DECEMBER 2021

INFN NEWSLETTER 88

Istituto Nazionale di Fisica Nucleare

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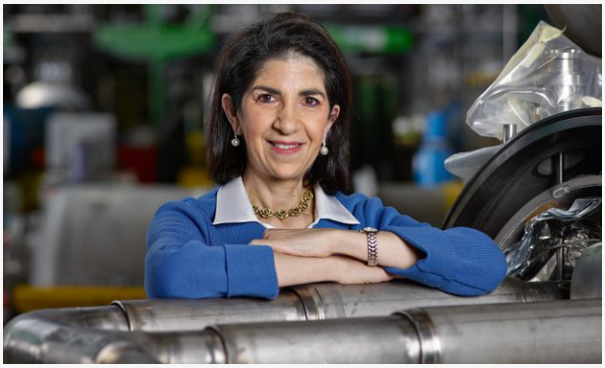

CERN IN THE 70 YEARS OF INFN

Interview with Fabiola Gianotti, director-general of CERN

From the founding of the Italian Institute for Nuclear Physics, on 8 August 1951, to today, the history of research into fundamental physics in Italy has known seventy years of excellence that led to historic results and discoveries. Rooted in the intertwining of two research currents, the physics of atomic nuclei and the study of cosmic particles, INFN was set up a short time after the founding of particle physics, constituting, right from the start, a solid base for the scientific successes that followed in subsequent years, in Italy and in the context of increasingly wide international collaborations. Three years after the founding of INFN, Europe joined its forces focusing on a single research goal: founding an international research centre for high-energy physics. CERN was, thus, founded in Geneva in 1954. From that moment, it accompanied the whole INFN research path in the field of high-energy physics, with extraordinary results, up to the most recent, in 2012: the discovery of the Higgs boson, which was awarded a Nobel Prize.

The protagonists of the opening event celebrating 70 years of INFN, "70 years of understanding the universe", which was held at the Auditorium Parco della Musica in Rome on 29 September 2021, included the director-general of CERN, Fabiola Gianotti. She re-traced the fundamental steps in the adventure that led to the discovery of the Higgs boson and that, today, paves the way for research into new frontiers of science and technology in the field of fundamental physics.

Below is the transcription of the whole interview.

Almost ten years ago, in 2012, you were head of the ATLAS experiment that, alongside the CMS experiment, announced the discovery of the Higgs boson. How did we get there?

It took 30 years. This is the time that passed from the very first ideas about the Large Hadron Collider in 1984 to the discovery of the Higgs boson in 2012. In my opinion, this discovery is emblematic of the way in which the scientific community works in our field. It was the result of the virtuous union between research, with its push towards exploration and the ambition to answer open questions, and technology, which finds its greatest expression in the relationship with industry and global collaboration. The research adventure always starts from an idea that is often trying to answer a crucial question: this was the case with the electroweak symmetry breaking, which could be explained by the Brout-Englert-Higgs mechanisms and then by the existence of the Higgs boson or, perhaps, by something else. Secondly, the following point is to ask themselves what tools are needed to answer the question

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that was posed. At the time of the first discussions on the LHC, there still weren't the data from the LEP, the previous CERN accelerator, and, therefore, there were no limits on the mass of the Higgs boson, which could make us think of a light particle. Generally, the mass of the Higgs boson could have been up to 1 TeV, so we needed a very powerful accelerator, capable of accelerating protons to energies of a few teraelectronvolts and producing very intense particle beams, since the Higgs boson production is a weak interaction process. The creation of the accelerator thus required very complex and cutting edge technologies, in particular in terms of high-field superconducting magnets. Furthermore, we knew that such a powerful accelerator would lead to very harsh conditions for the detectors. Thus, the detectors would need to ensure, not only high performance, but also the ability to operate in an extremely complex environment, resulting from the energies and intensities of the collisions. Hence a new need arose: to develop new technologies and tools that would be up to a challenge that, at the start, seemed impossible. But telling physicists or engineers that "the undertaking is impossible" is the best way to push them to find the solution to the problem.

They have been very exciting and very difficult years. The 1990s were engaged in developing technologies and tools - accelerators, detectors and computing infrastructures - that would allow us to observe the Higgs boson and explore a new energy frontier. And when you work at the limit of technology, the road to travel isn't downhill, nor is it flat, it's an uphill road: you take three steps forward, two backwards and one to the side, so you need a lot of tenacity, a lot of determination. Industry played a very important role. In general, the way in which CERN and the other facilities dedicated to research in our field, like the INFN Gran Sasso National Laboratories, work with industry is not a standard method, based on a classic customer-supplier relationship. We don't sign a cheque so that industry, for example, is charged with producing the 1232 magnetic dipoles for the LHC. We work together from the beginning. The prototypes are constructed in the laboratory, together with the most promising industrial partners. Then, when the technology is mature, the production is transferred to industry for the construction on a large scale of magnets or other components of accelerators and detectors. In this way, industry quickly became part of the LHC adventure. Furthermore, the LHC challenge was shared with the international scientific community and this common effort had a fundamental role. Large-scale international cooperation is a distinctive feature of our research field and can effectively represent an example of how humanity should and can work collectively to pursue noble goals. Incidentally, the need for a global collaboration to overcome societal challenges is one of the main lessons we have learned from the pandemic.
The discovery of the Higgs boson occurred relatively quickly. In reality, we weren't expecting to find it so quickly: we thought we would discover other particles before, for example the supersymmetric ones, which then weren't found to be present in nature, at least at the energies explored up until now. Already in 2011, only one year and a half after the LHC was switched on, when we passed to 7 TeV energy, we saw some indications at a given mass of about 125 GeV and then, in 2012, the signal of the Higgs boson manifested itself in all its intensity and beauty. We could then announce the discovery.

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The two big discoveries of the last decade, the ones of the Higgs boson and of gravitational waves, took a lot of time, much determination, and enormous vision. If I'm not mistaken, there's a new challenge knocking on the door, is that right?

Yes, luckily, there are new challenges. If there weren't, we wouldn't move forward along the path towards knowledge, which is a very long one. If there is one certainty in fundamental physics today, it is that there are many open questions that we cannot answer. Some of these questions have been identified and understood, even if we don't have the answers yet. These are what we call the known unknowns, for example, dark matter, the problem of the Higgs boson mass, the mass of neutrinos, etc. Then, there are the so-called unknown unknowns, that is the mysteries of which we are not yet aware. Progressing along the path of knowledge, also means understanding the right questions to pose.

Another important thing to highlight is that these open questions probably have solutions that are related to one another. Understanding, for example, the issue of the Higgs mass could also give us some indication about dark matter and vice versa. These are very complex questions and there isn't, as of today, a tool that allows us to answer everything. The best strategy, therefore, is to put into practice all the most promising experimental approaches that particle physics and astroparticle physics have developed in the last decades, also thanks to the extraordinary advancement in the technologies of particle accelerators and detectors and of the instrumentation in general. These approaches include the physics of accelerators, the underground experiments that study particles coming from the cosmos, the experiments installed on satellites, etcetera.

Historically, particle accelerators have been our main tool, from the experimental point of view, for building the Standard Model, since they replaced, in the middle of last century, the study of cosmic rays to studying elementary particles. And accelerators will continue to play a very important role in the future as well. It's impossible to think of answering the open questions without the contribution of accelerators. And, therefore, we need to start thinking about the next particle collider after LHC. As we know, the European community of particle physicists has identified the project called Future Circular Collider (FCC) as the most promising one from the scientific point of view. FCC is the project of a 90-100 km ring that would allow, first, electrons-positrons collisions and, then, would evolve in a hadron machine. The physics reason to pursue this enterprise comes mainly from the Higgs boson, which can only be studied with accelerators. And the Higgs boson is a special particle: it has very different characteristics from all the other elementary particles discovered to date and it interacts with a different force; we therefore believe that it may be the key to answering some of the open questions.

To study the Higgs boson in detail, we need a bigger and more powerful accelerator. FCC is a very ambitious project and, once again, as in the case of LHC, the undertaking seems impossible, but I'm sure that if we decide to move forward in this direction, we will achieve it.

About this, I'd like to highlight another important aspect. In the case of the LHC and its experiments, as with the experiments for the detection of gravitational waves, in the end, and despite their complexity and the difficulties that needed to be faced in constructing them, the performance exceeded the most rosy and optimistic of expectations,

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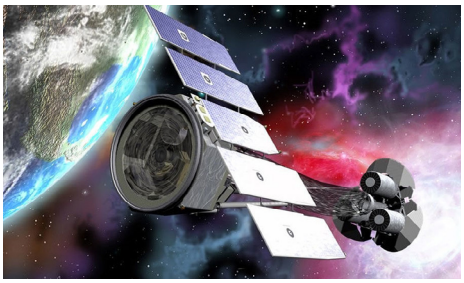
singnificantly. This means that our research field, our scientific community can carry out very complex and ambitious projects, respecting the set budget, fully achieving, or even exceeding expectations. And this is a milestone in view of even more ambitious future projects.

The whole recording of the event: “70 years’ knowledge of the Universe” can be found *here*.■

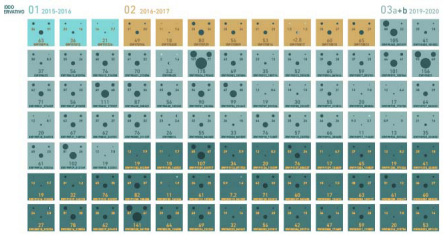


SPACE

IXPE TAKES OFF

On December 9, from NASA Kennedy Space Center at Cape Canaveral, Florida, IXPE (Imaging X-ray Polarimetry Explorer) satellite successfully took off aboard a Falcon 9 launcher. Born from the collaboration between NASA and the Italian Space Agency (ASI), as leading partner, the INFN and the INAF National Institute for Astrophysics, IXPE is the first mission entirely dedicated to the study of the universe through the polarization of X-rays, which will allow to better understand the characteristics of extreme astrophysics sources such as neutron stars, black holes and supernova remnants.

The measurement of the polarization of X-rays emitted by the celestial bodies will be made possible by Gas Pixel Detectors (GPD), the main detectors of the three telescopes that make up the satellite. The GPDs exploit a technology developed over the past 15 years and that uses the expertise acquired by INFN in the field of particle physics. In each of the detectors, every single photon absorbed in the gas is transformed into an electron (photoelectric effect), of which the GPD reconstructs the trajectory and the charge deposited, allowing to obtain direct indications on the characteristics of the electromagnetic fields of the astrophysical sources responsible for the emission of photons. In addition to the realization of the detectors, INFN, through the divisions of Pisa and Turin, has been responsible for the design, implementation, testing and space qualification of the IXPE Flight Detector Units, as well as for the coordination of activities related to the development of the simulation tools and scientific analysis. ■



RESEARCH

GROWING NUMBER OF GRAVITATIONAL EVENTS OBSERVED BY LIGO AND VIRGO

The total number of observed spacetime perturbations has increased. Certifying this is the updated gravitational wave transient catalogue (GWTC-3) published by the Virgo, LIGO and Kagra scientific collaborations on 8 November in the ArXiv online archive. The publication includes the data acquired between November 2019 and March 2020 by Virgo and LIGO and describes 35 new events associated with the merger of black hole pairs and neutron stars, bringing the total number of signals identified during the second part of the third observational campaign (O3b) to 90. GWTC-3 provides unprecedented insight into a new landscape of extreme cosmic events and outlines the characteristics of black hole populations, setting new records and limits on the masses of black holes and neutron stars and providing clues to the astrophysical environments where the observed extreme cosmic events are most likely to occur. GWTC-3 also highlights the problems related to the estimation of the masses of some of the sources of gravitational waves detected, not currently attributable to black holes or neutron stars. The increase in the number of events recorded in recent years has been possible thanks to continuous technological updates. The interventions are still in progress and the next observation period, in the second half of 2022, will also be facilitated by the Japanese interferometer Kagra joining the network of gravitational observatories. ■

AWARDS

ILARIA NARDECCHIA WINS THE VIRGO AWARD 2021

Ilaria Nardecchia, a researcher of the INFN Division of Rome Tor Vergata, is the winner of the first edition of the Virgo Award, an award given annually by the international collaboration Virgo to a young researcher for his or her significant contribution to the experiment. Nardecchia received the award “in recognition of her many relevant and continued contributions to the Virgo experiment, in particular of her deep involvement in the modeling and experimental activities which led to a successful implementation of the Virgo Thermal Compensation System”

The award ceremony was held on 18 November 2021 at EGO, the European Gravitational Observatory, during Virgo Week, a quarterly meeting of the entire international collaboration, held again in person for the first time since the beginning of the pandemic.■

RESEARCH

GAMMA RAYS PRODUCED IN THE RADIATION WINDS EMITTED BY BLACK HOLES DISCOVERED

Thanks to the observations of NASA's Fermi satellite telescope, an international team of researchers has, for the first time, identified the gamma rays emitted, in certain galaxies close to ours, by the so-called UFOs. UFOs (acronym of Ultra Fast Outflows) are winds of gas and particles produced at very high speeds by supermassive black holes found in the central regions of galaxies, and scientists believe that they play a decisive role in regulating the growth of black holes and the galaxies that host them.

The study was carried out thanks to the data collected by LAT (Large Area Telescope), an instrument on board Fermi, designed and built with a decisive contribution from Italy, thanks to the Italian Space Agency, INFN and the National Institute for Astrophysics.

The results of this survey, in which Italian researchers from ASI, INFN and INAF also participated, were published on 10 November in The Astrophysical Journal and will also allow a better understanding of the history of our Milky Way. Indeed, they could explain why, above and below our galaxy, there are spheroidal structures of hot gas called "Fermi bubbles": according to the model just published, these structures could be the remains of a past UFO activity of Sagittarius A*, the supermassive black hole that lies at the centre of our galaxy.■

AGREEMENTS

CONFINDUSTRIA, FBK AND INFN CREATE THE GAIA-X HUB ITALIA ASSOCIATION

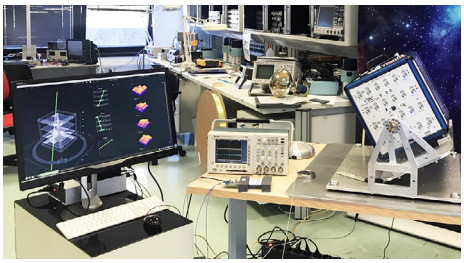
The Gaia-X Hub Italia Association was established on 3 December, with the aim of promoting the data ecosystem in the country. The initiative, shared with the Ministries of Economic Development, of Innovation and Digital Transition and of University and Research, sees among the founding members Confindustria, the Bruno Kessler Foundation (FBK) and the INFN. The Hub will represent the reference point for Italian companies and organizations interested in developing projects based on data enhancement, following principles such as interoperability, privacy and control of proprietary data. The project will lead to the creation of a series of data spaces divided by sector, industries or supply chains, in which companies and other public or private entities will be able to autonomously share data, information and services with each other. The Hub will also be a point of connection with the national counterparts of Gaia-X at the European level, to lead to the development of a broader continental ecosystem of federated, sovereign and fully operational data. The project was illustrated on December 3 in Milan as part of CONNEXT 2021, by the founding members and government representatives.■

AWARDS

FRANCESCA DORDEI WINS THE YOUNG WOMAN OF SCIENCE 2021 AWARD

On Novemer 9, during the final day of the Festival of Science in Cagliari, the Young Woman of Science 2021 Award was given to Francesca Dordei, researcher of the INFN Cagliari division and of the collaborations LHCb, at CERN, and DarkSide, at the INFN Gran Sasso National Laboratories, for her research achievements in particle physics and for her commitment in scientific outreach.

Established in 2019, the Woman of Science Award provides recognition to women who have distinguished themselves in science by contributing to increasing prestige and advancements in Sardinia. The initiative is promoted by the ScienzaSocietàScienza association in collaboration with the Universities of Cagliari and Sassari, INAF and the Astronomical Observatory of Cagliari, the INFN division of Cagliari, the Cagliari branch of the CNR Institute of Neuroscience and the Department of Equal Opportunities of the Municipality of Cagliari. ■



OUTREACH

THOUSANDS OF STUDENTS DISCOVERING RADIOACTIVITY AND COSMIC RAYS

In November, the European Radon Day and the International Cosmic Day were celebrated.

At the European level, the European Radon Day is the day dedicated to information and awareness on radon and natural radioactivity and falls every year on 7 November, the anniversary of the birth of Maria Skłodowska Curie. To celebrate it, the INFN project *RadioLab* for the dissemination of scientific culture, dedicated to the issues of environmental radioactivity, organised three events involving approximately 400 high school students. In particular, students from Cagliari, Lecce, Milan, Naples and Siena, as well as from the islands of Lampedusa, Ischia and San Pietro, participated in the project, sharing their experiences.

10 November was, on the other hand, the day dedicated to cosmic rays, International Cosmic Day, an initiative coordinated worldwide by the German laboratory DESY and, in Italy, by the INFN OCRA - Outreach Cosmic Ray Activities project, for the dissemination of scientific knowledge on cosmic rays. In Italy, the programme of in-person and on-line events involved the cities of Bari, Catania, Cosenza, Florence, L'Aquila, Lecce, Legnaro, Milan, Naples, Padua, Pisa, Rome, Sassari, Siena, Turin, Trento and Trieste. In total, approximately 4,500 students were involved. ■

OUTREACH

PHYSICS NOBEL PRIZE WINNER GIORGIO PARISI AT THE ROME SCIENCE FESTIVAL

28 November was the final day of the week of "Sfide" (Challenges), the 16th edition of the Rome Science Festival, produced by the Fondazione Musica per Roma with the project partnership of Codice Edizioni, implemented together with INFN, ASI Italian Space Agency, and with the participation of many research organisations and national scientific and cultural institutions.

Guest of honour of the Festival was the 2021 Physics Nobel Prize winner Giorgio Parisi. His meeting, “Order in Chaos,” held in person and conceived and coordinated by INFN, was the most attended special event of the week with all seats taken. In addition to narrating the topics that motivated the award of the Nobel Prize, the physics of complexity and its implications, during the event, Parisi went back over the years in which, as a physicist at INFN, he made fundamental contributions to theoretical research in particle physics. The dialogue was attended by the President of INFN, Antonio Zoccoli, the theoretical physicist Luciano Maiani, former INFN President and CERN Director General, and moderated by journalist, author and Rai3 TV anchorman Edoardo Camurri.

Among the events of the Festival, the multidisciplinary round tables organised by INFN with other scientific institutions, the educational activities and those dedicated to teachers, the "Faces and Challenges of Physics" exhibition created by the INFN ScienzaPerTutti project, the "A sign in space" event show with the INFN physicist and Professor at the University of Genoa, Marco Pallavicini, and the play "The hidden force", dedicated to the story of fundamental contributions of women scientists in research, were also very well received.■

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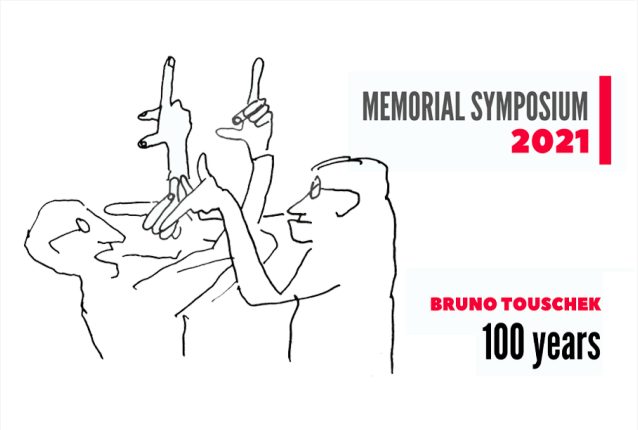

THE PHYSICIST WHO LIVED TWICE: ON THE 100TH ANNIVERSARY OF HIS BIRTH, A SYMPOSIUM REMEMBERS BRUNO TOUSCHEK

1921-2021: on the hundredth anniversary of his birth, INFN, the Sapienza University of Rome and the Accademia Nazionale dei Lincei celebrated Bruno Touschek and his scientific legacy.

A brilliant Austrian physicist, thanks to his ingenious insights and fruitful initiative, Touschek wrote a decisive chapter in the history of physics, and particularly marked the history of particle accelerators, creating the first accumulation ring, AdA, at the INFN Frascati National Laboratories, forerunner of subsequent collision rings. The three Italian scientific institutions, which played an important role in Touschek's scientific life, therefore decided to commemorate him in the course of the Bruno Touschek Memorial Symposium, a three-day event that took place from 2 to 4 December at the Amaldi Lecture Theatre of the Sapienza University, the Touschek Lecture Theatre of the Frascati Laboratories and at the premises of the Lincei, going back over not only his history and his legacy but also everything that subsequently derived from his contribution. The event was attended by representatives and scientists from institutions and major European laboratories, including Nobel laureates Carlo Rubbia and Giorgio Parisi.

The scientific career of Bruno Touschek was profoundly marked by dramatic personal events. His most tragic experience dates back to 1945 when, while marching among the deportees, Touschek became separated from his column of comrades, falling into a ditch by the side of the road, exhausted by pneumonia and the long march. One of the soldiers escorting the prisoners shot at him: one shot in the head and one in the chest. Fortunately, Touschek was only grazed and rescued from a fate that seemed already sealed.

Touschek moved permanently to Italy, where his dear maternal aunt Adele, called Ada, lived, only in the 1950s. Here he taught at the University of Rome and made his decisive contribution to the implementation and evolution of high energy accelerators at the INFN Frascati National Laboratories. It was in 1961, in fact, that the first prototype of an accelerator developed from a revolutionary idea of Touschek came into operation: make two particle beams, one of matter and one of antimatter, circulate in the same ring and in opposite directions; from

» FOCUS

the collisions of the two beams new particles can be produced. In honour of his aunt, Touschek named the new machine AdA, which stands also for “Anello di Accumulazione” (Italian for Accumulation Ring). An accelerator that paved the way for the development of subsequent collision rings and is the basis of the operation of the Large Hadron Collider at CERN, the largest and most powerful collider in the world (where protons collide).

In Italy, thanks to his brilliant personality, Touschek contributed to the great development of the academic and scientific environment, forming a new generation of theorists - among his first undergraduates Nicola Cabibbo and Francesco Calogero - and consolidated what would become a characteristic of the Frascati National Laboratories: the symbiosis between theory, experimentation and construction of acceleration machines.

In the context of the symposium, on Friday 3 December, the ceremony of naming the visitor centre of the INFN Frascati National Laboratories after Touschek was also held. The ceremony was attended by his son, Francis Touschek. The symposium closed on 4 December, at the Accademia Nazionale dei Lincei, in Palazzo Corsini, with two sessions presented by Giovanni Gallavotti and Giovanni Jona-Lasinio and the concluding seminar by Luciano Maiani.

The symposium was held as part of the initiatives celebrating the 70th anniversary of the Italian National Institute for Nuclear Physics.■

Link to the symposium page

TAKE PART IN

UNTIL FEBRUARY 27, 2022 - THE EXHIBITION “UNCERTAINTY” CONTINUES TOGETHER WITH ITS PROGRAM OF PUBLIC EVENTS

The exhibition curated by INFN "Uncertainty. Interpreting the present, predicting the future" continues at the Palazzo delle Esposizioni in Rome. The exhibition, dedicated to the theme of uncertainty and how science has learned to understand and "manage" it, is part of the wider Palaexpo special project "Three Stations for Art and Science", promoted by Roma Culture, which includes the exhibitions "La Scienza di Roma" and "Ti con Zero". Among the rich program of collateral public events, there will be in December a dialogue between Giorgio Parisi, Nobel Prize in Physics 2021, and Fernando Ferroni, physicist and one of the curators of the exhibition. At the centre of the meeting, the idea that uncertainty, seen as knowledge of the limits of analysis and measurements, is fundamental for the sciences, whether it is describing complex systems or the production mechanisms of the Higgs boson in collisions between particles. An approach that can become an ally and a valuable tool for aware citizens.

The complete program of events is available on the Palazzo delle Esposizioni website.

DECEMBER 15, 6.30 p.m.: QUARK AND GLACIATION. CONVERSATIONS ON THE SIMPLE AND THE COMPLEX

Rotonda of Palazzo delle Esposizioni, Rome

With Giorgio Parisi, Nobel Prize in Physics 2021, professor at Sapienza University of Rome, researcher associated with INFN National Institute for Nuclear Physics and vice-president of the Accademia Nazionale dei Lincei, and Fernando Ferroni, curator of the exhibition "Uncertainty", professor at GSSI Gran Sasso Science Institute and associate researcher at INFN.

16 DECEMBER, 6.30 p.m.: SCIENCE AND SOCIETY. IN MEMORY OF PIETRO GRECO AND ROSSELLA PANARESE

Rotonda of Palazzo delle Esposizioni, Rome

With Marco Cattaneo, director in charge of National Geographic Italia, National Geographic Traveler, Le Scienze e Mind, Marco Motta, scientific journalist, host of Radio3 Scienza - Radio3 RAI, Fabrizio Rufo, associate professor of Moral Philosophy at Sapienza University of Rome, Lucia Votano, astroparticle physics, emeritus research director of the INFN.

LIVE EVENTS ON SOCIAL MEDIA

13 DECEMBER, 6.30 p.m: IXPE, FROM THE LABORATORY TO SPACE

Live on the INFN Facebook and YouTube pages, from the Palazzo delle Esposizioni halls in Rome

An in-depth study on the objectives and characteristics of Ixpe, a NASA space mission in which Italy participates through the contributions of ASI, as leader, INAF and INFN.

With Melissa Pesce Rollins, researcher of the INFN Pisa division and member of the IXPE collaboration, and Luca Latronico, co-head for INFN of IXPE and researcher of the INFN Turin division.

Follow the event on Facebook: *https://fb.me/e/1NJBF5il5*.

Follow the event on YouTube: *https://youtu.be/DjDCkB7KYxs*

DECEMBER 16, 6.00 p.m: SPACE FOR GRAVITY

Live on the INFN Instagram profile @infn_insights

On the National Space Day, a meeting on the development of new space technologies, in which INFN collaborates, to test the gravity described by Albert Einstein's Theory of General Relativity.

With Francesca Dordei, researcher of the INFN Cagliari division, Eleonora Castelli, researcher of the University of Trieste and INFN, and Luciana Filomena, of the INFN Frascati National Laboratories, moderated by Giuliana Galati, researcher of the University of Bari and INFN and science communicator.

Follow the event on INFN Instagram profile *@infn_insights*

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Italian National Institute for Nuclear Physics

COVER
Drawing "Magnetic Discussion" by Bruno Touschek

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