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UNDER THE SIGN OF THREE: AMBER JOINS THE VLTI

AMBER IS THE LATEST ADDITION TO THE INTERFEROMETRIC INSTRUMENTATION ON PARANAL. THIS SHORT NOTE, WRITTEN AS THE PEOPLE WERE STILL TRAVELLING BACK FROM THE FIRST COMMISSIONING, REPORTS ON THE SUCCESSFUL INTERFEROMETRIC COMBINATION OF BOTH TWO AND THREE VLT UNIT TELESCOPES.

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On the night of March 20, 2004 and 9 weeks later, in the rising sun of June 1, champagne bottles popped again in the control room of the VLT Interferometer on Paranal. This is not such an uncommon sight in that room, but please do not think of the VLTI as a centre of repeated transgressions in what is known as a (mostly) alcohol-free observatory. In fact, the good collection of empty bottles on the shelves of the VLTI control room is the result of celebrations for the success of a long series of instruments and systems in this *Mecca* of interferometric technology. *Messenger* readers may be already familiar with the news concerning systems by the names of VINCI, MIDI, Delay Lines, MACAO-VLTI, FINITO, Auxiliary Telescopes, …

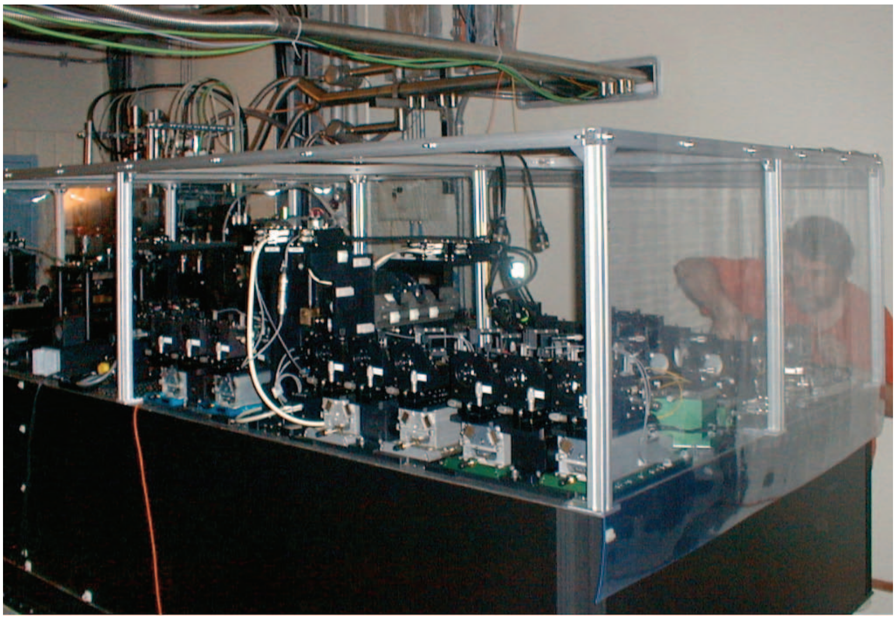

Figure 1: The AMBER instrument in the VLTI laboratory.

The most recent arrival, and the subject of the celebration on these particular nights, was AMBER. The acronym stands for *Astronomical Multiple BEam Recombiner*, and its specialty is the combination of three telescopes, yielding simultaneous measurements on three baselines at each time and therefore measuring the closure phase which is the elementary cell of image reconstruction with long baseline interferometers. For comparison, instruments like VINCI and MIDI only combine two telescopes, yielding measurements on one baseline at a time. In addition, AMBER offers operation in three bands of the near-infrared (namely *J*, *H* and *K*, from 1 to 2.4 microns), either independently or simultaneously. It can observe with three ranges of spectral resolution, the highest being $\lambda/\Delta\lambda$ = 10,000 which is unprecedented in an instrument of this kind. This higher potential of AMBER comes at the cost of complexity: a look at Figure 1 can quickly convince you of this. To put it in the words of an illustrious visitor to the VLTI laboratory during the integration of AMBER: "*Too many mirrors!*".

AMBER was designed and built by a consortium of several French (Observatoires de Grenoble et de la Côte d'Azur, Université de Nice, INSU), German (Max Planck Institute für Radioastronomie in Bonn) and Italian (Osservatorio Astrofisico di Arcetri in Florence) institutes, under the leadership of R. Petrov (Nice). As in the case of MIDI, its costs are borne mainly by the consortium, which is compensated by ESO by means of guaranteed time. AMBER arrived on Paranal in February 2004, and immediately a group of consortium members and ESO staff got busy with its assembly. The main goal of the first run in March was only to assemble the instrument and verify its performance in the laboratory, already a complicated and quite intensive process. This goal was accomplished in less than five weeks, and soon the first attempts on the sky with the VLTI test siderostats took place. As for all VLT and VLTI instruments, a long period of commissioning is needed, with the goal of characterizing the performance and the reliability of AMBER before actually offering it to the community. The first fringes, obtained on the two stars θ Centauri and Sirius, were an extra bonus.

The real observations on the sky started in May 20, when an AMBER team visited Paranal again and, with the support of ESO staff, began extensive tests using the small siderostats as well as the large UT telescopes. The first fringes, i.e. the first successful interferometric combination of two Unit Telescopes (UTs) using AMBER, were obtained on May 28, observing 51 Hydrae with a spectral resolution of 1,500, only seconds after acquiring the beams sent by the UTs in the VLTI focal laboratory. Many operational and software bugs were corrected and a sample of stars with different characteristics were observed. As a very preliminary and quite conservative result, it can be said that observing at low resolution up to magnitude *K*=8 and in medium resolution up to magnitude *K*=7 is fairly straightforward, because these are the magnitudes for which fringes can be immediately detected by eye in individual frames. The evaluation of the actual limiting magnitudes will need some further analysis of the data. In the last hour of this first commissioning period, simultaneous interference between the beams coming from three UTs was obtained, which is a first for telescopes of this size and might be some day recorded as the birth date of imaging with the VLT interferometer. This was a challenge indeed, since it was necessary to use two UTs with only tip-tilt correction, and one UT without. By next July, the analysis of the recorded data should allow us to assess the immediate possibilities of AMBER and pave the way toward its fully optimized operation, to be achieved in the next commissioning runs.

Stay tuned until then for more details and... keep those bottles cool!

Figure 2: The AMBER integration team on Paranal worked over a period of five weeks, and there was a considerable changeover of personnel. In the picture, the people present in the last part of the integration: Romain Petrov, Alain Délboulbé, Fredrik Rantakyro, Etienne Le Coarer, Andrea Richichi, Pierre Kern, Stéphane Lagarde, Carla Gil, Mike Fischer, Mario Kiekebush, Florence Puech, Gérard Zins, Fabien Malbet.

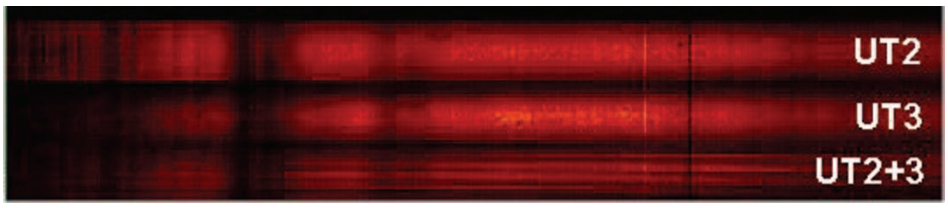

Figure 3: First fringes on the star 51 Hya, recorded with UT2 and UT3 on May 28. Top and middle: part of the light from UT2 and UT3, used for photometric monitoring. Bottom: interferometric combination. The fringes are slightly tilted due to the optical path difference between the two beams, a few tens of microns in this case. The fringes are spectrally dispersed in the horizontal direction. This raw image, recorded at medium spectral resolution of about 1200, covers the *K*-band from 2.0 (right) to 2.4 (left) microns

The MIDI Data Flow: First Observing Period

MIDI, the first scientific instrument for the VLTI, has been offered to the community since the beginning of the observing period P73. In this article, we present a number of different software tools that are available for the preparation of observations, the processing of MIDI data in real-time during observing, the pipeline reduction of data at the completion of observations and the distribution of these data.

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MIDI is the Mid-infrared Instrument for the VLT Interferometer (Leinert et al., 2003). It covers the wavelength range 8 to 12 microns and records spectrally-dispersed fringes, making it possible to reach a resolution (λ/B) of 20 milliarcsec at 10 microns. The main scientific objectives include the study of protostars and very young stars, circumstellar discs, brown dwarfs, tori around galactic nuclei, the centre of our own galaxy and the search for exoplanets. Recent observations of the Seyfert core of NGC1068 in the near-infrared (using the VINCI instrument; Wittkowski et al., 2004), as well as in the mid-infrared (MIDI; Jaffe et al., 2004) illustrate the possibilities offered by infrared long-baseline interferometry (Richichi & Paresce, 2003).

The Service Mode (SM) has been supported at the VLT since the beginning of operations with the first telescope ANTU in 1999 (Comeron et al., 2003). With MIDI, an interferometer is offered to the whole community for the first time. Here we present a suite of observation preparation, data processing and quality control tools that has been developed for MIDI observations. Drawing on the experience gained with the VLTI Commissioning instrument, VINCI, we show the first results of the quality control of interferometry observation data.

Observation Preparation

The science operations of the MIDI instrument from the proposal stage to data delivery are integrated into the general VLT scheme. For the current observing period, P73, a total of 20 MIDI programmes has been accepted and scheduled for observation. From these, 12 are "Service Mode" programmes and 8 are "Visitor Mode" programmes. A total of 71 hours of VLTI execution time has been scheduled for Service Mode. These P73 programmes cover the scientific categories "B: Galaxies and Galactic Nuclei", "C: Interstellar medium, star and planet formation" and "D: Stellar evolution" (see www.eso.org/observing).

Web Tools for VLTI Observation Preparation

In order to plan an interferometric observation and to assess its feasibility, one needs adequate tools to model the visibility for a specified array configuration, taking into account constraints like shadowing effects or the range of the delay lines. In addition, appropriate calibration stars must be selected. Two specific tools are provided for this purpose: the VLTI Visibility Calculator (*VisCalc*) and the calibrator selection tool (*CalVin*). *VisCalc* provides calculations of simulated dispersed visibilities based on software models of the VLTI instruments. The declination and spectral energy distribution, as well as the source geometry, are parameters used to specify the observation target. Visibilities are calculated analytically for uniform discs, gaussian discs and binaries. Visibilities may also be calculated numerically for a user-provided brightness distribution which is uploaded as a FITS file. The user-specified observation conditions include the starting hour angle and the duration of the observation, as well as the instrument and array configuration. Different results can be displayed (Fig. 1) including the *uv*-tracks, the input image and its Fourier transform, plots of visibility versus time, visibility squared versus time, loss of correlated magnitude, or the illumination distribution.

The calibrator selection tool (*CalVin*) provides a similar interface and involves a two stage selection process. On the first input page, the target coordinates, the array and instrument configurations can be selected. The default search criteria are displayed on an intermediate page which allows the search parameters to be refined. On the results' page, the table of matching calibrators (Fig. 1) is listed. For all matching calibrators, the visibility and "observability" information is calculated and displayed. It is then possible to use *VisCalc* for a more comprehensive calculation of the visibility information.

Both tools can be accessed from the VLT Exposure Time Calculators page on http://www.eso.org/observing/etc. The standard version shows only those configurations that

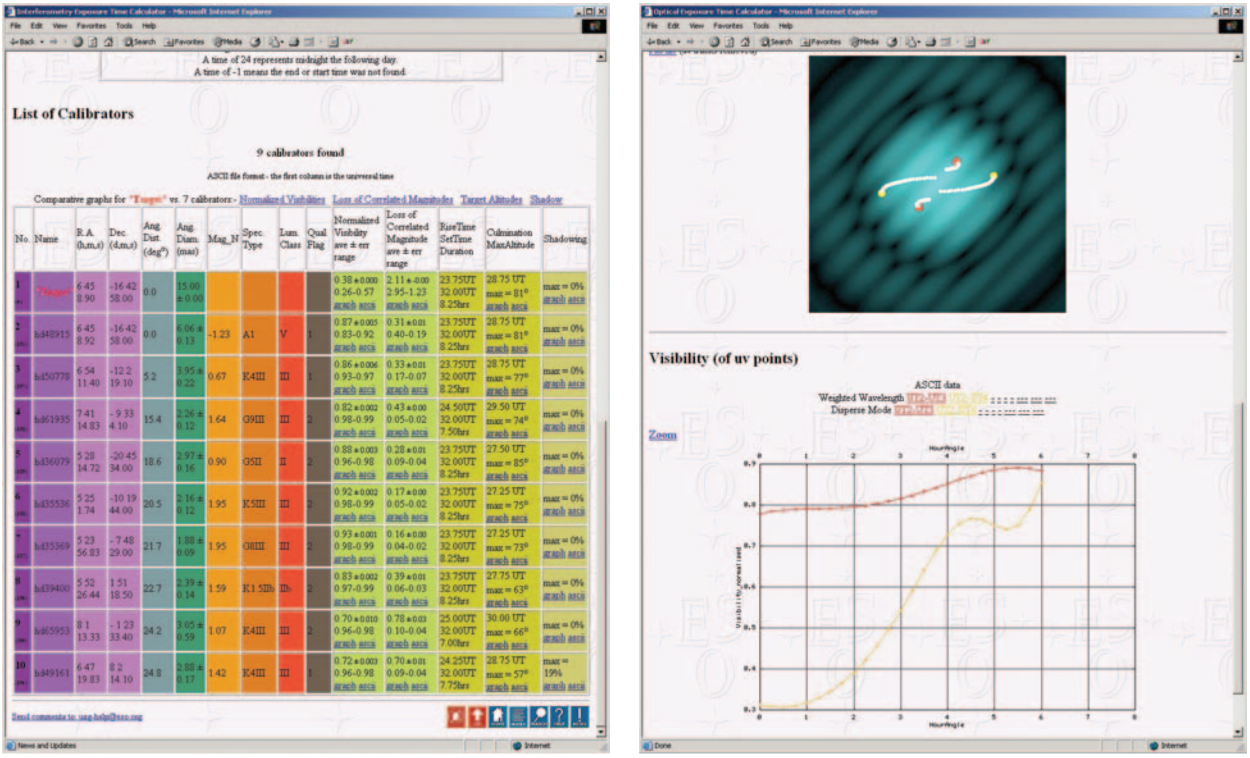

Figure 1: Sample results from the calibrator selection tool *CalVin* (left) and from the visibility calculator *VisCalc* (right).

are offered for the current *Call for Proposals*. It is updated for each new Call for Proposals in order to reflect the offered VLTI baseline configurations and instrument modes. An "expert" version, accessible from the ETC preview page (http://www.eso.org/observing/ etc/preview.html) offers an extended interface with many more choices. It supports the modes and configurations that are currently not offered.

MIDI Calibrators

To obtain a good accuracy for the calibrated visibility measurements, it is important to establish a list of calibration stars that do not show any strong features and that are neither variable nor multiple. In 2003, ESO organised a workshop on VLTI calibrators (Richichi et al., 2003). During this workshop, the following two strategies were discussed:

- The search for suitable objects, in large catalogues like CDS (http://cdsweb.u-strasbg.fr), based on specified criteria.
- Establishing a smaller set of calibration stars based on suitable objects in the literature (Richichi & Percheron, 2002). If necessary, complementary measurements can be taken (Kimeswenger et al., 2004). This strategy reduces the list, but it preserves objects which have already been studied. Furthermore, with a smaller list, the frequency of observations will be greater, and hence detailed knowledge of the sources could be acquired more rapidly.

In the case of MIDI, the calibrators used in *CalVin* are extracted from a list that is provided by the MIDI consortium. Photometry was performed for these stars and the limb-darkened diameter was obtained by fitting atmosphere models. The initial list contains more than 500 calibrators and after careful filtering, based on the "goodness-of-fit" of the atmosphere model, as well as the experience with VINCI observations, we selected nearly 200 potential MIDI calibrators for P73. The following graph (Fig. 2) shows the distribution of the size and accuracy of the MIDI calibrators.

Even though this list is still evolving, we still encourage the use of *CalVin* calibrators. There are at least two advantages to this strategy. Firstly, a large volume of data on *CalVin* calibrators is obtained and therefore their quality can be verified. The goal is to update the *CalVin* list with re-measured objects (see lessons learnt with VINCI). The second advantage is that by using the same calibrators through the year, it becomes possible to study changes in instrument performance over extended timescales.

Phase 2 and OB Preparation

The observation details, including finding charts and observing strategy, are specified by the user in Observation Blocks (OBs) that are assembled with P2PP (Phase 2 Proposal Preparation, www.eso.org/observing/p2pp). MIDI-specific information includes parameters such as the array configuration, a range of Local Sidereal Time (LST), and the specification of a calibration star. Using the LST

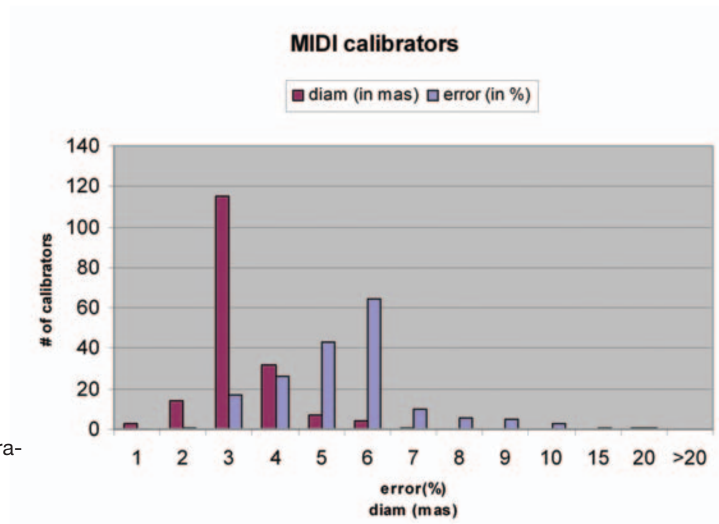

Figure 2: Distribution of the size and associated accuracies for the MIDI calibrators used in *CalVin*.

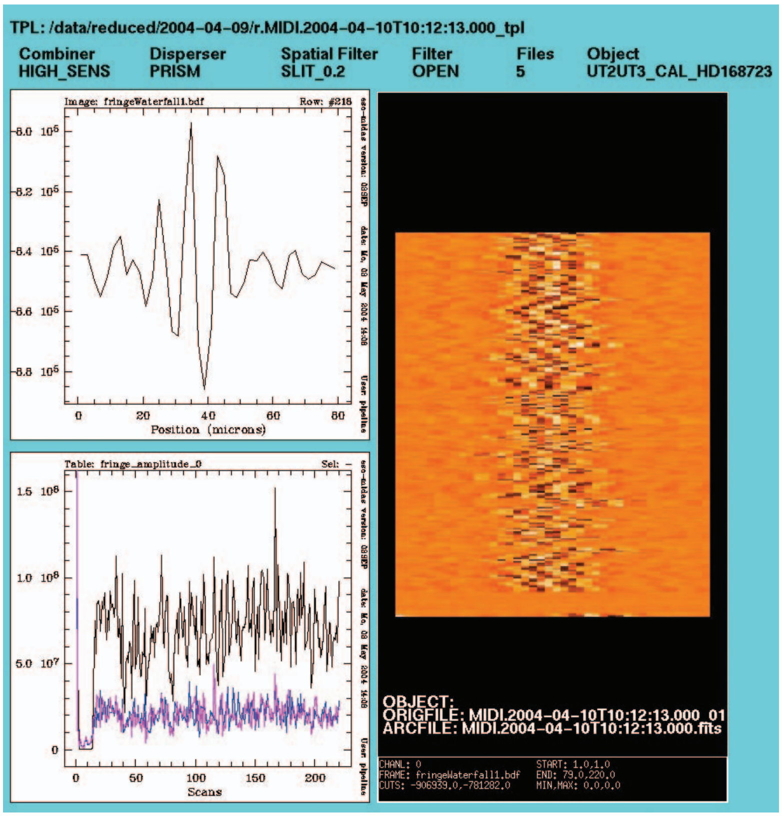

Figure 3: MIDI waterfall display. This example of the output display illustrates three components. The image on the right-hand-side is the so-called 'waterfall display' which shows the fringes in the entire data. The diagram on the top left-hand corner displays the central fringe and the one on the bottom left-hand corner is the result of the fringe amplitudes for the entire scan.

constraint, a user can specify the projected baseline length, the projected azimuth angle or the zenith distance. The calibration star is selected on the basis of criteria such as angular distance, brightness or spectral type (see Sect. MIDI Calibrators).

For the observing period P73, only one observing mode is offered. This is the dispersed-fringe mode, which uses a prism to provide a spectral resolution of R~30 at *N*-band (10 microns). In P73, observations are executed as pairs of science and calibration star OBs with an execution time of 1 hour per calibrated visibility spectrum. As a result, the user only needs to specify a few parameters in P2PP.

MIDI observations are scheduled in discreet units, or blocks. Two major time slots have been reserved for MIDI Service Mode observations, one at the beginning of April and a second one at the end of July. The first block of Service Mode observations using the UT2-UT3 baseline took place at the beginning of April and was very successful. A total of 30 pairs of science and calibration star OBs (30 hours of VLTI observing time, i.e. 60 hours of telescope time) have now been successfully executed. However, the scheduling of interferometric observations with several telescopes and matched LST constraints is complex and, for this reason, carry-overs for MIDI programmes are not offered at this stage.

Data Reduction Pipeline

The algorithms used in the data reduction pipeline have been described and provided by the MIDI consortium and adapted in the Data Flow System environment. The on-line pipeline infrastructure at Paranal provides an environment where the pipeline recipes are executed automatically. This task includes the recognition of the type of raw frames (an input data file with classification information), assignment of the appropriate reduction recipe, selection of the appropriate reference data and the execution of the reduction steps. The pipeline infrastructure receives the raw frames from the on-line archive system. It then classifies the incoming frames in accordance with a set of rules.

The MIDI raw data are delivered to the pipeline in the form of several FITS files. These files contain the results of both interferometry as well as the photometry observations, for calibrators and science targets. Since the interferometry data volume is rather large (about 1GB per visibility point) it is delivered in several split FITS files. The procedure for the data reduction involves two stages. In the first stage, when calibration data arrives, the raw undispersed visibilities are calculated from the dispersed-fringe data (Fig. 3). Additionally, the theoretical visibilities are also computed. This is achieved by extracting the necessary parameters from the calibrator database, based on the same list as used by the web-based calibrator selection tool *CalVin*. From the calibrator raw visibilities and the theoretical visibilities, the transfer functions are computed. In the second stage, when the science data is available, the calibrated visibilities are computed by using the above transfer function as well as the raw undispersed science visibilities. At Paranal, the Instrumental Transfer function can only be derived from observations that immediately precede that of the science object. In Garching, the association process can make use of all the calibration data taken during a certain period of time, including calibrations taken after the science observation. It is possible for instance to use either the closest calibrator in time or any other more suitable calibrators.

With MIDI, one had to face the challenge of large data volume (20 GB per night for MIDI) and therefore all efforts have been made to streamline the processing. The pipeline recipes currently make it possible to process one night of data (about 20 GB) in about half an hour. This enables immediate on-line data quality assessment and provides ample time for the off-line data quality control at Garching.

The off-line processing at Garching yields a number of product files providing the visibility results and all the information for the Quality Control. This allows the QC scientist and the PI to quickly assess the quality of the data. All observations are processed with a set of pre-defined parameters, which are a compromise to allow both consistent quality control and science reductions. In some cases, the resulting science products alone (e.g. uncalibrated visibilities with uncertainties) may be sufficient to achieve the overall science objectives. However, it is usually expected that some data re-processing will be necessary to achieve the optimal result.

Data Quality Control

Quality Control (QC) consists mainly of verifying the quality of the data, producing calibration data, and monitoring the instruments on different time scales.

During operation, several types of calibration data are evaluated for the purpose of quality control: technical calibrations such as the determination of the read out noise, the characterisation of the detector linearity, the stability of the reference pixels, the dispersive elements transmission, the wavelength calibration and the determination of the output of the instrument using a known source, and the calibration of the science target using an astronomical calibrator. The technical calibrations are used for the scientific data reduction as well as for the monitoring of the health of the instrument in order to detect any problems (for example transmission degradation of an optical ele-

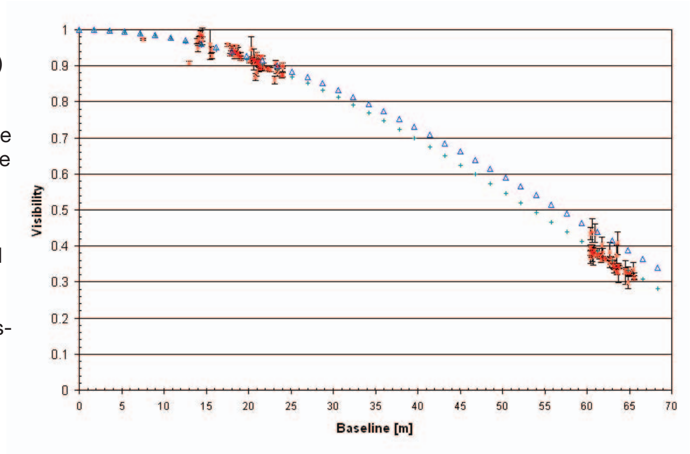

Figure 4: Data obtained on a potential calibrator (α CMa) using the VINCI instrument. The projected baselines range from 7 metres to more than 60 metres. The previously assumed diameter (blue triangles) could be refined using VINCI data (red crosses) and a new diameter (green crosses) could be fitted to the measurements.

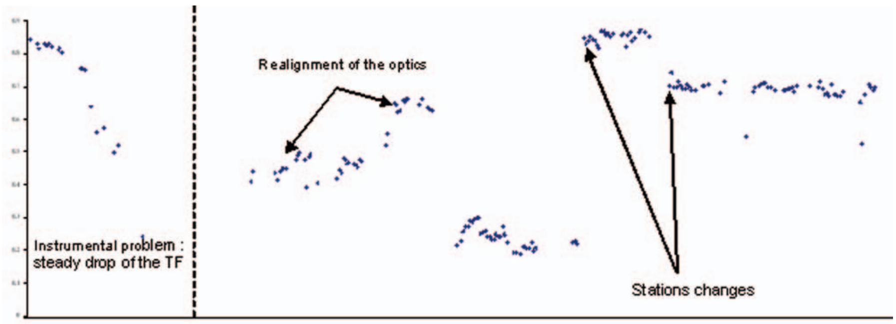

Figure 5: The instrumental transfer function for the commissioning instrument VINCI is shown for selected periods. Each dot represents a night of measurements on selected calibrators. The large jumps illustrate changes in the instrument configuration, while the small variations from one night to the next are due to atmospheric fluctuations.

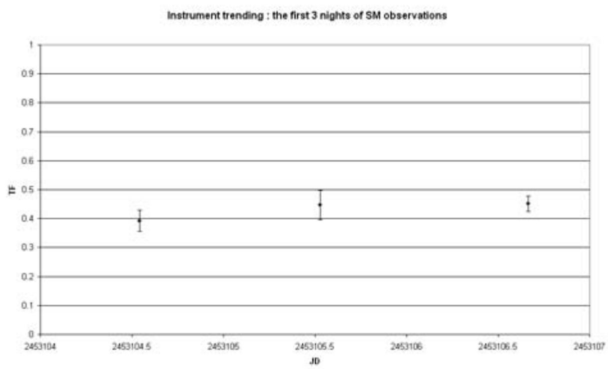

Figure 6: The same bright calibrator was observed each night during the first MIDI Service Mode (SM) run to provide initial trending data. As with VINCI, some of the transfer function (TF) variations are due to atmospheric fluctuations.

ment). More information on Quality Control can be found on www.eso.org/observing/dfo/quality.

Lessons learnt with VINCI

During the 3 years of VINCI operations (since the first fringes in March 2001), we systematically observed potential calibrators. We have been able to monitor these objects and to estimate more accurate diameters (Fig. 4).

We selected the list of potential MIDI calibrators for P73 based on the results from VINCI observations. However, one should recall that since the wavelength of observation with VINCI and MIDI is different, the quality of the calibrator can also change drastically between 2.2 and 10 microns. Fig. 5 shows the instrumental transfer function, covering several different array configurations during VLTI commissioning with the VINCI instrument. Trends of the instrumental transfer function will also be monitored for MIDI.

Quality Control, Instrument Trending and Monitoring

In the case of MIDI, we are still in the process of defining the list of QC parameters which best describes the status of the instrument and the quality of the observations. Using VINCI experience and the data from the first MIDI observations (commissioning and Service Mode observations), we are gaining knowledge about such instrument monitoring. Using calibrator stars from the *CalVin* list provides us with some objects which are observed several nights during each MIDI run. These objects allow us to detect any trends in the instrument and therefore identify any changes or systematic effects. Fig. 6 shows the instrumental transfer function measured over several nights.

Data packages

After each MIDI run, the full data set is processed. A package is created for each completed or terminated run. The data package follows the same structure as the other VLT instruments. We distribute all the raw data associated with the programme (acquisition on both telescopes, raw data on the fringe search, raw data on the fringe track and its associated calibration). Included in the package are the technical calibration data which are used to calibrate the science data. Concerning the astronomical calibrators, we decided to include in each package only the data associated to the astronomical calibrator requested by the PI. If the calibration of the science data requires more than one astronomical calibrator, the PI can request the data for additional calibrator stars from the Garching archive.

We also distribute product data when the data were processed successfully by the pipeline (FITS product, PAF file, and associated log file). If several calibrators were observed during the night we provide the instrumental transfer function measured on the calibrators.

Conclusion

MIDI is now fully integrated into the general science operations scheme of the VLT. Specific tools have been developed, particularly in the area of observation preparation, data quality control and instrument trending to deal with the specific aspects of interferometry. These developments will remain important as the VLTI Auxiliary Telescopes (Koehler et al., 2004) are installed as it will allow users to observe with the VLTI every night throughout the year. The publication of a follow-up *Messenger* article is anticipated, in which the overall VLTI science operations scheme and service mode philosophy will be discussed in more detail.

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Five years of science operations of the VLT on Paranal

The operations statistics of the first five years of VLT science operations are presented and analysed. The difficulties and successes encountered in the organisation and execution of the science operations support tasks are reviewed. The lessons drawn from this experience are discussed.

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Dinner time. One of my table fellows raises his glass of wine: "Cheers!". This would not be a particularly remarkable scene, if we were not in the dining room of Paranal Observatory – a place where consumption of alcoholic drinks is, as a rule, not allowed. Someone else asks me if I know why the Director of the Observatory has made the exception tonight of offering each of the diners one (and only one!) glass of wine. It takes me one second to realise today's date: April 1, 2004. Five years ago, exactly, on the evening of April 1, 1999, at the very same time, instead of enjoying a good Chilean Cabernet Sauvignon with some hearty food, I was sitting at the console of UT1, together with a couple of other early Paranal Science Operations staff members, for the first ever night of actual science operations of the VLT. This was quite an exciting time – almost: fog and clouds all night actually prevented us from even opening the dome! Yet, the night of April 1–2, 1999 would forever be recorded as the first night of science operations of the VLT, and we just celebrated a few weeks ago the fifth anniversary of this achievement. Incidentally, it was not before the night of April 3–4, 1999, that the first general observer data of the VLT could eventually be obtained, since the UT1 dome also had to be kept closed on April 2–3, due to high winds! This anniversary represents a good opportunity to take a look back at what has happened in those five years and to reflect on what we have learned from it. And a lot has happened, indeed! Science operations started in April 1999 with the lone UT1: today all four Unit Telescopes collect scientific data on a nightly basis. The rather simple and conventional instruments FORS-1 and ISAAC, which were originally mounted on UT1, are still there at present, but they have been joined by five more instruments on the other three telescopes. While FORS-2 and UVES remain rather traditional in their functionalities and bear quite a number of similarities with instruments that existed at 4-m class observatories before the VLT era, the last three arrivals, FLAMES, NACO and VIMOS, break new ground in the areas of observational paradigm and efficiency. This is not over, actually: around the corner come MIDI (the first VLTI instrument to be used in full science operations), VISIR and SINFONI (both to be commissioned in 2004), and a little later, AMBER, CRIRES and OMEGACAM (the latter on the VST). The number of service mode runs scheduled for Period 63 (April 1-September 30, 1999) was 84; this number reached 300 in Period 72 (October 1-March 31, 2004). To support this fast growing operation, and in parallel with its development, a huge recruitment and training effort had to be made. During the Science Verification of UT1, in August 1998, the embryonic Paranal Science Operations (PSO) department was composed of Roberto Gilmozzi (who in 1999 moved on to become Director of the Paranal Observatory), myself, and two data handling administrators (José Parra and Blanca Camucet). Nowadays, it counts 56 members (including 13 ESO fellows “on loan” from ESO's Office for Science for their functional duties).

These are but a few numbers, to illustrate where science operation of the VLT on Paranal has come from and where it stands now. What has happened along the way can be better understood by taking a finer look at the operations statistics. From their analysis, complemented by a reflection on the difficulties and successes encountered in the organisation and execution of the science operations support tasks, lessons can be drawn. The results of this exercise are presented in the rest of this article.

What the numbers tell us...

A fundamental feature of the science operations of the VLT is the implementation of two modes of observation: service and visitor. In the traditional Visitor Mode (VM), successful proposers are allocated a number of nights on fixed dates, on which they travel to Paranal to carry out their observations. By contrast, observations for Service Mode (SM) are queued for execution by PSO staff

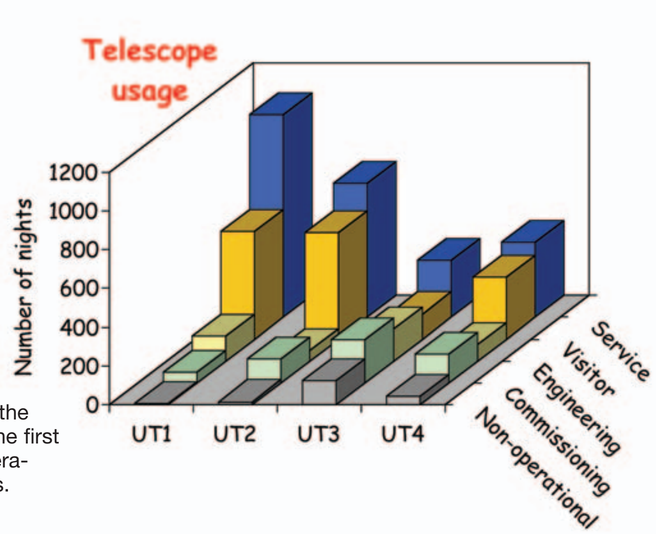

Figure 1: Distribution of the usage of each UT over the first five years of science operations of the VLT, in nights.

whenever the constraints set by the users are fulfilled. When SM was originally considered, it was realised that, in order to achieve the flexibility needed to take full advantage of this mode, it is necessary that a sufficient fraction of the available observing time be devoted to it. Yet, it was unclear whether it would be possible to reach a fraction of 50% of the time assigned to SM, which had been adopted as the target number, and this was a source of concern. Five years later, the challenge has been met beyond the most optimistic expectations, as illustrated in Figure 1. The ratio of the time actually used for SM observing to that devoted to VM, averaged over all four Unit Telescopes over the first five years of science operations, is close to 60/40. The concern nowadays is rather not to let this ratio be tipped even more towards SM, so as to maintain sufficient direct contact between the observatory and its users.

The total time available for execution of scientific observations, or science time, is the sum of the SM and VM nights. For UT1, between April 1, 1999 and April 1, 2004, 1604.5 nights have been dedicated to science, which represents more than 89% of the total number of 1796 nights corresponding to the five year interval from April 1, 1999 to April 1, 2004. The remaining 11% of the time were dedicated to planned technical interventions (labelled as engineering time in Figure 1) and to commissioning of new systems. Engineering time has primarily been spent on preventive maintenance activities, which are scheduled at regular intervals, and include mirror recoatings, which take place every 18 months. The ratio of science time to total time over the first four years of operations of UT2 is similar to UT1, 87%. By contrast, when UT3 and UT4 went into operations, they were equipped with a single instrument (FORS-1 and FORS-2, respectively), whose use made sense (almost) only in dark time periods. To this day, this is still the case for UT3, where the only instrument in operations is VIMOS. Therefore the fraction of the total time that could be devoted to the execution of scientific programmes was limited on these telescopes by the Moon phase, and hence is considerably lower than on UT1 and UT2. Paranal Observatory optimised the use of this time by concentrating on UT3 and UT4 commissioning and planned technical activities that could be carried out indifferently on any telescope. One can accordingly see in Figure 1 that the total numbers of commissioning and engineering nights on UT3 and UT4 are larger than on UT1 and UT2, although UT3 and UT4 have come into operations after UT1 and UT2. This left only a limited number of (bright time) nights when no useful technical or commissioning activities could be scheduled: these nights appear as non-operational time in the figure. The very small number of such nights that

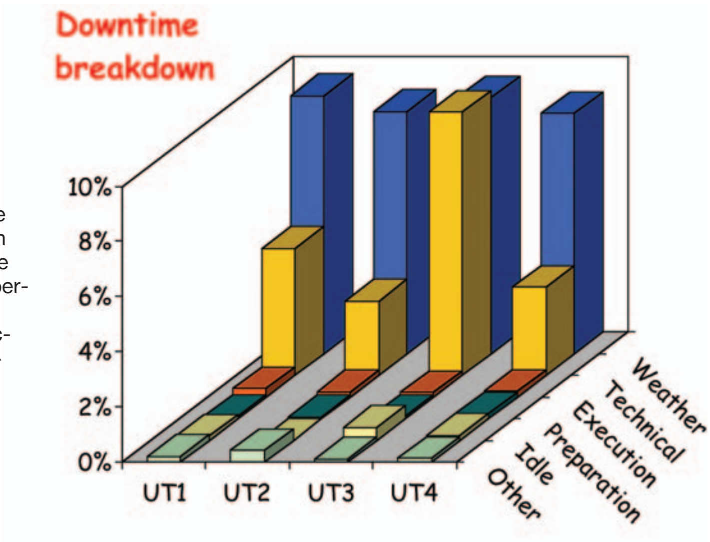

Figure 2: Downtime distribution for each UT over the first five years of science operations of the VLT, expressed as a fraction of the total science time.

also appear for UT1 and UT2 (less than 1% of the total number of nights since beginning of operations) mostly results from a higher than expected rate of completion of SM observations, a lower than planned need for time for maintenance activities, delays in the readiness of new instruments to be commissioned, and low demand of the astronomical commmunity for observations in specific right ascencion ranges. Such deficiencies in the scheduling process only appeared in the first periods of operations and they have since been corrected: there has been no non-operational time on either UT1 or UT2 since Period 68.

Of course, some unforeseen events occasionally hamper observation, such as bad weather or equipment failure. The resulting downtime is summarised in Figure 2. Bad weather is the primary source of loss of observation time, with losses averaging 9% of the science time. Leaving out UT3, downtime due to technical failures is of the order of 3.5%. The technical downtime number for UT3 is significantly higher than for the other telesccopes, mostly due to the difficulties encountered with VIMOS in the first months of its operations (see D'Odorico et al. 2003) and to a failure of the coating plant during the last re-coating of the primary and tertiary mirrors of UT3. Over its first five years of operations, the fraction of the time during which UT1 was not available for scientific observations for technical reasons (either because of planned engineering and commissioning activities or because of troubleshooting of technical problems) was less than 15%; a similar number applies to the first four years of science operations of UT2. Accounting also for weather downtime, both UT1 and UT2 were actually used for observing 76% of the time since their operations started. Downtime due to do other reasons is much smaller, less than 1% of the science time for all telesccopes. It includes execution downtime (due to operator errors during the observations), preparation downtime (resulting from mistakes in the preparation of the observation blocks by the users), and idle time (lack of executable observation blocks in the SM queues, reflecting deficiencies in the processes of telescope time allocation and long-term scheduling).

Of all the VLT instruments, the one that so far has been most used is ISAAC, with a grand total of 1070 nights of usage over the first five years of VLT operations (see Figure 3). It is followed by UVES, which has just overtaken FORS-1 in spite of totalling one year less in operations. Not surprisingly, the four instruments that have been most used until now are those that have been in operations for the longest time, that is the four instruments that were originally mounted on UT1 and UT2: ISAAC, UVES and the two FORS instruments. For these instruments, the usage number includes, in addition to the science time, the technical time that was specifically devoted to the instrument (e.g. to characterise its performance, to test new observation templates, to check its functionality after a technical intervention, etc.). For FLAMES, NACO, and VIMOS, which were commissioned on telescopes already in operation, the commissioning time also contributes to the usage statistics. Commissioning nights (including Science Demonstration Time) represent the major fraction of the VLTI entry in Figure 3 (which refers only to nights when interferometry was carried out with the Unit Telescopes - the far more numerous nights of siderostat use do not appear). A small amount of science time also contributes to the VLTI usage number, corresponding to MIDI Guaranteed Time Observations. The meaning of "No operations" is the same as in Figure 1, while "No instrument" refers to technical or commissioning time dedicated to work on the telescope itself: establishment of pointing models, calibration of adaptive optics system, various performance tests (such as tracking accuracy, etc.) and, of course, mirror recoatings. Finally, a very small number of nights were dedicated to a guest instrument on UT2 (SPIFFI, commissioned and used for science observations) and to preparatory work for the Laser Guide Star Facility (LGSF) on UT4.

Of course, mere statistics of usage of telescope time only give an incomplete picture of the value of VLT operations for their ultimate goal, that is, to maximise the scientific return of the VLT. In order to complement this picture, the opinions of the users represent an important element. At the end of their observing runs, visiting astronomers are requested to complete a questionaire, in which they rate various aspects of the support given by the Observatory and are invited to write the comments that they judge relevant. Over the first five years of operations, 357 end-of-run reports have been received: about 50% of the users return such reports. Their feedback is summarised in Figure 4.

More than 75% of the users report that they have completed at least 75% of their planned programme. Also, with the exception of the computing facilities (to which I shall come back below) the various aspects of the support given by the observatory that are considered in the questionnaire are rated "good" or "excellent" by more than 75% of the users. The work of the support astronomers and of the telescope operators is particularly appreciated, with almost 97% of the top two qualifications. The only reason why the technical support does not receive the same positive appraisal is that a significant fraction of the users consider its evaluation as "not applicable" (N/A): they had no need for it because they encountered no technical problem. This, of course, can also be interpreted as a high level of satisfaction, so that if the "not applicable" answers are added to the "good" and "excellent" ones, the fraction of the visiting astronomers who judge the technical support better than just acceptable reaches almost 99%. It is particularly pleasing that the perceived quality of the support work of the Paranal staff is significantly better than that of the food and lodging at the guest house, which is always very popular with visiting astronomers! It will be a great challenge to keep the level of satisfaction at the same height in the coming years, but we definitely intend to try to do so!

The more mitigated opinion of the users about the computing facilities on Paranal – "only" between 50 and 65% of "good" to "excellent" ratings appears to result from a rather complex conjunction of various factors. The on-line pipeline gets the highest number of N/A answers of all the items considered in the questionnaire. This generally arises when an on-line pipeline is not available (yet) for the instrument mode used by the visiting astronomer. However a fraction of visiting astronomers react to the lack of such a pipeline for a given observing mode by giving a rating of "poor". One should not be surprised that on-line pipeline reduction is not available for a significant fraction of VM runs: such pipelines are prioritarily developed for relatively standard observation modes, which are well suited to SM, while observations of a more experimental nature, which lend themselves poorly to automated data processing, tend also to require the presence of a visiting astronomer at the telescope. If one discards the N/A answers, one finds that "good" and "excellent" ratings account for 71% of the remaining answers. This represents a lower limit of the appreciation of the performance of the existing on-line pipelines, which brings them into the same ballpark as other items on which users are invited to give their opinion. On the other hand, for the offline workstation on which the users can process their data at the telescope as well as for the Linux PCs where they can prepare the observing run in the Paranal residence, a similar trend has surfaced in the past couple of years: namely, the number of N/A answers in the end-of-run reports is increasing. This reflects the fact that a growing number of users come to Paranal with their laptop computers, on which they carry out both observation block preparation and data reduction, not a deficiency of the service provided by the Observatory. Accordingly, it is justified to ignore the N/A answers to obtain the "true" image of the evaluation of the computing facilities put at the disposal of the visiting astronomers. This raises the fraction of "good" and "excellent" to, respectively, 74% and 67% for the offline workstations and the residence computers. For the latter, another factor has to be considered. Until the middle of Period 68, the visitors office was in the old camp, in a container, where the conditions were far from ideal for computers. Accordingly, it made little sense to invest in high-performance computing equipment, which would very quickly be damaged and rendered useless. In January 2002, the visitors offices were moved to their definitive location in the residence, and were equipped with state-of-the-art Linux PCs fully configured with all the major observation preparation and reduction tools. From that moment, the level of satisfaction expressed in the end-of-run reports increased considerably. Finally, a number of users appear to be disconcerted by the HP-UX operating system of the offline workstations of the control room, which was originally adopted for consistency with the computers that control the telescopes and instruments. However, few institutes in ESO member states use this operating system, and the improvement of performance of the ever more popular Linux machines in the past few years makes them an increasingly appealing alternative in the users' view. Use of this alternative for replacement of the current offline machines is under study.

The generally positive feedback of the visiting astronomers is mirrored by that of the SM users, which has been analysed in detail in a previous issue of *The Messenger* (Comerón et al. 2003).

...AND WHAT THEY DON'T

There is more to VLT science operations of the VLT on Paranal than just statistics. Efficient and smooth operations involve a wide range of aspects that cannot be reduced to dry numbers.

The popularity of SM observing with users, reflected by the fact that the number of SM nights exceeds by 50% that of VM nights, is a testimony to the success of SM operations. The latter, though, would not be achieved without a close-knit collaboration between PSO and the Garching based Users' Support Group (USG). I am pleased to stress here the excellent interaction that has been built between these two operations teams located 13,000 kilometers apart. One of its most concrete manifestations has been the implementation, since August 2002, of the so-called "Short-Medium Term Schedules" (SMTS). On a day-to-day basis, these (restricted access) Web pages provide the PSO astronomers with an up-to-date vision of the status of the SM queues, with

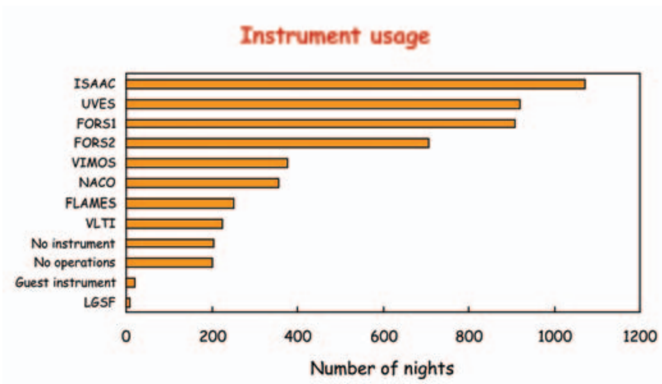

Figure 3: Usage of the various VLT instruments over the first five years of science operations of the VLT, in nights.

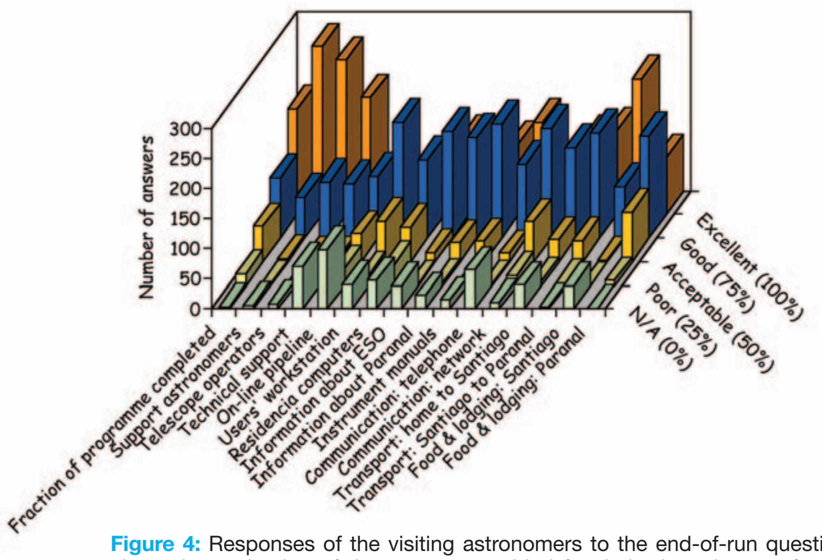

Figure 4: Responses of the visiting astronomers to the end-of-run questionnaire about the evaluation of the support provided for their observing run (qualitative marks) and the completed fraction of their intended programme (percentages in parentheses, applying only to first abscissa bin).

emphasis on the most critical aspects of the observations to be executed – stressing in particular the time-critical character of some of them. This tool, which has been developed as the result of a narrow interaction between USG and PSO, is instrumental for the optimisation of the real-time (or short-term) scheduling (STS) of SM observations. Proper handling of the latter, in turn, is the key to ensuring a high completion rate of the highest ranked runs. It can be noted that PSO night-time astronomers cannot rely on a computerised scheduling tool for STS decisions: in order for them to make such decisions "manually" in an adequate manner, it is essential that priorities are well defined and unambiguously communicated. What is also essential to ensure that high priority runs are completed is to avoid local oversubscriptions in the multi-dimensional parameter space (target location, sky transparency, seeing, lunar illumination) at the stage of creation of the SM queues. This has been described in detail in a previous *Messenger* article (Silva 2001). By contrast, the opposite effect, local undersubscription, may on occasion result in a lack of executable observation blocks in SM nights, leading to a telescope being left idle. It is now the reponsibility of the Visiting Astronomer Section (VISAS) to make sure that local over- and undersubscriptions are, as far as foreseeable, not built into the allocation of telescope time. Reaching this balance is not trivial, and some unfortunate experiences in the first few periods of science operations of the VLT taught us the hard way what had to be avoided. It must be put to the credit of USG (originally) and VISAS (more recently) that the number of deficiencies encountered in this area is now quite small.

Experience shows that the flexibility of observation scheduling in SM effectively allows the scientific return to be optimised and the technical downtime to be minimised, by switching during the night between the instruments mounted on the various foci of a given UT. The overheads involved in this operation prove to be small (of the order of a few minutes). By contrast, the benefits of a well-timed instrument switch for the scientific outcome of a night can be quite substantial. This is of course the case when one of the instruments undergoes a technical failure that requires time-consuming troubleshooting work. But more generally, instrument switches can also (and do regularly) happen to take the best advantage of the evolution of the observing conditions. This is especially beneficial for an instrument such as NACO, whose performance depends critically on environmental conditions (e.g. long correlation time of the turbulence) that are rather infrequently met and may be variable on short timescales. Such flexibility is quite demanding on the support staff, as it requires PSO astronomers to be cross-trained so as to be able to support the various instruments mounted on a given telescope. This challenging undertaking is well underway. But the understanding of flexible scheduling at Paranal Observatory goes beyond the alternation between instruments during a scheduled SM night. While some technical nights appear on fixed dates in the long-term schedule, in practice, planned night-time technical tests are to the extent possible executed during periods when the environmental conditions are not optimal for execution of SM observations and/or when the pressure in the SM queues is comparatively low. Also, on occasion, when delays in the arrival on Paranal of new instruments forced the observatory to cancel scheduled commissioning activities, the corresponding time was returned to science operations (primarily in SM). Several users benefitted from this as their programmes were belatedly allocated time that had been denied to them as part of the original time distribution. However this requires that the OPC ranking and comments are made in such a way as to allow additional runs, below the formal cutoff line, to be allocated time in the course of a period.

A couple of additional points about the VLT SM operations experience are worth noting. On the one hand, we have found that a clear definition of the respective priorities of the various Target of Opportunity (ToO) programmes approved by the OPC for execution on the same UT is needed. Even though the probability that conflicting triggers for execution of two different ToO observations with the same telescope at the same time can *a priori* seem negligibly small, in practice this has happened several times during the first five years of operations of the VLT! One can easily understand why the resolution of such cases in real time, when a delayed decision may result in missing the observation of a unique event of transitory nature, is far from ideal. On the other hand, we have learned (sometimes the hard way...) that allowing exceptions to the SM rules and handling observation blocks in a non-standard manner often turns out to be very time-consuming and error prone. This may (and does on occasion) ultimately prove counterproductive. Therefore requests from users to deviate from the established procedures cannot always be granted. This is not done lightly, but only after careful assessment of the balance between the gain that the considered exception can bring (to the single run of interest) and its possible negative impact (not only on this very run, but also overall, on all SM runs).

One feature of the organisation of the science operations support that is probably unique to the VLT is that, for each UT, a Paranal staff astronomer is present all night long to help the visiting astronomer throughout the whole run. This appears to be greatly appreciated by the users. The benefits of this operations scheme are especially significant for short VM runs, which makes it particularly appropriate to the current Paranal situation, where the average VM run length over the last 5 years has been below 2 days. Users have been encouraged, or even urged, by ESO to consider longer runs, without success. Short runs not only represent an additional burden for support astronomers, in particular by increasing the number of introductions to be given and by resulting in the simultaneous presence of more visiting astronomers on Paranal, all of whom have to be attended. They also put a significant stress on the logistic aspects, in particular the accommodation. Indeed room demand almost permanently exceeds the Paranal residence capacity, due in great part to the succession of visits of teams integrating and commissioning systems still to be put into operations. To make matters worse, both from the support and from the logistics points of view, runs consisting of half nights (or other fractions of nights) are becoming increasingly frequent. Nights shared between two (or more!) VM runs, or between a VM run and a SM part, are no longer exceptions. Besides the already mentioned crowding inconveniences, another consequence that should be pointed out is the increase of complexity and the accompanying decrease of flexibility of the SM STS process when only fractions of nights are available for SM operations. Finally, while shortage of accommodation is one of the reasons why it is not always possible to authorise the presence of two visiting astronomers for a single run, it is also worth noting that, with the highly automated VLT observation process and the support of a dedicated Paranal astronomer all night long, the presence of two observers during a VM run is effective only in a limited fraction of cases. For the same reasons, the value of a VLT run for the training of young astronomers in observations is often quite limited.

The staffing challenge

Beyond the numbers and the procedures, the successes and the difficulties, science operation of the VLT on Paranal is the work of a group of people. This group did not exist on April 1, 1998. Six years later, it counts 56 members. Taking into account staff turnover (some of the group members went to continue their career elsewhere, either inside or outside ESO), an average of more than twelve members of the PSO department were recruited each year for the last six years! All of them had to be integrated in the group, and to be trained: this represents a huge effort. That this could be achieved in such a way that, in spite of some deficiencies, science operations of the VLT have overall been successful, is a testimony probably more to the enthusiasm, motivation, dedication and competence of the people who joined the group than to particularly brilliant planning or organisation of the growth of the department. Planning, as a matter of fact, was made close to impossible by the difficulties met in the recruitment process, at least for the staff astronomers. Indeed after the first few staff astronomers had been hired, the response to subsequent vacancy notices was very low. Candidates were few and their qualification and experience level was often significantly below what had so far come to be expected for ESO staff astronomers. It just appeared that the limits of the market had been reached, that the large number of positions that had been opened in a very short time had absorbed all the astronomers in the community who fulfilled the requirements and were willing to work as operations support astronomers in a forefront but remote observatory. The shortage of candidates applying for positions of operations support staff astronomers on Paranal persists to this date (admittedly somewhat less extreme than a couple of years ago). While it is tempting to conclude that it would have been desirable to start recruiting PSO astronomers longer before the start of science operations, the persistent shortage of applicants for these positions leads one to question whether it would have been reasonably possible to start early enough to avoid the problem completely. As a consequence of the recruitment delays resulting from the shortage of suitable candidates, the PSO department was understaffed for four years. In order to reach a viable minimum staffing level, the recruitment requirements had to be lowered. The high level of enthusiasm and motivation of the more junior staff recruited under these conditions could not completely compensate for their lack of experience. Accordingly, a considerable training effort was required. This added to the demands put on the insufficient number of experienced PSO astronomers, some of whom started to show signs of wear. The combination of the predominence of junior astronomical staff in the department, with the excessive workload already assigned to its most experienced members, impedes the implementation of an intermediate managerial structure between the head of the department and the bulk of its members. Nevertheless, the recruitment difficulties that have been faced have also had some positive consequences. Most prominently, it gave the ESO Chile postdoctoral fellows the chance to grow into full operations support astronomers. This is beneficial both for the fellows, opening for them a career opportunity at the observatory earlier than would normally have been expected in the past, and for the observatory, since the training effort required to bring former fellows to the level of staff astronomers is considerably less than for external recruitees at the same stage of their career. It must be stressed however that, to be appointed as staff astronomers, ESO fellows have to go through the same open recruitment process as all other applicants, and they have to convince the selection board at that stage that they are effectively the best candidates for the considered positions. Note also that the use of ESO fellowships to develop operations support astronomer qualifications in young people is critical for the VLTI, since the very small community of astronomers with experience of optical interferometry does not represent a sufficient recruitment pool.

Fellows who move up to staff astronomer positions will eventually acquire sufficient experience to take up more senior responsibilities in the PSO department. However, for the time being, the additional experience that would be most valuable can only come out of the community. I can but encourage and urge our relatively senior readers to give more consideration to job opportunities that open on Paranal. In particular, one option that seems to have received little attention so far, is that of a limited-term contract as part of which an astronomer from some institution in Europe is either seconded to ESO or granted an extended leave of absence, so as to come and work in the PSO department for a few years, before going back to his/her original place. The continued success of the science operations of the VLT depends on the support of the community. In return astronomers who come to Paranal for a few years get a unique opportunity to further develop their expertise and experience, which upon their return to their original institution they can share with the astronomical community of their country. And the experience of working at Paranal Observatory, to keep the results of the operations at the same level as, or better than, described in this article, is without any doubt an exciting and very challenging one!

Acknowledgments

The support of the science operations of the VLT is a team work, and none of the achievements reported in this article could have been made without the participation of many people. First and above all, I wish to express my gratitude to all the past and present members of the PSO department, who night after night, and day after day, have worked and are working relentlessly to ensure the success of VLT science operations. Unfortunately they are too numerous for their names to be all listed here. The role of the Garching based Users' Support and Data Flow Operations groups in ensuring front and back end contacts with the SM users, in delivering timely and accurate information to PSO, and in monitoring the health of the instruments and checking the quality of the data that were obtained is essential to the success of the operations. I want particularly to thank their present and past leaders, F. Comerón, D. Silva, and B. Leibundgut, for the fruitful interactions that we have have had along the years towards building a close and reliable collaboration between these groups and PSO. Finally, I am deeply indebted to the Director of Paranal Observatory, Roberto Gilmozzi, for giving me the chance to run the science operations of what is, in my opinion, the world's foremost and best ground-based optical astronomical observatory.

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Th'ESObservatoire: merging La Silla and Paranal Observatories

Roberto Gilmozzi and Jorge Melnick (ESO)

The scientific role of La Silla beyond 2006 was assessed by a working group composed of members of the STC, of the UC and of ESO, and chaired by Andrea Cimatti. Their "*La Silla 2006+*" report is available through the ESO web (www.eso.org). The main conclusion of the report is that "*…. the La Silla observatory will still be a crucial component of the ESO facilities and will be a fundamental ESO component to perform world-class scientific research for European astronomers*". The report recommends that La Silla continues to operate beyond 2006 with only two telescopes: the NTT and the 3.6m.

The working group also examined the scientific productivity of La Silla in terms of publications and citations (these data are available in the report). Figure 1 presents a comparison of the productivity of La Silla with other major observatories compiled by Uta Grothkopf. La Silla is seen to be one of

Table 1: Operational costs of telescopes in the OPTICON/FP6 proposal

Installation	Telescope name	Country	Cost in Euros	Per
3.9m Tel	AAT	UK	7331	Night
3.5m Tel	CAHA 3.5m	D	7796	Night
2.2m Tel	CAHA 2.2m	D	2925	Night
3.6m Tel	CFHT	F	13895	Night
3.6m Tel	ESO-3.6	INT	6631	Night
3.5m Tel	ESO-NTT	INT	7296	Night
2.2m Tel	ESO/MPG-2.2	INT	2654	Night
4.2m Tel	WHT	UK	10727	Night
2.5m Tel	INT	UK	1999	Night
3.8m Tel	UKIRT	UK	926	Hour
3.5m Tel	TNG	I	7326	Night
2.5m Tel	NOT	INT	3745	Night
2.5m Tel	Aristarchos	Gr	1973	Night

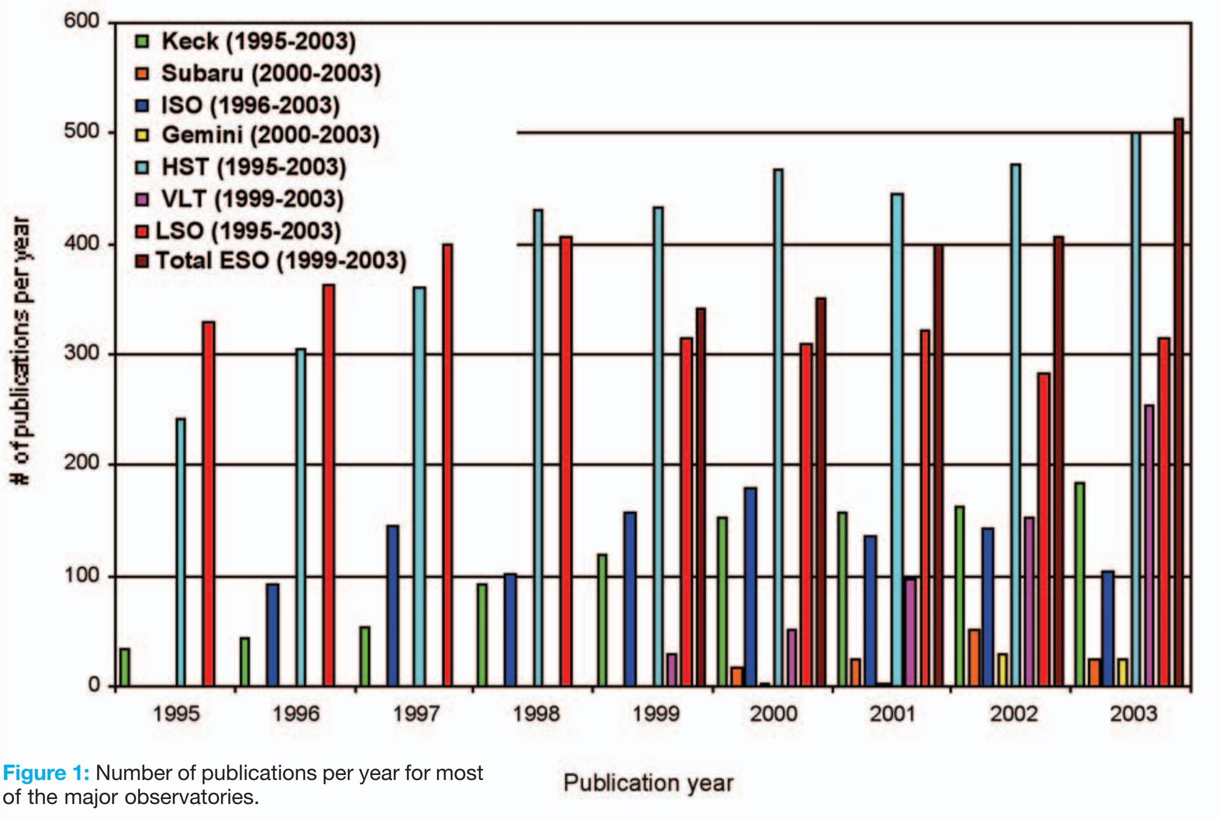

Figure 1: Number of publications per year for most of the major observatories.

YEAR	Telescopes operated by ESO	Number of Instruments (*)	National Projects (**)
1995	10	27	50cm Dan, 60cm Bochum, 35cm Marseille, DENIS, IRIS, 72cm Swiss
1996	10	24	50cm Dan, 60cm Bochum, 35cm Marseille, DENIS, IRIS. 72cm Swiss, MARLY, Brazil
1997	10	19	50cm Dan, 60cm Bochum, 35cm Marseille, DENIS, IRIS, 72cm Swiss, 1.2m Swiss, MARLY, Brazil
1998	8	18	50cm Dan, 60cm Bochum, 35cm Marseille, DENIS, IRIS, 1.2m Swiss, MARLY, Brazil
1999	6	17	50cm Dan, 35cm Marseille, DENIS, IRIS, 1.2m Swiss, Brazil
2000	6	14	50cm Dan, DENIS, IRIS, 1.2m Swiss, MARLY, Brazil
2001	6	13	50cm Dan, DENIS, IRIS, 1.2m Swiss, MARLY, Brazil
2002	6	14	50cm Dan, 1.2m Swiss, IRIS, MARLY, Brazil
2003	4 (3)	9	50cm Dan, 1.2m Swiss, REM, 1.54m Dan, Tarot II?
2006+	2	6	1.2m Swiss, REM, Tarot II, ILMT?, 2.2m?

Table 2: Evolution of La Silla facilities since 1995

(*) The March-September period was used when numbers varied within a year.
(**) The IRIS and Marseille agreements are still valid, but have operated only until the dates shown.

the most productive ground-based observatories in the world, and was only surpassed in publications by HST after 1997.

La Silla is also very cost effective. Table 1 presents a compilation of operating costs for all major European observatories. The data was gathered as part of the EC/FP6 OPTICON Access program (www.otri.iac.es/opticon). According to the EC definition, direct costs do not include items like instrument development, renewal of equipment (e.g. computers), etc. Therefore, although there are differences in the way the direct costs are computed by each observatory, the figures in Table 1 are directly comparable.

A rather surprising result of this comparison is that, while the operations models of the different observatories vary widely, the operations costs are remarkably similar (not counting the Hawaii telescopes).

So, whether an observatory operates with large numbers of staff permanently on the mountaintop, or with most of the technical staff located off the mountain, the cost of producing high quality data is roughly constant. Taking the numbers at face value, La Silla comes out as one of the most cost effective European observatories.

Optimizing costs

The LS2006+ working group also asked ESO to look for ways of optimizing the operation of La Silla in order to further reduce costs. Thus, the ESO management examined a number of different scenarios to estimate 2006+ operating costs. To set the results into perspective, it is useful to examine the evolution of La Silla both in terms of facilities and costs over the past decade. Table 2 presents the evolution of facilities operated by ESO and also by "National" consortia. Figure 2 presents the corresponding evolution in cost (past and projected future). The result is that going from four telescopes to only two does not lead to a factor of two reduction in cost. There are fixed costs – one third of the La Silla budget goes into maintaining the infrastructure. All the studied scenarios showed that it is impossible to reduce the costs of La Silla below a certain limit without seriously compromising the quality of the product. In fact, we can predict this limit from the OPTICON table: two telescopes times 330 nights times 7 k = 4.6 M .

The most cost effective scenario was found to be the one in which La Silla and Paranal are merged into a single observatory. By sharing highly qualified staff, and realizing all the potential synergies between the two observatories, the projected cost of running La Silla comes out very close to the OPTICON limit.

Thus, LS2006+ recommended that ESO investigate the possibility of merging the two observatories. The plan was studied during 2003, and the outcome is presented below.

A Merged La Silla and Paranal observatory

All relevant departments of the two observatories held consultations and discussions that resulted in joint proposals that underlie the merger plan. The plan is based on merging the individual groups within the observato-

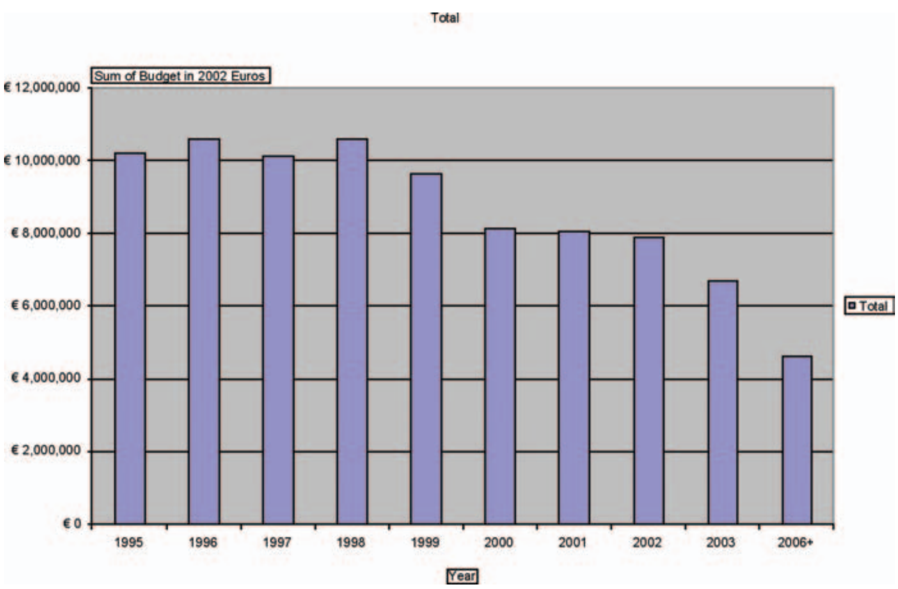

Figure 2: Evolution of La Silla costs since 1995

Table 3: Merger implementation

Stage 1	Stage 2	Stage 3	Stage 4
Merge electronics	Merge the software groups	Separate Power generation and distribution to 10kV (outsourcing option)	Merge Instrumentation
Merge mechanics	Communications on La Silla move to IT La Silla	Separate Electrical from Electronics on Paranal	Merge Optics
Create Instrumentation on La Silla	Create Maintenance team on La Silla	Merge Maintenance	Merge Logistics
Separate IT from software at La Silla		Possible upgrade of La Silla Paranal WAN bandwidth	

ries to a more matrix like structure rather than a La Silla department of Paranal observatory (this option did not arise within the low level technical discussions amongst the staff and was therefore not explored although it remains a viable option).

The current operational paradigms differ dramatically between the two observatories with La Silla mostly a stable operation supporting visitors and Paranal a growing observatory performing a significant fraction of service observing. We believe that this diversity is to the benefit of our users and the staff and therefore the Science Operations departments will not be merged, at least initially. Being a well-established and robust scientifically successful operation, La Silla provides the ideal conditions to explore innovative ways of carrying out science operations.

Additional benefits of the merger are identified in the training value, both for ESO staff and for future observational astronomers, and in possible long-term savings. The La Silla workshop will continue producing parts, and spare parts, for Paranal. La Silla support of Paranal's peak load activities will also continue. Moreover, La Silla will continue to provide the community with the infrastructure and support to deploy new instruments without the constraints of Paranal. An excellent example of such a project is the 3.6m/HARPS combination.

Merger implementation

The following phases are foreseen (see Table 3). They are broken down according to the sequence in which they would occur.

As they merge, groups report to the Heads of Department on Paranal (with the exclusion of the La Silla Science Operations department). After each stage, an assessment of the process will take place and modifications or improvements introduced if necessary. Th'ESObservatoire will, of course, have a single director.

Coda: is it possible to break the cost barrier?

La Silla has introduced two innovations (at least for medium size observatories) that should allow reduced costs and increased efficiency. The first is to control all (ESO operated) telescopes from a common Paranal-like control center. The new control *zentrum* (the RITZ) provides the environment required to optimize the time and expertise of the operations staff.

The second innovation is to implement a formal quality management system for continuous improvement. La Silla is probably the first observatory in the world to obtain an ISO9001:2000 certification. This process should allow us to optimize the use of resources.

The LS2006+ working group recommended that ESO should investigate ways of keeping the 2.2m telescope in operation without increasing the global cost of La Silla. With the innovations above, we believe we will be able to continue to offer FEROS to the community (if demanded) for part of the time. The complete telescope (with FEROS, WFI, and GROND) could be offered the rest of the time to groups interested in long term targeted programs (in a cost neutral way to ESO).

General view of the Paranal Observatory Platform with six domes (from left to right): ANTU, KUEYEN, MELIPAL, AT1, VLT Survey Telescope (still to be installed) and YEPUN. Some of the positions for the Auxiliary Telescopes and the railway tracks on which they move are seen in the foreground (*ESO PR Photo 02d/04*).

Do it yourself: La Silla quick-look tools

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During astronomical observations it has always been of great importance to be able to asses the quality of the data being collected at the telescope and the conditions of the night. The way astronomers normally do this is by processing the raw data transmitted from the instrument workstation with some semi-automated software package. The data reduction normally depends on the instrument characteristics, but basically the main divisions are set by the wavelength range covered (optical, infrared, sub-millimetric, radio) and by the way the light is collected (imaging or spectroscopy).

The codes are normally written either by dedicated software engineers, or by the astronomer him(her)self: the first case applies for all Paranal instruments and for some instruments at La Silla, namely FEROS, HARPS and TIMMI2, for which pipelines were written by the consortium that originally built the instrument.

The astronomical community felt that the remaining instruments at La Silla could also benefit from having similar tools. Although the Observatory does not have the resources to develop such extensive software, simple and targeted tools were implemented for the other instruments, in order to perform some specific steps of the data reduction quickly and with almost no interaction from the user, allowing the observer to assess the quality of the data in real time without diverting their attention from the observations. Given their simple structure it was decided to name these codes *quick-look tools*, rather than pipelines, in order to stress the difference from more complete reduction software.

With the exception of the tool developed for CES, which runs automatically as new frames are acquired, these quick-look scripts must be launched by the observer on a selected frame (or set of frames), and may require human interaction. A database of calibrations for most of the standards observing modes has been built (or is in the process of being completed) by the Instrument Scientist for each instrument, with the help of his/her colleagues: the users can choose to use this or to run the tool using the calibrations taken during the same observing run. Master calibration frames can be created in real time by ancillary scripts.

This note briefly describes the quick-look tools now available at La Silla and developed by resident astronomers for optical (CES, EFOSC2, EMMI, SUSI2, WFI) and infrared instruments (SofI), both for imaging and spectroscopic capabilities. All tools are installed on the off-line workstations used by the visitors and also available for download on the respective instrument web pages.

Optical instruments: CES, EFOSC2, EMMI, SUSI2, WFI

The CES (Coudé Echelle Spectrograph) is a very high resolution (R~220,000) spectrograph mounted at the 3.6m telescope: given its unique characteristics, it required a dedicated quick-look tool to examine the data. EMMI (the ESO Multi Mode Instrument) and EFOSC2 (the ESO Faint Object Spectrograph and Camera 2) are both imager and spectrographs at low resolution, while EMMI also has medium (R~5,000) and high (up to 70,000) resolution modes. In addition to this, EMMI has the additional complication of having two detectors, one optimized for the blue and another for the red. SUSI2 (SUperb Seeing Imager 2) and WFI (Wide Field Camera) are imaging cameras, the first optimized for high spatial resolution, while the second was optimized to cover a large field of view (30′). In total, five quick look packages were developed, four for spectroscopy and one for imaging.

For imaging, a specific package is available to obtain a complete photometric calibration of the images on the Landolt system for all La Silla optical instruments with imaging capability – EFOSC2, EMMI, SUSI2, WFI (see http://www.sc.eso.org/~ohainaut/bin/tmag.cgi).

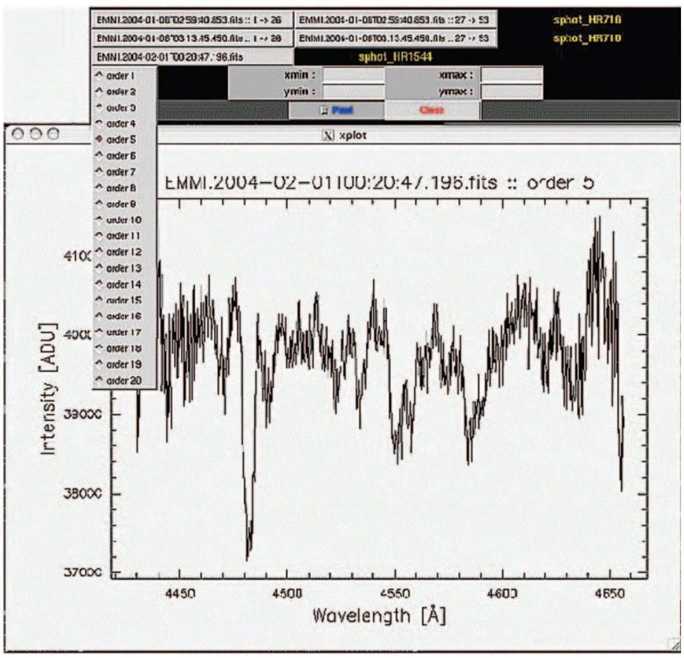

Figure 1: Visualization of one order of an echelle spectrum reduced by the EMMI echelle quick-look. The order is bias subtracted, flat fielded, de-blazed and dressed up for the occasion.

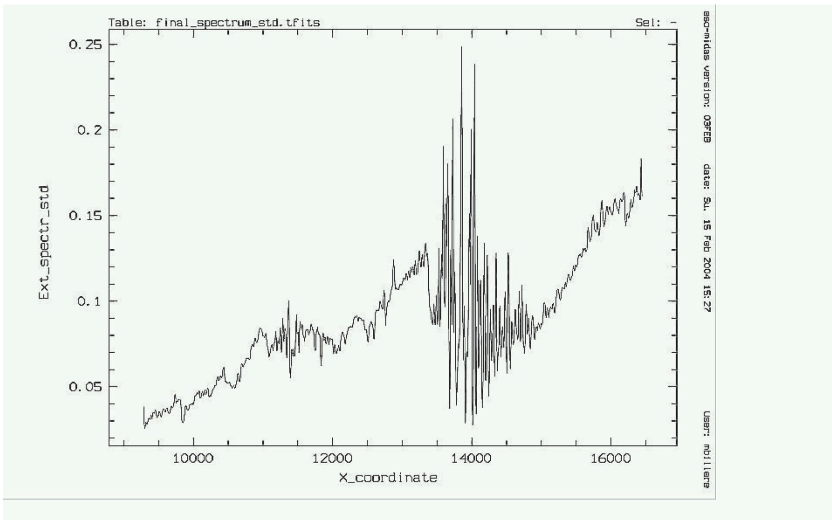

Figure 2 : Example of red spectrum obtained with the quick-tool. The science object is divided by a standard star. The region around 14,000 Å cannot be perfectly corrected due to the presence of an absorption band of the atmosphere.

For spectroscopy, several packages have been developed:

(1) for the CES, a quick-look tool for data quality and signal-to-noise evaluation. The output is a one dimensional spectrum, plotted in term of S/N ratio *vs.* pixel (see http://www.ls.eso.org/lasilla/sciops/3p6/ces/).

(2) for EMMI, a low and medium dispersion spectroscopy quick-look tool is available: it is possible to obtain good quality data with fine tuning of the parameters of the script and master calibrations derived during the observing run. The output is a bias corrected, flat-fielded, sky subtracted and wavelength calibrated one dimensional spectrum (see http://www.ls.eso.org/lasilla/sciops/ntt/emmi/quickred/EMMI_quickred.html).

(3) for EMMI-echelle spectra, a quick-look tool has been recently completed. The output is a bias corrected, flat-fielded, blaze corrected and wavelength calibrated multi-order or merged one dimensional spectrum (see http://www.ls.eso.org/lasilla/sciops/ntt/emmi/emmiPyQuick.html).

(4) And finally, for EFOSC2, a low dispersion spectroscopy quick-look tool: good quality data with fine tuning of the script and up-to-date calibrations. The output is a bias corrected, flat-fielded, sky subtracted and wavelength calibrated one dimensional spectrum (see http://www.ls.eso.org/lasilla/sciops/efosc/docs/qlook/).

An example of a quick-look reduced EMMI echelle spectra is shown in Fig. 1.

Infrared Instrument: SofI

SofI (short for *Son of Isaac*) is an infrared imager and spectrograph, both at low and high resolution. Two tools were written, one for imaging and another for spectroscopy. The first returns the zero-point of the night, without correction for colour or airmass, provided that standard stars have been observed, while the second returns a flat-fielded, sky subtracted and wavelength calibrated one-dimensional spectrum. Extensive information on how they work and what assumptions are done can be found on the respective tool web page. For imaging, see http://www.ls.eso.org/lasilla/sciops/ntt/sofi/reduction/SOFI_img_quicktool.html and for spectroscopy, see http://www.ls.eso.org/lasilla/sciops/ntt/sofi/reduction/SOFI_spec_quicktool.html. In Fig. 2 we show an example of a quick-look reduced spectrum in the NIR. Both tools make extensive use of the *eclipse* package developed by ESO; more information on it can be found at: http://www.eso.org/projects/aot/eclipse.

Conclusions

All instruments on La Silla Observatory now have a dedicated tool able to return an evaluation of the quality of the data taken by the observers. It should be stressed that, while these tools can certainly be improved, they were not intended to produce publication quality data. Our brief experience with the newly developed tools confirms that they have been very well received by the visiting astronomers.

NEWS FROM THE LA SILLA SITE

L. Germany, SciOps

Staffing Moves

There's been quite a bit of staff movement at La Silla over the last few months. We have had to bid farewell to Rene Mendez, who has now taken up a position at the Universidad de Chile, and Malvina Billeres who will finish off her last 6 months as an ESO fellow doing 100% research in Vitacura. We still have Fernando Selman with us at La Silla, though his official post is actually VST astronomer at Paranal. He will remain with us for the next 6 months or so (depending on the progress of VST), and has taken over responsibilities as head of the Imaging instrument force. We welcome Valentin Ivanov back to ESO Chile, and this time to La Silla. Valentin was a fellow at Paranal, went to Garching for his third year, and now is back in Chile as a staff member in the Infra-red team at La Silla. In particular, he will be instrument scientist of *SofI*, taking over from the wonderful job Malvina has done in recent years. Dominique Naef has also joined us from Switzerland. For the next year he will be working from a Swiss National Foundation grant primarily as a support astronomer for *HARPS*. Lastly, with the departure of Rene, John Pritchard has taken over as leader of the astronomers on La Silla – we wish him well and many happy schedules to come!

More Updated Manuals

In December, we bought you news of many upgrades to documentation (both paper and internet) here on La Silla. The latest addition is the new manual and the complete atlas of Echelle wavelength calibrations for *EMMI*. Both are linked to the main *EMMI* webpage. In addition, we now have a variety of quick-look tools, developed in-house by the La Silla support astronomers, for long-slit spectroscopy (*EMMI, EFOSC2*), *EMMI* Echelle Spectroscopy, *CES* observations, the optical imagers (*WFI, SUSI2, EFOSC2, EMMI*), and both the spectroscopic and imaging modes for SofI. See the full article in this same edition of *The Messenger*.

La Silla - certified!

At the end of March the Quality Management System implemented at La Silla during the past year underwent a thorough audit by SQS (The Swiss Association for Quality and Management System). At the end of the audit La Silla received a certification of compliance with the requirements set by the ISO 9001:2000 standard. La Silla is most likely the first Observatory to achieve this certification. More details to come in the next *Messenger*.

Exploring Cosmic Evolution with the FORS Deep Field

THE FORS INSTRUMENTS AT THE ESO VLT HAVE BEEN USED TO STUDY THE COSMIC EVOLUTION OF GALAXIES. FROM A LARGE SAMPLE OF DISTANT GALAXIES OBSERVED NEAR THE SOUTH GALACTIC POLE WE OBTAINED NEW RESULTS ON THE PHYSICAL PROPERTIES OF HIGH-REDSHIFT GALAXIES, ON THE EVOLUTION OF THE GALAXY LUMINOSITY FUNCTION AND OF THE COSMIC STAR FORMATION RATE, ON THE CHEMICAL ENRICHMENT OF THE UNIVERSE, AND OTHER SIGNPOSTS FOR CHANGES WITH COSMIC TIME.

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THE IDEA OF A "FORS DEEP Field" (FDF) was born in 1997 when scientists at the Heidelberg State Observatory and the University Observatories of Göttingen and München drew up plans for the use of the guaranteed observing time granted to them as a reward for building the two FORS instruments for the ESO VLT. By that time various deep field projects (notably the HDF-N) had already resulted in important new information on the distant universe and its evolution with cosmic age. But the combination of the larger (relative to the HDF) field-of-view of FORS, the excellent optical quality of the VLT, and the superior light collecting power of the VLT combined with the high efficiency of the FORS spectroscopic observing modes promised important new opportunities in this area. Therefore, a significant fraction of the guaranteed FORS observing time was set aside for very deep observations of a carefully selected region of the southern sky corresponding to the field-of-view of FORS in standard resolution mode. A description of the selection criteria, of the objectives of the FDF programme, and of various technical details has been provided in an earlier issue of *The Messenger* (Appenzeller et al., 2000), and thus will not be repeated here. Instead, the present contribution will be devoted to highlights among the scientific results obtained so far from the FDF.

Observing a complete sample of distant galaxies

The FDF programme started in 1999 as soon as the first unit telescope of the VLT became available for scientific work. As a first step we used FORS1 at the VLT unit telescope Antu to obtain deep images of the FDF through five standard broad-band filters (*U, B, g, R*, and *I*) during 1999 and 2000. The broad-band images were later supplemented with narrow-band images taken through selected interference filters. Although observing conditions during the 1999 runs were rather unfavourable and part of the time was lost to poor weather, it was eventually possible to collect more than 300 individual images with a total integration time of about 39 hours. The resulting co-added FORS image for the blue filter band turned out to be nearly as deep as the corresponding HDF-N image, while the visual and the *I*-band images were only about one magnitude less deep than those of the HDF-N. Of course, due to the atmospheric blurring typical of ground-based observations, the FORS images are less sharp than those of the HST deep fields. On the other hand, with (FWHM) angular resolutions ranging between 0.53 arcsec in the *I* and 0.97 arcsec in *U*-band, the resolution of the FDF images compares favourably with other ground-based deep fields. As a result, on our images, which cover a sky area of about seven by seven arcmin (or 1/15 of the area covered by the full moon), more than 10 000 objects are visible, i.e. the same number of objects as in the new (much deeper, but smaller) "HST Ultra Deep Field". Almost all objects are distant galaxies. There are also eight spectroscopically confirmed quasars and more than 50 faint stars. A colour image of the FDF, produced by combining our *B* (blue), *R* (red) and *I* (deep red) monochromatic images is presented in Fig. 1. To make fine details and the fainter objects better visible, an image sharpening procedure (the Lucy-Richardson deconvolution algorithm) and a non-linear flux scale has been applied to the original image. Therefore the image has an effective resolution of about 0.4 arcsec, but a somewhat higher noise level than the original images.

In addition to the FORS frames we obtained near-infrared (*J* and *Ks* bands) images of the FDF using the SofI instrument at the ESO NTT on La Silla. Due to the smaller telescope aperture, these images are much less deep. But they were important for the analysis of our data as they improved the accuracy of the photometric redshifts and they helped us to discriminate between very

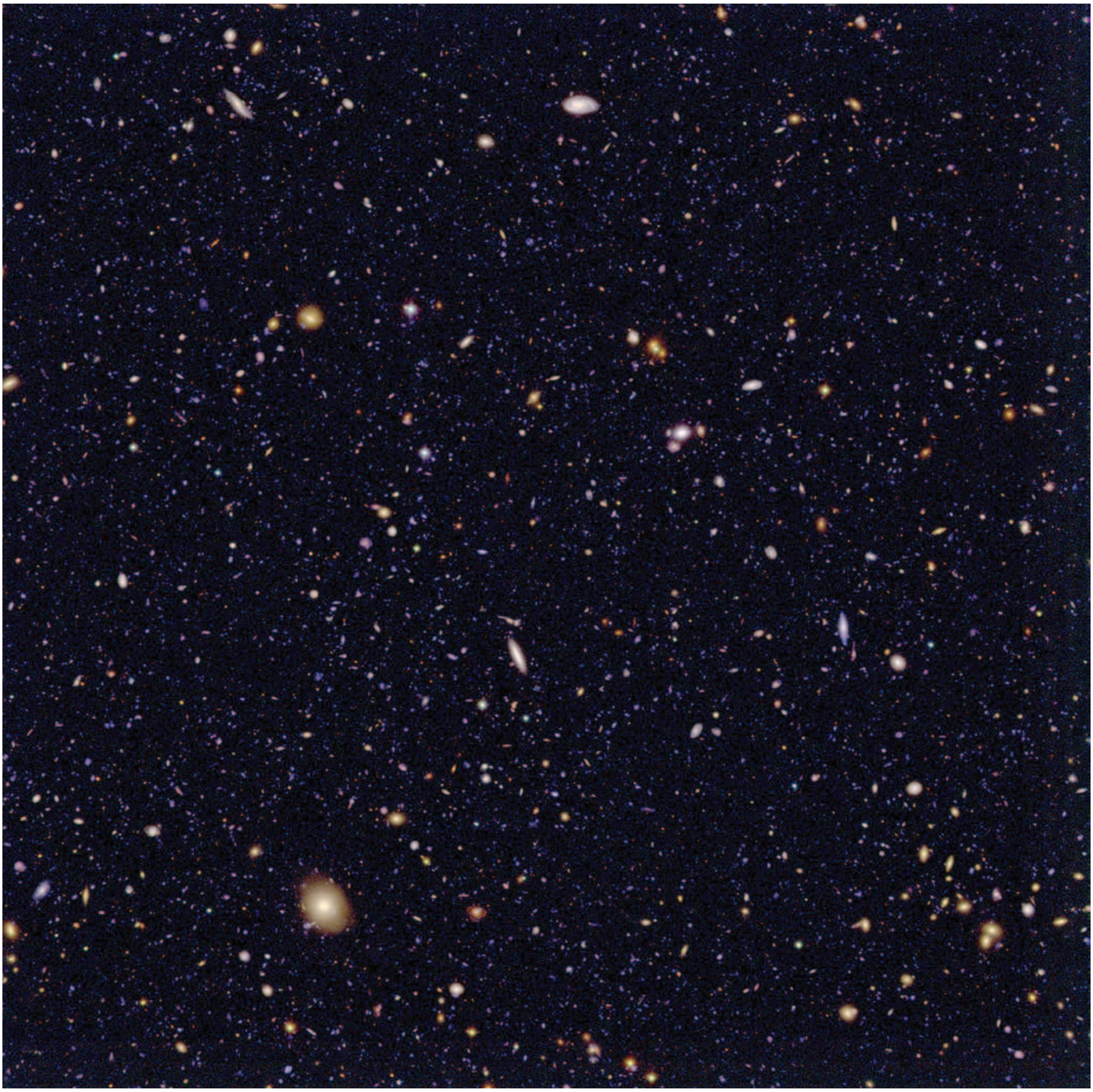

Figure 1: Colour image of the FORS Deep Field. The image was produced by combining images obtained in a blue, a red and a deep-red filter band. As pointed out in the text it has been processed to increase the resolution (to about 0.4 arcsec) and to make fainter features visible. The image covers a field of 7.1 × 7.1 $arcmin^2$. North is up, east to the left.

red compact galaxies and very cool stars. The large number of distant galaxies and the uniform conditions under which the different images were obtained make the FDF survey a unique data base for studying extragalactic stellar systems at different distances and cosmic ages. However, to evaluate our images, first the flux recorded from the individual objects had to be measured accurately. With about 10^4 targets this obviously required automatic procedures. While such procedures are standard tools of modern astronomy, their application to the FDF images turned out to be more complex than expected. Part of the difficulties encountered were due to the fact that most of our objects had (even in the moonless nights used for this programme) a surface brightness amounting to only a small fraction of the brightness of the night sky. Hence the background and the instrumental response functions had to be determined with very high accuracy to avoid introducing errors from an incorrect background subtraction. Moreover, instrumental effects and unresolved faint background galaxies produced unusual noise properties and artifacts which had to be studied and taken care of. As a result it took about two years of hard work to produce a catalogue of all objects for which the brightness could be measured with an error at least five times smaller than the observed value. This catalogue, published by Heidt et al. (2003), lists the coordinates, the brightness in the different filter bands, and other properties of 8753 FDF objects.

The Redshift Distribution of the FDF Galaxies

Because of the expansion of the universe, the wavelength of the light which we receive from distant galaxies is always shifted to a value larger than the wavelength at which the light had been emitted. Today astronomers normally describe this 'red-

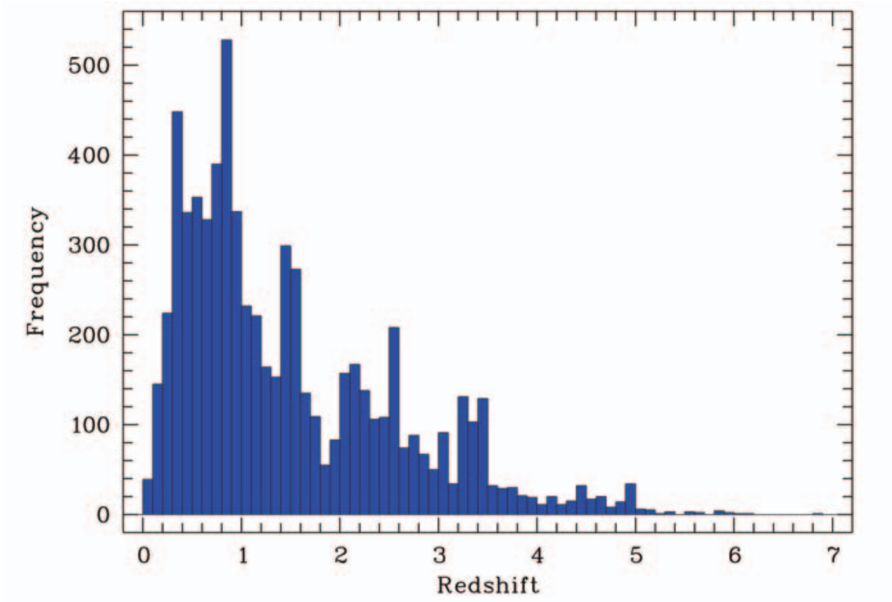

Figure 2: The distribution of the photometric redshifts in the FDF. The ordinate gives the number of galaxies observed within redshift intervals of 0.1.

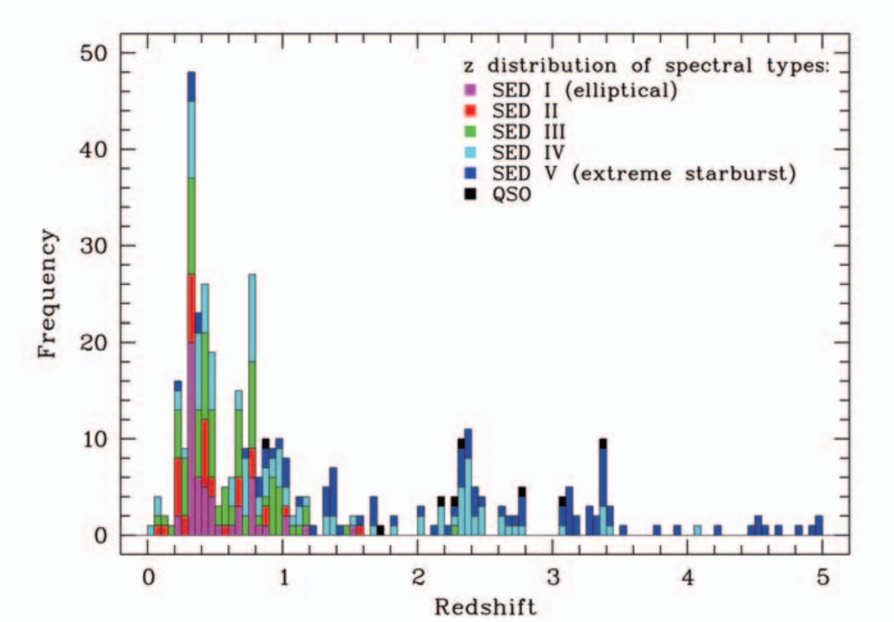

Figure 3: The distribution of the well measured spectroscopic redshifts in the FDF. The ordinate gives the number of galaxies per redshift interval of 0.05. The colours differentiate galaxies with different levels of star formation activity, ranging from insignificant star formation (magenta) to extreme starbursts (dark blue).

shift' by a dimensionless quantity denoted as z which is the ratio between this wavelength shift and the wavelength at which the light was emitted. Since the spectra of galaxies contain spectral lines and continuum features with known emitted wavelengths, redshifts can be derived from spectra or – less accurately – from photometric data (as described for the FDF sample by Bender et al. 2001). Since the redshift increases with distance, it can be used to determine distances. Moreover, because of the finite velocity of light, redshifts also provide information on the epoch when the light was emitted. Hence, observing galaxies with high redshifts allow us not only to look into the distant universe but, more importantly, it allows us to look back into cosmic history. So far photometric redshifts have been derived for about 7000 FDF galaxies. But accurate spectroscopic redshifts (which take much more observing time) have been determined and catalogued for a subsample of 341 FDF objects only (Noll et al. 2004). For statistical investigations the larger data base of the photometric redshifts is obviously an advantage. On the other hand, these redshifts are less accurate than those derived from spectra. Fortunately, for those FDF objects where both types of redshifts have been derived, a comparison has shown that the average mean error of our photometric redshifts is only about 0.03 for small redshifts (increasing proportional to $(1+z)$ for larger z), which is sufficient for most statistical purposes.

In Figs. 2 and 3 we present the distributions of the observed photometric and spectroscopic redshifts. As shown by Fig. 2 the number of observed galaxies increases rapidly with redshift for $z < 0.5$ and decreases again gradually for $z > 1$. As has been known from earlier studies, the initial increase reflects the increasing volume of space sampled with increasing redshift, while the decrease is due to the fact that at high redshifts (i.e. at large distances) we observe only the rare luminous galaxies. The range of redshifts in Fig. 2 ($0 < z < 7$) corresponds to a distance range of 0–13 billion light years or a look-back time of up to 13 billon years (which covers more than 90% of the present age of the universe). The appearance of FDF galaxies of different redshifts is illustrated by Fig. 4. As shown by this figure, at intermediate redshifts many galaxies appear blue due to the redshifted UV-radiation of massive young stars. At very high redshifts galaxies appear deep red and rather compact.

While Fig. 2 provides an essentially correct representation of the redshift distribution of our flux-limited FDF galaxy sample, Fig. 3 is affected by selection effects. Firstly, in order to include a sufficient numbers of distant galaxies, during the spectroscopic observations priority was given to targets with higher photometric redshifts. Therefore, compared to Fig. 2 our Fig. 3 contains a larger fraction of high-redshift objects. Secondly, galaxies with redshifts around $z = 1.5$ have no strong spectral features in the wavelength range accessible with FORS. Hence, although many such objects were observed, accurate redshifts could often not be determined, resulting in a dearth of such galaxies in Fig. 3. Our data also show that at different redshifts different types of galaxies tend to be observed. Typical elliptical galaxies, containing no young blue stars, are observed at low redshift only (since at higher redshifts their radiation is shifted out of the wavelength range of FORS). On the other hand, star forming galaxies can be observed at any redshift (≤ 7).

A characteristic property of Figs. 2 and 3 are conspicuous maxima of the galaxy densities at distinct redshifts (e.g. at $z = 0.3$, 0.8, 2.4, and 3.4). Because of the lower accuracy of the photometric redshifts, these maxima appear broader in Fig. 2. But they are present in both (independently derived) distributions and they obviously reflect the sponge-like large-scale structure of the matter distri-

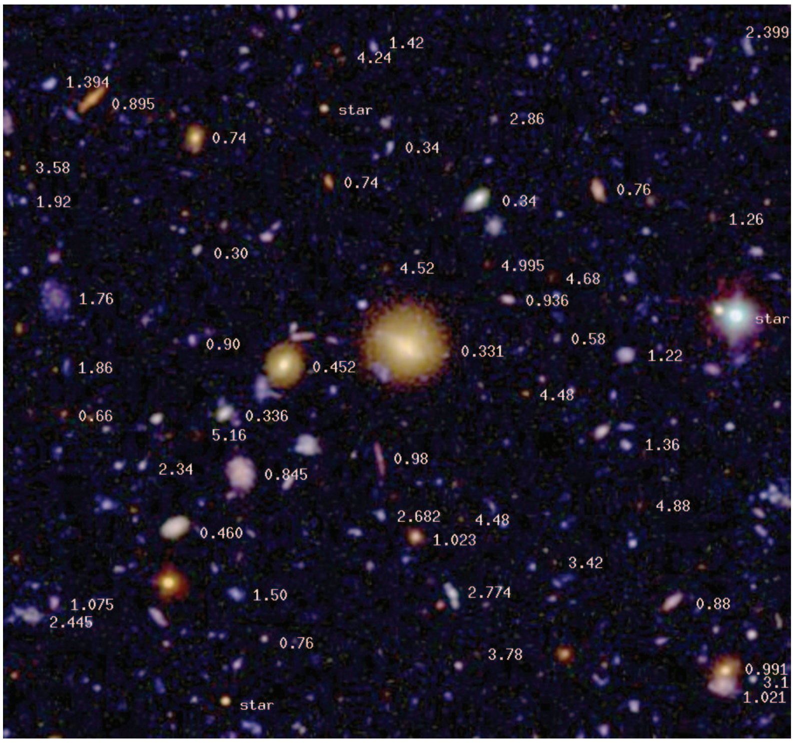

Figure 4: The appearance of FDF galaxies of different redshift. Examples of the observed redshifts are indicated by numbers placed to the right of the corresponding object. Three decimals indicate spectroscopic redshifts, 2 decimals photometric redshifts. The image covers about 80″ by 90″. North is up, east to the left. The bright (yellowish) elliptical galaxy near the centre (with z = 0.331) is FDF-6005. It is one of the brightest FDF galaxies and one of the few FDF objects visible on the Palomar Observatory Sky Survey. The galaxy north-west of FDF-6005 with z = 4.995 is one of the most distant FDF objects for which a spectroscopic redshift has been derived so far.

bution in the universe. A detailed analysis shows that the observed structure agrees well with the predictions of the CDM scenarios of cosmic structure formation. The conspicuous overdensity of galaxies at $z \approx 0.3$ can be traced to a galaxy cluster which is directly visible in the lower right of Fig. 1.

Observing cosmic evolution

Among the important new results of the FDF programme are new insights into the evolution with cosmic time of the properties of galaxies. Since our photometric redshift sample contains galaxies with very different redshifts and (at all redshifts) of very different intrinsic luminosity, it is particularly well suited to derive the luminosity distribution of galaxies as a function of the redshift (and cosmic age). Therefore, as described in detail by Gabasch et al. (2004), we were able to derive luminosity distributions for the FDF galaxies up to redshifts of 5, i.e. for about 90% of the cosmic history. Out to a redshift of 2.5, the UV data can be described with a flat slope of the luminosity function not changing throughout time (α = –1.1 in the Schechter notation). The slope in the rest frame blue is slightly steeper and also constant with time. At even higher redshifts, we found no evidence for the very steep slopes (α = –1.6) discussed for Lyman break galaxies in the literature. The analysis of the luminosity function fits between 0.5 and 5 yields a brightening of the UV rest frame characteristic magnitude by 2.6 mag and at the same time a decrease of the characteristic density by a factor of ten. The rest-frame luminosity functions furthermore allow us to derive the star formation rates as a function of cosmic time or redshift. From earlier investigations it has been known that, compared to today, star formation occurred at a much higher rate during the first few billion years of the cosmic history. As illustrated by Fig. 5 the FDF data confirm this result. Furthermore, the FDF results favour a scheme of the galaxy evolution where the overall star formation have stayed almost constant up to very early ages of the universe. Even more direct evidence for a change of the properties of the star forming galaxies with cosmic age is shown in Fig. 6. This figure (from Noll et al. 2004) compares the average spectra of FDF starburst galaxies observed in the redshift range $3 < z < 4$ (corresponding to a cosmic period when the universe had reached about 10% to 15% of its present age) and $2 < z < 3$ (corresponding to the time when the universe had reached about 15% to 25% of its present age). As shown by the figure, the spectra show the same basic features, but distinct quantitative differences. As an example we note that the galaxies observed at the earlier cosmic epochs show on average much stronger Ly-α emission and weaker absorption lines of heavy elements. Moreover, the UV continuum appears steeper. As pointed out by Noll et al. (2004) these differences can be explained assuming a lower abundance of heavy elements and a lower average mass of the star forming galaxies at the earlier epoch. This is not unexpected since we know that during the Big Bang only hydrogen and helium nuclei had been formed while practically all other elements were produced later in stars. In the FDF we obviously look back into epochs where the universe was too young to have already formed the fraction of heavy elements which we observe today.

A more quantitative view of the chemi-

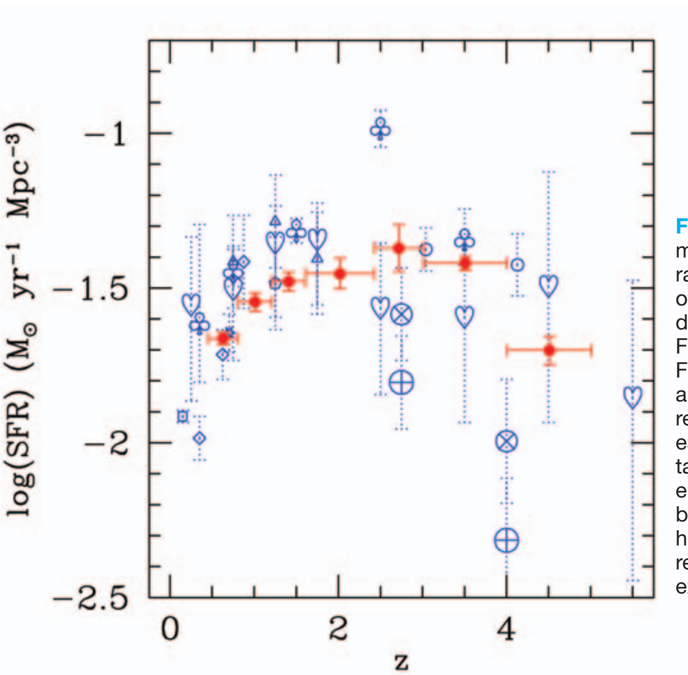

Figure 5: The cosmic star formation rate as a function of redshift as derived from the FDF (red symbols). For comparison we also included the results of various earlier studies taken from the literature (blue symbols). The data have not been corrected for dust extinction.

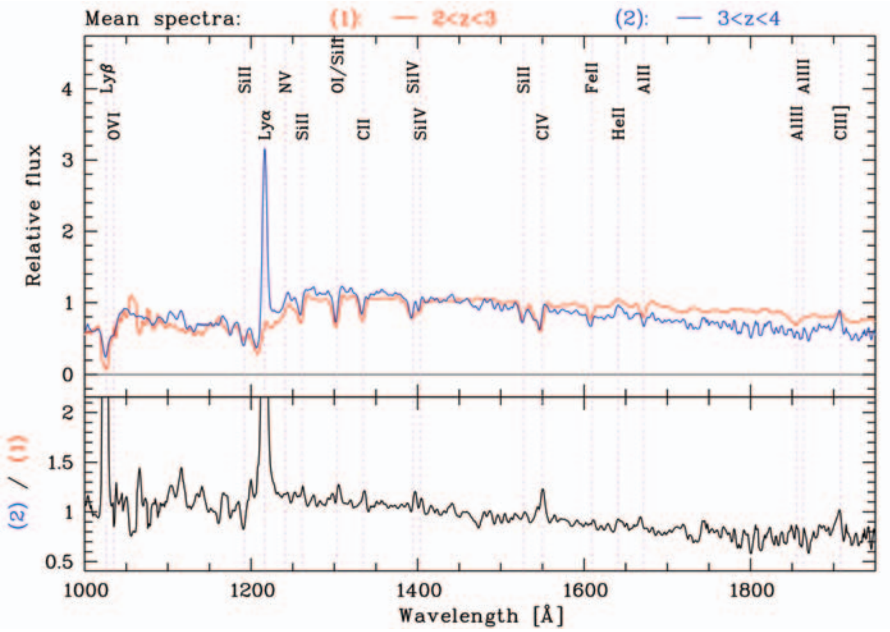

Figure 6: Comparison of the mean spectra of FDF starburst galaxies with redshifts 2 < *z* < 3 (red solid line) and 3 < *z* < 4 (blue solid line). The spectra are normalized to have the same flux level at the (rest frame) wavelength 1425 Å. The lower panel shows the ratio between the two spectra.

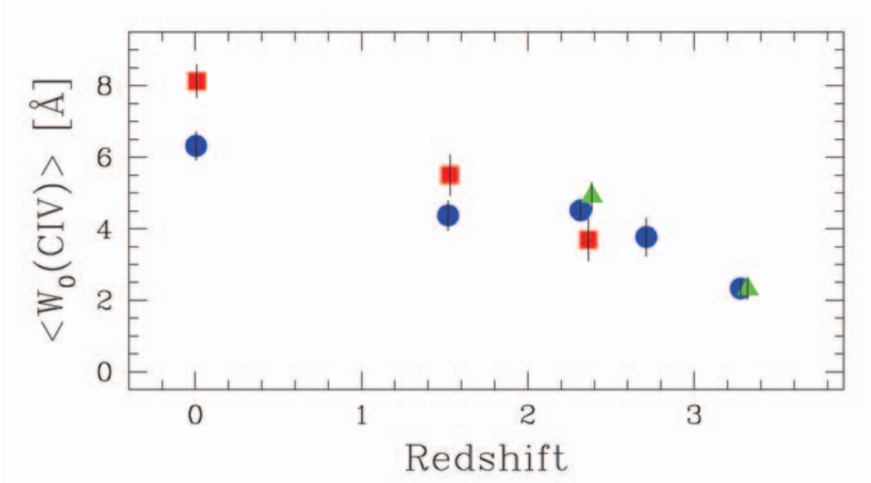

Figure 7: Mean strength of the resonance doublet of the carbon ion C^{+++} in the spectra of FDF starburst galaxies as a function of redshift. Since in starburst galaxies the strength of this blend is approximately proportional to the abundance of heavy elements, the diagram illustrates directly the chemical enrichment of the universe with decreasing redshift (or increasing cosmic age).

cal enrichment of the universe by stars is provided by Fig. 7 (from Mehlert et al. 2002) where the strength (in terms of the rest-frame equivalent width W_0) of the resonance doublet of the carbon ion C^{+++} in the spectra of starburst galaxies is plotted as a function of the redshift. The data points at $z > 1$ are from the FDF. The point at $z = 0$ is based on published spectra of local starburst galaxies. The blue symbols include all galaxies for which the line was measured. The green and red symbols refer to luminosity-selected subsamples which were investigated separately to make sure that the observed variation is not due to a selection effect. (For details see Mehlert et al., 2002). Since in local starburst galaxies the C^{+++} strength is found to be approximately proportional to the heavy element content, the blue data points in Fig. 7 trace directly the chemical enrichment history of the universe. According to this figure about 2/3 of the heavy nuclei seem to have been formed already at $z \approx 2.5$, i.e. during the first few billion years of the cosmic history. This result is in good agreement with the high star formation activity at these early epochs indicated by Fig. 5.

The Tully-Fisher relation at intermediate redshifts

Evolutionary effects such as those described above may also affect established relations between different properties of galaxies, such as the Tully–Fisher relation (TFR, Tully & Fisher 1977) connecting the luminosity and the maximum rotation velocity of the discs of spiral galaxies. This relation can be understood as a combination of the virial theorem and the centrifugal support of spiral galaxies. Comparing the TFR of present-day spirals and that of distant galaxies observed at earlier cosmic epochs, it is possible to quantify the evolution in luminosity which the spirals have undergone. This makes the TFR a powerful tool to test predictions of numerical simulations based on the hierarchical scenario of galaxy formation, according to which small galaxies have formed first, followed by the successive build-up of larger systems via merging processes. However, observational studies of the TFR of distant galaxies were so far limited to small samples with 10–20 objects and thus could not be used to test whether the luminosity evolution differs between slowly rotating (i.e. low-mass) and rapidly rotating (high-mass) spirals. Therefore, we carried out medium–resolution spectroscopy of 113 FDF spiral galaxies covering redshifts between $z = 0.1$ and $z = 1$ (Ziegler et al. 2002, Böhm et al. 2004).

From these spectra we extracted spatially resolved rotation curves. By fitting simulated velocity fields to the observed rotation curves, the maximum rotation velocity could be derived for 77 FDF spirals. The simulations took into account all geometric effects and, in particular, the seeing and the influence of the slit width. In Fig. 8, we compare our sample to the local TFR. The FDF sample was sub-divided according to the rotation curve quality. Solid symbols in Fig. 8 denote high-quality rotation curves with a large spatial extent and high symmetry, which yield robust values of the maximum rotation velocity. While the distant low-mass spirals were found to be brighter by up to 2 magnitudes in the rest–frame *B*-band than their local counterparts, the high-mass objects do not show a significant evolution in luminosity. This offers an explanation for the discrepancies between previous studies of the distant TFR as combination of selection effects and small number statistics. Our finding is at variance with the results of numerical simulations, which predict a stronger brightening of *high-mass* spirals. This may indicate the need for a more realistic modeling of the stellar population properties in *N*-body codes.

Ly-α galaxies

In addition to results of a statistical nature, the FDF also yielded new information on individual objects and on interesting particular classes of objects. Examples are the so-called “Ly-α galaxies”. These are starburst galaxies showing extremely strong Ly-α emission lines relative to the continuum. Such objects are not observed in the local universe but (as also indicated in Fig. 6) they become rather common at high redshifts.

Their strong Ly-α flux is surprising since multiple resonance scattering in this line results in a very long effective light path of this radiation. Hence any dust absorption will reduce the escape probability of Ly-α photons dramatically. Therefore, it has been suggested in the literature that the high-redshift Ly-α galaxies are very young galaxies which do not yet contain heavy elements which could condensate into dust particles. However, our FORS spectra (e.g. Fig. 9) contain conspicuous spectral lines of carbon, silicon and nitrogen, showing that such objects are not devoid of heavy elements. In fact, a model fit of the spectrum of the z = 3.304 Ly-α galaxy FDF-4691 indicates for this object a heavy element abundance comparable to that of the Magellanic Clouds (the closest major companion galaxies of the Milky Way; Tapken et al., 2004). Hence Ly-α photons obviously escape from this galaxy in spite of the presence of heavy elements, i.e. in the presence of matter which can form dust. A detailed model comparison and dedicated radiative transfer calculations for FDF-4691 have shown that this is possible since the Ly-α line is formed in a highly turbulent medium and since the line-of-sight HI column density is relatively low.

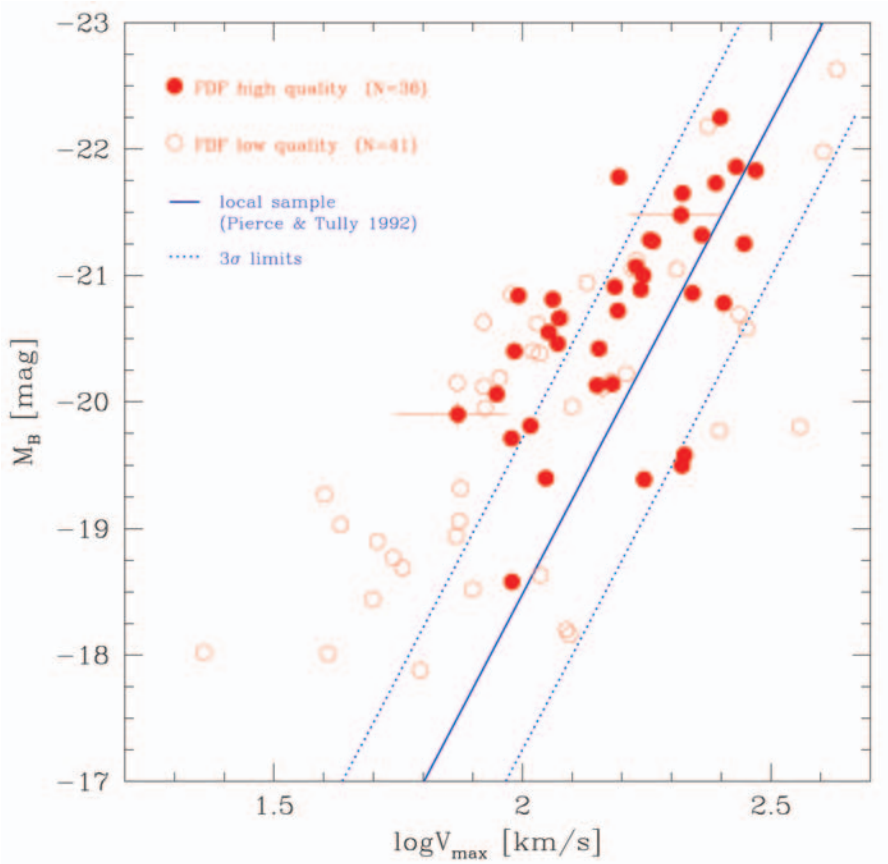

Figure 8: Blue absolute magnitudes M_B as a function of maximum disc rotation velocity V_{max} for 77 FDF spirals at redshifts $0.1 < z < 1.0$ (red symbols), compared to the local Tully–Fisher relation (blue line). Slowly rotating, low–mass distant spirals are significantly brighter than their local counterparts, whereas distant and local high–mass systems have similar luminosities.

Galaxies and the intergalactic gas

Among the eight quasars in the FDF one (Q0103-260, z = 3.36) is sufficiently bright for high-resolution spectroscopy. Therefore, we used the UVES echelle spectrograph at the VLT to study the absorption by the intergalactic gas in the direction of the FDF (Frank et al., 2003). As expected we found a close correlation between the redshift distribution of the intergalactic absorbers and of the galaxy density along the line-of-sight. As illustrated by Fig. 10, this correlation is particularly evident for the “metal absorption systems” which trace the high-density intergalactic matter. Since according to current CDM structure formation scenarios galaxies form first and most efficiently in volumes of the highest dark matter density (which also are regions of high baryonic matter density) and since galactic winds are expected to enrich the intergalactic medium with heavy nuclei as soon as star formation and stellar evolution have set in, the observed correlation is not surprising. However, more interestingly, the correspondence of metal absorption and galaxy clustering is not complete and the metal line strengths vary significantly between the different systems. At z = 2.558 we find, e.g., a reliably identified close pair of metal absorption systems in an apparent void of galaxies. However, this may be due to the incompleteness of our spectroscopic survey at faint magnitudes. On the other hand, the existence of a prominent galaxy clustering at z = 2.34 without a detectable metal absorption system is unexpected. At this redshift metal systems are easily detected. Therefore, the absence of detectable metal absorption can only be explained assuming that (compared to the other galaxy clusterings) the galaxies at z = 2.34 have been less efficient in chemically enriching their environment.

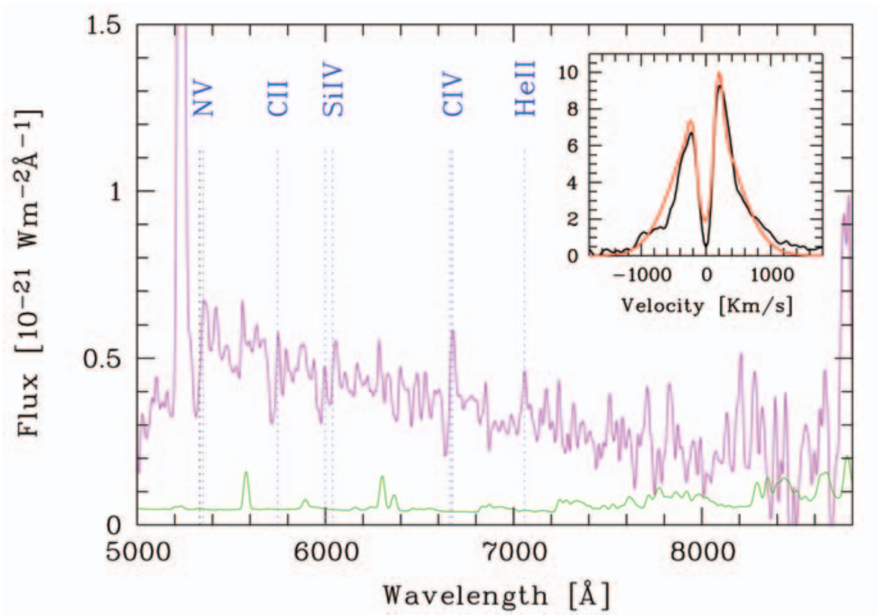

Figure 9: The spectrum of the Ly-α galaxy FDF-4691. In the low-resolution spectrum (magenta) the strong Ly-α line (observed at 5230 Å) is unresolved and truncated. The resolved profile of this line is presented in the inset (black line) together with a theoretical profile calculated from a model of the Ly-α forming region of FDF-4691 (red line).

With an angular size corresponding to the size of a large galaxy cluster at redshifts 2 - 5 the FDF is not well suited to study clustering effects in the angular distribution. On small scales, which can be investigated in the FDF, the observed clustering is consistent with the findings of other studies. But there are a few regions which show an unexpected behavior. Most interesting is a surprisingly high density of galaxies with redshifts near 3.36 within a few arc sec (projected distance ≤ 60 kpc) of the bright QSO observed at this redshift. It may indicate that this QSO is located in an exceptionally dense protocluster at this redshift.

Ongoing and future work

In this report we described a few examples of scientific results obtained so far from the FDF. Many studies using FDF data are still in progress and some of the data (such as the stellar content of the FDF and observations obtained outside the optical range) have hardly been touched. Among the exciting ongoing investigations is a more thorough study of cosmic chemical evolution using medium resolution spectra of FDF galaxies (obtained with the VPH grisms of FORS2) and improved synthetic spectra. Moreover, a significant effort is being made to extend the FDF galaxy sample to redshifts $z > 5$. In this range different search techniques have to be used since such objects show no flux in most of the FORS broad-band filters (except for a weak signal at I in some cases). Using narrow-band observations in deep-red filter bands we were able to identify a sample of very promising candidates for such very high redshift galaxies in the FDF. However, these objects still require a spectroscopic confirmation. Hence there is still much work to be done in the FDF, and there remains a significant potential for more reports in *The Messenger.*

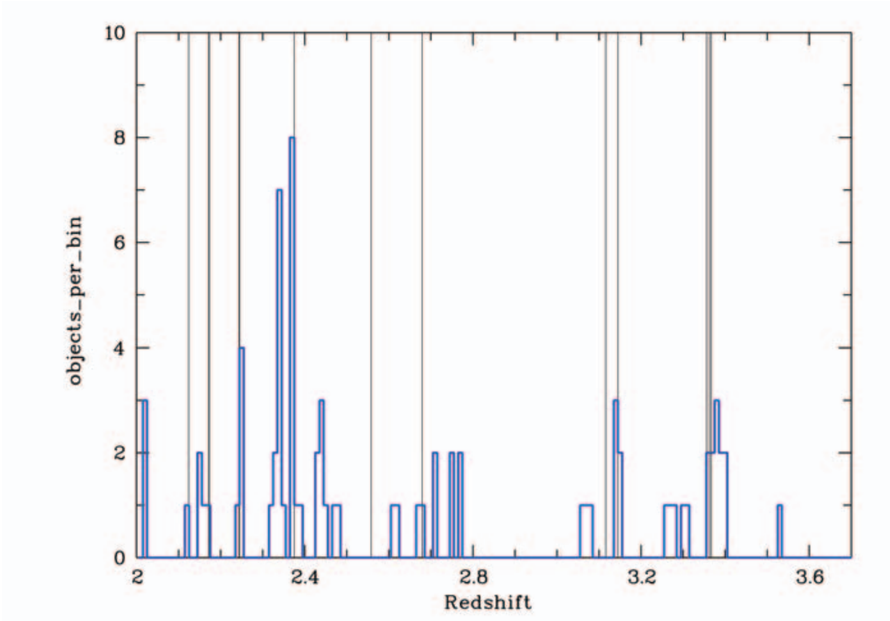

Figure 10: Histogram of the redshift distribution of spectroscopically observed FDF galaxies in the redshift interval 2 < z < 3.7 (blue line) and the redshift positions of the metal absorption systems of the FDF quasar Q0103-260 observed in this redshift range (black vertical lines).

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Revisiting the orion Nebula

Wide Field Imager Provides New View of a Stellar Nursery (ESO PR Photo 20/04)

An international team of astronomers, led by Massimo Robberto (European Space Agency and Space Telescope Institute), used the Wide Field Imager (WFI), a 67-million pixel digital camera that is installed at the ESO/MPG 2.2m telescope at La Silla, to obtain very deep images of this region. The image shown is a false-colour composite of all of the images obtained in B, Hα, [OIII], and [SII] where each waveband was associated to a given colour: B to blue, [OIII] to green; Hα to orange, and [SII] to red. The field of view covers 34′ × 33′. North is up and East is to the left.
Among others, these observations allow the astronomers to measure the rates of mass that falls onto the young stars and to determine if it depends on the position of the stars in the cluster. If this were the case, it would indicate that the final stages of star formation are affected by the onset of ionizing radiation from the most massive stars. The astronomers also obtained images of the Orion Nebula in several narrow-band filters corresponding to emission lines - hydrogen (Hα), oxygen ([OIII]), and sulphur ([SII]) - enabling them to probe the morphology of the nebula in these prominent lines.

Constraining the time variation of the fine structure constant

The variation of several fundamental constants in physics can be probed by measuring wavelengths of atomic transitions in the high redshift Universe. In particular any possible variation in the electromagnetic fine-structure constant ($\alpha = e^2/\hbar c$) can be detected in the absorption spectra of distant quasars. Using a well defined sample of absorption line systems we derive a 3σ upper limit on the time variation of α of -2.5×10^{-16} yr$^{-1} \leq (\Delta\alpha/\alpha\,\Delta t) \leq +1.2 \times 10^{-16}$ yr^{-1}.

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Most of the successful physical theories rely on the constancy of few fundamental quantities (such as the speed of light c, the fine structure constant α, the proton-to-electron mass ratio μ, etc.). However, some of the modern theories of fundamental physics try to unify fundamental interactions. They require the existence of extra "compactified" spatial dimensions and allow for the cosmological evolution of their scale size. As a result, these theories naturally lead to the prediction of cosmological variation of fundamental constants in a four-dimensional sub-space (Uzan 2003 and reference therein). Therefore constraining the possible time variations of these fundamental physical quantities is an important step towards a complete physical theory.

One of these constants is the fine-structure constant α ($=e^2/\hbar c= 1/137.03599976(50)$ on earth), where e is the charge of the electron and $\hbar$ the reduced Planck constant). It characterizes the strength of the electromagnetic interaction between charged particles. The time evolution of α can be probed in the framework of standard Big-Bang models using measurements performed at different redshifts (z). One has to measure a quantity that is sensitive to a change in α in the remote universe and to compare to its value on Earth. The strongest constraint on α comes from the Oklo phenomenon, a natural fission reactor that operated 2 Gyrs ago, corresponding to $z \sim 0.16$ (Fujii et al. 2000). By studying the products of nuclear reactions that occurred then it is possible to constrain

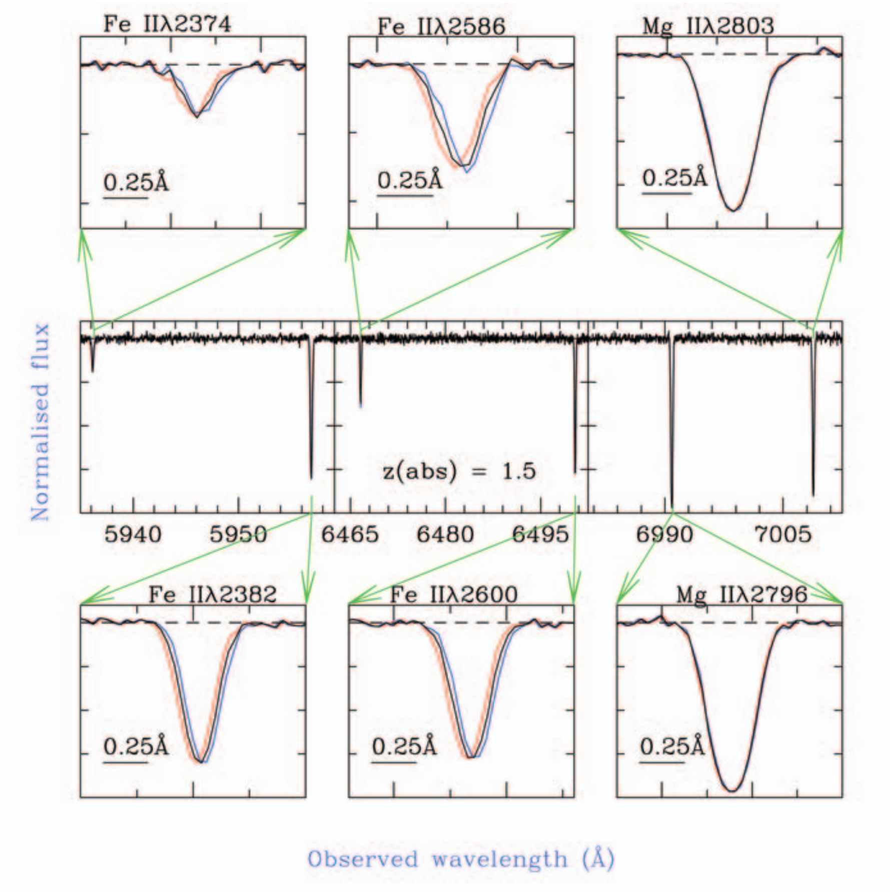

Figure 1: The figure shows a simulated spectrum of the Fe II multiplet and Mg II doublet produced by an absorbing cloud at z_{abs}= 1.5 for $\Delta\alpha/\alpha$ = 0.0 (black), 5.0 × 10^{-5} (red) and –5.0 × 10^{-5} (blue). The zoomed-in views of different absorption lines are shown in the bottom and top panels. It can be seen that Mg ii lines are virtually insensitive to small values of $\Delta\alpha/\alpha$, while Fe II lines are very sensitive to these changes. Thus the position of the Mg II lines gives the absorption redshift and the relative positions of the Fe II lines probe the variation in α. This is the main idea behind the MM method. The difficulty in detecting the α variation can be appreciated from the fact that the values of $\Delta\alpha/\alpha$, used in this illustration are 10 times larger than the detection claimed by Webb et al. (2003).

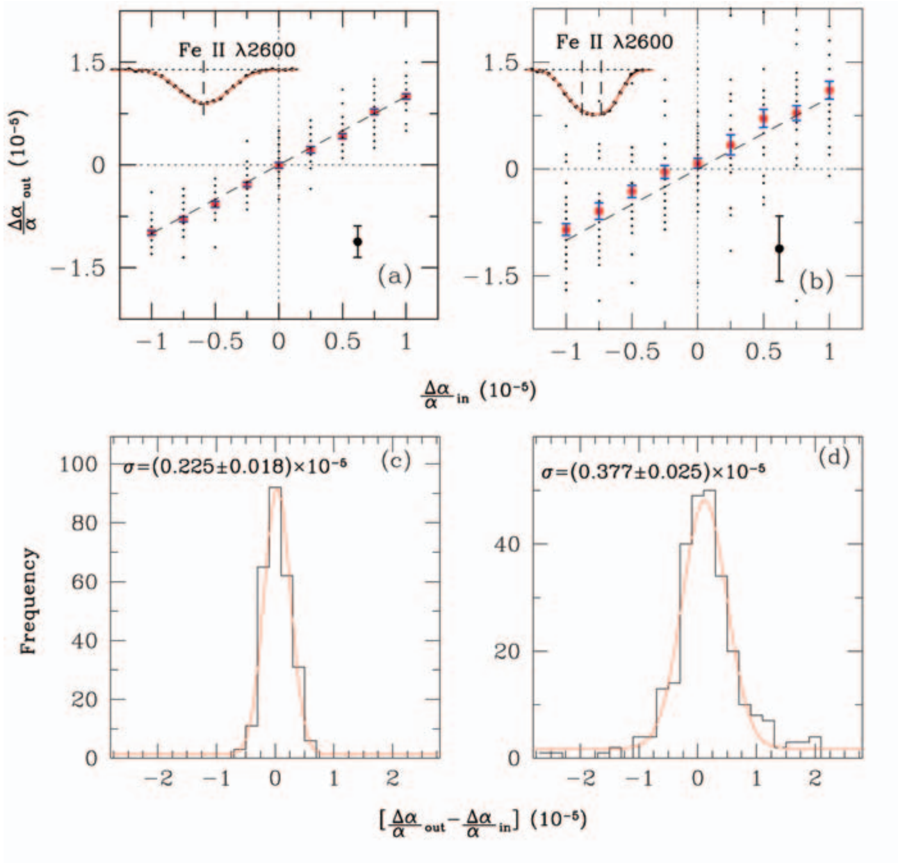

Figure 2: Absorption spectra of Mg II and Fe II are simulated using random values of the column densities, *N*, the Doppler parameter, *b*, and noise, keeping the signal-to-noise ratio, wavelength sampling and spectral resolution as in a typical UVES spectrum. Spectral shifts corresponding to a given value of $\Delta\alpha/\alpha$ are introduced. Our procedure is applied to the simulated data and the best fitted value of $\Delta\alpha/\alpha$ is recovered. Top panels show the relationship between the input and derived value of $\Delta\alpha/\alpha$ in the case of a single clean component (left-hand side) and a blend of two components (right-hand side). A typical absorption profile is also shown in these panels. Dots are the values from individual realizations and the points with the error bars are the weighted mean obtained from 30 realizations. The lower panels give the distribution of the recovered $\Delta\alpha/\alpha$ around the true one. Best fitted Gaussian distributions are overplotted.

some cross-sections that depend on α. It is found that $[\Delta\alpha/\alpha\Delta t] = (-0.2 \pm 0.8) \times 10^{-17}$ yr^{-1}.

Constraining α with QSO absorption lines

At higher redshifts, the possible time dependence will be registered as small shifts in the absorption line spectra seen toward high redshift QSOs as the energy of the atomic transitions depend on α. One has to disentangle the contributions of the global redshift due to the expansion of the universe and the shift due to the variation in α. To do so one needs at least two transitions with different sensitivity coefficients for the variations in α. As the redshift will be the same for all transitions the relative shift will therefore constrain Δα. Initial attempts to measure the variation of α were based on alkali-doublets (e.g. Varshalovich et al. 1996) such as the well known Si IV doublet. The best constraint obtained using this method is $\Delta\alpha/\alpha = (-0.5 \pm 1.3) \times 10^{-5}$ (Murphy et al. 2001). The generalization of this method, called the many-multiplet (MM) method (Dzuba et al. 1999) gives an order of magnitude improvement in the measurement of $\Delta\alpha/\alpha$ compared to the alkali-doublet method by using not only doublets from the same species but several multiplets from different species (e.g. Webb et al. 2001). The sensitivity to variations in α of different line transitions from different multiplets were computed using many-body calculations taking into account dominant relativistic effects (Dzuba et al. 2002).

In simple terms, the MM method exploits the fact that the energy of different line transitions vary differently for a given change in α. For example rest wavelengths of Mg II λλ2797, 2803 and Mg I λ2852 transitions are fairly insensitive to small changes in α thereby providing a good anchor for measuring the systemic redshift (see Fig. 1). By comparison the rest wavelengths of Fe II multiplets are quite sensitive to small variations in α. Thus, measuring consistent relative shifts between an anchor and different Fe II lines can in principle lead to an accurate measure of Δα. The accuracy at which the variation can be measured depends very much on how well absorption profiles can be modeled. It is usual to use for this Voigt profiles that are convolved with the instrumental profile and characterized by column density (*N*), velocity dispersion (*b*) and redshift (*z*) in addition to the rest-wavelength of the species. In real data small relative shifts can be introduced due to various systematic effects such as inhomogeneities in the absorbing region, poor wavelength calibration, isotopic abundances, and atmospheric dispersion effects, etc. However most of the random systematic effects may be canceled by using a large number of measurements. The MM method applied to a large heterogeneous samples of QSO absorption lines resulted in the claim for a smaller value of α in the past, $\Delta\alpha/\alpha = (-0.574 \pm 0.102) \times 10^{-5}$ for $0.2 \leq z \leq 3.7$ (Murphy et al. 2003).

An ESO-VLT Large Programme

The data used in this new study were obtained with the *Ultra-violet and Visible Echelle Spectrograph* (UVES) mounted on the ESO KUEYEN 8.2-m telescope at the Paranal observatory for the ESO-VLT Large Programme "Cosmological evolution of the Inter Galactic Medium" (PI Jacqueline Bergeron). This programme has been devised to gather a homogeneous sample of echelle spectra of 19 QSOs, with a uniform spectral coverage, resolution and signal-to-noise ratio suitable for studying the intergalactic medium in the redshift range 1.7–4.5. Spectra were obtained in service mode observations spread over four periods (two years) covering 30 nights under good seeing conditions (≤ 0.8 arcsec).

The data were reduced using the UVES pipeline, a set of procedures implemented in a dedicated context of MIDAS, the ESO data reduction package. The main characteristics of the pipeline is to perform a precise inter-order background subtraction for science frames and master flat-fields, and to allow for an optimal extraction of the object signal rejecting cosmic ray impacts and performing sky-subtraction at the same time. The reduction is checked step by step. The extraction slit length is adjusted to optimize the sky-background subtraction. The final accuracy is better than 1%. Addition of individual exposures is performed using a sliding window and weighting the signal by the total errors in each pixel. As the error spectrum is very important for our analysis, great care was taken while combining the error spectra of individual exposures. The wavelength calibration has been carefully checked using the calibration lamp and it is better than $\delta\lambda/\lambda \sim 7\times10^{-7}$ rms over the full wavelength

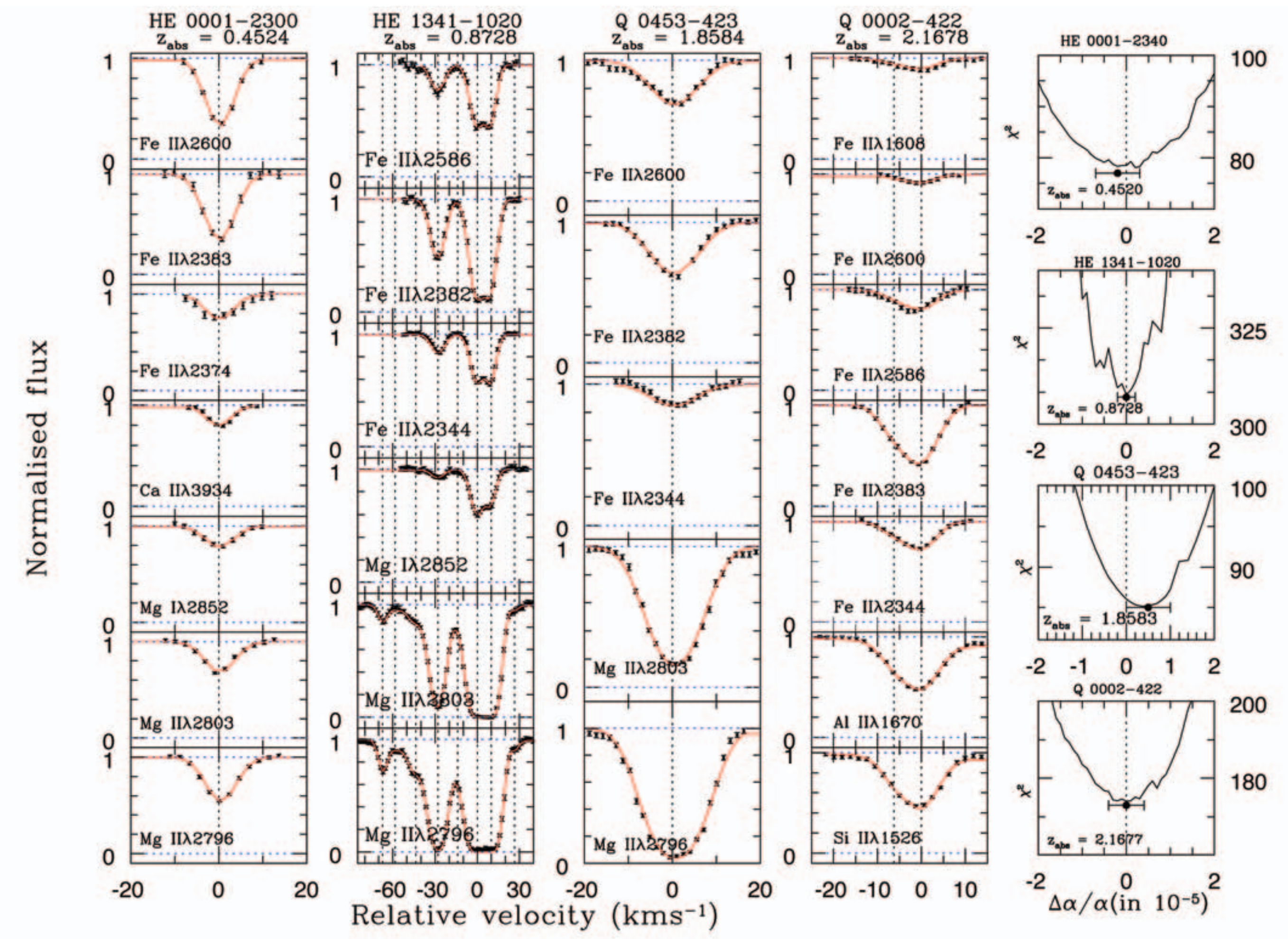

Figure 3: Example of Δα/α estimation from real data: Voigt profile fits to 4 randomly chosen systems (out of 23) in our sample are shown in the first 4 columns from the left. The QSO name and absorption redshifts are given on top of the panels. The points with the error bars are the observed data and the continuous curve is the fit obtained using multicomponent Voigt profile decomposition. The locations of different components are marked with vertical dotted lines. The plots in the right most column demonstrate how Δα/α is extracted from these systems. We plot χ^2 as the function of Δα/α . The minimum in this curve (marked with a dot) gives the best fitted value of Δα/α and the error in this measurement (error bar around the dot) is based on the standard statistical method of computing errors from $\Delta\chi^2 = 1$.

range of interest, 310–540 and 545–900 nm. Details can be found in Chand et al. (2004) and Aracil et al. (2004). In our analysis we have only used absorption lines that are redshifted beyond the position of the Lyman-α emission line from the quasar. Signal-to-noise ratio of ~40 to 80 per pixel and spectral resolution ≥ 45,000 are achieved over the wavelength range of interest. This is a factor two improvement on signal-to-noise ratio at similar (or slightly higher) resolution compared to data used in earlier studies.

Simulations

As a first step we performed a detailed analysis on simulated data to have a clearer understanding of various possible systematics that can affect the analysis of real data.

The results of this exercise are used to validate our procedure and define selection criteria that will minimise systematics in our analysis. Absorption spectra of Mg II and Fe II were simulated for given column density, *N*, and Doppler parameter, *b*, at spectral resolution and signal-to-noise ratio similar to our data, introducing spectral shifts corresponding to a given value of Δα/α. We considered two cases: a simple single component system and a highly blended two-component system. In the highly blended case we restricted the separation between the two components to be always smaller than the velocity dispersion of one of the components. We then fitted the absorption lines in order to recover Δα/α introduced in the input spectrum. This exercise allowed us to determine the precision that can be reached using our method and fitting procedure.

We used the Voigt profile fitting method and standard χ^2 statistics to fit the absorption profiles consistently and to determine the best fit value of Δα/α. The relationships between the input and recovered value of Δa/a are shown in Fig. 2. The method works very well in the case of simple single component systems where one expects minimum uncertainties due to systematics. The deviation of the recovered value with respect to the true one distributes like a Gaussian with $\sigma = 0.21 \times 10^{-5}$. This shows that Δα/α can be constrained with an accuracy of 0.06×10^{-5} when we use 10 such systems. In the blended case one can see that a tail in the distribution appears and that the accuracy is less ($\sigma = 0.34 \times 10^{-5}$). Using strongly blended systems may therefore lead to false alarm signals. Based on detailed simulations we come up with selection criteria that will minimise the systematics in our analysis (see Chand et al., 2004 for detail).

Fitting real data

We illustrate the method in Fig. 3 using 4 randomly chosen systems from our sample. We vary Δα/α ranging from -5.0×10^{-5} to 5.0×10^{-5} in step of 0.1×10^{-5}, and each time fit all the lines together. χ^2 minima obtained for each of these fits are plotted as a function of Δα/α (right most panel in Fig. 3). The value of Δα/α at which this Δα/α is minimum is accepted as the measure of the best possible Δα/α value. Following standard statistical procedure we assign a 1σ error bar to the best fitted value of Δα/α by computing the change in Δα/α implying

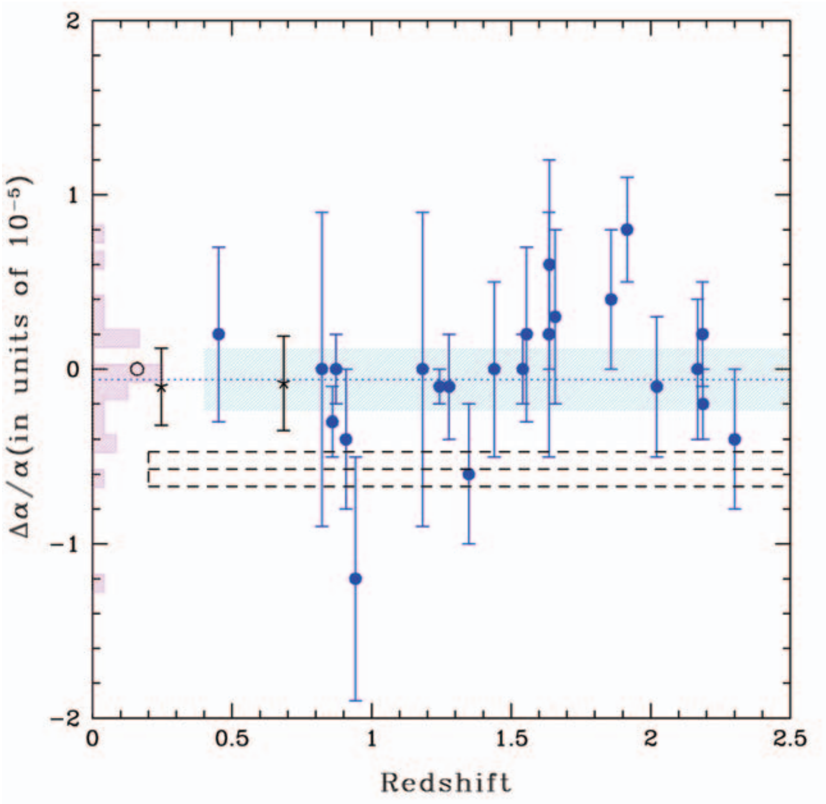

Figure 4: $\Delta\alpha/\alpha$ measurements from the UVES sample: The measured values of $\Delta\alpha/\alpha$ from our sample (filled circles) are plotted against the absorption redshifts of Mg II systems. Each point is the best fitted value obtained for individual systems using χ^2 minimization. The open circle and stars are the measurement from Oklo phenomenon (Fujii et al., 2000) and from molecular lines (Murphy et al., 2001a) respectively. The weighted mean and 1σ range measured by Murphy et al. (2003) are shown with the horizontal long dashed lines. Clearly most of our measurements are inconsistent with this range. The shadow region marks the weighted mean and its 3σ error obtained from our study [$< \Delta\alpha/\alpha >_w = (-0.06 \pm 0.06) \times 10^{-5}$]. Our data gives a 3σ constraint on the variation of $\Delta\alpha/\alpha$ to be $-2.5 \times 10^{-16}\ \mathrm{yr}^{-1} \leq (\Delta\alpha/\alpha\Delta t) \leq 1.2 \times 10^{-16}\ \mathrm{yr}^{-1}$ in the case of a flat universe with $\Omega_\lambda = 0.7$, $\Omega_m = 0.3$ and $H_0 = 68$ km/s/Mpc for the median redshift of 1.55.

$\Delta\chi^2 = \chi^2 - \chi^2_{min} = 1$. We always consider two different models: (i) one in which the b parameters for all species are the same and (ii) one in which b parameters for different species are different. In all systems we notice that $\Delta\alpha/\alpha$ derived in both cases are consistent with one another within 1σ uncertainty. We use the result with lower reduced χ^2 for our final analysis.

Results obtained for the 23 systems in our sample and that from the literature are summarized in Fig. 4. The shaded region passing through most of the error bars is the weighted mean (with 1/error^2 weights) and its 3σ error from our sample. The histogram in the left hand side of the panel shows the distribution of $\Delta\alpha/\alpha$. It is clear that most of our measurements are consistent with zero within the uncertainties. The simple mean, weighted mean and standard deviation around the mean obtained for our sample are $(-0.02 \pm 0.10) \times 10^{-5}$, $(-0.06 \pm 0.06) \times 10^{-5}$ and 0.41×10^{-5} respectively. The weighted mean value is consistent with all the data points with a reduced $\chi^2 = 0.95$. Thus our study gives a more stringent 3σ constraint of $-0.24 \leq \Delta\alpha/\alpha$ (in 10^{-5}) $\leq +0.12$ over the redshift range of $0.4 \leq z \leq 2.3$. The median redshift of the whole sample is 1.55 which corresponds to a look-back time of 9.7 Gyr in the most favoured cosmological today (see caption of Fig. 4). This gives a 3σ constraint on the time variation of $\Delta\alpha/\alpha$ to be $-2.5 \times 10^{-16} \leq (\Delta\alpha/\alpha\Delta t) \leq 1.2\ 10^{-16}\ \mathrm{yr}^{-1}$. To our knowledge, this is the strongest constraint from QSO absorption line studies till date (Chand et al. 2004, Srianand et al. 2004). In addition, our study does not support the claims by previous authors of a statistically significant change in $\Delta\alpha/\alpha$ with cosmic time at $z > 0.5$.

What's next?

Even though our study is consistent with no variation in α, it still does allow smaller variations in excess of what is found based on the Oklo phenomenon. Thus it is important to further improve the constraints at higher redshifts. In addition there are some shortcomings of the MM method that need to be avoided. For example, the MM method assumes that all species trace each other perfectly. However, any ionization or chemical inhomogeneity in the absorbing cloud may produce relative shifts between Mg II and Fe II lines at the level expected in the case of small variations in α. Also any peculiar isotopic abundance of Mg can mimic small variations. Thus it is important to perform detailed MM analysis using only multiplets from single species such as Ni II (or Fe II as in Quast et al. 2004) using a well defined high quality sample. It is also demonstrated that OH and other molecular lines can be used to improve limits on the variation in α (see for example Chengalur & Kanekar, 2003). In addition other constants can be constrained in a similar way. Although it is hard to make any quantitative prediction, theorists estimate that variations of the proton-to-electron mass ratio could be larger than that of the fine structure constant by a factor of 10–50. It is possible to constrain this constant by measuring the wavelengths of radiative transitions produced by the hydrogen molecule, H_2. On-going ESO programmes have been dedicated to this purpose (Ledoux et al. 2003, Ivanchik et al. 2002).

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Extragalactic Embedded Clusters: Exploring Star Formation

Infrared techniques today allow us to explore the first ages of star formation in starburst galaxies: young massive clusters buried in a thick dusty cocoon reveal their nature through infrared imaging and spectroscopy.

EMMANUEL GALLIANO & DANIELLE ALLOIN
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HOW STAR FORMATION TAKES place in galaxies is a topic which has been studied extensively over the past decades: in particular, the discovery of starburst galaxies in the early 80's (Weedman et al. 1981) drew attention to the fact that, under certain conditions, the star formation rate could be extremely high and very different from what is currently observed in our Galaxy or in the Magellanic Clouds. Of course, the diversity in star forming conditions was already known from the mere existence in galaxies of at least two populations of star clusters, the open clusters and the globular clusters. Yet, the starburst phenomenon was revealing a new side of star formation and its occurrence on unprecedented scales, opening insights into the history of star formation over cosmic times. Starbursts are mostly found in the central regions of spiral galaxies still rich in gas and dust, and are the site of ~25% of the high-mass star formation. One hundred solar masses of stars per year can be formed in a starburst galaxy, while this rate is only one solar mass per year in the disc of the Milky Way. Hence, extragalactic starbursts constitute a natural laboratory for testing our ideas about star formation, about the evolution of massive stars and the physics of the interstellar medium; they might be as well a testimony of processes which were certainly of prime importance in the early ages of galaxies.

Deep imaging surveys in the infrared and submillimetre (using ISO, SCUBA and/or COBE) have demonstrated that half of the energy of the extragalactic background at these wavelengths is emitted by extremely red starburst galaxies (Madau 1999). Consequently, studying their local analogues, the nearby dusty starburst galaxies, brings clues about the predominant mode of star formation at remote epochs and contributes to our understanding of the evolution with time of the initial mass function, the star formation rate and the chemical enrichment of galaxies.

Thanks to observations at increased spatial resolution, the star forming regions in starburst galaxies have been resolved into entities which are sometimes called super star clusters (SSCs) or young massive clusters (YMCs). These clusters have sizes from 0.5 to 20pc and weigh from 10^5 to 10^6 solar masses. Starburst galaxies like NGC253, M82 or NGC1808 contain hundreds of such clusters, while in the exceptional case of young mergers like the Antennae galaxies their numbers can surpass one thousand.

As of today, several questions remain matters of hot debate, among them:

- What are the specific physical conditions which lead to the formation of YMCs in starbursts, and in particular, what is the role –if any– of the active galactic nucleus (AGN) often observed at the centre of actively star forming galaxies? Is the long-standing claim of an AGN-starburst association (at face-value still unproven) a favourable factor for the formation of massive star clusters? Is this factor related to the infall of material toward the AGN?
- What is the fraction of stars which were indeed born in YMCs and is there a connection between the YMCs observed in starbursts and the evolved globular clusters in the halos of galaxies?

The sizes, masses and stellar velocity dispersions of YMCs are comparable to those of globular clusters. Conversely, the ages of these two classes of objects differ by a factor 1000: while the oldest globular clusters are nearly as old as the universe (~13 Gyr), young massive clusters are only a few to 100 Myr old. Numerical simulations as well as analysis of the observed cluster mass distribution in the two classes of objects suggest that only the most massive clusters remain bound through a Hubble time, while the least massive ones are dispersed, providing a potential reservoir for field stars (Fall & Zang 2001). Under such a scenario, the YMCs would be the progenitors of stars currently gravitationally bound in globular clusters or stars in the field, depending on their initial mass. Whether the observed stellar mass function in young massive clusters is consistent, after the stellar population has evolved, with that observed in globular clusters, remains an open and controversial point (Elmegreen 1999).

One of the limitations in the study of star formation processes within starbursts arises from the fact that most analyses of YMCs have focused on their optical properties. Yet, there is strong evidence that some young massive clusters are almost completely obscured by dust, and hence invisible in the optical. In such cases, only infrared (IR) or radio studies can reveal their presence. The first outstanding example of such embedded YMCs is to be found in the Antennae galaxies, where Mirabel et al. (1998), comparing mid-infrared (MIR) ISO images with HST optical images, discovered a powerful star forming region which was detectable only on the MIR images. Just a few other examples of such intense –and hidden– star forming activity are known to date. However, the near future –with MIR instruments such as VISIR on the VLT– promises many more discoveries and a better understanding of the starburst phenomenon and of its implications on the evolution of galaxies.

We present in the following how new populations of embedded young massive clusters were uncovered in NGC1365 and NGC1808, and illustrate the potentialities of NIR spectroscopy for the study of these objects.

Associated MIR/radio sources: embedded star clusters?

Let us now focus on NGC1365 and NGC1808. These two galaxies have long been known to display enhanced star formation in their central region (radius between 500pc and 1kpc) and to host an AGN. In both cases, HST has resolved out a population of bright (un-embedded), compact and young star clusters, in the star bursting central region.

In parallel, high-angular resolution radio

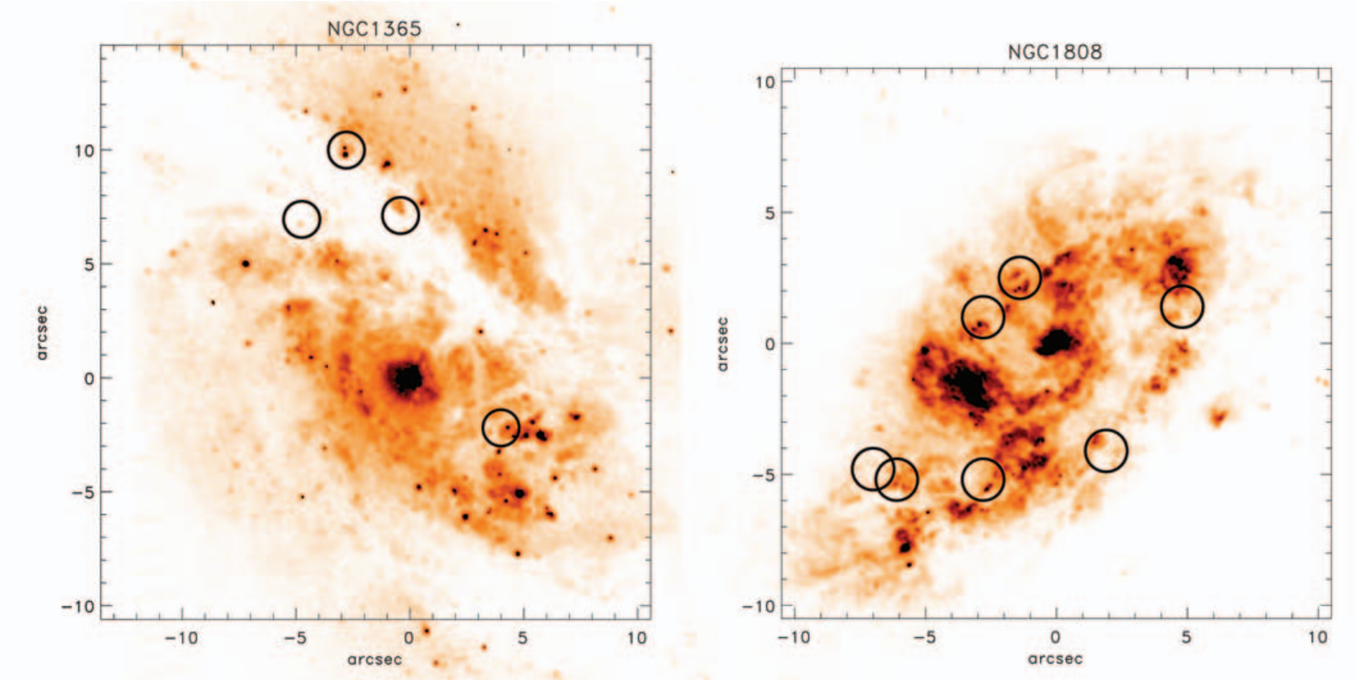

Figure1: Archive HST images of the starburst regions of NGC1365 (F814W) and NGC1808 (F658N). These galaxies are respectively located at 18.6Mpc and 10.9Mpc, translating into linear scales of 90 pc/″ and 50 pc/″. North is up and East is left. The circles show the locations of the brightest compact centimetre radio sources (Forbes & Norris 1998 and Collison et al. 1994). The lack of correlation between the structures seen in the optical and the radio sources is striking.

maps have been obtained at centimetre wavelengths and unveiled the presence of a population of circumnuclear bright radio sources. Interestingly, the positions of these sources do not match the positions of the brightest optical knots detected with HST. Figure 1 displays archive optical images obtained with HST/WFPC2, on top of which circles mark the positions of the brightest observed centimetre sources. The observed centimetre spectral index of the sources indicates the presence of non-thermal processes: as no obvious optical counterpart to most of the radio sources could be found, they were proposed to be individual radio supernovae. Indeed, radio supernovae are intense synchrotron sources that appear and disappear within periods of months to years after Type II or Type Ib supernovae events. However, because of the short lifetime of radio supernovae, the fact that several of the centimetre sources could be observed simultaneously made this interpretation rather unlikely, and the nature of these sources remained somewhat mysterious.

Recently, we have obtained high angular resolution images with 3.6m/TIMMI2 at La Silla, and discovered the bright MIR counterparts of these radio sources (Galliano et al. 2004). Hence, the whole picture gets clearer: they can now be interpreted as the signature of young embedded massive clusters. Rough estimates of their ages and masses corroborate this interpretation: from their centimetre and MIR fluxes, and from their spectral indexes, these embedded clusters are found to have masses on the order of 10^6 solar masses, and ages of a few million years. The observed non-thermal component at centimetre wavelengths can result from a high rate of supernovae, coinciding with the evolutionary stage of the star cluster population when the most massive stars undergo collapse (one every few thousand years). Still, the MIR observations only provide indirect evidence of the presence of massive young star clusters associated with the radio and MIR sources. Some more direct evidence ought to be found, such as signatures of the strong ultraviolet radiation field expected from the massive young stars.

Searching for HII regions through the dust

In this section, we present new data obtained with VLT/ISAAC, which give direct evidence for the presence of massive young star clusters associated with the compact radio/MIR sources in the circumnuclear regions of NGC1365 and NGC1808.

At the early evolutionary stages of a star cluster, very massive stars are still present, and until an age of about 6 Myr, the emission is dominated by nebular lines and continuum from the ionised regions (called HII regions) surrounding the massive hot stars, rather than by stellar photospheric emission. Hence, a direct proof that the radio/MIR sources are indeed young massive clusters is the detection of the nebular emission excited by the ionising photons emitted by the massive stars. There were good reasons to search for such a proof in the NIR: the effects of extinction are minimised and a wealth of nebular lines are present in this wavelength range. Nebular lines from embedded star clusters had so far only been detected in two sources, namely the Antennae Galaxy and NGC5253, respectively by Gilbert et al. (2000) and Turner et al. (2003) with NIRSPEC on the Keck telescope.

Using ISAAC/VLT, we have obtained *K* (2.2μm) and *L* (3.5μm) images of NGC1365 and NGC1808, as well as low resolution spectra of the brightest radio/MIR sources. The results are displayed in Fig. 2. Composite colour images (Red=10μm, Green=3.5μm and Blue=2.2μm) are shown together with the *K*-band (1.9-2.4μm) and *L*-band (3.2–4.2μm) spectra of the reddest sources. These coincide spatially with the intense radio centimetre sources mentioned above. The nebular emission from the HII regions surrounding the most massive stars still present in these clusters is clearly detected through Hydrogen recombination

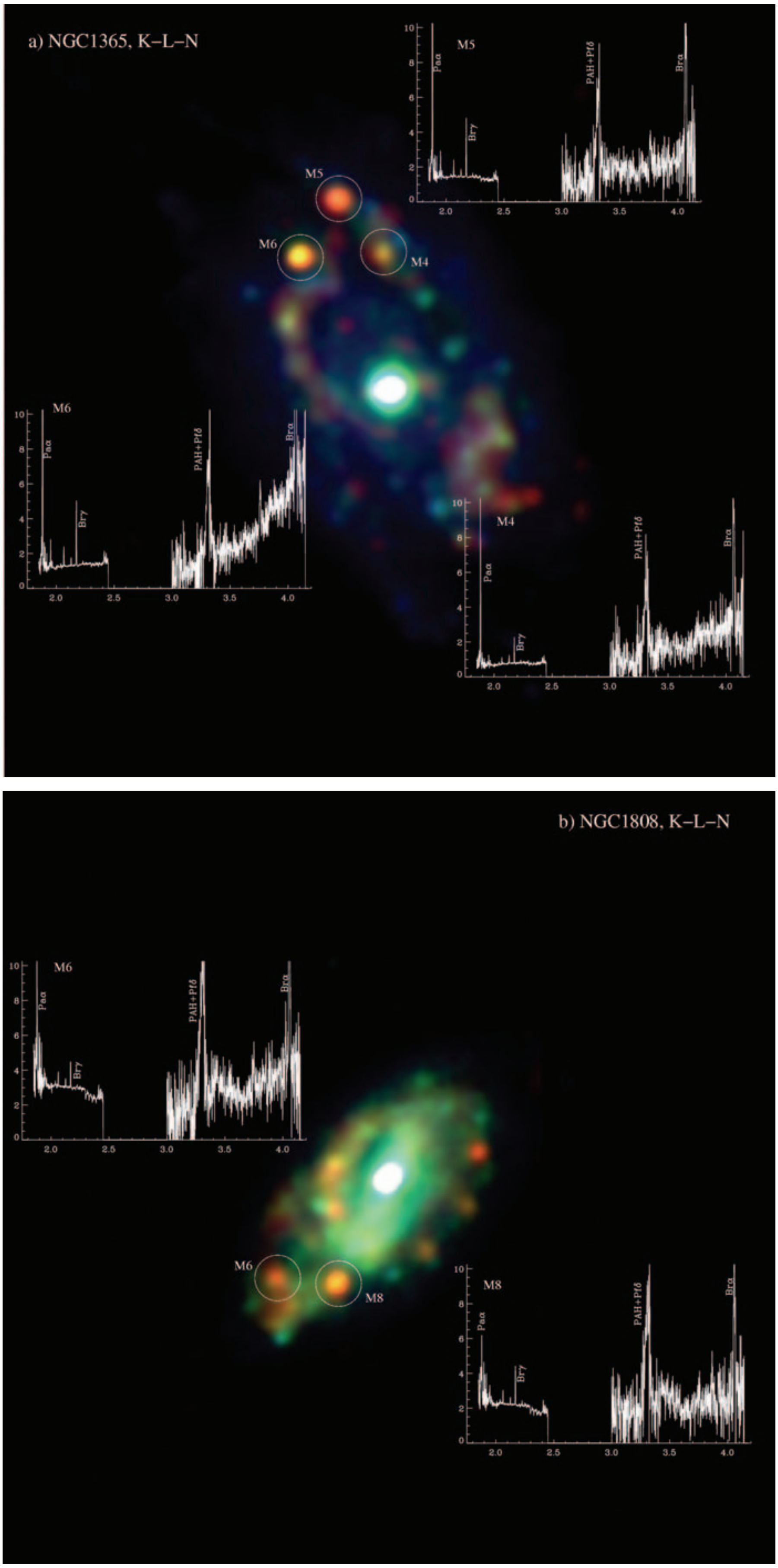

Figure2: Composite colour images of the central region of NGC1365 (a) and NGC1808 (b). Blue corresponds to the *K*-Band (2.2μm), green to the *L*-band (3.5μm) and red to the *N*-band (10μm). The dimensions of the image are 40″ × 40″ (3.6kpc × 3.6kpc for NGC1365 and 2.1kpc × 2.1kpc for NGC1808). North is up, East is left. The central bright source on each image is the AGN. The reddest sources in the circum-AGN environment identify the deeply embedded young massive star clusters, found in spatial coincidence with the observed intense centimetre radio sources. The nature of these sources is directly revealed by the *K*- and *L*-band spectra, given for the circled sources. The X-axis of each plot shows the wavelength in μm and the Y-axis the flux density in mJy. Between approximately 2.5μm and 3μm, the opacity of the atmosphere does not allow to record data from the ground. Nebular lines arising from the ionised regions surrounding the massive stars are detected (Paα, Brδ, Brγ, Pfγ and Brα). Moreover, the spectra show H_2 and PAH emission excited in the photo-dissociation regions surrounding the clusters. For clarity, only the most prominent lines were labelled. The observations were made with VLT/ISAAC in the *K*- and *L*-bands, and with TIMMI2 in the *N*-band.

lines (by increasing wavelength: Paα, Brδ, Brγ, Pfγ and Brα). Several H_2 lines are detected in the *K*-band spectrum and a clear signature of PAH emission is seen at 3.3μm. These molecular lines trace the emission from photo-dissociation regions (PDR) surrounding the clusters and are excited by far UV radiation from the massive stars. The analysis of these observations will be presented in a forthcoming paper.

The results presented above illustrate the potential of IR imaging and spectroscopy for the study and understanding of star cluster formation processes.

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TWO NEW VERY HOT JUPITERS IN THE FLAMES SPOTLIGHT

RADIAL VELOCITY FOLLOW-UP OF 41 OGLE PLANETARY TRANSIT CANDIDATES CARRIED OUT WITH THE MULTI-OBJECT SPECTROGRAPH FLAMES ON THE 8.2-M VLT KUEYEN TELESCOPE HAS REVEALED THE EXISTENCE OF JUPITER-MASS COMPANIONS AROUND TWO TRANSIT CANDIDATES. THEY ARE EXTREMELY CLOSE TO THEIR HOST STARS, ORBITING THEM IN LESS THAN 2 DAYS.

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FOR CENTURIES, THE BRIGHTNESS variations of the star Algol inspired the superstitions and fears of ancient cultures. The Ancient Arabs referred to Algol as the Al-Ghul, which means "The Ghoul" or "Demon Star", and Ri'B al Ohill, the "Demon's Head" while for the Greeks its behaviour was attributed to a pulsing eye of the Gorgon Medusa. John Goodricke in 1782 was the first to explain correctly the Algol variability by assuming the existence of a darker companion which eclipses the brighter star of a binary system. The binary nature of Algol was confirmed in 1889 by Hermann Carl Vogel who found periodic Doppler shifts in the spectrum of Algol A (spectral class B8V), and the overlaying spectrum of the companion, Algol B, of type Am. In March of this year, photometry and spectroscopy working in tandem again led to the discovery of two new giant planets belonging to the (still rare) family of the very hot Jupiters.

Since the pioneering discovery of 51Peg B by Mayor and Queloz in 1995, more than 120 extra-solar planets have been discovered so far. Almost all of them have in common the fact that their presence was revealed by radial velocity surveys, which consist in the monitoring of the periodic wobble of the spectral lines of the host star caused by the gravitational influence of its planet. Nonetheless, similar to the anecdotal example of Algol, planets can also reveal their existence by the imprints left in the light curve of their host stars. In order for a planetary transit to happen, the angle between the plane where the planet lies and the imaginary line joining our telescope to the host star should be close to zero. The probability of such alignment is roughly proportional to the ratio of the radius of the host star to the size of the orbit of the planet. This probability lies at 0.5% for planets orbiting at 1AU and rises up to 10% for those orbiting at 0.05AU. Looking at orbital properties of the extra-solar planets known to date around solar-like stars, we see that only 0.7% of them orbit at distances smaller than 0.05AU (which corresponds to an orbital period less than 4 days). If we further assume that 50% of stars are binaries for which planets are not expected to exist, we end up with the conclusion that in a sample of 3000 stars we should find only one planetary transit! Adding the fact that astronomical nights have a finite length (i.e, we only observe at night!) and that not all nights are clear nights, we can certainly consider the figures presented above as optimistic. Thus in reality, the probability of observing a transit is much smaller than 1/3000. Another important issue is the accuracy of the photometric measurement. Given the relative size of the planetary disc as compared to the stellar one, the observations of planetary transits are somewhat challenging and require a photometric precision of the order of a few millimagnitudes. The bottom line is simple: in order to find planets through photometric transits we need to be able to observe with high accuracy, for a long time, a huge number of stars.

This is exactly what the OGLE (Optical Gravitational Lensing Experiment) team has accomplished. Started more than one decade ago, the OGLE program was originally designed to detect microlensing events via photometric monitoring of a huge number of stars (of the order of millions of stars) in the Galactic bulge and Magellanic Clouds. OGLE not only found hundreds of microlensing events but also contributed to many other fields. In particular the second phase of the OGLE survey (Udalski et al. 2002) detected 62 short-period multi-transiting objects located in the direction of the constellation of Carina for which planets could be the root cause.

FLAMES: THE RELEVANCE OF THE ThAr TECHNIQUE IN A 8-M CLASS TELESCOPE

Although the shape of the light dip in the light curve can already give suspicions concerning the nature of the transiting object, its final characterization demands however spectroscopic measurements from which radial velocities will be derived, such as is done in the ongoing radial velocity surveys aimed to look for extra-solar planets. The amplitude of the radial velocity variations observed in the host star depends essentially on the mass of the planet and the size of its orbit around the host star. Typically for Hot Jupiters like 51Peg, these variations are around a hundred meters per second. These require the ability to monitor the shifts of the stellar spectra with an accuracy of about 10 m/s, i.e., to put it in terms of pixels, we need to be able to detect displacements of a spectrum on a CCD at a level of a hundredth of a pixel. Due to variations in the refractive index of air related to changes in atmospheric pressure and temperature, shifts of even a few hundred m/s per night might occur. To put it simply, all objects observed on a given night will show amplitudes at a hundred m/s level due only to the changes in the ambient conditions. Other systematic effects have to be added to this radial velocity error such as mechanical flexures, centring errors, etc.

Many of these problems were solved using fibre fed spectrographs, where one fibre is fed with the light from the object and a second fibre, called the simultaneous calibration fibre, receives light from a ThAr lamp. Comparing the ThAr emission line spectrum taken in parallel with the scientific observation with the one done in the beginning of the night, we can measure how much the spectrograph has shifted at a given time. This shift is then used to correct the shift of the fibre illuminated by the stellar light. This technique has been shown to be extremely successful in obtaining highly accurate radial velocities. The high-resolution spectrograph HARPS recently installed at the 3.6-m telescope at La Silla/ESO is state-of-the-art in the use of the simultaneous calibration technique. It can measure radial velocities to a precision of 1m/s!

The arrival of FLAMES (Fibre Large Array Multi-Element Spectrograph) to Kueyen in 2003 opened the doors of the VLT to the world of accurate radial velocities. Using the UVES-fibre link, FLAMES allows for the simultaneous observations of seven objects whose spectra are recorded in the red-arm CCD mosaic of UVES along with the emission line spectrum of the ThAr which is fed into an eighth fibre. The radial velocity accuracy is around 30–50 m/s. Work is in progress to bring these figures down to a 10–20 m/s level which requires a refinement in the reduction software to deal with this particular mode and a better characterization of the other possible sources of systematics effects (again at a level of a hundredth of a pixel).

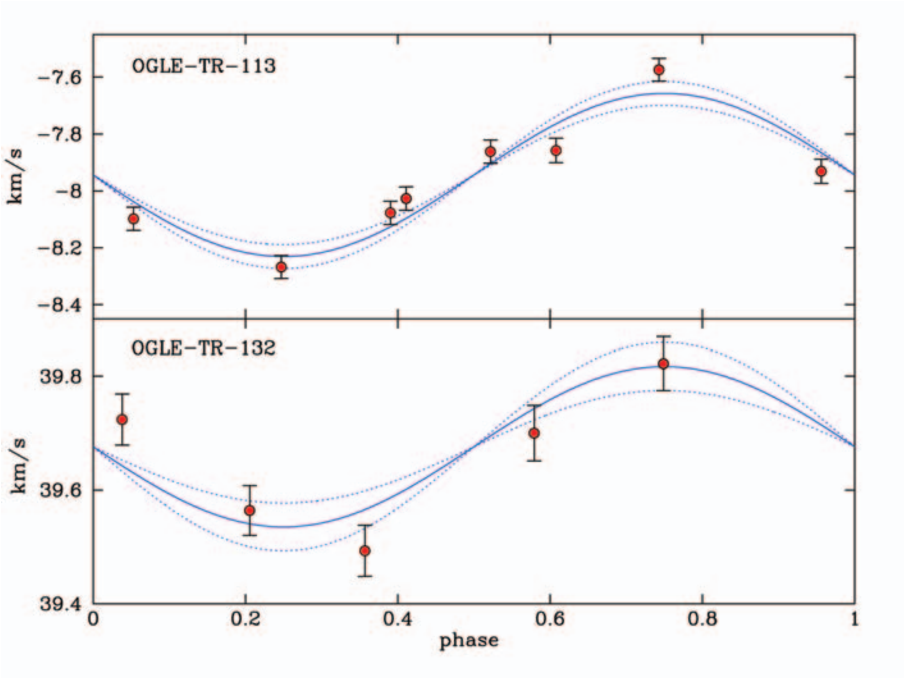

Figure 1. Phase-folded radial velocity measurements of OGLE-TR-113 and OGLE-TR-132 with the respective orbital solution (solid line). The dotted lines correspond to fit curves for lower and upper 1-sigma intervals in the semi-amplitude K of the radial velocity curve which is directly related to mass of the planet; the larger the semi-amplitude K, the more massive the planet is.

Very Hot Jupiters

The association of the collecting power of a 8-m class telescope with the simultaneous calibration technique makes FLAMES a superb instrument to look for extra-solar planets around faint stars such as the transit candidates found by OGLE, which have visual magnitudes around 16.

Thus, during eight consecutive half-nights in March 2004, Kueyen pointed towards the constellation Carina and the UVES red-arm CCD mosaic gradually received the light of the 41 OGLE top transit candidates. The data were reduced and analysed during the second half of each night. Objects showing large radial velocity variations (to a km/s level) as expected for the case of spectroscopic binaries, or showing large rotation as a sign of orbital synchronization resulting from tidal effects, were excluded. A few days later, when all velocity points collected during the 8 half-nights were analysed together, two new planets emerged from the data – one around OGLE-TR-113 and another around OGLE-TR-132! The phase-folded radial velocities of OGLE-TR-113 and OGLE-TR-132 are shown in Figure 1.

Orbital parameters of the systems and their physical parameters such as radii and masses for the host star and its planet can be

Name	Period (d)	Radius (R_J)	Mass (M_J)
OGLE-TR-56	1.21	1.23 ± 0.16	1.45 ± 0.23
OGLE-TR-113	1.43	$1.08^{-0.05}_{+0.07}$	1.35 ± 0.22
OGLE-TR-132	1.69	$1.15^{-0.13}_{+0.8}$	1.01 ± 0.31
HD209458	3.52	1.35 ± 0.02	0.69 ± 0.06
Jupiter	4332	1	1
Saturn	10756	0.84	0.3

Table 1. Properties of the four known transiting extrasolar planets. Jupiter and Saturn are listed for comparison.

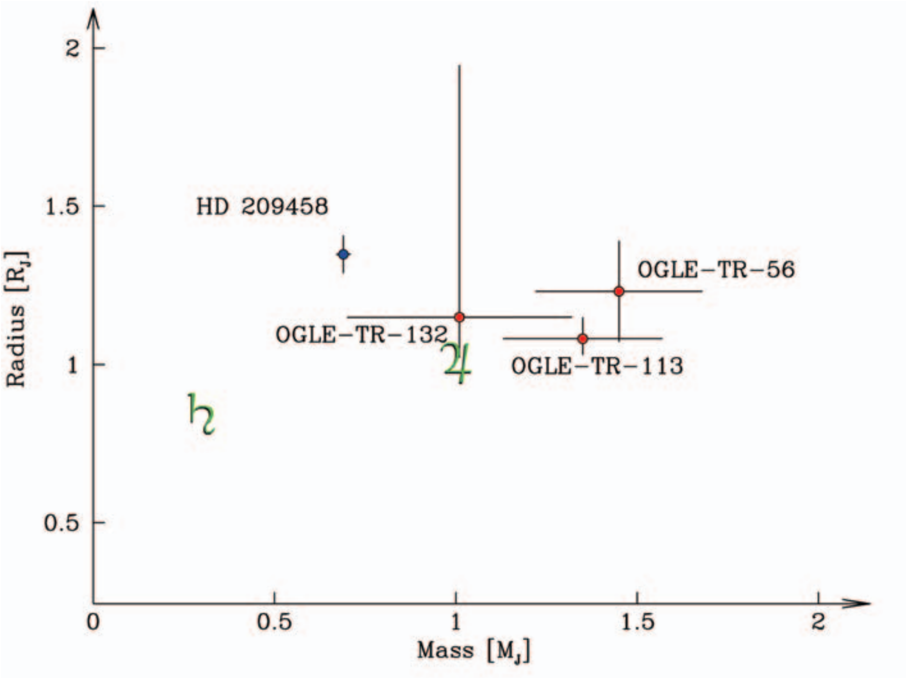

Figure 2. The four known transiting extrasolar planets plotted in the Mass-Radius diagram. The red solid points represent the three planets found by the OGLE survey. HD209458 (Charbonneau et al. 2000) is shown as a blue point. Jupiter and Saturn are indicated for sake of comparison.

derived when the spectroscopic, kinematic and photometric information are analysed together. The stellar spectrum yields the spectroscopic characteristics of the host star such as gravity, effective temperature and metallicity which are needed as input parameters for the combined analysis of the radial velocity curve and light curve which, in turn, contain information about the masses of star-planet system and geometry of the system (i.e., size of the transiting body and orbital inclination, for instance). Orbital periods, radii and masses derived by Bouchy et al. (2004) for OGLE-TR-113 and OGLE-TR-132 are summarized in Table 1. Also indicated in Table 1 are the characteristics of the other two transiting extrasolar planets known to date plus our own giant planets (Jupiter and Saturn). For OGLE-TR-113, the parent star is of the K-type (cooler and less massive than the Sun) and is located at a distance of about 1200 light-years. The orbiting planet is about 35% heavier and its diameter is 10% larger than that of Jupiter. It orbits the star once every 1.43 days at a distance of only 3.4 million km (0.0228 AU). By comparison, in our own solar system, Mercury is 17 times farther away from the Sun. The surface temperature of that planet, which like Jupiter is a gaseous giant, is correspondingly higher, probably above 1800 °C. The OGLE-TR-132 system is about 6000 light-years far from the Sun. This planet is about as heavy as Jupiter and about 15% larger. It orbits an F-dwarf star (slightly hotter and more massive than the Sun) once every 1.69 days at a distance of 4.6 million km (0.0306 AU). The photometric transit observed by OGLE is close to the detectability limit. As a consequence, the derived physical parameters are not as well constrained as for OGLE-TR-132. New photometric observations carried out with FORS2 are on the way to help to better constrain its light curve. In Figure 2 we compare the radii and masses of all four transiting giant planets found so far with Jupiter and Saturn. In spite of their very short orbital periods, they are quite similar to our own Jupiter.

The discovery of OGLE-TR-113 and OGLE-TR-132 shows that in spite of being quite rare, the case of OGLE-TR-56 (Konacki et al. 2003) is not an isolated and bizarre event of Nature. The distribution of orbital periods of the extra-solar planets discovered so far suggests that planets around the Jupiter mass pile up at an orbital period around three days (Udry et al. 2003). The three very hot Jupiters recently found provide evidence that in fact the three days of orbital period does not represent an absolute limit for the existence of giant planets. In addition, the fact that the spectral types of the host stars span from F to K also suggest that very hot Jupiters are possible around different types of stars.

The Future: space missions

The complementarity of the transit and radial velocity techniques now opens the door towards a detailed study of the true characteristics of exoplanets. Space-based searches for planetary transits – like the COROT and KEPLER missions, scheduled to fly in the coming years, will yield hundreds of transit candidates. With instruments like HARPS and FLAMES, the European extra-solar planet community (or the *planet hunters* as the media like to call us) is in an excellent position to take the lead in the ground-based radial velocity follow-up, which will in the future lead to the characterization of other worlds. Hopefully the fruitful tandem started in the 18th century will keep unmasking many other ghouls throughout the sky for years to come!

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New VLT/NACO Images of Titan

As a complement to the NASA/ESA Cassini/Huygens mission, new VLT/NACO images have been obtained of the atmosphere and surface of Titan, the largest moon in the Saturnian system.

(based on ESO press photos 08a-c/04 and ESO Press Release 09/04)

Titan, the largest moon of Saturn was discovered by Dutch astronomer Christian Huygens in 1655 and certainly deserves its name. With a diameter of no less than 5,150 km, it is larger than Mercury and twice as large as Pluto. It is unique in having a hazy atmosphere of nitrogen, methane and oily hydrocarbons. Although it was explored in some detail by the NASA Voyager missions, many aspects of the atmosphere and surface still remain unknown. Thus, the existence of seasonal or diurnal phenomena, the presence of clouds, the surface composition and topography are still under debate. There have even been speculations that some kind of primitive life (now possibly extinct) may be found on Titan.

Titan is the main target of the NASA/ESA Cassini/Huygens mission, launched in 1997 and scheduled to arrive at Saturn on July 1, 2004. The ESA Huygens probe is designed to enter the atmosphere of Titan in early 2005, and to descend by parachute to the surface.

Ground-based observations are essential to optimize the return of this space mission, because they will complement the information gained from space and add confidence to the interpretation of the data. Hence, the advent of the adaptive optics system NAOS-CONICA (NACO) in combination with the VLT now offers a unique opportunity to study the resolved disc of Titan with high sensitivity and increased spatial resolution, and two research teams have recently reported their results on Titan.

Images of Titan

A team of French astronomers [1] used the NACO state-of-the-art adaptive optics system on the fourth 8.2-m VLT unit telescope (Yepun) in November 2002 and 2003, to map the surface of Titan by means of near-infrared images and to search for changes in the dense atmosphere. These extraordinary images have a nominal resolution of 1/30th arcsec and show details of the order of 200 km on the surface of Titan. To provide the best possible views, the raw data from the instrument were subjected to deconvolution (image sharpening).

Images of Titan (figs. 1–3) were obtained through 9 narrow-band filters, sampling near-infrared wavelengths with large

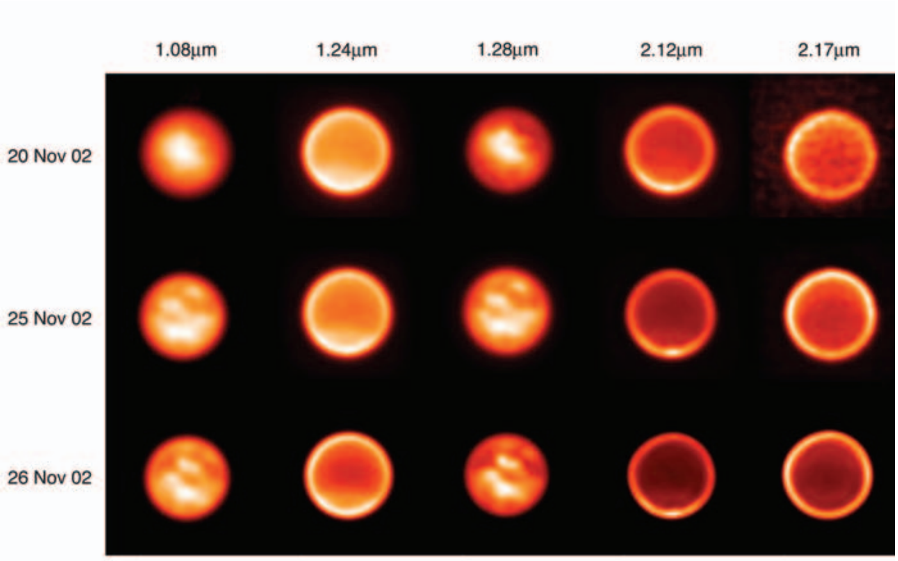
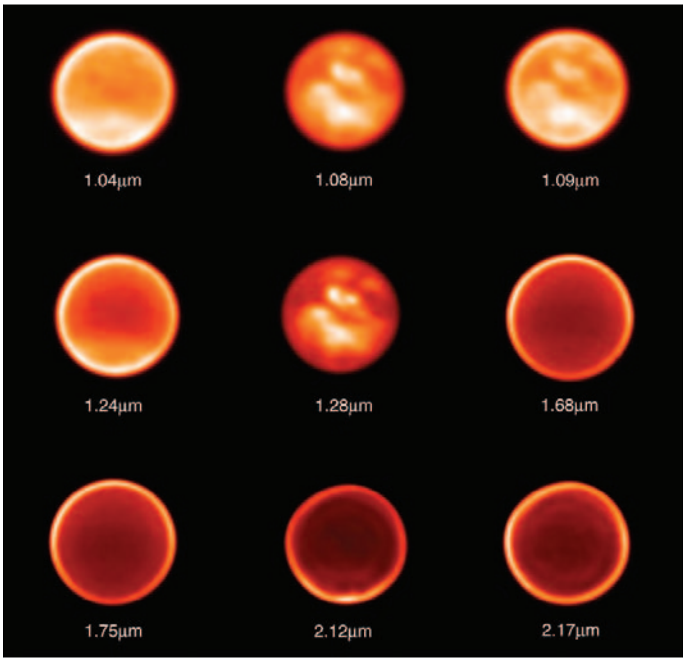


Figure 1 shows Titan (apparent visual magnitude 8.05, apparent diameter 0.87 arcsec) as observed with the NAOS/CONICA instrument at VLT Yepun on November 20, 25 and 26, 2002, between 6.00 UT and 9.00 UT. The median seeing values were 1.1 arcsec and 1.5 arcsec respectively for the 20th and 25th. Deconvoluted ("sharpened") images of Titan are shown through 5 different narrow-band filters - they allow to probe in some detail structures at different altitudes and on the surface. Depending on the filter, the integration time varies from 10 to 100 seconds. While Titan showed its leading hemisphere (i.e. the one observed when Titan moves towards us) on Nov. 20, the trailing side (i.e the one we see when Titan moves away from us in its course around Saturn) - which displays less bright surface features - was observed on the last two dates.

Figure 2: Images of Titan taken on November 26, 2002 through nine different filters to probe different altitudes, ranging from the stratosphere to the surface. On this night, a stable "seeing" (image quality before adaptive optics correction) of 0.9 arcsec allowed the astronomers to attain the diffraction limit of the telescope (0.032 arcsec resolution). Due to these good observing conditions, Titan's trailing hemisphere was observed with contrasts of about 40%, allowing the detection of several bright features on this surface region, once thought to be quite dark and featureless.



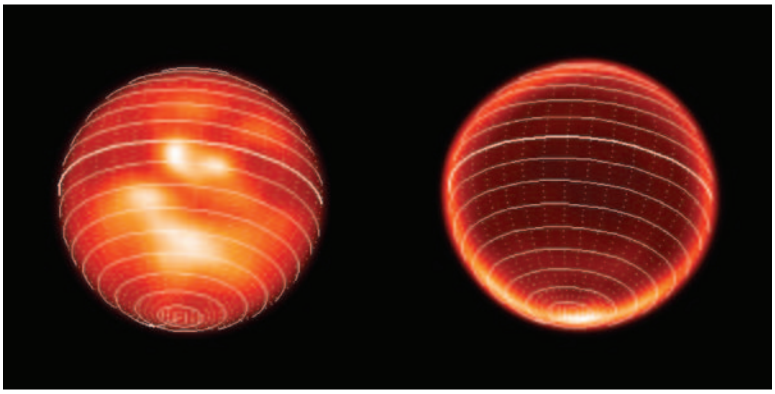


Figure 3: Titan images obtained with NACO on November 26th, 2002. Left: Titan's surface projection on the trailing hemisphere as observed at 1.3 µm, revealing a complex brightness structure thanks to the high image contrast of about 40%. Right: a new, possibly meteorological, phenomenon observed at 2.12 µm in Titan's atmosphere, in the form of a bright feature revolving around the South Pole.

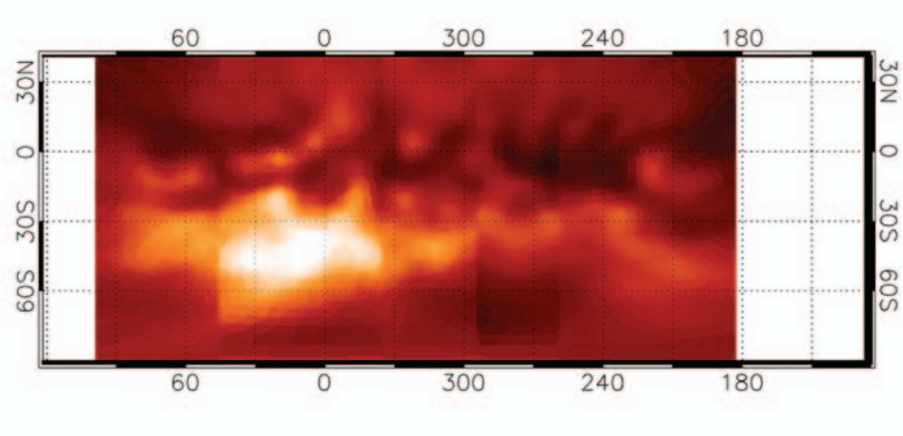


Figure 4: This shows the clearest view of Titan's surface available so far. It was obtained through a "transparent", narrow spectral window with the 8.2-m VLT YEPUN telescope and the NACO adaptive optics instrument operated in the Simultaneous Differential Imager (SDI) mode. It covers about three-quarters of the full surface and has an image resolution (sharpness) of 0.06 arcsec, corresponding to 360 km on the surface. One degree of longitude on the equator corresponds to 45 km on Titan's surface. The brightness is proportional to the surface reflectivity. The nature of the various regions is still unknown although it is speculated that the darkest areas may indicate the extent of reservoirs of liquid hydrocarbons.

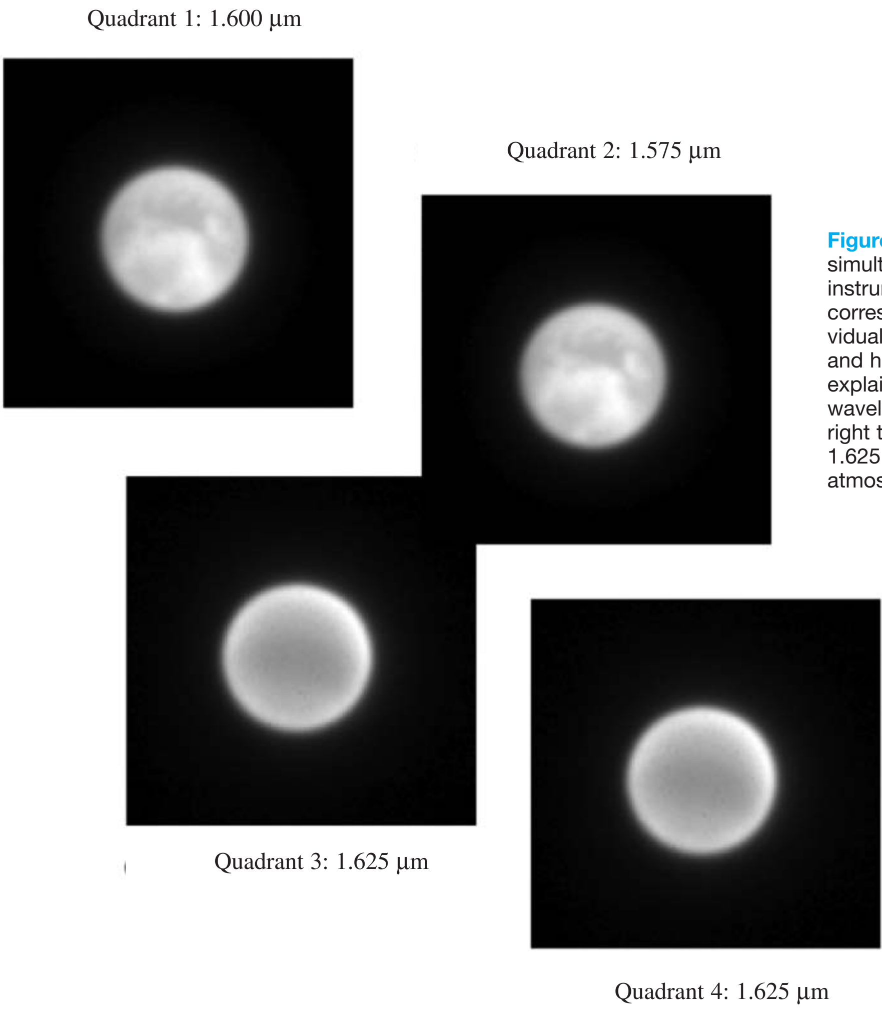


Figure 5 shows four images of Titan, obtained simultaneously with the NACO adaptive optics instrument in the SDI observing mode with the corresponding wavebands indicated. The individual images have a diameter of 0.86 arcsec and have here been magnified for clarity. As explained in the text, the images obtained at wavelengths 1.575 and 1.600 µm penetrate right to the surface while the images at 1.625 µm show the comparatively featureless atmosphere.

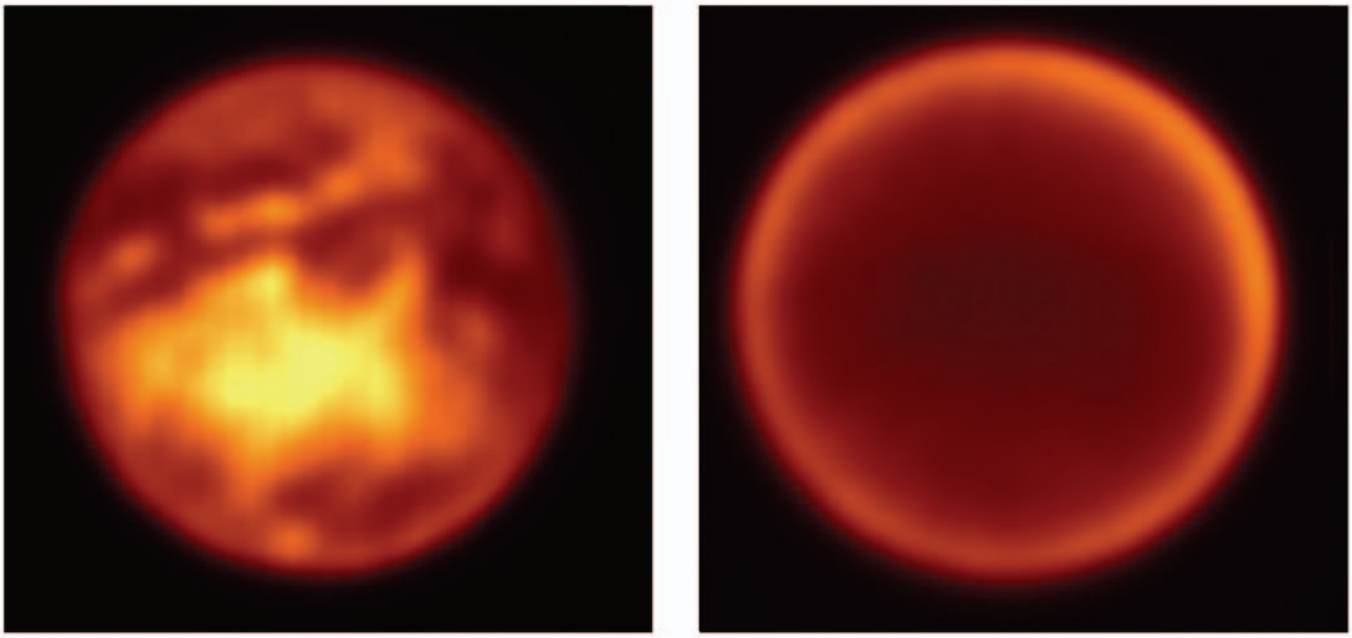


Figure 6 shows simultaneous images of Titan, obtained on February 7, 2004, with NACO in SDI mode. Left: at 1.575 µm with a clear view towards the surface. Right: at 1.625 µm, where the atmosphere appears entirely opaque.

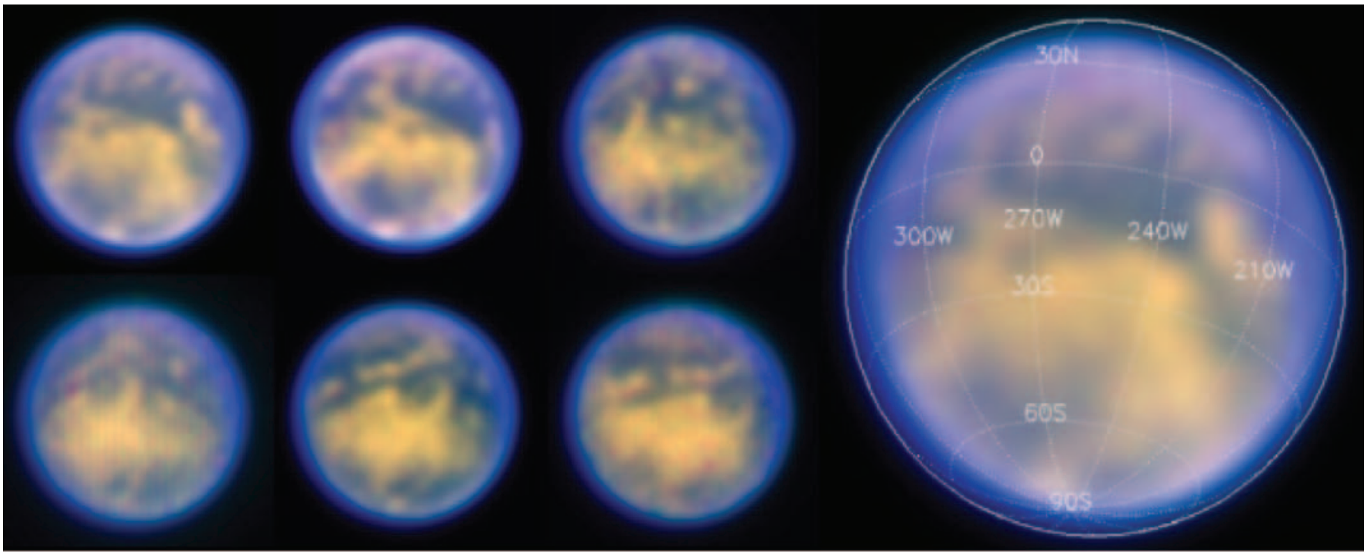


Figure 7 shows views of Titan, obtained on six nights in February 2004. At the right, the image from the first night (Feburary 1-2, 2004) has been enlarged for clarity and the coordinate grid on Titan is indicated. The images are false-colour renderings with the three SDI wavebands as red (1.575 µm; surface), green (1.600 µm; surface) and blue (1.625 µm; atmosphere), respectively.

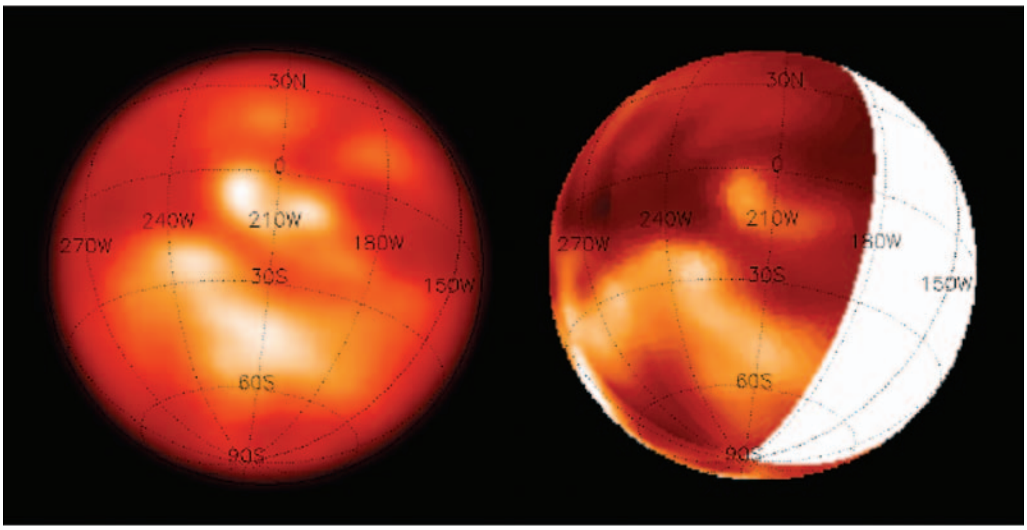


Figure 8: Earlier image of Titan by NACO, obtained in a waveband at 1.3 µm that does not perfectly match an atmospheric window (cf. Fig. 3) is compared to a new SDI-NACO image of the same region (right). The greater clarity and contrast of the latter is evident; it is due to the smaller degree of “atmospheric contamination”.

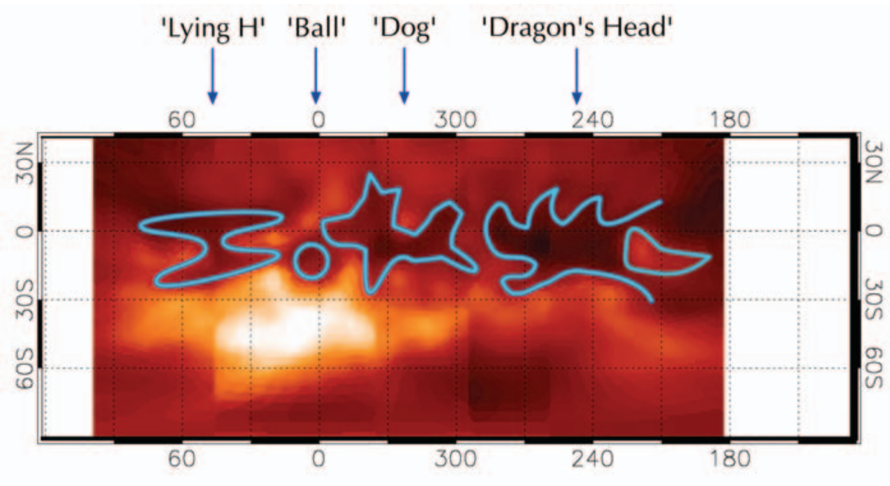


Figure 9 identifies the low-reflection areas now seen on the surface of Titan and which were given provisional names by the research team [2]; see the text.

variations in methane opacity. This permits sounding of different altitudes ranging from the stratosphere to the surface. Titan harbours a north-south asymmetry at 1.24 and 2.12 µm, while the opposite is observed with filters probing higher altitudes, such as 1.64, 1.75 and 2.17 µm. A high-contrast bright feature is observed at the South Pole and is apparently caused by a phenomenon in the atmosphere, at an altitude below 140 km or so. This feature was found to change its location on the images from one side of the south polar axis to the other during the week of observations.

SDI Views of Titan: the Quest for the Surface

To best observe the surface of Titan, one ideally looks in a spectral band in which the atmosphere is completely transparent. In February 2004, another team [2] working at the VLT obtained images of Titan's surface through a spectral window near wavelength 1.575 µm with unprecedented spatial resolution and with the lowest contamination of atmospheric condensates to date.

They accomplished this during six nights in February 2004, at the time of the commissioning phase of a novel high-contrast imaging mode for the NACO adaptive optics instrument on the 8.2-m VLT YEPUN telescope, using the Simultaneous Differential Imager (SDI, [3]). This novel optical device provides four simultaneous high-resolution images (Fig. 5) at three wavelengths around a near-infrared atmospheric methane absorption feature.

The main application of the SDI is high-contrast imaging for the search for substellar companions with methane in their atmosphere, e.g. brown dwarfs and giant exoplanets, near other stars. However, as the present photos demonstrate, it is also superbly suited for Titan imaging.

Titan is tidally-locked to Saturn, and hence always presents the same face towards the planet. To image all sides of Titan (from the Earth) therefore requires observations during almost one entire orbital period, 16 days. Still, the present week-long observing campaign enabled the team to map approximately three-quarters of the surface of Titan.

A new map of the surface of Titan (in cylindrical projection and covering most, but not all of the area imaged during these observations) is shown in Fig. 4. For this, the simultaneous "atmospheric" images (at waveband 1.625 µm) were "subtracted" from the "surface" images (1.575 and 1.600 µm) in order to remove any residual atmospheric features present in the latter. The ability to subtract simultaneous images is unique to the SDI camera.

This truly unique map shows the fraction of sunlight reflected from the surface – bright areas reflect more light than the darker ones. The amount of reflection (in astronomical terms: the "albedo") depends on the composition and structure of the surface layer and it is not possible with this single-wavelength ("monochromatic") map alone to elucidate the true nature of those features.

Nevertheless, recent radar observations with the Arecibo radiotelescope have provided evidence for liquid surfaces on Titan, and the low-reflection areas (dark in Fig. 4 and 9) could indicate the locations of those suspected reservoirs of liquid hydrocarbons. They also provide a possible source for the replenishment of methane that is continuously lost in the atmosphere because of decomposition by the sunlight.

Presumably, the bright, highly reflective regions are ice-covered highlands.

A comparison of Fig. 8 with Fig. 3 obtained through another filter is useful. It demonstrates the importance and gain of clarity of employing a filter that precisely fits the atmospheric window. It also provides independent confirmation of the reality of the gross features, since the observations are separated by 15 months in time.

Over the range of longitudes which have been mapped in Fig. 4, it is obvious that the southern hemisphere of Titan is dominated by a single bright region centered at approximately 15° longitude. (Note that this is not the so-called "bright feature" seen in HST images at longitude 80°–130°, an area that was not covered during these VLT observations).

The equatorial area displays the above mentioned, well-defined dark (low-reflection) structures. In order to facilitate their identification, the team decided to give these dark features provisional names – official names will be assigned at a later moment by the *Working Group on Planetary System Nomenclature* of the *International Astronomical Union* (IAU WGPSN). From left to right, the SDI team has referred to these features informally as: the "lying H", the "dog" chasing a "ball", and the "dragon's head".

More VLT observations of Titan will be made in the coming months, with the goal of assisting the Cassini-Huygens team in the interpretation and understanding of what will certainly be a rich and complex flow of information about this enigmatic moon.

Notes

[1] The results presented at the beginning of this article are based on an article published in *Astronomy & Astrophysics* (A&A 417, L21-24, 2004): "VLT/NACO adaptive optics imaging of Titan" by E. Gendron et al. The team is composed of Eric Gendron, Athéna Coustenis, Pierre Drossart, Michel Combes, Mathieu Hirtzig, François Lacombe, Daniel Rouan, Claude Collin, and Sylvain Pau (LESIA, Observatoire de Paris, CNRS, France), Anne-Marie Lagrange, David Mouillet, Patrick Rabou (Laboratoire d'Astrophysique, Observatoire de Grenoble, France), Thierry Fusco (ONERA) and Gérard Zins (ESO).

[2] The SDI work is described in detail in a research paper "First surface map of Titan at 1.575 microns" by M. Hartung et al., in press in *Astronomy & Astrophysics*.The team is composed of Markus Hartung (ESO-Chile), Laird M. Close (Steward Observatory, University of Arizona, Tucson, USA), Rainer Lenzen, Tom M. Herbst and Wolfgang Brandner (Max-Planck Institut for Astronomie, Heidelberg, Germany), Eric Nielsen and Beth Biller (Steward Observatory, University of Arizona, Tucson, USA), and Olivier Marco and Chris Lidman (ESO-Chile).

[3] The novel Simultaneous Differential Imager (SDI) is a special set of optics mounted into the near-infrared camera CONICA on VLT YEPUN. It is comprised of a double calcite Wollaston prism responsible for the quad beam splitting and a special four-quadrant narrow-band filter that is located directly in front of the detector. It was developed and deployed by Laird Close (Steward Observatory, University of Arizona) and Rainer Lenzen (Max-Planck-Institut für Astronomie in Heidelberg) in collaboration with ESO. NACO is an abbreviation of NAOS/CONICA. The NAOS adaptive optics corrector was built, under an ESO contract, by Office National d'Etudes et de Recherches Aérospatiales (ONERA), Laboratoire d'Astrophysique de Grenoble (LAOG) and the LESIA and GEPI laboratories of the Observatoire de Paris in France, in collaboration with ESO. The CONICA infra-red camera was built, under an ESO contract, by the Max-Planck-Institut für Astronomie (MPIA) (Heidelberg) and the Max-Planck Institut für Extraterrestrische Physik (MPE) (Garching) in Germany, in collaboration with ESO.

Venus Transit 2004: A Tremendous Success!

Henri Boffin & Richard West (ESO)

On June 8, a large part of the world shared a unique sight never seen before by any person now living. During a little more than six hours, planet Venus crossed the face of the Sun, offering a wonderful show for everybody to admire. And luckily, the observing conditions were rather favourable in large areas of the world.

Reports received testify to an extremely large numbers of public events spread over all continents. It appears that even the VT-2004 National Nodes, set up by the VT-2004 programme to, among others, provide access to comprehensive guides to events in their respective regions and countries in the local languages via their individual web-sites, are still struggling to get the full picture in their own area. Many events were indeed organized by the VT-2004 National Nodes and by other VT-2004 Network Members. Just to give a small hint of what was going on, here are some brief excerpts from recent reports by a few of the VT-2004 National Nodes:

Germany: Among the many public events, the most spectacular one in this country may have been that in the castle garden of Schwetzingen (a city close to Mannheim), organised by the most important astronomical institutions and publishers of astronomical journals in that region – the site was specially chosen as the Venus Transit was observed from here on June 6, 1761.

Hungary: Observations and demonstrations in high schools were organized by the Hungarian Astronomical Association (HAA) with the help of the Hungarian Schoolnet Physics Section. Visual, photographic and video observations were eagerly planned by dozens of active observers and co-ordinated by the Occultation Section of the Hungarian Astronomical Association. A member of the Association travelled to northern Norway to observe the transit from Vardø, i.e., the observing site of the famous expedition by Maximilian Hell in 1769. There were also Hungarian observers in Australia and Brazil.

Malta: Observations of the Venus Transit were held in the capital city Valletta in one of its recently restored public gardens, the Upper Barrakka Gardens which were used in the 16–17th centuries by the Knights of Malta.

A few examples of Venus Transit public events all around the world: Reckange/Mess (Luxembourg), Karditsa (Greece), Wroclaw (Poland), Constantine (Algeria), Dublin (Ireland), and Cologne (Germany).

A CD-Rom containing relevant information about the event and an 11-min video of how to observe the event (prepared with the courtesy of Czech producers Herafilm and Czech TV with the collaboration of the Czech British High Commission and with the assistance of ESO and NASA) was distributed in all Maltese schools. This was greatly appreciated by all schools and by the Ministry of Education. This activity was the climax event of the Malta Astronomy Week organised from the 3rd to the 9th June 2004. Considering that that period is a peak period for tourists in Malta, brochures were also distributed in the main hotels and this event was supported by the Malta Tourism Authority.

Spain: All national newspapers and monthly magazines carried news about the Venus Transit, and the National Radio Station (RNE-Radio 5) News Service was airing daily 3-min documentaries on the Venus Transit. Information brochure were distributed to over 150 planetariums, science centres, universities, observatories, amateur groups, etc. with a total of 30,000 copies. Several museums also printed materials, with information about the VT-2004 project. Three different planetarium shows were started, in Pamplona, La Coruña, Granada and Madrid, drawing many thousands of people. A CD-ROM with multimedia presentations, information and school activities was also distributed.


The ESO Amateur Astronomer group AGAPE was present on the central market place of Garching to share this unique event.

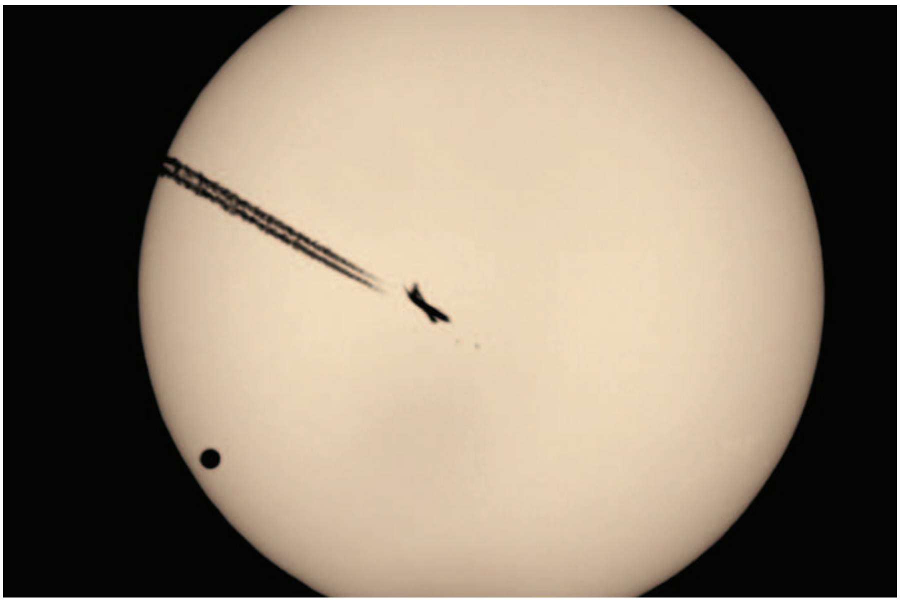
Events at ESO

Of course these were only a very minor part of the activities which took place all over the world. In Garching, the members of the ESO AGAPE amateur astronomers, in collaboration with the ESO Education and Public Relations Department, organized several activities. Apart from setting up some telescopes for ESO personnel to witness the event, a larger manifestation took place on the market place of Garching city, in close cooperation with the Garching City Council. Members of AGAPE welcomed about 1,000 persons eager to view the Venus Transit.

And for those who were as unlucky as astronomer Le Gentil in 1769 (who, having traversed a large portion of the globe, enduring all the perils of a long sea-voyage, and waiting for 8 years for the transit to occur, was unable to observe it because of a vexatious, black cloud that covered the Sun), or, more prosaically, for those who could not get to directly see the event for one reason or another, there was no need to despair. There were indeed ample opportunities to witness the event in real-time from several websites, and in particular from the VT-2004 Central Display page.

This page, powered by Akamai and therefore mirrored on many hundreds of sites all over the world, offered selected images from the event, acquired by colleagues at the large solar telescopes, from the Canary Island to China. All images were chosen and commented live by a team of professional astronomers in the "VT-2004 Control Room" at the ESO headquarters in Garching.

The Central Display was duly archived. Anybody who was unable to follow the event, can therefore still see the evolution of the Central Display in this comprehensive archive.


Credit: Observatoire de Paris/Meudon

Judging from the number of Web hits, there is no doubt that the VT-2004 web site was a resounding success. Following the record impact of the Mercury transit last year, the present one was more than ten times higher, with more than 54 millions hits on the VT-2004 website and 1.75 terabytes of data delivered during an 8-hour interval, covering the transit period. Thanks to good preparation, the VT-2004 website with its hundreds of Akamai mirrors did not suffer the fate of several smaller servers which collapsed under the load as was reported in the news.

Another way to measure the big success of the Venus transit is the number of images which have appeared on many web sites: those from the members of the VT-2004 Network, the listed webcast sites, the websites linked directly from the National Nodes pages, etc. Many are displayed at the "Photos" section of the VT-2004 website.

It might be worth mentioning that a very useful "by-product" of the VT-2004 programme is the basic *Image Processing*, now available to everybody! Digital images frequently contain more information than is obvious at first glance. Wanting to help observers in getting the most out of their digital camera images, also those of the Venus transit, an easy-to-use facility was set up at the Ondrejov Observatory in the Czech Republic in the framework of the VT-2004 programme. Here, observers could submit their images and have a variety of well documented operations performed on them. Many amateur astronomers used the pipeline to analyse their images of the Transit and provide better timing measurements (see below).

Also particularly welcome were the

large number of drawings made by children who witnessed the Venus transit. These drawings are now deposited in the VT-2004 Gallery and come from many different places in ESO countries and elsewhere, including, e.g., the Czech Republic, Luxembourg, Greece, Hungary, Slovenia or the United States. All drawings entered into the Gallery before June 30 had a chance to win one of 25 unique VT-2004 T-shirts. And apart from photos or drawings, the event has also inspired poetic expression and a new section on this subject was opened at the VT-2004 web site.

A random selection of drawings received by the VT-2004 programme.

Real-time AU measurement

A unique aspect of the VT-2004 programme, the VT-2004 Observing Campaign, consisted of the real-time measurement of the Astronomical Unit – that is, the mean distance between the Earth to the Sun. Also this went very well. Over 2700 observing teams registered and at this date, 1500 have already entered their observations of the timings of the "contacts" of Venus' black circle with the solar disc, with a total of ~4400 timings so far. This exceptional enterprise – a coordination of a large number of telescopes and instruments all over the world – has never been attempted before and proved very successful. During the event, and after, a real-time display showed the measured astronomical unit as more data came in. This allowed the VT-2004 computers to reenact live the measurement of the distance from the Earth to the Sun as was done by astronomers in the past centuries.

As could be expected, some contacts were easier to measure than others, and in particular, the data concerning the first contact were rather far off and the computed AU-value fluctuated as more and more observations were entered in the database. In retrospect, it appears that some observers posted their first contact measurements as if they corresponded to the third contact, making the dispersion larger than it really was. As soon as the second contact was measured, the measurement of the astronomical unit stabilized pretty close to the real value, 149.6 million km, with a dispersion of about 2 million km. It is perhaps somewhat surprising that the obtained value is so close to the correct one, therefore largely beating the uncertainty which plagued historical measurements of this fundamental unit. One reason is most certainly that in order to ensure maximum stability in this real-time calculation, it was necessary to introduce – for this particular phase of the project – scientifically more rigorous computations, within which it was assumed that the initial value of the astronomical unit was not too far from the real one. This particular mathematical method apparently stabilized the solution faster than anybody expected.

In a next phase, a solution according to Delisle's or Halley's method will be attempted once the deadline for receiving timings, July 10, is past. This new solution will reflect in a more realistic way the errors by individual observers. Further calculations will include the determination of the size of the Sun, of Venus, etc. by means of other algorithms. This will allow gaining a complete picture of the characteristics of this large and absolutely unique database collected during this exceptional public exercise. The database is open for everybody to use and apply their own tools or methods.

The Programme goes on

If the Venus transit is over, the VT-2004 programme certainly isn't. Apart from the living photo, videos, drawing, and writing galleries, the VT-2004 web site is a wonderful "memory" bank on the Venus Transit which will serve for many years to come. Information and Educational sheets, Teachers "cookbook", and "Guidelines for Observers" are but a few example of the rich material available.

Moreover, a video contest has been launched. In this, members of the public – either as individuals or in teams – are invited to present a video of maximum 8 minutes (in any European language but with an English transcript of the manuscript) in connection with the Transit of Venus on June 8, 2004. The video could either present the astronomical event, the local event that was witnessed, including preparations for the observations, reactions of participants and on-lookers, ... or it could try to demonstrate sociological or historical aspects, or wider scientific or philosophical issues, etc.

From all the entries received before September 15, an international Jury will select 12 laureate videos which will be shown during the VT-2004 Final Event, to take place in November 5–7, 2004 in central Paris (France), and made available to the media. Two members of each laureate team will be invited to this Final Event, during which the Jury will award the prizes. The first prize of the video contest is a free trip for two to the ESO Paranal Observatory in Chile. The VT-2004 organisers have already received many expressions of interest in this contest from different places.

The Final Event, which will take place during the *European Science Week*, will be a true encounter between Science and Society during which the VT-2004 programme and the public impact of the Venus Transit will be discussed. We are convinced that this pilot project will serve as a very useful guide to future ones whenever opportunities again present themselves.

To get more information on the VT-2004 programme or to browse the galleries, go to http://www.vt-2004.org.

Serving European Science: The EIROforum Collaboration

Claus Madsen (ESO)

Over the last few years, the idea of a "European Research Area" (ERA) has gained strong support among science policy makers and, increasingly, among scientists themselves. The goal of the ERA is to establish a single "market" for research on our continent, allowing for better co-ordination of research efforts, synergies between projects, the achievement of "critical mass" (both human and financial) and thus to strengthen the competitiveness of European research. These goals necessitate deep structural changes in the way science is organised, breaking up existing borderlines and barriers between national research systems in Europe.

Behind the ERA concept are strong drivers, as expressed not least in the now famous Conclusions from the pivotal European Council meeting in Lisbon (March 2000) and the European Council meeting two years later in Barcelona, firstly setting out very ambitious aims for Europe's further development towards becoming the world's most dynamic knowledge-based economy by the year 2010 and secondly recommending an increase in research spending in Europe by 50 % over the same period of time. These decisions have catapulted research policies to the centre stage of the European political discourse, both at the national level and in the context of the European Union.

While there is thus a strong political imperative behind the changes in European research and the goals seem clear, much discussion takes place over the way to realise the ERA. Indeed questions abound: What can we do to tackle the imminent recruitment crisis for European science and technology personnel? How can we increase the mobility of scientists in a way that enables attractive career perspectives and takes account of social issues and other legitimate concerns? How should the relationship be between fundamental, researcher-driven research and targeted research and technology development? To what extent should the public finance research – to what extent industry? How can we – at the European level – best support the pursuit of excellence as the primary driver for improving overall research performance? Are the current decision-making processes and structures adequate to support research at the European level? How do we best deal with research infrastructures in Europe? How do we co-ordinate decisions on new facilities in a way which makes sense to the scientific community and to society which pays for them? Clearly, these issues are very complex and challenging.

Responding to the challenge

Dealing with the challenges ahead of us and offering our experience and expertise in the common effort to forge a successful ERA is the background for the establishment of a close collaboration, under the name of EIROforum, among Europe's leading intergovernmental research organisations: the European Organization for Nuclear Research (CERN), the European Fusion Development Agreement (EFDA), the European Molecular Biology Laboratory (EMBL), the European Space Agency (ESA), the European Southern Observatory (ESO), the European Synchrotron radiation Facility (ESRF), and the Institut Laue-Langevin (ILL). Between them they cover a wide spectrum of scientific disciplines – from particle physics, astronomy and space research to molecular biology, materials science and neutron research. Each of them operates major research infrastructures for their respective scientific communities, most of which are highly organised. Within their disciplines, they had created their own European Research Areas long before the term was coined. These organisations represent a particular operating model, owned by their member-states, belonging to their scientific communities and with a European remit. At the same time, they represent "European success stories" having provided facilities and a working environment in which European scientists could develop and reach the highest standards amidst strong international competition. Given the overall problems regarding European scientific and technological competitiveness, this is a noteworthy achievement of which these organisations and European science can be proud.

A forum for exchange

The added value of the EIROforum collaboration lies in synergies between their individual activities – both at the technical level and concerning other areas, such as outreach, human resources and science policy – cross-fertilization through interdisciplinarity and the sharing of resources and ideas. Significantly, the EIROforum partnership represents an annual research investment in Europe of almost the same size as that of the European Union's Framework Programme. By working together, the partner organisations therefore achieve a higher visibility and considerably increased attention from science policy makers, raising the possibility for engaging in fruitful dialogue on matters of crucial importance to the long-term future of our Continent.

The EIROforum Council is comprised of the Directors General (or equivalent) of the partner organisations. Currently, the chair is held by EFDA, but rotates every July. The next period will be presided over by ESA. The Council is supported by a Co-ordination Group with senior staff members from the partners constituting the operational interface between the member organisations. A series of thematic working groups and ad-hoc teams complement the Council and the Co-ordination Group, dealing with a wide range of practical topics.

A platform for joint projects

Most, but not all, activities that are organised within the EIROforum frame involve all the member organisations. Among the most visible examples are a series of successful outreach activities targeting secondary school pupils. The programmes, carried out

ESO's Current EIROforum Team

Council: Catherine Cesarsky
Co-ordination Group: Claus Madsen, Peter Shaver
TWG on Human Resources: Roland Block
TWG on Outreach and Education: Richard West
TWG on Instrumentation: Guy Monnet
(**Detector Sub-group:** Reinhold Dorn)
TWG on Grid: Klaus Banse, Markus Dolensky
TWG on EU matters: Claus Madsen
Conference on infrastructure management and voting rights: Ian Corbett
Scientific Conferences: Peter Shaver

The signing of the EIROforum Charter in Brussels on the 12th of November 2002.

in collaboration with the European Commission, have included '*Life in the Universe*', '*Sci-tech/Couldn't be without it!*' (dealing with links between basic science and technology). A new programme, '*Einstein's Magic City Contest*' is under development for possible implementation during the Year of Physics in 2005.

A longer-term, Europe-wide activity targeting science teachers, has also been organised by the EIROforum. This programme was so far known under the name '*Physics on Stage*' and has involved many thousands of teachers since it commenced in the year 2000. From 2006, the programme will change name to '*Science on Stage*' to reflect the wider range of disciplines to be covered and an increased focus on interdisciplinarity.

While our organisations are of course devoted to front-line research, the engagement in educational activities is based on very worrying trends as regards the future recruitment of talented young people to science. For example, a recent survey showed a decline of 17 % in physics graduates over the period 1997/98–2001/2002.

None of these activities could have been carried out by the individual EIROforum organisations. Yet by working together and joining forces with some of Europe's most innovative and enthusiastic science teachers – and with substantial financial support by the European Commission – it has been possible to carry out activities of sufficient scale and visibility. Starting as *ad-hoc* activities, they have developed into a coherent, long-term programme aiming to reverse the serious drop in numbers of young people who declare themselves ready to pursue studies and careers and science (particularly in physics).

Scientific and technical collaboration is, by its very nature, more specialised and tends to involve clusters of organisations, rather than the whole group. Accordingly, EMBL, ESRF and ILL have established a Partnership for Structural Biology (PSB), whereas the collaboration between CERN, ESA and ESO is based on our traditional close links. Thematic Working Groups in detector development and Grid technologies are investigating possibilities for joint activities and has held first workshops. Other areas where cooperation may prove to be of great benefit are technology transfer and issues relating to human resources.

A voice in the science policy debate

On the background of the ERA development, science policy issues are clearly of high priority to the EIROforum. A series of briefings in the European Parliament, as well as frequent meetings and consultations with high representatives of the European Commission has enabled a fruitful dialogue with key decision makers. This dialogue has been reinforced by a Statement of Intent between the EIROforum partners and the European Commission, in which both parties pledge to cooperate towards the development of the ERA. The statement was signed by the Directors General of the organisations and the European Commissioner for Research, Philippe Busquin, in October last year. Among the current science policy issues we find the debate about the character and operational aspects of the new European Research Council, the preparation for the 7th EU Framework Programme and the long-term implications of the legal base for research as implied by the proposed Constitutional Treaty.

Forging the ERA

EIROforum is a child of the ERA, both with respect to its remit and regarding the particular time in which it was created. Together with its partners, ESO played a crucial role in its formation, not the least during its first tenure as EIROforum Chair (2001). The original team, the ESO DG assisted by Peter Quinn and Richard West, helped to shape the collaboration and prepare it for the challenges posed by the emerging European Research Area.

When, on 12 November 2002, the collaboration was sealed with the official signing of the EIROforum Charter at the Palais du Heysel, Commissioner Busquin, who attended the ceremony, stated that "*The establishment of EIROforum is a concrete example of the dynamic created by the European Research Area. Europe has unquestioned excellence in science. By working together, Europe's leading research organisations can make that more visible on the European and world stage.*"

In this sense, ESO's continued engagement in the EIROforum collaboration both provides a window for European astronomy and supports a partnership whose common expertise and experience constitutes a great asset as the European research landscape is re-modelled.

Further information is given at the EIROforum website: www.eiroforum.org.

The EIROforum information stand at the 2002 FP-6 Launch Conference in Brussels.

Report on

The visit of Prof R. Sunyaev to ESO/Chile and the Topical Meeting "Accretion onto Compact Objects"

Danielle Alloin, Elena Mason, Kieran O'Brien (ESO)

Over the period April 4 to April 17, we had the great pleasure of the visit of Prof. Rashid Sunyaev in Chile. This was an opportunity for him to visit some of ESO's facilities (Paranal, Santiago) as well as APEX, and also to pay a visit to the new facilities of our colleagues in La Serena (among others Magellan and Gemini).

For us, it was an opportunity to organize discussions and meetings to make use of his vast experience in the field of cosmology and high energy astrophysics.

On this occasion we held a Topical Meeting in Santiago, on April 15, on the subject of: "Accretion onto Compact Objects". About 30 participants attended the Meeting, among them many students from PUC and from ESO. Presentations ranged from theory (the theory of accretion, the evolution of low-mass X-ray binaries and millisecond pulsars controlled by gravitational radiation, the mapping of eccentric orbits in triaxial log potential, …) to observational results (echo-sounding in X-ray binaries, warped molecular gas around AGN, formation of high mass stars via accretion, …).

Theoretical problems in astrophysics are discussed only occasionally in Chile, as the astronomical activity is really dominated by observational subjects thanks to a top-level suite of telescopes. So, this provided an interesting change and gave new perspectives to the young audience at the *Topical Meeting*.

Report on the ESO Conference:

Planetary Nebulae beyond the Milky Way

J. R. Walsh and M. Rejkuba (ESO)

This three-day ESO workshop, held from 19 to 21 May 2004, devoted to extra-galactic planetary nebulae (PN), was the first full workshop on the topic. Previously there had been discussions of extra-galactic PN on the final day of the pentennial IAU Symposium on Planetary Nebulae (last held in Canberra in 2001) and a one day meeting during the IAU General Assembly in den Haag in 1994. The field has expanded considerably in the last decade with many PN now detected in Local Group galaxies, extensive surveys underway in nearby early-type galaxies and in the inter-galaxy regions of galaxy clusters, together with the use of PNe as kinematic probes for galaxy potentials. There are currently many thousands of PN catalogued in external galaxies, far surpassing the approximately 1500 known in the Milky Way.

Alan Moorwood, Head of Instrumentation at ESO, in his welcome address presented a reflection from his attendance at a PN Symposium in New York in 1977. He noted that the order of the first few talks at this workshop – on surveys in the Magellanic Clouds and Local Group galaxies – was similar to that 27 years before.

However after a few talks, Alan had to agree that a lot had happened in the field since 1977! There were 16 invited reviews, 26 contributed talks and two discussion sessions over three full days, and also 13 posters, for a total of 65 participants. We present a selection from among the topics. Since all the speakers presented their talks in electronic form we collected them together after the conference and made them available linked to the items in the conference programme at http://www.eso.org/gen-fac/meetings/extgalpn04/programme.html where the reader is referred for more details.

The first extra-galactic PN were those discovered in the Magellanic Clouds and surveys are still on-going. G. Jacoby (WIYN) suggested that all the PN had been probably been discovered in the SMC, whilst many more remain to be discovered in the LMC. The cumulative plot of the number of PN against the magnitude in the [OIII] 5007Å line – known as the PN Luminosity Function (PNLF) – showed a dip at about four magnitudes below the peak for the SMC (see Figure 1). This was subsequently referred to as "Jacoby's deficit". The photographic Hα survey of the UK Schmidt Telescope in Australia is still discovering many more LMC PN. W. Reid (MacQuarie University) showed how the Hα and matched *R*-band images are differenced to reveal more than a thousand new PN candidates in the LMC, which are then followed up with multi-object fibre spectroscopy on the AAT.

In other Local Group galaxies the census of PNe conducted with the Wide Field Camera at the Isaac Newton Telescope was presented by R. Corradi (ING). Local Group dwarf galaxies were surveyed in various narrow and broad filters and the images are reduced and publically available. L. Magrini (Firenze), P. Leisy (ING) and collaborators discussed spectroscopy of some of the candidates from this survey. The census of PN in the Local Group is complementary to various Asymptotic Giant Branch (AGB) stellar surveys which were summarized by M. Groenewegen (Leuven). The AGB surveys form not only an important test of stellar evolution models, but also an excellent tool for studying chemical evolution of dwarf galaxies.

Deep surveys in nearby galaxy clusters such as Virgo and Fornax reveal the presence of true intra-cluster PN. J. Feldmeier charted the discovery of these objects. The early surveys were beset by interlopers, mostly z=3.1 Lyman-alpha galaxies; but later surveys with spectroscopic follow-up (detection of the [O III] 5007,4959Å doublet allows clear discrimination from background emission line objects) are revealing numbers of PN wandering in the spaces between galaxies. The intra-cluster PN have enormous potential for studying the number, origin, metallicity and kinematics of the intra-cluster stars. Current estimates suggest that about 15% of cluster stellar mass may reside in intra-cluster stars. Multi-fibre instruments on large telescopes show that it is feasible to measure the kinematics of the intra-cluster PN and M. Arnaboldi showed some Virgo PN spectra recently taken with FLAMES on the VLT.

The PNLF is now an established secondary distance indicator and R. Ciardullo in his review showed that the first suggestion that PN could be used as distance indicators was made in 1966. It was not until the 1990's that the PNLF was routinely applied to nearby early-type galaxies. The method works comparably well to surface brightness fluctuations with very little dependence on metallicity of the galaxy. The next challenge for the observers is to compare the PNLF constructed from Hβ and other lines with the [O III] 5007Å PNLF.

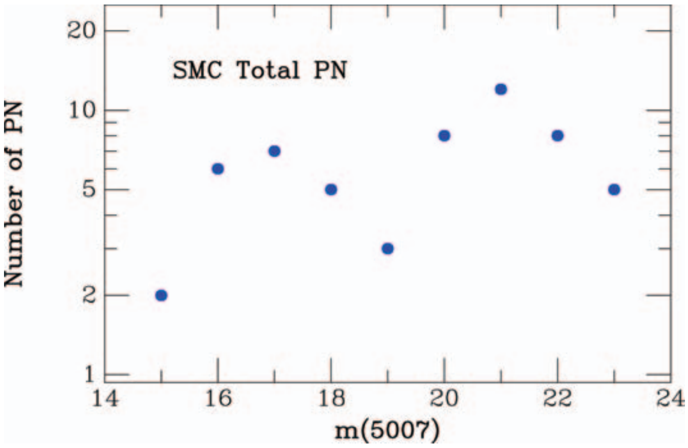


Figure 1: The Planetary Nebula Luminosity Function (PNLF) is shown for the Small Magellanic Cloud. This was presented by G. Jacoby and, given that searches for PN beyond 5007Å magnitude of 23 have failed to find further PN, it is suggested that this PNLF may be complete.

L. Girardi (Trieste) showed the advances in modelling PN evolution, but also the enormous difficulties and lack of a complete theoretical understanding of the PNLF.

R. Shaw, L. Stanghellini and E. Villaver (NOAO) presented different aspects and science from the high resolution HST survey of PN in the Magellanic Clouds. The high resolution slitless spectroscopy with STIS has enabled the study of expansion ages, connection of morphology to environment and the central star progenitor properties, such as winds and transition times, enabling tests of stellar and PN evolutionary models by placing the PN central stars in the HR diagram.

One of the aims of the conference was to draw-out the links of extra-galactic PN with other stellar indicators of galaxies and one session was devoted to the stellar connection, focussing on Asymptotic Giant Branch (AGB) stars, the progenitor stage to PN, and the stellar parameters of PN central stars. On the theoretical side, L. Willson (Iowa State) showed the complexities of mass loss on the AGB and how difficult is its parameterization.

One stumbling block to applying the classical abundance determination methods for emission line spectra is the, sometimes large, difference in the PN abundances derived from the optical recombination lines for O and Ne, for example, with those derived from the much brighter collisionally excited (forbidden) lines, such as [O II] 3727Å and [O III] 5007Å. X. Liu (Peking) showed that for some PN the discrepancy between the forbidden and recombination line abundances can reach a factor of ten. However the likely reason is that cold, metal-rich, clumps, with a small fraction of the gas mass, make a strong contribution to the recombination lines, whilst the majority of hotter and lower abundance gas produces most of the forbidden line emission. The metal-rich intrusions may be ejected by the star at late evolutionary stages or may even be planetismals within the ionized region. The bright collisionally excited lines are used to derive metal abundances and various talks discussed O abundance determination in NGC 6822, Sextans A and B and M33 extending out to NGC 5128 (3.5Mpc) and NGC 4697 (10Mpc). For the latter galaxy, R. Mendez (Univ. Hawaii) showed a comparison of the long-slit integrated stellar light metallicity with PN metallicities. These results suggest metallicities with large dispersions in the halos of ellipticals. With 8–10m class telescopes determinations of O, He, N, Ne, etc. in PN become feasible and large samples can be achieved with multi-object spectrometers, enabling studies of abundance gradients at large galactocentric radii.

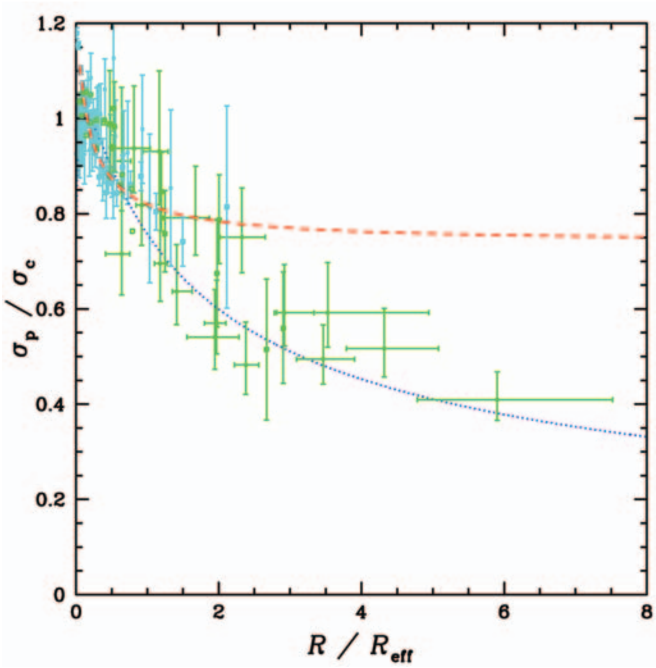
The final day of the conference was almost solely devoted to dynamical studies of galaxies using the PN as probes. On account of their strong line emission (in particular the [O III] 5007Å line) and the narrowness of the lines (typically < 30 km/s), PN make ideal tracers of the gravitational potential of a galaxy to large radii, where the integrated stellar light has surface brightness too low for detection. N. Douglas (Katpeyn Laboratory) described the work done by the Planetary Nebula Spectrograph (PN.S) group. This dedicated instrument provides detections and radial velocities in a single observation. Large samples of PN have been collected with the PN.S and detailed kinematic modelling is being undertaken. A. Romanowsky (Nottingham) showed the results of modelling PN kinematics for the ellipticals so far studied (most with low X-ray luminosity) by the PN.S team. There appears to be little evidence for dark matter (*M/L* stays low even at 6 R_e – see Figure 2) as also discussed by O. Gerhard (Basel) and N. Napolitano (Kapteyn Laboratory). Ideally samples of about 1000 PN are required per galaxy for detailed modelling of the components of the potential. For M31, velocities for over 2700 PN have been measured with the PN.S and H. Merrett (Nottingham) described the mapping of the various halo components, including the dwarf galaxies NGC 185 and 205. Comparison with the M31 stellar RGB kinematics was presented by A. Ferguson (MPA, Garching).

During the conference there were several "mini-workshops": one on M 31 as mentioned above and another on NGC 5128 which has over 1100 PN candidates and almost 800 confirmed. E. Peng (Rutgers University) presented extensive kinematic modelling, and studies of the AGB stars (M. Rejkuba) and abundance measurements of the PN (J. Walsh) were also discussed. There were two scheduled discussion sessions on "Observational Challenges" and "Future Challenges" at the end of the second and third days respectively.

With so many PN now known in galaxies beyond the Milky Way some standardization of the nomenclature is desperately required. This topic formed part of the first discussion session and was in fact triggered by an enquiry from a German amateur astronomer.

The meeting concluded with a conference summary by H. Ford (Johns Hopkins). He very bravely commented on every talk, with collages from the presentations and digital photos of the speakers. Many people contributed to the lively meeting: the SOC and in particular Letizia Stanghellini who co-chaired; Nausicaa Delmotte helped with the web pages. The smooth running of the conference organization was almost entirely due to Christina Stoffer, with Britt Sjoeberg helping out on the public holiday.

Figure 2: The observed velocity dispersion, scaled to that at the centre, derived from the PN is shown as a function of effective radius for four early type galaxies (NGC 821, 3379, 4494 and 4697) from the presentation of A. Romanowsky. The horizontal dashed line (red) is the result of a model based on an isotropic isothermal halo and the dotted blue line an isotropic constant *M/L* Hernquist model. The absence of increasing *M/L* suggests that any dark-matter halo must make a minor contribution in these galaxies.



Fellows at ESO

Thomas Dall

Since July 2002 I have been a Fellow at ESO Chile with duties at the La Silla Observatory. It is no coincidence that I asked to be assigned to La Silla: as a PhD student I had a studentship at the Nordic Optical Telescope on the island of La Palma, and there I experienced observatory work first hand, being granted responsibility as Support Astronomer and got involved in all aspects of the observatory work. I was getting my hands dirty – and getting an appetite for more.

On La Silla I find myself in a similar, although bigger, environment. The "hands-on" experience is one of the biggest assets of working at La Silla and cannot be underestimated. I learn a lot all the time, both scientifically from interacting with the visiting astronomers and from a technical point of view by working with the rest of the staff, and by getting ever more involved in different projects. Since April 2003 I have been the Instrument Scientist for the Coudé Echelle Spectrometer (CES) at the 3.6m telescope.

The subject of my PhD was pulsations in stars, mainly δ Scuti pulsators. The main complication in the understanding of these stars is that they are very fast rotators – a fact that has falsified all modelling attempts so far. Since I came to ESO my scientific work has shifted a bit. I still study stellar structure, and I am still intrigued by rotation, but my focus is now on late type active stars, studying the relationships between rotation and magnetic fields. Also symbiotic and cataclysmic variables are now part of my world. The atmosphere on La Silla and the work with the high-resolution spectrographs has fuelled my scientific work as well as given me valuable experience with a broad range of instrumentation, and I am very glad I made the decision to come to work for ESO in Chile.

Marina Rejkuba

I became a fellow at ESO Garching in October 2002 after finishing my PhD at Pontificia Universidad Católica de Chile in Santiago. For duties I opted for Paranal science operations support. This allowed me to learn a lot about all the VLT instruments, to meet visiting astronomers and gain an overview of the science done at the VLT. For that I travel to Chile four times a year and spend 56 days and nights on the mountain. The rest of the time I spend working on my scientific projects in Garching. In this way it is easy to divide the duties and science time and take the greatest advantage of both.

Life at ESO Garching is very inspiring. The large number of seminars and colloquia and many visiting astronomers ensure that no astrophysical topic passes undiscussed. It is also a place where I can always find an expert to answer my questions and many people to discuss with and share the ideas. During my PhD I studied in detail the nearby peculiar elliptical galaxy NGC 5128, also known as Centaurus A. In this galaxy we determined the recent star formation history in the halo, studied the old stellar populations and discovered many new globular clusters and more than 1000 Mira variable stars. The Mira variables are among the most luminous stars and can be used to determine not only the distance to the galaxy, but also the age distribution of its stars. Now, I still continue working on my pet object, Centaurus A, but also extend the studies of stellar populations to Magellanic Clouds, other Local Group and more distant galaxies. The central theme of these projects is the formation and evolution history of elliptical and dwarf galaxies.

In my free time I like to read books, learn new languages, or go for a bike ride or a hike in the Alps. In Germany table games are very popular and it is never a problem to gather a keen group of players and spend a pleasant evening chatting and fighting over some board or cards.

Gijsbert Verdoes

I was born and grew up in The Hague in the Netherlands. I chose to study astronomy in the university closest to the sea and my sailing dinghy: Leiden. After my undergrad studies, I moved to the Space Telescope Science Institute (STScI) in Baltimore, USA, to start the first half of my Leiden PhD under the joint supervision of Stefi Baum and Tim de Zeeuw. I studied the centres of radio galaxies using Hubble Space Telescope imaging and spectra. Today, still one of my favorite general astrophysical topics is to find out how different galaxy evolution would have been without active nuclei or, put more bluntly, do AGNs matter?

After my PhD I moved from STScI to ESO in November 2002. I knew a bit about the American 'sharp-eyed spider' and I wanted to get to know its European sharp- and large-eyed counterpart. ESO sits in many ways at the centre of the European web of observational astronomy. I also felt quite attracted to the spider's many legs: with the Fellowship system, ESO provides plenty of opportunities to gain experience and expertise not only in astrophysics, but also in fields such as instrument and software development, outreach, and organizational matters. My functional duties started in the Science Verification team for the VIMOS instrument. This also led me to start working on something new. For possible verification projects, I asked myself what the 'redshift-machine' VIMOS could do for the 'redshiftless' Universe. This eventually led, via a regular proposal, to a nice VIMOS project on globular clusters in Centaurus A and involves a few collaborators in and outside ESO. I am now carrying out functional duties in the department of Education and Public Relations, working on educational projects. It is great fun to be forced to approach astronomy from a completely different angle.

Lastly, as a flatlander by nature, a strong fringe benefit of working at ESO Germany is its proximity to beautiful mountains. Southbound trips provide for very nice recreation over the weekends all year round. To conclude: I am very happy at ESO and can see only one unimportant question. I love to see the alpine skyline on a clear day from the top floor at ESO, but.....where are the sea and my dinghy?

Paul Vreeswijk

I clearly remember the first time I saw Paranal observatory, from the plane between Santiago and Antofagasta (note that you have to be on the side of the Andes to be able to see it). Four tiny telescopes and some surrounding buildings in an ocean of reddish mountainous desert. The perspective changes completely when arriving at the telescope platform on Paranal: an impressive array of four immense telescopes, designed for the sole purpose of observing the night skies in great detail. After a dozen weeks as an ESO fellow on Paranal, the platform site is still just as amazing as the first time.

Scientifically my main interests are the use of gamma-ray burst (GRB) afterglows as a tool to study high-redshift star-forming regions. GRBs are distant explosions, caused by the deaths of massive stars, and the resulting afterglows in the optical can be a million times brighter than their host galaxies. But only for a few minutes, as the afterglows fade away extremely rapidly. So one has to be very quick to profit from their brightness. This requires different observing strategies than commonly used in astronomy; most objects in the sky do not change their brightness in zillions of years.

To allow rapid VLT observations of GRB afterglows, an ESO working group recommended to implement the so-called Rapid-Response Mode (RRM), the automatic mode of the VLT. As a fellow and because of my scientific interests, I'm involved in the implementation of this RRM on Paranal. I find this quite exciting: as a GRB goes off and is localized on the sky by a satellite, due to the implementation of the RRM, the VLT is now able to automatically start pointing to the GRB, and observe the afterglow within minutes of the GRB explosion. And thanks to high-precision instruments such as UVES, one can obtain detailed properties of high-redshift star-forming regions. So among other superlative statements one can make about the VLT project, one can add that it is the biggest robotic telescope in the world.

Former ESO DG Adriaan Blaauw turned 90

On April 12, former ESO DG professor Adriaan Blaauw reached his 90th birthday. Adriaan, together with many friends, family members, colleagues from The Netherlands and abroad, celebrated this occasion on April 17, during an informal get-together at the 19th-century country-mansion Nienoord in Leek, near Groningen.

Well over 200 people including ESO Director General Catherine Cesarsky, shown here with her predecessor, enjoyed a most pleasant event on a warm, sunny afternoon. The event was offered to Adriaan by his present and former colleagues from the Groningen Kapteyn Institute and Leiden Observatory, who join in with colleagues worldwide in congratulating Adriaan and his wife, and wishing them well for the years to come.

ESO at the Exploring the Frontier Symposium

Ed Janssen (ESO)

The symposium, which was co-chaired by ESO's Director General, Dr. Catherine Cesarsky, took place on 18–21 May 2004 at the Max-Planck Society's Harnack-Haus in Berlin. It was dedicated to presenting and discussing the fundamental scientific questions that will be addressed by major future astrophysical facilities during the next few decades. The meeting programme featured 11 invited reviews, 27 contributed talks and 49 posters. The meeting was attended by 160 participants from 17 countries.

ESO's presence included an exhibition/information stand with emphasis on the ALMA and OWL projects. The symposium (and thereby ESO) was presented widely in the local and international media; ESO's Director General gave several interviews, including one for a major television series on groundbreaking science. This was also a topic on the prime-time TV news on the second German channel.

Announcements

Science products from large programmes to be available from the ESO archive

Benoît Pirenne and Peter Quinn, ESO DMD

ESO is committed to producing and maintaining a data stream from the VLT Observatory that forms a data heritage for international astronomy. This goal is being realised by an end-to-end operational approach that maintains data integrity, produces appropriate metadata, maintains and executes calibration plans and produces quality controlled data products. ESO has also designed and produced advanced data products from surveys that are available from the ESO/ST-ECF Science Archive Facility (SAF) and which feed archival science programs and future applications for VLT time. ESO also wishes to ensure that the full scientific potential of the VLT is realised by granting large amounts of telescope resources to large programmes chosen on scientific merit by the Observing Programme Committee (OPC). To ensure that the scientific products from these programmes also form an effective part of the VLT data heritage and the emerging international virtual observatory, ESO is defining requirements and procedures for large programmes that will ensure their scientific output can be published through the SAF. This goal is directly supported by the recommendations of the recent ESO workshop on Large Programmes and Surveys, endorsed by the Scientific Technical Committee (STC) at its April 2004 meeting.

What does this mean?

Starting with Period 75 results, PIs of Observing Programme Committee-approved large programmes will be required to return the data products (processed images and spectra, catalogues) to the ESO archive at the time of the publication of their scientific results in a refereed publication. This requirement will be made clear in the call for observing proposals for Period 75 in the large programmes section. Each approved programme will have to agree on the content of their data product delivery with ESO before the start of the programme.

Some details

- The various files representing the processed products shall be delivered in FITS format for images and in VOTable or FITS format for tables (e.g., spectra or catalogues). FITS to VOTable conversion software will become available from ESO and other VO partners in the coming months, once a spectral data model has been agreed upon.
- Each new data delivery (or reduced data package) shall be accompanied by:
  - → A package description page in HTML format, such that it can be immediately made available on the ESO archive web site;
  - → An accompanying table containing one row per file and a short description of each file;
  - → An accompanying table containing, for each product file, a list of the original raw files that have been used in the fabrication of the product. In this way, future users of the product will be able to go from the products to its constituent raw files and conversely from the raw files to the products.
- Each data delivery will be considered as one single "Data Package" by default. A delivery can consist of several distinct packages if it makes sense. The package(s) will be made available to the community through the ESO archive web. See for example the way the "High-z QSO spectroscopy" program is made available: http://archive.eso.org/wdb/wdb/eso/packages/query?pkg_id=175. Also note the pointer to the package description within the page as well as the possibility to access each file individually.
- ESO will manage the incorporation of the science data products in the most effective form for publication and utilization within the VO.
- Principal Investigators of large programmes currently on-going (e.g., P73 or before) are strongly encouraged to consider delivering their products under the proposed scheme for early publication in the archive.

Everybody wins

The above implementation conditions may seem constraining and adding overhead to the production of the science results. However, the benefits of this initiative are large for both the future users of the archive or the VO and for the large programme teams. The former will have a large pool of high quality data to compare, cross-correlate and analyse whereas the PI of the large programme, whose products have been used in new work, will have a chance to dramatically increase his/her paper's citation rate as each product will be tagged with the ESO programme ID and hence with the PI name. Moreover, the "bibcode" of the accompanying publication will also be attached to the description of all products. Statistics of data download rates will also be made available to the large programme PIs on request. Finally, we would like to recommend to PIs of currently on-going large programmes to consider returning their data to the archive already now.

Visit EIROforum at ESOF 2004

The EuroScience Open Forum (ESOF2004) is the first pan-European interdisciplinary scientific conference, modelled on the well-known and highly successful meetings in the US by the American Association for the Advancement of Science (AAAS). ESOF2004 will be held at the Stockholm City Conference Centre in Stockholm, Sweden, this summer, between 25–28 August. It is intended to continue with ESOF meetings on a biannual basis in the future.

Its objective is to bring scientists from all fields, and people interested in science and technology, from all over Europe to a single meeting. The participants will be scientists, science policy makers, administrators and representatives from media as well as the science based industries. Some 2–3 000 participants are expected to take part in the conference.

The programme includes 270 speakers from 33 countries and more than 80 scientific workshops, symposia, plenary lectures and debates. The conference also includes public outreach activities in Stockholm. Another activity, known as the ESOF2004 Career Programme, is organised by the Marie Curie Fellowship Association and Naturejobs, the career resource of the journal, with the aim of furthering the career development of young researchers.

EIROforum and its member organisations will contribute to the programme by organising a special scientific session under the title '*European Research at the Cutting Edge*' providing an overview of some of the most exciting recent research results obtained at our facilities. Furthermore, a public outreach event involves video-conferences between several of our research organisations, including CERN in Geneva and the Paranal Observatory in Chile, and the central venue in Stockholm. Finally, EIROforum will have a 70 sq.m. information stand with a number of activities during the conference.

ESOF2004 is an inititative by Euroscience, but has received strong support by the European Commission, the European Science Foundation, Nature, The Swedish Research Council, DFG, the Stifterverband für die deutsche Wissenschaft, The Bank of Sweden Tercentenary Foundation, the Robert Bosch Stiftung, etc.

For more information, including registration, please see www.esof2004.org

Claus Madsen (ESO)

NOVA-ESO-MPIA workshop on

VLTI/MIDI
Data reduction, Analysis and Science

Leiden Observatory/Lorentz Centre, The Netherlands
October 11–15, 2004

The VLT-interferometer Mid-Infrared Instrument (MIDI) is unique in its kind and the only interferometric instrument available through an open call for proposals. The objective of the workshop is to provide the knowledge and tools to astronomers to:

1. Identify where MIDI can lead to new insights in astronomy
2. How to reduce MIDI data
3. How to interpret MIDI data

The program has sessions on:

A: Basics of optical interferometry
B: The VLTI/MIDI instrument
C: Science with MIDI
D: MIDI data reduction and analysis tools, and ESO observing preparation tools
E: Teams will be formed and be working on MIDI data of Active Galactic Nuclei, Evolved stars, Young stars, Hot stars

The format of the workshop will be lectures combined with teamwork. Teams will reduce and analyze MIDI data during the workshop.

SOC members: Walter Jaffe, Andreas Quirrenbach, Eric Bakker (contact person), Christoph Leinert, Uwe Graser, Francesco Paresce.
Full details and registration information can be found at: http://www.strw.leidenuniv.nl/~nevec/workshop_2004 or by email: bakker@strw.leidenuniv.nl

Date for interest to participate: 1 September 2004 (required)
Date for registration: 15 September 2004

International Astronomical Observatories in Chile (IAOC) Workshop in 2004

The Cool Universe: Observing Cosmic Dawn

Universidad Tecnica Federico Santa Maria (UTFSM), Valparaiso, Chile
2004, October 4–8

Sponsors: ESO, NOAO, LCO, Gemini, NRAO, NAOJ
Host: UTFSM
Rationale: With the official start of the ALMA construction phase, it is of utmost importance to usher in the astrophysical topics which will be the prime scientific drivers for this outstanding facility. This is why we have chosen to organize the 2004 IAOC workshop on the subject of the cool universe and in particular, the contribution ALMA will make towards our understanding of the formation of astronomical objects at scales that range from protoplanetary systems to galaxies. Chile, the home of ALMA and the location of several existing submm, mm and cm telescopes (ASTE, APEX, CBI...), is a place that is particularly appropriate for hosting such a workshop.
The workshop will consist of a series of tutorial and reviews, each followed by oral contributions, to discuss physical processes in cool material and the astronomical objects in which they take place.
Topics covered (tutorial and reviews):

Observing procedures and derivation of physical quantities in the submm/mm window
The cosmic microwave background (CMB): theory and observation
Galaxy formation up to enlightment: theory and predictions
Emission processes on the ISM (includes maser)
Molecular clouds and fragmentation: modeling and observations
Star formation, stellar evolution, astrochemistry: models and observations
The ISM properties across redshifts (includes absorbers)
Fragmentation within protoplanetary discs: models and predictions
Observational facilities on the Atacama Plateau
Concluding remarks and Prospective

Scientific Organizing Committee: Danielle Alloin (Chair), Claire Chandler, Edith Falgarone, Guido Garay, Santiago Garcia-Burillo, Ryohei Kawabe, Anthony Readhead, Luis Felipe Rodriguez, Peter Shaver
Local Organizing Committee: Danielle Alloin, Eduardo Hardy, Kotaro Kohno, Cedric Ledoux, Chris Lidman, Lars Nyman, Bernadette Rodgers, Miguel Roth, Malcolm Smith, Massimo Tarenghi

Dead-line for pre-registration: July 15, 2004
Full details, list of invited reviewers and registration information can be retrieved from http://www.sc.eso.org/santiago/science/cooluniv and by email at cooluniv@eso.org

Applications are invited for the position of a

Senior Astronomer
Director of the La Silla/Paranal Observatories

Career Path: VII

Assignment: The Director responsible for both Observatories will lead a multi-disciplinary team and act as a link between the User Community, the Director General and the Observatories. She/he will in particular be responsible for:

- the continuation, creation and implementation of scientific and technical policies for the operation of the Observatories in accordance with overall ESO policy
- the management of the Observatories and their staff members through the definiton and implementation of goals and objectives
- the Observatories budget
- the representation of both observatories in the science community, public and public relations (e.g.media support, exhibitions, presentations etc.) in close interaction with the Public Relation Officers in Garching and Santiago.

The Director of the Observatories reports directly to the Director General and as a member of the ESO Management contributes directly to the development of the overall policy, strategic planning and maintains professional contacts at highest level outside the Organisation. The Staff of the Observatories presently consist of about 70 International and 150 Local Staff Members who work in groups or teams.

As a Senior Astronomer the Director of the Observatories is a member of the ESO Science Faculty and is expected and encouraged to actively conduct astronomical research. She/he should foster the participation and integration of the scientists of the Observatories in the ESO Faculty and in the Office for Science in Santiago.

Qualification and Experience: Basic requirements for the position include a PhD in astronomy, astrophysics or physics or related fields, substantial and long or equivalent experience in management and leadership preferably gained within multinational scientific organisations. A proven record in astronomical systems such as instruments, large optical telescopes or systems of equivalent complexity as well as an outstanding record of astronomical research and international scientific collaborations are required. Initiative, ability to judge, to decide and to work with people of different nationalities as well as excellent communication skills are essential. The position requires a very good knowledge of English and a working knowledge of Spanish or willingness to learn it.

Duty stations: La Silla, Paranal and Santiago, with regular duty travels to Munich to ESO's Headquarter.

Starting date: 1 April 2005

Remuneration and Contract: We offer an attractive remuneration package including a competitive salary (tax free), comprehensive pension scheme and medical, educational and other social benefits as well as financial help in relocating your family. The initial contract is for a period of three years with the possibility of a fixed-term extension or permanence. Serious consideration will be given to outstanding candidates willing to be seconded to ESO on extended leaves from their home institutions. The title or the grade may be subject to change according to qualification and the number of years of experience.

Applications: If you are interested in working in a stimulating international research environment and in areas of frontline science and technology, please send us your CV (in English) **by 15 August 2004**.

All applications should include the names of four individuals willing to give professional references.

For further information, please contact Mr. Roland Block, Head of Personnel Department, Tel +49 89 320 06 589, e-mail: rblock@eso.org. You are also strongly encouraged to consult the ESO Home Page (http://www.eso.org/)

PERSONNEL MOVEMENTS

International Staff

(1 April 2004 - 31 May 2004)

ARRIVALS

EUROPE

AHMADIA, Aron (US)	Student
BERTA, Stefano (IT)	Student
GRILLO, Claudio (IT)	Student
IRWIN, Jimmy (US)	Associate
LOPS, Roberto (IT)	Associate
LUCUIX, Christian (FR)	Electronics Engineer
MARTINEZ, Pascal (FR)	Associate
MIRALLES, Joan-Marc (AD)	Associate
PUGLIESE, Giovanna (IT)	Associate
QUIROS-PACHECO, Fernando (MX)	Student
REUNANEN, Juha Pekka (FI)	Associate
SPECK, Hartmut (DE)	Associate
TOZZI, Paolo (IT)	Associate
UTTENTHALE, Stefan (AT)	Student

CHILE

ANDRETTA, Vincenzo (IT)	Associate
BECKER, Karl (DE)	Associate
DELVA, Pacome (FR)	Student
GIUFFRIDA, Giuliano (IT)	Student
HAUBOIS, Xavier (FR)	Student
HUNTER, Ian (GB)	Student
MILLOT, Nadia (FR)	Student
NOTERDAEME, Pasquier (BE)	Student
RAGAINI, Silvia (IT)	Student
RAHOUI, Farid (FR)	Student
REVERET, Vincent (FR)	Fellow

DEPARTURES

EUROPE

BAARS, Jacob (NL)	Associate

ESO Fellowship Programme 2004/2005

The European Southern Observatory awards several postdoctoral fellowships to provide young scientists opportunities and facilities to enhance their research programmes. Its goal is to bring them into close contact with the instruments, activities, and people at one of the world's foremost observatories. For more information about ESO's astronomical research activities please consult http://www.eso.org/science/.
Fellows have ample opportunities for scientific collaborations: a list of the ESO staff and fellows, and their research interest can be found at http://www.eso.org/science/sci-pers.html and http://www.sc.eso.org/santiago/science/person.html. The ESO Headquarters in Munich, Germany host the *Space Telescope European Coordinating Facility* and are situated in the immediate neighbourhood of the Max-Planck-Institutes for Astrophysics and for Extraterrestrial Physics and are only a few kilometers away from the Observatory of the Ludwig-Maximilian University. In Chile, fellows have the opportunity to collaborate with the rapidly expanding Chilean astronomical community in a growing partnership between ESO and the host country's academic community.
In Garching, fellows spend beside their personal research up to 25% of their time on support or development activities of their choice in the area of e.g. instrumentation, user support, archive, VLTI, ALMA, public relations or science operations at the Paranal Observatory. Fellowships in Garching start with an initial contract of one year followed by a two-year extension.
In Chile, the fellowships are granted for one year initially with an extension of three additional years. During the first three years, the fellows are assigned to either the Paranal or La Silla operations groups. Together with the astronomer in charge, they contribute to the operations at a level of 80 nights per year up on the mountain and 35 days per year at the Santiago Office. During the fourth year there is no functional work and several options are provided. The fellow may be hosted by a Chilean institution and will thus be eligible to apply for Chilean observing time on all telescopes in Chile. The other options are to spend the fourth year either at ESO's Astronomy Center in Santiago, Chile, or the ESO Headquarters in Garching, or any institute of astronomy/astrophysics in an ESO member state.

We offer an attractive remuneration package including a competitive salary (tax-free), comprehensive social benefits, and provide financial support in relocating families. Furthermore, an expatriation allowance as well as some other allowances may be added. The Outline of the Terms of Service for Fellows provides some more details on employment conditions/benefits.
Candidates will be notified of the results of the selection process in December 2004/January 2005. Fellowships begin between April and October of the year in which they are awarded. Selected fellows can join ESO only after having completed their doctorate.
The closing date for applications is **October 15, 2004**.

Please apply by:
- filling the form available at http://www.eso.org/gen-fac/adm/pers/forms/fellow04-form.pdf attaching to your application: a Curriculum Vitae including a publication list (the latter split into refereed and non-refereed articles, please) an outline of your current and past research, as well as of your research plans if you came to ESO (max. 2 pages) a brief outline of your technical/observational experience (max. 1 page)
- arranging for three letters of reference from persons familiar with your scientific work to be sent to ESO before the application deadline.

All documents should be typed and in English. The application material has to be addressed to:

European Southern Observatory
Fellowship Programme
Karl-Schwarzschild-Str. 2
85748 Garching bei Muenchen
Germany
vacancy@eso.org

Contact persons: Nathalie Kastelyn, Tel. +49 89 320 06-217, Fax +49 89 320 06-497, e-mail: nkastely@eso.org for applications for Chile
Katjuscha Haase, Tel. +49 89 320 06-219, Fax +49 89 320 06-497, e-mail: khaase@eso.org for applications for Garching

All material must reach ESO by the deadline (**October 15**); the same applies to recommendation letters which should be sent directly by the reference person; applications arriving after the deadline or incomplete applications will not be considered!

BASTIAN, Nathan (US)	Students
BAUME, Gustavo (AR)	Associate
COURVOISIER, Thierry J.-L.(CH)	Associate
DI FOLCO, Emmanuel (FR)	Students
EGEDAL, Carsten (DK)	Engineer
EGHOLM, Mathias (DK)	Students
EHMKE, Veronika (DE)	Students
ELMHAMDi, Abouazza (MA)	Associate
GARCIA, Perez Ana (ES)	Students
GREVE, Albert (NL)	Associate
HAU, George (GB)	Fellow
IRWIN, Jimmy (US)	Associate
KURZ, Richard (US)	European Project Manager
LEDO, Hugo (PT)	Students
LE POOLE, Rudolf Samuel (NL)	Associate
METZ, Manuel (DE)	Students
RAINER, Norbert (DE)	Associate
SNEL, Ralph (NL)	Associate
TOZZI, Paolo (IT)	Associate

CHILE

ANDRETTA, Vincenzo (IT)	Associate
FIOKTISTOVA, Irina (RU)	Student
GIUFFRIDA, Giuliano (IT)	Student
GRILLO, Claudio (IT)	Student
JOHNSON, Rachel (GB)	Operation Staff Astronomer
RAFFI, Hernan (IT)	Student
SCATARZI, Alberto (IT)	Associate

Local Staff

(1 April 2004 – 31 May 2004)

ARRIVALS

JIRON, Paulina	Executive Bilingual Secretary
PEÑA, Eduardo	Software Engineer
ZAGAL, Juan	Software Engineer

DEPARTURES

PEREZ, Juan Pablo	Electronics Engineer

ESO, the European Southern Observatory, was created in 1962 to "... establish and operate an astronomical observatory in the southern hemisphere, equipped with powerful instruments, with the aim of furthering and organising collaboration in astronomy..." It is supported by ten countries: Belgium, Denmark, France, Germany, Italy, the Netherlands, Portugal, Sweden, Switzerland and the United Kingdom. ESO operates at three sites in the Atacama desert region of Chile. The Very Large Telescope (VLT), is located on Paranal, a 2,600 m high mountain approximately 130 km south of Antofagasta. The VLT consists of four 8.2 metre diameter telescopes. These telescopes can be used separately, or in combination as a giant interferometer (VLTI). At La Silla, 600 km north of Santiago de Chile at 2,400 m altitude, ESO operates several optical telescopes with diameters up to 3.6 m. The third site is the 5,000 m high Llano de Chajnantor, near San Pedro de Atacama. Here a new submillimetre telescope (APEX) is being completed, and a large submillimetre-wave array of 64 antennas (ALMA) is under development. Over 1300 proposals are made each year for the use of the ESO telescopes. The ESO headquarters are located in Garching, near Munich, Germany. This is the scientific, technical and administrative centre of ESO where technical development programmes are carried out to provide the Paranal and La Silla observatories with the most advanced instruments. ESO employs about 320 international staff members, Fellows and Associates in Europe and Chile, and about 160 local staff members in Chile.

The ESO MESSENGER is published four times a year: normally in March, June, September and December. ESO also publishes Conference Proceedings, Preprints, Technical Notes and other material connected to its activities. Press Releases inform the media about particular events. For further information, contact the ESO Education and Public Relations Department at the following address:

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Front Cover Picture: ***Cosmic Ballet or Devil's Mask?***

Composite image of the superb triple system NGC 6769-71, located in the southern Pavo constellation (the Peacock) at a distance of 190 million light-years. This image was obtained on April 1, 2004, the day of the Fifth Anniversary of ESO's Very Large Telescope (VLT). It was taken in the imaging mode of the VIsible Multi-Object Spectrograph (VIMOS) on Melipal, one of the four 8.2-m Unit Telescopes of the VLT at the Paranal Observatory (Chile). The two upper galaxies, NGC 6769 (upper right) and NGC 6770 (upper left), are of equal brightness and size, while NGC 6771 (below) is about half as bright and slightly smaller. All three galaxies possess a central bulge of similar brightness. They consist of elderly, reddish stars and that of NGC 6771 is remarkable for its "boxy" shape, a rare occurrence among galaxies. (ESO PR Photo 12/04)