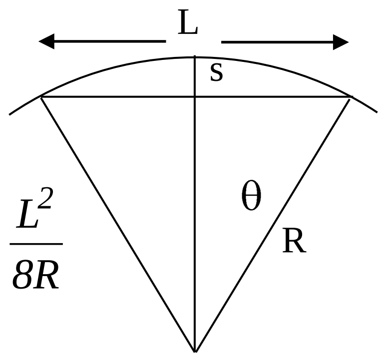
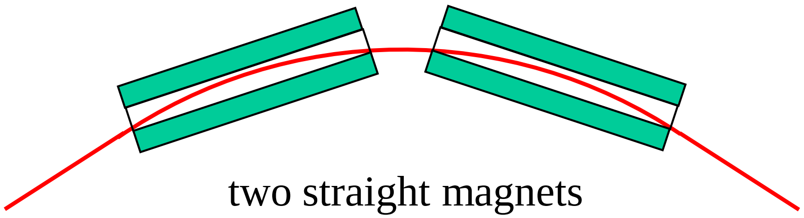
Problem of the sagitta in SIS300



$$s = \frac{L^2}{8R}$$

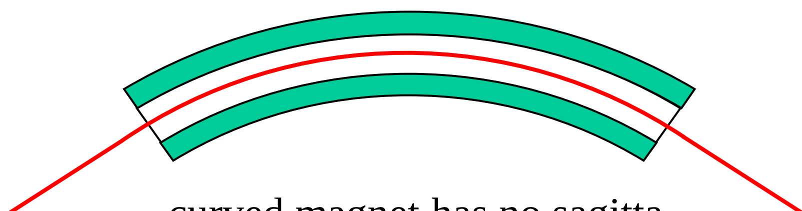


two straight magnets

must be short because of sagitta

$\Rightarrow$ B = 6T

must use double layer coil



curved magnet has no sagitta,

can be long, save space of end turns

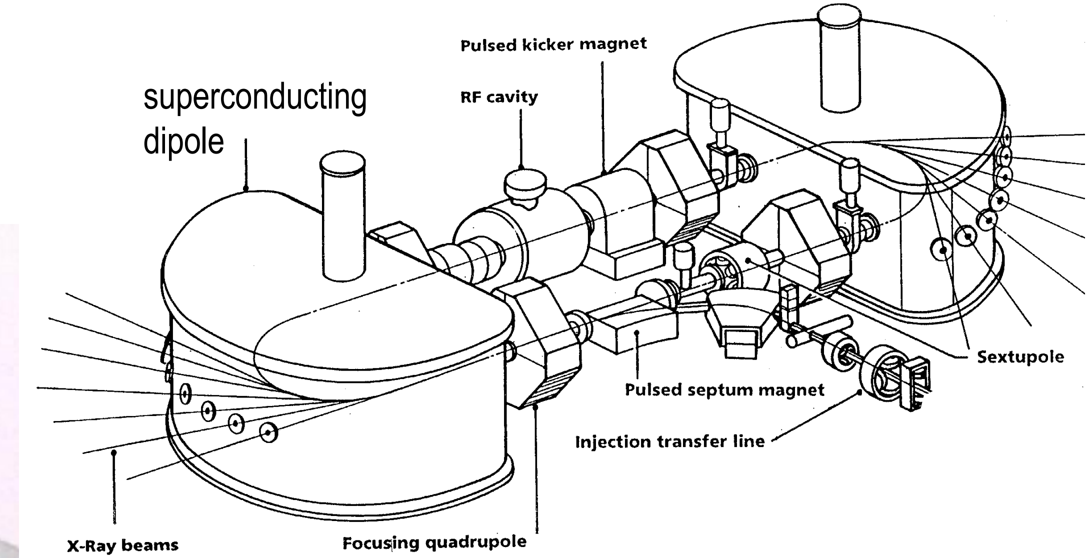
$\Rightarrow$ B = 4.5T

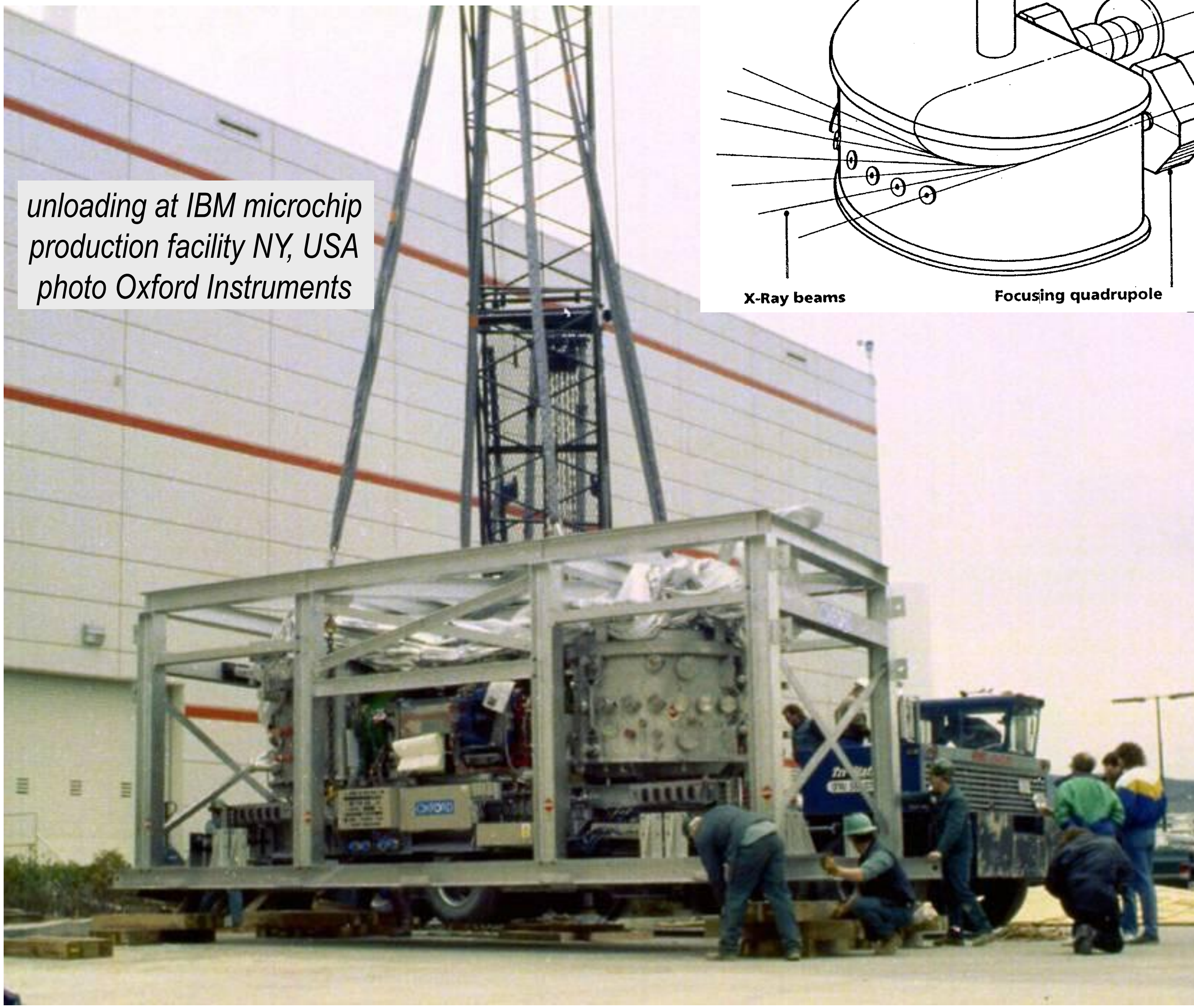
can use single layer coil

Discorap curved dipole INFN Frascati / Ansaldo

Helios

synchrotron X-ray source





unloading at IBM microchip production facility NY, USA photo Oxford Instruments

superconducting dipoles

$\Rightarrow$ high field

$\Rightarrow$ tight bending radius

$\Rightarrow$ compact size

$\Rightarrow$ transportability

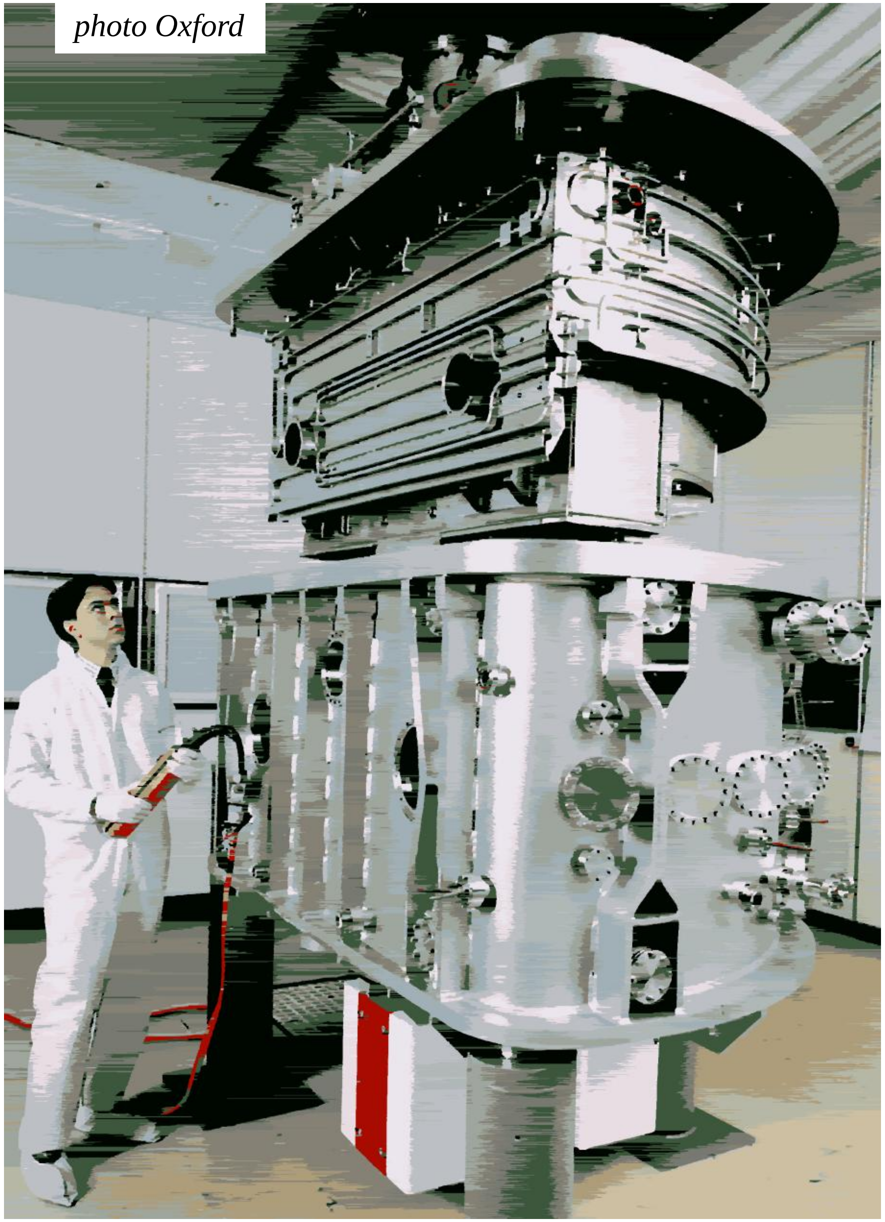
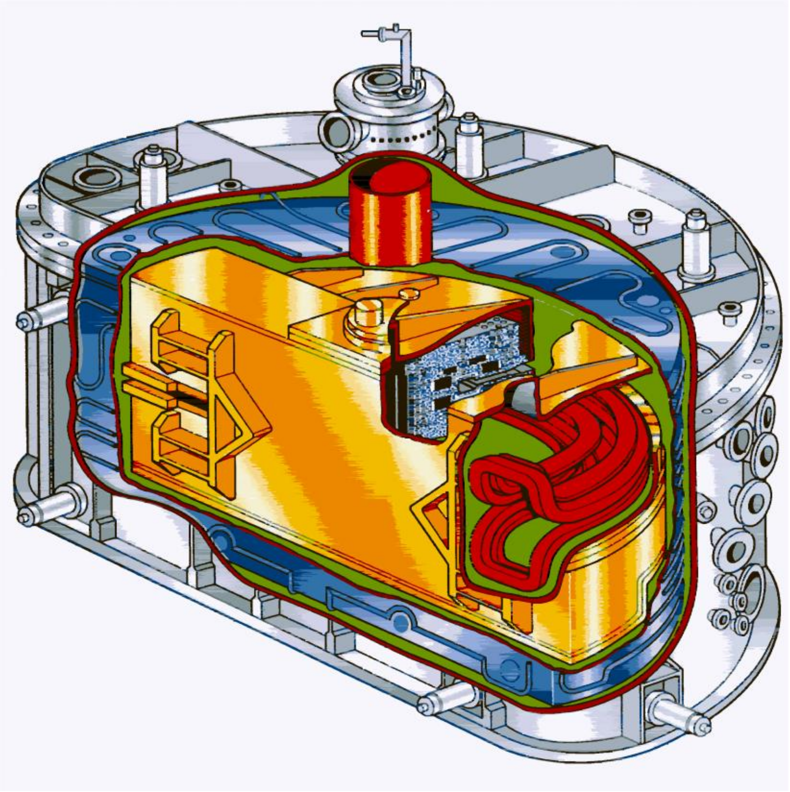


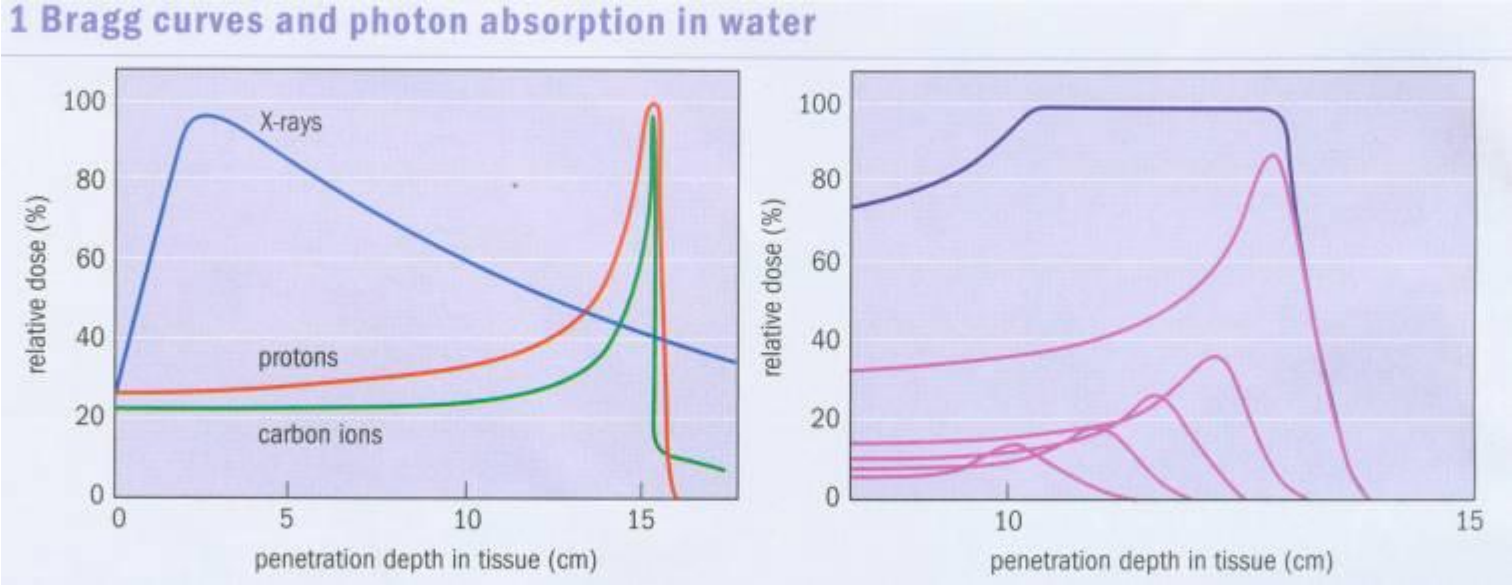
photo Oxford

Helios dipole

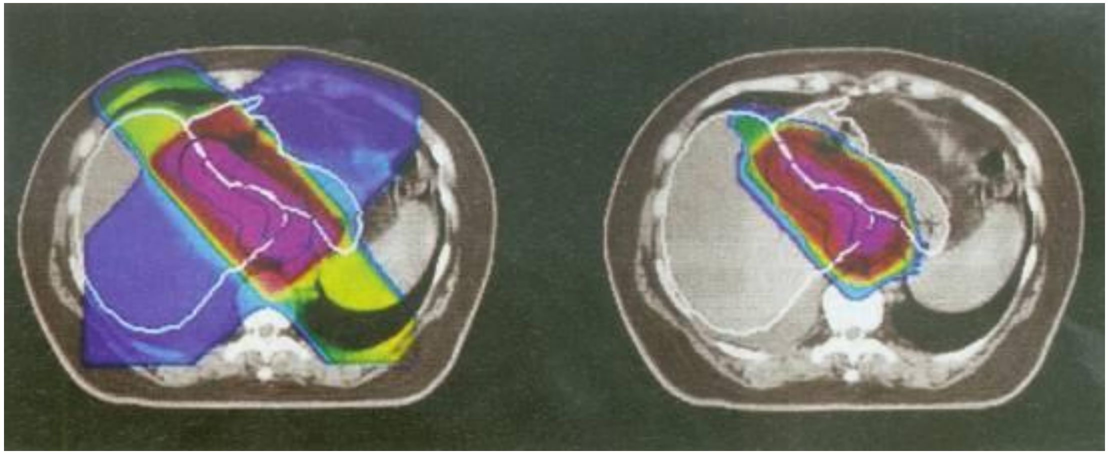


- bent around180°
- rectangular block coil section
- totally clear gap on outer mid plane for emerging X-rays (12 kW)

Cancer therapy by charged particle beams

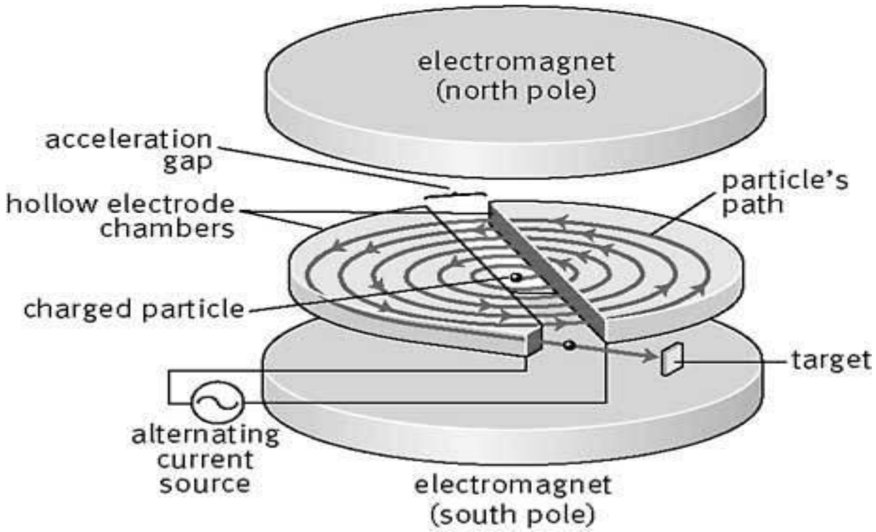


- photons (X-rays) deposit most energy at surface (skin)
- protons deposit most energy at depth
- adjust energy to make depth = tumour
- carbon ions are even better



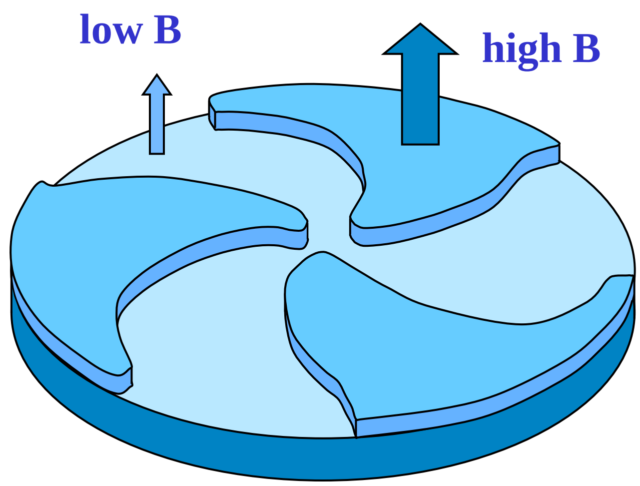
Cyclotron: the most popular source for proton therapy

Synchrocyclotron



- particles spiral outwards as their energy increases
- field decreases with radius ⇒ focussing
- particles get out of synchronism because field decreases and their (relativistic) mass increases
- ramp the rf frequency to keep in synchronism
- must be pulsed ⇒ low average beam current

Isochronous cyclotron



- focussing provided by azimuthally varying field AVF
- field can increase with radius to keep pace with relativistic mass increase
- synchronism at all radii
- continuous dc beam

Cyclotrons for proton therapy

IBA Proteus 235

Isochronous cyclotron
235MeV
conventional magnet
1.7 - 2.2T
220 tonne

Varian / Accel

Isochronous cyclotron
250MeV
superconducting magnet
2.4 - 3.1T
90 tonne

Mevion

Synchrocyclotron
250MeV
superconducting magnet
8.9T
20 tonne

Practical Matters: concluding remarks

- LHC quench problems come from series connection of many magnets and high current density
  - diodes across each coil, dump resistor and quench heaters

- current leads should be gas cooled and the optimum shape for minimum heat leak,
  - shape depends on the material used
  - impure material is less likely to burn out
  - use HTS to reduce heat leak at the bottom end

- making accelerator magnets is now a well established industrial process
  - winding ⇒ compact to exact size ⇒ heat to cure adhesive
  - fit collars ⇒ compress to required stress ⇒ lock in place
  - fit iron ⇒ add outer shell ⇒ compress to size ⇒ weld
  - assemble in cryostat ⇒ install in tunnel ⇒ make interconnects

- in recent years all the largest accelerators (and some small ones) have been superconducting

what comes next could be up to you

customer helpline
martin.n.wilson@btinternet.com