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ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
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RESTRICTED COUNCIL
227th Session
22 May 2026

COUNCIL RESOLUTION
ON
THE 2026 UPDATE OF THE EUROPEAN STRATEGY FOR PARTICLE PHYSICS

Council Resolution

on

the 2026 Update of the European Strategy for Particle Physics

THE COUNCIL,

WITH REGARD TO

(1) the CERN Convention, dated 1 July 1953 as amended on 17 January 1971, in particular its Article II.2 (b), according to which Organization's mission includes the organisation and sponsoring of international cooperation in nuclear (particle physics) research inside and outside the Laboratory;

(2) Rule 12 c) of the Rules of Procedure of the CERN Council (CERN/3388/Rev.4), pursuant to which decisions of major importance for the Organization can be taken in the form of a Resolution;

CONSIDERING

(3) its declared intention in 2003 "*to develop, in the framework of the CERN Convention, the Organization's coordinating role in the definition of European policy in the domain of particle physics*" (CERN/2538/Rev., Annex 4);

(4) that, in 2006, it approved the first European Strategy for Particle Physics, through which it acknowledged that the increased globalisation and scale of particle physics make a well-coordinated strategy in Europe paramount and decided that, under Article II.2 (b) of the CERN Convention, and acting as a council for European particle physics, it would hitherto define and update the Strategy based on proposals and observations from a dedicated scientific body that it would establish for this purpose (CERN-Council- S 002);

(5) the dedicated procedural framework for the periodic updates of the European Strategy for Particle Physics that it introduced in 2007/2008 (CERN/2732/Rev. and CERN/2779) and confirmed in 2013 (CERN/3092/RA/Rev.) and 2018 (CERN/3092/Rev.2 and CERN/3092/Rev.3), pursuant to which, *inter alia*, the European Strategy Group (ESG) was established as an intermittent Council working group mandated to periodically elaborate Strategy update proposals, based on input from the scientific community, for the Council's approval;

(6) that, on this basis, in May 2013 it approved the first update of the European Strategy for Particle Physics, as elaborated by the ESG, and explicitly confirmed that Strategy updates should continue to be undertaken according to the aforementioned procedure (CERN-Council-S/106);

(7) that thereafter, in June 2020, it decided to "*update the European Strategy for Particle Physics, proposed by the ESG …, as the scientific vision of the particle physics community in Europe*" and invited the CERN Management to use this update "*as input for its Medium-Term Plan and as the basis for developing a vision and a long-term plan for the Laboratory within the financial constraints of its constant budget whilst*

exploring additional funding sources" and "*to provide annual reports on the implementation of the high-priority recommendations of the Strategy update, including the results of the feasibility study for a future circular collider as well as accelerator R&D activities targeting other options, so that the Council [could] decide, based on the progress made, when the time is best suited to initiate the next Strategy update*" (CERN/3493/Rev.);

(8) its decision in November 2025 on the outcome of the Future Circular Collider [(FCC)] Feasibility Study in which it concluded "*the FCC Feasibility Study provides the basis for the FCC studies to continue and ... the funding scenarios presented and the financial pledges obtained so far provide the basis for the continuation of the work towards securing the full financial commitments required for approval of the FCC project*" and "*reaffirm[ed] its aim to reach a final decision relating to the possible implementation of the FCC project possibly in 2028*" (CERN/3947/Rev.)

CONSIDERING FURTHER THAT

(9) in March 2024, the Council approved the timeline for the next update of the European Strategy for Particle Physics, with a view to updating the Strategy by June 2026, as well as proposed amendments to the composition of the ESG (CERN/3802/RA);

(10) in June 2024, it appointed the Strategy Secretary and established the ESG Secretariat (CERN/3837/C), and approved the remit of the ESG (CERN/3834/Rev.2) which was "*to develop an update of the European Strategy for Particle Physics and submit it for approval by the Council*", with the aim of the Strategy update being "*to develop a visionary and concrete plan that greatly advances human knowledge in fundamental physics, in particular through the realisation of a next collider at CERN*", specifying that such plan "*should attract and value international collaboration and should allow Europe to continue to play a leading role in the field*";

(11) in so doing, it recalled that the ESG should take into consideration "*the input of the particle physics community[,] the status of implementation of the 2020 Strategy update[,] the accomplishments over recent years, including the results from the LHC and other experiments and facilities worldwide, the progress in the construction of the High-Luminosity LHC[,] the outcome of the Future Circular Collider Feasibility Study, and recent technological developments in accelerator, detector and computing[, and,] the international landscape of the field*";

(12) it indicated that the "*Strategy update should include the preferred option for the next collider at CERN and prioritised alternative options to be pursued if the chosen preferred plan turns out not to be feasible or competitive*" and "*should also indicate areas of priority for exploration complementary to colliders and for other experiments to be considered at CERN and at other laboratories in Europe, as well as for participation in projects outside Europe*";

(13) it determined that the ESG "*should review and update the Strategy and add other items identified as relevant to the field, including accelerator, detector and computing R&D, the theory frontier, actions to minimise the environmental impact and to improve the sustainability of accelerator-based particle physics, the strategy and initiatives to attract, train and retain the young generations, public engagement and outreach*";

(14) thereafter, on the basis of an in-depth, scrutinised analysis of the input submitted by the scientific community, the ESG drew up its proposal for the Strategy update;

ACKNOWLEDGING

(15) the extensive coordination, evaluation and consensus-building that led to this proposal, which is an essential contribution to the future of particle physics and a coherent vision for particle physics in Europe and, as such, provides valuable guidelines to all stakeholders;

(16) that this Strategy update proposal is a scientific vision and, as such, does not constitute a research policy or funding decision on the part of the Member States;

(17) that its implementation requires further decision-making by the stakeholders concerned; and

(18) that, as far as CERN is concerned, any implementation of the projects recommended in the Strategy update requires separate decisions by the Council, in line with the procedures set out in the Convention and the Organization's Financial Rules and Regulations;

DECIDES

(19) to update the European Strategy for Particle Physics, proposed by the ESG and set out in Annex 1, as the scientific vision of the particle physics community in Europe;

AND INVITES THE CERN MANAGEMENT

(20) to use the Strategy update as input for its Medium-Term Plan and the ongoing studies towards the FCC-ee as the possible next flagship project at CERN;

(21) to initiate discussions with the relevant authorities and entities in the Member and Associate Member States, as well as non-Member States and the European Union, with a view to obtaining pledges of additional cash and/or in-kind contributions to the cost of constructing and operating the FCC-ee, and, on this basis, to develop a financially feasible funding plan for the possible FCC-ee project;

(22) to provide annual reports on the implementation of the Strategy update and the necessary information to support national decision-making processes; and

(23) to make every effort to ensure that the Council is in a position by 2028 to take a decision on the FCC-ee, taking into account elements such as the scientific, technical and financial feasibility of the project.

ANNEX

THE EUROPEAN STRATEGY FOR PARTICLE PHYSICS: 2026 UPDATE

RECOMMENDATIONS BY THE EUROPEAN STRATEGY GROUP

European Strategy for Particle Physics

_Contents

Preamble 5

1. Major developments since the 2020 Strategy 6

2. General considerations for the 2026 update 7

3. The next CERN flagship collider project 8

4. Other research directions in particle physics 10

5. Theory 11

6. Technologies 12

7. Project implementation, cooperation with large physics laboratories in Europe 15

8. Synergies with neighbouring fields 16

9. Sustainability and environmental impact 17

10. Public engagement, education, communication, social and career aspects 18

Preamble

Particle physics explores the fundamental constituents of matter and the forces acting between them. The development of technologies to probe ever-smaller distance scales through exploration at higher energies and higher-precision measurements has led to extra¬ordinary discoveries that have revolutionised our understanding of the physical laws that govern the Universe. The observation of the Higgs boson represented a giant leap forward. Despite the enormous progress, many deep mysteries remain, such as the nature of dark matter, the preponderance of matter over antimatter and the observed pattern of masses of the fundamental particles. These profound questions provide a compelling argument for further exploration and addressing them requires a variety of approaches. High-energy colliders remain the only way to directly explore the Higgs boson, which may hold the key to understanding some of these questions.

Given the unique nature of the Higgs boson, a compelling scientific case was made at the 2020 update of the European Strategy for Particle Physics for a new electron–positron collider operating as a Higgs factory, followed by further exploration using a proton–proton collider at the highest achievable energy. In response, the CERN Council launched a study to investigate the feasibility of a Future Circular Collider (FCC) with an electron–positron Higgs and electroweak factory as a possible first stage. This study was successfully completed in 2025.

Over the past decade, experiments at the Large Hadron Collider (LHC) have made great strides in measuring properties of the Higgs boson and in exploring particle interactions at the TeV energy scale.

With its upcoming high-luminosity phase, the LHC will remain the world's primary instrument for exploring the high-energy frontier, with data taking scheduled until the early 2040s. To address the outstanding questions of particle physics beyond the reach of the High-Luminosity LHC (HL-LHC), significant advances in both precision and energy will be required.

The remit given by the CERN Council to the European Strategy Group (ESG) for this update of the Strategy is to develop a concrete plan for greatly advancing knowledge in fundamental physics through the construction of a new flagship project at CERN. This plan should attract and value international collaboration and should allow Europe to continue to play a leading role in the field.

1

Major developments since the 2020 Strategy

Following the successful installation and commissioning of the first phase of the detector upgrades of the experiments, the LHC entered its third data-taking period in 2022 with proton–proton and heavy-ion collisions. The accelerator, the experiments and the distributed computing infrastructure have performed outstandingly, with the total physics data set having more than doubled. Based on this increased data set and thanks to the development of innovative experimental techniques and theory advances, the LHC experiments have produced a wealth of remarkable physics results.

The LHC will shut down in 2026 to commence the installation of new components for the HL-LHC, including magnet systems based on technology that was not available when the LHC was built. In parallel, the activities of the detector upgrade programmes for the high-luminosity operation of the LHC have made good progress. The HL-LHC will ultimately deliver over a factor of five more data than the LHC, providing a leap forward in precision and new physics discovery potential.
The HL-LHC is planned to operate from 2030 to 2041. The completion of the HL-LHC programme according to the current schedule will be critical for the timely implementation of the next flagship collider project.

The successful completion of the FCC Feasibility Study at CERN, recommended in the 2020 Strategy update, constitutes another major achievement. A coherent baseline design for the FCC programme, including a well-advanced territorial implementation scenario, has been elaborated. The technical feasibility of electron–positron collisions in the FCC has been demonstrated and plausible funding scenarios have been developed.

Substantial progress has also been made in non-collider physics. Experiments at CERN and other European institutes have also significantly contributed to the important diversity of the particle physics programme. The global neutrino programme has made significant advances towards the determination of neutrino masses and leptonic mixing, and the construction of the next generation of accelerator-based neutrino experiments is progressing rapidly. The CERN Neutrino Platform is a focal point of European participation in the global long-baseline neutrino programme. In particular, the current commitments to the LBNF/DUNE project have been decisive and remain a priority for CERN.

Major progress has been made in improving the sustainability of particle physics research infrastructures and mitigating their impact on the environment. Examples include energy reuse and research and development on more environmentally friendly cooling systems and detector gases.

2

General considerations for the 2026 update

Europe's leadership in accelerator-based particle physics and related technologies is anchored in CERN. The future of the field, in Europe and beyond, relies on CERN and the particle physics community at universities and research centres continuing to carry out impactful scientific projects.

A. The full exploitation of the physics potential of the LHC and the HL-LHC and the completion of the high-luminosity upgrade remain the highest priorities of European particle physics. Every effort must be made to complete the HL-LHC upgrade within the current schedule.

According to the remit given by the CERN Council, the aim of the 2026 update of the European Strategy for Particle Physics is to develop a visionary and concrete plan that greatly advances human knowledge in fundamental physics through the realisation of the next flagship project at CERN, which will attract and value international collaboration and will allow Europe to continue to play a leading role in the field. The Strategy update should include the preferred option for the next collider at CERN and prioritised alternative options to be pursued if the preferred option turns out not to be feasible or competitive.
It should also indicate areas of priority for exploration complementary to colliders and for other experiments to be considered at CERN and at other laboratories in Europe, as well as for participation in projects outside Europe.

The current collaboration model between CERN and the national institutes, laboratories and universities in its Member and Associate Member States is essential for the future enduring success of the field. The extensive participation of non-Member State institutions in the CERN programme and their important contributions demonstrate the success of this model.

B. The unique ecosystem of particle physics research centres and universities in Europe should be further strengthened in order to address the objectives set out in this Strategy.

The broad range of fundamental questions in particle physics, the complexity of the diverse facilities required to address them and the need for efficient use of resources have resulted in the emergence of a worldwide particle physics community with common interests and goals. The 2026 European Strategy for Particle Physics takes into account the rich and complementary physics programmes being undertaken by Europe's partners across the world and the scientific and technological developments in neighbouring fields and industry.

C. The implementation of the Strategy should be pursued in strong collaboration with global partners and neighbouring fields.

The particle physics community and the European Commission have a strong record of collaboration.

D. The relationship between the particle physics community and the European Commission should be further strengthened, exploring funding opportunities for the realisation of infrastructure projects and R&D programmes in cooperation with other fields of science and industry.

3 The next CERN flagship collider project

A. The electron–positron Future Circular Collider (FCC-ee) is recommended as the preferred option for the next flagship collider at CERN.

The FCC-ee would deliver the world's broadest high-precision particle physics programme, with an outstanding discovery potential through the Higgs, electroweak, flavour and top-quark sectors, as well as advances in quantum chromodynamics (QCD). Its technical feasibility is demonstrated by the comprehensive FCC Feasibility Study, its scope and cost are well defined, plausible funding scenarios have been developed and its schedule enables first beams within five to seven years after the end of HL-LHC operations. The FCC-ee would maintain European leadership in high-energy particle physics, as well as advancing technology and providing significant societal benefits.

The FCC-ee would also pave the way towards a hadron collider reusing the tunnel and much of the infrastructure, providing direct discovery reach well beyond the 10 TeV parton energy scale, in line with the community's ambition for exploration at the highest achievable energy. The overwhelming endorsement of the FCC-ee by the particle physics communities of CERN's Member and Associate Member States further reinforces it as the preferred path.

B. A descoped FCC-ee is the preferred alternative option for the next flagship collider at CERN.

Descoping scenarios include removing the top-quark run, constructing two rather than four interaction regions and experiments and decreasing the radiofrequency (RF) system power. These measures would reduce the construction cost by approximately 15%. Although this would have a significant impact on the breadth of the physics programme and the precision achieved, the descoped FCC-ee would still provide a very strong physics programme and a viable path towards high energies, compared to the alternative collider options. Should additional resources become available, these descoping scenarios would be reversible.

Several other alternative options, listed here in alphabetical order, were also assessed. They offer substantially reduced precision physics programmes and would not be competitive with a collider like the FCC-ee. Moreover, in themselves, they currently lack a viable path towards energies of 10 TeV. At this stage, without knowing the reasons for which the FCC-ee would not be feasible, the other alternative options are not ranked.

CLIC and LCF, linear colliders operating at two energies and up to 550 GeV, would offer competitive programmes in Higgs and top-quark physics. Compared to circular colliders, they have significantly lower luminosities at lower energies, leading to limited precision in electroweak physics and non-competitive flavour physics programmes. The overall physics reach is thus less than that of the FCC-ee. Both colliders require a tunnel of up to a third of the length of that of the FCC-ee to reach their ultimate energies of 1.5 TeV and 550 GeV, respectively. The path towards 10 TeV collisions would require plasma wakefield acceleration, which is not yet proven to be a viable technology.

CLIC would initially operate at 380 GeV. The construction cost of the 550 GeV collider is estimated to be about 60% of that of the FCC-ee, whereas the full cost of the 1.5 TeV collider would be at the same level as that of the FCC-ee. The technology of CLIC is well developed but less mature than that of LCF.

LCF would initially operate at 250 GeV and could be extended up to 550 GeV. The construction cost of the 550 GeV collider would be at the same level as that of the FCC-ee. The technology of LCF is mature.

LEP3 and LHeC are colliders that would reuse the LHC tunnel, offering an intermediate physics programme at significantly lower construction costs than the other options. Neither, on its own, would be a flagship collider. To provide a long-term physics programme, they would need to be complemented by an energy-frontier machine, such as a hadron collider.

LEP3, an electron–positron collider operating at energies up to 230 GeV, would offer improvements in Higgs physics with respect to the HL-LHC, strong electroweak and flavour physics programmes, but no top-quark run.

LHeC, an electron–proton collider that would combine an energy recovery linear electron accelerator with the LHC, would offer a strong QCD programme and significantly extended knowledge of proton structure. Although it would also offer some improvements in Higgs physics with respect to the HL-LHC, its overall precision physics programme is limited.

In conclusion, the preferred next flagship collider for CERN is the FCC-ee, which offers an outstanding physics programme.

4 Other research directions in particle physics

The exploration of the neutrino sector, searches for dark sector particles, precision measurements in the flavour sector and tests of fundamental symmetries are crucial elements of particle physics. Major progress in these areas is expected in the next decade with the realisation of a broad programme of experiments from small to large scales, involving accelerator-based facilities, underground laboratories and other dedicated infrastructures, as well as a significant theoretical effort.

The origin of neutrino masses is one of the most important open questions in particle physics. The long-baseline experiments DUNE and Hyper-K, along with other neutrino experiments, will be key to determining the neutrino parameters. Searches for rare processes such as proton decay and neutrinoless double-beta decay could provide evidence for new physics at very high energy scales, while studies of neutrino interactions further expand the opportunities for discovery. Improving laboratory measurements of the absolute neutrino mass scale is increasingly important in the era of high-precision cosmology. Indirect evidence for dark matter is a long-standing indication of physics beyond the Standard Model. Dark matter could manifest itself in different ways, putting a premium on diversity in the searches. Particle physics searches comprise both accelerator and non-accelerator experiments with low-background detectors utilising a range of novel technologies. The complex of excellent underground laboratories in Europe is a key foundation of this endeavour.

European competitiveness in searches for dark matter and neutrinoless double-beta decay critically depends on the availability of rare and specialised materials. It is important that Europe develops its sovereign capability to produce such materials.

A. European contributions to both accelerator-based and non-accelerator neutrino and dark matter experiments are essential and should be supported.

B. CERN should continue to provide support to the global long-baseline neutrino programme via the Neutrino Platform. The collaboration between CERN and non-accelerator-based experiments on technologies of mutual benefit should be continued.

Tests of fundamental symmetries provide uniquely sensitive probes of possible new dynamics, complementary to high-energy colliders. High-precision measurements of Standard Model predictions and searches for electric dipole moments and for processes forbidden in the Standard Model have profound implications. These are performed both in university laboratories and in accelerator-based experiments. European particle physics laboratories offer unique and world-leading opportunities for experiments with neutrons, pions, kaons, muons, antiprotons and radioactive isotopes, providing a fertile environment for such efforts.

C. The ecosystem of European particle physics laboratories should continue to support a broad, diverse spectrum of key precision experiments in particle physics.

5 Theory

Theoretical physics is an essential pillar of particle physics, providing the conceptual frameworks, models and computational tools needed to interpret data, uncover new phenomena and guide future experiments.

A. Europe should maintain a strong and diverse particle theory landscape, from formal to phenomenological aspects, while further strengthening and leveraging connections to neighbouring fields.

The coming decades will be marked by the HL-LHC programme and the beginning of a new flagship facility at CERN. The success of these endeavours crucially depends on achieving theoretical predictions at an unprecedented level of precision. This relies on close interaction in collider phenomenology between theory and experiment. Collaborative efforts in perturbative quantum field theory and lattice QCD calculations, along with the development of theoretical tools for experimental analyses, will be essential.

B. Collaborative efforts to improve the precision of theoretical predictions should be recognised and supported. Europe is world-leading in these areas and should strive to remain so by attracting, fostering and retaining early-career global talent. CERN should continue to be an integral part of all these efforts.

6 Technologies

The science and technologies underpinning the areas of accelerators, detectors and computing, and related infrastructures, provide the foundation to address the key questions of particle physics. They are deeply embedded in the international particle physics community and are essential for the success of current and future projects. They have many synergies with other fields of science and industry and also enable applications of significant societal benefit in areas such as medicine, industry, security and fusion energy.

A. To ensure that Europe remains at the forefront of technologies for particle physics, R&D in collaboration with international partners and industry must continue to be supported with high priority, thereby enhancing sustainability and societal impact.

Accelerator science and technology

Advanced accelerators rely on detailed beam physics models, powerful simulations and key technologies such as high-field magnets, high-gradient normal-conducting and superconducting RF accelerating systems, high-gradient plasma-wakefield acceleration, bright muon beams and energy recovery linacs (ERLs). Several technology approaches directly address the requirement of greater sustainability for future accelerator-based facilities. These include superconducting magnets and resonators operated at higher cryogenic temperature, superconducting current links, use of permanent magnets, and more efficient RF power sources, complemented by a more extensive use of robotics and artificial intelligence.

B. In order to realise the visionary plan presented, the highest priority must be the development and industrialisation of key technologies: advanced superconducting and normal-conducting RF structures, efficient RF power sources and accelerator-quality magnets in the 14–20 T range, including those based on high-temperature superconductors.

C. Demonstration of high-current multi-turn energy recovery in linacs constitutes an important step towards power-efficient lepton accelerators for a broad range of applications and should be pursued.

D. The longer-term development of advanced technologies, such as high-gradient wakefield acceleration and those underpinning bright muon beams, should be supported at an appropriate level. Synergies with the US initiative on muon collider R&D should be exploited.

Detector development

Detector R&D is essential for realising future experimental research programmes. This effort is strengthened by the Detector R&D (DRD) collaborations, which have recently been established in accordance with the ECFA Detector R&D Roadmap as a result of the 2020 Strategy update. The roadmap outlined ten General Strategic Recommendations, including sustainable support of R&D facilities, such as test beam and irradiation centres, promoting distributed R&D activities and open science, maintaining engineering support and investing in blue-sky R&D.

E. For the DRD collaborations to address the requirements of future flagship projects, they must receive adequate funding. New R&D topics and initiatives should be integrated in the DRD scheme. The General Strategic Recommendations in the roadmap must be fully addressed by dedicated initiatives coordinated across the DRD collaborations.

F. A coherent, strategic approach and sufficient resources to support close cooperation with industry are required to address the rising costs and growing complexity in engineering, particularly in microelectronics.

G. To enhance efficiency and align developments with global technology trends in other fields, standardised, off-the-shelf solutions should be prioritised over custom designs, where applicable.

Computing

Computing for particle physics has far surpassed its initial design, enabling powerful workflows and major resource reductions through sustained technological and human investment. Computing needs can be modelled 50 years ahead, yet future challenges cannot be met by scaling alone, given the economic constraints. As particle physics and related fields become more complex and global initiatives expand, collaboration among them is essential for their enduring success.

The main areas of R&D are the optimal use of graphics processing units (GPUs), field-programmable gate arrays (FPGAs), artificial intelligence (AI) and emerging technologies such as quantum computing.

The sustained operation of the successful Worldwide LHC Computing Grid (WLCG) will be key for the HL-LHC and future experiments. The WLCG needs to adapt to evolving technologies and, at the same time, ensure synergies with similar global initiatives.

H. Adequate and sustained support for and coordination of software and computing must be provided to achieve the goals of future particle physics projects, starting with the HL-LHC. Planning of future projects should include software and computing from the outset, addressing energy efficiency and sustainability.

I. In order to address theoretical and experimental needs, such as those in lattice QCD, data-intensive workflows through WLCG and long-term data preservation and reinterpretation, the particle physics community should further engage with and help shape the evolution of EuroHPC, AI factories and other global initiatives.

AI is a transformative technology that already plays a crucial role in particle physics, which in turn is contributing to the evolution of AI with its specific competencies.

J. The European particle physics community must further intensify its activities in AI and sustain them with adequate resources. A roadmap, coordinated among CERN and national laboratories, institutes and universities, should be developed to prioritise AI activities, taking into account synergies with international partners and other communities.

Knowledge and Technology Transfer

Technologies developed in particle physics have significant potential for applications with a high impact on society. Conversely, particle physics benefits from both disruptive and incremental developments in other fields of science and industry (bidirectional knowledge and technology transfer, KTT).

In order to foster a joint KTT culture, it is important to increase awareness of KTT methods and instruments in education, training and research. KTT is the responsibility of all parties contributing to particle physics and needs to be recognised.

CERN, research institutes and universities have developed infrastructure, instruments and networks to support KTT at many levels; these provide a solid basis for KTT in particle physics. KTT solutions need to be further adapted, developed and documented to serve the needs of particle physics projects. The field would profit from a central repository of existing KTT solutions, best practice examples, metrics and studies.

K. The particle physics community should reinforce KTT as a pillar of basic research that enables its impact on society. Concepts and implementations for bidirectional KTT should be an integral part of all particle physics projects, including R&D collaborations.

7 Project implementation, cooperation with large particle physics laboratories in Europe

To optimise the implementation of the Strategy, collaboration between CERN and other particle physics laboratories (PPLs) is essential. The skilled workforce within the PPLs can deliver cost-effective contributions, often leveraging CERN support to secure national resources. The PPLs' activities on technological developments nurture cross-disciplinary synergies, maximising Europe's impact.

A. The next flagship collider at CERN should be developed under CERN's leadership, with coordinated in-kind contributions from the PPLs. Collaboration between CERN and PPLs should be strengthened for strategic technology developments.

A broad exploration, building on the success of CERN's Physics Beyond Colliders initiative, is required to develop a shared European vision that supports scientific diversity in particle physics, promoting the sharing of technologies, infrastructures and expertise.

B. The Large Particle Physics Laboratory Directors Group (LDG) should explore the possibility for a new initiative to enable and strengthen the implementation and promotion of scientific diversity in particle physics with a shared European vision.

The LDG should initially conduct a community-wide survey on existing facilities, projects and staff capabilities in Europe. The survey should cover particle physics research in Europe beyond the CERN flagship collider, also including activities at the PPLs in neighbouring fields that support the implementation of the particle physics strategy.

Europe pursues leading accelerator R&D focused on developing technologies for next-generation particle physics accelerators.

C. The LDG must continue the coordination of the Accelerator R&D Roadmap by integrating strategic priorities, enhancing collaboration across PPLs and CERN, and by optimising usage of laboratory resources. In addition, R&D efforts to enhance the sustainability and energy efficiency of accelerators from design to operation and decommissioning should be supported.

8 Synergies with neighbouring fields

Valuable synergies exist between particle physics and the neighbouring fields of nuclear and astroparticle physics.

Many research avenues in nuclear physics are important for particle physics and often cross the border into high-energy physics. Heavy-ion collisions provide unique information, essential for understanding strong interactions under extreme conditions. Neutrino experiments require thorough understanding of nuclear effects. There is significant potential for advancing research on fundamental symmetries and physics beyond the Standard Model through highly sensitive nuclear physics experiments.

Astroparticle physics and cosmology are key partners of particle physics in the exploration of fundamental physics. Multi-messenger astronomy, with coordinated observations of photons, cosmic rays, neutrinos and gravitational waves, provides a comprehensive view of the Universe and its evolution. Gravitational waves also provide valuable information on neutron stars. The next generation of instruments, ranging from large-scale neutrino telescopes to cosmic microwave background and gravitational-wave observatories, will yield a wealth of results, with potential for major advances in particle physics, including the determination of neutrino masses, tests of fundamental symmetries, indirect observation of dark matter or other relic particles and the nature of dark energy.

Strengthened collaboration across particle physics, nuclear physics, astrophysics and cosmology, supported by shared technology development and theoretical interpretation, will be key to unlocking the full potential of these endeavours. European laboratories have been at the cutting edge of the corresponding research. Europe should continue to provide strong support for these activities, with CERN playing a central role.

CERN operates a vibrant experimental research programme in nuclear physics. Data from CERN experiments play a vital role in interpreting cosmic observations. CERN also provides support for astroparticle physics initiatives through the recognised experiments programme, as well as through the EuCAPT initiative for theory.

A. The European particle physics community, in coordination with APPEC and NuPECC, should maintain its scientific diversity via strong collaboration with nuclear and astroparticle laboratories and research infrastructures in Europe and beyond, including the Einstein Telescope in Europe and the Electron–Ion Collider in the US.

B. CERN should continue its involvement in experimental nuclear physics and astroparticle physics at the current level. Consideration of additional experimental activities outside of CERN's accelerator-based particle physics programmes should be subject to adequate resources being available for CERN's primary mission.

9 Sustainability and environmental impact

Environmental considerations, in particular those relating to climate change, are driving the community's efforts to reduce the environmental impact of particle physics research and to develop sustainable solutions, which may also benefit society. Assessing and mitigating environmental impact is important at all levels: institutional, project and individual.

Energy consumption and emissions must be minimised when realising and operating facilities and projects. This requires the implementation of sustainability strategies, many of which can be coordinated among particle physics laboratories, environment protection, preservation of local biodiversity, energy reuse and climate-change resilience.

A. For new proposed projects, a detailed life cycle assessment should be carried out at each stage, from concept to design and implementation, in order to quantify and minimise environmental impact.

B. The particle physics community should continue and intensify its efforts to develop and adopt sustainable solutions.

Communication and collaboration are at the core of the scientific life and productivity of the particle physics community, but must be balanced against the environmental consequences.

C. An effective balance between in-person and online meetings should be considered in order to mitigate the environmental impact of carbon-intensive travel.

10

Public engagement, education, communication, social and career aspects

Inclusive education, communication and engagement are essential to strengthen public trust in science and its methodologies, foster critical thinking and counter misinformation. These activities are also vital to inspire future generations to pursue careers in particle physics and to reinforce public interest. The European Particle Physics Communication Network (EPPCN), the International Particle Physics Outreach Group (IPPOG) and the Teacher and Student Forum have been instrumental to these ends.

A. Education, communication and engagement in particle physics should target a broad range of stakeholders, with a dedicated effort to reach diverse and underrepresented audiences.

Such activities should highlight the societal and economic benefits of future colliders and the technological innovations developed to enhance their sustainability, as well as the value of inclusive international collaboration.

B. The many education, communication and outreach initiatives in the various European national communities, EPPCN, IPPOG and the Teacher and Student Forum should be further encouraged, integrated and supported by European institutions and CERN.

For the future of the field it is necessary to train the next generation of accelerator, computing and detector instrumentation scientists, engineers and technical staff. It is also important to ensure that experts in these areas are retained throughout the long durations of particle physics projects.

C. Dedicated European training programmes in accelerator science, computing and detector instrumentation, including sustainability aspects as well as first-hand exposure to the latest technologies, should be further developed at the master and doctoral levels. The existing international schools in these areas should be strengthened to offer an expanded, coherent training programme.

D. The community should actively promote the creation of long-term positions for engineers and technicians, as well as physicists with technological expertise in accelerators, detectors and computing. Two-way transfer of knowledge via mobility between industry and academia should also be encouraged.

Addressing the fundamental questions of particle physics and, in particular, the work towards the next flagship collider project and experiments at CERN, requires attracting and retaining the brightest young talents. This calls for a supportive, respectful and motivating work environment for early-career researchers.

E. The particle physics community should continue its unwavering commitment to place the principles of equity, diversity and inclusion (EDI) at the heart of all its activities.

This requires institutions to provide sustained support for EDI programmes and dedicated offices and to enable the participation of members of the community with diverse abilities.

F. Current efforts for mentoring, easing mobility across institutions and promoting well-being of early-career researchers should be reinforced. In addition to scientific achievements, career evaluation should also consider technological, outreach and knowledge transfer activities.

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