

3rd Swiss Input to ESPP

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Timeline approved by Council

March 2024 Council



- Council decision on the timeline for the Strategy update
- Call for nominations for the Strategy Secretary
- Call for nominations for the members of the ESG and PPG
- Announcement to the community that March 2025 is the deadline to submit input.

June 2024 Council



- Council appointment of the Strategy Secretary and establishment of the Strategy Secretariat
- Council establishment of the ESG
- Call for venues for the Open Symposium and the Strategy Drafting Session



September 2024 Council

- Council appointment of the members of the PPG



December 2024 Council

- Council decision on the venues for the Open Symposium and the Strategy Drafting Session



March 2025

- Deadline for the submission of input from the community



Early July 2025

- Open Symposium



End of September 2025

- Submission of the "Briefing Book" to the ESG



New: Project comparison mid-October

Early December 2025

- Strategy Drafting Session

End January 2026

- Submission of the Draft Strategy Document to the Council for feedback

March-June 2026 Council Sessions

- Discussion of the Draft Strategy Document by the Council followed by the updating of the Strategy by the Council.

Third National Swiss ESG input discussion

Three chances for national inputs to the ESPP

1. March 31st
2. May 26th
3. Nov.14th

Switzerland has submitted two inputs so far

- ❑ First input expressed our findings from our Feb. national strategy meeting
 - We expressly stated “no plan B”
- ❑ Second input expressed our unchanging stance (after reviewing ESPP inputs) & clarified misunderstandings
- ...

For third input, we have new information:

- ❑ **Physics Briefing Book**
 - ❑ Comprehensive physics comparison of all proposed experiments (including Swiss authors & Swiss convener, Gino)
- ❑ **Project comparison**
 - ❑ Short summary of a more complete report being prepared
 - ❑ Produced by ESG Working Group (including BK) and expert accelerator physicist panel (including Lenny Rivkin)

Physics briefing book

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Physics briefing book

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What are we discussing today ?

- We have spent years [1] converging on our statement ...
 - We want to make epsilon changes today, not a completely new statement
- For this (3rd) national input, in light of the findings in the Physics Briefing Book and in the project assessment, we are asked to focus on (only) three key questions:
 1. What is the preferred large-scale post-LHC accelerator for CERN?
i.e., What is our Plan A ? (CHIPP has been quite clear on this: FCC-ee followed by FCC-hh)
 2. What is the preferred alternative, if the preferred option is not feasible?
i.e., What is our Plan B if there is not enough money ? (CHIPP has insisted on FCC-ee/FCC-hh)
 3. What is the preferred alternative, if the preferred option would not be competitive?
i.e., What is our Plan B if China builds CEPC ? (CHIPP has insisted on FCC-ee/FCC-hh)

While we could maintain our current statement, it behooves us to consider whether this is strategic. The ESG strategy group will decide on a plan B. Do we want a say ?

[1]: CHIPP 2018 input to European strategy; CHIPP 2021, 2024 roadmaps

What does “Plan B” mean ?

- The “Plan B” option presented to CERN council does not mean plan B will happen
- It means:
 - Regardless of Plan B, Plan A will be presented to CERN council and an effort will be done to get it approved by 2028
 - Some CERN funding will be used in the next years to increase viability of plan B
 - If plan A is not approved by 2028-2029
 - CERN council may consider the next steps of the feasibility studies for plan B

Scenarios to consider

Projects that can start **mid-2040s**,
with a long-term vision
(More detailed evaluation)

Upgrades – not new machine



Stage 1

- FCC-ee
- LEP3
- LCF 250
- CLIC 380
- LHeC

Stage 2

- FCC-ee
- LEP3
- LCF **550**
- CLIC **1.5**
- LHeC

Long-term vision

- FCC-ee + FCC-hh
- LEP3 + FCC-hh
- LHeC + FCC-hh
- LCF 250 + 550 + MuC 10
- CLIC 380 + 1.5 + MuC 10

Projects that start **later**
(Less detailed evaluation –
hard to compare)

Standalone

- FCC-hh



Energy:

85 TeV (14T)

First beams:

2054 (technically limited)

2060 (considering funding)

Factors for consideration

Swiss Interests

Physics performance

Project feasibility

Schedule

- Time between end of HL-LHC and first data from new machine

Costs

- Capital costs
- Operation Cost

Funding scenarios

- Increases beyond FCC in funding required to achieve program

Political will

Considerations for Plan B “if China?” or “if too expensive” ?

- While not official, many of us have heard from knowledgeable sources that China has not included CEPC in their 5-year plan
 - It may still get chosen in future, but
 - They are set back at least 5 years
 - Perhaps less likely to be selected at all now...
- What does “too expensive” mean ?
 - FCC-ee financial plan requires funding beyond current CERN contributions
 - One possible funding scenario
 - 4-6 BCHF in external contributions
 - Much (or all) of this funding could come from EU sources* and private donations
 - The U.S. has also indicated possible support
 - An increase in member contributions (assuming 4BCHF external)
 - A cumulative 12.65% increase in member contributions beginning in 2029
 - Phased in at an increase of +1.5% per year

* European Commission 2025/0543 (COD): up to 20% of FCC-ee cost included

Costs of plan Bs

- LCF 550 (stage 1 + 2): funding profile is same as FCC-ee
- CLIC
 - Requires two 2 BCHF contributions (2035 & 2050)
 - And a one-time, 1% member contribution increase
- LEP3 and LHeC do not require additional funds
- FCC-hh standalone
 - Requires 10 BCHF external donations over 12 years starting 2047
 - And a 20.8% cumulative increase in member contributions
 - +2.5% per year beginning in 2040

General summary of Physics Briefing book

- Plan A: integrated FCC program (FCC-ee + FCC-hh) comes out on top in all physics areas
- Plan B's can be compared (this summary interpreted from Briefing Book)
 - All Plan B options give up something. What is tolerable ?

Stage 1	Higgs	Higgs self-coupling	EWPO	Top	Flavour
FCCee	Green	Yellow	Green	Yellow	Green
LEP3	Yellow	-	Yellow	-	Yellow
LCF 250	Orange	-	Orange	-	-
CLIC 380	Yellow	Yellow	Orange	Yellow	-
LHeC	Red	-	Red	Orange	-

Stage 2	Higgs	Higgs self-coupling	EWPO	Top	Flavour
LCF 550	Green	Green	Orange	Green	-
CLIC 1.5	Green	Green	Orange	Green	-

Integrated program

High energies	Higgs	Higgs self-coupling	EWPO	Top	Flavour	Heavy Ions
FCCee+FCChh	Green	Green	Green	Green	Green	Green
LEP3+FCChh	Yellow	Green	Yellow	Yellow	Yellow	Green
LCF 250+550+MuC 10	Green	Green	Green	Green	-	-
CLIC 380+1.5+MuC 10	Green	Green	Green	Green	-	-
LHeC+FCChh	Yellow	Green	Red	Yellow	-	Green

Not shown: QCD (such as α_s) and BSM 12

Swiss point of view of plan B physics

- Flavor physics: Swiss groups strong in this area across expt./theory/multiple expts.
 - These options not appealing from this perspective
 - LHeC
 - LCF
 - CLIC
 - Integrated LCF & CLIC programs
 - Integrated LHeC program
 - LEP3 with integrated LEP3+FCC-hh may be acceptable
- Higgs and Higgs self-coupling: Swiss groups strong in this area
 - Stage 1: no plan B as good as FCC-ee
 - Stage 2: LCF550 and CLIC1.5 slightly better than FCC-ee
- Electroweak precision observables
 - No plan B (stage1 or 2) as good as FCC-ee
- Top physics
 - Stage 1: CLIC380 comparable to FCC-ee
 - Stage 2: LCF550 and CLIC1.5 better than FCC-ee

Project comparison (Summary of ESG document*)

- LEP3:
 - Immature design
 - High risk of delivering a factor of 10 below luminosity projection (so, 2 orders below FCC-ee)
- LHeC:
 - Feasibility depends on successful PERLE program to demonstrate energy-recovery linac
 - Risk of delivering a factor of 10 below luminosity projection
- CLIC
 - Most advanced stage of plan Bs
 - Large scale demonstrator required
 - 100 MCHF and 570 FTEy of R&D required
- LCF
 - Several uncertainties & risks, but generally considered feasible
 - R&D required for achieving SRF quality factor and E-field gradient
 - 185 MCHF and 750 FTEy of R&D required
- FCC-hh standalone 85 TeV
 - Large cost uncertainties due to needed magnet development
 - 15-20 years R&D for industrializable 14T magnets
 - HTS magnets considered 10 years behind Nb₃Sn (default) technology
 - 12T magnets (rather than 14T) would reduce risk (and c.o.m. energy)
- Muon Collider
 - Substantial R&D required
 - Realistic performance, schedule and cost estimates not conceivable until R&D plan executed
 - Substantial risks (neutrino radiation)
 - > 300 MCHF & 1800 FTEy over 10 years to realize R&D program

See preliminary report of the ESG WG2a on Project Assessment (17/10/25)

- A 30-page document, accompanying this summary will be released at the end of the month. With green/yellow/red traffic light readiness

Reminder of why we like plan A: FCC-ee + FCC-hh

- Allows us to access (indirectly) an energy scale 10^* that of HL-LHC
 - Luminosities across different energies enable precision and rare-decay program
- Full range of physics possible
 - High value to flavor and electroweak program
- FCC-ee gets us one step closer to FCC-hh
 - Builds infrastructure for the more expensive high-energy machine
- Four experiments
 - Commensurate with LHC community size

What is lost with plan B

- Linear Collider options
 - Do not provide sufficient flavor-physics program for Swiss community
 - Do not provide a path to FCC-hh
- Cheaper options
 - Do not provide a path to FCC-hh
 - LHeC
 - Limited physics program
 - Limited participation (one experiment)
 - Uncertainties on performance
 - LEP3
 - Large uncertainties on performance
- Expensive options
 - Standalone, accelerated FCC-hh
 - Large cost uncertainties
 - Schedule does not permit advances in magnet design
- Bleeding edge option
 - Muon collider
 - Insufficient understanding of performance, schedule and cost
- Conclusion
 - No good options for plan B ?

Other strategies for plan B

- What we want is plan A
 - FCC-ee followed by highest energy FCC-hh possible
- How can we make this happen ?
- **Possibility 1:**
 - *Q: Plan B if Plan A is too expensive?* LEP3, while voicing strong support for FCC-hh
 - Con: Cheaper options may look appealing to funding agencies
 - Con: CERN council would approve LEP3, **not LEP3 + FCC-hh**
 - We kick the problem a few decades down the line
 - Con: Project comparison indicates high risk on LEP3 delivered performance
 - Con: FCC-hh becomes 6 BCHF more expensive (must add tunnel & infrastructure)
 - Con: Two experiments may not support full community
 - Con: Expiration of current FCC territorial reservations

Strategy for plan B

- What we want is plan A
 - FCC-ee followed by highest energy FCC-hh possible
- How can we make this happen ?
- **Possibility 2:**
 - **Q: Plan B if Plan A is too expensive?** Spread out profile of FCC-ee (decision still 2028)
 - If FCC-ee is too expensive, we delay by up to 5 years to make it happen (2050)
 - Savings of ~600 MCHF/year (?) when no machine operating at CERN
 - < 5 years, depending on what increase in funding is agreed to by CERN council
 - This delay is perhaps not so critical due to CEPC situation
 - ECRs have indicated they prioritize a decision on plan A over the time gap between HL-LHC and next machine
 - **HL-LHC is a rich physics program**, and we will be analyzing data from 2040 – 2050
 - **Q: Plan B if if Plan A is not competitive?** FCC-hh standalone (2060)
 - This question is less relevant with CEPC situation
 - While this option is expensive, that is not **the question**
 - This plan could allow funds to be allocated for Plan B to strengthen the overall FCC program — for example, by supporting R&D on high-field or high-temperature superconducting dipoles for FCC-hh

Other proposals ?

- Discussion

How to proceed

- Input is due November 14th
- Today: decide on general message
- Possible plan:
 - Write a short 1-page document answering Plan B questions, referring to previous input
 - **Q: Should we list vetoes ?**
 - First draft by Nov. 1st
 - Comments from full CHIPP Plenary
 - Second (final) draft by Nov. 8th
 - CHIPP board vote by Nov. 12th
 - Submit Nov. 14th
 - **Q: Any benefit to submitting earlier ?**
 - **Q: Should we do two drafts ?**
 - Draft 1: Nov. 1st
 - Draft 2: Nov. 7th
 - Final draft for vote: 12th