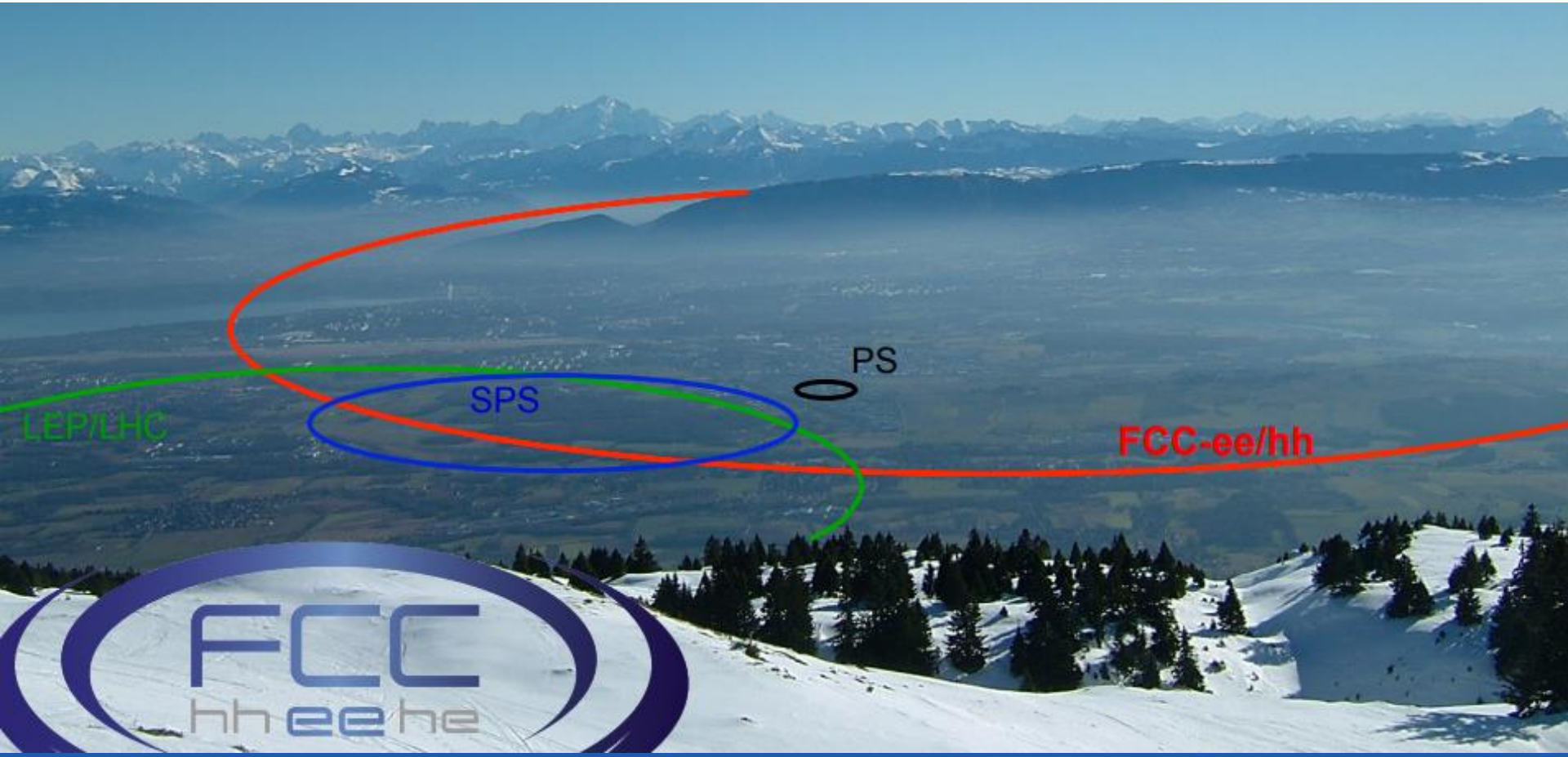
FCC week Brussels

Arjan Verweij, MPE-PE section meeting, 25 July 2019

most of the slides from the Overview talk by M. Benedikt on Monday morning



European Particle Physics Strategy

The **European Strategy for Particle Physics**:

- was initiated by the CERN council to coordinate activities across a large, international and fast-moving community with the aim to maximise scientific returns;
- provides a clear prioritisation of European ambitions in advancing the particle physics science;
- takes into account the **worldwide** particle physics landscape and developments in related fields.

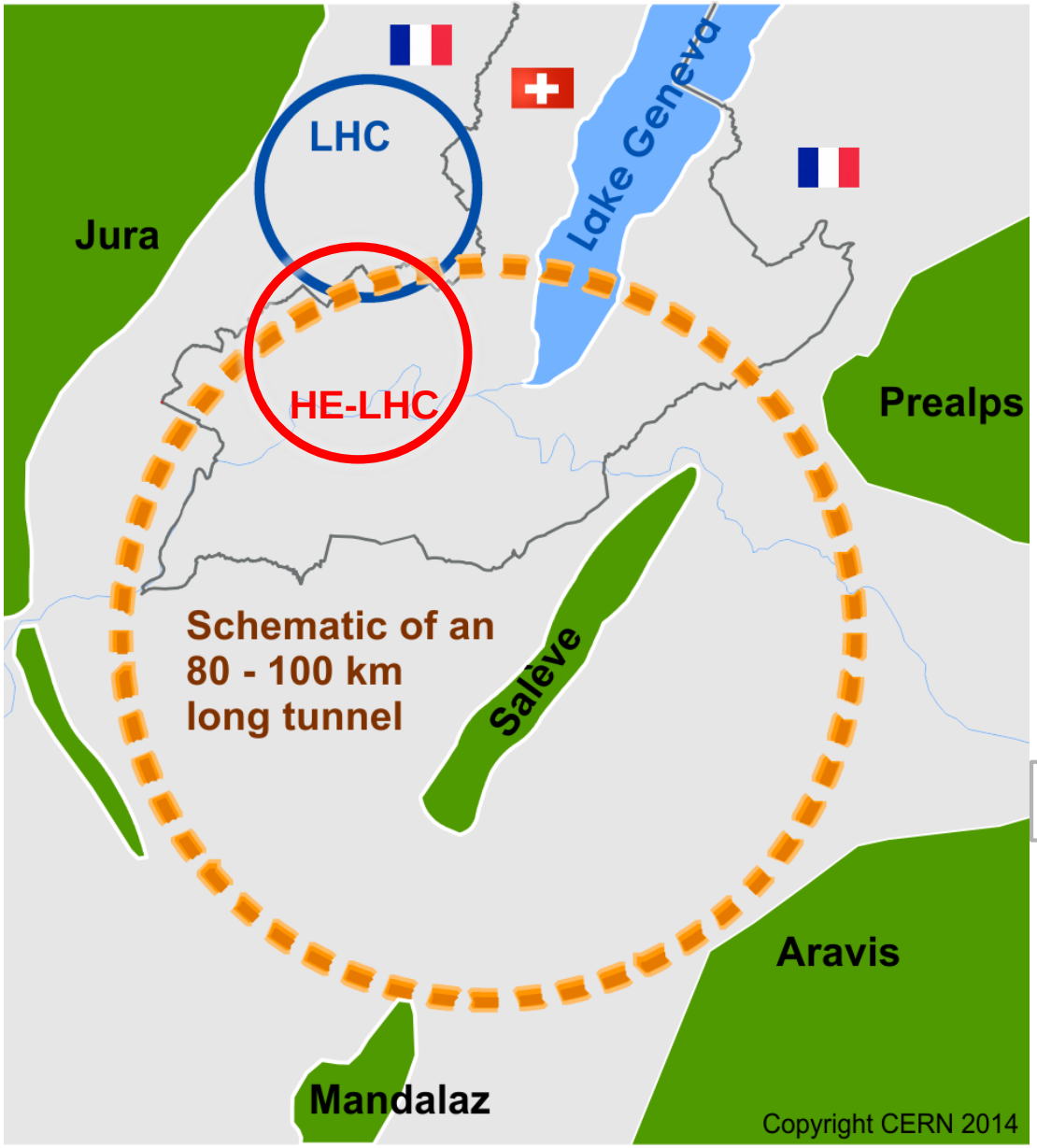
The Strategy is due to be updated by **May 2020** to guide the direction of the field to the mid-2020s and beyond.

Summary: European Strategy Update 2013

….“to propose an ambitious **post-LHC accelerator project at CERN** by the time of the next Strategy update”

CERN should undertake design studies for accelerator projects in a global context,

- *with emphasis on **proton-proton and electron-positron high-energy frontier machines**;*
- *coupled to a vigorous accelerator **R&D programme, including high-field magnets and high-gradient accelerating structures**;*
- ***in collaboration with national institutes, laboratories and universities worldwide.***

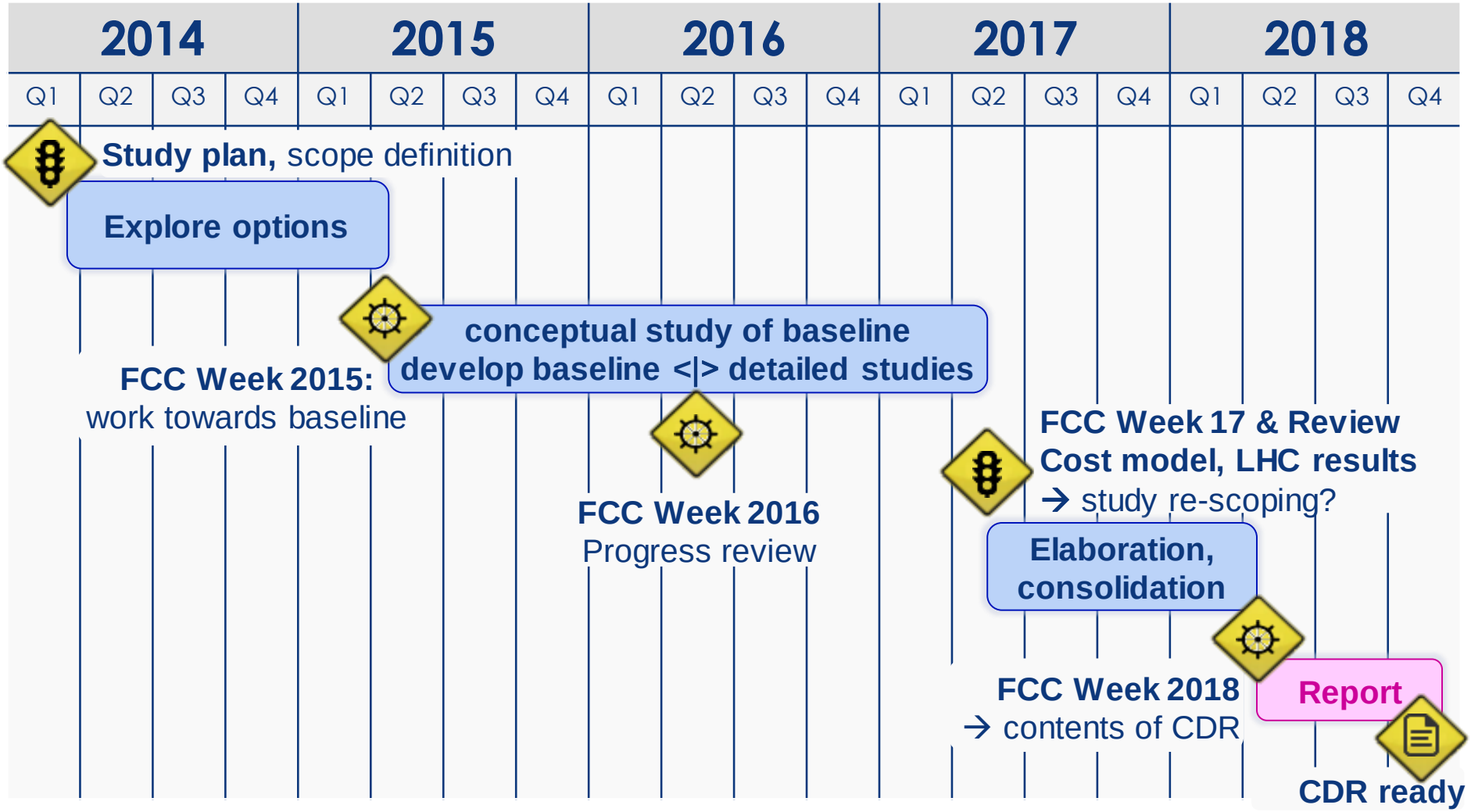


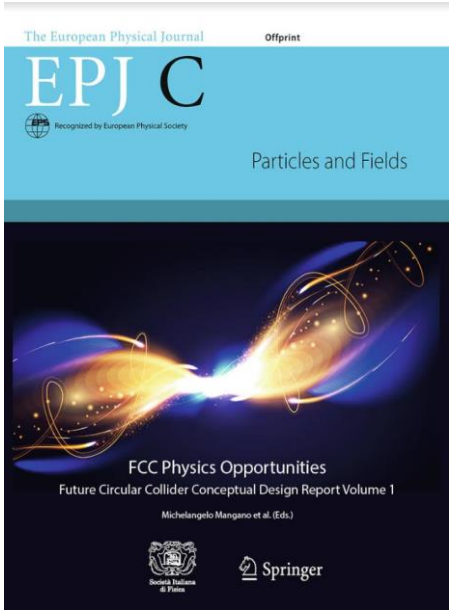
International FCC collaboration with CERN as host lab to study:

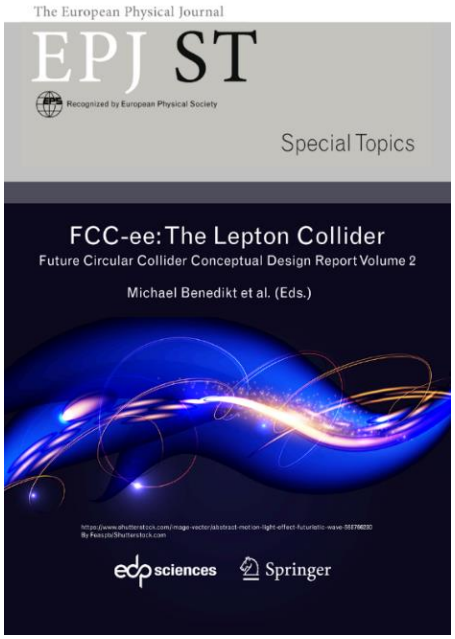
- **~100 km tunnel infrastructure** in Geneva area, linked to CERN
- ***e*⁺*e*⁻ collider (*FCC-ee*),** → potential first step
- ***pp*-collider (*FCC-hh*)** → long-term goal, defining infrastructure requirements

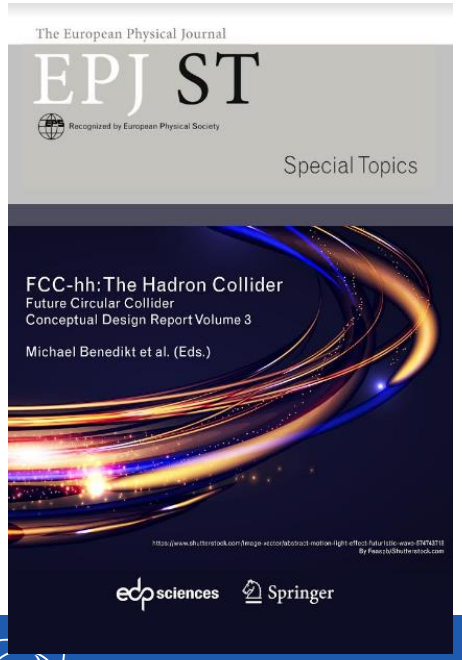
~16 T ⇒ 100 TeV *pp* in 100 km

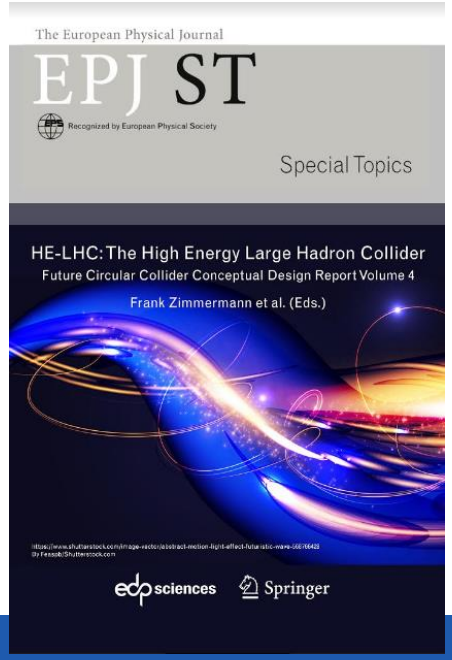
- **HE-LHC** with *FCC-hh* technology
- **Ions** and **lepton-hadron** options with hadron colliders


2014
2015
2016
2017
2018
Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4
Study plan, scope definition
Explore options
conceptual study of baseline
develop baseline <|> detailed studies
FCC Week 2015:
work towards baseline
FCC Week 2016
Progress review
FCC Week 17 & Review
Cost model, LHC results
→ study re-scoping?
Elaboration, consolidation
FCC Week 2018
→ contents of CDR
Report
CDR ready









4 CDR volumes submitted to EPJ in December 2018:

- FCC Physics Opportunities
- FCC-ee
- FCC-hh
- HE-LHC

more than 1350 contributors from 350 institutes

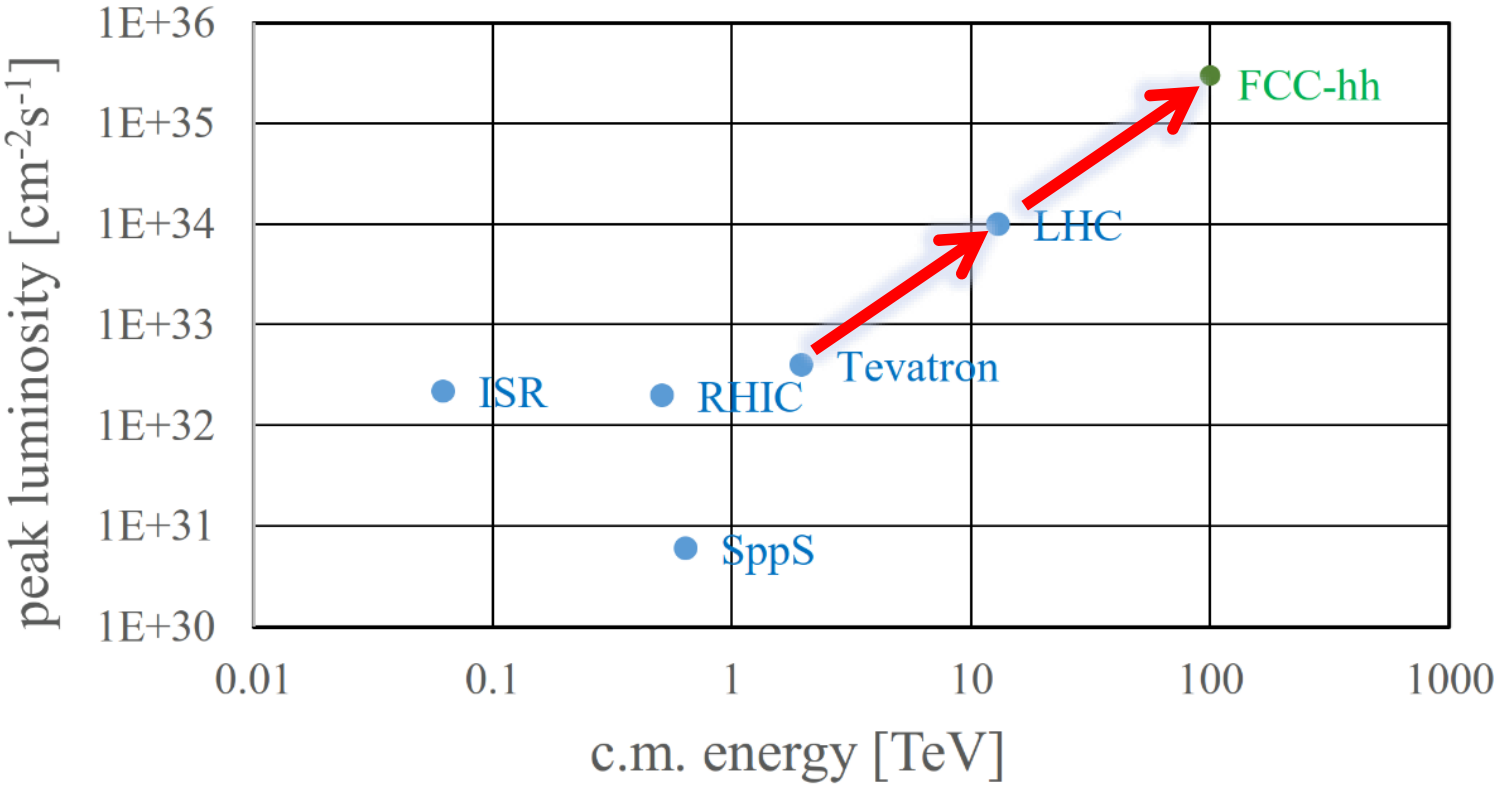
Comprehensive cost-effective program maximizing physics opportunities

Stage 1: FCC-ee

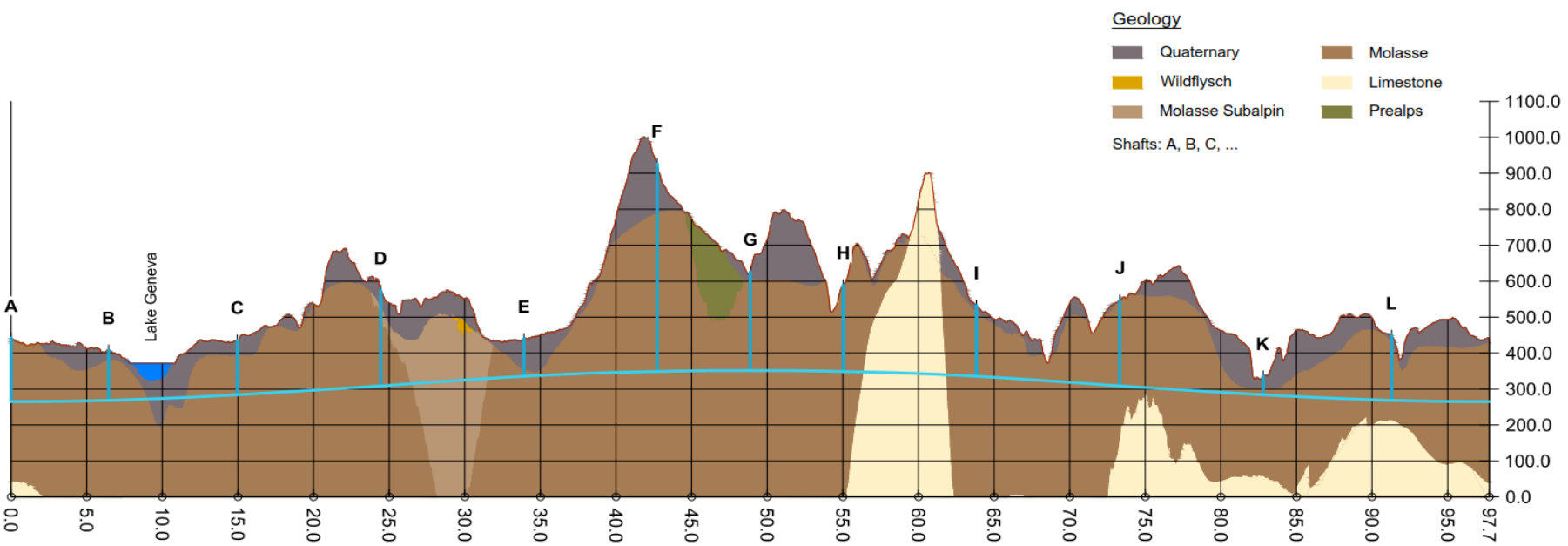
- 100 000 Z/sec (LEP: 1 Z/sec)
- 10 000 W/hr (LEP: 4 000 W/yr)
- 1 500 Higgs/day (10x more than ILC)
- 1 500 top quarks/day

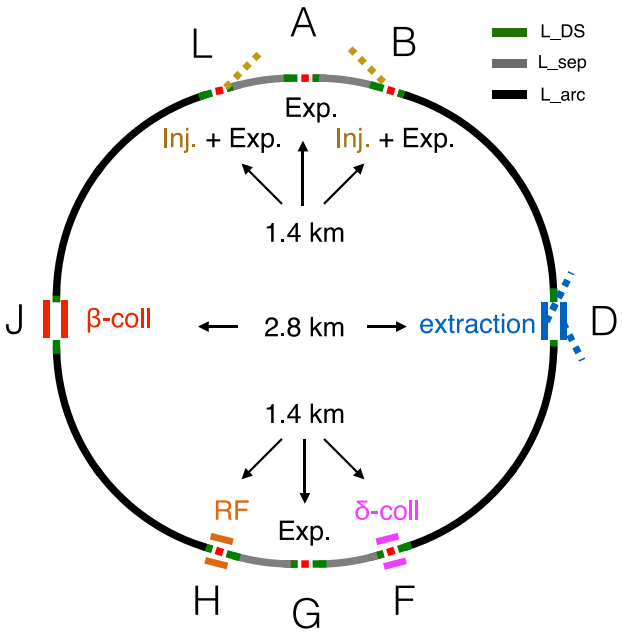
Stage 2: FCC-hh (~100 TeV) as natural continuation at energy frontier, with ion and eh options.

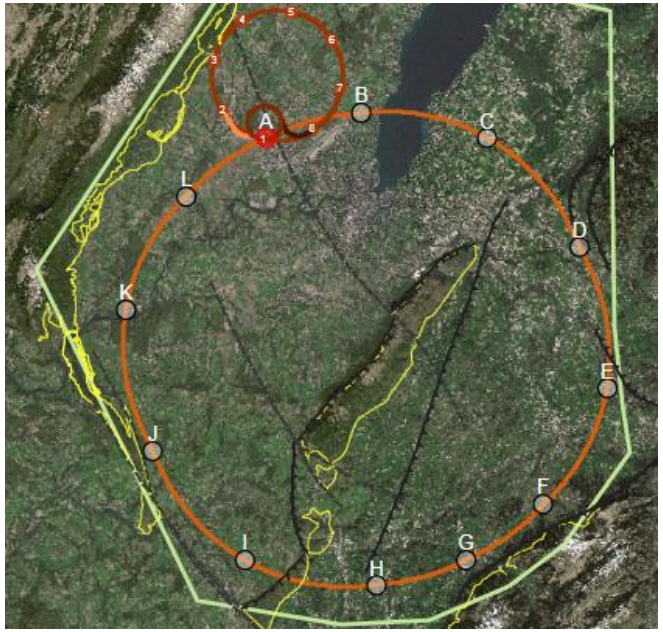
- Complementary physics
- Integrating an ambitious high-field magnet R&D program
- Common civil engineering and technical infrastructures
- Building on and reusing CERN's existing infrastructure.
- FCC integrated project plan is fully integrated with HL-LHC exploitation and provides for seamless continuation of HEP in Europe.



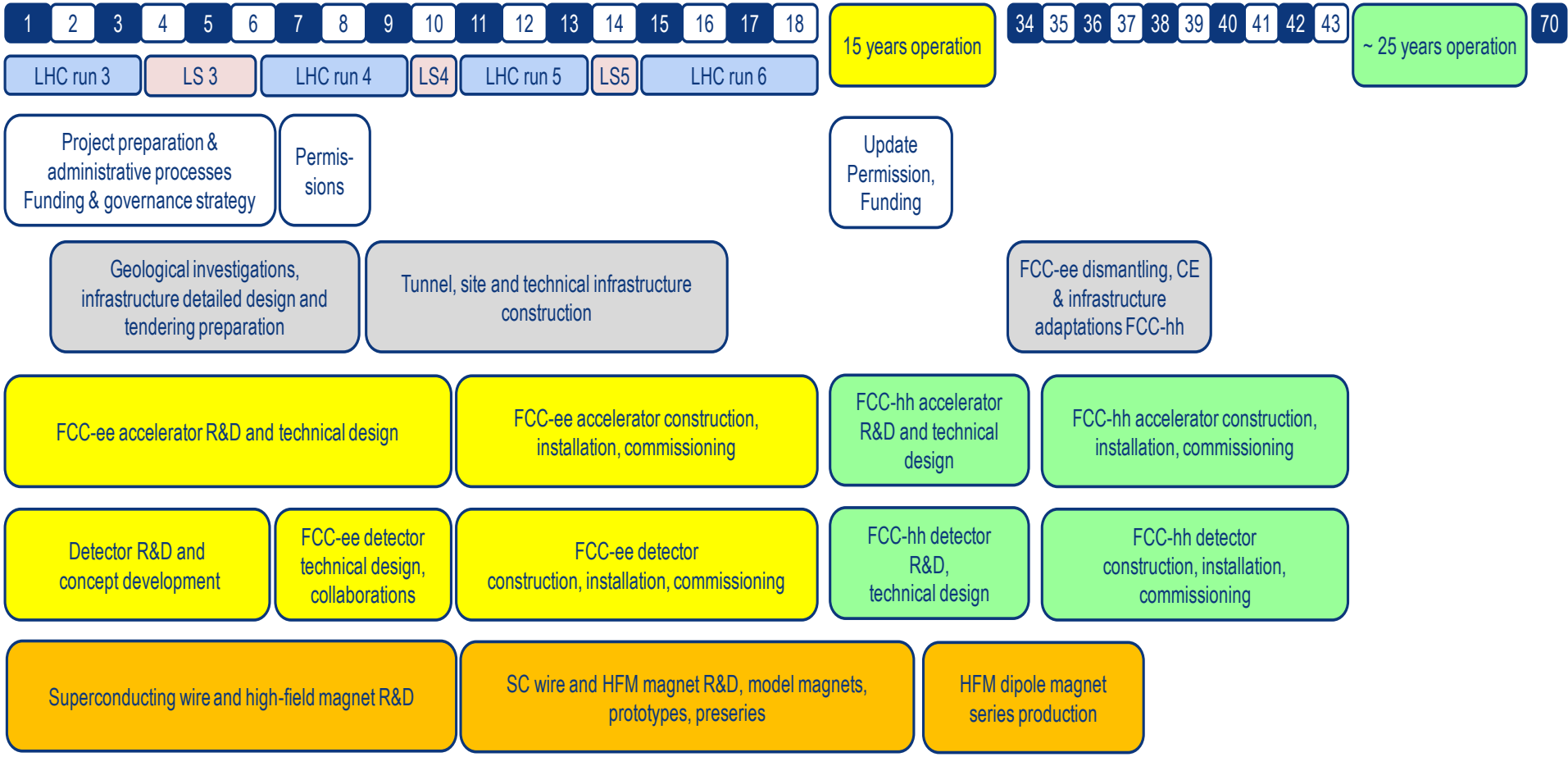
- Aim at **~one order of magnitude performance increase** in both **energy and luminosity w.r.t LHC**
- **100+ TeV cm collision energy** (vs 14 TeV for LHC)
- **20 ab^{-1} per experiment collected over 25 years** of operation time (vs 3 ab^{-1} for LHC).
- **Key technology: High-field magnets**







Tunnel construction estimated to take 7 years



FCC integrated project plan is fully integrated with HL-LHC exploitation and provides for seamless further continuation of HEP in Europe.

Construction cost phase1 (FCC-ee): 11.6 BCHF

- 5.4 BCHF for civil engineering (47%)
- 2.2 BCHF for technical infrastructure (19%)
- 4.0 BCHF for accelerator and injector (34%)

Construction cost phase 2 (FCC-hh): 17,0 BCHF.

- 13.6 BCHF accelerator and injector (57%)
  - Major part for 4700 Nb_3Sn 16 T main dipole magnets, totalling 94 BCHF, '*targeting*' 2 MCHF/magnet.
- 0.6 BCHF for adaptation of Civil Engineering and Technical Infrastructure of FCC-ee
- 2.8 BCHF for additional Technical Infrastructure, driven by cryogenics

parameter	FCC-hh		FCC-hh-6T	HE-LHC	HL-LHC	LHC
collision energy cms [TeV]	100		37.5	27	14	14
dipole field [T]	16		6	16	8.33	8.33
beam current [A]	0.5		0.6	1.1	1.1	0.58
synchr. rad. power/ring [kW]	2400		57	101	7.3	3.6
peak luminosity [10^{34} $cm^{-2}s^{-1}$]	5	30	10 (lev.)	16	5 (lev.)	1
events/bunch crossing	170	1000	~300	460	132	27
stored energy/beam [GJ]	8.4		3.75	1.4	0.7	0.36

2020/21 – 2025/26 project preparation phase (if supported by EPPSU and CERN Council)

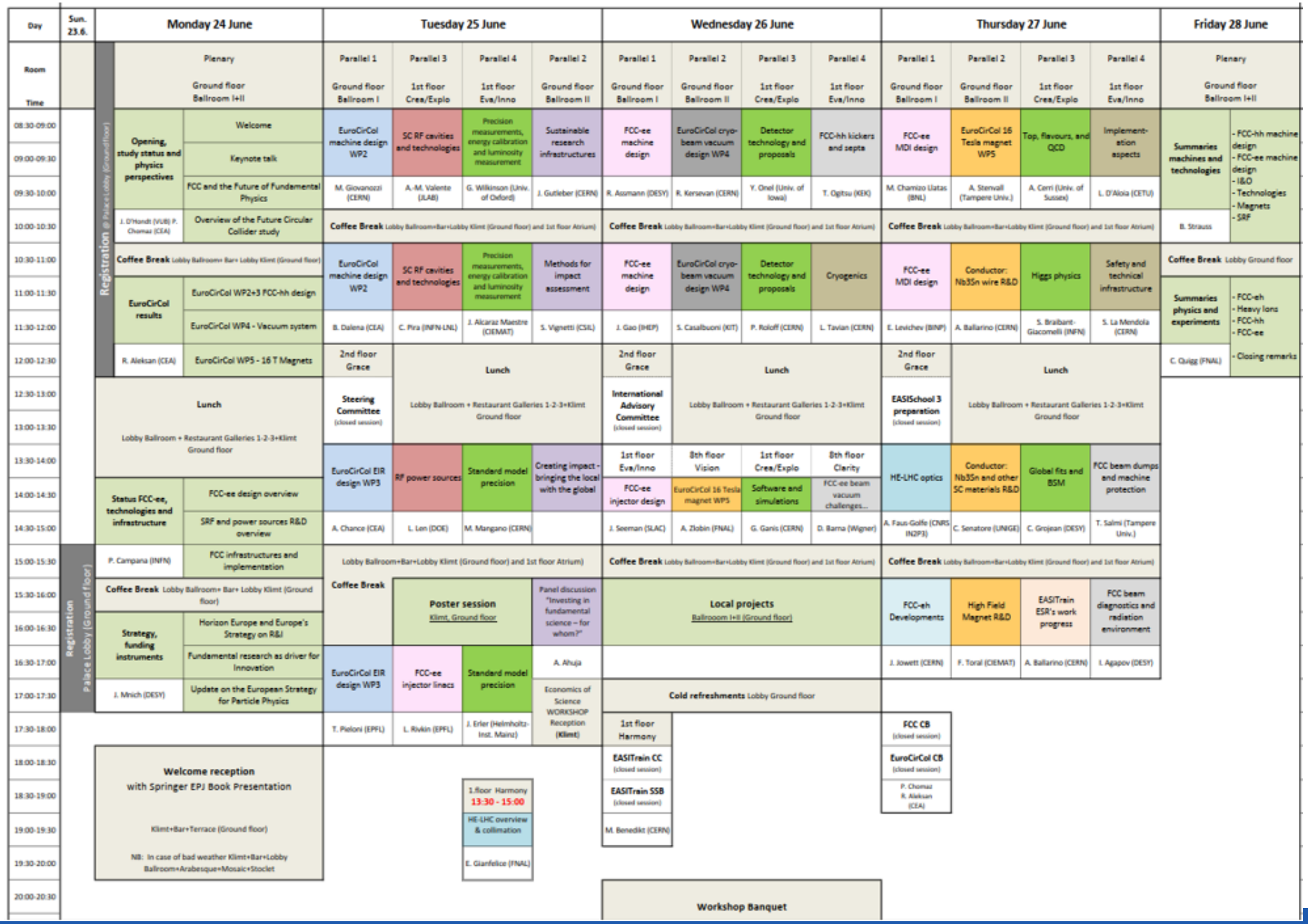
- Project preparatory activities with host states (landplot identification and acquisition plan, sector plan, EIA, “debat publique”, and study management
- Civil engineering site investigations and construction tender planning
- Technical design towards CDR++/TDR (ATS) (Accelerators, technology, technical infrastructure)
- Development of financing and governance models for project and operation phases including international in-kind contributions (CERN Council and Directorate).

Aiming for a definitive project decision by 2025/6.

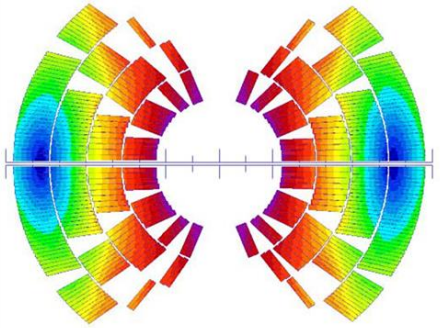
Program during the FFC week was a mix of mainly:

- hh and ee (and eh) machine optics
- hh and ee (and eh) physics potential
- 16 T magnet and superconductors
- RF cavities
- Infrastructure, civil engineering, cryogenics, vacuum, powering, other technical challenges

And one day (parallel sessions) of ‘Economics of Science’ (PS: impact not much presented in all the other talks…)

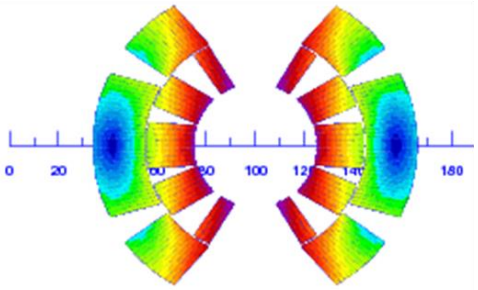

Day
Sun. 23.6.
Monday 24 June
Tuesday 25 June
Wednesday 26 June
Thursday 27 June
Friday 28 June
Room
Time
Plenary
Ground floor Ballroom I+II
Parallel 1
Ground floor Ballroom I
Parallel 3
1st floor Crea/Explo
Parallel 4
1st floor Eva/Inno
Parallel 2
Ground floor Ballroom II
Registration @ Palace Lobby (Ground floor)
Opening, study status and physics perspectives
Welcome
Keynote talk
FCC and the Future of Fundamental Physics
J. D'Hondt (VUB) P. Chomaz (CEA)
Overview of the Future Circular Collider study
Coffee Break Lobby Ballroom+ Bar+ Lobby Klimt (Ground floor)
EuroCirCol results
EuroCirCol WP2+3 FCC-hh design
EuroCirCol WP4 - Vacuum system
R. Aleksan (CEA)
EuroCirCol WP5 - 16 T Magnets
Lunch
Lobby Ballroom + Restaurant Galleries 1-2-3+Klimt Ground floor
Status FCC-ee, technologies and infrastructure
FCC-ee design overview
SRF and power sources R&D overview
P. Campana (INFN)
FCC infrastructures and implementation
Coffee Break Lobby Ballroom+ Bar+ Lobby Klimt (Ground floor)
Strategy, funding instruments
Horizon Europe and Europe's Strategy on R&I
Fundamental research as driver for Innovation
J. Mnich (DESY)
Update on the European Strategy for Particle Physics
Welcome reception with Springer EPJ Book Presentation
Klimt+Bar+Terrace (Ground floor)
NB: In case of bad weather Klimt+Bar+Lobby Ballroom+Arabesque+Mosaic+Stoclet
EuroCirCol machine design WP2
SC RF cavities and technologies
Precision measurements, energy calibration and luminosity measurement
Sustainable research infrastructures
M. Giovanozzi (CERN)
A.-M. Valente (JLAB)
G. Wilkinson (Univ. of Oxford)
J. Gutleber (CERN)
Coffee Break Lobby Ballroom+Bar+Lobby Klimt (Ground floor) and 1st floor Atrium)
EuroCirCol machine design WP2
SC RF cavities and technologies
Precision measurements, energy calibration and luminosity measurement
Methods for impact assessment
B. Dalena (CEA)
C. Pira (INFN-LNL)
J. Alcaraz Maestre (CIEMAT)
S. Vignetti (CSIL)
2nd floor Grace
Steering Committee (closed session)
Lunch
Lobby Ballroom + Restaurant Galleries 1-2-3+Klimt Ground floor
EuroCirCol EIR design WP3
RF power sources
Standard model precision
Creating impact - bringing the local with the global
A. Chance (CEA)
L. Len (DOE)
M. Mangano (CERN)
Lobby Ballroom+Bar+Lobby Klimt (Ground floor) and 1st floor Atrium)
Coffee Break
Poster session
Klimt, Ground floor
Panel discussion "Investing in fundamental science – for whom?"
EuroCirCol EIR design WP3
FCC-ee injector linacs
Standard model precision
A. Ahuja
Economics of Science WORKSHOP Reception (Klimt)
T. Pieloni (EPFL)
L. Rivkin (EPFL)
J. Erler (Helmholtz-Inst. Mainz)
1.floor Harmony
13:30 - 15:00
HE-LHC overview & collimation
E. Gianfelice (FNAL)
FCC-ee machine design
EuroCirCol cryo-beam vacuum design WP4
Detector technology and proposals
FCC-hh kickers and septa
R. Assmann (DESY)
R. Kersevan (CERN)
Y. Onel (Univ. of Iowa)
T. Ogitsu (KEK)
Coffee Break Lobby Ballroom+Bar+Lobby Klimt (Ground floor) and 1st floor Atrium)
FCC-ee machine design
EuroCirCol cryo-beam vacuum design WP4
Detector technology and proposals
Cryogenics
J. Gao (IHEP)
S. Casalbuoni (KIT)
P. Roloff (CERN)
L. Tavian (CERN)
2nd floor Grace
International Advisory Committee (closed session)
Lunch
Lobby Ballroom + Restaurant Galleries 1-2-3+Klimt Ground floor
1st floor Eva/Inno
8th floor Vision
1st floor Crea/Explo
8th floor Clarity
FCC-ee injector design
EuroCirCol 16 Tesla magnet WP5
Software and simulations
FCC-ee beam vacuum challenges...
A. Faus-Golfe (CNRS IN2P3)
A. Ziobin (FNAL)
G. Ganis (CERN)
D. Barna (Wigner)
Coffee Break Lobby Ballroom+Bar+Lobby Klimt (Ground floor) and 1st floor Atrium)
Local projects
Ballroom I+II (Ground floor)
Cold refreshments Lobby Ground floor
1st floor Harmony
EASITrain CC (closed session)
EASITrain SSB (closed session)
M. Benedikt (CERN)
Workshop Banquet
FCC-ee MDI design
EuroCirCol 16 Tesla magnet WP5
Top, flavours, and QCD
Implement-ation aspects
M. Chamizo Llatas (BNL)
A. Stenvall (Tampere Univ.)
A. Cerri (Univ. of Sussex)
L. D'Alioa (CETU)
Coffee Break Lobby Ballroom+Bar+Lobby Klimt (Ground floor) and 1st floor Atrium)
FCC-ee MDI design
Conductor: Nb3Sn wire R&D
Higgs physics
Safety and technical infrastructure
E. Levichev (BINP)
A. Ballarino (CERN)
S. Braibant-Giacomelli (INFN)
S. La Mendola (CERN)
2nd floor Grace
EASISchool 3 preparation (closed session)
Lunch
Lobby Ballroom + Restaurant Galleries 1-2-3+Klimt Ground floor
HE-LHC optics
Conductor: Nb3Sn and other SC materials R&D
Global fits and BSM
FCC beam dumps and machine protection
A. Faus-Golfe (CNRS IN2P3)
C. Senatore (UNIGE)
C. Grojean (DESY)
T. Salmi (Tampere Univ.)
Coffee Break Lobby Ballroom+Bar+Lobby Klimt (Ground floor) and 1st floor Atrium)
FCC-eh Developments
High Field Magnet R&D
EASITrain ESR's work progress
FCC beam diagnostics and radiation environment
J. Jowett (CERN)
F. Toral (CIEMAT)
A. Ballarino (CERN)
I. Agapov (DESY)
FCC CB (closed session)
EuroCirCol CB (closed session)
P. Chomaz
R. Aleksan (CEA)
Plenary
Ground floor Ballroom I+II
Summaries machines and technologies
- FCC-hh machine design
- FCC-ee machine design
- I&O
- Technologies
- Magnets
- SRF
B. Strauss
Coffee Break Lobby Ground floor
Summaries physics and experiments
- FCC-eh
- Heavy Ions
- FCC-hh
- FCC-ee
C. Quigg (FNAL)
- Closing remarks

What about the field level? (D. Schoerling)



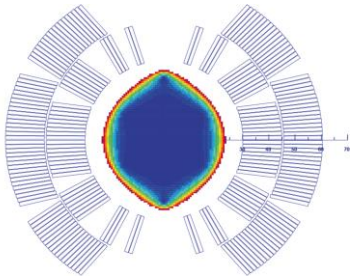
16 T (FCC spec)

- Past experience with Nb_3Sn high field magnets (13 programs), and the very recent success of FNAL shows the great potential of Nb_3Sn high-field magnet technology for a next collider in the ~14 T range



14 T (FCC spec)

- With the aim to reduce the cost and complexity, a ~40 TeV FCC-hh with 6 T may be considered (see M. Benedikt's talk)
- What about 12 T to 14 T which would also considerably reduce the magnet cost and complexity for a collider in the next decades?



11 T (HL-LHC spec)

Economics of Science

Designing a new research infrastructure with creating value over long-term in a sustainable way in mind, calls first for **identifying which value for society and economy is created**, **how it can be measured and where it comes from**.

J. Gutleber, CERN

Total Economic Value of Science (TEV)

TEV = Use Value + Non-Use Value

- *Use value = patents, licences, cultural visits, ….*
- *Non-Use Value = Option value + Bequest value + Existence Value*

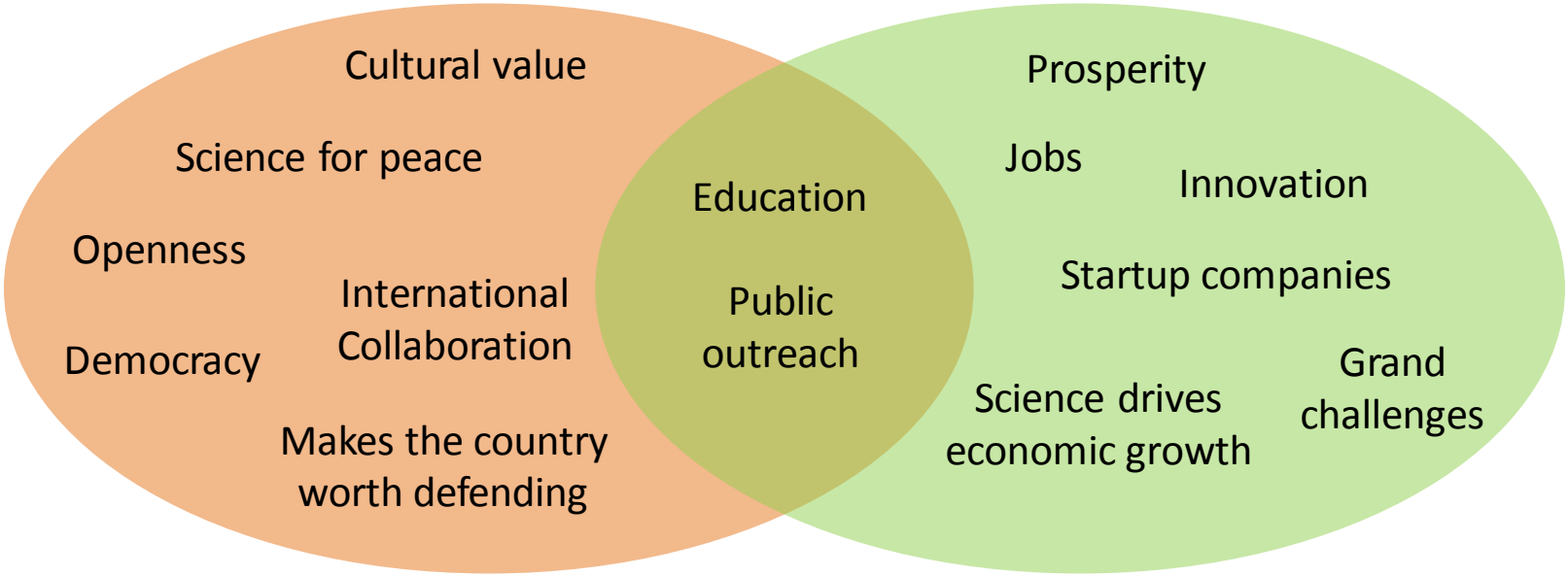
Option value = A resource or service is of no use today, but maybe extremely valuable in the future….

Bequest value = To transmit knowledge and cultural heritage to future generations…

Existence value = Willingness to pay to preserve a resource or service that exists (blue whales…), but you may never enjoy it (not today nor tomorrow)…

Why do big projects fail to get started? (J. Womersley, DG, ESS)

shift in emphasis since
the end of the Cold War



Scientists are much happier over here…

… but this is where investment decisions are now made

FCC week indico page:
https://indico.cern.ch/event/727555/overview

Physics potential:
http://dpnc.unige.ch/seminaire/talks/janot.pdf