4.9 Cryogenics Alarms (MCR, Shutdown 2016)

Cryogenics Expert Contact List:

1. David Kishi 604 418-8961
2. Howard Liu 778 788-2270

ISAC Operations Contact List

(when power restored after outage, etc.):

1. Jonathan Aoki 604 315-7979
2. Violeta Toma 604 222-9236
3. Spencer Kiy 604 376-2126
4. Ed Parton 778 858-9170

Each evening when ISAC OPS leaves for the night, enable MCR EPICS access by clicking 'Super_User_EPICS' on the desktop & entering password as noted in the book.

4.9.1 Overview

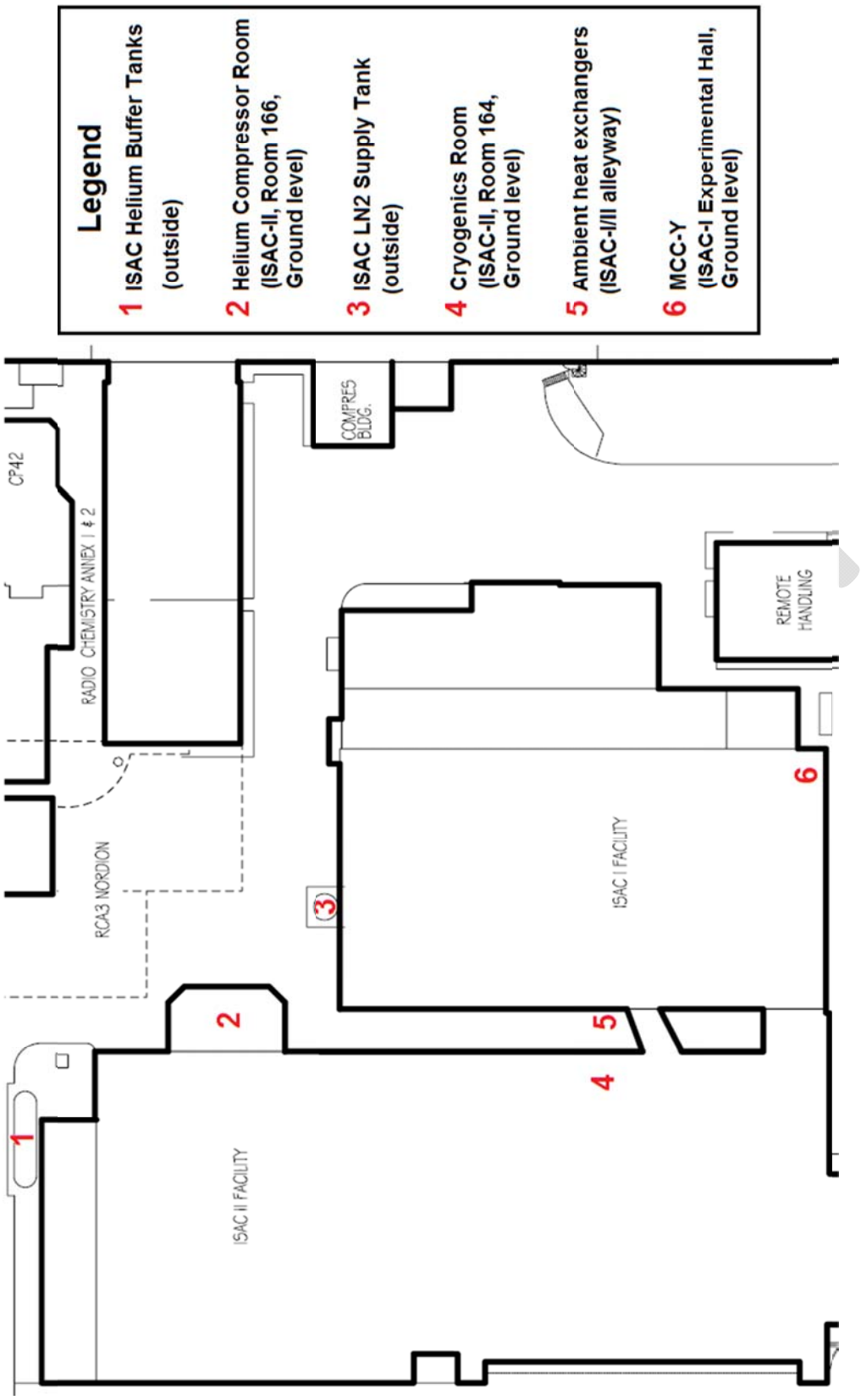
The ISAC-II cryogenics system cools the SCLinac (RF cavities, etc.). It consists of two distribution subsystems: LN2 (liquid nitrogen) and LHe (liquid helium).

LN2 provides a thermal shield for the helium distribution lines / cryomodules, and cools three cold fingers.

LHe is distributed and recovered by two independent cryoplants (Phase-I, Phase-II), both typically running simultaneously. Each has the capacity to cool the entire SCLinac, though a single cryoplant cannot sustain all SCRF cavities at full power.

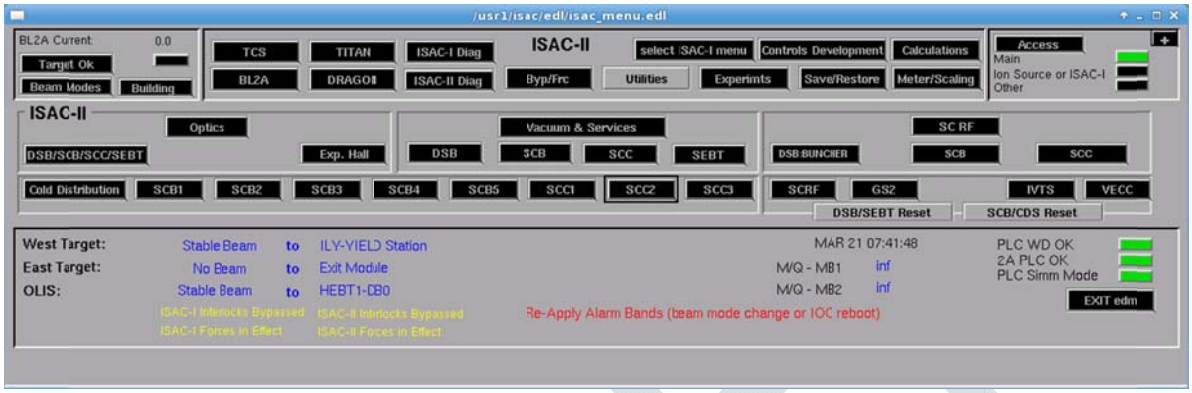
Failure to take timely action in responding to cryogenics alarms could result in an expensive loss of helium inventory.

The map on the following page depicts the locations where alarm response occurs (Legend #'s 2, 4-6) as well as the He Buffer (1) & LN2 Supply (3) Tanks for reference.


Legend
1 ISAC Helium Buffer Tanks (outside)
2 Helium Compressor Room (ISAC-II, Room 166, Ground level)
3 ISAC LN2 Supply Tank (outside)
4 Cryogenics Room (ISAC-II, Room 164, Ground level)
5 Ambient heat exchangers (ISAC-I/II alleyway)
6 MCC-Y (ISAC-I Experimental Hall, Ground level)
CP42
RADIO CHEMISTRY ANNEX I & 2
COMPRES BLDG.
REMOTE HANDLING
RCA3 NORDION
ISAC I FACILITY
ISAC II FACILITY
1
2
3
4
5
6

Navigation

EPICS is divided into ISAC-I & ISAC-II Main Menus, toggled between via the 'select ISAC-I[-II] menu' button. Cryogenics are accessed from the ISAC-II Main Menu 'Cold Distribution' button, and SC Linac amplifiers from the 'SC RF' button →'SCRF Overview.'



Helium Compressors

Each cryoplant (Phase-I, Phase-II) is equipped with a "main" helium compressor pressurizing room temperature helium gas (returning from the cryomodules and coldbox) to 13Bar (fed back into the coldbox or stored in buffer tank).

A single helium "recovery" compressor, supplied by diesel generator-backed emergency power, is used during power outages (i.e., when BOTH main helium compressors are offline) to recover helium gas into the Buffer Tanks. It is controlled from the Phase-I Linde PLC panel in ISAC-II Cryogenics Room 164.

All three compressors are located in the ISAC-II Helium Compressor Room 166.

Helium Buffer Tanks

Two helium buffer tanks (Phase-I, Phase-II), located immediately east of the ISAC-II Experimental Hall (Figure 4.9.1.a), accept excess gas from the system & store it at high pressure.

Figure 4.9.1.a – Helium buffer tanks, east of ISAC-II Experimental Hall.

LHe Supply Dewars

Two LHe dewars (Phase-I, Phase-II; Figure 4.9.1.b), located in ISAC-II Cryogenics Room 164, supply cooling to the SCLinac cryomodules. Each typically regulates a level of ~500L via control of heaters immersed in the helium volume.

Figure 4.9.1.b –LHe supply dewars (forefront), Cold Boxes (blue, background); ISAC-II Cryogenics Room 164

Cold Box (Refrigerator)

Two Cold Boxes (Phase-I, Phase-II; Figure 4.9.1.b), liquefy helium and supply it to the dewar, accepting pressurized He gas from the Compressors / Buffer Tanks and cold He gas returning from the cryomodules / dewar.

LN2 Supply Tank

The LN2 supply tank (east of the ISAC-I Experimental Hall) feeding the ISAC-II cryogenics system has local pressure and level monitoring that automatically notifies Praxair when a fill is required.

LN2 Phase Separator

The new LN2 phase separator, connected to the supply tank, is mounted to the wall in the NW corner of ISAC-II Cryogenics Room 164 (Figure 4.9.1.c). It returns liquid to the cryogenics system (venting gas into the alleyway between the ISAC buildings).

Figure 4.9.1.c – LN2 Phase Separator, ISAC-II Cryogenics Room 164, Northwest corner

4.9.2 Cryogenics Alarm Response Procedures

4.9.2.1 Phase-I and/or Phase-II Helium Compressor Trip

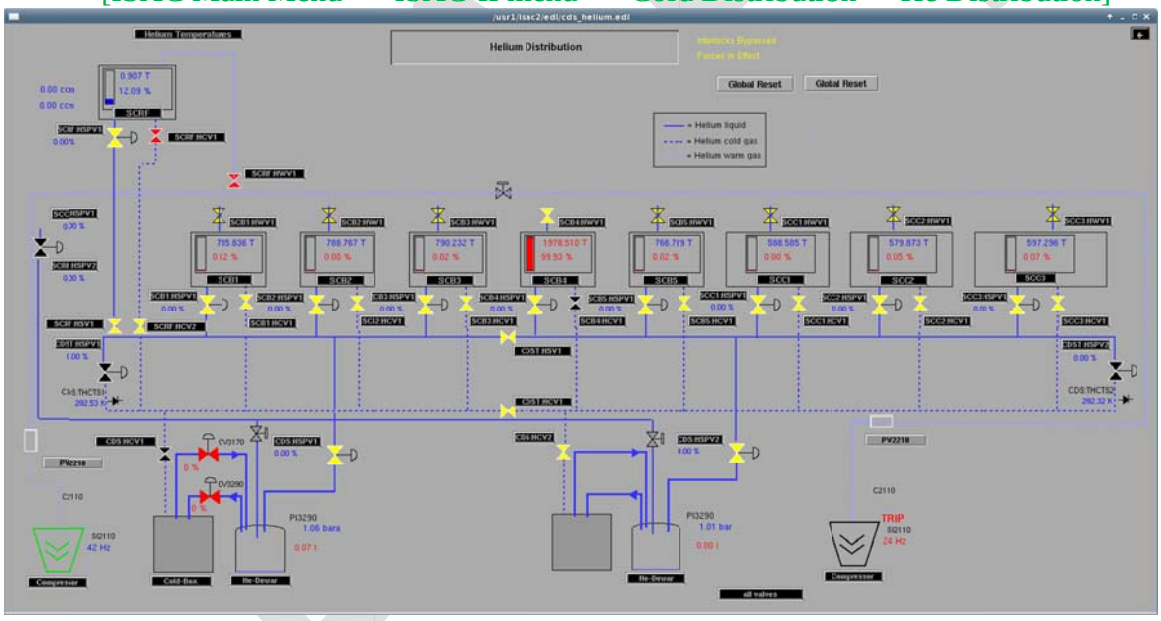
EPICS Alarm Handler: **"Phase 1 Compressor OFF"**
"Phase 2 Compressor OFF"

1. Determine the status of the Phase-I and Phase-II main helium compressors from the "Helium Distribution" page (green line colour, frequency readback ~29-60Hz in blue text indicate a compressor is running).

   - If only **ONE** of the main compressors is running, proceed to step 2.
     DO NOT START THE RECOVERY COMPRESSOR! as there is danger of overheating the main compressor still running via helium heat exchange.

   - If **BOTH** main compressors are off, proceed to step 4.

[ISAC Main Menu => ISAC-II menu => Cold Distribution=> He Distribution]



One of the main compressors is running; the other has tripped:

2. Press the “Amplifiers off” button on the SCRF Overview page.

   [ISAC Main Menu => ISAC-II menu => SC RF=> SCRF Overview]

3. In the alleyway between ISAC buildings, ensure both manual valves tagged with pink ribbons are closed (Figure 4.9.2.1.a). Open the left (east) valve fully. **Slowly** open the right (west) valve until you can just hear gas hissing through it. If this valve is opened too much or too quickly, the resulting high flow of helium may trip the remaining online compressor. **Inform a cryogenics expert** that one of the Main Compressors has tripped, the other is running and the manual helium heat exchange valves have been opened. Operator intervention is complete at this point.

Figure 4.9.2.1.a – Ambient heat exchangers in the alleyway between ISAC buildings.

Both helium compressors have tripped:

4. **Immediately inform a cryogenics expert** that both main compressors have tripped. The recovery compressor must be started in a timely manner to prevent loss of helium inventory ~30 minutes is a guideline, attend to any safety-critical issues first.

5. Locally inspect the small recovery compressor (ISAC-II He Compressor Room 166, Figure 4.9.2.1.b) panel's three LEDs required for startup (circled in Figure 4.9.2.8.c; indicating it is receiving power, in remote mode, and [**ready to be turned**] on). If all three required LEDs are lit, skip to step 7; otherwise, continue to step 6.

Figure 4.9.2.1.b – Helium recovery compressor (ISAC-II Helium Compressor Room 166).

Figure 4.9.2.8.c – Helium recovery compressor panel; circled LEDs must be lit to enable startup.

6.

- If the "Compressor Electrical Power" LED is not lit, reset and arm its breaker in MCC-Y as necessary (ISAC-I Experimental Hall SW corner, ground floor).
- If the "Remote Mode" LED is not lit, press its button.
- If the "Compressor [ready]" LED is not lit, press its button (recovery compressor will not turn on until command received from Linde PLC, see step 7).

7. Locate the Phase-I Linde PLC control panel in ISAC-II Cryogenics Room 164 (Figures 4.9.2.8.d and 4.9.2.8.e). Press the "K4" button to start the recovery compressor (LED will illuminate).

Figure 4.9.2.8.d –Phase-I (left), Phase-II Linde PLC control cabinets, ISAC-II Cryogenics Room 164.

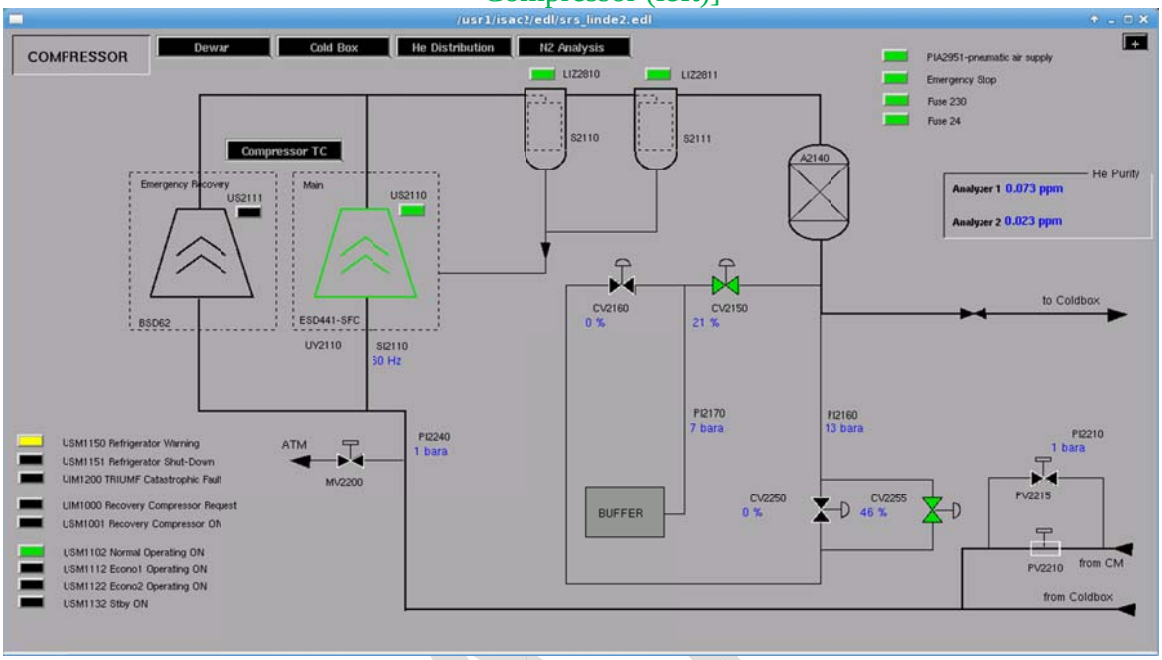
Figure 4.9.2.8.e – Phase-I Linde PLC control panel.

8. Verify locally that the recovery compressor is running. If compressor has tripped on startup, reset its breaker in MCC-Y as in step 6 then repeat step 7.

9. The recovery compressor is only connected to Phase-I helium piping. To also collect gas from Phase-II, first ensure that the two manual heat exchanger valves tagged with pink ribbons in the alleyway between ISAC buildings are closed. (Figure 4.9.2.8.a). Open the left (east) valve fully. **Slowly** open the right (west) valve until you can just hear gas hissing through it. If this valve is opened too much or too quickly, the resulting high flow of helium may trip off the recovery compressor.

10. The recovery compressor can then be monitored from the Phase-I compressor page (green outline indicates Emergency Recovery compressor is running). Operator intervention is complete at this point.

[ISAC Main Menu => ISAC-II menu => Cold Distribution => He Distribution => Compressor (left)]

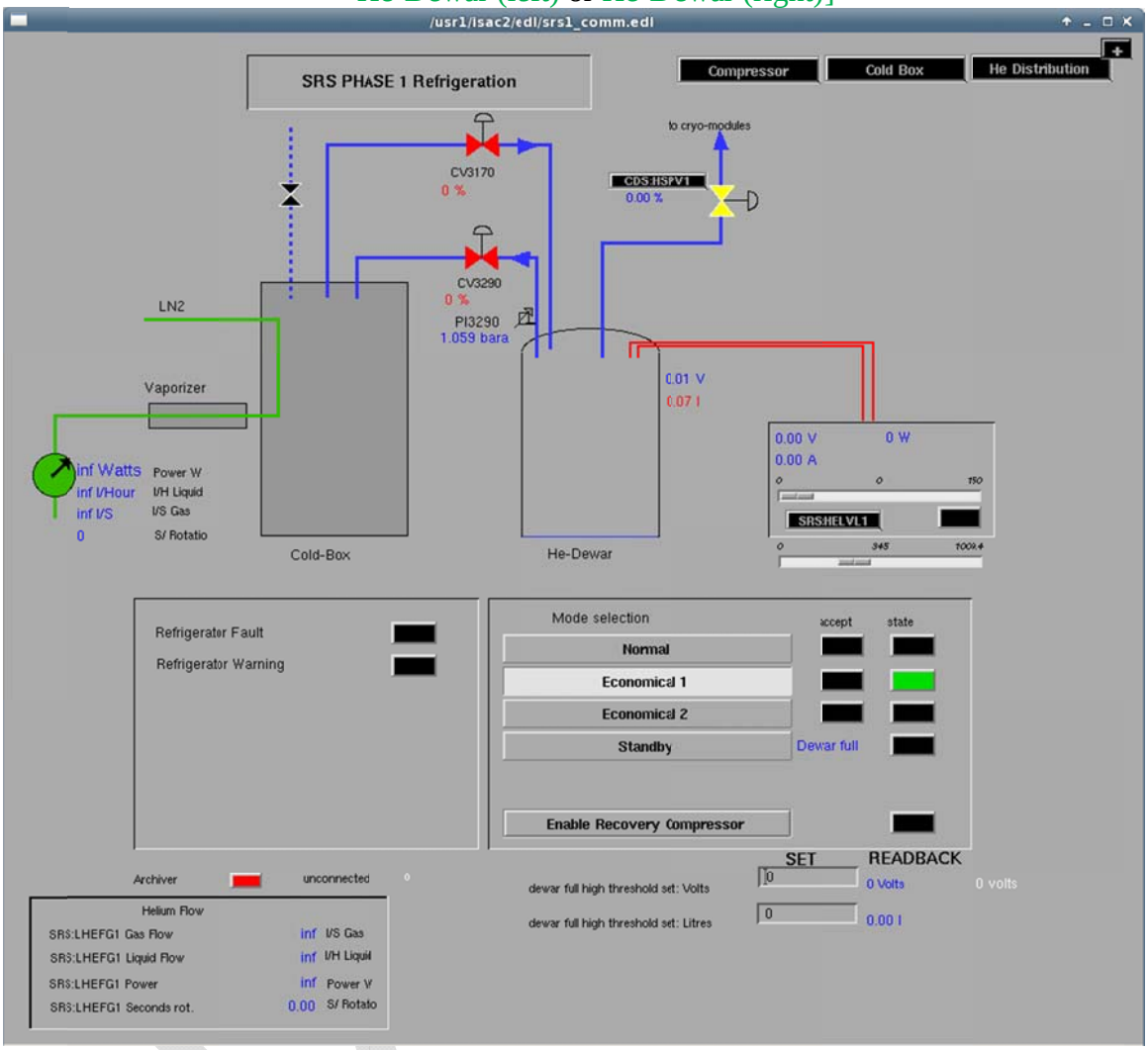


4.9.2.2 LHe Dewar Level Out of Range (<200L or > 700L)

EPICS Alarm Handler: **"Phase 1 Dewar Level Out of Range"**
"Phase 2 Dewar Level Out of Range"

1. If the LHe dewar (SRS PHASE 1 Refrigeration or SRS Refrigeration [Phase II] page) volume >500L, proceed to step 2; otherwise, proceed to step 7.

[ISAC Main Menu => ISAC-II menu => Cold Distribution=> He Distribution
=> He-Dewar (left) or He-Dewar (right)]

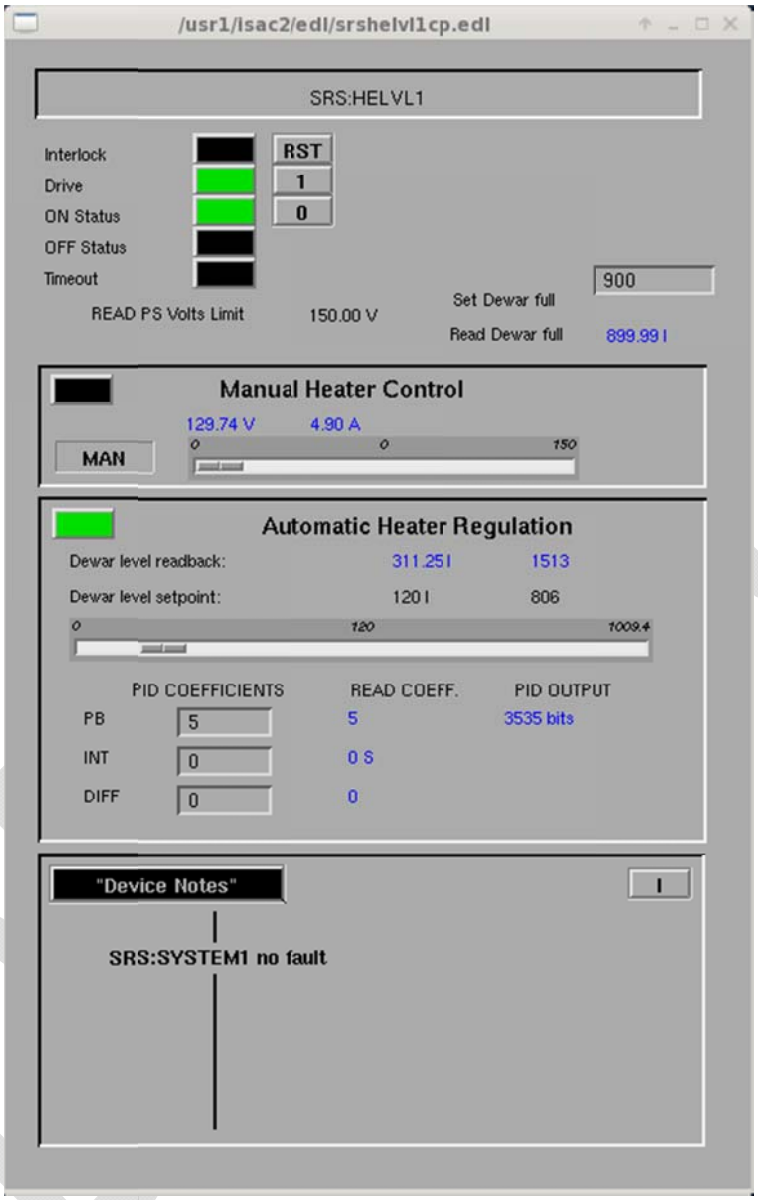


Dewar level too high:

2. Take note of the present relevant [Phase-I, Phase-II] compressor mode (“Normal”, “Economical 1 or 2”, or “Standby”); set the mode to “Standby”.

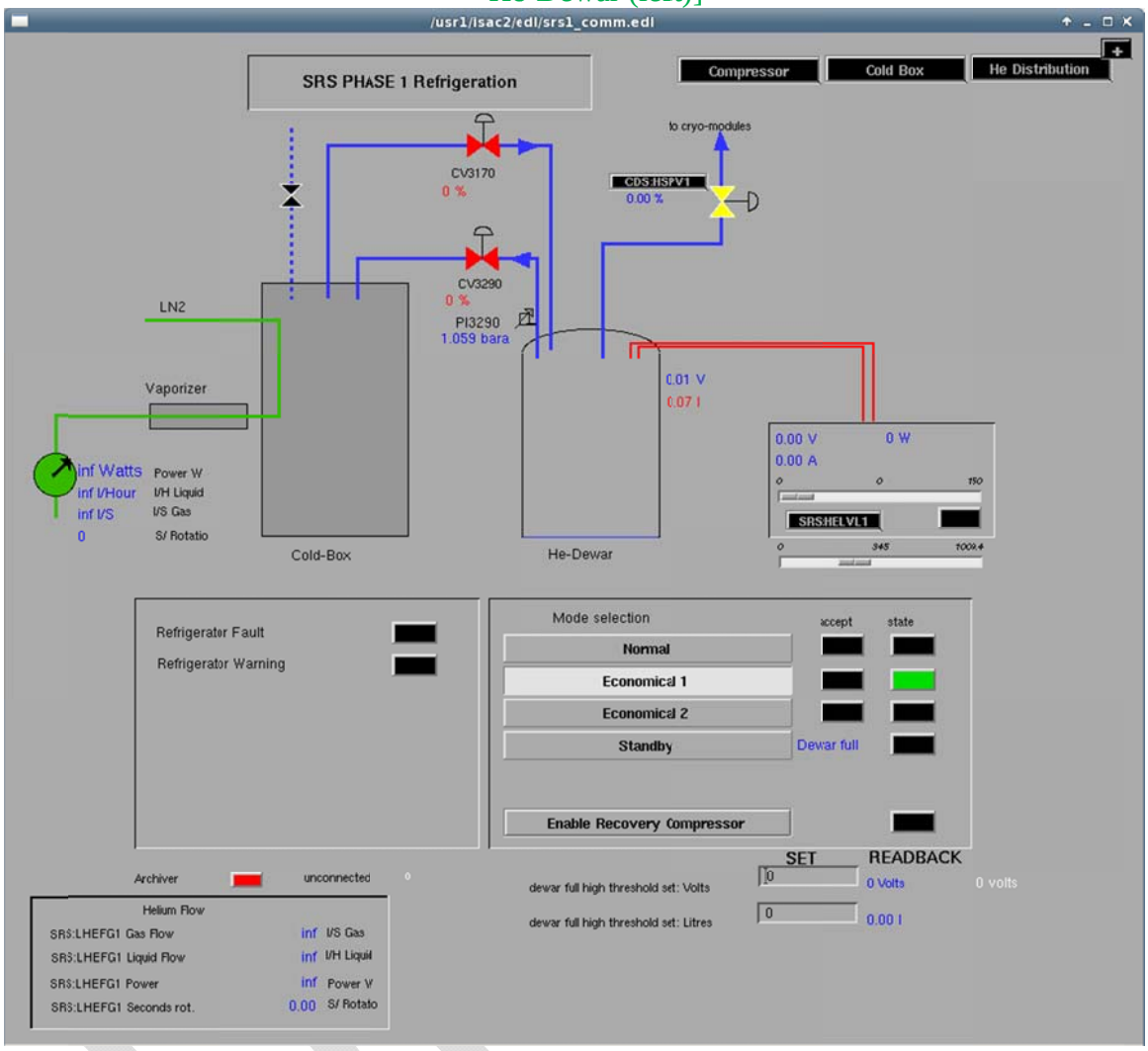
3. Turn relevant dewar’s heater on in ‘manual’ mode from its SRS:HELVLx page.

[ISAC Main Menu => ISAC-II menu => Cold Distribution=> He Distribution => He-Dewar (left) or He-Dewar (right) => SRS:HELVL1 or SRS:HELVL2]

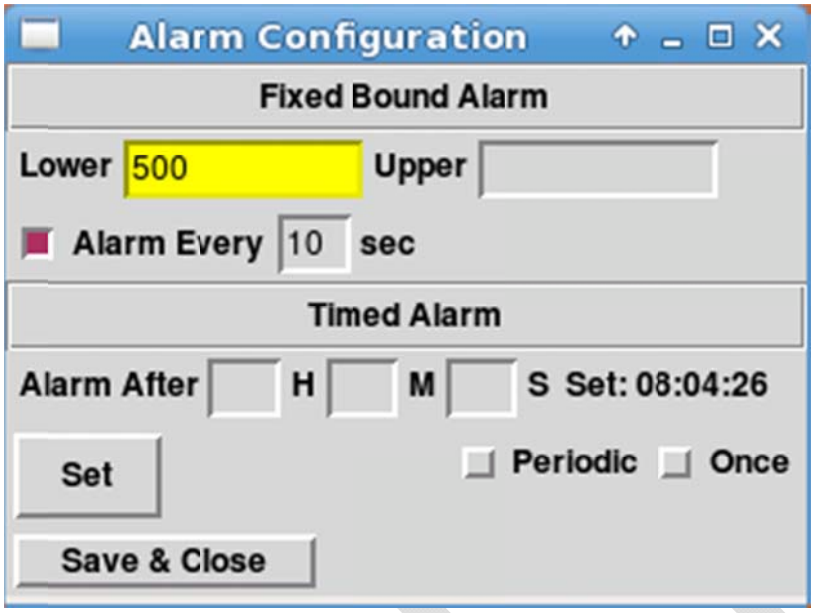


4. Raise the dewar heater voltage until its power readback (visible on relevant [Phase I, Phase II] SRS Refrigeration page) is ~500W. **Inform a cryogenics expert** that Phase-x dewar level is high, its compressor has been put in standby, and its heater is in manual mode with a power readback of 500W.

[ISAC Main Menu => ISAC-II menu => Cold Distribution => He Distribution => He-Dewar (left)]



5. When the dewar level drops to 500L (channel-monitor can be ‘Config[ured]’ & set to alarm), set its heater to regulation (auto) mode.

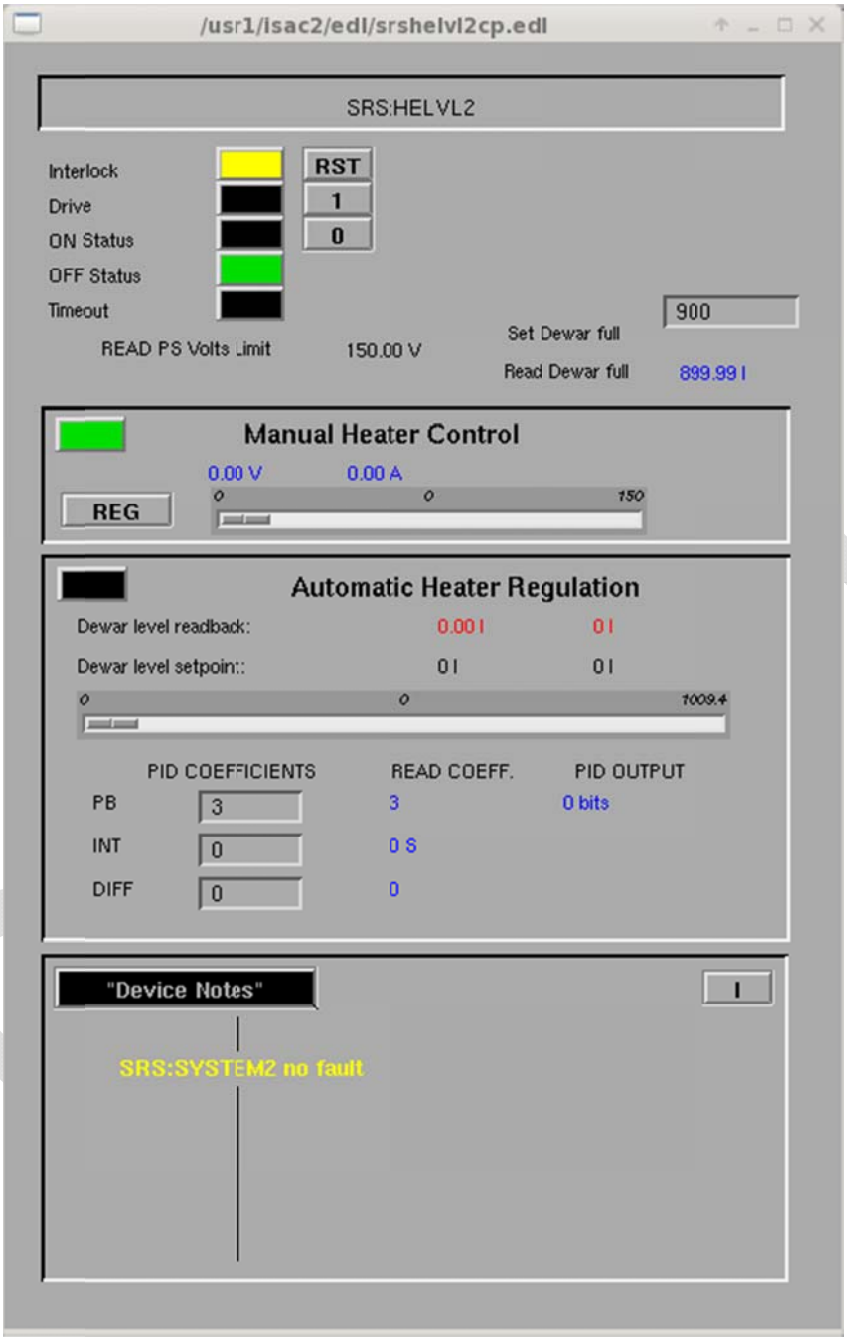


6. Restore the original compressor mode (noted in step 2 above). Operator intervention is complete at this point.

Dewar level too low:

7. If relevant dewar's heater (SRS:HELVLx) is in manual mode, continue to step 8; if in regulation mode, skip to step 9.

[ISAC Main Menu => ISAC-II menu => Cold Distribution=> He Distribution => He-Dewar (left) or He-Dewar (right) => SRS:HELVL1 or SRS:HELVL2]



Dewar heater in manual mode:

8. Set the "Automatic Heater Regulation" slider to 120L; toggle the heater to regulation mode. The helium level should begin to recover within ~15 minutes (striptool should be set up) and ultimately regulate around ~310L due to

setpoint/readback discrepancy. If it doesn't, press the "Amplifiers off" button on the SCRF Overview page. **If helium level does not begin to recover within another ~15 minutes, inform a cryogenics expert** that Phase-x dewar level is low, its heater is running in automatic mode to regulate 375L, SCRF is off & no improvements have occurred. Operator intervention is complete at this point.

[ISAC Main Menu => ISAC-II menu => SC RF=> SCRF Overview]

Dewar heater in automatic regulation mode:

9. Determine whether the relevant dewar's cold box is running, indicated by a 'SI3131' turbine speed readback (Figure 4.9.2.2.a) of ~3000-5000rps in blue font; if ~0rps in red font (or a Cold Box alarm has enunciated), the cold box has tripped.

[ISAC Main Menu => ISAC-II menu => Cold Distribution=> He Distribution=> He-Dewar (left) or He-Dewar (right) => Cold Box]

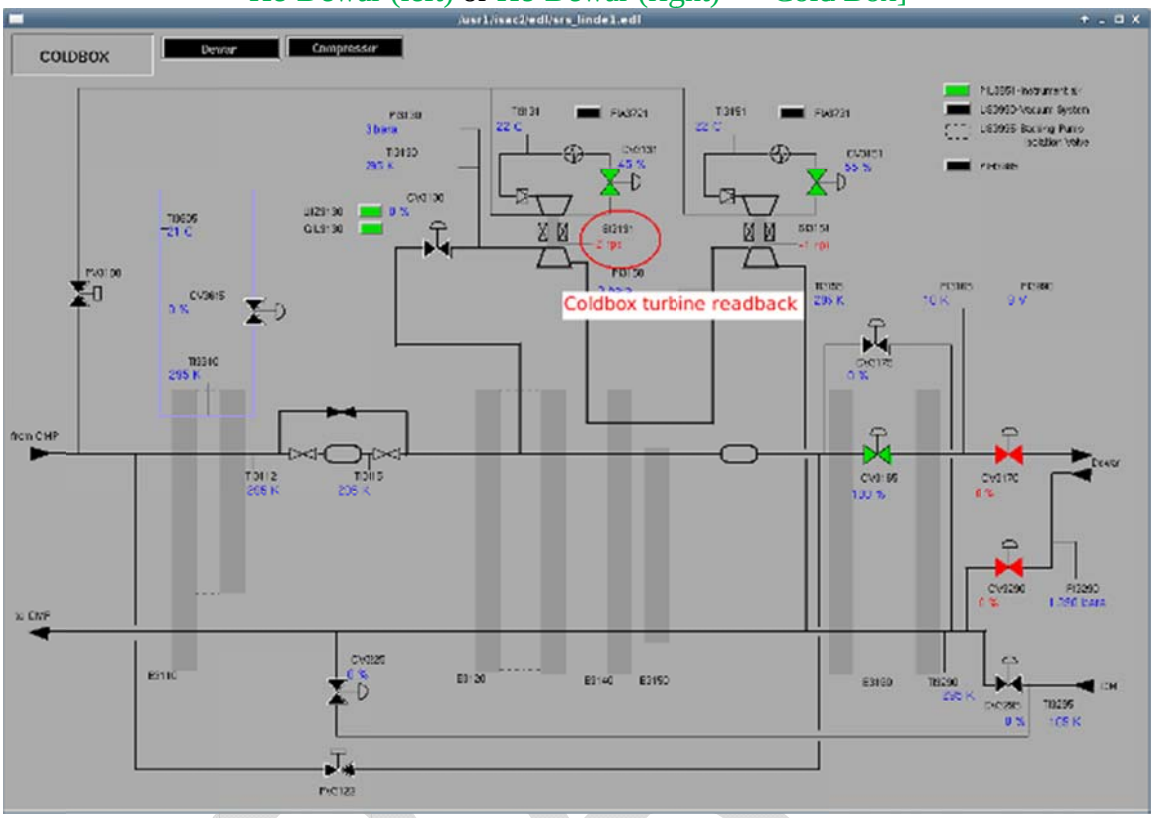


Figure 4.9.2.2.a – Phase-I Coldbox EPICS page, highlighting turbine readback (SI3131).

10. **Inform a cryogenics expert** that the Phase-x dewar level is low, its heater was found regulating at 375L and the status of the Cold Box.

11. Press the “Amplifiers off” button on the SCRF Overview page.

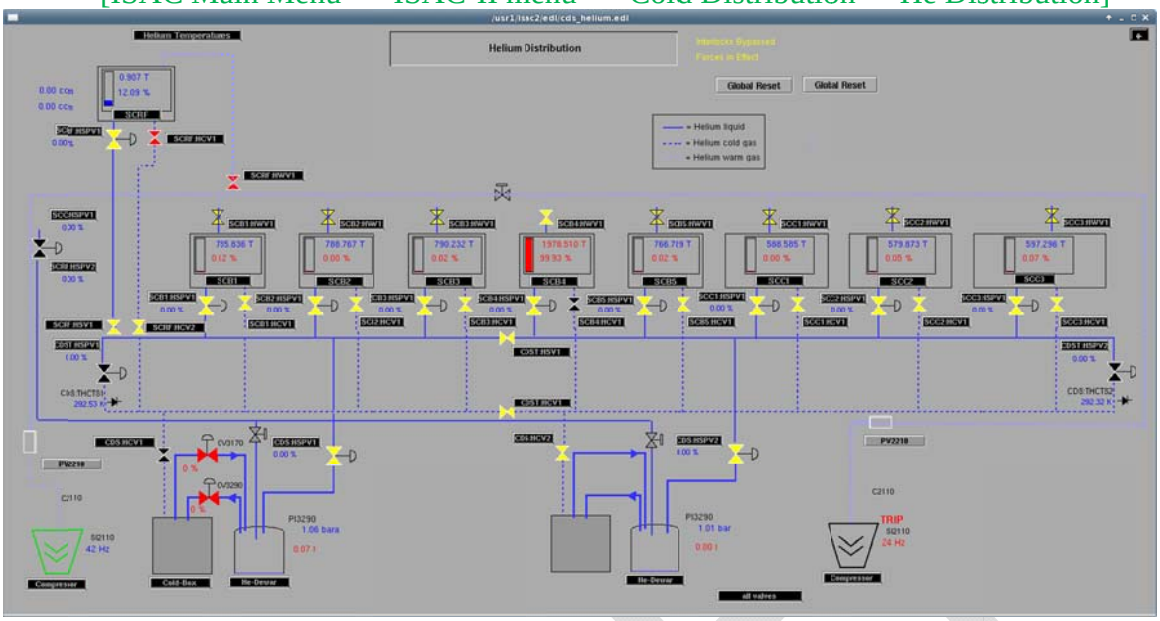
[ISAC Main Menu => ISAC-II menu => SC RF=> SCRF Overview]

If the Cold Box is running, operator intervention is complete at this point.

If the Cold Box has tripped:

12. Open the warm return valve SCxy:HWV1 (‘0’ = ‘open,’ valve outline turns black) above all affected cryomodules (Phase-I or Phase-II).

[ISAC Main Menu => ISAC-II menu => Cold Distribution=> He Distribution]



13. If the compressor ("Helium Distribution" page) associated with the problematic coldbox (Phase-I, Phase-II) is off (~0Hz, black outline & 'TRIP' in red font; or compressor alarm enunciated), proceed immediately to Section 4.9.2.1 'Compressor Trip.' If it is on (green line colour, frequency readback ~29-60Hz) operator intervention is complete at this point.

4.9.2.3 Cryomodule Helium Level is Low

EPICS Alarm Handler: **"SCxy Helium Level A Out of Range"**
"SCxy Helium Level B Out of Range"

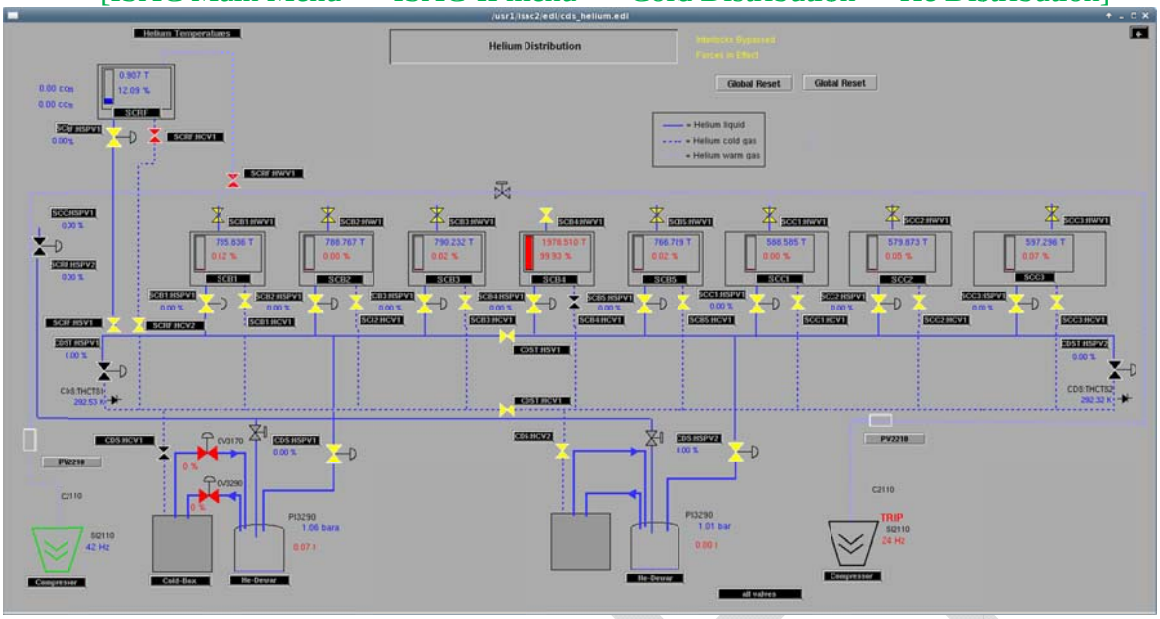
This procedure assumes a cryomodule's helium level is low (<30%). If it is high (>60%), **inform a cryogenics expert**.

1.

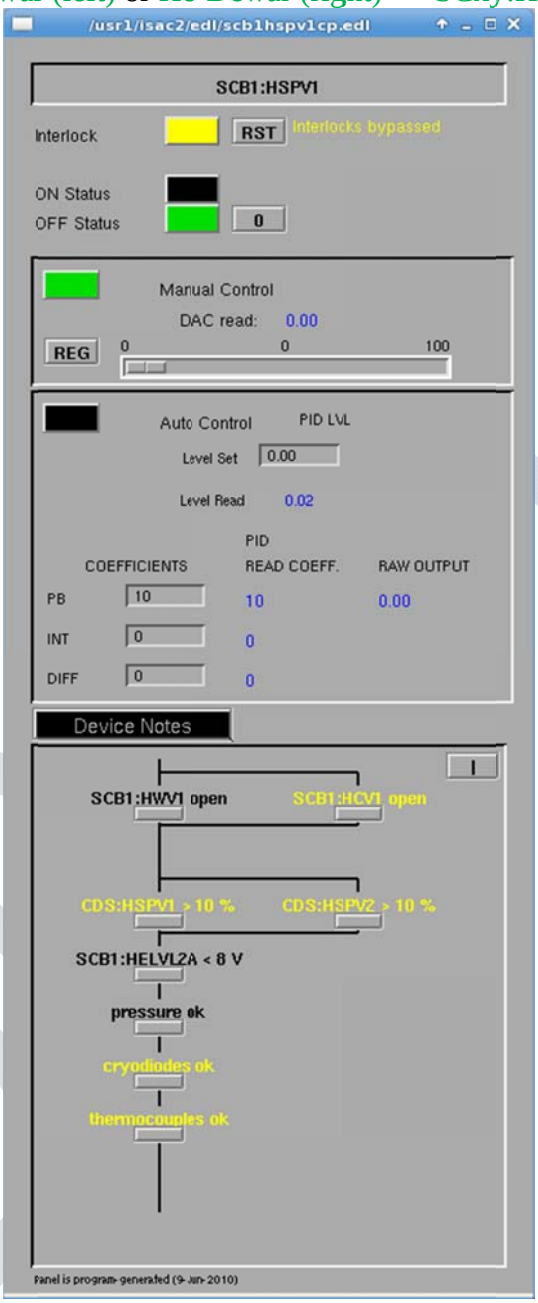
- If the helium supply valve SCxy:HSPV1 below the cryomodule is closed (DAC 0% on Helium Distribution page): set the manual control setpoint to '0%,' reset its interlocks, press the "MAN"/"REG" toggle button until the LED beside "Manual Control" turns green, open the valve manually to ~50%, set it to regulation (auto) mode. **Inform a cryogenics expert** that SCxy's cryomodule helium level is low and its supply valve has been opened in manual mode to 50%. Operator intervention is complete at this point.

[See 4.9.2.7 for 'Operation of Proportional Control Valves' note]

[ISAC Main Menu => ISAC-II menu => Cold Distribution=> He Distribution]



[ISAC Main Menu => ISAC-II menu => Cold Distribution=> He Distribution => He-Dewar (left) or He-Dewar (right) => SCxy:HSPV1]



- If the cryomodule's helium supply valve (SCxy:HSPV1) is already open and in manual mode, switch it to regulation (auto) mode.

- If the cryomodule's helium supply valve (SCxy:HSPV1) is already open and in regulation (auto) mode, the system's cooling capacity may be insufficient. If the relevant dewar level on the Helium Distribution page is <200L, proceed to section 4.9.2.2, step 7; otherwise, **inform a cryogenics**

expert that SCxy's helium level was low, its supply valve was found open in automatic regulation and its dewar level is not in alarm**.** Press the "Amplifiers off" button on the SCRF Overview page. Operator intervention is complete at this point.

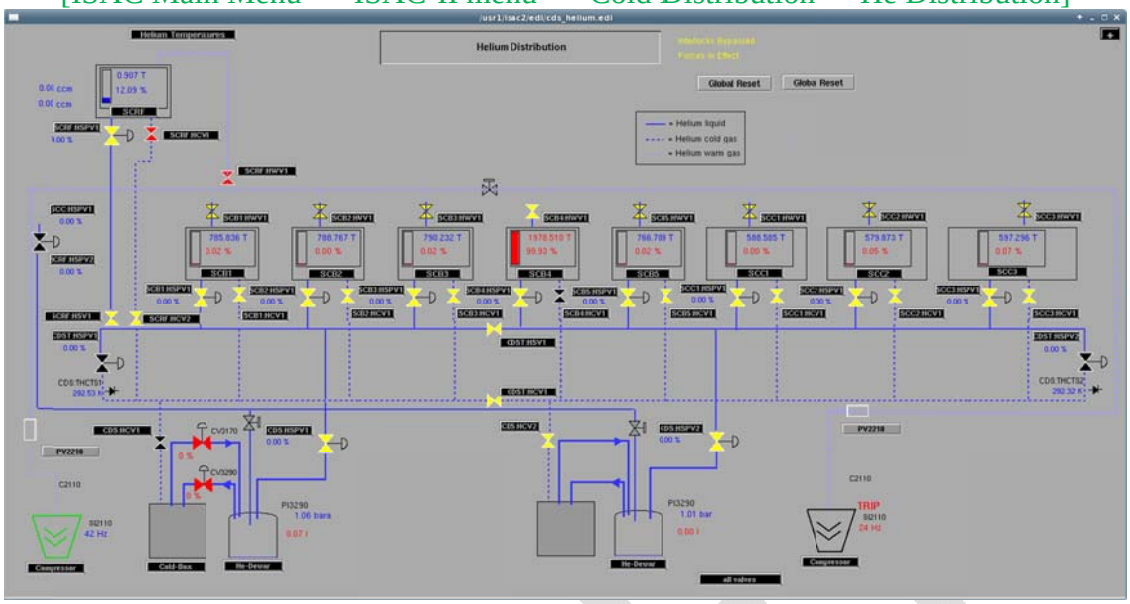
[ISAC Main Menu => ISAC-II menu => SC RF=> SCRF Overview]

4.9.2.4 Cryomodule Helium Space Over-pressure (>1000T)

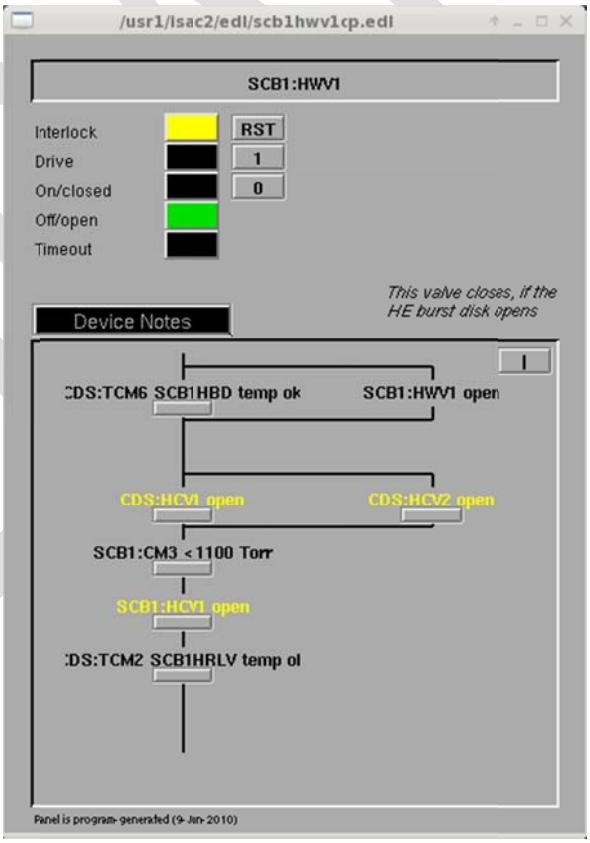
EPICS Alarm Handler: **"SCxy Helium Space Over-pressure"**

1. Open the warm return valve SCxy:HWV1 (0 = open) above the problematic cryomodule.

[ISAC Main Menu => ISAC-II menu => Cold Distribution=> He Distribution]

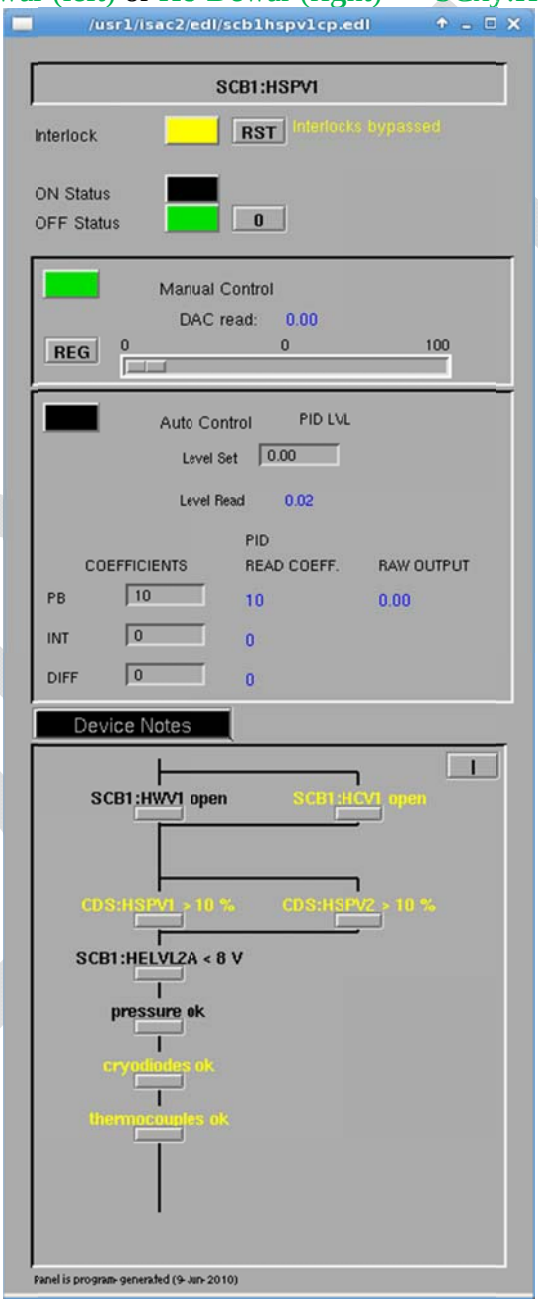


[ISAC Main Menu => ISAC-II menu => Cold Distribution=> He Distribution => SCxy:HWV1]

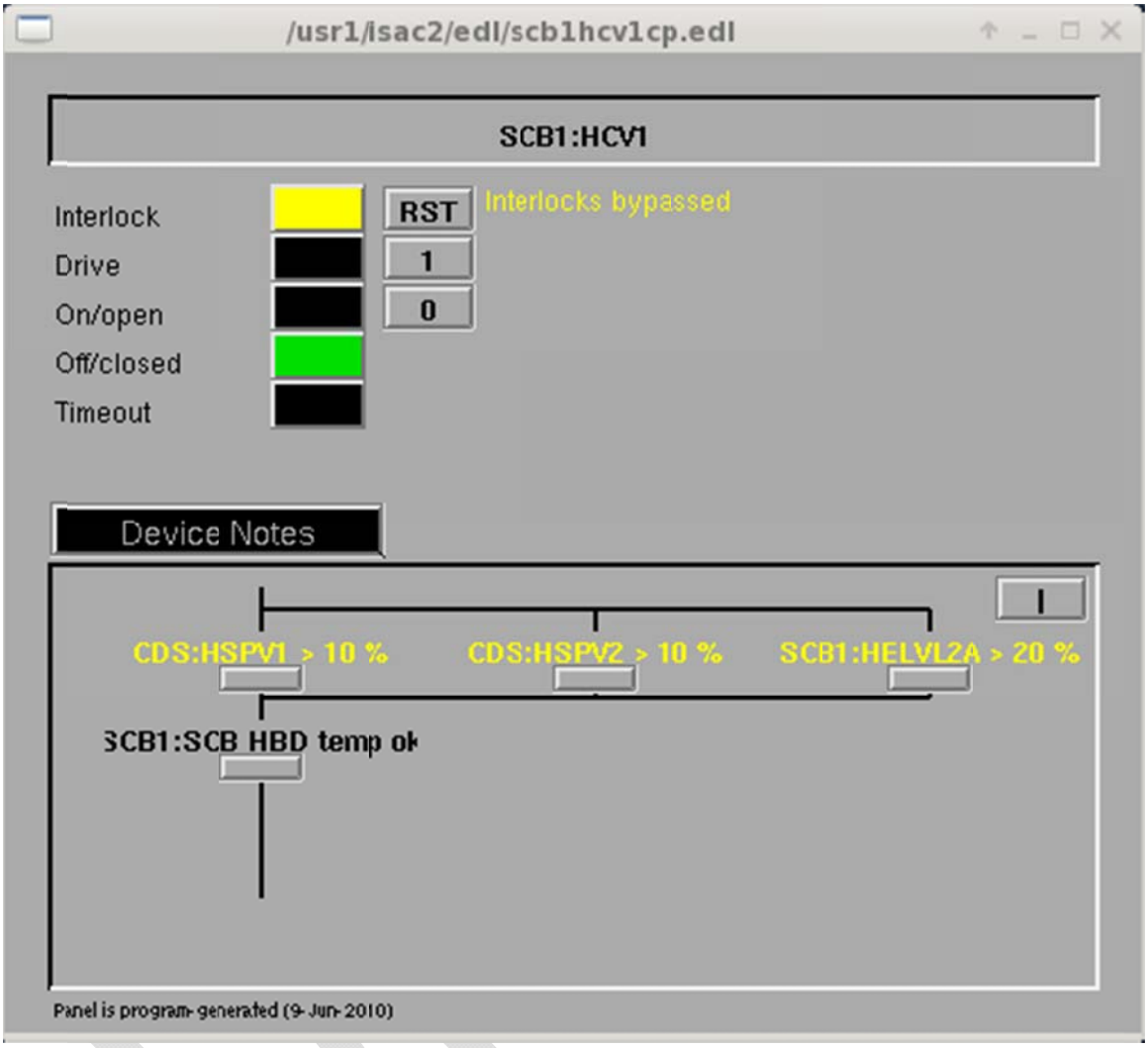


2. If the relevant cryomodule's helium supply and cold return valves are closed, SCxx:HSPV1 (DAC = '0') and SCxx:HCV1 respectively; open SCxy:HSPV1 first: set its manual control setpoint to '0%,' reset its interlocks, press the "MAN"/"REG" toggle button until the LED beside "Manual Control" turns green, open the valve manually to ~50%, set it to regulation (auto) mode; then open SCxy:HCV1 (1 = open).

[ISAC Main Menu => ISAC-II menu => Cold Distribution=> He Distribution => He-Dewar (left) or He-Dewar (right) => SCxy:HSPV1]



[ISAC Main Menu => ISAC-II menu => Cold Distribution=> He Distribution => SCxy:HCV1]



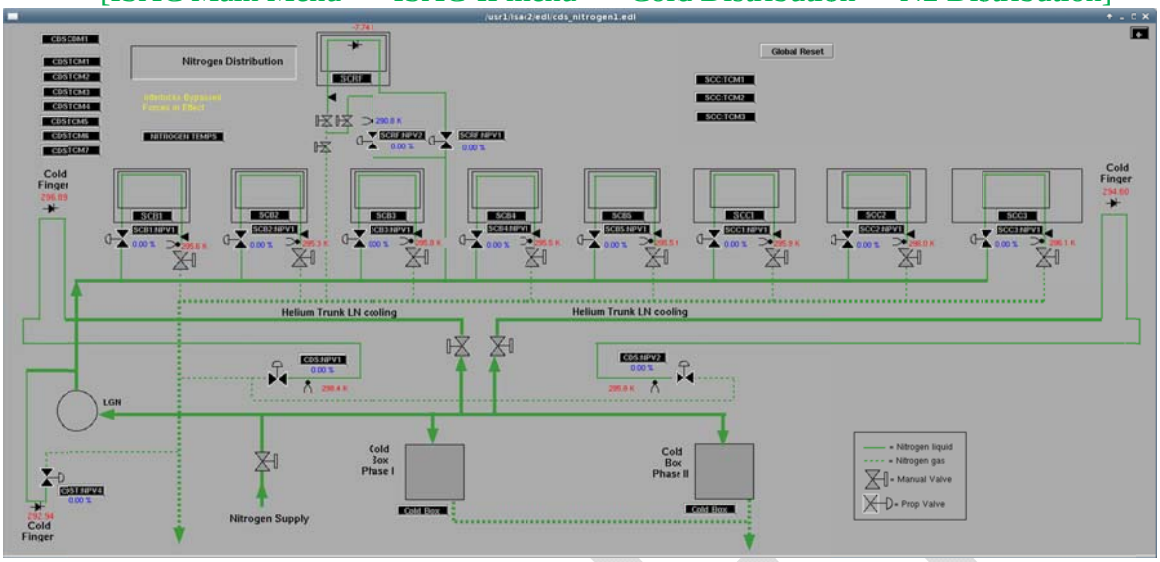
[See 4.9.2.7 for 'Operation of Proportional Control Valves' note]

3. **Contact a cryogenics expert** and relay the following information:

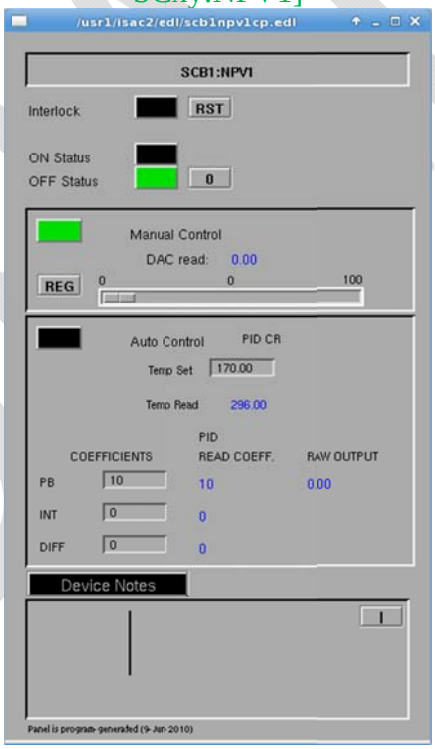
   - Cryomodule SCxy's helium space is over-pressure.

   - Its LN2 shield temperature (below the cryomodule on the N2 distribution page, typically ~170K) and nitrogen proportional valve SCxy:NPV1 status (% open, manual/regulation mode). If the temperature is high (& in red font), open the valve to ~10% in manual mode then set it to regulation (auto) mode.

[ISAC Main Menu => ISAC-II menu => Cold Distribution=> N2 Distribution]



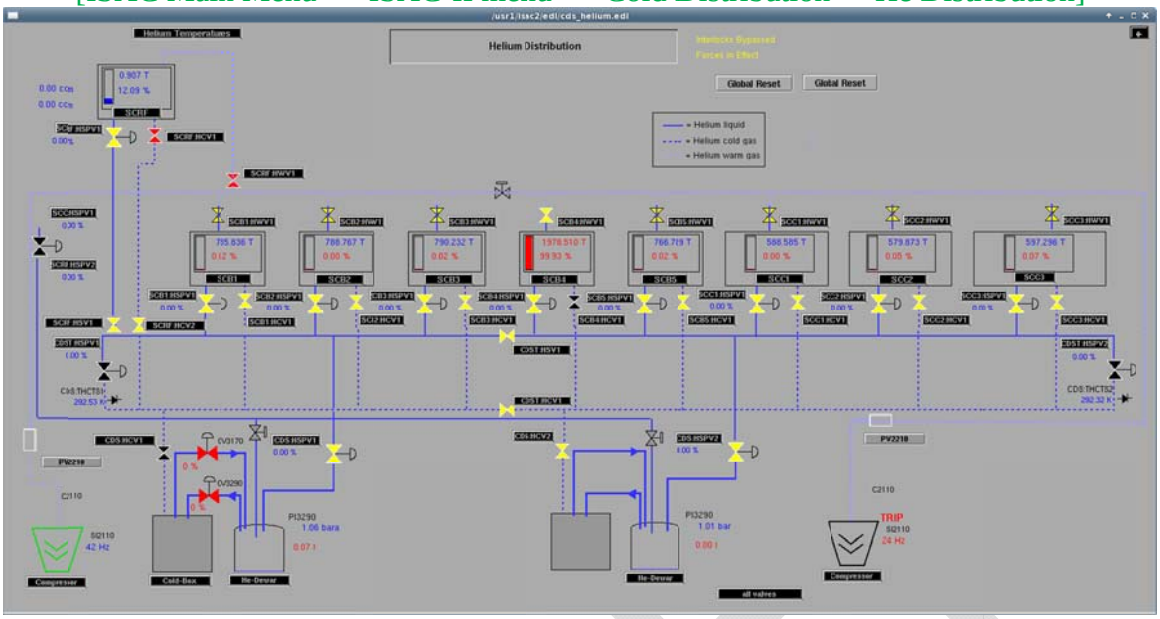
[ISAC Main Menu => ISAC-II menu => Cold Distribution=> N2 Distribution=> SCxy:NPV1]



[See 4.9.2.7 for 'Operation of Proportional Control Valves' note]

- The relevant helium dewar's pressure (typically ~1.35bar) from the He Distribution page.

[ISAC Main Menu => ISAC-II menu => Cold Distribution=> He Distribution]



- The cryomodule's associated helium compressor suction line pressures (P12240 and P12210 in Figure 4.9.2.3.a – typically ~1.05bar).
  Operator intervention is complete at this point.

[ISAC Main Menu => ISAC-II menu => Cold Distribution => He Distribution
=> Compressor (left) or Compressor (right)]

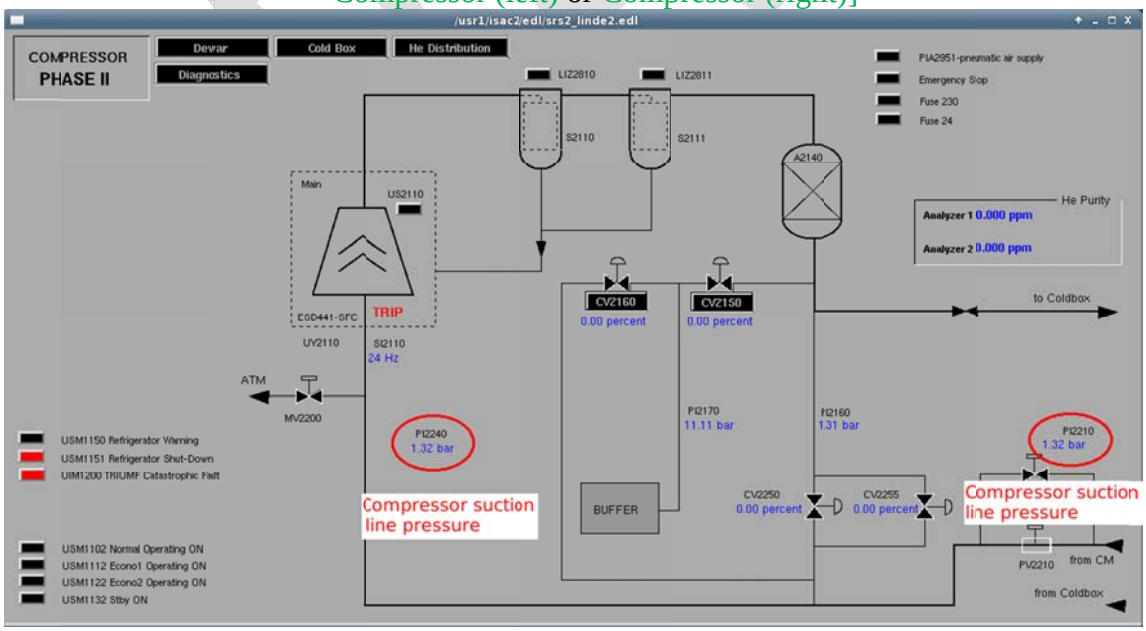


Figure 4.9.2.3.a – The Phase-II compressor EPICS page, highlighting the location of the compressor suction line pressure readbacks.

4.9.2.5 LN2 Phase Separator Pressure out of range (<8 or >15psi)

Pressure and level readbacks, presently only available locally in ISAC-II Cryogenics Room 164, should be implemented into EPICS alarms shutdown 2016. LN2 phase separator issues may cause persistent O2 Deficiency Monitoring System sensor #4 alarms (indicating a local release).

1.

- *If the LN2 Phase Separator's pressure is < 8psi (too low):*

  Ensure the manual "Phase Separator [Supply] Valve" (labelled, in ISAC-II Cryogenics Room 164, north wall behind the helium dewars) for the LN2 manifold is open.

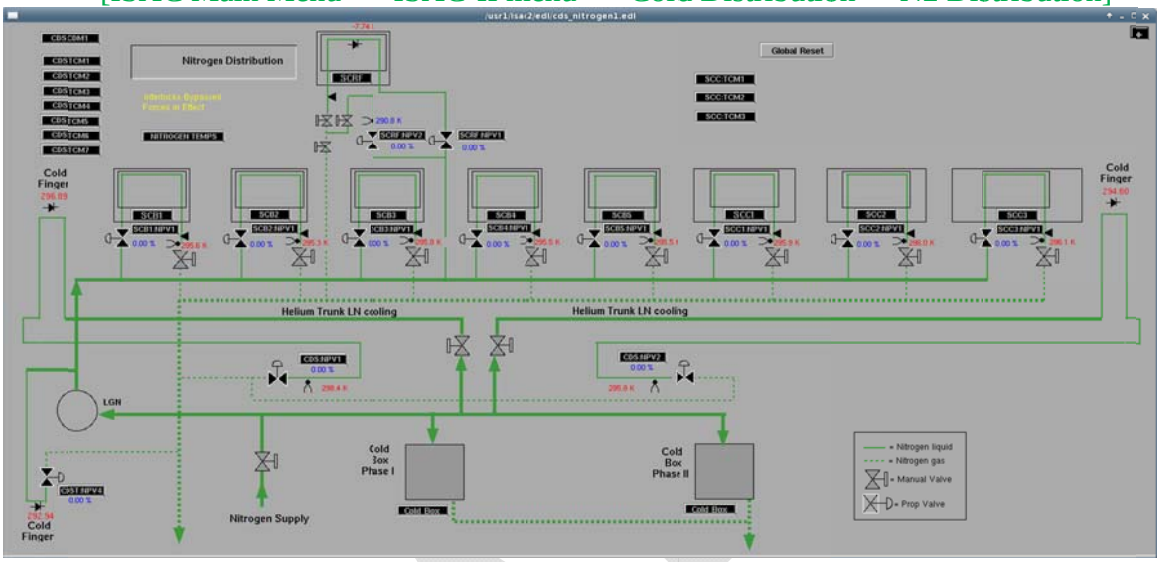
Phase Separator Nitrogen Supply valve (first red-topped valve on the left)

- *If the LN2 Phase Separator's pressure is >15psi (too high):*

  Close the manual "Phase Separator [Supply] Valve" (labelled, in ISAC-II Cryogenics Room 164, north wall behind the helium dewars) for the LN2 manifold.

2. Note any atypical cryomodule shield temperatures (normally ~170K) from the Nitrogen Distribution page.

[ISAC Main Menu => ISAC-II menu => Cold Distribution=> N2 Distribution]



3. **Contact a cryogenics expert** and relay your observations.
   Operator intervention is complete at this point.

4.9.2.6 LN2 Phase Separator Level out of range (<#? or >#?L)

Pressure and level readbacks, presently only available locally, should be implemented into EPICS alarms shutdown 2016. LN2 phase separator issues may cause persistent O2 Deficiency Monitoring System sensor #4 alarms (indicating a local release).

1.

- *If the LN2 Phase Separator's level is <#?L (too low):*

  Ensure the manual "Phase Separator [Supply] Valve" (labelled, in ISAC-II Cryogenics Room 164, north wall behind the helium dewars) for the LN2 manifold is open.

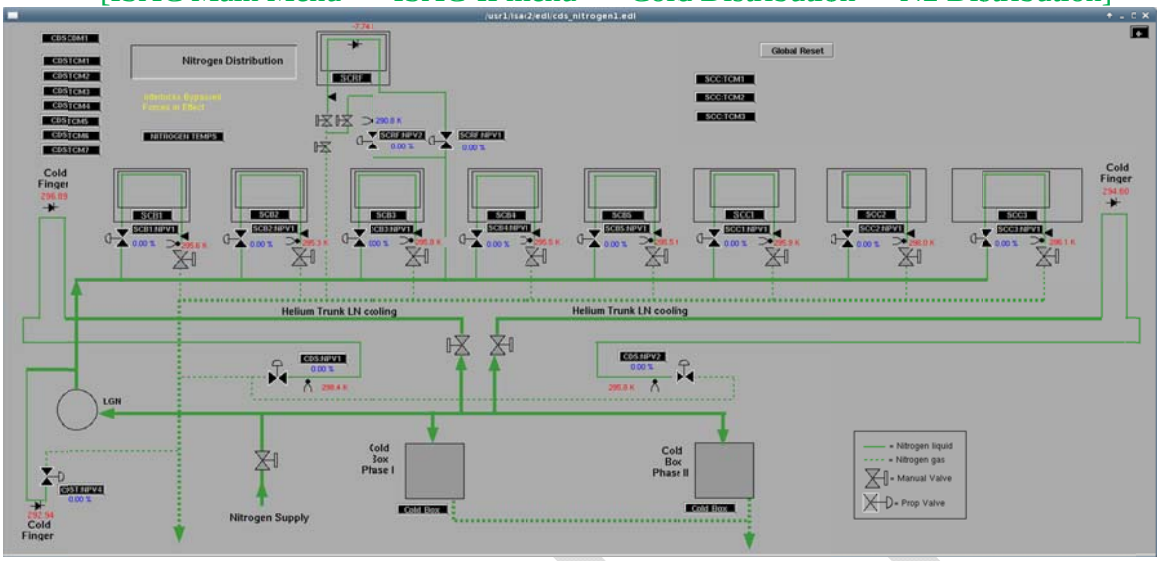
Phase Separator Nitrogen Supply valve (first red-topped valve on the left)

- *If the LN2 Phase Separator's level is >#?L (too high):*

  Close the manual "Phase Separator [Supply] Valve" (labelled, in ISAC-II Cryogenics Room 164, north wall behind the helium dewars) for the LN2 manifold.

2. Note any atypical cryomodule shield temperatures (normally ~170K) from the Nitrogen Distribution page.

[ISAC Main Menu => ISAC-II menu => Cold Distribution=> N2 Distribution]



3. **Contact a cryogenics expert** and relay your observations.
   Operator intervention is complete at this point.

4.9.2.7 LHe and LN2 Proportional Control Valves

EPICS valve status is indicated by outline colour: black = open, white = closed. Whether '0' or '1' buttons open or close a valve depends on the fail-safe mode, but will be indicated on the valve's device page.

Operation of LHe and LN2 proportional valves isn't intuitive. This procedure intends to explain how to restore PID control for a valve that has tripped closed. The EPICS panel for a typical proportional control valve is shown in Figure 4.9.1.e.

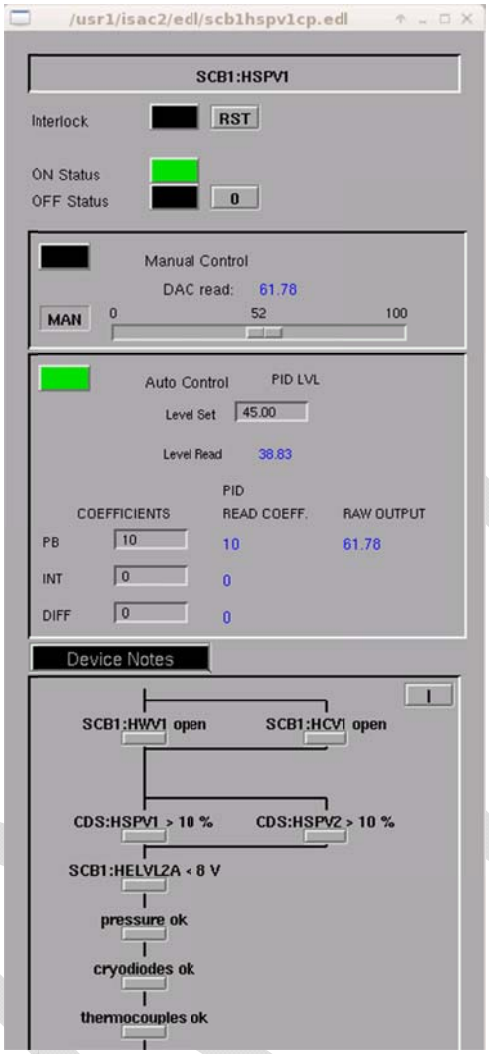


Figure 4.9.1.e – A typical EPICS panel for a cryogenics control valve.

If a proportional valve closes (i.e., its DAC read[back] is 0), perform the following steps to restore flow:

1. Press the "MAN"/"REG" toggle button until the LED beside "Manual Control" turns green.

2. Take note of the slider setpoint.

3. 'grab' the slider and set it to '0'.

4. Restore the slider setpoint (noted in step 2). The DAC readback will change, indicating that flow has been restored.

5. Press the "MAN/REG" toggle button and confirm that the LED beside "Auto[matic] Control" turns green.