Physics 233B (Murayama)
HW #2, due Oct 8, 12:30 pm

1. The energy spectrum of electron or muon from the tau decay is given by

$$\frac{d^2\Gamma}{d\hat{x}\, d\cos\hat{\theta}} = \frac{G_F^2 m_\tau^5}{192\pi^3}\left[3 - 2\hat{x} \pm P_\tau \cos\hat{\theta}(2\hat{x}-1)\right]\hat{x}^2. \tag{1}$$

Here, P_τ is the degree of tau polarization, and $\hat{x} = 2E_\ell/m_\tau$ and $\hat{\theta}$ are given in the rest frame of τ. Work out the energy spectra of the electron or muon from the tau in the Z-decay for both helicity states, and compare them to the histograms in A. Heister *et al.* [ALEPH Collaboration], "Measurement of the tau polarisation at LEP," Eur. Phys. J. C **20**, 401 (2001), Fig. 13, (a) and (b).

2. Consider a particle of lifetime $\tau = 1$ psec that decays isotropically. Plot the distribution in the impact parameter (with infinite position resolution) for the values of $\beta\gamma = 10^{-3}, 0.1, 1, 10, 10^3$.

3. A heavy Higgs decays predominantly into longitudianal W and Z bosons. This point has been used in some of the search strategies using the specific angular distributions expected in the longitudinal W decays, while background processes tend to involve transverse W. Plot a distribution from $W \to \ell\nu_\ell$ decay that demonstrates its longitudinal polarization. Note that Higgs itself cannot be fully reconstructed as it misses two neutrinos in the final state. You have three pieces of information, two four-vectors of charged leptons, and one missing transverse energy vector.