The SAAO 1.9-m Telescope and Grating Spectrograph

Version 6.5

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DON'T PANIC!

Contents

Chapter 1

Introduction

The 1.9m telescope and Cassegrain spectrograph were, until recently, operated with the aid of a night assistant – for visitors, at least – but from late 2004 onwards, this has no longer been possible. This manual is an attempt to provide enough information for observers to operate the various sub-systems comprising the telescope and spectrograph without assistance (though new observers will hopefully continue to get "start-up" help) and was based partially (in places, substantially) on earlier manuals and notes by Tom Lloyd Evans, John Menzies and Tom Williams.

If you have any suggestions for improvements or additions to this manual, please send them to Hannah Worters (hannah@saao.ac.za), who is responsible for updates to this manual, which was written by the legendary Dave Kilkenny.

I will attempt to adhere to the conventions that any command to be entered at a "prompt" in an xterm will appear in **bold font**, whilst an operation achieved by clicking a panel in a GUI will appear in a [Box] like this. Inevitably this will go wrong – e.g. I will also use bold font for things I feel are important and should be hammered into you, but try to work with me here.

1.1 Overview

The main components are:

- The telescope and dome and their control systems.
- The spectrograph at Cassegrain focus with various gratings and settings (grating angle, slit width, etc.).
- The spectrograph data acquisition software on a Linux PC called "giraffe" running software initiated by the command **RunSpect** (see Chapter 6)
- A thin client called "ltsp.suth" connected to the server, onto which **RunSpect** dumps the CCD frames and which can be used for data reduction, etc.
- An acquisition/autoguider system (Telescope Control Software – TCS), with new XY slides and a Linux based PC, installed in May 2005.

This manual will attempt to deal with the various components in some detail and then give you a "walk through" getting started with daytime operations (focusing the spectrograph and getting "dome" flat fields) and observing procedures.

It is important that you read the manuals *CCD Spectrograph Control Program, version 1.12* **by John Menzies – also at** *www.saao.ac.za/science/observing/operating-manuals/1-9m-manuals* **and** *1.9m Telescope Control Software – A User's Guide* **by Steve Potter & Hannah Worters – also at** *www.saao.ac.za/science/observing/operating-manuals/1-9m-manuals* **– copies of these manuals are also available in the warm room and the library.**

Chapter 2

Telescope and Dome Operations

2.1 General layout and power switches

As you enter the 1.9m building, on the wall to your right are four switches. The two close together (labelled "Light Switch Main L.T. board" and "Light Switch D.B.5") should be switched on – these give you mains power (switching them off kills the lights, but not the power to certain vital components such as PCs). The other two switches give you incandescent and fluorescent lights in the entrance area and should be switched off if you are going to do (e.g.) flat fields or focus tests with the spectrograph.

To your left in the entrance area are toilet and new, improved kitchen facilities! If you can't sort these out on your own, don't attempt to operate the telescope. There are also storage rooms and an aluminising plant on the ground floor of the building, but you don't need these.

A set of steps leads up to the observing floor. There is a light switch at the bottom and also at the top of these steps – again, you need the stairwell lights off (and all observing floor lights off) if you are going to do tests on the spectrograph.

As you reach the top of the stairs, immediately facing you is one of the doors to the "warm room" where the various systems which operate the spectrograph and telescope are kept. To your left is the observing floor itself. As you look into the dome, the south pier and stairs that leads up to the internal "catwalk" are right in front of you. The north pier is across the dome from you. On the right (east) side of this is mounted the telescope control panel. To the left of the north pier is a small room where the spectrograph gratings and arc lamps are kept.

Following the accident in late 2006, the telescope is always on the east side of the polar axis and is normally parked on the meridian at declination –32°.

2.2 Lights

The stairwell lights have already been mentioned. There are three other lighting systems on the observing floor which might need to be switched off:

- dome incandescent lights – the switch for these is on the dome wall, to the west side of the north pier (just to the right of the “grating room” door).
- dome fluorescent lights just below catwalk level – these are switched on/off at the electrical panel behind the metal doors on the south west wall of the dome (near the stair railing) by two circuit breakers marked “Fluorescent Lights” on the middle row of circuit breakers behind the right-hand door.
- dome fluorescent lights on the inside of the dome itself – these can be operated from three different places:

  1. The control room, using the DOME dropdown menu on the TCS (see Section 5.2).
  2. The observing floor, using the panel on the North pier (Fig. 2.4). If the switch does not work the first time, press the “Request Control” button at the top of the panel and try again.
  3. The catwalk, using the control cabinet by the dome shutters (Fig. 2.5).

2.3 Telescope

2.3.1 Telescope power control

The original telescope isolator switch at the top of the stairs has been replaced by a three position switch (see figure below) that should be in the “PLC” position and left that way for normal operations, day and night. Observers should not use this switch unless authorised to do so by a technician. If the switch is not found in the “PLC” position, contact the electronics technician for guidance. Telescope power is now switched on/off at a new multifunctional control panel in the warm room, described in the following section.

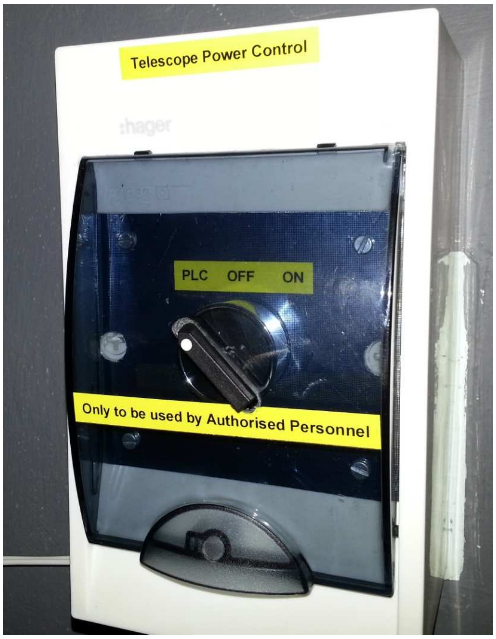


Figure 2.1: The new power switch at the top of the stairs. Ordinarily, it should be in the “PLC” position, day and night. Observers should not use this switch unless authorised by a technician.

2.3.2 The new warm room control panel

In April 2013, a new panel was installed in the warm room to control power to the telescope, slow motion drive and automatic dome rotation, and to indicate the status of a number of telescope subsystems (see figure below). Its functionality is described below.

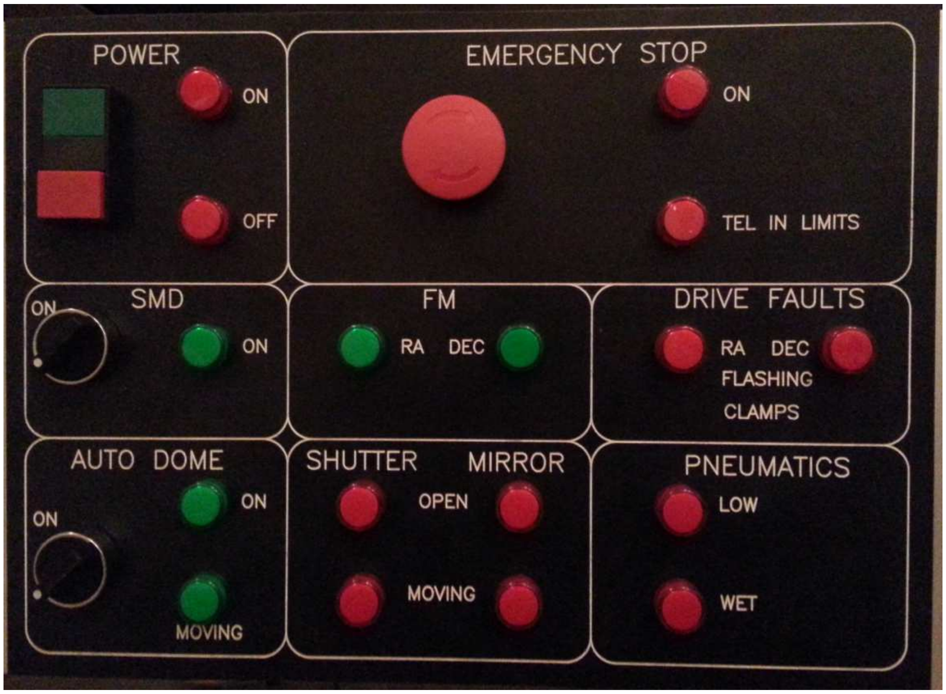


Figure 2.2: The new control panel installed in the warm room in April 2013. Power to the slow motion drive is controlled by turning the switch in the "SMD" section. When the drive power is on, the green light illuminates.

Telescope power

Large green "On" and red "Off" buttons are located in the top left section of the panel, with corresponding indicators that illuminate to show the current status. To operate, push and hold in for ~ 3 seconds. These buttons replace the power switch previously located at the top of the stairs.
There is a safety interlock preventing telescope power from being switched off unless:

- Dome shutter is CLOSED (both "SHUTTER" indicators are off)
- Mirror shutter is CLOSED (both "MIRROR" indicators are off)
- RA and Dec are set to SLOW (both "FM" indicators are off)

The power OFF indicator will flash if an attempt is made to power down the telescope while the above subsystems are not in a safe state.

Emergency Stop

Pressing the emergency stop button on the warm room panel or the grey box on the North pier stops all telescope motors (drive motors, focus motor) and dome motion. An indicator illuminates when an E-stop is pushed. Only the XY-slides and acquisition box mirrors will respond to motion commands while an E-stop button remains depressed. To resume operations, rotate the E-stop button slightly clockwise and it will jump back to the off position.

The "TEL IN LIMITS" indicator illuminates if the telescope tracks or is driven outside of the safe operating envelope. See Section 2.5 for the recovery procedure.

Slow motion drive

Power to the slow motion drive is now switched on and off in the "SMD" section of the new warm room control panel. The accompanying green indicator will illuminate when the drive is active. The drive should be switched on at the start of observations to enable RA tracking, and switched off when the telescope is not in use. This switch replaces that previously found on the floor-standing electronics rack in the warm room.

Fast motion indicators

The indicators in the "FM" section of the warm room control panel illuminate when the RA and/or Dec drives are in fast motion, i.e. unclamped for slewing. Telescope power cannot be switched off in this state.

Drive Fault indicators

If the indicators in the "Drive Fault" section of the warm room control panel flash, call for technical assistance as there will likely be a fault with the clutch/clamp systems.

Auto dome rotation

Auto dome rotation is switched on/off at the blue console on the North pier. The switch on the new warm room panel is not active, but the green indicators will illuminate when the dome is in auto mode ("ON"), or is rotating ("MOVING"). Auto dome rotation should be switched off when the telescope is not in use.

Shutter and Mirror Indicators

The lower central section of the warm room panel has "Open" and "Moving" indicators for the shutter and dome, that illuminate in such circumstances. Telescope power cannot be switched off while these indicators are on.

Pneumatics

The pneumatic indicators are not active yet; they will be activated once a forthcoming monitoring system for instrument air is installed.

2.3.3 Blue Telescope Control Console

The telescope is slewed using the blue console on the east side of the north pier. A photograph of the console is shown in the figure, and operation of this unit is fairly obvious:

- The central switches toggle the telescope motion between fast ("slewing" speed) and slow ("setting" and "guiding") speeds.

  You must always park the telescope (i.e. before you switch off the "Telescope Isolator" switch at the top of the stairs) with these two switches in the "slow" setting.

- This telescope is ~70 years old, so there's a lot of backlash and you might have to "blip" the buttons to get near to your desired RA and Dec. Note that Dec has two "fast" speed options – the inner buttons give a slower slewing speed. You will probably need to get within 20 or 30 seconds of time (in RA) and a few arcminutes (in Dec) before toggling to the "slow" speed motions.

- Both slow speed motions are also available on a handset in the warm room. For this reason, I always leave the slow motions on "set" on the blue console (the toggle switch between the two "focus" buttons) and do fine tuning of position using the handset in the warm room (where you can see the CCD field). It's not worth trying to set the co-ordinates too accurately at the telescope, as the telescope can only be pointed to about 15 or 20 arcsecond accuracy (at best) using the encoders.

Figure 2.3: Blue telescope control console (east side of north pier).

- Two buttons near the top right-hand corner of the panel give focus control (by moving the secondary mirror) but I can't think of a reason why you'd want to do it from there.
- Two buttons near the bottom right-hand corner of the panel give dome rotation control. In normal night-time use of the telescope, you'd toggle the "auto-dome" on here and forget about it. In day-time operation you will need manual control (e.g when doing dome flat fields you will need to position the flat screen manually).
- At the left-hand edge of the panel, there's an "RA fast motion speed control" knob. Note that **if you can't get the telescope to move in RA in fast mode, it could be that somebody has turned this down to the minimum setting.** I've been caught by this and have switched the whole system on and off a couple of times before realising what had happened. Best to check this before calling out a technician.
- In the bottom left-hand corner of the panel is a "panel lights dimmer". If you can't figure out what this is for, don't operate the telescope.

Above the blue console is a small VDU which shows the co-ordinates and other useful information (see figure). There are repeater screens inside the warm room.

Figure 2.4: Co-ordinate display VDU.

2.3.4 Telescope Control Software

New Telescope Control Software (TCS) and hardware were installed in May 2005; if you haven't used the telescope since then, this will be new to you and you should read the manual by Steve Potter & Hannah Worters available on the SAAO web page at:
www.saao.ac.za/science/observing/operating-manuals/1-9m-manuals
or from the home page by selecting the "Scientists" top menu, then from the left-hand menu clicking "Observing", "Operating Manuals", "1.9m Manuals" and selecting "TCS User Guide" from the list. A hard copy is also available in the warm room and in the Cape Town and Sutherland hostel libraries.

2.4 Dome

2.4.1 Dome shutters and wind blind

In December 2009, the dome shutters and wind blind were upgraded with new motors and drive electronics. The user now has the choice of operating the shutters and wind blind from the observing floor or via the TCS, so it should no longer be necessary to climb up to the catwalk during the night.

2.4.2 Dome shutter and wind blind control points

Note that the telescope power must be **on** in order to operate the shutters and wind blind. **Once the telescope is switched on there is a ∼60 second "lock-out" period before these subsystems can be operated from the observing floor or TCS** (this delay is to enable the drive systems to initialise and to allow the RF units to establish communications).

1. **The TCS**
   The dome shutters can be opened/closed and the wind blind raised/lowered from the control room by selecting the relevant option from the DOME dropdown menu on the TCS interface. The operation will continue until stopped by the user, i.e. after clicking "*Blind RAISE*", the blind will continue to rise until the the user selects "*Blind STOP*". The TCS also indicates the status of the shutters and wind blind. For more details on the TCS, see Chapter 5.

2. **Observing floor control panel**

   The observing floor control panel for the dome shutters and wind blind (Fig. 2.4) is located next to the blue telescope control console on the North pier.

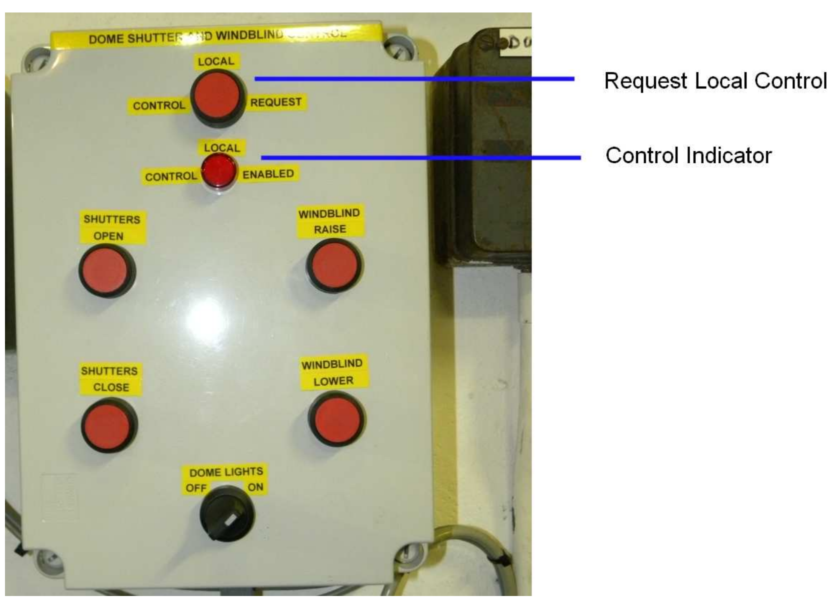


Figure 2.5: Shutters and Wind Blind control panel on the North pier.

To operate the blind and shutters from the observing floor, the user must first press the "Request Control" button at the top of the panel. This activates the panel and illuminates the "Control Enabled" indicator. After a minute has passed since the last button was pressed, the indicator light is extinguished but the panel will remain active. The light will reilluminate when another button is pushed.

Once the user has control, the appropriate buttons on the panel can be used to open or close the dome shutters and to raise or lower the wind blind. The shutter and blind will only move while the button is held in, and will stop automatically when the dome is fully open or closed and when the wind blind reaches the limit of its travel.

3. **Catwalk control cabinet**
   The control cabinet and drive electronics are located on the shutter and wind blind assembly on the dome itself (Fig. 2.5), accessible from the catwalk. During normal operation the user will not use this control point, and the "OVERRIDE" switch on the cabinet should be set to "REMOTE" to enable shutter and blind control from the TCS and observing floor.

Figure 2.6: Shutters and Wind Blind control cabinet on the catwalk.

4. **Manual override**
   In case all of the above control points fail, the dome can be closed manually. See Section 8.2.

2.4.3 Auto-dome

The automatic tracking of the dome (the dome following the telescope pointing direction) or "auto-dome" has been mentioned in the previous section. Unlike the previous control system, there is now only one switch – on the blue telescope control console (east side of the north pier). **Please switch this to MANUAL at the end of the night.**

You can check the position of the dome by looking at one of the telescope co-ordinate screens (see figure) or the TCS screen itself. The bottom line (or top right-hand corner on the TCS screen) indicates what the software thinks the azimuth of the telescope is ("REQD") and where the encoders think the dome is ("DOME"). These should be the same within two or three degrees (there's some leeway so that the dome is not making continuous tiny movements – and if you think this is trivial, try following a star going close to the zenith and have the dome moving for a few seconds every few seconds – it's quite an irritant).

If you go up to the catwalk inside the dome and especially if anyone is working on the catwalk outside the dome, "auto-dome" MUST be switched to MANUAL.

2.5 Telescope limits

Following the telescope crash in late 2006 and the subsequent re-fit of the declination drive, **software** limits have been imposed on the RA and Dec drives, indicated in the Figure. **The software limits do not prevent the telescope tube from hitting the dome shutters.** When slewing the telescope, be aware of the direction the dome shutters are facing; it may be necessary to allow the dome to "catch up" with the telescope before pointing to certain declinations.

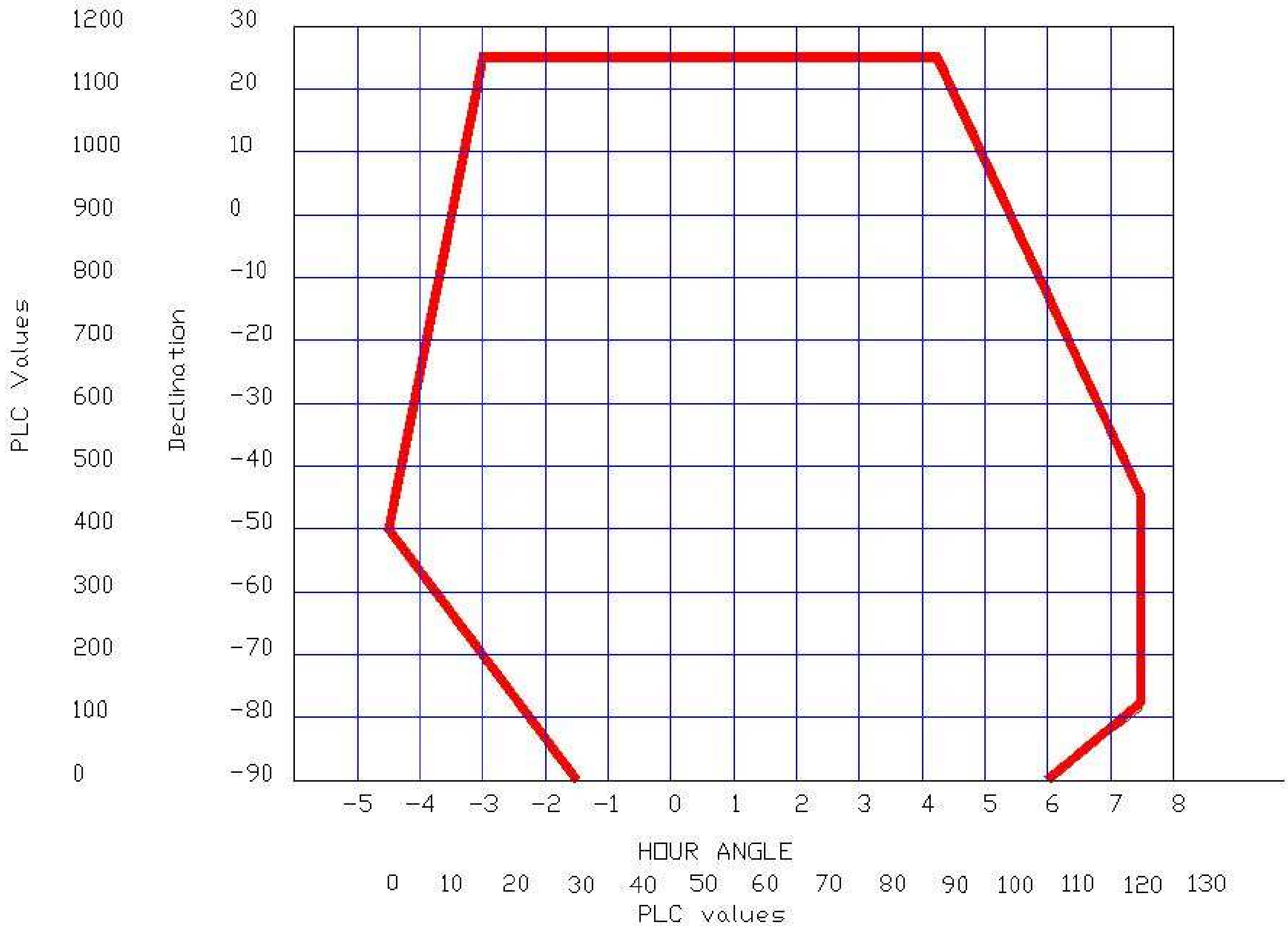


Figure 2.7: Telescope limits. The red line indicates where the telescope reaches software limits and stops.

Prior to the installation of the software limits, in the east, the telescope could hit the balcony rail and (∼ due east) the wind blind. In the south-east and south, the telescope tube could hit the south pier and the spectrograph could hit the north pier. In the west, it was possible to take the telescope dangerously far over.
Now, if the software limits are reached, an alarm will sound and the telescope drive motors will not work at all. In this case, it is necessary to go to the "Emergency Stop" box (next to the blue telescope control console on the north pier – see figure).
In the upper left-hand corner of the box, there is an override key. This must be turned about 45° clockwise, which will free the drive motors. The appropriate drive can then be used to return the telescope to within the software

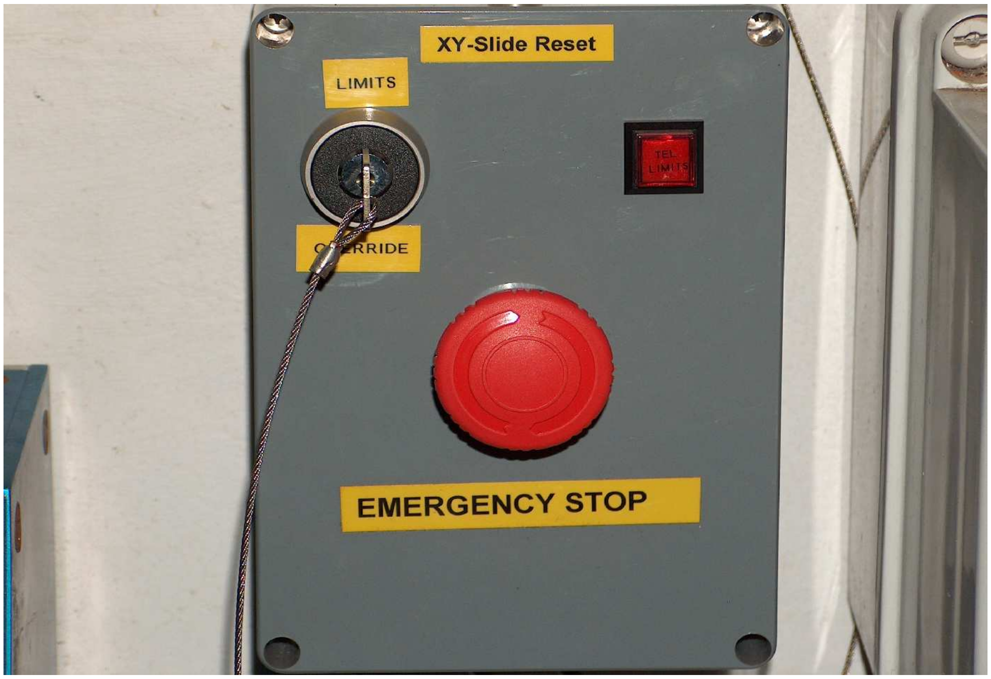


Figure 2.8: Limit override key.

limits where normal operation can be resumed and the override key released.

It is up to the observer to be extremely cautious when moving the telescope using the override key, as the telescope can clearly be crashed if moved the wrong way in this mode.

For more details on the new Declination drive system and the software limits, see the notes produced by Piet Fourie.

Tracking far west, a good rule of thumb is not to exceed 2 air masses (In any case, recall that at 2 air masses, the atmospheric dispersion will be spreading the “visible” image by an amount comparable to the spectrograph slit width).

Chapter 3

The Spectrograph

3.1 Optical layout

The simplified sketch indicates the internal layout of the spectrograph. Light from the telescope should be focused on the entrance slit. After the slit, the light is collimated on to the diffraction grating and the dispersed light is focused on to the detector – the CCD.

Just above the slit (and not shown) is a filter wheel containing neutral density and order-separation filters. Also not shown is the arc mirror which can be interposed just above the slit to reflect the calibration light (usually from a Cu-Ar lamp) on to the slit jaws. These and other details can be found in Chapter 4.

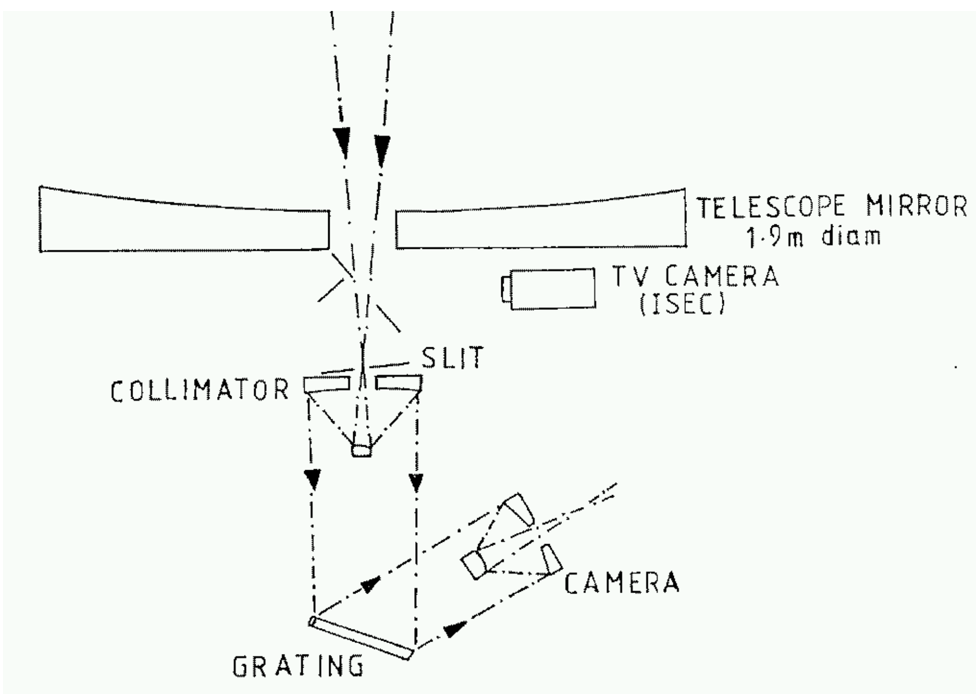


Figure 3.1: Sketch of the basic elements in the spectrograph. Note that a CCD now replaces the "TV Camera" on the xy slides.

3.2 Operations

If you stand near the south pier, with the telescope east of the polar axis, the side of the spectrograph facing you contains the “xy slides” for offset guiding and the knob for setting the grating angle. I shall refer to this side as the front (or south) side of the spectrograph. If the telescope is reversed - well, figure it out for yourself. There are several aspects of the spectrograph which the observer needs to consider, and these are discussed below.

3.2.1 Setting the grating angle

At the bottom of the front (south) side of the spectrograph is a small knob for setting the grating angle. This is simple in principle, but can be confusing because of the poor scales. I hope the attached notes will help, but ultimately **your check on the grating angle setting is the arc (or star) spectrum.**

Figure 3.2: Grating angle setting unit.

As can be seen in the figure, there are two graduated circles:

- The one nearest the body of the spectrograph is calibrated in degrees, but this is rather crude. When the grating is set to 0° (perpendicular to the collimated beam), the fiducial mark should appear to be slightly below the zero on the calibrated scale; if the scale appears to read slightly more than zero, you are probably set to +1°. (I usually start off the week by setting the grating angle to zero – best thing to do if you need to change gratings anyway – then count the turns of the setting knob to get the integer part of the angle correct).
- The fine scale is attached to the knurled knob that you use to set the grating angle. This scale is 1° per rotation. The scale is finely divided into 60 - so each fine division is one arcminute. These are grouped into

five divisions 0 - 1 - 2 - 3 - 4 - 0 of 12 arcminutes each, so that a setting of “2” on this scale is 24 arcminutes or 0.4°.

Thus, if you start at zero, turn the knurled knob around 5 full turns, then continue to the “3” setting, the grating angle is +5.6°. If you start from zero and turn it the other way two full turns and continue to “4”, you are at −2.2° or 357.8°

It’s a good idea always to set to the desired angle from the same direction and to set the angle carefully. This can be helpful with automated reduction programs.

In order to determine what grating angle you need, consult the graphs in section 9 of this manual.

3.2.2 Changing gratings

At the start of your week the diffraction grating will usually be inserted into the spectrograph for you, though you may need to change the grating during your run. At the bottom of the spectrograph is a small hatch which covers the grating (see figure). As mentioned previously, the gratings are kept in small protective wooden boxes in the room just to the west of the north pier. Gratings are stored in a locked box on the bench. Please contact Jaci Cloete or Francois van Wyk if you need access to a grating.

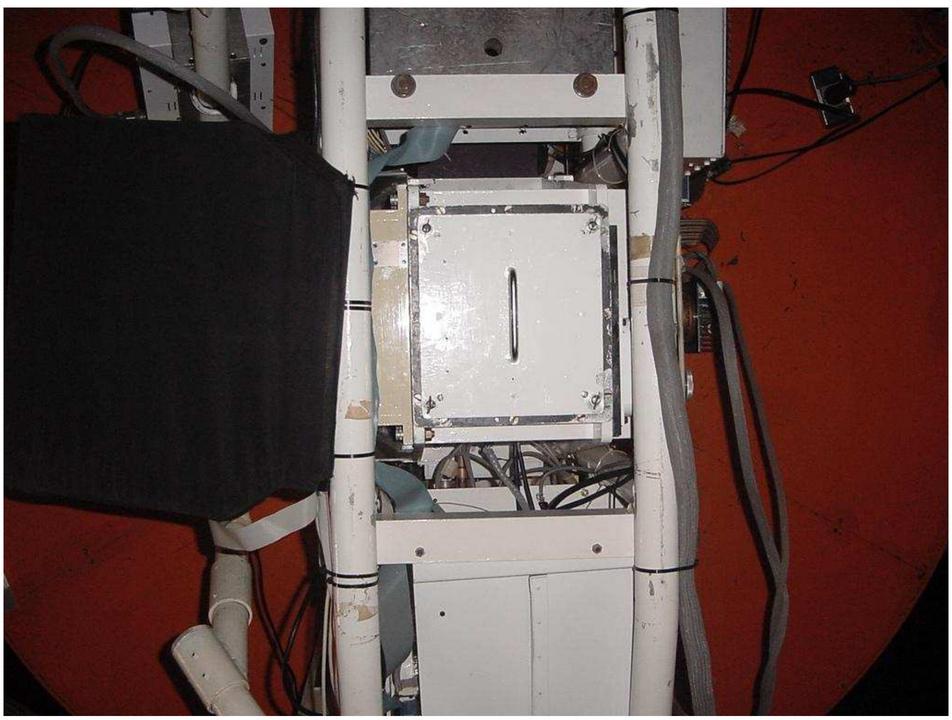


Figure 3.3: Bottom of the spectrograph; the grating cover is central.

I use the following procedure:

- Set the telescope to about -32°, on the meridian.
- Set the grating angle to 0° (see section 3.2.1).
- Position the rolling steps under the spectrograph so that you can access the grating hatch easily.
- Loosen the four bolts which secure the cover (a $\sim$ 90° turn anti-clockwise will free these but they remain in the cover) and remove the cover.

- The inside of the grating cover has a wire-covered container for dessicant. This should have been replaced during the instrument change and should look blue. If it doesn't, contact the duty technician. (This is not critical, you can continue with the change and get the dessicant replaced later).
- Remove the grating by loosening the three nuts attached to the grating housing (see figure) and withdraw the grating from the grating cavity.

Figure 3.4: Back of grating 6.

- Take the grating to the grating room, replace it in its box and find the grating you need.
- Insert the new grating into the grating cavity, ensuring the grating settles flat into the cavity. I usually do this by slightly tilting the grating relative to the retaining flange, entering the east side first and then straightening the grating so the west side clicks in. **It is vitally important to get the grating in correctly.**
- Holding the grating securely in place, tighten up the three retaining screws. (This is not always easy, as the grating handle can get in the way of one screw – worse for some gratings than others).
- Check the grating visually – that it looks in place correctly. I usually run my finger around the four sides of the grating back to check it feels in place – flat against the retaining flange.
- Replace the grating cover and check it is secure.
- Set the grating angle to the desired position (see previous subsection).
- Check the setting by exposing an arc and checking this against the arc plots (section 7.1). First, you might need to change the arc lamp, depending on the wavelength range covered (see section 3.2.4)

Note that you cannot rely on the spectrograph focus being the same for all gratings (see Chapter 9). If you change gratings, you should check the camera focus.

At all times, treat the gratings with care. NEVER touch the ruled surface of a grating.

3.2.3 Changing the arc lamp

On the west side of the spectrograph is the arc lamp unit (see figure). This was planned to contain two lamps (e.g. Cu-Ar and Cu-Ne) which could be used separately or together to give good arc spectra across the visible region. Due to some problems, this is not yet working and the usual (Cu-Ar) arc lamp has to be changed for certain spectral regions, specifically ∼6000 – 7000Å. When changing the arc lamp, ensure that the lamp you install has a current rating of 20 mA. Only two lamps are in current use; they are stored in small wooden boxes on the table in the grating room (though one will always be in the spectrograph). The recommendations for arc lamps and filters for different wavelength ranges are:

Colour	Wavelengths	Lamp	Filter	Comment
Blue	3600-6000Å	Cu/Ar	BG39	Order separation; scattered light suppression.
			or BG38	Grating 7 (use BG38 for grating 7; see comments under "Gratings")
Red	6000-7000Å	Cu/Ne	–	Shorter exposure
		Cu/Ar	–	
IR	7000-10000Å	Cu/Ar	–	Try Ne redwards of 8500A

Recommendations for arc lamps and filters to use with each grating are given at the end of Section 9.

Figure 3.5: West side of the spectrograph. The arc lamp unit is near top, centre. Just above the centre of the picture is the filter unit for the arc beam.

Figure 3.6: Close up of the arc lamp unit with the hatch folded down. The small retaining “gate” for the arc lamp and the lamp itself (with socket at the top) can be seen.

To change arc lamps:

- Locate the arc lamp housing – the black rectangular box on the west side of the spectrograph (see figure)
- loosen the screw at the top/front of the box and open the arc lamp cover.
- loosen the screw on the small “gate” which retains the arc lamp in position and open the gate.
- **Very** carefully ease the arc lamp out of the holder.
- carefully detach the lamp from its socket.
- Arc lamps are kept on the table in the same room as the gratings. Put the lamp in its wooden box and take the appropriate 20 mA replacement from the other box.
- Back at the telescope, carefully insert the replacement lamp into the socket. There is a specific orientation for this: ensure that the small notch on the lamp fits into the slot on the connector.

- Replace the lamp in the holder. This can be tricky; do not rush the operation and do not use force.
- Close the "gate" and tighten the screw. The lamp should be firmly held in its mounting but not crushed.
- Close the arc lamp cover and secure it with the screw.

Care must be taken when changing lamps; be especially careful of the cable and lamp socket. If possible, ask for the lamp change to be done by a technician in the daytime.

3.2.4 Arc beam filters

Filters for the arc beam were noted in the table in section 3.2.4; these filters are kept in a small wooden box on the table in the grating room. In the case of the blue spectral region, a BG39 filter should be in the beam, while the BG38 filter is used in the arc beam for grating 7 to reduce the strength of the far red lines. These filters are labelled on the mounts, but the BG38 filter is identifiable as it has a smaller area and is a paler blue than the BG39. The BG38 filter mounting is delicate and force must not be used to put it in place.

Filters are inserted in slots just below the arc lamp, with provision for a ND filter in the upper position and a colour filter below. A small flap has to be slid upwards to allow the filters to be inserted, then slid back down to help prevent light leak into the spectrograph. Note that:

The star beam filter wheels, operated from the warm room, do not affect the arc beam, nor do the arc filters affect the star/flat field beam.

The figure shows the Cu-Ar arc spectrum for grating 7, centred $\sim$ 5800Å (Range is $\sim$ 3800–7800 Å with blue at the right. The strong line near pixel 400 is 6965 Å. **Note the lack of lines between pixels $\sim$400–800 ($\sim$ 6000–7000Å) – hence the use of a CuNe arc around Hα.**
The reason for showing this plot is to note that if you use a BG39 filter instead of the BG38, you will find the strengths of the red lines substantially reduced. BG39 has a somewhat shorter wavelength red "cut-off" than BG38 and suppresses red light better between the blue part of the pass band and the infra-red "leak".

3.2.5 Topping up the liquid nitrogen (LN_2)

The LN_2 dewar is on the North side of the spectrograph (assuming a default instrument angle of 90°). A small white nylon ring on top of the dewar is the hole for re-filling the LN_2 (see figure).
To top up the dewar:

- Park the telescope near the zenith (Hour angle $\sim$ 0; Dec $\sim$ –32°).
- Put the rolling ladder at the north side of the instrument, close to the dewar.
- The big liquid nitrogen storage dewars are generally kept just to the east side of the north pier. (These are damned heavy when full and you might need to ask the technicians to decant some LN_2 into a smaller storage dewar). From the storage dewar, fill the small thermos flask and use this to top up the spectrograph dewar.
- Carefully pour the LN_2 from the thermos into the nylon ring on top of the dewar. If you pour too fast, the LN_2 will tend to splutter and you can be fooled into thinking the dewar is full when it isn't.
- With a steady pour, as the dewar gets near to full, you will hear a change in sound, like filling a bottle from a tap, shortly followed by a merry little splutter as the LN_2 reaches the bottom of the filler tube and starts to boil off. The dewar is full.
- Go to the giraffe PC and – assuming you have **RunSpect** up and running (see section 6) – click on [Temperature] and check the temperatures on the status panel (upper left-hand panel of main panel). The LN_2 ("Tank") and CCD ("Cu block") temperatures should read about 90K and 180K respectively.
- An A4-size check sheet is provided at the start of the week, please fill this in each time you refill the dewar.

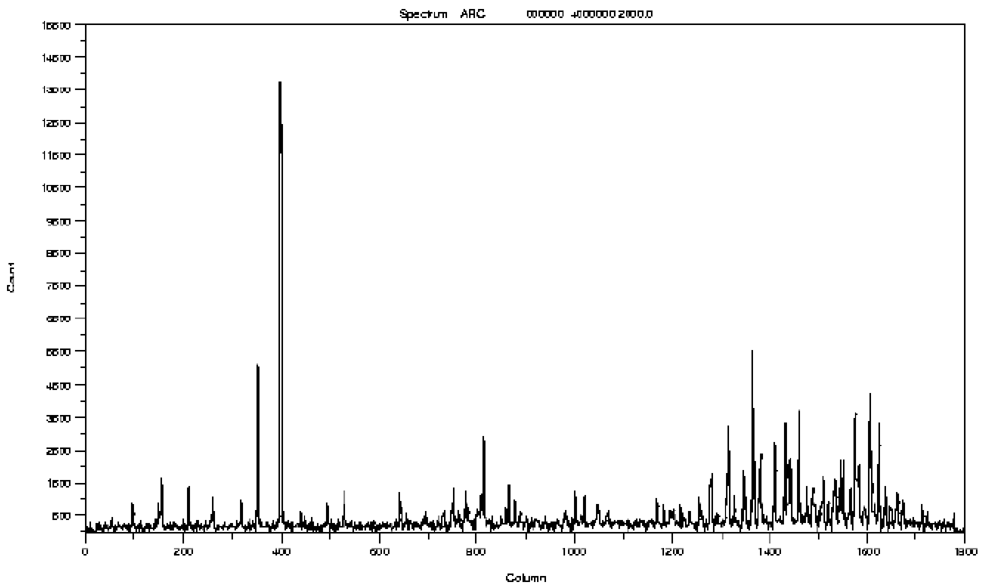


Figure 3.7: Grating 7 Cu-Ar arc (grating angle 17°; central wavelength ∼ 5900Å; BG38 filter).

Suggestions:

- The technicians will generally fill up the dewar in the morning (typically around 08:00). I usually fill the dewar *after* doing flat fields in the late afternoon. (This is because you need to tip the telescope a long way over to do flats and if you fill the dewar *before* that, some of the LN_2 pours out as you tip the telescope).
- For the same reason, if my first few objects are at (relatively) extreme zenith distances, I observe them, then top up the dewar.
- Some people also fill up in the middle of the night. This is not really necessary if the vacuum is in good shape, but is probably a good thing to do – especially if you have been moving the telescope around a lot.
- A typical late afternoon fill should take about one vacuum flask full of LN_2; maybe a little more. If it needs a lot more, you might be losing vacuum and should contact a technician.
- During the course of a week, the CCD temperature might drift up a bit. As long as this is only a degree or two, it shouldn't be a problem. If the CCD temperature starts to go up more quickly – first make sure the dewar is not empty (and re-fill it) – if it still goes up, you're probably losing vacuum and will need technical help.
- If the "Status" readout (on the spectrograph control program window, next to the temperatures) goes from "Normal" to "Hot", the dewar is empty and you could be in trouble.

  If you try to re-fill a dewar which has emptied, be EXTREMELY careful. I did this once, and when the LN_2 hit the bottom of the somewhat warmer dewar, a fountain of LN_2 showered

Figure 3.8: Dewar refill hole (white nylon ring)

over me. It was probably only a tiny amount of fluid/vapour and I wasn't harmed – but be warned.

If the CCD ("Cu block") temperature goes above 240K, do NOT attempt to re-fill the dewar; this will need to be pumped down again before re-filling.

Because we are having to modify our operating procedures somewhat, it it possible that the spectrograph might be on the 1.9m telescope for long periods. In this case, it is likely that the vacuum on the LN_2 dewar will start to deteriorate after some weeks of operation. The vacuum will need to be re-pumped and some observing time might be lost. This is undesirable but might be unavoidable. (As far as possible, we will try to use poor weather conditions for this process).

3.2.6 Instrument rotation

Following an upgrade in December 2009, it is now possible to rotate the instrument on the 1.9-m. The instrument angle is reported on the TCS and the software enables the usual acquisition and autoguiding procedure to be followed at any angle. Please note the following:

- You must **consult the technicians before rotating the instrument.** Currently none of the instruments is set up to be rotated without careful checking and removal of several cables and hoses to prevent damage.
- During normal operations with the instrument in the standard position, the instrument angle will be reported as 90° on the TCS (see Section 5.1). If you have not intentionally rotated the instrument and the TCS reports an instrument angle not equal to 90, the acquisition camera will not function correctly. Call a technician to remedy this.
- The maximum possible rotation is from about 10° East of the default position to 90° West of default. Limit switches will stop the rotation when it reaches the end of its travel.

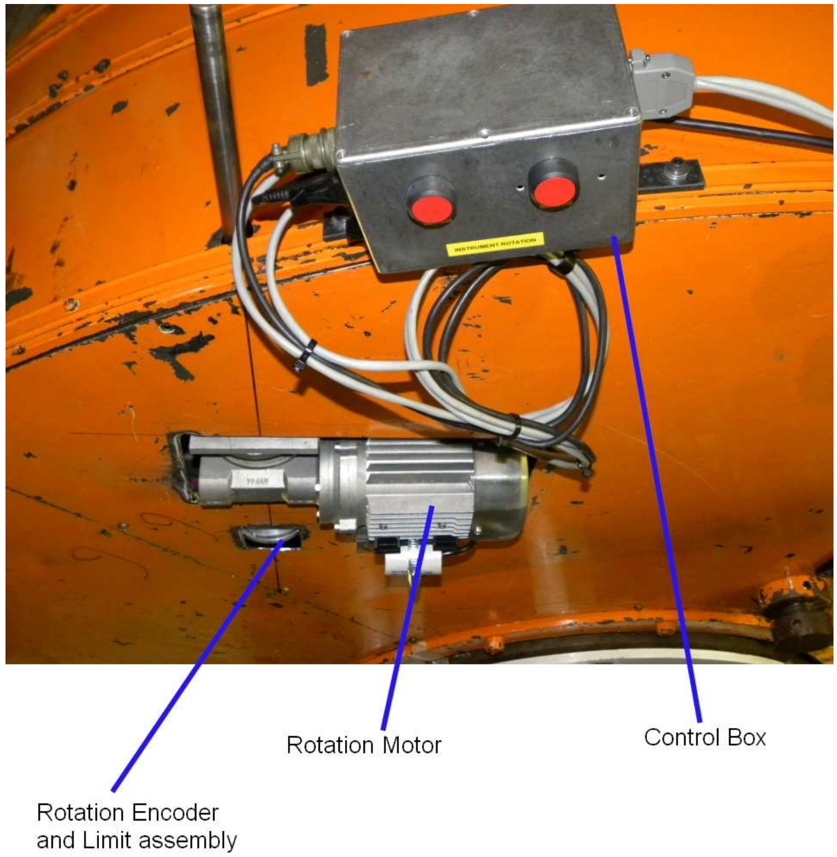


Figure 3.9: Instrument angle setting unit.

3.3 The Science CCD

The CCD in current use is a SITe1 1798 x 266 pixel chip. Some parameters:

- 1 second minimum exposure time.
- 40,000 counts/pixel is the linearity maximum.
- gain = 1.0
- Readout noise = 6.7 electrons.

3.4 Focussing the Acquisition/Guide CCD

See section 7.1

Chapter 4

The new spectrograph control panel

In July 2010, the spectrograph was upgraded to place certain operations under software control. The slit width and star beam filters are no longer adjusted manually, but are controlled by the instrument PC. The dekker was removed, and a single filter wheel replaces the previous two.
The old Spectrograph Control Panel (the rack on the desk in the warm room) has been replaced with an additional GUI that opens with the Spectrograph Control Program on the giraffe PC (**RunSpect** command). **Due to gremlins, this has been temporarily replaced with a LabView programme running on a separate Windows PC or laptop, located next to the monitor for the giraffe PC**.
The following operations are now performed from this program:

- Moving guide mirror in/out of beam
- Selecting filters in star beam
- Moving arc mirror in/out of arc beam and switching arc lamp on/off
- Adjusting slit width
- Opening/closing slit shutter and illuminating slit
- Moving rear view mirror in/out of beam
- Moving Hartmann shutters in/out of beam

The figure on the next page shows an updated representation of elements of the optical and mechanical system of the spectrograph as they are actually placed. It is very helpful to have the TCS running when you start to investigate the spectrograph features and functions, as a number of important things can be seen (e.g. the spectograph entrance slit). If you are not familiar with the TCS, it's worth checking that out first (see Chapter 5).

4.1 Starting up the control panel

1. On the Dell Windows laptop, double click on the "Spectrograph Upgrade 7, VISA" icon in the centre of the Desktop. A LabView GUI will open.
2. Click on the white arrow in the top left-hand corner. The arrow will turn black to show the program is running.
3. Select "ARSL1: INSTR" in the "VISA Resource Name" dropdown menu above the "SPECTROGRAPH UPGRADE" text.
4. The program is now ready to accept commands to operate the various spectrograph subsystems.

No username or password is required to log in to the Windows laptop.

4.2 Functions of the Spectrograph Control Panel

The following figure shows the LabView Spectrograph Control Panel GUI, entitled "Spectrograph Upgrade". Each element is explained below:

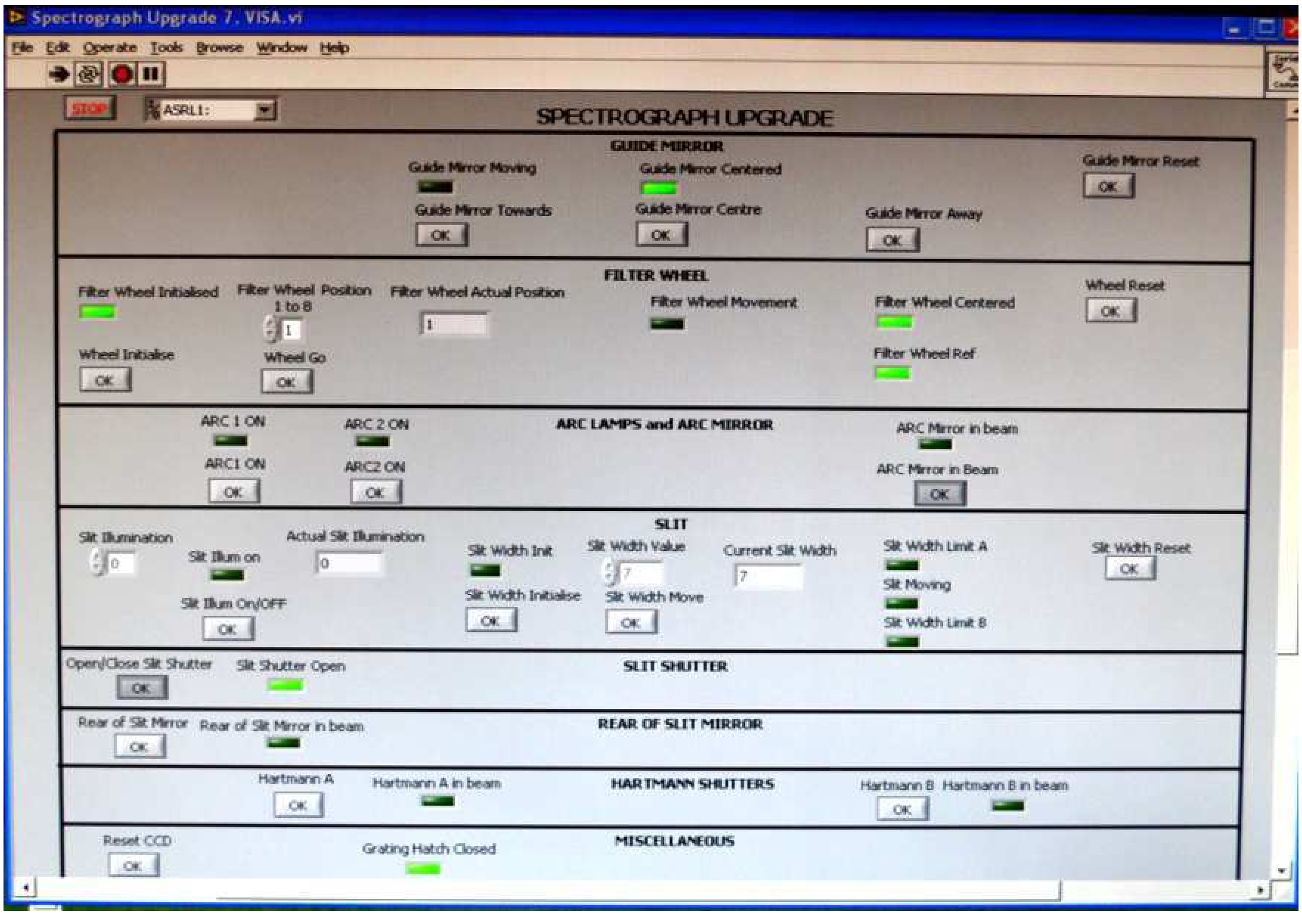


Figure 4.1: The LabView Spectrograph Control Panel GUI.

4.2.1 Guide Mirror

This is a plane mirror at 45° to the optical axis with a circular hole in it. When this hole is centred, the "Guide Mirror Centred" indicator will turn light green, and you should be able to see the spectrograph slit on the Acquisition/Guiding panel of the TCS (if you have the **slit illumination** on and the **slit shutter** closed – see below).

To move the mirror, click OK below the position you wish to move it to: towards, centre or away, i.e. to the centre or to either side. The "Guide Mirror Moving" indicator lights up in green while the mirror is in motion, and turns off when the mirror is in position. **After clicking OK to move the guide mirror "towards" or "away", the OK button will be greyed out. You must click the button a second time before issuing another guide mirror movement command.**

4.2.2 Filter wheel

The spectrograph contains a wheel containing filters for the star/flat field beam (**Note that these filters do NOT affect the arc beam**). The wheel has 8 positions, the first of which (the reference position) is empty.

Select the required filter number by clicking the up/down arrows or entering the number into the "Filter Wheel Position" box, then OK under "Wheel Go". As the wheel moves, the "Filter Wheel Movement" indicator will turn green, followed by the "Filter Wheel Centred" indicator when the selected filter is in the beam. **When changing filters, always click "Wheel Initialise" OK first and check that the the "Filter Wheel Ref" indicator illuminates, before selecting and and moving to the desired filter position.** If the reference indicator does not illuminate after sending the command to go to filter 1, or if the filter wheel does not respond ("Filter Wheel Movement" indicator does not turn green), click the "Wheel Reset" OK button.

A table of filters and their corresponding filter number is displayed above the TCS monitor. The most important are the "colour" filters (BG39 and GG495), necessary for order separation with some grating configurations. Neutral density filters are also mounted.

Remember to use the same filter(s) in your flat fields as you use for observing stars.

4.2.3 Arc lamps and Arc mirror

To take an arc lamp exposure, click on the "Arc Mirror in Beam" OK button, to move into the beam the mirror that reflects the beam from the arc lamp into the spectrograph. The button will turn grey while the mirror is in the beam, and must be clicked again to move the arc mirror out of the beam after the exposure. The arc lamp is switched on by clicking the "ARC2 ON" OK button, whose corresponding indicator will turn green. The same button is used to switch the lamp off.

Note that the spectrograph control software (i.e. the Runspect window on the giraffe PC) does not know the position of the arc mirror. If you run an arc exposure with this mirror out, you'll get nothing; if you observe a star with this mirror in, it blocks the starlight and you get nothing. So control of this is up to you!

4.2.4 Slit (width and illumination)

The slit width is set by entering a number between 0 and 28 into the appropriate box using the keyboard or arrow keys and clicking "Slit Width Move" OK. A green indicator labelled "Slit Moving" will light up to show the slit jaws are opening/closing, and one of two further indicators will light if you reach the limit of travel. If you get no response from the slit, click "Slit Width Initialise" OK. If this fails, click "Slit Width Reset" OK.

Each division of the scale corresponds to 25 μm, so a setting of "10" corresponds to a 250 μm wide slit. The scale at the slit is 1 arcsecond = 167 μm. A conversion table is given below and is displayed above the PCs in the warm room.

Clicking the up/down arrows labelled "Slit Illumination" sets the brightness of a lamp to illuminate the slit. Click "Slit Illum On/Off" OK to switch the lamp on or off. **The slit shutter must be closed for this to work** (see next subsection). Slit illumination is useful for focussing the acquisition camera and determining the position of the slit on the acquisition image. When the lamp is on, the "Slit Illum on" indicator turns green.

4.2.5 Slit shutter

The "Open/Close Slit Shutter" OK button operates a safety shutter directly behind the slit that prevents light from reaching the science CCD. It is a good idea to close this at the end of the night, but it's not critical.

4.2.6 Rear of slit mirror

This can be used for "knife–edge" focussing of the telescope (getting a star in focus at the slit; see later), and is moved using the "Rear of Slit Mirror" OK button. **For all modes (obtaining star, arc or flat exposures) make sure it's out of the beam.**

Slit number	Slit width (arcsec)	Slit width (μm)
1	0.15	25
2	0.30	50
3	0.45	75
4	0.60	100
5	0.75	125
6	0.90	150
7	1.05	175
8	1.20	200
9	1.35	225
10	1.50	250
11	1.65	275
12	1.80	300
13	1.95	325
14	2.10	350
15	2.25	375
16	2.40	400
17	2.54	425
18	2.69	450
19	2.84	475
20	2.99	500
21	3.14	525
22	3.29	550
23	3.44	575
24	3.59	600
25	3.74	625
26	3.89	650
27	4.04	675
28	4.19	700

4.2.7 Hartmann shutters

Used in turn, these cover approximately one half of the collimated beam and then the other half, enabling a focus test of the spectrograph camera to be carried out (see section 7.2.1). Each shutter is moved into the beam using the respective “Hartmann A” or “Hartmann B” [OK] button. Green indicators light when each shutter is in the beam.

4.2.8 Miscellaneous

A green light should indicate **Grating Hatch Closed** at all times (except when changing gratings). If it does not, check that the cover is secured over the grating cell.

4.2.9 Grating angle

The motorised grating angle adjustment has been disabled. Please see Section 3.2 for instructions on how to adjust the grating angle manually.

4.2.10 Camera shutter

The camera shutter has not been automated. You can ignore this section of the software. There is a manually-operated camera shutter below the micrometer clamps on the back of the spectrograph (see figure 7.4). Usually the camera shutter is left open, but if you can’t get any light to the detector, and all else on the panel seems OK, check this.

4.3 Observing check lists

The following are check lists for different observing configurations. A quick look at the green indicators on the Spectrograph Control Panel window will ensure that your setup is correct:

When observing a star (or flat field):

- Guide Mirror and Filter Wheel must be **centred**
- Arc Mirror must be **out**
- Arc Lamp and Slit Illumination must be **off -** i.e. there should be no yellow indicators
- Slit Shutter must be **open**
- Rear Slit Mirror and Hartmann Shutters A & B must be **out**
- Grate Hatch must be **closed**

When taking an arc:

- Guide Mirror can be **in or out** because the arc mirror is below it
- Arc Mirror must be **in**
- Arc Lamp must be **on** (yellow light on)
- Slit Shutter must be **open**
- Rear Slit mirror and Hartmann Shutters A & B must be **out**
- Slit Illumination must be **off**
- Grate Hatch must be **closed**

Chapter 5

The acquisition and offset autoguiding system (Telescope Control Software)

This is now a Linux-based system which should be up and running when you arrive in the dome. If not, check the TCS manual for the procedure. The screen should look something like:

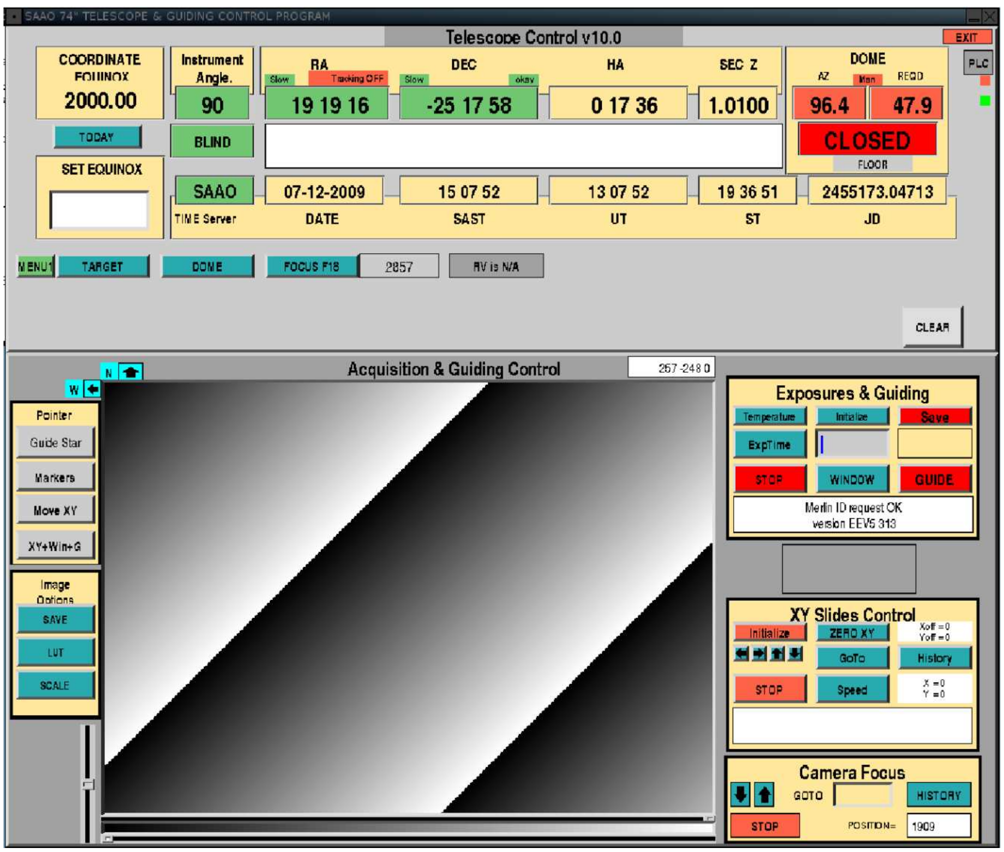


Figure 5.1: The telescope Control System user interface.

This is not intended to be a comprehensive description of TCS, just sufficient notes that you can carry out some basic tasks. (See *1.9-m Telescope Control Software – A User's Guide* **by Steve Potter)**

There are a number of important points:

- In general, **do not re-boot the PC or exit the TCS program.**
- **Do not use the TCS PC for any other operations**. (Software; e-mail; etc.)
- If the TCS locks, move the cursor to the left of the screen and right-click on the background. Select the "START TCS74" option, which will kill the existing session and restart the TCS.
- If the mouse pointer disappears, it's probably gone off the right-hand edge of the screen on to the RA/Dec monitor. Bring it back. (If you can't find it at all, a PC restart might be needed).

5.1 Telescope status display

The top part of the TCS screen reports time, pointing and subsystem status information:

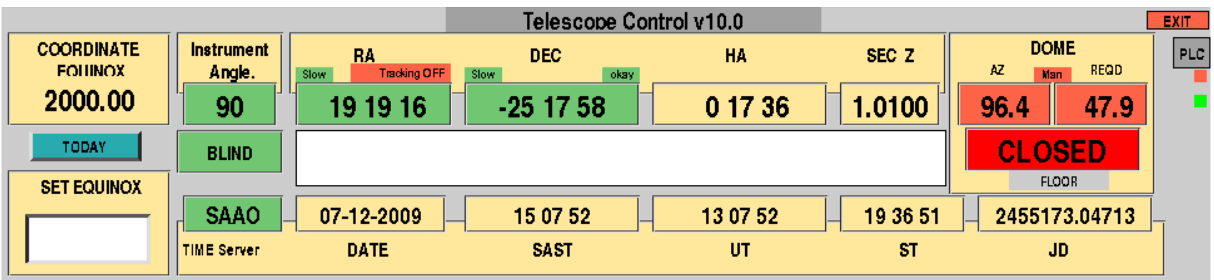


Figure 5.2: Telescope and dome status information is given in the top portion of the TCS software display.

In normal operation, the RA, Dec and dome boxes are green; the RA and Dec boxes turn red when the telescope is unclamped (in "fast" mode) and the dome boxes are red when dome rotation is in manual mode. Most boxes are blank when the telescope power is off. One thing that can be altered here is the equinox of the coordinate display on the left-hand side, but note that:

To implement an equinox typed in the "Set Equinox" box, you need to press the Enter key on the TCS PC keyboard.

Just to the right of the coordinate display is a box reporting the **Instrument Angle**. The default here is 90. The instrument angle cannot be changed from the TCS, but must be controlled at the telescope with technical assistance. The **BLIND** box below the Instrument Angle indicator shows the status of the wind blind: red indicates movement and green means it is stationary.

The **DOME** section on the right-hand side reports the following (from top to bottom):

- A status flag indicating whether dome rotation is Manual (red) or Automatic (green)
- The current azimuth of the dome shutters and the azimuth required for the telescope to point out of the open shutter. These are green during normal operation, but turn red when the difference between the two is more than a few degrees.
- The status of the dome, whether OPEN (green), CLOSED (red), PART OPEN (red) or MOVING (red), i.e. opening or closing.
- The status of the primary mirror covers, whether OPEN (green), CLOSED (red) or MOVING (red), i.e. opening or closing.

- A status flag indicating whether control of the dome shutters and wind blind is LOCAL (cyan), i.e. can be operated via the TCS software, or FLOOR (grey), which means the panel by the North pier on the observing floor has control. Local (TCS) control can be gained using the dropdown DOME menu (see next section).

5.2 Operations panels – MENU 1

Immediately below the time/position panel are two sets of operations controls. If the 'MENU 1' set is showing, clicking on the 'MENU 1' button brings up the 'MENU 2' set, and vice versa. For full details, see the TCS manual.

Note the following:

- The rear view mirror always displays RV is N/A when the spectrograph is mounted.
- After selecting one of the buttons in the 'MENU 1' panel (e.g. TARGET), you must press CLEAR before you can select another (e.g. FOCUS).

Figure 5.3: The Telescope Control Software – Operations Panel 'MENU 1'

5.2.1 The TARGET button

Clicking on the TARGET button will bring up boxes in which to enter the RA and Dec of your star. At present, the sole purpose of this is to display the coordinates on the repeater monitors in the control room and dome, to assist the observer in slewing to the target (but watch this space...).

5.2.2 The DOME dropdown menu

The dome, primary mirror covers, wind blind and the top ring of fluorescent lights in the dome can be operated from the TCS by clicking on the DOME button and selecting the appropriate option from the dropdown menu. The telescope power must be switched **on**. There is a 30–40 second delay between switching on the telescope power and these functions being enabled on the TCS. If at first it fails, wait and try again.
If the dome status flag is grey and indicates that the observing FLOOR panel has control, select "*Request Control*" in the DOME menu. Once the dome status flag turns cyan and indicates LOCAL control, the other functions in the DOME menu can be used.
On requesting movement of the dome or wind blind, the movement will continue unless stopped by the user, i.e. after clicking "*Blind RAISE*", the blind will continue to rise until the the user selects "*Blind STOP*". In the same way, one click on "*Shutter OPEN*" will open the dome fully, unless "*Shutter STOP* is selected part way. The dome shutters will stop moving automatically when they are fully open or closed, as will the mirror covers. Similarly, when the wind blind reaches its upper or lower limit, it will also come to a stop.

5.2.3 The FOCUS button

The telescope focus can be changed by clicking on FOCUS, entering a new value and clicking GO. However, with the spectrograph it will probably be easier to focus (eg. a star on the slit) by using the focus buttons on the handset. In this case, the changing focus position will be displayed next to the FOCUS button. Note that F18 is selected for the spectrograph.

Figure 5.4: The Telescope Control Software – Parameter Panel 'MENU 2'

5.3 Operations panels – MENU 2

In the 'MENU 2' Panel:

- Click on the POINTING box and ensure the pointing corrections are ON.
- Clicking the DRIVE SPEEDS box enables you to change the set and guide speeds. The defaults for these are not as shown, they are now 30.0 for "set" and 3.0 for "guide", which seem to be quite convenient in practice.

Figure 5.5: The Telescope Control Software – Parameter Panel 'MENU 2'

The "Track" speed should, of course, be left at or near the default value.

- ZERO POINTS is most usually used in the "Enter RA and Dec of a star" mode. After pointing the telescope at a bright (or at least identifiable) star and centering the star in the field, you can type in the actual RA and Dec and the system will compute the zero points of the co-ordinate system. If you make a note of these, they can be entered using the "Enter zeros directly" mode if there should be (e.g.) a PC crash.

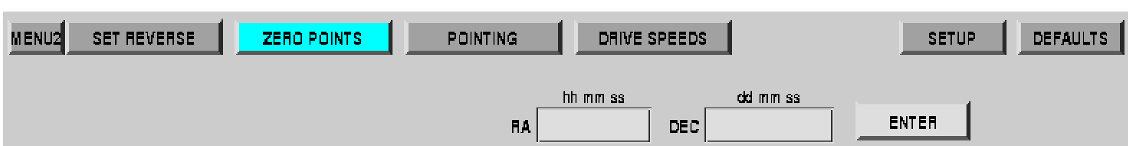


Figure 5.6: The Telescope Control Software – Parameter Panel 'MENU 2'

There are many other commands, specifically important ones are related to setting up for offset guiding – these I shall attempt to cover in section 7.3 (because you need a star field to try them out).

5.4 Some things to test at the start of the week

If you are new to the equipment, a few things might help you get some better idea of what is going on:

- In the LabView "Spectrograph Upgrade" Control Panel GUI, centre the guide mirror, close the slit shutter and turn up the slit illumination a couple of digits. On the A/G screen, you should be able to see the slit running horizontally across the whole screen. If you can't see anything, try increasing the slit illumination or the A/G CCD integration time.
- Move the guide mirror in and out, so you can see what effect that has.
- With the guide mirror centred, press the arc mirror button. You will see a part of the slit obscured by the arc mirror.
- At the A/G keyboard, experiment with the CCD exposure time.
- When you tire of the above, make sure the slit is clear, the guide mirror is centred and the arc mirror out of the beam (then you are ready to do flat fields, for example).

5.5 Aquisition camera crashes

If the A/G camera crashes (the guide star frame is clearly not being updated) but the TCS software **is** still running, then the Initialise button in the Exposures & Guiding panel allows a "hard reset" and re-boot of the Merlin crate (see the TCS manual for more details), but the telescope power has to be on for this to work (which it will be – at night). If this does not work, you might have to go to the Merlin crate itself and re-start it using the red button on the crate. Note that there are two crates, one on the front of the spectrograph that you need to reset the A/G CCD and one at the back (by the dewar) for the science CCD.
The "hard reset" is equivalent to pressing the red button on the Merlin crate and the re-boot uploads some software to the camera.

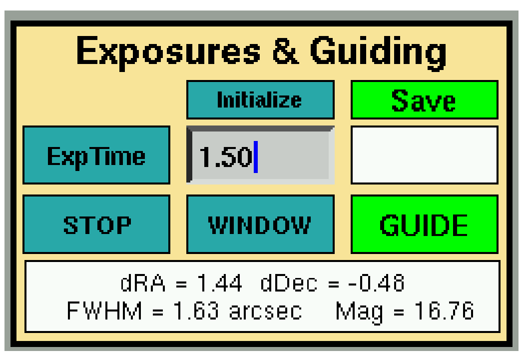


Figure 5.7: The Exposures & Guiding panel of the TCS. Initialise allows resetting of the Merlin crate.

Chapter 6

Data acquisition and storage PCs

6.1 The "giraffe" PC

Username: spect
Password: consult support astronomer or technician

A daft name for a PC, especially since no one can remember what the acronym stands for, but there you go. Normally, this PC (and the others) will be up and running because, as far as possible, the technicians check everything is working after an instrument change. However, it is useful to operate the data acquisition program (**RunSpect**) from within your own directory – and you need to start off with the right run number. So, using the mouse, click on the Quit button in the bottom right-hand corner (see figure) which will take you back to an xterm window.

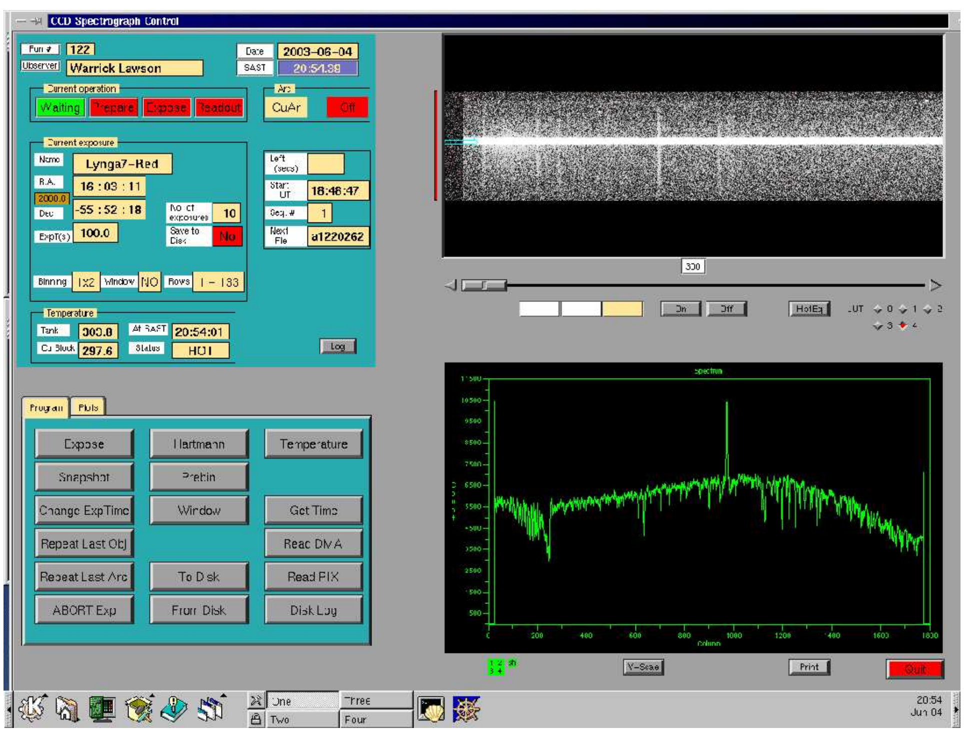


Figure 6.1: The spectrograph control program – Main Panel

Note that this section is not intended to be a comprehensive description of the spectrograph control program; for this, you should see the manual *CCD Spectrograph Control Program* **by John Menzies.**

Enter the following:

mkdir name – where **name** is the name you want to call your directory (eg. xyz, fred, your intials, whatever).

cd name – to get into that directory.

RunSpect – to run the spectrograph program.

The advantage of starting RunSpect from within your own directory is that it will store the following files there (and they generally persist to your next run):

- disk_log_nnn – where nnn is your current run number – a log of your observations. I find this occasionally useful when I lose track of where I am (!)
- setup_data.dat – which keeps track of you, your run number and last file number – useful if you have to re-start RunSpect. Finally, and perhaps most usefully,
- objects.dat – a list of your target co-ordinates. This file is updated as you observe and means you don't have to re-enter co-ordinates after the first time.

The first result of entering RunSpect is:

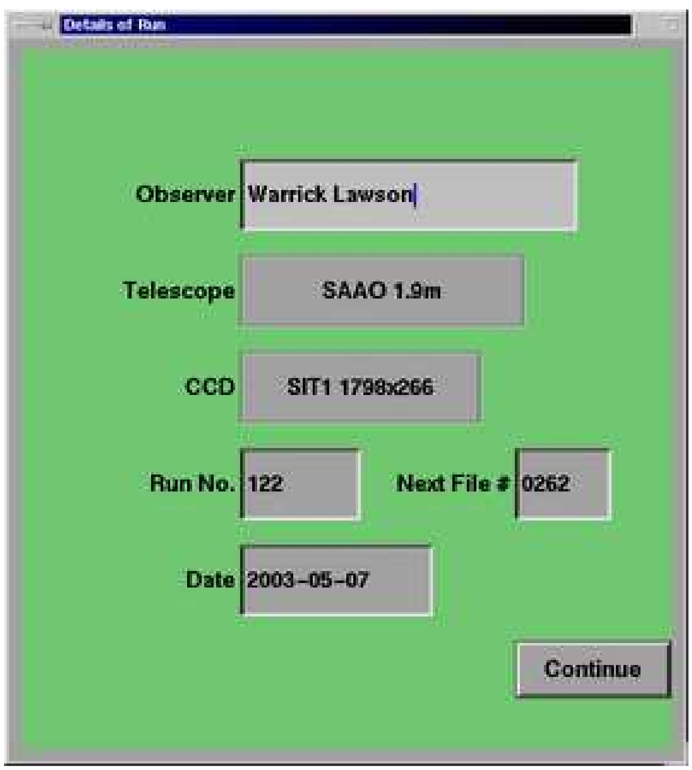


Figure 6.2: The spectrograph control program – Start up Panel

– the start up panel – a box asking for your name and run number. You get the run number by looking in the CCD and Unit Spectrograph log book. Add one to the run number of the last user (!). The "next file" box should be one, IF this is the start of your run **otherwise it should be the last file you obtained plus one**. The basic information in this box is remembered in the set-up file and, providing you restart from within your own directory, you won't need to enter things in subsequent logins.

Images that are saved will have names composed of the three digit run number appended to an "a", followed by an incremented four digit image number. Thus the twenty first image saved in run 299 will be named a2990021.fits.

In the event of a program crash – or a restart for any reason – it's VITAL to check that the run number AND the file number are correct, otherwise you could overwrite existing data.

If you now click on Continue, you should get to the RunSpect Main panel shown at the start of this section. You can now use this to obtain and store CCD spectra.

You will get a reminder about prebinning – that's because it's easy to forget after a re-start – but you can switch prebinning on/off at almost any time (not while exposing).

Again, I emphasise that this section is not intended to be a comprehensive description of the spectrograph control program; for this, you should see the manual *CCD Spectrograph Control Program* by John Menzies. But since I want to describe using the spectrograph to obtain arcs, flat fields and spectra, I feel it necessary to include some notes on **RunSpect**, including the very nice figures plagiarised from John's manual.

6.1.1 The status panel

The upper left-hand area of the main panel gives various status signals:

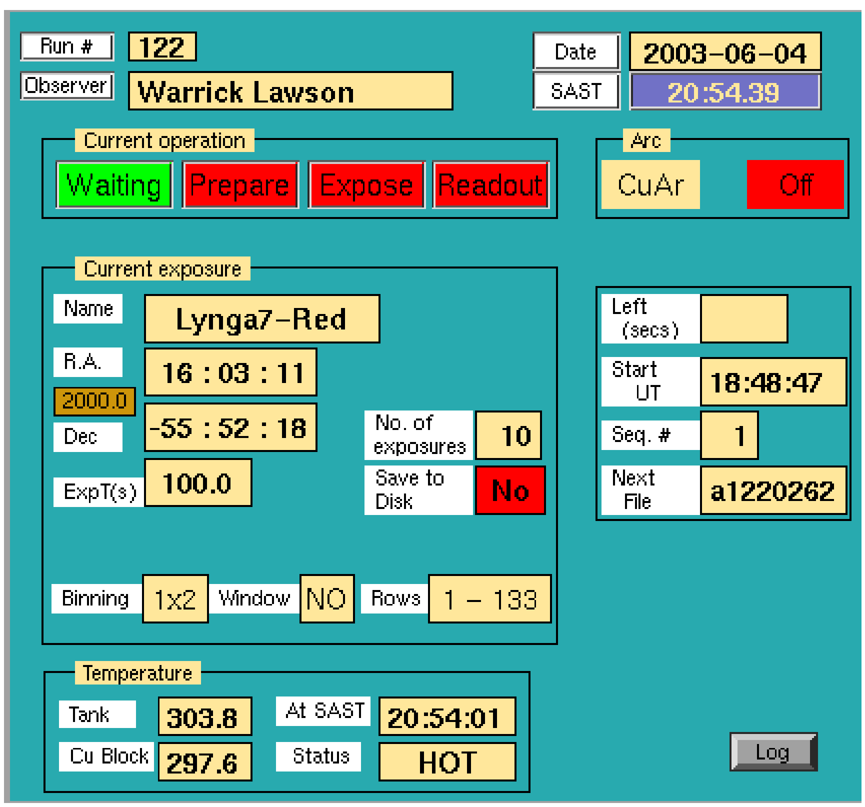


Figure 6.3: The spectrograph control program – Status Panel

All are useful and more-or-less self-explanatory, but note particularly:

- The four "Current operation" panels – if "Prepare" and "Readout" are green for more than a few seconds, the program (or Merlin crate) has probably crashed. If “Expose” is green, you should be able to see “Left (secs)” counting down. If “Readout” is green, you should be able to see the CCD reading out on the upper right-hand area of the main panel.

- Check “Save to Disk” is “Yes” or “No” (whichever you need).
- It is a good idea to check the CCD and LN_2 temperatures occasionally (and see section 3.2.6)
- I frequently check the file number (last four digits of “Next file”) as I’m good at making mistakes. (You can also bring up another xterm window and check the file disk_log_nnn in your directory).

6.1.2 The control panel

The lower left-hand area of the main panel is actually two panels (click on Plots to see the other – which allows you to manipulate the lower right-hand display panel).

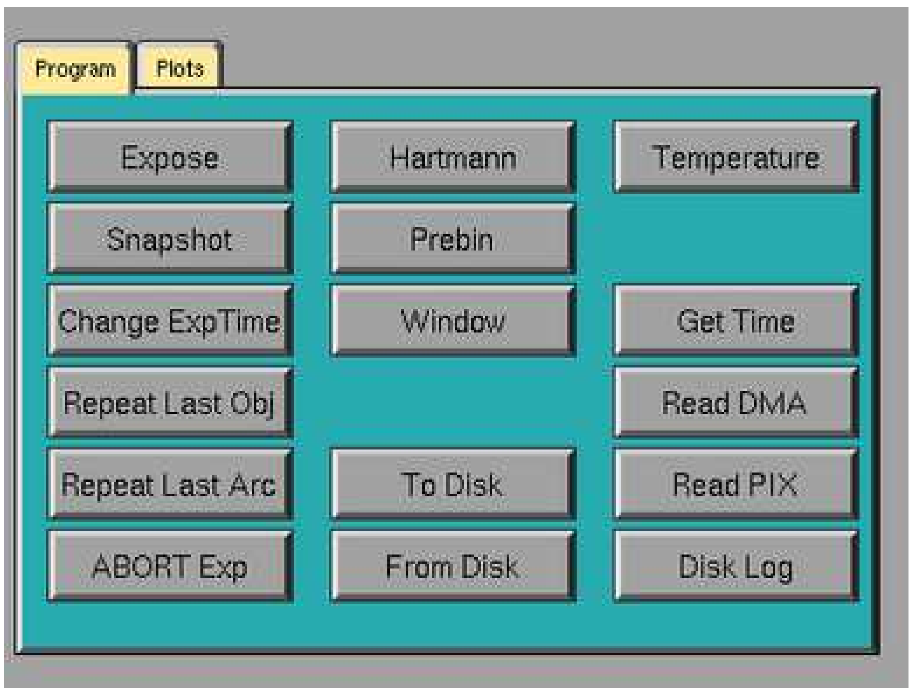


Figure 6.4: The spectrograph control program – Control Panel

The Program panel allows you to carry out the basic data gathering operations; I refer to only a few crucial ones (for more details, see the Menzies manual):

Hartmann – enables you to carry out focus tests on the spectrograph camera. (See section 7.2.1).

Prebin – early in the proceedings, you will need to decide whether or not to “prebin”. Prebinning reduces the number of pixels read out and, since each pixel picks up electronic “readout noise”, reducing the number of effective pixels reduces this noise. The only prebinning available is 1 x 2 prebinning – where the rows are added in pairs. Effectively, this halves the resolution perpendicular to the dispersion but should not affect resolution along the dispersion. So, if you are observing point sources (e.g. stars) there is no reason not to prebin. If you are observing extended objects, you have to balance readout noise against resolution and only you can decide what you want ....

Change Exp Time – in principle this allows you to change the length of the exposure during integration (within limits - obviously you can't make the exposure time less than the time already elapsed !). **In practice, this function quite often crashes the PC – it locks solid and will not respond at all**. Sometimes you might have to use this button (e.g. if you enter 10000 seconds instead of 1000) but I'd avoid it if you can.

Expose – the fundamental command we need to actually get data. Clicking on this brings up the Exposure panel:

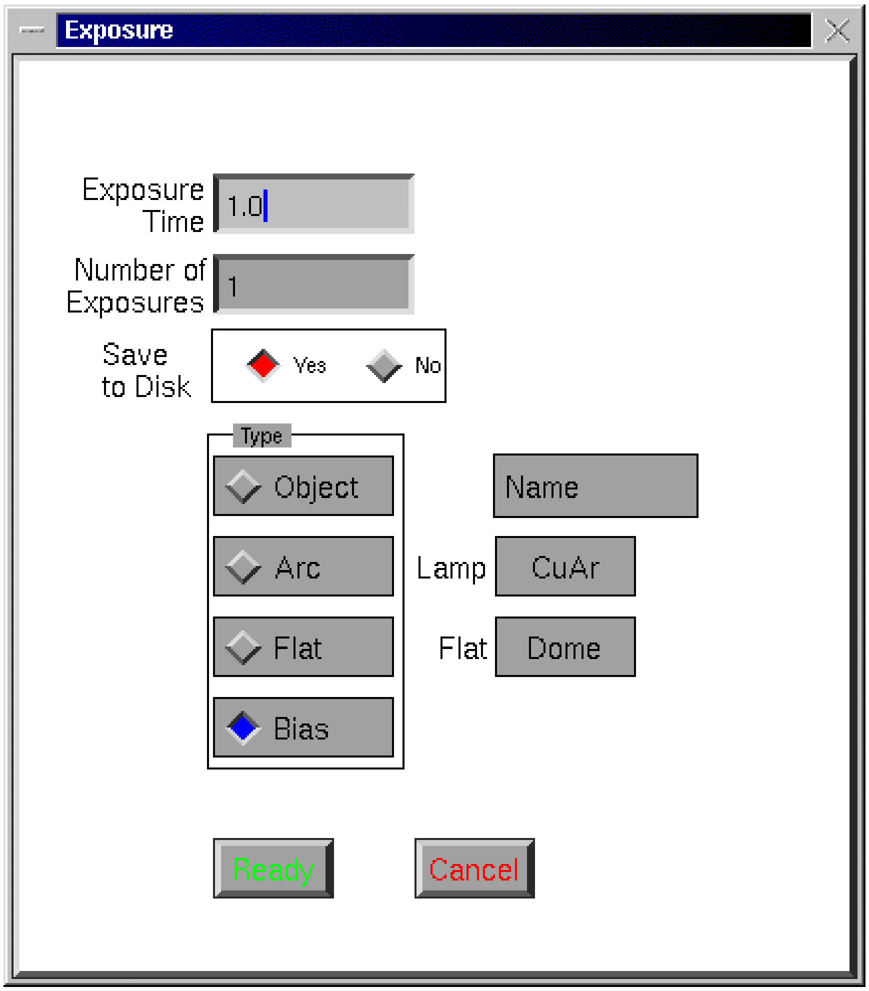


Figure 6.5: The spectrograph control program – Exposure Panel

Important things to note here:

- If the "Number of exposures" is more than 1, the program will continue until these are all done. ABORT Exp in the Program area (Control panel) **should** get you out of this.
- If you forget to say Yes to "Save to Disk" you can fix this at the end of the exposure using To Disk in the Program area. But if the next exposure reads out, you've lost the previous one (so if you are running several exposures sequentially ("Number of Exposures" is > 1, none will be saved).

- Click on [Object], [Arc], ... as appropriate. If the system does not recognise the name, you will have to fill in the details in the "Object choice" box which will appear (see figure). Be careful to copy the format exactly (e.g. a RA of 12^h 34^m 56^s is entered as 123456. You can edit this box directly. **After typing in a name and co-ordinates, click [Add] or [Insert] (see figure) to add the object to objects.dat** then, if you enter the same name again, it should be remembered.

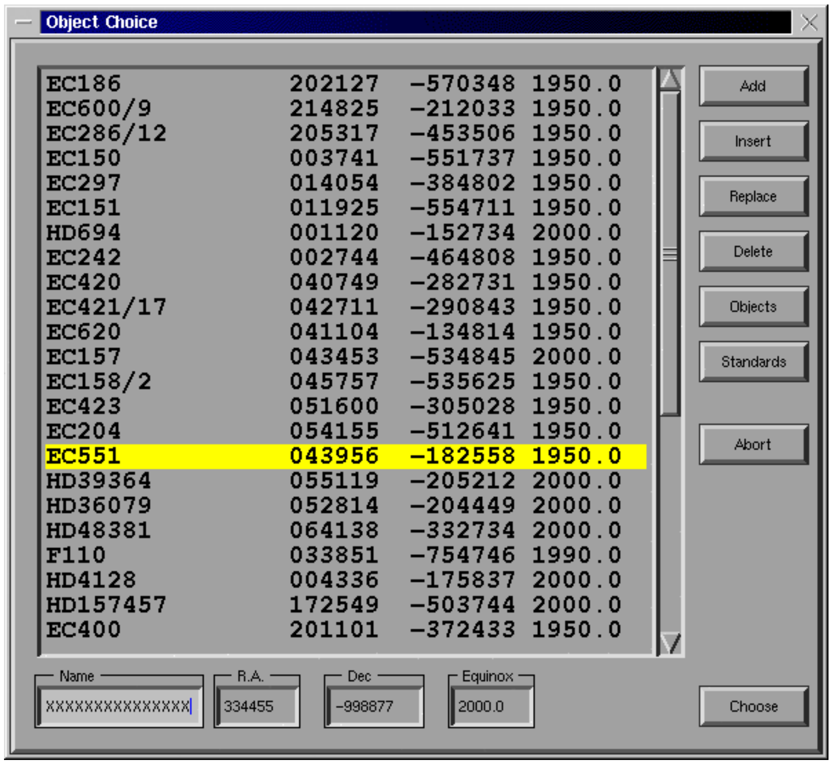


Figure 6.6: Object names and co-ordinates (stored in objects.dat).

- Clicking on [Flat] gives you options – [Dome], [Sky]
- If you try to take **Bias frames**, the system will not work with an exposure time of 0 seconds. But if you tell it (say) 1 second, a bias frame will be produced with zero exposure.
- Most importantly, **whatever arc lamp you are using, make sure you select [CuAr]**. This is because CuAr and CuNe refer to the electronics intended to operate the two types of arc lamp. Currently, only the CuAr system works, so if you change the CuAr lamp for a CuNe lamp, you still need to run the CuAr circuit. Trying to run CuNe will have no effect. Sorry.

You should now be in a position to carry out simple data gathering with the spectrograph.

6.2 The thin client: ltsp PC

Username: ccd74
Password: consult label on monitor

The thin client (ltsp.suth) acts as a data store as far as the spectrograph system is concerned – this is a left-over from the days when a Sun workstation with very little storage space controlled data acquisition. (You can also do reductions here, for example, and you can use it for your e-mailing and other trivia). It also runs the guiders software for identifying guide stars.

Again, this PC is normally up and running, but if you have to re-boot it, log on as **ccd74** and consult the label on the monitor for the password.

If you ask RunSpect to save a CCD frame, it will be stored on ltsp in /data/74in/giraffe/data/image, so at the start of your run, it's a good idea to try to save a few CCD frames and check they get to ltsp. If this doesn't happen, you probably need technical help – it's easier to get this during the day, so check early!

6.3 Data backup

Copies of the CCD frames should be made regularly – preferably every day – by uploading your files to a laptop or PC at your home institute. You can connect to ltsp by sftp, or use the following command to copy all the files of run number nnn to the current working directory:
scp ccd74@ltsp.suth:/data/74in/giraffe/data/image/ annn*fits . (include the full stop).
To accompany your data, the observing log book is in triplicate with two detachable copies – keep one for yourself and put the other in the "End of Run" tray in the warm room for our archives.

Chapter 7

Getting started

This chapter is intended to be a "walk through" the basic tasks required to prepare for observing and to acquire data. I list the way I do things but "feedback" is welcome.
If the spectrograph was not on the telescope during the week before your run, the instrument change will normally have been done by late morning. The technical staff will have tested things as far as they are able (some things can only be checked at night) and will have verified that basic systems are working (such things as data acquisition - using arc or dome light, data transfer (giraffe to ltsp) and so on), but it is up to you to check that everything is ready for your run (including such things as installing the correct grating, setting the grating angle, etc).
If the spectrograph was on the telescope before your week, it is a good idea to ask the incumbent observer if you can spend some time looking over his/her shoulder (and not getting under her/his feet) on the Monday night.

7.1 Preliminary (daytime) checks

- Make sure you have a torch (flashlight).
- On entering the dome, switch on the power circuits just inside the door and switch off all the lights.
- Go up the stairs and check that the Telescope Power Control switch is set to PLC. If not, call the electronics technician for guidance.
- Switch off any fluorescent lights (leave on the incandescents until you've done (e.g.) the grating change).
- Go into the warm room. Turn on telescope power by pushing (and holding for ~ 3 seconds) the green "ON" button on the control panel by the TCS monitor.
- Check all systems are on:
  - the giraffe PC,
  - the ltsp PC,
  - the auto-guider (Telescope Control Software) PC,
  - at least one co-ordinate repeater screen,
- The following manuals/documents will be useful (they are stored in labelled file boxes in the warm room, below the wind speed monitor):
  - *CCD & Unit Spectrograph log book* – vital for logging data (and for finding current run number !) **Please complete the log book for all observations.**
  - *CCD Spectrograph Control Program, version 1.12* by John Menzies – a detailed description of **RunSpect** – also at *http://www.saao.ac.za/science/observing/operating-manuals/1-9m-manuals*
  - *1.9m Telescope Control Software* by Steve Potter & Hannah Worters – also at *http://www.saao.ac.za/science/observing/operating-manuals/1-9m-manuals*

- *Almanac for Sutherland* – contains information on rise/set times ($0°, -6°, -12°, -18°$) of the Sun and much other useful information.
- Various plots of CuAr and other arc lines.

- Find the warm-room telescope handset and check that the focus works. Pressing the buttons in the top corners of the handset should produce a response on the focus readout display on the TCS screen.

  If an instrument change has occurred (i.e. the previous night's observer was not using the spectrograph), the focus will probably be a long way out. Set this to about 2600 and make fine adjustments on-sky.

Figure 7.1: The Telescope Control Software – Operation Panel 'MENU 1' – telescope focus readout.

- Stop the giraffe program (**RunSpect**) and restart it in your own directory (see section 6.1). Remember, you need the *CCD & Unit Spectrograph log book* to determine what your current run number is.
- You will be reminded about pre-binning. You don't have to set this up right away, but remember to do it – if that's what you want.
- Check the CCD temperature (click Temperature in the RunSpect control panel). The "Tank" should be about 90 K and the "Cu block" about 180 K.
- Navigate to /data/74in/giraffe/data/image on ltsp (see section 6.2), where your data will be saved.
- At the spectrograph control panel, centre the guide mirror, close the slit shutter and click the slit illumination up a couple of notches. Check:
  - that the A/G CCD is in reasonable focus – perhaps the easiest way to do this is to look at the small scratches on the slit jaws. If these can be clearly and sharply seen, you're probably OK. If you feel the need to re-focus the A/G CCD, this is now vastly easier as it can be done using the Camera Focus box:

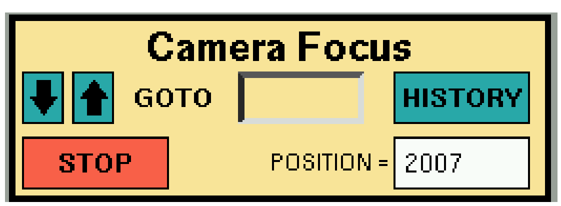


Figure 7.2: The Telescope Control Software – Acquisition CCD focus box.

The focus of the A/G CCD is not critical but if you have it reasonably well focused, you can see fainter objects and it's easy to focus the telescope by just looking at a bright star on the slit jaws. Also, you can "tweak" the telescope focus during the night by the appearance of the A/G CCD images **(IF these images look in focus** *after* **you have focused the telescope by focusing a star on the slit jaws**).

- On ltsp, move to another panel, open an xterm and go to /home/ccd74/guiders/. Type **source runit** which will bring up a DS9 interface showing a sample field. The green circle represents the hole in the A/G mirror, so any guide star must be outside that (r > 7500) but nearer the center than about r=13000 (where $r^2 = x^2 + y^2$). Moving the mouse cursor over the field gives the (x,y) positions for any star.

To bring up your target field, click on the Analysis option at top right and select DSS server in which you can enter new RA and Dec values (**The components must be separated by colons as indicated**).

The default server no longer connects. In the DSS Server box, go to the "DSS Server" menu and select either DSS@ESO or DSS@STSCI. **DSS@SAO no longer connects.**

Do not change "Height" and "Width" from the default values.

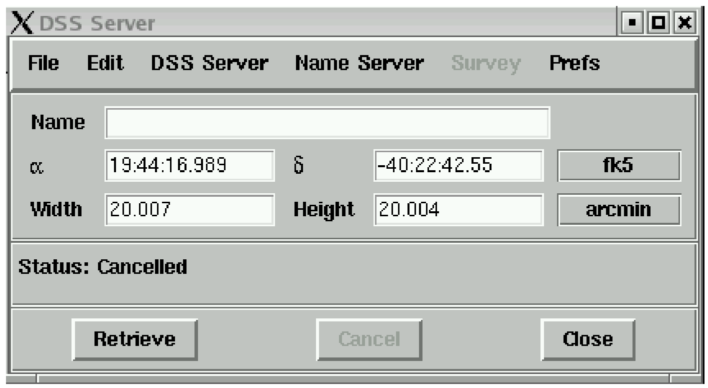


Figure 7.3: The DSS Server under DS9. Note - the default height and width for the 1.9m telescope is 10, not 20.

- At the spectrograph:
  - Set the grating angle to zero (section 3.2.1) – if you want to change gratings.
  - Change the grating (if necessary) and check the dessicant (section 3.2.2)
  - Set the grating angle to the desired position
  - Check the arc lamp and change, if necessary (section 3.2.4)
  - Check the arc lamp filters (section 3.2.5)
  - Set the required slit width (section 3.2.3)
- Switch off all the dome lights. If it is not as dark as possible in the dome, you will easily see evidence of stray light in your test/focus spectra (but see also section 8.6).
- In the warm room, check the grating angle setting by:
  - in the Labview "Spectrograph Upgrade" Control Panel window, click the arrow to move the arc mirror in the beam.
  - Use RunSpect to expose the arc – Expose; enter a time of 30 sec (this will obviously vary, depending on grating angle and arc – in the region 5000 – 6000Åwith a CuNe arc, for example, you might only need 1 sec); select No to "Save to Disk"; select Arc (**always** CuAr) and click on Ready.
  - When the CCD reads out (upper right-hand panel) a plot will appear in the lower right-hand panel. Compare this with the plots of arc lines to be found in the warm room (small bookshelf; right hand partition) and adjust the grating angle if necessary. Try to keep important spectral features away from the edge of the CCD, for example.

    Note that the default of the plots is to have the red end of the spectrogram to the left, contrary to usual practice. You can change this in the Plots area of the RunSpect control panel (see figure 6.4) by clicking ReverseX.

7.2 Routine daytime tasks

If I remembered to tell you everything, and you remembered to do everything I told you, AND got it right, the spectrograph should now be set up to produce spectra in the appropriate wavelength range. There are still some tasks to be done during the day – and essentially every day – to produce good data.

7.2.1 Focusing the spectrograph camera

The first of these is to focus the spectrograph. This process is a matter of ensuring that the image of the slit is focused correctly on the CCD detector and is clearly independent of focusing the telescope so that a sharp image of the star appears on the slit jaws (though you obviously need both !).

First, find the micrometer focusing unit. This is at the back of the spectrograph, under the dewar:

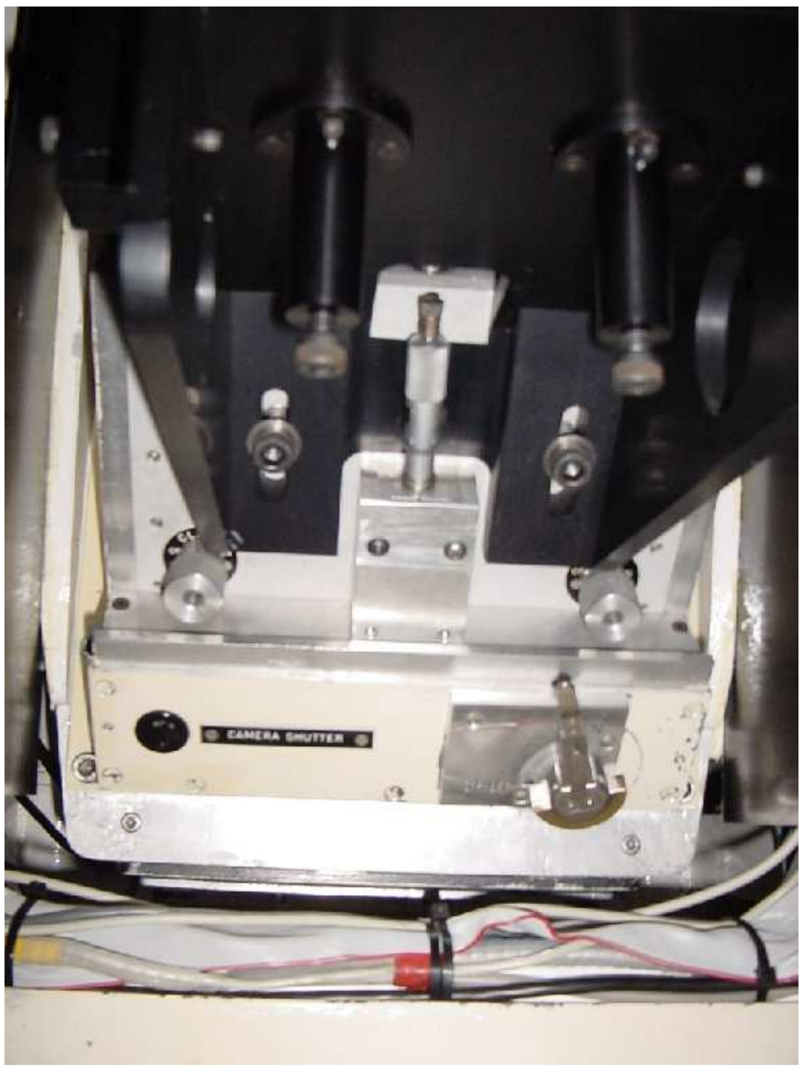


Figure 7.4: The back of the spectrograph with the black cloth "box" removed. The micrometer unit for setting the spectrograph focus is central; just below it, to left and right, are the two knurled cylindrical clamps. Just below the right-hand clamp is the lever that opens and closes the camera shutter.

To focus the spectrograph:

- Make sure all dome lights are off – including lights in the stairwell and downstairs.
- Set the spectrograph slit to 100 – 150 μm. Not absolutely vital – though obviously a narrower slit is better – but I have forgotten to do this and then repeated the process with a narrower slit – and got the same answer.
- Read the vernier scale on the micrometer.

Figure 7.5: A vernier scale similar, but not identical, to the one on the spectrograph camera unit used for focusing the spectrograph. The rotating "thimble" (at right) is calibrated in 50 small divisions of 0.01mm. The fixed "sleeve" on the left has small divisions of 0.5mm. So one complete rotation of the thimble moves it along the sleeve scale by 0.5mm. When reading the scale, the only difficulty (apart from seeing it – remember I told you to bring a flashlight ?) is that you might read (see figure) 18.41 instead of 18.91

Actually, the reading itself is not critical, as we are only really interested in relative position for the purposes of focusing. But you, and other observers, might find it useful to have actual values, so please enter the final focus position for each night in the CCD Spectrograph log book (top left-hand corner of each page).

- in the Spectrograph Control Panel window, put the arc mirror in the beam and switch on the arc lamp.
- Do test exposures of the arc – Expose, select Arc, CuAr or CuNe as appropriate, Ready – to decide what is a good exposure. You need at least a few hundred counts – preferably a few thousand counts – and remember that the count rate will be ∼ halved by the Hartmann shutters. I generally find that ∼ 30 seconds is OK for grating 6 in the blue. But with the CuNe lamp in the red, you will be able to use much shorter exposures; with the higher dispersion gratings (which will also give you fewer lines) you might need significantly longer.
- in the Spectrograph Control Panel window, click the button to move Hartmann shutter A into the beam (and check that it lights up).
- In the RunSpect control panel – Program – click on Hartmann which will bring up the Hartmann Focus Test panel (see figure). In this you need to:
  - enter at "Focus Setting" the micrometer setting you have just noted;
  - enter at "Exp time(s)" the arc exposure time you need;
  - select CuAr or CuNe, depending which arc lamp you are using;

Figure 7.6: Hartmann Test Panel.

- set the Min and Max values which determine between which pixel numbers the cross-correlation is done. You can leave these as they are, or adjust (for example, I usually set Max to 1400 with grating 6 because there are no useful arc lines beyond that value).
- Click the A button in the "Shutter" panel,
- then click Expose.

- The arc spectrum will be exposed, the CCD will read out and you can then:
  - in the Spectrograph Control Panel window, click the Hartmann A and B buttons (so shutter A moves out of the beam (light off) and B moves in (light on)).
  - At the RunSpect Hartmann panel, click the B button in the "Shutter" panel,
  - then click Expose.
- After the second exposure has completed, you will get data in the bottom half of the Hartmann panel which includes the focus setting ("Micro"), the Full Width Half Maximum of the arc lines (FWHM) and the amount the focus is out ("Shift").
- Two things need you to know about the "Shift":
  - **the direction** – If the shift value is negative, you need to move the micrometer to a smaller reading; if positive, move to a larger reading.
  - **the scale** – whatever shift is indicated, move the micrometer by about a quarter of that. If the move indicated is, say, 1.0, I would move the micrometer by about 0.25
- You can now change the micrometer setting (but also see "hints" below) by loosening the knurled cylindrical clamps, moving the micrometer thimble and then tightening the clamps (Note: **always follow this procedure**). The focus is clamped when the knurled cylinders are tight at the limit – either clockwise or anticlockwise – and unclamped when the cylinders feel loose between those extremes.

You can then repeat the process of exposing the arc, first with Hartmann shutter A in the beam, then with shutter B in the beam (remember to click the appropriate letter in the Hartmann panel in RunSpect).

- Repeat with different micrometer settings until the "Shift" is smaller than about (±) 0.05
- Enter the final focus setting in the top left-hand corner of the CCD & Unit Spectrograph log book. I usually enter the dome temperature as well.

After completing the Hartmann focus procedure, remember to take the Hartmann shutter out of the beam and remember to return the slit width to your operating choice.

- Hints:
  - It is good practice **always to turn the micrometer to smaller readings** – so as to be working against the spring tension. So, if you need to move the micrometer up by a few tenths, I would take it up two full turns and then come back down to where you want to be – or a little above that.
  - I generally try to creep up to the focus so I don't overshoot (see example below).
  - Since a reduction in temperature tends to move the focus to higher readings of the micrometer, and the dome temperature tends to drop during the night, I tend to leave the focus setting a little on the high side ("Shift" slightly negative). Results from a sample run are shown below (note that I went the wrong way on the second try !):

```
Micro      Rows   FWHM   Shift
 8.48     50- 80  2.92  -0.90
 8.80     50- 80  3.24  -2.06
 8.50     50- 80  2.95  -1.05
 8.30     50- 80  2.86  -0.37
 8.20     50- 80  2.84  -0.04
```

    The FWHM also decreases as you get nearer to focus – as you would expect – but this is less sensitive than the measure of pixel shift from the cross-correlation process.
  - Check the focus every day (I usually do it in the late afternoon) – particularly if there has been a significant temperature drop (e.g. a cold front passing through).
  - Similarly, if the temperature drops a lot during the night, it is worth doing a focus check (and probably vital if you're getting very high S/N spectra).

7.2.2 Dome flat fields

Dome flats give you a measure of the pixel-to-pixel sensitivity variations over the CCD. The dome whiteboard is anything but uniformly illuminated, but as the light goes through a slit, is then collimated, diffracted and re-focussed, it doesn't seem to matter. (You can't use the sky for this because you get spectra of the Sun).

- On desk behind the TCS monitor is a variable voltage transformer. Turn this on and turn the rheostat to 220 volts. (**Do not exceed this limit**). This powers up the dome flat lights at the top end of the telescope. If you can't see the lights on, check the connections in and out of the transformer; they can come loose.
- Make sure the auto-dome is off (blue console on North pier).
- At the telescope, open the mirror cover (motorised in June 2012). To open, locate the "Mirror Cover Controller" box shown in the following figure on the North side of the primary mirror cell (in the same place the wheel was previously). Push and release the "Open" button; there is no need to hold the button in while the covers open. The motor will stop automatically when the mirror covers are fully open or fully closed. To close the mirror covers, push and release the "Close" button. This operation can also be performed from the [D]ome menu on the TCS.

  It's important to open the mirror at this stage – if I had a dollar for every time I've tipped the telescope over and then realised I can't get to the mirror cover wheel – I'd have about $7.

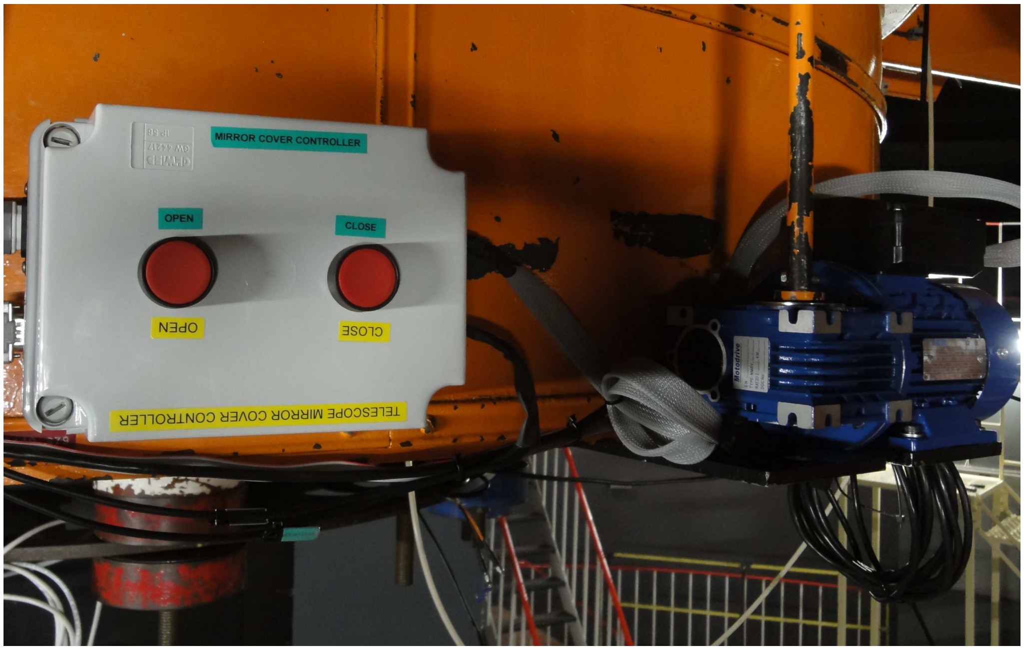


Figure 7.7: The Mirror Cover Controller box, located on the north side of the primary mirror cell.

- Move the dome so that the white board is just to the left of the south pier (slightly east of south). The azimuth of the dome ("DOME" reading on the telescope co-ordinates VDU) should be about 127°

It's a good idea to move the dome before the telescope, as the telescope top end can foul the Newtonian carriage in certain positions.

- With the telescope on the meridian (HA close to 0), move the telescope in declination to the south pole and then go past that to about $\delta = -86.5°$ (but check it looks OK). **Approach this declination carefully, as the software cut out is at $\delta = -85°$**

- Adjust the dome/telescope position so that the white board covers the front end of the telescope.

- If you have the guide mirror centred (Spectrograph Control Panel window) and the A/G system integration time turned to its lowest setting (0.05 sec) you should now see a patch of light on the A/G (TCS) screen which clearly touches the slit (the angle of viewing of the slit is rather acute, so it looks odd).

- Use **RunSpect** to get an exposure. Try, say 20 seconds and experiment to get a suitable value. (Tom Williams reckons the CCD is linear to about 40000 counts; the pixels will saturate at $\sim$ 64000 counts. I usually aim for about 30000 – 35000 counts at peak.

- Take as many exposures as you want. this might depend on what the flat field looks like. With grating 6 (and any grating), the flux dies towards the ultra-violet, so I generally take 30 or 40 frames (using the "Number of Exposure" box in Expose – it's not dark, so who cares?). For red spectra, the flat field flux will be more even across wavelength and you might just need a few flats.

  Alternatively, you can use a different grating set in the red – or turn your current grating to a redder angle for flats. Since you are only interested in pixel-to-pixel variation, this should be OK.

- If you are running several exposures – and this is the start of your week – here is a good place to check the files are all being transferred to /data/74in/giraffe/data/image on ltsp.

- When you have obtained a good flat field, one thing you can do is to enter the Plots panel of **RunSpect** (see figure) and click on X–sect which will display a cross-section of the flat field. This will give you an idea of where on the CCD (which row(s)) to aim to get your object spectra.

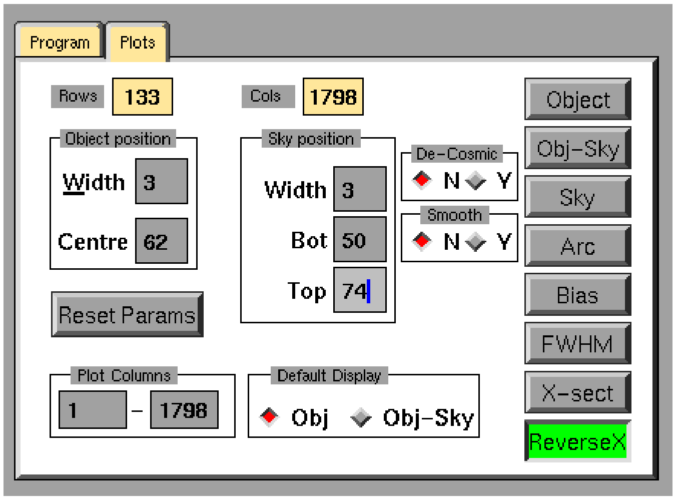


Figure 7.8: The Plots panel of **RunSpect**. Note, in this example ReverseX has been clicked; blue will be on the left in the spectrum display. Also, three rows ("width") will be displayed.

A sample cross-section is shown in the next figure and a sample flat field:

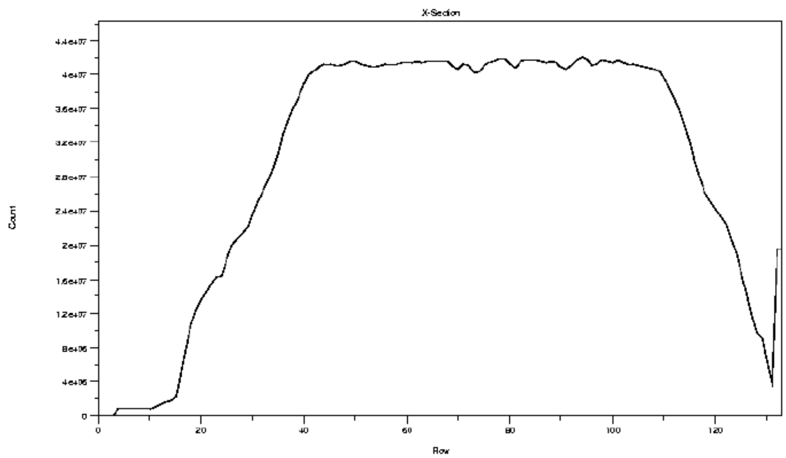


Figure 7.9: A cross section of a (grating 7) flat field.

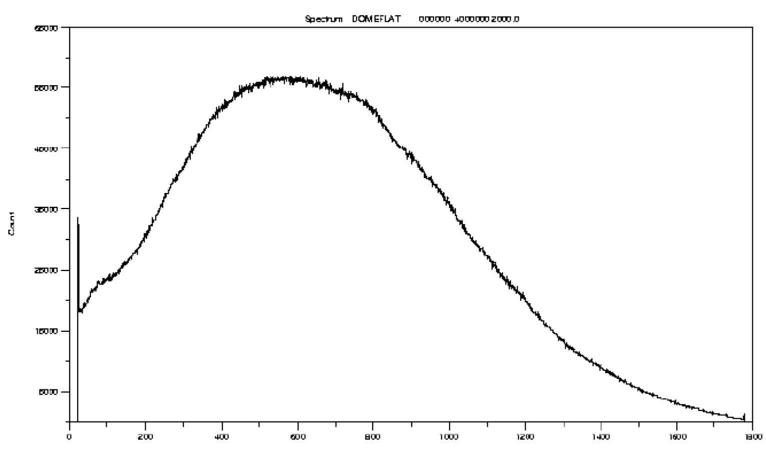


Figure 7.10: A sample grating 7 flat field. Note the rapid fall off in flux towards the blue end (right in this case). Flats obtained in the red will tend to be much flatter – and especially if they span a smaller wavelength range.

- When done:
  - Turn the transformer back to 0 volts and switch it off
  - Return the telescope to nearer the zenith. (Very carefully ! Watch it as you move it)
  - Close the mirror cover (at the TCS, or push and release the "Close" button on the Mirror Cover Controller box on North side of the primary mirror cell).
  - Remember to switch the telescope settings to "Slow" if you are going to switch off at the telescope isolator.
- If you are close to dinner time, now might be a good time to top up the LN_2.

7.3 Getting started on the first night

Assuming you've done the spectrograph focusing, got your flats and other desiderata, had your dinner, now you want to observe real goodies:

- Enter the dome, switch on the two power switches inside the door (and switch off the downstairs lights).
- Top of the stairs, check the "Telescope Power Control" switch is set to PLC - if not call the electronics technician for guidance.
- In the warm room switch on
  - telescope power (warm room control panel - push and hold big green button for ∼ 3 seconds),
  - the telescope slow motion drive (warm room control panel),
- Open the dome (TCS or Control panel on North pier)
- Unless it's quite windy; I have the wind blind right down. If you see significant "telescope shake", rethink.
- Open the mirror cover (TCS, or push and release the "Open" button on the Mirror Cover Controller box on North side of the primary mirror cell).

**** Always open and close the dome with the mirror cover closed. ****

- Do sky flats if you need them. These basically tell you about any sensitivity variations along the slit and are useful if you are dealing with extended objects. **To do sky flats, you will need to be at the telescope, ready to go, around sunset.** You will be able to see the sky light on the A/G screen – looking pretty much like the dome flat light. You should be able to take a few exposures at relatively short times (I usually get something like 3 x 5 sec, 3 x 10 sec, ...).
- Set the telescope on a bright star. I usually pick something around 4th mag – and, if possible, a B or A star, so the Balmer lines (for example) will be unambiguous (to check grating angle).

  Bright stars can be found in the *The Astronomical Almanac*, the E–region lists or the *Almanac for Sutherland*, for example.

  You might need to change the epoch of the telescope co-ordinates in the TCS – remember to press [Enter] on the keyboard ...
- Switch on auto-dome at the blue telescope control console (north pier).

- in the Spectrograph Control Panel window move the guide mirror off centre (by clicking on one of the arrow buttons). You should now be able to see a bright star.

  If you can't, try turning up the integration time on the TCS screen using Exp Time – the star might just be off to one side and you may be able to locate it if its light "streams in" from that side of the chip in a longer integration time.

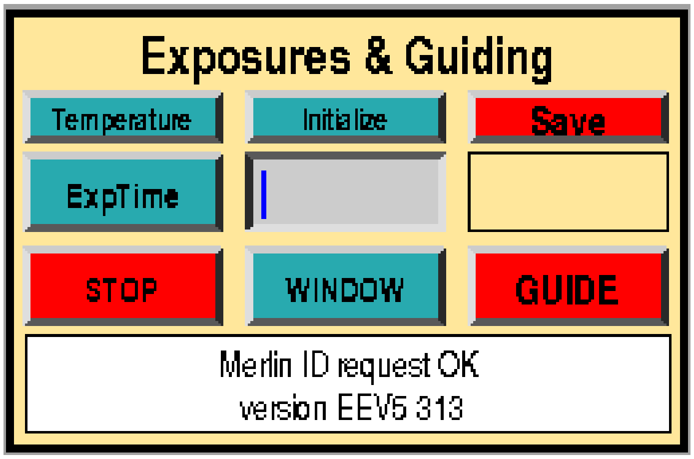


Figure 7.11: The Exposures & Guiding panel of the TCS. Exp Time – or just typing in a different time – will change the A/G exposure time.

If that doesn't work, look for the *74" encoders* book and look for recent zero points and collimation coefficients for the SpCCD. These can then be entered using the "Enter zeros directly" option in the ZERO POINTS box of the MENU 2 operation panel

Figure 7.12: Entering co-ordinate zeros directly.

If that fails, search in RA and Dec. If you still don't find the bright star you may need help.

- when you find the right star, centre it on the A/G screen **using the telescope handset**.
- You might then want to update the RA and Dec zero points, using "Enter RA and Dec of a Star" in ZERO POINTS. This will ask you to input the actual co-ordinates and will output the new zero points.
- Move the star to about about three quarters of the way up the A/G screen and then move the guide mirror to "Centred" (using the central square button on the Spectrograph Control Panel window). You should now see a much fainter star (because the slit jaws are not especially reflective).
- Use the handset to move the star just above the slit and use the handset focus buttons to focus the telescope (the image will jump around a bit, but over a range of about 30 on the focus scale, you should see the star image go from slightly astigmatic (oval) through circular to oval.

  You will probably need the integration time down to minimum (0.05 sec).

  A more reliable method of focussing the telescope using a "knife-edge" test is described in the next subsection.

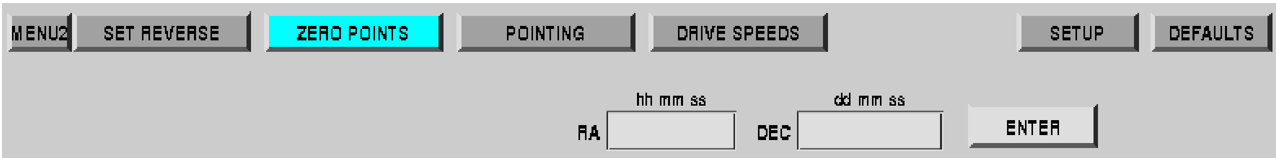


Figure 7.13: Entering co-ordinates of a star to determine zero points.

- With the telescope focused, set the star on the slit (you should be able to see the spectrograph slit across the image) and take a 1 second exposure ("Not saved", "Object" any name will do).
- Just below the CCD readout picture (top right-hand corner of the RunSpect Main Panel) is a slide which enables you to scan along the spectrum (only about a third is visible at any time). Set this slide in the middle. Also there are small on/off buttons. Click On and you can move the screen cursor over the image using the mouse. The three little panels to the left of the Off box will now show x and y positions and intensity (yellow panel).

  I do a short series of exposures, moving the star along the slit a small amount between each exposure, until the peak of the spectrum near the middle is at y = 65. This seems a good place (BUT CHECK – see previous section) – not near any poor rows, etc. (for 1 x 2 prebinning; if you are not prebinning, this will be y ∼ 130).

  If you check the ends of the spectrum, you will find one end peaks near y = 64 and the other near y = 66 – the spectrum is not perfectly aligned, but reduction software should be able to handle that.

  To the right of the little On/Off buttons is a Look-Up Table setting. For most uses, I find clicking on 1 is best, but you might need to experiment.
- When you have the bright star where you want it on the slit, it's a good idea to mark this position with a box using the "Add a Red Marker" option in Markers (see figure).

Figure 7.14: Use the "Add a red Marker" option in Markers.

- Bright stars can be seen on the spectrograph slit, but faint stars can't, so you need to determine a position on the A/G mirror which corresponds to the position on the slit that you've just marked with the red box. To do this, I generally get an 10 – 11 mag star, because you can see it on the slit but it doesn't swamp the CCD with the A/G mirror in the beam (often, I use the spectrophotometric standard that I want to observe at the start of the night). Putting the star on the slit (A/G guide mirror centred) exactly where you want it, then moving the A/G mirror off-centre leaves the star in a somewhat different position (apparently) on the A/G mirror. You can then mark this position with the another small box ("Add a Red Marker" option in Markers).

You might need to reduce the A/G integration time to make the image a nice size, and you might need to centre and off-centre the A/G mirror a couple of times to get things right.

Once you have the markers where you want them, it's a good idea to write down their x and y positions (see top right of A/G panel on TCS screen). If the PC crashes, after a re-start you can bring the markers back, then easily move them to the desired positions using the mouse.

This method of offsetting is fairly robust, but if you move a long way from the position you set the offset marker, it would be wise to check with a brightish (11 – 12 mag) star that it is still correct.

The above might seem complicated, but once you have done the basic set up procedures, subsequent nights should be simpler with much less to do.

7.3.1 Focussing the telescope with a "knife–edge" test

Focussing the telescope (onto the spectrograph slit) using a knife-edge test is a more reliable procedure than simply focussing by eye. To do this:

- Put a fairly bright star on the slit and put the "Rear Slit Mirror" in the beam (in the Spectrograph Control Panel window)
- Open the slit an extra 20 steps (to slit number 30, or about 750 μm) in the Spectrograph Control Panel window.
- At the telescope, open the shutter on the rear-of-slit viewing eyepiece – the tag just to the right of the eyepiece (see Figure).

Figure 7.15: Rear-of-slit viewing eyepiece.

- Remove the eyepiece, which will allow you to see an out-of-focus image of the star – essentially you will see the primary mirror illuminated by the star – with a central dark circle which is the obscuration of the primary by the secondary mirror.
- Push the brass slide (on the left of the eyepiece – see Figure) all the way to the left

- Using the handset on the telescope and “set” speed in declination, move the star so that it is occulted by the edge of the slit jaws (the “knife-edge”). If the image is not in focus at the slit, you will see one side of the image darken before the other.
- Change the focus slightly and repeat the process (there are focus control buttons on the handset).
- Repeat until you see the mirror image darken almost instantaneously. When this happens, the star is in focus at the slit and all the light is cut off at the same time as the star passes behind the slit jaws.
- After focussing, remember to:
  - Replace the eyepiece
  - Close the shutter on the eyepiece
  - Reset the slit to the normal operating width
  - In the warmroom, remove the rear-of-slit mirror from the beam

7.4 Opening up - Review

After the first night, opening up procedure should go something like:

- Switch on the two power switches inside the door.
- In the warm room, switch on the telescope power and slow motion drive at the panel beside the TCS monitor.
- Open the dome.
- Open the mirror cover.
- Do sky flats if you want them.
- Set the telescope to a bright star (if you want to check pointing).
- Switch on auto-dome at the blue telescope control console (North pier).
- in the Spectrograph Control Panel window move the guide mirror off-centre to see the target star.
- You will need to focus the telescope at the start of each night (by focusing on a star on the slit jaws or carrying out a “knife-edge” test) and may want to check it from time to time during the night.
- And it’s probably a good idea to check that your red box markers look OK at the start of each night – and at “extreme” positions.
- (If the dome temperature changes by more than 2 or 3 degrees, it’s a good idea also to check the spectograph focus during the night).

7.5 Arc spectra

To take arc spectra, do the following:

- in the Spectrograph Control Panel window, the arc lamp must be on and the arc mirror must be in (see Section 4.2).
- At the **RunSpect** main panel click [Expose] – this brings up the Exposure panel, then:
  - set the exposure time
  - number of exposures will usually be one
  - “Save to disk” should be [Yes] (unless you are just testing things).

– click Arc and CuAr — **whatever the arc lamp**.

– click Ready to start the exposure

- Subsequent arcs can be taken by clicking Repeat Last Arc in the control panel, assuming you want exactly the same parameters – same integration time, to save to disk, etc.

Note that when the arc spectrum is plotted, it displays the total counts for the middle third of the slit, NOT a single row. To get a better idea of the actual arc line strength, either use the cursor on the image display area (top right-hand panel) or enter the Plots area of the control panel and click Object – this will then display as many pixels as you have indicated in "Width" (and you can always make this 1, if you wish).

7.6 Star spectra

By "star" of course, I mean your astronomical targets.

- With a star on the A/G screen, use the handset to move it to your pre-set cursor (which corresponds to where you want it on the slit). (Of course, if the object is bright enough to see on the slit, it is best to set it on the slit directly).
- Centre the guide mirror. The starlight should now be entering the slit (and it's not a bad idea to check this with a short exposure).
- You now need a guide star:
  – Get the (x,y slide) position of a suitable guide star (moderately bright) from the autoguider program (see section 7.1) and use the "XY Slides Control" panel to move to that star by clicking Go To and entering the (x,y) position from the DS9 output.

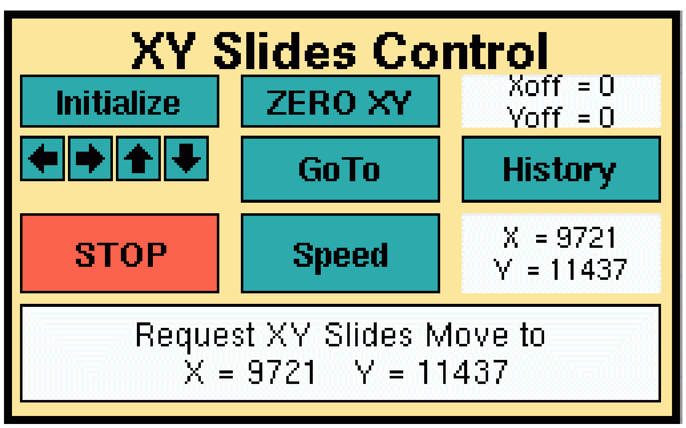


Figure 7.16: XY Slides Control box.

Be aware that x and y must be less than about 13000 or you're off the A/G mirror. Also $\sqrt{(x^2 + y^2)}$ has to be bigger than about 7500 or you're still in the central hole.

Note that the guide star might not be exactly central in the field (because the offset is usually done with the target star on the slit, not in the centre of the field) but you can centre it using Move XY

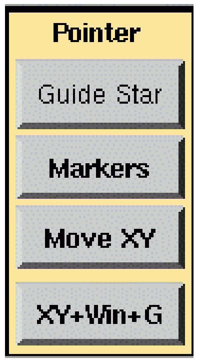


Figure 7.17: Use the Move XY option to move a star to the centre of the field and Guide Star to mark the selected guide star.

in the "Pointers" panel (click on Move XY, then if you click on a point in the A/G field (e.g. a star) that point will be moved to the centre of the field).

Having selected and centred a suitable star, click on Guide Star in the "Pointers" panel, then if you click on the centred star, that will be the position that the auto-guider will try to keep the star.

Then go to the "Exposures & Guiding" panel, reduce the window size using WINDOW (I usually use 128 x 128) and start the guiding with GUIDE.

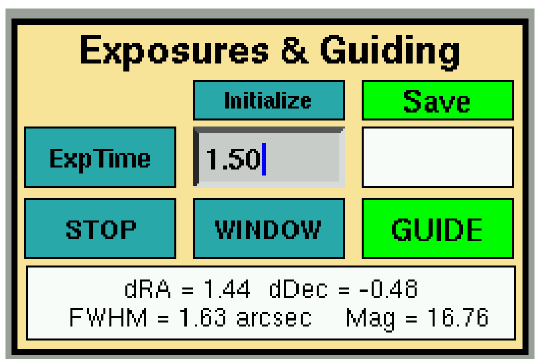


Figure 7.18: Exposures & Guiding panel. Guide is green when guiding; red when not.

With the guiding in operation, most other functions will not work, but you can, for example, change the integration time using Exp Time which is useful in poor conditions.

If conditions are cloudy, you might find that the auto-guider switches itself off (it will do this if it can't find a star after a few tries). You need to keep an eye on it so you can switch it back on as (say) transparency improves and the guide star becomes usable again.

- At the end of the star integration:
  - Click on GUIDE to stop the auto-guiding (in "Exposures & Guiding" panel).
  - Restore the full A/G screen using the WINDOW pull-down.
  - **Click on Initialise to recentre the xy slides. DO NOT use Zero XY unless you know what it does !**

– in the Spectrograph Control Panel window, put the arc mirror in the beam (if you want to do an arc after the target).

– Move the guide mirror off-centre to be ready for the next target field (you can do this while the arc is running, because the arc mirror is below the guide mirror).

7.7 The spectrum plot

Having obtained a spectrum, you can manipulate this to some extent using the lower left-hand panel of the RunSpect display – see Fig 6.1. The display appears with the [Program] panel displayed; if you click on [Plots], you will get a panel something like:

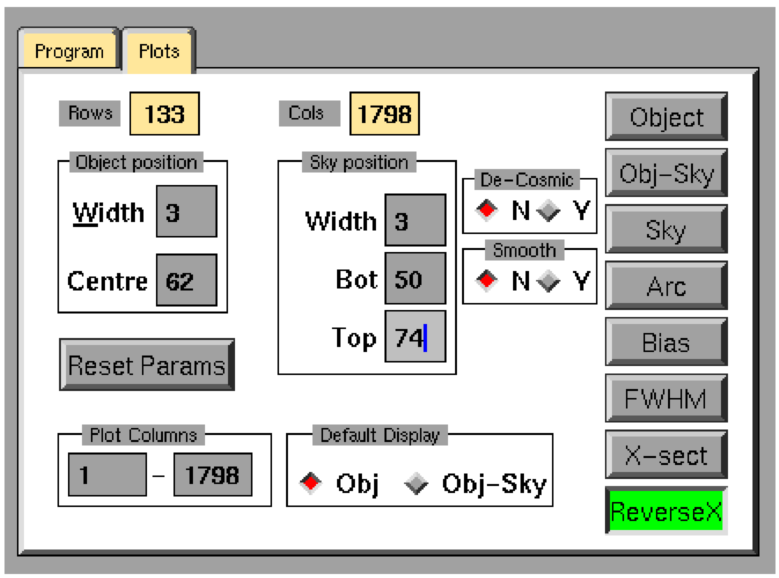


Figure 7.19: The [Plots] panel of **RunSpect**. In the figure, [ReverseX] is clicked which will put the blue end of the spectrum displayed on the left of the display panel.

Again, for full details, you should consult the manual CCD Spectrograph Control Program, but I give here some basic comments:

- **Note that any settings you make here do not affect the raw spectrum – they are just for the purposes of a "first look" at your data; quality control, if you like.**
- In "Object position", you should set "Centre" to be the row number (on the CCD) of the middle of the spectrum (in both x and y). The spectrum is slightly tilted and the exact position might vary a bit from spectrum to spectrum (because you won't get the star in *exactly* the same place along the slit every time). So you can correct for that here.
- In "Object position", I usually set "Width" to be 3 (rows). The spectrum clearly spreads over more than one row (and is slightly tilted). You can try more than 3; it would probably be beneficial in poor seeing, for example. Try increasing the number of rows and checking how the peak count increases.
- If you change a parameter in the [Plots] panel, you need to re-display the spectrum to see the effect. Do this by clicking [Object] or [Obj – Sky] (for example).
- You can effectively expand the scale in the direction of dispersion by changing the number of columns plotted; do this in the lower left-hand corner of the [Plots] panel.

- The “De-Cosmic” option sometimes works, but sometimes produces a funny step function. Again, you need to re-display the spectrum to see the effect.
- If you have the “Centre” of the spectrum significantly far away from the default value (65), you will need to alter the “Sky position”. Sometimes the software objects to this but displays the spectrum anyway...

You can use the Print option near the lower right-hand corner of the **RunSpect** main screen to print out whatever is displayed in the lower right-hand panel. A couple of samples follow:

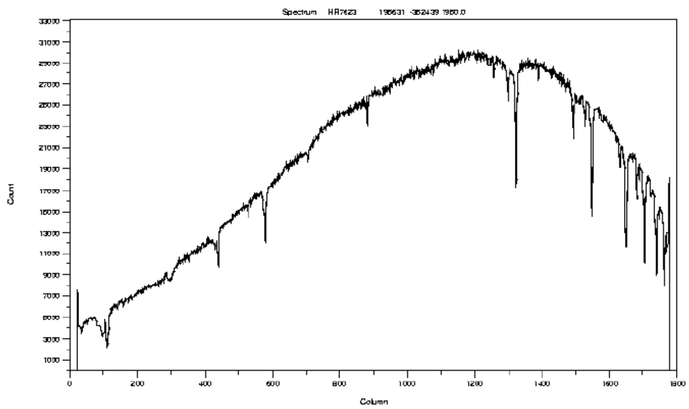


Figure 7.20: Spectrum of a bright B2IV star (HR7623). This was a 4-second exposure taken with grating 7 (angle 17°; centred near 5700Å). Balmer series lines are obvious with atmospheric bands at the left (red) end.

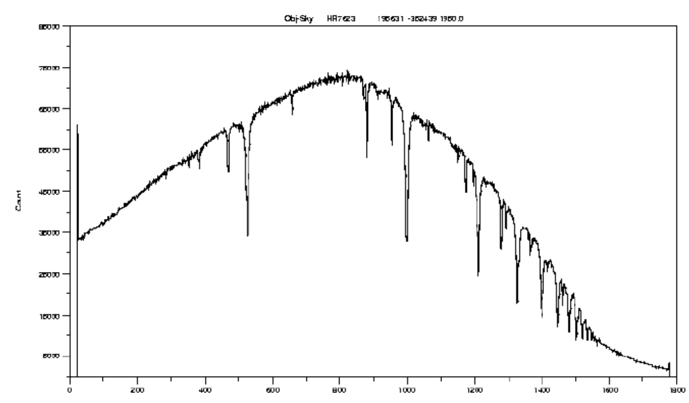


Figure 7.21: Spectrum of a bright B2IV star (HR7623). This was a 10-second exposure taken with grating 6 (angle 14.1°; centred near 4400Å.) Balmer series lines are evident with (weaker) He I lines.

7.8 Closing down the telescope

At the end of the night:

- In the dome:
  - Switch off auto-dome at the blue telescope control console on the north pier.
  - Park the telescope at HA = 0; Dec = -32° (well, you can leave it at -32° if you've just filled up the LN_2 – or for the technician who will do it).
  - Make sure both RA and Dec are set to "SLOW" on the blue telescope control console (on the north pier).
  - Close the mirror cover.
  - Close the dome.
- In the warm room, switch off the telescope slow motion drive, then telescope power.
- Switch off the two power switches inside the front door (on your way out).

Chapter 8

When things go wrogn

I will try to list in this chapter some of the things that can go wrong and how you might try to fix them. Of course, **lots of things won't work if they're not switched on** – I once switched off the "telescope isolator" then tried to close the dome. In the end, I closed it manually – which takes a *long* time. Well, it was the end of the night ....

Figure 8.1: "I told you not to touch that"

If you cannot get out of trouble, try first to 'phone any other telescope whose operators have experience with the spectrograph; they might be able to advise you how to proceed. (Suitable people include Francois van Wyk, Hannah Worters, Dave Kilkenny, John Menzies, Darragh O'Donoghue, Steve Potter). If that fails, call a technician. I welcome additions to this list and will try to add to it as time passes.

8.1 Telescope

- **If the telescope won't move at all and an alarm is sounding**, you need to move the telescope back into its "safe" zone using the override key (see section 2.5).
- **If the telescope won't slew in R.A.** – check the "RA fast motion speed control" has not been turned to minimum (telescope control panel on the north pier).
- **If the telescope won't set/guide in R.A.** – check the drive is on (control panel in warm room).
- **If the telescope "set" speed is very slow on the handset** – check the speed has not been set to "guide" on the telescope control panel (north pier) – this overrides the handset.

8.2 Dome and wind blind

- **If the dome/shutters/wind blind don't work** – check you have the "Telescope Isolator" at the top of the stairs switched **on**. If it is, try moving the dome a little to the left or right and then try the shutters/blind again. (Occasionally the dome stops in a "bad" position for the electrical pick-ups).
- **If the dome slit doesn't follow the telescope front-end** – check you have the auto-dome switched **on** at the blue panel on the North pier.
- **No control possible from the observing floor.** Is the telescope switched on? Remember the 30-40 second "lock out" period after the telescope is switched on. Press the "Request Local Control" button on the control panel. The control indicator will illuminate to indicate that the user has control from the control panel. If control has failed shortly after the dome was moved it could be that the slip-rings on the dome supplying power to the dome has briefly made a bad contact. If this happens then the system operation will recover after the 30-40 second "lock out" period. Make sure the Emergency stop button next to the telescope control panel is not pressed. If it is pressed an indicator on the TCS will also indicate this. Release the Emergency stop.
- **No Control possible from the TCS.** Is the telescope switched on? Remember the 30-40 second "lock out" period after the telescope is switched on. Select "Request Control" under the [Dome] dropdown window. If control has failed shortly after the dome was moved it could be that the slip-rings on the dome supplying power to the dome has briefly made a bad contact. If this happens then the system operation will recover after the 30-40 second "lock out" period. Refer to Section 5.2 for details on controlling the dome shutters and wind blind from the TCS. Make sure the Emergency stop button next to the telescope control panel is not pressed. If it is pressed an indicator on the TCS will also indicate this. Release the Emergency stop.
- **If all else fails.** Check that the dome control cabinet on the catwalk is not set to local control. If control panel is set to local control an indicator on the control panel will illuminate (Fig. 8.2). The user cannot control the dome shutters and wind blind from the observing floor or TCS if the control cabinet is set to local mode. Switch the control switch to remote mode to enable remote operations. Check that the emergency stops on the control cabinet are not pushed. If they are, check why with the technicians before disengaging the emergency switches. There is no indication on the TCS if these switches are pressed. It may also be possible that the sliprings are not making proper contact. Move the dome slightly and see if control returns.
- Closing the shutters manually. In an extreme emergency the shutters can be closed manually.

  Locate the manual control handle. This handle looks like a ship's steering wheel next to the dome shutters control cabinet. Looking at the right side of the steering wheel you will see two locking latches. Fig. 8.2 shows the latches in the "wheel disengaged" position.

  Flick the front latch over to allow the wheel to be moved forward and backwards, as in Fig. 8.2. Once the wheel is free, push the wheel forwards to engage the wheel with the drive systems and throw the front latch over to lock the wheel in the engage position, as shown in Fig. 8.2.

  Turn the wheel to close the shutters. Once the shutters are closed move the latches to the free position and pull the wheel back. Lock the wheel with the front latch in the disengage position.

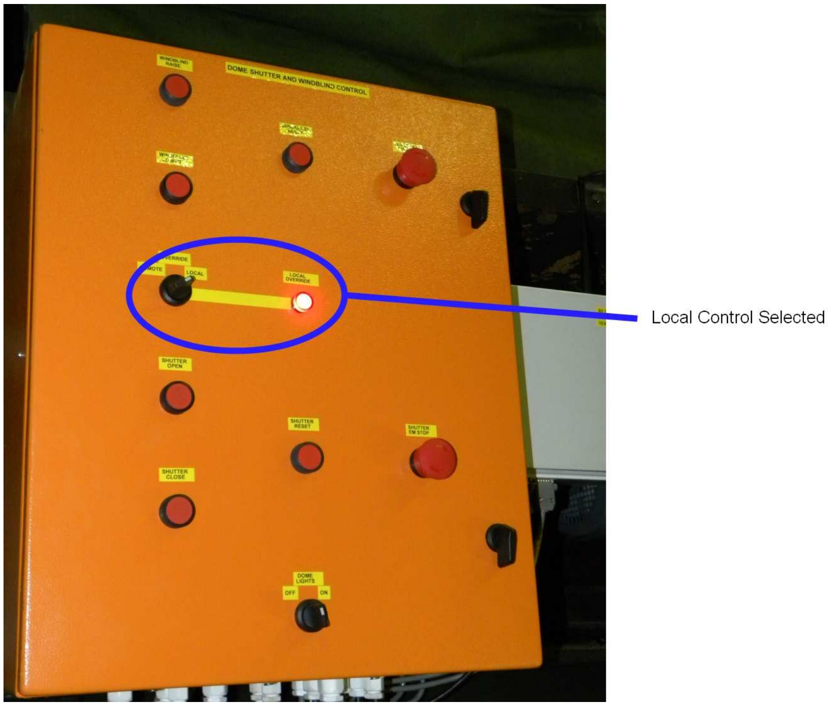


Figure 8.2: An indicator illuminates to show local control on the dome shutter control panel on the catwalk.

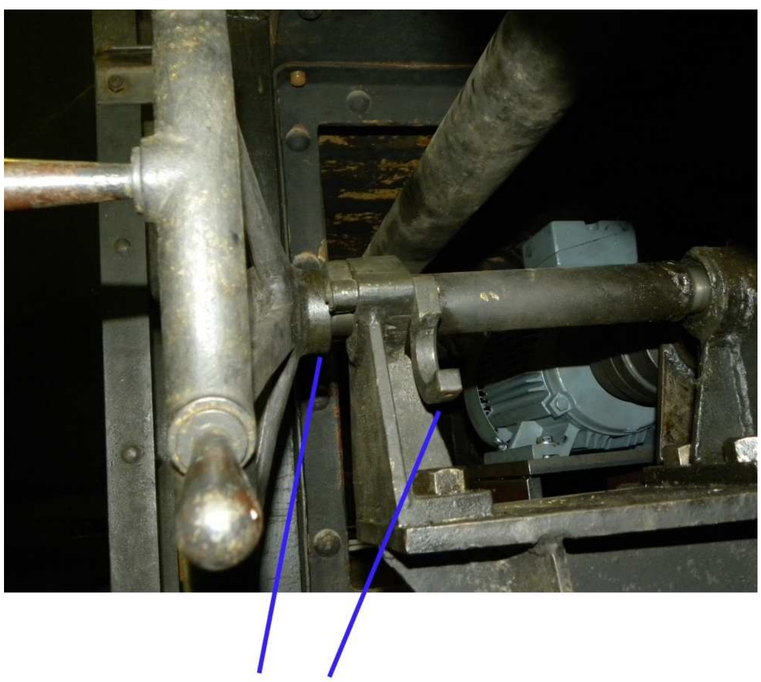


Figure 8.3: Manual shutter control wheel in disengaged position.

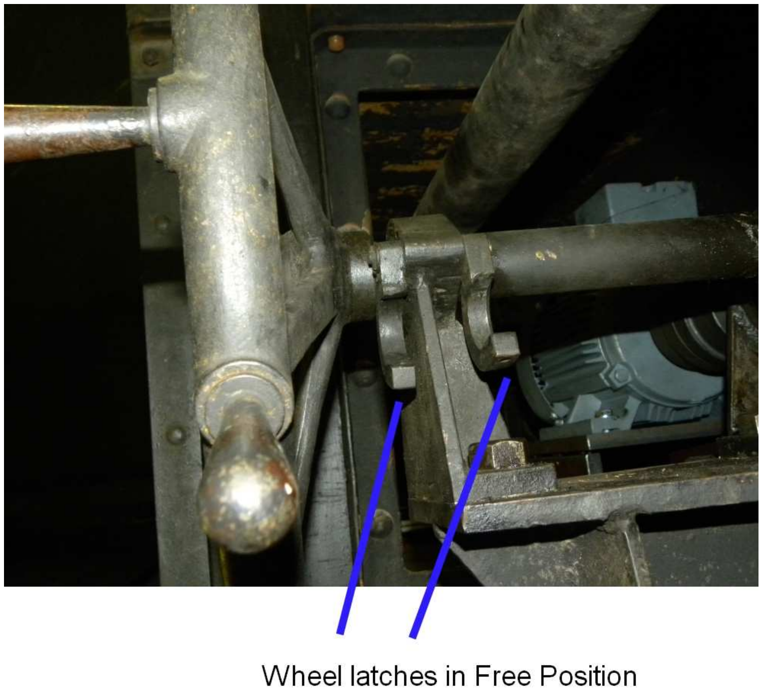


Figure 8.4: Shutter control wheel in free position.

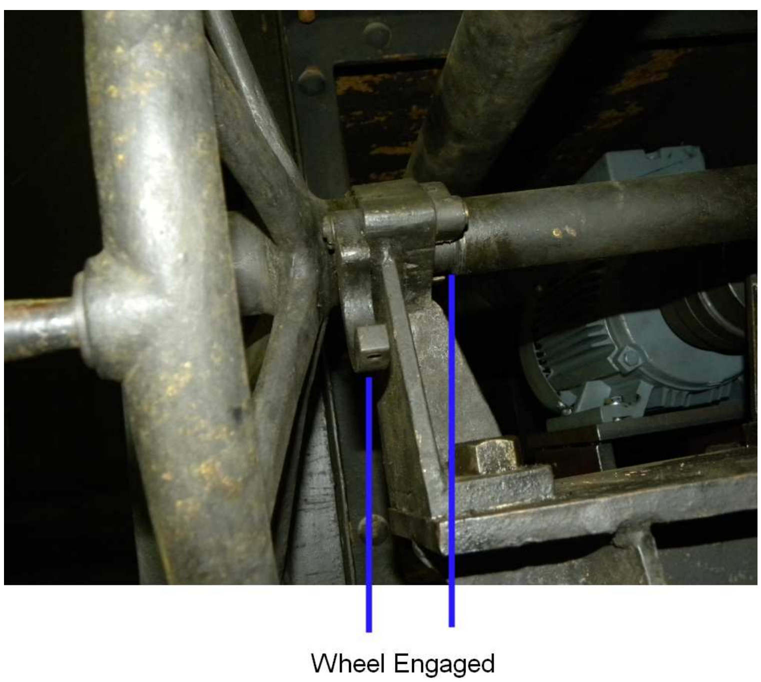


Figure 8.5: Shutter control wheel engaged for opening or closing the dome.

8.3 Spectrograph

- **Light not getting to the detector**
  - for stars/flats – check the guide mirror is centred and see Section 4.2.
  - for arcs – see Section 4.2.
  - if the above fail – check the camera shutter (just below the camera focus clamps) is out of the beam. Remember, this shutter is not represented in the Spectrograph Control Panel window.

8.4 Computers

- **If either the A/G (TCS) PC or the RunSpect (giraffe) PC lock** – you will need to re-boot them.
  - In the case of the A/G (TCS) PC, restart the software from the dropdown menu by right-clicking on the desktop and **remember to reset any field orientation changes**.
  - In the case of the RunSpect PC, **remember to check the run number and file number when you start up. After crashes, the file number can be quite wrong**.
  - **If either PC crashes, it's a good idea to re-set the appropriate CCD/Merlin crate**. This is most easily done in the "Exposures & Guiding" panel (Initialise) for the A/G CCD, and on using the red button on the Merlin crate for the Science CCD.
  - **If a big red EMERGENCY box appears on the TCS screen and doesn't go away when you press Terminate Emergency Status** (and don't you wish life had a button like that?) then you need to reset the the red knob labelled "Emergency Stop" on the 'x-y slide reset box' just to the right of the main telescope control console on the north pier (see Figures). Reset the knob by turning it clockwise, when it will pop out a little way and the red EMERGENCY box should disappear.

Figure 8.6: Blue telescope control console with "Emergency Stop" box.

8.5 Flats

- **No flat field light**
  - check the connections to the voltage transformer; these can come loose.
  - If you can see light on the dome flat screen, **did you remember to open the mirror cover?**
- **Weak flat field light** – if the flat field seems about half strength, check you have both Hartmann shutters out of the beam. (Been there; done that).

Figure 8.7: Close-up of "Emergency Stop" box.

8.6 Spectra

- **If the arc or flat field spectra only occupy the middle few rows of the CCD** – check the guide mirror is centred; slit shutter closed; slit shutter illumination on).
- **If the arc spectrum has significant background** – in the figure, the very significant background light is caused by the light at the top of the stairwell being left on. The light leaks into the spectrograph – mainly around the dewar/spectrograph connection, it appears – and does not go through the normal optical path.

  In extreme cases (e.g. with the main dome incandescent lights on), the arc signal will be swamped by the vastly increased background.

Note: At the time of writing (Sep 2008), the "background" problem seems to have disappeared – probably due to the recent refurbishing of the CCD dewar and its seals. At present, even relatively high levels of dome light seem not to affect the background. The above figure is retained in case the problem recurs.

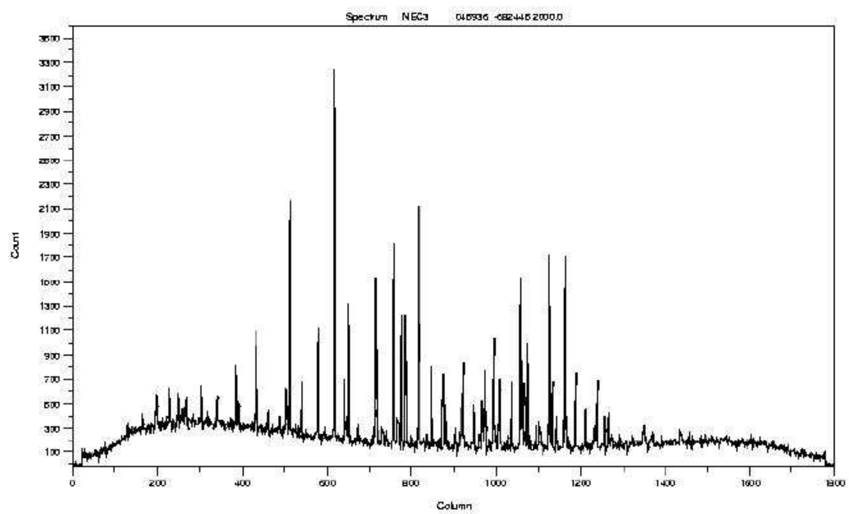


Figure 8.8: Grating 6 arc (range about 3600 – 5200 Å). Note the underlying background "bumps" caused by the light at the top of the stairwell.

Chapter 9

Gratings

The table provides a summary of grating characteristics copied from Tom Lloyd Evans 1990 manual. I am not familiar with all of them; in particular, I know nothing about the newer (infra-red) gratings 10 – 12, but will try to provide wavelength/angle plots in the near future. Gratings 7, 8 and 9 are direct replacements for the much older gratings 1, 2 and 3.

As of February 2012, the damaged gratings 4, 5, 6 and 8 have been replaced with gratings of the same specification.

Grating	Lines (mm^{-1})	Order	Dispersion (Å/mm)	Useful range (Å)	Blaze	Resolution (Å)
4	1200	1	50	800	4600	1
5	1200	1	50	800	6800	1
		2	20	350	3400	0.5
6	600	1	100	1600	4600	2
7	300	1	210	4200	4600	5
8	400	1	155	2300	7800	4
		2	75	1150	3900	2
9	830	1	65	960	7800	1.5
		2	30	480	3900	0.7
10	1200	1	50	800	10000	1
11	600	1	100	1600	10000	2
12	300	1			10000	

Tom Lloyd Evans writes:

> Grating 10 offers 1200 lines/mm (the same as gratings 4 and 5) at a blaze of 10000A. This grating is intended for the region longward of about 8000A at a resolution of about 1.2Å. Extrapolate the grating angle/central wavelength plot for grating 5 in first order in the User's Manual. Note that these figures are only approximate for all gratings, and you must check settings to ensure that the required wavelength range is covered and that the few permanent defects on the chip do not coincide with important features if you cannot avoid using that part of the CCD chip.
>
> Gratings 11 and 12 are the far red equivalents of Gratings 6 and 7.

I have compared focus settings for various gratings by setting the focus for grating 6 (the one I usually use) then changing gratings and measuring the focus for the new grating. The focus measurements below are thus relative to grating 6.

Grating	Focus – Gr6				Average
4	+0.12				+0.12
5	+0.32	+0.24			+0.28
7	+0.06	–0.01	–0.06	+0.03	0.00
8	+0.05				+0.05
9	+0.44	+0.47	+0.51		+0.47
10	+0.53				+0.53
11	+0.10				+0.10
12	–0.04				–0.04

Thus, gratings 7, 8 and 12 seem to be in good agreement with grating 6 and gratings 5, 9 and 10 definitely don't. I will try to provide more measures when I get chance. If you have occasion to measure two gratings in quick succession, I'd be grateful for the comparative measurements.

9.1 Grating angle settings

The following plots are adapted from the plots in the 1990 manual – which are by now rather faded and covered in pencil marks (!). I stress the comment by TLE that one should always check grating settings by examining the calibration arc lines, for example.

9.1.1 Grating 4

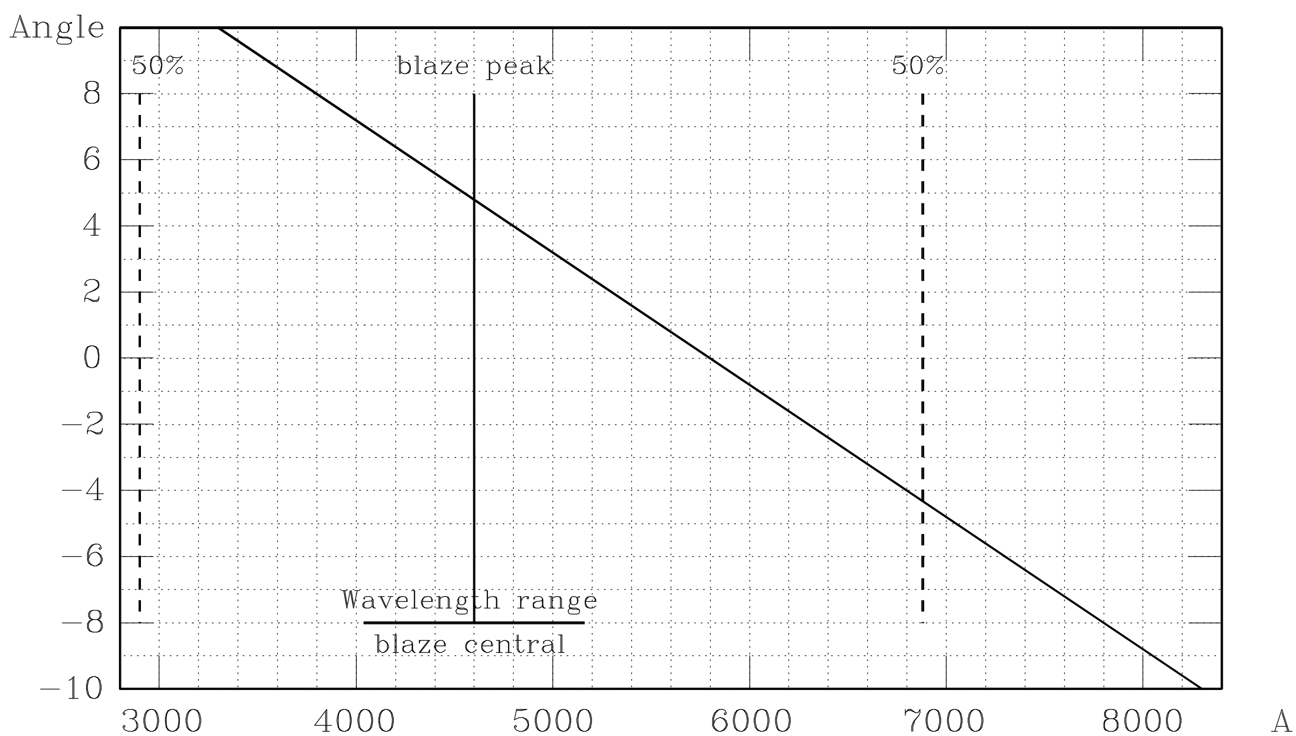


Figure 9.1: Grating 4 – 1st order

9.1.2 Grating 5

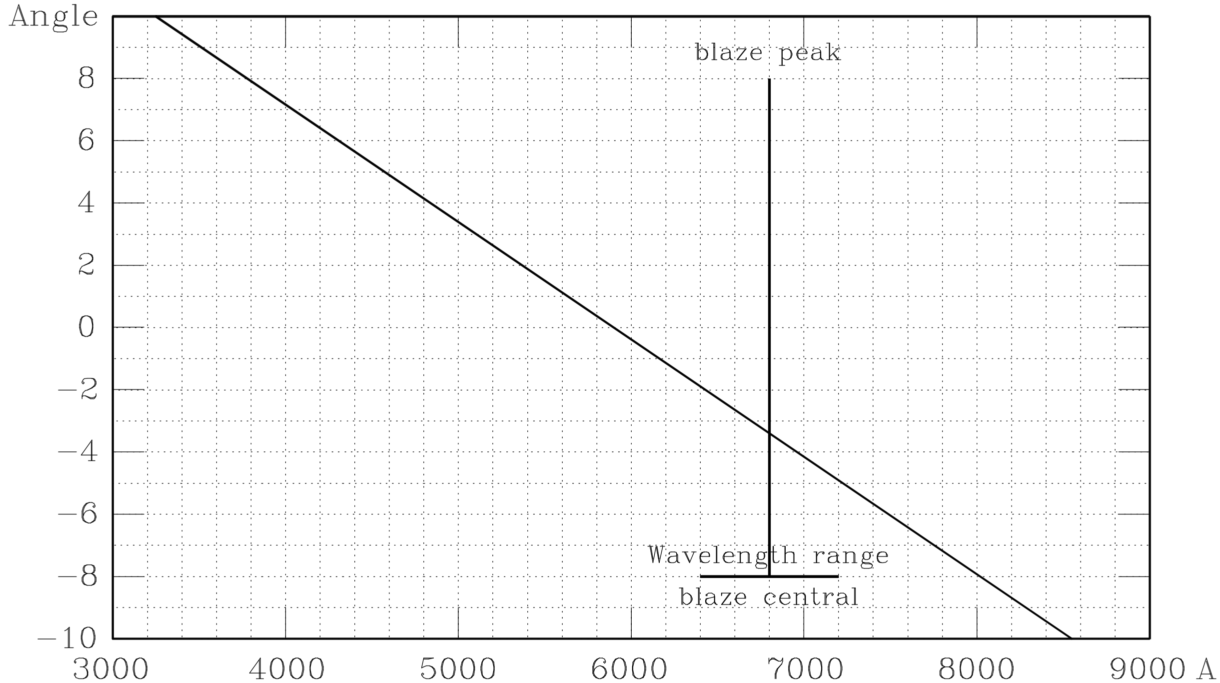


Figure 9.2: Grating 5 – 1st order

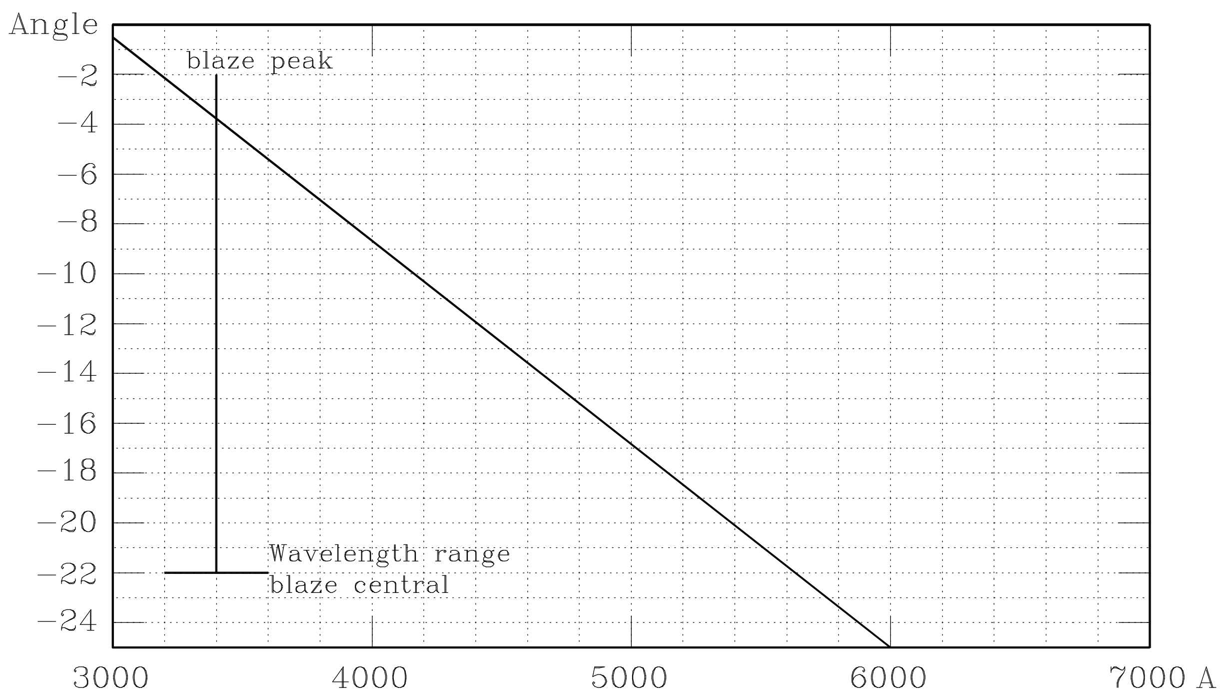


Figure 9.3: Grating 5 – 2nd order

9.1.3 Grating 6

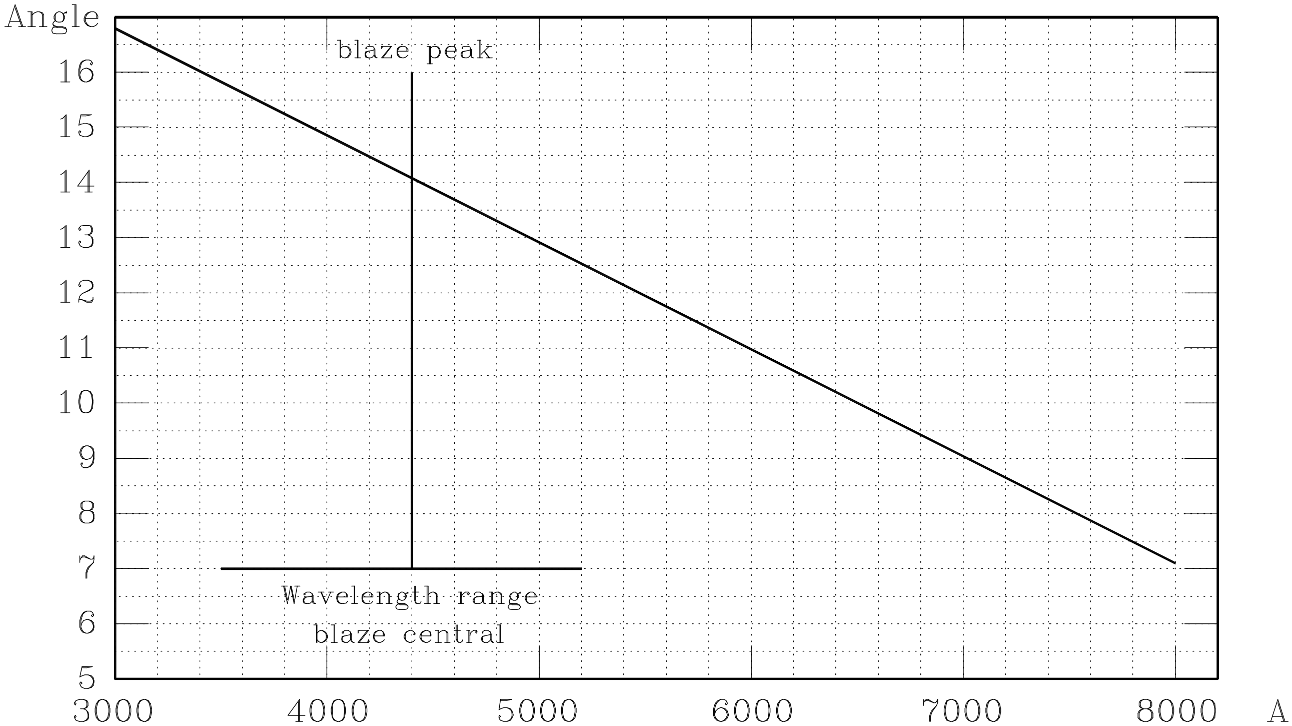


Figure 9.4: Grating 6 – 1st order

9.1.4 Grating 7

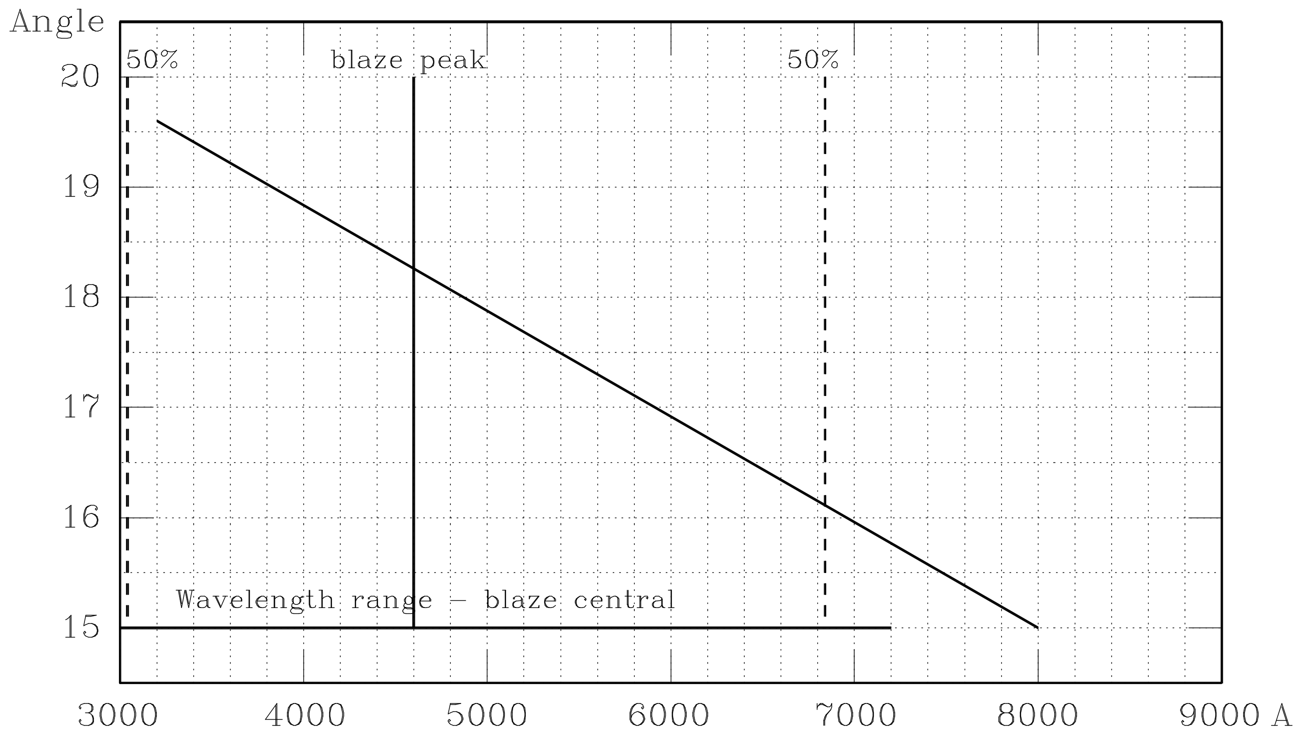


Figure 9.5: Grating 7 – 1st order

When using grating 7, you need to put a BG38 filter in the arc beam (i.e. it has to be inserted in the box on the side of the spectrograph - see Fig 3.7). The BG38 filter reduces the strength of the red lines which otherwise would saturate before you had enough light in the blue end of the arc. If your red arc lines disappear altogether, it probably means the BG39 filter is in the beam instead of the BG38. See Figures for a demonstration of the effect and see the next section – "Order blocking filters" – for representative filter transmission functions.

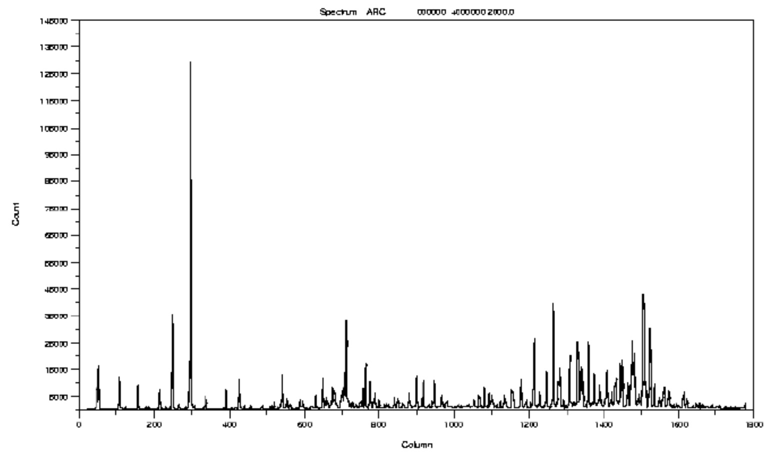


Figure 9.6: CuAr arc for grating 7 (angle 17.2°; $\lambda_c \approx 5700$Å) with a BG38 filter in the **arc** beam.

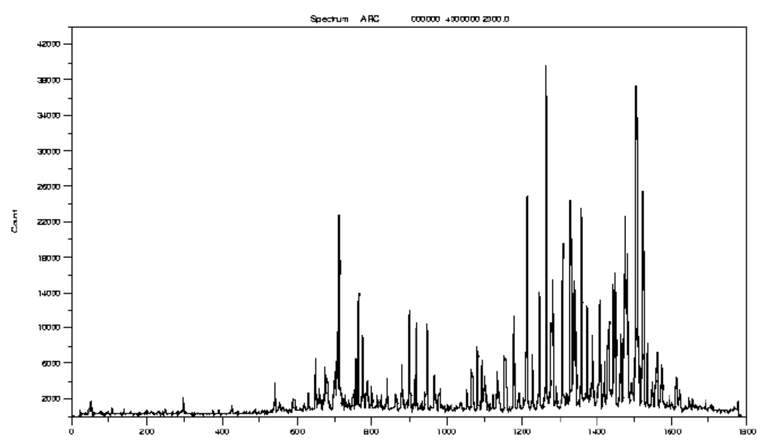


Figure 9.7: CuAr arc for grating 7 (angle 17.2°; $\lambda_c \approx 5700$Å) with a BG39 filter in the **arc** beam. Note the almost total disappearance of the red lines (and the scale difference)

9.1.5 Grating 8

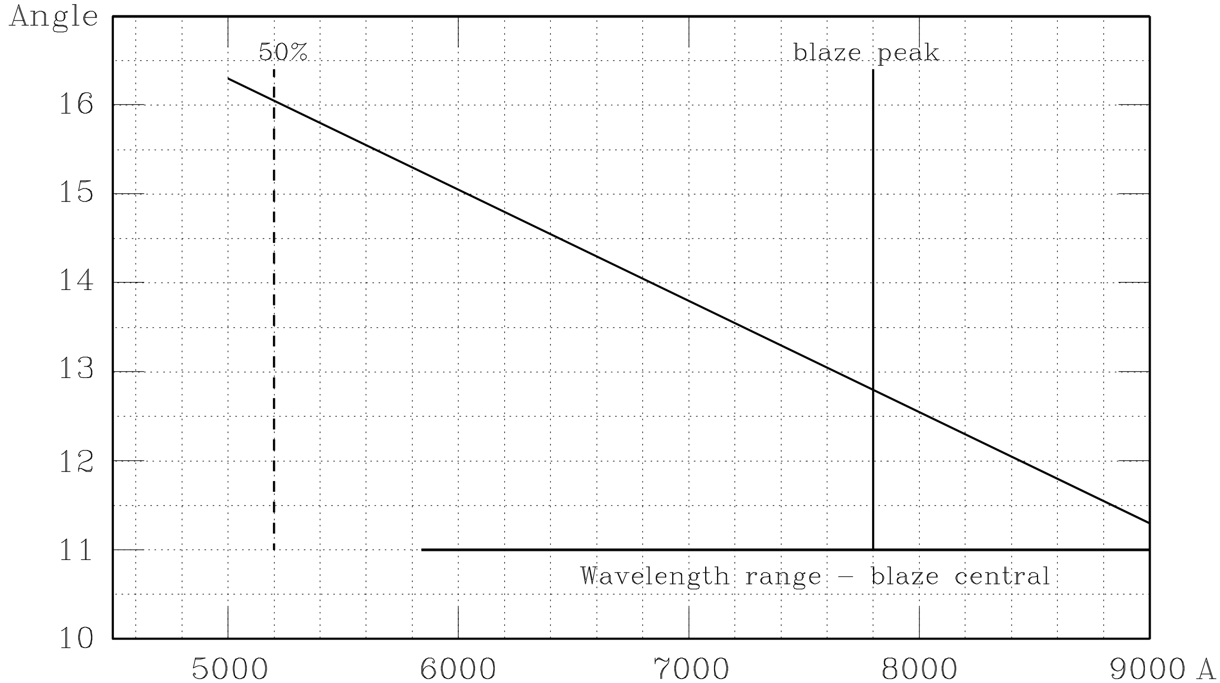


Figure 9.8: Grating 8 – 1st order

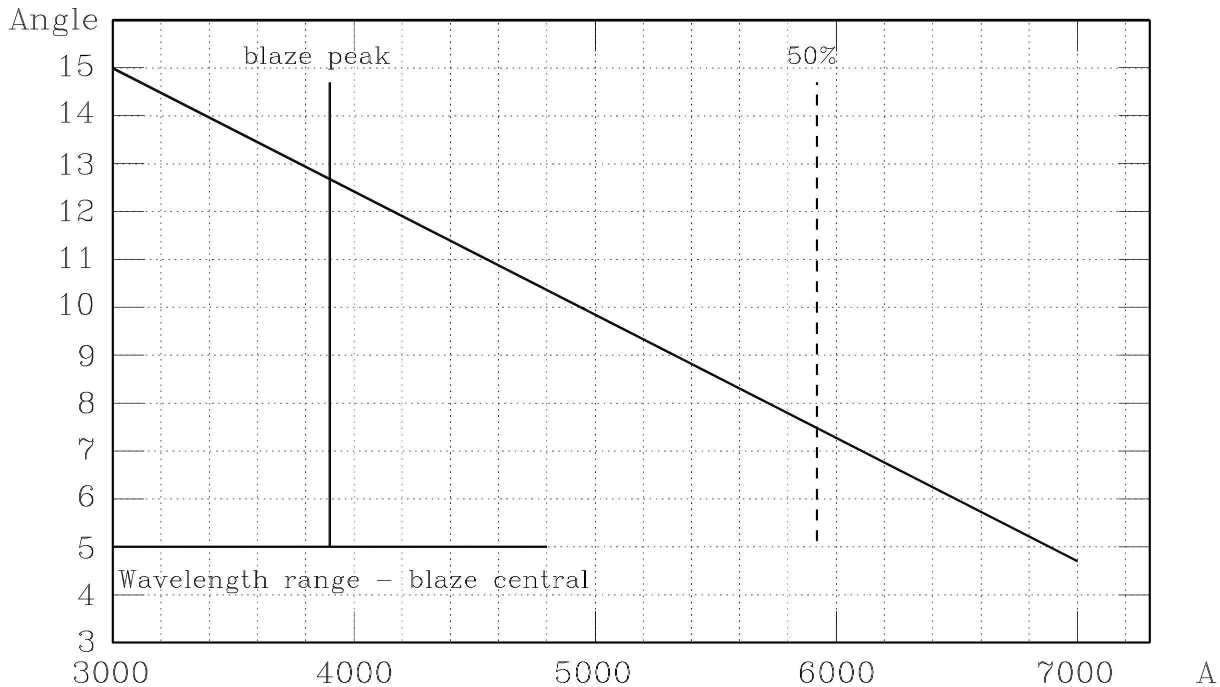


Figure 9.9: Grating 8 – 2nd order

9.1.6 Grating 9

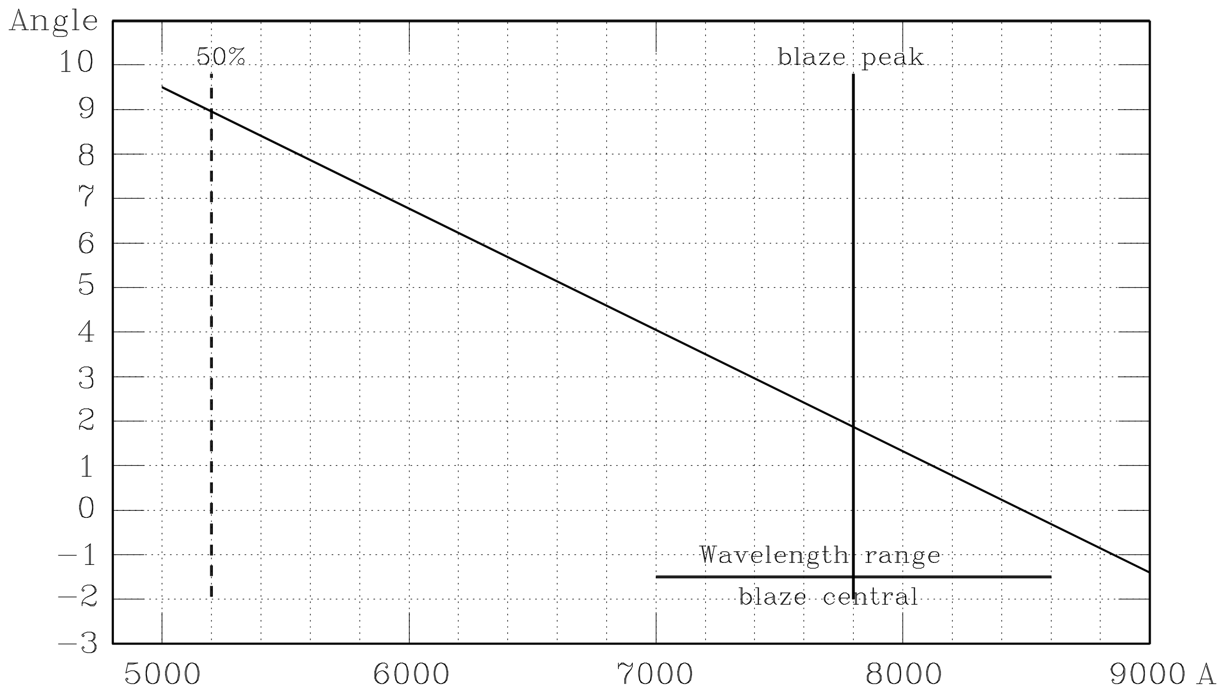


Figure 9.10: Grating 9 – 1st order

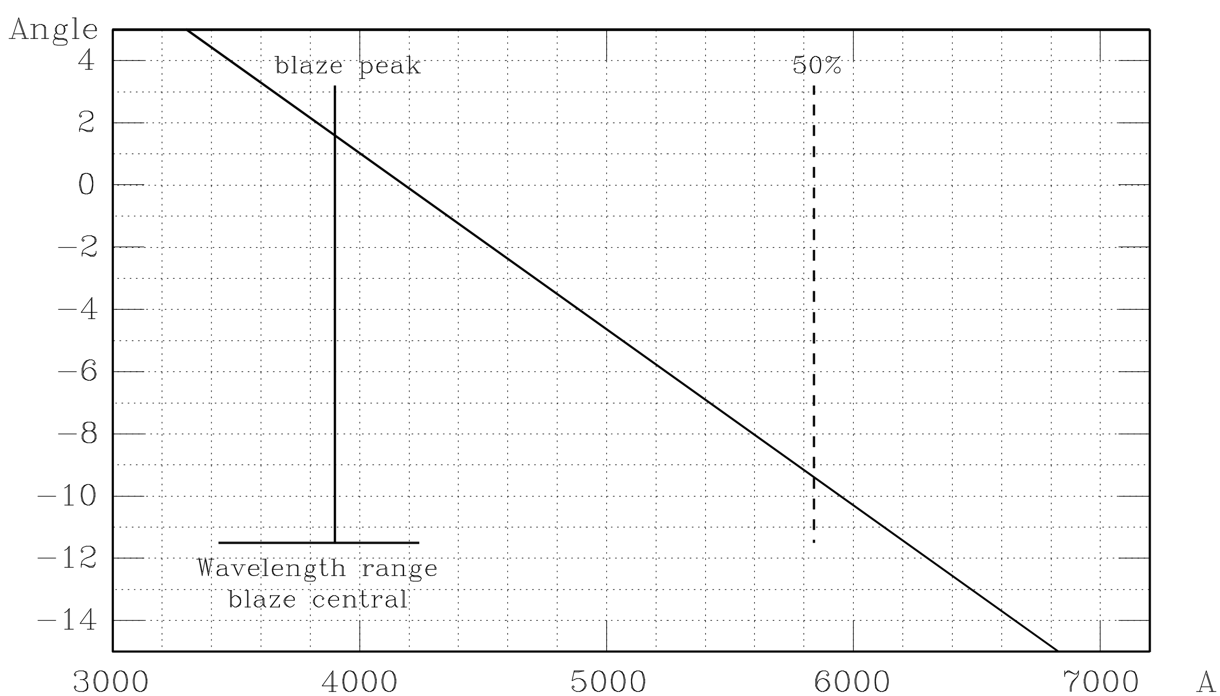


Figure 9.11: Grating 9 – 2nd order

9.1.7 Gratings 10 – 12

I have determined approximate grating angle/wavelength calibrations for gratings 10, 11 and 12 but, as with all settings, you should check these for yourself by looking at the arc line output.
A couple of things to watch out for:

- You will definitely need a GG495 filter in the arc beam redwards of about 8000Å to block out second-order blue lines.
- Unless observing VERY red stars, you will probably also need a GG495 filter in the star/flat beam.
- You might need to experiment a bit with neutral density filters. In the near infrared, some arc lines can be very strong (which is good, because you can use short exposure times for your arcs) but might saturate even with the shortest exposure possible (1 second) if you don't have some ND in the arc beam.
- Even with a Cu-Ar lamp, as you go beyond 9000 Å you start to run out of arc lines completely. There's not much redward of about 9000 Å. And, of course, the CCD sensitivity will be decreasing sharply as well.
- I haven't made any measurements, but just looking at the strengths of the arc lines, it would seem clear (and not surprising) that bluewards of 7000Å (and maybe even redder than that) the grating efficiencies fall off quickly and you should rather use the equivalent "blue" gratings (4, 5, 6 or 7). But you can experiment.

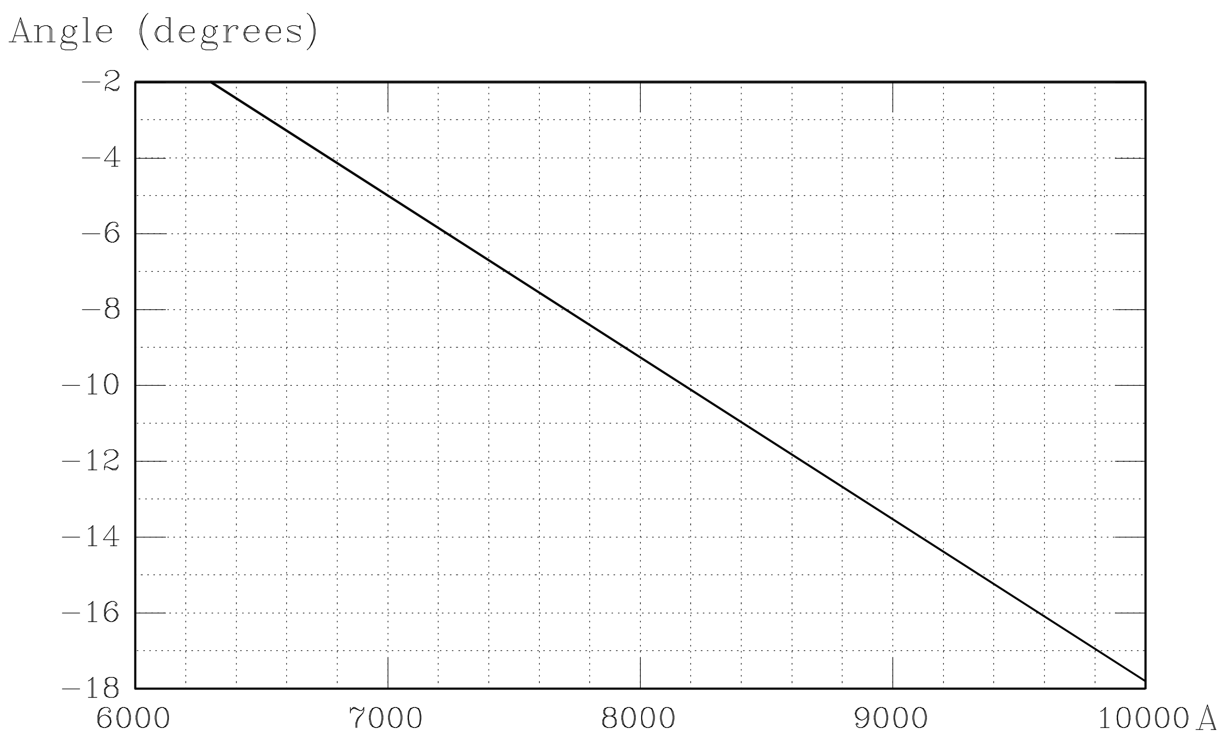


Figure 9.12: Grating 10 – 1st order

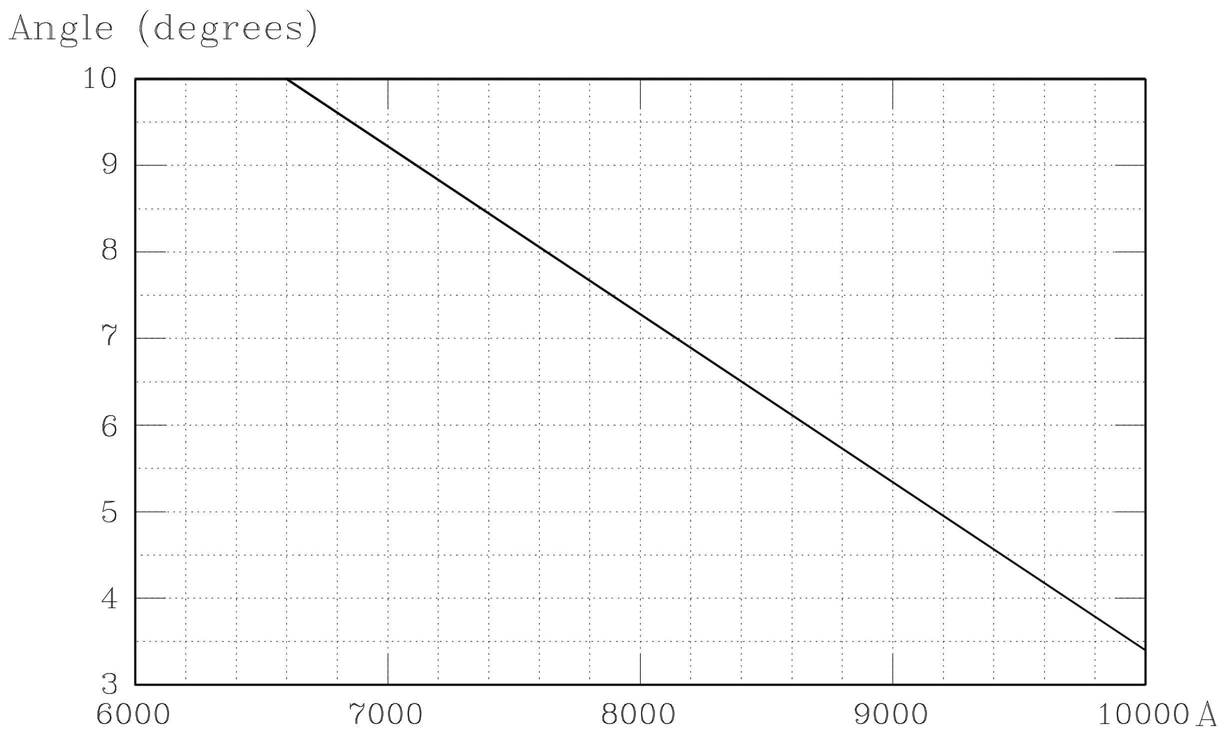


Figure 9.13: Grating 11 – 1st order

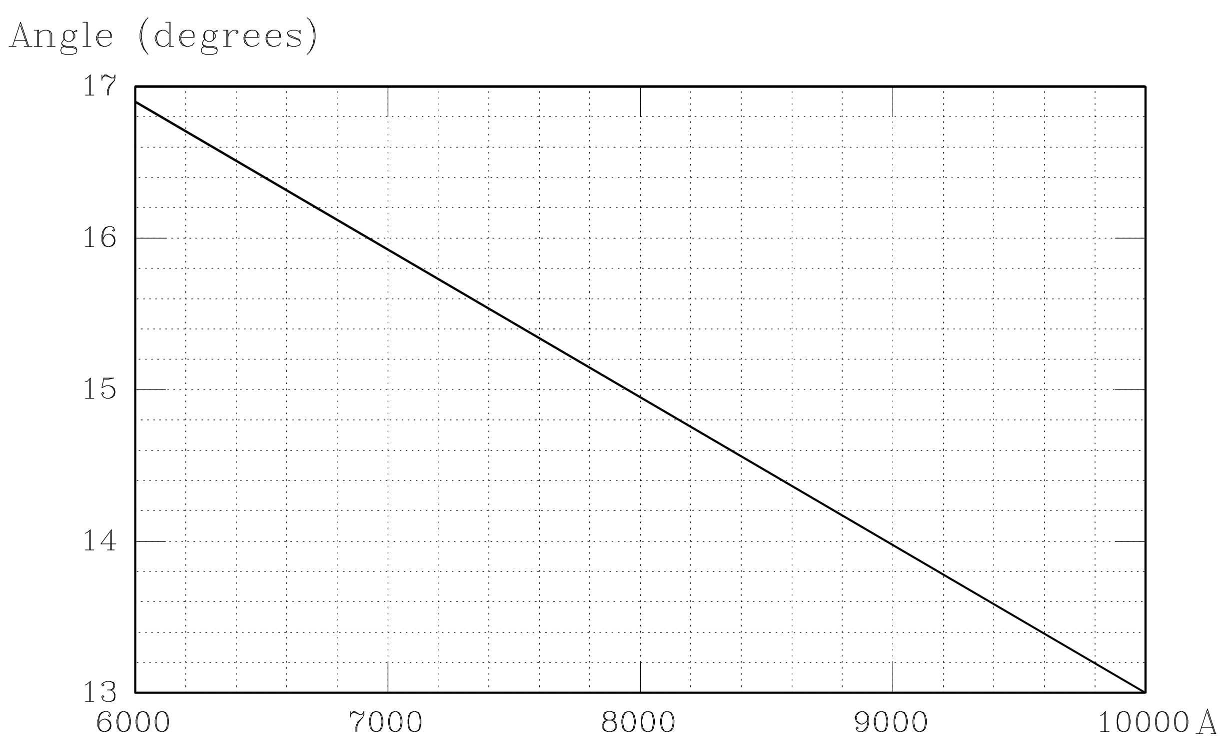


Figure 9.14: Grating 12 – 1st order

9.2 Grating Efficiencies

The attached figure gives relative response curves for most of the available gratings – and in relevant cases for both first and second order. Comparison will enable to observer to get some idea of how the grating efficiency will fall off as the grating is tilted away from the blaze angle.

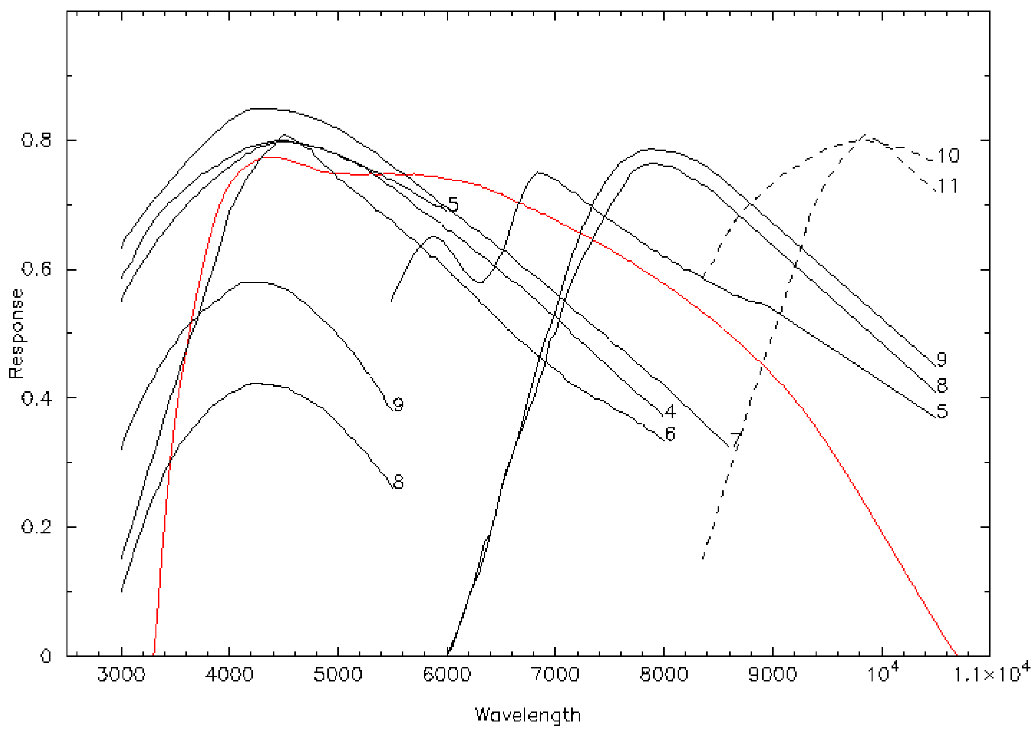


Figure 9.15: Grating efficiencies. Note that some grating efficiencies are displayed for both first and second order. The red line indicates an illustrative efficiency for the CCD detector.

9.3 Order blocking filters

The necessity for filters to prevent order overlap has been mentioned. The first figure shows transmission curves for the filters available.

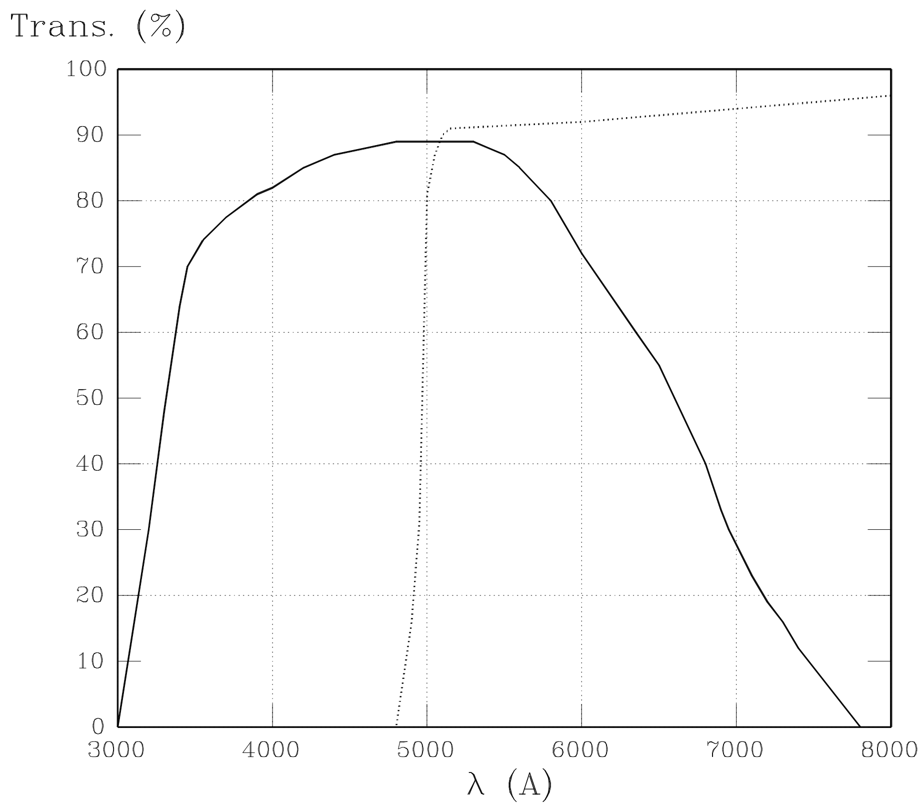


Figure 9.16: Approximate transmission curves for the BG39 (solid line) and GG495 (broken line) filters.

Note that BG39 glass (and similar glasses such as BG38 and BG40) have a "red leak" – though this doesn't become large until above about a micron (10000 Å). You can see in the figures on the next page that the transmission of BG38 isn't completely zero between, say, 7000 and 12000Å.

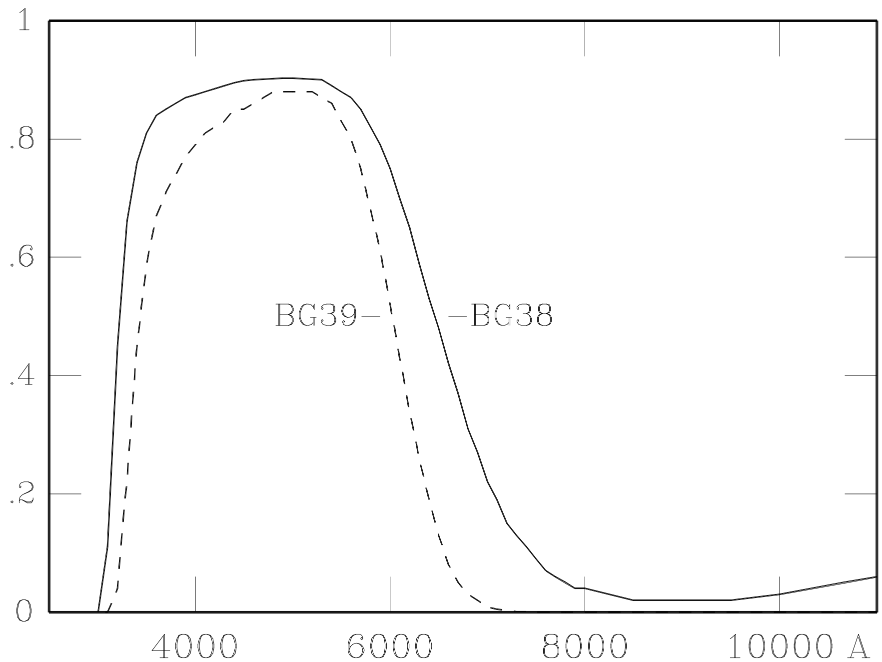


Figure 9.17: Representative transmission functions for Schott BG38 (solid line) and BG39 (broken line) glasses (1mm thickness). Note the "red leak" and the fact that BG39 suppresses red light more effectively than BG38.

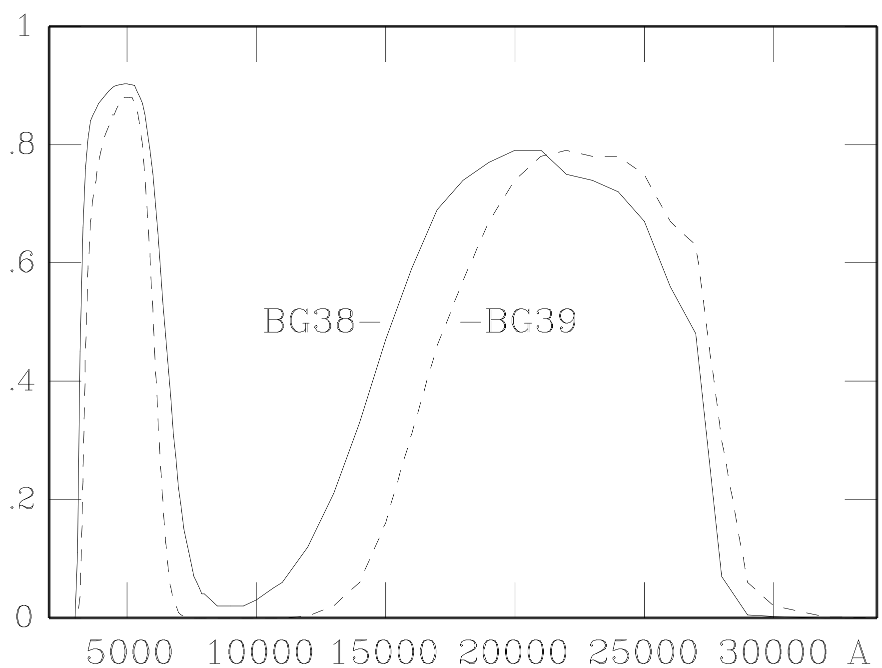


Figure 9.18: Representative transmission functions for Schott BG38 (solid line) and BG39 (broken line) glasses (1mm thickness) over a much larger wavelength range.

9.4 Recommended grating-arc-filter combinations

The following table gives recommended combinations of filters and arc lamps to use for each grating setting. **Note that these assume the central wavelength to be the blaze wavelength.** You should check the filter plots earlier in this section if your chosen central wavelength is significantly different.

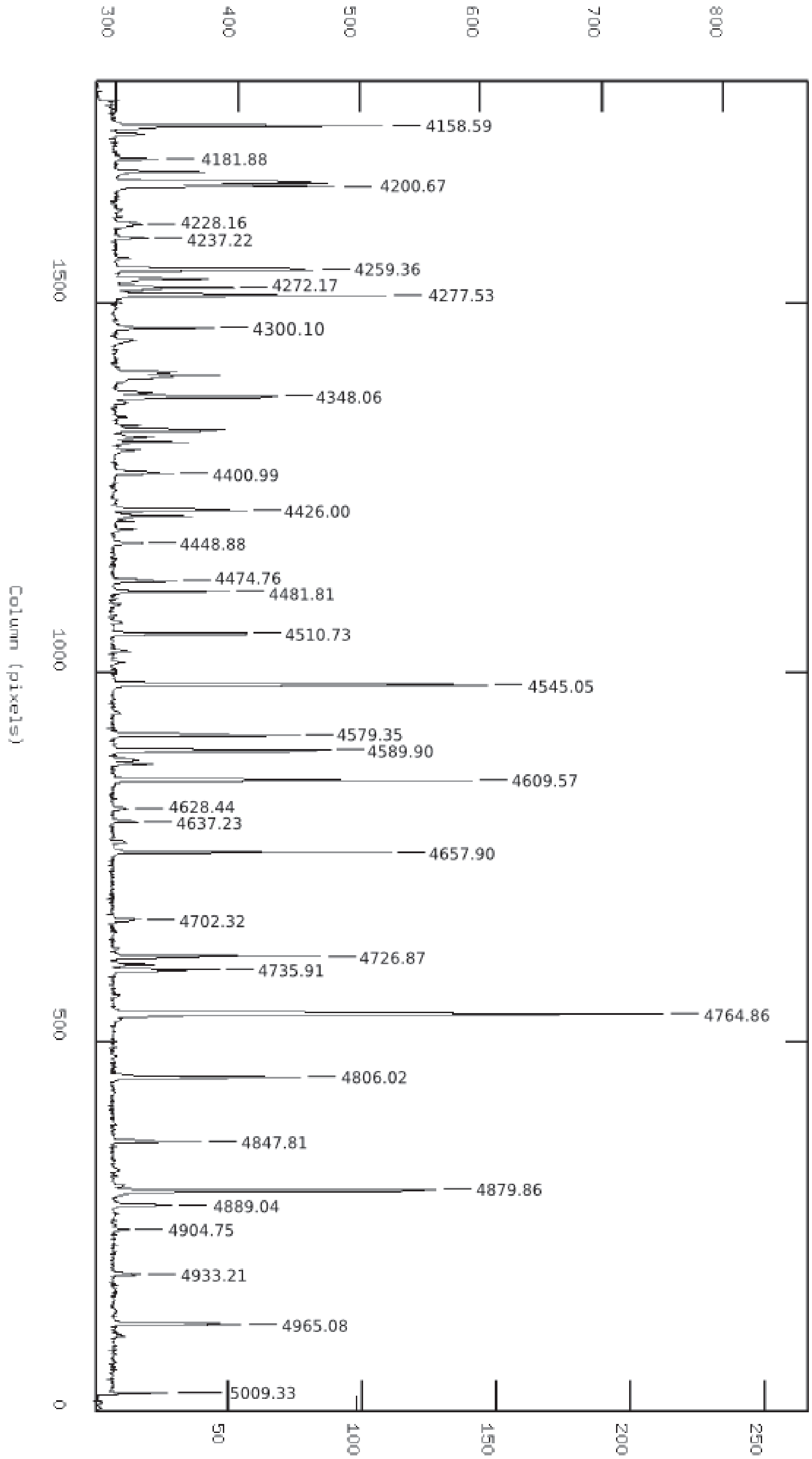
Grating	Order	Central wavelength (Å)	Star filter	Arc lamp	Arc filter
4	1	4600	None	CuAr	None
5	1	6800	GG495	CuNe	GG495 & ND
5	2	3400	BG39	CuAr	BG39
6	1	4600	None	CuAr	None
7	1	4600	None	CuAr	BG38
8	1	7800	GG495	CuAr	GG495
8	2	3900	BG39	CuAr	BG39
9	1	7800	GG495	CuAr	GG495
9	2	3900	BG39	CuAr	BG39
10	1	10000	GG495	CuAr	GG495 (& ND)
11	1	10000	GG495	CuAr	GG495 (& ND)
12	1	10000	GG495	CuAr	GG495 (& ND)

Chapter 10

Comparison arcs

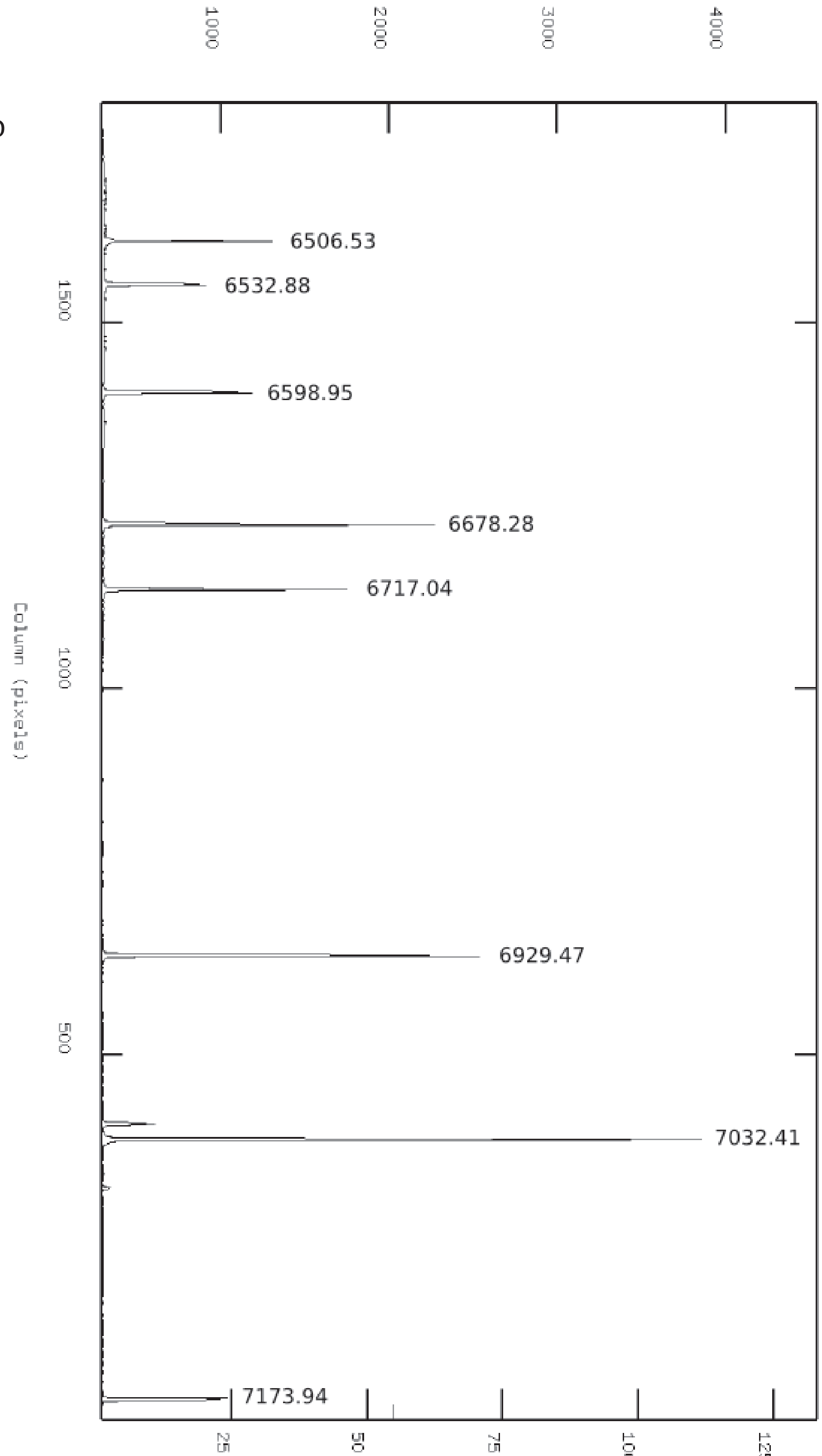
Grating 4, 1st order

λ_c = blaze = 4600Å
θ ~ -4.8°
Lamp: CuAr
Arc filters: None
Recommended t_{exp} = 30s



Grating 5, 1st order

λ_c = blaze = 6800Å
θ ~ -3.5°
Lamp: CuNe
Arc filters: GG495 + ND
Recommended t_{exp} = 1s



Grating 5, 1st order

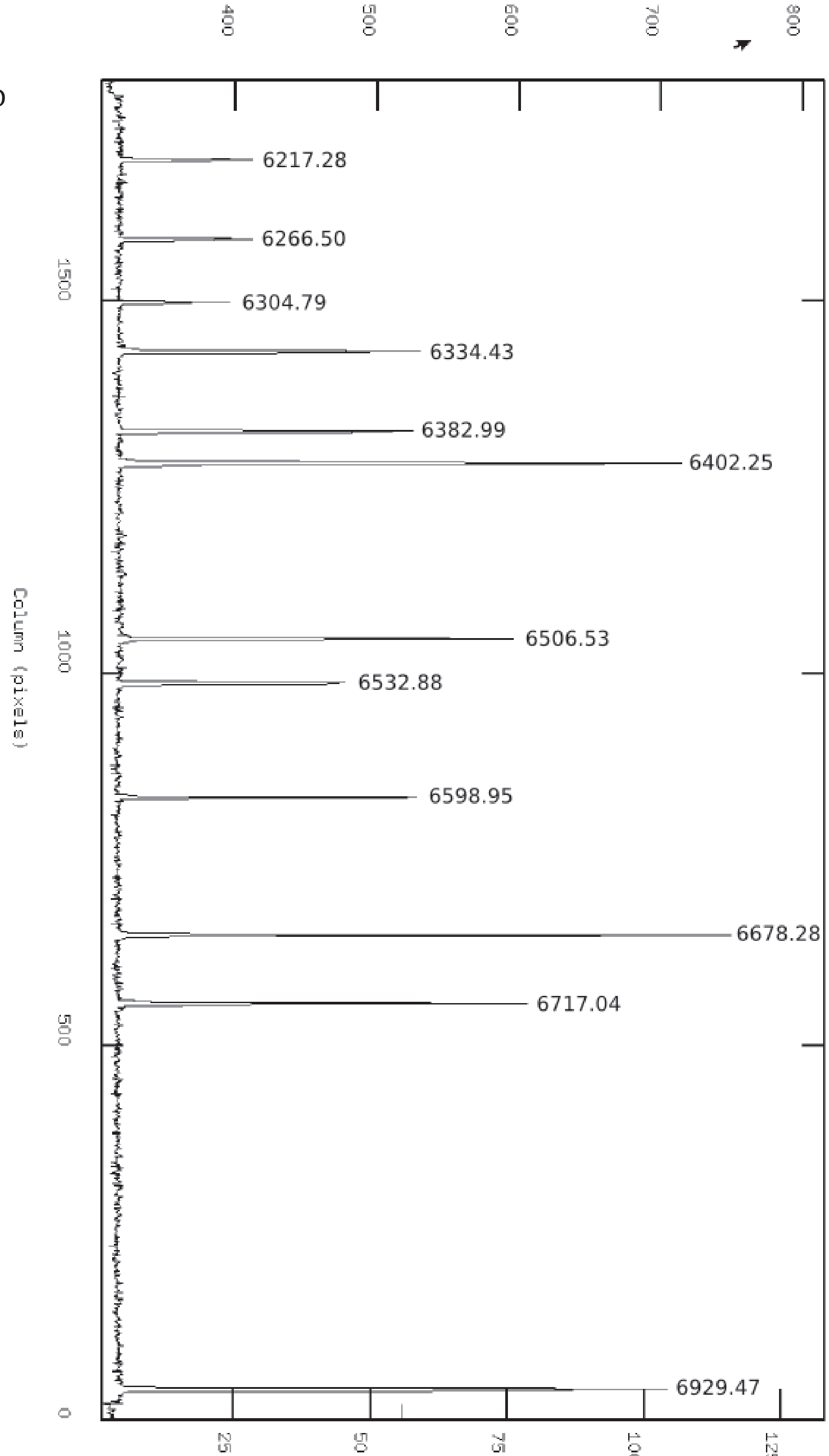
λ_c = Hα

θ ~ -2.6°

Lamp: CuNe

Arc filters: GG495+ND

Recommended t_{exp}=1s



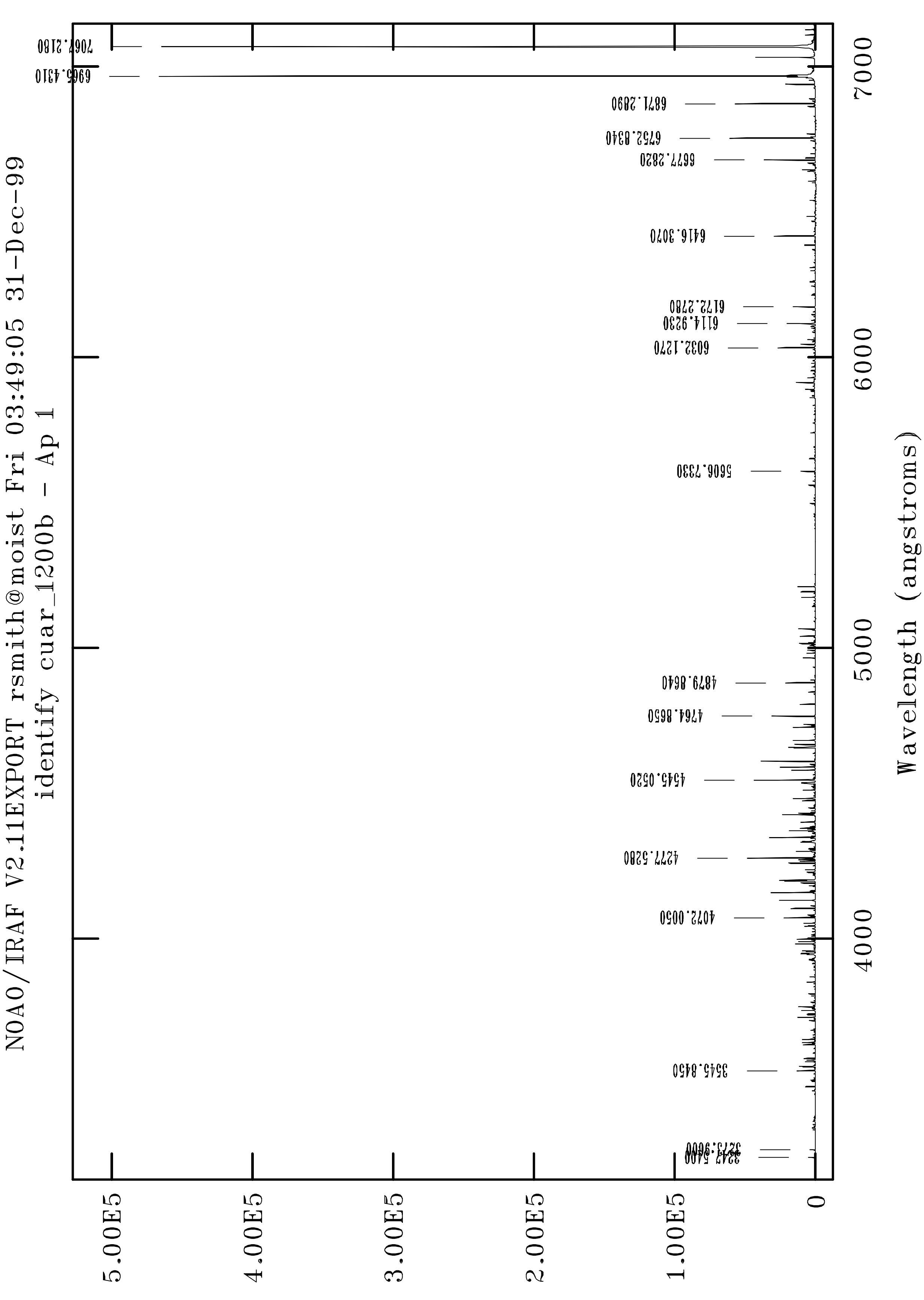
In the following few pages are some sample comparison arc spectra; Copper-Argon (CuAr) and Copper-Neon (CuNe). These are stolen from the Mt Stromlo & Siding Spring web page (specifically for the Double-Beam Spectrograph) see:

$http://www.mso.anu.edu.au/observing/2.3m/DBS/dbs_arcs.html$

However, note that these arcs were produced on a different instrument and might look somewhat different (e.g. different relative line strengths) to the 1.9m Cass spectra.

I still find the old Reticon arc plots (large pages, stapled together and now decidedly ageing; kept in a box file marked "Arc Atlases" in warm room) to be the easiest for line identifications – especially since they are plotted on a rather large scale. **But make sure you know which end of the displayed spectrum is blue/red – recall that you can change this using the ReverseX button in the spectrograph control panel "Plots" (Fig 7.7)**

10.1 Copper-Argon Arcs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identify cuar_1200b - Ap 1
Wavelength (angstroms)
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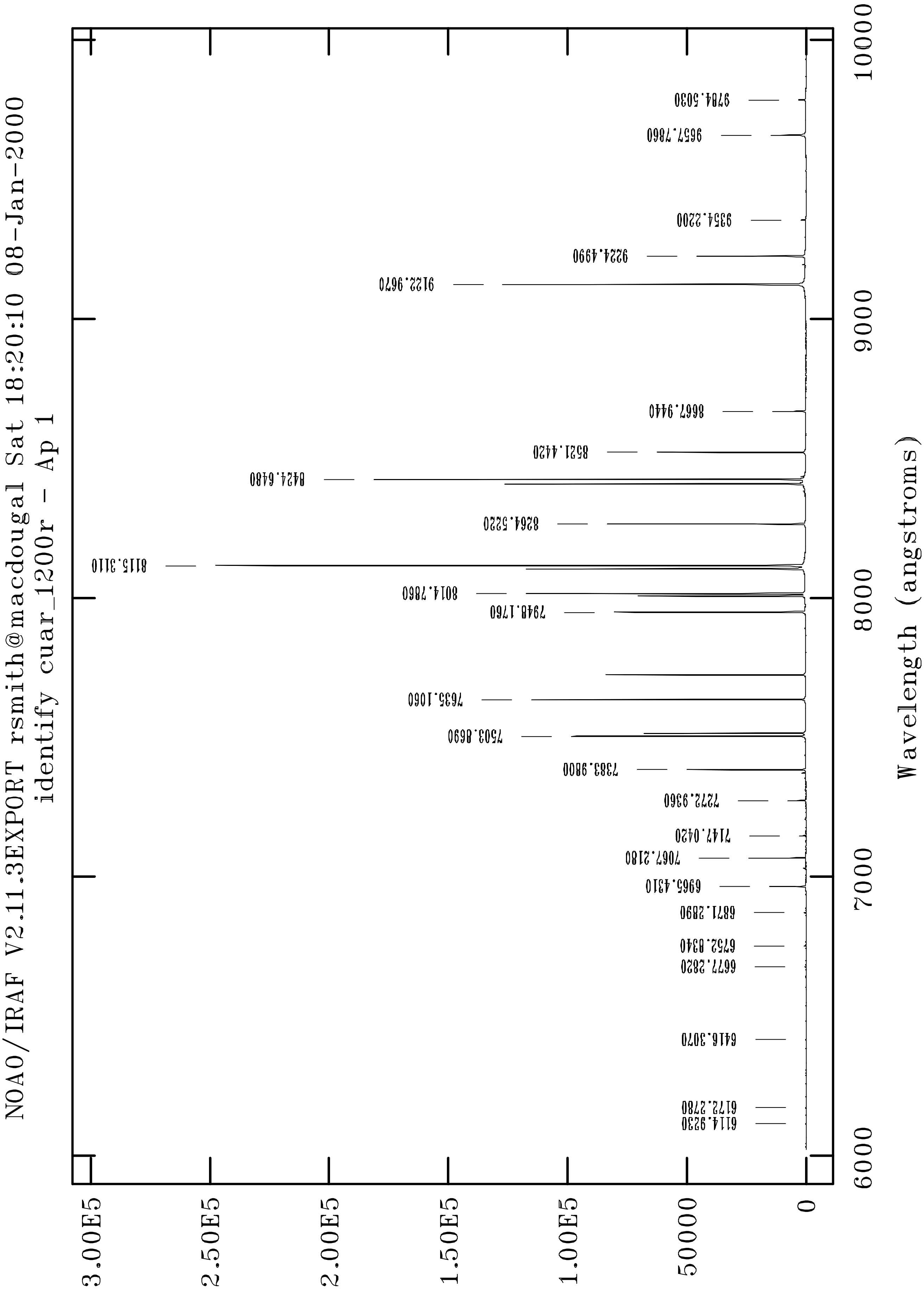
5000
6000
7000
0
1.00E5
2.00E5
3.00E5
4.00E5
5.00E5
3247.5400
3273.9600
3545.8450
4072.0050
4277.5280
4545.0520
4764.8650
4879.8640
5606.7330
6032.1270
6114.9230
6172.2780
6416.3070
6677.2820
6752.8340
6871.2890
6965.4310
7067.2180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Wavelength (angstroms)
6000
7000
8000
9000
10000
0
50000
1.00E5
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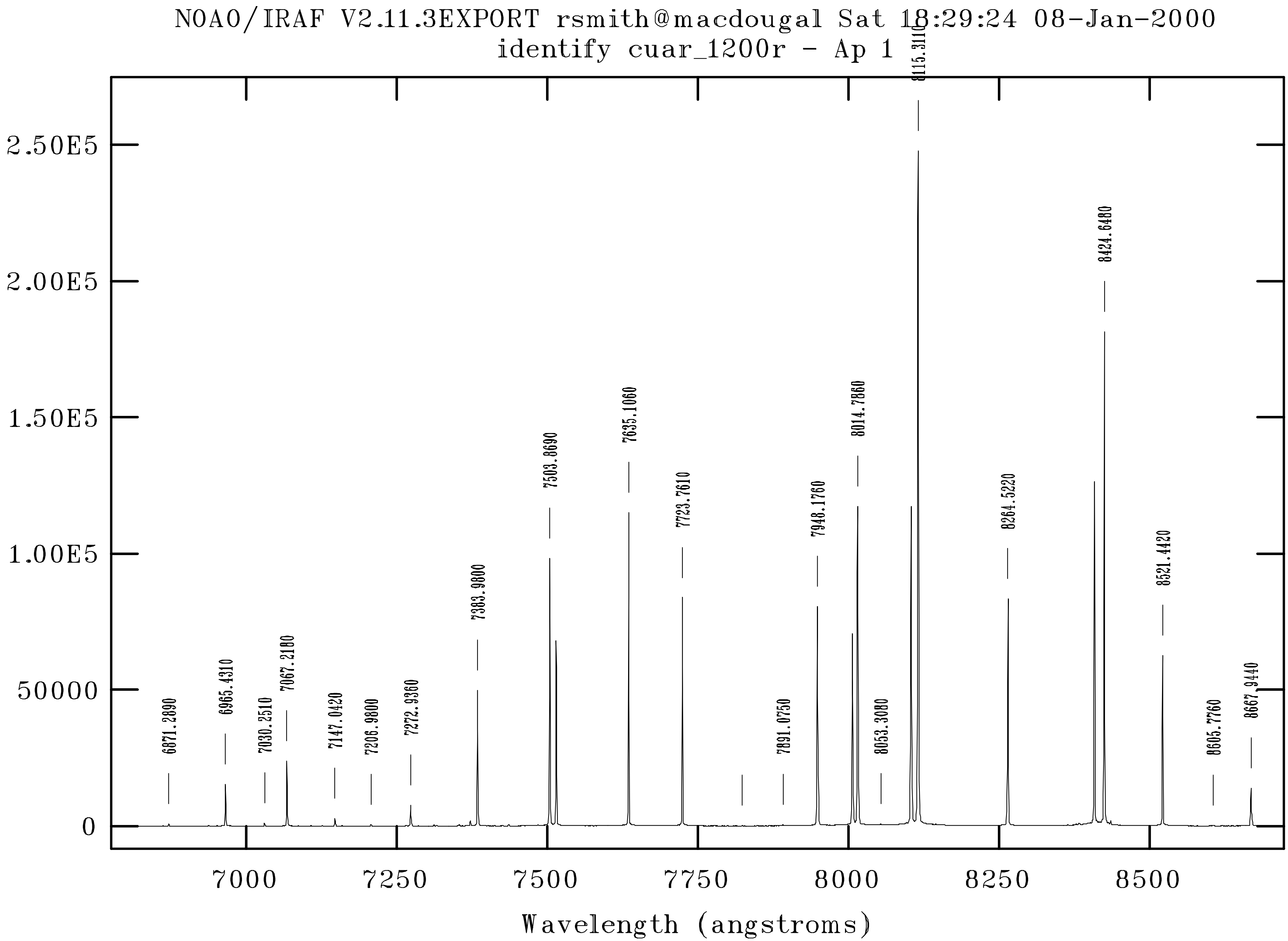
2.00E5
2.50E5
3.00E5
6114.9230
6172.2780
6416.3070
6677.2820
6752.8340
6871.2890
6965.4310
7067.2180
7147.0420
7272.9360
7383.9800
7503.8690
7635.1060
7948.1760
8014.7860
8115.3110
8264.5220
8424.6480
8521.4420
8667.9440
9122.9670
9224.4990
9354.2200
9657.7860
9784.5030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1.50E5
1.00E5
50000
0
7000
7250
7500
7750
8000
8250
8500
Wavelength (angstroms)
6871.2890
6965.4310
7030.2510
7067.2180
7147.0420
7206.9800
7272.9360
7383.9800
7503.8690
7635.1060
7723.7610
7891.0750
7948.1760
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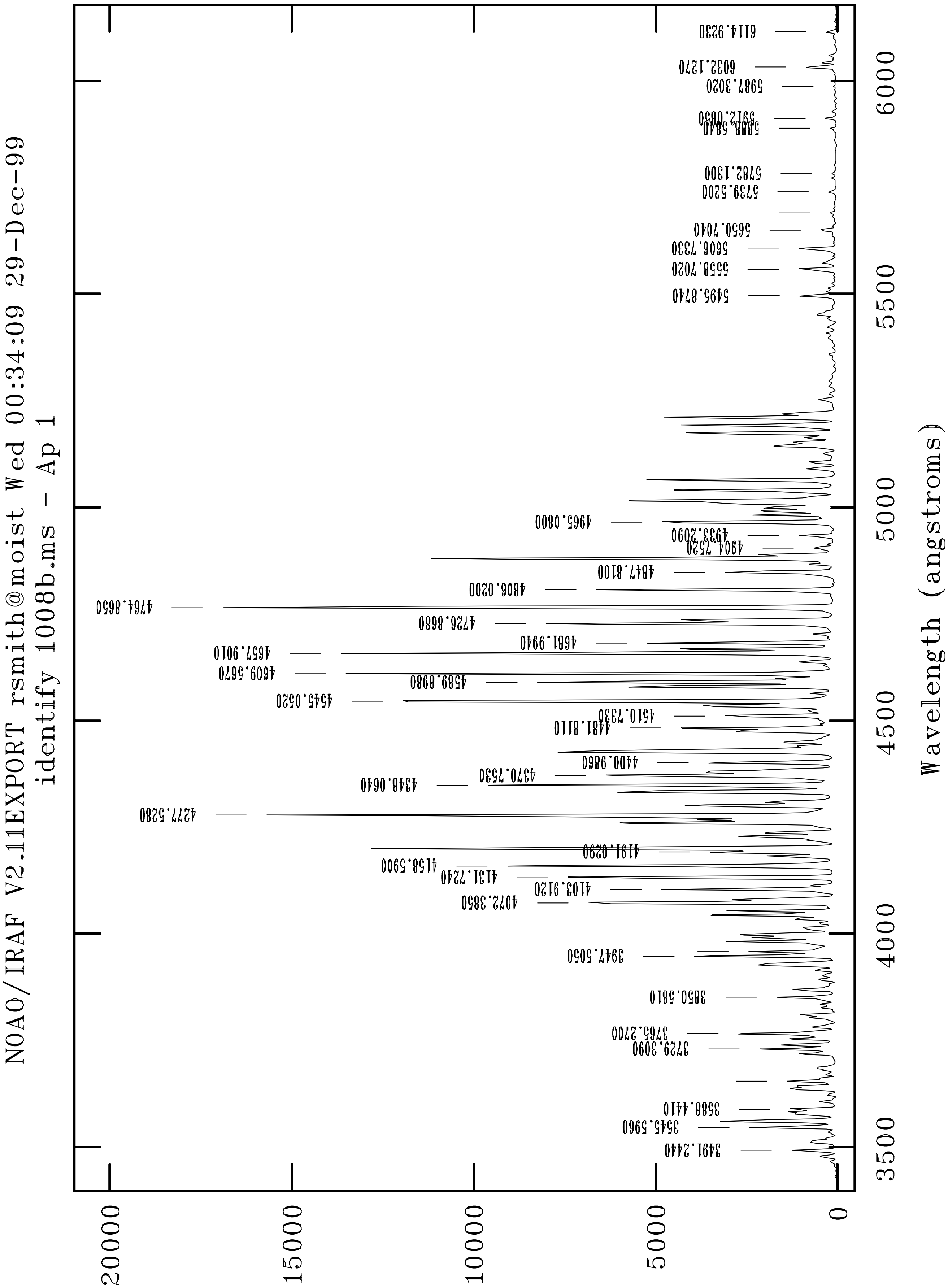
8424.6480
8521.4420
8605.7760
8667.9440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4500
5000
5500
6000
0
5000
10000
15000
20000
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3545.5960
3588.4410
3729.3090
3765.2700
3850.5810
3947.5050
4072.3850
4103.9120
4131.7240
4158.5900
4191.0290
4277.5280
4348.0640
4370.7530
4400.9860
4481.8110
4510.7330
4545.0520
4589.8980
4609.5670
4657.9010
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4904.7520
4933.2090
4965.0800
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5558.7020
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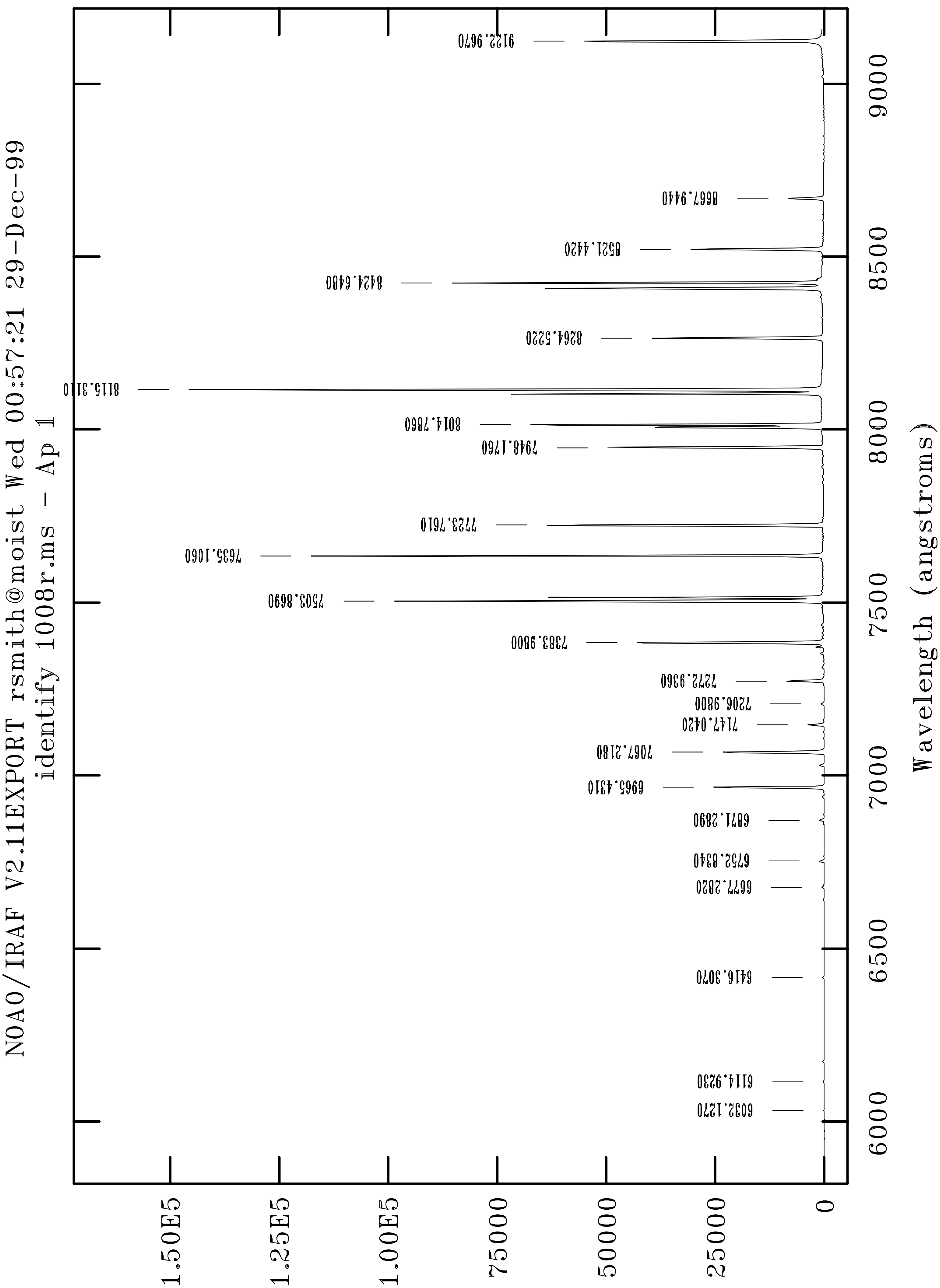
6114.9230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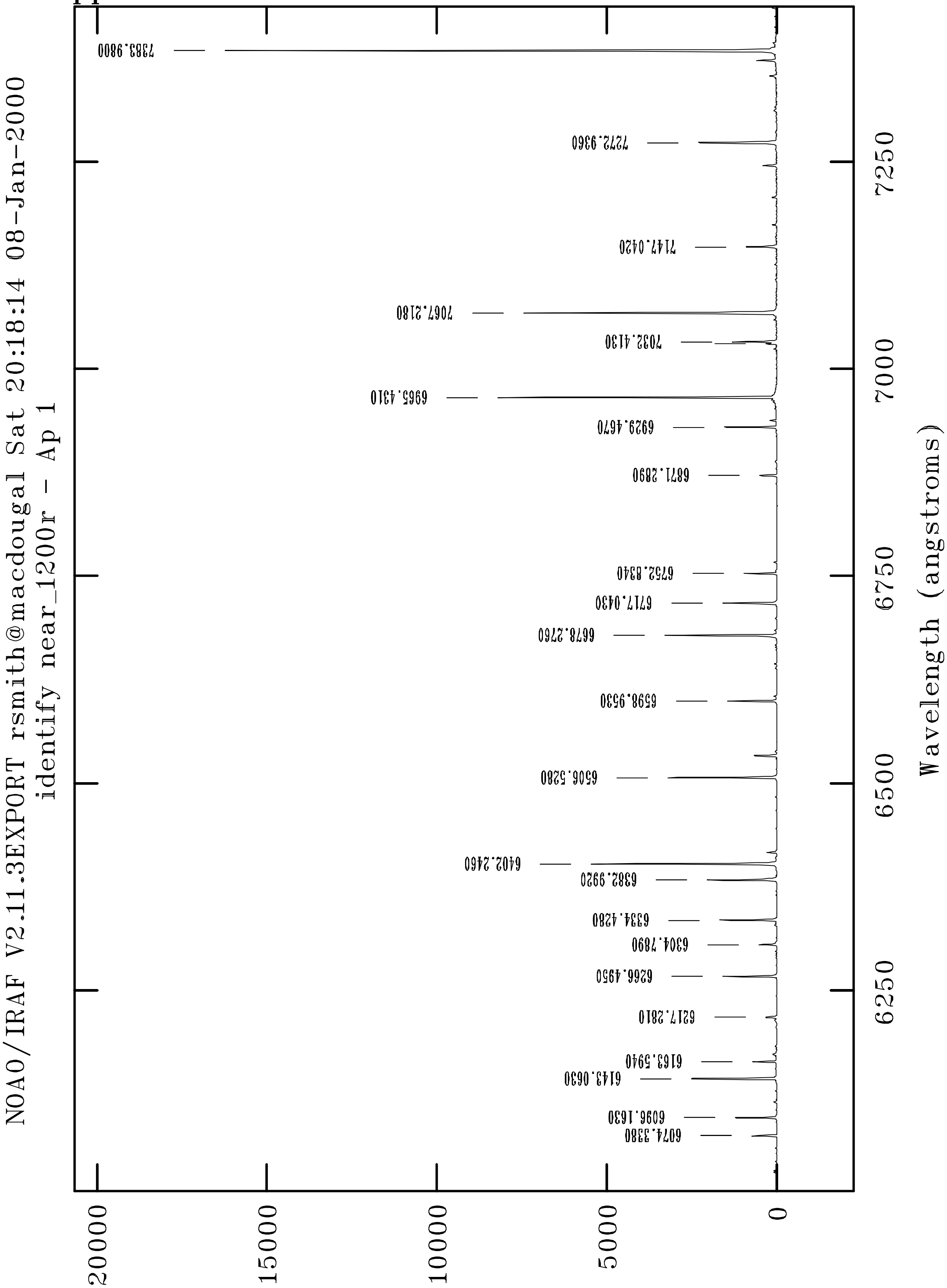
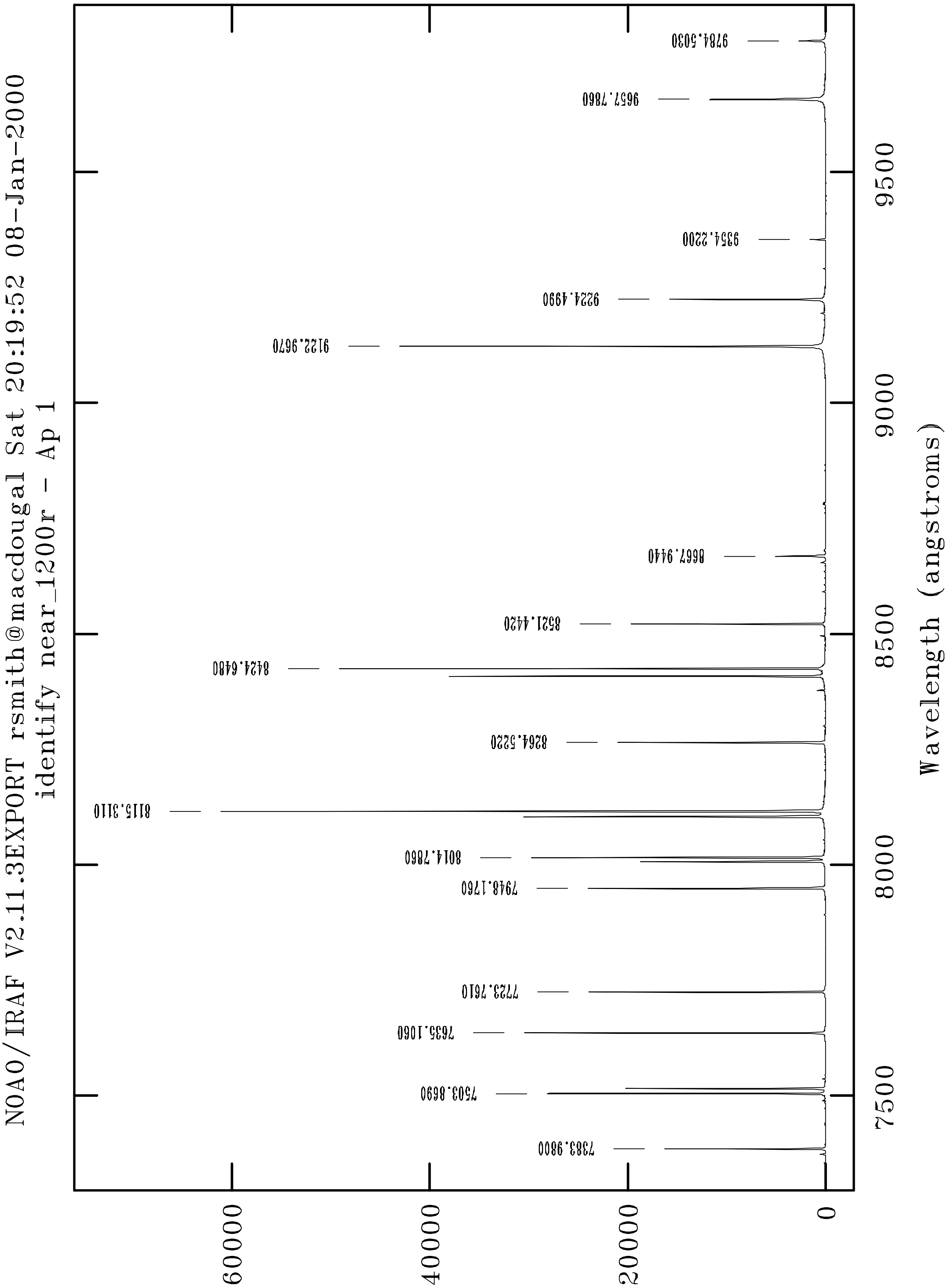
6965.4310
7067.2180
7147.0420
7206.9800
7272.9360
7383.9800
7503.8690
7635.1060
7723.7610
7948.1760
8014.7860
8115.3110
8264.5220
8424.6480
8521.4420
8667.9440
9122.9670
6000
6500
7000
7500
8000
8500
9000
Wavelength (angstroms)
0
25000
50000
75000
1.00E5
1.25E5
1.50E5

10.2 Copper-Neon Arcs





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40000
60000
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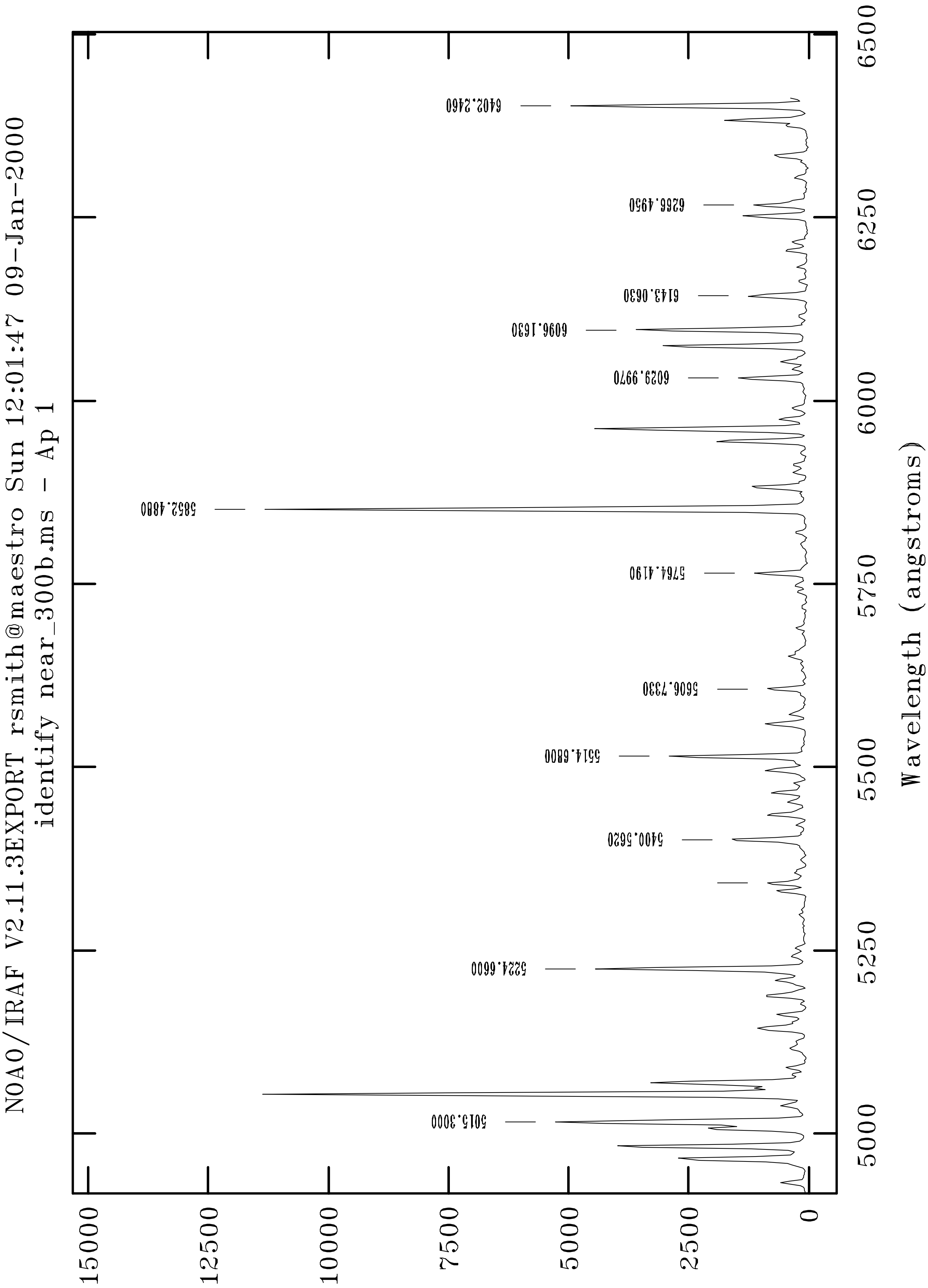
7503.8690
7635.1060
7723.7610
7948.1760
8014.7860
8115.3110
8264.5220
8424.6480
8521.4420
8667.9440
9122.9670
9224.4990
9354.2200
9657.7860
9784.5030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Wavelength (angstroms)
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5500
5750
6000
6250
6500
0
2500
5000
7500
10000
12500
15000
5015.3000
5224.6600
5400.5620
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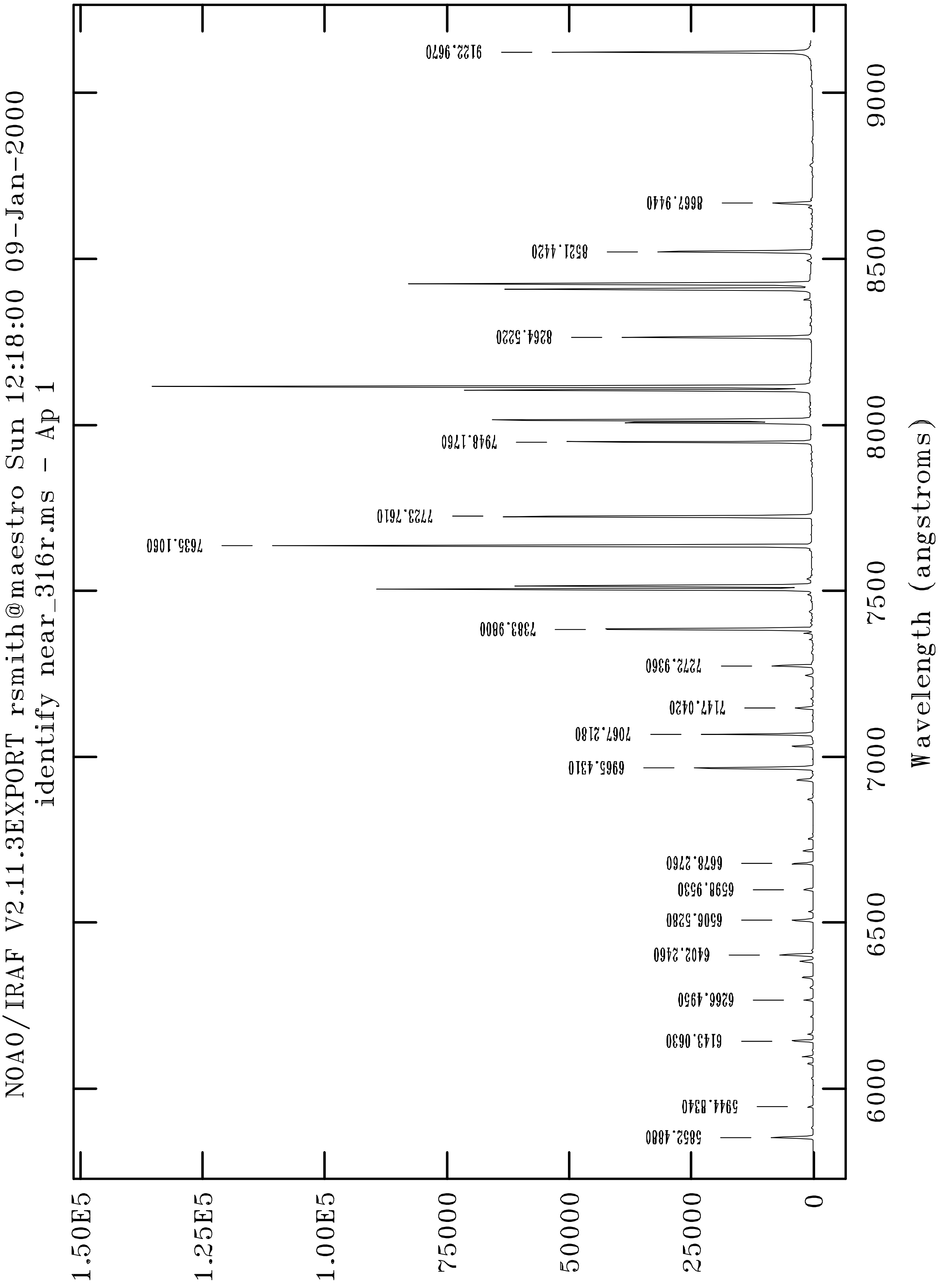
6266.4950
6402.2460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Wavelength (angstroms)
0
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50000
75000
1.00E5
1.25E5
1.50E5
6000
6500
7000
7500
8000
8500
9000
5852.4880
5944.8340
6143.0630
6266.4950
6402.2460
6506.5280
6598.9530
6678.2760
6965.4310
7067.2180
7147.0420
7272.9360
7383.9800
7635.1060
7723.7610
7948.1760
8264.5220
8521.4420
8667.9440
9122.9670

Chapter 11

Spectrophotometric standards

11.1 Introduction

Spectrophotometry might be less than successful with this system. If you want to do absolute spectrophotometry, you should effectively be doing photometry, which you can't do through a narrow slit.

Nonetheless, you can get approximate/relative flux for your spectra if you measure a star which has known flux values, so that you can calibrate counts as a function of wavelength. In this section, I have listed some basic information and finding charts for several stars which are "tertiary" flux standards. These stars were in a booklet which has been kicking around the warmroom for decades (*"Standards for Spectrophotometry"*, stored in the box file labelled "Standards"), but the finding charts are new and were extracted from the very nice ESO web page at *www.eso.org/ observing/standards/spectra/*. Click on *"an RA-Dec sky map with star positions"*, then clicking on any star number will reveal a chart and other useful information. The ESO source contains many more stars than are listed here.

Note that several of these stars have significant proper motions. They have, in at least two cases, moved substantially since the early epoch plates from which the charts were made – this is indicated nicely on the ESO charts.

The UBV photometry was taken from *SAAO Circulars* **13**, *25, (1989)* and the flux plots are from data by Hamuy et al. (*PASP* **104**, *533, 1992* and *PASP* **106**, *566, 1994*)

Since the new TCS was introduced, the x and y values for suitable guide stars have changed. The numbers indicated have been taken from the "guiders" software described in 7.1 and I have been able to check and improve some, but not all, of these. You should find the guide star is obvious in the field after entering the x and y values (using the Go To box) and can then can centre the star using the Move XY box. It would help if you can write in this manual the correct x,y values for a guide star once you have it centred, if it differs significantly from the quoted values.

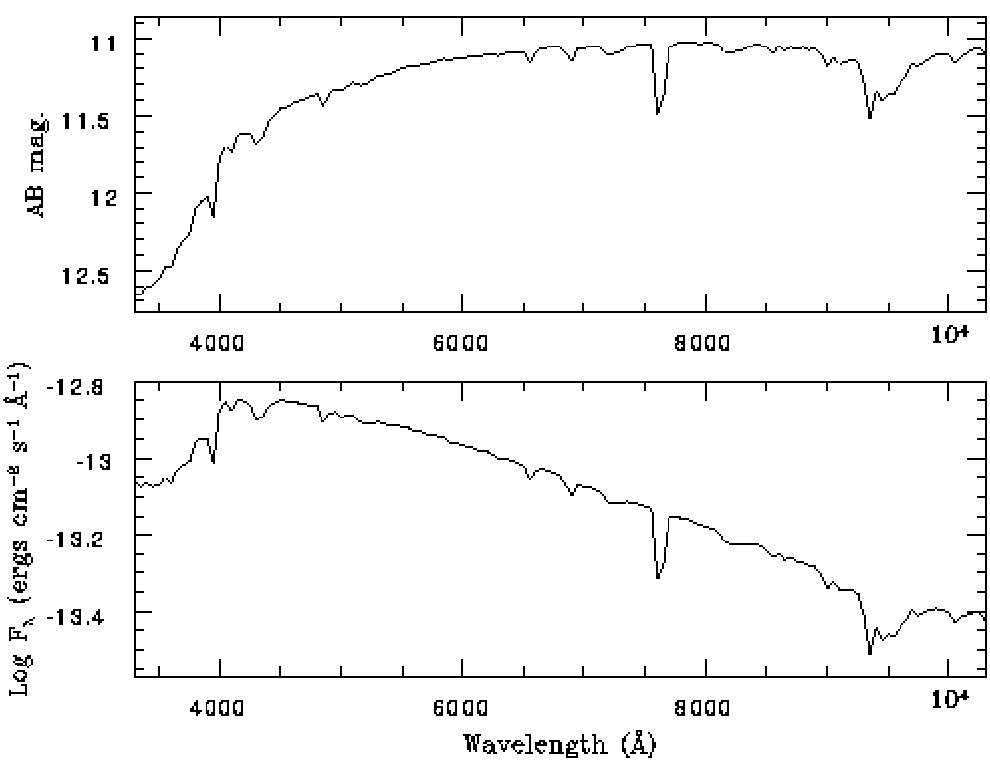
11.2 LTT 377

$\alpha = 00^h\ 41^m\ 46.8^s$ (2000) $\delta = -33^\circ\ 39'\ 08''$

$V = 11.21$ $(B - V) = 0.50$ $(U - B) = -0.06$ Spectrum: sdK

Suggested guide star: x = -10115 y = –4090

10 x 10 arcmin



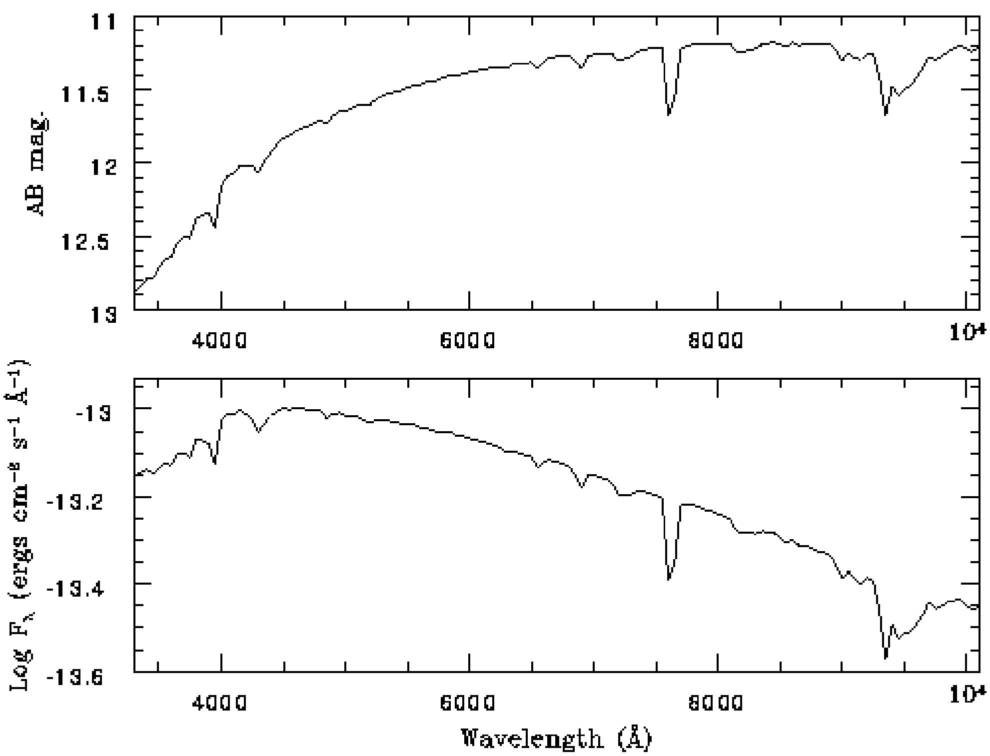
11.3 LTT 1020

$\alpha = 01^h\ 54^m\ 49.7^s$ (2000) $\delta = -27^\circ\ 28'\ 30''$

$V = 11.51$ $(B-V) = 0.57$ $(U-B) = -0.19$ Spectrum: sdG

Suggested guide star: x = –8830 y = 5450

10 x 10 arcmin



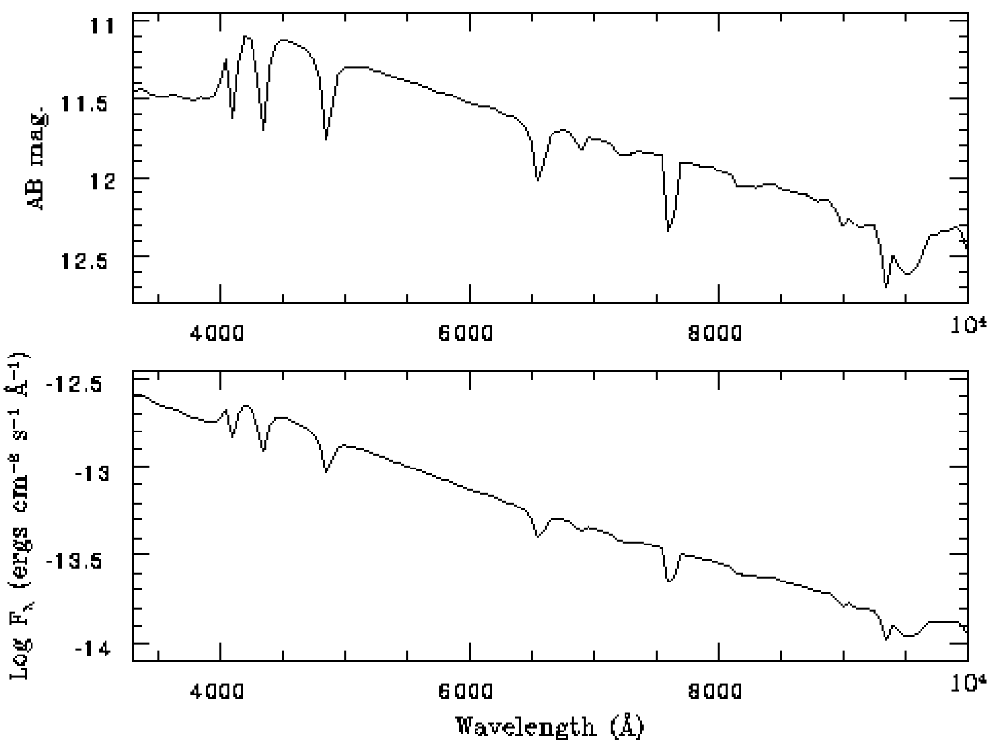
11.4 EG 21

$\alpha = 03^h\ 10^m\ 31.0^s$ (2000) $\delta = -68^\circ\ 36'\ 02''$

$V = 11.38$ $(B-V) = 0.04$ $(U-B) = -0.67$ Spectrum: DA3

Suggested guide star: x = 11720 y = -400

10 x 10 arcmin



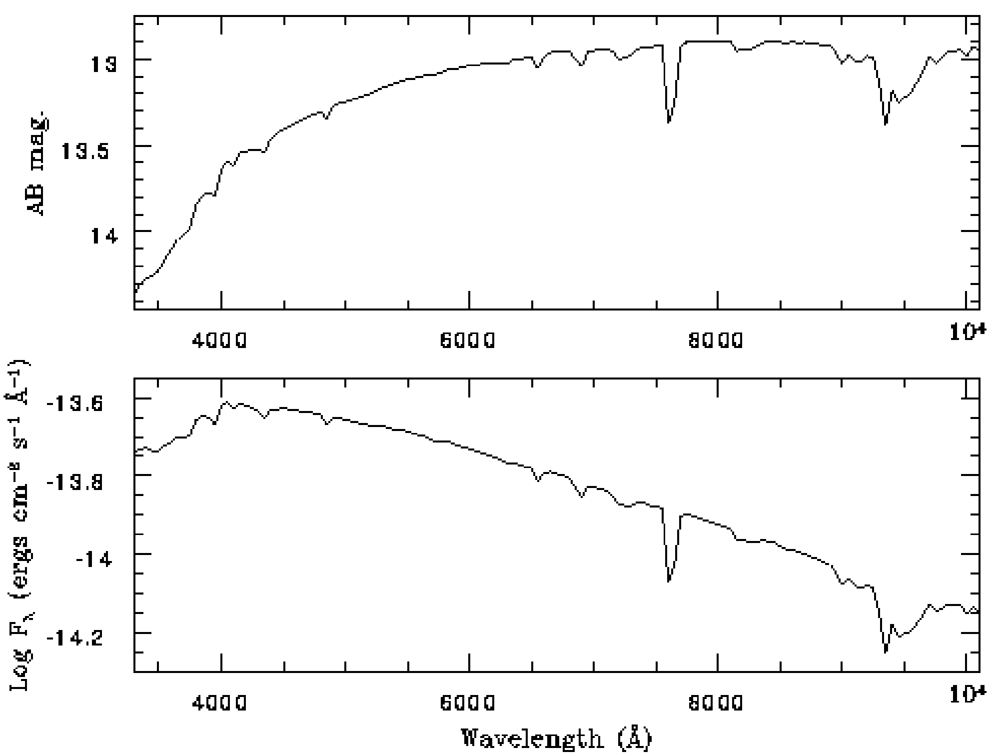
11.5 LTT 1788

$\alpha = 03^h\ 48^m\ 22.2^s$ (2000) $\delta = -39^\circ\ 08'\ 34''$

$V = 13.15$ $(B-V) = 0.48$ $(U-B) = -0.27$ Spectrum: sdG

Suggested guide star: x = –12450 y = –5470

10 x 10 arcmin



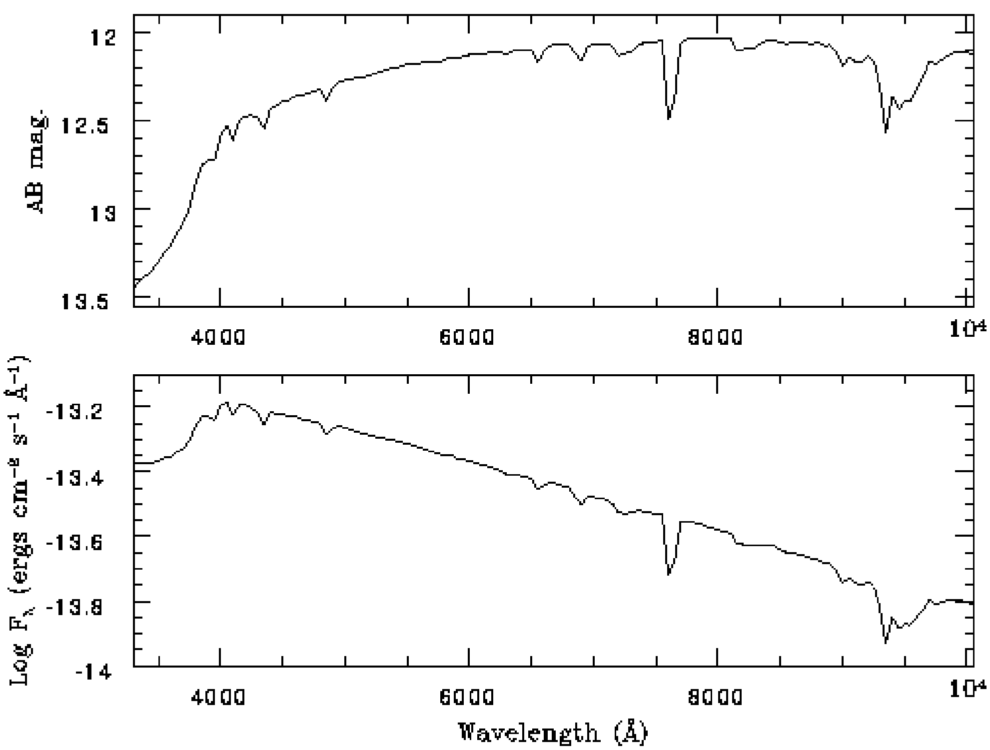
11.6 LTT 2415

$\alpha = 05^h\ 56^m\ 24.3^s$ (2000) $\delta = -27°\ 51'\ 29''$

$V = 12.21$ $(B - V) = 0.41$ $(U - B) = -0.20$ Spectrum: sdG

Suggested guide star: x = –6535 y = –8470

10 x 10 arcmin

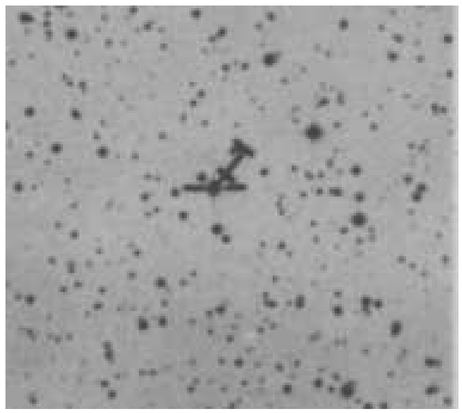


11.7 LTT 3218

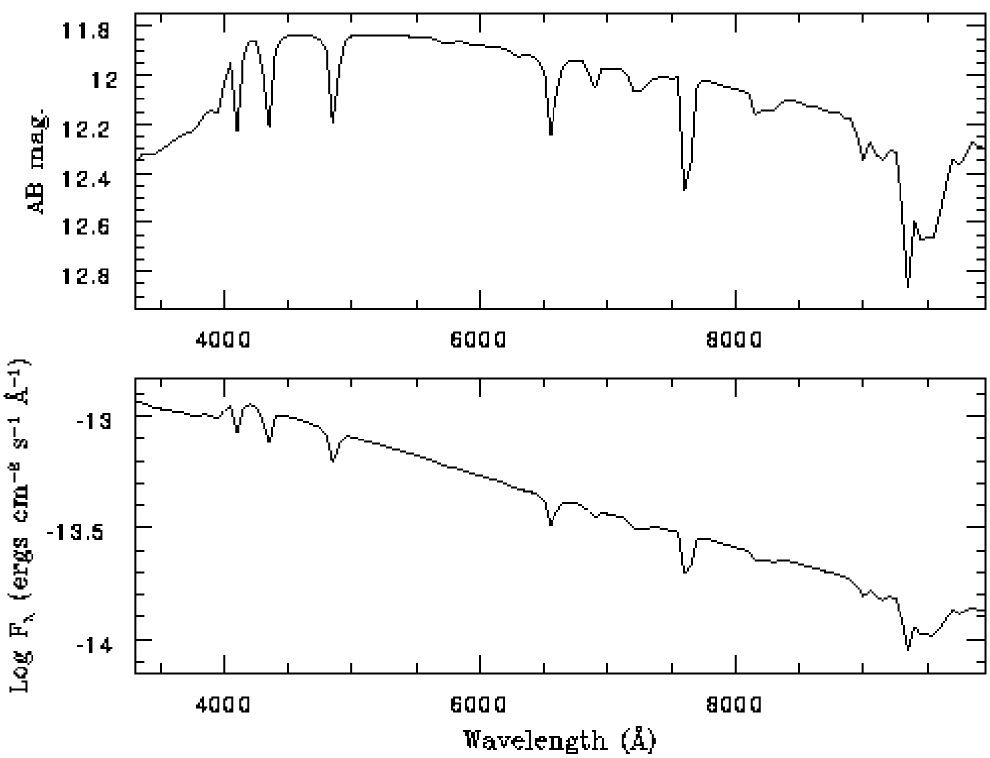
$\alpha = 08^h\ 41^m\ 34.1^s$ (2000) $\delta = -32^\circ\ 57'\ 00''$

$V = 11.85$ $(B-V) = 0.23$ $(U-B) = -0.53$ Spectrum: DA

Suggested guide star: x = –7400 y = –7570



7 x 7 arcmin (Note substantial proper motion)



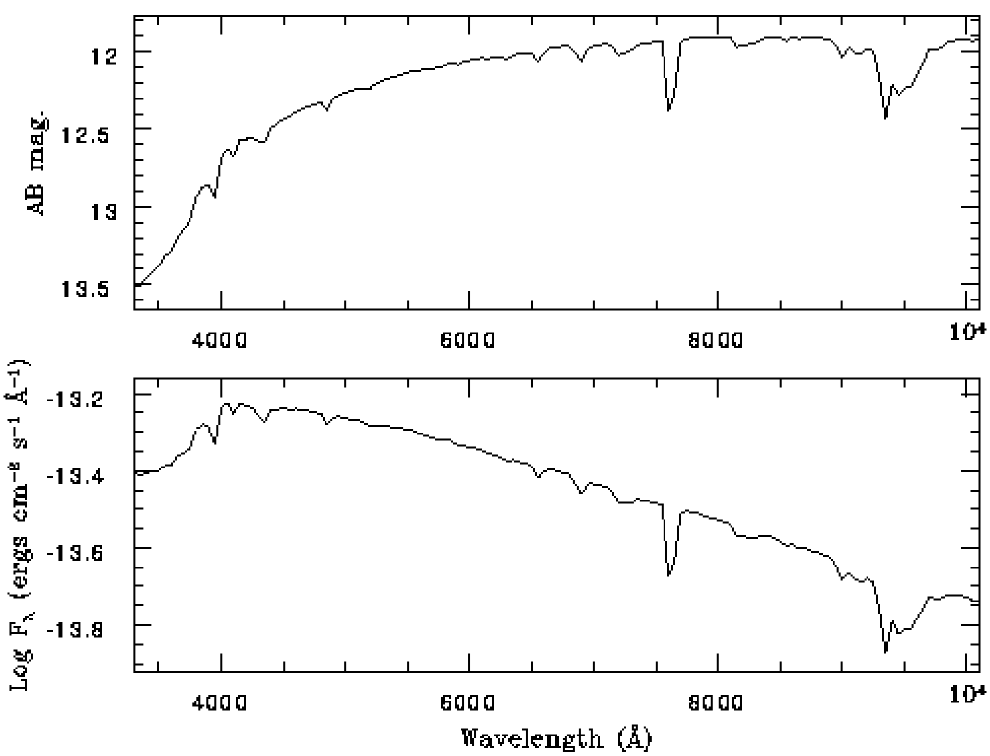
11.8 LTT 3864

$\alpha = 10^h\ 32^m\ 13.9^s$ (2000) $\delta = -35°\ 37'\ 42''$

$V = 12.16$ $(B - V) = 0.50$ $(U - B) = -0.16$ Spectrum: sdF

Suggested guide star: x = –10814 y = –8215

10 x 10 arcmin



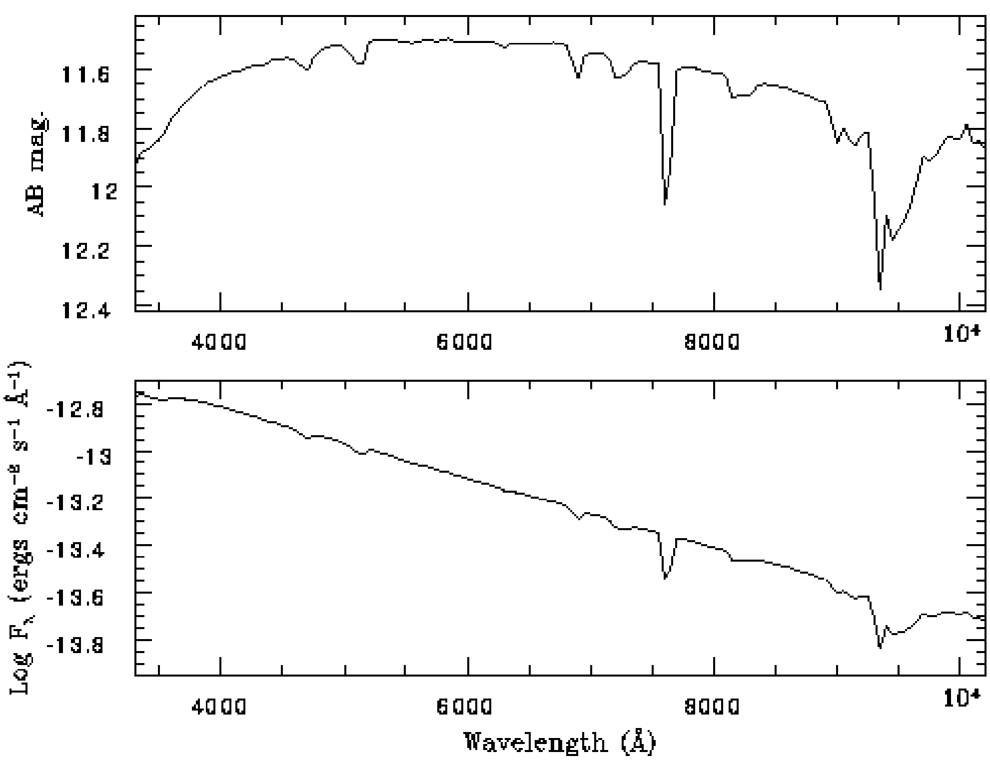
11.9 LTT 4364

$\alpha = 11^h\ 45^m\ 37.7^s$ (2000) $\delta = -64^\circ\ 50'\ 25''$

$V = 11.51$ $(B-V) = 0.19$ $(U-B) = -0.67$ Spectrum: DQ6

Suggested guide star: x = –2840 y = 10600

7 x 7 arcmin (Note substantial proper motion)

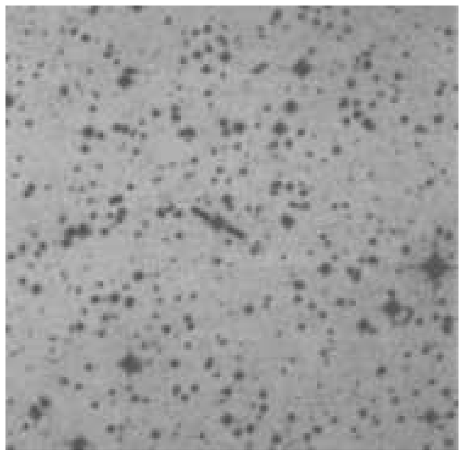


11.10 LTT 4816

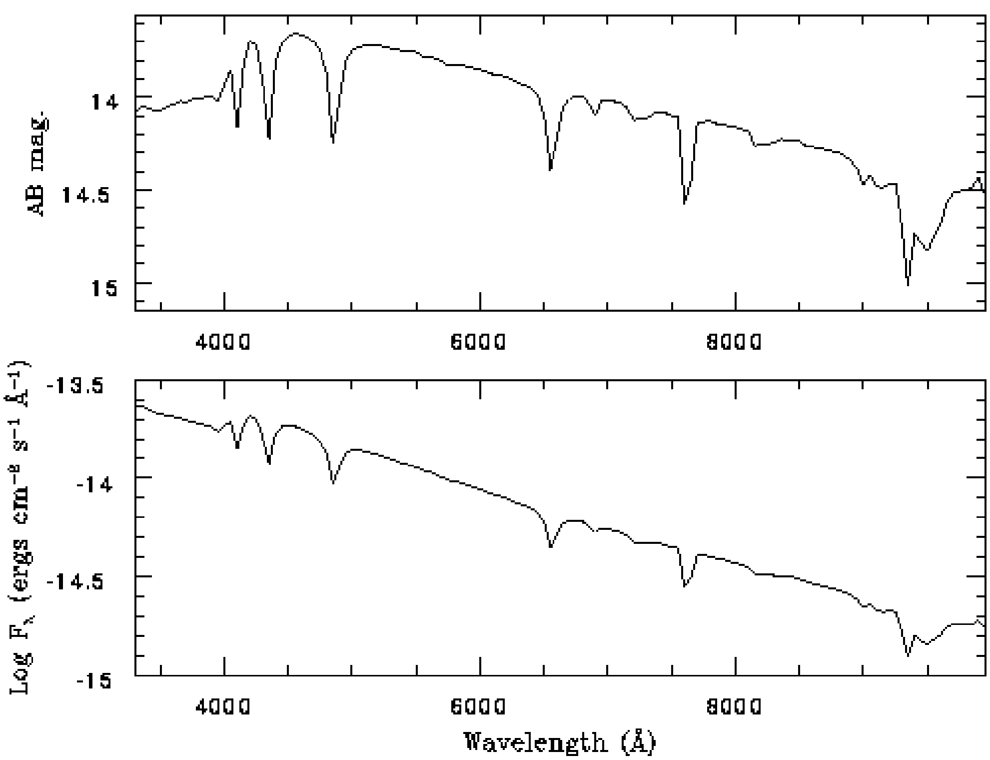
$\alpha = 12^h\ 38^m\ 50.9^s$ (2000) $\delta = -49^\circ\ 47'\ 59''$

$V = 13.78$ $(B - V) = 0.20$ $(U - B) = -0.65$ Spectrum: DA6

Suggested guide star: x = 9700 y = 1490



7 x 7 arcmin



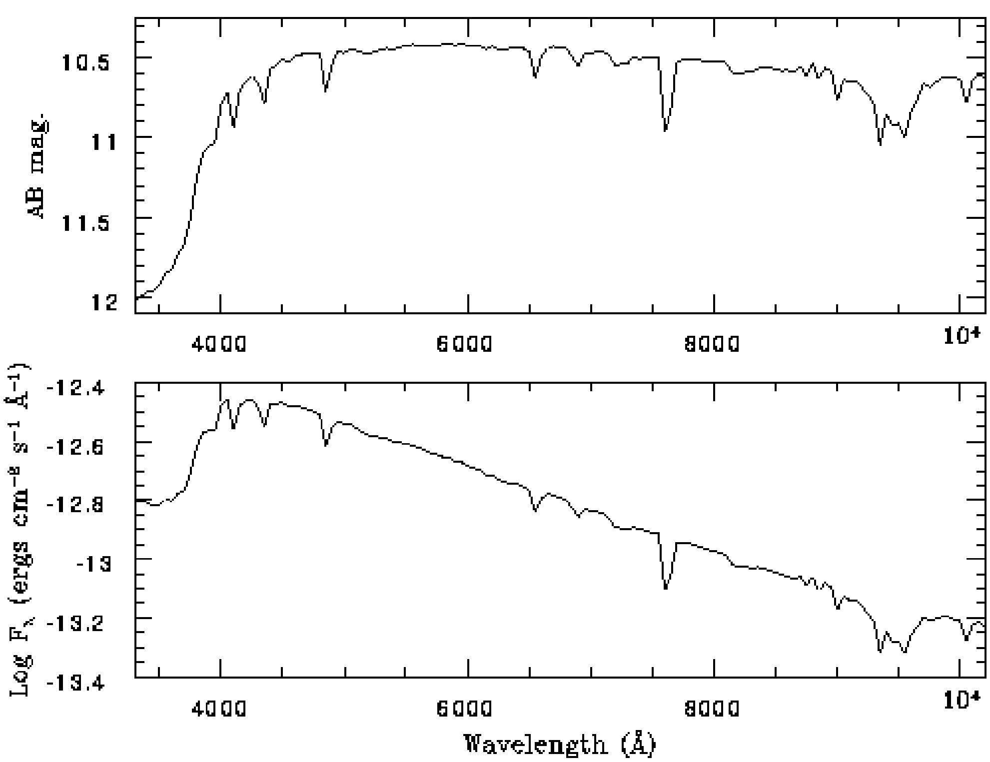
11.11 CD –32° 9927

$\alpha = 14^h\ 11^m\ 46.4^s$ (2000) $\delta = -33°\ 03'\ 14''$

$V = 10.44$ $(B-V) = 0.34$ $(U-B) = 0.12$ Spectrum: A0

Suggested guide star: x = –10570 y = –10990

10 x 10 arcmin



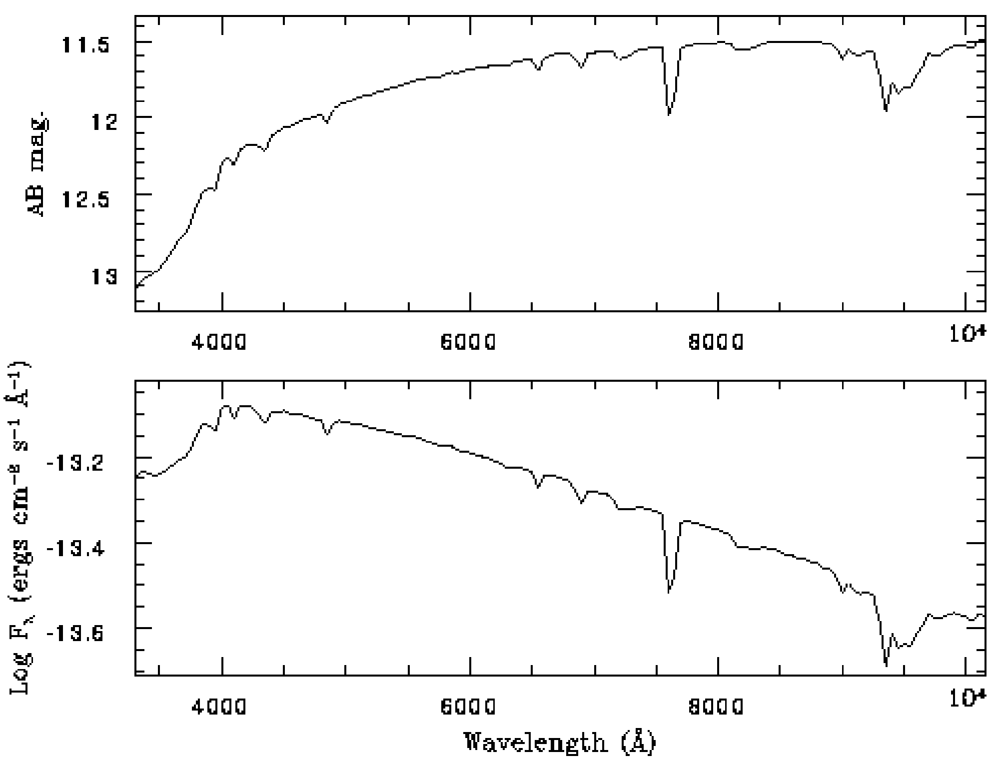
11.12 LTT 6248

$\alpha = 15^h\ 39^m\ 00.0^s$ (2000) $\delta = -28^\circ\ 35'\ 33''$

$V = 11.81$ $(B - V) = 0.49$ $(U - B) = -0.23$ Spectrum: sdG

Suggested guide star: x = –10500 y = –6850

10 x 10 arcmin

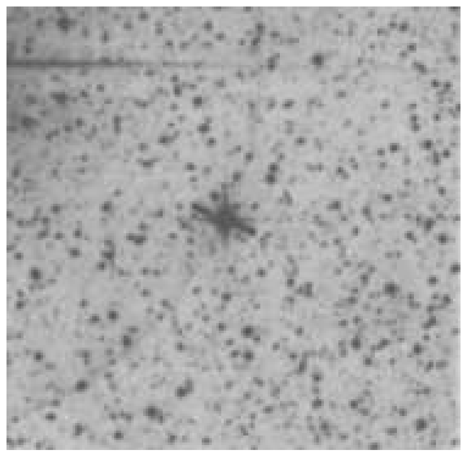


11.13 EG 274

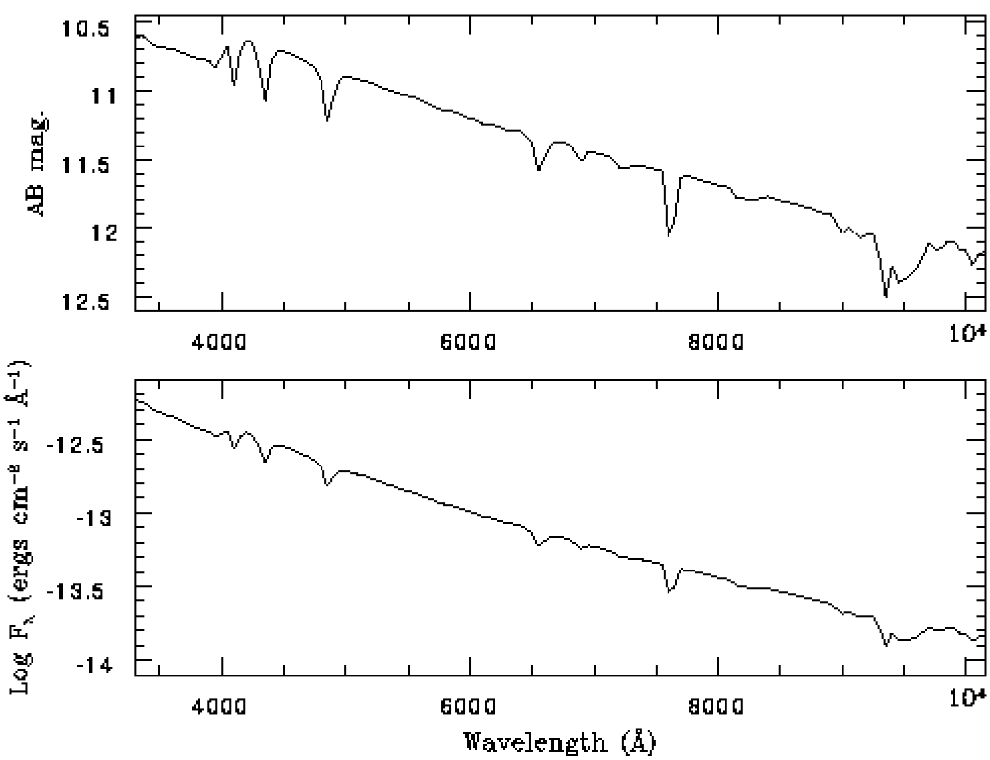
$\alpha = 16^h\ 23^m\ 33.8^s$ (2000) $\delta = -39^\circ\ 13'\ 48''$

$V = 11.01$ $(B-V) = -0.13$ $(U-B) = -0.95$ Spectrum: DA2

Suggested guide star: x = –7830 y = –4360



7 x 7 arcmin



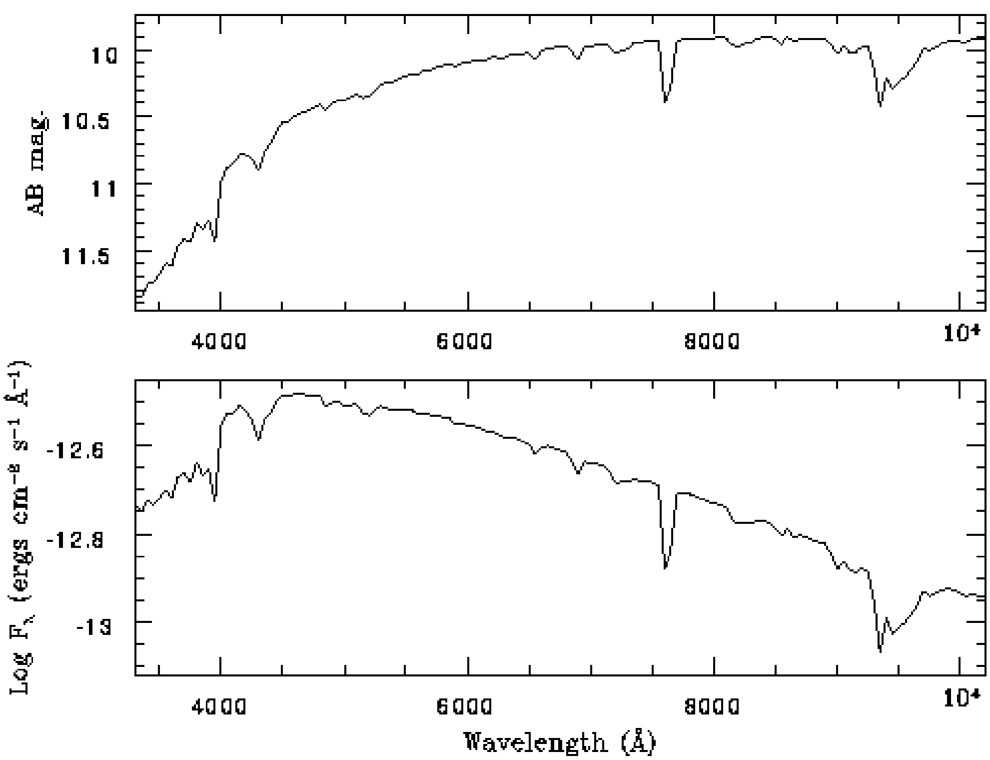
11.14 LTT 7379

$\alpha = 18^h\ 36^m\ 26.3^s$ (2000) $\delta = -44^\circ\ 18'\ 33''$

$V = 10.23$ $(B - V) = 0.62$ $(U - B) = -0.02$ Spectrum: sdG

Suggested guide star: x = –6170 y = 7000

10 x 10 arcmin



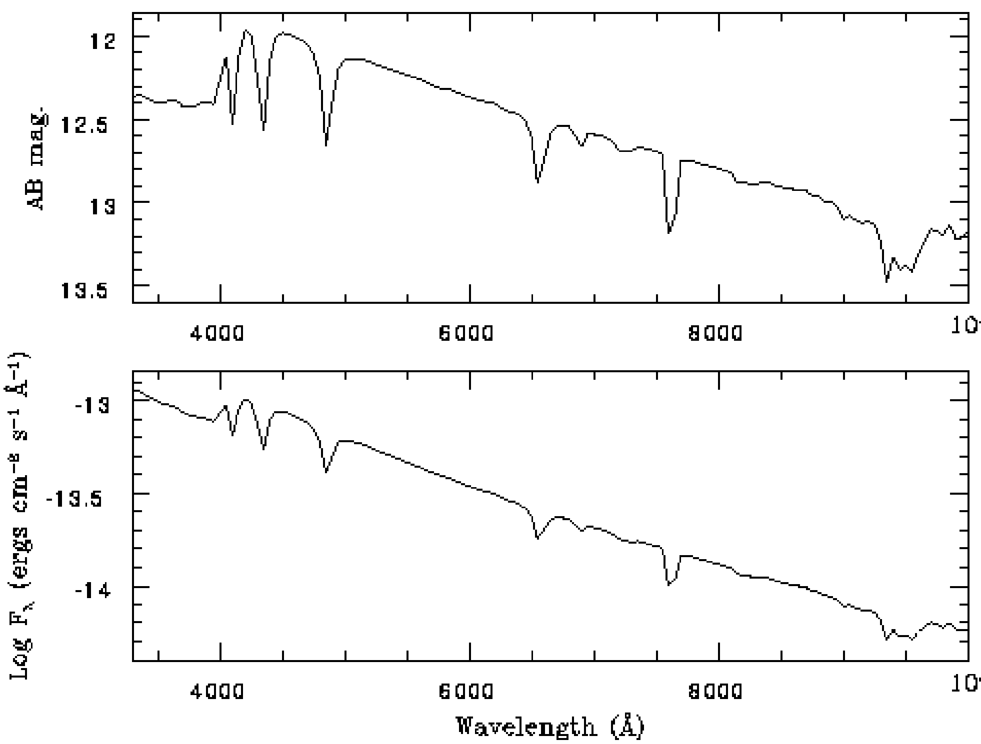
11.15 LTT 7987

$\alpha = 20^h\ 10^m\ 57.4^s$ (2000) $\delta = -30^\circ\ 13'\ 01''$

$V = 12.22$ $(B-V) = 0.06$ $(U-B) = -0.63$ Spectrum: DA4

Suggested guide star: x = –10640 y = 3950

10 x 10 arcmin



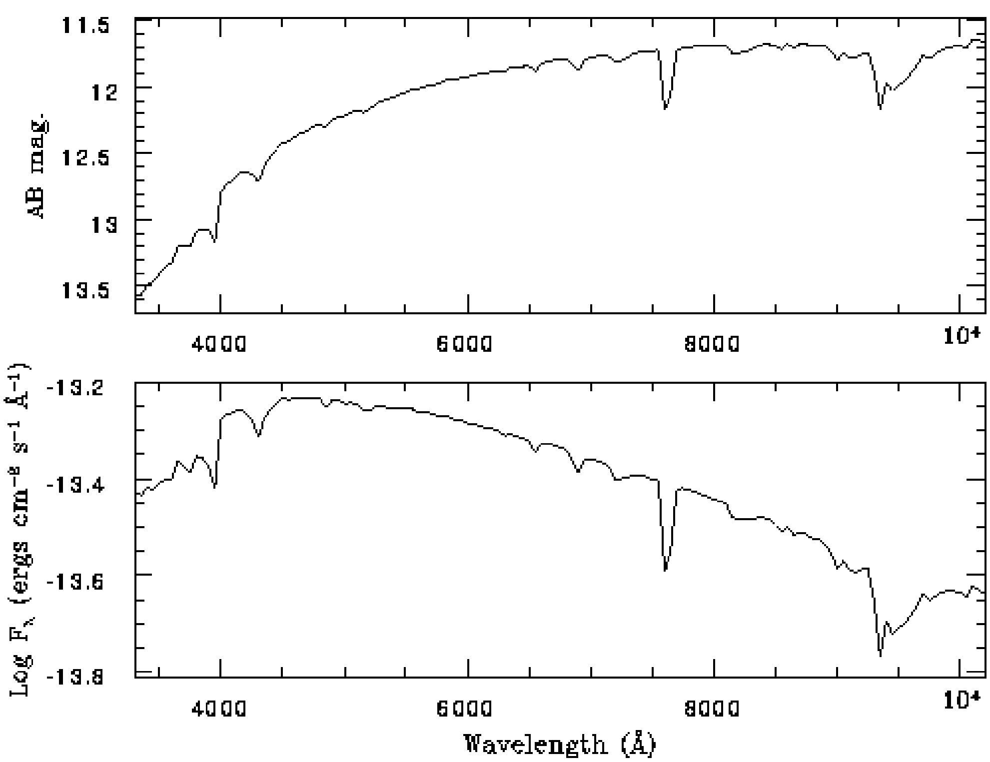
11.16 LTT 9239

$\alpha = 22^h\ 52^m\ 40.9^s$ (2000) $\delta = -20°\ 35'\ 26''$

$V = 12.06$ $(B - V) = 0.63$ $(U - B) = -0.12$ Spectrum: sdG

Suggested guide star: x = 6280 y = 6050

10 x 10 arcmin

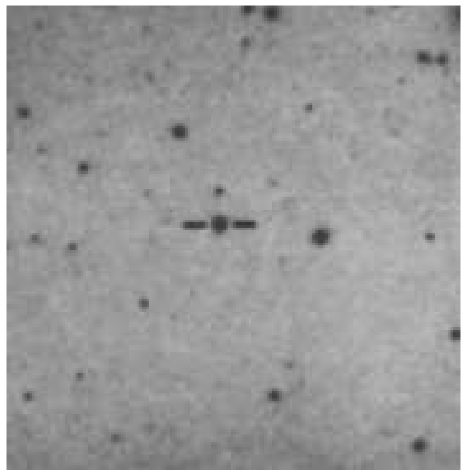


11.17 LTT 9491

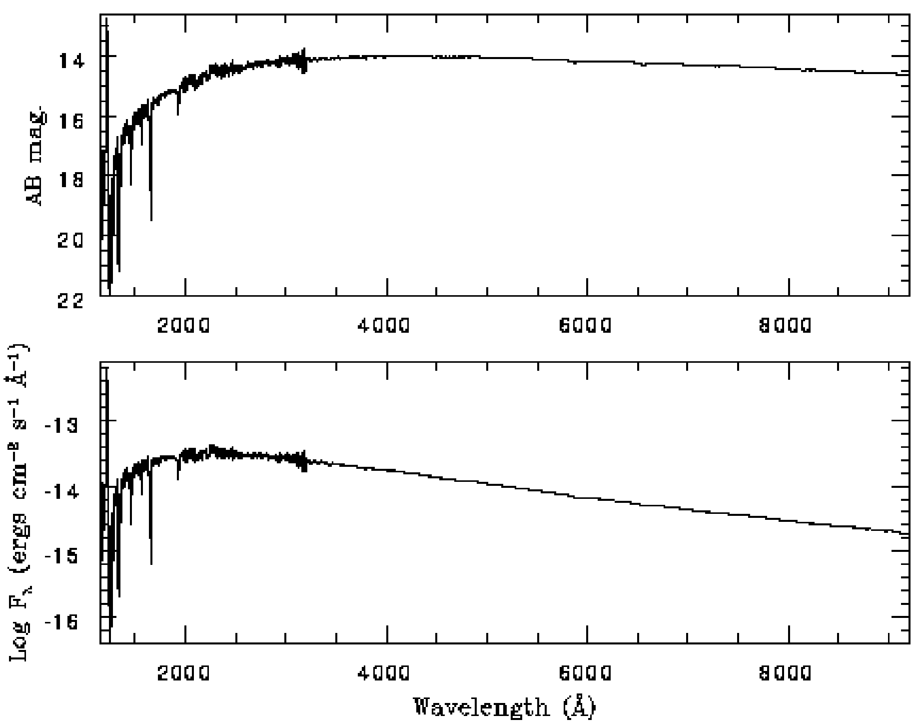
$\alpha = 23^h\ 19^m\ 35.0^s$ (2000) $\delta = -17°\ 05'\ 30''$

$V = 14.10$ $(B - V) = 0.03$ $(U - B) = -0.83$ Spectrum: DB3

Suggested guide star: x = 11020 y = –7810



7 x 7 arcmin

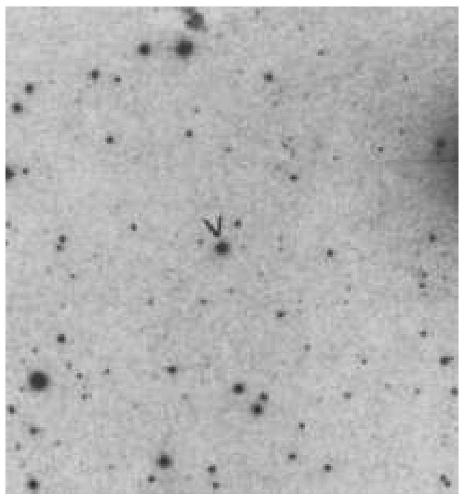


11.18 Feige 110

$\alpha = 23^h\ 19^m\ 58.4^s$ (2000) $\delta = -05°\ 09'\ 56''$

$V = 11.85$ $(B-V) = -0.30$ $(U-B) = -1.153$ Spectrum: sdO

Suggested guide star: x = 2520 y = 12230



14 x 14 arcmin