NEWSLETTER 03

Italian National Institute for Nuclear Physics

SEPTEMBER 2014

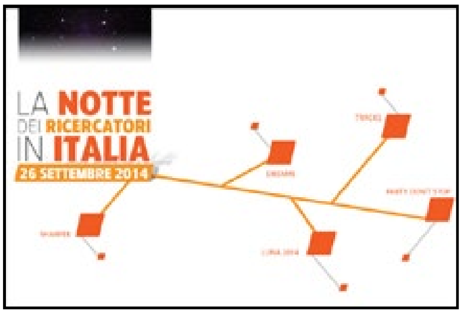
NEWS

SCIENCE
BOREXINO: THE FIRST REAL-TIME IMAGE OF THE SUN

The Borexino experiment at the INFN's Gran Sasso Laboratory has measured for the first time the flux of neutrinos produced in the thermonuclear fusion of two hydrogen atoms to form a deuterium atom, the primary reaction in the chain of reactions that fuels our star. Once produced, neutrinos arrive on Earth after just 8 minutes and this allowed Borexino to measure the energy of our star in real-time at the moment of its production. This is the first time that this has happened, because until now solar energy was studied through the detection of photons which take a full 100 thousand years to reach us. By comparing these two measurements it has been demonstrated that the energy of our star has not changed from then until now. ■

EVENTS
CERN: 60 YEARS OF EUROPEAN RESEARCH

September 29 has marked the 60th anniversary of the largest particle physics laboratory in the world. The event boasted the participation of heads of state and representatives of the governments of the member countries and institutions that collaborate with CERN. Italy has been represented by the Minister of Education, Universities and Research (MIUR) Stefania Giannini; Ambassador Maurizio Enrico Serra, Italy's Permanent Representative at the International Organizations of Geneva, and the President of the INFN Fernando Ferroni. Sixty years have passed since September 29, 1954, when twelve countries, including Italy, officially founded CERN, the European Organization for Nuclear Research. In these 60 years, CERN has come a long way. It has been a crucible for knowledge, but also for technological innovation with a strong impact on society. That is not all; with its current 21 member states, it is an example of how science can offer fertile ground for dialogue and collaboration. ■



Dissemination

EU RESEARCHERS' NIGHT: RECORD NUMBER OF EVENTS IN ITALY

26 September was the European Researchers' Night, this year dedicated to the theme of sustainability. Italy, with more than 300 initiatives in 22 cities has the record number of events in the whole of Europe. Dozens of initiatives, organised by the INFN, have been grouped into four projects to bring to the forefront Italian researchers. First classified in the list of the selected European projects, the Dreams project has been coordinated by the “Frascati Scienza” association and involved INFN’s Southern and Frascati National Laboratories and the INFN divisions in Trieste, Bologna, Milan, Ferrara, Catania, Bari, Cagliari, Pavia and Pisa.

Sharper is the name of the project in which the Gran Sasso National Laboratory, the GSSI and the Perugia INFN division partecipated. In Padua, the Legnaro National Laboratory and the Padua INFN division participated in the Venetonight events. In Turin the 60th anniversary of CERN was celebrated in collaboration with the Tracks project ■

Italy

FOUR STAMPS DEDICATED TO INFN LABORATORIES

On 16 September four stamps were issued in the "Knowledge excellence" series dedicated to the INFN’s Frascati, Gran Sasso, Legnaro and Southern National Laboratories. The stamps, issued in 2,700,000 copies, depict an experiment at each laboratory: the KLOE detector of the DAFNE particle accelerator at the Frascati National Laboratory, the interior (the photomultipliers) of the Borexino experiment at the Gran Sasso National Laboratory, a detail of the AGATE gamma ray spectrometer at the Legnaro National Laboratory and the K800 Superconducting Cyclotron at the Southern National Laboratory. The issue is accompanied by a series of philatelic products such as postcards, badges and an illustrative bulletin signed by the President of the INFN; the products are available for purchase online. The stamps were presented on 16 September with an event that was held at the Ministry of Economic Development in Rome. See the gallery. ■

» INTERVIEW

NUCLEAR PHYSICS IN EUROPE

Interview with Angela Bracco, president of the international committee NuPECC (Nuclear Physics European Collaboration Committee), "Expert Board" of the European Science Foundation.

NuPECC has the task of defining the priorities in the field of nuclear physics and promoting the coordination of European research in this field. What are the tools for defining recommendations for the national agencies?

NuPECC is recognized by the European Community as the entity of reference for defining a strategic plan for nuclear physics. It is included as observer in the strategic plan for particle physics and in the working group for the physics infrastructures of the European Strategy Forum on Research Infrastructures (ESFRI).
NuPECC's primary goal is defining the strategic Long Range Plan (LRP) for nuclear physics, a collection of recommendations that direct the coordinated choices of the individual national agencies. The document is issued by the Committee in alternate periods according to the American plan, every 5 or 6 years. This phasing allows periods of dialogue and ongoing communications able to create worldwide integration.
Additional goals are the preparation of specific reports, useful for drafting said LRP, and able to highlight the importance of the existing and future research infrastructures, for example in the field of technological applications and results.
Further tasks performed by NuPECC are the assessment and monitoring of the European projects that provide financing for access by foreign users to the research infrastructures in the various European countries; in the case of Italy, these are the three INFN laboratories of Frascati, Legnaro and Catania. Furthermore, it closely monitors the activities of the European Institute for theoretical studies in nuclear physics, the ECT*, with headquarters in Trento.

What priorities are indicated in the latest LRP 2010?

At the level of large facilities, we must certainly mention the two infrastructures of ESFRI (*European*

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Strategy Forum on Research Infrastructures), FAIR (*Facility for Antiproton and Ion Research in Europe*) in Darmstadt, engaged in wide-spectrum modern nuclear physics, from Hadronic physics to nuclear astrophysics, and SPIRAL2 (*Système de Production d'Ions Radioactifs en Ligne*) in Ganil, engaged in research on nuclear structures and nuclear astrophysics. Although in these cases, as in others, the driver for development of infrastructures of research is basic science, both projects have significant impact on applications, from the science of materials and recovery of cultural heritage, to Hadrotherapy and the development of radiopharmaceuticals.
Then there are the *Major Upgrades,* already existing infrastructures that provide updates in the direction of the new physics. Among these, the most demanding is SPES, a new and complex structure of accelerators at the National Laboratories of Legnaro for providing radioactive beans. Italy's involvement, with the INFN, includes the AGATA detector, an infrastructure used throughout the European territory, and the ALICE detector at the LHC accelerator at CERN.
To build parts for the new infrastructures, the 2010 issue of LRP made clear its desire for optimized use of the existing structures. This allows avoiding abrupt passage from the old to the new facilities, guaranteeing greater continuity for research. A further benefit of the continuity between the new and the old projects is to the *training & education* sector, which finds in medium-sized projects useful terrain for training new generations of researchers.

If we could summarize nuclear physics research goals in any general questions, in terms of knowledge acquisition, what would be the most relevant?

The first of the questions to which nuclear physics wishes to answer today is the origin of the elements that are differently distributed on Earth. The distribution depends on astrophysical processes that we call precursors, involving unstable atomic nuclei. By studying their behavior, it is possible to understand the processes that have led to the current elements distribution. This research requires very experimentally-advanced techniques and technologies, since it is necessary to study the nuclei during their formation. The times of instability are very brief, and currently we can study only those that survive more than a few microseconds.
An interesting analogy links the behavior of matter at the macroscopic and nuclear levels: this is the case of neutron stars. The knowledge of the structure of these stars requires detailed study of the behavior of the state of *quark gluon plasma* and of neutron matter that, together, determine the equilibrium of the atomic nuclei as well as of the neutron stars.
Moreover, the atomic nucleus is a complex many bodies system. This generates many analogies with matter physics; such as, for example, phenomenological studies on collective behaviors associated with superconductivity. In these aspects, the affinity stops at the descriptive level and in the nuclear field does not lead to direct applications, as in the case of the physics of superconductive materials, but it is of great interest in terms of knowledge.

There are many applications of nuclear physics to industrial and social utility. The

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importance of the applications in the medical field is such that NuPECC has dedicated a rich and detailed report to these aspects.

"*Nuclear Physics for Medicine*" will be presented in Brussels on November 24 in a conference at the University Foundation.
The event is sponsored by the Italian Ministry of Education, University and Research (MIUR) among the activities for the Italian Presidency of the EU Council. The main goal of the report is to highlight the role of nuclear physics research in the developments of modern medicine, in the diagnostic and therapeutic fields.
Also in the past, NuPECC has paid particular attention to applied research and has prepared other reports about applications of industrial and social utility, from the science of materials and the care of cultural heritage to medicine. The new report "*Nuclear Physics for Medicine*" aims to shed light on three aspects in particular: the same accelerators used in nuclear physics are increasingly used for treating tumors; the production of radioactive beams has an impact on the production of radioisotopes used for diagnostics; the new developments for complex particle detectors, and in particular for gamma radiation, allow increasingly precise image reconstruction of internal parts of the human body. ■

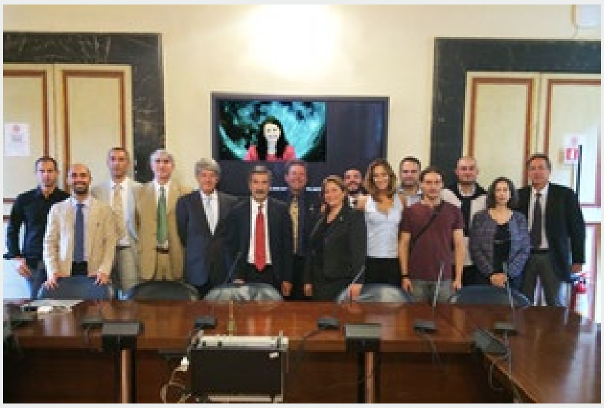
* NuPECC is an Expert Committee of the European Science Foundation, which includes members from 19 European countries. Its primary goal is defining priorities in the field of nuclear physics and coordinating research at the European level. The activities of NuPECC are regularly followed by non-European observers, and it is regularly evaluated by the European Science Foundation as its "expert board."

» FOCUS ON

ESS, THE MOST POWERFUL NEUTRON SOURCE IN THE WORLD

It will be a multi-disciplinary research centre based on the most powerful neutron source ever built in the world, approximately 30 times brighter than those currently available. It will enable new opportunities for researchers in the fields of fundamental physics, life sciences, energy, environmental technology and cultural heritage. It is called European Spallation Source (ESS) and is a European project costing 1.84 billion euros, which currently involves 17 countries, with Sweden and Denmark as host nations. ESS, included by the European Strategy Forum on Research Infrastructures (ESFRI) in the roadmap, as a strategic project, involves the construction of a new infrastructure for the neutron sector with advanced features, able to provide a world-class support and give a strong impetus to this important sector for Europe. The importance of this specific area of scientific research, which is aimed in particular at the use of neutron beams for the analysis of materials and biomaterials, lies in the fact that the neutron probe enables a number studies impossible with other probes, such as photons or electrons. The infrastructure, which is now in the start-up phase and will last approximately ten years, will be built in Lund in Sweden, while the supercomputing centre that will manage the data will be based in Copenhagen, Denmark. Italy is participating with the Ministry of Education, University and Research (MIUR) and with INFN, the National Research Council (CNR) and Elettra Sincrotrone Trieste. Italy's contribution will amount to 6% of the total cost, of which 80% will be in-kind, i.e. through the provision of machine parts. The European Spallation Source will therefore represent an opportunity not only for the world of scientific research but also for high-tech industries. Italy's participation in a project as important as ESS is strategic: on the one hand, it will provide researchers with new opportunities in various fields of fundamental and applied research, while on the other it will be an opportunity for Italian high-tech industries to contribute to the construction of ESS. ■

» TECHNOLOGY TRANSFER



PARTICLE PHYSICS FOR SPACE EXPLORATION

INFN is the first Italian partner of NASA/SSERVI, the NASA institute dedicated to research and exploration of the solar system. The affiliation agreement was signed on 15 September and involves collaboration between the two organisations for the development of joint activities, exchange of scientists, and shared use of their respective research laboratories. INFN thus puts the experience and the skills of its researchers and leading-edge technologies developed for particle physics, astroparticle physics and laser retroreflectors at the disposal of NASA, the most prestigious space agency in the world. An example of how curiosity-driven research and the resulting applications often find uses in fields very different from those originally envisaged. It all began ten years ago when a group of the INFN's Frascati National Laboratory focused on precision positioning in space using laser retroreflectors, with the aim of them becoming advanced tools for both fundamental as well as applied physics. A laser retroreflector is a cube edge made of glass, ultra-pure glass, suitable for the space environment, very smooth and with an almost perfect geometric shape, with dimensional inaccuracies of the active parts of just a few dozen nanometres. This led to the construction of a new laboratory at the INFN's Frascati National Laboratory, the SCF_LAB (*Satellite/lunar/GNSS laser ranging and altimetry Characterization Facilities' LABoratory*), with the precise goal of "characterising" the laser retroreflectors, i.e. measuring in detail all the aspects of their thermal behaviour and optical performance according to their location in space, with unprecedented accuracy, also in order to define new space qualification standards for these positioning devices for the Earth, satellites in Earth orbits, the moon and the rest of the solar system. Independently of NASA, and in collaboration with ASI and ESA, INFN characterises retro-reflectors already installed on the Galileo satellites, the global satellite navigation system, the European "GPS", and others will be developed to be installed on future Galileo satellites. Moreover, INFN calibrates particle and astroparticle detectors, many of which have been supplied to CERN and others are already in use in space activities. The INFN proposal was selected precisely because INFN carries out complementary research activities that will help NASA in achieving its objectives in human exploration of the solar system.■

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