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Italian National Institute for Nuclear Physics

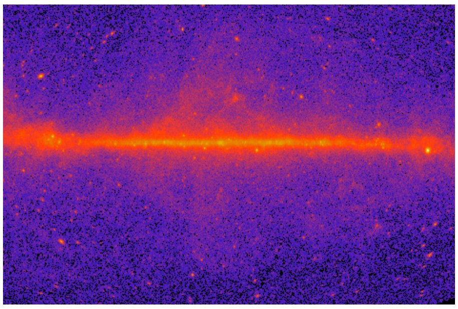
NEWS

PEOPLE
FAREWELL TO ROBERTO PETRONZIO

Roberto Petronzio, an outstanding theoretical physicist, Professor at the Tor Vergata University in Rome and President of the Italian Institute for Nuclear Physics (INFN) from 2004 until 2011, has died. As President of the INFN, Mr. Petronzio played a key role at a very delicate moment for the research agency. During a difficult period of reform, he succeeded in safeguarding our independence, autonomy and system of governance, characteristics which make the INFN unique in Italy and a centre of excellence that is recognised worldwide. Convinced of the need for a major international project to give new impetus to research in Italy and attract resources and talented young scientists from abroad, in recent years Mr. Petronzio was wholeheartedly committed to the SuperB project to build a new particle accelerator in the Italian region of Lazio. This project of great scientific importance was, however, unable to go ahead in Italy and is now being implemented in Japan using the original project design developed at the INFN's Frascati National aboratory. A physicist of international repute, Mr. Petronzio collaborated with CERN in Geneva, the Ecole Normale Supérieure in Paris, the Max Planck Institute in Munich and Boston University. His scientific activity mainly concerned the fundamental principles and development of perturbative quantum chromodynamics, constraints on the value of the Higg's mass, unified theories and physics signals beyond the Standard Model. He, along with Nicola Cabibbo, made a fundamental contribution to developing the INFN’s APE super-calculators project. He published more than 190 scientific works and has been cited over 11 thousand times.■

JOB POSITIONS
THE INFN ANNOUNCES 73 RESEARCH POSITIONS

A favourable opportunity for the recruitment system and an important message, for young researchers in Italy and abroad, that the world of national research is re-opening to new resources. This is represented by the over seventy research positions announced by the INFN, on the basis of what is provided for in the 2016 Stability Budget law signed by decree by the Minister of Education, University and Research (MIUR), Stefania Giannini. There will be exactly 73 positions, theoretical or experimental, which will be dealing with basic and applied research: from the LHC to neutrinos, from dark matter to applications in medicine, from computing to technologies for cultural heritage.
The Decree provides for a total of 215 research positions in Public Research Institutes supervised by MIUR, one third of which is reserved for INFN, with a special funding total of 8 million euro for 2016 and 9.5 million for 2017.
The funds allocated for the permanent contract employment of researchers shall be invested primarily for the entry of young scientiest with a high scientific profile and recruitment procedures will terminate by 31st December 2016. ■



RESEARCH
20,000 NEW SOURCES OF GAMMA RAYS DISCOVERED IN THE SKY

About 20,000 new sources of gamma rays were discovered by analysing, with a new statistical technique, six years of data collected by the Large Area Telescope (LAT), the detector for high and very high energy gamma rays, aboard the NASA's Fermi space telescope, in which Italy participates with the INFN, the Italian Space Agency (ASI) and the National Institute of Astrophysics (INAF). The study, published on the Astrophysical Journal Supplements (ApJS), uses an advanced analysis technique to identify the presence of very weak sources in the sky, because it allows to detect populations of sources rather than individual bright sources. It was therefore possible to infer the presence of a large number of sources, the existence of which we were unaware of up to now. This result is of the utmost importance for the understanding of the extreme universe's composition and properties. Furthermore, since even dark matter is expected to produce gamma radiation, a second study shows how the distribution of weak sources changes with the energy of the radiation that reaches us. This new analysis will help identify the nature of these sources and gain further depth in their understanding: this will remove, to an unprecedented level, the major background noise that might be concealing dark matter's long sought and very weak signal.■

CULTURAL HERITAGE
NEW TECHNIQUE FOR THE STUDY OF ANCIENT EGYPTIAN PAINTING

A new non invasive scientific technique, called macro scan X-ray fluorescence (Ma-XRF), was used for the first time to study artefacts belonging to an ancient Egyptian funerary set from the collection of the Egyptian Museum of Torino. The technique was developed by researchers of the LANDIS laboratory of the INFN, a node of the CHNet, the network for the study of cultural heritage of the INFN and IBAM-CNR, both of which are involved in the activities of E-RIHS, the European Research Infrastructures for Heritage Science of which Italy is the leader.

The Ma-XRF è was used on some painted wooden caskets found in the tomb of Kha, the Pharaoh's architect during the XVIII dynasty (1420-1351 BC). This is a non-invasive scanning technique that allows the acquisition of a chemical mapping of the analysed artefact without damaging it and thus providing important indications on raw materials, painting technique and state of conservation. The scanner, entirely designed and developed at LANDIS, allows the acquisition of high resolution images of chemical elements on painted surfaces and is currently the only one capable of working on large surfaces (105x70 cm), at a high speed (up to 200 mm/sec) and with a spatial resolution of up to 30 microns (equal to 30 hundredths of a millimetre). The analysis falls within a multidisciplinary project that also involves researchers from the Institute for physical chemical processes (IPCF) of Messina, from the Fermi Center, from the Soprintendenza Archeologica of Piedmont and the Università degli Studi of Milano-Bicocca and Roma Tor Vergata. ■

» THE INTERVIEW

THE DISCOVERY OF GRAVITATIONAL WAVES OPENS A NEW WINDOW ON MULTIMESSENGER ASTRONOMY.

Interview with Marco Pallavicini, professor at the University of Genoa and researcher of the Genoa section of the INFN, head of the astro-particle physics committee at INFN.

The two gravitational waves events detected by the LIGO and VIRGO international collaborations in September and December 2015, and respectively announced in February and June this year, not only represent a milestone in the history of the astronomical exploration of the universe, but also unexpectedly reveal a very active Universe in which black hole binary systems are more numerous than we thought. The recent development of new detectors and experimental methods had already allowed multimessenger astronomy - engaged in the coordinated detection of electromagnetic signals, cosmic rays, gamma rays and high energy neutrinos - to observe the universe in its variety and to integrate the results achieved in particle physics, theoretical physics and astronomy within a closely as possible unified framework. Gravitational astronomy, kicked off by the recent discovery of the first gravitational waves, not only adds a piece to this framework, but literally breaks through a barrier in the exploration of the most violent phenomena in the universe. And with the recent success of the LISA Pathfinder (Laser Interferometer Space Antenna Pathfinder) mission, whose goal was to test the technological feasibility of a space observatory for gravitational waves, the future of gravitational astronomy is already evolving. We asked Marco Pallavicini, head of the astroparticle physics committee at INFN, what will the next steps be for this new frontier of multi messenger astronomy.

The first detection of gravitational waves in history has given way to a new field of investigation called gravitational astronomy. We will be able to observe the universe under a new "light"?
It would be more correct to say that we reveal something that we had not ears to "hear". Gravitational waves are generated by physical phenomena that are profoundly different from those that emit photons, cosmic rays or neutrinos - particles with which we have studied the cosmos up to now. Electromagnetic radiation and particle messengers mainly provide information on the presence of cosmic sources and on the transformations of matter within them: changes that involve precisely the

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emission of radiation and particles. Gravitational waves, instead, provide information on the dynamics of masses in motion, that would otherwise not be observable Those observed by LIGO-VIRGO in particular were emitted during the collision of two black holes in orbit around each other, but in general it is the large masses in quick motion or collapse that emit gravitational waves. These are phenomena that can be studied only through this new "window" on the cosmos.

So the more traditional observation tools in the field of astronomy and astroparticles maintain their full validity but can now count on a new level of information.
The study of gravitational waves will teach us many things, especially on black holes and neutron stars, but perhaps we will learn even more from the joint observation of gravitational waves with other traditional sources. The primary one is certainly electromagnetic radiation, i.e. photons, matter of observation for telescopes in traditional astronomy, but also cosmic rays, caught today by experiments distributed on the surface of the earth or in orbit outside the Earth's atmosphere aboard satellites, and neutrinos, on which the experiments made in the abysses or under the ice of the Antarctic are more recently focusing. Gravitational waves complete and enrich the means available to better understand the universe.
Difficult to say today what we expect to observe in the composition of this puzzle. We will very probably gain new information on black holes, on neutron stars and on gravity in the presence of very intense gravitational fields. However, when you open a new way it is difficult to make predictions. The only easy prediction is that there will be many surprises.

Will the recent success of the LISA PATHFINDER mission further extend the future possibilities of gravitational astronomy?
LISA-PF has proved in a spectacular way that the detection of gravitational waves with a space interferometer in the near future will be possible. The future instrument eLISA will observe waves of a much lower frequency than those measurable by LIGO-VIRGO. This will open up new opportunities in physics, such as the observation of collisions of nuclei of galaxies or the measurement of very distant events in the cosmos and, at the same time, it will allow the observation of the signals, already observed with LIGO-VIRGO, hours or perhaps even days in advance, opening the way for largely more accurate and refined measures. In this way, in addition to detecting signals that would otherwise be undetectable, eLISA could work as a pre-alert for the detectors on the ground and on the satellites in orbit around the Earth, allowing them to prepare the field of revelation of the same event or signals connected to it.

What are the most promising outlooks and future developments of multimessenger observation? And what are the most prominent projects for the INFN?
The INFN is engaged in many experiments of "multi-messenger" observation of the Universe from

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Earth, from space, in underground laboratories and in the depths of the sea. We have instruments or we participate in other projects for the observation of different cosmic messengers, among which: low energy neutrinos, in the Gran Sasso National Laboratories; high energy neutrinos, with experiments in the abysses such as in the KM3NeT underwater observatory off the coast of Portopalo di Capo Passero; high energy photons (from GeV to PeV), with the large gamma ray telescopes such as Magic on the Canary Islands and the international CTA project; charged cosmic rays, reveald in their secondary showers by extended detectors on the terrestrial surface like the Auger in the Argentinian Pampa and in their primary composition by detectors placed outside the Earth's atmosphere, on the International Space Station, like Ams, or on satellites, like Pamela and Fermi; and, finally, gravitational waves, with VIRGO. The joint information of these instruments, and obtained through and others in many laboratories around the world, will provide a new way to study supernovae, neutron stars and black holes. And most importantly, they will tell us things that we cannot even imagine now, because this is what has always happened when fundamentally new technologies are acquired. ■

FOCUS

EXTREME, PARTICLES ON DISPLAY

It is the first permanent exhibition, in Italy, dedicated to the physics of the infinitely small. *"Extreme, in search of particles"* was inaugurated on 12th July at the Leonardo Da Vinci Museum of Science and Technology (MUST) of Milan, in the presence of Prime Minister Matteo Renzi and of the Minister of Education, University and Research, Stefania Giannini, of the Director of the MUST, Fiorenzo Galli, of the General Director of CERN, Fabiola Gianotti, and of the President of INFN, Fernando Ferroni. A project which was conceived and borne thanks to the collaboration between the three MUST, INFN and CERN institutions, *Extreme* introduces its visitors to a research area that can boast a long and prestigious tradition, and which in recent years has gained an ever increasing attention, thanks to important scientific achievements, such as the Nobel discovery of the Higgs boson. *Extreme* reveals what happens inside the CERN and INFN laboratories. The exhibition space, that extends for a total of about 350 m^2, composed by a main gallery, which fascinates for the exhibited large objects coming from the experiments, and by the side halls with insights on some of the base concepts of these studies. As a matter of fact, the exhibition path alternates objects of great historical and scientific value, with multimedia and interactive installations, and with textual and oral narration spoken also through the voices of the researches' main players. The narration starts off from the concept of track, as an element that allows the recognition and reconstruction of an event that cannot be observed directly: a fundamental element in particle physics. The path continues with the instruments used by physicists to find tracks of particles, the detectors, and those used to produce them, the accelerators: an area of activity in which the LHC is the key player. Three different interactive installations introduce then the status quo of our current knowledge of particle physics, and some of the most interesting theoretical hypotheses awaiting an experimental verification, such as the existence of dark matter and extra-dimensions. An installation curated by the INFN is dedicated to the latter theme in particular: visitors can go for a virtual dip into other dimensions, which, according

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to physicists, could be surrounding the three-dimensional space we live in. The narration also puts a special focus on the places and the people in research - specialists like physicists, engineers and technicians - describing their daily life inside the labs, and eventually showing some examples of the most important ramifications of these researches in other areas. A visit to *Extreme* puts the visitor in a position of both awe and concreteness at the same time while approaching the world of research on the infinitely small and the achievements of those who work in the field. ■

ISTITUTO NAZIONALE DI FISICA NUCLEARE

REDAZIONE
Coordinamento: Francesca Scianitti
Progetto e contenuti:
Eleonora Cossi, Francesca Scianitti, Antonella Varaschin
Grafica: Francesca Cuicchio

CONTATTI
Ufficio Comunicazione INFN
comunicazione@presid.infn.it
+ 39 06 6868162