European Strategy for Particle Physics: 2024 – 2026 update

- Status and Plans -

Karl Jakobs (Strategy Secretary)

US Strategic Joint Meeting of the HFCC
8th November 2024

https://europeanstrategyupdate.web.cern.ch/

Update of the European Strategy

- In March 2024, the CERN Council approved the timeline for the next update of the European Strategy for Particle Physics with a completion date in June 2026

- The proposed timeline is determined by physics (LHC, HL-LHC, results from other colliders) and strategic considerations:

  - **Physics landscape**: physics results from the LHC and other colliders, HL-LHC upgrades ongoing, exploration of the Higgs sector remains central

  - Excellent progress at CERN and beyond on the preparation for future colliders

  *** FCC Feasibility Study**
  (mid-term report presented, excellent progress on the technical side - no showstoppers identified for an FCC-ee as a first stage of an integrated FCC programme)
  Planned to complete the study in March 2025

  *** Clearer view on the international landscape for future colliders**
  - ILC in Japan as a global project; so far no commitments
  - P5 process in the US (→ participation in an off-shore Higgs factory (ILC, FCC-ee)
  - Technical Design Report for CEPC in China released in Dec 2023;
    Aim for adoption of the project in the next five-year funding cycle(s) in 2025

→ Very relevant information will become available by the end of 2025

Update of the European Strategy

- *In addition:*

  - ***Long timescales, long-term community engagement***

    * The gap between the end of the HL-LHC and the start of the next collider project should be minimised, to ensure continuity of expertise and commitment.

    * Wish of the young generation of physicists to have a clear vision of the future of our research field, as well as a credible timeline for the realisation of any future collider project

  - **Strategy recommendations on the complementary physics programme** at CERN and beyond are important for establishing / upgrading relevant facilities

Remit of the European Strategy Group (ESG)

- *In June 2024, the CERN Council established and approved the **remit of the European Strategy Group***

  *"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:
  - 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;
  - **The 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 Secretariat and European Strategy Group (ESG)

Strategy Secretariat: Organising and running the ESPP process
Karl Jakobs (Strategy Secretary, Chair) (bi-weekly meetings over the past two months to ramp up the process)
Hugh Montgomery (SPC Chair)
Dave Newbold (LDG Chair) (→ will be replaced by Mike Seidel (PSI, as new LDG Chair) on 1st Jan. 2025)
Paris Sphicas (ECFA Chair)

European Strategy Group (ESG) Preparation of the Strategy Document
(kick-off meeting held on 18th September)

- The Strategy Secretary (acting as Chair)
- **One representative appointed by each CERN Member State**
- **One representative appointed by each of the laboratories represented in the Large Particle Physics Laboratory Directors Group (LDG), including its Chair**
- **The CERN Director-General**
- **The CERN Director-General elect**
- The SPC Chair
- The ECFA Chair
- Invitees: President of CERN Council, one representative from each of the Associate Member and Observer States, one representative from the European Commission, the Chairs of APPEC, NuPECC and ESFRI, the members of the Physics Preparatory Group.

US representative: Mike Tuts (Columbia)

The Physics Preparatory Group (PPG)

Physics Preparatory Group collects input from the community, organises the Open Symposium, prepares the Briefing Book

- Strategy Secretary (acting as Chair)
- **Four members appointed by Council on the recommendation of the SPC**
- **Four members appointed by Council on the recommendation of ECFA**
- **One representative appointed by CERN**
- **Two representatives from the Americas**
- **Two representatives from Asia**
- The SPC Chair
- The ECFA Chair
- The LDG Chair

US representative: Anadi Canepa (Fermilab)

PPG MEMBERS	
Strategy Secretariat	
Scientific Secretary (Chair)	Prof. Karl Jakobs (DE)
SPC Chair	Dr Hugh Montgomery (USA)
ECFA Chair	Prof. Pareskevas Sphicas(GR)
LDG Chair	Prof. Dave Newbold (UK)
SPC	
Prof. Pilar Hernandez (ES)	
Prof. Gino Isidori (CH)	
Prof. Fabio Maltoni (BE/IT)	
Prof. Jocelyn Monroe (UK	
ECFA	
Dr Tommaso Boccali (IT)	
Dr Thomas Bergauer (AT)	
Dr Cristinel Diaconu (FR)	
Prof. Monica Dunford (DE)	
CERN	
Dr Gianluigi Arduini (CERN)	
ASIA/AMERICAS	
Dr Anadi Canepa (USA)	
Prof. Xinchou Lou (China)	
Prof. Rogerio Rosenfeld (Brazil)	
Prof. Yuji Yamazaki (Japan)	

Organisation of the work in PPG

- The Strategy Secretariat proposes **nine working groups** to cover the full range of physics topics as well as the technology areas of accelerators, detector technologies and computing.

Working Group		
	Co-convener (PPG member)	Co-convener
Electroweak physics	Monica Dunford (DE, exp)	Jorge de Blas (ES, theory)
Strong interaction	Cristinel Diaconu (FR, exp)	Andrea Dainese (IT, exp, HI)
Flavour physics	Gino Isidori (CH, theory)	Marie-Hélène Schune (FR, exp)
BSM physics	Fabio Maltoni (BE/IT, theory)	Rebeca Gonzalez-Suarez (SE, exp)
Neutrino physics and cosmic messengers	Pilar Hernandez (ES, theory)	Sara Bolognesi (FR, exp)
Dark matter and dark sector	Jocelyn Monroe (UK, exp)	Matthew McCullough (CERN, theory)
Accelerator science and technology	Gianluigi Arduini (CERN, acc)	Phil Burrows (UK, exp, acc)
Detector instrumentation	Thomas Bergauer (AT, exp)	Ulrich Husemann (DE, exp)
Computing	Tommaso Boccali (IT, exp, comp)	Borut Kersevan (SL, exp, comp)

To **increase the engagement by the broader particle physics community** in the current update, the Strategy Secretariat proposes additional co-conveners

(from SPC and ECFA nominations)

- Early Career Researchers (ECR) (one for each of the nine working groups) are proposed to act as Scientific Secretaries

Short summary of the charge to the co-conveners

- Selection of Early Career Researchers (✔)
- Definition of sub-topics and appointment of additional working group members (in preparation)
- Definition of benchmark processes / measurements (in preparation, will be shared with project groups)
- Organisation of working-group meetings
- Writing of the Physics Briefing Book
  (will be supported by Roger Forty, who has agreed to be Scientific Secretary of the Strategy update)

It is expected that for each physics area comparative assessments on the physics potential of various proposed projects for the defined benchmark are made. By construction this comparison should be made at the working group level;

A more global comparison across various physics areas is the responsibility of the ESG.

Baseline and possible alternative scenarios

Current baseline – justified by 2020 Strategy – :
FCC integrated programme (FCC-ee followed by a hadron collider of at least 100 TeV)

Possible alternative scenarios (for next collider, following the HL-LHC)

- Realisation of a lower-energy hadron collider (50 – 80 TeV) on an earlier timescale (2050 – 2055)
- Linear Collider at CERN (CLIC, …)
- Muon Collider at CERN
- Further exploitation of the LHC physics programme, eventually with the addition of e-h collisions
- …

Non-exhaustive list, other scenarios may come up and be proposed by the community

Expected input on baseline and alternative scenarios

- **FCC integrated programme:** Input via FCC Feasibility Study final report

  (technical feasibility, physics potential, environmental impact, …, update on the financial feasibility)
  In addition: reports from review committees will appear later in 2025

- **Lower-energy hadron collider:** Two important inputs are needed:

  (i) When will HFM magnets, e.g. accelerator magnets of 12 T or 14 T, become available?
  What technology? What price tag? Required R&D? To what extent can timeline be accelerated?
  Input from → LDG + HFM Collaboration (Accelerator Roadmap) + international experts(?)

  (ii) Physics potential of a 91 km hadron collider with 12 or 14 T magnets (or lower);
  → plan to include it in FCC Feasibility Study report

- Linear Collider at CERN
- Muon Collider at CERN
- Extended LHC / LHeC physics programme
- …

} Input will be prepared by respective communities

Guidelines for input by projects is under preparation by Strategy Secretariat

Work / topics covered and shared among PPG and ESG

PPG:
Physics + Technology working groups

- Electroweak physics (including Higgs physics)
- Strong interaction
- Flavour physics
- Beyond the Standard Model physics
- Neutrino physics and cosmic messengers
- Dark matter and dark sector
- Accelerator science and technology
- Detector instrumentation
- Computing

→ **Physics Briefing Book**

ESG: Overarching topics

- **National input / roadmaps (→ strategic)**
- **Projects (FCC, LC/C³, LE-FCC-hh, MC, ..)**
  (timeline, costs, …. (physics → PPG))
- Comparisons across proposed projects
- Relations with other fields of physics
- Implementation of the Strategy
  (role of CERN and National Labs, coordination of European participation in projects sited outside Europe, …)
- Knowledge and Technology transfer
- Sustainability, environmental impact
- Public engagement, education, communication
- …

→ *ESG working groups to be set up, in preparation*

Community Involvement

- Input and involvement of the community is important!
  (… and explicitly asked for in the remit)

  Goal must be to reach a consensus in the community on the way forward for our field!

- There are several ways the community should provide input:

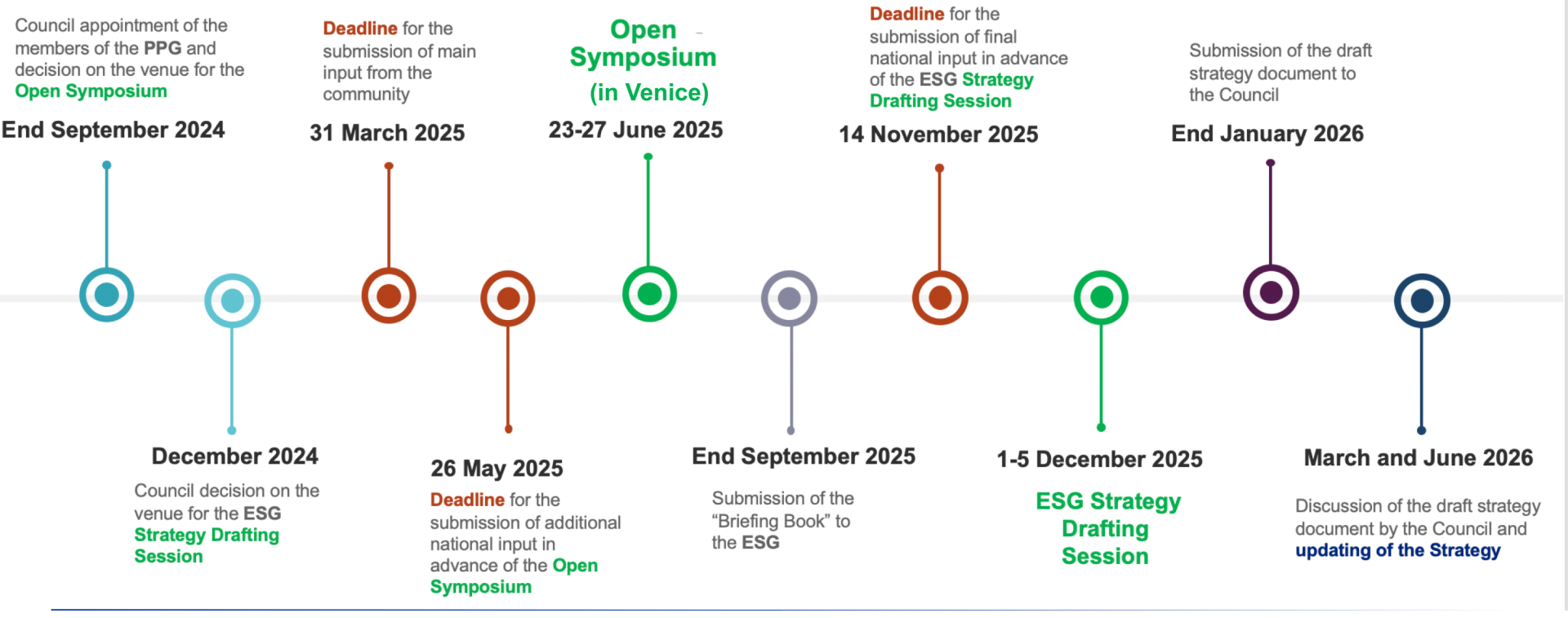
  Submission of input from the community by 31 March 2025

  Input from **projects** (FCC, Linear Collider, …, Muon Collider, …, theory, …) expected;
  Input from **national HEP communities** expected (process has already started in several countries)
  ….

, → Key input will become available only at end of March 2025
  * Final report on FCC feasibility study (including progress on financial feasibility)
  * Important input from alternative projects
  * Reports on accelerator R&D, detector R&D, …
  * …

Therefore, we foresee further community input (national HEP communities) at later stages

Timeline for the update of the European Strategy for Particle Physics



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

ECFA guidelines for input by the National HEP Communities

Central element of the next ESPP: the choice of the next collider at CERN

ESG remit: *"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."*

→ *It is imperative that the European HEP community provides explicit feedback on the preferred and alternative options and explanation of any specific prioritisation.*

- In order to be of greatest use in informing the ESPP, the information collected must be as coherent and as uniform as possible, especially when addressing the key issues.

  → ECFA has drawn guidelines (a list of "standard questions") to be addressed by the national HEP communities

- Details can be found here: ECFA guidelines for national HEP community input

ECFA guidelines / questions

a) Which is the preferred next major/flagship collider project for CERN?

b) What are the most important elements in the response to (a)?

i) Physics potential
ii) Long-term perspective
iii) Financial and human resources: requirements and effect on other projects
iv) Timing
v) Careers and training
vi) Sustainability

c) Should CERN/Europe proceed with the preferred option set out in (a) or should alternative options be considered:

i) if Japan proceeds with the ILC in a timely way?
ii) if China proceeds with the CEPC on the announced timescale?
iii) if the US proceeds with a muon collider?
iv) if there are major new (unexpected) results from the HL-LHC or other HEP experiments?

d) Beyond the preferred option in (a), what other accelerator R&D topics (e.g. high-field magnets, RF technology, alternative accelerators/colliders) should be pursued in parallel?

e) What is the prioritised list of alternative options if the preferred option is not feasible (due to cost, timing, international developments, or for other reasons)?

f) What are the most important elements in the response to (e)? (The set of considerations in (b) should be used).

Paris Sphicas
ECFA Chair

National HEP input on non-collider projects and other fields

Paris Sphicas
ECFA Chair

Remit to ESG also specifies:

> **"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."**

It would thus be most useful if the national inputs explicitly included the preferred prioritisation for non-collider projects. Specific questions to address:

a) What other areas of physics should be pursued, and with what relative priority?

b) What are the most important elements in the response to (a)? (The set of considerations as for the "next collider" should be used).

c) To what extent should CERN participate in nuclear physics, astroparticle physics or other areas of science, while keeping in mind and adhering to the CERN Convention? Please use the current level and form of activity as the baseline for comparisons.

Expectations from the US

- It is important to submit input by **31 March**

  (via project groups, or via national HEP community)

- National HEP community input from the US is highly welcome!

  - US view of the future of our field
  - US plans for engagement in a future large accelerator project at CERN
  - US expertise (accelerators, detectors, ..) and possible contributions
  - ... (address ECFA guidelines)