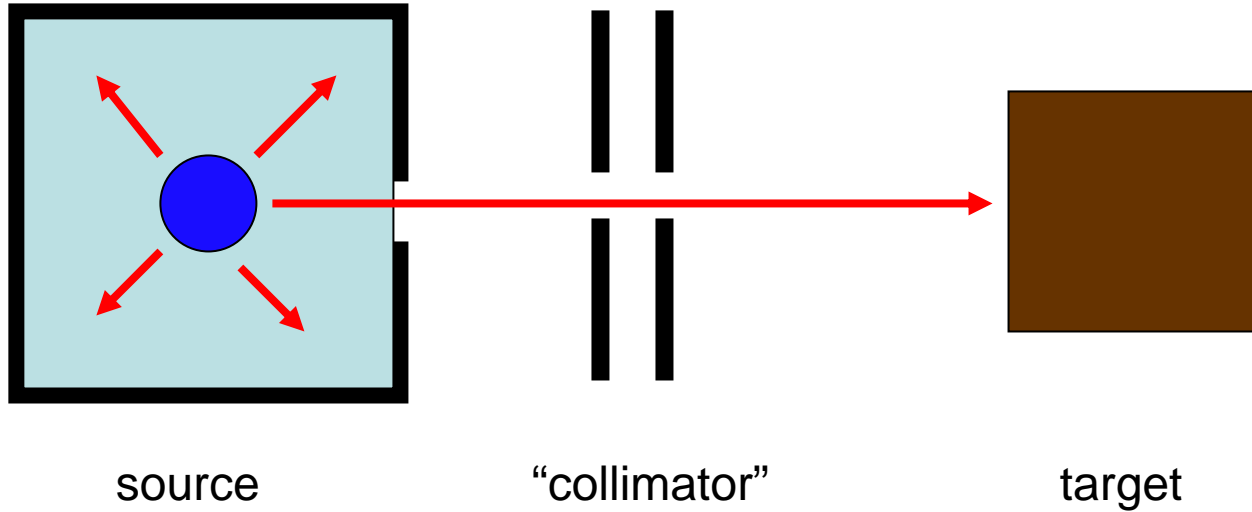


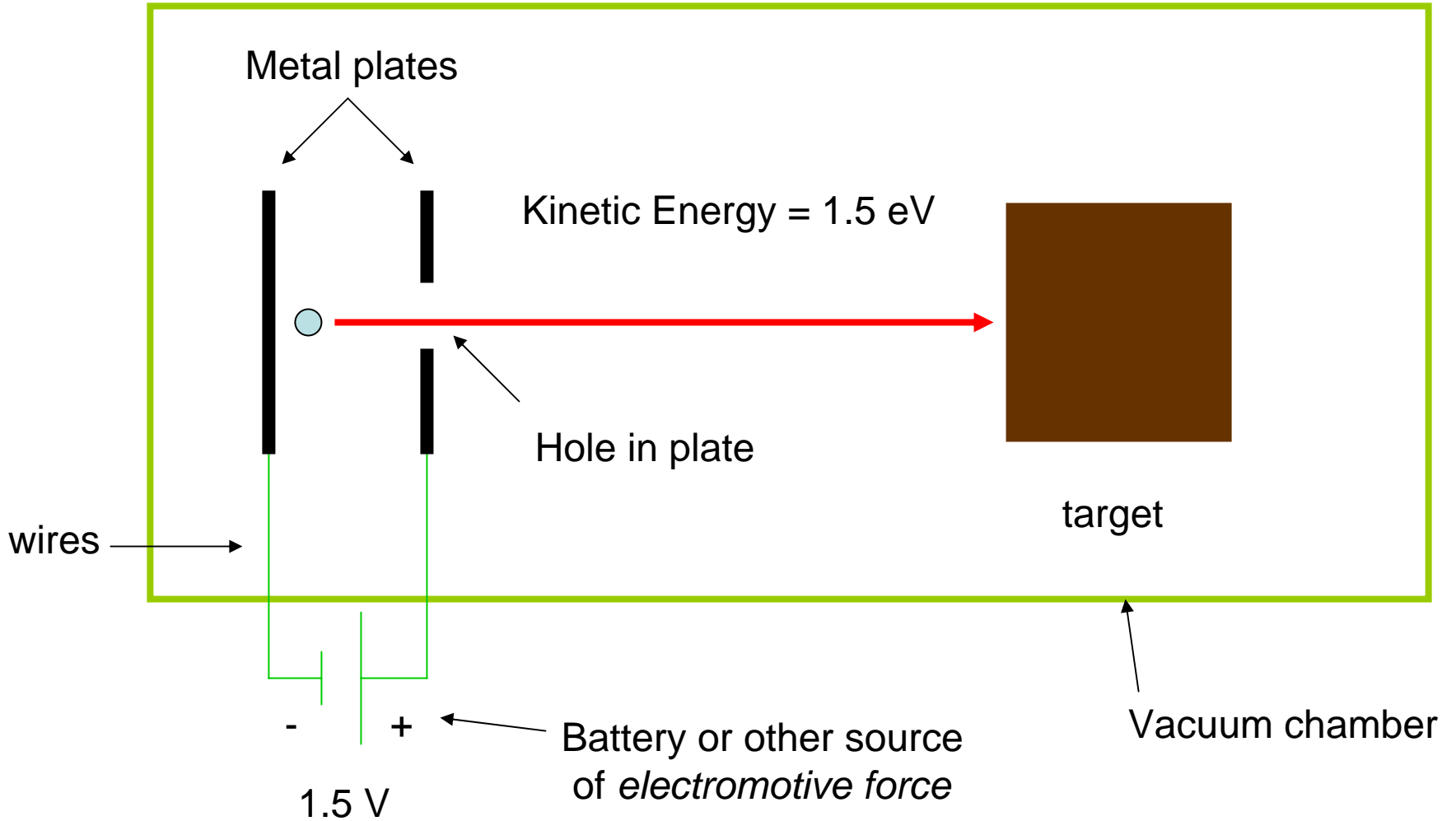
Natural radiation used as nuclear probe



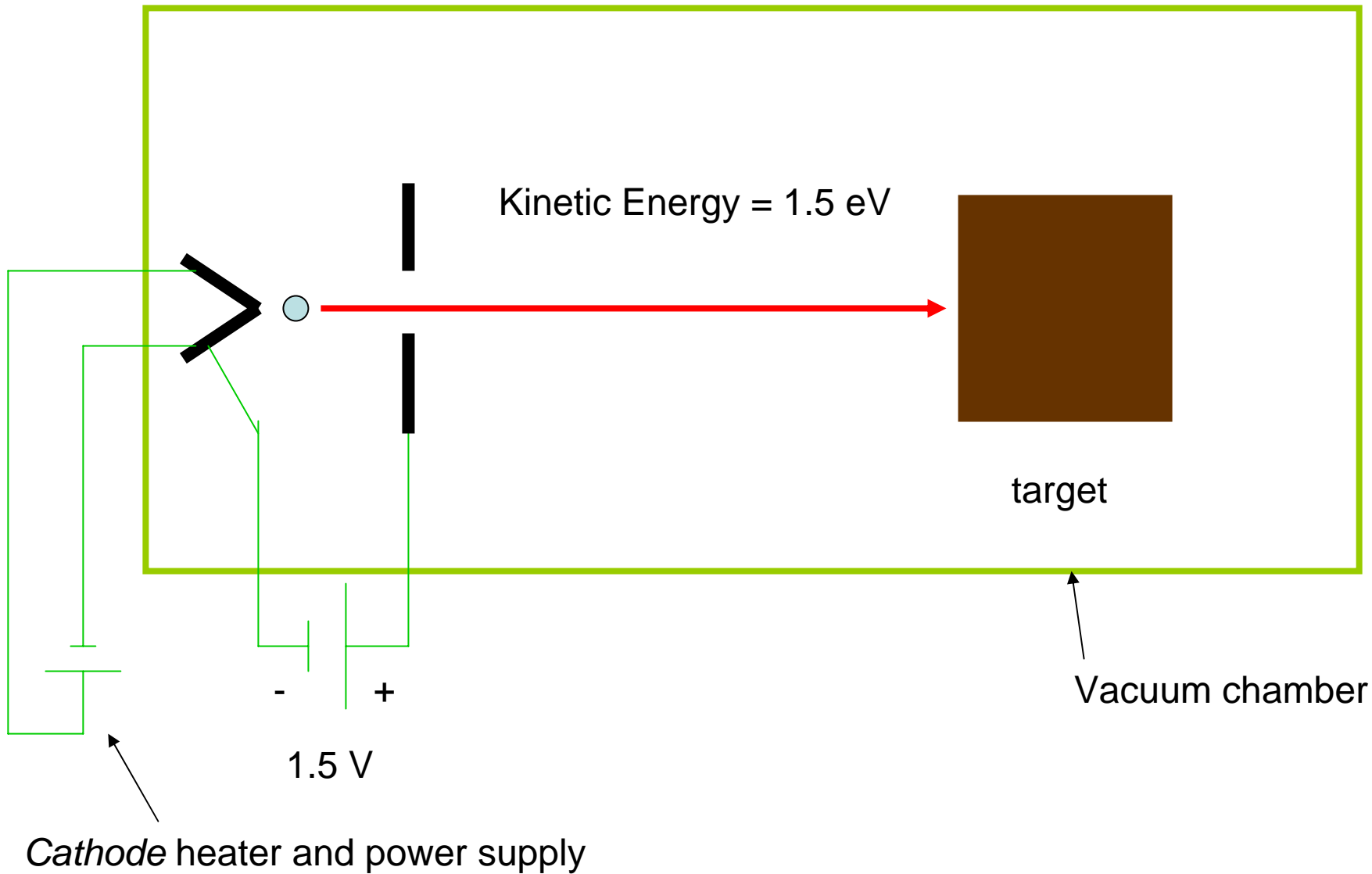
Ex: Gieger, Marsden, Rutherford: planetary model of the atom

Drawbacks: need large, highly radioactive source; limited energy and type of probe particles

Particle accelerators give you control over *charged* particles

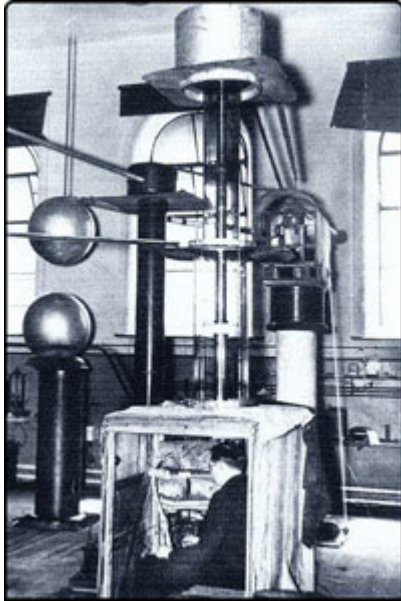


Cockroft, Walton, Lawrence

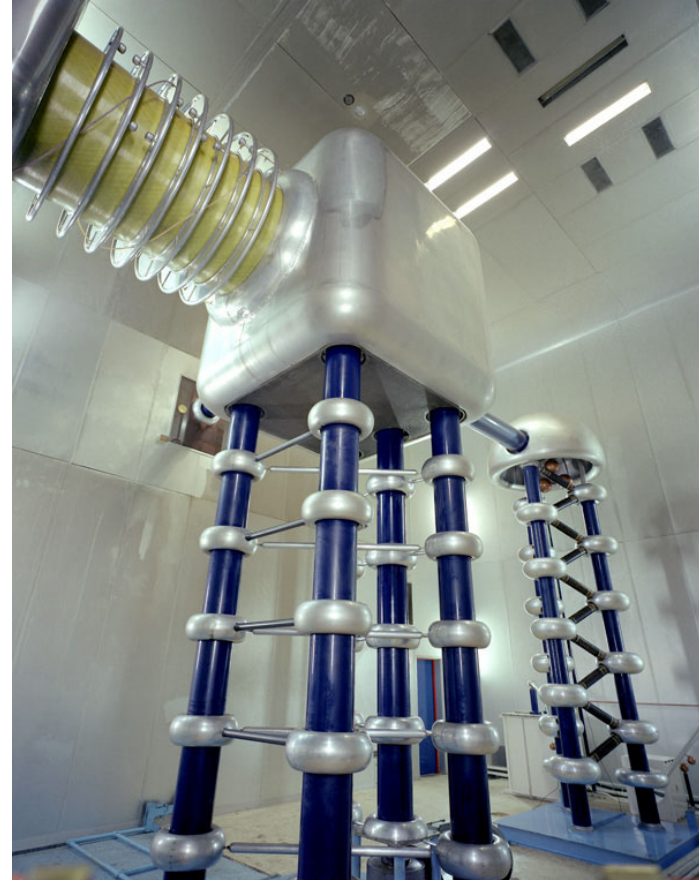


Physics is the “more power” science!

Need MeV to probe nucleus

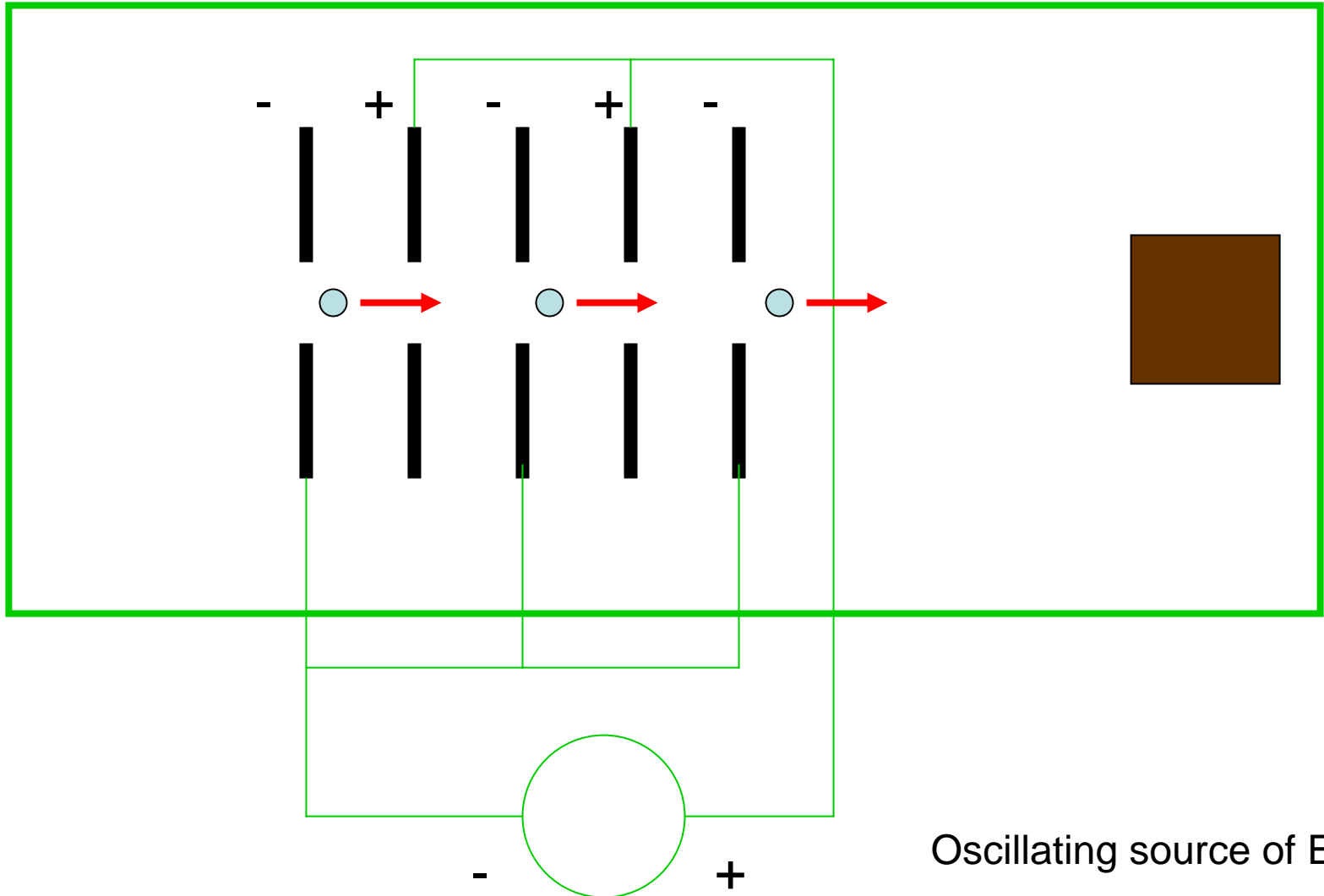


Original Cockroft Watson proton accelerator; first artificially induced radioactivity



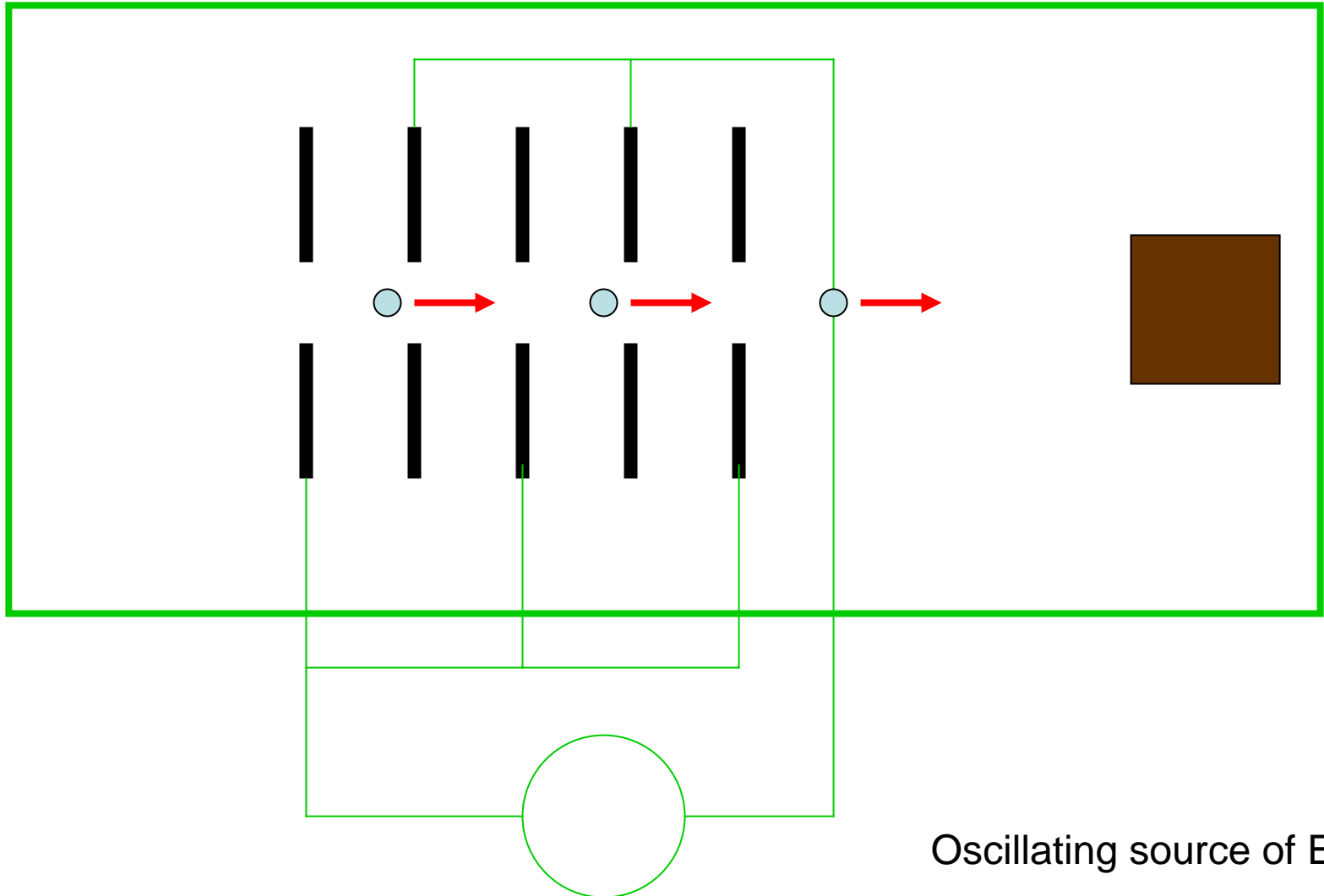
First stage (750 keV) of acceleration at FermiLab, the most powerful proton accelerator in US

To go even higher, accelerate particles multiple times; requires “bunching”

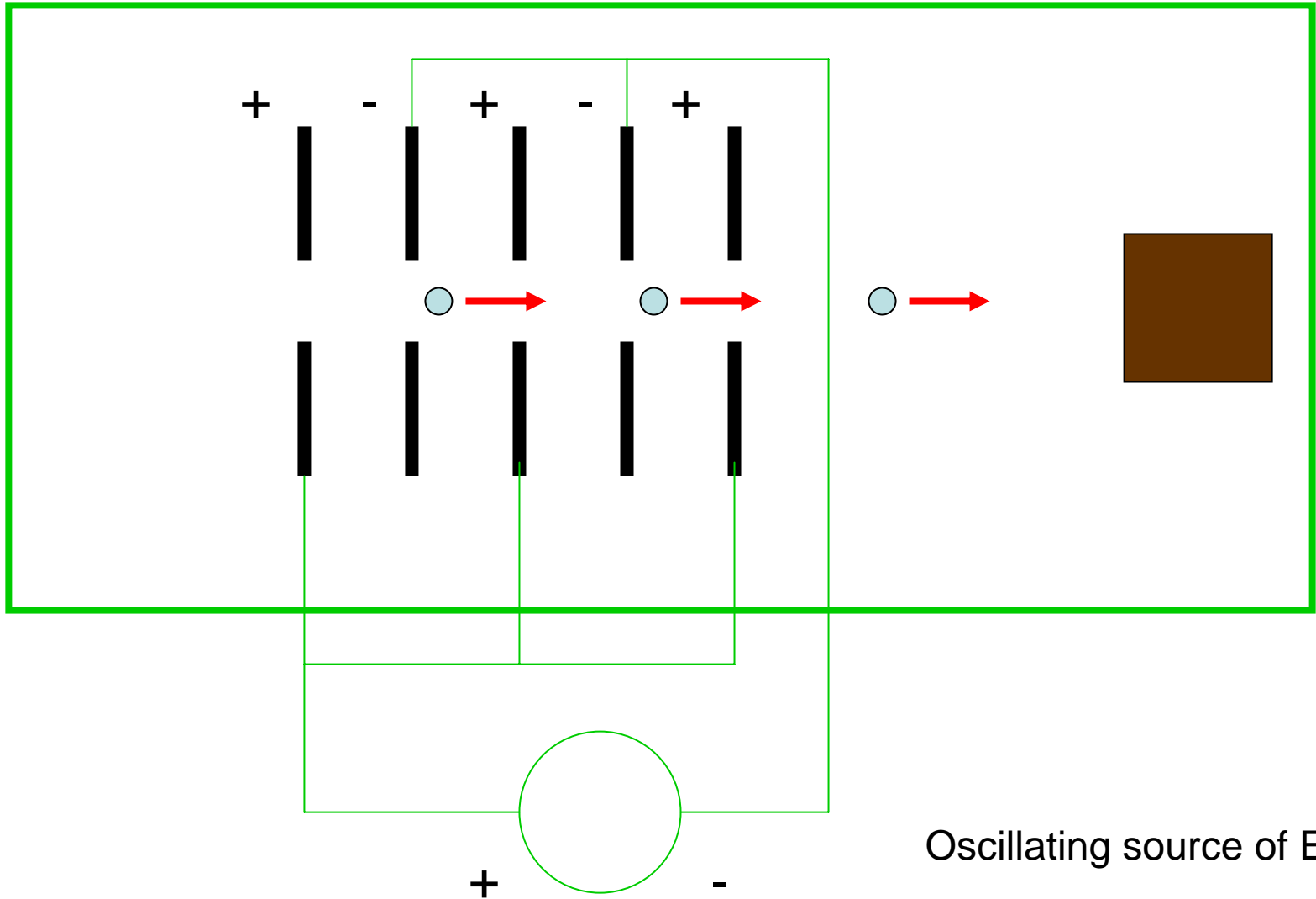


Oscillating source of EMF

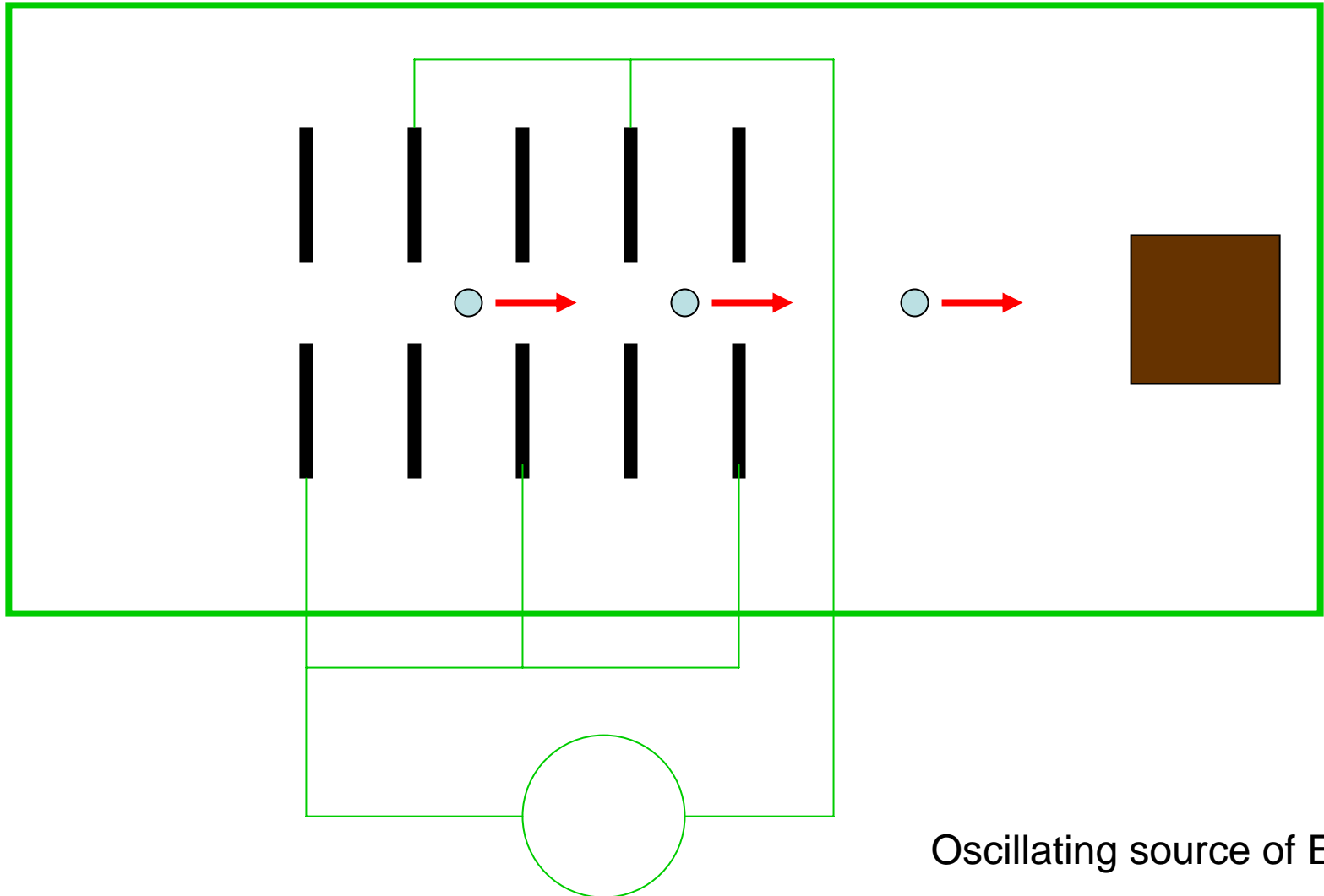
To go even higher, accelerate particles multiple times; requires “bunching”



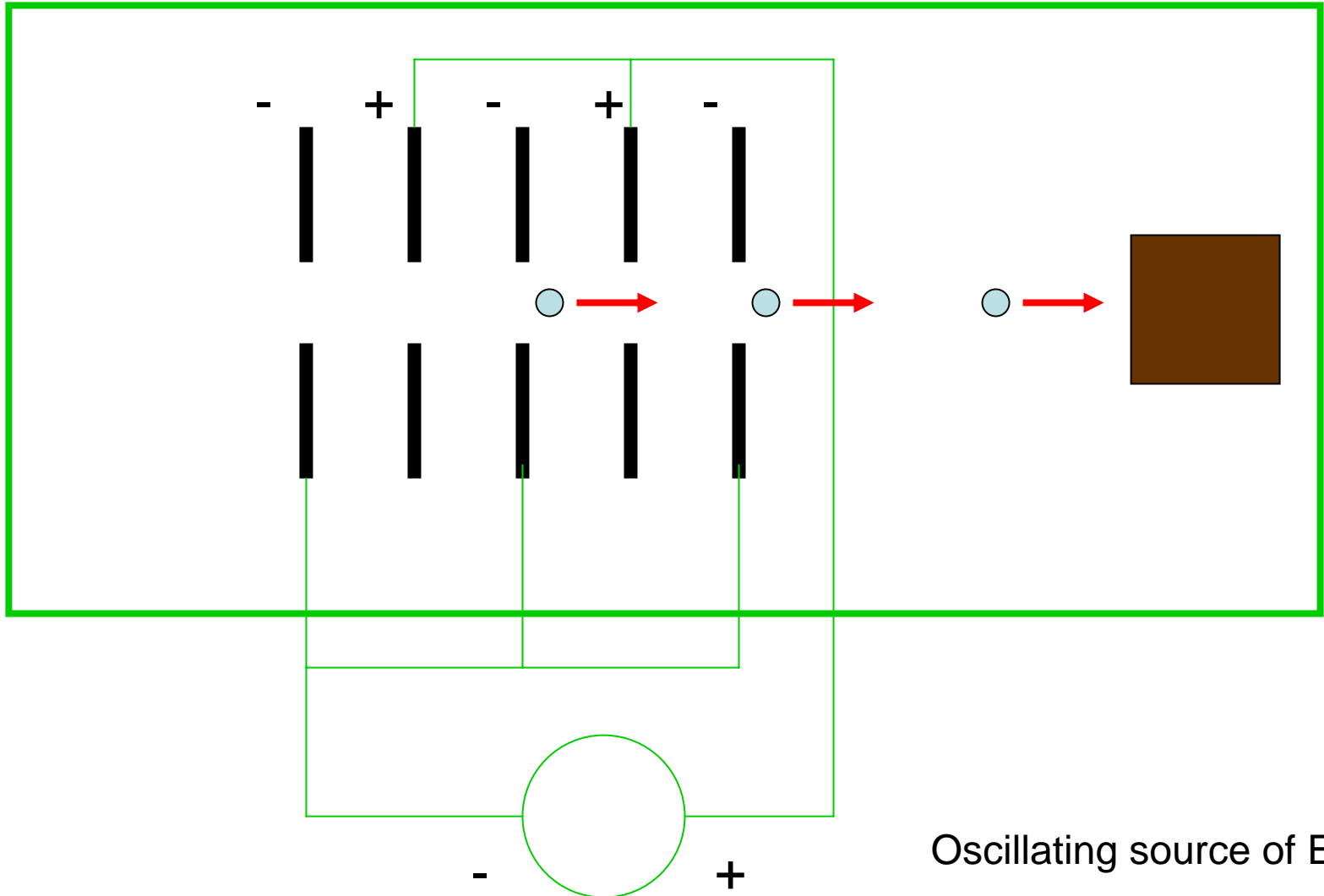
To go even higher, accelerate particles multiple times; requires “bunching”



To go even higher, accelerate particles multiple times; requires “bunching”



To go even higher, accelerate particles multiple times; requires “bunching”



Oscillating source of EMF

Linear accelerators

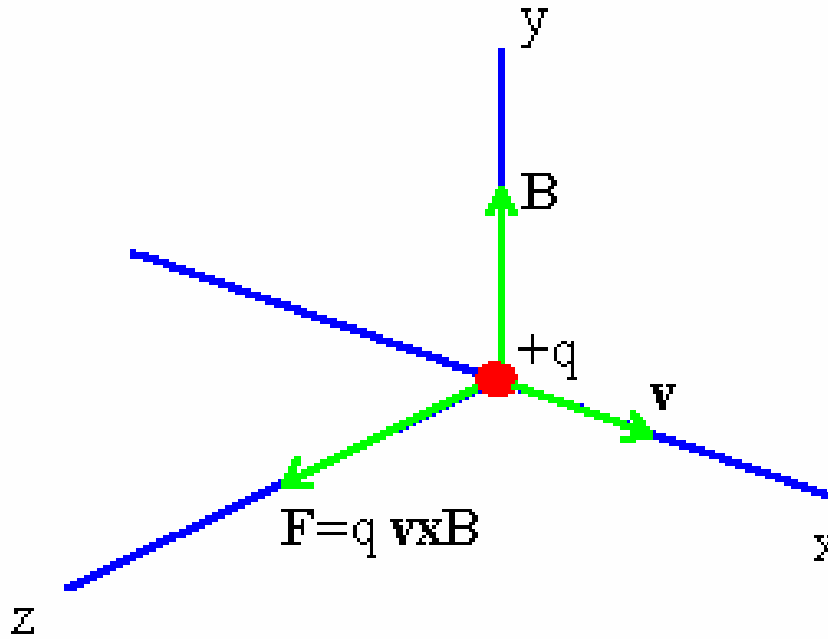


FNAL second stage linear
accelerator (400 MeV)

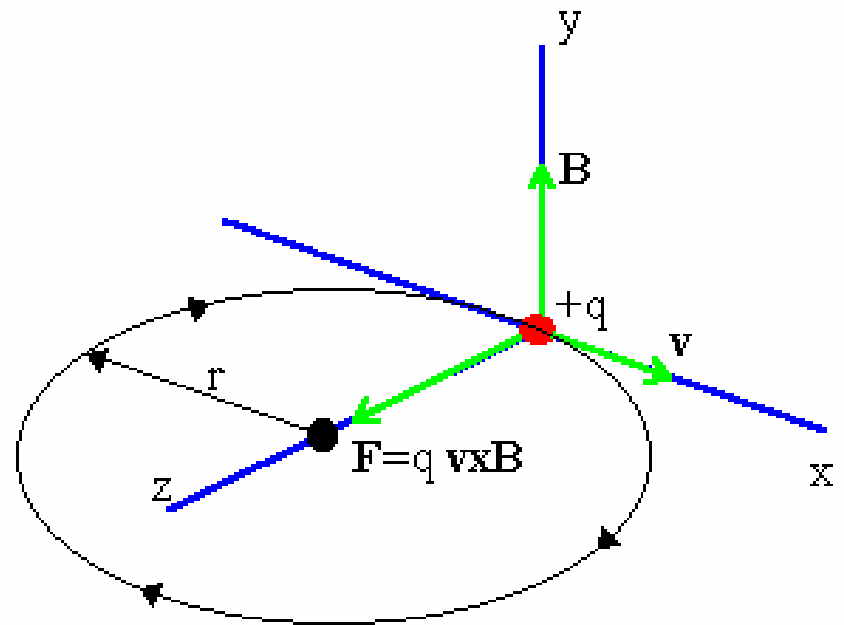


SLAC, two mile long, 50 GeV
linear accelerator, most powerful
electron accelerator in world

Magnetic fields cause moving charged particles to move in circles

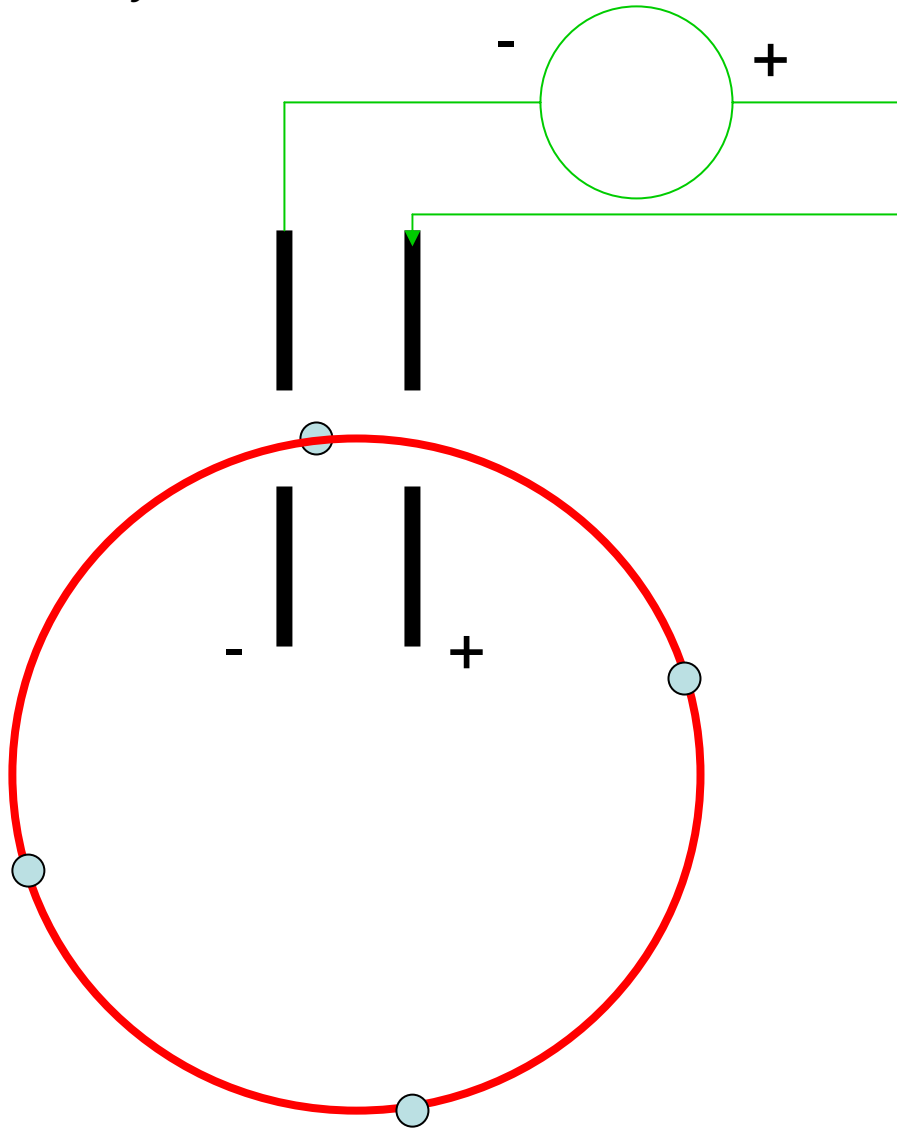


$$r = \frac{mv}{qB} = \frac{p}{qB}$$



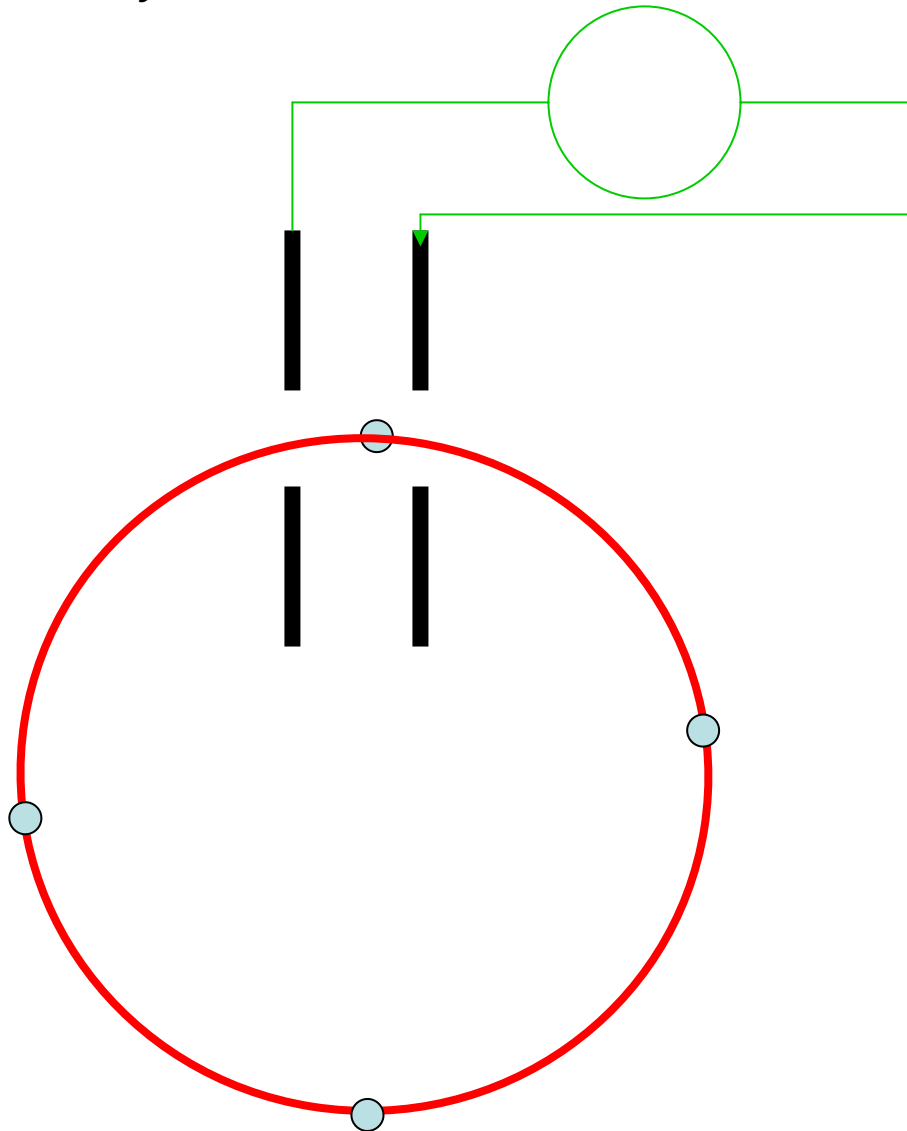
Opposite sign particles have opposite curvatures

So compact way to repeatedly accelerate particles
- *cyclotron*



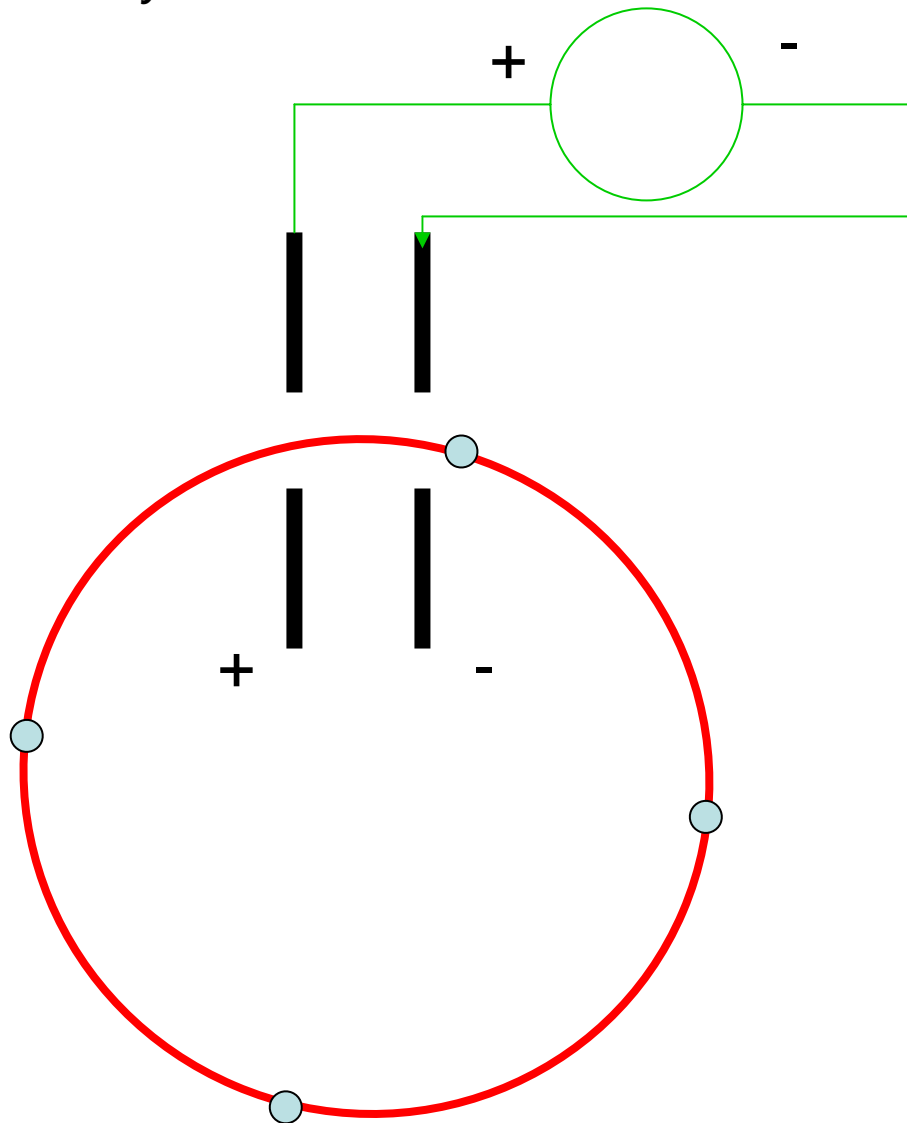
Magnetic field perpendicular everywhere to page, uniform

So compact way to repeatedly accelerate particles
- *cyclotron*

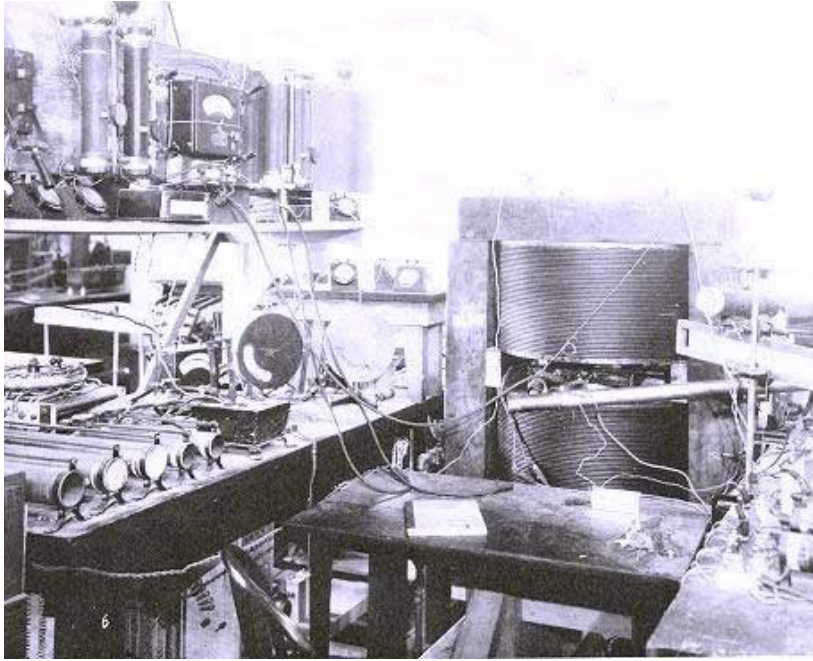


Magnetic field perpendicular
everywhere to page, uniform

So compact way to repeatedly accelerate particles
- *cyclotron*



Magnetic field perpendicular everywhere to page, uniform



Early table top cyclotron,
about 1 MeV



FNAL Tevatron, 1 TeV (10^{12} eV),
4 miles in circumference