STRONG FOCUSING SYNCHROTRON

A BRIEF INTRODUCTION

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

Bibliography

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[] JACoW http://www.jacow.org/
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http://www.esi-archamps.eu/Thematic-Schools/Discover-JUAS
[] USPAS archives
[] National Lab sites, US, EU
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[] Wikipedia
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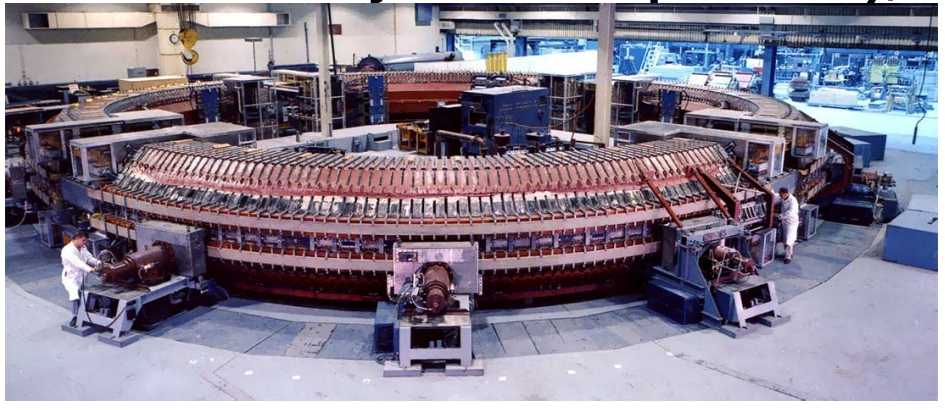
Synchrotron landscape, when strong focusing was invented, 1950

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

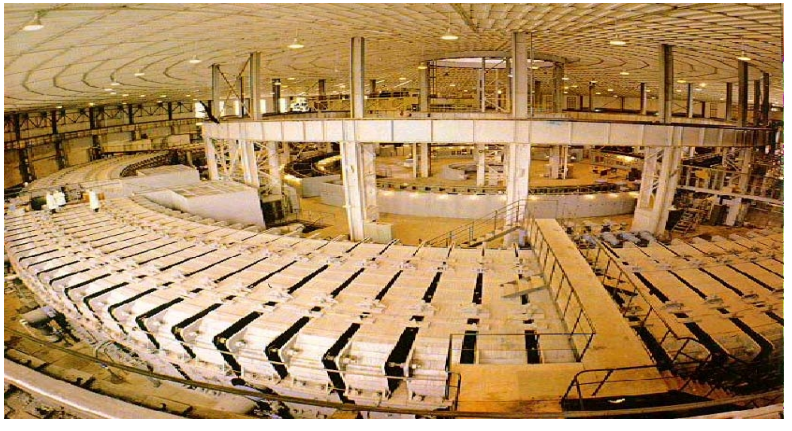


occupied the front of the scene.

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**

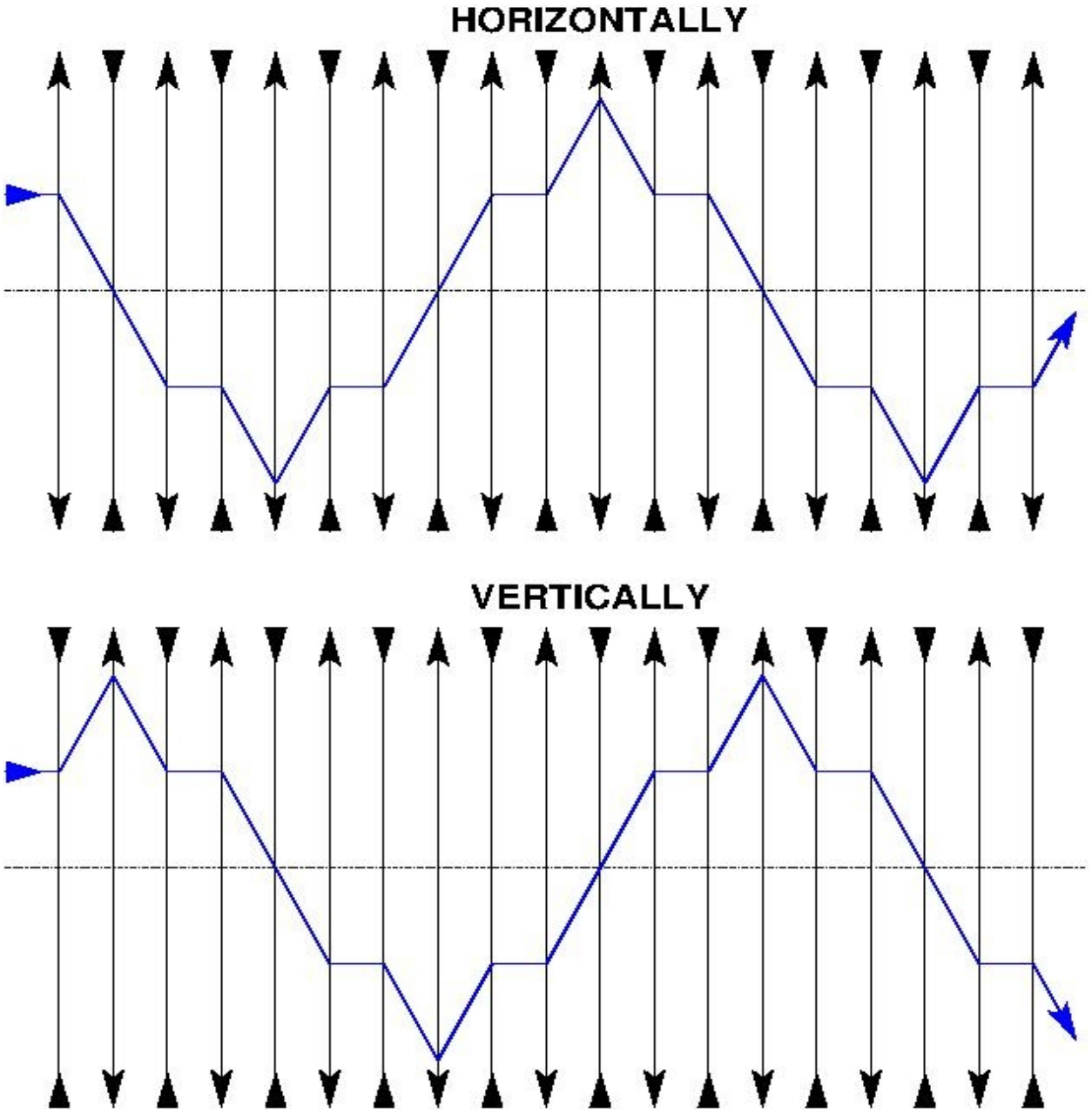
- **CERN visitors brought the idea back there, this led to the CERN PS, 25 GeV, started in 1959.**

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

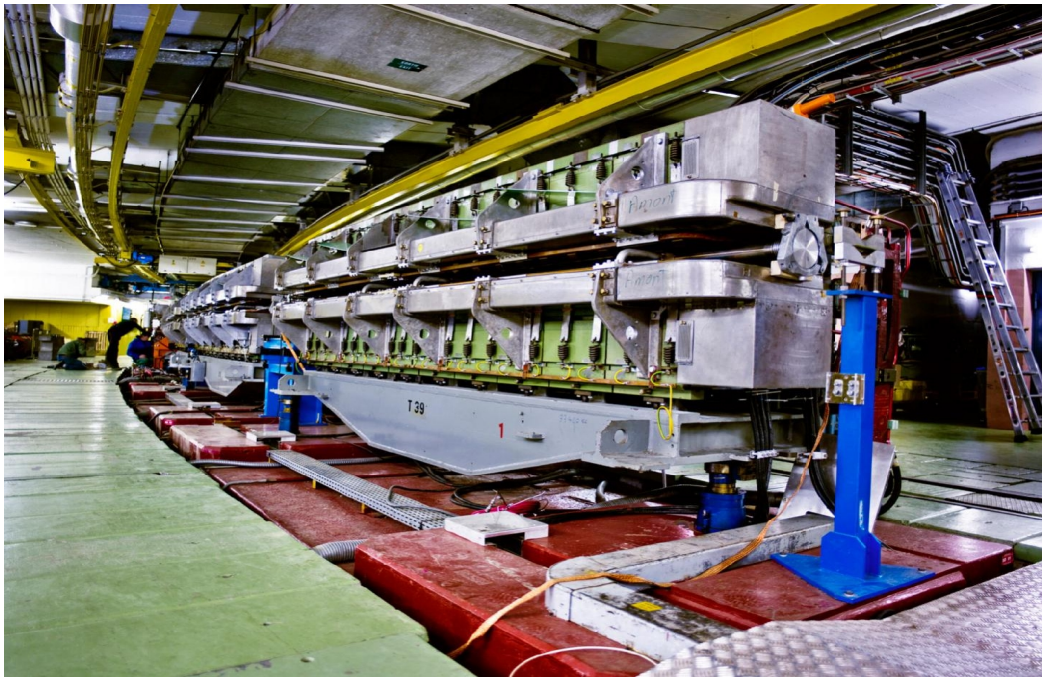
Today CERN PS is part of the injector chain to LHC

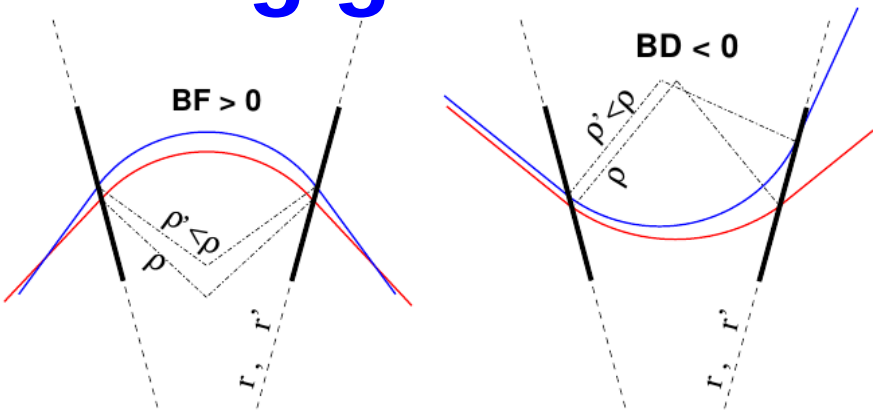
- **BNL AGS was switched on in 1960.**

Key element: strong index, alternating

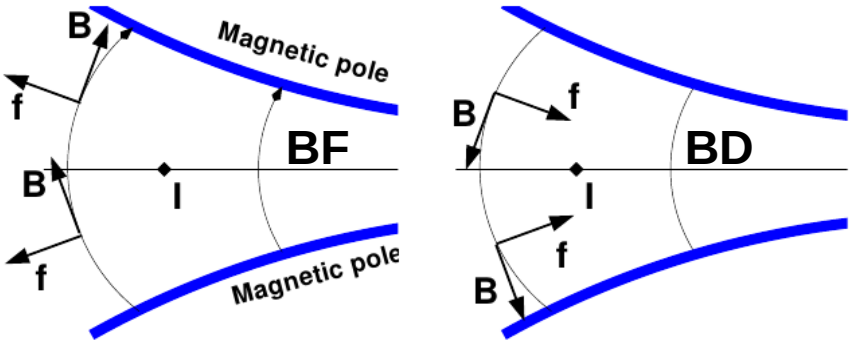


Strong index dipole + alternating gradient





Hyperbolic gap



Compare the dipoles:

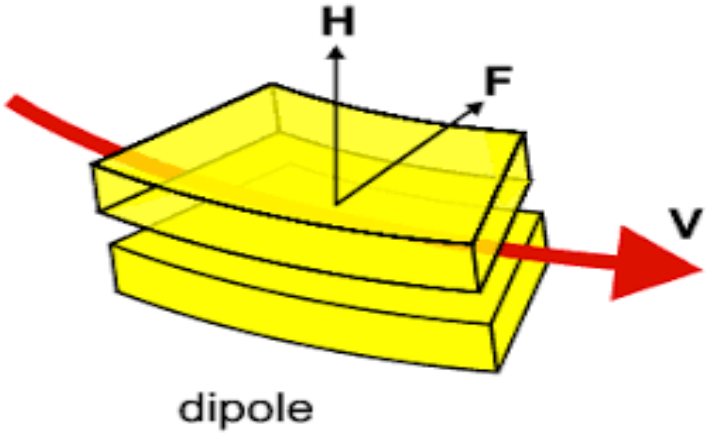
Cosmotron, 3 GeV
1.22mx0.22m vacuum chamber

AGS, 30 GeV
1.22mx0.22m vacuum chamber

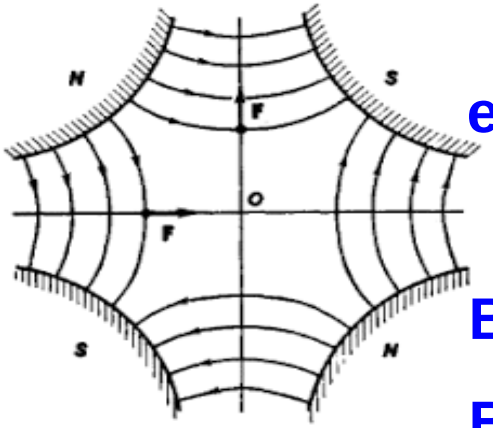
gap /10, field *10 for the same current

The concept evolve into separated function optics

Dipole: steering



Quadrupole:



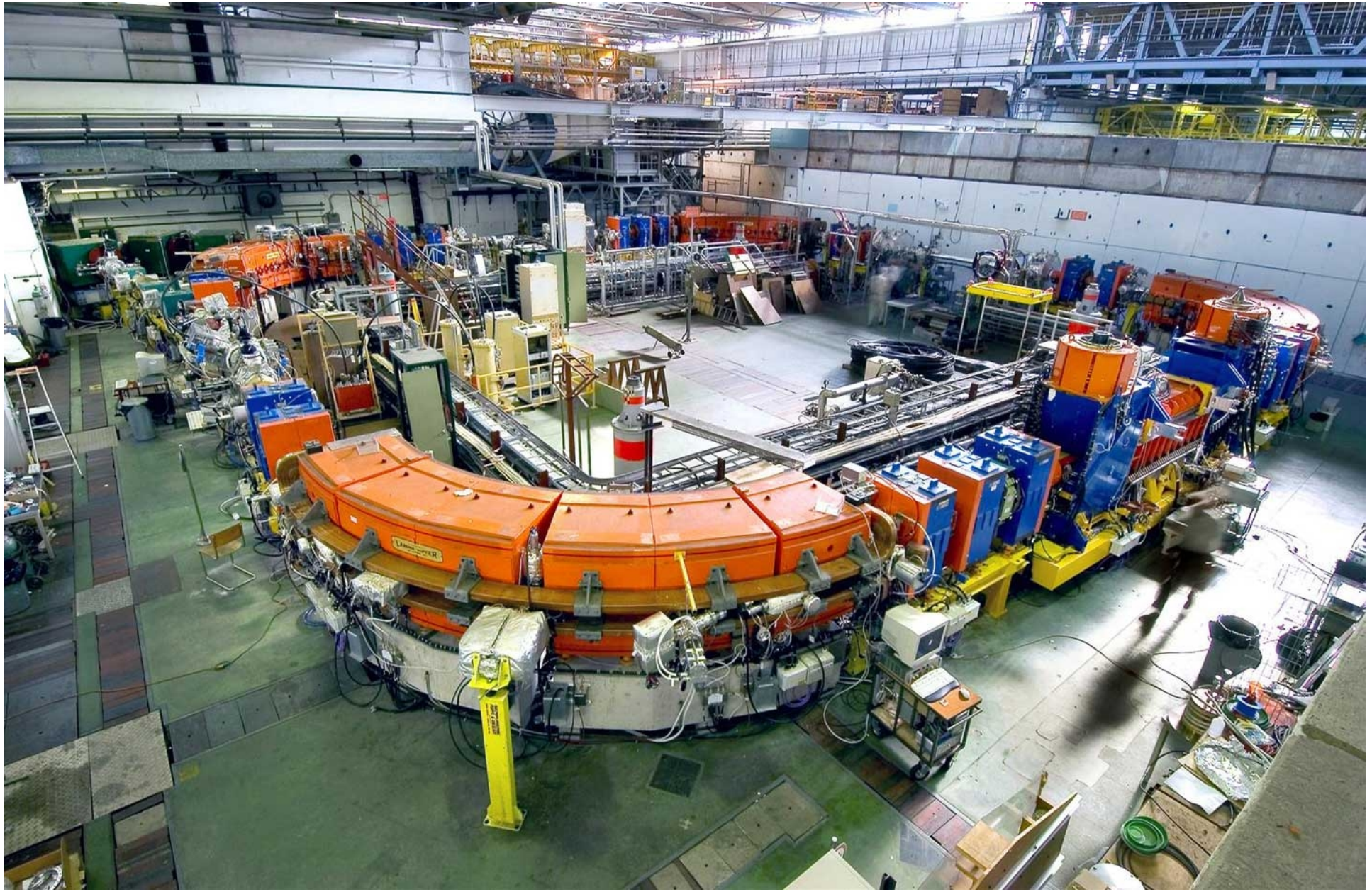
Parabolic equipotential:

V=Gxy

Bx=dV/dx=Gy

By=dV/dy=Gx

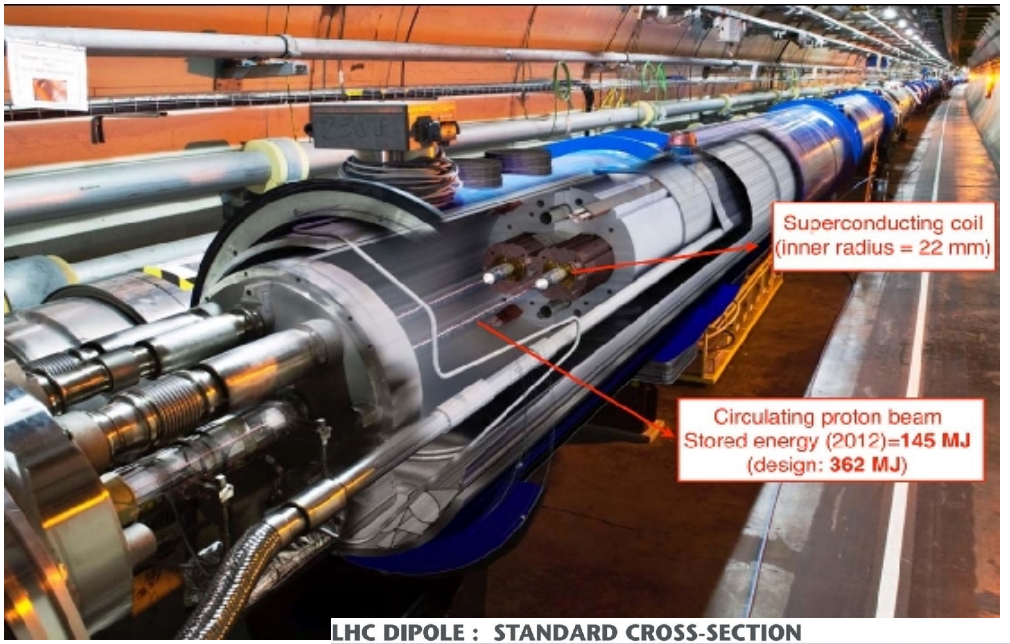
Separated function optics at LEIR



Cryo-magnetism today

LHC, circumference 27km, E=7TeV

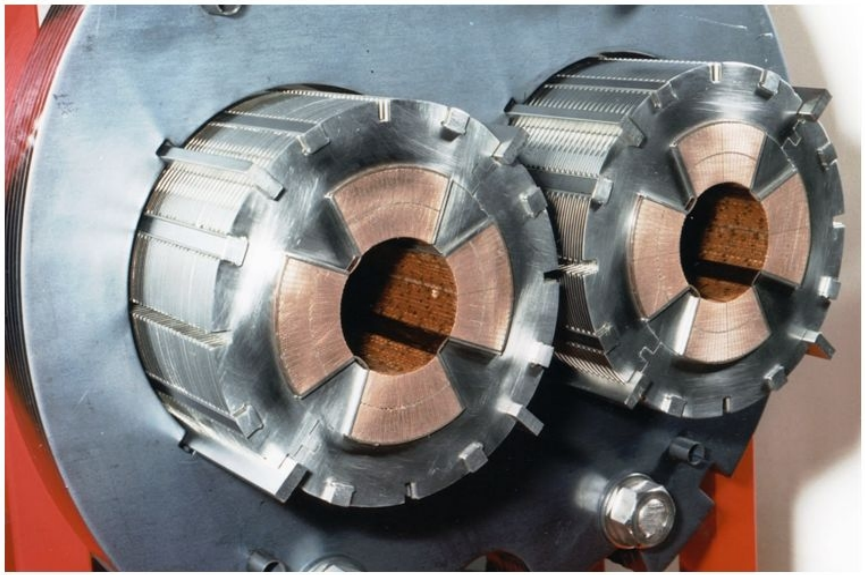
LHC dipole, 8.32 T

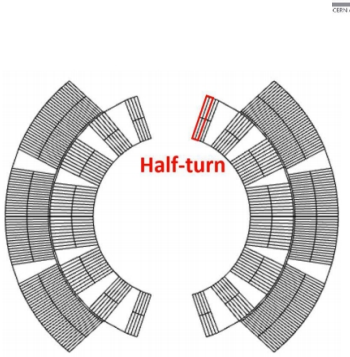


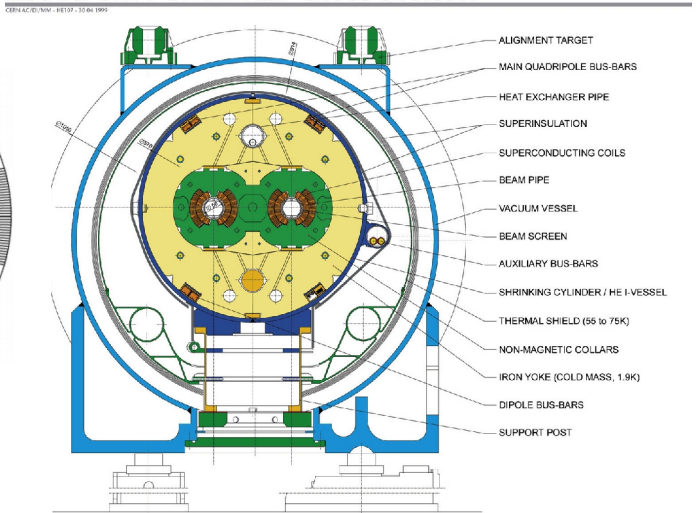
LHC quadrupoles

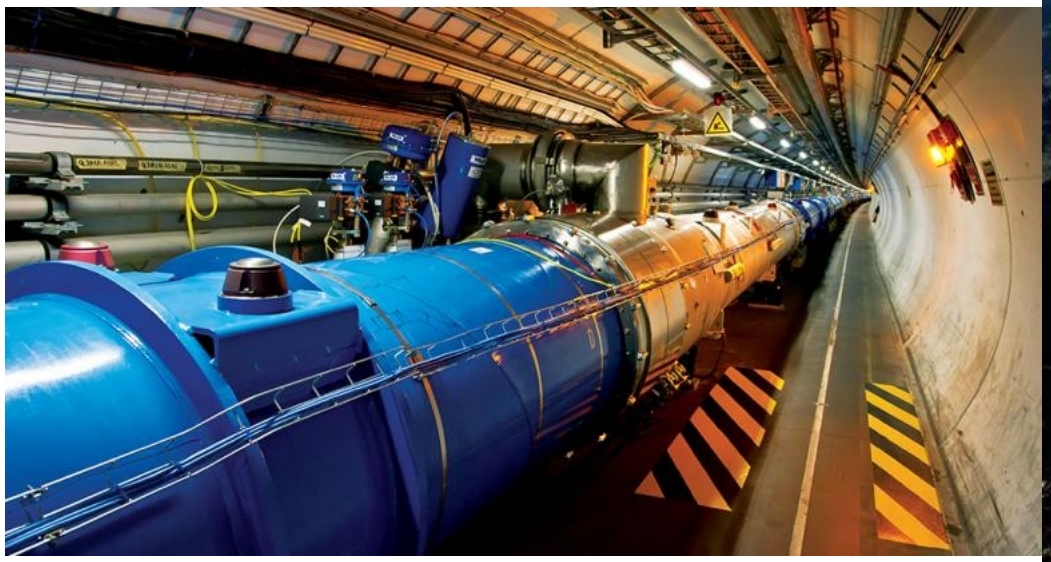
Bore ~5 cm

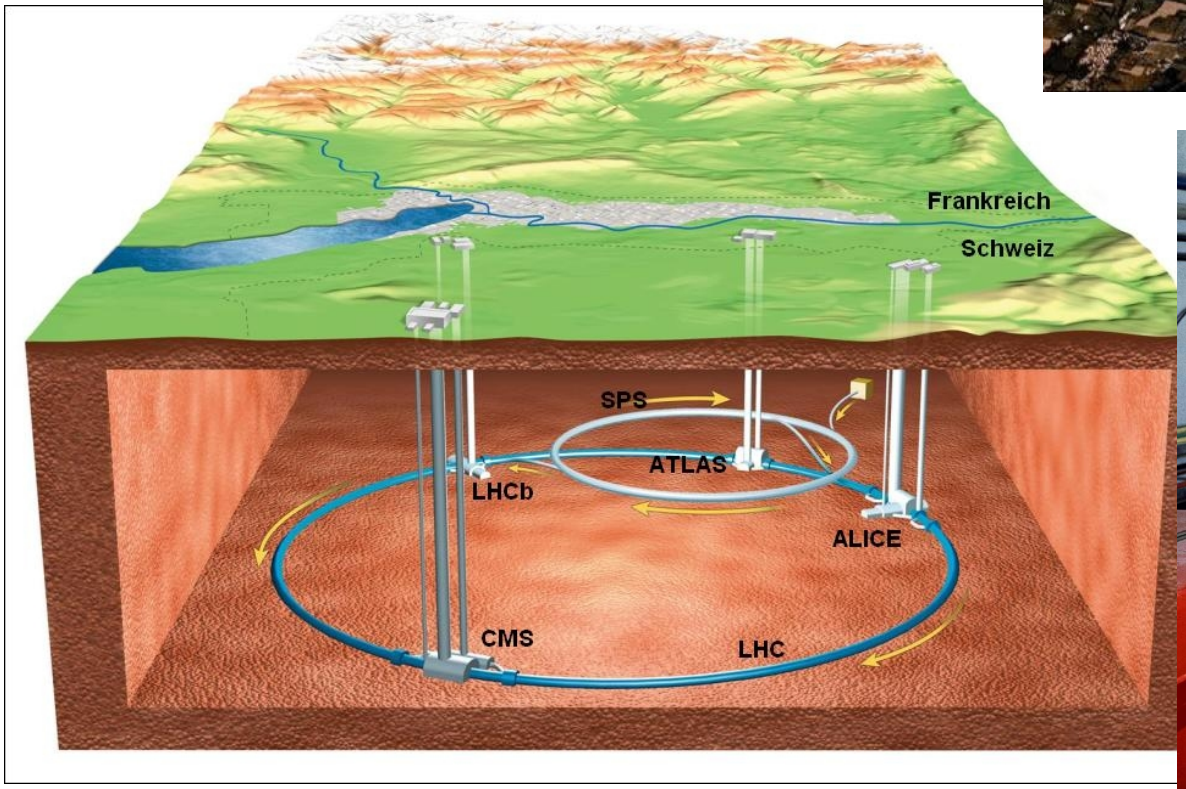
This is a cross section of a main quadrupole of the LHC at CERN: 223 T/m × 3.2 m







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