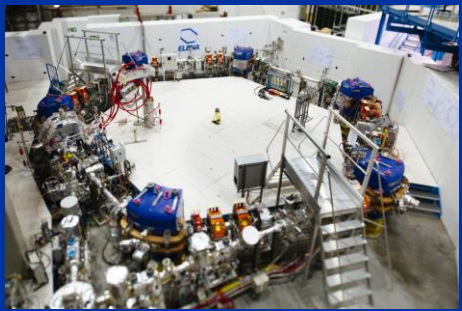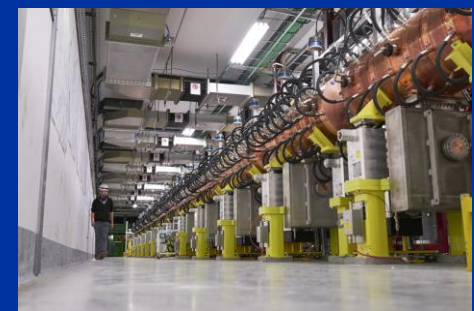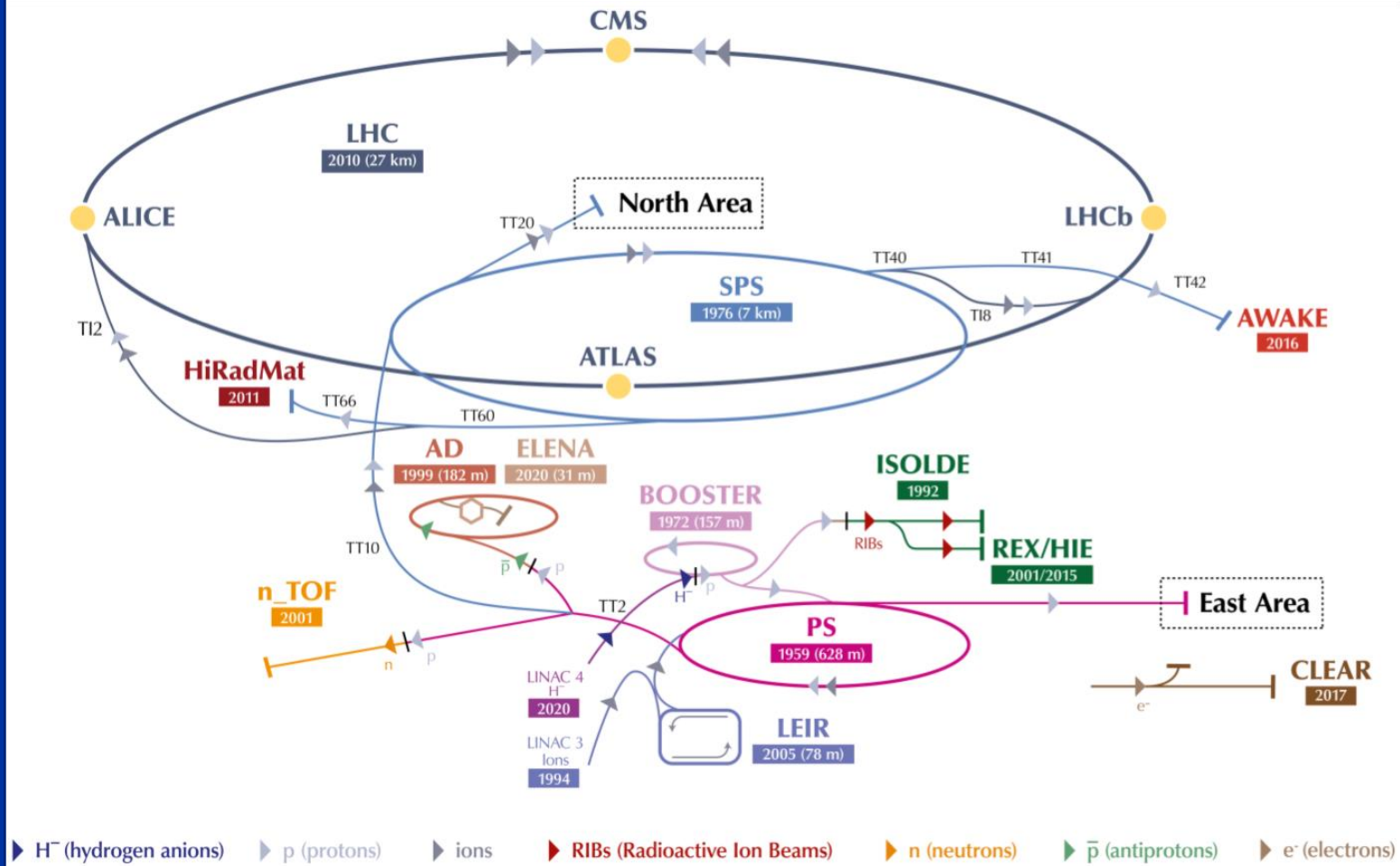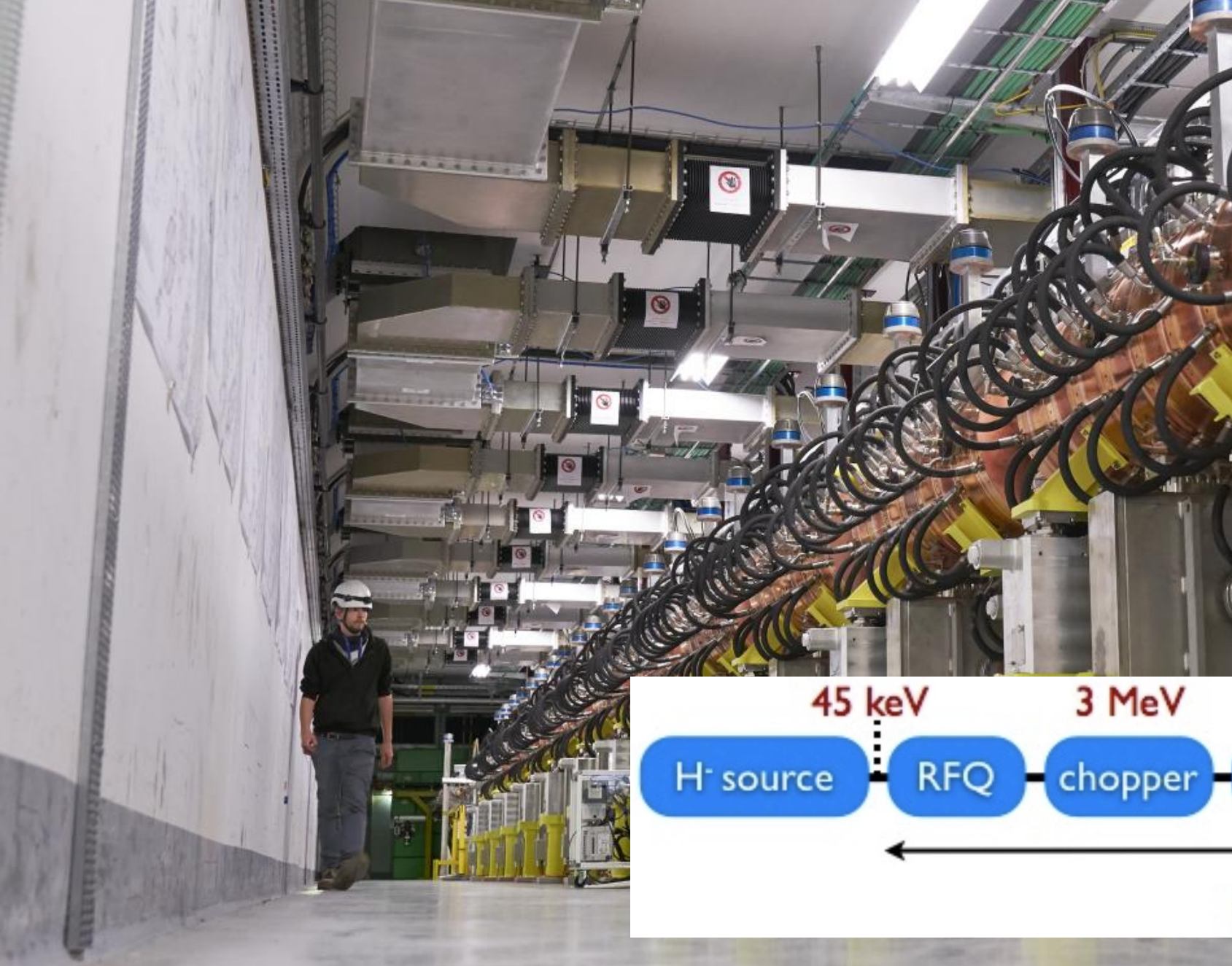# AXEL – 2023
Introduction to the CERN Accelerator Complex

Rende Steerenberg, BE-OP

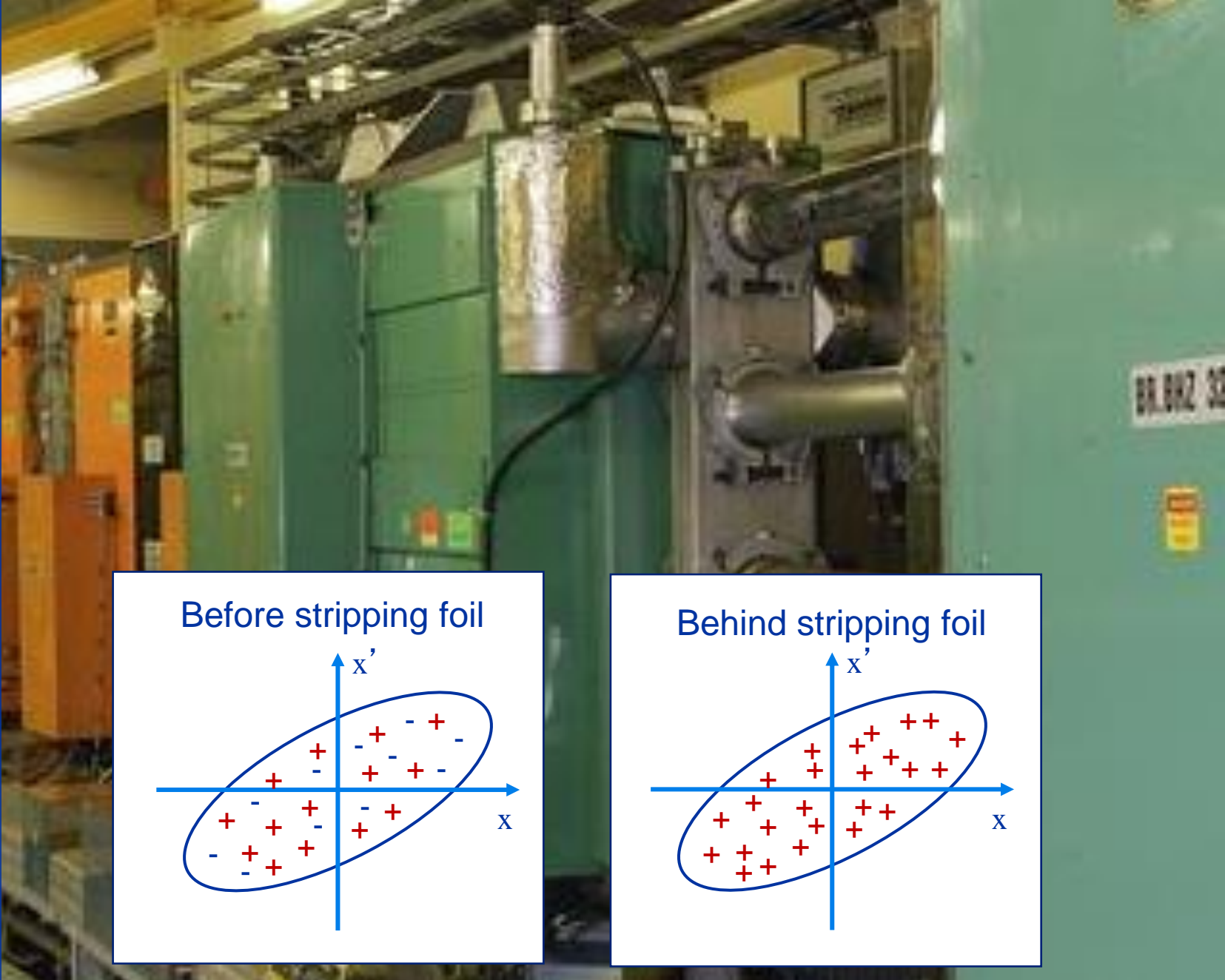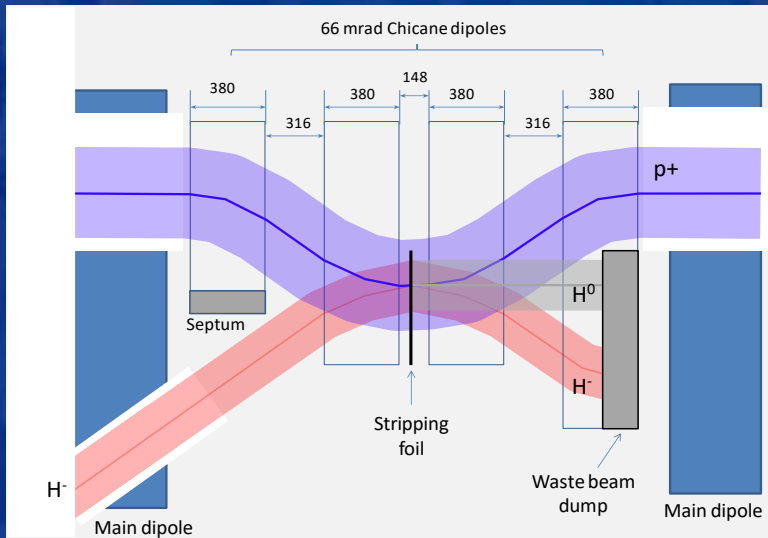27 November 2023

The CERN Accelerator Complex

Linac 4

- H⁻ ion source at 45 keV

- Accelerates beam up to 160 MeV

- The chopping scheme allows removing some of the Linac bunches to make the beam fit into the PS Booster RF buckets

- Pulse rate 1.2 s

| 45 keV | | 3 MeV | 50 MeV | 102 MeV | 160 MeV |

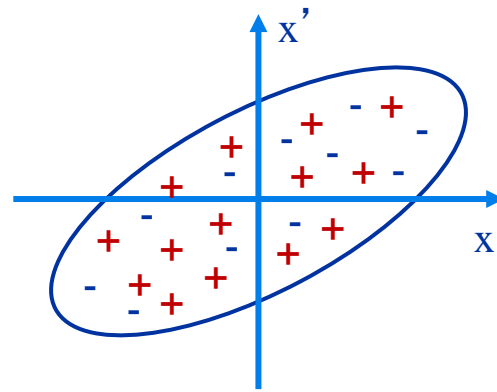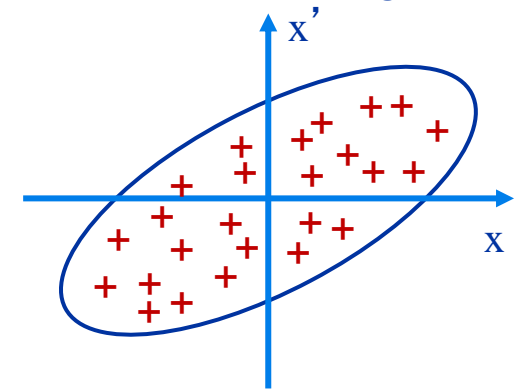H⁻ source — RFQ — chopper — DTL — CCDTL — PIMS

352.2 MHz

PS Booster

- 1st Synchrotron with 4 superposed rings
- Circumference of 157 m
- Proton energy from 160 MeV to 2 GeV
- Can cycle every 1.2 s
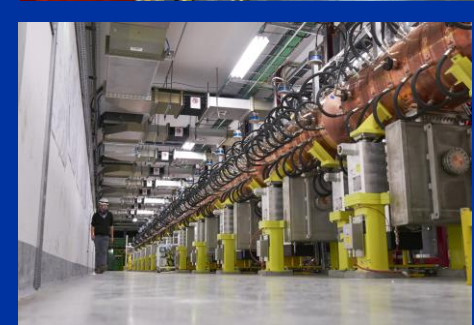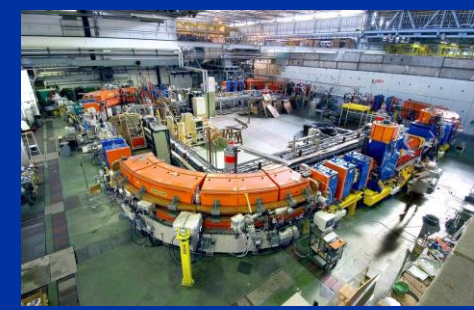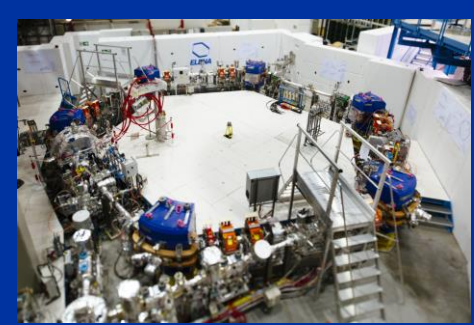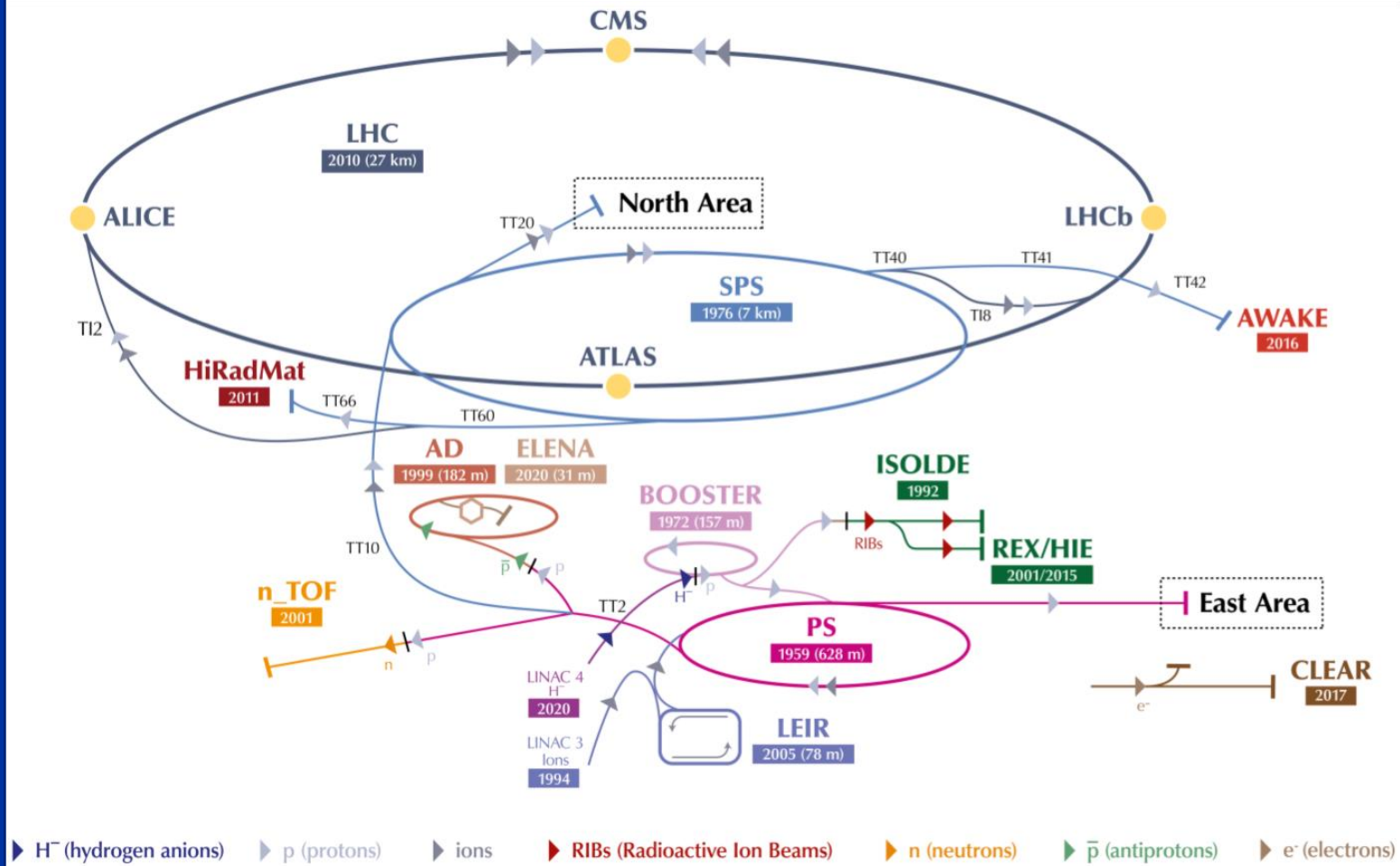- Each ring will inject over multi-turns, using charge exchange injection

Before stripping foil

Behind stripping foil

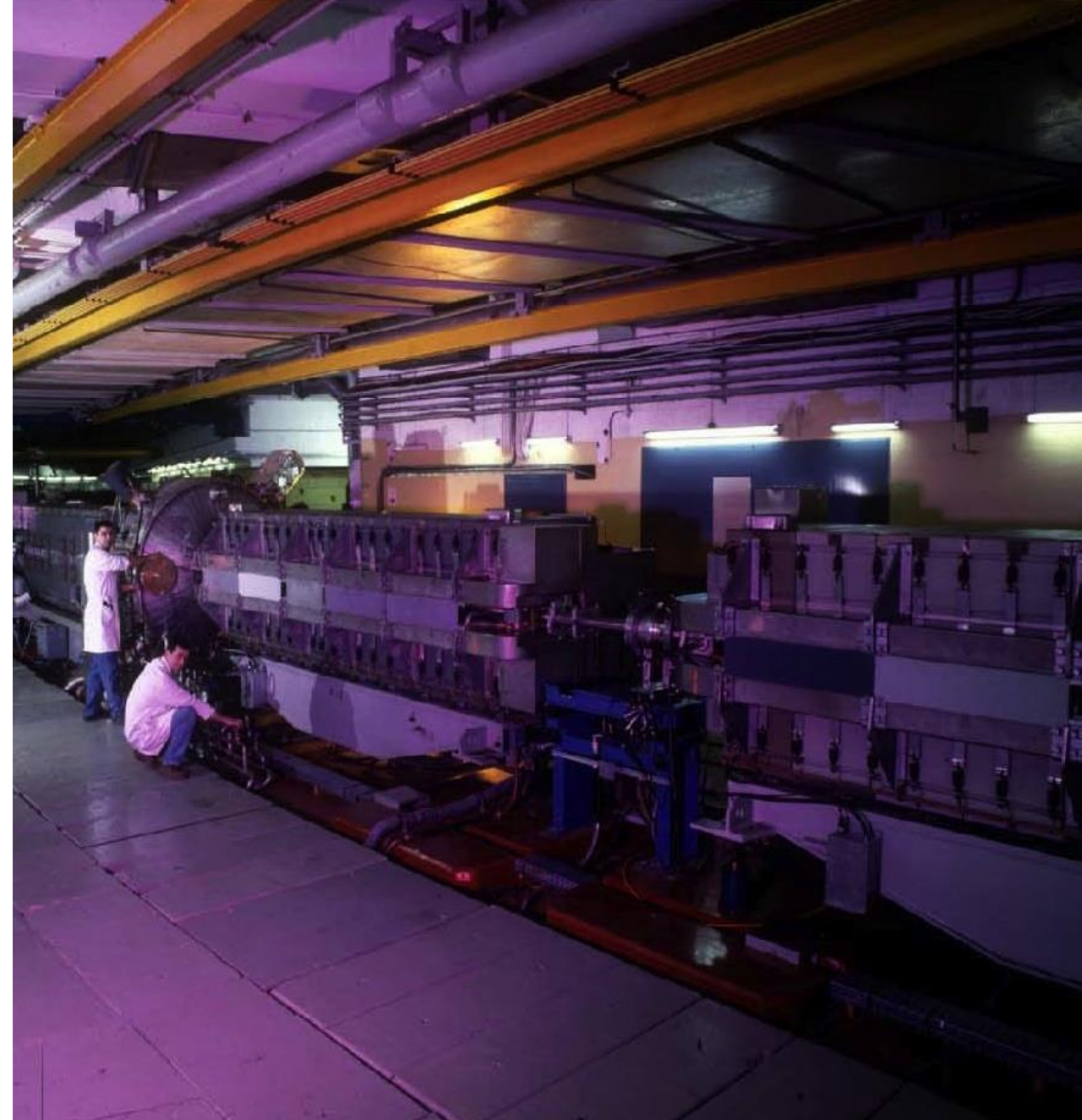# The CERN Accelerator Complex

PS

- **The oldest operating synchrotron at CERN**

- **Circumference of 628m**
  - 4 x PSB circumference

- **Increases proton energy from 2 GeV to max. 26 GeV**

- **Cycle length ranges from 1.2s to 3.6s**

- **Many RF systems allow for complex RF gymnastics**

- **Various types of extractions:**
  - Fast extraction
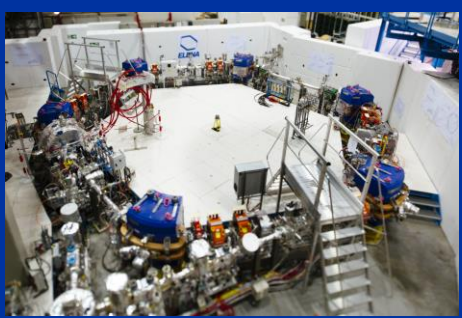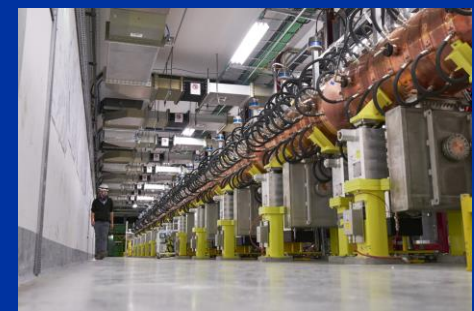 - Multi-turn extraction (MTE)
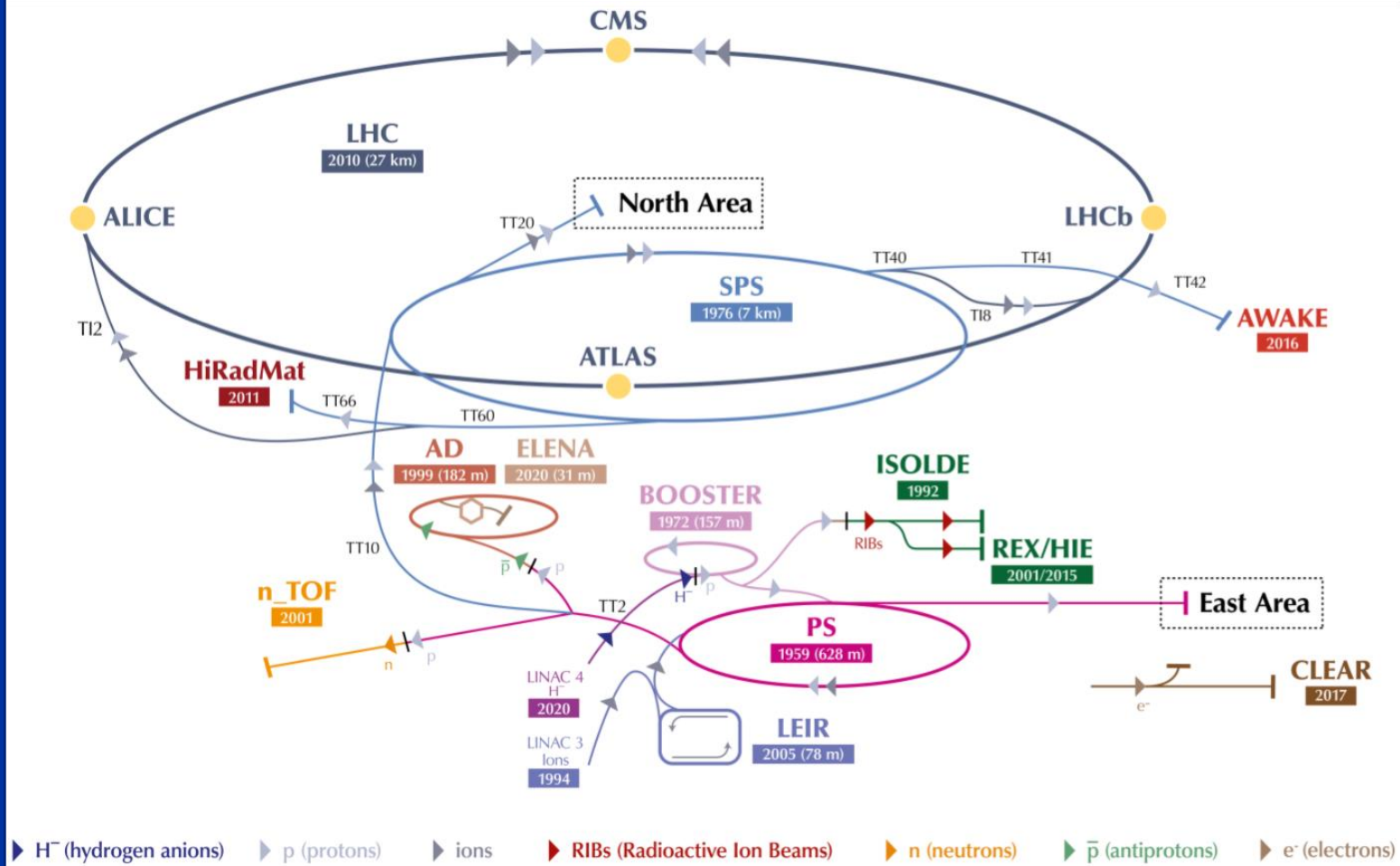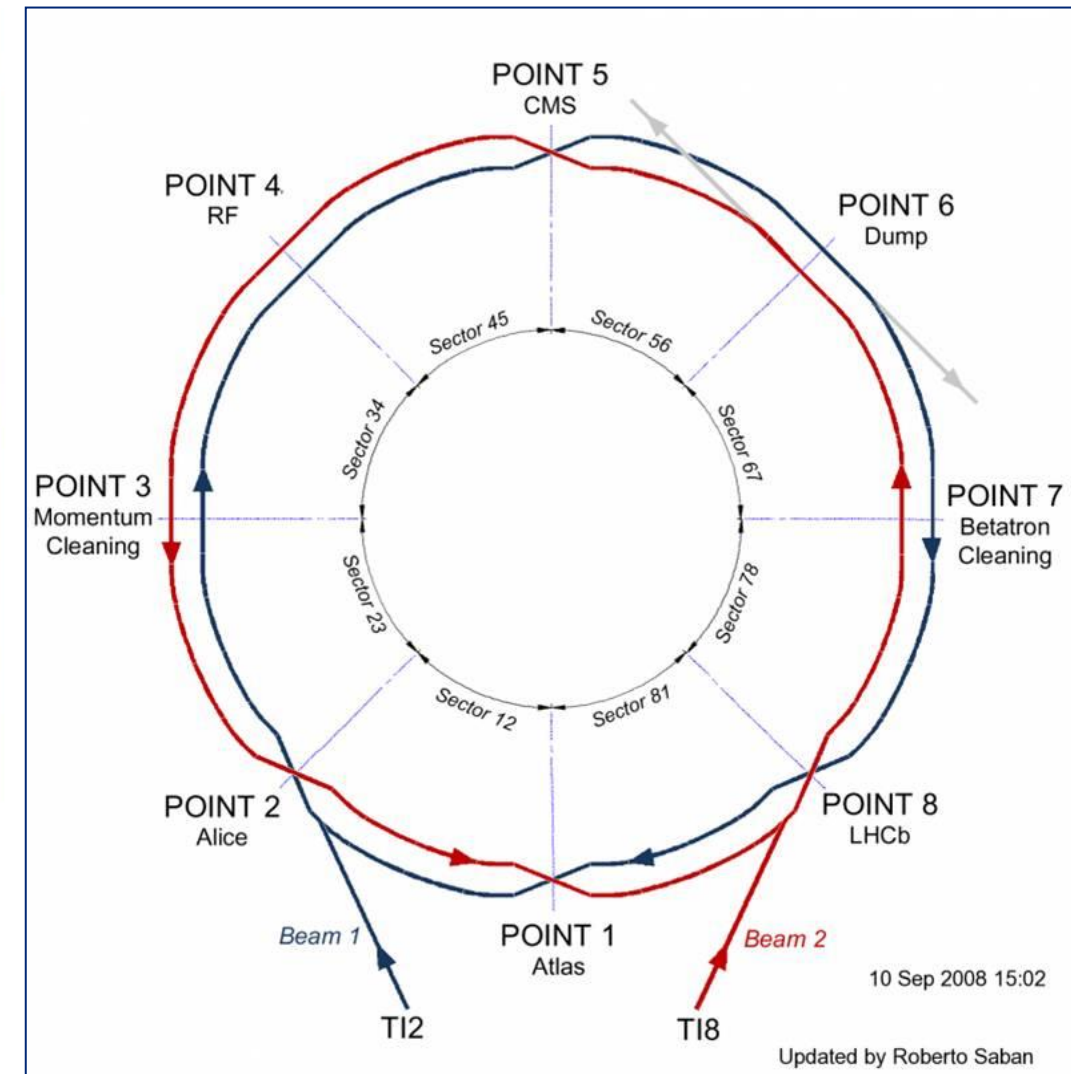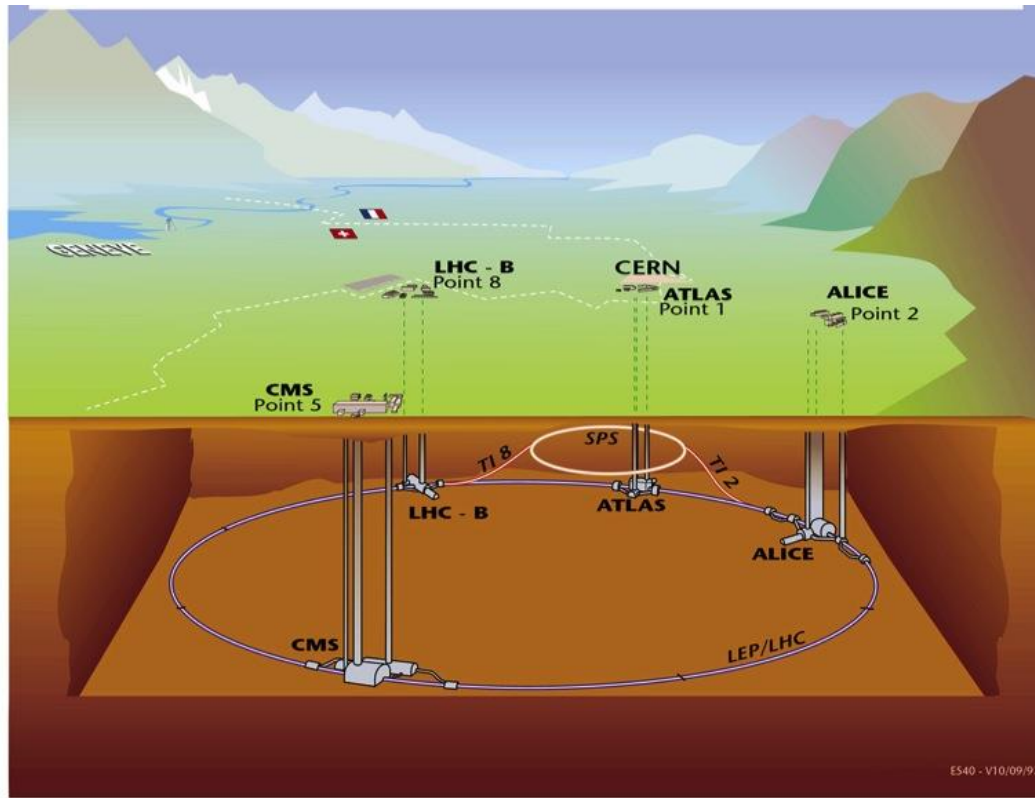 - Slow extraction

SPS

- **The first synchrotron in the chain at ~30m under ground**

- **Circumference of 6.9 km**
  - 11 x PS circumference

- **Increases proton beam energy up to 450 GeV with up to ~5x10^{13} protons per cycle**

- **Provides slow extracted beam to the North Area**

- **Provides fast extracted beam to LHC, AWAKE and HiRadMat**
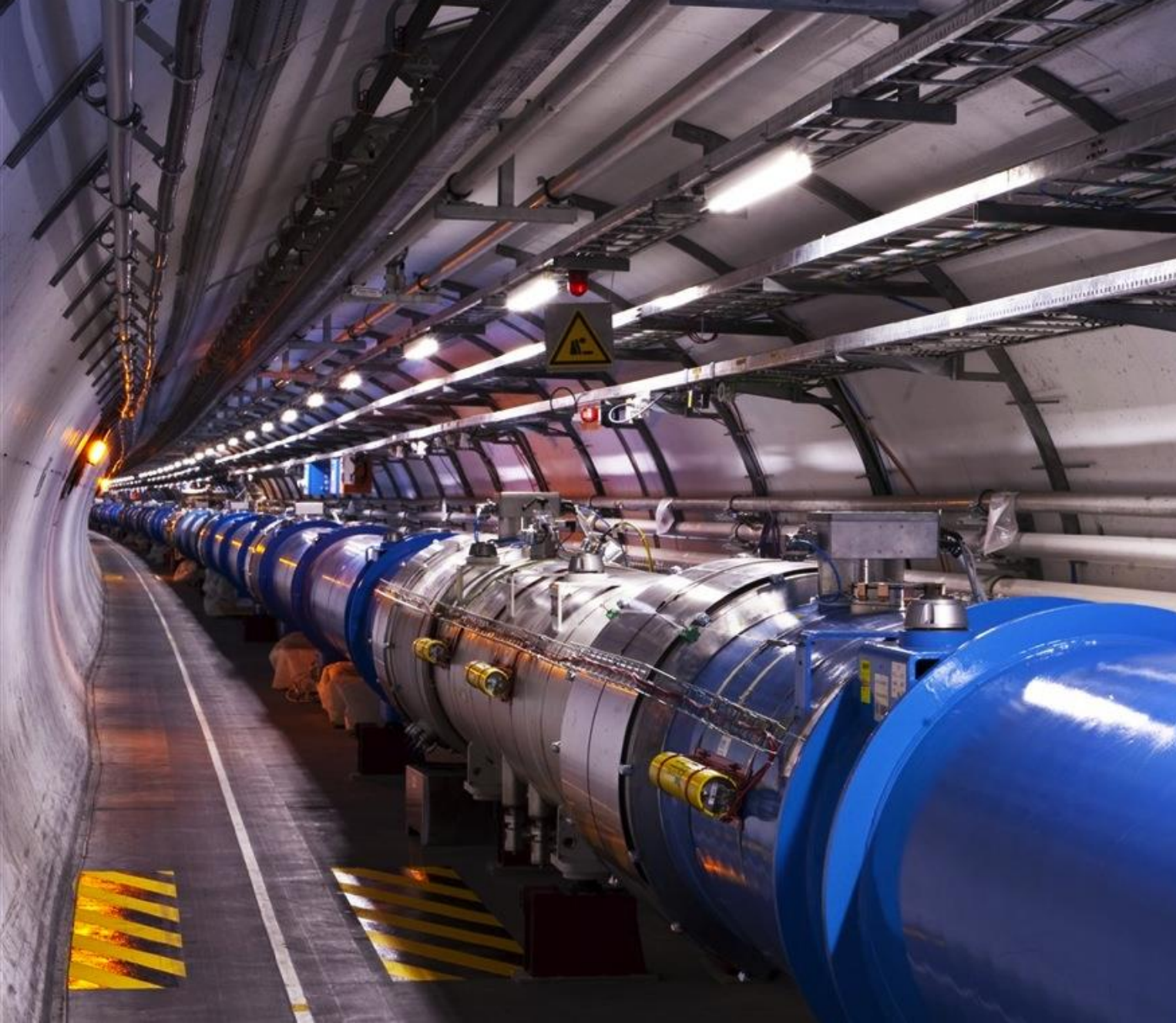
The CERN Accelerator Complex

LHC

- Situated on average ~100 m under ground

- Four major experiments

- Circumference 26.7 km

- Two separate beam pipes going through the same cold mass 19.4 cm apart

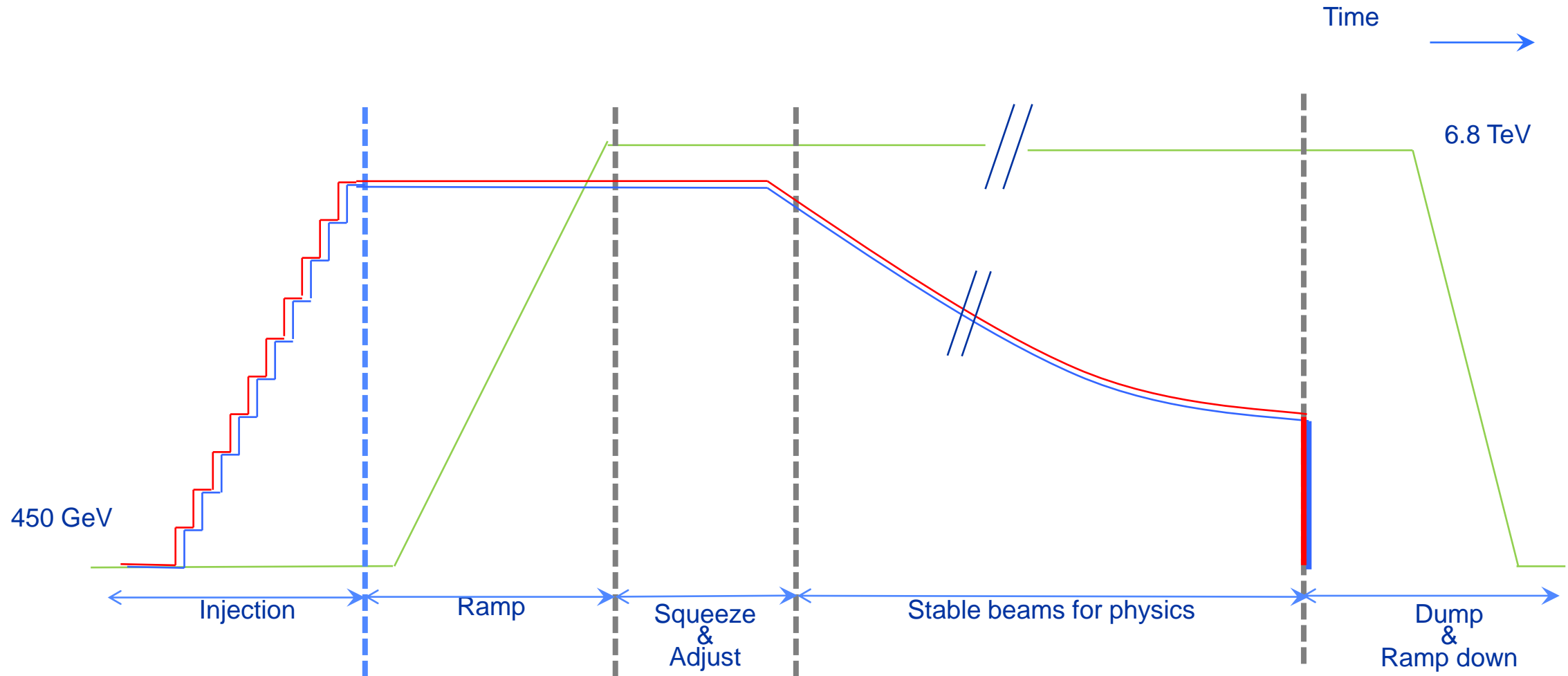- 150 tons of liquid helium to keep the magnets cold and superconducting

LHC

- 1232 main dipoles of 15 m each that deviate the beams around the 27 km circumference

- 858 main quadrupoles that keep the beam focused

- 6000 corrector magnets to preserve the beam quality

- Main magnets use superconducting cables (Cu-clad Nb-Ti)

- 12'000 A provides a nominal field of 8.33 Tesla

- Operating in superfluid helium at 1.9K

The LHC Cycle

Legend:
- = Field in main magnets
- = Beam 1 intensity (current)
- = Beam 2 intensity (current)

Time →

6.8 TeV

450 GeV

Injection | Ramp | Squeeze & Adjust | Stable beams for physics | Dump & Ramp down

Filling the LHC & Satisfying Fixed Target users