The Future Circular Collider Study
Planning a research infrastructure for the 21st century

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on behalf of the FCC collaboration

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http://cern.ch/fcc

photo: J. Wenninger
Colliders are powerful instruments in HEP for particle discoveries and precision measurements.
Open Questions

Despite of impressive progress and discoveries in the past decades several fundamental questions remain open:

Today 80% of the mass of the universe is unknown. What is the universe made of?

Is there only a single type of Higgs boson and does it behave exactly as predicted?

Why is the universe composed only of matter? Where has the anti-matter gone that was produced simultaneously in the big bang?

Why do neutrinos have mass? How do neutrinos get their masses?
Recommendations of the 2020 update of the European Strategy for Particle Physics (ESPP):

• Full exploitation of the high-luminosity LHC upgrade

• An electron-positron Higgs factory is the highest-priority next collider. For the longer term, the European particle physics community has the ambition to operate a proton-proton collider at the highest achievable energy.

• “Europe, together with its international partners, should investigate the 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."
The FCC integrated program inspired by successful LEP – LHC programs at CERN

comprehensive long-term program maximizing physics opportunities

- common civil engineering and technical infrastructures, building on and reusing CERN’s existing infrastructure

stage 1: FCC-ee: high-intensity electron-positron collider for detailed study of the Higgs boson ($10^6$), top-quark ($10^6$), $W$ ($10^8$), $Z$ ($10^{12}$) → indirect sensitivity to new physics up to ~ 70 TeV (> 10 times LHC)

stage 2: FCC-hh: proton-proton collider with collision energy of at least 100 TeV → direct discovery potential for new physics up to ~ 40 TeV (~ 10 times the LHC)
FCC – integrated programme

FCC integrated programme allows seamless continuation of collider-based HEP after completion of the HL-LHC program, until end of century
Goals of the feasibility study and roadmap towards first $e^+e^-$ collisions

Highest priority goals:

- **Financial feasibility**
- Technical and administrative feasibility of tunnel: no show-stopper for ~100 km tunnel
- Technologies of machine and experiments: magnets; minimised environmental impact; energy efficiency & recovery
- Gathering scientific, political, societal and other support

Fabiola Gianotti: “CERN vision and goals until next strategy update” FCCIS Kick-Off, 9 Nov. 2020

2012 Higgs discovery announced
2011 circular Higgs factory proposal

2013 ESPPU

2014 FCC study kickoff
2018 FCC CDR

2020 Feasibility proof
2020 FCCIS kickoff

2025/26 Financing model Operation concept

>2026/7 ESPPU

>2025/26 Feasibility proof

>2028 approval

>2030 start tunnel construction

>2026/7 ESPPU

>2030 - 37 element production

>2038 start tunnel construction

>2045 first $e^+e^-$ collisions

>2030 - 37 element production

>2026 - 30 full technical design

2020 FCCIS H2020 DS
Future Circular Colliders
Michael Benedikt
27/09/2022, Mining the Future, CERN

H2020 DS FCC Innovation Study 2020-24

- Optimise the design of the FCC-ee luminosity frontier particle collider and demonstrate the technical and organizational feasibility of a ~100 km long, particle collider research infrastructure, seamlessly integrated in the European research landscape.

- Develop an innovation plan for a long-term sustainable research infrastructure, focusing on responsible resource use and managing environmental impacts.

➢ Mining the Future competition

Benefits

- Optimise the design of the FCC-ee luminosity frontier particle collider and demonstrate the technical and organizational feasibility of a ~100 km long, particle collider research infrastructure, seamlessly integrated in the European research landscape.

- Develop an innovation plan for a long-term sustainable research infrastructure, focusing on responsible resource use and managing environmental impacts.

➢ Mining the Future competition

Partners

- DOE United States of America
- UOXF United Kingdom
- Writelatex DBA Overleaf United Kingdom
- D.R.R.T France
- Etat de Genève Switzerland
FCC tunnel - geological conditions

Shaft depth:
A: 202 m  B: 200 m  D: 177 m  F: 399 m  G: 228 m  H: 139 m  J: 251 m  L: 253 m

- FCC passes below Lake Geneva moraines
- FCC inclined at 0.5% gradient to minimise depth of point F
- Limestone unavoidable between G-H
- FCC passes above limestone
- Tunnelling mainly in molasse layer (soft rock), well suited for fast, low-risk TBM construction.
- Site investigations campaign planned for 2024 – 2025: ~40-50 drillings, 100 km of seismic lines
Increasing international collaboration as a prerequisite for success

The Future Circular Collider project at CERN, serves as a platform that brings together participants from the entire globe and from a diverse set of domains forming a pole of scientific excellency and technological innovation.
Conclusions

• The European Particle Physics Strategy Update 2020 issued the request for a feasibility study of the FCC integrated programme to be delivered for the next Strategy Update, with the goal to inform about technical, territorial and financial feasibility of the FCC project and bring all elements needed to decide on a potential project.

• Sustainability and environment are key topics for the feasibility study and the H2020 FCCIS design study with the Mining the Future competition is addressing a major topic, i.e. the potential reuse of excavation material. The results of the competition and future developments in this area will play a crucial role for FCC.

• Strengthening links with science, research & development, high-tech industry and society at large will be essential to further advance and prepare the implementation of FCC as a long-term sustainable world-leading HEP research infrastructure for the 21st century.
Thank you for your attention.