wavelength coverage of the planned VLT instruments?

• For wide-field imaging: Field size, m_{lim}, wavelength, detector type.

• For wide-field spectroscopy: Same questions, plus requirement on sky subtraction (fibres or multi-slits).

• Spatial resolution: What are the needs for tip-tilt corrected images or full adaptive optics?

• Spectral resolution: Where is high-resolution spectroscopy done most efficiently? If on the VLT, is an interim solution needed on La Silla?

• Continuous, long-term monitoring: What is the need for La Silla-size telescopes? Dedicated telescopes run by independent teams?

• Simultaneous observations: What is the need?

Educational aspects of La Silla

As a somewhat separate, but significant issue, is La Silla important in training the new generation of European observational astronomers? If so, how should it be organized?

All Hands on Deck!

This article and the questionnaire was sent in early November 1994 to Institute Directors and individual scientists throughout the ESO Member States. The Working Group strongly encourages the widest possible distribution to colleagues of all ranks – not least the younger ones who will be the most affected by the result.

The Working Group will consider all replies with equal interest and attention. Our draft conclusions and proposals will be discussed with the community in several iterations, possibly including some form of Workshop.

Please send your reply to the ESO Headquarters in Garching (*Attention:* La Silla 2000 W.G., c/o S. Teupke) **before February 1, 1995.**

ESO's planning must continue. In your own interest, take this opportunity to help us make the best of it!

TELESCOPES AND INSTRUMENTATION

N-Band Long-Slit Grism Spectroscopy with TIMMI at the 3.6-m Telescope

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Careful readers of *The Messenger* may remember that the acronym TIMMI stands for Thermal Infrared Multimode Instrument. So far, however, TIMMI could be offered as a monomode instrument (i.e. imaging) only. This has now changed and TIMMI has become a true multimode instrument, combining imaging and longslit spectroscopy with $\frac{\lambda}{\Delta\lambda} \approx 200$ for the 10 μm atmospheric window. The long-slit spectroscopic mode is now implemented utilizing grisms. Rather encouraging tests and scientific exposures on astronomical objects have been possible. The grisms in TIMMI have been manufactured utilizing anisotropic etching of mono-crystalline silicon which has a refractive index of $\approx$ 3.4. While grisms are widely used in optical and near infrared instrumentation, TIMMI is probably the first astronomical instrument for the 10 μm atmospheric window ever using grisms manufactured from such high-index materials.

1. Short Description of TIMMI[1]

Like all infrared instruments TIMMI is a cryogenic instrument. It is mounted inside a Solid Nitrogen/Liquid Helium cryostat. Its optical principle is best described as an 'infrared EFOSC'. For technical details see e.g. Käufl et al. 1992 or 1994. The telescope focal plane is located inside of the dewar. In the focal plane there is a mechanism to exchange the cryogenic field mask with a cryogenic slit assembly (slit-width $\approx$ 0.9 arcsec). Behind an f = 103 mm collimator there is a 3.6 mm Ø pupil stop. A filter wheel is located behind that pupil stop in the collimated beam. The grisms are mounted to the filter wheel. This is followed by a lens wheel. All three mechanical functions of TIMMI are operated remotely under com-

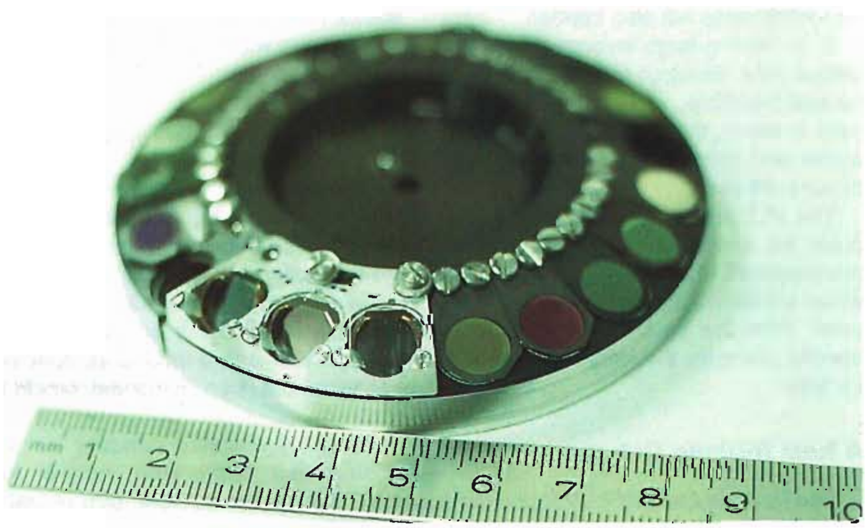

Figure 1: *The rare but essential ingredients are shown. The three grisms are mounted in one fixture to the filter wheel. For each grism the order sorting filter, the base prism and the silicon wafer carrying the diffractive structure had to be mounted in a space of less than 1 cm^3. The mount needed to be designed compatible with operation at 60 K. The silicon wafer is mounted in direct optical contact to the prism, and great care was required during assembly to avoid contamination of the optical surfaces. It was also required to carefully adjust the orientation of the grooves parallel to the apex of the prism.*

[1] The TIMMI project started in July 1990 when ESO signed a contract with the Service d'Astrophysique of the Commissariat à l'Energie Atomique (Principal Investigator: P.O. Lagage). The instrument was then built by the SAP according to ESO's specification in a period of two years.

puter control. TIMMI is mounted at ESO's 3.6-m telescope in the f/35 configuration. The camera features a 64×64 element Gallium doped Silicon photoconductor array bonded to a silicon Direct Voltage Read-out (DVR) circuit[2]. Various magnifications can be chosen (at present 0.3 arcsec/pix, 0.46 arcsec/pix and 0.6 arcsec/pix). For the long-slit spectroscopic mode the 0.6 arcsec/pix scale is used which allows for a useful slit length of TIMMI on the sky of ≈ 35 arcsec.

Because of the strong background radiation emitted by atmosphere and telescope in this part of the spectrum the observations need to be done in chopping and nodding mode.

While TIMMI provides new and fairly unique observational possibilities for the ESO users community, it was also supposed to be a test-bed to gain experience for similar instrumentation at the VLT.

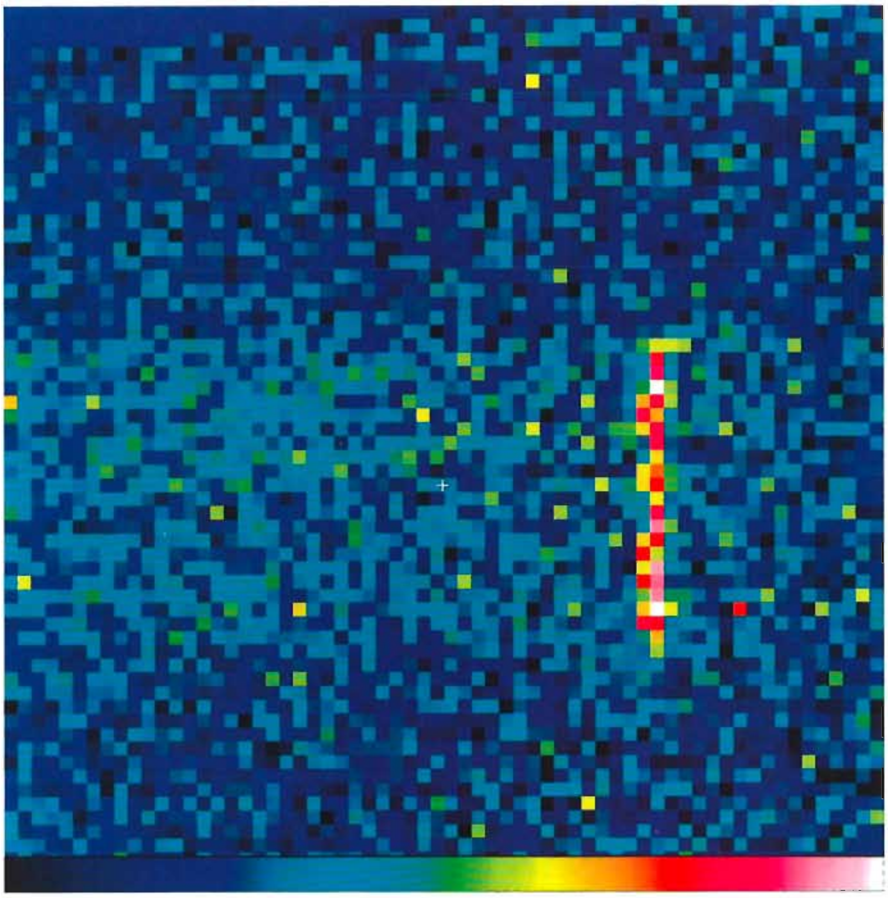

Figure 2: *This shows the long slit spectrum obtained for IC 418 after 1 hour of integration. The bright emission of [NeII] at $\lambda = 12.8\,\mu m$ of the ionized gas as well as the thermal continuum radiation of the dust can clearly be seen. North is up, increasing λ to the right. The scale along the slit is 0.6 arcsec per pixel.*

2. The Silicon/Germanium Grisms[3]

The standard technology to produce grisms for visible and near infrared applications is to replicate ruled gratings with resins to the back of glass prisms. Unfortunately, this technology cannot be applied to the spectral domain relevant for TIMMI because of the strong internal absorption of these resins at $\lambda \approx 10\,\mu m$. Moreover, for a given diameter of the collimated beam in a spectrograph, a grism made from material with refractive indices *n* of order 1.5 has roughly a factor of 4 less dispersive power than a standard reflection grating.

For a given collimator size the dispersion of grisms scales with *(n-1)*. When using high-index infrared optical matrials such as Silicon ($n \approx 3.4$) or Germanium ($n \approx 3.9$ at T = 77K) the dispersion is typically 5–6 times that of a glass/resin grism. For a given collimator size a Germanium grism then also has ≈ 50% higher dispersion than a normal reflection grating. This is extremely important and beneficial for infrared instruments since it can allow to reduce the size of the cryostats typically by 33% linearly or by 70% in volume and hence mass with respect to normal spectrographs.

Grisms are an extremely convenient and elegant way to convert a camera into a long slit spectrograph. Since the centre (i.e. zero deviation) wavelength is determined to first order only by the geometry of the grism itself but not by its orientation with respect to the optical axis, such a spectrograph is intrinsically very stable and rather simple from a mechanical point of view. There is no need for the delicate and complicated high-precision grating mounts (n.b. working in vacuum at 60–80 K) required in normal infrared spectrographs. This, however, also implies that grisms cannot be tuned effectively. The number of spectral elements (and hence the spectral resolution) a grism spectrograph can provide is therefore ultimately limited by the number of pixels of the camera detector in dispersion direction times the number of grisms one can afford on the exchange mechanism.

Nevertheless, all advantages described above will remain purely hypothetical unless there is a way of manufacturing these devices. In spite of major efforts which started in 1991, ESO has not been able to procure suitable grisms from a commercial source. Standard grating ruling techniques with a diamond stylus are incompatible with the relatively large groove spacing required (of the order of 10 μm) and the material properties of Germanium and Silicon (both are crystalline materials with diamond like structure). ESO therefore concluded a contract with the Fraunhofer Gesellschaft (Institut für Festkörpertechnologie, München) to produce such gratings from monocrystalline Germanium or Silicon wafers. The manufacturing of small silicon gratings is rather straightforward since it is based on standard techniques used for solid-state engineering. For a description of the underlying concept and other applications of this technology see e.g. Wiedemann et al., 1993. A similar process for Germanium, however, needed to be developed from scratch. This process is now available and can be used for second generation devices for TIMMI and all other upcoming projects in ESO, be it VLT or La Silla instrumentation.

3. First Observational Results

The grisms were mounted in TIMMI in May 1994 (Fig. 1). Special test time was

[2]This detector has been manufactured by Leti/LIR, Centre d'Etudes Nucléaires de Grenoble, France.

[3]For readers who are not entirely familiar with grisms: a grism is a transmission grating mounted to the back of a prism. Light, when passing the transmission grating, will be deflected according to its wavelength. The prism bends the light deflected by the grating back parallel to the optical axis of the incoming beam. In this way the device works like e.g. a prism of the Amici type. Inserted into a parallel beam light for a given centre-wavelength passes without deviation whereas light at other wavelengths will leave the device tilted with respect to the optical axis.

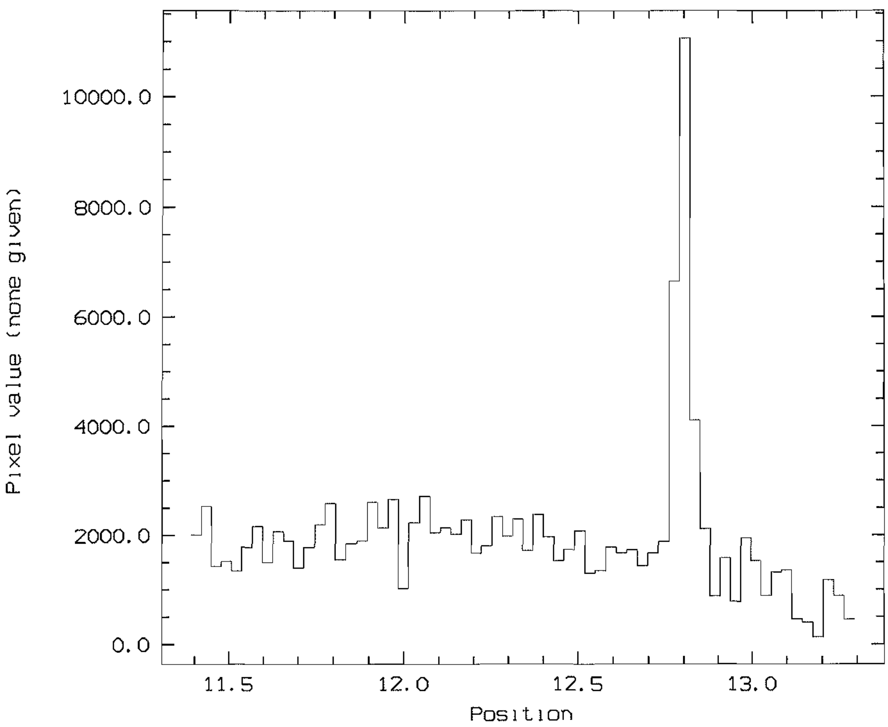

Figure 3: *This is a projection of the spectrum shown in Figure 2 on the wavelength axis. As the emission of [NeII] at λ = 12.8 μm is quasi monochromatic, this line shows the instrumental profile. The spectrum is not yet corrected for atmospheric absorption or instrumental efficiency. The noise on the right side of the spectrum is caused by absorption of atmospheric CO_2 which sets the red edge of the 10 μm window. What looks like noise of the continuum left of the line are most likely features created by other infrared active atmospheric components. It needs to be demonstrated in the future by further processing of the data how well such structures can be reduced by observing reference stars.*

allocated to assess the astronomical performance. This first test, however, was only marginally successful. The instrumental profile could be measured and was found to correspond exactly to the theoretical expectations. The astronomical tests, however, were severely affected by mechanical problems in TIMMI with the slit assembly. Also a major fraction of observation time was lost due to maintenance activities at the telescope and bad weather.

Most of the mechanical problems in TIMMI were resolved before the next scheduled run of TIMMI in November 1994. The grism mode was then tested in the setup night November 11–12. When observing stars it was found that inspite of the rather narrow slit (0.9 arcsec) typically 50–80% of the light reaches the detector. This depends obviously somewhat on the seeing which was between 0.6–2 arcsec as reported by the DIMM (ESO's on-site on-line seeing detector). Figure 2 shows a long-slit spectrum of IC418 covering the range from 11.5 μm to the atmospheric cut-off at 13.3 μm. From these data it will e.g. be possible to get the ratio of the [NeII] line at 12.8 μm to the thermal dust continuum along the slit with very high quality. This will allow for new insights into the excitation conditions of this dusty low excitation planetary nebula.

The grism mode was immediately used for the observing programme in the following night (*Infrared imaging of warm dust in starburst galaxies and AGNs*) to record a long slit spectrum of NGC 253. For this observation the position angle of the slit was aligned with the major axis of the galaxy by rotating TIMMI with the Cassegrain adaptor rotator.

4. Technical Data of Spectroscopy Mode

A summary of technical data of the spectroscopy mode is given in Table 1.

From the observations of IC418 the sensitivity of the spectroscopic mode can be provisionally estimated. A S/N of ≈10 can be expected in 1h total observing time for the [NeII] line for $0.6\times10^{-14}\frac{W}{m^2 arcsec^2}$. For a continuum source a S/N of 10 can be expected for a source of 400–800 mJy/arcsec^2 (≈ 4.5 mag) for 1 h total observing time.

5. Conclusion and Outlook

The first results obtained with the long-slit spectroscopy mode of TIMMI are extremely encouraging. There is certainly a great variety of astronomical programmes which will benefit from the spectroscopy mode as it is implemented now. Usage of the mode is hence strongly encouraged. Nevertheless, it is also clear that a lot of improvements are possible and desirable.

In the near future a new set of grisms made from Germanium will become available. These devices can then be much better antireflection coated than the present devices in TIMMI. An increase in transmission by 30% can be expected. These gratings will then also be chosen in such a way that the entire 10 μm window is covered with some overlap. In the tests it was also obvious, that the camera shows some internal radiation background. Finding ways to reduce this background will further enhance the sensitivity of this new mode of TIMMI.

Acknowledgements

The support of all staff of the ESO infrared group in Garching and La Silla was essential to make this project successful. Specifically, however, these grisms would never have materialized without the delicate mechanical design made by A. Silber and without G. Wiedemann who brought the idea for the manufacturing process to ESO. P. van der Werf provided valuable help during the astro-

TABLE 1. Summary of Technical Data of Spectroscopy Mode

Spectral resolution (2 pixel sampling):	$\frac{\lambda}{\Delta\lambda}\approx 200$
Slit width (fixed):	0.9 arcsec
Slit orientation:	nominally north–south (can be changed ± 90 deg)
Slit viewing:	with TIMMI in imaging mode through slit
Tracking of objects:	with TV camera in f-35 adaptor either with optical light from the object itself (through dichroic) or with field stars
Wavelength range:	
Grism 1	8.0–9.15 μm
Grism 2	9.6–11.0 μm (not yet operational)
Grism 3	11.5–13.3 μm
The grisms operate in first order. Order sorting is done with a long-pass filter. The period of the grooves is 11.9805, 10.0551 and 8.4505 μm. The blaze angle is approximately 23 degrees.	

nomical tests. The author also appreciates the fruitful and pleasant collaboration with the *Fraunhofer Institut für Festkörpertechnologie*

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NTT BITS & PIXELS

With this periodically compiled collection of short notes, the NTT Team intends to keep the community informed about changes in performance, configuration, and operation of the NTT and its subsystems.

EMMI and SUSI Receive Additional Attention

The NTT Team is slowly reaching its full staff complement. On September 19, Albert Zijlstra took up his duties as EMMI/SUSI instrument scientist. He will be in charge of all aspects which can be handled from Garching. A primary task will be the design and testing of standard calibration and reduction procedures for these two instruments. Besides various other assignments, he will also answer user inquiries about EMMI and SUSI (please e-mail them to `ntt@eso.org`) and he will organize the support for remote NTT observers. Having been in Garching for two years as a postdoctoral fellow, Albert is already well familiar with the environment of his new job.

Image Quality

The dynamical range of this subject is currently unusually extreme. On the one hand, several observers succeeded in securing images with an FWHM of 0.5 arcsec or even better (cf. *The Messenger* No. **76**, p. 21). In many of these excellent nights, the effective image quality obtained with the NTT has been slightly better than the seeing measured with DIMM, the Differential Image Motion Monitor.

On the other hand, NTT images are still often plagued by elongations. Some recent extreme cases could be quickly identified with a hardware failure of the guideprobe control. But some weaker aberrations continue to show up. Using the NTT's intrinsic image analysis capabilities, it could be shown that the zenith distance dependence of astigmatism has increased quite significantly since the commissioning. The follow-up work now concentrates on the lateral support of the primary mirror (the problem might be with the lateral support itself or due to imperfect centring of M1 in its cell).

We are grateful to Dr. S. Ortolani for granting permission to technically evaluate the sequence of excellent images which he obtained in May and to Dr. R. Falomo who, as a visitor to the Science Division in Garching, analysed them and several other datasets.

M1 Actuators Checked

As part of a systematic checkout of the active optics system, the currents of all 78 actuators of the M1 radial support system were measured and logged. A number of them were found to be far above the average and, in fact, out of specification, due to increased mechanical friction. These actuators were overhauled one by one in the mechanics workshop at La Silla.

TCS Computer Upgraded

The computer running the Telescope Control System (TCS) has for much of the time been working at a level of 50% or more of its capacity. In a real-time application this is dangerously high and has on a small number of occasions substantially increased the response time to TCS commands even in the case of relatively minor malfunctions of some components connected to the NTT Local Area Network. For this reason, the CPU has with the help of the HP Computer Group at La Silla been upgraded from an HP A900 to an A990 model which more than doubles the safety margin.

Slip Ring Replaced

During the technical maintenance period in August, the slip ring which is the central link for communications, including the time signal from the atomic clock, between the NTT and the outside world, was replaced. This action had become very critical because rapidly progressive corrosion had already paralysed some of the data channels. The reason had been the dripping of condensing water from the pipe through which the cooling liquid of the air conditioning system circulates. The slip ring was fully re-designed; the manufacture of spare parts required significant help from the mechanics workshop at La Silla. At the time of the installation, which went very smoothly, the new slip ring was also properly shielded against condensation.

Instrument Rotators

The rotation of the rotator on side B (EMMI) through 360 degrees in May continues to have the effect which had been hoped for. At telescope positions where the speed of rotation of the instrument rotators changes sign, the torque no longer increases by so much that the motor can hardly, or even not at all, overcome it. However, the same measure taken on side A has not brought about any perceptible improvement. Meanwhile, F. Franza and M. Ziebell have contacted the Technical University in Munich for advice where the problem has met much interest.

By removing a so-called watch dog from the interlock chain of the control system on side A (IRSPEC), the difference in frequency between sides A and B of sudden stops of the power amplifier (a problem completely independent of the one above) could be removed. The search for the origin of the remaining failures continues. But their intermittent origin makes this a difficult task.

Additional Field Tests of New Control Software

The preparation of the new control system proceeds closely along the lines of the NTT Upgrade Plan. The field test of Work Component No. 3 was executed in October. Its objective was the control of the secondary and tertiary mirror. With the help of the Electronics Group at La Silla an adapter board had been developed to map the signals between the present and the future system so