PHYS6011 Experimental Problem Set

Part II

1. Given an average luminosity of 50×10^{30} cm^{-2}s^{-1} estimate how often the following inclusive physics processes occur at CDF:

$$p\overline{p} \Rightarrow b\overline{b} : \ \sigma \sim 10 \ \mu\text{b}$$

$$p\overline{p} \Rightarrow W : \ \sigma \sim 10 \text{ nb}$$

$$p\overline{p} \Rightarrow t\overline{t} : \ \sigma \sim 10 \text{ pb}$$

2. The top width (i.e. the quantum uncertainty in its mass) is expected to be about 1.5 GeV. What is its lifetime? Explain why there are no top-flavoured hadrons given $\Lambda_{QCD} \approx 200$ MeV.

3. What fraction of top pair production events will have a "dilepton" final state, i.e.

$$p\overline{p} \rightarrow t\overline{t} \rightarrow l_1 l_2 \nu_1 \nu_2 b\overline{b}$$

where l_1 and l_2 can be either two electrons, two muons or one of each.

4. In a semileptonic top pair candidate event there is a muon, a transverse momentum imbalance, two b-tagged jets and two non-tagged jets. The measured jet energies and directions ($\theta = 0$ is the beam direction, the x axis is horizontal and all angles are in radians) are as follows:

b_1:	$E = 145$ GeV	$\theta = 0.3$	$\phi = -1.6$
b_2:	$E = 90$ GeV	$\theta = 1.3$	$\phi = -0.2$
j_1:	$E = 125$ GeV	$\theta = 0.9$	$\phi = 2.1$
j_2:	$E = 15$ GeV	$\theta = 1.7$	$\phi = -1.7$

   (a) The momenta of the jets approximates the momenta of the original partons. Write down the 4-momenta of the four final state quarks (assume j_1 and j_2 come from massless partons).

(b) Show that the light quark jets are consistent with being the decay products of a W (Hint: assume they come from the decay $X \to j_1 j_2$ and calculate the mass of X).

(c) Which of the two b jets probably came from the same top quark as this hadronically decaying W?

5. A search for the supersymmetric partner of the top quark, the stop or $\tilde{t}$, using 200 pb^{-1} has an expected background of 17 events with a total systematic error of 5 events. The data shows 30 selected events.

(a) How significant is this excess?

(b) Assuming that this excess is really due to a signal, approximately how much more data will need to be collected before a discovery can be claimed? (Assume the systematic error remains constant).