NEWSLETTER 12
Italian National Institute for Nuclear Physics

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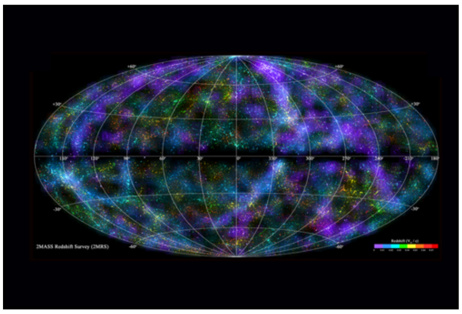
NEWS

INFRASTRUCTURE

SULCIS: FROM THE MINE A RESOURCE FOR DARK MATTER AND APPLIED RESEARCH

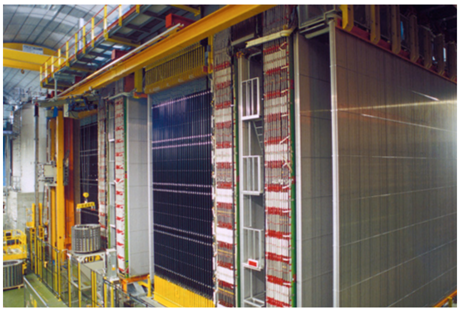
A Memorandum of Understanding was signed in June between INFN and the Autonomous Region of Sardinia for the forthcoming development of the Aria project, aimed at creating an innovative research infrastructure, a technological facility of the highest level, in the Sulcis coalfield in Sardinia. The objective of the project is the separation of air into its fundamental components, useful in various areas of research and application. The separation of argon-40, in particular, will enable the development of an innovative technique for the search for dark matter, designed and implemented for the DarkSide experiment, in the Gran Sasso National Laboratories, by an international team led by the INFN and consisting of 30 institutions from 9 countries worldwide. The overall objectives of Aria, however, go beyond its original research objectives. The project will in fact allow production of components such as oxygen-18 and carbon-13 that have an international market of great importance. The increased accessibility to these elements will help increase the availability of advanced medical screening technologies, including diagnostic techniques for the fight against cancer.

The project, unprecedented at the international level, has been made possible by the cooperation between INFN, with the role of leadership and coordination of the research groups, and Princeton University, in addition to the fundamental contribution of Italian companies. The first design phase has already started, thanks to the funding provided by the US National Science Foundation (US-NSF). In the same month of June, on the 22nd, the DarkSide experiment, from which the Aria project originates, was inaugurated at the Gran Sasso National Laboratories. The event was held in the presence of the US Ambassador to Italy, John Phillips, as well as representatives of the US-NSF which, together with INFN and the US Department of Energy (DOE), is funding DarkSide, and Kinder Morgan, the American company that currently supplies the argon for the experiment. ■



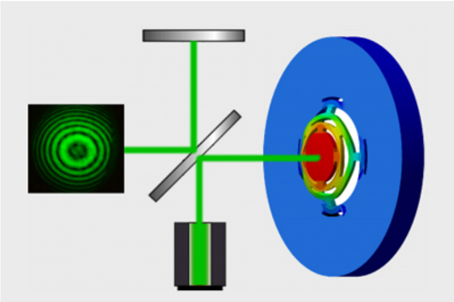
RESEARCH
DARK MATTER: POSSIBLE TRACES IN EXTRAGALACTIC RADIATION

Despite its name, dark matter might not be so dark, but associated with electromagnetic radiation. This is the hypothesis of a team of scientists of the INFN Turin, Roma Tre and Trieste sections, of the INAF and of the Chinese Academy of Science. The study, published in Physical Review Letters (PRL), describes a possiblecorrelation between the extragalactic gamma emission captured by the Fermi space telescope, in which INFN and INAF collaborate, and the distribution of cosmic dark matter rebuilt from the catalogue of 2MASS (Two Micron All Sky Survey) galaxies. According to the authors, this could be an indirect imprint of dark matter: its first possible non-gravitational trace.
The study shows, in fact, that the signal is compatible with the hypothesis that dark matter could be constituted by so-called Weakly Interacting Massive Particles (WIMP). WIMPs interact weakly and, so, they should go through a possible mutual annihilation or decay process. The goal of the reaserch is looking outside the group of galaxies which is part of our Milky Way, the so-called Local Group, for a gamma signal which can be associated with these processes. To do this, the gamma radiation map measured by the Fermi satellite was correlated with the distribution of 2MASS galaxies and it was possible to demonstrate that the signal that was found in this way is compatible with WIMPs". ■



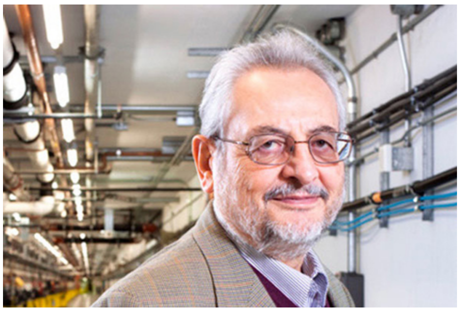
RESEARCH
FIFTH TAU NEUTRINO DETECTED BY OPERA

The OPERA (Oscillation Project with Emulsion-tRacking Apparatus) international experiment at the INFN Gran Sasso National Laboratories has detected the fifth interaction of the tau neutrino. The neutrino started its "flight" at CERN as a muon neutrino and, after travelling through the Earth crust for 730 km, reached the Gran Sasso Laboratories, manifesting itself as a tau neutrino. The detection of tau neutrinos from the oscillation of muon neutrinos is very difficult because of two conflicting requirements: a huge and very heavy detector and micrometer accuracy. The challenge was to reach the scale of thousands of tons with a detector based on nuclear emulsion technology, a unique photographic technique in ensuring the required accuracy.
In 1998 it was demonstrated that the number of muon neutrinos produced in cosmic ray interactions with the atmosphere arriving on Earth was less than expected. The results of OPERA now conclusively confirm that muon neutrinos can oscillate into tau neutrinos. Detection of the fifth tau neutrino is very important: direct observation of the transition from muon to tau neutrinos has now for the first time reached the statistical accuracy of 5 sigma, the level required for a discovery in particle physics. It so possible to announce the discovery of the appearance of tau neutrinos in a muon neutrino beam. This result emerges from the analysis of the data that OPERA collected during his activity at the INFN Gran Sasso National Laboratories. The construction of the OPERA detector has been completed in spring 2008 and the experiment was taking data up to the end of 2012. ■



RESEARCH
BUGS LISTEN TO SPACE-TIME NOISE

HUMOR (Heisenberg Uncertainty Measured with Opto-mechanical Resonators), the first experiment to have designed and implemented a new way of probing space-time at extremely small dimensions. Born from a collaboration between University of Florence and INFN, LENS and CNR- National Institute of Optics, HUMOR has published the first results in the prestigious journal Nature Communications, putting a new upper limit on the exploration of space-time at microscopic levels. The very high precision measurement was made possible by the use of very sensitive "bugs", able to hear the faint noise of space-time fluctuations.
Using very low energy "bench" experiments, HUMOR researchers have, in fact, managed to carry out, by means of lasers and electromagnetic sensors, displacement and time measurements with a very high precision, detecting the microscopic vibrations of oscillators of different sizes and masses, from a few nanograms up to a few milligrams.
These instruments have not yet observed a space-time graininess, but they have managed to set new limits. The road to a clear understanding of the space-time fabric around us is still long, but the current results can already be used to verify the predictions of theories that seek to unify gravity and quantum physics, constituting an important starting point for the experimental analysis of these issues.■



AWARDS
CLAUDIO PELLEGRINI WINS THE ENRICO FERMI AWARD

The Italian physicist Claudio Pellegrini has won the Enrico Fermi Award, one of the most prestigious scientific awards conferred by the US government. Established in 1956 in honour of the Italian Nobel laureate two years after his death, the award has also been given to Charles V. Shank, of the Howard Hughes Medical Institute and of the Lawrence Berkeley National Laboratory. Presenting the award will be no less than the President of the United States, Barack Obama.
The Italian scientist will receive the Enrico Fermi Award for his pioneering studies on free-electron lasers (FEL). A technology that will enable, for example, the structure and function of biomolecules, such as proteins, to be studied with a level of detail, at the atomic level, never before achieved.
“It is a great honour to receive this award. I recently turned 80 and this is a wonderful and certainly unexpected birthday present", were the first words of the scientist, on learning the news.
A physicist at the SLAC National Accelerator Laboratory and the University of California, Los Angeles (UCLA), before moving to the US, Claudio Pellegrini began his career in the INFN National Laboratories in Frascati, where he worked on the design and development of electron-positron colliders, discovering in Adone an instability, the so-called "spin effect", which can limit the brightness of these circular accelerators. ■

» INTERVIEW

A CENTRE OF EXCELLENCE FOR RESEARCH AND COOPERATION IN THE MIDDLE EAST

Interview with Giorgio Paolucci, Scientific Director of the SESAME project, for the construction of an infrastructure for research and advanced technology in Jordan.

SESAME (Synchrotron-light for Experimental Science and Applications in the Middle East) has a history spanning more than 25 years.
The international scientific project involves the construction in Allan, near Amman, Jordan, of a research infrastructure based on a third-generation synchrotron light source, a supermicroscope for applications in various fields: the first in the Middle East.
SESAME will soon constitute an international centre of excellence for research and advanced technology, able to attract scientists from very different fields: from archaeology to biology, from chemistry to physics and medicine. It will work under the auspices of UNESCO that is also the custodian institution of the statutes of SESAME, which establishment was unanimously approved by the Executive Council of UNESCO, in May 2002.
Today, a few months from becoming operational, thanks to the support of the worldwide community, SESAME is a shining example of global commitment, which sees countries that have never sat at the same table for a scientific project working together: Palestinian National Authority, Bahrain, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan and Turkey. In addition, Italy, France, Spain, Brazil, China, Germany, Greece, Japan, Kuwait, Russia, Sweden, Switzerland, United States and Great Britain are also collaborating. Italy is participating with INFN, Sapienza University of Rome and the City of Science.
The importance of an international laboratory with a synchrotron light source in this region of the world was first recognised in the 1990s by eminent scientists, including Pakistani Nobel laureate, Abdus Salam. This need was later underlined by CERN and by MESC (Middle East Scientific Cooperation), under the leadership of Sergio Fubini. The efforts of MESC to promote not only regional cooperation in science, but also solidarity and peace, began to take shape in 1995, with the organisation in Dahab, Egypt, of a meeting, during which the Egyptian Minister of Higher Education, Venice Gouda, and Eliezer Rabinovici, a MESC member and professor at the Hebrew University of Israel, took an official position in support of Arab-Israeli cooperation. The favourable

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opportunity to start the project presented itself in 1997, when Herman Winick of the SLAC National Accelerator Laboratory in the US, and Gustav-Adolf Voss of DESY, Deutsches Elektronen Synchrotron, in Germany, suggested the construction of a synchrotron light source in the Middle East, using the components of the BESSY structure which was soon be closed down in Berlin.
After the project was approved by UNESCO, Jordan was chosen to host the centre, competing with five other countries in the region. The Jordanian state provided the land, as well as funds for construction of the building. The user community, consisting of over 300 scientists in the region, is therefore getting ready for the first studies in the new laboratory, which is about to launch its research programme. During a meeting organised at the Sapienza University of Rome we met Giorgio Paolucci, Scientific Director of SESAME.

What are the scientific and other objectives of SESAME?
They are to carry out cutting-edge research in the field of materials science, where by material we mean anything from an isolated atom to a living being, including nanoscience, chemistry, archaeometry and analysis of ancient and modern artefacts. SESAME aims to offer scientists in the Middle East the possibility of growth and knowledge. In some way, SESAME aims to contribute to the reversal of the brain drain, a common and widespread phenomenon in many countries, as we well know, but which is particularly significant in the Middle East. But SESAME also aims to contribute to inter-cultural dialogue.

What does it mean to have managed to undertake and bring to fruition a complex project with global reach such as SESAME in a difficult and delicate region such as the Middle East?
I have only relatively recently started working on this project, since about a year and a half, but my predecessor was certainly very committed to and worked extremely hard on its implementation. SESAME is not yet operational, but we can say that we have achieved significant results which, in the light of what happens every day in that region of the world, would seem unthinkable. Yet SESAME will soon be operational, there is really not long to go. What has been carried out is an operation that presented very serious difficulties: it is the first time that a project of this type has been implemented in the Middle East. But what we are seeing, day after day, its progress, which to us certainly appears slower than we would like, is a source of great satisfaction for us, as scientists and as men.

What are the next steps that await SESAME?
At the moment, the main components of the accelerator are partly under construction in various laboratories around the world and are partly being assembled at CERN in Geneva, while others are under construction in Italy, including INFN laboratories and divisions. All these components will arrive in Jordan between the end of 2015 and the beginning of 2016. There their final assembly will take place in what will be their operational position, and we expect to achieve the final configuration of the accelerator by the middle of 2016. Then we will start putting

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the machine into service and, finally, when we have checked the operation and efficiency of the new synchrotron light source, we will finally start the first experiments with X-ray beams, toward the end of next year and the beginning of 2017.

What do you expect to be the impact of a project like this on the region?
Projects of this scope that have been implemented in other parts of the world have always had a major impact. It is rather difficult to define a priori what will happen, but certainly in France, in Italy and in the United States a constellation of research laboratories has been created around centres of this type, not necessarily directly related to the research that is done in the original laboratory. Moreover, also small and medium enterprises developing technologies and applications, both in the same field of research and in other areas, have sprung up. And frankly I expect this to happen here too. We do not have a business plan, as they say, yet, but surely this great scientific research centre, the only one of its kind in this region of the world, will attract people. There is a phrase that I like very much, it's a line from a film, pronounced by Kevin Costner when he has to build a baseball field in an area where no one had ever thought of doing so, and he says: “I'll build it and then they will come”. And I am sure that it will be so in our case, also the SESAME synchrotron laboratory will make the most brilliant scientists, from all over the world, come to us here in Jordan.

FOCUS ON

ULTRA FAST DETECTORS FOR PHOTOGRAPHING PARTICLES IN 4D

Develop a new ultra fast detector based on silicon and capable of providing a four-dimensional image of the particles that pass through it, simultaneously "photographing" both the position and time of transit of the particles: this is the core of the Ultra-Fast Silicon Detector (UFSD) project proposed by Nicolo Cartiglia of the INFN Turin section and winner of an ERC Advanced Grant of 1.8 million euros lasting five years.
The project is based on the development of a new type of silicon detector, similar to those used in many particle physics experiments, but which is characterised by the ability to determine the time of transit of a particle in an extremely precise manner, with a resolution of approximately 10 picoseconds. That is: a detector capable of an accuracy of 10 thousandths of a billionth of a second and equal, in the spatial dimensions, to that of a very thin hair.
The possibility of adding the time dimension to the tracking process is critical to properly associate the particles that belong to the same event, discarding instead those that transited in the detector at subsequent times. This new type of technology can be applied in contexts in which the detector must be very thin or very resistant to radiation, such as for example in oncological hadrontherapy in which very high precision technologies are developed to be used in dosimetry.
The activity that led to proposing the Ultra-Fast Silicon Detector project began in 2013 as part of the research of the Fifth National Commission INFN, which deals with technological and interdisciplinary research, and thanks to the collaboration between the Turin INFN division, Trento and Florence INFN groups and the Bruno Kessler Foundation (FBK). The Turin INFN division, which coordinate the project, will take care of the design, drawing and testing of the sensors, and will be also involved in the development of a simulator of silicon detectors (Weightfield2 project).
In 2014, UFSD was recognised as an "Italy-USA project of great scientific importance" and received a grant for a period of two years from the Ministry of Foreign Affairs. In 2015, it has been included in the European project AIDA2 (Advanced European Infrastructures for Detector Accelerators).

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