Physics 6260, Homework #1 (due 9/13)

P1 For a positively charged kaon with a momentum of 3 GeV, calculate (a) its total energy, (b) its speed.

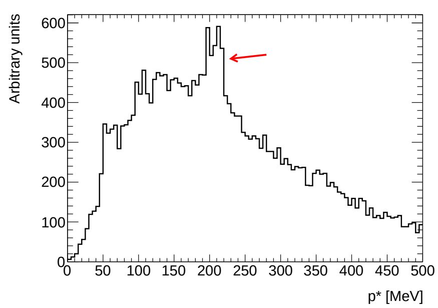
P2 A charged Sigma baryon having a momentum of 2 GeV in the laboratory frame decays into a proton and a neutral pion. What are the minimum and maximum possible momenta of the decay products (a) in the laboratory frame, (b) in the center-of-mass frame?

P3 In a sample of events recorded by the ATLAS detector, we consider pairs of reconstructed charged particles originating away from the point of main interaction ("primary vertex"). For every pair, we calculate the momentum p^* of particles in their center-of-mass reference frame (assuming the particles have the mass of a pion). The p^* distribution obtained for the sample (shown below) reveals a peak indicated by the red arrow.

(a) What is the possible origin of the peak?

(b) What is the expected position of the peak?

(c) Should the peak be more pronounced for particles of opposite or same charge?



P4 A beam of charged pions with a momentum of 10 GeV is incident at a right angle on a 500 μm thick silicon plate.

(a) Using the Bethe formula and neglecting the density correction term δ, calculate the average energy loss of pions in the plate. The mean ionization potential for silicon is 173 eV.

(b) How the result changes for the "low-energy approximation" $T_{max} = 2m_e c^2\beta^2\gamma^2$ (i.e. neglecting the terms in the denominator of the T_{max} formula)?

(c) How the result changes when taking into account the density effect? Use the following approximation (PRB 26 (1982) 6067):

$$\begin{cases} \delta(X) = 4.6052X + a(X_1 - X)^m + C, & X < X_1 \\ \delta(X) = 4.6052X + C, & X \geq X_1 \end{cases}$$

$$X = \log_{10}(\beta\gamma)$$

The constants for silicon are $a = 0.3755$, $X_1 = 2.5$, $m = 2.720$, $C = -4.435$.