

# SLArchetto Operation Procedure

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## General steps:

1. Precool the LAr filter first. During the precooling, vent to the venting line, but not to the SLArchetto vessel. This takes about 1 hour and we stop precooling when the temperature in the LAr filter is  $7^{\circ}\text{C}$ .
2. Fill the SLArchetto vessel, monitor the LArPix noise during the filling.
3. After LAr reaches the desired level, take pedestal data with LArPix.
4. Turn off LArPix and ramp up the high voltage.
5. Take pedestal data, set the trigger threshold of LArPix. Start data taking.

## Safety:

- All the doors of the LNTF hut have to be open.
- The intake fan has to be turned on.
- The oxygen deficiency sensor and monitor (ODM) have to be checked.
- The pressure in the LAr filter must not exceed 150 psi. The pressure is shown on PG3.
- The pressure in the SLArchetto vessel must not exceed 10 psig. The cracking pressure of the burst disk is 10 psig but likely it will break at  $\sim 6$  psig. The pressure is shown on PG5 on top of the vessel and PT1 in the detector control system (Ignition).

## Technical notes:

- V3, V5, V6, V16/V17, V18/V19 isolate the LAr filter. During the LAr filling, V5, V16, V19 should be always closed. V17 and V18 are metal valves, which will be always open in this run. We are learning whether we can get rid of them. We will rely on V16 and V19 to isolate the LAr filter, instead of V17 and V18.
- The vacuum vessel surrounding the LAr filter should be evacuated from V4 all the time during LAr filling. The pressure can be read from PG6.
- Purge the venting line of SLArchetto with ultra high purity Ar gas when V12 and V13 are open. If using a gas cylinder outside the LNTF hut, the gas pressure at the outline of the regulator should be  $20\text{ psig}$ .
- V9, V11, V12 (V13, V14, V15) isolate the SLArchetto vessel. V11, V14, V15 should be always closed, while V12 should be always open until LAr filling is completed. Make sure you know where V12 is; **the burst disk will rupture if V12 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 V6 and V7. Monitor the temperature from the “LAr Filter Regeneration” tab. 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 V13 to release the pressure.
- Keep the pressure in the SLArchetto vessel at 2 – 4 psig (16.5 – 18.5 psia). The pressure can be read from PG5 on the top of SLArchetto and from PT1 from the Ignition GUI.
- Keep the pressure in the LAr filter at 50 psig. The pressure can be read from PG3.
- The torque for V3 is 25 foot-pound.
- The torque for V6 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.
- 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, V13, V9.
- 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.





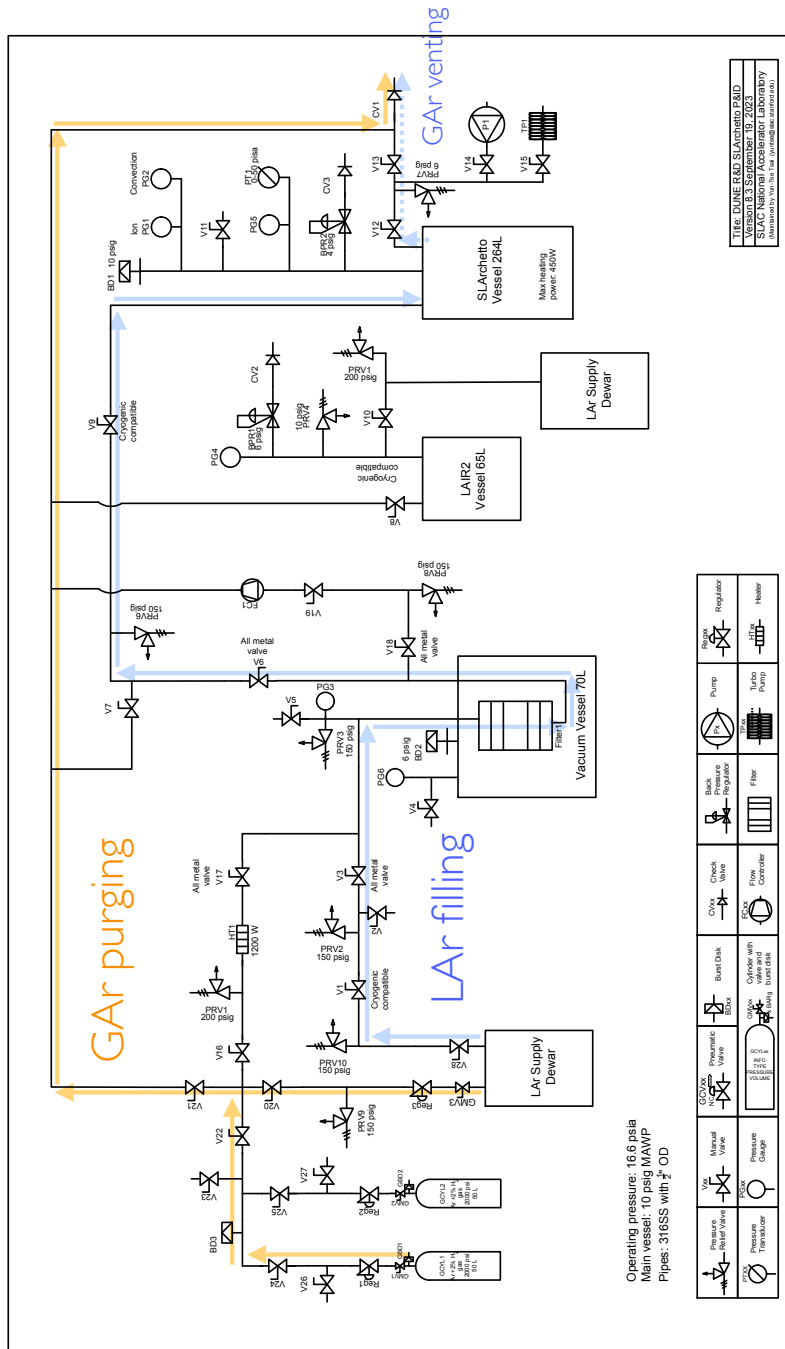


Figure 3: LAr flow direction for filling the SLArchetto vessel. The gas Ar for purging can be injected from the gas port of another LAr dewar, or from an ultra high purity gas argon cylinder. Do NOT use the same LAr dewar of LAr filling for gas Ar purging.

Checklist	What to Do and Detailed Description
<b>Readiness</b>	
TPC grounding checked	
LArPix tests in the room temperature at atmosphere	
Vessel closed and tightened	
Leak checked	
All valves are closed	
V12, V14 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 <b>Pressure</b> in the Ignition detector monitor
V14 closed	
P1 off	
V15 open	Prepare to start the turbo pump
TP1 (turbo pump) on for a few days	
V28 and the valve on the Hicube pump open	The Hicube pump is located behind the computer monitor. V28 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	
P1 connected to V4. V4 opened and P1 on	Evacuate the vacuum vessel insulating the LAr filter
<b>Prepare LAr filling</b>	
TP1 (turbo pump) pumped for a few days, PT1 (pressure transducer) at absolutely 0 for a few days, ion gauge at $10^{-3}$ mbar	Read PT1 from <b>Pressure</b> in the Ignition detector monitor. The ion gauge should be turned off when the pressure is greater than ? mbar
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

Use thermosyphon page in DUNE Ignition (button in the main menu or on the thermosyphon temperature panel on the left in the monitor page), select line TSL11 by clicking on the right thermosyphon or on SLArchetto on the minimap on the top right; make sure no other valves in the thermosyphon system are being used (large button on the left grey and saying “No TS valve open”), so that the control panel and the pressure plot under it are visible and enabled.

Click the top button **Purge** on the panel.

Purge will take about 3 minutes; while still running the traffic light shows green, turning back off when over.

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### **Safety Checks – Beginning of the Day**

All the doors of the LNTF hut opened

Intake fan on

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

Oxygen deficiency sensor in place, oxygen deficiency monitor green

Ventilation light on

Red light at the east wall of the LNTF

Ventilation of the clean room on

Feel the wind blowing

HEPAs speed high

HEPA control is in the back of the fans (outside the clean tent), and there are five HEPAs

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### **Cool down the LAr filter**

V15 closed, TP1 (the turbo pump) off

LAr supply dewar has < 230 psi

If it is higher, vent the argon to lower pressure ~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

PPE (cryo gloves, safety glasses) on

V1, V2 open

Purge the air in the tube

LAr supply dewar (V28) opened

When seeing LAr, V28, V2 closed

Stop purging

V6, V3 opened

LAr supply dewar (V28) opened, carefully opened V7 according to PG3

PG3 should be at 5 – 10 psig

Temperature in LAr filter at -100°C (the minimal of the readout device) or cooling for an hour, V28 (LAr supply dewar), V7 closed

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### Fill the main vessel

Start purging the SLArchetto venting line (downstream V13) with gas Ar

V15 closed

TP1 (turbo pump) off

LArPix fan on

Check V6, V12 open

Double check the closed valves: V2, V5, V7, V8, V9, V11, V13, V14, V15

LAr dewar (V28) closed

Double check the open valves: V1, V3, V6, **V12 (IMPORTANT)**

Oxygen sensor shows <1% or plateaued

One operator ready for adjusting V13 all the time according to the pressure in SLArchetto.

The second operator fully opens V9

The second operator opens V28 (LAr dewar) gradually

Fill with 10L at 10 slpm, and the pressure is less than 5 bar (better less than 3 bar)

LArPix power supply on. Voltage at 24 V, current limit at 1 A

LArPix starts taking data when the pressure reaches ~14.6 psia

Equilibrium reached and ~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

Two options: 1. Use gas Ar from the LAr dewar: Open GMV3, Reg3, V20, V21, DO NOT use the same LAr dewar for filling and purging, 2. Use UHP Ar gas cylinder: Hook the gas cylinder, close V26, open GMV1, Reg1, V24, V22, V21

Prepare for filling the main vessel

Plug the cable into the extension cord used for the turbo pump

V12 is on the top lid, connecting to the hose. If closed, the burst disk will crack when LAr just fills in.

Oxygen sensor is displayed at the “LAr Filter” page of the Ignition GUI

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 the numbers 10L (large box) at 10 slpm (smaller under the first), and click Add N<sub>2</sub>. Check the pressure on the purple graph under the controls.

Use Pedestal Monitor in the LArPix tutorial, <https://github.com/SLACube/slacube-daq-tutorial>.



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

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### LAr dewar transition

When the LAr dewar is almost empty, start to close the LAr dewar

1 – 3 psig at PG5 (pressure gauge for SLArchetto) or 15.6 – 17.6 psia at PT1 (pressure transducer for SLArchetto) during the LAr dewar transition

V1, V3 closed

The first LAr dewar disconnected, the second one connected

V1 opened

V28 (LAr dewar), V2 open

When seeing LAr from V2, V28 (LAr dewar), V2 closed

V3 open

Double check V6, V9 opened

Pressure at PG3 (pressure gauge for the LAr filter) will start dropping when the LAr dewar is almost empty

Adjust V13 to control the pressure. May need to completely close it. Read PT1 from **Pressure** in the Ignition detector monitor

Purge the air in the tube

One operator ready for adjusting V13 all the time according to the pressure in SLArchetto.

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.

The second operator opens V28 (LAr dewar) gradually

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### 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 Cryocon E (RTD 5) shows the beginning of the significant temperature drop, two operators ready to close the valves

One operator ready for adjusting V13 all the time according to the pressure in SLArchetto.

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.

V28 (LAr dewar), V13 closed

V1, V3, V6, V9, V12 closed

All valves closed

Stop purging the SLArchetto venting line (downstream V13)

Electrical box plugged and switched on

Toggle up, switch on in case we need heaters

Set the threshold of LArPix channels with HV off

LArPix DAQ tutorial: <https://github.com/SLACube/slacube-daq-tutorial>

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

20-40 minutes for equilibrium

Cryoncon A, B, C, D (RTD 1, 2, 3, 4) show  $< 90\text{K}$  at  $\sim 16$  psia

LAr filter vented through V5

All valves closed

Emergency exhaust fan button is red

Click the alarm button. Warning range:  $150 - 163\text{ K}$ ; Alert range:  $145 - 170\text{ K}$

Check for example, if temperature at RTD 4 is rising, if the pressure is stable

The valves likely were not closed because of the ice on them. Check them again and completely close them

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

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### 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  $1\text{mA}$

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  $15\text{ kV}$

Set **Target voltage** to  $15\text{ kV}$ , and click **HV ramping Interlock ON**, disabling the interlock. Click **Start**.  
More details in [RampingHighVoltage.pdf](#).

High voltage (Cathode voltage) at  $15\text{ kV}$ , field shell current (PicoAm Current) at  $\sim 9000 - 10000\text{ nA}$

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	
<b>Start data taking</b>	
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
<b>Stop operation</b>	
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
V12 and V13 open	Prepare for boiling LAr
Removed liquid nitrogen in the thermosyphon line	Set the total amount of $N_2$ found in the thermosyphon drawing, e.g. 60 L, to be removed at 1 slpm (click on Remove $N_2$ ). The script will stop after 4 minutes (i.e. 4 times the expected time), but when the flux meter at the top of the PID-like drawing shows 0, it's already basically done. When it's done, click on Purge.
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

Heater interlock on

Go to LAr evaporator, click Stop

Go to the main page and turn on the heater interlock

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