Workshop on Scientific Drivers for Future VLT/VLTI Instrumentation – Summary and First Orientations

R. BENDER[1], G. MONNET[2] and A. RENZINI[2]

[1]Universitäts-Sternwarte der Ludwig-Maximilians-Universität, München, Germany
[2]European Southern Observatory, Garching bei München, Germany

1. Introduction

At the instigation of the ESO Scientific and Technical Committee (STC), a Workshop was held on 11–15 June 2001 at ESO-Garching on Scientific Drivers for future VLT/VLTI Instrumentation. As stated in its announcement, the goals were (1) to obtain input from the ESO community on the VLT scientific results and the competitiveness of the current VLT/VLTI instrumentation, and (2) to identify the scientific drivers and the required characteristics of future instruments. During eight intense half-day sessions, fifty oral contributions and sixteen posters were presented, covering most of the astronomical scene from γ-ray bursts to extra-solar planets. All ESO member states, the United Kingdom and the Australian astronomical communities, were represented. Roughly half of the presentations were science-oriented, but also outlining relevant instrumental needs. The other half was more instrument-oriented, but also stressing corresponding scientific drivers.

Below is a tentative by the authors to summarise the major science drivers and draw possible lines of future VLT/VLTI instrumental developments, in light of the presentations and the 1-hour final general discussion. Instrument proposals that were presented at the meeting have been classified below in three different categories: (a) full-fledged 2nd-generation instruments that would replace present ones; (b) upgrades of 1st-generation instruments and (c) niche capabilities, potentially qualifying for the VLT visitor focus (see http://www.hq.eso.org /instruments/visitor_focus). This summary should be seen as a first attempt, open to even very substantial modifications in the next phases of project selection.

2. The Major Science Drivers

Most of the emphasis was put on:

– detecting the 1st fireworks; rapid follow-up of γ-ray bursts and Supernovae

– high-z evolution of galaxies and of the Inter-Galactic Medium

– 1st galaxy building blocks and galaxy mass assembly

– peering deeper into nearby galactic nuclei

– huge stellar spectroscopic surveys of Local Group galaxies

– stellar formation environment and detection of extra-solar planets

– a closer view of stars (direct and Doppler-Zeeman imaging; stellar oscillations)

3. Towards 1st-Generation Upgrades

The 1st Generation VLT/VLTI instrument complement was widely recognised as a powerful tool, especially if a strong upgrade programme is pursued. In particular, the present VLTI programme, both in infrastructure capability and initial instrumentation (MIDI, AMBER and PRIMA), was seen as representing the dawn of an era, with a number of major upgrades highly desirable, beginning by its imaging capability and the associated infrastructure (more auxiliary telescopes and delay lines) and instrumentation.

The FORS 1 and 2 upgrades are currently underway to cover efficiently the whole optical range from 0.32 to 1 μm. The alternative of developing a single 2nd Generation dichroic-fed spectro-imager, that would require a single Unit Telescope instead of two, was presented at the Workshop and should be carefully compared. Possible extensions of the multiplex capability of the 25′ diameter field FLAMES multi-fiber facility were proposed: MAXIMUS is a survey-oriented instrument with a much higher number of individual fibres and possibly an IR extension, and FALCON a deployable Integral Field Units (IFUs) based system, with sub-seeing corrections from small adaptive optics buttons. UVES may possibly get a spectropolarimetric mode, at the cost of substantial additional complexity however, and/or a medium spectral resolution mode through e.g. binning or implementation of photon-counting detectors. Finally, the so-called 2k × 2k SINFONI upgrade, already recognised as highly desirable, was presented. These potential upgrades are summarised in Table 1.

4. Towards 2nd-Generation Instruments

The case for new 2nd-generation VLT instrumentation was much emphasised for sub-seeing (adaptive optics assisted) imagery and spectroscopy, which require a vigorous long-term research and development programme. One goal would be to cover large field (a few arcmin.) imaging and spectroscopy (MCAO facility), provided the validity of the Multi-Conjugate Adaptive Optics (a.k.a. MCAO) concept is firmly established. Three possible MCAO-based instruments were presented viz. a Gemini-type imaging/multi-slit spectrometer or an integral field system, based either on a single large unit [MIFS] or deployable smaller units [CROMOS]. Another area would be zero field high Strehl imagery for the study of stellar formation and detection of extra-solar planets (Planet Imager). For the more conventional seeing-limit-

Table 1: Potential First Generation Upgrades.

NAME	DEFINITION	SCIENCE DRIVERS
VLTI	Priorities: (1)imaging; (2) shorter λ; (3) "wide-field" capability (> Airy disk); (4) larger baseline? Major R/D required (infrastructure and instruments)	A closer view to extra-solar planets, stellar environments and galactic nuclei
FORS1-2	FORS2-Red and FORS1-UV Tunable Filter mode? Integral Field mode? Or more efficient 2nd-Gen. dichroïc system?	Z ~ 1-1.5 and very high-z objects Detection of Lyα "galaxies" γ-ray Bursts and Supernovae
FLAMES	IR; higher multiplex [MAXIMUS] AO-corrected multiple IFUs [FALCON]	Large Surveys; z~1 galaxy dynamics Galaxies 1st building blocks
UVES	High-$\Re$ spectro-polarimetry X-dispersed medium-$\Re$ capability	A deeper look at stars Very faint stars and quasars
SINFONI	$(2k)^2$ 1-2.5 µm IR detector instead of $(1k)^2$ Higher $\Re \sim 10^4$ grating	Improved stability Stellar formation regions

Table 2: Possible 2nd-Generation Instruments.

NAME	DEFINITION	SCIENCE DRIVERS
KMOS	Cryogenic near-IR multi-object spectrometer Imaging/Multi-slit? Deployable IFUs? single IFU? Large field up to ~ 7'x 7'; cryo-robots?	Universe up to z ~ 3–5 Mass assembly of galaxies
MCAO facility	2' x 2' field; near-IR domain Imager/multi-slit? Deployable IFUs? single IFU? Requires proof of MCAO concept(s)	Galaxies building blocks Galactic nuclei
Planet Imager	Near-IR Imager High-order AO and advanced coronograph	Stellar environments Extra-solar planets
Stellar Surveyor	~ 5' x 5' medium-$\mathfrak{R}$ Integral Field System FTS or large IFU approach?	Nearby galaxies stellar census

(MC)AO: (Multi-Conjugate) Adaptive Optics; IFU: Integral Field Unit; FTS: Fourier Transform Spectrometer

ed instrumentation, emphasis was put on a K-band cryogenic survey-type system (dubbed here KMOS), for distant galaxy studies. Three different concepts were illustrated, viz. a wide-field spectro-imager [IRMOS], a single very large integral field system [MEIFU] or deployable integral field units [CROMOS]. KMOS eventual IR wide-field imaging capability should be evaluated in relation to the forthcoming VISTA ones. The case for very large stellar spectroscopic surveys of the Local Group (Stellar Surveyor) was also argued for.

Table 2 below show a 1st classification attempt of the themes discussed during the Workshop, listing possible new instruments. The numerous question marks in the Table reflect lively debates on competing approaches, e.g. multi-slit masks versus wide-field integral field systems. In virtually every case, prior development of enabling technologies appears as a prerequisite. In the coming year(s), these concepts will go through a two-steps filtering process: (1) choices and priorities with specific recommendations from the STC and (2) feasibility studies and programmatic analyses conducted with the help of our community.

5. Visitor Instruments

A number of scientific niches were also identified at the Workshop and could eventually be deployed at a VLT Visitor Focus, in particular:

– Fast spectro-photometry [ULTRACAM} to identify cosmic accelerator mechanisms

– AO-assisted spectrometry [AVES] for the study of stellar abundance and dynamics

– Stellar Oscillation measures [STOMACH] to derive stellar internal structure

– Ultra-high resolution heterodyne spectroscopy [THIS] to study the cold interstellar medium

– The case for (very) high-resolution spectroscopy and spectro-polarimetry was also strongly argued for. It may possibly be filled by a combination of an UVES upgrade and a dedicated Visitor instrument. A much more ambitious alternative would be a 0.37 to 2.5 μm dual-echelle 2nd-generation instrument.

6. And Now, What?

The next step in this filtering process will happen in the fall. Based on the Workshop input and STC advice at its regular October meeting, we will come back to the ESO community to launch feasibility studies of the highest priority projects. In many cases, this will in particular require the development of enabling technologies. A word of caution may be appropriate here. Our most important instrumental goal, with major involvement from member states institutes, is presently to complete and put into operation the remaining eleven[1] instruments in the 1st-generation instrument complement of the Paranal Observatory (VLT, VLTI and VST). This implies that the development of 2nd-generation instruments could only proceed gradually. Also, not every upgrade listed above could, nor even should, be made: there is a limit to complexity of a given instrument operation, in particular in terms of number and sophistication of observing modes, beyond which its overall scientific throughput would actually decline.

We deeply thank all Workshop participants for their invaluable help in that sometimes tortuous, but important, process to ensure the competitiveness of a significant fraction of European astronomical capabilities in the coming decade. Much more will be asked down the line! Please, stay tuned for exciting times ahead.

[1]VIMOS, NAOS/CONICA, FLAMES, VISIR, MIDI, AMBER, OMEGACAM, NIRMOS, SINFONI, CRIRES, PRIMA.

ESO VLT Laser Guide Star Facility

D. BONACCINI, W. HACKENBERG, M. CULLUM, E. BRUNETTO, M. QUATTRI, E. ALLAERT, M. DIMMLER, M. TARENGHI, A. VAN KERSTEREN, C. DI CHIRICO, M. SARAZIN, B. BUZZONI, P. GRAY, R. TAMAI, M. TAPIA, ESO

R. DAVIES, S. RABIEN, T. OTT, Max-Planck-Institut für Extraterrestrische Physik, Garching

S. HIPPLER, Max-Planck-Institut für Astronomie, Heidelberg

Abstract

We report in this paper on the design and progress of the ESO Laser Guide Star Facility. The project will create a user facility embedded in UT4, to produce in the Earth's Mesosphere Laser Guide Stars, which extend the sky coverage of Adaptive Optics systems on the VLT UT4 telescope. Embedded into the project are provisions for multiple LGS to cope with second-generation MCAO instruments.

1. Introduction

The ESO Laser Guide Star Facility (LGSF) will be available for general observing in October 2003. The LGSF will be installed on UT4 (Yepun) at Paranal Observatory (Fig. 1). It will produce a single LGS, to serve two of the 7 adaptive optics systems (AO) of the VLT, NAOS and SINFONI. The relevance and justification of a LGS-AO system has been analysed elsewhere[6]. The Lick Observatory LGS-AO system has