

2026 European Strategy for Particle Physics Update (ESPPU) - Introduction to Drafting day

Sarah Williams, on behalf of:

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Introduction

- Thanks to everyone for making the time to attend today's drafting day (both in-person and remotely)- it's great to have so many people (>130!) participating
- Thanks to UCL for hosting, and in-particular to Ruben Saakyan and Matthew Wing for their work behind the scenes.
- A lot of work has gone on behind the scenes to prepare for today, so additional thanks go to:
 - Haroon Rafique, Matthew Wing, Joel Goldstein, Alison Elliot, Harriet Watson, Mark Williams, Chris Parkes, Holly Pacey, Aidan Wiederhold, Patrick Dougan for agreeing to help with minute-taking and summarising (more on this later).
 - The drafting team members for their work following up on November/preparing for today.
 - All the names listed on the introductory slide for their efforts preparing the format of today.
- We want to allow as much time as possible for discussion, but will begin with very briefly taking stock of where we are at!

Where we are now

- Following the 4 November drafting day: <https://conference.ippp.dur.ac.uk/event/1391/> we circulated a set of 'draft statements' based on the discussions/survey: https://docs.google.com/document/d/1qByRWtqo2PL7P5Q3VCMgGj_5jNfmga5eyJWVvK78WgSI/edit?tab=t.0 with associated slido <https://app.sli.do/event/4tMKwA7JhCwQ72eZiz1cdX>.
- Today we do not want to repeat the November discussions but have tried to structure discussions to fill gaps/address outstanding points. Some have already added comments to the google doc for today https://docs.google.com/document/d/1qByRWtqo2PL7P5Q3VCMgGj_5jNfmga5eyJWVvK78WgSI/edit?tab=t.0
- Aiming to produce a first set of community input by deadline on 31st March.
- There will then be two additional meetings; one following the 31st March deadline but before the 26th May deadline (save the date: 28th April), and a second following the release of the briefing book (probably October 2025).

The meeting today and the route towards a draft

- Set of structured (and time-limited) discussions which will build on comments in the google doc and hopefully take additional points/comments in the room. We have tried to reduce the number of presentations/slides to a minimum
- Based on discussions, plan to prepare a set of short summaries: https://docs.google.com/document/d/1vMEN_C1u1B75NcuwxFX8-dg_EK9_0bTmb5JEDufvjy4/edit?tab=t.0#heading=h.Imun53becin that will be prepared after sessions and discussed (in some cases) in short wrap-up discussions.
- These summaries, and the previous draft statements will then form the basis for the draft that will be prepared (and circulated around the community in February).

Conclusion

- From now aim to move on so we have maximal time for discussion.
- We hope today will provide a respectful and inclusive environment to discuss the future. Please respect the [CERN code of conduct](#)

Request: we propose to record the meeting for minuting/drafting purposes only (it will not be made public)- please let us know if you have ~~objections to this.~~



Agenda

Session 1- part 1

10:30 → 12:30 Session 1



Google doc

10:30

Introduction: agreeing/discussing the physics priorities for the future

🕒 15m



This discussion aims to agree/discuss a set of (non-prioritised) physics goals for the future, with the view that these goals can be used to frame subsequent discussions on the future roadmap, including (but not limited to):

- Full characterisation of the properties of the Higgs
- Complementary coverage of possible dark matter candidates
- Push energy frontier exploration to highest achievable value
- Address unanswered questions in quark flavour physics
- Understand origin and nature of neutrino masses
- Precision in muon/kaon/EDM physics as a tool for indirect discoveries
- Others (to be proposed/discussed within the community)

10:45

Introduction- additional priorities for the future

🕒 15m



Opportunity to make specific statements on the list of non-physics considerations for the future. These will not be prioritised (we hope we can agree they are all important) but there are specific statements we may want to make on each of these areas:

- Long-term perspective
- Financial and human resources: requirements and effect on other projects
- Timing
- Careers and training
- Sustainability

Session 1- part 2

11:00

Metrics and timescales for answering q3a "Which is the preferred next major/flagship collider project for CERN?"

45m



We would like community input on what the metrics should be for converging on an answer to q3a, and what timescale we should be aiming to provide an answer (i.e. before March 31st or after all community inputs have been submitted).

[15] Framing discussion- summary of the additional information we expect to be available after 31st March i.e. updated HL-LHC projections, updated LEP3 proposal, linear collider visions update, ECFE e+e- study report, FCC feasibility study report (feel free to add others).

[30] Preliminary discussion on FCC as CERN's preferred project- we would like to have an open discussion about the community's thoughts about:

- The risks of not committing to building the FCC tunnel now.
- The risks of committing to building the FCC tunnel now

11:45

Scenario planning for the future: possible "plan A" options for CERN and scenarios for risk mitigation.

45m



It was agreed in November that we should aim to discuss the future roadmap in terms of optimisation/risk mitigation for different scenarios. For the January drafting day, we have prepared two lists of scenarios for the community to provide input on (both before the meeting and during the meeting). The first considers alternative "plan A" roadmaps for CERN, and the second focuses on risk-mitigation assuming (as a starting point) CERN's default plan of HL-LHC through to 2041 followed by FCC-ee in ~ 2047. The first set of scenarios will be discussed before lunch and the second afterwards; however, it is anticipated that some of the considerations may be linked.

Framing discussion (<15') on the key (collider-related) recommendations from the last ESPPU, i.e. that

- The successful completion of the high-luminosity upgrade of the machine and detectors should remain the focal point of European particle physics, together with continued innovation in experimental techniques. The full physics potential of the LHC and the HL-LHC, including the study of flavour physics and the quark-gluon plasma, should be exploited.
- An electron-positron Higgs factory is the highest-priority next collider. For the longer term, the European particle physics community has the ambition to operate a proton-proton collider at the highest achievable energy.

Scenarios for discussion:

Discussion of possible "plan As" - what are the risks and opportunities? (Note that 1b, 3, 4 and 5 are in tension with the recommendations of the last ESPPU so this discussion should also be steered by the input above).

1) FCC tunnel- part of discussion above but also additional options:

- FCC-ee followed by FCC-hh (baseline integrated programme)
 - Intermediate energy FCC-hh as the first step (aggressive energy frontier programme)
 - FCC-ee, FCC-hh, FCC-eh (extended integrated programme)
- Linear e+e- Higgs factory @ CERN
 - Expand LHC infrastructure (LHeC, FPF and other auxiliary experiments)
 - Delay next big collider experiment and focus on R&D
 - Muon collider @ CERN
 - LEP3 in LHC tunnel

Example risk mitigation exercise: assume CERN's default plan is HL-LHC to 2041 followed by FCC(ee) in ~ 2047.

- HL-LHC delayed/technical problems requiring >~5 years additional data-taking to reach 3000 /fb.
- Updated HL-LHC projections place Higgs coupling sensitivities closer to e+e- projections.
- Another Higgs factory begins construction prior to approval of FCC.
- A significant (5sigma) deviation from the SM observed within the field (either at the 5) HL-LHC/LHC or at another experiment).
- Technology (i.e. RF) required to deliver e+e- programme delayed by >~5 years.
- FCC integrated programme deemed technologically, environmentally or financially unfeasible

- 1 hour 30 minutes total..
- Obvious comment- there will be some overlap between these discussions but we want to get community input on when/how to answer q3a.

Session 2

13:15 → 14:45	Session 2		
13:15	Wrap-up summaries from session 1	10m	
13:25	Scenario planning Aim to continue and conclude discussion of possible future collider scenarios.	20m	
13:45	Accelerator R+D topics for the future <ul style="list-style-type: none">Blue skies R+D topics- do we want to prioritise any (subset) of technologies?Do we want to make a statement on the importance of ringfencing funding for disruptive technologies?	30m	
14:15	Additional considerations for the future collider roadmap <ul style="list-style-type: none">Industrial input/returnCommunication/public engagementTraining and retention of talent (including theory, software, instrumentation, accelerator science).	30m	

Session 3

15:15 → 17:00 Session 3



15:15

Framing discussion for non-collider topics

🕒 15m



- Aim to present information on which non-collider projects/ experiments exceed the resource threshold (in terms of costs) for possible direct consideration/mention in our ESPPU input.
- Will also attempt to summarise points raised in November and submitted through the community inputs.

15:30

Summary of comments/considerations for non-collider questions

🕒 30m



- Future of neutrino physics- statements on neutrino platform? Beyond accelerators?
- Dark matter and complementarity
 - a) Do we want a statement on Boulby ambitions?
 - b) Similar for FPF/Ship
- Importance of smaller (complementary) experiments
- Quantum technologies
- Others (based on community inputs)

16:00

Discussion of input related to astroparticle/ nuclear physics

🕒 30m



16:30

Wrap-up + next steps

🕒 30m



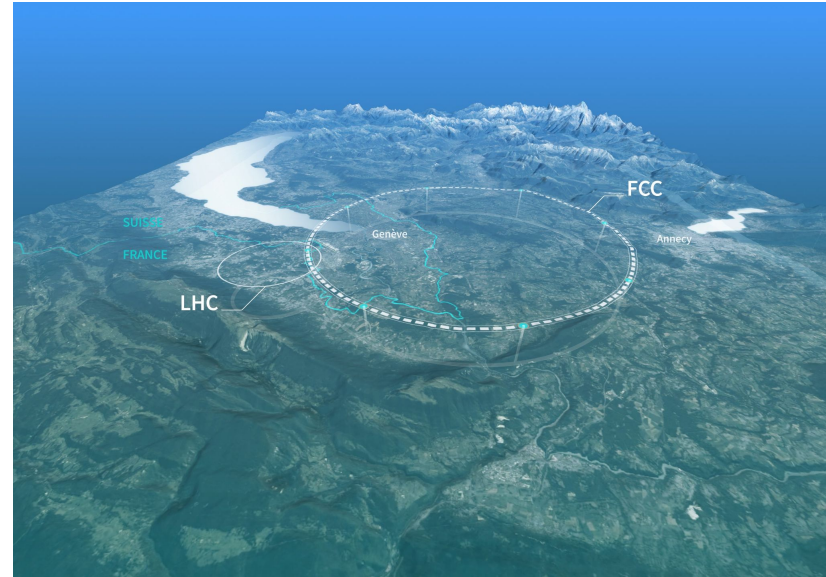
- (1) 15' for discussion of wrap-up summaries from session 2
- (2) 15' to discuss wrap-up/next steps for non-collider questions (session 3)

Framing discussion- new information
expected before 31st March

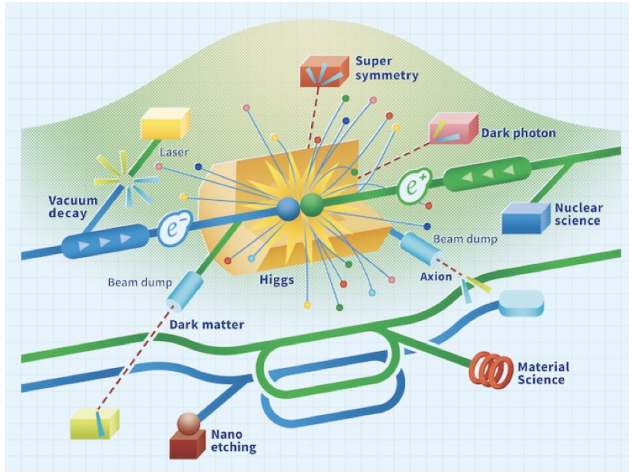
FCC feasibility study

Following mid-term report, final report of the FCC feasibility study will be submitted on 31st March. Including:

- Detailed scrutiny on technical, scientific and financial feasibility (verdict on mid-term report very positive).
- Updated costings.
- Additional effort to further understand physics capability of FCC-hh also ongoing.



Linear collider vision for ESPPU



Propose a versatile Linear Collider Facility (LCF) suited to hosting a long-term program at CERN

- starting from a baseline that is affordable and realizable in a timely way
- building on the mature LC proposals and all the related accelerator R&D
- with scientifically and technologically exciting upgrade options
- with a thorough sustainability analysis including full LCA

Civil construction is compatible with both ILC-like and CLIC-like options, with 2 IPs

Initial baseline is superconducting RF (ILC-like) – can be realized the fastest (to overlap with the end of HL-LHC)

CLIC technology (warm) is an alternative; allows higher \sqrt{s}

Costs are being updated using:

- industry input on cryomodule costings
- CLIC's site-specific civil engineering studies

CLIC luminosities are also revised (upwards)

ECFA e+e- study

<https://ecfa.web.cern.ch/ecfa-study-higgs-ew-top-factories>

- Both editors (Aidan Robson and Christos Leonidopoulos) from the UK!
- Culmination of an extended programme of work across 3 working groups aiming to bring together all higgs/EW/top factory projects.

Muon collider inputs

- As noted in November- expect additional scenarios (beyond those considered for snowmass- <https://arxiv.org/pdf/2209.01318>) including 8 TeV muon collider scenario @ CERN.

Updated HL-LHC inputs

- Joint ATLAS-CMS submission expected to make clear the physics case for 3000 fb⁻¹ at 14 TeV.
 - Focus on agreed set of physics scenarios.
 - Consider 2000 fb⁻¹ and 3000 fb⁻¹.
 - Where possible consider combined results and several extrapolation scenarios.
- LHCb submission planned including (based on November submission) at least 4 topics: Discovery potential; Technology developments (including sustainability); Heavy ion physics; Software and Computing

A (non-exhaustive) list of additional inputs expected?

- FPF @ CERN
- Global argon dark matter collaboration
- XLZD
- LHeC/FCCeh
- LEP3
- HALHF
- Ship
- Plus (presumably) others...

Disclaimer: this list has been put together this week based on information available from November/ discussions with collider projects and can be added to/corrected after the meeting...

Framing discussion- non-collider experiments

Large vs small projects vs R&D

For reference, the “ESG” is classifying “large-scale” projects, as “occupying the resources and efforts of an appreciable fraction of the European particle physics community for a number of years” - taken to correspond to capital investment of at least ~250 million CHF.

- In the UK submission: separate “large-scale” projects and other non-collider “themes” that include smaller scale projects
- Separate “large-scale” projects that are “construction ready” and R&D and enabling activities for longer-term future.

Large scale projects tentative list

- DUNE
- HyperK
- XLZD – connection with APPEC
- LEGEND – connection with APPEC
- SHIP (over threshold?)
- Other ?

Other non-collider themes and R&D

- Precision muon physics
- Precision kaon physics
- LAr Direct Dark Matter (R&D?)
- Quantum Technologies for Fundamental Physics – R&D
 - Dark matter
 - Neutrino physics
 - Precision Standard Model tests
 -
- Neutrinos beyond DUNE, HyperK, eg. nuSTORM – R&D
- EDM experiments – R&D?

Backup

(3) Questions to be considered by countries when forming and submitting their “national input” to the ESPP

- a) Which is the preferred next major/flagship collider project for CERN?
- b) What are the most important elements in the response to 3a)?
 - 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 3a) 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 3a), 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 3a) is not feasible (due to cost, timing, international developments, or for other reasons)?
- f) What are the most important elements in the response to 3e)? (The set of considerations in 3b should be used).

(4) The remit given to the ESG also specifies that “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 4a)? (The set of considerations in 3b 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.