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Successful Installation of the VIRMOS Laser Mask Manufacturing Unit (MMU) at Paranal

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The Mask Manufacturing Unit (MMU), one of the three main components of the VIRMOS project, has been delivered and successfully installed at Paranal Observatory at the beginning of August. The MMU is a laser-based system, which will be used to cut the slit masks for the VIMOS, NIRMOS and FORS2 spectrographs. The unit also manages the selection, storage and insertion of the masks into dedicated cabinets. A batch of masks has been manufactured on Paranal for a test with FORS2. The quality of the masks (position accuracy and roughness of the slits) are fully compliant with the instrument specifications.

Introduction

A consortium of French-Italian astronomical institutes is building three instruments for the VLT: VIMOS, NIRMOS and the MMU. The whole is the so-called VIRMOS project [1]. VIMOS (Visible Multi-Object Spectrograph) and NIRMOS (Near Infra-Red Multi-Object Spectrograph) are focal reducer and spectrographs with imaging capability to be used for deep and large field observations. VIMOS is right now in the system test phase at the Observatoire de Haute-Provence and is expected to be delivered to the community in July 2001. NIRMOS is entering the manufacturing phase.

The VIMOS field of view is split in 4 quadrants of 7′ × 8′ each (8′ × 6′ for NIRMOS) and therefore, for each, a slit mask is needed for a Multi-Object Spectroscopy observation. The masks (up to 15 per quadrant) are inserted during the day in the so-called Instrument Cabinets. Before the observations, the 4 cabinets are installed on the four channels of VIMOS. The Mask Exchanger Unit is a device in the instrument, which allows exchanging the masks remotely according to the observation programme. The MMU is

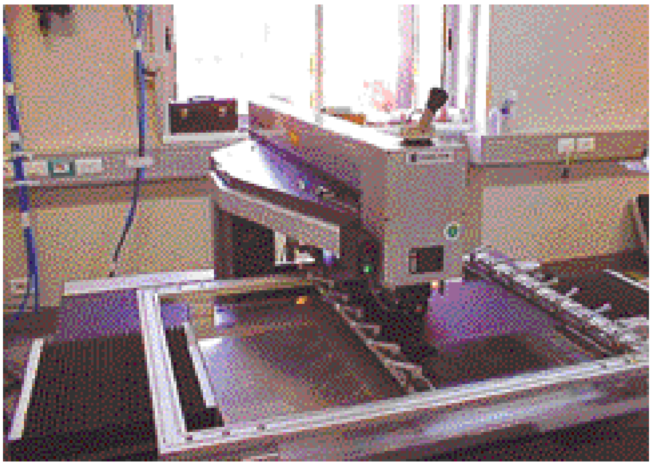

Figure 1: The laser cutting system as installed in the MMU Laboratory at Paranal. The invar sheet on which the slits will be cut is mounted and clamped on the X – Y translation stage.

Table 1. Required specifications for the VIRMOS masks. The results after installation in Paranal are included.

Item	**Specification**	**Test results in Paranal**
Slit width	300 to 1000 µm	≥ 100 µm
Shape	It shall be feasible to cut slits of arbitrary shapes, with the above-mentioned edge quality and slit width (degradation of 30% acceptable)	Any shape. Radius of curvature: > 2 mm. Same slit width and edge quality as above
Edge quality	< 5 µm peak to peak	1.3 ± 0.3 µm
Absolute positional accuracy with respect to the mask support frame	< 30 µm, including temperature variations between fabrication and operation in VIMOS and NIRMOS	≤ 15 µm
Speed	> 7 m/h (1.9 mm/s)	6 mm/s

located in a laboratory in the Camp Area. From there the 4 Instrument Cabinets, loaded with the masks, are transported by car to the telescope in suitcases re-arranged for this purpose.

The FORS Consortium has retrofitted in FORS2 a Mask eXchange Unit (MXU), which gives the possibility to place slit masks in the focal plane of the telescope [2]. The multiplex capabilities of the instrument may be increased up to 200 targets per mask. Up to 10 masks (produced by the MMU) can be stored in the unit. The loading of the masks into the MXU is done manually during the day, but the selection and exchange of the masks during the observations is remotely controlled by the instrument control software.

Description and Performance of the MMU [3]

Figure 1 shows a picture of the laser-cutting machine. An air pad X – Y translation stage is mounted on the polished surface of a very stable granite table of 2.5 tons. The 0.2 mm thick black coated invar sheets are mounted on the X – Y table and they are flatted with an air clamping system. A 20 W pulsed (1.6 KHz) Nd – YAG (λ 1064 nm) laser is mounted on top of the table. An expander and objective lens focus a 40 µm waist spot on the masks. Cutting of the material occurs under a 16 bar compressed air jet. The laser system (manufactured by the German LPKF company) is also equipped with a double close water circuit for the cooling of the pumping lamp and with an air pressured device for exhausting of the mask debris. The X – Y moving table allows a position absolute accuracy better than 15 µm and can cut slits with a width down to 100 µm (0.17 arcsec on the sky). The shape of the slits can be adapted to the observer needs, the width along the slit may even vary. The minimum radius of curvature of the slits is 2 mm.

The physical size of each VIMOS mask is 305 × 305 mm but the useful area is 244 × 279, which fits the detector field of view (7′× 8′). Figure 2 shows true to scale the 4 VIMOS quadrants and the location of the masks. The dispersion direction of the spectra on the CCDs is also shown.

Figure 3 gives a typical laser cut VIMOS mask showing, in addition to the slits, the reference marks for high position accuracy on the VIMOS focal plane, the attaching holes for the handling of the masks by the Mask Exchange Unit, the holes for reference stars and the identification code.

The main requirements on the masks for VIMOS and NIRMOS are listed in Table 1. It shows also the results obtained at Paranal after installation. All of them are better than the required values.

The number of slits per mask may be greater than 200 when VIMOS is used in low-resolution mode (R~200). Up to 5 slits can be drilled along the dispersion without spectra overlapping. The high cutting speed of 6 mm/s allows to produce up to 32 “low-resolution” masks (8 fields) in an 8-hour working time.

Since the spectroscopic observations through the masks have to be done at the best observing conditions (targets near the meridian), the direct images of the fields to be taken by VIMOS to prepare the masks have to be recorded at the beginning of the night several weeks before the spectroscopy

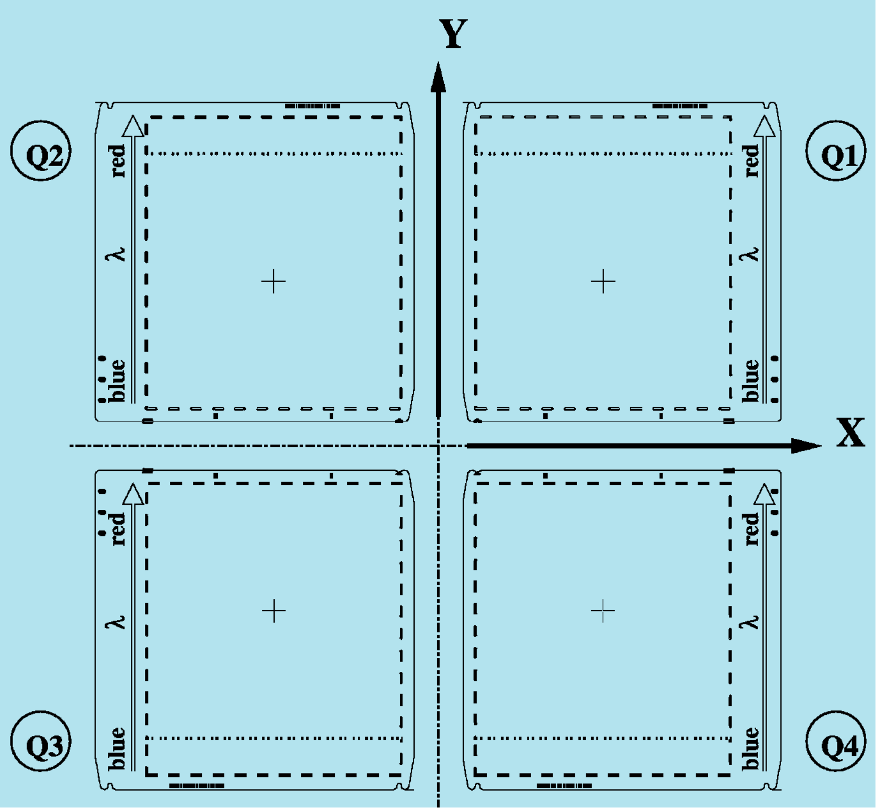

Figure 2: Distribution of the 4 slit masks on the focal plane of the VIMOS quadrants. Each mask is 305 × 305 mm.

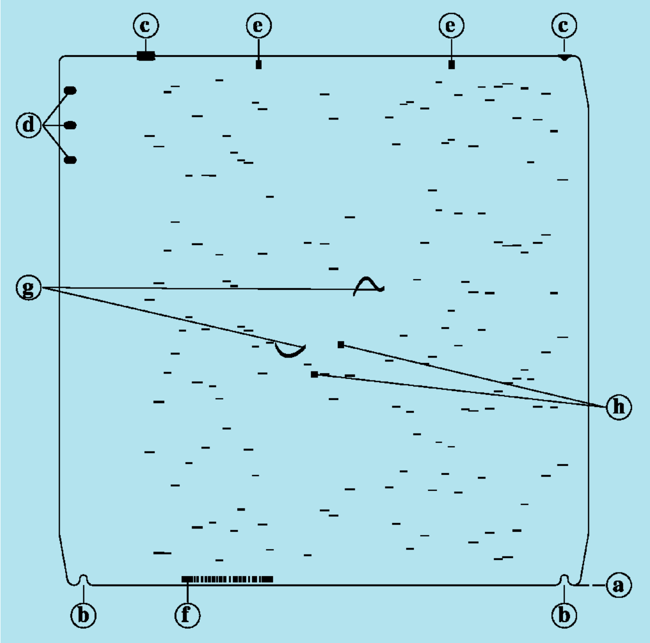

Figure 3: Typical VIMOS mask sample showing examples of straight and curved slits (g), square holes for reference stars (h), mechanical references for high position accuracy on the Nasmyth focal plane of the 4 masks (b, c) and identification code (f).

run. Also, masks for a large number of fields must be available to optimise and adapt to the scientific programme, the optimal target position with respect to the meridian and the required exposure times. For this purpose, a hardware and software system called Mask Handling System has been implemented to control the identification, classification and flow of the masks. The cutting machine engraves a bar code at the bottom of the masks (Figure 3, (f)) for the identifications.

A Storage Cabinet was built to store the manufactured masks (Figure 5) before they are inserted in the Instrument Cabinets (the boxes that contain the 15 masks to be placed on the VIMOS quadrants during the observations). Up to 400 masks may be stored (100 per VIMOS quadrant). A bar code laser system is used to keep track of the masks in the Storage Cabinet. Finally, the so-called Instrument Cabinet Robot (Figure 6), is a device to insert semi-automatically, in a known order, the masks into the Instrument Cabinets. Once loaded, the Instrument Cabinets are transported from the MMU Laboratory to the telescope and mounted into VIMOS (NIRMOS).

Three main software packages were built for the MMU. The Mask Handling Software provides a Graphical User Interface for all masks handling functions excluding the manufacturing. It records the storage order of the masks in the Storage Cabinet, interfaces the Instrument / VLT software and acts as front end for the LPKF file converter software. The Cut Manager Software is a GUI for the handling of mask files and is a front end of the LPKF cutting software.

The mask preparation begins with the preparation of a file by the observer from direct images taken with VIMOS (NIRMOS) with the positions (in mm) of the slits. The files are sent to a PC in the MMU Laboratory where they are converted in “gerber” CAD compatible format files. A final conversion is done by the LPKF-owned software to create a file with the cutting commands. Once the masks are made, they are stored in the Storage Cabinet and from there, they are inserted into the cabinets, which are installed into VIMOS (NIRMOS) for the spectroscopy observations.

Installation and Operation

A room in the General Storage building just in front of the Auxiliary Telescope Hall (ATH) in the Camp Area was built as the MMU Laboratory. All necessary facilities like electricity, water, pressurised air, LAN, telephone and air condition were designed and implemented in time by the Paranal Engineer and Facility departments. Due to the size and weight of the laser table, the front wall of the MMU Laboratory had to be removed for the installation (Figure 4).

Two weeks were necessary to install all the MMU components, interface them and put all the system in operation. Mr. A. Mueller from LPKF spent three days to install, align, operate the laser, and to perform the first maintenance protocol according to the Contract. On August 2 the first VIMOS mask was successfully produced in Paranal.

In the following days, the protocol to prepare the FORS-2 masks for the MXU was completed mainly by A. M. Aguayo and W. Hummel. All the necessary masks for the test run with FORS 2 were produced.

The MMU, after additional check-ups and minor failures during this installation period, is now in operation and ready to manufacture the observation masks for FORS2 visitor observers as of November 2000 and early next year for VIMOS commissioning.

We want to thank the Paranal Engineering and Facilities Departments

Figure 4: Moving the 2.5-ton Laser Table inside the MMU Laboratory. The wall had to be removed for this purpose.

Figure 5: The VIMOS Storage Cabinet. 400 masks may be stored (100 per VIMOS quadrant).

led by P. Gray and J. Eschwey for their work in preparation to and during the commissioning of the MMU. Special thanks go to P. Sansgasset, P. Robert, U. Kaberger, E. Bugueño, M. Tapia, G. Gillet and P. Mardones.

References

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Figure 6: The Instrument Cabinet Robot. The four Instrument Cabinets corresponding to the four channels of VIMOS (or NIRMOS) are inserted in the stand.

First Astronomical Light with TIMMI2, ESO’s 2nd-Generation Thermal Infrared Multimode Instrument at the La Silla 3.6-m Telescope

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Introduction

We report the first astronomical tests of TIMMI2 between October 6 and 11, 2000. A short overview of the project history and the project context is given. This is followed by a basic description of the instrument and its modes as well as a report on the achieved and projected sensitivities. A more in depth technical description including first operational experiences will be given in one of the upcoming issues of *The Messenger*. As to the scientific interest of TIMMI2, readers are referred to, e.g., Käufl 1993.

The TIMMI2 Project

In 1992, when ESO commissioned the original TIMMI instrument, visiting astronomers could use a modern competitive instrument featuring imaging and low-resolution spectroscopy in the wavelength region from $\lambda \approx 5$ μm to $\lambda \approx 17.5$ μm (cf. Käufl et al. 1992, 1994a, 1994b). Back in 1992, to the best of our knowledge, TIMMI was the only such instrument available as a common user instrument at any observatory. TIMMI was built under contract for ESO by the *Service d’Astrophysique,* Saclay, France (PI Pierre-Olivier Lagage). TIMMI, featuring a 64 × 64 gallium doped silicon array and mostly germanium refractive optics inside a solid-nitrogen/liquid-helium dewar, was in constant use until its decommissioning in 1999 (cf. Stecklum et al. 1999). By then, the development of detectors had progressed so rapidly, that the instrument no longer appeared competitive.

In fact, in 1993 ESO joined a consortium of French institutes to develop, based on the array used e.g. in TIMMI, a next-generation device (cf. e.g. Lucas et al. 1994). Already the format of this device (128 × 192 pixel) suggested that it would be desirable to build a new camera, rather than trying to use the new device in the existing set-up. Even larger arrays were announced by US suppliers. To that end ESO had developed some basic ideas for the optics of a next-generation instrument for the La Silla 3.6-m telescope (cf. Käufl & Delabre, 1994).

As a result of the *La Silla 2000 questionnaire* (see Anderson 1994) in *The Messenger* 78, ESO received a proposal from the *Astrophysikalisches Institut und Sternwarte* of the *Friedrich-Schiller-Universität* (FSU) in Jena, Germany, to build TIMMI2. This proposal, reflecting ESO’s optical concept, was based on a modern cryostat cooled by a Closed Cycle Expansion Cooler Machine and was also featuring a polarimetric option (not available in TIMMI). Personnel cost and capital investments could largely be covered by funds raised by the Institute in Jena. The PI in Jena was Hans-Georg Reimann. After some negotiations, a *Memorandum of Understanding* was signed and the work began in early 1996. The design sketch of ESO (see above) was first transformed into a FEM[1] certified conceptual design, both for the optics and mechanics, by the company Jena-Optronik GmbH. Based on this work, the final design and the detail design of the instrument were done at the physics department of the FSU. To the extent that this was feasible, all mechanical parts were manufactured in the workshops of the FSU. In the course of the project, the group at the FSU could enlist a team from the *Sternwarte der Universität Wien* for

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[1] A representative mechanical design for the optical bench was made and its flexure was modelled with the finite element method.