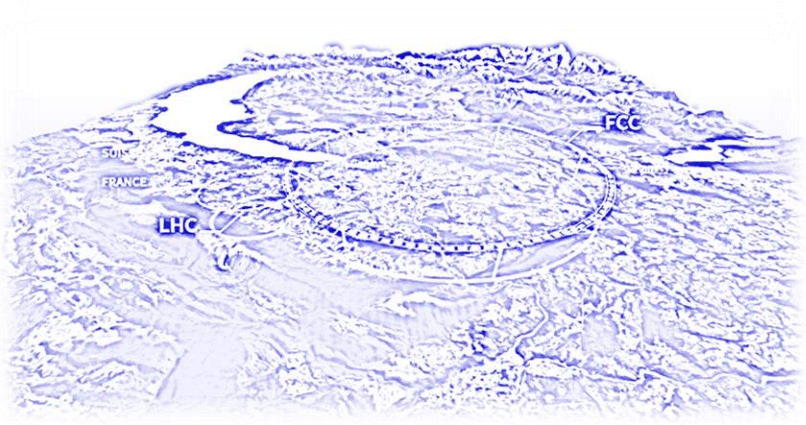
FCC

FUTUR CIRCULAR COLLIDER

FCC

a new large collider for the 21st century



FCC

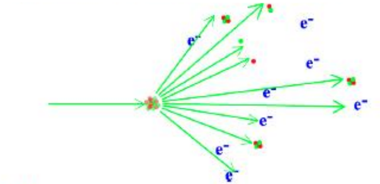
collider

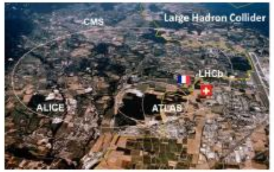
What it is and how it works ?

Particle Accelerators what it is ?

User community

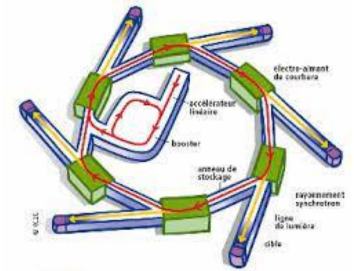
Study the matter -> collisions

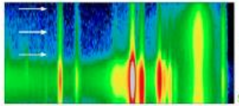


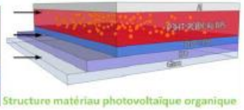


Particle physicists
Nuclear physicists

Synchrotron radiation production

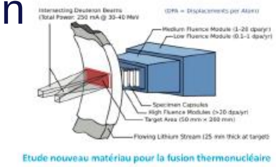


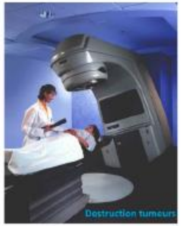


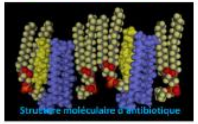


Physicists
Chemists
Biologists
Engineers
Industrialists
Historians
Artists

Irradiation



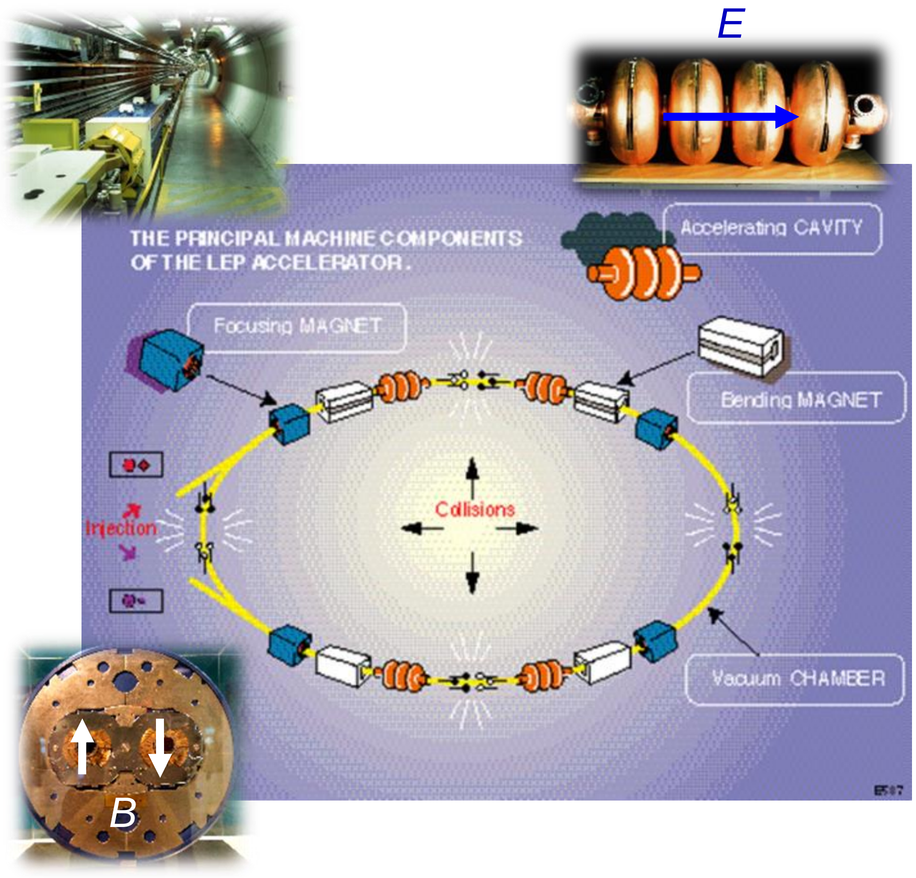




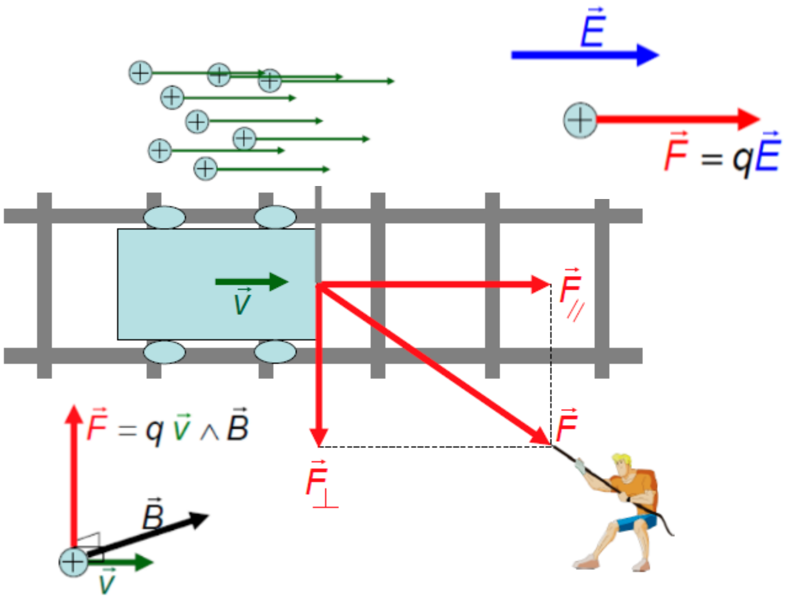
Physicists
Chemists
Physicians
Industrialists

Particle Accelerators how it works ?

$$\vec{F} = q\left(\vec{E} + \vec{v} \times \vec{B}\right)$$



Beam: a set of charged particles with an overall velocity



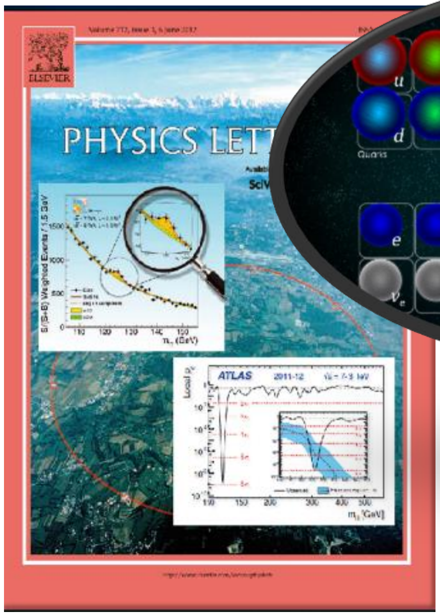
Force parallel to speed: acceleration, energy increases

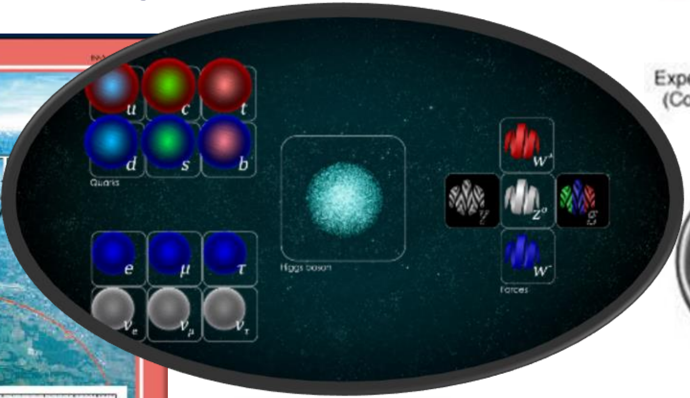
Force perpendicular to speed: deflection, energy remains constant

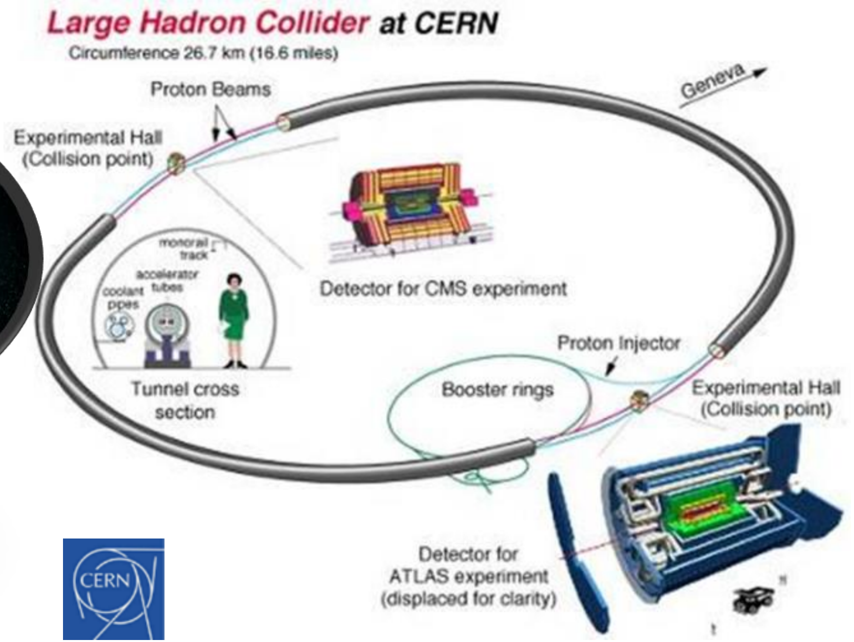
Large Hadron Collider @ CERN

14 TeV proton-proton 27-km collider with **8.3 T** superconducting magnets:
Installed in a 27 km tunnel, to produce the events needed to study the "Standard Model" of particles to understand "mass", the Higgs boson and more...

Higgs boson discovery 2012

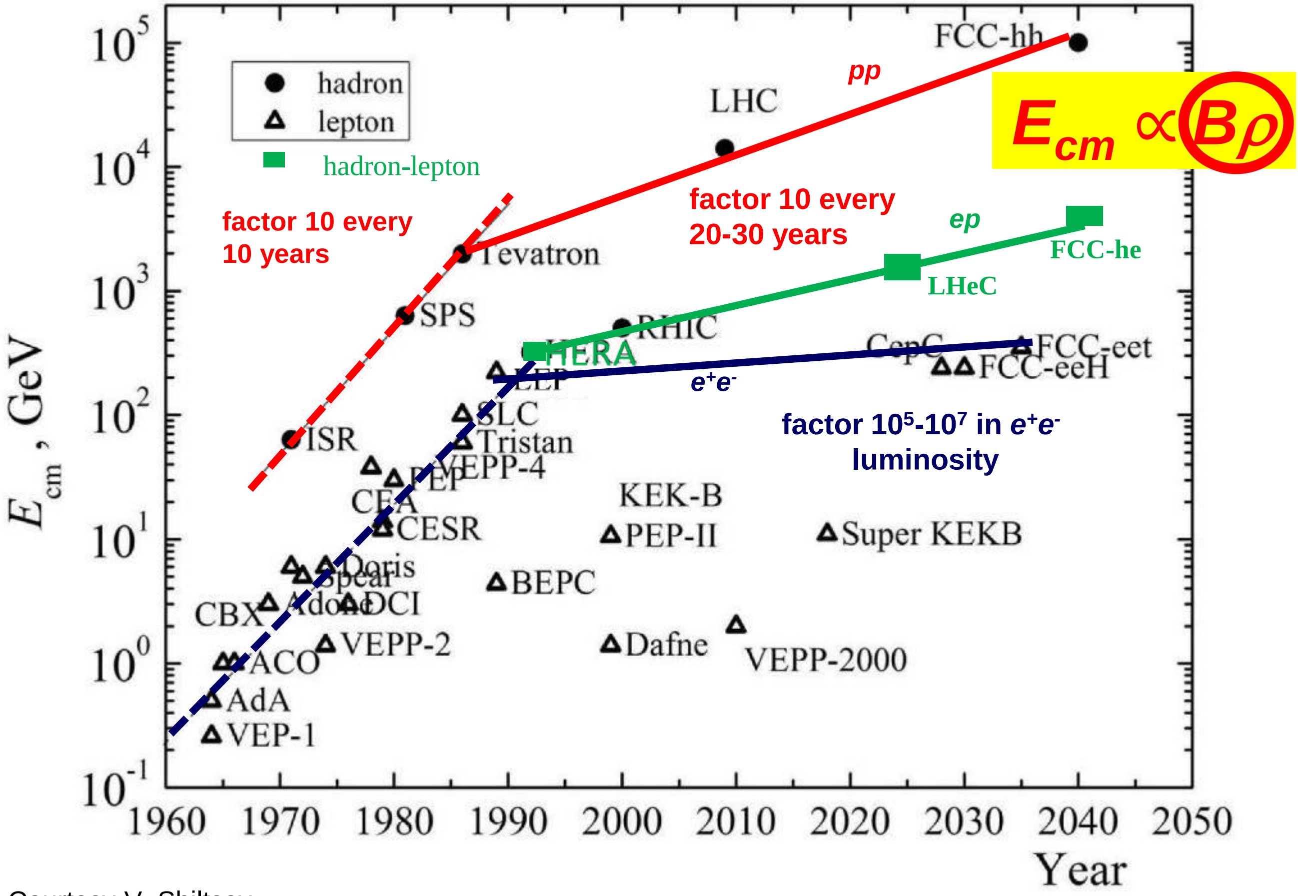






LHC Superconducting Magnets

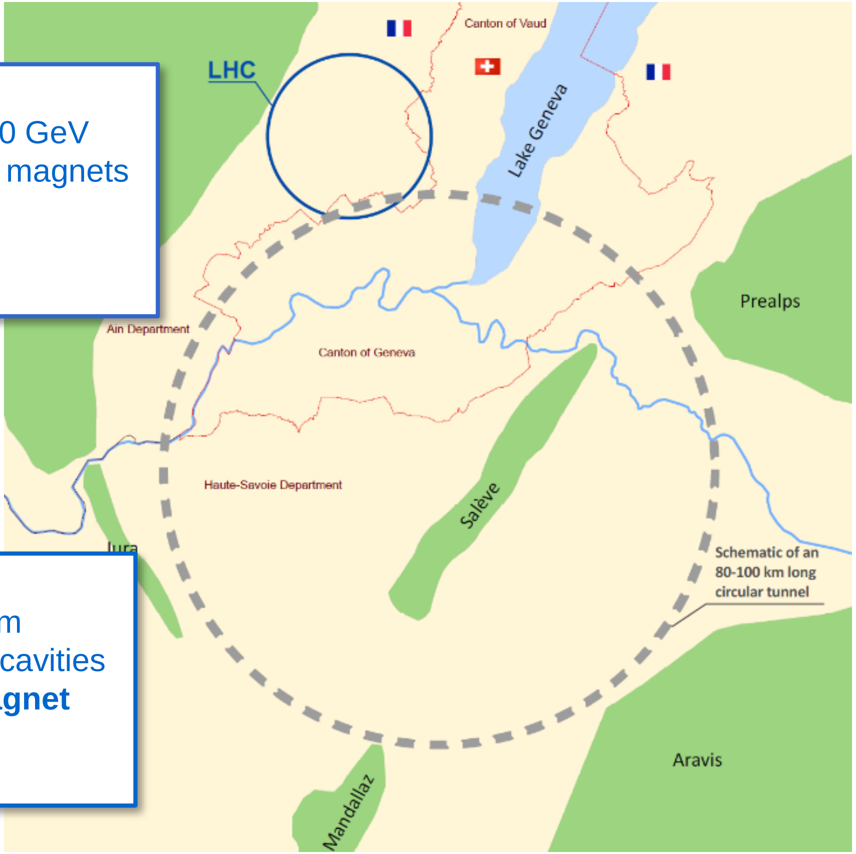
What's next after the LHC…



Courtesy V. Shiltsev

Introduction to the Future Circular Collider (FCC)

e+ e- collider
Collision energy 90 to 350 GeV
~600 cavities ~ 7000 NC magnets
Higgs Factory
Very high luminosity
2045-2060



Hadron collider
16 T ⇒ 100 TeV for 91 km
~17 000 SC magnets 48 cavities
16 T bending dipole magnet
Energy Frontier
2070-2090++

International FCC collaboration for the study of Future Circular Colliders in a quasi-circular tunnel of **91-km perimeter**

Complementary physics

Common civil engineering and technical infrastructures, building on and reusing CERN’s existing infrastructure

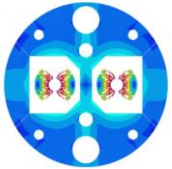
FCC–ee

FCC-hh

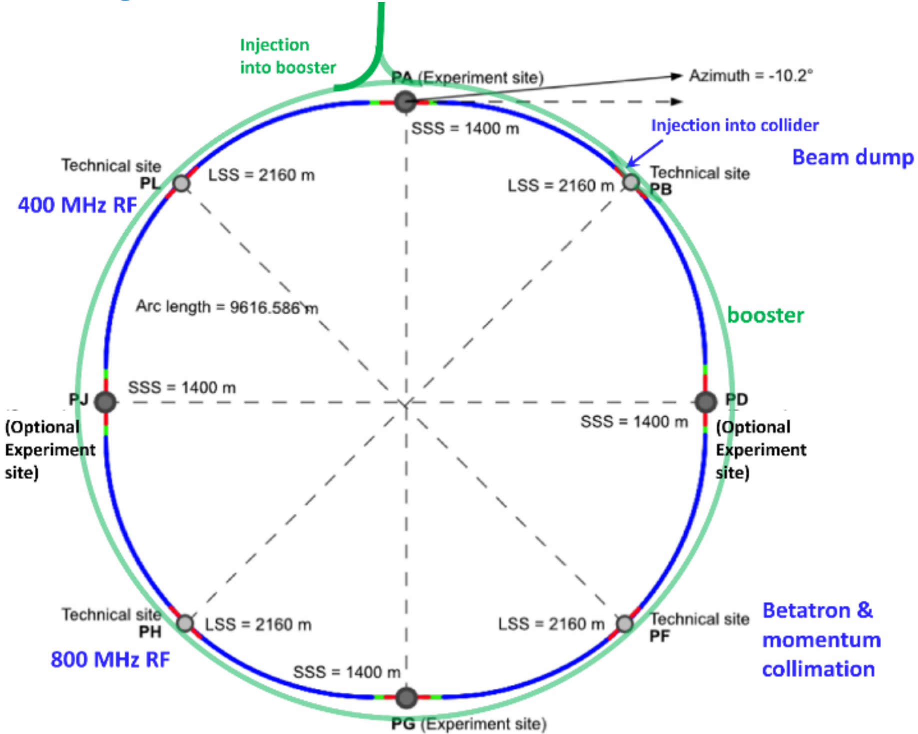
Double ring e+e- collider

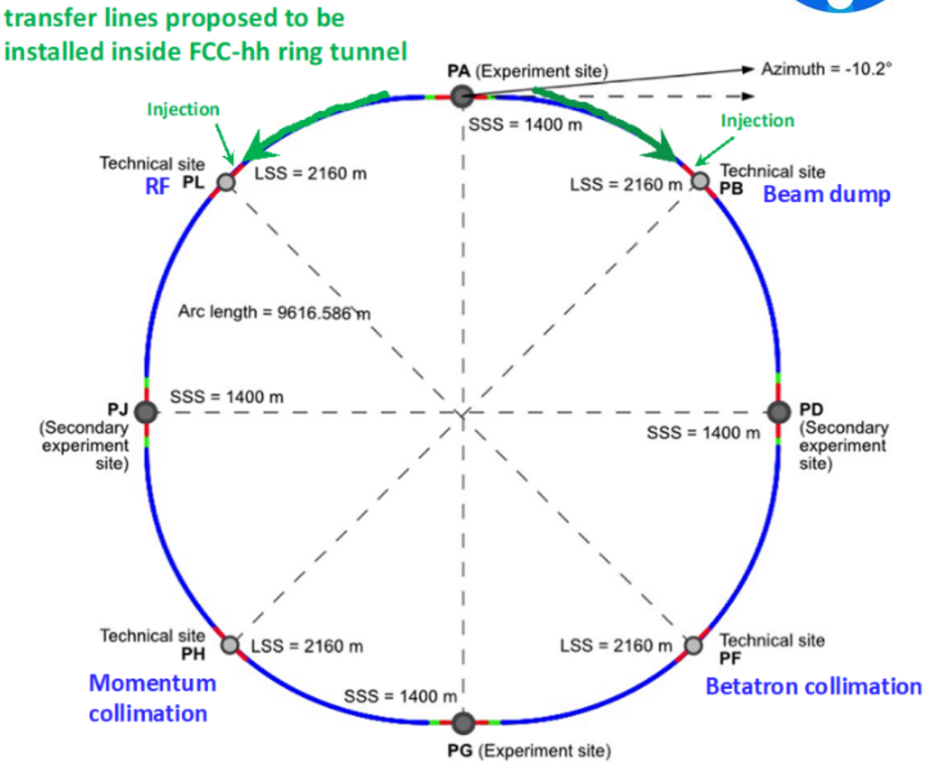
Common footprint

Two in one magnets



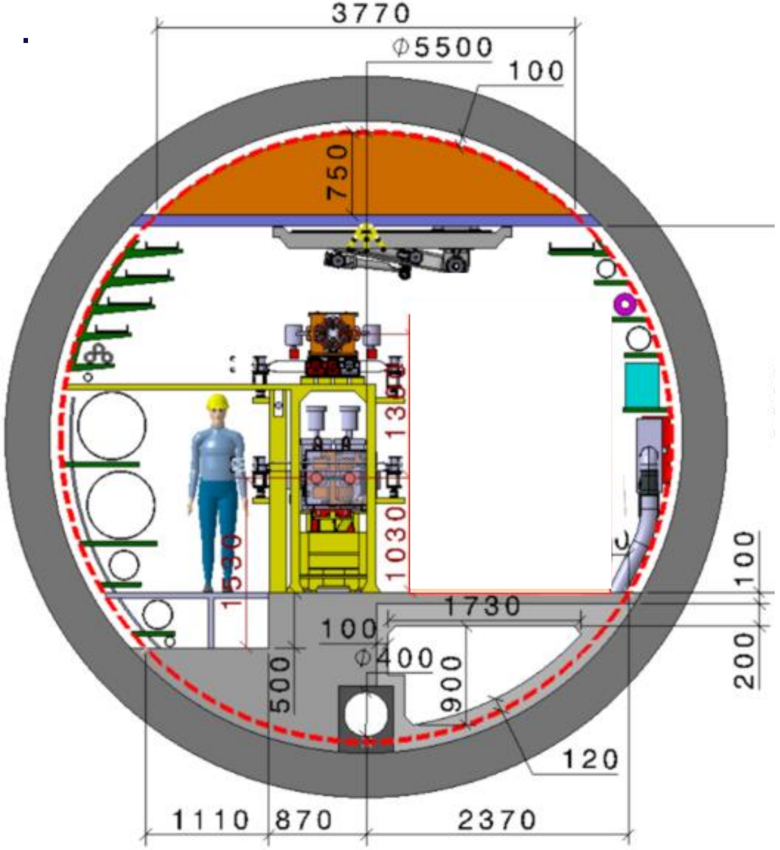
One ring booster 20 GeV -> 182 GeV



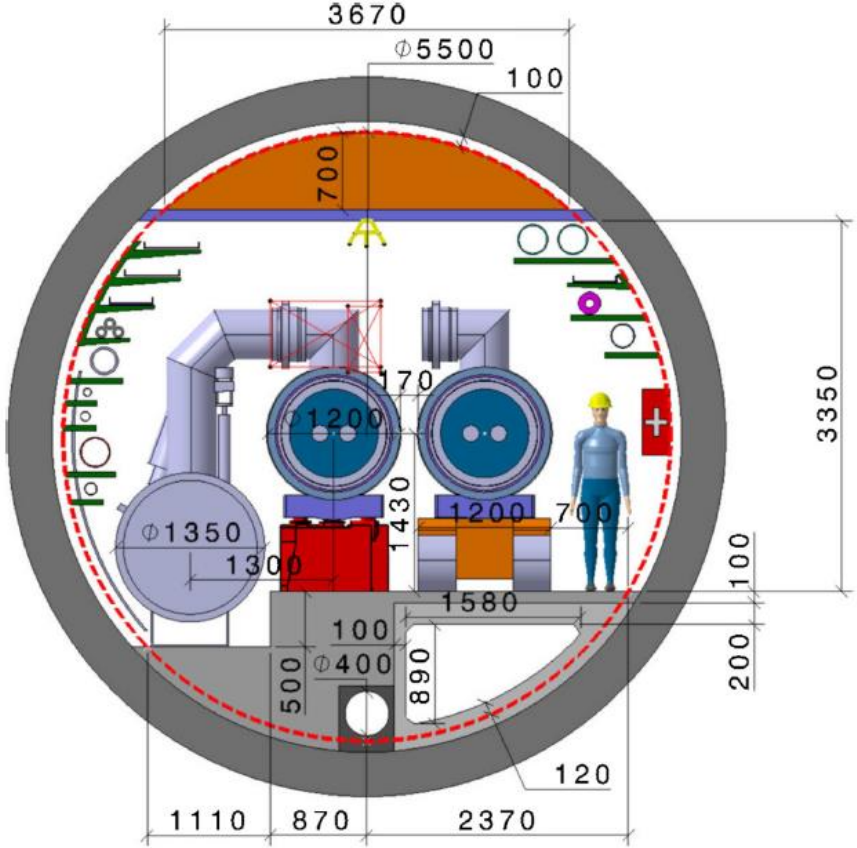


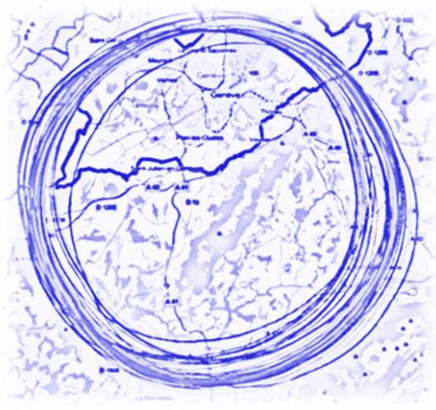
Tunnel Cross-section

FCC–ee



FCC-hh





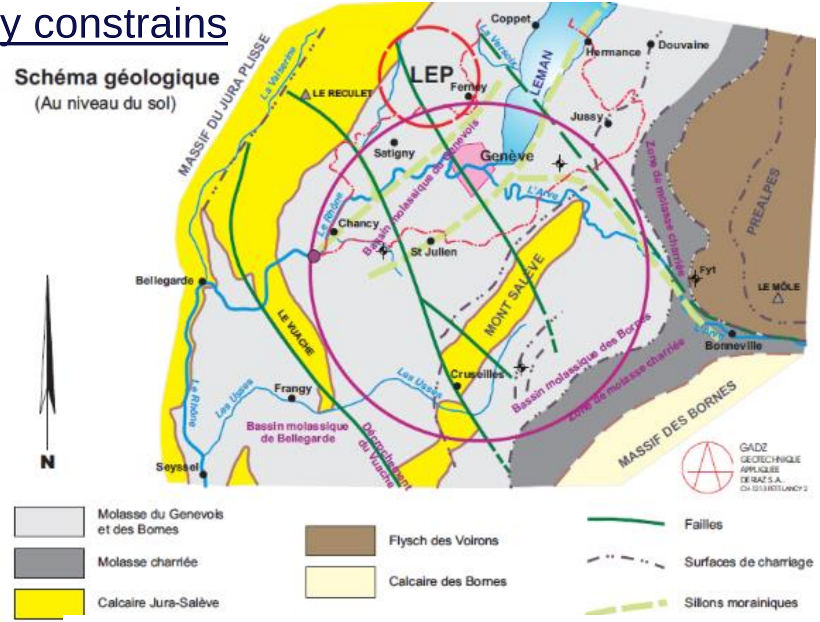
THE TUNNEL CHALLENGE

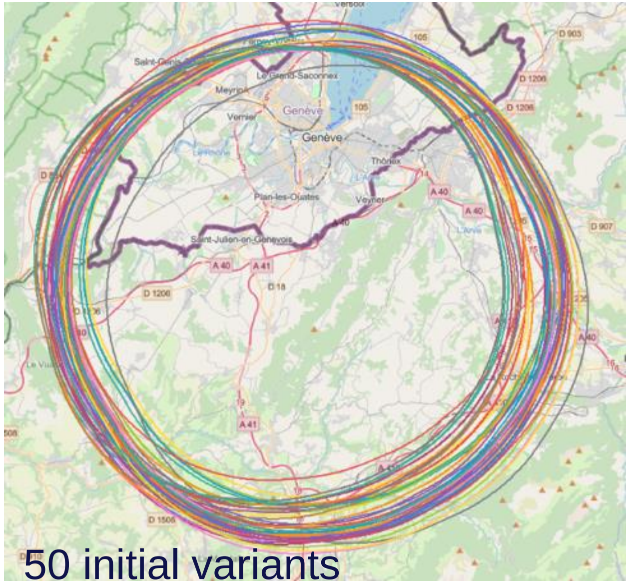
WASTE MANAGEMENT AND ENVIRONMENTAL IMPACT.

Implementation studies

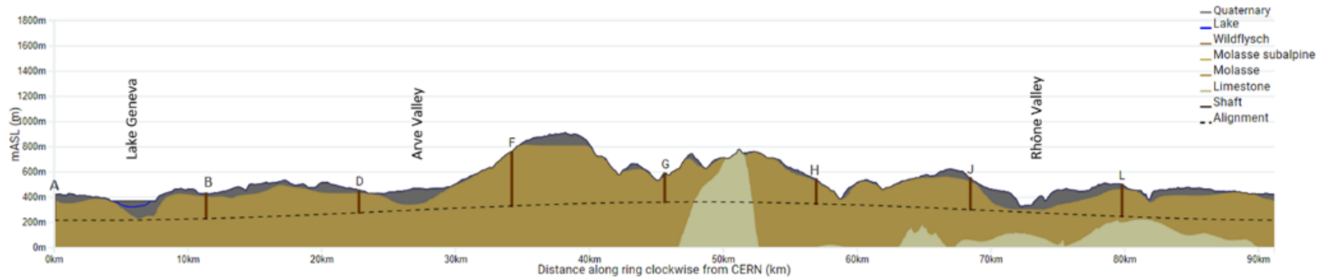
Based on geology and surface (land, availability, acess, etc..) environment (protected zone), infrastructure (water, electricity, transport, etc)

Geology constrains

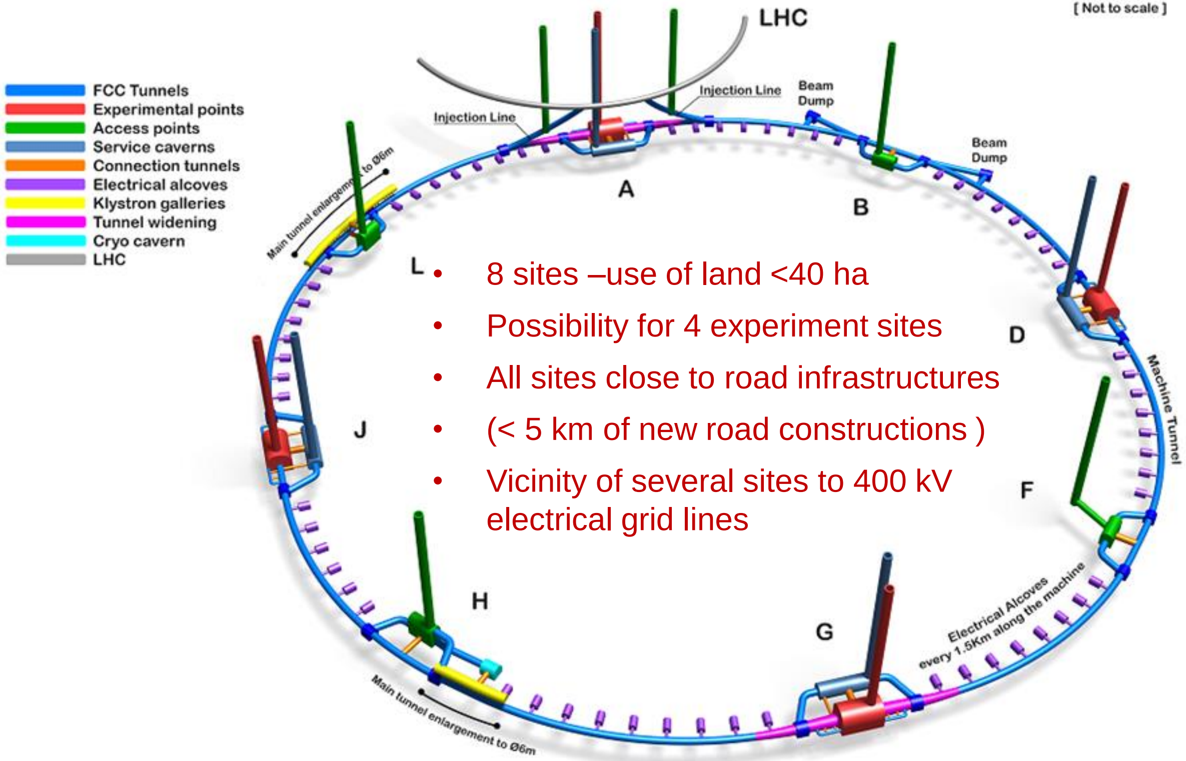




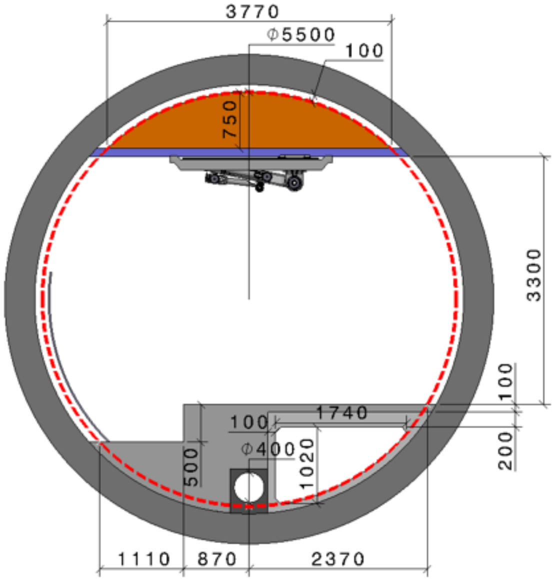
50 initial variants



Tunnel Layout and Cross Section



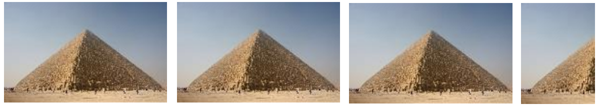
- 8 sites –use of land <40 ha
- Possibility for 4 experiment sites
- All sites close to road infrastructures
- (< 5 km of new road constructions)
- Vicinity of several sites to 400 kV electrical grid lines



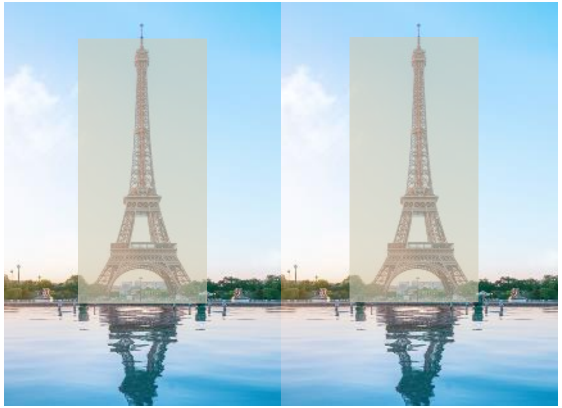
- **Total construction duration 7 years**
- **First sectors ready after 4.5 years**
- **150 m to 400 m deep underground**

Waste Management and Environmental Impact

Long-term environmental sustainability



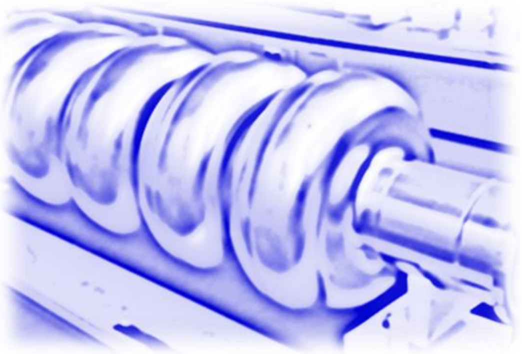
“Éviter, Réduire, Compenser” (Avoid, Reduce, Compensate) principle.



One example : Underground structure (tunnel, alcoves at regular intervals, large caverns and access shafts)
-> *9 million m^3 of excavated materials with a large quantity of molasses*.

“Mining the future” competition : identify credible solutions for innovative reuse and sustainable management of the estimated large quantities of excavated materials.

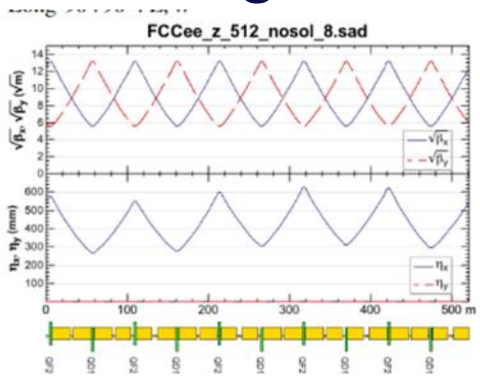
Mining the FUTURE®



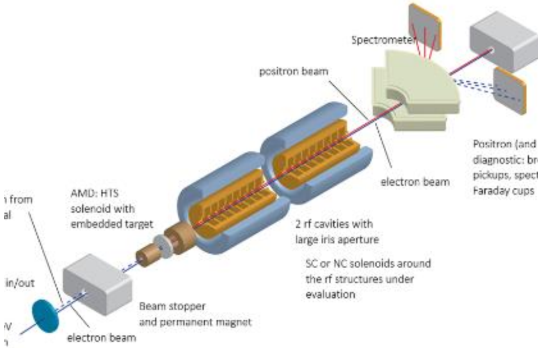
TECHNOLOGICAL CHALLENGES

AND THEIR POSSIBLE SOCIETAL IMPACT

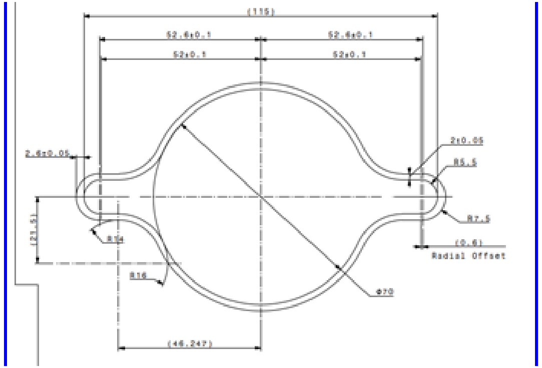
Technological Challenges



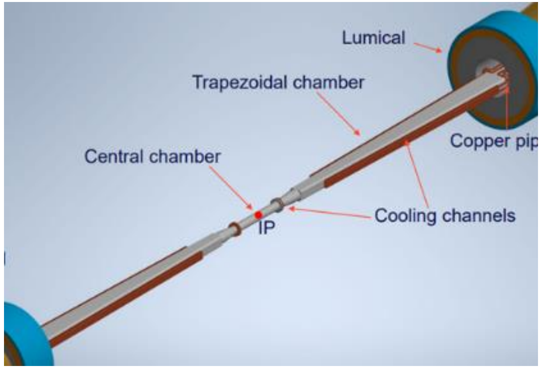
FCC optics



Positron source

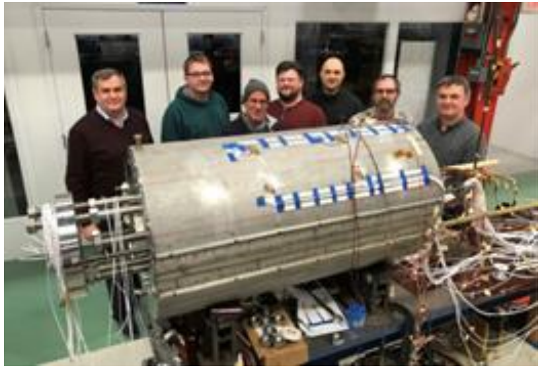


Vacuum system



Interaction region

RF Accelerating System



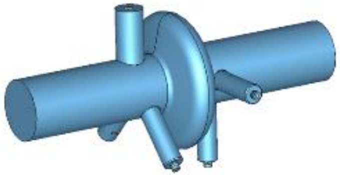
Magnets

FCC-ee SRF Technology :
Efficient superconducting cavities

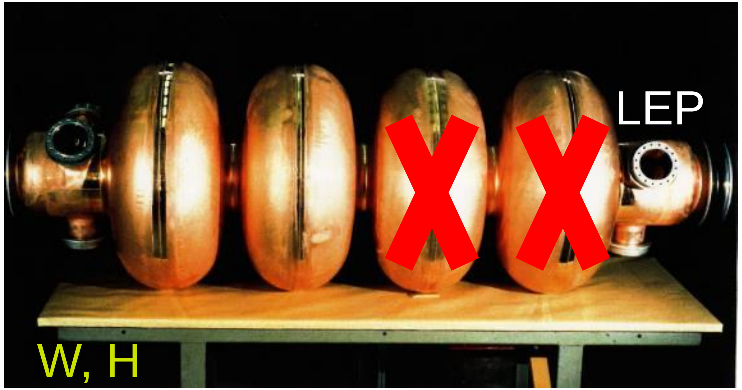
-271/-269 °C

E_{acc} = 5.7 MV/m, Q_0 = 3e9, P_{RF} = 900 kW

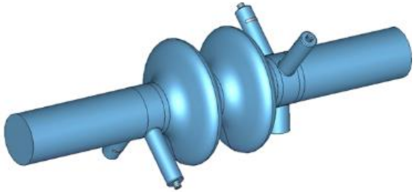
400 MHz 1-cell cavities Nb/Cu



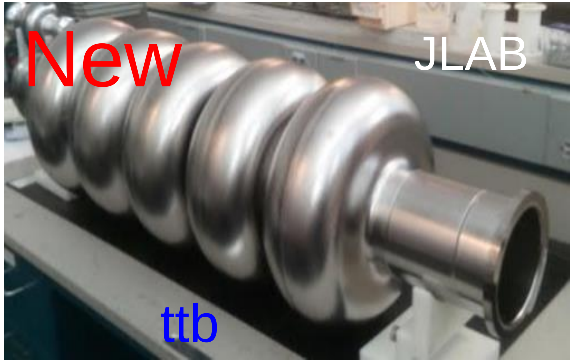
E_{acc} = 12 MV/m, Q_0 = 3e9
P_{RF} = 450 kW



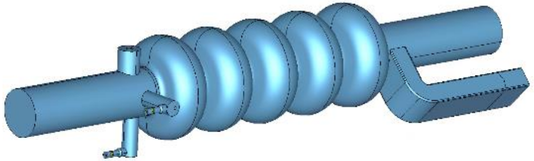
400 MHz 2-cell cavities Nb/Cu



E_{acc} = 25 MV/m, Q0 = 2e10
P_{RF} = 200 kW



800 MHz 5-cell cavities Bulk Nb



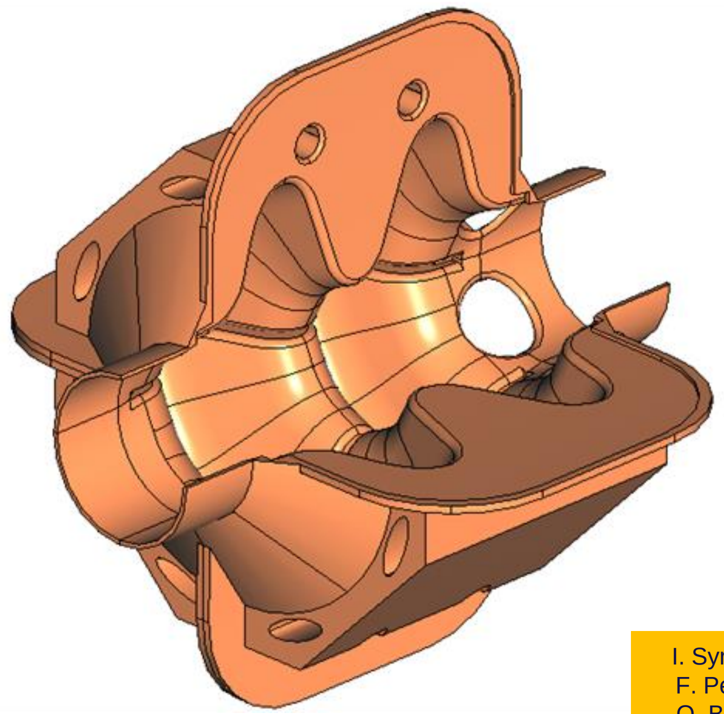
2-cell 600 MHz cavity for Z, W, H

- Alternative cavity option to cover the three machines

  E_{acc} = 12.5 MV/m, P_{RF} = 600 kW

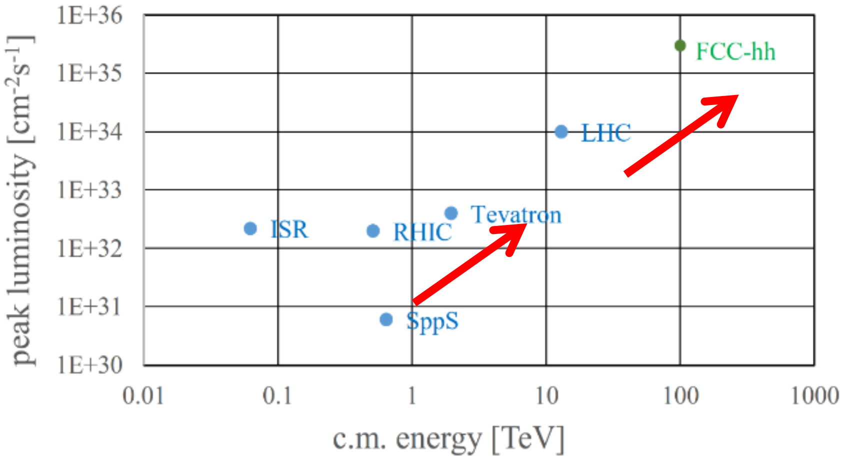
- Robust against vibrations and electromagnetic force deformations

- Innovative concept compatible with Nb/Cu technology



I. Syratchev
F. Peauger
O. Brunner
S. Gorgi Zadeh
CERN

FCC-hh: highest collision energies

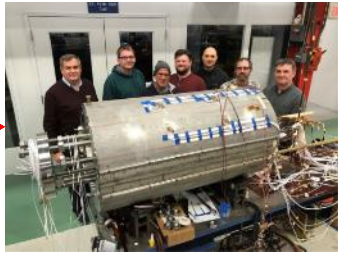


- **order of magnitude performance increase** in both **energy & luminosity**
- **100 TeV cm collision energy** (vs 14 TeV for LHC)
- similar performance increase as from Tevatron to LHC
- **key technology: high-field magnets**

from LHC technology 8.3 T NbTi dipole

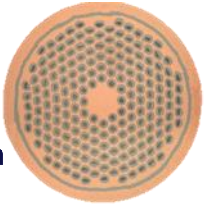
via HL-LHC technology 12 T Nb3Sn quadrupole

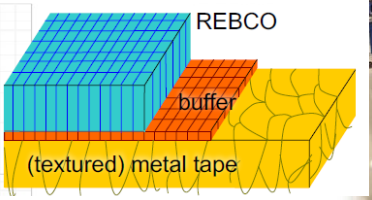
FNAL dipole demonstrator 14.5 T Nb3Sn



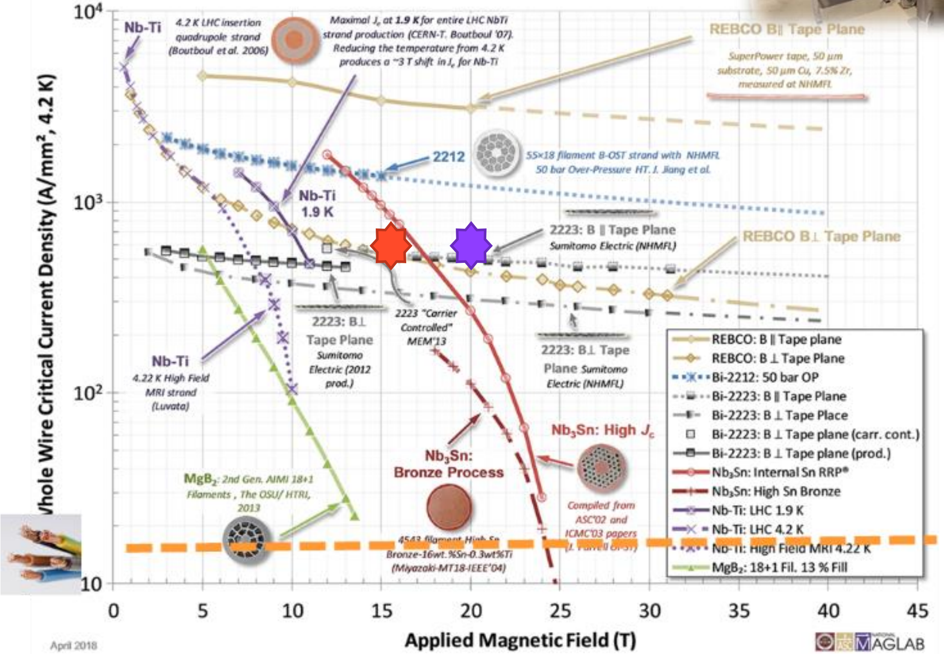
High-field magnets R&D towards FCC-hh

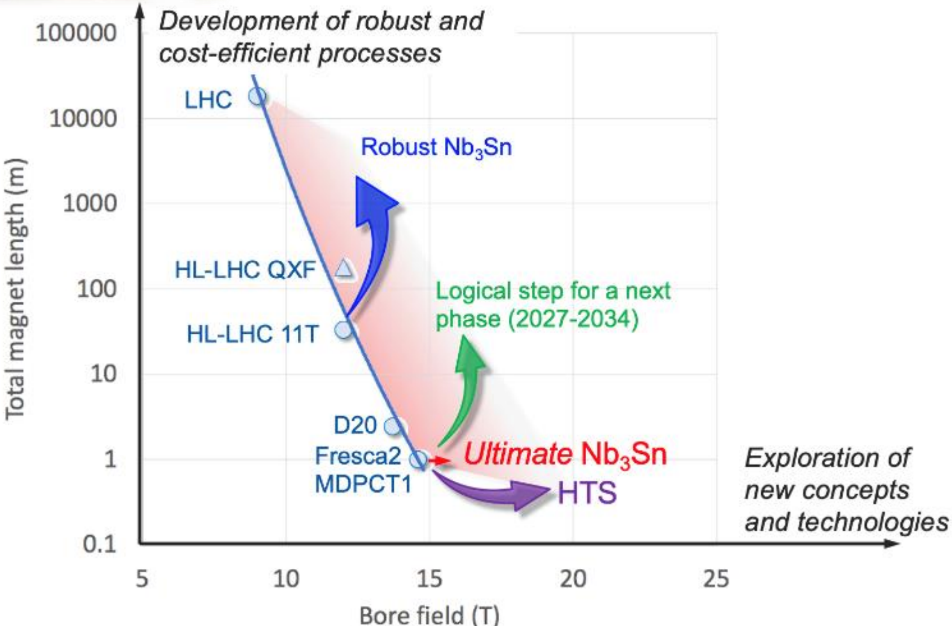
Nb$_3$Sn





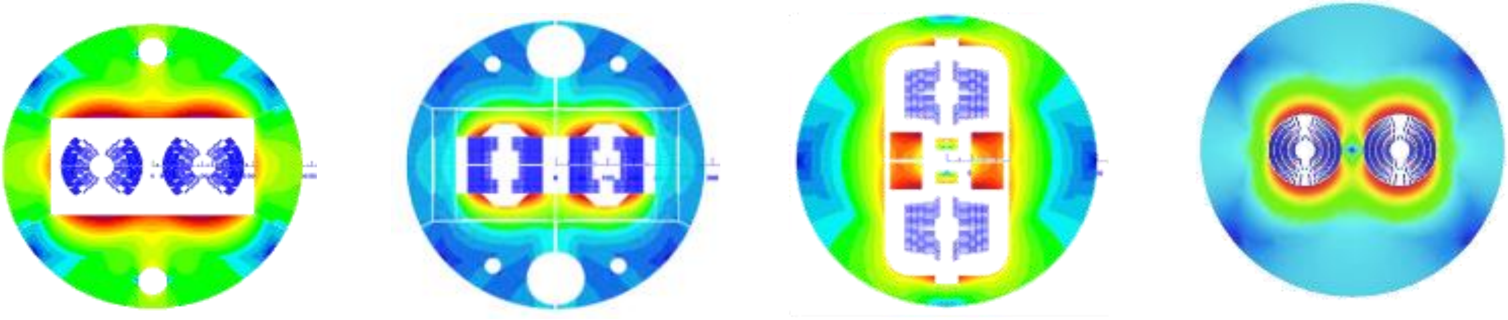
-271°C





Main Conceptual Design Highlights: Variants for the FCC hh Dipoles

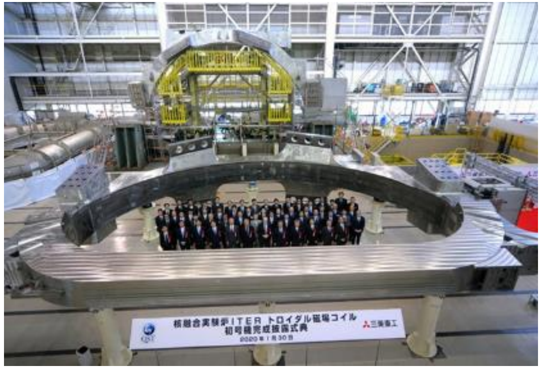
Dia = 600 mm
50 mm aperture
$B_{ultimate}$ = 16 T



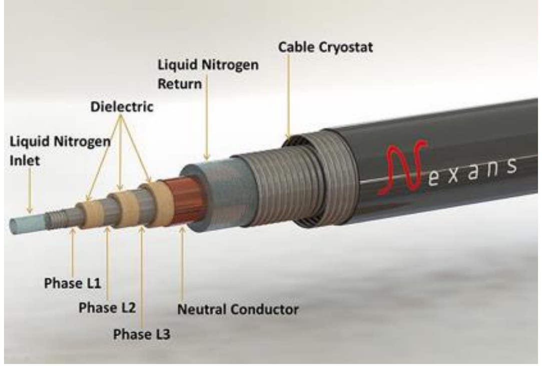
Societal Impact

NMR

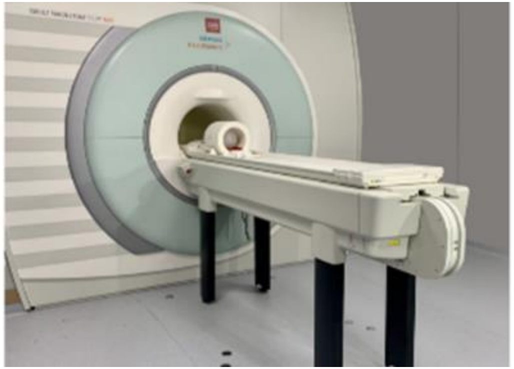
High Field Magnets



Fusion



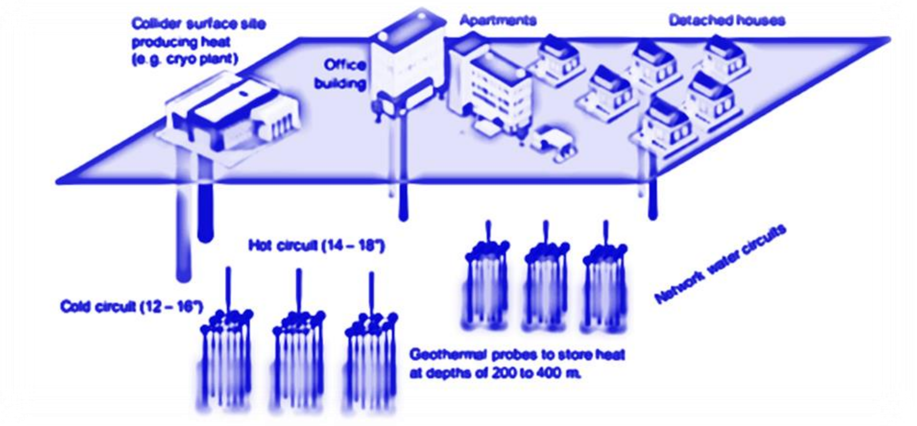
Power applications



MRI

Ion Therapy

FCC



THE ENERGY CHALLENGE

Electrical Power Estimate

FCC ee

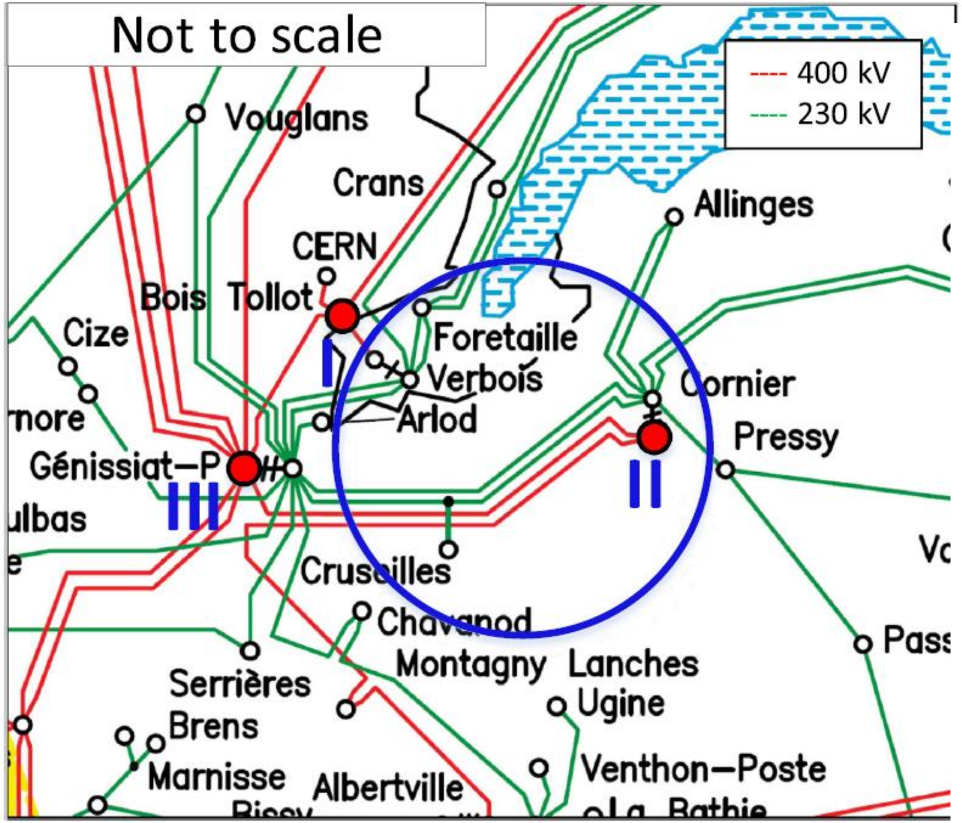
Electrical power	Z [MW]	W [MW]	H [MW]	ttbar [MW]
Radio Frequency	146	146	146	146
Cryogenics	1.3	12.6	15.8	47.5
Cooling and Ventilation	33	34	36	40
Magnets	7	20	44	100
Experiments	8	8	8	8
Data centers	4	4	4	4
General services	36	36	36	36
Total	**237**	**262**	**291**	**384**

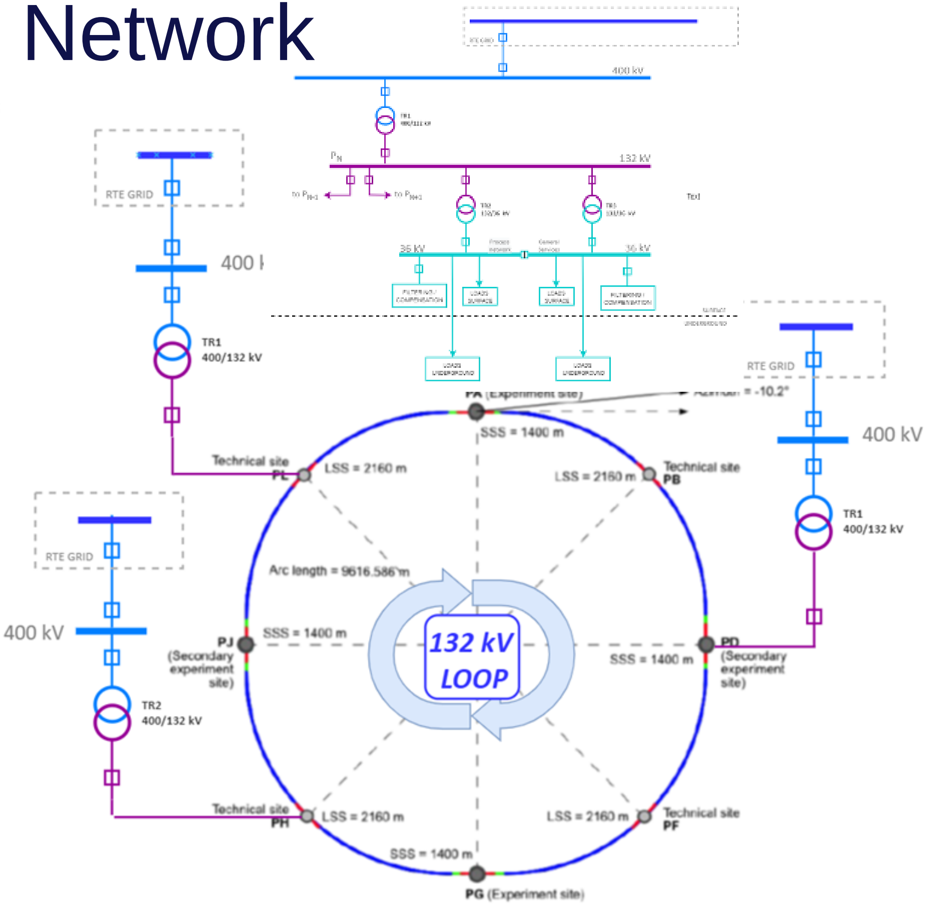
FCC hh

Subsystem	Electrical needs (approx. MW)
Cryogenics	276 (ca. 250 with further optimisations)
Radiofrequency	26
Magnets	80
Cooling and ventilation	30
General services	40
Four experiments	42
Data centres for four experiments	18
Injector complex	68
Total	580 (ca. 550 with further optimisations)

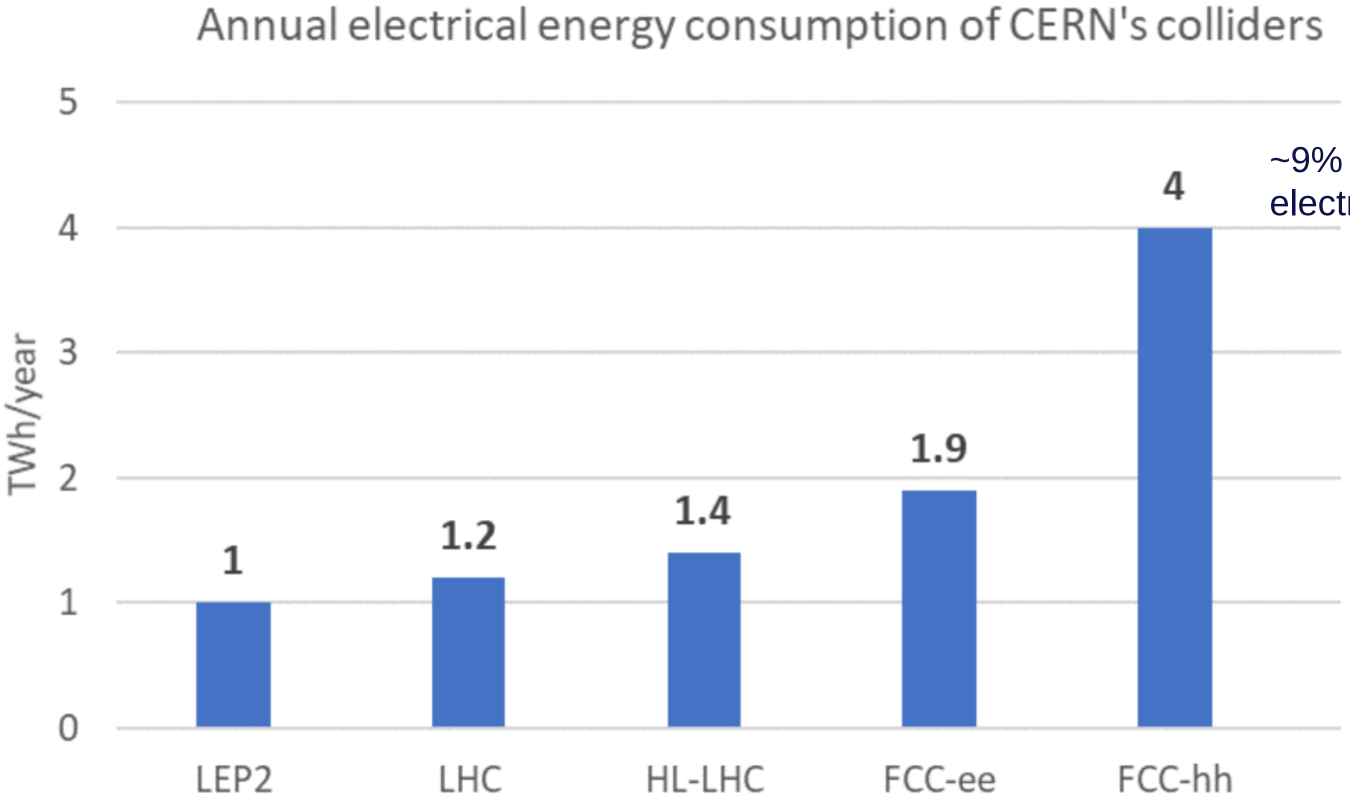
~Half unit of an electrical power plant

Connection to the Electrical Network



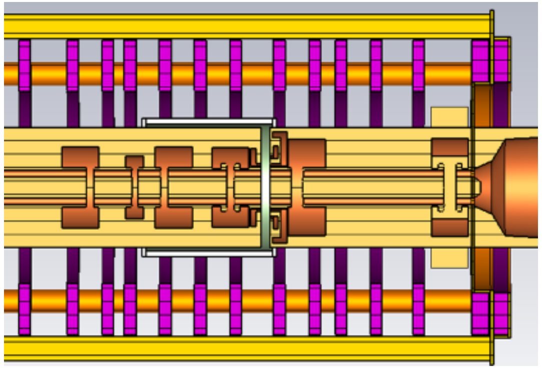


Motivation for Efficient Accelerator



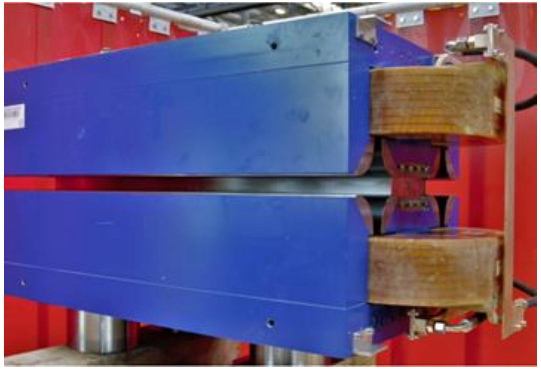
~9% of France's annual electricity production

Reducing - Efficiency Challenges



High-efficiency RF klystron, target 80%

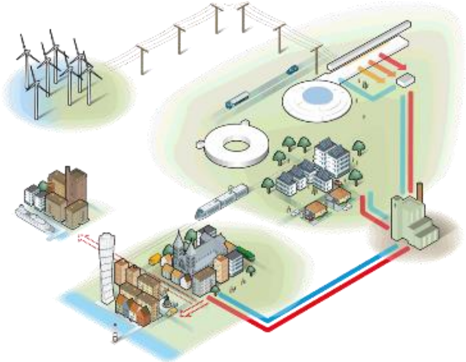
High efficiency large-scale cryogenics infrastructure



Low-loss magnet design

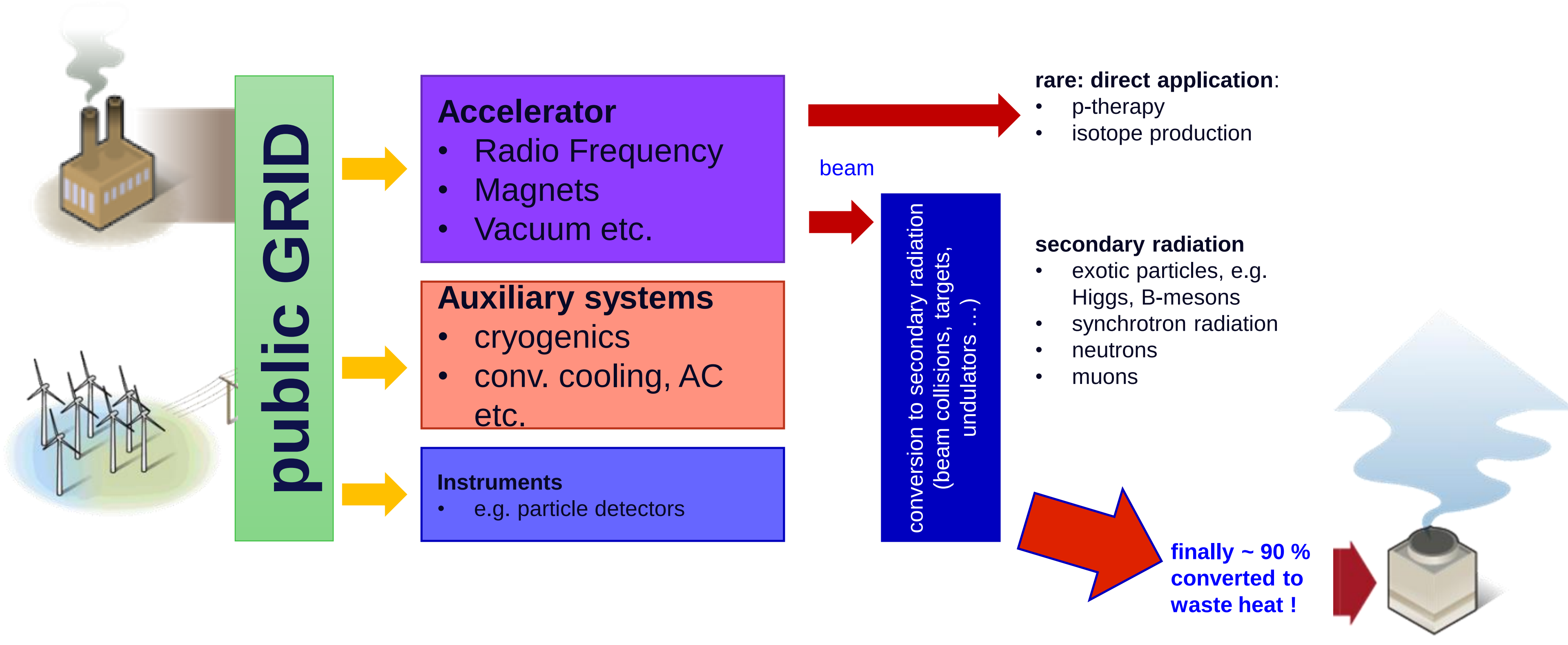
Low static losses of RF cavities

Economic mode for accelerator systems



Heat Recycling

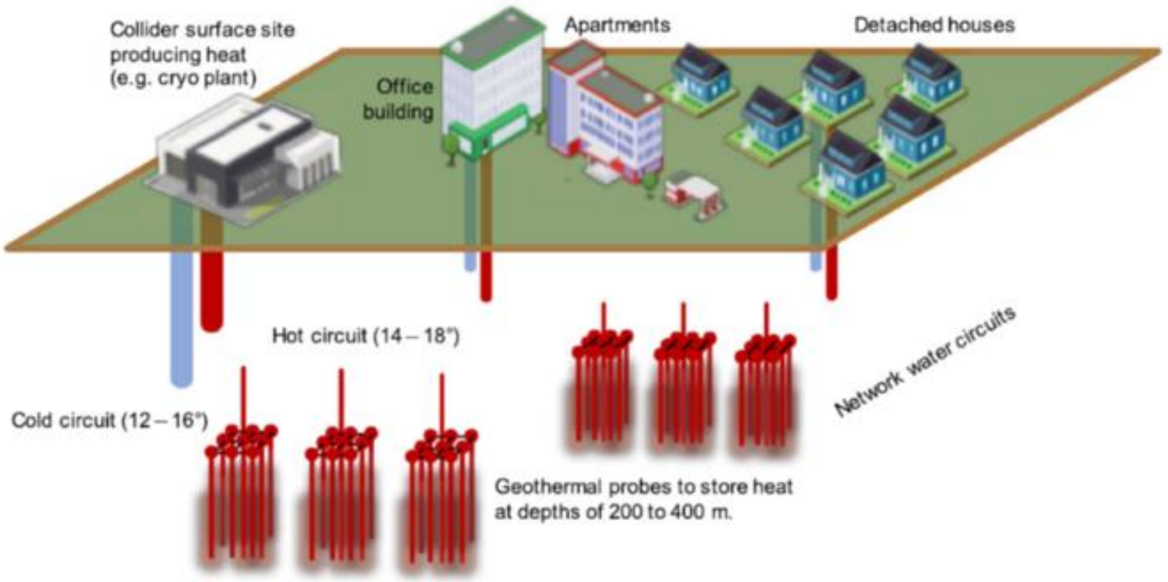
Powerflow in Accelerator Facilities



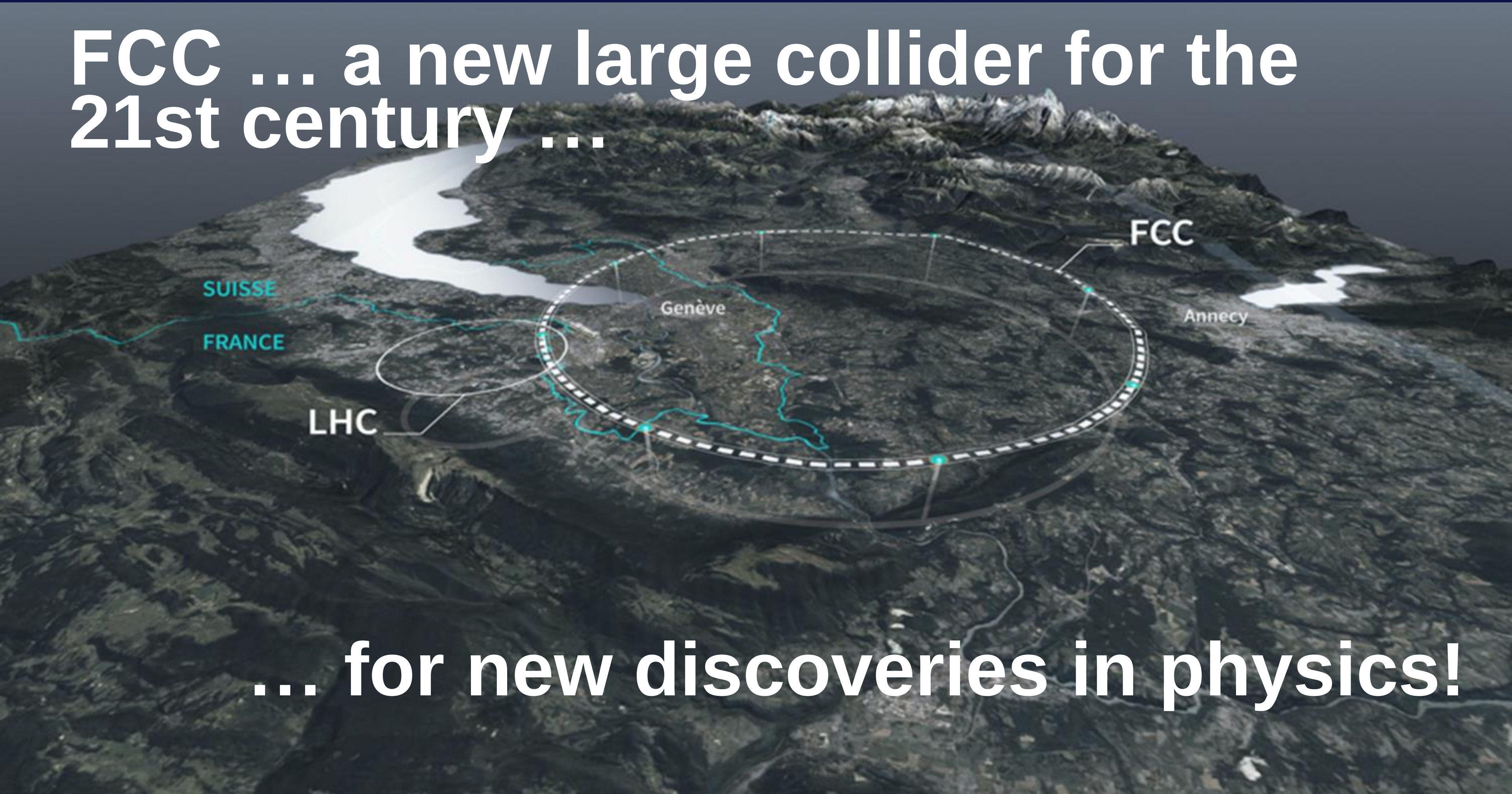
Heat Recycling

Hot water collected and diverted to parallel circuits

to supply the heating system of a new areas currently under construction.



FCC … a new large collider for the 21st century …



… for new discoveries in physics!

FCC

Merci
pour votre attention

Thank you
for your attention

.