ND CDR: Responses to Committee Questions

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Technical Question 1: LArTPC Module Size

1) What is the rationale behind the chosen dimension of the modules in the LAr TPC? Is simulation/reconstruction available to assess the impact on the physics performance if the volume segmentation is changed? Sections of 2x2 m^2? Not segmented at all?

The ND LArTPC is segmented in order to achieve signal fidelity in the high-rate near detector environment. Based on current simulations, an average of ~6 separate neutrino interactions produce significant charge signals in each 1m x 1m x 3m module per beam spill at 1.2 MW. This increases by potentially up to a factor of 2 at 2.4 MW beam power. Given the slow drift of the charge signals (1.6mm/us), they appear as effectively simultaneous across the 10-us-wide beam spill. We plan to use the fast timing (~20ns) of the corresponding scintillation light signals to correctly localize each of these charge signals in time, and thereby isolate independent neutrino interactions. So per beam spill, we will have a single 3D charge image and a corresponding train of light signals (mean ~6 signals at 1.2 MW, ~12 at 2.4 MW) from each module. We will then use the reconstructed position and amplitude of the light signals, provided by the high granularity of the light readout, to cluster the 3D charge image into charge regions occurring at specific times within the spill. This will then serve as input to a broader event reconstruction spanning across all the modules.

While it becomes easier to accurately match the of charge and light signals with finer detector segmentation, this comes at the expense of increasing the fraction of dead volume between modules. The current scale (1m x 1m x 3m), with a mean of 6 (potentially ~12 at 2.4 MW) signals per module, appears to be in the tractable regime, although these specific reconstruction tools are yet to be developed. A more rigorous analysis of the module size is an important target early in the preliminary design phase.

The ability to fully integrate and test every TPC module before installation in the near hall is also seen as an important feature of the design, substantially reducing risks during the installation and commissioning stage in the near hall. We have a plan to test each 1m x 1m x 3m module in a high-purity LAr test system of modest scale (~10-ton). This feature is an important factor when considering alternate module dimensions.

Technical Question 2: LArTPC Light Trap Design

2) What is the rationale of two different systems for light collection? wouldn't be better to perform some prototype tests and downselect a technology?

Our current plan is to instrument the detector with 50% LCM light traps and 50% ArCLight light traps. Both system share the same SiPMs, cryo circuit boards, cables, feedthrough, and warm readout electronics, which avoids duplication of effort for the rest of the system. The mechanical interface to the rest of the detector system is also identical, so the two trap designs are fully interchangeable.

The two light trap designs have different performance characteristics: the LCM design has higher photon collection efficiency while the ArCLight design has better position sensitivity. Our design makes use of the fact that the LCMs will provide the better measurement of light signal amplitude, while the ArCLight will provide the better estimate of light signal position within the module. Both amplitude and position information are important for accurate matching of light signals to charge signals within the module. For this reason we have currently planned for a 50/50 mix of the two light trap designs in the ND.

The ArgonCube 2x2 Demonstrator implements this 50/50 mix of light traps. Based on the results from this prototype, as well as continued efforts in simulation and reconstruction, we may adjust the ratio of the two types of light traps in order to optimize physics performance. Both systems are have credible resource plans.

General Question 1: Scope and Institutional Responsibilities

1) Our committee charge question 4 asks "Are the scope and institutional responsibilities for the major elements defined? Is all essential scope covered?" To answer this question it would be useful for us to have tabulated the major detector elements for each subdetector system and the institutions that are committed or may commit to these elements.

Example table for ND-LAr and related systems (cryostat, PRISM), based on current institutional commitments.

The TMS has a credible resource plan (in DOE baseline), but is new and has yet to establish institutional responsibilities.

SAND response pending.

WBS	Name	Institution(s)	Funder	Funding Status	Description
			13123.02.03.02 ND-LAr		
131.02.03.02.01	Module Structures	Univ. of Bern	Swiss	Expected	Mechanical interface between TPC and cryostat. LAr/GAr distribution to modules. Module temperatures sensors.
131.02.03.02.02	HV	Univ. of Bern	Swiss	Expected	HV supplies and HV filters for TPCs
131.02.03.02.03	Field Structures	SLAC, CSU	US-DOE	In DOE baseline	Cathode panels, Field Cage Panels, Anode support panel, fasteners
131.02.03.02.04	Charge Readout	LBNL, Caltech, UC-Irvine, UCSB, UTA, Rutgers, UC-Davis	US-DOE	In DOE baseline	Pixel tiles and ASICs (LBNL), ASIC Testing (Caltech, UC-Irvine, UCSB), Pixel Tile Testing (UTA), Cables and Feedthroughs (Rutgers), Warm Controllers (UC-Davis), Power Supplies (LBNL), Clock (LBNL)
131.02.03.02.05	Light Readout	JINR, Univ. of Bern	Russia, Swiss	Expected	LCM Light Traps (JINR), ArCLight Light Traps (Univ. of Bern), SiPMs, SiPM PCBs, cables, feedthroughs, warm digitizers, bias supplies, warm cables, power supplies (all items aside from light traps: design is JINR, procurement is 50/50 Russia/Swiss.)
131.02.03.02.06	Calibration	JINR, MSU	Russia, US-DOE	Expected (Russia), In DOE Baseline (US-DOE)	Light injection system: pulsed light sources, optical fibers and feedthroughs, diffusers (JINR), Charge injection system (MSU)
131.02.03.02.07	TPC Module Integration and Testing	Many	US-DOE, Swiss, Russia	In DOE baseline (US-DOE), Expected (Swiss, Russia)	TPC Module Integration and Testing system: Cryostat, cryogenics, mezzanine, clean tent, work platforms, fixtures (LBNL, CSU), Module Integration Facility Support: High-bay space with crane, external cryogen tanks and piping (iERC FNAL Project)
131.02.03.02.08	TPC Module Installation	Many	US-DOE, Swiss, Russia	In DOE baseline (US-DOE), Expected (Swiss, Russia)	Technical experts (primarily base-supported scientific personnel) to supplement Near Site Installation team during TPC module installation in the Near Hall
			Other		
131.02.03.03	ND LArTPC Cryostat	LBNL	US-DOE	In DOE baseline	Cryostat Cold Structure, Cryostat Warm Structure, Cryostat Support Platform
131.02.03.08	ND PRISM Movement System	LBNL, Stonybrook, Rochester, MSU	US-DOE	In DOE baseline	Movement system: Hilman skates, rails, control system, energy chain (LBNL, Rochester), Monitoring System (Stonybrook, MSU)