

FORS-Up: May the FORS Be With Us For Another 15 Years

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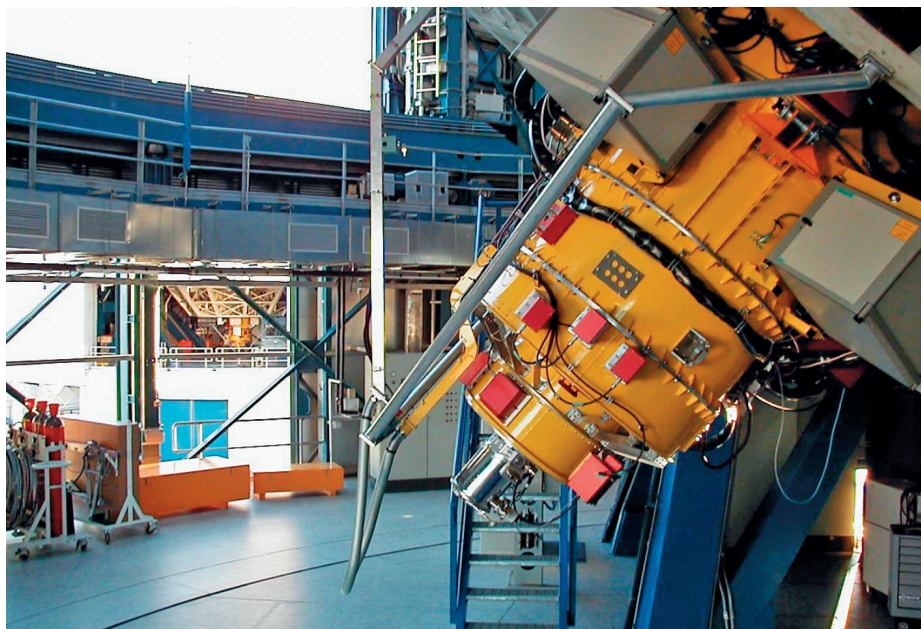
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The FORS Upgrade project (FORS-Up) will extend the life of the popular workhorse instrument attached to ESO's Very Large Telescope (VLT), FORS2. The project — a collaboration between ESO and INAF–Astronomical Observatory of Trieste — aims to bring to the telescope, in about three years' time, a refurbished instrument with a new scientific detector, upgraded instrument control software and electronics based on ESO's Extremely Large Telescope (ELT) standard technologies, a new calibration unit, and additional filters and grisms.

A brief history of FORS1/2

A focal reducer instrument was foreseen from the beginning of the VLT Instrumentation Plan. This led to the construction and deployment of two Focal Reducer and low-dispersion Spectrograph instruments (FORS1 and FORS2). FORS1 saw first light on 15 September 1998 and entered regular science operations on 1 April 1999, while FORS2 had first light on 29 October 1999 and entered regular science operations on 1 April 2000 (Figure 1). FORS1 was retired on 1 April 2009 and is now in storage at La Silla, and FORS2 has been observing since then



without significant interruption. In 2009 the polarisation optics of FORS1 were moved to FORS2, which thereby became an even more complete workhorse.

FORS2 is currently the only visible-light (broad- and narrow-band) imager with a field of view of 7×7 arcminutes (Figure 2), the only multi-object spectrograph in the blue and the only polarimeter on an 8-metre telescope available in the ESO instrument suite, at least when dealing with faint objects. It is still one of the most in-demand instruments in Paranal and most of its capabilities will not be covered by forthcoming instruments.

The FORS-Up project

Thanks to the versatility of FORS2, the ESO Scientific Technical Committee has identified it as a high-demand workhorse that shall remain operative for the next 15 years, a decision that has been confirmed by the ESO Council. This cannot be achieved, however, without a full upgrade of the instrument. This led to the FORS-Up project, which was approved in August 2020. The main goals of the project, besides upgrading the FORS2 scientific detector, are to upgrade the instrument control software and electronics to the standard developed for the forthcoming ELT, the replacement of motors, sensors and all of the cabling, and the

procurement of some additional optical components.

Figure 1. Prior to 2009, it was possible to see both FORS2 at Kueyen (UT2, in the foreground) and FORS1 at Antu (UT1), seen in the background through the open ventilation doors of the two telescope enclosures.

procurement of some additional optical components.

New detector

The upgrade foresees replacing the two (red and blue) science detectors that are each composed of two $2k \times 4k$ chips, with a single $4k \times 4k$ chip with an excellent response in both the blue and red parts of the spectrum. The proposed chip is a variant of the CCD used in the Multi Unit Spectroscopic Explorer (MUSE) instrument, the Teledyne e2v CCD231-84, with fringe suppression technology and an enhanced anti-reflection coating. Most importantly, the current FORS2 cryostat and optical mount are compatible with the selected new detector, which simplifies the design, development and operation of FORS-Up.

ESO has developed the New General detector Controller (NGC), which is the new standard controller for the second generation of VLT instruments. The NGC offers improved performance compared to the Fast Imager Electronic Readout Assembly (FIERA) controller currently



Figure 2. A montage of some of the most iconic VLT images, obtained with FORS1 or FORS2.

fulness of adding new grisms and filters to the instrument. This requirement will be established more precisely during Phase C of the project, which has just started.

Concerning grisms, three elements are identified for a possible upgrade, one with low dispersion to replace the current GRIS 600B+22, and two new ones with moderate dispersion (covering the Na I lines and the K I line, respectively).

Concerning filters, the lack of Sloan Digital Sky Survey (SDSS) filters or equivalent for FORS2 is potentially an issue. These filters have become widely adopted by many facilities (including the more recent ESO instruments, such as the VST/OmegaCam and the X-shooter acquisition camera) and will be of even greater importance when the Vera C. Rubin Observatory starts operating, as it will use a modified version based on six filters instead of five. Accordingly, Phase A has identified the need to consider whether FORS-Up should be provided with SDSS or Rubin Observatory filters.

Upgrade plan

The best option for the upgrade is to work on the decommissioned FORS1 instrument, by completely refurbishing it in Europe. The availability of the instrument structure and mechanics should allow complete refurbishment and exchange of every control system component, without impacting the operation of FORS2. FORS1 lacks the Mask eXchange Unit (MXU) part and the polarisation optics, but still has all the other parts that could be used for full system testing and validation before reintegration at the VLT. Only the top section of FORS2 and the polarisation optics will then be recovered, upgraded and moved to the refurbished FORS-Up instrument.

Phase A of the FORS-Up project was completed in August 2020 and the project was given a green light to proceed. This should extend the lifetime of the instrument by another 15 years and it is expected that the refurbished FORS-Up will be on sky in 2023 or 2024.

used: it has smaller size, lower weight and less heat dissipation, includes the shutter control and allows the implementation of more complex readout patterns. In the framework of the new ELT technologies, ESO is currently developing a new version (NGC II) and it is expected that this version will be used with the new detector on the upgraded FORS.

Control architecture

Although it was initially foreseen that the FORS-Up control software would be based on the latest VLT software release, following the recent developments in software and hardware technologies for the ELT it has been decided that the upgrade of the FORS control software will adhere to the ELT standards and will be based on the ELT Instrument Control Software (ICS) Framework. It will be the first ESO instrument to do so! The aim is to develop a fully-fledged control system able to efficiently resist hardware obsolescence, and offer modern software tools, lower costs, less integration and maintenance effort and easy installation.

The proposed baseline does not foresee changes in the mechanical architecture,

except for the use of brushless DC motors, chosen from the Beckhoff catalogue. This choice, following modern trends in control systems, should ensure long-term support for the components employed.

The baseline Beckhoff configuration was tested on FORS1 at La Silla in February 2020. This first-fit check confirms that the Beckhoff configuration can be mechanically integrated on FORS1 and that the selected motors are fulfilling their function. This test was performed with basic control and will be repeated in detail when FORS1 is in Europe.

Finally, the ESO-MIDAS routines used by the alignment algorithms during night-time operations will be re-implemented using the Online Data Processing (ODP), a component of the ELT ICS Framework which aims to provide a flexible data processing toolkit.

New grisms and filters

In addition to the main goals of the upgrade, namely replacing the detectors, motors, sensors and cabling and upgrading the control software, Phase A of the FORS-Up project also identified the use-