PHYSICS 722/822 - Fall Semester 2018 - ODU

Nuclear Physics - Problem Set 5 – Due Thursday, 10/11

Problem 1)

A high-energy physicist at SLAC (the Stanford Linear Accelerator Center) used a 20 GeV electron beam to study the structure of the proton. She set up a spectrometer with 2 msr acceptance at an angle of 4.5 degrees with respect to the beam line. The spectrometer accepts scattered electrons at energies E' between 14.9 and 15.1 GeV. The average beam current (averaged over one second) is 0.5 μA, and the target thickness 0.14 g/cm^2 (pure H_2). Calculate the count rate (detected electrons per second).
a) Calculate the kinematic variables x, Q^2 and whatever else you need to determine the cross section.
b) You can use the formula for deep inelastic scattering (assume scaling). Why? Ignore the contribution from $F_1(x)$ - the $F_2(x)$ part is sufficient. To find the proper value of $F_2(x)$, you can use Figure 7.4 in Povh, or any other source like the Particle Data Group website (citation!).
c) Use your result under b) and the information given to get the count rate..

Problem 2)

Using the quark-parton interpretation of the deep inelastic structure functions (and assuming the Callan-Gross relation), estimate the TOTAL fraction X of the proton momentum carried by ALL quarks:

$$X = \int_0^1 x\left(u(x) + \bar{u}(x) + d(x) + \bar{d}(x)\right)dx$$

Use eqs. 7.15-7.17 p. 96-96 in Povh and assume that the "up" quark distribution function $u(x)+\bar{u}(x)$ is twice the "down" quark distribution function $d(x)+\bar{d}(x)$ (why is that "semi-reasonable"?). Ignore the presence of other quark flavors (s, c,...).

Problem 3)

A 4 GeV electron hits a stationary proton. The experimenters observe an outgoing electron at a scattering angle $\theta_e = 30^o$ and 2.330 GeV energy, and a proton at $\theta_p = 30.44^o$ on the opposite side of the beam, with an energy of 1.617 GeV (momentum of 1.317 GeV).

a) The experimenters conclude that there must have been another particle created in the reaction that the detector didn't record. Why?

b) What is the energy and the momentum of the "missing" particle?

c) What is it? How did it escape detection?

d) The mystery particle and the detected proton are actually the decay products of a short-lived particle created in the reaction initially. Which particle is that?

e) Could we have found the answer to d) without detecting the proton in the final state (i.e., only measuring the final state electron)? If so, what additional information do we learn from observing the proton?