Particle Physics: Assignment # 6

Due Wednesday April 2nd before class (in class)

1 For the process:

$$e^-(s_1, p_1) + e^-(s_2, p_2) \to e^-(s_3, p_3) + e^-(s_4, p_4) \tag{1}$$

(1.1) Draw the lowest order the Feynman diagrams (remember time from left to right and label all momenta and helicities)

(1.2) Using the Feynman rules for QED construct the corresponding Feynman amplitudes.

(1.3) show that the spin average squared amplitude is (neglecting m_e)

$$\overline{|\mathcal{M}|^2} = 2e^4 \left(\frac{s^2 + u^2}{t^2} + \frac{2\,s^2}{t\,u} + \frac{s^2 + t^2}{u^2} \right)$$

$s = (p_1 + p_2)^2$, $t = (p_1 - p_3)^2$, $u = (p_1 - p_4)^2$

(1.4) Draw the angular dependence that you would expect for one of the outgoing e^- in the COM (as a function of its angle with respect to the direction of the incoming electron) and justify it.

2 Plot the QED prediction for the differential cross section in the COM in pb/sr ($pb = 10^{-40} m^2$) as a function of the angle between one of the outgoing electron and one of the incoming electrons for a collider with $\sqrt{s} = 100$ GeV. (I am asking to plot the value for several angles, for example $\theta = 0, 10, 45, 90, 135, 170, 180$). Neglect the running of the coupling constant.

3 We have built an $e^-\,e^-$ collider with beams of energy $E = 50$ GeV. Each beam contains 10^{11} particles per bunch and they cross every 25ns with a cross area of 400 μm^2. How many electrons per minute do you predict to be emitted within a sr around $\theta = 1^\circ$ with respect of one of the incoming electrons? (neglect the dependence of the cross section with θ within that sr). And around $\theta = 90^\circ$? Discuss the origin of the difference between those two numbers.