



NEWSLETTER 45

Istituto Nazionale di Fisica Nucleare

INTERVIEW



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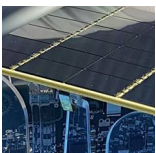
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In March, Federico Ferrini took over as director of the Cherenkov Telescope Array Observatory (CTAO), which will be the largest gamma ray telescope in the world. After having spent more than 30 years in astrophysics research and teaching at the University of Pisa, Ferrini was director, from 2011 to 2017, of the European Gravitational Observatory (EGO), the consortium which hosts the Virgo interferometer, right in the crucial years of implementation of the Advanced Virgo project for the upgrade of the detector and the discovery of gravitational waves. Now Ferrini begins a new experience as head of CTAO, a cutting edge scientific and technological enterprise, in which Italy is taking part with the National Institute for Astrophysics (INAF) and INFN. The significance of the CTAO project, whose headquarters are in Italy, in Bologna, has also been recognised by ESFRI, which has included it in the roadmap that indicates the research infrastructures of primary interest for Europe.

After the recent experience as head of EGO that ended with the success of Virgo, now you are facing a new and significant challenge as director of CTAO. What are the most stimulating and challenging aspects of this project?

CTAO is a project that involves the construction of a research infrastructure that will allow us to study the universe through gamma rays, which are the most intense electromagnetic signals coming from the cosmos, in an absolutely extraordinary range of energy amplitudes.

CTAO will be an observatory devoted to run certain key projects, as priority mission, but also dedicated to the requests of scientists worldwide interested in using this unique infrastructure. This is a fundamental novelty with respect to previous gamma research systems. I would like to underline, in fact, that it consists of two large installations: one in the northern hemisphere, on the

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island of Las Palmas in the Canary Islands, and one in the southern hemisphere, in Chile, about 20 kilometres from the large optical telescopes of the European Southern Observatory (ESO). In total, around 120 telescopes of three types will be installed, each one aiming at optimising sensitivity in different and complementary energy bands. CTAO will keep us busy with many challenges, big numbers and complexity of choices (from the R&D phase to production). Different problems to be faced, such as ensuring the quality of the mirrors for decades, fast tracking of transient phenomena by very heavy metal; and innovative detection chambers with technological solutions, which for now are competing with each other.

What is the roadmap of the CTAO project and what are the next steps?

There are numerous milestones in the CTAO roadmap, starting with the transformation from a German non-profit organisation into a European Research Infrastructure Consortium (ERIC), as decided by the Council of Member States. This objective, for the achievement of which we are in close collaboration with the Ministry of Education, University and Research (MIUR), will lead to an ERIC in Italy, hopefully by the end of 2019. By the same date, I have planned the complete definition of the design and engineering of both the infrastructures as well as the installation of the scientific equipment. During 2020, the construction process will start. It must be designed in an industrial manner, once the construction and integration contracts have been well planned and awarded. At the same time, preparation of all the data control, acquisition, distribution and analysis software will be completed, having built the data management centre in Zeuthen, near Berlin, in 2019. The construction, integration, acceptance and commissioning of the 120 telescopes and the overall systems of the North and South sites must be completed by the end of 2023, in order to start scientific observations at the beginning of 2024.

Large fundamental physics projects often require the development of new technologies. What are the most advanced aspects of this project, both from the scientific as well as technological point of view?

The scientific groups involved, the best worldwide in this field, have developed extremely refined solutions with impressive performance. An emerging problem is that there is a surplus of solutions for the same experimental request: the management task, therefore, will be to identify a single solution that has the characteristics to satisfy the scientific requests and, at the same time, is "simple", solid and sustainable, but the management will also have the task of having the choice accepted and obtaining the consent of all participants.

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Like all big projects, CTAO is also the result of significant international collaboration. What is Italy's role in this area?

Italy, thanks to INAF and INFN, has for years been one of the leading countries in gamma astronomy, both for its significant participation in the more specifically scientific aspects, as well as for the technological contributions in the history of high energy astrophysics instrumentation, with participation in satellite enterprises and the development of terrestrial systems. Having the management of CTAO, the world's leading project in the sector for the coming decades, in Italy is certainly a great opportunity, as well as a sign of international distinction and importance.

CTAO is an ESFRI project, an infrastructure considered of significance at the European level. What does this mean? What are the characteristics that allowed CTAO to become part of the ESFRI roadmap?

Being part of the ESFRI European roadmap for large research infrastructures, as well as being a clear recognition of the global excellence of the project, provides significant opportunities for ad hoc funding from the European Commission in the various research funding framework programmes. At the same time, being an ESFRI project puts CTAO in a prominent position within the now customary planning of investments in large research infrastructures of national interest by the main countries. CTAO is included in the national roadmaps of the major European countries and its implementation will be seen as both a European and national success.

What does it mean to be the head of large scientific infrastructures that have very ambitious goals, like EGO and CTAO?

After many years of scientific research in theoretical astrophysics, often aimed at the study of complex systems, I have put myself at disposal of the community with the aim of collaborating in the implementation of "difficult" projects, trying with my experience and my mental attitude to build that bridge that unites the conceptual and technological development of an experiment with its implementation, subject to finances, timing and many other kinds of constraints. At the same time, I try to maintain intellectual affinity with the scientific component and the ability to flexibly and diplomatically interface with the customer component, in order to develop the project to the satisfaction of both, as it should be. In other words, I have fun with my fellow scientists and engineers, and openly dialogue with the funding agencies. If all this makes it possible to facilitate the implementation of these ambitious projects, I am happy as a small cog in the machine of knowledge. ■



RESEARCH

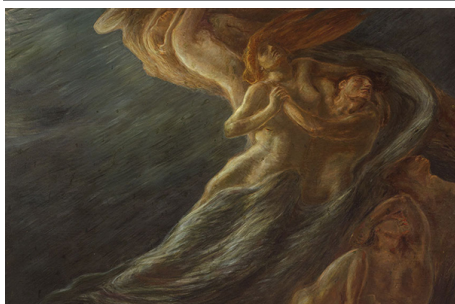
NA62 RESEARCH AND THE RARE DECAYS OF THE K-MESON

The NA62 experiment at CERN has recently presented its latest results concerning a very rare event: the decay of the charged K-meson into a pion and two neutrinos. The interest in extremely rare or even "forbidden" decays is motivated by the fact that these processes allow energy scales even much higher than those directly accessible to the most powerful particle colliders, such as the Large Hadron Collider (LHC) at CERN, to be indirectly probed. The study of these decays could therefore open a window in the near future on physics beyond the Standard Model. Moreover, the results just presented by NA62 are also interesting because they demonstrate the effectiveness of the new technique, called "in flight", used by the experiment to investigate these K-meson decays. In the coming years, this will allow the elusive process to be studied with a precision never achieved before. According to theoretical predictions, the charged K-meson decays into a pion and two neutrinos only in a very small fraction of cases. To understand the extreme rarity of this process, the Standard Model foresees, with considerable precision, that only eight decays of this type must occur every one hundred billion decays of the K-meson. In numerous theories that aim to overcome the Standard Model, the fraction of events expected for this decay is instead significantly different: therefore, a sufficiently precise measure could highlight the presence of what physicists call New Physics. The results obtained so far, at this level of statistical precision, are compatible with the Standard Model predictions. ■

**AWARD****GIANLUIGI FOGLI AND ELIGIO LISI AWARDED
THE PONTECORVO PRIZE**

The Italian physicists Gianluigi Fogli, former professor of theoretical physics at the University of Bari, and Eligio Lisi, head of research at the INFN Bari Section, have been awarded the prestigious international 2017 Bruno Pontecorvo Prize, awarded annually by the Joint Institute for Nuclear Research (JINR) of Dubna. The award ceremony will take place in Dubna next September.

The jury of the prize, chaired by Alexander Olshevskiy and consisting of Samoil Bilenky (2002 Pontecorvo Prize winner), Luciano Maiani (2014 Pontecorvo Prize winner), Arthur McDonald (2004 Pontecorvo Prize winner and 2015 Nobel Prize winner) and Yoichiro Suzuki (2010 Pontecorvo Prize winner), awarded the prize to Gianluigi Fogli and Eligio Lisi "for their pioneering contribution to the development of global analysis of neutrino oscillation data from different experiments". The award-winning results of Fogli and Lisi cover more than two decades of theoretical and phenomenological research, aimed at analysing in detail the phenomena of neutrino oscillation in an increasingly wide range of experimental data (solar, atmospheric, reactor, accelerator neutrinos, etc.). This analysis made it possible to determine certain parameters of the so-called Pontecorvo-Maki-Nakagawa-Sakata (PMNS) matrix with increasing accuracy and to estimate others still unknown. One of the major results obtained concerns the first estimate of the smallest element of the PMNS matrix (the theta-13 corner) a few years before its experimental discovery, which took place in the period 2011-2012, subject of the previous 2016 Pontecorvo Prize. ■

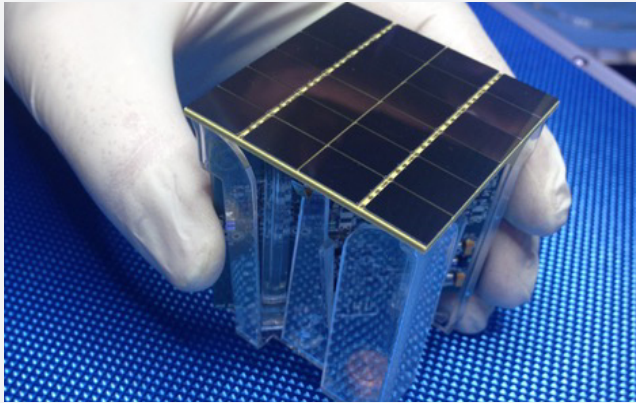


CULTURAL HERITAGE

SECRETS OF PREVIATI'S WORK 'PAOLO E FRANCESCA' REVEALED

A team of researchers from INFN and the University of Ferrara has analysed the "Paolo e Francesca" painting by Gaetano Previati, among the most famous works of the artist, currently exhibited at Palazzo dei Diamanti in Ferrara. The analysis work, presented at the International Exhibition of Restoration, was performed with the technique of digital radiography with a scanner for in situ radiographic diagnostics, built and designed thanks to the collaboration between the Department of Physics and Earth Sciences of the University of Ferrara and the INFN Ferrara section. The hidden story of the painting emerges from the more than 1,000 digital x-rays taken. Thanks to these analyses it was, in fact, possible to bring to light the first draft of the work, which reveals details hidden in the painting, such as the different position of the face of Francesca, initially painted by Previati with the head reclined backwards. The change is very evident because the first draft of the face of the young girl, subsequently abandoned and covered, is perfectly recognisable thanks to the radiopacity of the pigments used that are still under the painting's surface. The analyses were conducted as part of the activities of the cultural heritage network INFN-CHNet. The scientific diagnostic program was carried out in collaboration with the National Institute of Optics of the CNR, which performed imaging diagnostics in infrared and ultraviolet fluorescence. The interpretation of the scientific diagnostics, which have already been used in the restoration of the work, represents an important element for a historical-artistic investigation of early twentieth century art. ■

» FOCUS



DARK MATTER: FIRST PHOTO-DETECTOR MODULE FOR DARKSIDE READY

The Photo-Detector Modules (PDM), which will be used by the DarkSide-20k project for the direct search for dark matter at the Gran Sasso National Laboratories (LNGS), will be assembled in the Nuova Officina Assergi (NOA), the new technological centre of the LNGS of INFN. The first PDM built was presented during the Darkside International Collaboration meeting, which took place at the INFN Gran Sasso Science Institute (GSSI) from 5 to 9 March.

The main characteristic of this new device is the fact of combining state-of-the-art Silicon Photo Multipliers (SiPM) with very low noise cryogenic electronics.

Each PDM is a structural shell with peculiar characteristics: it must be strong enough to withstand temperature changes of more than 200 degrees (from ambient to liquid argon temperature) and as light and radiopure as possible, not to introduce signals in the detector that could be similar to the rare events produced by dark matter, the subject of the research.

The PDMs are made with highly radiopure components (i.e. with a very low level of radioactivity), consisting of 24 SiPMs with a total area of approx. 24 cm² each. The various parts comprising the PDM are assembled with an acrylic mechanical structure, with high radiopurity. Preliminary results show that the signal-to-noise ratio and the time resolution obtained by the first PDM are better by a factor of 3 compared to the Darkside-20k specifications.

The DarkSide-20k detector requires the use of more than 5,000 of these modules: its 20-tonne liquid argon Time Projection Chamber (TPC) provides a photosensitive surface of 14 m², implemented with over 125,000 SiPMs. To limit the number of electronic channels, each PDM must be read with a single channel. The main difficulty is due to the high capacity of the SiPM, which makes it difficult to read areas of several tens of square centimetres.

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This first module is the result of extensive R&D work carried out by the DarkSide photoelectronic group, consisting of over 30 researchers from Italian, Canadian and US research institutes. For INFN, in addition to LNGS, the divisions of Bologna, Cagliari, Milan, Naples, Pisa, Tifpa and Turin are involved. The SiPMs were produced by the Bruno Kessler Foundation (FBK) and the assembly was performed by researchers from the University of Princeton and LNGS. The mechanics of the PDM were implemented by the INFN Pisa section, the structure for PDM assembly and anchoring to the copper structure (motherboard) is the responsibility of the INFN Bologna section, while the optical fibre transmission of the PDM signals is the result of a joint effort by researchers from the INFN Cagliari division and LNGS.

The next objective will be the construction of a motherboard with 25 PDMs, to be used in the prototype with one tonne of liquid argon. ■

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Illustration of CTAO (Cherenkov Telescope Array Observatory)
