

## Physics 450 – Problem Set # 2

(due Tuesday, December 2)

1. Make a plot of the transverse momentum distribution for  $W^+$  and  $W^-$  bosons produced at the Tevatron collider. Include  $W$ 's in the range  $-1 < \eta < 1$ . Work to order  $\alpha_s$  (so the distribution will be singular as  $p_T \rightarrow 0$ ). Show the contributions of the annihilation and Compton diagrams. Make the analogous plots for the LHC, using  $-2 < \eta < 2$ . Are the distributions significantly different for  $W^+$  and  $W^-$ ?
2. Plot the cross section for direct photon production at the Tevatron and at the LHC, for photons with  $p_T > 40$  GeV in the rapidity ranges given in the previous problem. Consider all parton + parton  $\rightarrow$  parton +  $\gamma$  reactions.
3. Compute the total cross section for  $t\bar{t}$  production at the Tevatron and at the LHC, working to leading order in  $\alpha_s$ . Plot the distribution of events as a function of the  $t\bar{t}$  invariant mass ( $= \hat{s}^{1/2}$ ).
4. Repeat the previous computation for a spin-0 particle with the Standard Model quantum numbers of the top quark. Repeat the computation for a color octet massive fermion. Plot the three cross sections as a function of the heavy particle mass.
5. The top quark decays to  $W^+$ , and these  $W$ 's acquire a significant transverse momentum by virtue of the decay kinematics. Plot the transverse momentum distribution of the  $W$ 's from this source. How does this compare to the transverse momentum distribution computed in problem 1?