Chapter 2

OPERATION, MAINTENANCE AND ENHANCEMENTS

TELESCOPE OPERATION

During the two-year period 2002/03 covered by this report, the ING telescopes again performed very well, with downtime figures due to technical problems averaging only 2.4%, 1.0%, and 2.1% on the William Herschel Telescope (WHT), the Isaac Newton Telescope (INT), and the Jacobus Kapteyn Telescope (JKT), respectively. These figures are well below the target value of a maximum of 5 percent technical downtime. Observing time lost due to poor weather over the same period averaged 24%.

Day-to-day telescope operations support is carried out by a small operations team, taking responsibility for the three telescopes. Efforts of day-time and night-time support activities focus on the WHT. On this telescope, five common-user instruments are supported, as well as several visiting instruments. Many observing teams visit the telescope every year. The INT operates in a much simpler fashion and developed as of August 2003 into essentially a single-instrument facility. For the night-time operation a telescope operator in present each night on the WHT. Telescope operator support on the INT became unnecessary as a result of its simpler operating mode. Modernisation and integration of the various control systems over recent years have achieved that the INT and JKT can easily be operated by a single person. On the INT astronomy support is now largely carried out by students.

In view of the increasing importance of adaptive optics observations, night time operation at the WHT will gradually be adapted to ensure optimal scientific use of the best seeing periods. To achieve this, the observing programme has to be flexible, and the observer has to be able to switch from one observing programme to another, and even switch between instruments, in response to the actual observing conditions. Such queue-scheduled observations require hardware and software infrastructure to assist the astronomer in making the right decisions and to ensure that the scientifically most important observations are carried out. Developments are currently under way that prepare the WHT for queue scheduled observations.

The year 2002 marked the start of a significant reorganisation required by the phased reduction of operating cost of the observatory. These measures unavoidably have an impact on the service delivered to the visiting astronomers. Most notably, the 1-m Jacobus Kapteyn Telescope was withdrawn from normal operation in 2003, and the operation of the 2.5-m Isaac Newton Telescope was streamlined, with less scheduling flexibility and only the minimum of technical and astronomy support offered. However, in other areas the service, focussing on the WHT, has been strengthened.

As mentioned in the introduction to this report, the Instituto de Astrofísica de Canarias has become a full partner in the ING. The international agreement that formally establishes this new collaboration was signed on May 6th 2003 in Tenerife. This new partnership holds the prospect of stronger future collaborations in scientific programmes and projects. With this partnership, a re-adjustment of financial contributions has taken place, and as a result Spain obtains significantly more telescope time (see Table 1).

Figure 1. Signing of agreement between ING and IAC.

	2001	2002	2003	2004	2005+
UK	60.0	54.0	50.0	48.9	47.6
NL	15.0	15.0	15.9	17.0	18.3
Spain	0.0	6.0	9.1	9.1	9.1
Site contribution	20.0	20.0	20.0	20.0	20.0
CCI	5.0	5.0	5.0	5.0	5.0
Total	100.0	100.0	100.0	100.0	100.0

Table 1. Timeline of percentage breakdown of observing time.

Moreover, the IAC is constructing a world-class IR spectrograph, LIRIS, for the William Herschel Telescope, that will be offered to all users of the telescope, thus adding to the scientific capability.

Since 2002 the ING can count on a new advisory body: the Director's Advisory Committee, or DAC. This committee advises the Director on all major issues that affect ING, including strategic use of the telescopes, instrumentation developments, international collaborations, and operational aspects. The DAC, under chairmanship of Dr M McCaughrean (Potsdam), has already provided important advice on various issues.

From 2001 onwards, ideas for setting up collaborations between European observatory groups have been discussed intensely. The driving force was the realisation that there is significant overlap and duplication of interests and instrumentation between the various telescopes to which European astronomers have access. Better collaboration and coordination of development programmes across different telescopes could provide an overall better service to all astronomers than is currently the case through essentially national facilities. This initiative is sponsored by OPTICON, a EU-funded network for the wider coordination of optical and infra-red ground-based initiatives. As the goal of wider European collaboration is in line with the objectives set by the European Union, the EU decided it will provide financial support in future years for such collaboration between observatories.

As an example of European collaboration, an agreement for sharing observing time with the 3.6-m Italian Telescopio Nazionale Galileo (TNG), also located at the Roque de los Muchachos Observatory, was set up. As the TNG and WHT possess complementary instrumentation, it seemed opportune that through sharing of observing time both communities would obtain optimal access to the telescopes. So far, this time share scheme has worked very well: various Italian astronomers have been using the WHT for their observing programmes, while astronomers from the UK and the NL have exploited the TNG.

INFRASTRUCTURE

With Adaptive Optics (AO) being a key element of the development programme for the WHT, also infrastructure improvements have centred on supporting future AO activities at that telescope. In order to be much better prepared for future exploitation of the AO system, a dedicated controlled environment, GRACE, has been constructed. GRACE consists of a pre-fabricated building that encloses one of the Nasmyth foci. The internal environment is cooled and treated as a (moderate) clean room in order to protect and stabilise the AO equipment, in particular NAOMI, as much as possible. This new facility allows NAOMI to remain permanently mounted at the telescope, an essential requirement for future queue scheduled observations. Apart from NAOMI, its design also allows the deployment of OASIS, the AO-assisted integral field spectrograph, and even possible future equipment for laser guide star deployment. Dr A. Meijler, Director of the NWO Council for Physical Sciences, inaugurated the GRACE building in May of 2003.

Figure 2. Inside GRACE during its inauguration.

Creating a Nasmyth focus dedicated to AO implied the removal of the Utrecht Echelle Spectrograph occupying that focal station. That spectrograph was retired from service in 2002. A study is under way to explore the feasibility to adapt the spectrograph to work at the 10-m GTC telescope, currently under construction on La Palma.

Taking care of optical components is an important task at any observatory. Arguably the most important components are the telescope mirrors, for which general cleanliness is a major concern in order to maximize their light reflecting capability. ING's procedures for mirror maintenance include snow cleaning, washing, and re-coating. During the reporting period a new technique for mirror washing has been tested, using water vapor rather then classical wet washing techniques. The major advantage with vapor is the relatively small quantities of liquid involved, which is a major benefit when dealing with large mirrors in-situ.

Figure 3. Vapour mirror cleaning.

As part of a phased modernisation of key observing systems, all science CCD detector systems have now been converted to the SDSU controllers and new high-level data acquisition software. This and other infrastructure improvements help increase the overall observing efficiency and user friendliness. But equally important in having uniform systems is the advantage of easier maintenance and holding of spares.

The existing autoguider systems (and ultimately also the TV acquisition cameras) are also gradually being upgraded to SDSU controller-based systems with frame-transfer CCDs. This will allow ING to retire

Figure 4. Picture of one of the new CCD acquisition cameras.

older controllers and software that is becoming difficult to support, and at the same time improves overall performance. Three systems have been commissioned: one for NAOMI acquisition and two that will be used for object acquisition at Cassegrain and with INTEGRAL, and for autoguiding with AUTOFIB.

In August of 2003 the JKT was taken out of regular service as a common-user telescope. This unfortunate but necessary step had to be taken under the pressure of budget reductions. The telescope and its associated infrastructure, however, will be maintained for some time in a state so that it can be put back into service with little effort. An initiative has been started to seek potential self-financing activities to reactivate this still productive telescope facility.

The reporting period also saw the completion of ING's robotic seeing monitor, RoboDIMM. This system measures atmospheric seeing based on measurement of differential image motion of star images produced by pairs of small apertures. Free atmosphere seeing is deduced from the relative motion of two simultaneous

Figure 5. Left: RoboDIMM tower and dome. Middle: telescope. Right: typical seeing plot from a single day. RoboDIMM is situated some meters north of the WHT.

images obtained with very short exposures. The system consists of a small telescope and associated equipment, and is located on a dedicated tower, not far from the WHT dome. Apart from start-up and closedown, the system is fully automatic; it finds suitable stars and tracks these stars, measuring seeing all night. Seeing data is stored in a database, together with meteorology data. A web-based interface allows on-line assessment of the seeing, monitoring development of seeing during the night, as well as easy recovery of historic data. RoboDIMM will be a key tool for effective queue observing in the future.

A long-standing wish at ING has been the construction of an all-sky (cloud) monitor. Such system is useful for assessing sky quality, to plan observations at night, and even to measure sky transparency and sky brightness as a function of sky position. Recently a project at Michigan Technical University came to fruition, producing a visible-light all-sky continuous camera, CONCAM. Although originally developed for scientific purposes as an all-sky monitor for variable objects, it serves also well as a cloud monitor. ING has acquired a system that has been installed on the roof of one of its buildings, bringing the observatory's actual night sky live on the web.

At the INT, installation of a cold air circulation system to take away warm air that builds up during the day immediately below the INT observing floor was completed. It is expected that this system will reduce heat transfer into the dome area, and thus improve local seeing conditions.

At the WHT, a major infrastructure upgrade was the replacement of the air conditioning units servicing the control room, computer room and terminal area. The new system will be much easier to maintain, and will operate more cost efficiently as well.

ING's computing infrastructure has also seen considerable further evolution to keep abreast with the evolving requirements and ever increasing data rates. Faster machines and more data storage capacity was installed where most urgently required. Also firewalls to protect the computer network and computer systems from malicious, external intrusions were installed, both at the observatory and at the sea-level offices. Computing infrastructure is now properly protected against malicious use, while a reasonable level of flexibility can still be offered to visiting astronomers and their equipment.

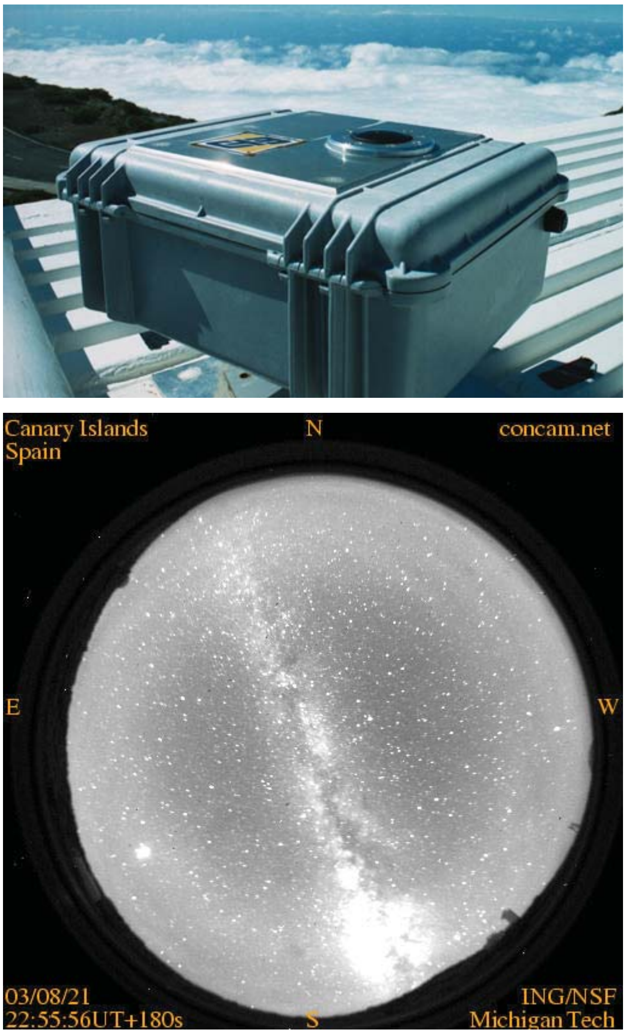


Figure 6. CONCAM camera and a typical night all-sky image.

A weak link in ING's network services is the reliability and bandwidth of the observatory's computer connection to the outside world. ING's critical dependence on the external network has grown. Moreover, new major telescope installations will soon start using the same limited bandwidth available to the observatory, while there is no matching growth of bandwidth capacity foreseen. For that reason the technical feasibility of alternative network connectivity is under study.

A significant re-organisation of office space has taken place in the sea-level base, in the Mayantigo building in Santa Cruz de La Palma. As a result of staff reductions the required number of offices is reducing. Re-organisation of the offices will achieve more efficient use of the available space, and as a result some more space can be let to other observatory groups.

INSTRUMENTATION

Adaptive Optics remains central to the instrumentation development at ING and has progressed significantly during the reporting period. Various science observations were carried out and a much better understanding of the system performance was gained. An important step was the decision to dedicate one of the WHT Nasmyth foci to AO instrumentation. As a result, during 2003 a dedicated AO laboratory enclosure was completed and taken in use. This enclosure, called GRACE, not only provides a cleaner and more stable platform for AO exploitation, but it also avoids disruptive and labour intensive instrument changes. With the advent of GRACE, AO has become a permanent feature at the WHT.

Science observations covered circumstellar dusty shells, planets near isolated stars, microstructure in PNe, cD galaxies, post-AGB circumstellar envelopes, QSO hosts, companions to cool dwarfs, and near-Earth asteroids. One of the latter yielded FWHM 0.11-arcsec images of the fast-moving (up to 5 arcsec/sec) near-Earth asteroid 2002NY40 during its night of closest approach, resulting in a press release and BBC coverage.

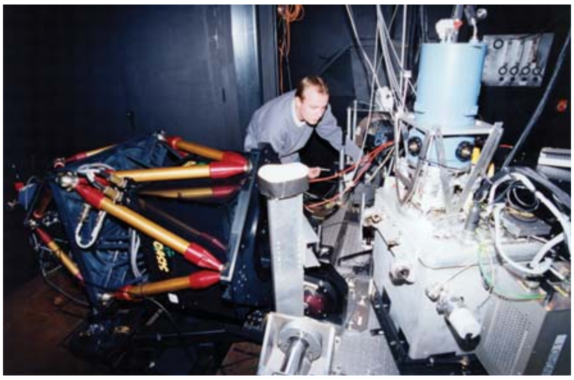
A key achievement for NAOMI has been the successful performance tests at visible wavelengths, in preparation for the integral-field spectrograph that has been installed and passed through its first commissioning tests in 2003. Significant improvements in image quality were proven, and the system could be locked on relative faint point sources as well as more extended sources such as the nucleus of the galaxy M31. NAOMI is now routinely delivering images with FWHM ~0.2 arcsec in the near-IR. Further characterisation of NAOMI's performance continues with measuring image quality as a function of wavelength, guide-star magnitude, radius from guide star and natural seeing.

Although operation of the AO system has become much more robust and streamlined, the overall performance of AO correction leaves room for improvement. Optimisation of AO performance has now become the focus of further activities.

Following extensive preparations, the OASIS integral field spectrograph was installed at the WHT in the summer of 2003. The OASIS spectrograph is optimised to work with AO instrumentation with its typical plate scale of 0.2 arcsecond per focal-plane lenslet element. OASIS was deployed before on the Canada-France-Hawaii Telescope. This project is being carried out in collaboration with the Centre de Recherche Astronomique de Lyon where OASIS was built. The project required modifications not only to OASIS itself, but also a new optical science port with a changeable pass band had to be constructed for the NAOMI AO system. Together, this system delivers unique capability for carrying out spectroscopy at high spatial resolution. Such facility will allow, for instance, the study of the dynamics within galaxy cores or star forming regions.

The NAOMI AO system was also enhanced in 2002 with a coronographic facility, OSCA. Basic functionality of OSCA was proven during the first commissioning run. The coronagraph unit sits on an articulated plate that can be deployed quickly in/out of the beam. This makes remote switching between 'normal' AO observations and coronographic work fast and easy. OSCA's all-reflective optics are designed to work both at optical and IR wavelengths. The system was designed and built at the University College London.

Another important development for the WHT is being carried out at the IAC, where the intermediate resolution IR spectrograph and imager, LIRIS, is being constructed. This instrument, based on a 1024 by 1024



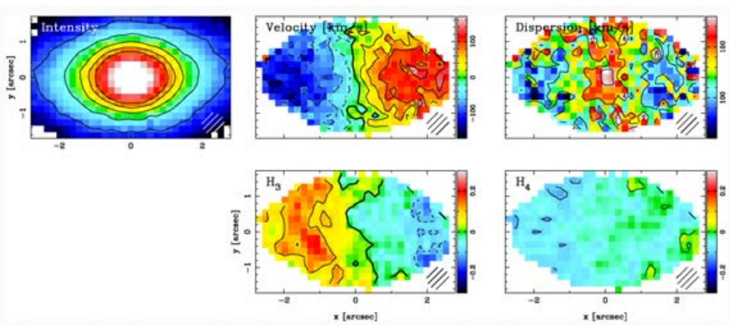


*Figure 7. Left: OASIS joins NAOMI in WHT's AO-dedicated, temperature-controlled Nasmyth enclosure, GRACE. The IR camera INGRID is visible in the foreground on the right. Right: OASIS stellar kinematical maps of NGC 3377 (Copin et al., 2004, A&A, **415**, 889).*

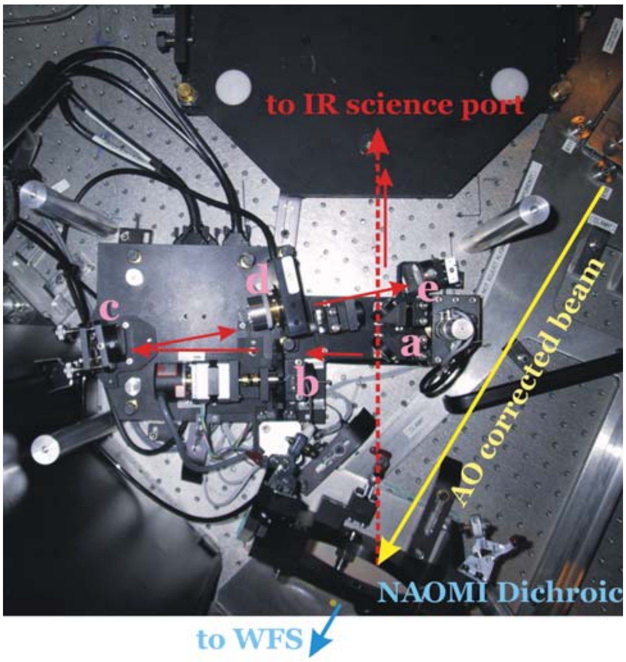


Figure 8. OSCA on the NAOMI bench. The light path is indicated by the arrows. The dashed red line shows the lightpath without OSCA. (a) OSCA picks up the converging beam coming from NAOMI and directs it onto the focal plane masks (b) and then onto the first off axis paraboloid (c). The beam leaves OSCA via an optical system (d) which conserves the focal point and f-ratio of the NAOMI beam.

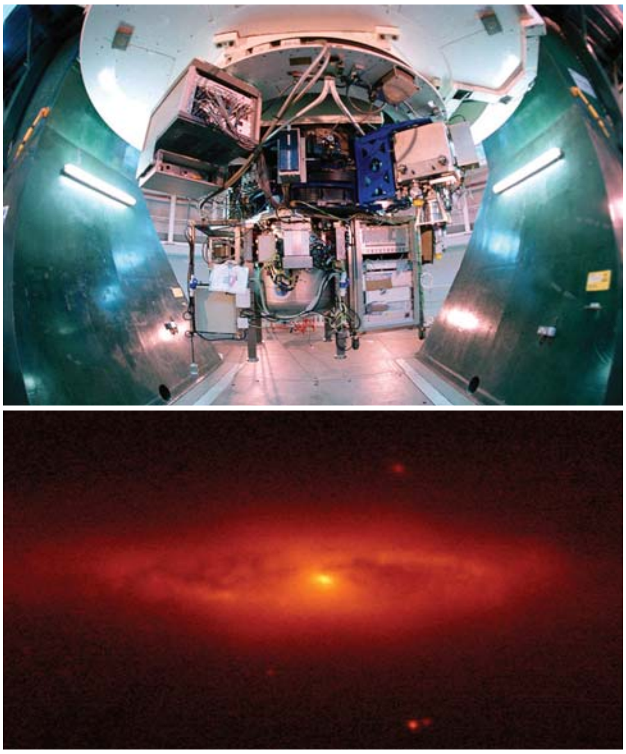


Figure 9. LIRIS mounted on the WHT Cassegrain focus. LIRIS cryostat can be seen at the bottom of the telescope focus, with the two electronics racks at both sides. First light image of the Seyfert 2 galaxy NGC4388 observed in the J filter. Note the very bright active nucleus and the patchy structure of the spiral arms, revealing the presence of obscuring dust lanes.

pixel Hawaii array detector will be placed in the Cassegrain focus of the telescope and allow high quality imaging and multi-object spectroscopy at near IR wavelengths. LIRIS has passed its first integration tests successfully and has produced high quality images and spectra in the laboratory. The instrument saw its first technical commissioning run at the WHT Cassegrain focus early in 2003, which worked out highly satisfactory. LIRIS is expected to become one of the workhorse instruments for the telescope. Final scientific commissioning and operation of LIRIS will take place during the first half of 2004.

In 2002 the Utrecht Echelle Spectrograph was decommissioned and removed from the telescope Nasmyth platform to the ground floor at the WHT. Although the instrument has been decommissioned in its original implementations, it is being studied how the instrument can continue to deliver scientific high resolution spectral observations, possibly as a fibre fed spectrograph on the 10-m GTC telescope.

The fibre-fed WYFFOS spectrograph is awaiting an important enhancement following the completion of a new camera. This so-call 'long camera' has the advantages over the current camera that it will (i) accommodate a much larger number of fibres (up to 1000), (ii) have an external focus permitting change of detector; and (iii) provide a somewhat higher spectral resolution. Detailed design and construction of the camera was largely carried out at ASTRON in The Netherlands. Although the optics and mechanics were completed in 2003, final commissioning has been postponed until 2004, mainly due to conflicts with other activities.

An integral part of the instrumentation strategy for the WHT is to act as a platform for visiting instruments and experimental setups. During the reporting period the WHT has enjoyed the interest of many such instruments. Visiting instruments included, for example, the integral field spectrograph SAURON that continued its large survey to study the kinematics of the cores of nearby galaxies, and the Planetary Nebula Spectrograph that has been used several times to detect PNe as tracers of the kinematics of the outer regions of galaxies.

A new visiting instrument that has come to the WHT is ULTRACAM, a triple-beam CCD camera, imaging up to a 5-arcmin field, designed for high-speed readout as fast as several times per second, and was commissioned in 2002. ULTRACAM fills a niche and has been used with great success during many nights. Since CCD exposures in the three different wavelength bands are carried out simultaneously, this system is capable of delivering very high quality photometric colour information of variable objects such as for instance cataclysmic variable stars and flare stars.

Observations of a more experimental nature have been carried out in the GHRIL Nasmyth focus of the WHT.

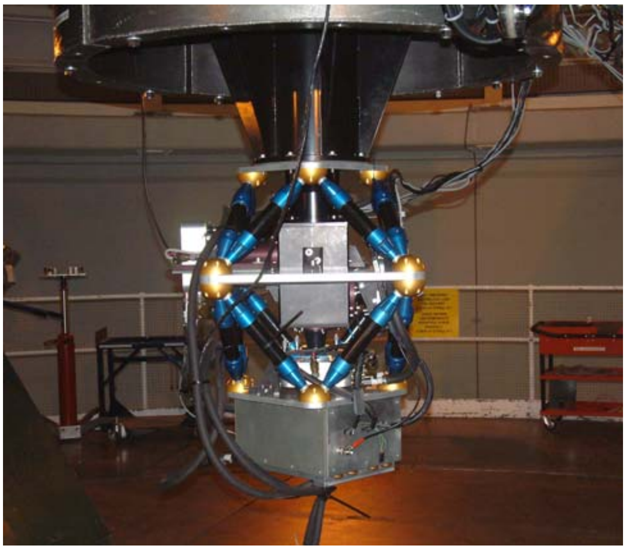


Figure 10. ULTRACAM on the WHT.

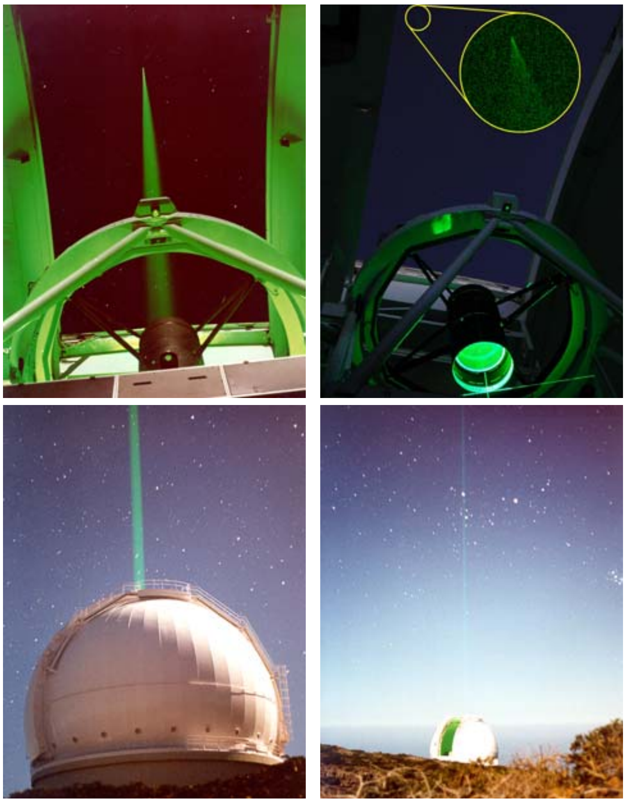


Figure 11. Different views of the Rayleigh laser launch.

In particular, a number of experiments for the deployment of laser guide stars and detection of atmospheric turbulence have been carried out. The laser guide star experiments mainly focus on testing new techniques for exploiting laser beacons on large and future extremely large telescopes. Through these experiments experience is build up that might benefit ING in the future, when a common-user laser system will be deployed at the WHT. The astronomical instrumentation group of the University of Durham has taken a central role in these developments.

Measurements of atmospheric turbulence were carried out by a team from Durham University and from the IAC. Various techniques exist to measure atmospheric turbulence. The IAC team deployed the SCIDAR (scintillation-detection-and-ranging) technique on the JKT, while the Durham team tested a new method, SLODAR (slope-detection-and-ranging) on the WHT using double stars to measure the C_n^2 profile of atmospheric turbulence. Both groups aim to obtain good statistics on the measurements of atmospheric turbulence through systematic measurements over extended periods. Such measurements are extremely valuable for understanding the atmosphere above the observatory.

Apart from major new developments in instrumentation, there are also various smaller scale projects that aim to significantly enhance the capabilities of existing instruments: ING's programme of continuing detector improvements has achieved some major successes. ING joined a large consortium to procure MIT-Lincoln Lab CCDs. These large format CCDs will nearly double the quantum efficiency in the

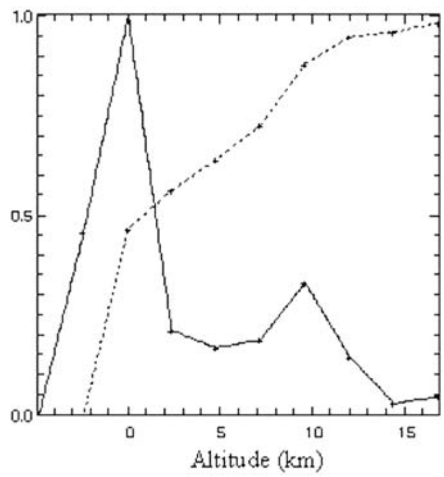


Figure 12. Example SLODAR normalised profile of the strength of optical turbulence versus altitude on 16 April, 2003.

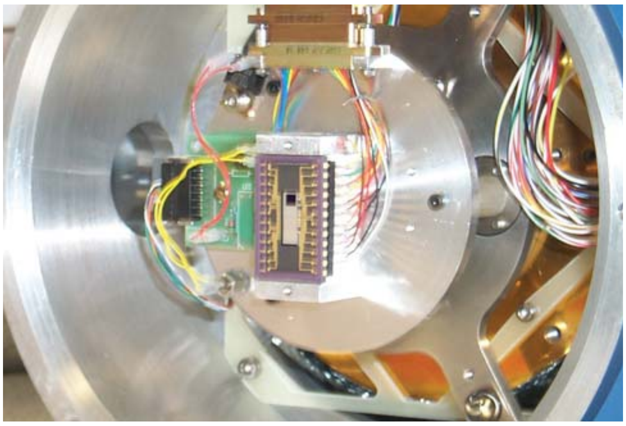


Figure 13. One of ING's L3 CCD.

far red, and suffer much less from 'fringing' than ING's older CCDs. The advantage of the new CCDs is particularly important for spectroscopic work on the red spectrograph arm of ISIS, and on OASIS. One of the CCDs was received and taken into operation as the dedicated detector for the OASIS spectrograph. A Marconi CCD of similar characteristics was purchased, taken into operation on the ISIS spectrograph.

Recently, a new development in CCD technology was announced by the company E2V (formerly Marconi/EEV) which allows read noise to be reduced to nearly zero electrons, providing very important gains in photon detection efficiency at low light levels. These Low-Light-Level CCDs (or L3 CCD) possess an extended readout register, allowing the weak signals from the detector to be amplified prior to digitisation, thus achieving very high signal gains. This reduces read noise to close to zero electrons, at the expense of effective loss of QE for high count rates. In situations where a measurement is read-noise limited, as it is usually the case for continuous high-speed wavefront sensing in AO applications, an L3 CCD can be of enormous benefit, and therefore an investigation was started to study the suitability of this new technology for the NAOMI wavefront sensor. Preliminary results have been very positive, predicting a possible very significant gain in faint detection limit for the wavefront sensor of 1–2 magnitudes.

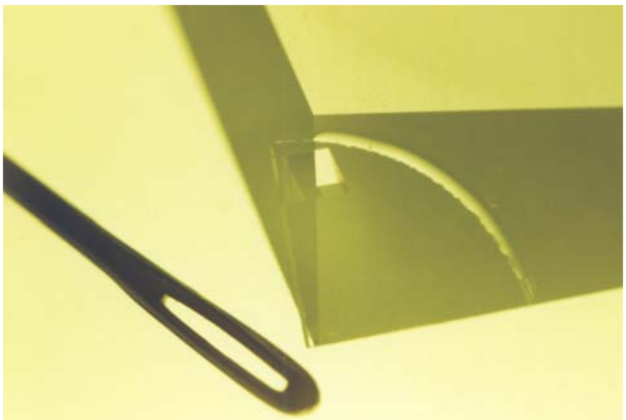


Figure 14. ISIS image slicer and needle for reference.

A very different and small but significant development is that of the design and construction of a focal plane image slicer for ISIS. An image slicer of the kind envisaged for ISIS will accept the full image of a star in the telescope focal plane, and cut the image by optical means into narrow slices. The optically re-arranged image slices will form a narrow, virtual spectrograph slit. The advantage of such a system is that even under mediocre seeing conditions all the light from a point source will still enter the spectrograph without compromising spectroscopic resolution. This image slicer therefore will greatly improve the overall throughput and effective resolution of the spectrograph for point sources under mediocre seeing conditions. The importance of this is particularly high, come the time of extensive queue observing with NAOMI, when under less than ideal seeing conditions another instrument such as ISIS must be used. The image slicer will ensure excellent throughput. This in-house development should be available for commissioning next year.

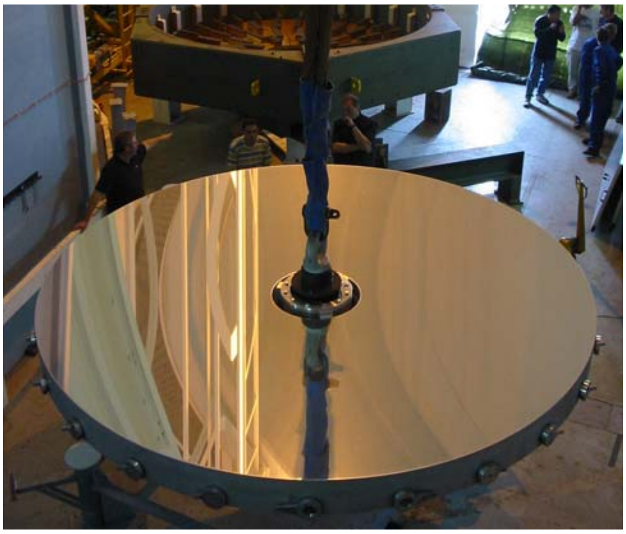


Figure 15. Part of aluminisation process of TNG's primary mirror at ING.

Apart from ING's in-house activities of telescope operation and instrument developments, some projects for other observatory groups are carried out as well. Recurrent activities include the production and distribution of liquid nitrogen, provision of backup generator power, and cleaning and re-aluminisation of mirrors. A major exercise was the aluminising of the TNG primary, secondary and tertiary mirrors.

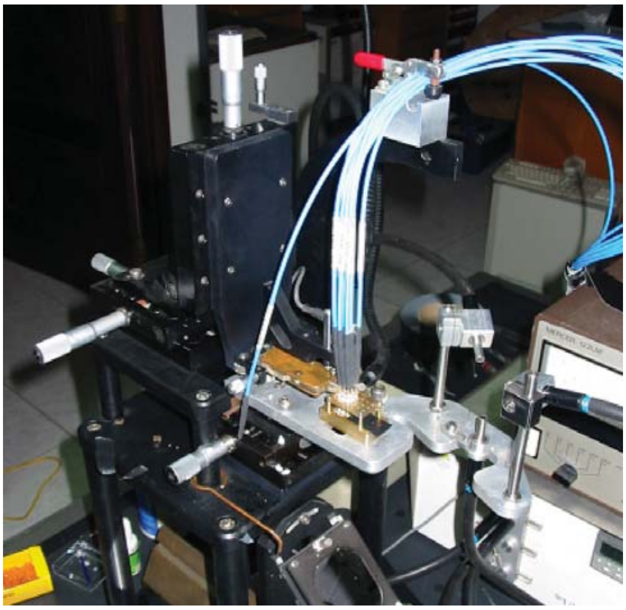


Figure 16. bHROS fibres being glued on base plate.

During the work on the AUTOFIB small fibre unit staff at ING acquired specialist skills on the preparation of optical fibres. ING was approached by the Gemini telescope bHROS team to carry out fibre work for that echelle spectrograph for Gemini-South. That work was carried out successfully, and the fibres are currently in use.

A recent new installation at the Roque de los Muchachos Observatory site houses the SUPERWASP experiment, led by the Queen's University Belfast. The installation consists of a number of wide-field cameras on a robotic mount, located in an automatic roll-off roof enclosure. ING has been providing assistance in the construction of this robotic wide-field camera system. The main scientific aim of this experiment is the detection of planets around stars through their occulting effect when the planet transits the stellar surface. The system saw first light only a few months after building permission was granted.

Figure 17. SUPERWASP enclosure.