NEWSLETTER 13

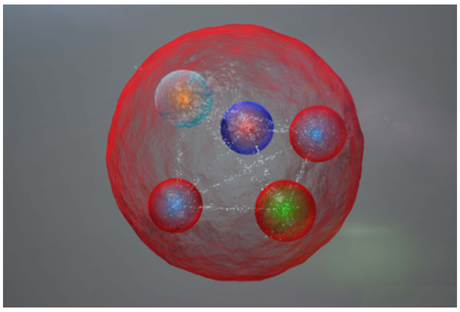
Italian National Institute for Nuclear Physics

JULY 2015

NEWS

INSTITUTIONS
PRIME MINISTER RENZI VISITS CERN

On 7 July, Italian Prime Minister Matteo Renzi visited CERN, in Geneva. Renzi, accompanied by Stefania Giannini, Minister of Instruction, University and Research, was welcomed by Rolf Heuer, Director General of CERN, together with Fabiola Gianotti, designated Director, Sergio Bertolucci, Director for Research and Computing, and the Nobel Prize Carlo Rubbia. The Prime Minister visited the ATLAS experiment and the LHC tunnel and met the Italian physicists working on the accelerator and various experiments. In his speech, he stressed the importance of research at CERN and of the work of Italian scientists and Italian industry, which has developed cutting-edge technologies to create such powerful and sophisticated machines. The presence of one of Italy's highest offices of state in the largest particle physics laboratory in the world is recognition of the excellence of CERN and of Italy's contribution. The resumption of activities at LHC RUN2, upgraded after consolidation works, promises a truly inspiring future for high-energy physics, allowing such excellence in science and technology to continue. ■

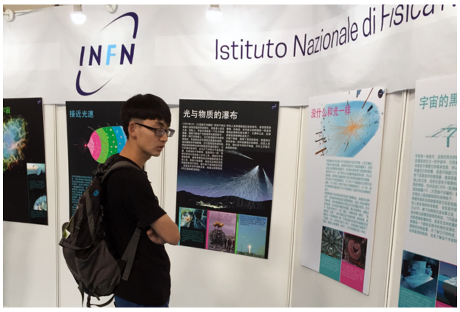


RESEARCH
PENTAQUARKS OBSERVED

LHCb, one of the four major experiments at the LHC Large Hadron Collider, CERN's supercollider in Geneva, reported the discovery of a class of exotic particles composed of five quarks, known as pentaquarks. The pentaquark that was observed is not simply a new particle but a new way in which quarks, which are the fundamental constituents of protons and neutrons, can combine with each other, and follows a pattern never observed before in over fifty years of experimental research. The result of the LHCb experiment is founded on extremely accurate and rigorous data analysis, based on very high-level statistics never achieved before, as well as on the extremely high accuracy of the detector. This result is not conclusive, as pentaquarks are a class of particles that can open the door to a much deeper understanding of matter. The next step will be to study how quarks are bounded within the pentaquarks. Further studies will therefore be needed, and the new data that LHCb will collect during LHC RUN2 will allow progress to be made in this field. ■

INTERNATIONAL COOPERATION
ITALY-UNITED STATES SIGN FRAMEWORK AGREEMENT FOR PHYSICS RESEARCH

A scientific-technological agreement between Italy and the United States was signed on 17 July in Washington. The agreement aims to promote cooperation on research into particle physics and nuclear physics. The document was signed by Italy's Ambassador to the United States, Claudio Bisogniero, representing the Ministry of Instruction, University and Research (MIUR), and by America's Under Secretary of the Department of Energy (DOE), Lynn Orr. "This agreement is a significant recognition: the DOE recognizes INFN as a key partner and, to better carry out the cooperation, enables an agreement at ministerial level: a great satisfaction for INFN and for Italy," said Fernando Ferroni, INFN President.The agreement will enable the two countries to share expertise, scientific material and research, as part of a major international partnership. The agreement provides for specific new projects, the first of which was signed on the same day, and includes the transfer of the ICARUS experiment to the Fermi National Laboratory (Fermilab) in Chicago. ICARUS was conceived and coordinated by Nobel Laureate Carlo Rubbia, who finished his research programme at the INFN Gran Sasso National Laboratory. ■



DISSEMINATION
INFN AT THE CHINA SCIENCE FESTIVAL IN BEIJING

Light and colours. For the International Year of Light, IYL2015. This is the theme of the second China Science Festival and Youth Science Education Expo 2015, Beijing's science festival. This year Italy is the guest of honour, and the Istituto Nazionale di Fisica Nucleare (National Institute of Nuclear Physics) – INFN – is also taking part. For the event, held at the Beijing Exhibition Center from July 17 to August 2, INFN has set up two interactive installations in its exhibition space. One of the installations is dedicated to particle accelerators and the other to the Higgs boson. Here, the young Chinese audience, on whom the festival is focused, can have fun while becoming acquainted with some fundamental concepts of physics. Besides the installations, posters and videos tell young people about the world of elementary particles and their interactions, as well as the work of physics researchers. ■

INTERVIEW

AN INFRASTRUCTURE FOR INTERDISCIPLINARY RESEARCH IN THE HEART OF EUROPE

Interview with Francesco Sette, Director General of the European Synchrotron Radiation Facility (ESRF)

Light for Science. This expression encapsulates the mission of the European Synchrotron Radiation Facility (ESRF)and is the perfect slogan for the UNESCO International Year of Light. It is light itself, specifically synchrotron radiation light, the main focus of this centre of excellence for basic, applied and industrial research, which uses and makes available to the international scientific community the most intense source of X-rays of the world, a hundred thousand billion times brighter than the X-rays used inside hospitals. Synchrotron light is electromagnetic radiation, emitted by *relativistic electrons* through a wise manipulation of their trajectory with powerful magnetic fields. Infact, photons with various wavelengths ranging, from infrared to hard X-rays, are created when electrons are driven at a speed close to the speed of light inside a storage ring, and are deflected by magnetic fields.
Opened in 1994 in Grenoble, France, ESRF was founded also thanks to the expertise at INFN, especially at the *Frascati National Laboratory*, involved from the beginning in the design of the storage ring of ESRF. Supported by 21 partner countries from three different continents and attended every year by 6,000 scientists, 13% of whom are Italians, ESRF is a great example of international cooperation. Among the supporting countries, Italy is one of the main contributors, after France and Germany, with 13.2% of the budget, one third of which is under responsibility of INFN.
The Grenoble machine, an 844-metre circumference ring, is the same size as a football stadium and produces numerous X-ray beams: there are 43 experimental stations, called *beamlines*, each of them highly specialized in different areas of research. Because of its versatility, the ESRF receives about 2,000 proposals for experiments every year, between 1994 and 2014, there are been more than 25,000 scientific publications.

We met Francesco Sette, Director General of ESRF. He is a matter physicist who studied at the *Frascati National Laboratory*, and one of the pioneers in synchrotron radiation research.

INTERVIEW

What is the ESRF research infrastructure's mission?
ESRF operates as a *super-microscope*, able to reveal the structure of matter in all its beauty and complexity. Observing and decoding the properties of materials and of living matter is fundamental to obtaining a better understanding of the origin of nature, and to improving the world around us, or to conceive more efficient and effective materials. For these purposes, ESRF hosts thousands of scientists from all over the world, and develops partnerships in strategic industries.

What are the main applications of synchrotron light?
At ESRF thousands of scientists from different disciplines work closely together: material physicists, material chemistry scientists, structural biologists, archaeologists, cultural heritage experts, nanotechnologists, IT engineers, geologists and doctors. They go to Grenoble to perform a variety of experiments, such as studying new materials, new drugs or complex chemical processes, but also to analyse archaeological artefacts, fossils and paintings. Indeed, in recent years, areas related in any way to cultural heritage have made increasing use of synchrotron light, which permits non-invasive and non-destructive studies. This technology, however, was created to explore the structure of matter at atomic and molecular level, through crystallography and X-ray spectroscopy of biological macromolecules; it can provide, for example, guidelines for developing new drugs. Other fields of research are real-time imaging of living cells and the study of new materials for next-generation electronics, such as graphene or volatile memories.

Can you tell us about the plan to design a new generation of synchrotrons between 2015 and 2022?
ESRF has embarked on a major challenge: opening a new window onto the nanoworld, at less than about 500 nanometers (billionths of a metre). The Upgrade Programme is an ambitious and innovative project of modernization involving an investment of €330 million between 2009 and 2022. With this programme - which includes, by 2015, the conclusion of construction of 19 next-generation experimental stations and, by 2020, a new storage ring within the existing one - ESRF is preparing to build the first of a new generation of synchrotrons, which will produce more intense, coherent and stable X-ray beams by a factor of 100. The aim is to improve, with unmatched nanometric spatial resolution, the analysis of materials and living matter, reusing 90% of the existing structure. The construction of the new ring will continue alongside the normal operation of the current machine until the end of 2018. Then, between 2019 and 2020, there will be a shutdown phase when operations will be halted for 18 months, to disassemble the ring, to assemble the new one and to do the *commissioning*. The date expected for a return of users is on june 1st 2020.

What is the role of INFN at ESRF?
ESRF was founded in the 1980s partly thanks to an idea from INFN which played a key role in the project's

» INTERVIEW

beginnings, for example in the design of the ring, and also thanks to the important work of Italian material physicists and high energy physicists, for example, with the unit of the *Frascati National Laboratory* operating with synchrotron radiation. These laboratories were important for me personally in my education as a physicist. In Frascati, I was part of the PULS group (a project dealing with applications of synchrotron light), which used the ADONE ring. Cooperation with INFN, however, is still ongoing, either as part of a wider interaction between institutions and European research infrastructures or about particular common projects of accelerators.

In which areas is this collaboration taking place?
In ESRF one of the major challenges for the future is the creation of more stable and reproducible *nanobeams*, in order to study matter with spatial resolution at nanometric scale. To achieve these scientific goals, however, in addition to the realization of a new generation of *beamlines* we need a brighter source, with a gain of brilliance by almost a factor of 100. This means that we need to develop a new machine with more revolutionary characteristics than today standards. The ESFR Accelerators Division has recently conceived and proposed a new storage ring, by working on an idea firstly originated by the leader of the Division, Pantaleo Raimondi, an Italian physicist coming from the *Frascati National Laboratory* and leading the group since 2012. Since a couple of years a strong ongoing collaboration is in progress with the *Frascati National Laboratory*, which researchers have an extensive experience in the field of leptonic storage rings, developed with the DAFNE (*Double Annular Φ Factory for Nice Experiments*) machine. The Frascati group, infact, is contributing to the development of sophisticated components like those for the vacuum system.
We are also developing a strong collaboration with INFN on *Big Data*, for the analysis, storage and access to scientific data produced by research infrastructures like CERN or ESRF. An exchange for the creation of *databanks* and *cloud resources* to connect various infrastructures is ongoing, for example, at an european level. Infact, ESRF produces every day around 10 terabytes (10 thousand billion bytes) of data, and these numbers will rise steeply next years, reaching numbers not much less than what is produced at the LHC. ■

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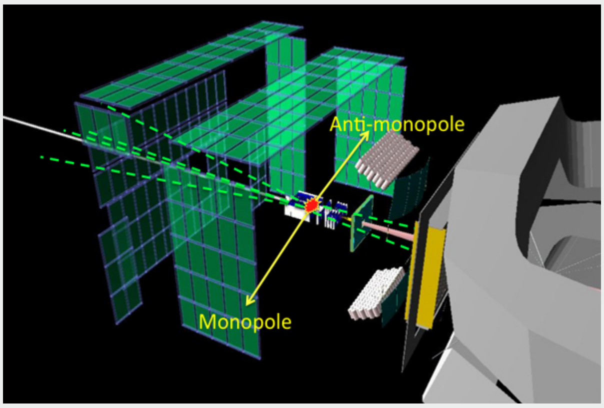
FOCUS ON



PURSUING THE QUEST FOR MAGNETIC MONOPOLES AT THE LHC WITH THE MoEDAL EXPERIMENT

There is one special particle, among all the unknown ones which physicists hope to discover with the restarting of the LHC: the magnetic monopole, the existence of which was theorised in 1931 by Nobel Laureate Paul Dirac. Italy has been committed to the quest for monopoles for decades, particularly thanks to researchers from the Bologna University and INFN division*.
Magnetic monopoles would represent the counterpart of the electric charge in Maxwell's equations of electromagnetism. In fact, while there are separate particles with a positive or negative electric charge, it is impossible to isolate a magnetic pole: if we break a magnet, we get two magnets, each with its own south pole and north pole.
The quest for magnetic monopoles, which began at the time of their theoretical introduction over 80 years ago, continues today with the MoEDAL experiment (The Monopole and Exotics Detector at the LHC). The search is being conducted by an international group of physicists from 21 institutions and 12 countries, including researchers from the Bologna INFN division.
To prove the existence of magnetic monopoles, MoEDAL makes use of stacks consisting of several sheets of two different types of nuclear track detectors: the CR39®, a polymer widely used for the production of sunglass lenses, and Makfrol®, a polycarbonate widely available on the market. The stacks cover a total area of approximately 25 m^2, close to the LHCb apparatus, one of LHC's four largest detectors, located at one of the collision points of the proton beams that circulate within the accelerator. If a magnetic monopole, produced by the collision of the LHC beams, passes through a stack it leaves a damage that is revealed by later chemical etching of the detector sheets. The monopole's passage would manifest itself as a sequence of micrometric conical etch-pits of equal size and shape, aligned in the various layers. No known particle would leave such a distinctive signature. For this reason, even just one single event of this type would herald the discovery of the magnetic monopole.

» FOCUS ON

The Grand Unification Theories, of electroweak and strong interactions, predict the existence of large mass magnetic monopoles, which may have been created in the early universe and be present today within cosmic rays as fossil particles. These monopoles were searched for in the late 1990s at the Gran Sasso National Laboratory, by the MACRO experiment (Monopole, Astrophysics and Cosmic Ray Observatory). Since no monopole was found MACRO could set a limit, still unbeaten, on the maximum flux of such incoming particles arriving on Earth from the cosmos.
The discovery of magnetic monopoles would provide a real breakthrough in the comprehension of the physics world, with regard to the understanding of electromagnetism, as well as in Astrophysics and in Cosmology. If monopoles are discovered at the LHC, it would imply they would also have been created in the early universe. As theoretical physicist Joseph Polchinski said at the 2002 Dirac Centennial Symposium, "the existence of magnetic monopoles is one of the safest bets that one can make about physics not yet seen". ■

* The development of this research in Italy is due in particular to Giorgio Giacomelli, Professor Emeritus at the University of Bologna and physicist at INFN, who died in 2014. Giacomelli's name is linked to the quest for monopoles at accelerators and in the cosmic radiation.

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