

European Strategy for Particle Physics: 2026 update

- ESG Recommendations -



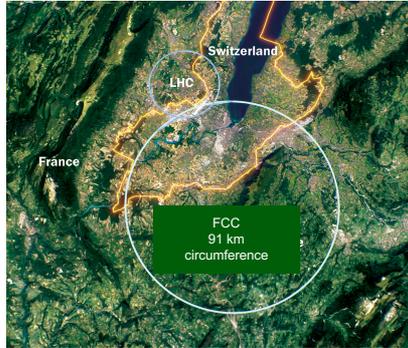
*Karl Jakobs (Strategy Secretary)
For the European Strategy Group*

*Linear Collider @CERN Workshop 2026
8th January 2026*

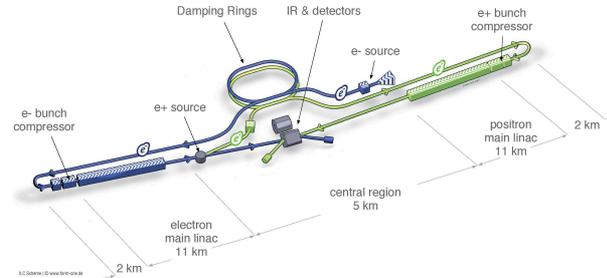
Proposed large-scale projects at CERN, ~ 2045

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

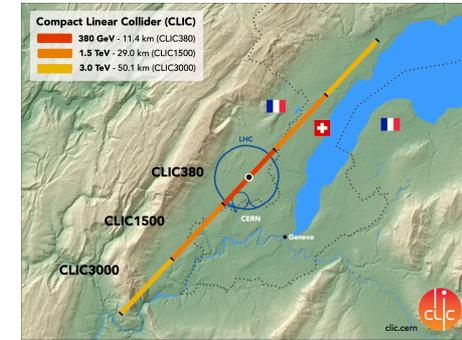
FCC-ee (e^+e^- , circular, 91 – 365 GeV)



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



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



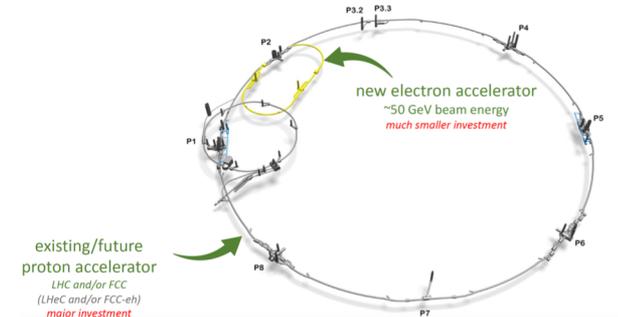
Intermediate projects

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

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

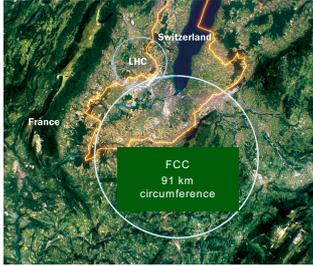


LHeC (ep, circular, electron ERL, 50 GeV e^- , > 1 TeV ep collisions)



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

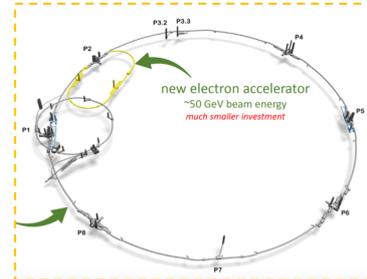
FCC-ee



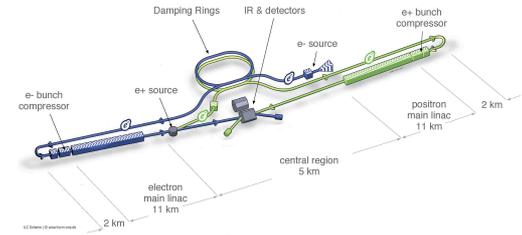
LEP3



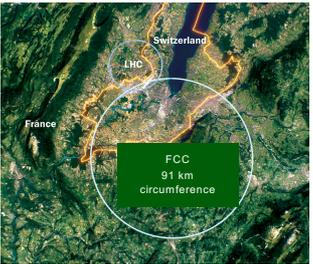
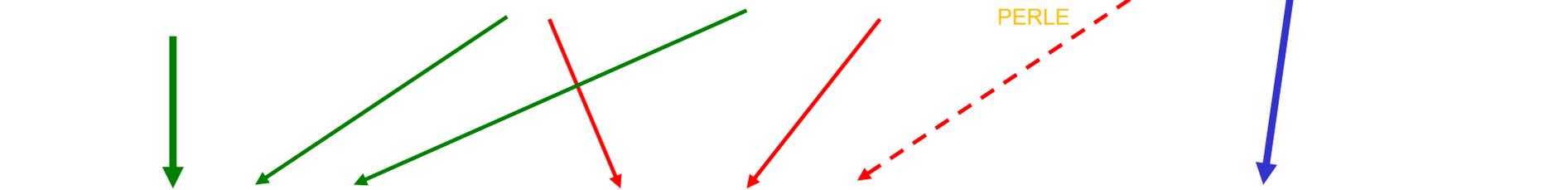
LHeC



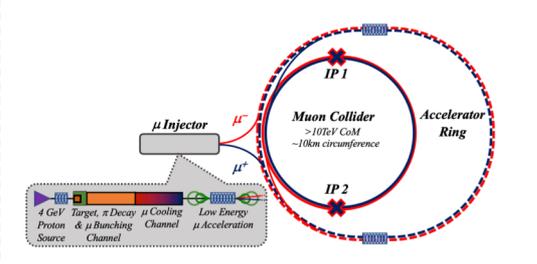
LCF, CLIC



PERLE



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



Muon Collider (3, 10 TeV)

R&D



e^+e^- with improved acceleration technologies
LCF, C³ (\rightarrow 1 TeV), CLIC (1.5 TeV), HALHF, ...
 \rightarrow plasma acceleration for higher energies
(can $\mathcal{O}(10)$ TeV be reached? on what timescale?)

Important Input for the decision 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)

Preliminary finding will be shared with the community around mid October

(iii) Final input by the National HEP communities (ESG Working Group 1)

CERN-ESU-2025-001
30 September 2025

Physics Briefing Book

Input for the 2026 update of the European Strategy for Particle Physics

Electroweak Physics: Jorge de Blas¹, Monica Dunford² (Conveners), Emanuele Bagnaschi¹ (Scientific Secretary), Ayres Freitas³, Pier Paolo Giardinò³, Christian Greife⁶, Michele Selvaggi⁴, Angela Taliercio⁸ (Contributors)

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Editors: Roger Forty⁷⁴, Karl Jakobs⁷⁴, Hugh Montgomery⁷⁵, Mike Seidel^{26,76}, Paris Sphicas⁷⁷

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<https://cds.cern.ch/record/2944678>

<https://arxiv.org/abs/2511.03883>

What is the preferred large-scale post LHC accelerator at CERN?

Member States (MS)	Preferred Collider
Austria	FCC-ee
Belgium	FCC-ee
Bulgaria	Muon Collider
Czech Republic	FCC-ee
Denmark	FCC-ee
Estonia	FCC-ee *
Finland	FCC-ee
France	FCC-ee *
Germany	FCC-ee
Greece	FCC-ee
Hungary	FCC-ee
Israel	FCC-ee
Italy	FCC-ee
Netherlands	FCC-ee
Norway	FCC-ee
Poland	FCC-ee
Portugal	FCC-ee
Romania	FCC-ee
Serbia	FCC-ee
Slovakia	FCC-ee
Slovenia	FCC-ee
Spain	FCC-ee
Sweden	FCC-ee
Switzerland	FCC-ee
United Kingdom	FCC-ee/FCC-hh

Associate Member States (AMS)

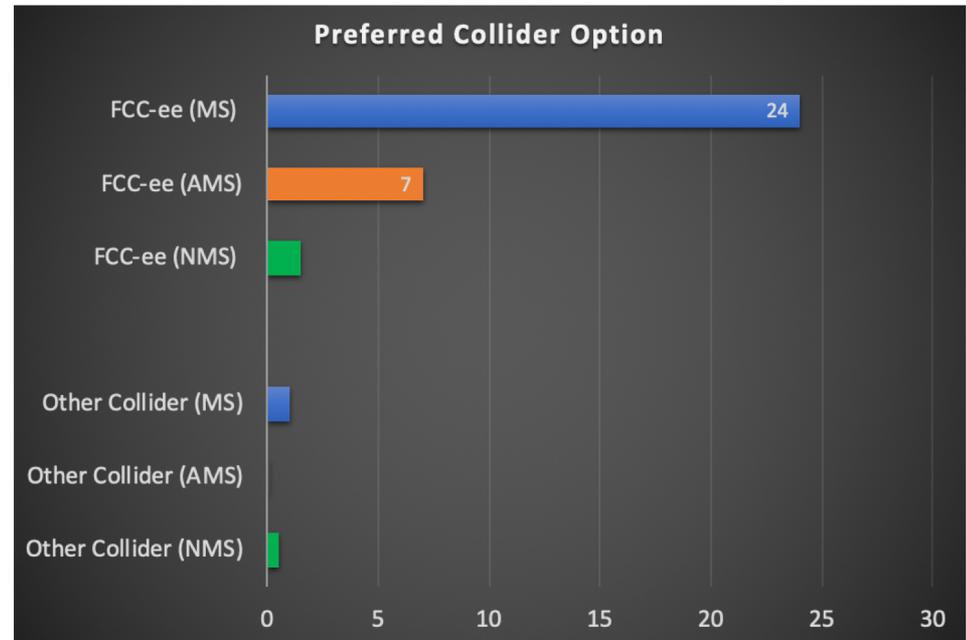
Brazil	FCC-ee
Croatia	FCC
Cyprus	
India	
Ireland	
Latvia	FCC-ee
Lithuania	FCC-ee
Pakistan	FCC-ee
Turkey	FCC-ee
Ukraine	FCC-ee

Non-Member States (NMS)

Japan	FCC-ee or LCF
USA	FCC-ee

* No updated input received, preference expressed in the previous submission taken

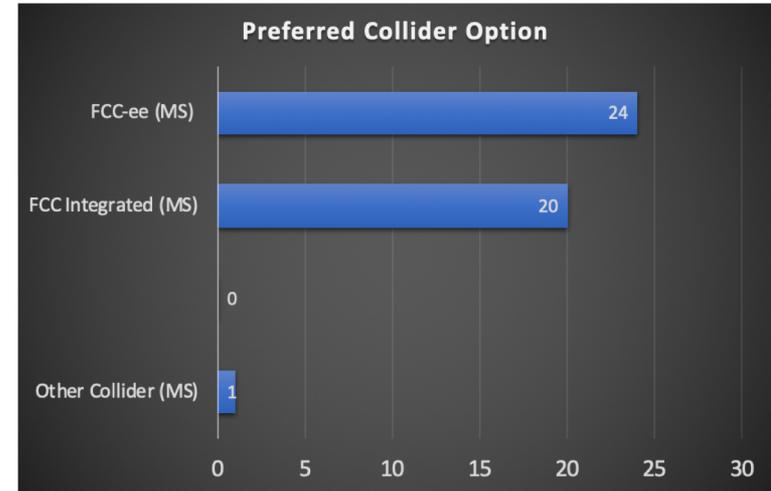
Update by France (30 Nov): FCC-ee / hh
(integrated programme)



- Overwhelming support (24/25 CERN Member States HEP communities) in favour of the FCC-ee programme
- Support as well from Associate Member States (AMS) and Non-Member States (NMS)

What is the preferred large-scale post LHC accelerator at CERN?

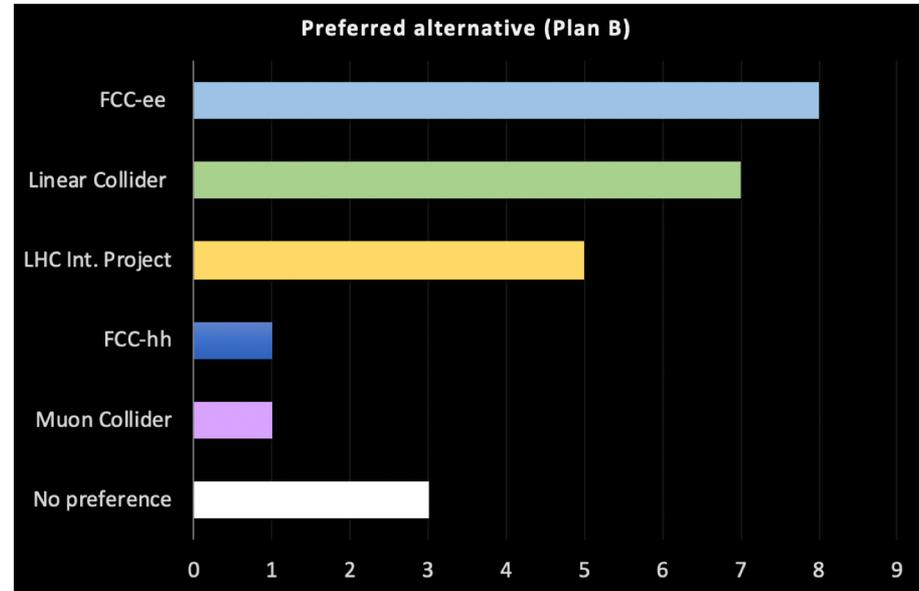
Member States	Preferred collider		Comments
Austria	FCC-ee		
Belgium	FCC-ee	FCC-hh	
Bulgaria	Muon. Collider		
Czech Republic	FCC-ee	FCC-hh	
Denmark	FCC-ee	FCC-hh	
Estonia	FCC-ee	FCC-hh	
Finland	FCC-ee		
France	FCC-ee	FCC-hh	
Germany	FCC-ee		re-use of tunnel for FCC-hh
Greece	FCC-ee	FCC-hh	
Hungary	FCC-ee	FCC-hh	
Israel	FCC-ee		stress path to FCC-hh
Italy	FCC-ee	FCC-hh	
Netherlands	FCC-ee	FCC-hh	
Norway	FCC-ee	FCC-hh	
Poland	FCC-ee	FCC-hh	
Portugal	FCC-ee	FCC-hh	
Romania	FCC-ee	FCC-hh	
Serbia	FCC-ee	FCC-hh	
Slovakia	FCC-ee	FCC-hh	
Slovenia	FCC-ee	FCC-hh	
Spain	FCC-ee	FCC-hh	
Sweden	FCC-ee	FCC-hh	
Switzerland	FCC-ee	FCC-hh	
United Kingdom	FCC-ee/FCC-hh	FCC-hh	FCC-ee/hh or FCC-hh direct



- 24/25 CERN Member States HEP communities in favour of the **FCC-ee programme**
- 20/24 CERN Member States HEP communities in favour of the **integrated FCC-ee / FCC-hh programme**

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

Member State	Preferred Alternative (Plan B)
Austria	Linear Collider (LCF, CLIC)
Belgium	LEP3 or LHeC
Bulgaria	Muon Collider
Czech Republic	FCC-hh (FCC-ee)
Denmark	FCC-ee
Estonia	Linear Collider (LCF, CLIC)
Finland	LCF
France	
Germany	LCF
Greece	FCC-ee
Hungary	FCC-ee
Israel	
Italy	FCC-ee
Netherlands	LHeC or LEP3
Norway	Linear Collider (CLIC (LCF))
Poland	FCC-ee
Portugal	
Romania	FCC-ee
Serbia	LEP3 (LHeC)
Slovakia	LHeC
Slovenia	FCC-ee
Spain	Linear Collider (LCF, CLIC)
Sweden	LCF
Switzerland	FCC-ee
United Kingdom	LHC extension, LHeC

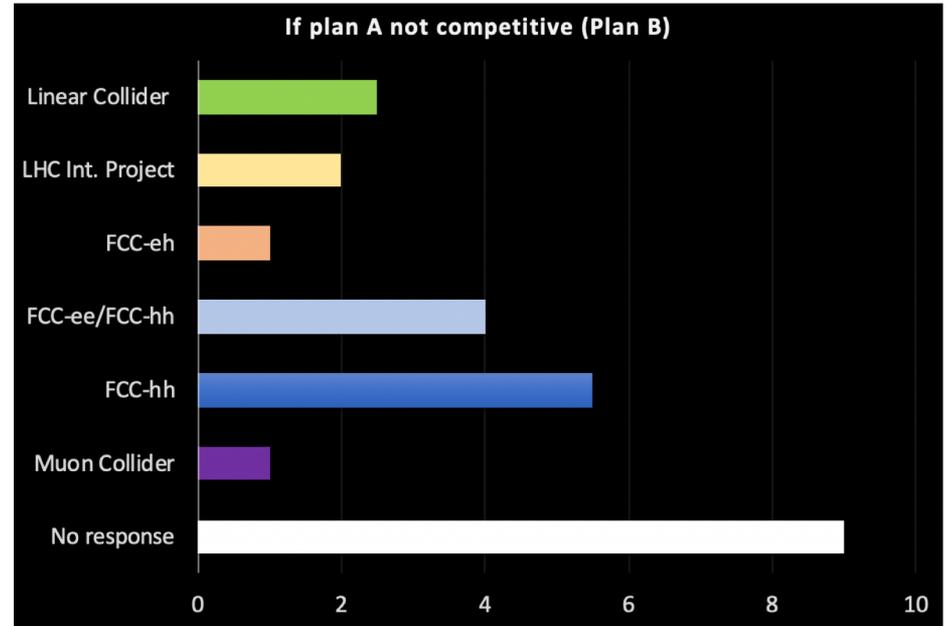


- No consensus
- Three main axes:
 - FCC (stretched in time, descoped, ...)
 - Linear Collider
 - Intermediate project in LHC tunnel as bridge towards FCC-hh (10++ TeV scale)

France (30 Nov): - staged FCC (if financially not feasible);
 - LHC Intermediate Project (if tunnel cannot be realised)

What is the preferred alternative if the preferred option would not be competitive?

Member State	Alternative (not competitive)
Austria	FCC-hh
Belgium	LHeC
Bulgaria	
Czech Republic	
Denmark	FCC-ee/hh
Estonia	
Finland	FCC-hh
France	
Germany	FCC-hh or LCF550
Greece	
Hungary	FCC-ee/hh
Israel	
Italy	FCC-hh
Netherlands	Muon Collider
Norway	CLIC
Poland	FCC-ee/hh
Portugal	LCF
Romania	
Serbia	LHC, LEP3, LHeC
Slovakia	FCC-eh
Slovenia	FCC-ee/hh
Spain	
Sweden	
Switzerland	FCC-hh
United Kingdom	FCC-hh



- No consensus
- Main axes:
 - FCC-hh
 - Stick to the FCC-ee/hh integrated programme

Evaluation by the European Strategy Group

Assessment of large-scale accelerator projects at CERN Report of ESG WG2a

31 October 2025

G. Arduini^{1,a} (convener), F. Bordry¹ (co-opted accelerator expert), R. Brinkmann² (co-opted accelerator expert), P. Burrows^{3,b} (convener), K. Desch⁴, S. Farrington^{5,6}, F. Gianotti¹, K. Hanagaki⁷, N. Holtkamp^{8,9} (co-opted accelerator expert), J. Keintzel^{1,c} (scientific secretary), B. Kilminster¹⁰, T. Lesiak¹¹, L. Rivkin^{12,13} (co-opted accelerator expert), F. Sabatié¹⁴, M. Tuts¹⁵, A. Zoccoli¹⁶.

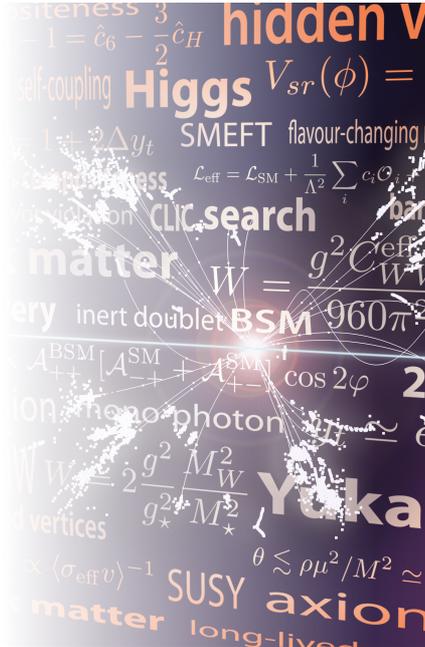
Project	Scope	TRL	R&D	Test facilities	Performance	Site preparation	Schedule	Cost	Risk
CLIC 380 GeV, 1.5 TeV		4 - 6 / 5.2							
FCC-ee 91-365 GeV		4 - 7 / 6.0							
FCC-hh 85 TeV		4 - 7 (Nb ₃ Sn) / 4.3							
		2 - 7 (HTS) / 3.2							
FCC-hh - SA 85 TeV		4 - 7 (Nb ₃ Sn) / 5					Nb ₃ Sn		
LCF 250 - 550 GeV		5 - 7 / 5.5							
LEP3 91 - 230 GeV		3 - 6 / 4.0							
LHeC: HL-LHC + 50 GeV ERL		3 - 6 / 4.5							
MC 3.2 TeV, 7.6 TeV		3.2 TeV: 3 - 5 7.6 TeV: 2 - 5							

Evaluation by the European Strategy Group

Project	Scope	TRL	R&D	Test facilities	Performance	Site preparation	Schedule	Cost	Risk
CLIC 380 GeV, 1.5 TeV		4 - 6 / 5.2							
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		2 - 7 (HTS) / 3.2							
FCC-hh - SA 85 TeV		4 - 7 (Nb ₃ Sn) / 5					Nb ₃ Sn		
LCF 250 - 550 GeV		5 - 7 / 5.5							
LEP3 91 - 230 GeV		3 - 6 / 4.0							
LHeC: HL-LHC + 50 GeV ERL		3 - 6 / 4.5							
MC 3.2 TeV, 7.6 TeV		3.2 TeV: 3 - 5 7.6 TeV: 2 - 5							

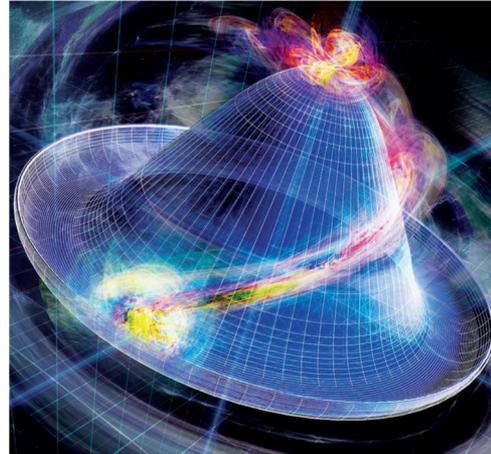
- Muon Collider: The technologies underpinning the MC design are in the early phases of exploration; Comprehensive R&D programme defined (300 MCHF, 1800 FTEy); Demonstrator need to be built.
- FCC-hh: Further R&D and industrialisation of high-field magnets (Nb₃Sn 15 - 20 y); Costs of HFM, further developments of high-temperature superconducting (HTS) magnets
- LEP3: Absence of a detailed lattice design and full-scale simulation → uncertainties on projected luminosity; Proposed baseline HTS nested quadrupoles/sextupoles represent the lowest TRL (luminosity, power)
- LHeC: Performance critically depends on a very high-current Energy-Recovery Linac (ERL); Uncertainty on luminosity of an order of magnitude; Successful demonstration of the PERLE programme at IJCLab is vital

Physics Potential



<https://cds.cern.ch/record/2944678>

<https://arxiv.org/abs/2511.03883>



CERN-ESU-2025-001
30 September 2025

Physics Briefing Book

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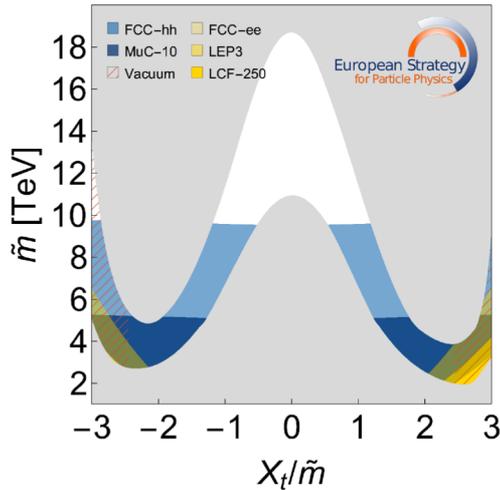
- Electroweak Physics:** Jorge de Blas¹, Monica Dunford² (Conveners), Emanuele Bagnaschi³ (Scientific Secretary), Ayres Freitas⁴, Pier Paolo Giardinò⁵, Christian Grefe⁶, Michele Selvaggi⁷, Angela Tilielová⁸ (Contributors)
- Strong Interaction Physics:** Andrea Dainese⁹, Cristina Diaconu¹⁰ (Conveners), Chiara Signorile-Sigausel¹¹ (Scientific Secretary), Néstor Arneso¹², Roberta Araldi¹³, Andy Buckley¹⁴, David d'Enterria¹⁵, Antoine Gérardin¹⁶, Valentina Mantovani Sarti¹⁷, Sven-Olaf Moch¹⁸, Marco Pappagallo¹⁹, Raimond Stelingsma²⁰, Urs Achim Wiedemann²¹ (Contributors)
- Flavour Physics:** Gino Isidori²², Marie-Hélène Schumè²³ (Conveners), Maria Laura Piscopo²⁴ (Scientific Secretary), Marta Calvi²⁵, Yuval Grossman²⁶, Thibaud Hamain²⁷, Andreas Jüttner²⁸, Jernej F. Kamenik²⁹, Matthew Kenzie³⁰, Patrick Koppenburg³¹, Radulescu Marcevschi³², Angela Papp³³, Guillaume Piguet³⁴, Justine Serreau³⁵ (Contributors)
- Neutrino Physics & Cosmic Messengers:** Pilar Hernandez³⁶, Sara Bolognani³⁷ (Conveners), Ivan Esteban³⁸ (Scientific Secretary), Stephen Dolan³⁹, Valerie Doncke⁴⁰, Joseph Formaggio⁴¹, M. C. Gonzalez-Garcia^{42,43}, Aart Heijboer⁴⁴, Aldo Ianni⁴⁵, Joachim Kopp⁴⁶, Elisa Resconi⁴⁷, Mark Scott⁴⁸, Viola Sordini⁴⁹ (Contributors)
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- Detector Instrumentation:** Thomas Bergauer⁹¹, Ulrich Husemann⁹² (Conveners), Dorothea von Bruch⁹³ (Scientific Secretary), Thea Aarstad⁹⁴, Daniela Bertolini⁹⁵, Shikma Bressler⁹⁶, Marcel Demarteau⁹⁷, Michael Doer⁹⁸, Gabriela Gaudes⁹⁹, Inés Gil-Boella¹⁰⁰, Andrea Giuliani¹⁰¹, Fabrizio Palla¹⁰², Rok Pestotnik¹⁰³, Felix Seifow¹⁰⁴, Frank Simon¹⁰⁵, Maksym Titov¹⁰⁶ (Contributors)
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- Editors:** Roger Forty¹³⁰, Karl Jakobs¹³¹, Hugh Montgomery¹³², Mike Seidel¹³³, Paris Splicha¹³⁴

Beyond the Technical Readiness, the physics potential and the long-term prospects of reaching the 10++ TeV energy scale are the driving arguments for the choice of the next collider;

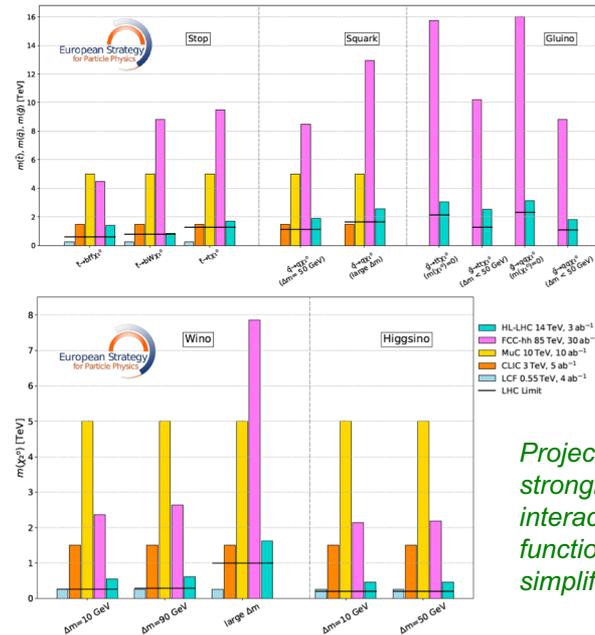
Precision and energy are required

Searches for BSM Physics

While evidence for superpartners near the weak scale has not yet emerged at the LHC, there is still strong motivation to search for SUSY at future colliders: in the MSSM, the observed Higgs mass suggests that top-quark superpartners lie beyond the reach of the LHC but are possibly within that of its successors.



Parameter space compatible with the measured Higgs boson mass $m_h = 125$ GeV as a function of the average stop mass \tilde{m} and mixing parameter $X_t = A_t - \mu \cot \beta$ ($\tan \beta = 20$, $\mu = 1$ TeV, all other SUSY masses at 5 TeV)



→ Strong arguments for reaching the 10++ TeV scale with a hadron collider (in combination with an e^+e^- precision machine)

Overall Physics Assessment. (Precision Physics)

Project		Higgs	EWPO	Top	Flavour	QCD (precision)	QCD (Partonic Struct. + HIs)
Circular	Linear						
HL-LHC	Start-of-the-art starting point at the end of HL-LHC						
Lepton and ep Colliders							
FCC-ee		4	5	3	5	5	1
FCC-ee no-top		2	5	2	5	5	1
LEP3		2	4	2	4	2	1
	LCF-250	2	3	2	1	2	1
	CLIC-380	2	2	3	1	2	1
LHeC		1	2	1	1	3	5
Mid-Energy Lepton Colliders							
	LCF-550	4	4	4	1	2	1
	LCF-1000	4	4	4	1	2	1
	CLIC-1500	4	3	4	1	2	1
	CLIC-3000	4	3	4	1	2	1
Energy frontier							
FCC-hh		3	No information		3	2	5
muC-10TeV		4	3	5	3	1	1
Precision w/ energy							
LHeC + FCC-hh		3	2	2	3	4	5
LEP3 + FCC-hh		4	4	3	4	3	5
LEP3 + muC		4	5	5	4	3	2
	LCF-1000 + muC	4	5	5	3	3	2
FCC-ee + FCC-hh		5	5	5	5	5	5

Overall Physics Assessment (BSM Physics)

Project		Comp. H & V	SUSY (QCD)	SUSY (EW)	DM	Scalar Singlet	New forces	Portals
Circular	Linear							
HL-LHC		State-of-the-art starting point at the end of HL-LHC						
Lepton and <i>ep</i> Colliders								
FCC-ee		4	3	2	2	4	4	4
FCC-ee no-top		3	3	2	2	3	4	4
LEP3		2	2	2	2	3	3	3
	LCF-250	2	2	2	2	2	3	3
	CLIC-380	2	2	2	2	2	3	3
LHeC		1	1	1	1	1	1	1
Mid-Energy Lepton colliders								
	LCF-550	2	2	2	2	3	3	3
	CLIC-1.5TeV	3	2	2	2	3	3	3
	LCF-1TeV	3	2	2	2	3	4	3
	CLIC-3TeV	4	3	3	3	4	4	3
Energy frontier								
FCC-hh		5	5	5	5	4	5	4
muC		5	4	5	5	5	5	4
Precision w/ energy								
LHeC+ FCC-hh		5	5	5	5	4	5	4
LEP3 + FCC-hh		5	5	5	5	4	5	4
LEP3 + muC		5	4	5	5	5	5	4
	LCF + muC	5	4	5	5	5	5	4
FCC-ee + FCC-hh		5	5	5	5	5	5	5

Intermediate Conclusions (Ascona)



Intermediate Conclusions (1)

- The **FCC-ee** would deliver the world's **broadest high-precision particle physics programme**
 - Outstanding discovery potential through the Higgs, electroweak, flavour and top sectors, as well as advances in QCD
 - Its technical feasibility is demonstrated via the FCC feasibility study
 - Scope and costs are well defined, plausible funding models exist
- The FCC-ee would maintain **European leadership in high-energy particle physics**, also advancing technology and providing societal benefits
- **FCC-ee** would also **pave the way towards a hadron collider** reusing the tunnel and much of the infrastructure, providing a direct **discovery reach well beyond the 10 TeV parton energy scale**
 - **Flagship project at CERN, which will allow Europe to play a leading role in the field**

Intermediate Conclusions (2)

LEP3 and LHeC as alternative options:

- Proposed as **intermediate colliders**; they offer an intermediate physics programme at **significantly lower construction cost**
- Substantially reduced precision physics programme
 - LEP3: - strong electroweak and flavour physics programmes
 - no top-quark programme
 - improvements in Higgs physics w.r.t. HL-LHC
 - LHeC: - strong QCD programme
 - significantly extended knowledge of the proton structure
 - overall precision programme limited, although some improvement in Higgs physics (w.r.t. HL-LHC)
- **Not competitive** with an FCC-ee-like collider
- To provide a long-term physics programme, they would **need to be complemented by an energy-frontier machine**, such as a hadron collider

→ No flagship colliders!

Intermediate Conclusions (3)

Linear Collider: CLIC and LCF as alternative options

- Substantially **reduced precision physics programme**
(less strong electroweak programme, non-competitive flavour programme due to lower luminosities at lower energies)
- **Operation at 550 GeV or higher** would offer **competitive programmes in Higgs and top-quark physics**, however, overall **not competitive** with an FCC-ee-like collider
- Both colliders require a new tunnel of about 33 km to reach their ultimate energies
 - * CLIC: 550 GeV collider: 60% of construction cost of FCC-ee
1500 GeV collider: construction costs at the same level as FCC-ee
CLIC technology is well developed, but less mature than the LCF technology
 - * LCF: 550 GeV collider: construction costs at the same level as FCC-ee
LCF technology is mature
- The **path towards 10 TeV collisions would require plasma wakefield acceleration**, which is **not yet proven to be a viable technology**.

- - Reduced physics
- Not competitive with an FCC-ee-like collider
- Currently no path exists to 10 TeV collisions

Other alternative options

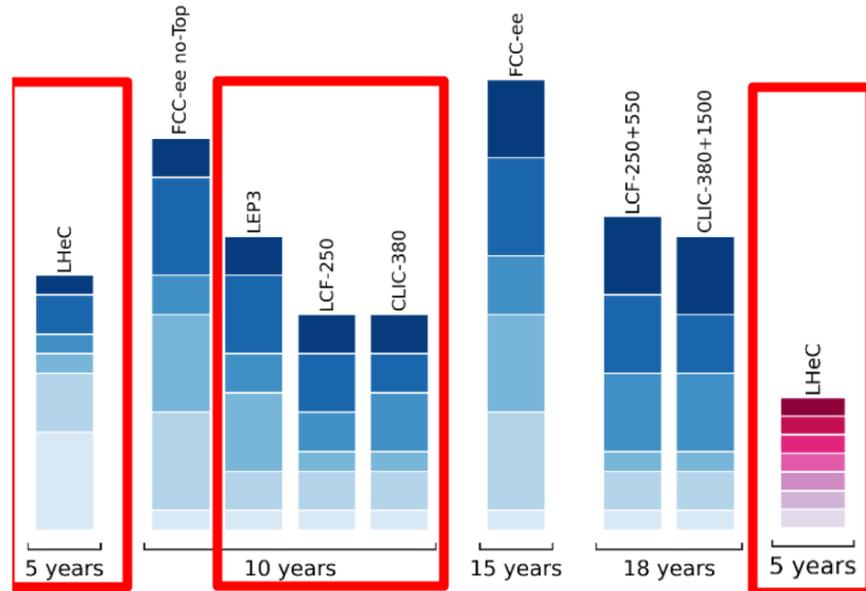
A descoped FCC-ee

(to improve the financial feasibility)

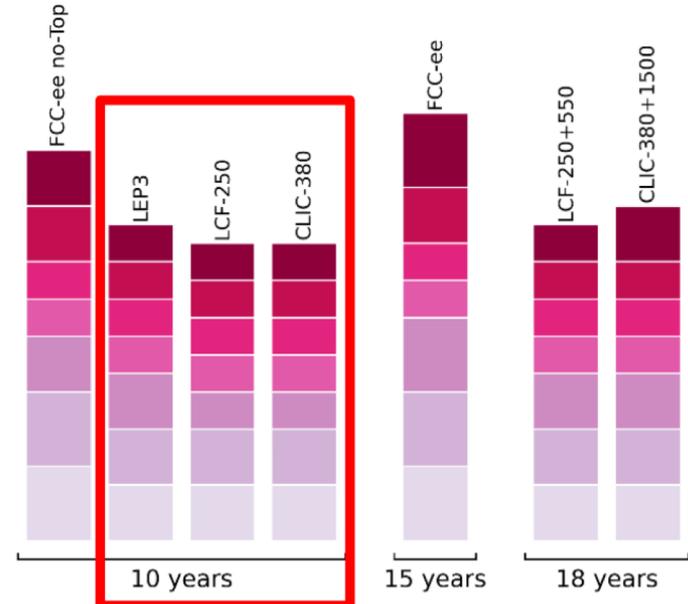
- Descoping scenarios include:
 - removing the top-quark run -1.26 BCHF
 - constructing two rather than four interaction regions and experiments - 0.80 BCHF
 - decreasing RF system power (50 MW → 30 MW) - 0.35 BCHF
- These measures would reduce the construction cost by approximately 15%.
- **Although this would have a significant impact on the breadth of the physics programme and the precision achieved, the descoped FCC-ee would still provide a very strong physics programme and a viable path towards high energies, compared to the alternative collider options.**
- Should additional resources become available, these descoping scenarios would be reversible.

Overall Physics Assessment (Linear Collider versus LHC-tunnel reuse)

Precision physics



BSM physics



Overall Summary

Machine	Precision Physics	BSM physics	Phys vs CEPC	Tech readiness	Const. cost (GCHF)	Path to ≥ 10 TeV
FCC-ee	22	23			15.3	
LCF250/ LCF550	15	17			14.8	
CLIC380/ CLIC1500	14	18			14.6	
LCF250	10	16			9.4	
CLIC380	10	16			7.5	
LEP3	14	17			4.1	
LHeC	8	7			2.1	

Physics: from WG2b: sum of precision/BSM physics
 Phys vs CEPC: competitiveness, assuming CEPC is running in parallel
 Tech readiness: from WG2a
 Construction cost: from proponents + exp. (CERN part)

Ascona Recommendations



CERN/3973/RA
5 December 2025



The European Strategy for Particle Physics: 2026 Update

*Recommendations
by the European Strategy Group*



Ascona Recommendations

I. The next CERN flagship collider project

- i. The electron–positron Future Circular Collider (FCC-ee) is recommended as the preferred option for the next flagship collider at CERN.*
- ii. A descoped FCC-ee is the preferred alternative option for the next flagship collider at CERN*

At this stage, without knowing the reasons for which the FCC-ee would not be feasible, other alternative options are not ranked.

Next Steps

Deliverables from the ESG:

1. **High-Level Recommendations** summarised
in a short document (Recommendation Document)

Released on 12th Dec. 2025

2. **Deliberation Document**

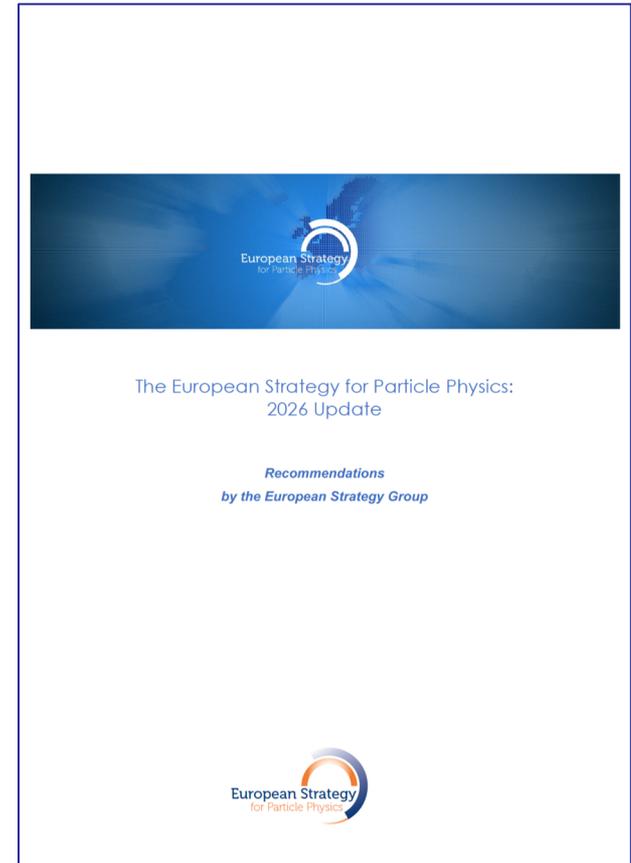
*More detailed explanations to justify the recommendations
(Targeted release date: end of January 2026)*

*This will include a more detailed assessment of the
performance of a descoped FCC-ee;
The luminosity for the descoped FCC-ee would be
(M. Benedikt, F. Zimmermann):*

$$L(\text{FCC-ee}) \times 3/5 \times 2/4 \times 1.2 = L(\text{FCC-ee}) \times 0.36$$

3. **Working Group Reports**

*Will be released as accompanying documents,
timeline: end of January 2026*



Final steps: Council Deliberations and Approval

- *Council deliberations will take place in their session in March 2026*
- *Update of the European Strategy for Particle Physics by the CERN Council in a dedicated meeting in Budapest on 21/22 May 2026*
 - *Official Release of all Strategy Update Documents*
 - *Accompanying Brochures to explain the Science case of the preferred project (FCC-ee) to decision makers and the public*



-
-
- Final deliberations on **project approval** by the CERN Council during 2027/2028

Why not ranking alternative options?

- If the (descoped) FCC-ee is not feasible due to **financial constraints**, then CLIC1500 and LCF550 would have similar problems, leaving LEP3 and LHeC, which reuse the LHC tunnel, as the only financially viable alternatives.
 - CLIC550 would be financially easier, however, would face the issue of a credible path to 10 TeV energies
 - The low-energy machines, CLIC380 and LCF250, at significantly lower cost, do not offer competitive physics programmes.

 - If instead **difficulties related to the construction of the tunnel are encountered**, then the fully technical feasibility of alternate tunnel constructions in the Geneva area would have to be considered prior to any further prioritisation.
 - In all scenarios, there would currently be no credible path to high-energy exploration
-
- There is a strong recommendation from the ESG for the realisation of the FCC-ee
 - Efforts will be made (CERN management) to convince Council to approve this plan!
 - If this fails, a “light-weight” strategy process will probably be called in 2028

Backup Slides

Ascona Recommendations

General Recommendations

- i. The **full exploitation of the physics potential of the LHC and the HL-LHC and the completion of the high-luminosity upgrade remain the highest priorities** of European particle physics. Every effort must be made to complete the HL-LHC upgrade within the current schedule.*
- ii. The unique ecosystem of particle physics research centres and universities in Europe should be further strengthened in order to address the objectives set out in this Strategy.*
- iii. The implementation of the Strategy should be pursued in strong collaboration with global partners and neighbouring fields.*
- iv. The relationship between the particle physics community and the European Commission should be further strengthened, exploring funding opportunities for the realisation of infrastructure projects and R&D programmes in cooperation with other fields of science and industry.*

Ascona Recommendations (cont.)

II. Technology

To ensure that Europe remains at the forefront of technologies for particle physics, R&D in collaboration with international partners and industry must continue to be supported with high priority, thereby enhancing sustainability and societal impact.

Accelerator Technology:

- i. In order to realise the visionary plan presented, the **highest priority** must be the **development and industrialisation of key technologies: advanced superconducting and normal-conducting RF structures, efficient RF power sources and accelerator-quality magnets in the 14 - 20 T range, including those based on high-temperature superconductors.***
- ii. Demonstration of **high-current multi-turn energy recovery** in linacs constitutes an important step towards power-efficient lepton accelerators for a broad range of applications and should be pursued.*
- iii. The **longer-term** development of advanced technologies, such as **high-gradient wakefield acceleration and those underpinning bright muon beams**, should be supported at an appropriate level. Synergies with the US initiative on muon collider R&D should be exploited.*

Ascona Recommendations (cont.)

Detector Technology:

- i. For the **DRD collaborations** to address the requirements of future flagship projects, they **must receive adequate funding**. New R&D topics and initiatives should be integrated in the DRD scheme. The General Strategic Recommendations in the roadmap must be fully addressed by dedicated initiatives coordinated across the DRD collaborations.*
- ii. A coherent, strategic approach and sufficient resources to support **close cooperation with industry are required to address the rising costs and growing complexity in engineering, particularly in microelectronics**.*
- iii. To enhance efficiency and align developments with global technology trends in other fields, standardised, off-the-shelf solutions should be prioritised over custom designs, where applicable*

Ascona Recommendations (cont.)

Computing:

- i. **Adequate and sustained support for and coordination of software and computing must be provided to achieve the goals of future particle physics projects, starting with the HL-LHC. Planning of future projects should include software and computing from the outset, addressing energy efficiency and sustainability.***
- ii. In order to address theoretical and experimental needs such as in lattice QCD, data intensive workflows through WLCG, long-term data preservation and reinterpretation, the particle physics community should further engage with, and **help shape the evolution of EuroHPC, AI factories, and other global initiatives.***
- iii. The European particle physics community must further **intensify its activities in AI** and sustain them with adequate resources. A **roadmap**, coordinated among CERN and national laboratories, institutes and universities, should be developed **to prioritise AI activities** taking into account synergies with international partners and other communities.*

Ascona Recommendations (cont.)

III. Other research directions in particle physics:

- i. European contributions to both accelerator-based and non-accelerator neutrino and dark matter experiments are essential and should be supported.***
- ii. CERN should continue to provide support to the global long-baseline neutrino programme via the Neutrino Platform. The collaboration between CERN and non-accelerator-based experiments on technologies of mutual benefit should be continued.***
- iii. The ecosystem of European particle physics laboratories should continue to support a broad, diverse spectrum of key precision experiments in particle physics.***

Ascona Recommendations (cont.)

IV. Theory

- i. Europe should maintain a strong and diverse particle theory landscape, from formal to phenomenological aspects, while further strengthening and leveraging connections to neighbouring fields.***
- ii. Collaborative efforts to improve the precision of theoretical predictions should be recognised and supported. Europe is world-leading in these areas and should strive to remain so by attracting, fostering and retaining early-career global talent. CERN should continue to be an integral part of all these efforts.***

Ascona Recommendations (cont.)

V. Project Implementation, cooperation with large Particle Physics Laboratories (PPLs) in Europe

- i. *The next flagship collider at CERN should be developed under CERN's leadership, with coordinated in-kind contributions from the PPLs. **Collaboration between CERN and PPLs should be strengthened for strategic technology developments.***
- ii. *The large particle physics **Laboratory Directors Group (LDG)** should explore the possibility for a new initiative **to enable and strengthen the implementation and promotion of scientific diversity in particle physics with a shared European vision.** It should initially conduct a community-wide survey on existing facilities, projects and staff capabilities in Europe.*
- iii. *LDG must continue the coordination of the accelerator R&D roadmap by integrating strategic priorities, by enhancing collaboration across PPLs and optimising usage of laboratory resources. In addition, R&D efforts to enhance the sustainability and energy efficiency of accelerators from design to operation and decommissioning should be supported.*

Ascona Recommendations (cont.)

VI. Synergies with Neighbouring Fields

- i. The European particle physics community, in coordination with APPEC and NuPECC, should maintain its scientific diversity via strong collaboration with nuclear and astroparticle laboratories and research infrastructures in Europe and beyond, including the Einstein Telescope in Europe and the Electron-Ion Collider in the US.*
- ii. CERN should continue its involvement in experimental nuclear physics and astroparticle physics at the current level. Consideration of additional experimental activities outside of CERN's accelerator-based particle physics programmes should be subject to adequate resources being available for CERN's primary mission.*

Ascona Recommendations (cont.)

VII. Sustainability

- i. For every new proposed project, a detailed Life Cycle Assessment should be carried out at each stage from concept, design and implementation to quantify and minimise environmental impact.*
- ii. The particle physics community should continue and intensify its efforts to develop and adopt sustainable solutions.*
- iii. An effective balance between in-person and online meetings should be considered, in order to mitigate the environmental impact of travel.*

Ascona Recommendations (cont.)

VIII. *Public engagement, education, communication, social and career aspects*

- i. *Education, communication and engagement in particle physics should target a broad range of stakeholders, with a dedicated effort to reach diverse and underrepresented audiences.*
- ii. *The many education, communication and outreach initiatives in the various European national communities, EPPCN, IPPOG and the Teacher and Student Forum should be further encouraged, integrated and supported by European institutions and CERN.*
- iii. ***Dedicated European training programmes in accelerator science, computing and detector instrumentation**, including sustainability aspects as well as first-hand exposure to the latest technologies, should be further developed at the master and doctoral levels. The existing international schools in these areas should be strengthened to offer an expanded, coherent training programme.*
- iv. *The community should actively promote the creation of **long-term positions for engineers and technicians**, as well as **physicists with technological expertise** in accelerators, detectors and computing. Two-way transfer of knowledge via mobility between industry and academia should also be encouraged.*
- v. *The particle physics community should continue its unwavering commitment to place the principles of Equity, Diversity, and Inclusion (EDI) at the heart of all its activities.*
- vi. *Current efforts for mentoring, easing mobility across institutions and promoting well-being of early-career researchers should be reinforced. In addition to scientific achievements, career evaluation should also consider technological, outreach and knowledge transfer activities.*