CERN's vision and plans for 2021-2025

Fabiola Gianotti, FCC week, 28/6/2021

Outline

CERN's three main objectives for 2021-2025

Scientific goals and future colliders

Organisation of the FCC Feasibility Study

Impact on society

Conclusions

Introduction: main objectives 2021-2025

The period 2021-2025 will be crucial for the full exploitation of LHC and the current experimental programme and to lay the foundations for a compelling, exciting scientific future for CERN.

At the same time, the world is facing unprecedented challenges → CERN should multiply its efforts to increase its "return" to society → this will in turn increase the support for CERN and its long-term future

3 main objectives for 2021-2025:

- ❑ Deliver world-class scientific results and knowledge
- ❑ Increase the return to the Member and Associate Member States
- ❑ Strengthen CERN's impact on society

Note: projects and activities described here are or will be carried out in strong cooperation with other labs and institutes in the Member and Associate Member States and beyond.

Deliver world-class scientific results and knowledge

CERN's scientific vision and objectives are based on the 2020 update of the European Strategy for Particle Physics (ESPP)

The 2020 Strategy update provides a realistic and prudent approach to visionary and ambitious scientific objectives.
It lays the foundations for a bright future for particle physics in Europe, within the global context of the field.

Scientific recommendations of the ESPP

CERN's implementation (2020 and 2021 Medium-Term Plans)

Full exploitation of the physics potential of LHC and high-luminosity LHC
→ LHC and HL-LHC are CERN's highest priority in the short/medium term

Highest-priority next collider: e^+e^- Higgs factory
→ FCC-ee, continued development of CLIC key technologies (includes limited support to ILC)

Increased R&D on accelerator technologies: high-field superconducting magnets, high-gradient accelerating structures, plasma wakefield, muon colliders, ERL, etc.
→ high-field magnet efforts enhanced, SCRF and NCRF, AWAKE, muon colliders, etc.

Investigation of the technical and financial feasibility of a future ≥ 100 TeV hadron collider at CERN, with e^+e^- Higgs and electroweak factory as a possible first stage.
→ see next slides

Support to long-baseline neutrino projects in US and Japan, in particular successful implementation of DUNE at LBNF
→ continued/expanded support to Neutrino Platform

Support to high-impact scientific diversity programme complementary to high-E colliders
→ increased support to Physics Beyond Colliders

Support to R&D on detector, SW and computing, as crucial tools for the field
→ R&D for future detectors initiative; new Quantum Technology Initiative at CERN

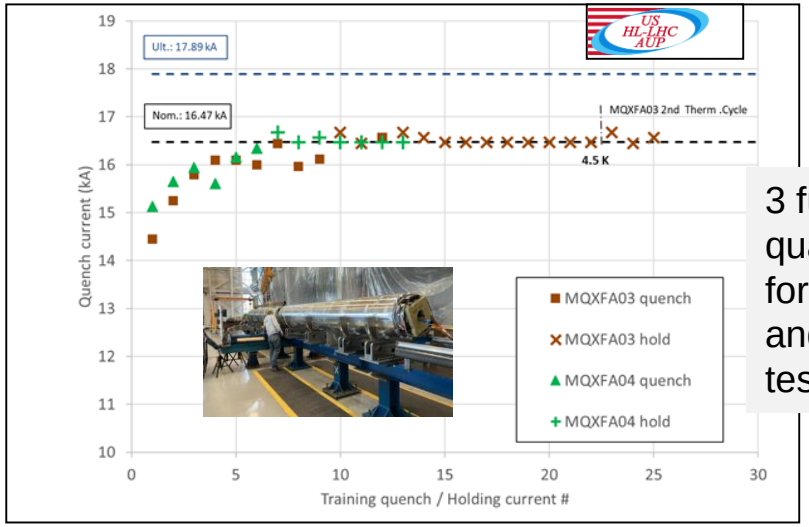
Support to theory as an essential driver for particle physics
→ increased synergies with neighbouring fields

High-field superconducting magnets: a step-wise approach

R&D on high-field superconducting magnets strengthened significantly at CERN (budget doubled, ~ 200 MCHF over 10 years): key technology for future accelerators (hadron colliders, muon colliders, neutrino beams, etc.) and detectors, with great potential for wider societal applications.

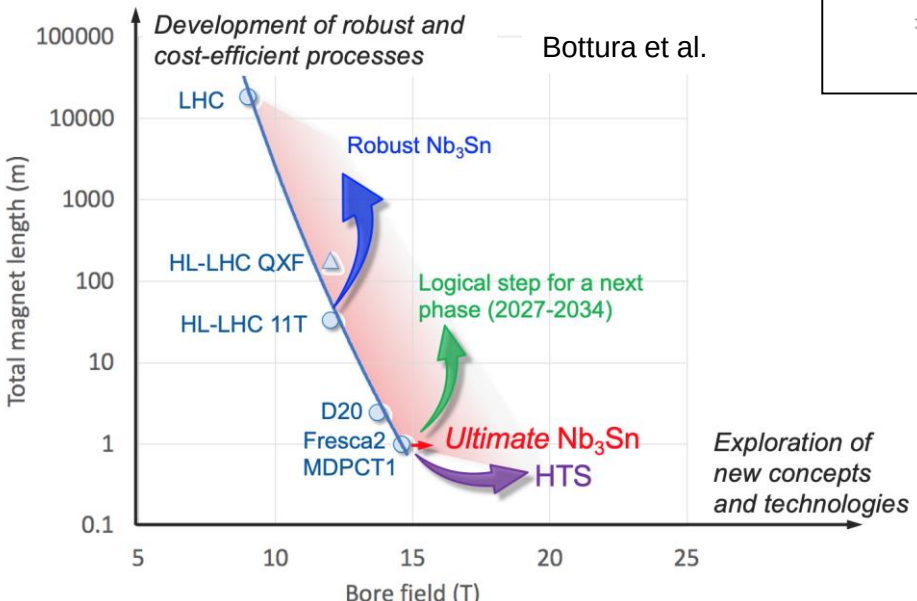
LHC 8.3 T NbTi dipoles

HL-LHC 11-12 T Nb_3Sn dipoles and quadrupoles



3 full-scale Nb_3Sn quadrupoles for HL-LHC built and successfully tested in the US.

16-20 T magnets for FCC



→ More in talks by D. Newbold and S. Prestemon

Remarks on a future collider at CERN

ESPP gives the preferred direction for future collider(s) at CERN: FCC

However, prudently:

- ❑ feasibility study first
- ❑ intensified accelerator R&D for FCC and to prepare alternative scenarios if FCC not pursued

No consensus in European community on which type of Higgs factory (linear or circular)

ILC:

- ❑ Strategy says it's compatible with ESPP if timely (otherwise conflict of resources with next collider at CERN)
- ❑ are ILC and FCC-ee complementary enough in terms of physics? No consensus.

Chinese colliders (CepC, SppC): "direct competition" with FCC

Desired timeline* for a future collider at CERN:

→ recommendation by next ESPP ~ 2026

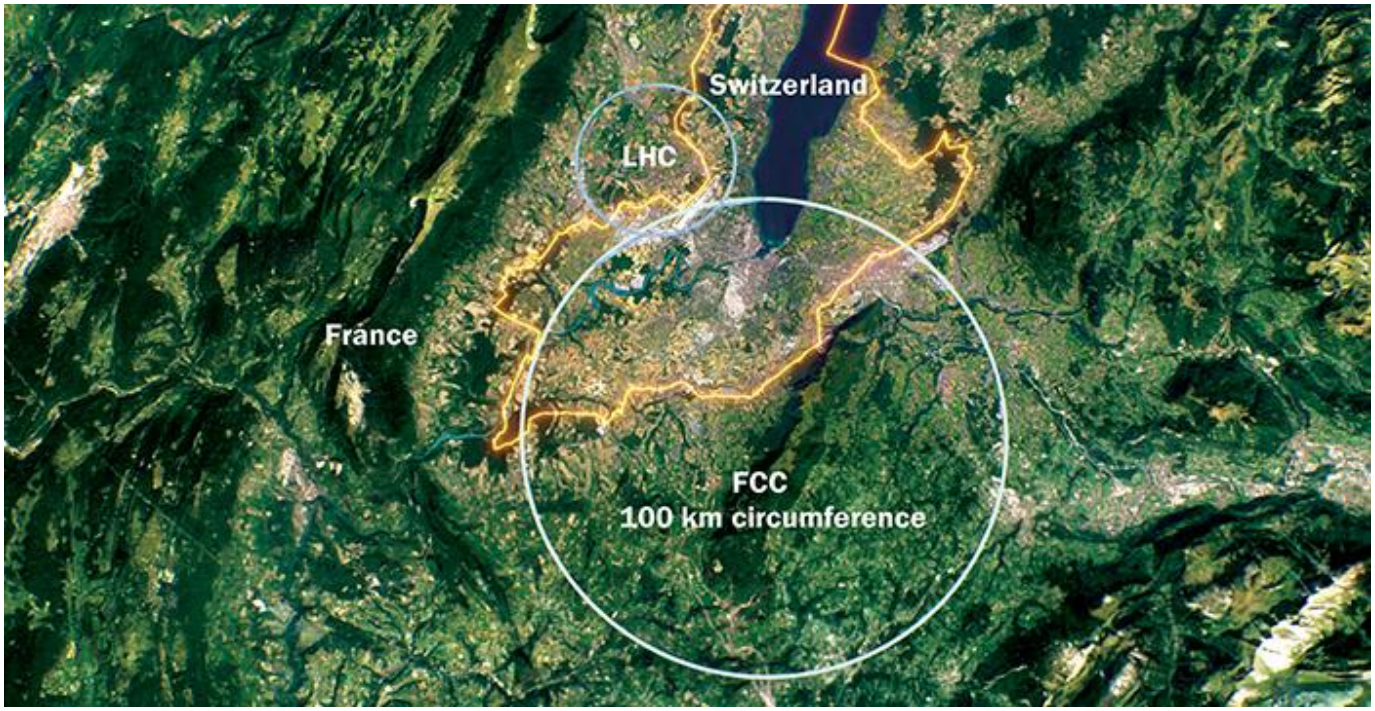
→ approval by CERN's Council by end of the decade → construction's start early-2030's

→ operation's start mid 2040's.

Such a timeline is realistic for FCC-ee and CLIC, more difficult for FCC-hh (magnet technology, cost)

* A new facility running in the mid-2040's, i.e. within 10 years of end of HL-LHC, is crucial to retain (and expand) CERN's expertise and community → crucial for long-term survival of the field.

FCC Feasibility Study (FS) 2021-2025



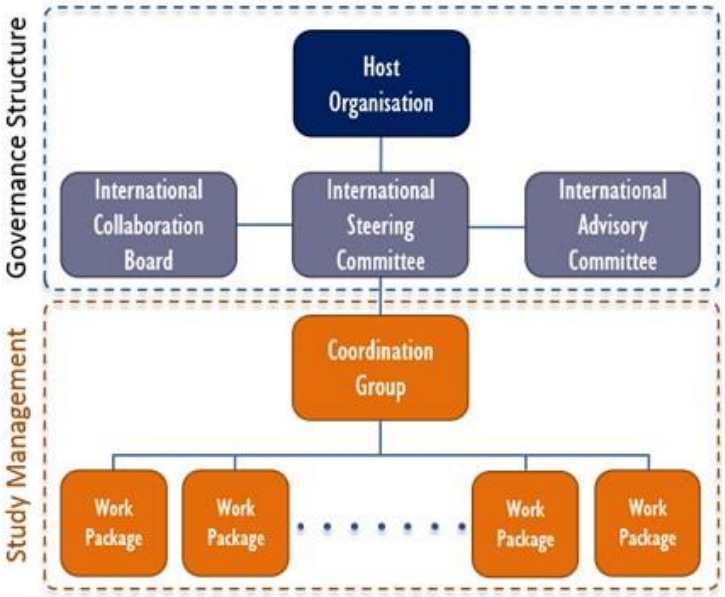
- Tunnel: assess geological, technical, administrative, environmental feasibility → aim is to demonstrate there is no show-stopper for ~ 100 km ring in Geneva region
- Technologies: superconducting high-field magnets and RF accelerating structures; high-efficiency power production; energy saving and other sustainable technologies
- Funding: development of funding model for first-stage machine (tunnel and FCC-ee, total ~ 10 BCHF) and identification of substantial resources from outside CERN's budget
- "Consensus building": gathering scientific, political, societal support → communication campaign targeting scientists, governmental and other authorities, industry, general public

→ Complete a Feasibility Study Report by end 2025

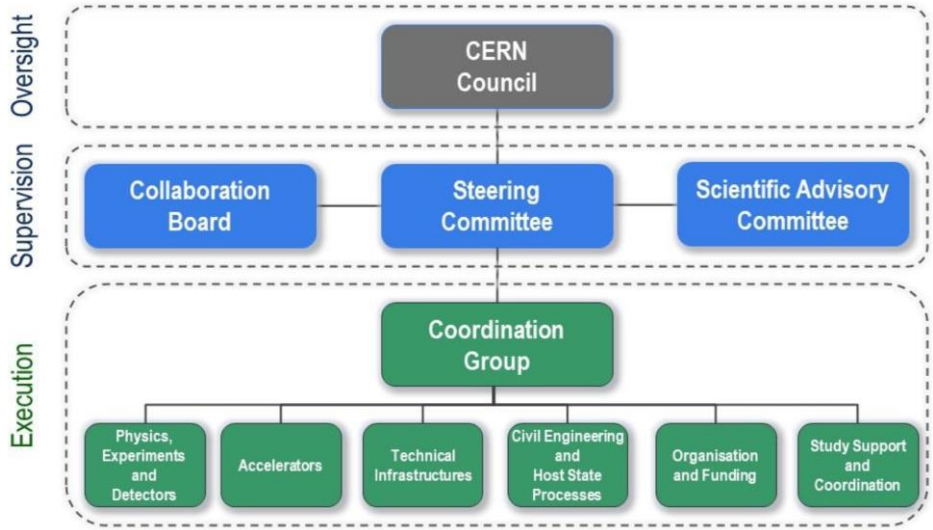
→ more in M. Benedikt's talk

Organisational structure for the FCC Feasibility Study

Current structure

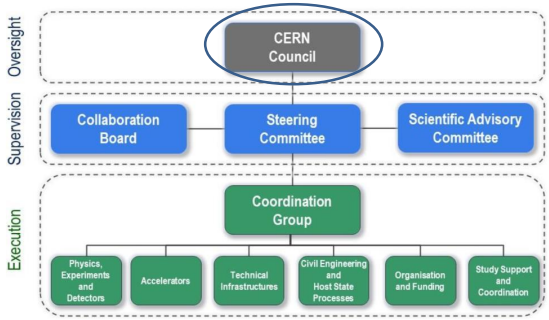


New structure



- New structure approved unanimously by CERN Council in June 2021
  Full document available here: https://cds.cern.ch/record/2774006/files/English.pdf
- No revolution; evolution of current structure to adress challenges of FS phase
- Main elements: ownership of FS by Council; involvement of representatives of the worldwide FCC community; integration of scientific and technical advice; participation of external stakeholders envisaging to make significant financial contributions to possible future project
- Smooth transition from current to new structure in the coming months (to be completed by end of year)

CERN COUNCIL



CERN hosts the FS, which is carried out in collaboration with institutions from Member and Associate Member States and beyond, under overall authority and strategic guidance of the Council.

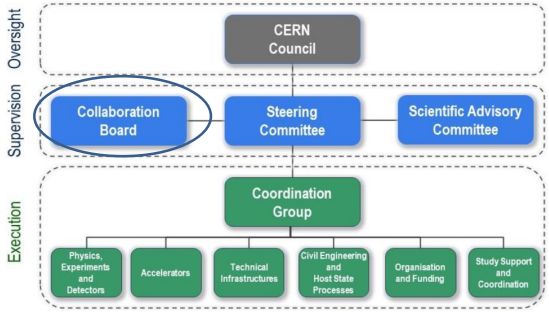
As stated by the ESPP:

" … Such a feasibility study of the colliders and related infrastructure should be established as a global endeavour "

→ The Council's President will invite representatives of entities (e.g. non-Member States, EC) envisaging to contribute meaningful level of resources towards a possible future project to attend the Council sessions agenda items dedicated to the FS.

Decision-making in the various bodies is by consensus, wherever possibile. Failing that, decisions will be taken by majority voting applying the Rules of Procedure of the Council (CERN/3388/Rev.2): appointment decisions will be taken by secret ballot and require a 2/3 majority; all other decisions will be taken by open ballot and require a simple majority of the members present and voting.

COLLABORATION BOARD



Membership

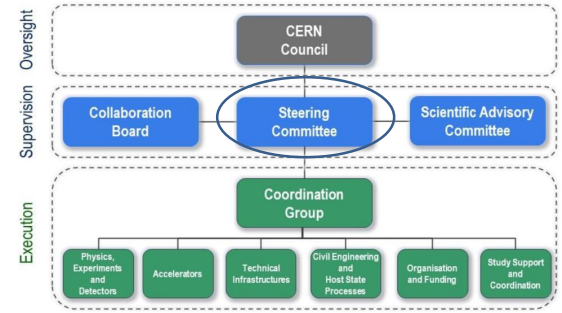
- 1 representative per institute contributing to the FS having signed the MoU (current MoU being updated), including 1 representative from CERN
- Chair elected from among CB members
- Meets typically once/year

Mandate

- Review work needs and resource requirements and their sharing among the participating institutes
- Appoints up to 5 members of the Steering Committee from the participating institutes

Similar role and composition as current ICB (International Collaboration Board)

STEERING COMMITTEE



Membership

- CERN Directorate (DG is Chair)
- CB Chair
- Up to five members from participanting institutes, appointed, by CB, to ensure scientific, technical and geographical diversity
- Study Leader (without voting rights)
- Meets typically three times/year

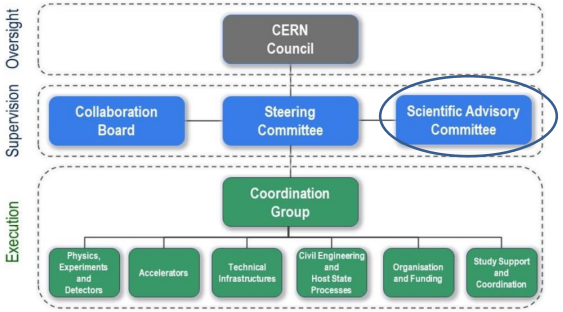
Attended by President of CERN's Council in an ex officio observer capacity

Mandate

- Provides technical and organisational supervision of FS
- Establishes work programme in line with high-level objectives
- Receives work package updates, and identify and evaluate milestones and deliverables to ensure compliance with work plan
- Appoints members of the SAC and of the Coordination Group
- Reports to CERN's Council at each Council session

Similar role and composition as current ISC (International Steering Committee)

SCIENTIFIC ADVISORY COMMITTEE



Membership

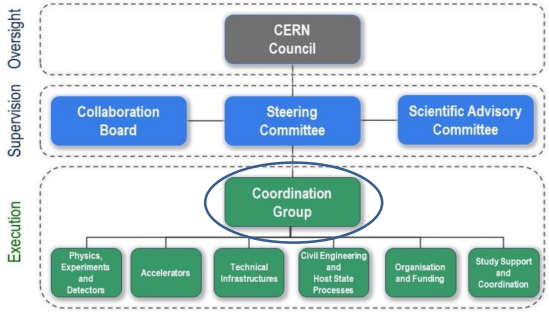
- Up to 16 international experts not directly involved in the FS, with renowned expertise in technical or scientific domains relevant for the FS.
- Members and Chair appointed by Steering Committee
- Chair is ex-officio member of Scientific Policy Committee
- Meets typically twice/year

Mandate

- Follows and reviews implementation of Feasibility Study
- Gives scientific and technical advice to Steering Committee and Coordination Group, and provides guidance to facilitate major technical decisions

Similar role and composition as current IAC (International Advisory Committee)

COORDINATION GROUP



Membership

- Study Leader (Chair), appointed by CERN's DG
- Coordinators of the 6 pillars being selected from worldwide community of experts, appointed by Steering Committee on proposal of Study Leader

Mandate

As executive body of the FS, the CG is in charge of the implementation of the work packages, of delivering the FS objectives according to the plan and milestones, and of the day-to-day management of the project

Similar role and composition as current Coordination Group

CLIC and Muon Colliders goals 2021-2025

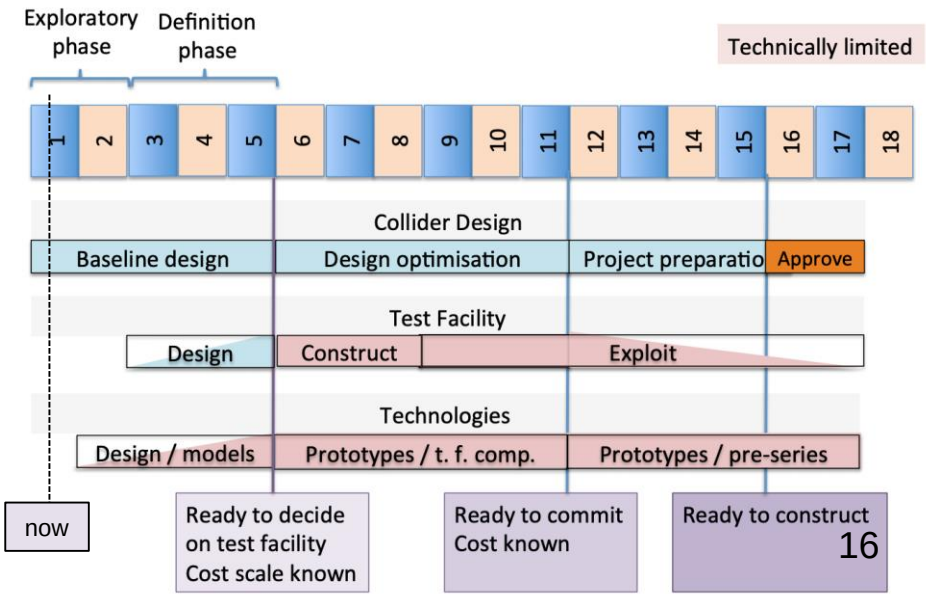
CLIC goals by end 2025 (as input to next ESPP):

- ❑ finalise X-band technology towards construction readiness (accelerating structure's conditioning and manufacturing)
- ❑ improve power efficiency (e.g. klystrons, etc.)
- ❑ optimise luminosity for first-stage machine (beam dynamic studies, machine alignment and stability, etc.)

→ "**Project Readiness Report**" by end 2025

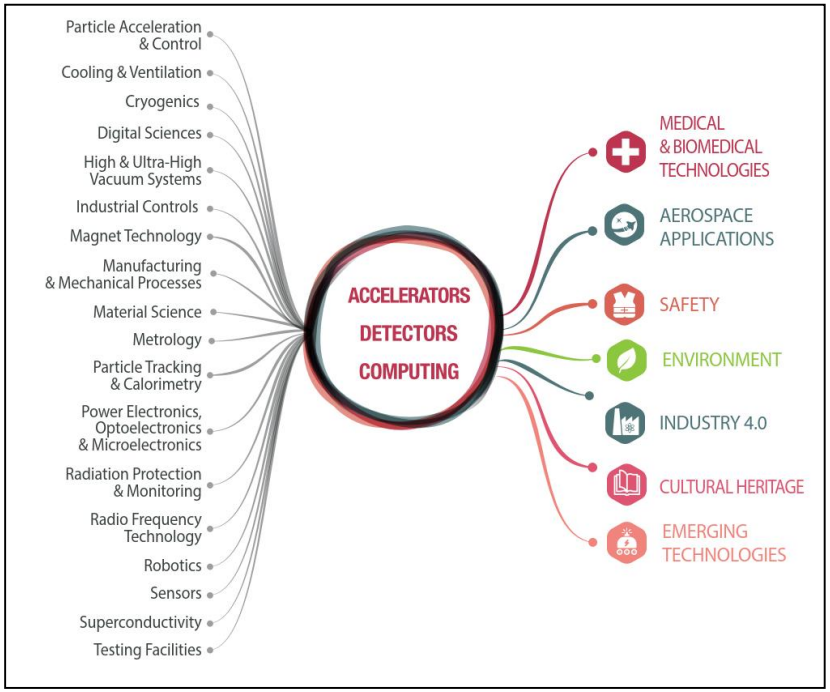
Parameter	Unit	Stage 1	Stage 2	Stage 3
√s	GeV	380	1500	3000
Tunnel length	km	11	29	50
Gradient	MV/m	72	72/100	72/100
Pulse length	ns	244	244	244
Luminosity (above 99% of √s)	10^{34} cm^{-2}s^{-1}	1.5 0.9	3.7 1.4	5.9 2
Repetition frequency	Hz	50	50	50
Bunches per train		352	312	312
Bunch spacing	ns	0.5	0.5	0.5
Particles/bunch	10^9	5.2	3.7	3.7
Beam size at IP (σ_y/σ_x)	nm	2.9/149	1.5/60	1/40
Annual energy consumption	TWh	0.8	1.7	2.8
Power consumption	MW	170	370	590
Construction cost	BCH	5.9	+5.1	+7.3

Muon collider's goals by end 2025 (as input to next ESPP): work on main challenges, including muon source and cooling, fast-ramping magnets, accelerator and collider rings, neutrino background and civil engineering → determine if **investment in Muon Collider test facility** and CDR **is justified** from a scientific perspective.



Strengthen CERN's impact on society

Necessary to increase CERN's visibility and the support of governments and the public



CERN and our field impact society in many ways

- scientific knowledge: our primary mission
  → need to share with the public the excitement, and the importance of what we do for humanity.
  FCC: more enticing/compelling message of scientific case is crucial for project's acceptance (communication)

- values: collaboration across borders, inclusiveness, openness (open science) → relevant as ever!
  → "CERN model" taken as an example by other institutions and fields.
  FCC: how can the project promote these values (communication)

- scientific training: contribution to tomorrow's workforce (society lacks STEM graduates)
  FCC: evaluate the (expanded) opportunities of FCC (part of impact study)

- development of advanced technologies: broad range, many potential applications
  → CERN decided to focus primarily on: environment and sustainability; health; computing
  FCC: must be a strong driver of innovation (part of feasibility and impact studies)

⬇

The Feasibility Study must address also the following aspects:

- environmental impact and sustainability of the project (e.g. energy consumption/re-use of FCC-hh!)
- how FCC can proactively develop sustainable technologies relevant for the environment
- technology transfer to society as an inherent goal (not just as a by-product)
- knowledge, technology and education accessible to all
- close connections with other fields of science and with industry
- training and career prospects of the future generations
- public engagement

Conclusions

The FCC Feasibility Study (2021-2025) is a crucial milestone for the future of CERN and the field → the efforts, commitment and enthusiasm of the FCC community are essential for the success of the Study.

The main goals, deliverables and timeline have been defined

A new organisation, evolution of the current structure, is being put in place following the approval of CERN's Council in June

The societal and environmental impact of a possible future project is an indispensable component of the Feasibility Study