European Strategy Update

Once upon a time in Venice…

Tadeusz Lesiak

July 15, 2025

Every love hides its own secrets

https://www.ebay.com/itm/275931164051

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)

The ESPP Process in the Nutshell

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."***

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.

- 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.*

European Strategy Update

Reminder of PPG/WG and ESG; and responsibilites

- Physics Preparatory Group (PPG): physicists/engineers, experts in different subfields of particle physics (nominated by SPC, ECFA, CERN, Americas/Asia)
- European Strategy Group (ESG): secretariat (secretary chairs ESG); One rep per CERN member state; One rep per lab in LDG; CERN DG, CERN DG-elect. Invitees: PPG, President of Council, 1 rep from each Associate Member State and Observer State, 1 rep from EC; chairs of ApPEC, NuPECC, ESFRI

PPG:

PPG Working Groups

Electroweak Physics Conveners: M. Dunford, JB	**Strong Interactions** Conveners: C. Diaconu , A. Dainese	**Flavour Physics** Conveners: G. Isidori, M-H. Schune
Neutrino Physics and Cosmic Messengers Conveners: P. Hernandez, S. Bolognesi	**BSM Physics** Conveners: F. Maltoni, R. Gonzalez-Suarez	**Dark Matter and Dark Sectors** Conveners: J. Monroe, M. McCullough
Accelerator Science and Technology Conveners: G. Arduini, P. Burrows	**Detector instrumentation** Conveners: T. Bergauer, U. Husemann	**Computing** Conveners: T. Boccali, B. Kersevan

→ Physics Briefing Book

ESG: Overarching topics

- National input / roadmaps (→ strategic)
- Projects (FCC, LC, 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

(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)

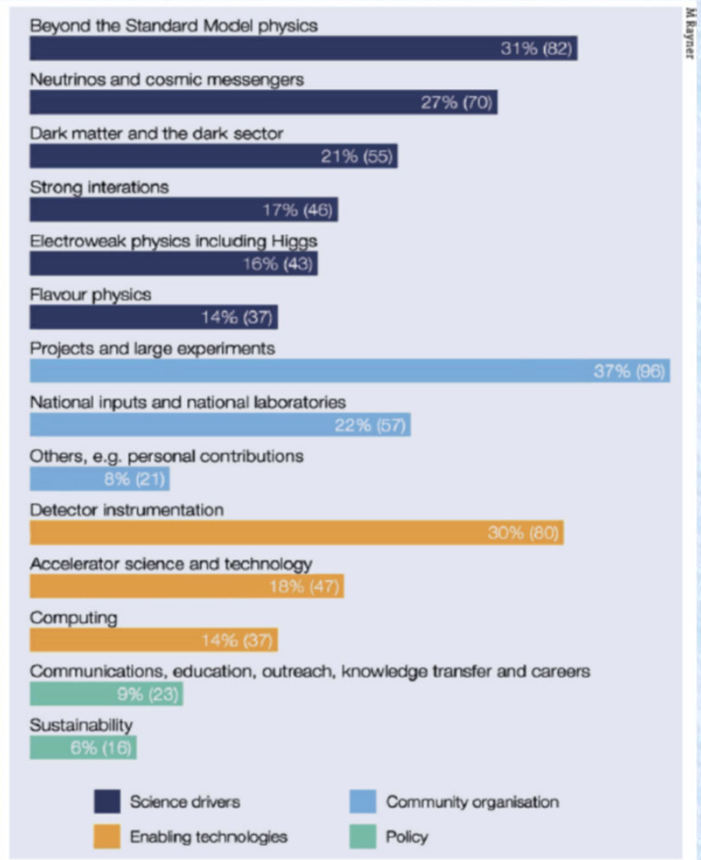
Timeline for the update of the European Strategy for Particle Physics

May 2026, Budapest – official announcement of the ESPP

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

6-7.Nov – extraordinary CERN Council devoted to the FCC FS

The ESPP Process in the Nutshell



Self-attributed themes of the 263 community inputs

ESPP submission by 31 March

- All 263 submissions are available here: https://indico.cern.ch/event/1439855/contributions/

- **Submissions received by 26th May**
  (possibility for updates by national HEP communities and large-scale projects (harmonisation)

  Summary of all inputs: https://europeanstrategyupdate.web.cern.ch/sites/default/files/Submitted_Input_2025.05.26.pdf

  Updates by National HEP communities: Austria, Canada, Slovenia, Switzerland, United Kingdom
  New National HEP submissions: Australia, Bulgaria

  Updated submissions by large-scale projects: CLIC, FCC-ee, FCC-hh, ILC, LCF@CERN, LEP3, Muon Collider

New submissions:

(i) Future Colliders Comparative Evaluation – Working Group Report -	**submission #281**
(ii) Fundamental Nuclear and Particle Physics at Neutron Sources	added to submission #190
(iii) D&I programme at CERN	added to submission #259

The ESPP Process in the Nutshell

Towards the recommendations on the next CERN flagship project

(1) Physics Potential

Physics Briefing Book (→ 30 Sept. 2025)

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

(2) Project assessment

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

(ESG working group)

(3) Final input by the National HEP communities

(→ 14 Nov. 2025)

Once upon a time in Venice…

Open Symposium in Venice

European Strategy for Particle Physics: 2026 Update

- Key messages from the Symposium -

From U. Husemann's talk

Strategy Secretariat
Karl Jakobs (Chair), Hugh Montgomery (SPC), Mike Seidel (LDG), Paris Sphicas (ECFA)

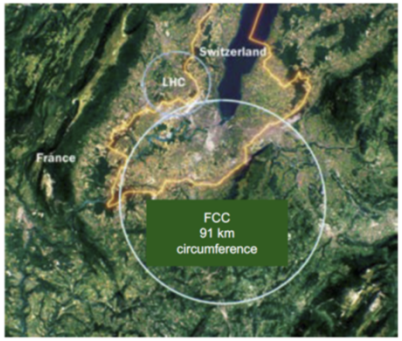
Venice Open Symposium, 27 June 2025

https://agenda.infn.it/event/44943/overview

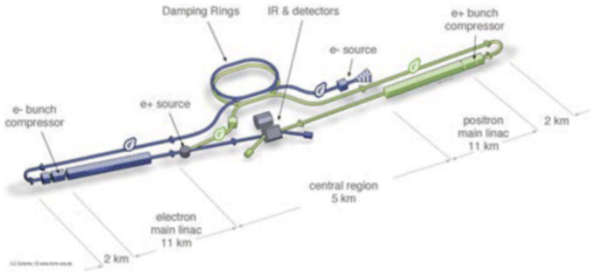
Proposed large-scale projects at CERN, ~ 2045

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

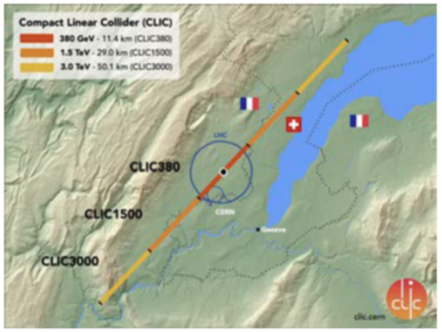
FCC-ee (e^+e^-, circular, 91 – 365 GeV)



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



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

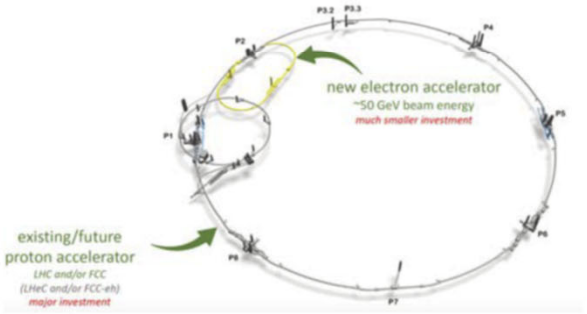


Intermediate projects

(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)



K. Jakobs, EPS-HEP Conference, Marseille, 10th July 2025

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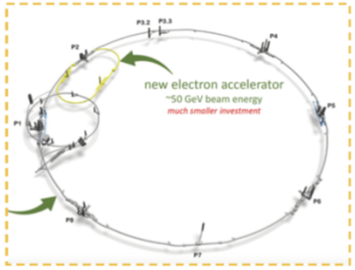
Potential for development: future 10 TeV parton-scale collider options

FCC-ee

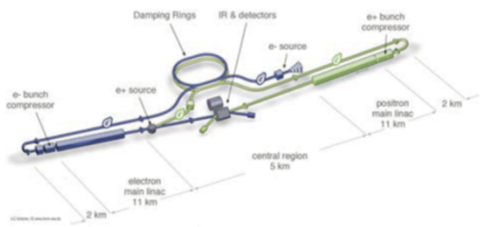
LEP3

LHeC

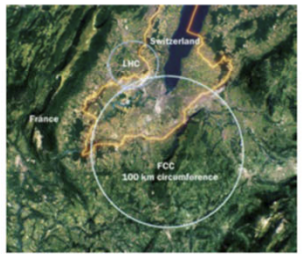


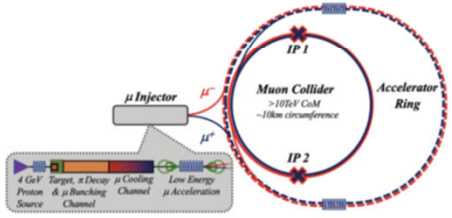
PERLE

LCF, CLIC



R&D





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

Muon Collider (3, 10 TeV)

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?)

K. Jakobs, ESPP Open Symposium, 27th June 2025

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ESG WG1 National Inputs

National Input, Diversity in European Particle Physics

- 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
- Chairperson: C. Alexa (RO); B. Kliček (HR), E. Laenen (NL), M. Lancaster (UK), S. Malvezzi (LNF), C. Roy (FR), J. Schieck (AT).

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 LHeC and LEP3 are recognised as strategically valuable by some member-states HEP communities

ESG WG1 National Inputs

Questions to be considered by countries/regions when forming and submitting their "national input" to the ESPP:
https://ecfa.web.cern.ch/ecfa-guidelines-inputs-national-hep-communities-european-strategy-particle-physics-0

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?

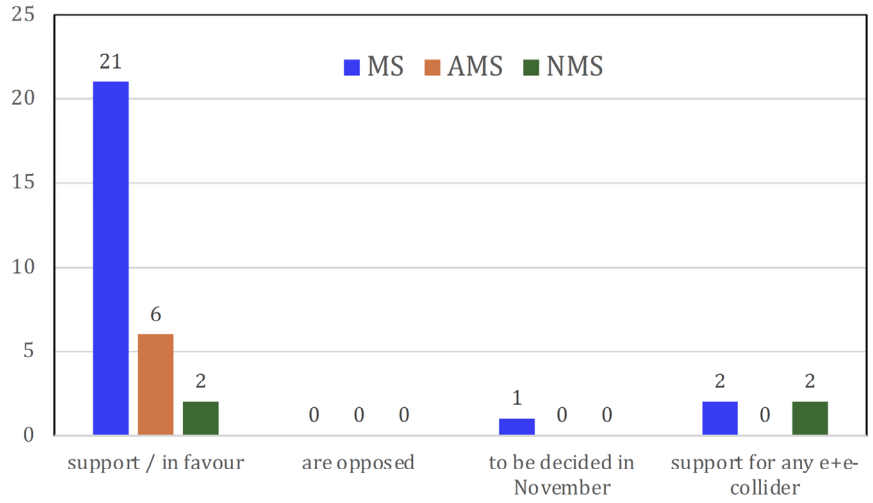
d) Beyond the preferred option in (a), what other accelerator R&D topics (e.g. Highfield magnets, RF technology, alternative accelerators/colliders) should be pursued in parallel?

e) What is the prioritised list of alternative options if the preferred option set out in (a) 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 3b should be used).

ESG WG1 National Inputs

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



Support for FCC	MS: Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Israel, Italy, Norway, Poland, Portugal, Romania, Serbia, Slovak Republic, Spain, Sweden, Switzerland, United Kingdom
	AMS: Bazil, Croatia, Lithuania, Pakistan, Slovenia, Ukraine
	NMS: Canada, United States of America
Opposed	None
To be finalized in November	Netherlands
Support for any e^+e^- collider	MS: Austria, Bulgaria; NMS: Australia, Japan

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ESG WG1 National Inputs

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

- **Broad consensus** among CERN Member States in support of the Future Circular Collider (FCC) integrated ee and hh programme as a key long-term project to maintain Europe's leadership in particle physics. (21 MS countries)
- **A phased approach** starting with the FCC-ee and transitioning to the FCC-hh has been supported for its strategic continuity, and re-use of existing infrastructure for the second phase of the project. (19 MS countries)
- The FCC-ee **widely identified** as the next flagship project due to its large potential as a Higgs and electroweak physics factory, scientific value, and technical feasibility. (20 MS countries)
- Strong support for **constructing the 91 km tunnel**, enabling future flexibility that supports both electron-positron (FCC-ee) and hadron-hadron (FCC-hh) collider.
- Alternative projects (e.g., Linear Collider Facility @CERN, CLIC, LEP3, LHeC) are mentioned, though none are seen as having the same comprehensive potential as the FCC.
- Delays would risk CERN's leadership and reduce global engagement.
- Strategic planning and financial viability are highlighted as key factors in decision-making.
- There is considerable support for fast-tracking FCC-hh with the present baseline design, with 14 T magnets and 85 TeV centre-of-mass energy to secure Europe's leadership in exploring high-energy frontiers.

ESG WG1 National Inputs

b) What are the most important elements in the response to 3a)? i) *Physics Potential*; ii) *Long-Term Vision*; iii) *Financial and human resources: requirements and effects on other projects*; iv) *Timing*; v) *Careers and training*; vi) *Sustainability*

- **The FCC project is widely supported for its outstanding physics potential and long-term strategic value.**
- **The investment is expected to yield long-term scientific and technological returns while maintaining Europe's leadership in particle physics.**
- **Human capital development** is considered a key aspect.
- Risks related to a potential post-HL-LHC gap in accelerator activity is noted, with **concerns raised about knowledge loss**.
- Early-career researchers' **concerns are recognized as significant**.
  *(ECR perspective, Christina Dimitriadi (KTH), Ulrich Einhaus (KIT Karlsruhe), at 10:45)
- **Sustainability is widely considered to be a foundational principle.**

ESG WG1 National Inputs

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

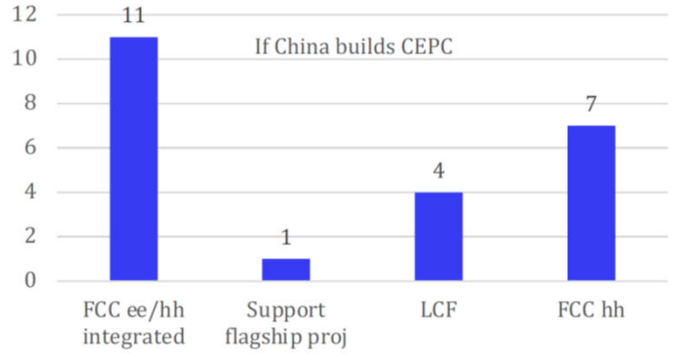
i. If Japan proceeds with the ILC in a timely way

National inputs that consider a potential ILC in Japan, consistently favour maintaining the FCC project.
The ILC is generally seen as having less physics potential and offering only a medium-term scientific perspective.
Several countries recall that a commitment from Japan has not yet been made.

ii. If China proceeds with the CEPC on the announced timescale

There's no unanimous view among the national inputs.
Many proposals suggest sticking with the FCC project.
While some inputs prefer the original FCC design, the majority shift focus to the FCC-hh, likely limited to 85-90 TeV due to technology limits.
Only one input proposes dropping the FCC altogether.

FCC ee/hh integrated	BE, CH, DK, FI, FR, GR, HU, IT, PL, PT, SE
Support flagship	ES
LCF	DE, FR, NO, PT
FCC hh	AU, CZ, DE, FI, FR, PT, RS, UK



ESG WG1 National Inputs

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

iii. If the US proceeds with a muon collider

A muon collider faces higher technical risks and a longer development timeline.
By and large, national HEP community inputs see no reason to change the preference.
According to the U.S. strategy input, the realization of a Muon Collider at the national level is not expected to be achievable within the 2045–2048 timescale.
However, a more optimistic view is presented in the National Academies report released on 11 June:
"Elementary Particle Physics: The Higgs and Beyond"
https://nap.nationalacademies.org/catalog/28839/elementary-particle-physics-the-higgs-and-beyond

iv. If there are major new (unexpected) results from the HL-LHC or other HEP experiments

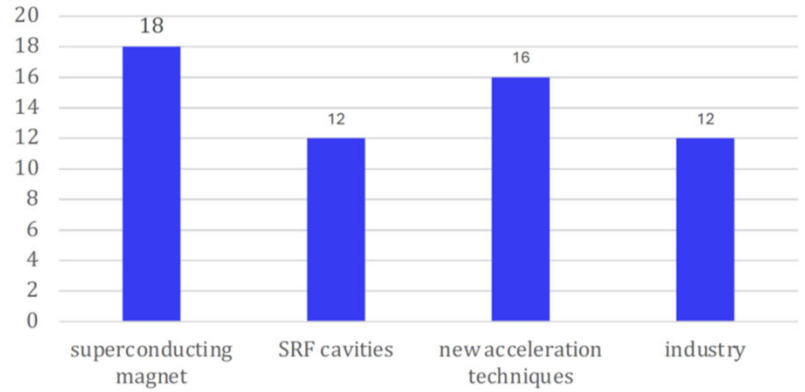
Although some Member States acknowledge that the HL-LHC or other experiments might yield surprises and consider a possible extension of the HL-LHC, there is a strong agreement that any delay would be detrimental to the overall scientific program of CERN.

ESG WG1 National Inputs

d) Beyond the preferred option, what other accelerator R&D topics?

- Continued innovation in **superconducting magnet technology**, especially using HTS, is deemed essential for collider performance limits to be pushed.
- **High-performance SRF cavities** are regarded as foundational for linear and circular accelerators, with research targeted at higher gradients and quality factors and industrial application transition.
- **Groundbreaking methods** such as Plasma Wakefield Acceleration, Muon Acceleration and Cooling, Energy Recovery Linacs, and Terahertz Acceleration are to be invested in, requiring extensive R&D and demonstration facilities.
- **Industry engagement** is to be strengthened to accelerate technology transfer and innovation. Accelerator R&D benefits beyond particle physics - to medicine, energy, and other infrastructures - are to be highlighted to support investment.

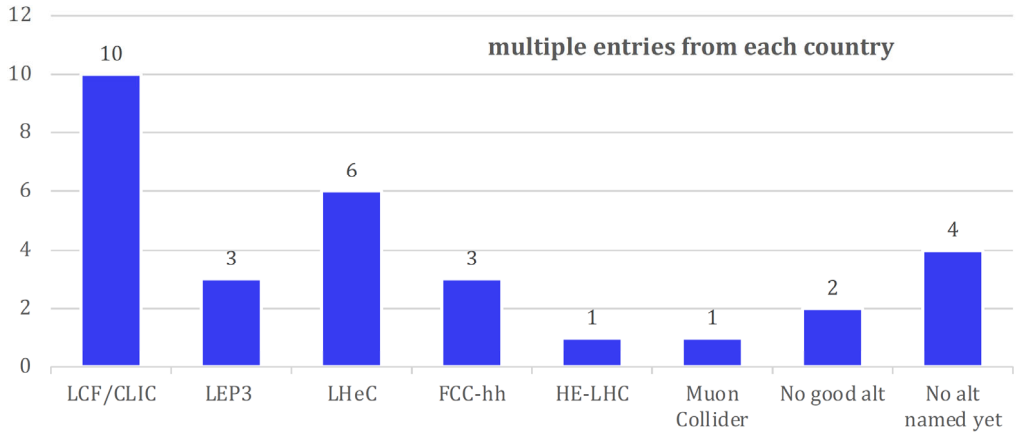
Superconducting magnet technology	AT, BE, CH, DE, DK, ES, FI, FR, GR IT, NL, PL, PT, RO, RS, SE, SK, UK
SRF cavities	AT, BE, DE, ES, FI, FR, GR, IT, PL, RO, RS, UK
New acceleration techniques	AT, BE, DE, DK, EE, ES, FR, GR, IT, PL, PT, RO, RS, SE, SK, UK
Industry engagement	AT, BE, DE, ES, FR, IT, NL, PL, RO, RS, SE, UK



ESG WG1 National Inputs

e) What is the prioritised list of alternative options if the preferred option is not feasible?

- Nine 10 countries (DE, ES, FI, FR, NO, PL, PT, SE, SR, SLK) list a linear collider at CERN as the next best choice, with one (FI) mentioning the need for it to be affordable. Two (DE, ES) of these countries highlight the benefits of polarized beams, the potential for two interaction points, and its ability to be upgraded.
- Two countries (CH, HU) see no reason for another option, as they would be equally costly.
- Three countries (BE, GR, UK) mention LEP3 as a genuinely less costly alternative to the FCC-ee.



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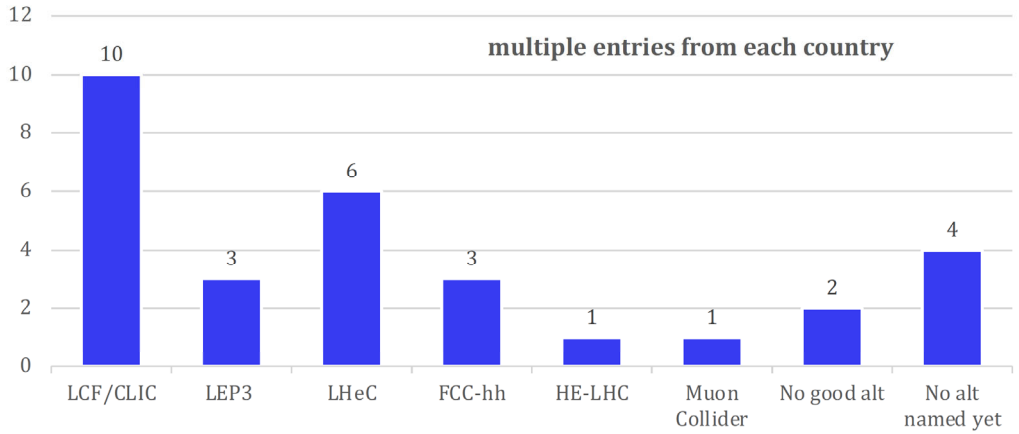
ESG WG1 National Inputs

e) What is the prioritised list of alternative options if the preferred option is not feasible?

- Two other countries (AT, NL) aren't yet committed to a preferred option and suggest a feasibility study for at least one alternative to the FCC-ee.
- No alternatives have been named yet by four other countries (CZ, DK, IT, SK).
- A muon collider would be the top alternative for one country (GR), and an option for later consideration for two others (RS, NO). For other countries, it's seen as interesting but not yet ready.
- Six countries (BE, DE, FR, NL, SE, UK) support the LHeC, mostly as an intermediate project before the 10 TeV scale.
- One country (RO) brings up a lower energy hadron collider with an ep collision option. Hadron collider options are also mentioned by three other countries (DE, RS, GR).



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ESG WG1 National Inputs

Concluding remarks

- The national contributions highlight national scientific priorities and strategic recommendations.
- One of the **key messages is the broad support** for the FCC integrated ee and hh programme, which clearly stands out as the top-priority option for the future of collider-based particle physics.
- If the FCC is not feasible, **no clear consensus on an alternative collider path emerges yet**, underscoring the importance of **continued dialogue and assessment**.
- Reminder: national HEP communities may, and are encouraged, to address the question of alternative options by submitting **updated contributions by 14 November 2025**.
- **Strong and consistent support for accelerator R&D**, recognizing its essential role in enabling future discoveries and maintaining technological leadership.
- **Near unanimity that we should keep Europe at the forefront of particle physics.**

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WG2a: Project Comparison

European Strategy for Particle Physics: 2026 Update

- Key messages from the Symposium -

Strategy Secretariat
Karl Jakobs (Chair), Hugh Montgomery (SPC), Mike Seidel (LDG), Paris Sphicas (ECFA)

Venice Open Symposium, 27 June 2025

For projects to be considered for realisation as the next flagship project at CERN, several aspects need to be thoroughly evaluated and compared. Two sub-groups tasked:

- 2a) Project assessment
  - Technical feasibility, required R&D
  - Risks
  - Timeline
  - Costs and human resources (including estimates for the associated detectors)
  - Environmental impact
- 2b) Physics potential

Gianluigi Arduini, Phil Burrows for WG2a

K. Desch, S. Farrington, F. Gianotti, K. Hanagaki, J. Keintzel, B. Kilminster, T. Lesiak, F. Sabatié, M. Tuts, A. Zoccoli

European Strategy Update

Accelerator Challenges

Circular Colliders (e^+/e^-)

Beam is recirculated, enabling high luminosity, but synchrotron radiation (SR) losses constrain the energy

- High luminosity is achieved with **advanced but challenging schemes (e.g. crab waist)**
- High-luminosity goals may be constrained by **beam-beam and intensity effects**

  Lumi / bunch pair (different machines: E, # bunches)

  (SuperKEKB^{2024}: 2.2×10^{31} cm^{-2}s^{-1} → FCC-ee Z: 1.3×10^{32} cm^{-2}s^{-1})
- Smaller circumference imply strong quadrupoles / sextupoles to maintain luminosity (e.g. LEP3)
- Simulation benchmarking with reliable input parameters and diagnostics are required (SuperKEKB and DAΦNE experience/test are very valuable)

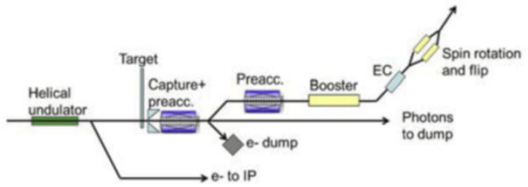
Linear Colliders

No SR but beam energy dumped after a single collision

- **High acceleration gradients** needed for cost efficient accelerators with reasonable length
- **Beamstrahlung constrains** beam parameters at IP
- The small beams needed for high luminosity require stabilisation and extremely tight optics control and correction capabilities
- **Positron production** and capture at high intensity is critical

  (SLC: ~6×10^{12} e^+/s

  LCF: ~4-8×10^{14} e^+/s) → R&D needed



K. Jakobs, ESPP Open Symposium, 27th June 2025

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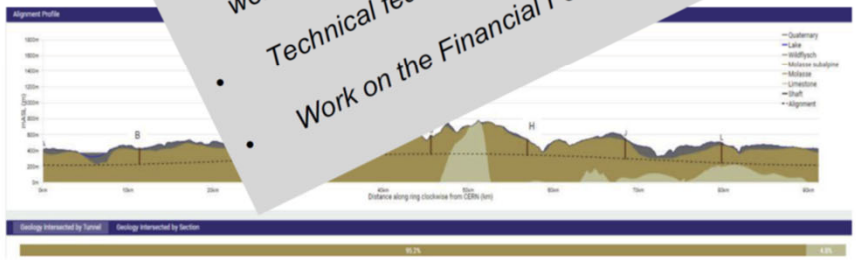
FCC Feasibility Study

- Layout converged on an optimised placement, chosen out of ~ 100 initial variants;

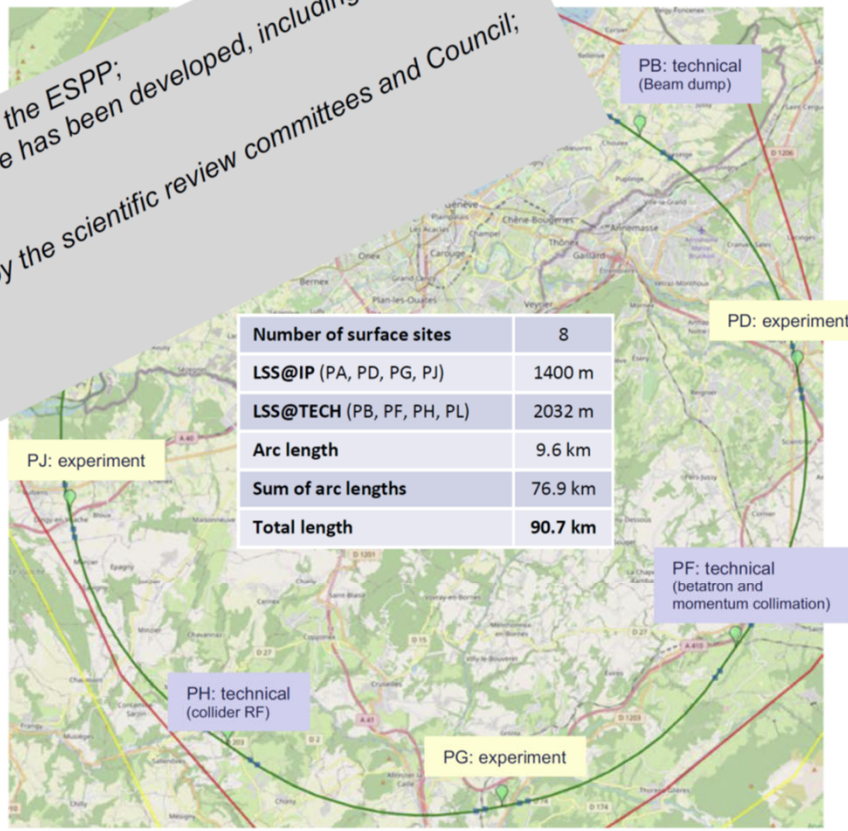
  (based on **geology** and **surface constraints** (land availability, access to roads, etc.), **environment,** (protected zones), **infrastructure** (water, electricity, transport), **machine**

- 90.7 km ring, 4-fold symmetry
  8 surface
  Whole project

- Feasibility Study has been concluded; final report submitted to the ESPP;
- → coherent baseline design for the FCC integrated programme has been developed, including a well advanced territorial implementation scenario.
- Technical feasibility demonstrated, pending final review by the scientific review committees and Council;
- Work on the Financial Feasibility ongoing



95% in molasse geology → minimising tunnel construction risk



Number of surface sites	8
LSS@IP (PA, PD, PG, PJ)	1400 m
LSS@TECH (PB, PF, PH, PL)	2032 m
Arc length	9.6 km
Sum of arc lengths	76.9 km
Total length	**90.7 km**

K. Jakobs, ESPP Open Symposium, 27th June 2025

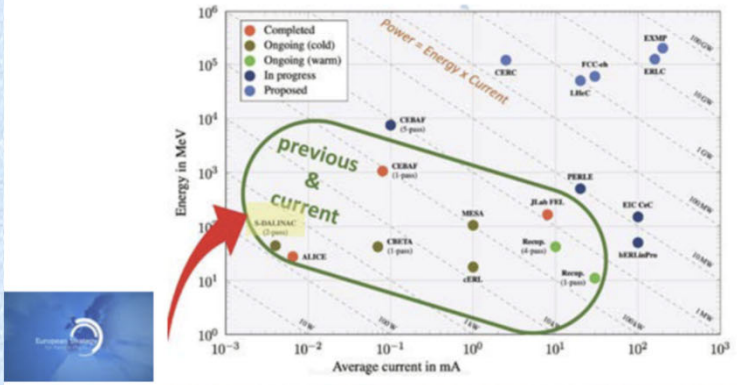
Accelerator Challenges

LHeC / Energy Recovery Linacs

Allow high luminosity for ep collisions

- Very high currents; recirculation efficiency is critical

  (25 mA@ 50GeV → 1.25 GW circulating power)
- R&D on superconducting linac technology:
  - high power couplers
  - fast reactive tuners
  - HOM suppression
- Comprehensive beam dynamics simulations needed to ensure performance

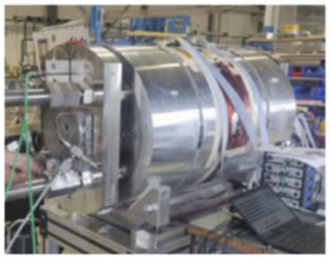


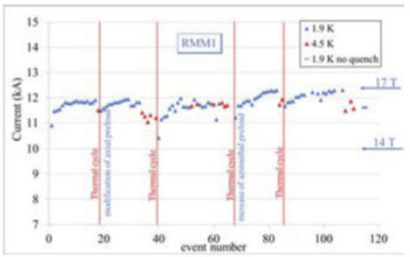
FCC-hh

Highest energy hadron collider

- **High-field magnets 14-20 T needed;**

  High priority R&D on HTS/LTS to identify the best solution
- Magnets need sophisticated system integration to ensure high field strength and acceptable field errors, but also efficient heat removal from SR deposition, good vacuum conditions for beam
- Increase of circulating beam energy by more than order of magnitude compared to LHC challenges machine protection and collimation
- **Superconductor supply and cost are critical**





Cost Estimates

FCC-ee cost estimate (FSR 2025)

Capital cost (2024 CHF) for construction of the FCC-ee is summarised below. This cost includes construction of the entire new infrastructure and all equipment for operation at the Z, WW and ZH working points.

FCC-ee

Domain	Cost [MCHF]
Civil engineering	6,160
Technical infrastructures	2,840
Injectors and transfer lines	590
Booster and collider	4,140
CERN contribution to four experiments	290
FCC-ee total	**14,020**
+ four experiments (non-CERN part)	1,300
FCC-ee total incl. four experiments	**15,320**

15.3

16.6

Note: Upgrade of SRF (800 MHz) & cryogenics for ttbar operation corresponds to additional cost of 1,260 MCHF

LCF CLIC

Unit: MCHF	LCF 250 (LP)	Δ LCF 550 (FP)	CLIC 380	Δ CLIC 1500
Collider	3864	4204	2471	4684
Main Beam inj./transfer	1181	86	1046	23
Drivebeam inj./transfer	-	-	1060	302
Civil Engineering	2338	0	1403	703
Technical Infrastructure	1109	1174	1361	1404
Sum	**8492**	**5464**	**7341**	**7116**

14.0

14.4

LEP3

Cost Element	2 new Xpts	2 Exist Xpts
Accelerator	2705	2705
Injectors and Transfer Lines	295	295
Technical Infrastructures	435	435
Experiments	130	60
Civil Engineering	165	165
LHC Removal/LEP3 Installation	140	140
Total CERN (MCHF)	**3870**	**3800**
Experiments non-CERN part	900	270

3.9

FCC-hh
(after FCC-ee)

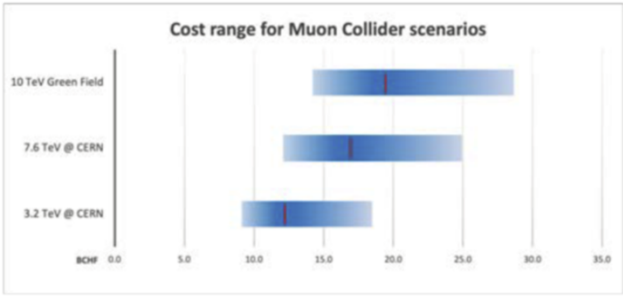
Cost summary table in 2024 MCHF for the construction of FCC-hh.

Domain	FCC-hh Cost [MCHF]
FCC-ee dismantling	200
Collider*	13400
Injectors and transfer linear	1000
Civil Engineering	520
Technical infrastructures	3960
Experiments	N/A
Total	**19080**

*target price of 2.0 MCHF per 14.3 m long magnet with 1.0 MCHF of conductor, 0.5 MCHF for assembly, and 0.5 MCHF for components

19.1

Muon Collider



9-28

LHeC (cost estimate 2018, 60 GeV e-)

Budget Item	Cost
SRF System	805MCHF
SRF R&D and Proto Typing	31MCHF
Injector	40MCHF
Magnet and Vacuum System	215MCHF
SC IR magnets	105MCHF
Dump System and Source	5MCHF
Cryogenic Infrastructure	100MCHF
General Infrastructure and installation	69MCHF
Civil Engineering	386MCHF
Total	1756MCHF

→ ~ 2.0

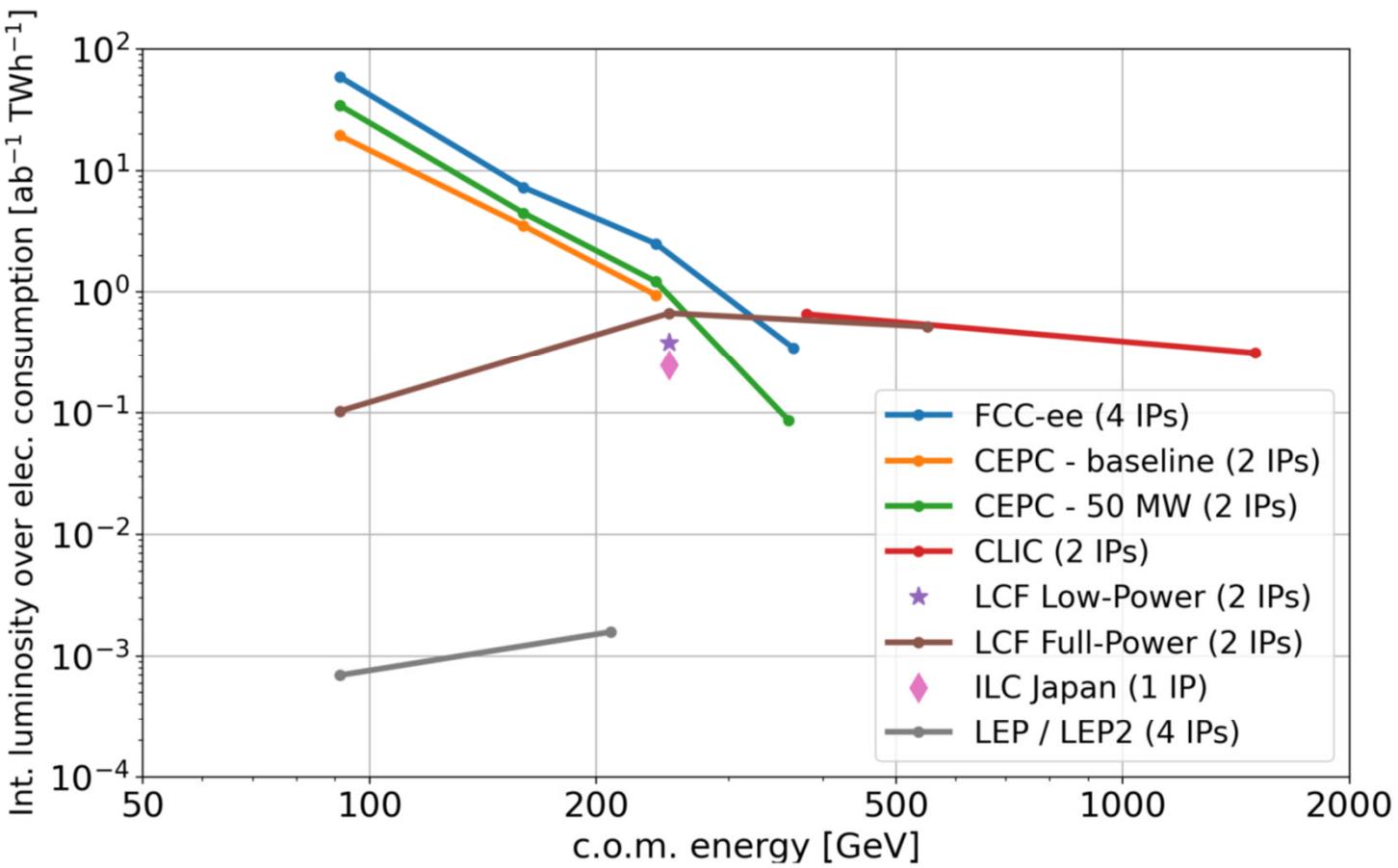


Fig. 1.1: Integrated luminosity over all experiments per year, per unit of electricity consumption for future electron-positron colliders (excluding off-line computing); the performance has been rescaled to the FCC-ee operational year for CEPC and to LCF 250 Low-Power (LP) for the ILC (see Table A.1). For LCs the total luminosity (including that below 99 % of the nominal c.o.m. energy) is considered. LEP and LEP2 data were respectively taken for the years 1993 and 2000 [1–3]. For the ILC, a single IP is considered but with two experiments (in "push-pull" mode, see Section 8.1). The information for LEP3 has not been added at this stage.

Pursuing a compelling scientific programme complementary to high-energy colliders

Physics Beyond Colliders Study Group

Neutrino physics

SHiP
SBN@CERN (ENUBET/NuTAG)
FASER, FPF, ***SND@LHC***

QCD related and other SM precision measurements:

AMBER, SMOG2, LHCspin, ALADDIN, ***TWOCRYST***
DICE/NA60+, ***NA61/SHINE***
(***FASER***, FPF, ***SHiP***, ***SND@LHC)***
MUonE, FAMU
EDMs (ALADDIN, cpEDM, @ISOLDE)
Strong-field QED (PAX, @AWAKE, @FCC-ee/LC)
Gravitational field of LHC beam

Hidden sector with "beam dump"

NA62, NA64, SHiP
BD@AWAKE
NA64@FCC-ee(injector), BD@LC
REDTOP

From the DG talk
at Venice Symposium

Bold: running or approved experiments

The Physics Beyond Colliders Study Group, established in 2016 and supported by the 2020 ESPP update, explores scientific opportunities offered by CERN accelerator complex that are complementary to LHC main programme.
Also wide support to similar efforts in other Member State laboratories.

New long-lived particles from LHC:

ANUBIS, CODEX-B, MAPP-2, MATHUSLA40, SHIFT
FASER, FPF, ***SND@LHC***

Non-accelerator projects:

Exploit CERN's technology (RF, vacuum, magnets, optics, cryogenics) for experiments at CERN or at other laboratories.

AION-100, axion heterodyne detection, ***BabyIAXO***, FLASH, RADES

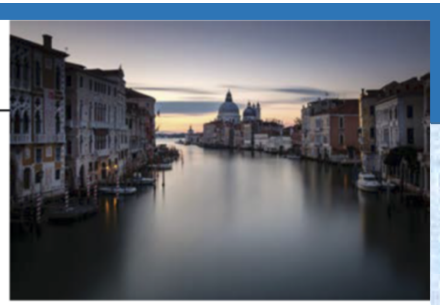
Other facilities

cpEDM
γ-factory from partially stripped ions
SBN@CERN (ENUBET/NuTAG)

Courtesy G. Schnell

European Strategy Update

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

Timeline for the update of the European Strategy for Particle Physics

May 2026, Budapest – official announcement of the ESPP

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

6-7.Nov – extraordinary CERN Council devoted to the FCC FS

Once upon a time in Venice…

https://www.ebay.com/itm/275931164051

Holidays, Love and the Most Beautiful City in the World:

Copyright: Tadeusz Lesiak

Once upon a time in Venice…

Ania and Janek have been living together for some time now.

Despite their affection, Janek begins to be fascinated by her mysterious neighbor

His acquaintance with the other woman begins unluckily,
but soon it turns out that they are not indifferent to each other.

?

A surprising twist of fate makes them both go to Venice in the summer. Staying together in a magical city changes their lives forever...

Magda Knedler's new novel is a true cocktail of emotions. It's a touching and complicated romance balancing between happy and unfulfilled love.

Is it only in Venice that you discover who you really love?

Text from:
https://www.ebay.com/itm/275931164051

Backup

ESG WG1 National Inputs

f) What are the most important elements in the response to (e)?

- *Physics Potential:*
  - The chosen project must address fundamental questions and offer significant discovery potential or precision measurements: 11 countries (AT, BE, DK, FI, GR, NO, PL, RS, CH, SE, UK).
  - Although alternatives may involve compromises like lower energy or luminosity compared to the preferred FCC program (BE, CH, SE, UK, RS):
    - Their physics goals should still align with community priorities, such as serving as a Higgs factory (DE, PL, UK).
    - Additionally, they are expected to explore complementary areas or build on HL-LHC results (AT, BE, DK, FI, NO).

- *Financial and Human Resources / Cost / Affordability:* These are significant considerations, especially if the preferred option's non-feasibility is primarily due to cost, a point emphasized by 6 countries (BE, DE, GR, NO, RO, RS).
  - In such scenarios, 3 countries (AT, BE, NO) view less resource-intensive projects or those fitting within existing budgets as viable alternatives.

- *Timing:* To maintain expertise and provide opportunities for the community, especially for early-career researchers, it is crucial to ensure the research program continues without long gaps between major facilities, a point emphasized by 10 countries (BE, CA, DK, GR, RO, RS, FI, ES, UK, SI).

- *Long-term Perspective / Maintaining CERN's Role:* Alternatives are evaluated based on how each country contributes to the future of particle physics and secure CERN's position as a leading global hub, a point highlighted by 9 countries (AT, BE, FI, GR, RO, RS, SE, UK, SI). This also includes considering the potential for future upgrades or stages, such as hadron colliders after lepton colliders, which 4 countries noted (PL, SI, SE, CH).

14

ESG WG1 National Inputs

f) What are the most important elements in the response to (e)?

- *Careers and Training:* A key concern addressed by pursuing new projects is providing opportunities for young scientists and engineers and preventing a loss of expertise in the field, as highlighted by 8 countries (DK, FI, GR, RO, RS, ES, UK, SI]).

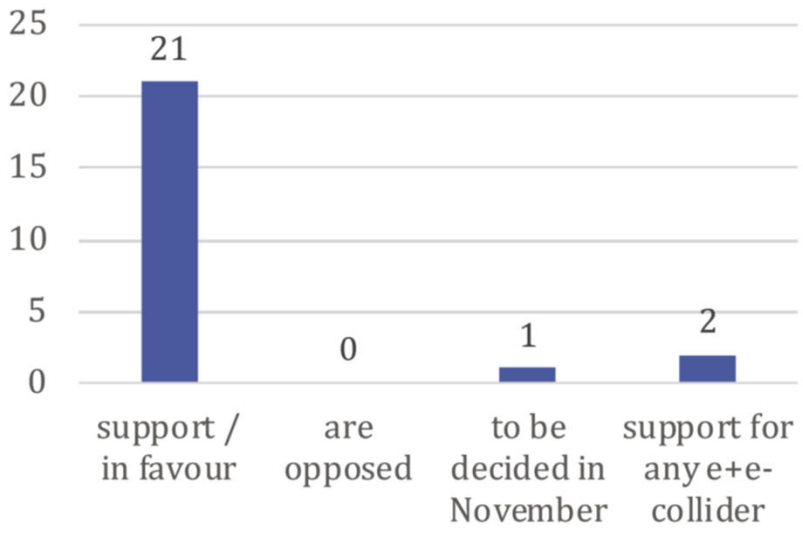
- *International Developments:* The global landscape of projects, such as the ILC, CEPC, and Muon Collider, can influence the strategic choice of alternatives at CERN to ensure complementarity or competitiveness, a factor highlighted by 4 countries (DK, GR, RO, RS).

- *Sustainability:* While sometimes not the top priority compared to physics or cost, the environmental impact and long-term energy sustainability are recognized as important factors for future projects by 7 countries (BE, GR, RO, RS, DK, FR, SI).
  - Some countries didn't present prioritized alternatives.
  - One country (HR) cites a lack of community agreement, while 3 others (CH, HU, SE) believe no truly viable alternative exists compared to the preferred program, based on factors like physics potential, timeline, or community support. Additionally, one country (SI) notes having limited insight into alternatives.

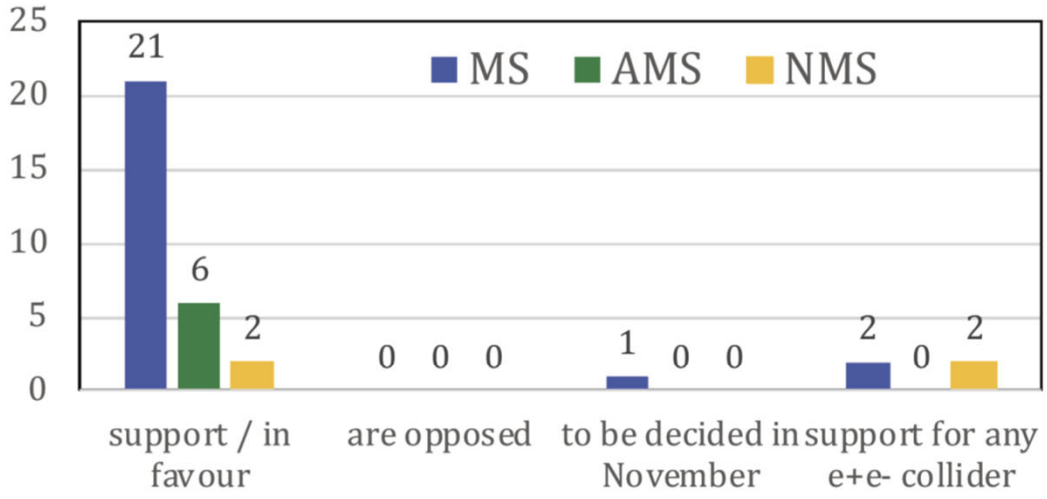
ESG WG1 National Inputs

What is the preferred large-scale accelerator for CERN

CERN Member States (MS)



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

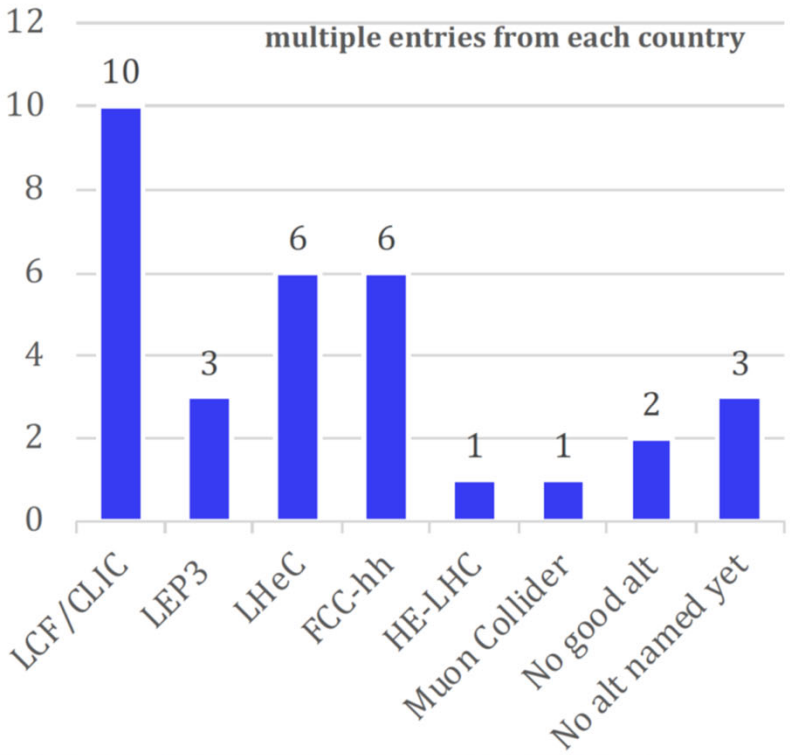


- Overwhelming support (21/24 CERN MS HEP communities) in favour of the integrated FCC-ee/hh programme

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

ESG WG1 National Inputs

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.

Accelerator Challenges

Muon Colliders

Muon colliders provide a path towards high energy lepton collisions but are not at the level of maturity of the other proposals at present.

- Demonstration of the **6D-cooling technology** is critical
- **Technological challenges are associated with the various acceleration steps**, in particular s.c. magnets, RF systems, fast cycling magnets
- Reliable start-to-end simulation tools need to be further developed to validate and optimise the overall performance
- Mitigation of **neutrino flux** and resulting secondary radiation remains a critical issue