Chapter 2

OPERATION, MAINTENANCE AND ENHANCEMENTS

TELESCOPE OPERATION

Day-to-day telescope operations activities are carried out by a single Operation Team covering the three telescopes. Efforts of day-time and night-time support activities focus on the WHT. On this telescope six main common-user instruments are offered, and many observing teams pass the scene. The INT on the other hand operates in a much simpler fashion and is essentially a two-instrument facility, while the JKT only supports one instrument. For the night time operation a telescope operator is present each night on the WHT and some of the nights on the INT. At the JKT no night time operator support is available to visiting observers. Astronomy support is offered to all visiting astronomers on the first night of their observing run, and at night engineering support is always around. Modernisation and integration of the various control systems have resulted that the INT and JKT can now easily be operated by a single person. On the JKT astronomy support is largely carried out by students.

Care of ING's prime optical components, the telescope mirrors, remains an important recurrent aspect of the day-to-day work at the observatory. We continued to CO_2 snow-clean the WHT primary mirror. However, in line with findings at other observatories, tests have shown that regular mirror washing in combination with snow cleaning helps keep reflectivity high, reduces scatter of light, and relaxes the need for regular re-aluminising. During the year the first experiments with mirror washing were carried out with good results. In situ mirror washing offers a significant engineering challenge in order to protect the telescope and ancillary equipment against water.

INFRASTRUCTURE

The implementation programme of the new San Diego controllers (SDSU-2) and control software and hardware to replace the older generation of controllers has progressed well. The new system was taken in use with all science detectors available on the INT and with nearly all detectors at the WHT. It provides much faster readout of CCDs and significantly improves observing efficiency. The same system has now also been implemented for operation with the IR Hawaii array in the new infrared camera on the WHT, INGRID.

The CCDs currently available at ING have overall excellent characteristics, but one weakness in the suite of CCDs offered to astronomers is the relatively low quantum efficiency beyond 800 nm and interference fringes between the front surface and the back plane of the detector, hampering accurate flat field calibration. To resolve this weakness ING has joined a consortium effort for the development of a new generation of MIT/Lincoln laboratory CCDs with nearly twice the quantum efficiency at far red wavelengths and very little fringing. The first of the science grade devices are expected for delivery in 2002.

In previous years ING's Differential Image Motion Monitor (DIMM) had provided valuable information on the site seeing conditions. The operational overheads in operating the DIMM have meant that this system could only be operated on a campaign basis. In view of the adaptive optics observations, in particular when carried out in queue scheduled mode, the need for continuous information on the actual seeing condition becomes essential. But also for other types of observations it has been found useful to have an accurate measure of the free atmosphere seeing. For this reason the ROBODIMM project was initiated to provide continuous seeing measurements using a system that can operate in an unassisted, robotic fashion. ROBODIMM will become operational in 2002.

Over the two reporting years the legacy computer network infrastructure was successfully replaced with a 100 megabit per second network using structured cabling. Due to the complexity of the computer infrastructure and the requirement not to interrupt telescope operation this took more than a year to complete. This network enhancement not only provides an increase in network capacity of an order of magnitude, but it also provides a backbone upon which further increases in network capacity may be realised. This new network has brought many advantages to the ING in terms of network management and security, and these improvements have also been appreciated by visiting astronomers.

In line with the network enhancements, data archiving and storage within the ING has witnessed a number of disparate but crucial changes such as the successful testing of a system to automatically create "D" tapes, the introduction of an elaborate backup system, which was developed in-house, and the inauguration of two new RAID systems. These projects are complemented by the introduction of a Pioneer library system capable of writing to and reading from CDs and DVDs. These towers each have the capability of housing 6.8Tb of double-sided medium allowing data to remain on-line for ten times longer than was previously possible. This is not only advantageous for visiting observers, but also reduces much of the day-to-day pressure to manage and guarantee a secure data flow as raw data from the ING telescopes is now automatically recorded on DVD-R disks for eventual transfer to the ING archive at Cambridge. With these enhancements in place ING can keep abreast with the ever growing quantity of data generated by our observing systems.

On the INT the Wide Field Camera is used much of the time for carrying out a wide field survey of the sky. This survey project prompted the initiation of a project to vastly improve the data processing capability for pipeline data reduction. This so-called Beowulf system is based upon a specialised parallel processing Linux-PC cluster running the pipeline data processing software developed at the Cambridge Astronomy Survey Unit in the UK. The introduction of a Beowulf system complemented ING's data handling strategy and in particular consolidated the above mentioned new computer network with the new CD/DVD systems. The pipeline offers fully automatic quick-look reduction for immediate quality assessment at the telescope, and a science pipeline offers a reduced data product shortly after the end of the observing run. Observers can submit their observations to the pipeline at the end of the night and allow them to view fully processed data — including object catalogues — the following afternoon. The science pipeline requires only a small amount of human intervention in order to ensure use of the best possible calibration frames.

The consumption of liquid nitrogen has gradually increased over the years and is expected to increase further in the future as more detectors and instruments come on line. The production capacity of the existing plant had become insufficient to meet future demands, as the plant supplies not only the ING telescopes but also other telescopes at the observatory. To resolve this problem, jointly with the Galileo Telescope and Nordic Optical Telescope groups a second liquid nitrogen production unit was purchased and installed. The new plant together with the old unit and enhanced storage capacity will be able to meet current and future demand.

An initiative has been started to implement a number of low-cost house-keeping measures in the INT building with the aim to reduce locally induced seeing and hence improve image quality. Experiments with the Differential Image Motion Monitor in previous years provided firm quantitative evidence for the popular belief that seeing at the INT is worse than the quality of the sky would allow. On the basis of this it was decided to implement a number of simple measures to reduce the heat input into the dome, such as ventilation of cold air into the building below the observing floor.

The ageing Westinghouse acquisition TV system on the WHT was replaced by a modern commercial CCD-based TV system. The new system, although somewhat limited in capability, provides much improved image quality and allows acquisition of much fainter objects.

During the summer of 2000 both the WHT and INT domes were painted externally. This major maintenance work was managed so not to affect the observing programme in any way.

Figure 1. A view of the ING liquid nitrogen plant with the new production unit in the foreground.

INSTRUMENTATION

The WHT supports a versatile set of common-user instruments, ranging from optical and IR imagers, to medium and high resolution spectrographs. But apart from the facility-class instruments, as in previous years the WHT has remained popular with visiting instruments. Most notable *visitors* have been the ESA/ESTEC's super conducting-tunnel-junction camera S-Cam, the SAURON integral field spectrograph, and the Planetary Nebula Spectrograph.

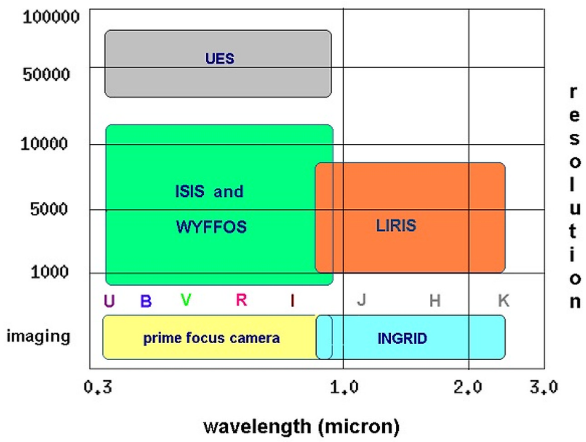

Figure 2. Instrument capability of the William Herschel Telescope.

Of these visiting instrument, the ESA/ESTEC's innovative super conducting-tunnel-junction camera S-Cam was probably the most technologically exciting. The unique technology deployed in this camera permits measurement of both the energy and time of arrival of each photon striking the detector array at very high detection efficiency. During three observing runs technical commissioning was combined with science observations. The detector deployed in S-Cam had only 6 by 6 pixels, but it is expected that in the near future S-Cam will feature a larger format detector with better wavelength resolution.

The SAURON integral field spectrograph had several visits to the WHT. This instrument is a collaborative project between research groups in Leiden, Lyon and Durham. The instrument uses a lenslet array to dissect the telescope focal plane in many apertures, and in one exposure a spectrum for each aperture is obtained. A huge multiplexing advantage is thus obtained, which makes this spectrograph highly suitable for measuring the kinematics of nearby galaxies.

The Planetary Nebula Spectrograph, PN.S, designed and built by an international consortium with groups from Australia, The Netherlands, Italy, the UK and the USA, is an instrument that has been designed with a very specific scientific objective in mind. This slit-less spectrograph produces counter-dispersed images of galaxies in the OIII line. This setup allows very easy and efficient detection of planetary nebulae in galaxies through their emission line nature. The images obtained provide not only the position of the PNe, but also the radial velocity of the objects that can then be used to study the dynamics in galaxies.

Apart from these new visitors, also other visiting instruments that had been to the telescopes before, like the MUSICOS fibre-fed echelle spectrograph, the CIRSI panoramic IR camera, and the Texas-Tromso Photometer, returned to the ING telescopes.

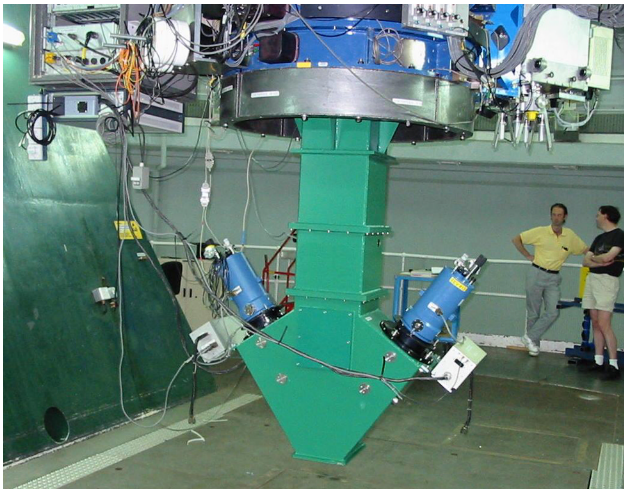

Figure 3. The Planetary Nebula Spectrograph fully assembled and integrated with the WHT, and EEV CCDs and controllers mounted on each arm of the spectrograph.

INSTRUMENT DEVELOPMENTS

Instrumentation development activities now strongly involve ING's engineers and astronomers on La Palma, a trend that has become more apparent during the reporting years. Reorganisation of the operational activities has enabled ING staff to gradually become more involved in development projects than used to be the case. The following main projects came to fruition.

Early 2000 saw the completion and commissioning of ING's new infra-red imager, INGRID, for the WHT. The system performed well from the very start. INGRID is made available at a new port on the Cassegrain focus and is also used as the premier imaging system for adaptive optics. This camera at its heart has a Rockwell 1024 by 1024 pixel HgCdTl array detector covering a

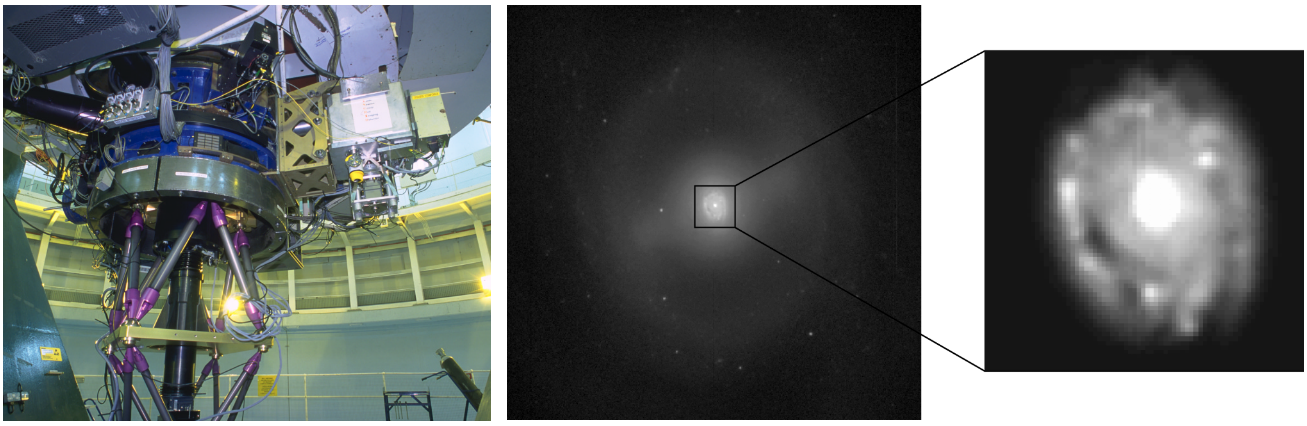

Figure 4. Left: INGRID mounted on one of the WHT folded Cassegrain foci (top right). The instrument on the Cassegrain focus is SAURON. Right: This image acquired using INGRID on the first nights is a J-band image of M95. The inset on the right shows the nuclear ring of enhanced star formation.

field of over four minutes of arc. It has been very popular within the user community, judging from the number of applications and post-observing feedback received. In particular the field of view has proven to be an attraction to observers.

A second important project carried out at the ING was the design and construction of a new fibre module for the AUTOFIB multi-object fibre spectrograph in the prime focus of the William Herschel Telescope. AUTOFIB has considerably increased in popularity, most likely due to the fact that this instrument fulfils a pivotal role for spectroscopic follow-up observations of ongoing imaging surveys such as the ones being conducted at the INT. The new fibre module with smaller, 1.6 arcsec diameter fibres has the advantage of reduced sky background contamination and higher throughput. Design and manufacturing work on the new fibre module was fully carried out at ING. A further enhancement of the fibre spectrograph has been initiated, with the design and construction of a new spectrograph camera that will allow imaging more fibres and deployment of larger format CCDs.

Arguably the most important development project that came to fruition was the technical commissioning and first science observations of the common-user adaptive optics system for the WHT, NAOMI. The Adaptive Optics (AO) programme is a corner stone development area for the WHT. The 4-m class telescopes will more readily be able to effectively exploit AO techniques at relatively short wavelengths and over moderately wide fields than the larger telescopes, in particular on a good observing site such as La Palma. The WHT AO system was designed and built by a team from Durham University and the UK-Astronomy Technology Centre in Edinburgh. The advent of NAOMI required a range of modifications and improvements to be made to the Nasmyth focal station and telescope performance in order to make the telescope ready for the 0.1 arcsecond world of adaptive optics.

During pre-commissioning tests diffraction-limited images were readily obtained in the J, H and K bands with a small pinhole illuminating the focal plane. And also on celestial objects in the K band the diffraction limit was reached. Most of the commissioning goals

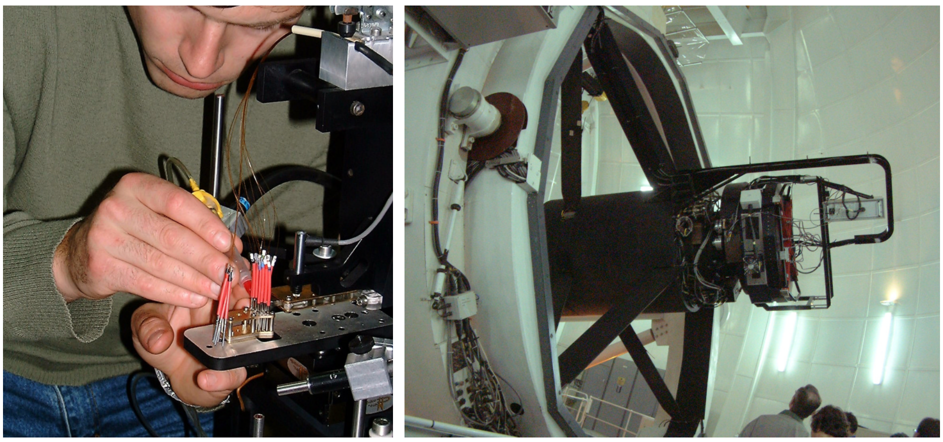

Figure 5. Left: Alignment of fibres into micro-lens finger holder at ING. Right: The Small Fibre Module at WHT prime focus.

were met, proving basic functionality of the system. Particularly impressive was the quality of optical alignment achieved with the modular NAOMI design and the success of largely automated methods for determining and correcting for so-called non-common path error (differential optical aberrations between wavefront sensor camera and science camera). The complex interplay between the segmented deformable mirror, the fast steering mirror, and the telescope tracking was achieved reliably.

Following initial commissioning in 2000, further on-sky tests have focussed on optimising and characterising system performance. Key achievements included regular diffraction limited 0.12 arcsec FWHM performance in the K band, closing the loop on a 15th-mag star, and automatic dithering with the AO loop closed. In September 2001 tests were conducted to gauge NAOMI's performance in the optical, in preparation for the OASIS integral-field spectrograph that will come to the WHT in 2003.

Further development of the adaptive optics programme at the WHT includes deployment of a coronagraph (OSCA), built at the University College London, and of an integral field spectrograph (OASIS) in collaboration with Centre de Recherche Astronomique in Lyon, France. Both instruments will provide important new science capability to the adaptive optics system and are expected to be commissioned in 2003.

The NAOMI AO instrumentation relies on natural guide stars to measure wavefront distortions. Optimal exploitation of AO would require the deployment of artificial guide stars produced by a laser beam, as this would provide nearly full sky coverage. Large sky coverage enables a much wider range of astronomical applications of adaptive optics to be carried out. A sodium laser produces a fluorescent spot high in the Earth's atmosphere, at an altitude of approximately 90 km that can then be used as an artificial star. In preparation for possible future sodium beacon deployment on La Palma a study has been completed to investigate whether the atmospheric conditions above the observatory are suitable for this technique and to learn about the technical complexities of sodium laser guide star deployment. This programme, led by the Imperial College in London, resulted in a number of laser firings during several nights over the period of one year. The very successful trials gave invaluable information and experience on both technical and atmospheric parameters. For instance the tests allowed measurement of the temporal variation of the mesospheric sodium layer thickness and profile, as is shown in the adjacent figures.

An exciting instrument under development at the Instituto de Astrofisica de Canarias that will likely serve a large user community in the future is the LIRIS IR spectrograph and imaging system. This versatile system, designed for the Cassegrain focus of the WHT,

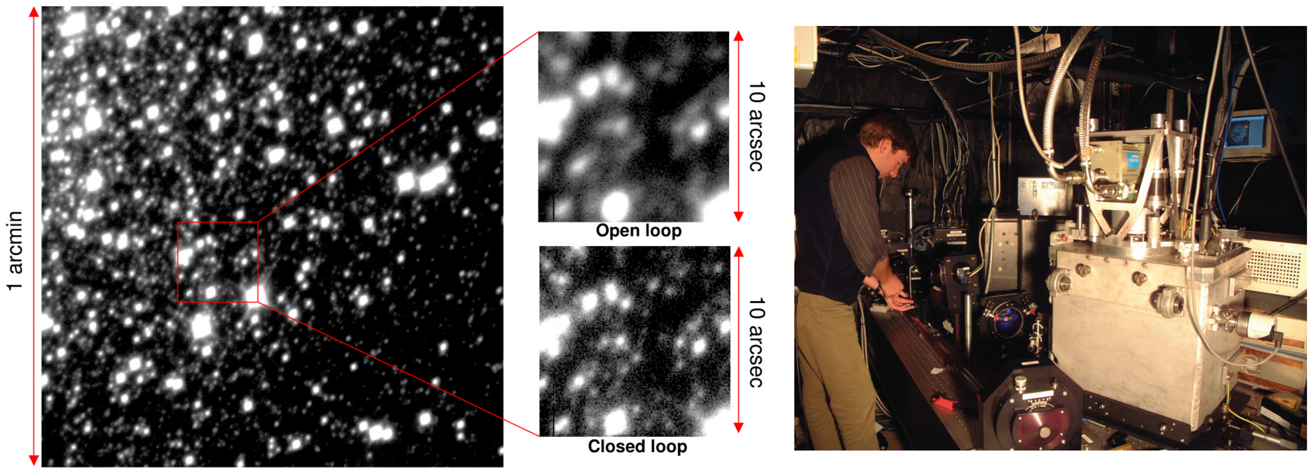

Figure 6. Left: H-alpha image of globular cluster M13 obtained using NAOMI. The FWHM has been improved from 0.8 arcsec (natural seeing) to 0.4 arcsec, allowing many faint stars to be resolved. The image was taken during September 2001 tests of NAOMI's performance at optical wavelengths, and provides a realistic outlook of the AO potential at the William Herschel Telescope. Given that the median natural seeing on La Palma is about 0.7 arcsec, an image quality of ~0.3 arcsec in the R and I bands should be achieved regularly. Right: NAOMI in GHRIL, with INGRID in the foreground.

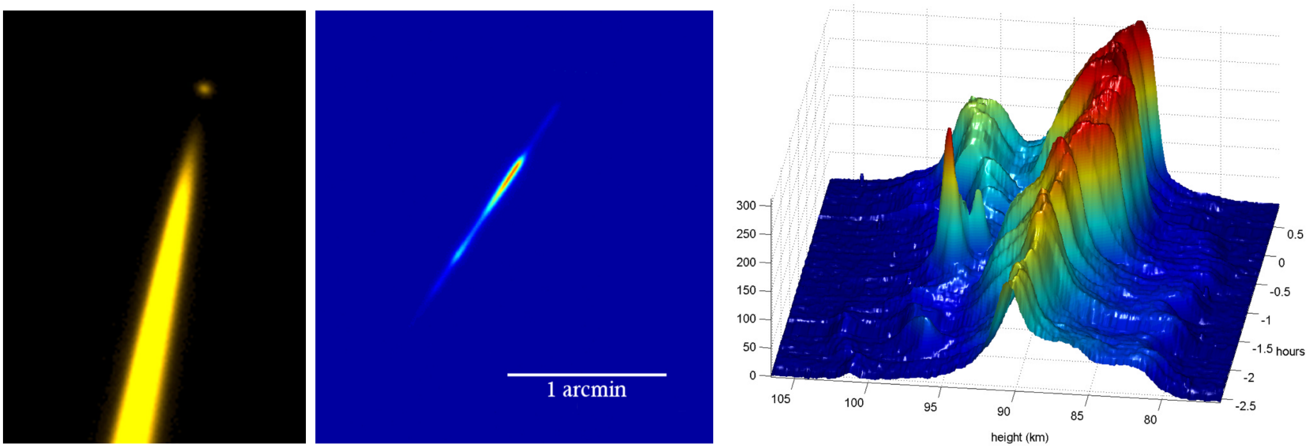

Figure 7. Left: Sodium laser beam projected in the sky. Clearly visible are the low altitude Rayleigh back scatter plume and the sodium 'spot' at some 90 km above the observatory. Middle: The Sodium spot at 90 km as seen from the Jacobus Kapteyn Telescope. Due to projection effects the spot is seen elongated against the sky. Right: Temporal and spatial profile of the sodium spot during one observing night.

will be capable not only of high quality imaging from 0.9 to 2.4 micron, but also of long-slit and multi-slit spectroscopy, coronography and polarimetry. Commissioning is expected to take place in 2003.

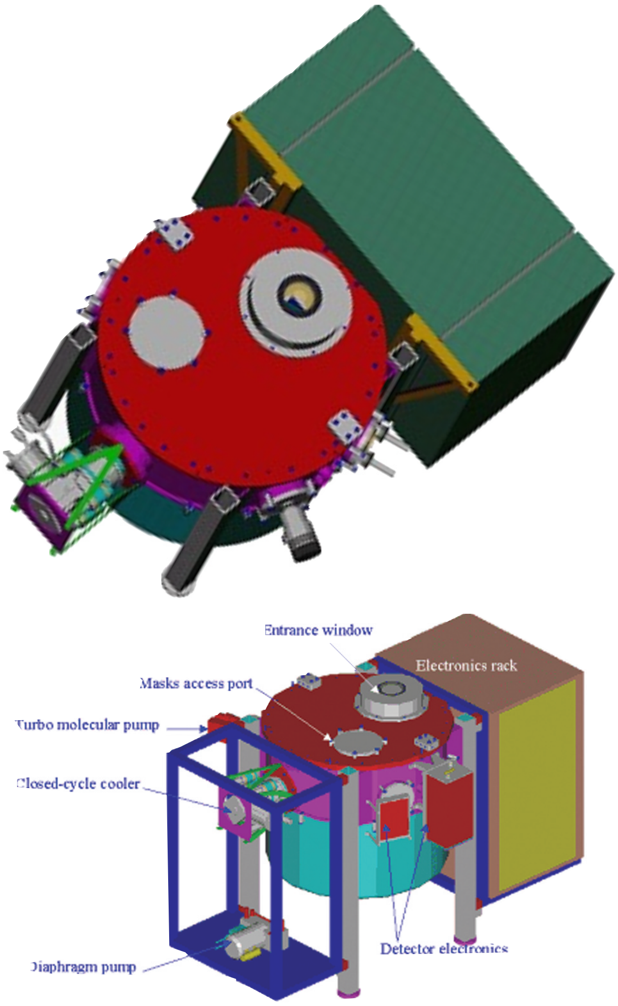

Figure 8. LIRIS external schematic view.

THE INT WIDE FIELD SURVEY PROGRAMME

On the 2.5-m Isaac Newton Telescope survey activities with the Wide Field Camera continued to fulfil an important role in the scientific exploitation of this telescope. Survey proposals ranged from deep galaxy surveys to a census of the Local Group and an extensive investigation of time-dependent phenomena. Sky coverage of the main science programme of the survey passed the 150 square degrees mark.

The first round of proposals for the Wide Field Survey has completed a full three years, and a second call for proposals was send out as a continuation of the scheme. Following this second announcement of opportunity for Wide Field Survey activities, six proposals were selected by the time allocation committee. The principal investigators and the titles of the selected proposals are:

— Dalton (Oxford), *The Oxford deep WFC survey*

— Davies (Cardiff), *Multi-coloured large area survey of the Virgo cluster*

— Van den Heuvel (Amsterdam), *The faint sky variability survey*

— McMahon (Cambridge), *The INT wide angle survey*

— Walton (Cambridge), *The Local Group census*

— Watson (Leicester), *An imaging programme for the XMM-Newton serendipitous X-ray sky survey*

Clearly the offer of survey time has again inspired the principal investigators to request large blocks of observing time over several semesters that would otherwise be difficult to get approved through the normal time allocation procedures.