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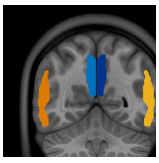
NEWSLETTER 27

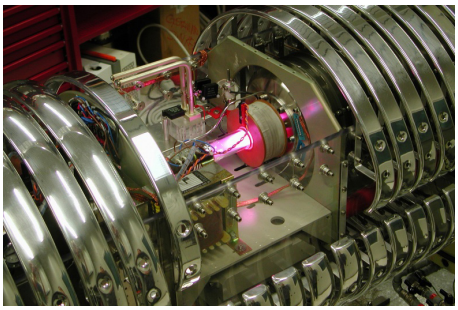
Italian National Institute for Nuclear Physics

NEWS



RESEARCH
CUORE: DETECTOR INSTALLATION COMPLETED

The CUORE (Cryogenic Underground Observatory for Rare Events) experiment at the Gran Sasso National Laboratories (LNGS) of INFN has completed the installation of the 19 towers that make up the detector. The operation, involving very delicate and high-precision procedures performed by a team of scientists, engineers and technicians, was recently completed. The 19 towers that make up the detector, consisting of 988 tellurium oxide crystals and weighing almost 750 kg, are now all suspended in the coldest point of the experiment's cryostat. The collaboration is currently preparing to make the finishing touches to the system. Then, in the coming months, the cryostat will be closed, the system will be cooled and scientific operations will start.
CUORE is an experiment designed to study the properties of neutrinos and, specifically, it will look for a rare process called neutrinoless double beta decay. Detecting this process would allow scientists to measure the mass of neutrinos, and also determine whether or not they are Majorana particles, thus offering a possible explanation for the prevalence of matter over antimatter in the universe. The experiment is an international collaboration involving some 157 scientists from thirty organisations in Italy, the USA, China and France. The INFN is taking part through its Bologna, Genoa, Milan Bicocca, Padua and Rome divisions and the Frascati, Gran Sasso and Legnaro National Laboratories. ■



RESEARCH

FROM DEEP UNDER THE GRAN SASSO MASSIF TO THE HEART OF RED GIANTS

A rare nuclear reaction that occurs in stars, specifically in red giants, has been observed with unprecedented precision by LUNA (Laboratory for Underground Nuclear Astrophysics) at the Gran Sasso National Laboratories of INFN. In detail, the experiment has revealed that oxygen-17, a rare oxygen isotope, heavier than the oxygen in the atmosphere, is destroyed at twice the speed originally estimated. This finding represents a milestone in the research being conducted by the LUNA collaboration to investigate the origin of the elements that make up the matter in the Universe and which, for billions of years, have been formed by the nuclear reactions that take place inside stars, and are still being produced. LUNA is a research facility based on a compact linear accelerator. It is the only one in the world installed in an underground laboratory, in order to observe extremely rare processes. The aim is to recreate the energy ranges found inside stars, and to go back in time to one hundred million years after the Big Bang, when the first stars were formed. We still do not fully understand all the processes that occurred at this point in the formation of the universe, including those that led to the huge variety in the quantities of the elements that exist.
LUNA is an international collaboration involving some 40 researchers from Italy, Germany, Scotland and Hungary. Italy is contributing through the INFN Gran Sasso National Laboratories, the INFN divisions, the Universities of Bari, Genoa, Milan, Naples, Padua, Rome La Sapienza and Turin and the INAF Observatory in Teramo. The findings have been published in Physical Review Letters. ■

INTERNATIONAL COLLABORATION

INFN AT THE AFRICAN SCHOOL OF PHYSICS 2016 TO RE-LAUNCH RESEARCH IN AFRICA

The fourth edition of the African School of Fundamental Physics and Applications (ASP-2016) has been held in Kigali, Rwanda. It brought together 75 students from universities in 28 African countries. The event was made possible thanks to the support of numerous American and European laboratories, universities and research agencies, including the INFN, which contributed around 20% of the total budget of the latest edition of the School. The first edition of the biennial African School was held in 2010. Its objective is to enhance the continent's development capacity in fundamental and applied physics. The scientific programme of the 2016 edition mainly focused on sub-nuclear physics and physics beyond the Standard Model, with some lectures on notions of astrophysics and nuclear physics. Workshops were also held on topics of particular scientific interest and issues that have been the subject of widespread media coverage, such as the discovery of gravitational waves. Rwanda University then hosted a Forum Day which was attended by Rwanda's Education Minister and various members of the East African Union, specifically the East African Science and Technology COmmission (EASTCO). During the event the INFN outlined the possibility of creating a compact research infrastructure, as an incubator for the African Light Source (ALS), an ambitious project that aims to provide Africa with a synchrotron light source to boost capacity building throughout the continent, through advanced applications in medicine, palaeontology and life science. This project will be one of the central topics of discussion at the next edition of the African School. The appointment is for 2018 in Windhoek, Namibia. ■

NOMINATION

PAOLO GIUBELLINO APPOINTED DIRECTOR OF GSI AND FAIR, IN GERMANY

Paolo Giubellino, Research Manager at the INFN has been appointed Scientific Director of the prestigious GSI Helmholzzentrum für Schwerionenforschung (Helmholtz GSI Centre for Heavy Ion Research) with headquarters in Darmstadt, Germany. He will also become Director of FAIR (the Facility for Antiproton and Ion Research in Europe), an international laboratory currently under construction, close to the GSI. Paolo Giubellino will take office on 1 January 2017, once his term of office as head of the ALICE experiment at CERN ends. He was one of the founders of this international collaboration involving more than 1,500 physicists from 42 countries and has been its spokesman since 2011.

Born in Turin, Italy, in 1960, since 2000 Paolo Giubellino has been a member of the ICFA (International Commitee for Future Accelerator) Instrumentation Panel, the body which gathers together the world's high-energy physics laboratories. He holds several research coordination and evaluation positions in various countries. He has received scientific awards in Mexico, Cuba, Ukraine and Slovakia. In 2014 he was the first Italian physicist to be awarded the "Lise Meitner" prize, the most prestigious recognition for work in the field of nuclear physics, awarded by the European Physical Society. He is the author of over 300 articles published in international scientific journals. ■

» INTERVIEW

INFN PROJECT TO STUDY NEUTRINOS RECEIVES EUROPEAN FUNDING

Interview with Manuela Cavallaro, researcher at the Southern National Laboratories (LNS) of the INFN in Catania, who has been awarded a European Research Council (ERC) Starting Grant 2016 .

When Manuela Cavallaro heard that the European Research Council (ERC) had awarded her the ERC Starting Grant 2016 (ERC-2016-SGT), her reaction was a mixture of enthusiasm and incredulity. The prestigious award supports young talented researchers who are starting their careers. The physicist from Catania, a researcher at the INFN Southern National Laboratories (LNS), received the grant for research in fundamental physics. The name of the project is NURE (NUclear REactions for neutrinoless double beta decay) and the € 1,271 million grant is the full amount of funding requested. There were almost 3,000 applications and the European Research Council has awarded 325 ERC-2016-SGTs to young European researchers, for a total of € 485 million.
We asked this young researcher at the LNS to explain the importance of this scientific project.

What is the ERC-funded project about?
This is a fundamental physics project that spans the fields of neutrino and nuclear physics. It acts a bit like a bridge between these two different aspects of physics and the ERC was impressed by this feature of the project.
At the LNS we will conduct experiments on systems relevant to double beta decay, an extremely rare decay process, yet undetected, that occurs spontaneously, in which a nucleus is transformed into another nucleus. The idea behind the project is to use nuclear reactions, in particular double charge exchange reactions, to obtain important information about the nuclear matrix elements involved in the crucial phenomenon of neutrinoless double beta decay. While being mediated by different interactions, the two processes - double beta decay and double charge exchange reaction - have many aspects in common, which can be explored in the laboratory.

» INTERVIEW

Why is it important to study this phenomenon?
The purpose of this project is to investigate certain aspects of the nature of neutrinos. We will study their mass, and test the hypothesis proposed by Ettore Majorana about 80 years ago on the dual identity of neutrinos. According to this hypothesis, a neutrino is both a tiny particle of matter and its own antimatter counterpart: an antineutrino.
Specifically, our project is an experimental contribution to the measurement of one of nature's building blocks, the nuclear matrix element, which links the average life of the nucleus that decays to the mass of the neutrino. Up until now this has been based on theoretical models. In this respect, our experiment can be considered complementary to others conducted elsewhere, for instance at the Gran Sasso National Laboratories (LNGS) of the INFN.

What was your reaction when you were told you had been awarded the grant?
When I first heard the news I was in the United States for a science congress. I still feel really excited when I think about it. This is the greatest achievement in my career. A truly satisfying result, but also a huge responsibility. Now it's time to roll up our sleeves and get down to work.

The grant also proves that excellent research can be undertaken, without having to leave Italy.
Besides giving me great personal satisfaction, this achievement also transmits a broader positive message. It shows that Italy has excellent research facilities as well, and that important results can be attained through dedication and determination. That was something I bore in mind whenever I had to consider moving abroad to continue my research. Fortunately, I eventually found the right conditions and was able to stay in my home town, also thanks to the high-level training provided by the University of Catania and to the INFN's Southern Laboratories, which have enabled the project to compete at European level.

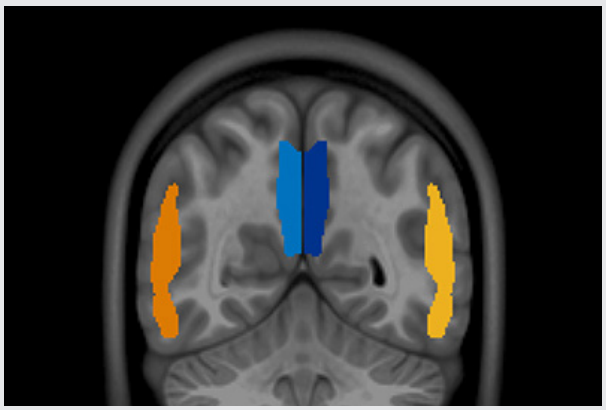
How will the grant be used?
There is one aspect concerning the ERC grant that I wish to underline because for me it is fundamental.
The entire European grant will be used for the physicists who are already working at the INFN Southern National Laboratories in Catania, not to develop new scientific instruments. In fact, this European grant also creates job opportunities for young researchers. There are five of us in the research group. We will work with the entire team at Catania University and the LNS over the next five years to carry out the experiments and analyse the data obtained.

What are the possible future developments for the project?

» INTERVIEW

The project is part of *What Next?* the INFN think tank established in 2014 to investigate new directions and approaches for research, and falls within the scope of a broader project called NUMEN (NUclear MEthods for the ENvironment). NUMEN will run for about ten years and should lead to an upgrade of the superconducting cyclotron in Catania and of the detector, the magnetic spectrometer MAGNEX (MAGNetic spectrometer for EXcyt beams). When this upgrade is complete, it will be easier to study the double charge exchange reaction. It will take less time and we will be able to investigate all ten or so candidate nuclei. ■

» FOCUS



FROM THE STUDY OF GRAVITATIONAL WAVES A DIAGNOSTIC PROTOCOL FOR ALZHEIMER'S DISEASE

The medical diagnostic protocol developed as a result of the nextMR project is currently in the trial stage at Genoa hospital and is an example of how expertise developed in basic physics research can be directly of use in medical diagnostics. Its primary objectives include the early diagnosis of Alzheimer's disease and, more generally, medical diagnosis in the fields of neurology and oncology. The nextMR project is working on the direct application of data analysis, a key feature of physics research in terms of human and computing resources. At all levels, from high-energy physics to the search for dark matter and gravitational waves, researchers have had to develop increasingly sophisticated measurement systems capable of extracting signals from background noise, and create adequate computing resources. Starting from this potential, about ten years ago a team of physicists at the Genoa division of the INFN set about developing methods and systems for analysing clinical data, using processing techniques already used to some extent in basic research, but which required substantial adaptation before they could be used in medicine.
The aim is identical to that of basic physics research and consists in obtaining a measurement by extracting a signal from the noise, i.e. distinguishing the pathology from "normality". However, with medical data, the "background noise" depends on the individual patient's clinical history and specific characteristics and not on particle which are made up of identical "subjects", as it is in physics. The data set has very different statistical characteristics from those used in physics and the fact that they are extremely variable and cannot be characterised a priori must be taken into account. In this type of context, many hypotheses applicable to physics have fallen apart and had to be adapted or completely reviewed. The nextMR group in Genoa has experience in "ordinary" basic research in the field of gravitational waves, an area that has unexpectedly turned out to be very similar to that of the diagnosis of degenerative diseases. As in the case of medical diagnostics, to detect the signal of a gravitational wave in a data set, you must know the characteristics of the potential signal and "enter" it

» FOCUS

in the data set to check for any similarities. There are many possible signal templates, and the data of a large part of them have to be compared. The problem with diagnosing degenerative diseases is very similar: the disease leaves a sort of signature in the neuro-images of the affected part, an anomaly that can be detected after comparing the image with numerous possible "signatures".
Improved diagnostics will allow medicine to shift more quickly towards preventive treatment, i.e., making it possible to predict the probable course of the disease and so provide more effective treatment, well before the symptoms become evident. This is especially true for Alzheimer's disease, which starts about 15-20 years before the first symptoms appear, and results in increasingly irreversible damage to the brain until - at the onset of the first symptoms - it is no longer possible to stop the progression of the disease and the effects can only be mildly controlled.
Another aspect not to be overlooked and that is essential for successful data analysis is computation. Given the need to handle huge amounts of data, cutting-edge distributed computing systems and highly advanced programming tools have been developed for use in basic physics research. It is thanks to these that discoveries such as the Higgs boson or gravitational waves have been made simply by using highly complex algorithms and extremely powerful computing resources. These data processing capabilities are an extremely valuable resource for medical diagnostics.
One branch of the research activity under the nextMR project is about to enter the clinical application phase. The verification of the analysis technique has already been published and it is now undergoing clinical validation at Genoa hospital. The protocol provides that the ultimate diagnosis, by the hospital and physician, is supported by physicists who provide an imaging data report - obtained through the combined use of innovative positron emission tomography (PET) technology and magnetic resonance (MR) data - giving physicians quantitative information about the regions of the brain most affected.
The entire methodology is the result of close cooperation with physicians and has led to the creation of an interdisciplinary working group of a type rarely seen before in the history of physics and medicine. The entire nextMR project – which follows on from the previous stage called MIND (Medical Imaging for Neurodegenerative Diseases) – is the result of a collaboration between the INFN, specifically the Trieste, Genoa, Pisa, Cagliari, Bari, Catania, L'Aquila and Bologna divisions, the Imago7 consortium in Pisa, the EADC (European Alzheimer's Disease Consortium), the hospitals of Pisa, Genoa, Catania and Trieste and the Recas data centre. ■

ITALIAN NATIONAL INSTITUTE FOR NUCLEAR PHYSICS

EDITORIAL BOARD
Coordination: Francesca Scianitti
Project and contents: Eleonora Cossi, Francesca Scianitti,
Antonella Varaschin.
Graphic design: Francesca Cuicchio

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

cover image:
Bottom view of the CUORE towers installed in the cryostat.