Krister Wirenstrand and Rodrigo Amestica. It was a cold night, appropriate to the late Chilean winter, and we could hear the wind howling outside. We had chosen our first light target in advance: the planetary nebula He 2-428. In a few minutes, the guide star was acquired, the position and shape of the mirrors were actively corrected, and we could see on the computer screen the unmistakable shape of the source, with an image quality limited only by the atmospheric seeing (0.9 arcsec at the time). The rest of the evening was spent in the VLT Control room in the appropriate celebratory manner, taking more images, attending to the PR requirements, and drinking champagne with the teams observing on the other telescopes.

Everyone present felt the sense of accomplishment, triumph and elation that always accompanies the culmination of a great human adventure.

Thus did I celebrate the beginning of my second year at ESO. I cannot imagine any better way.

Two important challenges remain for ESO and for the numerous laboratories throughout Europe with which it collaborates: the completion of the ambitious instrumental programme and of the corresponding data-acquisition, flow and reduction tools, and the development of the VLT Interferometer, the next project on the mountain. Already underway, these will both come to fruition in the next few years.

Finally, the whole ESO scientific community faces the biggest challenge: to make momentous and original discoveries with the VLT!

ISAAC: 18 Months of Paranal Science Operations

J.G. CUBY, C. LIDMAN and C. MOUTOU

1. Introduction

ISAAC was offered to the ESO astronomical community on April 1st, 1999, as one of the first two VLT instruments installed at UT1-Antu.

ISAAC (Infrared Spectrometer And Array Camera) is a 1–5 μm imager and spectrometer and has been fully developed by ESO (P.I. Alan Moorwood). Figure 1 shows it mounted on the adaptor/rotator of the Nasmyth B focus. Following integration and extensive testing in Garching, ISAAC was delivered to the Paranal Observatory in June 1998, where it was re-assembled and re-tested in the Integration Laboratory prior to installation on the telescope as scheduled. There were two commissioning periods, in November 1998 and in February 1999 (Moorwood et al., 1998; Moorwood et al., 1999).

ISAAC weighs 1.5 tons, is 2 m in diameter and required 3000 drawings for its design. It is made of 15,000 pieces, which were shipped in 40 boxes (30 tons) to Paranal (including laboratory equipment). Its cost amounted to 4.5 MDM, and 50 man-years were needed to build it. It has had, up to now, more than 40 cool-downs, operates at 70 K and uses 11 cryogenic functions. In some operational situations, the telescope field stabilises (i.e. M2 tip-tilt) at 70 Hz with full active optics control, while chopping every second (in the Long Wavelength (LW)), nodding every minute, synchronising M2 and detector while reading out 10^6 pixels every 70 ms, and can deliver images as good as, or better than, 0.3 arcsec.

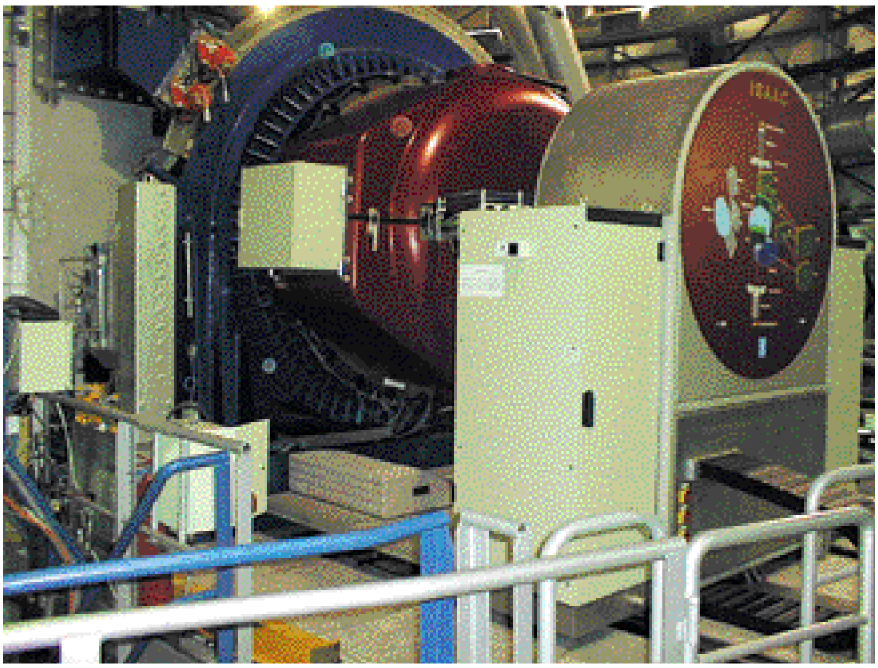


Figure 1: ISAAC at the Nasmyth B focus of the VLT UT1. The instrument is attached to the adapter/rotator system and has a total weight of around 1.5 tons. The box at the left contains some of the electronics required for controlling and reading the two infrared array detectors. To the right is the co-rotator system that transfers all the electrical cables and gas hoses for the closed-cycle coolers to the instrument and rotates with it and the adapter. At each side of the co-rotator are cabinets containing electronics for controlling and monitoring the instrument functions and the vacuum and cryogenic system. Under the vacuum vessel, one can see part of the platform to which the instrument is attached for installation, removal and maintenance activities.

From this, let us make an obvious statement: getting ISAAC to run on sky was a challenge. The instrument and the telescope have to work, the thousands of parameters controlling this complex system have to be fine-tuned. This would not have been possible to achieve without the prior success of the instrument design, development and integration, and the incontestable success of the VLT.

The first year of ISAAC operations was punctuated by a number of technical failures, mainly related to the cryogenic functions (gears, motors, bearings). Fortunately, the impact on the Science Operations could be limited to a minimum. On one hand, most of the problems were temporarily fixed by immediate interventions on the instrument by people from the Instrument Division and/or from Paranal Engineering, and, on the other hand, the flexibility offered by the service mode allowed to run FORS1 instead, hence preserving telescope time. A few visitor runs had however to be re-scheduled, or transferred to service, or cancelled, and only one visitor run (ironically with the visitor being one of the authors of these lines) was affected in real time by a technical failure. In total, no more than about 10 ISAAC nights were lost in one year, the most affected programmes being in the LW domain. In the meantime, the Instrument Division in Garching spent tireless efforts to investigate and understand the cause of the problems, and eventually ended up with a new design for the faulty mechanical parts. In February 2000, a major overhaul took place, and these parts were replaced. In addition, the LW detector was upgraded from a 256 × 256 array to an Aladdin 1024 × 1024, together with a new detector acquisition system. Since then, ISAAC has run quietly without any need for further interventions.

Operating ISAAC is yet another challenge. The performance, as it reaches unprecedented levels, has to be assessed, understood and monitored, scientific needs have to be anticipated, users have to be offered simple, yet powerful, tools, unanticipated situations have to be dealt with, experience from real observations and data reduction has to be fed back as soon as possible while preserving configuration control, and this can only be achieved if the various people involved in the operation chain work together.

In practice, Science Operations started on D-day; many science programmes were completed in visitor and service modes in the very first weeks of operations. Still, many things have been improved since the start of the operations, and the steep learning curve of the first months has now stabilised towards a flatter one. We have learned a lot, optimised accordingly, developed tools to ease the operations and data reduction. All of our first visitors, whenever the weather was on their side, left Paranal enthusiastic about the observatory, the VLT, ISAAC and their data.

We will summarise in this *Messenger* article where we are with ISAAC, from a Paranal perspective, after about 18 months of operations.

2. Characteristics and Performance

The main characteristics of ISAAC are summarised in Table 1. There are two channels, one covering the [1–2.5] μm range (SW) and one covering the [2–5.5] μm range. In spectroscopy, there are 2 gratings providing low (Rs ~ 500) and medium (Rs ~ 3000) resolution spectroscopy with a 1-arcsec slit. The highest achievable resolution is ~ 10,000 with a 0.3 arcsec slit. The interested reader can find more information on the capabilities of ISAAC at http://www.eso.org/instruments/isaac.

Table 1: Main characteristics of ISAAC

	Short Wavelength (SW)	Long Wavelength (LW)
Detector	Hawaii 1024 × 1024 2.5 × 2.5 arcmin, 0.147 arcsec/pixel	Aladdin 1024 × 1024 1.2 × 1.2 arcmin, 0.07 arcsec/pixel
Imaging	21 filters (5 BB, 16 NB) 1 Wollaston prism (+ mask)	6 filters (5 NB, 1 BB (L))
Spectroscopy	Rs ≈ 500 (Low Resolution, 1 arcsec slit) Rs ≈ 3000 (Medium Resolution, 1 arcsec slit) 4 slit widths (s): 0.3, 0.6, 1.0 and 2.0 arcsec	

Sky backgrounds and emissivity

The telescope emissivity was measured in Medium Resolution Spectroscopy at ~ 2.5 μm, in Narrow-Band imaging at 3.28 μm and in broad band L. With a freshly coated mirror the emissivity is 17%.

Typical backgrounds in mag/arcsec^{-2} are given in Table 2.

The background between the OH lines was measured and its dependence with the Moon phase was assessed during an eclipse of the Moon (January 2000). The main results are, pending more careful analysis to be described elsewhere:

• In J, the background at 1.19 μm is 1200 phot s^{-1} arcsec^{-2} μm^{-1} m^{-2}, corresponding to a magnitude of ~ 18 in dark sky conditions.

• In H, the background at 1.70 μm is 2300 phot s^{-1} arcsec^{-2} μm^{-1} m^{-2}, corresponding to a magnitude ~16.5 in dark sky conditions. This value is 4 times higher than the value reported by Maihara et al., 1993 as measured in Hawaii.

• At ~ 30° distance from the Moon, the background between the OH lines increases by a factor 4 to 5 depending on phase.

• At more than 70° from the Moon, there is little dependence on the phase, meaning that the background is almost at its minimum, within a factor of 2.

Background-limited observations between the OH lines require long integration times, above 10–15 minutes of time, and low readout noise. With long integration times, the density of hot pixels increases significantly, and a compromise has to be found between data integrity and purely background-limited performances.

Efficiency

The overall efficiency, measured as detected electrons to photons incident at the top of the atmosphere varies from ~ 20% at 1 μm to ~ 30% in K or L, in imaging. In spectroscopy, the efficiency is further modulated by the grating diffraction efficiency, and varies from ~ 8% to 20%, from top of the atmosphere to the detector.

Image quality, distortion

The image quality in the LW and SW channels is extremely good, from 1 to 1.5 pixels (0.147 arcsec/pixel) all over the array. The field distortion in SW amounts to 2 pixels at the edges and 3.5 pixels at the very corners of the field of view.

Detector performance

The Hawaii array equipping the SW channel is used in Double Correlated Readout mode in imaging, and in Non-Destructive Readout mode in spectroscopy. The readout noise varies from less than 10 e$^-$ rms in non-destructive mode to ~ 15 e$^-$ rms in DCR mode, the dark current is as low as 0.01 e$^-$ s^{-1}. The Aladdin array equipping the LW channel is used in Uncorrelated or Double Correlated reads depending on application. The readout noise varies accordingly between 50 and 100 e$^-$ rms. See Finger et al., 2000, for a more detailed description of the ISAAC detectors.

Spectroscopic detection limits

As a guideline, a detection limit of 10^{-17} ergs s^{-1} cm^{-2} for emission lines between the OH lines is achievable in just a few hours of time in Medium-Resolution Spectroscopy, depending on wavelength, line width, slit width, etc.

2.1 Miscellaneous performance issues

During the course of the first year of operation, we had to live with, or discover a number of issues, most of them intrinsic to the detectors and/or to a cryogenic instrument, for which procedures have been implemented (SW) or are being investigated (LW).

Short Wavelengths (SW)

• Electrical ghost with the Hawaii array. A feature of this detector is to generate on each line and on the line 512 lines away a bias of constant intensity proportional to the number of counts integrated along the line. This effect has been characterised, and a reduction routine has been implemented (*is_ghost*, in the *eclipse data* reduction package, Devillard, 1997) and allows to accurately correct for it.

• Persistence effects with the Hawaii array. These persistence effects have some operational consequences (see section 3.1).

Table 2: Typical backgrounds (mag/arcsec^{-2})

Band	J	H	Ks	L	M_NB
Magnitude	16.5	14.4	13.0	3.9	1.2

• The Hawaii array suffers from bias variations with detector integration time and flux. The latter behaviour (together with persistence effects) limits the ability to use dark subtraction techniques as in the visible, but rather encourages one, as usual in the IR, to resort to sky-subtraction data-reduction techniques.

• Some low level (1 to 2 e^-) 50 Hz pickup noise is occasionally seen, mostly visible in spectroscopy where the background levels are the lowest.

• The Hawaii array also shows fringing, with well-defined Fabry-Perot rings, originating from the sapphire substrate on top of the array. Although very stable, this fringing has a secondary effect, related to the reproducibility of the grating in spectroscopy. If the grating does not reproduce well between consecutive set-ups (even at the level of a fraction of a pixel), the fringing pattern will be slightly displaced, and will not flat field out perfectly, leaving some residuals on the array. In order to circumvent this potentially limiting factor for high S/N observations, we implemented special procedures to take, if deemed necessary, night-time spectroscopic flat fields at the end of the spectroscopic observations.

Long Wavelengths (LW)

• Aladdin electrical ghosts. Like the Hawaii array, the Aladdin detector, or its associated electronics, also presents some electrical ghosts that are being investigated.

• For still non understood reasons, there is a 'scattering feature' in the LW spectroscopic modes, generating scattered light depending on where the object spectrum lies on the array. Until further evaluation, the problem is simply circumvented by acquiring the target asymmetrically along the slit so as to avoid this scattering feature.

• For the same reason as above regarding the reproducibility of the functions, it is not desirable to move from imaging to spectroscopy during a night. The objective wheel, bearing the 2 objectives in use in these LW modes, will not perfectly reposition, and hence affect the calibrations that can be done at the end or beginning of night.

3. Operations

3.1 General aspects

ISAAC shares Antu with FORS1, a visible imager and multi-object spectrograph. The observing time at Antu is therefore roughly split between FORS1 in dark time and ISAAC in bright time, pending the arrival of another instrument at the Nasmyth A focus.

ISAAC is operated in service and visitor modes with slightly more time allocated in service mode. The full process of data flow operation is performed by an Instrument Operation Team, gathering people from the various groups involved in Paranal and Garching. The VLT is operated within the Data Flow System (Quinn et al., 2000), and an overview of VLT science operations is given in Gilmozzi et al., 2000.

Operations in visitor mode only involve Paranal, save for data archiving. The high satisfaction of the visitors is in itself a demonstration of the effectiveness of the Paranal Science Operation (PSO) scheme.

A specific aspect of the service-mode operations is that the front and back ends are in Garching (User Support Group (USG) and Quality Control Group (QCG) from the Data Management Division), Paranal Science Operations (PSO) being at the core of the chain. This chain therefore includes persons from different Divisions, 12,000 km away, and working in different time zones. Keeping the information synchronised all along the chain requires constant efforts, and heavy e-mail traffic.

The regular operations on Paranal involve, at minimum, (i) one night astronomer per telescope performing the observations in both visitor and service modes, (ii) one day astronomer for 2 telescopes in charge of supporting the visitors, performing the daytime calibrations, checking the data, and of many other miscellaneous duties, (iii) one Telescope and Instrument Operator per telescope, (iv) one data-flow operator in charge of handling/packing the data and maintaining data flow operations.

In service mode, the users interact with USG and prepare their Observation Blocks (OBs) in advance at their home institute using the Phase II Proposal Preparation tool (P2PP). In addition, users provide readme files and finding charts. The importance of carefully preparing this material cannot be overstated: imagine a long winter night, when the astronomer on duty will typically work 15 hours per night, 10 nights in a row, execute up to 10 service programmes in a night, execute the Calibration Plan accordingly, check the OBs, read the proposals and associated material, perform the acquisitions, start the observations and monitor them all during their execution, check the pipeline reduced data, report on their quality, while writing down in the night log everything happening for any single executed OB, all of that not mentioning possible problems to deal with. In these conditions, the winning User will be the one who has carefully prepared his material and provided the clearest explanations and finding charts. Observations insufficiently prepared are usually returned to the User via the User Support Group, resulting in a waste of time for all, and reducing the chances for this programme to be executed.

The User Support Group generates the queues for every scheduled service period (Medium Term Schedule). The material is then sent to Paranal a few days before the start of the service period. The staff astronomer on duty then browses through the monthly queue and in real time during the night selects the programmes that can be executed. The selection is a human-based process, and essentially relies on common sense, taking into account:

• The priority of the programme. There are three categories of programmes, from A to C, reflecting the ranking given by the OPC. Class A programmes have the highest priority, and all efforts are made to execute and complete them within the constraints specified by the user.

• Distance to the Moon and phase of the Moon constraints as specified by the user. In most cases, the constraints on the Moon are irrelevant in the infrared. There are, however, 2 cases where the Moon constraints are to be taken into account: (i) distance to the Moon is too small, preventing active optics (performed in the optical) to work, (ii) medium-resolution spectroscopy, with increased background between the OH lines.

• Air mass constraint as specified by the user.

• Seeing (understood as the actual image quality) constraint as specified by the user. The seeing, as measured by the Paranal Astronomical Site Monitor (see e.g. Sandrok, 2000, or *http://www.eso.org/gen-fac/pubs/astclim/paranal/asm*) can vary during a night. The seeing variations, although dimmed in the IR, forces one to adapt in real time the Short Term Schedule during a night, and occasionally to abort the running observations if the user-specified constraints are not met.

• Sky transparency constraint as specified by the user (choices are photometric, clear, thin cirrus, thick cirrus).

• Time critical observations (e.g. Targets of Opportunity like Gamma Ray Bursts, Supernovae follow up, monitoring programmes,...)

• Status of a programme. Clearly, the aim is to complete and finish programmes rather than starting them all. Since time allocated in service is over-subscribed (for obvious reasons intrinsic to service observations), this criterion of choice is particularly important and calls for a timely preparation of the observations by the users..

• Persistence effects. The Hawaii array suffers from persistence effects when it is strongly illuminated (see section 2.1). This prevents one from observing in Medium-Resolution Spectroscopy at low flux between the OH lines after imaging of bright, saturated stars (e.g. acquisition of bright standard stars for spectroscopy). This particular problem has led us to enforce rules regarding the brightness of the targets.

In addition to executing the observations, Paranal Science Operations also performs on-line quality control on the service data: the executed observations are classified as “Completed within constraints”, “Not completed within constraints but should not be repeated”, “Not completed within constraints and should be repeated”. Note that this classification is usually done with ISAAC on the pipeline reduced images, (see section 3.5) or, if not available in case of non supported templates, on the raw images. The Quality Control Group in Garching performs the final Quality Control on fully processed and calibrated frames (see Amico & Hanuschik, 2000).

In visitor mode, the users interact exclusively with Paranal Science Operations for the preparation and execution of their observations, and may also request calibration frames maintained in Garching. They arrive on site two days in advance of their observing run, discuss the observation strategy and prepare their Observation Blocks with the daytime astronomer. They receive their data as tapes or CD-Roms upon their departure from Paranal the day following their last night.

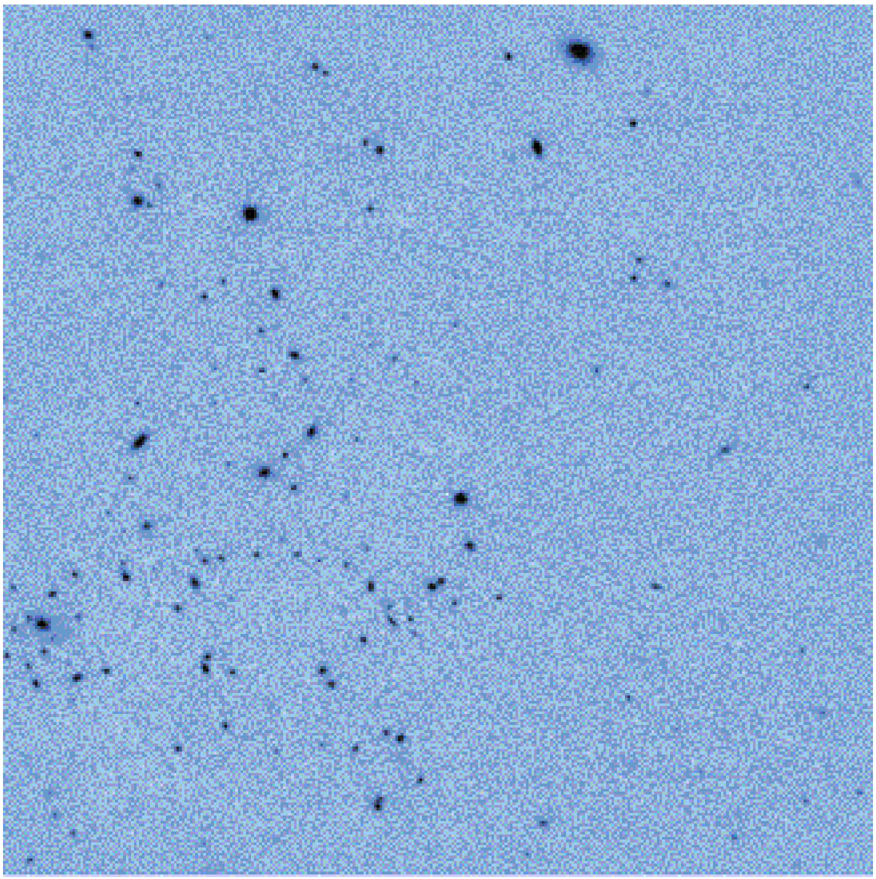


Figure 2: Illustration of the imaging pipeline. A full ISAAC frame resulting from a jitter sequence of 30 images corresponding to 1/2 hour integration on sky in the Ks filter. This is a partial image from a public deep-imaging survey (Franx, 2000). This image is the raw image delivered in a fully automatic way by the pipeline at the telescope a few minutes after the observations were finished.

3.2 Exposure Time Calculator

Exposure Time Calculators (ETCs) have been developed for all modes of operation of ISAAC, for imaging and spectroscopy, SW and LW.

These exposure time calculators reflect the performance of the instrument. They include an accurate modelling of the sky emission and absorption, including the thermal background above 2.0 μm. Note that we are currently working at compiling a Paranal atmospheric absorption spectrum, whereas the current spectrum used by the ETC comes from a model and is not accurate in terms of depth of the atmospheric features.

The ETC allows simulating objects of different spectral types (continuum, black body, single emission line). It is the entry point to the Phase I Proposal Preparation, and users are requested to use it beforehand to estimate the required exposure time.

These ETCs are available on line at http://www.eso.org/observing/etc.

3.3 Templates

All observations are executed via templates. ISAAC is equipped with a variety of templates, providing for most observing needs. Excluding the calibration templates (flats, darks, arcs, etc.) the offered ISAAC templates are:

• Imaging. The ‘AutoJitter’ template automatically generates a random pattern of telescope offsets within a box width that is defined; the ‘AutoJitterOffset’ template, executes Object-Sky-Sky-Object sequences; the ‘GenericOffset’ template, allows the user to define any telescope offset sequence either in sky or detector co-ordinates. Note that these templates are constrained so that the Detector Integration Time (DIT)and the filter are fixed for the whole template.

• Spectroscopy. The ‘AutoNodOnSlit’ template nods the telescope along the slit between two positions separated by a throw defined, with the choice of additional jittering around each position of the nod; the ‘GenericOffset’ template allows to define any sequence of offsets, along or perpendicular to the slit.

• LW templates combine telescope nodding and chopping in both imaging and spectroscopy for a cancellation of the sky residuals left by the chopping.

Additionally, there is a variety of acquisition templates allowing one to move objects interactively to a particular position on the array, or to centre them in the selected slit. Most of the acquisition procedures rely on subtracting an offset sky image.

3.4 Calibration plan

In addition to the scientific observations, calibrations are regularly performed. On a daily/nightly basis (only when the instrument is used at night), the calibrations are:

• Twilight flat fields in imaging, usually 1 or 2 filter(s) per twilight (broadband only, the narrow-band twilight flats are performed as these filters are used).

• Zero points of the night. At least one standard star is observed nightly in imaging for zero point determination.

• Spectroscopic flat fields. They are performed at the end of the night according to the set-ups used during the night. Flat fields are occasionally taken during the night.

• Arcs. Same as spectroscopic flat fields. In most cases, arcs (at least below 2.2 μm) are not needed for wavelength calibration, the OH lines providing *in-situ* references for this purpose (see Rousselot et al., 2000, for a detailed atlas of the OH lines measured with ISAAC).

• Darks. They are taken with the Detector Integration Times (DITs) used during the night.

On a less frequent basis, other calibrations are performed, such as:

• Star trace. A star is stepped along the slit, in imaging first, then in spectroscopy for both Low and Medium resolutions. This is used to calibrate the distortion of the spectra as a position along the slit, and to calibrate the geo-

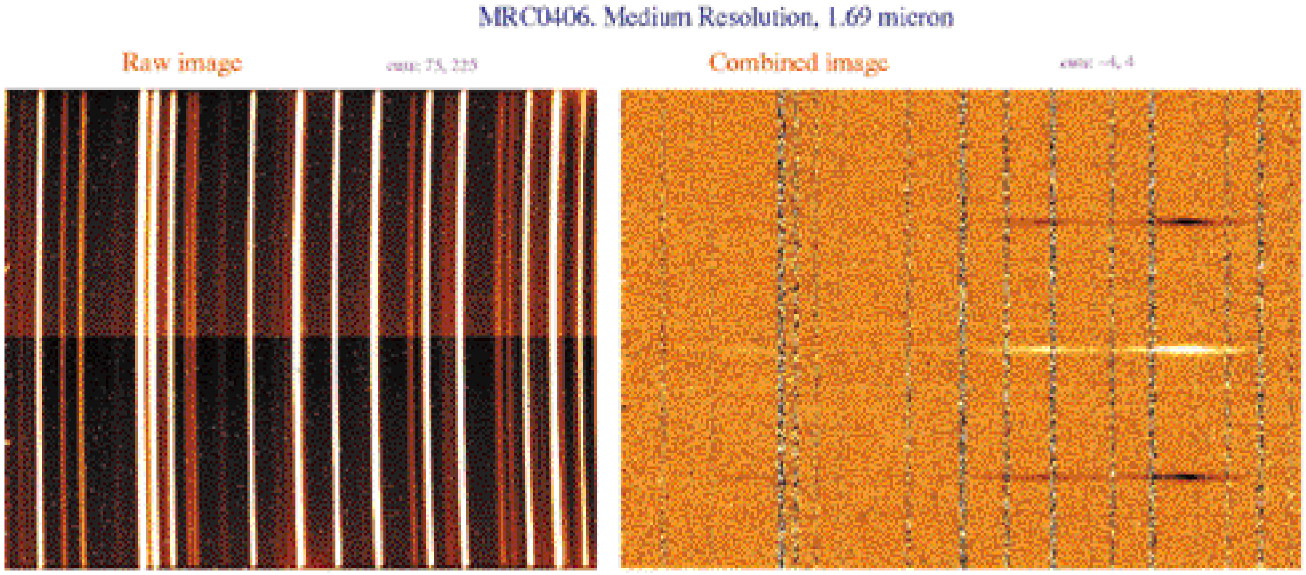
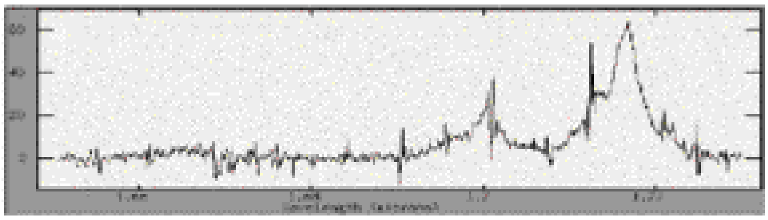


Figure 3: This figure illustrates the ISAAC spectroscopic pipeline 'AutoNodOnSlit' template. This is the spectrum of [OIII]5007/4959 in the z = 2.4 radio galaxy MRC 0406-244. Left: raw image (Medium Resolution Spectroscopy), showing the curved OH lines. Right: fully processed im - age, showing how well 'double'subtraction works. The OH lines are perfectly subtracted, leaving on the image only the photon shot noise. Bottom: extracted spectrum, showing the variation of the noise where OH lines are present.



metrical transformation between imaging and spectroscopy.

• Illumination frame. A star is imaged at different locations across the array, allowing one to remove low-frequency variations which are not removed by using sky flats.

3.5 Data Reduction – Pipeline

Pipelines are supported for the most commonly used templates (non-'generic'ones). The ISAAC pipeline has been developed as a library of C routines, which are available under the eclipse package (Devillard, 1997; see also *http://www. eso.org/eclipse*). The package is also available for off-line data reduction. In the pipeline mode, the frames are classified with a data organiser as they are delivered from the instrument workstation to the pipeline workstation. Whenever a template has finished, the pipeline automatically starts reducing all frames belonging to the template, according to a pre-established recipe.

The aim of these tools is not to provide in all cases ready to publish results. E.g., in spectroscopy, wavelength calibration is not as accurate as it could be. In most cases, the users will need to refine their wavelength calibrations. Still, these tools allow to generate reduced frames to be then analysed with other standard reduction packages (e.g iraf, midas), for e.g. aperture photometry, accurate wavelength calibration, spectrum extraction, etc.

In imaging, the 'AutoJitter' template is the most common template used. The pipeline performs:

• Dark subtraction, flat fielding and bad pixel correction on each input image if requested.

• Running sky subtraction. N (user defined) images around each image in the stack are filtered and averaged to produce a running sky which is then subtracted from each input image.

• Sky subtracted images are then shifted and added. The offsets between images are either taken from the image headers, as a user defined list, or automatically found by cross-correlating frames. If offsets are provided, the cross-correlation is run to refine them. The input objects for the offset determination are either user defined, or automatically found. The shift and add process includes image resampling. Various interpolation kernels are available.

• The final image is then averaged, with rejection.

Figure 2 illustrates the capabilities of the imaging pipeline. This image is the absolutely raw pipeline result obtained at the telescope from a jitter sequence of 30 images, and shows how efficient the tool is in reducing data in fully automatic manner.

In spectroscopy ('AutoNodOnSlit' template), the pipeline performs:

• Dark subtraction, flat fielding and bad pixel correction on each input image if requested.

• Grouping and subtraction of images within one AB or BA cycle.

• Distortion correction in the spatial and spectral directions. In the spatial direction, an input calibration file is needed. This file comes from another routine which reduces and calibrates the 'star traces', i.e. the profile of the spectra across the array as a function of the position along the slit. In the spectral direction, the pipeline performs automatically a correction of the slit curvature as measured on the OH lines in the input images. Conversely, an arc frame can be given as input for the slit curvature correction.

• Wavelength calibration from the OH lines automatically found in the input images. Conversely, the wavelength calibration can be performed either from an arc given as input frame, or from a model of the instrument dispersion.

• Combination of A-B and B-A images within one cycle, based on the offset between A and B positions as reported in the image headers. This 'double subtraction' perfectly subtracts out the sky line residuals present on individual A-B or B-A images, thanks to the slit curvature distortion correction that was done in the previous step.

• Averaging with rejection of all doubly subtracted frames belonging to the template.

• Extraction of the brightest spectrum in the image. Optionally, a spectrum can be extracted at some user-defined position.

Figure 3 illustrates the principle of the spectroscopic pipeline.

In addition to the above-mentioned pipeline recipes for the scientific data, the pipeline also performs a number of tasks related to calibration: dark frame creation and computation of the read-out noise, creation of flat field frames from twilight cubes, automatic computation of the imaging zero points, automatic calibration of the spectroscopic spatial distortions (star trace), automatic computation of the response functions in spectroscopy, etc.

The pipeline has many applications on site, such as faint object identification prior to spectroscopy, on-line quality control, etc. The pipeline is re-run off-line in Garching by the Quality Control Group to reduce the service data (and all calibration data) prior to shipment to the service users. The main difference between the on-line and off-line versions running on the mountain and in Garching is with the calibration data (flat fields, arcs, darks, etc.) that are used.

3.6 Miscellaneous facts

After 18 months of operational experience, a few facts emerge.

• The Image Quality with ISAAC is very frequently better than 0.6 arcsec, and often below 0.4 arcsec. The latter allows one to execute programmes in service mode that require superb image quality.

• The on-target overheads (i.e. excluding pre-setting operations) range from ~ 30% in imaging to less than 10% in spectroscopy.

• The open shutter time as a fraction of the night time varies from ~ 40% (imaging, many sources) to more than 80% (spectroscopy, few targets).

4. Pending Issues

Nothing is perfect. We still have a few pending issues which are not entirely satisfactory with ISAAC, and we will address them as time and resources permit.

Instrument and telescope

• Improvement of the positioning reproducibility of the cryogenic functions.

• The polarimetric mode is for the time being basically non operational. This needs intervention on the instrument.

• There is some vignetting in both imaging and spectroscopic modes, needing to re-align the optical train.

• The image quality across the dispersion correction is not constant, degrading the highest spectral resolution that can be achieved.

• Two filters need to be replaced.

• Residual pick-up noise with the Hawaii array. Occasionally, some 50 Hz pick-up noise pops up in spectroscopic data, with so far no tool to get rid of it.

• The image quality in chopping mode is not stable and occasionally exhibits image elongation. This is under investigation.

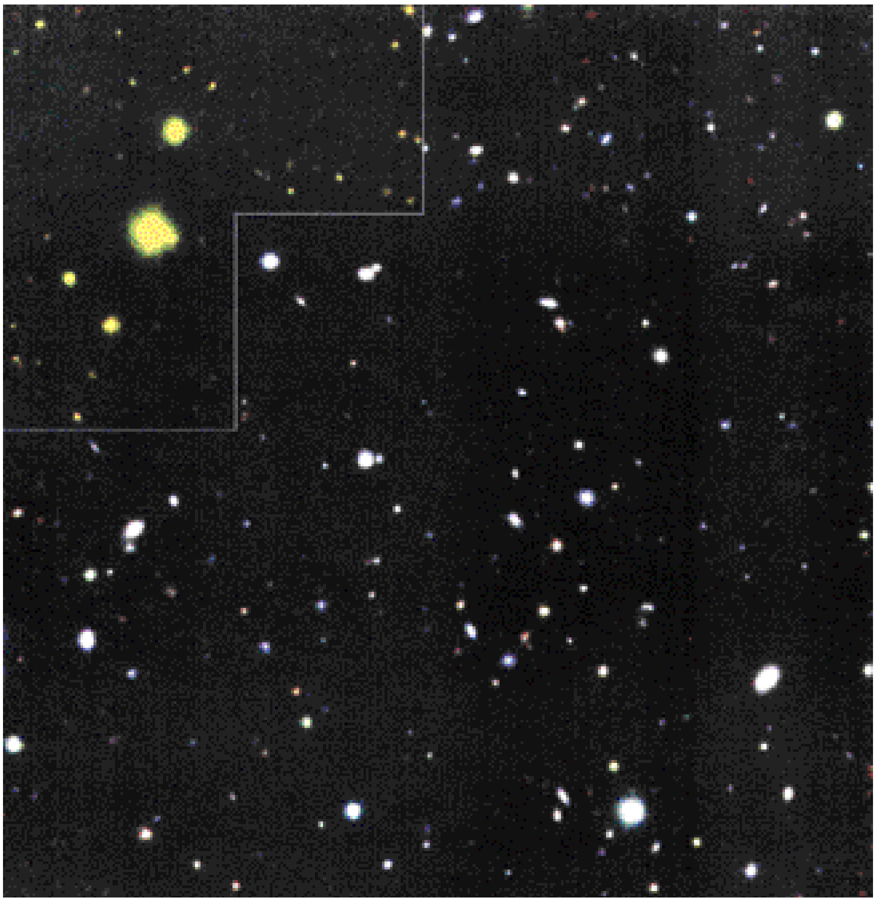


Figure 4: Deep HDFS image from a public survey (Franx et al., 2000). Field is 2.5 × 2.5 arc - min. This is a combined image of HST I images and ISAAC Js (4.7 hrs) and K images (7.45 hrs). Limiting AB magnitudes are J ~ 26, Ks ~ 25.5 at 3σ (see The Messenger No. 99, p. 20).

Operations and tools

• Finalise the LW pipeline. The pipeline group in Garching is actively working at developing new recipes, this should be implemented very soon, both on Paranal in pipeline mode and in Garching for data processing of the service data.

• Spectrophotometric calibration of standard stars in spectroscopy. So far, we resorted to existing material available elsewhere. More compilation is needed, as well as dedicated observations if deemed necessary.

• Monitoring statistics. With the implementation of the so-called QC1 (Quality Control 1), it will become easier in the near future to log parameters measured by the pipeline (e.g. Image Quality, Background values in imaging), monitor these parameters and their variations with external parameters (e.g. outside seeing, temperature, etc.) and perform trend analysis.

• Reducing the number of calibrations. Within the execution of the Calibration Plan, we have been so far

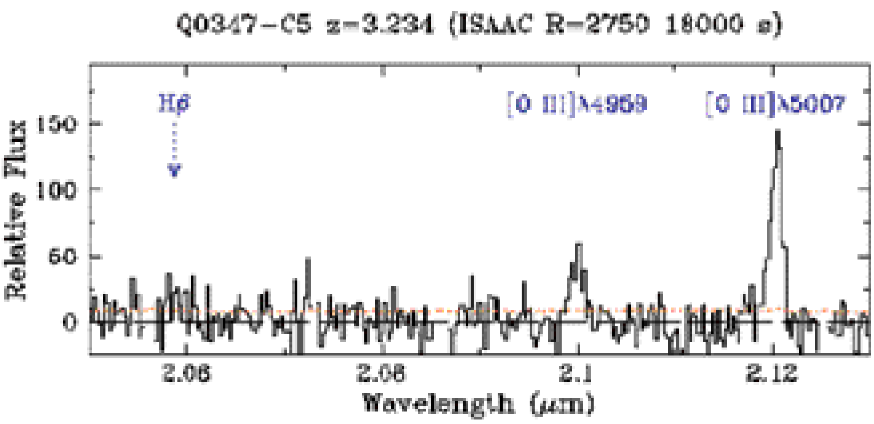


Figure 5: Example of an [OIII] line detection on a galaxy at redshift 3.2. The intensity of the [OIII]/5007 is 7.10^{-17} ergs s^{-1} cm^{-2}. See Cuby et al., 2000, and Pettini et al., 2000.

very conservative regarding the obtainment of calibration frames. We are aiming at reducing the number of daytime calibration frames produced, e.g., the number of dark frames, usually not of very much use for data reduction, still interesting to monitor instrument performance like readout noise.

• LW operations resumed in June 2000 with a new detector. We are still in a learning curve for optimising the operation and assessing the performance and the calibration needs of this mode, in imaging and spectroscopy. The difficulty is here to carry out this exercise while keeping the instrument fully operational.

5. Main Achievements

After almost 18 months of operations, we believe that our main achievements regarding ISAAC operations are:

• Template operations. All templates seem to cover the main requirements from the users. Only in exceptional cases did we have to develop specific templates. The control system is powerful and flexible enough that exceptional requests (e.g. occultation) can usually be accommodated, provided that this is anticipated long enough in advance and iterated upon with Paranal staff. The philosophy adopted for these templates was to hard wire as many parameters as possible (e.g. detector readout mode), so as to limit the number of parameters to be defined by the users, and to simplify the calibrations.

• Calibration Plan. The calibration plan fulfils the needs for the calibration of the instrument and of the science data.

• Automatic generation of daytime calibrations. Sequences of daytime calibrations are automatically generated at the end of the night, based on the FITS header information of the images taken during the night.

• Miscellaneous material provided to the users. Beyond the User Manual, we provide lists of standard stars, atlas of OH and arc lines (to be complemented soon by an atlas of atmospheric absorption lines), library of available IR spectra, etc.

• ETC. The ETC has proved to be reasonably reliable in estimating the performance of the instrument, and all major modes are now supported.

• Pipeline and Data Reduction Tools. Most of the ISAAC modes and/or templates are supported by data reduction tools, running in pipeline, fully automatic mode on Paranal, and available off-line for data reduction. The usefulness of these tools cannot be overstated, both from the user point of view and from the Paranal Operations view. Reduced frames in imaging or spectroscopy allow to assess in real time the quality of the data and determine whether the science goals of the observations are reached.

With the forthcoming addition of some more material for the LW channel in the next months, we believe that we are providing the user community with a self-consistent set of tools and documentation allowing them to use ISAAC in the best of its capabilities for any particular scientific observation.

6. Conclusion

After its first year and a half of successful operation at the VLT, ISAAC has already provided a vast amount of first-class scientific results. See Cuby, 2000, for a presentation of some scientific results obtained in the past year. Figure 4 shows a partial image from a deep, wide-field public imaging programme carried out in service mode with image quality below 0.5 arcsec on the HDFS field, which is described in Franx et al., 2000. Figure 5 shows a Medium Resolution spectrum of a galaxy at redshift 3, illustrating the line detection capabilities between the OH lines.

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MESSAGE TO THE ESO COMMUNITY:

Opening of the VLT Visitor Focus

ESO plans to open on 1 April 2002 a Visitor focus located at a Nasmyth Focus of UT3 (Melipal).

The Visitor Focus has been reserved to permit innovative observations by teams stand-alone instruments, free from a substantial fraction of the requirements for fully automated VLT general-use instruments.

The instruments will be provided by institutes or consortia, and they can be temporarily mounted at the Visitor focus. In addition, this could provide a powerful scientific/technical test bench for new instrumental concepts, eventually incorporated later in standard VLT instruments. The set of guidelines on how to propose and carry out this type of observations can be found at: http://www.eso.org/instruments/visitor_focus/

Note that the side port of NAOS could also hold a small visitor instrument.

Interested parties should contact the VLT Programme Scientist (arenzini@eso.org), Instrumentation (gmonnet@eso.org) and Paranal (rgilmozz@eso.org).