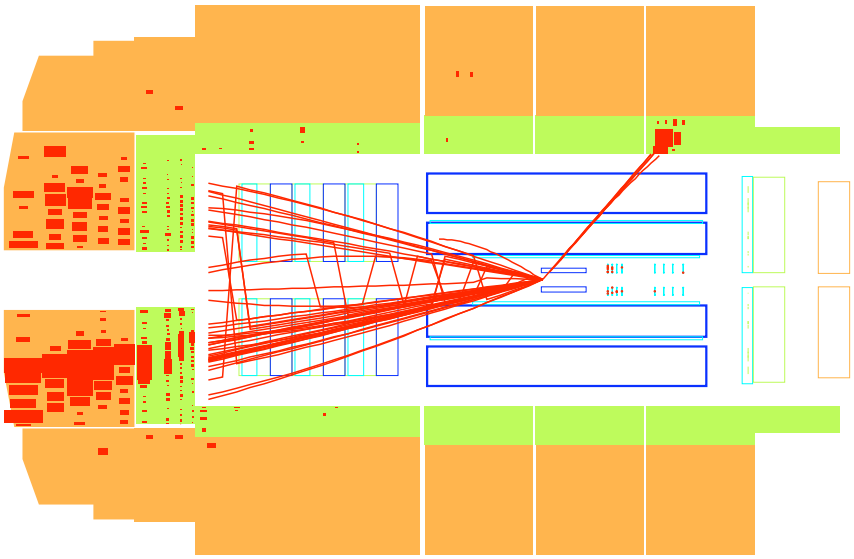
P424 Assignment 7

Due Monday, Mar. 23

1. The figure below shows a deep-inelastic scattering event $\mathrm{e^+p} \rightarrow \mathrm{e^+X}$ recorded by the H1 experiment at the HERA collider. The positron beam, of energy $E_1 = 27.5\,\mathrm{GeV}$, enters from the left and the proton beam, of energy $E_2 = 820\,\mathrm{GeV}$, enters from the right. The energy of the outgoing positron is measured to be $E_3 = 31\,\mathrm{GeV}$.



a) Show that the Bjorken scaling variable x is given by

$$x = \frac{E_3}{E_2}\left[\frac{1-\cos\theta}{2-(E_3/E_1)(1+\cos\theta)}\right]$$

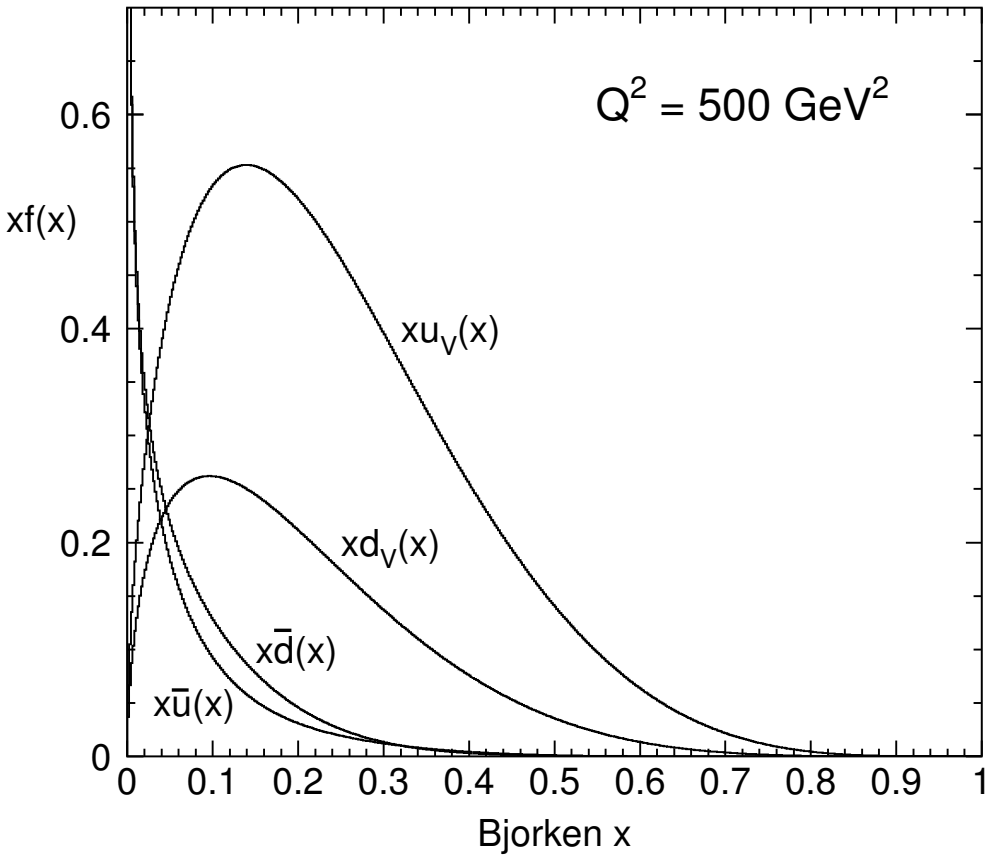
where θ is the angle through which the positron has scattered.

b) Estimate the values of Q^2, x and y for this event.

c) Estimate the invariant mass M_X of the final state hadronic system.

d) Draw quark level diagrams to illustrate the possible origins of this event. Using the plot overleaf of the parton distribution functions $xu_\mathrm{V}(x)$, $xd_\mathrm{V}(x)$, $x\overline{u}(x)$ and $x\overline{d}(x)$, estimate the relative probabilities of the various possible quark-level processes for the event.

[Neglect contributions from the heavier quarks s, c, b, t.]



2. Pseudo-scalar meson leptonic decay.

a) Calculate the decay rate for $K^+ \to \mu^+ \nu_\mu$. We now know that neutrinos have mass, so use m_ν as the mass of the neutrino (i.e. don't set it to zero).

b) Repeat the above calculation with a purely vector current for the charged weak interaction (i.e. replace $\gamma^\mu(1-\gamma^5)/\sqrt{2}$ by γ^μ in the Feynman rules).

c) Compare your answers to parts (a) and (b) in the limit $m_\nu \to 0$. Try to give a physical meaning to this.