European Strategy for Particle Physics: 2026 Update

- Process, Status and Next Steps -

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- Chair of the Strategy Secretariat -

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The European Strategy for Particle Physics

- *The **European Strategy for Particle Physics** is a cornerstone of Europe's decision-making process for the long-term future of the field.*
- *Mandated by the CERN Council, the Strategy is formed through a broad consultation of the particle physics communities in the CERN Member and Associate Member States, and beyond.*
- *In the Strategy process recommendations are developed which will be submitted to the CERN Council for an update of the Strategy.*

The European Strategy for Particle Physics is not a project approval process. Projects are approved by the CERN Council through a separate decision process, taking the Strategy recommendations into account.

Original Strategy (2006):	LHC, mooting of luminosity upgrade of LHC, R&D in accelerator technologies, coordination with a potential ILC project
1st Update (2013):	High Luminosity LHC, need for a post-LHC programme
2nd Update (2020):	FCC feasibility study
3rd Update (2026):	→ recommendation for the next large-scale accelerator project at CERN (reach consensus on the preferred option and possible alternatives)

Remit of the European Strategy Group (ESG)

- *The aim of the Strategy update should be 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**. This plan should attract and value **international collaboration** and should **allow Europe to continue to play a leading role in the field."***

- The ESG should take into consideration:
  - Input of the particle physics community;
  - Status of implementation of the 2020 Strategy update;
  - Accomplishments over recent years

    (Results from the LHC and other experiments and facilities worldwide, progress in the construction of the High-Luminosity LHC, outcome of the FCC Feasibility Study, recent technological developments in accelerator, detector and computing areas)
  - International landscape of 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 chosen preferred plan turns out not to be feasible or competitive.*

- *The Strategy update 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.*

Timeline for the update of the European Strategy for Particle Physics

More details on ESPP web page: https://europeanstrategyupdate.web.cern.ch/

Input received

- 263 contributions received by 31 March,
  + 3 new contributions + updates by 26 *May*:

- Major flagship projects

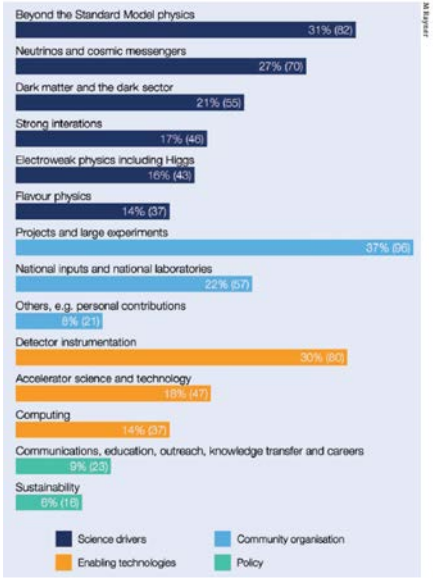
- Many projects in other physics areas

- Input from national HEP communities in ECFA countries and beyond

- Input from National European Labs (e.g. DESY, Frascati, …)

- Input from Early Career Researchers (via ECFA ECR panel)

- Input from APPEC, NuPECC, ..



Self-attributed themes of the 263 community inputs

- All contributions are public: https://indico.cern.ch/event/1439855/contributions/

  Alphabetical list: https://europeanstrategyupdate.web.cern.ch/sites/default/files/Submitted_Input_2025.03.04.pdf

- These submissions have been analysed by the Physics Preparatory Group (PPG) and ESG working groups;
  They provided the input for the presentations and discussions at the Open Symposium in Venice

The vision by CERN Council

*"The aim of the Strategy update should be 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**. This plan should attract and value **international collaboration** and should **allow Europe to continue to play a leading role in the field.**"*

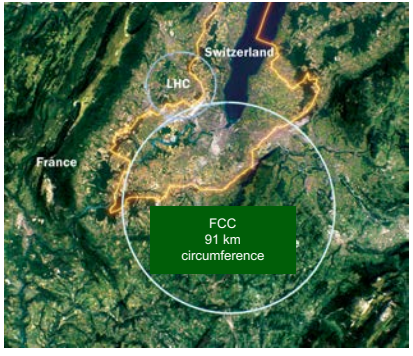
This vision is strongly echoed by the High-Energy Physics communities in Europe and beyond, as testified by the input received from the **national HEP communities**

Many HEP communities support a forward-looking European strategy that **maintains CERN as the global centre for collider physics** and ensures a balanced, ambitious, and innovative research programme.

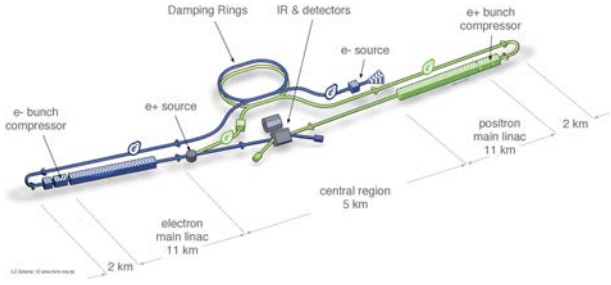
Proposed large-scale projects at CERN, ~ 2045

e^+e^- colliders
("Higgs factories")

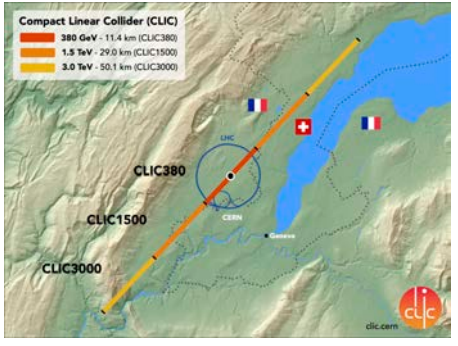
FCC-ee (e^+e^-, circular, 91 – 365 GeV)



LCF (e^+e^-, linear, 91 – 240, 550 GeV)



CLIC (e^+e^-, linear, 380 GeV, 1.5 TeV)

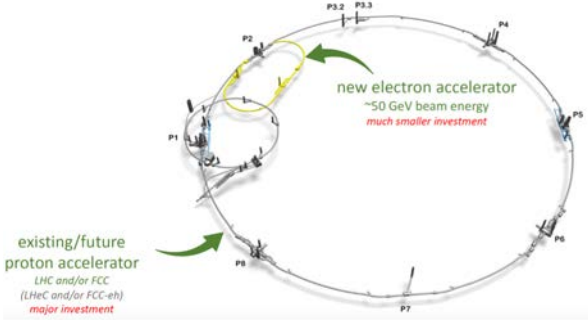


Intermediate projects

(Leave room (time, budget, resources) for further development of THE machine that can probe directly the energy frontier at the 10 TeV parton scale)

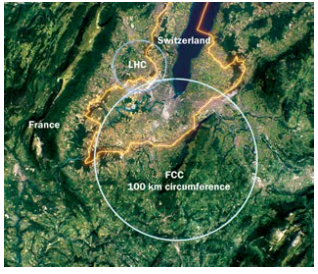
LEP3 (e^+e^-, circular, 91 – 230 GeV)

LHeC (ep, circular, electron ERL, 50 GeV e^-, > 1 TeV ep collisions)



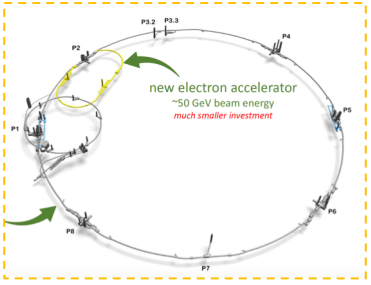
Potential for development: future 10 TeV parton-scale collider options

FCC-ee



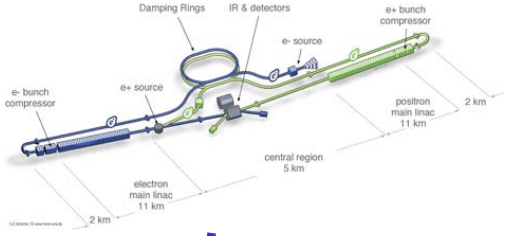
LEP3

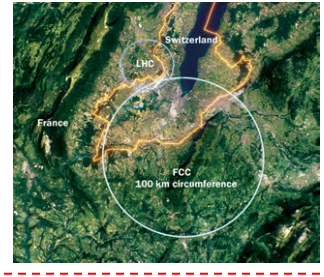
LHeC



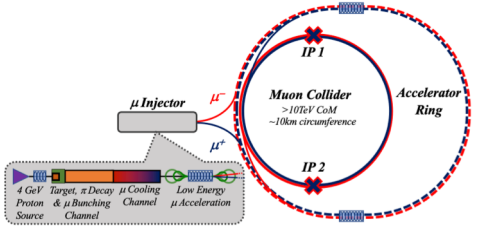
PERLE

LCF, CLIC





FCC-hh,
baseline 85 TeV (→ 120 TeV)
+ possibility for HI collisions



Muon Collider (3, 10 TeV)

R&D

e^+e^- with improved acceleration technologies
LCF, C^3 (→ 1 TeV), CLIC (1.5 TeV), HALHF, …
→ plasma acceleration for higher energies
(can $\mathcal{O}(10)$ TeV be reached? on what timescale?)

The view of the national HEP communities

- **Completing the full HL-LHC programme** is essential and must remain a high priority for CERN;

  It is paramount to fully exploit the High-Luminosity LHC (HL-LHC) to maximise scientific returns

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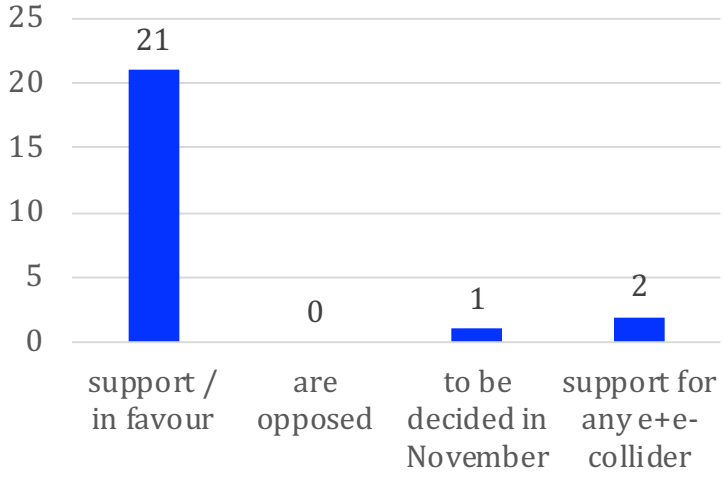
- It is important that the **next flagship collider supports a broad physics programme**, given that it is not clear where new physics will show up.

- Should a dedicated energy-frontier collider or a high-luminosity e^+e^- machine not prove feasible or face significant delays, **intermediate collider projects** such as LEP3 and LHeC are recognised as strategically valuable by some member-states HEP communities

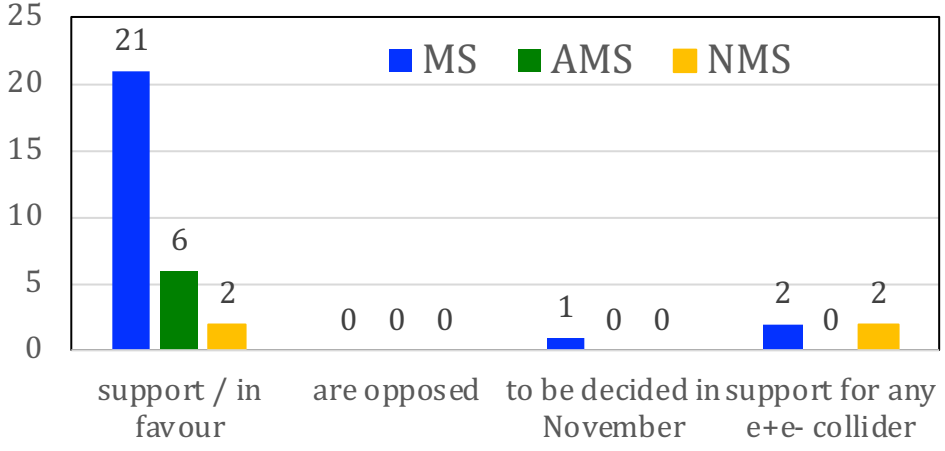
What is the preferred large-scale accelerator for CERN

CERN Member States (MS)



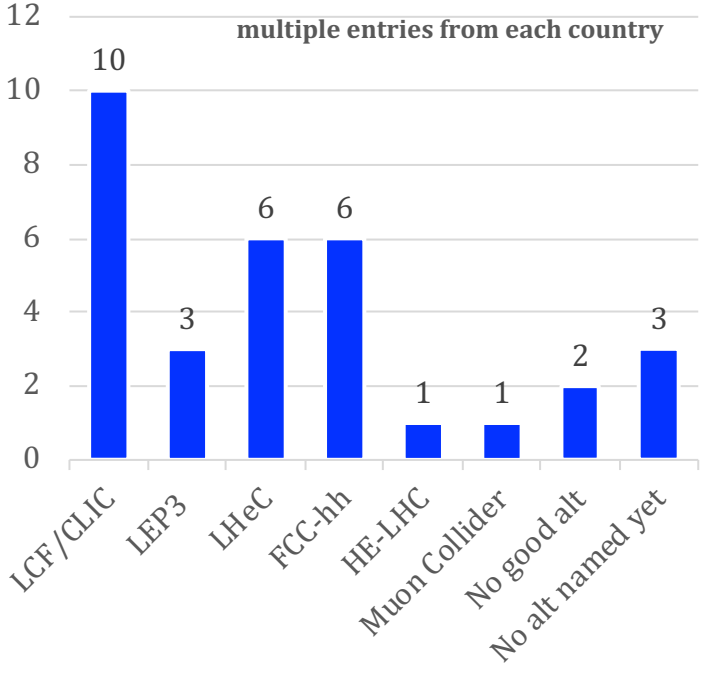
- Overwhelming support (21/24 CERN MS HEP communities) in favour of the integrated FCC-ee/hh programme

… incl. Associate- and Non-Member States (MS)



- Support as well from Associate Member states (AMS) and Non-member states (NMS)

What is the alternative if the preferred option is not feasible?



CERN Member States (MS) (multiple entries allowed)

- 10 MS HEP communities list a Linear Collider (LCF, CLIC) as second best choice
  (LCF is preferred to be realised with 550 GeV)
- 3 MS HEP mention LEP3 as a genuinely less costly alternative to FCC-ee
- 6 MS HEP communities support LHeC
- 6 MS HEP communities support a lower-energy hadron collider
- 2 MS HEP see no reason for another option, as they would be equally costly.

ESG Working Groups

(1) National Input, Diversity in European Particle Physics (Chairperson Calin Alexa)

- Analyse and summarise the input that will be submitted by the national HEP communities.
- Discuss constraints imposed by a large accelerator project at CERN. What fraction of the CERN and European research budget should be put on a single flagship project?
- Discuss the level of European participation in projects outside Europe

Will also analyse final input by the national HEP communities to be submitted by 14 Nov 2025

(2) Project Comparison Group

(a) Project Assessment Group (Chairpersons: Gianluigi Arduini, Phil Burrows)

For projects to be considered for realisation as the next flagship project at CERN, several aspects need to be thoroughly evaluated and compared:

- Technical feasibility, R&D requirements
- Risks
- Timeline
- Cost and human resources (including estimates for the associated detectors)
- Environmental impact

(b) Physics potential (Chairperson: Monica Dunford)

- Discussion and the comparison of the physics potential in the different physics areas will be carried out by the physics working groups in the PPG..
- A more global comparison across various physics areas is the responsibility of the ESG

ESG Working Groups

(3) Implementation of the Strategy / Deliverability of larger projects (Chairperson: Achille Stocchi)

Main purpose: assess how European National Laboratories and institutes can best work together with CERN to deliver large scale accelerator and detector projects.

("Distributed delivery model" for CERN's next major infrastructure? New management practices and tools?
What lessons can be learnt from the recent major projects (e.g. ATLAS and CMS upgrades)?
What could be a model for international participation (beyond CERN Member and Associate Member States)?)

(4) Relations with other fields of physics (Chairperson: Marek Karliner)

(5) Sustainability and environmental impact (Chairperson: Tadeusz Lesiak)

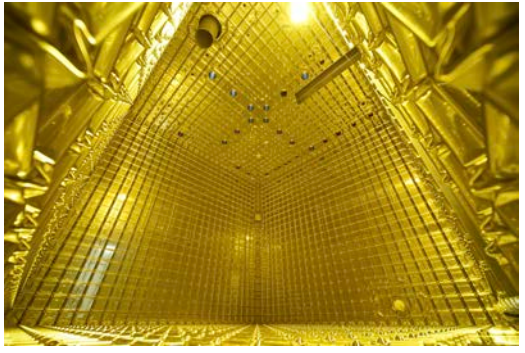
(6) Public Engagement, Education, Communication, Social and career aspects for the next generation (Chairperson: Pierre van Mechelen)

(7) Knowledge and Technology Transfer (Chairperson: Beate Heinemann)

Relations to other fields of physics

- Many projects in neutrino and astroparticle physics stress the importance of CERN's support for this science.
  Projects in these areas grow in scale and complexity
  (neutrino telescopes, neutrino-less double β decay, Dark Matter and Gravitational Wave detectors)

- It is argued that an expansion of CERN's support for these neighbouring fields could help to exploit the synergies further by transferring CERN's technical and managerial knowhow.



- CERN already has a strong Nuclear Physics programme and is involved in astroparticle physics projects through its unique technologies

- The technical/engineering/purchasing capabilities of CERN are already much stressed. A significant engagement into other areas would require as well a change of the CERN convention

- Most Member States national communities advocate maintaining the involvement at the present level; CERN must focus and successfully realise the core activities on accelerator-based particle physics
  (HL-LHC, phase-II detector upgrades, future collider project, ..)

→ The issue will be further discussed by the Strategy Group

Sustainability

- Awareness has reached the community / CERN / institutes / labs
- The evaluation of future HEP projects should take into account principles of environmental sustainability

  (Life Cycle Analyses)

- Many good examples of R&D efforts of the HEP community revolving around technological advances (accelerators, detectors, computing…) towards mitigating CO_2 emissions as much as possible;

  These efforts must be continued and strengthened;

  Sustainability issues are already addressed in the proposed flagship accelerator projects

Domain	Value in reference year (2018)	Current status	Target for 2030
Scope 1 emissions (tCO_2e)	192 100	170 100 (2023)	➢ Reduce by 50% w.r.t. 2018
Electricity consumption (GWh)	1252	1142 (2023) 1290 (estimation 2024)	➢ Max 1500 ➢ 10% renewable
Gas consumption (GWh)	61 (average 2016-2018)	39 (2024)	➢ Reduce by 60% w.r.t. 2018

Education, Career Development, Outreach

General guiding principles

Outreach and Communication

- Strengthen public trust in science through outreach that fosters critical thinking, counters misinformation and inspires future scientist
- Boost interest in STEM by expanding outreach
- Communicate effectively and transparently to build public and political support for the next European flagship project

Training and Education

- Strengthen training in instrumentation
- Establish closer ties with industry
- Integrate modern physics into school curricula

Open Science

- Promote Open Access to scientific knowledge
- Encourage the use of Open Data in education, outreach, and citizen science

Many good practices and suggestions received; they will be further discussed by ESG

Important: - Strengthen training in instrumentation
- Closer ties with industry

- Regarding Career Development: short-term contracts, frequent relocations, and uncertain job perspectives are perceived as major issues

Main Conclusions from the Venice Symposium

- Over the past years very significant progress has been made towards the realisation of the next flagship project at CERN

  - FCC: Successful completion of the Feasibility Study; No technical showstoppers identified
  - Overwhelming support for the integrated FCC-ee/hh programme by the HEP communities in the CERN Member and Associate Member states and beyond;
  - The strong support is largely based on the superb physics potential and the long-term prospects (FCC-ee /hh)
  - Discussions on the financial feasibility are ongoing (CERN management and Council)

- Discussions on the prioritisation of large-scale project will be continued

  - Linear colliders (LCF, CLIC) present as well mature options for a Higgs factory at CERN
  - LEP3 and LHeC could be considered as “intermediate” collider projects
  - The differences in the physics potential (→ Physics Briefing Book), review of the technical readiness and costs and the final input from the national HEP communities (due by 14 Nov.) will be important ingredients in the final recommendations by the European Strategy Group

- Keeping a strong complementary physics programme beyond colliders is essential

  - The areas of Neutrino Physics, Dark Matter Search experiments, astroparticle (covered by the APPEC Roadmap) and nuclear physics experiments (covered by the NuPPEC Long Run Plan) are also important to complement the future collider programme

Towards the recommendations on the next CERN flagship project

(i) Physics Potential

Physics Briefing Book (→ 30 Sept. 2025)

→ Assessment of overall Physics Potential **(ESG Working Group 2b)**

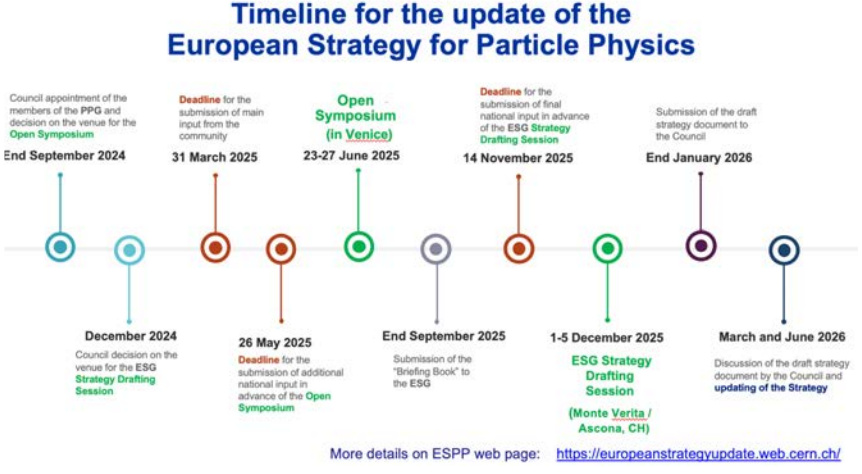
(ii) Project assessment

(Technical feasibility, required R&D, risks, timeline, costs and human resources (including estimates for the associated detectors), environmental impact

(**ESG working group 2a)**

(iii) Final input by the National HEP communities

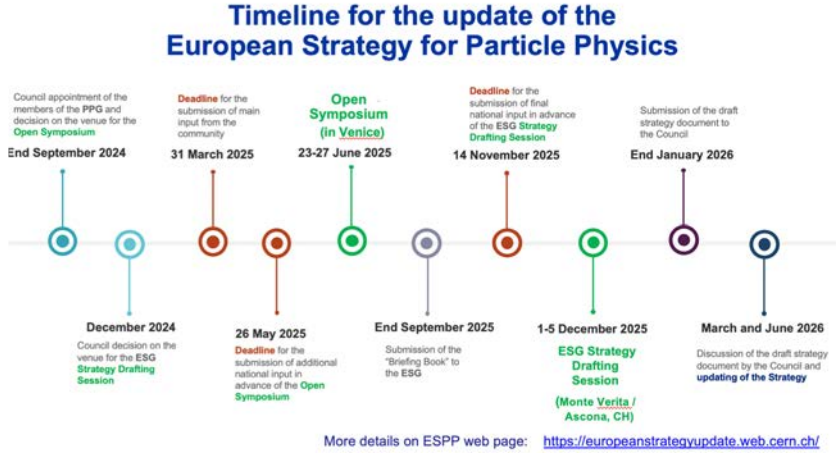
(→ 14 Nov. 2025)



Towards the recommendations on the next CERN flagship project (cont.)

(iv) ESG Strategy Drafting Session, 01 – 05 Dec 2025
in Ascona / Monte Verita

→ ESG recommendations
Will be submitted to the CERN Council



(v) Update of the European Strategy for Particle Physics by the CERN Council
(Discussions in March 2026, final meeting in Budapest in May 2026)

(6) Final deliberations on **project approval** by the CERN Council during 2027/2028