INFN NEWSLETTER 62

INTERVIEW



CNAO: TECHNOLOGICAL RESEARCH IN PHYSICS AT THE SERVICE OF MEDICINE Interview with Gianluca Vago, physician and professor at the University of Milan, and, as of January 2019, President of CNAO (the National Centre for Oncological Hadrontherapy), p. 2

NEWS

RECOGNITIONS SUPERGRAVITY WINS THE 2019 BREAKTHROUGH PRIZE, p. 5 INFN AND CNR AMONG THE TEN MOST INNOVATIVE PUBLIC INSTITUTIONS IN THE WORLD, p.9

SPACE

MINI-EUSO LEAVES FOR THE INTERNATIONAL SPACE STATION, p. 6 IXPE - FLYING WITH A FALCON TO OBSERVE THE UNIVERSE IN X-RAYS, p. 10

INTERNATIONAL COLLABORATIONS

GSI-INFN SIGN AN AGREEMENT FOR CRYOGENIC TESTING OF FAIR'S MAGNETIC MODULES, $p.\ 7$

TECHNOLOGIES

FASTEST X-RAY CAMERA AT XFEL, p. 8

OUTREACH

IN CATANIA THE NEW VISITOR CENTRE OF THE SOUTHERN NATIONAL LABORATORIES HAS BEEN INAUGURATED, p.11

FOCUS



RECAS: COMPUTING RESOURCE FOR SCIENCE AND FOR THE TERRITORY, p. 12 **AUGUST 2019**



» INTERVIEW



CNAO: TECHNOLOGICAL RESEARCH IN PHYSICS AT THE SERVICE OF MEDICINE

Interview with Gianluca Vago, physician and professor at the University of Milan, and, as of January 2019, President of CNAO (the National Centre for Oncological Hadrontherapy)

CNAO of Pavia, which was inaugurated in 2010, is a centre at the forefront of the treatment of tumours with hadrontherapy. This is a form of radiotherapy that exploits the extreme precision guaranteed by particle accelerators developed for basic research in physics. CNAO, the heart of which is a particle accelerator, a synchrotron realized in collaboration with INFN and CERN, is the second hadrontherapy centre in Europe and one of the few in the world to perform treatments that irradiate tumour cells with proton beams or, depending on the tumor, with carbon ions. CNAO is also the only one in Europe with the CE marking and with experience performing clinical trials to evaluate the safety and efficacy of such treatments. The use of proton beams or carbon ions has a great advantage when compared to the X-rays used in traditional radiotherapy, in particular in the treatment of deep cancers, as it allows the release of energy in proximity to the tumour mass, thus reducing the impact on healthy surrounding tissues and, therefore, consequent side-effects.

As well as being a cutting-edge centre, CNAO is in continuous evolution, adapting the techniques it employs to the most recent developments in the technology used in basic research in physics. Recently, CNAO launched the INSIDE (Innovative Solution for Dosimetry) trial, along with INFN, the University of Pisa, Sapienza University of Rome, and the Enrico Fermi Historical Museum of Physics and Study and Research Centre. INSIDE is an imaging system capable of "photographing" the proton beams and carbon ions used to strike tumours in hadrontherapy and of rendering therapies more precise and effective, by observing radiation in "real time".

We asked Gianluca Vago, President of the CNAO Foundation as of January 2019, and past Vice-Chancellor of the University of Milan, to describe the state of the art and prospects for development at the Pavia centre.



» INTERVIEW

CNAO has a long history, from the first project design, to its construction, to the implementation of patient treatment.

CNAO is a concrete example of the collaboration between physics, medicine and engineering; it was conceived as an idea in 1991 thanks to the insight of Ugo Amaldi, particle and accelerator physicist, and Giampiero Tosi. At the time, Amaldi was working at CERN and Tosi was directing the Health Physics department at the Niguarda Hospital in Milan. Amaldi and Tosi's initial idea immediately received the support of INFN management, which – thanks to President Nicola Cabibbo – decided to directly allocate the first lot of funding. Subsequently, INFN kept supporting CNAO via research projects financed by Group V.

The centre, for which Amaldi and Tosi had laid the scientific foundations, first saw the light of day at the beginning of the 2000s under the impetus of Umberto Veronesi - in his capacity as Minister of Health – and Erminio Borloni. Borloni, thanks to his vision and his managerial skills, succeeded in providing Italy with a unique, cutting-edge facility, weaving around the centre a network of essential national and international collaborations. The most numerous and important collaborations were conceived with INFN's different laboratories and divisions - some 15 - and these contributed, in many different ways, to the creation of the centre's special technology and infrastructure.

In 2011, the first patient arrived and, up until today, 2,500 people affected by radioresistant or nonoperable tumours have been treated at CNAO with hadrontherapy. Since 2017, hadrontherapy has been part of the basic benefit package (LEA) that is funded by the National Health Service (SSN).

What makes CNAO a centre of excellence at an international level?

CNAO is one of only six multi-particle (protons and carbon ions) centres in the world able to treat tumours with hadrontherapy, an advanced form of radiotherapy that, instead of X-rays, uses proton beams and carbon ions. The latter are heavy particles that strike the tumour mass with greater biological efficacy, thus preserving the surrounding healthy tissues. It is an innovative cancer treatment that is used when traditional radiotherapy isn't effective or in the case of inoperable tumours.

At CNAO, we also do research with the aim of translating results into clinical practice and, in this regard, the link with INFN is strong and essential.

Can you give us an account of CNAO's activities from when you began treatments on voluntary patients until today?

2,500 patients have been treated, and the results have exceeded expectations. The data, though only partial since the observation period is still short, tell us that hadrontherapy is capable of halting the disease in more than 80% of cases. Some of the diseases that we treat at CNAO include sarcomas,



» INTERVIEW

chordomas, chondrosarcomas, ocular melanomas, meningiomas, adenoid cystic carcinomas, paediatric solid tumours.

From the perspective of treatment precision, we have also observed a reduction in the toxicity in healthy tissue, which is essential for patients with a long life expectancy.

The INSIDE trial, fruit of the collaboration between CNAO, INFN, the University of Pisa, Sapienza University of Rome and the Fermi Centre, was recently launched. What does it involve?

It is an important project that emerged from the combination of the different strengths and ideas of prestigious centres and universities. INSIDE is the first two-mode system in the world (consisting in a PET scanner and a charged particle tracking system) capable of monitoring the beams of carbon ions and protons used in hadrontherapy in real time. We will be able to observe in real time where the particle beams have their maximum destructive effect and, on the basis of these observations, recalibrate the particle beams' parameters to render treatment increasingly efficient.

The new line of research at CNAO, which is also being undertaken in collaboration with INFN, is in the development phase. What activities will you be undertaking?

Since last May, the new line of research has been active in terms of testing and fine-tuning. It is a completely separate line from the patient treatment rooms and wholly dedicated to research. We will exploit the potential of our particle accelerator for research, for example, in the fields of radiobiology and radiation protection, to simulate the effects of radiation on materials used in aviation and in the aerospace industry. We will test new ions, such as oxygen and helium, to observe their action and to offer increasingly innovative treatments.

What do you foresee and plan for the future of CNAO in the short and long term?

We want to increase the scientific research that we undertake in collaboration with INFN and explore the potential of hadrontherapy in the treatment of tumours. It will be important to further increase the clinical collaborations that already exist with the main national treatment institutes in order to attain a complete, multi-disciplinary approach. We will also work a lot with advocacy groups to improve cancer patients', and their families', awareness and understanding of hadrontherapy.

Finally, we intend, in collaboration with INFN, to enhance the cutting-edge technological tools to have increasingly effective equipment available for the treatment of tumours.





RECOGNITIONS SUPERGRAVITY WINS THE 2019 BREAKTHROUGH PRIZE

The 2019 Breakthrough Prize in Fundamental Physics, which is worth 3 million dollars, was awarded to the theoretical physicists Sergio Ferrara (CERN and INFN Frascati National Laboratories), Dan

Freedman (Massachusetts Institute of Technology and Stanford University), and Peter van Nieuwenhuizen (Stony Brook University) for the "invention of supergravity, in which quantum variables are part of the description of the geometry of spacetime". Ferrara, Freedman and van Nieuwenhuizen are the architects of supergravity, a very influential theory dating back to 1976 that successfully integrated the force of gravity with a particular type of quantum field theory. The winners will be given their prize at a ceremony that will take place on 3 November 2019 at NASA.





SPACE MINI-EUSO LEAVES FOR THE INTERNATIONAL SPACE STATION

The Soyuz MS14 spacecraft, which was launched on 22 August from the Baikonur Cosmodrome, hooked the International Space Station (ISS) on 27 August. On board the craft was the Mini-EUSO

(Multiwavelength Imaging New Instrument for the Extreme Universe Space Observatory) ultraviolet telescope. The telescope is the product of an agreement between the Italian Space Agency (ASI), the financing body, and the Russian Space Agency Roscosmos, and was developed by an international collaboration led by INFN, with the contribution of the Ministry of Foreign Affairs and International Cooperation (MAECI). Mini-EUSO, which will be activated in the next few months by the astronaut Luca Parmitano, will observe the Earth from Russia's Zvezda module of the ISS. It will be pointed towards the Earth to record ultraviolet emissions of cosmic, atmospheric, and terrestrial origins, thanks to the optical system and to the new generation focal plane, which allow the telescope to reach an unprecedented level of sensitivity.

The main scientific objectives of Mini-EUSO include: the first mapping of the Earth's nocturnal ultraviolet emissions and of their variations - whether anthropic or bioluminescent, i.e. linked to particular behaviours of plankton and algae; the study of the upper atmosphere; and the study of signals produced when meteors impact the atmosphere. Mini-EUSO is, moreover, capable of observing ultra-high-energy cosmic rays, particles the origins of which are still being debated and which, it is presumed, come from other galaxies.





INTERNATIONAL COLLABORATIONS GSI-INFN SIGN AN AGREEMENT FOR CRYOGENIC TESTING OF FAIR'S MAGNETIC MODULES

INFN and GSI Helmholtzzentrum für Schweronenforschung recently signed an agreement to test a series of complex magnetic systems – the quadrupole modules of the FAIR (Facility for Antiproton and

Ion Research) accelerator's SIS100 machine – through the execution of extensive cryogenic tests. The agreement is based on a long and successful collaboration between the two research institutes in the development and construction of superconducting magnets. For FAIR, the advanced technology modules are the result of a complex international production process. First, the quadrupoles' superconducting units are custom manufactured in Russia. These are composed of various types of magnets, for the focusing and correction of the particle beam. Next, these units are sent to Germany, to the Bilfinger Noell laboratory in Würzburg, where they are assembled with the other components. More than 80 of these quadrupole modules, once assembled, are then sent to the superconductivity laboratory in Salerno, Italy. Here they will be run at the final operational temperature of -269°C on a cryogenic testing structure specially created for this process. In addition to INFN, with the Salerno group associated to the Naples division, and the University of Salerno, ENEA and the Competence Centre for New Technologies and Productive Activities (CRdC) participated in establishing the laboratory with PON funding.



NEWSLETTER 62 Istituto Nazionale di Fisica Nucleare

AUGUST 2019



TECHNOLOGIES FASTEST X-RAY CAMERA AT XFEL

The installation of the fastest low-energy X-ray camera in the world was recently, successfully concluded at the European XFEL in Hamburg. It is an image detector for electromagnetic radiation in the X band (called

DePFET Sensor with Signal Compression, DSSC) and is based on silicon sensors. The detector is unique of its kind and represents the culmination of more than ten years of research and collaborative, international development by a group of researchers associated with the INFN divisions in Milan and Pavia. This group worked in collaboration with DESY, the University of Heidelberg, and the European XFEL, which coordinates the international DSSC consortium. The detector was specifically planned for X-rays of energy between 0.5 and 6 keV. Specifically, it will enable the ultrafast study of electronic, spin, and atomic structures on a time scale of tens of femtoseconds. The European XFEL is able to produce packets that contain up to 2,700 X-ray flashes. These can be launched in quick succession with only a 220-nanosecond time difference between two flashes. At full capacity, the DSSC detector will acquire images at the speed of 4.5 million images per second and will be able to store 800 images of 1 megapixel. At the moment, a second camera, which will allow better energy resolution and an even higher dynamic interval, is already under development.





RECOGNITIONS

INFN AND CNR AMONG THE TEN MOST INNOVATIVE PUBLIC INSTITUTIONS IN THE WORLD

The INFN and the Italian National Research Council (CNR) occupy respectively the ninth and tenth position in the 2019 Nature Index of the most innovative government institutions in the world, the ranking

drawn up annually by Nature and based on the number of articles of great scientific relevance, published in 82 of the leading scientific journals. Already present in the 2018 Nature Index, the INFN climbs a position, moving from tenth to ninth, while the CNR enters the ranking this year. Italy, with two positions among the top ten, is the first among European countries.

The Chinese Academy of Sciences (CAS) is in first place in the Nature Index 2019 of world government institutions, followed by the French National Center for Scientific Research (CNRS) and the American National Institutes of Health (NIH). NASA occupies the seventh position. For the fourth consecutive year, moreover, the INFN appears in third place in the ranking of world government institutions dedicated to physical sciences.





SPACE

IXPE - FLYING WITH A FALCON TO OBSERVE THE UNIVERSE IN X-RAYS

It's full speed ahead for the NASA mission involving the IXPE satellite (Imaging X-Ray Polarimetry Explorer), a mission that has the ambitious task of opening a new window onto polarimetry X-ray

astronomy. This promises to provide new and important information on the emission mechanisms and geometry of compact objects, such as neutron stars, and on the configuration of magnetic fields at the sites of celestial X-ray sources. In recent days, the rigorous testing of the satellite equipment was successfully completed, and the American space agency has now officially announced that the launch vehicle that will take the IXPE into orbit will be one of the private company SpaceX's Falcon-9s.

The very high technological level of the detectors Italy is providing for the mission allowed IXPE to implement a very rich scientific programme, as confirmed by the NASA board that promoted it from a Small Explorer programme (SMEX) to a Medium-Class Explorers (MIDEX) programme. The most significant Italian contributions are those of the National Institute for Astrophysics (INAF), the National Institute for Nuclear Physics (INFN), and the Italian Space Agency (ASI).



NEWSLETTER 62 Istituto Nazionale di Fisica Nucleare

AUGUST 2019



OUTREACH

IN CATANIA THE NEW VISITOR CENTRE OF THE SOUTHERN NATIONAL LABORATORIES HAS BEEN INAUGURATED

The new visitor centre for INFN Southern National Laboratories (LNS) was inaugurated on 27 July. It is a space where the INFN-led scientific endeavours, including those in which LNS participate, are recounted

in an interactive, multimedia way. It is a place for welcoming the public, a space that is to be made available, in particular, for the city of Catania and the Sicilian Region for the development of cultural itineraries that also explore the historical collaboration with INFN. The visitor centre is a multimedia centre of 400 m² incorporating an itinerary of interactive exhibits and installations. Here, the visitor will be able to delve into a history of science ranging from nuclear physics to astroparticle physics, from particle accelerators to interdisciplinary research, and which includes important repercussions in the field of cultural goods and medicine. These are all activities in which LNS are a protagonist on the international stage. Thanks to this new piece of infrastructure, the Southern Laboratories will present citizens with an evocative narrative of research, technological developments, and the economic and social repercussions of the basic research activities that they lead, beginning in Sicily, and thanks also to the support of the Region.



» FOCUS



RECAS: COMPUTING RESOURCE FOR SCIENCE AND FOR THE TERRITORY

On 12 July, the second "Meeting with the users" of the Bari ReCaS DataCenter took place at the INFN division in Bari and the University of Bari Aldo Moro's Department of Physics. The event involved wide participation from the entire, multidisciplinary community that revolves around the Bari data centre. This community includes high energy experimental physicists – the centre's principal users – users who work in the field of environmental and regional monitoring through the use of data from satellites or sensors, and those who work in the field of life sciences as well as in research and teaching activities within the university community.

The Bari ReCaS DataCenter, inaugurated at the Department of Physics in July 2015, was established by the University of Bari Aldo Moro and INFN within the context of the ReCaS project (PON [National Operational Programme] "Research and Competitiveness" 2007-2013 funding programme). The project aimed to strengthen the southern regions' computing infrastructure, in order to assure there were adequate scientific computing resources for big subnuclear physics and astrophysics experiments, with data coming from CERN and from satellites. It also aimed to undertake the High Performance Computing required by other communities of researchers, such as biologists, doctors, engineers and geologists. Overall, ReCaS involves data centres in Apulia, Campania, Sicily and Calabria, where the INFN divisions in Bari, Catania and Naples respectively are involved, and the associated group in Cosenza, together with the University of Bari Aldo Moro and the University of Naples Federico II.

ReCaS-Bari today represents one of the most powerful and versatile data centres in the national landscape: it is a piece of infrastructure that is mainly dedicated to scientific computing, but which also has a multidisciplinary vocation, and is, therefore, open to the needs of a wide and diversified community that also includes the public administration and regional businesses.



» FOCUS

The data centre is currently equipped with more than 12,000 processors, has a storage capacity of around 7,000 terabytes between magnetic disks and supports (tape library) and is capable of exchanging data externally at a speed of 20 gigabytes per second. The centre is integrated, at a national and international level, with the Italian Grid Infrastructure (IGI), the Worldwide LHC Computing GRID (WLGC), the European GRID Infrastructure (EGI), and the EGI Federated Cloud.

After its first four years of activity, ReCaS-Bari is moving towards a phase of profound renewal and development. The centre will, in fact, benefit from funding from the PON "Research and Innovation" 2014-2020 programme, totalling more than 8 million Euros, which will be distributed across three distinct projects. The most significant project is IBiSCo ("Infrastructure for Big data and Scientific Computing"), which is associated with the IPCEI-HPC-BDA ("Important Project of Common European Interest on High Performance Computing and Big Data enabled Applications") infrastructure within the context of the European research strategy's "Pillar 2 Infrastructure". ReCaS also participates in LifewatchPlus projects (associated with the ELIXIR infrastructure that is dedicated to the study of biodiversity) and CNRBiOmics (associated with the ELIXIR infrastructure that is dedicated to genomics research).



NEWSLETTER 62 Istituto Nazionale di Fisica Nucleare

AUGUST 2019

Italian National Institute for Nuclear Physics

COORDINATION: Francesca Scianitti

EDITORIAL BOARD

Eleonora Cossi Francesca Mazzotta Francesca Scianitti Antonella Varaschin

GRAPHIC DESIGN:

Francesca Cuicchio

TRANSLATION:

ALLtrad

ICT SERVICE: Servizio Infrastrutture e Servizi Informatici Nazionali INFN

COVER

The Synchroton of the National Centre for Oncological Hadrontherapy (CNAO)

CONTACTS Communications Office

comunicazione@presid.infn.it + 39 06 6868162