HFM Annual Meeting 2023
Welcome and Introduction


Portail de la science du CERN
CERN Science Gateway

ESPP Update 2020

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.

A focused, mission-style approach should be launched for R&D on high-field magnets (16 T and beyond)

Development and industrialisation of such magnets based on Nb_3Sn technology, together with the high-temperature superconductor (HTS) option to reach 20 T, are expected to take around 20 years and will require an intense global effort.

LDG mandated to implement Roadmap

Lab Directors Group

- Is appointed by CERN Council
- Reports on its activities on a regular basis to Council
- Facilitate dialogue between laboratories
- Liaises with the European Commission and national funding agencies, research institutes, and universities

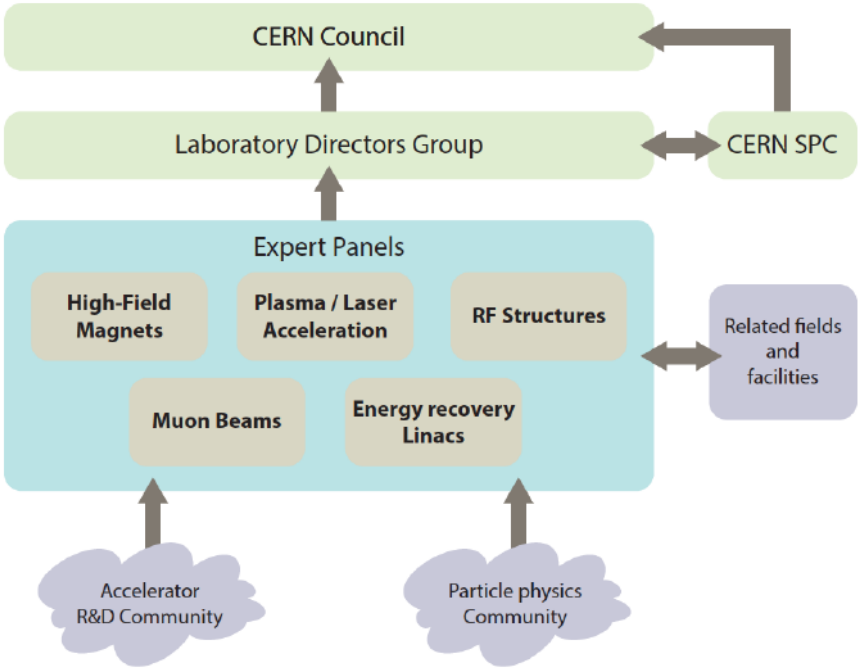
European Accelerator R&D Roadmap

- **Define and maintain a prioritised accelerator R&D roadmap towards future large-scale facilities for particle physics**
- **Coordinate accelerator R&D activities within the roadmap, with the aim of strengthening cooperation and ensuring effective use of complementary capabilities.**

Roadmap

The Roadmap, inter alia, is required to:

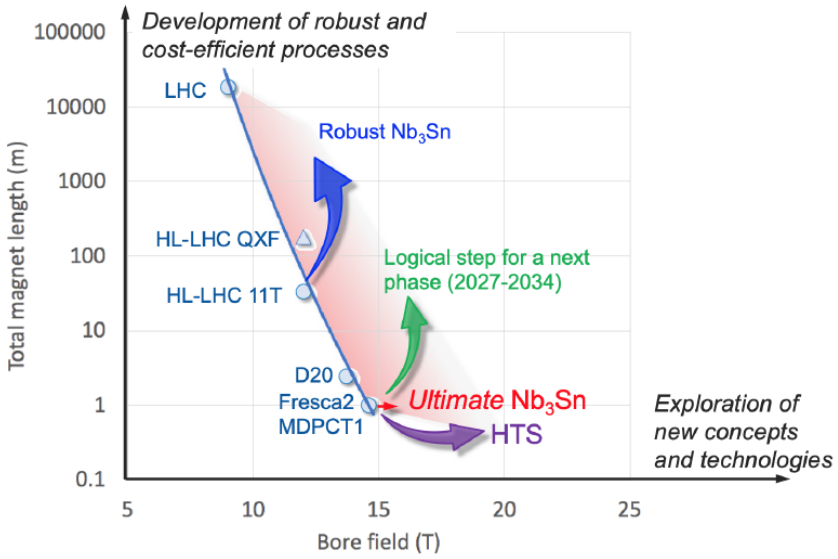
- provide an agreed structure for a coordinated and intensified **programme of accelerator R&D across national institutes and CERN;**
- have its **implementation defined through consultation with the community** and, where appropriate, through the work of expert panels;
- take into account, and **coordinate with, international activities** and work being carried out in other related scientific fields, including the development of new large-scale facilities;
- be designed to **inform, through its outcomes, future updates of the European Strategy for Particle Physics**.



HFM

Demonstrate Nb3Sn magnet technology for large scale deployment, pushing it to its limits in terms of maximum field and production scale.

Demonstrate the suitability of HTS for accelerator magnets, providing a proof-of-principle of HTS magnet technology beyond the reach of Nb_3Sn via a vigorous R&D effort.



- Many collaboration-based activities already ongoing (FCC)
- CERN responded to the ESPPU in MTP 2020 - HFM programme launched
- Roadmap developed in 2021 in consultation with community

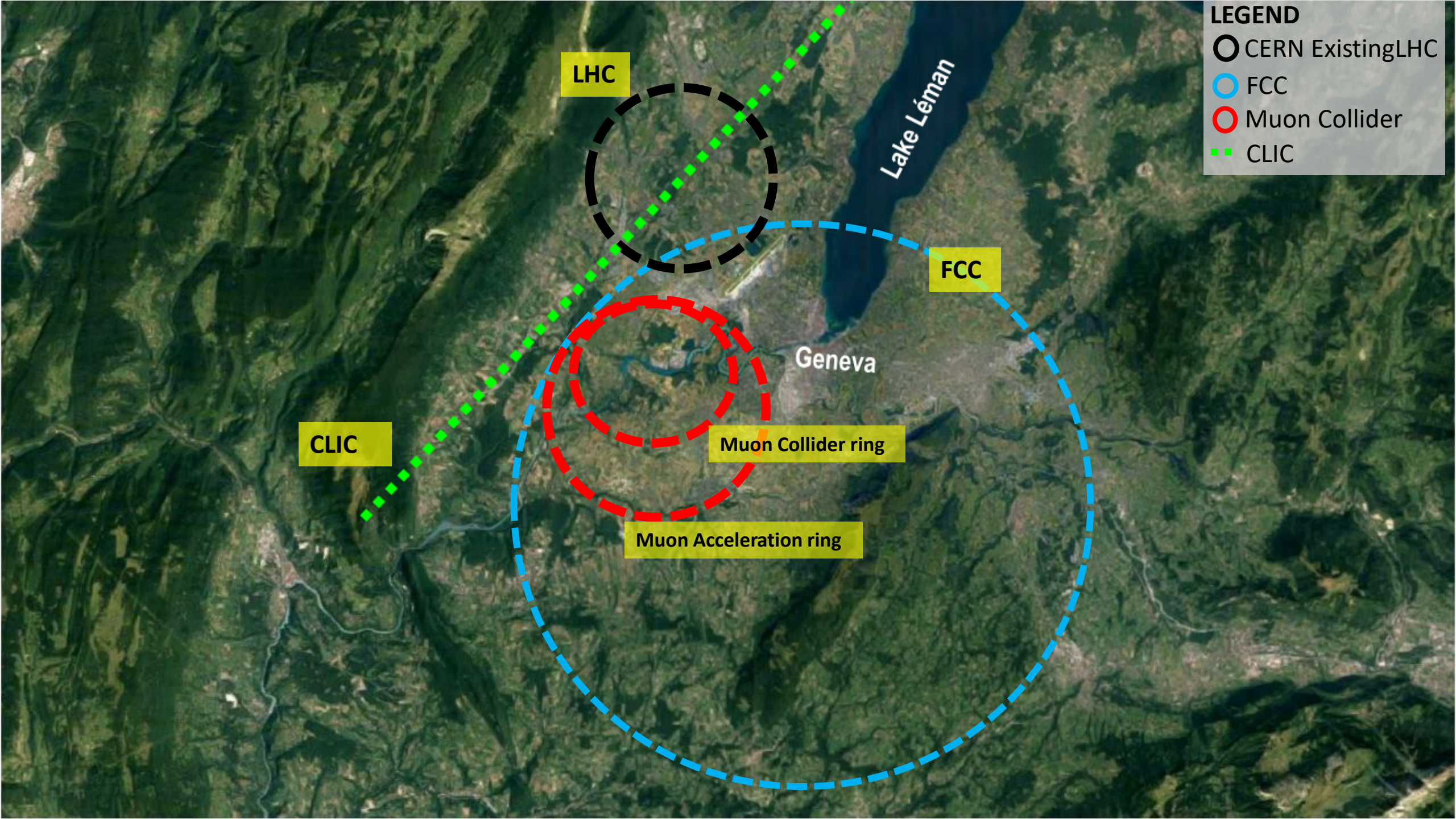
HFM R&D programme
a collaborative endeavour endorsed by our MS

Magnets

Conductors

Enabling Technologies

Teamwork, communication, coordination, and cooperation
are required to address the significant challenges!


LEGEND
CERN ExistingLHC
FCC
Muon Collider
CLIC
LHC
Lake Léman
FCC
Geneva
CLIC
Muon Collider ring
Muon Acceleration ring

FUTURE CIRCULAR COLLIDER

FCC-hh: main machine parameters

In the meantime…

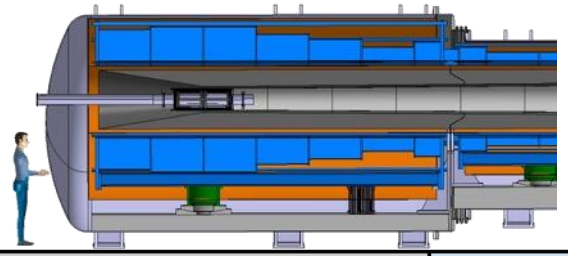
80-116

14 (Nb_3Sn) – 20 (HTS/Hybrid)

parameter	FCC-hh	HL-LHC	LHC
collision energy cms [TeV]	81 - 115	14	
dipole field [T]	14 - 20	8.33	
circumference [km]	90.7	26.7	
arc length [km]	76.9	22.5	
beam current [A]	0.5	1.1	0.58
bunch intensity [10^{11}]	1	2.2	1.15
bunch spacing [ns]	25	25	
synchr. rad. power / ring [kW]	1020 - 4250	7.3	3.6
SR power / length [W/m/ap.]	13 - 54	0.33	0.17
long. emit. damping time [h]	0.77 – 0.26	12.9	
peak luminosity [10^{34} $cm^{-2}s^{-1}$]	~30	5 (lev.)	1
events/bunch crossing	~1000	132	27
stored energy/beam [GJ]	6.1 - 8.9	0.7	0.36

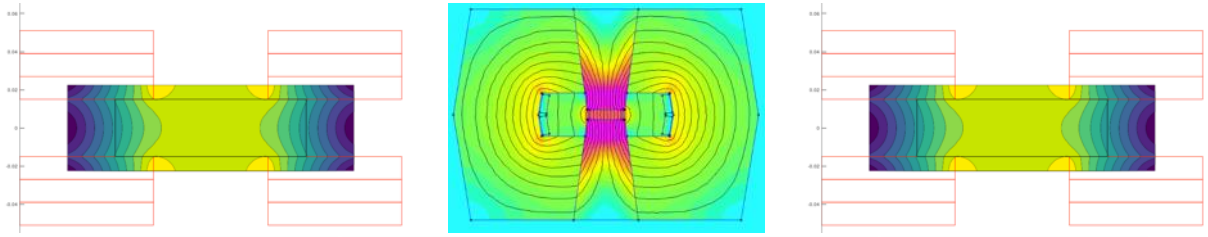
Muon Collider magnets

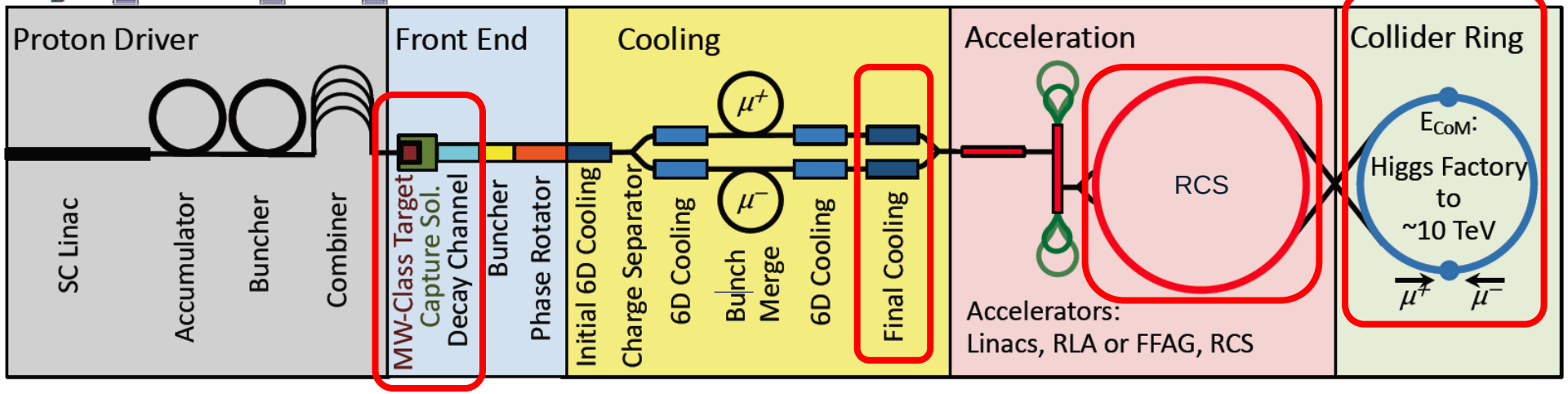
20 T, 200 mm
Radiation heat load ≈ 5…10 kW
Radiation dose: 80 MGy



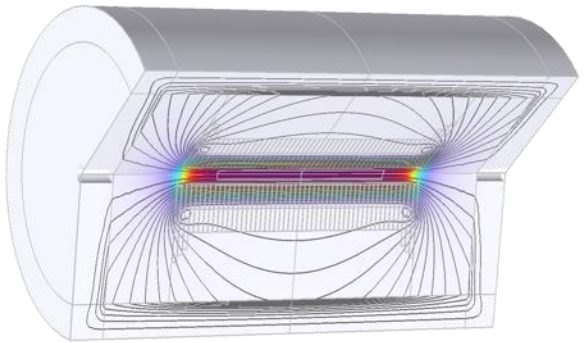
NC ±1.8 T, 400 Hz
100 mm x 30 mm

SC < 10T
100 mm x 30 mm

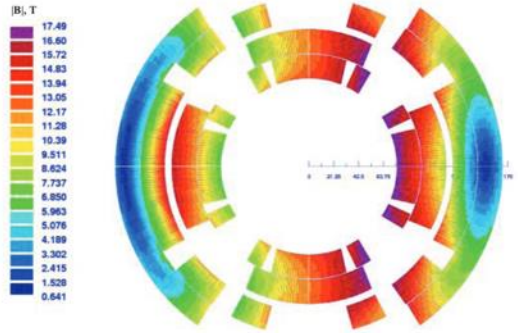




> 40 T, 60 mm



16 T peak, 160 mm
Radiation heat load ≈ 5 W/m
Radiation dose ≈ 20…40 MGy



The path forward

The vision is for another major project commensurate with the laboratory's capabilities, communities, and resources to assure the future of CERN for the next 50+ years

- Engine for continued investment, innovation, R&D and scientific engagement
- CERN remains a world leading Research Infrastructure
- CERN remains a prestigious symbol of worldwide collaboration, scientific excellence at the leading edge
- Geopolitical implications

The preferred direction for a future collider at CERN is the FCC

- As mandated by the European Strategy for Particle Physics - well motivated physics case
- Feasibility study to be delivered end 2025 – expect full and detailed scrutiny
- This a big, hairy, audacious goal – but then so was LEP, so was the LHC

There are plan Bs but…!

The path forward

Magnetic technology remains pivotal to the future of HEP

HL-LHC - flagship machine at the energy frontier out to end ~2041

- Fully dependent on the successful deployment of Nb_3Sn and NbTi in collaboration with with our international partners

It is important that FCC-hh is seen as a credible successor to FCC-ee.

- **Execution of a European Accelerator R&D Roadmap** with High Field Magnets as a major pillar.
  - Push Nb_3Sn as a known unknown for the next generation of HEP compliant magnets
  - Potential of HTS - exciting times and real opportunity - measured push to reprofile towards HTS.
- Credible progress of the **HFM programme** is important at this stage.

Muon Collider is an interesting option in the longer term

- Opening another vista of magnet challenges!
- Strong synergies with fusion, sustainability… and the HFM programme

Performance in wider context

Without which we are going nowhere!

Sustainability is mission critical and a moral obligation

- Full life cycle including operational electricity use
- Energy and resource efficiency across the board
- Technology

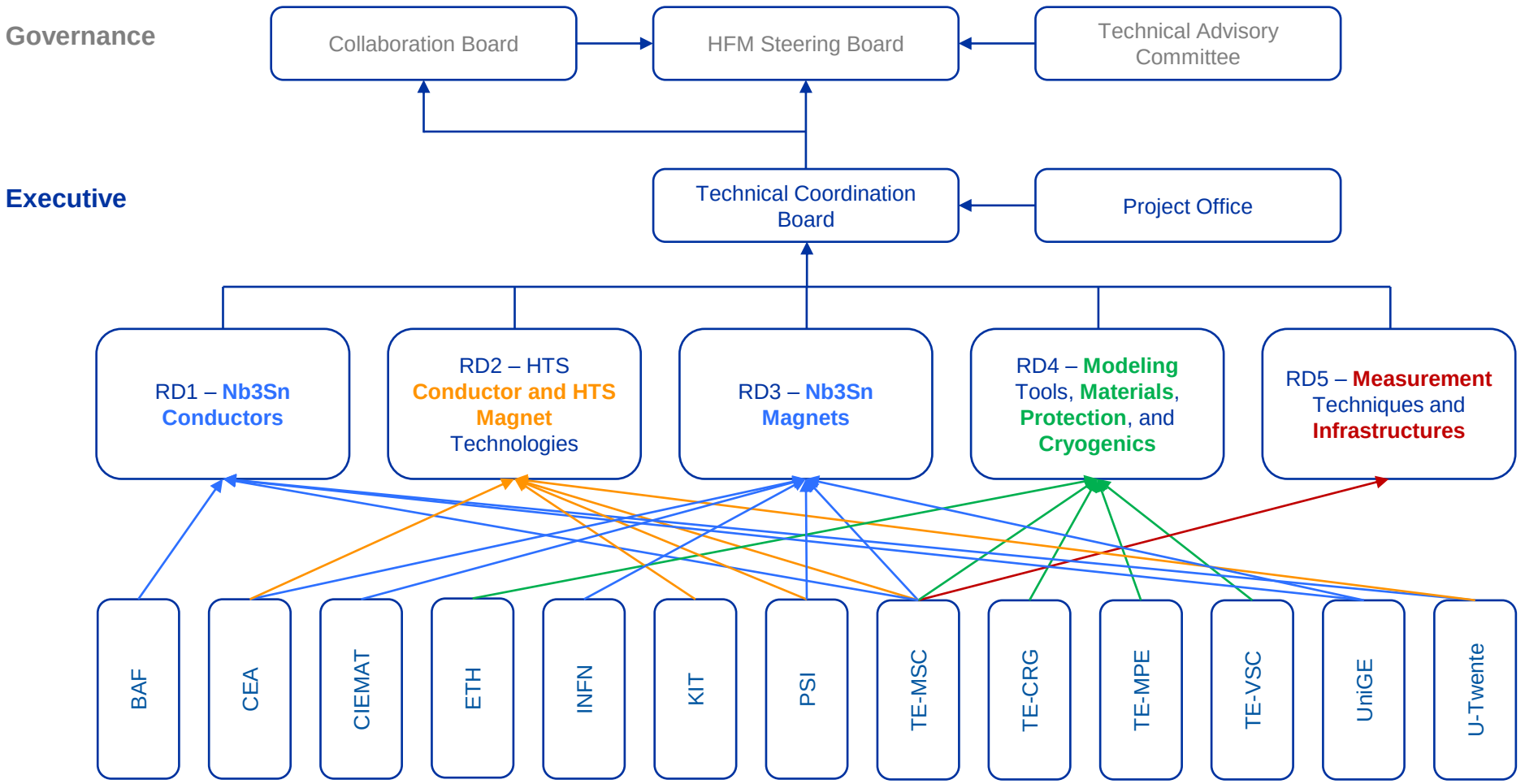
Cost (construction and operations)

- Component cost (compact magnets, high J_E, conductor etc. etc.)
- Sustainable Maintenance and Operation

Innovation and Knowledge Transfer

- Important that HEP is seen a driver of innovation with valued cross-over
- CERN must continue to play its role as a major Research Infrastructure (innovation, integration, industry, societal impact, education)
- HTS clearly has a transformative potential, with wide ranging synergetic possibilities (and is the only path beyond ~16 T) – competition in other places, we need to be there.

THANKS!


Governance
Collaboration Board
HFM Steering Board
Technical Advisory Committee
Executive
Technical Coordination Board
Project Office
RD1 – Nb3Sn Conductors
RD2 – HTS Conductor and HTS Magnet Technologies
RD3 – Nb3Sn Magnets
RD4 – Modeling Tools, Materials, Protection, and Cryogenics
RD5 – Measurement Techniques and Infrastructures
BAF
CEA
CIEMAT
ETH
INFN
KIT
PSI
TE-MSC
TE-CRG
TE-MPE
TE-VSC
UniGE
U-Twente