**Calibration/Cryogenic Instrumentation**

**Workshop/Scope Review**

**May 11 – June 5, 2020**

**Charge**

**Context:** Initial workshops focusing on the scope of calibration and cryogenic instrumentation systems for the DUNE Far Detectors were held on June 18-19, 2019 at CERN. Review committees were assigned for each topic and responded to sets of charge questions drafted prior to the workshop. The final reports from the calibration and cryogenic instrumentation review committees are posted to DUNE DocDB 15812 and DUNE DocDB 16034. Follow-up workshops on the time scale of 6-9 months were deemed necessary to address the issues raised by the review committees in these reports. Initially DUNE was planning to hold these follow-up workshops on May 7-9, 2020 at CERN. Due to the current situation with the world-wide pandemic the workshop will now be held remotely over a multi-week period beginning on May 11 and culminating on June 5, 2020. The Agenda can be found in <https://indico.fnal.gov/event/24155/>.

Several different types of cryogenic instrumentation were deployed in ProtoDUNE-SP, for which performance information is available. DUNE also has some operational experience with alternative instrumentation currently deployed in the ProtoDUNE-DP detector. Except for the photon detection monitoring systems, no calibration systems were in place for the initial running of either ProtoDUNE detector.

An established DUNE policy is that any piece of instrumentation to be deployed in the Far Detectors must first be deployed and validated in one of the ProtoDUNE detectors. A second period of ProtoDUNE-SP operations based on updated “Module Zero” far detector components is planned for 2022. All instrumentation to be installed in the ProtoDUNE-II SP detector must be produced and available at CERN by September 2021.

Currently, funding has been identified for only a small fraction of the proposed calibration and cryogenic instrumentation systems for the DUNE Far Detectors. Ideally, the CALCI consortium will work with DUNE management to identify institutions/funding agencies that can provide resources for currently unfunded systems. If there are essential systems for which resources cannot be identified, DUNE will need to look for alternative methods for delivering these systems such as tapping into common collaboration resources. Module Zero Far Detector components to be installed in ProtoDUNE-II SP are ideally to be provided by the institution/funding agency that will deliver these components for the DUNE Far Detectors. In the case of some critical systems for which funding has not yet been identified (e.g. the ionization laser system and pulsed neutron source), the DUNE-US project is currently supporting the development of necessary instrumentation for the ProtoDUNE-II SP detector with the expectation that another partner will be able to step in and deliver these systems for the Far Detectors.

Two sub-committees have been established to review the scope proposed for Cryogenic Instrumentation and Calibrations systems, respectively.

**Review Committee Charge – Part I:** The review committees are asked to look at each of the proposed systems and evaluate the following:

* Does the system have a well-justified role in safeguarding the far detectors and facilitating their operation, and if so, what is the minimum amount of system scope needed to carry out this role? (Cryogenic Instrumentation only)
* Does the system have a well-justified role in facilitating the analysis of far detector data, and if so, what is the minimum amount of system scope required to fulfill this role?
* Have all technical issues related to the feasibility of the system (including those raised in the previous workshops) been resolved?
* Are there any risks to overall detector performance associated with the implementation of the system, and if so, is there a plan in place for mitigating these risks?
* Is there a credible plan in place for demonstrating system performance in ProtoDUNE-II?
* Does the functionality of the system justify its overall cost?

Note that the workshop is not intended to serve as a design review for the systems under discussion. As stated above, the review committees should attempt to assess the technical viability of each proposed system but not worry directly about more detailed technical questions such as how cryostat penetrations will be allocated among the different systems. The intention is to first define the overall required scope for calibration and cryogenic instrumentation systems and then work to figure out how to best globally integrate them. If the committees believe that certain calibration and cryogenics instrumentation systems are likely to have interference issues with other existing detector systems, these concerns would be appropriately be addressed as part of their evaluation of potential risks to overall detector performance.

**Review Committee Charge – Part II:** Based on their evaluations of the individual systems, the review committees are asked to classify each of the proposed systems in terms of the following categorizations:

1. Essential – Experiment should not be run without this system in place.
2. Highly-desirable – Strong justification for including this system but not viewed as absolutely necessary.
3. Advantageous – Good arguments exist for why this system might be useful but not fully justified in terms of its contribution to overall detector performance.
4. Debatable – System could potentially be useful but not fully supportable based on current arguments.

Note that when making these assignments, the committees should do so within the context of the full list of proposed systems. If the functionality of one system is seen as fully or partially redundant with another on the list, this information should be accounted for when making the individual assignments. In some cases, it may also be appropriate to place a single system into multiple categories based on differing levels of scope. A hypothetical example would be if one were to classify an ionization laser system with 6 lasers as essential, with 12 lasers as highly-desirable, and with 20 lasers as advantageous. As a final step, we also ask the review committees to attempt to prioritize the systems that are assigned within each of the above categorizations. The current list of proposed calibration and cryogenic instrumentation systems are provided here for reference.

Proposed Calibration Systems:

1. Ionization Laser System
   1. Twelve laser ports penetrating TPC through top field cage modules (baseline)
   2. Additional eight laser ports outside TPC volume that direct beams through the profiles of end-wall field cage modules (proposed upgrade)
2. Laser Beam Location Systems (proposed PIN-diode and Mirror options)
3. Photo-electron Laser System (fibers attached to APAs direct light onto photo-electric targets attached to CPA planes)
4. Pulsed Neutron Source
   1. Two sources located above two of the existing four cryostat manholes (baseline)
   2. Additional source locations in central region of cryostat (proposed upgrade)
5. Radioactive Source System (deployment system for lowering a radioactive source along outside ends of TPC drift volume)

Proposed Cryogenic Instrumentation Systems:

1. Temperature Sensors
   1. Within the TPC volume (attached directly to the APAs)
   2. Outside of the TPC volume
   3. Static temperature monitors
   4. Dynamic temperature monitors
2. Purity Monitors
   1. Inline monitors for cryogenic system
   2. Monitors sitting inside of cryostat (short and long options)
3. Level Meters and Pressure Sensors
4. Cameras
   1. Warm (in ullage)
   2. Cold (in liquid)
5. Gas Analyzers