FCC Feasibility Study Status

Plenary ECFA, 17 November 2023

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on behalf of FCC collaboration & FCCIS DS team

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http://cern.ch/fcc
Status and progress on

• Implementation activities
• Site investigations and environmental studies
• Civil engineering
• Cooling water supply concepts
• Excavation material management

Mid-term review update
Meetings with municipalities concerned in France (31) and Switzerland (10)

PA – Ferney Voltaire (FR) – site experimental
PB – Présinge/Choulex (CH) – site technique
PD – Nangy (FR) – site experimental
PF – Roche sur Foron/Etaux (FR) – site technique
PG – Charvonnex/Groisy (FR) – site experimental
PH – Cercier (FR) – site technique
PJ – Vulbens/Dingy en Vuache (FR) site experimental
PL – Challex (FR) – site technique

The support of the host states is greatly appreciated and essential for the study progress!
Examples of Fermilab Deliverables

• bills of quantities extracted from FNAL designs

• basis for cost estimate by consultant with experience on industrial constructions in CH-FR area.

• next steps: individual integration studies and design optimization with municipalities concerned
CE underground progress

- Full 3D model of underground structures as basis for costing exercise
- Update of scheduling and costing with external consultant
- Technical Site (PB)

**next steps:** adaptation of vertical alignment and tilt of tunnel and revision of construction methodology based on results from site investigations.
Potential sources of cooling water Geneva lake (PA), Rhone (PJ) and Arve (PD).

Existing line with lake water provided by SIG to CERN LHC P8 (LHCb) sufficient for FCC-ee.

Pipework in the tunnel will connect the remaining points to points PA, PD and PJ.

Main cooling towers placed at experiment points (PA, PD, PG, PJ), and RF sites (PL, PH).
Tunnel implementation summary

- 91 km circumference
- 95% in molasse geology for minimising tunnel construction risks
- 8 surface sites with ~5 ha area each.
Status of subsurface investigations

- Site investigations in areas with uncertain geological conditions:
  - Optimisation of localisation of drilling locations ongoing with site visits since end 2022.
  - Work with FR and CH ongoing to obtain autorisations for start of seismic investigations and drillings in Q2 2024.

- Contracts Status:
  - Contract for engineering services and role of Engineer during works, active since July 2022
  - Tendering for execution contracts is ongoing towards contract placement in December 2023 and mobilization from January 2024.
Studies of environmental aspects ongoing

- Studies of relevant environmental aspects over 18 months (> 4 seasons to see full cycle) with a consortium of specialized companies
- Necessary inventory for the “Avoid-reduce-compensate” approach and costing (compensation measures)
- Input for surface site designs, installation and operation aspects
- Pre-requisite for the required initial state report, before an environmental impact assessment
- Exhaustive list of topics covered:
  - Topography, geology, hydrogeology, surface water, natural risks, urbanistic planning, fauna & flora survey, habitats and wetland analysis, soil quality and pollution, noise, light, radiation, technological risks, demography, economic activities, landscape and visibility, patrimony
- Central management of all data in an “Environmental Information System” to be able to document the evolutions of the territory, the civil construction designs and the technical infrastructure development integrated with classical “Geographical Information System”
Examples for field investigations and environmental studies

Identification of protected species

Determination of quality of the top soil and potential pollution, determination of the economic land value

Inventory of fauna & flora on surface sites

Description of surrounding, views to be preserved, architectural aspects to be considered.
An innovative local approach for excavated materials:

Excavated material from FCC subsurface infrastructures: 6.5 Mm$^3$ in situ, 8.4 Mm$^3$ excavated (bulk factor 1.3)

2021-2022: International competition “Mining the Future”, launched with the support of the EU Horizon 2020 grant agreement 951754, to find innovative and realistic ideas for the reuse of Molasse (95% of excavated materials)

2023: Definition of the “OpenSky Laboratory” project:

- **Objective**: Develop and test an innovative process to transform sterile “molasse” into fertile soil for agricultural use and afforestation.
- **Duration**: 4 years (2024-2027)
OpenSky Laboratory : HOW?

• 3'000 m² at LHC P5 in Cessy, France.

• Trial with 5 000 t of excavated local molasse

• 18 cells for agriculture trials (10*10 m)

• 2 cells for forestry trials (20*20 m)

• Different types of plants selected as function of regional specificities

1) Initial laboratory analysis to **identify** the **most suitable mixing** of molasse and amendments,

2) **Mixing/spreading** of the molasse with amendments on the trial cells,

3) **Planting and treatment with monitoring** of the field conditions in a **controlled environment**.
OpenSky Laboratory: WHO?

A collaborative effort of industry and academic/educational institutes

BG Ingénieurs Conseils
- Support for quality soil management during construction
- Mixing of the molasses with amendments during exploitation
- Support in field restoration after the experience (depending on the results)

ETS Nabaffa
- NOT PART OF THE FCC MoU Collaboration
- Local molasses supply
- On-site pre-treatment of molasses (grain size separation and recombination)

M-S
- Off-site pre-treatment of molasses for laboratory test (grain size separation and recombination)

University of Leoben
- Molasses characterization
- Comparison of molasses characteristics with existing FCC underground database
- Scientific support in geology and geotechnics

BECC
- Field instrumentation with connected field measurement devices for soil, plant and weather monitoring
- Creation of a supervisory control and data acquisition system

Open Sky Laboratory (Located at HL-LHC P5)

Molasse Pre-Treatment

BECC
- Field instrumentation with connected field measurement devices for soil, plant and weather monitoring
- Creation of a supervisory control and data acquisition system

Edaphos
- Biological analyses
- Selection, sourcing and characterization of organic matter
- Formulation and production of biodynamisation amendment (capsule)
- Molasses mixing methodology

Microhumus
- Laboratory tests to evaluate material treatment suitability
- Culture selection in function of regional specificities and culture rotation plan

HEPIA
- Design of the experimental field
- Culture selection in function of regional specificities and culture rotation plan
- Culture rotation plan
- Soil engineering and pedogenesis

CSIL
- Economic and societal impacts analyses
- Business plan development
- Environmental compensation quantification

BOKU
- Development of a scientific protocol and tracking of the field trials
- Design of the experimental field
- Socio-economic study
To start the excavation of the first shafts in 2033, a significant amount of preparatory work is required. An initial consideration of these preparatory works including scheduling and resource aspects has been made:

<table>
<thead>
<tr>
<th>Year</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2025-26</td>
<td>Permits and authorization for complementary site investigations</td>
</tr>
<tr>
<td></td>
<td>Tendering for environmental impact and authorisation processes contract, tendering for subsurface investigations</td>
</tr>
<tr>
<td>2027-28</td>
<td>Complementary subsurface investigations</td>
</tr>
<tr>
<td></td>
<td>Tendering for CE consultants, environmental impact studies, public concertation</td>
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<tr>
<td>2028</td>
<td>Project approval</td>
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<tr>
<td></td>
<td>Award of CE consultant contracts</td>
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<tr>
<td>2029-30</td>
<td>Tender design</td>
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<tr>
<td></td>
<td>Preparing calls for tenders for CE construction,</td>
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<tr>
<td></td>
<td>Project authorisations in France and Switzerland obtained</td>
</tr>
<tr>
<td>2031 mid 2032</td>
<td>Construction design, Tendering for construction</td>
</tr>
<tr>
<td>mid 2032</td>
<td>Award of CE construction contracts</td>
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<tr>
<td></td>
<td>Preparation of site (road access, electricity, water...)</td>
</tr>
<tr>
<td>2033</td>
<td>Ground breaking</td>
</tr>
</tbody>
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## Preparatory phase planning civil engineering

<table>
<thead>
<tr>
<th>Activity</th>
<th>Duration</th>
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<tbody>
<tr>
<td><strong>FCC Civil Engineering</strong></td>
<td></td>
</tr>
<tr>
<td>Mid-term Review</td>
<td>0 days</td>
</tr>
<tr>
<td>Feasibility Study Complete</td>
<td></td>
</tr>
<tr>
<td>European Strategy</td>
<td>31/12</td>
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<tr>
<td>Start Civil Engineering</td>
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<tr>
<td>Civil Engineering Works</td>
<td>175 days</td>
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<tr>
<td><strong>Pre Feasibility Study</strong></td>
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<tr>
<td>Site Investigations</td>
<td>206 days</td>
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<tr>
<td>MS and CFT for site investigation consultants</td>
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<tr>
<td>Award contract for site investigation consultants</td>
<td>01/04</td>
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<tr>
<td>Prepare MS documentation for Site Investigations</td>
<td>01/04</td>
</tr>
<tr>
<td>Prepare Tender Documents for Site Investigations</td>
<td>01/04</td>
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<tr>
<td>Prepare Tender Documents for Site Investigations</td>
<td>01/04</td>
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<tr>
<td>Site Investigations Phase 1</td>
<td>01/04</td>
</tr>
<tr>
<td>Site Investigations Phase 2</td>
<td>01/04</td>
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<tr>
<td>Prepare Contract Strategy for FCC Civil Works</td>
<td></td>
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<tr>
<td><strong>CE Consultants</strong></td>
<td></td>
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<tr>
<td>Prepare MS documents for CE Consultants</td>
<td>01/04</td>
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<tr>
<td>Prepare CFT documents for CE Consultants</td>
<td>01/04</td>
</tr>
<tr>
<td><strong>Tender for CE Works</strong></td>
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<tr>
<td>Preliminary Designs and MS Documents</td>
<td>01/10</td>
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<tr>
<td>Tender Designs and CFT Document</td>
<td>01/10</td>
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<tr>
<td>Construction Designs</td>
<td>01/10</td>
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<tr>
<td><strong>CE Preparatory Works</strong></td>
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<td>MS for CE Works</td>
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FCC FS mid-term review

Mid-term review setup and deliverables are defined in CERN/SPC/1183/Rev.2:

- the scientific and technical results be reviewed by the FCC FS Scientific Advisory Committee, augmented by additional experts as needed;

- the cost and financial feasibility, which will focus on the first-stage project (tunnel, technical infrastructure, FCC-ee machine and injectors), be reviewed by a committee including external experts, as proposed in CERN/3588;

FCC Scientific Advisory Committee
Riccardo Bartolini (DESY), Alain Chabert (Société Française du Tunnel Routier Fréjus), Heinz Ehrbar (HEP), Brigitte Fargevieille (Électricité de France), Belen Gavela Legazpi (UAM), Gudrun Hiller (Dortmund), Srinivas Krishnagopal (BARC), Peter Krizan (Ljubljana), Philippe Lebrun (CERN, retired), Peter McIntosh (STFC), Michiko Minty (BNL), Andrew Parker (Chair, Cambridge), Kyo Shibata (KEK), Roberto Tenchini (Pisa)

FCC Cost Review Panel
Carlos Alejaldre (Fusion for Energy), Austin Ball (CERN, retired), Umberto Dosselli (INFN), Heinz Ehrbar (HEP), Vincent Gorgues (CEA), Norbert Holtkamp (Chair, Stanford), Christa Laurila (National Audit Office, Finland), Ursula Weyrich (German Cancer Research Centre), Jim Yeck (BNL), Thomas Zurbuchen (ETH Zürich)
Scientific Advisory Committee: review technical deliverables

- D1: Definition of the baseline scenario
- D2: Civil engineering
- D3: Processes and implementation studies with the Host States
- D4: Technical infrastructure
- D5: FCC-ee accelerator
- D6: FCC-hh accelerator
- (D7: Project cost and financial feasibility)
- D8: Physics, experiments and detectors

Cost Review Panel Mandate: (review of D7)

- Review the methodology and assumptions used in producing the cost estimates
- Identify inaccurate or missing cost information
- Check the consistency of the cost estimates with respect to applicable reference work, e.g., recent large-scale infrastructure and accelerator projects
- Review the uncertainty estimates
- Identify potential areas of savings and cost mitigation for future work
- Advise the FCC study team on matters of cost estimation in view of preparation of the final Feasibility Study Report for end 2025
Status

- Both SAC and CRP have formed expert groups for individual domains to interact with FCC team
- More than 30 topical review meetings during August and September 2023
- Final overall review meeting of SAC and CRP with FCC team 16-18 October 2023
- Complete set of documentation material submitted for CERN Council Committees begin November 2023
  - Future Circular Collider Mid-term Report
  - Executive Summary of the Future Circular Collider Mid-term Report
  - Updated Cost Assessment for the FCC Civil Engineering, Infrastructure and the FCC-ee Collider
  - Future Circular Collider Funding Model: A First Analysis
  - Cost Review Panel Mid-Term Review Report
  - Scientific Advisory Committee Mid-Term Review Report

Further process

- Special meetings of CERN Scientific Policy Committee and Finance Committee: 20-22 November
  - SPC and FC Reports to Council by 31 December
- Special Council meeting on mid-term review: 2 February 2024
The first half of the FCC Feasibility Study will soon be completed with the mid-term review

- End October 2023: Review committee reports available to Scientific Policy Committee and Finance Committee
- 20 – 22 November 2023: SPC and FC review meetings on mid-term review
- 2 February 2024: CERN Council meeting on mid-term review

Focus 2021 - 2023:

- identifying best placement & layout and adapting entire project to new placement
- this provided the input for the mid-term review

Fruitful collaboration between scientific & technical actors, in close cooperation with the host state services concerned, at departmental/cantonal and local level. Direct exchange in place with communes concerned by surface sites. Environmental studies ongoing.

Focus 2024 - 2025:

- Subsurface investigations, further optimization of implementation, surface sites, synergies, etc.
- Full design iteration in view of technical and cost optimisation of entire project