PHYS 633: Elementary Particle Physics **Fall 2012**

Homework #1 **Due Date: 8/30/12**

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1. **Problem 1.1**

2. The collision of two particles, each of mass M, is viewed in a Lorentz frame in which they hit head on with momenta equal in magnitude but opposite in direction. We speak of this as the "center-of-mass" (CM) frame (though the name "center-of-momentum" would be more appropriate). The total energy of the system is E_{cm}. Show that the Lorentz invariant
$$s \equiv (p_1 + p_2)_\mu (p_1 + p_2)^\mu \equiv (p_1 + p_2)^2 = E_{cm}^2.$$
If the collision is viewed in the "laboratory" frame where one of the particles is at rest, then show, by evaluating the invariant s, that the other has energy $E_{lab} = \frac{E_{cm}^2}{2M} - M$.
We can see from this result that colliding-beam accelerators have an enormous advantage over fixed-target accelerators in achieving a given total CM energy, $\sqrt{s}$. List some advantages of fixed-target accelerators.

3. a) When a 100 GeV π^+ decays to $\mu^+\nu$, the energies in the lab system will depend on the decay angle in the CM system. Find $E_\nu(\text{max})$ and $E_\nu(\text{min})$ in the lab. Numerical values are required.
b) Find the neutrino energy if the decay angle in the lab is 1 mrad (corresponding to the edge of a 2 m target at the end of a 1 km beam line).
c) Repeat both a) and b) for the decay $K^+ \to \mu^+\nu$.

4. **Problem 2.1**

5. **Problem 2.4**

6. **Problem 2.5**

7. **Problem 2.6**