Update of the EU Strategy for Particle Physics 2025

Preparation of GT1 contribution

EU Strategy for Particle Physics 2020

Last update - June 2020

Highlights of an (ambitious) project:

- Successful **completion** of the **High-Luminosity LHC**
  (focal point of EU particle physics)

- Ramp up **R&D** for advanced **accelerator, detector and computing**
  (pre-requisite for all future projects)

- **Highest priory facility after LHC:** electron-positron collider acting as a "Higgs factory"
  ⇒ mapping the Higgs sector an essential part of rich ambitious programme of precision measurements and discoveries beyond the SM
  ⇒ exploitation @ CERN within 10 yrs after full exploitation of HL-LHC (end 2038)

- Pursue technical and financial **feasibility studies** for a next-generation hadron collider at highest possible energy (with electron-positron acting as possible first stage)

- **Support** neutrino projects in Japan and USA; cooperation with other (neighbouring) fields

More info : https://www.home.cern/news/news/physics/particle-physicists-update-strategy-future-field-europe

EU Strategy for Particle Physics 2020

Document link

High-priority future initiatives

A. An electron-positron Higgs factory is the highest-priority next collider. For the longer term, the European particle physics community has the ambition to operate a proton-proton collider at the highest achievable energy. Accomplishing these compelling goals will require innovation and cutting-edge technology:

• the particle physics community should ramp up its R&D effort focused on advanced accelerator technologies, in particular that for high-field superconducting magnets, including high-temperature superconductors;

• Europe, together with its international partners, should investigate the technical and financial feasibility of a future hadron collider at CERN with a centre-of-mass energy of at least 100 TeV and with an electron-positron Higgs and electroweak factory as a possible first stage. Such a feasibility study of the colliders and related infrastructure should be established as a global endeavour and be completed on the timescale of the next Strategy update.

The timely realisation of the electron-positron International Linear Collider (ILC) in Japan would be compatible with this strategy and, in that case, the European particle physics community would wish to collaborate.

B. Innovative accelerator technology underpins the physics reach of high-energy and high-intensity colliders. It is also a powerful driver for many accelerator-based fields of science and industry. The technologies under consideration include high-field magnets, high-temperature superconductors, plasma wakefield acceleration and other high-gradient accelerating structures, bright muon beams, energy recovery linacs. ***The European particle physics community must intensify accelerator R&D and sustain it with adequate resources. A roadmap should prioritise the technology, taking into account synergies with international partners and other communities such as photon and neutron sources, fusion energy and industry. Deliverables for this decade should be defined in a timely fashion and coordinated among CERN and national laboratories and institutes.***

EU Strategy for Particle Physics 2020

Other essential scientific activities for particle physics

A. The quest for dark matter and the exploration of flavour and fundamental symmetries are crucial components of the search for new physics. This search can be done in many ways, for example through precision measurements of flavour physics and electric or magnetic dipole moments, and searches for axions, dark sector candidates and feebly interacting particles. There are many options to address such physics topics including energy-frontier colliders, accelerator and non-accelerator experiments. A diverse programme that is complementary to the energy frontier is an essential part of the European particle physics Strategy. ***Experiments in such diverse areas that offer potential high-impact particle physics programmes at laboratories in Europe should be supported, as well as participation in such experiments in other regions of the world.***

B. Theoretical physics is an essential driver of particle physics that opens new, daring lines of research, motivates experimental searches and provides the tools needed to fully exploit experimental results. It also plays an important role in capturing the imagination of the public and inspiring young researchers. The success of the field depends on dedicated theoretical work and intense collaboration between the theoretical and experimental communities. ***Europe should continue to vigorously support a broad programme of theoretical research covering the full spectrum of particle physics from abstract to phenomenological topics. The pursuit of new research directions should be encouraged and links with fields such as cosmology, astroparticle physics, and nuclear physics fostered. Both exploratory research and theoretical research with direct impact on experiments should be supported, including recognition for the activity of providing and developing computational tools.***

C. The success of particle physics experiments relies on innovative instrumentation and state-of-the-art infrastructures. To prepare and realise future experimental research programmes, the community must maintain a strong focus on instrumentation. ***Detector R&D programmes and associated infrastructures should be supported at CERN, national institutes, laboratories and universities. Synergies between the needs of different scientific fields and industry should be identified and exploited to boost efficiency in the development process and increase opportunities for more technology transfer benefiting society at large. Collaborative platforms and consortia must be adequately supported to provide coherence in these R&D activities. The community should define a global detector R&D roadmap that should be used to support proposals at the European and national levels.***

D. Large-scale data-intensive software and computing infrastructures are an essential ingredient to particle physics research programmes. The community faces major challenges in this area, notably with a view to the HL-LHC. As a result, the software and computing models used in particle physics research must evolve to meet the future needs of the field. ***The community must vigorously pursue common, coordinated R&D efforts in collaboration with other fields of science and industry, to develop software and computing infrastructures that exploit recent advances in information technology and data science. Further development of internal policies on open data and data preservation should be encouraged, and an adequate level of resources invested in their implementation.***

CERN-ESU-004
10 January 2020

Physics Briefing Book

Input for the European Strategy for Particle Physics Update 2020

Electroweak Physics: Richard Keith Ellis[1], Beate Heinemann[2,3] *(Conveners)*
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Klaus Kirch[23], Uta Klein[24], Jean-Philippe Lansberg[25], Gavin P. Salam[26], Gunar Schnell[27],
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Marie-Helene Schune[42], Marco Sozzi[43], Stephan Paul[44], Carlos Pena[31] *(Contributors)*

Neutrino Physics & Cosmic Messengers: Stan Bentvelsen[45], Marco Zito[46,47] *(Conveners)*
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Beyond the Standard Model: Gian F. Giudice[20], Paris Sphicas[20,52] *(Conveners)*
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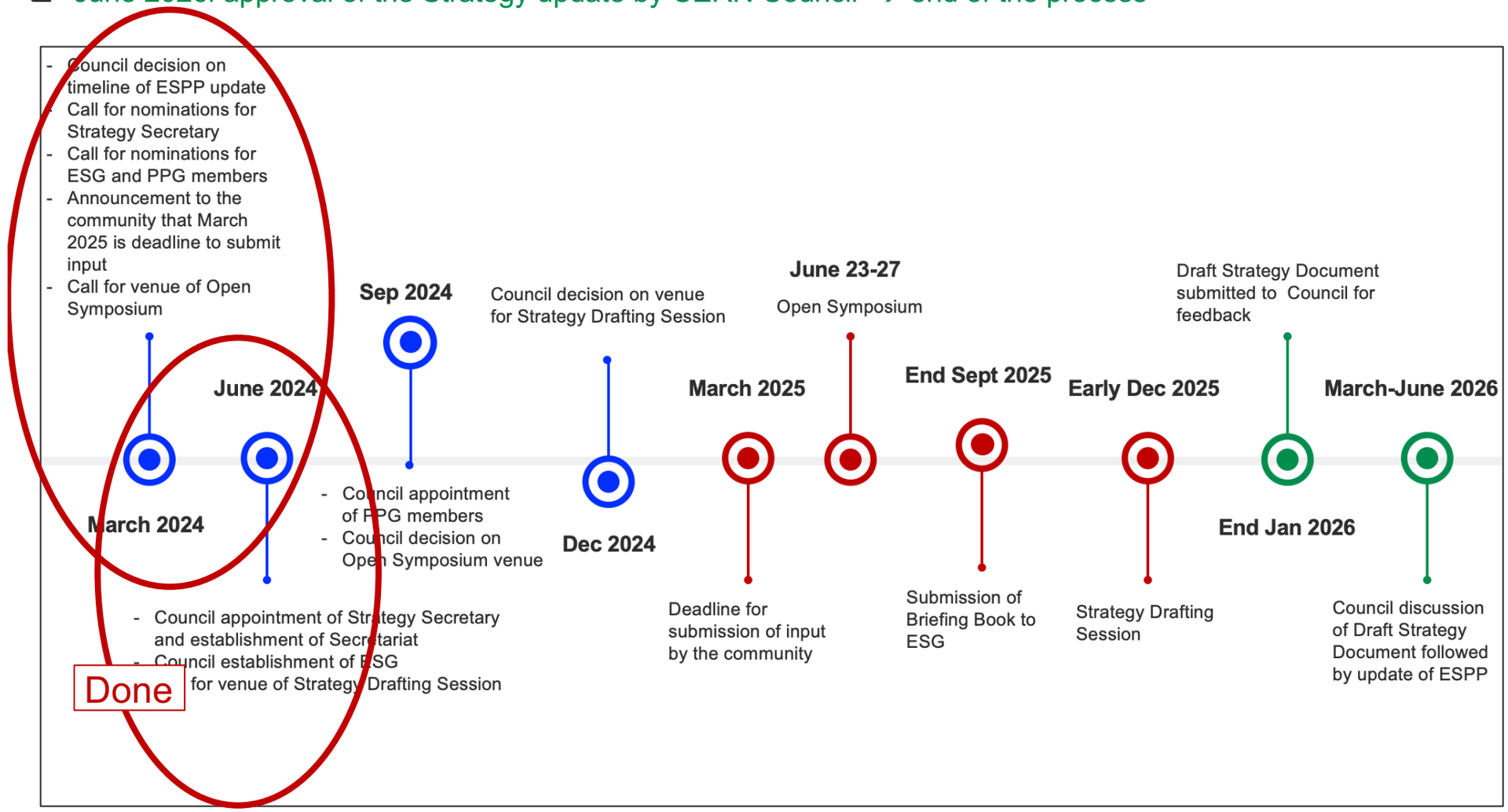
EPPSU 2025: calendar

Timeline of European Strategy update (I)

- March 2025: deadline for submission of community input
- June 23-27 2025: Open Symposium
- Early Dec 2025: Strategy Drafting Session
- June 2026: approval of the Strategy update by CERN Council → end of the process



From F. Gianotti's slides (Summer 2024)

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From F. Gianotti's slides (Summer 2024)

EPPSU 2025: ESG "remit"

European Strategy Group (ESG) remit

Approved by Council in June

The remit of the European Strategy Group (ESG), established in June 2024, is to develop an update of the European Strategy for Particle Physics and submit it for approval by the 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.

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 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.

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.

The ESG should submit the proposed Strategy update to the Council by the end of January 2026.

From F. Gianotti's slides (Summer 2024)

EPPSU 2025: Key points

"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 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."

F. Gianotti (Summer 2024)

EPPSU 2025: French contribution

IN2P3/CNRS & IRFU/CEA, document de **10 pages; Steering** - L. Vacavant & N. Besson

GT1 : Standard Model and beyond [IRN Terascale] **(4/10 & 13/11)**
Fabrice Couderc, Marie-Hélène Genest, Ana M. Teixeira

GT2 : Flavour physics and fundamental interaction tests [GDR Intensity Frontier]
Yasmine Ahmis, Giulio Dujany, Christopher Smith **(6/11)**

GT3 : Neutrinos (especially Long-baseline) [IRN Neutrinos] **(9/10)**
Sara Bolognesi, Stéphane Lavignac, Anselmo Meregaglia

GT4 : QCD and heavy ion collisions [GDR QCD] **(19/09)**
Cyrille Marquet, Carlos Munoz Camacho, Michael Winn

GTS Scenarios **(16/12)**
Cristinel Diaconu, Jeremy Andrea, Maarten Boonekamp et Stéphane Monteil

Direct input deadline**: 25 October** online depository - https://survey.in2p3.fr/ESPPU

Symposium 20-21 January 2025 (Jussieu)

EPPSU 2025: french contribution

Preparing the GT1 Contribution: 2 meetings

- **Today**
- **First session** of the coming **Terascale meeting** (Lyon, IP2I) - **13 November**

Today: overview of the evolution of the global context and challenges since last update

Review **highlights of EPPSU2020** on aspects which are at the core of **GT1**

Electroweak Physics & SM precision tests

Strong Interactions

Beyond the SM

Dark matter and dark sectors

Instrumentation (R&D) and computational challenges

Thanks to all speakers!

Amazing effort & contributions

EPPSU 2025: french contribution

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Start discussing, and identify the points we wish to highlight in our contribution!

Just "**raise your hand**" in your Zoom connection 🖐

Envisage (in)direct contribution to preferred and alternative scenarios (GTS)?

EPPSU 2025: french contribution - II

Next time: **which are the key-points to discuss and emphasise in the GT1 contribution?**

1) **Physics problems** that remain "beacons" for future machines - **Physics cases**
Higgs sector / new resonances / ...
Which can **only** be addressed with a given experimental setup (energy/precision/...)
Best approach? Challenges (precision, computational tools, ...)

2) **Prospects for machines** (EU, JP, CH, US, ...)
Comparative physics programme ; R&D status

3) Increasing the **sustainability** - ideas to ***reduce environmental impact*** (dedicated group!)

4) Realistic options: if not ... then...

5) Other **non-collider experiments** that should be **prioritised:** what they can **uniquely probe?**

6) **Updates to the HL-LHC** projections given the progress made since 2020
either in **terms of reach** due to improved techniques / reduced systematics
or in **terms of focus** (EFT vs models gathering more interest) ...

7) ??? Please contribute !! (all of you - especially younger generations!)