

# Italian National Institute for Nuclear Physics

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### INTERNATIONAL AGREEMENTS INFN SIGNS AN AGREEMENT FOR A HADRONTHERAPY CENTRE IN THE US

One of the first US centres for cancer treatment with hadron therapy will be built in Dallas, Texas, with the scientific contribution of INFN. The decision came during the international conference on

heavy ion therapy (International Symposium on Ion Therapy - ISIT), held at the beginning of November in Milan. The agreement with the University of Texas Southwestern Medical centre - UTSW was signed by the President of INFN, Fernando Ferroni, and by Hak Choy, head of the radio-oncology department of UTSW.

The agreement stems from the experience and expertise acquired over the past decade by INFN through interdisciplinary partnerships that have brought about several initiatives. These include: implementation of the CATANA project, in place since 2002, at the National Laboratories of the South, for the treatment of ocular melanoma, design and construction of the synchrotron, hub of the activity of the CNAO (National Centre for Oncological Hadrontherapy) Foundation in Pavia and the recent creation of the new proton therapy centre in Trento, with the cooperation of the INFN TIFPA (Trento Institute for Fundamentals Physics Applications) centre. CNAO, in particular, one of 10 accelerators in the world used in the treatment of tumours with hadron therapy using heavy ions - 5 in Japan, 2 in China and 3 in Europe - is working in close collaboration with the University of Texas to provide assistance in coordination of activities throughout the implementation phase of the centre. The University of Dallas will also carry out radiobiology research at CNAO and, pending opening of the US centre, tests will be carried out at CNAO with carbon ion beams.



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### APPOINTMENTS ANTONIO MASIERO ELECTED PRESIDENT OF ApPEC

Antonio Masiero, Vice President of INFN, a theoretical physicist and professor at the University of Padua, has been elected president of ApPEC (Astroparticle Physics European Consortium), the consortium

formed by European agencies funding astroparticle physics in individual countries, with the primary objective of promoting and facilitating cooperation in this field at the European level. Representatives of the 13 member countries of the consortium also elected Job de Kleuver from the Dutch institute FOM International Affairs and Large Scale Facilities to the position of General Secretary. Masiero and de Kleuver will take office on 1 January 2017, succeeding respectively Frank Linde (from Nikhef, Holland) and Thomas Berghöfer (from DESY, Germany), at the end of their term.

Astroparticle physics, a combination of particle physics, cosmology and astrophysics, is a relatively new and rapidly growing research field. With experiments in underground and underwater laboratories, extensive networks of ground-based telescopes, as well as detectors in space, Europe is taking on increasingly exciting challenges, with the aim of studying the most elusive particles and revealing the darkest mysteries on the structure of the universe.



NOVEMBER 2016



### **RESEARCH** COSMIC REPLAY UNDER THE LENS OF EINSTEIN

After seven billion years, the photons emitted by the galaxy "QSO B0218+357", which is home to a supermassive black hole, have reached the Earth. Observing the most distant source of gamma

rays ever observed at high energy were the Fermi-LAT (Large Area Telescope) space telescope and the two MAGIC (Major Atmospheric Gamma-rayImaging Cherenkov) ground-based telescopes, in the Canary Islands, which were alerted by Fermi-LAT. Due to the full moon, however, whose light overshadowed the signal, the large MAGIC mirrors were not able to immediately observe the emission of the ultraenergetic photons. The observation was again possible 11 days after the signal recorded by Fermi-LAT, thanks to the gravitational lensing effect (Einstein lens). The phenomenon, due to the presence of a second nearer galaxy, caused the separation of the light into two different paths, with a delay between the two signals which, calculated based on the General Relativity predictions, corresponds exactly to the 11 days actually experienced. The correspondence is of great interest and indicates that the structure of the cosmic void is that predicted by the theories, with particular reference to the number of background photons, approx. one hundred per cubic centimetre. The observation also shows that the gravitational lensing effect does depend on the wavelength of the photons.



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### **RESEARCH** LHCf EXPERIMENT RESTARTED AT CERN

Following successful completion, in the course of last week, of reinstallation of the detector in the LHC tunnel, on 25 November the small LHCf detector started acquiring the data of the new proton-

lead run, which got underway on 10 November in the LHC super-accelerator at CERN in Geneva. After a first phase of low intensity and low energy (2.5 TeV) collisions, the LHC will provide its experiments with collisions at 8.16 TeV and a low-luminosity run will be totally dedicated to LHCf data acquisition. Unlike the four big experiments installed at the LHC, LHCf is positioned in a straight line at 140 m from the point of collision of ATLAS. In this way it is able to detect particles produced "very far forward", similar to those produced in the cascades of cosmic rays impacting the Earth's atmosphere. Analysis of the number of secondary particles produced, and of their energy spectrum, is of fundamental importance for interpreting the interaction mechanism of primary cosmic rays with the nuclei of the atmosphere. The models currently used to describe these processes in fact show significant mutual discrepancies and also with to data collected from the LHCf experiment to date. This new run will provide useful information for selecting the most realistic models currently in use in order to allow better calibration and will thus have a fundamental impact on the understanding of the mysteries related to very high energy cosmic rays.



### >> THE INTERVIEW



### **BEYOND RESEARCH** Interview with Speranza Falciano, Vice President of

INFN and Technology Transfer representative of the executive board of the Institution.

As a public research organization, INFN carries out its mandate by combining the transfer of knowledge and technologies useful to society with the basic research mission. This takes place in the direct form of communication and public engagement, as well as thanks to technology transfer initiatives, with the transmission of know-how acquired in basic research to the development of technologies of public utility.

#### How are the technology transfer activities structured in the institution?

The strategy implemented by INFN for technology transfer is mostly based on the exploitation of innovative ideas and techniques that arise in the context of basic research and, subsequently, trying to facilitate and speed up the processes that drive the exchange of knowledge between the research world and society, be it the world of business or any context that can be the recipient of applications, thus allowing new technologies to translate into goods and services usable by the community. To achieve this goal INFN, consisting of several facilities distributed around the country, has set up an organisation specifically covering aspects of an administrative-legal and scientific-technological nature, all coordinated by a steering committee, the National Committee for Technology Transfer (CNTT), whose connection with the central governing bodies is ensured by a member of the Executive Committee constantly attending the meetings. The Committee is supported operationally by the Technology Transfer Department (UTT) that takes care of administrative issues and those of operational support to researchers and is reinforced by qualified human resources with various profiles of expertise (legal/patents, economic, technological), typical of a sector with strong interdisciplinary characteristics.

### Technology transfer primarily involves researchers. How do they participate in the strategic decisions?

INFN has also paid a lot of attention and effort in the organisation and training of so-called Local Technology Transfer Representatives, one or two for INFN facility, dealing, on the one hand, with awareness building of



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the scientific network and, on the other, providing initial feedback to researchers who submit questions on the exploitation of their research. As of September 2012, regular meetings are held, attended by the Local Representatives and members of the CNTT. Training is considered an opportunity for communication and sharing of the technology transfer guidelines and for aggregation and feedback with respect to the results achieved.

Finally, the formulation of specific regulations approved by the Governing Board of the Institute has made an important contribution to the development of technology transfer activities by establishing a set of rules on the exploitation of research conducted.

# Being part of the institution's mission, the dissemination of skills is somewhat a duty. Who benefits from it?

Basic research needs advanced technologies that often are not yet part of the industrial know-how and require innovative solutions. The search for these solutions continuously provides opportunities for technology transfer to the social and industrial fabric, in particular allows a wealth of expertise that makes our companies more innovative on the world market to be transferred to Industry. The use of highly qualified industry partners allows INFN to be competitive in international collaborations in which it participates to build the complex instrumentation required by our research, and this is definitely an example of a return that benefits us.

More generally, I think it is fundamental to encourage and make an effort on the "third mission" in order to instil in society the idea of research as an indispensable means for the modernisation and competitiveness of the country. This too is an important return that impacts on funding and on the transfer capacities of our know-how.

# Which are the most significant examples of fruitful relationships between INFN and the business world?

An excellent example of how frontier technologies necessary for INFN research have produced important effects on the domestic industry in terms of knowledge transfer, economic and innovation impact is the scientific enterprise at the Large Hadron Collider (LHC) at CERN in Geneva that led to the discovery of the Higgs boson. Many Italian industries have built high-tech objects for the LHC, Italy has been able to secure a return on investments in research superior to that of other European countries. For example, in industrial supplies in 2006, year of full construction of the machine, in the ranking of the twenty participating nations, Italy was second in the civil engineering (approx. 23% of the total) and electrical engineering (approx. 30%) sector, second in mechanical engineering (19%) and third in the vacuum and refrigeration technologies (13%). Overall it was second (18%), preceded only by France (34%, host nation) and followed by Germany (15%). It should be noted that the Italian contribution to CERN, proportional to GDP, is 11%. Besides the domestic industry participation at CERN, INFN has also well-established relationships with numerous other companies, with which we have created and developed new technologies for research purposes,



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which have found a market and have become the subject of large-scale industrial production. The fields of micro-electronics and superconductivity are examples of this. Success stories like these have given rise to contracts or collaboration agreements with two advantages: the possibility to develop technologies for which we have skills but not always the right tools, and the economic exploitation of ideas developed within the institution, which can be disseminated if exploited at the industrial level.

#### Which tools are most used for exploiting the innovation capacity of INFN?

INFN uses all the traditional tools for the exploitation of its knowledge such as patents, collaborative research and contract work. In particular, collaborative research, more congenial to the research and development activities conducted in our institution, often benefits from external funding to collaborate with companies, making use of regional or national calls. The difficulty of collaborative research is that it must be conducted choosing partners with the procedures of the procurement code and this greatly limits the freedom of research and collaboration. This tool will therefore remain little used until administrative simplification tools have been identified for research institutes. Conversely, INFN conducts a lot of research commissioned for the technologies and methodologies that it possesses, i.e. it is chosen by third parties for research and development.

### And which are the projects to strengthen TT activities in the near future?

In the future, TT activities on which the institution will focus most, in addition to those already in place, concern initiatives suitable for systematising the development potential in a given area. This takes place through the creation of an increasing number of skills networks which connect the facilities which inside INFN possess the know-how and technology in a specific sector, making collaboration possible with national Technology Districts and Clusters. Examples are CHnet (Cultural Heritage network) and RADnet (irradiation facility network based on the accelerators of the INFN National Laboratories). In addition, INFN spin-offs and technology incubators developed at CERN and transferred to Italy with very favourable conditions (licenses, training, etc.) will be supported. Start-up incubators may be located with INFN facilities or operating units that have a relationship with INFN (Universities, other Organisations, Consortia or Companies that want to innovate and grow). A CERN-INFN collaboration agreement, already signed, will regulate support to Italian incubators that will form a network coordinated by INFN.

# In your opinion, is there full awareness of the benefits of doing TT by institutions traditionally oriented towards basic research, such as INFN?

Unfortunately, the third mission involves and engages only a part of the institution's researchers. A large part is inclined to think that it is a distraction from the main science activities. This should not however limit our strategy in this direction. Everyone has their own preferences and vocation, and I think we can leverage the specific vocation of those who today think of their know-how as a resource that goes beyond the research purpose for which it was developed. Among the goals is that of enhancing our reputation and



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a social consensus towards activities whose purpose is not always understood or shared by the public. Then there is the aspect of access to funding. Increasingly often, projects for which specific funding is requested are better evaluated if presented in collaboration with external parties, or when they highlight the possibility of technology and skills transfer to society. The examples in this case range from the development of technologies for space missions, to medical applications where accelerator physics plays an important role in the treatment of cancer and detectors developed for INFN research become a powerful diagnostic tool. The cultural heritage and the environment are other sectors that benefit from the use of our technologies and the list of applications is certainly not exhaustive.

The researcher is of course not requested to change his job, only to make a small cultural step. Small because the possibility of doing technology transfer is often written in the research or technology that you have in your hands: it's a matter of seeing it, understanding its importance and seeking support to exploit it and make it concrete. As researchers we should have a complete cultural training which enables us to perform our main mission, that of knowledge producers, but leaves room for the ability to understand that a new technology - and thus our doing research - acquires greater value if it finds a useful application in society and encourages innovation and development in the broad sense.



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# 25<sup>TH</sup> ANNIVERSARY OF LUNA

LUNA (Laboratory for Underground Nuclear Astrophysics) is an international experiment based on a small linear accelerator, the only one in the world to be installed in an underground laboratory to shelter it from the shower of particles coming from the cosmos. The experiment, whose 25<sup>th</sup> anniversary will be celebrated on 1 December next, is installed at the Gran Sasso National Laboratories, shielded by 1400 metres of rock that protect the infrastructure from cosmic rays, allowing the observation of extremely rare processes. LUNA aims to study the thermonuclear fusion reactions that take place in the core of the stars where, for billions of years, and still today, the elements that make up matter are produced. The experiment recreates in the laboratory the energy of nuclei at the centre of stars, from tens to several hundred keV, turning back the clock with its accelerator. LUNA is able to recreate the conditions of the stellar matter up to one hundred million years after the Big Bang when the first stars were formed and those processes that gave rise to the mysteries that we have not yet fully understood were triggered, such as, for example, the enormous variability in the quantity of elements in the Universe.

The core of LUNA is a small linear accelerator (terminal voltage of 400 kV), which provides hydrogen or helium beams with very high current (up to approx.  $600 \,\mu$ A), sending them to a solid or a gaseous target and inducing nuclear fusion reactions. Special silicon, germanium or scintillating crystal detectors photograph the products of the collisions and identify the reaction, starting from the particles produced and the radiation emitted. To take full advantage of the peculiar conditions of the Gran Sasso Laboratories, the materials used in the experiment, in particular the detectors, are selected to have a very low internal radioactivity. Thanks to this, LUNA holds the sensitivity record in a nuclear physics experiment, having been able to observe and isolate, in a particular experiment, a single event in two months of continuous interaction between the projectile beam and the atoms of the target.

The first phase of LUNA was dedicated to the study of the fundamental reactions of the proton-proton fusion chain of the so-called "CNO" (Carbon-Nitrogen-Oxygen) reaction cycle. Subsequently, the activity



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was focused on hydrogen combustion processes in cycles that are triggered at temperatures higher than that of the Sun, such as Ne-Na (neon-sodium) and Mg-Al (magnesium-aluminium) reactions. More recently, significant results have also been obtained with regard to "primordial nucleosynthesis", i.e. the network of nuclear reactions that took place in the very first moments after the Big Bang, and which determine the abundance of hydrogen and helium in the material that extended into space starting from the initial flash.

Following the numerous successes in over 15 years of work, in 2007 the collaboration proposed the installation of LUNA-MV, a machine capable of achieving higher energies and of allowing reactions that take place in the stars at temperatures between 500 million and one billion degrees to be studied. Installation of the new accelerator, which will occupy a total area of approx. 400m<sup>2</sup>, is scheduled for autumn 2018 in room B of LNGS. The accelerator will be able to provide intense proton, alpha particle and carbon ion beams in two different beam lines, one with solid targets and the other with gaseous targets. The machine and the beam lines will be housed in an 80 cm thick concrete infrastructure, which will ensure complete shielding of the accelerator from the rest of LNGS.

LUNA is an international collaboration of approx. 40 researchers including Italians, Germans, Scots and Hungarians, in wich INFN and GSSI are taking part for Italy, the Helmholtz-Zentrum Dresden-Rossendorf for Germany, the Hungarian Academy of Sciences - Institute for Nuclear Research (MTA-ATOMKI), for Hungary and the School of Physics and Astronomy of the University of Edinburgh for the UK. In Italy, the Gran Sasso National Laboratories of INFN, the INFN sections and the Universities of Bari, Genoa, Milan, Naples, Padua, Rome La Sapienza, Turin and the INAF Observatory in Teramo are collaborating in the experiment.



NOVEMBER 2016

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### COVER

Coils of a cyclotron used in nuclear medicine (©AAA, lvrea)