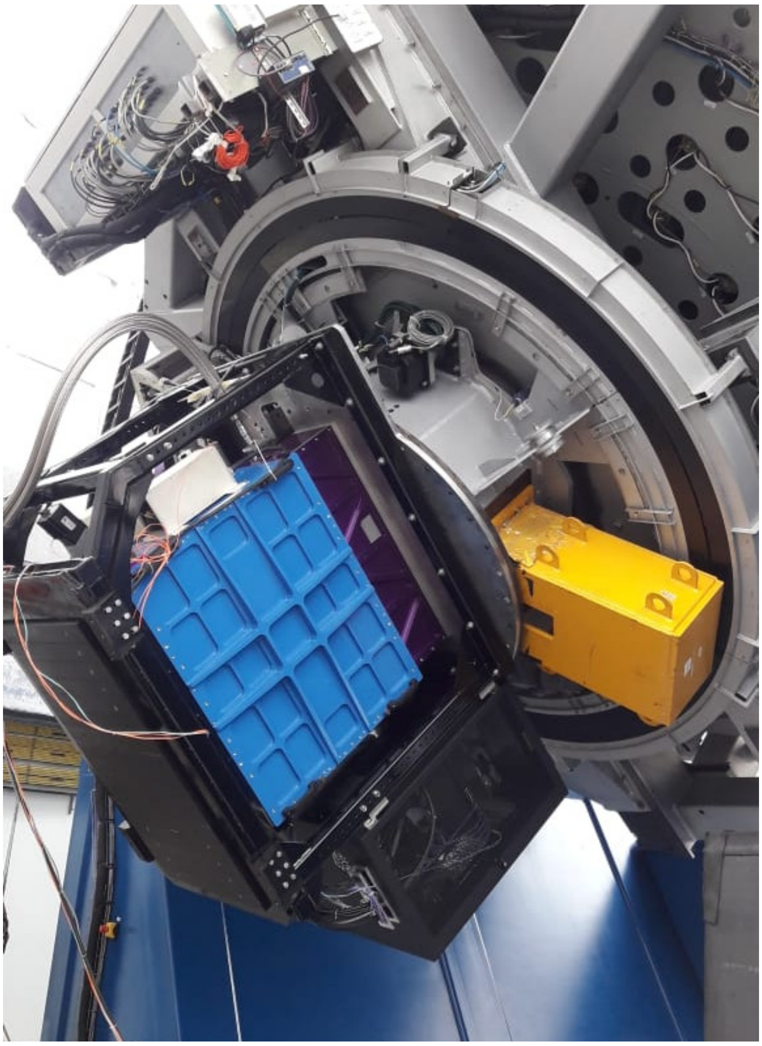

Technical Document
TANSPEC Operation Manual

Version 2.0

Saurabh Sharma (ARIES), Nainital, D K Ojha (TIFR), Mumbai and Douglas Toomey (MKIR), Hawaii

July 25, 2022

Contents

1 Introduction

This manual “TANSPEC-Operation-Manual.pdf” is for the day to day operation/run of TANSPEC.

(a) If you want to know about TANSPEC instrument, plz refer : TANSPEC-Instrument-Paper.pdf[1]

(b) If you want to do night-sky obsevations from TANSPEC, plz refer : TANSPEC-Observation-Manual.pdf[2]

(c) If you want to know day-to-day TANSPEC operations, plz refer: TANSPEC-Operation-Manual.pdf[3]

Recent updates on TANSPEC are available at TANSPEC instrument Page[4].

For any queries, please email: Dr Saurabh (saurabh@aries.res.in), ARIES or Prof D. K. Ojha (ojha@tifr.res.in), TIFR.

2 Safety

2.1 Danger to people

2.1.1 Liquid Nitrogen handling

TANSPEC is a cryogenic instrument. Liquid cryogenics represent a burn hazard and a suffocation hazard. Personnel working with the instrument must receive formal training in the handling and use of liquid cryogenics.

2.1.2 Liquid Nitrogen suffocation hazard

During accelerated cool-down using the LN2 pre-charge can will consume more than 160 liters of liquid nitrogen. When the liquid nitrogen is consumed it becomes nitrogen gas at a ratio of about 700:1. This nitrogen gas can displace the oxygen in the air reducing the partial pressure of oxygen, creating a suffocation hazard. Cool-down should be performed in a large room with adequate ventilation. If in doubt calculate the oxygen partial pressure reduction based on the room volume and the added nitrogen gas volume of 112 thousand liters to the room.

[1] https://aries.res.in/sites/default/files/files/3.6-DOT/Tanspec-Instrument-Paper.pdf
[2] https://aries.res.in/sites/default/files/files/3.6-DOT/Tanspec-Observation-Manual.pdf
[3] https://aries.res.in/sites/default/files/files/3.6-DOT/Tanspec-Operation-Manual.pdf
[4] https://aries.res.in/facilities/astronomical-telescopes/36m-telescope/Instruments

2.1.3 Explosion danger

Under certain circumstances an ice plug can develop in the LN2 can neck tubes or filling manifold. This can create an over pressure in the LN2 can sufficient to cause it to burst. If this happens the vacuum jacket can blow apart and could injure or kill someone nearby.

LN2 is so cold that as air enters the neck tubes it reduces in volume and water vapor and CO2 will freeze. If sufficient gas freezes it will plug the tube. This is a form of cryopumping.

This has happened twice with cryostats of similar design. The first case was a hybrid design similar to TANSPEC except that the closed cycle cooler was attached to the cold structure. During cold weather the cooler was capable of bringing the temperature of the cold structure and LN2 precharge can below the freezing point of LN2 so there was no boil off gas. This cryostat was equipped with a cover plate for the LN2 can that sealed the neck tubes and was equipped with a check valve to vent gases in the case of a warm up. After 10 years of use the O-ring in the check valve became cracked. There was a forest fire nearby that caused the telescope to be evacuated and then the power failed for an unknown amount of time and then was restored. Some combination of these events caused an ice plug. The liquid nitrogen can ruptured explosively and the vacuum jacket blew apart. The bottom portion of the vacuum jacket was found against the wall of the observing floor. About 150 screws were stripped.

The second time was also a cryostat that was capable of cooling the the liquid nitrogen precharge can to below the freezing point of LN2. This cryostat also suffered an explosive failure that blew apart the vacuum jacket. In this case the fill neck cover was replaced by the day crew but the design was so that cover did not have tubes going down into the LN2 can. This allowed it to be installed 90 degrees rotated such that the O-rings did not seal the necks. Both necks developed ice plugs and the can failed.

TANSPEC has a different design that makes this situation much less likely. The closed cycle cooler only cools the radiation shield. The inner cold structure is cooled with the LN2 can. In the lab in Hawaii the shield never went below 77 K so there was always sufficient boil off in the LN2 to continually purge the neck tubes with dry nitrogen gas. At ARIES in the winter the temperature will be much lower so we will have to monitor the temperature of the shield and the LN2 boil off. We may need to adjust the closed cycle cooler gas pressure to reduce cooling so that we can maintain a gas flow in the necks.

Also it is important to have a long rubber hoses on the fill port tubes so that the water vapor condenses and/or freezes in the rubber tube not the necks. We recommend one long tube be plugged at the far end from the neck and the other plugged as well but a 2 cm slit cut at the plugged end. Both plugs are removed for initial filling.

2.1.4 Calibration lamp voltage danger

The calibration lamps operate with 300 volts DC between the lamps and the power supply that is located in the enclosed area above the cryostat. The power supplies are powered with 120 volts AC that originates in the electronics rack and travels through the cal box cable.

2.2 Danger to TANSPEC

2.2.1 Closed cycle cooler contamination

For the closed cycle cooler to function it requires very pure Helium. Five 9s or 99.999% pure helium must be used. Any impurities will freeze in the cold head which has close tolerances. When this happens the cold head makes a crunchy noise and as it gets worse more of a banging noise. This will shorten the life of the cold head and reduce it's cooling power. Contamination most often is caused by:

Improper purging of the regulator Improper tightening or loosening of the helium hoses Leaks developing in the helium lines Improper maintenance of the helium compressor

The manual covers these issues and they must be taken seriously.

Decontamination involves venting and refilling the helium gas 25 times. This is costly and time consuming. The contamination will collect in the cold head so it can be cooled and then disconnected not at the cold head but at the first set of lines.

The cold head must never be disconnected while cold without one set of lines attached. As the gasses inside the cold head warm up they expand greatly and will create dangerously high pressures in the cold head. The warm lines reduce this pressure.

2.2.2 Electrostatic discharge (ESD)

The Detectors in TANSPEC are very expensive and can be destroyed by one touch from something statically charged like your finger. The array electronics and most of the rest of the electronics are also static discharge sensitive. Consistent ESD procedures must be established and followed when working with the instrument.

The Instrument should be grounded at all times particularly when it is not on the telescope. Before any spare board is plugged into the array controller it must have its ground connected to the cryostat ground before it is plugged into the back plane.

Wrist straps should be used when working on the instrument. This is most important when working on the array controller. This connects directly to the arrays so ESD to the array controller can destroy the detectors.

2.2.3 Calibration lamp power supplies

The calibration lamp power supplies will fail if powered up without a lamp installed.

2.2.4 Calibration lamps

The calibration lamps have a limited life and should not be left on when not being used.

2.2.5 Fill port manifold

The fill port manifold is made with 0.125 mm thin wall stainless tubing. This is a vacuum brazed double wall assembly that is expensive and takes quite a while to make. It will be damaged if banged or if the rubber tubes are pulled on.

3 Cryostat Evacuation

The cryostat should be pumped down every time before cooling. It may require periodic warm-up and pump-down if it is kept cold for long periods of time. The vacuum will improve with time but there will always be some out-gassing from the warm inner surface of the vacuum jacket.

The preferred setup for pumping is to connect a three-way or four-way manifold to the cryostat valve. The other ports would have a high vacuum gauge, a low vacuum gauge and a second valve connected. A 70 l/min turbo pump is connected to the valve. This is shown below.

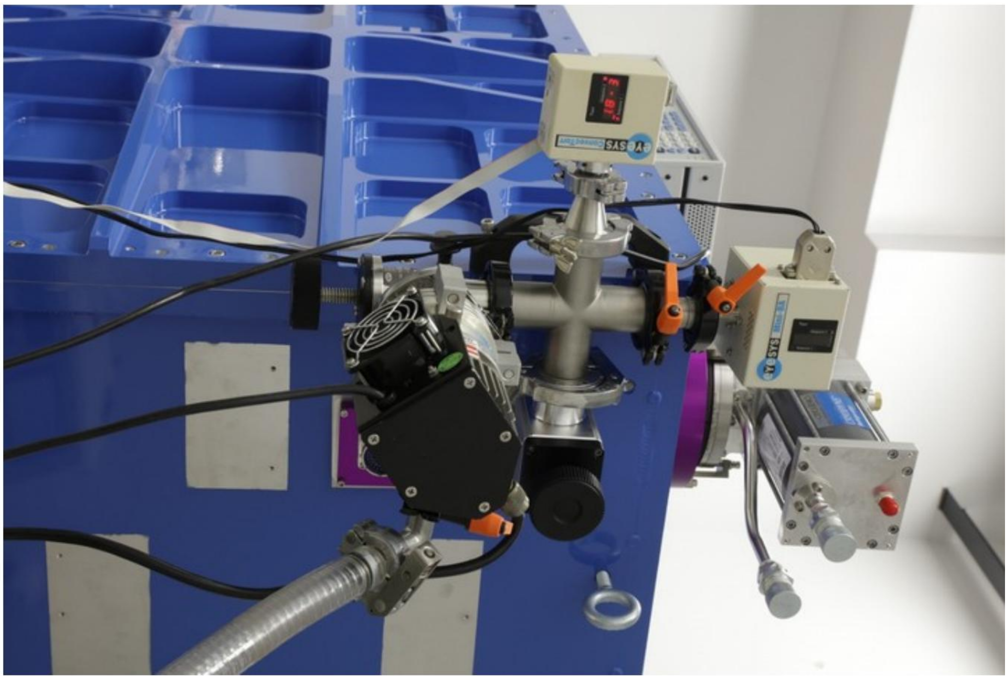

Figure 1: Four-way manifold.

Using the manifold in this manner you can check the pressure in the cryostat without venting it. Evacuate the manifold with the cryostat valve still closed and then close the outer valve isolating the turbo pump. Then open the cryostat valve and read the pressure. Close the cryostat valve and then pump the manifold down. When it reaches the cryostat pressure open the turbo valve.

The other advantage of this manifold is that it lets you measure the over night leak back rate using intermittent pumping. This is also preferred if the pump station does not automatically valve off if power is lost.

3.1 Intermittent pumping

This method is a bit safer because you only pump during the day while you can monitor the equipment and watch for power failures. This is my preferred method when the cryostat has been vented to atmosphere for service.

First day pump for a few hours down to at least 10^{-3} Torr. Valve off and turn off the turbo. Second day - check the vacuum level in the cryostat as described above. It should be about 3×10^{-1} Torr. Pump for 3-5 hours down to about 10^{-4} Torr. Third day is usually in the 10^{-2} range with time it may get lower than this

Continue in this manner measuring the leak back rate every day.

How many days is up to your schedule. After the third if you wish to cool the instrument sooner just pump longer. The cryostat will eventually get down to 10^{-5} but that depends on the pump and the location of the pressure gauge.

Record the leak back pressure and you will know what to expect.

When you are down to the low 10^{-4} Torr or 10^{-5} range after a couple of days of pumping at least you can cool down. The cryostat will cool-down at higher pressures but you run the risk of plating the optics with a thin layer of frost which can degrade performance. The closed cycle cooler has a second stage that cools down to 12 K and has an activated charcoal getter that will cryopump most gases. Still it is better to have a clean Dewar before you cool. If you are planning to leave the cryostat cold for months it is more important to pump longer before cooling. Perhaps 5 days but even more will help.

4 TANSPEC cabling

4.1 TANSPEC external cabling

TANSPEC external connections are Facility line power, Ethernet switch fibers, Fibers from the array controllers to the computer and helium lines and power for the closed cycle cooler as shown below.

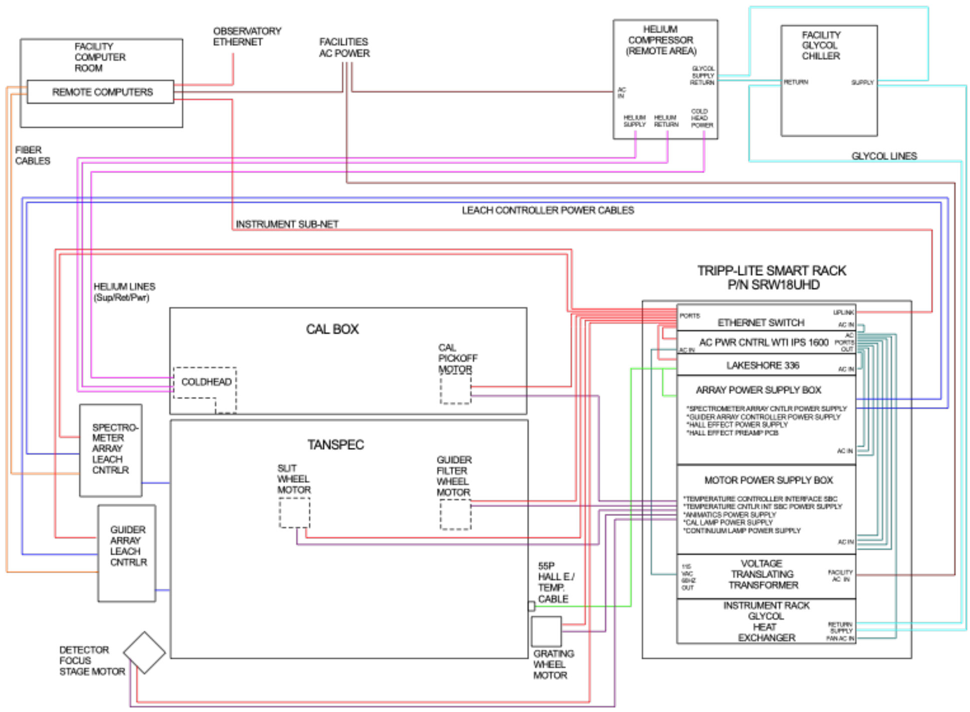

Figure 2: TANSPEC external cabling.

4.2 TANSPEC Internal cabling

ARIES facility line power is provided through a AC power cable with a twist lock that is located on the back of the electronics rack on the cryostat side. The connector is shown below.

Figure 3: AC power connector.

The AC line in goes to the power transformer to convert the facility power to 115 volts for all of the equipment in the rack. The transformer powers the two banks of outlets on the network power switch WTI NPS-16HD. The WTI can switch the AC power for 16 outlets remotely via a browser page or from within the TANSPEC software.

Figure 4: Power transformer.

4.3 WTI Switch

The WTI has two banks of outlets labeled A1-A8 and B1-B8. Each item in the rack must plug into a specific output on the WTI. These are listed below:

- A1: Spectrometer array power
- A2: Guider array power
- A3: unused
- A4: unused
- A5: Fan Power Glycol [5]
- A6: Hall Power
- A7: Continuum lamp 1 Hot
- A8: Argon lamp
- B1: Ethernet switch [6]

[5] There are two fans on the Glycol heat exchanger – presently unplugged

[6] This is normally left on since if it is powered down you will not be able to connect with the WTI to turn it back on.

- B2: unused
- B3: unused
- B4: Lakeshore
- B5: Fan Power Glycol
- B6: Motor Power
- B7: Continuum lamp 2- cool
- B8: Neon lamp

A6-A8 and B6-B8 control the calibration lamps, hall effect pre-amp power and motor power. These are located on the back of the power supply box.

Figure 5: Array power supply.

Figure 6: Hard switches for lamps, motor and hall sensors.

4.4 Motor cables

The motor cables are unique to each motor. Not shown is the focus motor 104

Figure 7: Motor power cables.

Figure 8: Different motors along with LAN connectors.

4.5 Temperature/Hall sensor cable

There is a utility 61 pin hermetic connector that brings the hall effect signals and the temperature sensor cables out of the cryostat. The connector is next to the grating motor.

Figure 9: Temperature/Hall sensor cable.

One end of the cable goes to the cryostat connector labeled util. The other end has one connector that goes to the power supply box. This brings the hall sensor voltages to the hall effect preamplifier. The rest of the cables go to the Lakeshore temperature controller.

Figure 10: Lakeshore temperature controller.

There are four inputs A,B,C and D. A is the spectrograph detector, B is tbe guider detector, C is the spectrograph cold structure and D is the Radiation shield. Output 1 heater goes to the Spectrograph detector and Output 2 heat goes to the guider heater.

4.6 Calibration Box cable

The Calibration cable goes from the calibration unit on the top of the cryostat to the bottom left side on the back of the power supply box. It carries the control wires for the continuum lamps and the calibration lamps.

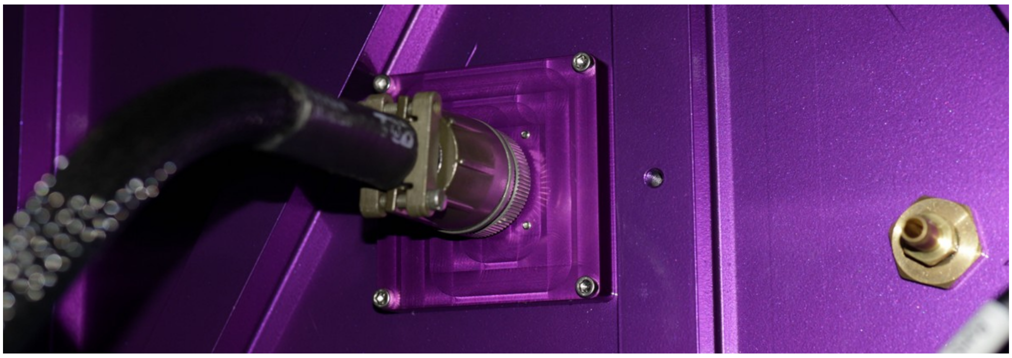

Figure 11: Calibration box cable.

4.7 Guider array controller Power cable and the Spectrometer array controller power cable.

These two cables are the same although one is longer than the other. One runs from the spectrometer power supply to the spectrometer array controller and the other from the guider power supply to the guider array controller. Connect to the power supply first so the cable is grounded.

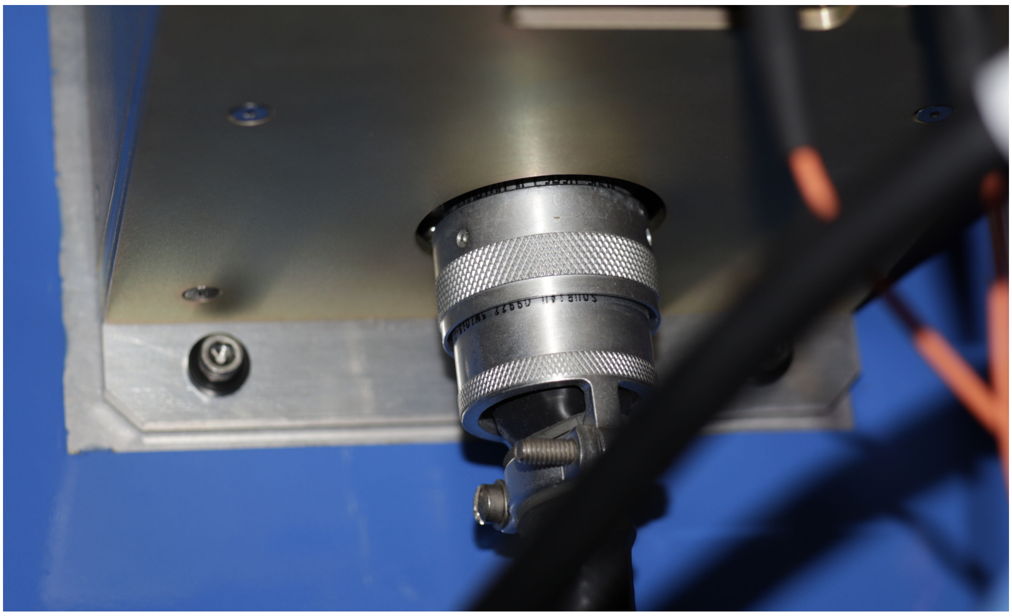

Figure 12: Array power cable.

Guider Array cable array controller to cryostat and Spectrometer Array cable array controller to Cryostat Danger! The array can be damaged if any static electricity were to be conducted to the pins on the cryostat. The array could be destroyed.

4.8 Shorting plugs

There are shorting plugs that should be used when there are no cables connected. This is shown below:

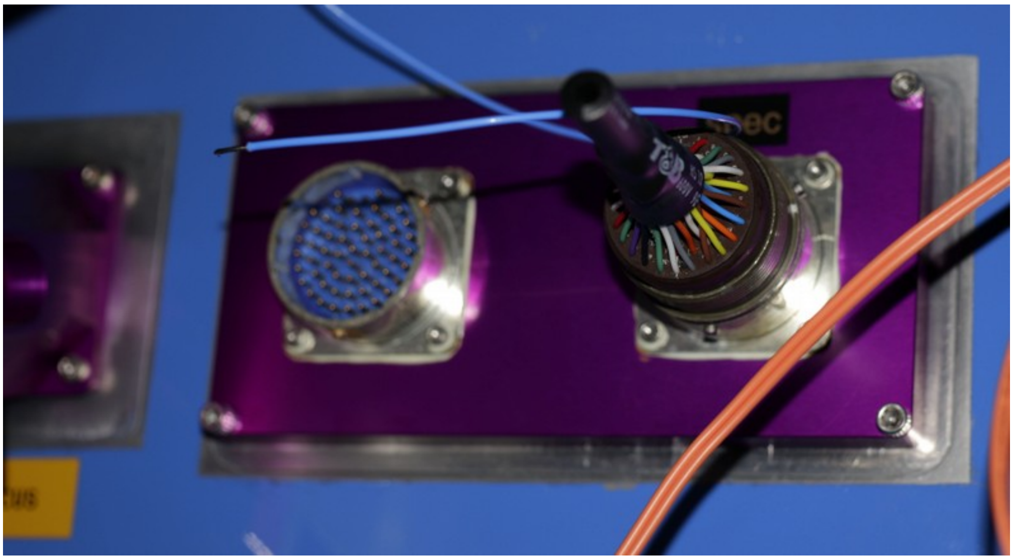

Figure 13: Shorting plug for spectrograph array.

The spectrograph has two connects to allow an upgrade to 32 outputs but only the connector on the right is used for now.

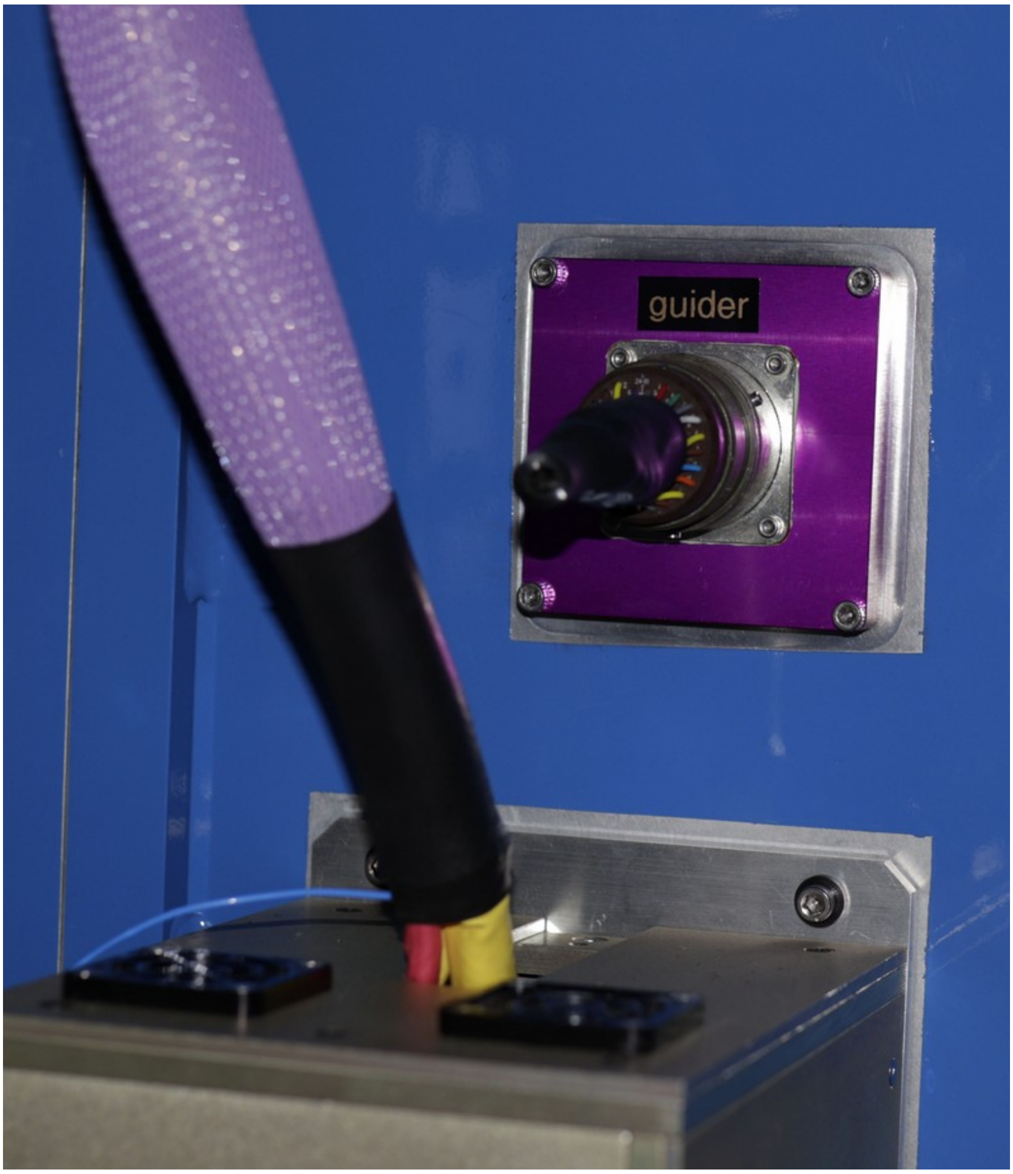

Figure 14: shorting plug for imager array.

The purple braid cable coming from the array controller plugs into the 61 pin hermetic connector which goes straight to the array. Care must be taken with the alignment of the connector to make sure that it is straight. Push inward and rotate the bayonet clamp until in engages but continue to push the cable in rather than use the bayonet so that you can feel if it is not going in evenly. Is is easy to bend a pin on these connector so great care should be used when connecting them.

4.9 Ethernet cables

Ethernet cables are needed between the Cisco switch and the following:

- WTI
- Lakeshore
- Motors(5 quant)

There is an Ethernet switch in the instrument rack and one in the control room rack. They are connected with a fiber cable and the blue cable to the internal NIC on the computer.

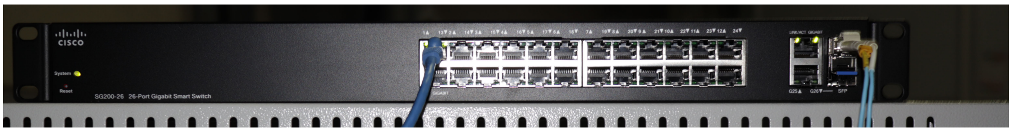

Figure 15: Ethernet switch.

4.10 Cryostat cold head motor cable

There is a cable that runs from the closed cycle cooler compressor to the cold head on the cryostat.

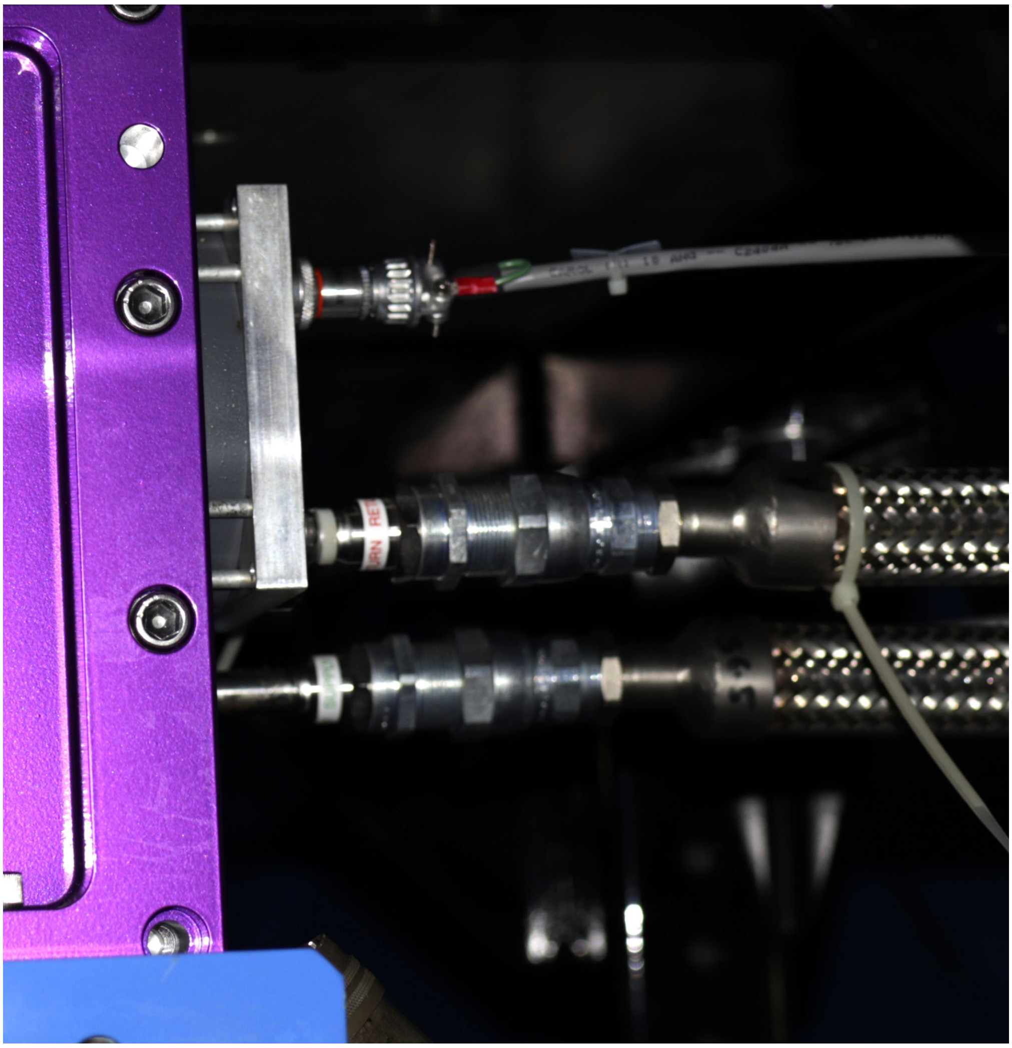

Figure 16: Cryostat cold head motor cable connector.

4.11 Fiber cables

Guider array controller fiber cables and the Spectrometer array controller fiber cables

Each array controller is connected back to the computer in the control room with a pair of fibers. The guider controller should connect to the guider PCIe interface board and the spectrometer to the spectrometer board. If the fibers are connected backwards the will be a red light on the fiber board in the computer switching the fibers should make the light go out which is the normal state.

Figure 17: TANSPEC PC and imager/spectrograph OFCs (orange).

The purple Ethernet cable connects to the observatory network and the blue cable connects to the instrument subnet.

5 Cooling

Connect two rubber hoses 3/8 inch or 9 mm to the fill port tubes. Remember to be gentle with the tubes. Secure with a zip tie or hose clamp(do not over tighten). The rubber tubes should be about 2 feet (0.66 meters) long. Both are left un-plugged.

Shown in the picture below is a 50 liter transfer tank that we use in the lab. It is important to have short lines to the cryostat. Longer lines can use much more LN2.

The storage tank is pressurized to 7 psi using a tank of nitrogen gas which is left connected for the initial cool-down. Once the cryostat is cold the storage tank self pressurizes to 10 psi and the nitrogen gas is not needed until the tank is refilled.

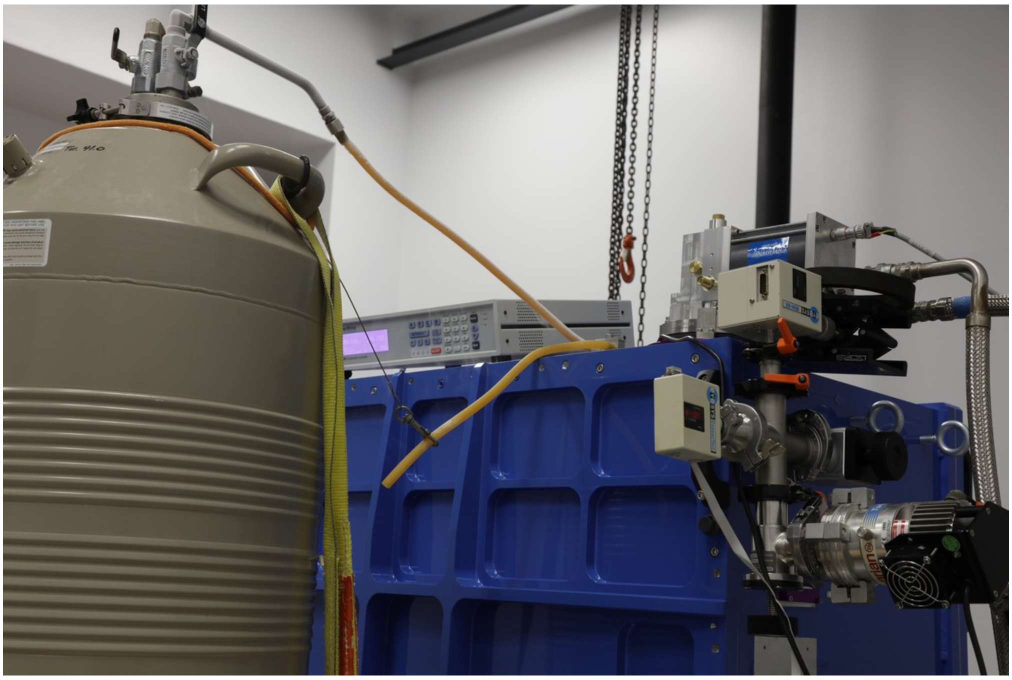

Figure 18: LN2 filling arrangment.

With this arraignment open the valve on the storage Dewar and nitrogen will flow into the LN2 can. The humidity was about 70

After the first cool-downs we designed and installed a drainage try that will be installed at ARIES. You can see that the rubber tubes get covered with frost and this melts when you stop flowing LN2. The drainage tray directs this away from the cryostat and motors.

Figure 19: LN2 filling pipe.

The frost should not extend lower than shown below. If it does you run the risk of freezing the O-ring which shrinks and causing a vacuum leak. If your humidity is lower things may look different.

As the cool-down proceeds some where between 50 and 100 liters the venting volume will increase. This is because the LN2 can is getting to around 77 K and the LN2 starts to wet the inner surface of the LN2 can. This increases the heat transfer and increases the boil off rate. This is normal but if it is too violent or the manifold is getting too cold you should back off the pressure in the LN2 storage tank.

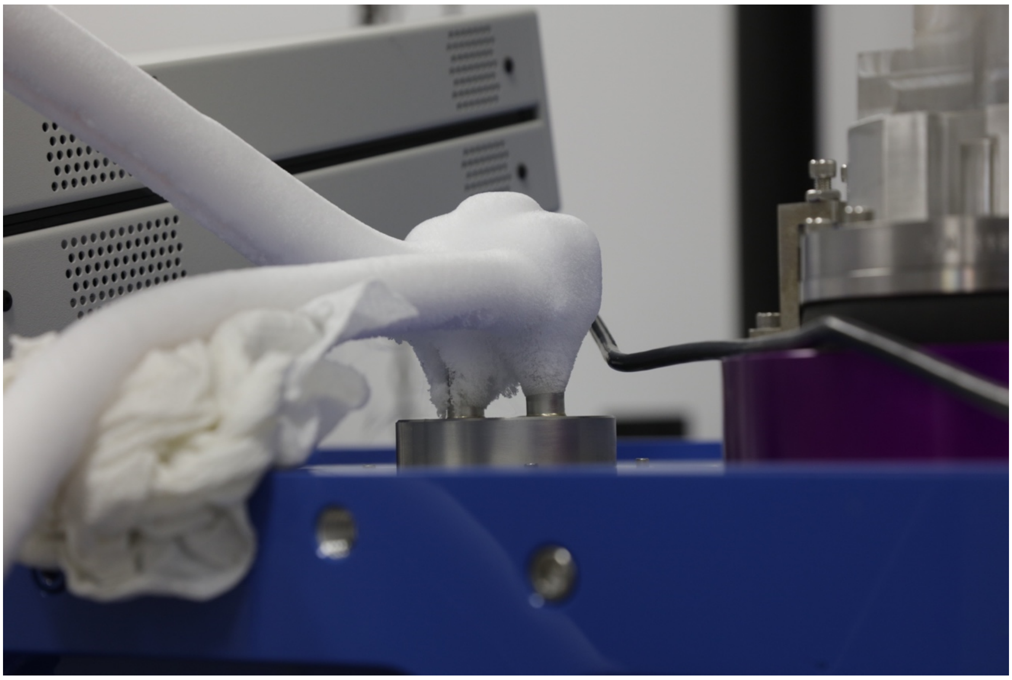

Figure 20: LN2 filing pipe.

Eventually you will hear a change in the venting and the tube will start spitting liquid. Turn off the feed valve on the storage tank. There will still be a rapid build off and this liquid will boil away in a few hours. When the boil off vent drops off open the valve and re fill the LN2 can. This will also boil off but will take much longer. By the time you have put 150 liters into the cryostat the boil off will be quite low but it takes about 24 hours for the mechanism wheels to cool down. So the boil off will remain a bit elevated until the mechanisms equilibrate.

The can has a volume of about 14 liters and needs to be filled about every 4-5 days depending on the ambient temperature.

6 Power Up Procedure

This procedure assumes that the cryostat is cold and that the array cables are plugged in. There is no required power up sequence for the instrument but in order to be consistent it is best to have one that we follow. Power can be controlled by the individual power switches on each unit and can be controlled by the WTI.

1. First using a browser login to the WTI (HTPP://10.0.1.10) Verify that all outputs are off except for the Ethernet switch on B1.

2. At the cryostat turn on the following in the electronics rack.
   - Spectrometer array controller power supply
   - Guider array power supply
3. All six switches on the back of the power supply box (lamps, motors and hall pre-amp) Lakeshore temperature controller
4. Then using the WTI through the browser turn on the following in sequence.
   - Lakeshore controller
   - Motor power
   - Hall effect power
   - Guider array power supply
   - Spectrograph power supply
5. The WTI can also be controlled by the command line in the GUI in the following way:
6. From the command line: power
   - all off | on
   - arrays off | on
   - lamps off | on
   - motor off | on
   - argon off | on
   - cont1 off | on
   - cont2 off | on
   - neon off | on
7. Examples:
   - powerarrays off
   - powermotor on
   - powercont2 off
   - powerneon on

7 Power Down Procedure

Using the WTI power down the following:

1. Spectrograph power supply
2. Guider array power supply
3. Motor power
4. Lakeshore controller
5. Hall effect power
6. All four cal lamps

This is sufficient for a nightly power down.

If powering down for a longer period this should be followed with turning off all the power switches in the instrument rack for the same items:

1. Spectrograph power supply
2. Guider array power supply
3. Motor power
4. Lakeshore controller
5. Hall effect power
6. All four cal lamps

8 Warm up of the instrument

To warm up the instrument power down as described above including turning off all of the physical power switches except for the Lakeshore so you can monitor the temperatures.

Turn off the closed cycle cooler compressor. The nitrogen in the inner can will boil off once the shield has warmed.

If it is then to be removed from the telescope the first section of helium lines should be left attached to the cold head to allow for gas expansion.

If it is removed from the telescope a grounding wire must be attached to the cryostat for safety.