The Future of Particle Accelerators

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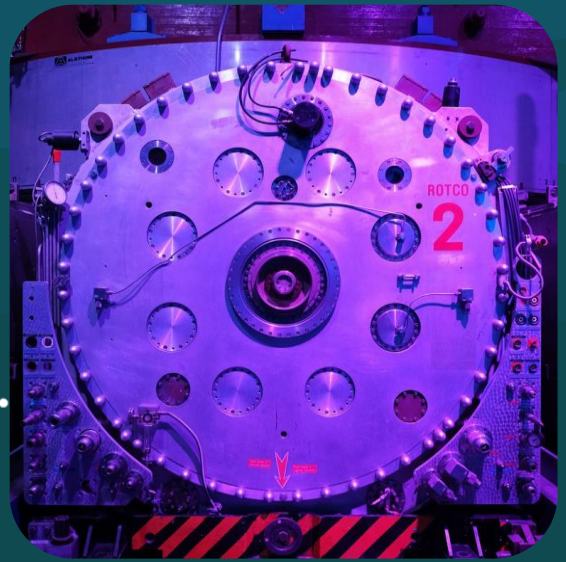
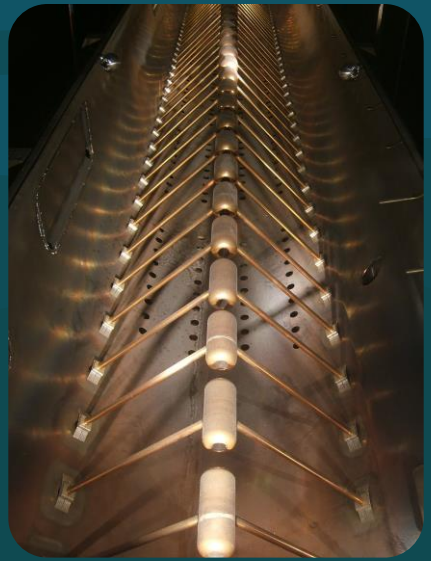
But first... A quick recap

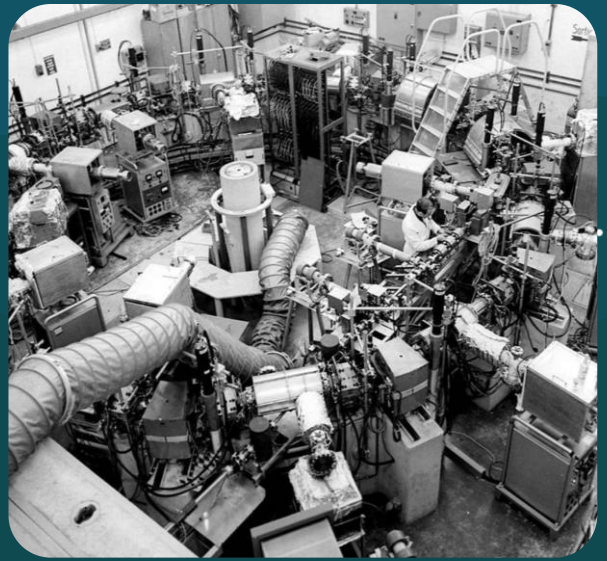
Past accelerators



Synchrocyclotron
1957 - 1990



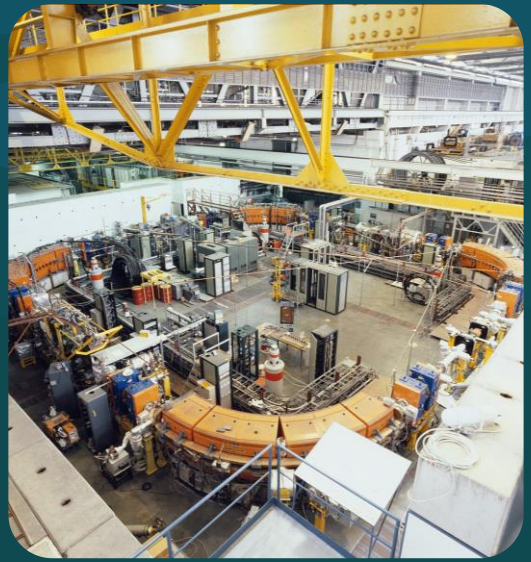
Linear Accelerator 1
1959 - 1992



Intersecting Storage Rings
1971 - 1984

Past accelerators

Linear Accelerator 2
1978 - 2018

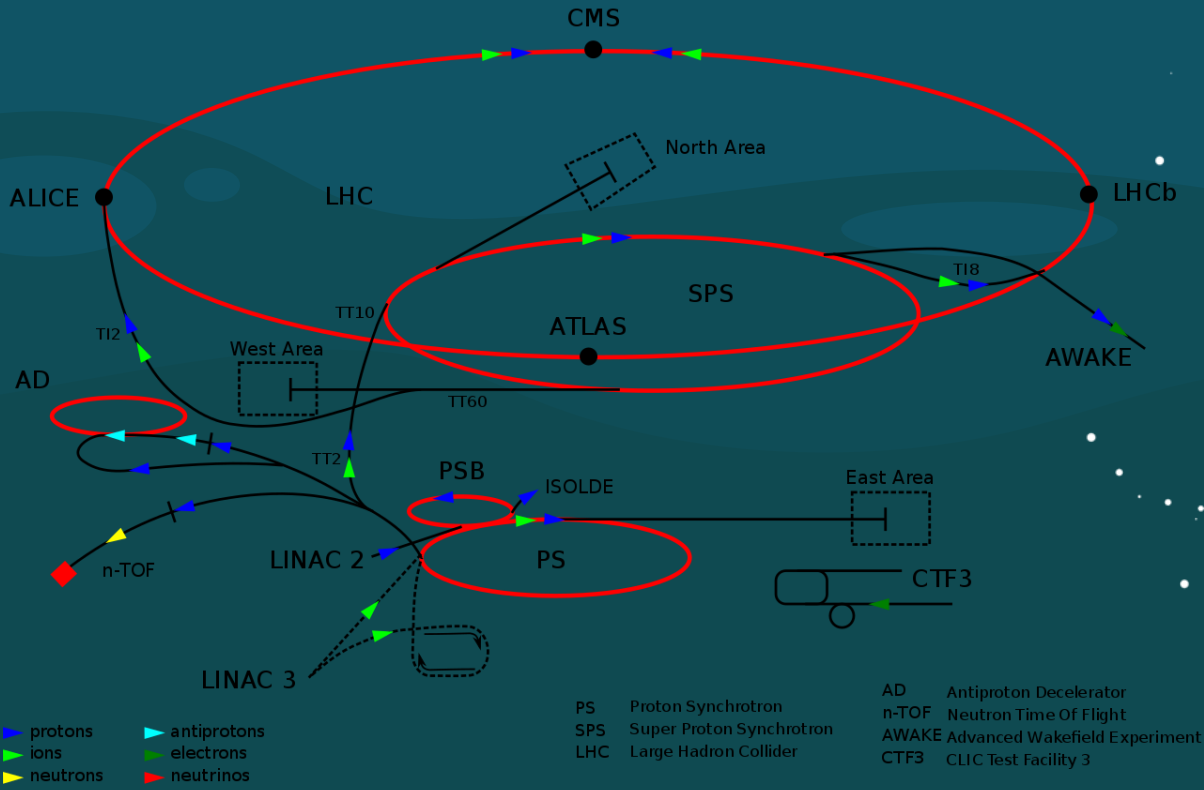


Low Energy Antiproton Ring
1982 - 1996

Large Electron-Positron Collider
1989 - 2000

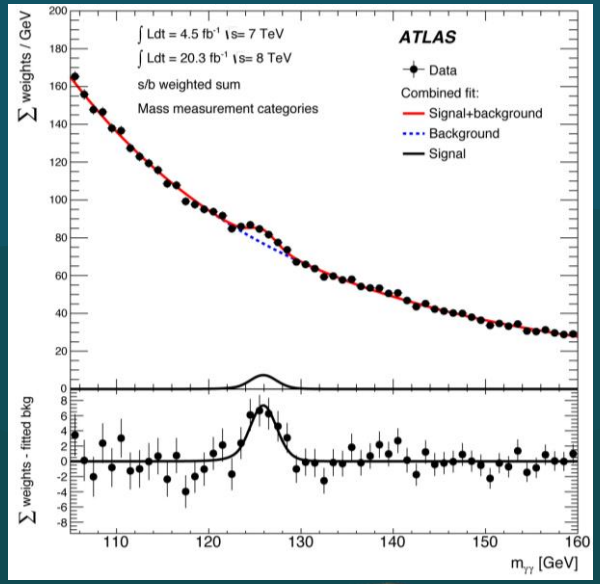
Present accelerators

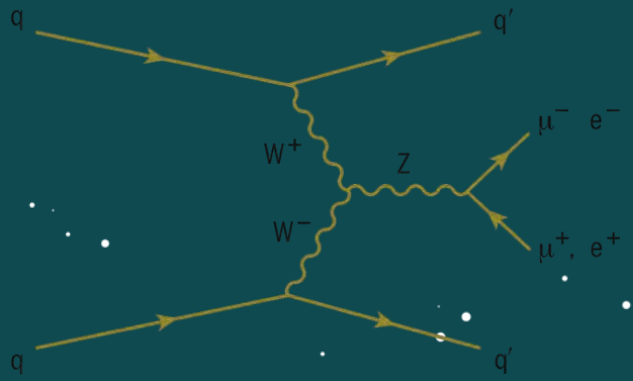
- Large Hadron Collider (LHC)
- Super Proton Synchrotron (SPS)
- Proton Synchrotron (PS)
- LINAC 4
- PS Booster
- Antiproton Decelerator (AD)
- LINAC 3
- Low Energy Ion Ring (LEIR)

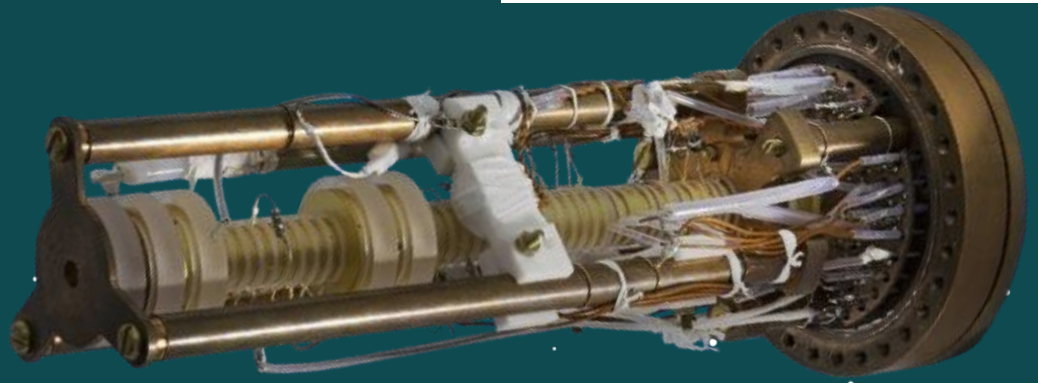


CERN's scientific achievements so far:

1. W and Z bosons – the Super Proton Synchrotron (1983)
2. The Higgs boson (2012) and exotic hadrons (the tetraquark, the pentaquark) – the LHC
3. Antimatter research – the Low Energy Antiproton Ring (LEAR), Antiproton Decelerator (AD), ELENA







Future accelerators

Why do we need better accelerators? What is not explained by the SM?

-Discovery of new particles

-Matter/Antimatter asymmetry

-CP violations

-Mass of neutrino particles

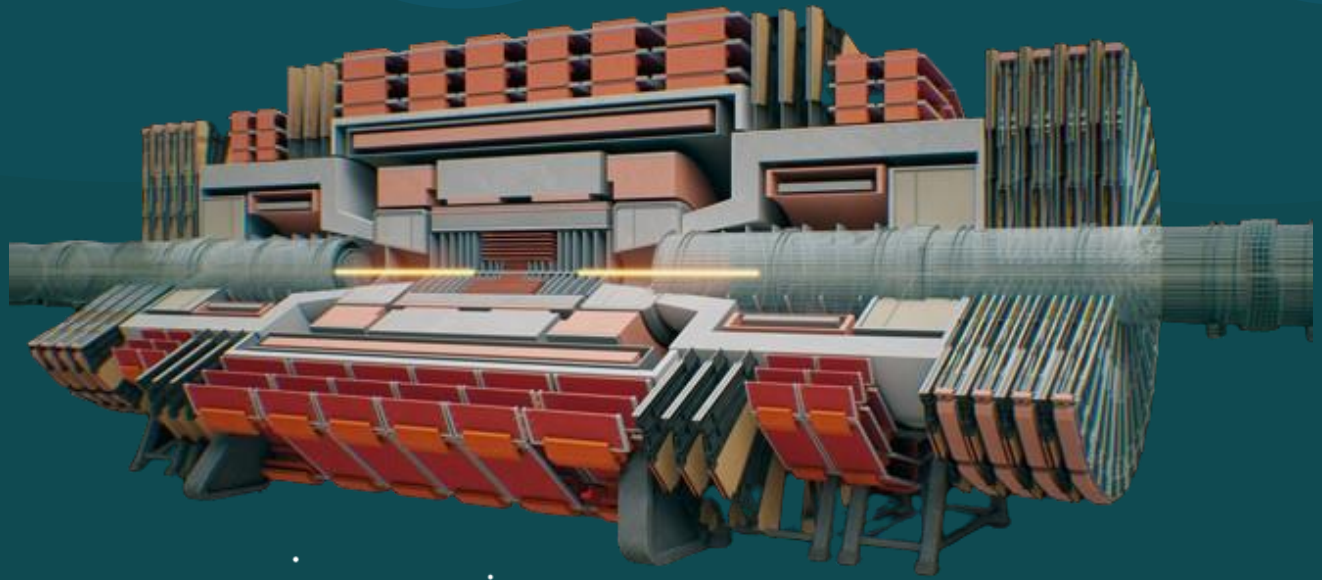
-Quark and lepton flavour puzzle

-Dark matter studies

-Higher resolution readings

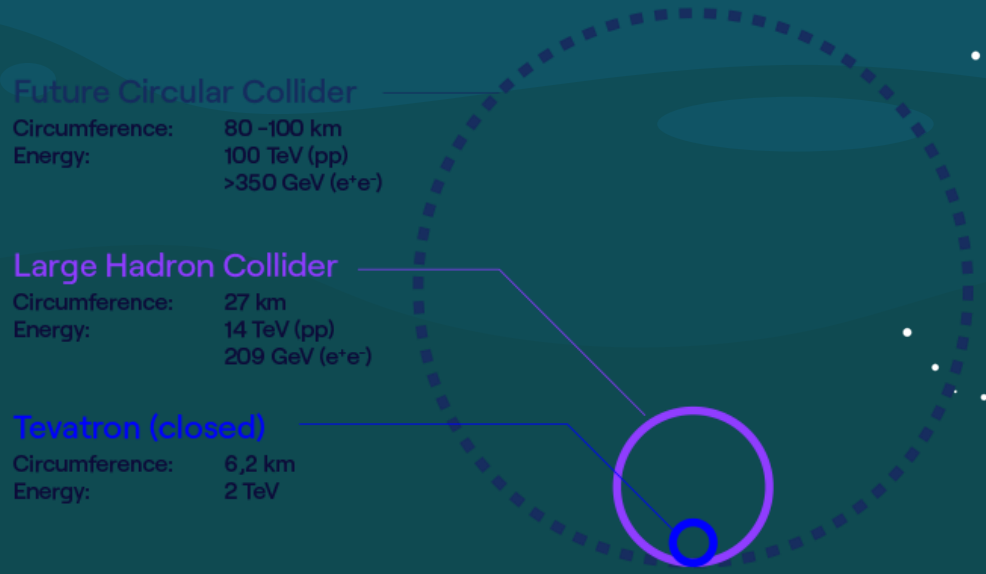
-Other candidates for physics beyond the SM (such as heavy axions, dark photons, long-lived particles)

The Future Circular Collider



The Future Circular Collider

The Future Circular Collider (FCC) study is developing designs for the next generation of higher performance particle colliders that could follow on from the Large Hadron Collider (LHC) once it reaches the end of its High-Luminosity Phase.



FCC in a nutshell

Timeline

-2025: Completion of the FCC Feasibility Study
-2027–2028: Decision by CERN Member States and international partners

Tunnel

-90.7 km circumference
-200 m average depth
-8 surface points (7 in France, 1 in Switzerland)

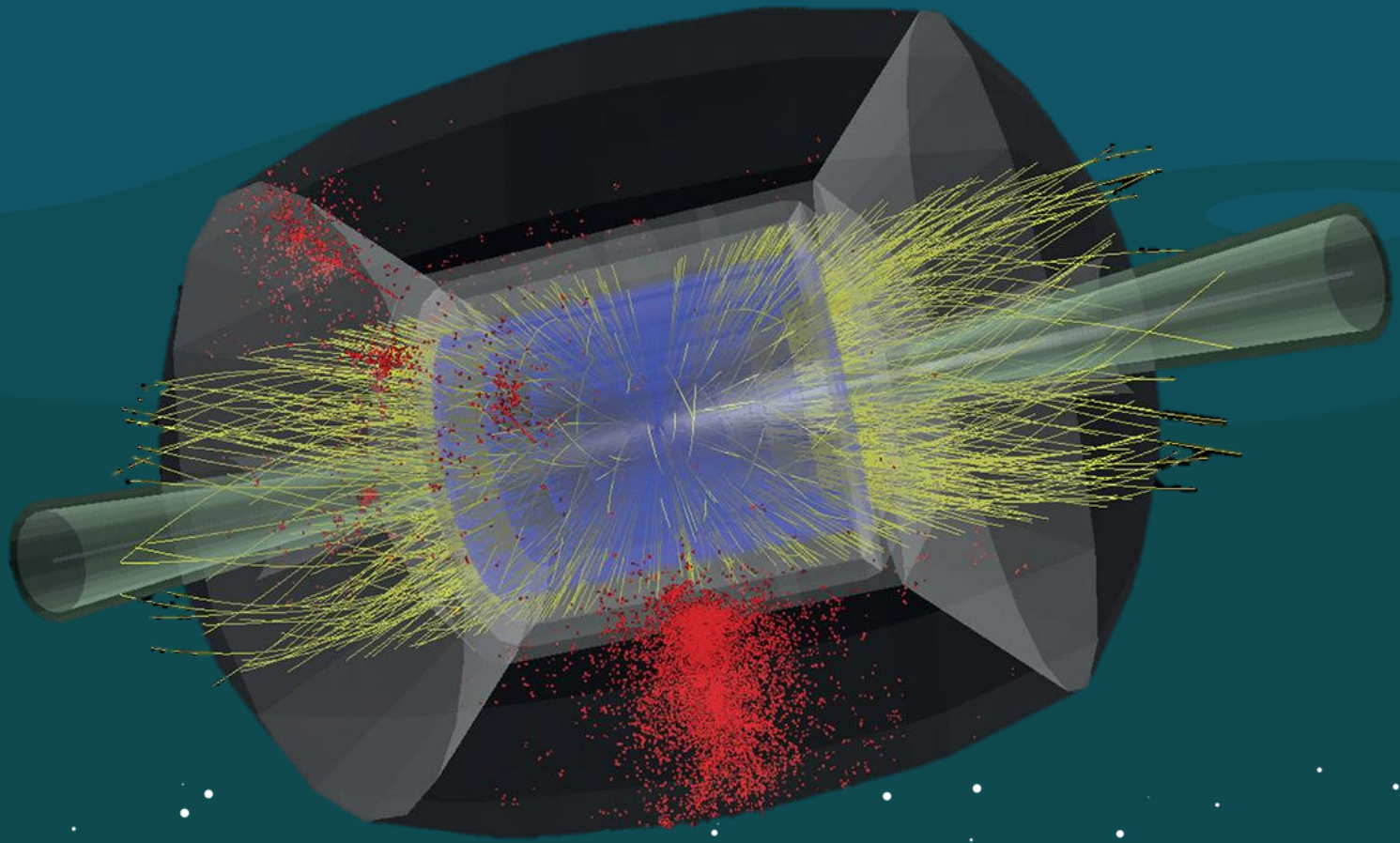
Two stages:

-FCC-ee (precision measurements) about 15 years from the mid-2040s. The FCC-hh, would then be installed in the same tunnel, reusing the existing infrastructure, similar to when the LHC replaced LEP
-FCC-hh (high energy) about 25 years from the 2070s

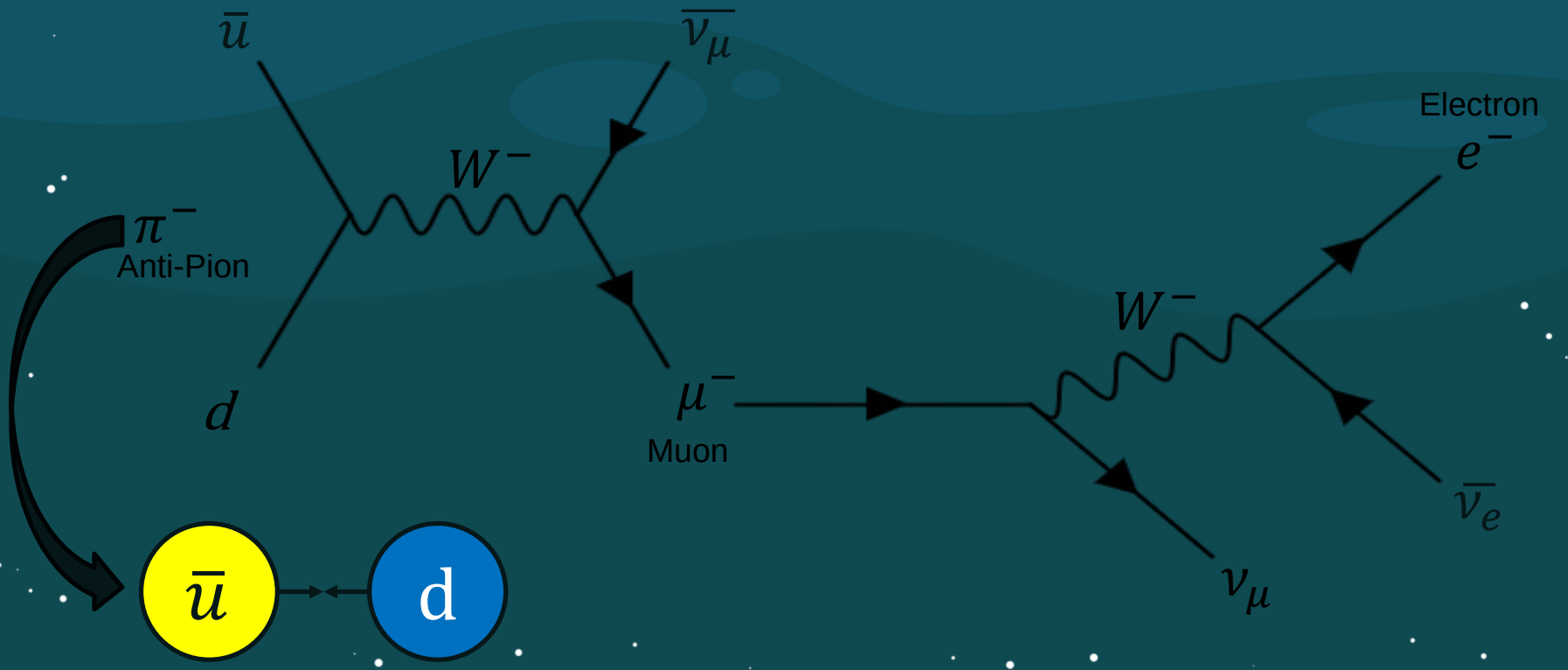
Costs/benefits

-15 billion CHF, spread over at least 15 years for FCC-ee with four experiments
-Estimated benefit-cost ratio of 1.66
-About 800 000 person-years of employment created

The Muon Collider

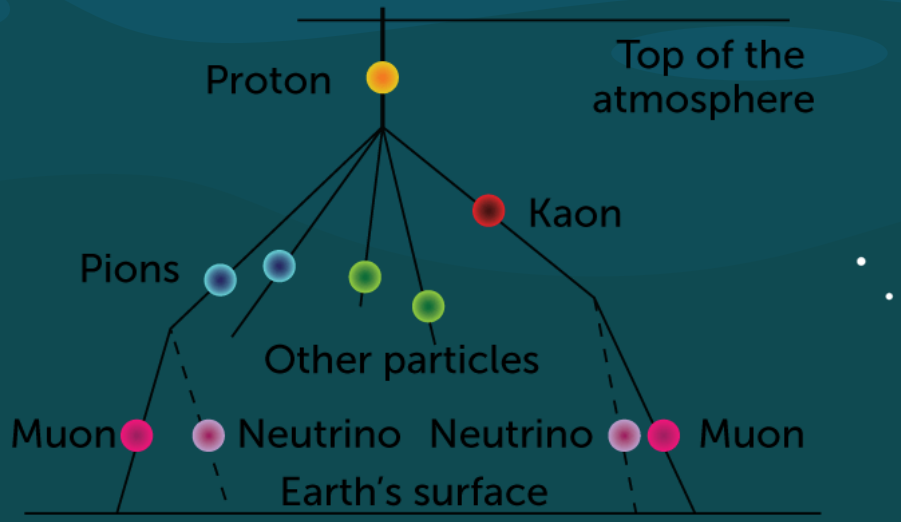


The problem with muons

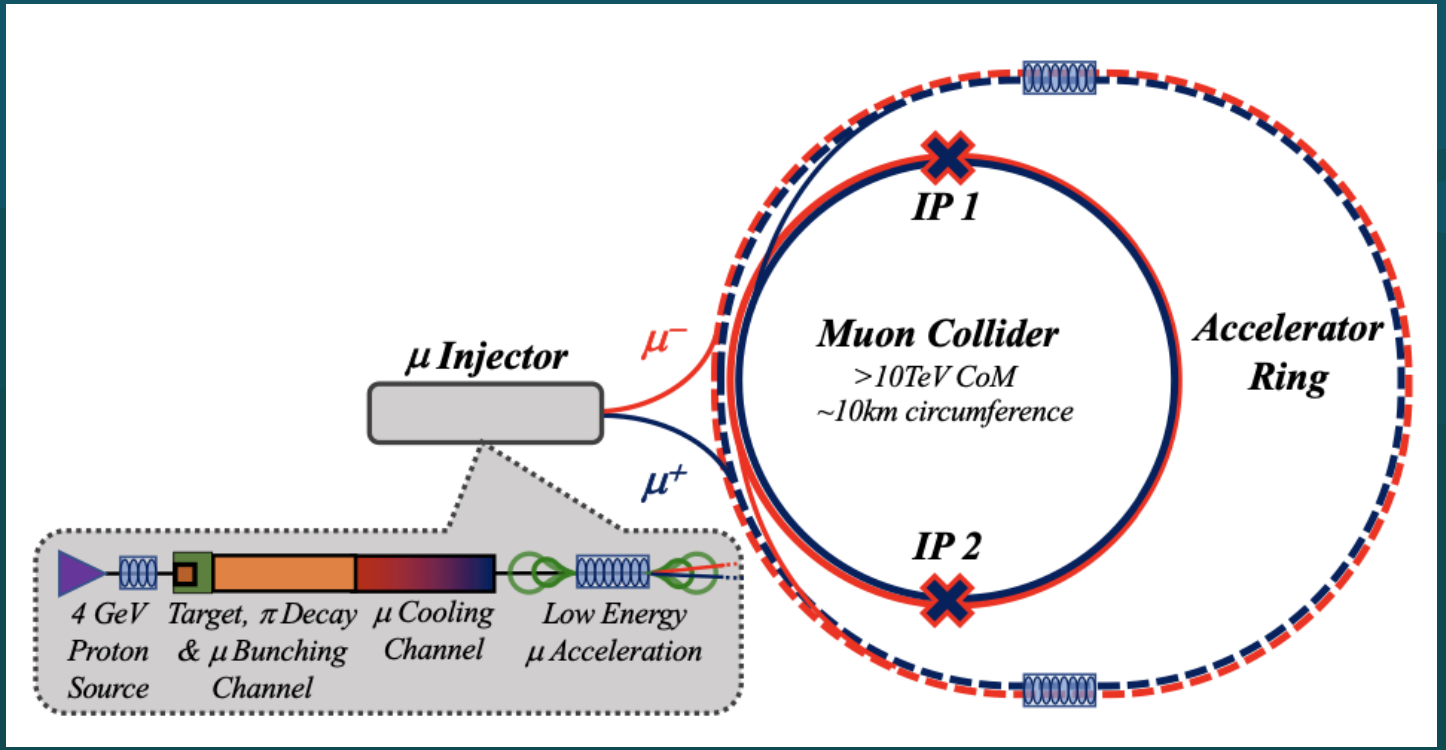


What makes this possible?

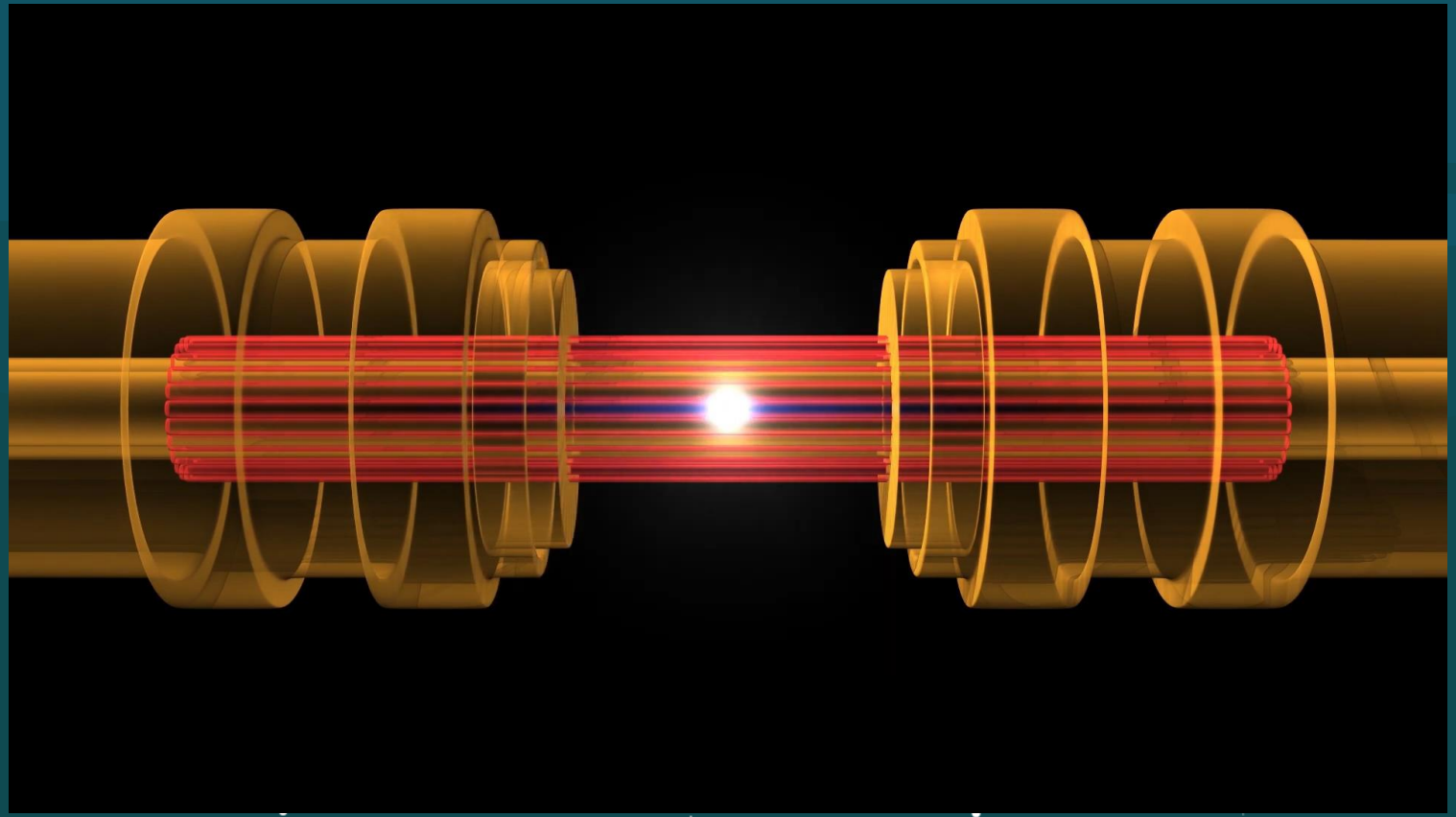
$$\Delta t' = \frac{\Delta t}{\sqrt{1 - \frac{v^2}{c^2}}}$$



The Muon Collider



The Muon Collider



THANK YOU!