

# ESPPU drafting discussions- questions and sample statements

UK national drafting day- 4th November 2024, STFC  
Daresbury National Laboratory

# Collider-related questions

105 minutes total

Note: all the timings are ~guidelines to ensure we cover all topics!

## Overview of timings for session 2

- 15 minutes for discussion on 3a
- 10 minutes (additional) discussion on 3b
- Followed by 10 minutes for wrap-up and to (hopefully) converge on some points for inclusion in the draft.

[2 min break]

- 20 minutes for discussion on 3c and 3d
- Followed by 10 minutes for wrap-up and to (hopefully) converge on some points for inclusion in the draft.

[2 min break]

- 20 minutes for discussion of 3e and 3f .
- Followed by 10 minutes for wrap-up and to (hopefully) converge on some points for inclusion in the draft.
- ~ 6 minutes “overflow” to raise additional points for follow-up.

### 3a) What is the preferred next major/flagship collider for CERN?

*“CERN should remain a global laboratory for particle physics so it is important that a post-HL-LHC collider is built”*

*“For a full understanding of the Higgs sector an e+e- Higgs factory must be realised somewhere in the world.”*

*“From an accelerator physics perspective the FCC in all three flavours is a technically feasible flagship European collider.”*

*“FCC-hh is not affordable under any foreseeable budget scenario and thus the FCC tunnel should not be built and a Higgs factory should be a linear e+e- collider at CERN.”*

*“The only project mature enough in terms of a robust feasibility study and costing is FCC-ee and this should be pursued as the number-1 priority.”*

*“A decision on a 10 TeV pcm collider cannot be made now owing to the level of accelerator R&D still required. A next-generation e+e- collider should therefore be independent of a further-future 10 TeV pcm collider.”*

*“Any future collider should fit within the existing CERN sites.”*

*“The quickest path to a 10 TeV pcm collider is a muon collider at CERN and this should be pursued as the number-1 priority.”*

*“None of the collider projects currently proposed is acceptable due to either cost or sustainability issues and so this decision should be deferred until an acceptable project has been proposed.”*

## 3b) What are the most important elements in the response to 3a)?

Factors to discuss:

- 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

*“The future programme should be compatible with full exploitation of the HL-LHC, where the current programme runs to 2041”*

*“The operation and construction of a world leading collider based experiment must take careful consideration of the impact to the climate, and by extension or otherwise the ecosystems and societies in proximity.”*

*“The next collider at CERN should have the same or lower environmental impact to both construct and to operate as the LHC.”*

10 minutes for (additional) discussion - assuming some will have happened in 3a

## Points for convergence after discussion on 3a) and 3b)

Do we want CERN to remain global laboratory for collider physics after HL-LHC?

Do we want the next collider to be a  $e^+e^-$  Higgs factory and should it be at CERN?

[If yes- FCC-ee or LC @ CERN?]

If an affordable financial model were provided, would we support the integrated FCC programme as a vision for collider physics @ CERN for the future?

(Combining intensity-frontier and energy-frontier explorations).

What considerations from the HL-LHC programme (exploitation criteria, timescales) should be considered?

Pause (2 minutes)

3c) 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?

*“There should not be two Higgs factory machines operating globally at the same time”*

*“If China proceeds with CEPC then CERN should build ILC”*

*“CERN should prioritise energy-frontier exploration and proceed towards FCC-hh as quickly as possible”*

*“If China proceeds with CEPC then CERN should not build FCC-ee”*

*“If China or Japan proceed with CEPC or ILC then Europe should seek to participate”*



3d) 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?

*General accelerator R&D Topics for consideration (not in any order):*

- *High temperature superconductors.*
- *High efficiency RF (klystrons)*
- *Muon acceleration (including production, cooling, etc)*
- *Neutrino beam technologies*
- *+....?*

*“In order to maintain European expertise and recruit new members to the field of accelerators, novel technologies such as those underpinning the Muon Collider should be pursued.” (also relevant for 3b-ii,v)*

*“There should be a significant investment now in R&D for high-field dipoles for FCC-hh so that a feasibility study can be concluded on FCC-hh within a decade i.e. before significant spending on FCC-ee begins.”*

*“The priority for accelerator R&D topics should be those which have the potential for a significant impact in making future colliders more sustainable (e.g. HTS magnets, high efficiency klystrons, thin film superconducting RF cavities, fast reactive RF tuners, permanent magnets).”*

*“Plasma acceleration (both laser and beam driven) R&D for future colliders should receive significant investment as this technology offers the most likely long term future for HEP colliders.”*

## Points for convergence after discussion on 3c) and 3d)

Do we think there could/should be two Higgs' factories operating globally?

What level of participation should Europe have in overseas Higgs' factory projects?

Level of European participation in a muon collider?

Considerations from results at the HL-LHC/elsewhere?

Additional accelerator R+D topics to be pursued in parallel?

Pause (2 minutes)

3e) 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)?

*Should be discussed in light of previous responses/discussions.*

*[LHeC] “The LHeC would bridge a gap in time and physics between the HL-LHC and the next major collider.”*

*[LHeC/FCC-eh] “The LHeC and FCC-eh strengthen the physics discovery potential of the HL-LHC and FCC programmes.”*

3f) Most important elements in response to 3e:

Factors to discuss:

- 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

+10 minutes for wrap-up

Time for remaining points (6 minutes)

# Non-collider-related questions

*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:*

75 minutes total, including the “additional points” discussion at the end!

# Overview of timings for session 3

- 25 minutes for discussion of 4a and 4b)
- Followed by 10 minutes for wrap-up and to (hopefully) converge on some points for inclusion in the draft.

[2 min break]

- 15 minutes for discussion on 4c)
- Followed by 5 minutes for wrap-up and to (hopefully) converge on some points for inclusion in the draft.

[2 min break]

- 16 minutes for discussion on of 'additional points' (including SW+ computing, instrumentation, theory) before moving to closeout

## 4a) What other areas of physics should be pursued, and with what relative priority?

**Note: this is NOT a prioritised list and intended to reflect possible statements in different areas. We also anticipate there will be additional suggestions for other non-collider areas!**

*[Neutrinos] “Europe should prioritise its leading contributions to the construction and scientific exploitation of the long-baseline neutrino oscillation experiments DUNE and Hyper-K, as well as to at least one, preferably two, neutrinoless double beta decay experiments capable of fully probing the inverted ordering parameter space for Majorana neutrino masses. This programme is highly complementary to the collider physics goals and should be regarded as the highest priority for non-collider particle physics activities in Europe. In the longer term, Europe should identify the scientific drivers and develop technologies for the neutrino physics programme beyond the currently planned oscillation and neutrino mass experiments.”*

*[QTFP] “Integrating quantum technologies into the European Strategy for Particle Physics offers a unique opportunity to leverage the existing expertise in the UK, at CERN and other European labs. By building on these strengths, we can open new avenues for exploring the fundamental laws of nature and position Europe at the forefront of innovation in particle physics.”*

*[Direct dark matter] “There is clear interest in the UK to host a large dark matter detector with interest also from other European countries and the US. This should be flagged as a priority and we should understand what support CERN could offer, similarly to what currently on offer with the neutrino platform.”*

*[Non-collider including SHiP, FPF/Faser2, ANUBIS, Codex-B, KOTO-II, nEDM, pEDM, MuEDM, eEDM, Mu2e-II/AMF, Mu3e-II, COMET-II] “ There are many non-collider experimental opportunities that should be pursued in the next 25 years that complement and extend those at energy-frontier colliders. These experiments are sensitive to many phenomena and BSM parameter space not accessible to energy-frontier colliders e.g. FIPs, FIMPs, Quirks, milli-charged particles, LLPs, EDMs, dark-sector phenomena and very rare muon and kaon decays. These experiments exploit existing or planned accelerator infrastructures at CERN, PSI, FNAL, JPARC, ESS, BNL and provide a cost-effective means to broaden the physics landscape.”*



## 4b) Most important elements in response to 4a:

Factors to discuss:

- 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

*Physics potential complementary to energy-frontier colliders (we don't know what the BSM physics will be ....), training, timing: filling large gaps in the programme.*

*Experiments that mostly use existing large-scale resources and infrastructure are cost-effective and the environmental impact is reduced.*

*Several of the planned non-collider programs will continue beyond HL-LHC and will thus provide continuity in the particle physics programme, avoiding long gaps without running experiments which is important in attracting future students to the field. Critically they also provide important training opportunities in the R&D, construction and commissioning of experiments that will be required to realise the future energy-frontier collider programme.*

10 minutes for (additional) discussion - assuming some will have happened in 3a

10 minutes for wrap-up/  
convergence on  $4a+4b$

Pause (2 minutes)

## 25 minutes for discussion

4c) 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.

*“CERN’s accelerator complex is well suited to cater to both nuclear and particle physics. The injector synchrotrons have been robustly upgraded to cater to many types of user, and around 50% of protons produced at CERN are used by ISOLDE. As the LHC typically uses around an hour of beam time in the injector synchrotrons a day, it is efficient to maintain CERN’s nuclear physics capability.”*

+10 minutes for wrap-up

Pause (2 minutes)

# Additional points for discussion

*To be integrated into the questions OR submitted as additional “free-text” input following drafting discussions*

## Software and Computing, Detector R&D, Theory

*To protect R&D in detectors, software, and computing, funding should be safeguarded and ideally ring-fenced. This will ensure the R&D programme is not eroded by current or future large-scale project commitments. This strategy is essential for securing the technical capabilities and advancements that will drive future success of particle physics.*

*Software and computing are essential for the development and operation of modern particle physics experiments, which generate and process massive datasets (exabytes by the late 2020s). To maximize the physics potential of future colliders, we must leverage modern computing technology for both low-latency (e.g., trigger-level) and high-latency (e.g., offline processing). Advancements in hardware and software will be pivotal for future particle physics research. To stay at the forefront, we must adopt emerging technologies like AI, collaborating with other research and industry sectors.*

*Detector R+D is essential for the success of collider and non-collider programmes, so additional support for the DRD collaborations emerging from the 2021 ECFA detector R+D roadmap is key for the field. This includes financial resources and ensuring that training is provided for new researchers to get involved.*

*Advances in theory will be essential for future experiments to test the Standard Model. The European community should ensure that essential infrastructure (e.g. Monte Carlo generators) are supported and recognised, and support the establishment of new roadmaps to meet the theory needs of future experiments.*