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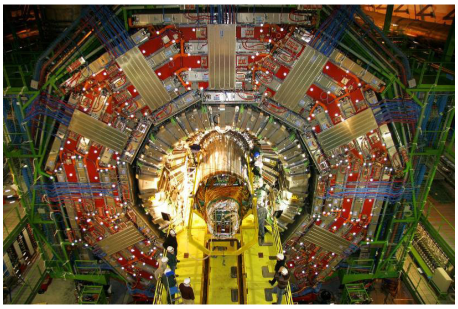
Italian National Institute for Nuclear Physics

NEWS

RESEARCH
ITALIAN MINISTER DE VINCENTI AT THE GRAN SASSO LABORATORIES

On 27 March, the Italian Minister for Territorial Cohesion and the South, Claudio De Vincenti, visited the INFN Gran Sasso National Laboratories (LNGS). The visit of Minister De Vincenti provided the opportunity to present experiments that are on the cutting edge worldwide in areas such as neutrino physics and the search for dark matter. Among them, the DarkSide-20K project involves the construction of one of the most advanced experiments in the world at the Laboratories to search for dark matter, based on unique and innovative technology solutions.
The overall project centred around NOA, the Nuova Officina Assergi (New Assergi Workshop), consists of several synergistic activities with scientific application in the DarkSide-20k experiment, but which at the same time put other laboratories into operation, which form a very advanced Technological Hub, where companies and research centres can find cutting-edge technologies and equipment, thereby strengthening the role of LNGS as a research infrastructure with a strong national impact.
“A formidable team for a formidable structure, pride of the country, not only of Abruzzo, which the Government is supporting - also financially - with conviction, starting with the Regional Pact”, Minister Claudio De Vincenti commented. “Here is the demonstration of Italian excellence in research that rightfully makes us major players in the international scientific network. And this is not all. The laboratories, in fact, combine, as latterly demonstrated by the DarkSide project, the highest expressions of pure research with the study of its applications to social purposes.”
“The high-level professional skills and innovative technologies that the project requires for its implementation - Giovanni Lolli, Vice President of the Abruzzo Region, commented - have led to the development of a high-impact integrated project for research, economy and local growth”. “For these reasons - in line with the Intelligent Specialisation Strategy, on which the planning of 2014-2020 EU funds is based, and with the provisions of the Master Plan - the Abruzzo Region has deemed the DarkSide-20k project to be of interest and has decided to support its implementation with a major contribution”. ■



RESEARCH
A NEW HEART FOR CMS

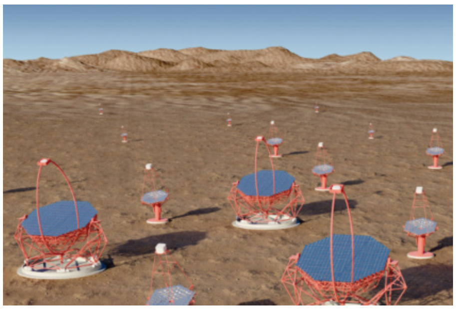
The restart of the LHC is approaching and the experiments are preparing for a new run full of scientific challenges. After the usual winter break, the big accelerator at CERN will start again in a few weeks. In March, physicists and engineers at CERN replaced the heart of CMS, one of the four main detectors of the LHC. At the centre of the experiment a new pixel detector has been installed, with better performance than the previous one in order to cope with the greater luminosity of the LHC. In May, the first particle beams will be injected into the accelerator that is expected to reach its maximum operating level before the summer. The number of collisions in the LHC has been greatly increased and, therefore, it was also necessary to increase the performance of the detectors, in order to be able to obtain a greater number of simultaneous images of collisions that take place inside the accelerator. This is the main reason why in the last five years 9 European institutions, including INFN, and American universities supported by the Department Of Energy (DOE) and by the National Science Foundation (NSF) built a new pixel detector for CMS. The new detector has almost twice as many pixels as the previous version, 124 million compared 66, and four layers in the central part, one more than the previous one. The inner layer of the new detector is closer to the point where the collisions take place, 30 millimetres from the beam line, much less compared to the previous version which was approx. 44 mm away from the beam line. The new heart of CMS will allow more precise tracking of charged particles coming from the interaction centre, provide crucial information to determine more precisely the point from which the particles originated from a collision, and facilitate the identification of heavy quarks and tau leptons. ■

RESEARCH
COSMIC ANTIMATTER AT LHCb

The LHCb experiment has managed to recreate in the laboratory cosmic collisions between protons, accelerated in the ring to an energy of 6.5 TeV, and helium atoms at rest. This is the first measurement of the production of antimatter in proton-helium collisions and represents, therefore, a significant step towards a better understanding of the production of secondary antiprotons in the propagation of cosmic rays. In particular, this data is important for a more accurate interpretation of the results of the PAMELA and AMS-02 space experiments on the measurement of the relationship between protons and antiprotons in cosmic rays. To run the new measurement, the LHCb physicists injected a tiny amount of helium gas into the high-vacuum tube where the LHC beams circulate in the vicinity of their detector, using a device evocatively called SMOG. The pressure of the gas is less than a billionth of an atmosphere, which is necessary not to alter the LHC beams, but thanks to the intensity of the proton beams it is nevertheless sufficient to complete the measurement in a few hours. Thanks to the ability to distinguish the antiprotons from the other charged particles, a speciality of the experiment, the LHCb physicists measured the probability that antiprotons are formed in these collisions, that take place precisely at the energy relevant for the current measurements in space. To measure the density of this gaseous target with accuracy, an ad hoc technique was developed: counting the individual atomic electrons which, "hit" by the protons of the beam, are projected inside the detector. This process is known with great precision, and thus makes it possible to calculate the number of helium atoms exposed to the beam. The measurement carried out could contribute to reducing the current uncertainties on the estimate of the number of secondary antiprotons in cosmic rays, thus providing the possibility of a clearer interpretation of the difficult measurements made on antiprotons by PAMELA and AMS-02. This is also a clear demonstration of the importance of the multidisciplinary approach in science. ■

COMPUTING
BIG DATA: INFN INVESTS IN TRAINING

INFN invests a million Euros in training future big data professionals, publishing 12 post-doc scholarships to collaborate with experiments at the Large Hadron Collider (LHC) at CERN. New scientific discoveries and the advancement of technologies always proceed in parallel in modern society. This is also true for high-energy physics and computing technologies. And to address the challenges of the next generation of experiments at the LHC, the LHC High Luminosity project requires far more resources. It is envisaged, in fact, that a CPU 60 times more powerful than nowadays ones will be required, together with a storage space 40 times larger than the current one to manage the data produced by the future machine. The people selected will deal with the development of innovative work procedures for computing and data management solutions in the field of big science, data analysis and algorithms for high performance computing and development of deep learning machines and techniques. This important initiative, to train young people with cutting-edge skills in supercomputing, is a good example of a national framework of excellence in this area, as demonstrated by the recent choice of Bologna - which is already home to many major centres, including INFN's CNAF, one of the first level nodes of the LHC GRID network, and CINECA - as the headquarters of ECMWF, European Centre for Medium-Range Weather Forecasts.



INTERNATIONAL COLLABORATION
INFN JOINS CTAO

INFN membership of CTAO GmbH (Cherenkov Telescope Array Observatory), which will be the largest earth-based gamma ray astronomy research infrastructure in the world, has been formalised. CTAO will, in fact, consist of over 100 new-generation telescopes, dedicated to the study of gamma rays, i.e. high and very high energy photons, of galactic and extragalactic origin, which manage to reach our planet. Italy is participating in CTAO, as well as with INFN which now makes its official entry on the company's Council, with the National Institute for Astrophysics (INAF) and a consortium of universities led by the University of Padua. INAF and INFN will participate in the project with a contribution in kind which will be designed and built in collaboration with domestic companies. ■

» INTERVIEW

FROM STARS TO MEDICINE: A LABORATORY FOR BASIC AND APPLIED RESEARCH

Interview with Diego Bettoni, director of the INFN Legnaro National Laboratories

Diego Bettoni is the new director of the Legnaro National Laboratories (LNL) starting from January 2017. LNL is one of the four INFN national laboratories; it is engaged in basic research in nuclear physics and astrophysics and in the applications arising from the development of nuclear technologies. The laboratory, inaugurated on 27 November 1961 as "Centre on Nuclear Research of Veneto Region", has its roots in INFN excellence for particles accelerators and detectors. LNL strength points are nuclear particles accelerators and nuclear radiation detectors; it is hence a centre that gathers many researches and developments on low energy nuclear physics in Northern Italy. Today, over 800 researchers coming from all over the world regularly join LNL research programmes. The laboratory does not only host its five accelerators and the detectors for its ongoing experiments but also major European collaborations' research projects.

Is it possible to identify a progressive development of the Laboratories in a defined direction? What are the main basic research topics that the laboratory is focussing on today?
Ever since their foundation in 1961 the Legnaro National Laboratories (LNL) have distinguished themselves for forefront research in the field of fundamental nuclear physics. This excellence has been maintained over the years, on one hand thanks to the construction and operation of accelerators meeting the demands of an ever growing national and international user community; on the other hand thanks to the development of innovative detectors for nuclear spectroscopy, from the early scintillation detectors, to Germanium-Lithium detectors, until the modern "gamma arrays". This advanced know-how in the field of accelerators and detectors for nuclear spectroscopy has been attracting an ever growing international community. The next step of this development will be the fulfilment of the SPES (Selective Production of Exotic

» INTERVIEW

Species) project, a second generation ISOL (Isotope Separation On-Line) facility which will become a reference for the international nuclear physics community.
Another characterising feature in the history of Legnaro is the ever increasing role of applied and interdisciplinary research, which represents a natural integration to the fundamental science.
The most prominent research lines in Legnaro are the study of nuclear spectroscopy and of reaction dynamics. Also the applied part gives a significant contribution to the laboratory's activities: an example is the laboratory for Superconductivity and Surfaces Treatment.

Experiments at LNL are characterised by a strongly applicative tendency starting from the design phases. Is this due to a characteristic of nuclear physics research or is it a consequence of a defined strategy?
It is undoubtedly a feature of Nuclear Physics to have many applications in other fields. The relevance of applied research in the activity of Legnaro is however the result of a precise strategy of the management, both of the lab and of INFN, which has led to the establishment of various applied research programs in fields such as biomedicine, environment and cultural heritage. This strategy creates synergies between basic and applied research and thus enhances the potential of the laboratory. Basic and applied researches are both fundamental components of a modern nuclear physics laboratory. Curiosity-driven research allows maintaining a lively and motivated community, whose projects and ideas can then be applied to other fields. Technology transfer is the natural fallback of our research and provides a partial return of the financial investments sustained by society to fund basic science.

Applied research at LNL covers very different activities: from environmental radioactivity monitoring, at regional scales, to the study of the materials for the future of nuclear reactors, in partnership with international research centres, until the analysis of materials and the development of technologies for cultural heritages, in partnership with companies and private and public institutions. How do you deal with so diverse contexts?
Interdisciplinary research has always been a fundamental part of the LNL activity, so that the interaction with other, very diversified communities has somehow entered into the laboratory DNA. The relationship and interaction with other communities represent an added value. The research activity in physics requires great flexibility and an open mind, the ability to deal with and find solutions for problems of all kinds. These features become an essential part of our culture and allow us to interact efficiently with the other communities.

In the past you have been working not only in INFN but also in major international collaborations such as CERN, Fermilab and SLAC. How big is the influence of international collaborations on LNL activities?

» INTERVIEW

The international context plays a fundamental role for LNL, whose project for the future is to become a major research pole attracting a large national and international community. Now researchers from Europe and all over the world have already an experimental activity in Legnaro while our researchers work on experiments in various laboratories abroad. The international nuclear physics community exploits the synergies coming from the complementarities of the various laboratories, whose experimental programmes are at the same time competing and complementary. In this context the laboratory strongly supports an initiative, called EURISOL-DF, which aims at the creation of a network of nuclear physics laboratories in Europe, to be managed as a single distributed research infrastructure, allowing scientists to choose the best laboratory for their experiments.
Furthermore LNL participates in important international programs, such as the realization of the European Spallation Source (ESS) or the IFMIF (International Fusion Materials Irradiation Facility) project, which exploit the competencies of the laboratory in the field of accelerator technology, which represent one of its major strengths and allow the acquisition of significant external funds.

A leading project for the next future of the Laboratory is the new infrastructure SPES, dedicated to fundamental research in nuclear physics and to the interdisciplinary applications. What are the objectives and the state of art of this project?
The SPES project is the perfect declination of the twofold nature of the lab as a centre for basic and applied science. SPES is a second-generation ISOL facility with two main objectives. The first goal is to better understand the origin of elements in the universe, an ambitious endeavour requiring the study of the properties of unstable (radioactive) nuclei through their decays and interactions. The second important objective of SPES is the construction of a laboratory for the production of innovative radioisotopes for nuclear medicine (therapy and diagnosis). A further project under study is the possible realisation of a neutron source with applications to material science, medicine and astrophysics.
The first phase of the project is presently being completed, consisting in the construction of the building and in the acquisition and commissioning of the proton cyclotron. In the next few years the remaining elements for the production and reacceleration of radioactive beams will be built and installed. The medium term goal is to begin experiments with non-reaccelerated beams in 2019 and with reaccelerated beams two years later.
The activity bound to the production of innovative radioisotopes of biomedical interest will start in parallel. This activity will be conducted in partnership with a private company within the framework of a collaborative research agreement.

INTERVIEW

Is there a link between the LNL attitude to research and the scientific tradition of Padova, mainly arisen after Galileo's first astronomic observations?
The Legnaro National Laboratories were founded thanks to the initiative of a group of scientists from the University of Padua. The relationship between Padova and Legnaro is still very strong, it concerns the core activities of the laboratory and involves not only the Physics and Astrophysics Department and the local INFN unit, but also other university structures (Engineering, Pharmacology and more Departments). The research activity in LNL is principally in the field of nuclear physics and astrophysics and is in continuity with the Padua scientific tradition.

» FOCUS

IPPOG, A SCIENTIFIC COLLABORATION FOR PARTICLE PHYSICS OUTREACH

A rare mix of scientists, science communicators, and educators from the most prominent laboratories and institutions engaged in particle physics around the world, working in science education and public outreach for particle physics: this is IPPOG, the International Particle Physics Outreach Group. IPPOG's goal is to contribute to global efforts that strengthen cultural awareness, improve understanding and support of particle physics and related sciences, and develop the next generation of researchers, by raising the standard of public outreach and science education. Current members come from the 22 member states of CERN, which include the Italian INFN, and other countries active in particle physics, like Australia, Ireland, Slovenia, South Africa, and the USA.

Established 20 years ago, IPPOG first evolved from a European to a global network and now, on 19 December 2016, has become a formal scientific collaboration based on a memorandum of understanding, signed by INFN in January. A total of 13 countries have joined the collaboration and there are several candidate members expected to join soon. IPPOG's members include representatives of several national-level science networks, helping to establish it as a global network of laboratories, institutions, organizations, and individuals, all passionate about particle physics.

IPPOG is best known for its International Masterclass (IMC) programme, which emerged in the mid-1990s from national outreach efforts in the days of LEP (a former CERN collider). Since 2005, the programme has offered high-school students the opportunity to become physicists for a day by performing tailor-made analyses on real particle physics data from the LHC (the current accelerator at CERN) experiments, and is currently expanding scope to detectors, such as LIGO-VIRGO, Ice Cube, and the Auger Observatory. Lectures from active scientists give students insight to topics and methods of research of the fundamental components of matter and their forces, enabling the students to perform measurements on real data. At the end of each day, like in an international research collaboration, the participants join a video conference (moderated from CERN or Fermilab)

» FOCUS

for discussion and combination of their results.
In terms of numbers, this year's edition of the IMC included more than 200 institutions in 52 countries and around 13,000 students took part. INFN joined the IMC from the beginning in 2005. In Italy, every year, around 3000 students participate in the IMC, organized by all INFN's divisions and the Frascati Laboratory.
Reaching out to high-school students and their teachers to convey the methods and tools used in fundamental science is a strong investment in the future. While only a fraction of young students will become scientists, and fewer still will become particle physicists, all will become ambassadors for the scientific method and evidence-based decision-making. In this spirit, future IPPOG efforts are underway to add global cosmic ray measurement and neutrino programmes to its core activities. ■

Links:
http://ippog.org
http://physicsmasterclasses.org/
http://masterclass.infn.it/

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Cover
Cyclotron P70 at the Legnaro National Laboratories of INFN.