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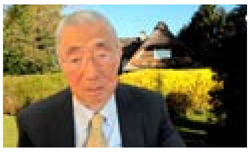
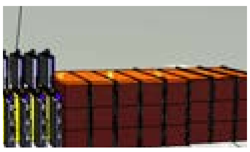
Istituto Nazionale di Fisica Nucleare





INFN _ COMMUNICATION OFFICE

» INTERVIEW

THE ANTIMATTER HUNTER AMS-02 TURNS 10

Interview with Samuel Ting, Nobel Prize in Physics in 1976 and AMS spokesperson.

Last May 19, the Alpha Magnetic Spectrometer AMS-02, the largest particle detector operating in space, celebrated its 10th birthday. Hosted on the International Space Station (ISS), where it was transported and installed in 2011, the experiment is successfully continuing its scientific mission. The study of cosmic rays, the particles that are messengers of astrophysical phenomena in the Universe, is its main objective. On the occasion of this birthday, we talked to the father of this experiment, the Nobel Prize winner Samuel Ting, who is also the international spokesperson of the AMS-02 collaboration.

How was the project of building a great experiment on board of the International Space Station such as the Alpha Magnetic Spectrometer born?
In the early 1990s, I was working in my garden, and I was thinking, I've been doing particle physics all my life maybe I should do something different, something I know nothing about. Then I remembered, many years ago I did an experiment that discovered the anti-deuteron (a particle made of an anti-proton and of an anti-neutron; ed. the antideuteron was discovered in 1965 independently by a team led by Antonino Zichichi at CERN and at by a team from Columbia University, where Samuel Ting was working, at Brookhaven National Laboratory) and I started thinking: if the universe has come from a Big Bang, at the beginning, there should have been an equal amount of matter and antimatter. So, where is the universe made of antimatter? Hence, I thought I should try to put a magnetic spectrometer into space to try to answer to this question. And that's how this experiment started even if, at that time, I had absolutely no experience with space.

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Was it hard to design and build an experiment to be installed in space with no previous experience in this field? How was the journey that brought AMS-02 in space?

At the beginning, indeed, it was quite difficult because I had no concept that in space weight is very important. On the ground, you can build a spectrometer of thousands of tons but in space, the scenario is completely different. When you lift a kilogram into space, the cost is enormous. Another challenge to bear in mind when designing an experiment for space is that you cannot repair it once it's there.

Fortunately, I had many friends, among them Antonino Zichichi, Roberto Battiston and Bruna Bertucci, from INFN, and many others. So, together with researchers from Italy and INFN, but also from many other countries such as Germany and France, we decided to propose this experiment. So, in 1994, on May 9th, I went to see the head of NASA, Daniel Goldin, and he thought that we were proposing a good experiment that could be installed on the International Space Station, but he also suggested to run an experiment on a space shuttle first, since we had no experience in space. Then, if the space shuttle was successful, we could run the experiment on the International Space Station. So, we built the experiment to be run on the space shuttle very quickly. It took us only over two years to build this experiment, when NASA thought it would have taken ten years. And the experiment flew successfully on the space shuttle. After the success of this first experiment, NASA proposed to install the same detector on the International Space Station. However, we thought it was better to build a super precise detector for the space station and it took us nearly ten years to build this experiment. This is basically how AMS-02 is in space.

The story of AMS is strongly entangled with the history of cosmic rays and particle physics. How has this experiment pushed forward the study of particle physics from space?

Cosmic rays were discovered in 1911 by Victor Hess, who was awarded the Nobel Prize in Physics in 1936. This discovery paved the way to the detection of many elementary particles, such as the positron, discovered by the Nobel Prize winner Carl Anderson and the pion, discovered by Cecil Powell, who also received a Nobel Prize.

Basically, before the development of accelerators, many elementary particles were discovered in space and after the first accelerators were built, many physicists switched their attention to these powerful machines. But now, as the accelerators become larger and more expensive, many researchers are gradually going back to space.

In the past, people went to space using balloons and satellites, but these two methods have some drawbacks. Balloons are only for short-term missions, because at night when the temperature cools down, a balloon tends to go back to the ground, while it is difficult to put a large magnet on a satellite. So, before AMS, there were many experiments taking data from space and most of them could only

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perform measurements at low energies and with large uncertainties (30 to 50%) with the exception of the PAMELA experiment that did a very good work. AMS is a much larger detector, much more precise, and so it allows us to examine cosmic rays with a much higher accuracy. We can see totally different things, as if we are now finally looking at the sky with the telescope rather than with the eye.

What are the main scientific results achieved by the AMS experiment in these ten years of data-taking?
In these ten years, thanks to all the efforts from AMS researchers, from INFN Divisions and Italian Universities of Perugia, Milano, Roma, Trento, Bologna and Pisa together with colleagues from the United States, Germany and many other countries, we have basically changed our understanding of cosmic rays. None of our results agrees with theoretical models and the reason is very simple: previously theoretical models were to fit experiments with a much lower accuracy than AMS. Now, with our data the models are constantly under evolution, constantly under changes.
I give you a very simple example related to positrons, anti-electrons. The first experiment to observe that the positron rate gradually goes up, with the increase of energy, was HEAT, a balloon experiment. After HEAT, the same trend was observed by AMS-01, our experiment that flew on the space shuttle, and the experiments PAMELA and Fermi. However, now with AMS-02, after ten years of data, we see that the positron rate goes up, up to an energy of 300 billion eV, and after that it drops down. So, it reaches a maximum and then goes down: this is a totally unexpected behavior and there are two possible explanations for this. One is that these positrons come from pulsars (rotating neutron stars with a strong magnetic field), because when a photon interacts with the strong magnetic field of a pulsar, it produces an electron-positron pair. However, at the moment, we are starting to observe that the flux of anti-protons is very much like the positron one and most likely this cannot be explained with pulsars: proton-antiproton pairs cannot be produced in pulsars since the mass of photons is too low to produce the heavy protons and antiprotons.
The second possible explanation is dark matter. There are many dark matter models. If you assume the existence of dark matter particles with a mass of 1TeV, when they collide, they will produce positrons but also antiprotons. And this explanation seems to fit our data. However, this is not yet sufficient: we have to get more data and check whether there is a large number of positrons at higher energies, because a dark matter particle with a mass of 1 TeV would not be able to produce positrons with energies higher that 1 TeV. That's why we continue collecting data above 1 trillion eV and indeed we begin to see the rate of energy goes down at higher energies. It is rather exciting to see this!
Another totally unexpected behavior we observed with AMS-02 is related to the elements across the

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periodic table. In cosmic rays, the elements can be divided into two groups. One group is called “primary cosmic rays”, and these are produced directly from the explosion of stars, and they include hydrogen, carbon, oxygen or iron. Then, there’s a second group, “secondary cosmic rays” (lithium, beryllium, boron and fluorine), and these are the ones produced by the interaction of primary cosmic rays with a medium. We studied the different elements in terms of a property named “rigidity” and we observed that primary and secondary cosmic rays are characterized by different distributions in rigidity. All primary cosmic rays share a similar behavior and can be grouped in two subclasses corresponding to light and heavy elements. Similarly, all secondary cosmic rays have a similar trend in rigidity and can be grouped into two different subclasses. However, just a few weeks ago, we found out there's a third class of cosmic rays, with a rigidity distribution that does not follow neither that of primaries nor of secondaries: these cosmic rays (like nitrogen, sodium, aluminum) are partially of primary and partially of secondary origin. So, we discovered there’s a new class of cosmic rays between primary and secondary not predicted by any theory. Hence, our data based on 175 billion cosmic rays disagree with what hypotized.
One final observation by the AMS experiment I would like to mention is related to the rate of cosmic rays, of radiation. At low energies, well below 100 GeV, the flow of cosmic rays changes violently every day, every month, every year. This observation is of great importance for human journeys to the Moon or to Mars because this radiation could seriously damage astronauts if we do not understand how it works and behaves. Fortunately, AMS will take data until 2028 and so it will go through the 11 years long solar cycle, so eventually we could know whether after 11 years, the rate of radiation will repeat itself or not.

How do you see the future of the AMS experiment? What other results do you expect to achieve?
I think in the next 20 years there will be no other magnetic spectrometer with this precision in space, so it is our obligation to make sure we make no mistakes in the analysis of our data. All the analyses are done by two or three independent international groups. Only if all the groups agree with each other we publish the results.
So far, none of our results agrees with theoretical predictions, so it's difficult to see the future. However, we still need to measure the properties of about 10 elements near iron and above iron, not yet measured, so one aim is to measure all the elements in the periodic table up to the iron region. Another major objective is to measure the positrons and anti-protons rates at very high energies and check if they really fall down very quickly after a certain energy to see whether they really come from dark matter or from something else. Concerning antimatter, we are also beginning to see hints of heavy antimatter, so one of our future goals is to understand how many antiheliums, anticarbons, antioxygens we will see.
Those are fundamental questions; hence, it will take a long time to find the answers.

» INTERVIEW

Let me add one last thing, for me it has always been a great pleasure to work with Italian and INFN researchers, Italy has always had a good tradition in Physics and I have always enjoyed working with such great collaborators. ■

AWARDS

BOREXINO WINS THE PRESTIGIOUS 2021 COCCONI PRIZE

The EPS European Physical Society has awarded the prestigious 2021 Giuseppe and Vanna Cocconi Prize to the Borexino Scientific Collaboration. The important international prize, established in 2011 and awarded every two years for outstanding contributions to astroparticle physics and cosmology, has gone to the Borexino experiment at the INFN Gran Sasso National Laboratories “for their ground-breaking observation of solar neutrinos from the pp chain and CNO cycle that provided unique and comprehensive tests of the Sun as a nuclear fusion engine”, as stated in the EPS motivation.

The award confirms the Borexino Collaboration’s great success in its intensive scientific and technological development activities which have spanned over more than three decades. Immersed in the cosmic silence of the Gran Sasso underground laboratories, since the beginning of its data production on 15 May 2007, Borexino has demonstrated such a high level of radiopurity that it is unprecedented in its field of research. It is thanks to this characteristic, achieved through the development of innovative methods for radio-purification, as well as the long and careful work of selecting and developing all its components during the construction phase, that Borexino - an intense collaboration between Italy, Germany, France, Poland, the United States and Russia - has been able to achieve the results highlighted in the motivation for the Cocconi prize: the first spectroscopic observation, in real time and in the same experimental setup, of solar neutrinos from the proton-proton fusion chain, and the first detection of neutrinos from the CNO fusion cycle. ■

AGREEMENTS

THE STAR X-RAY SOURCE UPGRADE BEGINS AT THE UNIVERSITY OF CALABRIA

The University of Calabria and the INFN have signed a contractual agreement for the enhancement of the X-ray source of STAR, the University of Calabria's research infrastructure dedicated to advanced materials analysis. The agreement is funded by the Italian Ministry of University and Research in implementation of Action II.1 of the 2014-2020 National Operational Program for Research and Innovation.

The INFN, consistently with its specific mission to promote the use, innovative development and exploitation of its own technologies in large scientific infrastructures, especially those developed in the particle accelerator sector, will equip the STAR X-ray source with features that are unique in Europe, allowing the use of two distinct beamlines that will operate at different energies and on different materials. A high-energy line (up to 350 keV) will be dedicated to non-invasive and non-destructive investigations of objects and devices, even under operating conditions. The second, low-energy line (up to 160 keV), will instead be dedicated to the investigation of biological matter and, in general, of so-called soft matter (i.e. polymers, biomaterials). STAR is conceived as a facility open to external users, taking advantage of its operation within a large university campus. Guest researchers of the infrastructure will be able to conduct their experiments in the STAR experimental stations, also in synergy with other international centres, and they will have the opportunity to prepare their samples and immediately start analysing the obtained data directly in the six support laboratories that complete the infrastructure. ■

RESEARCH AGREEMENTS

QUANTUM BITS IGNITE THE ENGINE OF INNOVATION

The University of Trento, Fondazione Bruno Kessler and the National Institute for Nuclear Physics (INFN) have signed an agreement to share the Q@TN project in order to establish in Trento a reference centre for quantum research and technologies in Italy and in Europe and to build an ecosystem of quantum technologies that will drive innovation. The laboratory will cover the entire innovation chain, from university training to the development of new devices and the prototyping of systems ready for industrialisation. The agreement marks the transition to a new phase for the lab, which was set up at the University of Trento in 2017 by a collaboration between the University of Trento, Fondazione Bruno Kessler and the National Research Council (CNR) with the support of the Autonomous Province of Trento and Fondazione Caritro.

In its first years of activity Q@TN accounts for 4.5 million of funding obtained for research projects, the filing of five patents, over 55 scientific publications and 24 students in the cross-disciplinary PhD programme in Quantum Sciences and Technologies. As a first action of the new phase, the lab is promoting a call for access to computing resources on quantum computers made available by Cineca to support collaborative research and development projects between the various Q@TN units.

One of the next steps will be to open up the Q@TN technology infrastructure, Fbk's Quantum Technology Hub, to Italian research so that it can experiment with new concepts and ideas on advanced technological platforms with the aim of creating new quantum devices. This infrastructure will also be used by INFN researchers to contribute to the development of ultra-high-precision detectors for fundamental physics experiments. ■

TECHNOLOGICAL RESEARCH

I.FAST PAVES THE WAY FOR NEXT-GENERATION ACCELERATORS

I.FAST, the European programme dedicated to strengthening the integration between European laboratories engaged in research and development of particle accelerator technologies, was launched on 4th May 2021 during an online event. Coordinated by CERN, I.FAST will be funded by the European Commission with € 10 million for the next four years and will receive an important contribution from the INFN. I.FAST will continue on the tracks made by ARIES, the current European reference programme for the funding of activities focused on accelerator physics, by promoting and supporting different lines of research. For Italy, the INFN will coordinate the development of technologies for superconducting magnets for hadron therapy and studies on radiofrequency (RF) cavities and new acceleration techniques. The INFN will lead projects dedicated to understanding the potential of the plasma-based particle acceleration system and to the technological transfer of materials and innovative manufacturing methodologies, such as additive manufacturing, for the creation of beamlines. The I.FAST programme will also fund transnational access to various test facilities and distribute resources to collaborations and networks of researchers, also coordinated by the INFN, engaged in studies of alternative paradigms for the creation and acceleration of ultra-high energy particles, such as those aimed at testing the feasibility of a Muon Collider.

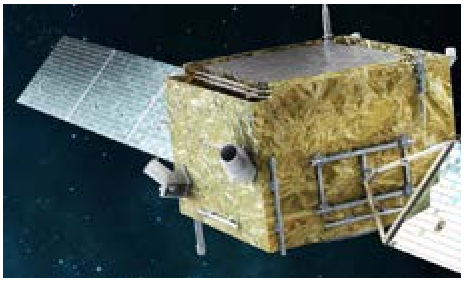
The INFN facilities that will take part in I.FAST are the National Laboratories of Frascati and Legnaro, the Accelerators and Applied Superconductivity Laboratory (LASA) of Milan and the divisions of Genoa, Padua, Rome 1 and Turin, which will be supported by the computing and networks service of the Ferrara division. ■

RESEARCH

IN THE POOL TO TEST JUNO'S ELECTRONICS

From 23rd to 25th May, researchers from the INFN division of Padua and the University of Padua successfully tested the data acquisition electronics of the JUNO (Jiangmen Underground Neutrino Observatory) detector, a next-generation neutrino physics experiment under construction in southern China, in the Guangdong region. Carried out as part of the project to develop and build the detector's electronic component, in which the INFN is lead partner together with the Chinese Academy of Science, the tests were executed at the Y-40 facility in Montegrotto Terme (PD), the deepest thermal water pool in the world. The context is similar to that in which JUNO's electronics will operate: a tank containing 20,000 tonnes of liquid scintillator, a medium capable of highlighting the passage of neutrinos with the emission of photons, the latter detected by more than 40,000 photomultipliers. Once completed, JUNO, which will be the largest detector of its kind in the world, will use neutrinos produced in two nuclear power plants to measure their energy with unprecedented precision, in order to study and explain the difference between the masses of the three types (flavours) of neutrinos that exist in nature (mass hierarchy).

In addition to its fundamental involvement in the development and realisation of the photomultiplier electronics, INFN is one of the international members of the JUNO collaboration, taking part in it with the divisions of Padua, Ferrara, Catania, Milan, Milan Bicocca, Perugia, Rome 3 and the National Laboratories of Frascati (LNF). The electronics project was listed by the Italian Ministry of Foreign Affairs and International Cooperation (MAECI) among the major projects between Italy and China in 2018 and jointly funded with the National Natural Science Foundation of China (NSFC) for the successive three years. The project was born and developed within the collaboration between the INFN Padua division and the Institute of High Energy Physics (IHEP) in Beijing. ■



RESEARCH

DAMPE, A NEW PRECISION MEASUREMENT OF THE FLUX OF HIGH-ENERGY HELIUM NUCLEI IN COSMIC RAYS

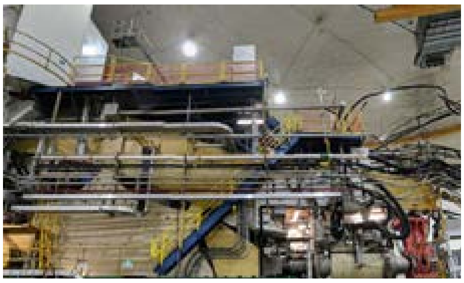
The collaboration of the DAMPE (DArk Matter Particle Explorer) satellite experiment, with a major contribution from the INFN, has measured with unprecedented accuracy the flux of helium nuclei in cosmic rays up to very high energies (80 TeV). The result, which increases the accuracy of similar measurements made in the past by other space missions, was published on 18th May 2021 in Physical Review Letters (PRL). In addition to confirming a softening of the flux as the energy increases to around one TeV, the data collected by the detector showed, for the first time, a faster softening of the flux at energies of 34 TeV, which is about 34,000 times the energy corresponding to the rest mass of a proton. The result, obtained by analysing the entire dataset acquired by DAMPE up to the middle of 2020, may contribute to the development of more accurate theoretical models for the description of cosmic ray sources and their scattering mechanisms in the interstellar medium.

The aim of DAMPE, launched into orbit in December 2015 by the Chinese Space Agency, is to search for elusive dark matter by studying high-energy particles of astrophysical origin. DAMPE is also capable of studying galactic and extragalactic gamma-ray sources, distinguishing cosmic photons from charged particles and measuring their direction of arrival and energy with great precision. These measurements are crucial in the search for particles that may be generated by the dark matter that is assumed to pervade the entire galaxy. The experiment is the result of an international collaboration between the INFN, with divisions of Perugia, Bari, Lecce and the associated group in L'Aquila, the Chinese Academy of Sciences (CAS), the Universities of Perugia, Bari and Salento, the Gran Sasso Science Institute and the University of Geneva. More than 100 scientists, PhD students and technicians work in the DAMPE collaboration. ■

TECHNOLOGICAL RESEARCH

COSMIC SILENCE MAKES QUANTUM COMPUTERS MORE POWERFUL

In the paper published in Nature Communications, a team of researchers from INFN and from the Karlsruhe Institute of Technology (Germany) tested the operation of a superconducting circuit in a quantum regime located in the INFN Gran Sasso National Laboratories (LNGS), thus demonstrating that protecting a superconducting qubit from the effects of natural radioactivity significantly improves its performance.
At the LNGS, the natural shielding provided by the 1400 metres of rock allows the flux of cosmic rays to be reduced by about a million times compared to surface laboratories, offering an unparalleled environment for its characteristics of radio-purity. The study was developed as part of the DEMETRA project, funded by an INFN grant dedicated to young researchers, with the aim of understanding and eliminating one of the sources of disturbance for qubits: natural radioactivity.
Thanks to the unique characteristics of the LNGS, in terms of cryogenic infrastructure and an environment with a very low natural radioactivity, the SQMS (Superconducting quantum materials and systems centre) project, for the development of a new quantum computer, decided to invest in the development of a facility at the Gran Sasso National Laboratories to test its devices. SQMS is coordinated by Fermilab in Chicago and funded by the US Department of Energy (DoE), with the INFN as the only non-US partner. ■



RESEARCH

PREX-II DEMONSTRATES THE EXISTENCE OF THE NEUTRON SKIN IN LEAD NUCLEI

The existence of a neutron "skin" in heavy nuclei in which the number of neutrons exceeds the number of protons has recently been confirmed by a research published on Physical Review Letters on 28th April 2021 by the PREX-II collaboration, an experiment held at Jefferson Lab, the US research centre dedicated to particle physics, based in Virginia, whose members include INFN. The "skin" would appear to be like a uniform shell made up by the excess neutrons surrounding an agglomeration of protons and neutrons. The study also showed that the thickness of the outer layer of neutrons in the nuclei of lead 208, the most widespread and stable isotope of this element, is thicker than previously thought.

The data collected by PREX-II allowed to measure with unprecedented precision the thickness of the neutron skin, defined quantitatively as the difference between the radius of the neutron distribution and the radius of the proton distribution. This peculiar configuration of neutrons in the heaviest elements of the periodic table is the result of the forces acting inside the atomic nuclei, which tend to contrastingly minimise the surface area of the nuclei (surface tension) and to push out the excess neutrons to balance the energy needed to keep the nuclei together (symmetry energy).

The result of the PREX-II collaboration is also of great importance for astrophysics because it provides valuable insights into the characteristics of neutron stars, whose radius is determined by the symmetry pressure, which is in turn responsible for the neutron skin in lead nuclei. The measurement of this physical quantity will also allow to describe more accurately the deformations which a neutron star undergoes because of the gravitational field induced by another star, in the fusion phenomena of these celestial bodies. ■

PUBLIC ENGAGEMENT

AMEDEO BALBI WINS THE 2021 ASIMOV PRIZE WITH A JURY OF ALMOST 10,000 STUDENTS

L'ultimo orizzonte. Cosa sappiamo dell'universo. (The Last Horizon. What we know about the universe) by Amedeo Balbi is the most highly appreciated book by the thousands of students who made up the jury of the sixth edition of the ASIMOV Prize, the prize for the popularisation of science promoted by the INFN.
"The book proved to be a valuable debate experience with the scientific community, an excellent guide for grasping the links between the formulas on the cover and the bizarre world they describe". These are the words of the review by Leonardo Rapposelli, from the Liceo Classico Gian Battista Vico in Chieti, who together with almost 10,000 students was part of the jury that read and reviewed the five finalist books, selected by the Scientific Committee amongst those published in the last two years.
The national ceremony on 29th May marked the end of the sixth edition of the ASIMOV Prize, which involved almost three times as many students as last year, from almost 200 schools in 15 Italian regions, and an increasingly strong collaboration between schools and the world of research, university and culture. In order to find out which book was most appreciated by the students, the reviews were read and assessed by the Regional Scientific Committees, in which almost 700 teachers, researchers from INFN, Universities and CNR took part, as well as journalists, writers and representatives of the world of science and literature. ■

TAKE PART IN

PHYSICS ON THE WAVES: THE PHYSICS OF ENERGY TOLD TO CHILDREN BY CHILDREN

Physics on the waves is a new series of 10 physics videos for children (6-13 years old) made by the INFN in collaboration with Shibumi. A family at sea. About 3 minutes long, the videos will be broadcasted on the INFN YouTube and Facebook channels from 3rd June to 5th August every Thursday at 10.00 am. The storytellers are Timo (4 years old), Nina (9 years old) and Iago (12 years old) who have been travelling for almost a year on an energy self-sufficient sailing boat, called Shibumi. This series of videos will talk about energy, where it comes from, how it is measured, how it is transformed and how it is consumed. A parallel between life on board and life on land told by children to children with some intervention of their dad, Stefano Barberis, a physicist from the INFN section in Milan.

June 8, 4 pm A JOURNEY TO THE HEART OF THE MOUNTAIN: VISIT TO THE INFN NATIONAL GRAN SASSO LABORATORIES

On Tuesday 8 June at 4:00 pm, the INFN National Laboratories of Gran Sasso (LNGS) will open their doors to the public to accompany them on a virtual journey inside the largest operational underground research center in the world.
The visit to the Laboratories will be introduced by the Director Ezio Previtali and then conducted by Paolo Gorla, LNGS researcher, who will illustrate the leading researches that constitute a window on understanding the Universe. A "question and answer" session will conclude the visit.

It will be possible to access the virtual visit, live, *on the Facebook page* of the Gran Sasso National Laboratories - INFN.

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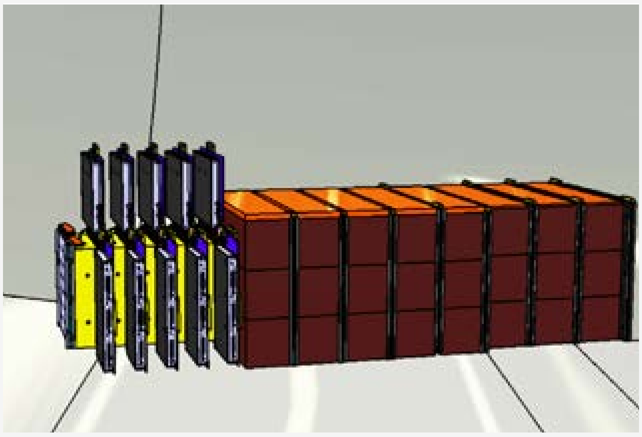

LHC: CERN APPROVES SDN@LHC EXPERIMENT

CERN in Geneva is opening up a new frontier in the search for dark matter and the study of neutrinos. A new experiment will operate on the world's largest and most powerful particle accelerator. CERN's Research Board has approved the ninth experiment that will use the Large Hadron Collider: SND@LHC, or Scattering and Neutrino Detector at the LHC, the new SND particle detector.
Designed to detect and study neutrinos, SND@LHC will be installed 480m far from the collision point of the ATLAS experiment, at a very small angle to the beams' direction of incidence. It will be installed in 2021 in an underground tunnel connecting the LHC to the Super Proton Synchrotron, and it will start recording data in 2022 when the LHC will restart.
With a volume of roughly 2 m^3, the experimental apparatus has the ambitious goal of concentrating into such a compact volume the equipment needed to carry out all the measurements required to identify neutrinos and to study their properties.
Theorised by Austrian physicist Wolfgang Pauli in 1930 and first observed in 1956, neutrinos, amongst the most enigmatic elementary particles in the Universe, are studied using both natural and artificial sources, such as accelerators. SND@LHC will measure neutrinos of unprecedented energy and, for the first time, produced by a particle collider (an accelerator in which two beams of particles collide with each other). It will, thus, open a new frontier in neutrino physics. SND@LHC will open a new frontier in the study of neutrinos and the search for dark matter. More specifically, since most of them originate from decays of heavy quarks, neutrinos provide a unique way to study the production of these quarks, which would otherwise be inaccessible.
SND@LHC will also search for new particles, that interact with matter very weakly, not predicted by the Standard Model of particles and fields, and which might constitute the so-called dark matter of the Universe. The SND setup, in fact, consists of a so-called target region where neutrinos interact in the

» FOCUS

tungsten material and micrometer-resolution tracer detectors reconstruct the interaction vertex. After this region, there is a calorimeter that measures the energy of the neutrinos and an identification system for the muons. The setup is also able to measure the time between the production and interaction of neutrinos, which is about 480m away, thus telling them apart from possible new particles of larger mass that would travel more slowly.

The experiment involves a group of 180 scientists from 20 institutes in 10 countries from Asia to America, coordinated by Giovanni De Lellis, physicist at the University of Naples Federico II and INFN associate. The Universities of Bari, Bologna and Naples and the corresponding INFN divisions are collaborating on the project. The National Institute for Nuclear Physics (INFN) is making a decisive contribution to the construction of the particle detectors produced in the neutrino interaction and to the development of systems for analysing the data that will be acquired in the coming years. ■

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Italian National Institute for Nuclear Physics

COVER:
AMS-2, credit NASA

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