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STUDYING THE UNIVERSE, FROM NUCLEI TO STARS

Interview with Eugenio Nappi, member of the Executive Board of INFN and its representative for research projects in experimental nuclear physics.

Experimental nuclear physics represents the link between the study of the primordial stages of the universe, carried out with the aid of large particle accelerators, and research into star, galaxy and galaxy cluster formation mechanisms, with experiments on nuclei stability and exotic nuclei production. At INFN, research activities in this field are carried out in the four national laboratories, at TIFPA (Trento Institute for Fundamental Physics Applications) and in several divisions, with important repercussions in various fields other than fundamental research, such as medical physics, physics for the cultural heritage, energy research and development of new materials and technologies for nuclear safety.

The INFN is engaged in several projects on experimental nuclear physics, ranging from fundamental physics to medical applications. How are the various activities coordinated in the Institute?

The coordination of experimental nuclear physics research activities in INFN is carried out by the third National Scientific Commission (CSN3) which establishes the priorities and funding of individual projects. But the broad spectrum of research activities in this field doesn't end with CSN3.

Since 2006, following the signing of a collaboration agreement between INFN and Ansaldo Nucleare, the development of skills and instruments in the field of nuclear physics applications in the energy sector, with particular attention to safety issues, is coordinated by the INFN-E strategic project. Since 2012, INFN-E has an annual budget of 200.000 euros. Also to be listed are the many nuclear physics activities related to the fifth National Scientific Board (CSN5), dedicated to technological developments. Among these, a very important role is played by medical applications that, in the development of diagnostic systems and the related simulation and analysis software, are rooted in a tradition of excellence of INFN. With the appointment of Marco Durante, an internationally renowned expert in hadron-therapy, as Director of TIFPA,

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we wanted to give a strong impetus to activities in the field of particle beam therapy techniques.
Again within the scope of CSN5, the activities related to nuclear physics applied to the cultural heritage, environmental pollution monitoring and detector and accelerator development are of great importance.

How does the INFN's strategy fit into the European scenario?
Priorities in funding nuclear physics activities are established by CSN3 in complete harmony with the guidelines of NuPECC, the European Coordinating Committee, which recently completed the work of drafting the Long Range Plan, the European roadmap for nuclear physics, whose conclusions will be presented on 27 November in Brussels. In particular, INFN's nuclear physics projects, following international nomenclature, belong to two major research branches: nuclear structure and hadronic physics. In the first case, the aim is the study of the nucleus as a composite system, to investigate the characteristics of radioactive vs stable atoms, the evolution of the universe and the formation of stars. Internationally, major investments are in progress to implement research infrastructures that accelerate exotic radioactive nuclear beams. In this context, the project on which the Institute is focussing is SPES (Selective Production of Exotic Species) at the Legnaro National Laboratories. In parallel with fundamental research, SPES will allow new radiopharmaceuticals to be synthesised for medical diagnostics.
The second branch, hadronic physics, is closer to the objectives and experimental techniques of research in high energy physics, coordinated in the Institute by CSN1. Hadronic physics represents the link between elementary particle physics and nuclear structure physics. In other words, hadronic physics aims to study the mechanisms by which the fundamental constituents of nucleons, quarks and gluons contribute to defining the actual properties of the nucleus. The most wide-ranging international hadronic physics initiatives in which the Institute is participating are ALICE, at CERN, and the experiments in progress at the Jefferson lab in the US and, in perspective, those that will be implemented at the EIC-Electron Ion Collider currently being designed in the United States (at the Brookhaven National Laboratory or at Jlab).

What are the objectives of the strategic INFN-E project?
The activities of INFN-E focus in particular on the following two lines of action. The first concerns the dismantling of nuclear sites, management of radioactive material repositories, personnel protection at nuclear sites and security. The second deals with contacts with organisations dedicated to energy issues, such as Ansaldo Nucleare, ASG Superconductors, CAEN, Gilardoni and the Euratom-Ispra Joint Research Center. In these areas, INFN-E acts as both an incubator for the development of products to be offered to industries and other entities, as well as an initiative centre for forms of external financing.

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What is the institute's involvement in experimental nuclear physics at the international level?

INFN contributes at the international level to all the most important initiatives in the field, with top level presence in the main European and global management committees. At the European level, Angela Bracco, from the University and INFN Milan Section, is in his second term as Chairman of NuPECC.

Nicola Bianchi from the Frascati National Laboratories is head of the EPS-NPB (European Physical Society – Nuclear Physics Board) since 1 January 2017. I myself have for three years been a member of the IUPAP C12 (International Union of Pure and Applied Physics – Nuclear Physics) and of the ICFA panel for the development of new detectors.

Paolo Giubellino, from the INFN Turin division, formerly spokesperson of ALICE, was appointed a few months ago as Scientific Director of FAIR in Darmstadt, Germany, a new research infrastructure, under construction, which from 2020 will become the most important German nuclear physics laboratory. Since the beginning of the present year, another INFN researcher is spokesperson of the ALICE experiment at CERN. From September 2017, Raffaella De Vita, from the INFN Genoa Section, will take on the role of spokesperson of the CLAS12 experiment at Jlab (of which Patrizia Rossi, LNF, has been deputy director for about 5 years). Recently, an Italian researcher from the Frascati National Laboratories, Catalina Curceanu, received the EPS “Emma Noether Distinction” Prize for women who have proven to be excellent in nuclear physics research at the European level.

Which are the main future nuclear physics research initiatives in Italy?

At the Legnaro National Laboratories, the SPES project, starting in 2019, is currently being installed. At the Southern Laboratories, the NUMEN (NUclear Matrix Elements of Neutrinoless double beta decay) project has important implications in astroparticle physics, in particular for the study of neutrinos and dark matter.

At the Gran Sasso National Laboratories, the most ambitious project is LUNA MV (Laboratory for Underground Nuclear Astrophysics-Mega Volts), an experiment in nuclear astrophysics which is expected to start within a couple of years, consisting of a research infrastructure able to study the formation of nuclei using an accelerator capable of producing nuclear reactions at energies comparable to those that occur in the stars. In 2018 SIDDHARTA - intended for fundamental research in nuclear physics - will enter into operation at the Frascati Laboratories, at the end of the KLOE (K-LOng Experiment experiment), currently in progress at the Dafne accelerator. In Trento, the TIFPA is engaged in the application of and research on oncological hadron-therapy, not only for treating patients but also for the study of therapy optimisation techniques. ■