Physics 56400 Assignment #2 – Due September 21st

1. A muon has a mass of 105.7 MeV/c^2 and decays into an electron and two massless neutrinos. Calculate the maximum energy that the electron can have if the muon decays at rest.
2. A hypothetical (but so far unobserved) decay mode of the muon is a two-body decay to a photon and an electron. Calculate the energy of the final state electron if a muon at rest decays in this way.
3. Suppose a negative muon is electrostatically bound to an aluminum nucleus, which has a mass of 26.98 amu. Calculate the energy that the final state electron will have if the muon in the bound state of μ-Al decays to an electron and an isolated aluminum nucleus.
4. Pions have a mass of 139.6 MeV/c^2, while kaons have a mass of 493.7 MeV/c^2. Suppose that both types of particles are produced with a measured momentum, p, and travel a distance, $d = 150\ \mathrm{cm}$ before hitting a piece of plastic scintillator that measures their arrival time with a precision of 100 ps. Over what range of momenta can kaons and pions be distinguished with a confidence interval of 2-sigma?
5. The Moliere radius of an electromagnetic shower in a mixture of pure elements is

$$\frac{1}{R_M} = \sum_j \frac{w_j}{R_{Mj}}$$

where w_j is the mass fraction of element j and R_{Mj} is the Moliere radius of an electromagnetic shower in the pure element, expressed in units of cm^2/g when scaled by the density.

   (a) Calculate the Moliere radius in brass ($w_{Cu} = 0.65$ and $w_{Zn} = 0.35$) of an electromagnetic shower of a 10 GeV incident electron.

   (b) Calculate the Moliere radius of a 10 GeV electron in a sampling calorimeter made a stack of 300 μm thick wafers of silicon and 5 mm thick sheets of tungsten.