



# NEWSLETTER 23

Italian National Institute for Nuclear Physics

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## INSTITUTIONS

### JAPAN, MINISTER GIANNINI VISITS KEK LABORATORY

As part of the G7 Science & Technology Ministers' meetings taking place in Japan, the Italian Minister of Education, University and Research, Stefania Giannini paid a visit to the KEK fundamental physics laboratory, in Tsukuba, where INFN researchers are making a significant contribution, particularly in the Belle-II and T2K (Tokay to Kamioka experiment) experiments. Accompanied by the General Director of KEK, Masanori Yamauchi, the Minister visited the experimental hall of Belle II, where technologies developed by Italian groups are currently being installed.

The result of an international collaboration comprising more than 600 physicists and engineers from 23 different countries, with more than 60 scientists from 9 INFN teams, including divisions and laboratories, the Belle-II detector will be dedicated to the discovery of rare physical phenomena that do not fit in with predictions of the Standard Model, the current theory of elementary particles and their interactions. Belle II will operate on the SuperKEKB accelerator, whose operation is based on the interaction scheme called crab-waist, which was developed in collaboration with the accelerator division of the Frascati National Laboratories.

The aim of the T2K experiment, which is currently in the data uptake phase, is the high precision measurement of the neutrino oscillations produced by the accelerator of the J-PARC complex - at the Tokai campus of KEK - and sent into the large SuperKamiokande detector, installed 1000 meters under the ground near Kamioka. The T2K collaboration, in which INFN is collaborating with teams from different sections, includes more than 500 members from 64 research organisations in 12 countries. Last year it was awarded the prestigious Breakthrough Prize in Fundamental Physics, for its role in the discovery of neutrino oscillations. ■

**NOMINATIONS****BRUNO QUARTA GENERAL DIRECTOR OF INFN**

Bruno Quarta, an expert in public and private management with extensive and significant experience, first abroad and then in Italy, took office as the General Director of the INFN at the beginning of

May. Mr. Quarta studied economics and management, with a specialisation in business management, strategic development and risk management. After completing his studies, he started his career by founding a consulting company in the field of teleworking. A few years later he joined Microsoft, first in France and then in the UK. In more than a decade with this company he held managerial positions in business, marketing and external relations. Moving on from the entrepreneurial private sector to that of public sector research and education, Mr Quarta took on the position of Director of Research at the Alma Mater University of Bologna. Here he worked on the development of research processes, the increase of funding from regional, national and European programmes, the development of a knowledge transfer policy and the implementation of an organisational structure to support researchers in the enhancement of their activities at an international level. He then moved to Turin as Director of Strategies and Operations of the Common Strategic Task Force, a team created from the collaboration between the University of Turin and the San Paolo Foundation, with a twofold aim: first, to improve the competitiveness of public research and second, to address issues concerning human capital upon exiting research training paths. After this, Mr. Quarta took the position of General Director of the University of Milan, which he held until joining the INFN. ■



## EVENTS

### THE SOUTHERN NATIONAL LABORATORIES TURN 40

Forty years ago, the Southern National Laboratories (LNS) of the INFN were set up in Sicily, Catania. This centre of excellence of Italian physics is currently engaged in major international projects - including the KM3NeT underwater observatory for neutrinos - and national ones like the CATANA project for the treatment of eye tumours with proton therapy.

The anniversary celebrations in Catania were attended by, among others, Fernando Ferroni, President of the INFN, Giacomo Cuttone, Director of the LNS, and Antonino Zichichi, who had commissioned the construction of the facility at a time of major transformation for the INFN. From its birth to the critical step of installing the Superconducting Cyclotron, conceived and built in Milan, the Southern National Laboratories' history is all about fundamental and applied research, that is continuously changing and constantly abreast of the frontier challenges at the international level. The facility employs around 200 people who carry out fundamental research in the field of accelerator physics, nuclear physics (using the superconducting cyclotron and the Tandem Van de Graaff accelerator), astroparticle physics, and multi-disciplinary physics with applications in medicine, cultural heritage, biology and the environment. ■

**AWARD****BREAKTHROUGH PRIZE: 3 MILLION DOLLARS FOR GRAVITATIONAL WAVES**

The selection committee for the Breakthrough Prize in Fundamental Physics has awarded this year's special prize to the LIGO and VIRGO collaborations - in which Italy is taking part with the INFN - and to the founders of the American research project. The prize was awarded for the historical milestone achieved by the scientists who, one hundred years after Albert Einstein's theoretical prediction, have demonstrated the existence of gravitational waves. A one million dollar prize was awarded to Ronald W.P. Drever, professor emeritus of physics at Caltech; Kip S. Thorne, professor emeritus of theoretical physics at Caltech; and Rainer Weiss, professor emeritus of physics at MIT. The two LIGO and VIRGO collaborations, involving more than 1,000 scientists, 150 of whom Italian, were awarded a total of two million dollar. The winners will receive their prizes at a ceremony in the autumn of this year, where the Annual Breakthrough Prize for fundamental physics (separate from the special prize) will also be presented, along with the other awards in life sciences and mathematics.

The Breakthrough Prize, awarded by the Breakthrough Foundation founded by Sergey Brin and Anne Wojcicki, Jack Ma and Cathy Zhang, Mark Zuckerberg and Priscilla Chan, and Yuri and Julia Milner, celebrates the best achievements in science and has the ambitious aim of inspiring future generations of scientists. The Selection Committee is made up of former winners of the prize. ■

**» INTERVIEW**

**10 YEARS AGO THE BIRTH OF THE FIRST EUROPEAN INSTITUTE FOR THEORETICAL PHYSICS IN THE FIELD OF PARTICLE PHYSICS**

*Interview with Alberto Lerda, president of the INFN National Scientific Commission for theoretical physics and coordinator of the Galileo Galilei Institute (GGI) in Florence*

*The ceremony marking the tenth anniversary of the GGI took place on 17th May, on the opening day of the national conference on theoretical physics, in the historic seat of the Institute, on the hill of Arcetri. In the same place, a symbolic one for physics and astronomy, are also the National Institute of Optics, the Astronomical Observatory and Villa Il Gioiello, Galileo Galilei's last home, and as such recognised as a "historic site" by the European Physical Society in 2013. We talked to Alberto Lerda, coordinator of the GGI, about the activities promoted by the Institute and also touched briefly on the new frontiers of theoretical physics, in light of the most recent discoveries.*

**The Galileo Galilei Institute was founded ten years ago, an original and unique project on the European landscape. Where did the idea come from?**

The GGI was born from an intuition of Giuseppe Marchesini, at that time president of the National Scientific Committee of the INFN for theoretical physics, who recently passed away. Together with some colleagues in Florence, he promoted the idea of creating a centre within the INFN dedicated to the organization of workshops and conferences on theoretical physics of elementary particles, based on the model of the Kavli Institute for Theoretical Physics in Santa Barbara in California, and located in the premises on the hill of Arcetri, which had become available after the University's Department of Physics moved to Sesto Fiorentino. Thus, the partnership between the INFN and the University of Florence produced the GGI, which started operations with an inaugural conference in September 2005 and held its first workshop in May 2006.

**What activities does the GGI promote and implement? What have been the most important experiences in this decade of history, and can you please give us some numbers?**

The GGI's main activity is to organize 6-8 week "extended" workshops, each one on hot topics in theoretical physics. So far 30 workshops have been organised with the participation of more than

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3500 physicists from around the world. The thirty-first workshop will begin next week and end in early July. The schedule of activities has already been defined for all of 2017 and in the coming months we will be receiving requests for 2018. Last year the GGI won a considerable grant from the American Simons foundation that will allow eminent scientists of world-wide fame to make extended visits to our workshops over the next five years. In between these activities, the GGI also hosts short seminars and conferences as well as partnership and committee meetings. Starting from 2013, the GGI has also organised a series of schools for doctoral students during the winter months. At the moment we have four schools (one for string theory, one for the phenomenology of fundamental interactions, one for statistical field theory and one for nuclear and hadronic physics). The number of students taking part (over 150 per year) continues to grow, and about half of them come from abroad. This is also a sign of the success that the GGI is having internationally.

### **Over the years, other similar centres have been created in Europe. What is the current scenario? Do the different centres collaborate with one another?**

When the GGI was founded it was the only centre of its kind in Europe dedicated to theoretical physics. There were the Isaac Newton Institute for mathematical sciences in Cambridge in the UK and the Erwin Schrödinger International Institute for mathematical physics in Vienna, but there was no centre dedicated mainly to theoretical high-energy physics. Today, alongside the GGI, we have the Mainz Institute for Theoretical Physics and the Munich Institute for Astro and Particle Physics in Germany, the NORDITA in Stockholm and the programmes of the so-called TH Institutes at CERN in Geneva. All these centres complement one other and each one has its own characteristics and peculiarities. The GGI's particular characteristic is that it organises long programmes, even up to two months.

### **What are the main areas of research covered at the GGI?**

In the early years, the GGI workshops were mainly focused on elementary particle physics, both of the Standard Model and its extensions, on quantum field and string theory and on what is known as astroparticle physics. In recent years, the scope of interest has widened to include statistical mechanics and nuclear physics and astrophysics. In other words, we now cover all the lines of research in theoretical physics addressed by the INFN. Next year we will also host a programme dedicated to cold atom physics and their use for simulations in gauge theories.

### **With the discovery of the Higgs boson, experimental researchers now have to change their approach: they must sail by sight and scan the horizon for signs of New Physics...**

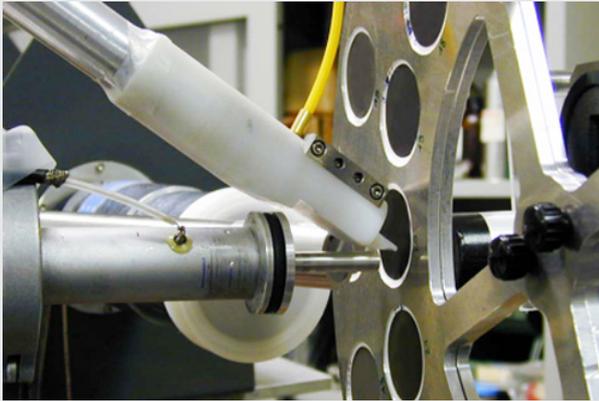
Yes, the discovery of the Higgs boson in 2012 completed the Standard Model in an amazing way, which seems to work very well, indeed, too well! As a matter of fact, all the properties predicted by the theory have so far been experimentally verified with great precision and without significant

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deviations. However, for various reasons, the Standard Model cannot be the final theory of fundamental interactions and the structure of matter and of the Universe: so scientists must look further. We are still missing a good explanation of the so-called dark matter, and of how gravitational interaction can be incorporated into the model. The data gathered in the coming months from the experiments of the LHC at CERN will be crucial to see if there are signs of new physics beyond the Standard Model. Compared to the past, however, the boundary conditions have changed, in the sense that, whereas before we knew we had to look for something like the Higgs boson, now it isn't clear exactly what we are looking for. Ironically, this uncertainty or wait might be even more stimulating and exciting, because whatever is discovered will almost certainly be something revolutionary.

### **This year we were announced yet another historic discovery: gravitational waves. How will this affect the theoretical work?**

The recent observation of gravitational waves is another extraordinary success of physics. Predicted by Einstein's Theory of General Relativity in 1916, one hundred years later gravitational waves have been observed in an experiment, thanks to remarkable progress in interferometry and to the development of numerical relativity models. This is a repetition of what happened with electromagnetic waves, that were theoretically predicted by Maxwell, roughly in 1865, and then experimentally demonstrated by Hertz some twenty years later. Just as electromagnetic waves radically changed our knowledge and our research tools, we can expect that, in the coming years, gravitational waves will open up new horizons and scenarios, giving rise to real gravitational astronomy. Clearly these developments will have a big impact on our knowledge, perhaps allowing us to understand the quantum structure of space-time and the true nature of gravitational interaction. In short, we expect a very interesting and exciting future! ■

**» FOCUS ON**

**ACCELERATORS TO STUDY  
ATMOSPHERIC POLLUTION**

Originating from fundamental research, accelerator physics has developed technologies and skills that are currently used in fields that have a direct impact on society such as medicine, health, the environment and the study and conservation of cultural heritage.

Physicists at the Laboratory of nuclear techniques for the Environment and Cultural Heritage (LABEC - INFN) in Florence, in collaboration with the INFN divisions of Genoa and Milan, are exploiting the knowledge and technologies developed in accelerator physics to study particulate pollution and analyse its composition. To identify the sources of pollution and develop appropriate pollution control methods, it is in fact essential to determine not only the concentrations of particulate matter (PM) in the atmosphere, but also its composition: PM is the mixture of particles, suspended in the atmosphere, that have an impact on the environment and climate, and that can be very harmful to the respiratory system. Accelerators are machines capable of generating particle beams and of launching them at very high speeds, close to the speed of light, against another particle beam or a particular fixed target. In this second case, the products of these collisions can be analysed in order to determine the composition of the bombarded samples with great precision. This same principle is used to study the composition of atmospheric particulate. The sample to be analysed is hit with a beam of accelerated charged particles. From the interaction of the beam with the sample-target, which produces for example X- and gamma rays, it is possible to identify and measure the elements in the particulate.

In this research, physicists employ techniques called "Ion beam analysis" (IBA): the most powerful and most widely used of these techniques is Particle Induced X-ray Emission (PIXE), which identifies all elements with an atomic number greater than 10, or heavier than sodium, such as, for example, aluminium, silicon, calcium, titanium and iron (tracers of soil dust), potassium (emissions from biomass combustion), zinc and lead (products of industrial operations), vanadium and nickel (combustion of

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heavy oils), copper and barium (released by vehicular traffic).

One type of sampler that is used to collect atmospheric particulate is the streaker. It separates the components of large and fine particulate (those with a diameter of between 2.5 and 10 micron from those with a diameter of less than 2.5 micron) on an hourly basis, producing a continuous strip (called a streak). By performing a "point to point" analysis of the strips with the dust deposit, which can only be done with the PIXE technique, it is possible to determine the hourly concentration of the elements in the air, hence also to identify peak episodes of pollution. At the end of February results were released from the European LIFE + AIRUSE project, dedicated to particulate air pollution in cities in Southern Europe. Researchers from seven European institutions took part in the project, including the University of Florence and the INFN - which contributed to the investigation with the particle accelerators at the LABEC laboratory. The research teams took samples of air in Athens, Barcelona, Porto, Milan and Florence and used chemical and physical techniques to analyse the air quality. The results indicate that the sources that cause most air pollution are traffic and biomass combustion and, to a lesser extent, industry, port and ship emissions, building works, local or Saharan dust, sea spray, and activities related to agriculture and livestock farming. Moreover, one finding that emerged clearly from the study is that part of the dust (secondary aerosols) is formed in the atmosphere by gaseous pollutants, which may even have been released at a considerable distance from the sampling site. ■



### ITALIAN NATIONAL INSTITUTE FOR NUCLEAR PHYSICS

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