Aileen
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Midterm 2

1. $\begin{pmatrix} u \\ d \end{pmatrix}\begin{pmatrix} s \\ c \end{pmatrix}\begin{pmatrix} t \\ b \end{pmatrix}$ $\begin{pmatrix} e \\ \nu_e \end{pmatrix}\begin{pmatrix} \mu \\ \nu_\mu \end{pmatrix}\begin{pmatrix} \tau \\ \nu_\tau \end{pmatrix}$ $\begin{bmatrix} \gamma \\ g \\ W^0 \\ Z^* \\ \text{Higgs} \end{bmatrix}$

Spin? +3

2. The range of the forces is different and causes different particles to be affected. +1

why?

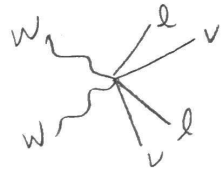
3. # ways WZ can decay: 6 leptons + 6 quarks × 3 colors +2
$= 6+18 = 24$

can decay to t quark because combined W + Z mass > mass of t

$Br(WZ \to e\nu\nu\nu) = \frac{1}{24}$

$Br(WZ \to \mu\nu\nu\nu) = \frac{1}{24}$

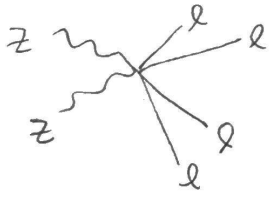
combined = $\frac{1}{12}$

4. 

only 2 leptons to decay ⇒ 4 (ee, eμ, μe, μμ)
total decay modes

⇒ 6 leptons + 5 quarks × 3 colors

⇒ $\frac{4}{21}$ $\left(\frac{2}{9}\right)^2$ +1



can have: eeμμ, eeee, μμμμ

⇒ $\frac{3}{21}$

rank: ~~WW~~
~~lνl'ν'~~
~~llll'l'~~
~~ZZ~~
~~γγ~~

$H \to WW \to l\nu l\nu$

$H \to \gamma\gamma$

$H \to ZZ \to llll'$

5. (a) Power loss through synchotron radiation +3
(b) same as (a).

6. (a) $R \equiv \frac{\sigma(ee \to jets)}{\sigma(ee \to \mu\mu)} = \sum Q^2$ +2 $\Rightarrow$ as E_{cm} increases, ee can decay to more types of quarks

As E_{CM} increases, $R(E_{CM})$ increases.

$R(<2m_{charm}) \Rightarrow$ only up & down:

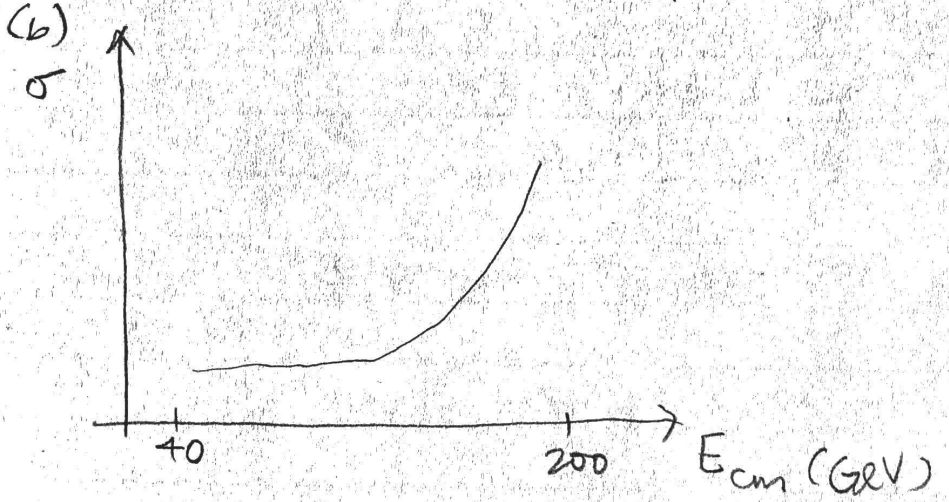
$$R(<2m_{charm}) = \left(\frac{2}{3}\right)^2 + \left(\frac{2}{3}\right)^2 = \frac{}{9}$$

$R(>2m_{charm}) \Rightarrow$ +up, down, & charm:

$$R(>2m_{charm}) = \left(\frac{2}{3}\right)^2 + \left(\frac{2}{3}\right)^2 + \left(\frac{1}{3}\right)^2 = \frac{10}{9}$$

x Colors

(b)



7. (a) Electrons and muons both produce ~~showers~~ tracks, however μ's travel much farther in a calorimeter than e's do. +2

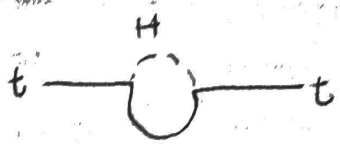
(b) γ and e⁻ both produce showers in EM calorimeters. However, γ showers start with pair production whereas e⁻ showers start with Bremsstrahlung radiation. e's have tracks γ's don't

8. Hadronic showers are more difficult to accurately measure because they involve processes at different length scales, and have fluctuations, whereas EM showers are only on the length scale of X_0. +4

9. $X \to ee$ should measure more precisely because each e⁻ would have more energy than a corresponding μ, which would leave more energy in a detector for reconstructing the X mass. +3

10. ν's are detected by a P_T imbalance of an event at the LHC. +2

11. (a)



+0

(b) Higgs have spin 0 but W, Z have spin 1

+0

12. ~~$H \to \mu\mu\nu\nu$~~ is the best way to look because the branching ratio of $H \to WW$ is high, and $Br(WW \to \mu\mu)$ is also high.

W not lepton

+4

13. (a) Symmetry dictates the spin of particles in the group.
(b) $SU(2) \times U(1)$
(c) The particles of $U(1)$ are able to interact via the weak force.

+4

14. (a) SSB → when the ground state of a particle in a potential is not on the axis of symmetry
(b) Particles having mass
(c) we can see an imbalance of right or left handed particles after interaction via weak force.