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Italian National Institute for Nuclear Physics

INTERVIEW

NEWS

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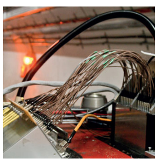

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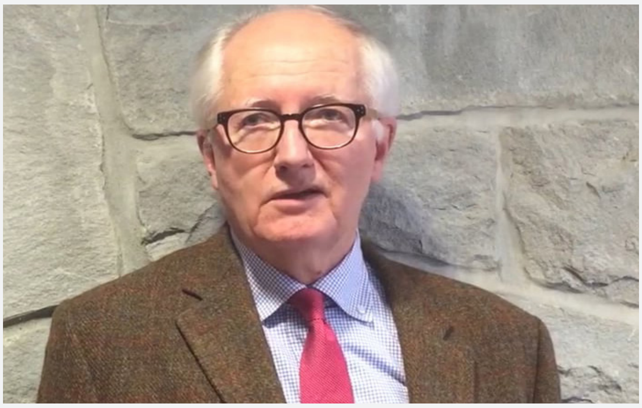

FROM THE HIGGS BOSON IDENTIKIT TO GRAVITATIONAL WAVES, ONE WEEK AT EPS HEP 2017 CONFERENCE

Interview with Rüdiger Voss, president of the European physical society. He has also been the Head of International Relations at CERN from 2013 to 2015.

The European physical society (EPS) was established in 1968 and represents over 120,000 physicists organised in 42 different national societies. On July 5, one of its most prestigious conferences worldwide, the EPS conference on High Energy Physics (HEP), came back to Italy after over thirty years. It took place at Lido Island in Venice, which hence became the gathering point of international top physicists for one full week. The conference dealt with some of the most fascinating themes in physics research: from the origin of our universe to the Higgs Boson identikit, from the hunt for dark matter to the properties of the elusive neutrino, from New Physics to gravitational waves.

The 2017 edition of the EPS conference on High Energy Physics provided a vast scientific program. Do you think there has been a leading topic?
This year's program was, without any doubt, exceptionally rich and well organised. LHC physics has been in the focus of attention. Once again, the Higgs discovery, first announced in 2012, was one of the main topics of the conference. A lot of new results on Higgs Boson properties were presented. A major one was the first evidence of the Higgs decaying into one quark and one anti-quark beauty ($H \to b\bar{b}$). Furthermore, new precision measurements of the Higgs mass were shown. Overall, there is increasing evidence that the particle whose discovery was announced in 2012 corresponds to the Higgs Boson, as it is predicted by the Standard Model. However, during the conference, it also emerged that many more results and data are needed to establish that this particle fully corresponds to the Standard Model Higgs. Otherwise, if small differences from the Standard Model predictions are detected, windows to New Physics may be opened.

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So the Higgs was surely one of the main topics of the conference, have you witnessed other interesting results coming from the Large hadron collider at CERN?
LHC physics is not just the Higgs boson, there have been many new results which reflect the fantastic performances of the collider in 2016, but also in 2017. An example is the beautiful discovery announced by the LHCb collaboration of a new doubly charmed hadron. This discovery could allow us to understand better how the strong interaction works.

And what about physics research other than the LHC?
Of course high energy physics is not just LHC physics, there are many other areas which continue to work hard and produce interesting results. An example is neutrino physics. Vigorous new programs for neutrinos studies are under preparation in particular in Japan, in the United States and in Italy. For example at INFN Gran Sasso National laboratories there several experiments dedicated to neutrinos studies that are undergoing further improvements.
Moreover this conference has given a lot of room to new exciting results from neighbouring fields such as gravitational physics and cosmology. Here, of course, the recent discovery of gravitational waves rightly took a very prominent place. Not to forget other areas such as particle astrophysics and dark matter searches.
This conference has been a demonstration of the strong interdependences and synergies among these neighbouring fields. The various disciplines that make up fundamental physics are coming closer and closer. This is fundamental to establish a complete picture of the universe, which goes much beyond the current Standard Model of particle physics.

Have you had the chance to hear some of the reactions of conference participants?
The excellent program of this conference has been reflected by an exceptional participation of about a thousand scientists from all over the world, not just from Europe. I think we have not seen participation like this in many years. All participants I talked to were impressed by the excellent scientific and local organization.
As the president of the European Physical Society, I would like to pay a tribute to the excellent work of the international organising committee and the board of the High Energy Particle Physics Division of the EPS (EPS HEPP) and, in particular, to its outgoing chair Yves Sirois. The success of this conference has been a powerful demonstration of the excellent leadership Yves has provided to the European Physical Society and to the High Energy Physics Division. I would also like to thank from the bottom of my heart the Local Organising Committee, chaired by Mauro Mezzetto and Paolo Checchia, and their

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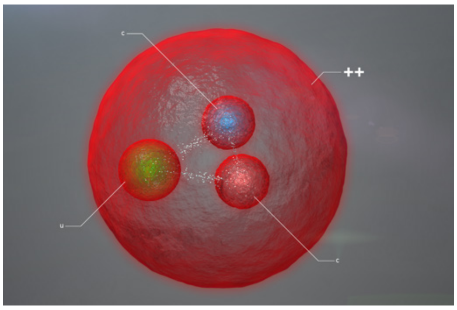
many collaborators in particular from the INFN Padua Division who have been working very hard over the past two years to make this conference a success.

The main prize awarded by the EPS HEPP division during the conference was to a breakthrough development in detector technology. Do you think the wind is changing and the relevance of technical applications for the success of research is going to be formally recognised?
I do not think that this reflects a change of wind. The history of particle physics, but also that of many other branches of our science, shows that there can be no breakthrough discoveries in fundamental science without breakthrough developments in accelerator and detector technologies. For this reason, even the Nobel prize was awarded to key technological innovations more than once. Some examples are the Nobel prizes awarded to Donald Glaser for the bubble chamber, Simon van der Meer for stochastic cooling, or Georges Charpak for the drift chamber. The award of the 2017 High Energy and Particle Physics prize to Erik Heijne, Robert Klanner and Gerhard Lutz for their pioneering contributions to the development of silicon microstrip detectors was timely and appropriate: the LHC experiments and their ability to process the enormous data rates provided by this machine would not be possible without the silicon detector technology. ■



RESEARCH

LHCb ANNOUNCES OBSERVATION OF A NEW PARTICLE WITH TWO HEAVY QUARKS

The LHCb experiment of the Large Hadron Collider (LHC) at CERN has presented the first experimental observation of the particle named Xii, belonging to the baryon family and containing two charm quarks and an up quark to the conference of the European Physical Society on High Energy Physics (EPS High Energy Physics 2017), which was held in Venice from 5 to 12 July. This is the first time that this particle has been identified with certainty. With a mass of approx. 3621 MeV, Xii is nearly four times heavier than the more familiar baryon, the proton, a property that derives from the fact that the particle contains two charm quarks, namely heavy quarks. The result is based on the data collected during run 2 of the LHC at 13 TeV and was confirmed using the 8 TeV data of run 1. The collaboration has submitted an article describing the results to the Physical Review Letters journal. ■

APPOINTMENTS

CERN: ITALIAN GIOVANNI PASSALEVA HEAD OF LHCb

The Italian Giovanni Passaleva is the new spokesperson of the international LHCb collaboration, one of the four big experiments of the LHC, CERN's super accelerator, in Geneva. Passaleva took office on 1 July on expiry of the term of office of Guy Wilkinson. In the past, another Italian had been head of LHCb, Pierluigi Campana, currently director of the INFN Frascati National Laboratories. In addition to Passaleva, another Italian, Federico Antinori, is the spokesperson of an international collaboration at CERN, the ALICE experiment one.

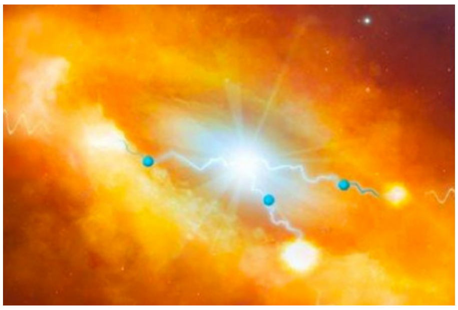
Giovanni Passaleva, aged 52, is research director at INFN. From 2008 to 2012 he was project leader of the LHCb muon detector. From 2012 to 2014, he was the national head of LHCb. From 2014 to 2017, he was coordinator of the LHCb upgrade. At LHCb he has participated in the measurement of the impact cross section of J/ψ meson production in proton-proton collisions and, recently, in the measurement of antiproton production in proton-helium collisions using the LHCb gas injection system, which allows the measurement of "fixed targets”. He has been the referee of various experiments, including ATLAS and CMS. ■

APPOINTMENTS

INFN GRAN SASSO NATIONAL LABORATORIES: RICCARDO BRUGNERA IS THE NEW SPOKESPERSON OF GERDA

The new spokesperson of the international collaboration GERDA (GERmanium Detector Array) is the Italian researcher Riccardo Brugnera. The experimental collaboration operates at the Italian Gran Sasso National Laboratories (LNGS) of INFN on the GERDA experiment, whose goal is to study the neutrino-less double beta decay process. Brugnera will be in charge as spokesperson of the experiment for three years, following the previous GERDA spokesperson, Berhard Swingenheuer from Heidelber Max Planck Institut für Kernphysik.

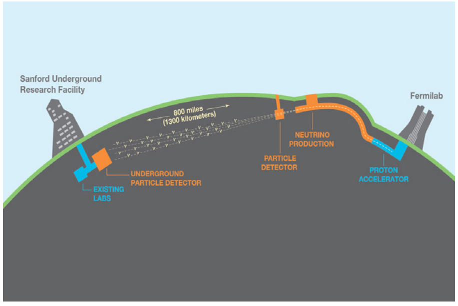
Brugnera is associate professor at the University of Padua. At the start of his career, he has been working on electron-proton collisions at the HERA collider, by studying the elastic and inelastic production of J/Ψ mesons. After that, his interest was caught by neutrino oscillations, so that he joined the OPERA experiment at the INFN Gran Sasso National Laboratories: here he worked on the construction of the RPC detectors, which are part of the magnetic spectrometers. Since 2008, he has been part of the GERDA experiment at LNGS where he has worked on the slow control system of the experiment and the characterization of the new detectors. Starting from 2014, he has been the chair of the GERDA collaboration board for three years. He is a member of the JUNO experiment in China since 2015. ■



RESEARCH

IS THERE A TRAP FOR COSMIC RAYS IN THE CENTRE OF THE MILKY WAY?

A combined analysis of data from Fermi, NASA's space telescope for the study of gamma rays, in which Italy participates with INFN, the National Institute of Astrophysics (INAF) and the Italian Space Agency (ASI), and from the HESS terrestrial telescope in Namibia, suggests that the centre of our Milky Way contains a "trap" capable of concentrating some of the fastest particles in the galaxy: ultra-high-energy cosmic rays. Fermi detects gamma rays when they enter its LAT (Large Area Telescope) detector, and, on the ground, HESS detects the emissions resulting when the atmosphere absorbs the gamma rays, triggering a cascade of particles that produces, in turn, a blue light flash, called Cherenkov light.
Last March, scientists at the HESS collaboration found evidence of a diffuse flash of gamma rays at the centre of the galaxy, reaching almost 50 trillion electron volts (TeV). These are about 50 times higher than the energies of the gamma rays observed by Fermi's LAT. The analysis published in Physical Review Letters combines the low energy LAT data with the high energy HESS data: the result is a continuous gamma ray spectrum that describes the emission from the centre of the galaxy ranging from a few GeV up to 50 TeV. The study also confirms previous LAT results, indicating that cosmic rays along the plane of the Milky Way are more energetic as they approach the centre of the galaxy. How and where exactly the cosmic rays reach these energies continues to remain a mystery. This behaviour is interpreted as a change in the way cosmic rays move through our galaxy, with the more energy-charged particles constrained for long periods in the central region. ■



RESEARCH INFRASTRUCTURES

SOUTH DAKOTA: CONSTRUCTION OF THE GIGANTIC LBNF GETS UNDER WAY

The inauguration ceremony of the construction work for the gigantic Long Baseline Neutrino Facility (LNBF), which involves a community of about 1,000 scientists and engineers from 30 countries, took place on July 21 in the Sanford Underground Research Facility (SURF) in South Dakota (USA).

LNBF will host the world's largest experiment, with international governance, for the study of the properties of neutrinos: the Deep Underground Neutrino Experiment (DUNE), which will study neutrinos generated and sent 1300 km away from the Fermilab in Chicago, the leading American national laboratory for research on accelerators and particle physics. The experiment has two main scientific goals in studying neutrinos: measuring the neutrino mass hierarchy and measuring the violation of symmetry between matter and antimatter (CP violation).

The project is funded by the United States Department of Energy - Office of Science in collaboration with CERN and international partners from nearly 30 countries. Fermilab is a scientific laboratory of the US Department of Energy - Office of Science, located near Chicago, Illinois, and is managed by the Fermi Research Alliance, LLC. ■

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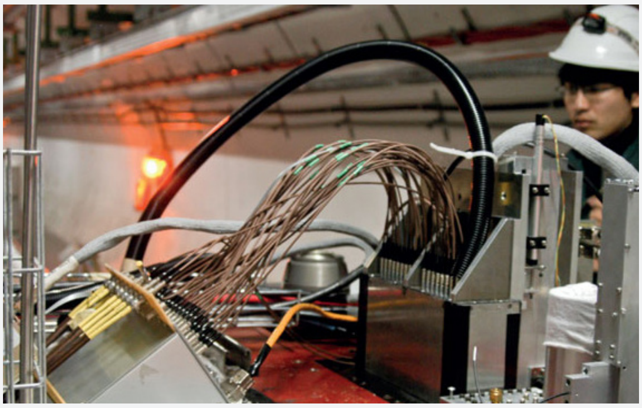

LHCf, the small experiment, is conquering America

LHCf is the smallest of the six experiments at LHC. The LHCf detectors are only 30 cm long and weigh only 70 kg, but the technology is similar to that of the large LHC experiments. LHCf consists of two independent calorimeters, ARM1 and ARM2, normally positioned along the LHC vacuum tube, at the point where it is divided into two. In this area, only neutral particles, not deflected by the strong magnetic fields driving the beam, reach LHCf to be identified. LHCf was created to reproduce in the laboratory the production processes of particles that occur when cosmic rays meet the Earth's atmosphere and help clarify the mysteries concerning their origin and their properties.

In fact, the upper layers of the Earth's atmosphere are constantly affected by a shower of particles called cosmic rays. These particles collide with the atomic nuclei present in the atmosphere and produce many secondary particles that in turn collide with other nuclei, thus generating a cascade of particles whose size depends on the energy of the primary particle.

Analysis of the number of secondary particles produced, and of their energy spectrum, is of fundamental importance for trying to interpret the interaction mechanism of primary cosmic rays with the nuclei of the atmosphere. The properties of primary ultra-high energy cosmic rays are, in fact, obtained through measurements made by detecting the secondary products and using Monte Carlo simulations that describe the interactions of the primary rays with the atmosphere. The models currently used to describe the hadronic interaction of the primary rays with the nuclei of the atmosphere have shown significant mutual discrepancies and also with respect to the data collected by the LHCf experiment. The runs carried out so far by the LHCf experiment with different energies and in lead-proton collisions are of paramount importance for a more realistic description of the process.

Last June, a new milestone was reached by the LHCf experiment which, for the occasion, took on a

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new name, becoming RHICf. Indeed, in September 2016, the two calorimeters, ARM1 and ARM2, which comprise the LHCf detector, were separated for the first time. ARM2 remained at CERN where it was re-installed in the LHC tunnel to take part in the lead-proton collision data acquisition between October and November 2016, while ARM1 flew across the ocean to the Brookhaven National Laboratory to become RHICf. After an intense period of work, at the end of last year ARM1 was installed at 18 metres from the STAR experiment interaction point and during the first months of this year the detector was tested and configured ahead of the dedicated run approved by the BNL PAC. In the third week of June, it then acquired data together with the STAR experiment in proton-proton collisions at 510 GeV of energy in the centre of mass. The configuration of RHICf is very similar to that which the detector occupies when it is installed at LHC, 140 metres from the ATLAS interaction point. At both LHC and RHIC, the experiment is able to detect particles produced far ahead, similar to those produced in cosmic ray cascades. This new run at RHIC fits precisely into this context. The data analysis will provide additional useful information to understand which of the models currently in use best describes the data across the energy range explored so far and will add further important information to better understand the behaviour of ultra-high energy cosmic rays. In particular, by comparing the results of the analysis of the data collected at RHIC (Relativistic Heavy Ion Collider) with those of LHC, it will be possible to carry out an experimental verification of the validity of the scaling law predicted by Feynman in a wide range of energy and in a region traditionally very difficult to explore. ■

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Cover

Large Hadron Collider (LHC) at CERN