Future Circular Collider (FCC)

7/7/2023

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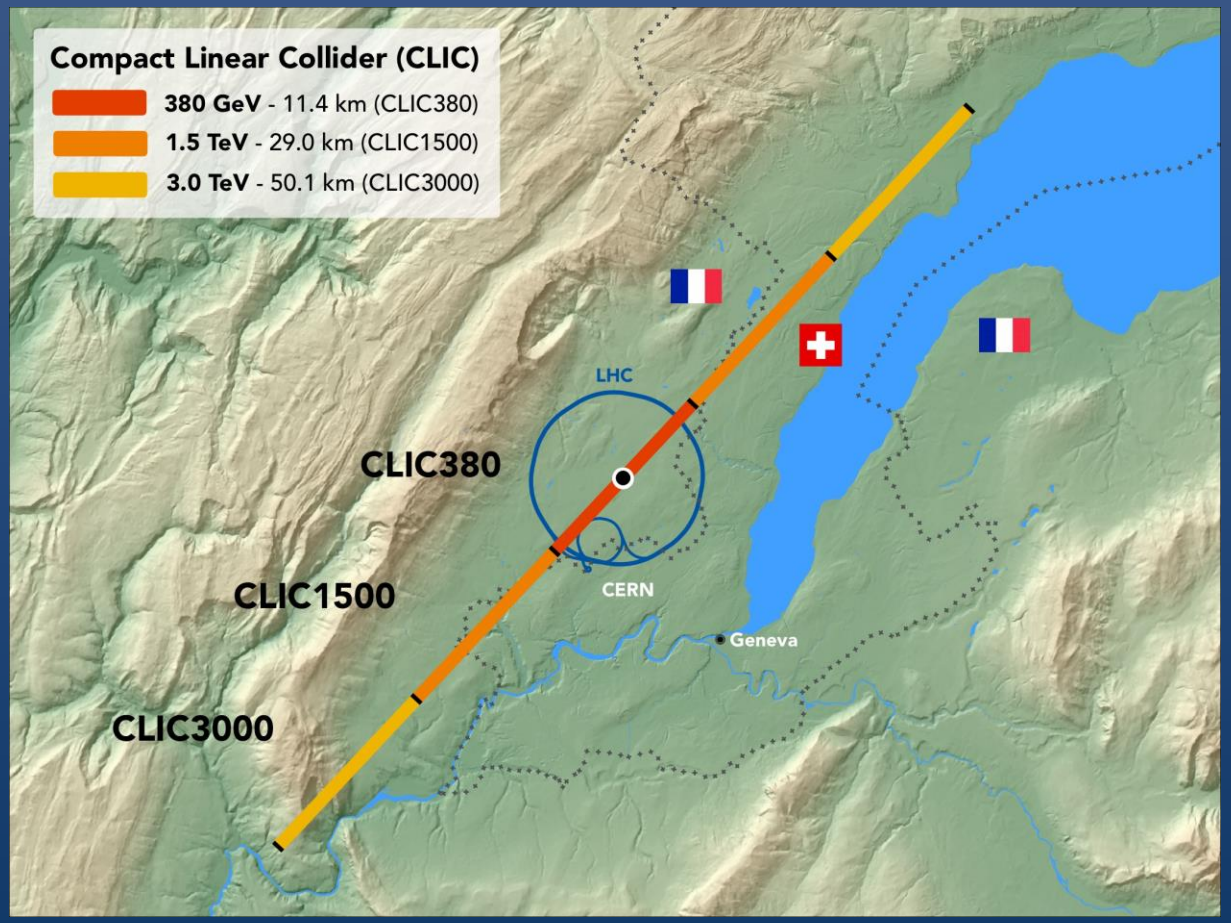
Background

Synchrotron radiation
(energy lost by the curve)

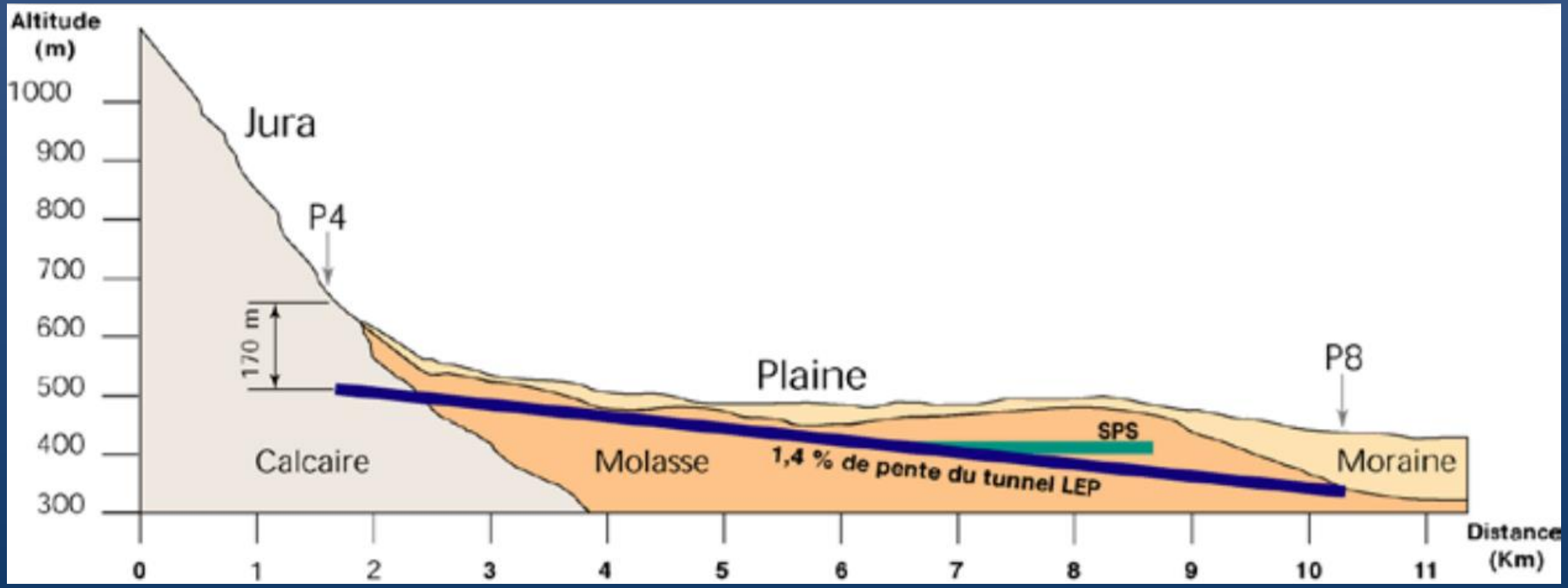
Linear collider(CLIC)
-> very long

LHC ~2040

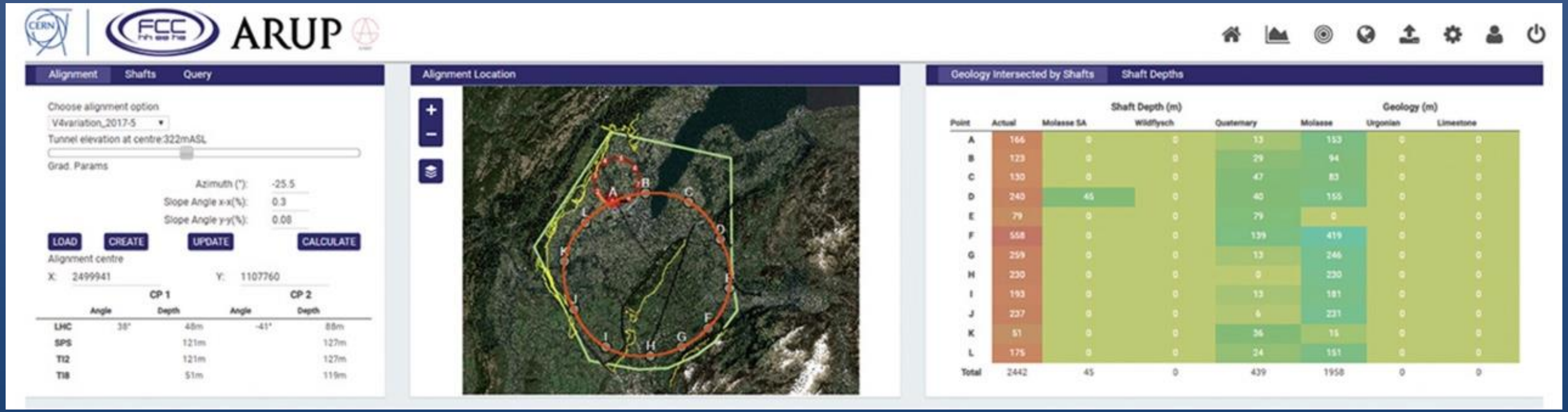
2020 European Strategy for
Particle Physics



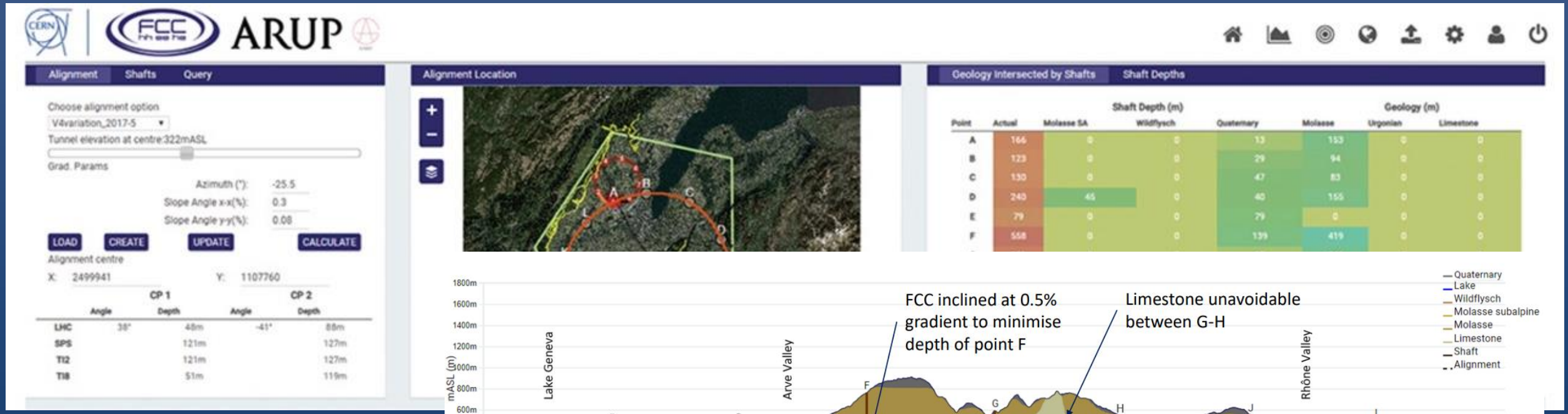
Tunnel Optimization tool

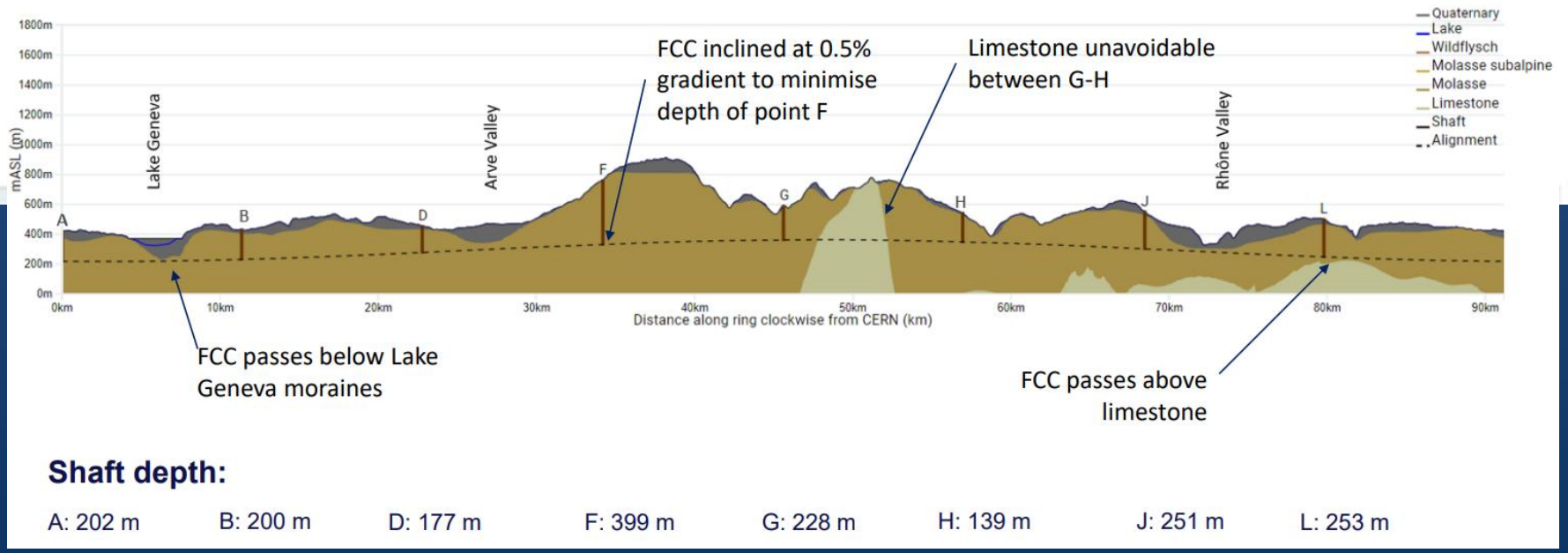


Tunnel Optimization tool



Tunnel Optimization tool



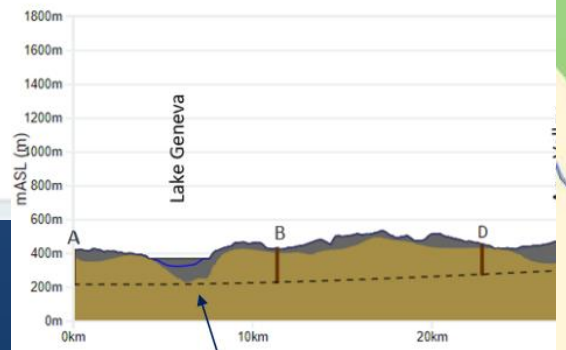


Preparation of geological investigations

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

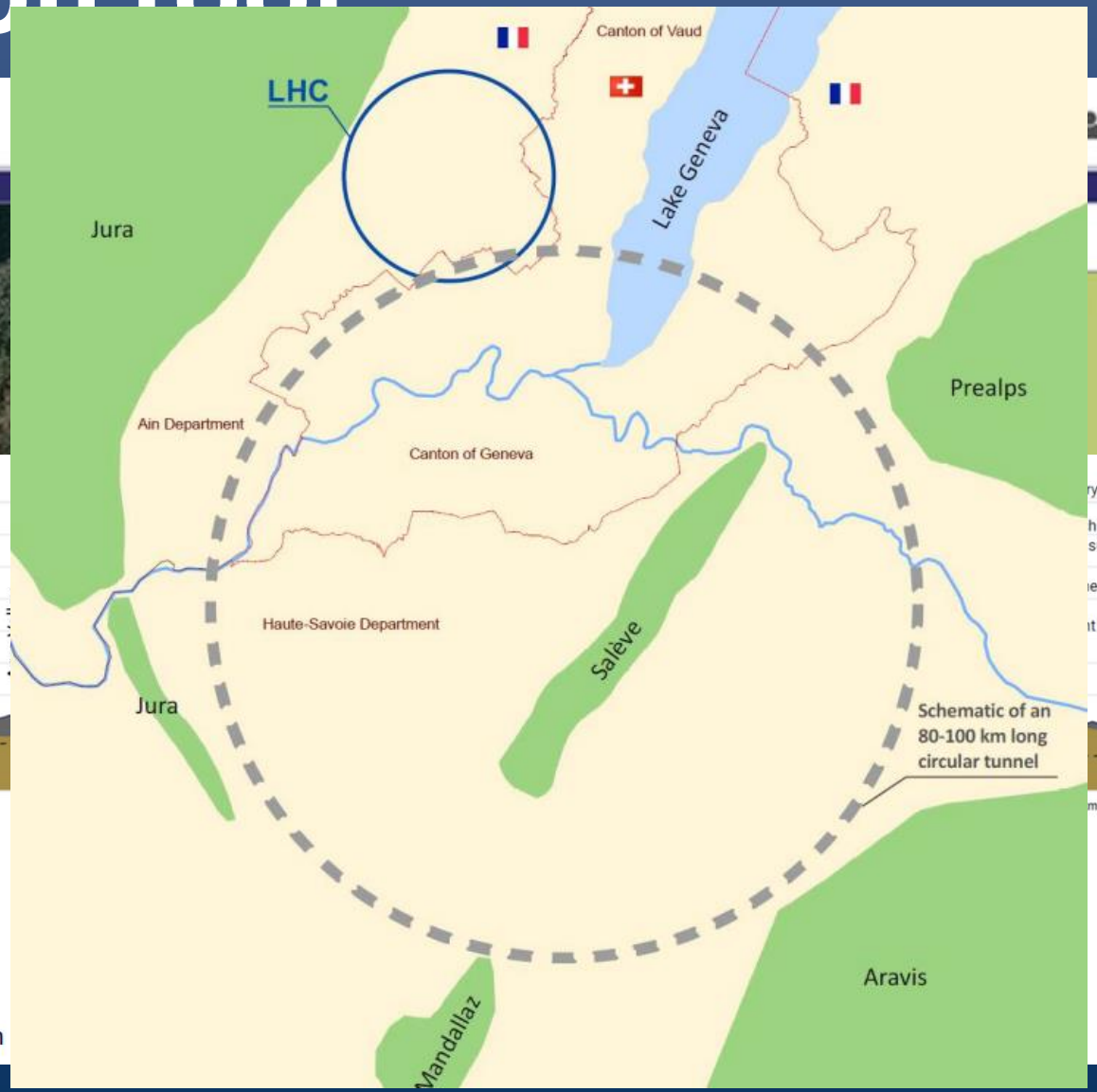
Tunnel Optimization tool



FCC passes below Lake Geneva moraines

Shaft depth:

A: 202 m B: 200 m D: 177 m



Preparation of geological investigations

FCC feasibility study

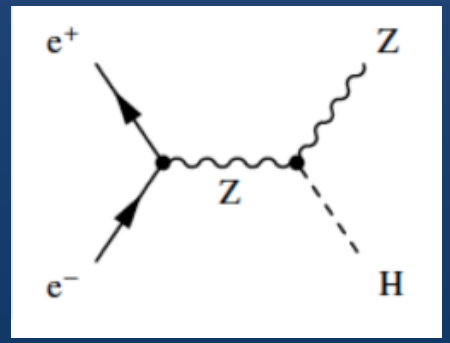
- Focus on machine design
- Effects on the landscape
- Seismic studies and drilling in 2024
- Sustainable & environment friendly
- Decision about the project in 2028

https://indico.cern.ch/event/1202105/timetable/

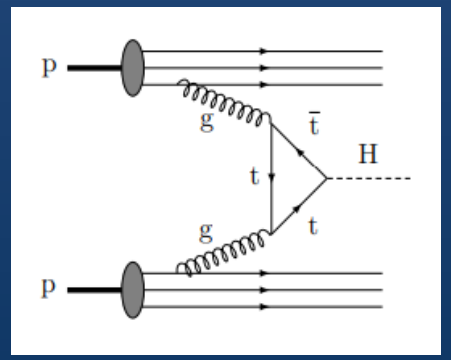
Phase 1(FCC-ee) / Phase 2(FCC-hh)

Circumference: 90.7km / Bunch spacing: 25ns

FCC-ee
Electron – positron collision
80 – 300GeV
Z, ZH, W, ttbar



FCC-hh
Proton – proton collision
1000 pp collisions
80-100TeV (LHC – 14TeV)

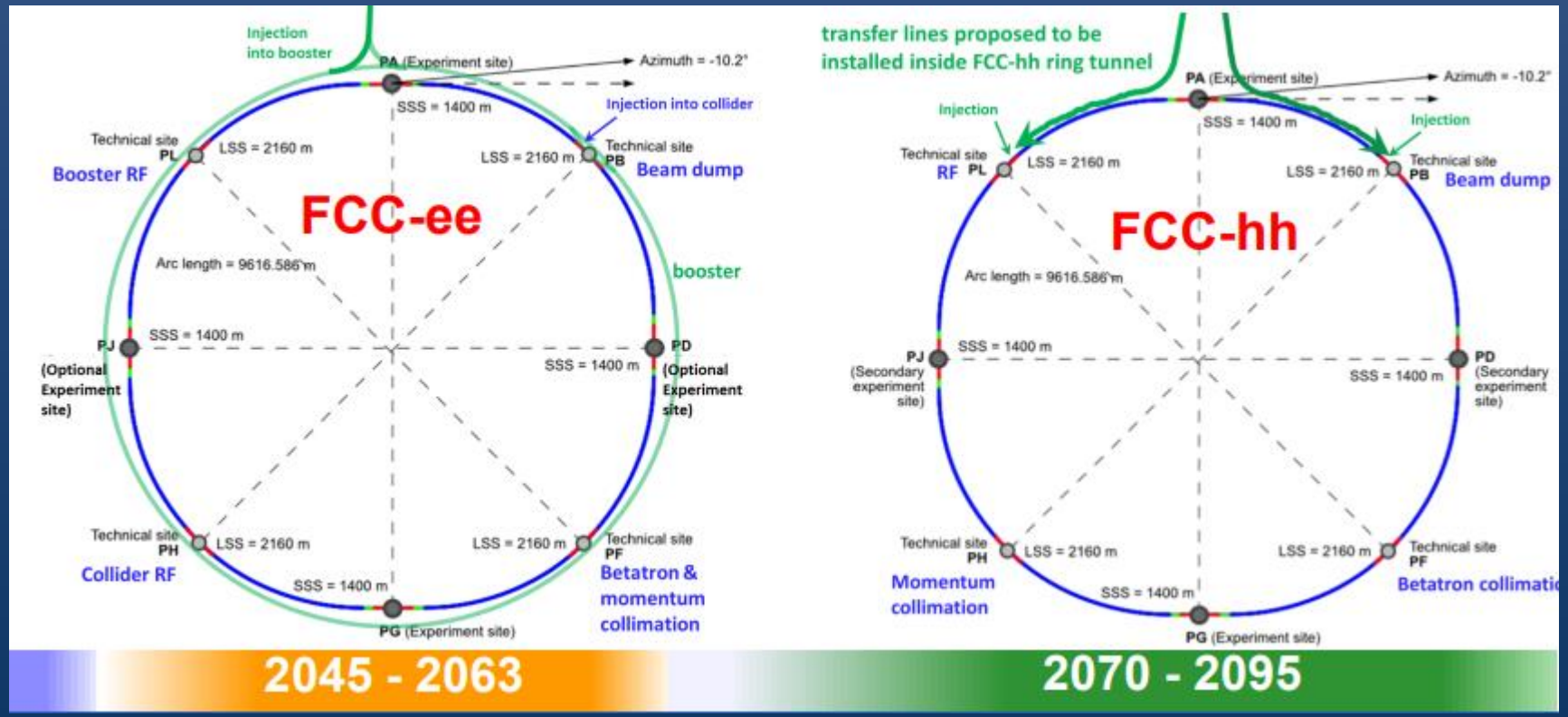


Phase 1(FCC-ee) / Phase 2(FCC-hh)

2031	Engineering design
2040	Installation
2041	(HL-LHC Operation End)
2045	FCC-ee Run
2070	FCC-hh Run?

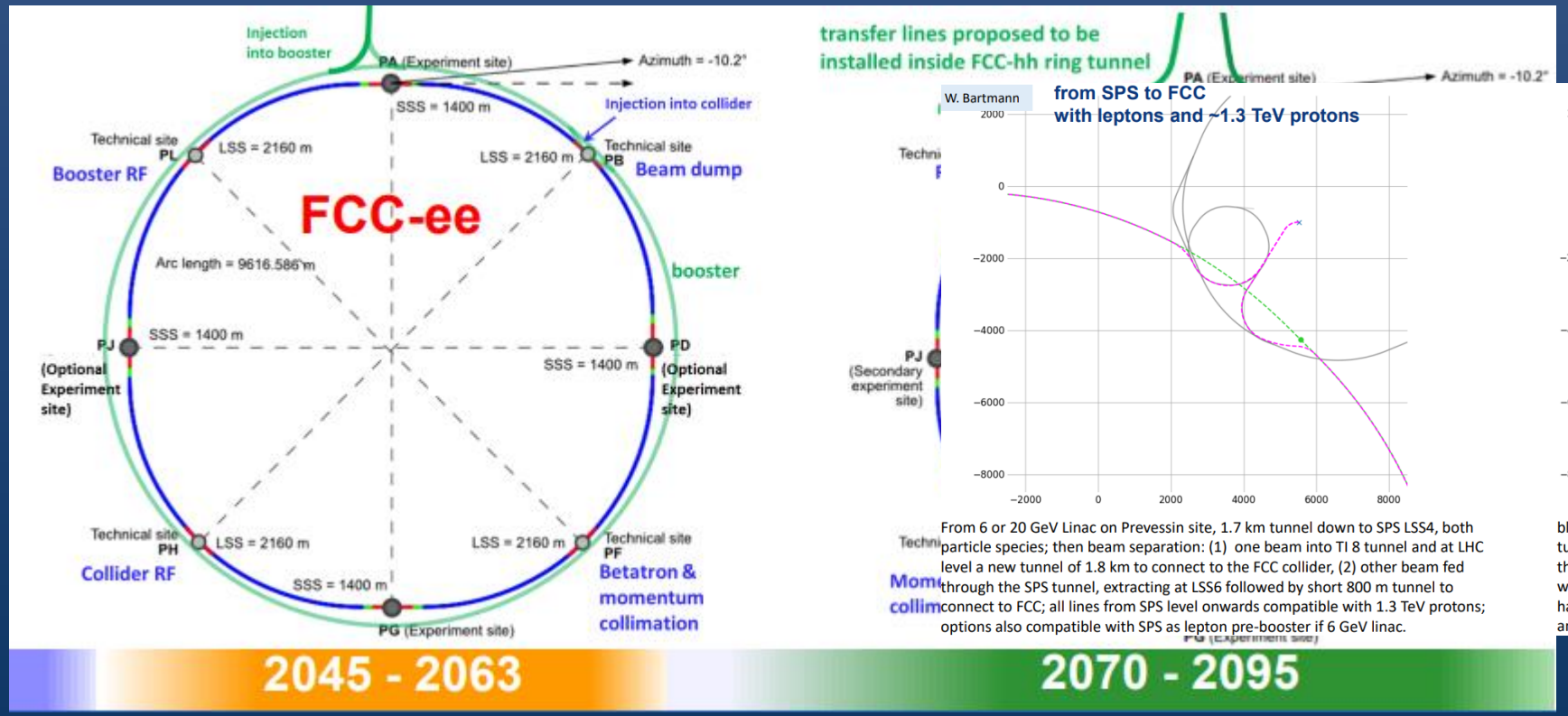
Phase 1(FCC-ee) / Phase 2(FCC-hh)

Connected to LHC, SPS with new tunnel

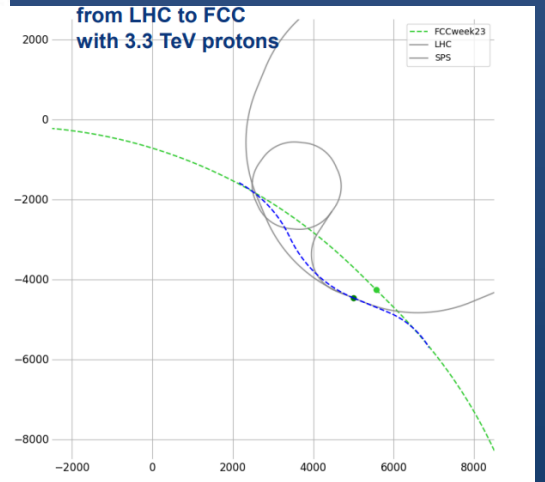


Phase 1(FCC-ee) / Phase 2(FCC-hh)

Connected to LHC, SPS with new tunnel



From 6 or 20 GeV Linac on Prevessin site, 1.7 km tunnel down to SPS LSS4, both particle species; then beam separation: (1) one beam into TI 8 tunnel and at LHC level a new tunnel of 1.8 km to connect to the FCC collider, (2) other beam fed through the SPS tunnel, extracting at LSS6 followed by short 800 m tunnel to connect to FCC; all lines from SPS level onwards compatible with 1.3 TeV protons; options also compatible with SPS as lepton pre-booster if 6 GeV linac.

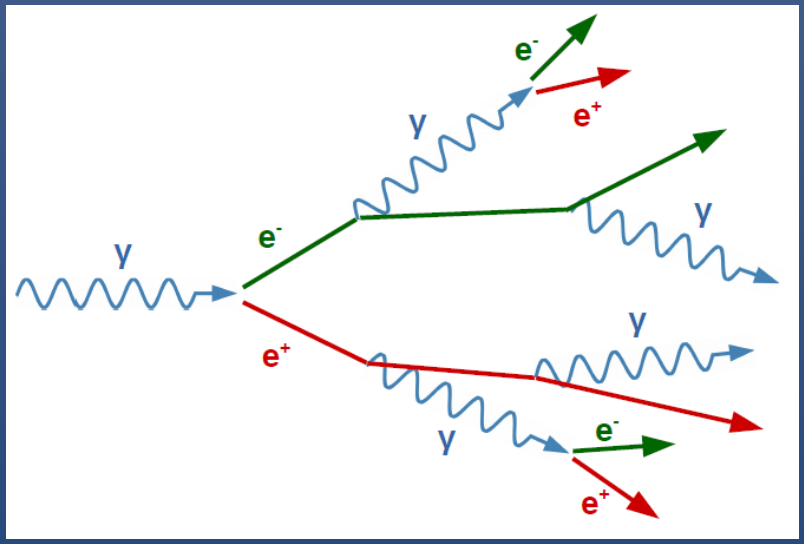


blue lines are compatible with 3.3 TeV hadrons and would need new tunnels; leptons could be fed down as for the SPS option via TI8 and then one beam just continue in the same direction, the other beam would need a small u-turn around LHC P8 to use the same line as hadrons, or a u-turn to the collider tunnel or come directly via the SPS and a small connection tunnel as in the SPS option

FCC-ee

6eV electron beam => fixed W target
Pair production e- + e+

$$\sigma \propto Z^4$$



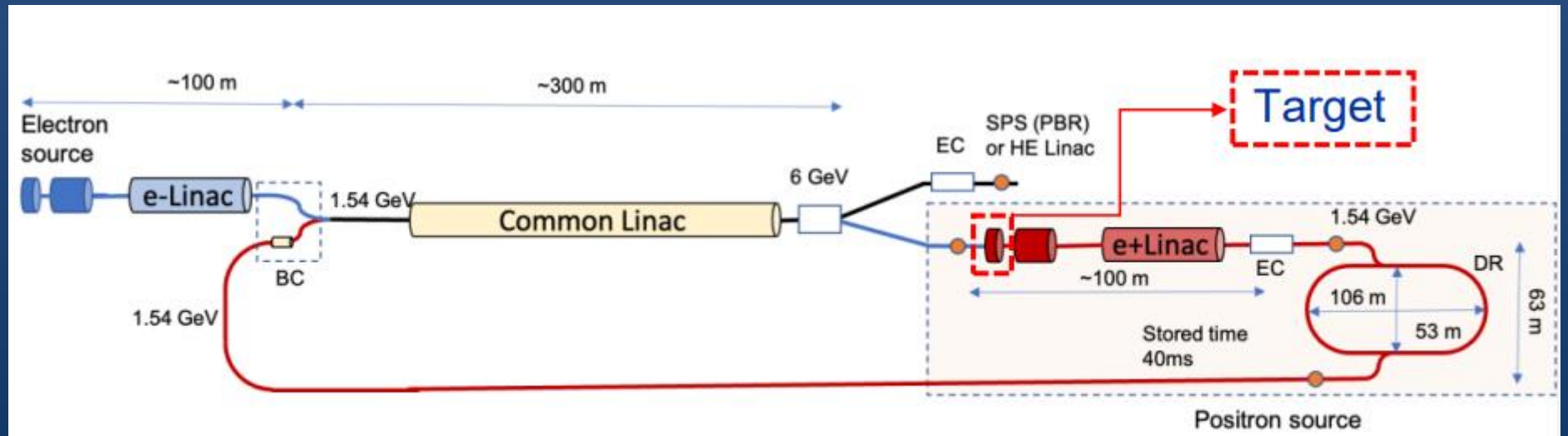


Fig. Layout of the FCC-ee injector complex. BC: bunch Compressor. EC: Energy Compressor.
[Craievich et al 2022]

FCC-ee

1. Properties of Higgs boson studies
mass, self-couplings, decays(bb, cc, ..etc)

2. Improvements of Electroweak observables
high precision W, Z, top quarks

3. Large production of B mesons
b-quarks - prevalence of matter?

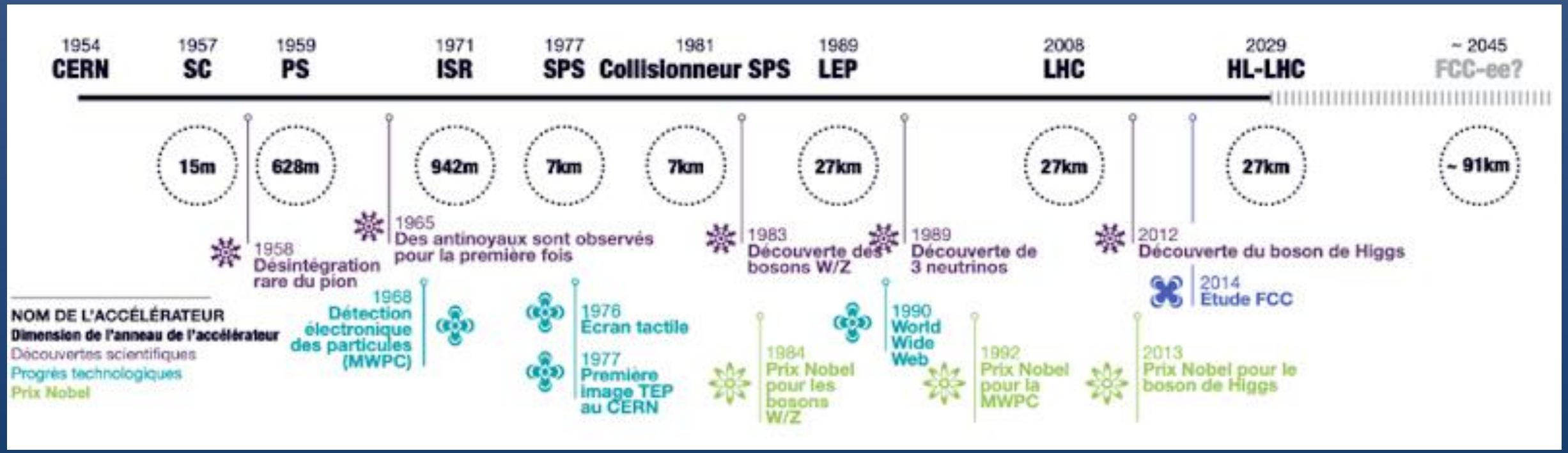
B^+	:	$u\bar{b}$	B_s^0	:	$s\bar{b}$
B^-	:	$\bar{u}b$	$\bar{B}_s^0$	:	$\bar{s}b$
B^0	:	$d\bar{b}$	B_c^+	:	$c\bar{b}$
$\bar{B}^0$	:	$\bar{d}b$	$\bar{B}_c^+$	:	$\bar{c}b$

Criticism / Challenges

Cost over 20B$ expected
Technical challenges(HE superconducting magnets 14 – 20T)
Yearly Energy consumption: 4TWh

$$P \propto \gamma^4 \propto (E/m)^{-4}$$

μμ collider?
Large mass ($207m_e$) => 16×10^8 less synchrotron radiation
Lifetime 2.2μs at rest - too short to make a bunch


1954
CERN
15m
1957
SC
628m
1959
PS
942m
1971
ISR
7km
1977
SPS
7km
1981
Collisionneur SPS
27km
1989
LEP
27km
2008
LHC
27km
2029
HL-LHC
~ 2045
FCC-ee?
~ 91km
1958
Désintégration rare du pion
1965
Des antinoyaux sont observés pour la première fois
1968
Détection électronique des particules (MWPC)
1976
Écran tactile
1977
Première image TEP au CERN
1983
Découverte des bosons W/Z
1984
Prix Nobel pour les bosons W/Z
1989
Découverte de 3 neutrinos
1990
World Wide Web
1992
Prix Nobel pour la MWPC
2012
Découverte du boson de Higgs
2013
Prix Nobel pour le boson de Higgs
2014
Etude FCC
NOM DE L'ACCÉLÉRATEUR
Dimension de l'anneau de l'accélérateur
Découvertes scientifiques
Progrès technologiques
Prix Nobel

Thank you!