INAF
ISTITUTO NAZIONALE DI ASTROFISICA
NATIONAL INSTITUTE FOR ASTROPHYSICS

PRESENTATION

Today, all of the world's countries are engaged in an unprecedented race for the construction of impressive astronomical facilities, as well as for the development of increasingly-ambitious space missions to explore the Universe. It is becoming clearer that modern astronomy has a strategic role for the future of humanity: it not only pushes our knowledge to the edges of the Universe, but also creates assets that are crucial for innovation and our planet's safety.

In modern astronomy, ground and space observations are two inseparable, complementary aspects of the study of the Universe. The National Institute for Astrophysics (INAF), founded in 1999 and composed today of about 1,400 staff members spread out over twelve cities, possesses all of the intellectual and instrumental power needed for the exploration of the Universe; it operates at all wavelengths, from the ground and from space.

INAF is a "young" institution: it will be 20 years old in 2019. It is therefore a next-generation institution: it drives innovation and produces great industrial returns for our country. It has a significant presence on the national territory, with a strong impact in terms of training, higher education, public outreach, technology transfer, and historical heritage preservation.

INAF has been ranked second in the world for international collaborations by the authoritative, international scientific journal Nature

(see Il Sole 24 Ore, 16 November 2016, "Technology" section)

Modern astronomy: a strategic engine for socio-economic development

"Astronomy has the power to bring about development where it is needed. Establishing groups of professional astronomers, technicians, engineers and other highly trained staff can provide ongoing economic and educational stimulus to a region. Moreover, the construction of new observing facilities injects much-needed money, employment and infrastructure".
Nature Publishing Group (Focus of *Nature Astronomy*, 3 July 2018)


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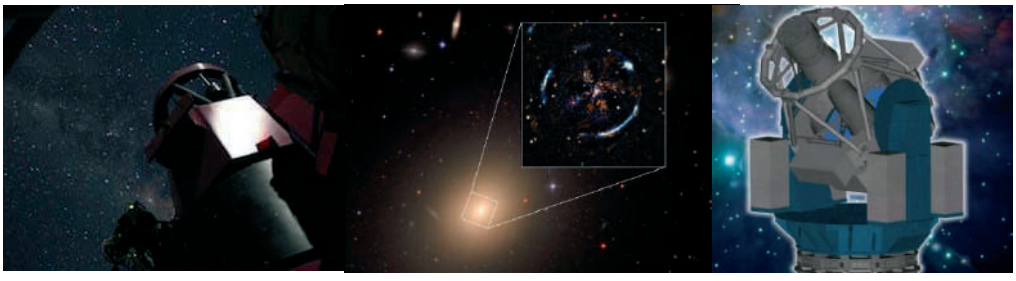
INAF's role in the most powerful astronomical facilities in the world

INAF'S ROLE IN ESO
THE EUROPEAN SOUTHERN OBSERVATORY

The *European Southern Observatory* (ESO), an organization for astronomical research in the southern hemisphere, is an International Treaty Organization, which Italy joined in 1982. Today, Italy is the fourth country for its annual contributions to ESO. The organization employs about 750 staff members, including 80 Italians, and receives annual contributions of around 150 million euros from member states. The organization's headquarters is located in Germany, in Garching bei München, while its facilities are located in the highlands of Chile.

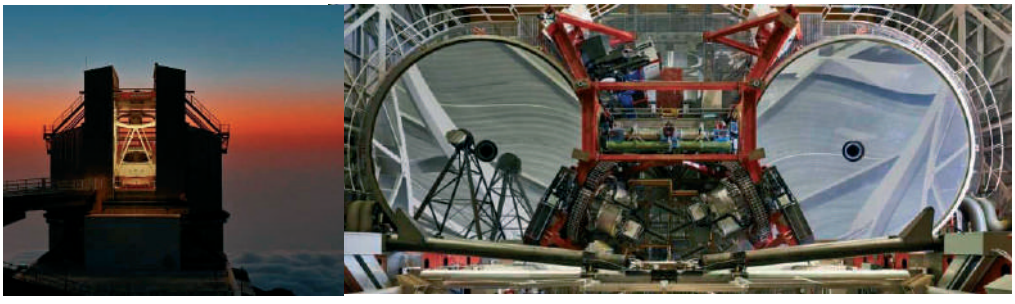
The president of INAF represents our country in the ESO *Council*, upon appointment by the Ministry of Foreign Affairs and International Cooperation

INAF has a decisive role worldwide in the development and implementation of all the ESO instrumentation. Through the continuous process of technology transfer to the national industry, this involvement leads today to considerable economic returns for our country. Over the past fifteen years, the volume of orders for the national industry was estimated at approximately 700 million euros. In addition, two prestigious telescopes installed at ESO's "Paranal" Observatory in Chile, the VST and REM, were entirely designed and implemented by INAF.



INAF'S PRESTIGIOUS TELESCOPES IN THE VISIBLE BAND

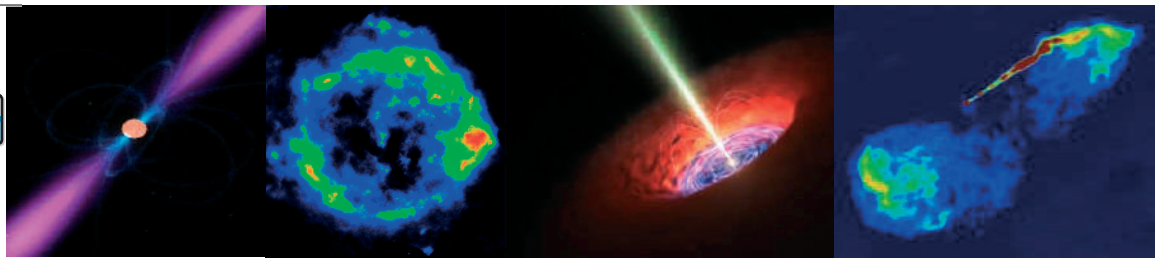
Large Binocular Telescope (LBT). The Large Binocular Telescope is unique in the world. Using two 8.4-meter mirrors placed on a binocular mount and the most advanced adaptive optics technology, which was developed entirely by INAF and then adopted at all of the world's telescopes, LBT is both a powerful instrument and a laboratory for the development of avant-garde optics technology. The telescope is located on top of Mt. Graham (Arizona), is managed by an international collaboration composed of the United States (50%), Germany (25%) and Italy (25%, through INAF), and was built in its entirety by the Italian industry.



Telescopio Nazionale Galileo (TNG). The Galileo national telescope is a 3.58-meter diameter telescope located on the top of the island of La Palma. The large diameter of the telescope, the excellent quality of the images and its advanced instrumentation make it a very advanced instrument. The telescope is available to the Italian community, and is used for the research and study of extrasolar planets and the Milky Way.

In March 2018, INAF's TNG telescope discovered the presence of water molecules in the atmosphere of an extrasolar planet

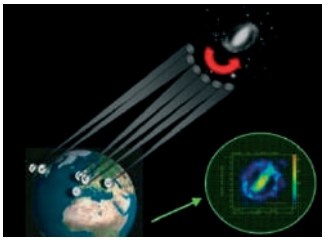
The network of small telescopes. INAF also owns several small telescopes that are distributed throughout the country. They are used for scientific purposes as well as education and public outreach. One observation of particular interest was done with the Loiano telescope, which tracked the Chinese space station Tiangong-1 during its re-entry into the atmosphere in March 2018.



INAF'S RADIO TELESCOPES AND PARTICIPATION IN THE VLBI NETWORK

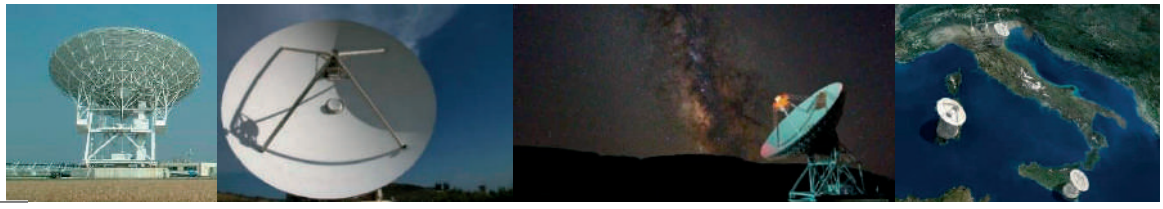
Very Long Baseline Interferometry (VLBI). This international network consists of dozens of large radio telescopes located in various parts of the planet. Using the Earth's rotation and correlating the data collected at each radio telescope, one obtains very high resolution "radio images" of distant cosmic objects from the deep universe. In essence, with the VLBI, one can observe cosmic objects with a resolution that is equal to that obtained with a radio telescope that is as large as the maximum distance between the network's radio telescopes.

VLBI observations, in which INAF radio telescopes have participated, have measured the characteristics of a black hole located about 13 billion light years away



National radio telescopes. Two radio telescopes characterized by a diameter of 32 meters are located respectively in the province of Bologna and in Sicily. Another radio telescope of recent construction, with a diameter of 64 meters, is located in Sardinia. In addition to their use in "single-dish" mode, the country participates in the operations of the international VLBI network with the three INAF radio telescopes. INAF radio astronomers are also very active in the use of radio telescopes of the American network and the Australian network, for which the observation time is assigned through a very competitive protocol.

Space VLBI. The RadioAstron radio telescope is in an elliptical orbit around the Earth, and can reach a maximum distance of 360,000 km. By operating alongside ground-based radio telescopes, images can be obtained with a very high angular resolution. Joint observations between RadioAstron and one of the INAF radio telescopes have reached angular resolutions that would make it possible to read, from the Earth, a book lying on the surface of the Moon!



INAF'S AWARDS IN THE FIELD OF GROUND-BASED ASTRONOMICAL OBSERVATIONS

European Descartes Prize 2005

Bessel Prize 2005

Premio SIGRAV 2006

IUPAP Prize 2006

Marsden Prize 2010

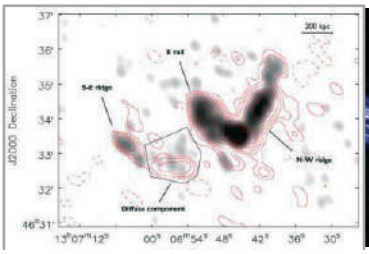
Bessel Prize 2014

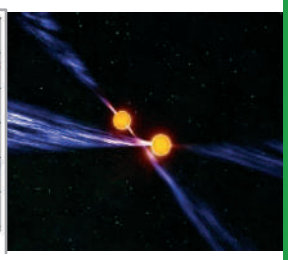
MERAC Prize 2015

Premio Feltrinelli dei Lincei 2016

Bessel Prize 2017

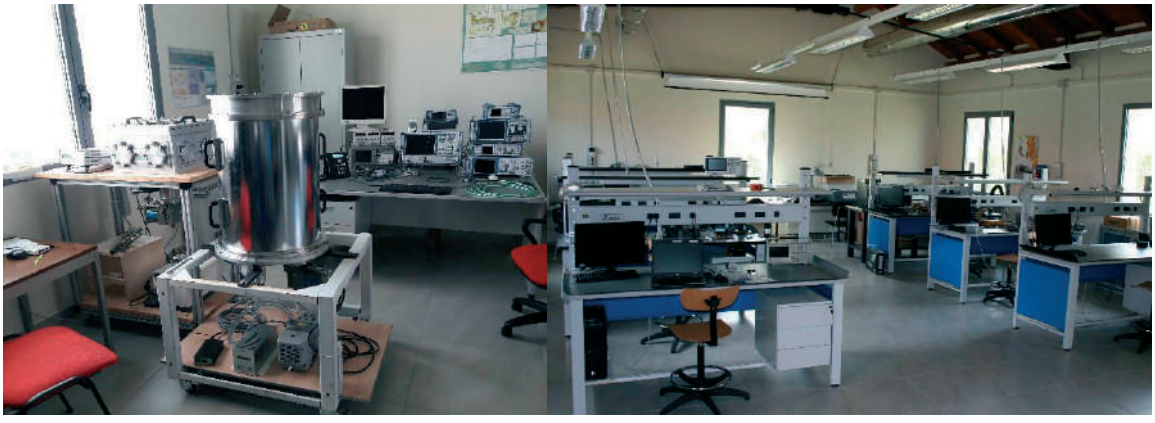
INAF scientists hold important positions in the IAU (International Astronomical Union) commissions





INAF LABORATORIES FOR THE DEVELOPMENT OF DEVICES FOR GROUND-BASED OBSERVATIONS

The instrumentation that operates in the focal plane of modern telescopes (whether in the visible band or in the other bands), optical systems and a large part of the electronic circuitry, are innovative and highly-prototypical tools that are in constant evolution. They are being developed in the most advanced research centers in the world. At its facilities located throughout the country, INAF owns modern laboratories and workshops that produce advanced and innovative instrumentation for ground-based observations at all wavelengths.



One of the most advanced devices of the VLBI radio telescope network, the Digital Base Band Converter (DBBC), which was adopted throughout Europe, is produced by a spin-off company of INAF

INAF regularly participates in the competitive selection for the instrumentation to be installed at all telescopes around the world, in particular at ESO telescopes, thereby transferring innovative skills to the national industry and Small and Medium Enterprises.

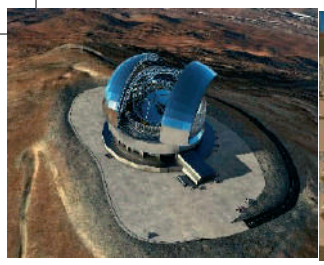
Science nature THE ASTROPHYSICAL JOURNAL LETTERS

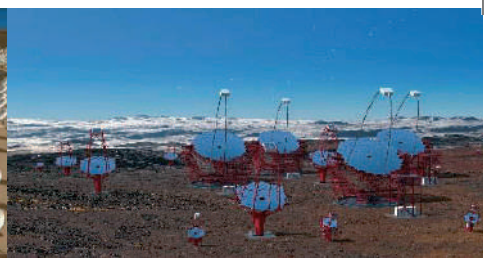
INAF COVERED BY THE MAIN NATIONAL AND INTERNATIONAL NEWSPAPERS

THE FIRST PHOTOGRAPHS OF A SOURCE OF GRAVITATIONAL WAVES

A few weeks after the awarding of the Nobel Prize for the detection of gravitational waves, whose existence is one of the most intriguing consequences of Einstein's General Theory of Relativity, an additional event was announced on October 16th 2017 in an incredible sequence of press conferences around the world. This event manifested itself in all of its scenic beauty: it was a real pyrotechnic show, in which INAF played a leading role. A barrage of articles in Nature and Science and other prestigious international scientific journals, led by INAF researchers, presented the first photographs of a source of gravitational waves "taken" with the most modern ground-based and space telescopes.

On October 16th 2017, in a crowded press conference at MIUR, Paolo D'Avanzo, a young INAF researcher, presented the results of the observing campaign. From Google Analytics data, the "Media INAF" website registered over 40 thousand visits in the single day of the announcement.



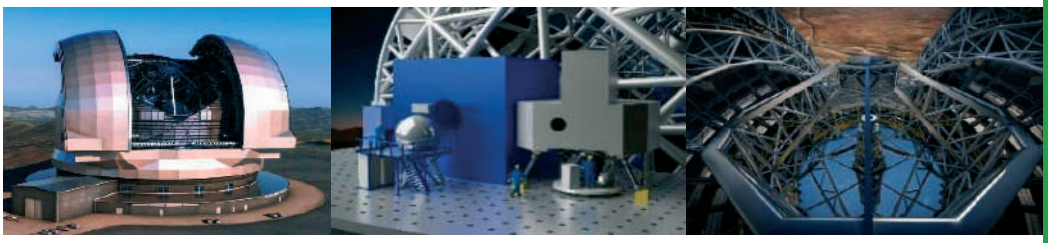


NEXT-GENERATION TELESCOPES: STRATEGIC FACILITIESFOR THE FUTURE OF HUMANITY

Today, the most successful countries are engaged in a real race towards the construction of huge telescopes that are increasingly "powerful". There are two complementary aspects underlying this challenge. On the one hand, an ever-increasing number of exoplanets are being discovered (these planets are different from those orbiting our Sun, they are associated with other stars). We are certainly interested in studying their chemical-physical characteristics, in order to find definite evidence for the presence of life in the Universe, even at its primordial stage. In this case, we are talking about “close" objects, with typical distances of a few hundred light years; the "power" of the telescopes is used to make ever more accurate measurements. Here we are still looking within our Galaxy.

On the other hand, we are now used to "going outside” of our galaxy with our telescopes, to study increasingly distant cosmic objects. The radiation we receive from the Universe travels at the speed of light, which, despite being very high compared to our daily experience, is finite. Therefore, observing distant objects means "seeing them" as they were in the past. In essence, pushing our observations to farther distances, with increasingly powerful telescopes, means observing the Universe further in the past, with obvious consequences for our understanding of the Universe’s origin and evolution.

INAF is our country’s authoritative reference in the realization of three of the most ambitious global astronomical ground-based facilities of the future: the Extremely Large Telescope (ELT), which, with its forty-meter diameter mirror, will be the largest telescope in the world; the Square Kilometre Array (SKA), with thousands of antennas to be installed in South Africa and Australia; the Cherenkov Telescope Array (CTA), with hundreds of gamma-ray telescopes to be installed in Chile and the Canaries

THE "COUNTRY SYSTEM" AS PROTAGONIST IN THE ELT PROJECT, THE LARGEST TELESCOPE IN THE WORLD

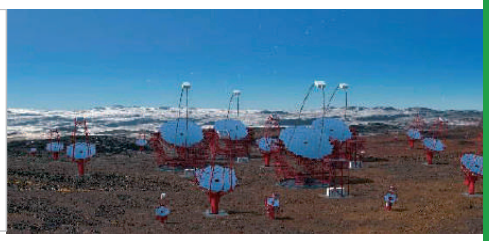
Extremely Large Telescope (ELT). With a mirror of almost 40 meters in diameter, ELT will be the largest telescope in the world, and will rise in the Cerro Armazones plateau in Chile. Italy is significantly involved in the construction of this huge facility.

400 Million euros	**the contract awarded by ESO to the Italian industrial consortium "ACe" for the construction of the mechanical structure**
45 Million euros	**the contract awarded by ESO to the Italian Consortium "AdOptica", of which INAF is a sub-contractor, for the M4 mirror**
18 Million euros	**the nomination of INAF by ESO for the design and implementation of the "MAORY" module, the instrumentation's heart**

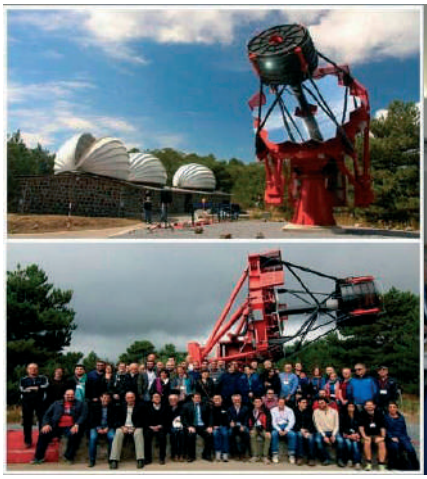
THE MAECI LEADS THE NEGOTIATIONS FOR THE CONSTITUTIONOF AN IGO FOR THE SKA PROJECT

Square Kilometre Array (SKA). Thousands of antennas for radio astronomy and space science, to be installed in Australia and South Africa, will allow unprecedented observations of the Universe. After having revolutionized the world with the invention of WI-FI, today radio astronomy is engaged in new technologies that will lead to a new revolution in the field of telecommunications. The negotiations for the establishment of an Intergovernmental Organization (IGO) to build the facilities, which were chaired by the MAECI, are now concluded.

The national industry and INAF are already at the forefront in the development of components for the SKA prototypes, which are already being tested in South Africa. INAF has already participated in the testing of the first prototypes of low-frequency antennas in Australia



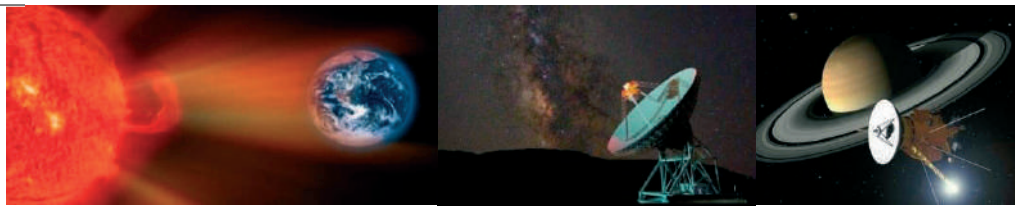
THE MIUR LEADS THE NEGOTIATIONS FOR THE ESTABLISHMENT OF AN ERIC FOR THE CTA PROJECT



Cherenkov Telescope Array (CTA). CTA is one of the most important global research facilities, and consists of a network of gamma-ray telescopes to be installed in the Canaries and Chile. Negotiations are underway for the establishment of an ERIC (European Research Infrastructure Consortium) to build and operate the facilities, whose headquarters will be located in Italy, at one of the INAF institutes in Bologna.

The "ASTRI" Project. As part of the CTA project, INAF holds an important record for having already implemented an advanced prototype called ASTRI, thanks to a grant from the MIUR for the so-called Flag Projects. Based on this prototype, the first (100% Italian) 9-unit "Mini Array", which will form the basis for the entire array, will be built in the two-year 2019-2020 period.

The "ASTRI" prototype has been the subject of an INAF patent for geodesy applications. This telescope can in fact perform “X-rays" of tectonic plates and volcanoes, thus exploiting the differential absorption of atmospheric muons



INAF'S LARGE GROUND-BASED FACILITIES FOR SPACE ACTIVITIES

INAF's large radio telescope in Sardinia. The Sardinia Radio Telescope (SRT) is one of INAF's most important national facilities, which was ordered by the MIUR through the National Program for Research Facilities (PNIR). The use of SRT for space applications, in particular for NASA's Deep Space Network, is the subject of a Program Agreement signed between INAF and ASI. In September 2017, for example, the telescope tracked the Cassini probe in its dive final into Saturn.

INAF facilities for "Space Weather". In addition to the SVIRCO Observatory, which is unique in Italy and has continuously measured the intensity of cosmic rays since 1954, INAF is successfully equipping its radio telescopes for the so-called "Space Meteorology". Space Meteorology studies the perturbations in the interplanetary Space caused by phenomena that occur on the Sun, in the solar wind, in the magnetosphere and in the terrestrial ionosphere, and which propagate up to the Earth, thus affecting life and its activities.

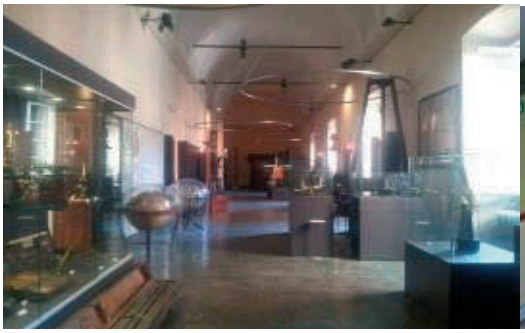
INAF and BIG DATA in the space sector. INAF operates a space data center with ASI and INFN, which is called the Space Science Data Center (SSDC). It provides services and support to users of space mission data.

An Agreement between INAF, ASI and the Ministry of Defense involves the use of INAF's ground-based facilities for monitoring the so-called "space debris".
The monitoring of the re-entry of the Chinese space station Tiangong-1 in the atmosphere was of particular interest.
INAF was involved in the activities coordinated by the Civil Protection.

INAF TRANSFERS ITS INTERNATIONAL EXCELLENCE ONTO THE NATIONAL TERRITORY

INAF is spread out over 12 cities, and has a strong impact on the territory in terms of training, higher education, public outreach, technology transfer, historical heritage preservation, and operates its own online newspaper.

With its territorial institutes, INAF participates in most regional aerospace districts, thereby attracting funding and investments, contributing to regional development, and involving industry and SMEs



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translation by Delphine Perrodin, INAF.

INAF – Istituto Nazionale di Astrofisica - Viale del Parco Mellini 84, 00136 Roma
www.inaf.it – media.inaf.it - @mediainaf
ufficiostampa@inaf.it