The GTC 10 m Telescope

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Abstract

The GTC is a high performance 10-m class telescope to be installed at the Roque de los Muchachos Observatory (ORM), on the island of La Palma. First light is planned for end 2002 and the start of full scientific operations for end 2003. The GTC top level science requirements are to achieve: 1) A major improvement in limiting magnitude between 0.3 and 25 microns; 2) Excellent image quality over a reasonably large field of view; 3) The simultaneous availability of imaging and spectroscopic capabilities over a wide wavelength range (0.3 to 2.5 microns); and 4) High operational efficiency and reliability. The contract for the primary mirror blanks has recently been awarded. This constitutes the first main contract awarded and is the beginning of a list of major contracts planned for the current and next year. The selection of the first generation science instruments is proceeding and will be known shortly.

Key words: Large Telescopes; Astronomical Instrumentation

1 Introduction

The GTC Project is a Spanish initiative lead by the IAC (Instituto de Astrofsica de Canarias), aimed at building a large telescope at the ORM (Observatorio del Roque de los Muchachos), in the Island of La Palma. The GTC Project was approved early in 1996 and is funded by both the Spanish Central Government (through the Science and Technology Office) and the Regional Government of the Canary Islands. While there is a commitment to make the project happen and therefore the necessary funds will be allocated, there is a keen interest in having external partners for an important share of the project. The Conceptual Design of the project is summarized in (Alvarez et al. 1997). The current status of the project is presented here.

2 The GTC requirements

The science programmes to be made with the GTC are avid of photons and spatial resolution. They therefore require a large collecting area and excellent image quality. Also, the useful time available on the GTC is finite and hence the scientific return has to be maximized. These are to be achieved by making design decisions preventing the loss of observing time during operation and through the use of optimum modes of operation. These ideas provide the GTC Project with simple, clear and ambitious scientific drivers, namely: A major improvement in limiting magnitude between 0.3 and 25 microns. Excellent image quality over a reasonable field of view (FOV). The simultaneous availability of imaging and spectroscopic capabilities over a wide wavelength range. High operational efficiency and reliability. Next sections explain the GTC strategies to achieve these high level requirements.

2.1 Improving the limiting magnitude

To achieve, at least, 1 magnitude of improvement in limiting magnitude over the existing 4-meter class telescopes available to the Spanish community, a minimum collecting surface of 10 meters in diameter is needed. The segmentation scheme adopted for the GTC is similar to that of Keck's, namely 36 hexagonal segments slightly larger and thicker than those of Keck's.

In the infrared the emissivity of the GTC will be kept below 5% with fresh coating and always maintained below 8% with frequent *in-situ* cleaning. To achieve this low emissivity level the telescope aperture stop is located at the secondary mirror.

2.2 Excellent image quality

The GTC will be erected at the Roque de Los Muchachos Observatory (ORM), in the Island of La Palma at 28°N and 17°W and 2400 meter high. This is well above a stable inversion layer generally situated between 800 and 1500 meters. The ORM is a well proven site for astronomical observations (Ardeberg 1984, Murdin 1985, Sarazin 1995, Sánchez 1968, Muñoz-Tuñón et al. 1997, Brandt & Righini 1985) where many first class telescopes have been installed and successfully exploited for the last 15 years. Many seeing monitoring campaigns (Vernin & Muñoz-Tuñón 1992, 1994), have been carried out at the ORM. The latest for the selection of the actual GTC site within the ORM (Muñoz-Tuñón et al. 1997). The median seeing value obtained is 0.6 arcsec and values as low as 0.2 arcsec have been often measured. Specific measurements have been carried out to improve the knowledge of the site for IR observations (Picirillo et al. 1997). A median value of 4 mm of water-vapour column has been obtained, with more than 25% of the nights measured yielding values below 2 mm.

The quality of the atmosphere above the ORM allows establishing tight image quality requirements for the GTC. The quantitative requirement on image quality that has been adopted for the GTC is that a free-air seeing in the visible of 0.4 arcsec (FWHM) should not be degraded more than 10%. This implies that the combined image degradation from dome seeing, mirror seeing and optics should be under 0.18 arcsec on axis (FWHM), or that θ_{80} is 0.84 arcsec. Image quality can also be expressed in terms of the Central Intensity Ratio (CIR), which is defined as the ratio of the peak intensity of the images of a point function produced by the actual telescope and a perfect telescope of equal diameter under the same seeing condition. For the GTC the CIR=0.75, which compares favorably with the VLT (CIR=0.8) given the difference in effective diameters. The GTC will have a well-ventilated enclosure to facilitate the flux of outside air. Additionally, any heat produced inside the telescope chamber will be exhausted. The telescope chamber will be kept actively cooled during the day.

A complex system of actuators and sensors, working on real time, will keep the overall primary figure under specifications. Tip-tilt and piston correction on the segments will be made with actuators and sensors similar to those used by Keck. To correct low frequency errors on the figure of each segment a system of force actuators will be placed behind every segment. A wave-front sensor in the A&G box will measure the quality of the primary surface and close the loop with the control system. The secondary mirror will be used to correct misalignments of the optical system due to gravitational and temperature deformations of the telescope mechanical structure. It will therefore have the capability to move in five degrees of freedom to keep the alignment of the primary mirror and science instruments and to do focus corrections.

The secondary mirror will be a lightweight piece of glass of about 60kg, 1.17 meters in size. This is where the entrance pupil is situated producing a f/17 telescope with 1.21 arcsec mm^{-1} plate scale. A Cassegrain focus, two Nasmyth foci and four folded Cassegrain foci will be available. These foci will be fed by the tertiary mirror, which will be controlled on real time to allow switching between these foci. The available field of view (FOV) will be 25 arcmin in diameter both at Cassegrain and Nasmyth, the unvignetted FOV being 8 arcmin in diameter in both foci. The available FOV at prime focus, when installed, will be 40 arcmin. Very strict requirements on the dynamic behavior of the telescope structure and mechanisms are driving the GTC structural design. This is important to correct for image motion correction. Residuals will be corrected by tip-tilt capabilities on the secondary mirror. The GTC is being designed to host an adaptive optics system soon after first light. The design requirement is to achieve diffraction-limited images at 2.2 microns with a Strehl Ratio (SR) of 0.8 under a visible seeing of 0.5 arcsec.

2.3 High operational efficiency

Efficient operation of the GTC is required to maximize the scientific return. Various observing modes will be possible with the GTC. It is foreseen however that a large fraction of the time will be devoted to queued service observing. This observing mode will provide a scheme to adequate the observing programs to the prevailing conditions. It will also facilitate the standardization of observing protocols and the buildup of a useful data archive. This archive, fully integrated in the Control System, will be a powerful tool to optimize the scientific return from GTC observations. To facilitate queue observing a single secondary configuration has been adopted to be used at visible and IR wavelengths. Finally, a strategy is being studied to do most of the alignment and phasing of the primary during daytime. The GTC is being designed to be highly reliable, with maintenance requirements being considered in the design stage. The maximum percentage of down-time due to failures is required to not exceed 2% of the useful time, with a total of 6% down time due to both scheduled maintenance and failures.

The estimated cost of the project, based mainly on information obtained directly from potential suppliers of subsystems, on the experience of other telescope projects and the costs of constructions carried out at the Canarian observatories, is Euro 85 Million (1997). 17% of this budget is earmarked for the first generation of scientific instruments. The operation budget is estimated to be Euro 5.5 Million (1997), including development of new instruments and system upgrades.

3 Scientific Instruments

Three science instruments have been approved for phase A studies upon recommendation of the GTC Science Advisory Committee. These are CanariCam, a 1 to 25μ imaging spectrograph [1], EMIR, a multi-object near infra-red spectrometer employing an exchangeable cold mask unit [2], and OSIRIS, a high throughput visible imaging and low resolution Integrated Spectrograph, employing volume phase holographic gratings and tunable filters [3]. Consortia

[1] http://www.gtc.iac.es/Instrumentation/canari_s.asp
[2] http://www.gtc.iac.es/Instrumentation/emir_s.asp
[3] http://www.gtc.iac.es/Instrumentation/osiris_s.asp

with a high level of international expertise are involved in the development of all these instruments.

4 GTC control system

The GTC control system is a very important part of the GTC. As such it is being designed to produce a state of the art though reliable modular system that caters for every single subsystem of the GTC. The control system design is based on industrial standards, to minimize dependence upon single vendors and to guarantee that the standard will be maintained and updated for some time in the future.

5 Project status

Intensive work is being carried out on the preliminary design of the different subsystems of the GTC. Following the Project Schedule, the Civil Work and Enclosure have been the first subsystems opened for tender. Ground breaking is planed for mid 1999. A prototype primary mirror segment support test rig has been fabricated and is undergoing tests at the GTC headquarters. The main purpose of this test rig is to check the prototype control algorithms for the primary mirror control loop, and the daytime alignment and phasing subsystem. A contract has been awarded early this year for the provision of 42 primary mirror segment blanks. The contract for the polishing and verification of these blanks will be issued in September 1999. Additional lesser contracts for smaller optical systems will be issued during this and next year. Those include contracts for the acquisition and guiding box, the tertiary mirror and the coating chamber, amongst others.

Intensive work is also being done on the preliminary design of the Telescope mechanical structure and drives. The contract for detailed design and construction of the telescope structure will be issued in July 1999. Current results from finite element analysis of the telescope structure indicate that reasonably high values of the first eigenfrequencies can be obtained. These are important for achieving the required image quality values.

The project is scheduled to have first light at the end of 2002 and start full scientific operations at the end of 2003. The project is being run as a schedule driven project given based on the interest of the Spanish astronomical community to have access to a large telescope as soon as practicable, and on the interest to remain within budget, in the understanding that schedule delays inevitably lead to budget overruns.

6 International participation

The Spanish authorities have expressed unequivocally their interest in internationalizing the GTC project. This interest stems from the idea that a larger community will provide a broader field for the exchange of scientific ideas leading to a better and quicker exploitation of the scientific capabilities of the GTC. Furthermore, the participation in the GTC of communities with larger expertise in scientific instrumentation will be beneficial for the scientific success of the GTC.

7 The GTC and the ING

It is a pleasure to thank the organizers of this meeting for allowing me the opportunity to mention the great possibilities that open up for collaboration between the ING and the GTC. The ING is nowadays the larger and stronger astronomy community on the ORM. The Spanish community, through the GTC will be in charge, from now on, of running a very important facility at the site. Many different ways exist for collaborations. From using the 2 and 4 meter class telescope for supporting the GTC, to implementing coordinated schedules, to collaborating in engineering and maintenance tasks, to the planning of new instrumentation to complement existing instrumentation in the mountain, to agreeing on the coordinated use of several telescopes in the mountain, etc.

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