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NEWSLETTER 31

Italian National Institute for Nuclear Physics

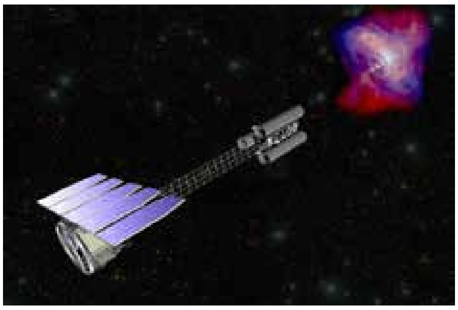
NEWS

INTERNATIONAL COLLABORATIONS
MIDDLE EAST, FIRST PARTICLE BEAM FOR SESAME

In mid-January, a particle beam circulated for the first time in the SESAME (Synchrotron-light for Experimental Science and Application in the Middle East) synchrotron, in Amman, Jordan: an important step towards the start of scientific research activities of the first synchrotron light source in the Middle East. The mission of SESAME, a project based on the CERN model, is to give the Middle Eastern region a world-class research infrastructure, while promoting international scientific cooperation.

SESAME is a light source, based on a particle accelerator, that uses electromagnetic radiation emitted by electron beams. The experiments at SESAME will enable research in fields ranging from medicine to biology, materials science, physics and chemistry for health, environment, agriculture and archaeology sectors.

INFN has contributed to the development of the heart of the accelerator, the resonant cavities that accelerate the electrons, realized by Elettra, is building innovative detectors for the experiments and will provide the structure for hosting researchers: an Italian investment of 5 million euros for science and peace, obtained thanks to the commitment of the Ministry of Education, University and Research (MIUR). Promoted in the mid-90s and approved by UNESCO in 2002, SESAME saw the first brick laid in 2003. Under the auspices of UNESCO and thanks to the support of the worldwide community, SESAME today represents a shining example of global commitment, which sees countries that have never sat at the same table working together for a scientific project. Italy is participating with INFN, Sapienza University of Rome, Elettra Sincrotrone Trieste and Città della Scienza. The first call for proposals for carrying out research at SESAME was recently published and the first experiments are expected to start in the summer of 2017. ■



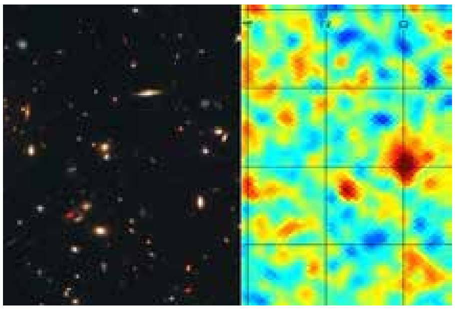
SPACE

IXPE SELECTED BY NASA AS THE NEXT SPACE MISSION OF THE EXPLORER PROGRAM

The project approved by NASA as the next space mission of the Explorer program is called IXPE (Imaging X-Ray Polarimetry Explorer). The satellite detector, in which Italy is participating with INFN and the National Institute for Astrophysics (INAF) with the coordination of the Italian Space Agency Coordination (ASI), is dedicated to the study of the X Polarimetry of celestial sources, such as black holes, neutron stars, magnetars and pulsars, and to the study of the effects of fundamental physics in extreme environments, such as Quantum Gravity (QG), vacuum birefringence and the manifestation of new exotic particles such as Axion Like Particles (ALP). The scheduled launch date is the end of 2020.
The core of IXPE will be built around innovative detectors of X-rays sensitive to polarization, invented, developed and brought to space qualification by INFN, in collaboration with INAF and with the support of ASI, which will also provide its base in Malindi for data reception. In particular, three IXPE's detectors, the Gas Pixel Detectors (GPD), implemented under the responsibility of the INFN Pisa and Turin division, will be placed in the focus of three X-ray telescopes, housed inside the satellite. GPD is the first system capable of simultaneously measuring all the properties of the X photons emitted by celestial sources, including direction of arrival, energy, time of arrival and direction of the associated electric field. In particular, by measuring the direction of the electric field of an adequate number of photons emitted by an X-ray source, it will be possible to measure for the first time, with great efficiency and sensitivity, the polarization of the radiation emitted by the source. Thus providing unique and hitherto inaccessible information on the geometry of the mass distributions and fields of the source. ■

APPOINTMENTS
LHC: FEDERICO ANTINORI HEAD OF ALICE

Another Italian is heading one of the four major experiments at the Large Hadron Collider (LHC) at CERN in Geneva. Federico Antinori, an INFN researcher, is in fact the new head of ALICE (A Large Ion Collider Experiment), dedicated in particular to the study of quark-gluon plasma, a state of matter believed to have existed soon after the Big Bang. ALICE is an international collaboration of more than 1,500 physicists, engineers and technicians from 37 countries worldwide.
Federico Antinori is a researcher of the Padua Section of the National Institute for Nuclear Physics (INFN). A graduate of the University of Genoa with a thesis on the WA82 experiment, implemented at the SPS accelerator at CERN, already in the early 90s he started to study ultra-relativistic nucleus-nucleus collisions. He has participated in numerous experiments with heavy ions, such as WA85, WA94 and WA97 at CERN. In 1996, he presented the proposal for the NA57 nucleus-nucleus collision experiment, for which he was responsible throughout the life of the detector. The results of NA57, along with those of WA97, contributed to determining the evidence of the existence of quark and gluon plasma, which was announced at CERN in 2000. Antinori has been part of the ALICE collaboration since its inception, acting as deputy director of the experiment 2007-2008, a period in which ALICE passed from the construction to the operational phase. Antinori has held numerous senior management positions over the years, from 2012 to date, the years in which the experiment produced many of its key results, he has been the coordinator of the physics of ALICE. Antinori takes over from another Italian, Paolo Giubellino, who coordinated ALICE from 2011 to 2016. ■



RESEARCH
FERMI, GAMMA LIGHT FROM GALAXY CLUSTERS

Also galaxy clusters shine with gamma light. This is the conclusion reached by a group of researchers from INAF, INFN, the Universities of Rome Tre, Turin, Aachen, Manchester, Beijing and the International School for Advanced Studies (SISSA), in analysing the data collected over six and a half years of the NASA Fermi space telescope mission, in which Italy is participating with the Italian Space Agency (ASI), INAF and INFN. From the study of galaxy clusters, astronomers obtain crucial information on high-energy photon emission and particle acceleration mechanisms. For this reason, they have been observed in all regions of the electromagnetic spectrum with the exception, until today, of the gamma band. The team used the observations made by the Fermi Large Area Telescope (LAT) in the very high energy gamma ray band, the processing of which led to the identification of different types of astrophysical sources. In particular, the aim of the study was to identify the gamma radiation produced by galaxy clusters, analysing the gamma radiation not associated with known sources. Most of the emissions detected by Fermi are produced by Active Galactic Nuclei inside or in close proximity to the cluster. However, there seems to be a second component which, in terms of spatial and energy distribution, could be associated with the cluster itself, the dark matter it consists of, rather than with the objects it contains. The study, of statistical nature, was published in January in The Astrophysical Journal Supplement: the results presented do not yet provide a definitive answer but definitely indicate the direction in which to move to understand it. ■

INTERVIEW

WHEN RESEARCH INFN'S 2017 STARTS WITH A VIEW TO CHANGE

Interview with Fernando Ferroni, INFN President since 2011

"Time of change" is the motto with which, at the Legnaro National Laboratories, Ferroni opened the INFN 2017-2019 three-years plan seminar last December. Change, already at the end of the year, marked by completion of the selection procedures for the recruitment of 73 new researchers and by approval by the government of the decree simplifying the activities of public research bodies. Of course, the scientific challenges which in the course of 2017 will engage INFN are many: from the research on gravitational waves with the Virgo interferometer, to high energy physics at CERN, which will be able to count on the outstanding performance of the LHC, as well as ongoing research at the Gran Sasso National Laboratories on dark matter and neutrinos. The high level contribution of INFN in numerous international collaborations is highlighted by the managerial roles of INFN researchers and by the coordination in the realization of vital parts of the scientific apparatuses. In addition, in the near future it will be fully launched the administrative reorganization process started in the second half of 2016 with the entry into office of the new Director General of the INFN, Bruno Quarta.

Time of change, therefore. Which of the transformations in progress will mostly affect the institute's future?

The most important change for the year which has just begun is certainly in the implementation decree on the operation of research institutes. This guarantees us independence in general, especially in the field of personnel recruitment. As a first important step, at the end of 2016 we completed the selection procedures to hire, after years of hiring freezes, 73 new researchers, of which 58 experimental and 15 theoretical, who will bring new life to the institute's research activities. An expectation of renewal that also depends on the type of new researchers hired: about a third of the winners come from abroad and this will undoubtedly result in an infusion of innovation and variety in the mentality and way of working, which can only enrich us. We have

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decided to encourage their training and growth with the award of an initial grant and we hope they will soon be able to compete individually in the assignment of European grants for research projects. As a further element of innovation, by no means secondary, the decree simplifying research institutes finally recognises the roles of researchers and technologists, as provided for by the European Charter for Researchers. This provides the due dignity to vital professional figures for the institute, aligning the methods of management of Italian research institutes with the global context, which we have been part of for years having to cope, with difficulty, with an incongruous difference in treatment.

The recent discovery of gravitational waves provides encouragement to address the major scientific challenges put in place for the coming years. Frontiers such as that on the nature of dark matter are, however, particularly difficult to overcome. Is there a clear vision of the strategy to be followed in this and other fields?
In terms of strategy, one thing certain is that when we know what to look for we find it. This is demonstrated by recent discoveries, albeit with lengthy investigations, such as those of the Higgs boson and gravitational waves. In the case of dark matter, the issue is more complex because we are not sure what we are looking for. That is why we are looking a bit in all plausible directions and the variety of experiments is justified in this context. To date, the results have only allowed to exclude some possibilities while a certain variety remains: focussing on one direction only would be a strategic mistake. For dark matter we are following three parallel roads, the results of which, however, bring complementary information: the production of dark matter particles at the LHC, their detection in space with satellite detectors such as AMS (Alpha Magnetic Spectrometer) and DAMPE (DArk Matter Particle Explorer), and soon by the Chinese space station, and detection in the underground Gran Sasso laboratories where, protected from cosmic rays, we hope to detect the rare interaction of dark matter particles with large-scale detectors. Of the latter, the experiment par excellence engaged in the search for dark matter candidates is certainly XENON, but we are also working on next-generation detectors such as DARKSide, with important repercussions, among other things, on the industrial fabric of the country such as those of the ARIA project, whose realisation foresees the conversion of a mine in Sardinia.

The place of excellence for the search for dark matter, at the worldwide level, is the Gran Sasso Laboratories. In general, what will be the focus of research in the four major INFN national laboratories?
The Gran Sasso laboratories are engaged, as we said, in the detection of dark matter and as a second major focus on the study of the properties of neutrinos. Research in which the laboratory is a global excellence and attracts researchers and collaborations from all over the world. Also in the field of neutrinos, the Southern National Laboratories are now in full swing in the construction of

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KM3NeT, the submarine telescope for the detection of cosmic neutrinos, implemented at a depth of 3500 metres off the coast of Porto Palo di Capo Passero in Sicily, a European collaboration that also has important technological and marine environment monitoring repercussions. Also at the Southern Laboratories, upgrade is in progress of the cyclotron, the accelerator of the laboratories used to develop important experiments in nuclear physics also used for cancer protonterapy with the CATANA (Hadroterapy and advanced nuclear applications center) project. A new cyclotron was installed last year at the Legnaro laboratories for the SPES (Selective Production of Exotic Species) project, dedicated to the study of atomic nuclei produced in the late stages of stellar evolution, as well as the production of radiopharmaceuticals. The Frascati laboratories, an INFN tradition of excellence in the field of particle accelerators, are now engaged, as well as in research on the DAFNE collider, in the European EUPRAXIA (European Plasma Research Accelerator with eXcellence In Applications) project for plasma acceleration, with the SPARC (Auto-amplified Pulsed Coherent Radiation Source) free electron laser.

In addition to being the unique reference in Italy for nuclear and particle physics, INFN has a strong penetration internationally. Which are the most promising collaborations?
INFN research is mainly conducted within international collaborations. This is one of the institute's strengths. In this context, the activity takes place along three large and well-designed highways on which we are working at full capacity: high energy physics at the LHC, detection of gravitational waves with the Virgo interferometer and the search for rare events in the Gran Sasso laboratories. INFN is also active in the multimessenger field, the part of astroparticle research which is based on multiple cosmic messengers detection and which is now taking benefits from KM3NeT and Virgo and the information brought, respectively, by neutrinos and by gravitational waves.
We are also exploiting the recommendations that emerged from WHAT NEXT, the internal process of definition and sharing of strategies for research in the near future. In particular, INFN is activating collaborations in the cosmological field for the study of cosmic background radiation and dark energy, fields in which the institute's skills and specific abilities can make a difference. INFN's contribution in building new accelerators worldwide is also very significant, based on our tradition and high level of knowledge in this area. A commitment that sees us involved in projects such as ELI (European Laser Infrastructure), a new research infrastructure of pan-European interest for multidisciplinary research and applications. Thanks to INFN, moreover, Italy is one of the international partners of the European XFEL project for the construction of a Free Electron Laser synchrotron radiation source. We are providing a major contribution to the implementation of the ESS (European Spallation Source) multi-disciplinary research centre in Lund, Sweden, based on a powerful neutron source, in which we are coordinating the Italian participation in the construction of the particle accelerators. Again at the European level, for some time now we have been providing our expertise and technologies for the European Synchrotron Radiation Facility

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(ESRF) in Grenoble, France, for the implementation of an intense X-ray source. Our contribution to accelerator development also involves the Middle East with SESAME (Synchrotron-light for Experimental Science and Application in the Middle East), for which INFN is contributing to implement the accelerator's core. In Europe we have already mentioned the EUPRAXIA and KM3NeT projects, while on the other side of the Atlantic we have a long-standing collaboration with Fermilab, whose activities we currently support in particular in the neutrino field; finally, we share with China important projects on neutrinos and in space.

In the Nature Index 2016, the Nature ranking of worldwide research institutes, INFN is eleventh among more than 3700 institutes involved in physics research worldwide*. How can a similar level of performance be maintained over time?
Our researchers are excellent and this is demonstrated by the high-level posts assigned to them worldwide, where we export not only well prepared young people constituting the brain drain from Italy, but also experts covering management roles of high level. In recent years, many of our researchers have been appointed as spokespersons of experiments at CERN or to the guidance of important international projects and foreign institutions.
Part of INFN's excellence is also due to its organisation and ability to make wise investments. We spend no more than 50% of our budget in salaries and the remaining half is completely invested in research. We also have continuous and fruitful collaborations with the business world.
In the technology transfer field, the number of patents, spin-offs and start-ups, as well as cooperation agreements with businesses, are constantly growing. And this takes place because our researchers are not only excellent, but are becoming increasingly aware of the strong relationship between what they do and the possible external use of the technologies they develop.■

*https://www.natureindex.com/institution-outputs/generate/Physical%20Sciences/global/All/weighted_score/1

» FOCUS

AISHa, NEW ION BEAMS FOR HADRONTHERAPY AND RESEARCH

At the end of 2016, AISHa (Advanced Ion Source for Hadron Therapy) produced its first ion beam. Designed at the INFN Southern National Laboratories, AISHa is an innovative source of ions for hadrontherapy, a technique for the treatment of tumours in which protons or ions beams, accelerated in cyclotrons or synchrotrons, are directed against tumour cells.
AISHa was designed with the objective of creating a source of high-performance ions suitable for installation and use in hospital environments. It must therefore be easy to use and maintain, consume little energy and produce particle beams with high reliability, intensity, charge and brilliance. The recent launch of the source with production of the first beam has shown that AISHa's operating parameters meet these requirements and that it is therefore now possible to start the source characterisation phase, which will continue throughout 2017. AISHa also presents technological innovations that will allow it to compete with the best ion sources currently available.
AISHa is the result of the work of a team of over twenty researchers and technicians, engaged on the project since 2013. In February last year, the core of the source was produced and, after being completed over the year with the mechanical part, it produced the first ion beam.
Compared to other ion sources currently used in hadrontherapy, AISHa envisages a more intense and flexible magnetic field, thanks to the use of 4 superconducting coils brought to an operating temperature of 4 Kelvin. The source is also characterised by an innovative plasma heating system - a key element of the source itself - that increases the probability of producing ions with the desired state of charge.
A further peculiarity of AISHa lies in the fact that the source is not limited to the production of protons or carbon ions, it is additionally able to produce a wide variety of ionic species, from lithium to heavier metal ions, a characteristic for which it could also be useful in basic research. Moreover, the new source was designed to be compact, despite its high performance. It will therefore be suitable to be

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used in Italian hadrontherapy centres, as well as in basic nuclear physics research internationally. The AISHa project was funded also thanks to the regional development fund dedicated to small and medium enterprises integrated with research institutes, the ROP Sicily ERDF fund, in the context of which the Region has earmarked around four million euros for the project. The INFN partners in this context are HITEC2000 srl, UNICO srl and C3SL. ■

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Immagine di copertina
INFN 2017-2019 three-year plan seminar at Legnaro National Laboratories.