SECTION 3

slide 5

linac

eg. SLAC had RF cavities $\frac{dE}{dx} = \frac{50\,GeV}{3.2\,km}$

$= 16\,GeV\,km^{-1}$

for 7 TeV electrons

$x = \frac{7000}{16} = 440\,km!$

LHC magnets

protons $E = 7\,TeV$

radius $= 4.3\,km$

$B = \frac{7000}{0.3 \times 4.3 \times 1000} = 5.4\,T$ (Earth μT)

BUT can't have all ring being magnets (need RF cavities)

at LHC ~ 60% ring is magnets $\Rightarrow B = 8.4\,T!$

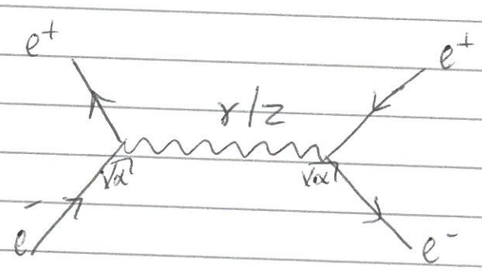
Synchrotron radiation

$\frac{P_e}{P_p} = \frac{m_p^4}{m_e^4} \sim 10^{13}$

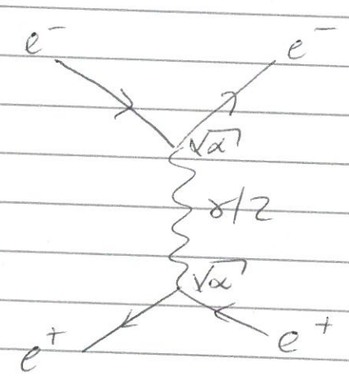
slide 14 e^+e^- collide, typical cylindrical detector

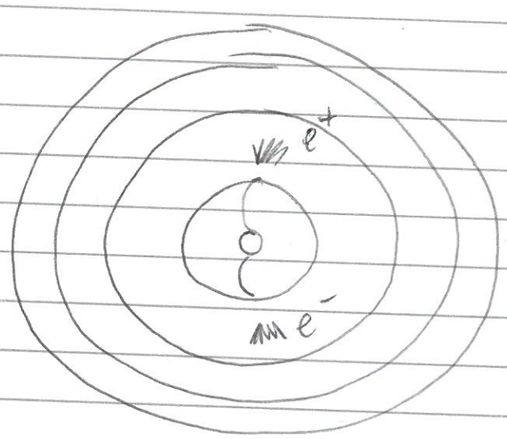
e^+ $E_1 = 44.7\,GeV$ $|\vec{p}_1| = 46\,GeV$

e^- $E_2 = 46.0\,GeV$ $|\vec{p}_2| = 49.5\,GeV$



and





Balance from $\vec{p}$ cons.

Likely the $\vec{p}$ & E measurement are not exact. Assume $\frac{\sigma_p}{p} \sim 10\%$

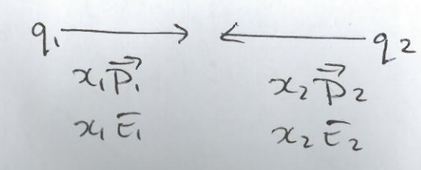
To conserve momentum, e^+ & e^- are back to back

ie $\vec{p}_1 = -46\,GeV$ $\vec{p}_2 = 49.5\,GeV$

$$m_{ee}^2 = \underbrace{(E_1 + E_2)^2}_{44.7+46} - \underbrace{(\vec{p}_1 + \vec{p}_2)^2}_{+3.5}$$

$m_{ee} = 90.6\,GeV$ Close to Z mass!

slide 15 protons are not fundamental, point-like particles!



$$E_{cm}^2 = (x_1E_1 + x_2E_2)^2 - (x_1\vec{p}_1 + x_2\vec{p}_2)^2$$

$$= \underbrace{m_{q_1}^2}_{0} + \underbrace{m_{q_2}^2}_{0} + 2x_1x_2E_1E_2 - 2x_1x_2\vec{p}_1\vec{p}_2$$

$$= 2x_1x_2E_1E_2(1-\cos\theta) \qquad \theta = \pi$$

$$= 4x_1x_2E_1E_2 \qquad E_1 = E_2 = E$$

$$= 4x_1x_2E^2$$

$$E_{cm} = 2\sqrt{x_1x_2}\,E$$

Need to understand x_1 & x_2 (gluons! & sea quarks)

→ probability!