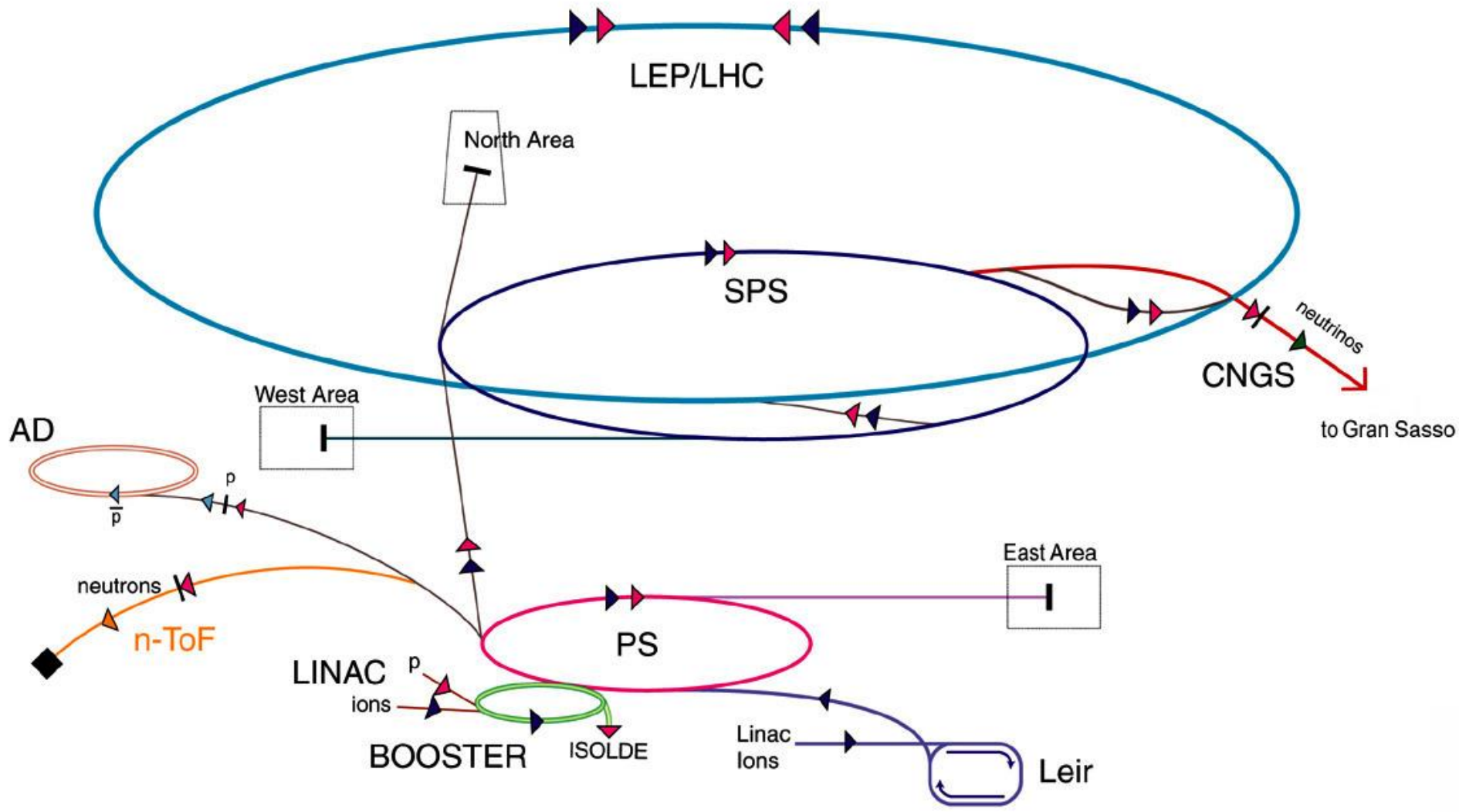


CERN accelerators



The CERN accelerators

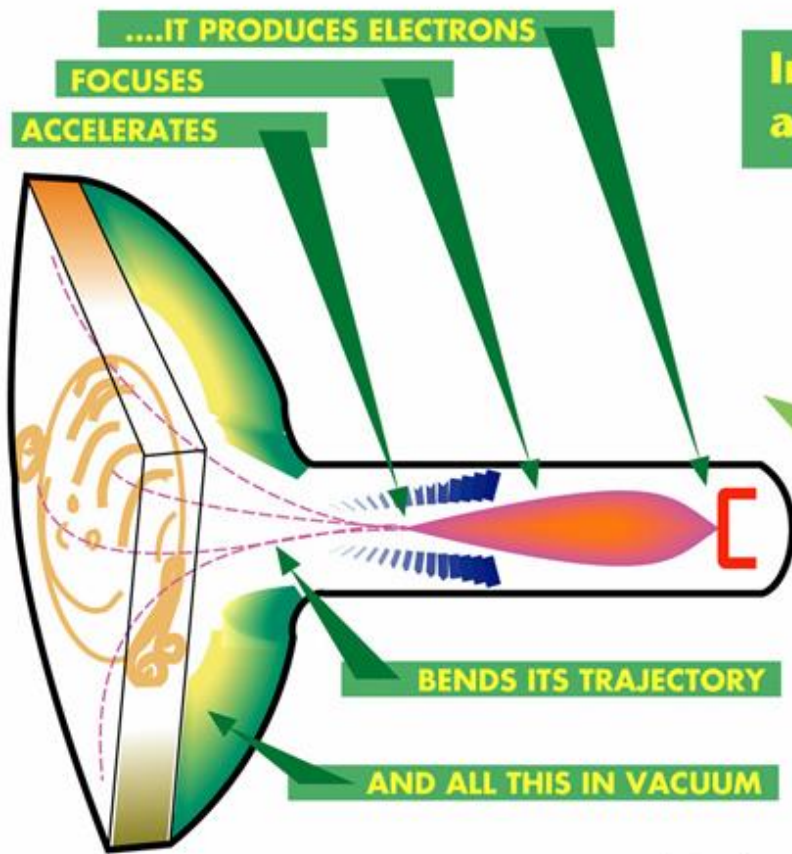


- ▶ p (proton)
- ▶ ion
- ▶ neutron
- ▶ \bar{p} (antiproton)
- ▶ ▶ proton/antiproton conversion
- ▶ neutrino

- AD Antiproton Decelerator
- PS Proton Synchrotron
- SPS Super Proton Synchrotron

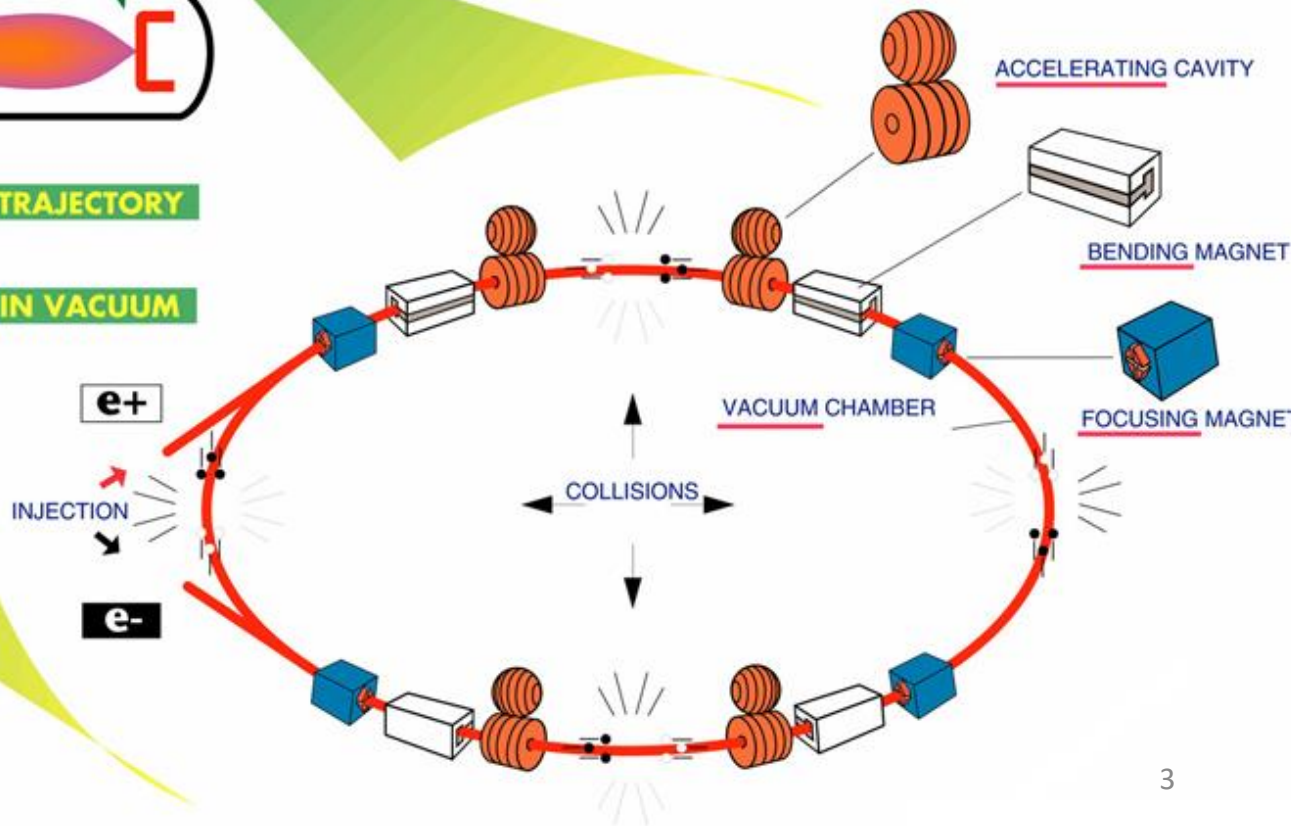
- LHC Large Hadron Collider
- n-ToF Neutron Time of Flight
- CNGS CERN Neutrinos to Gran Sasso²

DID YOU KNOW YOUR TELEVISION SET IS AN ACCELERATOR ?



In your TV set, the electrons are accelerated to 20000 volts.

In LEP, they are accelerated to 100 000 000 000 volts.





8 radiofrequency (RF) cavities for each beam, installed in groups of 4 in cryomodules, accelerate the beams

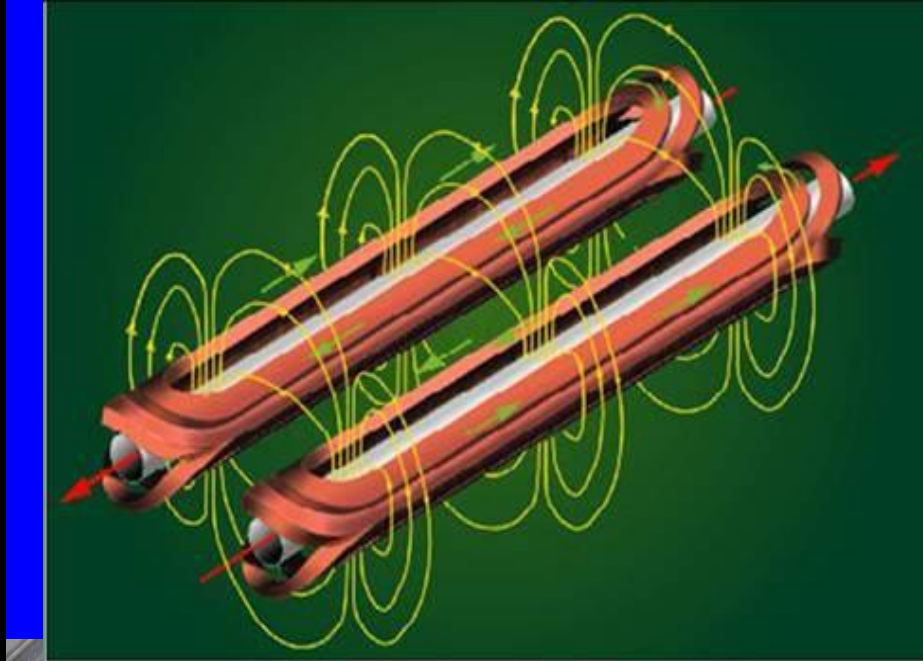
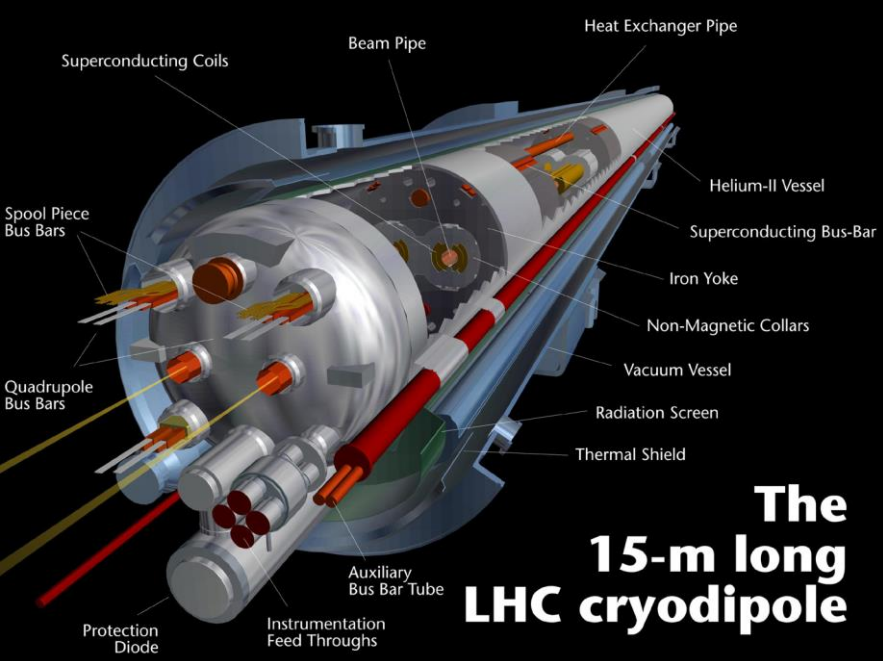
Each delivers 2 MV
Frequency : 400 MHz

The RF cavities are superconducting, cooled at 4.5 K

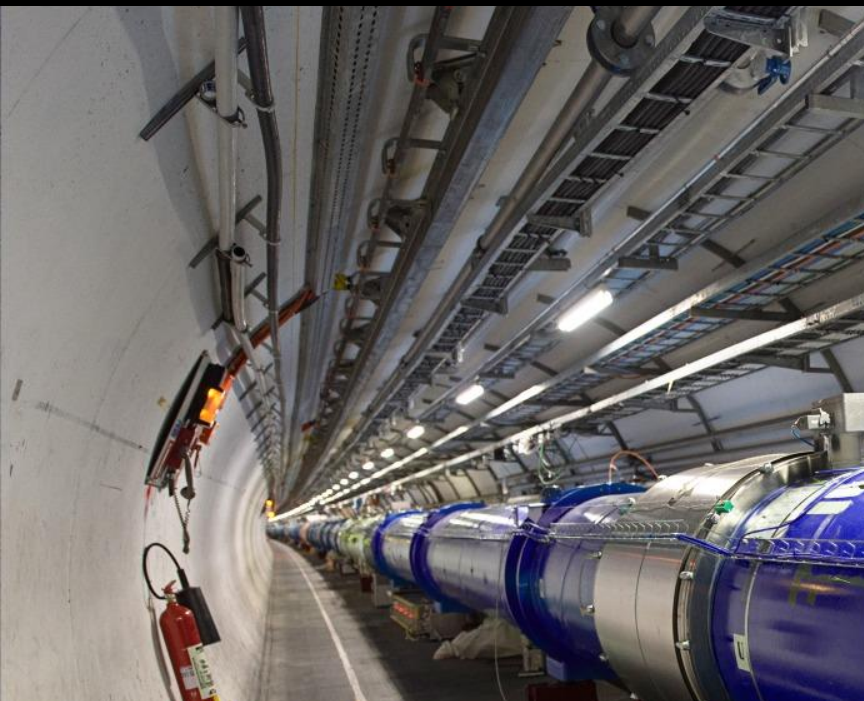
The beams circulate in specially designed beam pipes, with very high vacuum, 10^{-13} atm

<https://videos.cern.ch/record/1709737>





8.3 Tesla for 7 TeV beams; ~ 12 000 A needed

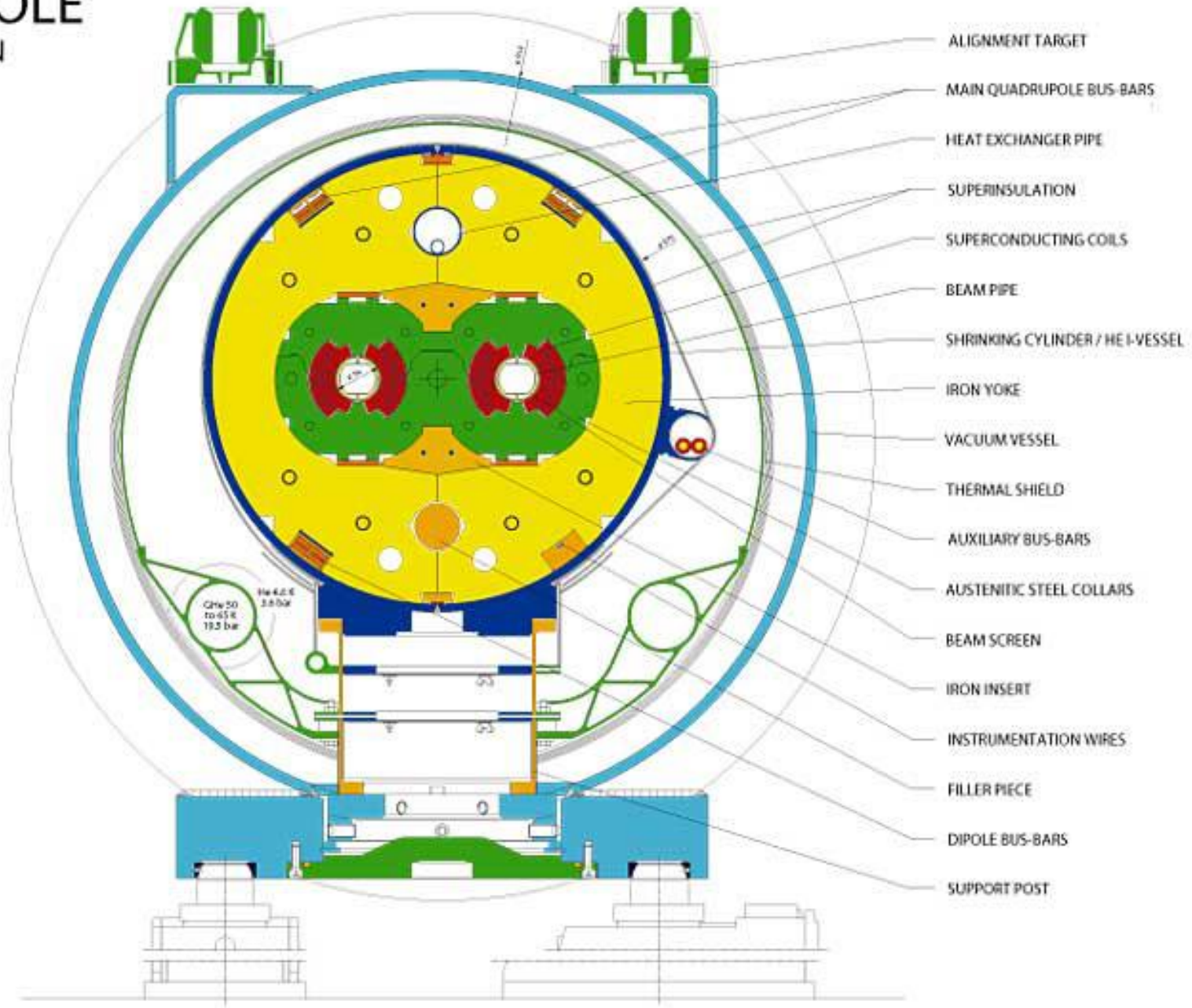


1232 magnetic dipoles bend the beams



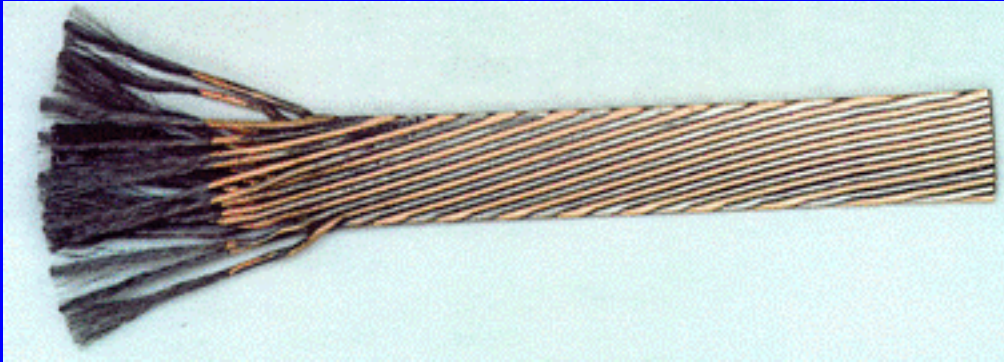
<https://videos.cern.ch/record/1709735>

LHC DIPOLE CROSS SECTION



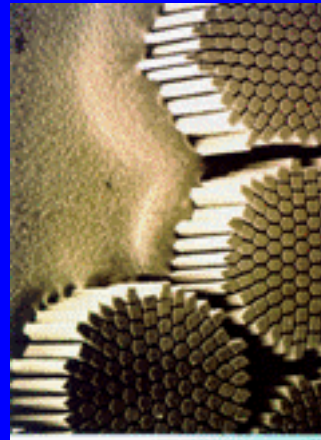
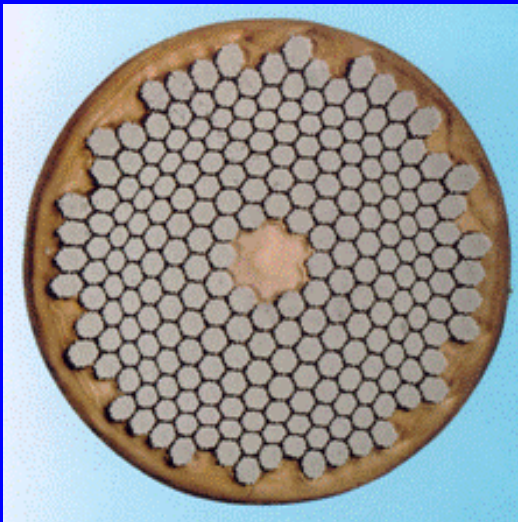
- ALIGNMENT TARGET
- MAIN QUADRUPOLE BUS-BARS
- HEAT EXCHANGER PIPE
- SUPERINSULATION
- SUPERCONDUCTING COILS
- BEAM PIPE
- SHRINKING CYLINDER / HE I-VESSEL
- IRON YOKE
- VACUUM VESSEL
- THERMAL SHIELD
- AUXILIARY BUS-BARS
- AUSTENITIC STEEL COLLARS
- BEAM SCREEN
- IRON INSERT
- INSTRUMENTATION WIRES
- FILLER PIECE
- DIPOLE BUS-BARS
- SUPPORT POST

Superconducting cable : zero resistance; no losses (no heat)



- 1200 tons of superconducting cable
- 7600 km of cable
- Total length of filaments : 10 times the distance earth - sun

Rutherford cable : 36 strands



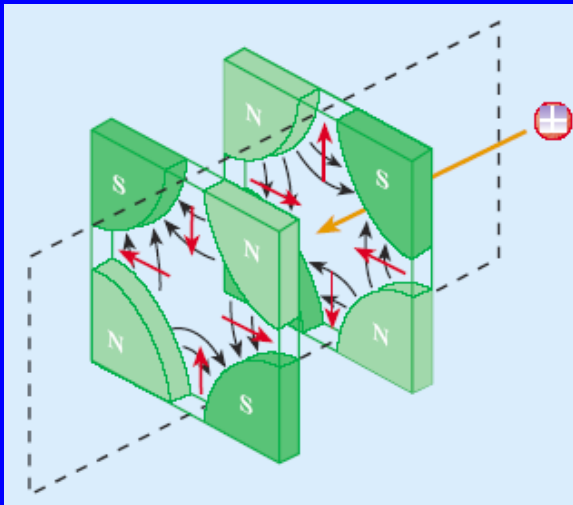
Cryogenics

- Cooled with 5000 tons of liquid Helium at 1.9 K
- 10000 tons of liquid Nitrogen cool the gaseous Helium to 80 K

Each strand ($d = 0.825$ mm) \sim 6500 filaments ($d = 8$ μ m)
Niobium – Titanium superconducting filament
(+ 0.5 μ m layer of high-purity copper)



quadrupole magnets focus the beams



<https://videos.cern.ch/record/1709736>

Proton Duoplasmatron source <https://videos.cern.ch/record/1750714>

Linac accelerating cavity <https://videos.cern.ch/record/1750713>

PS booster <https://videos.cern.ch/record/1750712>

Proton Synchrotron (PS) <https://videos.cern.ch/record/1750711>

Super Proton Synchrotron (SPS) <https://videos.cern.ch/record/1750710>

Large Hadron Collider (LHC) <https://videos.cern.ch/record/1750708>

Beam visualisation screens <https://videos.cern.ch/record/1750709>

Wire scanners for beam diagnostics <https://videos.cern.ch/record/1750707>

LHC dipole magnets <https://videos.cern.ch/record/1750706>

LHC quadrupole magnets <https://videos.cern.ch/record/1750723>

LHC accelerating cavities <https://videos.cern.ch/record/1750705>

Collimators <https://videos.cern.ch/record/1750704>

Current lead <https://videos.cern.ch/record/1709734>