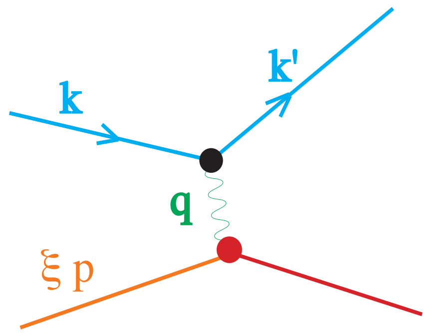
Phenomenology course: Problem Sheet 4

1. Consider the process (photon exchange only)

$$e^-(k) + Q(\xi p) \to e^-(k') + Q(\xi p + q)$$

where Q represents a generic massless quark of EM charge e_q and e^- a massless electron. Schematically:



Show that

$$\frac{d^2\hat{\sigma}}{dx dQ^2} = \frac{4\pi\alpha^2}{Q^4}\left[1 + (1-y)^2\right]\frac{1}{2}e_q^2\delta(x-\xi).$$

You may use the expression

$$|\overline{\mathcal{M}}|^2 = 2e_q^2 e^4 \frac{\hat{s}^2 + \hat{u}^2}{\hat{t}^2}$$

for the matrix element squared summed/averaged over final/initial colours and spins. (Hint: express $\hat{s}$, $\hat{t}$ and $\hat{u}$ in terms of the standard DIS variables

$$Q^2 = -q^2, \qquad x = \frac{-q^2}{2p\cdot q} \qquad \text{and} \qquad y = \frac{q\cdot p}{k\cdot p}.)$$

2. In calculating the Z^0 lineshape I neglected the interference between the γ and Z contributions (i.e. the correct result should have been obtained by computing $|\mathcal{M}_\gamma + \mathcal{M}_{Z^0}|^2$ instead of $|\mathcal{M}_\gamma|^2$ and $|\mathcal{M}_{Z^0}|^2$ separately. Estimate the interference contribution. What is its value on the peak ($\sqrt{s} = M_{Z^0}$) ?

3. Given that neutrinos cannot be detected, how is Γ_ν, the partial decay width of a Z^0 into neutrinos, measured ?