SLArchetto Operation Procedure

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February 27, 2022

Notes:

- P&ID is attached in the end of this list. Valve labels have been changed.
- We have to avoid air flowing into the LAr filter and the plumbing system, which will compromise the filter and the LAr purity. Check the valves' status carefully.
- Every time when we have air in a section of the plumbing system (typically before V0 when starting filling LAr from a new dewar), do close V4 and open the purging valve, V3.
- 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.
- We want to take LArPix data during filling (but after the vessel is at $\geq$ atmospheric pressure).
- Need to turn off the LArPix tile before ramping up the high voltage.

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	
V18 and the valve on the Hicube pump open	The Hicube pump is located behind the computer monitor. V18 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
V4, V5, V9, V10, V11, V12 closed, V6 opened	Prepare to evacuate the LAr filter up to V11/V12 with the scroll pump
P1 connected to V5. V5 opened and P1 on	Evacuate the LAr filter up to V11/V12 with the scroll pump
Prepare LAr filling	
TP1 (turbo pump) pumped for 24 hours, PT1 (pressure transducer) at absolutely 0 for at least 24 hours	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	
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` $\mathtt{LN}_2$. Click on the pressure graph below the value of liters to check the pressure
Fill the open mouth dewar (LAr filter cooling)	
V2 closed	
V5 closed, the scroll 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
PPE (cryo gloves, safety glasses) on	
LAr supply dewar connected to the transfer line	
V0, V1 open	Start filling the open mouth dewar. It will take about 40 minutes

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	
Open mouth dewar full. V1 closed. LAr dewar closed	Finish filling the open mouth dewar
Fill the main vessel	
V17 closed	V17 is a torque valve
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: V1, V2, V3, V4, V5, V9, V10, V11, V13, V15, V16, V17	
Air in the tube before V4 purged	Open V2 and LAr dewar valve. Slowly open V3 until the liquid is spraying
LAr dewar closed	
V4 closed	
V2 open	
Double check the open valves: V0, V2, 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.
LAr dewar open, V3 open	Purge the air in the line and vent through V3
Liquid spill observed from V3. V3 closed. LAr dewar closed	End the purge
PT1 (pressure transducer) at absolutely 0	Read PT1 from **Pressure** in the Ignition detector monitor
V4 opened	V4 is a torque valve

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.
LArPix power supply on. Voltage at 24 V, current limit at 1 A	
LArPix starts taking data when the pressure reaches ∼14.6 psia	Ask Patrick
Equilibrium reached and ∼3 bar at PG3 (pressure gauge on top of the LAr filter)	
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	
During fill when the liquid level in the open mouth vessel goes down, open V1 and increase flow to refill	
LAr dewar transition	
When the LAr dewar is almost empty, close V0, V2, and V4	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
The second LAr dewar connected	
V0 and V1 open, V2 closed	Refill the open mouth dewar first after the LAr dewar transition
Air in the tube before V4 purged	Open V2 and LAr dewar valve. Slowly open V3 until the liquid is spraying
LAr dewar closed	

V4 open	
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 ∼90 K at ∼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)
V15, V14, V12, V6, V4, V2, and V0 closed	
All valves closed	
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

Open mouth dewar lowered. LAr filter warming up.	Prepare to release the pressure from the LAr evaporation in the LAr filter
20-40 minutes for equilibrium	Check for example, if temprature at RTD 4 is rising, if the pressure is stable
Cryoncon A, B, C, D (RTD 1, 2, 3, 4) show < 90K at $\sim$16 psia	
V4, V5, V9, V11, V12 closed. V6 opened	Prepare to vent the LAr filter
LAr filter vented through V10	
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 $\sim$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
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

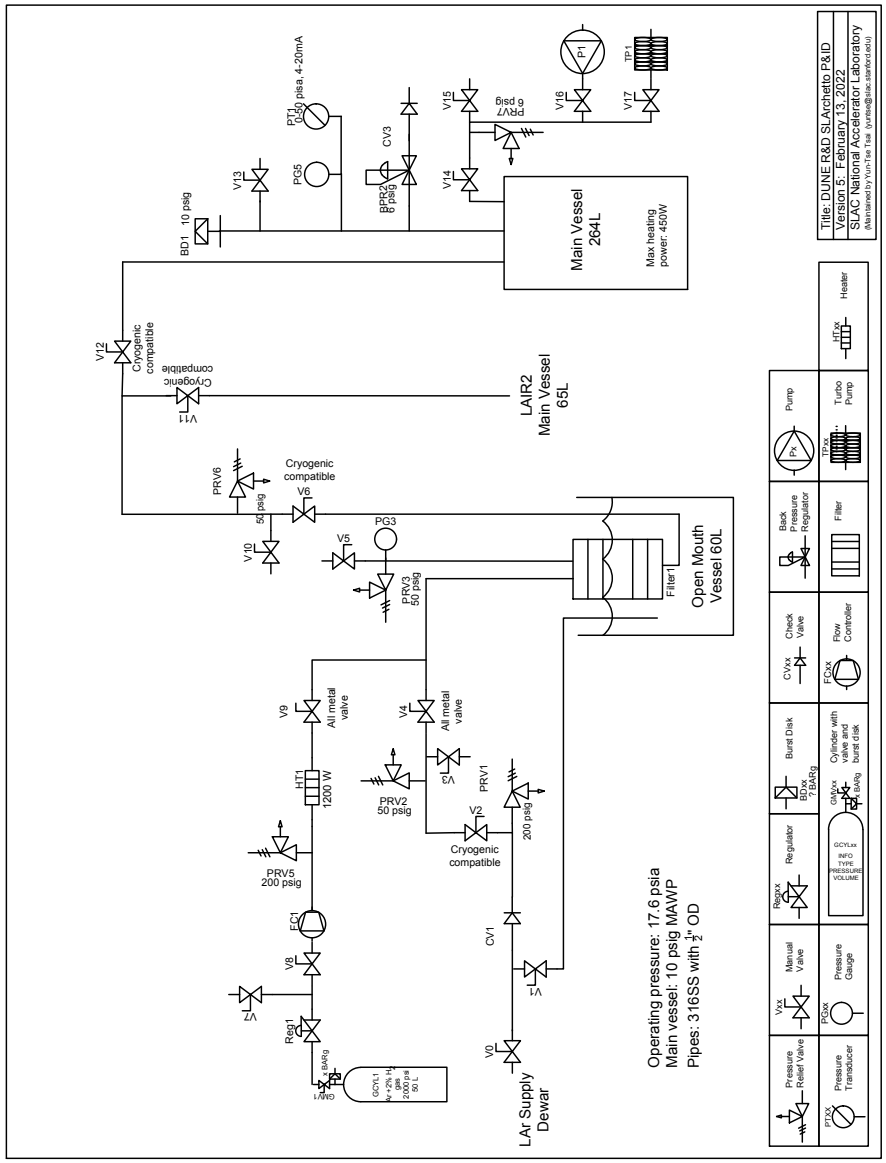
Title: DUNE R&D SLArchetp P&ID
Version 5 - February 13, 2022
SLAC National Accelerator Laboratory
Main Vessel 264L
Max heating power: 450W
LAIR2 Main Vessel 65L
Open Mouth Vessel 60L
LAr Supply Dewar
Operating pressure: 17.6 psia
Main vessel: 10 psig MAWP
Pipes: 316SS with ½" OD
Cryogenic compatible
All metal valve
Heater
Turbo Pump
Pump
Filter
Back Pressure Regulator
Flow Controller
Check Valve
Burst Disk
Regulator
Manual Valve
Pressure Gauge
Pressure Relief Valve
Pressure Transducer

Figure 1: P&ID