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Telescopio Nazionale Galileo: a status report

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Abstract. Since the remarkable summer of 2000, which witnessed the first light of its three baseline imager-spectrometers, the ⌀ 3.58m "Telescopio Nazionale Galileo" (TNG) has been offering to the Italian and international community one of the most complete and flexible combination of optical and infrared instrumentations worldwide. Some of its numerous – and always on-line – observing modes are virtually unique and optimized to the point of challenging, and sometimes outperforming, existing facilities on 10m class telescopes. With a typical over-subscription rate of about 3, TNG could be considered a mature and highly successful astronomical facility.
Parallel to its routine astronomical work, TNG is also undergoing a thorough refurbishing of a substantial fraction of its, admittedly, fragile and not up-to-date hardware and software systems. To optimize the observing efficiency and minimize the negative impact of technical works, TNG is now handling a large fraction (almost 50%) of observations in service mode using a flexible system of queuing scheduling. This approach, very popular among astronomers, also helps diluting the negative effects of the recursive periods of adverse weather conditions which often affect the winterly months.

Key words. Telescopes – Instrumentation

1. An overview of the TNG instruments

The main characteristics of the TNG instruments are summarized in Table 1 and Fig. 1. A more detailed description can be found in Rodonò & Setti (2000) and in the – continuously updated – TNG web pages.

Alike in many other telescopes, the multi-mode optical imager-spectrometer (DOLORES) acts as the workhorse for all those programs requiring standard optical observations which are still very popular among Italian astronomers (see Fig. 2). The performances of this instrument are in line with those of the numerous, high efficiency multi-mode facilities available on other 4m class telescopes.

SARG, the high resolution spectrometer, is a remarkably high-efficiency and high-stability instrument designed with the specific purpose of obtaining very accurate radial velocity measurements ($\lesssim$1 km/s). At wavelengths longer than 4000 Å it is one of the best high resolution instruments presently available on 4m class telescopes.

Its capabilities are well demonstrated by the spectacular results obtained in the fields of stellar chemical abundances and extra-solar planets (see the recent news and press releases on the TNG and SARG web pages). OIG, the direct optical imager, is optimized for high

Table 1. Main characteristics of the TNG instruments

OIG Direct imager	5’×5’ f.o.v. 0.072”/pix	0.3 – 1 μm U-z + nar. band filters
DOLORES Multi-mode opt. inst.	9.4’×9.4’ f.o.v. 0.275”/pix Long slit spec. RS =500–5,000 Multi-object spectr. over 4’×9’	0.3 – 1 μm U-z + nar. band filters Low, medium and high-res (VPH) grisms
SARG High Res. spectrom.	RS =46,000 R_{max}=164,000 (0.27” slit) Slit length = 5” – 25” Polarimetric capabilities	0.4 – 1 μm Ech. + Grisms cross-disp 4 spec. ranges/formats
NICS Multi-mode IR inst.	4.2’×4.2’ f.o.v. 0.25”/pix 2.2’×2.2’ f.o.v. 0.13”/pix Long slit spec. RS =50–1500 Imaging-polarimetry over 4’×0.8’ Spectro-pol. with 0.8’ long slit	0.9 – 2.5 μm J-K + nar. band filters Amici prism + grisms
AdOpt Adaptive-optics	Fixed optical bench which can feed NICS or OIG with a 3× magnification, f.o.v. ≤1.4’×1.4’ Also includes a speckle-camera	Tip-tilt + high order corrections

Fig. 1. Overview of the TNG and its permanently mounted instruments

Fig. 2. Distribution of TNG observing time with instruments

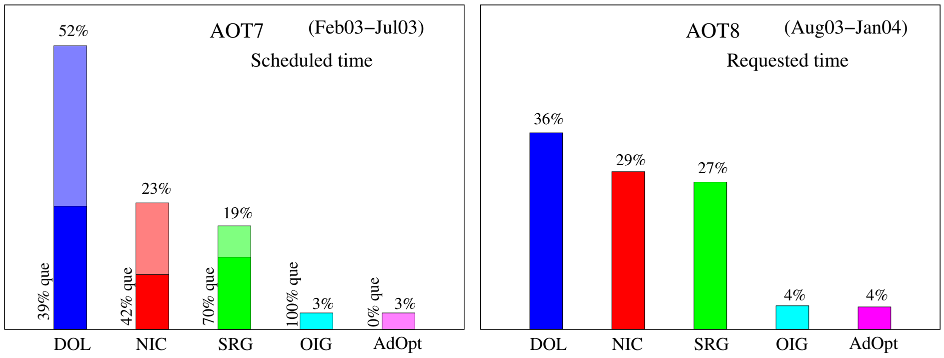
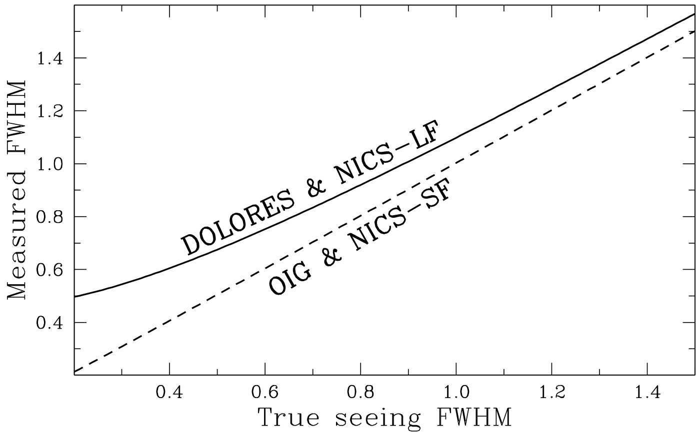


Fig. 3. Measured point spread function vs. seeing for the TNG imaging instruments



quality imaging and is the only optical imager which can take full advantage of the relatively frequent periods of good seeing when the PSF cannot be sampled by the much coarser scale and intrinsic image quality offered by DOLORES (Fig. 3). Although little requested by the astronomical community (Fig. 2), however, OIG is likely to regain popularity once the queuing scheduling and service observing will be fully functional and TNG will offer a truly efficient capability of switching to direct imaging on dark nights whenever the seeing is under-sampled by the DOLORES camera.

NICS, the infrared imager, spectrometer and polarimeter, is one of the most efficient and versatile multi-mode near IR instruments available to the international astronomical community. Thanks also to the quite limited number and capabilities of similar astronomical instruments worldwide, NICS can directly compete with 10m-class facilities, especially in spectroscopy (see e.g. Fig. 4). Although its wide-field imaging capabilities suffer by sampling limitations similar to those of DOLORES, however, the astronomer can take advantage of the moment of good seeing by using the finer scale "SF" objective (see Fig. 3). Up until the end of 2002 NICS recursively suffered by a number of serious mechanical, optical and

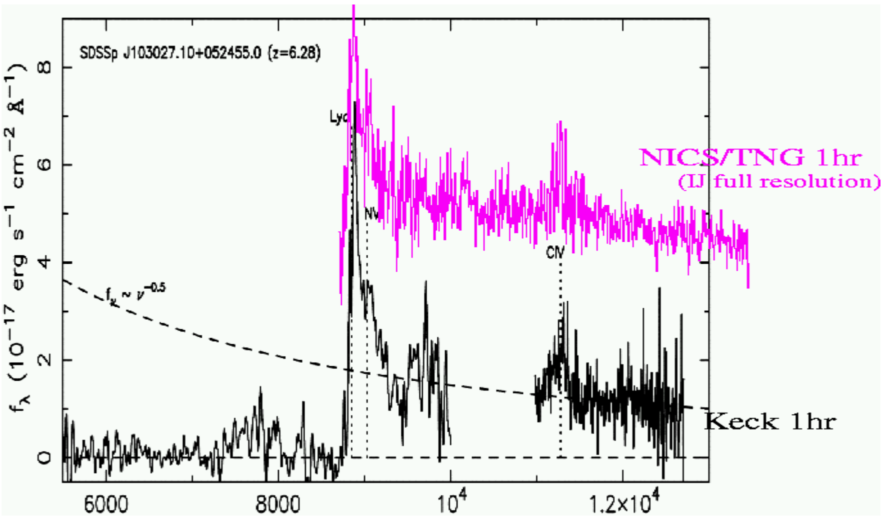


Fig. 4. Direct comparison between NICS (upper plot) and Keck (lower plot) spectra taken with the same integration time. The NICS spectrum has been shifted vertically for clarity.

electronic problems which strongly limited its use and negatively affected the technical downtime statistics of the telescope. Fortunately, all these problems could be solved during a major technical refurbishment which recently took place in Arcetri (Firenze).

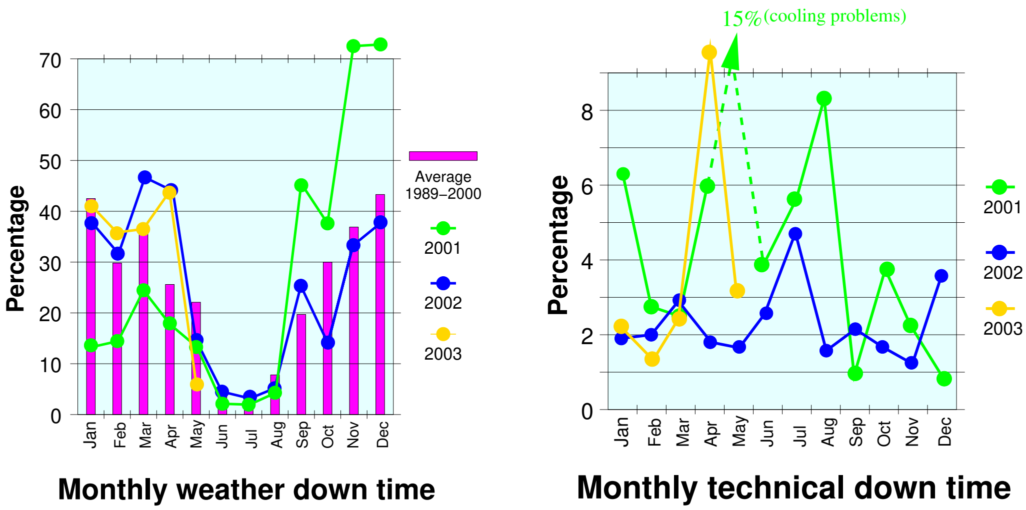
AdOpt is an optical bench permanently mounted on the Nasmyth-A derotators, the same focal station of NICS and OIG (see Fig. 1). It includes a tip-tilt corrector plus a deformable mirror with 97 actuators, and delivers a 3× magnified image on either NICS or OIG. As compared with similar instruments available on other telescopes, AdOpt has the great advantage of being always on-line and available for observations. The switch from/to AdOpt only requires moving 2 mirrors and could be made in a few minutes. Unfortunately however, this unique capability is not exploited because of the great complication and fragility of the instrument control system which can only be handled by experts of the team who built it. Indeed, this is a common problem among adaptive optics systems and partly explains their limited popularity among the astronomical community (see Fig. 2). Nevertheless, the AdOpt module of TNG served as a very successful bench-mark for the most advanced instrumental technologies.

2. Optimizing the observational efficiency

Among 4m-class telescopes, TNG could be considered a privileged telescope because all its versatile and comprehensive instruments are permanently mounted and available for observations. The switch from/to any instrument within the same focal station takes just a few minutes, while the change of Nasmyth takes a little less than half an hour. Therefore, such a facility is ideally suited for exploiting the intrinsic advantages of service observing with flexible scheduling.

Following also the pressing request from the astronomical community, TNG has taken a quite brave step toward flexible service observations and scheduled in queuing mode almost 50% of the observing time for the AOT7 (Feb03 – Jul03) period (see Fig. 2). The queuing system follows an approach similar to that of VLT and trying to simplify as much as possible all the steps which, unlike ESO, must

Fig. 5. Monthly distribution of weather *(left panel)* and technical *(right panel)* downtimes. Data prior to 1999 are taken from the ING archive. The Apr03 peak in the right panel is due to the major upgrade works on the derotator control system.



be handled by just an handful of persons. The observations are organized in “blocks” loaded into a database which can be accessed using a dedicated web-interface that allows a quick and efficient selection by the astronomer on duty at the telescope. This interface, called “SerPiCo” is already operating and having a remarkable success among astronomers, including visitors who often ask if they could use something similar to organize their observations. The software for the handling of the observing blocks – “Flex”, presently under test – will be soon released and allow external astronomers to directly enter, update and verify if the blocks have been already executed. In the meantime, all the operations are presently handled by the TNG resident astronomers who are also encouraged to directly collaborate in some of the proposals.

Another important advantage of the flexible scheduling with queuing observations is that of averaging-out the effect of the relatively long periods of adverse weather conditions which often occur during the winter period (see Fig. 5, left panel). In this respect it is worth noticing that the time request for TNG is usually concentrated on the months when the weather is worse, while little request exist for the summertime, and in particular for July and August.

3. Major technical works

Parallel to its routine astronomical work, TNG is also undergoing a thorough refurbishing of a substantial fraction of its, admittedly, fragile and not up-to-date hardware and software systems. Table 2 lists the most important works underway which do not usually influence the observing efficiency of the telescope (see Fig. 5, right panel), thanks also to the scheduling flexibility provided by the queuing observations. However, there are a few remarkable exceptions, like the downtimes in Apr 2003 produced by the maintenance/upgrade works on the control system of the derotators. Moreover, the substitution of the mechanical support of the rotating building will require a stop of all telescope activities for at least 3 weeks.

Table 2. Overview of the major technical works underway at TNG

Description	Status
Upgrade and porting to PC-platform of the high level software of the control system (WSS)	80% completed
Upgrade of all CCD controllers	20% completed
Active optics: off-axis analysis and new control system	15% completed
New autoguide control system	60% completed
Maintenance of telescope encoders	80% completed
Maintenance and upgrade of the optical and mechanical systems of the Nas-A derotator and instruments interface	Terminated in Apr03
Upgrade of the derotator software control system	Terminated in May03
Refurbishing of NICS	Terminated in Mar03
Substitution of the mechanical support of the rotating building	Works start on Jul 14 2003

4. Future perspectives

Besides the maintenance/upgrade works aimed at improving the overall efficiency and reliability of the system, INAF has also foreseen a number of instrumental upgrades aimed at increasing the observing capabilities and maintain the TNG at high level of competitivity worldwide.

The first device, named "GOHSS", is a fiber-fed near infrared (0.9–1.7 μm) spectrometer with spectral resolution $R \simeq 5000$ optimized for multi-object spectroscopy. The instrument is under construction since about 6 years and should be soon commissioned at the telescope.

The other proposed instruments, some of which should soon start its phase A study, are as follows.

A high resolution ($R > 30,000$) IR spectrometer which could cover most of the 0.9–2.5 μm wavelength range in a single shot.

A high resolution UV spectrometer highly optimized for the $\lambda < 4000$ Å wavelength range.

An IR imager-spectrometer with a much wider field of view than NICS.

References

Rodonò M., Setti G., 2000, *'Scientific Dedication of the Telescopio Nazionale Galileo'*, conference held in S. Cruz on 3-5 Nov 2000, M. Rodonò & G. Setti eds. (CNAA: Catania)