

- LC Vision - (Not only) Discussion

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P2I
Physique
des deux
Infinis

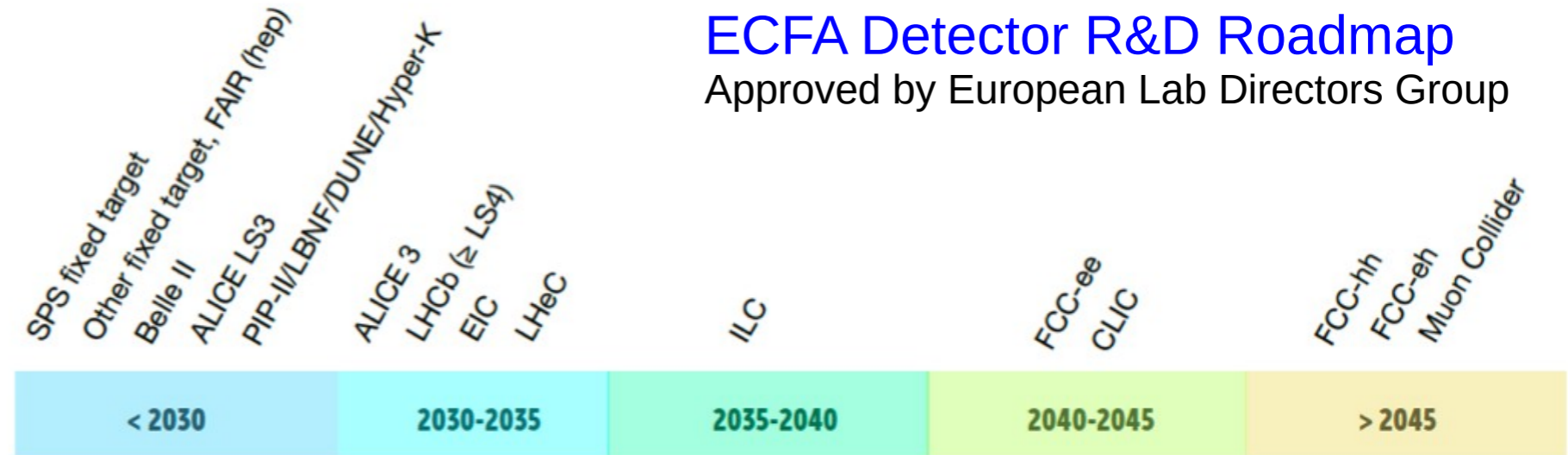
IDT WG3 Physics Meeting November 2024

Snowmass EF-Vision (L. Reina)

Collider	Type	\sqrt{s}	$\mathcal{P}[\%]$ e^-/e^+	\mathcal{L}_{int} ab^{-1}/IP	Start Date	
					Const.	Physics
HL-LHC	pp	14 TeV		3		2027
ILC & C ³	ee	250 GeV	$\pm 80/\pm 30$	2	2028	2038
		350 GeV	$\pm 80/\pm 30$	0.2		
		500 GeV	$\pm 80/\pm 30$	4		
		1 TeV	$\pm 80/\pm 20$	8		
CLIC	ee	380 GeV	$\pm 80/0$	1	2041	2048
CEPC	ee	M_Z		50	2026	2035
		$2M_W$		3		
		240 GeV		10		
		360 GeV		0.5		
FCC-ee	ee	M_Z		75	2033	2048
		$2M_W$		5		
		240 GeV		2.5		
		$2 M_{top}$		0.8		
μ -collider	$\mu\mu$	125 GeV		0.02		

ECFA Detector R&D Roadmap

Approved by European Lab Directors Group



- International roadmaps consider construction of a linear collider towards the end of this decade
- We may seek to combine the best of all (linear) worlds into a linear facility
 - Avoids entangling of a electron-positron collider and a hadron machine
- It would be the parallel running of a TeV hadron machine and a electron positron collider at the TeV scale that “maximises scientific output “

Slide by R.P.,
LISHEP March 2023



European Strategy Group (ESG) remit

Approved by Council in June

The remit of the European Strategy Group (ESG), established in June 2024, is to develop an update of the European Strategy for Particle Physics and submit it for approval by the Council. The aim of the Strategy update should be to develop a visionary and concrete plan that greatly advances human knowledge in fundamental physics through the realisation of the next flagship project at CERN. This plan should attract and value international collaboration and should allow Europe to continue to play a leading role in the field.

The ESG should take into consideration:

- the input of the particle physics community;
- the status of implementation of the 2020 Strategy update;
- the accomplishments over recent years, including the results from the LHC and other experiments and facilities worldwide, the progress in the construction of the High-Luminosity LHC, the outcome of the Future Circular Collider Feasibility Study, and recent technological developments in accelerator, detector and computing; the international landscape of the field.

The Strategy update should include the preferred option for the next collider at CERN and prioritised alternative options to be pursued if the chosen preferred plan turns out not to be feasible or competitive. The Strategy update should also indicate areas of priority for exploration complementary to colliders and for other experiments to be considered at CERN and at other laboratories in Europe, as well as for participation in projects outside Europe.

The ESG should review and update the Strategy and add other items identified as relevant to the field, including accelerator, detector and computing R&D, the theory frontier, actions to minimise the environmental impact and to improve the sustainability of accelerator-based particle physics, the strategy and initiatives to attract, train and retain the young generations, public engagement and outreach.

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

Community Involvement (cont.)

(ii) Open Symposium 23 – 27 June 2025

In addition to plenary (and parallel) presentations, this Symposium should be organised such that there is room for discussions

(iii) Based on the collected input (March 2025) and Briefing Book (Sept. 2025) **further input from the national communities is welcome**

A proposal on how to collect and structure this input is presented by ECFA

- **31st of March 2025 not the end for contributions to the strategy since**
 - FCC report just available on 31 mars
 - What about CEPC ?

Summary on Community Input

31 March 2025

Deadline for the submission of input from the community

Further input from national communities

23 – 27 June 2025

Open Symposium

End of September 2025

Submission of the “Briefing Book”

Further input from national communities, deadline 14 Nov 2025

01 – 05 December 2025

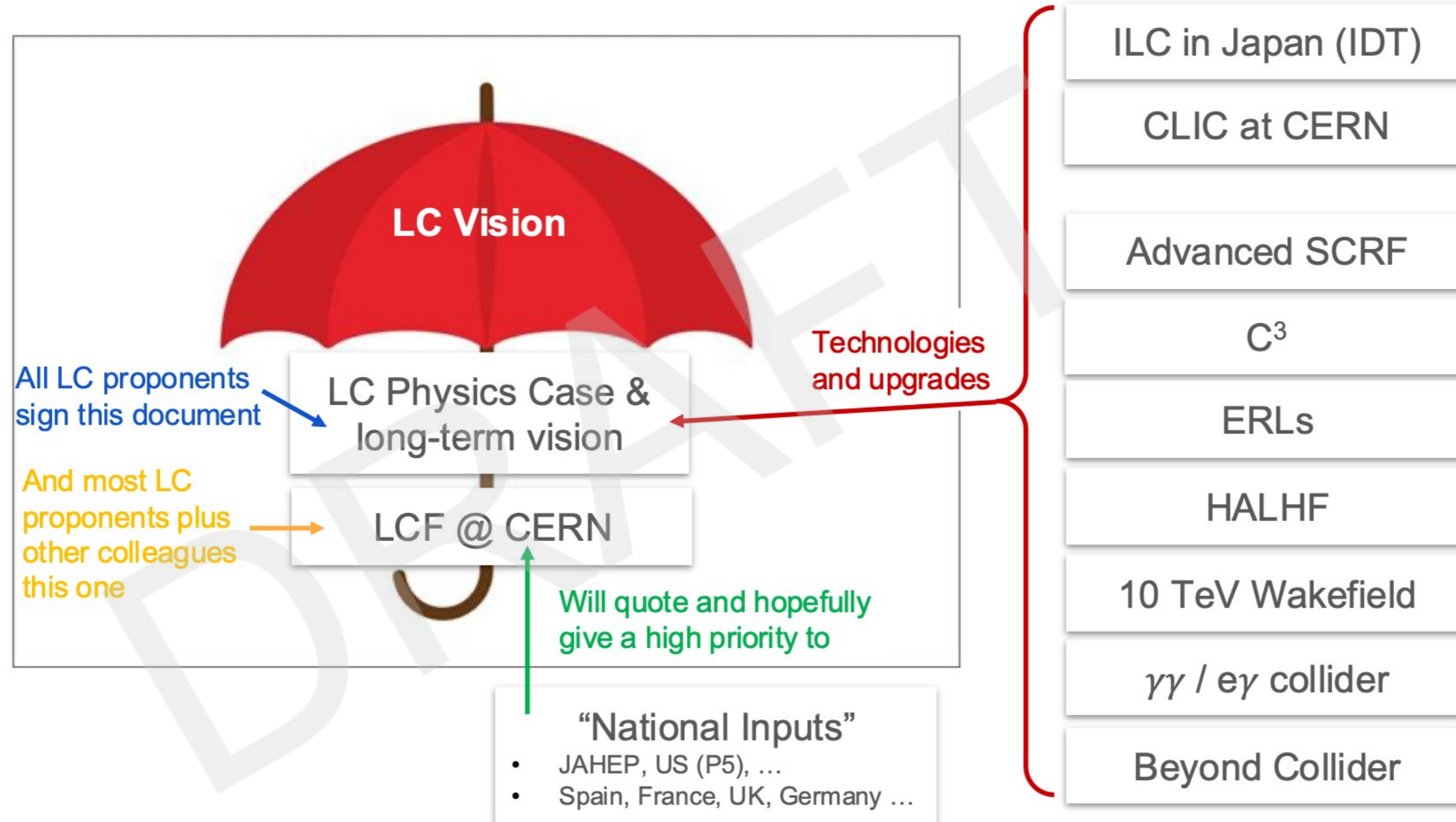
Strategy Drafting Session



- the exploration of the fundamental laws of our universe requires, in addition to the HL-LHC and Belle II, a long-term e⁺e⁻ program over a wide range of energies - not just a “gap-filler”
- this program should start “now” by unveiling the mysteries of the Higgs boson, with an affordable project based on technology at-hand - and then evolve from there
- the long-term program should not be statically defined “today” for decades into the future, but instead the initial facility must be sufficiently versatile to allow choices to be taken as scientific knowledge and technologies advance - or even see revolutions
- this applies to the evolution of the e⁺e⁻ facility itself as well as for the choice of the best avenue to eventually explore the 10-TeV parton-energy scale, for all of which sufficient resources for R&D and demonstrators must remain available

**A few months ago, a spontaneous “think-tank” formed to reflect on these ideas
— and put them up for discussion at LCWS 2024!**

- LC Vision Documents and their relations to other EPPSU inputs** idea: S. Gessner



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LC Vision Overview

Chairs: J. List, S. Stapnes

Coordination Group

Halina Abrahmovic, Erik Adli, Ties Behnke, Ivanka Bosovic, Phil Burrows, Marcel Demarteau, Yuanning Gao, Carsten Hensel, Mark Hogan, Masaya Ishino, Daniel Jeans, Imad Laktineh, Andy Lankford, Benno List, Kajari Mazumar, Shin Michizono, Emmanuela Musumeci, Tatsuya Nakada, Mihoko Nojiri, Dimitris Ntounis, Jens Osterhoff, Ritchie Patterson, Aidan Robson, Daniel Schulte, Taikan Suehara, Geoffrey Taylor, Caterina Vernieri, Marcel Vos, Georg Weiglein, Filip Zarnecki, Jinlong Zhang, Laura Monaco, Patrick Koppenburg, Hitoshi Murayama, NN Canada

Expert Team 1

“Physics-driven run plan
and EPPSU documents”
Roman Poeschl, Michael
Peskin

Expert Team 3

“SCRF upgrades”
Sergey Belomestnykh,
Hiroshi Sakai,
Marc Wenskat

Expert Team 5

“ERL upgrades”
Walid Kaabi,
Vladimir Litvinenko,
Kaoru Yokoya

Expert Team 7

“Beyond Collider”
Yasuhito Sakaki,
Ivo Schulthess

Expert Team 2

“LCF@CERN”
Steinar Stapnes, Thomas
Schörner

Expert Team 4

“C3/CLIC upgrades”
Angeles Faus-Golfe,
Enrico Nanni

Expert Team 6

“Plasma upgrades”
Brian Foster,
Spencer Gessner

Expert Team 8

“Alternative Collider Modes”
Tim Barklow, Gudi
Moortgat-Pick



- **Important to define a baseline**
 - **Two interaction points are considered as default**
 - Machine based on SCRF (=ILC) as starting point
 - Currently discussion turn around the question “What is a minimal scenario”?
 - 20km minimal as currently foreseen for ILC in Japan
 - A machine that can reach ttbar in its initial stage?
 - Already a 550 GeV machine from the start?
 - The latter two options imply (as of today) a longer initial tunnel (=> higher cost)
- **Luminosity may/will become an issue**
 - Can we increase the luminosity at least by a factor of two everywhere
 - ... and maybe a factor of four at higher energies to e.g. target 5% on Higgs self-coupling
 - Note that HL-LHC gave recently promising prospects on measuring the self-coupling
 - Can energy recovery linacs help on a reasonable time scale?



The Linear Collider Project - A Vision for the Future of Particle Physics

Contents

1 Introduction 2 pages, Michael, Roman	2
2 The Portal to New Physics 25 pages, eds. Michael, Roman	2
3 Accelerator - Baseline and Roadmap introduction 0.5 page max., Michael, Roman	2
3.1 Baseline based on Superconduction Radio Frequency (SCRF) Cavities 15 pages, Angeles, Jenny, Steinar, Hiroshi, Nobuhiro, Tom Markiewicz	2
3.2 Energy upgrades to 500 GeV, 1 TeV and more	3
3.2.1 "Straightforward" - Upgrade with higher gradient cavities 5 pages Sergey Belomestnykh, Hiroshi Sakai, Marc Wenskat, Enrico Cenni, Akira Miyamoto	3
3.2.2 Upgrade using CLIC technology 10 pages, Steinar Stapnes, Aidan Robson, Angeles	4
3.2.3 Upgrade using C3 technology 5-10 pages, Caterina Vernieri, Emilio Nanni	4
3.2.4 Upgrade with PWA technology 10 pages total, Brian Foster, Spencer Gessner, Arnd Specka or Brigitte Cros, Cameron Geddes	4
3.2.5 Alternative collider modes 5-10 pages, Tim Barklow, Gudi Moortgat-Pick	5
3.3 Luminosity upgrades	5
3.3.1 "Straightforward" by e.g. increasing beam repetition frequency tbd	5
3.3.2 Energy recovery technologies 5-10 pages, V. Litvinenko, W. Kaabi, Kaoru Yokoya	5
4 Detectors - Exciting opportunities for the community 15 -20 pages, tbd	5
5 Non collider experiments 10 pages, Yasuhito Sakaki, Ivo Schulthess, Claude Vallée	5
5.1 Beam Dump	5
5.1.1 Positrons	5
5.2 LC as Photon Source	5
6 Governance 5 pages max., 1	6
7 Governance 5 pages max., 1	6
8 Scientific and societal impact of LC research programme 3-5 pages,a	6
9 Summary and Conclusion 2 pages max., Michael, Roman, Jenny, Steinar	6
10 References	6

- A generic “site independent” document
 - ... to outline the physics case
- Options for start and upgrade and how this will fit together
- Length (100-150) pages

Linear Collider Strategy for the Study of the Higgs Boson

Contents

1 Introduction	1
2 Importance of the Higgs Boson	2
3 The Full Program of Higgs Boson Measurement	4
4 Update on the ILC	8
4.1 Current parameters and costs for the ILC 250	9
4.2 ILC at CERN	9
4.3 ILC in Japan	9
4.4 1 vs. 2 Interaction Regions	9
5 Giga-Z	9
6 Extension – Higher Energy	9
6.1 ILC design for 550 GeV	10
6.2 Linear Collider at High Energy with CLIC technology	10
6.3 Linear Collider at High Energy with C ³ technology	10
6.4 Linear Collider at High Energy with SRF technology (HELEN)	10
7 Extension – Higher Luminosity	10
7.1 Energy Recovery Linac Designs for Higgs Factories	11
8 Extension – Photon Colliders	11
8.1 XCC Photon Collider	11
9 Extension – Plasma Wakefield Acceleration	11
9.1 HALHF	12
9.2 Plasma Wakefield Afterburner Designs	12
9.3 Laser-Driven Plasma Designs	12
10 Toward the 10 TeV Scale	12
11 Conclusions	13

- A document tailored to a Linear Collider Facility at CERN
- Content will be short version of generic document
- Plus arguments why LCF and not FCCee
 - ... with the necessary portion of caution
- Length 30 pages
→ Shortened to 10 pages for European Strategy

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- Higgs at 250 GeV
- Z-Pole and 250 GeV (2-fermion processes and $ee \rightarrow WW$)
- Higgs at high(est) energies
 - Self-coupling (including quartic coupling?)
 - if possible overlap with other fields of science
 - e.g. how serious is the overlap with signals by Gravitational Waves
- ttH and WW scattering
- top physics programme: from threshold to highest energies
- Direct searches for BSM including SUSY
- Non collider physics
- Guidelines:
 - 3-4 pages for each topic, “Higgs at high(est) energies” maybe 6-7 pages
 - Concentrate on new results since Snowmass or identify key plots results that should be repeated (that may even benefit from an update)
 - “Higgs at high(est) energies maybe most important topic
 - Point out how a LC could react on HL-LHC results
- Author team will be contacted soon (weekend/beginning next week)
- Be aware: Some arguments against LC that appear as “endless loop”
 - No new physics until 1 TeV
 - “Nowhere” sufficient luminosity
 - Not enough Zs



- **Idea of the chapter**
 - Basic assumption is to provide a scenario that can start “now” and that can be progressively upgraded to cover the physics needs and/or to be able to react on “surprises”
 - Guiding line: No or little further major civil construction later on
 - => Upgrades will have to adapt to the baseline
- **Baseline and upgrades**
 - Baseline based on superconductive RF cavities
 - Energy upgrades to 500, 1 TeV and more
 - “Straightforward” - Mixture of “ILC Standard” and Helen
 - Basic idea
 - Timeline and R&D needed
 - Necessary civil construction and environmental impact
 - Upgrade using C3 technology
 - Basic idea
 - Timeline and R&D needed
 - Necessary civil construction and environmental impact
 - Upgrade using CLIC technology
 - Basic idea
 - Timeline and R&D needed
 - Necessary civil construction and environmental impact
 - Upgrade with PWA
 - “Booster” (→ Asymmetric beams)
 - Basic idea
 - Timeline and R&D needed
 - Necessary civil construction and environmental impact



- ILC250 cont'd
 - Energy upgrades to 500, 1 TeV and more
 - Upgrade with PWA (cont'd)
 - Full PWA upgrade
 - Basic idea
 - Timeline and R&D needed
 - Necessary civil construction and environmental impact



- **Luminosity upgrades**
 - “Straightforward” by e.g. increasing beam repetition frequency
 - Energy recovery technologies (should fit into one of the baseline scenarios above, with minimal civil construction)
 - ReLIC
 - ERL
- **Alternative collider options, e.g. photon collider**
 - Basic idea
 - Timeline and R&D needed
 - Necessary civil construction and environmental impact
- **Non collider experiments**
- **Governance**
 - e.g. procedure of technological decisions of upgrades
- **Scientific and societal impact of research programme (including diversity aspects)**
- **Annexes**
 - “Compatibility matrix”
 - Cost estimations in table

- Community Event at CERN 8/1/25 – 10/1/25 <https://indico.cern.ch/event/1471891/>

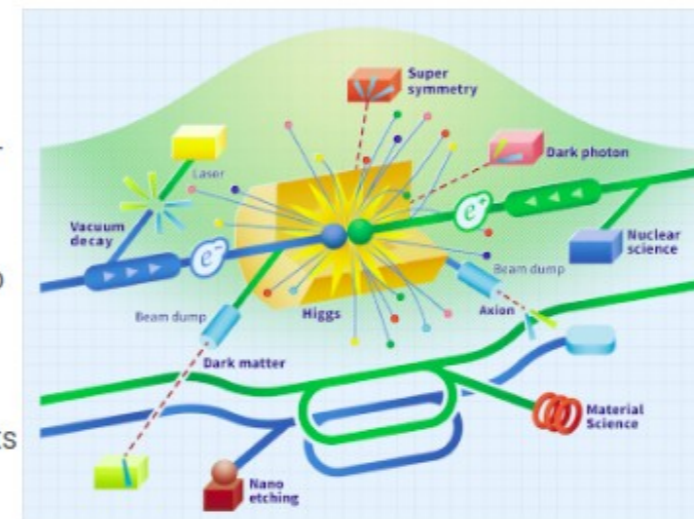
Linear Collider Vision Community Event 2025

8–10 Jan 2025
CERN
Europe/Zurich timezone

- Overview
- Timetable
- Registration
- Privacy Information
- Videoconference
- Administrative Support
- ✉ Alexia.augier@cern.ch

Born at LCWS2024, LC Vision brings together proponents and supporters of all kinds of Linear Collider projects, in order to discuss common topics, to develop a united perspective on the long-term evolution of a Linear Collider Facility, and to propose such a facility for CERN. At this meeting, the LC Vision plans for the EPPSU will be presented to the interested community.

The meeting will be run in hybrid mode, the zoom link will be communicated to registered participants only. The registration is free of charge, but please register by December 15. For participants at CERN, a number of hostel rooms has been blocked.... A visitor card for CERN can be requested during registration.



- LC Vision e-mail list (follow link)



- **LC Vision aims to federate all ideas for LC technologies under one project**
 - Choice of baseline such to be able to start the LC Project “now”
 - Show up ways for upgrades
- **LCVision tries to convey the following messages**
 - A LC is able to address the current questions in particle physics at affordable cost in particular it could provide a full Higgs programme
 - A LC provides a long term vision of the field in general including CERN while not precluding or jeopardising other projects
 - A LC supports/fosters innovation and is therefore of strategic importance?
- **Expert teams have been formed**
- **Documents start taking shape**
 - Generic document will be complemented by a detector part (not discussed today)
- **European strategy requires “preferred option” and alternative options for CERN**
 - ... but consider also projects outside of Europe
- **Joining LCVision**
 - Community meeting 8-10 January 2025 at CERN
 - LC Vision e-mail list (follow link)



Backup



Committees for the ESPP update

Strategy Secretariat

Assists the ESG by organising and running the ESPP process
Strategy Secretary (Chair), SPC Chair, ECFA Chair, LDG Chair



Karl Jakobs (Freiburg) appointed
Strategy Secretary at the June Council

Physics Preparatory Group (PPG)

Collects community's input, organises Open Symposium, prepares Briefing Book
Strategy Secretariat (Strategy Secretary is Chair of PPG)
4 members appointed by Council on recommendation of SPC
4 members appointed by Council on recommendation of ECFA
1 representative appointed by CERN
2 representatives from Americas and 2 from Asia (appointed by respective ICFA representatives)

European Strategy Group (ESG)

Prepares the (Draft) Strategy Document
Strategy Secretariat (Strategy Secretary is Chair of ESG)
1 representative appointed by each Member State
1 representative appointed by each LDG laboratory
CERN DG and DG-elect
Invitees: PPG, President of Council, 1 representative from each Associate Member State and Observer State,
1 representative from EC; chairs of ApPEC, NuPECC, ESFRI