

Faces & Places

APPOINTMENTS

ECFA elects new chairperson



Newly elected ECFA chair Jorgen D'Hondt is also a member of the CMS Collaboration.

At a plenary meeting of the European Committee for Future Accelerators (ECFA) held at CERN on 16–17 November, Jorgen D'Hondt of the Vrije Universiteit Brussel in Belgium was elected ECFA chairperson, with a three-year-long mandate running from 2018 to 2020. ECFA carries out long-range planning for European high-energy accelerators, large-scale facilities and equipment, and plays an important role in building the physics community in preparation for the upcoming update of the European

Strategy for Particle Physics. D'Hondt, who works on the CMS experiment, is co-director of the Interuniversity Institute for High Energies in Brussels, with research activities including top-quark physics and dark matter. His team is also involved in the upgrade of the CMS silicon tracker and in the development of heavy-flavour tagging algorithms. He takes over from previous ECFA chairperson Halina Abramowicz of Tel Aviv University in Israel, who is now secretary of the European Strategy Group (*CERN Courier* November p37).

Change of director at US accelerator school

Steven Lund of Michigan State University in the US has been named the new director of the US Particle Accelerator School (USPAS), succeeding William Barletta of Fermilab who has led the school since 2006. Lund, whose focus is theoretical accelerator physics, took up the role on 1 December with a four-year renewable term. Considered the premier training programme in accelerator science and engineering in the US, USPAS offers a continually updated curriculum of courses ranging from the fundamentals of accelerator science to advanced physics and engineering concepts. The school, which is a collaboration of 10 institutions hosted at Fermilab on behalf of the US Department



Steven Lund takes the helm at USPAS.

of Energy, has many parallels with its European cousin the CERN Accelerator School, and is intended to train, develop and educate people on the many uses of particle accelerators in particle physics and beyond.

AWARDS

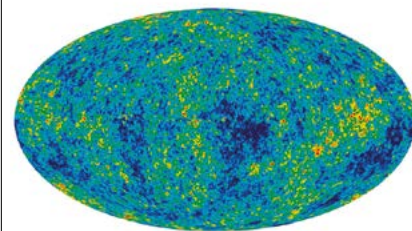
WMAP scientists awarded 2018 Breakthrough Prize

The team that mapped the temperature of the cosmic microwave background using NASA's Wilkinson Microwave Anisotropy Probe (WMAP) has won the 2018 Breakthrough Prize in fundamental physics. The \$3 million sum was awarded to Charles Bennett (Johns Hopkins University), Gary Hinshaw (University of British Columbia), Norman Jarosik (Princeton University), Lyman Page Jr. (Princeton University), David N Spergel (Princeton University) and the WMAP Science Team on 3 December.

NASA launched WMAP in 2001 to measure tiny temperature fluctuations across the sky imprinted by processes in the very early universe. Its many precise measurements have helped establish the standard model of cosmology.

Now in their sixth year, the Breakthrough prizes honour top achievements in the fields of physics, life sciences and mathematics. They were founded by Sergey Brin, Yuri and Julia Milner, Mark Zuckerberg and Priscilla Chan, Anne Wojcicki, and Pony Ma, with seven \$3 million prizes awarded this year at a televised ceremony in Silicon Valley.

In addition, three New Horizons in Physics Prizes of \$100,000 were awarded to promising junior researchers who have already produced important work: Christopher Hirata of Ohio State University, Andrea Young of the University of California, Santa Barbara, and Douglas Stanford of the Institute for Advanced Study and Stanford University.



WMAP's results have helped transform cosmology into a precision science. (Image: NASA)

Faces & Places

AWARDS

Weizmann Institute honours Jenni



Peter Jenni before the ceremony at the Weizmann Institute of Science.

On 6 November the Weizmann Institute of Science in Israel awarded Peter Jenni of CERN and Albert Ludwigs University of Freiburg an honorary PhD. The award recognizes Jenni's landmark contributions to experimental particle physics and his impressive achievements leading the LHC's ATLAS experiment. It also noted

his advocacy of high-energy physics research and education, and his instrumental role in inducting Israel into CERN as its first non-European Member State. Jenni was a founding spokesperson of ATLAS, continuing to lead the experiment until 2009, and previously played a major role in the UA2 experiment at the Super Proton Synchrotron.

Dublin City University acclaim for Myers

Stephen Myers, former CERN director of accelerators and technology, has been awarded an honorary doctorate by Dublin City University in Ireland for his outstanding contributions to the physics community. Myers trained as an electrical engineer at Queen's University Belfast and spent most of his career at CERN, where he was responsible for the operation and exploitation of the CERN accelerator complex. He is currently executive chairman of CERN spin-out company ADAM Advanced Oncotherapy. On acceptance of his honorary degree on 3 November, Myers highlighted the importance of CERN and the benefits of membership. "Ireland's continued



Myers spoke about the benefits of CERN membership for Ireland.

non-membership of CERN puts our country at an enormous technological disadvantage, since we cannot profit from the technology transfer and training that comes from being a member state of CERN," he said.

Schukraft receives Niels Bohr Institute's Honorary Medal



Jürgen Schukraft with his medal.

Heavy-ion physicist Jürgen Schukraft of CERN has been awarded the Niels Bohr Institute's Honorary Medal for his long-standing work in the study of heavy-ion collisions at relativistic energies and for his role as leader of the ALICE experiment at the LHC. Schukraft is one of the people behind the creation of ALICE and was spokesperson of the collaboration for its first 20 years from 1990, overseeing groundbreaking results concerning the quark–gluon plasma. Over the years Schukraft has been closely connected with the Niels Bohr Institute group in ALICE and he is also a member of the Discovery Danish National Research Foundation (DNRF) centre of excellence advisory board.

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ANNIVERSARY

25 years of the LHC experimental programme

On 15 December a special scientific symposium at CERN celebrated the 25th anniversary of the LHC experimental programme. During the event, speakers reflected on the LHC's history, the physics landscape into which the LHC experiments were born, and the challenging path that led to the very successful LHC programme today.

In early March 1992 a meeting took place in the town of Evian on Lake Geneva titled "Towards the LHC Experimental Programme". It would, quoting *CERN Courier* in May that year, "always be remembered as the stage where these ideas made their debut". The road since then has been full of challenges, new ideas and innovative technologies. A great deal of motivation, determination and patience was finally rewarded with excellent performance from the accelerators, detectors and computing, and with major physics results such as the discovery of the Higgs boson.

At the Evian event, a dozen teams presented an expression of interest (EOI) to carry out research at the LHC, including: four for general-purpose experiments; three for dedicated B-physics experiments; two for neutrino experiments; and two for dedicated



The symposium "25 years since Evian" attracted leading figures linked to the LHC programme.

heavy-ion experiments. The 12th EOI concerned a heavy-ion programme within the CMS experiment. ATLAS was formed from the merger of two proposals, ASCOT and EAGLE, whereas CMS had evolved from a single proposal at Evian. ATLAS and CMS submitted their letters of intent on 1 October 1992, with ALICE following in 1993 and LHCb in 1995 – completing the set of large LHC experiments.

Evian was a landmark, but it was also part of a longer process. The LHC had been formally launched at a workshop in

Lausanne in 1984 and was recommended by CERN's long-range planning committee three years later, leading to a succession of meetings and workshops and, finally, to the CERN Council voting unanimously at its December 1991 meeting that the LHC was the "right machine for the advance of the subject and the future of CERN".

The December symposium concluded with a presentation of the latest results from the four large LHC experiments, which continue to subject the Standard Model of particle physics to unprecedented levels of scrutiny.

EVENTS

Inauguration ceremony promotes Hyper-Kamiokande project

On 1 October the University of Tokyo inaugurated the Next-generation Neutrino Science Organization (NNSO) and appointed the 2015 Nobel Prize-winning neutrino physicist Takaaki Kajita as its director. The NNSO's main purpose is to promote the construction of the Hyper-Kamiokande project, a new neutrino facility in Japan, involving some 74 institutions in 14 countries, and to work towards the development of state-of-the-art neutrino research techniques and detector technologies. Hyper-Kamiokande will investigate CP violation in the neutrino sector by observing oscillations in a neutrino/anti-neutrino beam produced by the J-PARC accelerator. It will use a 260,000 tonne tank of pure water located 650 m underground in Kamioka to detect the Cherenkov radiation produced by the collision of neutrinos with water molecules using 40,000



The ceremony was attended by about 100 people from MEXT, the University of Tokyo, KEK, local government and community, the Kamioka Mining and Smelting Company, and collaborating scientists.

photomultiplier tubes. "Understanding the neutrino is not only important to particle physics, but is also thought to have deep connections to the origins of matter," said Kajita in his opening remarks.

Dark-matter and cosmic-ray celebrations

Towards the end of 2017, two world-wide cosmic celebrations reached out to new audiences with tales about dark matter and cosmic rays. On 31 October the historic hunt for dark matter was celebrated with the first ever "Dark Matter Day". Many laboratories and institutes organised dedicated events targeting new audiences, including CERN, which opened its doors to the public and invited experts to talk about the status of dark-matter science. The following month, on 30 November, International Cosmic Day took place for the sixth time, organised by DESY in Germany. Young people around the world had the chance to experience research in an international collaboration in science by analysing real cosmic-ray data, with more than 60 groups of young people in 17 countries around the world taking part.

Faces & Places

Japan science festival looks beyond the boundaries

Science Agora 2017, Japan's largest science festival, took place in Tokyo on 24–26 November, giving researchers the opportunity to interact with non-scientists and policy-makers alike. The key theme of this year's festival was “beyond the boundaries”, including a dedicated session in which the European Union (EU) delegation to Japan highlighted several big-science projects enabled by the collaboration of European and Japanese researchers.

The Future Circular Collider (FCC) study, launched at CERN in 2014 and supported through the European Commission's EuroCirCol programme, was presented as a primary example of how scientific collaboration in a big scientific project transcends geographical and cultural boundaries. The neutrino project Super-Kamiokande Plus was also highlighted, as were joint international projects concerning fusion energy, photovoltaic cells, smart cities and climate change. “Participation in Science Agora is driven by our twofold desire to show in a tangible manner some of the best science



Deputy FCC study leader Frank Zimmermann discusses how the project requires experts from different fields and countries.

and innovation that are being developed in Europe, and to demonstrate the diverse ways in which European and Japanese researchers and scientists are cooperating,” said EU ambassador Viorel Isticioaia-Budura.

● The fourth annual meeting of the FCC study will take place from 9–13 April 2018 in Amsterdam: cern.ch/fccw2018.

Fun at the fair



Science immersion at the Geneva exhibition.

CERN was guest of honour at Geneva's major annual fair the Automnales, held from 10 to 19 November. Some 145,000 people attended the event and most of them stopped at the CERN stand to immerse themselves in the world of fundamental science. The stand covered an area of 1000 m² and was designed to resemble a particle collision. Guests young and old had the chance to take a virtual-reality tour of the LHC and one of its detectors, learn how to conduct physics experiments using household objects, play proton football and program robots, among other activities. Most importantly, they met enthusiastic researchers, engineers, technicians and administrative employees who were delighted to share their passion for research.

LETTERS

ISOLDE then and now

I was pleased to see your piece about the 50th anniversary of the ISOLDE project (*CERN Courier* December 2017 p36). It is truly remarkable how ISOLDE, over such a long time and in its evolving shapes, has succeeded in maintaining world leadership in the study of exotic nuclei. This is a success story for the scientists involved and CERN as an organisation willing to support excellent science in areas other than mainstream particle physics.

The picture from 1967 that you used shows the original ISOLDE team in the underground cavern between the Synchrocyclotron building and the main gates (note the white lab coats – the experiment was run by the then nuclear chemistry group). The person standing to the right in the picture is group leader Arve Kjelberg, a nuclear chemist originating from Pappas' group in Oslo. Kjelberg moved on to become deputy director of the nuclear physics division under Herwig Schopper and, after leaving CERN, he held senior positions in the Norwegian Ministry of Science and Education until retirement. He passed peacefully away in June 2016.

● Leif Westgaard

Neutrinos and the Standard Model

I read with interest your interview with Weinberg (*CERN Courier* November 2017 p31) and would like to draw attention to a statement made on page 34, “Whereas simply inserting neutrino masses into the theory would violate the $SU(2) \times U(1)$ symmetry.”

There is a simple way to put neutrino masses into the Standard Model (SM): just add their right-handed terms like any other fermion, and standard Higgs doublet couplings, and you get masses, $SU(2) \times U(1)$ symmetry and renormalisability. This point was not addressed in the article and it gives the impression that it is really impossible to maintain SM renormalisability and give mass to the neutrinos at the same time. This would be a clear failure of the SM and gauge theories, but it isn't the case.

● Biagio Di Micco

Editor's reply:

The article perhaps could have been clearer that the symmetries of the SM make it impossible to give masses to neutrinos without introducing either non-renormalisable interactions or new fields, namely right-handed neutrino fields that have no interactions with SM gauge

fields. The latter would leave the mystery of why neutrino masses are so tiny, however, while the effective-field theory point of view ensures that non-renormalisable terms in the SM are naturally very small, explaining the smallness of neutrino masses and potentially other observables, too.

Dick Garwin and g-2

Last year *CERN Courier* reported on measurements of the anomalous magnetic moment of the muon, g-2 (July/August 2017 p11). There was a second (hidden) occasion in the January/February issue (p50) where it was reported that Dick Garwin received the Presidential Medal of Freedom from former US president Barack Obama for his long career in research and invention. Garwin's significant contributions to particle physics and his work at CERN, however, were not mentioned.

In an experiment undertaken at Columbia in 1957 together with Leon Lederman and Marcel Weinrich, Garwin made the first observation of parity violation in muon decay and measured the value of g-2 to a precision of around 10%. At CERN, starting in 1959, Garwin was also a member of the group that performed the first g-2 experiment at the Synchrocyclotron.

● Pier Giorgio Innocenti

Faces & Places

DIVERSITY

Berkeley physicists march in Pride Parade

A group of about 30 Lawrence Berkeley National Laboratory employees and friends, along with staff from Sandia and Lawrence Livermore National Labs, marched in the 2017 San Francisco Pride Parade. The group, which included many with strong ties to nuclear and particle physics, raised colourful placards and demonstrated the lab's support for diversity and inclusion. Berkeley Lab's participation was organized by the Lambda Alliance, which aims to promote an inclusive atmosphere, enhance policies of non-discrimination, create guidance for institutional processes, identify and address emerging challenges, and increase awareness of issues impacting the Berkeley Lab community.



The 2017 Pride Parade celebrated the 50th anniversary of the "Summer of Love".



Ninety years after the famous photograph of the 1927 Solvay conference (top) was taken, depicting 28 male scientists and a single woman (Marie Skłodowska-Curie), the University of Trento and the Italian Physical Society created a more modern picture: a new photo showing 28 female physicists and one man (former CMS spokesperson Guido Tonelli). The aim was to give more visibility to women in physics, one of the topics of the conference of the Italian Physical Society in Trento after which the photo was taken on 14 September. At the 1927 Solvay conference, devoted to electrons and photons, 17 of the 29 attendees photographed were or became Nobel Prize winners – including Curie, who alone among them, had won Nobel Prizes in two separate scientific disciplines.

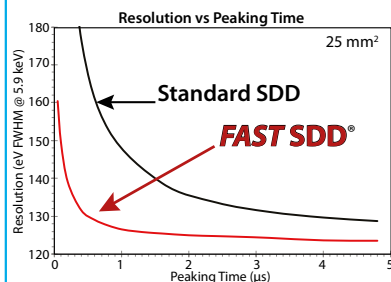
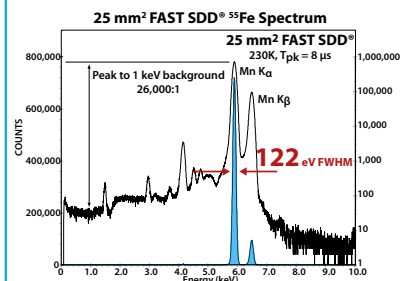
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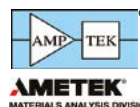
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MEETINGS

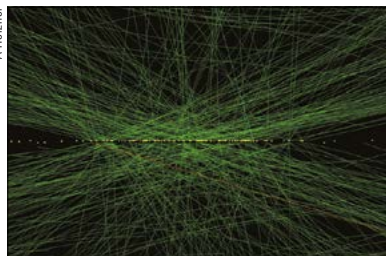
Weighing up the LHC's future

As the LHC's 2017 run drew to a close late last year, CERN hosted a workshop addressing future physics opportunities at the flagship collider. The first workshop on the physics of High-Luminosity LHC (HL-LHC) and perspectives at High-Energy LHC (HE-LHC) took place from 30 October to 1 November, attracting around 500 participants. HL-LHC is an approved extension of the LHC programme that aims to achieve a total integrated luminosity of 3 ab^{-1} by the second half of the 2030s (for reference, the LHC has amassed around 0.1 ab^{-1} so far). HE-LHC, by contrast, is one of CERN's possible options for the future beyond the LHC; its target collision energy of 27 TeV, twice the LHC energy, would be made possible using the 16 T dipole magnets under development in the context of the Future Circular Collider study.

The workshop was the first of a series of meetings scheduled throughout 2018 to review and further refine our understanding of the physics potential of the HL-LHC, and to begin a systematic study of physics at the HE-LHC.

Close to 2000 physics papers have been published by the LHC experiments. In addition to the discovery of the Higgs boson and the first studies of its properties, these papers document progress in hundreds of different directions, ranging from searches for new particles and interactions to the measurement of a multitude of cross-sections with unprecedented precision, from the improved determination of the top-quark and W-boson masses to the opening of new directions in the exploration of flavour phenomena, from the discovery of hadrons made of exotic quark configurations to the observation of new collective phenomena in both proton and nuclear collisions. That these results were extracted from datasets representing only a few percent of the data sample promised by the HL-LHC, shows how vast and incisive its ultimate achievements may be.

There is nevertheless a recurrent concern expressed by many physicists that the lack of direct evidence for new physics at the LHC is already diminishing the expected returns from the HL-LHC. The conflict with the expectation that new physics should have already appeared at the LHC forces us to reconsider that prejudice, and strongly underscores the mysterious origin of the Higgs boson and the need to study it in the greatest detail. This orients the HL-LHC goals towards increasing the sensitivity to elusive exotic phenomena, and increasing the



HL-LHC will produce ~200 simultaneous proton collisions in a single bunch crossing. Shown is a real-life example of 78 reconstructed collisions in a single event.

precision of Standard Model measurements and of their interpretation, in particular for the Higgs. These directions pose severe challenges to experimentalists and theorists, pushing us to develop original approaches for the best exploitation of the HL-LHC statistics and to use experience to reduce future systematic uncertainties in theory and experiment. The full HL-LHC dataset will be needed to challenge the Higgs mechanism. With it, we will be able to attain percent-level precision for the most prominent of the Higgs interactions, test the couplings to the second fermion generation, and find evidence for the self-interaction of the Higgs.

Progress and precision

A priority of the workshop series is to study the added value provided by the HE-LHC. And, since minor deviations from the Standard Model could be hiding anywhere, no stone should be left unturned. We have already seen the emergence of new proposals and techniques, which have extended beyond expectations the new-physics reach. Examples include the use of boosted jet topologies to enhance sensitivity to weakly interacting light particles decaying hadronically, or the use of quantum interference effects to constrain the Higgs-decay width. New proposals are also emerging to detect exotic long-lived particles, with the possible help of additional detector elements. The workshop environment should stimulate the youngest researchers to develop ideas and leave their own signature on future analyses.

Indications of lepton-flavour-universality violation (see p48) are being closely monitored and will be further scrutinised during the workshop. Were these hints to be confirmed with more data, it would open a

hunt for their microscopic origin and provide concrete ground in which to examine the power of the HL-LHC and the potential of a future HE-LHC to test the proposed models. The workshop series will explore the synergy and complementarity of the flavour studies carried out with the precise measurement of b-hadron decays and with the direct search for these new interactions.

The LHC running into the mid-2030s also provides new opportunities for the study of hadronic matter at high densities. The established existence of a quark-gluon plasma phase should be probed under a broader set of experimental conditions, using ions lighter than lead, and thoroughly addressing the novel indications that unexpected collective effects appear in proton collisions. Surprises such as this show that the field of high-density hadronic matter is rapidly evolving, and the workshop will outline the ambitious future programme needed to answer all open questions.

The discussion of the prospects of HL-LHC physics builds on the experience gained so far by the LHC experiments, in particular the dedicated work done for the preparation of future detector upgrades to cope with the harsher high-luminosity environment of HL-LHC, addressing problems of increased event rates and complexity. The workshop will try to go beyond the existing performance studies, exploring the opportunities offered by the superior detector and data-acquisition systems.

On the theory side, the computing techniques discovered in the last few years are being pushed to new heights, promising continued progress in the modelling of LHC interactions. This goes hand in hand with the improved precision of the measurements, and the workshop will examine new ideas for the direct validation of theoretical calculations, to improve the extraction of Standard Model parameters and to gain higher sensitivity to deviations from the Standard Model.

The strong attendance at the kick-off workshop attests the great interest present in the community in the post-LHC era. The outcomes will be documented in a report to be submitted to the 2019 review of the European Strategy for Particle Physics. The projections for the ultimate outcome of the HL-LHC will provide an essential reference for the assessment of the other future initiatives to be evaluated during the strategy review.

● indico.cern.ch/event/647676

Sizing up physics beyond colliders

The Physics Beyond Colliders (PBC) initiative, launched in 2016, explores the opportunities offered by the CERN accelerator complex and infrastructure that are complementary to high-energy collider experiments and other initiatives worldwide. It takes place in an exciting and quickly developing physics landscape. To quote a contribution by theorist Jonathan Feng at the recent ICFA seminar in Ottawa: "In particle theory, this is a time of great creativity, new ideas, and best of all, new proposals for experiments and connections to other fields."

Following a kick-off workshop in September 2016 (*CERN Courier* November 2016 p28), the second general PBC workshop took place at CERN on 21–22 November. With more than 230 physicists in attendance, it provided an opportunity to review the progress of the studies and to collect further ideas from the community.

During the past year, the PBC study was organised into working groups to connect experts in the various relevant fields to representatives of the projects. Two physics working groups dealing with searches for physics beyond the Standard Model (BSM) and QCD measurements address the design of the experiments and their physics motivation, while several accelerator working groups are pursuing initiatives ranging from exploratory studies to more concrete plans for possible implementation at CERN. The effort has already spawned new collaborations between different groups at CERN and with external institutes, and significant progress is already visible in many areas.

The potential performance increase for existing and new users of the upgraded HL-LHC injector chain, following the culmination of the LHC injector upgrade project (*CERN Courier* October 2017 p22), is being actively pursued with one key client being the SPS North Area at CERN. The interplay between potential future operation of the existing SPS fixed-target experiments (NA61, NA62, NA64, COMPASS) and the installation of new proposed detectors (NA64++, MUonE, DIRAC++, NA60++) has started to be addressed in both accelerator and physics respects. The technical study of the SPS proton beam dump facility and the optimisation of the SHiP detector for investigating the hidden sector are also advancing well.

Different options for fixed-target experiments at the LHC, for instance using



The November workshop at CERN is the second in the Physics Beyond Colliders series.

gas targets or crystal extraction, are under investigation, including feasibility tests with the LHC beams. The novel use of partially stripped ions (PSI) to produce high-energy gamma rays in a so-called gamma factory (*CERN Courier* November 2017 p7) is also gaining traction. Having taken PSI into the SPS this year, near-term plans include the injection of partially stripped lead ions into the SPS and LHC in 2018.

New opportunities

The design study of a storage ring for a proton electric-dipole-moment (EDM) measurement is progressing, and new opportunities to use such a ring for relic axion searches through oscillating EDMs have been put forward. In the loop are the COSY team at Jülich who continue to break new ground with polarised deuteron experiments (*CERN Courier* September 2016 p27).

Last but not least are non-accelerator projects that wish to benefit from CERN's technological expertise. One highlight is the future IAXO helioscope, proposed as a successor of the CERN CAST experiment for the search of solar axions. Recently IAXO has formed as a full collaboration and is in discussion with DESY as a potential site. IAXO and a potential precursor experiment (Baby-IAXO) benefit from CERN PBC support for the design of their magnets.

The workshop also included a session devoted to the presentation of exciting new ideas, following a call for contributions from the community. One noticeable new idea consists of the construction of a low-energy linac using CLIC technology for electron injection and acceleration in the SPS. A slow extracted SPS e-beam in the 10–20 GeV energy range would allow hidden sector searches similar to NA64

but at higher intensity, and the linac would provide unique R&D possibilities for future linear accelerators. Another highlight is the prospect of performing the first optical detection of vacuum magnetic birefringence using high-field magnets under development at CERN. New projects are also being proposed elsewhere, including a first QED measurement in the strong field regime at the DESY XFEL (LUXE project) and a search for η meson rare decays at FNAL (REDTOP experiment).

The presentations and discussions at the workshop have also shown that, beyond its support to the individual projects, the PBC study group provides a useful forum for communication between communities with similar motivations. This will be an important ingredient to optimise the scope of the future projects.

The PBC study is now at a crucial point, with deliverables due at the end of 2018 as input to the European Strategy for Particle Physics Update the following year. The PBC documents will include the results of the design studies of the accelerator working groups, with a level of detail matched to the maturity of the projects, and summaries of the physics motivation of the proposed experiments in the worldwide context by the BSM and QCD physics groups. One overview document will provide an executive summary of the overall landscape, prospects and relevant issues. It should also be emphasised that the goal of the PBC study is to gather facts on the proposed projects, not to rank them.

A follow-up plenary meeting of the PBC working groups is foreseen in mid-2018, and the main findings of the PBC study will be presented to the community in an open closeout workshop towards the end of the year.

● pbc.web.cern.ch

CERN and Member States talk med-tech

The first annual knowledge-transfer thematic forum on medical applications took place at CERN on 30 November, bringing CERN and its Member State and associate Member State representatives together to discuss the

application of CERN's technologies and know-how to the medical field.

The knowledge transfer (KT) forum, known as ENET until the end of 2015 comprises one or more representatives for

each country, allowing CERN to develop common approaches with its Member States and to identify potential industry and academic partners while minimising duplication of effort. Medical applications are one of CERN's most significant KT activities, and this year CERN gave each country the chance to nominate an expert in the field to attend special sessions of the KT forum dedicated to medical applications.

Some 20 invited speakers from the physics and medical communities took part in the inaugural event in November. The scope of the discussions demonstrated CERN's deep and longstanding involvement in areas such as medical imaging, hadron therapy and computing, and highlighted the enormous potential for future applications of high-energy physics technologies to the medical arena.

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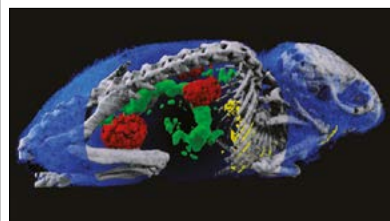


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After an introduction regarding CERN's strategy for medical applications and the governance put in place for these activities (see p5), much of the event was devoted to updates from individual Member States and associate Member States, where much activity is taking place. Some of them clearly indicated that medical applications are an important activity in their countries, and that engaging with CERN more closely is of great added value to such efforts.

In the second half of the meeting, presentations from CERN experts introduced the various technology fields in which CERN is already actively pursuing the application of its technologies to the medical fields, such as high-field superconducting magnets, computing and simulations, and high-performance particle detectors.

The event was an all-round success, and more will follow this year to continue identifying ways in which CERN can contribute to the medical applications strategy of its Member States.

Top physics focus in Portugal

Since its discovery in 1995 by the CDF and D0 experiments at the Tevatron, Fermilab, the top quark has provided physicists with a powerful handle on the Standard Model (SM). Being the heaviest known elementary particle, the top quark is difficult to produce and study but its large mass makes it sensitive to new physics beyond the SM.

The series of international workshops on top-quark physics started in 2006 in Coimbra, Portugal, with the main goal of establishing a close collaboration between experimentalists and theorists. The 10th edition took place in Bom Jesus Sanctuary in Braga, northern Portugal, from 17–22 September and attracted around 150 participants.

The mass of the top quark has always triggered passionate discussion, given the increasing precision of its measurement. The mass measurement has come a long way since the first edition of the top-quark workshop, when the Tevatron Run I/II mass combination was 172.7 ± 2.9 GeV, to the present sub-GeV precision obtained at the LHC in 2017. Still, the interpretation of the measurement, both from theoretical and experimental points of view, is a continuing hot topic that motivated vivid sessions at TOP2017.

Measured cross sections for both double and single top-quark production are in remarkable agreement with the SM



Participants of TOP2017 in Braga, Portugal.

predictions. It is also noteworthy that the measurements can now be compared with predictions at next-to-next-to-leading order (NNLO) in QCD with next-to-next-to-leading-logarithm (NNLL) soft gluon resummation, as presented at TOP2017. Describing the differential distributions, for instance of the transverse momentum of top quarks, is an increasing challenge to top-quark researchers. In particular, the mis-modelling of the distribution tails are coming under increasing scrutiny in case they contain hidden signs of physics beyond the SM, and will be a particularly important target of analyses at the high-luminosity LHC. A significant effort from the theoretical community is ongoing to understand the shape of differential distributions.

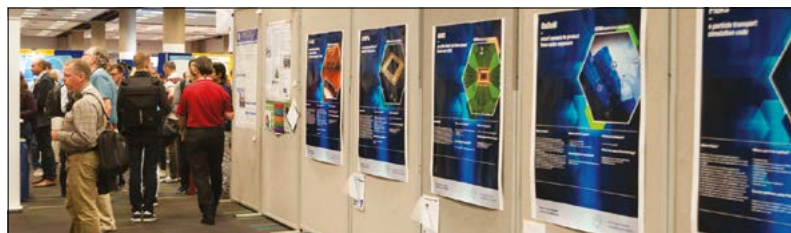
The top-quark couplings to gauge bosons can be tested at the LHC via measurements of the production cross sections of $t\bar{t}W$, $t\bar{t}Z$, $t\bar{t}\gamma$ and $t\bar{t}H$ processes, which was another source of detailed discussion at the Portugal event. The measurements are particularly challenging given the low predicted cross sections and the overwhelming irreducible backgrounds. These measurements will become more important during the high luminosity phase of the LHC. The current precision of the measurements, as presented at TOP2017, ranged from 13% for the $t\bar{t}\gamma$ channel to 15% for the $t\bar{t}Z$ production and 22% for $t\bar{t}W$. All measurements are within the SM expectations and were therefore used to set constraints on new physics. Also, for the first time, the search for the production of the rare four top-quark production at the LHC ($pp \rightarrow t\bar{t}t\bar{t}$) was shown at TOP2017. This process puts in perspective the different contributions from the gauge bosons to the overall production cross section, allowing a reinterpretation of the result as a constraint on the Yukawa couplings of top quarks to the Higgs boson.

On its 10th anniversary, the series of International Workshops on Top Quark Physics continues to build a sense of community worldwide on top-quark physics, with a strong physics case ahead. Stay tuned for the next edition in Bad Neuenahr, Germany, in 2018.

CERN presents high readiness-level technologies in Atlanta

During the IEEE Nuclear Science Symposium and Medical Imaging Conference (NSS/MIC), held on 21–28 October in Atlanta in the US, a technology-transfer programme organised by HEP-Tech, CERN and Siemens presented CERN technologies with a high technology-readiness level. To be selected for the programme, the technologies had to prove the availability of solid academic substance in addition to clear IP access conditions, applications and dissemination/commercialisation plans. Ten posters were exhibited, representing mature technologies originating from the US, Canada and Europe. Seven of them visualised CERN's radiation detection, pixel detector and electronic technologies, as well as software developments.

Among the CERN technologies presented were: Timepix3, a general-purpose integrated circuit for read-out of



The poster-themed knowledge-transfer event was attended by more than 500 visitors.

semiconductor and gas-filled detectors that can be applied in X-ray imaging, particle track reconstruction or radiation detection and monitoring; GEMPix, a novel generation of radiation detectors for dose measurements in hadron therapy; NINO ASIC, an ultrafast and low-power front-end amplifier discriminator ASIC chip for use in medical imaging, life science or materials research;

FLUKA, a particle-transport simulation code with many applications in high-energy particle physics and engineering; and RaDoM, a very compact radon detector measuring indoor radiation concentrations rapidly and accurately. The annual IEEE NSS/MIC forum is the main event for the detector and electronic community and attracts more than 1500 participants.

Faces & Places

Implications of LHCb results brought into focus

More than 300 physicists from the LHCb Collaboration and the theory community met at CERN on 8–10 November for a workshop devoted to the implications of LHCb measurements, the seventh since the series began. The very accurate results obtained by LHCb in a broad range of topics have made a large impact on the flavour-physics landscape and have implications on classes of extensions of the Standard Model (SM). The discussions also considered the interplay of searches for on-shell production of new particles at ATLAS and CMS. This series of joint workshops allows informal discussions between theorists and LHCb experimentalists, leading to a fruitful, mutual exchange of information.

New ideas

Four streams were addressed: mixing and CP violation in beauty and charm; semileptonic decays, rare decays and tests of lepton-flavour universality; electroweak physics, heavy-flavour production, implications for PDFs and exotic searches; and QCD spectroscopy and exotic hadrons. Following an experimental overview of each stream, a series of theoretical presentations covered the latest calculations or suggested interesting observables or analysis methods to test new ideas.

Examples of recent results that have attracted a lot of interest include spectroscopy of conventional and exotic hadrons such as four- and five-quark hadrons, which provide new challenges for QCD. Measurements of CP-violating observables in B meson decays are another hot topic, since they can be used to determine the angles of the unitarity triangle and hence probe for manifestations of new physics beyond the SM paradigm. Unfortunately, the



The attendance at the LHCb workshop in November was such that it had to be moved to the more spacious main auditorium.

data present an overwhelming agreement with the SM, but the majority of these measurements are so far statistically limited, with theoretical uncertainties on the interpretation of the physical observables much smaller than the attainable experimental precision.

A significant part of the workshop was devoted to exciting and intriguing anomalies in the b-quark sector that test lepton-flavour universality (LFU), a cornerstone of the SM. These anomalies can naturally be grouped into two categories according to the underlying quark-level transition: those arising in $b \rightarrow s l^+ l^-$ flavour-changing neutral-currents at one-loop level when measuring $B^0 \rightarrow K^{*1} l^-$, or $B^+ \rightarrow K^{*1} l^+ l^-$ (with $l = e$ or μ); and those arising in $b \rightarrow c l \nu$ charged-currents at tree

level, when measuring $B^0 \rightarrow D^{(*)} l \nu$, or $B_c^+ \rightarrow J/\psi l \nu$ (with $l = \tau, \mu$ or e). Taken together, these anomalies represent the largest coherent set of possible new-physics effects in the present LHCb data.

Although there are well-motivated models that attempt to explain the effects, it is too early to draw definite conclusions. So far not a single LFU measurement deviates with respect to the SM above the 3σ level. However, what is particularly interesting, is that these anomalies challenge the assumption of LFU, which we have taken for granted for many years. Furthermore, these measurements have been performed so far with Run-1 data only. Updates with Run-2 data are under way and should allow LHCb to rule out the possibility of statistical fluctuations.

Electromagnetic interactions with nucleons

The 12th Electromagnetic Interactions with Nucleons and Nuclei (EINN) conference took place in Paphos, Cyprus on 29 October to 4 November and attracted 84 participants from 39 institutes located in 15 countries in Europe, North America, Asia and Australia. The conference was dedicated to the memory of Kees de Jager, the first conference chair in 1995 who passed away in 2016. The conference series covers experimental and theoretical topics in the

areas of nuclear and hadronic physics. It also serves as a forum for contacts and discussions of current and future developments in the field.

The conference covered a wide range of theoretical and experimental developments in hadron physics including: contributions beyond single-photon exchange; the proton radius puzzle; new experimental facilities; dark-matter searches; neutrino physics; lattice QCD; spectroscopy; spin structure

of the proton; precision electroweak physics; and new physics searches. With the study of QCD being a major focus of present activities and future plans in physics research worldwide, the EINN conference will continue to provide an important international forum, particularly for young physicists, for the foreseeable future. Since 2011 the event has also offered dedicated skills sessions for postdoctoral fellows and advanced graduate students.

Particle physics meets quantum optics

The sixth International Conference on New Frontiers in Physics (ICNFP) took place on 17–29 August in Kolymbari, Crete, Greece, bringing together about 360 participants. Results from LHC Run 2 were shown, in addition to some of the latest advances in quantum optics.

A mini-workshop dedicated to “highly-ionising avatars of new physics” brought together an ever-growing community of theorists, astroparticle physicists and collider experimentalists. There were also presentations of advances in the theory of highly ionising particles as well as light monopoles, with masses accessible to LHC and future colliders, and discussions included experimental searches both extraterrestrial and terrestrial, including results on magnetic monopoles from MoEDAL-LHC experiment that have set the strongest limits so far on high-charge monopoles at colliders.

In the “quantum” workshops, this year dedicated to the 85th birthday of theorist Yakir Aharonov, leading experts addressed fundamental concepts and topics in quantum mechanics, such as continuous variables and relativistic quantum information measurement theory, collapse, time’s arrow,



The roundtable discussion, with panel members including former CERN director of research, Sergio Bertolucci (left), and two directors-general of major laboratories: John Womersley of the ESS (middle) and Victor Matveev of JINR (right).

entanglement and nonlocality.

In the exotic hadron workshop the nature of the exotic meson $X(3872)$ was discussed in considerable detail, especially with regard to its content: is it a mixture of a hadronic molecule and excited charmonium, or a diquark–antidiquark state? Detailed studies of the decay modes and p_T dependence of the production cross section in proton–proton collisions emerged as two most promising avenues for clarifying this issue. Following the recent LHCb discovery of

doubly-charmed χ_{cc} baryon, new results were reported including the prediction of a stable bbbud tetraquark and a quark-level analogue of nuclear fusion.

Presentations on the future low-energy heavy-ion accelerator centres, FAIR in Darmstadt and NICA at JINR in Dubna, showed that the projects are progressing on schedule for operation in the mid-2020s. Delegates were also treated to the role of non-commutative geometry as a way to unify gauge theories and gravity, self-interactions among right-handed neutrinos with masses in the warm-dark-matter regime, and the subtle physics behind sunsets and the aurora.

The conference ended with two-day workshops on supergravity and strings, and a workshop on the future of fundamental physics. Major future projects were presented, together with visionary talks about the future of accelerators and the challenges ahead in the interaction of fundamental physics and society. The conference also hosted a well-attended special session on physics education and outreach. The next ICNFP conference will take place on 4–12 July 2018 in Kolymbari, Crete.

• <https://indico.cern.ch/event/559774/>

VISITS



Italian minister for education, university and research, **Valeria Fedeli**, came to CERN on 18 December. After signing the guestbook she toured ATLAS and met with Italian staff at CERN.

Manuel Heitor, minister of science, technology and higher education of the Portuguese Republic, visited CERN on 15 December on the occasion of the symposium “25 Years of the LHC Experimental Programme”, during which he signed an administrative protocol between Portugal and CERN, represented by Director-General Fabiola Gianotti.



On 8 November, Czech minister for regional development **Karla Šlechtová** toured CERN's Synchrocyclotron, ATLAS experiment and LHC superconducting magnet test hall. She is photographed signing the guest book with management liaison Vladislav Benda (left) and Czech engineer David Belohrad.

On 17 November, **Wolfgang Bartscher**, deputy director-general for research and innovation at the European Commission (EC), visited CERN for the annual EC–CERN meeting, signing the guestbook with CERN Director-General Fabiola Gianotti.



Faces & Places

OBITUARIES

Lev Lipatov 1940–2017

On 4 September our friend and colleague Lev Nikolaevich Lipatov of the Russian Academy of Sciences (RAS) passed away unexpectedly while attending a physics meeting in Dubna. Lev grew up in Leningrad (now St. Petersburg) and entered the physics faculty at the Leningrad State University in 1957. In 1963 he joined the group of Vladimir Gribov at the Ioffe Physical-Technical Institute of RAS, defending his dissertation in 1968. He remained in Gribov's group when it moved to the Leningrad Nuclear Physics Institute in Gatchina in 1970 and obtained a permanent position. He became a professor of physics in 1990 and, since 1997, was the director of the theory division. In 1998 he also became a member of St. Petersburg State University, where he lectured, and in 2011 he was elected as a full member of the RAS.

Lev was a leading figure worldwide in the high-energy behaviour of quantum field theory. Supported by Gribov, he began to analyse the high-energy behaviour of QED processes and became involved in the investigation of the “double logarithms”. His main focus was first on the Regge limit (at the time, Regge theory had just started to become popular for analysing high-energy scattering processes), but the discovery of Bjorken scaling transferred his focus to the kinematic limit of deep inelastic scattering. It was after a seminar given by Gribov when Lev spotted a gap in the theoretical argument – leading to the famous “GL” paper, which later became a theoretical cornerstone of the DGLAP evolution equations. These are now an important pillar in the analysis of high-energy scattering processes at the LHC.

After the rise of non-abelian gauge theories in the early 1970s, it was again the Regge limit that attracted Lev's interest: together with his collaborators in 1975 he derived an integral equation which, after



Lipatov was an expert in the high-energy behaviour of quantum field theory.

applying it to QCD, became known as the “BFKL” equation. It took several years before this equation received international attention, but today the BFKL papers are among the publications with the highest numbers of citations in high-energy physics.

Lev's scientific work extends much further, however. He found a new approach for investigating large orders in perturbation theory, generalized the concept of partonic evolution equations beyond the leading-twist approximation and spent several years computing the NLO corrections to the BFKL equation. He discovered that the BFKL Hamiltonian (after generalizing to many-gluon states) is equivalent to an integrable Heisenberg spin model, thus demonstrating that the concept of integrability plays an important role in high-energy physics, and developed a new formulation in terms of a gauge-invariant “effective action”. In gravity he discovered the reggeization of the graviton and within the conjectured AdS/CFT duality he pointed out the need for correcting the BDS formula

using remainder functions, and worked on the duality of the BFKL pomeron with the graviton. Although Lev's work was purely theoretical, he never neglected experimental data: his last papers studied the application of the QCD BFKL equation to HERA data, thus gaining a deeper understanding of his “favourite child”, the BFKL pomeron.

Lev was well known in the high-energy physics community and was invited to give talks at countless international meetings and conferences. He set up numerous collaborations, paid several visits to CERN and, since the early 1990s, made regular visits to DESY. Lev received many national and international prizes and awards, including the research award of the Alexander von Humboldt Foundation in 1993, the Pomeranchuk Prize in 2001, the Marie Curie Excellence Chair of the European Community, hosted by Hamburg University in 2006–2009, and the European Physical Society High Energy and Particle Physics Prize in 2015. As well as his research in Russia, he set up collaborations in Germany, France, England, Spain, Israel and Chile.

Those who had the privilege to know Lev up close experienced a very friendly person whose interest and understanding in physics was extraordinary. In any situation he was ready and more than happy to discuss physics, and was enthusiastic about new ideas. Behind this, Lev was a loving husband to his wife Elvira and a caring father of his daughters Irina and Katja, and their families. Last but not least, he was very attached to his home city of Leningrad and to his home country of Russia.

Together with his numerous collaborators and friends, we deeply regret that Lev is no longer with us.

● *Jochen Bartels, on behalf of his collaborators and friends.*

John Smith 1938–2017

John Smith, an eminent theoretical particle physicist at the C. N. Yang Institute for Theoretical Physics (ITP) at Stony Brook University in the US, passed away on 16 July aged 79. John, who was known by everyone as “Jack”, was born in Selkirk, Scotland, and earned a BSc, MSc and PhD at the University of Edinburgh. During his graduate study, he spent a year at the Joint Institute for Nuclear Research (JINR) in Dubna, receiving his doctorate in 1963. He held postdoctoral

positions at Nordita as a NATO fellow and at the University of Adelaide as a Rothman fellow. In 1967 he joined the ITP as a research associate, becoming a key member of the faculty for more than three decades. Jack retired in 2007 but kept active in research as professor emeritus.

Jack made important contributions spanning a range of areas in particle physics, and a constant theme in his work was to perform calculations that could be compared

with data. Among his early works were papers on weak interactions, calculating predictions of various electroweak gauge theories for neutral-current reactions and using these in conjunction with new data to constrain the theories. In a 1983 paper he co-authored, Jack demonstrated the power of the Jacobean peak in determining the mass and width of the W boson – a method still in use today at the LHC. Over the ensuing years, Jack's often-legendary calculations



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Best 30u (Upgradeable)	30	Best 15 + ^{123}I , ^{111}In , $^{68}\text{Ge}/^{68}\text{Ga}$
Best 35	35–15	Greater production of Best 15, 20u/25 isotopes plus ^{201}Tl , $^{81}\text{Rb}/^{81}\text{Kr}$
Best 70	70–35	$^{82}\text{Sr}/^{82}\text{Rb}$, ^{123}I , ^{67}Cu , ^{81}Kr + research

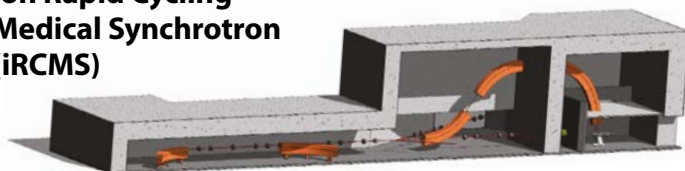


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Faces & Places

in perturbative QCD contributed mightily toward establishing the contemporary picture of fundamental interactions. These included several papers in 1989 and the early 1990s with various coauthors, in which calculations of the production of heavy quark–antiquark pairs in $p\bar{p}$ and pp collisions were presented. These provided valuable and timely input for the analysis of Fermilab data by the CDF and D0 collaborations that led to the discovery of the top quark in 1995.

In 2003, together with his colleagues Willy van Neerven and Vajravelu Ravindran, Jack published a landmark calculation of higher-order QCD corrections to the cross-section for Higgs-boson production in hadronic collisions. This work was valuable in the analysis of LHC by the ATLAS and CMS collaborations that led to the discovery of the Higgs boson in 2012. It was quite fitting that Jack was invited to attend the 2013 ceremony at which his doctoral advisor, Peter Higgs, received the Nobel Prize (shared with François Englert).

Jack was renowned for his modest and



Smith carried out landmark calculations in QCD.

gentle personality. He gave generously of his time to colleagues and students, and taught the full range of courses, from advanced quantum field theory to freshman physics. Students were very much aware of his expertise in research, his dedication to teaching and mentoring, and his kind nature. Jack served as the supervisor for many doctoral thesis students and as a mentor for a number of postdoctoral research associates at Stony

Brook. His excellent pedagogical skills were evident in the textbook *Field Theory and Particle Physics* (1986), and one of the last projects he worked on was the completion of a new textbook on quantum field theory.

Jack Smith's research accomplishments were recognised with a Humboldt Research Award and as a fellow of the American Physical Society. In the autumn of 1993 he held the visiting Kramers chair at Utrecht University, in 2005 he received the Stony Brook President's Award for Excellence in Scholarship and Creative Activities, and in October 2016 we were honoured when he was able to participate in a symposium celebrating the anniversary of the establishment of the ITP, in whose development he played such an important role.

We miss Jack greatly. He will always be remembered by his former students, postdocs, colleagues and co-authors, and, indeed, by all the people who knew him across the world.

● *Bernard de Wit, Rohini Godbole, Eric Laenen, Robert Shrock, George Sterman, and Jos Vermaseren.*

Maria Krawczyk 1946–2017

Maria Krawczyk passed away suddenly on 24 May 2017. It was a shock not only for her family but also for many of the physicists and her friends in the faculty of physics at the University of Warsaw and abroad. She was a very well-known and respected scientist within the physics community for her passion and involvement in research, teaching and outreach.

Maria graduated from the University of Warsaw, and her scientific career was intertwined with the university, first as an assistant, then adjunct university professor and full professor. In 1975 she defended her PhD thesis under the supervision of Grzegorz Białkowski based on studies of the charge exchange reaction $\pi^+ p \rightarrow \pi^0 n$. During a postdoc at the Max Planck Institute in Munich in 1977/78 her scientific interest shifted towards the parton model and quantum chromodynamics (QCD). She worked on the hadronic properties of photons within QCD, where her speculations on direct photon pair production in hard collisions were then verified by experiments. Later she worked on the resummation of higher order QCD corrections.

In 1990 Maria became interested in electroweak interactions, in particular the Brout–Englert–Higgs mechanism of spontaneous electroweak symmetry breaking and the Higgs sector. The Higgs particle became her main research direction,



Maria Krawczyk was a proponent of the International Linear Collider, in particular the photon–photon option.

including the two-Higgs-doublet models, searches for light Higgs particles in existing and planned accelerators, the CP properties of the scalar sector, the role of the Higgs in astrophysics and cosmology, and the structure of the vacuum. She was an enthusiast for studying photon collisions at a future linear collider, and took an active role in workshops devoted to the physics potential of future experiments. During a stay at CERN in 2002 she initiated discussions and studies of CP violation in non-standard Higgs models, becoming an organiser of the workshop on CP studies and non-standard Higgs physics – which culminated in the delivery of a CERN Yellow Report. With the advent of the LHC,

she concentrated mainly on LHC physics.

During her career, Maria collaborated with many distinguished physicists around the world and coordinated a number of scientific grants financed by Polish and European agencies – right up to her last project, HARMONIA. She served in a number of advisory committees and was involved in several international workshops and conferences. Maria served on the TESLA collaboration board, represented Poland in outreach within the European linear collider steering group, and in 2004 was invited to join the programme committee of the Rencontres de Moriond series of conferences on QCD.

Maria enjoyed contact with students. She was concerned not only with their scientific development but also their living conditions, and helped in sending them to physics schools and conferences, finding grant opportunities and editing grant applications. She was very active in daily matters at the faculty and university, and engaged heavily in outreach activities, giving radio and TV interviews, lecturing at scientific festivals and organising LHC exhibitions.

Maria was a very kind and helpful person. Her advice, including in private matters, and friendliness will be greatly missed. She was also a beloved wife, a mother of two children and grandmother of four grandchildren.

● *Colleagues and friends from the University of Warsaw.*

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