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VERY LARGE TELESCOPE

X-shooter
User Manual

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CHANGE RECORD

ISSUE	DATE	SECTION/PARA. AFFECTED	REASON/INITIATION DOCUMENTS/REMARKS
0.1	13.01.06	All	FDR version: Table of Content prepared by Céline Péroux
0.2	14.08.08	All	PAE version prepared by Joël Vernet
1	01.03.09	All	First release prepared by Joël Vernet, with contributions by Elena Mason
2	01.07.09	All	Prepared by Joël Vernet and Elena Mason. - Added description of IFU centring and tracking wavelength - Updated all TSF in Sec 5. - Added spectrograph orientation figure. - Added description of Threshold Limited Integration in the NIR - Added information about ghost spectra - Added information about slit/ifu position information in acq image header. - Updated limiting mags with measured NIR sensitivity and background between OH lines in VIS - Updated UVB/VIS/NIR detector parameters - Added warning about 2x2 binning mode and inter-order bck subtraction
2.1	15.01.2010	Section 5	- Templates name changed from SHOOT to XSHOOTER; default parameters and hidden parameters.
		Sections 2.4.3 and 3.3.1	-... plus sparse minor corrections.
86.1	09.02.2010	None	cmmModule creation

87	25.08.2010 26.08.2010	All	CMa, sections 2.4.7 and 2.4.8, 2.4.9, 4.4, 4.7, 4.8 added. Sections 2.2.1, 3.2, 4.5.2, 4.6, 5.1.1, 5.1.2 modified. Figure added in 5.1.1, Table 11 updated, old Table 3 removed. + modified structure of the sections
88	27.02.2011 01.03.2011 03.03.2011 07.03.2011 28.03.2011 20.06.2011	Modified sects. 1.3, 2.2.1.3, 2.2.4.2, 2.3.2, 2.4, 2.4.3, 2.4.4, 2.4.6.1, 2.4.7, 3, 3.2, 3.3.1, 3.3.2, 3.3.3, 3.3.4, 4.1.1, 5, 5.1, 5.6.1, 5.6.2, 5.7, 5.9, 6.1.3, 6.2.3 New Sects 2.4.10, 2.4.11, 2.4.12, 2.4.13, 2.4.13, 2.4.14, 3.4, 3.4.1, 3.4.2, 3.4.3, 3.4.4, 3.4.5, 3.4.6 Modified tables: 2, 7, 11, 12, 66 New tables: 10, 13 Modified figures: 10, 15 New figures: 5, 11 New subsections 2.4.6, 6.1.3	CMa, update wrt the performances, new identified problems and status + description of the current ones. New items in the FAQ, new calibration plan, new section about the observation strategy. Figures updated to be more clear and useful. NIR 1.5” slit removed. Intervention of July 2011 briefly described +additional corrections of figures and sections according to IOT comments. Very minor changes. New templates added + minor corrections
89	04.08.2011 30.11.2011	Modified Sections: 2.1, 2.2.1.4, 2.2.4.2, 2.2.4.5, 2.3.2, 2.4.6, 2.4.9, 2.4.13, 2.4.15, 3.4.1, 5.1, 5.5, 5.7, 6.1.5, 6.2.3. New sections: 2.2.4.3, 2.4.7 Modified tables: 1, 9, 12, 13, 16, 72 New tables: 3, 4, 10	CMa, major modifications wrt the new slits in the NIR + new slits with K-band blocking filter added and background performances + the new TCCD performances + the new calibration plan + correction of typos and clarification of different points (attached calibrations, known problems, etc), weblinks modified.
			Modifications regarding phase2 + changes for the acquisition+setup+readout+ wiping overheads. + additional information regarding integration times for the TCCD.

90	20.02.2012 03.04.2012	Modified sections: 2.2.1.4, 2.2.4.5, 2.4.3, 3.4.3, 4.1.2, 5.1, 5.4, Table 16 revised	DIT of 1800s with JH slits, TCCD limiting magnitudes + direct acquisition. Telluric std star observations,
		Clarification of 2.2.4.3 (new NIR slits) New 6.1.2 for better explanation of slit orientation and offsets.	How to minimize the overheads and optimize the integration times. Calibration plan revised.
			Phase 2: minor modifications, re-writing sentences + new draws+ contacts added at the beginning (already present in other pages) Other minor adjustments of the tables and links.
90/91	08.08.2012	No ADCs mode: sect. 2.2.2, updates of sects. 2.4.2, 24.13-1.4.15, 3.1, 3.4.3, 5.7, 5.9	Adding a new section about the observations without ADCs (2.2.2). Updates of sections for the observations in slit with disabled ADCs + more infos for the IFU. Updates wrt the telluric std star policy starting in P91.

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1. Introduction

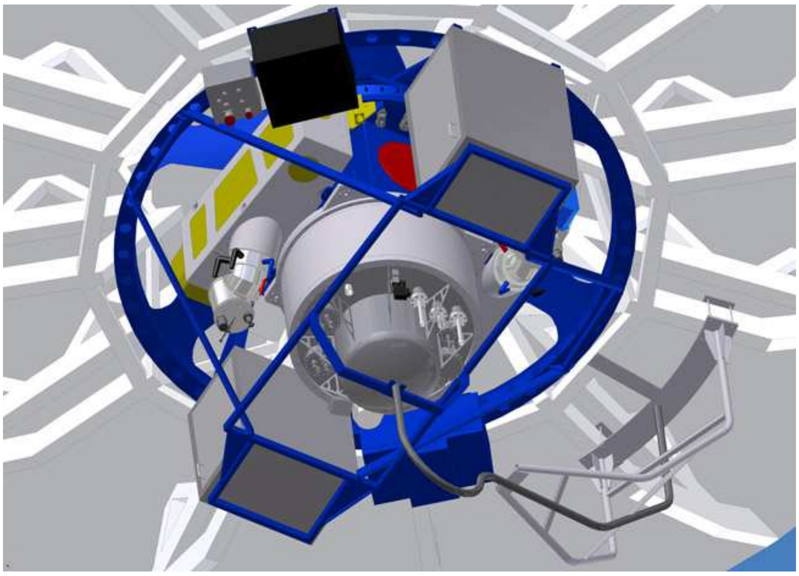


Figure 1: 3D CAD view of the X-shooter spectrograph at the Cassegrain focus of one of the VLT Unit Telescopes.

Table 1: X-shooter characteristics and observing capabilities

Wavelength range	300-2500 nm split in 3 arms
UV-blue arm	Range: 300-550 nm in 12 orders Resolution: 5100 (1" slit) Slit width: 0.5”, 0.8”, 1.0”, 1.3”, 1.6”, 5.0” Detector: 4k x 2k E2V CCD
Visual-red arm	Range: 550-1000 nm in 14 orders Resolution: 8800 (0.9" slit) Slit width: 0.4”, 0.7”, 0.9”, 1.2”, 1.5”, 5.0” Detector: 4k x 2k MIT/LL CCD
Near-IR arm	Range: 1000-2500 nm in 16 orders Resolution: 5100 (0.9" slit) Slit width: 0.4”, 0.6”, 0.9”, 1.2”, 1”, 5.0”, 0.6”JH, 0.9”JH Detector: 2k x 1k Hawaii 2RG
Slit length	11” (SLIT) or 12.6” (IFU)
Beam separation	Two high efficiency dichroics
Atmospheric dispersion compensation	In the UV-Blue and Visual-red arms Disabled on Aug. 1st ,2012
Integral field unit	1.8" x 4" reformatted into 0.6" x 12"

1.1 Scope

The X-shooter User Manual provides extensive information on the technical characteristics of the instrument, its performances, observing and calibration procedures and data reduction.

1.2 X-shooter in a nutshell

X-shooter is a single target spectrograph for the Cassegrain focus of one of the VLT UTs covering in a single exposure the spectral range from the UV to the K band. The spectral format is fixed. The instrument is designed to maximize the sensitivity in the spectral range through the splitting in three arms with optimized optics, coatings, dispersive elements and detectors. It operates at intermediate resolutions (R=4000-18000, depending on wavelength and slit width) sufficient to address quantitatively a vast number of astrophysical applications while working in a background-limited S/N regime in the regions of the spectrum free from strong atmospheric emission and absorption lines. A 3D CAD view of the instrument attached to the telescope is shown on Figure 1. Main instrument characteristics are summarized in Table 1.

X-shooter was built by a Consortium involving institutes from Denmark, Italy, The Netherlands, France and ESO. Name of the institutes and their respective contributions are given in Table 2.

1.3 Shortcuts to most relevant facts for proposal preparation

Table 2: collaborating institutes and their contributions

Collaborating institutes	**Contribution**
Copenhagen University Observatory	Backbone unit, UVB spectrograph, Mechanical design and FEA, Control electronics
ESO	Project Management and Systems Engineering, Detectors, final system integration, commissioning, logistics, Data Reduction Software
Paris-Meudon Observatory, Paris VII University	Integral Field Unit, Data Reduction Software
INAF - Observatories of Brera, Catania, Trieste and Palermo	UVB and VIS spectrograph, Instrument Control Software, optomechanical design.
Astron, Universities of Amsterdam and Nijmegen	NIR spectrograph, contribution to Data Reduction Software

- The fixed **spectral format** of X-shooter: see Table 12 on page 41
- **Spectral resolution** as a function of slit width: see Table 13 on page 43
- Information on the **IFU**: see Section 2.2.1.3
- Information on **limiting magnitudes** in the continuum: see Section 2.3.3 on page 44
- Information on **observing modes**: see section 3.1 on page 53
- Observing strategy and **sky subtraction**: see Section 3.3 on page 54
- **Overhead** computation: see Section 4 on page 63

1.4 List of Abbreviations & Acronyms

This document employs several abbreviations and acronyms to refer concisely to an item, after it has been introduced. The following list is aimed to help the reader in recalling the extended meaning of each short expression:

A&G/AG	Acquisition and Guiding
ADC	Atmospheric Dispersion Compensator
AFC	Active Flexure Compensation
DCS	Detector Control Software
DFS	Data Flow System
DIT	Detector Integration Time
ESO	European Southern Observatory
FDR	Final Design Review
FF	Flat Field
GUI	Graphical User Interface
ICS	Instrument Control Software
IFU	Integral Field Unit
ISF	Instrument Summary File
IWS	Instrument Workstation
LCU	Local Control Unit
N/A	Not Applicable
PAE	Preliminary Acceptance Europe
P2PP	Phase 2 Proposal Preparation
TBC	To Be Clarified
QE	Quantum Efficiency
SNR	Signal to Noise Ratio
TBD	To Be Defined
TCS	Telescope Control Software
TLI	Threshold Limited Integration
TSF	Template Signature File
VLT	Very Large Telescope
WCS	World Coordinate System

1.5 Reference Documents

1. X-shooter Calibration plan, v1.0, XSH-PLA-ESO-12000-0088
2. X-shooter Templates Reference Manual, v0.2, XSH-MAN-ITA-8000-0031
3. X-shooter technical note about the 11th order vignetting in K band
4. X-shooter A&A article: Vernet et al. 2011A&A...536A.105V
5. Report about the non destructive NIR readout mode

http://www.eso.org/sci/facilities/paranal/instruments/xshooter/doc/reportNDreadoutpublic.pdf

1.6 Contact

In case of instrument related questions, use xshooter@eso.org
In case of phase1/2 related questions, use usd_xshooter@eso.org

2. Technical description of the instrument

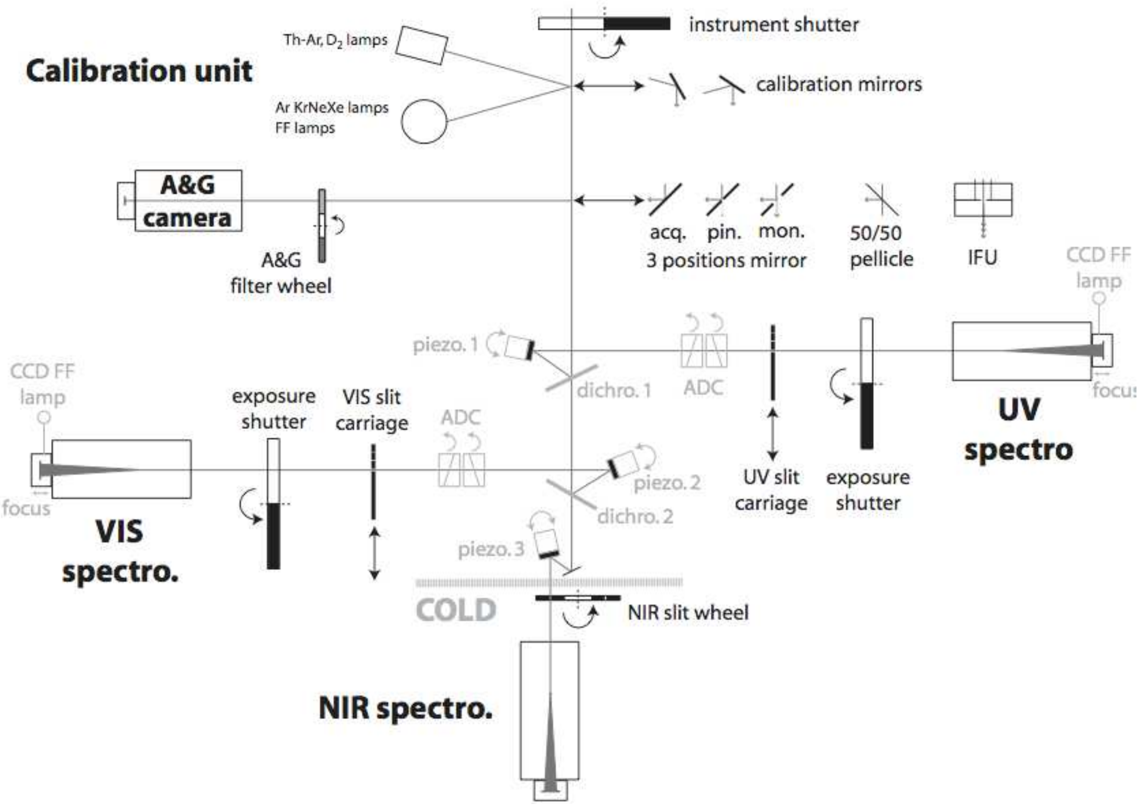


Figure 2: Schematic overview of X-shooter

2.1 Overview of the opto-mechanical design

Figure 2 shows a schematic view of the layout of the instrument. It consists of four main components:

- The backbone which is directly mounted on the Cassegrain derotator of the telescope. It contains all pre-slit optics: the calibration unit, a slide with the 3-positions mirror and the IFU, the acquisition and guiding camera, the dichroic box which splits the light between the three arms, one piezo tip-tilt mirror for each arm to allow active compensation of backbone flexures, atmospheric dispersion compensators (ADCs) in the UVB and VIS arms and a warm optical box in the NIR arm.

- The three arms are fixed format cross-dispersed échelle spectrographs that operate in parallel. Each one has its own slit selection device.

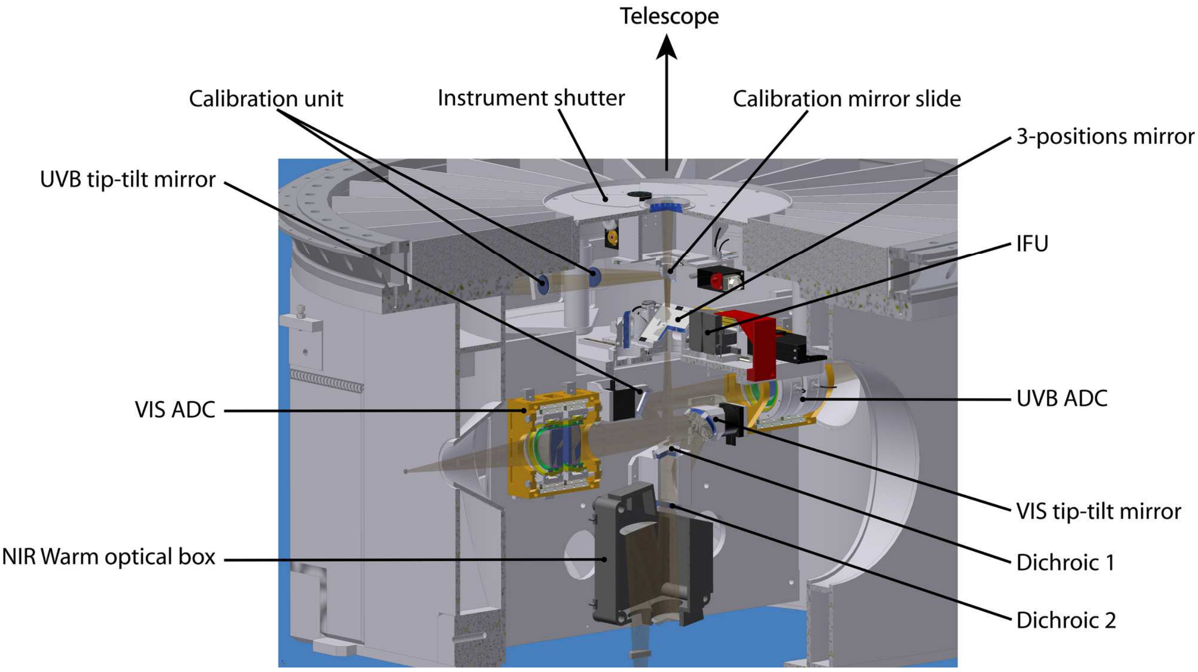


Figure 3: 3D view of a cut through the backbone.

  - The UV-Blue spectrograph covers the 300 – 550 nm wavelength range with a resolving power of 5100 (for a 1” slit)
  - The Visible spectrograph covers the range 550 - 1000 nm with a resolving power of 7500 (0.9” slit).
  - The near-IR spectrograph: this arm covers the range 1000 - 2500 nm with a resolving power of 5300 (0.9” slit). It is fully cryogenic.

2.2 Description of the instrument sub-systems

This section describes the different sub-systems of X-shooter in the order they are encountered along the optical path going from the telescope to the detectors (see

Figure 2). The functionalities of the different sub-units are explained and reference is made to their measured performance.

2.2.1 The Backbone

2.2.1.1 The Instrument Shutter and The calibration unit

In the converging beam coming from the telescope, the first element is the telescope entrance shutter.
Then follows the Calibration Unit that allows to select a choice of flat-fielding and wavelength calibration lamps. This unit consists of a mechanical structure with calibration lamps, an integrating sphere, relay optics that simulate the f/13.6 telescope beam, and a mirror slide with 3 positions that can be inserted in the telescope beam:

- one free position for a direct feed from the telescope,
- one mirror which reflects the light from the integrating sphere equipped with:
    - Wavelength calibration Ar, Hg, Ne and Xe Penray lamps operating simultaneously
    - three flatfield halogen lamps equipped with different balancing filters to optimize the spectral energy distribution for each arm
- one mirror which reflects light from:
    - a wavelength calibration hollow cathode Th-Ar lamp
    - a D_2 lamp for flatfielding the bluest part of the UV-Blue spectral range

A more detailed description of the functionalities of the calibration system is given in Sect. 5.

2.2.1.2 The Acquisition and Guiding slide

Light coming either directly from the telescope or from the Calibration Unit described above reaches first the A&G slide. This structure allows to put into the beam either:

- a flat 45° mirror with 3 positions mirror:
    - *acquisition and imaging*: send the full 1.5’×1.5’ field of view to the A&G camera. This is the position used during all acquisition sequences;
    - *spectroscopic observations and monitoring*: a slot lets the central 10”×15” of the field go through to the spectrographs while reflecting the peripheral field to the A&G camera. This is the position used for all science observations.
    - *artificial star*: a 0.5” pinhole used for optical alignment and engineering purposes;
- the IFU (described in Sect. 2.2.1.3);
- a 50/50 pellicle beam splitter at 45° which is to used look down into the instrument with the A&G camera and is exclusively used for engineering purposes.

2.2.1.3 The IFU

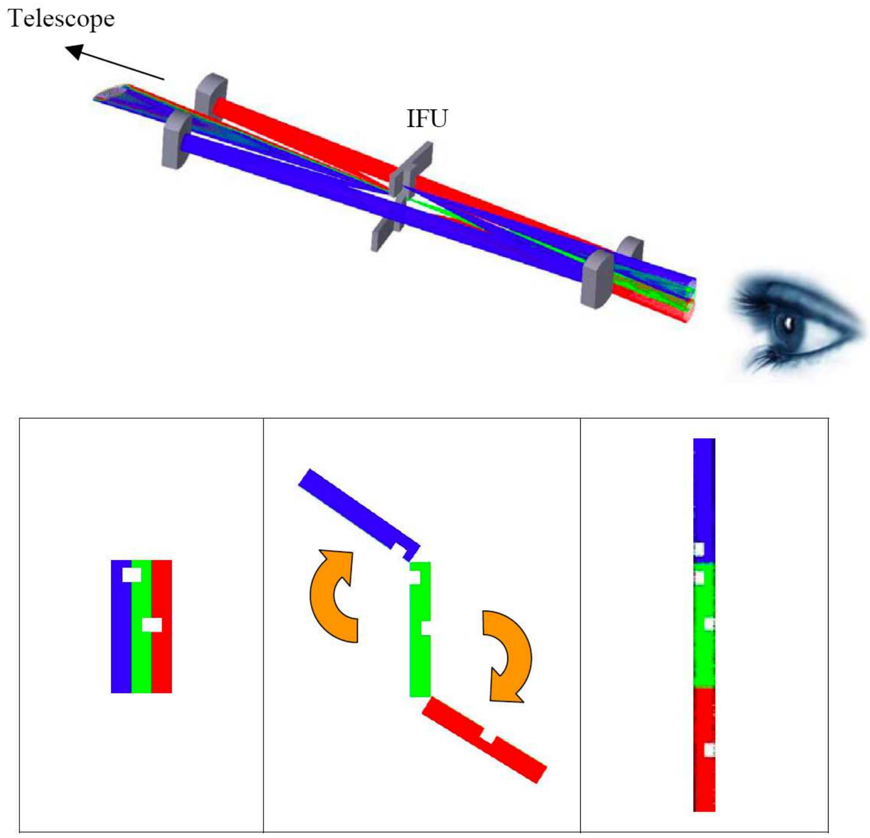


Figure 4: *Top*: view of the effect of the IFU. The central field is directly transmitted to form the central slitlet (green) while the each lateral field (in blue and red) are reflected toward a pair of spherical mirrors and realigned at the end of the central slice to form the exit slit. *Bottom:* The field before (left) and after the IFU (right). The IFU acts such that the lateral fields seem to rotate around a corner of their small edge. The two white slots are not real gaps but just guides to help visualize the top and the bottom of each slice in the drawing.

The Integral Field Unit is an image slicer that re-images an input field of 4”x1.8” into a pseudo slit of 12”x0.6”. The light from the central slice is directly transmitted to the spectrographs. The two lateral sliced fields are reflected toward the two pairs of spherical mirrors and re-aligned at both ends of the central slice in order to form the exit slit as illustrated in Figure 4. Due to these four reflections the throughput of the two lateral fields is reduced with respect to the directly transmitted central one. The measured overall efficiency of the two lateral slitlets is ~85% of the direct transmission but drops to ~50% below 400 nm due to reduced coating efficiency in the blue. An example of an IFU standard star is showed in Figure 5.

Below is an example of IFU observation of a telluric standard star:

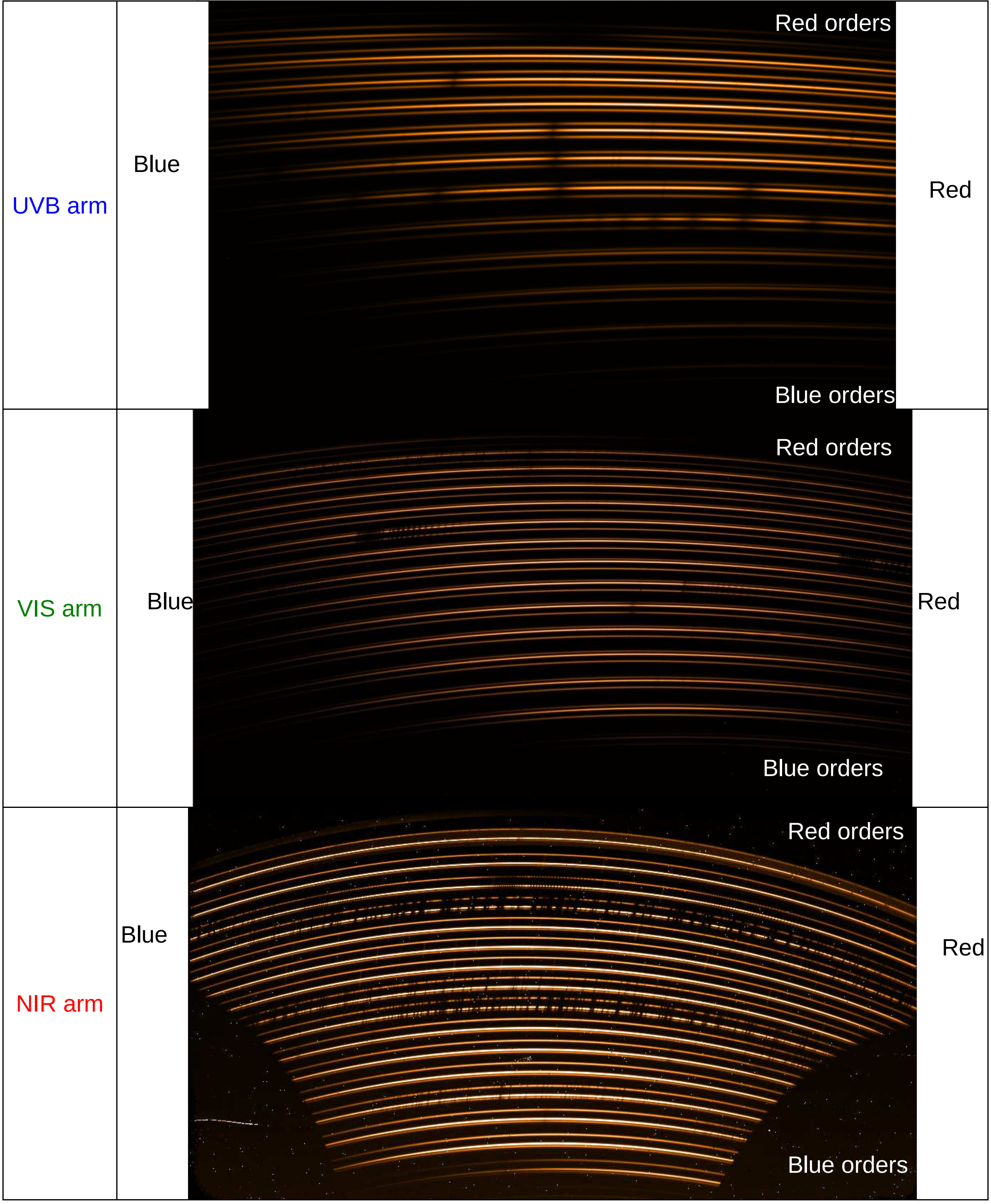


Figure 5: IFU telluric standard star (B-type star). One can note the three slices in each order of each arm. The telluric absorption lines are easily visible in the VIS and NIR arms.
One can also note the the effect of the atmospheric dispersion (change of distance between the slices between blue and red orders in UVB/VIS arms).

2.2.1.4 The Acquisition and Guiding Camera

The A&G camera allows to visually detecting and center objects from the U- to the z-band. This unit consists in:

- a filter wheel equipped with a full UBVRI Johnson filter set and a full Sloan Digital Sky Survey (SDDS) filter set. Transmission curves are provided in appendix 6.4.
- a Pelletier cooled, 13 µm pixel, 512×512 E2V broad band coated Technical CCD57-10 onto which the focal plane is re-imaged at f/1.91 through a focal reducer. This setup provides a plate scale of 0.173”/pix and a field of view of 1.47’×1.47’. The QE curve of the detector is provided in appendix 6.3.

This acquisition device –that can also be used to record images of the target field through different filters– provides a good enough sampling to centroid targets to <0.1” accuracy in all seeing conditions.

The noise of the technical CCD was improved a lot (RON of 3.2 e-) resulting in a better quality of the images and improving the possibility to do a direct acquisition on fainter objects.

The limiting magnitudes for a direct acquisition were measured for different filters under relatively bad conditions (thin cirrus, full Moon, seeing about 0.7”), see Table 3.

Table 3: Limiting magnitudes for a direct acquisition

U	B	V	R	I
22	22	22.5	22.5	22.5
30s	30s	20s	20s	20s

We still have to measure their limiting magnitudes under clear conditions and in dark time. However, in case of worse weather the limiting magnitudes are smaller.

We still recommend to use blind offsets in case the object is fainter than 22-22.5, especially if the weather constraints are selected for thin/thick transparency and seeing worse than 0.7”. In case of blind offsets, we recommend to select an acquisition star with a magnitude about 19 or brighter to ensure a good centering before the offsets are done.

Examples of recommended exposure times for the acquisition CCD:

Vmag=6 integration time=0.001s
Vmag=7 integration time=0.005s
Vmag=16-20 integration time=5s
V, R mag=23 integration time=60-120s
V,R mag>=24 integration time≥180s

These integration time should suffice for doing a direct acquisition in case of clear conditions, darktime and usual seeing. However, in case of very faint objects, the blind offset could be the best solution as it could shorten the acquisition overheads.

Table 4: TCCD zeropoints measured during the re-commissioning of XSHOOTER (07/2011) under photometric conditions and compared to FORS2 zeropoints.

	U	B	V	R	I
ZP XSHOOTER	24.946	27.744	27.634	27.826	27.485
ZP FORS2	24.312	27.683	28.085	28.324	27.671

They still need to be monitored and are given here as indications.

Recently the WCS information in the header was greatly improved and the AG snapshot WCS is better. The RMS of the difference between TCCD coordinates and reference star coordinates is better than 0.1” in the center of the CCD.
The centring on the spectrographs of the spectra does not depend of the filter used for the acquisition and centring of the target.

2.2.1.5 The dichroic box

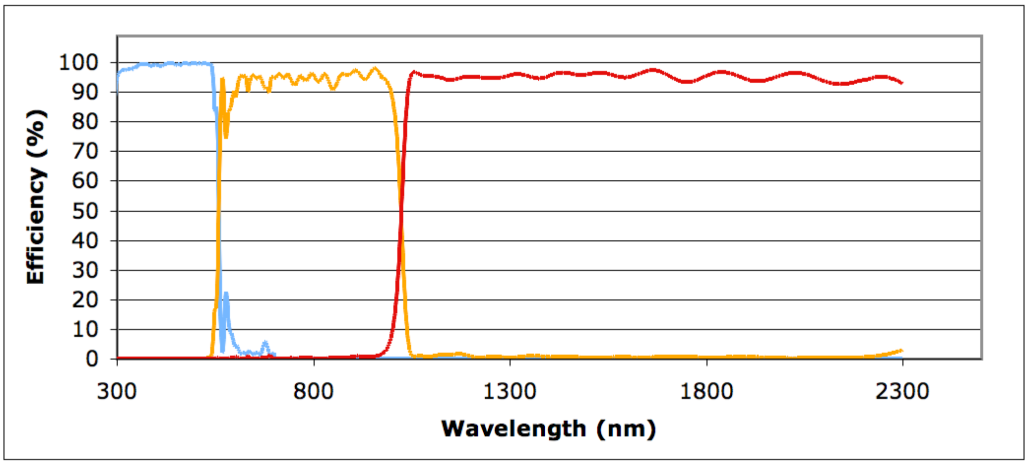


Figure 6: The combined efficiency of the two dichroic beam splitters. *In blue*: reflection on dichroic 1; *in orange*: transmission through dichroic 1 and reflection on dichroic 2; *in red*: transmission through dichroics 1 & 2.

Light is split and distributed to the three arms by two highly efficient dichroic beam splitters. These are the first optical elements encountered by the science light. The first dichroic at an incidence angle of 15˚ reflects more than 98% of the light between 350 and 543 nm and transmits ~95% of the light between 600 and 2300 nm. The second dichroic, also at 15˚ incidence, has a reflectivity above 98% between 535 nm and 985 nm and transmits more than 96% of the light between 1045 and 2300 nm. The combined efficiency of the two dichroics is shown in Fig. 6: it is well above 90% over most of the spectral range.

2.2.1.6 The flexure compensation tip-tilt mirrors

Light reflected and/or transmitted by the two dichroics reaches, in each arm, a folding mirror mounted on piezo tip-tilt mount. These mirrors are used to fold the beam and correct for backbone flexure to keep the relative alignment of the three spectrograph slits within less than 0.02” at any position of the instrument. They also compensate for shifts due to atmospheric differential refraction between the telescope tracking wavelength (fixed at 470 nm for all SLIT X-shooter observations) and the undeviated wavelength of the two ADCs (for UVB and VIS arms) and the middle of the atmospheric dispersion range for the NIR arm.
In case of IFU observations, one can select the telescope tracking wavelength.

2.2.1.7 The Focal Reducer and Atmospheric Dispersion Correctors

Both UVB and VIS pre-slit arms contain a focal reducer and an ADC. These focal reducer-ADCs consist of two doublets cemented onto two counter rotating double prisms. The focal reducers bring the focal ratio from f/13.41 to ~f/6.5 and provide a measured plate scale at the entrance slit of the spectrographs of 3.91"/mm in the UVB and 3.82"/mm in the VIS.

The ADCs compensate for atmospheric dispersion in order to minimize slit losses and allow orienting the slit to any position angle on the sky up to a zenith distance of 60˚. The zero-deviation wavelengths are 405 and 633 nm for the UVB and the VIS ADCs respectively. In the AUTO mode, their position is updated every 60s based on information taken from the telescope database.
Unfortunately due to some problems affecting the ADCs, they have been disabled since August 1st, 2012. See the following section for more information about the observations without ADCs.

The NIR arm is not equipped with an ADC. The NIR arm tip-tilt mirror compensates for atmospheric refraction between the telescope tracking wavelength (470 nm) and 1310 nm, which corresponds to the middle of the atmospheric dispersion range for the NIR arm. This means that this wavelength is kept at the center of the NIR slit. At a zenithal distance of 60° the length of the spectrum dispersed by the atmosphere is 0.35", so the extremes of the spectrum can be displaced with respect to the center of the slit by up to 0.175". If measurement of absolute flux is an important issue, the slit should then be placed at parallactic angle.

2.2.2 ADCs problems and disabled ADCs observing mode in SLIT and IFU

During March to July 2012 the ADCs (atmospheric dispersion correctors) for the UVB and VIS arms in X-shooter have been occasionally failing. Unfortunately recently the rate of such failures has increased until being daily, leading sometimes to data taken in sub-optimal instrument configuration, which needs to be taken into account when reducing and analysing such observations.

There is an ongoing investigation to find the cause for the ADCs' misbehaviour, but it is unlikely that the situation is back to normal for the next few months. Incorrect position of ADCs might lead to slit losses worse than if they are not used. Consequently, the ADCs were temporarily disabled (set at the non deviation position as in the IFU mode) on August 1st. A major intervention to fix the problem is currently under investigation.

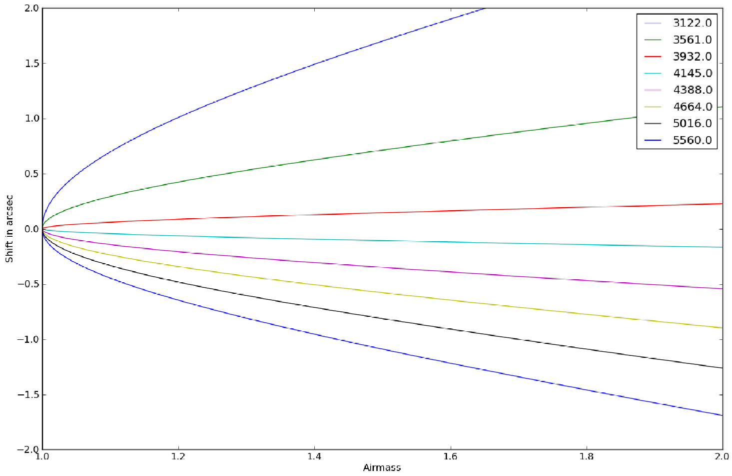
In the following pages, you will find useful information characterizing the observations without working ADCs to compensate the atmospheric dispersion in UVB and VIS arms.

Measurements were performed in the various orders of the UVB/VIS arms, some comparisons are performed and the average, the min/max values and the standard deviation are provided. The slits used are 1.0”, 0.9”, 0.9” in the UVB, VIS, and NIR arms respectively.

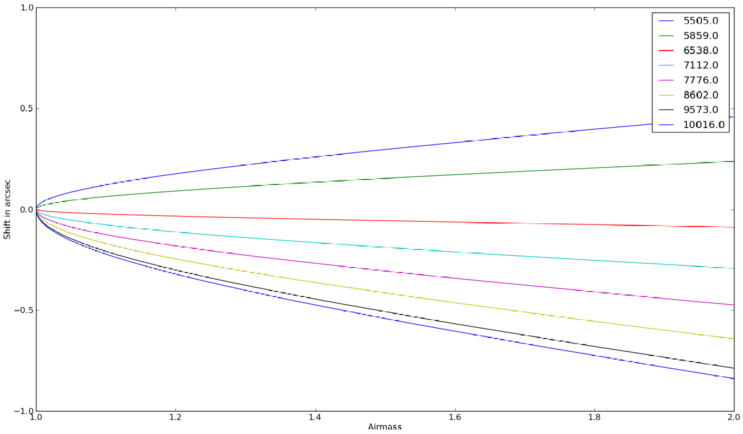
a) Atmospheric dispersion effect on the XSHOOTER spectra without ADCs

The tracking in XSHOOTER is by default 470nm, and
The dispersion effect of the atmosphere on XSHOOTER spectra depends on the tracking wavelength used (by default 470nm).
Therefore the current effect is shown in the following plots for the UVB, VIS, and NIR arms.

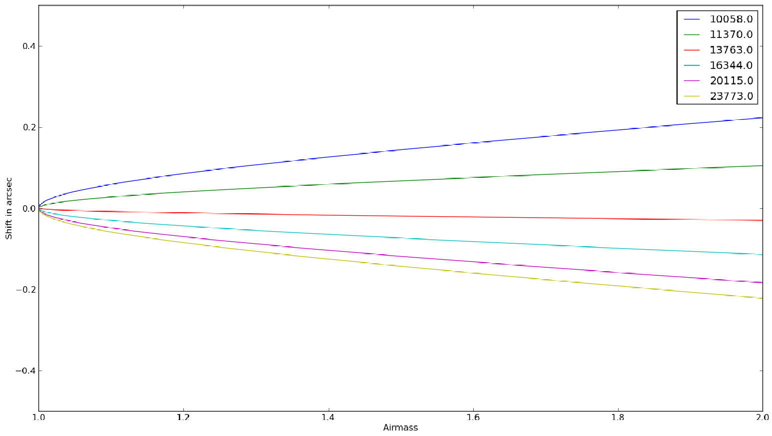
UVB arm



VIS arm



NIR arm



Atmospheric dispersion effect (no ADCs) on the position of the spectrum inside different orders depending on the airmass and the arm (UVB:top, VIS: middle, NIR:bottom). The wavelength is in Angstroms.

As consequences, in stare mode (object centered in the slit):

-if the observation is conducted at airmass 1.2 with the slit angle at parallactic angle, then the drift between the blue and red order spectrum will be of ~1.6” in the UVB arm, ~0.6” in the VIS arm, and ~0.2” in the NIR arm.

--if the observation is conducted at airmass 1.6 with the slit angle at parallactic angle, then the drift between the blue and red order spectrum will be of ~3.5” in the UVB arm, ~0.8” in the VIS arm, and ~0.3” in the NIR arm.

Such kind of drifts is important to take into account in case of nodding observations to avoid too many flux losses even with the slit at the parallactic angle.
It is again more important if the slit angle is different than the parallactic angle.

b) Comparison of ADCs efficiency at different slit angle.

The measure was performed at relatively high airmass (AM=1.8) and compares the flux between the slit position parallactic+90 degrees and parallactic angles (ratio flux perpendicular/flux parallactic). The average value corresponds to the average of measurements for each order, the range gives the min/max values of the ratio and the standard deviation (std) is given.

Stare mode, AM=1.8
With ADCs ratio perpendicular/parallactic

Arm	**Average**	**range**	**std**
UVB	0.88	0.85-0.92	±0.01
VIS	0.94	0.92-0.97	±0.01

c) Comparison of observations with/without ADCs

There are 2 sets of measurements comparing the efficiency of observations with/without the ADCs for the slit angle at parallactic angle or perpendicular to it:
One in stare mode at airmass =1.8 that can be compared to the subsection b.
One in nodding mode at airmass=1.35.

Stare mode, AM=1.8
Ratios no ADCs/with ADCs

Arm, slit angle	**Average**	**range**	**std**
UVB parallactic	0.88	0.46-1.0	±0.12
UVB perpendicular	0.46	0.10-1.0	±0.33
VIS parallactic	0.92	0.86-1.0	±0.03
VIS perpendicular	0.77	0.47-1.0	±0.18

Nodding mode, AM=1.35
Ratios no ADCs/with ADCs

Arm, slit angle	Average	range	std
UVB parallactic	0.87	0.87-0.9	±0.01
UVB perpendicular	0.82	0.56-1.0	±0.15
VIS parallactic	0.88	0.82-0.9	±0.02
VIS perpendicular	0.81	0.66-0.99	±0.11

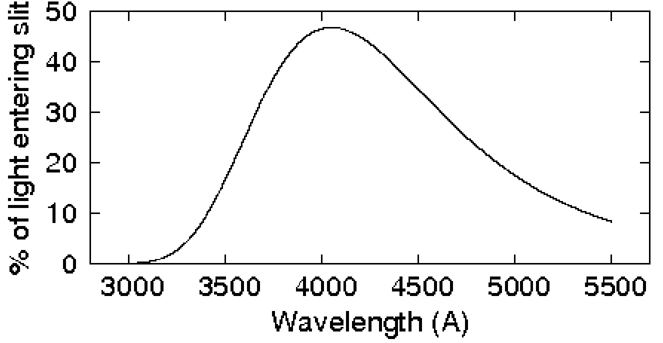
The measurements were performed on short integration times and if possible in stable conditions of the seeing.

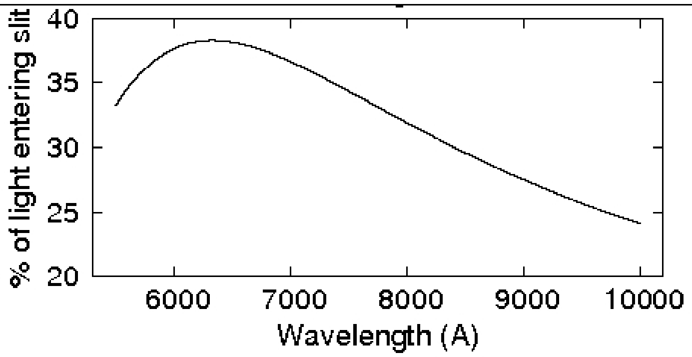
d) Efficiency of observations without ADCs at different given slit angles and airmasses

In this subsection a summary is presented first, a modelling for narrower slits is shown in second, and finally the detailed measurements corresponding to the first part are provided. We consider here the ratios of the observation at 45 degrees or 90 degrees of the parallactic angle to the parallactic angle for different airmasses.
Summary:

Arm	airmass	Ratio 45/parall	Ratio 90/parall
UVB	1.10	0.98	0.83
UVB	1.51	0.84	0.63
UVB	2.20	0.31	0.18
VIS	1.10	0.87	0.80
VIS	1.51	0.92	0.72
VIS	2.20	0.63	0.31

The similar information was computed theoretically and is shown in the following plots.





On those plots for observations at 90 degrees of the parallactic angle, slits of 0.4” in the UVB arm (top), 0.5” in the VIS arm (bottom) and a seeing of 0.8” have been considered.

Arm	airmass	Type of ratio	average	range	std
UVB	1.10	45/parall	0.98	0.84-1.0	±0.19
UVB	1.10	90/parall	0.83	0.74-1.0	±0.15
UVB	1.51	45/parall	0.84	0.56-1.0	±0.13
UVB	1.51	90/parall	0.63	0.25-1.0	±0.26
UVB	2.20	45/parall	0.31	0.05-0.64	±0.20
UVB	2.20	90/parall	0.18	0.04-0.23	±0.06
VIS	1.10	45/parall	0.87	0.83-0.94	±0.03
VIS	1.10	90/parall	0.80	0.75-0.92	±0.04
VIS	1.51	45/parall	0.92	0.87-1.0	±0.04
VIS	1.51	90/parall	0.72	0.47-1.0	±0.17
VIS	2.20	45/parall	0.63	0.37-0.83	±0.16
VIS	2.20	90/parall	0.31	0.28-0.34	±0.02

e) Efficiency of observations without ADCs at given airmass and slit angle but with different tracking wavelength

Up to now only in IFU mode, the user can choose the tracking wavelength. This option will be considered for the SLIT mode as well. In the following tables we compare the flux ratios other the orders for the observations at 470nm (default tracking wavelength) with respect to the observation at another wavelength. The observations were performed without ADCs, in nodding mode at AM=1.35.

- If the user chooses the tracking wavelength equals to 600nm instead of 470nm

Arm	Average	range	std
UVB	0.96	0.66-1.47	±0.25
VIS	0.85	0.74-1.00	±0.09

For the UVB arm, the ratio is higher in blue orders (~1.4) with the 470nm tracking wavelength and lower in the red orders (~0.7) compared to the 600nm tracking wavelength. This is the same evolution for the VIS arm.

- Same measurements but with the tracking wavelength at 850nm instead of 470nm

Arm	Average	range	std
UVB	1.04	0.54-1.89	±0.45
VIS	0.79	0.62-1.08	±0.14

For the UVB arm, the ratio is higher in blue orders (~1.9) with the 470nm tracking wavelength and lower in the red orders (~0.6) compared to the 850nm tracking wavelength. This is the same evolution for the VIS arm.

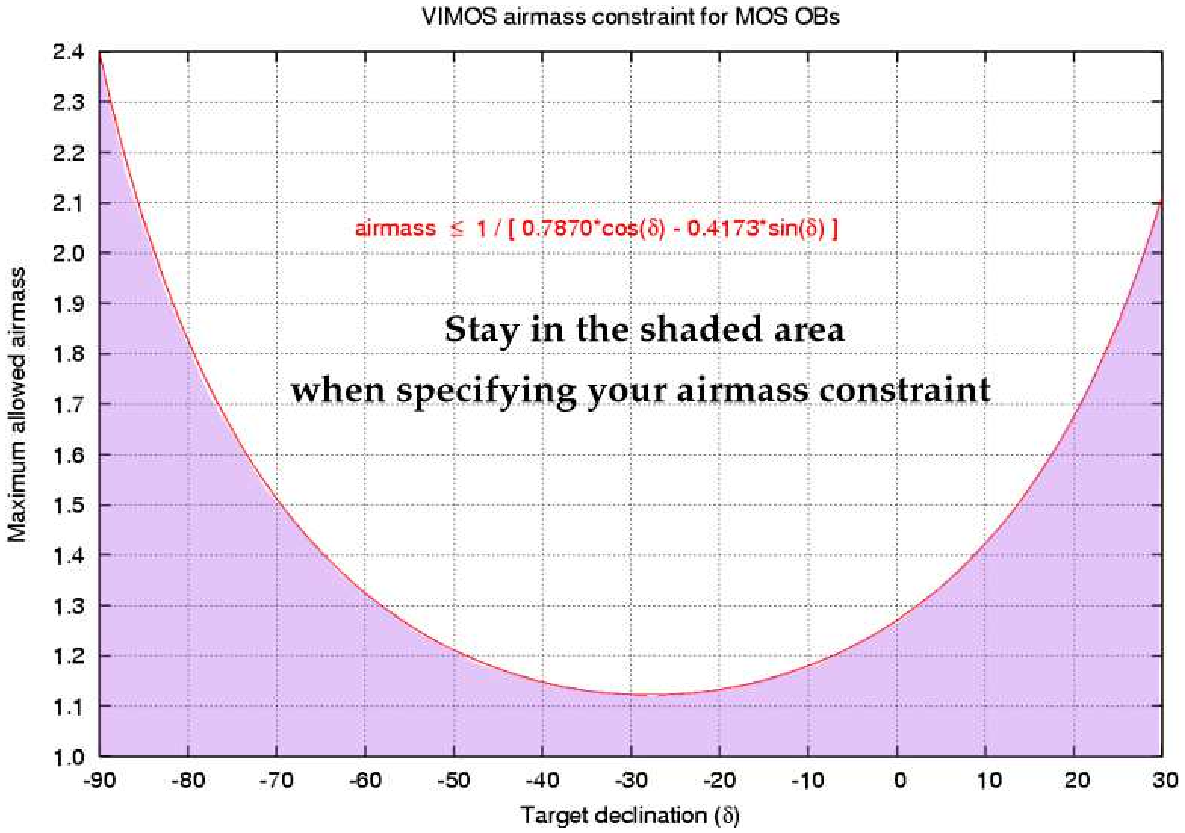
f) Comparison of observations efficiency between airmasses and slit angles

In the following table the efficiency is compared between airmass 1.51 and 1.10 (flux ratio AM=1.51/AM=1.10).

arm	Slit angle	average	range	std
UVB	Parallactic	0.89	0.43-1.0	±0.16
UVB	Parall+45	0.81	0.59-0.95	±0.12
UVB	Parall+90	0.68	0.30-1.0	±0.24
VIS	Parallactic	0.92	0.82-1.0	±0.05
VIS	Parall+45	0.81	0.70-0.98	±0.09
VIS	Parall+90	0.66	0.42-1.0	±0.18

g) Airmass constraints for observations

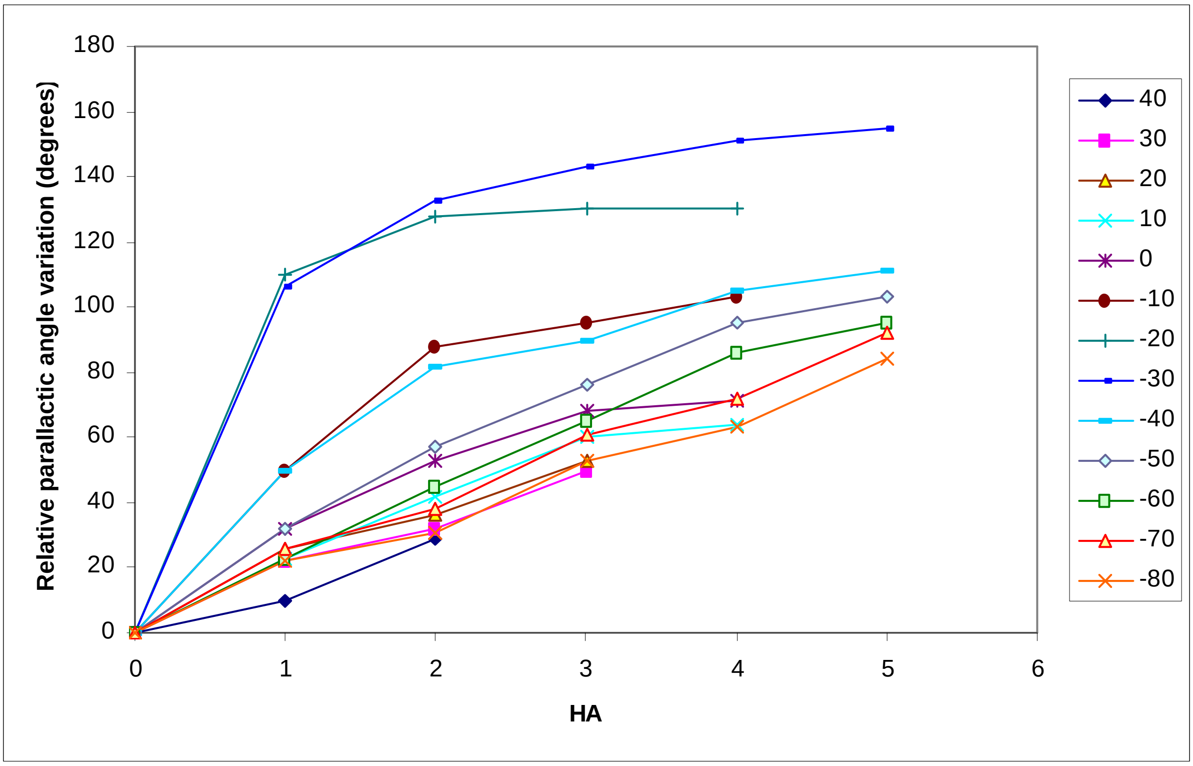
To help in the process of observation preparation, below is a plot from VIMOS-MOS mode showing the airmass limit depending of the target declination for an observation at ±2h of the meridian.



At the Cassegrain focus there is no possibility yet to do a secondary guiding. Therefore the evolution of the parallactic angle is not followed during the exposures but the slit is setup at the parallactic angle at the moment of the acquisition. This angle is followed during the exposure.

It implies that the atmospheric dispersion direction will change with the time with respect to the slit angle.

The (approximate) relative evolution of the parallactic angle postmeridian crossing (for different hour angles) is shown in the following figure for different declinations.



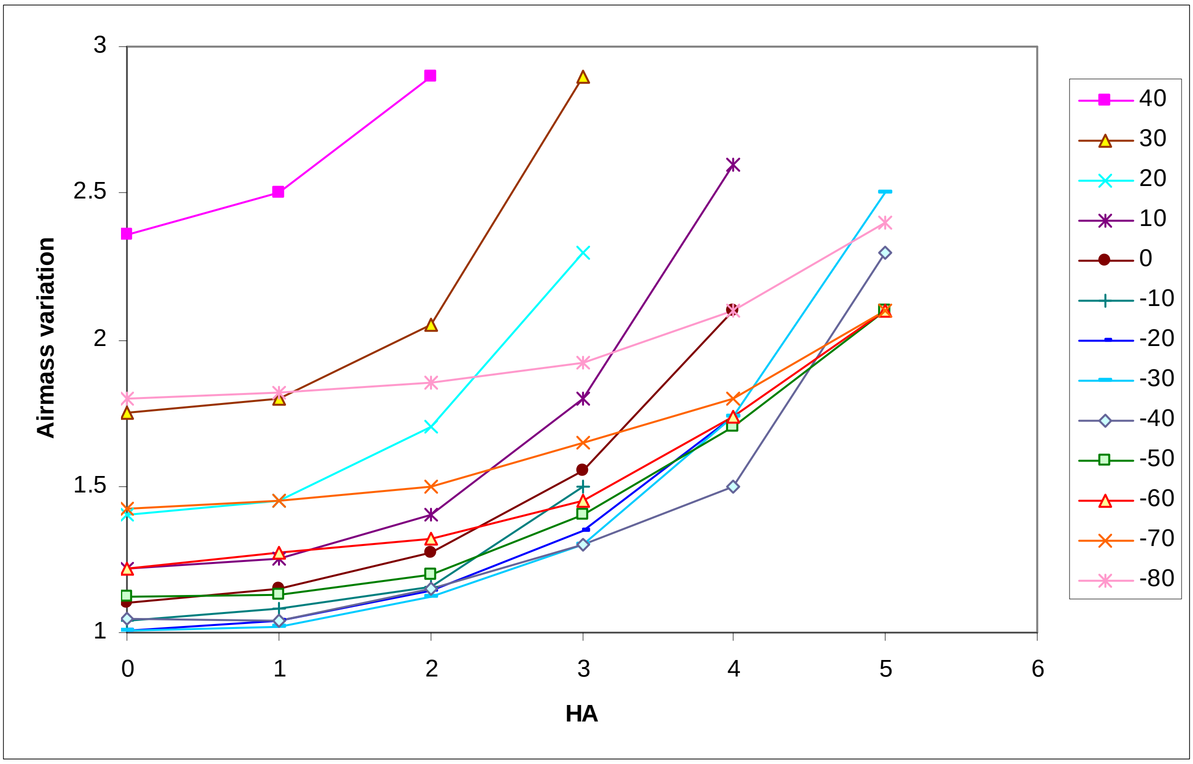
For example, the parallactic angle changes by ~110 degrees in 1h (1 HA) for declination equals to +40 degrees (at Paranal). For declination –50 degrees, in 1h (1 HA) the parallactic angle will change by ~35 degrees.

In the case of declination of +40 degrees at the start of the observation the slit angle is set at 0 degree for relative reference, then in less than 1 h the atmospheric dispersion is perpendicular to the slit.

With the ADCs such evolution was not a problem but without ADCs, one has to take this evolution into account and the airmass values + its evolution.

Of course the full dispersion between the blue and the red also depends on the airmass.

The airmass evolution is shown in the following figure depending on the declination of the target. One can see that for HA=2, the values correspond to those reported in the figure above for VIMOS.



From this plot about the airmass variation, one can see that for declination +40 degrees, the airmass will change from AM=2.4 to 2.5 in 1h so a relative small change but it means for the UVB arm a dispersion between the blue and red orders of about 5" while the parallactic angle will change by ~110 degrees in 1 h. As a consequence for such observation it is recommended to do short exposures and do some re-acquisitions to setup frequently the slit at the parallactic angle. If it is not performed after few minutes, the main dispersion direction will imply that some orders will be missed.

For declination –50 degrees, in 1h (1 HA) the airmass will change from AM=1.12 to 1.13, therefore the dispersion for the UVB arm between the blue and red orders is about 1" while the parallactic angle changes by ~35 degrees. It means that the orders at the border will be affected by flux losses but less important that in the case of the declination + 40 degrees.

In case of large dispersion, it could be better to use the stare mode with the parallactic angle and with short OBs or to use the nodding with a smaller nodding throw (by default 5").

2.2.3 The UVB spectrograph

2.2.3.1 Slit carriage

The first opto-mechanical element of the spectrograph is the slit carriage. Besides the slit selection mechanism, this unit consists of a field lens placed just in front of the slit to re-image the telescope pupil onto the spectrograph grating, and the spectrograph shutter just after the slit. The slit mask is a laser cut Invar plate manufactured with the LPKF Laser Cutter used for FORS and VIMOS. It is mounted on a motorized slide in order to select one of the 9 positions available. All science observation slits are 11” high and different widths from 0.5” to 5” (the latter for spectro-photometric calibration) are offered. In addition a single pinhole for spectral format check and order tracing and a 9-pinhole mask for wavelength calibration and spatial scale mapping are available (see Table 5).

Table 5: UVB spectrograph slits and calibration masks

Size	Purpose
0.5”×11” slit	SCI / CAL
0.8”×11” slit	SCI / CAL
1.0”×11” slit	SCI / CAL
1.3”×11” slit	SCI / CAL
1.6”×11” slit	SCI / CAL
5.0”×11” slit	CAL
Row of 9 pinholes of 0.5” ∅ spaced at 1.4”	CAL
0.5” ∅ pinhole	CAL

2.2.3.2 Optical layout

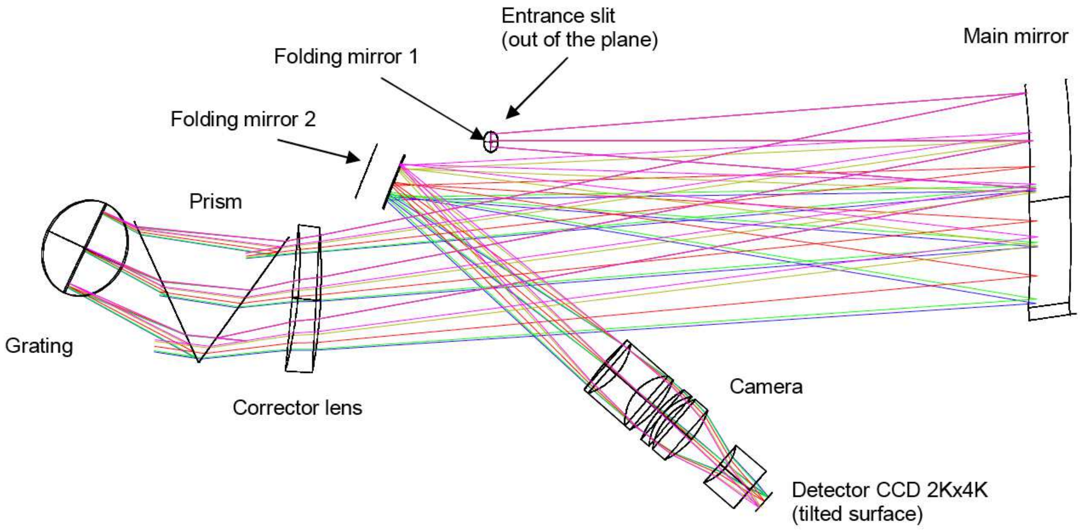


Figure 7: The UVB spectrograph optical layout

The optical layout of the UVB spectrograph is presented in Figure 7. Light from the entrance slit, placed behind the plane of the figure, feeds a 5° off-axis Maksutov-type collimator through a folding mirror. The collimator consists of a spherical mirror and a diverging fused silica corrector lens with only spherical surfaces. The collimated beam passes through a 60° silica prism twice to gain enough cross-dispersion. Main dispersion is achieved through a 180 grooves/mm échelle grating blazed at 41.77°. The off-blaze angle is 0.0°, while the off-plane angle is 2.2°. After dispersion, the collimator creates an intermediate spectrum near the entrance slit, where a second folding mirror has been placed. This folding mirror acts also as field mirror. Then a dioptric camera (4 lens groups with CaF2 or silica lenses, 1 aspherical surface) reimages the cross-dispersed spectrum at f/2.7 (plate scale 9.31"/mm) onto a detector that is slightly tilted to compensate for a variation of best focus with wavelength. The back focal length is rather sensitive to temperature changes. It varies by ~22.7µm/°C which corresponds to a defocus of 9µm/°C or ~0.08"/°C. This is automatically compensated at the beginning of every exposure by moving the triplet+doublet of the camera by -10.9µm/°C.

2.2.3.3 Detector

The UVB detector is a 2048×4102, 15µm pixel CCD from E2V (type CCD44-82) of which only a 1800×3000 pixels window is used. The CCD cryostat is attached to the camera with the last optical element acting as a window. The operating temperature is 153K. The CCD control system is a standard ESO FIERA controller shared with the VIS CCD. The list of readout modes offered for science observations is given in Table 6.

Table 6: List of detector readout modes offered for science observations. *The 2x2 binning is not recommended whenever a good inter-order background subtraction is required (see also section 2.4.5).

Readout mode name	Gain [e-/ADU]		Speed [kpix/s]	Binning	
	UVB	VIS		Spatial dir.	Dispersion dir.
100k/1pt/hg	High [0.62]	High [0.595]	Slow [100]	1	1
100k/1pt/hg/1x2				1	2
100k/1pt/hg/2x2*				2	2
400k/1pt/lg	Low [1.75]	Low [1.4]	Fast [400]	1	1
400k/1pt/lg/1x2				1	2
400k/1pt/lg/2x2*				2	2

One more readout mode (1000×1000 window, low gain, fast readout, 1x1 binning) exclusively used for flexure measurement and engineering purposes is also implemented. Measured properties and performances of this system are summarized in Table 7. The associated shutter, located just after the slit is a 25mm bi-stable (2 coil, zero dissipation) shutter from Uniblitz (type BDS 25). Full transit time is 13ms. Since the slit is 2.8mm high (11” at f/6.5), the illumination of the detector is homogenous within <<10ms.

	UVB	**VIS**	**NIR**
Detector **type**	E2V CCD44-82	MIT/LL CCID 20	substrate removed Hawaii 2RG
Operating **temperature**	153 K	135 K	81 K
QE	80% at 320 nm 88% at 400 nm 83% at 500 nm 81% at 540 nm	78% at 550 nm 91% at 700 nm 74% at 900 nm 23% at 1000 nm	85%
Number of pixels	2048×3000 (2048×4102 used in windowed readout)	2048×4096	2048×2048 (1024×2048 used)
Pixel size	15 µm	15µm	18µm
Gain (e$^-$/ADU)	High: 0.62 Low: 1.75	High: 0.595 Low: 1.4	2.12
Readout **noise** (e$^-$ rms)	Slow: 2.5 Fast: 4.5	Slow: 3.1 Fast: 5.2	Short DIT: ~25 DIT>300s: ~8.0
Saturation (ADU)	65000	65000	45000 (for a single readout). TLI: 42000 ADUs used for long DITs
Full frame **readout time** (s)	1x1, slow-fast: 70-19 1x2, slow-fast: 38-12 2x2, slow-fast: 22-8	1x1, slow-fast: 92-24 1x2, slow-fast: 48-14 2x2, slow-fast: 27-9	0.88 (for a single readout)
Dark current level	<0.2e-/pix/h	<1.1e-/pix/h	21 e-/pix/h
Fringing amplitude	-	~5% peak-to-valley	-
Non-linearity	Slow: 0.4% Fast: 1.0%	Slow:0.8% Fast: 0.8%	<1% up to 45000 ADUs
Readout direction	Main disp. dir.	Main disp. dir.	-
Prescan and **overscan** areas	1x1 and 1x2: X=1-48 and 2097-2144 2x2: X=1-24 and 1049-1072	1x1 and 1x2: pix 39-48 and 2097-2144 2x2: 19-24 and 1049-1072	-
Flatness	<8µm peak-to-valley		

Table 7: measured properties of the X-shooter detectors

2.2.4 The VIS spectrograph

2.2.4.1 Slit carriage

The slit carriage of the VIS spectrograph is identical to that of the UVB but the available slits are different. All the science observation slits are 11” high and different widths are offered from 0.4” to 5” (see Table 8).

Table 8: VIS spectrograph slits and calibration masks

Size	**Purpose**
0.4”×11” slit	SCI / CAL
0.7”×11” slit	SCI / CAL
0.9”×11” slit	SCI / CAL
1.2”×11” slit	SCI / CAL
1.5”×11” slit	SCI / CAL
5.0”×11” slit	CAL
Row of 9 pinholes of 0.5” ∅ spaced at 1.4”	CAL
0.5” ∅ pinhole	CAL

2.2.4.2 Optical layout

The optical layout of the VIS spectrograph is very similar to that of the UVB (see Figure 7). The collimator (mirror+corrector lens) is identical. For cross-dispersion, it uses a 49° Schott SF6 prism in double pass. The main dispersion is achieved through a 99.4 grooves/mm, 54.0° blaze échelle grating. The off-blaze angle is 0.0° and the off-plane angle is 2.0°. The camera (3 lens groups, 1 aspherical surface) reimages the cross-dispersed spectrum at f/2.8 (plate scale 8.98”/mm) onto the detector (not tilted). Focussing is obtained by acting on the triplet+doublet sub-unit of the camera. However, unlike the UVB arm, the back focal length varies less than 1µm/°C (image blur <0.004”/°C) hence no thermal focus compensation is needed.

2.2.4.3 Detector

The VIS detector is 2048×4096, 15µm pixel CCD from MIT/LL (type CCID-20). Like for the UVB arm, the cryostat is attached to the camera with the last optical element acting as a window. The operating temperature is 135K. It shares its controller with the UVB detector and the same readout modes are available (see Table 6). Measured properties and performances are given in Table 7. The shutter system is identical to the UVB one.

2.2.5 The NIR spectrograph

The NIR spectrograph is fully cryogenic. It is cooled with a liquid nitrogen bath cryostat and operates at 105 K.

2.2.5.1 Pre-slit optics and entrance window

After the dichroic box and two warm mirrors M1 (cylindrical) and M2 (spherical, mounted on a tip-tilt stage and used for flexure compensation, see description on p. 18) light enters the cryostat via the Infrasil vacuum window. To avoid ghosts, this window is tilted 3 degrees about the Y-axis. After the window, light passes the cold stop, and is directed towards the entrance slit via two folding mirrors M3 (flat) and M4 (spherical).

2.2.5.2 Slit wheels

A circular laser cut Invar slit mask is pressed in between two stainless steel disks with 12 openings forming the wheel. The wheel is positioned by indents on the circumference of the wheel with a roll clicking into the indents. All the science observation slits are 11” high and different widths are offered from 0.4” to 5” (see Table 9).

Table 9: NIR spectrograph slits and calibration masks

Size	**Purpose**
0.4”×11” slit	SCI / CAL
0.6”×11” slit	SCI / CAL
0.9”×11” slit	SCI / CAL
1.2”×11” slit	SCI / CAL
5.0”×11” slit	CAL
0.6”×11” JH slit#	SCI / CAL
0.9”×11” JH slit#	SCI / CAL
Row of 9 pinholes of 0.5” ∅ spaced at 1.4”	CAL
0.5” ∅ pinhole	CAL
Blind*	SCI / CAL

In July 2011 during the intervention on XSHOOTER the NIR slit wheel was modified, the 1.5” slit was removed (not offered since P88) and 2 new slits of 0.6” and 0.9” with a stray-light K band blocking filter added. Scattered light from the strong thermal radiation in the reddest order of the NIR arm affects very significantly the background level in the J and H bands. The goal is to offer the possibility of low background observations in the J and H bands, to the expense of wavelength coverage (i.e cutting **the K-band**). Note that the normal 0.6" and 0.9" slit with the full wavelength coverage are still offered.

* The blind position can be set if the NIR arm observation is not needed or in case the NIR arm will be highly saturated to do not damage the detector and avoid the remanence. It is also used for the measurement of the instrumental background.
# new slits with K-band blocking filter

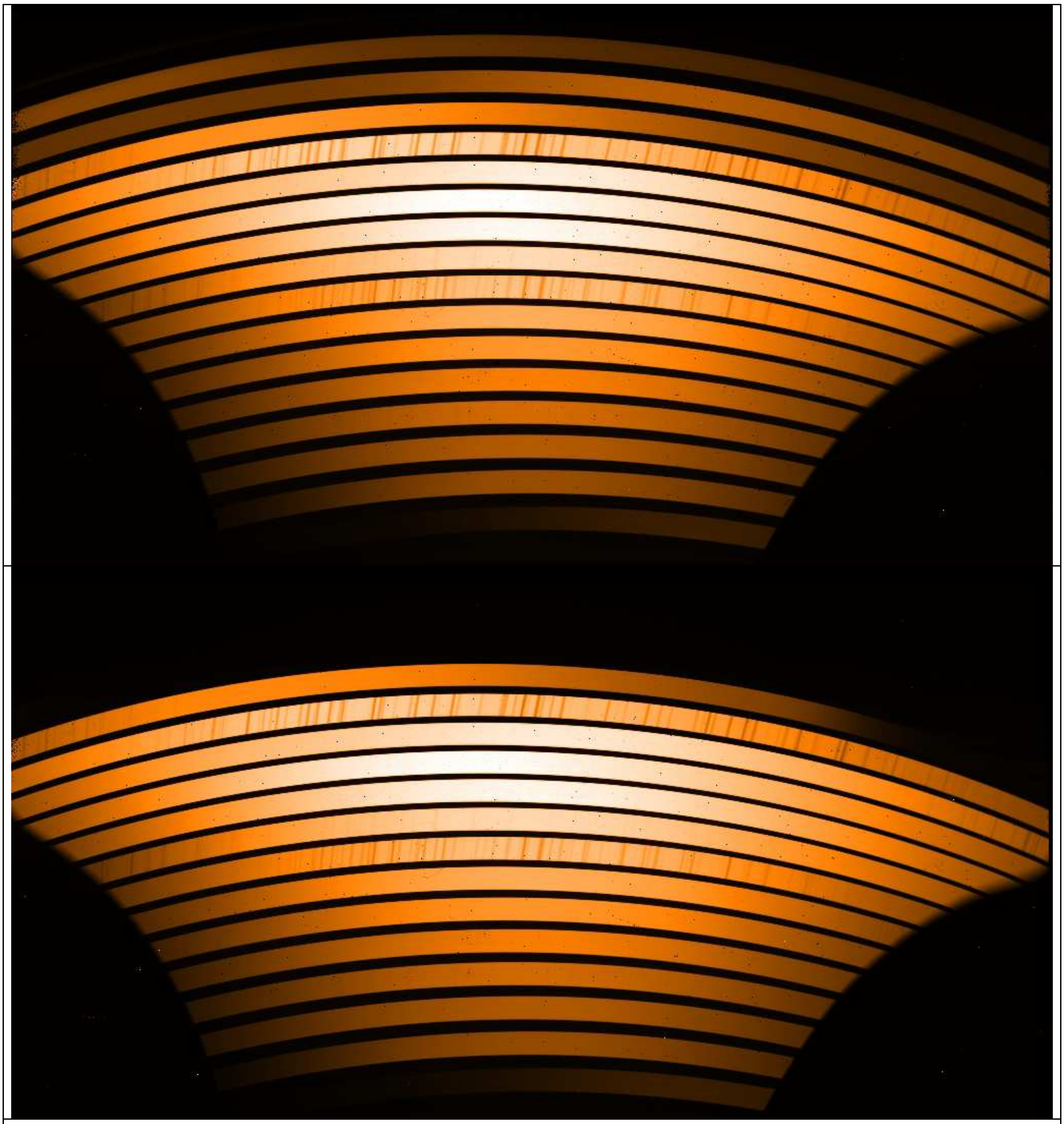
With the change of slits, the resolving power is slightly different:
They are indicated in the following table 10.

Table 10: NIR spectrograph slits and resolving power

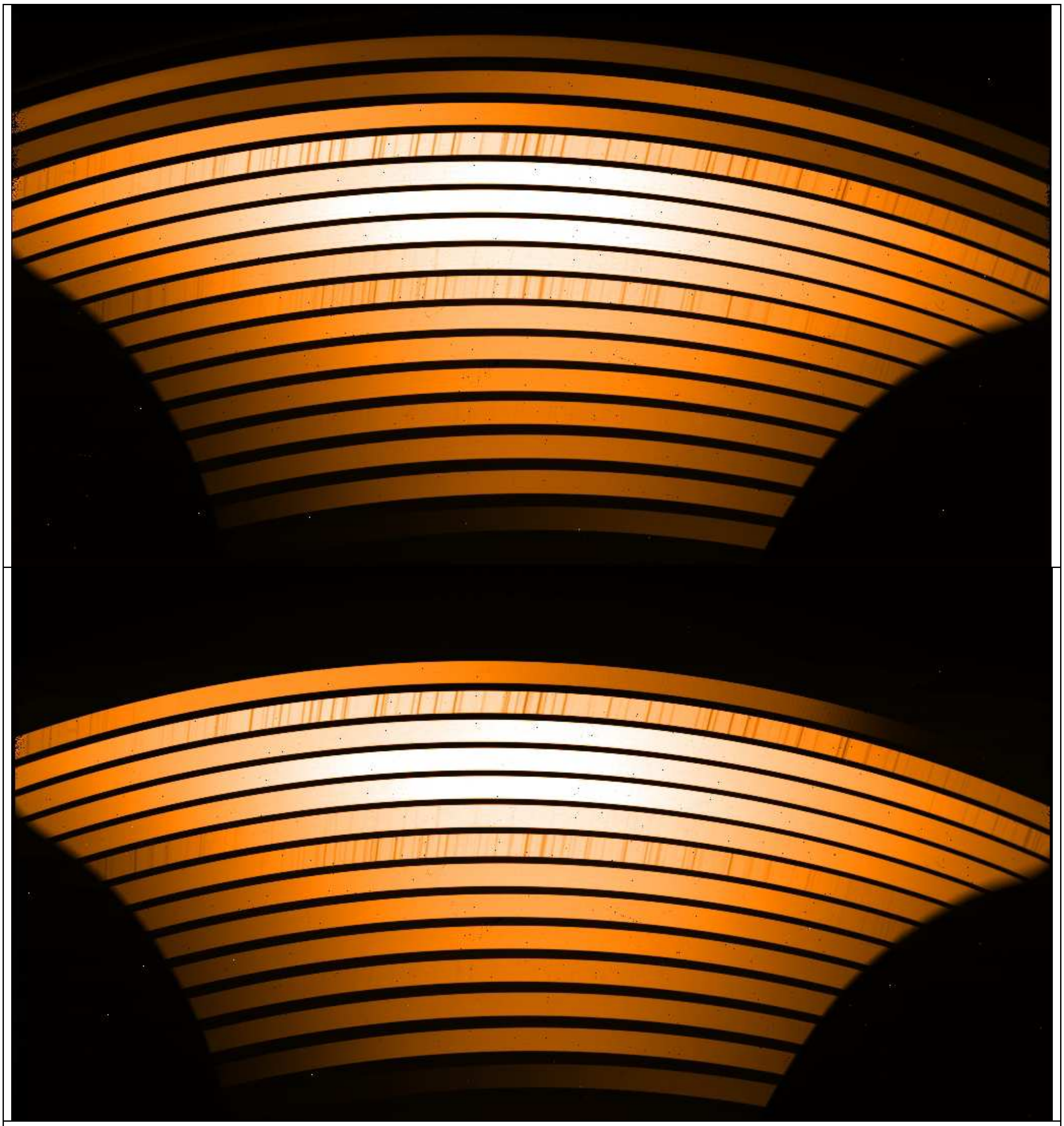
slit	R old slit wheel	R new slit wheel
0.4”	11000	10500
0.6”	7950	7780
0.6”JH*	X	7760
0.9”	5700	5300
0.9”JH*	X	5300
1.2”	3990	3890
1.5”	2540	X
5”	-	1400
IFU	8400	8300

***slits with the K band blocking filter.**

Below one can see flat-field frames for the slits with and without K band blocking filter.



ON-OFF Flat field frames for the normal 0.9” NIR slit (top) and for the 0.9” with blocking filter (bottom). One can easily note that the last orders are cut by the K-band blocking filter.



ON-OFF Flat field frames for the normal 0.6” NIR slit (top) and for the 0.6” with blocking filter (bottom). One can easily note that the last orders are cut by the K-band blocking filter.

2.2.5.3 NIR Backgrounds

The background of the new slits 0.6”JH and 0.9”JH with the blocking filter was compared to the background of the normal slits 0.6” and 0.9”.
The table 11 below gives example of the background measurements at different wavelengths for slits with and without filter.

Table 11: Background measurements of the slits with and without filter. The measurements were normalized to a theoretical 1” slit. The RON is not included here.

Wavelength nm	Background with filter e-/s/pix	Background without filter e-/s/pix	Reduction in %	Reduction factor	Sky darktime e-/s/pix
1048	0.0195	0.056	65	2.9	0.018
1238	0.027	0.10	73	3.7	0.022
1300	0.035	0.13	73	3.7	0.040
1682	0.040	0.15	73	3.8	0.050

The measurements (see above table) show that with the blocking filter the background is reduced in J and H bands by factors 3 to 4. They also show that at 1300nm, for the slits with blocking filter the background would be sky limited (not taking into account the RON).
For more complete information, see next pages the figures and explanations.

The figures below for the 0.9” and 0.6” slits with/without filter show the different noises at different wavelength taking into account all the sources of background noises:
thermal background, RON, sky background, dark current.
The black curve corresponds to the RON. The back dashed curve corresponds to the dark current. The dashed color curves correspond to the measurements at different wavelength for the slit without filter, the normal color curves correspond to the measurements at different wavelength for the slit with filter.

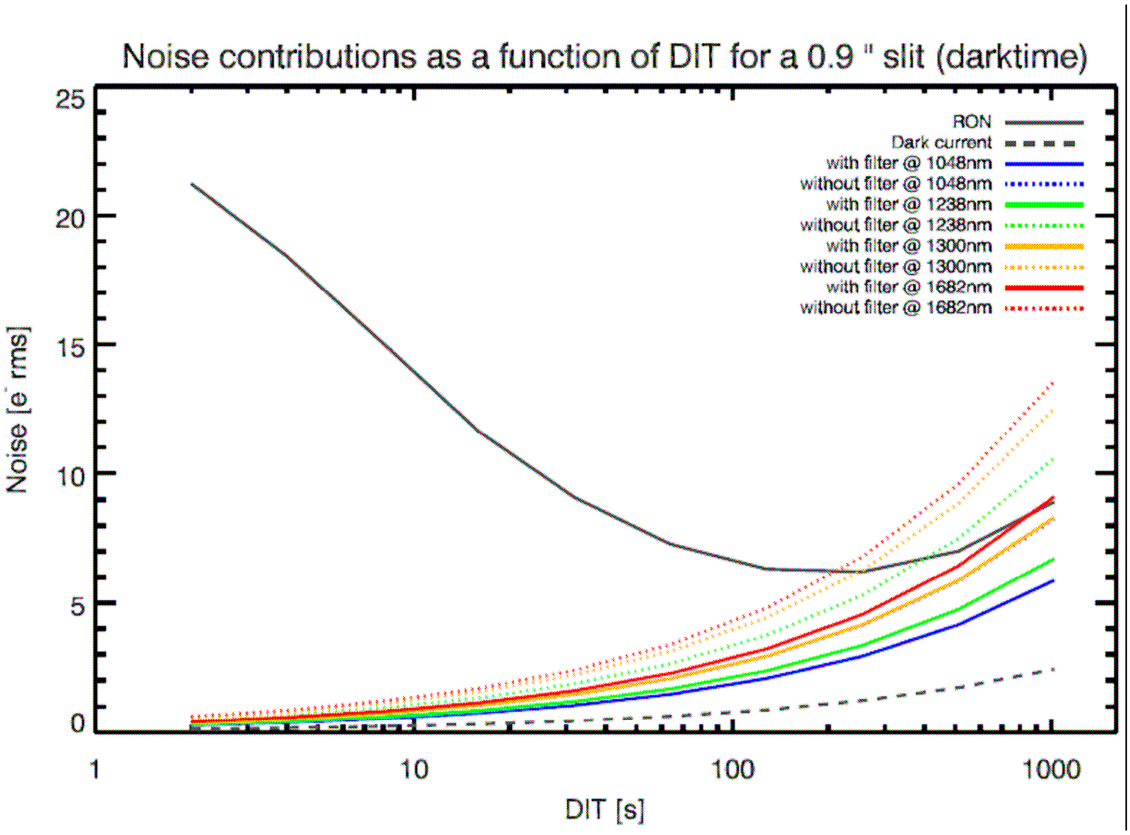
A Backgrounds with 0.9” slits with/without filters

a) For 0.9” slit with K-band blocking filter:

Unfortunately, the background is always RON limited for DIT shorter than 1000s whatever the wavelength is for this slit with filter despite a strong decrease of the RON. For DIT longer than 1000s, the background is sly limited at least at the 1682nm.

b) For normal 0.9” slit without filter:

For this slit, the background is RON limited for DIT up to 200s-300s at wavelengths 1682nm and 1300nm. Then for longer DIT the background is sky limited.



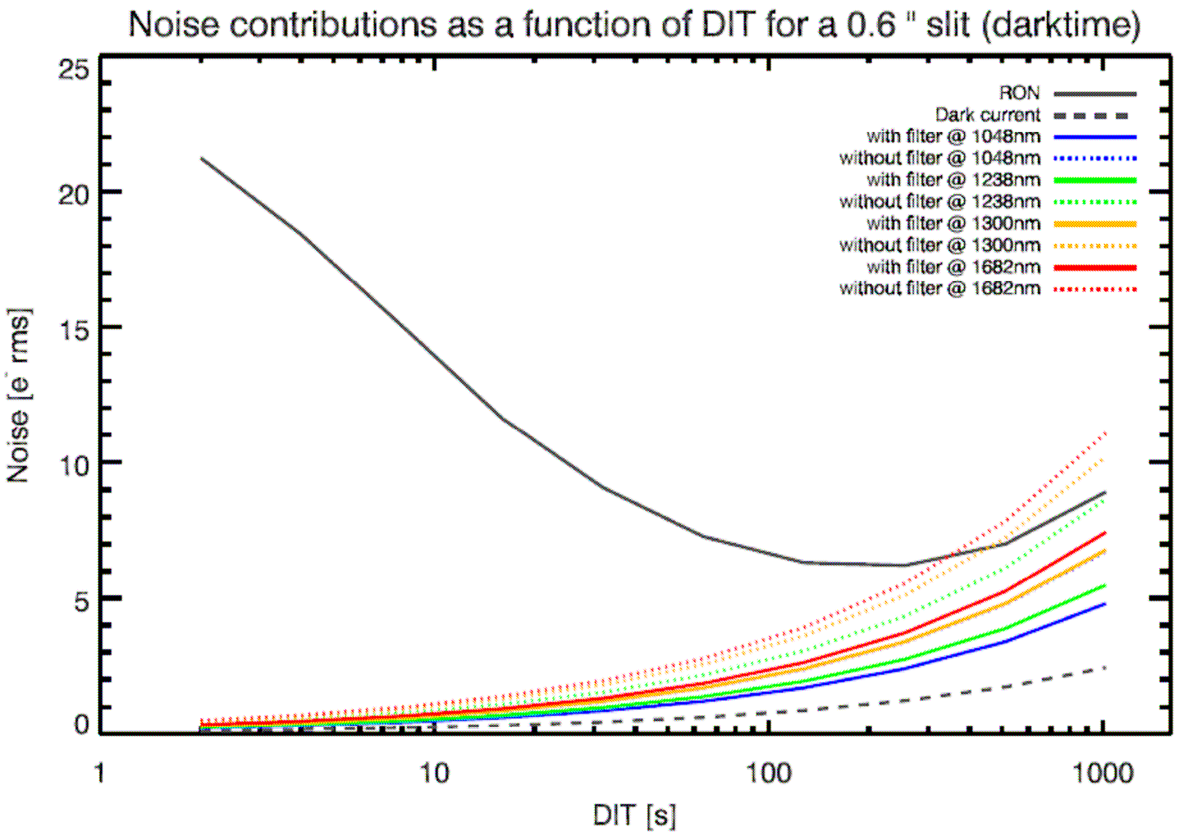
B Backgrounds with 0.6” slits with/without filters

a) For 0.6” ” slit with K-band blocking filter:

Unfortunately, the background is always RON limited.

b) For normal 0.6” slit without filter:

For this slit, the background is RON limited for DIT up to ~360s at wavelength 1682nm and 450s at 1300nm. Then for longer DIT the background is sky limited.



2.2.5.4 Optical layout

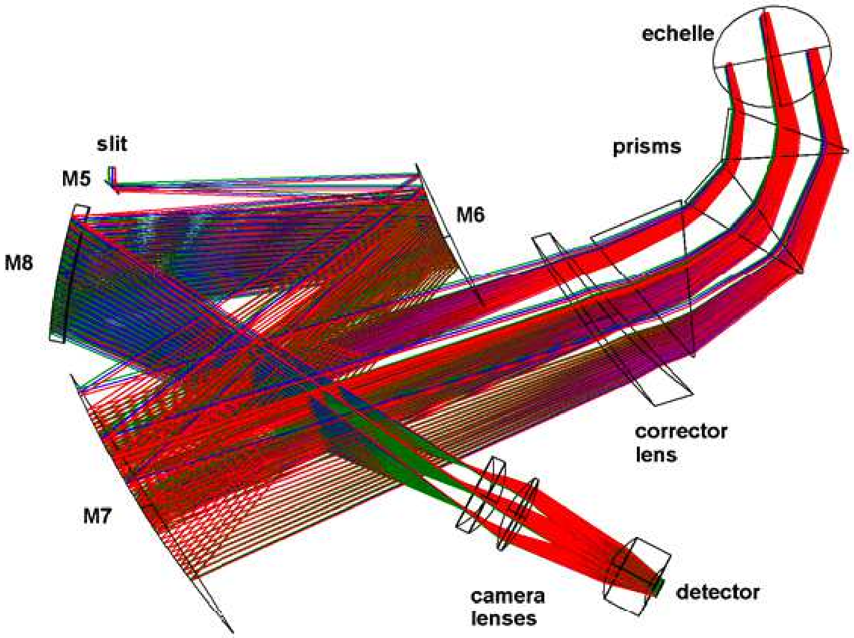


Figure 8: The NIR spectrograph optical layout.

The optical layout of the NIR spectrograph is presented in Figure 8. The conceptual design is the same than for the UVB and the VIS spectrographs. Light entering the spectrograph via the entrance slit and folding mirror M5 feeds an off-axis Maksutov-inspired collimator. In this case, the collimator is made of 2 spherical mirrors M6 and M7 plus an Infrasil corrector lens (with only spherical surfaces). In order to get enough cross dispersion, three prisms are used in double path. Prism 1 is a 35° top angle made of Infrasil; prisms 2 and 3 are two 22° top angle ZnSe prisms. This design provides an almost constant order separation. Main dispersion is provided by a 55 grooves/mm échelle grating with a blaze angle of 46.07˚. The off-blaze angle is 0.0˚, while the off-plane angle is 1.8˚. After dispersion, the collimator creates an intermediate spectrum near the entrance slit, where M8, a spherical mirror, acts as a field mirror, relocating the pupil between L2 and L3, the last lenses of the camera. The fixed focus camera re-images the échellogramme onto the detector at f/2.1 (plate scale 12.1"/mm).

2.2.5.5 Detector

The NIR detector is a Teledyne substrate-removed HgCdTe, 2k×2k, 18µm pixel Hawaii 2RG from of which only 1k×2k is used. It is operated at 81K. Measured characteristics and performances are given in Table 7. Sample-up-the-ramp (non-destructive) readout is always used. This means that during integration, the detector is continuously read out without resetting it and counts in each pixel are computed by fitting the slope of the signal vs. time. In addition, Threshold Limited Integration (TLI) mode is used to extend the dynamical range for long exposure times: if one pixel is illuminated by a bright source and reaches an absolute value above a certain threshold (close to detector saturation), only detector readouts before the threshold is reached are used to compute the slope and the counts written in the FITS image for this pixel are extrapolated to the entire exposure time (see Finger et al. 2008, Proc. SPIE, Vol. 7021 for a more detailed description).

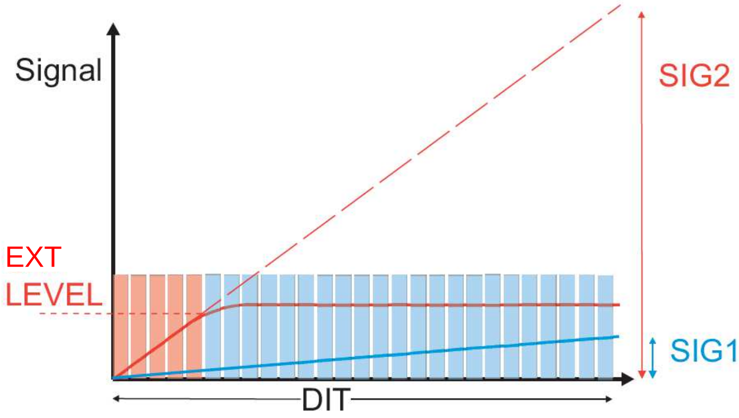


Figure 9: Extrapolation threshold for nondestructive sampling and extrapolation of detector signal for high flux levels. For pixels with high flux (red) only readout values below EXTLEVEL (orange rectangles) are taken into account in the calculation of the slope and values written in the FITS files are extrapolated to the full DIT (SIG2). For low flux pixels (blue) all nondestructive readouts are used (light blue rectangles). Modified figure coming from Finger at al. (2008).

Note that for operational reasons only a limited number of DITs is offered to the user in case of exposures longer than 300s (see 3.3)

Important Warning: adjacent pixels can follow different regimes by using this readout mode, one can follow the normal regime and its neighbour can follow and extrapolated regime (if the counts reach the extrapolation threshold). This may lead to bad line profile and then to affect for example the chemical abundances determination, etc. Therefore we strongly recommend to do as short as possible DIT and that the counts never reached 89000e- (or 42000 ADUs) in the ETC (meaning that the count will not be extrapolated).
A document explaining in details this readout mode and its different regimes with their consequences is available at:
http://www.eso.org/sci/facilities/paranal/instruments/xshooter/doc/reportNDreadoutpublic.pdf

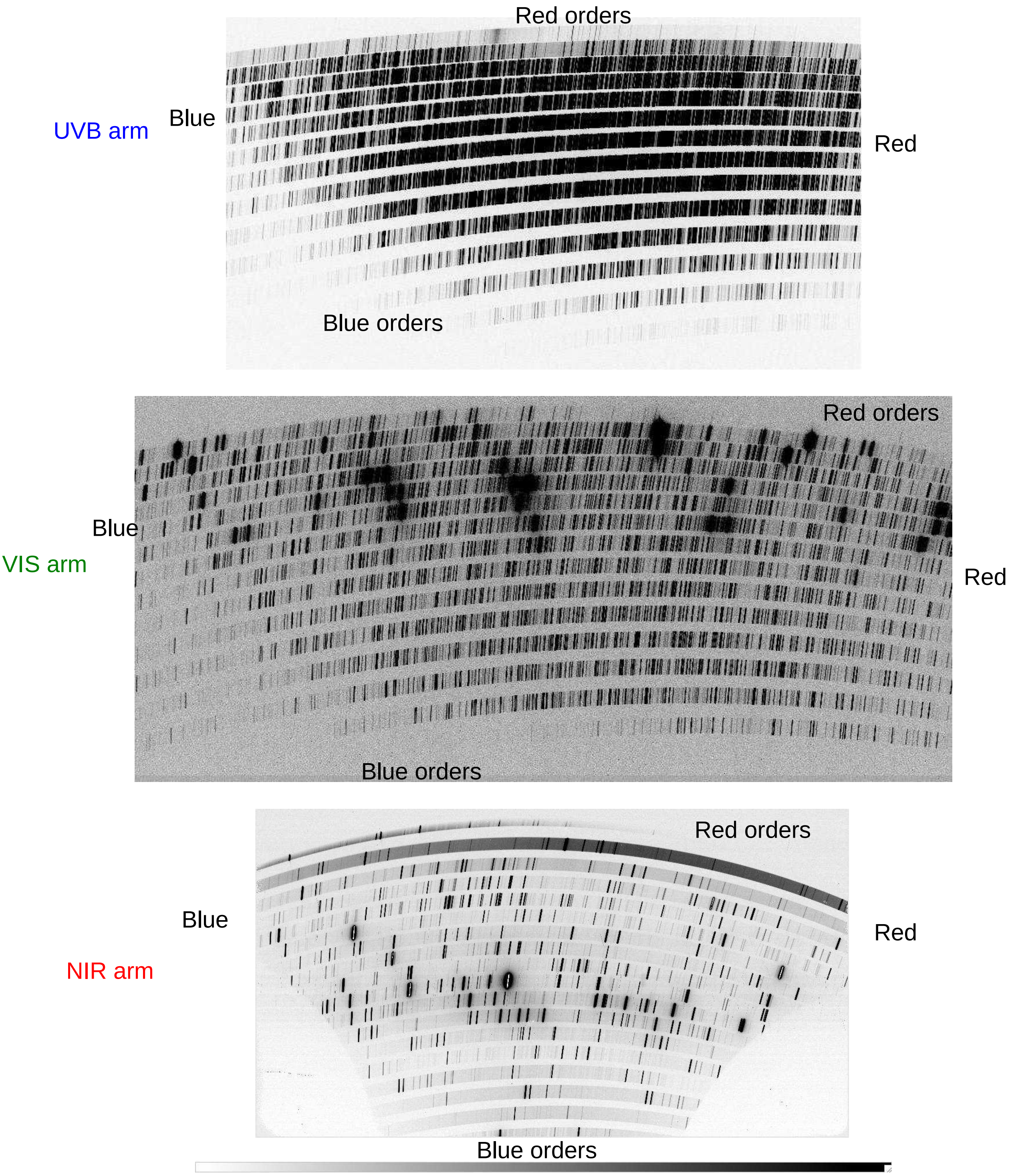


Figure 10: example of UVB (top), VIS (middle) and NIR (bottom) calibration frames. Strong order curvature and varying slit tilt and scale are clearly visible. Note for the NIR arm the higher thermal background in longer wavelength. This is specially the case in the 11th order that corresponds to the K band.

Table 12: X-shooter spectral format. * These orders are cut for the slits with the K band-blocking filter

Order	**Min. wavelength [nm]**	**Blaze wavelength [nm]**	**Max. wavelength [nm]**
UVB			
24	293.6	312.2	322.3
23	306.2	325.0	336.2
22	320.0	339.8	351.4
21	335.1	356.1	368.0
20	351.8	373.5	386.2
19	370.1	393.2	406.4
18	390.6	414.5	428.9
17	413.4	438.8	454.0
16	439.1	466.4	482.2
15	468.3	496.8	514.2
14	501.6	531.0	550.8
13	540.1	556.0	593.0
VIS			
30	525.3	550.5	561.0
29	535.8	568.0	580.2
28	554.6	585.9	600.8
27	575.2	607.7	622.9
26	597.4	629.5	646.8
25	621.3	653.8	672.5
24	647.2	682.1	700.4
23	675.4	711.2	730.7
22	706.1	742.6	763.8
21	739.7	777.6	800.0
20	777.0	815.8	839.8
19	817.6	860.2	883.8
18	862.9	904.3	932.7
17	913.7	957.3	987.4
16	970.7	1001.6	1048.9
NIR			
26	982.7	1005.8	1034.2
25	1020.5	1046.0	1076.7
24	1062.0	1089.6	1122.9
23	1106.6	1137.0	1173.1
22	1155.2	1188.6	1228.0
21	1208.2	1245.2	1288.5
20	1266.5	1307.5	1355.2
19	1330.3	1376.3	1429.4
18	1400.8	1452.8	1511.5
17	1479.5	1538.2	1604.0
16	1567.1	1634.4	1708.7
15	1667.8	1743.3	1823.3
14	1785.7	1867.9	1952.8
13	1922.6	2011.5	2102.0
12*	2082.9	2179.3	2275.6
11*	2272.3	2377.28	2480.7

2.3 Spectral format, resolution and overall performances

2.3.1 Spectral format

The spectral format of X-shooter is fixed. The spectral ranges on the detector and blaze wavelength for each order are given in Table 12 and an example of ThAr slit frame for each arm is shown Figure 10. The whole spectral range is covered by 12 orders in the UVB, 15 in the VIS, and 16 in the NIR. Orders are strongly curved (parabolic) and the spectral line tilt varies along orders. Both slit height and width projection also vary from order to order and along each order due to a variable anamorphic effect introduced by the prisms (crossed twice). For instance, the projected slit height (11") measured at the center of an order changes from:

- UVB: 65.9 pixels (0.167"/pix) at order 14 to 70.8 pixels (0.155"/pix) at order 24
- VIS: 65.9 pixels (0.167"/pix) at order 17 to 72.0 pixels (0.153"/pix) at order 30
- NIR: 52.4 pixels (0.21"/pix) at order 11 to 59.9 pixels (0.184"/pix) at order 26

The minimum separation between orders is ~4 (unbinned) pixels to allow inter-order background evaluation.

The dichroic crossover region between UVB-VIS and VIS-NIR is at 559.5 nm and 1024 nm respectively:

- Between UVB and VIS, the region where the combined dichroics transmit less than 80% is 556.0 -- 563.8 nm (7.8 nm wide). This region falls in the UVB order 13 (see Figure 11) and VIS order 29. Note that the VIS order 30 will still get some flux since dichroics still reflect/transmit ~15% of the light at 550nm.

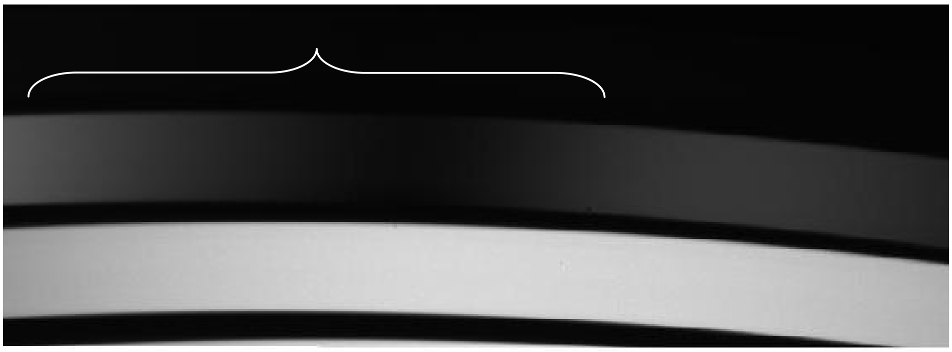


Figure 11: SLIT UVB QTH flat field, UVB arm, the dip due to the first dichroic is easily visible in the top order.

- Between VIS and NIR, the combined dichroics transmit less than 80% of the light between 1009.5 – 1035 nm (35.5 nm wide). This transition region falls in the VIS order 16 and NIR orders 26 and 25.

2.3.2 Spectral resolution and sampling

The user can only affect the spectral resolution through the choice of slit width (and to some extent with the binning in UVB and VIS). The resolution and pixel sampling (without binning) as a function of the slit width is given in Table 13.

Table 13: Resolution as a function of slit width

UVB			VIS			NIR		
Slit width	**R λ/Δλ**	**Sampling [pix/FWHM]**	**Slit width**	**R λ/Δλ**	**Sampling [pix/FWHM]**	**Slit width**	**R λ/Δλ**	**Sampling [pix/FWHM]**
0.5	9100	3.5	0.4	17400	3.0	0.4	10500	2.2
0.8	6200	5.2	0.7	11000	4.8	0.6	7770	2.9
1.0	5100	6.3	0.9	8800	6.0	0.9	5300	4.2
1.3	4000	8.1	1.2	6700	7.9	1.2	3900	5.8
1.6	3300	9.9	1.5	5400	9.7			
IFU	7900	4.1	IFU	12600	4.2	IFU	8300	2.7

2.3.3 Overall sensitivity

The total efficiency has been measured on sky using several standard stars observed during commissioning. Based on these values, the expected limiting AB magnitudes at blaze in 1 hour for a S/N of 10 per spectral bin are given in Figure 12.

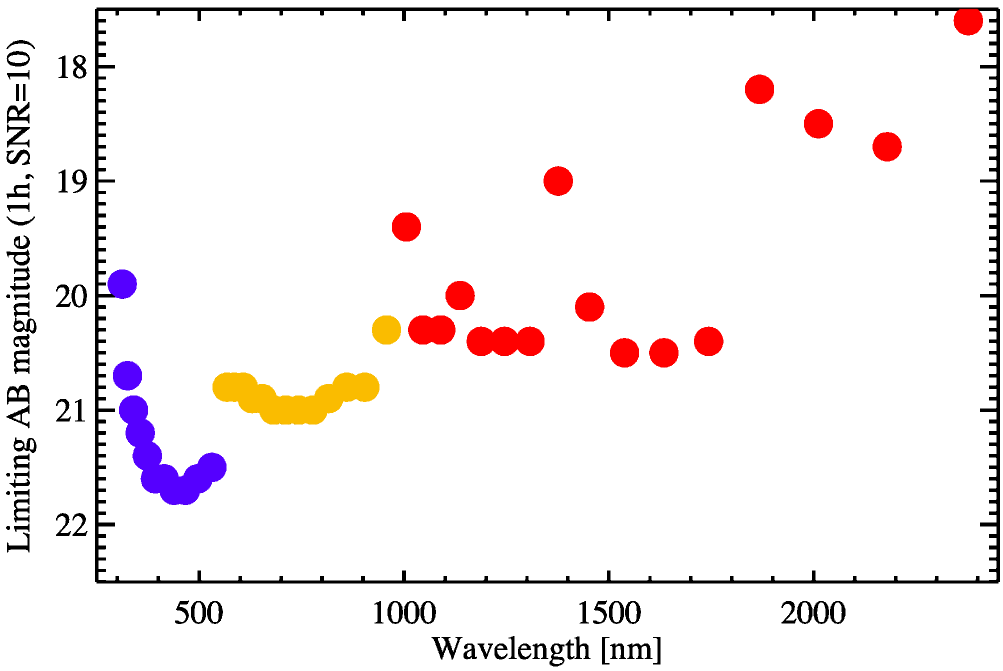


Figure 12: Limiting AB magnitude of X-shooter per spectral bin (using 2 pixels binning in the spectral direction) at S/N=10 in a 1 hour exposure. Other parameters: air mass 1.2, 0.8" seeing, 3 days from new moon, 1" slit for UVB, 0.9" slit for VIS and NIR. The ESO ETC was used to compute these values. The model uses overall efficiencies measured during commissioning. Note that these performance estimates assume no degradation of the SNR in the extraction process or in the sky subtraction. The decrease in efficiency to the blue side of the UVB range is due to the atmospheric absorption, at the red side of the VIS band it is due to the decrease in efficiency of the CCD, while on the long-wavelength side of the NIR range it is due to the rise of the thermal background.

2.4 Instrument features and known problems to be aware of

2.4.1 UVB and VIS detectors sequential readout

UVB and VIS detectors share the same FIERA controller. While both arms can expose simultaneously, readout is done sequentially. In practice, this means that if an exposure finishes in one of the arms while the other one is being read out, the shutter of the second arm is closed but readout is delayed until data from the first arm are fully transferred to disk.
See also Sect.3.4.6, which gives advices on how to use/reduce the dead-time corresponding to this sequential readout.

2.4.2 Effects of atmospheric dispersion

In IFU mode, there is no correction for atmospheric dispersion (see sections 3.3.1, 2.2.2).
Unfortunately due to ADCs problem, they were disabled on August 1st, 2012 and therefore the slit observations are now performed with disabled ADCs. See section 2.2.2 for information about the performances without ADCs and the atmospheric effect.

2.4.3 Remanence

After a few months of operation it has been verified that long DITs (namely 1800s DITs) in the NIR arm, especially when used continuously during the night, leave significant remnants by the thermal background in the K band and by the strongest sky emission lines. These remnants may still be visible in the morning DARK calibrations and certainly affect the nighttime observations, which follow the long exposures. For this reason starting from P86 the DIT=1800s is no longer offered. Remnants due to the thermal background in the reddest order of the K-band, has been observed, occasionally, also with shorter DIT. This is currently under discussion and analysis.

However, starting with P90, the DIT of 1800s will be offered again under strong constraints:
- it must be combined with a slit with the K-band blocking filter, meaning with the 0.6x11JH or 0.9x11JH slits only. In this way the remnants coming from the thermal background do not exist.
- the gain by using this long DIT must be highly relevant and has to be justified (waiver request).
- the users have to be aware that the remnants from the sky lines could/will remain but the spectral format is fixed, therefore it should not affect too much the observations. However, if it is observed during the calibration the presence of remnants (specially in dark frames), this could lead to forbid again this DIT (excepted in VM).

Remnants have been observed in the three arms also after ThAr calibrations (arcs, 2D-maps or format-checks). For this reason we discourage attached arc calibrations during the night (see section 5.4). The optimal exposure time, which allows the detection of a sufficient number of lines minimizing the presence of remnants, is being discussed. During daytime, arc exposures are taken last, in order to not affect the other calibrations.

About the UVB CCD, the recent tests show that the detector does not have remnants after arc exposures of 6 to 300s with the 1x1 binning and the normal readout mode, 3s exposure in the 1x2 binning for the normal readout mode, and 1s exposure for the 2x2 binning in the normal readout mode.

However it was observed some remnants after the observation during 300s of a very bright star that saturated the UVB detector.

2.4.4 Ghosts

Spurious reflections from the rear surfaces of the dichroics towards the first surface and back again produce a secondary image of the object on the slit that is displaced from its parent by few arcsec and leads to almost in focus ghost spectra in the bottom part of the spectra.
For a centered object the ghost is located on the edge of the orders but when a bright object is placed on the top part of the slit (positive x) it moves in and becomes particularly noticeable in the dichroic cut-off region between UVB and VIS arms. It is strongest in the last order of the UVB spectrum in the wavelength range of the dichroic reflectivity cut-off (see Figure 13, left). In the VIS, the ghost is noticeable in several orders and its intensity is <0.5% of the parent spectrum (see Figure 13, right). It is particularly relevant when observing a bright object with the nod on slit template.

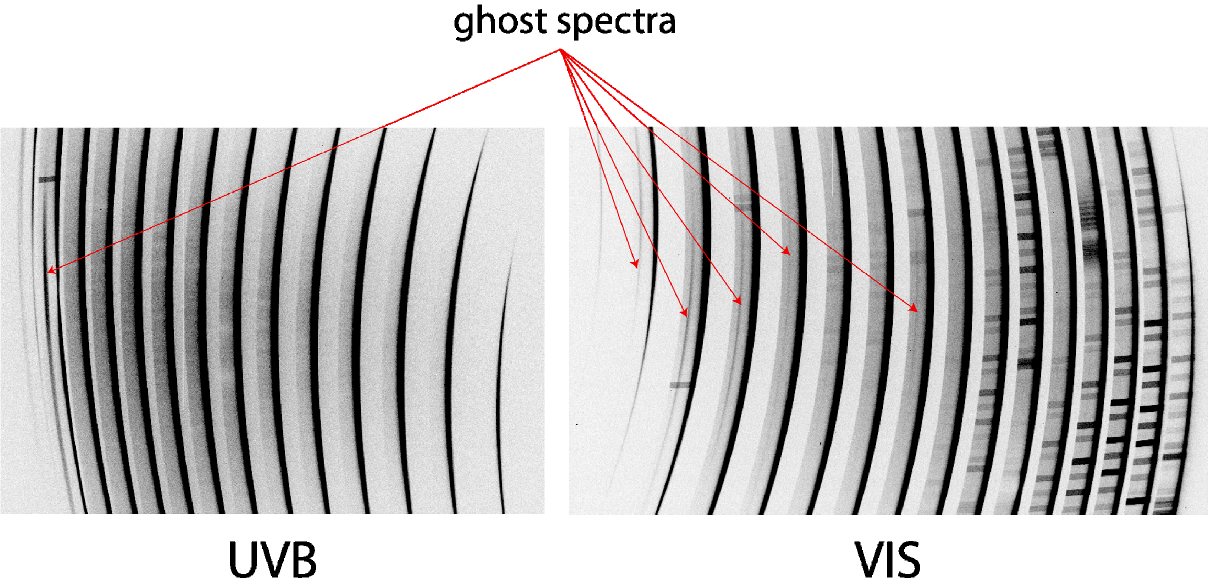


Figure 13: ghost spectra in UVB and VIS produced by back reflection in the two dichroics

A possible ghost seems also to exist in the NIR arm (Figure 14), it lies at the bottom-edge of some orders (at ~5”) when the observed object is bright. It counts for less than 1%.

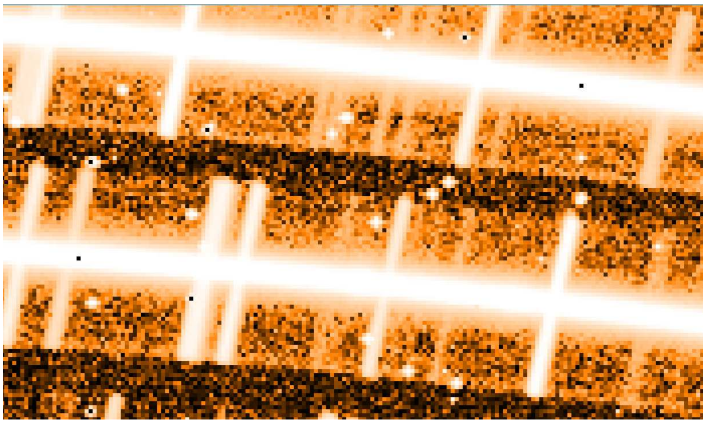


Figure 14: Ghost spectrum in the NIR arm.

2.4.5 Inter-order background

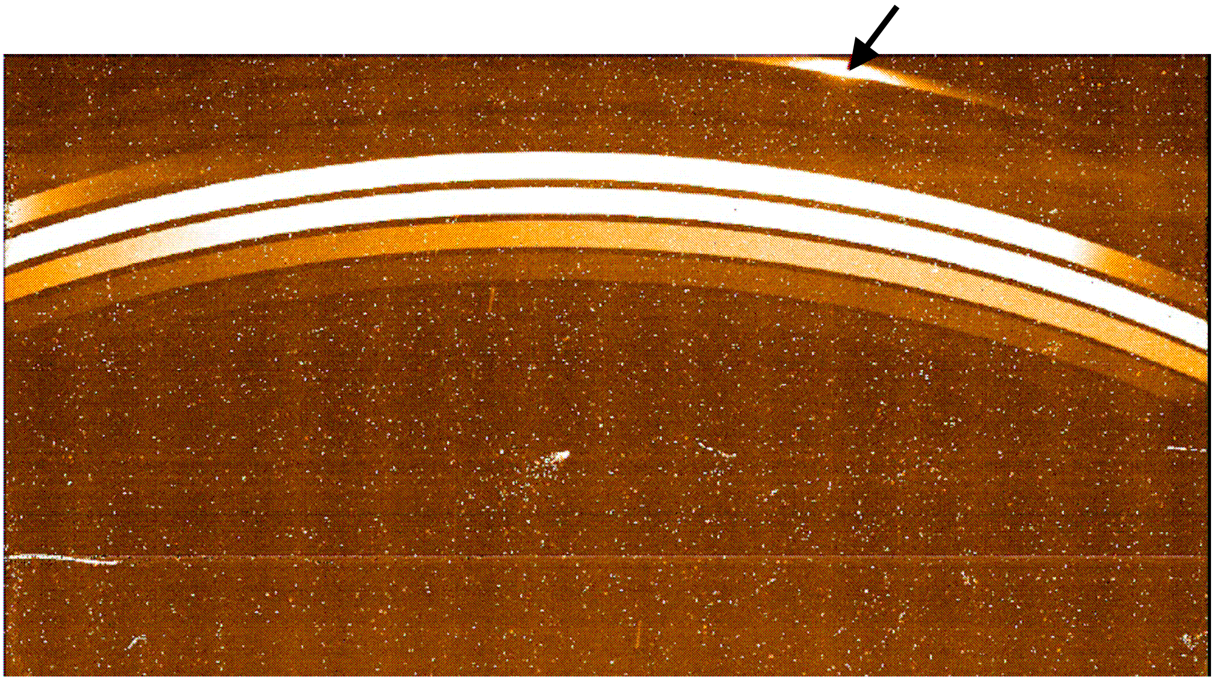
Inter-order background subtraction is a difficult task, in particular where order spacing is minimum in the red part of the VIS (~4 unbinned pixels). Therefore, whenever a good inter-order background subtraction by the pipeline is important, we recommend not using the 2x2 binning mode.

2.4.6 Dichroic 1 UVB-VIS/NIR arm dip oscillation

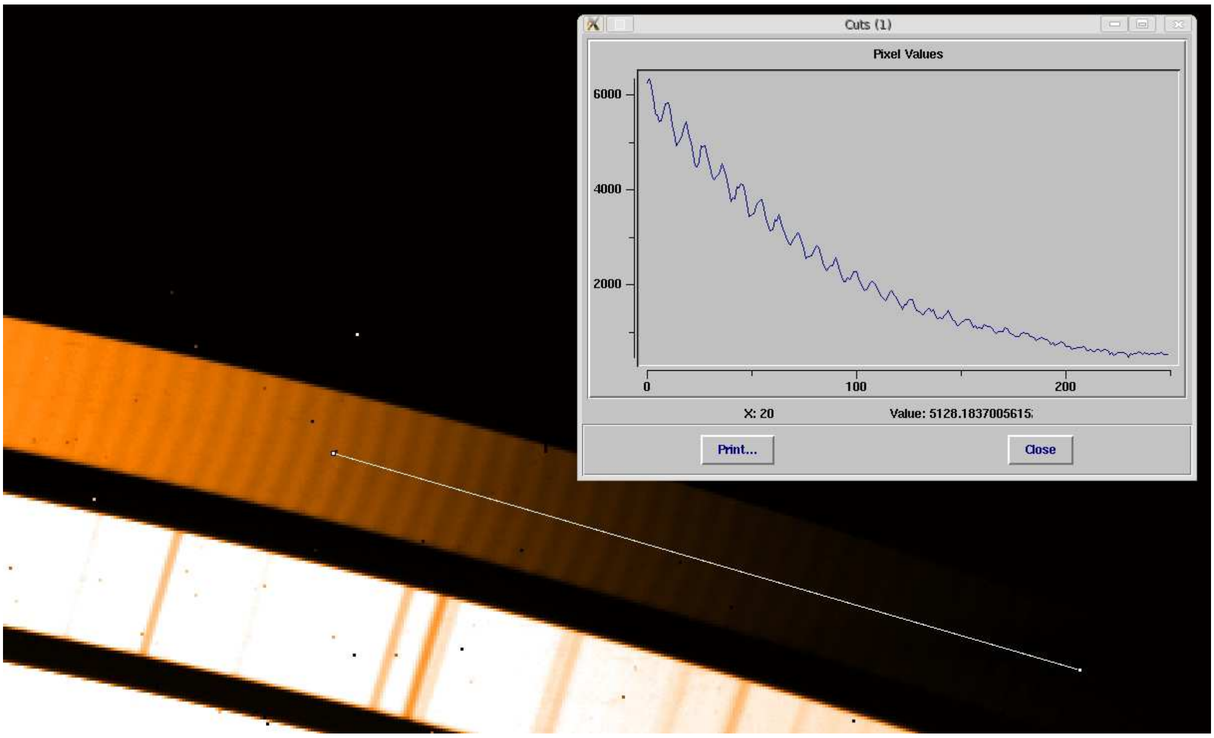
It was recently reported an “oscillation of the dichroic dip” in both the UVB and VIS arms. It means that the transmitted and reflected efficiency of the dichroic could be affected in the crossover regions. This problem is currently under investigation. It was possible to see that the flexures could cause similar effects as well as the ADCs (at least in the UVB arm and recently it was noticed in the VIS arm) in different positions. Nothing specific to the dichroics was found. The investigation will continue.

2.4.7 NIR frames with the K-band blocking filter features

- There is a leak in the K-band blocking filters implying that one can see in the right top corner some light. However, this light count is much lower than without the filter and in all cases the corresponding order is never used for science with those slits.



- With the 0.6”JH slit, some low level interferences are visible in the reddest part of the last order. The fringe peak-to-peak difference accounts for 10% of the level in the worse case. They are due to the filter itself. However they look stable over the different positions and could be corrected through the flat fields.



2.4.8 Instrument stability

2.4.8.1 Backbone flexures

The active flexure compensation (AFC) allows to maintain the three slits aligned with respect to the reference A&G pinhole to within ~0.02" in both at any rotation angle for ZD<60°.
It is advised to run again the AFC procedure every hour (it takes 70-80s) to correct for both the effect of a varying gravity vector and drifts of the piezo mirror position related to the control electronics of these devices. In all cases, it is better not to skip the AFC when a new OB is started.

2.4.8.2 Spectrograph flexures

From 0° to 60° zenithal distance for any rotator angle, the spectra format in all three arms stays within ~1.2 pixels from the zenith position.

2.4.9 Technical acquisition CCD

Even if the quality of the acquisition and guiding camera was improved, its performances are still not yet characterized. Therefore the possibility to do accurate photometry is not yet offered.

2.4.10 NIR 11th order vignetting (K band)

The flux in this 11th order decreases towards the top of the order by a factor of ~10% and is due to a bad design of the mask located in front of the NIR array. The same effect is present in the blue part of the 10th order.

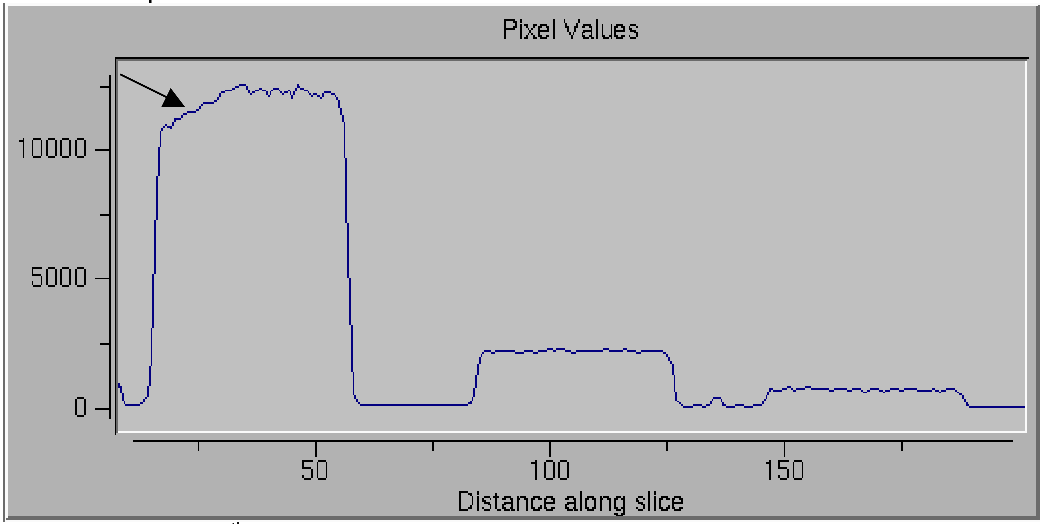


Figure 15: NIR11th order vignetting corresponding to a flux decrease (arrow). Figure from L. Christensen (technical note).

Trying to correct this vignetting would imply a major operation on the NIR arm with possible risks to degrade much more the NIR performances than they currently are.

2.4.11 VIS CCD pick-up noise

The pick-up noise in the VIS detector is present in every readout modes (with a deviation from the background level of lower than 0.5%). This pick-up noise is comparable to the pick-up noise measured on the UVES CCD for example. In case you want to observe faint targets with long exposure times, it is not recommended to use the fast readout mode due to its readout noise.

In addition the fast readout mode of the VIS CCD shows also very low level pattern with a deviation from the background level of 1%.
Figures are available at:
http://www.eso.org/observing/dfo/quality/XSHOOTER/qc/problems/problems_xshooter.html

In the slow readout mode, the pick-up noise is lower and the patterns are not seen.

2.4.12 NIR –IFU parasitic reflections

In the IFU mode, some reflections of small irregularities of the edges of the IFU mirrors can be visible in the images. However, they are faint and should not affect the observations.
An example is shown below in Figure 16 with an IFU flat field.

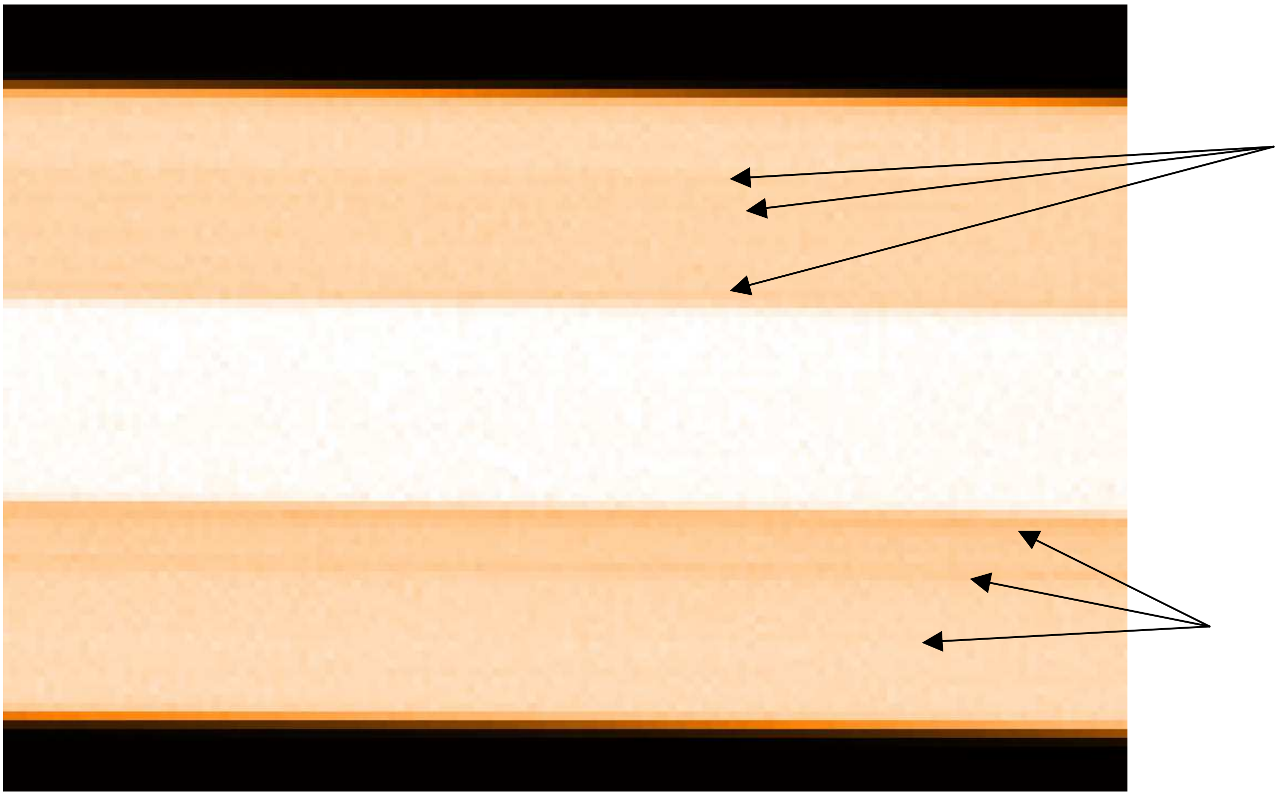


Figure 16: Example of small irregularities of the edges of the IFU mirrors in the NIR arm.

2.4.13 UVB/VIS ADCs problem

UVB/VIS ADCs intermittently show initialization problems, especially in cold conditions.
Since August 2010 a new operational procedure has been implemented to prevent starting science observations with the UVB/VIS ADCs in a wrong position. In the evening at the time of the instrument startup and during the morning calibrations the ADCs are closely monitored to ensure that the systems are working as expected.

Unfortunately the ADCs failed more and more frequently between March and July 2012 and it has been necessary to disable them since August 1st, 2012.
See section 2.2.2 for the relevant information about the efficiency of XSHOOTER with disabled ADCs.

2.4.14 TCCD loss of communication problem

Some time losses were due to losses of communication with the TCCD. A software solution was implemented and no major problem occurred again (only few mn lost vs hours). This is however still under monitoring. No more problems were reported till July 2011.

2.4.15 TCCD features

The cooling system of the CCD produces small oscillations of the temperature of the CCD around an average. Temperature variations affect the dark current level, so in case of short exposure times, when the image sampling frequency happens to align with the frequency of the temperature oscillations, this leads to "beats" and background level variations from one image to the next one. These variations in background level disappear if a longer exposure time is selected. In any case they do not affect the acquisition performance.
In addition since June 2011 the noise was improved and the quality of images allow under good weather conditions to see objects as faint as magnitudes 25 in R, V bands in 3mn.

3. Observing with X-shooter

3.1 Observing modes and basic choices

X-shooter offers two observing modes: SLIT spectroscopy and IFU spectroscopy. The spectral format is fixed for both observing modes. The three arms (UVB, VIS and NIR) operate in parallel.

In SLIT mode, the user can select, for each arm independently, a slit width among those listed in Table 13.

In IFU mode, the only important parameter the user has to choose is the wavelength that is placed and kept fixed at the centre of the IFU during observations. See section 2.2.2 for indications about the effects of this wavelength choice on the spectrum flux depending on the orders.

In both observing modes, one of the detector readout modes given in section 2.2.3 and 2.2.4 can be selected for the UVB and the VIS arm independently. The readout mode is fixed for the NIR arm.

All X-shooter science observing blocks (OB) are composed of an acquisition template (see 3.2) followed by one or several science templates selected depending on the observing strategy chosen by the user.

3.2 Target acquisition

Target acquisition for SLIT and IFU modes is almost identical. The main steps of a typical acquisition sequence are the following:

1. Warmup of the lamp for the flexure correction measurement.
2. Preset the telescope to the target coordinates and set the adaptor-rotator to the chosen position angle.
3. UVB and VIS ADCs start tracking to compensate for atmospheric dispersion in SLIT mode or set to their OFF position (i.e. at minimum deviation) in IFU mode.
4. Cross-correlating two frames of arc lamp spectra measures backbone flexure. The first frame corresponds to an arc lamp spectrum taken with the Acquisition and Guiding slide 0.5” pinhole with the 5” slit in each arm. The second frame is an arc spectrum taken with the 0.5” pinhole present in each slit slide/arm and the slot position in the Acquisition and Guiding camera. Commands are sent to the three tip-tilt mirrors based on computed flexures. If necessary this process is re-iterated.
5. The Acquisition and Guiding slide is set to MIR position: the field is now visible in the acquisition camera and an acquisition image can be acquired.
6. The spectroscopic target is identified (or the reference object in case of blind offset) and its coordinates on the detector are determined by a centring algorithm.
7. The telescope is offset to the reference pixel on the detector corresponding to the position of the image the Acquisition and Guiding slide reference pinhole corrected in real time from effects of atmospheric refraction between the wavelength of the selected acquisition filter and the telescope tracking wavelength (470 nm for SLIT mode, user selected for IFU observations). At the same time, whenever an offset is performed a snapshot of the A&G fov is saved.
8. Loop over steps 5 and 6.

9. When the observer is satisfied with the object centring, an acquisition image is saved and the Acquisition and Guiding slide is either set to the spectroscopic observations position (10” x 15” slot) in SLIT mode or to the IFU position along with other mode specific instrument setup.
10. In alternative to step 8, in case of a blind offset, the offsets are applied before acquiring the final image and moving to spectroscopic observation position. Note that the blind offsets are mandatory in case the target is too faint to be acquired directly.
11. At this point, the instrument is ready for science observations.

This acquisition sequence is performed by one of the two acquisition templates: `XSHOOTER_slt_acq` or `XSHOOTER_ifu_acq` (also the RRM possibility), depending on the selected observing mode. A full description of these templates is given in section 6.1.3. Note that the instrument setup is done within the acquisition template so that for instance an IFU observation can *never* follow a SLIT acquisition sequence and vice versa.

At the end of the acquisition sequence, an acquisition image of the field is saved after blind offsets have been applied (if any). Also note that everytime an offset is performed, the acquisition image is now saved. This can be useful for quickly varying objects such as GRBs.

FITS header keywords HIERARCH ESO SEQ AG XCEN and YCEN record the location of the centre of the SLIT or IFU in the image.

3.3 Spectroscopic observations

3.3.1 Overview and important remarks

3.3.1.1 Observing modes

X-shooter science templates support different observing strategies: staring (commonly used for UV and visible observations), nodding along the slit (classical near-IR observations, for SLIT only), offsetting to a fixed sky position (for extended objects) or lets the user free to choose any sequence of offsets (e.g. for mapping). Note that due to the small field of view of the IFU, we recommend to offset to a pure sky position in case good sky subtraction is needed.

3.3.1.2 Effect of atmospheric dispersion

See section 2.2.2 for the update of the situation, unfortunately the ADCs have been disabled due to their unreliability at night. Therefore the observations are conducted with the ADCs fixed at the non deviation position for both the IFU and SLIT modes.

Obsolete: In SLIT mode, effects of atmospheric dispersion are automatically corrected in the UVB and VIS arms thanks to the two ADCs. However they are fully working up to airmass 2. For larger airmass the compensation is not perfect and above airmass 2.5 bad.

In *IFU mode however, there is no correction for atmospheric dispersion* (the two ADCs come *after* the IFU in the light path and are set to their OFF position where they do not disperse light). The user has to choose which wavelength will be kept fixed at the centre of the IFU during observations using the SEQ.IFU.WLGT parameter in the `XSHOOTER_ifu_acq` template. It is set to the middle of the atmospheric dispersion range (470nm) by default. Users are therefore recommended to orient the IFU parallel to the parallactic angle whenever possible and should keep in mind that at high airmass, the amplitude of the dispersion is larger than the 4" of the IFU field. Therefore we always recommend to specify a low airmass for the observations (better than 1.5 should be enough).

3.3.1.3 Exposure time in the NIR arm

Only a limited choice of DIT values is allowed for the NIR observations in service mode. This has been decided only on an operational basis, i.e. to avoid endless daytime calibrations. In particular, there are no constraints for short NIR exposure (up to 300s), while only the following selection is available in the case of longer exposure (≥ 300s): DIT=300, 480, 600, 900 and 1200 s. Note that the DIT=1800s is no longer offered as it has been verified that it leaves remnants (see section 2.4.3). However, the minimum DIT is 0.66s.

The use of the NDIT different than 1, will give one "averaged" exposure internally of the DIT integrations. The pre-processor of the system is averaging internally the NDIT individual DIT integrations. The number of counts will only correspond to DIT but the noise will be reduced.

Example, NDIT=2, DIT=100s,NINT=1 will give 1 averaged exposure. The total integration time will be of 200s.
NDIT=1, DIT=100s, NINT=2 will give 2 exposures of 100s each. The total integration time will be of 200s.
NDIT=2, DIT=100s, NINT=2 will give 2 averaged exposures. The total integration time will be of 400s.

NDIT=1 should be used in most cases.

3.3.2 Staring (SLIT and IFU)

With the `XSHOOTER_slt_obs_Stare` and `XSHOOTER_ifu_obs_Stare` templates, one or more spectra are taken with each arm independently at a fixed position on sky. For each arm, the user chooses the exposure time and the number of exposures. Exposures are completely asynchronous i.e. in each arm, whenever an exposure is finished the next one starts immediately, independently of what is happening with the other arms.

3.3.3 Staring synchronized (SLIT and IFU)

Whenever exposures in the three arms have to be parallel, the templates `XSHOOTER_slt_obs_StareSynchro` or `XSHOOTER_ifu_obs_StareSynchro` should be used. In this case, the number of exposures is fixed to one per arm. Exposure times can still be different in each arm but the exposures are synchronized to their mid-time. In case the exposure times in all three arms are identical, exposures in the three arms will have the same start time within approximately one second. In case of different exposure times, the mid-exposure time of the three will coincide within about one second.

3.3.4 Nodding along the slit (SLIT only)

This corresponds to the standard way of observing in the near-IR primarily aimed at a double pass sky subtraction. The template `XSHOOTER_slt_obs_AutoNodOnSlit` automatically nods the telescope between two positions (A and B) along the slit. The user defines a *Nod Throw* and optionally a small *jitter* box (in the slit direction). The *Nod Throw* is defined as the distance between the two nodding position i.e. the center of the two jitter boxes inside the slit (see Figure 17). Ditto for the jittering box, the jitter value corresponds to the size of the box.
One cycle is a pair of AB or BA observations. Cycles are repeated in ABBA sequences. For each arm, the user chooses the number of exposures at each position and the exposure time (both identical for all A and B positions). Exposures are asynchronous. Note that nodding is not offered in IFU mode because the field of view (4"x1.8") is too small to nod within the IFU. Also note that it is not possible to move the target in one arm independently from the other arms.

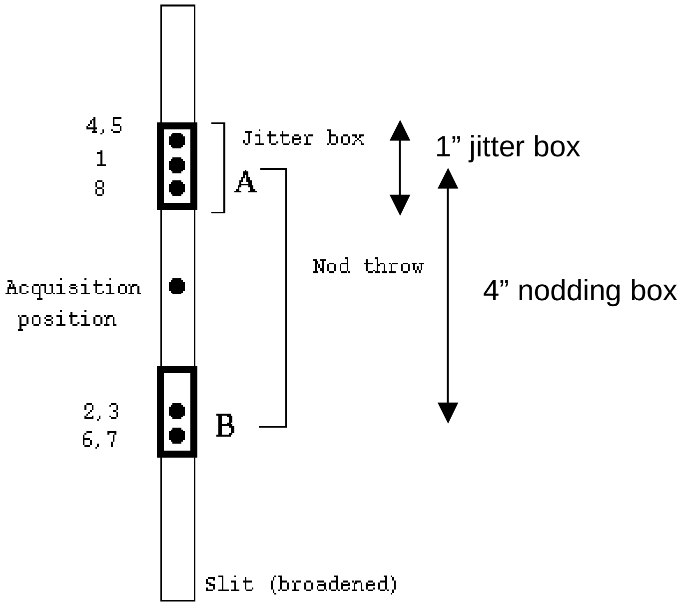


Figure 17: conventions used for nodding of 4" along slit observations. The sequence illustrated here corresponds to 4 cycles (8 exposures, ABBAABBA) with a jitter box of 1".

3.3.5 Fixed offset to sky (SLIT and IFU)

When observing extended objects for which there is no or not enough pure sky in the 11” slit to perform a good sky subtraction one should use the template `XSHOOTER_slt_obs_FixedSkyOffset` or `XSHOOTER_ifu_obs_FixedSkyOffset.` It allows alternating between an object (O) and sky position (S) with the possibility of adding a small jittering around the object and the sky position. One cycle is a pair of OS or SO observations. Cycles are repeated in OSSO sequences. For each arm, the user chooses the number of exposures taken at each position and the exposure time (both identical for all O and S positions). Exposures are asynchronous.

3.3.6 Generic offset (SLIT and IFU)

These are the most flexible observing templates. `XSHOOTER_slt_obs_GenericOffset` and `XSHOOTER_ifu_obs_GenericOffset` allow the user to define any pattern by providing a list of (cumulative) telescope offsets. This is particularly useful in case one wants to map an object with several slit or IFU positons. The number of exposures taken at each position and the exposure time (both identical at all positions) have to be defined. Exposures are asynchronous. See also Orientation and conventions.

3.4 Observation strategy, summary, and tricks

3.4.1 Instrument setup

Instrument mode	Observing mode	Readout/binning	slits	PA
SLIT (RRM or normal)	STARE NODDING FIXED-OFFSET GENERIC OFFSET SYNCHRONIZED ETC	UVB 100k,1x1 UVB 100k,1x2 UVB 100k,2x2 UVB 400k,1x1 UVB 400k,1x2 UVB 400k,2x2 VIS 100k,1x1 VIS 100k,1x2 VIS 100k,2x2 VIS 400k,1x1 VIS 400k,1x2 VIS 400k,2x2 NIR non-dest	UVB, 0.5”,0.8”,1.0”,1.3”,1.6”,5” VIS 0.4”,0.7”,0.9”,1.2”,1.5”,5” NIR 0.4”,0.6”,0.9”,1.2”,5”, blind, 0.6”JH, 0.9”JH	9999=parallactic angle or choose another value
IFU (RRM or normal)	STARE FIXED-OFFSET GENERIC OFFSET SYNCHRONIZED ETC	UVB 100k,1x1 UVB 100k,1x2 UVB 100k,2x2 UVB 400k,1x1 UVB 400k,1x2 UVB 400k,2x2 VIS 100k,1x1 VIS 100k,1x2 VIS 100k,2x2 VIS 400k,1x1 VIS 400k,1x2 VIS 400k,2x2 NIR non-dest	IFU 1.0”x12.6” fixed in each arm	9999=parallactic angle or choose another value

Table 14: Instrument setup summary

3.4.2 Observation strategy

This section provides basic information for the observations. To better specify the strategy of your observations, you should contact usd-help@eso.org (SM and VM), or discuss it with the Paranal day/night astronomers (in VM).

In all cases, you can choose different kind of observing modes (see Sect.3.4.1) and different slits on the different arms (if no IFU) after the acquisition template.
For example you can do:
SLIT acquisition - SLIT STARE- SLIT NODDING

- **Point-source object:**

Usually if your object is a point source-like the slit spectroscopic observation is the best.
In such case, select the SLIT instrument mode.

-If the infrared observations are critical, the NODDING mode is preferable than the other ones because it will allow to better correcting the sky emission lines and the sky variation.

-In case the NIR observation is not so critical, the use of the STARE mode is OK. The object will stay in the same position of the slit. This mode corresponds to the usual observing mode with other optical instrument as UVES.

-Select a slit of about 0.9”-1” if you want to match the slit with the median seeing at Paranal (0.8”). However, if you are interesting in the resolving power, select narrower slit. At the opposite if you are interesting in the flux calibration, select the 5” slits.

-As shown in the example above, you can combine in the same OB different templates/observing mode. One can use the STARE mode with 5” slits for the flux calibration and then move in the next template to the NODDING mode with narrower slits for more accurate spectroscopic investigations.

- **Point-source object with bad seeing:** IFU as image slicer

-As indicating above, the SLIT mode is commonly used for the observation of point source object. However, in case of faint object or you allow observations of the object with bad seeing, the use of the IFU could be appropriate because this is physically an image-slicer.

-However, the nodding is not possible with such instrument mode and for better sky correction an offset to the sky position (FIXED-OFFSET mode) is required.

-The resolving power is also fixed due to the slits fixed in the IFU observation.

-Another point is that the user has to specify the tracking wavelength because the ADCs are in OFF position.

- **Extended object (galaxy) or crowded field (globular cluster):**

-In case of an extended object, let say a galaxy of 25” in the sky or a star in a huge nebula, the use of the SLIT mode if you are interested by the core of the galaxy or by the star is OK. However, the sky correction will be difficult.

-Doing the NODDING is useless in such case because after offset the slit will still be in the surrounding environment (galaxy-disk or nebula).

-The use of the STARE mode is OK and the sky lines correction is performed with the pipeline. In addition, in case of extended object you will also get spatial information along the slit. In such case, you can choose to specify another position angle than the default one that is the parallactic angle.
Note that with the pipeline, you can select the region of spectra-extraction and extract in a first iteration, the object spectrum, and in a second iteration, the nebula spectrum for instance (see the data reduction cookbook that is coming soon).

-The FIXED-OFFSET or GENERIC-OFFSET observing modes are suitable. With the first one, you will do the couple of observation: object-sky positions. With the second one, you are able to do a mapping of the environment and also do offset to sky position. However, in the GENERIC-OFFSET template, all the offset values are cumulative and refer to the current position (see also Sect.6.1.1).

- **Extended object: radial velocity map, structure, or other: IFU**

-In case you want to investigate the structure of an extended object such as a nebula, to do the radial velocity mapping of a galaxy, etc, the use of the IFU is recommended.

- **Time series of variable object:**

-The observing mode SYNCHONIZED was foreseen for such kind of observations. It synchronizes the three arms at the middle of their exposures. This template can be used for following spectroscopic binaries.

-The readout time should be chosen as small as possible, i.e. here the 400kHz mode should be preferred to the 100kHz mode for the UVB and VIS mode. However it depends on the target too (timescale of the variation, faintness).

- **Highly time-critical object**: fast flux variation: GRBs etc: **RRM**

-In case you want to observe objects visible during few minutes or hours such as Gamma Ray Bursts, the Rapide Response Mode is appropriate.

-Just follow the same strategy than indicated above and instead of the normal acquisition template, you will use the RRM acquisition template.

-In addition you may want the snapshot of the acquisition camera corresponding to the object at the end of the acquisition process and at the end of the OB. In such case, set the snapshot flag to TRUE instead of FALSE in the observing template. However, the imaging mode of XSHOOTER is not yet characterized and offered.

3.4.3 Telluric standard stars (see also Sect.5.6.1)

The user should specify in the README of their observation, which kind of telluric standard star is needed for the science observation. The telluric standard stars are in P89 as in the previous periods automatically observed in service mode in the Observatory time.
Currently the telluric standard stars observed by the Observatory should have about 10000 ADUs in the middle of the brightest orders of each arms (S/N~50-100).
If the user needs the observation of a specific star or needs very high signal to noise, corresponding calibration OBs should be prepared and submitted. The corresponding time will be charged to his/her program.
In addition, the Observatory does not provide observations of telluric standard stars with slits of 5”.
Up tp P90, for saving time by default in service mode, the telluric standard stars are observed in (IFU or SLIT) stare mode. If the users need other kind of observations, they should indicate it in the README or better supply their own OBs. The Observatory already spend about 10% of the available time for taking telluring standard stars spectra, a change from stare to nodding mode would increase by 25% this time spent.
In P91, the telluric standard stars observations will be performed in nodding mode but with the fast readout modes in UVB/VIS arms irrespective to the readout speed used in the science OB. The binning will match the one of the science OB.

Such kind of change should increase by about 10% the time spent on telluric standard stars observations. However despite the use of the fast readout modes, the SNR will not be dramatically modified and the telluric, sky, background and bad pixels corrections should be improved.
This modification in the strategy of the telluric standard stars observations is mostly relevant for the bright objects.

3.4.4 Observing bright objects

With respect to the previous periods, it was found that some of the proposed objects are too bright for doing their observation with XSHOOTER.
In particular, do not forget that the minimum DIT in the infrared is 0.66s, this means that no DIT lower than 0.66s exist and the IRACE controller will transform DIT shorter than 0.66s to 0.66s integration.
According to the ETC and measurements, one must not try to observe stars brighter than magnitude 3 because it will lead to saturate the detectors:
It is the case of an A0V or O5 or F0 stars observed under a seeing of 0.8”, at an airmass of 1.2, with the slits 0.5” in the UVB, 0.4” in the VIS, 0.4” in the NIR and integration times of 0.1s in the UVB and VIS and the minimum DIT 0.66s in the NIR.

In case of saturation indicated by the ETC for the object, try to reduce the exposure time if possible, and to choose a narrower slit.
Usually the OBs have to be observed within the specification, i.e. with better conditions than requested but in such case, for bright objects the detector can saturate leading to time losses, useless data, remnants in different arms, and possibility to classify the OB as not feasible (no repeated observation). Thus we strongly encourage the users to check their objects with the ETC, and to avoid observing extremely bright objects.
Ditto we encourage the users to check that the counts never enter the extrapolated regime of readout in the NIR.

3.4.5 Image snapshot

Starting in P88, a snapshot of the acquisition camera (AG) is saved every time an offset is performed in order to show the position of the target after the offset performed. It is also useful in case of variable objects like fast fading GRBs. In addition a snapshot is saved at the end of the acquisition process, replacing the AG snapshot that was taken from the science template.
In case of blind offset, an AG snapshot is taken after the blind offset performed and at end of this acquisition sequence.
As a consequence, the possibility to take an extra-snapshot from the science template is removed from P89.

3.4.6 Readout times in the UVB and VIS arms: minimization of overheads

Because the UVB and VIS detectors are sharing the same FIERA controller, both detectors cannot be read at same time. Therefore it may happen that one arm, although its exposure is already finished, has to wait the end of the read-out of the other arm. To minimize this dead-time, one should increase a little bit the exposure time in the UVB or VIS arm. Then, once the first image is finished and being transferred, the other arm is still integrating.
Then the second image of the remaining arm will be read.

For example, if you will read out in slow, unbinned mode, and expect to be photon starved in the UVB, then according to Table 15 (see next page) you should make the VIS integration at least 92 s shorter than the UVB one.

The readout time of the NIR is very short ~1s and does not interfere with the UVB and VIS because it is using a different controller (IRACE).

4. Instrument and telescope overheads

4.1.1 Summary of telescope and instrument overheads

Table 15: overheads

Acquisition and setup		
Telescope pointing, guide star acquisition, start active optics. X-shooter backbone flexure measurement.		360s
Interactive acquisition loop		See a
Instrument setup at the end of acquisition		SLIT: see b
		IFU: see b
Observations		
Detector readout, See also c	UVB	1x1, slow / fast: 68s / 16s 1x2, slow / fast: 34s /8s 2x2, slow / fast: 17s / 4s
	VIS	1x1, slow / fast: 89s / 21s 1x2, slow / fast: 45s / 11s 2x2, slow / fast: 22s / 5s
	NIR	1.46
Each telescope offset		15 s

a): Acquisition overheads

the acquisition time depends on the integration time set in the AG camera:
Direct acquisition loop = Preset time
+ (Tel offset + AG_EXPOSURE)*3
+ AG_EXPOSURE (saved)
Blind offset acquisition loop = Preset time
+ (Tel offset+ AG_EXPOSURE)*3
+ telescope blind offset to target
+ AG_EXPOSURE for check
+ AG_EXPOSURE saved.
Tel offset= The telescope offset could be up to 15 sec

The telescope (blind) offset to the target could be up to 30 sec.

Acquisition template | acquisition time (s)
-----------------------+--------------------
XSHOOTER_slt_acq =360+(Tel offset + AG_EXPOSURE)*3+AG_EXPOSURE
XSHOOTER_ifu_acq 360+(Tel offset + AG_EXPOSURE)*3+AG_EXPOSURE
XSHOOTER_slt_acq_RRM=360+(Tel offset + AG_EXPOSURE)*3+AG_EXPOSURE
XSHOOTER_ifu_acq_RRM=360+(Tel offset + AG_EXPOSURE)*3+AG_EXPOSURE

if the AG_EXPOSURE time is setup at 1s:
XSHOOTER_slt/ifu_acq=360+(15+1)*3+1=409s
if the AG_EXPOSURE time is setup at 3mn or 180s:
XSHOOTER_slt/ifu_acq=360+(15+180)*3+180=1025s

If the AG exposure time is lower than 1s, the wiping time for doing the snapshot takes about 1s, therefore a minimum time of 1s is considered.

b) Setup overheads

In addition to these acquisition overheads, overheads regarding the instrument setup must be added.
For the slit mode, the setup overhead is 30s, while for the IFU mode it lasts for 60s.

In the case of
Integration time of 1s
XSHOOTER_slt_acq+setup=409+30=439s
XSHOOTER_ifu_acq+setup=409+60=469s
Integration time of 180s
XSHOOTER_slt_acq+setup=1025+30=1055s
XSHOOTER_ifu_acq+setup=1025+60=1085s

In addition to these times, wiping time of the detector (6.1s) has to be taken into account and the readout times.

c) Readout overheads

Because the UVB and VIS arms share the same FIERA controller, if the exposure of CCD1 ends while the controller is reading CCD2, the readout of CCD1 will only take place once the readout of CCD2 is finished.
This must be compared to the execution of the NIR arm and the slowest of NIR vs UVB + VIS arms gives the final execution time.
In case the readout of the UVB, VIS detectors is performed consecutively, one has to sum their readouts (and if the NIR arm exposure + readout is finished before).
If the VIS exposure is longer than the UVB exposure + UVB readout and the NIR exposure + the NIR readout, then the execution time will correspond to the VIS exposure + the VIS readout time.

4.1.2 Execution time computation and how to minimize the overheads

a) Example 1: slit mode, UVB/VIS arms execution time higher than the NIR one

An user defines the observation of a star magnitude 15 in V.
He uses a direct acquisition.
He needs for reaching the desired signal to noise ratios, exposure times of 100s in UVB, 100s in VIS, 60s in NIR.

In such case, the overheads are:
The acquisition and setup overheads
XSHOOTER_slt_acq+setup=409+30=439s (acquisition integration times of 1s)
+ the overheads coming from the readout times:

The UVB and VIS arms will integrate both during 100s but because they share the same FIERA and that the exposures will be readout sequentially, this implies a large deadtime. The

NIR arm exposure will be finished in 60s+1.46s readout, it is negligible with respect to the UVB/VIS arms times.
The UVB/VIS arms dominate the execution time of the OB.
If the readout mode is 100KHz,1x1 for both arms, it means that the total time will be:
UVB or VIS integration + readout time of UVB arm + readout time of the VIS arm=257s, corresponding to 100s of integration time and 157s of readout time
To optimize this time, then one can do:
UVB exposure of 100s, the readout time is here of 68s, therefore the VIS arm can still integrate during 68s more.
One solution could be to do
UVB exposure of 100s, VIS exposure of 168s.
Then the execution time will be:
VIS exposure time of 168s + readout time of VIS arm=257s
that is the same time than before but better optimized for science purpose. This is a way to decrease the deadtime because we have 168s of integration time and only 89s of readout time.
In this example, the user could also increase without problems the number of NIR exposures from 1 to 4 exposures (4x61.46=246s < 257s).

b) Example 2: NIR execution time higher than the UVB/VIS arms

Same kind of observation than in a) but the NIR integration time must be of 600s and the readout modes for the UVB/VIS are 400khz,1x1.
In such case, they can optimize the UVB and VIS exposures like this:
UVB arm t=100s
VIS arm t=100s+16s(readout time of the UVB arm)=116s
The execution time for the UVB/VIS arms is 116+21(VIS readout time)=137s
The execution time in the NIR is 600s + 1.46s=601.46s
In such case, the users can decide to take 4 UVB/VIS exposures (4x137=548s <601s), if the user decide to go to 5 UVB/VIS exposures, then the execution time will be dominated by the UVB/VIS couple (5x137=685s > 601s=NIR time).

c) p2pp check:

In p2pp the algorithm takes into account the different exposure times and their number, readout times, the acquisition time, and the instrument setups.
Note that there is an extra 5s time between the moment of the UVB/VIS arms setup is done and the NIR one is done.
In P90, an algorithm providing indications about the optimization of the overheads was included. We kindly ask the users to report potential improvements or incorrectness of this algorithm.

5. Calibrating and reducing X-shooter data

5.1 X-shooter calibration plan

The calibration plan has been revised during P86, P87, P88, P89, it is now implemented as indicated below. A better follow-up of and new long term calibrations have been included.
A summary of the calibration plan manual is given in Table 16 and 17.

Table 16: X-shooter calibration plan summary

Calibration	UVB frames	VIS frames	NIR frames	Frequency	Purpose
Bias	5/read. mode	5/read. mode		daily	Master bias and check CCD bias properties
NIR darks[a]	N/A	N/A	3 per DIT	daily	Master dark, bad pix. map
IFU UVB/VIS/NIR flats	1 $D_{2,}$1 halo lamp	1	1 ON-OFF	Bi-daily	IFU FF for monitoring of the UVB/VIS ADCs and the IFU
Slit/IFU flats	5/setting D_2 lamp 5/setting halo. lamp	5/setting	5 ON-OFF	daily	Pixel-to-pixel variations, blaze function correction when triggered by science
Arcs single pinhole (Th/Ar or Ar/Xe/Hg/Kr)	1	1	1 ON-OFF	Every 2 days	Pipeline calibration: first guess disp. solution. FMCK
Flat single pinhole[b]	1 D_2 lamp 1 Halo. lamp	1	1 ON-OFF	Every 2 days	Pipeline calibration: order localization ORDERDEF 1x1 binning in UVB/VIS
Arcs multi-pinhole (Th/Ar or Ar/Xe/Hg/Kr)	1	1	1 ON-OFF	Every 2 days	Wavelength and spatial scale determination/calibration WAVE
Arcs through slit/IFU (Th/Ar or Ar/Xe/Hg/Kr)	1/setting	1/setting	1 ON-OFF / setting	Every 3 days in SM	Wavelength shift between multi-pinholes and slits, spectral resolution, ARC
Flat multi pinhole	1	1	1 ON-OFF	On request	Multi-order definition taken on request
IFU slitlet distances	2	2	2	6-monthly TBC	Pipeline calibration: cube reconstruction
Radial velocity standard[c]	2	2	2	On request	Accurate radial vel. calibration
Telluric standard	1 2 (P91)	1 2 (P91)	1 2 (P91)	1/obs.	Correct for telluric abs. Only in stare mode in SM up to P90, in nodding starting from P91. No 5” slits observations
Spectro-photometric standard	2	2	2	daily	Response curve, absolute flux calib. In nodding mode, in slit mode it is taken every time the instrument is used, in IFU mode, only when the science performed at night did it.
Spectroscopic skyflats	As requested	As requested	As requested	On request	Twilight spectroscopic skyflats

a: Darks: every day monitoring darks DITxNDITxNEXP of
1sx3x3; 5sx3x3; 300sx1x3; 600sx1x3 are taken.
The other darks are taken only if they are science triggered.
They are taken at daytime following the science observation as follows:

Science of standard		Triggered calibrations		
DIT	NDIT	DIT	NDIT	N exposures
≤300s	≤2	DIT	1	3
≤300s	≥3	DIT	3	1
300s<	≤2	DIT	1	3
300s<	≥3	DIT	3	1

In case the science frames use a combination DITxNDIT corresponding to the monitoring darks or to other science/standard frames, the darks are not duplicated.
There is not anymore a difference SM or VM.

b: Now only the 1x1 binning is taken in the UVB/VIS. Other binning ORDERDEF are taken upon request.

c: The RV standard star OBs are not ready, we encourage the users to specify their own RV standard star by submitting corresponding OBs (using the telluric star templates).

Table 17: long –term calibration plan

Calibration	**UVB frames**	**VIS frames**	**NIR frames**	**Frequency**	**Purpose**
DARK_UVB_100k	3x1hour			monthly	dark
DARK_UVB_400k	3x1hour			monthly	dark
DARK_VIS_100k		3x1hour		monthly	dark
DARK_VIS_400k		3x1hour		monthly	dark
DARK_UVB_100k_1x2	3x1hour			monthly	dark
DARK_UVB_400k_1x2	3x1hour			monthly	dark
DARK_VIS_100k_1x2		3x1hour		monthly	dark
DARK_VIS_400k_1x2		3x1hour		monthly	dark
DARK_UVB_100k_2x2	3x1hour			2 months	dark
DARK_UVB_400k_2x2	3x1hour			2 months	dark
DARK_VIS_100k_2x2		3x1hour		2 months	dark
DARK_VIS_400k_2x2		3x1hour		2 months	dark
Long darks NIR			3x1hour	On request	dark
LINEARITY_UVB_100k	Set of detector FF + biases			monthly	detector monitoring
LINEARITY_UVB_400k	Set of detector FF + biases			monthly	detector monitoring
LINEARITY_VIS_100k		Set of detector FF + biases		monthly	detector monitoring
LINEARITY_VIS_400k		Set of detector FF + biases		monthly	detector monitoring
LINEARITY_UVB_100k_1x2	Set of detector FF + biases			monthly	detector monitoring
LINEARITY_UVB_400k_1x2	Set of detector FF + biases			monthly	detector monitoring
LINEARITY_VIS_100k_1x2		Set of detector FF + biases		monthly	detector monitoring
LINEARITY_VIS_400k_1x2		Set of detector FF + biases		monthly	detector monitoring
LINEARITY_UVB_100k_2x2	Set of detector FF + biases			monthly	detector monitoring
LINEARITY_UVB_400k_2x2	Set of detector FF + biases			monthly	detector monitoring
LINEARITY_VIS_100k_2x2		Set of detector FF + biases		monthly	detector monitoring
LINEARITY_VIS_400k_2x2		Set of detector FF + biases		monthly	detector monitoring
LINEARITY_NIR			Set of detector FF	monthly	detector monitoring

All of these calibrations are taken for the monitoring of the instrument health but also for calibrating the science and calibration (telluric and flux standard stars) observations. One should use at the time of the data reduction both daily and long-term calibrations in the different corresponding pipeline recipes.

5.2 Wavelength and spatial scale calibration

As described in section 2.3.1, the spectral format of X-shooter is relatively complex with highly curved orders, variable line tilt, dispersion and spatial scale along each order. Using just long slit arc spectra is not sufficient because it is essential to also calibrate the change of spatial scale (just measuring the slit height is not accurate enough).

Wavelength and spatial scale are well calibrated simultaneously with a dedicated mask of 9 equidistant pinholes present in each slit unit (see Table 5, Table 8 and Table 9) in combination with the ThAr lamp. Exposure time for each arm is given in Table 18. An example of such a frame is given in Figure 18. The templates used for this calibration is `XSHOOTER_slt_cal_UvbVisArcsMultiplePinhole` and `XSHOOTER_slt_cal_NIRArcsMultiplePinhole`
The accuracy of the wavelength calibration typically achieved using the X-shooter Data Reduction Software is better than ~2km/s over the whole wavelength range (TBC for the NIR arm). In this process, the quality of the list of lines used to perform the calibration is critical (in particular, it has to be carefully cleaned from blends). Such a ThAr line list is provided together with the X-shooter Data Reduction Software package.

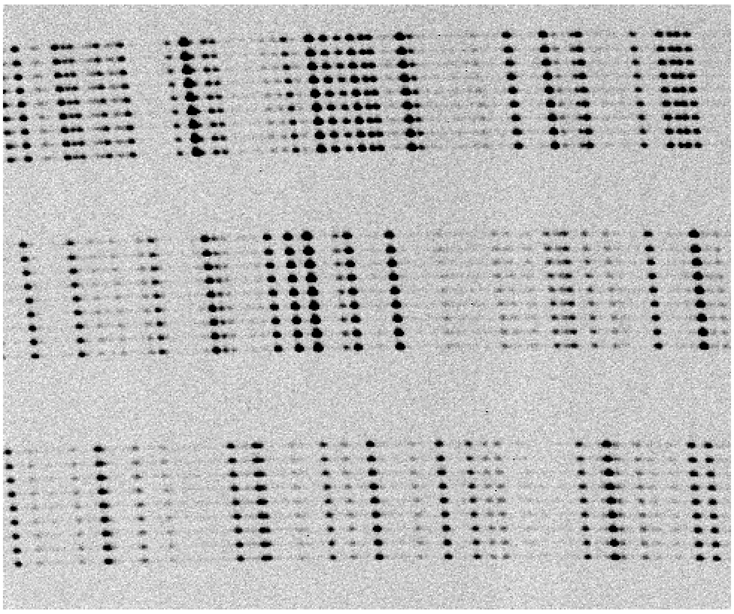


Figure 18: portion of a 9-pinhole ThAr VIS frame used for wavelength and spatial scale calibration.

Full slit ThAr spectra are also useful to correct the slight (fixed) displacement between the 9-pinhole masks and each slit. This is also used to monitor the spectral resolution of the different spectrographs. Templates to use for these calibrations are `XSHOOTER_slt_cal_UVBVisArcs`, `XSHOOTER_slt_cal_NIRArcs`, `XSHOOTER_ifu_cal_UVBVisArcs`, `XSHOOTER_ifu_cal_UVBVisArcs`.

5.3 Flat-field and Wavelength calibrations

Flatfield spectra allow to correct for the pixel-to-pixel variations in detector sensitivity as a function of impinging wavelength of the light and to correct for the structures introduced by imperfections of the slits. They also provide a good correction of the blaze function of the échelle.

Table 18: exposure time for arc frames and flat field frames. Values are given for the fast readout, low gain mode (in UVB and VIS) for a 1.0" or 0.9" slit and the IFU. For the flatfield, values can be adapted to other slit widths and readout modes applying a simple scaling. These values depend on the lamp but should be closed to those indicated in this table.

UVB 1x1, low gain			VIS 1x1 low gain		NIR	
ThAr arc lamp						
Slit 1.0”	30 s (TBC)		Slit 0.9”	5 s	Slit 0.9”	0.66 s
IFU	45 s (TBC)		IFU	4 s (TBC)	IFU	1.32 s
9-pin.	15 s		9-pin.	10 s	9-pin.	0.66 s
Flatfield						
Slit 1.0”	D_2	7.3 s	Slit 0.9”	18.8 s	Slit 0.9”	40 s
	Halo	19.3 s				
IFU	D_2	14 s	IFU	52 s	IFU	60 s
	Halo	32 s				

For each arm, a dedicated halogen lamp with appropriate balancing filters is available to give well-exposed, flat continuum spectra at all wavelengths within a reasonably short exposure time (see Table 18). A deuterium lamp is used for the spectral region shortwards of 350 nm. Flatfielding the whole spectral range therefore requires four exposures (2 in UVB, 1 in VIS and ON/OFF in NIR) that have to be taken sequentially. Flatfield templates are:

- `XSHOOTER_slt_cal_UVBLowLampFlat` (UVB deuterium-D_2- lamp flat)
- `XSHOOTER_slt_cal_UVBHighLampFlat` (UVB halogen lamp flat)
- `XSHOOTER_slt_cal_VISLampFlat`
- `XSHOOTER_slt_cal_NIRLampFlat`

And their equivalent for IFU flatfield named `XSHOOTER_ifu_cal_...LampFlat`.

Note that low frequency fringes with peak-to-valley amplitudes up to ~5% are present in the red part of the VIS spectra.

5.4 Spectroscopic skyflats

It is now possible to request the support astronomers to take spectroscopic skyflats (both slit and IFU modes). They will be taken on the best effort basis.
The performed tests show that the slits are uniformly illuminated.

5.5 Attached calibrations

It is possible to include arc and flat calibration in an observing OB. For the selection of offered night time attached calibrations, see Table 41 and following). However, we strongly discourage taking night time attached arcs in the VIS arm (SLIT or IFU) because of remnants caused by a few strong ThAr lines. These remnants persist in the following exposure for up to one hour affecting the subsequent observations. Therefore, attached VIS arcs can be granted only in visitor mode or in service mode, which will be executed only at the very end of the night, if possible. The user should refer to Table 18 to select the exposure time of the attached calibrations.
On the UVB side, an arc exposure of, 6s in the 1x1 binning, 3s in the 1x2 binning, 1s in the 2x2 binning with the normal readout speed does not produce remnants and should provide enough lines for an accurate radial velocity calibration.

To take attached calibrations, the attached calibration template MUST come after the corresponding science template because it will use the setup of the instrument performed by the science template.
Therefore if one needs to bracket the observations by attached flat fields, he/she needs to create an OB like this:

Acquisition template-dummy exposures in a science template for instrument setup-attached calibration here flat fields-normal observation with the science template-attached calibration.

If one does directly the attached calibration after the acquisition template, the system will use the setup corresponding to the AFC.

5.6 Spectrophotometric calibration

5.6.1 Telluric absorption correction

The visual-red and a near-IR part of the spectrum are strongly affected by the absorption lines of the Earth's atmosphere. Many of these telluric lines do not scale linearly with airmass, so it is necessary to observe a star with a well-known spectrum at the same airmass and with the same instrument setup as that used for the science target. Furthermore, the strength of the telluric lines varies with time, so it is also necessary to observe the telluric standard soon after or just before the science observation. Two templates are designed for this purpose: `XSHOOTER_slt_cal_TelluricStd` and `XSHOOTER_ifu_cal_TelluricStd`.

In general, we use either main sequence hot stars (B0 to B4 whenever possible, or to B9 otherwise) or solar analogs as telluric standards selected from the Hipparcos Catalog.

Unfortunately, hot stars still contain some features, usually lines of hydrogen and helium, which can be difficult to remove. If the regions around the hydrogen and helium lines are of interest, then one can also observe a late type star, which should have weak hydrogen and helium lines. This star is then used to correct for the helium and hydrogen absorption in the spectrum of the hot star. Some hot stars also have emission lines or are in dusty regions. These stars should be avoided. The V-I colour of the star can be used as an indicator of dust. For stars hotter than A0, it should be negative. And lastly, hot stars tend to lie near the galactic plane, so there may be situations where there are no nearby hot stars.

Solar analogs, (for the purpose of removing telluric features) are stars with spectral type G0V to G4V. These standards have many absorption lines in the IR, particularly in the J band. The features can be removed by dividing by the solar spectrum that has been degraded to the resolution of the observations.

In addition to hot stars and solar analogs, IR astronomers have used other stellar types as telluric standards. For example, F dwarfs are commonly used.

Users should think carefully about which star is best for their program. Although the Observatory will automatically observe a telluric standard for service programs, we cannot guarantee that we will make the best choice, as this depends on the science users wish to do. If you think that a specific spectral type suits your program better than others, we recommend that you submit calibration OBs using the proper calibration templates see sect.6.1.6 (in such case the time will be charged to your program), or to specify in the *readme file* of your program what kind of telluric star is needed.

Currently the telluric standard stars observed by the Observatory should have about 10000 ADUs in the middle of the brightest orders of each arms (S/N~50-100). The Observatory does not provide observations of telluric standard stars with 5” slits. If this S/N is not enough for the purpose of your programme, as previously we encourage you to submit your own calibration OBs. In addition, the telluric standard star observation is carried out with the stare mode only in SM. This already uses 10% of the available time. The use of another mode instead of the stare would lead to spend 25% time more in standard star observation or 12.5% of the available time at UT2. Therefore if the user needs nodding mode or IFU-offset observations instead of stare observations, we encourage him/her to submit his/her own OBs.

Note that the telluric standard star observations are useless for the UVB arm (no telluric lines) but are useful for the correction of telluric lines present in the VIS and NIR arms.

5.6.2 Absolute flux calibration

Spectrophotometric standard stars can be used to obtain the absolute efficiency of the instrument and derive an absolute flux calibration of the science data. These observations are done by the Observatory with the wide 5.0” slit with dedicated templates
`XSHOOTER_slt_cal_StandardStar` and `XSHOOTER_ifu_cal_StandardStar`.
The use of the 5” is better in order to obtain most of the flux of the specphot standard star.
Starting from P88, the spectrophotometric standard stars will be observed in nodding mode with a new specific template.

The classical set of UV-optical standard stars from Oke (1990, AJ 99, 1621) and Hamuy et al. (1994, PASP 106, 566) do not cover the whole spectral range of X-shooter thus making calibration of full spectral range of X-shooter problematic. To remedy this situation dedicated 2 years observing campaign has been undertaken as an ESO Observatory Programme (`PID 278.D-5008`) to extend to the near-IR a subset of 12 standard stars from the two references cited above to the near-IR. Tabulated fluxes used by the pipeline for those 12 stars from 300 to 2500 nm allow an absolute flux calibration to the 5-10%. Details of this programme can be found in Vernet et al. (Proc. SPIE 7016, 2008, available on the X-shooter web pages).

Currently 7 spectrophotometric standard stars are available and are fully flux calibrated, see
http://www.eso.org/sci/facilities/paranal/instruments/xshooter/tools/specphot_list.html
However, BD+17 4708 a HST standard star was found to be a spectroscopic binary and is now observed only if no other suitable star can be observed.

If you use the fluxes available in the X-shooter pipeline, please cite:
Vernet, Kerber, Mainieri et al. 2010, Highlights of Astronomy, Volume 15, p. 535-535
and Hamuy et al. 1994, PASP, 106, 566.

5.7 The X-shooter pipeline

The X-shooter pipeline v1.5.0 has been recently released with its REFLEX support.
With REFLEX several recipes are user-interactive with displayed plots allowing to check the results on the fly and re-run the recipes with modified parameter values.

It is available at:
http://www.eso.org/sci/software/pipelines/

It supports both instrument modes (SLIT and IFU).

- It delivers the sky subtracted or not, cosmic ray hits cleaned, flux and wavelength calibrated 2D spectra, rectified to a regular grid in wavelength and spatial directions. 1D extracted spectra is produced whenever a bright enough object is detected. It is also possible to specify a region where the spectra have to be located and treated. For example, in case of 2 objects inside the slit, the extraction can be performed for both objects using different boxes of research.

- 3D reconstructed data cubes will be produced for IFU data.

- Additional products to verify the quality of the results and a set of Quality Control parameters instrument health check and trend analysis.

Some of the functionalities are still in development, more information is available in the pipeline user manual and in the website of the pipelines at:
http://www.eso.org/observing/dfo/quality/pipeline-status.html#XSHOOTER

More information on the current pipeline problems and limits is available at:
http://www.eso.org/observing/dfo/quality/XSHOOTER/pipeline/pipe_problems.html

The cookbook reduction of the data reduction with the pipeline is currently ongoing and will be available as soon as possible at:
http://www.eso.org/sci/facilities/paranal/instruments/xshooter/doc/

Note that a cookbook is already included in the pipeline manual.

If you use the X-shooter pipeline to reduce the data, please cite:

Modigliani et al. 2010SPIE.7737E..56M

5.8 Examples of observations with X-shooter

During this first year of operation, some achievements were done. For example:
- galaxies at high redshift (z=7.5) were observed,
- highly extinguished stars (Vmag=27) were observed,
-GRB host galaxy of R>=24 were observed as well as GRB afterglow of Rmag=23.5.
- the RRM was successfully activated and several z of GRBs obtained,
- time series of variable objects (more than 100 consecutive exposures) were done,
- the continuous scanning of open and globular clusters was done for obtaining their integrated light.

Some bright objects were also observed but with some difficulties because in normal weather conditions they saturate the detectors. Among them, were observed:
-very bright stars and 48 presets were performed in a single summer night (~1 OB every 9mn),
-the Moon (!)

5.9 Frequently Asked Questions

- *The health of the instrument is monitored every day. You may want to see the current Quality control plots at*

http://www.eso.org/observing/dfo/quality/XSHOOTER/reports/HEALTH/trend_report_BIAS_UVB_med_master_HC.html

- *Is it possible to do pre-imaging for astrometric and photometric purposes with the AG technical CCD?*
  Not yet, even if It was successfully used during VM runs for preparing the OBs for blind offsets or to investigate better the field.
  However, the imaging mode is not yet characterized and thus not yet offered to the community. In addition, the AG detector suffers from pick-up noise. About the WCS it is good but an offset of about 1" in DEC is still present.
  We will improve the WCS in P88.

- *Is it possible to do the nodding in 1 arm only, the NIR one for instance?*
  No, it is not possible due to the current technological limitations.

- *Can we skip the AFC?*
  It is possible to occasionally skip AFC in BOB for observations done near zenith, with a wide slit and/or under bad seeing. However, this is not a recommended action since it may make data extraction more difficult (object no longer at the expected position along the slit), and/or lead to additional slit losses. Moreover the AFC is used to take into account the spectrograph flexures with respect to the WAVE calibration at daytime.

- *What is the frequency of the AFC?*
  After 1h, 1h15mn it is necessary to do the measurements and correct the instrument flexures. Only the backbone flexures are actually measured, not the internal spectrograph flexures.
  One can add between science templates the new templates SLIT or IFU AFC for doing the measurements and the flexure correction without the need to re-acquire the object (useful in case of long OB with slit position angle fixed by the user).

- *Does the slit follow the parallactic angle during an exposure?*
  For the moment the parallactic angle is only computed during the acquisition/preset step and the angle of the rotator set at that time.
  Thus the observations will start at the parallactic angle and the slit position angle on sky will remain fixed during the integration i.e. not following the parallactic angle.

- *How can I find the slit-object position in the acquisition image?*
  FITS header keywords HIERARCH ESO SEQ AG XCEN and YCEN record the location of the centre of the SLIT or IFU in the image.

- *Which airmass should I specify for the IFU observations?*

Because the ADCs are not used in IFU mode, one should consider not to use a large airmass. Typically the airmass should be better than 1.5. However, the tip/tilt are used to correct as much as possible the DAC but cannot replace the ADCs. Actually the maximum airmass would depend on the declination of the object.
One should have a look at section 2.2.2.

- *A list of previous problems can be found too at*

http://www.eso.org/observing/dfo/quality/XSHOOTER/qc/problems/problems_xshooter.html

- More information is available at

http://www.eso.org/sci/observing/phase2/SMGuidelines/FAQP2.html

and do not forget to consult the XSHOOTER website in particular the news webpage:
http://www.eso.org/sci/facilities/paranal/instruments/xshooter/index.html

- In case of instrumental question please contact xshooter@eso.org

- In case of questions regarding the phase 1 and phase 2, OB preparation, observing strategy, please contact usd-help@eso.org

6. Reference material

6.1 Templates reference

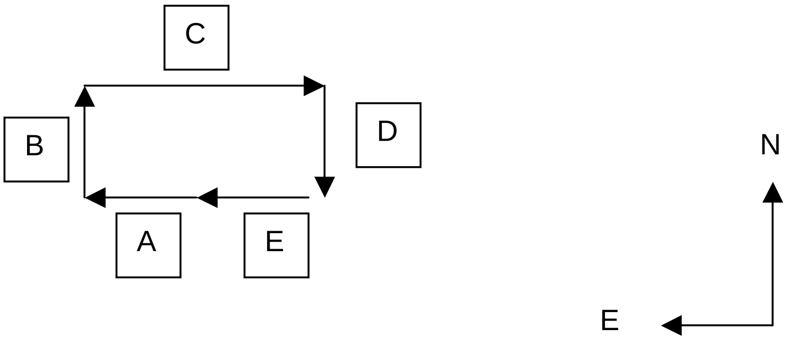
In the following sections all the currently defined X-shooter templates are listed with their free and fixed parameters. When using the P2PP tool the user has to fill only the fields (keywords) shown on white background colour in the following tables. Keywords shown on gray background colour are fixed within the template itself and can only be modified by the astronomer operating the instrument during the night or during daytime calibration activities.

6.1.1 Orientation and conventions

X-shooter follows the standard astronomical offset conventions and definitions.

The positive position angle (PA) is defined from North to East. This is the value that should be entered in the TEL.ROT.OFFANGLE in all the acquisition templates to set the slit position angle on the sky. The fits header keyword HIEARCH ESO ADA POSANG is all X-shooter data is *minus* the position angle of the slit on the sky. Note that the value “9999” can be used to set the position angle to the parallactic angle. Note also that the parallactic angle is that at the time of the preset/acquisition. The slit is not maintained at the parallactic angle during the science exposure.

Offsets are always given in arc seconds, but the reference system can be chosen to be the sky (Alpha, Delta) or X-shooter slit coordinate system (X,Y). Offset conventions are illustrated below. Templates use **cumulative offsets**: the position at a given time is derived from the *sum* of all offsets specified so far in the template. For example, the series of offsets: 0, -10, 0, 10 brings the telescope back to the original position for the last exposure. This example could have been for instance the definition of a series in which we define an exposure on object, followed by two sky exposures at -10” of the original position, before pointing back on the object for the fourth exposure.



Other example of series of offsets:
offset A= (RA= + 10”, DEC=0”); offset B= (RA=0”, DEC= + 10”),
offset C= (RA= - 20”, DEC=0”), offset D= (RA= 0”, DEC= - 10”), offset E= (RA= +10”, DEC=0”).
And the telescope is back to the original position.

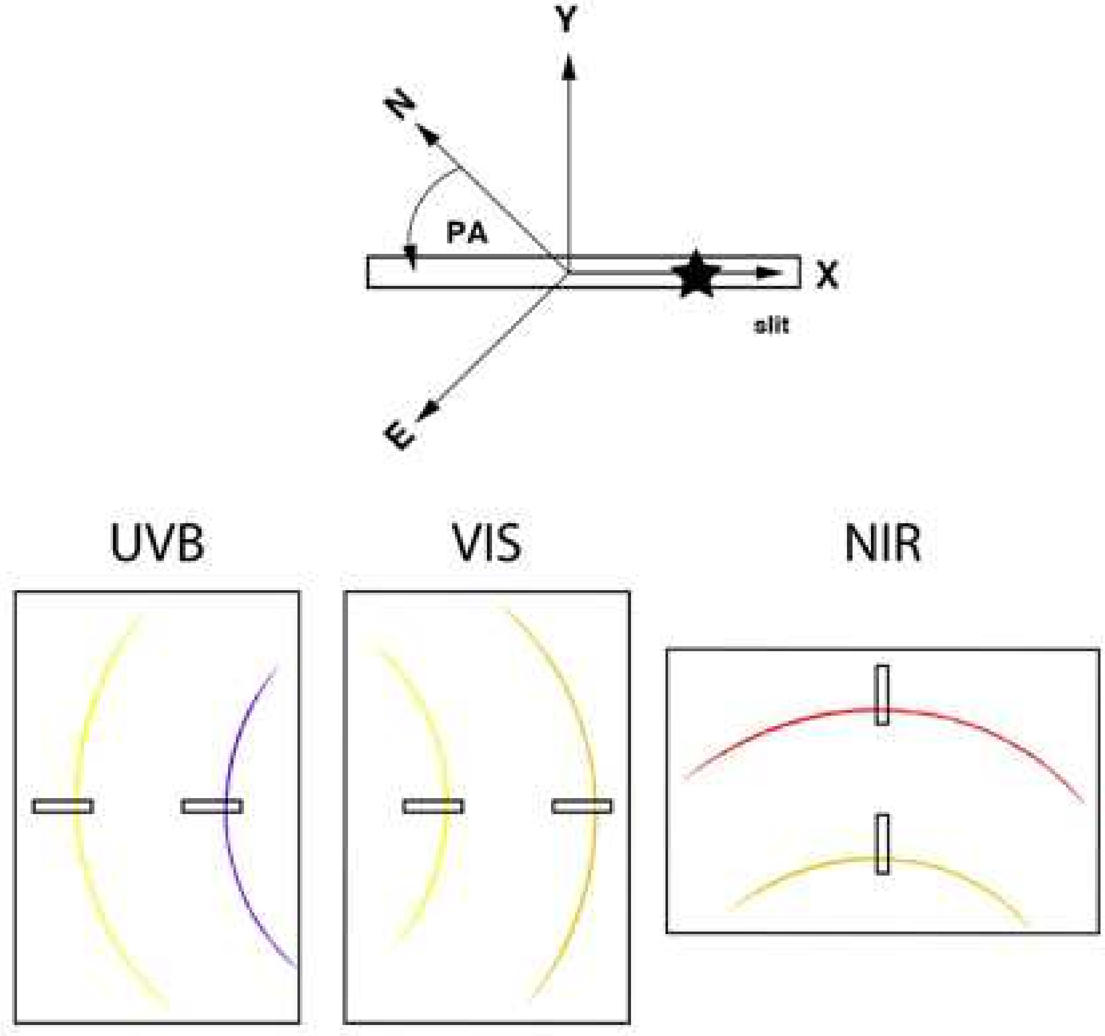


Figure 19: The slit coordinate system and correspondence between object position in the slit and position on the spectrum for each arm. An object at positive x (black star top panel) produces spectra placed as illustrated in the bottom panels. NOTE: a positive offset in the x or y direction will move the object in direction of +x and +y axis.

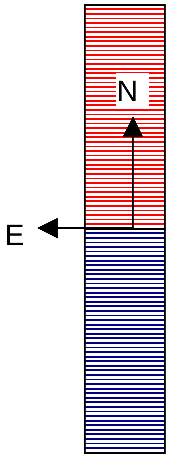
Note that the keyword ADA.POSANG in the header indicates the opposite of the slit angle specified by the user. It corresponds to the rotator angle.

6.1.2 Examples of position angles and offsets

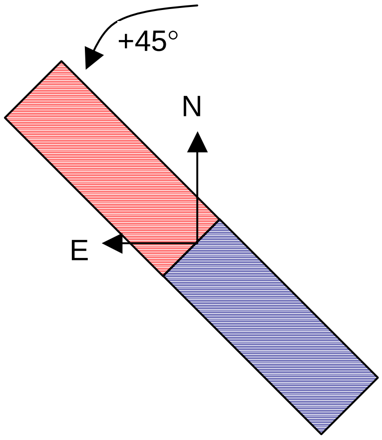
TEL.ROT.OFFANGLE is the keyword in the acquisition templates to set up the slit position angle on sky. A value of 9999 (default) means that the parallactic angle is used.
The parallactic angle is not followed during the exposure, the system uses the parallactic angle at the start of the OB. If another PA is defined, the telescope will follow this angle on sky.

h) Examples of position angles

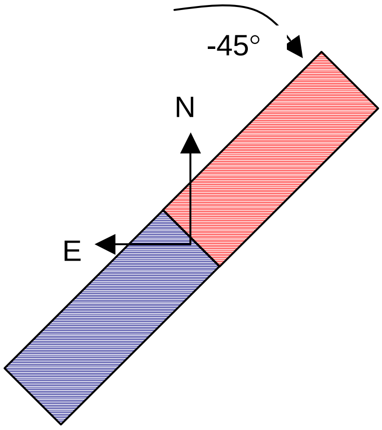
If the user needs a position angle of +45 degrees, it is just needed to enter + 45 degrees in the acquisition template. If the user needs a position angle of 315 degrees, it is needed to enter in the acquisition template an angle of –45 degrees (=315-360).
The convention is to use angles from 0 to +180 degrees and from 0 to –180 degrees.



PA=0 degree



PA=+45 degrees

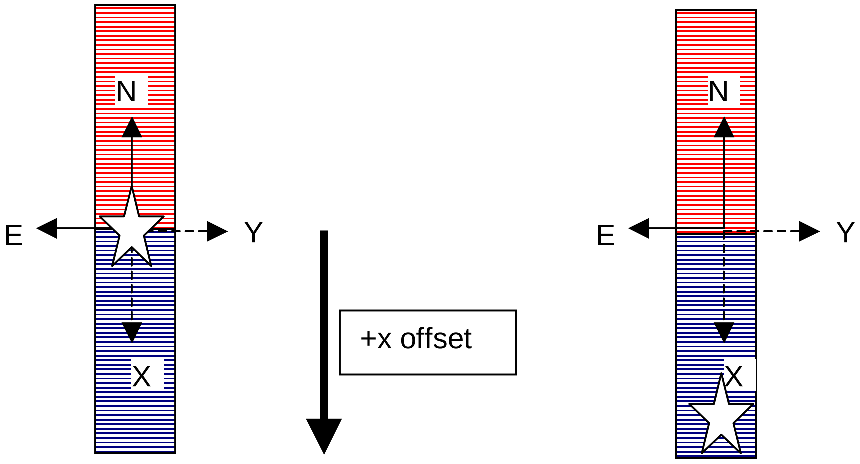


PA= –45 or +315 degrees

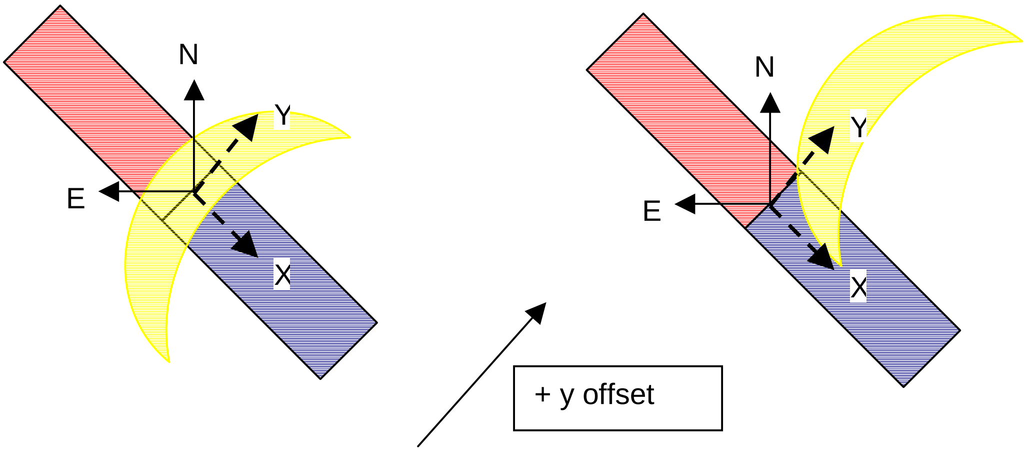
i) Examples of offsets

As indicated a positive offset in the x or y direction will move the **object** in direction of +x and +y axis.

The first example with PA=0 degree shows the results of a positive offset in +x. The object/star moves in the direction of the +x axis and the slit moves in the –x axis. The x,y axis are attached to the slit.



The second offset with PA= +45 degrees shows a positive offset in y axis. The Moon goes to the upper right corner (movement in +y axis), while the slit moves in the lower left corner (reverse movement in the –y axis).



6.1.3 Acquisition templates

Slit acquisition templates

We encourage the users to select the filter in which the target is best visible. We also advice to set the shortest possible acquisition exposure time. This would allow a minimum acquisition overhead.

Table 19: User defined and fixed keywords for `XSHOOTER_slt_acq.`

XSHOOTER_slt_acq			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free parameters			
TEL.TARG.ALPHA		000000.000	Target RA
TEL.TARG.DELTA		000000.000	Target DEC
TEL.TARG.EQUINOX	-2000..3000	2000	Equinox
TEL.TARG.PMA	-10.0..10.0	0.0	RA proper motion (“/yr)
TEL.TARG.PMD	-10.0..10.0	0.0	DEC proper motion (“/yr)
TEL.TARG.EPOCH	1950, 2000	2000	Epoch
TEL.TARG.ADDVELALPHA		0.0	RA differential tracking velocity (“/s)
TEL.TARG.ADDVELDELTA		0.0	DEC differential tracking velocity (“/s)
TEL.TARG.OFFSETALPHA	-36000 .. 36000	0.0	RA blind offset (“)
TEL.TARG.OFFSETDELTA	-36000 .. 36000	0.0	DEC blind offset (“)
TEL.ROT.OFFANGLE	-179.99..179.99 9999.	9999.	Slit position angle on Sky 9999. for parallactic angle
INS.FILT1.NAME	u’, g’, r’, i’, z’, U, B, V, R, I		A&G filter
DET4.WIN1.UIT1	0..36000		TCCD exposure time
TEL.AG.GUIDESTAR	CATALOGUE, SETUPFILE, NONE	CATALOGUE	Telescope guide star selection mode
TEL.GS1.ALPHA		0.0	Guide Star RA
TEL.GS1.DELTA		0.0	Guide Star DEC
Fixed parameters			
DET1.WIN1.UIT1		2	AFC UVB exposure time
DET2.WIN1.UIT1		0.5	AFC VIS exposure time
DET3.DIT		1	AFC NIR DIT
DET3.NDIT		1	number of AFC NIR DITs
SEQ.AFC.CORRECT	F, T	T	AFC correct flag
SEQ.AFC.WSIZE		64	Window size for AFC Cross Correlation
SEQ.AFC.MAXD		20	Maximum distance for AFC Cross Correlation
SEQ.PRESET	T, F	T	Preset flag
INS.MODE	SLITSPEC, IFUSPEC	SLITSPEC	Instrument mode

Table 20: User defined and fixed keywords for `XSHOOTER_slt_acq_rmm`.

XSHOOTER_slt_acq_rrm			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free parameters			
SEQ.RRM.REGISTER	T, F	T	Register OB in RRM system
SEQ. RRM.VISITOR	T, F	T	Allow RRM activation in visitor mode
TEL.TARG.DELTA		000000.000	Target DEC
TEL.TARG.EQUINOX	-2000..3000	2000	Equinox
TEL.TARG.PMA	-10.0..10.0	0.0	RA proper motion (“/year)
TEL.TARG.PMD	-10.0..10.0	0.0	DEC proper motion (“/year)
TEL.TARG.EPOCH	1950, 2000	2000	Epoch
TEL.TARG.ADDVELALPHA		0.0	RA differential tracking velocity (“/s)
TEL.TARG.ADDVELDELTA		0.0	DEC differential tracking velocity (“/s)
TEL.TARG.OFFSETALPHA	-36000..36000	0.0	RA blind offset (“)
TEL.TARG.OFFSETDELTA	-36000..36000	0.0	DEC blind offset (“)
TEL.ROT.OFFANGLE	-179.99 ... 179.99, 9999.	9999.	Slit position angle on Sky 9999. for parallactic angle
INS.FILT1.NAME	u’, g’, r’, i’, z’, U, B, V, R, I		A&G filter
DET4.WIN1.UIT1	0..36000		TCCD exposure time
TEL.AG.GUIDESTAR	CATALOGUE, SETUPFILE, NONE	CATALOGUE	Telescope guide star selection mode
TEL.GS1.ALPHA		0.0	Guide Star RA
TEL.GS1.DELTA		0.0	Guide Star DEC
Fixed parameters			
DET1.WIN1.UIT1		2	AFC UVB exposure time
DET2.WIN1.UIT1		0.5	AFC VIS exposure time
DET3.DIT		1	AFC NIR DIT
DET3.NDIT		1	number of AFC NIR DITs
SEQ.AFC.CORRECT	F, T	T	AFC correct flag
SEQ.AFC.WSIZE		64	Window size for AFC Cross Correlation
SEQ.AFC.MAXD		20	Maximum distance for AFC Cross Correlation
SEQ.PRESET	T, F	T	Preset flag
INS.MODE	SLITSPEC, IFUSPEC	SLITSPEC	Instrument mode

IFU acquisition templates

Table 21: User defined and fixed parameters for `XSHOOTER_ifu_acq`.

XSHOOTER_ifu_acq			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free parameters			
TEL.TARG.ALPHA		000000.000	Target RA
TEL.TARG.DELTA		000000.000	Target DEC
TEL.TARG.EQUINOX	-2000..3000	2000	Equinox
TEL.TARG.EPOCH	1950, 2000	2000	Epoch
TEL.TARG.PMA	-10.0..10.0	0.0	RA proper motion (“/year)
TEL.TARG.PMD	-10.0..10.0	0.0	DEC proper motion (“/year)
TEL.TARG.ADDVELALPHA		0.0	Additional velocity RA in “/s
TEL.TARG.ADDVELDELTA		0.0	Additional velocity DEC in “/s
TEL.TARG.OFFSETALPHA		0.0	RA blind offset (“)
TEL.TARG.OFFSETDELTA		0.0	DEC blind offset (“)
TEL.ROT.OFFANGLE	-179.99..179.99, 9999.	9999.	IFU position angle on Sky 9999. for parallactic angle
INS.FILT1.NAME	u’, g’, r’, i’, z’, U, B, V, R, I		A&G filter
DET4.WIN1.UIT1	0..36000		TCCD exposure time
SEQ.IFU.WLGT	300..2000	470	Wavelength for target centring and tracking
TEL.AG.GUIDESTAR	CATALOGUE, SETUPFILE, NONE	CATALOGUE	Telescope guide star selection mode
TEL.GS1.ALPHA		0.0	Guide Star RA
TEL.GS1.DELTA		0.0	Guide Star DEC
Fixed parameters			
DET1.WIN1.UIT1		2	AFC UVB exposure time
DET2.WIN1.UIT1		0.5	AFC VIS exposure time
DET3.DIT		1	AFC NIR DIT
DET3.NDIT		1	Number of AFC NIR DITs
SEQ.AFC.CORRECT	F, T	T	AFC correct flag
SEQ.AFC.MAXD		20	Maximum distance for AFC cross correlation
SEQ.AFC.WSIZE		64	Window size for AFC cross correlation
SEQ.PRESET	T, F	T	Preset flag
INS.MODE	SLITSPEC, IFUSPEC	IFUSPEC	Instrument mode

Table 22: User defined and fixed parameters for `XSHOOTER_ifu_acq_rrm`.

XSHOOTER_ifu_acq_rrm			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free parameters			
SEQ.RRM.REGISTER	T, F	T	Register OB in RRM system
SEQ. RRM.VISITOR	T, F	T	Allow RRM activation in visitor mode
TEL.TARG.ALPHA		000000.000	Target RA
TEL.TARG.DELTA		000000.000	Target DEC
TEL.TARG.EQUINOX	-2000..3000	2000	Equinox
TEL.TARG.EPOCH	1950, 2000	2000	Epoch
TEL.TARG.PMA	-10.0..10.0	0.0	RA proper motion (“/year)
TEL.TARG.PMD	-10.0..10.0	0.0	DEC proper motion (“/year)
TEL.TARG.ADDVELALPHA		0.0	Additional velocity RA in “/s
TEL.TARG.ADDVELDELTA		0.0	Additional velocity DEC in “/s
TEL.TARG.OFFSETALPHA		0.0	RA blind offset (“)
TEL.TARG.OFFSETDELTA		0.0	DEC blind offset (“)
TEL.ROT.OFFANGLE	-179.99..179.99, 9999.	9999.	IFU position angle on Sky 9999. for parallactic angle
INS.FILT1.NAME	u’, g’, r’, i’, z’, U, B, V, R, I		A&G filter
DET4.WIN1.UIT1	0..36000		TCCD exposure time
SEQ.IFU.WLGT	300..2000	470	Wavelength for target centring and tracking
TEL.AG.GUIDESTAR	CATALOGUE, SETUPFILE, NONE	CATALOGUE	Telescope guide star selection mode
TEL.GS1.ALPHA		0.0	Guide Star RA
TEL.GS1.DELTA		0.0	Guide Star DEC
Fixed parameters			
DET1.WIN1.UIT1		2	AFC UVB exposure time
DET2.WIN1.UIT1		0.5	AFC VIS exposure time
DET3.DIT		1	AFC NIR DIT
DET3.NDIT		1	Number of AFC NIR sub-integrations (NDIT)
SEQ.AFC.CORRECT	F, T	T	AFC correct flag
SEQ.AFC.MAXD		20	Maximum distance for AFC cross correlation
SEQ.AFC.WSIZE		64	Window size for AFC cross correlation
SEQ.PRESET	T, F	T	Preset flag
INS.MODE	SLITSPEC, IFUSPEC	IFUSPEC	Instrument mode

6.1.4 Flexure compensation templates that can be used in OBs

Two new templates are available in order to provide the possibility for the user to do additional flexure compensations in case of a long OB (longer than 1h-1h15mn). This new kind of template can be inserted between 2 science templates for instance.
In all cases, the flexures compensation is always performed at the beginning of an OB through the acquisition template. Thus, for usual OB (shorter than 1h-1h15mn) there are no needs to add this kind of template.

In case of slit observation, you could use the XSHOOTER_slt_AFC template. In case of IFU observation, you could use the XSHOOTER_ifu_AFC template.

6.1.5 Science templates

Slit observations

The SEQ.AGSNAPSHOT is not available anymore because during the acquisition, everytime an offset is performed, a snapshot of the A&G camera is saved.

Table 23: Parameters for stare mode observations with the template `XSHOOTER_slt_obs_Stare.`

XSHOOTER_slt_obs_Stare			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free parameters			
INS.OPTI3.NAME	*see* Table 5	1.0x11	UVB slit
INS.OPTI4.NAME	*see* Table 8	0.9x11	VIS slit
INS.OPTI5.NAME	*see* Table 9	0.9x11	NIR slit
DET1.WIN1.UIT1	0..36000		UVB Exposure Time (s)
DET1.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	UVB readout mode
DET2.WIN1.UIT1	0..36000		VIS Exposure Time (s)
DET2.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	VIS readout mode
DET3.DIT	0..36000		NIR Detector Integration Time (s)
DET3.NDIT	1..20	1	number of DITs
SEQ.NEXPO.UVB	0..100	1	UVB number of exposures
SEQ.NEXPO.VIS	0..100	1	VIS number of exposures
SEQ.NEXPO.NIR	0..100	1	NIR number of exposures
Fixed Values			
INS.MODE	SLITSPEC, IFUSPEC	SLITSPEC	Instrument Mode
SEQ.AGSNAPSHOT	T, F	F	Take an acquisition image before science exposures

Table 24: Parameters for synchronized stare UVB, VIS and NIR observations with the template `XSHOOTER_slt_obs_StareSynchro`.

XSHOOTER_slt_obs_StareSynchro			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free parameters			
INS.OPTI3.NAME	*see* Table 5	1.0x11	UVB slit
INS.OPTI4.NAME	*see* Table 8	0.9x11	VIS slit
INS.OPTI5.NAME	*see* Table 9	0.9x11	NIR slit
DET1.WIN1.UIT1	0..36000		UVB exposure time (s)
DET1.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	UVB readout mode
DET2.WIN1.UIT1	0..36000		VIS exposure time (s)
DET2.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	VIS readout mode
DET3.DIT	0.66..36000		NIR Detector Integration Time (s)
DET3.NDIT	1..9999	1	number of DITs
Fixed Values			
INS.MODE	SLITSPEC, IFUSPEC	SLITSPEC	Instrument Mode
SEQ.AGSNAPSHOT	T, F	F	Take an acquisition image before science exposures?

Table 25: Parameters for the template `XSHOOTER_slt_obs_AutoNodOnSlit.`It allows to observe nodding along the slit. The values of the nodding and jitter correspond to the width of the box, float values are allowed.

XSHOOTER_slt_obs_AutoNodOnSlit			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free parameters			
INS.OPTI3.NAME	*see* Table 5	1.0x11	UVB slit
INS.OPTI4.NAME	*see* Table 8	0.9x11	VIS slit
INS.OPTI5.NAME	*see* Table 9	0.9x11	NIR slit
DET1.WIN1.UIT1	0..36000		UVB exposure time (s)
DET1.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	UVB readout mode
DET2.WIN1.UIT1	0..36000		VIS exposure time (s)
DET2.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	VIS readout mode
DET3.DIT	0..36000		NIR Detector Integration Time (s)
DET3.NDIT	1..9999	1	Number of DITs
SEQ.NEXP.UVB	0..100	1	UVB number of exposures per offset position
SEQ.NEXP.VIS	0..100	1	VIS number of exposures per offset position
SEQ.NEXP.NIR	0..100	1	NIR number of exposures per offset position
SEQ.SKYTHROW	0..10	5	Nod Throw in “
SEQ.JITTER.WIDTH	0..2	0	Jitter box width in “
SEQ.NABCYCLES	0..100	1	Number AB or BA cycles
SEQ.OFFSET.ZERO	T, F	T	Return to Origin?
Fixed Values			
INS.MODE	SLITSPEC, IFUSPEC	SLITSPEC	Instrument Mode
SEQ.AGSNAPSHOT	T, F	F	Take an acquisition image before science exposures?

Table 26: Parameters for the template `XSHOOTER_slt_obs_FixedSkyOffset`.It allows to alternate object and sky observations.

XSHOOTER_slt_obs_FixedSkyOffset			
Keyword	*Range*	*Default Value*	*Label in P2PP*
		Free parameters	
INS.OPTI3.NAME	*see* Table 5	1.0x11	UVB slit
INS.OPTI4.NAME	*see* Table 8	0.9x11	VIS slit
INS.OPTI5.NAME	*see* Table 9	0.9x11	NIR slit
DET1.WIN1.UIT1	0..36000		UVB Exposure Time (s)
DET1.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	UVB read-out mode
DET2.WIN1.UIT1	0..36000		VIS Exposure Time (s)
DET2.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	VIS read-out mode
DET3.DIT	0.66..36000		NIR Detector Integration Time (s)
DET3.NDIT	1..20	1	number of DITs
SEQ.NEXP.UVB	0..100	1	UVB number of exposures per offset position
SEQ.NEXP.VIS	0..100	1	VIS number of exposures per offset position
SEQ.NEXP.NIR	0..100	1	NIR number of exposures per offset position
SEQ.FIXOFF.RA	-100..100	0	RA fixed offset (“)
SEQ.FIXOFF.DEC	-100..100	0	DEC fixed offset (“)
SEQ.JITTER.WIDTH	0..2	0	Jitter box width in “
SEQ.NABCYCLES	0..100	1	Number OS or SO cycles
SEQ.OFFSET.ZERO	T, F	T	Return to Origin?
		Fixed Values	
INS.MODE	SLITSPEC, IFUSPEC	SLITSPEC	Instrument Mode
SEQ.AGSNAPSHOT	T, F	F	Take an acquisition image before science exposures?

Table 27: Parameters for the template `XSHOOTER_slt_obs_GenericOffset`. It allows to decide the sequence of offsets and object or sky observations.

XSHOOTER_slt_obs_GenericOffset			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free parameters			
INS.OPTI3.NAME	*see* Table 5	1.0x11	UVB slit
INS.OPTI4.NAME	*see* Table 8	0.9x11	VIS slit
INS.OPTI5.NAME	*see* Table 9	0.9x11	NIR slit
DET1.WIN1.UIT1	0..36000		UVB exposure time (s)
DET1.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	UVB readout mode
DET2.WIN1.UIT1	0..36000		VIS exposure time (s)
DET2.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	VIS readout mode
DET3.DIT	0..36000		NIR Detector Integration Time (s)
DET3.NDIT	1..20	1	number of DITs
SEQ.NEXP.UVB	0..100	1	UVB number of exposures per offset position
SEQ.NEXP.VIS	0..100	1	VIS number of exposures per offset position
SEQ.NEXP.NIR	0..100	1	NIR number of exposures per offset position
SEQ.OFFSET.COORDS	SKY,SLIT	SKY	Offset coordinate type (RA/DEC or X/Y) in “
SEQ.RELOFF1	-1000..1000	0	List of RA/X offsets (“)
SEQ.RELOFF2	-1000..1000	0	List of DEC/Y offsets (“)
SEQ.OBS.TYPE	O,S	O S	List of observation type (object or sky)
SEQ.NOFFSET	0..100	2	Number of offsets
SEQ.OFFSET.ZERO	T, F	T	Return to Origin
Fixed Values			
INS.MODE	SLITSPEC, IFUSPEC	SLITSPEC	Instrument Mode
SEQ.AGSNAPSHOT	T, F	F	Take an acquisition image before science exposures?

IFU observations

Table 28: User defined and fixed parameters for IFU observations in stare mode with the template `XSHOOTER_ifu_obs_Stare`.

XSHOOTER_ifu_obs_Stare			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free parameters			
DET1.WIN1.UIT1	0..36000		UVB exposure time (s)
DET1.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	UVB readout mode
DET2.WIN1.UIT1	0..36000		VIS exposure time (s)
DET2.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	VIS readout mode
DET3.DIT	0..36000		NIR Detector Integration Time (s)
DET3.NDIT	1..20	1	number of DITs
SEQ.NEXP.UVB	0..100	1	UVB number of exposures
SEQ.NEXP.VIS	0..100	1	VIS number of exposures
SEQ.NEXP.NIR	0..100	1	NIR number of exposures
Fixed Values			
INS.MODE	SLITSPEC, IFUSPEC	IFUSPEC	Instrument Mode
INS.OPTI3.NAME	see Table 5	1x12.6	UVB slit
INS.OPTI4.NAME	see Table 8	1x12.6	VIS slit
INS.OPTI5.NAME	see Table 9	1x12.6	NIR slit
SEQ.AGSNAPSHOT	T, F	F	Take an acquisition image before science exposures?

Table 29: User defined and fixed parameters for the template `XSHOOTER_ifu_obs_StareSynchro` to perform synchronized observations in stare mode.

XSHOOTER_slt_ifu_StareSynchro			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free parameters			
DET1.WIN1.UIT1	0..36000		UVB exposure time (s)
DET1.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	UVB readout mode
DET2.WIN1.UIT1	0..36000		VIS exposure time (s)
DET2.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	VIS readout mode
DET3.DIT	0..36000		NIR Detector Integration Time (s)
DET3.NDIT	1..20	1	number of DITs
Fixed Values			
INS.MODE	SLITSPEC, IFUSPEC	IFUSPEC	Instrument Mode
INS.OPTI3.NAME	see Table 5	1x12.6	UVB Slit slide
INS.OPTI4.NAME	see Table 8	1x12.6	VIS Slit slide
INS.OPTI5.NAME	see Table 9	1x12.6	NIR Slit slide
SEQ.AGSNAPSHOT	T, F	F	Take an acquisition image before science exposures?

Table 30: User defined and fixed parameters for the template `XSHOOTER_ifu_obs_FixedSkyOffset`. It allows to alternate object and sky observations taking the sky at fixed postion.

XSHOOTER_slt_ifu_FixedSkyOffset			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free parameters			
DET1.WIN1.UIT1	0..36000		UVB exposure time (s)
DET1.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	UVB readout mode
DET2.WIN1.UIT1	0..36000		VIS exposure time (s)
DET2.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	VIS readout mode
DET3.DIT	0..36000		NIR Detector Integration Time (s)
DET3.NDIT	1..20	1	number of DITs
SEQ.NEXP.UVB	0..100	1	UVB number of exposures per offset position
SEQ.NEXP.VIS	0..100	1	VIS number of exposures per offset position
SEQ.NEXP.NIR	0..100	1	NIR number of exposures per offset position
SEQ.FIXOFF.RA	-100..100	0	RA fixed offset (“)
SEQ.FIXOFF.DEC	-100..100	0	DEC fixed offset (“)
SEQ.JITTER.WIDTH	0..2	0	Jitter box width in “
SEQ.NABCYCLES	0..100	1	Number OS or SO cycles
SEQ.OFFSET.ZERO	T, F	T	Return to Origin?
Fixed Values			
INS.MODE	SLITSPEC, IFUSPEC	IFUSPEC	Instrument Mode
INS.OPTI3.NAME	see Table 5	1x12.6	UVB slit
INS.OPTI4.NAME	see Table 8	1x12.6	VIS slit
INS.OPTI5.NAME	see Table 9	1x12.6	NIR slit
SEQ.AGSNAPSHOT	T, F	F	Take an acquisition image before science exposures?

Table 31: User defined and fixed parameters for the template `XSHOOTER_ifu_obs_GenericOffset`. It allows any sequence of offsets and object or sky observations.

XSHOOTER_ifu_obs_GenericOffset			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free parameters			
DET1.WIN1.UIT1	0..36000		UVB exposure time (s)
DET1.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	UVB readout mode
DET2.WIN1.UIT1	0..36000		VIS exposure time (s)
DET2.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	VIS readout mode
DET3.DIT	0..36000		NIR Detector Integration Time (s)
DET3.NDIT	1..20	1	number of DITs
SEQ.NEXP.UVB	0..100	1	UVB number of exposures per offset position
SEQ.NEXP.VIS	0..100	1	VIS number of exposures per offset position
SEQ.NEXP.NIR	0..100	1	NIR number of exposures per offset position
SEQ.OFFSET.COORDS	SKY, SLIT	SKY	Offset coordinate type RA/DEC or X/Y
SEQ.RELOFF1	-1000..1000	0	List of RA/X offsets (“)
SEQ.RELOFF2	-1000..1000	0	List of DEC/Y offsets (“)
SEQ.OBS.TYPE	O,S	O S	List of observation type (object or sky)
SEQ.NOFFSET	0..100	2	Number of offsets
SEQ.OFFSET.ZERO	T, F	T	Return to Origin?
Fixed Values			
INS.MODE	SLITSPEC, IFUSPEC	IFUSPEC	Instrument Mode
INS.OPTI3.NAME	see Table 5	1x12.6	UVB Slit slide
INS.OPTI4.NAME	see Table 8	1x12.6	VIS Slit slide
INS.OPTI5.NAME	see Table 9	1x12.6	NIR Slit slide
SEQ.AGSNAPSHOT	T,F	F	Take an acquisition image before science exposures?

6.1.6 Night-time Calibration Templates

Spectro-photometric Standard Stars

Table 32: User and fixed keywords for `XSHOOTER_slt_cal_SpecphotStdStare.` The template is identical to that for slit observation in stare mode except for some of the default parameters.

XSHOOTER_slt_cal_SpecphotStdStare			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free parameters			
INS.OPTI3.NAME	*see* Table 5	5.0x11	UVB slit
INS.OPTI4.NAME	*see* Table 8	5.0x11	VIS slit
INS.OPTI5.NAME	*see* Table 9	5.0x11	NIR slit
DET1.WIN1.UIT1	0..36000		UVB exposure time (s)
DET1.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	UVB readout mode
DET2.WIN1.UIT1	0..36000		VIS exposure time (s)
DET2.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	VIS readout mode
DET3.DIT	0..36000		NIR Detector Integration Time (s)
DET3.NDIT	1..20	1	number of DITs
SEQ.NEXPO.UVB	0..100	1	UVB number of exposures
SEQ.NEXPO.VIS	0..100	1	VIS number of exposures
SEQ.NEXPO.NIR	0..100	1	NIR number of exposures
Fixed Values			
INS.MODE	SLITSPEC, IFUSPEC	SLITSPEC	Instrument Mode
SEQ.AGSNAPSHOT	T, F	F	Take an acquisition image before science exposures?

Table 33: User defined and fixed parameters for `XSHOOTER_slt_cal_SpecphotStdOffset.` The template is identical to that for alternate object-sky slit observations except for some of the default parameters.

XSHOOTER_slt_cal_SpecphotStdOffset			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free parameters			
INS.OPTI3.NAME	*see* Table 5	5.0x11	UVB slit
INS.OPTI4.NAME	*see* Table 8	5.0x11	VIS slit
INS.OPTI5.NAME	*see* Table 9	5.0x11	NIR slit
DET1.WIN1.UIT1	0..36000		UVB exposure time (s)
DET1.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	UVB readout mode
DET2.WIN1.UIT1	0..36000		VIS exposure time (s)
DET2.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	VIS readout mode
DET3.DIT	0..36000		NIR Detector Integration Time (s)
DET3.NDIT	1..20	1	number of DITs
SEQ.NEXP.UVB	0..100	1	UVB number of exposures per offset position
SEQ.NEXP.VIS	0..100	1	VIS number of exposures per offset position
SEQ.NEXP.NIR	0..100	1	NIR number of exposures per offset position
SEQ.FIXOFF.RA	-100..100	0	RA fixed offset (“)
SEQ.FIXOFF.DEC	-100..100	0	DEC fixed offset (“)
SEQ.JITTER.WIDTH	0..2	0	Jitter box width in “
SEQ.NABCYCLES	0..100	1	Number OS or SO cycles
SEQ.OFFSET.ZERO	T, F	T	Return to Origin?
Fixed Values			
INS.MODE	SLITSPEC, IFUSPEC	SLITSPEC	Instrument Mode
SEQ.AGSNAPSHOT	T, F	F	Take an acquisition image before science exposures?

Table 34: User defined and fixed parameters for `XSHOOTER_slt_cal_SpecphotNodding`. The template is identical to the `XSHOOTER_slt_obs_AutoNodOnSlit` one

XSHOOTER_slt_cal_SpecphotNodding			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free parameters			
INS.OPTI3.NAME	*see* Table 5	5.0”x11”	UVB slit
INS.OPTI4.NAME	*see* Table 8	5.0”x11”	VIS slit
INS.OPTI5.NAME	*see* Table 9	5.0”x11”	NIR slit
DET1.WIN1.UIT1	0..36000		UVB exposure time (s)
DET1.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	UVB readout mode
DET2.WIN1.UIT1	0..36000		VIS exposure time (s)
DET2.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	VIS readout mode
DET3.DIT	0..36000		NIR Detector Integration Time (s)
DET3.NDIT	1..20	1	number of DITs
SEQ.NEXP.UVB	0..100	1	UVB number of exposures per offset position
SEQ.NEXP.VIS	0..100	1	VIS number of exposures per offset position
SEQ.NEXP.NIR	0..100	1	NIR number of exposures per offset position
SEQ.SKYTHROW	0..10	5	Nod Throw in “
SEQ.JITTER.WIDTH	0..2	0	Jitter box width in “
SEQ.NABCYCLES	0..100	1	Number AB or BA cycles
SEQ.OFFSET.ZERO	T, F	T	Return to Origin?
Fixed Values			
INS.MODE	SLITSPEC, IFUSPEC	SLITSPEC	Instrument Mode
SEQ.AGSNAPSHOT	T, F	F	Take an acquisition image before science exposures?

Table 35: User defined and fixed parameters for `XSHOOTER_ifu_cal_SpecphotStdStare`. The template is identical to that for the IFU observations in stare mode.

XSHOOTER_ifu_cal_SpecphotStdStare			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free parameters			
DET1.WIN1.UIT1	0..36000		UVB exposure time (s)
DET1.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	UVB readout mode
DET2.WIN1.UIT1	0..36000		VIS exposure time (s)
DET2.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	VIS readout mode
DET3.DIT	0..36000		NIR Detector Integration Time (s)
DET3.NDIT	1..20	1	number of DITs
SEQ.NEXP.UVB	0..100	1	UVB number of exposures
SEQ.NEXP.VIS	0..100	1	VIS number of exposures
SEQ.NEXP.NIR	0..100	1	NIR number of exposures
Fixed Values			
INS.MODE	SLITSPEC,IFUSPEC	IFUSPEC	Instrument Mode
INS.OPTI3.NAME	see Table 5	1x12.6	UVB slit
INS.OPTI4.NAME	see Table 8	1x12.6	VIS slit
INS.OPTI5.NAME	see Table 9	1x12.6	NIR slit
SEQ.AGSNAPSHOT	T, F	F	Take an acquisition image before science exposures?

Table 36: User defined and fixed parameters for `XSHOOTER_ifu_cal_SpecphotStdOffset.` The template is identical to the `XSHOOTER_ifu_obs_FixedSkyOffset.`

XSHOOTER_ifu_cal_SpecphotStdOffset			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free parameters			
DET1.WIN1.UIT1	0..36000		UVB exposure time (s)
DET1.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	UVB read-out mode
DET2.WIN1.UIT1	0..36000		VIS exposure time (s)
DET2.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	VIS read-out mode
DET3.DIT	0..36000		NIR Detector Integration Time (s)
DET3.NDIT	1..20	1	number of DITs
SEQ.NEXP.UVB	0..100	1	UVB number of exposures per offset position
SEQ.NEXP.VIS	0..100	1	VIS number of exposures per offset position
SEQ.NEXP.NIR	0..100	1	NIR number of exposures per offset position
SEQ.FIXOFF.RA	-100..100	0	RA fixed offset (“)
SEQ.FIXOFF.DEC	-100..100	0	DEC fixed offset (“)
SEQ.JITTER.WIDTH	0..2	0	Jitter box width in “
SEQ.NABCYCLES	0..100	1	Number OS or SO cycles
SEQ.OFFSET.ZERO	T, F	T	Return to Origin?
Fixed Values			
INS.MODE	SLITSPEC,IFUSPEC	IFUSPEC	Instrument Mode
INS.OPTI3.NAME	see Table 5	1x12.6	UVB slit
INS.OPTI4.NAME	see Table 8	1x12.6	VIS slit
INS.OPTI5.NAME	see Table 9	1x12.6	NIR slit
SEQ.AGSNAPSHOT	T, F	F	Take an acquisition image before science exposures?

Telluric standards

Table 37: User and fixed keywords for `XSHOOTER_slt_cal_TelluricStdStare.` The template is identical to the `XSHOOTER_slt_obs_Stare` one.

XSHOOTER_slt_cal_TelluricStdStare			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free parameters			
INS.OPTI3.NAME	*see* Table 5	1.0x11	UVB slit
INS.OPTI4.NAME	*see* Table 8	0.9x11	VIS slit
INS.OPTI5.NAME	*see* Table 9	0.9x11	NIR slit
DET1.WIN1.UIT1	0..36000		UVB exposure time (s)
DET1.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	UVB readout mode
DET2.WIN1.UIT1	0..36000		VIS exposure time (s)
DET2.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	VIS readout mode
DET3.DIT	0..36000		NIR Detector Integration Time (s)
DET3.NDIT	1..20	1	number of DITs
SEQ.NEXPO.UVB	0..100	1	UVB number of exposures
SEQ.NEXPO.VIS	0..100	1	VIS number of exposures
SEQ.NEXPO.NIR	0..100	1	NIR number of exposures
Fixed Values			
INS.MODE	IFUSPEC,SLITSPEC	SLITSPEC	Instrument Mode
SEQ.AGSNAPSHOT	T, F	F	Take an acquisition image before science exposures?

Table 38: User defined and fixed parameters for `SHOOT_slt_cal_TelluricStdNod.` The template is identical to the `XSHOOTER_slt_obs_AutoNodOnSlit` one.

XSHOOTER_slt_cal_TelluricStdNod			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free parameters			
INS.OPTI3.NAME	*see* Table 5	1.0x11	UVB slit
INS.OPTI4.NAME	*see* Table 8	0.9x11	VIS slit
INS.OPTI5.NAME	*see* Table 9	0.9x11	NIR slit
DET1.WIN1.UIT1	0..36000		UVB exposure time (s)
DET1.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	UVB readout mode
DET2.WIN1.UIT1	0..36000		VIS exposure time (s)
DET2.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	VIS readout mode
DET3.DIT	0..36000		NIR Detector Integration Time (s)
DET3.NDIT	1..9999	1	Number of DITs
SEQ.NEXP.UVB	0..100	1	UVB number of exposures per offset position
SEQ.NEXP.VIS	0..100	1	VIS number of exposures per offset position
SEQ.NEXP.NIR	0..100	1	NIR number of exposures per offset position
SEQ.SKYTHROW	0..10	5	Nod Throw in "
SEQ.JITTER.WIDTH	0..2	0	Jitter box width in "
SEQ.NABCYCLES	0..100	1	Number AB or BA cycles
SEQ.OFFSET.ZERO	T, F	T	Return to Origin?
Fixed Values			
INS.MODE	IFUSPEC,SLITSPEC	SLITSPEC	Instrument Mode
SEQ.AGSNAPSHOT	T, F	F	Take an acquisition image before science exposures?

Table 39: User defined and fixed parameters for `SHOOT_ifu_cal_TelluricStdStare`. The template is identical to `XSHOOTER_ifu_obs_Stare`.

XSHOOTER_ifu_cal_TelluricStdStare			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free parameters			
DET1.WIN1.UIT1	0..36000		UVB exposure time (s)
DET1.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	UVB readout mode
DET2.WIN1.UIT1	0..36000		VIS exposure time (s)
DET2.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	VIS readout mode
DET3.DIT	0..36000		NIR Detector Integration Time (s)
DET3.NDIT	1..20	1	number of DITs
SEQ.NEXP.UVB	0..100	1	UVB number of exposures
SEQ.NEXP.VIS	0..100	1	VIS number of exposures
SEQ.NEXP.NIR	0..100	1	NIR number of exposures
Fixed Values			
INS.MODE	IFUSPEC,SLITSPEC	IFUSPEC	Instrument Mode
INS.OPTI3.NAME	see Table 5	1x12.6	UVB slit
INS.OPTI4.NAME	see Table 8	1x12.6	VIS slit
INS.OPTI5.NAME	see Table 9	1x12.6	NIR slit
SEQ.AGSNAPSHOT	T, F	F	Take an acquisition image before science exposures?

Table 40: User defined and fixed parameters for `SHOOT_ifu_cal_TelluricStdOffset.` The template is identical to `XSHOOTER_ifu_obs_FixedSkyOffset.`
Be careful, the offsets in RA and DEC are setup by default to 1".

XSHOOTER_ifu_cal_TelluricStdOffset			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free parameters			
DET1.WIN1.UIT1	0..36000		UVB Exposure Time (s)
DET1.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	UVB read-out mode
DET2.WIN1.UIT1	0..36000		VIS Exposure Time (s)
DET2.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	VIS read-out mode
DET3.DIT	0..36000		NIR Detector Integration Time (s)
DET3.NDIT	1..20	1	number of DITs
SEQ.NEXP.UVB	0..100	1	UVB number of exposures per offset position
SEQ.NEXP.VIS	0..100	1	VIS number of exposure per offset position
SEQ.NEXP.NIR	0..100	1	NIR number of exposure per offset position
SEQ.FIXOFF.RA	-100..100	0	RA fixed offset (arcsec)
SEQ.FIXOFF.DEC	-100..100	0	DEC fixed offset (arcsec)
SEQ.JITTER.WIDTH	0..2	0	Jitter box width in arcsec
SEQ.NABCYCLES	0..100	1	Number OS or SO cycles
SEQ.OFFSET.ZERO	T, F	T	Return to Origin?
Fixed Values			
INS.MODE	IFUSPEC,SLITSPEC	IFUSPEC	Instrument Mode
INS.OPTI3.NAME	see Table 5	1x12.6	UVB slit
INS.OPTI4.NAME	see Table 8	1x12.6	VIS slit
INS.OPTI5.NAME	see Table 9	1x12.6	NIR slit
SEQ.AGSNAPSHOT	T, F	F	Take an acquisition image before science exposures?

Attached night calibrations: <u>must be taken after a science template</u>

Table 41: Parameters for the template `XSHOOTER_slt_cal_UVBVISArcAtt`.

XSHOOTER_slt_cal_UVBVisArcsAtt			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free Parameters			
DET1.WIN1.UIT1	0..36000		UVB exposure time
DET1.READ.CLKDESCR	*see* Table 6	400/1pt/lg	UVB readout mode
DET2.WIN1.UIT1	0..36000		VIS exposure time
DET2.READ.CLKDESCR	*see* Table 6	400/1pt/lg	VIS readout mode
SEQ.NEXPO.UVB	0..100	1	No. of UVB exposures
SEQ.NEXPO.VIS	0..100	1	No. of VIS exposures
Fixed Value			
INS.MODE	IFUSPEC,SLITSPEC	SLITSPEC	Instrument Mode

Table 42: Parameters for the template `XSHOOTER_slt_cal_UVBLampFlatAtt`.

XSHOOTER_slt_cal_UVBLampFlatAtt			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free Parameters			
DET1.WIN1.UIT1.HIGHF	0..36000		UVB exposure time (High Flat)
DET1.WIN1.UIT1.LOWF	0..36000		UVB exposure time (Low Flat)
DET2.READ.CLKDESCR	*see* Table 6		VIS readout mode
SEQ.NEXPO.HIGHF	0..100		No. of exposures (High Flat)
SEQ.NEXPO.LOWF	0..100		No. of exposures (Low Flat)
Fixed Value			
INS.MODE	IFUSPEC,SLITSPEC	SLTSPEC	Instrument Mode

Table 43: Parameters for the template `XSHOOTER_slt_cal_VISLampFlatAtt`.

XSHOOTER_slt_cal_VISLampFlatAtt			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free Parameters			
DET2.WIN1.UIT1	0..36000		VIS exposure time
DET2.READ.CLKDESCR	*see* Table 6		VIS readout mode
SEQ.NEXPO	0..100		No. of exposures
Fixed Value			
INS.MODE	IFUSPEC,SLITSPEC	SLITSPEC	Instrument Mode

Table 44: Parameters for the template `XSHOOTER_slt_cal_VISLampFlatAtt`.

XSHOOTER_slt_cal_NIRLampFlatAtt			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free Parameters			
DET3.DIT	0..36000		NIR exposure time (DIT)
DET3.NDIT	0..20		No. of NIR sub-integrations
SEQ.NEXPO	0..100		No. of exposures
Fixed Value			
INS.MODE	IFUSPEC,SLITSPEC	SLITSPEC	Instrument Mode

Table 45: Parameters for the template `XSHOOTER_ifu_cal_UVBVisArcAtt`.

XSHOOTER_ifu_cal_UVBVisArcsAtt			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free Parameters			
DET1.WIN1.UIT1	0..36000		UVB exposure time
DET1.READ.CLKDESCR	*see* Table 6		UVB readout mode
DET2.WIN1.UIT1	0..36000		VIS exposure time
DET2.READ.CLKDESCR	*see* Table 6		VIS readout mode
SEQ.NEXPO.UVB	0..100	1	No. of UVB exposures
SEQ.NEXPO.VIS	0..100	1	No. of VIS exposures
Fixed Value			
INS.MODE	IFUSPEC,SLITSPEC	IFUSPEC	Instrument Mode

Table 46: Parameters for the template `XSHOOTER_ifu_cal_UVBVisArcAtt`.

XSHOOTER_ifu_cal_UVBLampFlatAtt			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free Parameters			
DET1.WIN1.UIT1.HIGHF	0..36000		UVB exposure time (High Flat)
DET1.WIN1.UIT1.LOWF	0..36000		UVB exposure time (Low Flat)
DET2.READ.CLKDESCR	*see* Table 6		VIS readout mode
SEQ.NEXPO.HIGHF	0..100		No. of exposures (High Flat)
SEQ.NEXPO.LOWF	0..100		No. of exposures (Low Flat)
Fixed Value			
INS.MODE	IFUSPEC,SLITSPEC	IFUSPEC	Instrument Mode

Table 47: Parameters for the template `XSHOOTER_ifu_cal_VISLampFlatAtt`.

XSHOOTER_ifu_cal_VISLampFlatAtt			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free Parameters			
DET2.WIN1.UIT1	0..36000		VIS exposure time
DET2.READ.CLKDESCR	*see* Table 6		VIS readout mode
SEQ.NEXPO	0..100		No. of exposures
Fixed Value			
INS.MODE	IFUSPEC,SLITSPEC	IFUSPEC	Instrument Mode

Table 48: Parameters for the template `XSHOOTER_ifu_cal_NIRLampFlatAtt`.

XSHOOTER_ifu_cal_NIRLampFlatAtt			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free Parameters			
DET3.DIT	0..36000	60	NIR exposure time (DIT)
DET3.NDIT	0..20	1	No. of NIR sub-integrations
SEQ.NEXPO	0..100		No. of exposures
Fixed Value			
INS.MODE	IFUSPEC,SLITSPEC	IFUSPEC	Instrument Mode

6.1.7 Daytime Calibration templates

Slit and IFU arc lamp calibrations (resolution, tilt)

Table 49: User and fixed keywords for `XSHOOTER_slt_cal_UVBVisArcs.`

XSHOOTER_slt_cal_UVBVisArcs			
Keyword	*Range*	*Default Value*	*Label in P2PP*
Free Parameters			
INS.OPTI3.NAME	*see* Table 5	1.0x11	UVB slit
INS.OPTI4.NAME	*see* Table 8	0.9x11	VIS slit
DET1.WIN1.UIT1	0..36000	30	UVB exposure time
DET1.READ.CLKDESCR	*see* Table 6	400/1pt/lg	UVB readout mode
DET2.WIN1.UIT1	0..36000	5	VIS exposure time
DET2.READ.CLKDESCR	*see* Table 6	400/1pt/lg	VIS readout mode
SEQ.NEXPO.UVB	0..100	1	No. of UVB exposures
SEQ.NEXPO.VIS	0..100	1	No. of VIS exposures
Fixed Value			
INS.MODE	SLITSPEC,IFUSPEC	SLITSPEC	Instrument Mode

Table 50: User and fixed keywords for `XSHOOTER_slt_cal_NIRArcs.`

XSHOOTER_slt_cal_NIRArcs			
Free Parameters			
Keyword	*Range*	*Default Value*	*Label in P2PP*
INS.OPTI5.NAME	*see* Table 9	0.9x11	NIR Slit slide
DET3.DIT	0..36000	0.66	NIR Exposure Time
DET3.NDIT	1..20	1	Number of DITs
SEQ.NEXPO	0..100	1	No. of NIR exposures
Fixed Value			
INS.MODE	SLITSPEC,IFUSPEC	SLITSPEC	Instrument Mode

Table 51: User and fixed keywords for `XSHOOTER_ifu_cal_UVBVisArcs`

XSHOOTER_ifu_cal_UVBVisArcs			
Free Parameters			
Keyword	*Range*	*Default Value*	*Label in P2PP*
DET1.WIN1.UIT1	0..36000	45	UVB Exposure Time
DET1.READ.CLKDESCR	*see* Table 6	400k/1pt/lg	UVB readout mode
DET2.WIN1.UIT1	0..36000	4	VIS Exposure Time
DET2.READ.CLKDESCR	*see* Table 6	400k/1pt/lg	VIS readout mode
SEQ.NEXPO.UVB	0..100	1	No. of UVB exposures
SEQ.NEXPO.VIS	0..100	1	No. of VIS exposures
Fixed Value			
INS.MODE	IFUSPEC,SLITSPEC	IFUSPEC	Instrument Mode
INS.OPTI3.NAME	see Table 5	1.0x12.6	UVB slit
INS.OPTI4.NAME	see Table 8	1.0x12.6	VIS slit

Table 52: User and fixed keywords for `XSHOOTER_slt_cal_NIRArcs.`

XSHOOTER_ifu_cal_NIRArcs			
Free Parameters			
Keyword	*Range*	*Default Value*	*Label in P2PP*
DET3.DIT	0..36000	1.32	NIR Exposure Time
DET3.NDIT	1..20	1	Number of DITs
SEQ.NEXPO	0..100	1	No. of NIR exposures
Fixed Value			
INS.MODE	IFUSPEC,SLITSPEC	IFUSPEC	Instrument Mode
INS.OPTI5.NAME	see Table 9	1.0x12.6	NIR slit

Flatfield (pixel response, orders localization)

Table 53: User and fixed keywords for `XSHOOTER_slt_cal_UBVLampFlat`

XSHOOTER_slt_cal_UVBLampFlat			
Free Paramters			
Keyword	*Range*	*Default Value*	*Label in P2PP*
INS.OPTI3.NAME	*see* Table 5	1.0x11	UVB slit
DET1.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	UVB readout mode
DET1.WIN1.UIT1.HIGHF	0..36000	7.4	Halogen lamp exposure time
DET1.WIN1.UIT1.LOWF	0..36000	2.8	D_2 lamp exposure time
SEQ.NEXPO.HIGHF	0..100	5	Number of Halogen lamp exp
SEQ.NEXPO.LOWF	0..100	5	Number of D_2 lamp exp.
Fixed Value			
INS.MODE	SLITSPEC,IFUSPEC	SLITSPEC	Instrument Mode

Table 54: User and fixed keywords for `XSHOOTER_slt_cal_VISLampFlat`

XSHOOTER_slt_cal_VISLampFlat			
Free Parameters			
Keyword	*Range*	*Default Value*	*Label in P2PP*
INS.OPTI4.NAME	*see* Table 5	0.9x11	VIS slit
DET2.WIN1.UIT1	0..36000	8	VIS Exposure Time
DET2.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	VIS readout mode
SEQ.NEXPO	0..100	5	VIS # of exposure
Fixed Value			
INS.MODE	SLITSPEC,IFUSPEC	SLITSPEC	Instrument Mode

Table 55: User and fixed keywords for `XSHOOTER_slt_cal_NIRLampFlat.`

XSHOOTER_slt_cal_NIRLampFlat			
Free Parameters			
Keyword	*Range*	*Default Value*	*Label in P2PP*
INS.OPTI5.NAME	*see* Table 9	0.9x11	NIR slit
DET3.DIT	0..36000	40	NIR exposure time
DET3.NDIT	1..20	1	Number of DITs
SEQ.NEXPO	0..100	5	NIR No. of exposure
Fixed Value			
INS.MODE	SLITSPEC,IFUSPEC	SLITSPEC	Instrument Mode

Table 56: User and fixed keywords for `XSHOOTER_ifu_cal_UBVLampFlat`

XSHOOTER_ifu_cal_UVBLampFlat			
Free Parameters			
Keyword	*Range*	*Default Value*	*Label in P2PP*
DET1.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	UVB readout mode
DET1.WIN1.UIT1.HIGHF	0..36000	12.3	Halo. lamp exposure time
DET1.WIN1.UIT1.LOWF	0..36000	4.7	D_2 lamp exposure time
SEQ.NEXPO.HIGHF	0..100	5	Number of Halo. lamp exp
SEQ.NEXPO.LOWF	0..100	5	Number of D_2 lamp exp.
Fixed Value			
INS.MODE	IFUSPEC,SLITSPEC	IFUSPEC	Instrument Mode
INS.OPTI3.NAME	see Table 5	1.0x12.6	UVB slit

Table 57: User and fixed keywords for `XSHOOTER_ifu_cal_VISLampFlat`

XSHOOTER_ifu_cal_VISLampFlat			
Free Paramters			
Keyword	*Range*	*Default Value*	*Label in P2PP*
DET2.WIN1.UIT1	0..36000	12.2	VIS Exposure Time
DET2.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	VIS readout mode
SEQ.NEXPO	0..100	5	VIS No. of exposure
Fixed Value			
INS.MODE	IFUSPEC,SLITSPEC	IFUSPEC	Instrument Mode
INS.OPTI4.NAME	see Table 8	1.0x12.6	VIS slit

Table 58: User and fixed keywords for `XSHOOTER_ifu_cal_NIRLampFlat.`

XSHOOTER_ifu_cal_NIRLampFlat			
Free Parameters			
Keyword	*Range*	*Default Value*	*Label in P2PP*
DET3.DIT	0..36000	60	NIR exposure time
DET3.NDIT	1..20	1	Number of DITs
SEQ.NEXPO	0..100	5	NIR No. of exposures
Fixed Value			
INS.MODE	IFUSPEC,SLITSPEC	IFUSPEC	Instrument Mode
INS.OPTI5.NAME	see Table 9	1.0x12.6	NIR slit

Format check (1st guess of wavelength solution)

Table 59: User and fixed keywords for `XSHOOTER_slt_cal_UVBVisArcsSinglePinhole`

XSHOOTER_slt_cal_UVBVisArcsSinglePinhole			
Free Parameters			
Keyword	*Range*	*Default Value*	*Label in P2PP*
DET1.WIN1.UIT1	0..36000	40	UVB Exposure Time
DET1.READ.CLKDESCR	*see* Table 6	400k/1pt/lg	UVB readout mode
DET2.WIN1.UIT1	0..36000	15	VIS Exposure Time
DET2.READ.CLKDESCR	*see* Table 6	400k/1pt/lg	VIS readout mode
SEQ.NEXPO.UVB	0..100	1	No. of UVB exposures
SEQ.NEXPO.VIS	0..100	1	No. of VIS exposures
Fixed Value			
INS.MODE	SLITSPEC,IFUSPEC	SLITSPEC	Instrument Mode
INS.OPTI3.NAME	see Table 5	Pin_0.5	UVB slit
INS.OPTI4.NAME	see Table 8	Pin_0.5	VIS slit

Table 60: User and fixed keywords for `XSHOOTER_slt_cal_NIRArcsSinglePinhole.`

XSHOOTER_slt_cal_NIRArcsSinglePinhole			
Free Parameters			
Keyword	*Range*	*Default Value*	*Label in P2PP*
DET3.DIT	0..36000	10	NIR Exposure Time
DET3.NDIT	1..20	5	Number of DITs
SEQ.NEXPO	0..100	1	NIR # of exposure
Fixed Value			
INS.MODE	SLITSPEC,IFUSPEC	SLITSPEC	Instrument Mode
INS.OPTI5.NAME	see Table 9	Pin_0.5	NIR slit

Order definition (1st guess of order localization)

Table 61: User and fixed keywords for `XSHOOTER_slt_cal_UBVLampFlaSinglePinhole`

XSHOOTER_slt_cal_UVBLampFlatSinglePinhole			
Free Parameters			
Keyword	*Range*	*Default Value*	*Label in P2PP*
DET1.WIN1.UIT1.HIGHF	0..36000	30	UVB exposure time (High Flat)
DET1.WIN1.UIT1.LOWF	0..36000	20	UVB exposure time (Low Flat)
DET1.READ.CLKDESCR	*see* Table 6	400k/1pt/lg	UVB readout mode
SEQ.NEXPO.HIGHF	0..30	1	No. of exposures (High Flat)
SEQ.NEXPO.LOWF	0..30	1	No. of exposures (Low Flat)
Fixed Value			
INS.MODE	SLITSPEC,IFUSPEC	SLITSPEC	Instrument Mode
INS.OPTI3.NAME	see Table 9	Pin_0.5	UVB Slit slide

Table 62: User and fixed keywords for `XSHOOTER_slt_cal_VISLampFlatSinglePinhole.`

XSHOOTER_slt_cal_VISLampFlatSinglePinhole			
Free Paramters			
Keyword	*Range*	*Default Value*	*Label in P2PP*
DET2.WIN1.UIT1	0..36000	60	VIS exposure time
DET2.READ.CLKDESCR	*see* Table 6	400k/1pt/lg	VIS readout mode
SEQ.NEXPO	0..100	1	No. of exposures
Fixed Value			
INS.MODE	SLITSPEC,IFUSPEC	SLITSPEC	Instrument Mode
INS.OPTI4.NAME	see Table 8	Pin_0.5	VIS slit

Table 63: User and fixed keywords for `XSHOOTER_slt_cal_NIRLampFlatSinglePinhole`

XSHOOTER_slt_cal_NIRLampFlatSinglePinhole.			
Free Parameters			
Keyword	*Range*	*Default Value*	*Label in P2PP*
DET3.DIT	0..36000	1	NIR exposure time
DET3.NDIT	1..20	1	Number of DITs
SEQ.NEXPO	0..100	1	NIR No. of exposures
Fixed Value			
INS.MODE	SLITSPEC,IFUSPEC	SLITSPEC	Instrument Mode
INS.OPTI5.NAME	see Table 9	Pin_0.5	NIR Slit slide

Arcs multi-pinhole: 2d wave maps (wavelength calibration)

Table 64: User and fixed keywords for `XSHOOTER_slt_cal_UVBVisArcsMultiplePinhole.`

XSHOOTER_slt_cal_UVBVisArcsMultiplePinhole			
Free Parameters			
Keyword	*Range*	*Default Value*	*Label in P2PP*
DET1.WIN1.UIT1	0..36000	15	UVB exposure time
DET1.READ.CLKDESCR	*see* Table 6	400k/1pt/lg	UVB readout mode
DET2.WIN1.UIT1	0..36000	10	VIS exposure time
DET2.READ.CLKDESCR	*see* Table 6	400k/1pt/lg	VIS readout mode
SEQ.NEXPO.UVB	0..100	1	UVB No. of exposure
SEQ.NEXPO.VIS	0..100	1	VIS No. of exposure
Fixed Value			
INS.MODE	SLITSPEC,IFUSPEC	SLITSPEC	Instrument Mode
INS.OPTI3.NAME	see Table 5	Pin_row	UVB Slit slide
INS.OPTI4.NAME	see Table 8	Pin_row	VIS Slit slide

Table 65: User and fixed keywords for `XSHOOTER_slt_cal_NIRArcsMultiplePinhole.`

XSHOOTER_slt_cal_NIRArcsMultiplePinhole			
Keyword	*Range*	*Default Value*	*Label in P2PP*
DET3.DIT	0..36000	5	NIR exposure time
DET3.NDIT	1..20	10	Number of DITs
SEQ.NEXPO	0..100	1	NIR No. of exposures
Fixed Value			
INS.MODE	SLITSPEC,IFUSPEC	SLITSPEC	Instrument Mode
INS.OPTI5.NAME	see Table 9	Pin_row	NIR Slit wheel

Detector calibrations

Table 66: User and fixed keywords for `XSHOOTER_gen_cal_Bias`

XSHOOTER_gen_cal_Bias			
Free Parameters			
Keyword	*Range*	*Default Value*	*Label in P2PP*
DET1.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	UVB read-out mode
DET2.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	VIS read-out mode
SEQ.NEXPO.UVB	0..100	1	UVB No. of exposures
SEQ.NEXPO.VIS	0..100	1	VIS No. of exposure
Fixed Value			
DET1.WIN1.UIT1		0	UVB exposure time
DET2.WIN1.UIT1		0	VIS exposure time

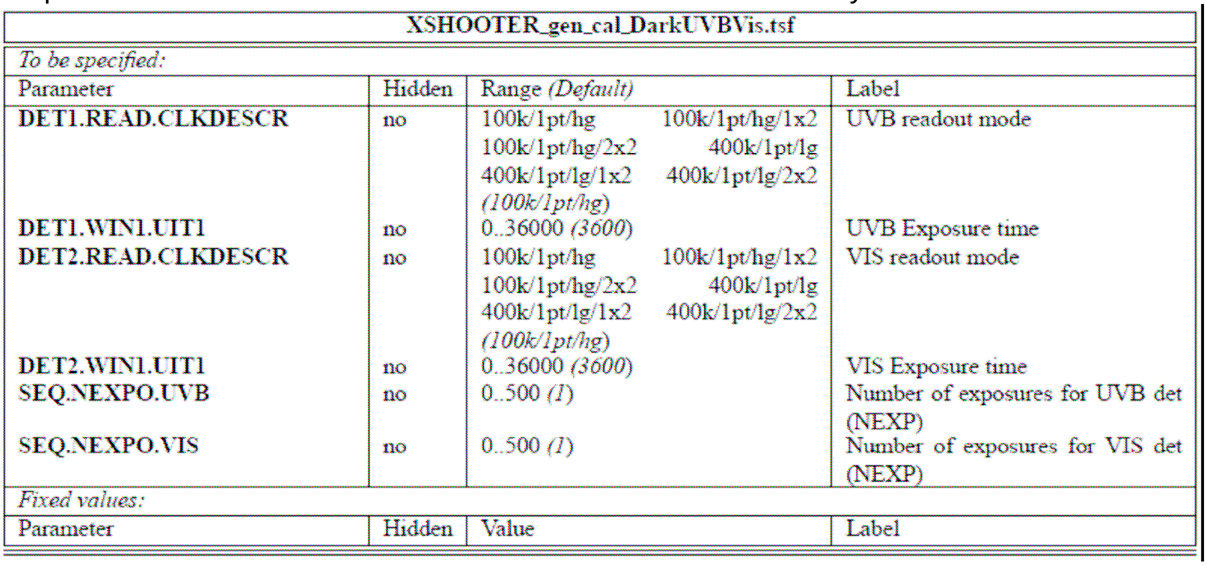
Table 67: User and fixed keywords for `XSHOOTER_gen_cal_DarkUVBVis`

XSHOOTER_gen_cal_DarkUVBVis			
Free Parameters			
Keyword	*Range*	*Default Value*	*Label in P2PP*
DET1.WIN1.UIT1	0..36000	3600	UVB Exposure Time
DET1.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	UVB read-out mode
DET2.WIN1.UIT1	0..36000	3600	VIS Exposure Time
DET2.READ.CLKDESCR	*see* Table 6	100k/1pt/hg	VIS read-out mode
SEQ.NEXPO.UVB	0..100	1	UVB No. of exposures
SEQ.NEXPO.VIS	0..100	1	VIS No. of exposures
Fixed Value			

Table 68: User and fixed keywords for `XSHOOTER_gen_cal_DarkNIR`

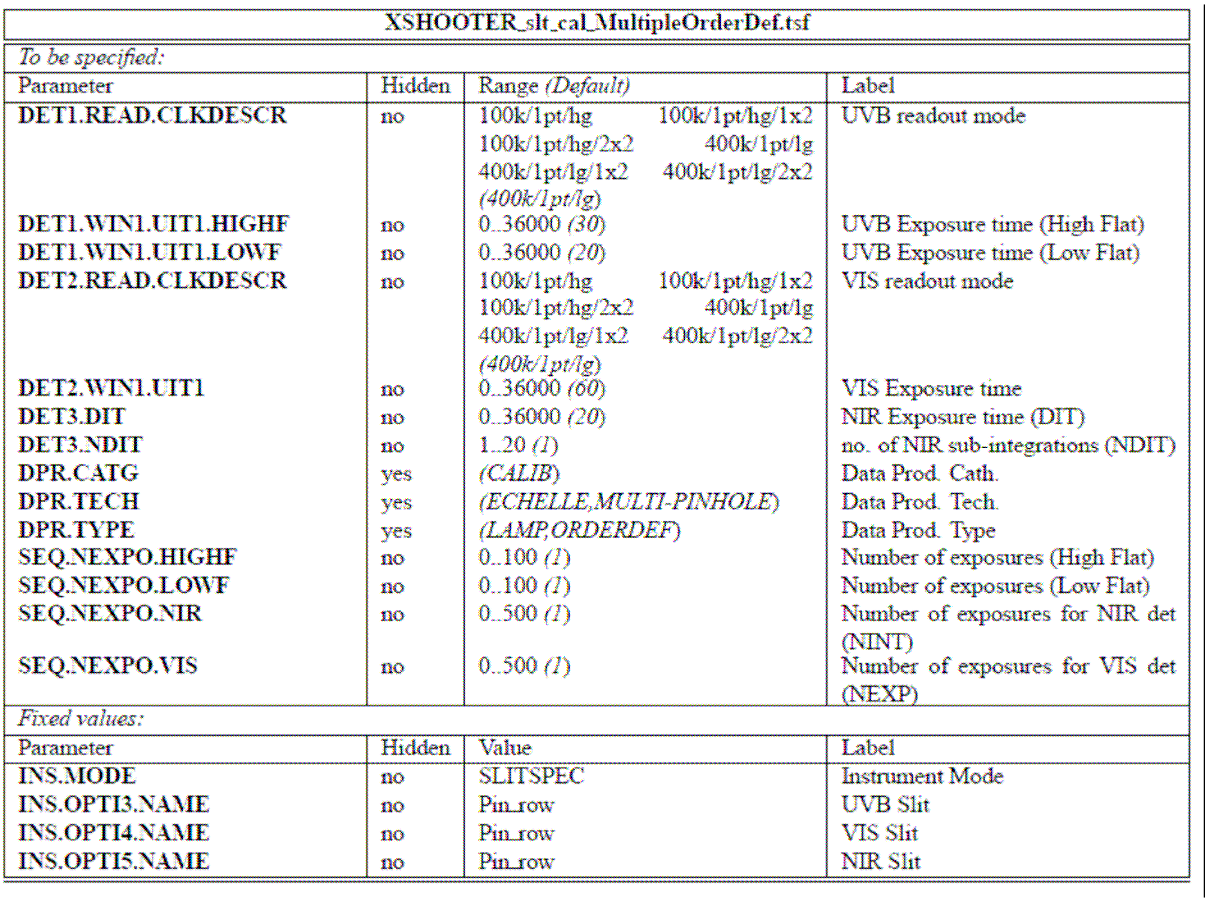
XSHOOTER_gen_cal_DarkNIR			
Free Parameters			
Keyword	*Range*	*Default Value*	*Label in P2PP*
DET3.DIT	0..36000		NIR Exposure Time
DET3.NDIT	1..20	1	Number of DITs
SEQ.NEXPO	0..100	3	No. of NIR exposures
Fixed Value			

Table 69: User and fixed keywords for XSHOOTER_gen_cal_DarkUVBVIS template. This template allows to run biases for the UVB/VIS arms simultaneously of darks in the NIR arm.



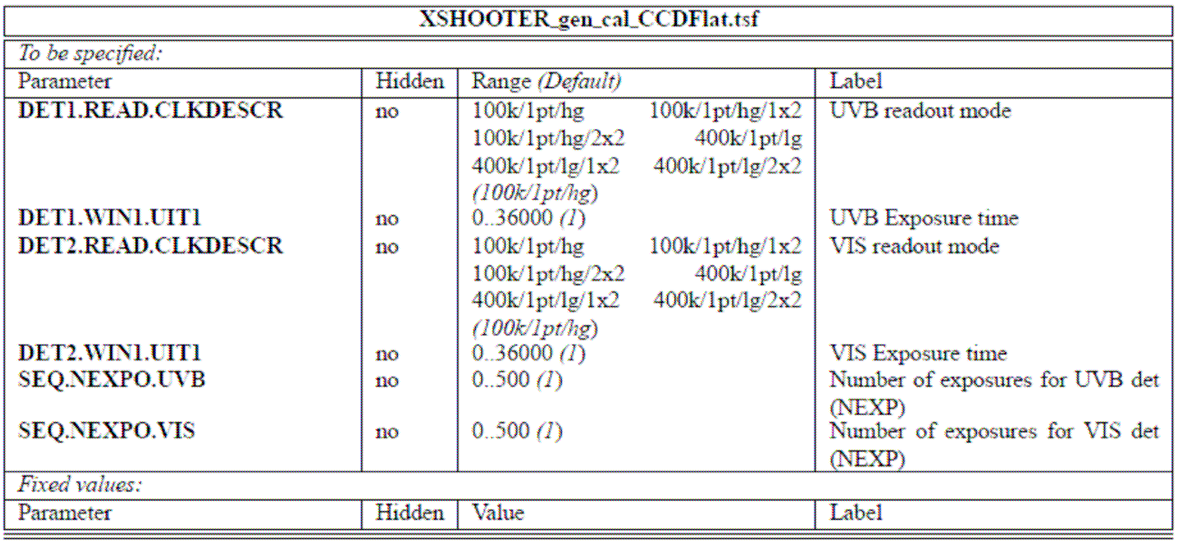
XSHOOTER_gen_cal_DarkUVBVis.tsf			
To be specified:			
Parameter	Hidden	Range *(Default)*	Label
DET1.READ.CLKDESCR	no	100k/1pt/hg 100k/1pt/hg/1x2 100k/1pt/hg/2x2 400k/1pt/lg 400k/1pt/lg/1x2 400k/1pt/lg/2x2 *(100k/1pt/hg)*	UVB readout mode
DET1.WIN1.UIT1	no	0..36000 *(3600)*	UVB Exposure time
DET2.READ.CLKDESCR	no	100k/1pt/hg 100k/1pt/hg/1x2 100k/1pt/hg/2x2 400k/1pt/lg 400k/1pt/lg/1x2 400k/1pt/lg/2x2 *(100k/1pt/hg)*	VIS readout mode
DET2.WIN1.UIT1	no	0..36000 *(3600)*	VIS Exposure time
SEQ.NEXPO.UVB	no	0..500 *(1)*	Number of exposures for UVB det (NEXP)
SEQ.NEXPO.VIS	no	0..500 *(1)*	Number of exposures for VIS det (NEXP)
Fixed values:			
Parameter	Hidden	Value	Label

Table 70: New multi-order definition template XSHOOTER_slt_cal_MultipleOrderDef running for multi-pinholes with FF lamps and giving order definition for each pinhole of the row.



XSHOOTER_slt_cal_MultipleOrderDef.tsf			
To be specified:			
Parameter	Hidden	Range *(Default)*	Label
DET1.READ.CLKDESCR	no	100k/1pt/hg 100k/1pt/hg/1x2 100k/1pt/hg/2x2 400k/1pt/lg 400k/1pt/lg/1x2 400k/1pt/lg/2x2 *(400k/1pt/lg)*	UVB readout mode
DET1.WIN1.UIT1.HIGHF	no	0..36000 *(30)*	UVB Exposure time (High Flat)
DET1.WIN1.UIT1.LOWF	no	0..36000 *(20)*	UVB Exposure time (Low Flat)
DET2.READ.CLKDESCR	no	100k/1pt/hg 100k/1pt/hg/1x2 100k/1pt/hg/2x2 400k/1pt/lg 400k/1pt/lg/1x2 400k/1pt/lg/2x2 *(400k/1pt/lg)*	VIS readout mode
DET2.WIN1.UIT1	no	0..36000 *(60)*	VIS Exposure time
DET3.DIT	no	0..36000 *(20)*	NIR Exposure time (DIT)
DET3.NDIT	no	1..20 *(1)*	no. of NIR sub-integrations (NDIT)
DPR.CATG	yes	*(CALIB)*	Data Prod. Cath.
DPR.TECH	yes	*(ECHELLE,MULTI-PINHOLE)*	Data Prod. Tech.
DPR.TYPE	yes	*(LAMP,ORDERDEF)*	Data Prod. Type
SEQ.NEXPO.HIGHF	no	0..100 *(1)*	Number of exposures (High Flat)
SEQ.NEXPO.LOWF	no	0..100 *(1)*	Number of exposures (Low Flat)
SEQ.NEXPO.NIR	no	0..500 *(1)*	Number of exposures for NIR det (NINT)
SEQ.NEXPO.VIS	no	0..500 *(1)*	Number of exposures for VIS det (NEXP)
Fixed values:			
Parameter	Hidden	Value	Label
INS.MODE	no	SLITSPEC	Instrument Mode
INS.OPTI3.NAME	no	Pin_row	UVB Slit
INS.OPTI4.NAME	no	Pin_row	VIS Slit
INS.OPTI5.NAME	no	Pin_row	NIR Slit

Table 71: Template for taking detector FF and biases for the linearity measurements of the detectors.



XSHOOTER_gen_cal_CCDFlat.tsf			
To be specified:			
Parameter	Hidden	Range *(Default)*	Label
DET1.READ.CLKDESCR	no	100k/1pt/hg 100k/1pt/hg/1x2 100k/1pt/hg/2x2 400k/1pt/lg 400k/1pt/lg/1x2 400k/1pt/lg/2x2 *(100k/1pt/hg)*	UVB readout mode
DET1.WIN1.UIT1	no	0..36000 *(1)*	UVB Exposure time
DET2.READ.CLKDESCR	no	100k/1pt/hg 100k/1pt/hg/1x2 100k/1pt/hg/2x2 400k/1pt/lg 400k/1pt/lg/1x2 400k/1pt/lg/2x2 *(100k/1pt/hg)*	VIS readout mode
DET2.WIN1.UIT1	no	0..36000 *(1)*	VIS Exposure time
SEQ.NEXPO.UVB	no	0..500 *(1)*	Number of exposures for UVB det (NEXP)
SEQ.NEXPO.VIS	no	0..500 *(1)*	Number of exposures for VIS det (NEXP)
Fixed values:			
Parameter	Hidden	Value	Label

]

6.2 Slit masks

6.2.1 UVB

Table 72: full description of the UVB slit mask

Position	Size	Physcal size (µm)	Purpose
1	0.5” ∅ pinhole	126 ∅ hole	CAL
2	5”×11” slit	1256 × 2763	CAL
3	1.6”×11” slit	402 × 2763	SCI / CAL
4	1.3”×11” slit	327 × 2763	SCI / CAL
5	0.8”×11” slit	201 × 2763	SCI / CAL
6	1”×12.6” slit	251 × 3165	With IFU only
7	Raw of 9 pinholes of 0.5” ∅ spaced at 1.4”	126 ∅ holes spaced by 352	CAL
8	0.5”×11” slit	126 × 2763	SCI / CAL
9	1.0”x11” slit	251 × 2763	SCI / CAL

6.2.2 VIS

Table 73: full description of the VIS slit mask

Position	Size	Physcal size (µm)	Purpose
1	0.5” ∅ pinhole	131 ∅ hole	CAL
2	5”×11” slit	1307 × 2875	CAL
3	1.5”×11” slit	392 × 2875	SCI / CAL
4	1.2”×11” slit	314 × 2875	SCI / CAL
5	0.7”×11” slit	183 × 2875	SCI / CAL
6	1.0”×12.6” slit	261 × 3294	With IFU only
7	Raw of 9 pinholes of 0.5” ∅ spaced at 1.4”	131 ∅ holes spaced by 352	CAL
8	0.4”×11” slit	105 × 2875	SCI / CAL
9	0.9” ×11” slit	235 × 2875	SCI / CAL

6.2.3 NIR

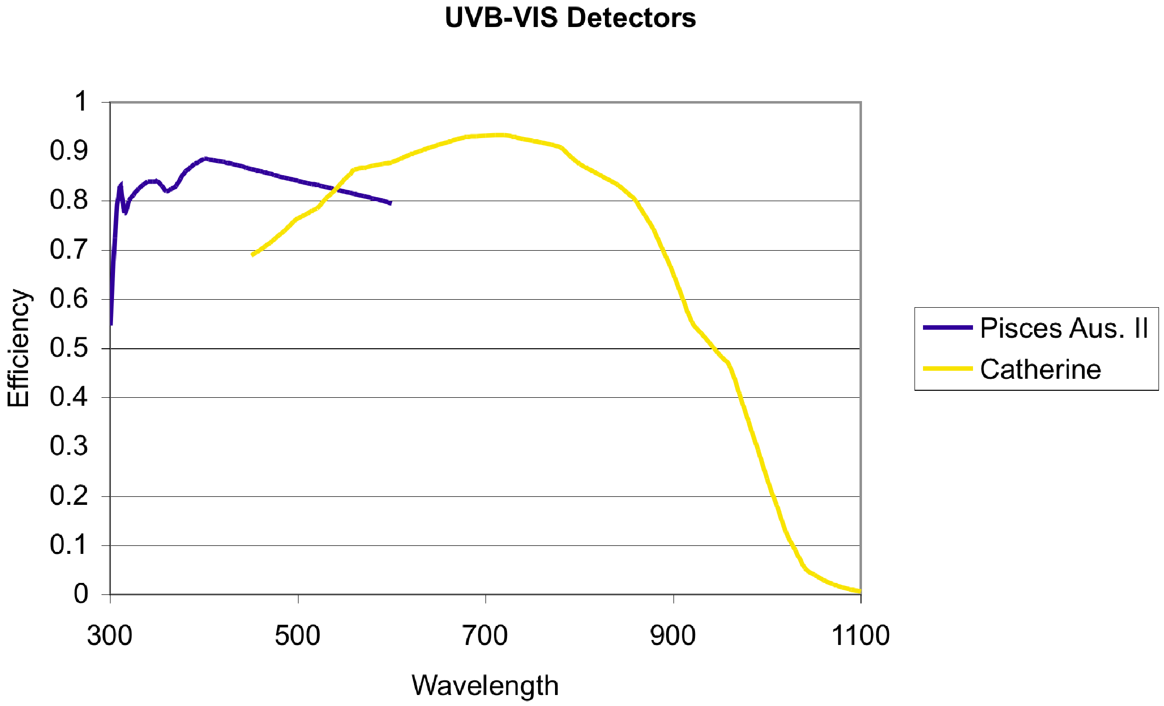
Table 74: full description of the new NIR slit mask

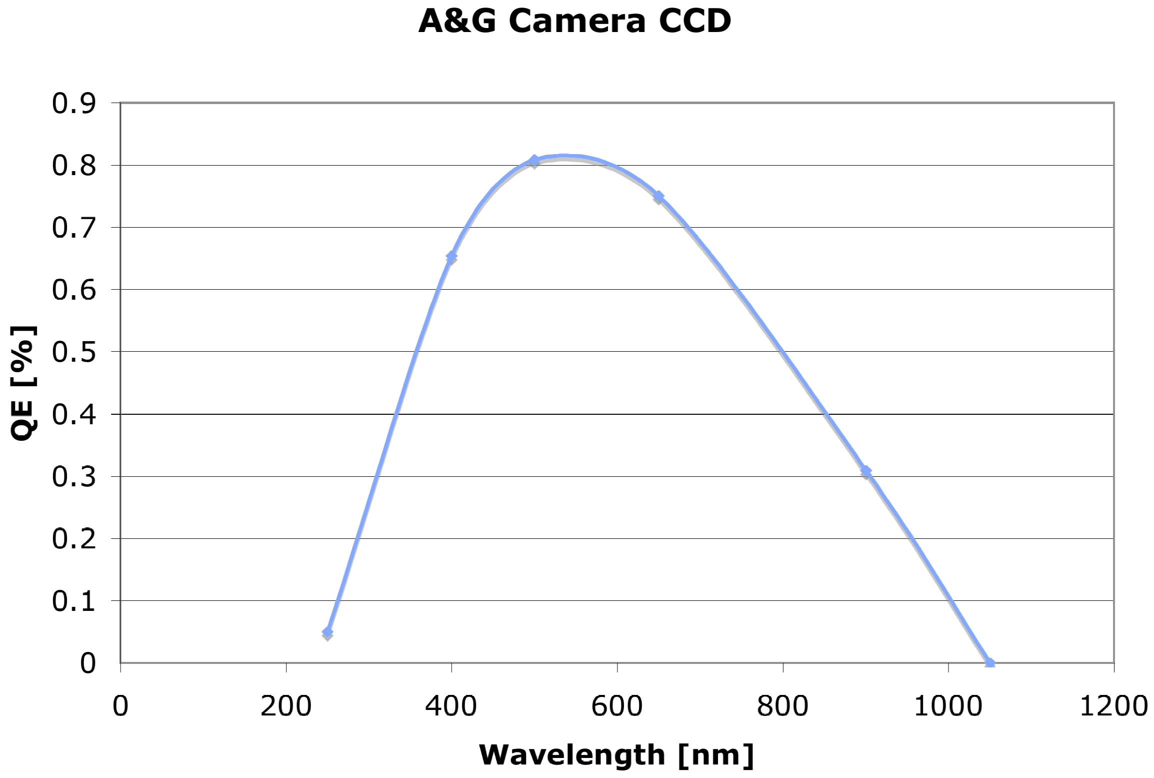
Position	**Size**	**Physcal size (”)**	**Purpose**
1	0.5” ∅ pinhole	0.490	CAL
2	5”×11” slit	5.004	SCI / CAL
3	0.9”×11” slit	0.917	SCI / CAL
4	1.0”×12.6” slit	0.991	With IFU only
5	1.2”×11” slit	1.191	SCI / CAL
6	tilted slit		TECH (focus)
7	0.6”x11” JH	0.623	SCI / CAL
8	Blind		
9	0.9”x11” JH	0.904	SCI / CAL
10	0.4”×11” slit	0.386	SCI/CAL
11	Raw of 9 pinholes of 0.5” ∅ spaced at 1.4”	0.501	CAL
12	0.6”×11” slit	0.612	SCI/CAL

Table 75: full description of the old NIR slit mask

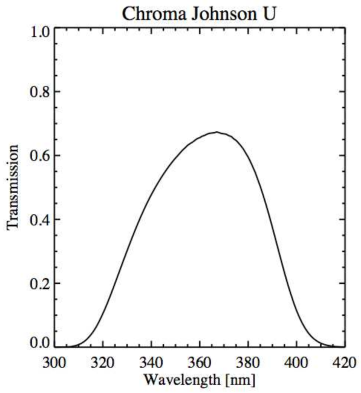
Position	**Size**	**Physcal size (μm)**	**Purpose**
1	0.5” ∅ pinhole	270 ∅ hole	CAL
2	5”×11” slit	2695×5683	CAL
3	0.9”×11” slit	485×5683	SCI / CAL
4	1.0”×12.6” slit	544×6510	With IFU only
5	1.2”×11” slit	647×5683	SCI / CAL
6	tilted slit		TECH (focus)
7	1.5”×11” slit		
8	Blind		
9	0.4” ∅ pinhole	216 ∅ hole	TECH
10	0.4”×11” slit	216×5683	SCI/CAL
11	Raw of 9 pinholes of 0.5” ∅ spaced at 1.4”	270 ∅ holes spaced by 723	CAL
12	0.6”×11” slit	323×5683	SCI/CAL

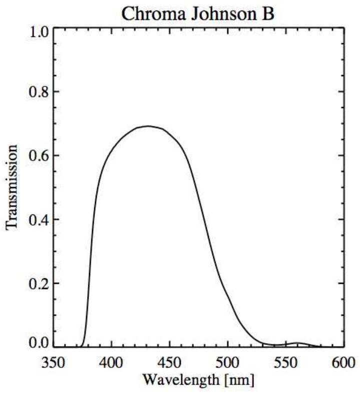
6.3 Detector QE curves

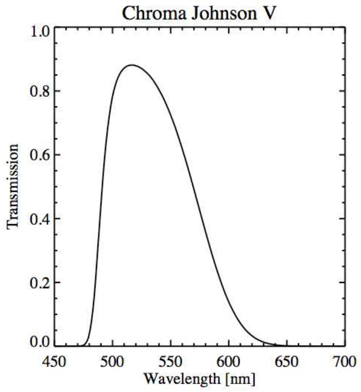


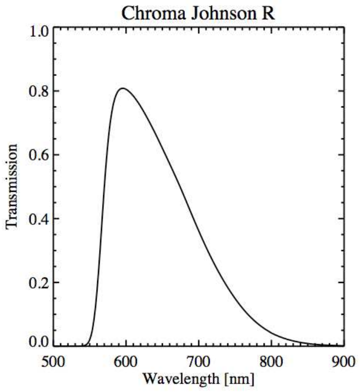


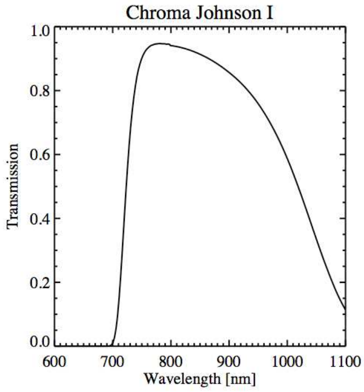
6.4 A&G camera filter curves

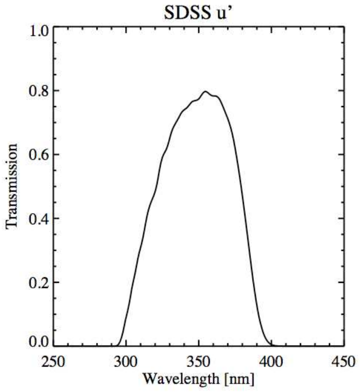

Chroma Johnson U

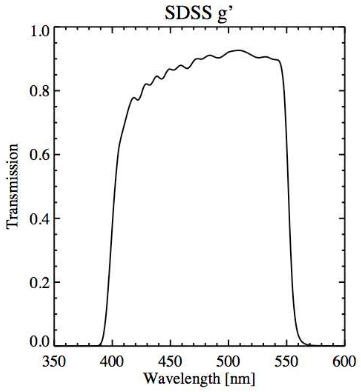

Chroma Johnson B

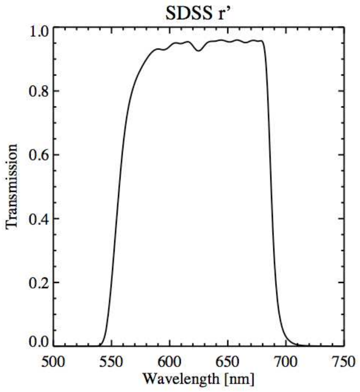

Chroma Johnson V

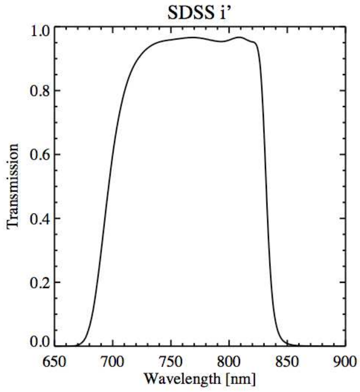

Chroma Johnson R

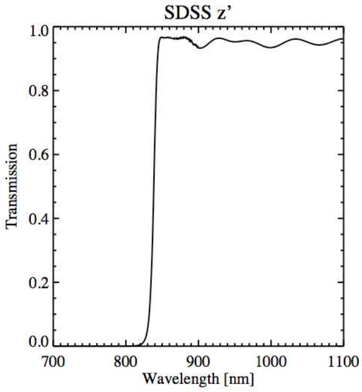

Chroma Johnson I


SDSS u’


SDSS g’


SDSS r’


SDSS i’
Transmission
Wavelength [nm]
0.0
0.2
0.4
0.6
0.8
1.0
650
700
750
800
850
900


SDSS z’
Transmission
Wavelength [nm]
0.0
0.2
0.4
0.6
0.8
1.0
700
800
900
1000
1100