**Introduction**

**­­­**Lepton flavour violation is exciting. Why? Because of all the new physics it can probe. We will not be looking at all lepton flavour violation (LFV); in this literature review we specifically cover charged LFV of the form tau->l gamma. Of the tau processes, these modes are predicted to be the most dominant. We choose to investigate tau LFV rather than, say, muon LFV because of the relative scaling of branching fractions due to mass. The decay tau->mu gamma has a predicted branching fraction ~6 orders of magnitude greater than the analogous mu -> e gamma!

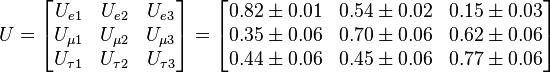
**LFV and the Standard Model**

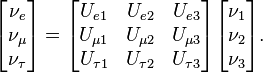
Lepton flavour violation necessarily requires generation mixing between leptons to occur. Though this is prohibited in the Standard Model, the discovery of neutrino oscillations proves that flavour mixing does occur in our universe; that is, flavour is not conserved. We seek to discover whether this LFV can be observed in other areas of flavour physics.

In the Standard Model + massive neutrinos, the only source of LFV is from the operators responsible for neutrino mass. However, the relevant Feynman diagrams (see Figure) are “loop suppressed” and proportional to the GIM factor, given as (m\_nu/M\_W)^4; as neutrino mass is very small (O(0.3eV)) we expect the LFV effects to be negligible! With these operators the branching ratio for, say, tau->mu gamma is ~10^{-40} (possibly include a calculation?). With such little SM background, observation of an LFV process of the type tau->l gamma would be an unambiguous signature of NP.

**Flavour mixing and the mass matrices**

“Flavor mixing will appear through the off diagonal elements of the mass matrix. In the SM, Higgs will produce them. For quark and lepton masses, (mf )ij = Yijv, where Yij is the Yukawa coupling lement and v is the vacuum expectation value. In SUSY, for the squark and slepton mass matrix, (m2 f )ij = (Y †Y )ijv2 + m2 ij . The SUSY breaking mass term (the second term) dominates the mass matrix and induces LFV. There are many models to explain what kind of physics induces this breaking mass term, such as GUT, a seesaw mechanism, leptogenesis, etc. Tau’s LFV relates to the off-diagonal elements of m2 31 and m2 32.” (Ohshima, 2007).

The Pontecorvo–Maki–Nakagawa–Sakata (PMNS) matrix was introduced by MNS in 1962 to explain neutrino oscillations predicted by P.



Using this matrix model, we see that neutrino mixing occurs because the flavour eigenstates are not equal to the mass eigenstates.

**Hints of LFV beyond the Standard Model**

While we can naively say such things as “in the Standard Model + massive neutrinos”, we have no understanding of the mechanisms which allow neutrino oscillations.

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**Searches for tau -> l gamma**

The most recent searches for tau -> l gamma were undertaken at Belle (2007) and Babar (2010), for both l=mu, e modes.

**Belle searches**

**Other tau LFV modes and their constraints on tau -> l gamma**