Phys 56400 Assignment #3 – Due September 24th, 2019

In some of these problems you can look up the properties of materials using the interactive tool provided by the Particle Data Group: http://pdg.lbl.gov/2019/AtomicNuclearProperties/index.html

1. Suppose an electromagnetic calorimeter is designed to have a total thickness of 20 X_0. What would its physical thickness be if it was primarily made of (a) lead, (b) iron, (c) tungsten?

2. Suppose a hadronic calorimeter was designed to have a total thickness of 16 nuclear interaction lengths (λ_I). What would the physical thickness be if it was primarily made of (a) lead, (b) iron, (c) brass? Consider brass to be a homogenous mixture of 67% copper and 33% zinc.

3. (a) Assuming that a muon is essentially a minimum ionizing particle, calculate the amount of energy lost by a high energy muon as it travels through 5 km of air. (b) Estimate the range of a muon with an energy of 100 GeV in water. (c) Estimate the range of a muon with an energy of 100 GeV in rock? Consult https://en.wikipedia.org/wiki/Meter_water_equivalent and explain any approximations you need to make.

4. The OPAL tracking chamber (had an inner diameter of 0.5 m and an outer diameter of 3.7 m and was filled with a gas mixture of approximately 90% argon and 10% methane at a pressure of 4 atmospheres. Charged tracks were reconstructed from hits on 159 sense wires in a magnetic field of 0.435 Tesla. The single hit resolution was approximately 130 μm. (a) Calculate the expected momentum resolution σ_{p_T}/p_T using the Gluckstern formula for a charged track with $p_T = 50\ \mathrm{GeV/c}$. (b) Describe how the momentum resolution would be affected if the pressure was reduced to one atmosphere. That is, would the momentum resolution get better or worse? Explain why… (c) Describe how and why the resolution of $\langle dE/dx \rangle$ would be affected by reducing the pressure to one atmosphere.