

TNG history

The Telescopio Nazionale Galileo (TNG) arises with a project originated in 1982 with the preliminary study of a new generation of telescopes which would take Italian astronomy in the vanguard, in terms of both instrumentation and technology.

The TNG is the largest optical/infrared Italian altazimuth telescope with a Ritchey-Chretien optical configuration and a primary mirror of 3.58m.



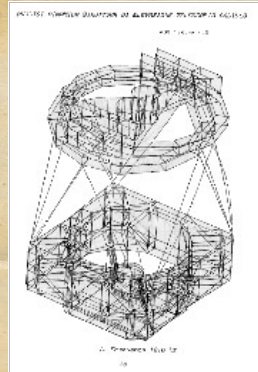
The project, started for care of the Council for Astronomical Research (C.R.A.), has carried out by the National Consortium for Astronomy and Astrophysics. It is the fruit of collaboration between all the Italian astrophysics institutes and a score of Italian high technology companies.

In 1988 the C.R.A. gave a first indication of a possible site (La Palma) for the TNG to which is added Mauna Kea (Hawaii, USA) in 1990.

Finally in July 1991 the C.R.A. dictates a change of site and TNG migrate definitely from Mauna Kea to Roque de los Muchachos (La Palma, Canary Islands: geodetic coordinates: $28^{\circ} 45' 14.4''$ N and $17^{\circ} 53' 20.6''$ W) at an elevation of 2387.2 m.a.s.l. . The TNG was fully mounted in the Ansaldo workshop in Milano by the end of 1993.

Mechanical and alignment tests have been performed subsequently, as well as fitting and cabling of the motors and interfacing of the control system.

At the end of 1994 the telescope was fully erected and in the first months of 1995 was shipped to the Roque de los Muchachos. The difficult transport of the big azimuth box on the close bends of the road to the Roque.



In the second half of 1995, the metal frame of the dome started to be installed.

Comet Hyakutake went by, unobservable by the TNG.

By the end of May 1996 the frame was finished and the outer skin could be mounted.

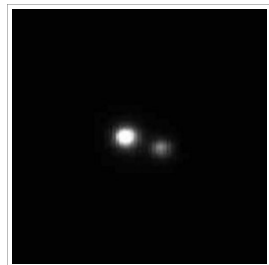


Finally, in June 1996 the TNG was formally inaugurated in the presence of the King and Queen of Spain and Italian Minister of Universities, Science and Technology Research.

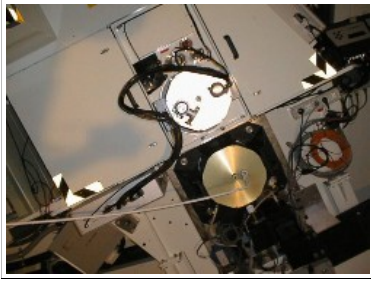
In 1997 the *Consorzio Nazionale per l'Astronomia e l'Astrofisica* (CNAA) took upon itself the financing and administration responsibility of the "*Centro Galileo Galilei*" CGG which operates the TNG. Nowadays the TNG is managed by the Fundacion Galileo Galilei - INAF, a non-profit organization founded by INAF (Istituto Nazionale di Astrofisica).

The "first light" of the telescope was in the evening of June 6 1998. During this night, a number of astronomical exposures were made with the tracking camera, with the aim of evaluating the telescope performances.

The first object observed after the preliminary set-up was the double system *epsilon-lirae*.

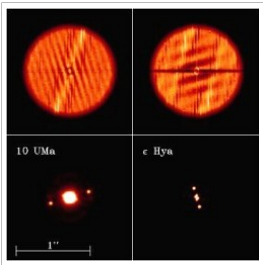
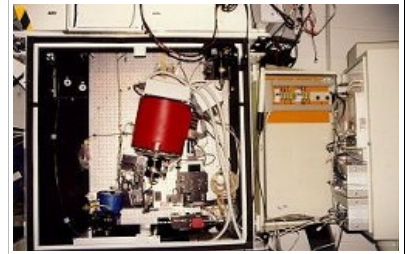


In December of 1998 the first instrument of the TNG was mounted on the Nasmyth A Adapter interface: the Optical Imager Galileo (OIG), a CCD camera for direct imaging at optical wavelengths (between 0.32 and 1.1 microns) equipped with a mosaic of two thinned and back-illuminated CCDs with



2048 x 4096 pixels each giving a total field of view of about 4.9×4.9 arcmin.
The first light of the telescope was taken with this instrument which worked until 2007.

In the same year also the Adaptive Optics at TNG (AdOpt@TNG) was mounted and provided high resolution images for the near IR camera thanks to tip-tilt (TT) and to high-orders (HO) corrections.



The AdOpt@TNG system was mounted at the Nasmyth A focus and was used to remove most of the aberrations due to atmospheric turbulence with a tiltable off-axis parabola and a 97 piezo-stack actuators deformable mirror, being the unique TNG instrument which allowed to obtain diffraction-limited images (0.15 arcsec in the K filter), exploiting the full resolution power of the 3.6m TNG aperture. From September 2009 AdOpt will no more be offered to the astronomical community.

In May 2000 DOLORES (Device Optimized for the LOW RESolution) was installed on Nashmit B and took his first light.

It was designed to allow imaging and low resolution spectroscopy observations.

His camera was equipped with a 2048 x 2048 CCD giving a field of view of 9.4×9.4 arcmin. During May 2007 DOLORES was refurbished with a completely new acquisition system based on the new generation CCD controller, Acquisition Software, User Interface and CCD.



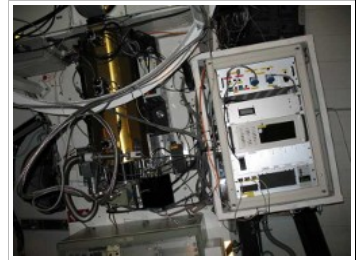


In June 2000 SARG (mounted in Nasmyth B) took his first light and it worked for 12 great years.

It was a high efficiency spectrograph designed for the spectral range from 370 up to 900 nm, and for resolution from $R=29,000$ up to $R=164,000$. SARG used an R4 echelle grating in Quasi-Littrow mode; the beam size of 100 mm gave an RS product of $RS=46,000$ at order center.

In February 2001 was equipped with a polarization analyzer.

In September 2000 NICS (Near Infrared Camera Spectrometer) was installed in Nashmit A and took his first light. The instrument is equipped with two cameras: the Large Field (LF) and the Small Field (SF) which give a field of view respectively of 4.2×4.2 and 2.2×2.2 arcmin.



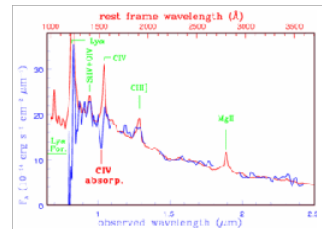
The follow years are full of discoveries performed by these instruments:

2000

NICS discovers an extremely powerful expanding wind in the most distant quasar known

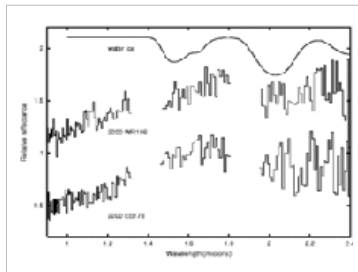
Due to the cosmological redshift many of the most interesting features of the most distant quasars are shifted into the near-IR band, a spectral region where the reduced sensitivity of past instrumentation prevented a detailed study of many of their spectral features.

The blue line in the figure shows the near-IR spectrum of the most distant quasar known. The red line is a template obtained by the combination of a sample of quasars at $z \sim 1$.



2001

NICS obtains the first infrared spectra of trans-neptunian objects ever done with a 4m class telescope



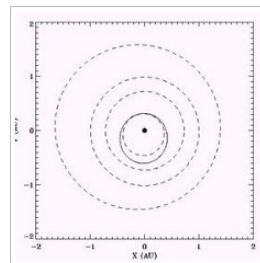
Complete near-infrared (0.9-2.4 microns) spectral observations of trans-neptunian objects (TNOs) 2000 WR106 (actually named 20000 VARUNA) and 2000 EB173 were done using the Near Infrared Spectrograph (NICS) low-dispersion - high throughput spectroscopic mode with an Amici prism disperser. TNOs spectra together with the reflectance spectrum of 10 microns water ice particles at 90 K are shown in the figure. Both spectra correspond to very red objects.

2002

An Exo-Solar planet candidate discovered by an Italian Group

Using the high resolution spectrograph SARG a group of astronomers of Padova and Catania, led by Raffaele Gratton (Padova Observatory, INAF), has found a planet candidate orbiting the star HD219542B. This is the first of a hopefully long series for Italy.

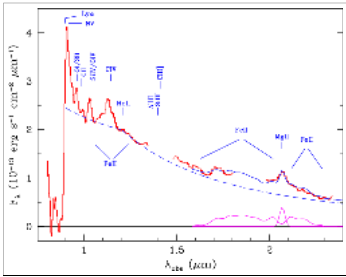
The planet should have the mass of Saturn, but at a distance from the star intermediate between those of Mercury and Venus from the Sun.



2003

TNG casts new light on star formation and chemical evolution at high redshifts (z>6)

NICS-Amici, the very low resolution spectroscopic mode of the TNG IR instrument, has once more proved its unique capabilities by producing the by far most complete sample of



IR spectra of high redshift quasars, including those at $z > 6$ recently discovered by the SLOAN project.

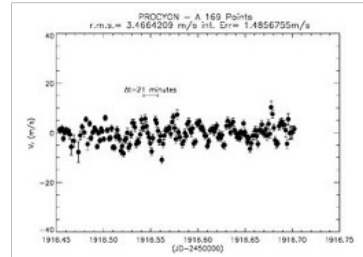
The works included major modifications to the mechanics, optics, electronics and led to an instrument with a much improved image quality.

Red line: NICS-Amici spectrum of the farthest QSO known at $z=6.4$. The blue-dashed line shows the fit to the continuum emission.

2004

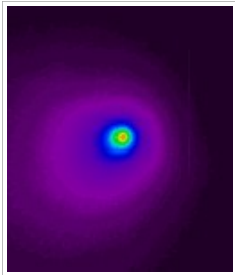
SARG confirms the 21 minutes oscillations of Procyon

Doppler shift measurement over one of the six nights of the observing run with an internal error of 1.5 m/s. The 21 minutes pulsation is clearly visible.



2005

Deep Impact at the TNG: recording of the event from ground-based telescope in the ORM



On July 4th, at 5:52 UT (6:52 in Canary Islands local time), NASA Deep Impact spacecraft concludes a six-month voyage to reach 9P/Tempel 1 by sending a projectile crashing into this comet. The impact of the projectil of 370 Kg into the comet nucleus, will cause a crater on the surface and will eject fresh material from its interior.

2006

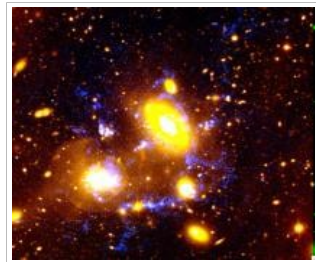
TNG and WHT Observations Prove that the Large Trans-Neptunian Object 2005 FY₉ is Very Similar to Pluto



2005 FY₉ is the third brightest known TNO, after 2003 UB₃₁₃ and Pluto; his size is 0.7 times that of Pluto approximately. The semi-major axis of its orbit is 46 Astronomical Units (AU, 1 AU=149,597,892 kilometers), the perihelion distance is 39 AU and the inclination of the orbit is 29°. These values are typical of the classical TNO family.

TNG images unveil giant filament structures in a galaxy cluster

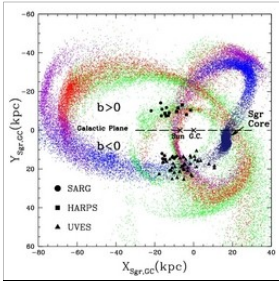
An international team of astronomers has used DOLORES-TNG to study the physical properties of a compact group of starburst galaxies which is falling at a speed of 1700 km/s towards the center the galaxy cluster Abell 1367. The group, which was discovered in 2002 and named "BIG", has the highest density of star forming objects ever observed in local clusters. It contains two giant galaxies, at least ten dwarf galaxies or extragalactic clouds of gas and over a billion solar masses of diffuse gas filaments.



2007

SARG high resolution spectra help reconstructing the star formation history of the halo of our Galaxy

Accretion from dwarf satellite galaxies is one potential origin of the stellar halo of our galaxy, but the remnant cores of these galaxies have both ages and metallicity distributions that do not match those of the bulk of the halo population.

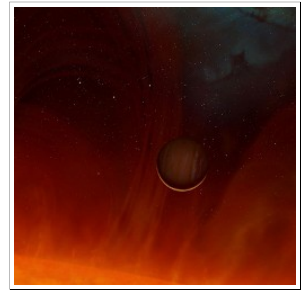


Stars that have already been stripped from the outer regions of those galaxies might however have significantly different properties. SARG found that these stars are poorer in metals, thus suggesting that additional observations might find stars to match the properties of the galactic halo.

DOLoRes data contribute to the discovery of a giant planet which survived to the expansion of its home star

The new planet (named V391 Pegasi b) is one of the more than 200 exoplanets found around stars other than the Sun.

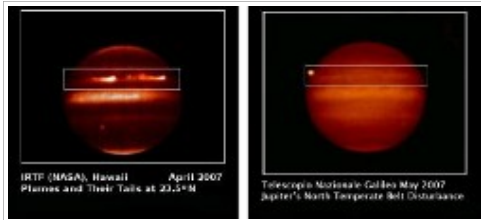
Located about 4,500 light years away from the Solar System, V391 Pegasi b is by far the oldest exoplanet and the first to be seen orbiting a post-red-giant star.



2008

NICS data contribute to the analysis of an unusual atmospheric perturbation on Jupiter

In March 2007 Jupiter surprised the scientific community with a violent change in its atmosphere. A giant turbulence triggered two extended storms in the Northern hemisphere of the planet.



The unusual phenomenon was studied by an international team of scientists, including astronomers of TNG. They suggest the internal energy of Jupiter is the main responsible for the formation of the storms. In the issue of January 24th, Nature dedicates its cover to this research.

SARG data contribute to unveil the origin of the diffuse interstellar bands

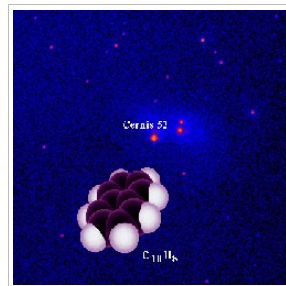
The origin of the diffuse interstellar bands is a long-standing observational problem that now can see some light. A systematic survey of post-AGB stars, conducted by a team of Spanish and Dutch astronomers, has demonstrated for the first time that the carriers of the diffuse bands cannot be present in circumstellar envelopes. The result has been highlighted in *Astronomy & Astrophysics* journal and it indeed places the origin of the diffuse bands in the interstellar medium.

SARG spectra play a key role in the discovery of naphthalene in the interstellar space

Spanish researchers have succeeded in identifying naphthalene, one of the most complex molecules yet discovered in the interstellar medium.

The naphthalene was discovered in a star formation region in the constellation Perseus, in the direction of the star Cernis 52. The spectral bands found in this constellation coincide with laboratory measurements of the naphthalene cation. Optical spectra taken with SARG in November 2006 provided the first evidence of the presence of the naphthalene. Subsequently, spectra obtained with other telescopes confirmed the results obtained with SARG.

This molecule plays a fundamental role in the development of life as we know it on Earth.



2009

The control room is moved from the upper to the ground floor and offers more comfort and security for telescope operators and observers.

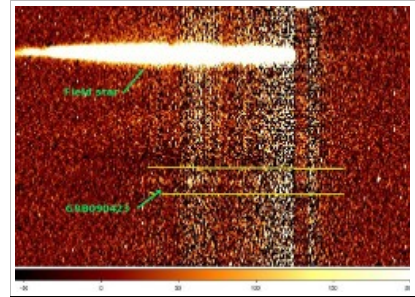


The farthest GRB ever observed in Nature

The Nature journal published the paper based on the TNG observation for the farthest object ever observed by human beings.

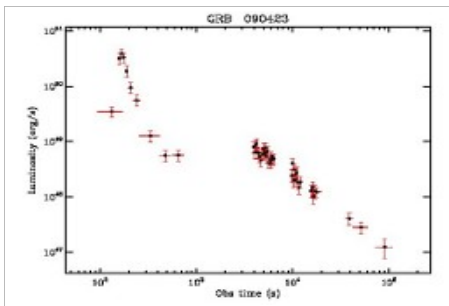
Gamma-Ray Bursts are among the brightest explosions in the universe, and in a few seconds they release a tremendous amount of energy, with their light illuminating the path from the source towards us. Although these events, as observed from Earth, are rather frequent, on April 23 at 7:55:19 UT the Swift satellite detected one of these events that represented a scientific breakthrough: GRB 090423.

As shown by follow-up observations performed with ground-based telescopes, it was a very distant event, and soon it looked like this was the farthest GRB ever observed.



A team of international astronomers led by Swift Italian Team and CIBO, using the AMICI prism with the Italian Telescopio Nazionale Galileo, was able to compute its redshift at about 8.1, corresponding to a distance of more than 80 Gpc, when the universe was only slightly more than 600 million years old.

TNG data help to discover a new class of very dim Supernovae



Supernovae are among the most energetic and violent events in the Universe. They constitute the final tremendous explosions that end the life cycles of some stars.

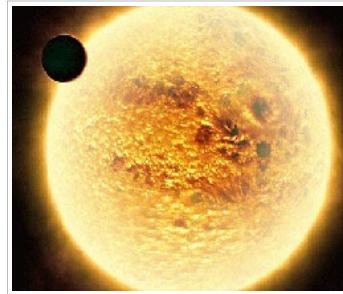
A team of researchers of the Queen's University in Belfast, the Italian National Institute for Astrophysics (INAF), the Max Planck Institute for Astrophysics (MPA) and several other institutions have now for the first time found a dim supernova in which no hydrogen was detectable. This new event, SN 2008ha, was discovered in the

constellation Pegasus, 67 million lightyears away from Earth. The analysis and results of the work leading to this discovery are published by *Nature*.

SARG contributes to the follow-up observations of the hottest extrasolar planet yet discovered

An international team of astronomers reports the discovery of a planet that sizzles at about 2500 degrees Celsius, which is as hot as some stars.

The new planet, known as WASP-12b, is about 1.4 times as massive as Jupiter. It takes just over a day to circle its host star (2MASS J063032.79+294020.4 , hereafter WASP-12), orbiting at only 1/40th the distance between the Earth and the Sun.



A new Galactic globular cluster identified by using DOLoRes data



Observational data taken in June 2008 with DOLoRes led to the identification in our Galaxy of a new interesting globular cluster.

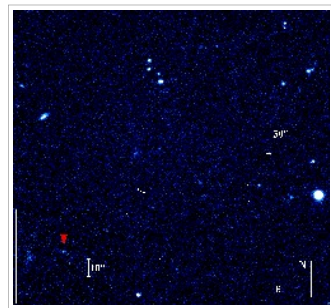
This star system, known as Pfliegerer 2, was discovered in 1977 and classified as an open cluster projected in a rich star field. BVI photometry performed with DOLoRes allowed to draw its color-magnitude diagram (CMD) and to reveal its true nature.

The golden year of GRBs@TNG: the intriguing case of GRB 090426

After the follow-up observations of GRB 090423 (the farthest object ever observed by human beings), TNG plays a fundamental role in the study of another important gamma-ray burst: GRB 090426.

With observed and rest-frame durations of <2 s and <0.5 s, respectively, this object is classified as a short GRB. Observations performed with DOLoRes@TNG about 0.4 days after the burst clearly showed the optical afterglow in bands B, V, R and I. More

important, a medium-resolution spectrum taken with the same instrument unveiled the redshift of the object: 2.61 ± 0.1 . This value, together with its duration of ~ 0.3 seconds, makes of this GRB the farthest short GRB ever discovered!



2010

SARG data contribute to the discovery of the youngest candidate exoplanet ever observed



In the last 15 years more than 400 exoplanets (planets orbiting around stars other than the Sun and thus beyond the Solar System) have been discovered.

A team of Spanish researchers has reported the detection of a very young candidate planet.

It has been found by analyzing high-resolution echelle spectra of BD+20 1790, a young, active, metal rich, K5V star located in the constellation of Gemini. SARG has played an important role in this investigation.

2011

TNG discovers a giant planet in the triple system HD132563

An extrasolar planet in the triple stellar system has been discovered at TNG. Very few planets are known in this kind of systems.

This discovery was entirely based on TNG data, as part of a survey looking for planets in multiple stellar systems. It made use of the high resolution spectrograph SARG to measure the subtle variations of the velocity of the star due to the presence of the planet.

At the end of December, an international agreement has been signed by INAF, to officially launch the project HARPS-N.

HARPS-N (High Accuracy Radial velocity Planet Searcher) – where the 'N' stands for

Northern hemisphere, the planned location for the instrument – is a precision spectrograph designed to detect and characterize extrasolar planets similar to Earth, both in mass and structure, and for studies of asteroseismology.

“I’m really pleased with this agreement because it will allow the Italian astronomical community to access this important and efficient instrument in the exoplanets research field. Furthermore INAF, with TNG, is going to play a stronger role in such an important field of research”.

(Tommaso Maccacaro, President of the National Institute for Astrophysics)

HARPS-N is thus going to be the Northern counterpart of Harps, its twin instrument already installed and operating on the 3.6 meters ESO telescope at La Silla, in the Andes of Chile. Actually, thanks to its location above the equator, Harps-N is likely to become Kepler satellite’s best partner in discovering new lands outside the Solar system.

Kepler, NASA's space probe launched in March 2009 to look for earth-like planets, has a hundred of potential candidates located precisely within the Cygnus constellation in the Northern hemisphere. In order to ascertain that these “warnings” are actually produced by planets, astronomers need to record the small perturbations in the motion of stars due to gravitational effects produced by celestial bodies – planets, in this case - orbiting around them. This requires to carry out long and repeated high precision measurements from Earth based telescopes.

2012

In March 25 2012 Harps-N took his First Light

HARPS-N (High Accuracy Radial velocity Planet Searcher in North hemisphere) is an echelle spectrograph covering the wavelength range between 383 to 693 nm, with a spectral resolution $R=115000$. This instrument allows the measurement of radial velocities with the highest accuracy currently available in the north hemisphere (1 m/s) and is designed to avoid spectral drift due to temperature and air pressure variations thanks to a very accurate control of pressure and temperature.



The main scientific rationale of HARPS-N is the characterization and discovery of terrestrial planets by combining transits and Doppler measurements.

HARPS-N project is a consortium of the Observatory of Geneva University (Switzerland), INAF-TNG (Italy), CfA and Harvard University (USA), ATC Edinburgh, Queens University and University of St. Andrews (UK).



The star Groombridge 1830, aka HD103095, a G8, metal poor, fast moving halo star was aimed with TNG and its spectrum recorded by the complete optical path of the newly installed Harps-North.

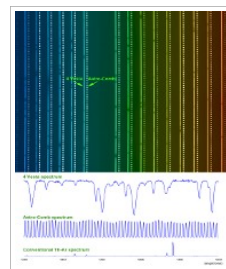
On April 23, 2012 HARPS-N was inaugurated. The inauguration ceremony was done inside the dome of TNG in the presence of the telescope staff, science team members, guests from other telescopes of the observatory and local and international press. Speeches by the TNG director Emilio Molinari, HARPS-N PI Francesco Pepe and INAF and FGG president Giovanni Bignami (via Skype) were delivered.

2013

The TNG and NOT telescopes on La Palma, Canary Islands, have agreed to enter into a closer collaboration.

A green laser astro-comb for Harps-N

A new, experimental, upgrade to the TNG+Harps-N system has been successfully carried out in the last two weeks. An astro-comb, an ultra accurate, light source for spectral calibration has been tested with the Harps-N spectrograph, a step forward in the direction of more precise measurements of star radial velocities (under 20 cm/s), and thus of smaller, Earth-like exoplanets. The astro-comb is a laser frequency comb based calibrator for high resolution astrophysical spectrographs.



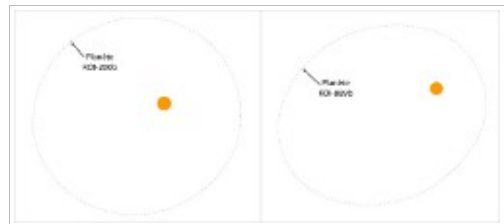
The transiting system Qatar-1

One of the first results from HARPS has been the full characterization of the orbital properties of the transiting system Qatar-1, and of the physical properties of the star and the planet. The GAPS (Global Architecture of Planetary Systems project) team, exploited HARPS-N high-precision radial velocity measurements, obtained during a transit of the planet ahead its star, to measure the Rossiter-McLaughlin effect in the Qatar-1 system, and exploited out-of-transit measurements to re-determine the spectroscopic orbit. They founded that the system is well aligned and so they could definitely ruled out any significant orbital eccentricity: the orbital solution for the Qatar-1 system is consistent with a circular orbit and the system. The planet is also found to be significantly more massive than previously reported and the host star is confirmed to be metal-rich and slowly rotating, though moderately active.

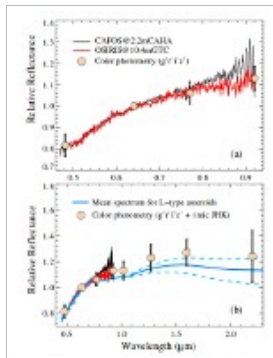
Detection of two extrasolar planets with the Kepler, HARPS-N and SOPHIE instruments

Two new extrasolar planets have been identified and characterized thanks to combined observations from the Kepler space telescope and the spectrographs SOPHIE and HARPS-N respectively mounted at the Observatoire de Haute-Provence (France) and at the TNG.

These two planets are among the first ones detected with HARPS-N. The team that announced these planets obtained time on the Italian telescope through the OPTICON program that share nights of European telescopes between astronomers. These two new planets, called KOI-200b and KOI-889b, have about the size of Jupiter but are orbiting in less than 10 days on eccentric orbits. These new results help to understand the evolution of planets located very close to their star.



Visible and near-infrared observations of asteroid 2012 DA14



On Friday 15th February 2013, amateurs and professional astronomers put their eyes on the near-Earth asteroid 2012 DA14. The approach of this small object (estimated size ~ 50 m) to the Earth was the closest ever predicted.

During this event the object was at about 27.700 km above Earth's surface, which means it was inside satellite's geostationary orbit (~ 35.800 km).

DOLORES and NICS mounted at the TNG were used to monitor 2012 DA14 roughly around the moment of peaking brightness. As a result, the optical and near infrared broad and narrow-band filter imaging of the asteroid were obtained.

An Earth-like planet characterized by HARPS-N

Kepler-78b is an extra solar planet orbiting a Sun-like star located in the constellation of Cygnus, some 400 light-years away from Earth.

According to the study published today in the Nature magazine, it has a mass and density very similar to those of the Earth.

Kepler-78b was first spotted by the NASA's Kepler satellite. Kepler detected the tiny variation of the host star's light caused by the passage of the planet in front of it. Shortly after the discovery, TNG pointed the planet's star.

Kepler-78b has a radius of only 1.17 times that of the Earth, while the mass is 1.86 Earth masses. These numbers yield a density of 5.57 grams per cubic centimeter, and imply a composition of rock and iron, thus making Kepler-78b the most Earth-like exoplanet known so far.

