FCC General Overview

“Educational Outreach Activity at CERN”, 8 April 2024

Frank Zimmermann, CERN
on behalf of FCC collaboration

with many warm thanks to Sehban Kartal and Michael Benedikt

Work supported by the European Commission under the HORIZON 2020 projects EuroCirCol, grant agreement 654305; EASITrain, grant agreement no. 764879; iFAST, grant agreement 101004730; FCCIS, grant agreement 951754; E-JADE, contract no. 645479; EAJADE, contract number 101086276; and by the Swiss CHART program

http://cern.ch/fcc
FCC integrated program

comprehensive long-term program maximizing physics opportunities

• stage 1: FCC-ee (Z, W, H, t\bar{t}) as Higgs factory, electroweak & top factory at highest luminosities
• stage 2: FCC-hh (~100 TeV) as natural continuation at energy frontier, pp & AA collisions; e-h option
• highly synergetic and complementary programme boosting the physics reach of both colliders
• common civil engineering and technical infrastructures, building on and reusing CERN’s existing infrastructure
• FCC integrated project allows the start of a new, major facility at CERN within a few years of the end of HL-LHC

a similar two-stage project CEPC/SPPC is under study in China
FCC integrated program - timeline

Note: FCC Conceptual Design Study started in 2014 leading to CDR in 2018

Ambitious schedule taking into account:
- past experience in building colliders at CERN
- approval timeline: ESPP, Council decision
- that HL-LHC will run until 2041
- project preparatory phase with adequate resources immediately after Feasibility Study
FCC Feasibility Study (2021-2025): high-level objectives

- demonstration of the **geological, technical, environmental and administrative feasibility of the tunnel and surface areas** and optimisation of **placement and layout of the ring** and related infrastructure;

- pursuit, **together with the Host States**, of the preparatory administrative processes required for a potential project approval to identify and remove any showstopper;

- optimisation of the design of the colliders and their injector chains, supported by R&D to develop the needed key technologies;

- elaboration of a **sustainable operational model** for the colliders and experiments in terms of human and financial resource needs, as well as environmental aspects and energy efficiency;

- development of a **consolidated cost estimate**, as well as the funding and organisational models needed to enable the project’s technical design completion, implementation and operation;

- identification of substantial resources from outside CERN’s budget for the implementation of the first stage of a possible future project (tunnel and FCC-ee);

- consolidation of the physics case and detector concepts for both colliders.

**Results will be summarised in a Feasibility Study Report to be released by March 2025**
**FCC FS mid-term review**

The goal of the FCC FS mid-term review is to assess the progress of the Study towards the final report.

Deliverables approved by the Council in September 2022:

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

Documents:
- Mid-term report (all deliverables except D7)
- Executive Summary of mid-term report
- Updated cost assessment (D7)
- Funding model (D7)

Review process:
- Oct 2023: Scientific Advisory Committee (scientific and technical aspects) and Cost Review Panel (ad hoc committee; cost and financial aspects)
- Nov 2023: SPC and FC
- 2 Feb 2024: Council

Many thanks to the SAC, CRP, SPC, FC and the Council for the very useful reviews!

Many thanks to the Host States for their strong support!
Both documents are available to the CERN community at: https://doi.org/10.17181/mhas5-1f263

Please note that the midterm report of the FCC Feasibility Study reflects work in progress and should therefore not be propagated to people without direct access to this page.

You are kindly asked to treat the information with the appropriate level of confidentiality, as defined in the CERN Data Protection Policy.

For questions on access please contact the FCC Secretariat: fcc.secretariat@cern.ch
Layout chosen out of ~ 100 initial variants, based on **geology** and **surface constraints** (land availability, access to roads, etc.), **environment** (protected zones), **infrastructure** (water, electricity, transport), **machine performance** etc.

“Avoid-reduce-compensate” principle of EU and French regulations

**Overall lowest-risk baseline:** 90.7 km ring, 8 surface points, Whole project now adapted to this placement

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**Number of surface sites** | 8
---|---
**Surface requirements** | ~40 ha
**LSS@IP (PA, PD, PG, PJ)** | 1400 m
**LSS@TECH (PB, PF, PH, PL)** | 2032 m
**Arc length** | 9.6 km
**Sum of arc lengths** | 76.9 m
**Total length** | 90.7 km
Meetings ongoing with all communes concerned by surface sites to identify individual land-plots for development of surface site layout and land reservation.

- **PA**: Ferney Voltaire: 01/2024
- **PB**: Choulex: 12/2023
- **PB**: Presinge: 01/2024, plenary session with community council 04/2024
- **PD**: Nangy: 05/2024
- **PF**: Éteaux: 03/2024
- **PG**: Groisy / Charvonnex: 04/2024
- **PH**: Marlioz / Cercier: 02/2024
- **PJ**: Vulbens / Dingy en Vuache: 09/2023, 01/2024
- **PL**: Challex: 03/2024, further meetings in Q2/24 to identify best site location

*Green: parcelles identified and agreed  
Blue: ongoing*
FCC tunnel implementation summary

- 91 km circumference
- 95% in molasse geology for minimising tunnel construction risks
- Site investigations in zones where tunnel is close to geological interfaces: moraines-molasse-limestone
Status site investigations

- Site investigations in areas with uncertain geological conditions:
  - Optimisation of localisation of drilling locations ongoing with site visits since end 2022.

- Contracts Status:
  - Contract for engineering services and role of Engineer during works, active since July 2022
  - Contracts for drillings and seismics in final negotiation round.
  - Start of work in Q2/2024.

Drilling works on the lake
CE underground and surface progress

- Full 3D model of all underground structures as basis for costing and scheduling exercises with external consultant.
- Experiment Site (PA)
  - Generic study of experiment site and technical site done by FNAL
  - bills of quantities extracted from FNAL designs
  - basis for cost estimate by consultant with experience on industrial constructions in CH-FR area.
Studies on excavation strategy and material quantities

2 TBMs from each experimental point

Alternative with no TBMs from PA

<table>
<thead>
<tr>
<th>Limestone (m³)</th>
<th>Molasse (m³)</th>
<th>Moraine (m³)</th>
<th>Total (in-situ) (m³)</th>
<th>Total (Bulk factor 1.3) (m³)</th>
<th>% Start Excavation</th>
<th>End Excavation</th>
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</thead>
<tbody>
<tr>
<td>PA</td>
<td>1,315,336</td>
<td>62,721</td>
<td>1,378,058</td>
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<td>PB</td>
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<td>PD</td>
<td>1,248,824</td>
<td>24,925</td>
<td>1,273,749</td>
<td>1,655,874</td>
<td>20%</td>
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<tr>
<td>PF</td>
<td>165,213</td>
<td>7,482</td>
<td>172,695</td>
<td>214,777</td>
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<tr>
<td>PG</td>
<td>141,175</td>
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<tr>
<td>PH</td>
<td>304,083</td>
<td>7,482</td>
<td>311,565</td>
<td>405,045</td>
<td>5%</td>
<td>Jan-33</td>
</tr>
<tr>
<td>PI</td>
<td>1,258,608</td>
<td>29,910</td>
<td>1,288,518</td>
<td>1,675,073</td>
<td>20%</td>
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<tr>
<td>PL</td>
<td>127,281</td>
<td>13,408</td>
<td>132,699</td>
<td>167,221</td>
<td>4%</td>
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<tr>
<td>Inj</td>
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<td>19,028</td>
<td>141,357</td>
<td>177,385</td>
<td>2%</td>
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<td>Total</td>
<td>141,175</td>
<td>179,808</td>
<td>6,292,937</td>
<td>8,180,819</td>
<td>100%</td>
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<td>562,457</td>
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<td>625,178</td>
<td>812,721</td>
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<tr>
<td>PB</td>
<td>499,592</td>
<td>10,473</td>
<td>510,066</td>
<td>665,085</td>
<td>8%</td>
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OpenSky Laboratory: demonstrate molasse reuse cases

GOAL: demonstrate the feasibility to transform Molasse (excavated material) into fertile soil.

- Project launched in January 2024
- 10000 m² near LHC P5 in Cessy, France.

Project phases:

1) Laboratory tests to identify the most suitable mix of molasse and amendments.

2) Field tests in a controlled environment (plants selected in function of regional specificities and possible soil reuse cases)

International collaboration with partners from academia and industry specialised in agronomy, soil paedogenesis, phytoremediation

Status - March 2024:
- Project approved at CERN level
- Collaboration agreements being signed
- Definition of the laboratory and field tests
Connections with regional infrastructure

- Road accesses developed for all 8 surface sites
- Four possible highway connections defined
- Less than 4 km new departmental roads required

Electrical connection concept studied by RTE (French electrical grid operator) ➔ requested loads have no significant impact on grid

Powering concept and power rating of the three substations compatible with FCC-hh

R&D efforts aiming at further reduction of the energy consumption of FCC-ee and FCC-hh
LINAC and Injection Tunnels

- Injector with ~20 GeV HE Linac sited on surface at CERN-Prevessin

- Single transfer tunnel to FCC Booster with spur to enable anti-clockwise injection

- Design allows re-use for FCC-hh if injector in the SPS tunnel (SC-SPS option)
  - SPS Point 4 to FCC (clockwise)
  - SPS Point 6 to FCC (counter-c.w.)
FCC-ee injector layout & implementation

P. Craievich, I. Chaikovska, A. Grudiev, C. Milardi, et al

HTS NI target solenoid
J. Kosse, T. Michlmayr, H. Rodrigues

“Positron production experiment” at PSI’s SwissFEL, beam tests from 2025/26

W. Bartmann

6 GeV linac
20 GeV linac

Implementation study on Prevessin site

Courtesy T. Watson
## FCC-ee: main machine parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Z</th>
<th>WW</th>
<th>H (ZH)</th>
<th>ttbar</th>
</tr>
</thead>
<tbody>
<tr>
<td>beam energy [GeV]</td>
<td>45.6</td>
<td>80</td>
<td>120</td>
<td>182.5</td>
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<tr>
<td>beam current [mA]</td>
<td>1270</td>
<td>137</td>
<td>26.7</td>
<td>4.9</td>
</tr>
<tr>
<td>number bunches/beam</td>
<td>11200</td>
<td>1780</td>
<td>440</td>
<td>60</td>
</tr>
<tr>
<td>bunch intensity (10^{11})</td>
<td>2.14</td>
<td>1.45</td>
<td>1.15</td>
<td>1.55</td>
</tr>
<tr>
<td>SR energy loss / turn [GeV]</td>
<td>0.0394</td>
<td>0.374</td>
<td>1.89</td>
<td>10.4</td>
</tr>
<tr>
<td>total RF voltage 400/800 MHz [GV]</td>
<td>0.120/0</td>
<td>1.0/0</td>
<td>2.1/0</td>
<td>2.1/9.4</td>
</tr>
<tr>
<td>long. damping time [turns]</td>
<td>1158</td>
<td>215</td>
<td>64</td>
<td>18</td>
</tr>
<tr>
<td>horizontal beta* [m]</td>
<td>0.11</td>
<td>0.2</td>
<td>0.24</td>
<td>1.0</td>
</tr>
<tr>
<td>vertical beta* [mm]</td>
<td>0.7</td>
<td>1.0</td>
<td>1.0</td>
<td>1.59</td>
</tr>
<tr>
<td>horizontal geometric emittance [nm]</td>
<td>0.71</td>
<td>2.17</td>
<td>0.71</td>
<td>1.59</td>
</tr>
<tr>
<td>vertical geom. emittance [pm]</td>
<td>1.9</td>
<td>2.2</td>
<td>1.4</td>
<td>1.6</td>
</tr>
<tr>
<td>horizontal rms IP spot size [μm]</td>
<td>9</td>
<td>21</td>
<td>13</td>
<td>40</td>
</tr>
<tr>
<td>vertical rms IP spot size [nm]</td>
<td>36</td>
<td>47</td>
<td>40</td>
<td>51</td>
</tr>
<tr>
<td>beam-beam parameter (\xi_x / \xi_y)</td>
<td>0.002/0.0973</td>
<td>0.013/0.128</td>
<td>0.010/0.088</td>
<td>0.073/0.134</td>
</tr>
<tr>
<td>rms bunch length with SR / BS [mm]</td>
<td>5.6 / 15.5</td>
<td>3.5 / 5.4</td>
<td>3.4 / 4.7</td>
<td>1.8 / 2.2</td>
</tr>
<tr>
<td>luminosity per IP (10^{34} \text{cm}^{-2}\text{s}^{-1})</td>
<td>140</td>
<td>20</td>
<td>5.0</td>
<td>1.25</td>
</tr>
<tr>
<td>total integrated luminosity / IP / year (\text{ab}^{-1}\text{yr})</td>
<td>17</td>
<td>2.4</td>
<td>0.6</td>
<td>0.15</td>
</tr>
<tr>
<td>beam lifetime rad Bhabha + BS [min]</td>
<td>15</td>
<td>12</td>
<td>12</td>
<td>11</td>
</tr>
</tbody>
</table>

- x 10-50 improvements on all EW observables
- up to x 10 improvement on Higgs coupling (model-indep.) measurements over HL-LHC
- x10 Belle II statistics for b, c, τ
- indirect discovery potential up to ~ 70 TeV
- direct discovery potential for feebly-interacting particles over 5-100 GeV mass range

Up to 4 interaction points → robustness, statistics, possibility of specialised detectors to maximise physics output.
• Evolution of RF configuration of collider and booster with beam energies and physics operation points
• Long-term R&D for SRF, in particular for the 800 MHz system
RF R&D activities

RF system R&D is key for increasing energy efficiency of FCC-ee
- Nb on Cu 400 MHz cavities, seamless cavity production, coating techniques
- Bulk Nb 800 MHz cavities, surface treatment techniques, cryomodule design
- RF power source R&D in synergy with HL-LHC.

800 MHz cavity and CM design collaborations with JLAB and FNAL

high-efficiency klystron R&D in collaborations with THALES & CANON

400 MHz cavity production in collaboration with KEK

800 MHz segmented design, based on PIP-II

~7 m monoblock prototype
FCC-ee optics baseline & further evolution(s)

**regular arc**

FODO lattice, many -l sext pairs;
periodic unit cell length ~ 260 m

- hybrid FODO lattice,
  with few sext. families,
  periodic unit cell length ~ 300 m

**interaction region**

- 1.5" sext.s per final focus,
- asymmetric

**optimisation goals:**
- reduced power consumption
- lower SR energy loss
- increased momentum acceptance
- relaxed tolerances
- larger dynamic aperture
- simplified powering schemes
Arc layout and integration optimisation

Arc cell optimisation – 80 km total system length, dedicated working group active.
• Including support, girder and alignment systems, shielding systems
• Vacuum system with antechamber + pumps, dipole, quadrupole + sext. magnets, BPMs,
• Cabling, cooling & technical infrastructure interfaces.
• Safety aspects, access and transport concept,

FCC-ee arc half-cell mock up
Prototype Q1 (left) & Interaction Region Mock-Up (right)

Testing at cold in SM18 (CERN), 27-31 October 2023

Field quality: all multipole errors <1 unit!

INFN-LNF, CERN and INFN-Pisa collaboration

CERN-PSI collaboration
Formidable challenges:
- High-field superconducting magnets: 14 - 20 T
- Power load in arcs from synchrotron radiation: 4 MW $\rightarrow$ cryogenics, vacuum
- Stored beam energy: $\sim 9$ GJ $\rightarrow$ machine protection
- Pile-up in the detectors: $\sim 1000$ events/xing
- Energy consumption: 4 TWh/year $\rightarrow$ R&D on cryo, HTS, beam current, ...

Formidable physics reach, including:
- Direct discovery potential up to $\sim 40$ TeV
- Measurement of Higgs self to $\sim 5\%$ and $ttH$ to $\sim 1\%$
- High-precision and model-independent (with FCC-ee input) measurements of rare Higgs decays ($\gamma\gamma$, $Z\gamma$, $\mu\mu$)
- Final word about WIMP dark matter

### FCC-hh parameters

<table>
<thead>
<tr>
<th>parameter</th>
<th>FCC-hh</th>
<th>HL-LHC</th>
<th>LHC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collision energy cms [TeV]</td>
<td>81 - 115</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Dipole field [T]</td>
<td>14 - 20</td>
<td>8.33</td>
<td></td>
</tr>
<tr>
<td>Circumference [km]</td>
<td>90.7</td>
<td>26.7</td>
<td></td>
</tr>
<tr>
<td>Arc length [km]</td>
<td>76.9</td>
<td>22.5</td>
<td></td>
</tr>
<tr>
<td>Beam current [A]</td>
<td>0.5</td>
<td>1.1</td>
<td>0.58</td>
</tr>
<tr>
<td>Bunch intensity [$10^{11}$]</td>
<td>1</td>
<td>2.2</td>
<td>1.15</td>
</tr>
<tr>
<td>Bunch spacing [ns]</td>
<td>25</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Synchrotron radiation power / ring [kW]</td>
<td>1020 - 4250</td>
<td>7.3</td>
<td>3.6</td>
</tr>
<tr>
<td>SR power / length [W/m/ap.]</td>
<td>13 - 54</td>
<td>0.33</td>
<td>0.17</td>
</tr>
<tr>
<td>Long. emit. damping time [h]</td>
<td>0.77 – 0.26</td>
<td>12.9</td>
<td></td>
</tr>
<tr>
<td>Peak luminosity [$10^{34}$ cm$^{-2}$s$^{-1}$]</td>
<td>$\sim 30$</td>
<td>5 (lev.)</td>
<td>1</td>
</tr>
<tr>
<td>Events/bunch crossing</td>
<td>$\sim 1000$</td>
<td>132</td>
<td>27</td>
</tr>
<tr>
<td>Stored energy/beam [GJ]</td>
<td>6.1 - 8.9</td>
<td>0.7</td>
<td>0.36</td>
</tr>
<tr>
<td>Integrated luminosity/main IP [fb$^{-1}$]</td>
<td>20000</td>
<td>3000</td>
<td>300</td>
</tr>
</tbody>
</table>

With FCC-hh after FCC-ee: significantly more time for high-field magnet R&D aiming at highest possible energies.
Key activities on FCC-hh: cryo magnet system, optics design

Optics design activities:
• adaptation to new layout and geometry
• shrink $\beta$ collimation & extraction by $\sim30\%$
• optics optimisation (filling factor etc.)

High-field cryo-magnet system activities
• Conceptual study of cryogenics concept and temperature layout for LTS and HTS based magnets, in view of electrical consumption.
• HFM R&D (LTS and HTS) on technology and magnet design, aiming also at bridging the TRL gap between HTS and Nb$_3$Sn.
• Integration studies for HFM designs (LTS and HTS) to ensure compatibility with tunnel.
The CERN Council reviewed the work undertaken in a fruitful meeting on 2 February 2024. It congratulated and thanked all the teams involved in the study for the excellent and significant work done so far and for the impressive progress, and looks forward to receiving the final report in 2025.

From Türkiye 15 FCC Collaboration members: Giresun University, IYTE Urla Izmir, Izmir University of Economics, Istanbul University, TOBB University of Economics and Technology Ankara, Istanbul Aydin U., Piri Reis Üniversitesi Tuzla/Istanbul, Izmir University Bakırçay (IBU), İsk University Sile/Istanbul, Bursa Uludağ University Nilüfer, Ege University Bornova-Izmir, Ankara U Tandogan/Ankara, İstinye University Istanbul, Kirikkale University, Kirikkale, AIBU Bolu

FCC Feasibility Study: Aim is to increase further the collaboration, on all aspects, in particular, on Accelerator and Particle/Experiments/Detectors (PED).
2013 Update of European Strategy for Particle Physics:

“CERN should undertake design studies for accelerator projects in a global context, with emphasis on proton-proton and electron-positron high-energy frontier machines.”

→ FCC Conceptual Design Reports (2018/19)

2020 Update of European Strategy for Particle Physics:

“Europe, together with its international partners, should investigate technical and financial feasibility of a future hadron collider at CERN with a centre-of-mass energy of at least 100 TeV and with an electron-positron Higgs and electroweak factory as a possible first stage.”
FCC theses by students from Turkish universities

**PhD theses**

Ozgur ETISKEN, Ankara University, “Pre-Booster Ring Design for FCC-e⁺e⁻ Injector complex”, CERN/Ankara PhD 2021

Kaan Yuksel OYULMAZ, Bolu Abant Izzet Baysal University, “Upgrade and performance studies of CMOS sensors for future colliders,” PhD 2022, now U. of Edinburgh

Umit KAYA, Ankara U / TOBB, “Search for Color Octet Electron (e8) at TeV Energy Scale Colliders”, PhD 2019

Salim OGUR, Bogazici University, “Linac and Damping Ring Designs of the future Circular e⁺e⁻ Collider of CERN”, CERN/Bogazici PhD April 2019 – later CERN fellow, now JLAB

**MSc theses**

Yunus Emre OKYAYLI, 2018, “Search for R-parity violation interactions of scalar leptons at future circular collider”, Istanbul U.

Gökhan HALİMOĞLU, 2018, “Measurement of leptons + jets at 100 TeV at future circular collider”, Istanbul U.

Rokia Omar Ali ALAMIN, 2017, “Anomalous heavy down type b' quark production at the future circular collider”, Kastamonu University


Çağla ÇAĞLAR, 2019, “Search for quarkonium consists of E6 model predicted isosinglet quark at future colliders,”, Ege University

Alev Ezgi DEMİRCİ, 2017, “Production and decay channels of charged higgs boson at high energy hadron colliders”, Ankara U.
Organisational Structure of the FCC Feasibility Study – approved by CERN Council in June 2021


FCC organizational structure and collaboration framework

- A **consortium** of partners based on a Memorandum Of Understanding (MoU)
- Working together on a best effort basis
- Incremental & open to academia and industry
- Individual **projects** defined in specific addenda

FCC collaboration framework during CDR and FS phases
FCC Feasibility Study – summary and outlook

• The first half of the FCC Feasibility Study has been completed with the mid-term review
  • placement & layout was defined, and entire project adapted to the new geometry
  • dialogue with local-regional actors and stakeholders for implementation established and ongoing
  • all deliverables met, list of recommendations from committees towards final Feasibility Study

• Progress was made possible by a fruitful collaboration between scientific & technical actors, in close cooperation with the host state services concerned.

• Next milestone is completion of the FCC Feasibility Study by March 2025 to enable advancing project decision and project start date:
  • Complete technical work for FCC FS by end 2024
  • Implementation of recommendations of the mid-term review with focus on “feasibility items” and items with important impact on cost/performance
  • Full design iteration in view of technical and cost optimisation of entire project.
  • Update of cost estimate
  • Further development of an affordable funding model and related governance implications (with Council).
  • Setup structure for preparatory phase
Main goals during preparatory phase until 2031/32

• By 2027-2028, project approval, start of CE design contract:
  • provision of requirements and specifications to enable CE tender design to start from 2028 (underground) and 2029 (surface)
  • requires overall integration study and designs based on technical pre-design of accelerators, technical infrastructure and detectors
  • refined input for environmental evaluation and project authorisation process.

• By 2031-32, start of CE construction:
  • CE groundbreaking
  • TDR to enable prototyping industrialization towards component production

• Strong collaborations with Türkiye are important for the success of the Feasibility Study and will be even more so for the FCC project to go ahead. Thank you for your contributions and looking forward to further collaboration.
Future Circular Collider (FCC) Week 2024, at the Westin St. Francis in San Francisco.

From Monday 10 June to Friday 14 June 2024. Registration is open!

We look forward to welcoming you in San Francisco for what promises to be an exciting and informative event!

https://fccweek2024.web.cern.ch/
European Strategy for Particle Physics

2013 Update of European Strategy for Particle Physics:

“CERN should undertake design studies for accelerator projects in a global context, with emphasis on proton-proton and electron-positron high-energy frontier machines.”

→ FCC Conceptual Design Reports (2018/19)


2020 Update of European Strategy for Particle Physics:

“Europe, together with its international partners, should investigate technical and financial feasibility of a future hadron collider at CERN with a centre-of-mass energy of at least 100 TeV and with an electron-positron Higgs and electroweak factory as a possible first stage.”
RF for collider and booster in separate straight sections H and L.

- fully separated technical infrastructure systems (cryogenics)
- collider RF (highest power demand) in point H with optimum connection to existing 400 kV grid line and better suited surface site
prototypes of FCC-ee low-power magnets

Twin-dipole design with 2× power saving
16 MW (at 175 GeV), with Al busbars

Twin F/D arc quad design with
2× power saving
25 MW (at 175 GeV),
with Cu conductor

even more efficient alternative magnet designs are being explored
HTS option for FCC-ee arc quads and sextupoles

CDR: 2900 quads & 4700 sextupoles
- Normal conducting, ~50 MW @ ttbar
- 3 different types of short straight sections

• Normal conducting, ~50 MW @ ttbar
• 3 different types of short straight sections

“HTS4” project within CHART collaboration
- Nested SC sextupole and quadrupole.
- HTS conductors operating at around 40K.
- Cryo-cooler supplied cryostat.
- Produce a ~1m prototype by 2026

“HTS4” potential
- Power saving
- Reduced length and increased dipole filling factor
- Optics flexibility

Cad design of HTS short sextupole demonstrator based on CCT coils

M. Koratzinos, B. Auchmann