C/KOSMOS

Operations Manual

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Revision History

Version	Version Authors	Date	Description
1.0	JE	April 2, 2014	Initial draft assembled from prior documents (authors as above)
1.1	JE	July 9, 2014	Various edits
1.2	JE	Sept 17, 2014	Minor edits; correlate with User Manual V1.4
1.3	JE	October 7, 2014	Add KOSMOS dewar alignment photo; other alignment info; update on instrument start-up & troubleshooting

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1 Introduction and Purpose

KOSMOS is the Kitt Peak Ohio State Multi-Object Spectrograph, a visible-wavelength spectrograph and imager at the 4-m Mayall telescope at Kitt Peak National Observatory. This instrument was built to provide a modern, high-efficiency spectrograph for the U.S. community that meets many of the scientific needs described in the ReSTAR (Renewing Small Telescopes for Astronomical Research) Report. KOSMOS was commissioned in October 2013. Figure 1 shows KOSMOS mounted in the Cassegrain Cage of the 4-m Mayall telescope.

Figure 1: *KOSMOS mounted in the Cassegrain Cage of the 4-m Mayall telescope.*

KOSMOS was built by a partnership between Ohio State and NOAO, and is largely based on the OSMOS (Ohio State Multi-Object Spectrograph) instrument at the MDM 2.4m Hiltner telescope. The heritage from OSMOS includes an all-refractive optical design that enables imaging, longslit, and multi-slit spectroscopy over a wide field, rapid

reconfiguration between observing modes, and the capability to have a wide range of slits, filters, and dispersers mounted simultaneously.

KOSMOS has a nearly identical twin named COSMOS (Cerro Tololo Ohio State Multi-Object Spectrograph) at the 4-m Blanco Telescope of the Cerro Tololo Inter-American Observatory. Except where noted otherwise explicitly, all contents of this manual apply to both instruments, even if only KOSMOS is named.

This manual is intended to describe operational tasks required to support the instrument; its target audience is therefore the NOAO scientific/mountain support staff, rather than the outside user. Support staff should also become familiar with the *User Manual*, as this provides a more complete description of the instrument and how it is used while observing.

2 Safety

This section summarizes safety hazards associated with KOSMOS and COSMOS, and describes the procedures and design modifications that have been adopted to reduce or mitigate these hazards. Unless indicated otherwise, all descriptions of hazards and mitigations apply to both instruments.

The tables below contain a column identifying the hazard, a column describing the hazard in detail, and a column describing the mitigation for that hazard. The first table comprises hazards posing a risk to personnel; these hazards may also pose a risk to equipment. The second table lists hazards that only pose a risk to equipment.

For some hazards, safety labels are provided as part of the mitigation. Subsequent sections in this manual will provide documentation on associated handling procedures; this document will be included as part of such manuals. In addition, mountain staff will be trained regarding instrument safety as part of the commissioning and acceptance of the instrument at each observatory site. *This document is not intended as a substitute for training, and any potentially hazardous procedures should not be carried out by un-trained personnel.*

General observatory safety procedures are not covered in this document, but should be followed at all times. *These include use of safety harnesses while installing equipment using the mirror lift.*

Note: this section of the manual replaces the “KOSMOS/COSMOS Safety Document”, which was last revised March 13, 2014.

Note: the list of labels should be cross-checked against the individual instruments and implemented where any are missing.

Personnel Hazards

Hazard Name	Hazard Description	Hazard Reduction/Mitigation
Instrument Weight	The instrument plus adapter have a combined weight of ~600 lb.	1) A suitable handling cart is provided, which includes provisions for installation/removal on the telescope 2) Installation and removal procedures will be documented; these are (by design) very similar to those for existing NOAO instruments. 3) Procedures for instrument disassembly will be documented. However, disassembly is expected to occur infrequently (less than once/year).
Tip Hazard on Cart	The instrument must be located on the cart at a height suitable for installation on the telescope and for servicing, which raises the center of gravity.	The cart design includes a steel baseplate intended to ensure that the cart will not tip over even if tilted 30 degrees [exact tilt TBC]. The cart caster locations have been moved to increase “footprint”. Cart casters are spring-mounted and appropriately sized.

Hazard Name	**Hazard Description**	**Hazard Reduction / Mitigation**
Rotation Hazards on Cart	1) The instrument is mounted on the cart so it can be manually rotated from vertical to horizontal on the cart with the telescope adapter removed. *However, attaching the telescope adapter creates a moment that does not allow safe manual rotation.* 2) The rotation of the instrument, even without the adapter, should be restrained manually until the locking pins are engaged	1) Provide safety labels for telescope adapter and locking pins (plungers) on cart. 2) Require 2 people to be involved when the instrument is rotated on the cart, unless the rotation moment has been verified to be acceptably small (normally the case when electronics+ dewar are installed; otherwise this precaution is necessary)
Sharp corners	In the cage, it is possible to hit one's head on sharp edges or corners of the instrument	1) Primary access to the instrument for changing masks, filters, etc. is through the side facing the cage door in the default rotator position. 2) The instrument design does not include corners likely to interfere with normal servicing. However, the instrument access will be reviewed after installation and padding can be added if required.
Adapter Weight	The adapter must be removed for major service, and requires lifting equipment due to its weight (~130 lb).	Safety label for telescope adapter, plus documentation of handling procedure (including lift points).

Hazard Name	Hazard Description	Hazard Reduction / Mitigation
Cryogen Hazards	The detector dewars use liquid nitrogen. Cryogen burns are possible; suffocation is possible but unlikely in the dome environment.	1) The dewars are standard observatory dewars, for which appropriate cryogen safety procedures have been established. KOSMOS and COSMOS will follow the standard procedures. 2) A fill tube extender will be attached to the dewar to provide better access (e.g, at the side of the instrument or near the cage door)
Electrical Hazards	The instrument electronics box contains standard AC line voltage.	The hazardous voltages are only exposed by removing covers. Safety labels will be provided. The electronics box can be disconnected from power if required.
Slew Hazard	The user software can request telescope motions; large motions (slews) can be hazardous if executed unexpectedly	In practice large motions never occur; if requested they will not be performed as slews (high speed)
Trip Hazard	Cables between connectors on the cage wall and the instrument can pose a trip hazard if not secured properly; tripping may damage the cables as well as injure people	Cables should run across floor of cage under a cable protector (Mayall), or in troughs under the floor (Blanco). However, the cables must be secured with enough slack to permit operation of the rotator throughout its range. Rotation should be verified at the time of initial instrument installation.

Equipment Hazards

Hazard Name	Hazard Description	Hazard Reduction / Mitigation
Collision Hazard on Cart	Electronics boxes on the outside of the instrument could be damaged if the cart collides with walls or door frames.	The cart base has been enlarged to define a “footprint” larger than the instrument.
Electrical Hazard to Detectors	Removal of detector controller from dewar creates a static hazard to the CCD	Safety label and training. Mountain staff have extensive training already regarding static hazards for CCDs.
Hazard from Moving Mechanisms	The mechanisms inside the instrument might move while a person is working on them. The motors driving the mechanisms do not have enough power to cause injury, and will stall. There might be contact with optical surfaces, however, which is not desirable.	1) Mechanisms cannot be accessed without removing access covers. 2) Motor motions can be prevented by disconnecting either the power cable or the Ethernet cable to the instrument electronics (preferred solution for day-time servicing). Alternatively, a second person can be stationed at the instrument’s computer console (preferred solution for night-time access). 3) All mechanism access, such as for filter or mask exchange, will be performed by trained observatory personnel (not by observers).

Hazard Name	Hazard Description	Hazard Reduction / Mitigation
Optics Hazards - Exposure	1) The instrument entrance port is "up-looking" and dirt, water and small objects can enter and contaminate or damage optics 2) The instrument rear port is open when the dewar is removed, and dirt, water and small objects can enter and contaminate or damage optics	1) There is a "dark slide" at the front of the instrument that should be closed when the instrument is not in use (i.e., during the day or when not installed on the telescope). The cover can be accessed for debris removal through the guider when the instrument is on the telescope. 2) There is a cover for the rear of the instrument that should be installed when no dewar is installed. The cover attaches to the side of the instrument when not installed, so it will not get lost. 3) There will be labels for the dark slide and the rear cover. 4) The covers and electronics boxes are not necessarily fully hermetic, and water can occasionally drip in the coudé lab storage area, so a cover for the instrument will also be provided, for use when off the telescope. This will provide additional dust protection.
Optics Hazards - Handling	The instrument is designed to allow slit masks, filters, and dispersers to be exchanged, but they can be damaged if they are mishandled, and may also damage other optics elements if dropped on them.	1) All exchanges will be performed by trained observatory personnel. 2) All optics will be installed in their cells prior to the exchange; the cells are designed with captive screws through access covers. 3) Disperser exchanges are scheduled in advance and performed only during the day-time.

Hazard Name	Hazard Description	Hazard Reduction/Mitigation
Dewar Installation Hazard	The clearance between the rear of the spectrograph camera and the front of the dewar is only ~4 mm. There is thus potential for damaging the dewar window or the rear lens of the camera during installation.	1) Final element of camera is slightly recessed inside camera barrel. Dewar window is recessed inside faceplate. 2) The dewar assembly will be aligned to rear of instrument using alignment pin and installation jack; this allows careful and repeatable installation. 3) Dewar installation is scheduled in advance, performed only during the day-time, and only by trained observatory personnel.
CCD Exposure to Light	The LBNL CCD can be damaged by exposure to high light levels when powered on.	The constraints imposed by this hazard are not yet well-defined, but it appears probable that there is no astronomical observation that will damage the CCD. Appropriate procedures will be established once the hazard is quantified, which are likely to require either powering down the CCD or implementation of a special erase mode while the instrument is being serviced (including filter and slit mask changes). This hazard applies only to the LBNL CCD; there is no such hazard associated with the e2v CCD.
Cass Rotation Hazard - Cables	The KPNO cassegrain rotator cannot safely rotate over large angles (many degrees) when the telescope is not at zenith, due to the design of the rotator cable wrap-up.	Until the cable wrap-up is modified, all rotations greater than 1 degree will be done at zenith. This restriction does not apply to CTIO.

Hazard Name	Hazard Description	Hazard Reduction/Mitigation
Cass Rotation Hazard - Drives	The cassegrain rotators on both telescope may suffer drive damage if the moment around the rotation axis is too large.	Provide appropriate ballast weight for the instrument to ensure rotation moment is within specifications [<150 ft-lb; weight design balances to 50 ft-lb].

3 C/KOSMOS Installation and Removal

This section covers the installation of the instrument on the telescope, its removal, and the installation of the CCD dewars on the instrument. This section, as well as sections 4-6, includes material from two prior documents: the "KOSMOS Installation and Removal" document, last revised March 13, 2014, and the "Dewar Installation and Operation Document", last revised April 1, 2014.

3.1 C/KOSMOS Installation

This section describes the detailed procedures for installing and removing KOSMOS and COSMOS from the 4-m telescopes. *Unless explicitly stated otherwise "KOSMOS" refers to both instruments and the procedures are the same for both telescopes*.

All procedures described below should be carried out by 2 people, except for cabling and wiring. For some procedures an additional person may be helpful but is not essential.

For reference, keep in mind the following weights:

KOSMOS Weights

Component	Weight, lb (kg)
KOSMOS instrument, with electronics and counterweight	530 lb (240 kg)
KOSMOS telescope adapter	145 lb (66 kg)
KOSMOS cart	445 lb (202 kg)

3.1.1 Preparation for Installation

KOSMOS is installed on the telescope while oriented vertically on its handling cart, with the telescope adapter attached. It will normally be stored in this configuration, with a water-resistant cover over the instrument.

The figure below shows the instrument, with several components that are referenced in the text appropriately labelled.

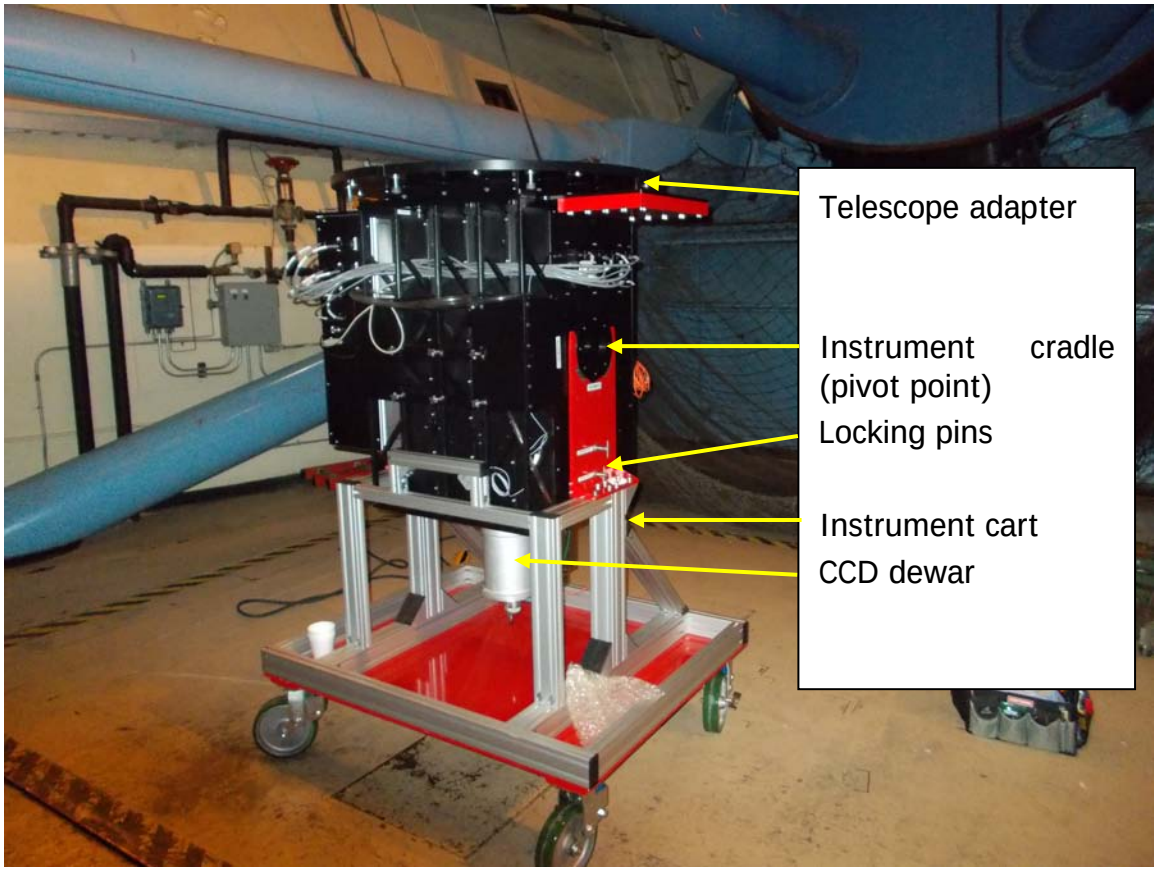

Figure 2: *KOSMOS on handling cart, on mirror lift with dewar installed. This is the normal orientation for storage, and the required orientation for installation. Several elements referenced in the text are labelled. This view is from the side opposite the access hatches. The CCD dewar shown is a KPNO dewar used on KOSMOS; the CTIO dewars (SOI style) for COSMOS are larger and colored black.*

Note – for extended laboratory testing, the telescope adapter may have been removed, and the instrument then rotated to the horizontal position. See steps below if this is the case.

Figure 3: *COSMOS on handling cart; note the different dewar design. This figure shows the instrument in the horizontal position with the adapter plate removed.*

Assuming the instrument is in the vertical storage position, it is prepared for installation by removing the cover and performing a visual inspection of the mounting surface and area around the dark slide (see last step, below).

The CCD dewar may be left installed on the instrument while it is stored, in which case it can be left on the instrument for installation on the telescope. If not, it should be installed on the instrument after the instrument is installed on the telescope, as described below. It is recommended that the dewar be cooled down prior to installation, following standard procedures for KPNO or CTIO CCD dewars (see section 4, below). This should be done whether the dewar is installed on the instrument beforehand, or subsequently.

If the instrument is oriented horizontally, it should be rotated to the vertical position. If the telescope adapter is attached (which is unlikely), it must be removed in order to rotate the instrument safely, because the instrument is in or near balance only with the adapter removed. It is not recommended to store the instrument in the horizontal position, because the cover won't fit, and therefore it is unlikely to be horizontal unless it has just undergone maintenance.

Removal of adapter (if required). Two straps should be attached to 4 eyebolts that in turn are fastened to the adapter using holes in the outer bolt circle at approximately 90-degree intervals, with one strap on the upper pair and one on the lower pair. A hoist is

used to take up the weight of the adapter using the upper strap. (The lower strap is not required for removal, so if the adapter will not be re-installed immediately, it can be omitted.) The bolts attaching the adapter to the instrument are then removed. These are accessed through the top plate (surface attaching to the telescope) of the adapter. Once the adapter is removed, it can be lowered to the ground. *Note* – alternative arrangements are acceptable, provided the adapter's orientation is properly constrained.

Rotation of instrument (if required). The 2 locking spring-pins on the carts that retain the instrument in the horizontal position are retracted and turned to lock them in the "out" position. The instrument is then rotated to vertical by one person while the second person rotates and inserts the spring pins for the vertical position.

Note that, while horizontal, the instrument rests on a cross-bar and will not rotate spontaneously when the locking pins are removed. This is not the case when the instrument is vertical and the instrument must be manually restrained until the locking pins are inserted. The instrument imbalance is small, so lifting equipment is not required for this purpose. The CCD dewar can be installed before rotating to the vertical position, although this is not required.

Installation of adapter (if required). Prior to attaching the adapter, inspect the surface of the instrument front plate and the area around the dark slide and make sure they are clean – wipe them off if necessary.

For purposes of installation on the telescope the adapter should be installed when the instrument is vertical. This requires the same arrangement of eyebolts and straps used for installation, except that the adapter is lifted using both straps, so it remains horizontal. The adapter is then aligned with the top of the instrument, and bolts are inserted through the top and partially threaded. The hoist is then lowered so the adapter weight is fully borne by the instrument and the bolts are tightened. Remove the straps and eyebolts.

The height of the instrument on the cart is such that it may be helpful to use a small stepladder or stool when fastening the adapter.

Inspection. If a visual inspection was not already performed (see preceding step), check the mounting surface of the adapter and the area around the instrument dark slide; clean is necessary.

3.1.2 Installation on Telescope

KOSMOS is installed on the telescope using the regular cage bottom. It may be possible to use the NEWFIRM cage bottom on the Blanco, for COSMOS, but on the Mayall it is not possible to add enough weight to the NEWFIRM cage bottom, and it should not be used. At present, the original cage bottom is used on both telescopes.

Remove the cass cage bottom and whatever instrument is installed on the telescope, using the mirror lift and following standard observatory procedures for those two items.

Lower the lift and move the instrument that was removed into its customary storage location.

If the rotator guider assembly was not in use, it should be installed at this point following standard observatory procedures. **The rotator should be oriented to position angle 90 (approximately) for Mayall installation, and to position angle 270 for Blanco installation**.

KOSMOS installation on rotator guider:

- Move KOSMOS onto the mirror lift.
- Rotate KOSMOS on its cart so the access covers on the instrument are facing the location of the cage door. In this orientation, the electronics box will be on the right as you enter the cage. *Note* – this applies to both telescopes, however the access covers are facing South on the Mayall and North on the Blanco, which is why the rotator angles specified above differ by 180 degrees.
- Raise the lift until the locating pins on the bottom on the rotator guider engage the notches in the telescope adapter on top of the instrument. The top of the adapter does not need to be in contact with the underside of the rotator. There is some travel in the spring casters, but it is important not to raise the lift too far, as this could damage the handling cart or the instrument enclosure if the allowable travel is exceeded.
- Insert and partially thread the mounting bolts.
- **IMPORTANT!** Retract and lock the spring pins on the cart in the retracted position. Failure to do this will damage the pins and may damage the instrument and/or cart when the lift is lowered.
- Tighten the mounting bolts.
- The mirror lift can now be lowered; the cart will drop away from the instrument and can be moved out of the way.
- The “cradle” (interface between cart and spectrograph enclosure) could be removed at this point. We recommend leaving it installed, however, as it does not get in the way.

Figure 4: *KOSMOS on handling cart, on mirror lift while being installed on the rotator. The view is from the direction of the cage door; note the access hatches visible from this position.*

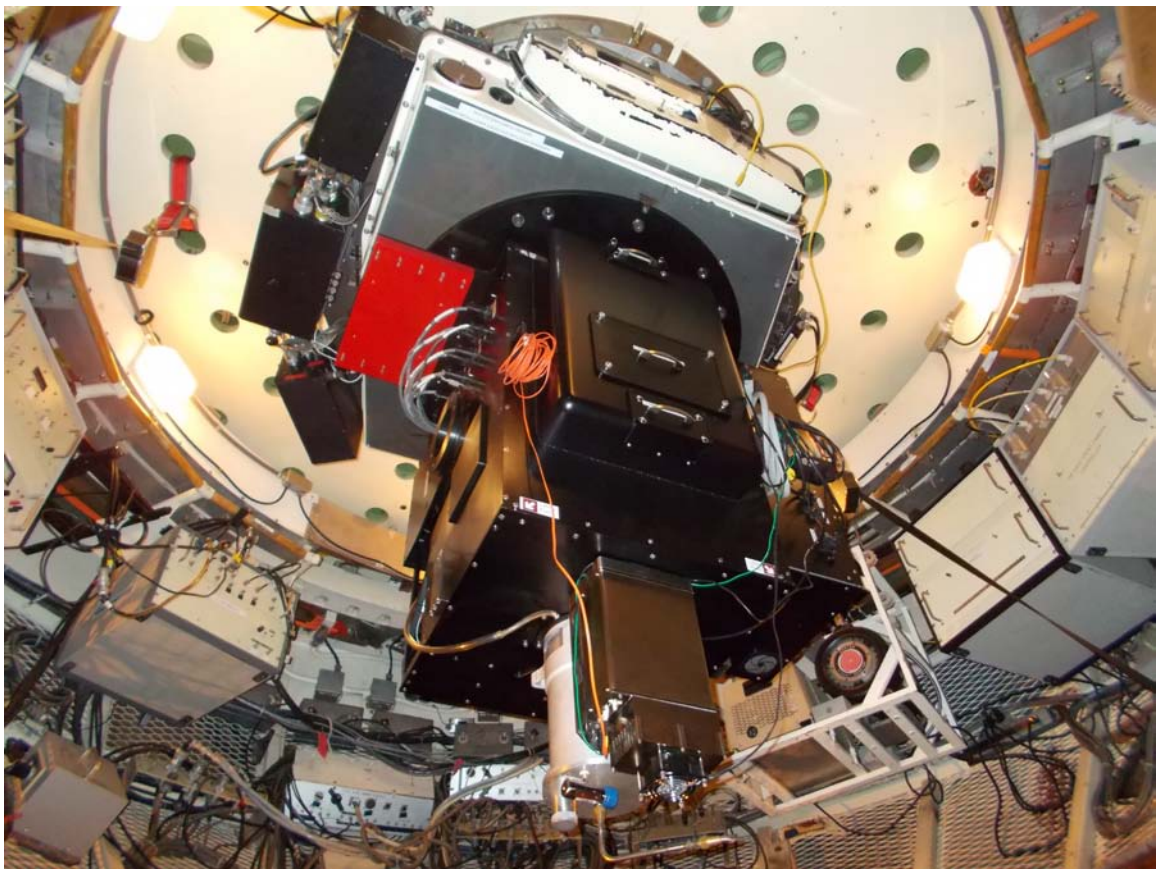

Figure 5: *View from below of KOSMOS after installation. The cradle has been left attached to the instrument. Note safety harnesses attached to the mirror cell bottom (top left, lower right).*

Now move the cage bottom onto the lift, raise the lift, and attach the cage bottom according to standard procedures.

Note: The cage bottom can be attached either after or before installing the CCD dewar and completing cable connections; at present it appears to be preferable to install the dewar itself first, but complete any cabling steps after installing the cage bottom.

Once installation of the instrument is complete, the mirror lift should be lowered and the cart and instrument cover should be stored.

Dewar alignment. This procedure is not required if the dewar adapter ring has been left attached to the dewar. However, it does no harm to verify alignment if there is any doubt. The critical parameter for dewar alignment is rotation, where the slit should be aligned parallel to the short axis of the CCD (which may be either rows or columns, depending on the CCD used). See section 6 for details of this procedure.

3.2 Instrument Removal

The procedure for instrument removal is the reverse of that for installation. It is not necessary to remove the CCD dewar, but it may be desirable to do so if the instrument will not be used for a long time and the dewar needs to be kept cold or requires maintenance.

- Disconnect the power, ground and Ethernet cables for the CCD dewar and spectrograph
- Bring the handling cart up on the mirror lift. If the dewar is to be removed, also bring the lab cart and dewar installation fixture.
- Remove the cage bottom, lower the lift and set the cage bottom aside.
- If the dewar is to be removed, do so at this point following the procedure outlined above.
- If the "cradle" for the instrument was removed during installation, attach it to the instrument at this point. *Note* – normally it would be left in place.
- Bring the mirror lift up so the cart is close to or touching the instrument. As with installation, do not bring the lift up so far that the travel of the cart casters is exceeded. Make sure all locking pins are retracted. *Caution:* the forks have limited clearance around the instrument; make sure they clear the instrument *and* do not catch or pinch any cables. It may be necessary to remove cables or cable ties beforehand.
- Loosen the bolts attaching the instrument to the rotator/guider, until the instrument is resting on the cart.
- Engage the locking pins on the cart that hold the instrument in the vertical position.
- Remove the bolts that attach the instrument to the rotator guider.
- Lower the mirror lift, take the instrument on its handling cart to the storage area, and cover it.

You can now install another instrument, or just the cage bottom.

3.3 Dewar and Controller Installation

This section describes the preparation and installation of the COSMOS dewar on the spectrograph. Section 4 describes basic operation of the Torrent controller, Section 5 reviews basic cryogen fill procedures. The alignment interface is described in Section 6.

The controller operation on COSMOS is identical with operation on KOSMOS; other procedures differ to some extent.

3.3.1 Dewar Preparation

Prior to installing the instrument on the telescope, the dewar should be pumped down and cooled. When, in future, there is more than one dewar available, dewars should be pumped and cooled before being installed on the telescope.

If the dewar was recently pumped (within a month or so), pumping may be omitted, but if time permits it's always preferable to start with an optimal vacuum. The dewar can be cooled after installation on the telescope, if necessary.

The steps are summarized below; staff performing these steps are assumed to be familiar with vacuum/cryogenic procedures. Anyone without such training should seek further instruction first.

- Dewar pumping should be done with a quality turbo pump or similar device. The dewar should be warm when pumped. Generally, the measured pressure should be in the few mTorr range or less after a few hours; at this point the dewar's vacuum valve should be closed and the pump can be turned off. The pump can be run longer (e.g., overnight or over a weekend), but there is little advantage to doing so.
- The dewar should be filled (see section 5). Because the initial fill has to cool the nitrogen tank, detector mount, and other hardware, you should re-fill after ~2-6 hours to ensure it holds for the expected amount of time. **Do not** fill the dewar while the vacuum pump is pumping it.

3.3.2 Dewar Installation

When the dewar is not installed on the spectrograph, a cover plate is installed over the opening. There is also a cap that is installed on the rear of the camera (Figure 6). Do not forget to remove this cap before installing the dewar (Figure 7)!

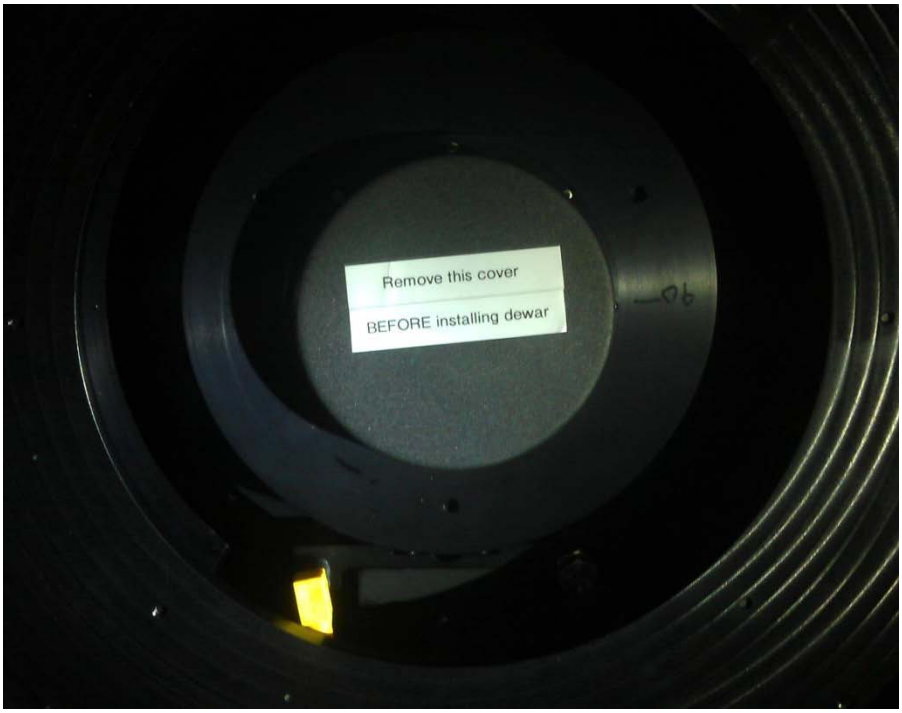

Figure 6: *View through rear of spectrograph showing end cap on camera.*

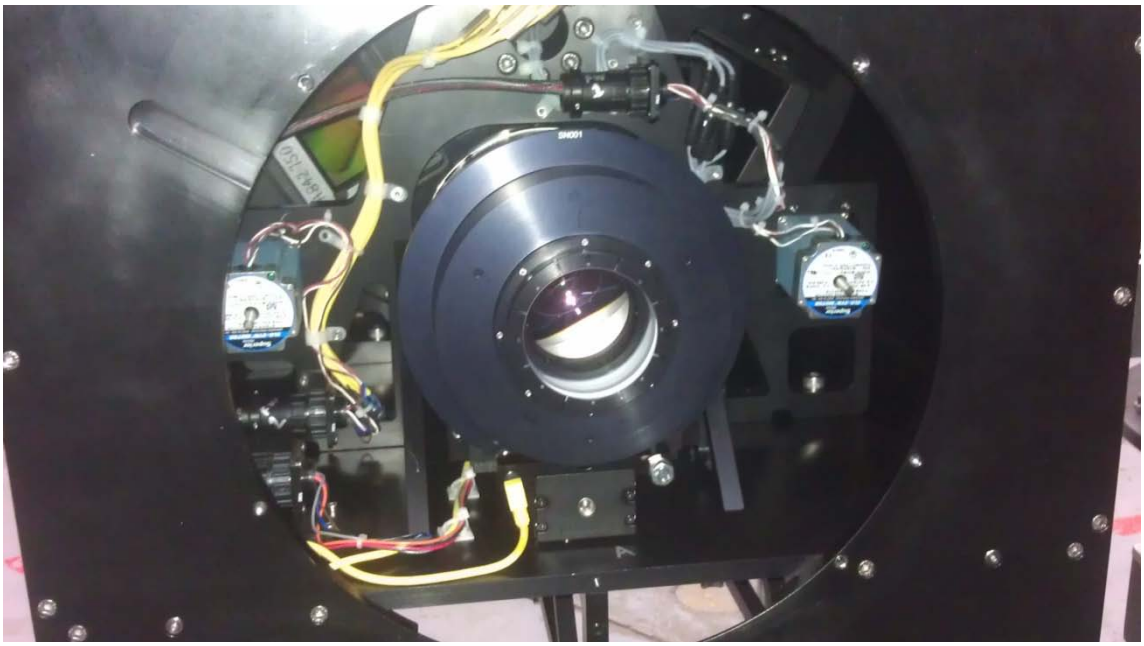

Figure 7: *View with end cap removed.*

The procedure for KOSMOS is similar, however the opening for the dewar adapter is smaller.

The dewar adapter (see Figure 8) is attached *first* to the dewar.

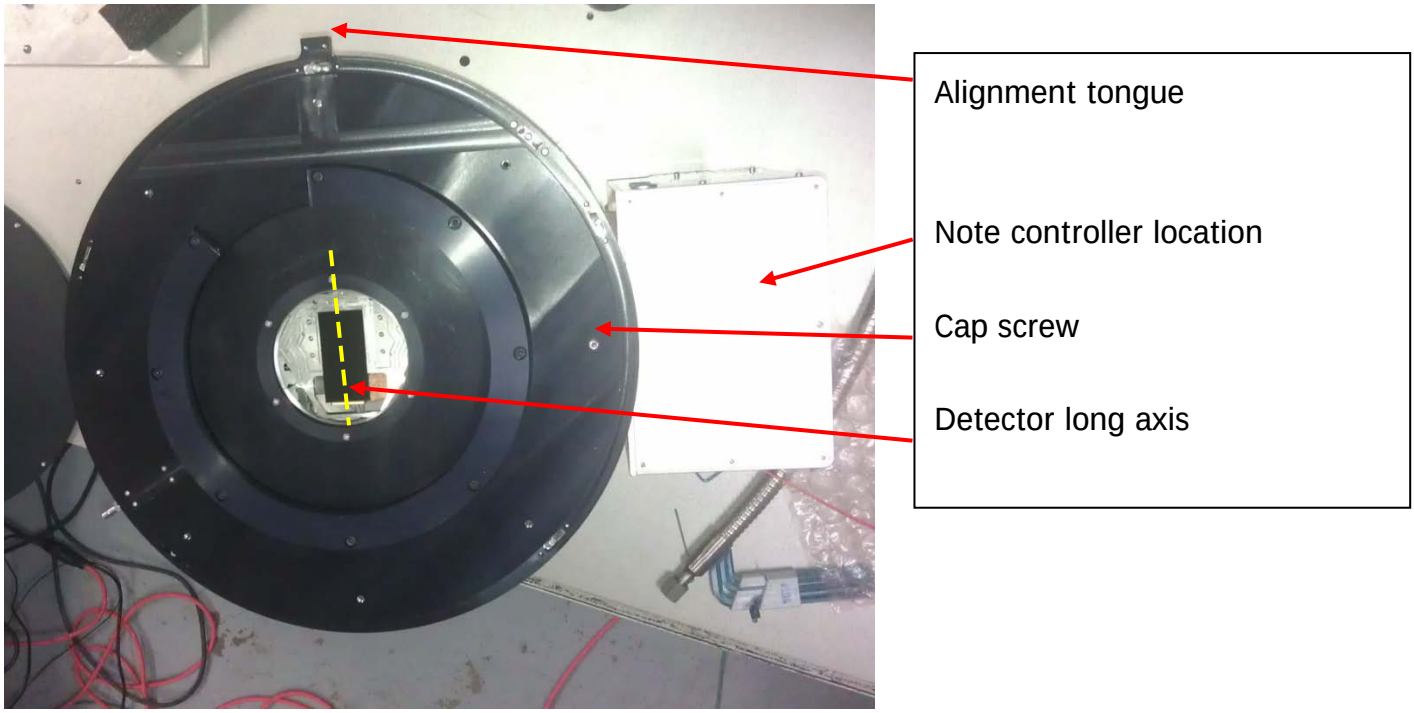

Figure 8: *COSMOS dewar adapter attached to dewar, viewed from above. The tongue that is used for precision alignment goes at the bottom when installed (shown at the top here), and the dewar is installed so that the Torrent controller is on the right side when looking at the spectrograph from behind the dewar. Note the cap screw in the adapter covering the hole in front of the controller.*

Figure 9 shows the COSMOS dewar adapter installed *without* the dewar, in order to show the interface better. The basic concept is that the adapter is permanently bolted to the dewar; when it is installed, the central boss fits into the hole in the back of the instrument (see Figure 7). The adapter plate allows for a limited amount of rotational adjustment (see Figure 9); once the rotation is determined the pin shown in Figure 4 is bolted down. Thereafter, the dewar can be removed and re-installed without losing rotational adjustment. (See Section 6 for details on dewar alignment.)

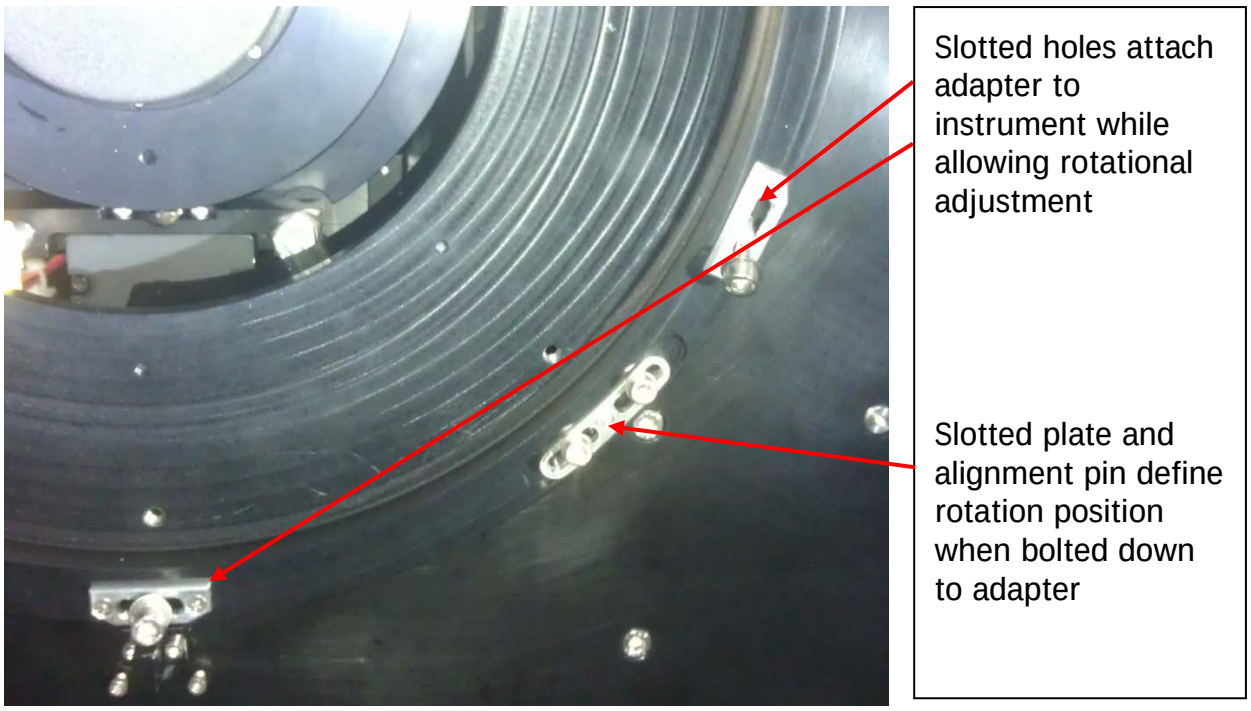

Figure 9: *COSMOS dewar interface installed on spectrograph, without dewar, to illustrate installation features.*

The equivalent features for KOSMOS are shown below (see also Figure 13). Reference these figures when reading the rotational alignment procedures in Section 6.

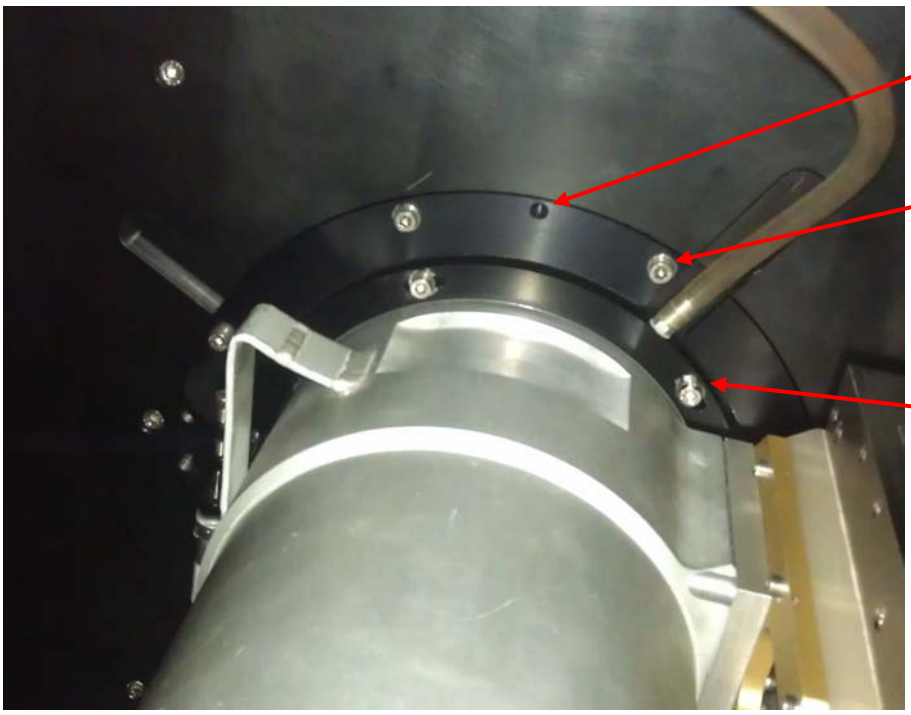

Figure 10: *KOSMOS dewar installed on spectrograph, with installation and alignment features indicated*

Figure 11: *KOSMOS dewar rotation adjustment micrometer. The micrometer for COSMOS is essentially the same.*

3.3.3 Electrical Connections and Related

Once the dewar is installed, several electrical connections must be made (see Figure 10). These are:

- Power for the controller (via the laptop power supply); connect to clean power
- Power for the controller fan; connect to clean power
- Fiber connection to "pan" computer
- Ground connection, between Torrent, dewar, and power strip 3rd pin
- Shutter control cable, from side of Torrent to input on instrument electronics box (IEB) on the side of the instrument
- In addition, connect the dry air hose to the barbed connector near the dewar faceplate; connect the other end of the hose to the dry air outlet in the cage. Make sure dry air is flowing! This step is not required when the instrument is being operated in a laboratory environment.
- Power cord to the IEB should be connected to clean power.
- *Important:* run the cables across the slanted surface of the cage under a cable protector, which should then be taped in place using cable tape (Mayall) or in the troughs in the cage bottom (Blanco). This reduces trip hazards. *Make sure there is enough slack directly beneath the instrument to allow it to rotate through the full range of the rotator.*

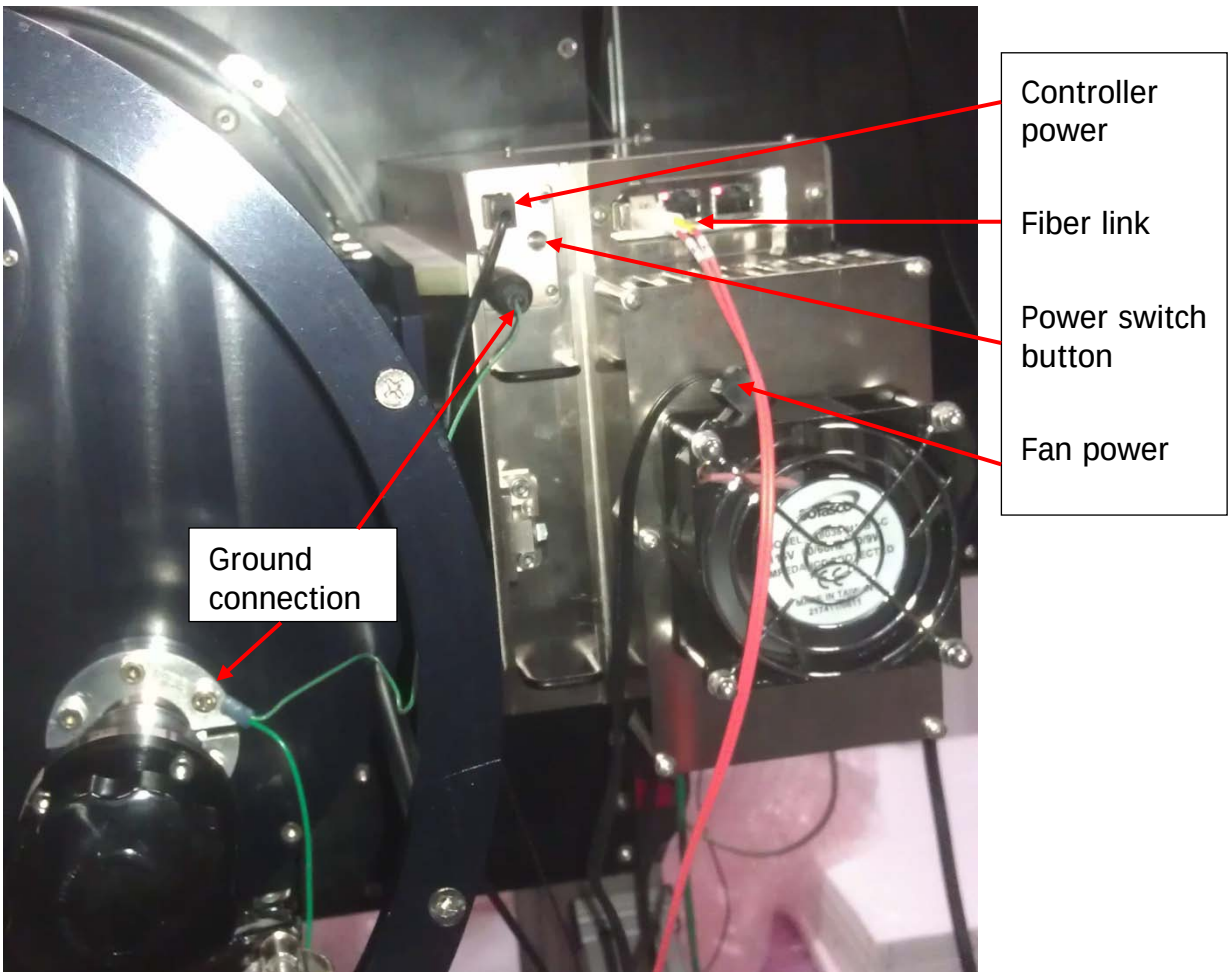

Figure 12: *Torrent controller connections. The fiber cable is the orange pair connected at the top of the box; the power connection is to its left and the ground connection just below that. Note the ground cable is also connected to the dewar body at the vacuum gauge (lower left). The fan power cable connects to the fan at its top in this view. The shutter connector is on the underside of the controller. The shutter cable connection is underneath the controller in the view; it is shown better in Figure 14. These connections are the same for both instruments.*

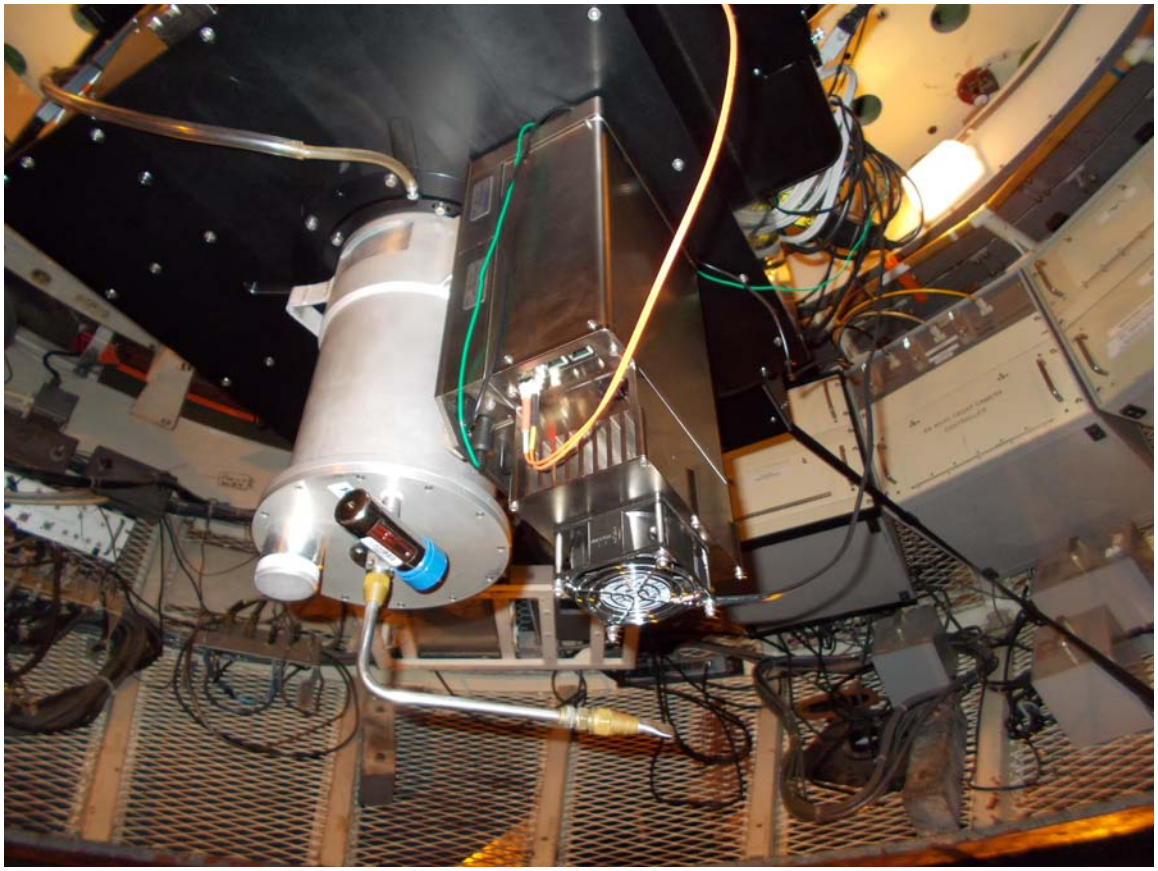

Figure 13: *View from below of KOSMOS CCD dewar after installation. Note that the cage bottom, when installed, is only a few inches below the fill fixture. The Torrent box (attached to dewar, on right) has the ground, fiber, and fan power cables already connected. Note the dry air hose at the fitting on the dewar adapter.*

3.3.4 Dewar Installation in Cage

The KOSMOS dewar can be installed after the instrument has been installed on the telescope; procedures for doing this for COSMOS have not been developed yet. The procedure is as follows:

- There should be a cover in place over the exit port on the spectrograph. Remove it and attach it to the side of the instrument. There may also be a cap over the back of the spectrograph camera; this must be removed as well.
- The dewar will normally be stored with its adapter ring attached. If the adapter ring is not attached, attach it to the front of the dewar. Note that this means the dewar must be re-aligned rotationally after installation (see below).

- The dewar should preferably already be cold at the time of installation, but it can be cooled after installation; this is recommended only when the instrument is installed well before any use on the telescope.
- If the dewar is being installed *without* the cage bottom in place:
    - The dewar installation fixture should be placed on a lab cart and the dewar should be clamped into it, facing up. The jack on the installation fixture should be lowered.
    - The mirror lift is then used to raise the dewar until it is close to the bottom of the instrument. “Close” means within the range of travel of the jack on the installation fixture. *Do not* try to use the mirror lift to engage the alignment pin on the back of the instrument, as it does not have the required fine motion capability, and you may seriously damage the dewar or the spectrograph optics.
- If the dewar is being installed *with* the cage bottom in place, lower the jack on the the installation fixture, clamp the dewar in place, and slide the fixture under the instrument
- Carefully use the jack on the installation fixture to raise the dewar while guiding it onto the dowel pin. Check before doing this that the hole in the dewar adapter ring matches up with this dowel pin on the back of the instrument. When the front of the dewar is nearly flush with the back of the instrument, this pin will accurately define dewar rotation about the optical axis.
- Install and tighten bolts through the adapter ring in the back of the instrument.
- Attach the fill tube extender to the dewar fill tube and the side of the instrument.

3.3.5 Dewar Removal and Exchange

KOSMOS (and COSMOS) will eventually have 2 available dewars, which can be exchanged when the instrument is mounted on the telescope. The exchange can be carried out while the cage bottom is installed, as described above.

Dewar removal. The process is essentially the reverse of installation.

- Remove the fill tube extender and disconnect the power, ground and fiber cables. Remove the dry air hose.
- Lower the jack in the installation fixture, and slide it under the dewar, then raise the jack
- Loosen and remove the mounting bolts on the dewar adapter ring.
- Clamp the dewar to the installation fixture

- Lower the jack in the installation fixture until the dewar is clear of the instrument.
- Slide the installation fixture out from under the instrument
- Unclamp and remove the dewar.

The second dewar can now be installed following the procedures outlined under instrument installation.

4 Controller Operation

4.1 Basic Operation

The controller is normally in one of three states: off, on but not connected, and connected. When the controller is on, whether connected or not, pushing the power button briefly (see Figure 14, below) will cause it to light up green. If on but not connected, the ethernet connectors (to the right of the fiber connector in Figures 12 and 14) will glow orange (the controller is in this state in Figure 12).

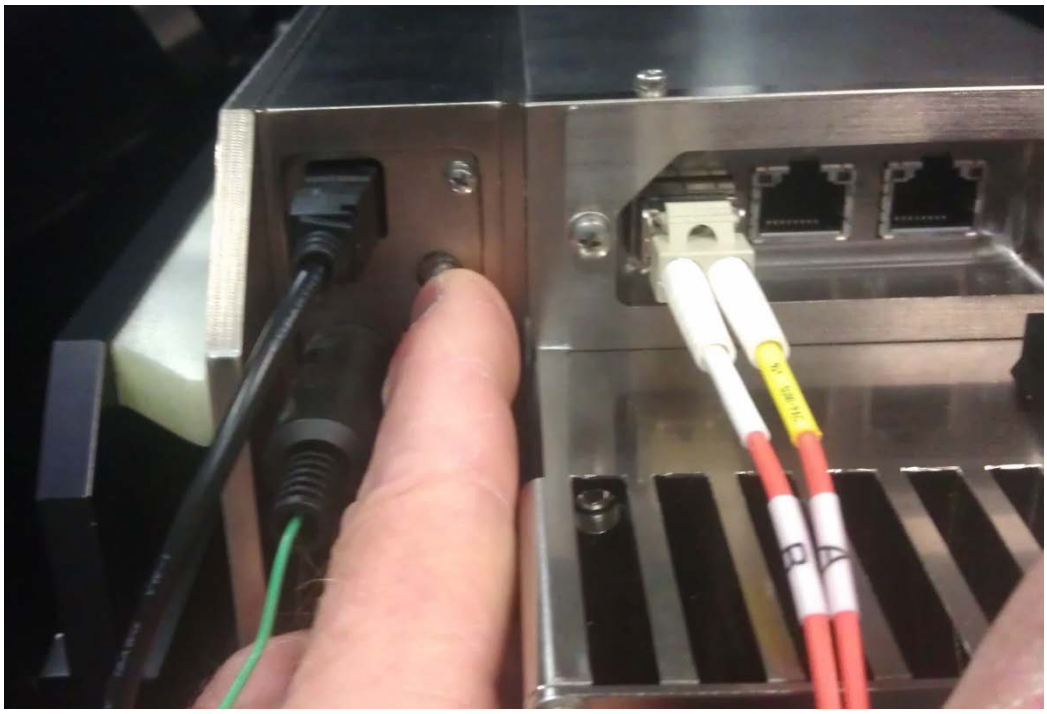

Figure 14: *Location of power button. Note that the Ethernet connectors are not lit up (compare with Figure 12) – this means that the controller is off, or is on and connected.*

In order to start up the controller, the following steps are required:

- Make sure the software is stopped. In the xterm window for the NOCS, type:

  nocs stop all

  nocs stop hardware

  (For more details, see the relevant section of the User Manual)
- Now start the controller by pushing and holding the power button for a second or two. The ethernet connectors will glow orange. If the shutter is connected and the instrument electronics are on, the shutter will cycle.

- Now start the NOCS (see the User Manual for additional details) by typing in the xterm:

  nocs start hardware

  nocs start all

  Wait for all the windows to display. Once the detector control window (NMSL) displays, the lights on the ethernet connectors should turn off. The text at the top of the NMSL window may sometime show error messages regarding incorrect voltages; these can usually by fixed by typing

  nmslReset

  in the xterm.
- Verify that everything is working by taking an image (a bias or "zero" frame is easiest, see the User Manual for details).

4.2 Troubleshooting - Controller Not Working

When the instrument is first installed, it is a good idea to re-start everything, including the computer racks. The command to use is:

nocs reboot rack

from the xterm connected to the KOSMOS (or COSMOS) rack. Note that this action will close the connection, so you will need to re-connect once the re-boot is complete. This step can be omitted if the instrument has been running without problems in the lab immediately before installation, but should be kept in mind if all else fails.

More generally, if there are problems getting the detector controller to operate properly (either error messages, or operation in simulation mode [NMSL text window shows orange background, not white]), a careful and complete shutdown and restart is recommended (but read the notes at the end of this section first):

1. Issue NOCS commands:

   nocs stop all

   nocs stop hardware
2. Turn off Torrent controller (see above, make sure shutter activates when doing this)
3. Turn off IEB (instrument electronics)
4. Disconnect power from the Torrent for 30 seconds (controller power, don't mix this up with the fan power, which is separate)
5. Reconnect power to Torrent
6. Turn on IEB; wait 10 seconds or so
7. Turn on Torrent controller (see above, make sure shutter activates and LEDs in Ethernet connectors on Torrent illuminate)

8. Issue NOCS commands

   nocs start hardware

   nocs start all

A shortcut procedure that will solve most connection problems is to follow the sequence above, but skipping steps 3-7. In this case, wait ~30 seconds after powering the Torrent controller off before re-starting it. If the shutter is not activating, or the LEDs on the Ethernet connectors do not illuminate, you should execute the full procedure.

Note - if you think it may be necessary to reboot the rack computers, do so after step 4; since the reboot takes more than 30 seconds (several minutes), you can proceed to step 5 as soon as the racks come alive and you have connected to them again.

Note - when you install the instrument, you should consider that you are at step 4 in the procedure above, and continue accordingly.

Note - there are also circumstances where the fiber link between the Torrent and the computer rack should be reset. Try this before re-booting the rack.

4.3 Troubleshooting - Noise

If everything appears to be working, but there is excess noise in the bias ("zero") images, there is undoubtedly a grounding issue. The noise will manifest itself as a pattern on the raw images.

- If the noise is very high, there is most likely a missing connection - check that the connections have all been made (see figures above for the COSMOS and KOSMOS dewars, which are not identical).
- If the noise is somewhat higher than expected (i.e., above 10 ADU standard deviation), you can try moving the location where the ground plug is plugged in to a cage power socket. This may or may not help. There isn't a location that is *guaranteed* to reduce noise below 10 ADU, for either instrument. (At least not right now.)

5 Dewar Filling

The COSMOS dewar has a hold time of 40 hours or longer; it is recommended that it be filled daily, but the exact time of day is obviously not critical.

The fill tube attaches as shown in Figure 15 - *do not overtighten* the fitting onto the dewar neck! Use two wrenches if needed to tighten the additional fittings. The fill tube will be somewhat loose; this is OK. Put a piece of dense foam or cardboard underneath the fill tube when filling from the side, in order to protect the vacuum gauge and valve. If you are filling on the telescope, the dewar is vertical and the foam or cardboard is not necessary. If you are filling on the telescope, you will also need a fitting with bend in it because there is not enough space between the dewar and the cage bottom for a straight fitting. See Figure 13 for a view of KOSMOS with such a bent fitting attached.

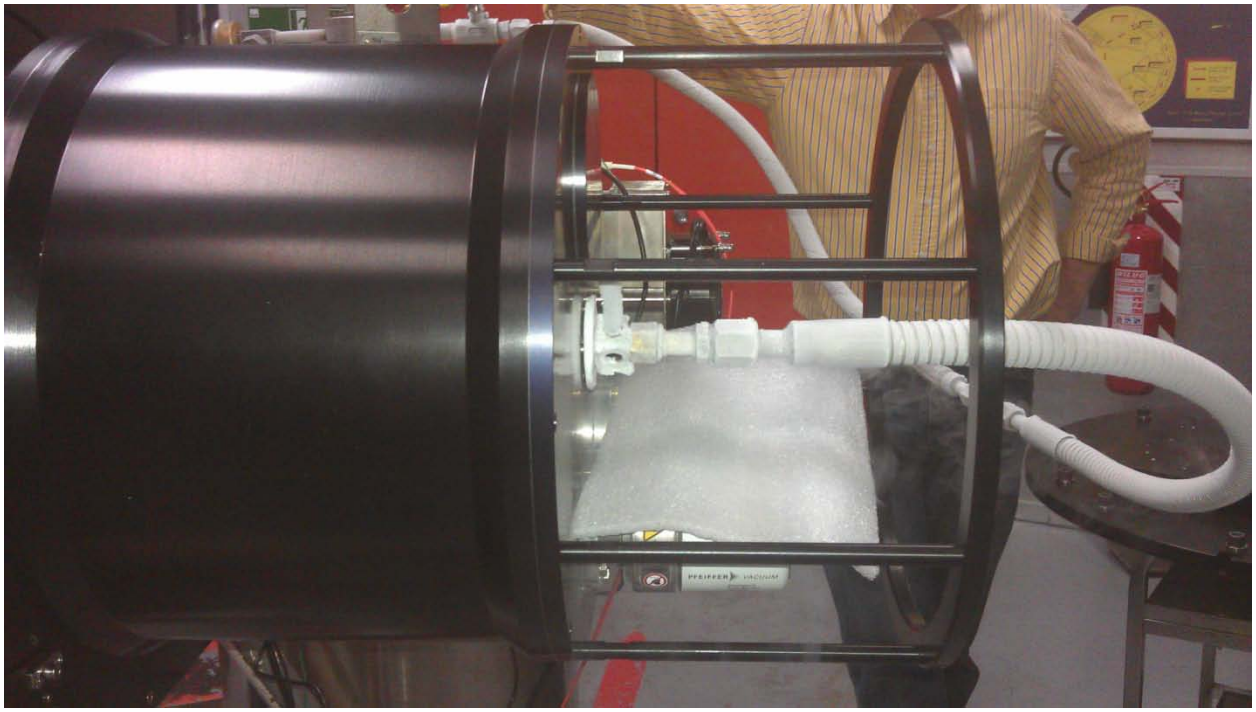

Figure 15: *Fill fitting and nitrogen line attached to dewar.*

Once you have attached the fill tube, open the valve to the storage dewar slightly. Liquid nitrogen will cool the line initially, and will then start flowing into the dewar. Some dripping from the fill fixture is normal at this point. You can open the valve to the storage dewar more fully at this point. Once the dewar is full (typically about a couple of minutes), liquid will start to spill out of the holes in the side of the fitting. Close the valve.

If you are in the lab, or have time, you can wait for the fitting to warm up and remove it by hand. Otherwise you will need wrenches to do so - *always use two wrenches for this*, in order to protect the dewar neck. For lab work, it is not necessary to remove the nitrogen line.

The procedure for KOSMOS is generally similar (see Figure 13 for a view of the fill fitting). However, the hold time is substantially less than for COSMOS - about 15 hours. Therefore the dewar must be filled twice a day, generally at the start of the night and at the end of the night.

6 Dewar Alignment

The dewar rotation should be adjusted using the following procedure:

1. Loosen the screws holding the dewar to the back of the spectrograph, the screws holding the alignment pin plate to the adapter, and the micrometer and screw that engage the alignment tongue (see Figures 8 and 9).

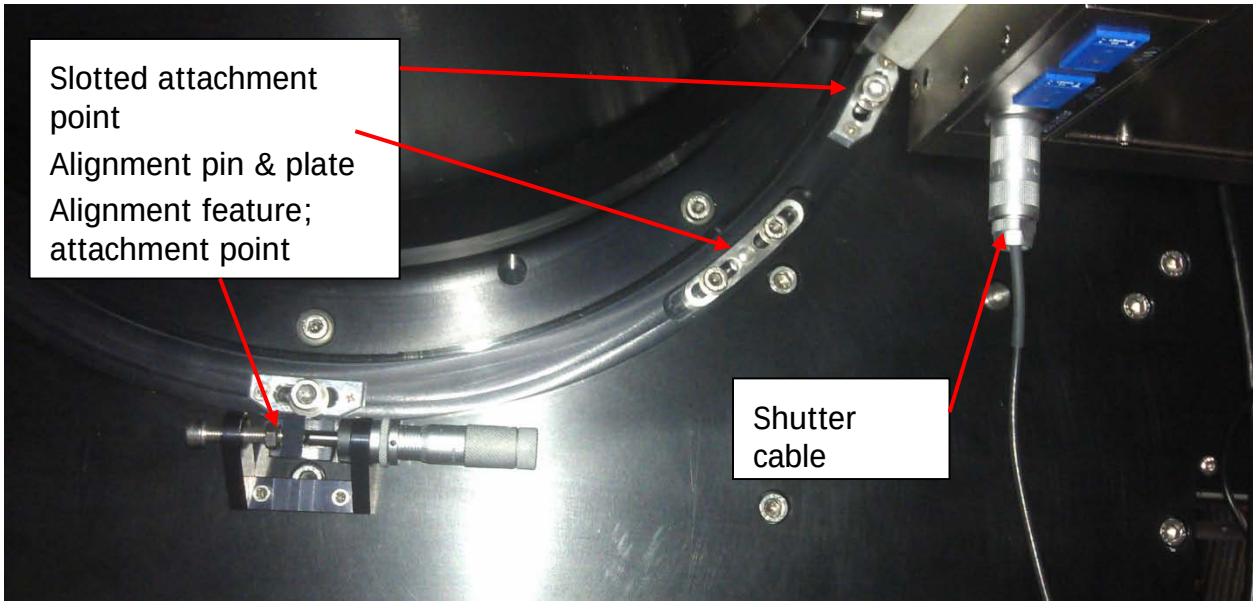

Figure 16: *View of COSMOS mounted on instrument showing the micrometer and screw engaging the alignment feature, the alignment pin plate, and one of the slotted attachment points. The shutter cable is also shown installed on the controller, at right. See Figures 10 and 11 for KOSMOS equivalent features.*

Figure 17: *View of COSMOS dewar showing additional slotted attachment points. There are a total of 5. See Figure 10 for KOSMOS features; it has 4 bolts that must be loosened for rotational adjustment*

2. Take an image through the spectrograph with one of the long slits in position, but without a disperser. This produces a single image of the slit, regardless of light source. If a disperser is used, an arc lamp is required and the lines will be curved.
3. Compare the "Y" positions of the 2 ends of the slit; unless they are within ~1 pixel you will likely want to make an adjustment.
4. Tighten the micrometer against the adjustment tongue and rotate a couple of turns of the micrometer.
5. Repeat the measurement (2) and see how the ends of the slit have moved.
    a. If the rotation is in the desired direction, continue turning the micrometer and repeating the measurement. One turn of the micrometer is (very roughly) a couple of pixels difference end-to-end on the slit.
    b. If the rotation is in the wrong direction (or if you over-shoot), back off the micrometer by the desired amount, then tighten the opposing screw until the tongue is touching the micrometer end. Don't over-tighten.
6. You should be able to get the end-to-end difference smaller than a pixel.
7. Once you are satisfied, tighten the attachment screws and the alignment pin plate, then take one last image to verify that nothing has shifted.

7 Filter and Mask Changes

Filter changes are normally performed only during the day; mask changes can be carried out at night (by the telescope operator, but the observer may be able to help).

Filters or multislit masks should be installed in holders. Longslits are pre-assembled into holders, so it's a matter of selecting the longslits to be installed.

Filters are installed in holders by the day crew; since there are spare filter holders, any filters you may have requested should be already installed in holders. At the Mayall, they will be kept in the loading room (old plate loading room outside the control room).

Access to the instrument for this purpose is shown in the figures below:

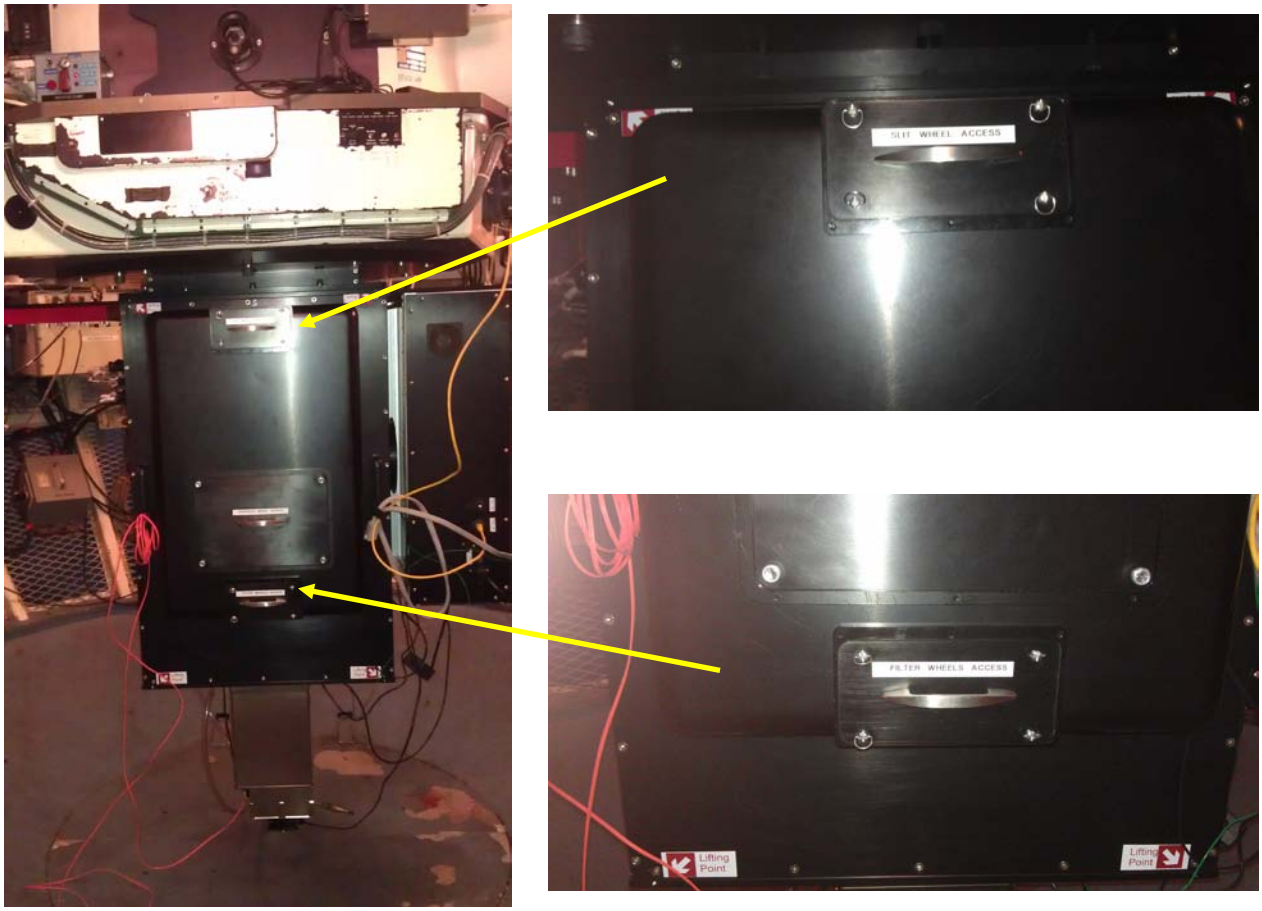

Figure 18: *Location of access ports for slits (top) and filters (bottom).*

7.1 Installing Multislit Masks in Holders

To install masks, you need a vacant mask holder and a 1.5 mm [TBC] Allen key or driver. Use the driver to loosen and rotate the clamps holding the retaining ring in the holder, and carefully remove the ring (see Figure 19, below).

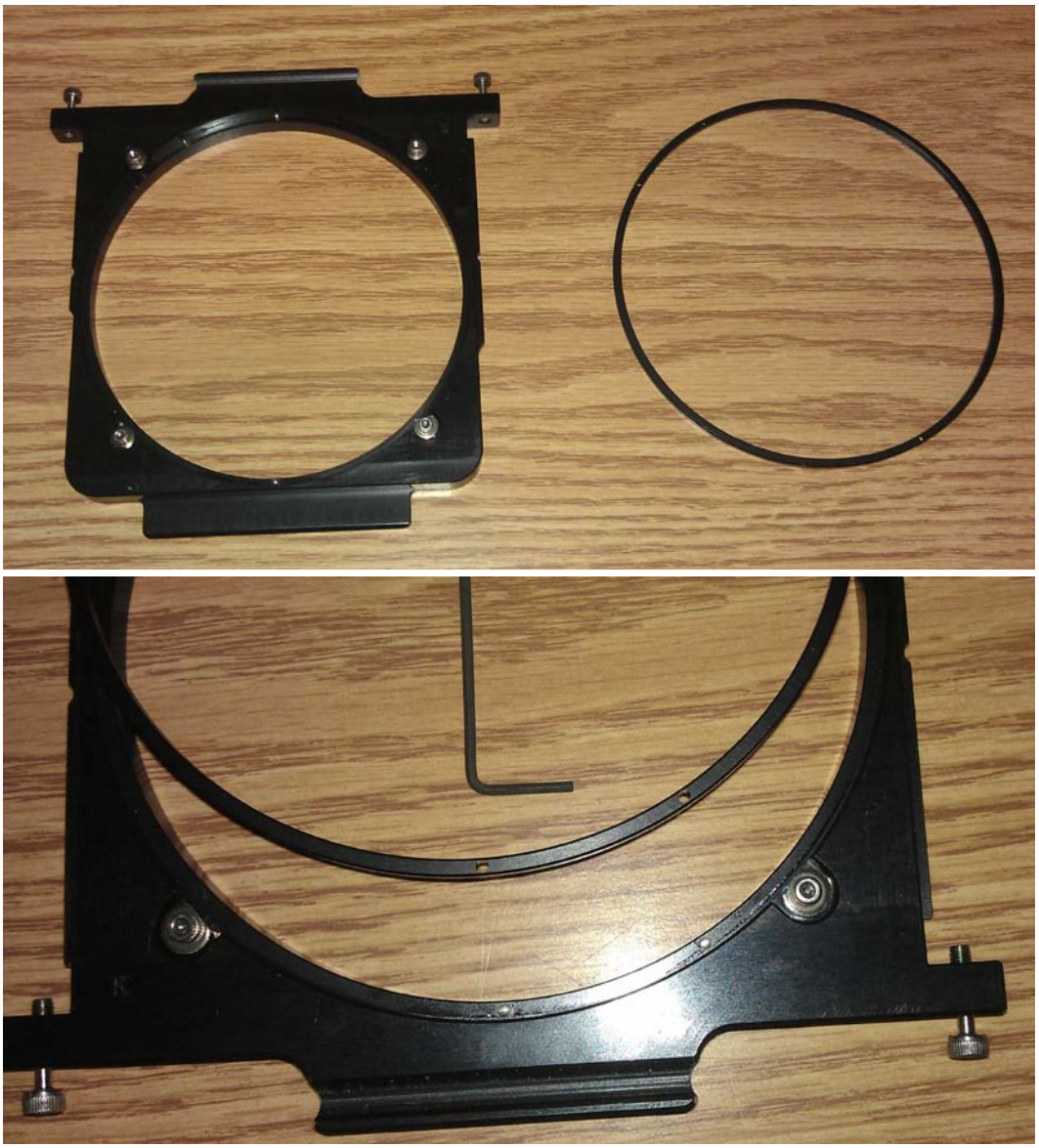

Figure 19: *Mask holder with retaining ring removed (top). The 4 clamps can be seen around the inner edge of the holder. Alignment pins can also be seen at approximately the 6, 11, and 12 o'clock positions. A close-up is shown (bottom) where you can see the clamps and alignment pins.*

The KOSMOS masks are cut from stainless steel shim stock that is coated black on one side. One such mask is shown in Figure 20, below.

COSMOS masks are cut either from aluminum shim stock that is blackened on both sides, or a thin carbon fiber sheet. The general appearance for the COSMOS masks will be similar to those for KOSMOS, except that neither side will be shiny.

The black side of the KOSMOS masks faces the collimator, to reduce ghost images. While both sides of the COSMOS masks are black, the alignment pins in the mask holders ensure that the orientation is always correct.

Figure 20: *Typical multislit mask.*

The mask should be inserted in the holder, making sure to align the holes in the edge of the mask with the alignment pins. If this is done correctly, the shiny side should be **down** for correct alignment. (For COSMOS masks, where there is no shiny side, there is still only one way the pins and holes will line up.) Now install the retaining ring over the mask and alignment pins, and then tighten the clamps to hold the ring in place. The clamps may need a little assistance to rotate to the correct position. If correctly assembled, the mask in its holder should look like Figure 21.

The black side of the mask is facing the detector, not the telescope secondary, when installed in the instrument. This is to minimize ghost images on the detector.

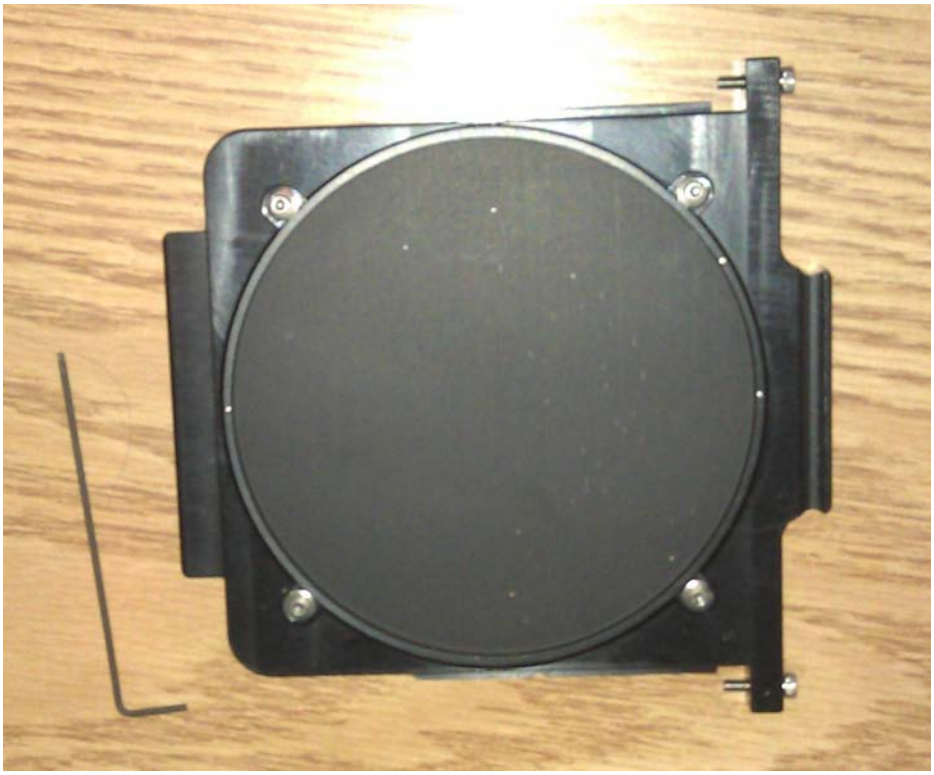

Figure 21: *Mask installed in holder. Note black side facing up.*

7.2 Installing Filters and Slits into KOSMOS

Using the transport box, take slits or filters out to the cass cage. It is recommended that you write down what you are installing in which position, and take the paper out to the cage with you. *Also make sure that anyone in the control room knows not to try to operate the mechanisms while you are doing this*. If you are doing an extensive series of changes, you may want to stop the NOCS and even power down the IEB.

Access covers on the side of the instrument allow installation of slits (top cover) and for which there is no current need. To make a change:

- Remove the access cover
- *Manually* rotate the wheel to the desired location. Position numbers are scribed on the wheel on the left-hand side of each position.
- If there is something installed in that position, loosen the 2 cap screws that hold it in place (2.5 mm ball driver). The screws are captive. Loosen the screws until you can remove the holder.
- Put the holder you've removed into the transport box.
- Install the new holder and tighten its retaining screw. Don't over-tighten.
- Continue with any additional replacements.
- Remember that every wheel must have a physically open (vacant) position.

- Install the access cover

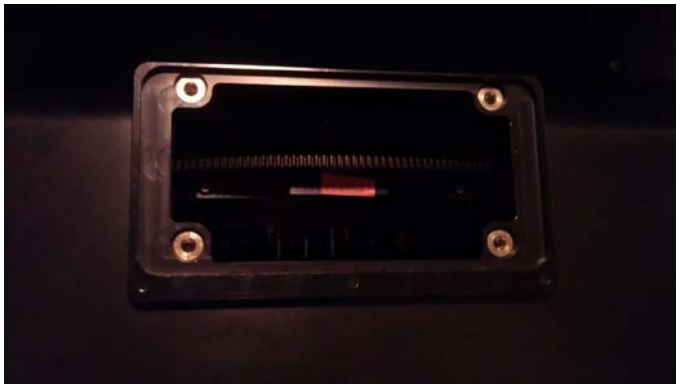

Figure 22: *Longslits in holders (left) with ball driver used for installation. The slit holders shown are for a centered slit (top) and a blue-displaced slit (bottom), marked by the arrows. The red-displaced slits have the slit in the position near the handle of the holder. Slit mask mounted in wheel (top).*

Figure 23: *Filter in holder (left), filter installed in wheel, partially rotated to show position number scribed on the wheel (top, right) and different view showing filters installed in both wheels (bottom, right).*

7.3 Updating the Instrument Configuration

Now you need to update the configuration files. These are in /home/logs. The configuration file for the slits is *kosmos_slits.conf* (same name for COSMOS); the file for the filters is *kosmos_filters.conf* .

- Open the file for editing.
- If you have replaced something, edit the line for the item you removed to substitute what you've installed. For filters, the KPNO (or CTIO) filter ID goes in the last column. For multislit masks, the 6-digit ID goes in the last column [TBC]. Note that the filters require that you define the position of *both* filter wheels, normally the open position in one and a filter in the other. (But it is possible,

though not very useful, to define a "filter" that is actually two filters in the light path.)

- Make sure there is an open position in the wheel *and* that it is called “Open”. You can change which physical location in the wheel this is.
- Save the file
- When you've made all the changes, type "~/bin/change_hardware" to update the NOCS. Starting the NOCS automatically uses the updated files, so the change_hardware command isn't required.
- If you want to verify that everything is correct, open the NICS window (see section 3.2 of the User Manual) and confirm that the filters and slits displayed there are what you expect; you can then try moving to the position of one of the new items (enable command buttons to do so).

For reference, the configuration file for the dispersers is located in the same directory and would be edited in the same way if dispersers are added or changed at some point in the future.

Also, as indicated in the Users Manual, the configuration file for the camera focus is located in this directory. If the focus setting is being updated it is simpler to follow the procedure in the User Manual, where you manually set the desired focus after a focus check, and just update the file. However, the hardware update command will also apply the new focus value.