FEBRUARY 2019

NEWSLETTER 56

Istituto Nazionale di Fisica Nucleare

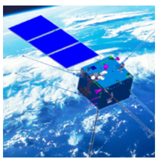
INTERVIEW

WHEN RESEARCH FINDS APPLICATIONS

Interview with Valter Bonvicini, INFN researcher and chair of the INFN Scientific National Commission 5, dedicated to the coordination of applied research activities, p. 2

NEWS

FOCUS



LIMADOU IN SPACE
WITH THE CHINESE CSES MISSION, p. 10

» INTERVIEW

WHEN RESEARCH FINDS APPLICATIONS

Interview with Valter Bonvicini, INFN researcher and chair of the INFN Scientific National Commission 5, dedicated to the coordination of applied research activities

The achievements of the research carried out at INFN are increasingly exploited in areas other than fundamental physics. This is due to the ambitious research objectives of frontier physics experiments. The need to push technologies beyond the limits of existing possibilities often leads to the development of solutions whose high performance can easily be applied inmany sectors. INFN, in particular, is a solid reference at the national and international level for applications related to the development of prototypes and to the creation of today's particle accelerators. Those technologies find application in other research fields and in areas with several and econiomic impact, such as medicine, sensors, electronics, information technology and materials analysis. The INFN National Scientific Commission 5 was established to coordinate technological research and the development of applications of the methods and technologies developed at INFN.
We asked Valter Bonvicini, chair of the Commission, to describe the main lines of research and development in which INFN is investing currently and in the foreseeable future.

Which are the main interdisciplinary applications of the techniques and technologies developed at INFN in recent years?
They are many. Developments in the fields of radiation detectors, electronics, accelerators and calculation techniques are in fact extremely important applications in very different scientific fields: in medicine, for example, both from the point of view of diagnostic imaging as well as treatment, in radiobiology, in the cultural heritage sector, in environmental physics, in geology and volcanology and in the space sector.

How do you define an investment strategy in a sector that depends so strongly on other INFN research activities? What did CSN 5 choose to invest most in and based on which criteria?
In my opinion, it is necessary to act on two levels. The starting point is always frontier R&D for the "core"

» INTERVIEW

activities of the institute. This involves pushing technologies beyond the existing limit, exploring new solutions and new approaches that, in turn, will open new paths for interdisciplinary applications. One of the many possible examples: the new charged particle plasma acceleration techniques could help in the future to implement a technology for building particle accelerators with high accelerating fields and small dimensions compared to conventional accelerators. In perspective, this is of course extremely interesting for high energy physics, due to the possibility of building compact accelerators, but this technology can also open the road to a whole range of applications in other sectors, such as hadron therapy using ion beams accelerated through laser-plasma interaction.
The other level consists of rationalising and directing the efforts of the scientific community on cutting-edge and high-impact projects, instead of dispersing the resources available in a large number of limited impact experiments. In this sense, to better fulfil its coordination and steering role, the CSN 5 has also adopted new funding mechanisms ("Calls for proposals") that are effective scientific policy instruments.
To answer the last part of the question, among the strategic and growing scientific sectors in recent years, I would mention accelerator technologies and the developments related to oncological hadron therapy (radiobiology, dosimetry, calculation, treatment plan simulation and modelling and detectors).

Is it possible to make a rough assessment of the socio-economic impact of a new technology when it is developed?
Scientific and technological advances have always had an impact not only on society but also on economy. Often, the potential socio-economic impact of a new technology is clear (or at least perceivable) from the outset, while sometimes it becomes evident only as the development progresses. For example, since the last decades of the last century, Artificial Intelligence has undergone an impressive development which is already revolutionising society and economy and which will have even more marked effects in the near future. The computing power available increases exponentially every year and, thanks to this, machine learning techniques are now possible: computers "learn by themselves" to improve the performance of an algorithm, using statistical methods on a huge amount of data.
Another very active field of research, whose overall socio-economic repercussions are however more difficult to estimate at the moment, are quantum technologies; however, considering only their possible application to particle physics, I'd say that the most promising aspects concern quantum sensors and certain aspects related to quantum computation, such as the development of algorithms that can be used in future quantum machines.

How does the idea of applying a technology developed to study particles to a completely different

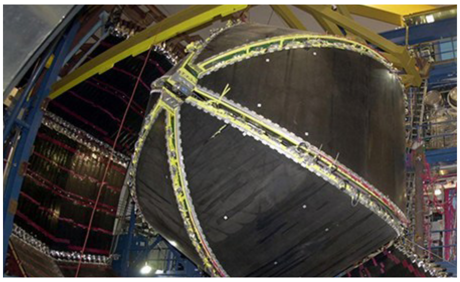
» INTERVIEW

area come about? Is it necessary to constantly dialogue with other scientific and industrial realities?
In interdisciplinary applications, the relationship and continuous discussion with the scientific community to which the application is addressed is fundamental. One always starts from the idea of the researcher, but this must be subjected to a proof of principle and then gradually tested and validated with the methodologies of the scientific community to which it is addressed. For example, in the development of a new diagnostic imaging system, interactions with the medical community must begin immediately to understand, first of all, if there is an effective interest in the proposed development in relation to the state of the art in the industry. Then, the prototype must be tested and validated with preliminary, pre-clinical, clinical, and other studies. All this presupposes a complete collaboration with the community of reference (doctors, in this case).
Also for what concerns any industrial applications, communication and collaboration with companies are essential right from the outset. Here our scientific community can count on the functions responsible for coordinating INFN Technological Transfer activities, in order to protect intellectual property, file patents arising from the research activities and for everything related to exploiting innovative skills. It is certainly not surprising that the majority of patents in the institute's portfolio derive from research activities conducted in CSN 5. Ultimately, the close collaboration between CSN 5 and Technology Transfer is natural on the one hand, and fundamental on the other.

Your activity as an experimental physicist concerned and above all concerns the development of detectors for particle physics and astroparticle physics experiments, with the search for antimatter in cosmic radiation. What led you to coordinate the commission that promotes technological application of the skills acquired in research work?
Basically, the belief that CSN 5 is a great resource for our institute. In fact, our Commission plays some fundamental and quite peculiar roles within INFN: it is above all the "forge of ideas", where frontier technologies are proposed and developed for the future experimental activities of INFN; it is the place where scientifically and socially important activities are supported, such as those linked to the interdisciplinary field; and finally, it is the natural incubator where certain activities grow and develop, which then have potential for application and exploitation in the industrial field.
These unique and distinctive characteristics must, in my opinion, be safeguarded and further developed, within a general context that, on the one hand, sees a continuous contraction of the "ordinary" resources of the institute and, on the other, the consequent increasing importance of enhancing the competitiveness of INFN in the acquisition of external funding through participation in competitive tenders. In this way, also the introduction by CSN 5 of grants for young researchers is part of a strategy that aims to foster

» INTERVIEW

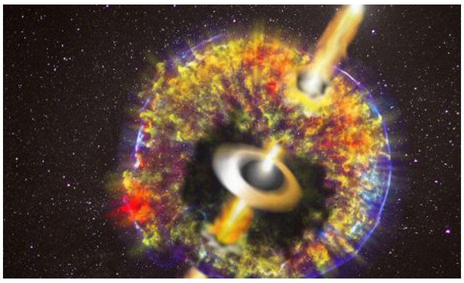
the scientific autonomy of our young people and allow them to gain experience in the preparation, management and scientific execution of projects on key topics for the technological research of the institute. ■



RESEARCH

CLAS SHEDS LIGHT ON THE BEHAVIOR OF QUARK

The CLAS experiment at the CEBAF accelerator of the Jefferson Laboratory, in the United States, with the collaboration of INFN researchers, has published on Nature a study on the behaviour of quarks that could unveil a mystery that has lasted 35 years. In 1984 the European Muon Collaboration (EMC) of CERN in Geneva discovered that the quarks that make up the protons and neutrons of the atomic nuclei behave differently than the quarks that make up free protons and neutrons. The unexpected phenomenon - which scientists called the EMC Effect from the acronym of their experiment - remained however all these years without a universally accepted explanation. Now, the new research by CLAS could shed light on this unsolved question: the result obtained shows that the internal structure of protons and neutrons changes when these particles aggregate forming related pairs: in these pairs a strong overlap of protons and neutrons is created, that gives the quarks inside them more space to move and leads them to move more slowly. The analysis represents a step forward for the study of low-energy QCD in nuclear systems. ■



RESEARCH

THE RELATIVISTIC JET PRODUCED BY THE SOURCE GW170817 OBSERVED

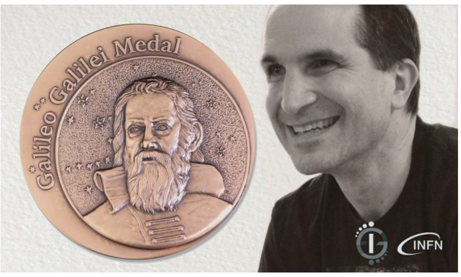
It took thirty-three radio telescopes spread across five continents to measure the dimensions of the astrophysical source GW170817, detected in both gravitational waves and electromagnetic radiation. The result was obtained by researchers from INAF National Institute for Astrophysics, INFN, University of Milano-Bicocca, GSSI Gran Sasso Science Institute and ASI Italian Space Agency, and published on Science. The study shows how a jet of energy and matter originated from the merge of two neutron stars, and propagated into the interstellar space at almost the speed of light. The two merging neutron stars released neutron-rich material into the surrounding space, which then formed heavy metals. The jet had to make its way through this material. Had it not been able to emerge, it would have deposited its energy, causing a quasi-spherical explosion. This information adds another element to our understanding of these phenomena: thanks to observations of this type we will have, in the coming years, a more complete and precise idea of the various phases in the life of black holes and neutron stars, starting from their formation. ■

Illustration by S. Salafia e G. Ghirlanda.

APPLICATIONS

DIGITAL ARCHAEOLOGY: EUROPEAN ARIADNEPLUS PROJECT LAUNCHED

Monuments, sites and archaeological finds, in Europe and other countries, can be reached just with a click. This is the ambitious goal of the ARIADNEPLUS project, which aims to build a platform to integrate data from archaeological investigations, and which sees among its new partners also INFN, with its CHNet network dedicated to the cultural heritage. The project, whose launch event took place in February, is the geographic and thematic extension of the previous ARIADNE project: Israel, Argentina, Japan and the United States joined it and scientific investigations were integrated. And to implement scientific investigations the INFN-CHNet network joined the project, since it is active in the field of archaeological heritage analysis with a great variety of techniques. The INFN-CHNet network is already working on the creation of digilabs, digital archives that will initially allow researchers, followed by the entire community and subsequently the public, to share data coming from all the nodes of the network. This will open enormous possibilities for researchers, including the reuse of data: indeed, the data acquired by one group can be used by other researchers to respond to new queries and guide any subsequent experimental campaigns.

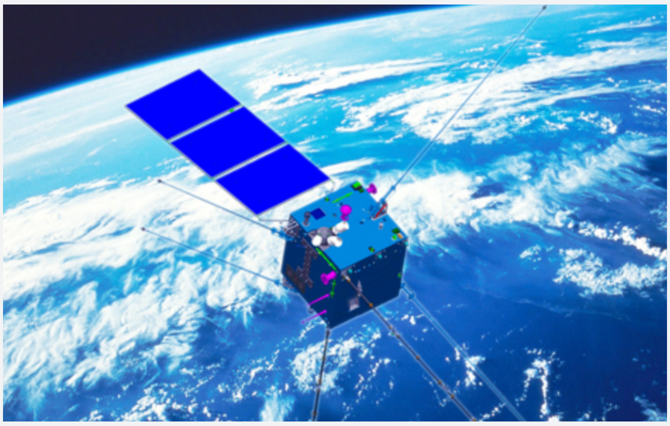


AWARDS

THE 2019 GALILEO GALILEI MEDAL GOES TO JUAN MARTIN MALDACENA

On February 15th, the Argentinian physicist Juan Martín Maldacena, Professor at the Institute for Advanced Study of Princeton, was awarded the Galileo Galilei Medal, an award given by the INFN in collaboration with its Galileo Galilei Institute (GGI) National Centre for Theoretical Physics of Florence to researchers who have made an exceptional contribution to the progress of research in theoretical physics. Maldacena received the award "for his pioneering ideas in theoretical physics, and in particular for the discovery of duality between gravity and quantum field theory, with far-reaching implications”. Maldacena has been one of the most influential figures of theoretical physics in recent decades. His numerous and fundamental insights have opened new perspectives in the field of string theory, field theory and quantum gravity. The Galileo Galilei Medal, established in 2018, is awarded every two years by a special international committee nominated by the INFN to one or at most three scientists who, in the 25 years preceding the award date, have achieved significant results in the theoretical physics field with regard to the fundamental interactions between particles, including gravity and nuclear phenomena. ■

» FOCUS



LIMADOU IN SPACE WITH THE CHINESE CSES MISSION

Studying earthquakes and volcanic eruptions from space. This is the challenge of the first great space mission resulting from the Italy-China scientific cooperation that, last year, brought the China Seismo-Electromagnetic Satellite (CSES satellite) into orbit and that was presented in Vienna, this February, during the meeting of the United Nations Committee on Peaceful Uses of Outer Space (COPUOS).

Launched a year ago from the Chinese Jiuquan Satellite Launch Centre, in the Gobi Desert, CSES was developed by the Chinese (CNSA) and Italian (ASI) Space Agencies with the aim of developing new methods for the study of geophysical phenomena, such as earthquakes and volcanic eruptions, on a global scale. Indeed, China shares with Italy a high seismic risk that has led the China National Space Administration (CNSA) to invest in the development of frontier technologies for the study of earthquakes. CSES has nine instruments on board, including one made in Italy, the HEPD (High Energy Particle Detector) built by INFN in close collaboration with ASI, within the framework of the "LIMADOU Collaboration", named in honour of Matteo Ricci, mathematician and explorer of China in the sixteenth century (the name comes from the transliteration in Mandarin of his initials).

LIMADOU is a strongly interdisciplinary mission that studies the structure and dynamics of the high ionosphere by conducting large-scale measurements of the electromagnetic environment, of plasma and of particles close to Earth. In particular, the HEPD detector, through joint observations and coordinated with the other eight instruments on board the satellite, is studying the mechanisms that connect the internal processes of our planet with the dynamics of the charged particle regions (called Van Allen bands) that surround the Earth, with the aim of identifying and developing new techniques for seismic monitoring from space. In fact, there are some indications that earthquakes may be preceded by disturbances in the terrestrial ionosphere. These disturbances could be observed by means of changes in ionospheric electric fields or through changes in

» FOCUS

the flow of high energy particles. HEPD is a high-energy particle detector based on technologies developed from particle physics experiments in space, successfully implemented by INFN in the last twenty years, in particular of silicon particle detectors. The set of the nine instruments installed on the CSES satellite will allow an accurate study of electromagnetic fields and plasma parameters in the high ionosphere and detection of the anomalous fluxes of particles caused by natural and artificial electromagnetic sources in the space close to Earth.

The LIMADOU collaboration involves numerous Italian research institutions, including, first of all, the Italian Space Agency (ASI), INFN - through the Bologna, Perugia, Rome Tor Vergata and Naples Divisions, the TIFPA Centre of Trento and the Frascati National Laboratories - the Universities of Bologna, Rome Tor Vergata, Trento and Uninettuno, as well as the National Institute of Astrophysics through the INAF-IAPS institute and CNR with IFAC. The contribution of other entities of the Italian scientific community, such as the National Institute of Geophysics and Volcanology (INGV) is equally significant. ■

Italian National Institute for Nuclear Physics

CONTACTS:
Communications Office
comunicazione@presid.infn.it
+ 39 06 6868162

Cover
The launch of CSES (China Seismo-Electromagnetic Satellite), 07/02/2018.