

*Additional notes: 1) We will provide the full PBS (item 1) and personal requirements for installation (item 2) as soon as we can for discussion by the installation team, but did not feel an intermediate document was helpful here.*

**Item 3: QA and testing plans for CAL: LBNF/DUNE Installation Aug 2019 workshop**

*Relevant TDR section is CAL SP, Ch 1.5, abbreviated here. This is a work in progress and needs further development.*

Each system will be tested in dedicated test stands (QA of the relevant commercial systems, design validation), ProtoDUNE-2 (design validation), and then as appropriate at SDSMT, and underground; specifics to be found below for the work at SDSMT and underground. For all systems, the electronics and racks associated to the system will be tested before transportation underground.

**Ionization Laser System:** A mock up flange at SDSMT will be used to test the assembly and operation of laser and feedthrough interface for each of the full hardware sets (periscope, feedthrough, laser, power supply, and electronics). All operational parts (UV laser, red alignment laser, trigger photodiode, attenuator, diaphragm, movement motors, and encoders) will be tested for functionality before being transported underground. Once underground, the system will be aligned after installation; this requires special safety precautions as it is a Class 4 laser.

**Photoelectron Laser System:** All the fibers to be used will be tested for light transmission of all fibers at 266 nm. A suitable transmission acceptance threshold will be established based on studies during the development phase. Studies to estimate the number of photoelectrons emitted as a function of intensity (based on distance of fiber output to the metallic tab) will also be undertaken. The photoelectric targets will be attached to the cathode; this will be tested in dedicated tests stands, ProtoDUNE-2 to confirm design, and will be installed after the cathode assembly but before the cathode is installed in the cryostat. A high precision survey will be done to record the target locations.

**Laser Beam Location System:** The PIN diodes used will be tested for functionality and sufficient light detection efficiency within a specified range, to ensure uniformity across all clusters. For the mirror-based system, the reflectivity of all mirrors will also be tested prior to assembly. The system has several parts which need to be installed within the TCO, and some which are integrated with the HV system (diodes sit on below the bottom FC, mirrors are attached to the bottom FC profiles facing into the TPC) during installation underground. The attachment/assembly of the mirror clusters will be done during FC assembly underground.

**Pulsed Neutron Source System:** The design and operation of the system will be done first in a member institution radiation-safe facility. Then, the system will be validated at ProtoDUNE-2. The same procedure will be carried out for any subsequent devices before the devices are transported to SURF and underground. System operation will be tested with shielding

assembled to confirm safe operating conditions and sufficient neutron yields using an external dosimeter as well as with the installed neutron monitor. The entire system, once assembled, can be brought down the Ross shaft. The whole system will be tested underground in a dedicated radiation safe area. Then, the system will be lifted by crane to be installed over the human access ports.. Final QC testing of the system will be to operate the source and measure the flux with the integrated neutron monitor and dosimeter.