2 LArTPC-ND

2.1 Findings

- The LArTPC-ND conceptual design is well underway.
- The corresponding International Dune ND consortium was formed in early 2020.
- The size of the TPC is determined to provide <1% of muons lost in the neutrino energy range of interest.
- The light signal in ND tags pileup; they expect on average 6 particles to be distinguished per module per spill
- There is a phased plan of prototyping to establish the LArTPC-ND design, including a neutrino test at Fermilab using the Nova beam
- The cryostat is based on the membrane concept but is substantially different from the one of ProtoDUNE and include a low density windows
- They aim at measuring the flux with different methods including ν-e elastic scattering at 4% in Day 1
- The sharing of responsibilities among institutions is appropriate
- Heat input is driven by the power consumption of the field shaping cell and the pixel readout
- The cold custom ASIC (LArPix) development is led by LBNL, with a strong team involved in testing and quality control.

2.2 Comments

- The low material budget wall of the cryostat is a critical and new component. Possible sloshing and other “worst case scenario” should be considered in the design.
- The design of the detector has still some open issues related to the flushing of the argon and the tightness of the modules. Unfortunately, a real small scale prototype with all these features is not planned due to schedule and cost constraints
- Liquid argon purity is a concern given the difficulty to the argon to circulate freely in the volume.
- Further optimisation of the number (size and drift length) of modules is possible and needed based on full simulation and reconstruction. The cost of the detector is driven by the implications of the segmentation.
- Simulation work on neutrino/antineutrino identification (together with TMS) is still in a preliminary phase
- It is likely that they will need more than one power supply to achieve complete modularity.
- The need of two different light readout systems is not fully demonstrated yet
- The phased plan of prototyping will retire many imaginable risks involved in the LArTPC-ND design and production. Formal tracking of risks will be beneficial.
- Sealing the different modules would complicate the cryogenic system significantly.
- It seems that there is no plan to extract the modules when the cryostat is full of liquid argon.
- Challenges with cold ASIC development have delayed other projects; we encourage LBNL to maintain resources on LArPix.
- Preliminary cost estimation for the fabrication of the warm and cold cryostats doesn’t appear to exist
- Try to simplify the design of the outer structure. Explore the possibility to replace the small beams with reinforced plates as of the SBDN, LBNF or DarkSide current designs.

- A further study, how the roof stiffness and deflection could influence the detector performance. This is especially valid through the operation of the cryostat due to pressure variations (external and internal).
- Try to arrange a preassembly of the warm structure at the manufacturer's premises.

2.3 Recommendations

- The test plan should be revised, considering an apparatus (not necessarily the one to be sent in Nova) that can test all cryogenic issues.
- Establish a risk registry, update it periodically, and track the retirement of risks, generally, and include those retired via the prototyping program.
- The light + charge particle ID in a spill should be substantiated by a full simulation.
- Some tests on light tagging should be done with cosmics as soon as possible.

3 SAND

3.1 Findings

- The magnet and calorimeter are already available
- Still to decide whether the calo electronics must be replaced
- Interaction between detector experts and integration team already started
- Revision of the LHe system still in progress
- SAND has been shown to be sensitive to reasonable variations in the neutrino beamline parameters
- The configuration of the tracking system is not yet final

3.2 Comments

- SAND has a significant impact on infrastructure and integration (dimensioning of the crane) and installation which has to be identified very early in the design phase
- The tracker options seem to have been largely developed without reference to the requirements of beam monitoring and likely exceed the minimal requirements for beam monitoring.
- The committee is concerned that the operational stability of the trackers may complicate the detector’s beam monitoring role.
- Full simulation for the tracking options have just started. Simulations should quantify the occupancies including all entering particles from upstream detectors. The use of neutrons is still to be clarified in terms of physics output.

3.3 Recommendations

- The consortium should work with the project to develop a schedule to finalize the tracker design with a focus on the base requirements of neutrino beam monitoring.

4 TMS

4.1 Findings

- The TMS conceptual design is in the preliminary stages.
- The mechanical design is as simple as possible, which makes sense.
- The magnetic field strength is chosen to allow for air cooling, but water cooling might be required. Further study will be done.
- Simulation and analysis are yet to be done.
- The physics performance is still at the back of the envelope stage.
- A team to deliver the TMS is being developed. Several US groups have joined, but more would be helpful.

- No workplan. Decision depends on Ge-Ar. Cost (9M with 50% uncertainty)
- 1 GeV muons are somehow troublesome—just a few hits in the spectrometer.

4.2 Comments

- The LAr-TMS detector combination has gaps in the phase space in which a sign-selection determination cannot be made. These gaps would be covered by the MPD, via neutrino interaction in the argon gas.
- The group needs to develop a strategy for allocating the resources and the matrix responsibility stressing that the spectrometer will have a crucial impact on the first measurements of DUNE (evidence of CP and mass hierarchy) and a lifetime of several years.
- We suggest to deepen the study on heat dissipation and heat load also accounting for the other detectors.

4.3 Recommendations

- The decision on the suitability of the TMS to achieve the 3-sigma max CPV physics goals can only be evaluated on the basis of a full physics study. We encourage the TMS groups to prepare that as quickly as possible.

5 **PRISM**

5.1 Findings

- The PRISM concept has been endorsed by the collaboration and LBNC as required to meet the goal of 3-sigma observation of maximal CPV in the first three years of operation.
- The technical needs of PRISM are met by commercial rollers and energy chain devices. All three detector components will be moved into place by similar systems.
- Plans are being made to make tests with static loads and fluid loads at Stony Brook.
- Interlocks and warning signals are being planned to stop motion of the detectors when personnel cross keep-out boundaries

The documentation exists, but is at a conceptual level. A lot of analysis has been completed considering this is a conceptual design review.

The components have been analyzed for strength and results indicate that they have adequate safety margins.

The scope of the ND cryostat is reasonably well defined. The thickness of the insulation is still under review.

Interfaces are defined but in a very preliminary state.

5.2 Comments

- The plans for other automatic interlocks for power supplies etc. for all three detector systems seem to be less well developed than those for personnel safety.
- The roller and energy chain systems have many interfaces to the detectors and cryostats and the detector hall. These multiple interfaces will need to be carefully managed.
- It was stated that there is ample space in the energy chains for all pipes and cables. The project should consider sizing these channels with enough spare capacity to accommodate possible future detector needs and upgrades.

- The interface, cryostat to floor support structure, is not finalized. It could require a major redesign. It shall be assessed in more detail and eventually validated as a concept. The cryostat structure is very sensitive to differences in the stiffness of the floor support structure. Also the cryostat could provide highly non-uniform load to the floor support structure.
- ·An alternative and more cost effective moving option, not just the rails and rollers could explored.
    - All loading, including the percentage of uncertainties, shall be defined. Especially for: operational gas pressure, accidental overpressure, dry detector weight, as well as wet, all dynamic loadings, etc.

5.3 Recommendations

- We suggest to consider with particular care the impact of the deformation of the cryostat to the load of PRISM

6 **Infrastructure**

6.1 Findings

- LAr Cryogenic Systems scope includes design, procurement of materials, installation and testing of cryogenic systems (LAr and LNs), including Process Controls.
- LHe Cryogenics scope includes design, procurement of materials, installation and testing of cryogenic systems for magnets (SAND + capability to support future SC magnet), including Process Controls
- 50 ton overhead crane/gantry is necessary to install SAND solenoid cryostat
- Installation of the detector suite is constrained by the dimensions of the cavern and the detectors and the installation is quite sequential: SAND, PRISM, LAr TPC and TMS.

6.2 Comments

- We agree that the crane is an issue that has to be solved very soon.
- The responsibility in the proper way the LAr TPC is in charge of the LAr TPC consortium and the scope of cryogenics is limited to the cryostat roof. The Cryogenic requirements need to be better defined and agreed soon.
- Deformation on the PRISM changes the load case, possibly in a critical way, on the cryostat and vice versa.
- Full integration FE model, to properly model the loads through the major interfaces, is preferred.
- Submodels, based on the global model, for the interfaces, and the critical connections and locations, should be done. Number of load case scenarios shall be considered for each model. The analysis plan is recommended to be agreed soon at project level.
- It is strongly advisable, the design codes, engineering and manufacturing standards, validation and QA plans and all their details, as well as all the loading scenarios to be agreed at project level too. The QA plans shall include the fabrication process qualifications, as well as the operators qualifications and acceptance tests.
- An agreed process on a project level, for an approval of the official documents, models & drawings doesn't appear to still exist.

6.3 Recommendations

Answers to charge questions:

1. Are the DUNE-ND requirements sufficiently well understood and documented and are they sufficiently complete for proceeding with the designs of each element?

   The requirements are well understood for this stage of DUNE-ND. Achieving the near detector contribution to the physics goals of the first three years of data taking is challenging and its potential achievement is not fully documented, yet. In fact, it mostly depends on the actual performance of the subdetectors. Such performance will become clear after the prototyping programme and the completion of the end-to-end simulation propagating the uncertainties propagating the uncertainties through an oscillation analysis.

2. Do the designs address detector requirements? Are the designs feasible? Are the key technical specifications for the major DUNE-ND elements understood and addressed?

   The design addresses the general strategy to achieve the requirements in a way that is appropriate at this stage. The committee did not find any major fault in the design. Some issues may be to be solved during the prototyping phase, especially for the modular LAr detector and the tracking system for SAND.

3. Have interfaces between detector elements been identified? Are the interfaces with the cryostat, cryogenic systems, facility, and installation sufficiently understood?

   Yes, the interfaces are well defined and the problems related to interfaces are understood. The people involved have the experience and the capability of solving these issues during the integration work.

4. Are the scope and institutional responsibilities for the major elements defined? Is all essential scope covered?

   Yes, at this stage of the review. There are elements and institutional responsibilities that need to be finalized especially for the TMS and the SAND tracker.

5. Are plans for prototyping tests sufficient to validate viability of the designs?

   Yes but in the recommendations, we suggested additional improvements compatible with the timescale of day 1 readiness. It is important that the tests provide information to downselect the currently open options.

6. Do conceptual engineering models or schematics provide sufficient information to ascertain constructability and functionality? Do conceptual engineering calculations validate the design?

   Yes, at the design level but the design validation and Q/A standards should be defined beforehand.

7. Have installation plans been sufficiently developed to give confidence that the detector elements can be installed?

   Yes, the integration is well advanced and more detailed than what is required for a conceptual design. The scope of the remaining engineering is well defined.

8. Have appropriate manufacturing methods been identified and have rough cost and schedule estimates been developed? Is the schedule to move forward towards preliminary design, prototyping, and production realistic?

Yes, at the stage of this review. Note that some parts are unconventional (e.g. the cryostat of the LAr ND) and requires a full validation. Schedule are realistic if the work on the downselection of the options and the full simulation study is carried out promptly.