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MARCH 2016



SPACE EXOMARS, EUROPEAN MISSION TO MARS GETS UNDERWAY

The ExoMars (Exobiology on Mars) robotic mission, implemented by the European Space Agency (ESA) in cooperation with the Russian agency Roscosmos, has left from the Baikonur Cosmodrome, in

the steppes of Kazakhstan, bound for the Red Planet to search under the surface for any signs of Martian life, past or present. On board the ExoMars lander is also the INstrument for landing-Roving laser Retroreflector Investigations (INRRI) of the ASI (Italian Space Agency) and INFN, first passive laser target on the Martian surface and the first beyond the Moon. The Schiaparelli lander, dedicated to the Italian astronomer who drew the first map of Mars, will land on the surface of the Red Planet after a seven-month journey. On board the lander - a concentrate of Italian technology, with Thales Alenia Space (Thales-Finmeccanica) as a leader industry among those which contributed to the mission - there's also the meteo station "DREAMS" (Dust characterization, Risk assessment and Environment Analyser on the Martian Surface), realized by the Italian Space Agency under the scientific guidance of INAF (Italian National Institute for AstroPhysics).

ExoMars has among its objectives the first measurement of electric fields on the surface of Mars and a map of methane sources of the Red Planet, possible indicators of microbial alien life. The mission will also continue beyond its operational phase thanks to the INRRI retroreflector that can be used as a new primary and precise geodetic reference point of Mars. INRRI will also be the forerunner of a probable series of micro-reflectors brought by future landers or rovers, which together will form a Mars Geophysics Network (MGN), a network of reference points for geodesy measurements of Mars and General Relativity tests. In the long run, MGN could become a precision positioning network similar to that of the laser retroreflectors of the Apollo and Lunokhod missions on the Moon.



MARCH 2016



RESEARCH A NEW PHASE FOR PROTON BEAMS AT THE LHC

LHC has started up again. On 25 March 2016, after the usual winter technical break, which began on 14 December last, at 11:33 the first two proton beams completed their first lap inside the 27 km

ring of the CERN super-accelerator in Geneva. During the commissioning phase of all the systems and instrumentation of the LHC, the beams were circulated at low energy, to then increase towards an energy of 6.5 TeV per beam, with only one protons bunch and a number of protons which is around a tenth of that will be used for physics. In this way the machine operators can verify the correct functioning of the accelerator and also check during all phases whether they can keep the proton beams under control or not: this is done using bunches of intensities suitable to avoid damage to the machine in case something does not work properly. At present, the beams are circulating regularly at an energy of 6.5 TeV, always with a bunch per beam, but at the nominal intensity, that is the intensity that will be used for physics experiments. Optical measurements are currently in progress, in order to increase the stability of the beams and reduce losses. Subsequently, after establishing the ideal orbit and have aligned the collimators around it, the beams will be put into collision with one another: even in this case, collisions will be initially made with only one protons bunch. Finally, the number of bunches will progressively increase. The machine protection tests designed to verify that the machine is safe will continue in the coming weeks and within a month the performance of the LHC should reach a level close to that achieved in 2015. The first collisions for physics experiments should therefore take place towards the end of April, launching the second phase of RUN2 at an energy of 13 TeV in the mass centre, i.e. at the point of proton collision. Scientific expectations are high, because in the next few months it will be possible to collect enough data to know whether the bump, the peak at 750 GeV of mass – which is now small – corresponding to an excess of energy photon pairs, is a simple statistical fluctuation or not. If the result will be confirmed, it would open up unexpected scenarios all to be interpreted.



MARCH 2016



COOPERATION SCIENTIFIC COOPERATION AGREEMENTS BETWEEN INFN AND IRANIAN RESEARCH INSTITUTES SIGNED

During a series of meetings, which were held in March in Iran, INFN signed five cooperation agreements with the same number of scientific research institutes in the country. These are

memoranda of understanding to facilitate future collaboration between the parties in scientific and technological areas, in the sectors of greatest interest to INFN, such as fundamental physics and technology transfer. The signing of these agreements takes place in a positive opening-up period for Tehran, following the end of the sanctions imposed by the international community. These initiatives will help to strengthen bilateral relations between the Organisations and support the exchange of scientific and technological information and knowledge. In particular, the Iranian Institutes also have as their main objective the possibility of offering their students the opportunity to spend a period abroad during their PhD studies. The Institutes with which INFN has signed agreements are the Sharif University of Technology, the Institute for Research in Nuclear Science and Technology, the Atomic Energy Organisation, the Institute for Research in Fundamental Sciences, the Isfahan University of Technology and the University of Kashan.



MARCH 2016



RESEARCH THE FIRST BEAMS ARE CIRCULATING IN THE SUPERKEKB ACCELERATOR

The first particle beams were injected and stably circulated for the first time in the SuperKEKB accelerator at the KEK laboratory in Tsukuba, Japan. SuperKEKB is the first accelerator for research in

fundamental physics to come into operation after the LHC at CERN in Geneva, and has been designed to work at a luminosity never achieved before, as much as forty times greater than that of the most powerful previous generation accelerator. Unlike the LHC, in which proton beams circulate, SuperKEKB uses electron and positron beams, which travel in separate rings, 3 km in diameter and with different energies, 7 and 4 billion electron volts (GeV), respectively. SuperKEKB uses an innovative scheme of so-called "nano-beams" for collision of the beams - originally proposed by the INFN National Laboratories of Frascati for the SuperB collider project - capable of maximising the region in space in which the beams overlap, and thus the luminosity. When up to speed, the particles produced in the collisions will be detected and measured by the Belle-II experiment, a highly sensitive detector fruit of an international collaboration consisting of more than 600 physicists and engineers from 23 different countries. Belle-II will search for signs of physics beyond the currently known theories.

The Italian contribution is significant, with a community of more than 60 scientists from nine universities and INFN laboratories. The Italian groups are engaged in the construction of the three key elements of the experiment, necessary for the precise measurement of the point in which the particles decay, recognition of which particles pass through the detector and measurement of their energy. Italy also provides a significant contribution to the computing resources necessary for analysis of the huge amount of data that the experiment will collect.



MARCH 2016



APPLICATIONS HERITAGE SCIENCE: E-RHIS NET INCLUDED IN THE EUROPEAN STRATEGY FOR RESEARCH INFRASTRUCTURES

Knowledge and preservation of the cultural and natural heritage today have a new ally: E-RIHS, the only European research

infrastructure on Heritage Science to be officially included in the ESFRI (*European Strategy For Research Infrastructures*) Roadmap that identifies the research infrastructure considered strategic for the scientific community in Europe. E-RIHS, of which Italy is the leader with the CNR (Italian National Research Centre), is a distributed European infrastructure: a network of laboratories and highly advanced fixed and mobile instruments, as well as cutting-edge physical and digital archives, made available to European researchers.

The community addressed by E-RIHS is that of the new multidisciplinary field of heritage science, which links hard sciences and the humanities in a cross-disciplinary perspective to address all the issues and problems related to the cultural, natural and archaeological heritage. From restoration to fruition, from preservation to exploitation, from monitoring to management, from protection requirements to those of the tourism market. With the support of the Ministry of Education, University and Research (MIUR), the Ministry of Economic Development (MISE) and of the Ministry of the Cultural Heritage and Tourism (MIBACT), under the guidance of CNR with the participation of ENEA (Italian National Agency for new technologies, Energy and sustainable Economic development), OPD (Opificio delle Pietre Dure), INSTM (National Interuniversity Consortium of Materials Science and Technology) and the other Italian entities and universities involved, E-RIHS currently includes 18 member states and 11 third countries. The step following inclusion in the Roadmap is the start of a preparatory phase for the establishment of an ERIC (*European Research Infrastructure Consortium*), which also sees the involvement of ICCROM (International Centre for the Study of the Preservation and Restoration of Cultural Property), an intergovernmental research body for the cultural heritage. Italy is therefore proposing to host the headquarters of the only ERIC under Italian leadership in the new ESFRI Roadmap.



>> INTERVIEW



EUROPE BETS ON THE KM3NET SUBMARINE NEUTRINO TELESCOPE

Interview with Giacomo Cuttone, director of the INFN National Laboratories of the South

The KM3NeT project in which INFN plays an important role with its National Laboratories of the South, has been selected as part of the 2016 ESFRI (European Strategy Forum for Research Infrastructures) Roadmap.

KM3NeT is a project for the construction of a submarine neutrino detector in the Mediterranean Sea, which will have as its scientific objectives the study of astrophysical sources of cosmic neutrinos, determination of the mass of the neutrino and creation of new opportunities for synergistic research in marine and environmental studies. The project envisages a research infrastructure distributed among three deep-sea sites: off Portopalo di Capo Passero in Sicily (Italy), Toulon (France) and Pylos (Greece). The preparatory phase of the experiment ended in December 2015 when the Capo Passero site concluded sea laying and land connection operations of the first KM3NeT string.

Inclusion of the KM3NeT project in the ESFRI Roadmap was announced on 10 March during the launch event of the roadmap 2016. A result based on a history of frontier research started many years ago. Could you tell us about the most salient points?

Inclusion in the ESFRI Roadmap is a very important result for the KM3NeT project, which comes after a rigorous selection process, in which projects are evaluated for their scientific excellence, pan-European importance, socio-economic impact and level of maturity. KM3NeT was selected along with another 20 projects that have been identified as those new research infrastructures of pan-European interest, reflecting the long-term needs of the European research community.

The idea of KM3NeT dates back to the early 2000s and has seen INFN and, in particular, the National Laboratories of the South as a key player, having proposed and developed the idea of installing a very high energy submarine neutrino telescope in the Mediterranean Sea, an ideal location for observing our Universe. Thus Sicily was identified as the candidate site to host the observatory, at a distance of 100 km off the coast of Portopalo di Capo Passero and at a depth of 3500m. An ideal location for the



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installation, also due to the ideal conditions of water transparency.

In 2008, a research laboratory was built in Portopalo from where a 96 km long electro-optical cable departs, connecting it with the installation site. Thanks to the direct funding of INFN and that received within the scope of the program "PON Ricerca" of the Italian Ministry of Education, University and Research (MIUR), the first part of the telescope (approx. 25%) was constructed and wired.

Once completed, KM3NeT will be a submarine neutrino observatory with a total extension of one cubic kilometre. Why are we building a giant experiment at a depth of 3500 metres? What are the research objectives?

The KM3NeT neutrino telescope must be installed at these depths in the sea since the objective is to exploit the water both to shield the detector from cosmic background radiation as well as to use the sea water itself as a Cherenkov scintillator for the detection of neutrinos. The latter are among the most important messengers of information on the creation of the universe and its evolution.

This project has a strong interdisciplinary characterisation. Which are the scientific communities that will benefit? What will be the impact in terms of technological innovation?

The construction of a wired observatory at a depth of 3500m in the Mediterranean Sea offers a unique opportunity for the study of geophysical and volcanological processes in an area characterised by the clash between the North African and the European plates and the presence of the largest active volcano in Europe, Mount Etna. It also represents a unique opportunity for the study of marine biology and the ecosystem of such a particular sea as the Mediterranean. It has therefore been possible, and will be even more so in the future, to launch an intensive research and development programme in the field of detectors, gauges and wiring and data transmission systems in extreme environments such as the depths of the sea. A sea that is not just a route for escaping from poverty, hunger and war, but also an opportunity for the recovery of our economy and our entrepreneurs.

In physics, KM3NeT is the only research project to be included in the ESFRI Roadmap with a location in Italy, and in this case managed by a research facility based in the South...

The inclusion of KM3NeT in the ESFRI Roadmap recognises the efforts and the role of the National Laboratories of the South in the construction of the submarine telescope for high energy neutrinos at its headquarters in Portopalo. The significant investments made to date, both in economic as well as human capital terms, have enabled this goal to be achieved and have had a crucial affect in determining the role of our laboratory and the Sicily Region, which has also acknowledged in its development plan the decisive role of KM3NeT for the growth of our area

What will be the next challenge?

The next and perhaps the most difficult challenge will be convincing our regional, national and European



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institutions to transform the plans, which to date has seen KM3NeT excel, in actions aimed to raise funding for completion of our activities and full development of the human capital that we have created in this field, not only in Sicily and in Italy but throughout Europe.



>> FOCUS ON



A EUROPEAN ERC GRANT FOR THE NEW ENUBET NEUTRINO SOURCE

Andrea Longhin, a researcher at the Frascati National Laboratories (LNF) INFN has been awarded one of the 302 2015 Consolidator Grants of the ERC (*European Research Council*) addressed, on a competitive basis, to high-impact research programmes. The grant, amounting to 2 million euros, will support the *Enhanced NeUtrino BEams from kaon Tagging* (ENUBET) neutrino physics project for a period of five years, which will officially start on 1 June.

The objective of the ENUBET project, which promises to open a new frontier in neutrino physics, is to provide physicists with an innovative technology for the production of intense sources of electron neutrinos (v_e), with an accuracy ten times greater than standard: a novel investigation instrument in the field of neutrino physics.

Traditional beams, conceived back in the 60s of the last century, are characterised by severe limitations, which have heavily influenced the precision study of the oscillation phenomenon. The phenomenon is characterised by gradual transitions between the three neutrino families, which take place during propagation and which are due to the fact that neutrinos have a mass, even if small. Being able to measure, in particular, small differences in the oscillation from a muon neutrino into an electron neutrino ($v_{\mu} \rightarrow v_{e}$) and that involving their antiparticles - a phenomenon known as leptonic CP violation - would have important consequences. The predominance of matter over antimatter, which is observed in all that surrounds us, could in fact be a consequence of the behaviour of primordial neutrinos present shortly after the Big Bang.

For this reason, ENUBET will particularly focus on producing a well-controlled beam of electron neutrinos. This will allow, as never before, analysis of all the details of their interactions with ordinary matter: an almost obligatory step for a solid measurement of CP violation in neutrinos. The measurement will help the physicist community engaged on this front, which is preparing to build huge underground tests planned in Japan (*Hyper-Kamiokande*) and in the USA (DUNE).



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Thanks to the ERC funding and a team of physicists from INFN and other European institutions, ENUBET will address its challenge by measuring the positrons that accompany the production of electron neutrinos in the decay tunnels of traditional beams. In the tunnels, the particles flows are very high, reaching one million particles per second per square centimetre, which makes them unfavourable for the installation of detectors. The "intelligent" decay tunnel which ENUBET proposes is the basis for a large detector (approx. 50 metres long) based on innovative photosilicon sensors, potentially able to overcome the difficulties - radiation resistance, response speed, competition of disturbance processes, high costs - that would have made such a programme totally unrealistic until a few years ago.

The idea of this positron detector (tagger) will be tested on a prototype subjected to testing with particle beams in specific areas at CERN in Geneva and at INFN in Frascati. The project, moreover, also potentially has the possibility to implement the first time-tagged neutrino beam: in this configuration, not only is the number of electron neutrinos accurately determined by counting the positrons, but it is also possible to individually associate each neutrino with its mother particle. The result is a priori knowledge of the characteristics of each neutrino in terms of energy and lepton family. This is among the most ambitious and complex objectives of the project, which would implement one of the pioneering ideas that Bruno Pontecorvo speculatively formulated in an article in the 1980s.



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