EUROPEAN SOUTHERN OBSERVATORY

Organisation Européenne pour des Recherches Astronomiques dans l'Hémisphère Austral
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Very Large Telescope

Paranal Science Operations

UV-Visual Echelle Spectrograph User manual

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Change Record

Issue/Rev.	Date	Section/Parag. affected	Reason/Initiation/Documents/Remarks
Draft	15/07/99	all	
Issue 1.0	26/01/00	all	first release after commissioning
Issue 1.1	02/08/00	all	update for P66, after 4 m of operation
Issue 1.2	21/12/00		update for P67:
		2.2	preslit filters, new CD#4
		2.5	Fig. 2.6 added: detection efficiency
		3.3	Fig. 3.1 added: order separation
Issue 1.3	01/07/01		update for P68:
		1.7	bibliography reduced and updated
		2	schematic view added (Fig.2.2),
			2D CAD drawings removed
		2.3	Measured resolving power (Fig.2.3)
		3.2	R600 standard setting added
		3.3	Tab. 3.2 recommended slit lengths updated
		4.1	Calibration Plan added (Tab.4.1)
		4.6	section Quality Control added
		4.7.1	iodine cell info added
		6.2	qc/pipeline web links added
		6.4.1	iodine cell reductions info added
Issue 1.3.1	01/10/01		minor corrections
Issue 1.4	21/12/01		update for P69:
		3.6	acquisition: moving targets
		3.3 & 7	CUSO4 filter replaced by HER_5
		3.3	final CD#1 installed
			added Index (prepared by T.S.Kim)
Issue 1.5	29/06/02		update for P70:
		Tab. 2.1	IS efficiencies updated
		Fig. 2.3	IS vs. Slit added
		Fig. 2.5	replaced by 2002 measurements
		6.2	dark frame policy, source types
		4.4,6.2	master response curves added
		5.2.2	filenaming scheme updated
Issue 1.6	19/02/03		update for P71:
		4.5	calibration plan info added
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		2.2.4	MIT CCD info updated
		Tab. 4.2	exp. times for calibration lamps updated
Issue 1.8	10/01/04		update for P73:
		3.1	link to the Garching QC webpage added
		3.5	new section about RRM observations
		7.3	references for ThAr line table added
Issue 1.9	04/06/04		update for P74:
		6.3	red CCD image format change vs. pipeline
Issue 75	14/02/05		update for P75:
		2.2.4 & Tab. 2.3	information about new Blue CCD added
		3.3 & Tab. 3.1	standard Dichroic settings with 760nm added

Issue/Rev.	Date	Section/Parag. affected	Reason/Initiation/Documents/Remarks
Issue 76	01/06/05		update for P76:
		2.2.1	new setting with IS #3 and DIC2 +760 nm
		3.3 & Tab. 3.1	new standard setting RED600 w/o iodine cell
Issue 77	20/12/05		update for P77:
		2.2.2	announcement of availability of 8 interf. filters
		Tab. 7.1.2 & Fig. 7.1	information about interference filters
		Tab. 4.2	exp. times for calibration lamps updated
		6.4.3	reduction of interference filter data
Issue 78	14/01/06		update for P78
Issue 79	09/06/06		update for P79

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Contents

Chapter 1

Introduction

1.1 On the contents of the UVES User Manual

The current version of the UVES User Manual is available as a retrievable postscript file at the ESO home page on the World Wide Web (`http://www.eso.org/observing/vlt/instruments/uves/`). Before the observing proposal application deadlines, the User Manual is normally updated; any significant changes are announced on the UVES webpages. If you have no access to the WWW, a printed copy can be requested from ESO's Visiting Astronomers Section (on Internet: `visas@eso.org`) in Garching, Germany. Paper copies of a new version of the UVES User Manual are printed out only after a major revision of the document. The reader is referred to the web version of this document for the best quality of the included (color) figures.

The **first Chapter** of this manual is addressed to users who are not familiar with the UVES instrument and who are interested in a **quick overview** of its capabilities, in comparison with similar VLT (and La Silla) instruments. This should enable a potential user to select the best instrument for a given observing program. It also includes information on how to access FITS files of reference UVES spectra and a glossary of terms used in the Manual. The **second Chapter** provides the **description of the instrument**: the instrument layout (§2.1), its components (§2.2), the properties of the two CCD slit viewers and of the two scientific CCD detectors (§2.3, 2.4), the resolving power and overall efficiency (§2.5) and reference to instrument features to be kept in mind while planning the observations or reducing the data (§2.6). It can be consulted by users who want to prepare an Observing Proposal (Phase I), but should definitely be read by those who have been granted observing time and have to prepare their observations (Phase II).

The **third Chapter** provides the basic information needed to **prepare an observing program**: the identification of the instrument observing modes (§3.2), of the standard instrument wavelength settings (§3.3), and a description of the Exposure Time Calculator (§3.6). The **fourth Chapter** deals with **calibration** strategy (wavelength, flat-fielding, relative and absolute calibrations) of data obtained in standard operation. It also outlines calibration techniques for high velocity accuracy and very high S/N ratios. The **fifth Chapter** provides information for the visiting astronomers who come to the Paranal Observatory to use UVES. The **sixth Chapter** summarizes the properties of the **pipeline reduction** carried out for data obtained using the standard set-ups of the instrument.

1.2 Information available outside this manual

If you cannot find a specific piece of information in the UVES User Manual or in case you have remaining questions, please contact: `http://www.eso.org/observing/support.html`, or more specifically:

- For information on the instrument performance and Phase I and Phase II proposal preparation, please contact the User Support Department (`usd-help@eso.org`).
- For questions directly related to your granted observing run in Visitor Mode, please contact Paranal Science Operations (`pso@eso.org`).
- For Phase II preparation of Observation Blocks (OBs) follow the instructions given in the UVES Template Reference Guide: `http://www.eso.org/instruments/uves/doc/` UVES specific P2PP information is found in:
  `http://www.eso.org/observing/p2pp/UVES/UVES-P2PP.html`
  the P2PP instrument package is downloadable from
  `http://www.eso.org/observing/p2pp/P2PP-instr.html`
- For checking on possible recent changes in the instrument not yet recorded in the current version of the UM consult the UVES web page at `http://www.eso.org/instruments/uves/`
- Information on the current instrument performance and on the Service Mode pipeline data processing can be found on the UVES Quality Control pages at
  `http://www.eso.org/observing/dfo/quality/index_uves.html`

1.3 Capabilities of the Instrument

UVES, the **U**ltraviolet and **V**isual **E**chelle **S**pectrograph located at Nasmyth platform B of the second Unit Telescope (*Kueyen*) of the VLT (Fig 1.1), is a cross-dispersed echelle spectrograph designed to operate with high efficiency from the atmospheric cut-off at 300 nm to the long-wavelength limit of the CCD detectors ($\sim$ 1100 nm). To this purpose, the light beam coming from the telescope is split into two arms (UV-Blue and Visual-Red) within the instrument. The two arms can be operated separately or in parallel with a dichroic beam splitter. The resolving power is $\sim 40,000$ when a 1 arcsec slit is used. The two-pixel resolution (to be obtained with a narrower slit or with the use of an image slicer) is 80,000 or 110,000 in the Blue- and the Red Arm, respectively. The instrument is built for maximum mechanical stability and for accurate calibration of the wavelength scale down to an accuracy of at least 50 m/s. An iodine cell can be inserted in the light beam for observations requiring higher accuracy.

The main capabilities of the two UVES arms are summarized in Table 1.1.

In 2003, a new mode of operation involving multi-object spectroscopy was implemented. Eight fibers (input diameter 1 arcsec) coming from the fibre positioner of FLAMES, the instrument mounted at the opposite Nasmyth platform, can feed the red arm of the UVES spectrograph.

Table 1.1: UVES characteristics and observing capabilities

	Blue Arm	**Red Arm**
Wavelength range	300–500 nm	420–1100 nm
Resolving power-slit product **nm/pixel**	41,400 0.0019 nm at 450 nm	38,700 0.0025 nm at 600 nm
Max. Resolving power (2-pixel sampling)	$\sim$80,000	$\sim$110,000
Throughput at blaze (TEL+UVES, no slit, no atm.)	12% at 400 nm	14% at 600 nm
Limiting magnitude (90m exp. time, S/N=10, 0.7 arcsec slit,seeing 0.7)	18 R=58,000 at 360 nm	19.5 R=62,000 at 600 nm
CCDs	2048×4096 (windowed to 2048×3000)	two 2048×4096 (mosaic of different types)
Pixel (15μm) scale disp. dir. (varying along order) along slit (dep. on cross-disp.)	 $0.215'' \pm 20\%$ 0.25"(CD1 and CD2)	 $0.155'' \pm 20\%$ 0.18"(CD3),0.17 (CD4)
Echelle (R4 mosaic)	41.59 g/mm	31.6 g/mm
Cross dispersers Blaze wavelength Blaze wavelength	CD1: 1000 g/mm 430 nm CD2: 660 g/mm 460 nm	CD3: 600 g/mm 560 nm CD4: 312 g/mm 770 nm
Typ. wavel. cov. CD1 and CD3 (CD2 and CD4 in parenthesis)	85 (126) nm in 33 (31) orders	200 (403) nm in 37 (33) orders
Min. order separation (standard setup)	10 arcsec (40 pixels)	9 arcsec (51 pixels)

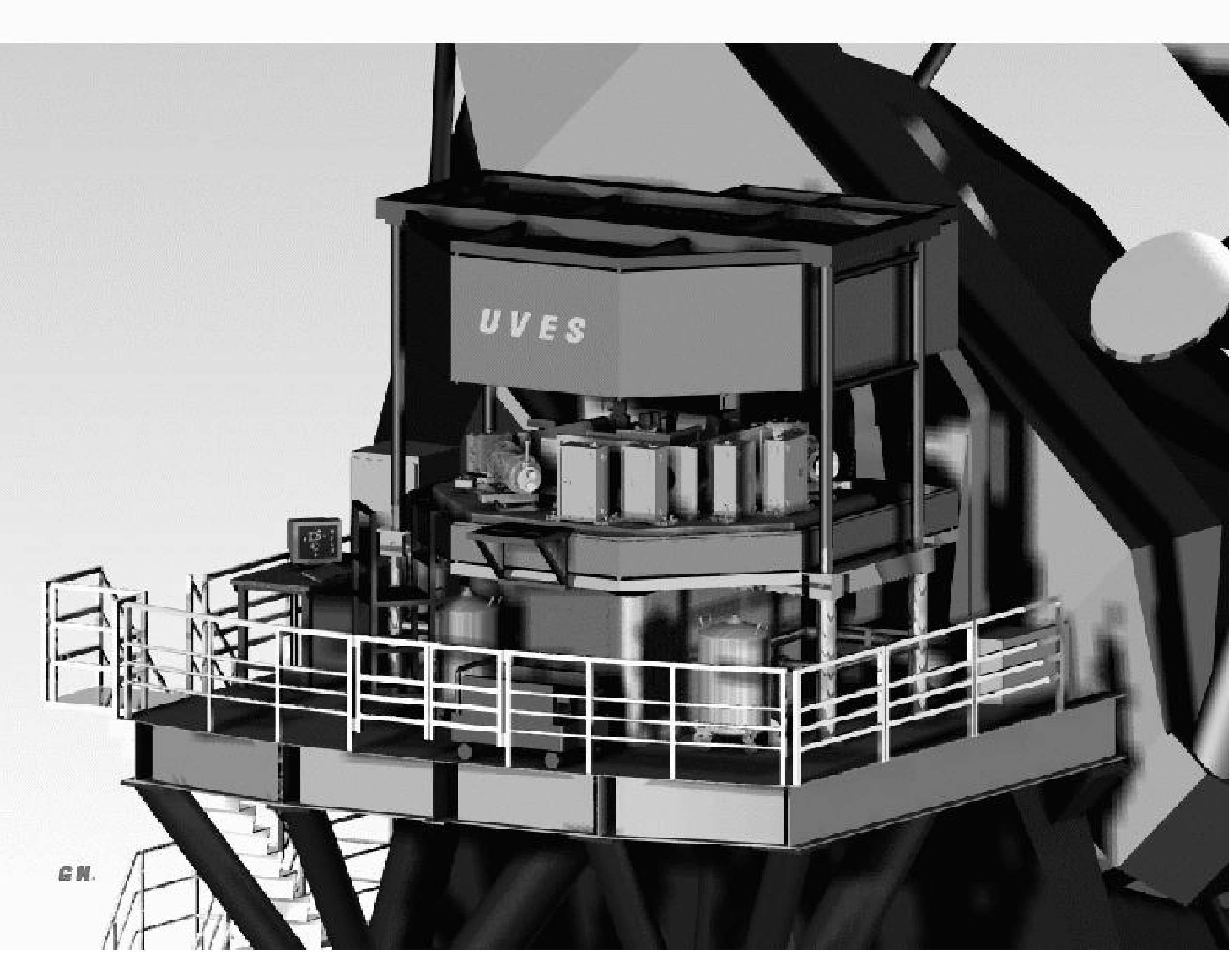

Figure 1.1: The UVES spectrograph on the Nasmyth B platform of VLT Unit Telescope #2 (3D CAD view).

1.4 UVES within the VLT Observatory

A detailed overview of the different instruments on the VLT is shown on the ESO homepage under VLT Instrumentation (`http://www.eso.org/observing/vlt/instruments/`). In the choice of the best instrument for a given observing program, the following trade-offs have to be taken into consideration:

Spectroscopy in the UV-Visual-Red regions (300-1100 nm)

- **FORS1** at UT2 since June 2004 can be used for spectroscopy in the spectral range 360-1100 nm. Its overall efficiency is on average 2 times higher than UVES (one reflection less in the telescope and simpler instrument optics) but the maximum resolving power to be obtained with a 0.5 arcsec slit is 2,500 only.
- **FORS2** at UT1 is a replica of FORS1 but it will eventually include two transmission echelle gratings which, when used in conjunction with a grism cross disperser, will provide a resolving power of up to 6,000 and a wider spectral coverage comparable to that of UVES.
- **GIRAFFE**, which is part of the FLAMES instrument at the opposite Nasmyth platform of UT2, is the instrument which approaches UVES in resolution. An automatic fibre-positioning unit is installed at the Nasmyth focal plane. It can use up to 132 fibers in the field of view of 25 arcminutes in diameter. The fibers feed the GIRAFFE long-slit spectrograph mounted on the Nasmyth platform. The data are collected by a 2048×4096 pixels CCD. One CCD frame contains the linear spectra of up to 132 objects observed in parallel with a limiting resolving power of $\sim 20,000$ and a spectral coverage in a single exposure of 26-60 nm depending on the wavelength. GIRAFFE is on average 30% less efficient than UVES, but the multiplexing gain can make it the best choice if the observing program includes many objects in a single field at intermediate spectral resolution.

Spectroscopy at infrared wavelengths (1-5 μm)
Complementary spectroscopic observations at infrared wavelengths can be obtained with two other VLT instruments:

- The infrared imager-spectrometer **ISAAC** can be used to obtain spectra in the 1-5 μm spectral region. Two separate cameras in the same cryogenic/vacuum vessel are optimized separately for the 1-2.5 μm and 2.5-5 μm spectral ranges with resolving power up to 10,000 if a 0.5 arcsec slit is used.
- A high-resolution infrared spectrometer, **CRIRES**, is currently under study. It is intended to be the counterpart of UVES in the 1-5 micron spectral region providing a resolution up to 40,000 (0.5 arcsec slit) in a single order or cross-dispersed format.

1.5 How to access UVES sample calibrations and observations

A large number of scientific observations of a variety of targets and the associated calibrations have been obtained during the UVES Commissioning in October and December 1999 and in

January 2000. They are available as public data from the ESO archive. The list is accessible at `http://www.eso.org/science/uves_comm`

1.6 High-resolution spectrographs at ESO La Silla

Other high-dispersion, echelle format spectrographs available at ESO La Silla are **FEROS** at the MPG/ESO 2.2m telescope (R∼48,000), **EMMI** at the NTT (R∼7,700 – 60,500) and **HARPS** (R∼110,000) and **CES** (R∼220,000) at the ESO 3.6m telescope. Information on these instruments can be found at `http://www.ls.eso.org/lasilla/sciops`

1.7 Bibliography

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1.8 Glossary

Acquisition: Accurate positioning of the telescope in order to center the target on the spectrograph slit.

Atmospheric Dispersion Correction (ADC) unit: This unit can be inserted in the pre-slit area of UVES to correct for atmospheric dispersion.

BIAS frame: Read-out of the CCD detector of zero integration time with shutter closed. The registered number of electrons per pixel has to be subtracted from a science exposure, because these were not created by photons from the source.

Calibration: Procedures to remove the instrumental signature from the scientific data (e.g., by subtracting BIAS frames and by dividing through the flatfield).

Camera: UVES has two dioptric cameras (red and blue arm) imaging the dispersed parallel beams on two CCD detectors.

Charge-Coupled Device: Electronic 2D-array detector converting photons into electrons.

Cross-disperser grating: An echelle spectrograph contains two dispersive elements, in the case of UVES two gratings. One is the echelle grating, the other one is called the cross-disperser grating. UVES hosts two cross-dispersers, each with two different gratings. The cross-disperser grating determines the distance between the echelle orders.

Decker: Reflecting, movable blades placed in front of the slit and determining its length.

Derotator: This element (not to be confused with the telescope adapter/rotator unit) is placed in the diverging beam coming from the telescope and compensates for field rotation (which is inherent to the Nasmyth focus).

Dichroic: This element in the UVES mode selector reflects all the light below a certain wavelength and is transparent for longer wavelengths. This allows the operation of the spectrograph using both spectrograph arms simultaneously.

Grating: The main light dispersing elements of UVES are two echelle gratings, one blue, one red optimized.

Flatfield: Spectrum obtained from light source with a flat (i.e. without spectral features) energy distribution, e.g., a tungsten lamp. The registered signal provides information about the response of the detector, allowing a determination of the variation in sensitivity from pixel to pixel, the echelle order shape, the presence of bad columns on the detector, etc.

Guide star: A point source used for accurate tracking (and active control of the telescope mirrors).

Image slicer: This device converts a two-dimensional image (e.g., of a star) in the focal plane of the telescope into a one-dimensional slit. In this way, the light that normally would fall outside the slit (especially when using a narrow slit for high spectral resolution) is fed to the spectrograph.

Iodine cell: A glass cell filled with heated I_2 gas can be inserted in the light beam to superimpose a molecular absorption spectrum, containing many lines, on the observed astronomical spectrum. This enables very accurate wavelength calibration in the spectral range 500-600 nm.

Maintenance: Technical procedures developed to control and maintain the quality of telescope, instrument, and detector.

Mode Selector: Unit in the pre-slit area of UVES which directs the light to one of the two spectrograph arms or to both arms simultaneously (with the help of a dichroic).

Observation Block: A logical unit of exposures needed to obtain a coherent set of data. Encompasses all relevant information for a successful data acquisition on a target. It consists of target information, a set of templates, parameter files for the templates, conditions, requirements and comments concerning the specified observations. It represents the entity the short-term scheduler deals with. Constructing Observation Blocks is part of the Phase II Proposal Preparation Process.

Phase II Proposal Preparation (P2PP): During this phase the successful applicant (whose Phase I proposal has been accepted based on the scientific rationale and technical feasibility) prepares the Observation Blocks to carry out the observing program.

Pre-slit area: UVES spectral elements located in front of the spectrograph slits.

Secondary Guiding The image of the target reflected by the slit jaws is used to correct for possible small displacements between the telescope optical axis and the instrument which is mounted on the Nasmyth platform.

Sequencer: A sequence of exposures on different targets (i.e., different OBs) can be obtained using the Sequencer (or Scheduler). The Sequencer is capable of conditional branching and has knowledge of parameters not necessarily accessible to the observation software (e.g., the seeing conditions).

Slit Viewers: Simple optics which focus the light reflected by the slit jaws on two CCDs detector. They are used to center the targets on the slit.

Spectrograph arm: UVES consists of two "separate" spectrographs, one optimized for the blue (blue arm) and one for the red wavelength region (red arm).

Spectrograph slit: Two parallel, reflecting metal blades with an adjustable separation (slit width) form the entrance slit of the spectrograph. The image of the astronomical source produced by the telescope is focussed on the slit plane.

Standard Setting: A pre-defined setting of the instrument facilitating the preparation of the observations. The Observatory keeps an updated database of the relevant calibration files for all Standard Settings of the instrument.

Template: A set of instructions for the performance of a standard operation on an instrument, typically an instrument and detector setups. The templates represent specially devised sequences for all instrument operations and calibrations.

Template Signature File: This is a description of a Template and its parameters. It contains information about the type and allowed ranges of the parameters; some of the parameters have to be set by the observer.

Wavelength calibration: Spectrum obtained from a reference emission-line lamp. The wavelengths of the (many) emission lines are accurately known and are used to transform pixel space into wavelength space.

1.9 Abbreviations and Acronyms

AT	Acquisition Template
BLUE	Blue arm of the spectrograph
BOB	Broker for Observations Blocks
CAL	Calibration exposure
CCD	Charge-Coupled Device
CD	Crossdisperser
DIC	Dichroic beam splitter: feed to red and blue arm
ESO	European Southern Observatory
ETC	Exposure Time Calculator
EM	Exposure Meter
IS	Image Slicer
OB	Observation Block
OS	Observation Software
OBS	Observation Template for a scientific target
P2PP	Phase II Proposal Preparation
RED	Red arm of the spectrograph
RTD	Real-Time Display
STD	Standard star
SM	Service Mode
SV	Slit Viewer
TSF	Template Signature File
UVES	Ultraviolet and Visual Echelle Spectrograph
VLT	Very Large telescope
VM	Visitor Mode

Chapter 2

Instrument Characteristics

2.1 Opto-mechanical layout

Figure 2.1 is a 3D-CAD view of the instrument table with the mounted spectrograph elements; Fig. 2.2 shows a schematic layout of the instrument. The present configuration was selected in May 1994 after a trade-off among the different concepts outlined in the initial feasibility study.

The instrument consists of two main parts: the first part is mounted on the rotator (which remains stationary while the telescope adapter rotates to follow the field rotation). It includes the calibration system, a removable iodine cell, a slide with image slicers and an optical derotator which is permanently installed in the beam. The second part, the two arms cross-dispersed echelle spectrograph, is mounted on a steel table fixed to the floor of the Nasmyth platform and is covered by a light-tight enclosure which also provides thermal insulation and protection from dust. The light beam from the telescope is focussed on the red arm entrance slit or is directed to the blue arm slit by a mirror.

On the fixed table in the pre-slit area, additional optical components are available for insertion in the optical beam: filters, a depolarizer, an Atmospheric Dispersion Compensator (ADC) and two pupil stops of different size.

Two dichroics are available to work in parallel with the two arms. The blue arm ($\lambda\lambda$ 300-500 nm) and the red arm ($\lambda\lambda$ 420-1100 nm) have an identical layout. They are folded and cross each other to minimize the size of the table on the platform. The two-arm solution gives high efficiency because it permits to optimize the spectral response of coatings, gratings and detectors. The design of both arms is of the white-pupil type (Baranne, 1972, ESO-Cern Conference on Large Telescopes). With a beam of 200 mm, the off-axis parabolic collimators illuminate the echelle gratings of $214 \times 840 \times 125$ mm with a large blaze angle (76°). The echelle R4 gratings are the largest ever made of this type. They are operated in quasi-Littrow mode, that is with the angle of incidence and diffraction equal but in a different plane, to maximize efficiency.

The grating cross-dispersers provide an order separation larger than 10 arcsec at any wavelength in the spectral range $300 - 1100$ nm. This separation allows to perform semi-long-slit spectroscopy of compact objects, the use of image slicers, a good sampling of sky emission at red wavelengths and the possibility of accurate interorder background estimates.

The cameras are dioptric (no central obstruction) and provide an external focal plane for easy detector interfacing and upgrading during the lifetime of the instrument, together with a large field, good image quality and high optical transmission.

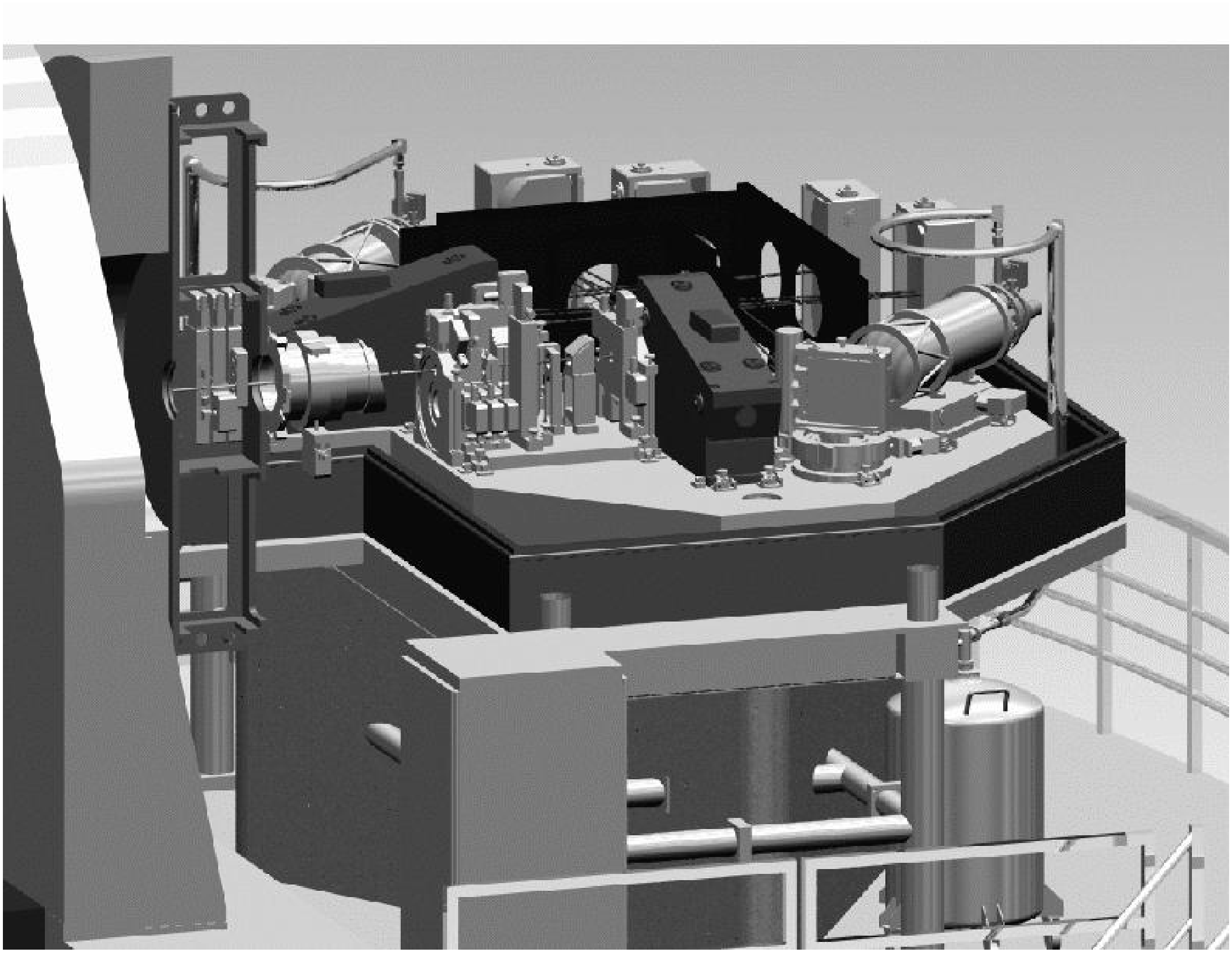

Figure 2.1: A three-dimensional CAD view of the UVES instrument table with the mounted spectrograph elements. The telescope beam enters the spectrograph from the left while we look at the pre-slit area. The cylindrical element at the left side of the table is the derotator. The calibration unit is not included in this picture. The mode selector splits the light in a red beam (going straight) and a blue beam (reflected to the left). The echelle gratings are mounted face down (the red one in the rectangular unit at the front side of the table). Each beam is reflected by a flat mirror, first collimator, echelle grating, first collimator, linear flat mirror, second collimator, and into the camera (the red camera is visible at the right edge of the table) via one of the two available cross-disperser gratings. For a schematic overview, see Fig. 2.2.

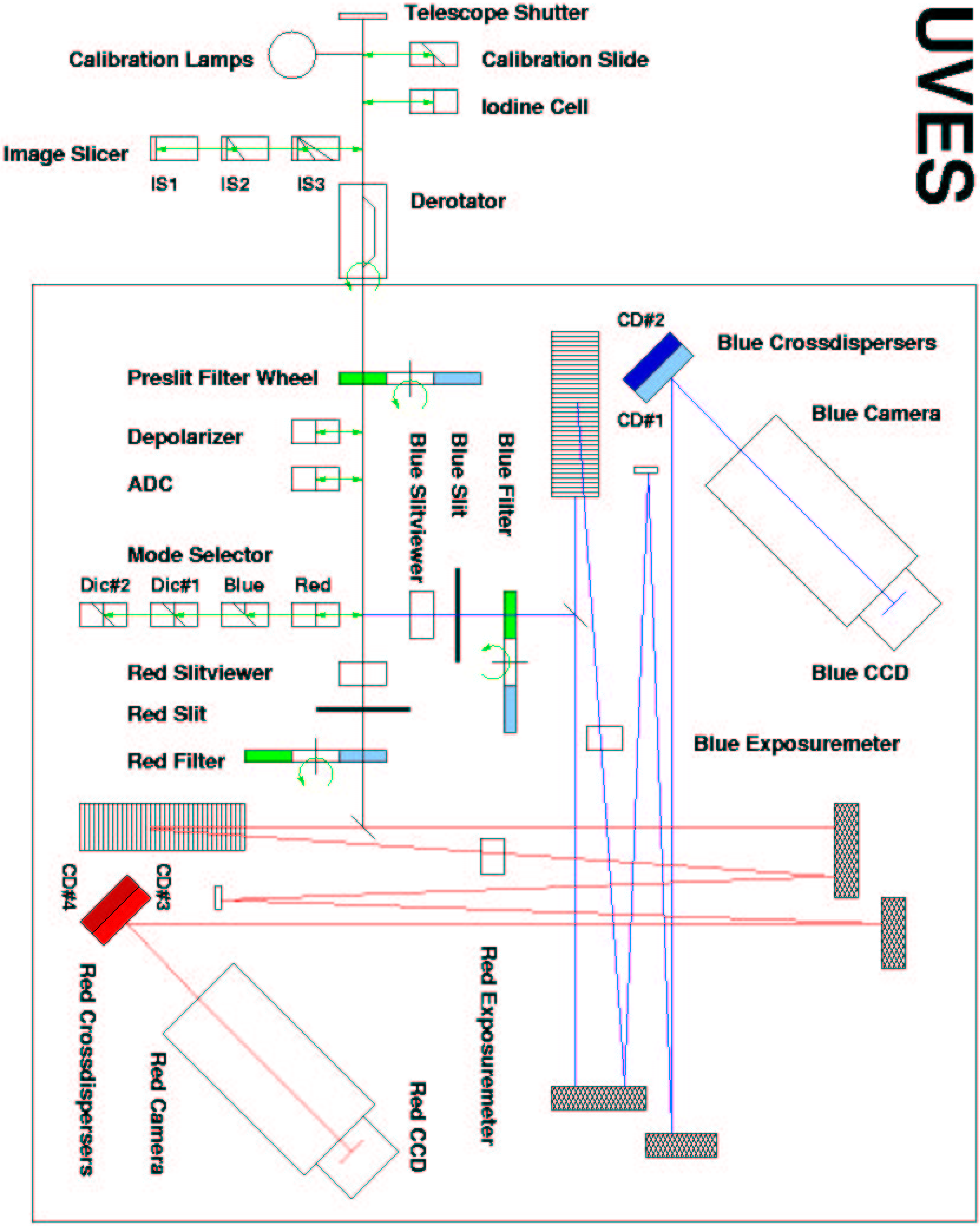

Figure 2.2: Schematic overview of the UVES spectrograph.

The blue CCD detector format is 2048 × 4096 pixels, windowed to 2048 × 3000. In the red, a mosaic of two 4096 × 2048 pixels CCDs is offered, separated by about 1 mm (loss of one order in the gap). The direction of the spectral dispersion (= echelle orders) is along the larger dimension of the CCDs. The instrument spectral formats (wavelength coverage, etc.) are always computed for these fixed CCD window settings.

2.2 Instrument subsystems

This section describes the UVES subsystems in the order they are encountered along the optical path going from the telescope to the instrument detector (cf. Fig. 2.2). It is intended to guide the users in the selection of the optimal instrument configuration for his/her observing program. The functionalities of the different subunits are explained and reference is made to their measured performance.

Efficiencies (e.g., in the form of transmission curves) of the main instrument components including the CCDs are available in the UVES database accessible through the UVES Exposure Time Calculator (see Chapter 3.5)

2.2.1 The preslit system

The light path

The light from the telescope (or from the calibration unit, enters from the top and passes through the calibration-mirror unit, the iodine cell, and image-slicer unit, respectively, before entering the derotator. The next elements are the pre-slit filter wheel, the ADC, the depolarizer and the pupil stop. At the position of the mode selector (which includes the dichroic filters) the beam is split into a red (going straight) and blue path (reflected to the right). Fibers coming from FLAMES at the opposite Nasmyth platform can be inserted in the mode-selector unit from the left to feed the red arm. The slit view cameras are located in front of the spectrograph slits.

The preslit functions

In the converging f/15 beam coming from the telescope, the first element is the **telescope entrance shutter** which allows safe daytime use of UVES for tests and calibration without stray-light entering the system from the telescope side.

Then follows the **Calibration Unit**. It consists of a mechanical structure with calibration lamps, an integrating sphere, relay optics that simulate the F/15 telescope beam, and a mirror slide with four positions that can be inserted in the telescope beam: one free for a direct feed from the telescope, three occupied by mirrors which reflect the light from the integrating sphere, from a Thorium-Argon or Deuterium lamp towards the instrument. A description of the functionalities of the calibration system is given in Chapter 4.

The **Iodine Cell** slide is used to insert a glass cell filled with I_2 gas in the telescope beam. Consequently, when it is at the operating temperature of 70°C an absorption spectrum of that molecule is superposed on the object spectrum, which can be used as a wavelength reference in the wavelength region 490 − 640 nm for high precision radial-velocity studies (see Chapter 4 for more details).

Table 2.1: UVES image slicers

Slicer number	Entrance Opening	Slit width	Slit length	Number of slices	Resolving power	Efficiency [%]
1	$2.1'' \times 2.6''$	$0.68''$	$7.9''$	3	$\sim 60,000$	70 @ 350, 78 @ 450, 80 > 650 nm
2	$1.8'' \times 2''$	$0.44''$	$7.9''$	4	$\sim 75,000$	73 @ 350, 82 @ 450, 83 > 500 nm
3	$1.5'' \times 2''$	$0.30''$	$10.0''$	5	$\sim 110,000$	73 @ 400 – 1000 nm

The **Image Slicer** slide can be used to insert one out of three image slicers (IS), which reformat the 2D-image of a rectangular area in the F/15 focal plane of the telescope into a narrow slit which is imaged on the spectrograph entrance slits. The IS is inserted in the beam before the field derotator and thus no spatial resolution is possible. Their entrance dimensions and output format are given in Table 2.1. The efficiencies given there are the optical transmission of the slicers. The users can acquire the target through an image slicer to obtain spectra at the highest spectral resolution (slit projection → 2 pixels on detector) or intermediate resolution (R=60,000) without the strong losses of a narrow slit (< 1") during periods of mediocre seeing. The spectrograph entrance slit will be automatically adjusted to the width of the virtual slit produced by the image slicer. The actual gain with respect to a standard observation through a narrow slit depends on the value of the seeing and is shown in Fig. 2.3. The turnover points where the use of a slicer is giving a better efficiency than the use of a narrow slit are at a seeing of $> 0.7''$ for IS#1, $> 0.5''$ for IS#2, and $> 0.3''$ for IS#3 slightly depending on the actual wavelength of the observation. The length ($7.9''$) of the #1 and #2 image slicer slits is smaller than the minimum decker height (typically 10 to $12''$) of the spectrograph slit, so that the remaining part of the spectrograph slit can be used to monitor the sky background. IS #2 and #3 are dedicated to the blue and red arm respectively. Due to the unavailability of a red arm setting with central wavelength 760 nm, the possibility of using the combination of IS #3 with DIC2 and the setting with a central wavelength of 760 nm has been implemented for use starting with Period 76. The blue arm spectrum will be taken simultaneously but is of lower quality and thus only partly useful. In particular, the blue arm setting with a central wavelength at 390 nm has a decker height of $8''$ which is smaller than the $10''$ length of the IS #3 implying some loss of light.

IS #1 is for general use. If IS #1 is used in a dichroic mode, it is important to avoid observations at airmasses higher than 1.3. Otherwise considerable light losses due to the atmospheric dispersion (and therefore the displacement of the blue with respect to the red image) have to be expected. This is also true in case of observations with IS #2 in the very blue, e.g., in the Blue 346 nm standard setting.

The **Derotator** (not to be confused with the telescope adapter/rotator unit) is an Abbe-Koenig type silica prism that is placed in the diverging beam of the telescope and provides compensation for the field rotation. It incorporates a lens to create a parallel beam. It cannot be taken out of the beam and it introduces an average loss of 4% of the light. The user has two options: (a) of derotating the field (fixed projected position angle on the sky of the spectrograph slit, "SKY" mode, with the position angle PA of the slit measured positive from North over East. For $PA = 0$ the slit is aligned North-South); (b) of maintaining the slit along the direction of atmospheric dispersion to reduce the losses due to atmospheric dispersion and to keep the target on both the blue and red entrance slit ("ELEV"ation mode).

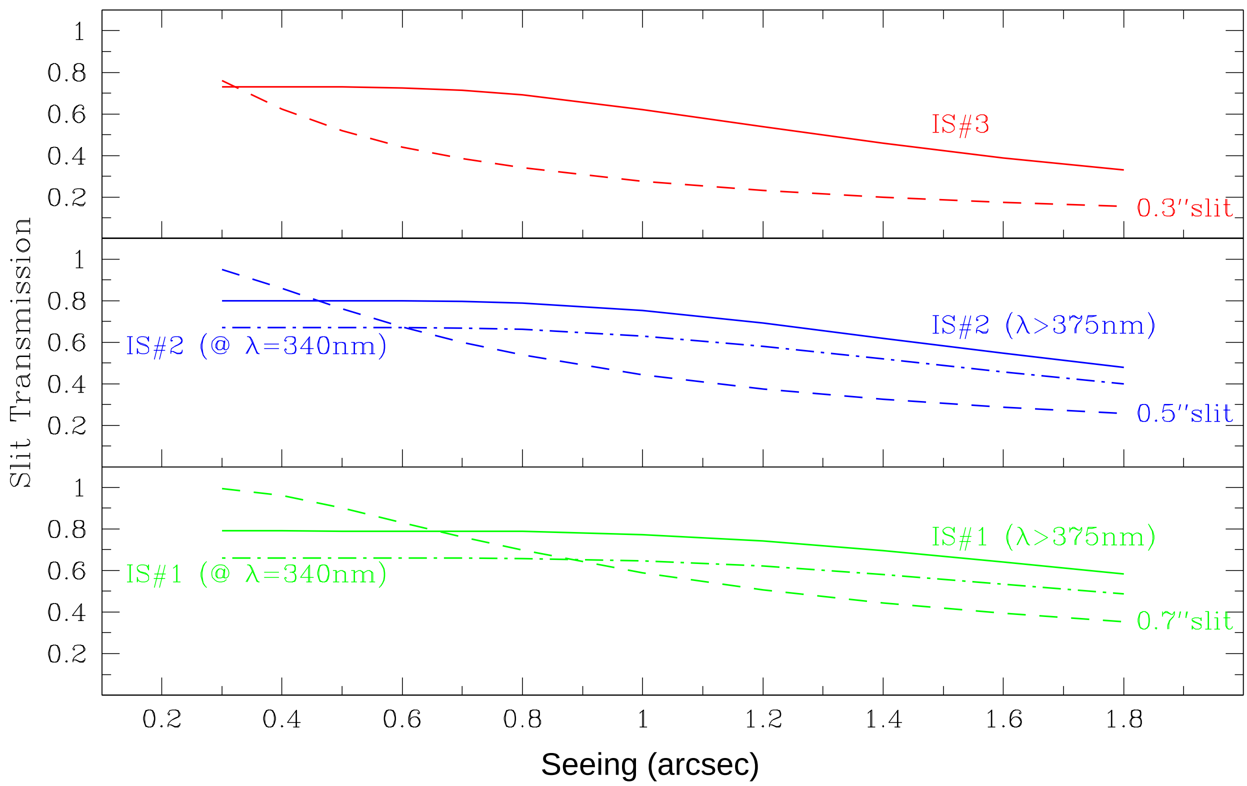

Figure 2.3: Image Slicer vs. Narrow Slit.

When retaining spatial information and a fixed slit orientation is important (e.g., extended objects or multiple targets) the derotator must be placed in "SKY" mode and the Atmospheric Dispersion Corrector (see below) should be used (especially if observations cover the blue spectral range).

The **pre-slit filter wheel** has 16 positions of which 15 are dedicated to filters of 40 mm diameter. These are neutral density filters and a set of Johnson broad-band filters. The table listing the properties of the available filters is given in the Appendix. The measured transmissions are available in the UVES database. The color filters are used for instrument maintenance only; the neutral density filters (ND1...ND3) have to be used to acquire very bright objects (< 6 mag) on the slit viewer not to saturate the slit-viewer technical CCD which would lead to a degradation of the centering accuracy during the interactive acquisition procedure. For filter NDn ($n = 1 \ldots 3$) the brightness is lowered by $n * 2.5$ mag. Make sure that the effective brightness of the target is between $7 - 11$ mag. Note, that the filter will be forced to "FREE" (no filter) for the science exposure. The "U" filter must be used for acquisitions with an image slicer if the subsequent observations are carried out in the blue arm of UVES with CD#1 to minimize the effects of atmospheric dispersion (the ADC, cf. below, and the derotator mode "ELEV" cannot be used in combination with the image slicers).

The **Atmospheric Dispersion Corrector (ADC) unit** is a slide that can be used to insert two counter-rotating prisms in the telescope beam, which compensate for atmospheric dispersion up to zenith distances of ~ 65 degrees. The ADC is useful when the derotator cannot be used to align the average atmospheric dispersion direction with the long slit direction on the sky, which may be the case, for instance, when observing extended objects or close pairs. It helps to reduce slit losses and so provides a better absolute flux calibration in the blue and, when observing with a dichroic, at large zenith distances. The ADC transmission is higher than 90% from 350 to 900 nm. Note that the ADC cannot be used in combination with the image slicers because the ADC is located in the optical path *behind* the slicers.

The **Depolarizer slide** can be used to insert a rotating $\lambda/2$ plate in the beam to cancel any intrinsic or telescope-induced polarization that might affect the detected signal level since also some UVES components (notably the cross-dispersers) have a polarization-dependent efficiency. No strong instrumental polarization effects have been measured so far.

The **Pupil Stop slide** is used to insert a stop at the position of the image of M2 that is produced by the derotator. This is required because apart from the sky baffle ring around M2, the telescope is not baffled so that the instrument may "see" the sky around M2 beyond this ring. Three stop positions are available: (1) regular stop: a slightly oversized (2%) stray light mask to stop any sky radiation bypassing M2; (2) undersized stop: a $\sim 6\%$ undersized mask that provides a very stable pupil entering the instrument; (3) unused. The regular stop is the default one. The undersized stop results in a light loss of 13% , but has the advantage that the telescope and calibration light beams are perfectly stable and identical. It is offered for high accuracy radial-velocity measurements with the iodine cell only.

The **Arm Selector** unit has four positions: Free (direct feed to the red arm), Mirror#1 to feed the blue arm, Dichroic#1 and Dichroic#2 to feed both arms. When the UVES main beam is stopped by the shutter, the backside of Mirror#1 will be used to feed the red arm of UVES with light from 8 fibres from the FLAMES positioner located on the other Nasmyth focus (expected start of this mode: beginning of 2003). Mirror #1 has a coating optimized for the wavelength range covered by the blue arm. Dichroic#1 has a cross-over wavelength at 450 nm, Dichroic#2 at 550 nm. The efficiencies of the two Dichroics can be found in the UVES database available through the ETC. The working position of this unit is determined automatically by the instrument software once the instrument observing mode is selected.

Red and blue **Slit viewer CCDs** (see Section 2.3) are available to view the field location of the spectrograph slit within the field. The diameter of the unvignetted field at the slits is 30 arcsec, while the useful field of the slit-viewer CCDs extends up to 60 arcsec diameter. Slit-viewer images at the beginning of spectroscopic UVES exposures are automatically archived. The operator can request the system to save or print additional slit-viewer images.

2.2.2 The two spectrograph arms

The blue and red arms are functionally identical. Differences in the properties of coatings, cross-dispersers and CCDs are addressed below where appropriate.

The light path

In both arms, the respective beams that enter the spectrograph are reflected by a folding mirror to the main collimators. From here, the collimated beams are dispersed by the echelle gratings and sent back to the main collimators. The small fraction of light (about 1%) that hits the small gap in the center of the echelle mosaics is reflected to the exposure meters in front of the echelle gratings. Via the intermediate spectrum mirrors and the transfer collimators the dispersed beams fall on the cross-disperser units. From here the echelle spectra enter the cameras and are recorded on the CCD detectors.

The spectrograph arm functions and components

The **slit units** consist of two reflecting diamond-machined Al blades whose separation (slit width) is continuously adjustable (from 0.15 to a maximum of 20 arcsec). The height of the slit is determined by continuously adjustable deckers of the same material which can open up to 30 arcsec.

The **below slit filter wheels** have 23 positions each for 25 mm filters for order sorting or stray-light rejection. The filters are used in the diverging F/10 beam and thus cause a defocus blur of 0.08 arcsec mm^{-1} of thickness (in the CCD plane, this corresponds to a blur of 5.9 μm in the blue and 8.3 μm in the red). The spectrograph is normally focused for a nominal filter thickness of 5 mm, as of the filters used in the standard instrument setting for scattered light or second order suppression.

Recently, eight **interference filters** have been installed to use with the UVES red arm in visitor mode. The purpose of these filters is to isolate certain echelle orders to allow the use of the maximum slit length of 30″. The filters and their central wavelengths are: Hα (656.6 nm), Hβ (486.1 nm), OIII (500.7 nm), OIII (436.3 nm), NII (575.5 nm), OI (630.0 nm), SII (672.4 nm), and HeII (468.6 nm). The central wavelength of each filter was chosen to permit observations of the most important emission lines in extended objects. The peak transmissions of the individual filters range from 70 to 90%.

The blue and red **mirror collimators** each consist of two off-axis parabolas and two flat mirrors. They are of the "white pupil" type and so have two 200 mm pupils: one for the echelle, and one at the crossdisperser/camera which leads to moderate size and simplified design of these components.

The blue and red **echelle gratings** are 84 cm long and 21 cm wide. Because grating masters of this size cannot be ruled, a new process has been developed in which a replica is made of two precisely aligned masters. The result is a "monolithic mosaic" with a resolving power on the order of 2,000,000 and a stable Line Spread Function. The groove density and hence the order length has been selected such that the order length is equal to the CCD width at 500 nm (blue arm) and 990 nm (red arm). Loss of the ends of the orders beyond these wavelengths can be recovered using the tilt tables (see below). Further information on the echelle (and cross-disperser) gratings can be found in Table 2.2.

The **exposure-meter** pickup mirrors (see below) are permanently mounted before the echelles, covering the 14 mm gaps between the two echelle segments and directing light (that would otherwise be lost) to blue- and red-optimized uncooled photomultipliers operating in photon counting mode. The dark-current rate is on the order of 1 (blue) to 10 counts per second (red) at a table temperature of 12 °C. The EMs are mostly useful to monitor the count rate during an exposure. The actual signal is a function of the magnitude and color of the target, of the spectrograph mode, of the seeing and the slit width, of the selected below-slit filter, but not of the CD set-up. The results are presented to the user in a strip-chart-like display which can be printed. Counts statistics are stored in the image headers. Note that the EM signal is proportional to the total flux entering through the slit, including sky. During commissioning at the telescope it was possible to monitor the flux of objects as faint as 19^{th}-magnitude object in both arms (typically 20 cps above the background).

The blue and red **cross-disperser units** are grating turrets with two gratings mounted back-to-back on each unit. Selection of the grating is done by rotation of the unit; the angle of the grating is automatically set according to the required wavelength of the central echelle order. The properties of the cross-disperser gratings $1-4$ can be found in Table 2.2. At start of

Table 2.2: UVES echelle and cross-disperser gratings

Echelle gratings					
	g/mm	Resolving Power	Spatial resolution	Blaze angle	Blaze Eff. (%)
Blue	41.59	1.900.000	0.1″	76.0°	67
Red	31.6	2.100.000	0.09″	75.04°	63
Cross-disperser gratings					
	g/mm	Wav. range (nm)	Average Eff. (%)	Wav of Peak Eff. (nm)	Blaze Eff. (%)
CD1-prot	1000	300 – 390	> 55	430	60
CD2	660	370 – 500	> 60	460	65
CD3	600	420 – 680	> 60	520	68
CD4	312	660 – 1100	> 70	770	80

the operation of UVES, prototype gratings were installed for grating #1 and #4. The final gratings #4 and #1 have been installed in November 2000 and October 2001, respectively. The performance is identical to that of the prototypes but with a higher efficiency.

The **Cameras** are both of the dioptric type with an external focus to facilitate detector exchange. Focus is set manually and then maintained automatically by thermal expansion rods in the camera support structure. The blue and red cameras have unvignetted entrance apertures of 210 and 230 mm, focal lengths of 360 and 500 mm, and fields of 43.5 and 87 mm diameter, respectively. Their image quality is 20 μm on-axis to 30 μm in the corners (diameter of circle containing 80% of the energy). The transmission curves can be found in the UVES database available through the instrument ETC.

The camera/CCD units are mounted on **Tilt Tables** that allow to tilt the optical axis by $\sim$ 0.48 degrees. This allows a shift of the echellogram in the main dispersion direction of up to $\sim$ 200 pixels in the blue and $\sim$ 280 pixels in the red, to recover spectral features that are lost at the order ends or fall on a bad column. The setting accuracy and repeatability is better than 0.1 pixel.

2.2.3 The Slit-Viewer CCDs

UVES includes four CCD systems: two slit-viewer technical CCDs and two scientific CCD detectors for the blue and the red echelle spectra. The red and blue **slit-viewer** units incorporate Peltier-cooled, 288 × 385, 22μm pixel frame-transfer, front illuminated CCDs on which an image of the slit plane is focussed with a scale of 0.15 arcsec/pixel. The unvignetted field has a diameter of 30 arcsec. A filter is permanently mounted on the blue-CCD objective to match the imaging bandpass with the wavelength range of the spectra. The objective is focussed on the slit jaws and deckers. It is used to identify the target, to center it on the slit aperture, and optionally for secondary guiding.

The limiting magnitudes of the SV cameras for target acquisition are a function of seeing, color of the target and sky brightness. As an example with a 5 sec integration, 1 arcsec FWHM seeing and dark sky, $m(B) = 19.4$ and $m(R) = 21$ are detected at $S/N = 10$ with the blue and red camera, respectively. SV cameras are essentially able to acquire all objects for which spectroscopic observations can be made. If the target is too faint to be visible on the SVs, blind offset procedures from a nearby star are provided (cf. Ref. [1]).

The corresponding limiting magnitudes for secondary guiding of a point source centered on the slit are 18.9 and 20.3 in the blue and red respectively (1 arcsec seeing and slit, 5 sec integration).

2.2.4 The Scientific CCDs and the associated shutters

A summary of the properties of the **blue and red arm scientific CCDs** is given in Tab 2.3. The detailed QE curves can be found in the UVES database available through the ETC. The detector in the blue camera consists of one EEV CCD (EEV 44-82) The detector in the red camera consists of a mosaic of one EEV (EEV 44-82) and one MIT-LL (CCID-20) 4k×2k CCD; this is to optimize the detector response as a function of wavelength and to reduce fringing at far-red wavelengths. The gap between the two CCDs is ∼ 0.96 mm. This and the non-perfect alignment of the two chips require that the spectra on the two chips of the mosaic are extracted separately. The CCD control system (the ESO standard system FIERA) reads the mosaic as a single image with nominally 100 pixels between the two sensitive areas. The file has to be splitted before applying a standard echelle reduction package. Windowing of the CCDs is not allowed.

Five read out modes of the CCDs can be selected:

1. Low gain, fast read-out, 1x1 binning (VM, SM);
2. Low gain, ultrafast read-out, 1x1 binning (VM only);
3. Low gain, fast read-out, 1x2 binning (VM only);
4. High gain, slow read-out, 2x2 binning (VM, SM);
5. High gain, slow read-out, 2x3 binning (VM only).

The second digit in binning applies to the direction of the spectral dispersion. The characteristics of these modes are given in Tab 2.3. The linearity of the CCDs is measured to be better than 1% over the range from ∼200 e^- to the saturation limit. Note that counts per pixel above 40000 ADU should be avoided for the MIT CCD chip because of non-linearity. The relatively high value of the dark current of the CCD in the blue arm is measured with the shutter open only and it is due to a glowing of the camera optics. The CCD parameters are periodically remeasured as part of the UVES calibration plan [2]. The updated values are entered in the instrument database and are recorded in the FITS headers, for use in the data reduction.

The cosmetic quality of the three scientific CCDs is very good. Details are given in Chapter 2.6.5.

The CCD cryostats are attached to the blue and red dioptric cameras, with the last optical element acting as window. The Blue and Red CCDs are operated at a temperature of ∼ 153 K and 135 K respectively. Two liquid-nitrogen tanks ensure continuous operation without manual intervention for ∼ 2 weeks. The **shutters** are located between the cryostat windows and the cameras. They are actuated by solenoids with an open/close time of 50 ms. The illumination of the detectors is homogeneous within 50 ms but a **minimum exposure time**

Table 2.3: Measured properties of UVES scientific CCDs (Dec 99 values).

	Blue, EEV	**Red Mosaic**
Quantum efficiency	49% at 320 nm 56% at 350 nm 82% at 400 nm 88% at 500 nm	89% at 450 nm (EEV) 89% at 600 nm (EEV) 81% at 800 nm (MIT-LL) 46% at 900 nm (MIT-LL)
Number of pixels	2048×3000 (2048×4096, used in windowed readout)	4096×4096 (2048×4096 2×1 mosaic)
Pixel size	15 μm	15 μm
Gain (MIT-LL values in brackets)	low: 1.84 e^-/ADU high: 0.54 e^-/ADU	low: 1.6(1.5)e^-/ADU high: 0.57(0.57)e^-/ADU
Read-out noise fast read-out, low gain (slow read-out, high gain)	3.9 (2.1) e^- rms	EEV 3.4 (2.0) e^- rms MIT 3.8 (3.4)e^- rms
Saturation low gain (MIT-LL in brackets)	~65000 ADU	~65000 ADU (~43000 ADU)
Full frame readout (s) at 50 kpix, 2x2 bin at 225 kpix, unbinned at 625 kpix, unbinned	 34 (1-port) 30 (1-port) 6.4 (2-ports)	 45 (2-ports) 40 (2-ports) 10 (4-ports)
Dark current levels	0.4 e^-/pix/h at $-120°$C	EEV 0.5,MIT 1.1 e^-/pix/h at $-120°$C
Fringing amplitude at 850nm	-	EEV: up to 40% MIT: up to 20%
CTE	> 0.99993	> 0.99995
Read-out direction	in disp. dir.	in disp. dir.
Prescan, Overscan areas	Pix. 1-50 and 2098-2148	MIT: pix 40-50,2098-3008 EEV: pix 1-50,2098-2148
Flatness	$< 15\mu$m peak to peak	$< 60\mu$m peak to peak

of 0.5 sec is recommended. The reader is referred to the CCD webpages of the ESO Optical Detector Team for additional general information on the CCDs and the Control System (FIERA): `http://www.eso.org/odt/`.

2.3 Spectral Resolution and Overall Efficiency

The user can only affect the spectral resolution by the choice of the slit width and to some extent by binning the CCD. The factors outside his/her control which affect the resolving power are the image quality of the optics including the focus and the alignment, CCD effects (chip tilt, diffusion of photoelectrons, charge transfer) as well as the echelle dispersion. The instrument does not include a remotely controlled focus adjustment, since the cameras automatically compensate for temperature variations of the complete optical train from slit to CCD. The image quality over the entire spectral range is expected to be better than $20 - 30$ μm over the full CCD (80% of the energy). This allows to reach the maximum resolving power (two pixel sampling) using slits as narrow as 0.4 arcsec (blue arm) and 0.3 arcsec (red arm).

The measured resolving power as a function of slitwidth is shown in Fig. 2.4. The blue arm achieves a resolving power which is better than the predicted performance. The resolving power as measured for the red arm with the EEV CCD chip is consistent with the predictions. In the measurements with the MIT-LL CCD a $\sim 5-10\%$ reduction of the resolving power with respect to the predictions (and to the EEV chip) is measured for slit widths narrower than 0.8 arcsec. Charge diffusion effects in the MIT-LL chip lead to this (apparent) degradation in spectrograph resolution.

Recent measurements of the resolving power (and other instrument characteristics) are available under `http://www.eso.org/observing/dfo/quality/UVES/qc/qc1.html`.

The transmission and reflection efficiency curves of the various optical components and of the CCDs (cf. UVES database available through the instrument ETC) can be combined to compute the predicted global instrument efficiency, which is higher than 0.2 from 400 to 800 nm. Making appropriate assumptions on the reflectivity of the three telescope mirrors, the overall telescope + instrument + detector efficiency has been computed and compared with measurements of the standard stars observed during the commissioning, corrected for atmospheric absorption. The efficiency curve available in the UVES database (cf. the instrument ETC) has been verified with the standard star observations during the instrument commissioning runs (Ref. [3]). An overview of the measured overall detection efficiency of instrument + telescope is shown in Fig. 2.5 and recent measurements of the efficiency can be found under the same link as above.

2.4 Instrument Features and Problems to be aware of

2.4.1 Spectral gaps in the Red Arm

The CCD detector in the red arm (see Section 2.4) consists of a mosaic of two chips, separated by a gap of approximately 0.96 mm. This results in the loss of one echelle order in the recorded spectrum around the central wavelength selected by the observer. At 580 nm the gap spans around 5 nm, at 860 nm the gap is 10 nm.

The extension of the gap at any value of the central wavelength can be predicted with high accuracy (≤ 0.5 nm) using the instrument ETC.

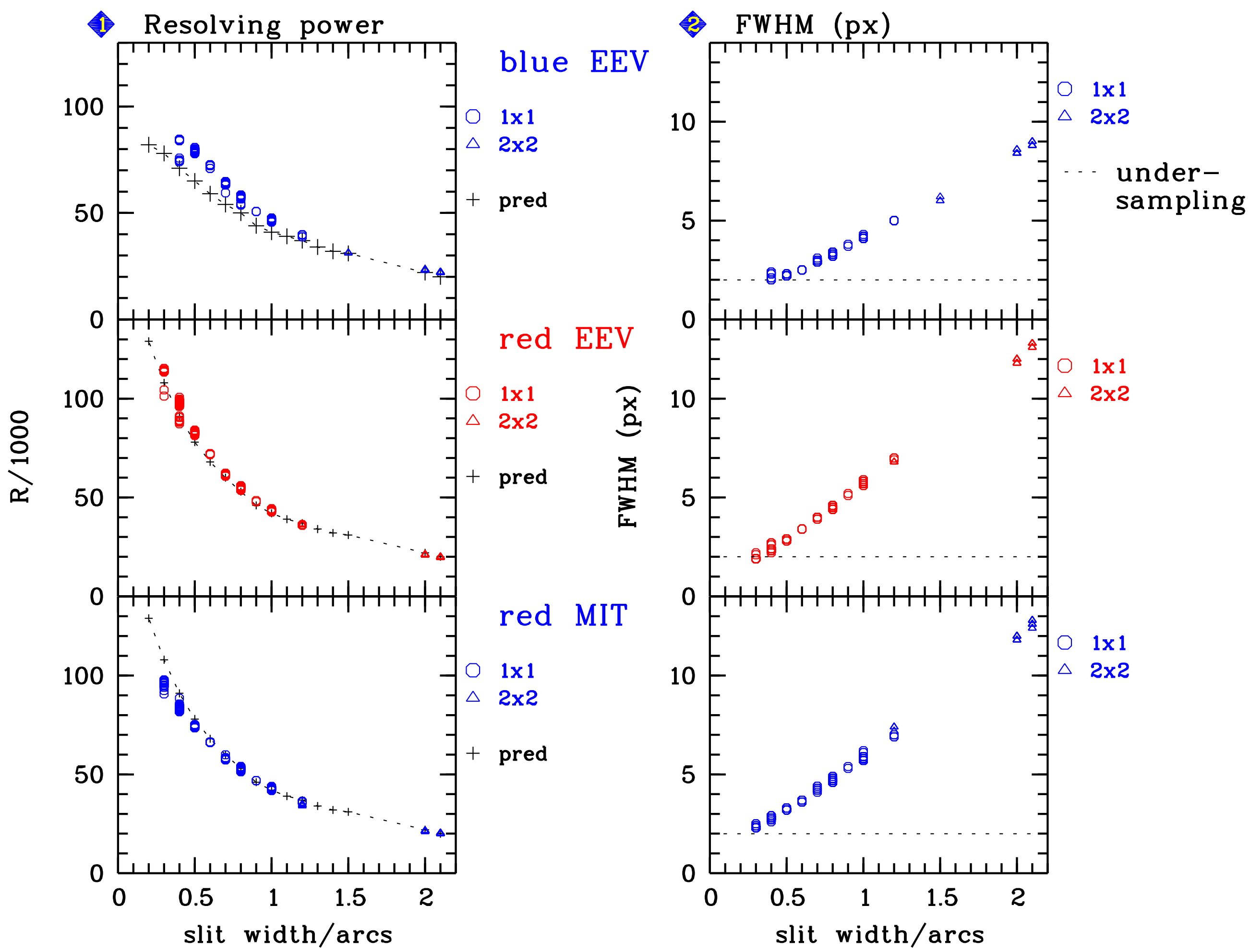

Figure 2.4: Measured (mean) resolving power R (in 1000) and FWHM (in pixels) as a function of the slit width. The data have been measured as part of the pipeline processing of service mode data in the time between October 2000 and June 2001. Values for 2×2 binning modes are scaled and were added only for slit widths ≥ 1.0 arcsec where no 1×1 data was available. The predicted values for R are indicated by + symbols. The 10%-reduced resolving power measured on the MIT/LL chip is due to charge diffusion effects in this CCD (cf. text). The 2-pixel sampling limit is indicated by dashed horizontal lines. In the blue, the CCD bin size in the center of an order is $\sim 1/193,000$ of the wavelength or 0.215 arcsec in the spectral direction. In the red, these numbers are $1/250,000$ and 0.155 arcsec.

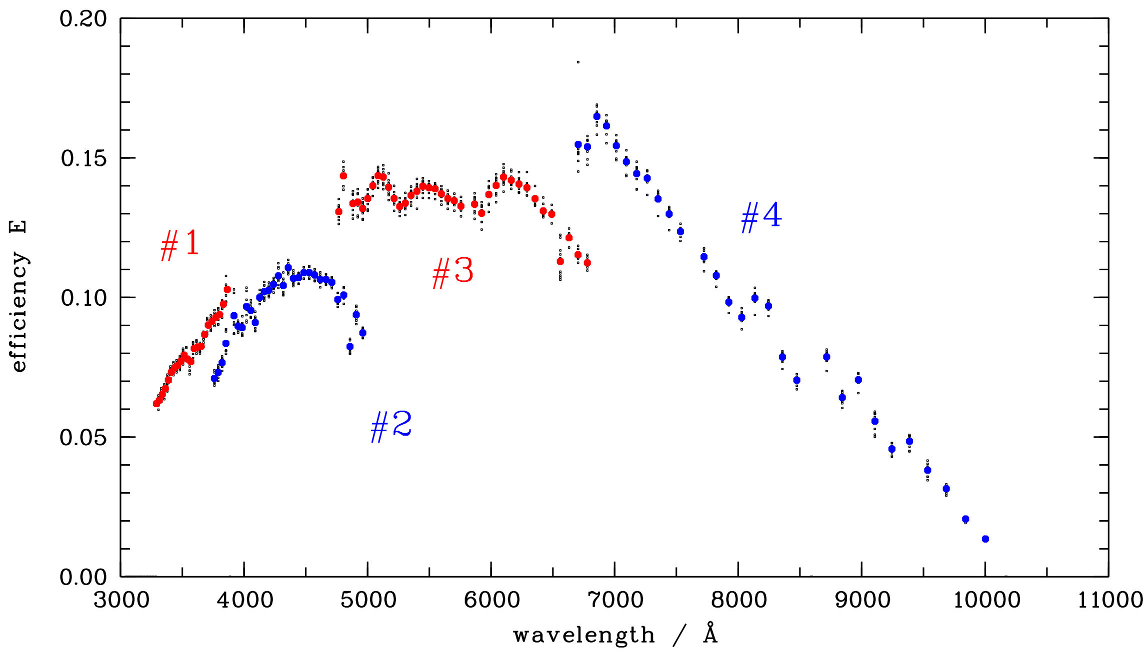

Figure 2.5: The measured overall detection efficiency of UVES + detectors + 3 mirrors of UT2, corrected for the contribution of the atmosphere. The values are from measurements of different standard stars in the period July to September 2004, i.e. one year after recoating of the primary mirror. The measurements used the standard wavelengths (Dic#1 346+580, Dic#2 437+860 nm) with the four different crossdispersers (CD#1, CD#2, CD#3, CD#4, respectively). The average uncertainty on the individual points is estimated from the scatter of the results to be about 5%. Note that the prototype CDs #4 and #1 have been replaced by the final, more efficient gratings in November 2000 and October 2001, respectively.

2.4.2 Optical Ghosts in the far red and UV spectra

Spectra imaged on the CCD mosaic in the red arm are partly reflected back to the cross disperser grating through the camera lenses. After a further reflection on the grating, the second order spectrum is re-imaged by the camera on the CCDs. These "ghosts" appear as in-focus echelle orders, with a steeper inclination and approximately twice the order separation than the primary spectra. The effect is relevant with the #4th CD at the far end of the spectrum (central wavelength 860nm) where the efficiency of the CCDs decreases and the importance of reflections is higher. On the MIT chip (upper CCD in the mosaic), reflections from the EEV (lower CCD of the mosaic) are seen. For reference, see the flat-field data available through the UVES webpage. The relative intensity of the ghosts to the primary echelle orders depends on the shape of the target spectrum. With flat fields, at a central wavelength of 860 nm, the intensity of the ghost orders is $< 1\%$ of the real orders on the EEV chip and between 1 and 7% on the MIT chip. The same effect is seen with CD #1 at the standard setting with central wavelength 346nm. For a source with a flat spectrum over the range 300-400 nm , the intensity of the ghosts is $\sim 1\%$ of the primary spectrum.

The measurements of the ghost intensities were carried out with the prototype crossdisperser gratings #1 and #4. With the installation of the final #1 and #4 gratings in October 2001 and November 2000, respectively, the intensities of the ghost orders have been reduced as expected from their higher efficiencies in the relavant wavelength regimes.

2.4.3 Remnants of ThAr lamp spectra

In the spectral region above 700 nm the ThAr lamp has some very bright Argon lines which saturates the CCDs even for the short exposures time needed for a wavelength calibration exposure. The standard read-out will not completely remove the electrons at the positions of the heavily saturated lines. Faint remnants will then "surface" in any relatively long integration which follows the calibration exposure. The effects vanishes after several CCD wipings or typically after 1-2 hours.

It is recommended not to take a ThAr calibration in the far red spectral region during the night if they are to be followed by a long integration on a faint object. In particular, this applies to the standard settings with central wavelengths at 760 and 860 nm for which ThAr calibrations attached to science OBs are not allowed in service mode. If highest wavelength calibration accuracy is required, the use of the numerous night-sky emission lines in this spectral region should instead be considered.

2.4.4 Enhanced Dark Current after a FIERA start-up

When the CCD Control System FIERA has to be restarted, e.g., due to a general power failure or for an update of the database, the level of the dark current will be a few times higher than the value measured in the running system. It is important to check the performance of the detectors by taking, e.g., a dark exposure of a few minutes in binned mode. An interval of 3 hours is normally sufficient to return to optimal performance of the CCD.

2.4.5 CCD Cosmetic Defects

The three CCDs of UVES are of excellent (EEVs) or good (MIT/LL) cosmetic quality. The number of hot or less sensitive pixels is limited ($< 0.1\%$)and has little effect on the quality of the data because of the large sampling.

The defects which, depending on the signal-to-noise of the spectrum, might be visible in the extracted data are listed below. In the EEV CCD on the blue side of the red arm mosaic there are four trails of hot pixels which appear in long exposures (X coordinates 3896,3963, 4052 and 4140 in an unbinned fits file, middle of the chip in y). They each affect a single column (longer dimension of the CCD) and are almost parallel to the echelle orders. They would appear as broadish emission in the bluer part of the extracted spectrum of a faint object.

In the MIT-LL chip (red side of the CCD mosaic of the red arm) there is a trap in the column X1609 which might show up as a slight depression over 130 pixels in the extracted spectrum of one order. In long, binned exposures this CCD shows also an emission band starting on the red side and extending over the rows 2790-2850 with decreasing intensity toward the blue side of the CD spectrum format. Since this band is perpendicular to the orders, it is usually well subtracted in the sky subtraction step of the reduction process.

2.4.6 Telluric features in flatfield exposures

Due to the long optical path length inside the UVES spectrograph, the flatfield exposures taken with the internal flatfield lamps display telluric absorption features of O_2 and H_2O. The flatfielding performance in these spectral regions is reduced and possible wavelength shifts between calibration and science exposure will lead to spurious residual spectral features.

Chapter 3

Preparing the Observations

3.1 Introduction

Before the actual execution of observations, several steps have to be taken. The preparation of an observing program is split in two parts: Phase I and Phase II. In Phase I the emphasis in the application for VLT observing time is put on the scientific justification and on the technical feasibility of the proposed observations. In Phase II the successful applicants prepare the detailed instrument set-up and observing plan through the completion of so-called **Observation Blocks**. Together with the Phase I and Phase II documentation (`http://www.eso.org/observing/proposals/`), the information contained in this chapter (and in Chapter 4) provides a guideline for the Phase I and Phase II preparation process for UVES observations. In Chapter 5 information is given for astronomers who come to Paranal to observe with UVES.

The preparation process can be summarized as follows:

Phase I

- Definition of scientific justification
- Choice of instrument mode
- Estimate of exposure time to reach the needed S/N ratio at the desired resolution.
- Estimate of telescope and instrument overheads
- Determination of scheduling constraints (e.g., visibility, time-critical observations)
- Overview observation plan (e.g., target list, calibration needs)

Phase II (*for successful applicants*)

- Identification of detailed instrument set-ups
- Identification of target acquisition requirements (e.g., finding charts, slit orientation, offset star)
- Preparation of needed Observation and Calibration Blocks.

Part of the VLT observing time is carried out in **service mode** by the Observatory Staff (i.e., in absence of the applicant). All information necessary to successfully execute the proposed observing program has to be provided (in the form of Observation Blocks, finding charts, and other relevant information) in advance of the observations to ESO, following the instructions sent to the applicants. The Observatory staff will combine the execution of different programs in the same night optimizing the time sequence and the seeing and moon requirements. Observations carried out with the applicant present at the telescope are referred to as **visitor-mode** observations. In this mode the astronomer prepares (or finalizes) the OBs at the Observatory in advance of his/her nights. He/she decides about the sequence of observations during the night, but their execution is, however, still performed by the telescope and instrument operator.

To facilitate the preparation of Phase I (and Phase II) proposals, besides the information provided in this User Manual, ESO has developed a sophisticated Exposure Time Calculator (**ETC**, see Section 3.5). The ETC permits to estimate the signal-to-noise ratio for a given configuration and exposure time (taking into account specific atmospheric conditions) and determines the spectral format resulting from the selected instrument set-up.

The Observing Blocks are prepared using another ESO-provided software tool called **P2PP**, see [8] and `http://www.eso.org/observing/p2pp/`.

Before preparing the observations, it is advisable to look at the UVES quality control webpage `http://www.eso.org/observing/dfo/quality/UVES/qc/problems.html` which gives information on current problems and possible new instrument artifacts detected during the current observing period and not yet described in the UVES User Manual.

A UVES data-reduction pipeline is also running at the Observatory. It enables automatic extraction and wavelength calibration of all spectra of stellar objects taken in standard UVES settings. It permits an on-line check of the quality of the observations (resolution, S/N in the extracted spectra). For visitors observing with non-standard settings, the on-line pipeline at Paranal can be prepared to handle (in most cases) their settings (limited to 2 non-standard settings per visitor run). The science data are calibrated with calibration exposures obtained upon arrival of the visitor, i.e., two days before the start of the observing run. Note, that the Paranal on-line pipeline is intended as a quick-look and quality-control tool and was designed for robustness of the reduction and not for best-possible reductions.

3.2 UVES instrument modes and basic choices

After the detailed description of the UVES spectrograph, its subsystems and functions (Chapter 2), we provide an overview of the different UVES observing modes. The UVES spectrograph has two arms, one optimized for the blue and one for the red wavelength domain, resulting in four different modes of operation:

1. **BLUE**: only the blue arm is used (wavelength range: 300-500 nm)
2. **RED**: only the red arm is used (wavelength range: 420-1100 nm)
3. **DICHROIC1**: both arms are used (cross-over wavelength 450 nm; wavelength ranges: 300-400 and 500-800 nm)
4. **DICHROIC2**: both arms are used (cross-over wavelength 550 nm; wavelength ranges: 400-500 and 600-1100 nm)

Apart from the instrument mode, a decision has to be made regarding the acquisition of the target. Under normal conditions, the target is centered directly on one of the spectrograph slits; the spectral resolution will then be determined by the slit width (the resolving power - slit width (in arcsec) product Rs is $\sim 40,000$). The resolution increases when the slit is narrowed (see Fig. 2.4). In case of a seeing profile significantly wider than the slit, the slit losses become significant and it becomes attractive to acquire the target through one of the image slicers (see Table 2.1).

3.3 UVES Standard settings

To facilitate the preparation of Observation Blocks (Section 3.4), **standard settings** have been defined that allow the observer to select a pre-programmed instrument setting for which most parameters are set to fixed (optimal) values and only a few have to be defined (e.g., the slit width). **The users are encouraged to use these standard settings to the extent that they are compatible with their program.** In service-mode observations, only standard settings are accepted. Another advantage is that the Observatory keeps an updated database of calibrations obtained at a standard setting, i.e., flatfields, bias frames, and wavelength calibrations do not need to be taken during observing time allocated to the program of the observer, unless very high accuracy is required (see Chapter 4). Furthermore, for these standard settings an automatic data extraction procedure is available (i.e., the pipeline reduction).

The standard settings for UVES are listed in Table 3.1. They are chosen such that together they cover the optical wavelength domain from $300 - 1100$ nm. The standard settings comprised in Table 3.1 correspond to **Observation Templates** which can be selected for the preparation of the Observing Blocks with P2PP. The wavelength coverage is computed for a 4k×4k red mosaic and a 2k×3k blue CCD. In each standard setting a decker height has been chosen such that sufficient space (at least 8 pixels or > 2 arcsec) is left between neighboring orders to be able to accurately estimate the stray-light background. Table 3.2 lists the recommended slit lengths at different wavelengths with the current set of crossdispersers. In addition Fig. 3.1 shows the order separation as function of the order number for all four crossdispersers in the standard wavelength settings. The below-the-slit filters are used to suppress the second order of the CD gratings or undesired light from entering the spectrograph. Their transmission curves are given in the UVES database. The spectrograph is focussed with a below-slit filter of 5 mm thickness. Therefore, a filter has always to be inserted to achieve the best possible image quality. In configurations where no order separation or straylight rejection filter can be used, the 5 mm clear filters, i.e., HER_5 in the blue and BK7_5 in the red have to be inserted. The HER_5 filter has replaced the CUSO4 straylight rejection filter in December 2001 as below-slit filter in the blue settings. The CUSO4 filter has been decommissioned because of degrading performance of its transmission.

By combining the standard settings DIC1 (346+580) and DIC2 (437+860) the full spectrum ($300 - 1006$ nm) of a target can be covered with only two exposures of the instrument (with the exception of the small gaps due to the CCD mosaic). At wavelengths longer than 993 nm the orders do not overlap anymore and the wavelength coverage is incomplete. A shift of up to 200 or 280 pixels of the blue, respectively red, echelle spectrum in the dispersion direction can be obtained by changing the tilt of the camera (see §2.2). This might be useful in case an important spectral line falls outside the edge of the CCD. With the standard setting DIC1 (390+564) it is possible to cover the continuous wavelength region from 332 to 668 nm;

Table 3.1: The UVES standard settings, 2 in the blue, 4 in the red, and 7 in dichroic mode are listed below. The two CCDs in the red camera are separated by approximately 0.96 mm; this results in a gap in the wavelength coverage, approximately centered on the central wavelength. The start and end points of the spectral ranges reported in the table are generally conservative as they do not include the echelle orders which are outside the sensitive area of the CCD by more than 50% of their length.

UVES standard settings							
Mode	Cross Disp.	Below slit filter	Min. Wav.	Central Wav. (nm)	Max. Wav.	Decker Height	Gap (nm)
Using dichroic							
DIC1	CD#1	HER_5	303	**346**	388	10."	=
	CD#3	SHP700	476	**580**	684	12."	5
DIC1	CD#2	HER_5	326	**390**	445	8."	=
	CD#3	SHP700	458	**564**	668	11."	2
DIC1	CD#1	HER_5	303	**346**	388	10."	=
	CD#3	SHP700	458	**564**	668	11."	2
DIC1	CD#2	HER_5	326	**390**	445	8."	=
	CD#3	SHP700	476	**580**	684	12."	5
DIC2	CD#2	HER_5	303	**346**	388	10."	=
	CD#4	BK7_5	565	**760**	946	8."	7
DIC2	CD#2	HER_5	326	**390**	445	8."	=
	CD#4	BK7_5	565	**760**	946	8."	7
DIC2	CD#2	HER_5	373	**437**	499	10."	=
	CD#4	BK7_5	565	**760**	946	8."	7
DIC2	CD#2	HER_5	373	**437**	499	10."	=
	CD#4	OG590	660	**860**	1060	12."	10
DIC2	CD#1	HER_5	303	**346**	388	10."	=
	CD#4	OG590	660	**860**	1060	12."	10
DIC2	CD#2	HER_5	326	**390**	445	8."	=
	CD#4	OG590	660	**860**	1060	12."	10
Using blue arm only							
BLUE	CD#1	HER_5	303	**346**	388	10."	=
BLUE	CD#2	HER_5	373	**437**	499	10."	=
Using red arm only							
RED	CD#3	SHP700	414	**520**	621	8.9"	1
RED	CD#3	SHP700	476	**580**	684	12."	5
RED	CD#3	SHP700	500	**600**	705	12."	5
RED	CD#4	OG590	660	**860**	1060	12."	10

Table 3.2: Recommended slit lengths for different wavelengths and crossdisperser combinations.

CD	wavelength [nm]	separation [pixels]	separation ["]	recommended slit length ["]
1	330	42.0	10.8	8.0
1	346	48.5	12.4	10.0
1	370	56.6	14.5	12.0
1	395	65.6	16.8	14.0
2	370	38.6	9.5	7.0
2	395	38.9	9.6	7.0
2	437	49.9	12.3	10.0
2	470	59.2	14.6	12.0
3	460	48.0	8.7	6.0
3	490	48.4	8.8	6.0
3	520	57.2	10.4	8.0
3	550	66.9	12.2	10.0
3	580	77.4	14.1	12.0
3	640	98.8	18.0	16.0
4	610	29.6	5.1	3.0
4	660	38.7	6.7	4.5
4	710	48.6	8.4	6.0
4	760	58.6	10.1	8.0
4	810	70.3	12.1	10.0
4	860	81.9	14.1	12.0
4	910	96.3	16.6	14.5

however, in the region where the dichroic behavior changes from reflection to transmission (430–465 nm) the resulting spectrum will not be optimally exposed. Photometric accuracy may be lower due to polarization effects. Standard Dichroic#2 settings with 760nm central wavelength have been introduced to obtain simultaneous observations of all three Ca II near-infrared triplet lines along with Hα and many other spectral lines used as important diagnostics in the spectra of hot and cool stars. The RED 600 standard setting is defined for use with the iodine absorption cell. Starting with Period 76, it can also be used in service mode without the iodine cell. With this setting the 500 - 600 nm spectral range in which the iodine cell provides the highest density of absorption lines is placed completely on the EEV chip of the red CCD mosaic. This allows the best possible reconstruction of the instrument profile (IP) in the subsequent data modeling because the EEV does not suffer from charge diffusion as the MIT chip which leads to an apparent degradation of the spectrograph resolution.

Finally, the **"free" Observation Templates** can be used when the offered standard settings are not appropriate for a given program, however, in visitor mode only.

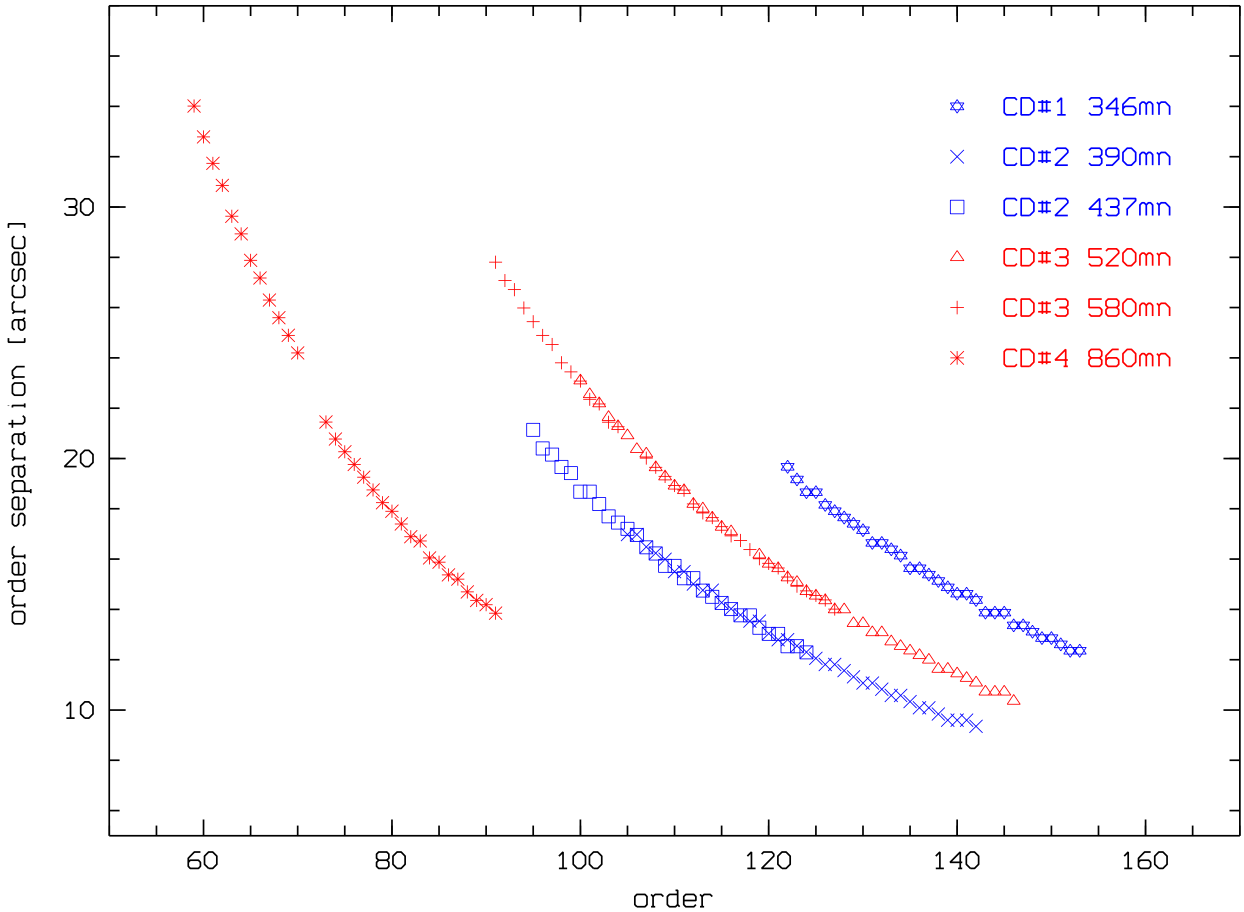

Figure 3.1: Measured separations in arcsecs of the spectral orders in crossdispersion direction for the 4 crossdispersers at standard wavelength settings. On the abscissa the physical order numbers of the red and blue echelle gratings are given.

3.4 Introducing Observation Blocks

An **Observation Block (OB)** is a logical unit specifying the telescope, instrument, and detector parameters and actions needed to obtain a "single" observation. It is the smallest "schedulable" entity, which means that the execution of an OB is normally not interrupted as soon as the target has been acquired and centered on the slit. An OB is executed only once; when identical observation sequences are required (e.g., repeated observations using the same instrument setting, but different targets), a series of OBs must be constructed. The detailed definition of UVES Observation Blocks and Templates is given in Ref. [1].

For example: one would like to obtain a spectrum of a point source in the wavelength region 500-680 nm with a resolving power of 60,000. First, the instrument mode has to be chosen. The wavelength region 500-680 nm is covered by the red arm of the spectrograph. The instrument mode is set by chosing the corresponding sets of acquisition, observation, and calibration templates containing the mode 'red' in their name. Second, it has to be decided if the observation should be carried out with a standard longslit or with an image slicer. Accordingly, one has either to select the red slit acquisition template (`UVES_red_acq_slit`) or the red image slicer acquisition template (`UVES_red_acq_imsl`) and select slicer #1 which provides the required resolving power. In addition the information on the target position has to be provided in the acquisition template. For the observation itself the red observation template `UVES_red_obs_exp` can be used with the predefined wavelength setting `580` which covers the requested wavelength region. The other parameters to set are in case of a normal slit exposure the slit width (e.g., 0.7" to obtain a resolving power of 60,000), the read-out mode of the detector (see §2.4) and the exposure time. If one likes to carry out a dedicated wavelength calibration after the science exposure, the attached wavelength calibration template (UVES_red_cal_waveatt) has to be added. Together, the three selected templates form an Observation Block that is used to perform the required observation.

The preparation and editing of Observation Blocks is done with the Phase II proposal preparation software (**P2PP**, [8]) which successful applicants for observing time can obtain from ESO
(`http://www.eso.org/observing/p2pp/`) for installation at the astronomer's home institute. This software is also available at the observer's station at the VLT Observatory, for preparation of the OBs in advance of the observations.

3.5 Rapid Response Mode for UVES

Starting in Period 73, a new mode, the Rapid Response Mode (RRM), is offered for observations of transient phenomena such as gamma-ray bursts or supernovae in semi-automatic mode. The user (PI or Co-I of an approved target-of-opportunity program) submits an ftp file with the coordinates of the target to a specific ftp server on Paranal. A special program at the telescope continuously monitors this ftp directory; when it detects a file, it checks if the filename corresponds to an approved activation code, and if this is the case, the on-going observations are ended, and a new BOB starts an OB with the same name as the ftp file. The telescope automatically presets to the coordinates specified in the ftp file, and the requested observations are performed straight away.

PIs of approved UVES ToO programs requesting this mode need to prepare their OBs in the usual way. However, these RRM programs use specific acquisition templates described in the

UVES Template Reference Guide. More information on the RRM can be found on the USD Phase II webpages (`http://www.eso.org/observing/p2pp/rrm.html`).

3.6 The UVES Exposure Time and Spectral Format calculator

The UVES **Exposure Time and Spectral Format Calculator (ETC)** is accessible through the ESO world-wide-webpage at `http://www.eso.org/observing/etc/`. The ETC models the instrument and detector in their different configurations. It is the basic tool for an observer in the planning of an UVES observation. It can be used to compute the detailed spectral format (wavelength and order number as function of x,y position on the detector) and the S/N to be expected for the specified target and atmospheric conditions and for a given instrument and detector setting as a function of exposure time. The ETC can also be used to access the efficiency curves of the various optical components of the instrument and of the CCDs as measured in the laboratory in advance of the installation.

3.6.1 Definition of the target

For the input flux distribution to the ETC four options can be selected: (1) A blackbody energy distribution at a given temperature; (2) a power-law distribution; (3) a template spectrum: stellar spectra from spectral type O5 to M2, nebular spectra, galaxy spectra, or a quasar spectrum; (4) a single line at a wavelength, width, and flux level to be specified. In all cases but point (4) the object magnitude (in a given broad-band filter) have to be entered. For extended sources magnitudes are given per square arcsec. In addition to the target, it is needed to enter the sky conditions (phase of the moon and FWHM of seeing disc).

3.6.2 Choice of instrument configuration and spectral format

Based on the properties of the optical components of the spectrograph, the format of the echelle spectrum covered by the detector depends exclusively on the selected central wavelength (order). The instrument templates with standard settings can be selected from the pull-down menu. The corresponding spectral formats are given in Table 3.1. In case that these formats are not compatible with the scientific program, a "free" template with a different central wavelength can be specified. The resolution is determined by the choice of the slit width as shown by Figure 2.4. An other key choice in the ETC is the selection of the CCD read-out-mode. The two options are listed in Chapter 2.4. The slow read-out, binned mode is suited for the faintest objects and observations at low-medium S/N ratios; the unbinned, fast read-out mode is best suited for high S/N, non read-out noise limited observations.

The final entry is the exposure time.

The output for the spectral format consists of a table listing the wavelength at the order maximum, the order separation in the direction perpendicular to the dispersion, the start and end wavelength of each order, and the start and end of the Free Spectral Range (i.e., the non-overlapping part of the consecutive orders).

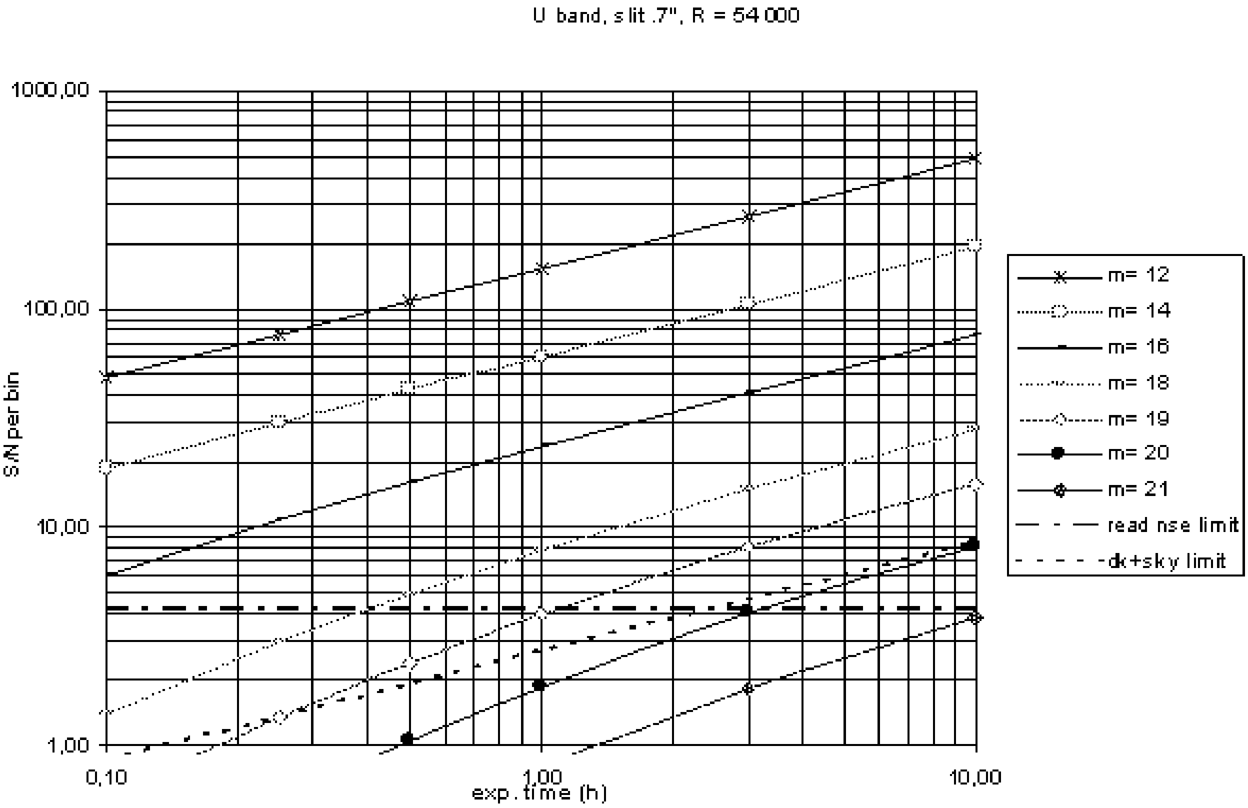

Figure 3.2: Predicted signal-to-noise ratio (S/N) in the U band (at a central wavelength of 400 nm) per wavelength bin as a function of exposure time. The slit width was set at 0.7 arcsec, corresponding to a resolving power of ∼ 57,000. Other data: 1 × 2 binning (pixel size 0.019 Å × 0.43 arcsec), dark sky, slit loss 30%, summation of 4 pixels along the slit, CCD quantum efficiency 65%, read noise 3 electrons rms, dark noise 1 e^-/pix/h. The S/N is shot noise dominated in the region above the "read noise" and "dark+sky" limit lines. Breaking up a long exposure in N partial exposures will raise up the read-out-noise line by $\sqrt{N}$.

3.6.3 Exposure time and predicted counts and S/N ratios

To be guided to a preliminary estimate of the exposure time, the predicted S/N (at the blaze peak efficiency) in the UV (360 nm) and V (550 nm) spectrograph arms, are given as a function of magnitude for different exposure times and a resolving power of $\sim 55,000$ (0.7 arcsec slitwidth) in Figs. 3.2, 3.3, and for an image slicer in Fig. 3.4). These plots have been produced with a set of parameters which are not yet exactly matched to the current parameters of the instrument. They can be used for a quick , first overview of the capabilities only. **The UVES ETC includes the updated instrument parameters and should be used to estimate the exposure times in Phase I and II of the observing proposals.** The output of the ETC is a table listing the pixel size in wavelength for each order, the computed efficiency, the total expected electrons for the object and the sky, the maximum pixel intensity (to monitor saturation), the predicted S/N ratio, the central wavelength of the order and the wavelength bin size. The computation is repeated for the minimum and maximum wavelengths of the free range of each echelle order.

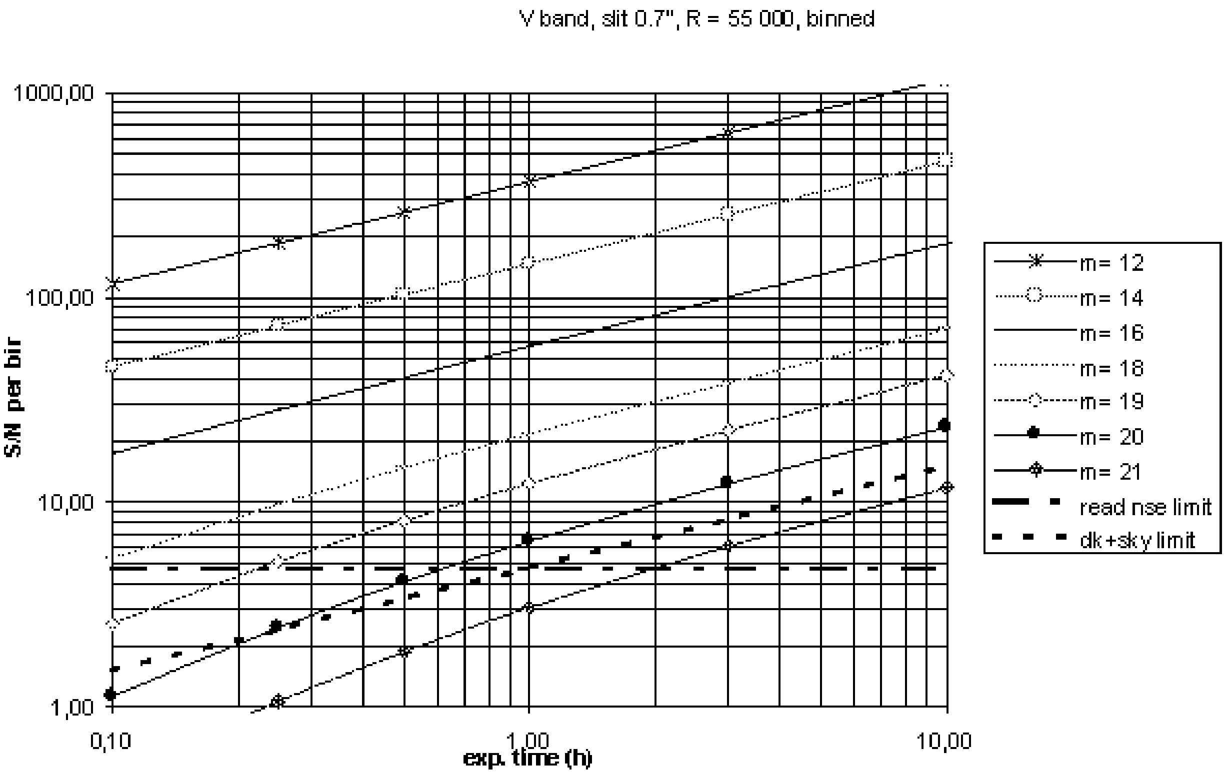

Figure 3.3: Same as Fig. 3.2, but now in the V band (at a central wavelength of 550 nm). The slit width was set at 0.7 arcsec, corresponding to a resolving power of ∼ 60,000. Other data: 2 × 2 binning (superpixel size 0.044 Å × 0.34 arcsec), dark sky, slit loss 30%, summation of 5 superpixels along the slit, CCD quantum efficiency 85%, read noise 3 electrons rms, dark noise 1 e^{-}/pix/h.

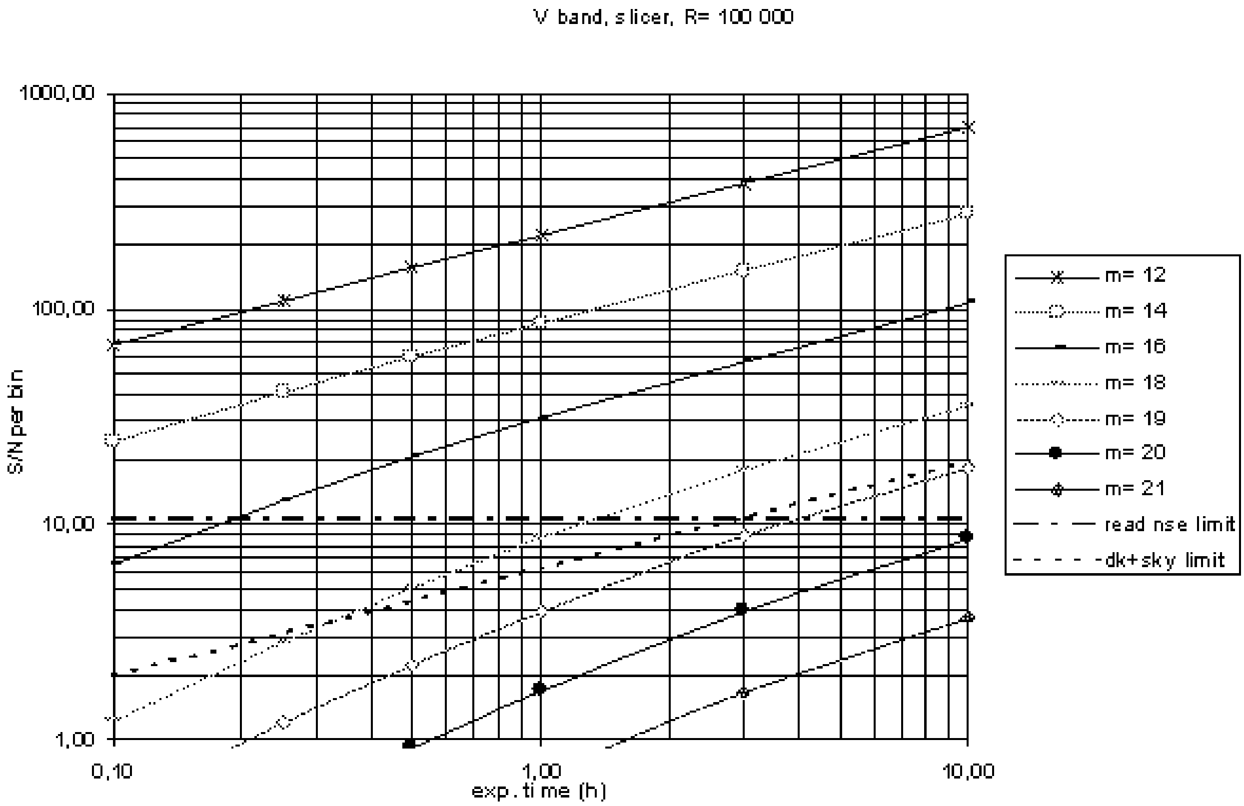

Figure 3.4: Same as Fig. 3.3, but now using image slicer #3. The resulting slit width is 0.3 arcsec, corresponding to a resolving power of 110,000. Other data: 1 × 2 binning (pixel size 0.022 Å × 0.18 arcsec), dark sky, slicer+slit loss 50%, simple summation of the signal over 25 superpixels along the 7.5 arcsec slicer slit, CCD quantum efficiency 85%, read noise 3 electrons rms, dark noise 1 e^{-}/pix/h.

3.7 Target Acquisition and Guiding

The pointing of the VLT is accurate to ≈ 1 arcsec (rms); this does, however, not guarantee that the target will be centered on the slit after telescope pointing. In case of crowded fields the identification of the object is carried out by the astronomer, or, in case of service observations, with help of a **finding chart** provided by the user. Final coordinates and when required the finding chart in the format specified in the Proposal Instructions must be submitted during Phase II of the proposal preparation. **The target coordinates must be accurate to** $\leq 1''$ to avoid an unnecessary waste of telescope time during the target acquisition phase. In most cases, the Digital Sky Survey (DSS) can be used to prepare finding charts and is accessible from the ESO world-wide-webpages (`http://archive.eso.org/dss/dss`) or using Skycat. For crowded fields or faint extended objects other well-suited image sources have to be used. The DSS and other tools can be accessed through the Proposal Preparation and Submission page (`http://www.eso.org/observing/proposals/`), which allow the calculation of site sky ephemerides, the determination of object observability, airmasses, etc. For the observation of **moving targets** or for drift scanning with the UVES slit, the acquisition templates allow to enter additional velocities in right ascension and declination in units of arseconds per second.

The target is identified on the image of one of the Slit Viewers (SVs) by the visiting astronomer or in case of service observations by the ESO staff astronomer. The target is identified by clicking on it with the mouse and automatically positioned on the slit. The optical derotator can be used in "SKY" mode to orientate the slit according to a desired position angle (PA) by entering the value in the acquisition template. During the exposure the derotator will keep the relative orientation sky-slit constant. If the "ELEV" mode is selected for the derotator, the slit will be kept aligned with the directrion of the atmospheric dispersion during the exposure. When the acquisition template for image slicers is used, the target is moved automatically to the position on the SV CCD that corresponds to the entrance aperture of each slicer. This has been calibrated in advance by the ESO operating staff. When this operation is completed, the IS is moved in blindly and the exposure started. Note that no atmospheric dispersion compensation nor alignment with the parallactic angle is available with image slicers. The atmospheric dispersion can be only compensated by the larger entrance apertures of the slicers (cf. Tab. 2.1).

In case of dichroic observations the target is visible on both the blue and red arm SV cameras. The user has to select one of the two as primary camera for acquisition and eventually secondary guiding. Note: if "ELEV" mode is used and one of the two slits in the red and blue arm is considerably shorter, it is better to center the star on the arm with the shorter slit, i.e., to select the guide camera of the corresponding arm. Otherwise, the atmospheric dispersion can displace the object close to the edge of the shorter slit.

The tracking of the telescope is corrected for errors of low frequency (< 1 Hz) by an autoguiding facility. The autoguider makes use of a **guide star** observed by the guide probe in the adapter/rotator that is moved into the telescope beam. The guide stars will be automatically selected from the VLT guide star catalogue.

The SV software allows automatic initial centering (using a SV image), as well as continuous monitoring of the position during the exposure. If systematic offsets are detected, slow frequency corrections are sent to the telescope (**secondary guiding**). This ensures that any possible relative motions of the optical axis of the telescope with respect to the plane of the entrance slit of the instrument are corrected for. During the commissioning the amplitude of these corrections has been observed to be very small if not negligible at all. The exposure meters can be used to monitor the centering of the target on the slit through the behaviour of the count rate as a function of time.

The SV image is automatically saved and stored in the archive at the start of each exposure.

3.8 Computing time overheads for your program

By using the UVES **Exposure Time Calculator** the user obtains estimates of the observing time needed to reach the desired S/N ratio depending on the object magnitude and observing configuration. In order to arrive to the total observing time in hours or nights required for the program it is needed to add the time for the various actions related to the scientific observation. When applying for service-mode observations, the **computation of the overheads is required** and has to be included in the application.

The current (date of this issue of the UM) estimate of the overheads is provided below.

- **Telescope pointing, guiding star acquisition, start active optics:**
  Assuming that the telescope is moving to a new object at 180 degree, the whole sequence can be completed in 6 minutes. If the new target requires just a small motion of the telescope and the re-acquisition of the guiding star, 4 min.

- **Target acquisition and centering on slit**
  The target has to be identified from the slit-viewer image and a finding chart. When pointed with the cursor, it is moved automatically to the slit. In the case of image slicers it is moved to the position in the slit viewer which corresponds to the entrance of the IS:

  → direct-slit or IS point source, average brightness : 2 minutes
  → direct-slit, faint point or extended source requiring two iterations: 5 minutes

- **Instrument set/up and CCD read-out time**
  A new instrument set-up takes at most 1 minute. The read out time for the CCD mosaic in the red arm (1 port/chip) is:

  → slow read-out mode (50 Kpix/sec, 2x2 binning): 45 seconds
  → fast read-out mode (225 Kpix/sec, unbinned) : 40 seconds

  and ∼10 sec shorter for the blue arm CCD. In a dichroic exposure with identical exposure times in the two arms, the CCDs are read out in parallel.

  The shortest possible cycle time with the UVES instrument can be achieved by using the:

  → ultrafast read-out mode (625 Kpix/sec, unbinned, 2 ports/per chip) : 10 seconds

  In this configuration, the dead-time between closing and re-opening of the CCD shutter is 25 sec (resp. 32 sec) with the Red arm (resp. in dichroic mode) only if no other movements of the instrument functions are needed. This read-out mode is only available in Visitor Mode.

- **Calibrations**
  BIAS frames and FF and ThAr calibration lamp exposures are taken with the same instrument and detector set-up as the science exposures during the day (for details cf. [2]). If the wavelength accuracy is critical, the ThAr calibration should be taken

immediately after the science exposure. This will take into account any significant change in the air pressure or in the air temperature (see Chapter 4.2). The same applies to the FF at wavelengths where the effect of fringing is important ($\lambda \geq 650$ nm). The time required for dichroic calibrations should be computed assuming sequential FF calibration exposures (different lamps have to be exposed one after the other).

As an example, we consider a target where the ETC computes an exposure time of 180 minutes to reach the desired S/N ratio in the red arm and it is required to obtain the highest accuracy in the wavelength calibration and in the FF correction. We split the exposure time in three integrations of 1 hour to permit median filtering of the cosmic rays. Additionally calibrations are attached for high radial velocity accuracy and a FF exposure. We thus have:
(telescope pointing,6min + slit centering,2min + UVES setup,1min) +
(1st exposure 60min + read-out-time 1min + ThAr 0.5min + read-out-time 1min + 1FF 0.5min + read-out-time 1min) x three times.

This leads to a total time of 201min, of which 183min of integration and 18min overheads ($\sim$10%). The overhead becomes relatively more important if many short exposures with different setups are required.

3.9 Check list

1. Decide whether to use standard wavelength setting or free template
2. In case of standard setting decide for visitor (justification needed) or service mode. In case of a free template the visitor mode is required.
3. Use ETC to check spectral format and exposure time
4. If resolving power $> 40,000$ is required, decide whether to use narrow slits or image slicers
5. Any special constraints needed (iodine cell, time-critical observations, etc.) ?
6. Define calibration needs exceeding the standard calibrations as defined in the calibration plan
7. Compute time to be requested including overheads

Chapter 4

The calibration of UVES data

4.1 The UVES Calibration Plan

The observatory's calibration strategy for the UVES instrument is described in detail in the UVES Calibration Plan (cf. [2] available at `http://www.eso.org/instruments/uves/doc/`). Table 4.1 provides a summary of the current calibration plan for scientific UVES data. All daily calibrations are defined and executed in a fully automatic procedure according to the science data obtained in the previous night. This procedure is applied for the UVES standard configurations as well as for "free" settings. If additional calibrations are needed, the corresponding Observation Blocks have to be provided by the Visitor observer or the Service mode PI using the data and instructions provided in the following sections.

4.2 The UVES calibration unit

The UVES Calibration Unit is a mechanical structure mounted on the Nasmyth rotator flange, which in the case of UVES is kept fixed during observations. It hosts continuum lamps which in combination with various filters are used for flatfield calibration at the different wavelengths and one ThAr lamp for wavelength calibration. The lamps are partly mounted on an integrating sphere and relay optics simulate the $F/15$ telescope beam. The light from the lamps is fed into the instrument beam by 45° mirrors mounted on a slide. Table 4.2 lists the lamps and exposure times (with 1 arcsec slit) to be used for the standard settings. The exposure time of ThAr frames is to a first order independent of the slit width. The exposure time of flatfields is inversely proportional to the slit width. In the corresponding dichroic mode, the exposure times should be increased by 10%. All exposure times have to be scaled with respect to gain and binning factors. When using image slicers, the exposure times have to be scaled according to the exit slit width of the slicer and the efficiency of the slicer.

4.3 Calibration in wavelength

The ThAr lamp provides accurate wavelength calibrations over the complete spectral range when the UVES-matched line table (available from `usd-help@eso.org`) is used. The rms of the wavelength fit is typically better than 0.0002 nm.

ThAr exposures can be taken immediately after the science exposures to minimize the effects of changing temperature and/or pressure, or of a (small) earthquake. To this purpose the

Table 4.1: UVES Science Data Calibration Plan (per instrument and detector setting)

Calibration	number	frequency [1/days]	purpose
Flatfields	5	1 / 3	creation of master flats
attached Flatfields	n	o.r.	high-precision flatfielding
Wavelength	1	1 / 1	dispersion solution, resolving power
attached Wavelength	n	o.r.	high-precision wavelength calibration
Order Definition	1	1 / 3	pipeline calibration: order definition
Format Check	1	1 / 3	pipeline calibration: physical model
Bias	5	1 / 7	creation of master biases
Dark	3	1 / 30	creation of master darks
Flux Standard	n	o.r.	response correction, flux calibration
Telluric Standard	n	o.r.	removal of telluric spectrum
Radial Velocity Std.	n	o.r.	absolute radial velocity calibration
Iodine Cell Flatfields[1]	5	1 / 1	master flats for IP reconstruction

[1] if iodine cell was used

o.r. = on request only, corresponding OBs to be provided by user

n = number to be defined by user

user can insert in the OB after the Observation Templates a so-called **attached calibration template** where a lamp is selected and all instrument parameters except the exposure time are left unchanged. The telescope will not lose the guide star during the lamp operation because the calibration unit is located after the adapter of the Nasmyth focus. The instrument currently repositions the moving functions with great accuracy. Taking different ThAr spectra after changing the instrument configuration leads to shifts which are less than 1/20 of pixel rms. This corresponds to errors in radial velocities of less than 50 m/sec. As a guidance, note that 1 hPa (millibar) change in the pressure corresponds to a shift of about 1/20 of a pixel. A change of 0.3 °C induces the same change. In a night the air pressure at Paranal can change by several hPa. Temperature changes inside the enclosure are normally very slow (a change of 0.3 °C can take several hours). The file header contains values of the airpressure and temperature at the beginning and end of the exposure.

4.4 Flat-fielding

There are four standard flat-fielding lamps combined with different filters to give well-exposed, flat continuum spectra at all wavelengths within a reasonably short exposure time (see Table 4.2). A deuterium lamp is recommended for the spectral region shortwards of 350 nm.

The flatfield spectra provide a good correction of the blaze function of the echelle. They are also useful to correct for the pixel-to-pixel variation in CCD sensitivity as a function of the impinging wavelength of the light and to correct for the structures introduced by imperfections of the slit geometry (slit function). In the red part of the spectra ($\lambda \geq 650$ nm) narrow fringes with peak-to-valley amplitudes up to 30% are present in the spectra on the EEV CCD of the mosaic. On the MIT-LL CCD, the fringes are less sharp and a smaller amplitude. Flat Field

Table 4.2: Exposure times for Calibration Lamps (for slit width of 1 arcsec, unbinned, low gain CCD read-out-mode). CCD pixel saturation occurs at ∼ 65000 ADU (∼ 43000 ADU for the MIT-LL, with non-linearity above 40000 ADU). Exposure times have to be scaled down by a factor of ∼ 12 for the 2x2 binning, high gain case.

LAMP	MAXIMUM INTENSITY ADU	EXPOSURE TIME sec	REMARKS
Central wavelength 346 nm			
Deuterium	30000	145	D spectral lines above 350nm
FFL1	30000	13	use D lamp below 340nm
ThAr		15	
Central wavelengths 390 or 437 nm			
FFL2	30000	50	
ThAr		15	
Central wavelengths 520, 564, 580 or 600 nm			
FFL3	30000	9	
ThAr		15	
Central wavelength 760 nm			
FFL4	30000	16	
ThAr		15	
Central wavelength 860 nm			
FFL4	30000	16	
ThAr		10	several strongly saturated lines

frames have been proven to correct well for fringing up to S/N ratios of at least 300. To the FF calibrations applies the same note of caution regarding stability depending on air pressure and temperature mentioned for the wavelength calibration in Chapter 4.2. FF exposures can also be attached to science OBs.

4.5 Flux standard star observations

Spectrophotometric standard stars can be used to obtain response curves of the instrument to allow a relative flux calibration of the spectra and at the same time to correct for the blaze function of the different orders before merging. Such calibrations are only obtained on the request of PIs, with usually a 10 arcsec wide slit, i.e. with negligible slit losses.

For an absolute flux calibration both, the science spectrum and the standard star spectrum have to be obtained under photometric conditions at similar airmasses and preferably with the same slit width. In this case, dedicated OBs have also to be provided by the observer or service mode PI. Recently for QC purposes, daily monitoring of spectrophotometric standard stars using three Dichroic settings (346+580, 390+564, 437+860) and 1×1 binning has been introduced during twilight.

A table of flux standard stars suitable for observations with UVES is given in the Appendix. For flux standards only, the **"std" Observing Templates** have to be used.

The response curves of the UVES spectrograph are found to be very stable with time. Therefore, **master response curves** for all standard instrument settings are provided through the quality control webpages under `http://www.eso.org/observing/dfo/quality/UVES/qc/std_qc1.html` which can be used to correct for the *relative* response of the instrument. A correction of the science spectra by the master response curves does allow to recover to a certain extent the *shape* of the source continuum or to measure *relative* line strengths across the complete UVES spectral range.

4.6 Quality Control

All calibrations taken in one of the standard settings are pipeline-processed and quality-controlled by the Quality Control group at ESO Garching. The calibration products are delivered with the corresponding Service Mode data. More information about the UVES quality control can be found under `http://www.eso.org/observing/dfo/quality/index_uves.html`. The time evolution of the most important instrument parameters like resolving power, spectral stability, detector characteristics, and others can be followed with the help of continuously updated trending plots as available on the UVES QC webpages.

4.7 Special calibrations

4.7.1 Use of the iodine cell for accurate radial-velocity measurements

As indicated in Chapter 2, UVES is equipped with an **iodine absorption cell** which can be inserted in the beam and operated remotely to obtain a dense grid of iodine absoprtion lines superimposed on the target spectrum. The iodine cell currently mounted on UVES has an operating temperature of 70 °C and produces a rich absorption line spectrum in the range 490-640 nm. Because of the operating temperature, the iodine cell requires a warming time of at least one hour and can be used only during dedicated observing runs. For the iodine cell observations the following R600 standard configuration is used: RED mode, free template, CD#3, central wavelength 600 nm. To make best use of the iodine absorption spectrum a slit width of 0.3" should be chosen and combined with the undersized pupil stop (and possibly with IS#3 to reduce slit losses).

ESO does currently not provide any support for the required modeling (IP reconstruction) of data obtained with the iodine absorption cell.

4.7.2 Use of exposure meter for flux-weighted exposures

During each exposure, the exposure meters monitor and plot counts as a function of time. The minimum and maximum count rates, the average value with its rms and the flux-weighted mean of the exposure are stored as FITS keywords in the header of the spectrum file.

4.7.3 Detector flats

Detector flats with direct (undispersed) illumination of the CCD through the camera are taken at regular intervals according to the UVES Calibration Plan (cf. [2]) to monitor the CCD performance. They are available on request (with a valid justification) from `usd-help@eso.org`.

4.7.4 Use of reference stars to correct for fringing or atmospheric lines

Stars with featureless spectra (typically white dwarfs or fast rotating hot stars) can be used to provide a good template to correct for fringing as an alternative to the use of internal flatfield lamps. These spectra can also be used to identify and estimate the depth of atmospheric H_2O and O_2 absorption lines. Stars of magnitudes between 5 and 9 are best suited for this type of observations because they require short exposures but do not saturate the detector at the shortest shutter opening times. The OBs for these stars should be prepared in Phase II by the observers who require them for their program. A bright subsample of the hot flux standards stars is well suited for these observations.

4.7.5 Use of camera tilt for spectral dithering (very high signal-to-noise ratios)

The two camera units of UVES can be slightly moved with respect to the incoming beams. In this way the spectrum is shifted in the direction of the dispersion (rows of the CCDs) up to ~ 200 pixels. The shift in pixels can be selected in the definition of a free observing template. This option can be used to move an interesting spectral feature out of a bad region of the detector or to achieve very high S/N ratios by obtaining multiple spectra on different pixels, in a way similar to the dithering technique used when a very accurate subtraction of the sky background in deep imaging is needed. It is important to obtain wavelength calibrations and flat-field at each position of the camera.

Chapter 5

Observing

This Chapter summarizes the instrument-related information for the visiting astronomers coming to Paranal to observe with UVES.

5.1 Before the observing nights: preparation of OBs

The visiting astronomers are normally asked to come to Paranal one night in advance of their observing run. They should arrive already well documented on the instrument properties and on the preparation of the OBs for their observing run (or ready to finalize them if they have been prepared in advance at the home institute). These activities take place on an X-terminal in an office at the Paranal base camp, which can also be used for electronic mail correspondence with the outside world, telnet connection to the home institute, access to the World Wide Web, text-file editing, etc. The visitors receive advice on the OB preparation by a staff astronomer of the Observatory.

5.2 During the night

Observations with the UVES instrument are carried out at the User Station of UT2, located in the VLT Control Building just below the Paranal summit. From there all telescopes and instruments are remotely controlled. The telescope and instrument operator carries out the observations and is responsible for the checking that the telescope and isntruments perform correctly; the main area of responsibility of the visiting astronomers is the selection of the OBs to be executed, based on the sky conditions and on the results of the first observations. The main actions are outlined below.

5.2.1 Target acquisition

The OB to be executed is loaded to the BOB panel and started. The Telescope Control Software (TCS) reads the target coordinates from the OB and the telescope is pointed. It automatically searches with the guide probe in the adapter for a tracking star which is also used for the active optics correction computation. Once the telescope has completed the pointing and has acquired the guide star with the Adapter Guiding Probe, the UVES Slit Viewing Cameras, which produce images of the target field (30×30 arcseconds) as reflected by the slit jaws, can be used for the final step of target acquisition. In the dicroic modes the user

has to identify one of the two cameras as the primary one for acquisition and guiding. The SV images are properly oriented in the sky and the coordinates, which can be read with the cursor, are converted to sky coordinates. The target coordinates entered in the OBs have to be accurate to better than $< 1''$ to avoid unnecessary waste of telescope time in the identification process. The image of the SV field is automatically archived at the start of the exposure. The telescope pointing rms accuracy is of the order of 1 arcsec so that the target does appear close to the center of the SV images displayed on the WS panel. The visiting astronomer has to validate the target identification on the image. This is particularly important if the field has other close-by objects of similar magnitude.
Note that **if the target is invisible** to the limit of the SV camera (e.g., an emission line nebula), it is possible to define in the OB a blind offset from a nearby visible star. The coordinates of the science target have to be entered in the target description. In the acquisition template of the OB, the offsets to the guidestar have to be entered in arcseconds (target coordinates + offsets = acquisition star coordinates).
Whatever the acquisition procedure, once the instrument operator signals that the target is centered on the slit, the exposure is started.
The tracking of the telescope is corrected for errors of low frequency ($<$ 1 Hz) by the autoguiding. This *primary* guiding is based on the tracking of the guide star detected with the guide probe in the telescope adapter. UVES is installed on the Nasmyth platform. To make sure that there are no displacements of the telescope optical axis with respect to the plane of the entrance slit of the spectrograph during long exposures (due, e.g., to flexures of the platform as the telescope moves in azimuth) the primary guiding is complemented regularly at slow frequency (typically every few minutes) using information provided by the Slit Viewing Camera. The reference object can be either the target itself or another object in the field. This facility is called *secondary* guiding.

In case that the OB foresees target acquisition with an image slicer, the identification procedure is initially identical. Once the target has been identified, the operator will move it automatically to the position in the field which corresponds to the entrance of the IS. When this step is completed, the IS is moved in the beam and the exposure is started. Secondary guiding is not available for observations with image slicers.

5.2.2 Monitoring the integration

The visiting astronomers can monitor the development of the observation on one of the terminals of the WS by following the continuously updated plots of the counts of the blue and red exposure meters (see 2.2.2). The instrument operator will set up the plot intensity and time scale according to the running observations. Any problems which might occur during the exposure due to clouds or a telescope failure will show up in the exposure meters counts and can be brought to the attention of the telescope operator. Exposure can be paused and if necessary the exposure time modified. The plots also show the variation of the flux entering the spectrograph as a function of seeing.

The panel showing the instrument status during the integration does also include the assigned archive name of the upcoming files. This would typically be `UVES_mode_OBS`*nnn_mmmm*`.fits` where the mode can be `BLUE`, `RED`, `DIC1R`, `DIC1B`, `DIC2R` or `DIC2B`, *nnn* is a progressive number for that date (the day of the year) and *mmmm* indicates the number of files that have already been created in this mode (*mmmm* starting with 0001 for the first frame). In case of a flux standard star the suffix `OBS` is replaced by `STD`, in case of calibrations by the type of calibration, e.g., `BIAS`, `FLAT`, `WAVE`.

5.2.3 Evaluation of the results, off-line data analysis

At the end of each integration, the CCD frames are read-out by the FIERA controller and transferred to the IW and subsequently to the archive. At the same time the frames are displayed automatically on two Real-Time Display (RTD) panels. They can be analysed using the standard RTD tools. Previous exposures can be re-loaded when necessary.

Data obtained with templates in standard settings are also reduced on-line by the UVES instrument pipeline using a pre-populated calibration database. Up to 2 non-standard settings can be set up per visitor run. The raw files and the products of the pipeline are FITS files (cf. Chapter 6.2). They can be accessed and inspected by the astronomer on the assigned off-line WS, which is also available for running the major image analysis systems like MIDAS, IDL and IRAF. This preliminary reduction (extraction, wavelength calibration, flat-fielding and sky subtraction) provides advanced information on the quality of the obtained data but has to be regarded as a quick-look reduction facility only.

Chapter 6

The reduction of UVES data

6.1 Real Time Display and quick look

As soon as they are read out by the FIERA Controller and transferred to the instrument WS, the CCD frames are automatically displayed on a Real-Time Display (RTD) panel on a screen of the instrument WS (on two windows in case of dichroic exposures). The visiting astronomer can use the standard tools of the RTD on the astronomer's offline WS to visually display and inspect the spectra, to produce intensity traces, and to compute the statistics of pixels values in a subwindow. Previous exposures can be reloaded.

6.2 Pipeline reduction of UVES data

ESO has developed a pipeline reduction for UVES which primarily supports the predefined standard central wavelength settings in 1x1 and 2x2 binning modes as available in Service Mode. For visitors observing with non-standard settings, the on-line pipeline at Paranal can (in most cases) be prepared to handle their settings (limited to 2 non-standard settings per visitor run). The science data are calibrated with calibration exposures obtained upon arrival of the visitor, i.e., one or two days before the start of the observing run.

The UVES Calibration Plan (cf. [2]) ensures that ESO maintains and provides bias, spectroscopic flatfield and order definition frames, calibration lamp spectra. The CCD characteristics like read-out noise and gain are measured on a monthly basis. Dark current and parasitic light measurements are carried out with the same frequency and are available on request from the ESO archive.

The following corrections of the science echelle spectra are available: bias subtraction, interorder background subtraction, flatfield correction, order extraction, sky subtraction, rebinning to wavelength scale, and order merging. Response corrections are applied using predetermined master response curves. All three detectors (1 blue, 2 in the red mosaic) are processed independently.

The extraction of the science data is carried out according to the selection of the "Source Type" (POINT or EXTENDED) in the UVES observation templates. For point sources, an optimum extraction algorithm with sky subtraction and cosmic rejection is applied; image slicer data are extracted as the sum over the slicer length, no sky subtraction is available here; in the extraction of extended (or multiple single) objects, the spatial infomation along the slit is maintained.

More information about the UVES pipeline and Service Mode data packages is available under http://www.eso.org/observing/dfo/quality/index_uves.html.

6.3 Off-line data reduction

Any echelle data reduction package (under MIDAS, IRAF, or based on IDL) can be easily adapted to extract and calibrate UVES data. MIDAS has a dedicated context “UVES” which uses the instrument’s physical model to speed up the order definition and wavelength calibration.

On the 1st of April 2004, the format of the raw files produced by the red arm of UVES has changed. The new format is a FITS file with one extension per detector, i.e. the two red CCD images are split. As a consequence of this, files produced in the new format cannot be processed by versions of the UVES pipeline 2.0.0 or older. A new version of the pipeline, 2.1, is able to handle both the new and the old formats, and is available at: http://www.eso.org/projects/dfs/dfs-shared/web/vlt/vlt-instrument-pipelines.html. On the other hand, the format of the products produced by the new pipeline has not changed.

6.4 Special reduction cases

6.4.1 Data taken with the iodine cell

With the beginning of Period 68, data taken with the iodine absorption cell in Service Mode will be pipeline processed in the same way as data obtained without the iodine cell. But ESO does not plan to provide a package for the modeling (IP reconstruction) of the iodine cell data. However, ESO has quantified the instrument capabilities for high radial-velocity accuracy measurements using IP reconstruction techniques on dedicated commissioning data (cf. Kürster et al., contact akaufer@eso.org): a long-term stability of $< 2\,\mathrm{m/s}$ (rms) has been achieved over the commissioning time span of one month.

6.4.2 Image slicer data

Standard echelle data reduction packages can be adapted to extract image slicer spectra taking into account the need to use an extended extraction slit which matches the length of the slicer. Monitoring of the sky spectrum is possible if slit lengths longer than the slicer length are chosen. The UVES pipeline extracts science data taken with image slicers in the “average extraction” mode, i.e., by summing the signal over the slicer slit.

6.4.3 Interference filter data

Spectra taken in long-slit mode with the interference filters can be reduced using both the MIDAS long-slit context or the IRAF package for the long slit case, see the link: http://ecf.hq.eso.org/iraf/web/docs/spectra.html, document “A User’s Guide to Reducing Slit Spectra with IRAF”.

Chapter 7

Other useful information

7.1 List of available filters

7.1.1 Pre-slit filters

The available pre-slit filters (for maintenance and Observatory calibrations only; neutral density filters in bold face for acquisition of bright stars and the Johnson U filter for image slicer acquisitions) are:

		Pre-slit filters		
#	Name	Peak λ (nm)	Peak Transom.	Comment
PS1	**U**	~ 350	$> 60\%$	Acquisition filter
PS2	B	~ 420	$> 60\%$	Acquisition filter
PS3	V	~ 540	$> 80\%$	Acquisition filter
PS4	R	~ 650	$> 75\%$	Acquisition filter
PS5	I	~ 800	$> 85\%$	Acquisition filter ($< 2\%$ 920-1100 nm)
PS6	UG5 (2mm)			ADC test filter
PS7	**ND1**	300-1100	10^{-1}	Neutral-density filter (2.5 mag)
PS8	**ND2**	300-1100	10^{-2}	Neutral-density filter (5.0 mag)
PS9	**ND3**	300-1100	10^{-3}	Neutral-density filter (7.5 mag)
PS10	ND4	300-1100	10^{-4}	Neutral-density filter (10.0 mag)
PS11	ND5	300-1100	10^{-5}	Neutral-density filter (12.5 mag)

7.1.2 Below-slit filters

#	Name	Spectral range (nm)	Transm.	Comment
		Blue below-slit filters **BFIL**		
BBS1	not available			CUSO4 decommissioned
BBS2	BG24	350 – 420	> 96%	Stray-light rejection filter
BBS3	**HER_5** Herasil (5mm)	310 – 500	> 98%	Focus compensation plate
BBS4	HER_10 Herasil (10mm)	310 – 500	> 98%	Focus compensation plate
BBS5	HER_15 Herasil (15mm)	310 – 500	> 98%	Focus compensation plate
		Red below-slit filters **RFIL**		
RBS1	BG40	420 – 570	> 90%	Stray-light rejection filter
RBS2	**SHP700** (hot mirror)	420 – 700	> 90%	Red Stray-light rejection
RBS3	**OG590**	605 – 930	> 90%	Order-sorting filter
		300 – 560	< 0.001%	(for use with CD 4)
RBS4	**BK7_5** (5mm)	420 – 850	> 90%	Focus compensation plate
RBS5	BK7_10 (10mm)	420 – 850	> 90%	Focus compensation plate
RBS6	BK7_15 (15mm)	420 – 850	> 90%	Focus compensation plate
RBS12	**H**α (5mm)	652.8 – 659.8	92%	Interference filter
RBS13	**H**β (5mm)	484.2 – 488.0	72%	Interference filter
RBS14	**O**III **500.7** (5mm)	498.6 – 502.7	71%	Interference filter
RBS15	**O**III **436.3** (5mm)	434.8 – 437.9	69%	Interference filter
RBS16	**N**II **575.5** (5mm)	573.0 – 578.5	86%	Interference filter
RBS17	**O**I **630.0** (5mm)	626.9 – 633.4	90%	Interference filter
RBS18	**S**II **672.4** (5mm)	668.7 – 676.0	86%	Interference filter
RBS19	**He**II **468.6** (5mm)	466.8 – 470.3	79%	Interference filter

The filters in bold face are recommended to be used for science observations. For the **interference filters**, peak transmissions are given; the complete curves are shown in Fig. 7.1. The curves for the other filters can be recovered from the UVES components database accessible through the ETC.

7.2 List of standard stars

Any flux standard star can be used for flux calibration and blaze correction. The standards to be preferred should have measurements at a step of 2 nm or less to have a few points for each echelle order. For the pipeline reduction it is necessary to use stars for which the flux Table is available in MIDAS. The UVES webpage (`http://www.eso.org/instruments/uves/`) contains a pointer to the lists of flux and radial velocity standards.

7.3 Lists of arc lines

Tables of the ThAr lines used in the pipeline reduction are available on request to `usd-help@eso.org`. A pointer to the UVES Atlas of the ThAr spectrum at resolution 100,000 can be found in the UVES webpage (`http://www.eso.org/instruments/uves`).

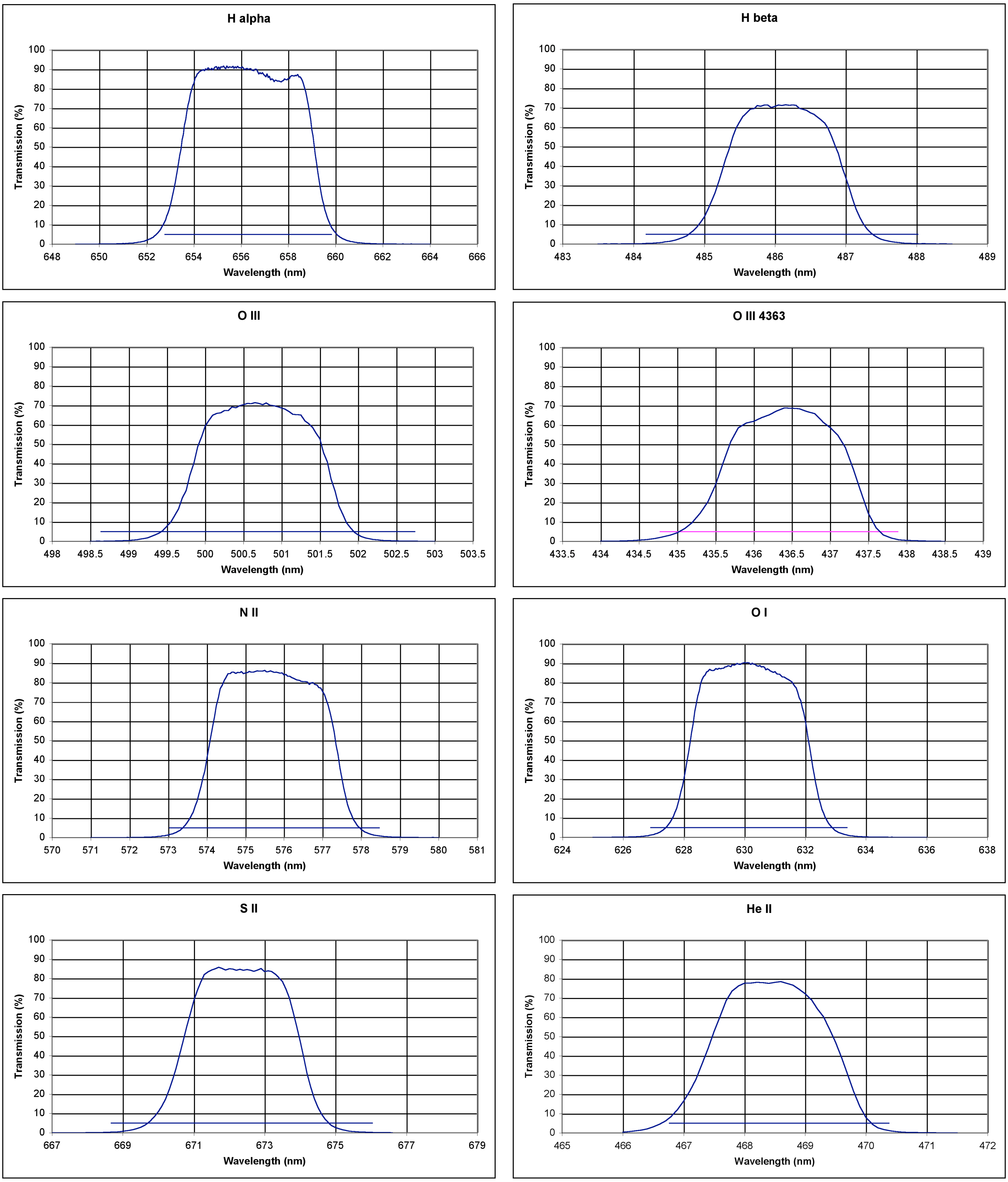

Figure 7.1: Transmission curves for the interference filters.

The Thorium line list is based on Palmer B. A., Engleman R. Jr., 1983, Atlas of the Thorium Spectrum, Sinoradzky H. (ed.), Los Alamos National Laboratory, and lines are selected according to R=100,000 based on de Cuyper J.-P., Hensberge H., 1998, A&AS 128, 409. For the Argon lines, the reference is Norlén G., 1973, Phys. Scripta 8, 249.

7.4 Pointers to UVES sample observations

The UVES webpage (`http://www.eso.org/instruments/uves/`) contains a pointer to the list of scientific observations and calibrations from the instrument Garching test phase, Commissioning, and Science Verification publicly available through the ESO ftp server and the ESO VLT archive.

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