FCC STUDY PLANS FOLLOWING MTR

Michael Benedikt, Jean-Paul Burnet, Frank Zimmermann

TE FCC workshop, 16 May 2024

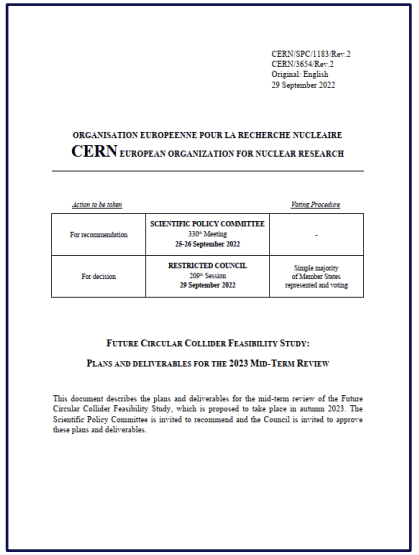
FCC FS Mid-Term Review concluded in February 2024

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:

https://indico.cern.ch/event/1197445/contributions/5034859/attachments/2510649/4315140/spc-e-1183-Rev2-c-e-3654-Rev2_FCC_Mid_Term_Review.pdf

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

← Many thanks to the Host States for their strong support!


CERN/SPC/1183/Rev.2
CERN/3654/Rev.2
Original: English
29 September 2022

ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Action to be taken		Voting Procedure
For recommendation	SCIENTIFIC POLICY COMMITTEE 330th Meeting 25-26 September 2022	-
For decision	RESTRICTED COUNCIL 209th Session 29 September 2022	Simple majority of Member States represented and voting

FUTURE CIRCULAR COLLIDER FEASIBILITY STUDY:
PLANS AND DELIVERABLES FOR THE 2023 MID-TERM REVIEW

This document describes the plans and deliverables for the mid-term review of the Future Circular Collider Feasibility Study, which is proposed to take place in autumn 2023. The Scientific Policy Committee is invited to recommend and the Council is invited to approve these plans and deliverables.

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!

FUTURE CIRCULAR COLLIDER

FCC key dates

Date	Deliverable | Achievement | Target
End 2024	Completion of technical work for Feasibility Study
March 2025	Feasibility Study Report - complete draft ready for submission to ESPPU
End 2025	Systems description for entire project
2027	Technical pre-design for entire project 2027 → requirements and specifications to enable CE tender design
2031/32	Start of CE construction ; TDR to enable prototyping, industrialization towards component production for TI and accelerator

Main goals for 2024/begin 2025

- **Completion of technical work for Feasibility Study until end 2024**
  - Implementation of recommendations of the mid-term review
  - Focus on “feasibility items” and items with important impact on cost/performance
  - Develop a risk register
  - Update cost estimate to reach cat 3 level on cost uncertainty.
  - Further develop the funding model based on discussions with the Council
- **Complete FS by March 2025 as input for ESPP update.**
- **In parallel, continue work with host states on project definition and responsibilities, authorization procedures, excavation material strategy and regional implementation development.**

Pre-TDR phase from April 2025 until end 2027

- Main goal is to provide all information to Council to allow taking a decision on the project **at the end of 2027 or mid-2028**
  - further develop the civil engineering and the technical design all major components, so as to provide a **more detailed cost estimate** with reduced uncertainties
  - Continuation ot **technical R&D activities**.
  - Continuation of site investigations and perform an **overall integration study to specify requirements of technical infrastructure, accelerators and detectors** for subsequent civil engineering design in case the project goes ahead.
  - Launch of **environmental impact study in 2026**
  - Work with host states on **regional implementation development** and authorization procedures.

Analysis of mid-term review recommendations from SAC, CRP, SPC, FC and Council (i)

Analysis of recommendations and planning for implementation, F. Gianotti and M. Benedikt, presented to Council in March 25.

Until/for Feasibility Study March 2025:

- Increase resources of FCC FS team (SAC, FC, SPC)
- Establish pre-project team to significantly improve confidence in design and cost estimate (CRP)
- Ramp-up accelerator R&D and design (CRP)
- Decision on FCC-ee injector system (SAC, SPC) and cost (CRP)
- Baseline on FCC-hh injector system (SAC, SPC)
- Avoid different RF systems for Z and W/H (SAC)
- Clarify logistic (safety) for a 10km-long 5.5m-diameter tunnel (CRP)
- Perform safety risk analysis with external consultant (SPC)
- Emphasize system integration and interfaces between work packages (CRP)
- Provide FCC-hh cost (although with less precision than for FCC-E) (FC, SPC)
- State cost of FCC-ee due to preparation for FCC-hh (FC)
- Identify opportunities for heat recovery to the benefit of local use (SAC)
- Procedures for conservation of He (SAC)

Analysis of mid-term review recommendations from SAC, CRP, SPC, FC and Council (ii)

Until/for Feasibility Study March 2025:

- Clarify LHC role in the FCC-ee era (FC)
- Financial implications of the various operational sequences and e.g. running at H peak (FC, SPC)
- For final report provide well-defined baseline layout for all aspects of the FCC ee machine (SPC)
- Provide well-understood and prioritized R&D plan for FCC-hh in the final FS report (SPC)
- Develop roadmaps for LTS & HTS magnets for FCC-hh and include report on HFM about FCC-hh feasibility (SPC)
- Provide more detailed construction schedule for tunnel and accelerator (SPC)
- Provide more info on the reliability of the simulation of transport and logistics for installation phase (SPC)
- Workshop to further define accelerator scope, define interfaces, identify missing scope/cost (CRP)
- Include FTEs needed for R&D, design and construction phases (SPC)

Analysis of mid-term review recommendations from SAC, CRP, SPC, FC and Council (iii)

For 2027-2028, project approval, start of CE design contract:

- CO2 footprint over full project lifecycle (SAC, SPC, Council)
- Environmental impact and sustainability (FC, Council)
- Discuss sustainability issues for FCC-hh (SPC)
- SCRF performance improvement (Q and gradient) (SAC)
- R&D on NEG coating to reduce risks (SPC)
- Sensitivity to commodity prices (SAC)
- Continue to develop benchmarks as reference for FCC-ee cost (CRP)
- Revisit CERN's procurement policies and learn for other big facilities to ensure balanced industrial return without increasing cost (FC)
- Risks of not achieving FCC-ee luminosity (SPC)
- Heat recovery to the benefit of local use technical implementation (SAC)
- FCC-hh magnet R&D (SAC)
- Evaluate pros/cons of commercial vs in-house systems for controls (SPC)

Further aspects to be taken into account

- Mid-term recommendations do not give the full picture. Many areas deserve attention and require collaborative transverse setups, e.g.
  - synchrotron radiation management & shielding concept
  - arc mock-up studies and integration optimisation

- Importance of design optimisation towards industrial production, maintenance, reliability, etc.

- Importance of parallel cost optimisation (CAPEX/OPEX) and cost CONTROL with respect to mid-term estimate

- Importance of international support for project approval

- Need for collaboration and integration of partners, also in view of low-risk management of potential in-kind contributions

FCC-ee Accelerator organisation 2024 (preliminary)

Accelerators FCC-ee F. Zimmermann, T. Raubenheimer /SLAC

Accelerator Technical Implementation

JP. Burnet, T. Raubenheimer

- Beam transfer systems
- Beam instrumentations
- Beam Intercepting Devices
- Magnets
- Vacuum
- Power converters
- Radiation & shielding
- Radio Frequency
- Survey & alignment
- Integration

- *Radiation WG*
- *MDI WG*
- *Arc mock-up WG*
- *System engineering and interface management*

Accelerator Design

C. Carli, F. Zimmermann

- Parameters & performance, C. Carli & F. Zimmermann
- Optics design, K. Oide/UNIGE
- Correction & tuning, R. Tomas, J. Keintzel
- Alignment, J. Wenninger
- Energy calibration and polarisation, J. Keintzel & G. Wilkinson / Oxford
- Beam-beam, X. Buffat
- Impedance & collective effects, M. Migliorati / Sapienza & C. Zannini
- Electron cloud and ion effects, L. Mether
- Collimation & machine protection, R. Bruce & J. Uythoven
- MDI, M. Boscolo/INFN-LNF
- Booster, A. Chance

- *Booster design WG*
- *EPOL WG*
- *Machine protection WG*

Transfer Lines Design

W. Bartmann

- Optics
- Machine protection
- Interfaces

Injector and TLs

P. Craievich/PSI, A. Grudiev

- e-/e+ sources
- Linacs
- Damping ring

all Accelerator Design activities should have indico meeting sites inside the FCC indico structure !

FCC Feasibility Study

EU Projects
NN

Collaboration building
Emmanuel Tsesmelis

Communications
Panagiotis Charitos, Arnaud Marsollier

Study Support and Coordination
Study Leader: Michael Benedikt
Deputy Study Leader: Frank Zimmermann

Study Support Unit
IT: Sylvain Girod
Procurement: Adam Horridge
Quality management: Beatriz Arias
Resources: Sylvie Prodon
Secretariat: Julie Hadre

Physics, Experiments and Detectors
Patrick Janot, Christophe Grojean

- **Physics programme** — Matthew McCullough, Frank Simon
- **Detector concept** — Mogens Dam, ???
- **Physics performance** — Patrizia Azzi, Emmanuel Perez
- **Software and computing** — Gerardo Ganis, NN

Accelerators
Tor Raubenheimer
Frank Zimmermann

- **FCC-ee accelerator design** — Christian Carli, Frank Zimmermann
- **FCC-ee technical implementation** — Jean-Paul Burnet, Tor Raubenheimer
- **FCC-ee injector** — Paolo Craievich, Alexej Grudiev
- **FCC transfer lines** — Wolfgang Bartmann
- **FCC-hh design** — Massimo Giovannozzi

Technical Infrastructures
Jean-Paul Burnet
Klaus Hanke

- **Integration** — Jean-Pierre Corso
- **Geodesy & survey** — Hélène Mainaud Durand
- **Electricity and energy management** — Jean-Paul Burnet
- **Cooling and ventilation** — Guillermo Peon
- **Cryogenics systems** — Laurent Delprat
- **Computing and controls infrastructure, communication and network** — Pablo Saiz
- **Safety** — Thomas Otto
- **Operation, maintenance, availability, reliability** — Jesper Nielsen
- **Transport, installation concepts** — Roberto Rinaldesi

Host State processes and civil engineering
Timothy Watson

- **Administrative processes** — Friedemann Eder
- **Placement studies** — Johannes Gutleber
- **Environmental evaluation** — Johannes Gutleber
- **Tunnel, subsurface design** — John Osborne
- **Surface sites layout, access and building design** — A. Mayoux

Organisation and financing models
Florian Sonnemann

- **Project organisation model** — NN
- **Financing model** — Florian Sonnemann
- **Procurement strategy and rules** — Anders Unnervik
- **In-kind contributions** — Anders Unnervik
- **Operation model** — Verena Kain

FCC Feasibility Study – summary and outlook

- **The first part 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
- **Next milestone is completion of the FCC Feasibility Study by March 2025 to enable advancing project decision and project start date.**
- **By 2027-2028, possible project approval, possible start of CE design contract**
- **By 2031-32, possible start of CE construction:**
  - CE groundbreaking
  - TDR to enable prototyping, industrialization towards component production
- **Challenging period ahead but hopefully significant resources from MTP 2024**
- **Many thanks for TE support and contributions!**