EMMI CONTEXT

USER's MANUAL

EMMI/EFOSC2 Numerical Simulator

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Contents

I. INTRODUCTION

The aim of these programs is to simulate the different configurations of EMMI and EFOSC2 at the NTT, and provide quantitative information to help the observer to select the parameters which are best suited to his/her observations (mode, disperser, filters, detector, slit size, etc).

The parameters which can be tuned during a real observation are present in the simulator, so a possible application of this tutorial would be to prepare the complete set of parameters needed to run an exposure, given certain atmospheric conditions, and zenith distance.

This simulator is written in Midas command language (version 90MAY) and uses Midas tables, but the user doesn't need to be familiar with Midas to be able to run it. It works in interactive mode using part of STARCAT interface. It is available on the Vax and on the Unix workstations in Garching. The Space Telescope Model Midas context (STMODEL) has been taken as a starting point and many programs of this context have been adapted to our purpose.

Here is the list of the commands which can be used in the EMMI context:

- `SET/CONTEXT EMMI`: to start EMMI context
- `EMMI`: to select EMMI instrument
- `EFOSC2`: to select EFOSC2 instrument
- `IMAGING`: to do a simulation in the imaging mode
- `SPECTRO`: to do a simulation in the spectroscopic mode
- `ECHELLE`: to do a simulation in the echelle mode (not fully implemented yet)
- `MYDATA`: to ask the program to look for the instrumental data first in the working directory and then, if not found, in the data base.

The default parameters are loaded at the first execution of a given mode (IMAGING in R channel for ex.). If the next command is the same again, the parameters are not initialized and keep the values chosen by the user in the previous run (except the grisms and gratings for EMMI). In this way the user can build up progressively his/her own set up. Running the simulation in a different mode (IMAGING in B channel for ex.) will load the default parameters for this new mode, and overwrite the old values.

Use the help on-line facility for commands, with

```
Midas008> HELP
```

for general help (MIDAS and EMMI context) or

```
Midas009> HELP IMAGING/
```

for more specific help on the imaging mode in that example (also available: SPECTRO, ECHELLE, EMMI and EFOSC2).

II. HOW TO GET STARTED

• First you need to set up some logical names (in order to tell the system where to look for data, executable files, and so on). On the ESO/VAX:

```
$ @MISC$DISK:[EMMI]LOGIN_EMMI
```

or on a ESO/Unix workstation:

ESONS007: `source /nsOf/software/emmi/login_emmi`

• Then start a Midas session, on the ESO/VAX:

```
$ INMIDAS
```

or on a ESO/Unix workstation:

ESONS008: `$inmidas`

A Midas prompt will appear:

```
Midas001>
```

• To get into the simulator environment, type: (the file EMMI.CTX must be in the working directory, if not, copy it from MISC$DISK:[EMMI]EMMI.CTX on the ESO/Vax, or from /nsOf/software/emmi/emmi.ctx on the ESO/Unix workstations)

```
Midas001> SET/CONTEXT EMMI
```

• Then choose the instrument:

```
Midas002> EMMI
```

Or, for EFOSC2/NTT:

```
Midas002> EFOSC2
```

• Then run the corresponding simulation program:

```
Midas003> IMAGING
```

for direct imaging, or SPECTRO for low and medium resolution spectroscopy, or ECHELLE for echelle spectroscopy (the echelle mode is not fully implemented yet).

III. A SIMULATION STEP BY STEP

Two simulations in imaging and spectroscopic mode have been done as examples (with the default values). The logfiles, output curves and hardcopies produced by these simulations are shown in Fig. 3 to 14.

The simulator assumes that the object is a stellar-like source. It starts from an "ideal" spectrum of this object outside the atmosphere and then takes into account the various components: atmosphere, mirrors, [slit,] lenses, [filter(s),] [disperser(s),] and detector.

III.a) Selecting the parameters

In the first step, the parameters of the simulation are displayed with their default values (or those from the previous run) and can be changed by writing directly their new values in the corresponding fields, and moving from one to another with the arrows. The format of the screen and the available parameters are shown in Fig. 1a. This part of the program uses the same structure as STARCAT. The syntax of the input parameters and their possible values, can be checked by using the on-line Help (type "H" for Help). To validate these changes, and proceed to the next step, type "CTR Z" and then "R" (for Run).

After this step, the input parameters are checked for consistency, and the detector/disperser characteristics are loaded in Midas keywords (cf. Fig. 1b). If no errors have been detected the full configuration is displayed, in the same way as in the beginning. This time, the detector characteristics are also displayed (cf. Fig. 2a). All the parameters which are displayed can be changed if wanted, but such changes should be done in a coherent way since their consistency will not be checked by the program.

III.b) Computing the overall transfer efficiency

The input spectra of the object and the sky are scaled to the V magnitude given by the user. All the tables are rebinned to a common step in wavelength. This requires some computer time, but has the advantage of a higher flexibility. The user can use his/her own tables for the object and the sky spectra. The only requirement is to have the wavelength in nm in the first column, and the relative flux in photons in the second column (phot/m2/s/nm, phot/cm2/s/A,...). Of course "standard" spectra are also available in the EMMI data base (cf. IV). In that case the full name with `EM_D:` directory is required (example: `EM_D:ESKY516` for the standard sky spectra, cf Fig. 5).

III.c) Signal to Noise ratio (SNR) computation

Then the main output characteristics are computed. For spectroscopy: dispersion, resolution, contribution of the object, sky, and noise from the detector. Two different SNR are computed assuming an integration of the output object spectrum perpendicular to the dispersion, of the central brightest pixels only (limit at half-maximum), or down to a 1% level (assuming a Gaussian profile), and this for the central wavelength and two others (`LBDA2` and `LBDA3`) which can be specified by the user (cf. Fig. 2a).

For imaging, the SNR computation assumes an integration within a disk of $6./2.3\times$FWHM arcsec in diameter centered on the object, which corresponds to a 1% level for a Gaussian PSF (Point Spread Function).

Four terms are taken into account for the SNR estimation: Read-Out-Noise, sky noise, preflash and dark current noise, and error coming from a bad calibration (its variance is taken as 1% of the total level for a given pixel), and are displayed in the logfile (cf. Fig. 3 and Fig. 10). The corresponding standard deviations are added quadratically. These errors are also assumed to be independent from one pixel to another (which may be wrong for the calibration errors).

III.d) Output of the results, curves, and hardcopies

The main results of the simulation are written in a logfile (`EMMI.LOG`) which is automatically printed on a laser printer (cf. Fig. 3 and Fig. 10). The computed curves can be displayed on a graphic terminal or sent to a laser printer in the last part of the program. This can also be done outside of the EMMI program by using Midas command:

```
Midas004> PLOT/IMA TRANSF
```

for example to plot the overall transfer function. The list of the curves and spectra computed by this simulation (which are 1-dimensional images in Midas format) is the following:

`OBJIN.BDF`: Input spectrum of the object (not scaled in flux)
`OBJOUT.BDF`: Output spectrum from the object (in e-/nm)
`SKYIN.BDF`: Input spectrum of the sky (not scaled in flux)
`SKYOUT.BDF`: Output spectrum from the sky (in e-/nm)
`TRANSF.BDF`: Overall transfer efficiency

Examples of these curves are shown in Fig 4 to 14.

`TRANSF` is the overall transfer efficiency (OTE) in e-/photon, which takes into account the transmission of the atmosphere, the effect of the central obscuration, the losses due to the reflections in the telescope, the transmission of the instrument, the dispersion and the detector response (cf. Fig. 9 and Fig. 13). This OTE can be used directly to obtain the output level of the detector in e-/nm/s. To do so the values of the OTE have to be multiplied by the total surface of the mirror (without obscuration) and by the input flux of the object in photons/nm/s/m^2.

III.e) Simulated frame

The programs can simulate the output image, or output spectrum (`SIMU_OUT.BDF`) as it should appear after an observation (resampled in CCD pixels and ADU units). Examples are given in Fig. 8 and 14.

In the imaging mode, the target is an open cluster like the Pleiades seen at a distance of 30 Kpc (250 times further than in reality). The brightest star is centered in the frame, and scaled to the V magnitude given by the user for the input object. The relative brightness of the other stars is conserved. Seeing effects, Poisson noise, read-out noise, charge-bleeding (when saturation), ADU conversion, and dark current are simulated. In the current implementation, and to limit the size of the simulated image, the program outputs only a squared window of 100 pixels in side (Fig. 14).

In the medium/low resolution spectroscopic mode, the output spectrum is computed from the input spectrum given by the user, normalized to the selected V magnitude. The simulated output spectrum corresponds to a raw spectrum as seen after adding the n rows which correspond to a cut at 1% of the maximum intensity (cf. III.c). The value of n is given in the logfile (in Fig. 3, we see that $n = 6$ for our example). Seeing effects, slit profile, Poisson noise, read-out-noise, charge-bleeding (when saturation), ADU conversion, and dark current are simulated (Fig. 8).

In the current version of the echelle mode only the central row is simulated, in the same way as in the medium/low resolution spectroscopy mode (but no attenuation is taken into account in the edges).

IV. EMMI DATA BASE

The corresponding Midas tables are in EM_D (see Appendix 2 for a more detailed description). They are accessible to the user who can plot them by using Midas commands:

```
Midas001> SET/PLOT STYPE=0 LTYPE=1
Midas001> PLOT/TABLE EM_D:EALUMI #1 #2
```

for instance to plot the aluminum reflectivity (columns 1 and 2).

IV.a) Atmosphere

Transmission of the atmosphere in ESOEXT.TBL for La Silla.

A spectrum of the night sky taken at La Silla (with EFOSC at the 3.6m), is available: ESKY516.TBL (cf. Fig. 5).

IV.b) Efficiency of the optics of the different modes

The reflectivity of the NTT telescope (primary, secondary and tertiary mirrors), the effect of central obscuration, and the transmission of the optics of EMMI in different configurations (channel B and R, in spectrocopy or direct imaging) have already been combined by EPREP and stored in the table EMMI_NTT.TBL.

EALUMI.TBL: Aluminum reflectivity (4-month old aluminization).

EMMITR.TBL: Transmission of the EMMI optics.

IV.c) Filters

Available filters:

ESO587 (HeI), ESO588 (HeII), ESO589 (OIII/0), ESO590 (OIII/3000), ESO591 (OIII/6000), ESO592 (OIII/9000), ESO593 (OIII/12000), ESO594 (OIII/15000), ESO595 (NII/0), ESO596 (Hα/0), ESO597 (Hα/3000), ESO598 (Hα/6000), ESO599 (Hα/9000), ESO600 (Hα/12000), ESO601 (Hα/15000), ESO602 (U), ESO603 (B), ESO604 (B), ESO605 (Bb), ESO606 (V), ESO608 (R), ESO610 (I), ESO611 (Z), ESO643 (BG38/2mm), ESO644 (GG375/3mm), ESO645 (OG530/3mm), and ESO646 (RG715/3mm).

See *EMMI User's guide* for more information.

IV.d) Disperser parameters

They are in EGRIS1.TBL and EGRAT1.TBL (characteristics), and EGRISTR.TBL and EGRATTR.TBL (transmission of the grisms and efficiency of the gratings).

Available gratings for the B channel: GRAT3, GRAT4, GRAT5, GRAT8.

Available gratings for the R channel: GRAT6, GRAT7.

Available grisms for the R channel: GRIS1, GRIS2, GRIS3, GRIS4, GRIS5, GRIS6.

For the echelle mode: GRAT9, and GRAT10 are available, and any of the 6 grisms can be used as cross-disperser.

IV.e) Detectors

Presently two CCD's are available: CCD18 and CCD19 for the R and B channels. They are of the same type: Thomson 31156 Grade A, front illuminated, UV-coated, and 1024x1024. The characteristics are in `EDET1.TBL`, and the quantum efficiency is in `CCD18.TBL` and `CCD19.TBL`.

IV.f) Spectra for the sky and the object

The user can provide his/her own tables for the object and the sky spectra. The only requirement is to have the wavelength in nm in the first column, and the relative flux in photons in the second column (phot/m2/s/nm, phot/cm2/s/A,... so if we start from a table in wavelength in 1st column and ergs/s/... in the 2nd, we simply multiply the second column with the first:

```
Midas019> COMPUTE/TAB table_name #2 = #2*#1
```

There are some "standard" spectra in the EMMI Data Base:

`ESTAR_05.TBL` (9 SGR), `ESTAR_A5.TBL` (η HYA), `ESTAR_B3.TBL` (θ1 SER), `ESTAR_FO.TBL` (ξ SER) (Fig. 5), `ESTAR_G8.TBL` (θ1 TAU), `ESTAR_K2.TBL` (α SER), and `ESTAR_M8.TBL` (z CYG)

corresponding to type O5, A5, B3,... These spectra are coming from `ASSTGSAT.TBL` in the ST-ECF data base, and correspond to the paper by Gunn, J.E., Stryker, L.L, 1983, *Astrophys. J. Suppl. Ser.*, **52**, 121. More information about these stars is available in `EM_D:GSATINFO.TBL`

There is also a set of galaxy spectra:

`EGAL_ESO.TBL` (E/SO), `EGAL_SAB.TBL` (Sab), `EGAL_SBC.TBL` (Sbc), `EGAL_SCD.TBL` (Scd), and `EGAL_SDM.TBL` (Sdm).

also from the ST-ECF data base, and originally from "Observational aspects of galaxy evolution" by R.S. Ellis in *Spectral evolution of galaxies*, Ed. P.M. Gondhalekar.

IV.g) Other files used by the simulation programs

`EPLEIA.TBL` is used to simulate images in the direct imaging mode. The Pleiades are assumed to be at a distance of 30 Kpc (250 times further than in reality), and the relative brightness of the stars is conserved. The brightest star is centered in the frame, and scaled to the V magnitude given by the user for the input object (cf. III.e).

`EPSF.TBL` is the PSF used to convolve the star positions given by `EPLEIA.TBL` into a simulated image (program `EMAPTAB`). Its integral in 2 dimensions is 1.0, and its FWHM is also 1.

`GAUSS1.BDF` is used to compute the efficiency of the slit. It is a simulated image of a star with a Gaussian PSF, with an integral of 100., and a sigma of 1.

V. EFOSC2 DATA BASE

In this section, we present only the tables which differ from the EMMI simulator. These tables are in `EM_D` (see Appendix 2).

V.a) Efficiency of the optics of the different modes

There is only one channel for EFOSC2, but to be consistent with EMMI, the program considers it as a channel R (Red).

The reflectivity of the NTT telescope (primary, secondary and tertiary mirrors), the effect of central obscuration, and the transmission of the optics of EFOSC2 have already been combined by `EPREP` and stored in the table `EF02_NTT.TBL`.

`EF02TR.TBL`: Transmission of the EFOSC2 optics.

V.b) Filters

Available filters: `ESO583.TBL` (B Bessel), `ESO584.TBL` (V Bessel), and `ESO585.TBL` (R Bessel).

V.c) Dispersers

Available grisms: GRIS1, GRIS2, GRIS3, GRIS4, GRIS5, GRIS6

They are in `FGRIS1.TBL` (characteristics) and `FGRISTR.TBL` (transmission).

V.d) Detectors

So far only one CCD is available: CCD17 (Thomson 31156 Grade A, front illuminated, and UV coated, 1024x1024). Its characteristics are in `EDET1.TBL`, and the quantum efficiency is in `CCD17.TBL`.

VI. CREATE YOUR OWN ENVIRONMENT

The menu allows the use of personnal data for the filters, and input spectra (object and sky). If you want to go further, different steps are possible:

VI.1) Redefine the path

If you wish to use your own data for the disperser and detector, type:

```
Midas008> MYDATA
```

so that the tables needed by the program will first be looked for in your working directory, and then (if not found) in the data base (defined by `EM_D`). When this option is selected, a warning message is displayed if a given table needed by the program has been found in the user's directory (*Nota: in a Unix machine, use capital letters for the table located in your working directory*, like: `CCD18.tbl`). These messages appear on the screen when the program checks the validity of the parameters.

This will apply to the tables concerning the filters, dispersers, detectors, atmospheric transmission, and telescope efficiency. But some of the tables (like `EPLEIA.TBL` for computing the synthetic image in the imaging mode) will still be looked for in the data base.

To inhibit this mode and come back to the standard configuration (data base only), type:

`Midas012> MYDATA NO`

VI.2) Build a new data base

Another simple way of using your own data is to copy the whole data base (which is only 1 Mbytes) to your own account and change the tables you want. Then redefine `EM_D` to your new subdirectory where you have copied the data base, with

ESONS012: `setenv EM_D ./my_data_base`

on a Unix machine, or with:

`$ DEFINE/LOGICAL EM_D [.MY_DATA_BASE]`

on the Vax (assuming that the corresponding subdirectory is `MY_DATA_BASE`)

VI.3) Redefine the set up

Copy the initialization procedure `FINIT.PRG` or `EINIT.PRG` (in `.../emmi/proc` or `[.EMMI.PROC]`) and change the default values to your own set up. Then run this new procedure (with the instrument mode as parameter) just before running the simulation with `IMAGING`, `SPECTRO`, or `ECHELLE`.

VI.3) Include a new instrument in the simulator

The simulator can be easily adapted to a new instrument of the EMMI/EFOSC2 type, by doing only what has been described in VI.2 and VI.3.

If you want to go further, read the Appendix 3 with the list of programs and procedures. Then copy the whole set of procedures contained in `.../emmi/proc` or `[.EMMI.PROC]` in your account, change what you want, and redefine `EM_PROC` as your new subdirectory. To change the menus, look at `EM_C:*.SDF`.

VII. LIMITS AND BUGS

VII.a) What is not taken into account in the simulation

Related to the CCD detectors, the flat fields of the corresponding chips are not multiplied by the simulated image, bad column transfer of charges, non-linearities, and cosmic ray events are not taken into account. Dark current is assumed to be uniform on the chip, and bad columns are not simulated.

The mirrors are assumed to be clean and with a 4-month-old aluminization (cf. IV.b). When measurements of the optics in different polarizations were available, we have taken the average.

The echelle mode is not fully implemented and is mainly treated as the spectroscopic mode (Version of June 1990). The full wavelength range is not computed (only the central row), and no simulated image of the full frame is done.

VII.b) Known bugs

• The simulator uses a maximum of 65 permanent keywords (in the echelle mode). Due to the limited number of keywords in Midas environment (around 140 in the 90MAY version), strange errors may occur after running a long Midas session. A good diagnostic is to try to create a new keyword:

```
Midas017> WRITE/KEY TESTXYZ/I/1/1 0
```

If an error message appears, then it means that the maximum number of keywords has been reached. The only solution is to exit with `BYE` and start a new session with `INMIDAS`.

• During the development of this simulator, I had often a simple problem with the protection of new files (executable and data files). The tables of the data base and the help files should be accessible in writing mode. The command procedure `[.EMMI.PROC]PROTECTION.COM` is designed to set the right protections after a change.

• In case of an unexpected exit (without any error message) after a message like "Rebinning table XXX", check the contents of the table with `SHOW/TAB EM_D:XXX`, and see whether the filter/disperser/detector you selected is present or not (this problem should have been solved in the current version, since the model now checks whether the files are there, but Midas does not allow to check if the files are accessible in write access...).

• If you try to edit a file on the Vax within the Midas session, and get a message like *"Change mode can be entered only from a terminal"*, exit from this session with `BYE`, restart it with `GOMIDAS`, and simply do `SET/CONTEXT EMMI`. Then you *do not need* to do `EMMI` or `EFOSC2` which would reset everything. Go on directly with your simulation program, and the previous selection of parameters will appear.

• For the other bugs: in case of crash, type `ECHO/ON` and run again the program. This is a way of checking what is going on.

List of figures

the central obscuration, the transmission of the optics (including the grism) and the response of the CCD have been taken into account.

Figure 10: Example of a logfile produced by a simulation in the imaging mode.

Figure 11: Contribution of the object in the output flux (for the imaging simulation).

Figure 12: Contribution of the sky in the output flux (for the imaging simulation).

Figure 13: Overall transfer function of the imaging mode simulation. The atmospheric transmission, the reflections on the mirrors of the NTT, the central obscuration, the transmission of the optics (including the filter) and the response of the CCD have been taken into account (cf. III.d).

Figure 14: Simulated output image as produced by real observations of an open cluster like the Pleiades at a distance of 30 kpcs. Seeing effects, Poisson noise, and detector characteristics (saturation, dark current, charge bleeding when saturation, and read-out-noise) have been taken into account (Cf. III.e).

Imaging mode

When finished press **CTRL/Z** and then on **R** (Help with **CTRL/G**)

Channel	*R*	Filter	*EM_D:ESO606*		
F/D cam	*2.5*	V obj	*22.0*	Obj spect	*EM_D:ESTAR_F0*
Detector	*CCD18*	V sky	*22.0*	Sky spect	*EM_D:ESKY516*
Prefl. e-	*0.0*	Seeing	*1.0*	Zenith dist	*10.0*
Binn in x	*1*	Exp time	*300.0*		
Binn in y	*1*			Out. image	*SIMU_OUT*

Spectroscopic mode

When finished press **CTRL/Z** and then on **R** (Help with **CTRL/G**)

Channel	*R*	Filter1	*CLEAR*	Filter2	*CLEAR*
F/D cam	*2.5*	V obj	*20.0*	Obj spect	*EM_D:ESTAR_F0*
Detector	*CCD18*	V sky	*22.0*	Sky spect	*EM_D:ESKY516*
Prefl. e-	*0.0*	Seeing	*1.0*	Zenith dist	*10.0*
Exp time	*3600.0*	Disperser	*GRIS1*	Slit width	*1.0*
Binn in x	*1*	Slit displ	*0.0*	Slit length	*10*
Binn in y	*1*	Dichroic	*N*		

Echelle spectroscopy mode

When finished press **CTRL/Z** and then on **R** (Help with **CTRL/G**)

Channel	*R*	Filter1	*CLEAR*	Filter2	*CLEAR*
F/D cam	*2.5*	V obj	*16.0*	Obj spect	*EM_D:ESTAR_F0*
Detector	*CCD18*	V sky	*22.0*	Sky spect	*EM_D:ESKY516*
Prefl. e-	*0.0*	Seeing	*1.0*	Zenith dist	*10.0*
Exp time	*3600.0*	Disperser	*GRAT9*	Slit width	*1.0*
Binn in x	*1*	Cross-disp	*GRIS3*	Slit length	*10*
Binn in y	*1*				

Figure 1a: First menu used to select the parameters in the 3 modes available (Cf. III.a), in the same format as it appears when running the program.

Imaging mode

When finished press **CTRL/Z** and then on **R** (Help with **CTRL/G**) *H*

Channel	*EM.CHA*	Filter	*EM_FILT1*		
F/D cam	*EM.FDCA*	V obj	*EM.OVM*	Obj spect	*EM_OSP*
Detector	*ED.DET*	V sky	*EM.SVM*	Sky spect	*EM_SSP*
Prefl. e-	*ED.PREF*	Seeing	*EM.FWHM*	Zenith dist	*EM.ZEDI*
Binn in x	*ED.BINX*	Exp time	*EM.EXPS*		
Binn in y	*ED.BINY*			Out. image	*EM_OIM*

Spectroscopic mode

When finished press **CTRL/Z** and then on **R** (Help with **CTRL/G**) *H*

Channel	*EM.CHA*	Filter1	*EM_FILT1*	Filter2	*EM_FILT2*
F/D cam	*EM.FDCA*	V obj	*EM.OVM*	Obj spect	*EM_OSP*
Detector	*ED.DET*	V sky	*EM.SVM*	Sky spect	*EM_SSP*
Prefl. e-	*ED.PREF*	Seeing	*EM.FWHM*	Zenith dist	*EM.ZEDI*
Exp time	*EM.EXPS*	Disperser	*ES.GRISM*	Slit width	*ES.SLIWI*
Binn in x	*ED.BINX*	Slit displ	*ES.DISPL*	Slit length	*ES.SLILE*
Binn in y	*ED.BINY*	Dichroic	*ES.DICHR*		

Echelle spectroscopy mode

When finished press **CTRL/Z** and then on **R** (Help with **CTRL/G**) *H*

Channel	*EM.CHA*	Filter1	*EM_FILT1*	Filter2	*EM_FILT2*
F/D cam	*EM.FDCA*	V obj	*EM.OVM*	Obj spect	*EM_OSP*
Detector	*ED.DET*	V sky	*EM.SVM*	Sky spect	*EM_SSP*
Prefl. e-	*ED.PREF*	Seeing	*EM.FWHM*	Zenith dist	*EM.ZEDI*
Exp time	*EM.EXPS*	Disperser	*ES.GRISM*	Slit width	*ES.SLIWI*
Binn in x	*ED.BINX*	Cross-disp	*ES.CRDIS*	Slit length	*ES.SLILE*
Binn in y	*ED.BINY*				

Figure 1b: Names of the Midas keywords actually used for the parameters of the first menu.

Imaging mode

When finished press **CTRL/Z** and then on **R** (Help with **CTRL/G**)

Channel	*R*	Filter	*EM_D:ESO606*		
F/D cam	*2.5*	V obj	*22.0*	Obj spect	*EM_D:ESTAR_F0*
Detector	*CCD18*	V sky	*22.0*	Sky spect	*EM_D:ESKY516*
Prefl. e-	*0.0*	Seeing	*1.0*	Zenith dist	*10.0*
Binn in x	*1*	Exp time	*300.0*		
Binn in y	*1*			Out. image	*SIMU_OUT*
DETECTOR:					
Ncol.	*1024*	Scale in x	*0.447*	Full name	*THX 31156 coated*
Nrows	*1024*	Scale in y	*0.447*	Dark e-/s	*0.00800*
ADU e-	*2.0*	Bias ADU	*300.0*	Satur. e-	*170000.0*
RON e-	*6.0*				

Spectroscopic mode

When finished press **CTRL/Z** and then on **R** (Help with **CTRL/G**)

Channel	*R*	Filter1	*CLEAR*	Filter2	*CLEAR*
F/D cam	*2.5*	V obj	*20.0*	Obj spect	*EM_D:ESTAR_F0*
Detector	*CCD18*	V sky	*22.0*	Sky spect	*EM_D:ESKY516*
Prefl. e-	*0.0*	Seeing	*1.0*	Zenith dist	*10.0*
Exp time	*3600.0*	Disperser	*GRIS1*	Slit width	*1.0*
Binn in x	*1*	Slit displ	*0.0*	Slit length	*10*
Binn in y	*1*	Dichroic	*N*	Dispersion	*0.856*
Cent. lbda	*600.0*	Lambda2	*400.0*	Lambda3	*800.0*
DETECTOR:					
Ncol.	*1024*	Scale in x	*0.447*	Full name	*THX 31156 coated*
Nrows	*1024*	Scale in y	*0.447*	Dark e-/s	*0.00800*
ADU e-	*2.0*	Bias ADU	*300.0*	Satur. e-	*170000.0*
RON e-	*6.0*				

Figure 2a: Second menu used to check the values of all the parameters used in the simulation(Cf. III.a), in the same format as it appears when running the program.

Imaging mode

When finished press **CTRL/Z** and then on **R** (Help with **CTRL/G**) *H*

Channel	*EM.CHA*	Filter	*EM_FILT1*		
F/D cam	*EM.FDCA*	V obj	*EM.OVM*	Obj spect	*EM_OSP*
Detector	*ED.DET*	V sky	*EM.SVM*	Sky spect	*EM_SSP*
Prefl. e-	*ED.PREF*	Seeing	*EM.FWHM*	Zenith dist	*EM.ZEDI*
Binn in x	*ED.BINX*	Exp time	*EM.EXPS*		
Binn in y	*ED.BINY*			Out. image	*EM_OIM*
DETECTOR:					
Ncol.	*ED.NCOL*	Scale in x	*EM.SCALX*	Full name	*ED.IDEN*
Nrows	*ED.NROW*	Scale in y	*EM.SCALY*	Dark e-/s	*ED.DARK*
ADU e-	*ED.ADU*	Bias ADU	*ED.BIAS*	Satur. e-	*ED.SATU*
RON e-	*ED.RON*				

Spectroscopic mode

When finished press **CTRL/Z** and then on **R** (Help with **CTRL/G**) *H*

Channel	*EM.CHA*	Filter1	*EM_FILT1*	Filter2	*EM_FILT2*
F/D cam	*EM.FDCA*	V obj	*EM.OVM*	Obj spect	*EM_OSP*
Detector	*ED.DET*	V sky	*EM.SVM*	Sky spect	*EM_SSP*
Prefl. e-	*ED.PREF*	Seeing	*EM.FWHM*	Zenith dist	*EM.ZEDI*
Exp time	*EM.EXPS*	Disperser	*ES.GRISM*	Slit width	*ES.SLIWI*
Binn in x	*ED.BINX*	Slit displ	*ES.DISPL*	Slit length	*ES.SLILE*
Binn in y	*ED.BINY*	Dichroic	*ES.DICHR*	Dispersion	*ES.DISPE*
Cent. lbda	*ES.LBDA1*	Lambda2	*ES.LBDA2*	Lambda3	*ES.LBDA3*
DETECTOR:					
Ncol.	*ED.NCOL*	Scale in x	*EM.SCALX*	Full name	*ED.IDEN*
Nrows	*ED.NROW*	Scale in y	*EM.SCALY*	Dark e-/s	*ED.DARK*
ADU e-	*ED.ADU*	Bias ADU	*ED.BIAS*	Satur. e-	*ED.SATU*
RON e-	*ED.RON*				

Figure 2b: Names of the Midas keywords actually used for the parameters of the second menu.

Echelle spectroscopy mode

When finished press **CTRL/Z** and then on **R** (Help with **CTRL/G**)

Channel	*R*	Filter1	*CLEAR*	Filter2	*CLEAR*
F/D cam	*2.5*	V obj	*16.0*	Obj spect	*EM_D:ESTAR_F0*
Detector	*CCD18*	V sky	*22.0*	Sky spect	*EM_D:ESKY516*
Prefl. e-	*0.0*	Seeing	*1.0*	Zenith dist	*10.0*
Exp time	*3600.0*	Disperser	*GRAT9*	Slit width	*1.0*
Binn in x	*1*	Cross-disp	*GRIS3*	Slit length	*10*
Binn in y	*1*				
Cent. lbda	*600.0*	Lambda2	*590.0*	Lambda3	*610.0*
DETECTOR:					
Ncol.	*1024*	Scale in x	*0.447*	Full name	*THX 31156 coated*
Nrows	*1024*	Scale in y	*0.447*	Dark e-/s	*0.00800*
ADU e-	*2.0*	Bias ADU	*300.0*	Satur. e-	*170000.0*
RON e-	*6.0*				

Echelle spectroscopy mode

When finished press **CTRL/Z** and then on **R** (Help with **CTRL/G**) *H*

Channel	*EM.CHA*	Filter1	*EM_FILT1*	Filter2	*EM_FILT2*
F/D cam	*EM.FDCA*	V obj	*EM.OVM*	Obj spect	*EM_OSP*
Detector	*ED.DET*	V sky	*EM.SVM*	Sky spect	*EM_SSP*
Prefl. e-	*ED.PREF*	Seeing	*EM.FWHM*	Zenith dist	*EM.ZEDI*
Exp time	*EM.EXPS*	Disperser	*ES.GRISM*	Slit width	*ES.SLIWI*
Binn in x	*ED.BINX*	Cross-disp	*ES.CRDIS*	Slit length	*ES.SLILE*
Binn in y	*ED.BINY*				
Cent. lbda	*ES.LBDA1*	Lambda2	*ES.LBDA2*	Lambda3	*ES.LBDA3*
DETECTOR:					
Ncol.	*ED.NCOL*	Scale in x	*EM.SCALX*	Full name	*ED.IDEN*
Nrows	*ED.NROW*	Scale in y	*EM.SCALY*	Dark e-/s	*ED.DARK*
ADU e-	*ED.ADU*	Bias ADU	*ED.BIAS*	Satur. e-	*ED.SATU*
RON e-	*ED.RON*				

Figure 2c: Same as Fig2a and 2b, but for the echelle mode.

```
  ***  MIDAS foreground logfile  *** 27-JUN-1990 16:12:18.01   Page    1

*******************************************************************

       EMMI simulator     - Version 22-06-90 -
       SPECTROSCOPIC MODE

*******************************************************************

 MDGR basic configuration:
   F/D ratio:  2.500E+00
   Filter1: CLEAR                    Filter2: CLEAR
   Disperser  GRIS1                  Slit (") 1.000E+00x1.000E+01
   Slit displ. (")     0.000E+00     Dichroic mirror:  N

Object and sky conditions:
  Seeing (FWHM in ")  1.000E+00     Zenith dist.(deg):   1.000E+01
  OBJECT: V magni     2.000E+01     Spectrum:          EM_D:ESTAR_F0
  SKY:    V magni     2.200E+01     Spectrum:          EM_D:ESKY516

Exposure and detector parameters:
  Exposure time (s)      3.600E+03
  Designation:           CCD18       Ident:  THX31156 UV-coated (EMMI R)
  Binning (x,y):  0001 0001 --> Format ncol x nrow 1024x1024
  Scale ("/pixel) in x: 4.471E-01    Scale ("/pixel) in y: 4.471E-01
  Read out noise (e-)   4.950E+00    ADU  (e-/unit)        2.050E+00
  Dark current (e-/s)   2.778E-04    Saturation (e-/pix)   1.750E+05
  Preflash (e-)         0.000E+00    Bias (ADU)            3.285E+02

*******************************************************************
 Characteristics of the output spectrum

      Slit transmission for the object    7.694E-01
      Dispersion: (nm/pixel)              9.576E-01
      Resolution at 5.600E+02 nm:        2.614E+02
      Wavelength at the center of the chip: 5.600E+02
      Spectral range: 3.000E+02 - 1.000E+03 nm

  Width of an emission line at 5.600E+02 nm: 2.237E+00 pixels
  Number of rows of the spectrum at 1% level: 0006
                               at half max: 0003

  Maxi. of the overall transfer function:      1.393E-01
  (Atmosphere + telescope + instrument + filter + detector)
  (units: e-/photon, i.e. the output level in e-/s/nm
   can be obtained by multiplying this value with the surface
   of a full 3.5 m mirror (without obscuration)
   and with the input flux in photons/s/nm/m2).

*******************************************************************
  RESULTS for lambda= 5.600E+02 nm

  Output from the object (in e-/column) at 5.600E+02 nm:  3.837E+03
           (at 1% level by integrating along 0006 rows)
   or 2.878E+03   at half max by  integrating along 0003 rows)

  Output from the sky (in e-/pix) at 5.600E+02 nm:  5.100E+02

   Mean and Max level of the pixels (in e-): 1.150E+03  2.321E+03
   Mean and Max level of the pixels (in ADU): 8.895E+02, 1.461E+03
```

Figure 3: Example of a logfile produced by a simulation in the spectroscopy mode.

```
*** MIDAS logfile              *** 27-JUN-1990 16:12:24.78    Page     2

  SNR1 = 6.697E+01   (integration along 0006 rows)
  SNR2 = 7.120E+01   (integration along 0003 rows)

  Noise contribution in SNR1 (e-rms) from
    sky      preflash_and_dark     read-out-noise     bad calibration
  5.532E+01       2.449E+00              2.970E+01           8.307E+00

*********************************************************************
 RESULTS for lambda= 3.500E+02 nm

 Output from the object (in e-/column) at 3.500E+02 nm:  8.667E-02
           (at 1% level by integrating along 0006 rows)
  or 6.500E-02    at half max by  integrating along 0003 rows)

 Output from the sky (in e-/pix) at 3.500E+02 nm:  3.282E-02

  Mean and Max level of the pixels (in e-): 1.047E+00  1.074E+00
  Mean and Max level of the pixels (in ADU): 3.290E+02, 3.290E+02
  SNR1 = 7.000E-03   (integration along 0006 rows)
  SNR2 = 7.441E-03   (integration along 0003 rows)

  Noise contribution in SNR1 (e-rms) from
    sky      preflash_and_dark     read-out-noise     bad calibration
  4.438E-01       2.449E+00              2.970E+01           2.506E-01

*********************************************************************
 RESULTS for lambda= 8.869E+02 nm

 Output from the object (in e-/column) at 8.869E+02 nm:  1.104E+03
           (at 1% level by integrating along 0006 rows)
  or 8.280E+02    at half max by  integrating along 0003 rows)

 Output from the sky (in e-/pix) at 8.869E+02 nm:  3.764E+02

  Mean and Max level of the pixels (in e-): 5.614E+02  8.982E+02
  Mean and Max level of the pixels (in ADU): 6.024E+02, 7.666E+02
  SNR1 = 2.233E+01   (integration along 0006 rows)
  SNR2 = 2.374E+01   (integration along 0003 rows)

  Noise contribution in SNR1 (e-rms) from
    sky      preflash_and_dark     read-out-noise     bad calibration
  4.752E+01       2.449E+00              2.970E+01           5.804E+00

*********************************************************************
One-dimensional Midas images computed in this simulation:

  Overall efficiency:        TRANSF
  Input object spectrum:     OBJIN    Input sky spectrum:       SKYIN
  Output object spectrum:    OBJOUT   Output sky spectrum:      SKYOUT

Simulated image: SIMU_OUT.BDF
```

Figure 3: (Cont.)

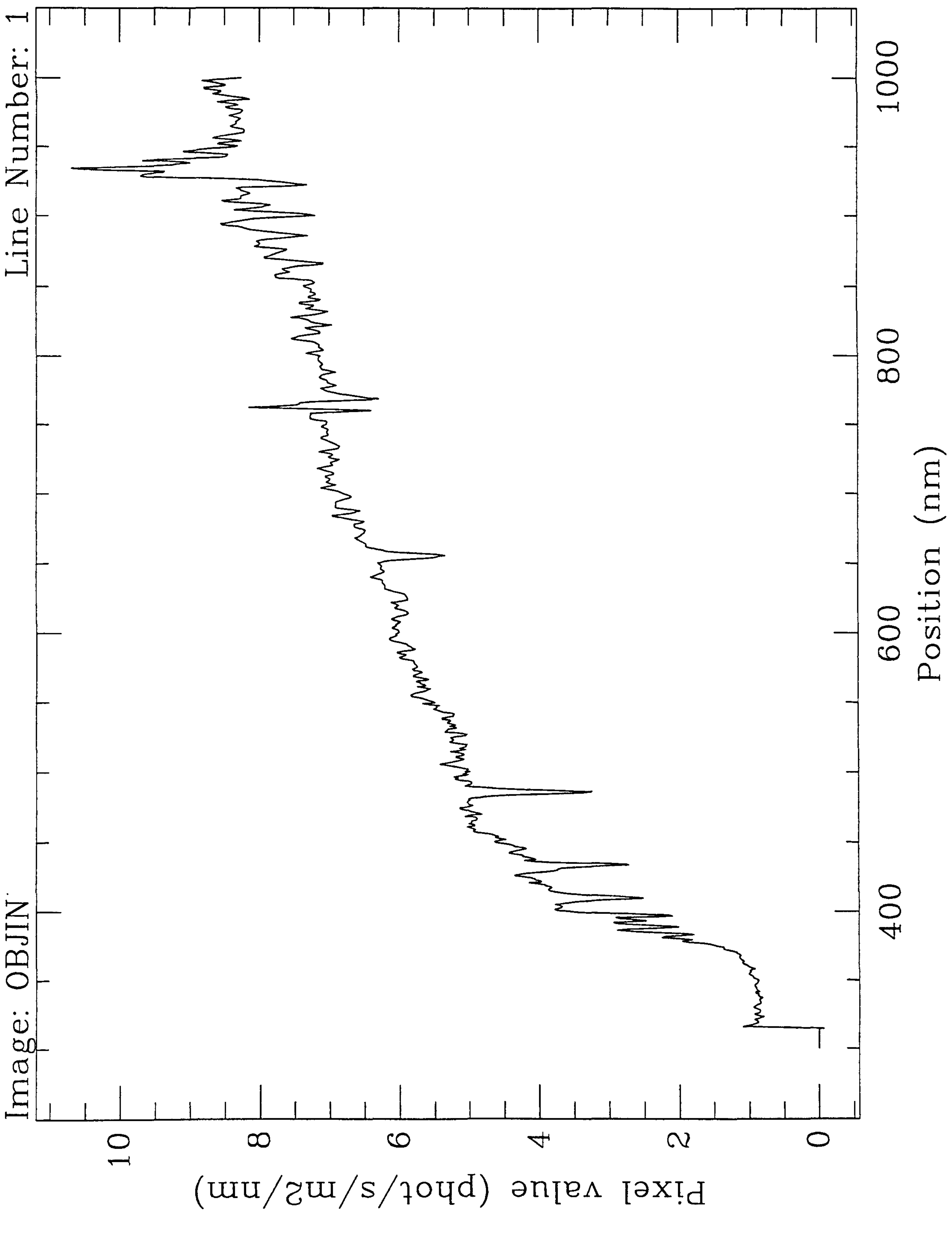

Figure 4: Spectrum of the input object used for the two examples (for imaging and spectroscopy).

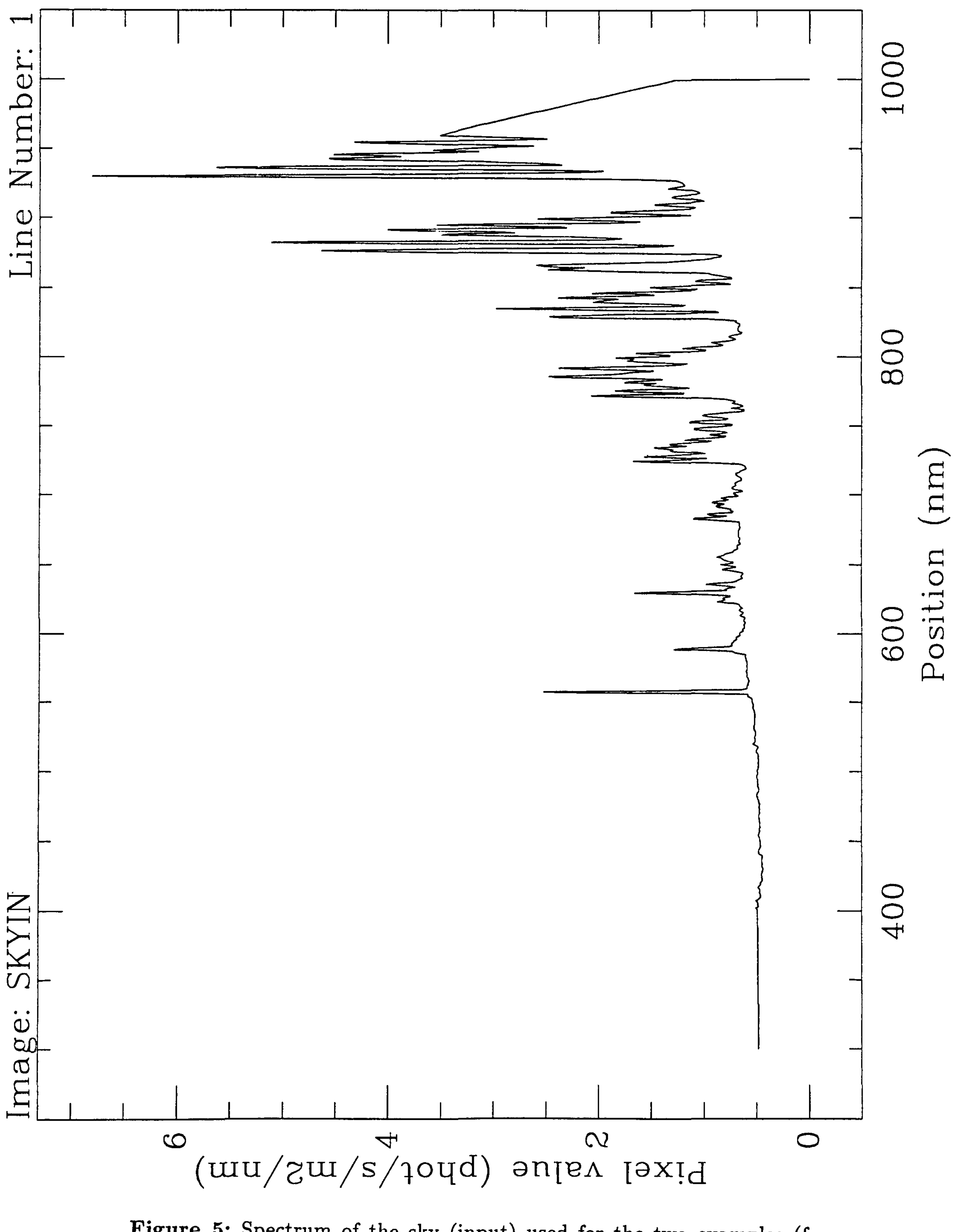

Figure 5: Spectrum of the sky (input) used for the two examples (for imaging and spectroscopy).

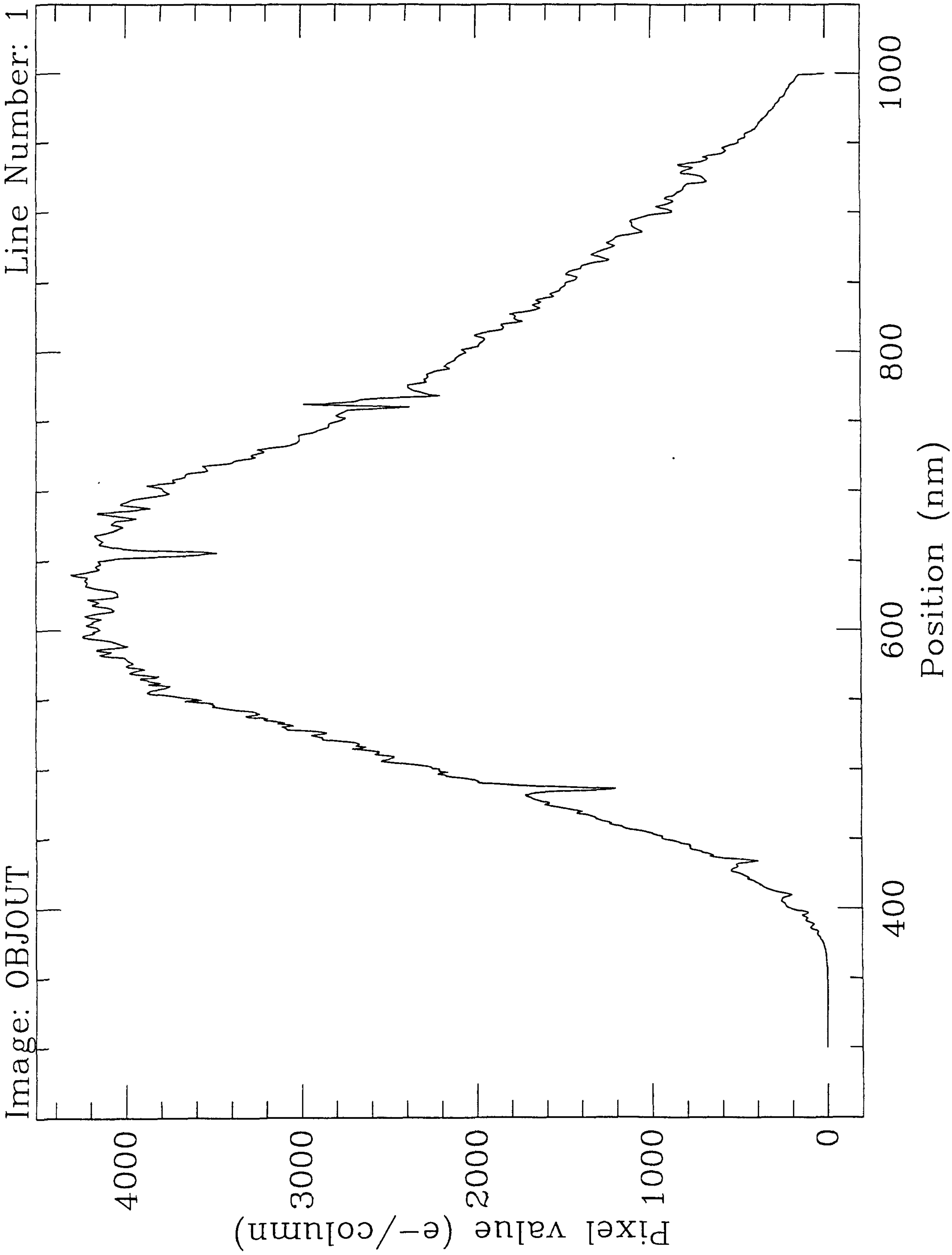

Figure 6: Contribution of the object in the output spectrum (for the spectroscopy simulation).

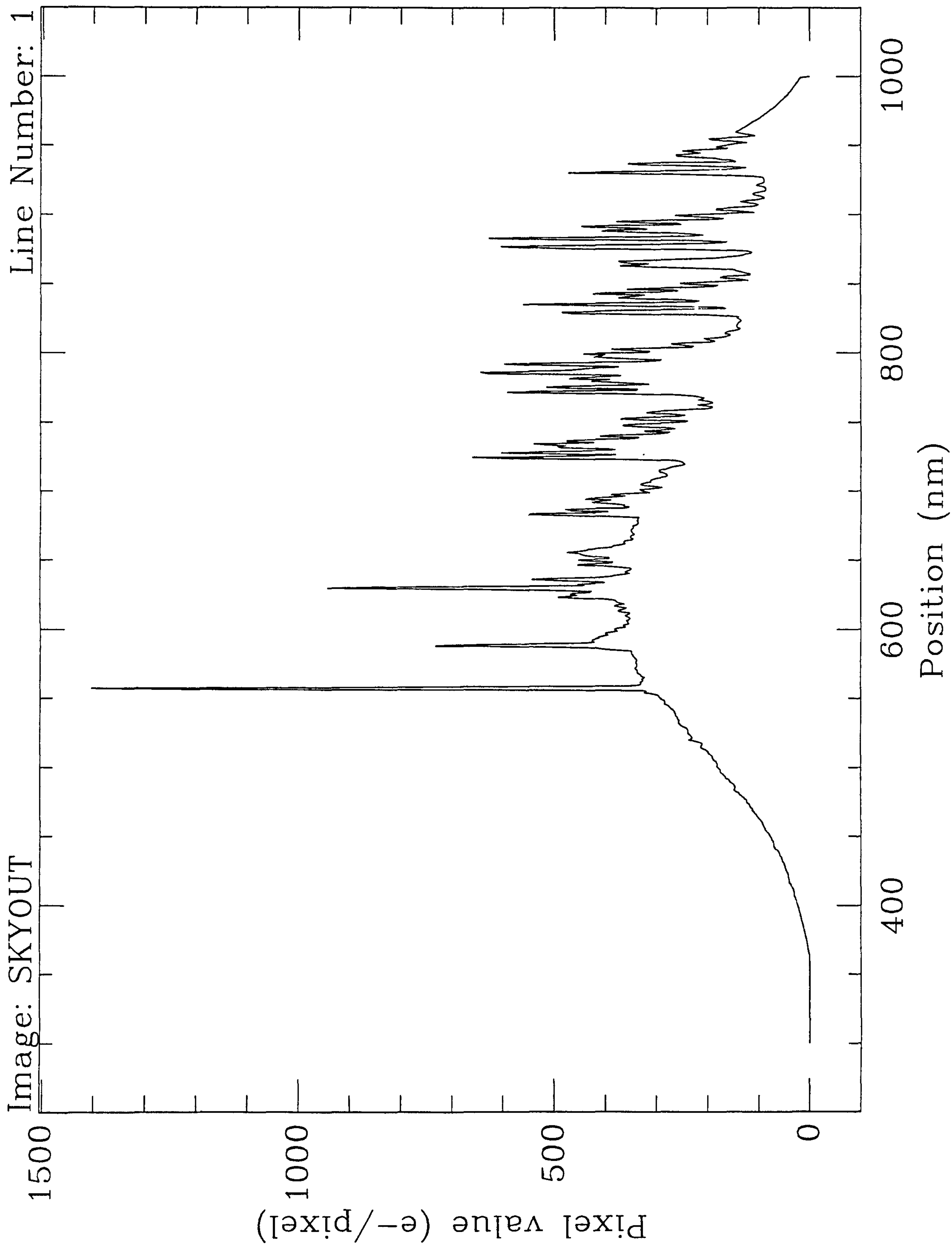

Figure 7: Contribution of the sky in the output spectrum (for the spectroscopy simulation).

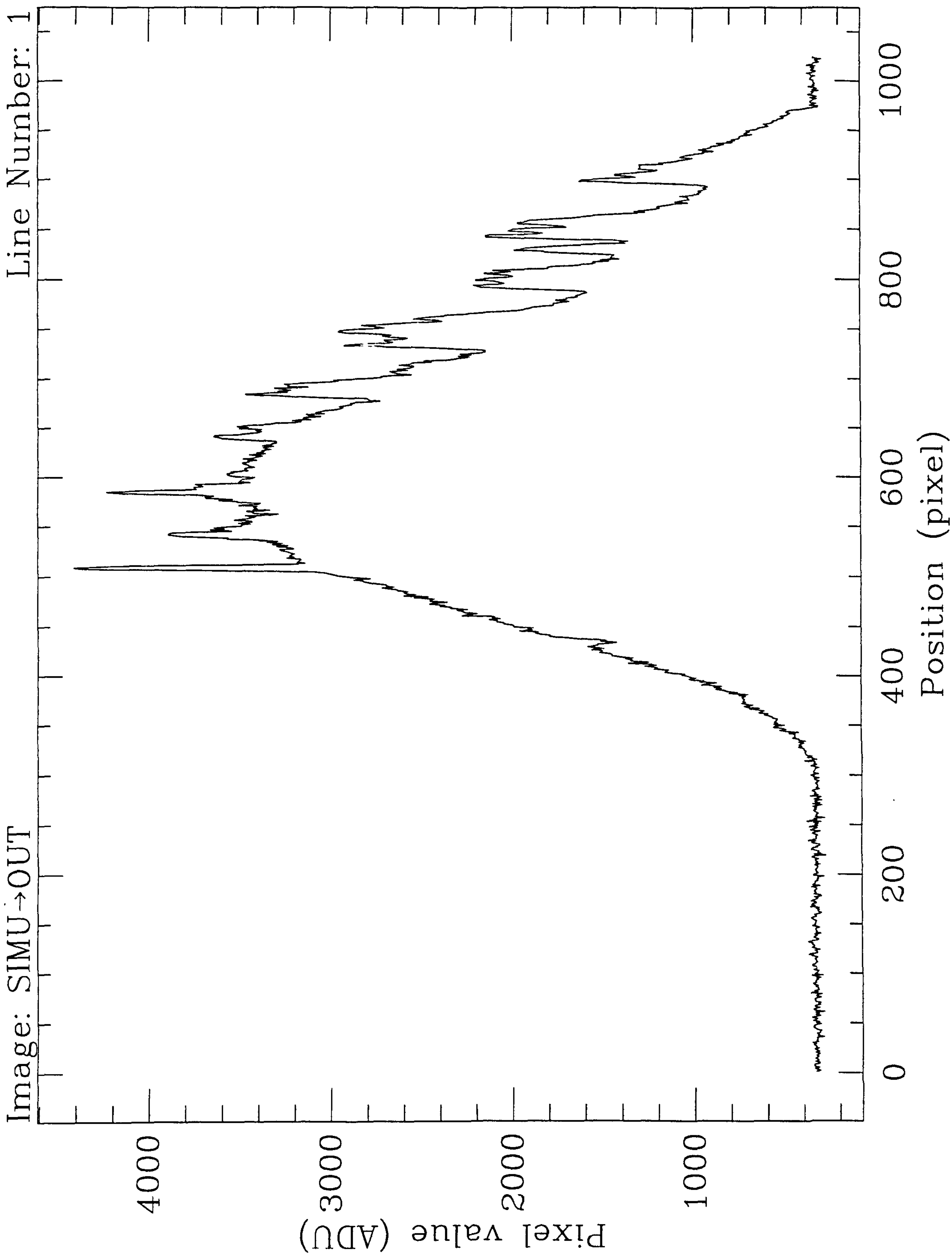

Figure 8: Simulated output spectrum as produced by real observations after adding the 6 brightest rows occupied by the object (cut at 1% level) (Cf. III.e).

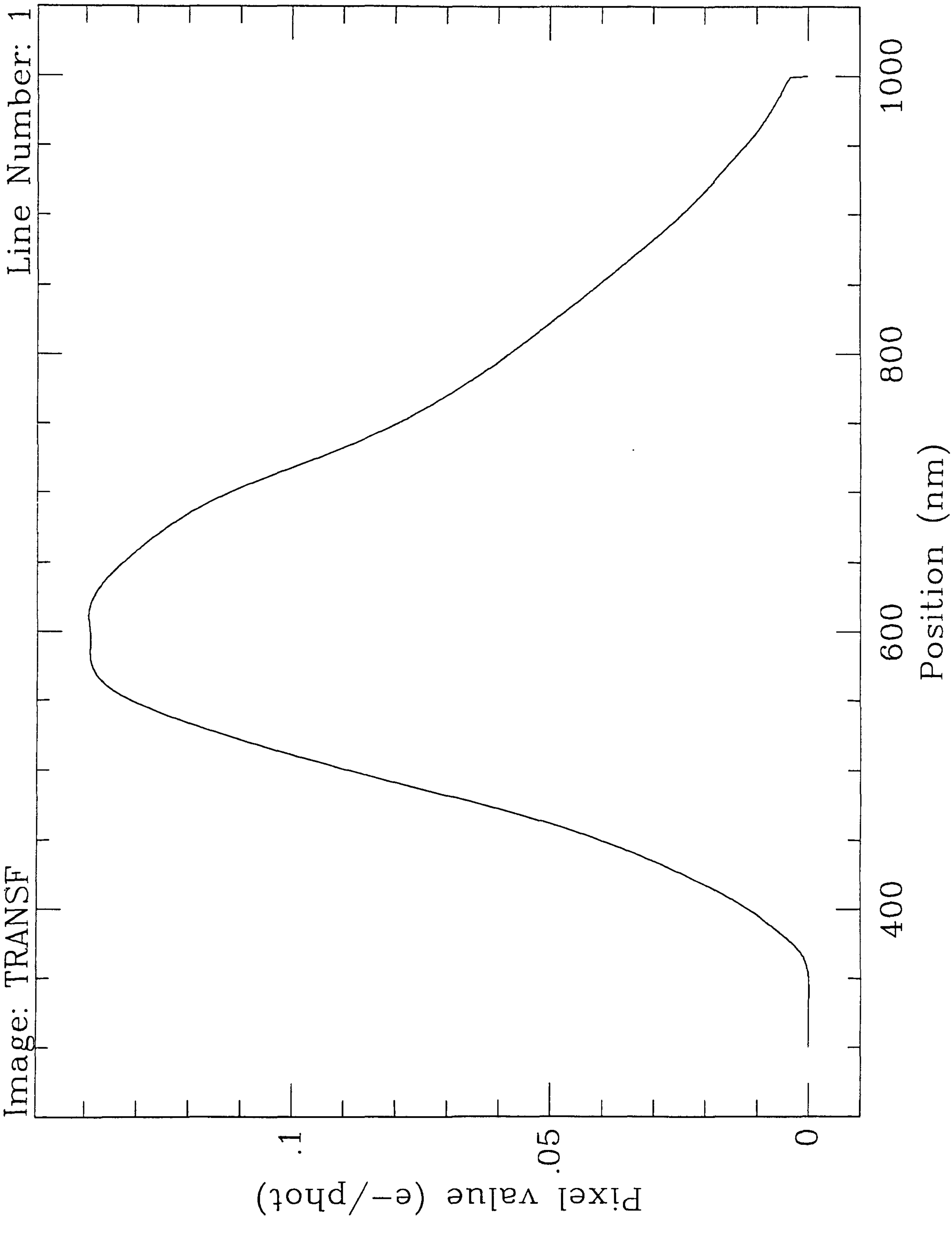

Figure 9: Overall transfer function of the spectroscopy mode simulation.

```
  ***  MIDAS foreground logfile  *** 27-JUN-1990 14:18:29.62   Page    1

********************************************************************
        EMMI simulator     - Version 22-06-90 -
        IMAGING MODE
********************************************************************

General configuration:
  Arm:          R                   F/D ratio:  2.500E+00
  Filter:   EM_D:ESO606

Object and sky conditions:
  Seeing (FWHM in ")  1.000E+00     Zenith dist.(deg):   1.000E'01
  OBJECT: V magni     2.200E+01     Spectrum:          EM_D:ESTAR_F0
  SKY:    V magni     2.200E+01     Spectrum:          EM_D:ESKY516

Exposure and detector parameters:
  Exposure Time (s)     3.000E+02
  Designation:          CCD18       Ident:  THX31156 UV-coated (EMMI R)
  Binning (x,y):  0001 0001 --> Format ncol x nrow 1024x1024
  Scale ("/pixel) in x: 4.471E-01   Scale ("/pixel) in y: 4.471E-01
  Read out noise (e-)   4.950E+00   ADU  (e-/unit)        2.050E+00
  Dark current (e-/s)   2.778E-04   Saturation (e-/pix)   1.750E+05
  Preflash (e-)         0.000E+00   Bias (ADU)            3.285E+02

********************************************************************
 RESULTS of this simulation:

  Maxi. of the overall transfer function:      1.408E-01
  (Atmosphere + telescope + instrument + filter + detector)
  (units: e-/photon, i.e. the output level in e-/s/nm
   can be obtained by multiplying this value with the surface
   of a full 3.5 m mirror (without obscuration)
   and with the input flux in photons/s/nm/m2).

  Total field of view (arcmin):  7.631E+00 x 7.631E+00

  Number of pixels occupied by the object (1% level): 0027
  Mean and Max level of these pixels (in e-): 1.683E+03 5.274E+03
  Total output from the object (e-): 7.124E+03
  Output level of the sky (e-/pixel): 1.419E+03
  Mean and Max level of the pixels (in ADU): 8.210E+02, 2.573E+03

   Signal to noise ratio = 3.587E+01

   Noise contribution (e-rms) from
     sky     preflash_and_dark    read-out-noise      bad calibration
   1.957E+02      1.500E+00            1.336E+02            2.132E+01


********************************************************************
 One-dimensional Midas images computed in this simulation:

   Overall efficiency:        TRANSF
   Input object spectrum:     OBJIN    Input sky spectrum:      SKYIN
   Output object spectrum:    OBJOUT   Output sky spectrum:     SKYOUT

 Simulated 2-D output image:   SIMU_OUT
```

Figure 10: Example of a logfile produced by a simulation in the imaging mode.

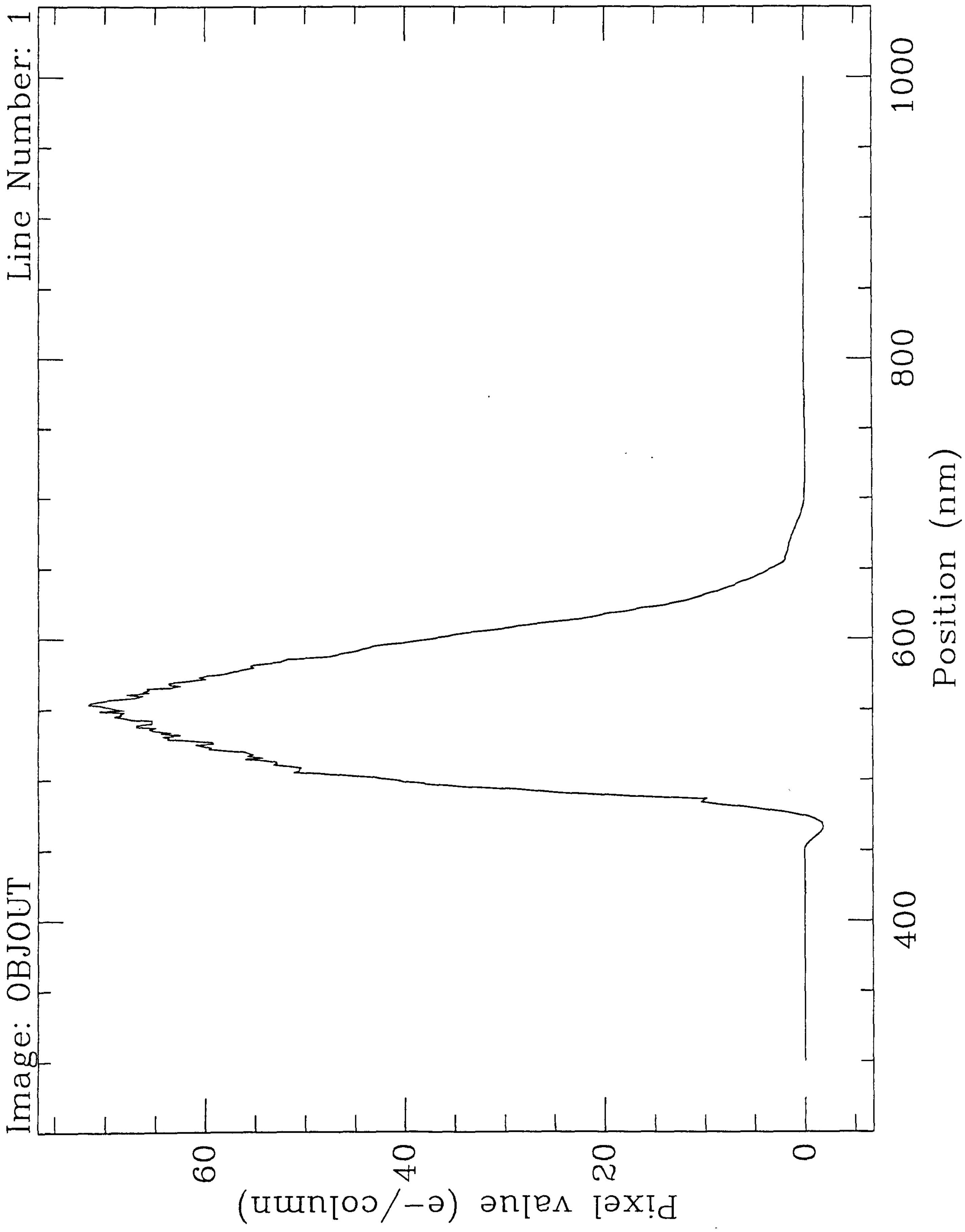

Figure 11: Contribution of the object in the output flux (for the imaging simulation).

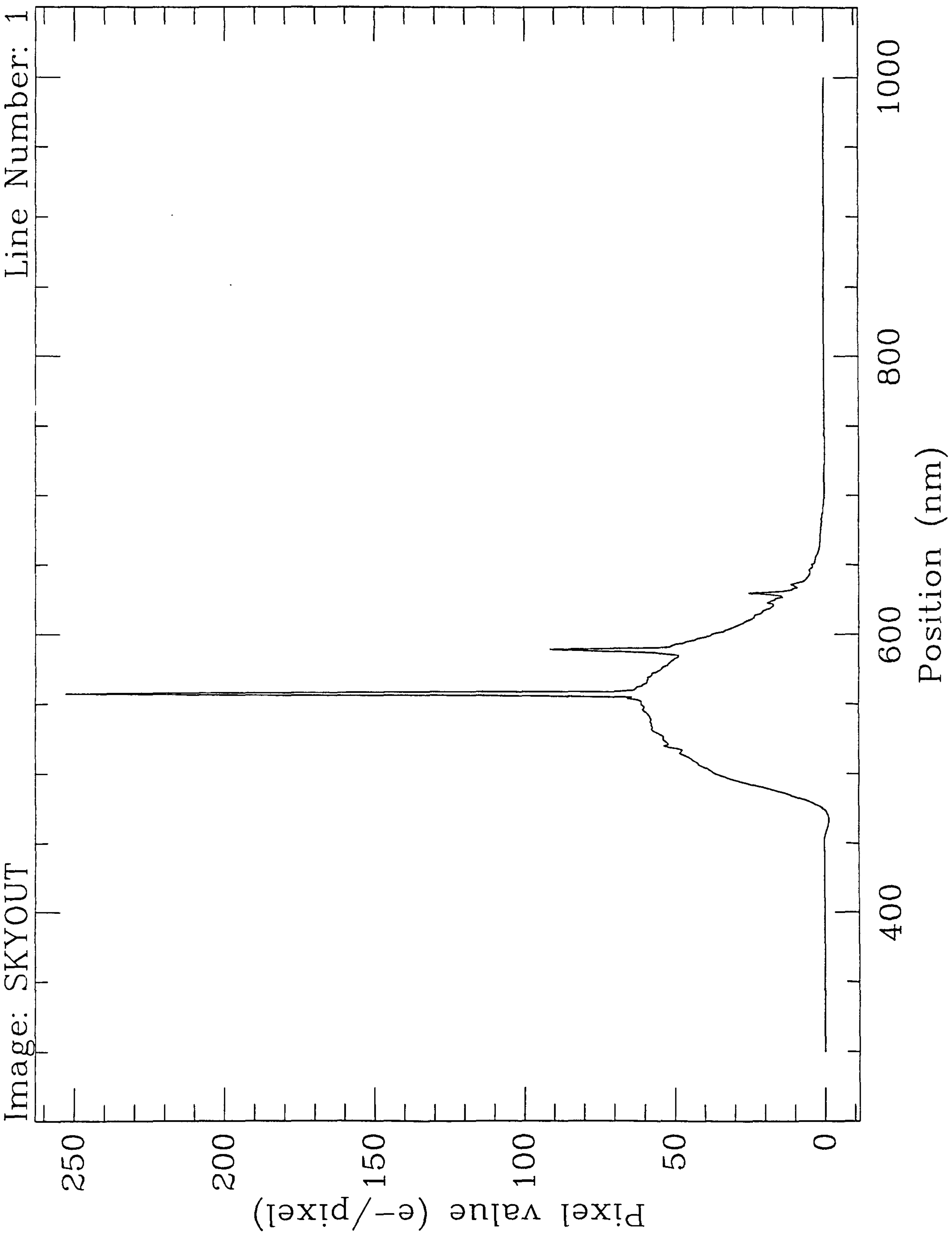

Figure 12: Contribution of the sky in the output flux (for the imaging simulation).

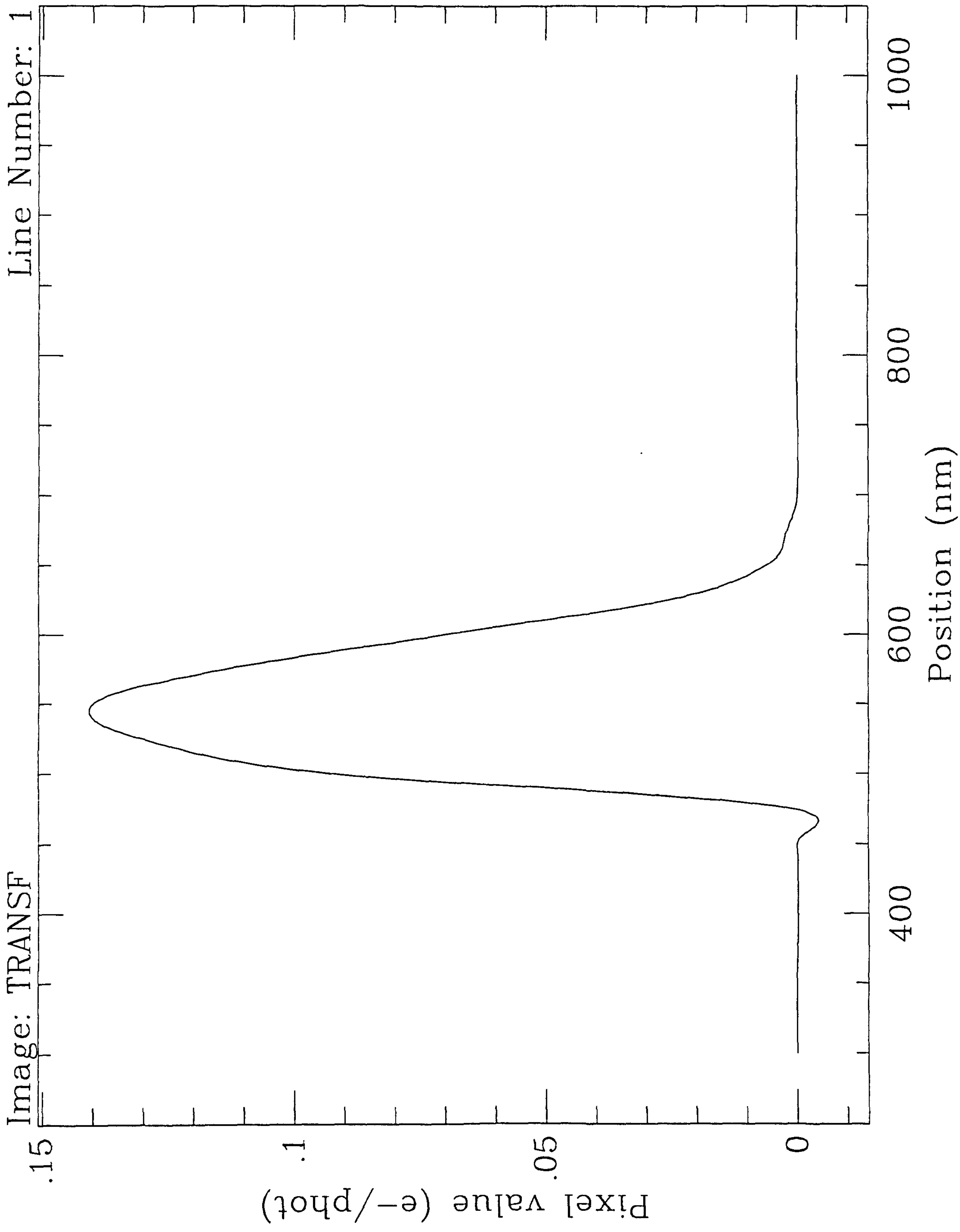

Figure 13: Overall transfer function of the imaging mode simulation.

SIMU_OUT

The entire image is displayed: 100 by 100 pixels.
Black corresponds to 0.144E+04, and white to 807. .
The image file was SIMU_OUT .
Comments: Simulated image .
Printed at 27-JUN-1990 14:20:57 for PRIEUR

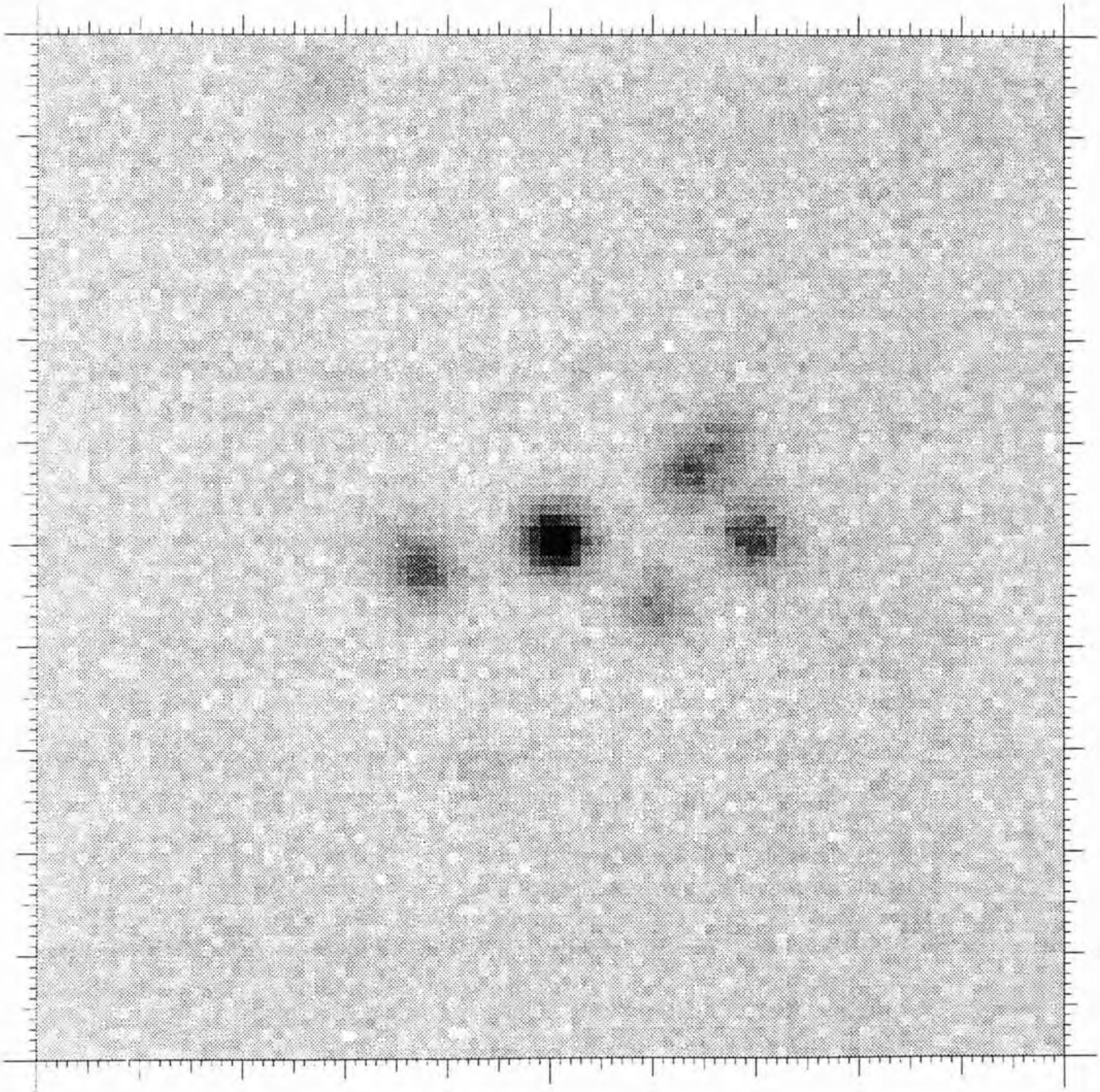

Figure 14: Simulated output image as produced by real observations of an open cluster like the Pleiades at a distance of 30 kpcs. Seeing effects, Poisson noise, and detector characteristics (saturation, dark current, charge bleeding when saturation, and read-out-noise) have been taken into account (Cf. III.e).

Appendix 1

EMMI SLITS

The size of the slit (width and height) are prompted to the user. Here is some information of the available slits.

1. Low dispersion grism spectroscopy, red channel

#1 fixed width 93.5 μm × 90 mm (0.5" × 481")
#2 fixed width 187.0 μm × 90 mm (1.0" × 481")
#3 fixed width 280.5 μm × 90 mm (1.5" × 481")
#4 fixed width 374.0 μm × 90 mm (2.0" × 481")
#5 fixed width 935.0 μm × 90 mm (5.0" × 481")
#6 fixed width 1870.0 μm × 90 mm (10.0" × 481")
(only four to be mounted on the instrument at a given time)

2. Medium dispersion grating spectroscopy, red and blue channels

width variable from 19.0 μm × 67 mm (0.1" × 360")
to 2000.0 μm × 67 mm (10.7" × 360")

3. Low dispersion multi-object spectroscopy, red channel

Starplate:
punch head #1 fixed width 200 μm (1.1")
#2 fixed width 300 μm (1.6")
#3 fixed width 500 μm (2.7")
slit length can be continuously varied by multiple punching
from 935 μm (5") to 3740 μm (20") or more.
(only one punch head to be mounted on the instrument at a given time)

4. Medium dispersion multi-object spectroscopy, red and blue channels

Multislit unit: width variable from 19.0 μm × 5 mm (0.1" × 26.7")
to 33660 μm × 5 mm (180" × 26.7"
width variable from 19.0 μm × 67 mm (0.1" × 360")
to 2000.0 μm × 67 mm (10.7" × 360")

5. Medium and high dispersion spectroscopy, red and blue channels

Image slicer:
Entrance aperture determining efficiency through slit losses:
#1 701 μm × 1169 μm (3.75" × 6.25")
#2 140 μm × 234 μm (0.75" × 1.25")
Exit aperture determining spectral resolution:
#1 234 μm × 3506 μm (1.25" × 18.75")
#2 47 μm × 701 μm (0.25" × 3.75")
(the entrance aperture, which acts as the slit in the focal plane, is transformed into exit aperture acting as slit for the spectrograph)

Appendix 2

DESCRIPTION OF THE EMMI/EFOSC2 DATA BASE

We describe hereafter the files contained in `EM_D` (presently `MISC$DISK:[EMMI.DATA]` on the ESO/Vax or `/ns0f/software/emmi/data` on the ESO/Unix workstations).

Unless specified, the range in wavelength of the tables is 300-1000 nm, the units are nm for wavelengths, and photons.m^{-2}.nm^{-1} for fluxes.

To update `EMMI_NTT.TBL` or `EFOSC2_NTT.TBL` when a new EMMI/EFOSC2 transmission, new telescope efficiency,... are available, use `EM_PROC:EPREP`.

I. ASTRONOMICAL DATA

`EGALAXY.TBL`: Flux of a "typical" early-type galaxy from HST data base (which was taken from *"Observational aspects of galaxy evolution"* by R.S. Ellis in *Spectral Evolution of Galaxies* Ed. P.M. Gondhalekar, RAL-84-008, UK) (#1: wavelength (nm), #2: E/SO flux in relative F_λ, #3: Sab, #4: Sbc, #5: Scd, #6 Sdm, #7 E/SO relative flux in photons/nm/s/m^2 #8: Sab, #9: Sbc, #10: Scd, #11 Sdm,)

`EGAL_xxx.TBL`: Flux of a "typical" galaxy from `EGALAXY` (#1: wavelength in nm, #2: relative flux in phot/nm/s/m^2). Available: `EGAL_ESO.TBL` (E/SO), `EGAL_SAB.TBL` (Sab), `EGAL_SBC.TBL` (Sbc), `EGAL_SCD.TBL` (Scd), and `EGAL_SDM.TBL` (Sdm).

`ESTAR_xx.TBL`: Flux of a "typical" xx-type star (#1: wavelength in nm, #2: relative flux in phot/nm/s/m^2). Available: `ESTAR_05.TBL` (9 SGR), `ESTAR_A5.TBL` (η HYA), `ESTAR_B3.TBL` (θ1 SER), `ESTAR_F0.TBL` (ξ SER), `ESTAR_G8.TBL` (θ1 TAU), `ESTAR_K2.TBL` (α SER), and `ESTAR_M8.TBL` (z CYG).

`ESKY516.TBL`: Flux of the night sky taken at La Silla with EFOSC at the 3.6m (#1: wavelength, #2: flux in phot/nm/s/m^2).

`EFEI24.TBL`: Flux of Feige 24 (#1: wavelength (nm), #2: flux(erg/s/cm^2/nm).

`EFEI25.TBL`: Flux of Feige 25, type B6 V, (#1: wavelength (nm), #2: flux(erg/s/cm^2/A).

`EPLEIA.TBL`: Pleiades: position and brightness of the stars (:XL relative right ascension, :YL relative declination,...).

`GSATINFO.TBL`: Information about the spectra of the stars ESTAR_A5, ESTAR_B3,... (Cf section IV-f).

II. EFFICIENCY OF OPTICS AND DETECTORS

`EDET1.TBL`: Detector parameters (CCD's) (#1: CCD1 (Thomson 1024x1024), #2: CCD2 (RCA 512x320), #3: CCD17, #4: CCD18, and #5: CCD19 which are of the same type: Thomson 31156, front illuminated, UV-coated, 1024x1024).

`EMMI_NTT.TBL`: EMMI overall efficiency in different modes (should be multiplied by the *full surface* of a 3.5m mirror). (#1: wavelength, #2: DIMB, #3: MDGB, #4: MDGR25 (camera f/2.5), #5: MDGR53, #6: DIMR25, #7: DIMR53).

`EF02_NTT.TBL`: EFOSC2 overall efficiency in different modes (should be multiplied by the *full surface* of a 3.5m mirror). (#1: wavelength, #2: DIMR, #3: MDGR).

`ESOxxx.TBL`: Filter transmission (#1: wavelength, #2: transmission).

For EFOSC2,

`ESO583.TBL` (B Bessel), `ESO584.TBL` (V Bessel), and `ESO585.TBL` (R Bessel).

For EMMI,

`ESO587.TBL` (HeI), `ESO588.TBL` (HeII), `ESO589.TBL` (OIII/0), `ESO590.TBL` (OIII/3000), `ESO591.TBL` (OIII/6000), `ESO592.TBL` (OIII/9000), `ESO593.TBL` (OIII/12000), `ESO594.TBL` (OIII/15000), `ESO595.TBL` (NII/0), `ESO596.TBL` (Hα/0), `ESO597.TBL` (Hα/3000), `ESO598.TBL` (Hα/6000), `ESO599.TBL` (Hα/9000), `ESO600.TBL` (Hα/12000), `ESO601.TBL` (Hα/15000), `ESO602.TBL` (U), `ESO603.TBL` (B), `ESO604.TBL` (B), `ESO605.TBL` (Bb), `ESO606.TBL` (V), `ESO608.TBL` (R), `ESO610.TBL` (I), `ESO611.TBL` (Z), `ESO643.TBL` (BG38/2mm), `ESO644.TBL` (GG375/3mm), `ESO645.TBL` (OG530/3mm), and `ESO646.TBL` (RG715/3mm).

See *EMMI User's guide* for more information.

`EGRIS1.TBL`: EMMI grism parameters (#1: Description, #2: GRIS1, #2: GRIS2, #3: GRIS3, #4: GRIS4, #5: GRIS5, #6: GRIS6).

`EGRAT1.TBL`: EMMI grating parameters (#1: Description, #2: GRAT3, #3: GRAT4, #4: GRAT5, #5: GRAT6, #6: GRAT7, #7: GRAT8, #8: GRAT9, #9: GRAT10).

`FGRIS1.TBL`: EFOSC2 grism parameters (#1: GRIS1, #2: GRIS2, #3: GRIS3, #4: GRIS4, #5: GRIS5, #6: GRIS6).

`EGRISTR.TBL`: EMMI grism transmission (#1: wavelength, #2: GRIS1, #3: GRIS2, #4: GRIS3, #5: GRIS4, #6: GRIS5, #7: GRIS6).

`EGRATTR.TBL`: EMMI grism transmission (#1: wavelength, #2: GRAT3, #3: GRAT4, #4: GRAT5, #5: GRAT6, #6: GRAT7, #7: GRAT8, #8: GRAT9, #9: GRAT10).

`FGRISTR.TBL`: EFOSC2 grism transmission (#1: wavelength, #2: GRIS1, #3: GRIS2, #4: GRIS3, #5: GRIS4, #6: GRIS5, #7: GRIS6).

`EMMITR.TBL`: EMMI transmission (#1: wavelength, #2: DIMR25 (camera f/2.5), #3: MDGR25, #4: DIMR53 (camera f/5.3), #5: MDGR53, #6: DIMB40, #7: MDGB40).

`EF02TR.TBL`: EFOSC2 transmission (#1: wavelength, #2: DIMR, #3: MDGR).

`CCD17.TBL, CCD18.TBL, CCD19.TBL`: Quantum efficiency of CCD17, CCD18 and CCD19 (#1: wavelength, #2: Q.E.), which are all of the same type: THX 31156, front illuminated, UV coated, 1024x1024.

`CCD05.TBL`: Quantum efficiency of CCD5 (#1: wavelength, #2: Q.E.).

`CFHTATMTR.TBL`: Atmospheric transmission at CFHT from 300 to 700 nm (#1:

wavelength in Å, #2: transmission, #3: wavelength in nm).

EALUMI.TBL: Aluminum reflectivity, measured at ESO, four months after aluminization.

EATMTR.TBL: Atmospheric transmission at CFHT (extrapolation of real data) (#1: wavelength, #2: transmission).

ESOEXT.TBL: Atmospheric extinction at La Silla (#1: wavelength (nm), #2: extinction mag/airmass, #3: transmission).

III. MISCELLANEOUS

EPSF.TBL: Gaussian Point-Spread-Function, FWHM=1., Integral in 2-dim=1.0 (#1: Radius, #2: flux).

GAUSS1.BDF: 2-D image of a Gaussian (σ=1.), in the range +/-4σ. This image simulates the PSF of the NTT, and is used to compute the slit losses in spectroscopy.

Appendix 3

DESCRIPTION OF THE EMMI PROGRAMS

The internal code for the instrument modes is the following:

DIMB : Direct imaging, blue channel
DIMR : Direct imaging, red channel
MDGB : Medium dispersion grism/grating spectroscopy, blue channel
MDGR : Medium/low dispersion grism/grating spectroscopy, red channel
HDGR : High dispersion grating spectroscopy, red channel (echelle).

The simulator uses the same programs for EFOSC2 and EMMI. Only the initialization differs.

I. EDIM (Imaging mode)

The main program is EDIM which successively calls EMMI_QUERY (to select the parameters), EDETINI, EDIMD01, EDIMD02, and EDIMGRA.

EDIM gets the input parameters for the simulation and checks their validity. It first calls EDIMCHECK to check if all the tables necessary for the simulation are there, and then EDETINI to read the detector characteristics and compute the scale.

EDIMD01 rebins the tables to a common scale, and computes the normalising factors for the input spectra (sky and object), to make them consistent with the V magnitude. The overall transfer function TRANSF.BDF is also computed, which takes into account the losses due to the atmosphere, telescope, filter, EMMI or EFOSC2 optics, and detector.

EDIMD02 computes the output spectra of the object and the sky (OBJOUT.BDF and SKYOUT.BDF), and the signal-to-noise ratio. If wanted a simulated image can also be computed using the Pleiades seen at 30 Kpc as an example. The brightest star is centered in the frame, and normalised in magnitude to the one given as input by the user for the object. All the stars keep their relative brightnesses.

EDIMGRA outputs the results on a file (EMMI.LOG or EFOSC2.LOG) which is automatically printed on a laserprinter, and displays the curves if wanted.

II. EMDG (Medium/low resolution spectroscopy)

The main program is EMDG which works in a similar way as EDIM, and successively calls EMMI_QUERY (to edit the fields), EDETINI, EDISPINI, EMDGD01, EMDGD02, and EMDGGRA.

EMDG gets the input parameters for the simulation, and checks their validity. It first calls EMDGCHECK to check if all the tables necessary for the simulation are there, and then EDETINI to read the detector characteristics and EDISPINI for the disperser.

EMDGD01 rebins the tables to a common scale, and computes the normalising factors for the input spectra (sky and object), to make them consistent with the V magnitude. The overall transfer function TRANSF.BDF is also computed, which takes into account the losses due to the atmosphere, telescope, filter, disperser, EMMI or EFOSC2 optics, and detector.

EMDGD02 computes the output spectra of the object and the sky (OBJOUT.BDF and SKYOUT.BDF), and the signal-to-noise ratio for 3 different wavelengths. If wanted a simulated image can also be computed.

EMDGGRA outputs the results in a logfile (EMMI.LOG or EFOSC2.LOG) which is automatically sent to a laserprinter, and displays the curves if wanted.

III. EHDG (Echelle spectroscopy)

The main program is EHDG which works in a similar way as EMDG, and successively calls EMMI_QUERY (to edit the fields), EHDGCHECK, EDETINI, EDISPINI, EHDGD01, EHDGD02, and EHDGGRA. It is not fully implemented and allows only a simulation of the central row. For the efficiency of the gratings, the maximum envelope has been entered in the data base, and no correction is done in the computations for the efficiency deterioration in the edges of the chip.

EHDG gets the input parameters for the simulation, and checks their validity. It calls EHDGCHECK, then EDETINI to read the detector characteristics, and EDISPINI for the echelle grating parameters.

EHDGD01 rebins the tables to a common scale, and computes the normalising factors for the input spectra (sky and object), to make them consistent with the V magnitude. The overall transfer function TRANSF.BDF is also computed, which takes into account the losses due to the atmosphere, telescope, filter, echelle grating, cross-disperser, EMMI optics, and detector.

EHDGD02 computes the output spectra of the object and the sky (OBJOUT.BDF and SKYOUT.BDF), and the signal-to-noise ratio for 3 different wavelengths. If wanted a simulated spectrum can also be computed.

EHDGGRA outputs the results on a logfile (EMMI.LOG) which is automatically sent to a laserprinter, and displays the curves if wanted.

IV. Other MIDAS command procedures developed for this application

EDESCRIP: To write the descriptors of the output images (units and identification).

EDETINI: To read the parameters of the detector in the corresponding tables and write them on Midas keywords.

EDISPINI: To read the parameters of the disperser in the corresponding tables and write them on Midas keywords.

EINIT: To initialize the keywords necessary for the simulator in the EMMI configuration.

ELASER: To print an ascii file to a laserprinter.

EMDGPIX: To map a file in wavelength to an image as output from a CCD.

EPLOT: To plot a Midas image on the terminal or on a laserprinter.

EPREP: To compute the efficiency of the optics of the instrument combined with the aluminum reflectivity, and central obscuration of the NTT. The output is stored in EM_D:EMMI_NTT.TBL or in EM_D:EFOSC2_NTT.TBL. This is used only for updating these tables when new data is available.

ETABCHECK: To find the exact location of a table using a path (cf. VI.1) and check if the table is there.

FINIT: To initialize the keywords necessary for the simulator in the EFOSC2 configuration (at the NTT).

V. Specific programs

A few programs have been written in Fortran and C to do specific tasks which were not available in MIDAS at the time I developed this simulator:

EMMI_QUERY: C program (STARCAT environment) to select the parameters of the simulation. Uses PROTEUS library to display forms which are initialized with the current values of MIDAS keywords and can be modified by the user.

ECCDREAD: Fortran program (from CCDREAD in HST model) to simulate the effects of a CCD detector on the data (bias, saturation, read-out noise, and conversion to ADU).

EFILEOK: C program, to check if the input table exists.

EMAPTAB: Fortran program to map a 2-dimensionnal image from a table of coordinates and fluxes (from MAPTAB in HST model). It is used in imaging mode to create the output image of the Pleiades from a table.

EPOISSON: Fortran program (from POISSON in HST model) to simulate Poisson noise on the data.

EREPORT: C program (from HREPORT.FOR in HST model) to keep a logbook of the use of EMMI/EFOSC2 simulator (logbook in EM_PROC:EREPORT.LOG).

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