EUROPEAN SOUTHERN OBSERVATORY

OPERATING MANUAL

No. 4 – December 1985

The ESO Faint Object Spectrograph and Camera (EFOSC)

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Chapter 1

Introduction

This manual describes the operation of the ESO Faint Object Spectrograph and Camera (EFOSC). It is intended to be a general guide for the observer who is going to use EFOSC; to help in the preparation of observations as well as during the observing run.

Although EFOSC is a very simple instrument with few functions, its flexibility and versatility require a good preparation on the part of the observers. First-time users are advised to read this manual carefully and to familiarise themselves with the optical system, focusing and pointing procedures and related special IHAP batches, calibration procedures and with the EFOSC control program. It is recommended to do a dry run with EFOSC in the late afternoon prior to the first observing night, taking some calibration spectra etc.

EFOSC can be used in four different modes: direct imaging, slit spectroscopy, grism field spectroscopy and Multiple Object Spectroscopy (MOS). This latter mode implies the preparation of a dedicated aperture plate for each field to be observed. It is described in a separate manual [6]. MOS will be offered for general use as of April 1986.

References [1] through [5] provide more information for those interested in the optical and mechanical design of EFOSC and its control software.

Chapter 2

System Description

2.1 General Description

Figure 1 gives a general view of EFOSC and figure 2 shows the optical design. Referring to figure 1, the aperture wheel is situated in the Cassegrain focal plane of the 3.6 m telescope and holds a number of slits. The collimator produces a collimated beam with a diameter of 40 mm which passes through the filter and/or grism (if working in spectroscopic mode). These are mounted in the filter and grism wheel, respectively. The F/2.5 camera focuses the beam on the CCD which is at present a thinned, back-illuminated RCA with 320×512 pixels. The pixel size is 30 μm which corresponds to .675$''$ on the sky. A shutter is mounted just in front of the camera.

2.2 Optical System

The combination collimator/camera provides very good images throughout the useful wavelength range. In imaging mode, using white light (3500–10000 Å), 80% of the energy from an on-axis star is concentrated in a circle with diameter .3$''$. In the field corners, image quality is still .5$''$.

The camera is mounted in a compensating unit, which moves the camera axially in order to stay in focus on the slit plane. The residual longitudinal defocus movement of the image of a slit at the CCD has been measured to be less than .2 μm/^{o}C and can thus be neglected. The defocus introduced by filters and grisms can also be neglected, as well as secondary colour, which has been largely eliminated by using special glasses. For all practical purposes, the EFOSC focus is stable and independent of temperature wavelength or mode of operation. It was therefore possible to build EFOSC without a remote focusing possibility; the focus is checked during maintenance prior to a run and set to better than .1–.2 pixel of blur. The astronomer can also check the EFOSC focus, see section 3.2.1.

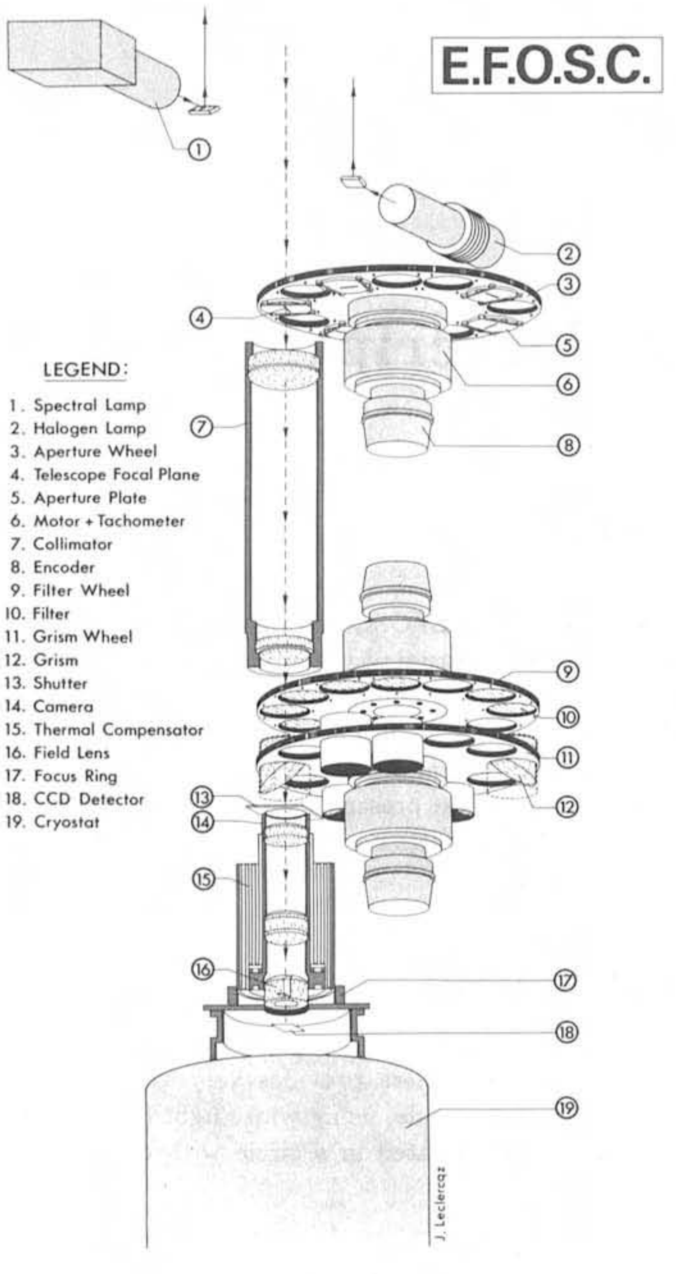


Figure 1: The optical and mechanical layout of EFOSC

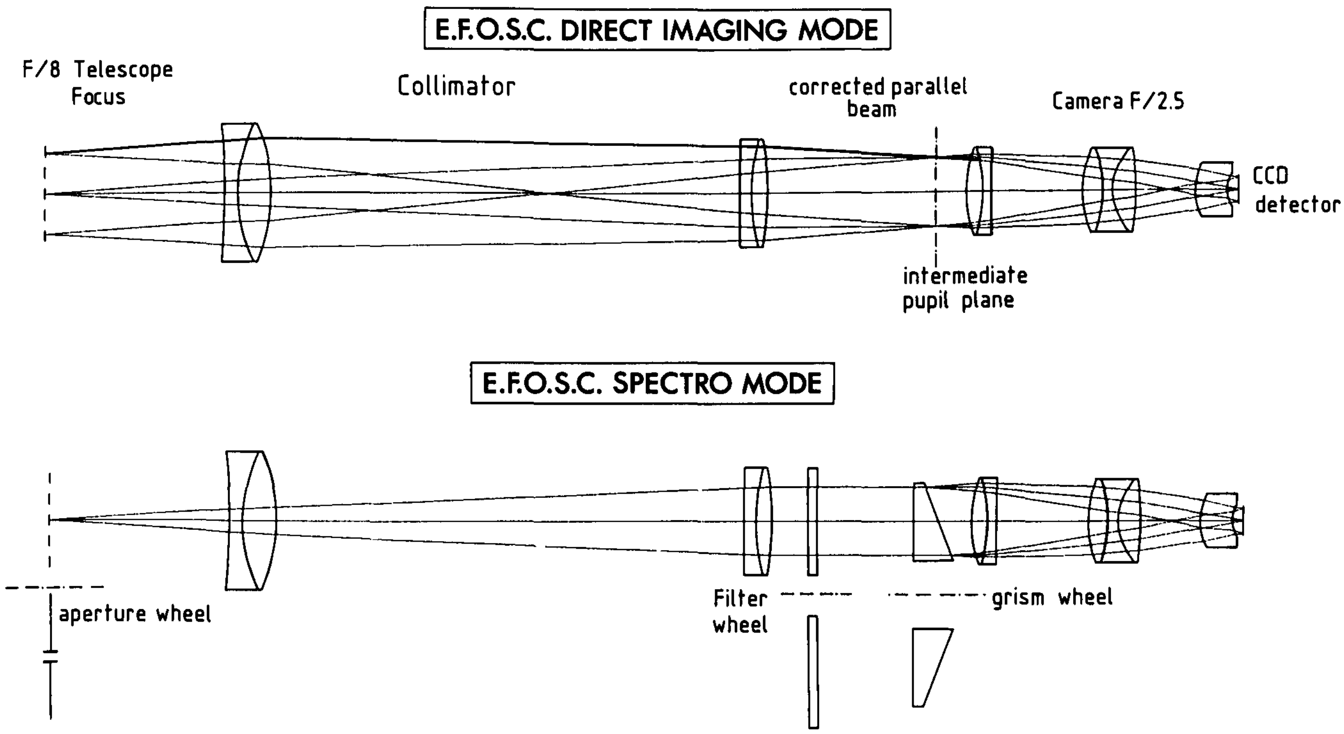


Figure 2: The optical design of EFOSC

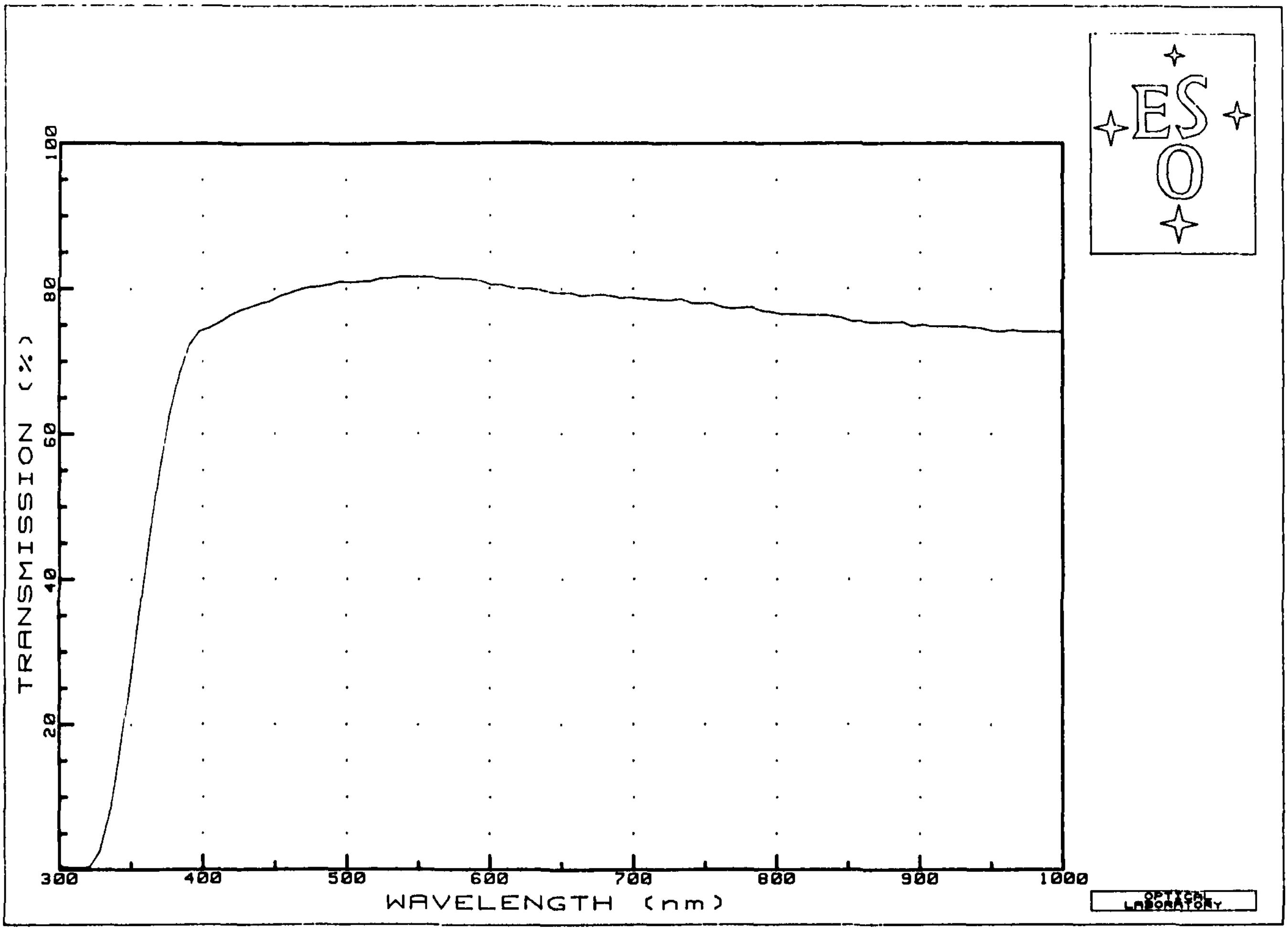


Figure 3: The overall transmission of EFOSC

The optical transmission is given in figure 3. The rapid decrease of efficiency below 4000 Å is due to intrinsic losses in cement and glass and increased glass/air interface losses. The lenses are anti-reflection coated with a $\lambda/4$ layer of MgF_2 peaked at 5500 Å.

2.3 Aperture Wheel

The wheel has a total of 12 positions, of which 2 are reserved for direct imaging and a tilted slit viewing mirror. A cross has been etched in the reflecting surface of the slit viewing mirror; it has been adjusted to closely correspond to the positions of the slits. The remaining 10 positions can hold standard slits or double apertures as well as Multiple Object Spectroscopy (MOS) starplate holders. These holders provide for quick and easy exchange of MOS starplates. The standard slit plates are positioned with greater accuracy, but cannot be exchanged so easily, since this involves dismounting the whole aperture wheel. It is recommended not to request configuration changes of the aperture wheel during your run. Table 2.1 lists the currently available aperture plates. The slits have a length of 3.6 arcmin. The double apertures are 50″ apart. As an example of how the

Table 2.1: EFOSC Standard Apertures

Unit	Description
1	Slit 0.5″
2	Slit 1.0″
3	Slit 1.5″
4	Slit 2.0″
5	Slit 2.5″
6	Slit 3.0″
7	Slit 5.0″
8	Double apertures 1.0″ × 5″
9	Double apertures 1.5″ × 5″
10	Double apertures 2.0″ × 5″
11	Double apertures 3.0″ × 5″
12	Double apertures 1.0″ × 5″

instrument configuration is presented, figure 4 shows the instrument configuration during the March 1985 test run; special pinholes were mounted in the MOS starplate holders (positions 11 and 12). This form is shown on the graphics screen when setting up an exposure.

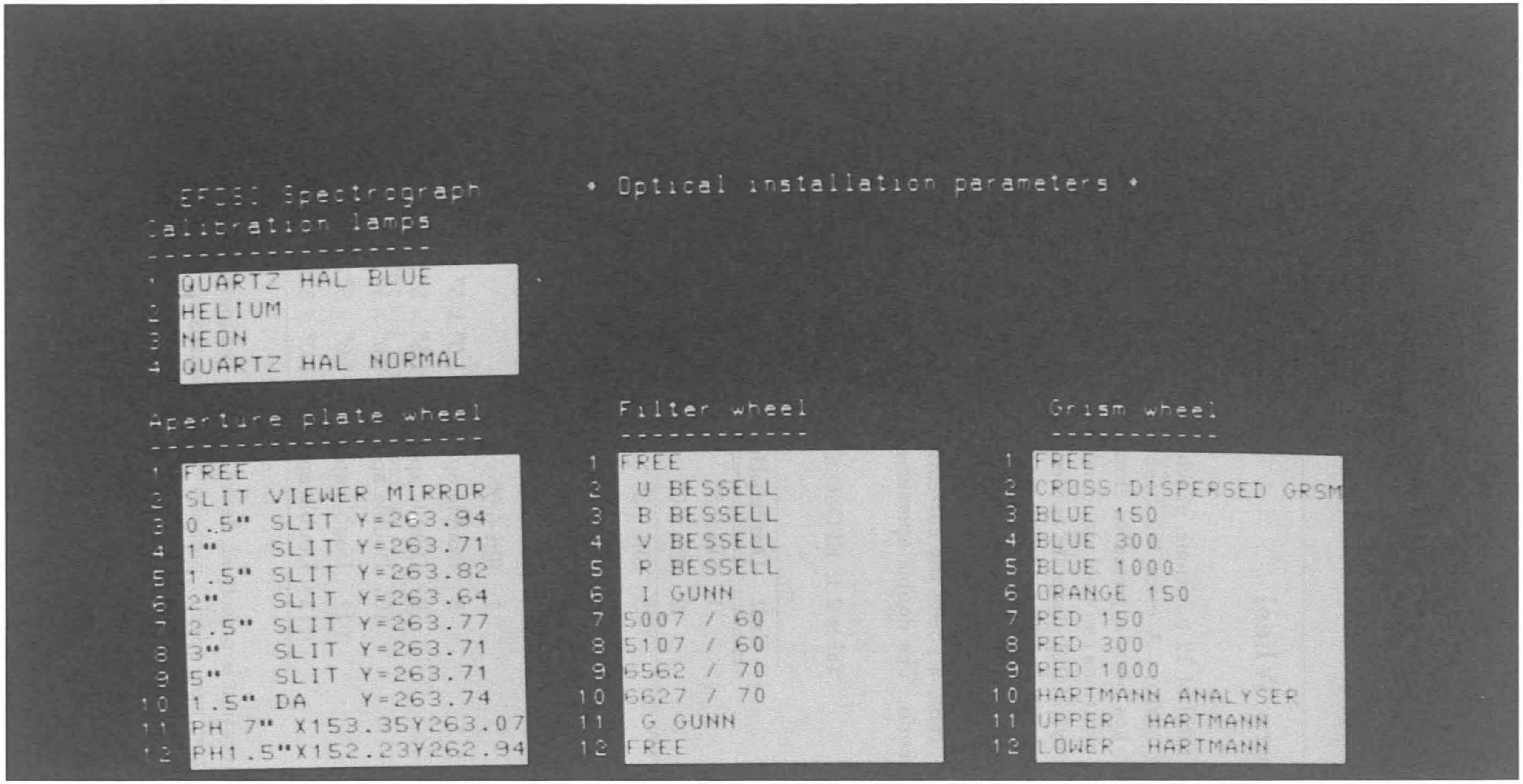


Figure 4: The optical installation parameters. This form is displayed on the graphics screen when you define an exposure. A hardcopy can be obtained by going to CHANGE OPTICAL SETUP in MAINTENANCE ; the Operations Group will provide you with a printout at the beginning of the run.

2.4 Filter Wheel

Up to 11 filters can be mounted in the filter wheel. Since they are used in parallel beam, they are image quality filters and generally produce less than half a wave of wavefront distortion. Small wedges are practically unavoidable and result in image shifts of up to a few pixels. The standard filters are marked on the edge in order to always mount them in the same orientation to have the same shift. Table 2.2 lists the filters currently available.

Users wishing to bring their own filters are reminded of the image quality requirements. For a maximum blur of 10 μm at the detector (the specification of the standard filters) the transmitted wavefront quality must be better than 1 λ peak–peak. The maximum allowable power and astigmatism is 2.5 millidioptres. These specifications will ensure that the filters have no influence on the image quality; one can relax them by about a factor of 3 while still getting acceptable results (remember that the pixel size of the RCA chip is 30 μm or $.675''$ on the sky).

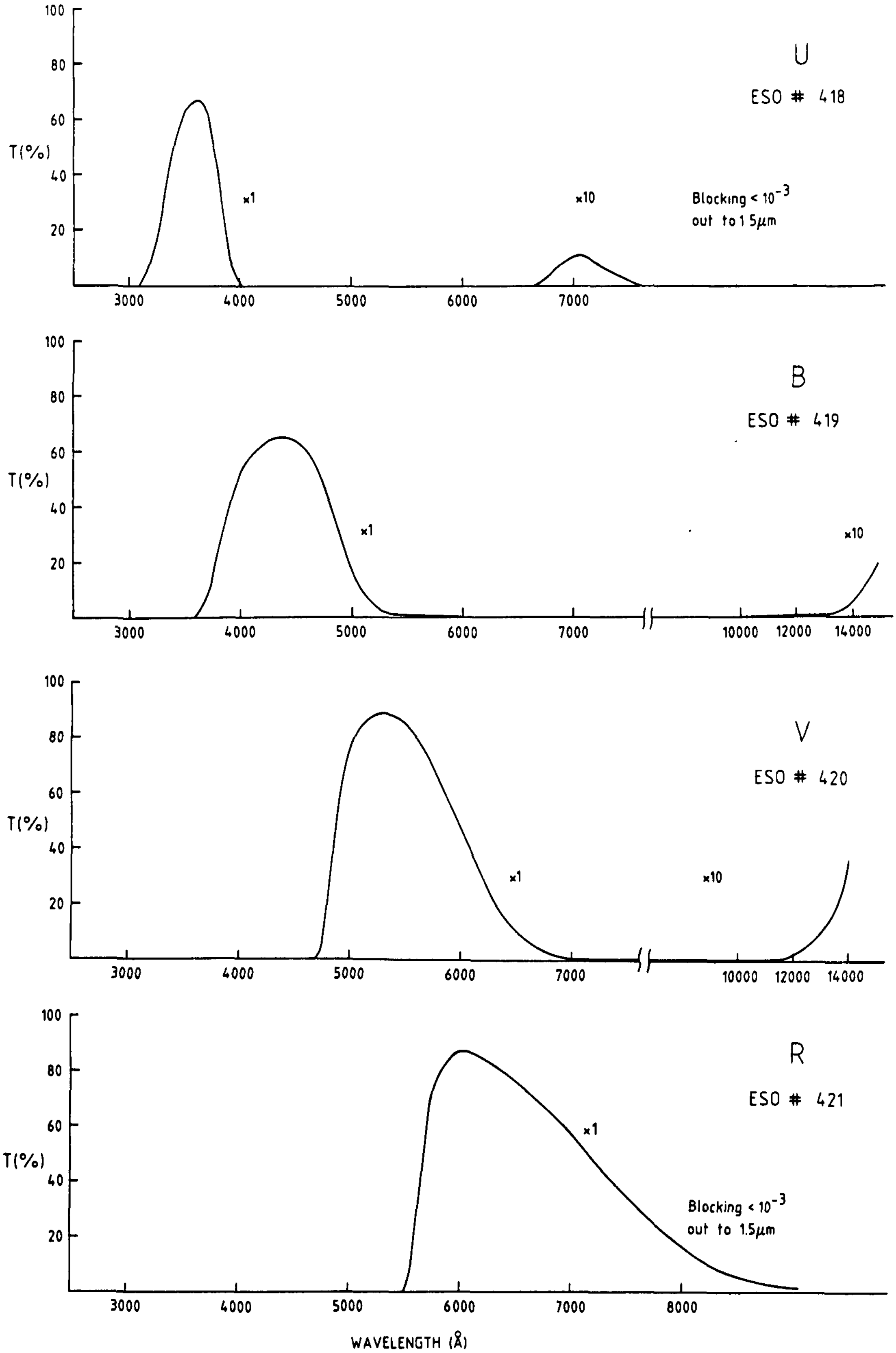
The filter diameter is $59.75 \pm .25$ mm; thickness may be up to 10 mm. The free diameter must be at least 48 mm.

2.5 Grism Wheel

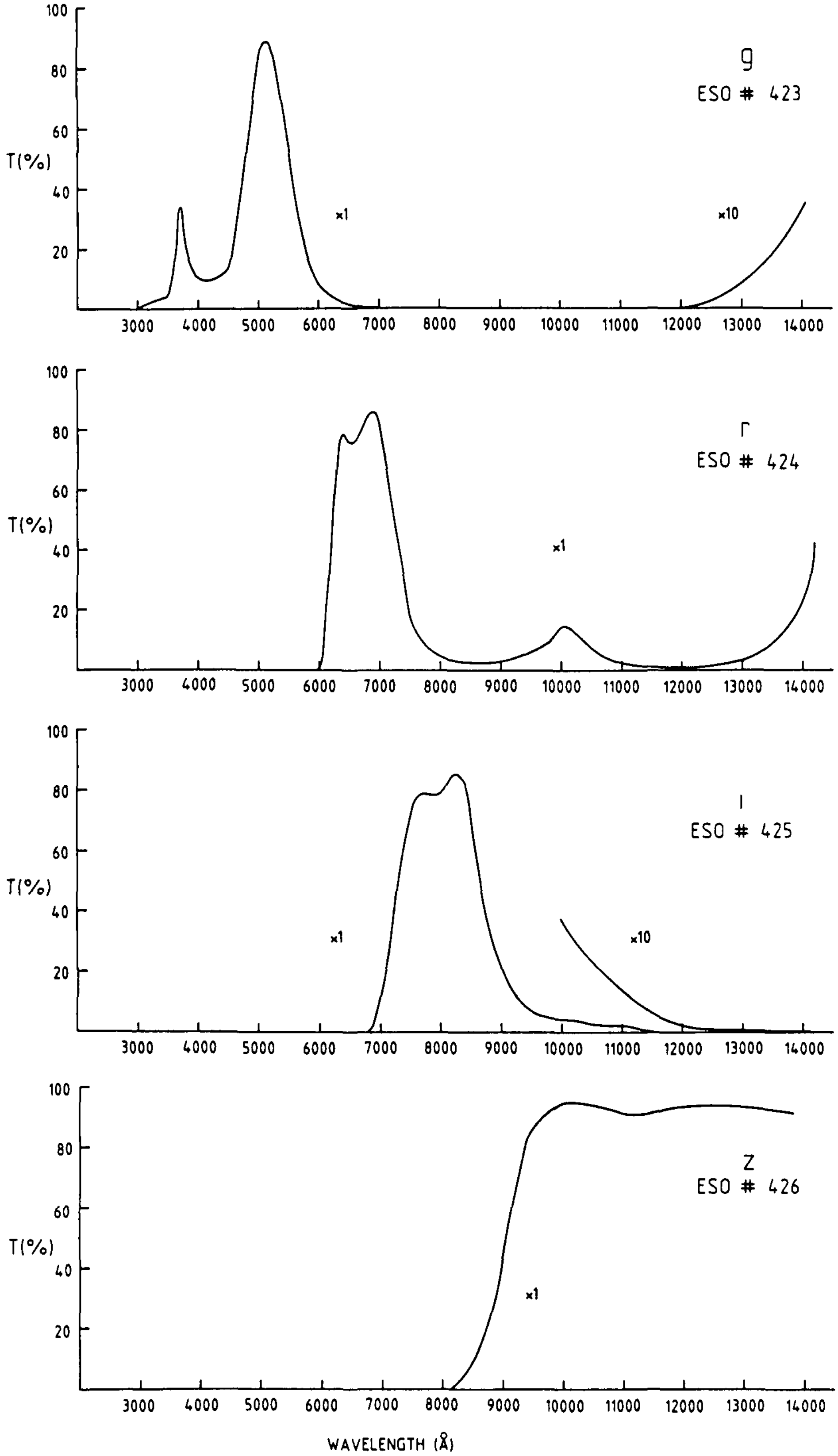
The grism wheel has 12 positions, of which 10 are available for grisms. One position is free and one position is taken up by a special unit that is used for focussing (see 3.2.1). Grism names designate the approximate wavelength region and dispersion. The substrate of the cross-dispersed grism consists of a cemented 3-element direct-vision prisms, which provides the cross-dispersion. This grism **must** be used with the twin apertures to prevent order overlap. Table 2.3 lists the grisms available. Note that the grism names provide only a rough indication of blaze wavelength and dispersion, e.g. the "Blue 1000" has its blaze at 4400 Ångstrøm and a true dispersion of 850 Å/mm. See figure 7 for efficiency curves.

All grisms are mounted in such a way that red will appear at the top of the RAMTEK picture. To facilitate the data reduction, the dispersion direction is aligned within better than a few tenths of a pixel with the CCD columns, except for the Cross-dispersed grism, where the cross-dispersion causes the spectra to be curved.

The resolution of the spectra depends on the slit width which is chosen. With a projected pixel size of $.675''$, the $1.5''$ slit projects on about 2.5 pixels and the numbers in the last column of table 3 must be multiplied by this factor to find the true resolution. The resolving power ranges from about 100 to 1000 with the low and high dispersion grisms, respectively.



BESSEL FILTER TRANSMISSION Figure 5



GUNN FILTER TRANSMISSION Figure 6

Table 2.2: EFOSC Filters

Redshift (km/sec)	λ_c/**FWHM** (Ångstrøm)	τ_{peak} (%)	**ESO no.**
[OIII] interference filters			
0	5009/66	76	427
0	5010/130	76	428
3000	5060/56	76	429
6000	5111/55	75	430
9000	5162/63	77	431
12000	5211/60	77	432
15000	5261/54	72	433
18000	5313/55	78	434
21000	5354/64	76	435
H_α interference filters			
0	6562/61	71	436
0	6555/142	63	437
3000	6634/70	66	438
6000	6693/94	57	439
9000	6766/68	65	440
12000	6832/74	66	441
18000	6956/64	64	442
21000	7018/64	63	443
He interference filters			
0	4471/60	79	510
0	4541/60	81	511
0	4686/60	82	512
Bessel U, B, V, R filters. See figure 5 and ref. [7].			
Gunn g, r, i, z filters. See figure 6.			
Clear filters with and without a wedge. The wedge can be used to move a feature of interest off a bad pixel. The filters are single-layer AR coated.			

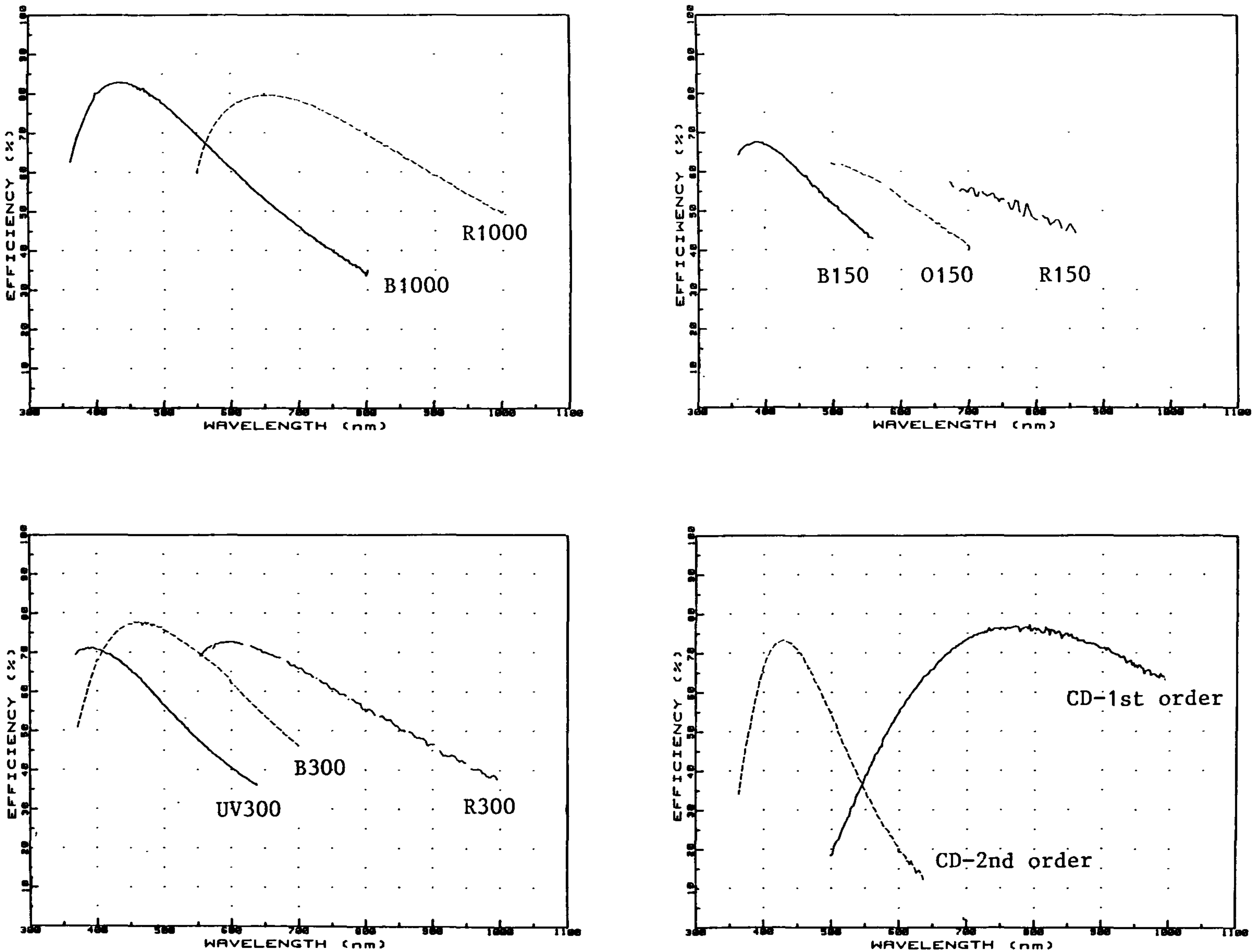


Figure 7: Efficiency curves of the EFOSC grisms

Table 2.3: EFOSC Grisms

Grism	**Dispersion** (Å/mm)	**Range** (Å)	**Wavelength bin** (Å/pixel) (*)
Blue 1000	850	3600–8000	26
Red 1000	920	5500–10000	28
UV 300	210	3600–6300	6.4
Blue 300	230	3600–7000	6.4
Red 300	270	5600–9900	7.0
Blue 150	120	3600–5590	3.6
Orange 150	130	5000–7000	4.0
Red 150	120	6700–8600	3.6
Cross-dispersed 1^{st} order	320	5000–9800	9.7
2^{nd} order	160	3600–6300	4.8

(*) : These values are based on the RCA SID 501 EX CCD with 30 μm pixels.

Contrary to grisms used in a converging beam, there are no wavelength-dependant optical aberrations introduced by the EFOSC grisms. The spectral resolution therefore only depends on the slit width (or on the seeing in slitless work) and the dispersion and is constant along the spectrum.

2.6 CCD

At the time this manual is being written (December 1985) EFOSC is used with the ESO CCD #3. It is a RCA device, with 320×512 pixels of 30 μm^2. The read-out noise is about 45 electrons per pixel. The charge transfer efficiency is good. Only a few columns display a slightly reduced charge transfer efficiency at very low background intensities. This effect is noticeable in calibration lamp lines in long slit spectra. A bad column (no. 48) is also present. The quantum efficiency, as measured in the ESO lab, is given in figure 8.

The frequency of radiation events ("cosmic rays") on this CCD at the telescope was measured as 0.08 events/sec/cm^2 with energies larger than 60 electrons, a typical value for RCA CCDs. Although there is a possibility to remove the most conspicuous events in the data reduction phase, this effect limits to the exposure time to something like two hours if serious contamination of the data is to be avoided.

Fringing due to interference within the CCD is relatively small in this chip. In direct imaging through a narrow H_α filter the fringe amplitude is of the order of 5% of the back-

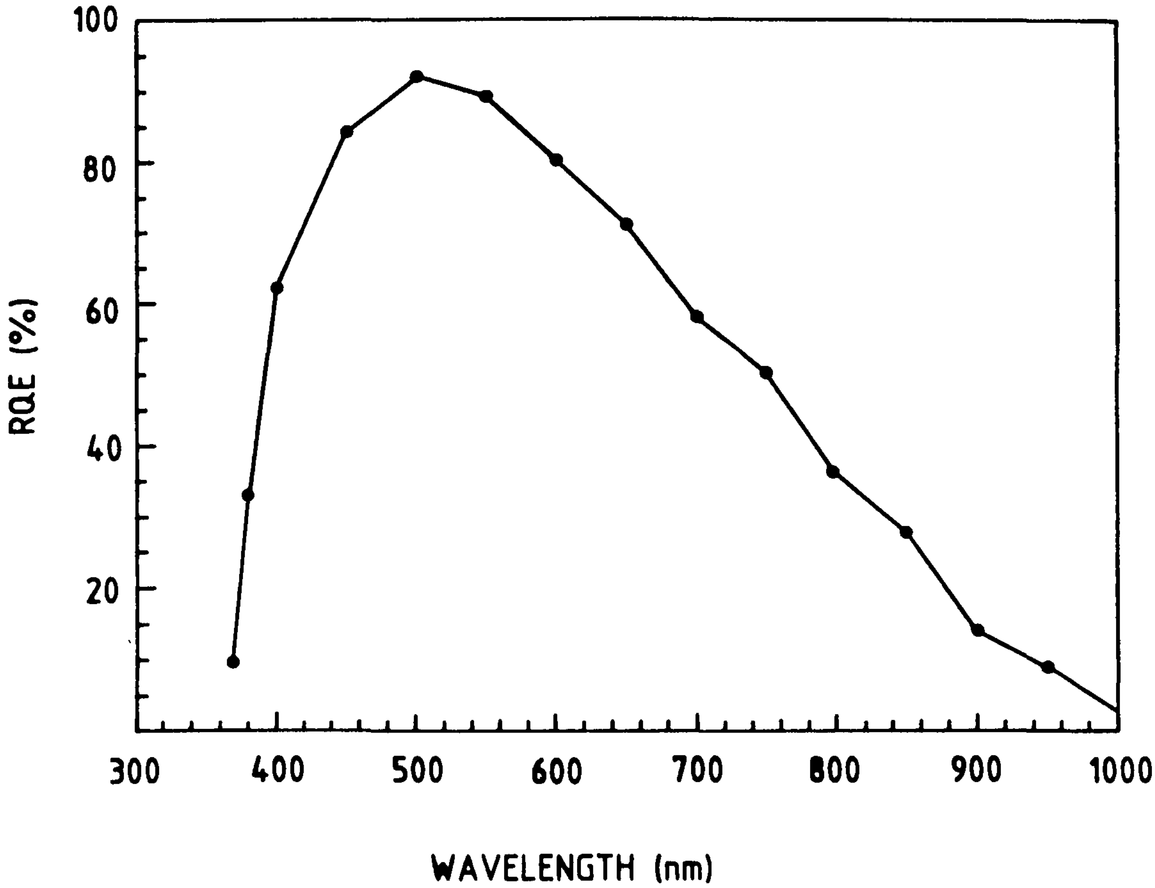


Figure 8: Quantum efficiency curve of ESO CCD # 3

ground intensity. In spectroscopy some fringing is visible above 5500 Å with a maximum amplitude of about 10% in the near infrared.

The field lens of EFOSC is used as the window of the CCD dewar. For this reason at present the dewar has to be warmed up and opened if the CCD is going to be used with another 3.6 m instrument (B&C, Caspec). In the standard mounting and with the adaptor at P.A. 270 degree, the long dimension of the CCD is aligned with the NS direction. This corresponds to the dispersion direction in spectroscopy. In the display of a direct image on the RAMTEK screen, north will appear at the top and east on the right of the screen.

It is likely that a new CCD dedicated to EFOSC will come into operation in 1986. The characteristics will be specified in an update to this manual. Note that the type and operating parameters of the CCD are registered in the header of the image file. It can be displayed with the IHAP command `WCOMMENTS,#(FILE)`.

2.7 Lamps

Up to 4 lamps can be mounted on EFOSC. Two halogen lamps are available for flatfielding, as well as one Helium and one Argon spectral lamp for wavelength calibration. The blue halogen lamp has some filters to attenuate the red in order to get a more balanced calibration curve. A neon spectral lamp is also available, but has been found to be not very useful. It can be mounted on request, replacing one of the other spectral lamps.

As can be seen in figure 1, the lamps are located just above the aperture wheel and shine upwards in the direction of the secondary mirror. A remotely controllable screen can be positioned over the sky baffle, at about 4.5 m distance from the focal plane. A white ring has been painted on it with the correct inner and outer diameter to simulate the telescope pupil. The result is a calibration beam with a high degree of uniformity over the field of view and having the same F/no as the telescope.

See par. 3.5.2 and 3.5.3 for more details on wavelength calibration and flatfielding.

Chapter 3

Observing

3.1 Control Software

The control program of EFOSC is entered by typing EFOSC from the instrument console in the control room. Setting up, maintenance and actual observing can then be controlled by a number of self-explanatory "menus" and by filling forms. The format and most of the options are similar to those of other ESO instruments (e.g. Caspec, B&C + CCD). In particular, they have the CCD program in common. Figures 9–17 illustrate the most frequently used forms.

3.2 Before Starting your Science Exposure

Some procedures have been developed to help observers in the setting up phase, with tasks like focusing, pointing the telescope and measuring the seeing. They use the direct imaging capabilities of EFOSC, combined with some IHAP batches to analyse the resulting images. To get a summary of available batches type BATCH,EFHELP. See figure 18. For information on a specific batch, e.g. OFPOIN, type BATCH,EFHELP,,OFPOIN. The August 1985 EFHELP output and examples are given in figure 18 and Appendix A. Note however that these batches will probably evolve in the future, so please use EFHELP to get the most up to date information.

In order to lose less time during the setting up phase, in which several short exposures have to be taken to check focus etc., you may choose the option START FAST EXPOSURE (see figure 10) instead of START SINGLE EXPOSURE This results in a slightly higher readout noise but substantially increased readout speed (6 seconds instead of 30 seconds). In a possible new CCD software version, this option may disappear if the normal readout speed is fast enough.

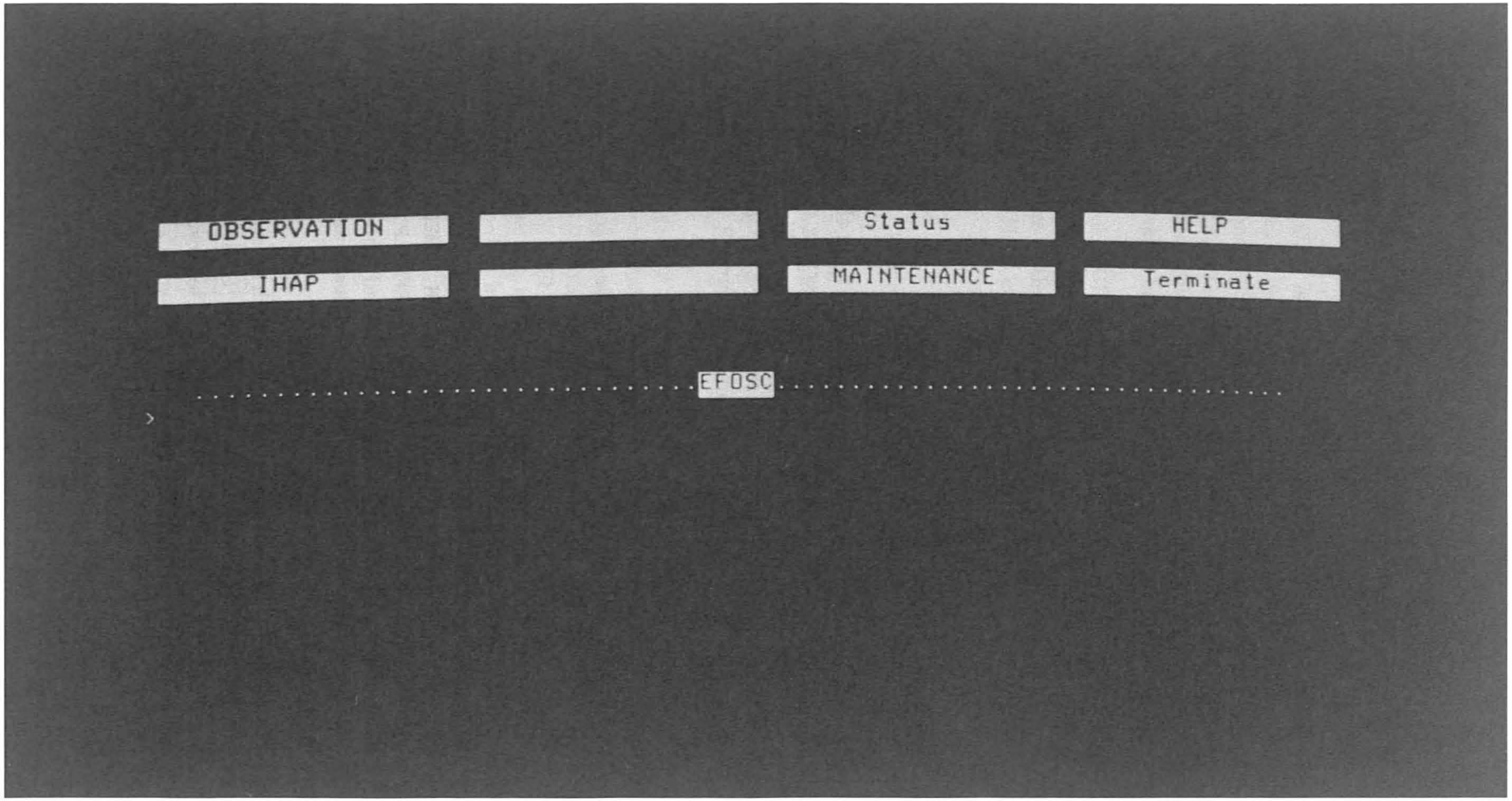


Figure 9: This form comes up when you log in with EFOSC on the instrument terminal. Pressing $\boxed{\text{OBSERVATION}}$ will bring you to the main menu.

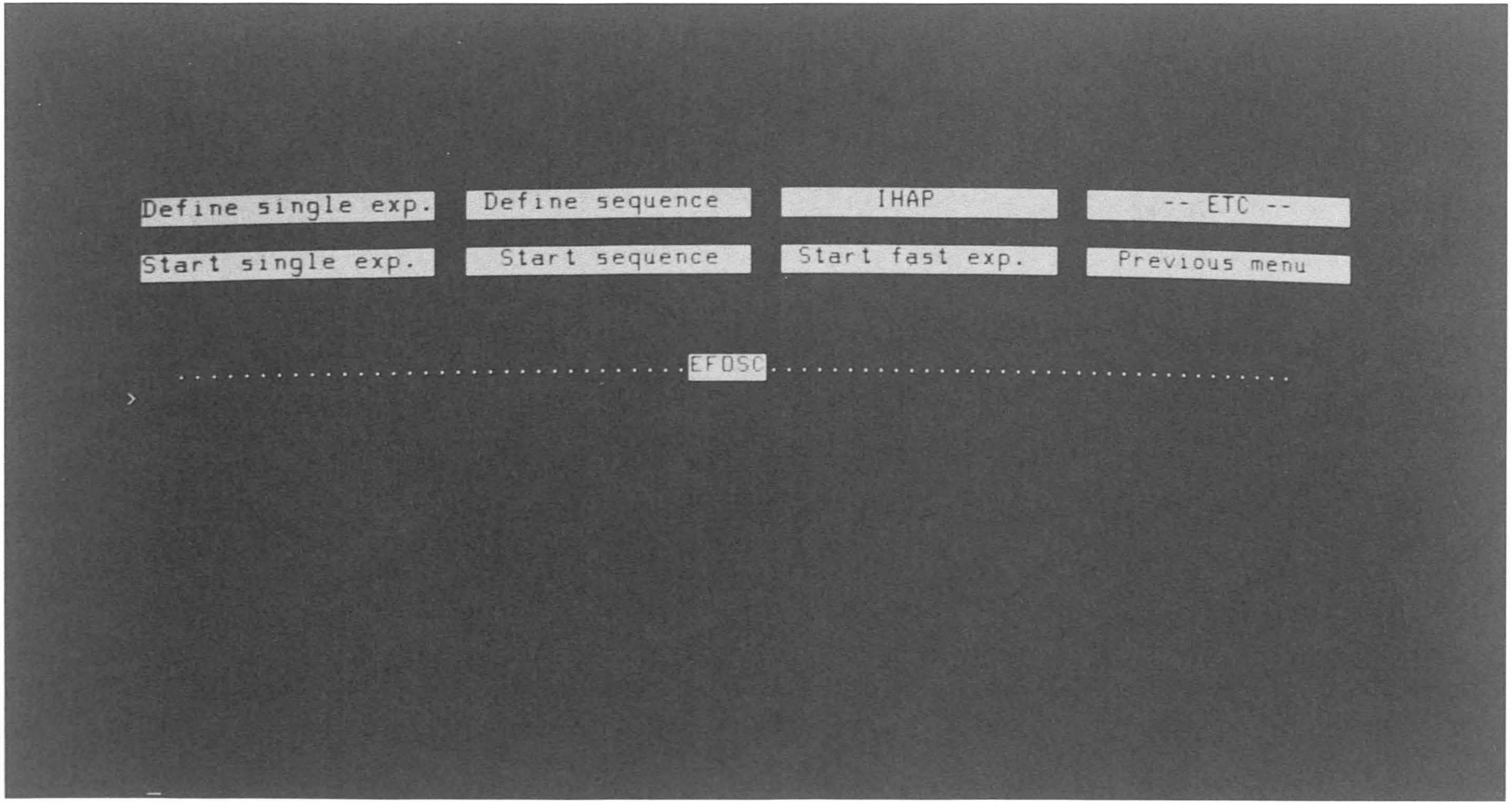


Figure 10A: The main observation menu of EFOSC, first part.
Pressing $\boxed{\text{--ETC--}}$ brings you to the second part.

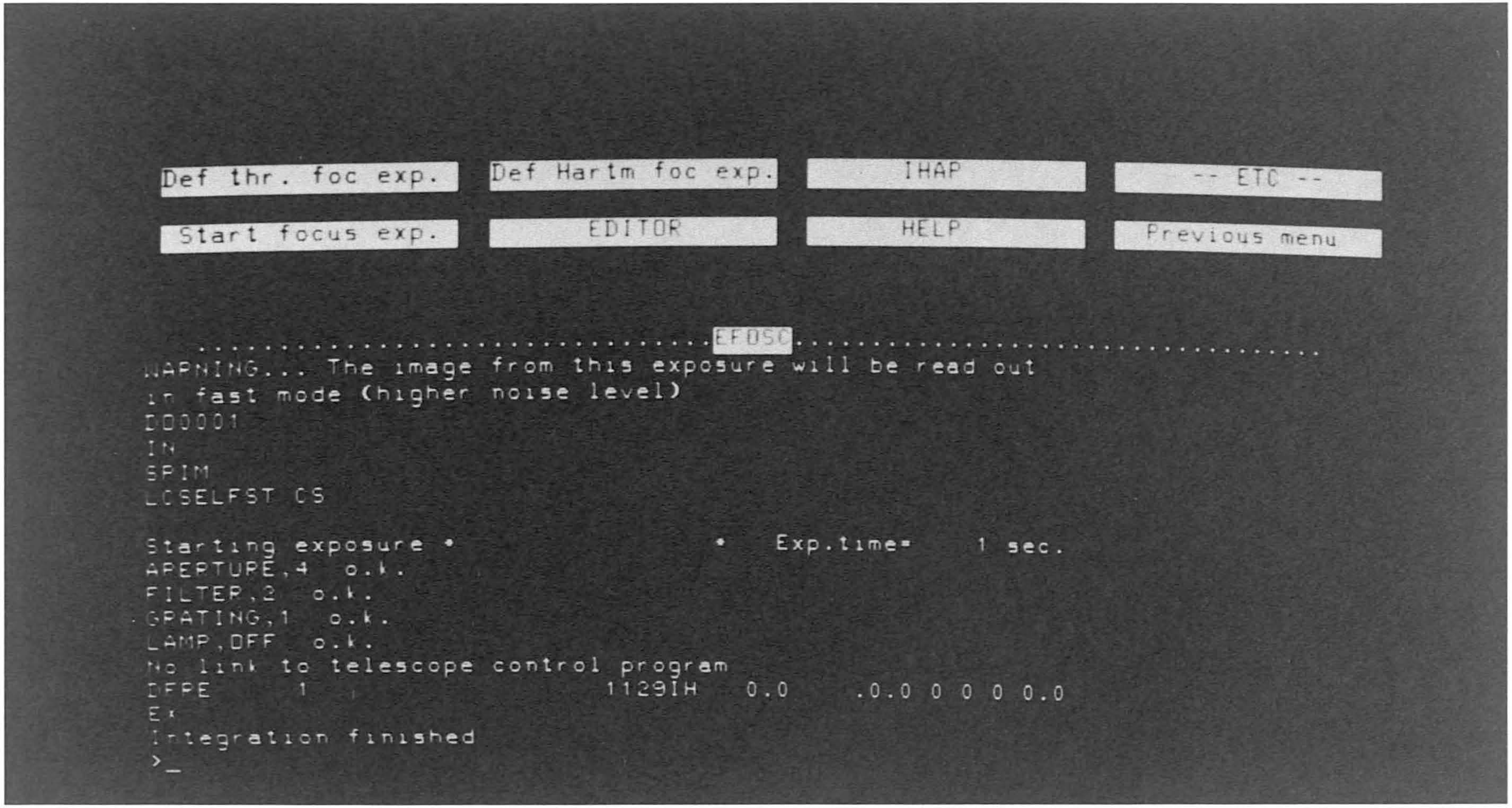
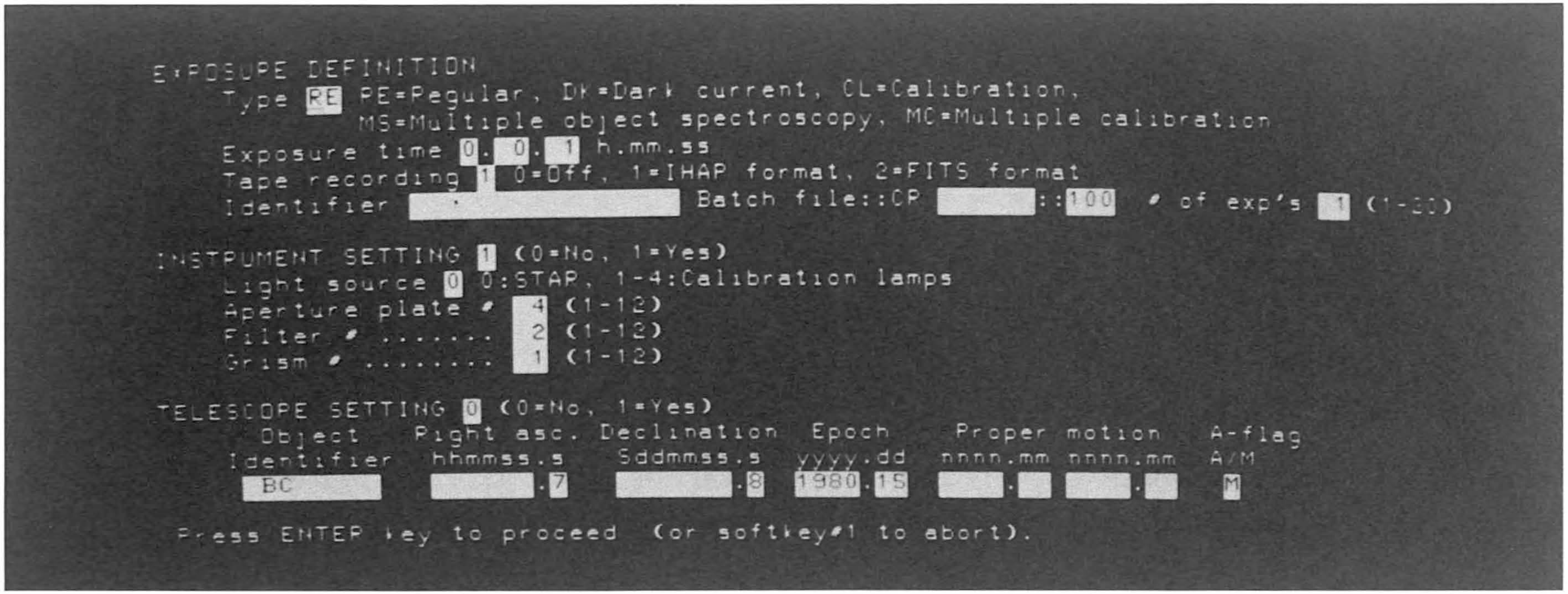


Figure 10B: The main observation menu, second part.



<u>Figure 11</u>: The exposure definition form is shown when you press 'DEFINE SINGLE EXP' in the main menu. Some remarks:

- Exposure type DK will keep the shutter closed during the exposure.
- Exposure type MC requires filling the form of fig. 12.
- Tape recording parameter default is 1 (IHAP format).
- Filling the Batch File field will cause this batch to be executed automatically after the exposure is completed. Useful batches are EDISP or EDISP2 (see Appendix).
- Telescope setting = 1 will move the telescope to the requested coordinates before starting the exposure.

Note that the parameters of the CCD, the spectrograph and the telescope are stored in the image file header and comments block and can be examined using the IHAP commands DLIST, #, LONG, WCOMMENT, # and WICOMMENT, #.

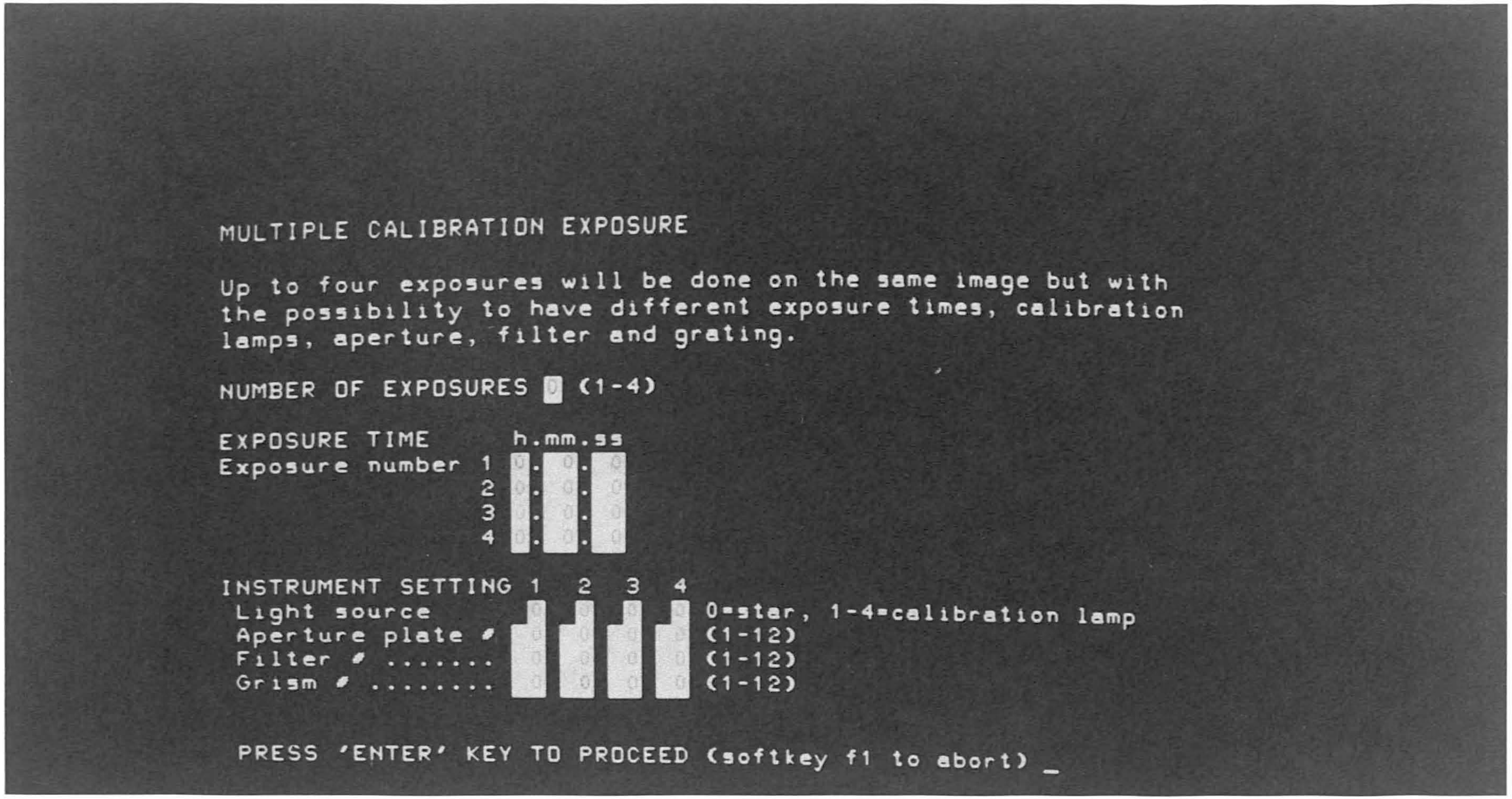


Figure 12: This form is displayed at exposure start if you specified exposure type "MC" in the exposure definition form. It is especially useful to record more than one spectrum on the same image (e.g. a He-Ar spectrum).

The exposure time and instrument settings that were specified in the regular exposure definition file (figure 11) will be overruled by anything specified in this form.

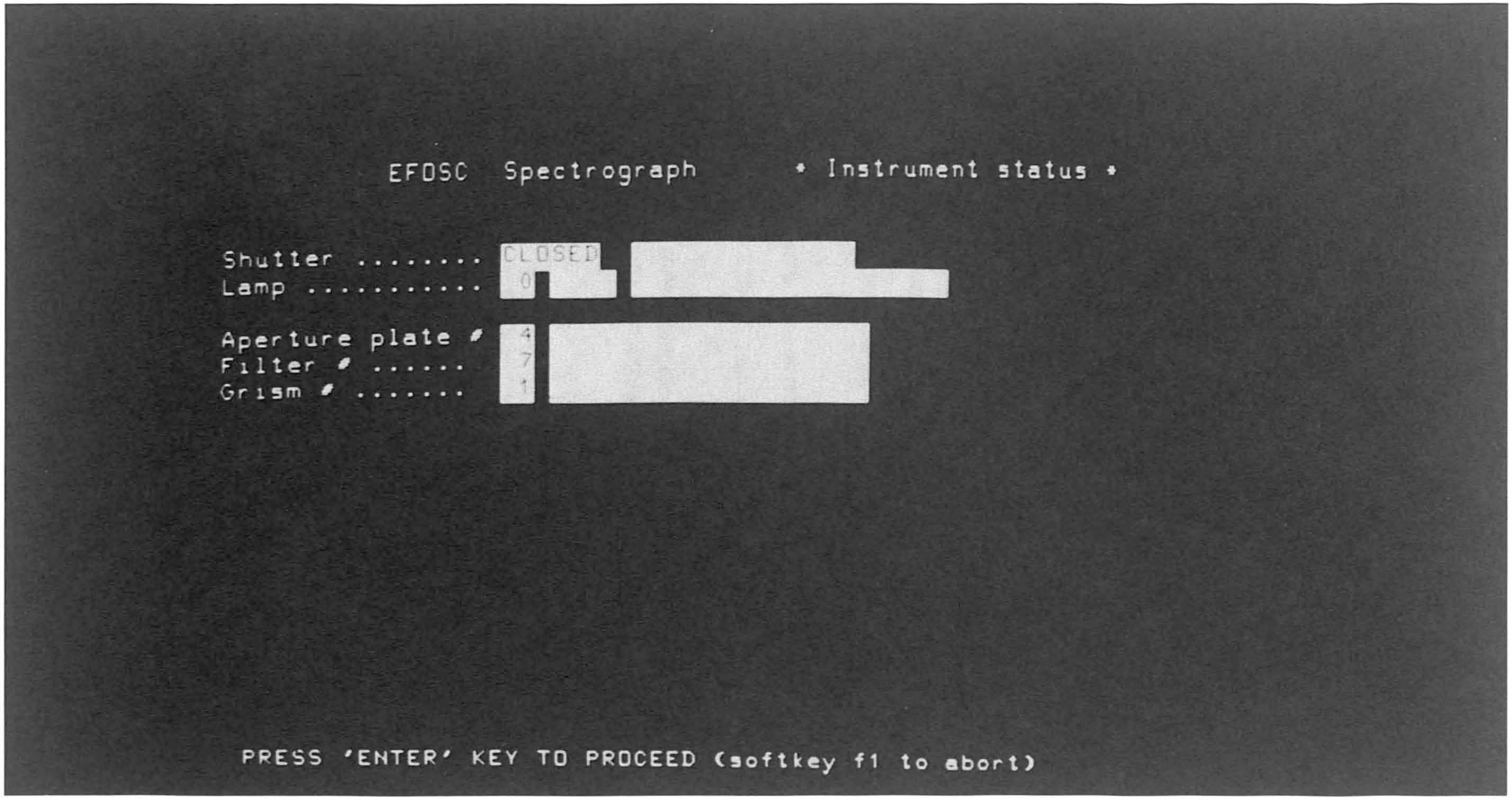


Figure 13: The instrument status is always shown on the graphics screen.
Check it at the start of an exposure to see if the instrument is doing what you expect.

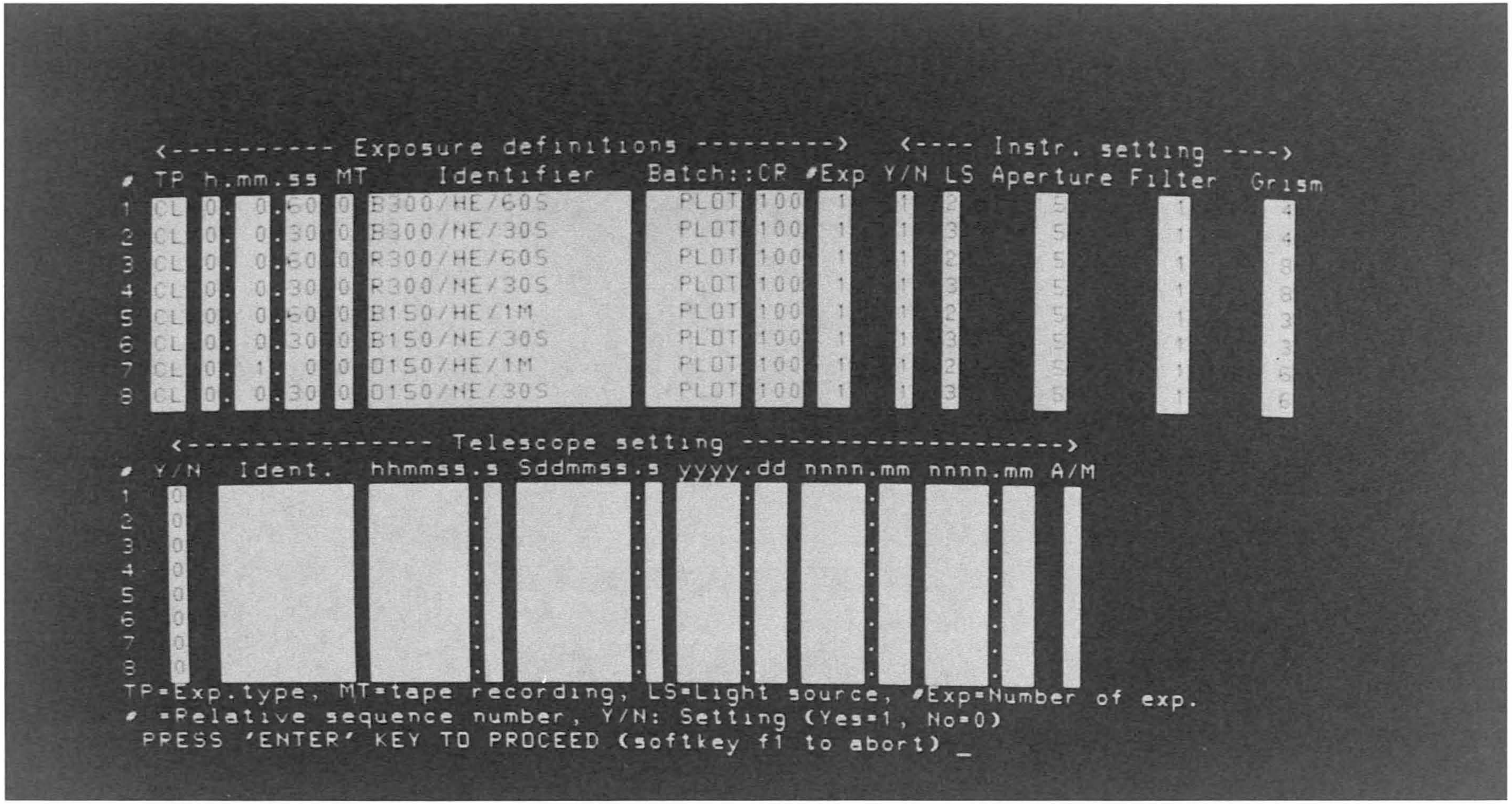


Figure 14: An exposure sequence. There are four of these, in each one up to eight exposures can be defined. These exposures are executed automatically when the sequence is started. It is recommended to use this option for all calibration exposures.

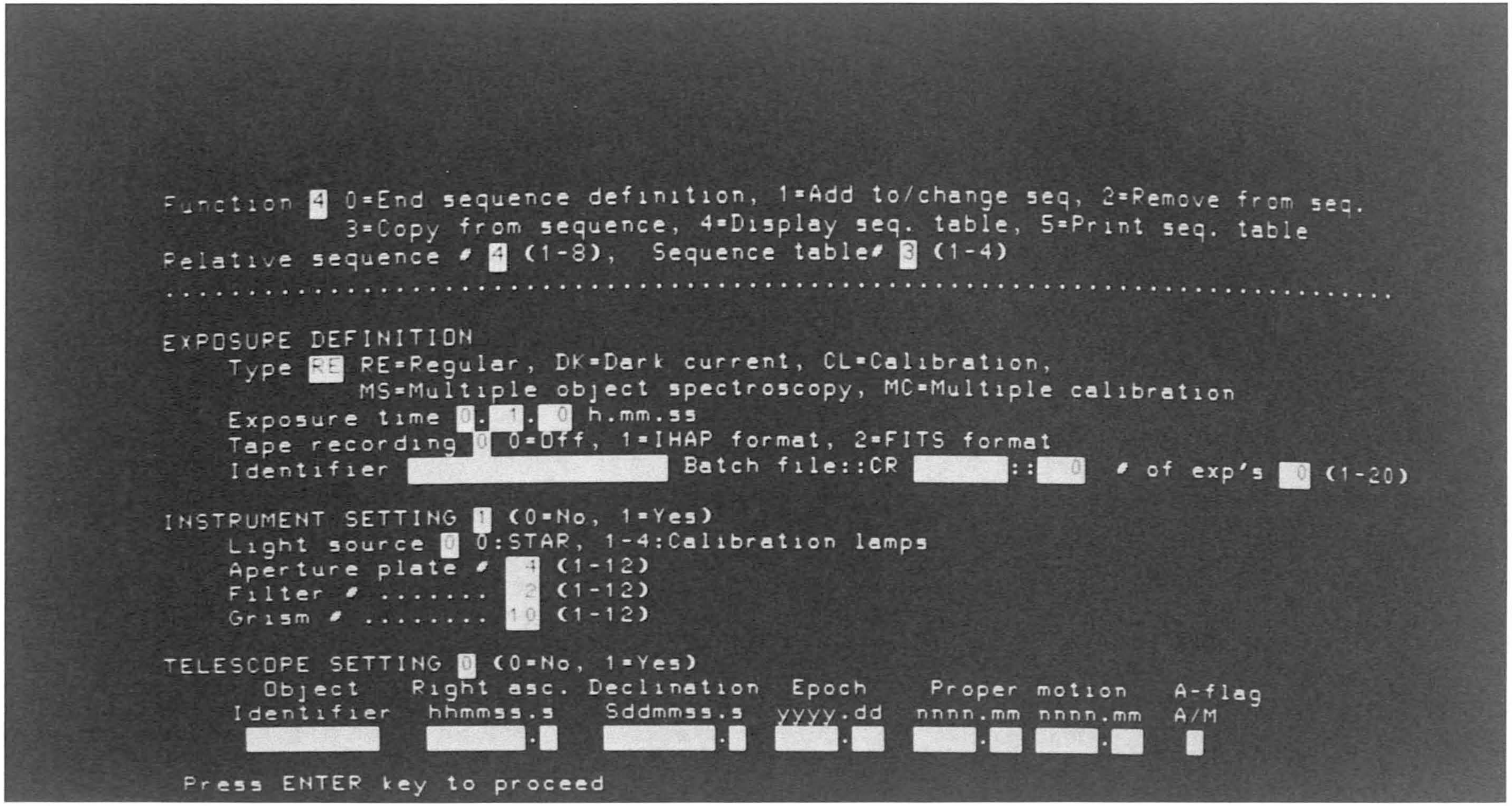


Figure 15: The sequence definition form. This form is filled and, when complete, copied to the sequence which is shown on the graphics terminal (Fig.14) (function = 1). Setting function to 3 will copy an exposure from the sequence table to this form (e.g. for editing).

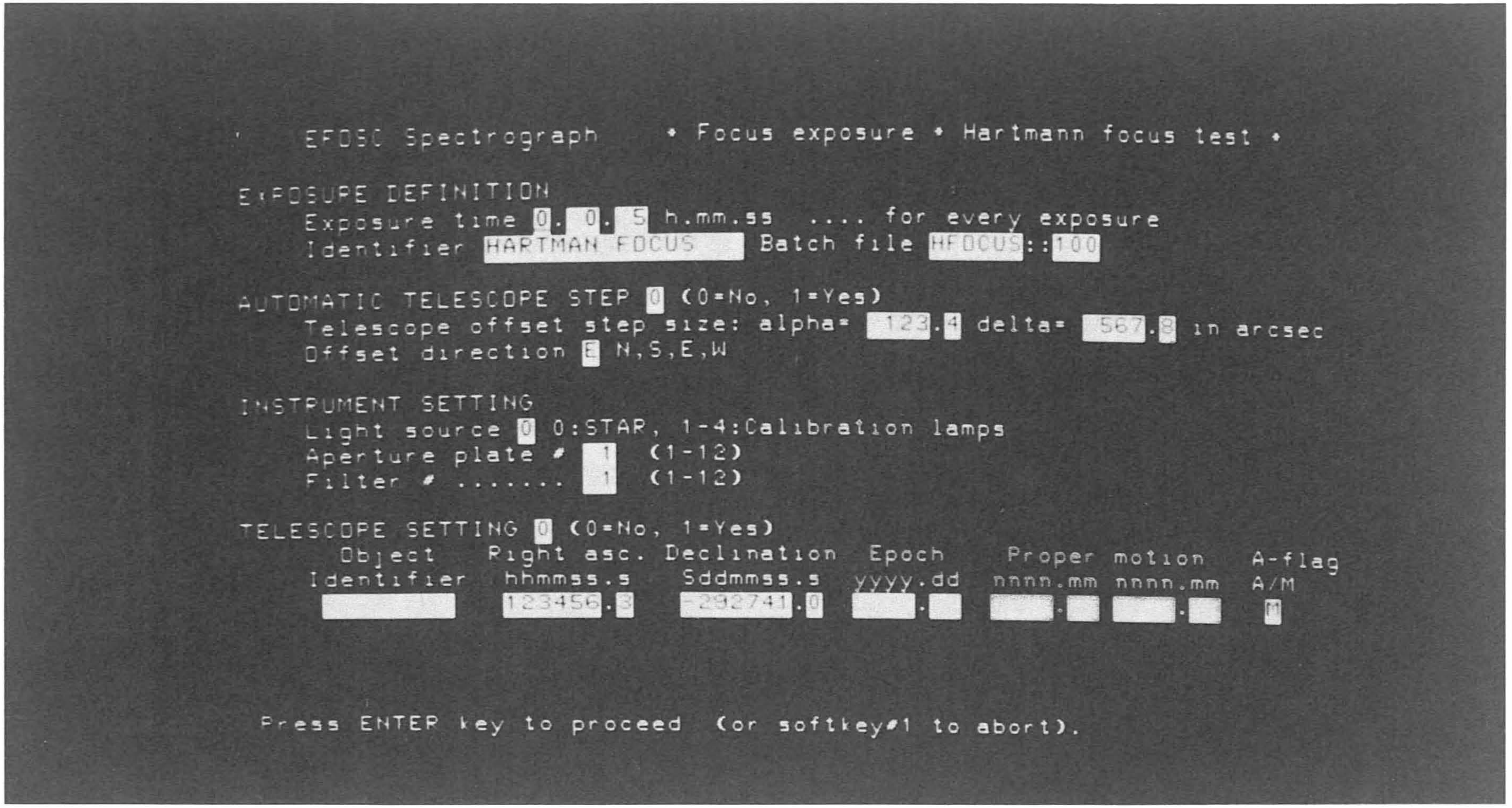
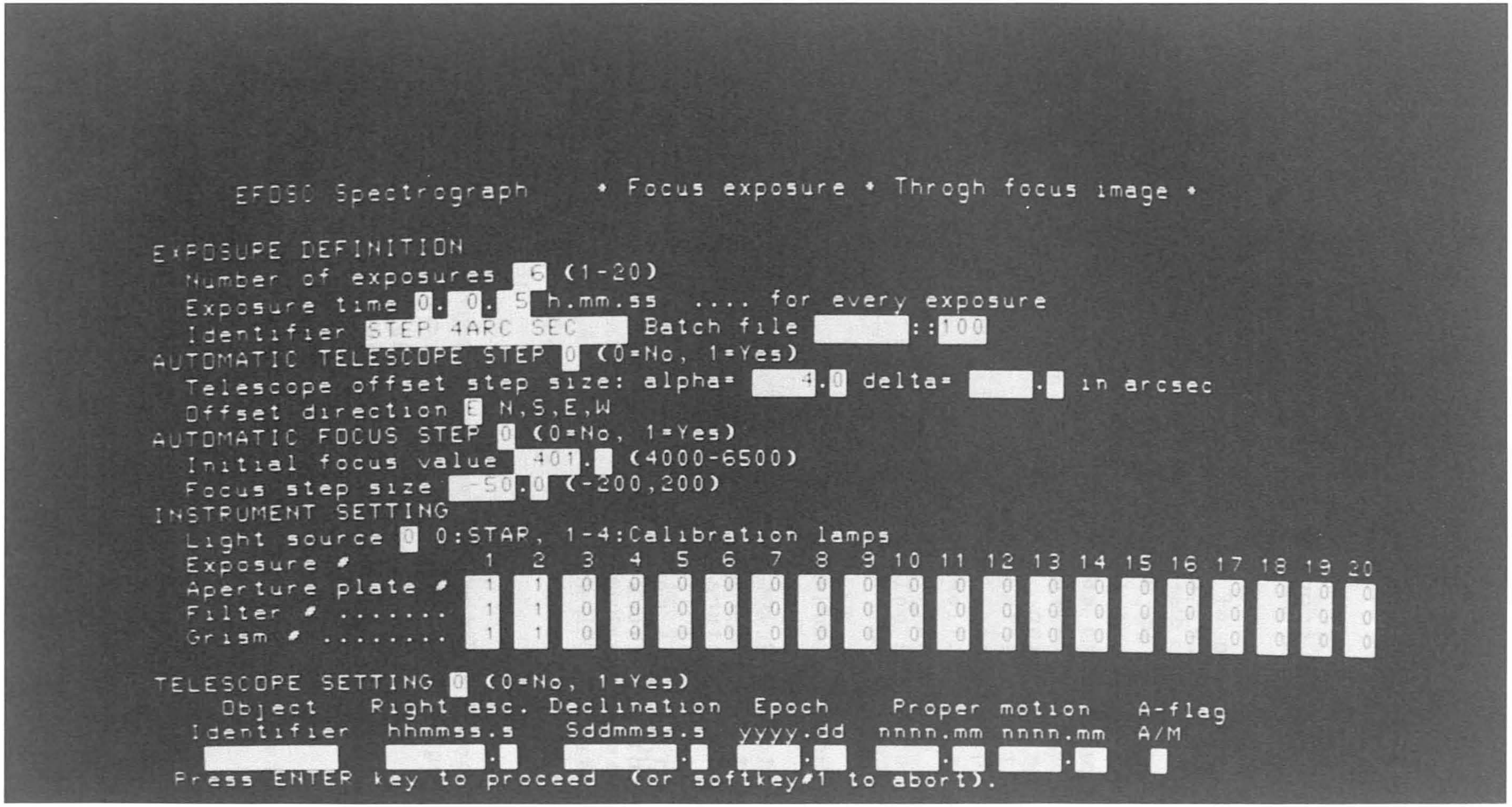


Figure 16: The Hartmann focus test form.
One exposure will be made, with the Hartmann focus analyser (grism wheel pos. 12) in position.
A Hartmann test can be used for testing telescope focus (light source = 0) or EFOSC focus.
In this case, the calibration screen is used, lit by a lamp. Specify HFOCUS in the batch file field. See the Appendix. The CCD will always be read out in fast mode.


EFOSC Spectrograph * Focus exposure * Throgh focus image *

EXPOSURE DEFINITION
Number of exposures 6 (1-20)
Exposure time 0. 0. 5 h.mm.ss .... for every exposure
Identifier STEP 4ARC SEC Batch file ::100
AUTOMATIC TELESCOPE STEP 0 (0=No, 1=Yes)
Telescope offset step size: alpha= 4.0 delta= . in arcsec
Offset direction E N,S,E,W
AUTOMATIC FOCUS STEP 0 (0=No, 1=Yes)
Initial focus value 401. (4000-6500)
Focus step size -50.0 (-200,200)
INSTRUMENT SETTING
Light source 0 0:STAR, 1-4:Calibration lamps

Exposure #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Aperture plate #	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Filter #	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grism #	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TELESCOPE SETTING 0 (0=No, 1=Yes)

Object	Right asc.	Declination	Epoch	Proper motion		A-flag
Identifier	hhmmss.s	Sddmmss.s	yyyy.dd	nnnn.mm	nnnn.mm	A/M
	.	.	.	.	.	

Press ENTER key to proceed (or softkey#1 to abort).

Figure 17: The through focus test form.
Up to 20 exposures on the same CCD image can be defined.

BATCH, EFHELP

```
     Summary of EFOSC batches

Help file                                                  EFHELP
To get a listing of all help,
type BATCH,EFHELP,,ALL

Observing aids
--------------
Display with auto cut setting                              EDISP
As EDISP, but better suited for spectra                    EDISP2
Telescope pointing                                         OFPOIN
Draw slit in overlay plane                                 DRSLIT
Focussing telescope or EFOSC collimator                    HFOCUS
Seeing determination                                       SEEING
Drilling coordinates for MOS starplates                    MOSDRL
Measure star and hole posns for MOS alignment              MOSMES
Determine starplate alignment corrections                  MOSALI

Maintenance and adjustment aids
-------------------------------
Find slit or CCD inclination & correct                     SORNT
Find slit viewer cross position                            SVORNT
Find Double Aperture positions & correct                   DAORNT
Find grism orientation & correct                           GRORNT
Find slit focus & correct                                  SFOCS
Find double aperture focus & correct                       DAFOCS
```

Figure 18: Currently available EFOSC batches. For more information, see the Appendix.

These batches are installed on the 3.6 m control computer. Use EFHELP to get the most up-to-date information.

3.2.1 Focusing

A good guess for the initial telescope focus setting is an encoder reading of 5270. A first focus check can be done with the slit viewer. For final precise focusing, the EFOSC software offers two different possibilities.

In the through-focus exposure sequence a number of exposures is taken of a star with an automatic change of telescope focus and offset for each exposure. This results in a CCD frame with (for each star) a row of images with varying size. Subsequently, a batch program is executed that requests the observer to mark these images on the RAMTEK screen, using the cursor. The image sizes in X and Y are then automatically evaluated and the image diameter as a function of focus encoder position is displayed. This method is accurate and yields the image diameter in X and Y at the best focus. Depending on the number of offset and focus steps specified, it can be somewhat time-consuming (5–10^m to obtain and analyse the CCD frame). See figure 17.

Because only one exposure is made, the Hartmann focus test is much faster (1–2^m). However, the test only *optimises* the image size in the Y direction; it does not allow a measurement of the seeing. If astigmatism is present (which can only be due to the telescope) the image FWHM in X can be slightly larger than in Y. A direct image is obtained with the focus analyser (grism wheel position 12). This analyser produces a small tilt in the horizontal (X) direction in the beam from the upper half of the pupil with respect to the lower half. (The designations lower, upper and horizontal correspond to the image as seen on the RAMTEK). Due to the action of the focus analyser, each stellar image is split in two. The shift in the vertical (Y) direction between the two is proportional to the amount of telescope defocus. The CCD image is analysed by the IHAP batch HFOCUS by comparing the difference in the positions of the centers of gravity of suitable stellar objects. If in the focus exposure definition form (figure 16) the name HFOCUS has been filled in, the batch is automatically executed after the exposures are finished. The following applies to both focusing methods:

- Do not use an excessively short exposure time; this will help to average out seeing effects and guiding errors. A minimum exposure time of 30^s per (sub)image is recommended.
- One focus encoder step corresponds to a change in image diameter of 3 μm (.1 pixel).
- It is recommended to check the focus after applying a correction.
- Because the EFOSC focus has been set during maintenance, the telescope will be accurately focused on the slit plane after focusing is complete.
- Field curvature of both EFOSC and telescope can be neglected.
- The dome temperature should be monitored during the night and the telescope refocused if the temperature changes by more than 1 ^oC.

3.2.2 Pointing using the slit viewer

Because the EFOSC slits are not inclined, it is not possible to guide using the adaptor slit viewing TV (most objects would be too faint anyway). Instead, the off-axis guide probe must always be used for guiding. The slit viewer mirror, which is mounted on the aperture wheel, can be switched in (by command `AP,2` — see section 4.2) to use the slit viewer TV *for pointing only*. In the surface of the mirror, a transparent cross (line width 0.7″) is etched. The central box has a size of 2.1″.

Note

The slit viewer mirror and its mounting have been designed in such a way, that a direct CCD image (in transmission) can be obtained of the crosshairs. The exact positions of slits and slit viewer cross can be compared by taking a direct image, using the Helium lamp (5^s) and the calibration screen. The appropiate maintenance batch (figure 18) will automatically calculate the positions. Normally, in maintenance the positions have been adjusted to within .3"; less for the narrowest slits.

Depending on the sky brightness, type of object and integration settings the cross may not be seen too clearly; switching on a spectral lamp (e.g. `LA,3`) will make it stand out better. **Turn the TV high voltage down before doing this!** When the object is centered on the cross, starting the exposure will automatically move the requested slit in place.

3.2.3 Pointing using EFOSC in imaging mode

This is the only possible way to point at objects fainter than magnitude 19–20. After setting the off axis guide probe on a suitable guide star, a direct image is taken, usually without filter. An exposure time of a few seconds is generally sufficient to clearly detect 21^{st} magnitude stars. The image is loaded on the RAMTEK and a batch (e.g. OFPOIN) is used to measure the target position and compare it with a previously measured slit position. They are measured by the Operations Group before your run; the positions are entered in the optical configuration form and a printout is made. See Appendix A–9 for more information about OFPOIN.

The batch GETTWO is useful if a special slit orientation on an extended object should be achieved or if the slit is to be aligned on two objects. To do this, the telescope adaptor and possibly also the EFOSC aperture wheel must be rotated. Please refer to the MOS manual for details.

Occasionally, the offsetting accuracy of the 3.6 m was found to be poor, possibly due to a hysteresis problem in the telescope drive system. For this reason, repeat the pointing procedure until accurate positioning is obtained. Using the long slit with the adaptor at the standard 270 degrees, it is only the accuracy in declination that is important.

Tip: if two otherwise identical images with and without the slit in place are compared the percentage of light passed by the slit can be found.

Most filters introduce a small offset so if a filter must be used, the images of object and slit must be taken through the same filter. The slit positions entered in the optical parameters form (figure 4) are taken without a filter. Filter offsets can be measured, contact La Silla staff.

The batch DRSLIT can be of occasional help to visualize the slit in a direct image of your object. Since it is drawn in the overlay plane of the RAMTEK where only integer pixels can be addressed, its position can be only approximately correct.

3.2.4 How to use the guide probe

The guide probe is mounted above the focal plane of EFOSC. If it is too close to the center it can obstruct (part of) the EFOSC field of view. If the image on the CCD appears to be vignetted, another guide star must be found.

When the starfield has been identified and you are about to bring your object on the slit, **FIRST LOOK FOR A SUITABLE GUIDE STAR**, using the guide probe, and lock on to it. After applying an offset calculated by OFPOIN or GETTWO, the offset guider must be brought back to the guide star as quickly as possible (the star will still be in the field of view of the guide probe) in order to reduce the time the telescope has to track. If this procedure is not followed, you may need more iterations than necessary before the object is well centered on the slit.

3.2.5 Seeing check

As an aid in determining which slit to use, you can use the batch SEEING. This batch requests you to point at several objects in an image, calculates image size in X and Y for each object as well as the average for all objects. See Appendix A-3.

3.3 Science Exposures: Efficiency and Limiting Magnitudes

3.3.1 Direct imaging

In direct imaging, the efficiency of EFOSC is the product of the transmission of the atmosphere, two reflections in the telescope, the transmission of EFOSC optics (figure 3) plus any filter which may be used and the quantum efficiency of the CCD (figure 8). At the effective wavelength of the V color one predicts a global efficiency of 35% at 1 air mass. This is also confirmed by the observations of standard stars.

The limiting magnitudes in wide band observations will depend on the sky brightness, the shot noise of the sky background dominating the read out noise of the CCD, on seeing conditions and on the crowding of the field to be observed. With the present pixel size (0.675 ″/mm) EFOSC is well matched to the average seeing conditions at the 3.6 m (1.5 arcsec). In the commissioning period B and V exposures of a reference field in the globular cluster Ω Cen were obtained. When reduced using the program INVENTORY in the MIDAS environment [8] these images indicated a limiting magnitude of $m_v = 25$ ($S/N = 3$) for a 15 minutes V exposure in a crowded field. The observers should be able to improve this value by at least one magnitude by using multiple exposures. Note also that in the 15^m exposure stars of $m_v = 17$ saturated the CCD.

In direct imaging of extended objects EFOSC is particularly efficient, the main advantages being the compact scale at the detector and the possibility to mount several filters at the same time. Table 3.1 lists the approximate fluxes that may be expected from the sky in a moonless night with EFOSC.

Table 3.1: Sky Background Fluxes

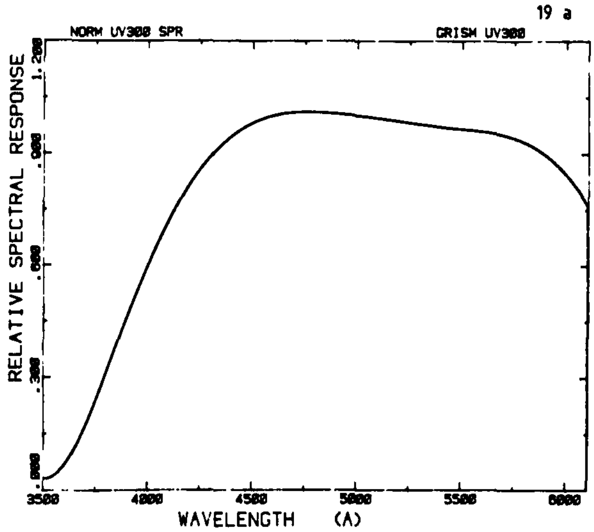
Filter	**Count rate** ADU/min./pixel (*)
B Bessel	50
V Bessel	160
R Bessel	160
r Gunn	100
5007/60	9
6563/70	15
No filter	800

(*) 1 ADU = 11 electrons

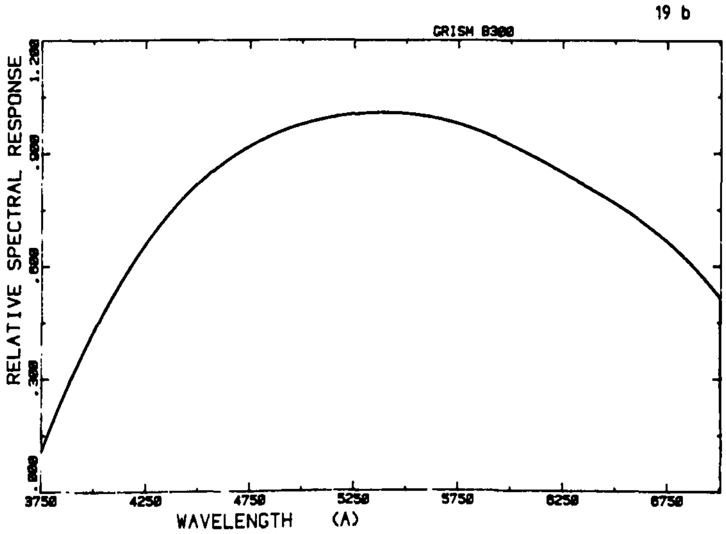
3.3.2 Spectroscopy

The characteristics of the EFOSC grisms and their efficiency curves are given in par. 2.5 and figure 7 respectively. The global efficiency of the system telescope+EFOSC+CCD has been determined by observations of standard stars (LDS235B and LTT3218) with a 5 arcsec slit. With the B300 grism the efficiency at 5500 Å is 30%. At the same wavelength the system detects 1 photon/sec/Å from a star of $m_v = 18$. The predicted Signal/Noise

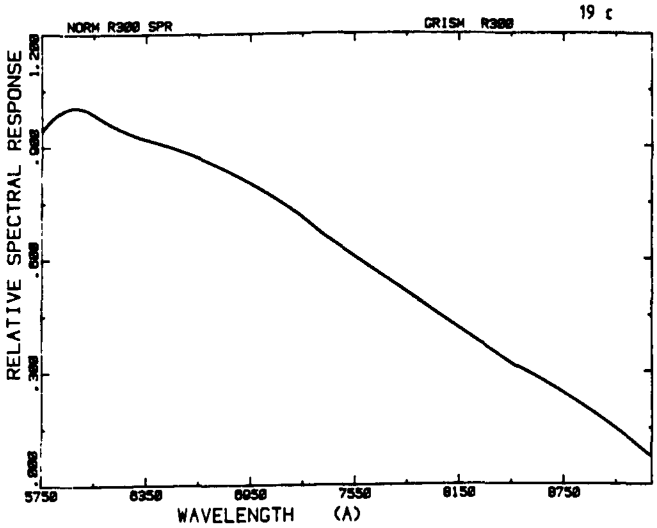
19 a



19 b



19 c



Figures 19 a, b, c:

Relative spectral response of the telescope + EFOSC + CCD system for the UV 300, B 300 and R 300 grism respectively ratio R for a given object can be computed with the standard formula:

$$R = \frac{S}{\sqrt{(S + RON^2 + SB)}}$$

where S is the number of detected photons per wavelength bin from the object. This figure can be derived from the magnitudes and the efficiencies given above after correction for the slit losses. RON is the read out noise of the CCD and SB is the intensity of the sky background over the effective area used in the extraction of the object spectrum. This formula does not include the accuracy of the FF calibration of the CCD (about 0.5%). Depending on the observing configuration, this can become a relevant factor in the determination of the final S/N ratio. One calculates that EFOSC is about 3 times more efficient than the B&C spectrograph with the same detector at comparable dispersions. This is confirmed by observation.

The efficiencies of the system with other grisms can be derived from the values above and the grism efficiencies curves of figure 7. For the three intermediate grisms(UV300, B300 and R300) relative spectral responses are also given from the observations of the same standard stars (figure 19 a,b,c).

Note

Efficiencies and spectral responses have been derived with the ESO CCD #8. They will have to be updated if an other detector is used.

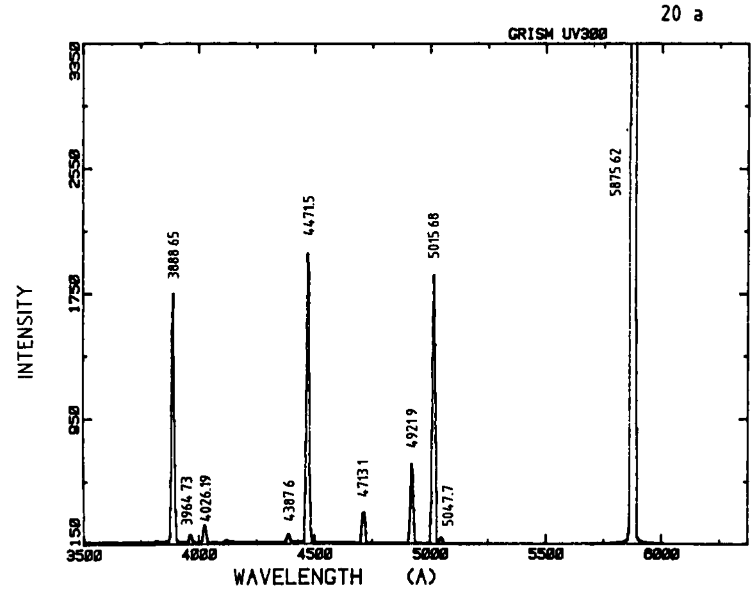
3.3.3 Grism field spectroscopy

This mode of operation should be useful in a variety of survey programs, due to large number of available grisms and the high overall efficiency. The limiting magnitude for a given S/N ratio and exposure time can be computed from the efficiencies given in the previous chapter. The limiting magnitudes are strongly dependant upon the seeing conditions. The use of filters in combination with a grism can be useful to isolate the spectral region of interest and to reduce crowding and sky background intensity.

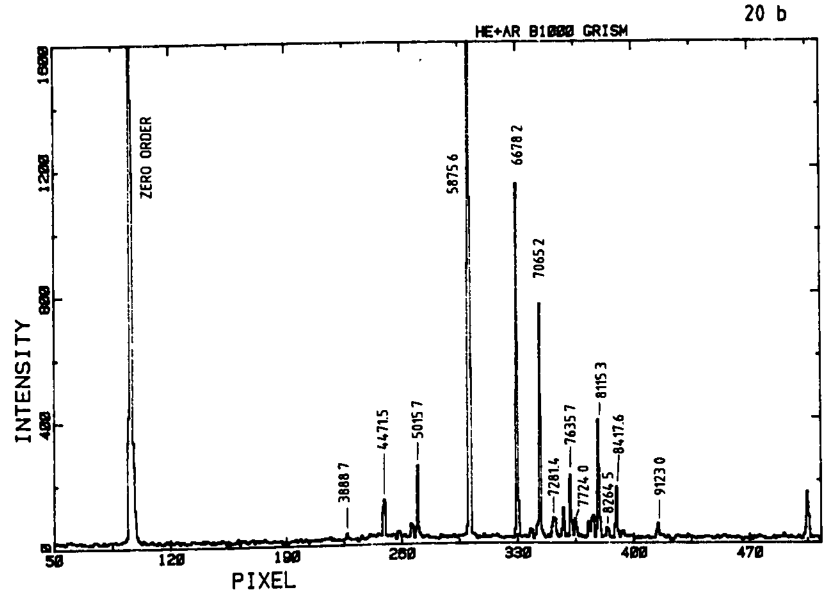
As an example, let us consider the case of the B1000 grism in combination with the V filter in a 5^m exposure. At 5500 Å, the efficiency of the combination of atmosphere, telescope, EFOSC optics, grism, filter and CCD is about 20%. With a seeing of 1.5 arcsec FWHM, the spectra are spread over three pixels perpendicular to the dispersion. The detected sky background is 8800 photons/pixel. The expected S/N ratio for a star with $m_v = 19$ in the wavelength bin (1 pixel corresponds to 26 Å) is 14. The main sources of noise are the photon noise from the sky background and flatfielding inaccuracy (about .5%).

Although for most purposes EFOSC slitless grism spectra are similar in appearance to e.g. those that can be obtained with the Hoag grism in the 3.6 m prime focus in a converging beam, there are some differences. A conspicuous feature in some EFOSC slitless

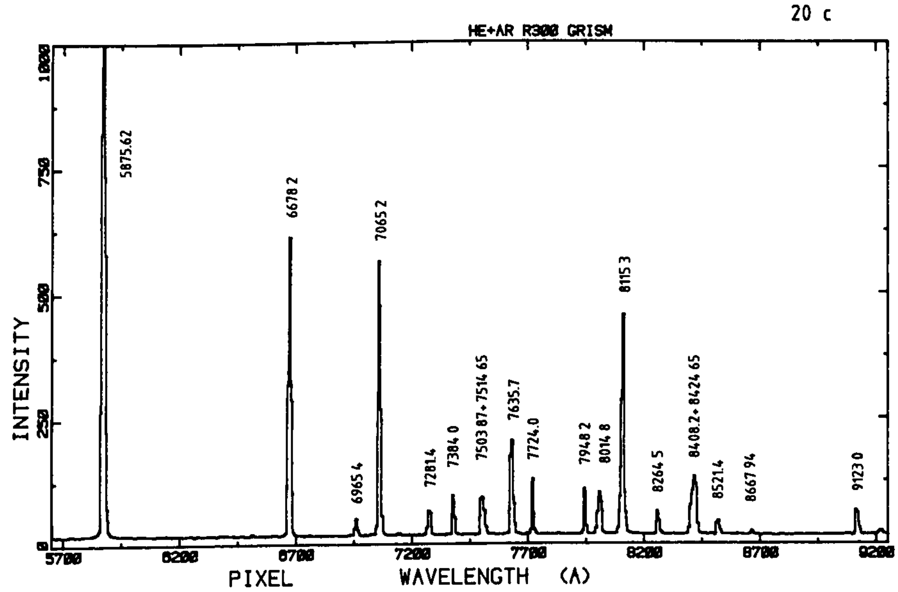
20 a



20 b



20 c



<u>Figures 20 a, b, c:</u>

He + Ar spectra with three grisms B 1000, UV 300 and R 300 respectively.

grism spectra is the presence of one or more distinct edges in the image. These edges run perpendicular to the dispersion direction; the background count rate shows a change when crossing an edge. The edges are due to the presence of an intermediate aperture in the EFOSC aperture wheel. This aperture acts as a field stop (slightly larger than the projected size of the CCD) and prevents stray light from entering the instrument. This aperture is effectively a very wide slit that passes the sky emission. In grism field spectroscopy, the resulting background intensity distribution on the CCD is the convolution of the sky spectrum that would be obtained with a narrow slit (including possibly the zero-order) and a RECT ("top-hat") function with a width corresponding to the field stop size.

3.4 Calibration Exposures

The minimum set of calibration exposures that should accompany the observations consists of a set of dark exposures, a wavelength calibration exposure and a set of flat field exposures.

We stress that **the calibration screen must be in position before taking any calibration exposure**. The only exception is when you wish to flatfield on the dome in direct imaging. The danger about forgetting the calibration screen is, that some light will still be returned by the secondary and so the error is not directly evident.

When using the lamps, the guide probe must be put in the park position, otherwise it might occult one of the lamps.

Note

The shortest exposure time that can be specified is 1 second. The actual exposure time however, will be about 400 msec longer due to timing delays in the CAMAC/computer communication. These delays depend somewhat on the computer activity level. In calibration sequences with short exposure times, this may cause an apparent nonlinearity of the CCD.

3.4.1 Dark exposures

Several 1 second dark exposures can be averaged and subtracted from the science images to take out the electronic bias (about 200 ADU).

At least one, but possibly more, long (about 1 hour) dark exposures are useful to monitor the dark current of the CCD and any exposure dependent features. If the voltages and the temperature of the CCD are kept constant, one dark exposure sequence per run should be sufficient.

3.4.2 Wavelength calibration exposures

A Helium and an Argon lamp are normally mounted on EFOSC. They are intended for wavelength calibration of slit spectra, including MOS. Exposures can be taken with one or both of the lamps by specifying the option CL or MC respectively in the exposure definition form. Table 3.2 lists indicative exposure times for the different grisms and a slit of 1.5 arcsec. Since lamps and CCD may be exchanged in the future, check some of these values at the beginning of your run run and scale them up or down if needed.

Table 3.2: Wavelength Calibration Exposure Times

Grism	Use lamps	Time (sec)
B1000	He + Ar	30 + 30
R1000	He + Ar	30 + 30
UV300	He	30
B300	He	30
R300	He + Ar	30 + 60
B150	He	30
O150	He + Ar	30 + 300
R150	He + Ar	60 + 60
CD	He + Ar	120 + 60

Figure 20 a,b,c shows the calibration spectra for three grisms with the line identifications.

3.4.3 Flat field exposures

Two halogen lamps (colour temperature about 3000°K) are mounted on EFOSC for flat fielding purposes. One of the two (BH) works with a BG38 and a UG3 filter to enhance the blue part of the spectrum and get a more balanced calibration intensity distribution along the spectrum for some grisms. Table 3.3 lists indicative exposure times to get well exposed flat fields with different grisms and the 1.5 arcsec slit (typically 5000–10000 ADU).

Note

Check the values given by table 3.3 at the beginning of a run because they may change after replacement of a lamp or the CCD.

Flat fields of direct images can also be obtained with the lamps and the screen. However, the lamps which are used for the spectroscopic calibration tend to saturate the CCD

Table 3.3: Grism Flat Field Exposure Times

Grism	Lamp	Time (sec)
B1000	BH	40
R1000	H	10
UV300	BH	10
B300	BH	10
R300	H	40
B150	BH	40
O150	BH	15
R150	H	180
CD	BH	30

— even in very short exposures — in direct imaging in a wide wavelength band. If the observer is going to work predominantly in this mode, he can ask to have a neutral density filter (T = 10%) inserted in one of the halogen lamps at the beginning of his run. In B and V colors, the exposure time will then be of the order of a few seconds.

When working with narrow bandpass filters (FWHM less than 200 Å), neutral density filters are not needed. Exposure times will be 5–10 seconds depending on wavelength and bandpass.

Observers may prefer to flat field on the dome lit by skylight or a lamp or on the night sky. For a discussion of CCD flat fielding see [9].

3.4.4 Absolute flux calibration

An absolute flux calibration can be obtained by observing standard stars through a wide slit. A list of these stars is given in the IHAP manual under the FLUX command. The reduction procedure is also given in the IHAP manual. Warning: a star with $m_v = 12$ will saturate the CCD in 3 minutes when using the B300 grism.

Chapter 4

Miscellaneous comments and advice

4.1 Ghosts and Sky Concentration

An on-axis star has a faint halo, generated by reflections in the CCD cover glass and the lenses, with an intensity level of at most 10^{-3} at 5 pixels, 3×10^{-4} at 10 pixels and 2×10^{-4} at 20 pixels distance. Off-axis stars produce less intense ghosts, but in addition have an out-of-focus ghost at the opposite side of the optical axis of intensity 10^{-4} to 10^{-5}, depending on field position. All these phenomena become apparent only when the parent image is heavily overexposed, since the dynamic range of the current CCD is about 4000 at its usual setting.

The so-called sky concentration is another, more important type of ghost image. It appears as a diffuse spot, 5–10% (depending on wavelengths and conditions like filter, sky lines, moon etc.) above the background in the centre of the image. The spot is caused by light — from the sky background and stars — which is back-reflected by the chip into the camera and returned by some optical surface. Optically, it can be seen as the superposition of several demagnified out-of-focus images of the CCD, each image corresponding to an optical surface. The largest contributions come from the field lens surfaces. Flat-fielding will generally correct this effect to better than 1%.

The first surface of the grisms is approximately perpendicular to the beam. About 1–2% of the light impinging on it will be reflected, causing a secondary image of the slit to be formed on the back of the slit plate, effectively acting as a secondary slit. (In case that it is *exactly* perpendicular, the reflected light will leave the instrument through the slit, causing no problems). When using a good black paint on the back of the slit (as is the case on the standard slits) the intensity of this ghost is between 10^{-3} and 10^{-4}. The position depends on the tilt of the grism and varies between grisms.

4.2 Controlling Individual Functions

In case the observer wants to set an individual function without starting an exposure, he/she can do so by typing the appropiate commands directly from the control console. Table 4.1 lists the commands available.

Table 4.1: Commands Controlling EFOSC Functions

Command	Description
`LA,3,ON`	Switch on lamp no. 3. More than 1 lamp can be switched on at the same time.
`LA,OFF`	Switch off all lamps now on.
`AP,2`	Switch in aperture wheel position no. 2.
`IN,AP`	Initialise aperture wheel. Similar for filter wheel (FI) and grism wheel (GR).
`FI,1`	Switch in filter wheel position no. 1.
`GR,1`	Similar for grism wheel.
`SH,OP`	Open shutter.
`SH,CL`	Close shutter.

The calibration screen is not controlled from the control program, but by a handset. Remember to remove the screen before taking a science exposure!

Note

If the observer wishes to interrupt an ongoing exposure, he/she should not try to close the shutter. Instead, type `EXTM,-10000` *to shorten the exposure time by 10000 seconds. This will effectively end the exposure and cause readout to commence. To abort an ongoing exposure with no storage of the image, press the softkey* ABORT

4.3 Troubleshooting

This section gives a mixed assortment of tips how to prevent many problems in the first place and apply "first aid" in case problems occur. To avoid making some elementary mistakes, it is suggested to use the checklist given later in this manual; put a copy of it near to the control terminal where it is easily visible.

4.3.1 IHAP problems

It is common practice, while a long exposure is going on, to do some preliminary data analysis with IHAP. Attempting to address the file # which has been reserved by IHAP for the ongoing exposure may cause a crash. Be especially careful with batches that address the last file # by default (e.g. HFOCUS).

4.3.2 EFOSC problems

Occasionally, an error message may ask you to re-initialise a wheel. This may be caused by a wheel being out of balance on which the end position is not reached quickly enough after a movement to a new position and so is more likely to occur at large zenith distances. The error message states the number of the wheel. The aperture, filter and grisms wheels are designated as no. 3, 2 and 1, respectively. Please use the appropiate command (see table 4.1) to re-initialise the function. If this does not help, move the telescope to the zenith, initialise the wheel and move it to the required position and then move the telescope back to the original position. Problems of this nature should be reported to the Operations Group so they can optimise the wheel balance or servo parameters.

If the count level is unexpectedly low in a wavelength calibration or flat field exposure, the guide probe may be in the way of the lamp. Check if it is in the park position. The adaptor shutter may also be still closed. This can be checked by the night assistant, but only by going into the Cassegrain cage.

If speckle patterns or heavy fringing appear in direct imaging flatfields, you have probably forgotten to put the calibration screen in place. What you see is light reflected by the secondary. In wavelength calibration images, strong ghosts are present when the screen is forgotten.

If no image or a partially obscured one is obtained in direct imaging, the guide probe or the calibration screen may be in the way.

The intensity of the zero order can sometimes be a problem in 1000 Å/mm grism spectra. The intensity can be reduced by the additional use of a photometric filter (e.g. the Bessel B in combination with the B1000), provided of course that the reduction in wavelength coverage can be tolerated.

You should strive for maximum clarity in requests to mount new filters, specifying both the name and ESO number of the filter. If nevertheless you start to doubt in the course of the night that a certain filter was mounted, make a calibration exposure using a halogen lamp, and a slit and a suitable grism in the beam in addition to the filter in question. The location of the filter transmission band in the image is usually sufficient to identify the filter. Incidentally, this also provides a means to get accurate filter curves; simply divide this image by a flatfield, made without the filter in the beam (first subtract the bias level).

4.3.3 CCD status

The CCD program monitors the CCD temperature and issues a warning if it goes outside preset limits. If the temperature is too high, this is usually a sign that the liquid nitrogen has run out. Call assistance immediately. The CCD status can also be checked by pressing the appropiate softkey from the CCD program.

A quick check on the operating conditions of the CCD can be made by inspecting a short dark exposure displayed on the RAMTEK with a narrow cut, e.g. `CUT, #FILE, 190, 210`. In the past, ground loops inside the dewar or the signal lines have sometimes caused pick-up noise which manifests itself as vertical, Moiré-like stripes of a few ADU's peak-peak intensity. The readout noise level can also be verified on this dark exposure. Use the IHAP command `SAMPLE, #FILE, X150, X250, Y250, Y350)`, which computes the average and RMS counts in the central CCD area. With CCD #3 and the present conversion factor (1 ADU is 11 electrons) the RMS should be about 4 units.

4.4 Switch On and Switch Off Procedures

Switch on:

Go to the instrument terminal in the control room and log on with `EFOSC`. After this, press softkey $\boxed{\text{OBSERVATION}}$ to get to the main menu.

Switch off:

The program has several layers. Press $\boxed{\text{TERMINATE}}$ a number of times (one time for each layer) to get out. Note that at several points, it is possible to enter IHAP or other programs. Make sure all your data has been saved!

EFOSC and the CAMAC crate should always be left switched on.

4.5 Reduction of EFOSC Data at ESO

The current data reduction possiblities at ESO Garching are as follows.

4.5.1 Direct imaging data

Complete reduction of CCD images is possible both with IHAP and with MIDAS (running on HP and VAX computers respectively, both in La Silla and in Garching). All the necessary information is provided in the two manuals. The users will have to choose between the two systems according to their experience and the nature of the scientific problem under investigation.

4.5.2 Long slit spectroscopy data

Individual IHAP commands can be built into a batch program to extract the spectra and subtract the sky. After this has been done, the usual (as for the IDS) IHAP commands are available for the calibration and analysis of the spectra.

On MIDAS, extraction of the spectra and subtraction of the sky is also possible. Dedicated commands for the analysis of spectra including wavelength calibration of one-dimensional files will become operational in the course of 1986.

4.5.3 Grism field spectroscopy data

No dedicated commands or extraction packages are yet available. Work has been started to implement spectrum extraction program in MIDAS.

4.5.4 Multiple Object Spectroscopy data

No dedicated commands or extraction package have been implemented. Reduction can be carried out in steps using commands available for long slit spectroscopy.

EFOSC Checklist

In the afternoon or at the beginning of the night

- **Compare the optical setup with your requests.**
- **If new slits were mounted, make sure that slit positions have been measured.**
- **Cassegrain shutter open?**
- **Dome lights off?**
- **CCD temperature OK?**

Before starting a calibration exposure

- **Calibration screen IN if using an EFOSC lamp, OUT if flatfielding on the dome.**
- **Guide probe in PARK; if the TV is left on, the gain should be turned low.**

Before starting a test exposure (pointing etc.)

- **Guide probe on guide star and not obstructing EFOSC image plane.**
- **Use fast readout mode.**

Before starting an exposure on the sky

- **Calibration screen OUT.**
- **Guide probe on guide star and not obstructing EFOSC image plane.**

After starting an exposure

- **Check instrument status display to see if correct slit, filter etc. are switched in.**
- **Check dome and CCD temperature from time to time (also before starting an exposure).**

Bibliography

[1] *The ESO Faint Object Spectrograph and Camera*, ESO Technical Report, in preparation.

[2] *The ESO Faint object Spectrograph and Camera*, ESO Maintenance Manual, August 1985.

[3] B. Buzzoni, B. Delabre, H. Dekker, S. D'odorico, D. Enard, P. Focardi, B. Gustafsson, R. Reiss, 1984, *The ESO Faint Object Spectrograph and Camera (EFOSC)*, The Messenger **38**, 9.

[4] P. Biereichel, B. Gustafsson, G. Raffi, 1983, *The New Data Acquisition System for ESO Instrumentation*, The Messenger **34**, 35.

[5] D. Enard, B. Delabre, 1982, *Two Design Approaches for High Efficiency, Low Resolution Spectroscopy*, Proc. SPIE **445**, 522.

[6] H. Dekker, S. D'odorico, *Multiple Object Spectroscopy with EFOSC*, ESO Operating Manual (preliminary version), August 1985.

[7] M. S. Bessel, 1976, *UBVRI Photometry with a Ga-As Photomultiplier*, PASP **88**, 557. The U filter described by Bessel, consisting of a $CuSo_4$ solution, has been replaced by a combination of 1 mm UG11 and 2 mm BG38 which has a 1% red leak at 7000 Å.

[8] S. Ortolani, private communication.

[9] *CCD manual for the 1.5 m Danish telescope*, ESO Operating Manual no. 3, April 1985.

Appendix A

Example: Use of EFOSC Batches

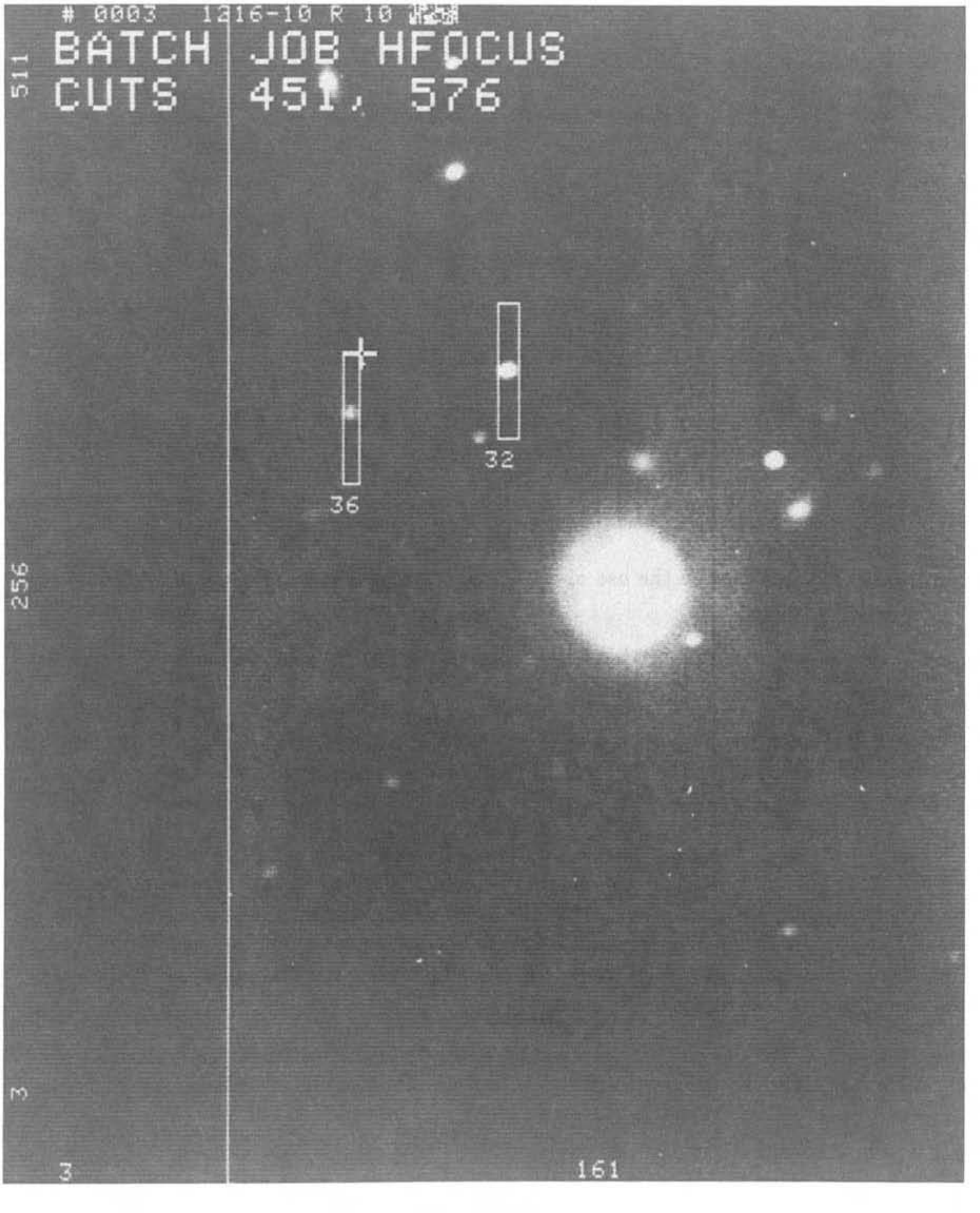
Figures A-1 to A-6 illustrate the use of the EFOSC batches in setting up the instrument before a science exposure.

Figure A-1 shows the RAMTEK after running HFOCUS. The computed focus encoder corrections were then applied.

In figure A-2, the telescope was moved to the field of interest, a guide star found and a short exposure taken, using the batch EDISP to automatically display the image after the exposure had been completed. It is recommended to use the fast readout mode.

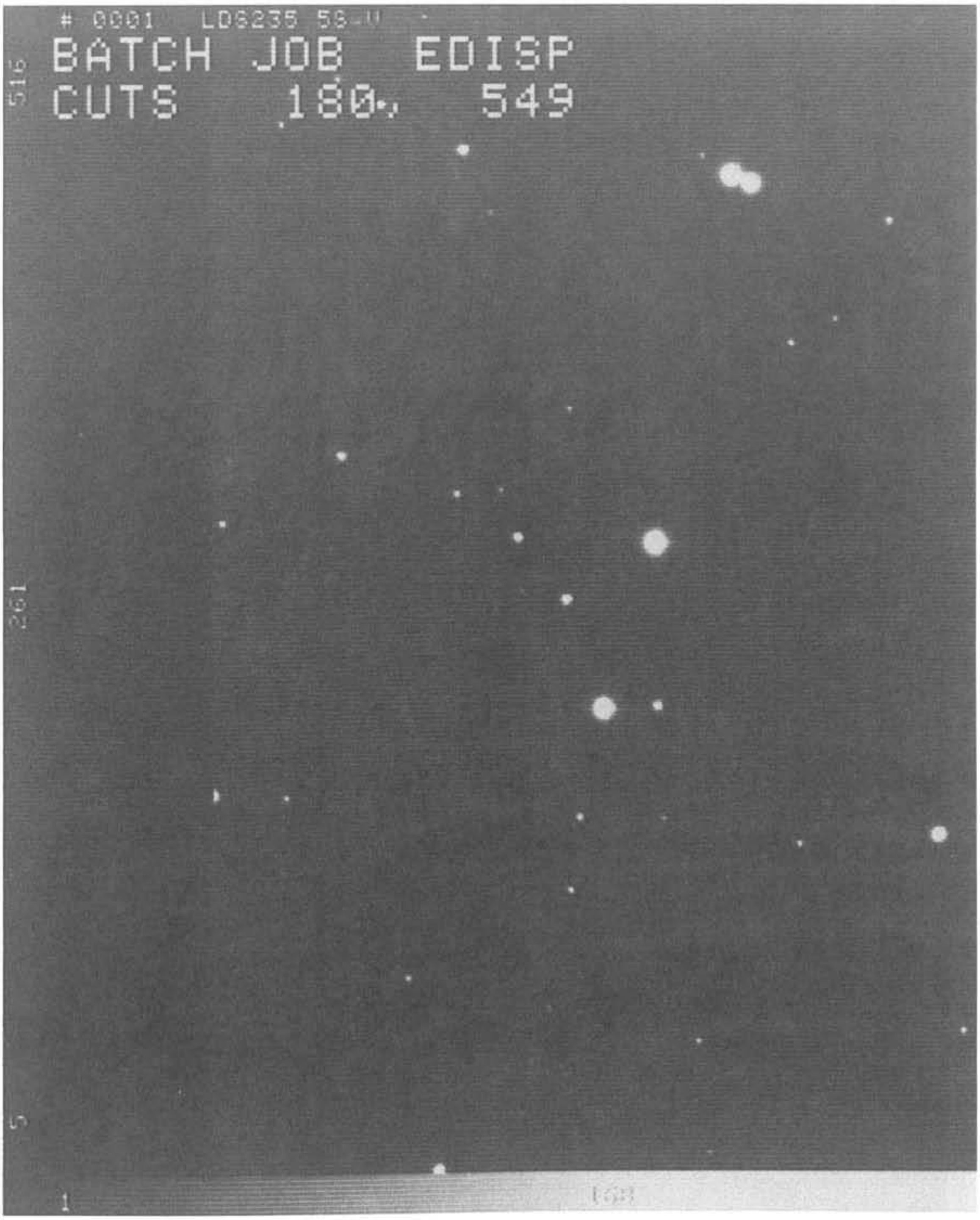
This image was used in A-3 to determine the seeing and select a slit. A slit of 1.5" was chosen. DRSLIT was run (A-4) to visualise the slit. The object can be seen to be very near to the required position. Next, OFPOIN was used to compute the corrections (figure A-5). After applying them a spectrum was taken, switching in the slit and the B300 grism. EDISP2 automatically calculated the cut levels and loaded the image on the RAMTEK when the exposure was finished (figure A-6).

Pages A-7 to A-9 list the current (December 1985) EFHELP on these batches. Batches will evolve; use EFHELP to get the most up to date information about available batches.

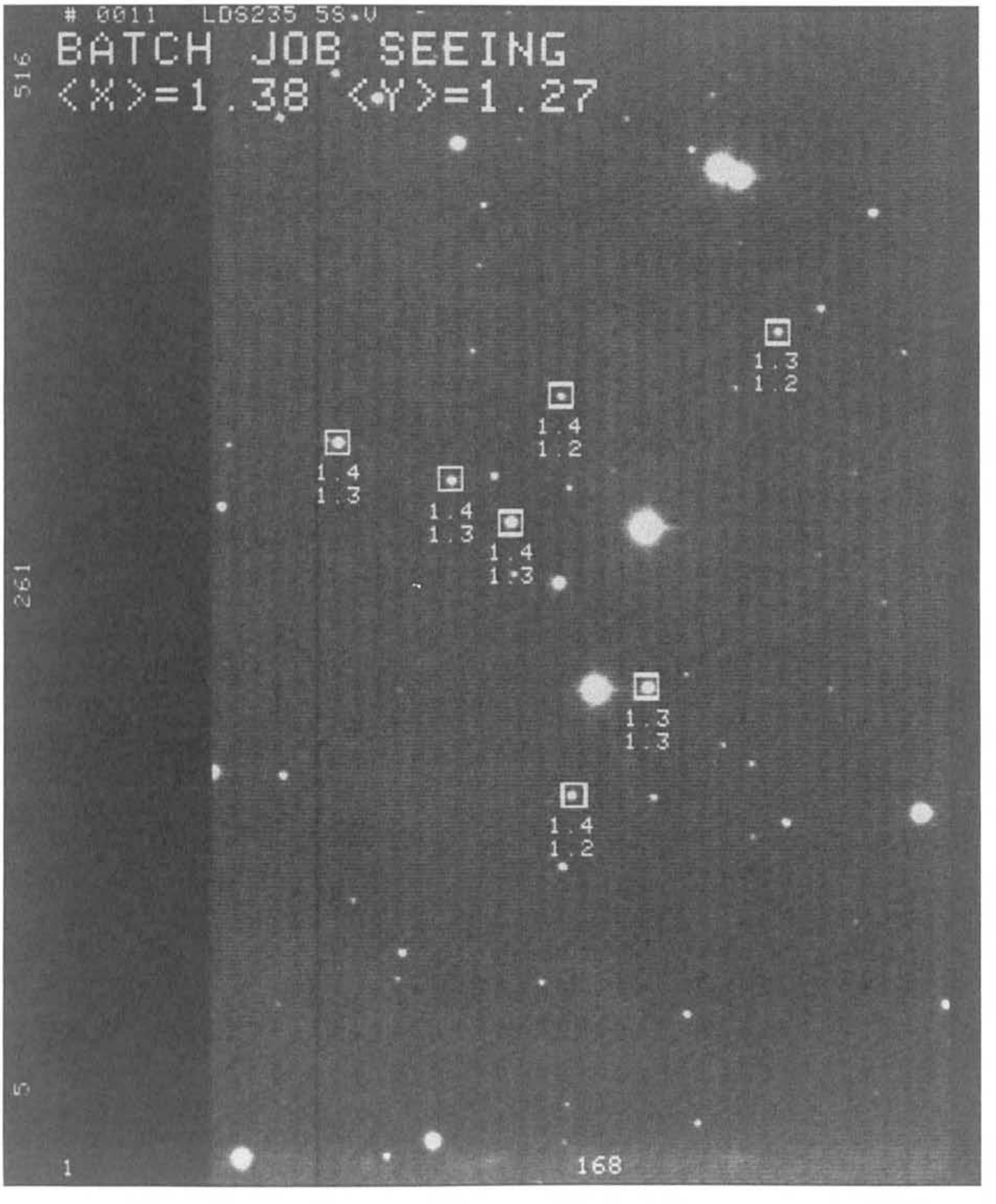


RAMTEK screen after executing HFOCUS.

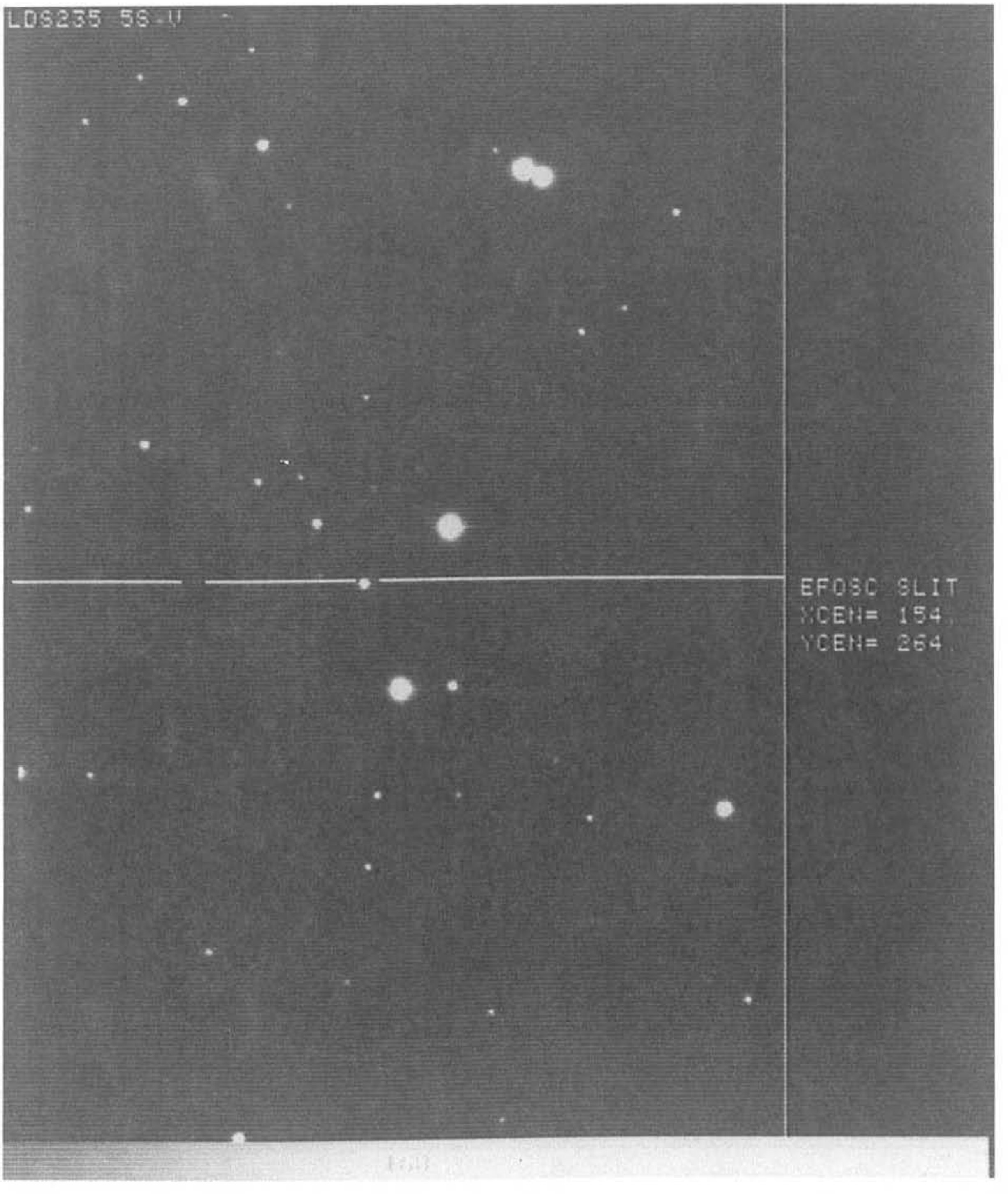
The number below the boxes is the correction to be applied to the telescope focus. Cut levels are automatically set (see EDISP).



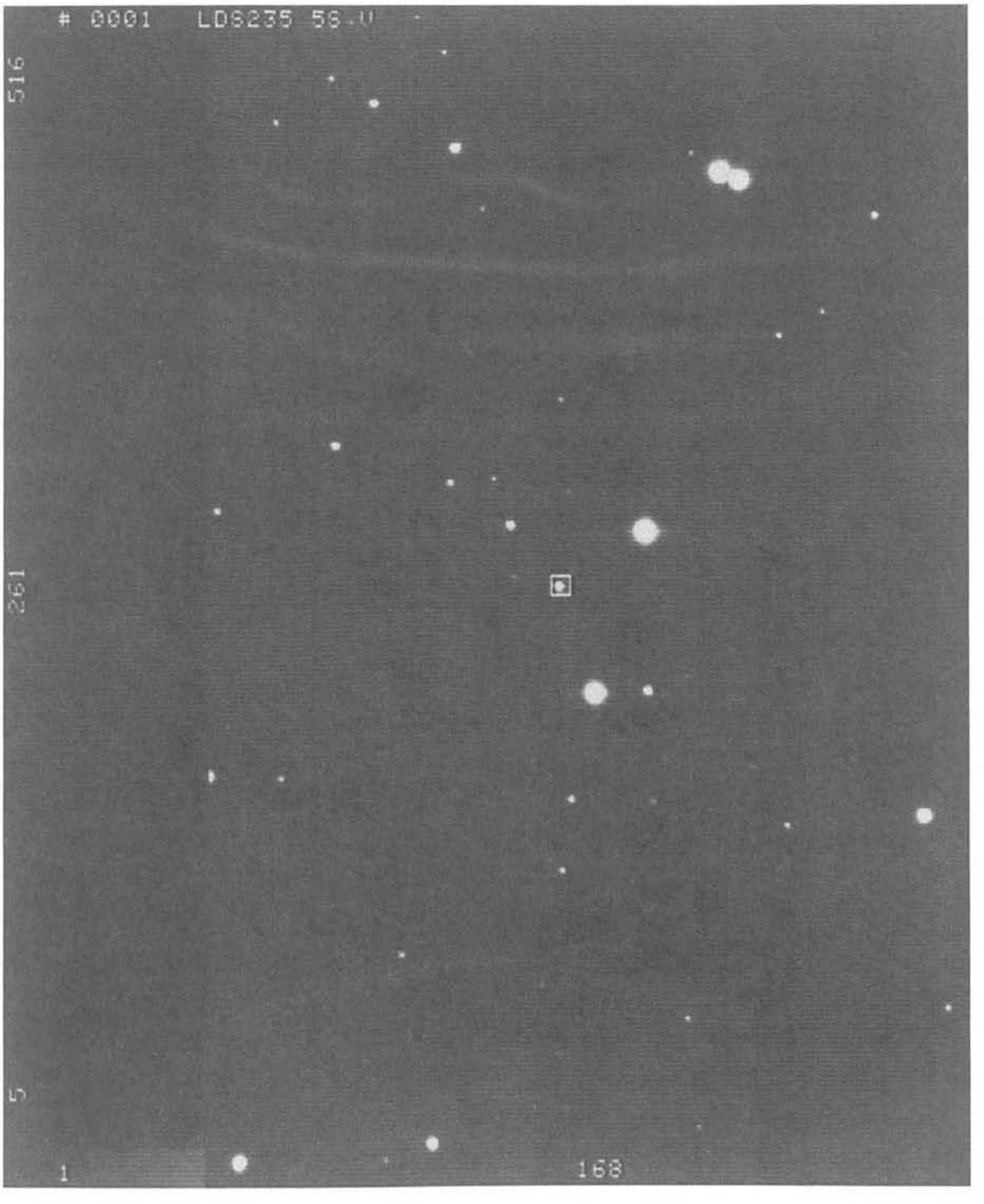
The RAMTEK screen after executing EDISP. This batch is executed automatically if specified in the exposure definition form.



The RAMTEK display after executing SEEING. For each star, its x- and y-FWHM (in arcsec) is shown. Average values are displayed in the top left corner when the batch is terminated.



The RAMTEK screen after running DRSLIT. The positions of the double apertures are indicated by the breaks in the line. Check if there is no object in the aperture you intend to use as sky aperture (when using the CD grism).

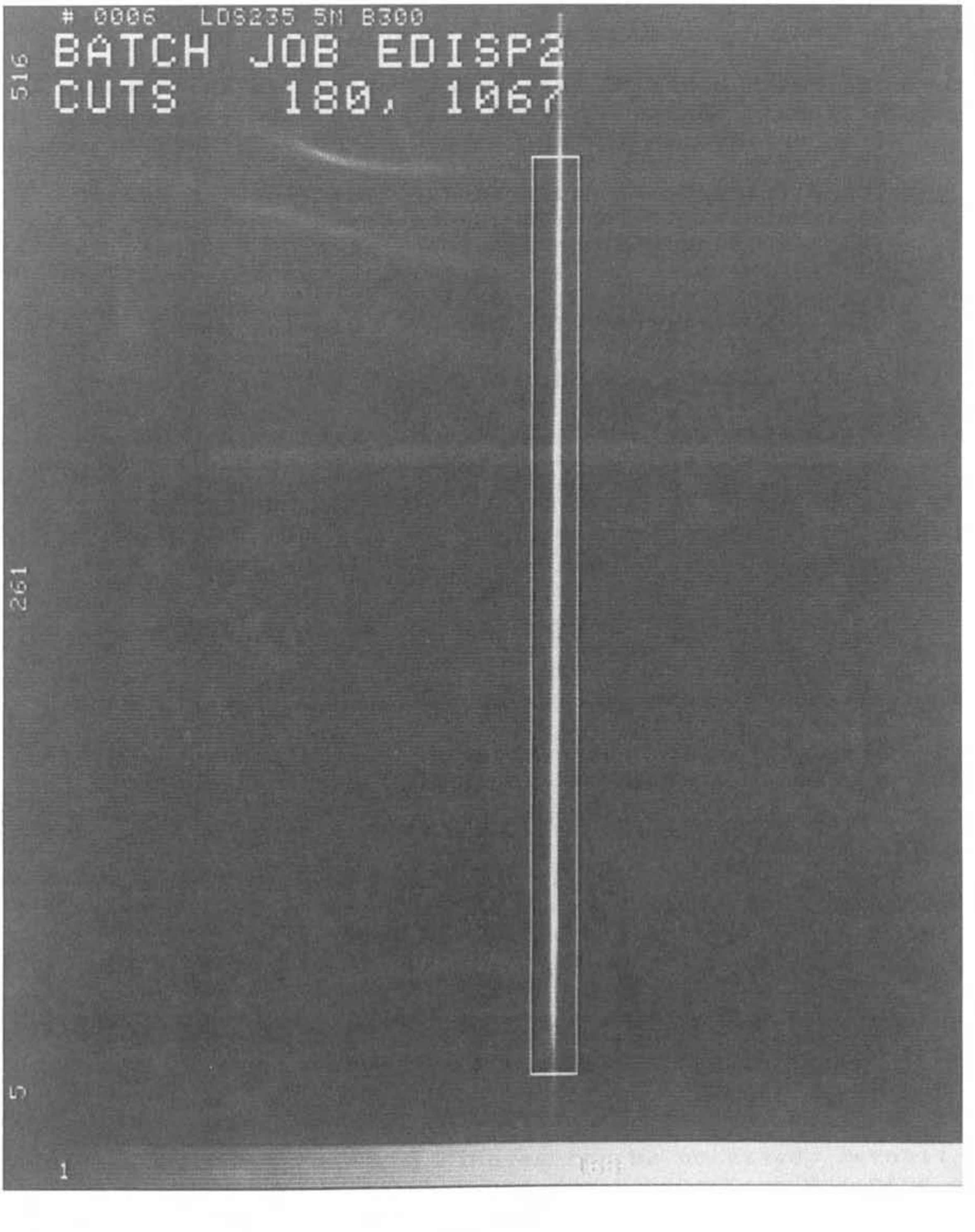



```
Offset to be applied in alfa (arcsec)

   2.192
Offset to be applied in delta (arcsec)

   1.138
```

The RAMTEK screen after executing OFPOIN and the output on the terminal.



The RAMTEK screen after running EDISP2. The box indicates where the sampling was done.

Purpose Determine telescope focus correction

Method The batch works on two images taken with the two alternate Hartmann screen halves in.
If a defocus is present, the centers of gravity of of stellar images or spectral lines will differ.
The difference is measured by extracting the region of interest, collapsing it and crosscorrelating the resulting 1-dimensional profiles. A Gaussian is then fit to the peak and its shift with respect to 0 determined
The batch works equally well on direct images and (emission) spectra. The crosscorrelation works best if you extend the horizontal borders of the area to be extracted well beyond the objects or lines.

Note It is essential that the telescope is guided during and between exposures. The exposures should not be too short in order to average out seeing effects.

Call BATCH,HFOCUS,[#FILE][,LOAD]
Where #FILE is # of image to be loaded;
default is last image.
LOAD indicates if image is to be loaded,
default is Y.

Output Telescope focus correction in encoder steps (also on RAMTEK),
EFOSC collimator correction in mm (maintenance only) and focus blur in pixels if left uncorrected.

```
BATCH,HFOCUS,,#20,N
                                   Star #1
Telescope focus correction to be applied (in encoder steps)

    .518

OR collimator focus correction to be applied (in mm)

    .042

Defocus blur (in pixels)

    .054

Type BATCH to continue...
BATCH
                                  star #2

Telescope focus correction to be applied (in encoder steps)

    .530                          etc
```

HFOCUS help and example terminal output.

BATCH, EFHELP,, SEEING

SEEING

Purpose Measure FWHM of stars in an image made in imaging mode.

Method The batch prompts to put the cursor on the star.
A Gaussian is fit to the star profile, using the IHAP
JCENTER command.

Call BATCH,SEEING,,#FILE ; #FILE must be loaded on RAMTEK.

Output X- and Y-position, X- and Y-FWHM.

BATCH, EFHELP,, DRSLIT

DRSLIT

Purpose Draw EFOSC slit to aid in pointing.

Method First a direct image must be obtained of the field.
The slit is drawn in the overlay plane and can be
deleted with KCLEA,2. The double apertures positions
are indicated by breaks in the line.

Call BATCH,DRSLIT[,,XCEN][,YCEN]
Where XCEN = optional slit X-center (default 154)
YCEN = optional slit Y-height (default 264)

Note Only the approximate position can be indicated, as only
discrete screen coordinates can be accessed. Default
positions were established during the commissioning run.
Actual Y's varied between 263.6 and 264.0

BATCH,EFHELP,, EDISP

EDISP

Purpose Display image with automatic setting of cut levels.

Method An area of the image is sampled.
Low and high cuts are calculated as follows:
HCUT = MEAN + C1*(RMS) + C2*(MEAN-180)
LCUT = MEAN - C3*(RMS) - C4*(MEAN-180)
Make a batch listing to get settings for area position and C values.

Call BATCH,EDISP[,,#FILE]
Where #FILE = optional file number, default last (G10)

Note The batch works well on direct images, flat fields, slitless spectra and darks but only fairly well on spectra.

BATCH,EFHELP,, EDISP 2

EDISP2

Purpose Display image with automatic setting of cut levels.

Method As EDISP, but at first some scanlines through the center are added and the highest point found.
The sampling window is centered around this feature.

Call BATCH,EDISP2 [,,#FILE]
Where #FILE = optional file number, default last (G10)

Note C's are different from EDISP. When used on direct images, pictures will generally have lower contrast.

BATCH,EFHELP,,OFPOIN

Batch OFPOIN

Purpose To bring stellar objects on the slit

Method The batch prompts to point at the object of interest in a previously taken direct image of the field, displayed on the RAMTEK. It determines its position by fitting a Gaussian to it (IHAP cmd. JCENTER) and computes the (alpha,delta) offset, taking the adapter orientation into account.

Call BATCH,OFPOIN,,XSLIT,YSLIT,[PHI]
XSLIT,YSLIT = Predetermined slit position
PHI = Optional adaptor position, default = 270.

Output alpha,delta offset to be applied TO THE TELESCOPE.

EFOSC - ESO OPERATING MANUAL NO. 4

UPDATE No. 1, MAY 1986

A NEW DOUBLE-DENSITY RCA CCD AS EFOSC STANDARD DETECTOR

As of June 1986, EFOSC will be equipped with an RCA SID 503 CCD. The parameters of this new chip are summarised in table 1.

The main difference between this CCD and the one used so far (ESO # 3) is the two times reduced pixel size (.337" on the sky).

When used with two-fold binning in the x- and y direction the format is identical to that of the standard CCD (30μm pixel = 0.675" on the sky). AS ALL OF THE EFOSC BATCHES (E.G. POINTING, MOS BATCHES, ETC.) HAVE BEEN WRITTEN ASSUMING A PIXEL SIZE OF 30 um THEY SHOULD BE USED FOR THE TIME BEING ON IMAGES TAKEN IN THE BINNED MODE. POSITIONS OF THE SLITS MEASURED BY THE OPTICIAN WILL ALSO CONTINUE TO BE GIVEN IN THE BINNED CCD COORDINATE SYSTEM.

The use of the unbinned mode in the actual observations is useful for specific applications only. Seeing, r.o.n. value, sky background surface brightness are the parameters to be considered in assessing the possible advantages of the high resolution mode. As each file contains four times the number of pixels of the standard RCA CCD, about 25 files fill already the space available on the disc. Read-out time at the telescope and reduction times are also increased.

One case where the "high resolution" mode would be clearly advantageous is in sky limited, direct imaging observations of stellar objects in crowded fields and/or with seeing ≙ 1 arcsec. If the observations are read-out-noise limited, the smaller pixel size is a disadvantage.

In spectroscopy, there is no gain in resolution if the small pixel is used in the direction of the dispersion (the 1 arcsec slit projects on about 2 30μm pixels). With very good seeing (≙ 1 arcsec), the use of the 15μm wide pixel in the x direction will increase the angular resolution perpendicular to the dispersion.

Table 1   ESO CCD # 8

Type: RCA CCD thinned, backside illuminated S.No. 5103/2/6

Format: 640x1024, 15 μm x 15 μm pixels

Read-out-noise: 33 e-

Gain: 3 e- / ADU at gain 100

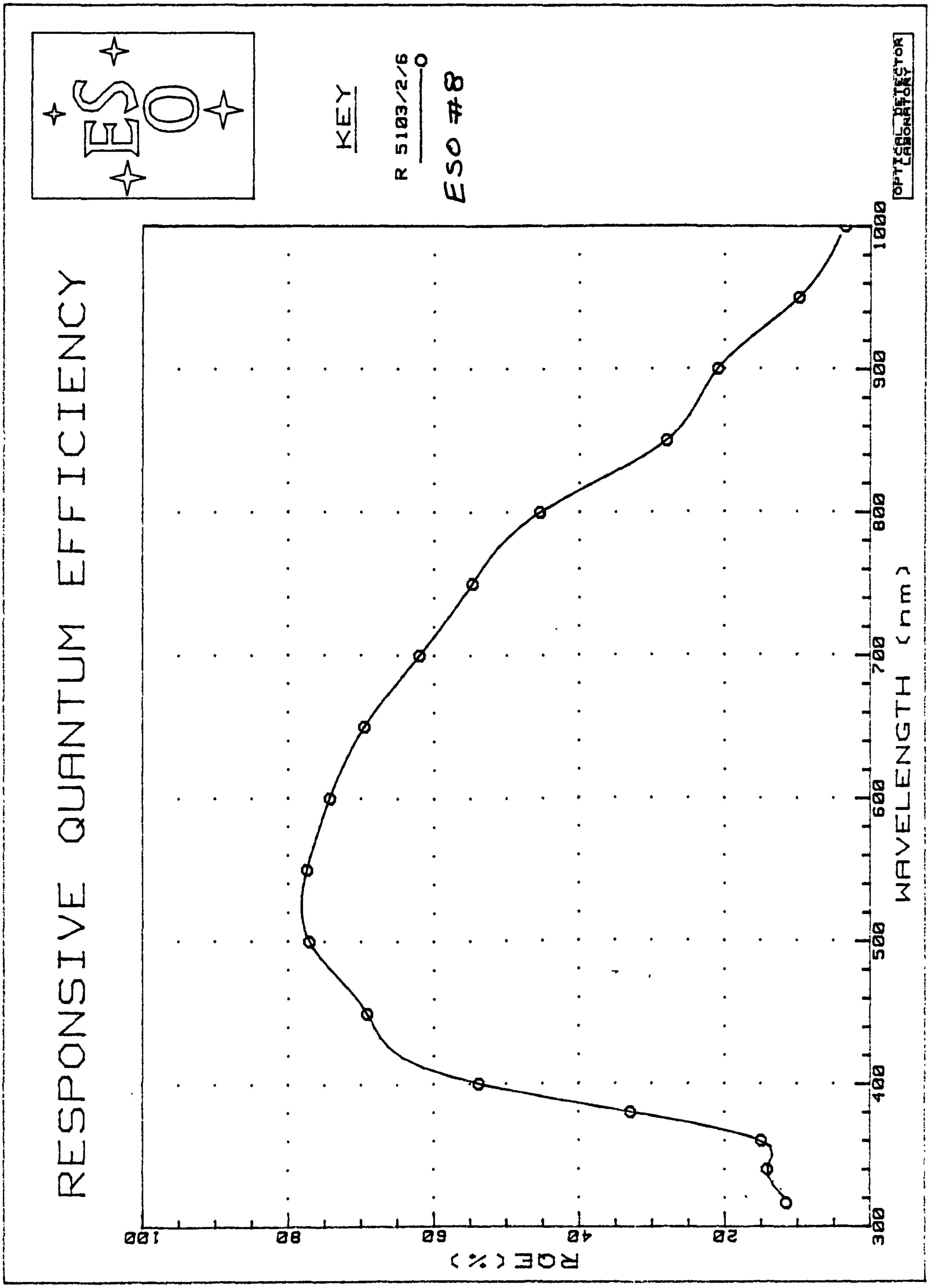
Quantum efficiency: 75% at 500 nm (see curve)

Dark current: 60 e-/pixel/hour at 140 K

Defects: Dead column at position x 41. Several column pairs with small negative/positive offset

Linearity: Found to be better than 0.1% with uniform illumination at low light levels

Please be reminded that the operating parameter of the CCD mounted on the instrument is automatically transferred to the header of the resulting IHAP file, from where they can be read with the WCOMMENT, #....command.


RESPONSIVE QUANTUM EFFICIENCY
KEY
R 5103/2/6
ESO #8
OPTICAL DETECTOR LABORATORY
WAVELENGTH (nm)
RQE (%)
300
400
500
600
700
800
900
1000
20
40
60
80
100