SLArchetto Operation Procedure

Yun-Tse Tsai

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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 ? °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 ∼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 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 Iginition 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.

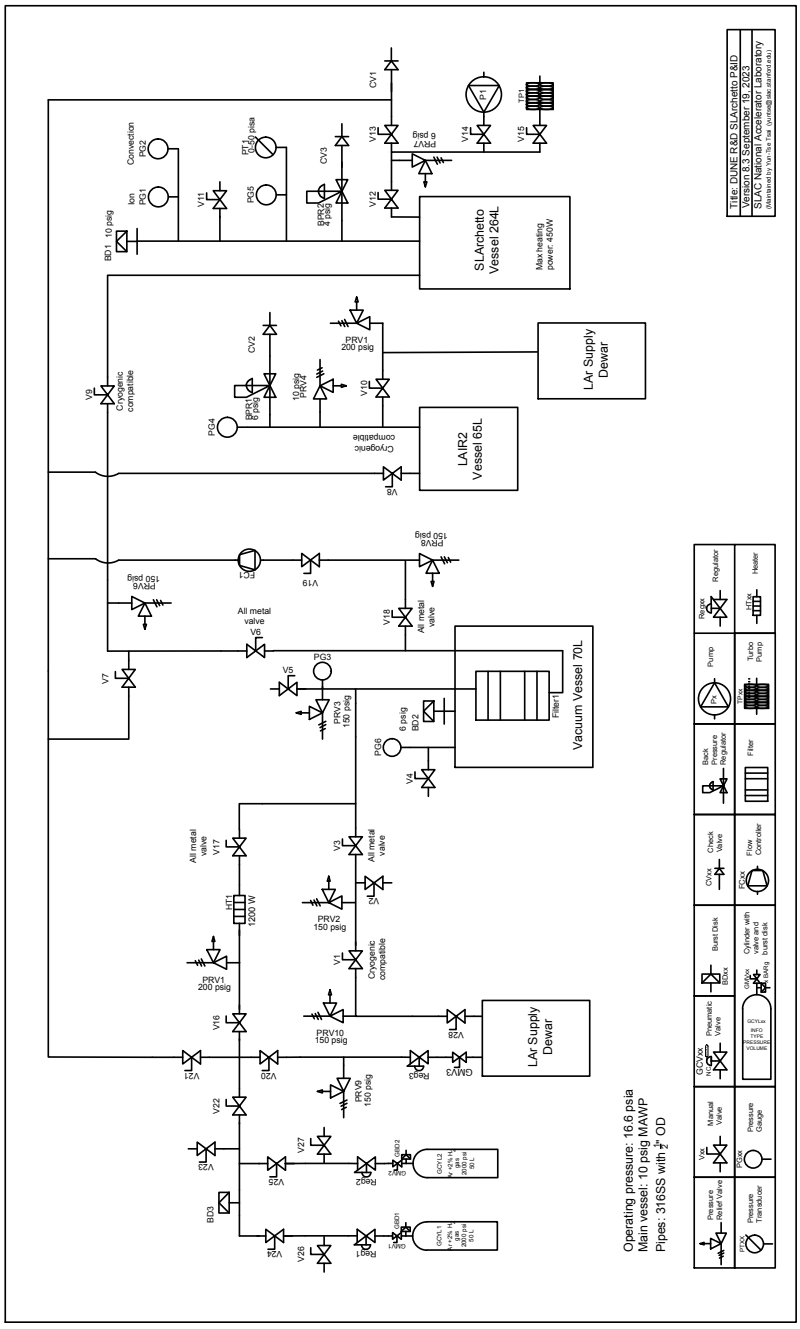
Title: DUNE R&D SLArchetto P&ID
Version 3: September 18, 2023
SLArchetto: Single Argon Cryostat Laboratory
(Maintained by Yun-Tse Tsai (yuntsai@slac.stanford.edu))
SLArchetto Vessel 264L
Max heating power: 450W
LAr Supply Dewar
LAR2 Vessel 65L
Cryogenic compatible
Vacuum Vessel 70L
Operating pressure: 16.6 psia
Main vessel: 10 psig MAWP
Pipes: 316SS with ½" OD

Figure 1: P&ID

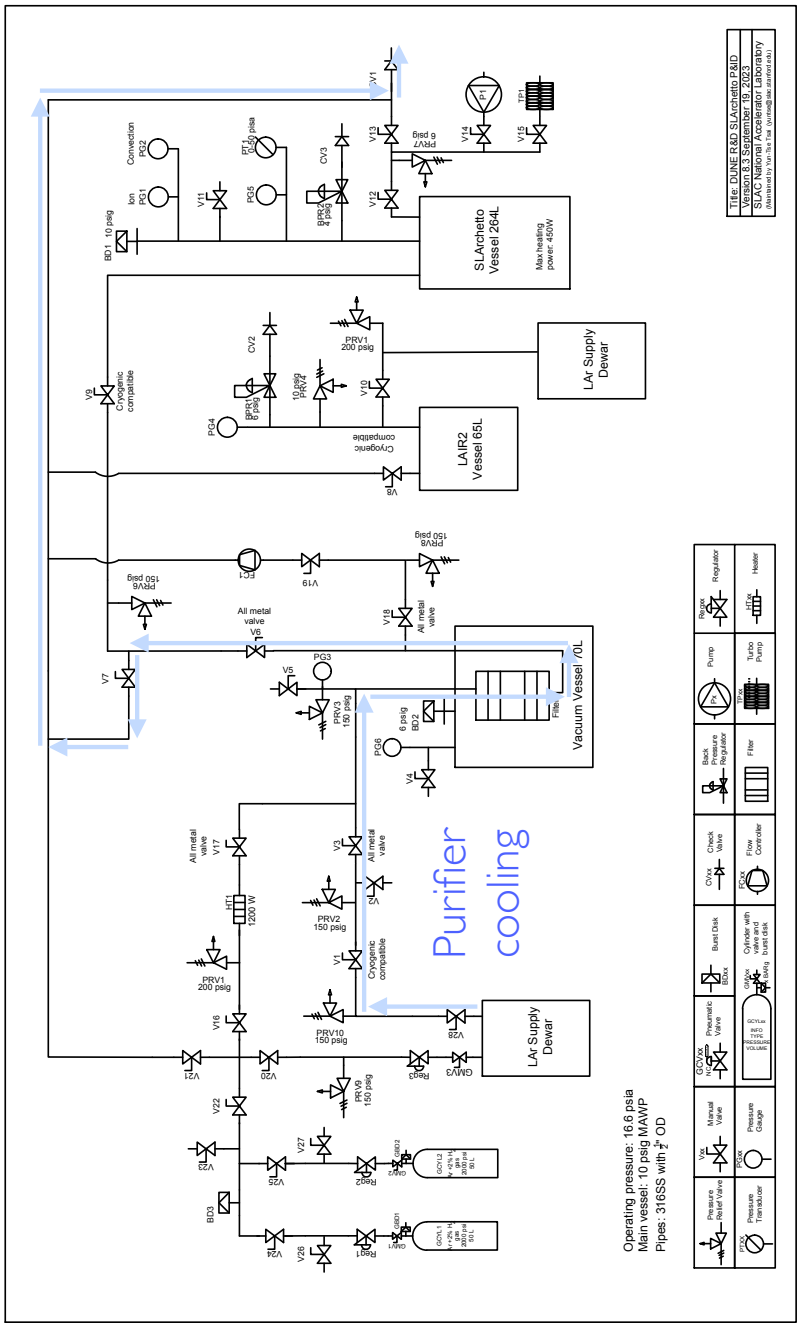

Figure 2: LAr flow direction for cooling the LAr purifier

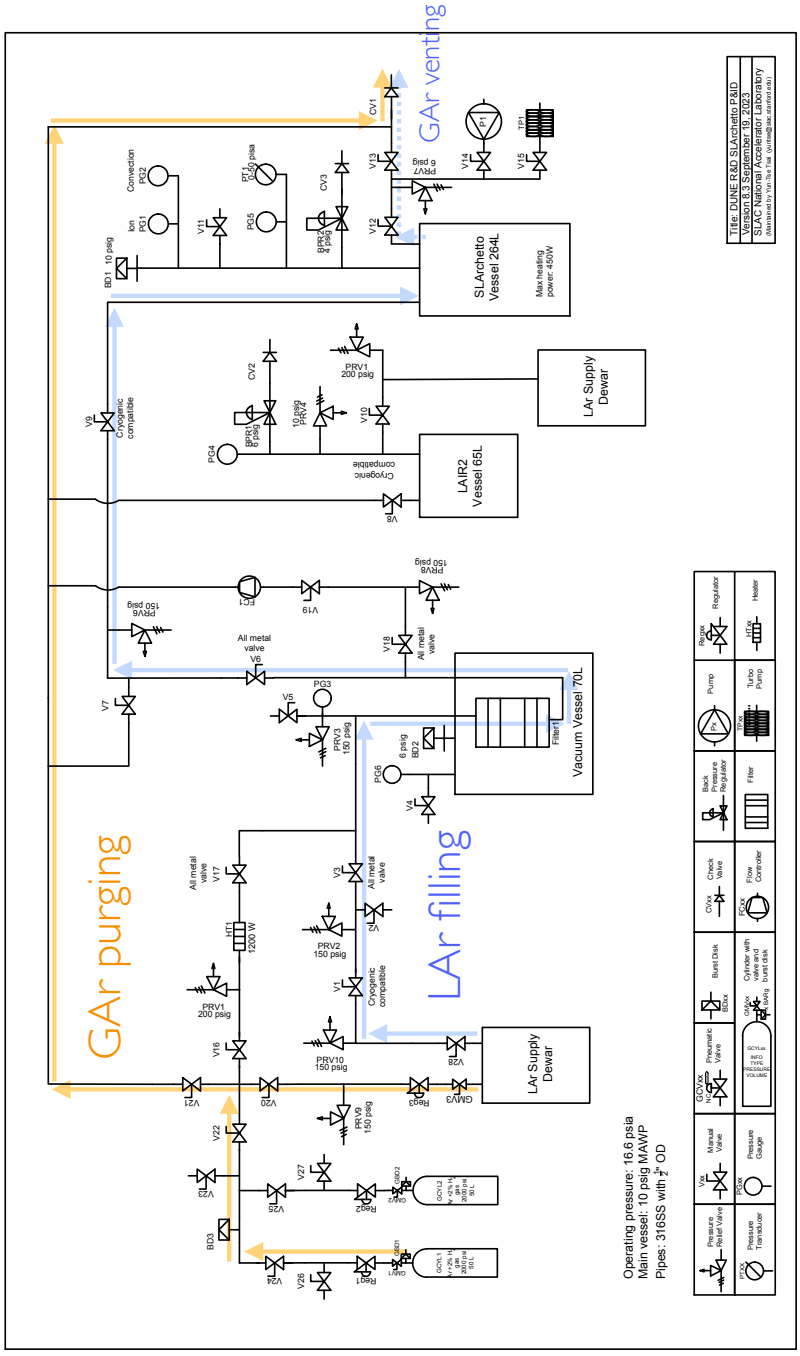

Figure 3: LAr flow direction for filling the SLArchetto vessel. The gas Ar for purging can be injected from the gas port of another LAr dewar, or from an ultra high purity gas argon cylinder. Do NOT use the same LAr dewar of LAr filling for gas Ar purging.

Checklist	What to Do and Detailed Description
Readiness	
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 **Pressure** 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
Prepare LAr filling	
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 **Pressure** 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 the DUNE Ignition, make sure no other valves in the thermosyphon system are being controlled. Click the number and a side panel will open, click `purge`. Purge will take about 3 minutes
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
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 $\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	
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	
Fill the main vessel	
Start purging the SLArchetto venting line (downstream V13) with gas Ar	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
V15 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
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)**	V12 is on the top lid, connecting to the hose. If closed, the burst disk will crack when LAr just fills in.
Oxygen sensor shows <1% or plateaued	Oxygen sensor is displayed at the "LAr Filter" page of the Ignition GUI
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 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)	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
LArPix power supply on. Voltage at 24 V, current limit at 1 A	
LArPix starts taking data when the pressure reaches ∼14.6 psia	Use `Pedestal Monitor` in the LArPix tutorial, `https://github.com/SLACube/slacube-daq-tutorial`.
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	
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 for the LAr filter) will start dropping when the LAr dewar is almost empty
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	Adjust V13 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	
V1 opened	
V28 (LAr dewar), V2 open	Purge the air in the tube
When seeing LAr from V2, V28 (LAr dewar), V2 closed	
V3 open	
Double check V6, V9 opened	
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	
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 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	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 $\sim$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
V12 and V13 open	Prepare for boiling LAr
Removed liquid nitrogen in the thermosyphon line	One way to do so is to remove 1000 L of LN_2 at 1 slpm. It will start pumping and never stop. Click `Abort` after a couple of hours, close all the valves and turn off the pump if it is not done automatically. Then click `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	Go to `LAr evaporator`, click `Stop`
Heater interlock on	Go to the main page and turn on the heater interlock