Trevor Russell Particle Midterm 2

1) $\begin{pmatrix} e \\ \nu_e \end{pmatrix}\begin{pmatrix} \tau \\ \nu_\tau \end{pmatrix}\begin{pmatrix} \mu \\ \nu_\mu \end{pmatrix}$ $\underbrace{\begin{pmatrix} u \\ d \end{pmatrix}\begin{pmatrix} c \\ s \end{pmatrix}\begin{pmatrix} t \\ b \end{pmatrix}}$ +3

x 3 colors

spin 1/2

$W^\pm$ Z^0 h γ – spin 1   g

spin 1

spin 0

~~matter~~ + anti particles

2) weak force has a massive force +1
carrier

~~3) ~~matter~~ later~~

Strong force?

(3) W can decay to $\binom{e}{\nu}, \binom{\mu}{\nu}, \binom{\tau}{\nu}$

Z can decay to $\ell\bar{\ell}$, $\nu\bar{\nu}$ $\times 5$

both can decay to pairs of 6 quarks − top quark $\times$ 3 colors.

So W has 18 $\rightarrow$ 9 possible decays,

Z has 21.

$Br(W \to e\nu) = Br(W \to \mu\nu)$

$= 1/18$

$Br(Z \to \nu\bar{\nu}) = \frac{3}{21} = \frac{1}{7}$

So $Br(WZ \to e\nu\nu\nu) = Br(WZ \to \mu\nu\nu\nu)$

$= 1/18(7) = 1/126$

(assumed universal coupling).

(4) similarly, $Br(WW \to \ell\nu\ell'\nu) = \frac{2}{\cancel{18}} \frac{2}{\cancel{18}} = 1/81$ $\times 3$

9

$Br(ZZ \to \ell\ell\ell'\ell') = \left(\frac{2}{21}\right)^2 = 4/441$

both ~ 1% Ranking?

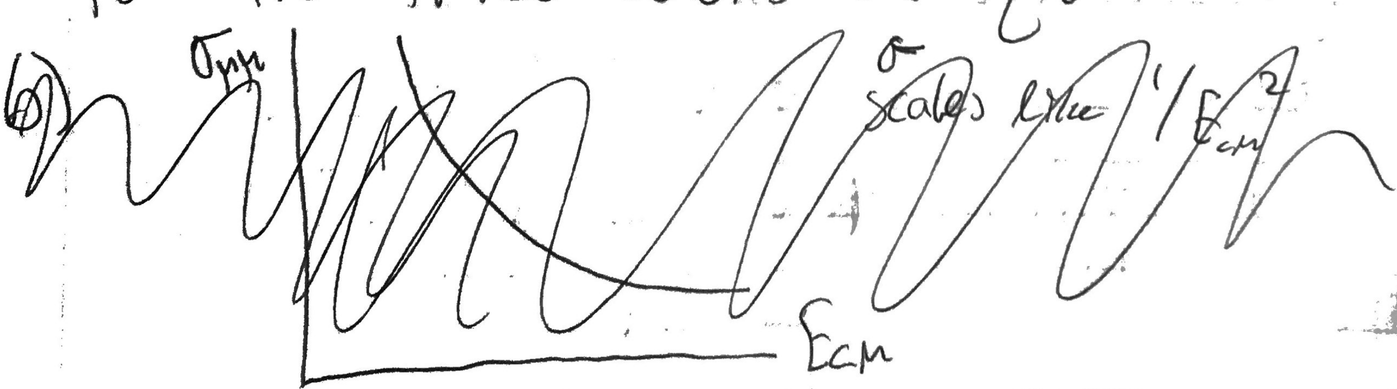
~~So Br(WW → ℓνℓ'ν') = Br(ZZ → ℓℓℓ'ℓ')~~
~~= 4/441 ≈ 1/110~~

(5) a) the size of the accelerator +4

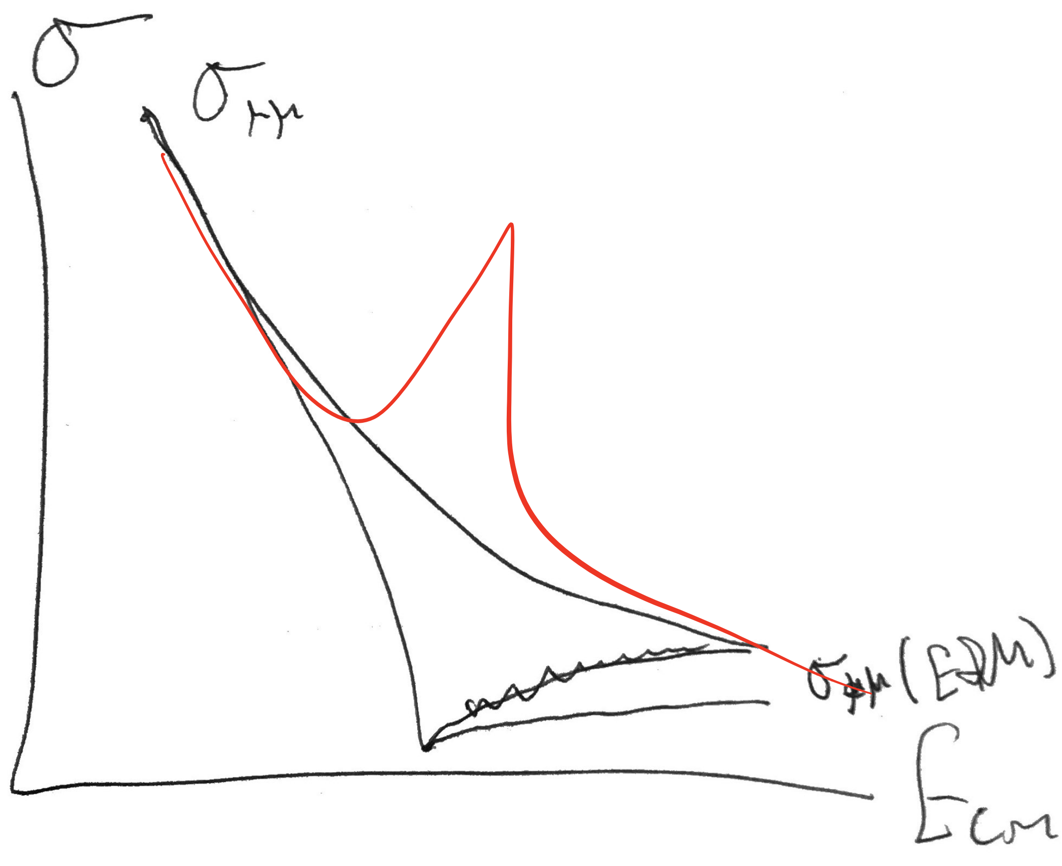
b) synchrotron radiation loss due to the higher E/m ratio.

(6) a) R comes out as the triangular sum +5 of quark charges. At lower energies, we expect $R \approx 2/3$. But when the energy raises above $2M_{charm}$, the phase space expands to include the charm quark decays, so R increases by 4/9 the square of the charm charge to 10/9. However these are multiplied by 3 to account for the three colors of quarks.

~~b)~~



b) σ scales like $1/E_{cm}^2$.
at $\sim M_W$ ($\sim$100 GeV), weak dominates.
at low E, EdM. at higher E,
$\sim$ equal



40 200

7) a) they both have tracks in the inner tracker, but electrons create a shower in the ECAL while muons leave another track in the muon tracking system

b) electrons leave a track and photons do not. The electron showers are also skewed, but they both leave showers in the ECAL

+4

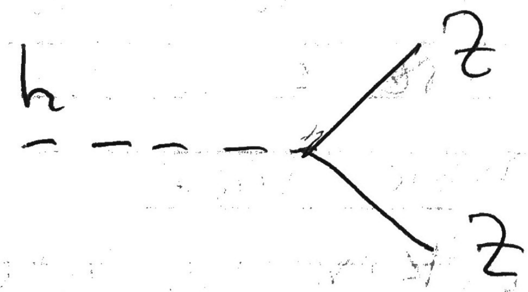
+4

8) Hadronic showers are harder to measure because they happen due to the nuclear interaction so the length scale is longer

9) $X \to ee$ because we have a better system for energy measurements +3

10) from momentum imbalances after all is said and done +2

11) a)



Production?

+3

b) higgs are produced by colliding W/Z, so we have to produce those and then some subset of interactions will produce the Higgs

~~12) Higgs decays because the coupling~~

(12) Muon decays because the coupling is stronger since it is mass-dependent for higgs, but the tau is unstable so it is harder to study. (and the cross section is dependent on coupling)

+4

+6

13) a) the generators can be associated to particles

b) $SU(2)_L$ and $U(1)$ from $SU(2)_L$

c) ~~the~~ two generators match w/ W bosons and a mixing of W^3 and B is responsible for photons and Z bosons

14) a) if we have multiple minima of the potential, one is spontaneously chosen to be expanded about. This expansion creates an asymmetry.

b) mass

c) it predicted neutral currents (the Z) and the higgs, which we have now found.

~~3) as in problem 4,~~

+6