Problem Sheet 3

3C24

February 23, 2001

1. (i) Which quantum number must particles have in order to be detected in a tracking detector? [1]
   (ii) What characteristic of a particle is measured in a tracking detector? [1]
   (iii) What is measured in a calorimeter? [2]
   (iv) Which particles can be detected in a hadron calorimeter? [2]
   (v) Which particles are typically measured in an EM calorimeter? [2]
   (vi) Can you measure the particles in (v) in a hadron calorimeter? [1]
   (vii) Can you detect the particles in (iv) in an EM calorimeter? [1]

2. Write down the Bethe-Bloch formula
   (i) Identify the terms and describe to what this equation applies [4]
   (ii) What does this equation say about the energy loss as a function of the mass of the incident particle? [1]
   (iii) Sketch the shape of this function and identify the interesting regions. [4]

3. (i) Which fundamental force is important for the detection of high energy particles? [1]
   (ii) What are the two types of particle which are actually detected? [2]
   (iii) Describe Ionization loss, Coulomb Scattering and Bremstrahlung radiation and state to what these apply and their relative importance. [5]
   (iii) Draw the Feynman Diagrams for the three processes in (iii) above. [6]
   (iv) Which particles are affected by Coulomb Scattering? [1]

4. (i) Explain what is meant by the **radiation length** [1]
   (ii) Draw the Feynman digrams for the three processes by which photons lose energy [4]
   (iii) Explain why scintillator is a good detector for electrons and photons. [5]

5. i) Draw a diagram of the simplest multi-wire proportional chamber. Label: [3]
      a) Anode Wire
      b) Cathode
      c) Electric Field lines
   ii) Explain what happens to the gas when a charged particle traverses the gas volume. [4]
   iii) Explain what happens close to the anode wire. [3]
   iv) Explain how the signal is extracted from the chamber. [4]
   v) What happens if a neutron traverses the gas volume? [1]

6. i) Describe briefly the construction and mode of operation of a calorimeter [6]

(ii) The energy actually measured in a calorimeter by summing up the energy deposited in the active detector layers is proportional to the energy of the primary particle. On what does this proportionality factor depend (name three things)? [3]

(iii) How would you measure this proportionality factor? [1]

(iv) What is the most likely interaction that a hadron will undergo in a piece of absrber such as lead or iron? (The typical distance a hadron travels before an interaction in a given material is called the *absorption length*). [2]

(v) Draw the Feynman diagram for this interaction. [4]