Observing at the Danish 1.54-m Telescope

A User's Manual for the TCS and DFOSC

Jesper Storm & James Brewer

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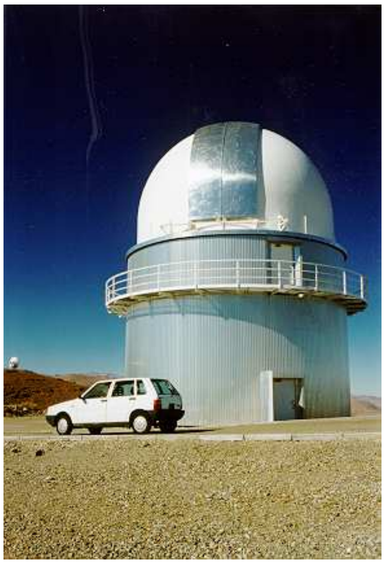

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Revision History

This manual was originally written by Jesper Storm, Bo Reipurth and Thomas Augusteijn. Below is a record of the changes made to this original manual.

Ver.	Date	Author	Changes
0.9	96 Nov	J.Brewer	Broken into LaTeX components.
0.9	96 Nov	J.Brewer	Makefile created.
0.9	96 Nov	J.Brewer	Checked and corrected for typos.
0.9	96 Nov	J.Brewer	DAISY chapter added.
0.9	96 Nov	J.Brewer	Appendix describing MIDAS functions added.
0.9	96 Nov	J.Brewer	Appendix with list of "empty fields" added.
0.9	96 Nov	J.Brewer	Appendix describing all TCS UIF commands.
0.9	96 Nov	J.Brewer	Manual updated for new TCS user interface.
0.9	96 Nov	J.Brewer	Troubleshooting chapter added.
1.0	97 Feb	J.Brewer	Focus Pyramid description.
1.0	97 Feb	J.Brewer	Coronograph descriptions added.
1.0	97 Feb	J.Brewer	Updated to reflect TCS changes.
1.0	97 Feb	J.Brewer	Checked and corrected for typos.
1.01	97 Mar	J.Brewer	Updated to reflect TCS changes.

Observers!

- Your comments and corrections to this manual are most welcome. Please send email to 2p2team@eso.org. Alternatively, write your comments and corrections on the manual in the Danish 1.54-m control room.
- Please check the Danish home page for the latest news (URL: http://www.ls.eso.org/lasilla/Telescopes/2p2T/D1p5M/D1p5M.html)

WARNING! WARNING! WARNING!

Do not leave valuables (calculators, CDs, cassette tapes) unattended in the control room.

Chapter 1

Telescope Operation

1.1 Start of the Night

During the day work is often carried out on the telescope, and we therefore recommend that you reset the TCS VME and reinitialize the telescope and adaptor before commencing your run. This will ensure that the system works as expected.

1.1.1 Starting the TCS VME

In the control room, use the green button in the electronics rack to switch on the hydraulics power system. If the power system has been left on, switch it off and then on again.

Go to the observing floor and open the rack on the north-eastern side. Switch on the α and δ KEPCO power amplifiers (large black "double" switches). Further down in the same rack check that the `DIGITAL/ANALOG` switch is in `DIGITAL` mode. Press the tiny `RESET` button to the left of the `DIGITAL/ANALOG` switch. Remember to close the rack as it is air-conditioned.

To the right of the rack there is a terminal. Lift up the screen cover on this terminal and wait to see a large "GO" appear on the screen. Don't forget to put the screen cover back in place!

1.1.2 Opening the Dome Slit

Never open or close the dome slit with either the M1 mirror cover or skybaffle open

Open the dome slit by first unplugging the cable for the dome movement (the large red plug) located up the stairs on the north side of the dome. The cable for the slit movement is located further up the stairs on the movable part of the dome in a cable dispenser. Connect this cable to the power outlet. If the red light on the upper of the two boxes on the inside of the dome is lit, the crane is not properly parked and you *must call operations.* Open the dome by pressing the button on the control panel marked "←→". When the slit is fully open the motor stops automatically. Unplug the cable and feed it back into the cable dispenser *without letting go.* Finally, reconnect the dome movement cable.

To the left of the electronics rack on the dome floor there is a large grey metal box. Check that the switch for the dome movement is on `AUTOMATIC`. The dome can be moved manually with the controls on the box when the switch is set to `MANUAL`.

1.1.3 Opening the M1 Cover and the Skybaffle

The M1 cover is opened and closed using the buttons on the northern base of the telescope. The skybaffle is controlled by a button in the electronics rack in the control room.

1.1.4 Starting the TCS User Interface

In the control room, log-in on the TCS terminal using:

userid: `tcs` (fully to the left, no trailing spaces)
password: `tcs`

An HP-Vue window environment will be started, and a graphical user interface window called TCS CONTROL PANEL (TCP) will appear. A full description of all the TCS functions can be found in Appendix D.

1.1.5 Initializing the Telescope

Before initializing, it should be checked that the telescope is close to the zenith. The telescope is initialized from the the TCS SETUP PANEL (TSP) which is created by clicking on the `Set-up...` button in the TCP. Locate the **Init** sub-panel and click on the `Telescope` button to start the initialization of the telescope.

To find its initialization point, the telescope moves in right ascension and declination until a sensor crosses the edge of a plate. After starting the initialization of the telescope, go upstairs and watch the telescope initializing. If at any time it appears to you that the telescope or instrument are in danger of colliding with the pier, hit the emergency stop button and call operations. After initialization, the telescope will be pointing to the zenith and the message `TCSlew` will appear in the telescope status box (below the sidereal time on the TCP).

1.1.6 Initializing the Dome

The dome is initialized using the `Dome` button below the `Telescope` button which was used to initialize the telescope. The dome will rotate until it finds its initialization point, and then stop.

The dome status (given at the top of the TCP) will be `Manual`. Put the dome into automatic mode from the **Dome** sub-panel in the TSP.

1.1.7 Initializing the Adapter

The adaptor is initialized from the **Adapter** sub-panel in the TSP. Click on `General Adaptor Init`, and the statuses above this button will change to `In Progr` while initializing, and `Ready` after initialization.

1.1.8 Checklist

To get light, make sure that:

1. the dome slit is open.
2. the switch on the dome control box on the observing floor is set to automatic.
3. the M1 mirror cover is opened.
4. the skybaffle is open (controlled from electronics rack in control room).
5. the dome status been set to automatic on the TSP.
6. the FASU unit (small grey box attached to electronics rack) is set to "Remote".
7. the guide probe is in the park position.

Some further checks that can be made are given in §5.2.1. After this, if you still get no light, contact operations for assistance.

1.2 Telescope Operation

1.2.1 Presetting

Telescope presetting (apart from fixed presets) is controlled from the **Presetting** sub-panel in the TCP. It is possible to enter coordinates or to use a catalogue. To enter coordinates, use the three `Object Coordinates` input boxes. The required format for the R.A. and Dec is hhmmss.ss Sddmmss.s, and for epoch YYYY.Y.

To select a catalogue, use the `Cat.Select` button. This will open a dialogue box in which you enter the name of the catalogue to be used. Catalogues should be located in the `/appl/users/tcs/catal` directory. Navigation within the catalogue is possible using the `Up`, `Dwn`, `Top`, and `Bot` buttons, while the name field of a catalogue can be searched using the `Search Object` box.

If you realize you mis-typed your coordinates or that the telescope is approaching its pointing limits, the preset can be terminated with the `ABORT` button. If you need to stop observing or leave the telescope unattended, put the telescope into `Slew` mode.

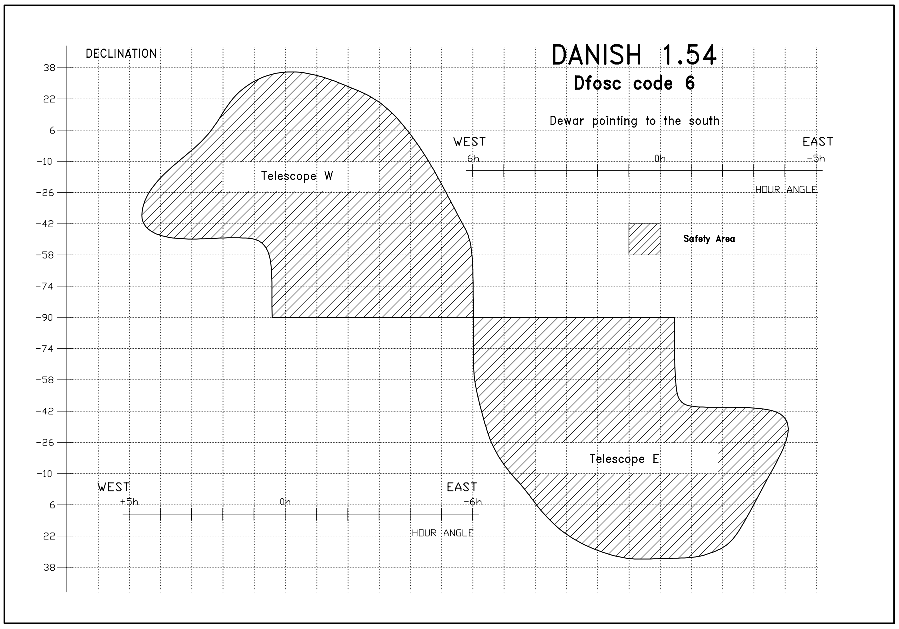

Figure 1.1: Safety map for the Danish 1.54-m telescope with DFOSC mounted. The shaded area shows the allowed area for the telescope. Remember, H.A.=S.T – R.A.

Pointing Limitations

As the dome is very small compared to the size of the telescope and the mount is asymmetric, there are very significant pointing restrictions for the telescope, especially south of –40°, as shown in Fig. 1.1.

You should mention on the set-up form which side of the pier you want the telescope mounted. It is not recommended to change side during the night but the day crew can change the side from one night to the next. Just ask for it in the night report.

The safe zone is *not coded into the TCS.* If a preset is made to outside the safe zone, the telescope will run into a hardware limit switch and start the alarm. Check Fig. 1.1 if you are in doubt about a preset!

1.2.2 The Guide Probe Camera

The guide camera is mounted on an X-Y carriage with a pick-up mirror. The camera is an image tube camera which can be seriously damaged if exposed to too much light when the voltage is on, so please turn down the voltage while presetting and set the voltage according to the brightness of the objects.

The guide probe monitor screen corresponds to 11000 encoder units in X and 14000 encoder units in Y (the orientation of X and Y on the guide probe monitor is shown in Fig. 2.2). The field of view of the guideprobe camera is $\sim 4' \times 3'$.

To look at the sky where the telescope is pointing, and where the CCD will observe, put the guide probe in the centre field position with the `Centre Field` button (in the **Adapter/Camera** sub-panel of the TCP). After the guide probe has reached the centre field position (indicated by green guide probe status flags) switch on the guide probe monitor and *gradually* turn up the camera voltage using the scrollbar control.

When you want to integrate with the instrument CCD you will have to take the guideprobe out of the beam so the photons can continue to the instrument. This can be done by pressing `Park Pos`. Again, wait for the green guide probe status flags. Don't forget to set the TV camera voltage back to zero when not in use!

Filters

The guide probe camera has a filter wheel with 6 positions. The filter wheel is controlled from the **TV Filters** sub-panel in the TSP. When autoguiding on an object at high airmass for a long time, it is recommended to use a filter which matches the passband used for the instrument to reduce the effect of differential refraction (see also Appendix C).

1.2.3 Correct Coordinates

To check the telescope pointing, go to a bright star with accurate coordinates, e.g. from the list of bright stars in the Astronomical Almanac. You can either: (1) put the guide probe in the centre field and align the star with the (unguaranteed) mark on the guideprobe monitor; or (2) take a very short exposure with the CCD through a narrowband or blue filter (guaranteed!).

If using the TV camera, centre the star in the field using the TCS handset (either real or virtual). The values for set- and guide-motions and for the offset can be read (and changed) under `Telescope Constants` in the TSP. If you imaged the star on the CCD, you can use the MIDAS batch `point` to determine the required telescope offsets to centre the star (see Appendix E).

Once the bright star is centred, make the coordinate correction by clicking on `CC` in the **Presetting** sub-panel.

There is a significant difference in the pointing in different regions of the sky. For example, pointing far south can have systematic offsets of more than $1'$ with respect to pointing close to the zenith. This means that, if possible, you should select the reference star in the general region of your targets.

1.2.4 Autoguiding

To acquire a guide star and start autoguiding, follow the below steps:

1. In the **Adapter/Camera** sub-panel, turn the camera voltage up to ~225 V if the sky is dark, though a lower voltage if the sky is bright (you should not see "snow" on the guideprobe monitor).
2. Click on `Start` (**Guide Probe Search** sub-panel). The guideprobe will start scanning along a path that avoids vignetting (provided the instrument has not been rotated).
3. When a candidate star is seen on the guide probe monitor, either:
   - click on the `Record Pos` button. The current guide probe coordinates will be saved as the preset coordinates. The scan will continue, and if a better star appears, click again on

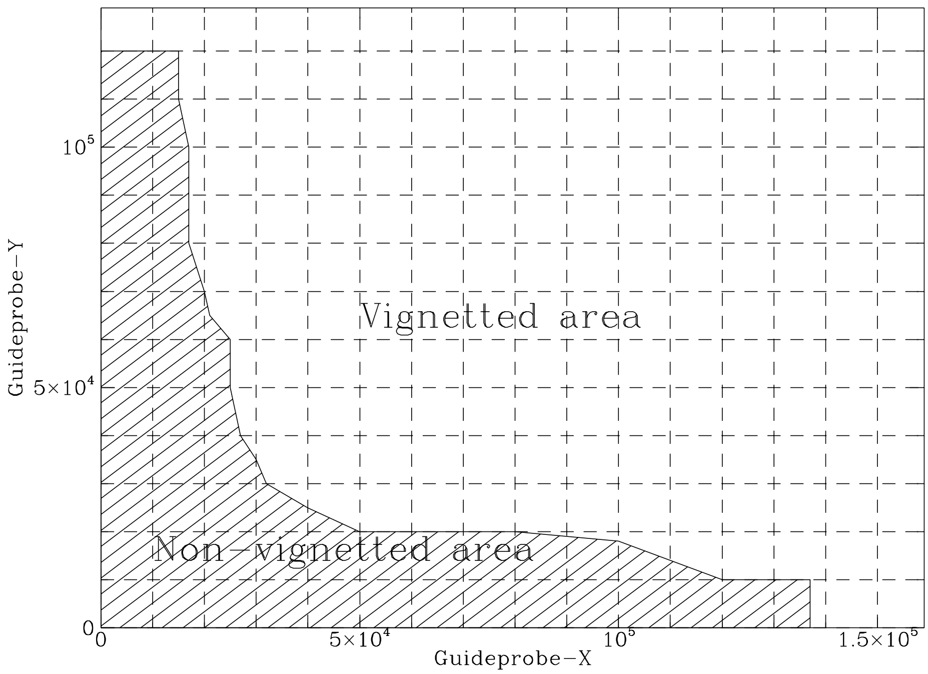

Figure 1.2: The permitted area for the guide probe is at the edge of the field. Note that this map was made with the instrument CCD dewar to the south when the telescope is pointing to the zenith. If you rotate the instrument, the map will no longer be valid.

`Record Pos` to save the present guide probe coordinates into the preset buffer. After the scan is complete, click on `Go To Pos` to return the guideprobe to the last recorded position.

- Click on the `Stop` button. Only use the `Stop` button if you are sure that the star is suitable as a guide star.

4. Move the star to the centre of the screen using the manual guideprobe movement controls (the `-X`, `+X`, `-Y`, and `+Y` buttons) in the **Guide Probe Search** sub-panel. Alternatively, the autoguider box can be moved to the star using the cross hair controls (in the **Autoguider** sub-panel). However, we recommend that the star be moved to the field centre as here the image is on-axis and less prone to optical aberrations.

5. If the guideprobe is vignetting the field a warning will appear in the guide probe status box. However, you may wish to check with the map in Fig. 1.2. Note that the map in Fig. 1.2 is only valid with the instrument in the default position, i.e. with the CCD dewar towards the south when the telescope is pointing to the zenith. If you have rotated the instrument the CCD will be rotated with respect to the guide probe and thus the constraints will have changed as well.

6. It is important to focus the camera to ensure the guide star has a well defined centre. The TV camera is focussed using the controls in the **Adapter/Camera** sub-panel. Remember to re-focus the TV camera if the telescope focus is changed!

7. Start autoguiding by clicking on either `Star to Box` or `Box to Star` in the **Autoguider** sub-panel. The `Star to Box` button starts autoguiding without relaxation, that is the telescope is

moved until the star is centred in the guide box. The `Box to Star` button starts autoguiding with relaxation, that is the box is centred on the star before autoguiding commences. We recommend that you start the autoguider using `Box to Star`, as this eliminates the possibility of making an exposure while the star is centring in the box.

8. The autoguider counts are displayed in the **Adapter/Camera** sub-panel. For good autoguiding you need of the order of 100,000 counts. The voltage can be turned up to increase the counts, but if you start to see "snow" on the screen, the voltage is too high. If your counts are too low after increasing the voltage, increase the integration time with the TV camera integration control (below the voltage control in the **Adapter/Camera** sub-panel.)

There are some additional autoguider parameters in the TSP that you may wish to try out, otherwise leave them with their default values (Resolution: High; Center line: Off; XH colour: White. See Appendix D for details).

Remember to stop autoguiding and set the TV camera voltage to 0 before starting a new preset. When not in use, put the guide probe into the park position.

1.2.5 Differential Guiding

Please read the technical report on differential guiding as the current system has to be tricked into giving good results

The TCS allows differential guiding by moving the guidebox on the guide probe image. Thus the maximum exposure is limited by the object's proper motion and the field of view of the guide probe. The maximum exposure will depend critically on where in the field you place the guide star.

To enable the differential guiding, start autoguiding on a suitable star. When the status of the autoguider shows `Autog_ON`, open an xterm on the TCS console (the current version of the TCS user interface does not support differential guiding) and issue the command:

```
cmd pltrack ΔRA ΔDEC
```

The 'cmd' bypasses the TCS UIF, and sends the command directly to the TCS.

With the telescope EAST of the pier use:

$$\begin{aligned} \Delta\mathtt{RA} &= +(d\mathtt{RA}/dt) \times 15\cos(\mathtt{DEC}) \\ \Delta\mathtt{DEC} &= +(d\mathtt{DEC}/dt) \end{aligned}$$

With the telescope WEST of the pier use:

$$\begin{aligned} \Delta\mathtt{RA} &= -(d\mathtt{RA}/dt) \times 15\cos(\mathtt{DEC}) \\ \Delta\mathtt{DEC} &= -(d\mathtt{DEC}/dt) \end{aligned}$$

The units are arcseconds per second of time, i.e. $''$/sec.

The differential guiding is stopped with the command

```
cmd nopltrack
```

in the xterm and the autoguiding is stopped as described previously.

1.3 End of the Night

At the end of the night, follow the below steps to protect the telescope and instrument from potential danger and from unnecessary dust contamination.

1. Check that the TV camera voltage is set to zero.
2. Open the TSP and preset the telescope to the zenith (`Zenith` button in the **Fixed Presets** sub-panel). After the preset has finished, close down the TSP panel using the `DONE` button.
3. In the TCP click on the `Shut Down...` button and confirm the operation. The TCP panel will disappear in around 5 seconds.
4. Switch off the hydraulics system (below the stereo).
5. Switch off the autoguider monitor.
6. Close the sky baffle.
7. Close the main mirror cover.
8. Close the dome slit (this must be done *after* closing the sky baffle and main mirror cover).

1.4 The Safety System

1.4.1 Alarms

There are two audio signals that tells you about problems with the telescope:

1. A high-pitched tone. This indicates that the telescope is approaching the limits of the safety system. When you hear this, you have roughly 5 minutes to terminate your exposure, and put the telescope in slew. Once in slew mode check the four LED's in the rack above the guide probe TV, they are usually all green, indicating that movement in any direction is safe. When the alarm sounds, one or more will not be lit, indicating that you must not move the telescope in those directions, choose one of the "green" directions for a safe way out.
2. A powerful beeping. This indicates that the telescope has already gone into the hardware limits. To restore the system, follow the instructions in §1.4.2.

1.4.2 Telescope in Limits

Don't panic! To recover control of the telescope, *carefully* follow the below instructions:

In the control room:

1. Set the TV voltage to 0.
2. If the emergency button has been used, turn it clockwise until it "pops out".
3. Click on `Shut Down...` in the TCP and confirm the operation. The panel will disappear in a few seconds.
4. If you used the emergency stop button on the dome floor, you will have to switch the hydraulic system (green button below the stereo) back on.

On the dome floor:

3. Use the dimmer switch to turn the dome lights on at the lowest level you can see clearly in.
4. Find the `DIGITAL/ANALOG` switch in the TCS-VME rack and switch it to `ANALOG`.
5. Switch on the two KEPCO power amplifiers (if one is still on (up), switch it off and on again).
6. To the left of the rack, above the dome control, push the orange button labelled `Push to override limit switches` and hold it in while doing point 7.
7. With the analogue handset (which is usually hanging up to the left of the large electronics rack) carefully take the telescope out of the limit. The safe directions out are given by the safety display on the dome floor (south-east corner, where there is also an additional orange override button and manual telescope controls), but visually check that the telescope is moving as you expect. Note that when the telescope is on the west side of the pier the $+\delta$ and $-\delta$ directions on the analogue handset are reversed.
8. Once out the limit, move the telescope to the zenith.
9. In the TCS-VME rack change the switch back to `DIGITAL` mode.
10. In the TCS-VME rack push the tiny red `RESET` button on the CPU board (the leftmost board in the rack). If the reset fails, a red LED will shine on the CPU board. In that case turn the VME main power off and on again (use the key hidden behind wires, just below the `DIGITAL/ANALOG` switch). Look on the terminal to the right of the rack, and wait for a big GO to appear.
11. Switch off the dome lights and return to the control room.

In the control room:

10. Restart the TCS user interface, reinitialize the telescope and dome, and do a new correct coordinates (see §1.1.5, §1.1.6, and §1.2.3).

Chapter 2

The Danish Faint Object Spectrograph and Camera

2.1 Introduction

The Danish Faint Object Spectrograph and Camera (DFOSC) is a focal reducer type of instrument, similar in concept to ESO's EFOSCs. DFOSC allows both wide field imaging ($\sim 13' \times 13'$ field of view) and low-resolution grism spectroscopy. The selection of available grisms give resolutions of between 1.2Å (in the optional echelle mode) and 20Å. In the future a multi-object spectroscopy (MOS) mode will be made available. The instrument was designed by Copenhagen University Observatory in collaboration with ESO and built by Copenhagen University Observatory.

The beam from the telescope passes through the FASU (Filter And Shutter Unit) where two filter wheels in the converging beam allow both narrow- and broad-band filters to be mounted. The field is unvignetted by FASU if circular filters with a minimum diameter of 80mm are used.

After the beam has passed the FASU it focuses on the aperture wheel where various slits can be mounted. The beam continues through the collimator and forms a parallel beam which passes the filter and grism

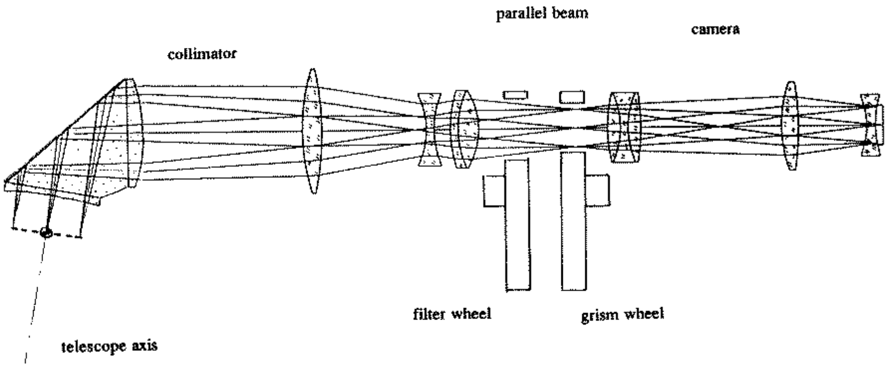

Figure 2.1: The optical layout of DFOSC. The aperture wheel is located along the telescope axis, just before the collimator.

Table 2.1: DFOSC Optical Characteristics

Parameter	Value
Collimator focal length	252.2mm
Collimator linear field	52.9×52.9mm
Camera focal length	146.3mm
Camera linear field	30.7×30.7mm
Reduction ratio	0.58
On the Danish 1.54-m (nominal values)	
Input f-number	8.6
Output f-number	5.0
Input scale	64.2 μm/$''$
Output scale	37.2 μm/$''$
Field of view	$13.7' \times 13.7'$

wheels before being imaged by the camera on the CCD. All the DFOSC wheels have 8 positions of which 7 can be used for optical components, while the eighth position is free (a 'free' position has a sky baffle, and should always be used instead of an 'empty' position). The field is unvignetted by DFOSC if circular filters with a minimum diameter of 45mm are used.

The optical layout of DFOSC is shown in Fig. 2.1, while the basic optical characteristics of DFOSC are summarized in Table 2.1.

2.2 The CCD

2.2.1 General Characteristics

The CCD currently in use with DFOSC was provided by the Copenhagen University Observatory and is a backside illuminated LORAL/LESSER chip with 2052 $\times$2052 15μm pixels. This CCD was supposed to be UV flooded to increase its quantum efficiency in the blue. Unfortunately, the UV flooding process failed and the chip is only offered in an unflooded state. This means that the efficiency in the blue is low. The Danes are currently trying to obtain a new chip to rectify this situation.

The CCD is controlled by the BROCAM CCD controller which is interfaced to a Linux PC on which the Brorfelde Image Acquisition System (BIAS) program is running. The controller reads out the entire chip in 75 seconds, though it is hoped to improve this in the near future. There are two output amplifiers, A and B, which can be operated in both high- and low-gain modes. The B amplifier is the default as it has the most stable bias level with respect to detector temperature (nominal operating temperature of the CCD is -100°C) and is usually operated in high-gain mode to achieve the lowest read-out noise. Various parameters for the CCD when using different gains and amplifiers are given in Table 2.2.

Table 2.2: Parameters for the LORAL/LESSER W11-4 CCD

Amplifier	Gain	Conversion Factor (e^-/ADU)	RON (e^-)	Linear Limit (e^-)	Linear Limit (ADU)	Bias/Temp. Slope (ADU/K)
A	high	1.31	6.9	135000	65535	4.7
A	low	2.94	8.7	135000	45000	4.7
B[1]	high	1.31	7.2	125000	65535	2.5
B	low	2.85	8.4	125000	40000	2.5

[1] This is the default setup.

2.2.2 Bias and Dark Current

With the present set-up the bias level is around 215 ADU for both amplifiers, with a slight gradient of about 3 ADU in the horizontal direction. The dark current is approximately 2.5 e^-/pixel/hour at –100°C.

Be aware that the bias level is temperature sensitive, and might drift a few ADU if the temperature of the chip deviates by around 1°C from the operating temperature. The effect is hard to monitor as the chip currently does not provide an overscan region. The laboratory values of this dependence (valid between –90°C and –101°C) are noted in Table 2.2 as the slope of the best fitting linear relation. Note that amplifier A is significantly more sensitive to temperature variations. If you are working with very low background levels, it is recommended that you obtain bias frames throughout the night.

2.2.3 Field of View

Mounted on DFOSC, the LORAL/LESSER CCD covers a field of $13.3' \times 13.3'$, with a pixel scale of $0.39''$/pxl. With the instrument rotator in the default position and using amplifier B (recommended) for the read-out, the image appears in the MIDAS display with north up and east to the left (see Fig. 2.2).

2.3 Imaging

DFOSC offers the possibility of imaging a large field, though naturally this comes at a price. DFOSC's limitations come from the fact that the light has to pass several optical components on its way to the detector.

2.3.1 Image Quality

The image quality is well matched to the current capabilities of the Danish 1.54-m telescope, and stellar images with a FWHM down to $0\overset{''}{.}8$ have been reported. The distortion is reported to be 0.5% in the corners of the field, i.e. $9'$ from the field centre.

2.3.2 Sky Concentration and Flat Fielding

As with most focal reducers, DFOSC is affected by "sky concentration". Sky concentration is an effect that makes it more difficult to produce really good flat fields because scattered light is preferentially directed towards the centre of the field by the optics. This causes a distortion of the flat field which will lead to an underestimate of the counts in the central part of the field. For DFOSC the effect has been measured at the 2% level. However, this is comparable to the accuracy with which normal flat fields can be obtained. If higher accuracy is needed a more sophisticated procedure has to be followed (see Andersen *et al.* 1995).

2.3.3 Narrow Band Imaging

Narrow band filters should *not* go into DFOSC itself but rather in the FASU. As the filter wheel in DFOSC is located in the parallel beam the light from sources in different positions in the field of view will pass the filter at different angles. For this reason the central wavelength of the filter will change slightly across the field if the filter is an interference filter, which is usually the case for narrow band filters. For broad band imaging this is no serious concern, but for narrow band imaging this can be very critical. Mounting the filters within the FASU places the filter in the converging beam where the light for all objects in the field enters the filter in more or less the same way and thus circumvents the problem in the parallel beam.

The central wavelength of a filter mounted in the parallel beam is determined from the formula:

$$\lambda_C = \lambda \times \sqrt{1 - \frac{\sin^2\theta}{n}} \tag{2.1}$$

Here n is the effective refraction index of the filter (a typical value is 2), θ is the angle between the beam and the filter and λ is the nominal central wavelength for a beam with 0° incidence. In DFOSC the filters are mounted with an inclination of 6° to avoid internal reflections and the beam itself covers 6° from one side of the detector to the other. Thus at one side of the detector the angle θ is 0° and at the other 12°. From corner to corner the difference is about 15°. This means that for a typical filter with $n = 2$ the central wavelength changes by almost 1% from one corner to the other, which for a 600nm filter would imply a shift of almost 6 nm!

The current set of reserved image quality narrow band filters are 60mm in diameter and *will* vignet the DFOSC field when used in the FASU. Filters in FASU must have a diameter of at least 80mm for an unvignetted field.

2.3.4 Broad Band Imaging

The current set of reserved image quality broad band filters (Bessel $UBVR$ and Gunn $griz$) are only 60mm in diameter and will introduce significant vignetting when mounted in the FASU (for an unvignetted field, 80mm diameter filters must be used in the FASU). For this reason it is important that the broadband filters are mounted in the DFOSC filter wheel.

Approximate count rates in BVR and i were measured in Jul.96 for the unflooded W11-4 CCD after the CCD had been cleaned. The efficiency improved significantly but is still far from the level obtained with

Table 2.3: Count Rates in $BVRI$ for a $15^{\mathrm{m}}_{\cdot}0$ Star.

Filter	Count Rate (e−/sec)
B	2560
V	3650
R	4330
i	1980

the UV-flooded CCD's. The resulting count rates for a $15^{\mathrm{m}}_{\cdot}0$ star with zero colour are given in Table 2.3.

No correction for extinction has been included, but the airmass was only about 1.15 for these measurements.

A set of simple equations for evaluating on-line magnitudes were also derived:

$$B - b = 0.10(\pm 0.) \times (b - v) + 23.52(\pm 0.) \quad (2.2)$$
$$V - v = 0.08(\pm 0.) \times (b - v) + 23.91(\pm 0.) \quad (2.3)$$
$$R - r = 0.04(\pm 0.) \times (v - r) + 24.09(\pm 0.) \quad (2.4)$$
$$I - i = 0.01(\pm 0.) \times (v - i) + 23.24(\pm 0.) \quad (2.5)$$

Here the lower case letters denote instrumental magnitudes computed on the basis of the number of electrons/seconds detected from the object, i.e.

$$m = -2.5 \log(f) \quad (2.6)$$

where f is the number of electrons detected from the star per second. The MIDAS command `imstat` can be used to measure the star counts (don't forget to subtract the sky). To convert the star counts into f, multiply by the gain and divide by the exposure time. Note that the strong colour term in B is most probably due to the rapid fall-off of the quantum efficiency of the CCD towards the blue.

2.3.5 Coronography

A coronograph is available for use with DFOSC. The coronograph is a glass plate (with an anti-reflection coating) on which there are four occulting spots. There is currently no Lyot stop available.

The location and size (in pixels and arcseconds) of the occulting spots is given in Table 2.4. These data were measured using the W11-4 CCD. Note that the W11-4 CCD has many bad columns near to the occulting spots, making observations awkward (it is not possible to move the position of the occulting spots).

Table 2.4: The Position and Size of the Occulting Spots Measured (V Filter in the Beam)

X (pix)	Y (pix)	Diam. (pix)	Diam. ($''$)
870	1160	50	19.5
1108	1160	9	3.5
1108	923	32	12.5
870	923	17	6.6

2.3.6 Shutter Timing

The shutter timing is adjustable in the BIAS program and the intrinsic timing error of 0.11 seconds has now been to reduced to around 0.01 seconds. However, the shutter error might be dependent on temperature as well as on telescope and instrument orientation. In conclusion, exposures of less than 5 seconds should be avoided for photometric purposes.

2.3.7 Image Orientation

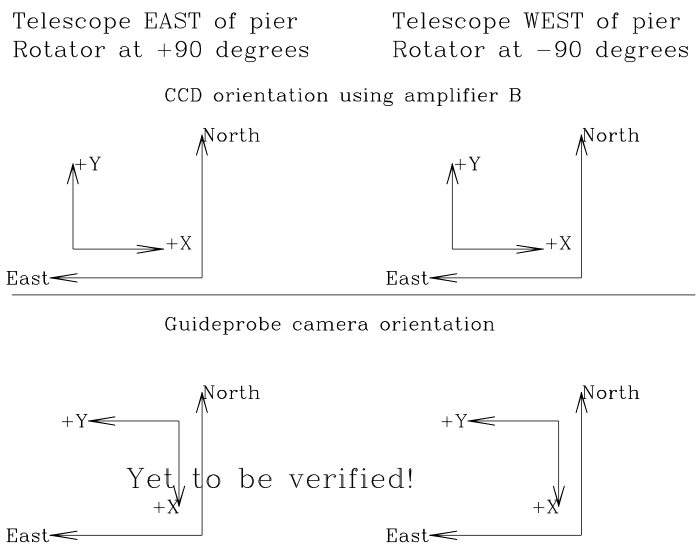

Figure 2.2: Orientation of the image on the CCD and on the TV guider camera. Note that the celestial coordinates rotate as the instrument is rotated, but the X,Y coordinates of the guide probe are fixed as the guideprobe is mounted within the adapter.

The default configuration of DFOSC is to use amplifier B with the instrument rotated in such a way that the dewar is in the south. This is achieved with a rotator angle of 90° when the telescope is east of the pier and –90° when the telescope is west of the pier. In this configuration north is up and east is to the left on the CCD as shown in Fig. 2.2. Using amplifier A will flip the east-west orientation and the MIDAS `point` batch will not work properly.

2.4 Spectroscopy

DFOSC provides a wide range of spectroscopic capabilities ranging from low-resolution long-slit spectroscopy to intermediate-resolution echelle and long-slit spectroscopy. In the future a multi-object spectroscopy (MOS) mode will also be made available.

2.4.1 Slits

A new set of slit was made available in January 1996. The following sizes are available: 1.″0, 1.″5, 2.″0, 2.″5, 5.″0, and 10.″0. The 1.″0 slit is not very smooth showing flux variations of ±5% along the slit. Due to the flexure and limited offset accuracy of the telescope the use of a 1.″0 slit is difficult. Furthermore it is often not very efficient considering that the seeing is often worse than 1.″0. Thus, the narrow slit is only recommended for when the highest possible resolution is required and some loss in efficiency can be tolerated.

For use in echelle mode a special set of slits is available which have a slit *length* of about 10″ to prevent the echelle orders from overlapping.

2.4.2 DFOSC Grisms

DFOSC is equipped with a large set of grisms. In resolving product they range from ≈ 200 to ≈ 4000 and in each resolution domain blue, visual, and red grisms are available. The choice of a blue or red grism not only improves the efficiency but also allows the user to avoid second order contamination in the red region if this is the region of interest.

Grisms #9 and #13 are echelle grisms, and grisms #10, #11 and #12 can be used as cross-dispersers, in which case they are mounted in the DFOSC filterwheel.

With the current set-up of the CCD, the red end of the spectrum is in the lower part of the image, and for echelle applications the red is also to the right.

2.4.3 Echelle Spectroscopy

DFOSC offers the possibility to do intermediate-resolution spectroscopy (R ≈ 4000) covering a large spectral range using one of the two echelle grisms (#9 and #13) and using one of the low-resolution grisms (#10, #11, and #12) as a cross-disperser.

Physically this is achieved by mounting the echelle grism in the grism wheel in the normal way and mounting the cross-disperser in the filter wheel, but turned 90° with respect to the normal grisms.

Grism #13 is intended for use with an order sorter filter to give intermediate-resolution spectroscopy with a long slit but it can also be used with one of the cross disperser grisms. Note, however, that

Table 2.5: Grism Characteristics

Grism	λ_c (nm)	λ_{blaze} (nm)	Grooves (mm^{-1})	Dispersion (nm/mm)	Resolving product[a]	$\Delta\lambda$ (nm)	Range (nm)
3	390	430	400	17	690	0.55	330-640
4	480	580	300	22	700	0.83	350-700
5	650	700	300	22	870	0.75	520-1020
6	390	400	600	11	990	0.39	320-550
7	530	525	600	11	1300	0.41	380-680
8	650	700	600	8.8	2200	0.30	580-830
9[b]			79	2.6	4300	0.12	330-1100
10	380	390	150	46	230	1.7	330-640
11	520	500	200	34	390	1.3	390-760
12	730	700	75	91	200	3.7	520-1020
13[b]	510	525	316	3.6	4200	0.12	480-580[c]

[a] The resolving power is computed for a $1''$slit.
[b] Grism #9 and #13 are echelle grisms.
[c] This range is achieved using a special order sorter filter.

grism #13 does not cover the full wavelength range as the individual orders are longer than the detector can accommodate (see Table 2.7).

An order sorter filter is currently available to select the third order (480–580 nm).

For both grisms the efficiency falls off dramatically towards the edges of the wavelength range, as is typical for echelle spectrographs. For grism #9 the efficiency as a function of wavelength can be found in Appendix A.2. We currently have no tracing of the efficiency of grism #13.

The Cross-Dispersers

Currently three cross-disperser grisms are available, namely grisms #10, #11, and #12. Not only do they have different peak transmission wavelengths (400, 500 and 700 nm) making it possible to optimize the efficiency for the wavelength of interest, but they also have very different blue cut-offs. This means that they can be selected to avoid second order contamination in the red. The blue cut-off of grism #12, for example, is about 510 nm and thus there will not be any second order contamination up to 1020 nm and the effective wavelength range with grism #9 will be from 530 nm to 1020 nm.

Echelle Wavelength Calibration

Currently we do not have much experience with the echelle mode.

To determine the wavelength solution there are a number of arc lamps available. They are Th-Ar, Cu(He-Ar), Cu(Ne-Ar), Fe(Ne-Ar-He) and He-Ne. The copper and iron arc lamps have copper and iron electrodes respectively and the filling gasses mentioned in parenthesis. The He-Ne lamps are installed in the sky baffle but provide too few lines to properly calibrate the echelle mode. The other lamps have to be mounted in the calibration unit.

Table 2.6: Approximate Wavelength Coverage of the Orders for Grism #9.

Order	λ_{start} (nm)	λ_{end} (nm)	Order	λ_{start} (nm)	λ_{end} (nm)
6	995	1190	15	425	504
7	857	1040	16	402	475
8	754	914	17	382	450
9	675	816	18	365	427
10	611	737	19	350	408
11	560	673	20	336	390
12	517	620	21	324	374
13	481	575	22	314	360
14	451	537	23	304	347

Table 2.7: Approximate Wavelength Coverage of the Orders for Grism #13.

Order	λ_{start} (nm)	λ_{end} (nm)	Order	λ_{start} (nm)	λ_{end} (nm)
2	701	862	3[1]	478	582
4	369	444	5	306	363

[1] A special order sorter filter is available for selecting this order.

The Th-Ar and Cu(He-Ar) lamps provide very rich spectra which are very hard to use due to crowding of the lines. The Cu(Ne-Ar) seems to provide the best balance between providing good coverage and little crowding, but Fe(Ne-Ar-He) also appears to be reasonable although slightly richer than the Cu(Ne-Ar). The exposure time also plays a major role in the visual impression of the richness of the spectra.

For tracking the wavelength shifts during the night, He-Ne exposures using the lamps in the sky baffle cover should be sufficient, if a good wavelength solution has already been established. This can save some time as the He-Ne lamps in the cover of the sky baffle are significantly faster to bring into the beam than the lamps in the calibration unit.

All the lamps are very bright and a typical exposure time is around 10 seconds. The overhead of moving in the calibration unit is of the order 2 minutes.

2.4.4 Multi-Object Spectroscopy (MOS) with DFOSC

DFOSC is foreseen to provide a MOS mode but it is not clear when this will be implemented.

2.4.5 Fringing

As the LORAL/LESSER chip is a thinned device it suffers from significant fringing in the red. With grism #8 the amplitude of the fringes is of the order 10% and the spatial frequency is about 20 pixels (see Fig. 2.3). The effect becomes really significant on the red side of 7000Å. As the slit is known to move slightly with position in the sky, the fringes are suspected to move as well, making correction very difficult.

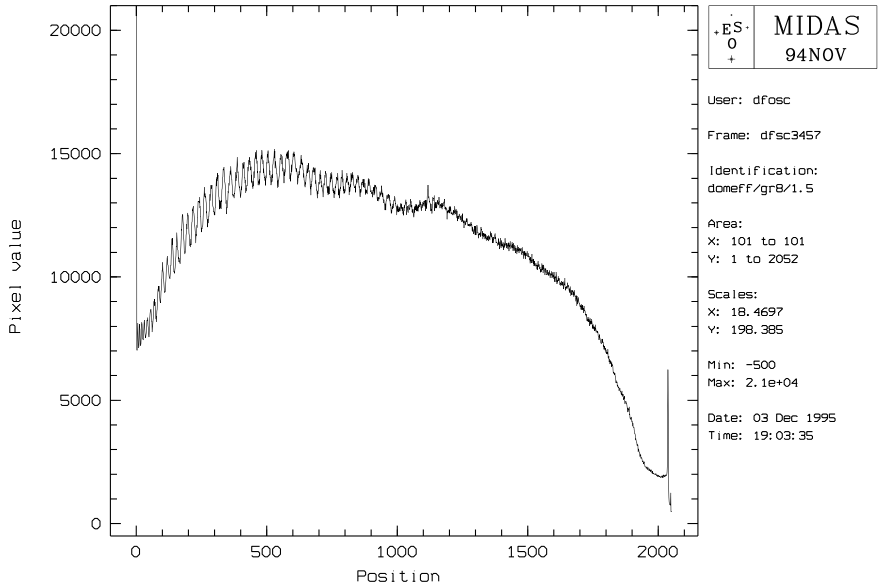

Figure 2.3: A dome flatfield with grism #8 (830-580 nm).

2.4.6 Spectroscopy in the Blue

The problem with most spectroscopic observations in the blue is the contamination by scattered light from the (usually) much brighter red part of the spectrum. This is true both for flat fields and for scientific observations. The effect has not yet been quantified.

If you are making long integrations at high airmasses, you might consider using a blue filter in front of the guideprobe to compensate for the differential refraction, especially if you are not able to put the slit along the parallactic angle. See Appendix C.

2.4.7 Flexure

The flexure in DFOSC has been measured in December 1995 by measuring the position on the CCD of the image of a pinhole in the aperture wheel. The measurements were done with the BROCAM dewar pointing to the south and with the telescope on the east side of the pier. In Figs. 2.4 and 2.5 the shift of the image in pixels has been plotted against HA and DEC respectively.

It can be seen that there is a significant movement of the slit both in the spatial direction (X) and in the dispersion direction (Y). Thus for obtaining accurate radial velocities it is important to acquire calibration spectra during the night in the same telescope position as used for the science exposure, if the night sky lines are not bright enough to provide the zero point offsets. The good thing is that the movement is largely elastic and there is not a significant amount of hysteresis present.

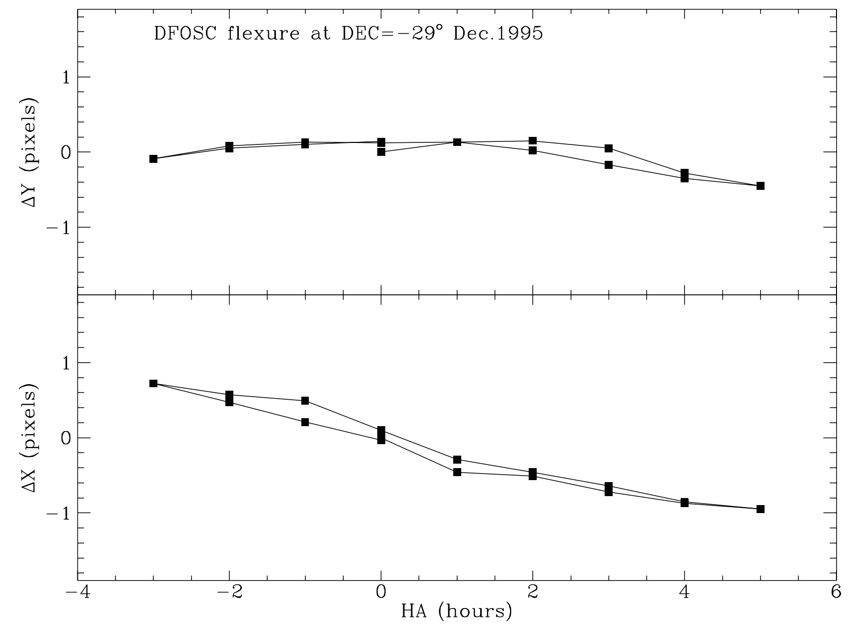

Figure 2.4: The flexure in DFOSC as a function of hour angle. The line tracks the sequence of the measurements and reveals that there is no significant hysteresis for this movement.

The flexure has implications for the procedure for putting the object on the slit as the slit position can change significantly depending on telescope position.

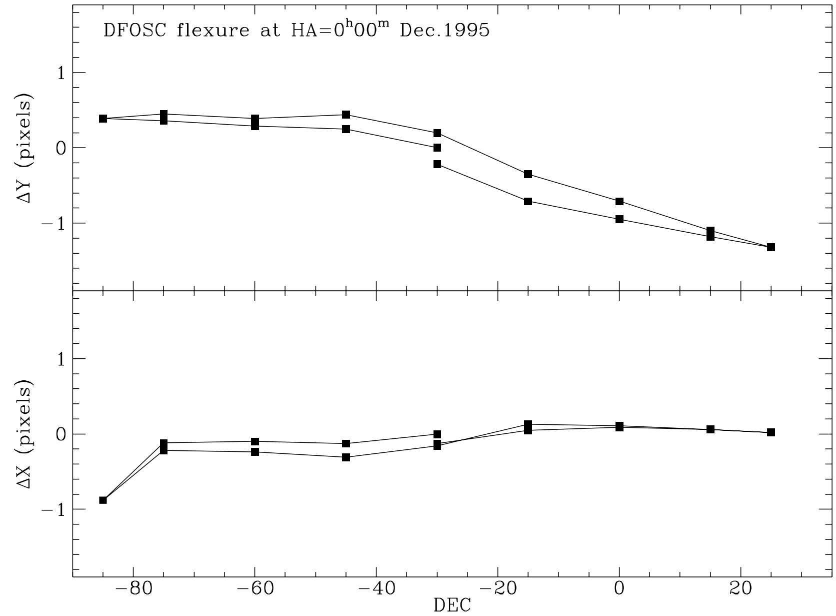

Figure 2.5: The flexure in DFOSC as a function of declination. The line tracks the sequence of measurements and reveals that there is no significant hysteresis for this movement

Chapter 3

DAISY: Data Acquisition Integrated SYstem

3.1 Introduction to DAISY

The Data Acquisition Integrated SYstem (DAISY) installed at the Danish 1.54-m telescope combines control of the CCD camera, the DFOSC, the FASU (Filter and Shutter Unit), and the telescope focus into an integrated system run from a dual screen workstation.

The CCD camera is controlled by DAISY via the BIAS (Brorfelde Image Acquisition System) program which runs on a Linux PC. The BIAS program has its own user interface, though this should *not* be used simultaneously with DAISY. To control the DFOSC and the FASU, DAISY communicates directly with the adaptor VME. The DFOSC can also be controlled from the Linux PC, though the DFOSC user interface should not be used when DAISY is running.

DAISY's windows have in general three areas: pull-down menus on top, data fields in the centre, and command buttons at the bottom. The menus and commands are "lit" when enabled and "dim" otherwise. Buttons and menus are accessed with the mouse in the usual way; activation is done with the left hand button, exiting with the middle or right button.

3.2 Starting and Stopping DAISY

DAISY automatically starts when you log in on the workstation. It may be necessary (and is often a good idea) to logout from the current session first so as to start everything afresh. To do this move the mouse to a region between windows and click and hold the right button. Then slide to the `Log out...` bar and release. After a moment a window will appear in the centre of the screen presenting Login and Password fields. Login with userid `daisy`, and the password posted on the notice board. Make sure both of these are fully to the left.

After some time the main DAISY windows will appear on the left screen of the dual screen display, while MIDAS command, image display, and graphics windows will start up on the right screen.

Before proceeding any further, you should check that the connection to DFOSC is enabled. On the left screen go to the **CCD** window and click on the `Maintenance` menu. Check on this menu that the `Connection to DFOSC` option is enabled (indicated by a "green light"). Also check at this stage that the switch on the manual FASU control (on the electronics rack) is set to "remote".

You are now ready to start using DAISY. The main windows of the system are:

- **CCD**: This window allows you to define up to 8 different exposures and also sequences of exposures to be executed. The DFOSC and FASU set-ups, and the MIDAS batch executed at the end of the exposure, are specified in this window. This window contains sub-menus at the top and exposure control commands at the bottom. Note that the **DFOSC**, **FASU**, and **CCD Status** windows can all be restarted from the `Observation` menu in this window.

- **CCD Status**: Gives all the relevant information about the status of the exposure and the CCD. The small dialogue area in the lower part of the window is used to display `CCD messages` giving information about the flow of events (e.g. `File 'dfsc0001.mt not saved'`). You are strongly advised to pay attention to this area. Urgent error messages from the CCD controller will appear in a yellow pop-up window.

- **DFOSC**: This window is used to control DFOSC. The panel shows which slits/filters/grisms are currently in the beam, and also gives rotator angle and camera focus values. The rotator angle and camera focus can both be changed by using the lower buttons (though note that the camera focus is set by operations and should not need adjustment). The `DFOSC Setup...` button is used to define permutations of DFOSC's filters, grisms, and slits.

- **FASU**: This window is used to control the FASU. The panel shows the current position of FASU's two filter wheels, as well as the status of FASU's shutter. The `FASU Setup...` button is used to define permutations of FASU's two filter wheels.

3.3 Defining DFOSC and FASU Set-Ups

Up to 8 set-ups for both DFOSC and FASU can be defined and saved. To define DFOSC set-ups click `DFOSC Setup...` in the **DFOSC** window. A new window will appear consisting of the set-up number (1-8)[1] and fields for DFOSC's three wheels. Each field has a button on the right hand side. Click this button and the list of optical components in the corresponding wheel will appear. Slide the mouse to select the desired optical component and release the button. Click `OK` to save your changes and exit, and `CANCEL` to exit without savng any changes.

The set-ups for FASU's two filter wheels are similarly defined and saved by clicking on `FASU Setup...` in the **FASU** window. Note that both DFOSC and FASU can be controlled "manually" using the `Manual` menus located in the **DFOSC** and **FASU** windows.

[1]The set-ups defined here are the ones which will be entered in the `DFOSC Setup` and `FASU Setup` fields of the exposure definition (CCD) window.

3.4 Defining and Executing Exposures

3.4.1 General

As with the other windows, **CCD** has three main areas. The upper area contains pull down menus, the central area boxes for exposure definition, while the lower area has command buttons to control aspects of the exposure.

3.4.2 The Pull-down Menus

- **File**. Contains self explanatory commands to manipulate the sequence files. The command `Multisequence` allows you to compose sequences of sequences in any order. This is done via a new window which appears when `Multisequence` is clicked. This window has two menus at the top: `File` and `Edit` which are used as follows:
  - `File` is used to create, save, recall, or delete multisequence files (`.mseq`).
  - `Edit` is used to select the sequence files (`.seq`) that will be included in the multisequence file, and includes options to swap entries, that is to change the order in which sequences are executed.
- **Observation**. Contains commands to open the **DFOSC**, **FASU**, and **CCD Status** windows, a command to initialize the CCD (via a pop-up window), a command to enable the **Exposure Summary** window, a command to reset the file counter (done via a pop-up window), and a command to enable a **Telescope Focus** window. The **Exposure Summary** window gives the exposure status and the remaining exposure time; this window is very useful to have in alternate workspaces. The **Telescope Focus** window allows control over the telescope focus. The encoder value in this window is mirrored by the manual telescope focus control located next to the stereo and vice-versa.
- **Tape**. Contains commands to control the tape position allowing you to rewind, eject, or advance to the end of the current data set stored.
- **Options**. Contains commands to control the edit modes (Explicit or Pointer) which act on all windows specifying the mode of action of the mouse. One can also enable or disable a bell at the end of each exposure or sequence. The CCD Default Values option allows you to change the default values for the CCD in the exposure parameters. This last option is useful if you shall be sub-rastering teh CCD during your entire run.
- **Comments**. Allows you to give your opinion about working with DAISY, or report DAISY specific errors. These messages will be emailed to both the 2p2 team and the programmer in charge of DAISY. Feedback is very much appreciated!

3.4.3 Exposure Definition

Up to 8 exposures with different DFOSC and FASU set-ups can be defined and executed from the **CCD** window. The defined sequences can be saved to disk, and later recalled using the self-explanatory commands in the `File` menu. The name of the file is indicated next to the name of the window. The command `Reset` in the File menu preserves the file name while resetting the exposures, while `New` allows you to define a new file.

In addition to sequences of exposures, you may define sequences of sequences or, *multisequences.* There is no limit to the number of sequences that you may link sequentially using the multisequence option. This option is especially useful for long test or calibration sequences. By using the software to prepare sky flats, such a sequence can be executed by one mouse click. Experience has shown that this allows full sets of *UBVRI* sky flats with nearly identical count levels to be obtained at every twilight. See §3.4.2 for details.

All exposure definition parameters must be entered in the data input boxes in the **CCD** window. To enable a data input box, it is necessary to click on it with the left mouse key. When enabled for input, the perimeter of the box will turn red. Below the various exposure definition parameters are listed together with a short explanation.

- **Active Expos** Up to 8 different exposures may be executed in sequence. To enable an exposure click the button immediately to the left of the exposure number. When activated this button will turn green. Click again to disable.
- **Exposure Type** There are three types of exposure in this menu, though presently only science (Sci), Dark (Dk) are implemented. In order to select one, click and hold the button to the right of the current type. A small pull down menu will appear. Slide to the desired exposure type and release the button. Note that it is not possible to pause a daek exposure.
- **Repeat** Specify the number of times the exposure will be repeated (1-99).
- **Identifier** The exposure identifier is typed in this field. Up to 16 characters may be used.
- **Time (sec.)** Enter here the desired exposure time in seconds. It is possible to enter small values, and even zero. However, for exposure times of less than around 0.3 seconds, the shutter will be open for around 0.3 seconds. This means that if you make a bias by taking a science frame with an exposure time of zero seconds, you would actually end up with a frame with a 0.3 second exposure. For this reason it is important to select the correct exposure type when making darks and biases. Also note that: (1) the shutter delay is of the order of 0.01 seconds, so avoid using very short exposures for photometric purposes; and (2) very short exposures will show scintillation. To summarize, don't use short exposures!
- **Set** This button allows you to toggle between the default values of the exposure parameters (readout speed, binning and window readout), and values which you can freely specify within the allowed ranges. When enabled, the `Set` button is lit and the window fields change from light brown to white.
- **Readout Speed** This pull-down menu allows you to select the readout speed (hi or lo) and the readout amplifier (A or B). See §2.2 for details on how changing amplifier and readout speed will affect your data.
- **Binning X,Y** The CCD can be used in binned mode. By specifying X and Y values the binning may be entered in these two fields. The defaults are 1,1, but any value m,n may be used. As on-chip binning is different to off-chip binning, it is not possible to determine the read-out noise of a binned frame by multiplying the read-out noise (r.o.n.) of an unbinned frame by *sqrt*mn. To determine the r.o.n. of a binned frame, divide a pair of binned bias frames and divide the R.M.S. of this frame by *sqrt*2. Note also that the number of cosmic ray hits increases as the product mn.

- **Window Readout** The X and Y size of the CCD readout may be specified here.
- **DFOSC Setup** This pull-down menu allows you to select the DFOSC set-up to be used for the exposure. Click and hold on the button and the 8 pre-defined set-ups (see §3.3) will appear. Slide the mouse to choose one of these and release the button. Due to lack of space only the set-up number is typed, but the full definition can be viewed by clicking on `DFOSC Setup...` in the **DFOSC** window.
- **FASU Setup** This works in the same way as the `DFOSC Setup` button, and allows a FASU set up to be chosen.
- **Tape Save** Enable this button to automatically save the exposure to DAT tape. The exposures are queued and stored in background mode, so a new exposure may be started while the previous one(s) is/are being written to tape. The program does not have a limit on the number of files pending for save to tape. If an error occurs this is notified with a message. Therefore check the dialogue area of the **CCD Status** window to make sure that the data are indeed being saved.
- **Midas Batch Procedure** The MIDAS procedure specified in this field will be automatically executed at the end of the exposure. In the case of `Repeat` exposures, the procedure will only be executed at the end of the sequence.

3.4.4 Exposure Control Buttons

At the bottom of the **CCD** window there are the following buttons which are used to control the execution of the exposures:

- Start Multi–Sequence.. Starts a multisequence of exposures. A pop-up window is used to select the multisequence to be executed.
- `Start` Starts the exposures which are "Active".
- `Pause` Interrupts the exposure. The status box in the **CCD Status** window is lit red. Note that this command closes the shutter of the CCD but that dark current and cosmic ray hits continue to accumulate during the pause.
- `Continue` Resumes a paused exposure.
- `Change Exposure Time...` Calls a pop-up window where the time (in seconds) to be added or subtracted from the exposure can be entered. After entering the number of seconds, click `OK` to execute the modification. Ensure that: (1) you do not modify the exposure time before the shutter is open; and (2) you do not subtract off more than the remaining exposure time.
- `Abort` Abort an exposure. The option `Exposure` will cancel the current exposure only, while `Sequence` will cancel a sequence of exposures.

Chapter 4

Observing with DFOSC

4.1 General

4.1.1 Empty and Free

Note that an "empty" position in a wheel is not the same as a "free" position. A baffle is installed in the free position, and this is the position which should be used.

4.2 Focusing the Telescope

Before starting any science exposures it is necessary to focus the telescope. This is quickly and easily done by using the focus pyramid which is mounted in the grism wheel of DFOSC, just follow the below instructions.

1. Use Eq. 4.1 to obtain an initial guess of the focus, and set the focus to this value.
2. Select a field with a few stars (not too crowded) close to the field where you will finally observe (there is a weak dependence of focus on zenith distance and maybe rotator angle). You may wish to subraster the chip to speed up the readout.
3. Obtain an image of the field with the filter and focus pyramid in the beam. Choose an exposure time that is long enough to average out atmospheric scintillation, though short enough that the stars are not saturated. A typical exposure time is 10 seconds.
4. Click on the MIDAS observing batch `focus` and select the `pyramid focus` option. The graphics cursor is activated and ypu need to click on the leftmost stars of the quartets with the left mouse button. Ensure that the quartets you select are not crowded. Upon exiting with the middle mouse button, the required focus offset is calculated and displayed.
5. Apply the focus offset from either the DAISY program, or directly from the the control. Note that the focus value should always be approached from at least 20 encoder units below.

6. If the absolute value of the applied focus offset is larger than 70 encoder units, repeat the above procedure. This is necessary as if the telescope is very badly focussed, the linear relationship between focus offset and quartet geometry no longer holds.

7. Make a note of the serrurier temperature (vertical LED display in the rack seen through the glass window). The focus changes +20 units per increasing °C, and it is necessary to adjust the focus for a change in serrurier temperature of about 0.3°C (this corresponds to the approximate accuracy of the focus pyramid). A new focus determination should be made for a change in temperature larger than 2°C.

8. Don't forget to re-focus the TV camera!

As it is so simple and quick to focus the telescope, we suggest that you focus whenever you move the telescope to a new field, or every hour if tracking the same object throughout the night.

For the broad band filters (Bessel *UBVR* and Gunn *i*) the focus (determined October 1996) is given by

$$\mathrm{Focus} = 15115 + 19.8\mathrm{T}, \tag{4.1}$$

where T is the serrurier temperature in °C. As the *UBVR* and *i* filters are mounted in the filter wheel within DFOSC, i.e. in the parallel beam of the instrument, there are no significant focus offsets among them. However, filters in FASU can have quite significant focus offsets as they are in the converging beam and the focus becomes dependent on the optical thickness of the filters.

4.3 Imaging

Below are some notes of specific interest if you are using DFOSC for imaging.

4.3.1 Flat Fields

We strongly advise that you obtain sky flats during evening or morning twilight. Experience shows that the variation between sky and dome flats can be as great as 10%.

Dome Flats

The telescope can be preset such that it is pointing to the flat field screen on the inside of the dome. Simply click on `FF Scr` in the **Fixed Presets** sub-panel.

If the telescope is on the west side of the pier, it will be very close to a limit and you will hear a warning alarm. This alarm can be silenced by pressing the red "Reset alarm" button on the safety system. Note also that the telescope is at a large zenith distance when pointing to the flat field screen (both sides of the pier), and you may notice LN2 leaking from the dewar. This is of no concern as enough LN2 remains to keep the CCD cooled for the whole night.

The flat field screen can be illuminated by either opening the outside door slightly to allowing scattered sunlight to fall upon it, or by using the quartz halogen lamp located in the dome.

Sky Flats

A list of "empty" fields useful for obtaining sky flats is given in Appendix G. The large DFOSC field size means that you will see some stars on the outer edges of these fields. Consequently, it is important that you dither the telescope between exposures so that these stars can be later median filtered out.

After initialization, the telescope pointing is sufficiently good that there is no need to make a coordinate correction before pointing to the empty fields. The sky gradient in the flat fields can be reduced by pointing the telescope away from the Sun. This means that the empty fields should be in the east at dusk and in the west at dawn. Finally, you can estimate the exposure times needed for your flat fields using the formulae given by Tyson and Gal (1993).

4.3.2 Coronography

If you are making coronographic observations, remember that you will need to obtain flat fields with the coronographic plate in the beam. Failure to do this will lead to dust and imperfections on the plate not being properly flat fielded out.

To locate an object below an occulting spot, follow the below procedure:

1. Obtain a flat field with the coronographic mask and a filter. Measure the centre of the spots using the graphics cursor. For a "clean" image of the spots, we suggest that you divide a dome flat taken with the coronographic plate in the beam by a dome flat taken without the coronographic plate in the beam. To save time, the positions of the spots can be measured during the day by taking dome flats.

2. Obtain a short (though preferably over 5 seconds to avoid scintillation) exposure image using the filter used in step (1) of the science field with the bright star to be occulted. If the star is saturated, use a narrowband filter (though see note below).

3. Use the `point` batch to determine the telescope offsets needed to locate the star under the spot, apply these offsets.

4. Find a guide star and start autoguiding with relaxation. Obtain another image of the field and use the `point` batch to determine the telescope and autoguider offsets.

5. Stop autoguiding, offset the guideprobe, and then offset the telescope. Start autoguiding *without* relaxation. After the star is centred in the guidebox, you can begin your exposure.

The procedure is essentially the same as that described in §4.4.4 for locating a spectrographic slit over a star. For more details on how to use the point batch and offset the telescope and guideprobe, consult §4.4.4.

If high accuracy is desired, it is important to use the same filter for the image of the coronograph (on which the spot centres were measured) and the acquisition image. By doing this, any positional shifts introduced by the filter are cancelled out. In reality, as the spots are so large, it is probably not necessary to use the same filter. This can be easily tested by measuring a few star positions in a field observed with both broad- and narrow-band filters.

4.4 Spectroscopy

Below are some notes of specific interest if you are using DFOSC for spectroscopy.

4.4.1 Flat Fields

Spectroscopic flat fields can be obtained using the flat field screen in the dome or on some blank area on the inside of the dome using the quartz lamp for illumination. To proper calibrate variations in the width of the slit, however, it is strongly recommended to acquire twilight flat fields of the blank sky. Sky flats of this kind can also provide significantly more photons in the blue region where the quartz lamp basically gives nothing. Actually one should be careful with flatfielding in the blue as a significant fraction of the photons reaching the CCD in this spectral region might in fact be scattered red photons and thus they do not represent a true flatfield! This has yet to be quantified though. Follow the instructions given in 4.3.1 for obtaining the flats.

4.4.2 Focusing the Telescope

When focussing the telescope for spectroscopy, it is important to use a filter so that "monochromatic" light is being focussed. In this way, stars will not appear spread out by atmospheric refraction. As previously mentioned, filters in FASU can have quite significant focus offsets as they are in the converging beam and the focus becomes dependent on the optical thickness of the filters. For this reason, it is important to focus the telescope using a filter in DFOSC (where they sit in the parallel beam). Finally, it is best to use a filter which has a bandpass similar to the spectral range in which you are obtaining spectra.

4.4.3 Wavelength Calibrations

Calibration exposures may be made by either using:

- the He and Ne lamps in the skybaffle. To use the skybaffle lamps first close the skybaffle using the button located in the electronics rack in the control room. Switch on the lamps using the two black power supplies located below the hydraulics system in the control room. Don't forget to switch the lamps off and open the skybaffle after taking your exposures.
- the internal calibration unit. In the **Adapter** sub-panel (on the TSP) click on the `Calibration` button to move the pick-up mirror to the correct location. Once in place (guide probe no longer moving) switch on the desired lamp with the controls in the **Cal.lamps** sub-panel. After taking your exposures, click on `Park` to put the adapter back into observing mode and remember to switch off the lamps.

Wavelength calibrations are usually made with the skybaffle lamps as the movement of the pick-up mirror in the internal calibration unit is very slow and the lamps too bright. For echelle work, however, the ThAr lamp in the calibration unit can be useful.

Typical integration times for the He and Ne lamps are of the order 10 seconds, and something similar for the ThAr lamp in conjunction with the echelle grisms. In Appendix B there are a couple of examples of wavelength calibrations.

4.4.4 Placing a Star in the Slit

As DFOSC does not have a slit viewer it is necessary to use a direct image of the field to determine the offset needed to bring the object onto the slit. This approach has the advantage that any object which can be imaged can also be placed on the slit.

To place an object on the slit it is necessary to superimpose the image of the object on the image of the slit. When this is done the object and slit are in the same position in the focal plane.

The dispersion is along the columns of the CCD as the slit is always aligned with the rows of the CCD. The CCD has a number of bad columns, and it is important not to place the spectrum on top of one of these. The bad columns can be impossible to see on the image display as the image has usually been displayed with a significant demagnification (only every fourth pixel is shown) so take care! The BROCAM CCD currently in use (W11-4) has bad columns at X=734,735, X=946,947, X=1005,1006, and at X=1137 when read through amplifier B.

As the slit is known to move slightly as a function of position in the sky (see §2.4.7) it is necessary to check the slit position before each scientific exposure. To check the slit position take a 30 second exposure with both the slit and the filter to be used for the acquisition image in the beam. Use the MIDAS command `GET/CURSOR` on a zoomed image to determine the Y position of the slit (see Appendix E.2 if you are unsure about MIDAS), or alternatively use the `seeing` batch.

To determine where the object image falls on the CCD, take a direct image of the field using the same filter as used to determine the slit position. It is necessary to use an exposure time of at least 10 seconds so as to average out scintillation. The telescope pointing is not very accurate so you will need a large field to uniquely identify your object. In the south the pointing can be off by more than 1′ if the coordinate correction was made at the zenith. This is probably due to a slightly misaligned polar axis.

Click on the MIDAS batch `point`. You will be asked for the X and Y position of the slit in world coordinates as determined above, the rotation angle of the instrument as displayed in DAISY's **DFOSC** window, and an option G or C. If option G is selected, a Gaussian fit is used to find the centre of a source, while C will simply read the cursor coordinates. The C option is only useful for extended, non-point sources. After entering the required information, click the left mouse button on the object in the frame and exit with the right mouse button. The batch determines the necessary telescope offsets to bring the object to the requested X-Y position as well as the guideprobe offsets needed to maintain the same guide star. At this stage you need only offset the telescope (you are not yet autoguiding!).

To offset the telescope enter the offset values returned by the `point` batch in the **Telescope Constants** sub-panel on the TSP. Click on `Apply` for these values to be accepted (though not executed). Use the handset (either real or virtual) to put the telescope into offset mode, and apply the offsets using the keys on the handset. We suggest that you look at the telescope coordinates to make sure that the offset was successfuly executed.

The telescope offset is not as accurate as the offset of the guideprobe (this is probably related to the periodic error on the α axis), and so the guideprobe should be used to make the final offset. Find a guide star such that the guideprobe is not at low values of X and Y (else it might not be possible to offset the guideprobe) and start autoguiding *with* relaxation (Box to Star). Obtain a second image of the field and apply the point batch as before. Stop the autoguiding, and offset the guideprobe the appropriate amounts. The guideprobe is offset by adding the offsets (given by the point batch) to the present guideprobe coordinates (these can be found in the **Guide Probe Status** sub-panel in the TCP). Enter the new X and Y values (input boxes in the **Guide Probe Preset** sub-panel), and click on the

`Apply` button to move the guide probe to the new coordinates. (Note that there is a slight backlash in the guide probe system and it is difficult to reproduce a given number to better than 10 units. This is reasonable considering that 1 unit corresponds to about $0''.015$.) It is now necessary to move the telescope so that the guide star once again falls in the autoguider box. This is done by either entering and applying the α and δ offsets supplied by the point batch as described before, or using the handset to manually move the guide star into the autoguider box. It is often the case that the guide probe offset is small, that it is not necessary to move the telescope at all. After the guide star is approximately centred in the autoguider box you need to start autoguiding *without* relaxation. This is the mode labelled "Star to Box" on the TCP.

It is *essential* to start the autoguider correctly with or without relaxation. Starting *with* relaxation means that the telescope will keep tracking the object while the autoguider centres on the guide star. Starting *without* relaxation means that the telescope will move to centre the star in the guidebox. As we take advantage of the accurate movement of the guideprobe, we want to force the telescope to the same position and consequently the autoguider should be started *without* relaxation after the second acquisition image has been analysed and the offsets been applied.

To summarize, to get an object on the slit:

1. Preset to your object.
2. (Optional) Window the chip to 1000×1000 pixels centred on the chip and also bin the readout by 2 in both X and Y to speed up the read-out.
3. Obtain a short exposure image (30 seconds typically) through the R or V filter with the slit in the beam as well.
4. Measure the Y-position of the slit with `GET/CURSOR` in MIDAS or by using the `seeing` batch.
5. Decide on an X-position that avoids the bad columns of the chip and any possible bad spots along the slit. (Note that the echelle slit is significantly off-centre with respect to the CCD).
6. Obtain a short exposure (30-60 seconds) image through the same filter as before but without the slit in the beam.
7. Use the `point` batch on the MIDAS workstation.
8. Offset the telescope the required amount.
9. Find a guide star (centred on the guideprobe monitor, though not at low values of X or Y) and start autoguiding *with* relaxation (see §1.2.4).
10. (Optional) Window the chip 500×500 pixels with 1×1 binning centred on the slit position you will use.
11. Obtain a short exposure image through the same filter as previously used.
12. If the CCD has been windowed or binned, **reset the CCD window size.**
13. Use the `point` batch on the MIDAS workstation.
14. Stop autoguiding.
15. Offset the guideprobe in X and Y by the amount given by the `point` batch.
16. Offset the telescope in α and δ by the amount given by the `point` batch.

17. Start autoguiding *without* relaxation.
18. (Optional) Make a final check by either: (1) obtaining a third image and calculating the offsets with the point batch (the offsets should be very small); or (2) taking an image with the slit in the beam but no filter or grism. Your object should be visible through the slit.

Tips

1. To reduce the size of the offsets necessary and thus improve the accuracy, you can correct the telescope coordinates (see subsection 1.2.3) so the star falls as close to the slit as possible. This is particularly useful for echelle observations where the slit is located far away from the centre of the CCD.
2. You can save time by generating DAISY exposure definition files in the afternoon which set the correct size of the window and binning, and exposes the acquisition frame.
3. The position of the slit is stable to within $\pm 0\farcs4$ for telescope positions within a zenith distance of about $60°$.
4. You should always use a filter for the acquisition images of your objects, especially if they are at high airmass, as the atmospheric diffraction will place the blue light in a different position from the red light. You should use a filter with a wavelength similar to the range you want spectroscopy for to make sure that you put the right wavelength range within the slit. This is less critical, however, if you have aligned the slit with the parallactic angle.
5. If you want to observe at high airmass you should be aware of the effects of the differential refraction which tend to stretch the image of the star into a small spectrum. You might decide to rotate the instrument so the slit is aligned with the parallactic angle at mid-exposure to make sure to include both the blue and red end of the spectrum in the slit. This is particularly important when doing spectrophotometric observations. See Appendix C for further details.
6. The R and V filters introduce positional shifts of less than 1.0 pixel. Other filters might introduce larger shifts. You can check the shift yourself by making an image of the slit with and without a filter and see the difference directly. However, if you use the same filter for the image of the slit as for the image of the object, the size of the offset is irrelevant.

4.4.5 Rotating the Slit

It can be useful to rotate the slit to align it with either: (1) several objects at the same time; (2) a specific axis of the object; or (3) the parallactic angle (see Appendix C).

Slit rotation is possible with DFOSC by rotating the whole instrument. The rotation of DFOSC is controlled from the **DFOSC** window in DAISY. When rotating DFOSC, one should be very careful that there are no cables in the way of the rotating instrument as the rotator motors are very powerful and will easily snap any obstacle in the instrument's way. The cables leading to the DFOSC include a couple of optical fibres which are *very hard to repair*. So, please, check the cables before starting the rotation, and have a look during the rotation. If you have to rotate large angles, please rotate in separate steps of $\sim 45°$, and check between each step that the cables are not in the way.

The system allows movements in the range $-100°$ to $+100°$, so in some cases you might have to rotate through large angles to obtain the required alignment. This limitation in the rotation is necessary so as not to further restrict the telescope movement.

Table 4.1: Relationship between Rotator and Position Angles

Telescope side of pier	Default Rotator	PA
East	90	90
West	−90	90

The encoders are absolute encoders and it should not be necessary to initialize them, except when the instrument has been dismounted. However it has happened that the initialization position was lost, in which case you will have to call the operations crew to reinitialize the rotator. As this initialization point is critical for the safety system, please call for assistance if you believe that DFOSC is not in the correct position. The CCD dewar should *never* be on the side towards the telescope pier except for the 10° at the ends which are allowed by the normal 200° range.

The standard position of the instrument is to have the CCD dewar pointing to the south when the telescope is pointing to the zenith. In this position the orientation of the CCD images will be east to the left and north up on the image display and you can operate the system safely in this position.

The Position Angle

The position angle is defined positive going from north towards east and is zero for the north direction.

You can determine the position angle (PA) of the slit from the rotator angle of the instrument displayed in the user interface. If the telescope is east of the pier the position angle is the same as the rotator angle and should be at 90° in the default setting, i.e the slit is E-W. If the telescope is west of the pier, the position angle is offset by 180° with respect to the rotator angle displayed in the user interface status window. This is summarized in Table 4.1.

Note that the zero-point is not very accurate, and so the true PA might be off by a couple of degrees with respect to the displayed value.

4.5 Data Storage

4.5.1 Workstation Disk

The FITS images are stored with the pixel values in the standard format, i.e. the data values are stored as unsigned 16 bit integers with a range from 0 to 65535.

If the disk of the UNIX workstation fills up, remove files by opening a command window (xterm/hpterm) and using the UNIX `ls` command to list files, and the `rm` command to remove files. As a first step you may wish to delete the MIDAS format files as these are not saved to tape (`rm *.bdf` – make sure there is no space after the *). It is possible to to delete files from the MIDAS window, simply type a `$` before a UNIX command (e.g. `$ls` and `$rm`).

The BIAS program obtains the telescope coordinates from the TCS computer and saves the values in the FITS image header together with the sidereal time (see Appendix F.1 for a sample header). The UT which is included in the header currently originates from the data acquisition workstation which is synchronized with the La Silla GPS clock. However, the procedures to obtain the time and to open the DFOSC shutter are not very closely linked and the precision is probably not better than a few seconds although this has not been carefully investigated yet. If you need accurate times, you are strongly adviced to enter them in your written log.

4.5.2 Saving to Tape

Instructions for Observers

Ensure you have enough DAT tapes available for your run. DAT tapes may be obtained from 2p2 Team operations (93-62) or your support astronomer.

There are two possibilities for data saving:

1. Tape saving can be enabled in DAISY. In this case place a tape in the DAT drive before making any exposures with DAISY.
2. Using UNIX `dd`: This method is recommendable because it will store all the FITS files currently on the disk.

   Prepare a list of the FITS files that you want to save using f.ex.

   `ls -1 *.mt > night_N`

   Option `-1` (digit one) gives one column output in HP-UNIX. Before you do this you might want to delete the FITS files from the previous night to avoid writing them to tape twice or move them to another directory. You can of course also edit the file `night_N` to remove files which you do not wish to be saved.

   Then do:

   `wfits -l night_N`

   and answer the question whether you want to overwrite the tape or append to the end. Option `-l` (letter l) means that the script will read the filenames from a list.

   The script can also be used for single files during the night if you prefer that. The syntax is then:

   `wfits dfscNNNN.mt`

   Don't forget to save data which you might have moved to the other disk areas during the night.

Please leave your `.mt` files in the data directory (not hidden in a subdirectory!) at least until the next evening so they can be archived during the day by operations. No files will be deleted by operations during an observing run, and so it is the observers responsibility to ensure that old `.mt` and `.bdf` files are deleted if more disk space is needed. The disk *will* be purged prior to the next observers' run.

The 2p2 Team will keep a backup of your data, and supply a copy if you are unable to read your DAT tape at your home institute. We do not provide a general archive at this point.

Instructions for 2p2 Team Operations

1. Ensure the observer has a sufficient supply of DAT tapes.

2. In the morning, list all the fits files from the previous night, and place in a file:
   `ls -1 *.mt > archive_XX_YYY_ZZ.lst` (XX=year, YYY=month, ZZ=date. e.g. archive_96_Oct_04.lst)
3. Use the `archive` script to append the data to the DLT tape.
4. Move the archive_XX_YYY_ZZ.lst file to subdirectory `archive`.
5. Check that the data was saved by reading in the first and last files of archive_XX_YYY_ZZ.lst from the DLT drive.

Chapter 5

Troubleshooting

Check the notice board for any recent bug reports!

If you cannot get the system going or something is not working as it is supposed to, you can call for technical assistance until 3 hours before twilight. The beeper code is 93-62. After this time limit you should only call for assistance if there is danger for the telescope or instrument.

5.1 Important Information

5.1.1 Rebooting Computers

The Linux PC and workstations are running multitasking operating systems and power cycling the systems can cause serious damage to the hard disks and poses a high risk of file system corruption. If you have problems which you suspect can only be recovered by a reboot, you will have to call for assistance.

5.1.2 CCD Warming Up

If the vacuum on the dewar is bad, refilling can lead to ice formation which can destroy the CCD. If the CCD temperature begins to rise, you must phone operations (no time restrictions, this is considered an emergency situation) so they can investigate the cause of the CCD warming.

5.2 General

5.2.1 No Light on the CCD

Make sure that:

- The dome slit is open (§1.1.2).

- The dome is in automatic mode (both on the large grey metal box in the dome, and on the TCS control) and the telescope points through the slit.
- The mirror cover is open (§1.1.3).
- The sky baffle is open.
- The FASU shutter is open (DAISY will open it automatically if the FASU handset is in "remote").
- The FASU filters are correctly set.
- The calibration unit is in park.
- The guideprobe is outside the vignetting area.
- The DFOSC aperture wheel, filter wheel and grism wheel are in the correct positions.
- The DFOSC instrument focus is properly set. (Correct value should be given on your set up sheet from operations).
- The exposure time is sufficiently long.
- The exposure type (in DAISY) is `sci`.
- The image is correctly transferred to the MIDAS session.
- There are no problems with the adapter (see §5.3.8).
- You are not observing through $10^{\mathrm{m}}.0$ of clouds!

5.2.2 Weird Looking Images

Check that:

- Dome is on position.
- Arc lamps in sky baffle are switched off.
- Lamps in the adapter are switched off.
- The adapter is in the "Park" position.
- Telescope and DFOSC in focus (the camera focus value is written on the set-up form).

5.2.3 No Light from the He and Ne Skybaffle Lamps

Check that the power cable for the lamps is connected. This is the only cable that comes from the south side of the observing floor, and is not bundled up with the other cables. With the lamps switched on and the skybaffle open, you should clearly see the light from these powerful lamps.

5.2.4 Ethernet Connection to Outside World Lost

This problem can often be solved by resetting the LAN bridge located in the kitchen on the ground floor. On the wall opposite the door you will see a perspex and aluminium box containing the LAN bridge. If the "fault" light is lit on the front of the LAN module, an attempt can be made at resetting the LAN bridge using the "reset" button located on the back of the module. If this doesn't work, it's likely a mountain wide problem and you should call operations.

5.3 Telescope and TCS

5.3.1 Telescope does not Initialize

- Check that the small switch in the electronics rack on the north-east side of the dome is set to `DIGITAL`.
- Reset the TCS VME and try again.

5.3.2 Dome does not Initialize

- Make sure that the switch in the dome (large grey metal box to the left of the VME rack on the telescope floor) is in automatic mode.
- Reset the TCS VME and try again.

5.3.3 Dome does not Move

Note that the dome will not move when the fixed preset to the pole is used. This is a feature of the TCS.

- Make sure that the switch in the dome (large grey metal box to the left of the VME rack on the telescope floor) is in automatic mode.
- Ensure the Dome is set to `Automatic` on the TCS SETUP PANEL.

5.3.4 Focus Unit Freezes

This can sometimes happen, and it is suspected that static electricity is to blame. To regain control, it is necessary to power cycle focus control unit which is located below the safety unit in the room adjoining the observing room.

5.3.5 No Guide Stars can be Found

The likely reason for this is that the TV camera is very poorly focussed (or the TV camera voltage not turned up). Turn down the TV camera voltage and point the telescope to a bright star. Turn up the

TV voltage until the bright star is visible, and then focus the telescope. You may try focussing the TV camera in a random field, however, it may be that there are no stars in the random field.

5.3.6 TCS VME Reset Button Fails

This sometimes happens and the solution is to power cycle the system using the key located further down in the rack.

5.3.7 E-W Reversed on Guide Probe Monitor

This problem will be seen when moving the autoguider crosshair. It will also be noticed that the orientations given in Figure 2.2 are no longer valid.

There is a switch on the back of the monitor which produces an E-W inversion. Toggle this switch to restore the correct orientation

5.3.8 The Adapter/Autoguider Freezes

It sometimes happens that the adapter gets stuck. This can happen with any of the components in the adapter but most often it happens with the two main parts of the adapter, namely the autoguider pick-up mirror or the calibration unit (i.e. the mirror unit which selects the beam). If the mirror gets stuck in the centre field position, it may prevent light from reaching the CCD.

To recover it is usually enough to restart the VME crate controlling the adapter (this is the big electronics box mounted on the side of the telescope) and restart the TCS session on the TCS computer. The reset button on the VME crate can be very hard to reach if the telescope is not at the zenith, and the current practice is to simply disconnect the power cord for approximately 20 seconds and then reconnect. This will start a reboot of the adapter VME system. If the TCS interface in the control room has frozen, you will need to log out and then log back in again. Note that after restarting the adaptor VME, you will also need to restart DAISY to re-establish the communication link between DAISY and the FASU.

5.4 DAISY/MIDAS

5.4.1 Shutter Still Open after an Abort

When an exposure is aborted the **CCD status** panel might show that the shutter is still open. This occurs as the **CCD status** panel is not updated after an abort, and so the status can be ignored.

5.4.2 Images Not Displayed in MIDAS

There are three possibilities:

- You are exceeding the data rate which the workstation can handle. This is typically the case if you do multiple exposures of very short duration on a windowed area.
- If you have an active graphics cursor when receiving the next image the incoming image will not be displayed and sometimes the workstation hangs.
- The MIDAS/DAISY session has hung, and you will need to restart as described in §5.4.8.

If it is only a few images which are not displayed on the MIDAS display, you can recover them by typing the command `@@ loadccd dfsc NNNN` where `NNNN` is the number of the image file (or more simply you can use the up arrow key and edit the last occurrence of this command). This command will convert the image from FITS to bdf format and display the image on the screen with automatic cuts.

5.4.3 The Point Batch Gives Unreasonable Values

Check that:

- the proper side of the pier was selected when the `point` button was pressed.
- the proper rotator angle was entered in the dialogue box which appeared when you pressed the `point` button.
- the image scale in the program obsinit.prg is still set at the correct value of 0.39
- you are reading the chip out using amplifier B. (Amplifier A will produce an E-W flip, which is unsupported by the batch).
- the rotator is properly initialized, i.e. that the dewar is on the south side of the DFOSC when the rotator display on the computer is at +90° (telescope east of pier) or –90° (telescope west of the pier).

5.4.4 CCD Fails to Entirely Read Out

Unfortunately your image is lost! To recover control of the CCD, you will need to quit and then restart daisy (type `stop_daisy` followed by `start_daisy` in an xterm).

5.4.5 Empty Frame after Modifying Exposure Time.

Note the following:

- If the exposure time is shortened by t>t(remaining), the output is a bias frame.
- If the time is shortened before the shutter actually opens, the resulting frame is a bias.
- If the time is shortened by t<t(remaining), the output is the expected shortened frame.

5.4.6 Descriptors of Frame are not Updated or are Wrong

The identifiers of the frames entered in the DAISY window are not updated in the frame descriptors if they contain an " ' " (apostrophe).

5.4.7 DAISY Loses Control of DFOSC

See §5.5.1.

5.4.8 Restarting DAISY

1. Exit DAISY via the `File` menu in the **CCD** window. If this fails, try typing `stop_daisy` in a command window.

2. Restart the DAISY session by typing: `start_daisy`

If for some reason this fails, exit HP Vue (from background menu) and restart DAISY by logging into the workstation.

5.5 DFOSC

5.5.1 Control of DFOSC lost

If DAISY appears to have lost control of DFOSC, and restarting DAISY does not solve the problem, it may be that the PC has crashed. To rebbot the PC, follow the below instructions.

- Press `Ctrl-Alt-F1`. This is done by pressing and holding the `Ctrl` key, pressing and holding the `Alt` key, and then pressing the `F1` key.

- Press `Ctrl-Alt-Del`. This is done by pressing and holding the `Ctrl` key, pressing and holding the `Alt` key, and then pressing the `Del` key. Note that either of the two `Del` keys can be used.

  You will see a menu appear, with a time out. As you do not need to change the option (`Linux boot scsi-disk`) just wait.

- When the login prompt appears, log-in using `userid: lasilla` and the password posted on the notice board. The windowing system and background BIAS will start automatically.

- To re-establish the communication link between DAISY and the PC, it is necessary to restart DAISY. This can be done by either exiting and restarting the HP-Vue session, or by using the commands `stop_daisy` and `start_daisy`.

5.5.2 DFOSC Rotator Fails to Reach a Final Position

In this case the rotator has stopped in such a way that the status is not known to the system. Go to the dome and press one of the small buttons on the rotator controller that manually moves the rotator (located at the opposite end of DFOSC from the CCD). You might have to try to go first to one side then the other.

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Comments and suggestions to this manual are very welcome. Please send e-mail to 2p2team@eso.org.

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Appendix A

System Efficiency

A.1 Efficiency of the Optical System

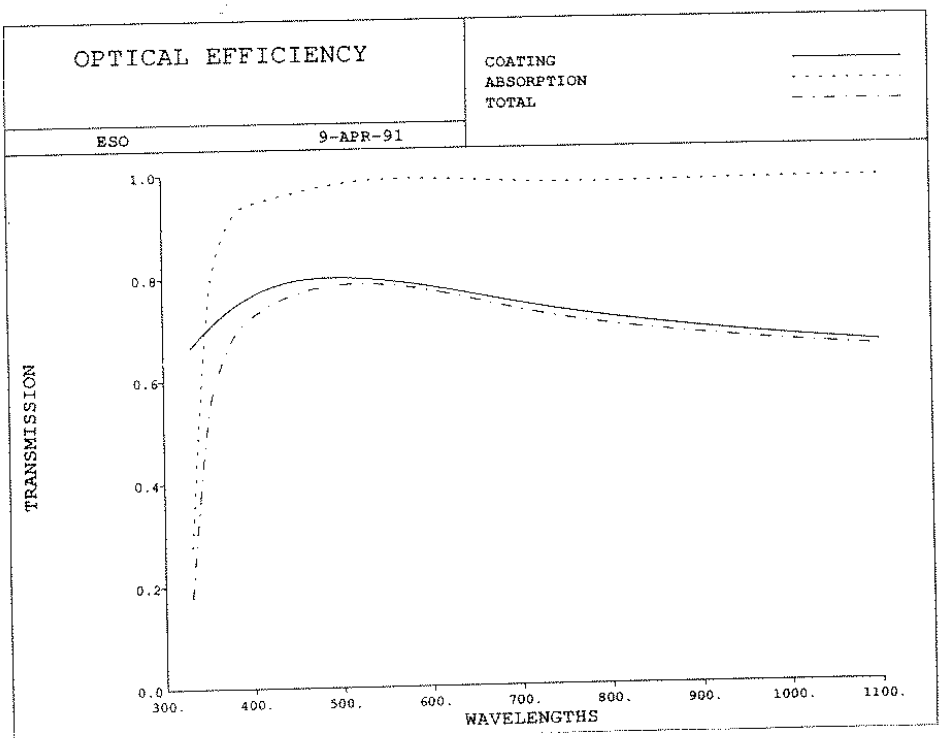

Figure A.1: The computed efficiency curve for the DFOSC collimator and camera. The CCD field lens has not been included in this computation.

A.2 Grism Efficiencies

The grism efficiencies have been measured by B. Buzzoni using the the ESO universal spectrophotometer in the optical laboratory in Garching. The results are presented in the following figures. The measurement spot on the grating is around five by three millimeters.

These measurements were performed on the first batch of grisms, but should be very similar to the current set as the manufacturing recipe is exactly the same.

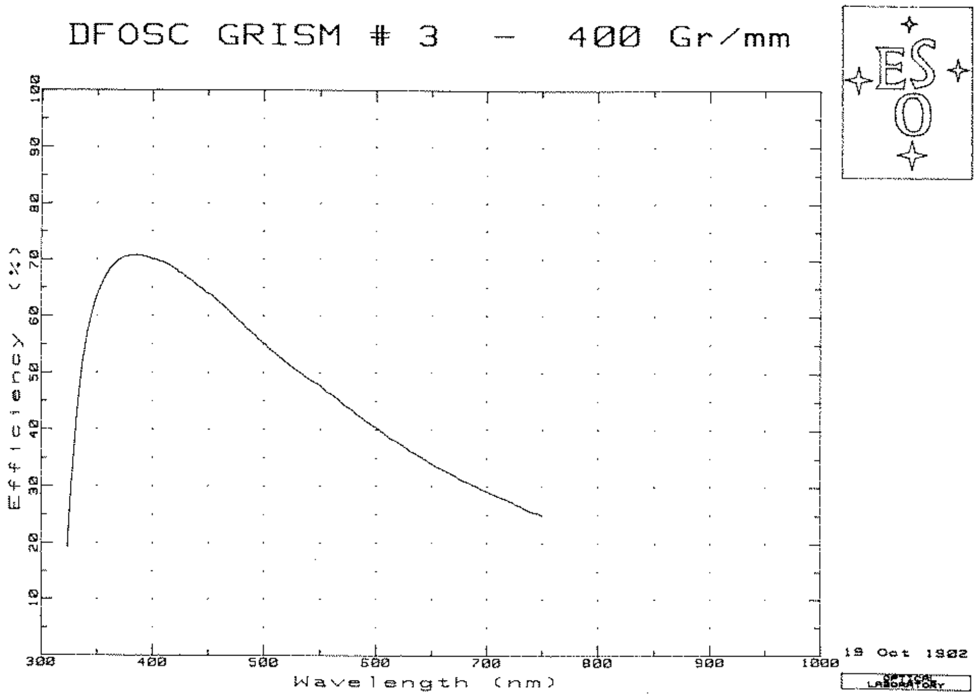

Figure A.2: The efficiency curve for Grism #3

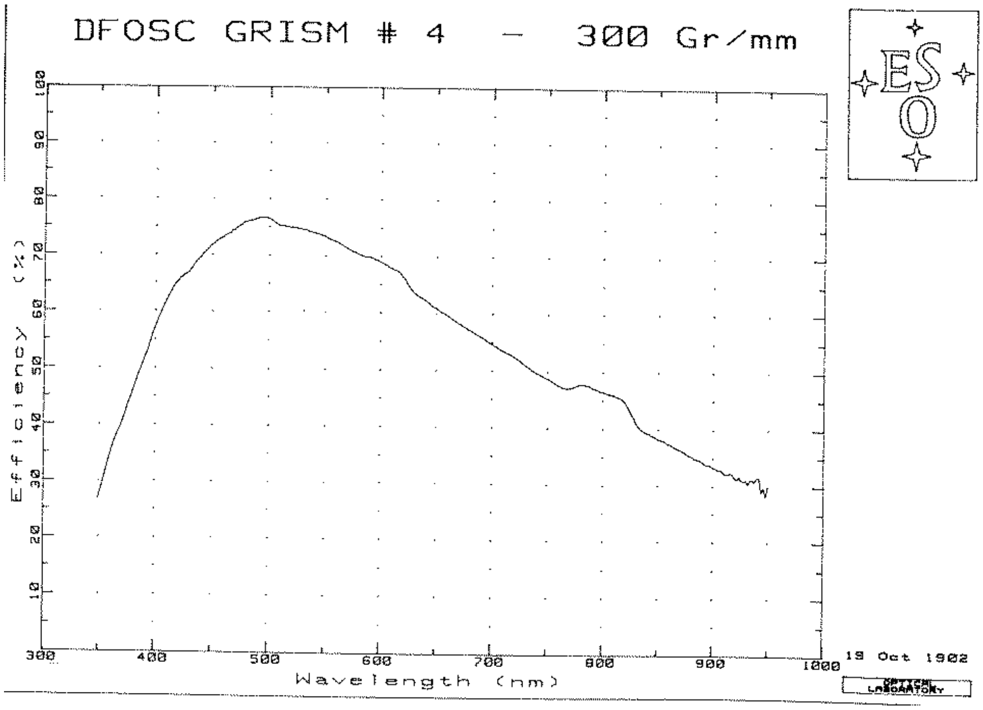

Figure A.3: The efficiency curve for Grism #4

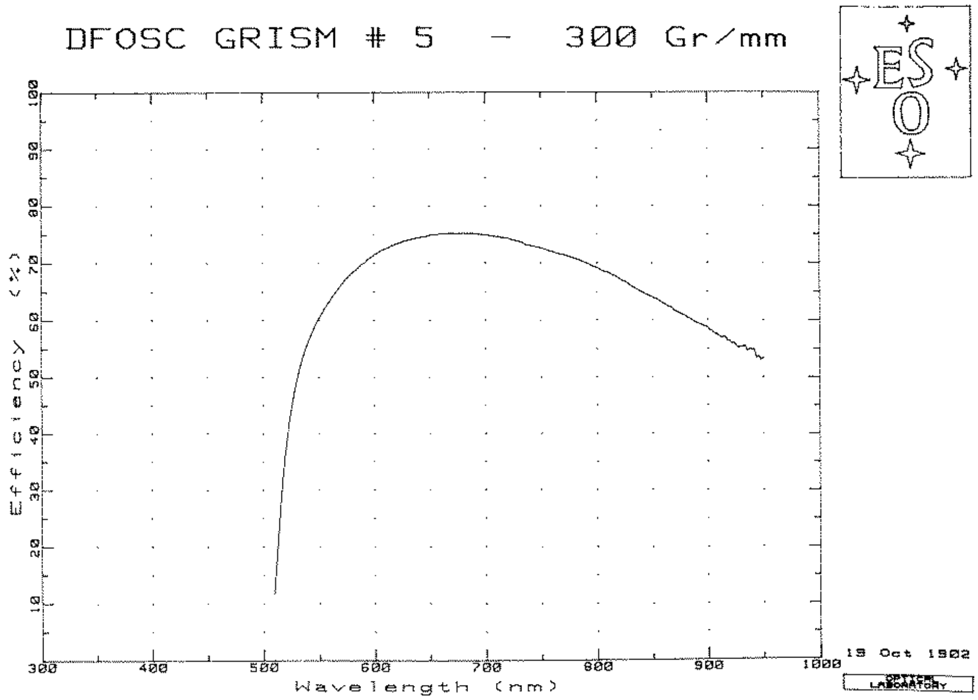

Figure A.4: The efficiency curve for Grism #5

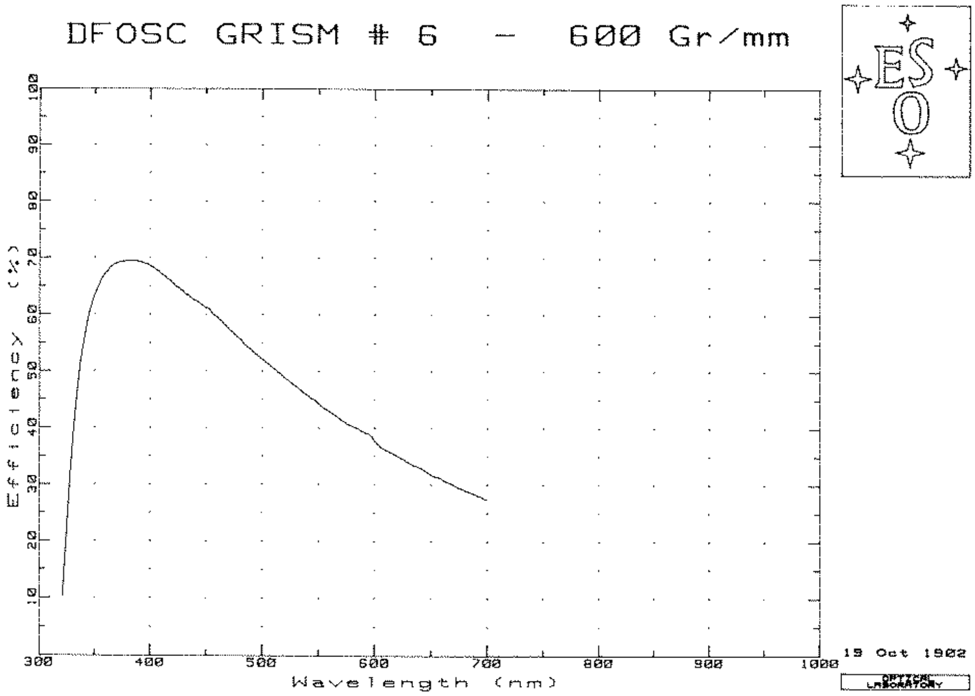

Figure A.5: The efficiency curve for Grism #6

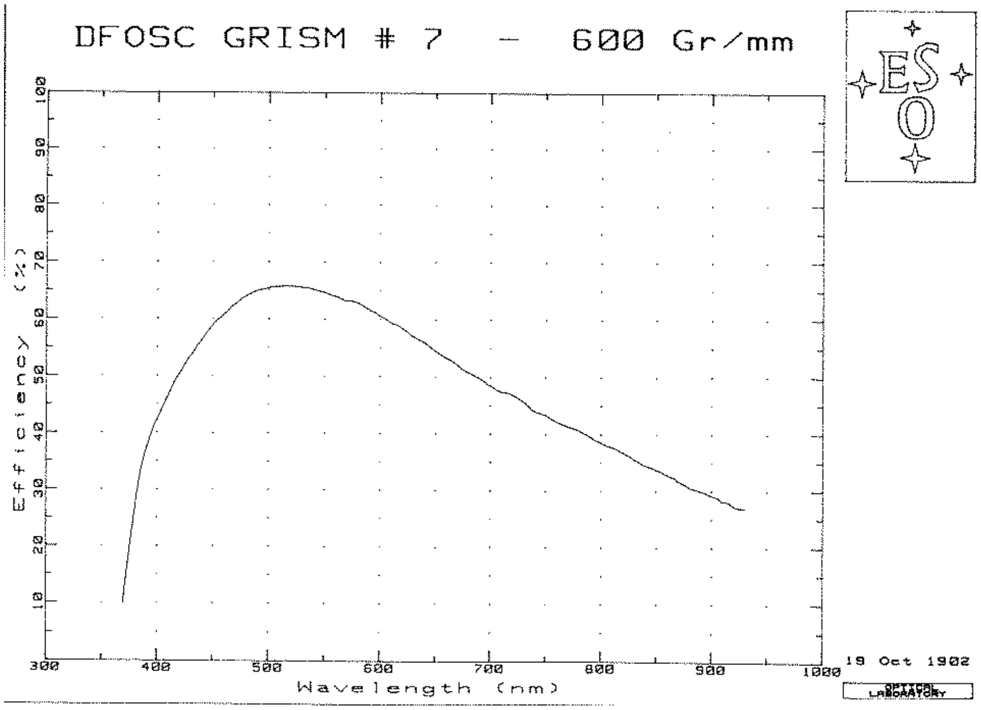

Figure A.6: The efficiency curve for Grism #7

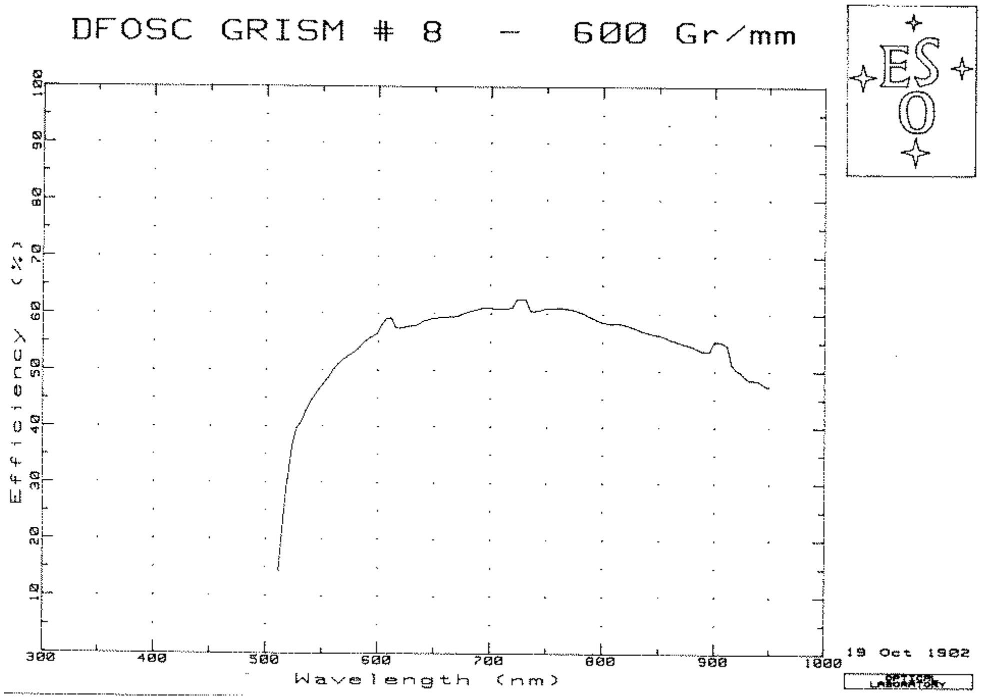

Figure A.7: The efficiency curve for Grism #8

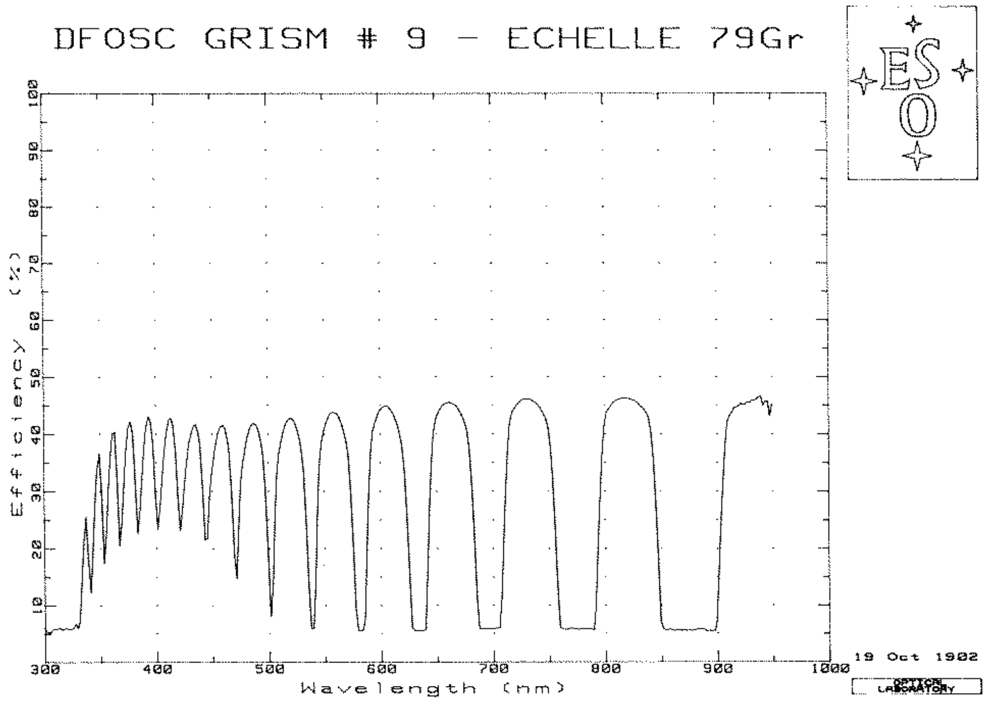

Figure A.8: The efficiency curve for Grism #9. The maxima of the curve represents the maximum efficiency of each of the orders.

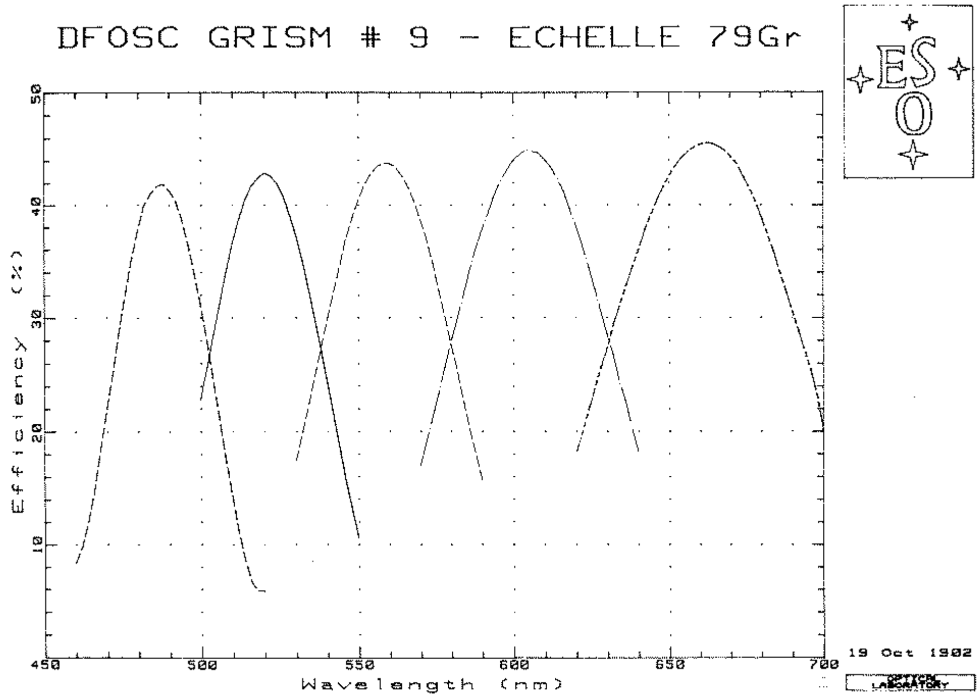

Figure A.9: The efficiency curve for Grism #9. The curves represents scans along five different orders and contains information about the relative efficiency within each order.

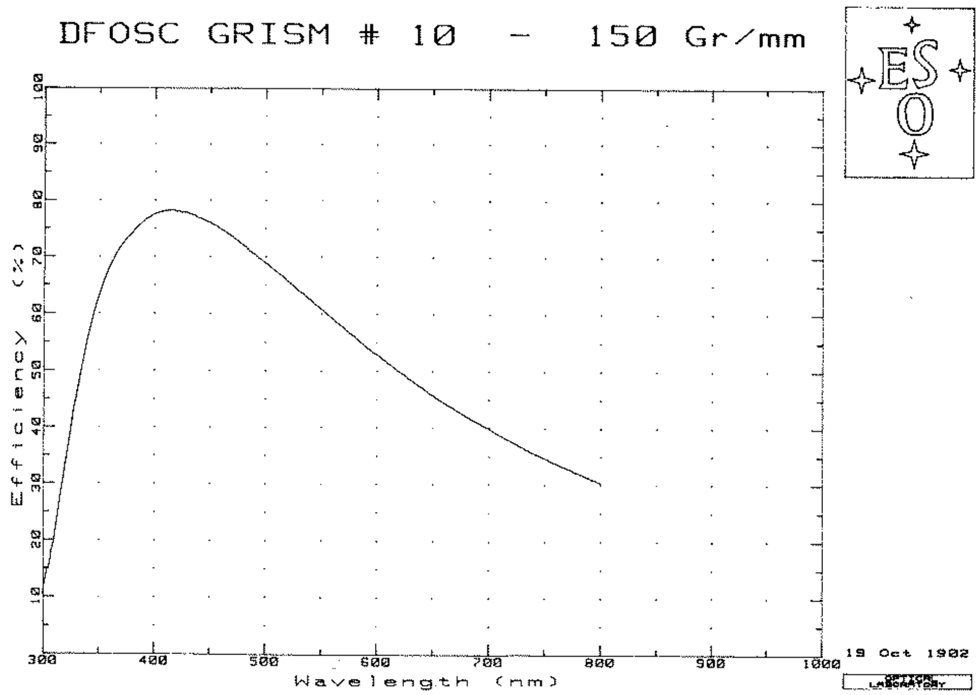

Figure A.10: The efficiency curve for Grism #10

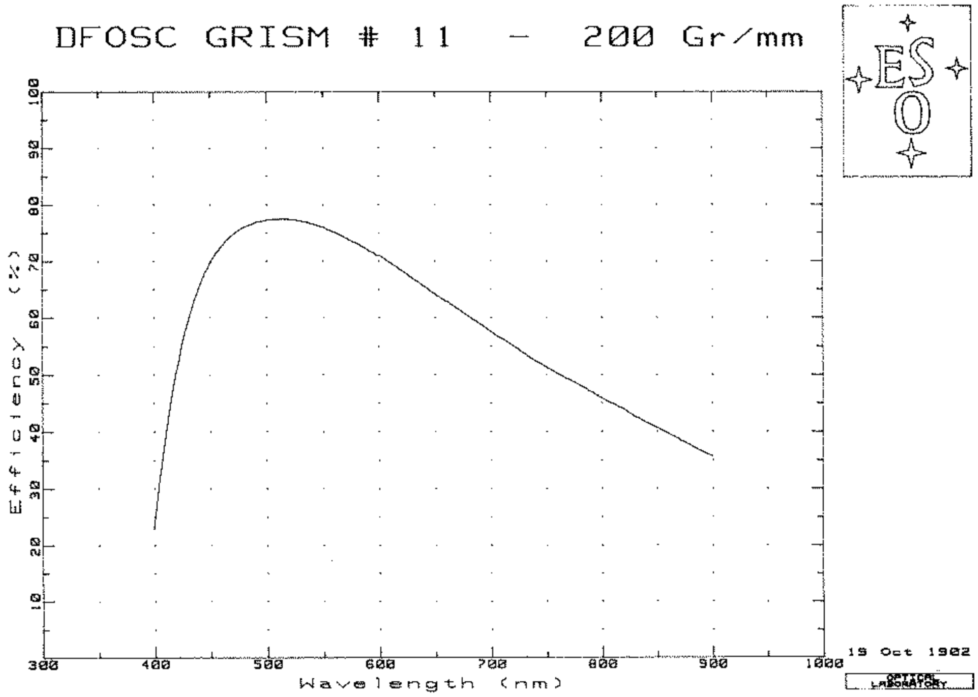

Figure A.11: The efficiency curve for Grism #11

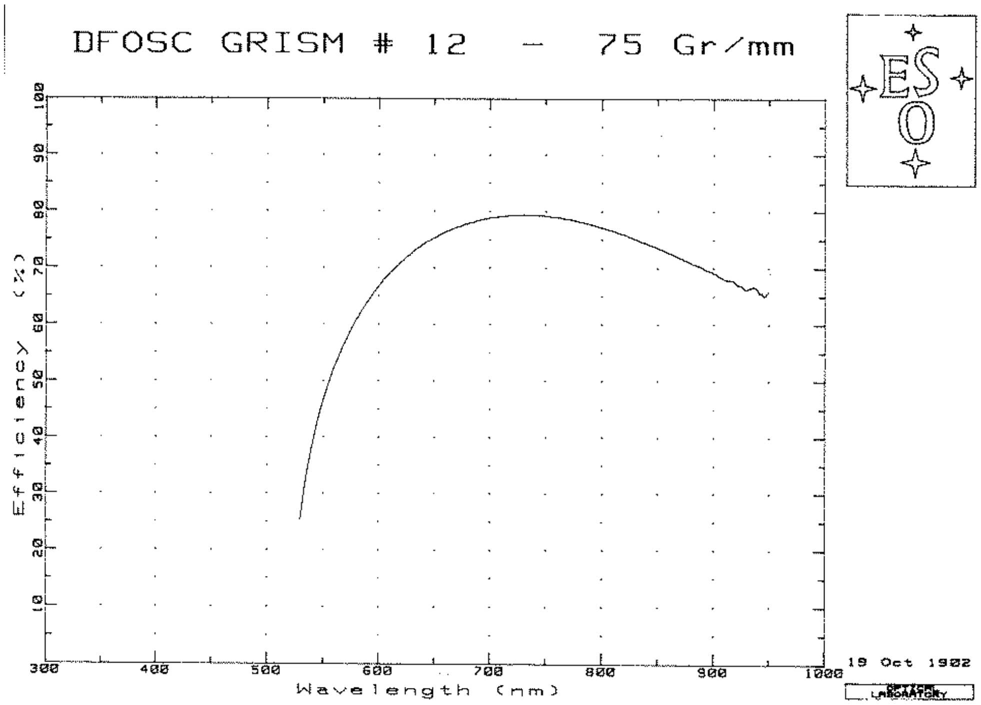

Figure A.12: The efficiency curve for Grism #12

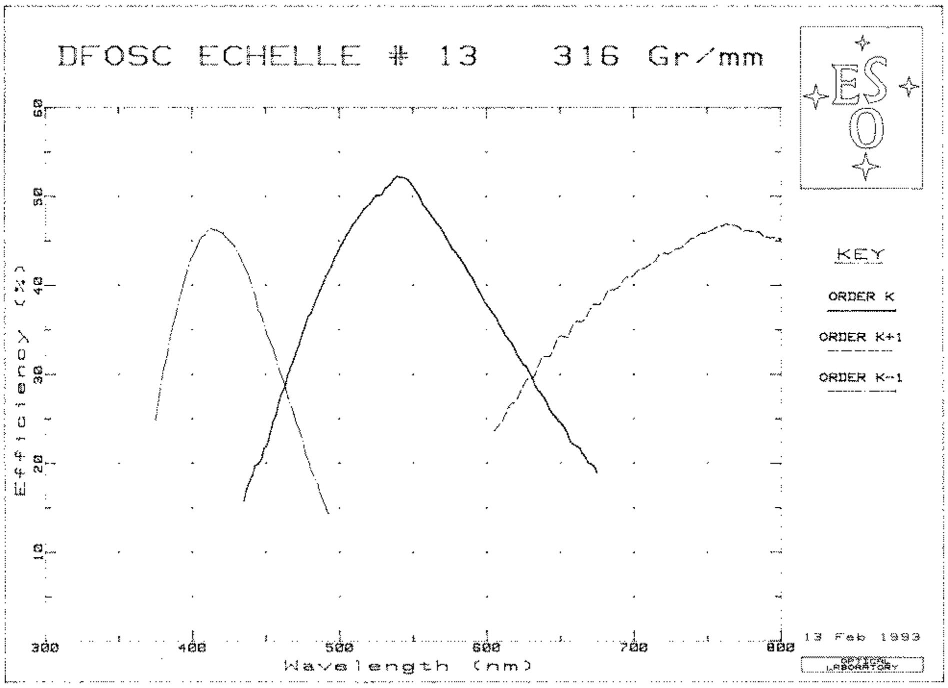

Figure A.13: The efficiency curve for Grism #13. The curves represents scans along three different orders (2,3 and 4) and contains information about the relative efficiency within each order.

Appendix B

HeNeAr Atlas

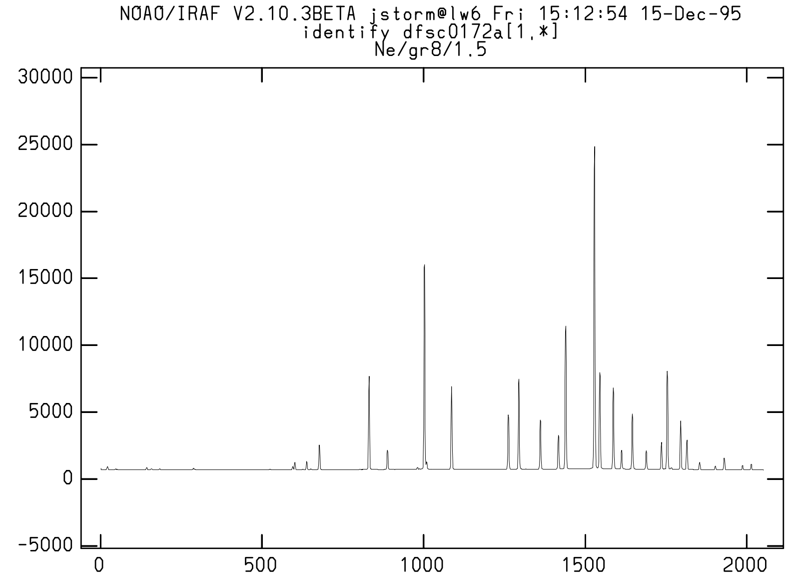

Figure B.1: A 10 second Ne spectrum with 1.''5 slit and grism #8. The neon lamp was mounted in the sky baffle. The CCD Y-coordinate (in pixels) is plotted along the X-axis and the count level (in ADU) along the Y-axis.

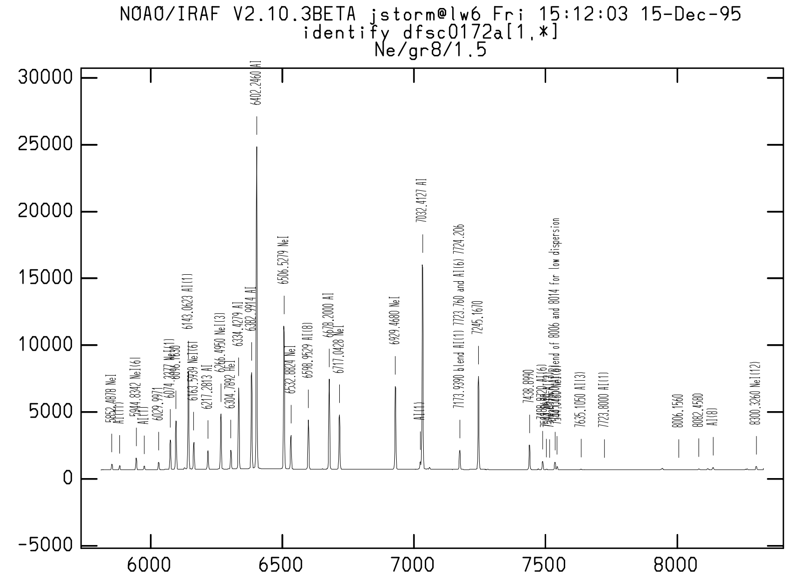

Figure B.2: A 10 second Ne spectrum with 1.''5 slit and grism #8. Wavelength calibrated on the basis of the line list in Table B.1.

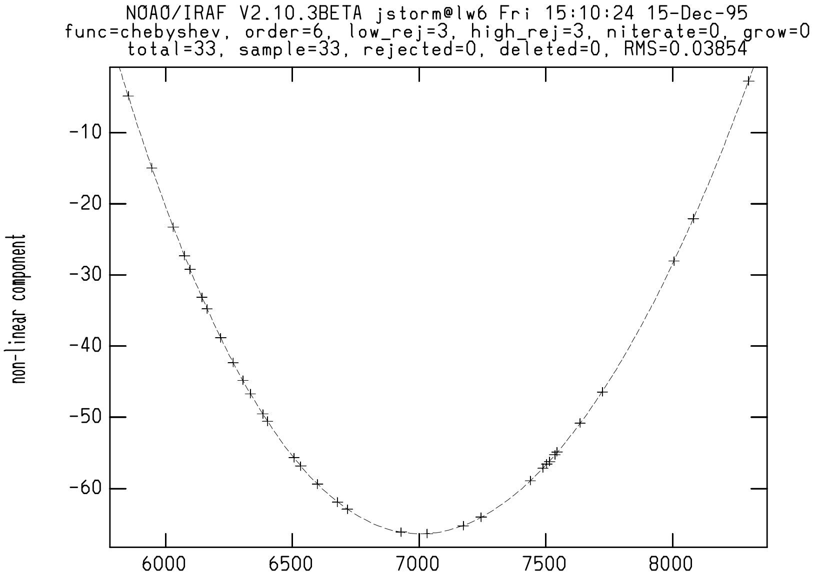

Figure B.3: The non-linear part of the wavelength solution. A 5'th order polynomial gives an excellent fit. (A 6'th order Chebychev polynomial is a 5'th order power series.)

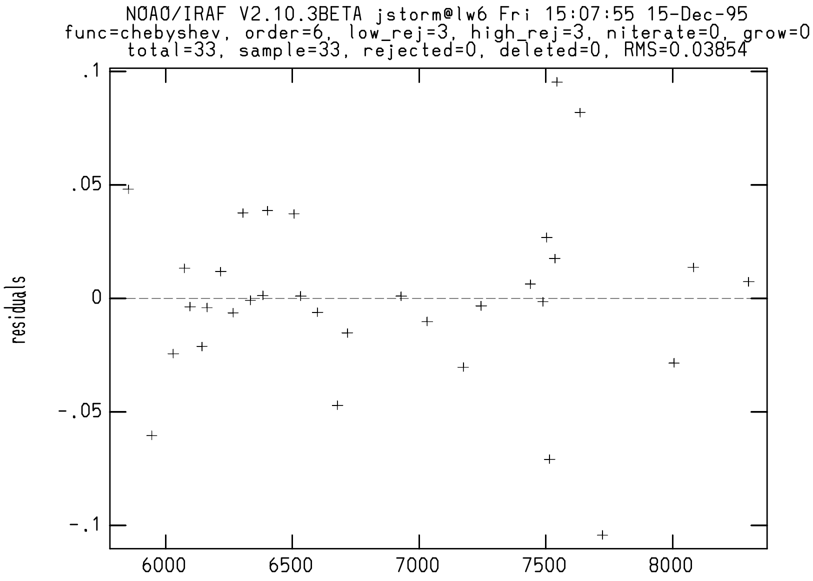

Figure B.4: The residuals of the wavelength solution shown in the previous figures.

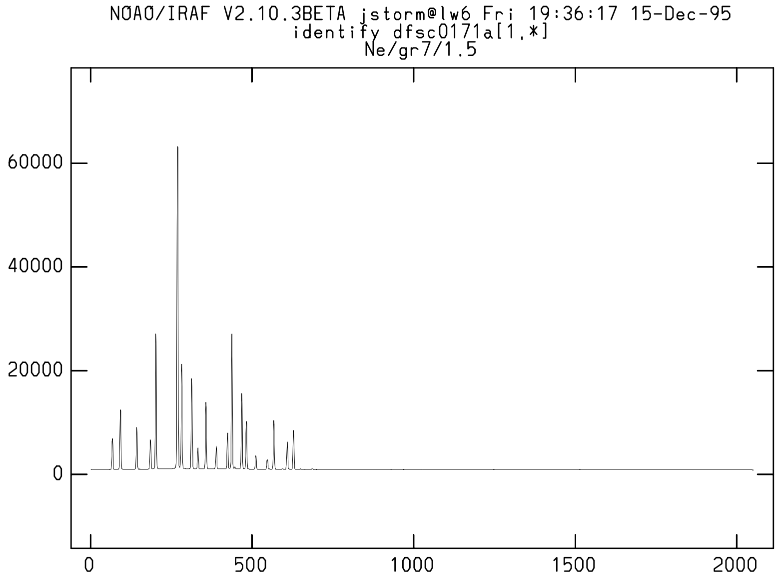

Figure B.5: A 30 second Ne spectrum with a 1.″5 slit and grism #7. The neon lamp was mounted in the sky baffle. The CCD Y-coordinate (in pixels) is plotted along the X-axis and the count level (in ADU) along the Y-axis.

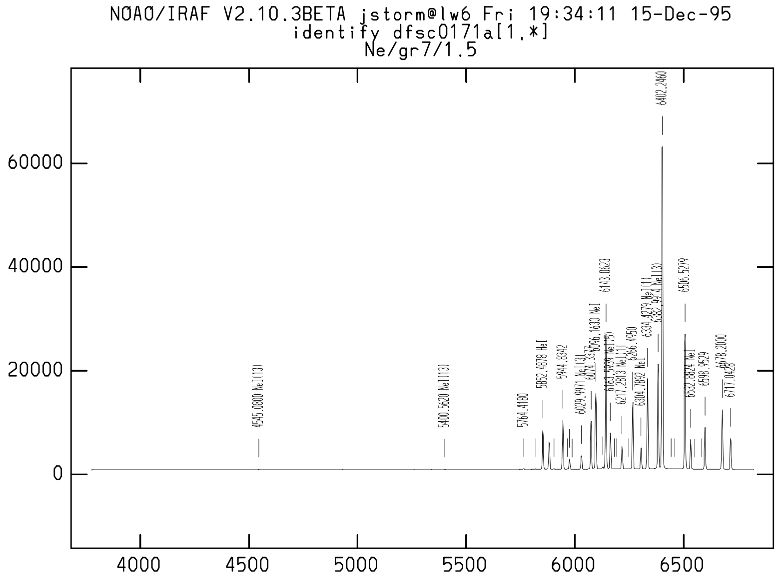

Figure B.6: A 30 second Ne spectrum with 1.″5 slit and Grism #7. Wavelength calibrated on the basis of the line list in Table B.1.

Table B.1: HeNeAr Line List from Kitt Peak National Observatory with Multiplet Numbers as Distributed with IRAF. Wavelengths are from MIT Wavelength Tables Vol.2 and Multiplet Numbers are from C. Moores's "A Multiplet Table of Astrophysical Interest".

λ (Å)	Ident	λ (Å)	Ident
3187.743	HeI	6871.290	AI
3464.14	AII(70)	6929.468	NeI(6)
3520.5	NeI 3520.472 blend with A 3520.0	6965.430	AI(1)
3545.58	AII(70)	7032.4127	NeI(1)
3559.51	AII(70)	7065.188	HeI
3718.21	AII(131) blend with 3724.51 AII(131)	7107.496	AI
3729.29	AII(10)	7125.80	AI
3737.89	AII(131)	7147.041	AI(1)
3780.84	AII(54)	7173.939	NeI(6)
3850.57	AII(10)	7206.986	AI
3888.646	HeI	7245.167	NeI(3)
3928.62	AII(10)	7272.936	AI
3964.727	HeI	7281.349	HeI
4026.189	HeI	7311.71	AI
4044.418	AI(4)	7353.316	AI
4072.2	blend A 4072.01 and 4072.40	7372.118	AI
4131.73	AII(32)	7383.980	AI
4158.590	AI(2)	7438.899	NeI
4259.361	AI(9)	7488.872	NeI
4277.55	AII(32) blend with AI(4) 4272.168	7503.867	AI(8)
4300.4	AI(4) blend	7514.651	AI
4426.01	AII(7)	7535.775	NeI
4471.477	HeI	7544.046	NeI
4510.733	AI(9)	7635.105	AI(1)
4545.08	AII(15)	7670.04	AI
4579.39	AII(17)	7723.8	blend AI(1) 7723.760 and AI(6) 7724.206
4657.94	AII(15)	7891.075	AI
4713.143	HeI	7948.175	AI(6)
4764.89	AII(15)	8006.156	AI(3)
4806.07	AII(6)	8012.000	AI Blend of 8006 and 8014
4879.90	AII(14)	8014.786	AI(1)
4921.929	HeI	8053.307	AI
4965.12	AII(14)	8082.458	NeI(6)
5015.675	HeI	8103.692	AI(3)
5187.746	AI	8110.000	AI Blend of 8103 and 8115
5221.270	AI	8115.311	AI(1)
5400.562	NeI(3)	8264.521	AI(8)
5495.872	AI(14)	8300.326	NeI(12)
5572.548	AI	8377.607	NeI(12)
5606.732	AI	8424.647	AI(3)
5650.703	AI(12)	8495.360	NeI(18)
5748.299	NeI(13)	8521.441	AI(8)
5764.418	NeI(13)	8605.78	AI
5852.4878	NeI(6)	8620.47	AI
5875.618	HeI	8634.648	NeI(23)
5944.8342	NeI(1)	8654.383	NeI(33)
6029.9971	NeI(3)	8667.943	AI(6)
6074.3377	NeI(3)	8761.72	AI
6096.1630	NeI	8780.622	NeI(27)
6143.0623	NeI(1)	8782.1872	Blend of 8780.622 and 8783.755
6163.5939	NeI(5)	8783.755	NeI(38)
6217.2813	NeI(1)	8853.866	NeI(27)
6266.4950	NeI(5)	9075.42	AI
6304.7892	NeI	9122.966	AI(1)
6334.4279	NeI(1)	9148.68	NeI(30)
6382.9914	NeI(3)	9194.68	AI
6402.246	NeI(1)	9224.498	AI(8)
6506.5279	NeI(3)	9291.58	AI
6532.8824	NeI	9354.218	AI(8)
6598.9529	NeI(6)	9425.38	NeI(36)
6678.2	Blend HeI 6678.149 with NeI 6678.2764	9534.167	NeI(38)
6717.0428	NeI	9657.784	AI(3)
6752.832	AI(11)	9784.501	AI(8)

Appendix C

Differential Refraction and the Parallactic Angle

Table C.1 gives atmospheric differential refraction in arcseconds as a function of airmass (sec z) for wavelengths between 3000Å and 10000Å, referenced to a wavelength of 5000Å. For example, at an airmass of 1.5 the differential refraction between 4000 Å and 6000Å is $1\overset{''}{.}08$. At an airmass of 3.0, it is $2\overset{''}{.}75$!

Since differential refraction occurs in a direction perpendicular to the horizon, the ideal slit position angle is also perpendicular to the horizon. In other words when the object is on the meridian, the position angle of the slit should be 0° or 180°. This angle, which is called the parallactic angle will change as the objects distance from the meridian changes. As the object is usually close to the zenith on the meridian the effect is generally small in this case. When observing at large hour angles, however, where the objects typically have a high airmass, the angle will be close to 90° which is why the default setting of the instrument is with the slit in the East-West direction.

If you want to find the correct slit position angle as a function of hour angle and declination to minimize light losses due to differential refraction, you can use the curves presented in Fig. C.1 which are adapted from Fillipenko (1982).

Table C.1: Atmospheric differential refraction at an altitude of 2 km in ″ with respect to a wavelength of 5000Å.

sec z	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500	8000	8500	9000	9500	10000
1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.05	0.68	0.38	0.20	0.08	0.00	−0.06	−0.11	−0.14	−0.17	−0.19	−0.21	−0.23	−0.24	−0.25	−0.26
1.10	0.97	0.55	0.29	0.12	0.00	−0.09	−0.15	−0.20	−0.24	−0.28	−0.30	−0.32	−0.34	−0.36	−0.37
1.15	1.20	0.68	0.36	0.15	0.00	−0.11	−0.19	−0.25	−0.30	−0.34	−0.38	−0.40	−0.42	−0.44	−0.46
1.20	1.40	0.80	0.42	0.17	0.00	−0.13	−0.22	−0.30	−0.35	−0.40	−0.44	−0.47	−0.50	−0.52	−0.54
1.25	1.59	0.90	0.48	0.20	0.00	−0.14	−0.25	−0.33	−0.40	−0.45	−0.50	−0.53	−0.56	−0.59	−0.61
1.30	1.76	1.00	0.53	0.22	0.00	−0.16	−0.28	−0.37	−0.44	−0.50	−0.55	−0.59	−0.62	−0.65	−0.67
1.35	1.92	1.09	0.58	0.24	0.00	−0.17	−0.30	−0.40	−0.48	−0.55	−0.60	−0.64	−0.68	−0.71	−0.73
1.40	2.07	1.18	0.62	0.26	0.00	−0.19	−0.33	−0.44	−0.52	−0.59	−0.65	−0.69	−0.73	−0.77	−0.79
1.45	0.22	1.26	0.67	0.28	0.00	−0.20	−0.35	−0.47	−0.56	−0.63	−0.69	−0.74	−0.79	−0.82	−0.85
1.50	2.37	1.34	0.71	0.29	0.00	−0.21	−0.37	−0.50	−0.60	−0.68	−0.74	−0.79	−0.84	−0.87	−0.91
1.55	2.51	1.42	0.75	0.31	0.00	−0.23	−0.40	−0.53	−0.63	−0.72	−0.78	−0.84	−0.89	−0.93	−0.96
1.60	2.64	1.50	0.80	0.33	0.00	−0.24	−0.42	−0.56	−0.67	−0.75	−0.83	−0.88	−0.93	−0.98	−1.01
1.65	2.78	1.58	0.84	0.34	0.00	−0.25	−0.44	−0.59	−0.70	−0.79	−0.87	−0.93	−0.98	−1.03	−1.06
1.70	2.91	1.65	0.88	0.36	0.00	−0.26	−0.46	−0.61	−0.73	−0.83	−0.91	−0.97	−1.03	−1.07	−1.11
1.75	3.04	1.73	0.92	0.38	0.00	−0.27	−0.48	−0.64	−0.77	−0.87	−0.95	−1.02	−1.07	−1.12	−1.16
1.80	3.17	1.80	0.95	0.39	0.00	−0.29	−0.50	−0.67	−0.80	−0.90	−0.99	−1.06	−1.12	−1.17	−1.21
1.85	3.29	1.87	0.99	0.41	0.00	−0.30	−0.52	−0.69	−0.83	−0.94	−1.03	−1.10	−1.16	−1.22	−1.26
1.90	3.42	1.94	1.03	0.42	0.00	−0.31	−0.54	−0.72	−0.86	−0.98	−1.07	−1.14	−1.21	−1.26	−1.31
1.95	3.54	2.01	1.07	0.44	0.00	−0.32	−0.56	−0.75	−0.89	−1.01	−1.11	−1.19	−1.25	−1.31	−1.36
2.00	3.67	2.08	1.10	0.45	0.00	−0.33	−0.58	−0.77	−0.92	−1.05	−1.15	−1.23	−1.30	−1.35	−1.40
2.10	3.91	2.22	1.18	0.48	0.00	−0.35	−0.62	−0.82	−0.99	−1.12	−1.22	−1.31	−1.38	−1.44	−1.50
2.20	4.15	2.36	1.25	0.51	0.00	−0.37	−0.66	−0.87	−1.05	−1.18	−1.30	−1.39	−1.47	−1.53	−1.59
2.30	4.38	2.49	1.32	0.54	0.00	−0.40	−0.69	−0.92	−1.11	−1.25	−1.37	−1.47	−1.55	−.162	−1.68
2.40	4.62	2.62	1.39	0.57	0.00	−0.42	−0.73	−0.97	−1.16	−1.32	−1.44	−1.55	−1.63	−1.70	−1.77
2.50	4.85	2.75	1.46	0.60	0.00	−0.44	−0.77	−1.02	−1.22	−1.38	−1.52	−1.62	−1.71	−1.79	−1.86
2.60	5.08	2.88	1.53	0.63	0.00	−0.46	−0.80	−1.07	−1.28	−1.45	−1.59	−1.70	−1.80	−1.88	−1.94
2.70	5.31	3.01	1.60	0.66	0.00	−0.48	−0.84	−1.12	−1.34	−1.51	−1.66	−1.78	−1.88	−1.96	−2.03
2.80	5.54	3.14	1.67	0.69	0.00	−0.50	−0.88	−1.17	−1.40	−1.58	−1.73	−1.85	−1.96	−2.04	−2.12
2.90	5.76	3.27	1.74	0.71	0.00	−0.52	−0.91	−1.21	−1.45	−1.64	−1.80	−1.93	−2.04	−2.13	−2.20
3.00	5.99	3.40	1.80	0.74	0.00	−0.54	−0.95	−1.26	−1.51	−1.71	−1.87	−2.00	−2.12	−2.21	−2.29
3.10	6.21	3.53	1.87	0.77	0.00	−0.56	−0.98	−1.31	−.1.57	−1.77	−1.94	−2.08	−2.19	−2.29	−2.38
3.20	6.44	3.65	1.94	0.80	0.00	−0.58	−1.02	−1.36	−1.62	−1.84	−2.01	−2.15	−2.27	−2.38	−2.46
3.30	6.66	3.78	2.00	0.83	0.00	−0.60	−1.05	−1.40	−1.68	−1.90	−2.08	−2.23	−2.35	−2.46	−2.55
3.40	6.88	3.91	2.07	0.85	0.00	−0.62	−1.09	−1.45	−1.73	−1.96	−2.15	−2.30	−2.43	−2.54	−2.63
3.50	7.10	4.03	2.14	0.88	0.00	−0.64	−1.12	−1.50	−1.79	−2.03	−2.22	−2.38	−2.51	−2.62	−2.72
3.60	7.32	4.16	2.20	0.91	0.00	−0.66	−1.16	−1.54	−1.85	−2.09	−2.29	−2.45	−2.59	−2.70	−2.80
3.70	7.54	4.28	2.27	0.94	0.00	−0.68	−1.19	−1.59	−1.90	−2.15	−2.36	−2.52	−2.66	−2.78	−2.88
3.80	7.76	4.41	2.34	0.96	0.00	−0.70	−1.23	−1.64	−1.96	−2.21	−2.42	−2.60	−2.74	−2.86	−2.97
3.90	7.98	4.53	2.40	0.99	0.00	−0.72	−1.26	−1.68	−2.01	−2.28	−2.49	−2.67	−2.82	−2.95	−3.05
4.00	8.20	4.66	2.47	1.02	0.00	−0.74	−1.30	−1.73	−2.07	−2.34	−2.56	−2.74	−2.90	−3.03	−3.14
4.10	8.42	4.78	2.53	1.04	0.00	−0.76	−1.33	−1.77	−2.12	−2.40	−2.63	−2.82	−2.97	−3.11	−3.22
4.20	8.64	4.90	2.60	1.07	0.00	−0.78	−1.37	−1.82	−2.18	−2.46	−2.70	−2.89	−3.05	−3.19	−3.30
4.30	8.85	5.03	2.67	1.10	0.00	−0.80	−1.40	−1.87	−2.23	−2.53	−2.77	−2.96	−3.13	−3.27	−3.39
4.40	9.07	5.15	2.73	1.12	0.00	−0.82	−1.44	−1.91	−2.29	−2.59	−2.83	−3.04	−3.21	−3.35	−3.47
4.50	9.29	5.27	2.80	1.15	0.00	−0.84	−1.47	−1.96	−2.34	−2.65	−2.90	−3.11	−3.28	−3.43	−3.55
4.60	9.51	5.40	2.86	1.18	0.00	−0.86	−1.51	−2.00	−2.40	−2.71	−2.97	−3.18	−3.36	−3.51	−3.64
4.70	9.72	5.52	2.93	1.21	0.00	−0.88	−1.54	−2.05	−2.45	−2.77	−3.04	−3.25	−3.44	−3.59	−3.72
4.80	9.94	5.64	2.99	1.23	0.00	−0.90	−1.57	−2.09	−2.51	−2.84	−3.10	−3.33	−3.51	−3.67	−3.80
4.90	10.15	5.77	3.06	1.26	0.00	−0.92	−1.61	−2.14	−2.56	−2.90	−3.17	−3.40	−3.59	−3.75	−3.88

This information has been copied from the B&C manual

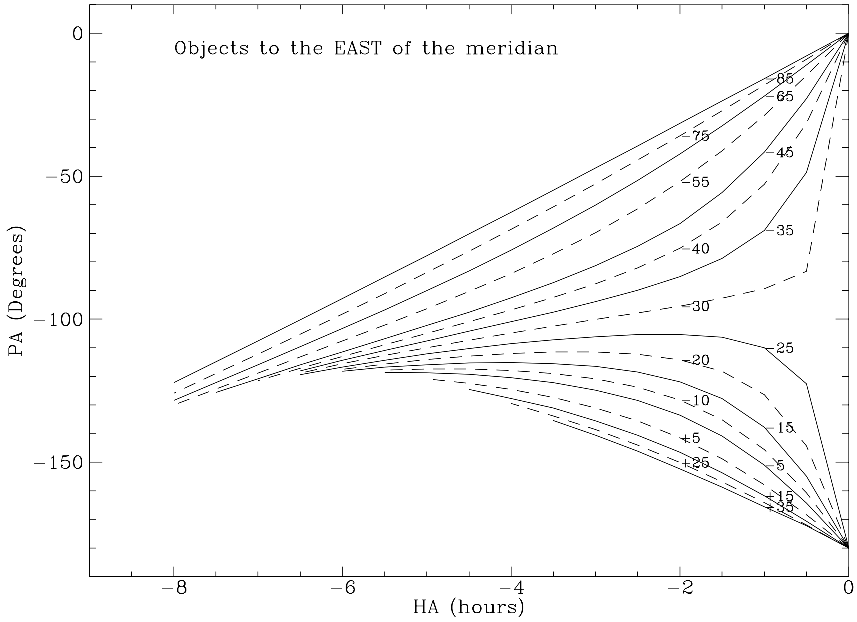

Figure C.1: Optimal slit position angle vs hour angle for La Silla. The curves are marked corresponding to the declination of the object. The full curves are marked at HA 1^h and the dashed curves are marked at HA 2^h.

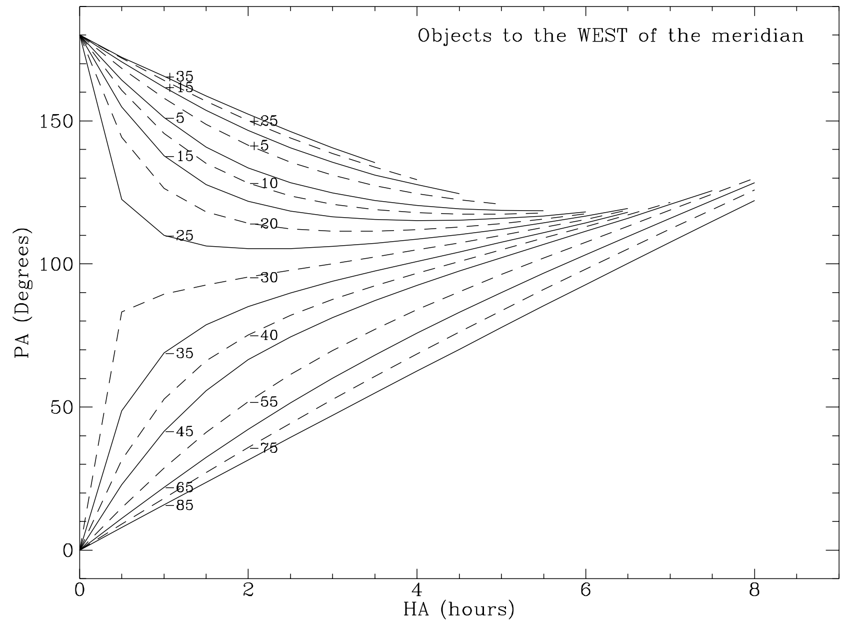

Figure C.2: Optimal slit position angle vs hour angle for La Silla. The curves are marked corresponding to the declination of the object. The full curves are marked at HA -1^h and the dashed curves are marked at HA -2^h.

Appendix D

The TCS User Interface

D.1 General

D.1.1 Controls

The TCS user interface uses the following types of controls:

Button: Buttons are recognizable by their shading. "Pressing" a button will cause an action to occur

Status box: Status boxes are unshaded and cast no shadows. These boxes give statuses, and no user interaction with these is possible.

Input box: Input boxes are unshaded though do cast shadows. These boxes are used for user input. Data is entered into an input box by selecting the box with the left mouse button. The perimeter of the box turns black indicating that the box is receiving keyboard input.

Scrollbar: Scrollbars are unshaded though cast shadows. They have the same functionality as input boxes, though a scrollbar is used to select a value. The perimeters of scrollbars will not turn black when used, as they are unable to receive keyboard input.

Radio Buttons: These are small squares which are either on (green) or off (grey). These buttons are used to select between modes which are mutually exclusive. (The name derives from the preset buttons found on car radios).

D.1.2 Help

A brief description of the function of each button, box and scrollbar appears at the bottom of the panel when the mouse cursor is located above the button, box or scrollbar.

D.2 TCS CONTROL PANEL (TCP)

In the upper part of the TCP there are 11 status boxes giving various telescope and dome statuses. The status boxes are all self explanatory. The speed scrollbars are used to indicate the speed and direction of the α and δ axes of the telescope.

In the lower part of the TCP there are three buttons. The `Set-up...` button will open the TCS SETUP PANEL (TSP, see §D.3), the `Virtual Handset...` button will open the virtual handset panel (see §D.4), while the `Shut Down...` button is used to exit the TCP.

The remainder of the TCP is divided into 'sub-panels' with headings. A description of each of these sub-panels follows. q

D.2.1 Guide Probe Status

The current X-Y position of the guide probe is given in the two status boxes. To the right of these are six status boxes containing flags. The upper three boxes give the status of the X-position of the guideprobe, and the lower three the Y-position of the guideprobe. A red "@" will appear in the left most of these boxes if the guideprobe X (upper) or Y (lower) is not initialized or is malfunctioning. You will notice that this status occurs when the guideprobe is being initialized. The middle status boxes are used to indicate that either the guide probe X or Y axes are moving, have been moved manually, or are not in the desired (preset) position. This is indicated by a blue "@" in the status box. A green "@" will appear in the right hand boxes when the guideprobe is locked at the desired X (upper) or Y (lower) position.

The two lower status boxes will inform you when the guide probe is vignetting the CCD.

D.2.2 Guide Probe Search

There are four buttons which provide the observer a quick means to acquire a guide star. The `Start` button will start the guideprobe scanning along a pre-defined path where the guideprobe does not vignet the field. If a potential guide star is seen, the `Record Pos.` button can be used to store the current guide probe values in the guide probe preset input boxes. The `Stop` button will stop the scan, while the `Go To Pos` button will go to the last recorded position. The `Go To Pos` button performs the same function as the `Apply` button in the Guide Probe Preset sub-panel.

To the right of the four auto-search buttons are the `-X`, `+X`, `-Y`, and `+Y` buttons, which allow the guideprobe to be moved "manually" in a self explanatory way. A single click of one of these buttons will cause a small movement, while rapid movement can be obtained by keeping the desired button depressed.

D.2.3 Guide Probe Preset

This sub-panel allows the user to send the guideprobe to specified X-Y coordinates. The coordinates can either be entered into the input boxes, or alternatively the scrollbars can be used to select the desired values. Values chosen using the scrollbars appear in the input boxes. The `Apply` button will start the preset of the guideprobe to the entered values, while the `ABORT` button will abort the preset.

D.2.4 Autoguider

This sub-panel contains the primary controls for the autoguider. Some additional autoguider controls can be found in the TSP.

The size of the autoguider box can be altered using the `+W` and `-W` to control width and the `+H` and `-H` buttons to control height. The height and width of the box can be simultaneously changed using the `+HW` and `-HW` buttons.

The 9 "X Hair" buttons are used to control the position of the autoguider cross hair on the guide probe monitor in a self explanatory way. The `R` button resets the cross hair to the centre of the screen and restores the box to its default size.

The autoguider is switched on using either the `Star to Box` button, or alternatively the `Box to Star` button. Note that if the `Box to Star` button is used the autoguider centres on the guide star (guiding with relaxation), while if the `Star to Box` button is used, the telescope is moved to centre the guide star in the autoguider box (guiding without relaxation). The `OFF` button switches off the autoguider. The current status of the autoguider is reported in the status box in the sub-panel. Note that if you start the autoguider using the `Star to Box` button, you should wait until the star is centred in the guide box before starting an exposure.

D.2.5 Presetting

This sub-panel controls the movement of the telescope itself (Note that the fixed presets are located on the TSP). Coordinates can either be read from a file, or entered directly. If a catalogue is to be used, the `Cat.Select` button has to be pressed. Clicking on the `Cat.Select` button opens a window in which the desired catalogue can be selected. Note that no special functionality exists for creating catalogues. To create a catalogue you must use a text editor to create a file containing the four fields name, RA, declination, and epoch, and optionally the proper motion in RA and declination (units of $''$/yr). If proper motion values are not entered, the program will enter values of 0. A valid (though we hope not typical!) catalogue is:

```
P904        55.03 -770824.5 1986.50 1 1 Comments are o.k if they
P1630      116.10  -60520.6 1986.50 0 0 start after the sixth field.
P5        1053.40 -275229.7 1986.50
P40      10754.64 -101512.8 1986.50 -2 0
P422    111323     203552   1986.50
```

Note that the catalogue is in free format – leading zeros, decimal points and trailing zeros are not necessary. However, you may put in zeros and decimal points if this is your preferred format.

Below the `Cat.Select` button are four status boxes in which appear entries from the selected catalogue. The text in the middle status box is blue, indicating that this is the current selected object. The upper two status boxes show the catalogue entries before the selected object, and the lower two status boxes show the catalogue entries after the selected objects. It is possible to scroll through the catalogue using the `Up` and `Dwn` buttons to the right of the status boxes. The buttons `Top` and `Bot` will move to the top and bottom of the selected catalogue respectively. Note that these four buttons are only active when a catalogue is loaded. It is possible to select an object by name. To do this click on the "Search Object" input box below the status boxes and start typing the name. Note that: (1) the search is case sensitive; and (2) after each character typed in, the catalogue changes to the first entry which starts with the string thus far entered. Each time a new catalogue entry is selected (either by using the `UP` and `Dwn` buttons, or using "Search Object"), the selection appears in the "Object Coordinate" input boxes.

If you do not wish to use a catalogue, you may enter coordinates directly into the "Object Coordinates" input boxes. Simply select the input box with the left mouse key and enter the data. Note that: (1) is not necessary to give a name; and (2) the coordinates and epoch are in "free" format.

Clicking on the `Preset` key will start the telescope presetting to the coordinates in the input boxes. Be warned that the TCS does not check the coordinates, and so it is possible to preset the telescope into its limits. If you realize this is happening, or you wish to stop your preset for some other reason, `ABORT` the preset.

When the `CC` (correct coordinates) button is pressed, the telescope will read the values in the input fields and assume that this is its present position.

There are two mutually exclusive radio buttons above the presetting status boxes. When the "Apparent" radio button is selected, the telescope will go to the coordinates in the "Object Coordinates" input boxes. In this case the epoch is no longer relevant, and the user will be informed of this by a message in the Epoch input box. If "Mean" is selected, the coordinates will be precessed to the current epoch.

The `Clear Fields` button will clear the name, R.A., Dec, and proper motions, though will leave the Epoch and Apparent/Mean radio buttons as they are.

D.2.6 Adapter/Camera

This sub-panel is used to control the TV camera, though note that filter selection for the TV camera is controlled from the TSP.

The voltage on the TV camera is controlled by the scrollbar. Note that the voltage changes as the scrollbar is moved. The TV camera voltage should be set to zero when the camera is not in use. To the right of the voltage control is a status box which gives the counts when autoguiding. This status box is only updated when the autoguider is switched on.

The "integration" input box is used to control the integration time of the TV camera. This option is useful if a faint star is being used for autoguiding, and it is not possible to get 100,000 counts (the counts needed for good autoguiding) by increasing the voltage alone. To change the value in this box click on the box with the left mouse button. A vertical bar will appear containing the allowed values for this parameter. Move the mouse down this bar and release on the desired value.

The focus of the TV camera is controlled by the four lower buttons. There are `In` and `Out` buttons for both slow and fast focus movements.

The buttons `Center Field` and `Park Pos` move the TV camera to the center of the field or to the park position. When these buttons are used, you will notice the guide probe coordinates changing in the **Guide Probe** sub-panel, and if the centre field is selected, a warning will appear in the **Guide Probe** sub-panel that the guide probe is vignetting the beam.

D.3 TCS SETUP PANEL (TSP)

This panel is started by clicking on the `Set-up...` button in the TCP. The TSP obscures the TCP. We suggest you that you either: (1) open the TSP as needed, closing it with the `DONE` button after use; (2) keep both the control panels in the same workspace, but raise and lower as needed (click on window perimeter to raise and lower); or (3) put the TSP in an alternative workspace (click on the "–" in the upper left hand corner of the frame and select `Occupy Workspace...`).

D.3.1 Telescope Constants

This sub-panel contains 8 input boxes and two buttons. The 8 input boxes are used to define the tracking, guiding, and setting rates ($''$/s) as well as the offset step size ($''$) in α and δ. To change one of the constants select the input box with the left mouse key and enter the desired value. To send this new value to the TCS (though not to execute it) click on the `Apply` button. The default values can be recalled using the `Default values` button, though don't forget to click on `Apply` to send the values to the TCS.

D.3.2 Autoguider

The autoguider sub-panel contains more rarely used autoguider options. The leftmost two radio buttons control the autoguider resolution. The default is to have high resolution. In the low resolution mode the number of camera lines is halved. The middle two radio buttons are used to either switch the center line on or off. The default is to have the center line off. When the center line is switched on, a reference cross is displayed (the reference cross has no impact on the guiding). The "XH color" option is used to invert the crosshair colour. The default is to have a white crosshair, a black crosshair is useful when, for example, guiding on star embedded in a bright nebula.

D.3.3 Cal.lamps

This sub-panel is used for controlling the flat field and line lamps in the calibration unit. Note that there are also line lamps in the sky baffle, but these are not controlled from the TCS interface. The 4 status buttons in this sub-panel are mutually exclusive, i.e. it is only ever possible to have one switched on (lit green). The internal flat field lamps are generally not used as they are too bright and do not produce a very uniform illumination. The line lamps are bright, and are generally only useful for echelle spectroscopy. If you wish to use any of these internal lamps, you must put the adapter into calibration mode. This is done from the Adapter sub-panel within the TSP.

D.3.4 Adapter

The Adapter sub-panel contains the more rarely used adapter options. The upper five buttons on the left of the panel are used to initialize the various elements of the adapter, while the button below these will initialize all of the adapter elements. The five status boxes give the initialization status of the 5 elements. When one of the elements is being initialized, the initialization status box will report `In Progr.`, and change to `Ready` if the element successfully initializes. If the requested element does not initialize within a specified period, an error message will appear.

To the right of the status boxes for the five elements are 5 more status boxes which report the current position of the various adapter elements.

The five lower buttons control the adapter mode. Only the `Calibration` and `Park` buttons are of interest to the observer. The `Calibration` button will move a pick-up mirror into the beam and is used when the internal flat field or line-lamps are being used. The `Park` button will put the adapter back into the configuration needed for observation.

D.3.5 Filters

This sub-panel contains six radio buttons which select the filter for the TV camera. The default setting is free. To change filters, click on the desired filter with the left mouse button.

When obtaining spectra at high airmasses it is advisable to use a filter with a similar bandpass to the spectral range you wish to observe in front of the TV camera. The reason for doing this is that differential refraction will spread the star into a spectrum, and you want to ensure that the wavelength region of interest stays on the slit.

D.3.6 Fixed Presets

This sub-panel contains three buttons used to preset the telescope to fixed positions, and one button to abort the preset. The buttons `Zenith`, `Pole`, and `FF Scr` will send the telescope to the Zenith, the south celestial pole, and the flat field screen position (which differs depending on which side of the pier the telescope is mounted) respectively. The `ABORT` will abort any of these three presets.

D.3.7 Init

The Init sub-panel contains two buttons which are used to initialize the telescope (§1.1.5) and dome (§1.1.6).

D.3.8 Dome

In the Dome sub-panel the radio buttons are used to either put the control of the dome under manual (position is controlled by from the dome floor), or automatic control (position is controlled by the TCS).

D.3.9 Miscellaneous

At the bottom of the TSP is a status box which will report the message after an action has been carried out (if any to report). Also located at the bottom of the panel is the `DONE` button which will exit the TSP.

D.4 The Virtual Handset

The virtual handset panel is started by clicking on `Virtual Handset...` in the TCP. The handset appears to the upper right of the TCP.

In the upper part of the handset are four buttons used to control the mode of the telescope. The possible modes are:

`GUIDE` In this mode the telescope will track and can be moved in α and δ by the handset. The rate at which the telescope moves is specified by the "Guiding" input boxes in the **Telescope Constants** sub-panel.

`SET` In this mode the telescope will continue to track and can be moved in α and δ by the handset. The rate at which the telescope moves is specified by the "Setting" input boxes in the **Telescope Constants** sub-panel.

`SLEW` In this mode the telescope will stop tracking, though can be moved in α and δ by the handset. The rate at which the telescope moves is ??

`OFFSET` In this mode, the telescope continues to track. A single press of one of the $+\alpha, -\alpha, +\delta, -\delta$ keys on the handset will cause the telscope to offset by the amount specified in the "Offset" input boxes in the **Telescope Constants** sub-panel. If a button is clicked multiple times, it will make multiple offsets. However, we suggest that only 1 offset be made at a time.

The `+D`, `-D`, `+A`, and `-A` buttons control the telescope movement in α and δ in a self explanatory way. The `DONE` will exit the virtual handset panel.

Appendix E

Midas Batches and Commands

E.1 Observing Batches

A MIDAS observing batch may be run by clicking on the corresponding button on the graphical X11 user interface (GUI) that appears on top of the MIDAS display window. The GUI is automatically started when you log on to the WS. It can also be started by typing `crea/gui OBS` in a `MIDAS` window. If the batch requires interaction with the displayed image, the left mouse button is used to record positions on the display, and the middle or right button to exit. The arrows on the keyboard can be used to change the size of the display box, or in the case of the command "trace", to move the fiducial mark. A description of the procedures invoked by these buttons is given below.

`seeing` This batch is used to determine the seeing on a frame. The cursor on the display appears as a box. Resize the box using the keyboard arrow keys so that it is a similar size to the displayed stars, and then locate the box over stars in the frame and click with the left mouse button. When the middle button is pressed, the cursor is exited and the mean FWHM of the selected stars is calculated. If you believe there were no extended sources amongst your sample, we kindly request that you register your value in our seeing data base. You will be prompted for the required input.

`point` This batch is used to determine the telescope offsets needed to locate a source at a specific position on the CCD. The batch also returns the offsets needed to restore the guideprobe to its original position on the sky after the telescope has been offset. After clicking on the button, a dialogue box appears in which you must enter the X and Y coordinates on the CCD where the source is to appear, the rotator angle (this is the angle which appears in DAISY's DFOSC window), and finally a G or a C. Entering a G will cause a Gaussian fitting routine to be used when selecting the source, whereas the C option will cause only the cursor position to be read. After the parameters have been entered the cursor becomes active in the display window. Locate the box (if G option was chosen) or cross (if C option was chosen) over the source and click the left mouse button. After exiting the cursor with the middle mouse button, the required offsets in α and δ are displayed, along with the aforementioned autoguider offsets.

`focus` This is a pull-down menu with the options `focus sequence` and `focus pyramid`.

Selecting `focus sequence` will open a dialogue box in which you must enter the focus value of the first image in your focus sequence and then the focus step size between the successive images. After entering these data, the cursor becomes active and you must click on the stars in a sequence in the same order in which the sequence was made. After exiting the cursor with the middle mouse button a graph showing the variation of FWHM with focus value in the X and Y coordinates will be plotted, and an estimate of the best focus value given.

Selecting `focus pyramid` will activate the graphics cursor. Resize the cursor box (using the arrow keys) so that it is a similar size to the stars on the image, and then click (left button) on the leftmost stars in the quartets (the routine will automatically find the other three stars). After exiting the cursor with the middle button, the *offset* which needs to be applied to the focus value will be displayed.

`rotate` This batch will return the angle through which the rotator must be turned to align two points horizontally. The batch will activate the graphics cursor. Click on the two points (left mouse button) and exit with the right mouse button.

This batch is useful when, for example, aligning two stars on a slit, or rotating a field such that a spectrum can be obtained of a galaxy along a specific axis.

`qextra` This batch allows you to make a quick extraction of the displayed spectrum. You must first click on a lower left and an upper right region of the image to define the region in which the image is to be extracted. After this, the selected region is collapsed in dispersion and a plot of this displayed. Define new cuts for this plot by clicking on lower left and upper right points. The graph is then replotted and you are asked to click two points between which the spectrum will be extracted and four points to define the sky. After selecting the spectrum and sky, the spectrum is extracted and displayed. The batch then allows the spectrum to be replotted at a different scale.

`slit` This batch is used to see where the slit will lie on an image. The batch opens a dialogue box in which you must enter the X position along the slit where you want your object to lie, and the Y position of the slit. After entering these data, the slit is drawn on the image and a small circle appears at the given X position.

`trace` This calls the MIDAS command `extract/trace`. The batch will activate the cursor in the display window. A second “fixed cursor” also appears in the display window, and this can be moved using the arrow keys on the keyboard (this motion may be sped up by pressing one of the 1-9 keys first). The trace is extracted along the line which connects the two cursors, and the location of the cursors are indicated by vertical lines on the plot. The plot is updated by clicking on the left mouse button, and the batch exited using the middle mouse button.

`options` This is a pull-down menu with 2 options: `image saving on DAT enabled/disabled` This option does not work as it is automatically enable from DAISY, and `set image scale` which sets the scaling of the automatic image display.

`catalog` This pull-down menu has options to list the headers of the dfsc files in the MIDAS window, and to reset the catalogues. Once the catalogues are reset, they must be created again with the `create/icat` command. This is automatically done at the beginning of the session.

`utils` This pull-down menu contains options to get the cursor and to print the display and graph windows on the laser printer.

`quit` This pull-down menu has a single option which will quit the observing batches GUI.

E.2 Survival MIDAS

E.3 Commands

Below is a summary of a few basic MIDAS commands which you might find useful during your observing run. For more detailed information see the MIDAS manuals located in the control room.

In the below descriptions, arguments given within [...] are optional, if no value is given a default will be chosen.

E.3.1 Getting Help

`help`

To display all existing MIDAS commands and topics.

`help` *comnd*

To display all the `comnd/qualif` combinations available for the given *comnd*.

`help` *comnd/qualif*

To get detailed information about the specified *comnd/qualif* combination.

comnd/qualif ??

To display full command syntax (one line) of specified *comnd/qualif*.

E.3.2 Image Display Window

`create/display`

Create an image display.

`load/image dfsc0001 [cuts=lo_cut,hi_cut] [center=centx,centy] [scale=xscale,yscale]`

Displays an image on the display window.

`statistics/image ?  cursor`

Obtain statistics for regions of the image. A box is created in the display area (which can be resized using the arrow keys on the keyboard) and when the left mouse button is pressed, the statistics inside this box will be printed on the screen. This command is particularly useful to see if any part of the image is saturated. To exit, click the middle mouse button.

`statistics/image dfsc0001`

Statistics for the whole image.

`get/cursor`

This command will create a cursor in the image display window. The location of the cursor can be obtained by clicking the left mouse button, use the central button to exit cursor mode.

`clear/overlay`

Clear the overlay plane of the image.

`copy/display laser`

Send the image in the display area to the printer.

E.3.3 Graphics Window

`create/graph`

Create a graphics window.

`plot graph1`

Plot graph1 in the graphics window. Note that if you used the observing batch 'trace' the graph is saved in the file trace.bdf

`set/graph xaxis=100,170 yaxis=0,1000`

Set graph limits. This command can similarly be used for the y-axis. Afterwards, replot your graph using the `plot` command.

`set/graph xaxis=auto yaxis=auto`

Reset graph limits to default values.

`get/gcur`

Opens a cursor in the graphics window. Read the cursor position by clicking on the left mouse button, and exit with the right mouse button.

`center/gauss`

Measure the FWHM of a line. Mark in the graph window two positions which bracket the line to be measured.

`copy/graph laser`

Send the image in the display area and the plot in the graph to the printer.

E.3.4 Image Manipulation

`compute d1 = d2/d3` and `compute d1 = d2+d3`

Perform simple arithmetic on images.

`average/image flat=ima1,ima2,ima3 ?  ?  median`

Create a median image. In this example, `ima1`, `ima2`, and `ima3` are the frames medianed to form `flat`.

`average/col graph1 = dfsc0001 1120,1130`

Average columns on an image. This is useful for a preliminary look at spectra, but also look at the `qextra` observing batch. the location of the spectrum can be obtained using the command `get/cursor`, while the spectrum can be plotted using the command `plot graph1`

E.3.5 Miscellaneous

`create/gui obs`

Creates the observing batch gui. Useful in case your GUI dies.

`create/gui filters`

Create a GUI to look at filters available at ESO.

E.4 How To...

Below we describe how to use MIDAS to perform some simple analysis which might be useful during your observing run.

E.4.1 Measure the Position and FWHM of a Spectral Line

(Under construction)

E.4.2 Measure the Position of a Slit

(Under construction)

Appendix F

The FITS Header

F.1 The FITS Header as Seen by MIDAS

```
Name: dfsc0310 (data = ui2)
NAXIS:                   2
NPIX:                 1000      1000
START:               501.00000000000         501.00000000000
STEP:                1.0000000000000         1.0000000000000
IDENT:          focus/r
CUNIT:
LHCUTS:                  0.             0.      0.1401298E-44  0.1401298E-44
O_POS:
    0.55269000000000        -73.834970000000                      0.
O_TIME:
     1996.7377049180                      0.                      0.
     50353.229143500         5.4994440001901                      0.
     70.000000000000
TM_START:            19798.000000000
TM_END:              19960.000000000
TELESCOP:       Danish 1.54m
INSTRUME:       DFOSC
OBSERVER:
ORIGIN:         ESO-LA SILLA
FILENAME:       dfsc0310.mt
DATE:              1996.738
AMPLM:          B
CCDTEMP:            -100.00000000000
AMBTEMP:             4.5000000000000
MPP:                     1
ST:                  4330.7000000000
HA:                 0.64967000000000
ZDIST:               44.900000000000
CAMERA:         1950
ROTATOR:        -89.96
```

```
_EGE_TYPE:       SCI
_ET_ID:          Danish 1.54m
_EIO1_NO:                 8
_EIO1_ID:
_EIO1_TYPE:      SLIT
_EIO1_NAME:      FREE
_EIO2_NO:                 4
_EIO2_ID:        ESO#452
_EIO2_TYPE:      FILTER
_EIO2_NAME:      R
_EIO3_NO:                 8
_EIO3_ID:
_EIO3_TYPE:      GRISM
_EIO3_NAME:      FREE
_EIO4_NO:                 0
_EIO4_ID:        #0
_EIO4_TYPE:      FILTER B
_EIO4_NAME:      Free
_EIO5_NO:                 0
_EIO5_ID:        #0
_EIO5_TYPE:      FILTER A
_EIO5_NAME:      Free
_ED_NAME:        LORAL 2k x 2k
_ED_ID:          2K3EB C1W11/4 2
_ED_BITS:                16
_EDF_NAXIS1:           1000
_EDF_NAXIS2:           1000
_EDF_CRPIX1:         1.0000000000000
_EDF_CRPIX2:         1.0000000000000
_EDF_CDELT1:         1.0000000000000
_EDF_CDELT2:         1.0000000000000
_EDF_CRVAL1:         501.00000000000
_EDF_CRVAL2:         501.00000000000
_ED_MODE:        HIB
_ED_UDIT:            70.000000000000
REFPIX:              1.0000000000000         1.0000000000000
ROTA:                            0.                       0.
total no. of descriptors:    63
```

F.2 The FITS Header as Seen by IRAF

```
dfsc0314[2052,2052][real]: HV1328
    No bad pixels, no histogram, min=0., max=65535.
    Line storage mode, physdim [2052,2052], length of user area 2471 s.u.
    Created Sat 04:37:08 28-Sep-96, Last modified Sat 04:37:08 28-Sep-96
    Pixel file 'HDR$pixdfsc0314.pix' [NO PIXEL FILE]
    'ESO-LA SILLA'  / Tape writing institution
    '27/09/96'      / Date file is written (UT)
    CRPIX1  =              1. / x ref. pixel of instrument optical axis
    CRPIX2  =              1. / y ref. pixel of instrument optical axis
    CRVAL1  =              1. / Physical coordinate of CRPIX1
    CRVAL2  =              1. / Physical coordinate of CRPIX2
    CDELT1  =              1. / Increment unit along x-axis
    CDELT2  =              1. / Increment unit along y-axis
    TM_START=        20891.00 / ' 5:48:11.00' measurement start time (UT)
    TM_END  =        20931.00 / ' 5:48:51.00' measurement end time (UT)
    TELESCOP= 'Danish 1.54m'  / Telescope identification
    INSTRUME= 'DFOSC'         / Instrument used
    OBSERVER= ' '             / Name of the observer
    FILENAME= 'dfsc0314.mt'   / Name of this file
    DATE-OBS= '27/09/96'      / Date of observation (UT)
    MJD-OBS =   50353.2417940 / Start of observation = 1996/09/27  5:48:11.00
    EXPTIME =           40.00 / Integration time (secs) is  0:00:40.00
    AMPLM   =    'B '               /  A / B or AB
    CCDTEMP =              -100.4  /
    AMBTEMP =                 4.3  /
    MPP     =                   1  /
    ST      =              5427.2 / Siderial time at start
    RA      =             0.55694 / Right accension at start
    DEC     =           -73.83517 / Declination at start
    HA      =             0.95003 / Hour Angle at start
    ZDIST   =            45.20000 / Zenit distance at start
    CAMERA  = '1950    '          / DFOSC Camera focus
    ROTATOR = '-89.96  '          / DFOSC Rotator angel, step position =     7
    HIERARCH ESO GEN EXPO TYPE  = 'SCI'           / Type of exposure
    HIERARCH ESO TEL ID         = 'Danish 1.54m'  / Telescope identification
    HIERARCH ESO INS OPTI-1 NO  =               8 / Wheel#1 position
    HIERARCH ESO INS OPTI-1 ID  = ' '             / Optical element identificati
    HIERARCH ESO INS OPTI-1 TYPE= 'SLIT    '      / What is this element
    HIERARCH ESO INS OPTI-1 NAME= 'FREE'          / Filter name
    HIERARCH ESO INS OPTI-2 NO  =               4 / Wheel#2 position
    HIERARCH ESO INS OPTI-2 ID  = 'ESO#452'       / Optical element identificati
    HIERARCH ESO INS OPTI-2 TYPE= 'FILTER  '      / What is this element
    HIERARCH ESO INS OPTI-2 NAME= 'R'             / Filter name
    HIERARCH ESO INS OPTI-3 NO  =               8 / Wheel#3 position
    HIERARCH ESO INS OPTI-3 ID  = ' '             / Optical element identificati
    HIERARCH ESO INS OPTI-3 TYPE= 'GRISM   '      / What is this element
    HIERARCH ESO INS OPTI-3 NAME= 'FREE'          / Filter name
    HIERARCH ESO INS OPTI-4 NO  =               0 / Wheel 4 position
    HIERARCH ESO INS OPTI-4 ID  = '#0'            / Optical element identificati
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HIERARCH ESO INS OPTI-4 TYPE= 'FILTER B'      / What is this element
HIERARCH ESO INS OPTI-4 NAME= 'Free'          / Filter name
HIERARCH ESO INS OPTI-5 NO  =               0 / Wheel 5 position
HIERARCH ESO INS OPTI-5 ID  = '#0'            / Optical element identificati
HIERARCH ESO INS OPTI-5 TYPE= 'FILTER A'      / What is this element
HIERARCH ESO INS OPTI-5 NAME= 'Free'          / Filter name
HIERARCH ESO DET NAME       = 'LORAL 2k x 2k' / Detector name
HIERARCH ESO DET ID         = '2K3EB C1W11/4 2' / Detector identification
HIERARCH ESO DET BITS       =              16 / ADU bits per pixel
HIERARCH ESO DET FRAM NAXIS1=            2052 / Number of pixels along horiz
HIERARCH ESO DET FRAM NAXIS2=            2052 / Number of pixels along verti
HIERARCH ESO DET FRAM CRPIX1=              1. / Reference pixel
HIERARCH ESO DET FRAM CRPIX2=              1. / Reference pixel
HIERARCH ESO DET FRAM CDELT1=              1. / Binning factor along horizon
HIERARCH ESO DET FRAM CDELT2=              1. / Binning factor along vertica
HIERARCH ESO DET FRAM CRVAL1=              1. / Position of window along hor
HIERARCH ESO DET FRAM CRVAL2=              1. / Position of window along ver
HIERARCH ESO DET MODE       = 'HIB'           / Readout mode
HIERARCH ESO DET UDIT       =           40.00 / User defined exposure time (
```

Appendix G

Empty Fields

Table G.1: Empty Fields

Field	α_{1950}	δ_{1950}	Comments
SGP	00 48 30.3	–28 03 01.0	Contains ~10 objects in $6\overset{'}{.}0 \times 6\overset{'}{.}4$
0102-265	01 02 48.5	–26 34 25.0	Contains ~15 objects in $6\overset{'}{.}0 \times 6\overset{'}{.}4$
0248-196	02 47 46.6	–19 46 11.1	
0427-36	04 27 26.1	–36 25 16.0	OK $5' \times 5'$
9090-7	09 09 32.6	–07 38 26.0	
CT1	10 04 27.0	–02 19 00.0	
1101-264	11 02 23.5	–26 43 56.7	
SPKS 02	11 07 06.0	–77 05 54.0	
CT5	12 26 08.7	–06 38 29.0	
SPKS 01	12 28 04.0	–07 46 54.0	A bright star in field
SPKS 03	12 28 38.0	–63 28 18.0	
CT2	12 54 58.7	–02 07 04.0	
SER1	15 13 13.9	–00 31 47.5	
SPKS 04	15 39 43.0	–33 56 54.0	No stars $5' \times 5'$
SPKS 05	16 02 43.0	–45 48 18.0	Few stars in $5' \times 5'$
SPKS 06	16 25 40.0	–25 09 48.0	Few stars in $5' \times 5'$
SPKS 12	16 49 42.0	–15 21 00.0	No stars.
SPKS 07	17 07 47.0	–40 34 06.0	
SPKS 08	17 31 06.0	–25 44 24.0	
SPKS 09	18 02 01.0	–04 32 36.0	
SPKS 10	19 00 48.0	–37 21 18.0	
SPKS 13	19 19 09.0	+12 22 05.0	
SPKS 14	21 26 54.4	–08 51 41.0	
2335-40	23 34 34.6	–39 49 04.0	
2345+007	23 45 45.9	+00 40 40.0	