STRONG FOCUSING SYNCHROTRON

A BRIEF INTRODUCTION

- ORIGINS, PRINCIPLE
- COMBINED/SEPARATED FUNCTION
- SF-SYNCHROTRON TODAY

Bibliography

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[] USPAS archives
[] National Lab sites, US, EU
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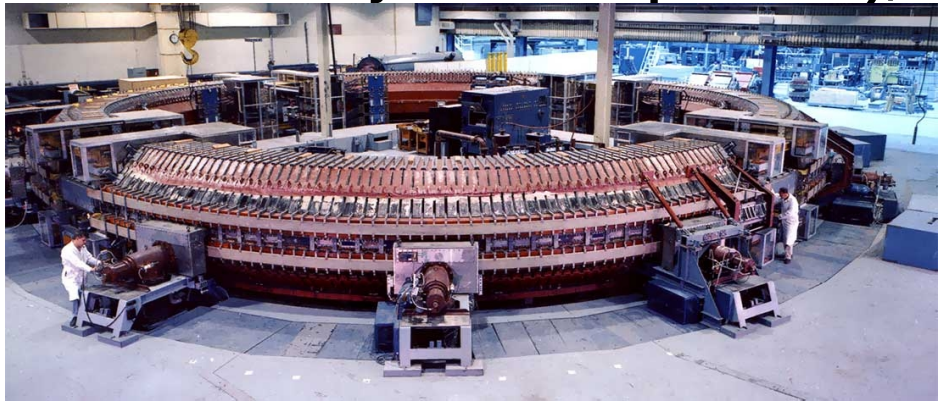
Synchrotron landscape, when strong focusing was invented, 1950

Cosmotron at BNL, 1952-1968, 3.3 GeV, the first GeV+ accelerator (beam to target, cosmic rays' mesons, heavy unstable particles),

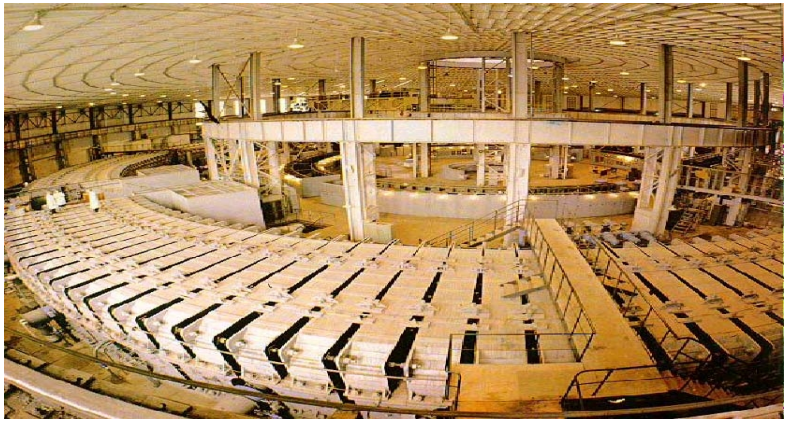


occupied the front of the scene.

and Bevatron at Berkley, 1954-1993, 6 GeV, 10,000 tons of iron (discovery of antiproton, of antineutron),

Even more ! In spite of that invention:

Synchrophasatron in Dubna (10GeV, 1957-2003!), Saturne in France (3GeV, 1958), ZGS at Argonne (12GeV, 1963!-1979), Nimrod in the UK (8 GeV, 1964!-1978) would be built.



Genesis

- **Strong focusing was patented in 1950, in Greece and USA**

- **At BNL it was desired to alternate the COSMOTRON C-shaped yokes opening (all were outward), looking alternately outward and inward ... It was realized that nothing precluded strongly increasing the gradient, from its weak 0<n<1 to a strong |n|>>1 with alternate sign. That's how it was discovered there in 1953**

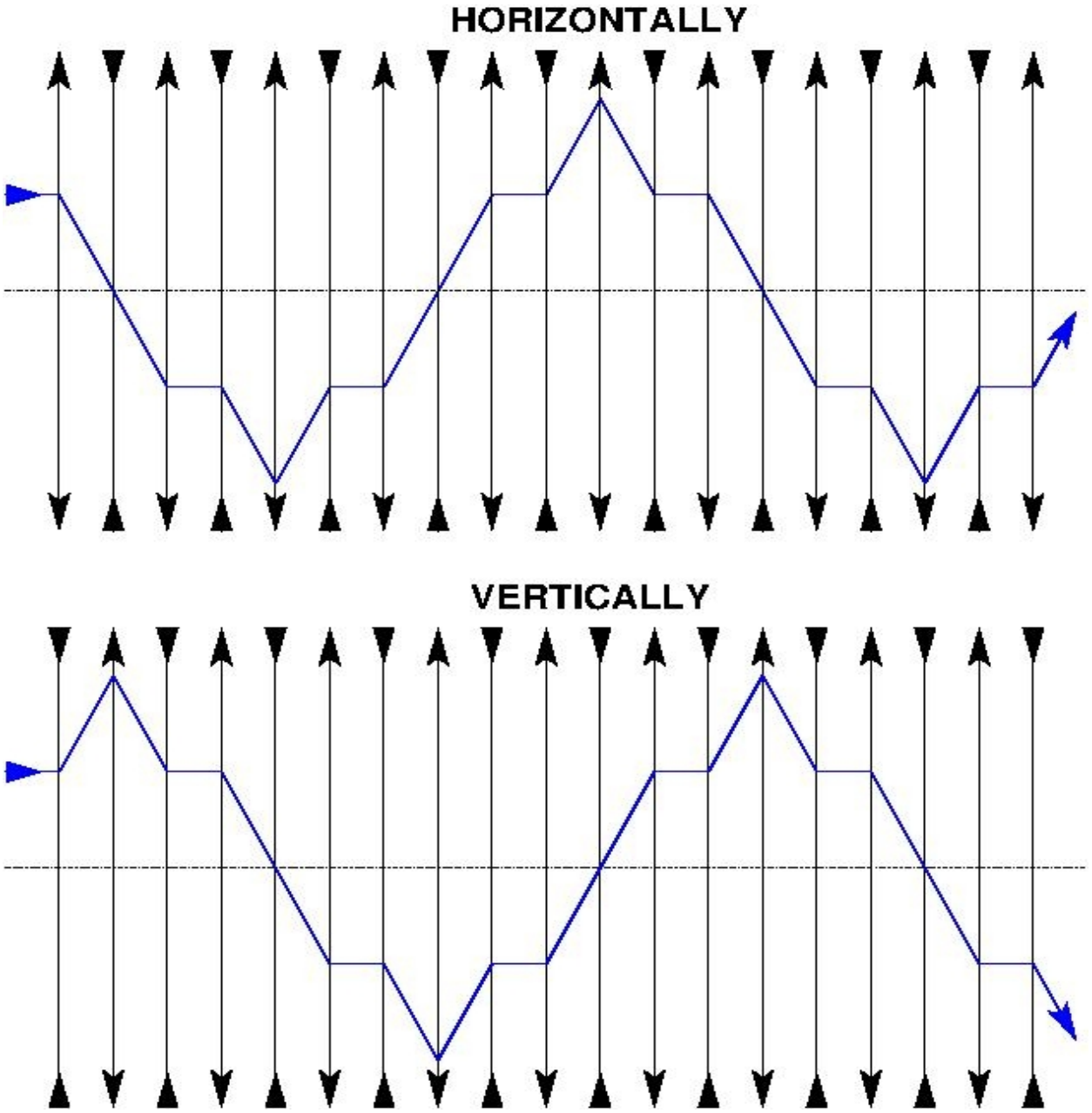
- **CERN visitors brought the idea back there, this led to the CERN PS, 25 GeV, started in 1959.**

Transition was an issue... it was solved on the fly by the PS group

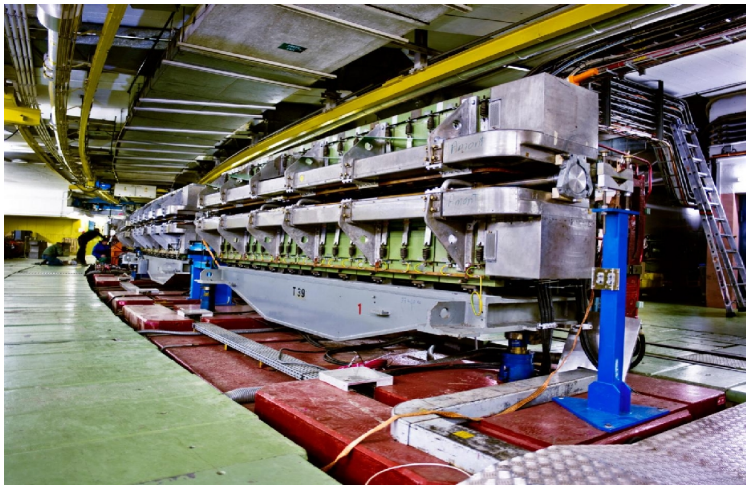
Today CERN PS is part of the injector chain to LHC

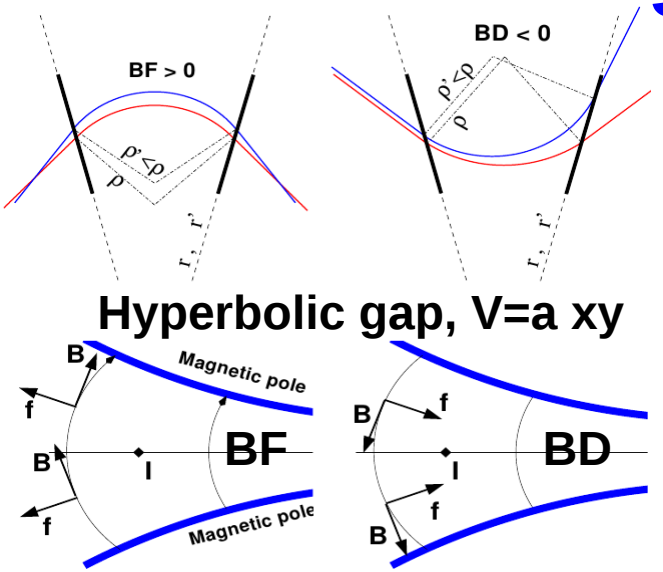
- **BNL AGS was switched on in 1960.**

Key element: strong index, alternating



Strong index dipole + alternating gradient

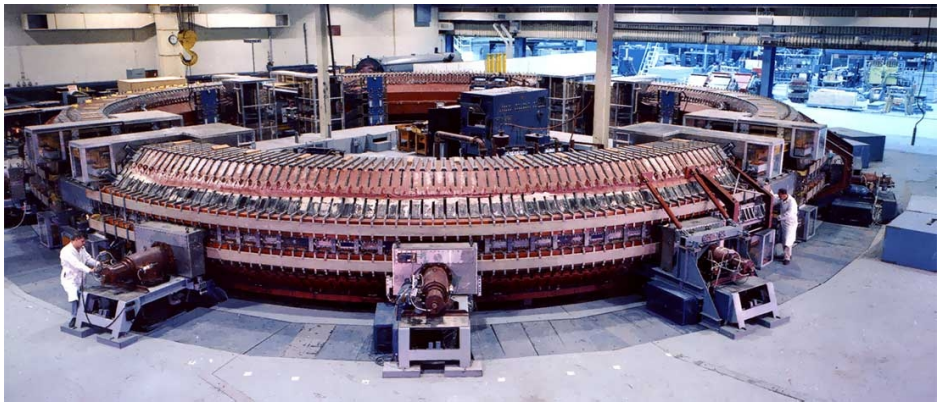




PS (1959, same combined function magnet as AGS, 1960), 30 GeV: few cm diameter vacuum chamber

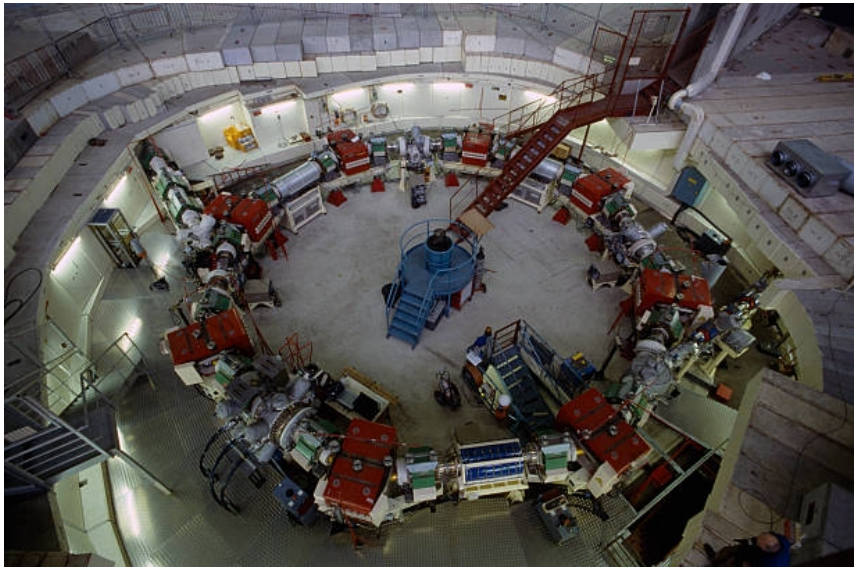
Compare the dipoles:

Cosmotron, 3 GeV: 1.22mx0.22m vacuum chamber



Compare SATURNE 1, weak focusing and SATURNE 2, strong focusing

Mimas injector of polarized particles, of the Saturn Synchrotron at the Atomic Energy Center (CEA) in Saclay. First beam March 02, 1988 License



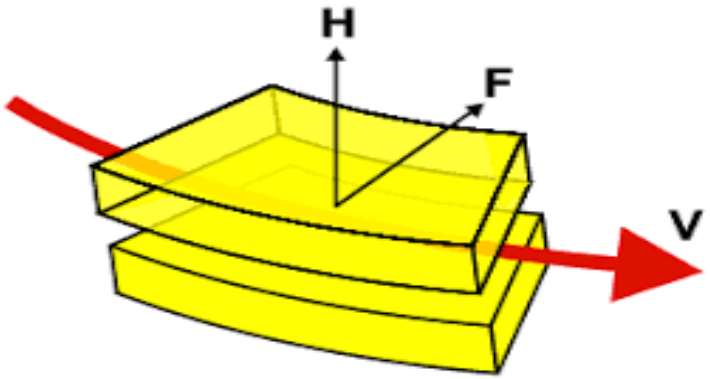
SATURNE 2, second (after ZGS) polarized proton synnchrotron. Same E as SAT1: 3GeV.

Same location,
same circumference (109 vs 105 m),
same energy (3 GeV)

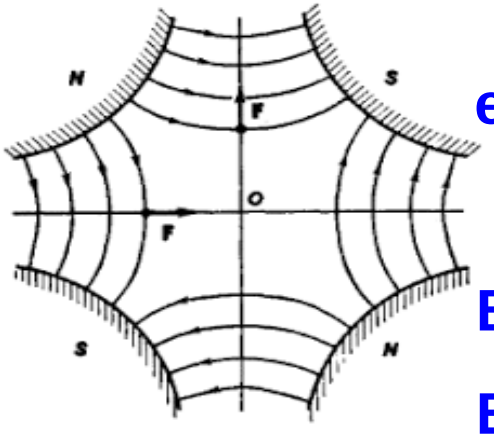
The concept evolved, from "combined function" to "separated function" optics

Dipole: steering

Quadrupole: strong focusing



dipole



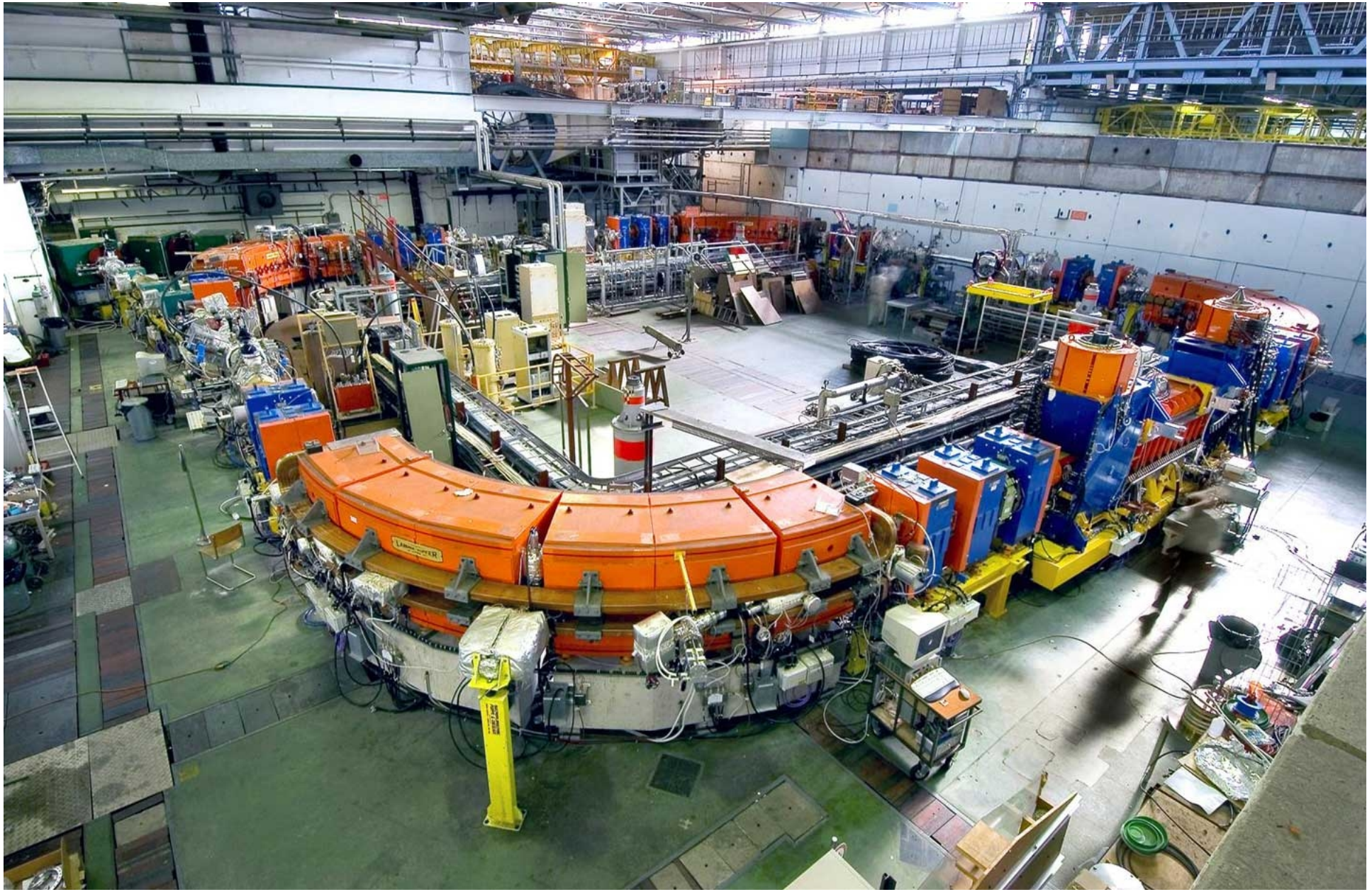
Parabolic equipotential:

$V = Gxy$

$B_x = dV/dx = Gy$

$B_y = dV/dy = Gx$

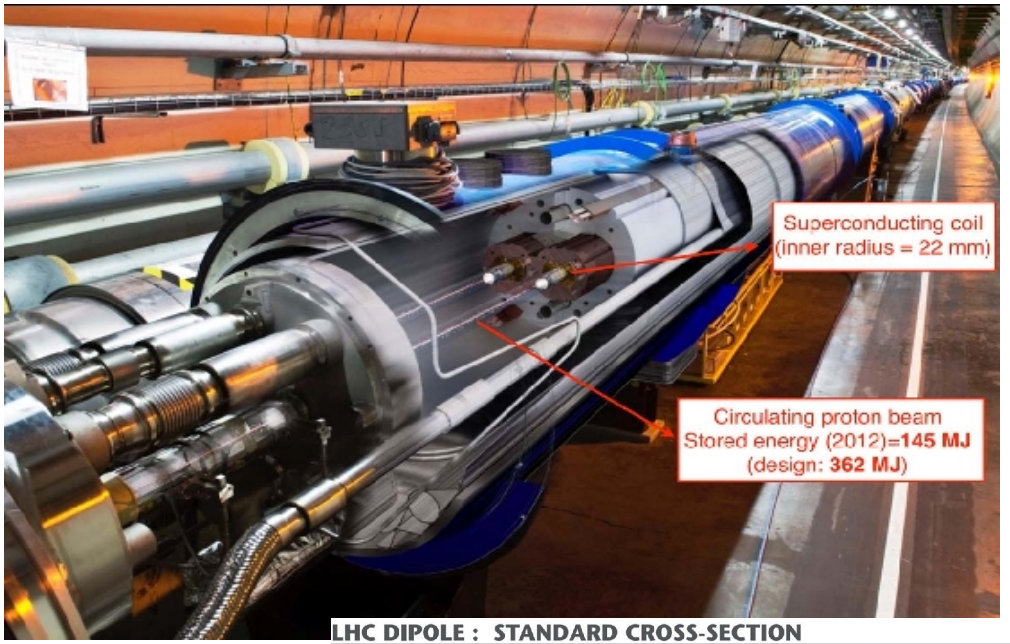
Separated function optics at LEIR



Cryo-magnetism today

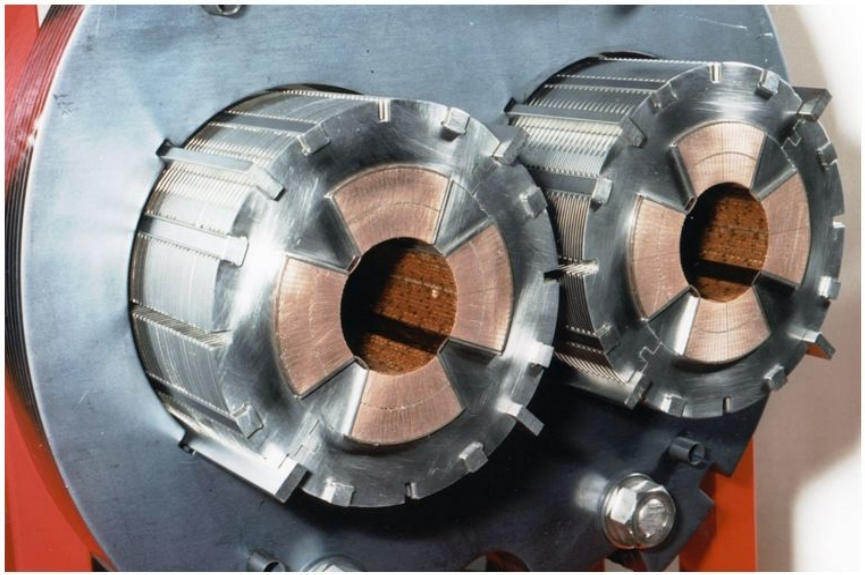
LHC, circumference 27km, E=7TeV

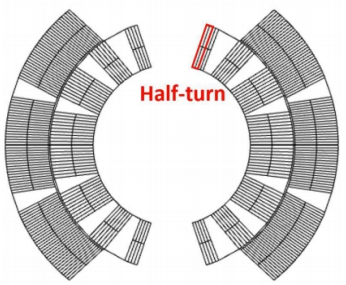
LHC dipole, 8.32 T (1232 units)



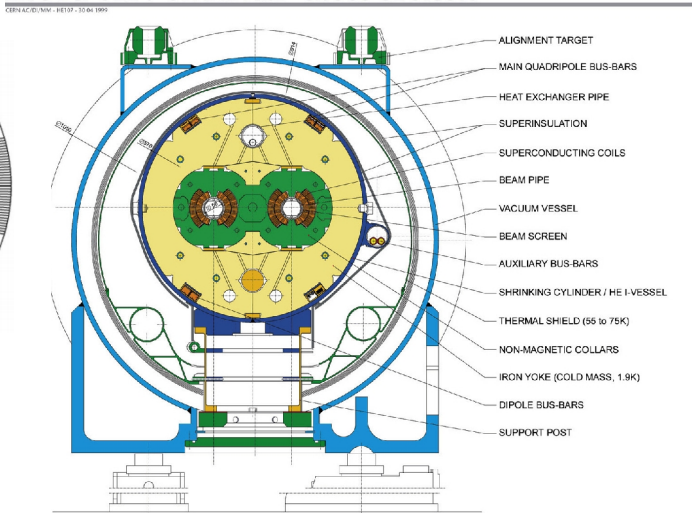
LHC quadrupoles (392 units)

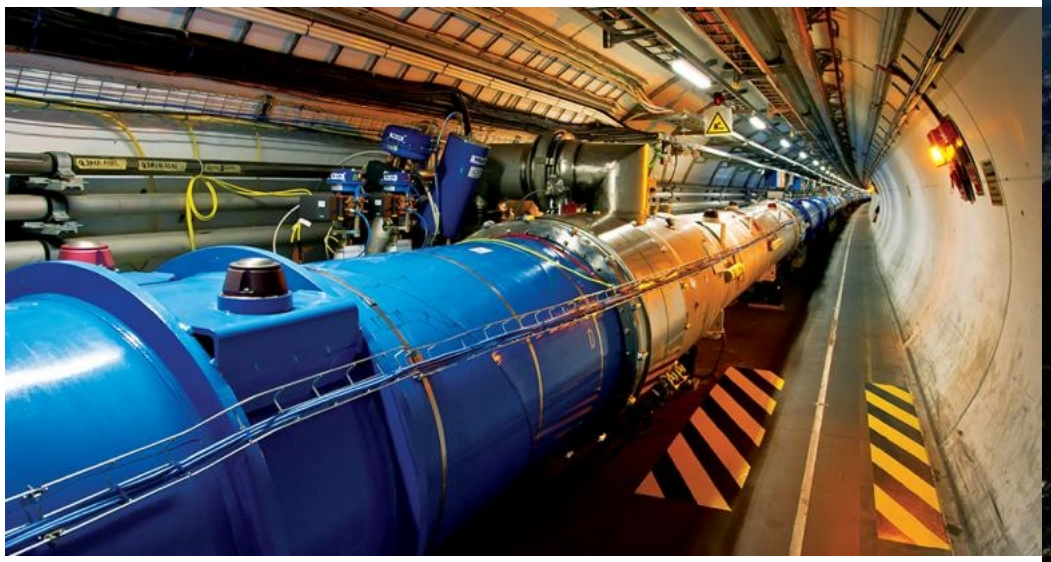
This is a cross section of a main quadrupole of the LHC at CERN: 223 T/m × 3.2 m

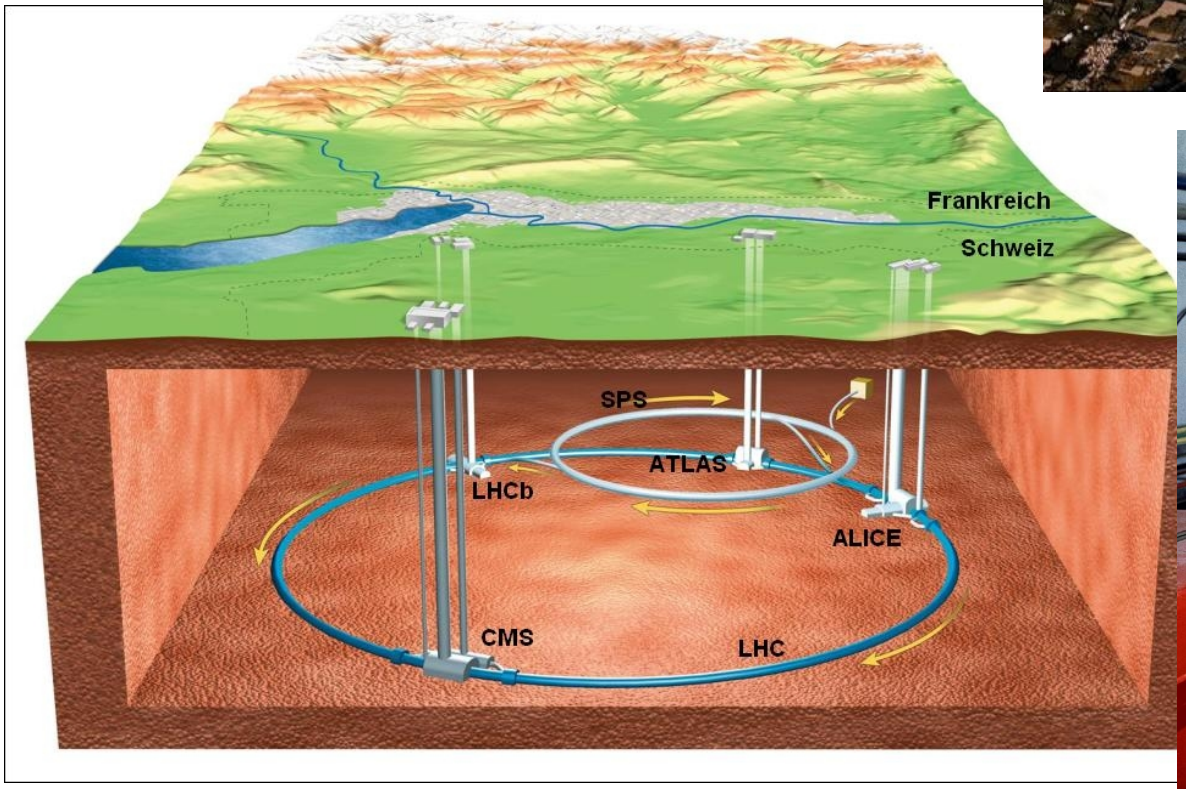




Aperture Φ56mm



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