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Istituto Nazionale di Fisica Nucleare

INTERVIEW

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FROM ACCELERATORS TO ASTROPARTICLE PHYSICS: THE FUTURE IN A UNIFIED STRATEGY

Interview with Chiara Meroni, newly elected member of the Executive Board of INFN, director of research and former director of the INFN Milan division.

Appointed as a member of the Executive Board of INFN by the INFN Board of Directors, during the meeting of 25 September 2019, from 1 November Chiara Meroni took office, relinquishing her position as director of the INFN Milan division, a role she has held since May 2012. The position of director also involved the management of an important laboratory, the LASA (Laboratory for Accelerators and Applied Superconductivity), which is an integral part of the INFN Milan division. LASA contributes to the experiments at CERN, DESY and Fermilab, with the development of cutting-edge technologies and important industrial collaborations.
Married with three children, Chiara Meroni has held positions of scientific and managerial responsibility since the beginning of her career. As an INFN director of research, she has been involved in elementary particle physics research in the context of international collaborations at CERN, where she carried out research in the field of semiconductor, strip and silicon pixel tracking detectors. She is currently working on the ATLAS experiment at the LHC. In the past, Meroni was the national coordinator of the European AIDA project for the implementation of infrastructures for the R&D of detectors for future experiments, a position she continued to hold in the subsequent development of the project, AIDA2020.
We asked her to tell us what currently emerges from the comparison between the two perspectives of the Institute, the local one, as division director, and the national one, as a member of the Executive Board, giving us an assessment of the experience acquired and the vision that will guide her in the near future.

You have been following the strategic development of research at INFN for several years, as director of the Milan division. Which direction did the division take in the years under your management?
The INFN division of Milan focuses on several key scientific lines, integrated in university life and representative of all INFN scientific committees. During my years as director, I tried to give value to the LASA laboratory and to the accelerator physics school, which are historical contributions of the Milan

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division to the life of the institute.
On this front, the division works in the ATLAS and LHCb collaborations at CERN. Its main contributions are the development and the maintenance of the ATLAS calorimeter and tracker, and of the LHCb tracker. The collaboration with CERN is also achieved through AEGIS, dedicated to the study of the fundamental properties of antimatter.
Historically, the Milan division has its strength in the nuclear physics group with the AGATA experiment, within the framework of the European Gamma collaboration, where the main technologies for experimental research in nuclear physics are designed. AGATA is currently installed at the Ganil laboratory in France and next year will be transferred to the INFN Legnaro National Laboratories, an infrastructure with which the division has had strong ties since its inception. Again, within the framework of the Gamma collaboration, in recent years, the nuclear physics group has strengthened its collaboration with RIKEN in Osaka, Japan. Then, of course, the research programmes of the division have always included the neutrino physics branch, which for some twenty years now has seen significant development with the Borexino experiment at LNGS and which, today, at the end of its career, is concluding a twenty-year cycle of measurements, completing the knowledge of the Sun's cycle and aiming to measure the CNO (Carbon Nitrogen Oxygen) cycle, which is the basis of the processes fuelling our star. This line of research has led to participation in DUNE experiment, at Fermilab in the United States, and in JUNO experiment, at the Institute of High Energy Physics (IHEP) in Beijing, for the study of sterile neutrinos and Majorana neutrinos. The division is also highly involved in the Auger collaboration, for the study of high-energy cosmic rays, which recently celebrated its 20th anniversary in Malargue, Argentina.
In the technological field, in addition to the significant commitment of LASA in the development of technologies for LHC magnets, the Milan division has an important collaboration with the Politecnico di Milano for the development of detectors electronics (CCD) with the significant involvement of the INFN Technology Transfer Committee.

The role of director of the Milan division also entails the duty and honour of managing the LASA (Laboratory of Accelerators and Applied Superconductivity), an important laboratory with close links to CERN and significant technological spin-offs.
At CERN, LASA has a significant engagement in the development of magnets for the LHC accelerator and its subsequent developments, with the involvement of prestigious Italian companies. In particular, with MAGIX (Innovative Magnets for Future Accelerators) – a project that won one of the calls issued by the INFN 5th National Committee – LASA is at the forefront of the development of technologies for the future of the LHC. MAGIX envisaged the design, construction and cryogenic testing of the prototypes of

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the superconducting magnets of the HL-LHC (High Luminosity – LHC) project, the future high-luminosity accelerator that will follow the last phase of the LHC's activity. Thanks to a new agreement with CERN, the production of the magnets in now taking place.

LASA is involved in several other projects at the European level for the development of new accelerator machines. In particular, it is involved in the design and development of superconducting cavities for the acceleration of proton beams of the European Spallation Source (ESS), in Lund, Sweden, and it was one of the key partners in the European project XFEL (European X Free Electron Laser), a project that is now completed and experimentally active. LASA is the coordinator of the technical and scientific contributions of Italy to XFEL. It also participates to another international project: the EUPRAXIA project, dedicated to the application of laser accelerators to medicine, nuclear physics and inertial fusion. This commitment, which is of a highly technological nature, involves not only the INFN 1st National Committee, dedicated to high energy physics, but also the 5th Committee, which coordinates investments in technological development and applications. The technological spin-offs of LASA's activities are also significant in the field of nuclear medicine, with a long tradition in optimising the production of radionuclides for radiodiagnostics and metabolic radiotherapy. An activity that requires the use of particle acceleration machines and is carried out in collaboration with the ARRONAX radioisotope production centre in Nantes, France.

INFN has a tradition in subnuclear physics research, in which you play a major role, and the study of cosmic rays that has developed into the broader field of astroparticle physics. How do you think the objectives of these two branches can be integrated into a single strategy of the institute?

Accelerator physics and astroparticle physics are, in my opinion, two complementary methodologies to investigate the same problem: how the universe and reality in which we are immersed work. For many years now, we have understood that studying the microcosm and the macrocosm have many points in common and for this reason the research strategy in the two areas must take this unitary objective into account.

The need for integration between the various research branches also arises at a global level. In November, a meeting was held in Paris, aimed at sharing the strategies of the three major European research planning networks, NUPPEC (Nuclear Physics European Collaboration Committee) APPEC (Astroparticle Physics European Consortium) e ECFA (European Commitee for Future Accelerators). The result was the establishment of a joint group with the aim, as far as possible, of defining common objectives in the three areas: high-energy physics, astroparticle physics and nuclear physics. One of the points raised in the meeting was the need to share methods and tools: on the one hand, at the level of theoretical research, the exchange of tools and models between the three fields is necessary. On the other, in the presentation of experimental data, greater uniformity of languages and techniques is required in order to make the

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exchange more effective. In order to optimise costs and benefits, we must also, as far as possible, share the technologies developed in the individual areas. CERN, for example, was asked to make its expertise in cryogenics and long-distance vacuum technology available to other projects. An example of this is the sought-after collaboration with the Einstein Telescope (ET) project for the study of gravitational waves.

In recent years, there were two major discoveries, in which INFN played a key role: the detection of the Higgs boson and of gravitational waves. How can INFN maintain the level of these results in the future and align its decisions with the international strategy?
The scientific level of our research can be maintained by continuing to work at the level of excellence that distinguishes INFN and by supporting the best proposals in these fields. At the international level, INFN plays a major role in defining the future European particle strategy, so it is not a question of aligning with a strategy defined by others but of bringing constructive and long-term proposals to the table to shape this strategy. INFN has contributed by supporting the design of what we call the “FCC all” strategy: the creation of a 100 km long accelerator, which in the first place would complete the measures in the field of electroweak physics with an electron-positron collider (e+e-). Afterwards, when the necessary technological progress has been made in the field of HTS (High Temperature Superconducting) magnets, the objective would be to open in the same tunnel the investigations with energies higher than 40 TeV at the centre-of-mass with a protons collider.
For the future of gravitational waves we are supporting the third observational phase of VIRGO O3, which will end in April 2020 and we will support the subsequent upgrade of the interferometer, protagonist with the LIGO-VIRGO collaboration of the first detection of gravitational waves and of subsequent detections. At the same time, we are working on a project of the next telescope for gravitational waves (ET-Einstein telescope), also proposing to install it in Sardinia. For the future development of our research lines, we also pay attention to data coming from other fields, for example on dark matter.

What do you think should be the focus of the work of the INFN Executive Board in the coming years? In your opinion, what are the strengths of the Institution and what aspects should be strengthened?
It is certainly necessary to focus first and foremost on enhancing the professionalisms of the employees at all levels, without forgetting that human resources are people who bring all their experience and expectations into their work experience, with real situations of difficulty. So in my work as a member of the Executive Board I will try to think about the real situation of the INFN community, to assess the impact of proposals and of development strategies. As to the distribution of human and financial resources, in some cases they need to be more focused so as not to disperse resources on too many fronts, because

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we move in a context of finite resources.

The future of INFN research is certainly focused on the European strategy for particle physics, with the development of future particle accelerators, the Einstein Telescope for the detection of gravitational waves and astroparticle physics, with very promising expectations. It is research of the highest scientific and technological level, which, as demonstrated in the past, leads to benefits in terms of knowledge acquired but also in terms of usable goods and services, in the mid to the long term. Our primary objective is the investigation of the universe, an ambitious goal that, for its greatness, opens up new knowledge at all levels, as demonstrated by many examples from the more and less recent past. For the next few years the work of the INFN Executive Board will be to continue on the path of scientific excellence, with an ever greater awareness of the social responsibility of our work, an awareness that is increasingly alive in our community. ■

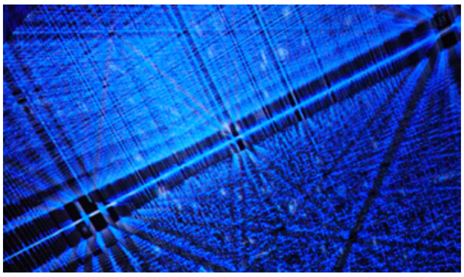
RESEARCH

ARIA, FIRST RESULTS CONFIRMING VALIDITY OF THE PROJECT TECHNOLOGY

It stems from the research in fundamental physics to respond to an experimental need: to have large amounts of argon available for the search for dark matter with the DarkSide experiment at the INFN Gran Sasso Laboratories. But in the future it could also be used for the distillation of other isotopes increasingly used in medicine, both in advanced diagnostics and in cancer therapy, and also in environmental and agricultural sciences. This is the ARIA project, whose first results, following the tests performed on the Seruci-0 cryogenic distillation pilot tower, were presented on 16 November, during an event held at the University of Cagliari, in the presence of the 2015 Physics Nobel Prize winner, Art McDonald, and representatives of the world of scientific research, business and institutions.

The ARIA infrastructure for the production of argon and other elements will consist of a 350-metre cryogenic distillation tower, which will be installed in Well 1 of the Seruci area of the Carbosulcis mine of Mount Sinni. In last July and October, the DarkSide international scientific collaboration carried out two operating campaigns of the Seruci-0 tower, a 24 metres high column. During the two operating campaigns, the Seruci-0 plant distilled nitrogen (N_2), allowing the expected performance of the Seruci-1 tower to be extrapolated, which is perfectly in line with the forecasts made during the design phase.

ARIA is an unprecedented project at the international level, made possible by the scientific cooperation between INFN, acting as leader and coordinator of the research groups involved, and Princeton University, supported by the Sardinia Region and Carbosulcis. The project also involves local scientific partners with the University of Cagliari and the INFN division of Cagliari and the University of Sassari, with the crucial contribution of Italian companies. ■



SPACE

PLANCK DATA HIGHLIGHT POSSIBLE DISCREPANCIES WITH THE CURRENT COSMOLOGICAL MODEL

A new analysis of the data collected by the Planck satellite has been published by Nature Astronomy, which could question some fundamental assumptions of our current vision of the Universe.

The study, conducted by an international team led by a research team from the Sapienza University of Rome and INFN, analysed the map, produced by Planck, of the cosmic microwave background (CMB), which provides a kind of primordial 'photograph' of the universe, as it was 380,000 years after the Big Bang. Similar maps of this primordial radiation, and in particular of its anisotropies and inhomogeneity, had already been obtained from the Boomerang experiment and from the WMAP satellite. The ESA Planck mission, however, in collaboration with ISA and NASA, active from 2009 to 2013, achieved unprecedented precision and sensitivity. Precisely thanks to Planck's high sensitivity, the study published in Nature Astronomy was able to estimate the gravitational distortion of the cosmic background radiation due to the dark matter of the Universe with greater precision. A measurement that indicates matter density in the cosmos higher than that measured so far. If this were the case, the universe would not be flat, as scientists have assumed until now, but curved. If we imagine the cosmos in just two dimensions, it would mean moving from an "infinite plane" form to a form with a "spherical surface". ■

STRATEGY

STUDY DAYS OF THE INFN 2020-2022 THREE-YEAR PLAN IN BARI

On 8 and 9 November in Bari, at the premises of the Polytechnic, the study days of INFN's 2020-2022 Three-Year Plan were held, which this year featured the opening address by the Minister for Regional Affairs and Autonomies, Francesco Boccia.

The Three-Year Plan is the event dedicated to the analysis, proposal and discussion of the scientific and other policies of the Institute in which the INFN community always participates in large numbers. In particular, this year's meeting, which was held just a few months after Antonio Zoccoli took over the Presidency of INFN from Fernando Ferroni, revolved around these three key words: vision, strategy and future.

Minister Boccia's keynote was followed by greetings from the local authorities and institutions, at the end of which the proceedings began. The first day was dedicated to scientific topics, including the future European particle physics strategy, research on new physics and quantum technology. The second day focused on two of the main research infrastructures of INFN, the Southern National Laboratories and the Frascati National Laboratories, and the issues of technology applications and transfer, addressed from different perspectives, concluding with a general discussion on the main issues that emerged during the two-day event. ■

OUTREACH

HIGH SCHOOL STUDENTS ALL OVER ITALY TOOK PART IN RADON DAY

1200 students throughout Italy explored environmental radioactivity: this is what happened on 7 November, the anniversary of the birth of Maria Skłodowska Curie, in more than 50 Italian high schools, on Radon Day, a day organised by the project for the dissemination of scientific culture, RadioLab, which aims to raise the awareness of students and the general public on environmental radioactivity issues.

In many cases, the activities by students have been part of School-Employment Alternation Programmes. Radon Day involved high school students from eight Italian cities – Cagliari, Cosenza, Ischia, Lecce, Milan, Padua, Ragusa and Siena – engaged in measuring radioactivity in the field and meetings with researchers. Moreover, for the first time, this year a non-Italian school, the Korça High School in Albania, participated in the RadioLab project. ■

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20TH ANNIVERSARY OF THE PIERRE AUGER OBSERVATORY

On 16 November in Malargue, Argentina, the 20th anniversary of the founding of the Pierre Auger Observatory was celebrated. Auger, which owes its name to the discoverer of cosmic ray showers, is the largest observatory in the world for the study of ultra-high-energy cosmic rays, consisting of a network of detectors distributed over a territory thirty times the size of the city of Florence (3,000 square kilometres). Located on the plateau of the Pampa Amarilla, at an altitude of 1400 metres, the observatory is managed by an international collaboration of more than 400 scientists from 17 different countries, in which Italy participates with groups from various universities, the INFN divisions and universities of Catania, Lecce, Milan, Naples, Rome Tor Vergata and Turin, the Gran Sasso National Laboratories and the INAF facilities of Palermo and Turin.

During its twenty years of activity, the Auger Observatory has made an important contribution to the physics of ultra-high-energy cosmic rays, from confirmation of the significant reduction in the intensity of the cosmic rays flow for energies above 30 EeV (exa-electronvolt) to the recent verification of the extragalactic nature of the highest energy cosmic rays. There are, however, still many unanswered questions on which the future of the Observatory will focus.

The Auger Observatory is a hybrid system that includes surface detectors and fluorescence telescopes. The former, 1600 water tanks located 1.5 kilometres apart, observe the cosmic ray shower when it strikes the Earth's surface, detecting and counting the particles produced at ground level. The 27 telescopes distributed around the detectors, on the other hand, detect the flashes of fluorescent light produced in the air by the charged particles of the shower, thus observing its longitudinal development along the direction of origin. When the ultra-high-energy cosmic rays interact with the nuclei of the atmosphere, they generate a shower of new particles. An extensive observatory such as Auger can detect showers of this type and,

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based on the number of particles detected and their energy, calculate the energy of the primary cosmic ray. Auger's upgrading programme, called AugerPrime, is currently being implemented and has been carefully designed to address the most current frontiers that the Observatory is preparing to explore, in order to shed more light on the nature and acceleration mechanisms of this ultra-high-energy radiation.
To celebrate Auger's twentieth anniversary, in Malargue, in the province of Mendoza, a day of celebrations was organised which was attended for Italy by Daniele Martello, national coordinator of the Observatory and director of the INFN division of Lecce, Fernando Ferroni, professor at GSSI and INFN researcher representing the MIUR – Italian Ministry of Education, University and Research – Jose Kenny, scientific attachè to the Italian Embassy in Argentina, and other representatives from the academic world. The day of celebrations was introduced by a scientific symposium on the current state of research not only in the field of ultra-high-energy cosmic rays but also in studies on neutrinos and high-energy gamma rays and in the field of multimessenger astronomy. ■

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