



NEWSLETTER 19

Italian National Institute for Nuclear Physics

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**INSTITUTIONS****FABIOLA GIANOTTI TAKES OFFICE
AS DIRECTOR GENERAL OF CERN**

On 1 January 2016, Fabiola Gianotti officially took office as Director General of CERN, the first woman to hold this position at the European laboratory for particle physics in its more than 60 years of history. Born in Rome in 1962, Fabiola Gianotti studied Physics at the University of Milan, where she received her PhD in subnuclear experimental physics and was later a research fellow at INFN. At CERN she worked in the Physics Department and, from 2009 to 2013, she was international coordinator of ATLAS, one of the main LHC accelerator experiments. Precisely as coordinator of the ATLAS experiment, on 4 July 2012 Fabiola Gianotti announced the discovery of the Higgs boson, awarded the following year with the Nobel Prize for Physics to the theorists who first postulated the existence of this particle. In addition to the important research objectives that will engage the largest particle accelerator in the world over the next few years, including the search for new physics beyond the current Standard Model of elementary particles and the study of dark matter, among the priorities announced by the new Director General are the training of young people, technological innovation and the peaceful collaboration of thousands of scientists worldwide. ■


RESEARCH
FROM THE SEAS OF SARDINIA THE ROMAN LEAD FOR THE GRAN SASSO LABORATORIES

After two thousand years spent under the sea, in the hold of a Roman ship which sank off the coast of Sardinia, 30 lead ingots of ancient Rome were transported in mid-January from Cagliari to the Gran Sasso National Laboratories (LNGS) of INFN, where they joined the 120 ingots arrived in 2010. The recovery and transportation of this cargo is part of the “Roman Lead” project for the CUORE (*Cryogenic Underground Observatory for Rare Events*) experiment, at the Gran Sasso Laboratories. The goal of the experiment is to study the double beta decay without neutrino emission, a rare physical phenomenon that, if revealed, would confirm the assumption made in the ‘30s by the physicist from Catania, Ettore Majorana, that neutrinos and antineutrinos are manifestations of the same particle. This phenomenon may have been frequent in the primordial universe immediately after the Big Bang, and have determined the prevalence of matter over antimatter. The importance of the scientific, as well as archaeological, value of the Roman lead, lies in the need to shield apparatuses for the detection of rare events, like CUORE, from contamination by ambient radioactivity. While the modern lead contains weak radioactive contamination, the Roman lead, having been produced two thousand years ago, no longer contains radioactive isotopes and is therefore an important contribution to the sensitivity of the experiments. CUORE is the result of the international cooperation of 157 scientists from 30 institutions in Italy, USA, China, Spain and France.

The consignment of the ingots, celebrated at the National Archaeological Museum in Cagliari, is the result of an agreement between INFN, which funded the excavation works of the wreck and recovery of its cargo, and the Sardinia Archaeology Authority, with the approval of the Ministry of the Cultural Heritage and Activities and of Tourism (MIBACT). ■



RESEARCH

RECORD EMISSION FOR THE CRAB PULSAR

It is the most energetic emission ever observed so far from the pulsar in the centre of the Crab nebula, in the Taurus constellation, approx. 6,000 light-years away from us. Discovering this pulsed radiation flux of energy over one thousand billion times that associated with the radiation in visible light, was the international team of MAGIC, the observatory consisting of two of the largest gamma ray telescopes in the world, situated on the island of La Palma in the Canary Islands, with the participation, for Italy, of INFN and INAF (National Institute for Astrophysics).

Newly formed as the nebula of the same name, both remnants of a supernova which exploded around the year 1054, the Crab pulsar rotates 30 times per second around its axis and is surrounded by an extremely intense magnetic field, emitting an intense pulsed signal up to the highest frequencies (X-rays and gamma rays). Until now it was thought that at the highest energies, this pulsed emission no longer took place. But the MAGIC observations, which lasted more than 300 hours in total between October 2007 and April 2014, have shown us a completely new view of the Crab pulsar in the gamma rays spectrum.

The discovery was published in the article *Teraelectronvolt pulsed emission from the Crab Pulsar detected by MAGIC*, on the journal *Astronomy&Astrophysics*. ■



AWARDS

CHINA AWARDS RUBBIA WITH THE MOST IMPORTANT SCIENTIFIC RECOGNITION OF THE COUNTRY

The physicist Carlo Rubbia has been awarded the Prize for International Scientific Cooperation of the Peoples Republic of China. Rubbia, who was awarded the Nobel Prize for Physics in 1984, and who since 2013 is a life senator, received the award in a ceremony that took place in Beijing on 8 January 2016. The prestigious award recognises “the important contribution of Professor Rubbia to scientific progress in the field of particle physics in China” and was given by President Xi Jinping and Premier Li Keqiang. The Prize for International Scientific and Technological Cooperation went to 7 non-Chinese scientists including, in addition to Carlo Rubbia, the Swede chemist Jan-Christer Janson, the Japanese research policy expert Kazuki Okimura, the Russian physicist Evgeny Velikhov, the Americans Peter J. Stang, chemist, and Walter Ian Lipkin, epidemiologist, and the Dutchman medical doctor Joannes Frencken. ■

» INTERVIEW

**ITALY-USA COOPERATION
FOR RESEARCH IN
FUNDAMENTAL PHYSICS**

*Interview with Stefano Lami,
Scientific Advisor at the Italian Embassy
in Washington*

In mid-January, in the presence of the Minister of Education, University and Research, Stefania Giannini, and the US Ambassador to Italy, John Phillips, the Italy-USA bilateral meeting for scientific and technological cooperation took place. At the end of the meeting, which was held at the Ministry of Foreign Affairs and International Cooperation, the new joint declaration on scientific and technological cooperation, for the two-year period 2016-2017, was signed by the representatives of the Italian and US delegations. In particular, the Ministry of Education University and Research (MIUR) and the US Department of Energy (DOE) signed a technical cooperation agreement in the field of nuclear physics, concerning the research activities carried out jointly by INFN and DOE. The agreement is linked to the more general accord signed in Washington last July, for cooperation on several fronts: from the detection of neutrinos and dark matter at the Gran Sasso National Laboratories of INFN, to the study of neutrinos at the Fermilab in Chicago and of atomic nuclei at the Jefferson Laboratory in Virginia; from the space program for the study of cosmic rays and antimatter with the Fermi and AMS space detectors, to the detection of gravitational waves with the LIGO and Virgo interferometers and the study of high-energy cosmic rays with the Auger Observatory in the Argentine Pampas. The Italian Embassy in Washington and its Science Counselor, Stefano Lami, played a fundamental role in establishing Italy-USA cooperation for scientific research.

Even though the horizon of research cooperation has expanded significantly in recent years, the relationship with the USA remains the cornerstone of INFN's international partnerships. What are the reasons for this special relationship?

The bilateral cooperation between Italy and the United States has certainly found, since the end of the Second World War to date, a solid basis for a long-standing and strong friendship in the technical-scientific sector; cooperation which was better defined and fostered by the first inter-governmental agreement in 1988. In the physics field, in particular, the fruitful exchange of know-how between

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the national laboratories involved in joint projects has over the years strengthened - among INFN's international relations - the privileged relationship with the USA.

The Scientific Office of the Embassy in Washington works to facilitate these relationships, hosting periodic meetings between INFN management and that of DOE and of the National Science Foundation (NSF), organising conferences and seminars and supporting the preparation of new agreements. With NSF, we are now looking to expand joint projects with INFN into an international partnership.

To study cosmic signals which are weak or uncertain in their nature, as it is in the case of dark matter, it is compelling to encourage the creation of global observers, providing for an exchange of expertises and scientific results. In this frame, an "Intent Agreement" will be soon approved by INFN and NSF for the joint participation in the Partnership for International Research and Education (PIRE) on mutual interest researches, including dark matter and gravitational waves detection. Referring to this second, in particular, the aim is to facilitate the sharing of scientific results and joint analysis between LIGO and Virgo interferometers, and carry on joint R&D actions for the realization of future third generation interferometers.

What is the current US strategy in the field of particle physics?

After the closure of the PEP-II and Tevatron accelerators at SLAC (Stanford Linear Accelerator) and at Fermilab in Chicago, respectively, and the attraction of many American physicists towards the LHC at CERN, the P5 (Particle Physics Project Prioritization Panel) report, issued in May 2014, defined the strategy for the next ten years for keeping a line of high quality research in the US while optimising investments. High priority was given to neutrino physics and to relaunch of the Fermilab: both with the neutrino beam of the new Long-Baseline Neutrino Facility, directed to an underground laboratory in Sanford, South Dakota, as well as with two major experiments for the study of muons, Muon g-2 and Mu2e. INFN is present in all these projects. In this regard, the statement given to the US Senate by the director of Fermilab, Nigel Lockyer, during his testimony on the P5 report, according to which "Italy represents its most important international partner", is significant.

What in your opinion are the peculiarities of the Italian and American research systems? What are the benefits that the two countries can derive from the exchange of skills?

Among the most evident differences, I would say that research in the USA receives much higher contributions in percentage terms from the private sector than research in Italy. American universities play a key role in research and technology transfer is closely related to their projects. Finally, there are many opportunities for young researchers.

Despite the criticism, I think the educational training offered by Italian universities is excellent, at a very low cost compared to the USA. It is unfortunate that in recent years the prospects for young graduates or PhDs are so limited, but perhaps something is changing. Research in particle physics has always been the flagship of Italy, despite the limited funds.

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I would say that a little osmosis of the positive things of the research systems of the two countries would be desirable. In particular, a greater synergy between research agencies is now essential, to share each other's expertise in order to optimize investments. The joint strategy will allow the best opportunities among those made possible by the available resources in each country.

Last January an existing agreement between MIUR and DOE to facilitate research cooperation in fundamental physics was extended. What are the most important aspects?

On 14 January last in Rome, INFN and MIUR signed a specific extension for Nuclear Physics of a more general agreement signed last July which, in broad terms, aims to meet the needs of future large international partnerships, especially concerning the exchange of personnel and scientific material. Just think of the transfer of the ICARUS detector from the INFN Gran Sasso Laboratories (where it has finished its research program under the guidance of Carlo Rubbia) to Fermilab where, with its 600 tons of liquid argon, it will become an integral part of neutrino research at the American laboratory. There is still much work to be done; I hope, for example, that the competent ministries can in the future simplify entry visas for researchers.

The recent agreements envisage, among other things, intensification of cooperation with the Jefferson Laboratory, the most important American laboratory for nuclear physics, which sees a significant presence of INFN.

That's right, the new agreement defines the common interests of the US and Italian laboratories involved. Among them is the Thomas Jefferson National Laboratory in Virginia, where the recent upgrade to an energy of 12 GeV of the CEBAF (Continuous Electron Beam Accelerator Facility) envisages a research program over the next five years, which will involve about 60 INFN researchers and technicians.

This program will allow us to improve our knowledge on the internal structure of nucleons, on their interactions and on the quark confinement mechanism. This is an important approach for the investigation of the structures of fundamental physics at intermediate energies - with the use of a high-luminosity electron beam - complementary to that carried out at high energies at CERN. As for the LHC experiments, in fact, the goal is to probe the limits of the Standard Model to identify any signs of new physics. ■

» FOCUS ON


ADVANCED VIRGO: TO THE LIMIT OF TECHNOLOGY FOR GRAVITATIONAL WAVE RESEARCH

Exactly a century has passed since Albert Einstein, in 1916, predicted the existence of gravitational waves with his theory of general relativity. Capturing these space-time ripples, produced by masses in accelerated motion, is difficult, but not impossible. Due to their infinitesimal amplitude, to increase the detection sensitivity it was necessary to push the technologies of laser interferometers, the detectors used for gravitational wave research, to the limit.

The INFN physicists, already engaged with their American and European colleagues in analysing the data of the Advanced LIGO (Laser Interferometer Gravitational-Wave Observatory) detector, are finalising the construction of Advanced Virgo, a 2nd generation interferometer at EGO (European Gravitational Observatory), in the countryside around Pisa, which will start taking data in the second half of 2016. Advanced Virgo is an upgrade of Virgo, the giant first-generation interferometer consisting of two 3 km-long perpendicular arms, situated in Cascina, near Pisa, and inaugurated in 2003. Each of the two arms of Virgo is traversed by a laser beam which, before overlapping with the other, is reflected back and forth several times in order to virtually lengthen the arms, thereby increasing the sensitivity of the instrument. When a gravitational wave passes through the interferometer, the length of the arms varies and the interference pattern created by the overlapping of the laser beams is modified: the measurable variation is related to the wave amplitude. Funded by INFN, by CNRS, the French Centre National de la Recherche Scientifique and with the participation of NIKHEF, the National Institute for Nuclear Physics and High Energy Physics in Amsterdam, the Polish Academy of Science and the Hungarian Wigner Institute, Advanced Virgo will increase the sensitivity of Virgo by about 10 times, thus extending the volume of the observable universe by 1000 times.

Officially approved in December 2009, Advanced VIRGO constitutes, with the two Advanced LIGO in the US, a worldwide network of interferometric detectors that operate as one big detector, sharing the data collected, analysing it jointly and publishing together the scientific results. Joint observation

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with three interferometers allows the direction of the sources of gravitational wave to be identified via the tiny differences in arrival times of the wave in the different devices. Locating the source in the sky subsequently allows the terrestrial and space telescopes to be pointed, looking for an electromagnetic counterparty, in the spectrum from radio waves up to high energy gamma rays.

The Pisa interferometer, subjected to profound improvements, has several features that are the result of years of intensive technological research. The optical design, the quality of the mirrors, the power of the laser, the thermal aberration compensation system, the seismic isolation and mirror control, as well as the vacuum, stray light reduction and environmental monitoring systems. The new mirrors, in particular, have double the mass of the previous one and are made of synthetic quartz, with purity and homogeneity at the frontier of technology, so much so that surface irregularities are reduced to the level of a few angstrom, a few tenths of a billionth of a metre. Thanks to this level of purity, in addition to the presence of advanced systems for the control of all aspects of the experiment, Advanced VIRGO is capable of measuring variations in the length of the arms, due to the passage of a gravitational wave, a billion times smaller than the diameter of a hydrogen atom.

The Virgo partnership, which manages the project together with EGO, currently consists of over 250 researchers - about half of which INFN - from 19 laboratories of 5 European countries: Italy, France, Holland, Poland and Hungary. ■



ITALIAN NATIONAL INSTITUTE FOR NUCLEAR PHYSICS

EDITORIAL BOARD

Coordination: Francesca Scianitti

Project and contents: Eleonora Cossi, Davide Patitucci, Francesca Scianitti, Antonella Varaschin.

Graphic design: Francesca Cuicchio

CONTACTS

Communications Office

comunicazione@presid.infn.it

+ 39 06 6868162