Coming Soon on Stage: X-shooter

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X-shooter is a single-target, intermediate-resolution, wide-wavelength-range (*UV*- to *K*-band) spectrograph. It will be the first of the second-generation VLT instruments to go to the telescope. First light is planned in the second half of 2008. Here we give an update on the integration status and on the expected performance.

X-shooter overview

X-shooter is a high-efficiency spectrograph with a spectral resolution of 4 000–10 000 (dependent on wavelength and slit width) capable of simultaneously observing the complete spectral range 300–2 500 nm. It will be located at the Cassegrain focus of one of the VLT UTs. The instrument is designed for a rapid response and has a fixed spectral format.

X-shooter consists of a central structure (backbone) which supports three prism-cross-dispersed echelle spectrographs optimised for the UV-Blue, Visible and Near-IR wavelength ranges respectively. The backbone contains the calibration and acquisition units, an IFU that can be inserted in the light path, two dichroics to split the beam among the three arms, and relay optics to feed the entrance slits of the three spectrographs. A functional diagram summarising all the functions of X-shooter is shown in Figure 1; the main instrument parameters are listed in Table 1.

The instrument concept has not changed since PDR and interested readers will find more information in the Messenger article of 2005 (Dekker and D'Odorico, The Messenger 120, page 2). The only modification, already hinted at, has been the implementation of three active flexure-correction mirrors in the light paths to the three spectrograph slits.

The larger fraction of the X-shooter hardware, as well as labour, is funded by the external members of the consortium. ESO is responsible for the detector systems, project management, and final system test and commissioning. More than 60 people are currently involved in the project at nine different institutes distributed over four ESO member states and at ESO (see Table 2). The overall cost of the project is 6.4 M€ and the staff effort 69 FTEs. Even with a complex distribution of the work tasks over many different sites, the X-shooter project has advanced well and on a relatively short time scale.

Table 1: X-shooter characteristics

Spectral format	Prism cross-dispersed echelle (order separation > 12″)
Wavelength range	300–2 500 nm, split in three arms using dichroics UVB: 300–550 nm VIS: 550–1000 nm NIR: 1000–2 500 nm
Spectral resolution	5 000 (UVB, NIR) and 7 000 (VIS) for a one arcsec slit
Slits/Image slicer	slit 12″ × 1″ (standard), 12″ × 0.6″ (high R), 12″ × 5″ (flux cal.) IFU 4 × 1.8″ input area, 12 × 0.6″ exit slit (3 slices)
Detectors	UVB: 2K × 4K E2V CCD VIS: 2X × 4K MIT/LL CCD IR: 2K × 2K Rockwell Hawaii2RG MBE (used area 1K × 2K)
Auxiliary functions	Calibration Unit; A & G unit with 1′ × 1′ field and comprehensive filter set; ADC for the UVB and VIS arms.

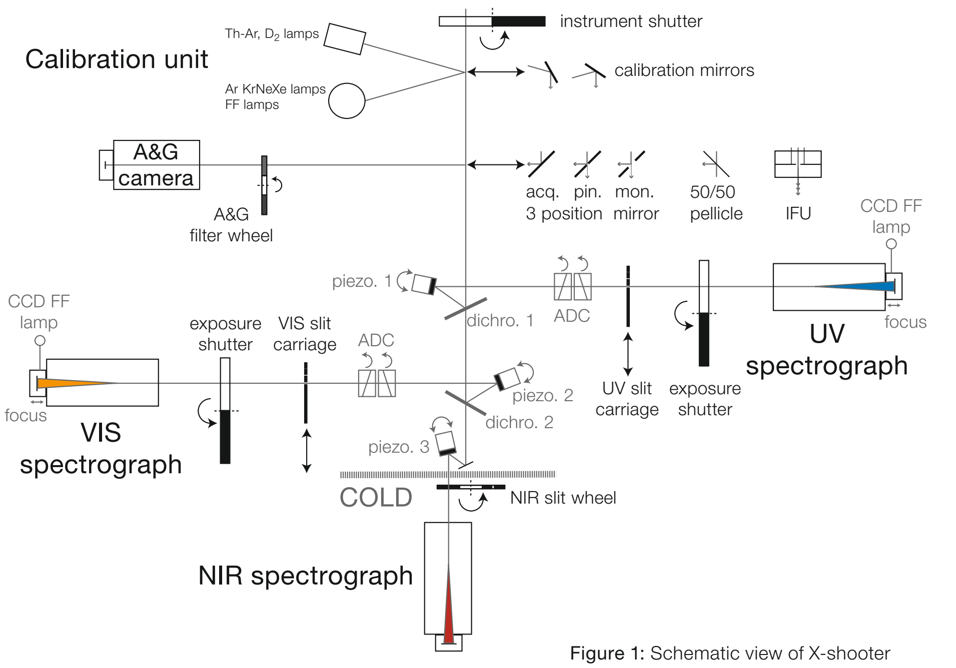

Figure 1: Schematic view of X-shooter

Project status

Since the FDR, which was completed in June 2006, all hardware items have been manufactured or ordered from industry and have been delivered (with two exceptions: the UVB camera and the NIR grating; now on the critical path). Since early 2007, subsystem integration and testing has been in progress at all six partner sites responsible for hardware deliveries (see Table 2). In the mean time, ESO has completed the handling carriage procurement and the detector systems for Acquisition and Guiding, as well as for each of the three spectrographs, and the Observatoire de Paris has completed and delivered the Integral Field Unit.

At the time of writing, the Backbone is under final system test at the Niels Bohr Institute in Copenhagen, while the UVB and VIS spectrographs are under test at INAF Brera-Merate Observatory near Milan. Figure 2 shows an early 'laboratory 1st light' image of the VIS spectrograph.

In the late summer of 2007, the vacuum/cryogenic test of the NIR spectrograph vessel was successfully completed at the University of Nijmegen. The vessel is now at Astron (Dwingeloo) for assembly with the cold bench that carries the optics and detector. First light is expected for November and delivery to ESO-Garching is projected to take place in February 2008.

Regarding software, coding and testing of the first modules of the Data Reduction Software was completed by the observatories of Paris and Amsterdam, who are closely working with the ESO pipeline group. A beta version of the Instrument Control Software, made available and supported by Trieste Observatory, is used for hardware testing at the various integration sites. ESO has completed and released early versions of the instrument model (see Figure 2) and of the Exposure Time Calculator (see Figure 4).

Expected efficiencies

Compared to efficiencies predicted at the Final Design Review in June 2006, most delivered optical components are well above specifications in terms of efficiency. In particular, critical components such as dichroics and gratings are of extremely good quality. As a result, the predicted total efficiency, obtained by multiplying actual measured efficiencies of individual components, is very high as can be judged from Figure 3. Based on these values, we have computed the expected limiting AB magnitudes at blaze peak in 1 hour for a S/N of 10 per spectral bin using a first version of the ETC (Figure 4). The ETC model uses the as-built values for optics (for UVB and VIS) and detector efficiency/noise, but still contains some assumptions that need confirmation during commissioning, like the quality of the spectral extraction and sky subtraction, and the values of the background in the infrared bands. The decrease in efficiency to the blue of the UVB range (Figure 3) 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.

Future steps toward installation at the telescope

Following the testing and acceptance of the subsystems at their integration sites, the final assembly of the single spectrographs into the instrument backbone will take place at ESO in Garching as of January 2008. As for all ESO instruments, the system test phase will be concluded with the so-called PAE (Provisional Acceptance Europe) review, now planned to occur in June 2008. The final installation at the telescope is planned for the second half of 2008, the exact date depending on the successful completion of the PAE and the availability of a commissioning slot at one Cassegrain focus at the VLT. Stay tuned in the next months. The goal is to offer the instrument for regular observing by 1 April 2009 at the latest.

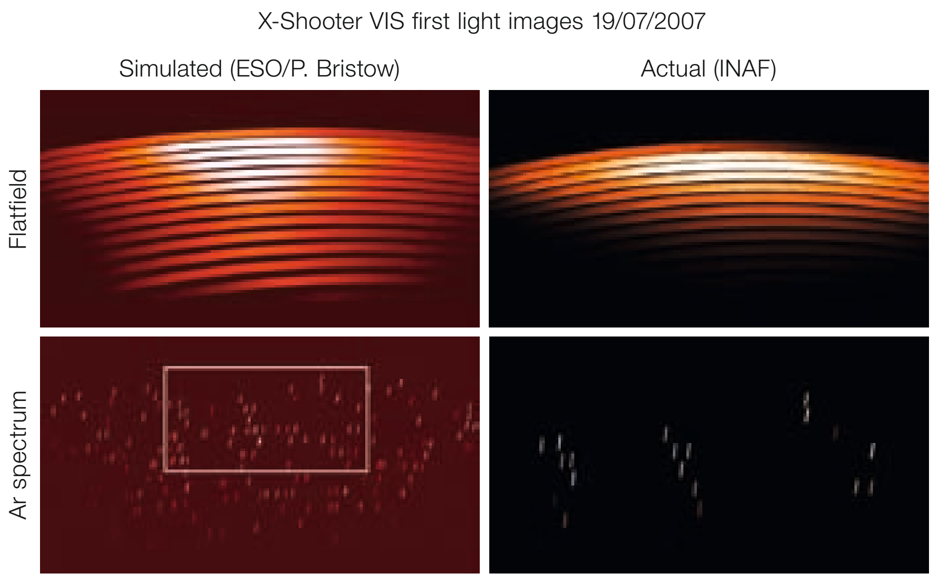

Figure 2: Halogen Flatfields and Ar line spectra in VIS spectrograph. Right column: first light images of July 19. Left column: simulated images, prepared in advance using the ESO instrument model. The first light Ar spectrum corresponds to the white-boxed region in the simulated spectrum. The agreement between the simulated spectral format and first light data is remarkable.

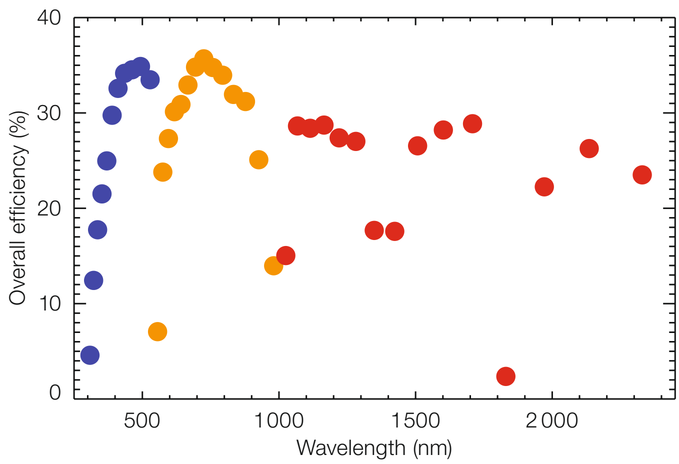

Figure 3: Total efficiency at blaze (atmosphere + telescope + instrument, excluding slit losses) obtained by combining actual measured (for UVB and VIS) or expected (for NIR) efficiencies of individual optical components.

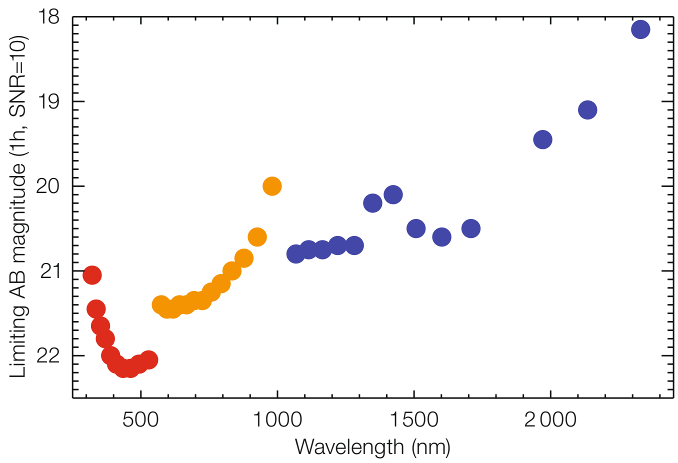

Figure 4: Limiting AB magnitude of X-shooter per spectral bin at S/N=10 in a 1 hour exposure. Other parameters: air mass 1.2, 0.8˝ seeing, 1˝ slit, 2× binning in spectral direction. The first version of the ESO ETC was used to compute these values.

Table 2: Participating institutes and staff currently working on the X-shooter project

ITALY	INAF Obs. Palermo: Roberto Pallavicini (Co-PI) INAF Obs. Brera: Filippo Maria Zerbi (Project Manager), Vincenzo De Caprio, Antonio De Ugarte Postigo, Marco Riva, Paolo Spanò, Matteo Tintori INAF Obs. Trieste: Paolo Santin (Project Manager), Paolo Di Marcantonio, Igor Coretti, Andrea Zacchei INAF Obs. Catania: Rosario Casentino, Pietro Bruno	NETHERLANDS	Amsterdam Univ.: Lex Kaper (Co-PI), Matthew Horrobin, Ron Manuputy Nijmegen Univ.: Paul Groot (Chair Science Team), Thijs Adolfse, Peter Albers, Pieter Van Dael, Ivo Hendriks, Edwin Sweers, Han van der Vliet, Gerben Wulterkens ASTRON: Ramon Navarro (Project Manager), Raymond van den Brink, Eddy Elswijk, Jan Idserda, Menno de Haan, Hiddo Hanenburg, Hendry Hof, Rik Ter Horst, Jan Kragt, Sjouke Kuindersma, Florence Rigal, Ronald Roelfsema, Ton Schoenmaker, Menno Schuil, Arjen Stam, Niels Tromp, Auke Veninga
FRANCE	Obs. Paris Meudon : François Hammer (Co-PI), Isabelle Guinouard (Project Manager), Jean-Philippe Amans, Fanny Chemla, Patrick François, Régis Haigron, David Horville, Frédéric Royer AstroParticle and Cosmology: Paolo Goldoni (Project Manager of DRS), Guillaume Blanc, Laurent Guglielmi. Cyril Dufour	DENMARK	Niels Bohr Institute: Per Kjærgaard Rasmussen (Co-PI, Project Manager), Jeppe Joench Andersen, Hans Henrik Larsen, Niels Michaelsen, Dennis Wistisen, Anton Norup Sorensen, Preben Nørregaard Danish National Space Centre: Niels Christian Jessen
ESO	Sandro D'Odorico (Co-PI), Hans Dekker (Project Manager, System Engineer), Joël Vernet (Instrument Scientist), Andrea Balestra, Pascal Ballester, Paul Bristow, Ralf Conzelmann, Bernard Delabre, Mark Downing, Gerd Finger, Florian Kerber, Jean-Louis Lizon, Henning Lorch, Christian Lucuix, Ruben Mazzoleni, Andrea Modigliani, Francesco Saitta, Jakob Vinther		