NIR Channel

Cooling system operation manual

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Issue	Date	Section / paragraph / page	Change description
0.1			New document
1.9	13/01/2017	Various	Updated parameters
2.0	09/03/2017	N2GPU pressure sensors	Added replacing instructions
2.1	30/05/2017	11.6 NIR-GP-S1 replacement	Added more information
2.2	06/06/2017	3.1 Vacuum sequence	Added info automatic valve

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1 Introduction

1.1 Purpose

This document includes the instructions that must be followed to operate the NIR channel cooling system during the different stages: the pre-cooling, the steady state and the warm-up. There are two subsystems that have to be cooled in parallel but each one with their own parameters and procedures: the vacuum tank and the detector system.

1.2 Abbreviations and acronyms

Abbreviation	
CARMENES	Calar Alto high-Resolution search for M dwarfs with Exoearths with Near-infrared and optical Échelle Spectrographs
NIR	Near Infra-Red
DS	Detector system
VT	Vacuum Tank
N2GPU	Nitrogen Gas Preparation Unit

1.3 Reference documents

Number	Document	Short Title	Issue Number
R.1	CARMENES/AIV-NIR/001		1.A
R.2	SP/CA-CS-IS	Interlocks sequences	1.E
R.3	MANIPULACION RANGERS CARMENES	How to manipulate 350L and 150L rangers	1.6

2 Objective

Ensure the optimal performance of the cooling system of the NIR channel during the start-up and operation. The main sequence is listed below:

- *Vacuum sequence:* how to initiate the vacuum sequence of the vacuum tank, the detector cryostat, the N2GPU and how to regenerate the detector cryostat.
- *Pre-cooling:* how to cool down with liquid nitrogen the VT and the N2GPU ***(1 day after the vacuum sequence)*** and the DS ***(2 days after the vacuum sequence)*.**
- *Steady-state:* how to change the layout to make the transition from the pre-cooling configuration to the steady-state one.
- *Warm-up sequence:* how to bring the instrument from operation temperature to room temperature.
- *Pressurization of the instrument:* how to pressurize the VT and the DS once the instrument is at a room temperature.
- *Opening the instrument: how to open the VT once it is pressurized.*

A part from the main points listed above there are other sections describing how to replace the pressure sensors, how to set-up the LN2 Rangers and how to evacuate the vacuum from the feed and transfer lines, etc.

There is an Interlocks document called “SP/CA-CS-IS” with the description and steps which have to be followed for the interlock sequences that appear in this document.

3 Vacuum sequence

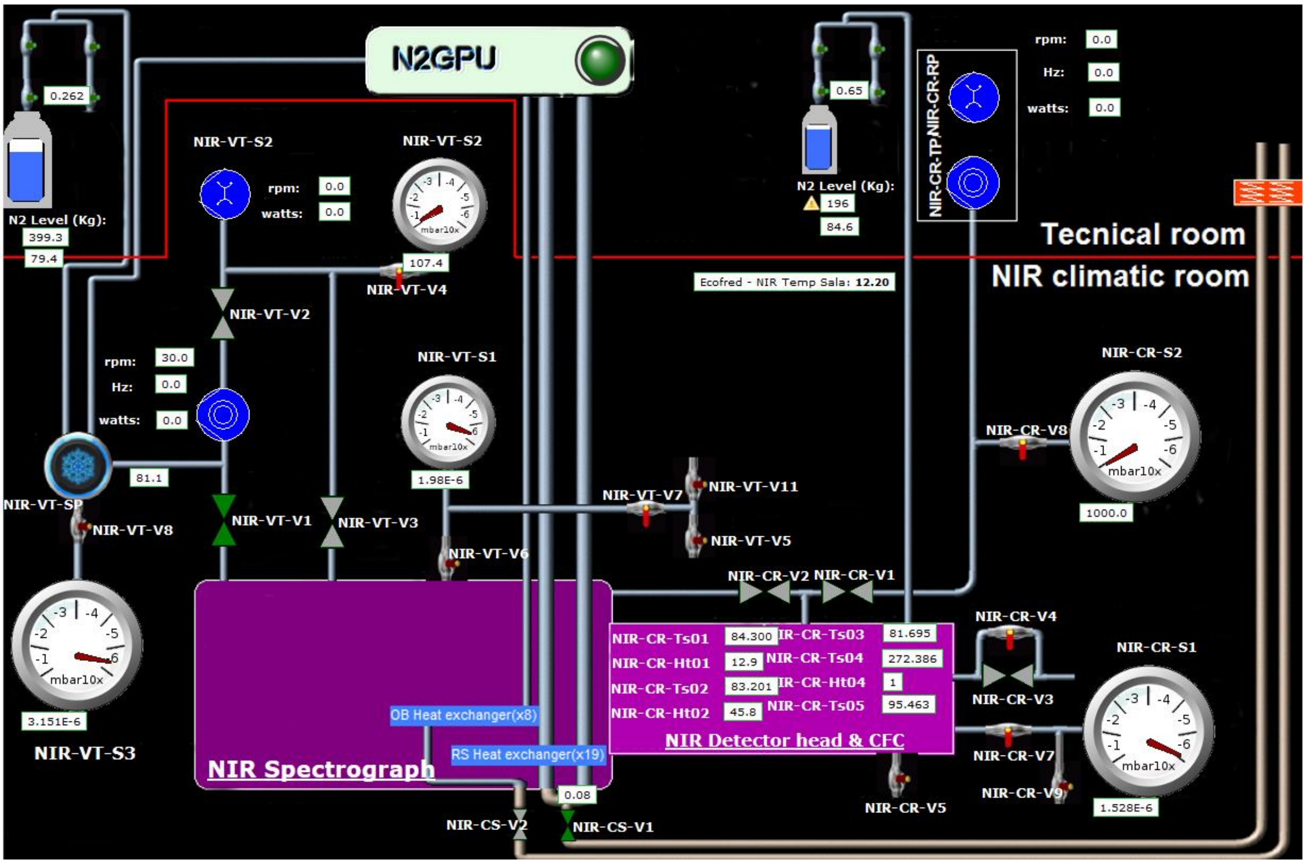

Image 1: Vacuum Tank and DS vacuum system layout

1. Activate through interlocks the vacuum sequence “SPE/CA-CS-IS/010-NIR channel starting up” and connect the pumps to achieve the required vacuum to the NIR vacuum tank, the preparation unit and the detector cryostat. There is an automatic controlled valve (NIR-CR-V2) which separates the volumes from the DS and the vacuum tank, it is opened when the pumping starts at atmospheric pressure and it closes when the difference between both volumes is below 1 mbar. Use next figure as a reference for the vacuum rate evolution after regenerating the sorption pump of the vacuum tank:

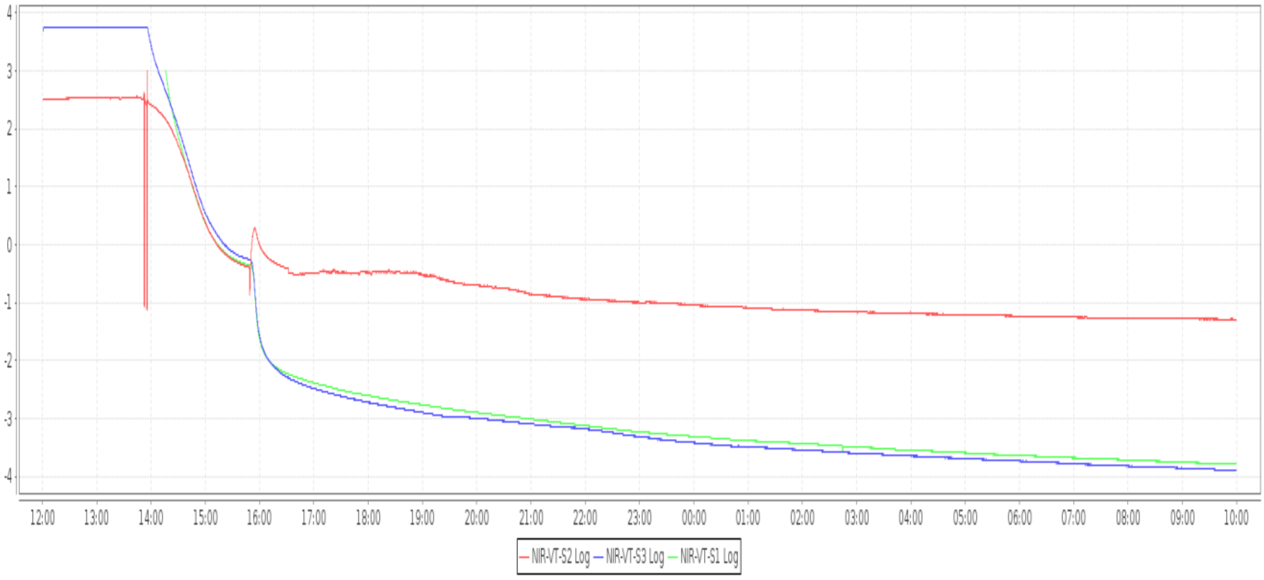

Image 2: Vacuum rate evolution of the vacuum tank pressure sensors

2. Regenerate the sorption pump of the vacuum tank through the interlocks sequence "SPE/CA-CS-IS/014-NIR VT sorption pump regeneration sequence" the sequence will be finished manually 6 hours after the temperature achieves 320K. If the instrument is cold, the SP of the VT can also be regenerated following the same sequence BUT the only difference is that the SP has to be isolated: it means connecting the 150L ranger straight to the DS.
3. Check that the vacuum level of the VT (NIR-VT-S1) is at the rate of 10-5mbar. If there is no leak the vacuum rates of the VT should be:
   - VT vacuum rate of 1x10-4mbar after 12hours pumping.
   - VT vacuum rate of 5x10-5mbar after 24hours pumping.

4. Regenerate the sorption pump of the DS when the vacuum is better than $9x10^{-4}$mbar. Image 3 shows the evolution of the vacuum during the regeneration and the start of the pre-cooling. The regeneration has to be done with the DS at ambient temperature; it is not worth to regenerate the SP if the DS if it is cold. Follow next steps to regenerate the SP of the DS:

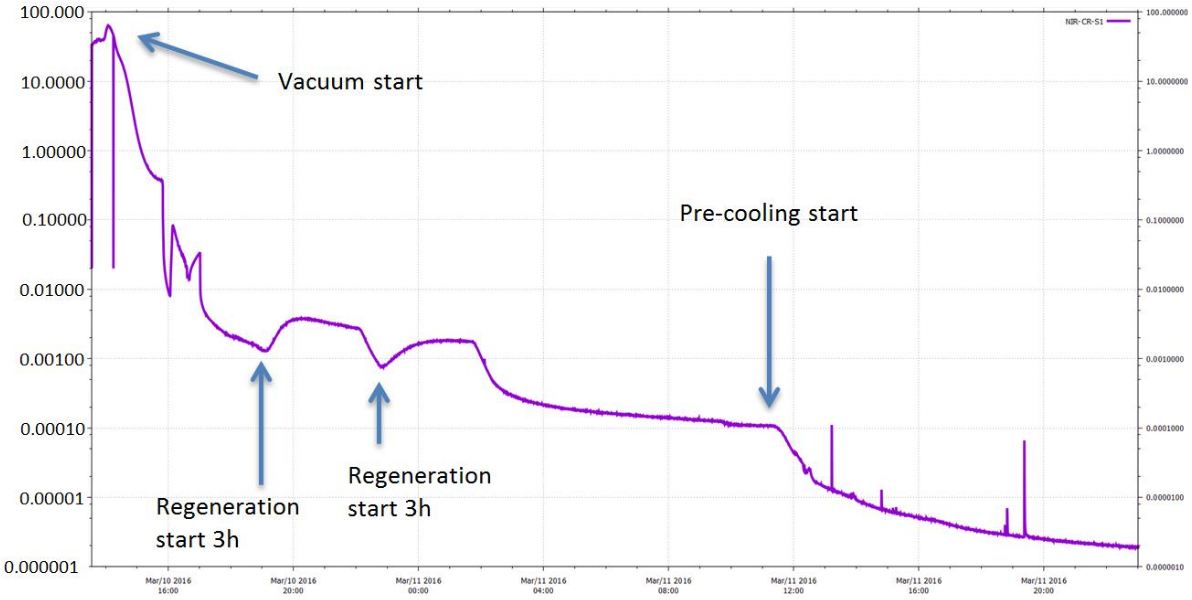

Image 3: DS vacuum evolution during regeneration and pre-cooling (pressure vs time)

- Set the DS in warm condition. S1 → warm condition, S3 → CPL-FLOW-OFF, S4 → EXG-HEAT-OFF and S5 → DISPLAY-ON.

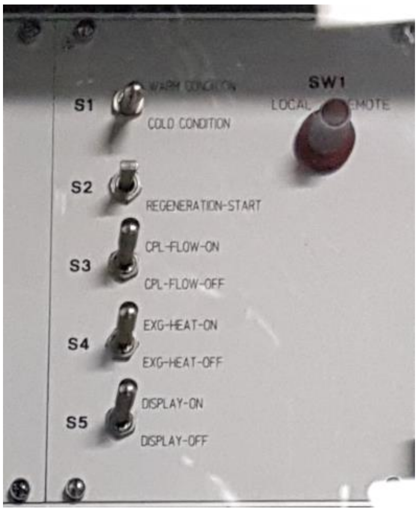

Image 4: Callipers

- Then press down the calliper corresponding to S2 → REGENERATION START.

Image 5: Regeneration calliper

- Check that the set point of the sorption pump increases to 363K.

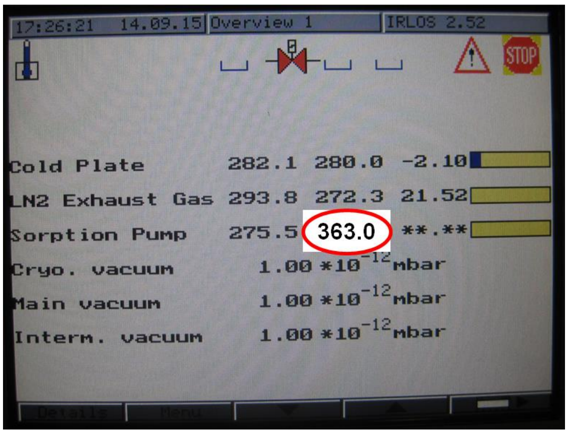

Image 6: Sorption pump set point

- After 3 hours it will automatically stop the regeneration even though the real temperature (left column) doesn't achieve the 363K.
- When the sorption pump goes passively again to room temperature the vacuum level of the DS (NIR-CR-S1) will rapidly drop at the rate of 10-5mbar.

5. Next figure shows the vacuum rate achieved after starting the pre-cooling of the VT and the DS, sections 4 and 5. This can be used as a reference for normal operation values:

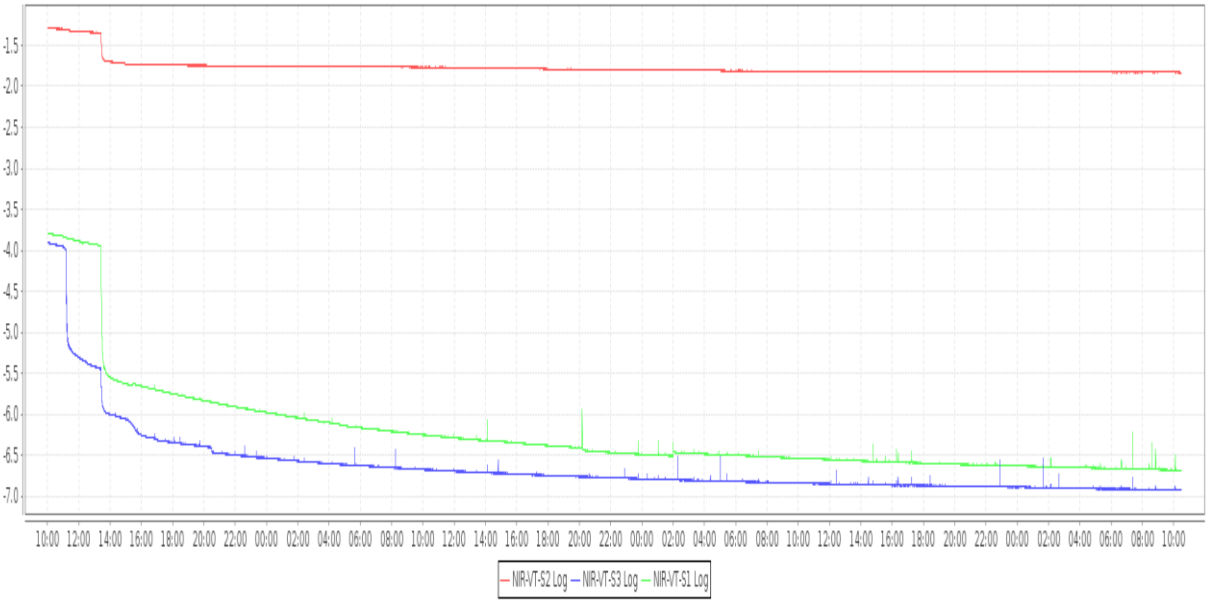

Image 7: Vacuum rate of the vacuum tank during the pre-cooling phase

4 Vacuum tank pre-cooling

This section describes the steps to be followed to proceed with the pre-cooling of the vacuum tank. It should be started when the pressure of the VT is better than $1x10^{-4}$mbar. Notice that it can be started before finishing the DS regeneration because at that moment they are already independent systems, furthermore the pre-cooling of the DS will start one day later (see section 5) because it takes less time to cool down.

1. The pre-cooling phase has a specific external cooling lines layout, next figure shows how they have to be properly connected.

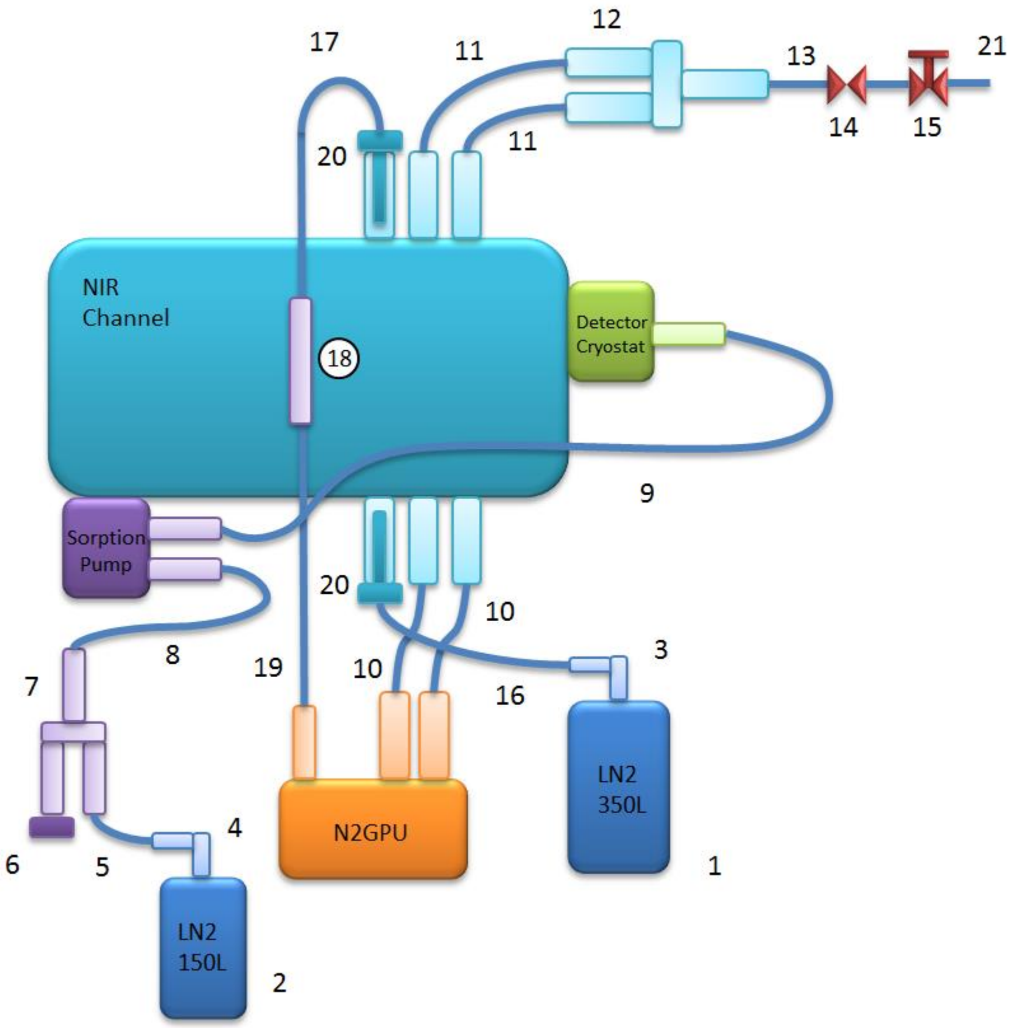

Image 8: Pre-cooling layout

1	LN2 Dewar 350L		11	Gas extension lines	
2	LN2 Dewar 150L		12	Gas exit manifold	
3	Long siphon	CA-NI-CS-5106	13	Gas transfer exit line	
4	Short siphon	CA-NI-DS-2306	14	On/Off Valve	
5	LN2 NIR Feed line	CA-NI-DS-2312	15	Manual angle valve	
6	Manifold lid		16	LN2 NIR Feed line	CA-NI-CS-4953
7	LN2 NIR Manifold	CA-NI-DS-2321	17	LN2 NIR Feed Line	CA-NI-CS-5113
8	LN2 NIR Feed line	CA-NI-CS-5114	18	LN2 Bypass	
9	LN2 NIR Feed line	CA-NI-CS-5111	19	LN2 NIR Feed Line	CA-NI-DS-2311
10	Gas transfer lines		20	LN2 to N2 adapter	
			21	Exhaust gas line	

Table 1: Pre-cooling layout components

Image 9: Pre-cooling configuration

2. Configure the N2GPU with the following set points:
   - 1st stage set point: 98.7K (-174.3ºC)
   - 2nd stage set point: 88.9K (-184.1ºC)
3. During this phase the on/off valve has to be permanently opened, therefore this valve has to be manually controlled by the Lakeshore controller number 1. The setup parameters are: Lakeshore 1: Relay Setup → Relay 2 → Mode ON → Escape.
4. Connect the pressure transmitter connector to the 350L Dewar.
5. Fully open the black key from the 350L Dewar ONLY during the pre-cooling to pressurize it at 0.8bar, the pressure of the Dewar is controlled by an intermediate

overpressure valve which is setup by the CAHA staff. The pre-cooling and the steady state have different intermediate valve setups.

Image 10: LN2 Dewar components

6. Connect the LN2 NIR feed line, number 16 on the figure, to the siphon of the 350L Dewar to start the pre-cooling of the NIR tank.

Note: It is possible when the Dewar is pressurized there is some liquid nitrogen leaking from the valve inside the siphon. If the siphon is leaking and freezes the end of the siphon it is necessary to heat it until the cooling line fits smoothly without twisting it, it has to enter straight and also using vacuum grease.

Image 11: Siphon end frozen

7. To see if the liquid nitrogen is flowing form the Dewar to the vacuum tank check that the temperature of the heat exchanger S1-3 corresponding to Lakeshore 1 is decreasing (NIR-CS-TS.03 on Scada).

Note: the pre-cooling of the OB will last from 2 to 3 days. In parallel the DS has to be also cooled down.

5 Detector cryostat pre-cooling

The DS pre-cooling should be started one day after the VT pre-cooling.

1. Connect the pressure transmitter connector to the 150L Dewar.
2. Check that the temperature of the DS Cold Plate is at 285K.
3. Check that the pressure is at the rate of $5 \cdot 10^{-4}$mbar.
4. Fully open the black key from the 150L Dewar to pressurize it at 0.65bar, leave it opened and use the same pressure for the pre-cooling and the steady state phases.

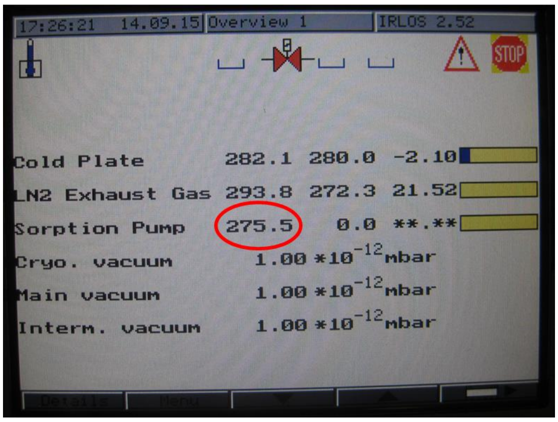

Image 12: DS temperatures before pre-cooling

5. Activate the detector system cool down sequence on the interlocks: General View → Start. Seq → SPE/CA-CS-IS/010-NIR Channel starting up (green button) → Start Detector Cooling Down.

6. You can follow the instructions from the original manual for the DS operation for more information to follow next steps if there is any doubt (MAN-04B1).

7. Open the manual venting valve V4 two full turns, after the pre-cooling it will be set to one full turn.

Image 13: Manual relief valve DS

8. ***Activate switches*** on the JUMO controller:
S1 → Cold condition, S3 → CPL flow-on, S4 → Exg-heat-on", S5 → Display on.

Image 14: DS Pre-cooling callipers position

9. ***Deactivate the Ramp*** of the cold plate from the JUMO controller: Menu → Configuration level → Generator code 0002 → Generator → Ramp → Ramp controller 2 → Function → Inactive → Enter → Then press Exit several times to go back to main screen menu.

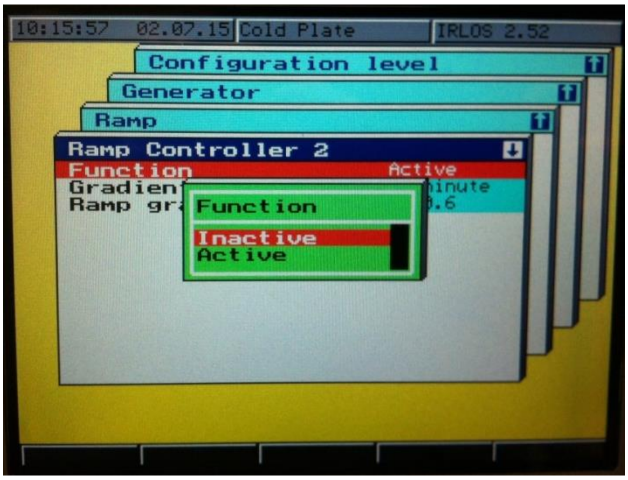

Image 15: Temperature ramp deactivation

10. ***Set point 1* to 298K:** Menu → Operating level → Setpoint → Controller 2 → Setpoint 1 → 298 → Enter → Then press Exit several time to go back to the main screen menu.

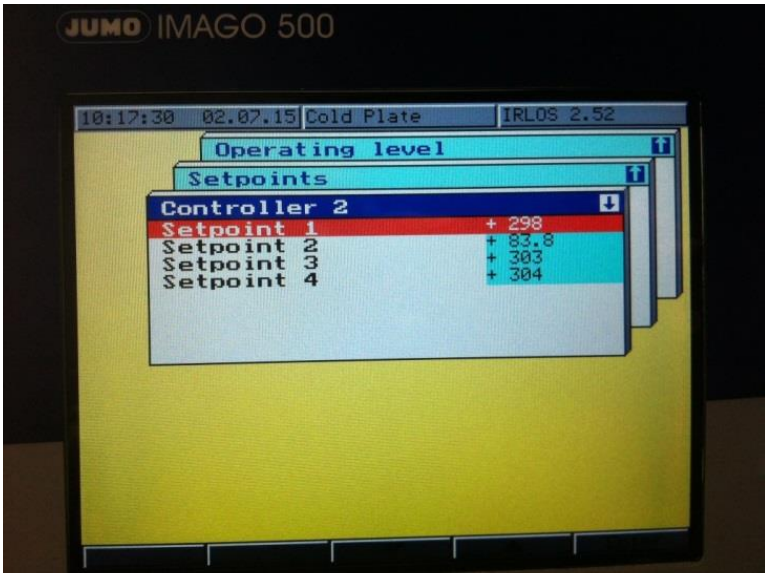

Image 16: Set point configuration

11. ***Activate ramp***: Menu → Configuration level → Generator code 0002 → Generator → Ramp → Ramp controller 2 → Function → Active → Enter → Then press Exit several time to go back to the main screen menu.
12. Check that the ***parameter levels*** are as shown in the next figure: Menu → Parameter level → Code 0001 → Parameter level Controller 2 → Parameter set 1 → Press Exit several times to go back to the main screen menu.

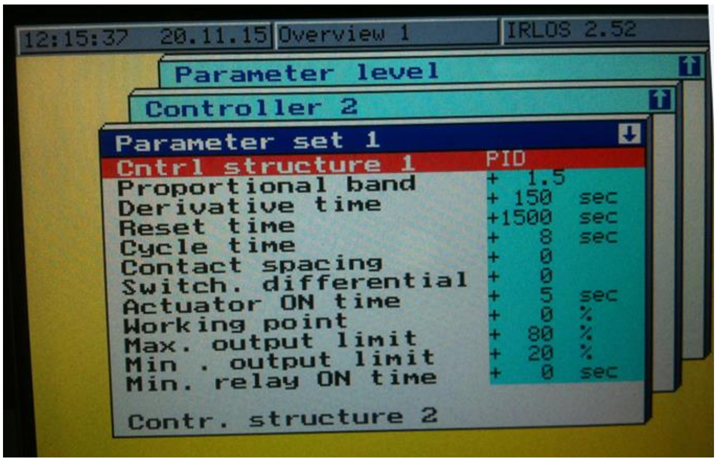

Image 17: Parameter levels menu

13. ***Set point 1* to 83.8K:** Menu → Operating level → Setpoint → Controller 2 → Setpoint 1 → 83.8 → Enter → Then press Exit several time to go back to the main screen menu.
14. *Check that the **heaters** of the Loops A and B are turned off.*
15. Connect the LN2 DS feed line to start the pre-cooling of the detector cryostat. **Very important:** remember to start **the cooling down of the DS the following day after regenerating it**. If not the DS will still be very warm (above 285K) and the gap between the ramp to follow and the real temperature will increase significantly (more than 15 degrees), the regular gap should be at around 2 degrees. If this happens there is the possibility of a sudden cool down and that could break some of the DS components.
Next picture shows the real temperatures and the ramp to follow of the cold plate:

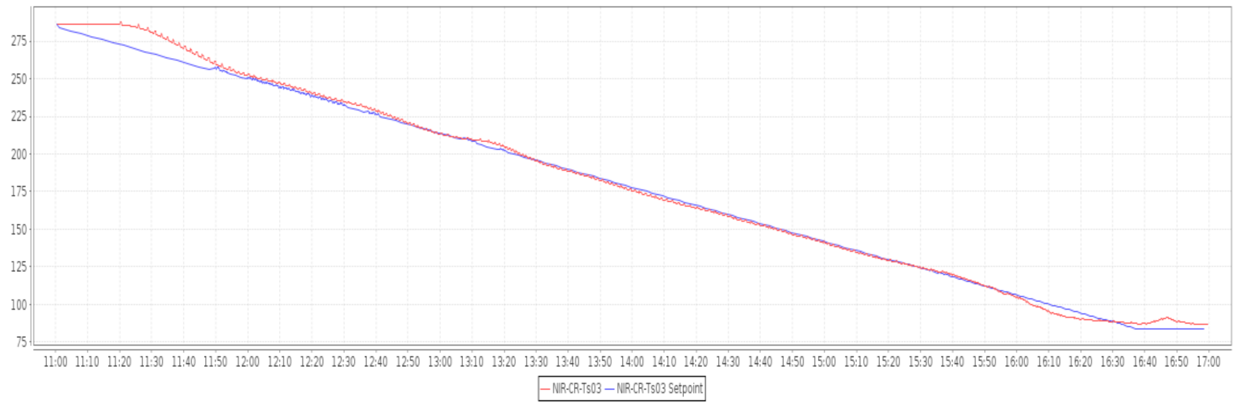

Image 18: Cooling down temperature graph

16. Check if there is gas flowing from the valve V4 to certificate that there is nitrogen flowing through the circuit.
17. When the temperature of the CPL is stabilized at the set point switch on the ROE.
18. When the temperature of the CPL is stabilized at the set point activate the set point of the detector housing "Loop B" from the Lakeshore controller:

    - Deactivate the ramp of the Loop B press Output Setup → Output 1 → Ramp rate off (go down with the arrows, it will appear).
    - Press B button until hear a "bip" → SET POINT → *add a set point 0.2 degrees higher than the temperature of the loop B at that moment with the numeric keyboard* → Enter.
    - Activate the ramp of the Loop B press Output Setup → Output 2 → Ramp rate 0.6K/min (go down with the arrows, it will appear).
    - Activate the heater of the Loop B at a high range: Lakeshore controller → Press B button until hear a "bip" → Heater range → High → Enter → Escape.

19. When the Loop B is stabilized repeat the same procedure but now with the detector base plate "Loop A". The set point has to be 0.4 degrees higher than the set point of the Loop B: Lakeshore controller:

    - Deactivate the ramp of the Loop A press Output Setup → Output 1 → Ramp rate off (go down with the arrows, it will appear).
    - Press A button until hear a "bip" → SET POINT → *add a set point 0.4 degrees higher than loop B set point with the numeric keyboard* → Enter.
    - Activate the ramp of the Loop A press Output Setup → Output 1 → Ramp rate 0.6K/min (go down with the arrows, it will appear).
    - Activate the heater from the Loop A at high range: Lakeshore controller → Press A button until hear a "bip" → Heater range → High → Enter → Escape.

20. As the temperature of the optical bench decreases the temperature of the CPL, Loop A and B go below the set point without being able to reach it, therefore the set points have to be decreased until the final setup, as shown on the next table and graph:

	start	after 7h	after 19h	after 31h
CPL	83,8K	83K	83K	83K
Loop B	-	85K	84K	83,2K
Heater B	off	High	High	High
Loop A	-	86,1K	85,1K	84,3K
Heater A	off	High	High	High
V4 Valve	2 turns	2 turns	2 turns	1 turn

Table 2: DS parameters evolution

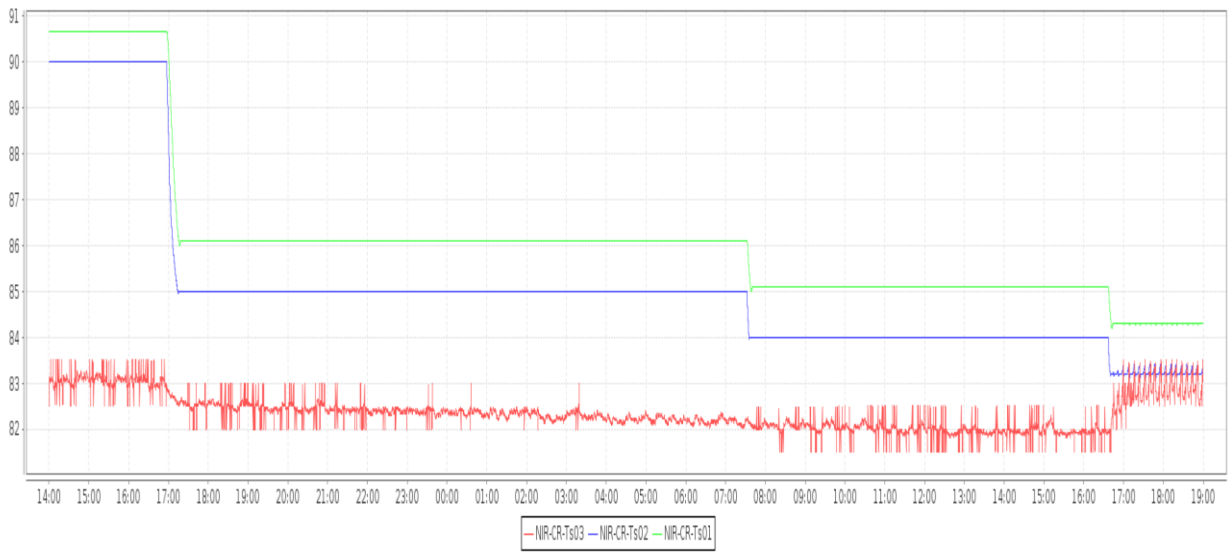

Image 19: DS temperature graph

6 Transition to steady state

1. Once the sensor Ts-10 on lakeshore number 2 has achieved the temperature of 133K the cooling lines configuration has to be changed to the final steady state layout:

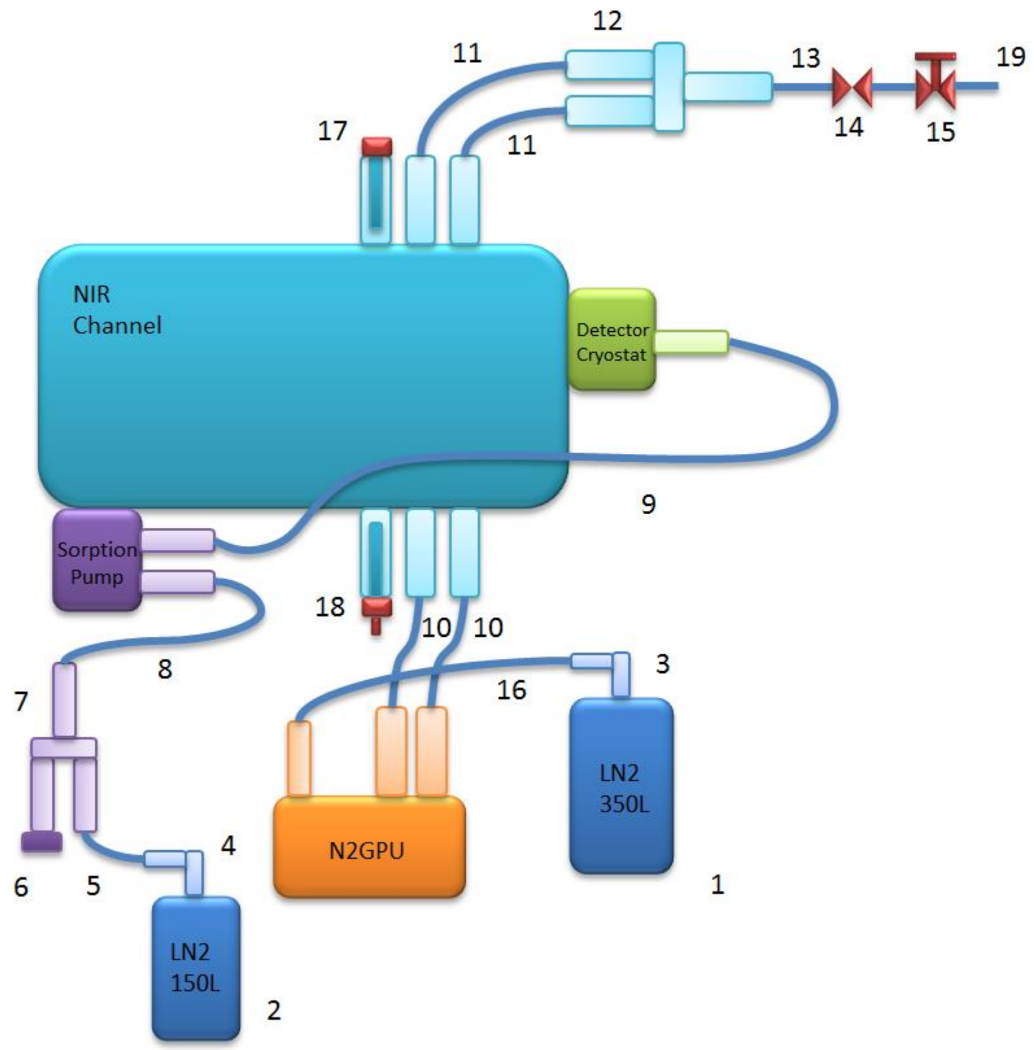

Image 20: Steady state configuration layout

1	LN2 Dewar 350L		10	Gas transfer lines	
2	LN2 Dewar 150L		11	Gas extension lines	
3	Long siphon	CA-NI-CS-5106	12	Gas exit manifold	
4	Short siphon	CA-NI-DS-2306	13	Gas transfer exit line	
5	LN2 NIR Feed line	CA-NI-DS-2312	14	On/Off Valve	
6	LN2 NIR Feed line	CA-NI-DS-2313	15	Manual angle valve	
7	LN2 NIR Manifold	CA-NI-DS-2321	16	LN2 NIR Feed line	CA-NI-CS-5114
8	LN2 NIR Feed line	CA-NI-CS-5114	17	Gas bayonet lid	
9	LN2 NIR Feed line	CA-NI-CS-5111	18	Relief valve	
			19	Exhaust gas line	

Table 3: Steady state layout components

2. Disconnect the LN2 feed line from the 350L Dewar to cut the nitrogen flow.
3. Remove from the VT side the LN2 OB feed line that goes to the N2GPU (item 17 from Table 1, Image 8). Be careful that might be nitrogen gas going out as the circuit might be with an overpressure. Then remove it also from the N2GPU side (item 19 from Table 1, Image 8).
4. Install an overpressure valve on that bayonet (item 18 from Table 3, Image 21).

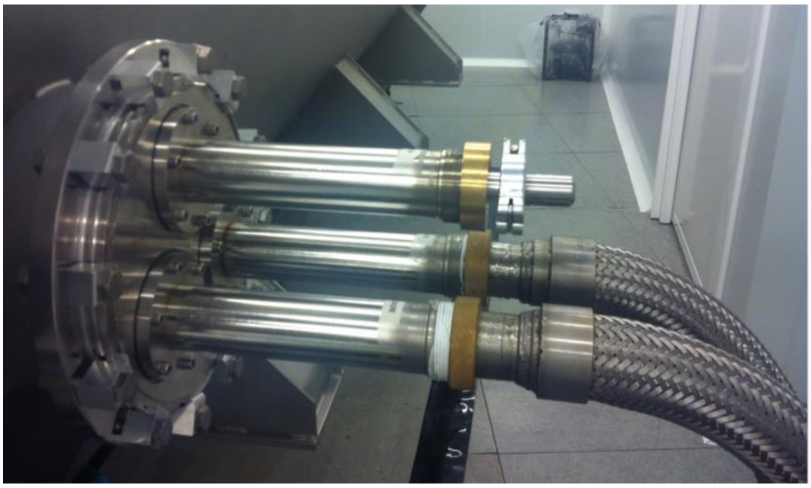

Image 21: Overpressure valve pre-cooling line

5. Disconnect the LN2 pre-cooling feed line from the VT and install a blank lid (item 17 from Table 3,Image 20). The connexion will be frozen and it is needed a heater to melt the ice.

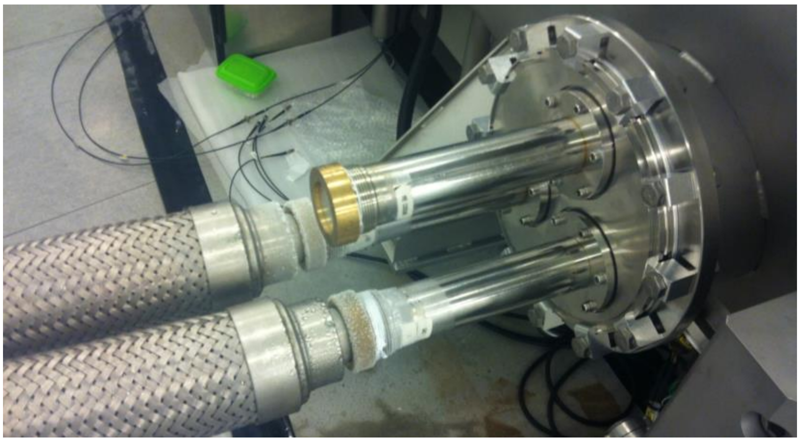

Image 22: Lid on the pre-cooling line

6. Install the flow reducer pin-hole with the diameter of 1.8mm to the LN2 feed line (item 16 from Table 3, Image 8) using a screw driver as shown on the Image 23 and connect it to the N2GPU.

Image 23: Pinhole installation

Image 24: Steady state configuration

7. Connect the LN2 NIR feed line (item 16 from Table 3 , Image 20) to the 350L Dewar to start the transition phase.

   Note: During this phase the radiation shield will be cooled down and to avoid liquid nitrogen overflow the set point of the on/off valve has to be manually controlled, decreasing it gradually.

8. Set the sensor S1-6, "NIR_Operations - NIR-CS-Ts06" on Scada, from the Lakeshore 1 to command the On/Off valve at 168K. Press enter to move forward through the menus: Alarm Setup → Input 6 → alarm on → Units K → Low Alarm Point 287.00K → High Alarm Point 168K → Deadband 1K → Latching off → Escape.

9. Activate the relay 2 from Lakeshore 1: Relay Setup → Relay 2 → Mode Alarms → Input 6 → High Alarm → Escape.

*Note: the set point of the sensor 1-6 (*Ts-06) *will be decreased when the curve of the sensor 1-1 (*Ts-01) *tends to stabilize. It is necessary to follow it on Scada, sensor "NIR_Operations - NIR-CS-Ts01". The full sequence is represented on the next picture:*

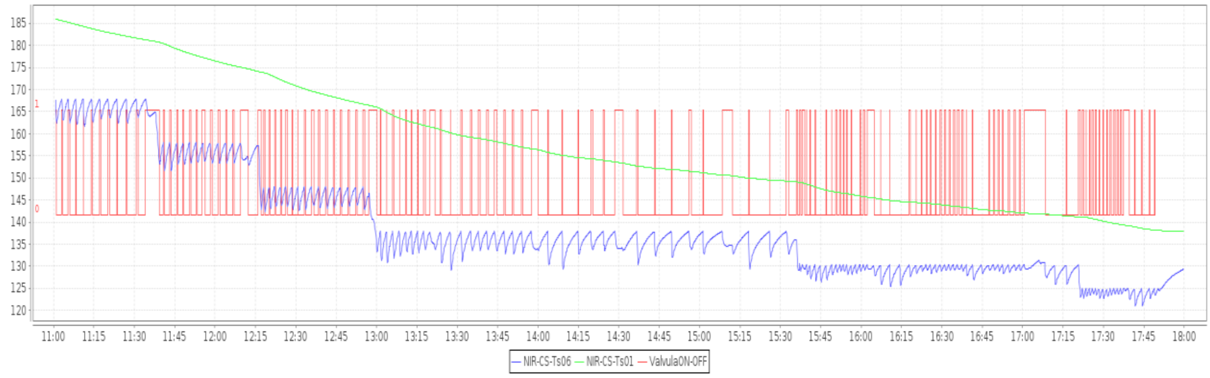

Image 25: Radiation shield cooling down sequence

A zoom in picture:

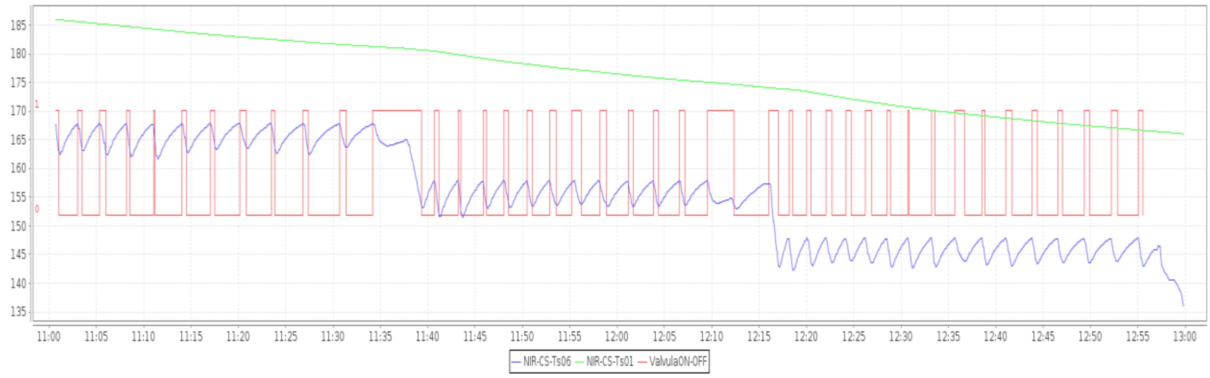

Image 26: Zoom in of the radiation shield cooling down sequence

10. When the sensor Ts-01 is getting stable at 168K change the set point of the sensor Ts-06: Alarm Setup → Input 6 → alarm on → Units K → Low Alarm Point 287.00K → High Alarm Point 158K → Escape.
11. When the sensor Ts-01 is getting stable at 158K change the set point of the sensor Ts-06: Alarm Setup → Input 6 → alarm on → Units K → Low Alarm Point 287.00K → High Alarm Point 148K → Escape.
12. When the sensor Ts-01 is getting stable at 148K change the set point of the sensor Ts-06: Alarm Setup → Input 6 → alarm on → Units K → Low Alarm Point 287.00K → High Alarm Point 138K → Escape.
13. When the sensor Ts-01 is getting stable at 138K change the set point of the sensor Ts-06: Alarm Setup → Input 6 → alarm on → Units K → Low Alarm Point 287.00K → High Alarm Point 135K → Escape.
14. When the sensor Ts-01 is getting stable at 135K change the control set point to the sensor Ts-22 from Lakeshore 3 at 134.1K with a dead band of 0.02K:
    a. Deactivate the control sensor Ts-06. Press enter to move forward through the menus from Lakeshore 1: Alarm Setup → Input 6 → alarm off → Escape.
    b. Activate the relay 2 from Lakeshore 3: Relay Setup → Relay 2 → Mode Alarms → Input 6 → High Alarm → Escape.
    c. Manually place the cable from the relay to the X37 input (Only CAHA staff, this is a critical operation.
    d. Set the sensor Ts-22 from the Lakeshore 3 to command the On/Off valve at 134.1K. Press enter to move forward through the menus from Lakeshore 3: Alarm Setup → Input 6 → alarm on → Units K → Low Alarm Point 287.00K → High Alarm Point 134.1K → Deadband 0.02K → Latching off → Escape.

7 Steady state

At June 2017, N2GPU tuning is still ongoing in order to ensure the best performance of the NIR-CS so, by the time this updated User Manual is being delivered, frozen PIDs values have not been yet reached (Contact person: Marco Azzaro).

1. Check and setup the N2GPU with the following inputs:

- 1^{st} stage (E1) set point: TBD
- Pb E1: TBD
- Y1 E1: TBD
- Y2 E1: TBD
- rt E1: TBD
- dt E1: TBD
- 2^{nd} stage (E2) set point: TBD
- Pb E2: TBD
- Y1 E2: TBD
- Y2 E2: TBD
- rt E2: TBD
- dt E2: TBD

2. Set the control sensor of the on off valve to the sensor number 22, on Scada is the NIR-CR-Ts22, and set it with a high alarm point of 134K and a dead-band of 0.02K.
3. Check that the parameters of the detector system are:
    - CPL set point: 81.9K
    - Loop B set point: 83.2K
    - Loop B heater range: high
    - Loop A set point: 84.3K
    - Loop A heater range: high
4. Check that the manual venting valve V4 of the DS is opened 1 full turn.
5. Check that the manual angle valve after the on-off valve is opened at 49º.
6. Change the overpressure in the 350L ranger to 0.25bar ±0.1bar. Use the intermediate dedicated overpressure valve.
7. Check that the overpressure in the 150L ranger is at 0.65bar ±0.02bar.
8. Regularly the LN2 rangers have to be changed following the steps from the section 11 “Protocol to change the 350L and 150L Rangers”.

8 Warm up of the OB and the Radiation Shield

1. Disconnect the LN2 feed line from the 350L Dewar.

2. Open the on/off valve from Lakeshore 1: Relay Setup *(Enter)* → Relay 2 *(Enter)* → Mode ON → Escape.

   Note: the on/off valve cannot be opened permanently because it gets too hot when there is no cooling gas flowing through, therefore, in parallel with the warming up sequence, an interval open/close manual action is needed: open it during 1 hour, close it 1 hour, open it 1 hour and finally leave it closed: Relay Setup (Enter) → Relay 2 (Enter) → Mode: OFF.

3. Start warm up sequence on the Interlocks "SPE/CA-CS-IS/011-NIR channel stopping sequence" (it includes switching on the pumps).
4. Activate the power switcher placed behind the rack.
5. Connect the heaters cable "R1" to the corresponding connector on the vacuum tank.
6. Enable "Optical Bench Heater" on the Interlocks Touch panel.
7. Configure the heaters set point using the Lakeshore number 3:
   - Assign sensor S3-5 as a control sensor and put the set point at 150K:

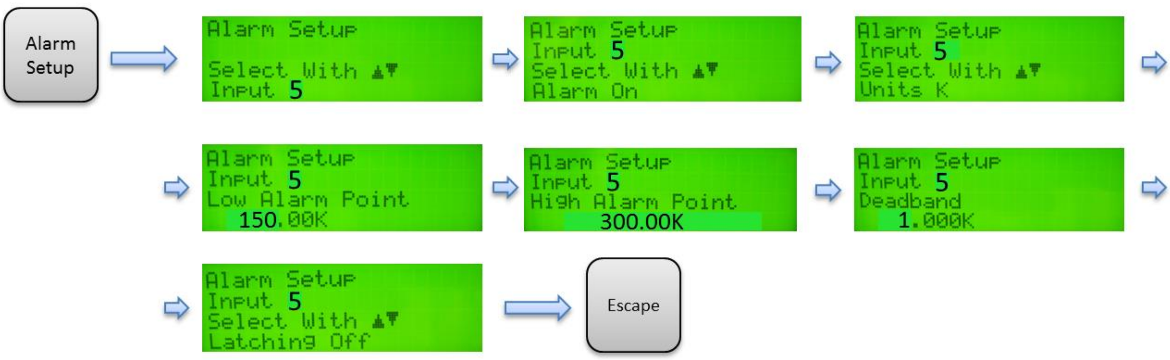

Image 27: Optical bench control sensor assignment

   - Assign relay 1 to input 5:

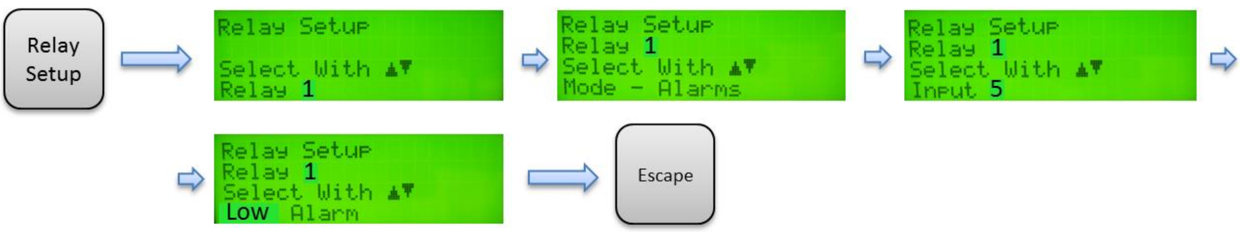

Image 28: optical bench relay assignment

8. Connect the radiation shield heaters cable "R2" to the corresponding connector on the vacuum tank.

9. Enable “Radiation Shield Heater” on the Interlocks Touch Panel.
10. Configure the heaters set point using the Lakeshore number 1:
    - Set the sensor S1-7 from Lakeshore 1 as a control sensor and put the set point at 200K:

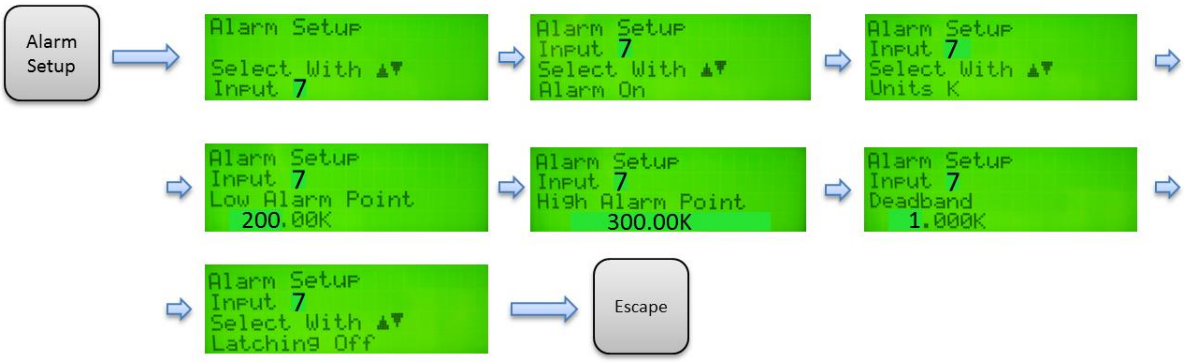

Image 29: Radiation shield control sensor assignment

    - Assign relay 1 to input 7:

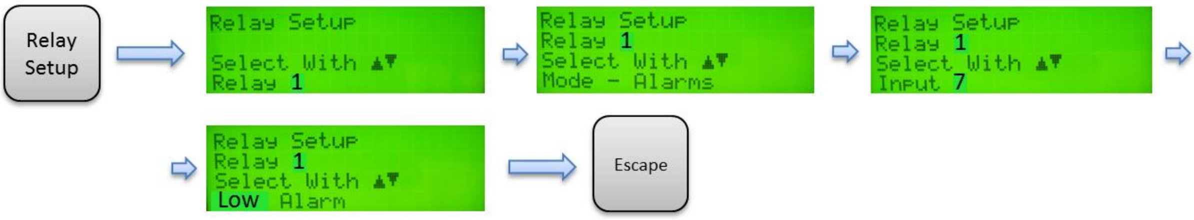

Image 30: Radiation shield relay assignment

Note: as each control sensor is placed close to a heater source they will rapidly achieve the set point but all the other sensors, far from the heaters, will need more time to increase their temperature. To manage that the control sensor of the radiation shield, S1-7 will not be updated until the sensor S1-1 tends to stabilize close to the temperature of S1-7. On the optical bench, the control sensor S3-5 will not be updated until the sensor S-3-2 tends to stabilize close to the temperature of S3-5.

11. Follow the steps to keep increasing the optical bench control sensor S3-5:
    - When the sensor S3-2 is at 150K or close change the set point to 170K.
    - When the sensor S3-2 is at 170K or close change the set point to 190K.
    - When the sensor S3-2 is at 190K or close change the set point to 210K.
    - When the sensor S3-2 is at 210K or close change the set point to 240K.
    - When the sensor S3-2 is at 240K or close change the set point to 270K.
    - When the sensor S3-2 is at 270K or close change the set point to 290K.

Next figure shows the warming up temperature plot from the optical bench:

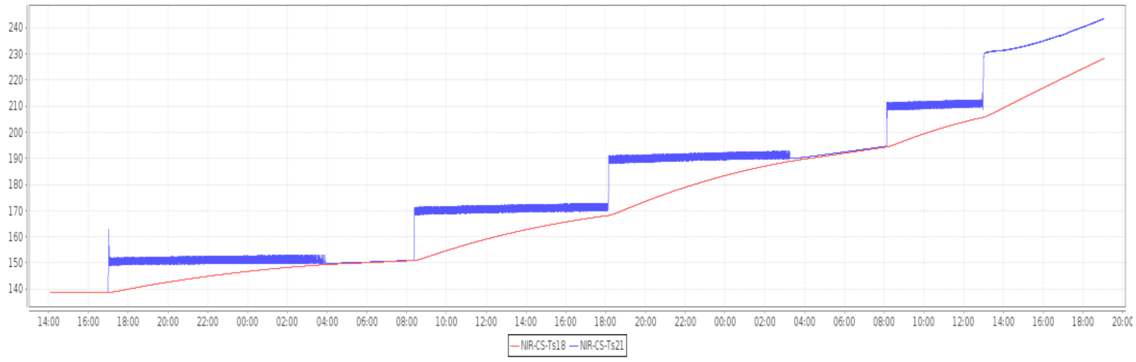

Image 31: Optical bench warming up reference graph

12. In parallel with point 9 keep increasing the radiation shield control sensor S1-7:
    - When the sensor S1-1 is at 200K or close change the set point to 240K.
    - When the sensor S1-1 is at 240K or close change the set point to 280K
    - When the sensor S1-1 is at 280K or close change the set point to 290K

Next figure shows the warming up temperature plot from the radiation shield:

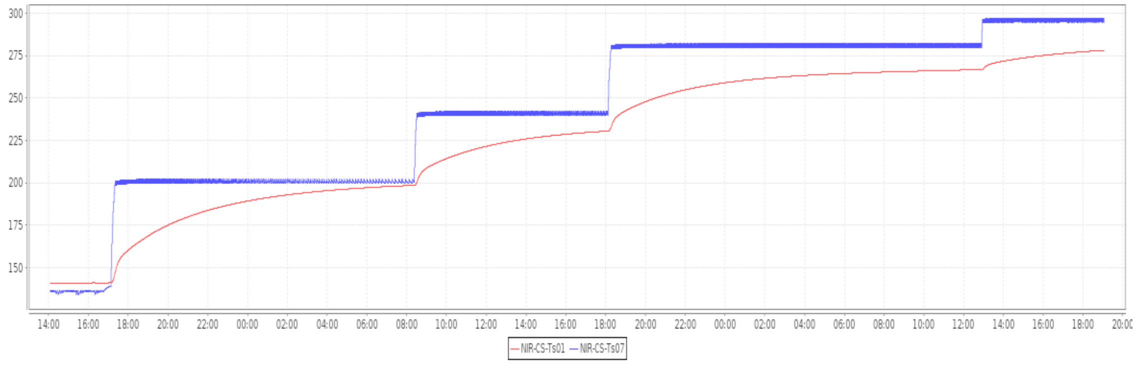

Image 32: Radiation shield warming up reference graph

9 Warm up of the Detector cryostat

The detector must not be warmed up faster than 0.6 K/min, therefore the most important thing is to set the ramp before starting the sequence. The warm-up of the detector should start approximately at the same time as the warm-up of the VT.

1. Activate the detector warming-up sequence on interlocks "SPE/CA-CS-IS/042-VIS detector warming up sequence": NIR-CR-TP/RP pumps switched on and

check that the vacuum tank by-pass valve NIR-CR-V2 is closed. This sequence belongs to the main sequence "SPE/CA-CS-IS/011-NIR channel stopping sequence" and cannot be run independently.

2. Keep the cooling of the DS with liquid nitrogen with unchanged set points.
3. Switch off all the heaters on DS Lakeshore controller: press “ALL OFF”.

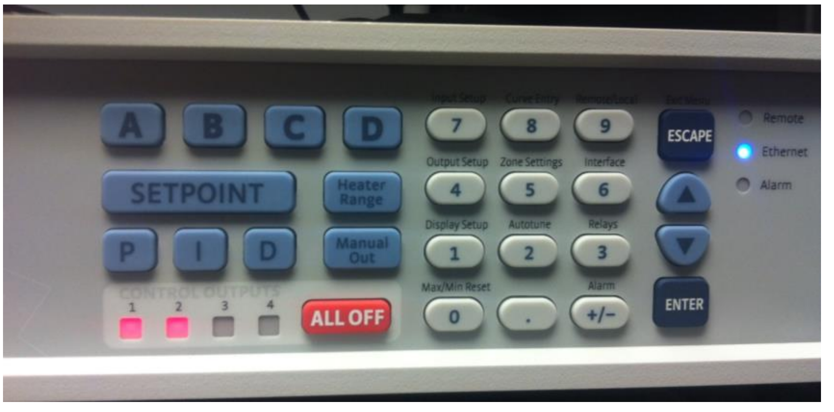

Image 33: Switch off heaters

4. Activate the ramp from the Loop A: Output Setup → Output 1 → Setpoint ramping ON.
5. Check the ramp rate from the Loop A: press Output Setup → Output 1 → Ramp rate 0.6K/min (go down with the arrows, it will appear).
6. Set the set point from the Loop A: press A until hear a beep → Setpoint → 290K → Enter.
7. Activate the ramp from the Loop B: Output Setup → Output 2 → Setpoint ramping ON.
8. Check the ramp rate from the Loop B: press Output Setup → Output 2 → Ramp rate 0.6K/min (go down with the arrows, it will appear).
9. Set the set point from the Loop B: press B until hear a beep → Setpoint → 290K → Enter.
10. Activate the heaters to the high level from Loop A: press A until hear a beep → Heater Range → High.
11. Activate the heaters to the high level from Loop B: press B until hear a beep → Heater Range → High.
12. Keep the cooling and the heating during 30 minutes.
13. Disconnect the LN2 feed line from the 150L Dewar to stop the cooling.

14. Adjust the switches from the JUMO controller to the warm configuration: S1 → Warm condition, S3 → CPL flow off, S4 → EXG-heat-off, S5 → display on.
15. Leave the manual venting valve V4 at the mark number 10.
16. In case the cryostat should be vented wait until all temperature readings have reached ambient temperature. Some parts will warm up with some delay and could be below dew point or even below freezing point. Venting should be done with dry nitrogen.
17. Also: venting of the flow cryostat must be done together with the big vessel to prevent the system from stress due to pressure difference.

Note: the warm up will finish automatically so no more manual actions are needed. Next figure shows the warming up rate plot:

Image 34: Detector system warm up evolution graph

10 Pressurization of the vacuum tank and Detector System

After warming up the instrument when the temperature of the sensor Ts-12 (echelle optical substrate) has reached at least 283K the instrument can be pressurized:

1. Turn off the heaters on the touch panel.
2. Turn off the pumping group of the detector system and the valve NIR-CR-V1 on the touch panel.
3. Turn off the turbo pump and the roughing pump of the vacuum tank.
4. Close valve NIR-VT-V2 on the touch panel.

5. Open the electromagnetic valve that communicates both volumes, VT and DS: NIR-CR-V2 on the touch panel.
6. Connect the nitrogen gas line to the port: NIR-N2, see next picture:

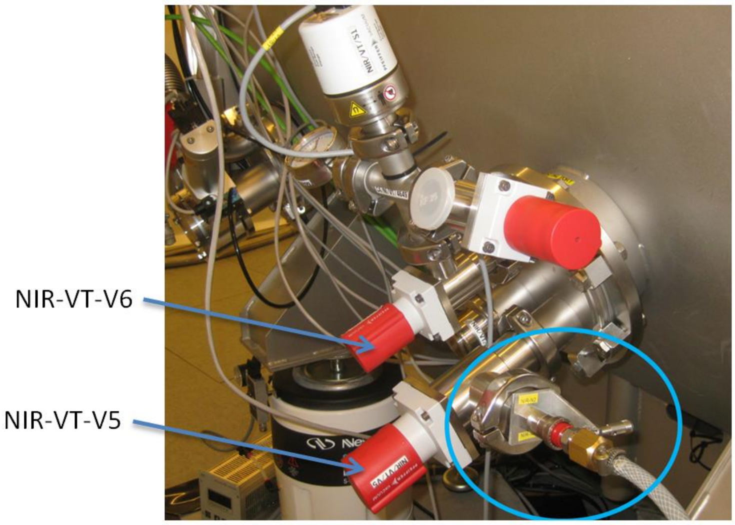

Image 35: Pressurization port

7. Open the manual valve NIR-VT-V5.
8. Open the nitrogen gas bottle to start the pressurization, verify that there is at least a pressure of 100bar inside the bottle and set the regulator to 0.5bar.

Image 36: Nitrogen gas pressure regulator

9. Check the analogic manometer from the VT to follow the pressurization more precisely, after approximately 1 hour one of the relief valves placed around the VT will let the nitrogen gas flow through, probably it will be the one placed on at the sorption pump module, you will hear the noise, after that the pressurization is done and the nitrogen gas bottle can be closed.
10. At this moment the tank is pressurized at approximately +0.4bar relative to the ambient pressure, therefore **before opening the tank or any other port open first the manual valve NIR-VT-V6 to equalize both pressures**. If both pressures are not equalized it can be dangerous because of the overpressure load.

11 Protocol to change the 350L and 150L rangers

Follow the instructions from the document “Manipulación Rangers LN2 CARMENES” produced by CAHA staff.

12 Protocol to replace pressure sensors

12.1 Pressure sensor NIR-VT-S1

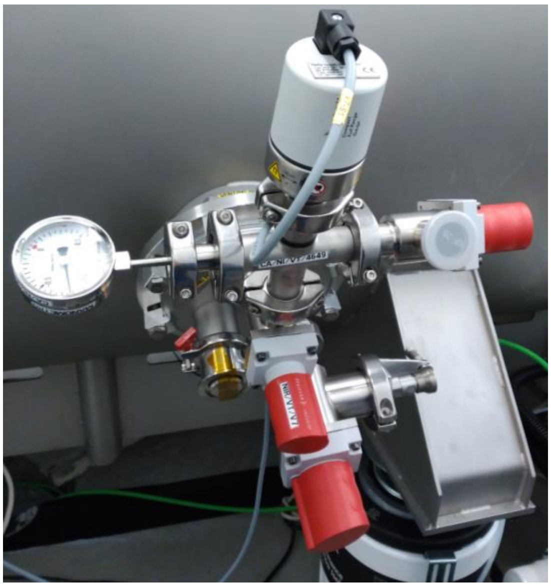

Image 37: Sensor NIR-VT-S1

- Close manual valve NIR-VT-V7.

- Open slowly manual valve NIR-VT-V6.
- Disconnect the sensor electronics and remove the old pressure sensor.
- Place the new pressure sensor and connect the electronics, the o-ring has to be cleaned with alcohol.
- Connect a portable vacuum pump to the manual valve NIR-VT-V6.
- Pump it until the pressure of the sensor NIR-VT-S1 is lower than NIR-VT-S2 or NIR-VT-S3, usually around 1x10-6mbar.
- Close manual valve NIR-VT-V6.
- Open slowly manual valve NIR-VT-V7.

12.2 Pressure sensor NIR-VT-S2

- Switch of the pumps according to the interlock protocol.
- Close electro-valve NIR-VT-V2.
- Remove the old pressure sensor.
- Place the new pressure sensor, the o-ring has to be cleaned with alcohol.
- Initiate again the pumping following the interlocks protocol.

12.3 Pressure sensor NIR-VT-S3

- Close manual valve NIR-VT-V8.
- Open slowly manual valve on the right on the next picture.
- Remove the old pressure sensor.
- Place the new pressure sensor, the o-ring has to be cleaned with alcohol.
- Connect a portable vacuum pump to the manual valve on the right on the next picture.
- Pump it until the pressure of the senor NIR-VT-S3 is lower than NIR-VT-S1 or NIR-VT-S2, usually around 1x10-6mbar.
- Close manual valve on the right on the next picture.
- Open slowly manual valve NIR-VT-V8.

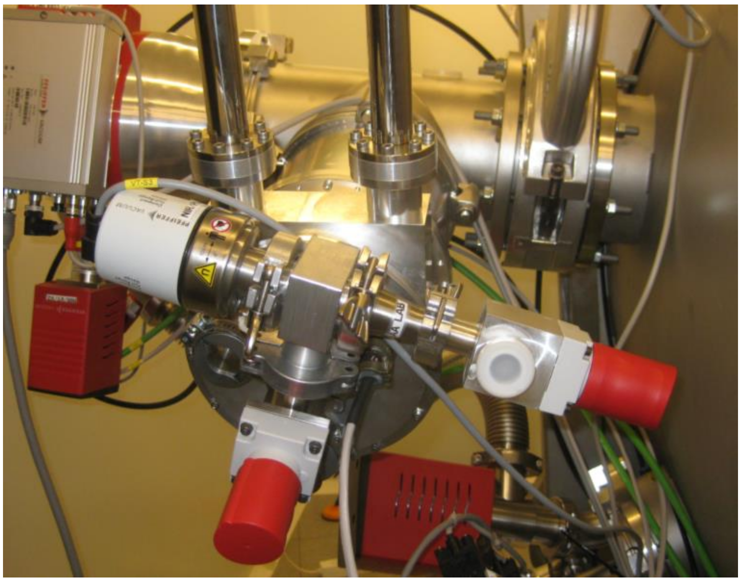

Image 38: Sensor NIR-VT-S3

12.4 Pressure sensor NIR-CR-S1

- Close manual valve NIR-CR-V7.
- Open slowly manual valve NIR-CR-V9.
- Remove the old pressure sensor.
- Place the new pressure sensor, the o-ring has to be cleaned with alcohol.
- Connect a portable vacuum pump to the manual valve NIR-CR-V9.
- Pump it until the pressure of the sensor NIR-CR-S1 is 1x10-6mbar.
- Close manual valve NIR-CR-V9.
- Open slowly manual valve NIR-CR-V7.

12.5 Pressure sensor NIR-CR-S2

- Close the electro-valve NIR-CR-V1.
- Remove the old pressure sensor.
- Place the new pressure sensor, the o-ring has to be cleaned with alcohol.
- The electro-valve NIR-CR-V1 will be automatically opened again accordingly with the interlocks protocol.

12.6 Pressure sensor NIR-GP-S1

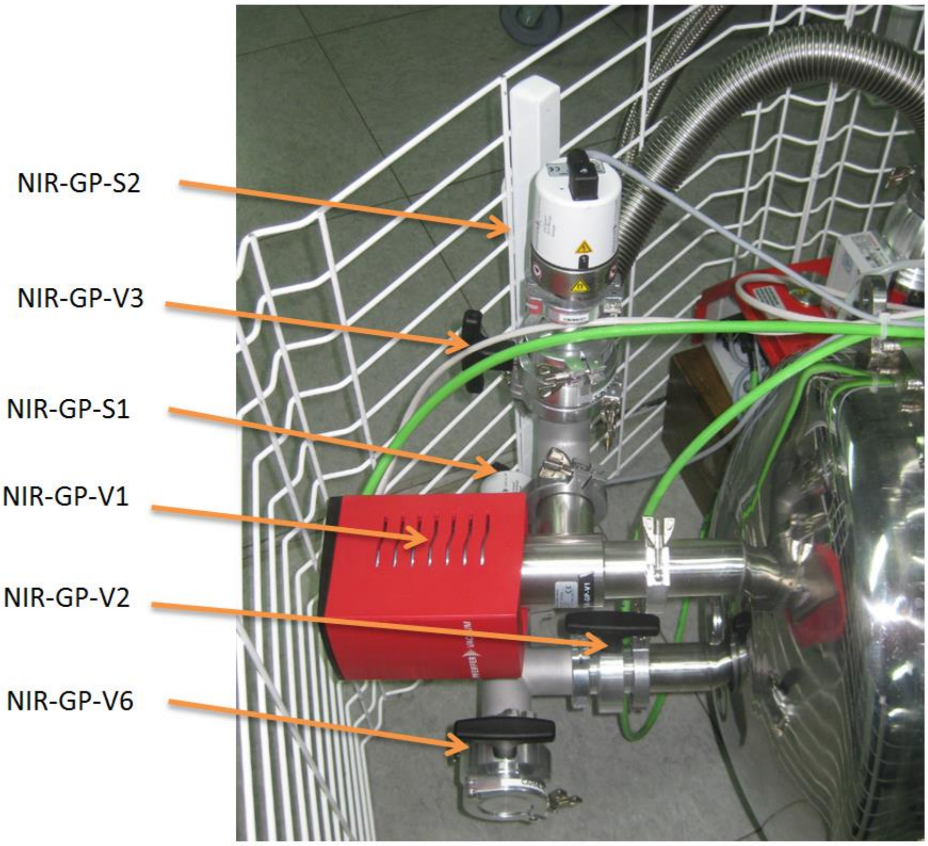

Image 39: Layout N2GPU valves and pressure sensors

- Turn on pumping group HiCube 80.
- Open valve NIR-GP-V1 when the pressure from NIR-GP-S2 is around 10-5mbar.
- Turn off the sensor form TPG 262 pressing the arrow looking up.
- Close the manual valve NIR-GP-V2.
- Open slowly the manual valve NIR-GP-V6
- Remove the old pressure sensor.
- Place the new pressure sensor, the o-ring has to be cleaned with alcohol.
- Turn on the sensor from the TPG 262 pressing the arrow looking down.
- With an external pumping group regenerate the vacuum lost in this section through the port of the manual valve NIR-GP-V6 to the previous level, around 10-5mbar.
- Once the vacuum is reached and still with the external pumping group working, open the manual valve NIR-GP-V2.
- Then close the manual valve NIR-GP-V6.

- Turn off valve NIR-GP-V1

- Turn off and disconnect the external pumping group and the HiCube 80.

12.7 Pressure sensor NIR-GP-S2

- Close the electro-valve NIR-GP-V1.

- Close the manual valve NIR-GP-V3.

- Remove the old pressure sensor.

- Place the new pressure sensor, the o-ring has to be cleaned with alcohol.

- Open the manual valve NIR-GP-V3 to regenerate the vacuum lost in this section to the previous level, around 10-5mbar.

- Once the vacuum is reached open the electro-valve NIR-GP-V1.

13 Opening the instrument

After pressurizing the vacuum tank volume:

1. Install the stiffener beams to the detector cryostat. It can be tricky to install because the beams have to go through the pieces of multilayer of the DS.
2. Remove the vacuum hardware that will collide with the vacuum tank door when opening it.
3. Disconnect the electronic connectors from the DS.
4. Disconnect the orange optical fibers from the ROE.
5. Unscrew the bolts from the DS flange but 2.
6. Unscrew the bolts from the vacuum tank door except the one near the opening handle.
7. Prepare the DS tool number 2.
8. Open the VT door, it is necessary at least 3 people (A, B and C), 4 is the best:
   - Person A holds the DS using the bayonet while person B unscrews the 2 remaining bolts.
   - Person C unscrews the remaining bolt from the VT door and opens it slowly.
   - When the door is half opened person C holds the DS.

- Person B screws the part from the tool 2 that goes to the DS while person A fully opens the door.
- Person B joints the other part from the tool 2 to the first part, using a key number 32 turns the nut until compensate the weight that the person C is doing.

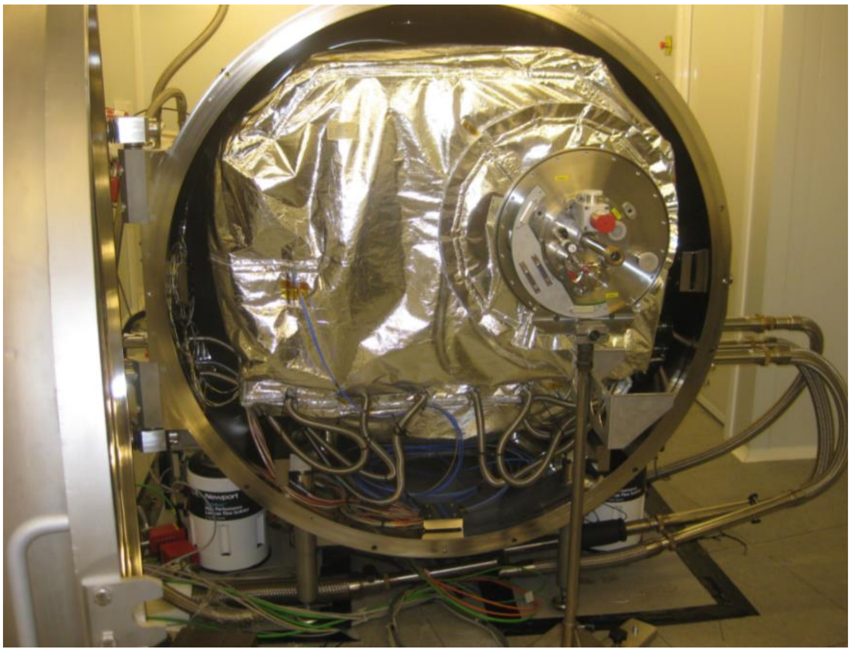

Image 40: NIR cannel with the front door opened

14 Water condensation evacuation

When opening the instrument after a cooling cycle it is possible that there is some water condensation inside the cooling pipes. Therefore, as a general procedure, water condensation will be removed using an external pumping group.

If the pumping group is powerful enough it can be connected to the three cooling lines at the same time using the appropriate pieces of hardware to connect them, on the other hand it can also be connected individually to each one of the three cooling circuits but in this case it will take longer as it needs a three overnight (12 hours) runs to evacuate the water condensation.

Next picture shows 2 pumping groups connected to 2 cooling circuits at the same time:

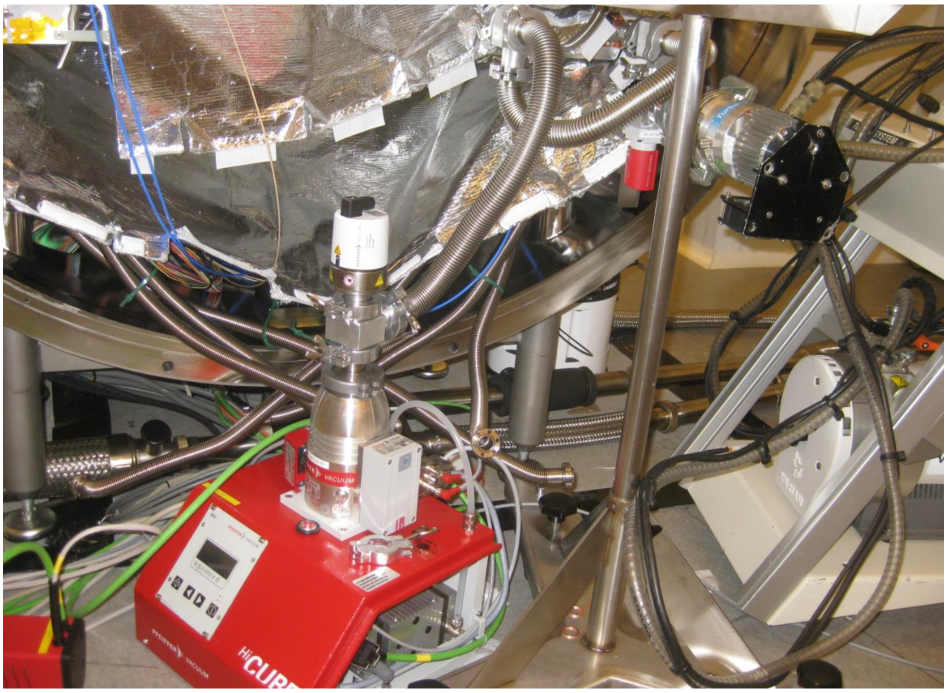

Image 41: Pumping group layout to evacuate water condensation form the lines

15 Regeneration of the vacuum lines

When the different type of vacuum isolated lines, LN2 feed lines and N2 transfer lines, show signs of losing the vacuum isolation with ice on different areas and also changing the performance of the instrument, it is time to regenerate the lines.

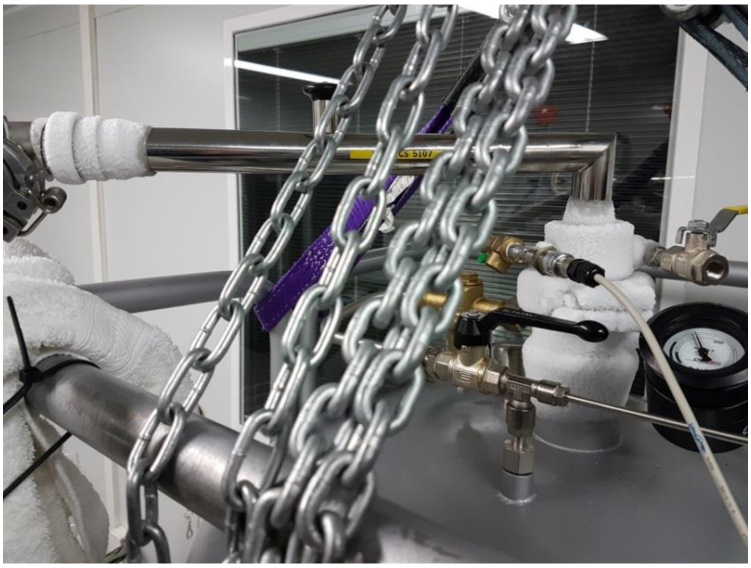

Image 42: Signs of degradation of the vacuum in the siphon

Image 43: Signs of degradation of the vacuum in the transfer lines

To do so there is a special tool designed to evacuate the lines, it is also necessary an external pumping group with a detachable turbo pump to install it near the tool and also a pressure sensor to control the vacuum rate. The procedure is the following:

- Attach the regeneration tool to the line pumping port.
- Screw the bar from the pumping tool to the valve of the line.
- Connect the turbo pump and the pressure sensor to the regeneration tool.
- Start pumping the tool to obtain a good vacuum level around 10-6mbar.
- Pull the bar to open the valve from the line, at that moment the vacuum level will get worse.
- Keep it pumping until the pressure inside the line is better than 5·10-5mbar.
- Push the bar to isolate the vacuum in the line.
- Turn off the turbo pump and dismount the regeneration tool unscrewing the bar from the valve.

Next pictures show the pumping tool mounted in to different scenarios:

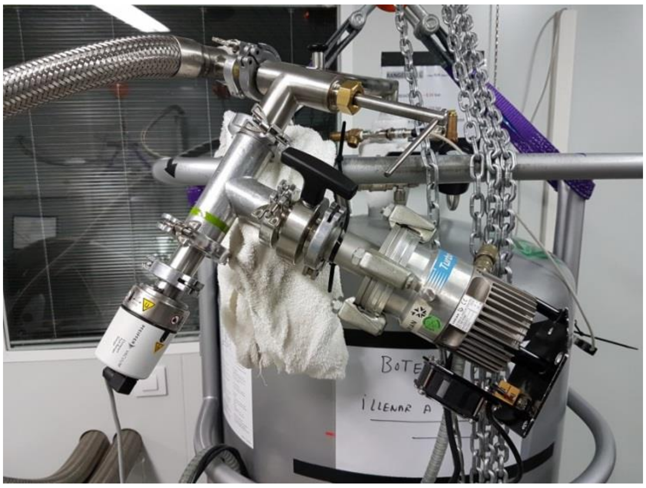

Image 44: Regeneration of the siphon

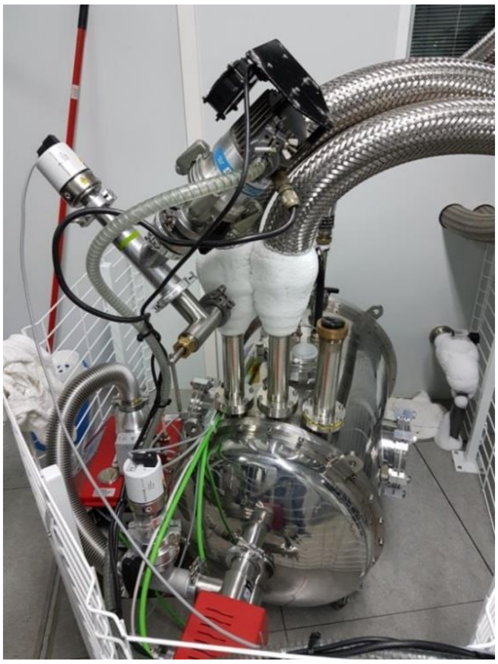

Image 45: Regeneration of the transfer line