DEEP UNDERGROUND NEUTRINO EXPERIMENT

DUNE Installation Workshop,
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CISC integration and installation

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Requested for this talk

(1) Parts Breakdown Structure for your system. This should include the list of deliverables & all tooling. In addition, identify any items that require special handling (i.e., deliverables that exceed the cage dimensions identified in Section 2.d. Hoisting Parameters for Ross Shaft, Docdb#328 facility access specification);

(2) Personnel requirements during installation & integration

(3) QA & testing plans

(4) expectations about services provided by detector installation team and facility services team

- Not covered in this talk because it was not in the emails sent around

Introduction (I)

- CISC consortium englobes many systems:
  - Thermometers
  - Purity monitors
  - Cameras & associated light emitting systems
  - Level meters
  - Pressure sensors
  - Gas analyzers
  - Slow controls
- All of them are relatively small and well localised devices with no major installation/integration needs

Introduction (II)

- All systems are still at the level of conceptual design (but all designs follow ProtoDUNE design closely and are actively being validated in the current run):
    - Most are standalone and have minimal interfaces with other systems
    - Final distribution depends on PD results and DUNE CFD simulations

- Thus, we don’t have yet all information for a PBS
- In any case, our PBS will be simple:
    - We have few units for each of the systems
    - Most systems will come preassembled

PBS

shipping box or content ?

As early as needed

	Item	Dimension	Weight	Origin	Earliest possible delivery date
PrM	Flanges			UCI	
	6 Preassembled Individual PrMs			UCI	
	Long supporting rod			UCI	
	Xenon light source, FEB, PC, digitizers			UCI	
	Tooling			UCI	
Static T-Gradient Monitor	Flanges			Spain	
	6 Preassembled Individual TGM			Spain	
	Sensors			Spain	
				Spain	
	Tooling			Spain	
Dynamic T-Gradient Monitor	Flange			Hawaii	
	. Preassembled top enclosure with stepper motor, pinion and gear			Hawaii	
	Preassembled Carrier rod segments with sensors and cables			Hawaii	
	Tooling			Hawaii	
Individual T-sensor	Flanges			Spain	
	anchoring system for cables: pipes, cryostat wall and GPs			Spain	
	Preassembled cables+connectors			Spain	
	Sensors			Spain	
	Tooling			Spain	
Camera	Flanges				
	anchoring system for cables				
	Preassembled cables+connectors				
	cameras				
	Tooling				

Tooling

- Just started collecting info about this

PrMs	Static TGM	Dynamic TGM
benches	benches	benches
Pump (hose, adaptors etc) for vacuum tests		power drill
Oscilloscope	wrenches	wrenches
Multimeters	multimeters	multimeters
Long, narrow Multimeter probes to test connectivity with Faraday cage		power to test motor
Long cables (SHV to banana) for connection tests during insertion	soldering station	soldering station
Ultra sonic cleaner, wipes, ethyl etc.	wipes, ethyl	wipes, ethyl
Supporting blocks for PrM assembly	Custom made holder	Custom made holder
SST bars to strengthen Faraday cage (if needed)		Knee pads
Electrometer (High Resistance Meter) to check PrM voltage divider resistor (1000V, 0.01fA -> 10^10 Ohm) to test overall resistance after insertion		
Capacitance meter to test overall capacitance after insertion		
Long testing tube to test the full assembly in vacuum before insertion		

Loads to go underground for DUNE

- extracted from DUNE-doc-8426 (Sep. 2018)

DUNE Loads							Package Dimensions							
Description	Contact	Date	Total Number of Units	Weight per unit	Units per package	Type of package	Width	Height	Length	Package weight	Number of packages per trip	Type of trip	Number of Hoist Trips	Comment
Dataroom Setup Phase														
CISC electronics modules														Included in DAQ electronic modules, since there it is assumed a rack is completely filled
CISC warm cables														
Installation SP Setup Phase														
Early cryogenics instrumentation														
Static T-Gradient monitors			6		6	Pallet	1	1	1		1	Cage	1	Each T-gradient fits in a 50x50x50 cm3 box.
Individual sensors (bottom)			6		6	Pallet	1	1	1		1	Cage	1	6 boxes 50x50x50 cm3 are assumed
Piping for gas analyzers						Crates	0,3	0,3	6,1			Slung		
SP cryostat roof outfitting Phase														Assume near maximum number of racks. 100 racks
Mid Cryogenics instrumentation														
Individual temperature sensors (top)			6		6	Pallets	1	1	1		1	Cage	1	6 boxes 50x50x50 cm3 are assumed
Level meters (????)														
Cameras														
Rack modules for CI readout														
Slow controls rack modules			100	5	10	Stk pallet box	1,2	2	0,8	50	3	Cage	4	2U module per rack (see above). Assume each module is 150 mm high with packaging and put them in the pallet boxes stacked two high. 5U per box and 10 U per stacked box
Endwall #2 installation														
Final cryogenics instrumentation installation														
Purity monitors			2		1	crate	1,25	1,5	3		2	Cage	1	
Dynamic T-Gradient monitors						crate	2	2	1		1	Cage	1	
Level meters			2		1	crate	0,10	0,10	3		2	Cage	1	
Level meters readout			2		2	crate	0,3	0,2	0,3		1	Cage	1	
Cold Cameras			12	10	12	pallet	0,6	0,3	0,8	120	1	Cage	1	each camera 0.2x0.2x0.3 m
Warm Cameras			3		3	pallet	1	0,5	1		1	Cage	1	each camera 0.5x0.5x0.5 m
Gas analyzers			6		2	pallet	1,22	1,36	1,22		2	Cage	1	6 boxes, each of 4’x4’x1.5’. 3 boxes per pallet
Rack modules for CI readout														Just a quick guess.

Personnel Installation/integ. (I)

- Installation will happen in several phases. Most systems will be installed in well defined periods (before or after TPC installation) having no major needs in terms of installation personnel
- Systems installed during TPC installation (e.g. T sensors or cameras attached to ground planes or DSS bins) will need special treatment

	Before TPC	During TPC	After TPC
Static T-Gradient monitors	x		
Top/bottom Individual sensors	x	x	
Dynamic T-Gradient monitors			x
Purity Monitors			x
Cameras & light emitting system	x	x	x
Gas Analyzers			x
Capacitive Level Meters(DUNE side)			x
GAr Pressure meters (DUNE side)			x
Slow Controls	x	x	

Personnel Installation/integ. (II)

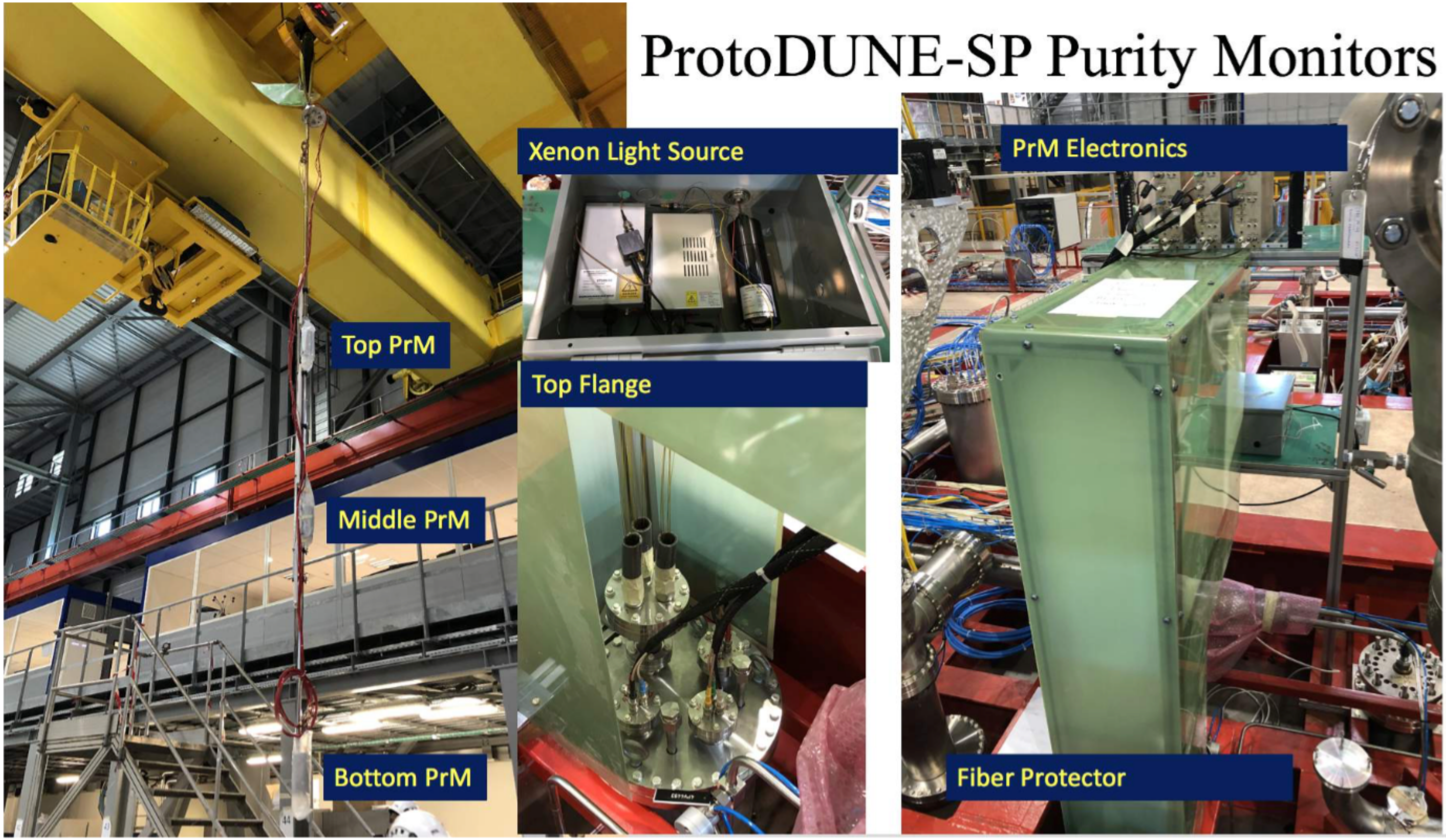
- The numbers in this table are taken from the cost-book rollup

	Engineer	Technicien	Grad. Student	Postdoc	Faculty/staff	TOTAL
LAr Thermometers	44		796	707	707	2254
Purity Monitors	32	398	2122	2122	1061	5735
Cameras & light emitting system			1768	1282	354	3404
Gas Analyzers	64	480				544
Capacitive Level Meters	35			35	14	84
GAr Pressure meters (DUNE side)	30					30
Slow Controls	70	66		1694	884	2714
TOTAL	240	997	4685	5805	3006	14733

QC and tests

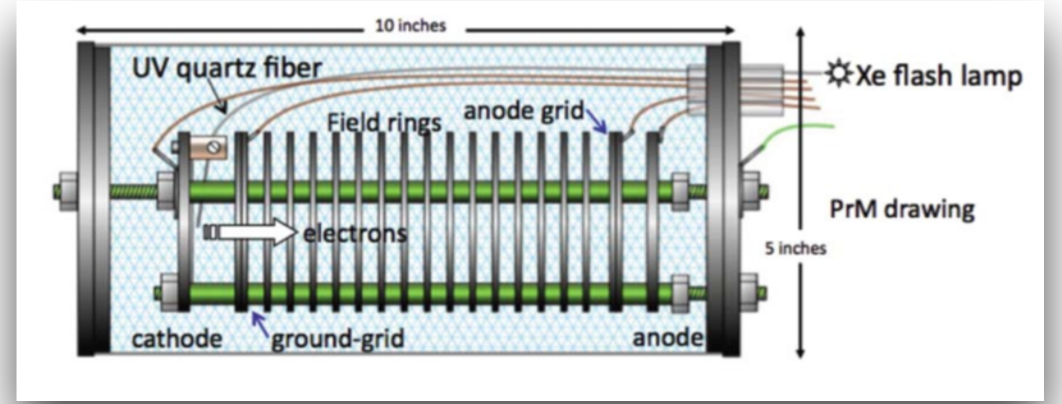
- All systems components and performance will be tested several times:
  - Before installation at production site, including tests in cryogenics conditions
  - Before installation and SURF
  - After installation
- Space and equipment needed for QC at SURF will be quite modest
  - No details in this talk

Purity Monitors



QA/QC: PrMs

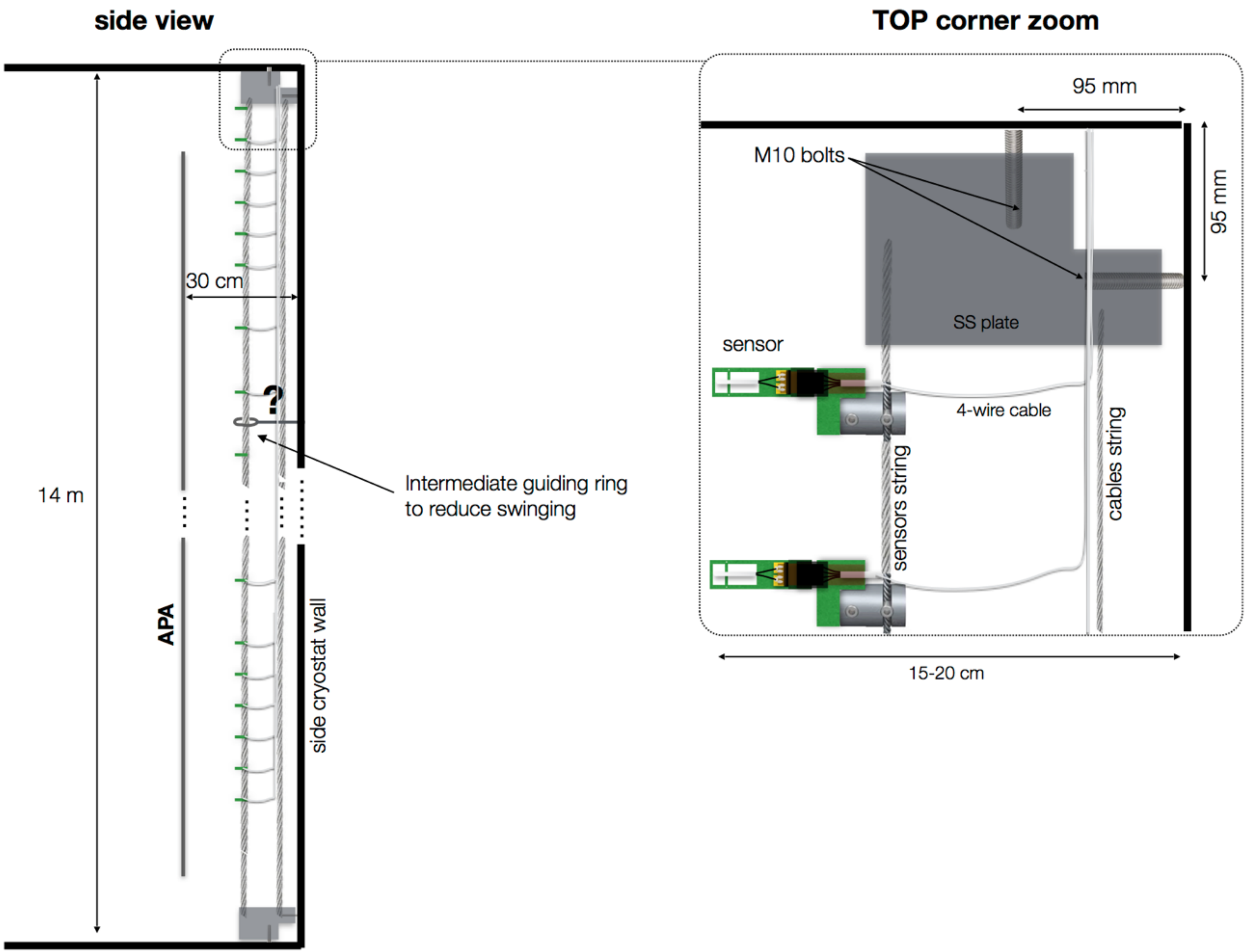
- Before installation:
  - Test individual PrMs in vacuum after each one is fabricated and assembled
    - This test looks at the amplitude of the signal generated by the drift electrons at the cathode and the anode. This ensures that the photocathode is able to provide a sufficient number of photoelectrons for the measurement with the required precision, and that the field gradient resistors are all working properly to maintain the drift field and hence transport the drift electrons to the anode.
  - Test individual purity monitors in LAr
  - Assemble the entire system (3 PrMs) and check all connections
  - Place it into the shipping tube (serves as a vacuum chamber) and test it
  - Assuming an adequate LAr test facility is available, a test at LAr temperature is made to ensure the required performance.



PrM activities at SURF

		QC and tests
1	Shipping	
2	Arrive at Surf	
3	Prepare tools, bench	
4	Ultrasonic clean	
5	PrM mechanical cold test	x
6	Repeat vacuum test in Dewar	x
7	Long supporting rod lifting mechanical test	x
8	Assemble PrMs on long supporting rods	
9	Test PrMs in long vacuum tube	x
10	Install PC/digitizers	
11	Insert PrM assembly	
12	Install Xenon light source and PrM FEB on the rack close to port	
13	Interface with slow control	
14	Gas running (during cryogenic commissioning)	x
15	LAr running (during cryogenic commissioning)	x

Static T-gradient monitor



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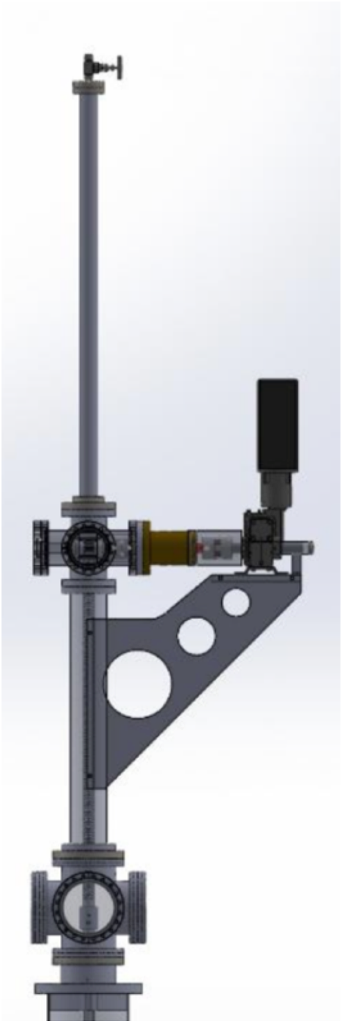
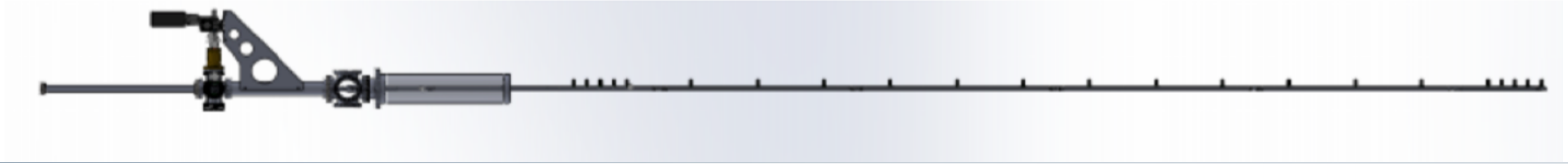
QA/QC:static T-gradient monitor

- Before installation, at production site:
  - The mechanical rigidity of the system is tested such that swinging is minimized (< 5cm) to reduce the risk of touching the APAs.
    - This is done with a 15 m stainless steel string, strung horizontal anchored to two points; its tension is controlled and measured.
  - All sensors are calibrated in the lab. This serves as QA/QC for sensors and readout
    - The main concern is the reproducibility of the results since sensors could potentially change their resistance (and hence their temperature scale) when undergoing successive immersions in LAr. In this case the QC is given by the calibration procedure itself since five independent measurements are planned for each set of sensors. Sensors with reproducibility (based on the RMS of those five measurements) beyond the requirements (2 mK for ProtoDUNE- SP) are discarded. The calibration serves as QC for the readout system (similar to the final one) and of the PCB-sensor-connector assembly.
  - Cable-connector assemblies are tested: sensors must measure the expected values with no additional noise introduced by the cable or connector.
- Before installation, at SURF:
  - Test the entire readout chain (sensors, connectors + readout)
- After installation:
  - The verticality of each array is checked and the tensions are adjusted as needed
  - Test the entire readout chain (sensors, connectors + readout)
    - This allows testing the sensor-connector assembly, the cable-connector assembly and the noise level inside the cryostat. If any of the sensors gives a problem, it is replaced. If the problem persists, the cable is checked and replaced if needed.

QA/QC:dynamic T-gradient monitor

- Before installation, at production site:
  - temperature sensors are tested in LN to verify correct operation and to set the baseline calibration for each sensor with respect to the absolutely calibrated reference sensor.
- Before installation, at SURF:
  - Test the entire readout chain (sensors, connectors + readout)
- After installation:
  - Sensors will be tested by measuring resistance from each sensor and by verifying connection on the flange on the outside. Also take measurement with the final readout chain.
  - Motor will be tested for correct performance (e.g. repeatability) as well as insured clearance of the extra cables slack inside the housing on the top of the detector.





QA/QC: Gas analyzers

- Before installation:
  - Guaranteed by the manufacturer.
  - Once received, the gas analyzer modules are checked for both zero and the span values using a gas-mixing instrument
    - This is done using two gas cylinders with both a zero level of the gas analyzer contaminant species and a cylinder with a known percentage of the contaminant gas. This should verify the proper operation of the gas analyzers.
- After installation:
  - this process is repeated before the commissioning of the cryostat. It is also important to repeat the calibrations at the manufacturer-recommended periods over the gas analyzer lifetime.

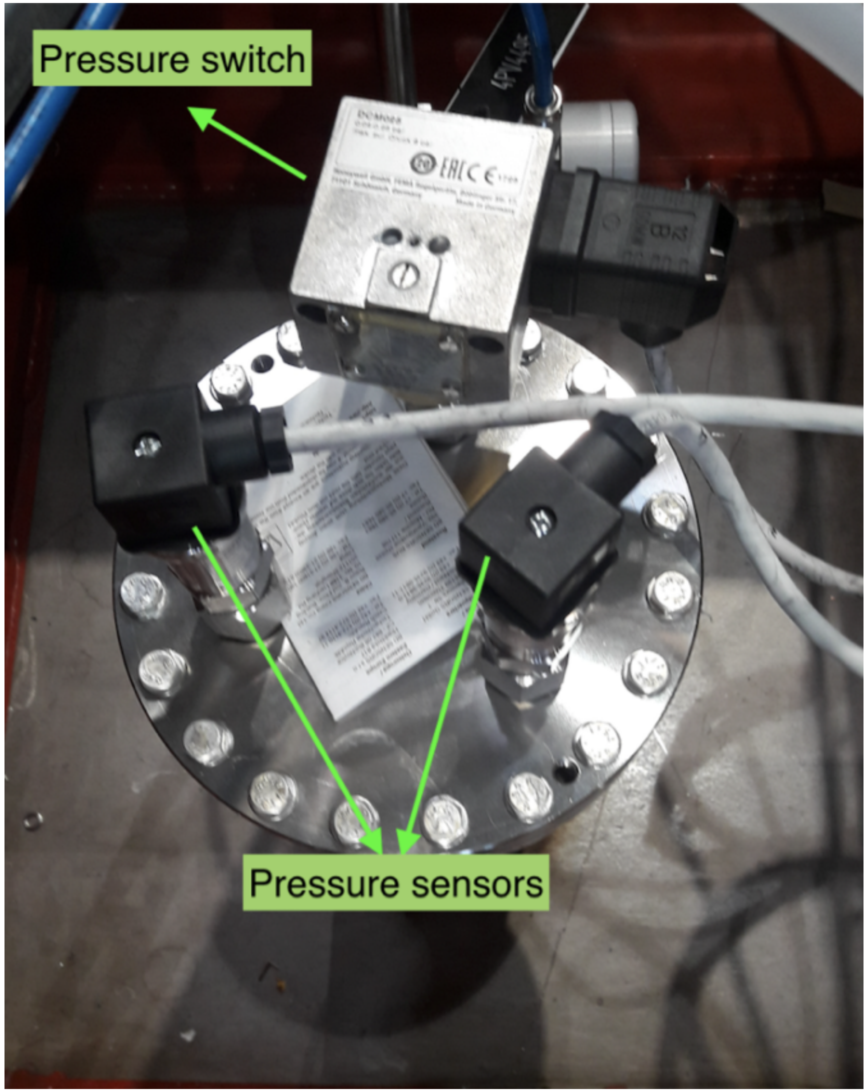
QA/QC: Liquid Level Monitoring

- Differential pressure level meters: Initial QC provided by manufacturer; further QC during and after installation is the responsibility of LBNF.

- Capacitive level meters:
  - Before installation:
    - If commercial, initial QC provided by manufacturer
    - Tested with a modest sample of LAr in the laboratory
  - After installation:
    - Tested in situ using a suitable dielectric in contact with the sensor.

QA/QC: Pressure sensors

- Before installation:
  - Initial QC provided by manufacturer
  - Tested with a modest sample of gaseous argon in the laboratory
- After installation:
  - Tested in situ at atmospheric pressure
  - Test the whole pressure readout chain, (including slow controls PLC and WINCC conversion)
  - Cross-checked with LBNF pressure sensors



Pressure sensors in ProtoDUNE-SP

QA/QC: Cameras

- Before installation, at production site:
  - each cryogenic camera unit (comprising the enclosure, camera, and internal thermal control and monitoring) is checked for correct operation of all operating features:
    - for recovery from 87K non-operating mode, for no leakage, and for physical defects. Lighting systems are similarly checked for operation.
    - Operations tests will include verification of correct current draw, image quality, and temperature readback and control. The movable inspection camera apparatus is inspected for physical defects, and checked for proper mechanical operation before shipping. A checklist is completed for each unit, filed electronically in the DUNE logbook, and a hard copy sent with each unit.
- Before installation, at SURF
  - each fixed cryogenic camera unit is inspected for physical damage or defects and checked in the CITF for correct operation of all operating features, for recovery from 87 K non- operating mode, and for no contamination of the LAr. Operations tests include correct current draw, image quality, and temperature readback and control.
- After installation:
  - fixed cameras and lighting are again checked for operation.
  - The movable inspection camera apparatus is inspected for physical defects and, after integration with a camera unit, tested in CITF for proper mechanical and electronic operation and cleanliness, before installation or storage. A checklist is completed for each QC check and filed electronically in the DUNE logbook.

QA/QC: lights

- Before installation:
  - The complete system is checked before installation to ensure the functionality of the light emission.
    - Initial testing of the light-emitting system is done by first measuring the current when a low voltage (1 V) is applied, to check that the resistive LED failover path is correct. Next, measurement of the forward voltage is done with the nominal forward current applied, to check that it is within 10 % of the nominal forward voltage drop of the LEDs, that all of the LEDs are illuminated, and that each of the LEDs is visible over the nominal angular range. If the LEDs are infrared, a video camera with IR filter removed is used for the visual check. This procedure is then duplicated with the current reversed for the LEDs oriented in the opposite direction.
- During and after installation:
  - These tests are duplicated during installation to make sure that the system has not been damaged in transportation or installation. However, once the LEDs are in the cryostat a visual check could be difficult or impossible.

QA/QC: SC hardware

- Networking and computing systems will be purchased commercially, requiring quality assurance (QA). However, the new servers are tested after delivery to confirm no damage during shipping. The new system is allowed to burn in overnight or for a few days, running a diagnostics suite on a loop. This should turn up anything that escaped the manufacturer's QA process.
- The system can be shipped directly to the underground, where an on-site expert performs the initial booting of systems and basic configuration. Then the specific configuration information is pulled over the network, after which others may log in remotely to do the final setup, minimizing the number of people underground.