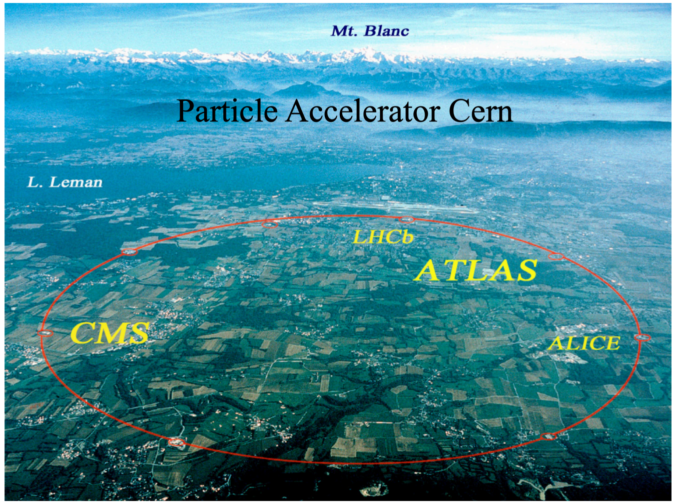
FCC WEEK 2024



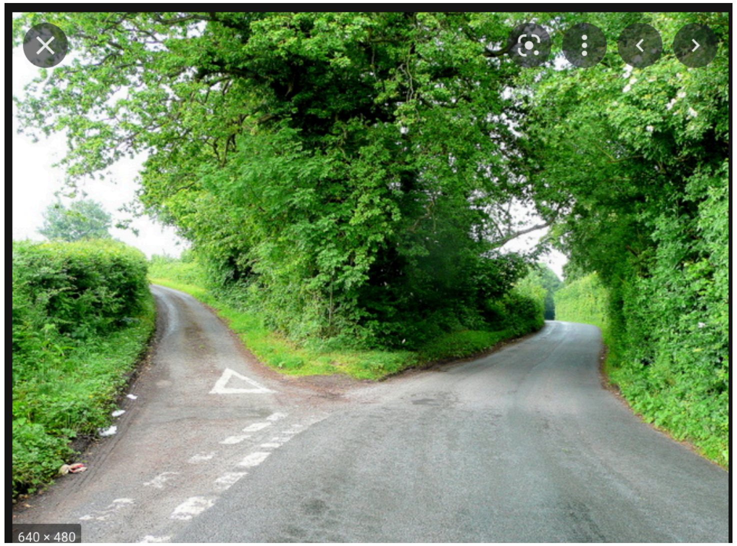
VIEW FROM THE CERN COUNCIL

ELIEZER RABINOVICI

PRESIDENT OF THE CERN COUNCIL

HEBREW UNIVERSITY, JERUSALEM, ISRAEL

Where does CERN go from here?



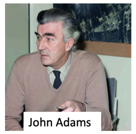
CERN

DECISION TIMES - WITH HISTORICAL PERSPECTIVE

Chris llewellyn Smith

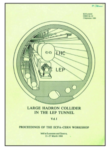
LHC Conception

As the Super Proton Synchrotron neared completion (switched on 1976)
→ idea of building a Large Electron Positron Collider quickly gained support
John Adams (Technical DG of CERN) favoured proton accelerators
and resisted…but in 1977 bowed to pressure to support LEP
provided the tunnel was made large enough to house
a 3 TeV superconducting proton accelerator later


John Adams

LHC Childhood LHC Adolescence Stages

CERN - late 1983 Herwig Schopper (DG) initiated LHC study in preparation for the 1984
International **C**ommittee for **F**uture **A**ccelerators seminar at KEK in Japan
↓
Lausanne Workshop March 1984 (I was theoretical convenor)



- first major LHC discussion
physics case (much developed by John Ellis and collaborators at CERN)
essentially unchanged for 30 years
except Higgs boson found


Herwig Schopper

ICFA Seminar: LHC-SSC shoot out

- LHC at 1/3 energy. Argued: compensate with higher luminosity* → experiments much harder

  Thanks to intensive R&D programme (also on magnets) the LHC is able to handle luminosities far higher than would have been available at the SSC

  [*Questions whether even 10^{33} cm^{2} s^{-1} could be used: *'consensus that the number of events per bunch crossing should not exceed one'.* **Today:** average of 35; maximum 70. High-luminosity LHC → up to 140-200 collisions/crossing]
- SSC presented as national project – *criticised by Japanese*
- LHC presented by Giorgio Brianti - based on 2-in-1 magnets but almost everything else changed subsequently: *"conceivable that luminosity could eventually approach or even exceed 10^{33}".* Today 10^{34} cm^{-2} s^{-1}

LHC Adolescence 1

CERN Council kept informed of plans
- varied reactions given SSC under construction (approved 1987)

Push by Carlo Rubbia (DG) and Bill Mitchell, President of Council (1990-93)

Presentation of the project to a special open Council session
- Ministers and senior advisors invited, December 1991

As Chair of the SPC, I presented the scientific case:

Meanwhile experimental collaborations forming (another story)

- Further progress needs higher energy – 1 TeV is next major goal
- Proton-proton collisions are the only open road to 1 TeV now
- LHC – most cost effective route
  – heavy ion and ep collisions as bonus

LHC must be the next project for CERN

•

LHC Adolescence 2

Conclusion (?) of the special Council meeting

'LHC is the right machine for the advance of the subject and the future of CERN'. Request for more detailed information on the project < end of 1993 'so that the Council may move towards a decision on the LHC'

May 1993 - Carlo Rubbia (DG) handed me (due to take over in January 1994) responsibility for putting together the LHC proposal + a long-term plan for CERN and presenting them to Council in December

October 1993: cancellation of SSC

December 1993: Proposal presented to the Council

Reaction generally positive, but Germany and the UK were not willing to approve the requested hump in the budget and asked CERN to look for further savings/cost reductions

Revised plan presented in June 1994 - 17 Members voted for approval **but** Germany & UK wanted further cost savings and substantial contributions from France and Switzerland

... so the vote was left open

LHC Adolescence 3

Autumn 1994 – Germany & UK only willing to vote yes assuming 2% inflation to be (under compensated) by 1% indexation of the budget

Missing magnet idea (used at one stage to sell the SPS) developed and deployed as only way to build LHC on budget declining in real terms

December 1994 LHC approved for construction in two stages (2/3 of magnets on day 1)
with the condition that 'any contributions from non-Members will be used to speed up and improve the project, not to allow reductions in the Members States' contributions', and the time-table would be reviewed in 1997

1995-6*

- Negotiated contributions from Canada, India, Japan, Russia, USA (albeit following the election of a Republican majority in the House of Representatives, this was not approved until late 1997)
- June 1996: decided to bring forward 1997 review and ask for approval of single stage construction, but then
- August 1996: Germany (suffering from financial impact of re-unification) asked for a 10% cut in its contribution – *this was seized on the by UK to ask for a 10% cut for all*
- Only way ahead – large loan, previously considered anathema by Germany

• **December 1996: Single Stage Construction of LHC Approved**

- Accompanied by cuts in the budget
- On the basis of loans

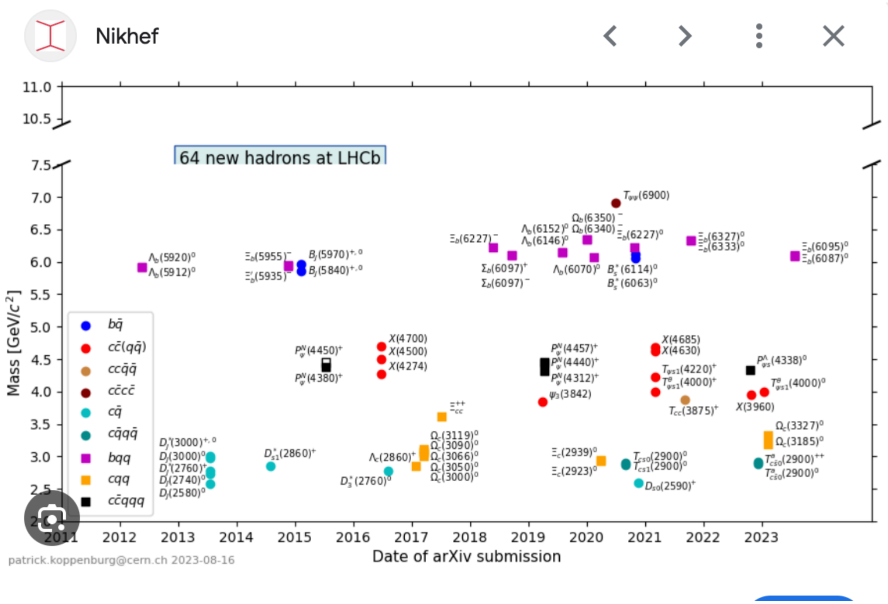
By the end of 1998, when I handed over to Luciano Maiani as DG, the LHC was well past the point of no return – agreement signed with USA, around half (by value) of the contacts signed (overall, in line with estimates), although the situation was clearly fragile

1977-1996- 2008 -2012 and….

WHAT PARTICLES WERE DISCOVERED?

New fundamental particles

Counter	Experiment	Particle	Mass [GeV]	Date	Reference	Note
1.	ATLAS	Higgs Boson	126.0 ± 0.6	31 Jul 2012	Phys. Lett. B716 (2012) 1	
1.	CMS	Higgs Boson	125.3 ± 0.7	31 Jul 2012	Phys. Lett. B716 (2012) 30	



72 new so far conventional and exotic.

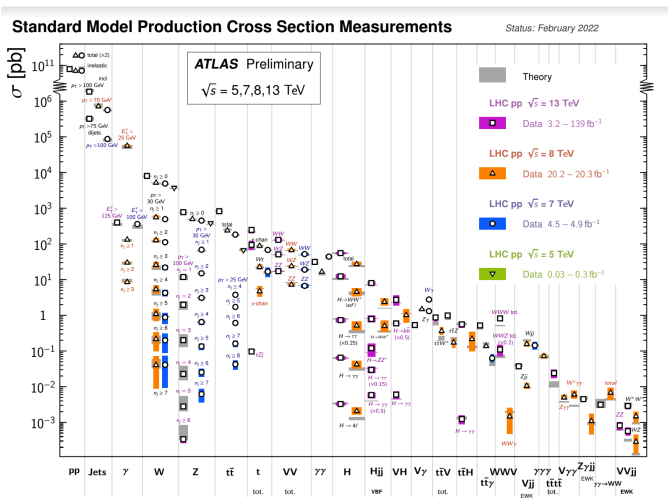
ATLAS and CMS

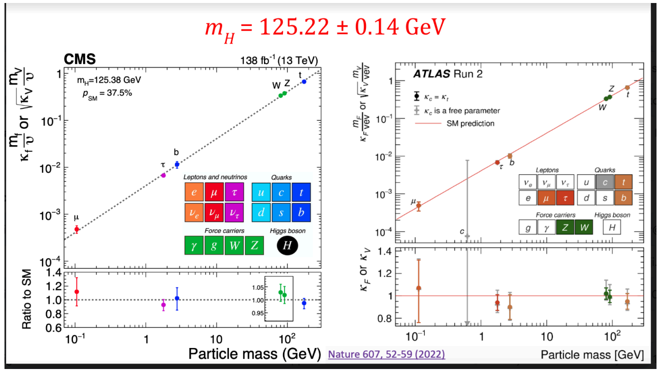
From: Nature

To: Physicists

Subject: Standard Model Status

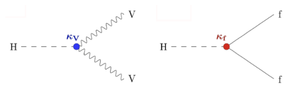
Via: LHC

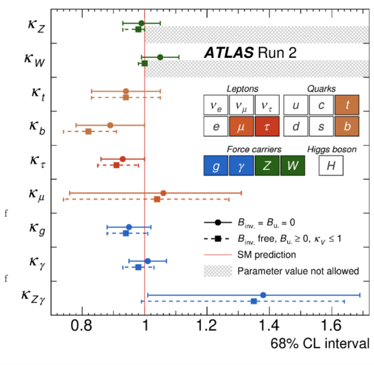




Precision in the measurements of Higgs couplings:

- Gauge bosons (below 10%)
- 3rd gen. fermions (below 20%)





WHAT PARTICLES WERE NOT DISCOVERED?

Shortly Before arriving in Stockholm, Klein received a letter from his good friend Pauli which reads in part:

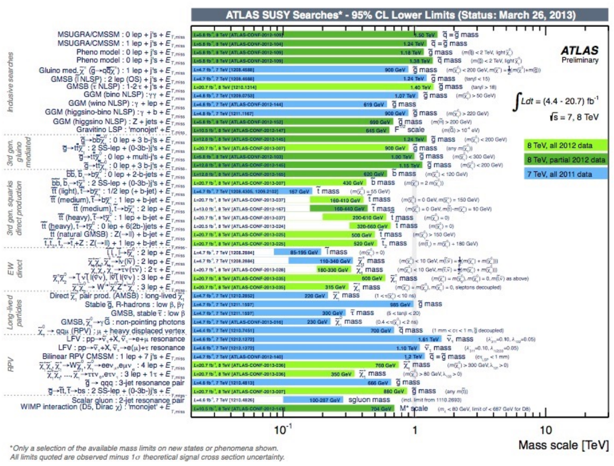
....I am not of the opinion that finding new laws of nature and indicating new directions of research is one of your great strengths,
although you have always developed a certain ambition in that direction...
I find much more beautiful those of your papers which deal with applications of known theories such as for example...
the paper with Nishina about the new scattering formula etc....

From: Nature

To: Physicists

Subject: SUSY Particles and more

Via: LHC



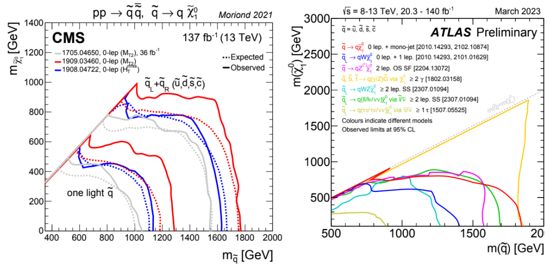


Figure 89.5: Left: 95% C.L. exclusion contours in the framework of simplified models assum a single decay chain of $\tilde{q} \to q\tilde{\chi}_1^0$, obtained by the CMS collaboration. Right: Assuming m complicated decay chains including W or Z bosons, obtained by the ATLAS collaboration.

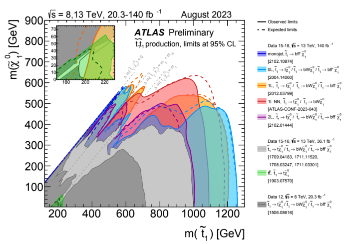
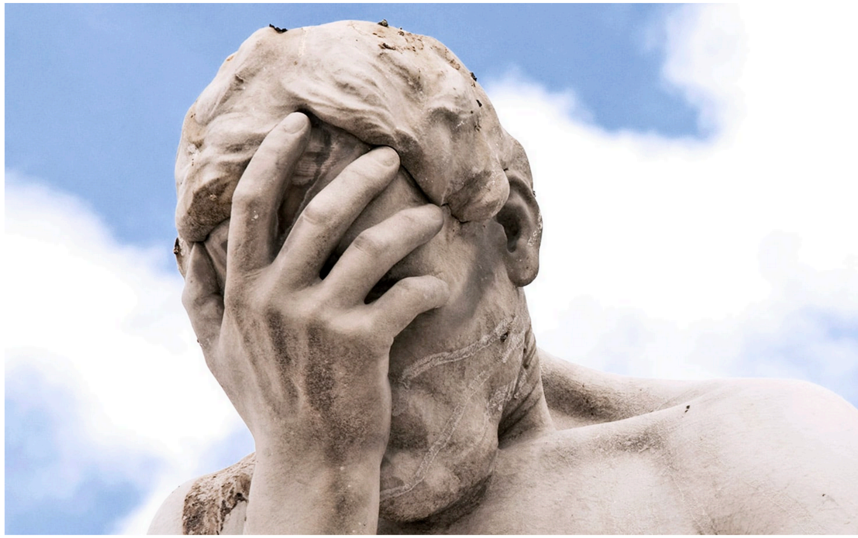


Figure 89.6: A summary of the 95% C.L. exclusion contours in the stop-neutralino mass plane for various possible decay chains, including two-, three- and four-body decays, as obtained in dedicated analyses by ATLAS.

Table 89.1: Summary of squark mass and gluino mass limits using different interpretation approaches assuming R-parity conservation. Masses in this table are provided in GeV. Further details about the assumptions and analyses from which these limits are obtained are discussed in the corresponding sections of the text.

Model	Assumption	$m_{\tilde{q}}$	$m_{\tilde{g}}$
Simplified models $\tilde{g}\tilde{g}$			
$\tilde{g} \to q\bar{q}\tilde{\chi}_1^0$	$m_{\tilde{\chi}_1^0}$ =0	-	≈ 2300
	$m_{\tilde{\chi}_1^0}$ >≈ 1200	-	no limit
$\tilde{g} \to b\bar{b}\tilde{\chi}_1^0$	$m_{\tilde{\chi}_1^0}$ =0	-	≈ 2440
	$m_{\tilde{\chi}_1^0}$ >≈ 1600	-	no limit
$\tilde{g} \to t\bar{t}\tilde{\chi}_1^0$	$m_{\tilde{\chi}_1^0}$ =0	-	≈ 2400
	$m_{\tilde{\chi}_1^0}$ >≈ 1400	-	no limit
Simplified models $\tilde{q}\bar{\tilde{q}}$			
$\tilde{q} \to q\tilde{\chi}_1^0$	$m_{\tilde{\chi}_1^0}$ =0	≈ 1900	-
	$m_{\tilde{\chi}_1^0}$ >≈ 800	no limit	-
$\tilde{u}_L \to q\tilde{\chi}_1^0$	$m_{\tilde{\chi}_1^0}$ =0	≈ 1300	-
	$m_{\tilde{\chi}_1^0}$ >≈ 600	no limit	-

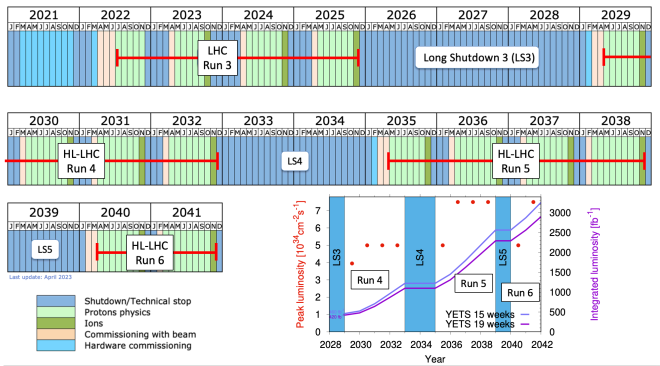
NOT TOO MANY

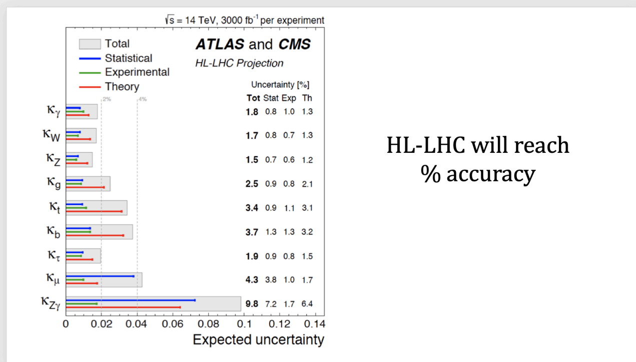


WHAT NEXT?

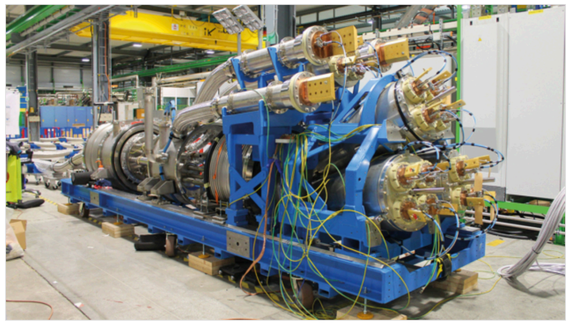
NEAR TERM : 2029(?)-2041(?)

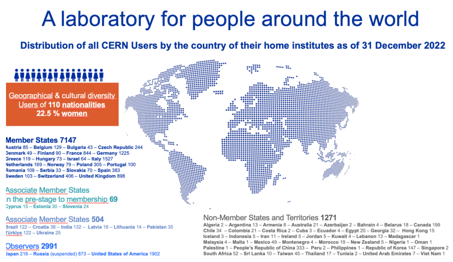
HIGH LUMINOSITY LHC- HL-LHC



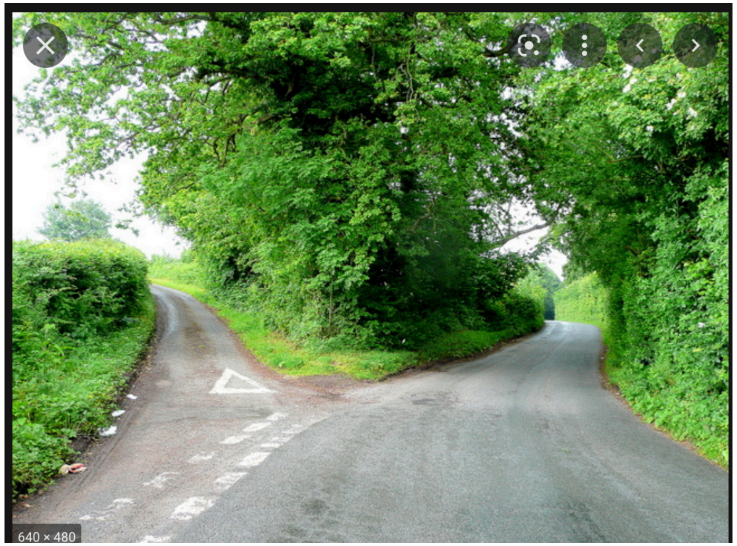


HL-LHC will reach
% accuracy



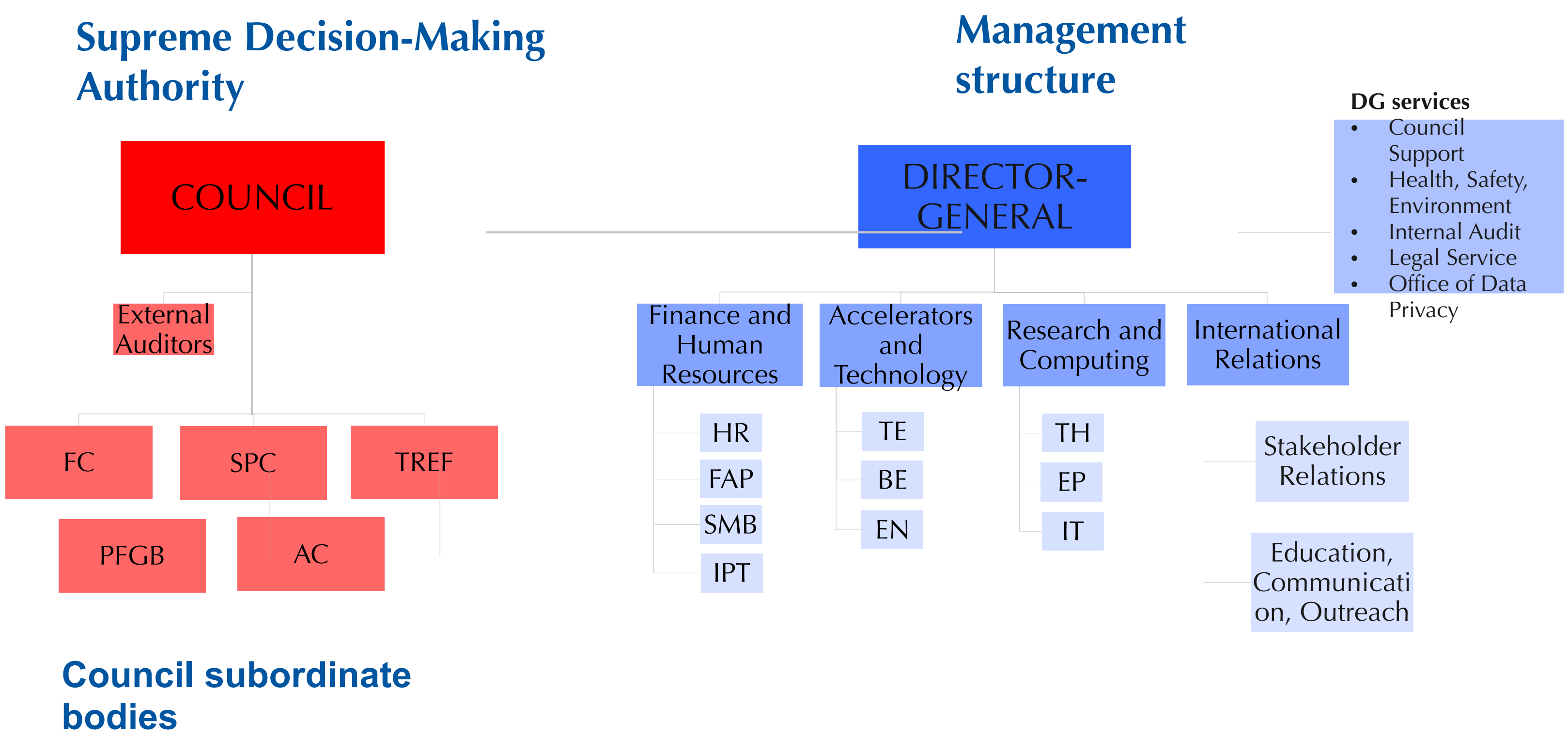


Where does CERN go from here?



WHO DECIDES AND HOW?

Organigram


Supreme Decision-Making Authority
Management structure
DG services
• Council Support
• Health, Safety, Environment
• Internal Audit
• Legal Service
• Office of Data Privacy
COUNCIL
DIRECTOR-GENERAL
External Auditors
FC
SPC
TREF
PFGB
AC
Finance and Human Resources
Accelerators and Technology
Research and Computing
International Relations
HR
FAP
SMB
IPT
TE
BE
EN
TH
EP
IT
Stakeholder Relations
Education, Communication, Outreach
Council subordinate bodies

State and institutional participation in CERN

23 Member States:

1954 Belgium, Denmark, France, Germany, Greece, Italy, Netherlands, Norway, Sweden, Switzerland, United Kingdom, Yugoslavia

1959 Austria, **1983** Spain, **1986** Portugal, **1991** Finland, Poland,

1992 Hungary, **1993** Czech Republic, Slovakia, **1999** Bulgaria,

2014 Israel, **2016** Romania, **2019** Serbia **2024(*)** Estonia

Pre-Stage to Membership: Cyprus (2016), Slovenia (2017)

Associate Member States: Turkey (2015), Pakistan (2015), Ukraine (2016), India (2017), Lithuania (2018), Croatia (2019), Latvia (2020), Brazil(2024).

Applications: Chile, Ireland

Observer States: Japan, United States of America (Russian Federation suspended March 2022)

Observer institutions: UNESCO, European Union, JINR

CERN's governance organs

CERN is governed by **two main organs** (Article IV, Convention)

- the **Council**
  - supreme decision-making authority
  - advised by specialised subordinate bodies, the Scientific Policy Committee, the Finance Committee, the Pension Fund Governing Board, the Audit Committee

- the **Director-General,** who is the Chief Executive Officer and legal representative of the Organization


0.0000000000001
or
0.0000000000002

H0W DID THIS WORK SO FAR ?

CERN- STABILITY- MS FUNDING

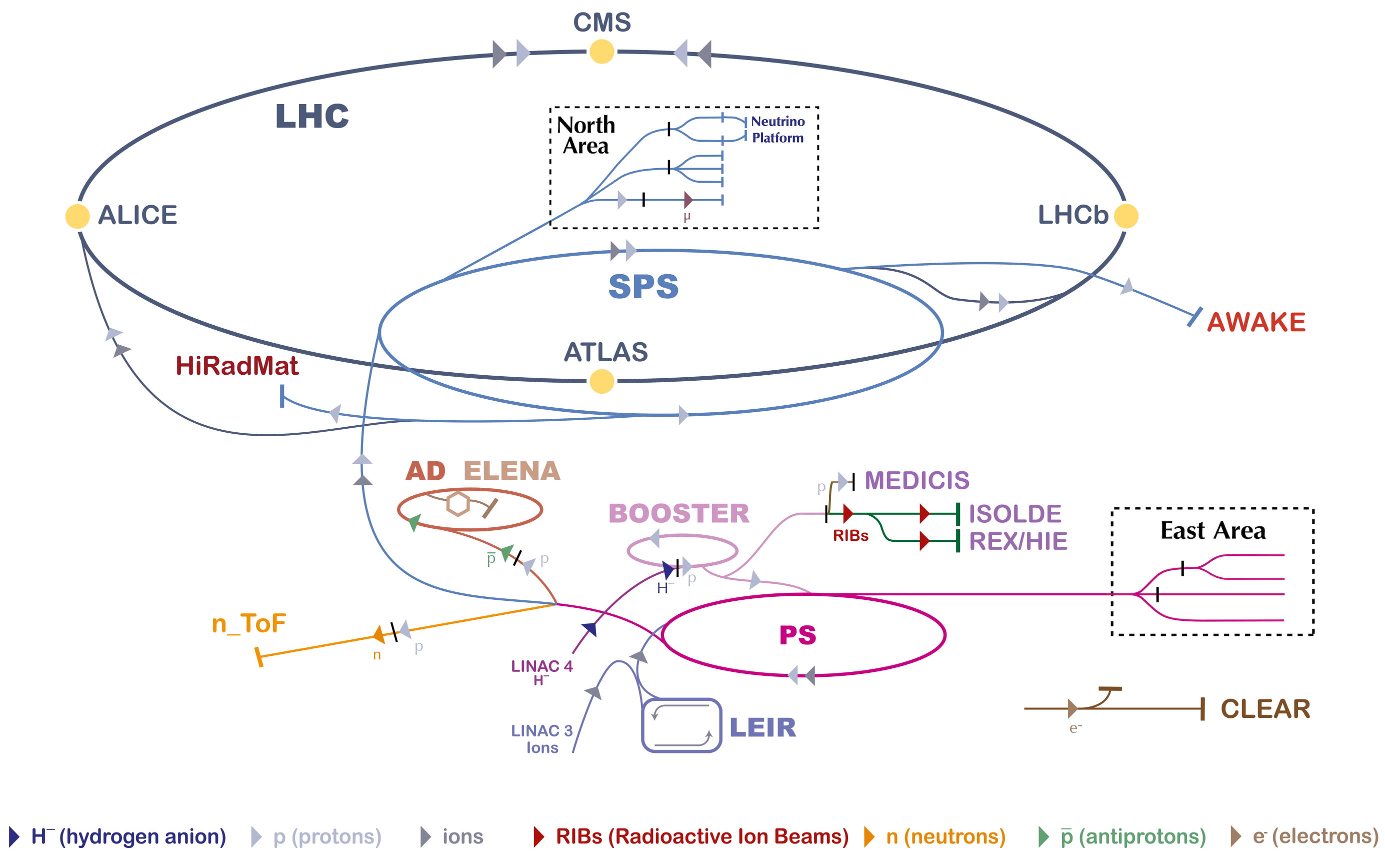
OVER 25 YEARS 1998-2022

OVER 29 BILLION CHFS. (RINGS A BELL?)

YEAR BY YEAR –FIXED AND INDEXED BUDGET. 100% PAID.

WILLING TO ASSUME LEADERSHIP-MONEY ON THE TABLE.

….ISR..SPS, Ppbar, LEP, LHC- 13.6 TEV July 5th. HL-LHC
NEUTRAL CURRENTS-NEUTRINO(USA BOTH WAYS)
-W- Z- H –PENTAQUARKS
AMAZING PROGRESS IN ACCELERATOR TECHNOLOGY.


CMS
LHC
North Area
Neutrino Platform
ALICE
LHCb
SPS
AWAKE
ATLAS
HiRadMat
AD
ELENA
BOOSTER
MEDICIS
ISOLDE
REX/HIE
RIBs
East Area
n_ToF
PS
LINAC 4
H⁻
LINAC 3
Ions
LEIR
CLEAR
H⁻ (hydrogen anion)
p (protons)
ions
RIBs (Radioactive Ion Beams)
n (neutrons)
p̄ (antiprotons)
e⁻ (electrons)

BOTTOM UP APPROACH - PROCESS

European Strategy for Particle Physics(ESGPP)

- First adopted by the Council in 2006 – Non Brainer - bottom up Orsay-Zeuthen- Lisbon
- Adopted in 2013 Bottom Up Krakow- Erice- CERN
- HL-LHC , Future vision (fcc ilc clic and others)

- Updated 2020 –BOTTOM-UP – POINT-LINE-CIRCLE
- Granada-Bad Honnef -CERN(Budapest) HL LHC the rest Complex

- The update of the ESGPP by the Council in June 2020 called for:

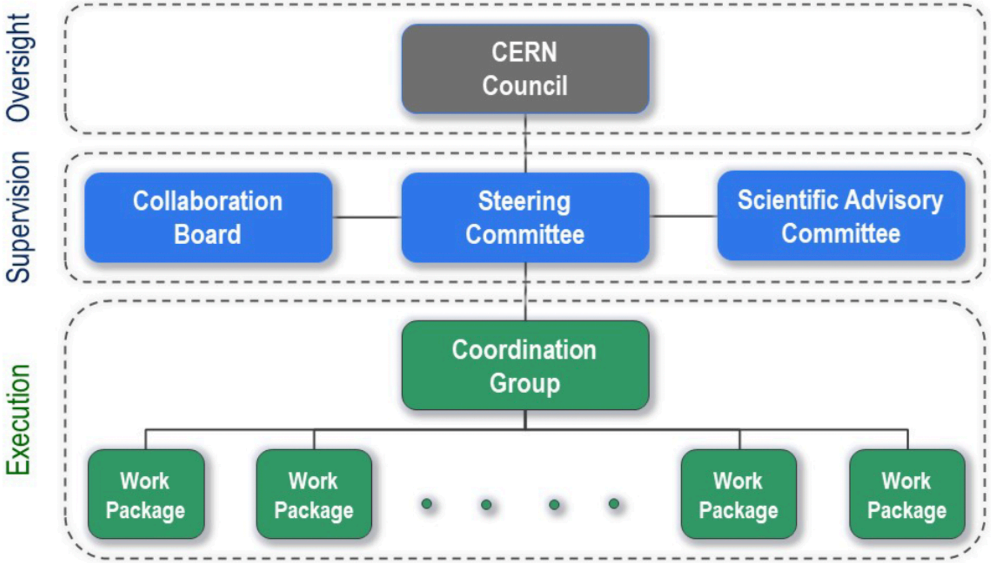
"a technical and financial feasibility of a future hadron collider at CERN with a centre-of-mass energy of at least 100 TeV and with an electron-positron Higgs and electroweak factory as a possible first stage. Such a feasibility study of the colliders and related infrastructure should be established as a global endeavour and be completed on the timescale of the next Strategy update"

- **CERN COUNCIL IS UNITED IN THE VISION OF WANTING TO MAKE SURE CERN CONTINUES TO PROVIDE THE MOST INTERERSTING AND SCIENTIFIC POSSIBILITIES AND THE MOST ADVANCED TECHNOLOGICAL TOOLS TO DO THE PHYSICS.**

- **CERN COUNCIL DOES NOT, YET, HAVE A CONSENSUS ON HOW THE ACTUALIZE THIS VISION.**

FCC Feasibility Study 2021-2025: organisation

Approved by Council in June 2021:
https://indico.cern.ch/event/1038466/contributions/4361057/attachments/2259575/3834906/spc-e-1155-Rev2-c-e-3566-Rev2-FCC_Organisational%20Structure.pdf



- Collaboration Board: 1 representative per Institute that signed or will sign FCC MoU (~ 150 currently). It reviews work needs and resources requirements and their sharing among participating institutes.
- Steering Committee: provides technical and organisational supervision of the study; includes CERN's Directorate, Study leader (M. Benedikt), CB Chair (Ph. Chomaz), 5 members appointed by CB (M. Cobal/Udine, B. Heinemann/DESY, T. Koseki/KEK, L. Merminga/FNAL, M. Seidel/PSI), Council President in ex-officio observer capacity (chair: DG).
- Scientific Advisory Committee: international experts covering all relevant scientific and technical areas (chair: A. Parker)
- Coordination group: chaired by Study leader, brings together conveners of the 5 WPs: Physics, Experiments and Detectors; Accelerators; Technical Infrastuctures; Host State Processes and Civil Engineering; Organisation and Financing Models

progress with implementation baseline PA31 90.7 km

Meetings with municipalities concerned in France (31) and Switzerland (10)

PA – Ferney Voltaire (FR) – site experimental

PB – Présinge/Choulex (CH) – site technique

PD – Nangy (FR) – site experimental

PF – Roche sur Foron/Etaux (FR) – site technique

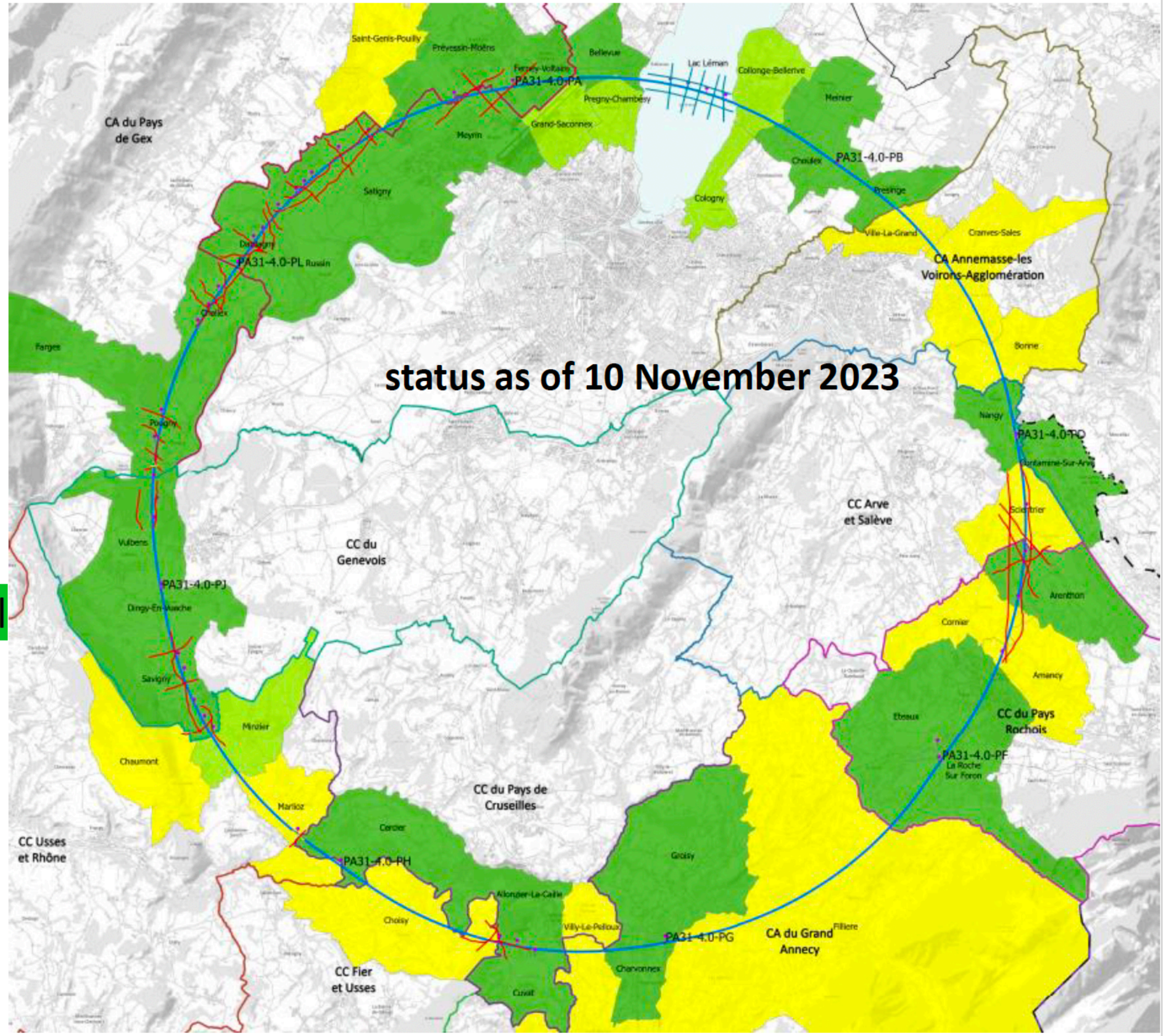
PG – Charvonnex/Groisy (FR) – site experimental

PH – Cercier (FR) – site technique

PJ – Vulbens/Dingy en Vuache (FR) site experimental

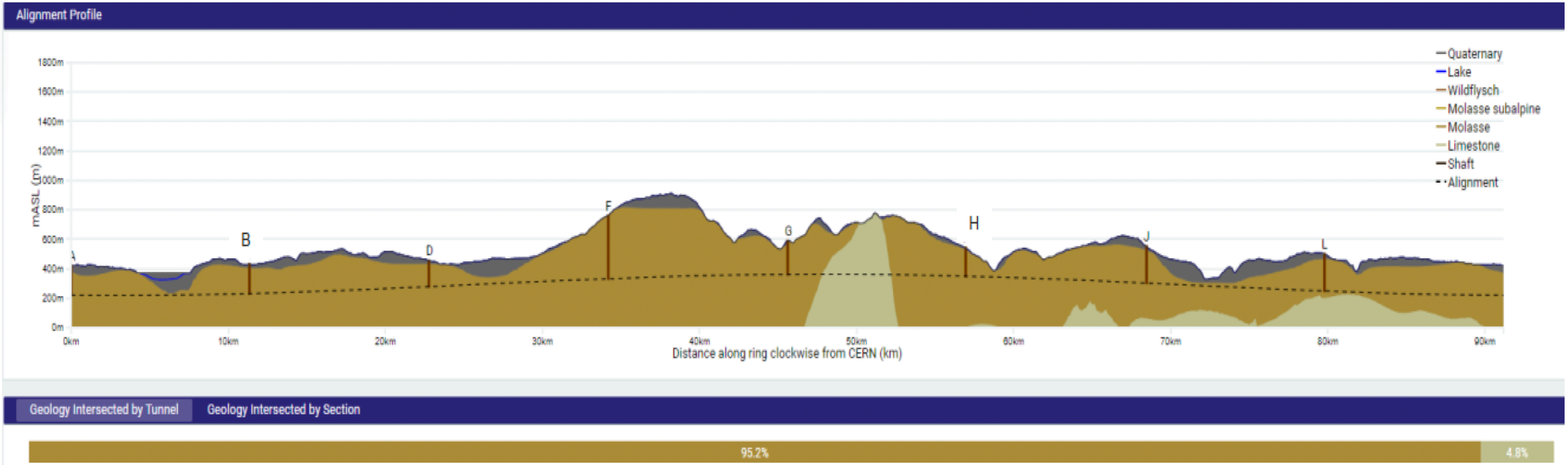
PL – Challex (FR) – site technique

- Individual meeting
- Individual meeting planned
- Collective meeting



The support of the host states is greatly appreciated and essential for the study progress!

FCC tunnel implementation



Tunnel implementation summary

- 91 km circumference
- 95% in molasse geology for minimising tunnel construction risks
- 8 surface sites with ~5 ha area each.

FCC-ee: main machine parameters

FUTURE CIRCULAR COLLIDER

Parameter	Z	WW	H (ZH)	ttbar
beam energy [GeV]	45.6	80	120	182.5
beam current [mA]	1270	137	26.7	4.9
number bunches/beam	11200	1780	440	60
bunch intensity [10^{11}]	2.14	1.45	1.15	1.55
SR energy loss / turn [GeV]	0.0394	0.374	1.89	10.4
total RF voltage 400/800 MHz [GV]	0.120/0	1.0/0	2.1/0	2.1/9.4
long. damping time [turns]	1158	215	64	18
horizontal beta* [m]	0.11	0.2	0.24	1.0
vertical beta* [mm]	0.7	1.0	1.0	1.6
horizontal geometric emittance [nm]	0.71	2.17	0.71	1.59
vertical geom. emittance [pm]	1.9	2.2	1.4	1.6
horizontal rms IP spot size [μm]	9	21	13	40
vertical rms IP spot size [nm]	36	47	40	51
beam-beam parameter ξ_x / ξ_y	0.002/0.0973	0.013/0.128	0.010/0.088	0.073/0.134
rms bunch length with SR / BS [mm]	5.6 / 15.5	3.5 / 5.4	3.4 / 4.7	1.8 / 2.2
luminosity per IP [10^{34} cm^{-2}s^{-1}]	140	20	5.0	1.25
total integrated luminosity / IP / year [ab^{-1}/yr]	17	2.4	0.6	0.15
beam lifetime rad Bhabha + BS [min]	15	12	12	11
	4 years 5×10^{12} Z LEP x 10^5	2 years > 10^8 WW LEP x 10^4	3 years 2×10^6 H	5 years 2×10^6 tt pairs

currently assessing technical feasibility of changing operation sequences (e.g. starting at ZH energy)

- ❑ x 10-50 improvements on all EW observables
- ❑ up to x 10 improvement on Higgs coupling (model-indep.) measurements over HL-LHC
- ❑ x10 Belle II statistics for b, c, τ
- ❑ indirect discovery potential up to ~ 70 TeV
- ❑ direct discovery potential for feebly-interacting particles over 5-100 GeV mass range

Up to 4 interaction points → robustness, statistics, possibility of specialised detectors to maximise physics output

F. Gianotti

FUTURE CIRCULAR COLLIDER

FCC-hh parameters

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
Integrated luminosity/main IP [fb^{-1}]	20000	3000	300

With FCC-hh after F
significantly
more time for high-
magnet R&D
aiming at highest p
energies

Formidable challenges:

- ❑ high-field superconducting magnets: 14 - 20 T
- ❑ power load in arcs from synchrotron radiation: 4 MW → cryogenics, vacuum
- ❑ stored beam energy: ~ 9 GJ → machine protection
- ❑ pile-up in the detectors: ~1000 events/xing
- ❑ energy consumption: 4 TWh/year → R&D on cryo, HTS, beam current, …

Formidable physics reach, including:

- ❑ Direct discovery potential up to ~ 40 TeV
- ❑ Measurement of Higgs self to ~ 5% and ttH to ~ 1%
- ❑ High-precision and model-indep (with FCC-ee input measurements of rare Higgs decays ($\gamma\gamma$, $Z\gamma$, $\mu\mu$)
- ❑ Final word about WIMP dark matter

CERN

A few holiday snaps...

SPECIAL COUNCIL MEETING

2 FEBRUARY 2024

MID-TERM REVIEW
OF THE FEASIBILITY STUDY (FINAL 2025)

2027(?)-SEVEN YEAR LEAPS- NEXT STRATEGY GROUP MEETING – STARTING SOON

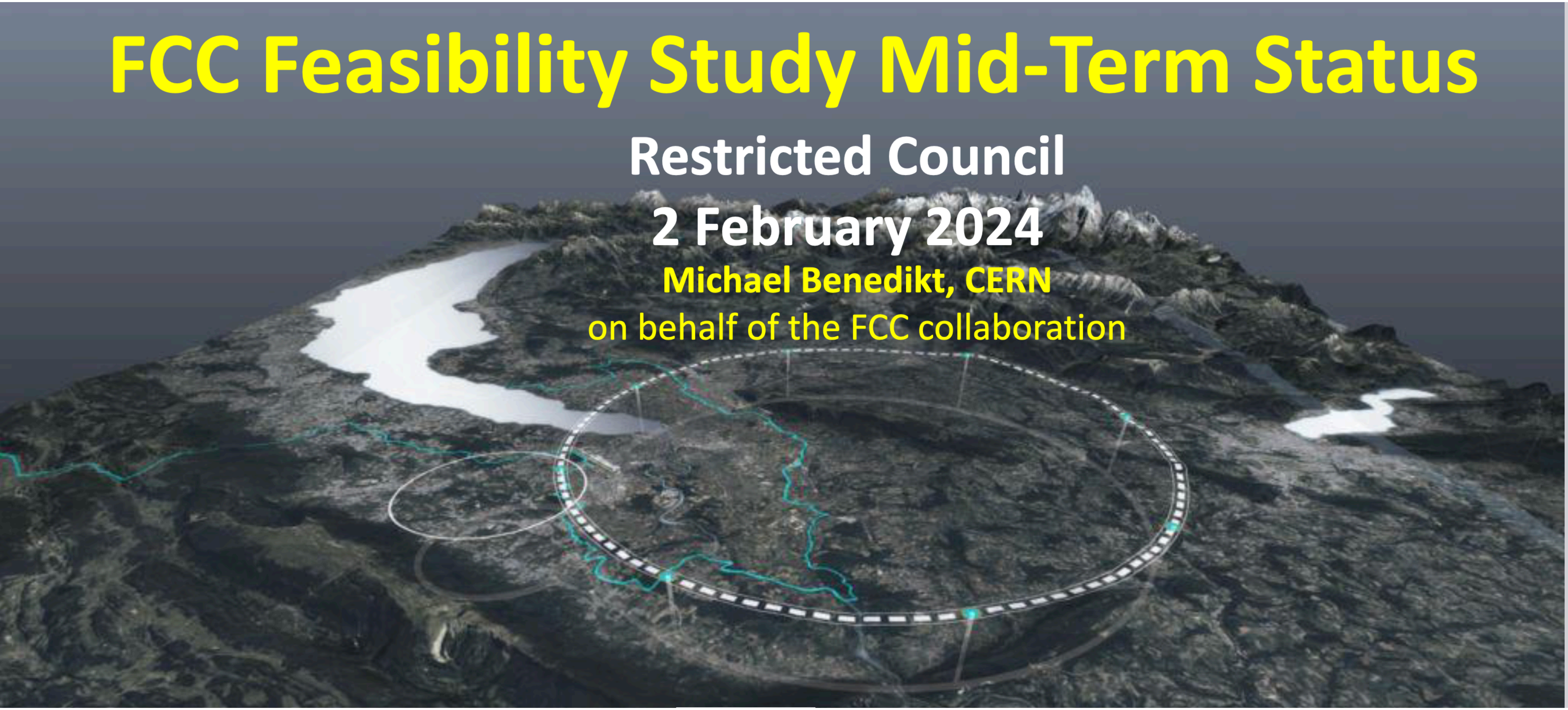
FCC Feasibility Study Mid-Term Status

Restricted Council

2 February 2024

Michael Benedikt, CERN

on behalf of the FCC collaboration



SAC Membership

Riccardo Bartolini (DESY)	Alain Chabert (SFTRF)
Heinz Ehbar (Heinz Ehbar Partners)[from 8/2023]	Brigitte Fargevieille (EDF)
Belen Gavela Legazpi (UAM)	Gudrun Hiller (Dortmund)[from 8/2023]
Katri Huitu (Helsinki)[until June 2023]	Srinivas Krishnagopal (BARC)
Peter Krizan (Ljubljana)	Philippe Lebrun (CERN, ret.)
Peter McIntosh (STFC)	Michiko Minty (BNL)
Andrew Parker (Cambridge)[Chair]	Kyo Shibata (KEK)
Roberto Tenchini (Pisa)	

SAC Overall Conclusions

The SAC has concluded that, at this stage, the feasibility study is on track to complete its objectives within the timescale expected: the mid-term deliverables have all been met.

After a careful review of the documentation provided, the SAC has not identified any technical issue that would prevent the FCC collaboration from delivering the FCC-hh accelerator with the FCC-ee as a first stage. The final feasibility study deliverables are achievable. However the SAC notes that they are challenging and require that the team be adequately resourced.

This accelerator complex would enable execution of a spectacular physics programme, addressing many of the open issues in the field and in particular providing comprehensive information on the Higgs potential which is critical to our understanding of the foundations of the Standard Model, as well as opening opportunities to discover physics beyond it. The SAC emphasises that the FCC-hh and FCC-ee are complementary and the full physics potential of the hadron machine can only be delivered with high precision measurements made in e^+e^- collisions.

The SAC is impressed by the progress and the steady improvement in the project designs. There are still a large number of issues to be addressed before the project can proceed to the construction phase, which is to be expected at this stage of a feasibility study. None of the comments in this report should be taken as a criticism of the work done so far, or as an indication that the SAC has doubts as to the feasibility of the project.

Feedback on the Mid-Term Review of the FCC Feasibility Study

- The Chair of the Scientific Advisory Committee, Professor Andrew Parker, said this to the Council:

The SAC would like to thank all the members of the FCC technical team who have worked so hard on the project and provided clear and informative explanations of their areas. We were extremely impressed by the presentations at the London FCC Week.

- The Chair of the Cost Review Panel, Professor Norbert Holtkamp, said this to the Council:

The FCC and CERN Team

- We want to congratulate everybody, external and internal to CERN, involved in the FCC-Study. The status of the study is impressive, shows a well integrated design and associated cost estimate. The quality reflects the commitment and competence of the people involved.

The Charge

The Mid-Term Cost Review of the FCC - ee Feasibility Study Close Out Report

CERN: Feb 2nd, 2024

The Cost Review Panel (CRP) Members

- Carlos Alejaldre (F4E)
- Austin Ball (STFC)
- Umberto Dosselli (INFN)
- Vincent Gorgues (CEA)
- Heinz Ehrbar (HEINZ EHRBAR PARTNERS GmbH)
- Christa Laurila (VTV)
- Ursula Weyrich (DKFZ)
- Jim Yeck (BNL)
- Thomas Zurbuchen (ETHZ)
- Norbert Holtkamp, chair (Hoover Institution, Stanford U.)

1. Review the methodology and assumptions used in producing the cost estimates
2. Identify inaccurate or missing cost information
3. Check the consistency of the cost estimates with respect to applicable reference work, e.g., recent large-scale infrastructure and accelerator projects
4. Review the uncertainty estimates
5. Identify potential areas of savings and cost mitigation for future work
6. Advise the FCC study team on matters of cost estimation in view of preparation of the final Feasibility Study Report for end 2025

Feedback on the Mid-Term Review of the FCC Feasibility Study

- The Chair of the Scientific Policy Committee, Dr Hugh Montgomery, said this:

- **The SPC would like to congratulate the FCC Feasibility Study team for successfully producing its Mid-Term Report, which substantially satisfies the designated deliverables specified by Council in 2022.**

H. Montgomery for the Scientific Policy Committee, February 2, 2024 2

- The Chair of the Finance Committee, Dr Laurent Salzarulo, said this:

Many thanks to

- Everyone involved in the **FCC Feasibility study**, for the huge amount of work in a large variety of topics, and for the quality of the information provided

ERN

Feedback on the Mid-Term Review of the FCC Feasibility Study

- The Finance Committee also made this remark regarding the project cost:

Project cost

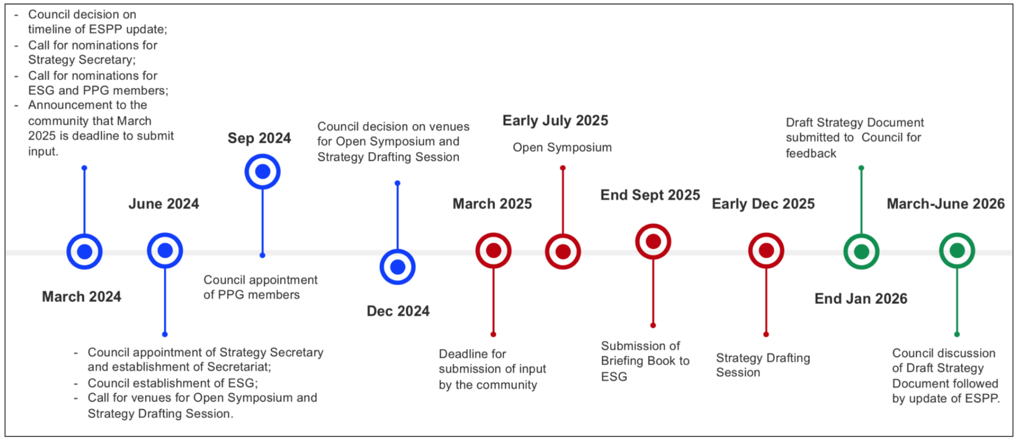
FC underlines the need to make the project **attractive from the physics viewpoint** and takes the view that it would be **unfortunate to sacrifice the attractiveness of the physics for the sake of reducing costs**.

In my closing remarks at the end of the Council meeting, I thanked the FCC Feasibility Study team for the very high quality, dedicated work on the midterm review, with which all stakeholders were very impressed. Of course, we are now very much looking forward to seeing the final feasibility report.


FCC Feasibility Study: the next steps
SPC Meeting, 18 March 2024
Michael Benedikt, CERN
on behalf of FCC collaboration

Proposed general timeline for next ESPP update

- 2024: preparatory year where all committees are established and venues of meetings chosen
- 2025: submission of scientific input by community, community Open Symposium and drafting of Strategy document
- 2026: Council discussion and update of the Strategy



As last time, a more detailed timeline will be presented to Council by the Strategy Secretariat once established


CERN

Vision of the 2023 Particle Physics Project Prioritization Panel (P5)

We envision a new era of scientific leadership, centered on decoding the quantum realm, unveiling the hidden universe, and exploring novel paradigms. Balancing current and future large- and mid-scale projects with the agility of small projects is crucial to our vision. We emphasize the importance of investing in a highly skilled scientific workforce and enhancing computational and technological infrastructure. Particle physics has a long-proven record of creating new technologies and provides a training ground for a skilled workforce that drives not only fundamental science, but also quantum information science, AI/ML, computational modeling, finance, national security, and microelectronics.

We recommend the following:

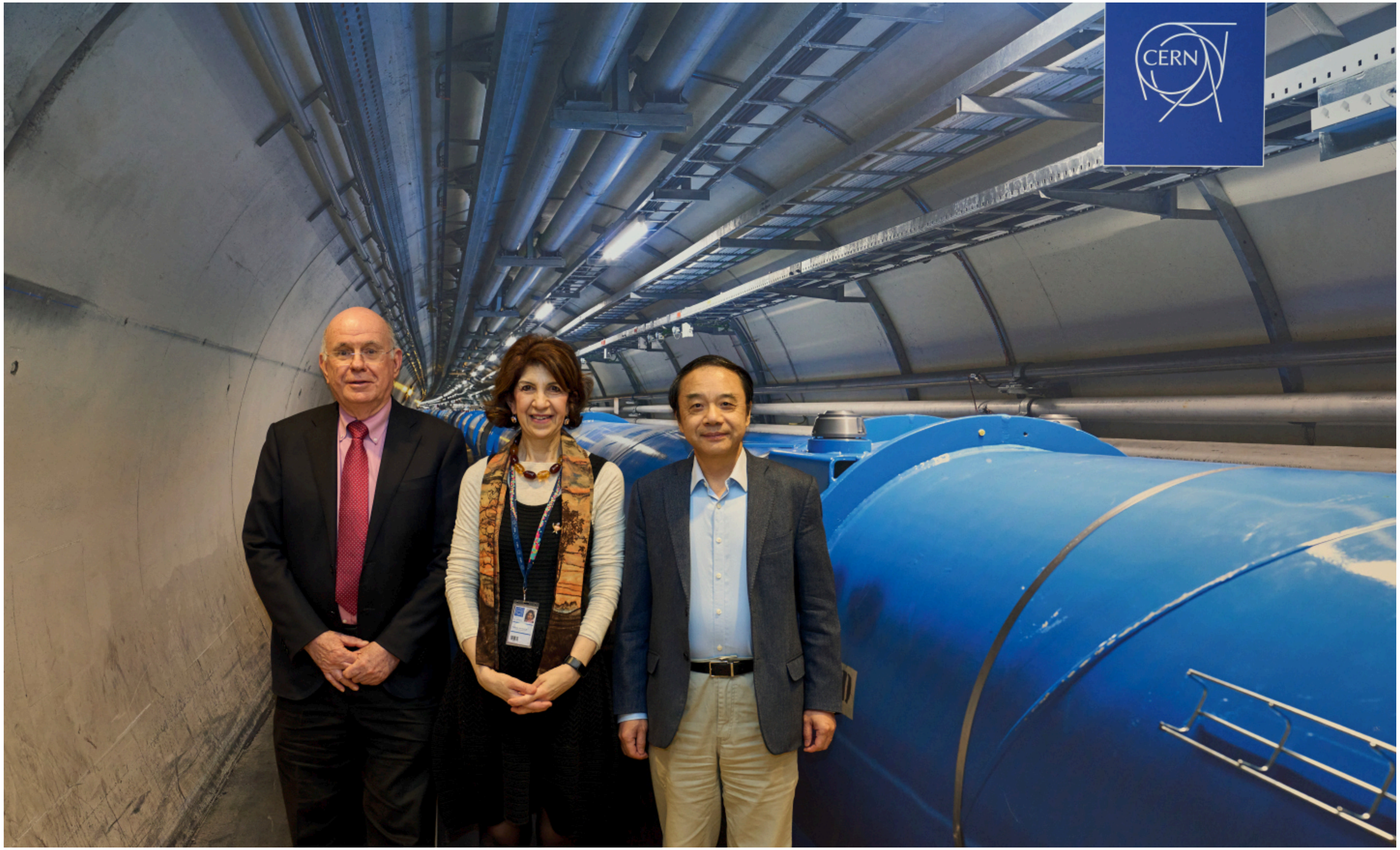
1. As the highest priority independent of the budget scenarios, complete construction projects and support operations of ongoing experiments and research to enable maximum science. This includes High-Luminosity LHC, the first phase of Deep Underground Neutrino Experiment (DUNE) and Proton Improvement Plan II, the Rubin Observatory to carry out the Legacy Survey of Space and Time (LSST).

2. Construct a portfolio of major projects that collectively study nearly all fundamental constituents of our universe and their interactions, as well as how those interactions determine both the cosmic past and future.

a. **CMB-S4**, which looks back at the earliest moments of the universe,

b. **Re-envisioned second phase of DUNE** with an early implementation of an enhanced 2.1 MW beam and a third far detector as the definitive long-baseline neutrino oscillation experiment,

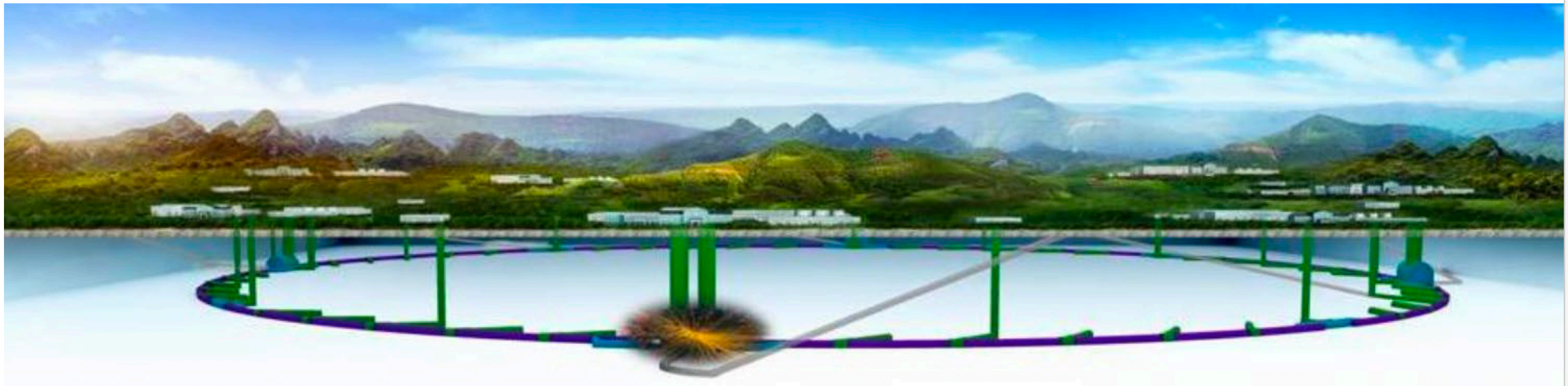
c. **Offshore Higgs factory, realized in collaboration with international partners**, in order to reveal the secrets of the Higgs boson,


CERN

Circular Electron-Positron Collider in China

Yifang Wang， IHEP

CERN, March 19, 2024



- **STRINGS ATTACHED!**

BON VOYAGE!