV system and 12m drift dedicated test stand should be in parallel, but must not divert the focus on the work towards protoDUNE-II
- With partial mitigation of the noise from the slow control cables, the current noise level is $\sim 1,300e$, still with significant common mode component. It looks promising that $< 900e$ will be achieved with full mitigation and noise filtering (which would meet spec $< 1000e$)
- Mapping CRP gain and S/N versus LEM voltage is ongoing – has been limited by insufficient periods of stable operation. Achieved CRP gain of 7.6 at 3.2kV (compare minimum spec for gain > 6). Plan to extend measurements and to study to higher voltage.

Dual Phase: ProtoDUNE DP Progress and R&D Plans

Jeff Spalding, Ties Behnke, Cristiano Galbiati, Eric Kajfasz, Jim Proudfoot, Darien Wood

Comments continued:

- Competing needs: completion of present CRP studies needs ~2 months of stable conditions, while purity, bubble and surface wave studies needs months of unstable conditions
- **Need to define priorities and to map out a “living” run plan**, which in turn needs stronger run coordination and a coherent prioritized plan to ensure efficient operation for next ~8 months.
- It is very important to complete this DP R&D through to conclusion: learning from this run, and the subsequent R&D/design program towards protoDUNE-II.
- **LBNC strongly endorses continuing to run for several months to complete this program.**
- The LBNC DP sub-team would appreciate an ongoing process (perhaps brief interim video meetings) to help us remain abreast of progress

Dual Phase: ProtoDUNE DP Progress and R&D Plans

Jeff Spalding, Ties Behnke, Cristiano Galbiati, Eric Kajfasz, Jim Proudfoot, Darien Wood

Recommendations:

- Provide a specification for the surface quality necessary for stable CRP/LEM operation.
- Develop a coherent prioritized run plan and stronger run coordination to support competing needs of mapping the CRP performance and the critical work to understand and mitigate the purity and surface issues.
- Develop planning for R&D and design changes with interim test steps to support successful protoDUNE-II validation of close-to-final design.

Near Detector Conceptual Design:

Scott Oser, Ties Behnke, Joachim Kopp, Naba Mondal, Niki Saoulidou

ND overview:

- DUNE has a clearly developed plan for the ND complex, including in the reference design liquid argon TPCs (ArgonCube) and an accompanying high-pressure gas TPC+ECAL (MPD), both of which can move off-axis, along with an on-axis beam monitor based on a 3D scintillator tracker inside the KLOE magnet +ECAL (the SAND detector).
- In case staging of the ND is required, DUNE is considering temporary minimal configurations. The “baseline” minimum detector in this case is the Argon detector, a simpler muon spectrometer (like MINOS) and SAND without any inner detectors.
Recommendation: DUNE needs to study how well these options would work, and quantify the requirements for any MPD replacement with a simpler muon spectrometer. LBNC recommends some effort be spent on this, but iterates that the MPD especially provides a lot of attractive features that a minimal design could not provide.
- Finding: the ND hall size is now settled, and the detectors will be fit into that size.
- We would like to hear about the engineering of the detector movement systems at the next meeting.

Near Detector Conceptual Design:

Scott Oser, Ties Behnke, Joachim Kopp, Naba Mondal, Niki Saoulidou

ArgonCube:

- We welcome the plan to run the ArgonCube 2x2 prototype at NuMI where MINERvA is now, in Sep 2020. This should be given high priority for developing the ND TDR.
- Version 2 of the LARPix ASIC is being developed, to be tested soon. Will another version be needed?
- A sharp increase in the cost of the Kapton for the resistive shell is a concern. Other materials are being investigated, or instead using strips of it to reduce the fill factor and hence the cost.

MPD:

- Finding: muon catcher is proposed to be added in the iron return yoke
- CALICE ECAL design is attractive option for MPD, but DUNE notes that “Fast timing [on ECAL] will need more work”. Can we have more details on this?
- The reference magnet design has 5 superconducting coils, with two alternates being considered. DUNE plans a downselect at end of January 2020. This seems very aggressive schedule---why so early? What’s driving this?
- **Recommendation:** The optimization for both the ECAL and the Magnet design should be driven by physics requirements, which we would like to see clarified and incorporated in the process of the design optimizations. Also, please explain design challenges that will be related to the movability of the detector.

Near Detector Conceptual Design:

Scott Oser, Ties Behnke, Joachim Kopp, Naba Mondal, Niki Saoulidou

SAND (on-axis detector):

- LBNC welcomes the excellent contribution from INFN of the KLOE magnet & ECAL.
- The collaboration plans to place a 3D scintillating tracker inside this magnet, with some kind of gas tracking (TPCs or straw tubes) surrounding it. DUNE needs to flesh out the details of these plans for the CDR, especially for the gas tracking element.
- Alternate designs using thin target layers with multiple nuclear targets have been studied. We note that these designs are not part of the reference design for DUNE's CDR.

CDR status and plans:

- Schedule calls for developing CDR with draft to LBNC in March. Much material actually exists already, and we think this is realistic, and look forward to the opportunity to review it. DUNE currently plans for IDR by the end of 2020, informed by ArgonCube 2x2 prototype results, and a final TDR a year later. We note that DOE may require a TDR for CD-2.

Recommendation: DUNE should flesh out how the DUNE-PRISM method + constraints on cross section and flux model uncertainties can be used in tandem to achieve the needed precision for CP violation, as well as how well these (reduction of systematics) will be achieved by the DUNE ND complex. We suggest doing this by incorporating DUNE-PRISM data samples into the oscillation fit. Aim for having this for CDR.

DP Computing and Analysis Status: **Simone Campana**, Dave Charlton, Hugh Montgomery

- We congratulate ProtoDUNE-DP for the successful data collection and distribution in 2019
- We find that the offline computing services demonstrated the capability to archive, process and distribute the data in a distributed environment
 - Data being made available rapidly in a CERN interactive environment, distributed and processed in the distributed environment
- We are pleased to see a fruitful collaboration with the DUNE Computing Consortium, CERN IT and Fermilab as we consider these essential for the success of the ProtoDUNE computing
 - Link with CERN IT through liaison person and dedicated meeting
 - Relationship with Fermilab DUNE computing operations team
- The LBNC looks forward to seeing results from analysis of reconstructed data

- The LBNC is impressed by the progress of DUNE computing since the last meeting
 - Computing Consortium workshops on many key areas (data model, computing model, databases) and new TF being created
- Reconstruction algorithms and simulation not in the scope of Computing. We encourage the DUNE collaboration to develop an organization which ensures synergy, and provides recognition of long-term responsibilities in these areas
- protoDUNE (SP and DP) activities well integrated into DUNE computing efforts – 2PB of data in 2019
 - Processing chain demonstrated end-to-end system, from detector to analysis
 - Caveats (DP): reconstruction at testing level, distributed analysis just being exercised. We are interested in progress at the next meeting
- We strongly support DUNE computing in its strategy of leveraging synergies in many areas
 - With WLCG/OSG for services and infrastructure, with HSF and neutrino projects for software

Software & Computing: **Simone Campana**, Dave Charlton, Hugh Montgomery

- DUNE made good progress in defining a computing model and resource needs up to 2022
- Hardware resource needs based on the computing model seem achievable
 - We suggest DUNE follows hardware technology tracking working groups (HEPIX/WLCG). We also suggest investing from the beginning in software portability to heterogeneous architecture
 - We encourage DUNE to start the process of understanding the user analysis needs
 - The reconstruction and simulation CPU needs for the near detector are currently not known and might be considerable due to the more complex layout wrt the far detector. We hope to hear more at the next meeting
- The currently identified effort does not yet match the long-term personnel needs
 - We support the newly created Computing Contributions Board to attempt securing more effort from key institutes

Software & Computing: **Simone Campana**, Dave Charlton, Hugh Montgomery

- We welcome the creation of the Contributions Computing board
 - We share its pragmatic and flexible approach defining in the short term the expected contribution of the different countries
- We are worried about the unclear situation concerning the provisioning of the network service between SURF and FNAL. We expect that FNAL and SURF will discuss this so that a statement can be provided at the next LBNC meeting
- We would like to hear about the current plans towards a CDR/TDR at the next LBNC meeting

Recommendation:

- Provide a statement clarifying the provisioning of the network link between SURF and FNAL

DUNE Executive Summary: **Hugh Montgomery et al**

- The committee congratulates DUNE and LBNF on its achievements over the past 5 months.
- The progress with LBNF is exciting
 - The committee recognizes the challenges in maintaining the momentum in excavation in the context of a changing DOE view of CD approval strategy.
- Overall, DUNE as a collaboration continues to grow and to adjust its organization as it gains experience with the Consortium based structure.
 - Care should be taken in the choice of consortium structure for the Near Detector complex.
- The results from the ProtoDUNE Single Phase continue to mature and to impress.
 - There is some concern that the photon detection system appears to enjoy little margin.

DUNE Executive Summary: **Hugh Montgomery et al**

- DUNE is congratulated in getting ProtoDUNE DP to an operational status
 - Significant progress has been made
 - Several issues have appeared during the initial months of operation.
 - DUNE is encouraged to put in place a plan to systematically address these issues during the next months and to strengthen the technical and run coordination.
 - A plan should be developed, with realistic schedule for the needed R&D and changes to bring to a future ProtoDUNE DP (NP-02) operation.
- The Committee would like to see the development of a coherent plan for the anticipated two SP modules and one DP module through to the Module of Opportunity.
- The progress with the Near Detector towards a Conceptual Design Report, is consistent with the recommendations of the positive LBNC review of the Near Detector in 2019.

DUNE Executive Summary: **Hugh Montgomery et al**

- The progress of the Computing Consortium is very positive.
 - The LBNC sees opportunities for enhanced interaction and participation by the algorithm and analysis efforts in the provision of core software frameworks.
- The LBNC sees DUNE making considerable progress. In the past year it:
 - Has completed four technical design reports which cover an important baseline technology, planned to be used for two of the installed modules
 - Has made great progress on exploring the dual phase technology in ProtoDUNE DP, the primary candidate for another of the planned modules.
 - Has made strides toward the completion of the Near Detector Conceptual Design.
 - Has established the DUNE Computing Consortium as a significant player in the world of HEP computing while provisioning the extant ProtoDUNE (both SP and DP) data handing and analysis program.
 - Is exploring options for a fourth module, perhaps with a new technology, as well as for innovative enhancements to baseline detector configurations. The consideration of such demands a certain level of prudence.