# Status of VLT Second Generation Instrumentation

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## I. The Call for Proposals

In the fall of 2001 and largely based on the June 2001 Workshop "Scientific Drivers for future VLT/VLTI Instrumentation", four main scientific objectives were highlighted by the ESO STC:

(a) A Near-Infrared (1–2.4 $\mu$m) Cryogenic Multi-Object Spectrometer ("KMOS") for the study of initial galaxy mass assembly.

(b) A wide-field 3D Optical Spectrometer ("3D Deep-Field Surveyor") for the exploration of the early Universe.

(c) A Medium Resolution Wide-band Spectrometer ("Fast-Shooter"), in particular to catch fast astronomical events from Supernova explosions to gamma ray bursts.

(d) A High-contrast, Adaptive Optics assisted Imager ("Planet Finder") for deep study of nearby stellar environments.

Based on this selection, a "Call for Preliminary Proposals" was issued in November 2001, with the deadline set on 18 February 2002.

## II. The Result

The community answered very favorably to the Call for proposals. Indeed, we have received a total of 11 answers from generally large Consortia. Given the very significant work that went into the often quite detailed and in depth proposals, it is gratifying to see that this Call was taken very seriously by our Community. I would like here to thank all proponents for the effort they invested to help maintain the competitivity of VLT instrumentation.

### *(a) Near-Infrared Cryogenic Multi-Object Spectrometer ("KMOS")*

Three answers were received in total:

• KMOS1 is a cryogenic near-infrared facility, with deployable Integral Field Units feeding an array of identical spectrometers. The project P.I. is Ralf Bender, Universitätssternwarte München (USM) and Max-Planck-Institut für Extraterrestrische Physik (MPE-Garching). The Co-PIs are Reiner Hofmann, MPE-Garching and Ray Sharples, University of Durham. The Consortium also includes the ATC-Edinburgh and the Universities of Oxford and Bristol.

• KMOS2 is a cryogenic imaging, multi-slit and multiple integral field Spectrometer. It uses an NGST-type 4K × 4K IR array. The Coordinator is Dario Maccagni, Istituto di Astrofisica Spaziale e Fisica Cosmica – Sezione di Milano (IASF-MI). The local responsibles are Jeremy Allington-Smith (IAG-Durham), Olivier Le Fèvre (LAM-Marseille), Jean-Pierre Picat (LAOMP-Toulouse) and Paolo Vettolani (IRA-Bologna).

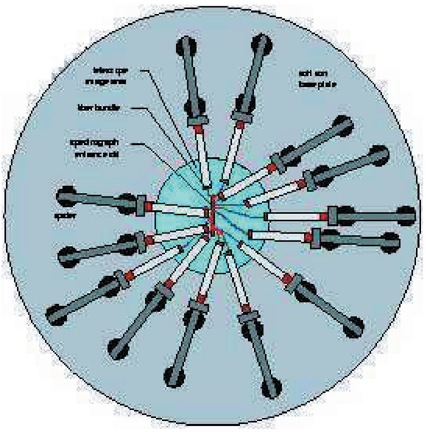

*Figure 1: Schematic view of the deployable cryogenic Integral Field Units in the ~ 8′ patrol field.*

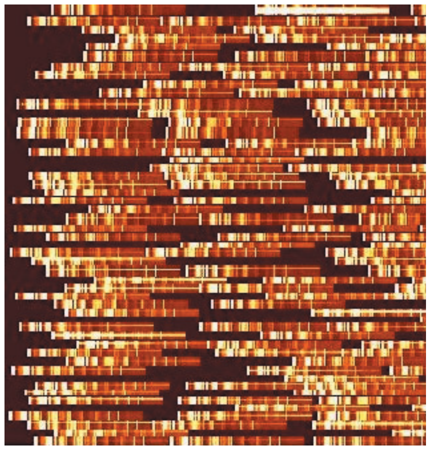

*Figure 2: Simulation of multi-slit spectra in the ~ 8′ × 8′ field.*

The cryogenic imaging and multi-slit Spectrometer FLAMINGOS-VLT is proposed by the Department of Astronomy, University of Florida. The P.I. is Richard Elston and the Project Manager Roger Julian. It is a near-clone of the Flamingo-2 instrument currently built by the Team for Gemini-S.

### *(b) "Wide-Field" 3D Optical Spectrometer*

• The Multi Unit Spectroscopic Explorer (MUSE) is a 1′ × 1′ Integral Field facility in the optical domain – actually a cluster of 24 identical spectrometers fed by a huge image slicer. The project is presented by Roland Bacon, Centre de Recherches Astrophysiques de Lyon (CRAL). The Consortium regroups six Institutes, AIP-Potsdam, CRAL-Lyon; ETH-Zurich; LAM-Marseille; the Physics department of Durham University and the Sterrewacht-Leiden (NOVA program).

• The 3D Wide-Field Optical Spectrometer FAST (FAbry-Perot Spectrometer Tunable) is a 7′ × 7′ facility, built around the scanning Fabry-Perot concept. The P.I. is Michel Marcelin, Laboratoire d'Astrophysique de Marseille (LAM). The Consortium regroups Bochum University, Byurakan Astrophysical Observatory, the GEPI-Observatoire de Paris, Keele University (UK), LAM-Marseille, Laboratoire d'Astrophysique Expérimentale de Montréal, Max Planck Institut für Astronomie (Heidelberg), Osservatorio di Brera (Milano), Oulu University (Finland),

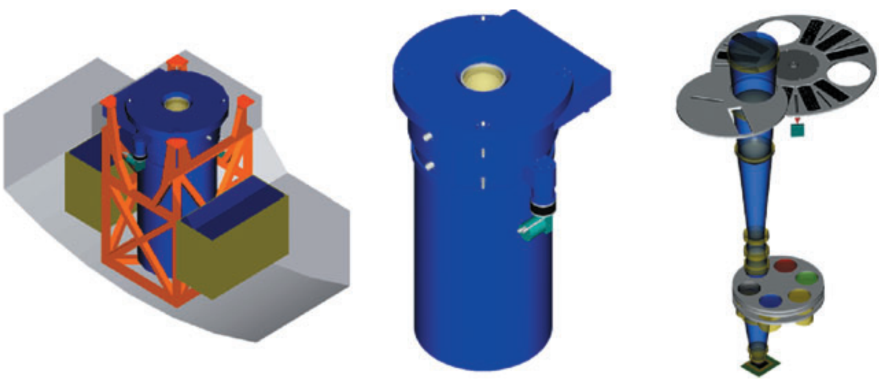

*Figure 3: FLAMINGOS-VLT. Left to right: a) mounted on the VLT; b) global view; c) internal functions.*

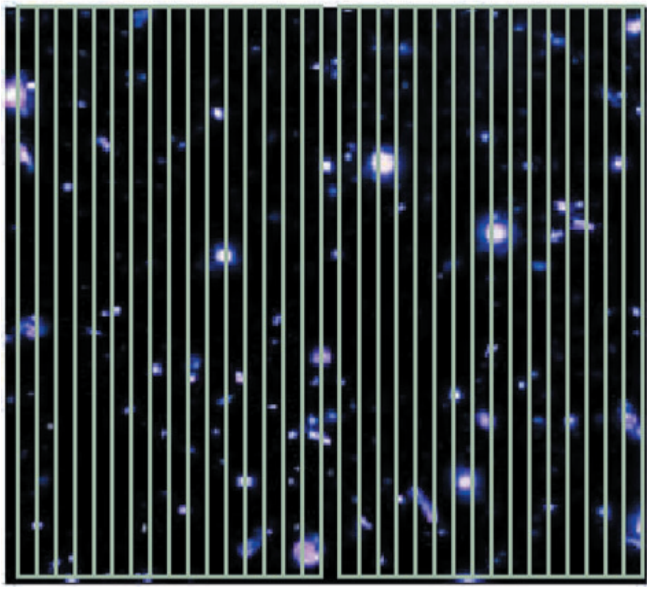

*Figure 4: MUSE-like 1′ x 1′ field overlaid with an Image Slicer grid.*

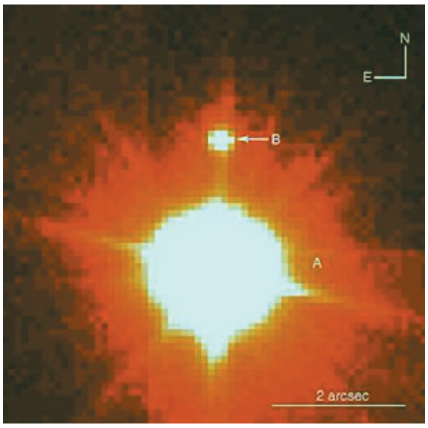


*Figure 6: Main goal of the Planet finder is to gain orders of magnitude in the detection of faint sources near a bright star, as compared to this 0.18″ FORS2 I band image.*

Physical Research Laboratory, Ahmedabad (India) and Université de Montréal. The project scope is quite similar to the so-called Tunable Filter upgrade of FORS1; it however also features a medium resolution ($\sim 10^4$) mode.

### *(c) Medium resolution Wide-band Spectrometer ("fast-shooter")*

Four answers were received in total:

• The High Efficiency, Intermediate Dispersion Instrument (HEIDI). The P.I. is Per Kjaergaard Rasmussen, Niels Bohr Institute for Astronomy, Physics & Geophysics (Copenhagen) and the Co-PI Lex Kaper, University of Amsterdam. The Consortium membership also includes Tuola Observatory (FIN), the Universities of Sheffield and Southampton (UK) and ASTRON-Dwingeloo (NL).

• The Fast Instrument Echelle Spectrograph with Triple Arm (FIESTA). The P.I. is Dario Lorenzetti and the project scientist, Fabrizio Fiore, both at the Osservatorio Astronomico di Roma. The Consortium regroups seven Italian Institutes, viz. the Observatories of Bologna (OABo), Brera (OABr), Catania (OACt), Roma (OAR), Padova (OAPd), Palermo (OAPa) and Trieste (OATs).

• The Integral Field Array Spectrophotometry in real Time (IFAST). The P.I. is François Hammer (GEPI-Observatoire de Paris). The Consortium membership also includes APC-Université Paris 7 and the Institut d'Astrophysique de Paris.

• An STJ based Echelle Spectrograph (SES). The P.I. is Mark Cropper, Mullard Space Science Laboratory, University College London. The Consortium also includes ESTEC (NL) and the Universities of Cambridge, St Andrews and Southampton (UK).

The first three proposals feature classical cross-dispersed echelle spectrometers with an entrance slit or a small integral field input. Wavelength separation is done *à la* UVES at the entrance of the instruments to get optimal efficiency. The last one uses a single (echelle) grating, the order separation being done by a 1-D Superconducting Tunnel Junction (STJ) array.

### *(d) High-contrast, Adaptive Optics assisted, Imager ("Planet Finder")*

A High-Contrast, Adaptive Optics Aided System for the Direct Detection of Extrasolar Planets (PF1). The P.I. is Markus Feldt and the Project Manager, Stefan Hippler, both of the Max Planck Institut für Astronomie (Heidelberg). The Instrument Scientist is Raffaele Gratton, Osservatorio Astronomica di Padova. The Consortium includes German Institutes (MPIA-Heidelberg, MPE-Garching, KSO-Tautenburg, AIP-Postdam, AIU-Jena), Italian Institutes (Padova University and Observatories of Padova, Arcetri, Naples and Brera), Dutch Institutes (Leiden Observatory and University of Amsterdam), ETH-Zurich and FCUL-Lisboa.

• A competing project (PF2) is presented by the Laboratoire d'Astrophysique de Grenoble (Anne-Marie Lagrange, P.I.) The Consortium also includes LAM-Marseille, ONERA-Paris, Observatoire de Paris, OCA-Nice and Université de Nice, LAE-Montréal, Durham University, UCL-London, ATC-Edinburgh and Observatoire de Genève.

The two proposals are rather comparable in terms of Adaptive-Optics firmware. On the other hand their scientific line of attack is quite different. The Heidelberg-led group aims at finding planets from their reflected light through high-Strehl imaging in J-H and extremely accurate polarimetry in the I-band. The Grenoble-led group looks in-

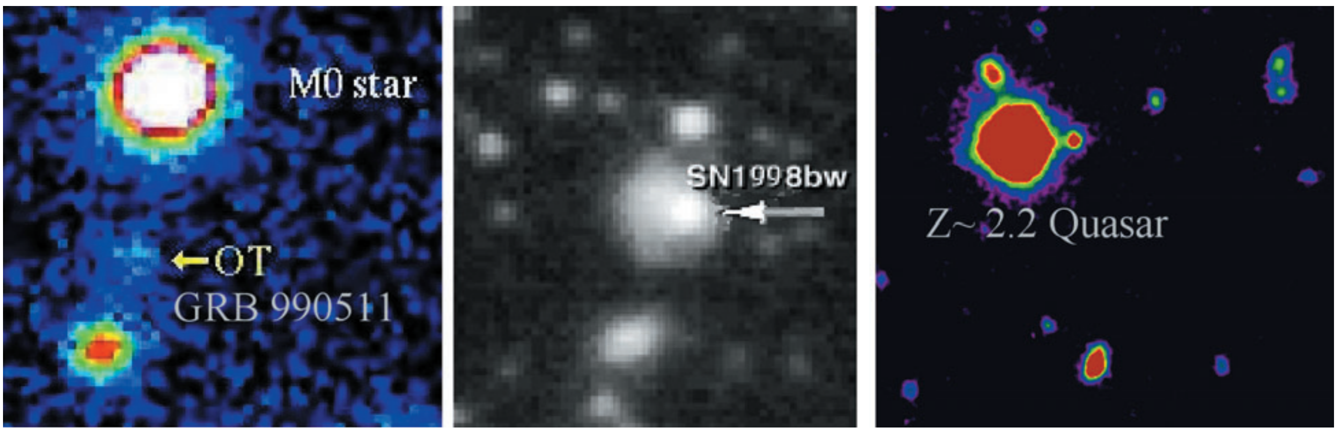


*Figure 5: Some types of potential "fast-shooter" targets.*

stead at the intrinsic planetary emission in the K and eventually L band.

*(e) First Generation Upgrade*

In addition, we have received from Jean-François Donati (Observatoire Midi-Pyrénées) a VLT instrument upgrade proposal, aimed at turning UVES into a high-resolution spectro-polarimeter. The Consortium also includes the Landessternwarte Heidelberg, Observatoire de Paris, University of St Andrews and University College London.

### III. Next Steps

Following recommendations at the last April STC meeting, we are currently contacting the Project Principal Investigators. The ESO staff responsible for the four domains are respectively A. Moorwood for the KMOS, G. Monnet for the Surveyor, S. D'Odorico for the Fast Shooter (& UVES upgrade), and N. Hubin for the Planet Finder. Following current negotiations with the Consortia, feasibility studies will start soon, with (partial) financing from ESO. On a longer scale, the goal is obviously to get efficient Teams to conduct these huge endeavors.

On the programmatic side, the intention is to initiate in the next 8-year period the development of one second generation instrument per year, starting in 2003. This is of course a rough guide only. The actual rate will depend on the capital and human resources cost of the selected facilities. It is thus quite appealing that a number of Consortia intend to raise a significant fraction of the capital cost for these expensive facilities.

It may be nevertheless worthwhile to recall that a huge effort still remains to be invested to complete and put into operation the remaining first generation VLT instruments; this is heavily taxing the present capabilities of both ESO and its community for "fast" deployment of these new, exciting, facilities.

In Conclusion, I would like to again extend our deep thanks to all proponents for their valuable contributions.

# VLT Quality Control and Trending Services

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### Why control quality?

Any observatory worldwide has staff who permanently look into the performance of the instruments and check the quality of the data. ESO's Very Large Telescope has the operational model of a data product facility. This means that it goes beyond the day-to-day performance checks and promises to deliver data of a defined and certified quality.

The Data Flow Operations Group in Garching (DFO, also frequently called QC Garching), provides many aspects of data management and quality control of the VLT data stream. One of the main responsibilities is to assess and control the quality of the calibration data taken, with the goal to know and control the performance of the VLT instruments. Information about the results of this process is fed back to Paranal Science Operations and to the ESO User Community via QC reports and web pages.

The constant flow of raw data from the VLT instruments splits into data streams for the science data and the calibration data. The calibration data stream has two separate components:

- calibrations taken to remove instrument signatures from science data
- calibrations taken for routine daily instrument health checks.

The focus of QC Garching is to process these data and extract Quality Control information. This process of course does not replace the on-site expertise of the Paranal staff. But it goes beyond the usual quick-look, on-the-spot checks and provides a permanent and in-depth knowledge of the instrument status. With the QC parameters routinely collected over years, it is possible to control, predict, and often even improve, the performance of the instruments.

This article describes the Quality Control process for the four presently operational VLT instruments: FORS1+2, ISAAC and UVES. This process will be extended and refined for the next suite of instruments coming soon, VIMOS, NACO, and FLAMES, and ultimately expanded to all VLT instruments.

### How to control data quality

The term quality control, though often used, needs some definition. Quality control, as we understand it, implies the control of the following:

- quality of the raw data
- quality of the products and of the product creation process
- performance of the instrument component involved.

Quality control does generally not imply aspects like the monitoring of ambient data (quality of a night), the proper format of FITS headers, or the tracking of programme execution. Responsible for these aspects, being part of Quality Control in a wider sense, are other groups, e.g. Paranal Science Operations, and the User Support Group.

**Pipelines**. Fundamental in the QC process is the use of automatic data processing packages, the pipelines. Without these, effective quality control of the huge amount of data produced by the Observatory would be impossible. In fact, the primary goal of the data reduction pipelines is to create calibration products and support quality control. Only after this comes the reduction of science data.

With the large-scale use of data processing pipelines, the Quality Control group has effectively also the function of assessing and improving the accuracy of the pipelines. As a by-product, we provide documentation about the pipeline functions from the user's point of view.

The usual day-to-day workflow of the QC scientists has as primary components: processing the raw data (calibration and science) using the instrument pipeline, performing the quality checks, and selecting the certified products and distributing them.

One might say that the use of the pipeline, once the process has been set up properly, is mainly number-crunching, while the quality checks require expertise.

**The QC process**. There is a natural three-floor pyramid in the QC process (Figure 1):

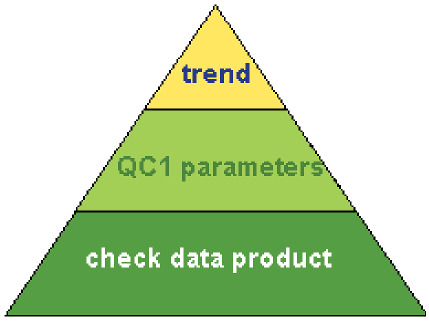


*Figure 1. The QC and trending pyramid.*