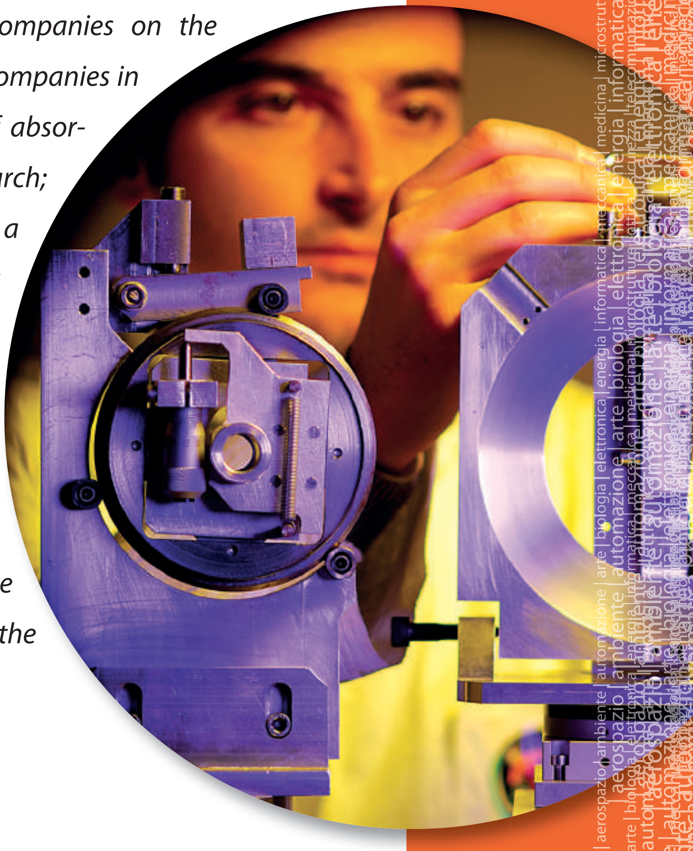
INAF
AND TECHNOLOGY
Innovative solutions and industrial applications of astrophysics

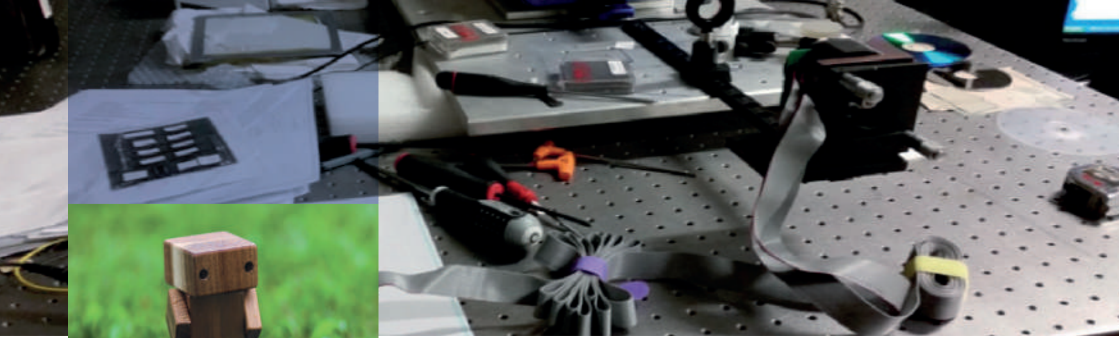
Every time a large telescope pushes its gaze beyond the limits of the known horizon, our horizon also expands. And every time a satellite explores the most remote meanders of the universe, something remains on Earth. Something about our daily life: new technologies, cutting-edge materials, new solutions to everyday problems. This is because, from the first Galileo telescopes to the Hubble Space Telescope, astrophysics has always been thirsty for cutting-edge technologies and materials: technologies and materials at the limits of the possible, not available on the market, and therefore to be designed and built from scratch. Technologies and materials - such as digital image processing or shape memory foams - that have radically improved not only our way of doing science, but also the quality of our lives.

Today, astrophysics and space research play a strategic role of incommensurable value for Europe and the whole world. This sector acts as an element of cohesion and brings us together to talk about platforms for civil security, the organization of defense systems, sensitive environmental issues, the development of future mobility systems and new frontiers in the energy field. The National Institute for Astrophysics is aware of this: it has been designing and using the most cutting-edge tools for observing the Universe every day, from the Earth and from space, and has always considered the development of innovative technologies to be of absolute priority.

The development and implementation of projects and experiments for astrophysical research has allowed the Institute's facilities to acquire levels of excellence and a reference know-how on the international scene in a considerable number of technological sectors: precision optics, of course, but also electronics, telecommunications, information technology, mechanics, environmental control, medicine, safety, energy and even cultural heritage.

These sectors represent the reason that INAF undertook its journey into the landscape of innovation and technology transfer. In its Technology Transfer program, INAF has set and undertaken two directions: transferring technologies to existing companies on the market, and growing new companies in sectors that are capable of absorbing the results of the research; for this, INAF has created a service that is specifically dedicated to technological innovation. And there are already concrete examples of applications and patents born thanks in part to the research of INAF. We have chosen to highlight some of the many applications.





Mechanical fingers
with a sense of touch

Electronic circuit for measuring a physical quantity generated by an actuator

|aerospace|environment|automation|art|biology|electronics|energy|IT|

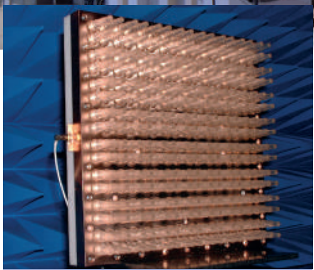
|mechanics|medicine|microstructures|optics|security|telecommunications|other|

Just as the fingers can exert pressure and at the same time give us sensitivity to touch, the patent adds the function and performance of a sensor to all types of actuators for which there is a relationship between their impedance and the generated physical quantity. This transformation into a device with dual performance is achieved by installing circuits that drive the actuator and simultaneously measure its impedance. The method can be advantageous for many industrial applications and for the most varied types of actuators, since it is adaptable to any type of impedance. From the point of view of an industrial use, the possibility of obtaining a sensor where there was only one actuator can allow existing control systems to be repositioned upwards. In fact, obtaining a measurement of a size without having to bear the cost and space occupied by a real sensor can be a considerable advantage for all those systems that aim to reduce costs and dimensions. Not to mention the increase in reliability, for example f
or all those systems that depend on sensors installed in hostile environments and subjected to extreme environmental conditions.

This patent was developed in Arcetri's INAF laboratories to obtain the measurement of the deformation directly from any type of actuator used in the mirrors for adaptive optics.

In one number

Zero: the number of sensors needed to control a closed loop system using this patent.



The satellite antenna?
It's a space tile

CAPSA - Compact Planar Array for Satellite Applications

| aerospace | environment | automation | art | biology | electronics | energy | IT | mechanics | medicine | microstructures | optics | security | telecommunications |

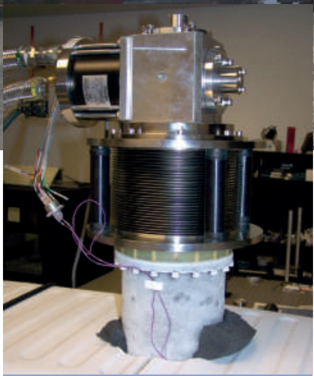
Urban landscapes disfigured and transformed into sprawling fields of electronic sunflowers. Ancient terracotta roofs smothered by myriads of metal pans, whose gaze is perennially oriented no longer towards the sun, but to track the geostationary orbit of some artificial satellite. Following the strong expansion in the field of satellite telecommunications over the last decade, an ever increasing number of satellite dishes populate city buildings. They create obvious eyesores, especially in historical centers and in areas of high artistic value. But should the antennas be just so ugly and bulky? Surely not. The INAF team that designed the Planck space telescope has developed "planar geometry antennas": they are flat, compact and with low environmental impact.

Thanks to their small dimensions and planar geometry, these antennas are able to offer a modest visual impact, while ensuring a high directivity. Not only that: the possibility of orienting the beam via software allows us to limit installation and maintenance costs.

The planar geometry antennas have been developed at INAF-Oas Bologna thanks to the modeling, design and characterization skills of the materials deriving from the ASI / INAF Planck-LFI project. The private companies that have collaborated are: Officine Pasquali Firenze (FI), RTW-Navacchio (PI), Sputtering S.r.l. (Bellusco, MB), T.O.P.P. Srl (Sandrigo, VI), NuovaEurotar (Tivoli, RM) and Ics Modena (MO).

In one number

300 x 300 x 80 mm: these are the dimensions of a panel of 256 radiating elements with a gain of 30 dBi.



A thrilling infrared camera

AMICA - Multiband infrared camera (2 - 25 µm) for astronomical observations from Antarctica

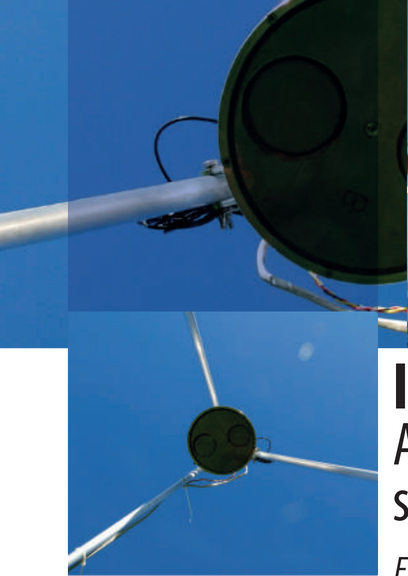
| aerospace | environment | automation | art | biology | electronics | energy | IT | mechanics | medicine | microstructures | optics | security | telecommunications | other |

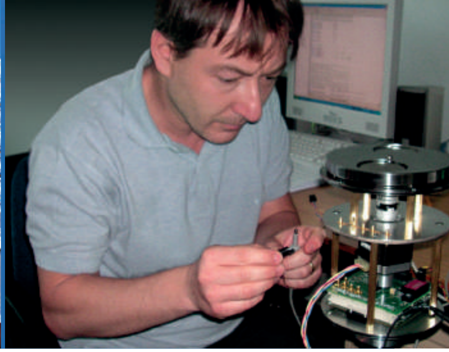
Coming from the eternal ice of Antarctica and called AMICA, this infrared camera can work wonderfully even at polar temperatures. Developed to perform astronomical observations from the South Pole, even at 90 degrees below zero, AMICA continues to work at full capacity, taking "thermal" images at the rate of 350 images per second. A technology with a vast field of applications: environmental monitoring in extreme conditions, high-speed control of the thermal behavior of electronic and mechanical devices, avalanche protection systems in high mountains. This technology was made possible by the challenge faced by astrophysicists in Antarctica: despite being the "earthly paradise" of infrared astronomy, the Antarctic plateau offers awful environmental conditions. Let us not mention the strict financial constraints imposed by the tight budget that is available to researchers. These obstacles have imposed the adoption of innovative and low-cost technological solutions, but without penalizing performance: 2.87 ms for each MIR image (7 - 25 µm) of 128 x 128 pixels.

AMICA was born as an astrophysical project to perform high-resolution astronomical observations from Antarctica in the near infrared (2 - 5.5 µm) and in the mid-infrared (7 - 25 µm). The INAF Astronomical Observatories of Collurania (Teramo), Padua, Turin and Milan took part in its creation. SkyTech S.r.l. (La Spezia) and IRLabs Inc. (Tucson, AZ, USA) collaborated in the creation of subsystems for AMICA.

In one number

-90 deg C: the minimum ambient temperature at which AMICA is able to work automatically at full speed, compared to -20 deg C for commercial devices and -55 deg C for military devices.





If lightning is approaching

An atmospheric sentinel will warn you

EFM - Atmospheric electric field meter

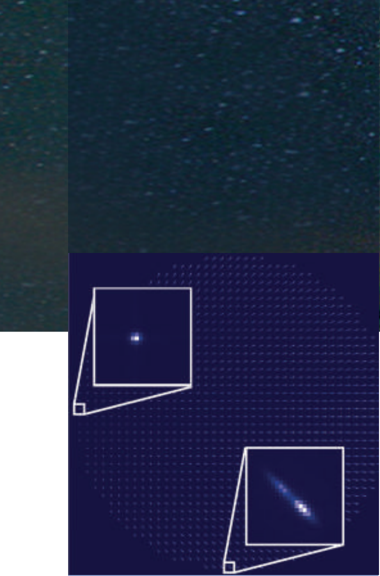
| aerospace | environment | automation | art | biology | electronics | energy | IT | mechanics | medicine | microstructures | optics | security | telecommunications | other |

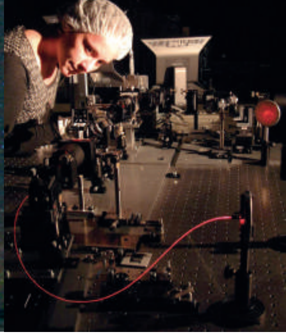
A sudden storm and the window was left open ... this has happened to everyone, despite the increasingly-reliable weather forecasts. Not too bad, pick up a bucket and rags, and the problem is solved. However, there are locations and situations in which a strong thunderstorm, or lightning, can cause far more serious damage: industrial plants, radio bridges, broadcasting stations, radars, airports, cable cars ... A device capable of signaling the approaching storm in time and automatically, would solve the problem: it could start emergency procedures, for example, or more simply activate actuators to close the windows. How can we do this? Once you had to rely on the flight of swallows, but now there is EFM, the Electric Field Meter: by measuring the variations of the atmospheric electric field at high frequencies (up to hundreds of kHz) and high intensities (up to 15kV/m), one can anticipate and follow the development of a storm in all its phases, from the first signs to the departure. Not only that: with a network of multiple EFM sensors, synchronized via an integrated GPS, the direction of the storm cell's arrival can also be determined. This thus extends the field of application of EFM from prevention to meteorology and monitoring of air pollution phenomena.

EFM was created to monitor the environmental conditions for the remote stations of the SKA (the Square Kilometre Array), and from the design of the control cards of the Sardinia Radio Telescope's receivers. It was designed and built by INAF-IRA in Medicina (BO), in collaboration with MTX srl (Padua).

In one number

From 22% to 60%: the energy savings of EFM compared to similar instruments that are already on the market. This feature allows it to be used in places without a network, by using batteries and photovoltaic panels.





A laser firmament
for an eagle vision

LGSWFS - High-order wavefront sensor for adaptive optical systems with artificial stars

| aerospace | environment | automation | art | biology | electronics | energy |
| IT | mechanics | medicine | microstructures | optics | security | telecommunications | other |

Even the best of telescopes, sooner or later, must surrender. However perfect its optics and components, when the required performance exceeds a certain threshold, the enemy comes from outside. It's called the atmosphere. To be precise, atmospheric turbulence: restless and unpredictable, the atmosphere introduces aberrations that can affect the sharpness of the images. Telescopes can be placed above it, in space. Or modern adaptive optics can be used: these systems are capable of correcting aberrations relentlessly, even thousands of times per second. However, these aberrations must be measured in real time. LGSWFS, the wavefront sensor prototype developed for E-ELT (the future 42-meter European telescope), succeeds thanks to an artificial "firmament" of reference stars made with a laser. Among the potential fields of application, there is, first of all, the field of ophthalmology: measuring the aberrations of the human eye, distinguishing the contribution of the cornea from that of the lens. But adaptive optics also appeals to anyone who needs to transmit data at very high speeds with a laser beam, or for example, to make ultra-efficient solar concentrators for the production of clean energy.

Created for the study of a multi-conjugated adaptive optics module for the future European Extremely Large Telescope, the LGSWFS prototype was designed and built, thanks to funding from the Seventh Framework Program of the European Union, in the laboratory of INAF's Astronomical Observatory of Bologna.

In one number

1250 sub-openings: the number of micro-lenses of LGSWFS' artificial firmament. That's 5 to 10 times more than the number of sensors at today's 8-meter diameter telescopes.

From comets to volcanoes
by measuring ultra-thin dust

DUSTING - Dust sensors for space

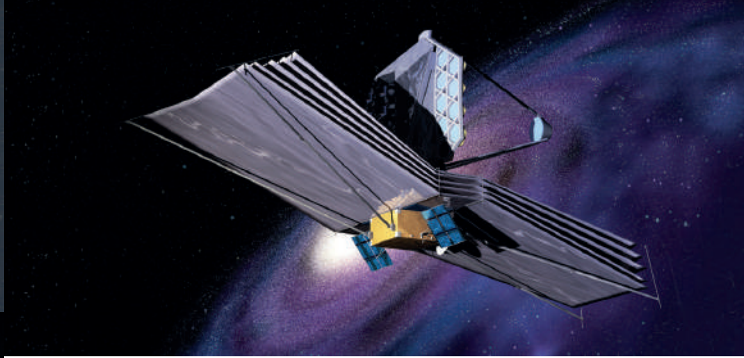
| *aerospace* | *environment* | *automation* | *art* | *biology* | *electronics* | *energy* |
| *IT* | *mechanics* | *medicine* | *microstructures* | *optics* | *security* | *telecommunications* | *other* |

They have weighed the dust of a comet's tail and the particles in large interstellar spaces at a billionth of a gram. They can measure particulate grains starting from a millionth of a millimeter. They exploit the properties of quartz crystals, and are among the most sensitive sensors in the world. Developed for the most extreme space applications, such as NASA's Stardust mission, these miniaturized sensors can also be used on Earth, wherever accurate measurements of ultra-fine dust are needed: from the active monitoring of particles in the earth's atmosphere to that of the particulate produced following explosions. Dust sensors can also be used on small remote-controlled aircraft, for example to monitor areas that are difficult to access: areas with high radioactivity, affected by fires, chemical accidents or volcanic eruptions, such as the Icelandic volcano Eyjafjöll, which blocked air traffic in half of Europe in the spring of 2010. Information on the dust's physical characteristics and concentration can be provided in real time, while the chemical characteristics of the collected sample can be analyzed later in the ground laboratories.

The sensors of the DUSTING project are on board some of ESA's most ambitious space missions, such as Rosetta and Exo-Mars. The INAF Astronomical Observatories of Capodimonte (NA) and Trieste, together with Selex-Galileo S.p.a. (FI), Techno System Developments S.r.l. (NA), Marotta A.T. Srl (NA) and Novaetech S.r.l. (NA), were involved in their design and development.

In one number

10-8 m: the minimum size of detectable particulate grains: this dust is a thousand times "thinner" than PM10.



Perfect mirrors
with ionic guns

IBF - High-precision optical processing using the Ion Beam Figuring technique

| aerospace | environment | automation | art | biology | electronics | energy |
| IT | mechanics | medicine | microstructures | optics | security | telecommunications | other |

It is a sort of atomic sandblaster: its cannon does not fire sand or metal microspheres, but gas ions. If you want to build a mirror with precision to the limits of the possible, it is the ideal tool: IBF technology allows you to obtain the maximum levels of correction on the optics, with errors in the order of nanometers. The procedure, called Ion Beam Figuring, can be applied to any type of optical form (free-form), and is deterministic. The processing of the optics is therefore efficient and fast. A single processing cycle is usually sufficient to complete the optics processing. Applications cover all areas where high-precision optics are required, such as those required in synchrotron beamlines, nano lithography concentrators, optical interferometers and terrestrial monitoring or space defense missions. At the INAF Astronomical Observatory of Brera (MI), two Ion Beam Figuring facilities have been developed, one of which is among the largest currently available in the world: it allows you to build optics of up to 1500 mm in diameter.

The IBF technology has been used at the INAF-Astronomical Observatory of Brera (MI) for the correction of the spindles for the manufacturing of X-ray optics intended for astronomical space missions. And, in collaboration with Selex-Galileo (Florence), for the processing of visible/infrared optics (for example, those of the Nirspec instrument, the spectrometer on board JWST, the successor of the Hubble space telescope).

In one number

λ / 100, a hundredth of a wavelength: the optical precision made possible by IBF technology. A value at the top of what is possible today.

Space materials for orthopedics and regenerative dentistry

SiC-PECVD - Silicon Carbide (SiC) Deposition using the PECVD technique

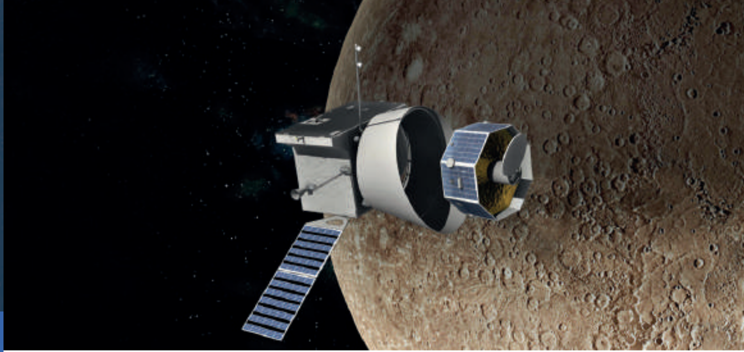
| aerospace | environment | automation | art | biology | electronics | energy | IT | mechanics | medicine | microstructures | optics | security | telecommunications | other |

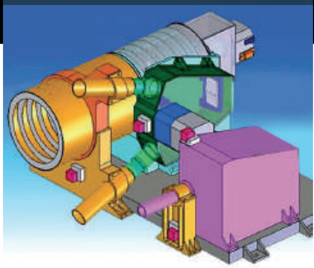
It's called silicon carbide (SiC). This material has stunning properties: light, resistant, very rigid, with enviable thermal stability. Now, thanks to the PECVD technology (Plasma Enhanced Chemical Vapor Deposition), developed by INAF for terrestrial and space telescopes, it is also easy and cheap to work with it. The PECVD technique makes it possible to deposit SiC on substrates of various kinds at low temperatures and with low costs. Possible applications include: optics for terrestrial monitoring satellites, avionics, production of X-ray mirrors for synchrotron radiation facilities, as well as biomedicine. The properties of silicon carbide, combined with its relative cheapness (for example, compared to ceramics), make it a perfect material for coating orthopedic prostheses, reducing the need to use re-implants and the emergence of allergies. Not only that: the known biocompatibility of silicon carbide, combined with the ability of human mesenchymal stem cells isolated from adult tissue to adhere to SiC-PECVD and to maintain their differentia tion capacity towards the osteogenic line (bone cells), opens up promising prospects for the use of SiC PECVD in the dental field as well.

Designed for telescopes on Earth (such as E-ELT, the European Extremely Large Telescope) and in space (for example, on board the BeppoSAX, Swift, XMM and IXO satellites), SiC-PECVD technology has been investigated, thanks to PRISMA funding obtained in 2005, from the INAF Astronomical Observatory of Brera (MI) together with the Cetev Lab (Selex-Galileo, Florence).

In one number

200 deg C: the temperature at which SiC-PECVD is deposited, 1000 degrees less than the CVD process. The low process temperature reduces costs and opens up new possible application fields.





Coming from Mercury
the radiation-resistant HIRES imager

HRIC - High spatial Resolution Imaging Channel

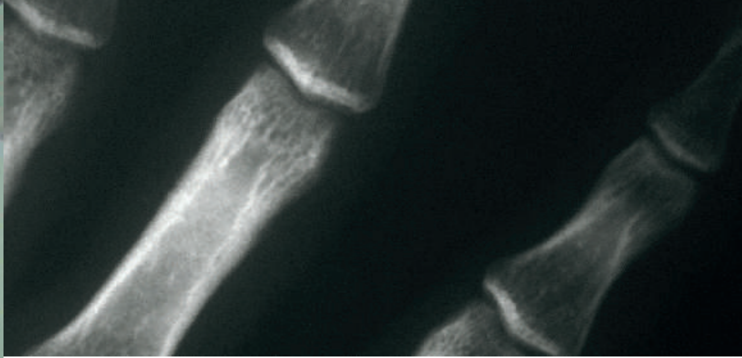
| *aerospace* | *environment* | *automation* | *art* | *biology* | *electronics* | *energy* | *IT* |
| *mechanics* | *medicine* | *microstructures* | *optics* | *security* | *telecommunications* | *other* |

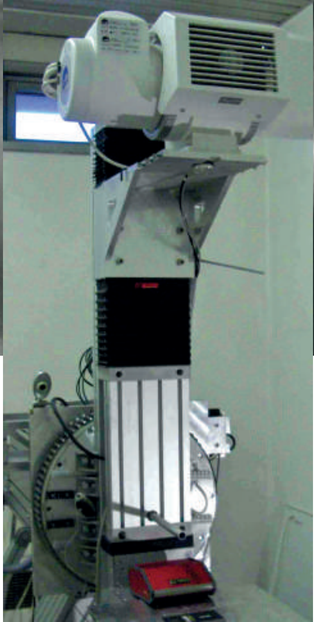
Indispensable for environmental monitoring, the satellites placed in low orbits are, however, the punching-ball of cosmic rays and van Allen's bands: forced to cross the battleground between the solar wind and the earth's magnetic field, their instruments are constantly in danger of remaining damaged by intense levels of radiation. Unless they are properly armored. Like the high resolution HRIC camera: designed to orbit around Mercury, therefore in a more hostile environment than ever, it has a compact optomechanical design, scalable and with high levels of radiation hardness tolerance. By implementing the technological solutions developed for HRIC on board satellites in low earth orbits, it is possible to create more robust space instruments that are more resistant to adverse environmental conditions. Without this coming at the expense of quality: HRIC will in fact make it possible to characterize the surface of Mercury at 5 meters per pixel, a level of detail never achieved before. The ideal technology, therefore, to guarantee detailed and prolonged monitoring of the earth's surface even at high latitudes.

HRIC is a component of the SIMBIO-SYS system (Spectrometers and Imagers for MPO BepiColombo Integrated Observatory SYStem), intended for the ESA BepiColombo space mission. Its purpose is the observation of the surface morphological structures (scarps, ditches, volcanic domes and craters) of Mercury. was developed by INAF - Astronomical Observatory of Capodimonte (NA) and by Selex-Galileo S.p.A. (FI).

In one number

5 m / px: the spatial resolution achievable by HRIC in orbit around Mercury.





Slabs without fear
with the X-ray identikit

SSRX - Online spectrometer system and Compton camera for X-ray spectrometry

| aerospace | environment | automation | art | biology | electronics | energy | IT | mechanics | medicine | microstructures | optics | security | telecommunications | other |

"Now stay as still as you can", the doctor orders. It just takes an instant: a little sinister noise, and the slab is ready. No pain, no visible signs that something happened. But that moment always leaves us with a slight apprehension: no matter how brief it was, we know that something happened: we were crossed by a beam of high-energy radiation. How much, exactly? In which areas? And again: was it the minimum indispensable dosage? Detailed knowledge of the spectrum of an X-ray diagnostic beam is essential for optimizing test protocols, not only to reduce the dose administered to the patient, but also to improve image quality. This is what the SSRX system can do: developed by astrophysicists to fine-tune the detectors of high-energy space missions, it allows real-time measurement of the operating parameters of an RX tube, as well as an integral evaluation of the emitted beam. It thus guarantees further safety margins to the diagnostic technique, which more than any other, has revolutionized the history of medicine.

SSRX is the result of the need to characterize the behavior of the detectors and space satellite systems for X-ray astronomy AGILE and INTEGRAL as accurately as possible. It was developed by the researchers of INAF-OAS Bologna, in collaboration with the Department of Physics of the University of Bologna and the technical and health staff of the Policlinico S. Orsola-Malpigh (BO).

In one number

50,000: the dynamic range of sensor and electronics used in the feedback loop to control the beam emitted by the RX tube in all its phases, from ignition to operation. The dynamic range of conventional systems rarely exceeds the value 1000, it is therefore 50 times lower.

Free control
with wireless sensor networks

Green Wireless Sensor Network

| *aerospace* | *environment* | *automation* | *art* | *biology* | *electronics* | *energy* | *IT* |
| *mechanics* | *medicine* | *microstructures* | *optics* | *security* | *telecommunications* | *other* |

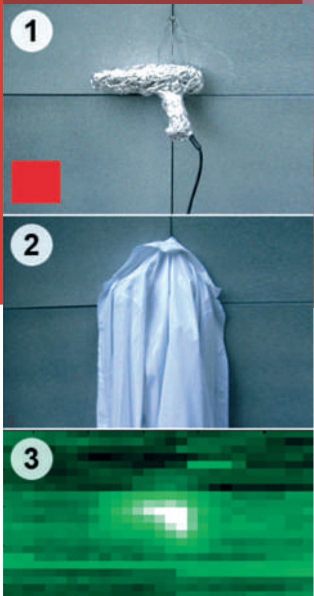
Take the five senses, add some more, and multiply them for all the devices you would like to keep constantly under control.

Starting from a technology that is already on the market, and taking advantage of the knowledge acquired in the field of radio astronomy and millimetric technologies in general, INAF-OAS Bologna and Raptech S.r.l. (Rome) have adapted the Green-WSN cards to accommodate multiple sensors of different types.

Temperature, pressure, humidity, energy consumed or produced, CO2 saved ... the only limit is fantasy. Spread out wherever they are needed (for example, in energy farms, each photovoltaic panel could have one), the wireless sensors of the Green-WSN platform, based on ZigBee technology, will behave as a single network, allowing an efficient verification and economic status of systems of all kinds, industrial plants and even individual homes. The Green-WSN platform makes it possible to manage even temporary installations without the need for any wiring. The cards, powered by battery and / or by photovoltaic panels, also supply the sensors connected to them, and send the acquired data wirelessly. Not only: the ZigBee technology allows the creation of mesh networks and the exploitation of data hopping between the various cards, thus guaranteeing great flexibility in the configuration.

In one number

255: the number of nodes that can be managed by the Green-WSN platform.



Reliable and harmless,
this body scanner comes from the cosmos

ViKy - Video camera for Ka-band images

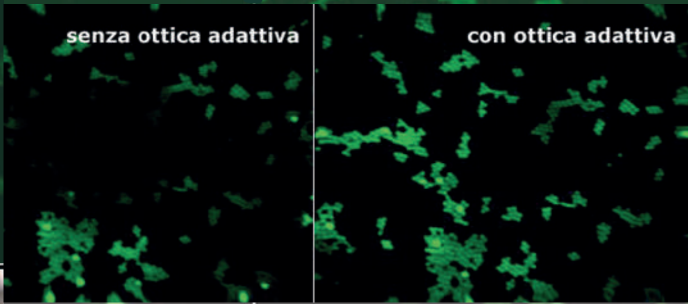
| aerospace | environment | automation | art | biology | electronics | energy | IT | mechanics | medicine | microstructures | optics | security | telecommunications | other |

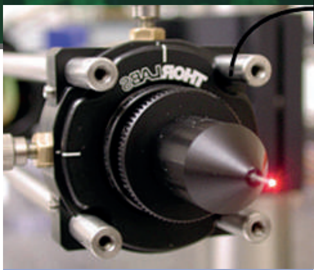
Following the intensification of threats of terrorist attacks on board aircraft, there has been a growing attention and request for body scanners for a few years to increase the security of airport gates by creating the least possible inconvenience to passengers. The ViKy video camera, which implements the technology developed to investigate the cosmic microwave background, meets these requirements: it allows the identification of metal objects even under clothing, in conditions of poor visibility and in a totally passive way: that is, without exposing the subject to any radiation. These features make the technology applicable to hidden weapons detection systems or video surveillance and airport assistance systems. The ViKy video camera, already in its current prototype configuration, is compact and easily transportable. The PC to which it is connected allows us to observe the scene's image both in the microwave and in the optical in real time. And compared to traditional thermal mapping systems, such as infrared sensors, with microwave technology, it is also possible to observe through fog, smoke, dust and rain.

The solutions implemented in ViKy come from the technology developed to create the corrugated horns at 30 GHz of the LFI instrument (Low Frequency Instrument), which is mounted on board the ESA Planck satellite. The study and construction of the ViKy prototype is the work of researchers from INAF-OAS Bologna.

In one number

1 : as opposed to an entire array of receivers, ViKy has only one motorized reflect-array and a single radiometric chain, which operate at room temperature. This makes the system more economical.





Miniature microscopes
with smart optics

MSO - Microscopy Smart Optics

| aerospace | environment | automation | art | **biology** | electronics | energy | IT |
| mechanics | medicine | **microstructures** | optics | security | telecommunications | other |

Zoom out an invented tool to enlarge. It seems like a play on words, but in many situations, the possibility of having both efficient and miniaturized microscopes offers important advantages. The current objectives used in microscopy applied to biology, based on traditional optics, present volumes and encumbrances that are often prohibitive for the investigation of samples that are difficult to reach, or in the case of in vivo microscopy applications, for which it is necessary to include the target in the area in question. Combining the technology of graded index (GRIN) optics and that of adaptive optics, the INAF-Astronomical Observatory of Padua, in collaboration with the VIMM institute, has succeeded in developing and testing miniaturized microscope solutions capable of opening new possibilities of investigation for in vivo microscopy (in various modes: confocal, fluorescence, OCT), for endoscopic probes (both for biological applications and for surface analysis of materials) and in the creation of optical tweezers for applications in micro and nano-structured systems.

Result of the experience acquired in the field of adaptive optics and focal-plane smart-optics used in astronomy, the MSO technology was developed at the INAF-Astronomical Observatory Padua, in collaboration with the Venetian Institute of Molecular Medicine (VIMM, Padua) and GRINTECH (Germany), thanks to a loan for the "Excellence Projects" of the Cassa di Risparmio di Padova and Rovigo Foundation.

In one number

0.5 mm : the physical dimensions of the graded-index lenses are one or two orders of magnitude smaller than those of lenses based on classic optics.



Libraries with telepass,
the privileged lane for books

Automated management of libraries based on RFID technology

| aerospace | environment | automation | art | biology | electronics | energy | IT | mechanics | medicine | microstructures | optics | security | telecommunications | other |

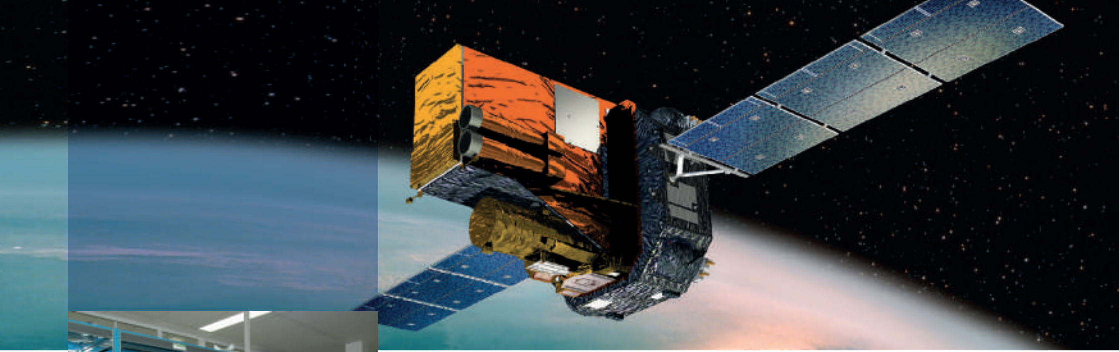
Take the volumes from the library shelves as if it were your own home library. Enter and leave freely, without filling out forms for loans or returns. With the speed and naturalness with which you cross a Telepass passage on the highway. And whenever necessary, update the entire inventory with the push of a button. A priceless convenience, a considerable saving in terms of time and costs. Especially in contexts such as academia and research, in which the speed of access to publications is crucial. Thanks to RFID technology, the library of the future is already a reality. Once the RFID readers are positioned on the shelves or reading stations, every time a book is consulted or stored, the position is automatically recorded and stored in the central database.

Compared to commonly used technologies, the system developed by INAF makes it possible to locate, track, make an automatic inventory and prepare automated stations for book loans or returns. Among the characteristics that distinguish it, in particular when compared with systems based on bar codes, the robustness and reliability of reading stand out, with a consequent increase in the efficiency of resource management.

The automated library management project based on RFID technology comes from research in radio astronomy and millimetric technologies of Inaf-Oas Bologna, and was developed in collaboration with Raptech Srl. (Rome).

In one number

2 meters: the reading distance that the gate can reach.



Integral's Italian brain
turns to bioinformatics

AVES - Scientific computing cluster dedicated to Integral

| aerospace | environment | automation | art | biology | electronics | energy | IT |
| mechanics | medicine | microstructures | optics | security | telecommunications | other |

For their silicon neurons, galaxies and molecules are even: whether running in the depths of huge databases or starting 3D models of complex interactions, its modular architecture is what it takes. Developed at Innaf-Iaps Rome to analyze data from the ESA high-energy Integral satellite, AVES is an innovative calculation system, of low cost and easily exportable to other applications.

AVES was designed and built at the INAF-IAPS Rome for the ESA Integral satellite. CNR's "Antonio Ruberti" Institute of Information Systems Analysis of Rome also took part in the development of the software.

Based on a cluster-type architecture, the AVES hardware currently consists of 34 commercial PCs. Thanks to its modular architecture, however, the system is easily expandable up to 120 knots, thus arriving at about 1.5 power teraflops, 1900 terabytes of storage and 480 gigabytes of fast ram: the ideal brain for managing fast databases or for architectural, industrial and scientific rendering. But also for 3D modeling in the medical and bioinformatics field, or for the study of molecular interactions through molecular dynamics and docking techniques. The interface software, developed ad hoc, performs an adaptation to the parallel calculation, thus increasing the speed of execution of programs that could not otherwise be recompiled on parallel architectures.

In one number

70: the factor for increasing the calculation speed for the OSA analysis software compared to the systems that are currently in use.

The format to preserve the past comes from the stars

Digitization of ancient books and manuscripts preserved in the Vatican Apostolic Library

| aerospace | environment | automation | art | biology | electronics | energy | IT | mechanics | medicine | microstructures | optics | security | telecommunications | other |

Ancient manuscripts and images of stars and galaxies, secular books and radio signals from the depths of the Universe. Space and cultural heritage now have one thing in common: the next generations of scholars and enthusiasts will be able to study them starting from the same digital format. The Vatican Apostolic Library, which owns one of the most important collections of ancient books and manuscripts in the world, began a study project in 2011 relating to the digitization in FITS format, so far used almost exclusively in the space field, of all the oldest manuscripts preserved in the Library. The FITS has passed all the tests and has been chosen for its characteristics of longevity, reliability, quality and because it is completely devoid of royalty.

Before starting, a long phase of study and experimentation was necessary, due to the unique and innovative characteristics of the project and to enrich the FITS standard and better adapt it to the bibliographic needs. Currently, the project is operational and the digitization of about 20% of the manuscripts has been completed, with the possibility of carrying out automatic searches. This opens up to the scientific and academic world possibilities of study never before explored, and offering everyone a view of these masterpieces.

INAF astronomers have collaborated with the BAV in this long phase of study and made an interface to the institutions that manage the FITS, i.e. the IAU and NASA. In the archiving project, the INAF IAPS of Rome and the INAF 'OA Trieste are involved.

In one number

42 x 100: The digitized data in FITS will occupy over 40 petabytes of space and its legibility will be guaranteed for at least 100 years, an eternity in the fast-paced world of computing where everything changes in a very short time.

Space training
for satellites

Plasma Chamber S.W.I.P.S. - Space plasma simulator

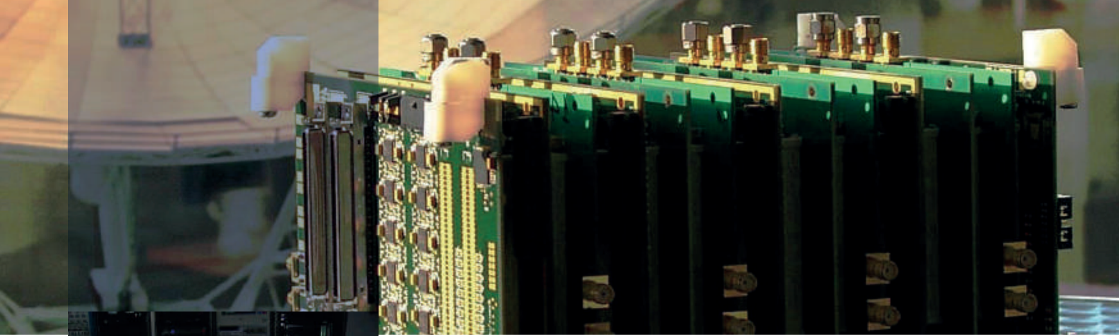
| aerospace | environment | automation | art | biology | electronics | energy | IT |
| mechanics | medicine | microstructures | optics | security | telecommunications | other |

Sending tools and devices in orbit is expensive. It is therefore crucial to be able to simulate before the launch how the payload will behave once up there. The S.W.I.P.S (Solar Wind and Ionospheric Plasma Simulator) plasma chamber is able to reproduce the environment experienced by satellites in low orbits (ionosphere) and in outer space (solar wind). This allows the verification of the functioning, the conformity to the project specifications and the compatibility with the plasma of the payloads designed to operate on board satellites. In the ionospheric plasma simulator mode, the plasma has a speed of about 8 km/s, which allows it to simulate the relative motion between the satellite and the ionosphere, while a system of coils controls the magnetic field environment simulating the attitude of the satellite, both for polar and equatorial orbits. The solar wind instead generates a more tenuous and faster plasma flow that reaches speeds of hundreds of km/s. Ambient plasma diagnostic probes measure plasma parameters around the device under test. The plasma parameters are represented in real time, allowing an immediate evaluation of the interactions between the payload and the surrounding space environment.

S.W.I.P.S., created by the INAF IAPS of Rome, is one of the few facilities in the world to allow an accurate simulation of the space environment as evidenced by the numerous space missions hosted for tests and instrumental developments (from NASA's TSS to the Chinese CSES).

In one number

9 m3: the ample useful experimental space of this facility, which allows tests on large-volume payloads and the implementation of complex experimental setups.



The devour-signals

travels at billions of readings per second

DBBC - Processing system for very wide band digital receivers

| aerospace | environment | automation | art | biology | electronics | energy | IT | mechanics | medicine | microstructures | optics | security | telecommunications | other |

Treat the radio signals at very high speeds, converting them directly into the digital domain for subsequent processing in the numerical domain. This is a task for which the Digital Base Band Converter (DBBC), developed by astronomers for interferometric radio astronomy known as VLBI (Very Long Baseline Interferometry), is unrivaled: thanks to state-of-the-art technologies, it manages to "grind" billions of samples per second in real time. This is just enough to be able to replace the radio receiver model existing today, and used for some decades by most of the existing radio telescopes. The possible uses range from the generation, transmission and real-time processing of large amounts of data in digital format to applications in the field of electromedical equipment and telecommunications. The DBBC system provides not only digital conversion, but also possible transmission on standard 10G Ethernet networks and numeric processing. Both the hardware and the firmware part can be composed of discrete elements, thus allowing an ad hoc dimensioning and a consequent cost reduction.

The processing system for digital broadband DBBC receivers has been developed, in the context of interferometric radio astronomy technologies known as VLBI, by Inaf-Ira, in collaboration with HAT-Lab S.r.l., an INAF spin-off.

In one number

In the field of VLBI radio astronomy, DBBC currently has no concurrent system as far as performance and functionality are concerned. In other words: it is unique.

With dancing mirrors,
goodbye to turbulence

LBT672 - Adaptive Secondary Mirrors for the Large Binocular Telescope

| aerospace | environment | automation | art | biology | electronics | energy | IT | mechanics | medicine | microstructures | optics | security | telecommunications | other |

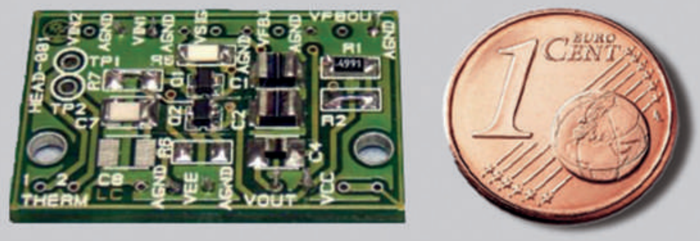
To return images with unparalleled sharpness, they deform, up to a thousand times a second, the curvature of their surface in a smart way. These adaptive mirrors are used to correct, in real time, the distortions of the light signals introduced by the turbulent motion of the atmosphere in which they propagate. In astrophysics, they are used to obtain high definition images from the ground, like in the absence of atmosphere.

INAF - Arcetri Astrophysical Observatory designed adaptive optics systems for the Large Binocular Telescope (Mt. Graham, AZ, USA), in collaboration with Microgate S.r.l. (Bolzano), A.D.S. International S.r.l. (Valmadrera, LC) and the Mirror Lab (Tucson, AZ, USA).

The same technology can be used to transmit encoded data in the light beam, compensating for propagation disturbances and increasing the transmission band. The ability to focus the beam can effectively transmit energy from the Earth to artificial satellites, and build active mirrors for large space telescopes to observe the planet's surface for environmental purposes in detail and efficiency. In the adaptive mirrors designed by INAF, the deformation takes place thanks to hundreds of contactless actuators (coil-magnets). This technology, in addition to being more robust with respect to faults, makes it possible to make mirrors of dimensions and excursion greater than those currently in use. This is the ideal solution for the giant telescopes of the future.

In one number

672: the number of actuators with a 100μm stroke that the LBT672 mirror possesses, compared to the 360 actuators with a 5-10μm stroke of the correcting mirrors currently used for observations at astronomical telescopes.



The microcalorimeter
that comes from the cold

Cryogenic X-ray microcalorimetry

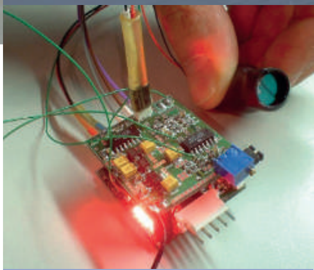
| aerospace | environment | automation | art | biology | electronics | energy | IT | mechanics | medicine | microstructures | optics | security | telecommunications | other |

Just one photon, a microscopic "light particle", is enough to trigger a radical transition in TES sensors: from the state of superconductivity to a "normal" state. This technology is so advanced that no complete system based on these microcalorimeters at the superconducting phase transition has yet been developed. The potential is enormous and varied: the physical analysis of materials, the medical field, the cultural heritage sector or defense. It can be used, for example, to reveal the presence of radioactive nuclei. Compared to the detectors that are already used, the TES sensors stand out for their high spectral resolution, which allows them to perform very high resolution spectroscopy, combined with good imaging capability, rapid response times and very high efficiency. Not surprisingly, these tools have been used in the field of particle physics. Furthermore, having to work at very low temperatures, their use is strongly linked to the development of cryogenic systems. Like the adiabatic demagnetizing cryostat used in our laboratories, capable of reaching temperatures around 0.04 K.

The use of TES in astrophysics for satellite missions is a sector with no precedent, except for rocket flights and the Suzaku mission, where, however, the sensor consisted of semiconductors and non-superconducting materials. The project is linked to the study of missions such as IXO (ESA-NASAJAXA) and SPICA (ESA JAXA), as well as R&D through the ASI and ESA space agencies, and was developed by INAF-IAPS Roma together with Thales Alenia Space (Milan).

In one number

0.0002: the very high spectral resolution (dE / E) of these detectors. This is one of their main strengths, together with the very rapid response time (<100 μs).



Lap record per millisecond with the laser trigger

Optical trigger for car races

| aerospace | environment | automation | art | biology | **electronics** | energy | IT |
| mechanics | medicine | microstructures | optics | security | telecommunications | other |

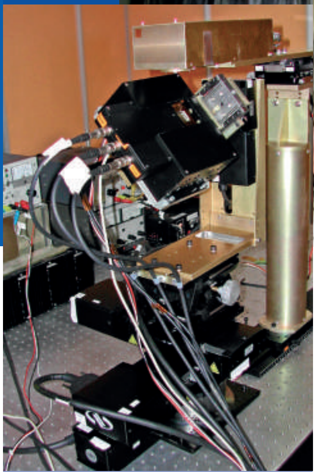
When a millisecond is enough to make the difference between the podium steps, an optical laser trigger is the solution. Currently, a lap trigger in the microwave band is used in sports competitions. However, a system in the optical band makes it possible to determine a time base with greater precision.

For the development of this system,the competences developed for the creation of a "laser range finder" for the closure of the control ring of the active optics system have been exploited. equipped with SRT, the Sardinia Radio Telescope. The design is by the INAF-Astronomical Observatory of Cagliari, in collaboration with Magneti Marelli S.r.l. (Corbetta - Milan) and ART - Advanced Researches & Technologies (Milan).

The transmission system is placed on the track, and consists of a scanning group and an anamorphic afocal lens designed to project a structured laser beam capable of maintaining a constant energy density over distances of up to 100 meters. The reception system is mounted on the car, and records the impulse when the car intersects the laser beam during the race. The time recorded serves as the basis for the time for the telemetry system, which records the data during the competition. Derived from optical systems for telescopes, the optical lap trigger developed by INAF - Cagliari is primarily applied in determining travel times in sports car races. But the laser transmission system can also be used in all areas where 3D scans and measurements are needed.

In one number

A millisecond: the margin of error in determining the lap times of the circuit



Radioactive waste
in the viewfinder of an X-ray camera

SDD - Detectors with technology Silicon Drift Detector

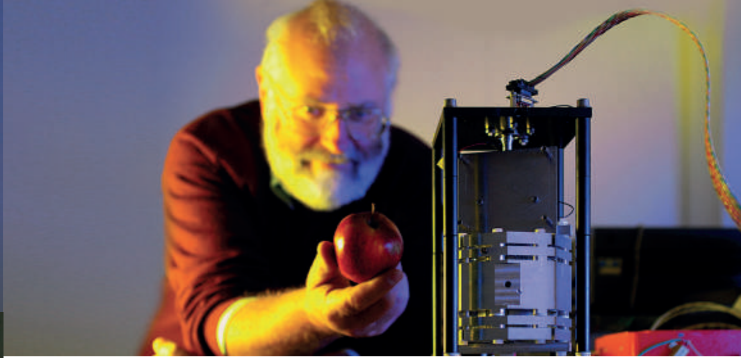
| aerospace | environment | automation | art | biology | electronics | energy | IT |
| mechanics | medicine | microstructures | optics | security | telecommunications | other |

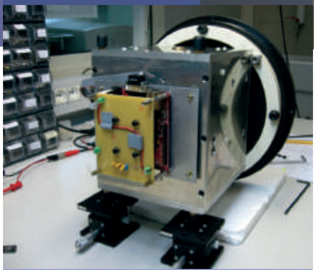
The legendary X-ray glasses of the old comic books have become reality. They don't let you look through walls and clothes, of course, but they are able to produce one-dimensional images of X-ray sources. Spatial sources, such as black holes in distant galaxies, for which these sensors have been developed. But also terrestrial sources, which have little to do with astronomy and much, instead, with our health and our safety. Like the trackers used in medical imaging imaging, for example. Or, in the field of prevention of environmental damage, to signal the presence of radioactive waste, locating it quickly even if hidden among other types of waste. The SDDs (Silicon Drift Detectors) are in fact one-dimensional large surface detectors (about 50 cm2) for X-rays, with good energy resolution (around 250 eV), good spatial resolution (tens of μm) and an extended energy band (2 - 50 keV). Thanks to these features, silicon drift chambers can represent the future of low-energy X-ray sensors.

The INAF Astrophysics High Energy and Related Technologies group, in collaboration with the INFN of Trieste, is engaged in a research and development project within the laboratories of the INAF-IAPS Rome to adapt the drift chambers of silicon to X-ray astrophysics.

In one number

50 cm2: the surface of a Silicon Drift Detector. The sensors that are currently available have instead a surface area of just over one square centimeter.





Earthquake and volcano monitoring
with a space accelerometer

NGS - New Tools for Geophysics

| aerospace | environment | automation | art | biology | electronics | energy | IT |
| mechanics | medicine | microstructures | optics | security | telecommunications | other |

Italy is a country with a high seismic risk, so in recent years the attention to seismological studies related to the monitoring of areas with high seismic risk has been gradually increasing, as well as to the volcanic areas. With the increase in these activities, the demand for new equipment has increased,capable of high sensitivity and of working in the most diverse conditions. The know-how acquired in the space field in the implementation of high sensitivity accelerometers allows us to effectively respond to this request. The adoption of solutions designed for space telescopes makes it possible to create highly sensitive geophysical instruments, able to be used in the most disparate situations: on the ground, in deep wells or on board vehicles in general. Not only: designed to work in extreme environments, such as a satellite in orbit around Mercury, the space-derived accelerometers behave very well even in adverse conditions. Another field of application for these instruments is the search for natural resources, such as gas and oil, with measurements carried out both on land and at sea.

The geophysical instrumentation developed at INAF-IFSI Rome, in collaboration with AGI (Assist in Gravitation and Instrumentation), comes from space projects such as ISA (Italian Spring Accelerometer), the high sensitivity accelerometer for ESA's BepiColombo mission, directed towards Mercury, and GReAT (General Relativity Accuracy Test), an experiment to verify the principle of equivalence.

In one number

10-10 g over square-root of Hertz: the sensitivity that these tools can achieve.

The energy of the Sun
in the mirror of a telescope

Optics
for photovoltaic concentrators

|aerospace|environment|automation|art|biology|electronics|energy|IT|
|mechanics|medicine|microstructures|optics|security|telecommunications|other|

Designed to collect as much light as possible from very weak sources, such as stars and remote galaxies, the optical technologies derived from astronomy have great potential even in the energy field. With an ad hoc mirror, for example, it is possible to concentrate the light coming from the Sun on a photovoltaic panel, increasing its yield. And it is precisely concentration photovoltaics, and in particular the design and construction of economic reflection and refraction concentrators, the goal of a study conducted by INAF-Cagliari. The prototype realized as a prototype is a real telescope: it has a parabolic primary mirror in aluminum, 300 mm in diameter, an elliptical secondary mirror, and a third optical component capable of recovering the rays that arrive within a pointing error +/- 0.25 degrees, thus losing a minimum portion of energy. The main application of solar concentration systems.
obviously the production of electricity from

The project comes from the design and construction of telescopes and optical systems for astronomy and was carried out by INAF-Astronomical Observatory of Cagliari, in collaboration with COSPAL Composites (Bergamo) and POEMA S.r.l. (Cagliari).

renewable sources. But it is not the only one: another potential use concerns the daytime lighting systems of rooms, always taking advantage of solar radiation.

In one number

30%: the photovoltaic concentration in the production of renewable energy. It is about twice that of the current flat photovoltaic panels.

Four-wheel protection
for the Sardinia Radio Telescope

MobLab - Mobile instrumentation
for the search for artificial radio interference

|aerospace|**environment**|automation|art|biology|**electronics**|energy|IT|
|mechanics|medicine|microstructures|optics|**security**|**telecommunications**|other|

The mobile laboratory is designed to protect from interference, due to artificial signals, the frequency bands of the Sardinia Radio Telescope or those allocated to the Radio Astronomy and Space Sciences service in the National Frequency Plan. It is conducted by specialized INAF personnel who carry out radio frequency measurements to protect scientific observations relating to the activity of the Italian Space Agency (telemetry and control of interplanetary probes) within the Deep Space Network. Set up on a Mercedes Sprinter 4x4, MobLab is fully equipped with state-of-the-art electronic equipment. The reception system has a working band between 50 MHz and 40 GHz, and is characterized by a high sensitivity, so as to be able to receive very weak signals. The vehicle is equipped with an innovative telescopic pole, with a maximum height of 11 m, electrically operable both for raising and for azimuth orientation and polarization of the antenna. Finally, a dedicated software performs the function of controlling the movement of the antenna and acquiring the received radio signals (spectra and data files).

The mobile laboratory for radio interference research was created by the INAF Astronomical Observatory of Cagliari and by the GB Barberi workshop in Sesto Calende (VA).

In one number

Up to 10000 times more sensitive than a latest generation LTE cellular receiver.

A scale in space

The CAM microbalance saves the instruments

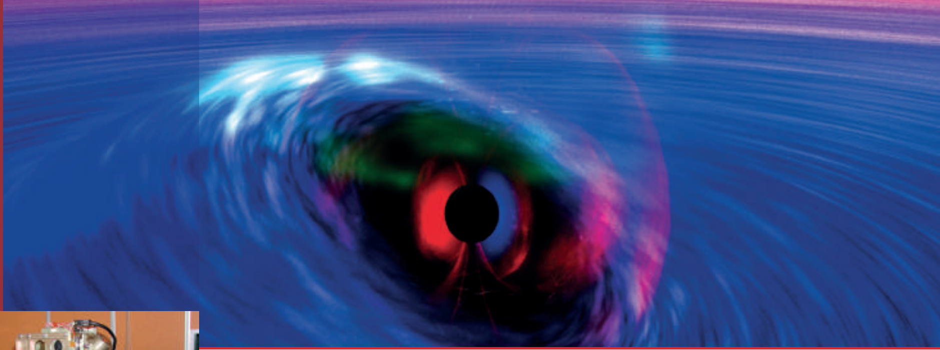
|aerospace|environment|automation|art|biology|electronics|energy|IT|
|mechanics|medicine|microstructures|optics|security|telecommunications|other|

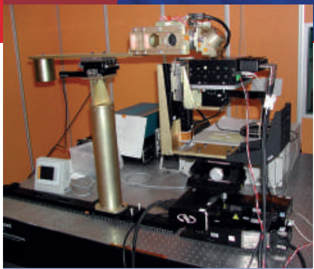
Many people, as soon as they put too much on, resort to light foods, such as yogurt. For expensive space instruments, the situation is even more delicate: just a very small amount of contaminants - less than a millionth of a gram! - to affect its performance. We need a scale that weighs the contaminants. But it must be a space-saving scale, so as not to make the probes too heavy. As big as a jar of yogurt. This is CAM (Contamination Assessment Microbalance): a microbalance capable of measuring mass changes up to the billionth of a gram. An innovative microbalance: like the personal scales that distinguish the lean mass from the fat one, CAM distinguishes the refractory mass (the powders) from the volatile one (the gases), thanks to the presence of an integrated heater. This is useful to understand what is contaminating our probe. But not only: it makes CAM also suitable for studying the surfaces of planetary bodies. Just a little dust from these bodies to understand if there is water or organic materials, or compounds related to the development of life.

The CAM project, financed by ESA, is led by INAF IAPS of Rome, with the collaboration of CNR IIA, Politecnico di Milano and Kayser Italia. The instrument was selected for the ESA MarcoPolo-R mission, won the WIRE 2016 Innovation Award (awarded by ESA ESRIN) and won an award at the StartCup Lazio 2018.

In one number

1 billionth: the minimum mass (in grams) measurable by CAM





A test bench for X-ray instrumentation

FCXP - Facility for calibration with polarized X-rays

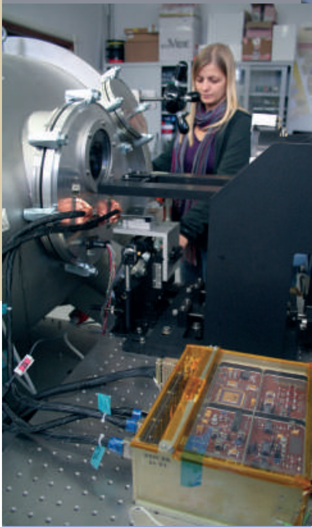
| aerospace | environment | automation | art | biology | electronics | energy | IT |
| mechanics | medicine | microstructures | optics | security | telecommunications | other |

How do we test X-ray tools? FCXP, a facility for calibration with polarized X-rays, provides everything you need. It is a dedicated environment that is fully equipped, in which to calibrate X-ray detectors destined for use on Earth and on satellites, at very high precision and in complete safety. In full compliance with safety regulations, the calibration environment is located in a room completely shielded by a layer of lead. Inside are available medium power X-ray tubes (50 W) with anodes of various materials (for example: titanium, molybdenum, gold and rhodium). The position of the X-ray sources is adjustable thanks to an optical bench with a system of motorized slides, remotely controlled by computer, able to move the detector to be calibrated in two directions in translation (with a precision of a few microns) and on two axes in rotation (with precision higher than an arcsecond). Collimators and diaphragms make it possible to vary the shape of the X-ray beam. The facility also offers the possibility of obtaining beams of emonochromatic polarized X-rays using of Bragg diffraction. The handling system allows you to characterize the system to be calibrated with excellent precision.

The facility was set up by the high energy and related technologies astrophysics group of INAF-IAPS Rome, and is currently used to calibrate X-ray astronomy instruments for space telescopes.

In one number

100%: the polarization level of the X-ray energy beam between 1.6 and 20 keV and mono-chromatic lines with a width of less than 10 eV.



Spectral images
unique in the world

SpIm - Spectral Imaging Facility

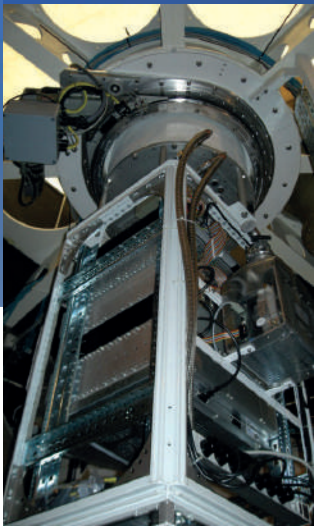
|aerospace|environment|automation|art|biology|electronics|energy|IT|
|mechanics|medicine|microstructures|optics|security|telecommunications|other|

Whether it is a very precious author's canvas or a rare fragment of rock rained down from the sky, if the goal is to analyze its composition in detail, SpImer's eye is unrivaled. First of all, it is the only existing image spectrometer sensitive to wavelengths between 250 and 5000 microns. Its spatial resolution is also record-breaking: thanks to the synchronization system between the sample-holder shifts and the spectral image acquisitions, it is less than 40 microns. No other spectrometer in the world is currently able to obtain images with a similar spectral extension and resolution. Although so precise and powerful, SpIm also knows how to be incredibly delicate. In fact, compared to a normal slit spectrometer, it allows performing non-destructive analyzes: what it takes to study rare or precious fragments. Archaeological finds, works of art or meteorites, for example. But SpIm is the perfect tool also to study in detail geological samples in critical situations, such as lava flows during eruptions. Or by installing the instrumentation on airborne platforms, to create spectral databases useful for monitoring the territory, the atmosphere and environmental assets.

SpIm was financed by ASI; it was designed and built thanks to a collaboration between INAF-IAPS Rome and Selex-Galileo. Spim is able to provide data that, used in synergy with those of similar in-flight spectrometers on different space missions (such as VIR, VIRTIS, VIMS and VIHI), allow us to increase our knowledge of the planets and minor bodies of the Solar System.

In one number

38µm: the spatial resolution of each spectrum acquired by SpIm. Analogous systems, with more limited spectral intervals, have a spatial resolution of about 100 µm.



Low-noise Microwave
with monolithic amplifiers

FARADAY - Focal-plane Arrays for Radio Astronomy, Design Access and Yield

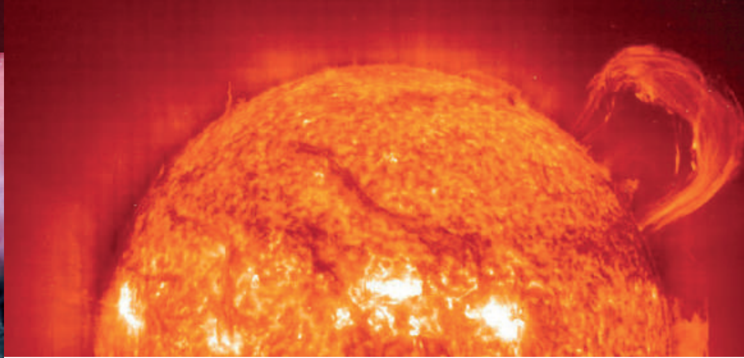
|aerospace|environment|automation|art|biology|electronics|energy|IT|
|mechanics|medicine|microstructures|optics|security|telecommunications|other|

In the microwave field, they are the equivalent of a top-of-the-range Hi-Fi system. Designed for SRT, the Sardinia Radio Telescope, which with its 64-meter diameter dish is about to become the most powerful European radio telescope, the components made by INAF in the field of microwave circuits are truly unique: today, there are no comparable ones on the market. These are components made with MMIC technology (monolithic integrated circuits for microwaves), which allows for the creation of broadband integrated circuits using a single substrate of semiconductor material. To meet the extreme requirements of the Sardinia Radio Telescope, the research focused on achieving the maximum possible performance in terms of low noise and broadband in the microwave field. Performances that could be useful not only to astronomers: amplifiers with these characteristics are in fact able to increase the sensitivity of the microwave and radio wave instruments used in medicine, particularly in the diagnostic field.

The MMIC components were made for surveys in the continuum and spectroscopy at the Sardinia Radio Telescope. In addition to the Institute for Radio Astronomy and the Arcetri Astrophysical Observatory of INAF, the following companies collaborated on the project: NGST (Northrop Grumman Space Technology, USA), Pasquali (Florence), RIAL (Parma) and Milltech (Bologna).

In one number

0.18dB: the noise figure achieved using a 3x2.5mm chip cooled to -250 degrees C with an operating band of 18 to 26.5GHz.



Polarized X-ray glasses
for the check-up of fusion reactors

GPD - Polarimeter
Gas Pixel Detector

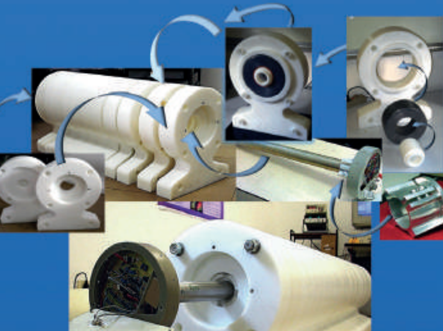
|aerospace|environment|automation|art|biology|electronics|energy|IT|
|mechanics|medicine|microstructures|optics|security|telecommunications|other|

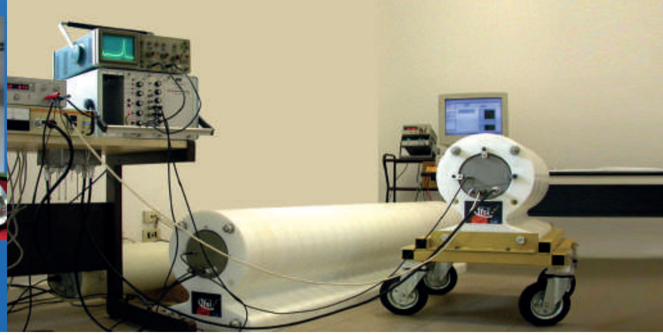
Tokamak devices for nuclear fusion flow in the veins. It is agitated in the magnetic fields of neutrons. High temperature plasma is a mixture of highly ionized gases that is not easy to analyze. One of the most important means of diagnostics for high temperature plasmas, the measurement of X-ray polarization, has in fact remained a largely unexplored field, due to the intrinsic difficulties of the measurement technique and the poor sensitivity of the instruments so far constructed .From the synergy between the INAF-IAPS of Rome and the INFN of Pisa comes a new type of polarimeter for X-rays, based on photo-electric effects, to fill this gap. Called Gas Pixel Detector (GPD), it is an X-ray image tool that allows you to "photograph" the path of hotoelectrons emitted in a gas cell even at low energy (1 - 35 keV) when the track is a few tenths of a millimeter long . The laboratory detectors are extremely compact (14x19x7 cm3) and have very reduced weight (1.6 kg) and consumption (5 W). Furthermore, unlike competing instruments built today around the world, GPD combines high sensitivity to polarization and good spectroscopic capabilities with the possibility of producing an image of the source.

The Gas Pixel Detector Polarimeter was developed by the INAF IAPS of Rome and the INFN of Pisa for the XPOL instrument on board the IXPE mission. It is a dedicated NASA-ASI project that will be launched in 2021.

In one number

> 0.2: the quality factor of the polarimeter. For the first time, the instrument combines good efficiency with excellent sensitivity to polarization.





A kit for hunters of radioactive material

Modular neutron detector for cosmic ray measurements

|aerospace|environment|automation|art|biology|electronics|energy|IT|
|mechanics|medicine|microstructures|optics|security|telecommunications|other|

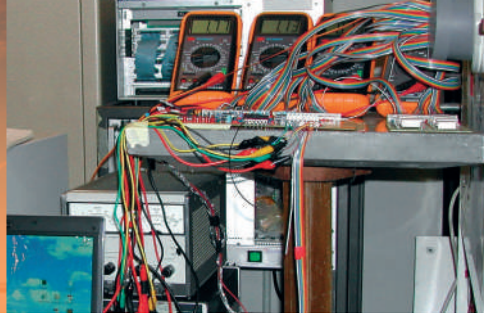
They manage to cover very long distances undisturbed. They are released during a nuclear reaction. And it's not easy to reveal them. They are neutrons, subatomic particles without electric charge. Free neutrons, unlike those present in atomic nuclei, are unstable, and their production occurs during the disintegration of an atomic nucleus. The devices able to intercept them are therefore of enormous interest not only for physicists and astrophysicists, but also for those involved in measuring environmental radiation. Like that produced by radioactive waste, for example.

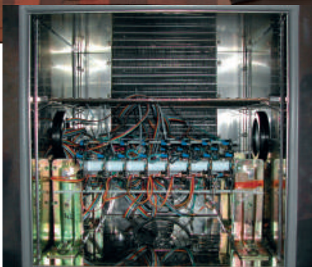
The modular neutron detector was developed by INAF-IFSI Roma as part of experiments for measuring the secondary nucleonic component of cosmic galactic radiation.

The skills acquired in the field of cosmic ray measurements have made it possible for the technical-scientific staff of Innaf-Ifsi Roma to produce different types of neutron detectors, complete with electronic instrumentation, to be used both in permanent observation sites for cosmic rays, both in measurement campaigns outside observers. Precisely for the latter, an innovative detector of easy transport and assembly was created. Thanks to its modular structure, only one operator. able to assemble it, in just two hours, in complete autonomy.

In one number

2 hours: the time required for a single operator for the complete assembly of the detector in its largest configuration (220 cm in length, 800 kg in weight).





A coupon for space.
Fast and low-cost

Burn-in test and extended range thermal compatibility of electronic circuits and instrumentation

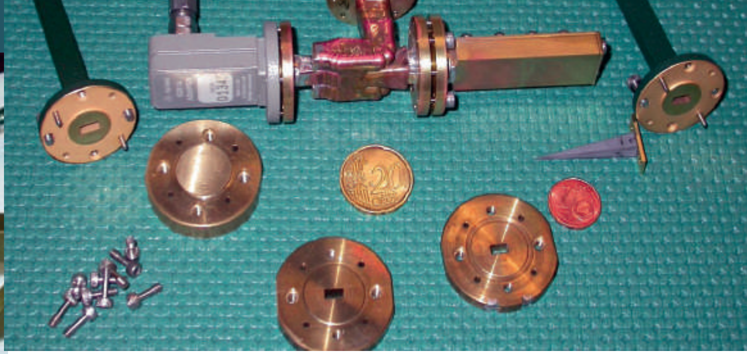
|aerospace|environment|automation|art|biology|**electronics**|energy|IT|mechanics|medicine|microstructures|optics|security|telecommunications|other|

In the jargon, it is called "bath curve", and indicates the trend of the failure rate during the stress tests of the electronic instrumentation: many failures at the beginning, less and less as time passes. Tests such as those of burn-in (with instruments left in operation for long periods in environments with temperatures higher than normal) or of thermal compatibility are indispensable, for example, before sending instruments into space, where any maintenance operation or repair, if not impossible, would be prohibitively expensive. In our laboratories, thanks to the experience gained in the preparation of space emissions, we are able to carry out these tests for any electronic circuit, instrument or material. And we are able to produce the relative quality certification, necessary, for example, to release space qualified products: the temperature range of the thermal tests can in fact be adapted according to the specifications ASI, ESA, NASA and ESO. We are also able to develop all of the interfaces (mechanical, electronic and IT) for the tests themselves.

Experience in these extreme tests has been gained by working with space telescopes (such as SAX and AGILE) and ground-based telescopes (such as VST). The INAF laboratories involved are those of IAPS Roma, OAS Bologna and the Capodimonte Observatory, together with the staff of the central office of INAF (Rome) and the ISC-CNR of Rome.

In one number

Up to 60%: the reduction of costs compared to similar certification processes. The test results are also available in much shorter times. All thanks to the elasticity of the instrumentation and the skills of the Institute's staff.



You need an ear to hear microwaves.
Better if polarized

Development of a prototype of an electroforming polarizer

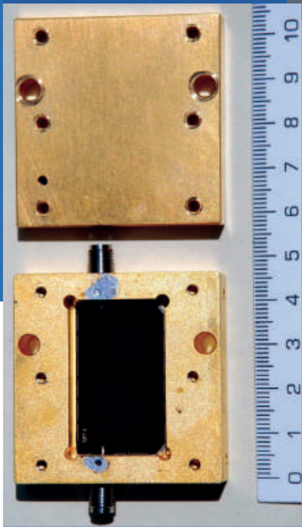
|aerospace|environment|automation|art|biology|electronics|energy|IT|
|mechanics|medicine|microstructures|optics|security|telecommunications|other|

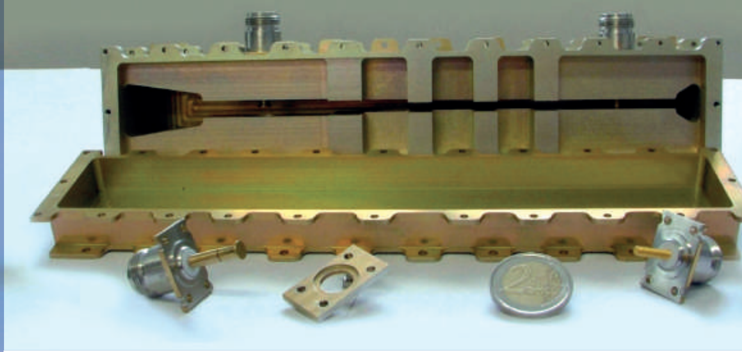
If you ever get your hands on the settings of a satellite receiver, you will have come across a choice between two different "families of channels": vertical and horizontal. Or, sometimes, right-handed and left-handed. They are the polarizing components of the electromagnetic signal, typically a microwave signal: being able to discriminate them allows the same frequencies to be used for pairs of different signals, thus doubling the number of channels. Inalienable source of information for astrophysicists, polarization has therefore many applications also in other sectors: telecommunications, of course, but also radar and remote sensing. The INAF project involves the construction of a 22GHz frequency polarizer prototype using an electroforming process, which allows the manufacture of these passive components at low cost. Seven identical polarizers, replicated precisely by means of the electroforming technique, were integrated into an array of as many receivers, kept at 20K within a cryostat. Electromagnetic tests have showed the expected performance.

The project, implemented by INAF-Astrophysical Observatory of Arcetri (FI) and INAF-OAS Bologna, aims to create a device for the study of the polarization components of celestial sources. This device must be integrated into a 22GHz receiver under development for the Sardinia Radio Telescope.

In one number

50dB: the level of isolation between the polarizations reached by the prototype.





From radio astronomy,
microwave devices for all tastes

Microwave components
for radio astronomy receivers

|aerospace|environment|automation|art|biology|**electronics**|energy|IT|
|mechanics|medicine|microstructures|optics|security|telecommunications|other|

Located in the middle ground between radio and infrared waves, microwaves have endless applications. For cosmologists, they are the ambassadors of the early universe, so much so that satellites are launched into very remote orbits in order to capture them. And all modern radio astronomy antennas have components that can also receive microwaves. But equally varied is their use outside of research: in commercial telecommunications systems and space applications, for example, or in systems of measurement and control in the food sector, or in the systems of surveying the territory and the environment. At INAF, the research and development of active and passive receiving components and systems is a continuous process: to obtain ever better performance in terms of noise figure, gain and insertion losses. Another parameter that we seek to innovate is integration, trying to bring together as many components as possible on a single device.

The research and development project of microwave components is carried out above all by the INAF locations that involve radio astronomy. In particular, from the Astronomical Observatory of Cagliari, from the Institute of Radio Astronomy and from the Astrophysical Observatory of Arcetri, in collaboration with Termomeccanica S.r.l. (Cagliari), Pasquali (Florence) and Milltech (Bologna).

In one number

Few Kelvin: the order of the noise figures of our devices.

Three-dimensional sub-micrometric metrology with "Number 5"

An interferometer for 3D measurements of microstructures

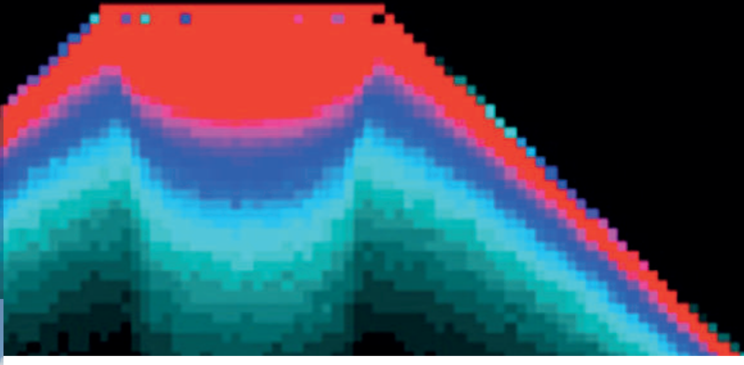
| aerospace | environment | automation | art | biology | electronics | energy | IT |
| mechanics | medicine | microstructures | optics | security | telecommunications | other |

Thanks to the use of a technique known as "low coherence interferometry", the National Institute of Astrophysics has developed a three-dimensional measurement system for microstructures with sub-micrometric accuracy. It is capable of achieving breathtaking precision: 0.1 micrometers, or just one ten thousandth of a millimeter. The instrument was named "Number 5" because of its resemblance to the robot of "Short Circuit", a popular science fiction film of 1988. Developed to operate the metrology of microwave antennas for the Planck mission of the European Space Agency, "Number 5 "Found many other applications outside astrophysics. Among these are the measures in the artistic field, for the three-dimensional monitoring of canvases and statues, and the forensic field, for the recognition of frauds in the making of holograms and for calligraphic expertise. The system is in fact able to measure the ink thickness of the written characters, even with laser printers. The instrument won a Start-Cup, a prize for spin-off activities, at the University of Padua.

The system was developed by INAF Padova for the metrology of microwave antennas within the Planck space project. The interest shown immediately by the community that deals with artistic diagnostics led to collaborations with ART-TEST sas (Florence), Uffizi Museum (Florence), where it was used on Caravaggio's Bacchus, and the Opificio delle Pietre dure (Florence).

In one number

0.1 micrometers: the accuracy with which "Number 5" is able to measure three-dimensional structures up to 3 mm deep.



Cherenkov camera
for CT scans of volcanoes

Non-invasive inspection with muonic imaging

|aerospace|environment|automation|geology|biology|electronics|energy|IT|
|archeology|medicine|volcanology|optics|security|telecommunications|other|

This technique is used in astrophysics in the Cherenkov telescope "ASTRI", but it also lends itself to the detection and spatial localization of muons in solid bodies through the Cherenkov light emitted by these particles along their path. In particular, the camera is able to detect the light emitted by muons, highly penetrating particles generated in the Earth's atmosphere, to obtain information on the distribution of densities within geological structures with a mechanism similar to that of X-ray radiography. Since muons lose energy as they pass through matter, there is a reduction in the flow that depends on the thickness and density of the material crossed. Therefore, by measuring the absorption of these particles in the massive structure, it is possible to trace the density distribution inside it (density structure), recognizing voids and/or areas with anomalous characteristics. In the case of volcanoes, for example, information can be obtained with an unprecedented detail of the geometrical characteristics of the ducts and surface accumulation zones, improving forecasts on the volcano's state of activity and consequently mitigating the risk linked to the occurrence of paroxysmal events .

The INAF locations involved in the project are: IASF-Palermo, for decades of experience in the design and construction of photo-rooms, and the Brera Astronomical Observatory, for experience in the design and production of optics.

In one number

12: the reduction factor of the observation time for the resolution of a structure within a massive solid body with respect to conventional techniques.

Science fiction glasses

Optoelectronic device for augmented reality applications

|aerospace|environment|automation|art|biology|electronics|energy|IT|mechanics|medicine|microstructures|optics|security|telecommunications|other|

They are special glasses for augmented reality, similar to the head-up displays applied in aeronautics and more recently in the automotive field. Wearing them, the view of the surrounding environment is enriched by information superimposed, such as the GPS coordinates of the position in which you are located, directions, SMS and various notifications. All this information is transmitted from another device - typically the smartphone - via Bluetooth. These are devices designed especially for industrial and medical applications: they can project information on the operation of a device, for example, or the procedures that the technical user must follow, or even vital parameters during a surgical operation. A fundamental element is the holographic lens, able to reflect only the images to be projected and be transparent - like a common lens - in all other cases. A bit like what happens in the hologram room on the Star Trek Enterprise.

For the development of the holographic lens the INAF location of Brera was involved, which has years of expertise in the holographic field, both related to the design of the optical element and of the holographic material, of another level and which have been used both for the realization of dispersant systems for astronomy both for optical applications, as in this case. The project (with the potential patent) involved the company GlassUp S.r.l., a Modena start-up that led the development of the wearable device.

In one number

5 inches: the size of the virtual smartphone that you can see through the holographic lens with an area of 2 cm.

Liquid crystals
to filter light

Electro-optical polarimeters for fast and wide spectral band applications

|Astrophysics|environment|material physics|art|biology|mechanics|chemistry|microstructures|control of industrial processes|medicine|security|microscopy|other|

Polarimetry is a technique that allows information to be obtained on the physical processes underlying the generation of the observed electromagnetic radiation. For this reason it is widely used in astrophysics. Hence the need to create devices that allow for ever greater spatial and temporal resolutions. The first step in this direction is the use of polarimeters which, instead of using delay blades with mechanically rotated birefringent crystals, use liquid crystals that introduce an "equivalent rotation" dependent on an electric field applied to the cells. This implies a transition time between states of the order of milliseconds instead of seconds. The liquid crystal polarimeters, besides being much faster than the traditional ones, allow the design of more compact and light instruments with less risk of failures, having no moving parts. Furthermore, even when operating at low voltages, they are ideal for space applications. However, commercial devices are highly dependent on field of view, wavelength and temperature. The patented device allows, using two or more liquid crystals of different types and thicknesses and with different dispersion laws to have a homogeneous response in large spectral bands, and large fields of view.

This polarimeter was developed by INAF of Turin in collaboration with the Instituto Nacional de T.cnica Aeroespacial - INTA- of Madrid.

In one number

100 milliseconds: the time required to change the polarization state.

INAF

THE TECHNOLOGIES OF THE FUTURE
FROM THE LARGEST OF LABORATORIES: THE UNIVERSE

INAF

ISTITUTO NAZIONALE DI ASTROFISICA

NATIONAL INSTITUTE FOR ASTROPHYSICS

Volume created in September 2018 by the Presidency,
the Scientific Directorate and the INAF Communication Department

Image credits: INAF, R. Cerisola, ESO, ESA/Hubble, NASA, Robert J. Vanderbei, Subaru Telescope (NAOJ), Hubble Legacy Archive, R. Gendler, IDA, R. Gendler, J.-E. Ovaldsen, NASA, VLA/NRAO/AUI/NSF, CXC, JPL-Caltech, STScI, Popular Mechanics, Large Binocular Telescope Observatory, JIVE, P. Boven, RadioASTRON, RAS, FSA, Ska Organisation, CTA Observatory, Gabriel Pérez-Diaz, IAC, TU Delft

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