Mem. S.A.It. Vol. 80, 44

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X-SHOOTER: a unique opportunity for the Italian community

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Abstract. X-Shooter is a high-efficiency, wide band (U to K), intermediate resolution (4,000-14,000), single-object spectrograph for the Very Large Telescope (VLT). To optimize efficiency and increase wavelength coverage, light is split by dichroics into three arms: UV-Blue, Visible, and Near Infrared. It will be the first second generation instrument of the VLT instrument suite. Currently in the last phase of integration, X-Shooter will see first light in the last quarter of 2008. This paper highlights first results obtained in our facilities.

1. Introduction

X-Shooter is a high-efficiency single-object spectrograph with a spectral resolution of 4,000–14,000 (depending on the wavelength range and the slit width) capable of simultaneously recording the full spectrum from 300 to 2500 nm. It will be mounted on the Cassegrain focal station of the VLT in the last quarter of 2008. It has been conceived as a "point and shoot" instrument for easy and reliable operations, therefore it has a fixed spectral format and only the slit width can be selected (D'Odorico et al. 2006; Kaper et al. 2008).

It consists of three optimized spectrographs, each one devoted to the observation of different wavelength bands: UV-blue, visible, and near infrared. A schematic layout is shown in Fig. 3. Main characteristics are summarized in Table 1. Three different slit widths and a small integral field unit (IFU) can be selected by the user. Light is sent to different arms through dichroics.

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2. Instrument overview

Spectrographs are hold in place with a backbone structure where relay optics (dichroics, atmospheric dispersion correctors, re-imaging optics, pupil stops) and auxiliary optics (acquisition and guiding unit, calibration unit, flexure active compensation system) take place. Relay optics has been designed in order to maximize efficiency. A detailed description can be found in Michaelsen et al. (2006);

Table 1. X-Shooter Characteristics

Spectral Format	Prism cross-dispersed echelle (order separation <12")
Wavelength range	300–2500 nm, split in three arms UVB: 300–550 nm VIS: 550–1000 nm NIR: 1000–2500 nm
Spectral resolution	5000 (UVB, NIR) for a 1 arcsec slit 7000 (VIS) for a 1 arcsec slit
Slits/Image slicer	slit 12"×1" (standard), 12"×0.6" (high res.), 12"×5" (flux cal.) IFU 4"×1.8" input, 12"×0.6" output (3 slices)
Detectors	UVB 2K×4K E2V CCD VIS 2K×4K MIT/LL CCD NIR 2K×2K Rockwell Hawaii 2RG MBE
Auxiliary functions	Calibration Unit, A&G unit 1'×1' field of view, ADC for UVB and VIS arms

Fig. 1. X-Shooter mounted on the VLT telescope simulator at ESO.

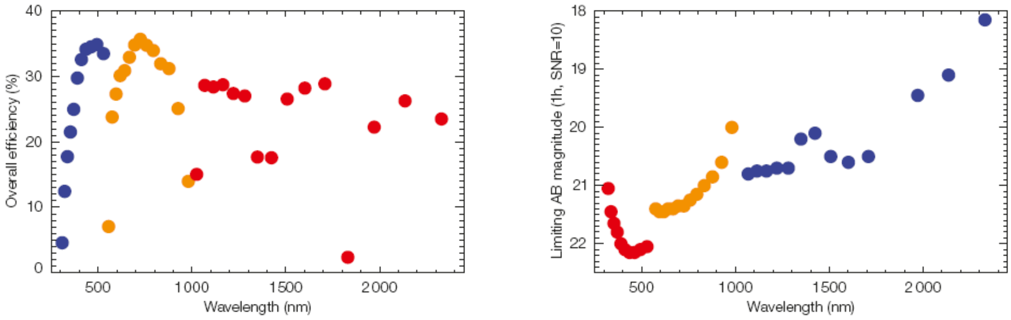

Fig. 2. Total efficiency at blaze, from atmosphere to detector, excluding slit losses (left) and related limiting AB magnitude per spectral bin at S/N=10 in a 1 hr exposure (right).

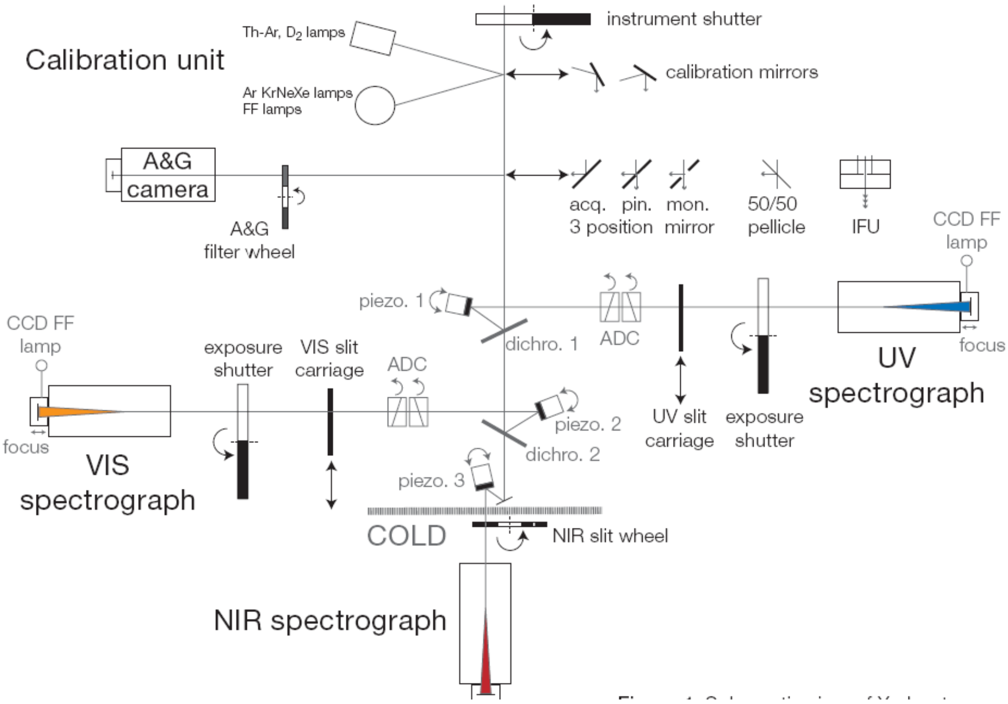

Fig. 3. Schematic view of X-Shooter

Rasmussen et al. (2008). Moreover, new calibration sources have been developed for X-shooter (Kerber et al. 2008).

Spectrographs share the same optical design scheme, the so-called 4C (Collimator Correction of Camera Chromatism, Delabre et al. 1989), for its very compact layout, reduced weight of optics and mechanics, improvement of the stiffness, higher efficiency (Spanò et al. 2006). UVB and VIS spectrographs are very similar and have been developed in parallel in Italy, in collaboration with Danish partners. The NIR spectrograph, being a cryogenic instrument, has been optimized separately in the Netherlands (Navarro et al. 2008).

3. Control software and data reduction

In parallel to the hardware development, the instrument control electronics and the instrument control SW was developed and tested in Trieste. An advanced data reduction pipeline has been also developed; it delivers a fully reduced and calibrated 1-D as well as a 2-D spectrum. The reduction pipeline is based on a physical model of the spectrograph (Bristow et al. 2008; Goldoni et al. 2008). This allows a better wavelength calibration of the spectrum and its rectification.

4. Expected performances

Most delivered optical components exceed specifications in terms of efficiency and image quality. This translates into an overall throughput and spectral r esolution higher than requirements. In particular, critical components like dichroics, ADC, gratings, and prisms exhibit very high quality (Vernet et al. 2007). As a result, predicted total efficiency is very high (Fig. 2) and limiting magnitudes are well below 21 (AB) in the UVB and visible for 1" slit and S/N=10 in 1 hour exposure, making X-Shooter the deepest spectrograph for this resolution band from ground.

5. Status

The instrument has been built by a European Consortium of four countries (Italy, Denmark, the Netherlands, and France), led by ESO. Major costs (in terms of FTEs and direct costs) were covered by national partners, obtaining about 150 nights of guaranteed time observations (GTO). Italy will receive 45 nights of GTO. Many different science cases have been proposed by different scientific panels, with the contribution of a lot of Italian researchers.

UVB and VIS spectrographs was aligned and successfully tested in Merate (INAF–O.A.Brera) late 2007. NIR was assembled at ASTRON (NL) and all subsystems were sent to ESO for the final integration (Fig. 1). The system has been tested with respect to mechanical flexures, thermal drifts, image quality, spectral resolution, spectral coverage, and efficiency. All technical requirements were met.

The instrument is scheduled for first light at a VLT telescope in September 2008. After a further commissioning, the instrument will be offered to the community in April 2009.

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