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The scientific use and productivity of the Telescopio Nazionale Galileo (TNG)

E. Oliva[1,2]

[1] INAF, Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, I-51025, Firenze, Italy
e-mail: oliva@arcetri.astro.it

[2] INAF, Telescopio Nazionale Galileo, Apartado de Correos 565, E-38700 Santa Cruz de la Palma, Spain

Abstract. This paper reviews the scientific use of the TNG from the beginning of regular observations till the end of 2007. Statistics are given for the time request, use and productivity of the telescope and its focal plane instruments. Information on the down-times and a list of the major technical works/upgrades are also included.

1. Introduction

The Telescopio Nazionale Galileo (TNG) is a national facility funded by the Italian Government through the Italian National Institute of Astrophysics (INAF). It consists of a ⌀3.58 m optical-infrared telescope with fixed, easily selectable focal plane instruments (see Sect.2). It is located at the Roque de Los Muchachos Observatory (La Palma, Spain) and has been operating for scientific observations since its first light in 1998.

Scientific observing time is available to the whole international community who can apply for observations to three different time allocation committees.

Following the international agreements and rules of the La Palma Observatory, the observing time is distributed as follows.

75% of the time is selected and allocated by the INAF Time Allocation Committee (TNG-TAC). Calls for proposals are issued twice a year, in March and September. The observations and scheduled are organized in two semesters, namely Feb-Jul (“*year*A”) and Ago-Jan (“*year*B”). For historical reasons, the observing campaigns are also named as “AOT*i*”, with AOT1 starting at the beginning of 2000.

20% of the time is reserved to the Spanish community, through their “Comisión para la Asignación de Tiempo” (CAT). The calls and allocations are organized along the same semesters as the TAC time.

5% is reserved to international projects (ITP) which make combined use of various telescopes available at the Canary Island Observatories. This time is allocated on annual basis by the “Comitè Científico Internacional” (CCI)

2. TNG instrumentation

The instruments available immediately after the first light were:

– OIG: an optical (U-Z bands) direct imager with a field of view of 4.9’×4.9’.

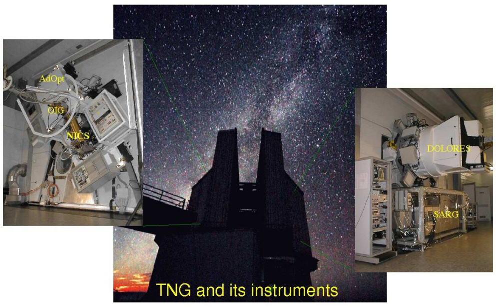

Fig. 1. The TNG and its instruments.

- ARNICA: a near infrared (J-K bands) imager with a f.o.v. of 1.3'×1.3'. It was decommissioned in Sept. 2000

The actual, complete set of instruments was installed in the second half of 2000. It consists of:

- DOLORES: an optical (U-Z bands) multi-mode, single-channel instrument with a field of view of 8.6'×8.6' and long-slit spectroscopic capabilities with resolving power (for 1" slit) ranging from 500 to 7000. It also includes a multi-slit mode using masks produced with a punching machine.
- SARG: a high resolution ($R_{\max} = 164,000$) cross-dispersed spectrometer covering the 4000-9000 Å wavelength range and especially designed for high accuracy radial velocity measurements. It also includes a polarimetric module.
- NICS: a near infrared (Y–K bands) multi-mode instrument with a field of view of 4.3'×4.3' and long-slit spectroscopic capabilities with resolving power (for 1" slit) ranging from 40 to 1500. Imaging-polarimetry and spectro-polarimetry modes are also available.

All the instruments are normally mounted on the two Nasmyth foci (see Fig.1) and can be rapidly selected by moving a few flat mirrors. Instruments are removed only in case of maintenance operations which cannot be performed otherwise. The largest instruments (DOLORES and SARG) have never been removed since their first installation.

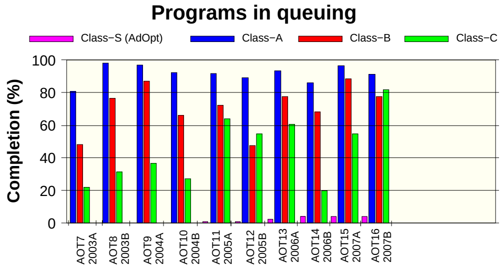

Fig. 2. Completion statistics of TNG programs scheduled in queuing mode in the semesters since the beginning of this observing mode in 2003.

The telescope also includes an adaptive optics module (AdOpt) in a dedicated interface which takes all the space, weigh and momentum available at the first Nasmyth derotator. When inserted in the optical path (by moving a few flat mirrors) it feeds NICS yielding images with a 3× expanded scale, suitable to properly sample the diffraction limit of the telescope. The AdOpt module also included a Speckle camera operating at optical wavelengths, this instrument was decommissioned in 2003.

3. Scheduling and service mode

Thanks to the wide range of observing mode offered by the focal plane instruments, their apparently rigid setup effectively translates into a remarkable flexibility of the scientific operations. In particular, it allows queuing scheduling of programs, where the observations are prioritized and executed when the system technical status and meteorological conditions are appropriate.

Starting from February 2003, TNG has regularly performed service observations and queuing scheduling for proposals approved by the Italian Time Allocation Committee (TAC). The proposals scheduled in queuing are divided and prioritized in three categories (A, B, C) depending on their scientific merit.

A fourth, top priority category (S) was experimentally added between 2005 and 2007 to favour the science verification programs for the adaptive optics endorsed by INAF. All the pro-

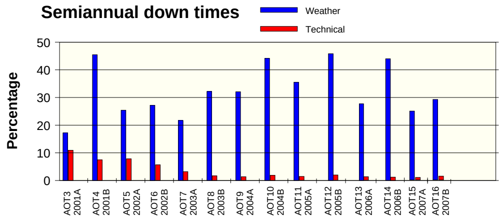

Fig. 3. Downtime statistics for TNG. The values are averaged over the Feb-Jul (”A”) and Ago-Jan (”B”) observing semesters/campaigns.

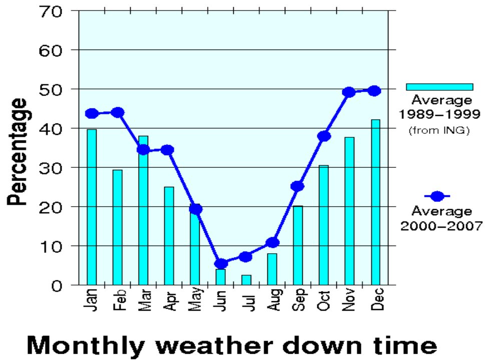

Fig. 4. Fraction of observing time lost for meteorological reasons.

posals for AdOpt approved by the TNG-TAC were therefore queued with higher priority than the remaining programs, and executed on a best effort basis.

Fig.2 summarizes the efficiency of queuing observations. The fraction of completion of class-A programs is always above 80%, and in most cases above 90%. The average figures for class-B (71%) and class-C (44%) programs are also very good. Due to the much lower efficiency of class-S programs it has been decided to separate the scheduling of AdOpt science verification from normal service/queuing observations.

The fraction of time scheduled in service and/or queuing mode has been about 45% of the total time allocated by the TAC.

4. Technical works

The major technical operations performed after the TNG commissioning phase (Bortoletto 2001) were:

– Installation and first light of DOLORES, SARG and NICS (2000)
– Refurbishment of the DOLORES mechanics (2001)
– Re-alignment and activation of the compensation correction of the telescope encoders (2002-2003)
– Substitution of the support bearings of the rotating building (2003)
– Refurbishment of the NICS mechanics (2003)
– Refurbishment of the AdOpt module (2004-2005)
– Upgrade of the derotators optics control system (2004-2006)
– Upgrade of the Telescope Active Optics control system (2004-present)
– Refurbishment of the NICS array control system (2006)
– Upgrade of the auto-guide system (2006-2007)
– Upgrade of the DOLORES detector, interface and instrument control system (2006-present)
– Refurbishment of the tacho-generator of the Telescope motors (2006-present)
– Substitution and re-phasing of damaged telescope motors (2006-present)

In practice, TNG underwent a general technical upgrade comparable to the NTT big-bang (Spyromilio 1997) maintaining, however, full operativity for science observations. This remarkable result was possible thanks to a quite large fraction of technical time ($\simeq$20% of the total) which was effectively coupled with the service observations, always guaranteeing that any night-time which remained available was used for scientific observations.

5. Downtimes

The downtimes averaged over the observing campaigns/semesters are summarized in Fig.3. The technical downtime is defined as the time lost for technical problems which could not be

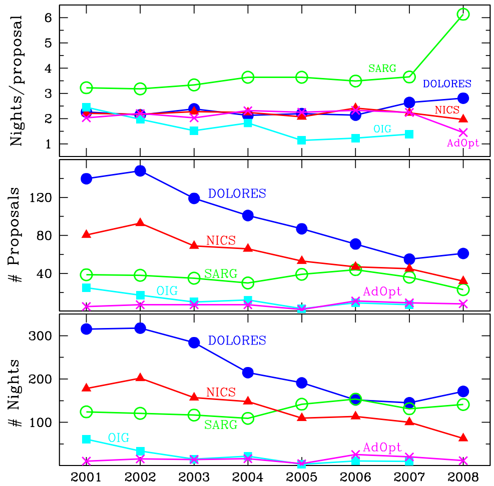

Fig. 5. Evolution of proposals for observations submitted to the TNG-TAC.

re-scheduled. The decrease in 2003 coincides with the beginning of the service observations, which allowed a more flexible organization of the technical time and (re-)scheduling of the programs.

The somewhat large fraction of time lost for meteorological reasons is not evenly distributed through the year. While the summer is extremely good (fraction of time lost ≃7%), however, downtimes of 45% are typical between November and February (see Fig.4).

The seasonal behaviour of weather downtimes affected in very different ways observing programs targeting galactic (visible in summer) and extra-galactic objects. Although the service mode with flexible scheduling made it possible to complete some of the programs targeting objects visible in winter, however, the general effect on the astronomical community was a decrease of proposals for wintry objects and an increase of the fraction of those specifically requesting the summer.

6. Observing proposals

Fig.5 shows the statistics and time evolution of the observing proposals submitted to the TNG-TAC. The proposals have decreased by about a factor of two between 2001 and 2006, and then flattened to a roughly constant value of 400 requested nights per year. The over-subscription factor has varied from 3.8 to 1.8, but still remains one of the largest among telescopes of similar class.

The most requested instrument is DOLORES, which acts as the workhorse for all the programs requiring imaging and/or low-medium resolution spectroscopy at visual wavelengths. The average number of nights requested by each program has remained ≃2.2 up until 2006, but increased to almost 3 in the following years. This positive trend reflects the increasing importance of large programs.

The time requests for SARG have remained roughly constant, and even increased in the last years, approaching the values of DOLORES. The SARG programs are fewer but typically request a larger number of nights than the other instruments. The average number of nights per proposal remained ≃3.5 between 2000 and 2007. The jump to 6.3 in 2008 coincides with the submission of a proposal for a large program which requires 60 nights/year.

NICS is the second most requested instrument in terms of number of proposals. However, the time requests after 2005 have been lower than those for SARG. The average time requested has always remained below 2.5 nights per program.

The time requests for OIG and AdOpt are much lower than for the other instruments. The OIG graph does not extend to 2008 because the instrument has been decommissioned.

Starting from 2003, a policy for long term programs was encouraged by INAF and implemented by the TNG Time Allocation Committee. The fraction of time allocated to long term programs has remained between 10 and 20%.

7. Scientific publications

The first, complete list of the refereed papers based on data collected at the TNG was compiled in 2005 (Boschin 2005). This list is periodically updated and the statistics of publications are summarized in Fig.6 which also includes the citations (from the ADS database)

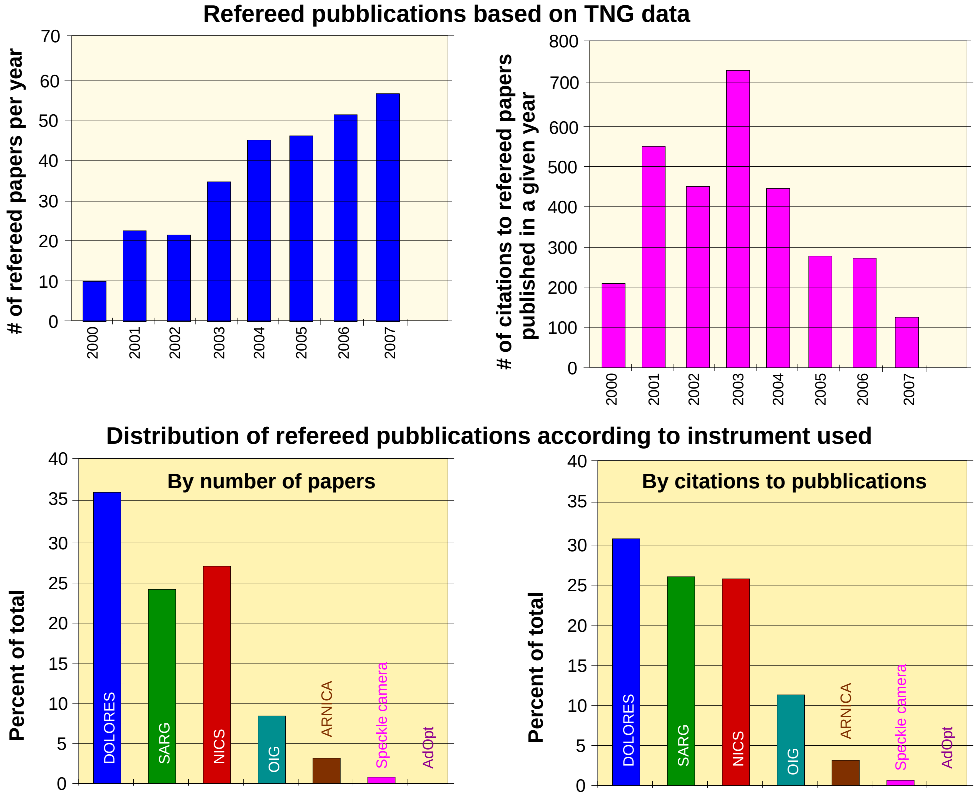

Fig. 6. Statistics of publications based on data collected at TNG. The numbers include papers published in refereed journals up to the end of 2007.

and the distribution of publications per instruments.

The first and most encouraging result is the constant increase of the number of publication which in 2007 surpassed the remarkable figure of 1 publication per week. Particularly positive is also the comparison between the total numbers of publications and of observing nights since the beginning of TNG scientific operation, which yields an efficiency rate of about 0.8 publications per week of scheduled time.

The evolution of the citations shown in upper-right panel of Fig.6 is characterized by a peak of almost 730 citations for the papers published in 2003. The values for the subsequent years are lower by a factor of about two. This decrease can be (at least partly) attributed to the cumulative effect of the citation index, which tends to favour older publications. The average number of citations per publication is 15. The efficiency rate is close to 1.6 citations per night of scheduled time.

The distribution of publications and citations among the various instruments (lower panels of Fig.6) substantially reflects their use. In other words, the ratio between number of publications/citations and scheduled time is roughly the same among the instruments. The only exception is the adaptive optics module which was scheduled for about 5% of the time but did not produce refereed publications.

Listed below are the papers with the largest number (≥60) of citations (from the ADS database, updated on May 2008)

Santos et al. (2004) *Spectroscopic [Fe/H] for 98 extra-solar planet-host stars. Exploring* *the probability of planet formation* Based on TNG-SARG and ESO-FEROS spectra, 206 citations. Similar works by Santos et al. (Santos et al. 2003, 2005) have 138 and 69 citations, respectively.

Fiore et al. (2003) *The HELLAS2XMM survey. IV. Optical identifications and the evolution of the accretion luminosity in the Universe*. Based on deep images taken with DOLORES-TNG and EFOSC2-ESO, 131 citations.

Fymbo et al. (2001) *Detection of the optical afterglow of GRB 000630: Implications for dark bursts*. Based on OIG-TNG images in combination with data from the Calar-Alto, USNO, and NOT telescopes; 96 citations.

Gratton et al. (2003) *Abundances for metal-poor stars with accurate parallaxes. I. Basic data*. Based on spectra taken with SARG-TNG, UVES-VLT and with the McDonald 2.7m telescope, 85 citations

Natta et al. (2002) *Exploring brown dwarf disks in rho Ophiuchi*. Based on spectra taken with NICS-TNG, 68 citations

Tagliaferri et al. (2005) *GRB 050904 at redshift 6.3: observations of the oldest cosmic explosion after the Big Bang*. Based on NICS-TNG images in combination with ESO and Calar-Alto imagers, 64 citations

Maiolino et al. (2004) *A supernova origin for dust in a high-redshift quasar*. Based on NICS-TNG spectra, 62 citations

Masetti et al. (2000) *Unusually rapid variability of the GRB000301C optical afterglow* Based on OIG-TNG images in combination with data from Calar-Alto, Loiano, UPSO and SNO telescopes; 62 citations.

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