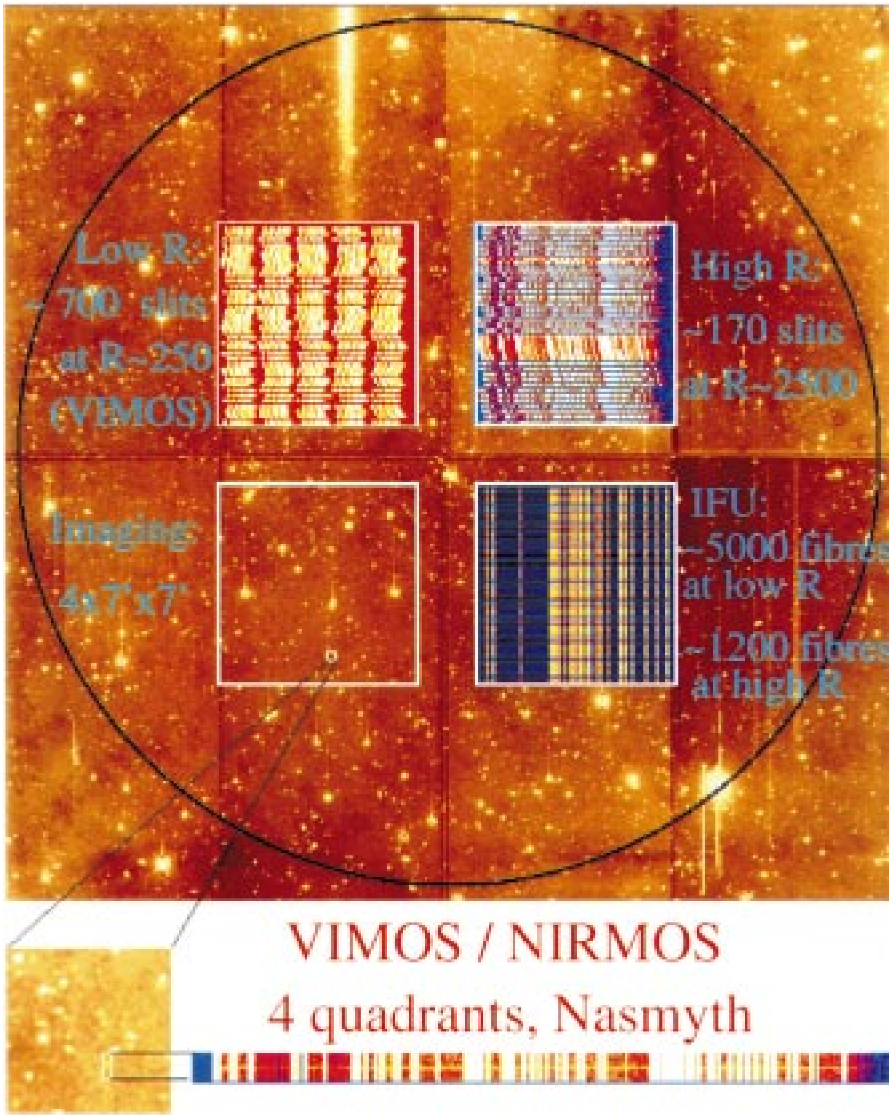
Figure 2: Illustration of the VIMOS and NIRMOS capabilities. The circle represents the Nasmyth field of view. The four squares are the instrument fields of view of the four channels. The four modes are represented: Imaging, low-resolution spectroscopy (VIMOS only), high-resolution spectroscopy, Integral Field Spectroscopy (tbd on NIRMOS). (Background image: courtesy Y. Mellier.) ▶



troscopy is achieved with masks, and the two instruments are complemented by the MMU (Mask Manufacturing Unit), to be located in the VLT buildings. Masks are inserted in cabinets holding up to 15 masks. The cabinets are manually installed in the instruments during daytime. VIMOS has in addition an Integral Field Unit providing contiguous low resolution spectroscopy with fibres in a field of view up to 1 arcmin × 1 arcmin.

Figure 1 shows the opto-mechanical layout of VIMOS.

In the IR (NIRMOS), only medium-resolution spectroscopy will be provided, as this is the most efficient way of observing faint targets between the OH sky emission lines.

VIMOS will reach very high multiplex gains at low spectral resolution, while NIRMOS will be a genuinely unique instrument world-wide.

Figure 2 illustrates the instrument capabilities.

Status

The contract between ESO and the VIRMOS consortium was signed in August 1997. The Preliminary Design Review of VIMOS and of the Mask Manufacturing Unit (MMU) took place in November. The Final Design Review will take place in July 1998.

The planning is the following:

Instrument	UT	Preliminary Acceptance in Chile
VIMOS & MMU	#3	May 2000
NIRMOS	#4	April 2001

Under discussion at the time of writing are the choice for the Mask Manufacturing Unit (milling machine or laser), and the material of the Focal Plane Corrector for NIRMOS.

ESO is responsible for the development and procurement of the four CCD cryostats of VIMOS, and of the 4 IR cryostats of NIRMOS. For VIMOS, continuous-flow cryostats with rotating feed-through are under consideration. For NIRMOS, it is expected to use 2k × 2k IR arrays currently under development at Rockwell. ESO is participating in the development contract, and expects to receive the first science grade array by the end of 1999.

jcuby@eso.org
rgilmozz@eso.org

VISIR at PDR

P. O. LAGAGE, Y. RIO, CEA/DSM/DAPNIA/Service d'Astrophysique, CE Saclay, Gif-sur-Yvette, France
J.W. PEL, H. TOLSMA, NFRA, Dwingeloo, The Netherlands

In 1995, we were reporting in this journal about the phase A study of VISIR, the VLT Imager and Spectrometer for the mid InfraRed [1]. Since then, the status of the instrument has evolved a lot. In November 1996, the contract to build VISIR was signed [2]. VISIR is built by a French-Dutch consortium of institutes led by the Service d'Astrophysique (SAp) of Commissariat à l'Energie Atomique (CEA, Saclay, France). The Dutch partner is the Netherlands Foundation for Research in Astronomy (NFRA, Dwingeloo, the Netherlands). Other contributing institutes are the Institut d'Astrophysique Spatiale (Orsay, France) and the Netherlands Foundation for Space Research (SRON, Gro-

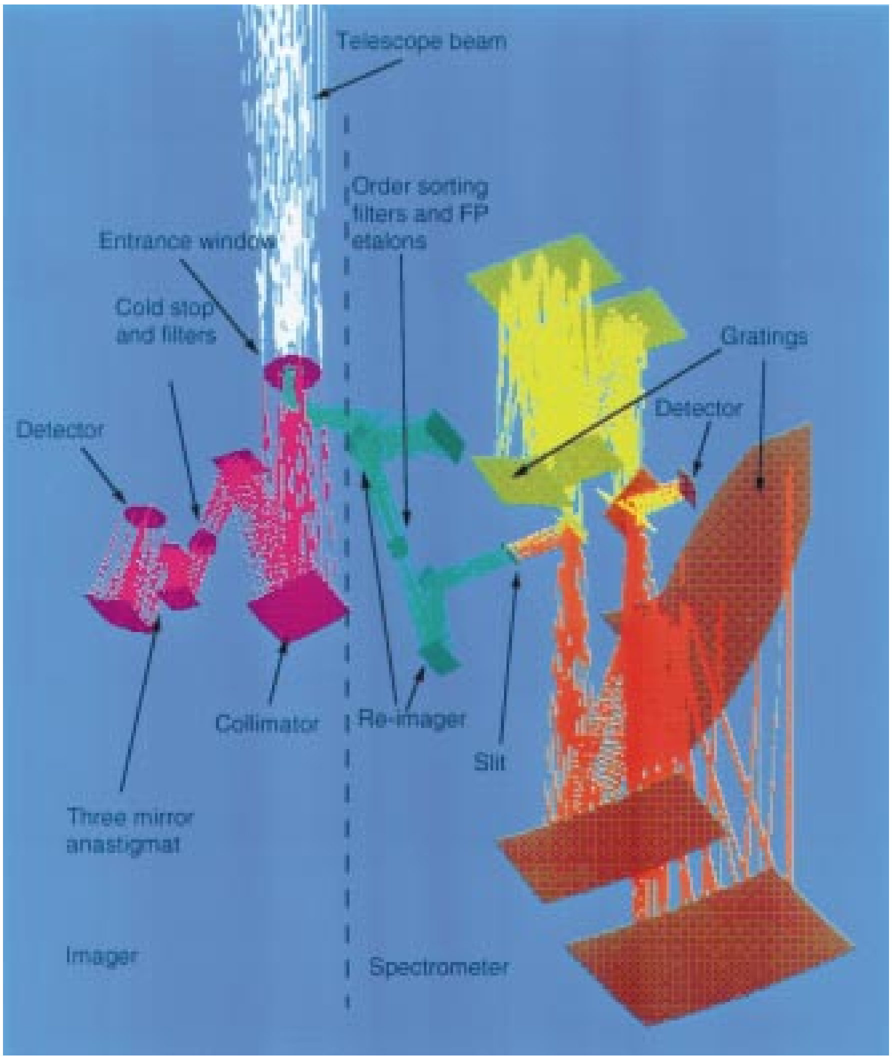


Figure 1: Overview of the optical layout of VISIR. The beam from the telescope is coming from the top. The imager, in pink, is on the left side of the diagram; the spectrometer is on the right side of the diagram. One can see the re-imager unit of the spectrometer in green, the low- and medium-resolution arm in yellow, and the high-resolution arm of the spectrometer in red. The re-imaging unit of the spectrometer was not shown in [1], because we had presented the option where the imager was used as re-imaging unit. This option was no longer viable with the new optical design. The spectrometer re-imaging unit consists of two concave off-axis paraboloids, two folding flats and a cold stop. The order selection filter wheel and the Fabry-Pérot wheel are located immediately behind the cold stop.

ningen, the Netherlands). One year after the signature of the contract, VISIR has reached the Preliminary Design Review (PDR) level. An abundant documentation has been written for this review (5 kilograms of papers!)[1]. A (25-gram) summary of the results of the preliminary design studies is given hereafter.

1. Scientific Aspects

1.1 Observing modes

As VISIR is the only VLT instrument working in the mid-infrared atmospheric windows (the N band, between 8 and 13 µm, and the Q band, between 16 and 24 µm), it has to cover a large range of observing modes. Those modes are:

- imaging over a field up to about 1 arcmin with a choice among three scales (0.075, 0.127, 0.200 arcseconds per pixel) and with a choice among 40 narrow- and broad-band filters.
- long-slit (> 30″) grating spectroscopy with various spectral resolutions (350, 3200, 25000 at 10 µm; 1600, 12500 at 20 µm).

1.2 Comparison with ISO

VISIR will naturally be an ideal instrument for ISO follow-up observations. The great success of ISO ensures that a large community will use VISIR. The main advantage of VISIR over ISO will be the much higher angular resolution that can be obtained with the 8-metre VLT mirrors, which are expected to be diffraction-limited in the superb Paranal seeing. The diffraction airy disk of ISO (FWHM of 3.5″ at 10 µm) will be resolved into more than 100 elements with VISIR. The situation is even more favourable for the VISIR spectrometer, whose spatial resolution of 0.5″ × 0.25″ has to be compared to the 14″ × 20″ entrance aperture of the ISO Short Wavelength Spectrometer (SWS).

The comparison of the expected sensitivity of VISIR with the measured sensitivity of SWS (see Table 1) shows that VISIR should beat ISO, especially at high spectral resolution (of course in the limited wavelength range accessible from the ground). The same is true when we consider the wavelength range covered in one setting of the grating.

At low spectral resolution, ground-based telescopes cannot compete with space facilities in terms of sensitivity, because of the large photon background generated by the atmosphere and the telescope. However, with an expected VISIR sensitivity in its imaging mode around 1 mJy (10 sigma 1 hour) in the N band, follow-up observations of many ISO objects will be possible. Note also that the observing time needed to reach a given signal over noise ratio on a point source from the ground is inversely proportional to the telescope diameter to the fourth power (D^4). Thus 1 hour of point source observations with VISIR will be equivalent to 2 nights of observations with a Mid-IR instrument on a 3.6-m telescope.

Apart from ISO follow-up programmes, key programmes such as the study of “post planetary” dust disks around main or pre-main sequence stars, with as best example the 41-Pictoris dust disk [3], will profit greatly from VISIR.

1.3 Operation plan

Astronomers familiar with ISO observations (or more generally with observations from space facilities) will not be surprised by the scientific operations of VISIR (and other VLT instruments). Given the complexity of VLT instruments, those instruments can only be used efficiently through well-defined Astronomical Observing Templates (AOTs). A preliminary set of three basic AOTs has been identified for VISIR. One template is devoted to imaging observations with the classical chopping and nodding technique. To account for the huge flux difference received by the spectrometer depending on the spectral resolution, two templates have been reserved for spectroscopic observations. One template corresponds to observations at low spectral resolution in the N-band and at medium spectral resolution in the Q-band with chopping and nodding. The second template corresponds to observations at medium spectral resolution in the N band and at high spectral resolution in the N and Q bands with only nodding. These templates are not supposed to cover all the observing

[1]The full package can be obtained upon request to Lagage@CEA.fr

possibilities, but are expected to cover a large fraction of the observer's needs. A discussion of these templates with the VISIR science team appointed by ESO and chaired by M. Rosa has been initiated.

A key element in the successful use of an instrument is its calibration. Various calibration tools have been incorporated in the VISIR design; for example, a wheel with fixed Fabry-Pérot etalons has been included in the spectrometer in order to calibrate accurately the wavelength. A preliminary calibration plan has been written. The basic idea of this plan is to ensure that each observing template will always be associated with a corresponding calibration.

The data reduction will be part of the general data-flow system developed by ESO [4]. Specific VISIR data reduction algorithms will be provided by the consortium to the data flow division.

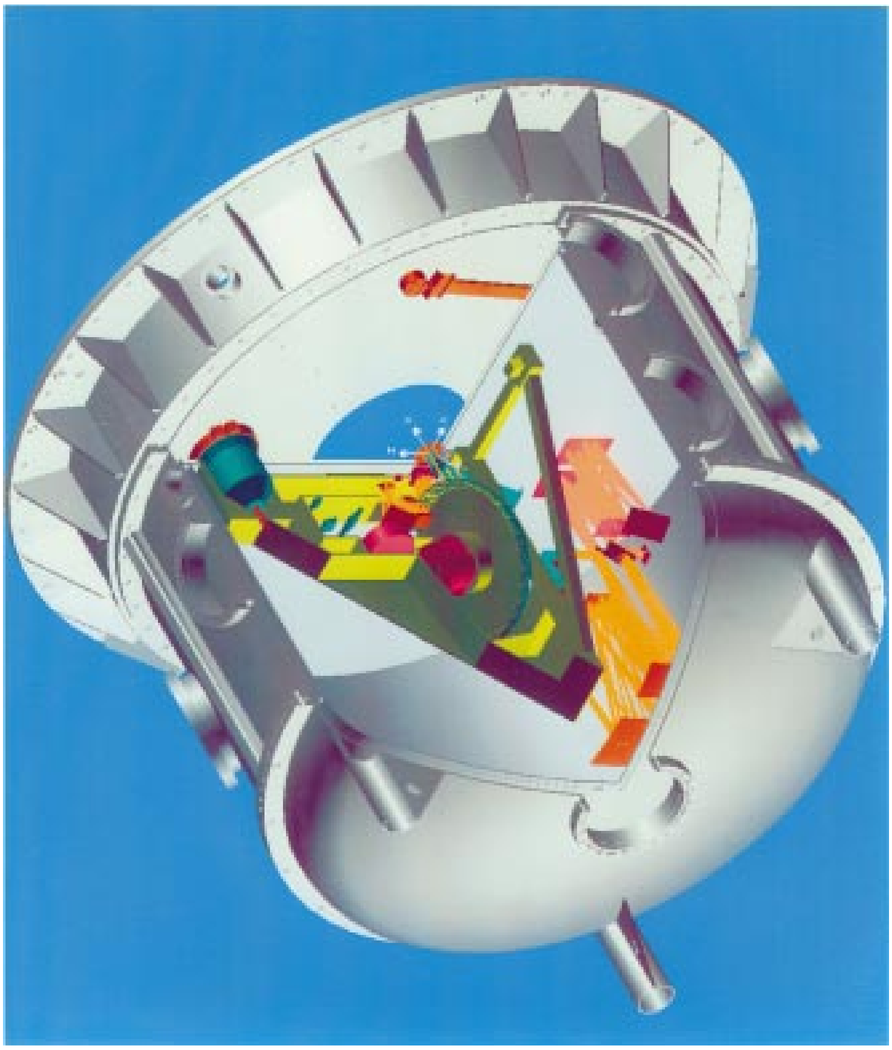


Figure 2: Drawing of the VISIR enclosure, "opened" to show a schematic drawing of the imager mechanical structure. The cryostat is a cylinder of length 0.7 m and diameter 1.2 m. The weight of the cryostat and of the enclosed optical bench is 1 ton. When we consider the total weight of VISIR (cryostat, pumps, cable wrap, electronics boxes ...), we are only 10% below the limit of the VLT unit (2.5 tons).

2. Instrument

2.1 Detectors and associated electronics

Two potential suppliers of large-format detector arrays for mid-IR ground-based instruments exist: Santa Barbara Research Center (SBRC), Santa Barbara (US) and Boeing (previously Rockwell), Anaheim (US). The arrays for ground-based use are characterised by a large storage capacity ($> 10^7$ electrons), needed to "absorb" the huge photon background generated by the atmosphere and the telescope. In the mid-IR domain, large format means 256 × 256 pixels for Boeing and 320 × 240 for SBRC. This is not yet large enough to have a field of one arcmin with an adequate sampling of the telescope diffraction pattern (0.127″ per pixel at 10 μm). That is why the imager needs to have several magnifications.

The development of these arrays has taken much more time than expected. Even if the first arrays now exist, optimisations are still needed, for example in terms of noise. Our aim is to be able to test these arrays at Saclay, in the operating conditions of VISIR. We are setting agreements with each of the two suppliers to this purpose. Those BIB (Blocked Impurity Band) Si:As detectors are convenient both for 10- and 20-μm observations. The figure of merit of a given detector in an imaging mode or in a spectroscopic mode is not the same. For example, dark current is much more crucial for a spectrometer than for an imager. Each of the two subsystems of VISIR, imager and spectrometer, will therefore have its own detector array.

The electronics associated with the detector should provide the clock drivers and biases to control the detector and the 16-bits analogue-to-digital conversion of the detector output signals. Even with the large storage capacity of the detectors, the frame rate can be up to 500 images per second. A data cruncher is thus needed. We have developed a preliminary design of the detector electronics largely based on commercial cards. For operational reasons, ESO would prefer us to use the ESO IRACE system [5]. We are presently investigating this possibility.

TABLE 1: VISIR Spectrograph sensitivity versus ISO-SWS sensitivity, as well as the wavelength coverage in one shot.

	Spectral Resolution		Signal/Noise for 1 Jy point source		Wavelength Coverage (km/s)	
	VISIR	SWS	VISIR	SWS	VISIR	SWS
N band	3200	1500	24	20	6500	2000
	25,000	20,000	14	0.14	850	100
Q band	1600	1100	5	40	6500	2750
	12500	25000	3	0.3	850	100

2.2 Optical design

A general sketch of the optical design of VISIR is shown in Figure 1.

2.2.1 Imager

The optical design of the imager has been completely changed since the Phase A report [1]. Because of bad experiences when testing the material considered for the optics at 20 μm (CdTe), we have moved from a lens design to a mirror design. Five mirrors are on the optical path (see Fig. 1). The first mirror

Figure 3: Test equipments of VISIR. One can see the test cryostat mounted on its integration support, which allows to simulate the telescope position and to measure the mechanical flexure.

is a concave aspherical collimator mirror, which provides an 18-mm cold stop pupil in parallel light (as usual for infrared instruments, the pupil of the telescope is imaged on a cold stop mask to avoid straylight). The second mirror is just a folding flat mirror which eases the mechanical implementation, especially of the two filter wheels immediately behind the cold stop. The last three mirrors form a Three Mirror Anastigmat (TMA) configuration, similar to the TMA systems used in the VISIR spectrometer. They ensure the re-imaging of the field onto the detector. The three magnifications required for the imager are obtained by three sets of TMA mirrors mounted on a wheel. The optical calculations have shown that the image quality of the system is excellent (well below the telescope diffraction limit).

2.2.2 Spectrometer

The optical design of the spectrometer has not changed very significantly since the completion of the Phase A study, and the reader is referred to [1] for details on the design. We only recall that, like the ISAAC instrument [6], it is a long-slit grating spectrometer based on TMA systems in double pass, (pass 1: collimator, pass 2: camera). The spectrometer has two arms, one for the low- and medium-resolution modes; the other for the high-resolution mode, which is based on the 'duo-echelle' concept: two large echelle gratings mounted back-to-back on one 350 × 130 mm blank. The opto-mechanical design allows for the implementation of an array with up to 512 × 512 50 μm pixels in the focal plane of the spectrometer. The implementation of two 256 × 256 arrays along the wavelength axis would double the efficiency of the instrument for many observations; but at the moment only one detector array is funded.

2.3 Mechanical and cryogenic design

2.3.1 Cryogeny aspects

To avoid prohibitive dark currents, mid-IR detector arrays need to be operated at a temperature around 6–8 K, much lower than near-IR or visible arrays. The optics and associated mechanical structure has also to be cooled, so that the amount of background photons radiated by these elements becomes negligible compared to background photons generated by the telescope and the atmosphere. A temperature lower than 35 K is required for the spectrometer optical bench. To avoid thermal gradients, the imager will be at the same temperature, even if a temperature up to 60 K could be accepted for this subsystem. A lot of intelligence will still be invested in the detailed studies to prevent "hot" photons from penetrating the heart of VISIR, e.g. via cables. That is the real difficulty of VISIR compared to instruments operating at shorter wavelengths.

The cooling of detectors down to 6–8 K with two-stage closed-cycle coolers was a problem at the end of the phase A study. The use of three-stage cryocoolers or even of liquid helium was considered. Such solutions were a pain in terms of technical operations and maintenance, which are crucial aspects in the VLT context. Recent developments on two-stage commercial cryocoolers allow now cooling power of 1 W at 4.2 K, which fulfils VISIR detector requirements.

Three cryocoolers are needed, one for the imager (detector 6–8 K, structure 35 K), one for the spectrometer (detector 6–8 K, structure 35 K) and one for the radiation screens (100 K) and the detector baffles (15 K).

A pre-cooling system based on the circulation of liquid nitrogen will be implemented in order to reduce the time to cool the instrument from room temperature down to 80 K to 8 hours, instead of 60 hours with only the cryocoolers.

2.3.2 Mechanical implementation

The mechanical structure of VISIR is made of two autonomous substructures: the imager optical bench and the spectrometer optical bench. Typical dimensions of the subsystem are 0.85 × 0.6 × 0.3 m for the spectrometer and 0.6 × 0.6 × 0.14 m for the imager. These two structures are connected isostatically in three points and together form a rigid unit, which in turn is connected isostatically in three points to the main structure inside the VISIR cryostat (see Fig. 2).

Given that VISIR is a cryogenic instrument, leading design criteria are: high stiffness-to-weight ratio, low mass and high thermal stability. It appears that the design goals of 40 kg for the imager and of 80 kg for the spectrometer can be achieved. A special effort has been done at Dwingeloo to lightweight the aluminium blanks of the duo-echelle and the TMA mirrors. Weight reductions of 70–80% with respect to solid blanks have been achieved without degrading the optical performances.

2.3.3 Flexure analysis

The instrument has to be stiff enough in order not to perturb the observations. The specification is a shift of the image on the detector by less than a pixel (50 μm) in one hour of observations. The analysis of the first mechanical structures has shown that we were able to fulfil the specifications. The results of finite element mechanical calculations have been injected into the optical model in order to compute the impact of mechanical deformations on the optical quality. Such a coupling between an optical model and a mechanical model has been done both at Saclay and Dwingeloo. Further optimisations of the mechanical structure will be done during the detailed study of VISIR.

2.4 Motorisation

There are a lot (16) of mechanisms in the cold part of VISIR. All the mechanisms, except those for the fine setting of grating positions, will use the same motor unit. This unit is a novel development, which combines in a very compact manner (outer diameter 100 mm, inner diameter 32 mm, thickness 37 mm), a space qualified stepper motor used in direct drive, a "dog" (tooth clutch) system which locks the mechanism in accurate discrete positions and bearings.

The power is down when the movable part is in position. Typical duration for movements will be 2 seconds and repeatability accuracy is expected to be 1 micron at 10 cm from the axis, as demonstrated with our warm dog prototype.

The grating scanner mechanisms are close copies of the scanners applied in the SWS and LWS spectrometers of ISO. These scanners are servo systems with linear motors as actuators and high-resolution LVDTs (Linear Variable Differential Transformers) as encoders. Adaptations of the SWS/LWS scanners for VISIR are being developed by SRON, (Groningen, the Netherlands).

2. 5 Control/software

The Control and associated software represent a heavy load. This work was not our priority during the predesign studies. Our group is well used to this aspect of an instrument and a lot of work has already been done for ISAAC, which will be used as a model.

3. Tools and Test Equipments

Final integration and tests of the instrument, which are the latest phase of a project, generally suffer from the cumulative delays which have happened in the earlier phases of the project. Then those tests are done under heavy time pressure. In order to avoid such a situation, we have decided to start very early in the project the construction of all the test and handling equipments and to prototype in full size many parts of VISIR. The VISIR test cryostat and integration support are already available, as can be seen on Figure 3. The installation of the test equipment has prompted the safety analysis of VISIR. We have the approval of the CEA internal safety panel to operate VISIR and its handling equipments at SAp.

Our early intensive test approach should prevent us from bad surprises during the final integration and tests, and help us to meet the contractual delivery date of VISIR at Paranal, beginning of 2001. The ESO decision to move VISIR from telescope unit 2 to telescope unit 3 should not prevent us from starting the commissioning of VISIR on telescope soon after arrival on site. Scientific observations are expected to start shortly after the commissioning, in the second semester 2001.

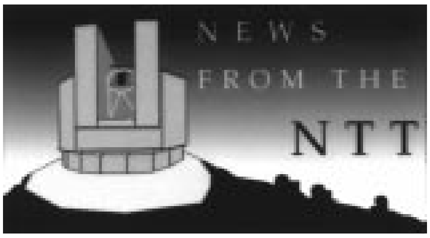
Acknowledgements

We wish to thank our VISIR colleagues who contributed so much to a very promising VISIR design and who are too numerous (23) to be quoted here. We also thank the members of the ESO infrared group and the PDR review panel for their numerous constructive comments. Our special thanks go to the panel chairman, Jason Spyromilio, who conducted the review with maestria. We use this occasion to salute Anton van Dijsseldonk, who is leaving ESO and will be missed by the VISIR team.

References

[1] P.O. Lagage et al., 1995, *The Messenger*, **80**, p. 13.
[2] H.U. Käufl, 1997, *The Messenger*, **88**, p. 8.
[3] P.O. Lagage and E. Pantin, 1994, *The Messenger*, **75**, p. 24.
[4] D. Silva and P. Quinn, 1997, *The Messenger*, **90**, p. 12.
[5] M. Meyer et al., 1996, *The Messenger*, **86**, p. 14.
[6] A. Moorwood et al., 1992, *The Messenger*, **72**, p. 10.

P.O. Lagage
lagage@sapvxa.saclay.cea.fr



NEWS FROM THE NTT

G. MATHYS, ESO

The relatively quiet situation that had prevailed at the NTT since the return into operations (see the News from the NTT of *The Messenger* No. 90) has come to an abrupt end beginning of December. Since then, the NTT has been the scene of a quick succession of events, which will be reported below in chronological order of occurrence.

SOFI

The installation of SOFI was the first major technical intervention scheduled at the NTT since the end of the big bang. The readers of *The Messenger* have already had various opportunities to get acquainted with this instrument, the first one of the VLT generation. Indeed, the acronym SOFI stands for Son OF ISAAC. It may not be necessary to recall that ISAAC, an IR imaging spectrograph, will be one of the first two instruments to be mounted on UT1 of the VLT. As suggested by its name, SOFI is essentially a scaled-down version of ISAAC. There are many similarities between the two instruments, all the way from the opto-mechanical design down to the control software, which is common to both.

At the NTT, SOFI takes the place on the Nasmyth focus A that has been left vacant by the decommissioning of IRSPEC at the end of June 1996. IRSPEC had already been dismounted during the big bang year. By end of November 1997, SUSI, which had been sharing adapter A with IRSPEC, was, in turn, decommissioned. This was needed because the adapter flange on which SUSI was mounted had to be replaced by a new one, required by SOFI. This new adapter flange furthermore bears SUSI2 (of which more below). As soon as SUSI had been removed from the telescope, the installation of SOFI started. This installation proceeded very smoothly, and the performance of the instrument turned out from the first moment to be very promising.

SOFI is operated from a dedicated workstation, *wsofi,* whose dual-screen console has taken place in the EMMI control room. Another sign of the presence of SOFI which is perceived immediately by the visitor entering the NTT building is the SOFI "heartbeat", that is, the sound of the Closed Cycle Cooler, which is permanently heard throughout the building and has already become one of its landmarks.

The reader will find more details about the installation of SOFI and SUSI2 at the NTT and preliminary information about the instruments' performance in separate, dedicated articles in this issue of *The Messenger*.

A New Release of the VLT Common Software

The VLT common software, which is the cornerstone of the NTT control system, keeps being developed. At regular intervals (6 months, for the time being), a new "official" package of this software is released, which contains the most recent versions of the various modules that have been fully tested and debugged off-line by the developers. This new release is then ported to the tele-