European Strategy for Particle Physics: 2026 update

- Status and plans -

Karl Jakobs (Strategy Secretary)

Canadian Subatomic Town-Hall Meeting
2nd April 2025

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

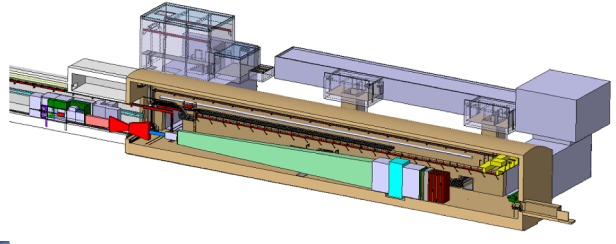
- *In addition:*

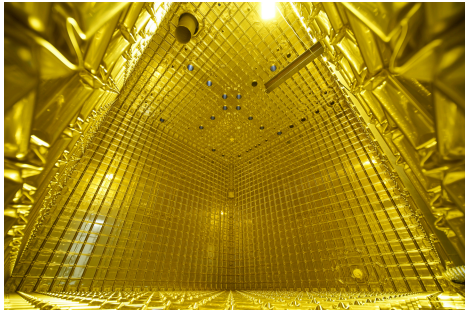
  - ***Long timescales, long-term community engagement***

    * 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)
Hugh Montgomery (SPC Chair)
Mike Seidel (LDG Chair) (→ has replaced Dave Newbold (STFC) as new LDG Chair on 1st Jan. 2025)
Paris Sphicas (ECFA Chair)

European Strategy Group (ESG) Preparation of the Strategy Document

- 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.

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

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 has set up **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	Scientific Secretary
Electroweak physics	Monica Dunford (DE, exp)	Jorge de Blas (ES, theory)	Emanuele Bagnaschi (IT)
Strong interaction	Cristinel Diaconu (FR, exp)	Andrea Dainese (IT, exp, HI)	Chiara Signorile-Signorile (DE)
Flavour physics	Gino Isidori (CH, theory)	Marie-Hélène Schune (FR, exp)	Maria Piscopo (NL)
BSM physics	Fabio Maltoni (BE/IT, theory)	Rebeca Gonzalez Suarez (SE, exp)	Benedikt Maier (UK)
Neutrino physics and cosmic messengers	Pilar Hernandez (ES, theory)	Sara Bolognesi (FR, exp)	Ivan Esteban (ES)
Dark matter and dark sector	Jocelyn Monroe (UK, exp)	Matthew McCullough (CERN, theory)	Yohei Ema (CERN)
Accelerator science and technology	Gianluigi Arduini (CERN, acc)	Phil Burrows (UK, exp, acc)	Jacqueline Keintzel (CERN)
Detector instrumentation	Thomas Bergauer (AT, exp)	Ulrich Husemann (DE, exp)	Dorothea vom Bruch (FR)
Computing	Tommaso Boccali (IT, exp, comp)	Borut Kersevan (SL, exp, comp)	Daniel Thomas Murnane (DK)

Physics Preparatory Group

- Each group has **two co-conveners** and one Early-Career Researcher (ECR) as **Scientific Secretary** to organise the work
- ECRs have been appointed by the co-conveners, in consultation with the Strategy Secretariat
  (partially based on nominations via ECFA)

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 (✔)
- Definition of benchmark processes / measurements (✔)
  (iteration with large-scale projects done)
- Organisation of working-group meetings ongoing
- Writing of the **Physics Briefing Book** → Sept 2025
  (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.

PPG work in Technical Areas

- **Detector instrumentation**: will look at requirements from projects and whether they are covered by the R&D activities as carried out in the DRD collaborations;

  (The DRD Collaborations have been established as a result of the 2020 Strategy, where the development of a Detector R&D Roadmap by ECFA was suggested)

- **Accelerator technologies**: similar, check on requirements of projects and whether they are properly addressed by the corresponding R&D activities;
  → Establish the R&D needs, timeline, resources for future projects

  (Also as a result of the 2020 Strategy, an Accelerator R&D Roadmap has been developed by the European Laboratory Directors Group (LDG))

- **Computing**: what will be the computing needs for new projects, how can they be covered, what R&D lines are needed?

In all of these discussions, **sustainability** arguments will be considered

Timeline for the update of the European Strategy for Particle Physics

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

Input on large collider 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?
  Input from → LDG + HFM Collaboration (Accelerator Roadmap)

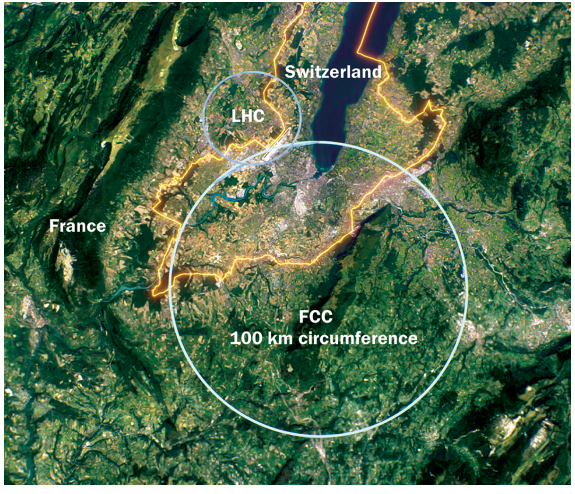
  (ii) Physics potential of a 91 km hadron collider with 12 or 14 T magnets (or lower);
  → plan to include it in FCC Feasibility Study report

- Linear Collider at CERN
- Muon Collider at CERN
- Extended LHC / LHeC physics programme
- Re-use of LEP/LHC ring for e^+e^- collisions: LEP3
- ….

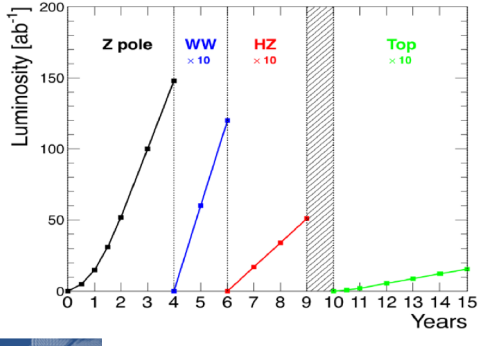
Input has been prepared by respective communities

Guidelines for Input by large-scale projects

Future e^+e^- collider options for CERN



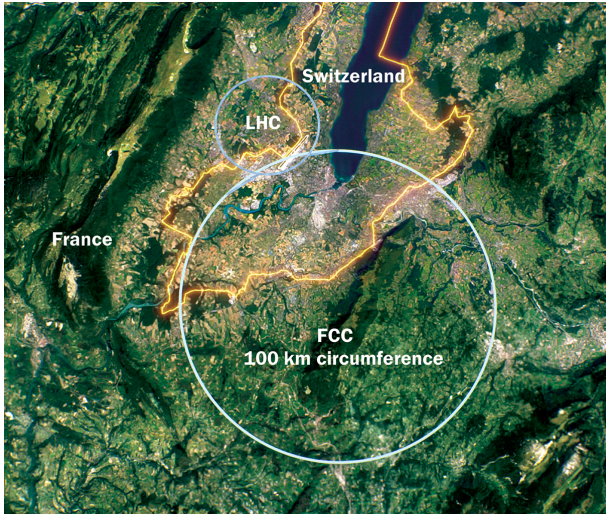
- FCC-ee
  (baseline, based on 2020 Strategy)



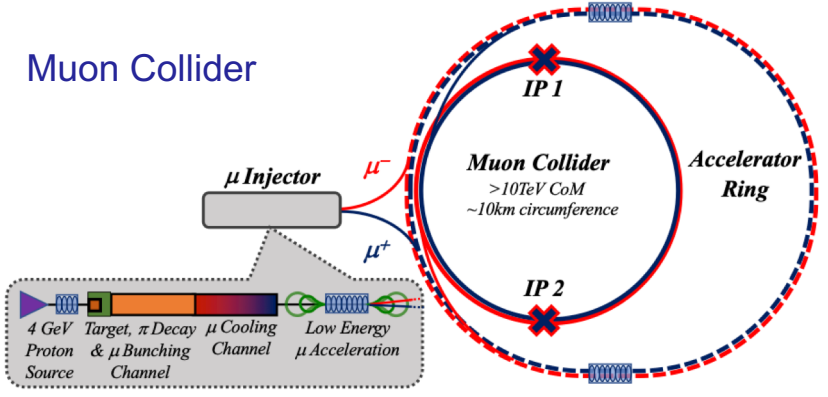
Linear Collider Facility
(ILC @CERN, CLIC, …)

Inital stage: 250 GeV → 550 GeV (2nd stage)

Future 10-TeV parton-scale collider options for CERN



Muon Collider

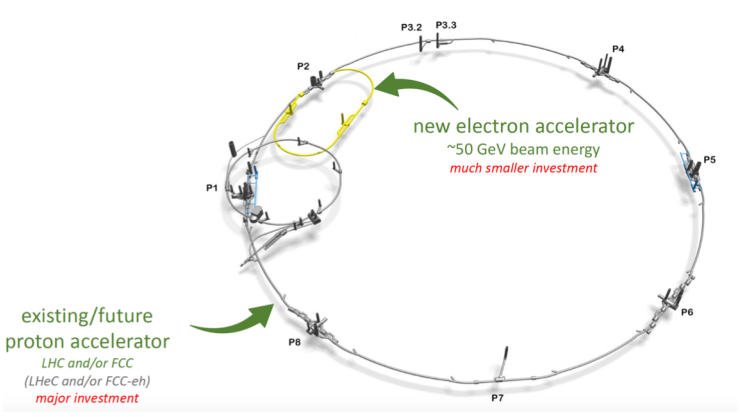


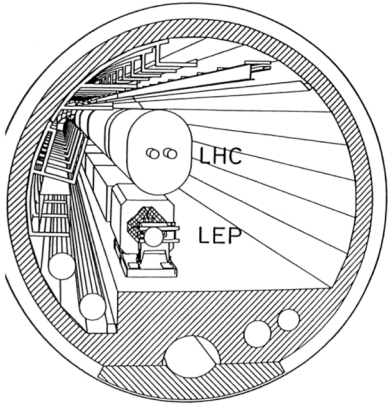
- FCC-hh (80 – 120 TeV)
  (depending on the magnet technology)

Linear Collider Facility
(with improved acceleration technology, e.g. plasma acceleration)

"Bridge projects" towards reaching the 10 TeV scale

LHeC (> 50 GeV electron beam)
E_{CM} = 0.2 – 1.3 TeV (Q^2,x) range beyond HERA;
Bridge between HL-LHC and future large facility





Further exploitation of the LHC;
Addition of an eh-programme

LEP3:
re-using the LEP/LHC tunnel for e^+e^- collisions at 230 GeV

Motivation:

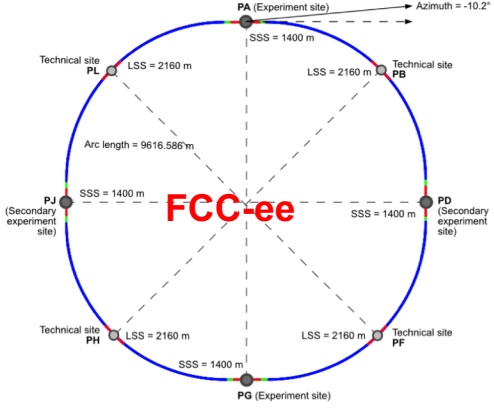
- *Leave room (time, budget, resources) for further development of THE machine that can probe directly the energy frontier at a constituent $\sqrt{s}$ ~ 10 times LHC*
- *Exploit interesting physics at CERN in the meantime*

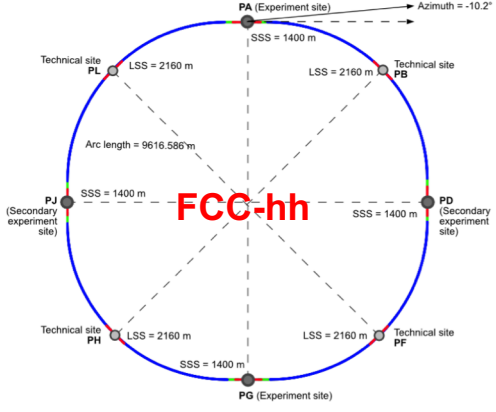
FCC integrated programme

Comprehensive long-term programme maximising physics opportunities:

- Stage 1: FCC-ee : e^+e^- Higgs, electroweak & top factory at highest luminosities [91 GeV → 365 GeV]
  Build on large progress made at circular e^+e^- colliders over the past decades → reach luminosities beyond 10^{34} cm^{-2} s^{-1}
- Stage 2: FCC-hh : 100 TeV pp collider, energy frontier machine (in addition: eh and ion options)

- Common civil engineering and technical infrastructures, building on and reusing CERN's existing infrastructure
- FCC project start is coupled to HL-LHC programme → start operation of FCC-ee around 2048;
  can be accelerated if more resources available





2030 - 2041 | 2048 - 2063 | 2074 -

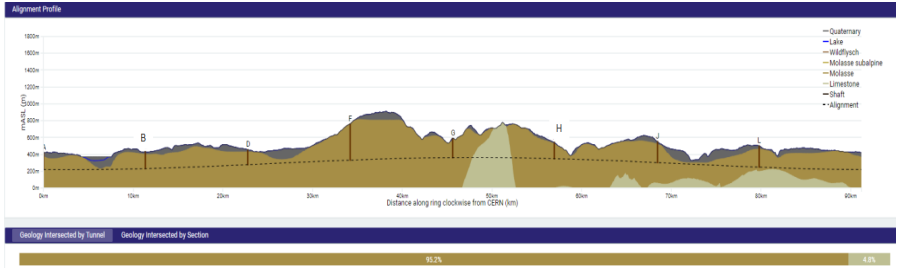
Optimised FCC layout (used for further feasibility studies)

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

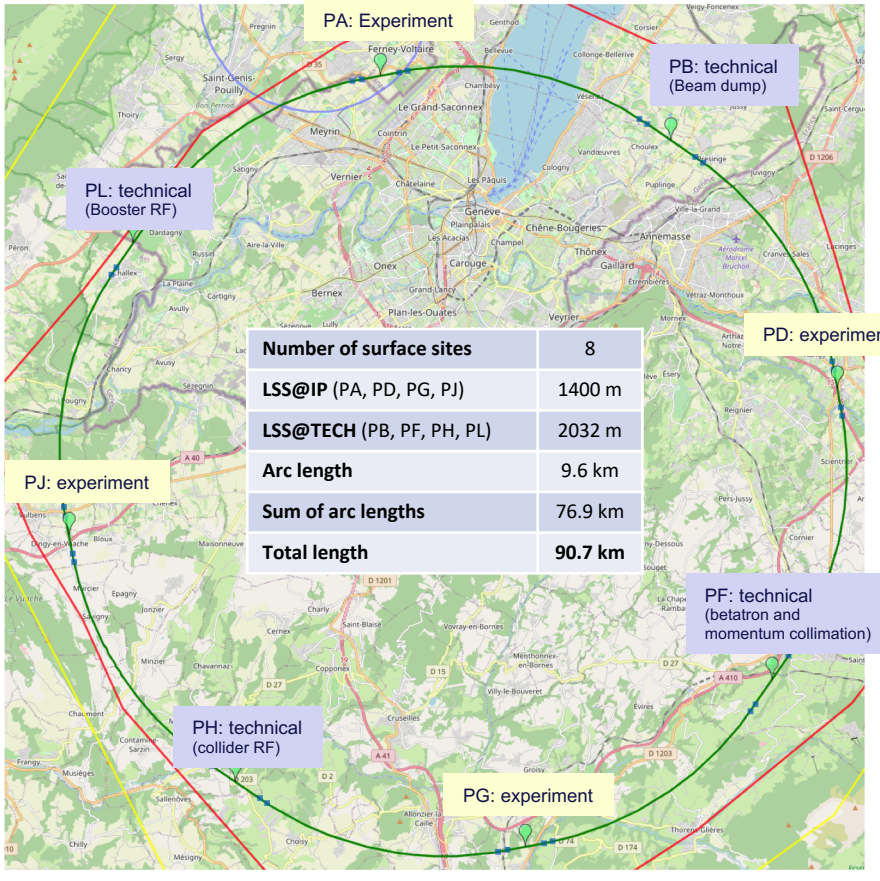
  (based on **geology** and **surface constraints** (land availability, access to roads, etc.), **environment,** (protected zones), **infrastructure** (water, electricity, transport), **machine perf.** etc.)

- 90.7 km ring, 4-fold symmetry
  8 surface points, 2 - 4 experiments

  Whole project now adapted to this placement



95% in molasse geology → minimising tunnel construction risk



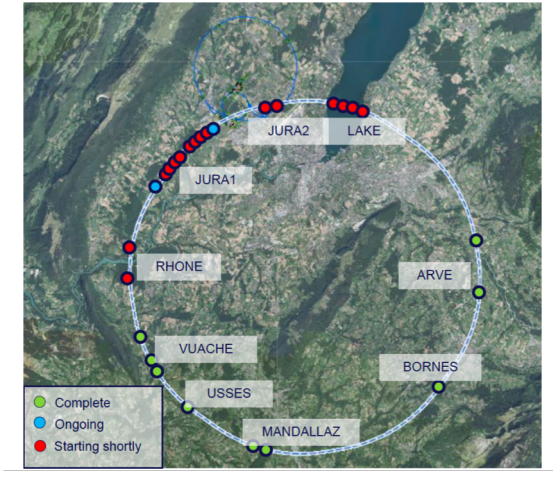
Number of surface sites	8
LSS@IP (PA, PD, PG, PJ)	1400 m
LSS@TECH (PB, PF, PH, PL)	2032 m
Arc length	9.6 km
Sum of arc lengths	76.9 km
Total length	**90.7 km**

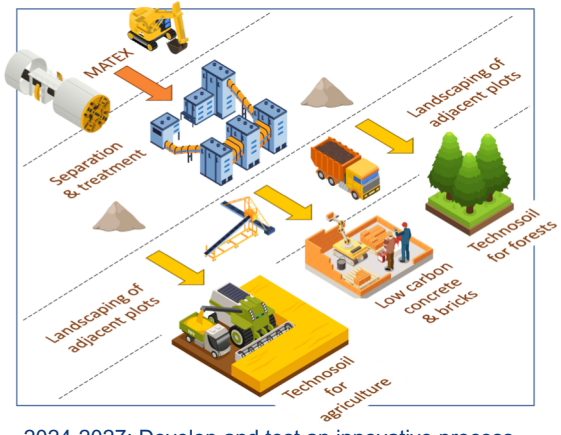
FCC Feasibility Study

Focus 2024 - 2025:

- Subsurface investigations, further optimisation of implementation
- Design iteration (technical and cost optimisation)
- Reduction of cost uncertainties, development of risk register
- Further development of an affordable funding model and related governance implications (with Council)
- Environmental impact (civil engineering, excavated materials, sustainability); geological investigations

→ Final FCC Feasibility Study Report has been submitted to the European Strategy Update on 31st March 2025

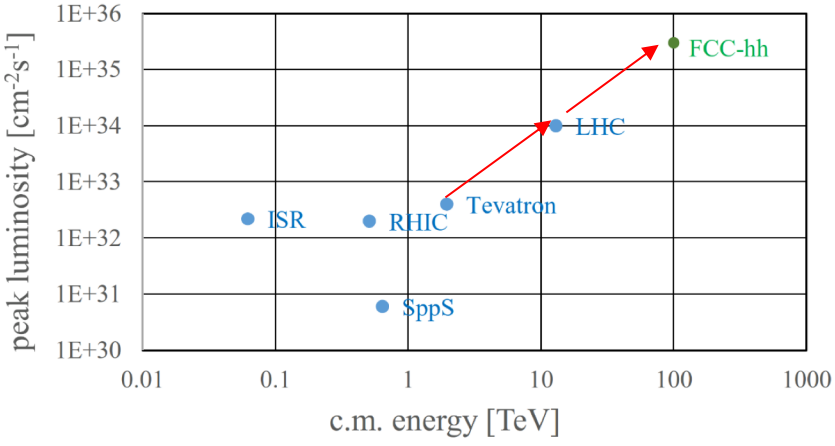




2024-2027: Develop and test an innovative process to transform sterile "molasse" into fertile soil for agricultural use and afforestation.

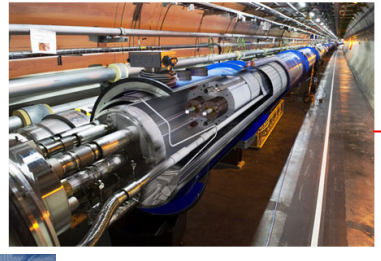
Stage 2: FCC-hh

- High energy frontier exploration machine, reaching **~100 TeV pp collisions**
- Performance increase by an order of magnitude in energy and luminosity w.r.t. LHC
- Planned to accumulate ~20 ab^{-1} per experiment, over 25 years



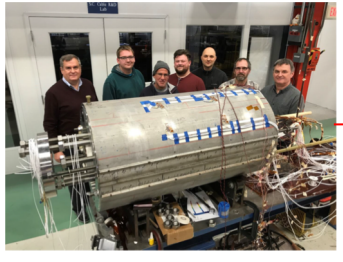
- Large challenges: - High bending power → high-field magnets with field strength of 16 – 20 T;
  - Costs (linked to magnets)

From LHC technology
8.3 T NbTi dipole



via HL-LHC technology
12 T Nb_3Sn quadrupole

via large R&D programme
(e.g. FNAL 14.5 T Nb_3Sn
dipole demonstrator, 2019)



.. to high-field, high performance, industrially mass-produced FCC-hh dipole magnets

14 T (Nb_3Sn)?
16 – 20 T ?
High-field magnets,
HTS technology?
(High Temperature Superconductors)

FCC-hh baseline for the Feasibility Study

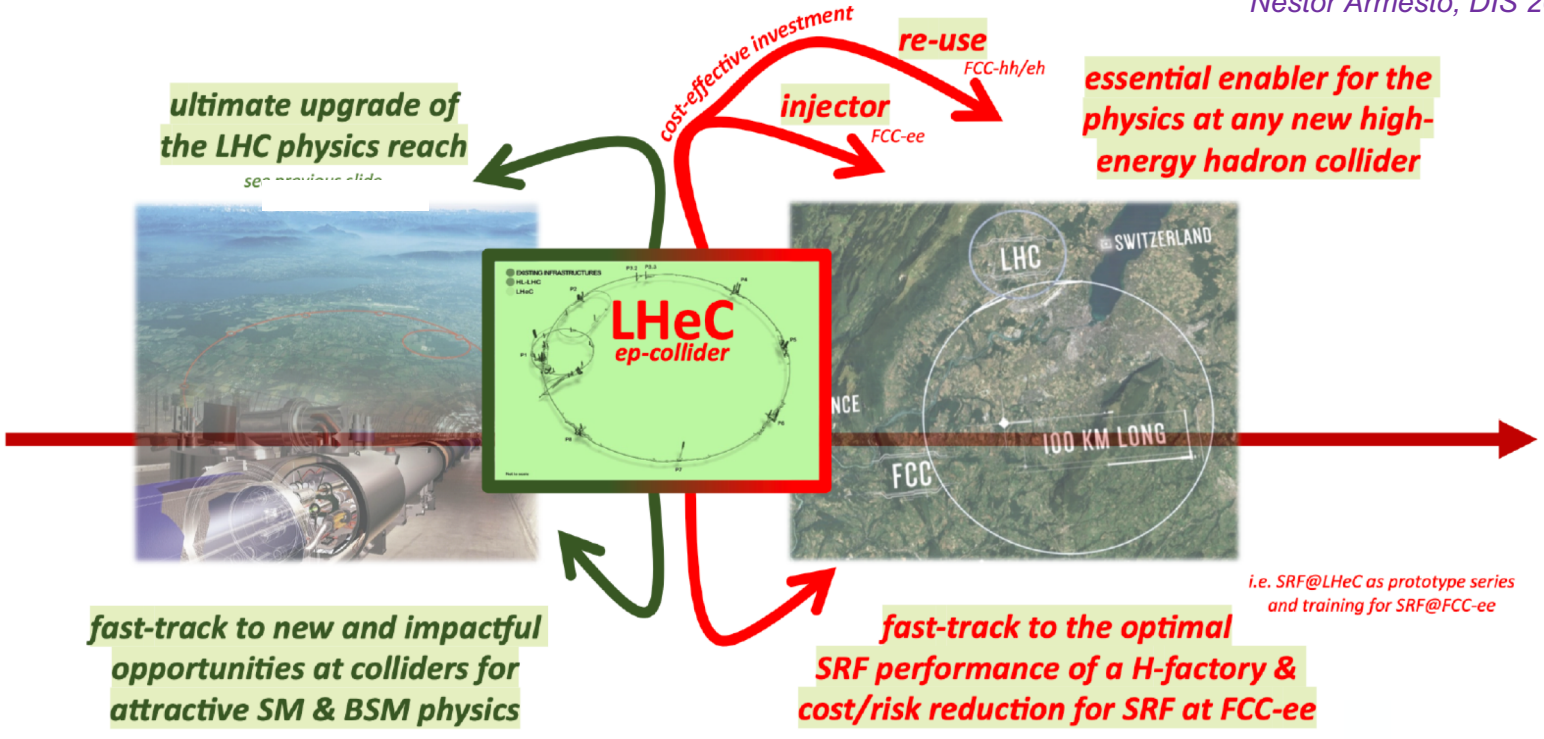
- Parameter optimisation towards "acceptable power consumption"
- Magnetic field considered realistic with today's technologies (Nb_3Sn, 14 T)
- Optimised accelerator optics design to increase arc dipole filling factor to maximise beam energy
- Increase cryo-magnet operation temperature

Parameter	Unit	FSR (2024)	CDR (2018)	(HL-)LHC
c.m. energy	TeV	85	100	14
dipole field	T	14	16	8.33
beam current	A	0.5	0.5	(1.12) 0.58
bunch population	10^{11}	1.0	1.0	(2.2) 1.15
bunches/beam		9500	10400	(2760) 2808
rf voltage	MV	35	20 - 48	(16) 16
longitudinal emit.	eVs	8.1	9.0	2.5
normalized transverse emittance	μm	2.2	2.2	(2.5) 3.75
IP beta*	m	0.3	0.3	(0.15) 0.55
initial σ*	μm	3.8	3.5	(7.1 min) 16.7
Initial luminosity	$nb^{-1}s^{-1}$	**170**	**200**	(50, lev'd) 10
initial pile up		590	690	(135) 27
ΔE / turn	MeV	2.4	4.7	0.0067
SR power/beam	kW	1200	2400	(7.3) 3.6

	FCC-hh 90.7km 14T	FCC-hh 90.7km 14T
Magnet temperature	**1.9 K**	4.5 K
Power consumption @ 85 TeV c.m.	**< 430 MW**	< 330 MW
Yearly electricity consumption	**< 2.8 TWh**	< 2.2 TWh

The LHeC as a “Bridge Project”

Jorgen D’Hondt, ICHEP Prague, July 2024
Néstor Armesto, DIS 2025

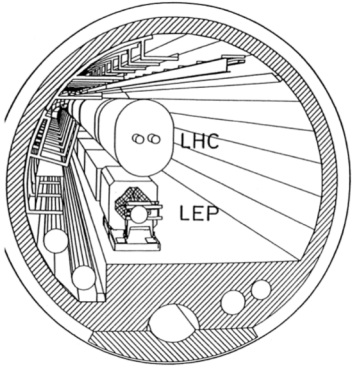


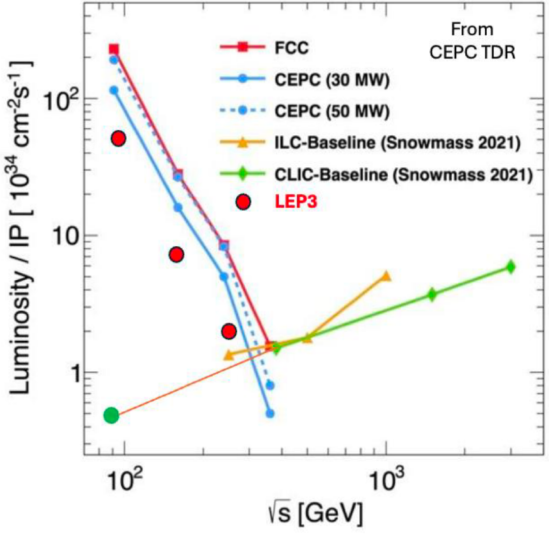
ep option with HL-LHC
e.g. 6 years ep-only > 1 ab^{-1}

LEP3 as a “Bridge Project”

Possible machine parameters:
(t.b.c, some technical details still need to be worked out)

- Luminosity: (2, 5.6, 32.5) · 10^{34} cm^{-2} s^{-1} at ZH, WW, Z energies, respectively
- Number of interaction regions: 2
- Synchrotron radiation power loss: 50 MW
- ZH run at 230 GeV





LEP3 is not competitive with FCC-ee or CEPC, but still has an interesting Higgs and el.weak physics programme

Community Involvement

Input and involvement of the community is important!

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

(i) Submission of input from the community by **31 March 2025** ***277 submissions received!***

Guidelines for documents to be submitted have been defined
→ **Comprehensive and self-contained summary of 10 pages (max)**

Additional information and details can be submitted in a **separate back-up document**, which can be consulted by the Physics Preparatory Group (PPG) if clarification on any aspects is required.
But the back-up document is not a mandatory component of the submission.

(ii) Input from **projects** (FCC, Linear Collider, …, Muon Collider, …, theory, …) is expected
In addition, input on technical data expected, needed for comparisons of projects

(iii) Input from **national HEP communities** is a vital component of the Strategy Process
(ECFA guidelines, already discussed in Plenary ECFA meetings and in many national meetings)
Details can be found here: ECFA guidelines for national HEP community input

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, LE-FCC-hh, MC, ..)**
  (timeline, costs, …. (physics → PPG))
- Comparisons across proposed projects
- Relations with other fields of physics
- …

ESG working groups have been set up;

→ *Working group structure approved by ESG*

Proposed ESG Working Groups

(1) 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

(2) Project Comparison Group

(a) Project assessment (technical feasibility, timeline, risks, cost and human resources, environmental impact)
(b) Physics potential

(3) Implementation of the Strategy / Deliverability of larger projects

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

(5) Sustainability and environmental impact

(6) Public Engagement, Education, Communication, Social and career aspects for the next generatio

(7) Knowledge and Technology Transfer

Open Symposium

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

Open Symposium (cont.)

	Monday	Tuesday	Wednesday	Thursday	Friday
09:00	**Opening Session**	**Large-scale accelerator projects at CERN, part I**	**Electroweak Physics** Talks (i), (ii) Discussion	**BSM** Talks (i), (ii) Discussion	**Overarching topics** (by ESG Working groups) e.g. National input and others
	Coffee break	Coffee break	Coffee break	Coffee break	Coffee break
11:15	**Parallel session I - IV**	**Large-scale accelerator projects at CERN, part II**	**Strong Interactions** Talks (i), (ii) Discussion	**Dark Matter / dark sector** Talks (i), (ii) Discussion	**Overarching topics (cont.)** (by ESG Working groups)
13:00	Lunch Break	Lunch break	Lunch break	Lunch break	**Closeout Session** Closeout talk, final discussion
14:00	**Parallel session I - IV**				
15:00		**Status in China, Japan, US**	**Flavour** Talks (i), (ii) Discussion	**Detector Technologies** status of DRDs, R&D needs, timeline, required resources	**ESG Meeting**
16:00	**Parallel sessions V - IX**	Coffee break	Coffee break	Coffee break	
	Coffee break	**Accelerator Technologies** Status of critical item, R&D needs timeline, required resources	**Neutrinos and Cosmic Messengers** Talks (i), (ii) Discussion	**Computing** Status of critical item, R&D needs timeline, required resources	
	Parallel sessions V - IX				
19:15					

9:00 - 10:45 Opening Session

Parallel Sessions I - IV
11:15 - 13:00 Parallel I - IV, part I
Lunch Break: 13:00 - 14:00

14:00 - 15:30 Parallel I - IV, part II
Very short break; 15:30 - 15:40 to change rooms
15:40 - 17:00 Parallel V - IX, part I
17:00 - 17:20 Coffee break
17:20 - 19:15 Parallel V-IX, part II

16:45 - 19:15 Accelerator Tech.

For each **Physics Block**:
(i) Status, open questions
(ii) How can they be addressed by the various projects
(iii) Discussion

11:15 - 12:30 ESG Session II
12:30 - 13:30 Closeout session

14:30 - 16:30 ESG Meeting

In-person participation is encouraged;
If not yet done, please register; early registration ends on 13 April
https://agenda.infn.it/event/44943/registrations/

All talks will be streamed, however, participation in the discussion is only possible for people in the auditorium

Summary / Outlook

- The ESPP process for the 2026 update in running full steam

  - All PPG and ESG working groups have been defined
  - PPG groups have been meeting in preparation for the contributions;

- 277 contributions received at the 31st March submission

Work to analyse them will commence now (PPG and ESG working groups)
→ presentations of findings + discussions at the Venice Symposium

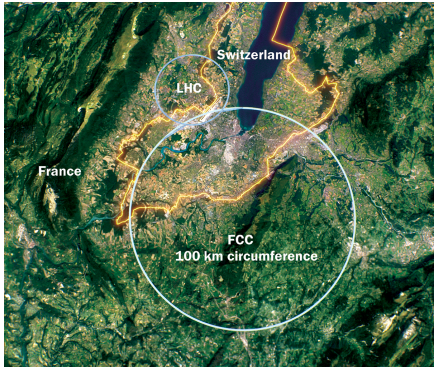
We are looking forward to receive further input by the national HEP communities by 26 May!

And we would be happy to welcome you in Venice!

In case of any questions, please contact us: eppsu2024-strategy-secretariat@cern.ch

Backup Slides

FCC Feasibility Study



- Demonstration of the **geological, technical, environmental and administrative feasibility** of the **tunnel and surface areas** and optimisation of the **placement and layout of the ring** and related infrastructure.
- Pursuit, together with the **Host States**, of the **preparatory administrative processes** required for a potential project approval.
- Optimisation of the **design of FCC-ee and FCC-hh colliders** and their injector chains, supported by **R&D to develop the needed key technologies**.
- Elaboration of a **sustainable operational model** for the colliders and experiments in terms of **human and financial resource** needs, as well as **environmental aspects** and **energy efficiency**.
- Development of a **consolidated cost estimate**, as well as the **funding and organisational models** needed to enable the project's technical design completion, implementation and operation.
- **Identification of substantial resources from outside CERN's Budget** for the implementation of the first stage of a possible future project (tunnel and FCC-ee).
- Consolidation of the **physics case** and **detector concepts** and technologies **for both colliders**.

Feasibility Study funded from CERN budget: 100 MCHF total over 5 years; in addition: ~ 20 MCHF/year for high-field magnet R&D;
Additional funding from the European Commission and collaborating institutes (e.g. CHART collaboration with Switzerland)

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.

Large-Scale Projects: Guidelines for Input

- It is anticipated that a number of proposals for large-scale research projects (capital investment of at least 250 MCHF) – including, but not limited to, particle colliders and collider detectors – will be submitted as input to the strategy process.

- In addition to studying the scientific potential of these projects, the ESG wishes to evaluate the sequence of delivery steps and the challenges associated with delivery, and to understand how each project could fit into the wider roadmap for European particle physics.

- In order to allow a straightforward comparison of projects, we therefore request that all large-scale projects submit – in addition to their physics case and technical description – a standardised set of technical data.

1. Stages and parameters

a. The main stages of the project and the key scientific goals of each
b. Whether the ordering of stages is fixed or whether there is flexibility
c. For each stage, the main technical parameters
d. The number of independent experimental activities and the number of scientists expected to be engaged in each.

2. Timeline

a. The technically-limited timeline for construction of each stage
b. The anticipated operational (running) time at each stage, and the expected operational duty cycle

Large-Scale Projects: Questions

3. Resource requirements

a. The capital cost of each stage in 2024 CHF
b. The annual cost of operations of each stage
c. The human resources (in FTE) needed to deliver or operate each stage over its lifetime, expressed as an annual profile
d. Commentary on the basis-of-estimate of the resource requirements

4. Environmental impact

a. The peak (MW) and integrated (TWh) energy consumption during operation of each stage
b. The integrated carbon-equivalent energy cost of construction
c. Any other significant expected environmental impacts

5. Technology and delivery

a. The key technologies needed for delivery that are still under development in 2024, and the targeted performance parameters
b. The critical path for technology development or design
c. A concise assessment of the key technical risks to the delivery of the project

6. Dependencies

a. Whether a specific host site is foreseen, or whether options are available
b. The dependencies on existing or required infrastructure
c. The technical effects of project execution on the operations of existing infrastructures at the host site

7. Commentary on current project status

a. A concise description of the current design / R&D / simulation activities leading to the project, and the community pursuing these
b. A statement of any major in-kind deliverables already negotiated
c. Any other key technical information points in addition to those captured above, including references to additional public documents