Physics 233B (Murayama)
HW #3, due Oct 22, 12:30 pm

1. The process $e^+e^- \to q\bar{q}g$ has the differential cross section

$$\frac{1}{\sigma_0}\frac{d^2\sigma}{dx_1 dx_2} = C_F \frac{\alpha_s}{2\pi}\frac{x_1^2 + x_2^2}{(1-x_1)(1-x_2)} \ , \tag{1}$$

where $\sigma_0 = \frac{4\pi\alpha^2}{3s} 3 \sum_q Q_q^2$ is the lowest order $e^+e^- \to q\bar{q}$ cross section. For *scalar* gluons, however, the distribution changes to

$$\frac{1}{\sigma_0}\frac{d^2\sigma}{dx_1 dx_2} = C_F \frac{\alpha_s}{2\pi}\frac{x_3^2/2}{(1-x_1)(1-x_2)} \ . \tag{2}$$

Answer the following questions.

(a) Using the jet clustering algorithm that requires $y_{ij} = 2p_i \cdot p_j / s > y_{cut}$ to define separate jets, compute the three-jet fraction R_3 as a function of y_{cut}. Note that for a small y_{cut} you encounter unphysical singularities, which must be cancelled by the one-loop correction.

(b) Compute the distribution in thrust

$$T = \max_{\vec{n}} \frac{\sum_i |\vec{p}_i \cdot \vec{n}|}{\sum_i |\vec{p}_i|} \tag{3}$$

for both vector and scalar gluons.

2. In the leading order calculation of the W production in $p\bar{p}$ annihilation (namely no hard gluon emission), compute the p_T and m_T distributions. Note that W is *always* polarized along the beam direction.