The CRSP Reference Manual

1. Introduction

This manual is intended as a guide to those support personnel who are involved with the installation, observing support, and troubleshooting of CRSP. It is **not** an operating manual for the instrument, and is complementary to the CRSP User's Manual in that it covers aspects of CRSP which are not of concern to the user. In addition, many of the procedures covered here, particularly with respect to troubleshooting, are potentially hazardous to the health of the instrument and should **not**be attempted by visiting observers or casual users of CRSP.

2. Instrument Storage -- The Big Box

CRSP, rotator, and all associated knicknacks are intended for storage in a single large box. This box has wheels which permit it to be moved about (with some difficulty), and two steel bars across the top by which it may be lifted by crane hooks (one at each corner, outboard of the large nuts) or fork lift. One may also transport the box by fork lift from below, although care is required in inserting the forks. Unlike IRIM, the internal structure of CRSP is not supported by the cryogen fill necks, so there are no support tubes which must be inserted before transporting, but care should still be exercised to avoid excessive jarring of the instrument.

Main Compartment

CRSP sits on a hydraulic cart, with the four instrument "legs" fitting into guides on the cart table. Two of these have spring detents which lock the legs into place. THESE MUST BE LOCKED WHEN THE INSTRUMENT IS BEING ROLLED ABOUT, ESPECIALLY WITH THE ROTATOR INSTALLED. The instrument/rotator combination is topheavy, and it could tip over, with catastrophic consequences. The cart has a set of "elevated" wheels which fit into U-channel guides in the instrument box; when the cart is all the way in, it may be locked in

place by two removable pins. In the initial preparation steps, CRSP is detached from the rotator and moved around separately on the cart; for installation on the telescope, CRSP and rotator are moved together. Detailed steps will follow in the checklist.

Important -- Before the cart and CRSP are rolled into the box, the cart must be in the FULL DOWN position, and the window cover must be removed from CRSP.

Drawers and Cabinet

The box has a built-in cabinet, a large sliding drawer, and four small sliding drawers for housing associated paraphernalia. Each of these is marked as to the contents. The top two small drawers contain the tools and alignment pins for installing CRSP. The third drawer contains antistatic gear for use if the electronics must be disconnected, as well as spectral calibration lamps.

The cabinet is used to store the ~ 12-foot cable wrapup connecting the instrument to the Cassegrain J-box when the instrument is shipped downtown. Two cables provide power to the instrument, while the third is a bundle of six fiber optic cables. THE FIBER OPTIC CABLES MUST BE TREATED WITH CARE. When installed, they should be secured to prevent strain or tight radius (< 7 cm) bending.

3. Installation Procedure

Although the mounting configurations of CRSP at the 2.1-m and 4-m telescopes are quite different, the general installation and removal procedures are similar. At the 2.1-m, the CRSP/rotator installs directly to the nominal gold guider; at the 4-m, the back focal position of the f/15 secondary requires that the CRSP/rotator mounts to the "white adapter" on its handling cart, with an additional guider (which is effectively a spacer) in between. The whole assembly is then installed on the 4-m guider using the elevator. At the 2.1-m, the guider should be installed with the TV mount to the South; CRSP should be installed with the fill tubes to the North. On the 4-m, it is necessary to install CRSP with the fill lines to the South for access from the cage door.

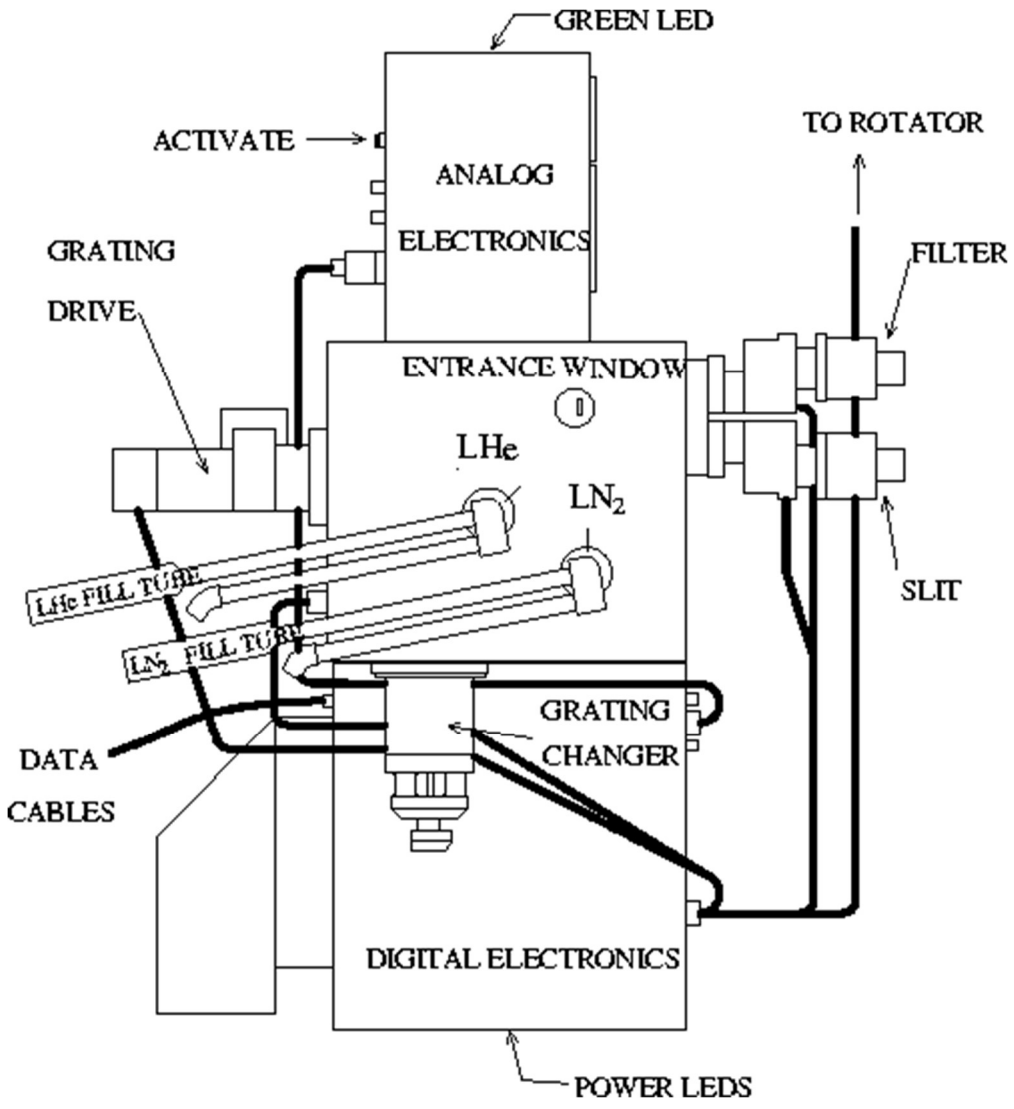

Fig. 1 Top View of CRSP

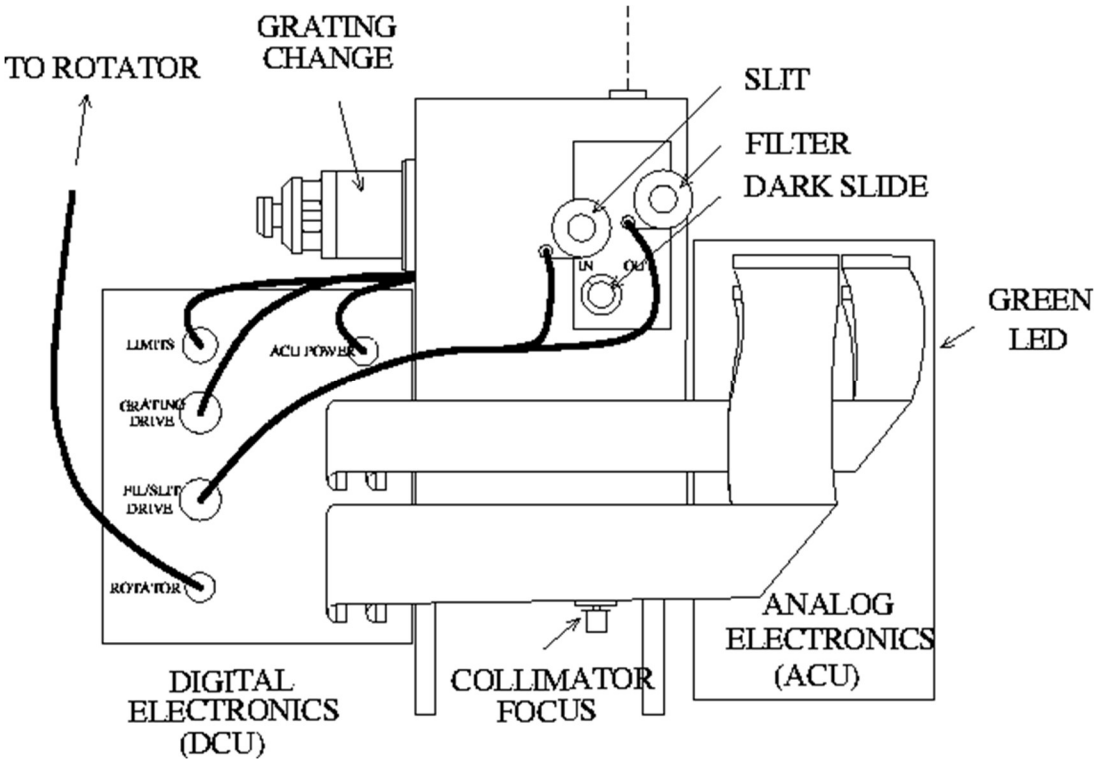

Fig. 2 Side View of CRSP

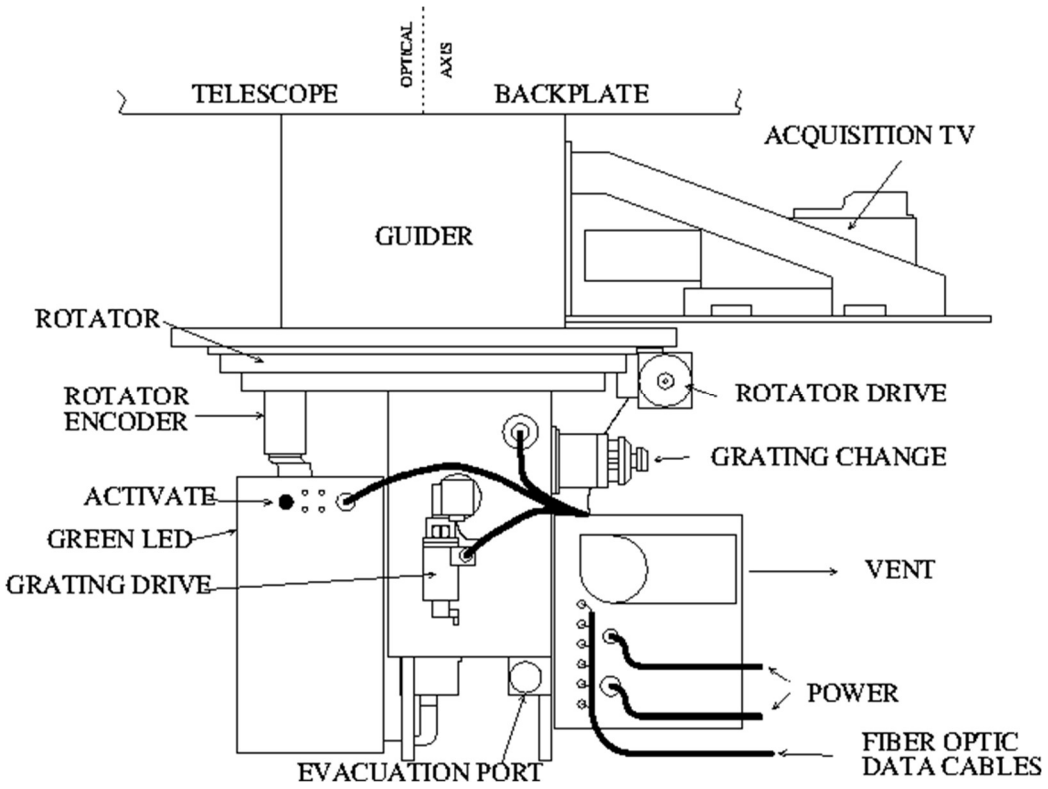

Fig. 3 Side View of CRSP, showing installation on Gold Guider

General Rules

For continued happiness and long life, there are a few useful rules which should be kept in mind when working with this instrument.

- Whenever CRSP and rotator are being moved about in the box, the CRSP cart and rotator lock pins should all be properly in place. CRSP should be jacked up against the rotator and the four bolts securing CRSP to the rotator should be tightened up.
- Whenever the in-place cryogen fill tubes are installed on CRSP, exercise care wheeling the CRSP cart in and out of the box, and in raising or lowering the hydraulic lift, as it is possible to catch or bend them on many obstacles.
- Once there is LHe in the CRSP, **NEVER** use N_2 gas to attempt to remove an ice plug in the cryogen line or to warm up the cryostat after use (until one is positive the flask temperature is above 77 K). Ice plugs in the LHe cryogen line may often be removed by blowing **He gas** in the vent tube.
- Initial cooling of the LN_2 and LHe flasks is best done using a source of pressurized LN_2, unless one has a lot of time on his hands. Use moderation in filling, as excessive pressure could damage the thin bellows in the cryogen necks.

Pumpout and Precooling

When possible, this should be started the day before a scheduled block of observing time, since this permits adequate time for CRSP to precool. Starting the day of a run will result in late installation (at least 6 - 8 hours of precool are needed before filling with LHe), and dark current will be elevated during the first night due to slow cooling of some of the optics.

- Remove CRSP from box: make sure cart is supporting CRSP against the rotator, loosen four 1/4-20 bolts securing CRSP to rotator (holes are marked with blue). Slowly lower cart all the way, remove cart lock pins, carefully roll CRSP out of box.
- Install window cover.
- Pump on vacuum jacket at least 1 - 2 hours, using Tribodyn pump.
- Close vacuum pump port and remove pump.
- Fill both CRSP flasks with LN_2. The LN_2 flask will require some time to fill and will vigorously boil off for the first couple of hours.
- After a couple of hours, top off LN_2 in both flasks. The cryogen should hold overnight.

- If the instrument is transported before final cooling, remove window cover and install in box (see below). Transport, remove from box, and install window cover.
- Since the instrument is often tilted to extreme angles during telescope balancing, do not top off the LN_2 flask to more than half capacity (~ 6 inches). This will prevent LN_2 from spilling out of the flask and possibly freezing the neck O-ring joint.
- Top off cryogen in LN_2 flask to about half capacity.
- Using special tube, blow LN_2 out of LHe flask, making sure it is all gone. Wait a few minutes to allow any residual to boil off.
- Fill LHe flask with LHe, using standard U tube. The boiloff will be quite high for about an hour, as the detector mount cools down.

Telescope Installation

It will require several hours and about 50% or so of the LHe fill to cool the detector mount. During this time, CRSP may be reinstalled in the box and moved to the telescope dome, if it is not there already.

- Top off LHe with standard U tube after boiloff has stabilized (optional).
- Install special cryogen fill tubes on CRSP. The LHe tube takes the long insert; make sure the inserts are screwed in tightly. Use the teflon gasket between the fill tube flange and the top of the dewar. Make **sure** that the witness marks on the fill tube flanges line up with those on the top of the dewar; this is necessary to clear the rotator.
- Align the fill tubes in the direction indicated in Fig. 1 (CRSP top view), make sure window cover is removed and cart in down position. Roll cart into box, being very careful not to bang fill tubes into anything.
- Carefully raise CRSP until it is against rotator, again watching out for fill lines, which can be caught under rotator parts. Tighten down the four 1/4-20 bolts (blue holes) which secure CRSP to the rotator.
- Remove the three locking pins securing the rotator to the box and jack up the cart so the rotator is raised about 2 inches.
- Remove the steel bar supporting the rotator in the front of the box and carefully roll the cart out of the box. With the combined weight of CRSP and the rotator, it is somewhat topheavy, so it is a good idea for a second person to provide lateral support. Roll the cart under the telescope, with the handle end to the South, and center the rotator under the guider as closely as possible.
- Carefully lower the cart to its limit. Check that the rotator is properly aligned for installation on the guider, using the white witness mark and

pointer on the bottom of the rotator on the SE side. Rotate by hand until the two are lined up, if necessary.

- Install two guide pins at opposite sides of the guider. They should not need to be threaded in more than a couple of turns.
- Remove plug in center of rotator.
- Make sure the telescope is at the zenith. Raise the observing platform until the rotator is almost at the level of the guide pins projecting down from the guider. Adjust the cart until the guide pins will go into the corresponding holes on the rotator. Raise instrument with the cart, guiding pins into rotator holes, until rotator is snug against guider.
- Bolt rotator to guider with standard bolts (1.5 inch bolts are long enough). Clearance is sufficiently limited for some of the holes to require an Allen L wrench. After at least three bolts are securely in, lowering the cart to take some load off the instrument may make removal of the guide pins and installation of the remaining bolts easier. Depending on the guider, 7 or 8 bolts can be installed.
- Unlock pins securing CRSP legs to cart, lower cart, and reinstall it in instrument box. Reinstall steel rotator support bar in box, clean up other loose parts, etc.
- Check that rotator is properly bolted to telescope. Rotate instrument manually to check that no bolts are improperly installed and interfering with the rotator.

Guider

At the 2.1-m, the focal plane of CRSP is very close to the nominal telescope focus (5 cm behind guider), and the normal focus range of the guide probes is sufficient. The acquisition TV is used with a custom lens with a f/15 pupil stop to reject scattered moonlight.

At the 4-m, the f/15 focus is about 30 cm behind the f/8 focus, far beyond the range of travel of the guide probes or the acquisition TV. A 2000 mm focal length lens must be installed on the guide probe assembly to bring the f/15 beam to focus on the guide camera. A similar lens mounted in a long tube is installed on the acquisition TV to keep it within its nominal travel range. A secondary benefit is some demagnification and a consequent increased acquisition field.

Cable Installation

There are two sets of cables, a wrapup (3 cables) between the instrument and junction box, and individual cables (4) from the DCU to CRSP. They should all be in the instrument box.

- Make sure the instrument power supply is OFF before hooking up cables. The instrument power may be controlled from the small switchbox in the control room if the power switch on the power supply itself is in the "remote" position.
- Install telescope cable wrapup. The two power cables connect to the left hand side of the DCU, as seen from the top (Fig. 1). The other ends go to the Cassegrain junction box connectors "CCD Power" and "Aux Power". **Note:** Do not connect the larger power cable to the "PS-10" connector by mistake!
- Remove the teeny condoms from the fiber optic connectors on the DCU, and hook the cables labeled "TRANS1", "TRANS2", "RCVR1" and "RCVR2" to the similarly labeled connectors (the spares attach to the unmarked connectors). After carefully routing the cables to minimize strain and kinks, hook up the fiber cables in the same manner to the telescope fiber connector panel. These panels are located on the S side of the telescope at the 2.1-m and on the N side of the Cassegrain cage (4-m).
- Install Dewar Cables (refer to Figs. 2 & 3):
    - Filter/Slit -- This is a Y-cable from the DCU to two 7-pin Deutsch connectors on the Filter and Slit LEDEX motors.
    - Grating Drive -- Another Y-cable from the DCU to the grating drive motor and encoder. The plastic connector on the encoder cable is fragile.
    - Rotator Drive -- Another Y-cable, the ribbon going to the position encoder on the rotator, the 7-pin Deutsch to the rotator drive motor. The latter cable should not be tied up too tightly, since the instrument moves with respect to the rotator.
    - Safety Limits -- A single cable from the DCU to a 10-pin connector on the dewar case. Encodes the selected grating and safety limit microswitches.

Installing Counterweights

The electronics are sufficiently off center to require additional counterweights on the instrument to permit easy operation of the instrument rotator at large zenith

angles. Two sets of weights, one on the cover of the ACU, the other above the LEDEX motors on the rotator, are sufficiently bulky that the instrument cannot be installed in the cart with the weights attached. The weights should be removed from CRSP when it is taken off the telescope and stored in one of the drawers in the cart; conversely, they should be installed after CRSP is put on the telescope.

Electronics Cooling

The WILDFIRE electronics generate sufficient heat that they must be actively cooled. The air vent fixture kept in the CRSP box should be installed on the left side of the DCU (Fig. 1, 3). The vent hose (at telescope where it exists) should be attached to this fixture and the vent fan turned on before powering up the electronics. Alternatively, one may attach a fan directly to the vent and exhaust the warm air into the dome at sites where the vent hose has not been effectively installed.

Balancing Telescope

Do your own thing, brah!

At the 2.1-m telescope, this may be a good time to install the "Christmas Lights" on the secondary and dress the cable so it can be accessed from the observing floor. These are used in aligning the instrument to the optical axis of the telescope.

At the 4-m, the Christmas Lights" are permanently installed on the f/15 secondary on swing arms and are usually left in place. The lights are accessed through the hatch on the side of the secondary cage. At both telescopes, a custom controller box powers the lights.

4. Getting Started

Most of this is covered exhaustively in the User's Manual, so only a brief outline is given here, except for the Twist & Shout procedure.

The CRSP instrument power supply is located in the computer room; with the switch on "remote", the power may be controlled by a small switchbox next to the observer's console.

- On the IR instrument computer (royal at the 2.1-m; khaki at the 4-m), login as [telescope], with the current password. Execute `obsinit`, choosing `fire` as the environment, and enter the observer name and proposal ID.

- Logout and back into the computer. In the Instrument Control window, enter startwf to bring up WILDFIRE; follow the interactive procedure. The detector bias should default to 0.6.
- Check status of detector and instrument with status s and ?filter.
- If detector is below 77 K (det temp sensor reading > 0.99), activate by pushing the blue button on the right side of the ACU (Fig. 1). The green LED should be illuminated, visible through the hole in the ACU cover.

Twist & Shout

As long as the detector is sufficiently cold to activate, this operation can be done in the afternoon. It need be done only before the first night of a block scheduled run, and if the previous run was on the same telescope, no actual adjustment may be necessary.

The purpose of T&S is to adjust the tilt of CRSP so its intrinsic optical axis is aligned with that of the telescope. This is effectively done when the detector can see all of the four "Christmas lights" at the periphery of the secondary mirror, and that lights on opposite sides give roughly the same signal. Because the lights may differ in intrinsic intensity, and illuminate the detector differently along and across the slit direction, it may not be possible to obtain equal signals for all four lights.

- On the 4-m, open the secondary and #3 mirror covers and check that the guider mirror is in the "thru" position. The primary covers should be closed. On the 2.1-m, check that the guider mirror is in the "thru" position and open the primary covers just enough to permit the instrument to see the secondary.
- Set up CRSP to the H band flatfield configuration (grating 1, H filter, slit 1, 2300 ECU). This should give significant signal in a short (1 s) exposure.
- At the 2.1-m, connect the light selector control to the PS-10 connector at the cassegrain J-box, power up the PS-10, and visually verify that any or all of the lights can be selected. At the 4-m, the controller box is powered by the AC line and the output goes to a connector over the cage door.
- Turn all the lights on and take a 1 s exposure. One should get a bright vertical stripe on the image display. Cycle through the lights and check whether all lights give some signal. You may want to reset zs for better visibility, depending on the signal level.
- Check relative signals for opposite pairs of lights (1,3 and 2,4). If the signal levels appear close for each pair and good signals are seen for each light, the instrument should already be well aligned. At the 4-m, begin with the

inner lights and work out to the outer lights, checking symmetry at each layer.

- If one light of a pair gives much less signal than the other, the instrument needs to be tilted in the direction of that light, using the four bolts on the rotator (see detail, Fig. 4). You will need a 9/16" open-end wrench to do this.
    - Loosen the (top) lock nuts on all four tilt bolts. The instrument is now effectively supported by the bottom nuts on the bolts, and can be tilted by adjusting them.
    - Tilt the instrument toward the light giving less signal. Switch back and forth between the opposite lights, checking the relative signals frequently, until the signals are essentially the same. Fig. 5 illustrates a well-balanced condition.
    - Repeat the procedure for the orthogonal pair of lights.
    - If adjustment in the second coordinate was necessary, go back to the first pair and verify alignment, making small adjustments if needed.
    - When alignment is complete, tighten down the lock nuts on the tilt bolts.
- Turn off lights, power down PS-10, disconnect light cable from connector. At the 2.1-m, remove "Christmas light" assembly from secondary. At the 4-m, it is necessary to move the telescope to the SE annex and stow the secondary to flip the lights out of the beam if one is working in the thermal infrared. CRSP should now be ready for observing.

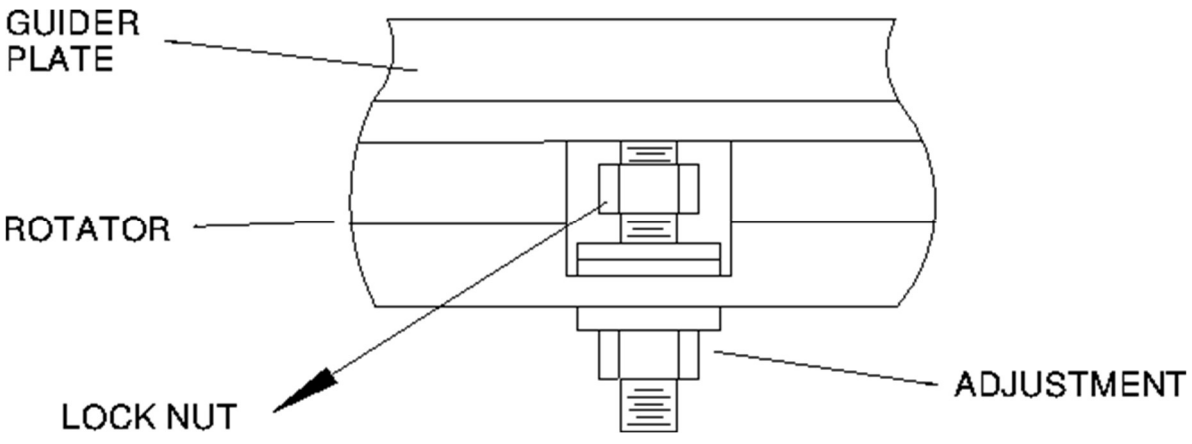

Fig. 4 Detail of tilt adjustment bolts on CRSP rotator.

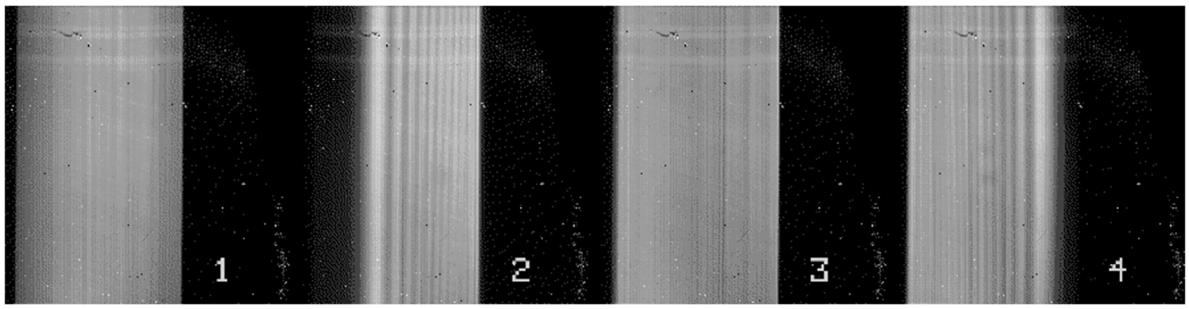

Fig. 5 Images of all four alignment lights in balance.

Cryogen Refills

When all is well, the cryogen hold times for CRSP in powered up configuration should be > 18 hr for the LN_2 and > 14 hr for the LHe. Filling at the beginning and ending of the night should be adequate.

Keeping a cryogen fill log and measuring the LHe level in the storage dewar once/day is good practice, as it can prevent duplicate fills and avoid unpleasant surprises.

5. Observing and Troubleshooting

The procedures for observing with CRSP are covered exhaustively in the CRSP User's Manual. For reference, proper values for `status s` and typical readouts for `?filter` and `ped` are given at the end of this manual.

Troubleshooting is covered in Appendix III. An exception is the procedure for recovering from a limit switch activation, which is sufficiently critical to not be attempted by the observer without consultation with the instrument scientist.

Grating Limit Recovery

Activation of any of the three grating limit switches; short wavelength, long wavelength, or detent, immediately removes power to the grating motor to avoid driving the grating into a hard stop and possibly shearing the grating drive shaft. In the case of the long or short limits, the grating must be manually driven, using the knob on the grating drive motor, until it is backed out of the limit. It is imperative that the motor be turned in the correct direction to recover from these limits.

Short Limit Recovery

Symptoms are a "short lambda limit" error message in `?filter` and a grating position readout < 100. To recover, turn the knob on the grating motor CLOCKWISE and verify that `?filter` registers increasing grating positions. Continue until `?filter` no longer gives a "short lambda limit" message. Normal motor control should then be possible.

Long Limit Recovery

Symptoms are a "long lambda limit" error message in `?filter`. The grating encoder may read a value > 4000. To recover, turn the knob on the grating motor COUNTERCLOCKWISE and verify that `?filter` registers decreasing grating positions. Continue until `?filter` no longer gives a "long lambda limit" message. Normal motor control should then be possible.

Detent Limit Recovery

In theory, this limit should never activate, although it is remotely possible that one can change gratings without the detent engaging fully, with subsequent motion vibrating the grating out of its detent. The danger is that a partially rotated grating turret can impact the radiation shield before the short wavelength limit is reached. This problem is most likely to arise during a programmed motion; the symptom would be a shutoff of the motor during the motion and an `?filter` reading of a grating position other than the programmed destination and a "detent" error message. Recovery is in two steps:

- Manually move the grating motor to the change position of 4000 ECU. If the error occurred during a motion, the actual position may be close to that value. Use ?filter to check the position in this procedure.
- Push in the grating changer knob and attempt to engage the grating. If the grating has rotated only a few degrees out of the detent, it may be possible to engage it and seat it firmly in the proper position. The "detent" LED should go out and ?filter should read properly.
- If that doesn't work, it is necessary to fish for the proper engagment. On the grating change mechanism, back out the set screw next to the changer knob; this set screw constrains the rotation of the knob unless it is pushed in. When this is backed out, free rotation of the knob is possible. Push it in at different angles of rotation until it goes in all the way and the grating turret is engaged; it should now be possible to rotate the grating turret back to the proper position. Since a 180 ° error is possible, make sure the

indicator on the changer knob points to the proper grating number as read by ?filter! Once ?filter reads that all is well, drive the set screw back in, but not so far that it impedes rotation of the changer when it is pushed all the way in.

6. Removal (Deinstallation) of CRSP

In general, removal of CRSP may be accomplished by reversing the installation steps. Since time is usually an issue, many of the installation steps do not have to be undone; for example, one may simply remove CRSP and the rotator and install them in the box without removal of the cryogen fill tubes. Below is a short list of important items:

- Before removing cables or the instrument, ensure that the detector has been deactivated and the instrument power turned off. Usually the observer will have been instructed to do so. If there is doubt, check the green LED in the ACU; if it is on, it will be necessary to:
    - Enter deactivate in the Instrument Control window
    - Enter exit in the Instrument Control window (this should return the hostcomputer prompt instead of "%")
    - Turn off the instrument power supply
- Turn off the electronics vent fan and remove the vent hose (if installed). Remove the vent from the DCU and store in the CRSP box
- Remove the counterweights from the ACU cover and the CRSP rotator and store them in the CRSP box. CRSP will not fit in its box when they are installed
- Carefully disconnect the power/fiber optic cables from CRSP and the Cassegrain junction box. Install the teeny condoms on the cable, DCU, and junction box connectors. Wrap some bubble wrap around the ends of the fiber optic cable to protect the connectors. Carefully roll up the cables and store in the CRSP box or secure on the telescope
- The cables on CRSP may be left in place. However, we recommend removal of the rotator cable, since a later removal of CRSP (without rotator) from the box may damage this cable
- Make sure CRSP is rotated so the white witness mark on the rotator lines up with indicator on rotator motor
- Remove the CRSP cart from the box and roll it under the telescope. Bring the floor up until the cart is close to CRSP, then jack up the cart until the legs are inserted in the guides in the cart and the cart is pushing against CRSP with reasonable force. Engage the two locking pins

- Remove bolts securing CRSP rotator to guider, then carefully lower CRSP cart all the way. Lower platform to clear telescope, then roll CRSP over to its box
- Remove steel bar from CRSP box. Jack up CRSP cart until rotator clears top of box, and carefully roll cart into box. Make sure cryogen tubes do not hit anything
- Install steel bar in box and slowly lower cart until three locking pins securing rotator to box can be installed
- Install two locking pins securing cart in box
- Install plug in center of rotator
- Gather up tools, other items, etc., and store in appropriate drawers in the CRSP box. Close and latch all the drawers. Install top covers

7. Useful Information

CRSP InSb Status Display

Detector Temp = 1.099	Detector Htr Power (mw) = 20.444
LN2 (cy7) = 0.938	LHe (cy7) = 3.103
Stage (cy7) = 1.138	
VDet = -3.038	VDDuc = -3.624
Voff = 0.444	
VDDout : = -1.055	VGG = -1.514
V3 = -2.686	
Data Offset 0 = -2.515	Data Offset 1 = -2.002

Typical ?filter Reply

```
% ?filter
The grating is at position 2580
The slit is at 380um (position 3)
The rotator is at position 2179
The filter is at j (position 4)
The limit switches are set to 0x008
Grating number 1 is in the beam
%
```

Typical ped Display

title[]	Alpha Nuti g1 K 2.280 microns 600s
coadds[1]	1
lnrs[1]	8
pics[1]	1
integration_time[50]	600
filename[data%03d]	data%03d
header_dir	/data2/2meter/crsp/29feb
pixel_dir	/data2/2meter/pixels
mode[stare]	stare
pic-num[41]	41
ucode[CrspMed01_01]	CrspMed01_01
display[only]	only
ra[0:00:00]	
dec[0:00:00]	
epoch[1950]	
offset[0]	0
imag_typ[object]	object
airmass[1]	
comment[]	CRSP 2.1-m 29 Feb 1939 Charfman
im_list[/tmp/list]	
var1[]	
var2[]	
var3[]	
var4[]	
save[only]	only
archive[only]	only

Temperature Sensor Calibrations

There are three types of temperature sensors in CRSP, all of which operate on the principle of a temperature-dependent electrical resistance. These sensors are biased with a constant current (10 μA) and the resultant voltage is read and displayed in the Instrument Status window.

The **LN_2** sensor is a 1n914 diode which has a relatively linear temperature/resistance relation from 50 - 300 K. The sensor in CRSP apparently has a voltage offset, so the values in the table should not be used to reference any other instrument.

The **Detector** sensor is a DT470 diode which has been individually calibrated by Lakeshore over the temperature range 10 - 340 K.

The **LHe** sensor is a 5.1 KΩ Allen-Bradley resistor which has an exponential resistance/temperature behavior at low temperatures. It serves as an "empty" warning indicator for the LHe flask, since exhaustion of the LHe will cause the resistance to drop precipitously.

CRSP Temperature Sensors

Detector		**LN_2**		**LHe**	
V	**T(K)**	**V**	**T(K)**	**V**	**T(K)**
0.584	273	0.40	273	4.50	4.0
0.900	136	0.60	197	3.10	4.5
0.940	117	0.70	162	2.70	5.0
0.980	98	0.80	126	1.50	6.0
1.000	88	0.85	107	1.05	7.0
1.020	77.4	0.90	88	0.82	8.0
1.030	72	0.91	85	0.65	9.0
1.040	67	0.92	81	0.56	10.0
1.050	61.5	0.93	77	0.31	15.0
1.060	56	0.94	73	0.22	20.0
1.070	50	0.95	69	0.16	30.0
1.080	44	0.96	65		
1.090	39	0.97	61		
1.095	36	0.98	57		
1.100	33	0.99	53		
1.105	31	1.00	48		
1.110	28.8	1.05	33		
1.115	27	1.10	23		