SLArchetto Operation Procedure

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Notes:

- All the doors of the LNTF hut have to be open, the intake fan has to be turned on, and oxygen deficiency sensor and monitor (ODM) have to be checked.
- Purge the venting line of SLArchetto with ultra high purity Ar gas when V14 and V15 are open. If using a gas bottle outside the LNTF hut, the gas pressure at the outline of the regulator should be 15 psig.
- V3, V5, V6, V9, V18 isolate the LAr filter. During the LAr filling, V5, V9, and V18 should be always closed.
- V12, V13, V14 (V15, V16, V17) isolate the SLArchetto vessel. V13 and V16 should be always closed, while V14 should be always open until LAr filling is completed. Make sure you know where V14 is; **the burst disk will rupture if V14 is closed.**
- After connecting a new LAr supply dewar, purge the air in the tube from V2.
- Cool down the LAr filter by filling it with LAr from V3 and venting the gas Ar from V18. Monitor the thermocouples from the "LAr Filter Regeneration" tab (which have the lower range of -100°C). This takes about 1 hour.
- When starting filling LAr in SLArchetto (at the room temperature), all the LAr will evaporate. This is the time that pressure will build up in the system. Carefully control V15 to release the pressure.
- Keep the pressure in the SLArchetto vessel at 2 – 4 psig (16.5 – 18.5 psia).
- Keep the pressure in the LAr filter at 50 psig.
- The torque for V3 is 25 foot-pound.
- The torque for V18 is 21.7 foot-pound, 3/4" socket.
- Load 65 L of nitrogen in the thermosyphon line 11 (TSL11), monitor the pressure in SLArchetto and adjust accordingly.
- RTD2 (the bottom one) is not available in this run, but it is repetitive to RTD1.
- RTD3 in this run is connected to Cryocon channel B.
- Take LArPix data during filling (but after the vessel is at $\geq$ atmospheric pressure).
- Turn off the LArPix tile while ramping up the high voltage.
- Once SLArchetto is filled, close V12, V14, V15.

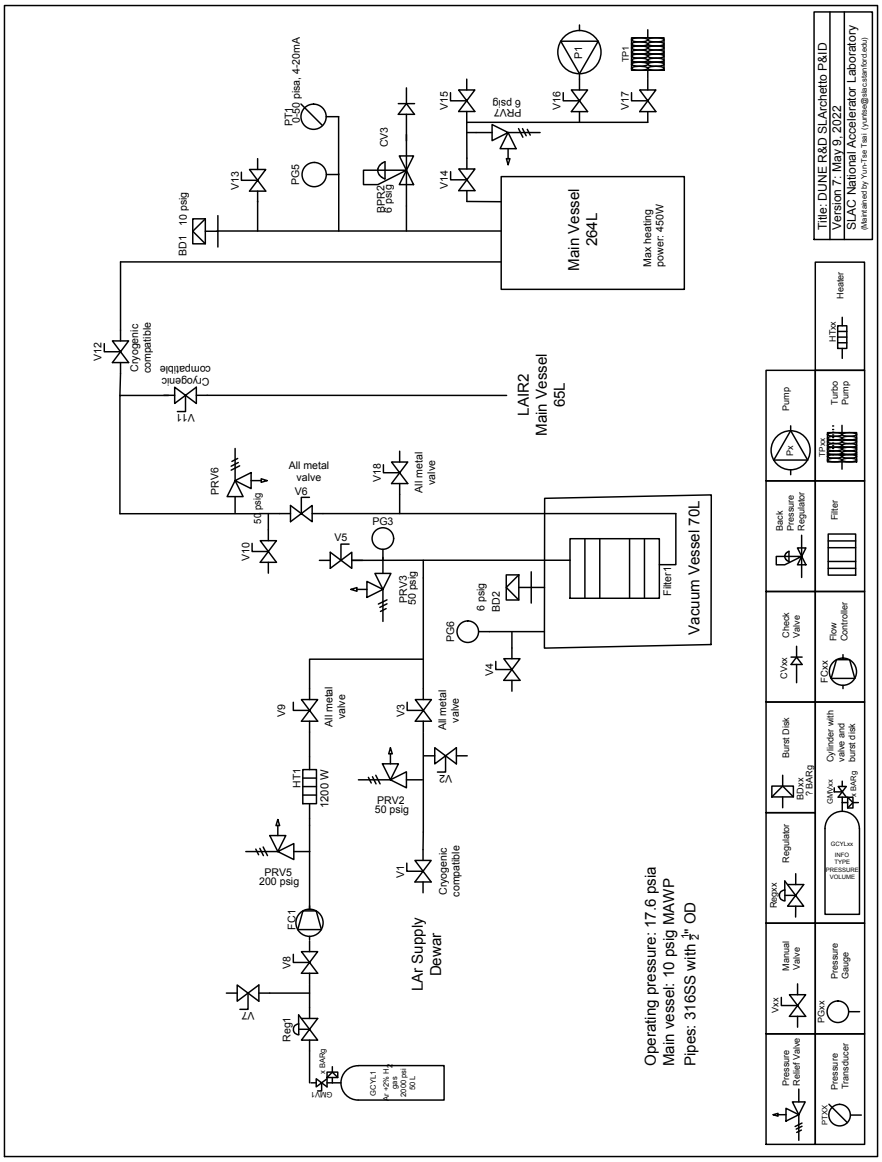
Title: DUNE R&D SLArchetto P&ID
Version 7: May 9, 2022
SLAC National Accelerator Laboratory
Main Vessel 264L
Max heating power: 450W
LAr Supply Dewar
LAIR2 Main Vessel 65L
Vacuum Vessel 70L
Operating pressure: 17.6 psia
Main vessel: 10 psig MAWP
Pipes: 316SS with ½" OD
Pressure Relief Valve
Pressure Transducer
Manual Valve
Pressure Gauge
Regulator
Burst Disk
Check Valve
Flow Controller
Back Pressure Regulator
Filter
Pump
Turbo Pump
Heater

Figure 1: P&ID

Checklist	What to Do and Detailed Description
24 hours before LAr filling	
Vessel closed and tightened	
Leak check	
All valves are closed	
V14, V16 are open	For pumping the vessel
P1 (scroll pump) on	Need to use the scroll pump first
P1 on for 30 minutes, PG5 (pressure gauge) way below 0 psig, PT1 (pressure transducer) at absolutely 0 for more than 10 minutes	Read PT1 from **Pressure** in the Ignition detector monitor
V16 closed	
P1 off	
V17 open	Prepare to start the turbo pump
TP1 (turbo pump) on	
V19 and the valve on the Hicube pump open	The Hicube pump is located behind the computer monitor. V19 is connected on the thermosyphon evaporator, and is not shown in the current version of P&ID
The HiCube pump on	Pump the thermosyphon vacuum jacket
LAr filter regenerated	See the procedure for LAr filter regeneration
Wrap the tubes along the LAr path with foam	
V6, V11, V12 closed, V10 connected to a turbo pump and opened	Evacuate the tube between V6 and V11/V12 with a turbo pump
P1 connected to V4. V4 opened and P1 on	Evacuate the vacuum vessel insulating the LAr filter
Prepare LAr filling	
TP1 (turbo pump) pumped for 24 hours, PT1 (pressure transducer) at absolutely 0 for at least 24 hours, ion gauge at 10^{-3} mbar	Read PT1 from **Pressure** in the Ignition detector monitor
The vacuum in the thermosyphon line jacket is at 10^{-3} hPa level or below	Read the display at the Hicube pump
Purge the thermosyphon line	Open the Tree (botton near home at the top left corner) → subsystems → services → Thermosyphons (we are TSL11). Click the number and a side panel will open, click `purge`. Purge will take about 3 minutes
HEPAs speed high	HEPA control is in the back of the fans (outside the clean tent), and there are five HEPAs

Ventilation light on	Red light at the east wall of the LNTF
Ventilation of the clean room on	Feel the wind blowing
Emergency exhaust fan button is yellow	Press the red button on the east wall of the LNTF to turn the exhaust fan to high speed. Note: Button turns "yellow" when the fan is on high speed
The front and back doors of LNTF are open and stay open	
Cool down the LAr filter	
V10 closed, the turbo pump off	
LAr supply dewar has < 230 psi	If it is higher, vent the argon to lower pressure $\sim$230 psi. If it is too low (such as 30 psi), open the pressure builder to build the pressure to > 100 psi
Connect the LAr dewar	Note that the transfer line between the LAr dewar and V1 is rigid, and we must not overstretch it. Align the connector, and if it is not well aligned, loosen the fitting at V1. If you loosen the fitting at V1, don't forget to change the gasket
PPE (cryo gloves, safety glasses) on	
LAr supply dewar connected to the transfer line	
V1, V2 open	Purge the air in the tube
LAr supply dewar opened	
When seeing LAr, LAr supply dewar, V1, V2 closed	Stop purging
V1, V3 opened	
LAR supply dewar opened, carefully opened V18 according to PG3	PG3 should be at 5 – 10 psig
When seeing LAr from V18 or cooling for an hour, LAr supply dewar, V18 closed	
Start taking data from the oxygen sensor	`miniterm.py --eol=CR --echo /dev/ttyUSB1 | tee 202207xx-01-oxygen.log`, the complete instruction can be found in OxygenSensor.pdf
Start purging the SLArchetto venting line (downstream V15) $\sim$10 minutes before starting filling LAr to SLArchetto	
Fill the main vessel	
V17 closed	
TP1 (turbo pump) off	Prepare for filling the main vessel
LArPix fan on	Plug the cable into the extension cord used for the turbo pump

V6, V12 open	
Double check the closed valves: V2, V5, V9, V10, V11, V13, V15, V16, V17	
LAr dewar closed	
Double check the open valves: V1, V3, V6, V12, **V14 (IMPORTANT)**	V14 is on the top lid, connecting to the hose. If closed, the burst disk will crack when LAr just fills in.
Two people ready: One adjusting the LAr flow, the other adjusting V15 (venting)	One opens the LAr dewar slightly, and the other monitors PG5 (pressure gauge) or PT1. When the pressure reaches 2.5 psig at PG5 (17.1 psia at PT1), open V15 slightly to prevent the pressure from building up. We want to keep the pressure at about 2 psig at PG5 (16.6 psia at PT1) and not to exceed 4 psig at PG5 (18.6 psia at PT1) all the time. We also don't want the vessel pressure to go below 0 psig at PG5 (14.6 psia at PT1), in which condition the air would come in and contaminate the LAr purity.
Fill with 10L at 10 slpm, and the pressure is less than 5 bar (better less than 3 bar)	Fill the numbers 10L at 10 slpm, and click `Add LN2`. Click on the pressure graph below the value of liters to check the pressure
LArPix power supply on. Voltage at 24 V, current limit at 1 A	
LArPix starts taking data when the pressure reaches $\sim$14.6 psia	Ask Patrick
Equilibrium reached and $\sim$50 psig at PG3 (pressure gauge on top of the LAr filter)	
Pressure in TSL11 stable and < 3 bar, add 5 L at 5 slpm. Totally 15 L	
Pressure in TSL11 stable and < 3 bar, add 5 L at 5 slpm. Totally 20 L	
Pressure in TSL11 stable and < 3 bar, add 5 L at 5 slpm. Totally 25 L	
Pressure in TSL11 stable and < 3 bar, add 5 L at 5 slpm. Totally 30 L	
Pressure in TSL11 stable and < 3 bar, add 5 L at 5 slpm. Totally 35 L	
Pressure in TSL11 stable and < 3 bar, add 5 L at 5 slpm. Totally 40 L	
Pressure in TSL11 stable and < 3 bar, add 5 L at 5 slpm. Totally 45 L	

Pressure in TSL11 stable and < 3 bar, add 5 L at 5 slpm. Totally 50 L	
Pressure in TSL11 stable and < 3 bar, add 5 L at 5 slpm. Totally 55 L	
Pressure in TSL11 stable and < 3 bar, add 5 L at 5 slpm. Totally 60 L	
Pressure in TSL11 stable and < 3 bar, add 5 L at 5 slpm. Totally 65 L	
LAr dewar transition	
When the LAr dewar is almost empty, start to close the LAr dewar	Pressure at PG3 (pressure gauge) will start dropping when the LAr dewar is almost empty
1 – 3 psig at PG5 (pressure gauge) or 15.6 – 17.6 psia at PT1 (pressure transducer) during the LAr dewar transition	Adjust V15 to control the pressure. May need to completely close it. Read PT1 from **Pressure** in the Ignition detector monitor
V1, V3 closed	
The first LAr dewar disconnected, the second one connected	Note that the transfer line between the LAr dewar and V1 is rigid, and we must not overstretch it. Align the connector, and if it is not well aligned, loosen the fitting at V1. If you loosen the fitting at V1, don't forget to change the gasket
V1 opened	
LAr dewar, V2 open	Purge the air in the tube
When seeing LAr from V2, LAr dewar, V2 closed	
V3 open	
Double check V6, V12 opened	
Two people ready: One adjusting the LAr flow, the other adjusting V15 (venting)	One opens the LAr dewar slightly, and the other monitors PG5 or PT1. When the pressure reaches 2.5 psig at PG5 (17.1 psia at PT1), open V15 slightly to prevent the pressure from building up. We want to keep the pressure at about 2 psig at PG5 (16.6 psia at PT1) and not to exceed 4 psig at PG5 (18.6 psia at PT1) all the time. We also don't want the vessel pressure to go below 0 psig at PG5 (14.6 psia at PT1), in which condition the air would come in and contaminate the LAr purity.
Stop LAr filling	
Cryocon D (RTD 4) reaches $\sim$90 K at $\sim$16.1 psia, or drops significantly	This means the LAr reaches the desired liquid level. Read RTD values at the Ignition detector monitor or the Cryocon device

Liquid seen through the viewport	Turn on the flash light and place it on top of the viewport shield
When Cryocan E (RTD 5) shows the beginning of the significant temperature drop, two people ready to close the valves	Stop filling LAr from now. When the pressure starts to drop, slightly close V15. Adjust V15 according to the pressure – we don't want the pressure to go below 2 psig at PG5 (pressure gauge) or 16.6 psia at PT1 (pressure transducer) nor above 3 psig at PG5 (17.6 psia at PT1). The working pressure should be ∼3 psig at PG5 (17.6 psia at PT1)
LAr dewar, V15 closed	
V1, V3, V6, V12 closed	
All valves closed	
Stop purging the SLArchetto venting line (downstream V15)	
Electrical box plugged and switched on	Toggle up, switch on in case we need heaters
Set the threshold of LArPix channels	Need to set the threshold with HV off. Call Patrick at this moment
Enable the warning, alert, and alarm for the pressure	Click the alarm button. Warning range: 14 – 17.7 psia; Alert range: 14 – 18.7 psia; Alarm range: 14 – 19.7 psia
Enable the warning, alert, and alarm for RTD 1, 3, and 4	Click the alarm button. Warning range: 87 – 91 K; Alert range: 85 – 92 K; Alarm range: 83 – 93 K
Enable the warning, alert, and alarm for RTD 5	Click the alarm button. Warning range: 87 – 130 K; Alert range: 85 – 130 K; Alarm range: 83 – 130 K
Enable the warning and alert for RTD 6	Click the alarm button. Warning range: 150 – 163 K; Alert range: 145 – 170 K
20-40 minutes for equilibrium	Check for example, if temperature at RTD 4 is rising, if the pressure is stable
Cryoncon A, B, C, D (RTD 1, 2, 3, 4) show < 90K at ∼16 psia	
LAr filter vented through V5	
All valves closed	The valves likely were not closed because of the ice on them. Check them again and completely close them
Emergency exhaust fan button is red	Press the yellow button on the east wall of the LNTF to turn the exhaust fan to low speed. Note: Button turns "red" when the fan is on low speed

Ramp up high voltage

LArPix data taking stopped	At this moment, ask Patrick. Will have instructions later
LArPix tile powered off	At this moment, ask Patrick. Will have instructions later
High voltage power supply on	
PicoAmmeter on, set to the 'zcheck' mode	

PicoAmmter DAQ script running and field shell current updating	Log in
	`neutrino@nu-daq01-ir2.slac.stanford.edu`
	run
	`cd ~/kapton_daq`
	`source setup.sh`
	`nohup python3 daq.py --config config/config_keithley6485.yaml &`
	Check the `Current` in the `HV Control` panel in the main page, or `PicoAm Current` in the `SLArchetto High Voltage Control` page

HV status on and HV current set to 1mA	Go to the `HV Control` panel, and then go to `HV ramping`. Click `PS initialization`. Then the button `HV Status On/Off` should be On and green.
High voltage ramped up to 15 kV	Set `Target voltage` to 15 kV, and click `HV ramping Interlock ON`, disabling the interlock. Click `Start`. More details in RampingHighVoltage.pdf.
High voltage (Cathode voltage) at 15 kV, field shell current (PicoAm Current) at ∼9000 – 10000 nA	Check `Cathode Voltage` and `PicoAm Current` in the SLArchetto High Voltage Control page, or `Voltage` and `Current` in the main monitor
Enable the alert and alarm for high voltage	Click the alarm button. Warning range: 14.95 – 15.05 kV; Alert range: 14.9 – 15.1 kV; Alarm range: 14.8 – 15.2 kV
Enable the warning, alert, and alarm for the current	Click the alarm button. Warning range: -20,000 – 0 nA; Alert range: -25,000 – 0 nA; Alarm range: -30,000 – 0 nA
HV ramping Interlock OFF	
Start data taking	
LArPix tile powered on	At this moment, ask Patrick. Will have instructions later
LArPix data taking	At this moment, ask Patrick. Will have instructions later
Stop operation	
Stop data taking	At this moment, ask Patrick. Will have instructions later

LArPix tile powered off	At this moment, ask Patrick. Will have instructions later
HV and current alarms disabled	Click the alarm button and disable the alarms
HV ramped down	Go to the `HV Control` panel, and then go to `HV ramping`. Set `Target voltage` to 0 kV, and click `HV ramping Interlock ON`, disabling the interlock. Click `Start`. More details in RampingHighVoltage.pdf.
High voltage (Cathode voltage) at 0 kV, field shell current (PicoAm Current) at 0 nA	Check `Cathode Voltage` and `PicoAm Current` in the SLArchetto High Voltage Control page, or `Voltage` and `Current` in the main monitor
HV Status off	Click `Switch On`, and the button will become grey and `HV Status Off` will show
V14 and V15 open	Prepare for boiling LAr
Removed liquid nitrogen in the thermosyphon line	
Heater interlock off	Go to SLArchetto main page, turn off the `Heater ITLK ON`
Set up the heater range: 91 – 95 K	Go to `LAr evaporator`, set `Heater OFF temperature` to 95 K while `Heater ON temperature` to 91 K
Heater on	Click `Start`
Heat for 24 hours, and heater off	Go to `LAr evaporator`, click `Stop`
Heater interlock on	Go to the main page and turn on the heater interlock