Particle Accelerators

Cyclotron

The first circular accelerator was the cyclotron.

Metal "dee", radius R

Magnetic field, B

Accelerated protons
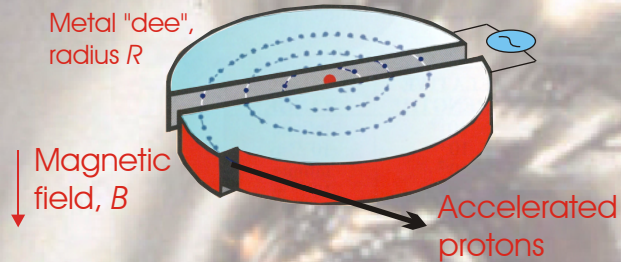
Equating forces $mv^2/r = Bev$ and the time for half a turn, $t = \pi r/v$; hence $t = \pi m/eB$. This is independent of radius, so with the correct choice of frequency for the ac voltage protons will be accelerated every time they cross the gap. The final kinetic energy $= (BeR)^2/2m$ and is about 10 MeV for $R = 0.3$ m.

The largest machines

Some of the largest machines ever built accelerate the smallest particles to a speed very close to the speed of light. The equation $E \approx hc/\lambda$ shows that high energy particles have a short wavelength and can therefore probe smaller distances when they collide. In the largest accelerators particles circulate at a fixed radius and the magnetic field is increased as they gain energy.

Television set

A television set is a particle accelerator in which electrons reach an energy of about 20 keV. The same features were found in the LEP accelerator at CERN. LEP accelerated electrons and positrons to 100 GeV before colliding them. LEP completed its research programme in 2000 and is being replaced by the Large Hadron Collider.

VACUUM

DEFLECTION COILS

CATHODE

ANODE

ELECTRON BEAM
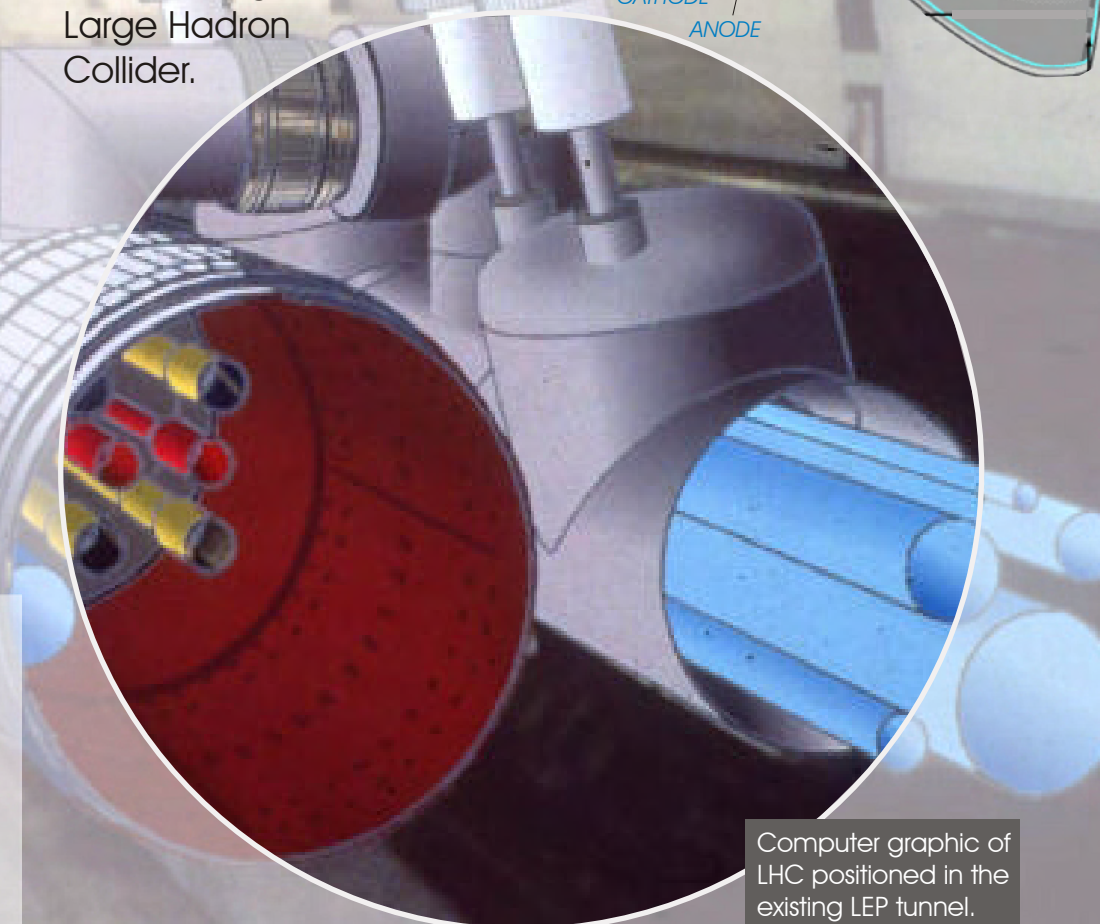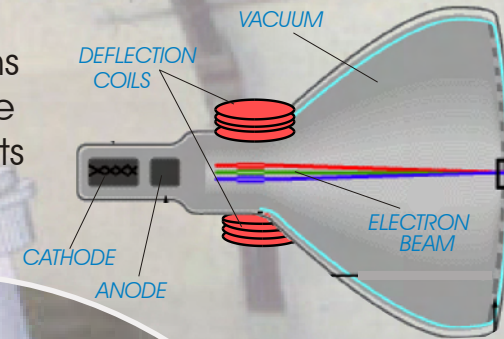
Computer graphic of LHC positioned in the existing LEP tunnel.

Inside the LEP tunnel at CERN