Physics 225a Problem Set 4

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due Tuesday, Nov. 4 in class

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1. In this problem, estimate the consequence of multiple scattering in a layer of silicon on ability to track charged particles back to their origin. Suppose a charged particle of momentum p starts at the origin, and passes through vacuum until it reaches a first layer of silicon detector of thickness in the direction parallel to the 'track' of $300\,\mu$m, and positioned a distance of $2\,$cm from the origin. Assume that the silicon detector can itself localize the the track to $15\,\mu$m, in the direction perpendicular to the track. Assume that subsequent layers of particle detectors can measure the *direction* of the track with perfect accuracy. But, in making an extrapolation back to the origin, one is limited both by the $15\,\mu$m localization, and multiple scattering in the silicon itself. At what value of momentum will the contributions of measurement error in the silicon and of multiple scattering be equal?

2. Estimate, using the non-relativistic Bethe energy-loss formula derived in class, the minimum kinetic energy an electron must have to penetrate $300\,\mu$m of silicon. Neglect multiple scattering... assume the electron goes straight, through $300\,\mu$m of silicon. Then, estimate the probability that a relativistic ($\beta \approx 1$) singly charged particle collides with an atomic electron while passing through $300\,\mu$m of silicon, and imparts at least enough energy for the electron to traverse $300\,\mu$m of silicon.

3. Estimate the minimum energy a muon must have to penetrate 4 meters of iron; you can use the simplest effective approximation for dE/dx you wish; but you must look up the density of iron. For a $p \approx E \approx 500\,$GeV muon that penetrates 4 meters of iron, what is the r.m.s. scattering angle projected into the plane of the muon's momentum?
