

Figure 2: The efficiency of the CES at different wavelengths when fed by the CAT and when used with the fibre link from the 3.6-m telescope. The reference magnitudes on the Y-axis are for stars which give one detected photoelectron/Å/sec.

absorption in the fibre itself is important. The CAT observations were obtained with a 5 arcsec wide slit. The actual gain in a science exposure can be larger than that shown in Figure 2. In medium-poor seeing the narrow slit of the CES will admit less light than the fibre. As an example, with a stellar image of 2 arcsec

FWHM, a typical slit of the CES (1.5 arcsec width, 10 arcsec length) transmits 55% of the light while in the same condition the 3.4 arcsec circular diaphragm transmits 70% of the stellar light.

The measurements have also been used to derive the absolute efficiencies, that is the ratio between the detected

photons and the number of photons falling on the unit surface of the telescope. These numbers take into account the effect of all of the telescope and instrument optics and of the detector. For the measurements with the CAT, these average efficiencies are 0.5, 3.4, 8.6, 9, 7.7 and 2.9 at 3636, 4030, 5020, 5520, 6460 and 8080 Å respectively. The agreement with the values given in the CES Operating manual at slightly different wavelengths is reasonable. The corresponding values from the observations with the 3.6-m and the link are 0.26, 2.1, 6.4, 7, 6 and 2.3 respectively. At wavelengths longer than 4000 Å, the CAT+CES combination is on average 1.3 times more efficient. This advantage is however fully lost when the seeing is 2 arcsec or worse. In those nights the link works at its best and the gain of the larger collecting area is fully realized.

Finally, it is important to call attention to the problems related to the long slit format of the spectra that one obtains with the link. At the beginning of an observing run, the artificial slit produced by the image slicer must be well aligned with the rows of the CCD to avoid a loss of resolution. The use of CCD binning in the direction normal to the dispersion is recommended for those observations where the read-out noise of the CCD (around 30 e/pixel) is a limiting factor. However, binning cannot be too strong if the cosmic ray events which accumulate on the CCD over long integrations have to be identified and corrected for.

## A Programme to Simulate Observations with EFOSC2 and EMMI

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### Introduction

Every astronomer appreciates the importance of preparing accurately an observing run to optimize the use of the time assigned at the telescope. The preparation implies, among other things, the selection of the observing mode which is best suited to the needs of the scientific programme and the computation of the signal-to-noise ratios (SNRs) one can achieve in a given observing time on the selected targets.

Instrumental models have been developed especially for space instruments to simulate the data obtainable at the telescope and to help in the detailed planning of the sequence of the observations. The possibility of a full simulation is relatively less common with

ground-based telescopes. At ESO, would-be observers have still to rely on the information of the Operating Manuals and do their own computations. This has the disadvantage that the parameters of the instruments are not available in digital form, that a change in the instrument configuration or in the detectors cannot be taken promptly into account and that the results of the computation of the final SNRs come in as many flavours as the number of astronomers.

As a first step in building a set of models which will describe the behaviour of the mostly used instruments at ESO one of us (J.L.P.) has developed in MIDAS a simulation programme for observations with EFOSC2 and EMMI,

two new ESO instruments which are about to come into general use at the NTT. EFOSC2 (eventually to be assigned to the 2.2-m telescope) has the same operating modes as EFOSC, the well-known focal reducer at the Cassegrain focus of the 3.6-m. EMMI is a more complex device which offers the possibility to select in real time among several observing modes. A description is attached to the ESO Call for Applications for Observing Time for period 45. The properties of EFOSC2 (such as the transmission of the optics, of the grisms, etc.) have been fully measured in the laboratory and can be used in the simulation. In the case of EMMI the data set is not complete and a realistic simulation will be working from March 1990

### Imaging mode

When finished press CTRL/Z and then on R

Channel	<i>R</i>	Filter	<i>ESO585</i>	Obj spect	<i>EM\$D:EGAL</i>
F/D cam	<i>6.7</i>	V obj	<i>25.0</i>	Sky spect	<i>EM\$D:ESKY</i>
Detector	<i>CCD1</i>	V sky	<i>22.0</i>	Zenith dist	<i>20.0</i>
Prefl. e-	<i>0.0</i>	Seeing	<i>1.0</i>	Out. image	<i>OUT_SIMU</i>
Binn in x	<i>1</i>	Exp time	<i>300.0</i>		
Binn in y	<i>1</i>				
DETECTOR:					
ESO ident	<i>CCD1</i>	Scale in x	<i>0.167</i>	Full name	<i>THX 31156 coated</i>
Ncol.	<i>1024</i>	Scale in y	<i>0.167</i>	Dark e-/s	<i>0.00800</i>
Nrows	<i>1024</i>	Bias ADU	<i>100.0</i>	Satur. e-	<i>200000.0</i>
ADU e-	<i>2.0</i>	RON e-	<i>6.0</i>		

### Spectroscopic mode

When finished press CTRL/Z and then on R

Channel	<i>R</i>	Filter1	<i>CLEAR</i>	Filter2	<i>CLEAR</i>
F/D cam	<i>6.7</i>	V obj	<i>25.0</i>	Obj spect	<i>EM\$D:EGAL</i>
Detector	<i>CCD1</i>	V sky	<i>22.0</i>	Sky spect	<i>EM\$D:ESKY</i>
Prefl. e-	<i>200.0</i>	Seeing	<i>1.0</i>	Zenith dist	<i>20.0</i>
Exp time	<i>3600.0</i>	Disperser	<i>GRIS1</i>	Slit width	<i>0.8</i>
Binn in x	<i>1</i>	Slit displ	<i>0.0</i>	Slit length	<i>20</i>
Binn in y	<i>1</i>	Dichroic	<i>N</i>	Dispersion	<i>0.856</i>
Lambda1	<i>500.0</i>	Lambda2	<i>600.0</i>	Lambda3	<i>700.0</i>
DETECTOR:					
ESO ident	<i>CCD1</i>	Scale in x	<i>0.167</i>	Full name	<i>THX 31156 coated</i>
Ncol.	<i>1024</i>	Scale in y	<i>0.167</i>	Dark e-/s	<i>0.00800</i>
Nrows	<i>1024</i>	Bias ADU	<i>100.0</i>	Satur. e-	<i>200000.0</i>
ADU e-	<i>2.0</i>	RON e-	<i>6.0</i>		

Figure 1: The appearance of the screen at the beginning of a session of the programme is shown. The various parameters which are needed in a simulation of a direct image or of a spectroscopic observation are displayed and can be edited in an interactive way.

only. The programme is written in MIDAS command language (version 89NOV), and uses MIDAS tables, but the user does not need to be familiar with MIDAS to be able to run it. It works in interactive mode using part of the STARCAT interface. A preliminary User Manual is available with J. L. Prieur, and astronomers at Garching and La Silla are encouraged to experiment with it.

The ST-ECF Space Telescope Model (Rosa, M., Baade, D., 1986, *The Messenger*, 45), was used as a starting point and adapted to our needs and to the portable version of Midas. Although we have not yet tested its portability on work stations and its use on other systems than VAX VMS, it is expected that this should be possible without a major effort. When that step will be completed, the simulation programme will be made part of the official MIDAS software as a new CONTEXT.

### Description of the Programmes

For the time being the programme handles stellar-like targets only. The case of a diffuse object of constant brightness will be implemented together with the full EMMI simulator. The computation starts from the spectrum of the

target outside the atmosphere and then takes into account the effect of atmosphere, telescope, instrument optics and detector, to compute the observed data, these being direct images or spectra.

At the beginning of a session, the default parameters for one observation (or those from the previous session) are displayed and the user can change them by moving around the screen with the arrows. An example of the screen with the default parameters for imaging, spectroscopy and the detector with EFOSC2 is shown in Figure 1. The input parameters are checked for consistency, and the transmission and efficiency curves for the telescope, instrument, filter, grism and detector are loaded from tables in the EFOSC2 data base. The user can also modify the detector properties and check in this way whether a different device is better suited for his/her programme.

In the next stage, the input spectra of the object and the sky are normalized to the V magnitudes given by the user. All the tables are resampled to a common scale in wavelength. This requires some computer time, but has the advantage of a higher flexibility. The user can use his 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. Standard spectra and an average sky spectrum are available in the programme data base.

With this input the format and the quality of the final data are computed. In the case of spectroscopy, the programme will give the spectral range, the transmission of the slit, the average dispersion and resolution and will compute at three different wavelengths chosen by the users the SNRs of the extracted sky-subtracted spectrum. For imaging, the SNR computation assumes an integration of the total flux of the star-like object, down to a 1% level for a gaussian point spread function.

Four sources of noise are taken into account in the SNR computation: the read-out-noise of the detector, the shot noise coming from the object, the sky, the preflash (if any) and the dark current, and the error in the calibration of the detector pixel-to-pixel sensitivity (taken as 1% of the total level for a given pixel in the default case). These errors are added quadratically and assumed to be independent from one pixel to another.

The main results of the simulation are written in a logfile (SIMU.LOG) which is automatically printed on a laser printer. Curves of the spectral input and output for a given object, sky spectra, and the overall efficiency can be displayed on a graphic terminal, and then sent to a laser printer within the programme.

There is also a possibility of simulating a 2D output image, or an output spectrum (Fig. 2). In the first case the Pleiades cluster as seen at 30 kpc (250 times further than in reality) is used as reference image. The brightest star is placed in the middle of the frame, and normalized to the magnitude given by the user for the object. The relative brightness of the other stars is maintained and the stellar images are scaled according to the seeing and the scale at the detector. A visual impression of the angular resolution and limiting magnitude in the field is then possible.

For spectroscopy, an extracted spectrum is computed from the addition of the brightest rows in the simulated 2D CCD frame down to a 1% level relative to the peak value. The starting point is always the spectral energy distribution of a standard object in the data file scaled at the desired magnitude and including the contribution of the sky over the same aperture. The output spectra from the object alone and sky alone are also available.

The simulation programme includes also parameters which are peculiar to

ground-based observations, that is the average seeing and airmass at the time of the observations.

## Conclusion

Even at this early stage of implementation, the EFOSC2 simulator appears as a useful tool to plan and optimize the observations at the NTT. In addition to the planned extension to EMMI, the programme could be easily extended to other, similar instruments by modifying the initial parameters. This can be done using a simple MIDAS procedure to write the desired values in the corresponding MIDAS keywords. The integration into the MIDAS environment makes it possible to display, edit, and print easily the characteristics of the different components which enter in the computation. If this updating is done in a systematic way, the programme will also provide on line an accurate description of the status of a given instrument. One can envisage that in the future potential users will check by a remote login whether the actual status of the instrument corresponds to the version recorded on their local workstation, introduce the upgraded parameters, if any, and then go on with the planning of their observing programme.

It is of course clear that the results of these first simulations need to be systematically compared with the output of real observations to refine the model. This interactive process will start when the first data with EFOSC2 will become available. As the model will become rel-

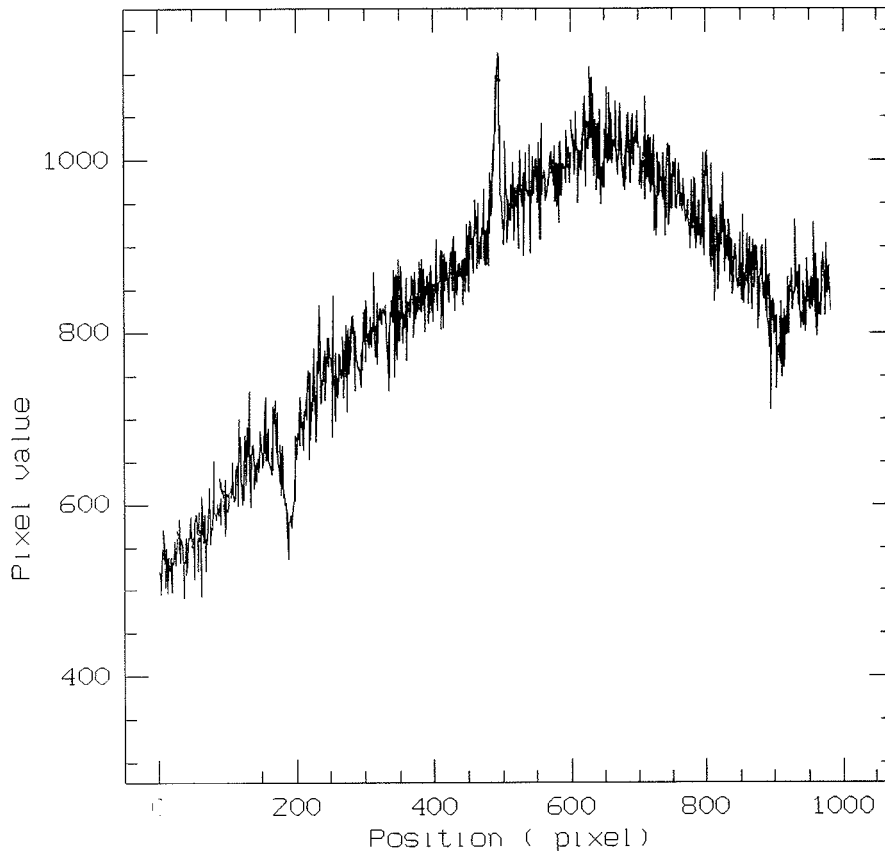


Figure 2: A simulated spectrum of an A5 star of  $m(v) = 20$  obtained in 1 hr exposure with EFOSC2 and grism # 4, which gives on the detector (a  $1024 \times 1024$  CCD with  $19 \mu$  pixels) the wavelength range 4100–7200 Å. The seeing was assumed 0.5 arcsec (FWHM). The slit width was also 0.5 arcsec. The various sources of noise and the sky spectrum have been added to the stellar continuum.

atively stable and the results fully reliable, one could also think to use the quantitative information that it provides

into the programmes which in the not-too-far future will optimize the use of the telescope by flexible scheduling.

# MIDAS Memo

## ESO Image Processing Group

### 1. Application Developments

The FIT package is now available in the portable MIDAS for both VMS and UNIX systems. It was upgraded in a number of areas. Some deficiencies of the old VMS version were corrected, in particular the methods applied to problems with constraints. The implementation is still using some NAG library routines.

A new context LONG has been implemented for the reduction of Long-Slit spectra. This first version provides only basic tools for calibration and analysis. It is planned to perform major upgrades for the spectral packages e.g. ECHELLE and LONG when the final archive tape format has been implemented as output format from instruments. This will en-

able a much more automated reduction sequence than is possible today.

A new context STATIST has been developed for statistical tests on tables. This includes specifically the comparison of empirical distribution with theoretical distribution, the comparison of independent data samples, the measurement of correlation. The Multivariate Analysis package (previously named STATIST) has been renamed to MVA.

In the stellar photometry package ROMAFOT, a major part of the code has been rewritten in order to integrate the software completely within MIDAS environment. In the new version the various file extensions for the different intermediate files (e.g. .Q, .F, .R) are no longer used: ROMAFOT now uses exclusively the MIDAS table file system for storing intermediate and final results. Obviously, with the introduction of the MIDAS tables in the ROMAFOT pack-

age the user is offered greater flexibility since MIDAS commands can now be used to manage the (intermediate) results.

The display parts of the new version of ROMAFOT are either directly based on the Image Display Interfaces or have been rewritten in the MIDAS Command Language (MCL). Hence, ROMAFOT can be used on all systems (VMS and UNIX) with display devices supported by MIDAS. For workstations this implies that an implementation of the X11 windowing software should be available.

### 2. System Development: Astronet Graphic Library

A new version of the AGL software has been completed. Besides several small improvements, a major effort has been made to improve the management of the graphic window on workstations.