LEPTON FLAVOUR VIOLATION AT THE ILC*

P.M. Ferreira[a,†], R.B. Guedes[a,‡], R. Santos[a,b,§]

[a]Centro de Física Teórica e Computacional
Faculdade de Ciência, Universidade de Lisboa
Avenida Professor Gama Pinto, 2, 1649–003 Lisboa, Portugal

[b]Department of Physics, Royal Holloway, University of London
Egham, Surrey TW20 0EX, United Kingdom

(Received November 29, 2007)

We explore the possibility of detecting lepton flavour violation, now a well established experimental fact, at the International Linear Collider. Using a model independent approach we conclude that, given all experimental constraints available, there is still room to detect lepton flavour violation at the ILC.

PACS numbers: 12.60.–i, 11.30.Hv, 14.60.–z

This work is based on *Lepton Flavour Violating Processes at the International Linear Collider* [1] (please see paper for the complete list of references). The effective operator formalism is based on the assumption that the Standard Model (SM) is the low energy limit of a more general theory. Such a theory would be valid at very high energies but, at a lower energy scale Λ, we would only perceive its effects through a set of effective operators of dimensions higher than four. The effective operators that are important for our studies fall into two categories: those that generate lepton flavour violating (LFV) vertices of the form $Z l_{\rm h} l_{\rm l}$ and $\gamma l_{\rm h} l_{\rm l}$, where $l_{\rm h}$ and $l_{\rm l}$ are a heavy lepton and a light lepton, respectively, and four-fermion operators, involving only leptonic spinors. The effect of these LFV operators can be seen in two types of decays: a heavy lepton decaying into three light ones, $l_{\rm h} \to lll$ and a Z boson decaying to two different leptons, $Z \to l_{\rm h} l_{\rm l}$. Experimentally, the upper bound on the branching ratio for τ decaying into three light leptons

* Presented at the Symposium "Physics in Collision", Annecy, France, June 26–29, 2007.

† ferreira@cii.fc.ul.pt
‡ renato@cii.fc.ul.pt
§ rsantos@cii.fc.ul.pt

is of the order of 10^{-7} and of order 10^{-12} for the μ. The bounds on the Z branching ratios are of the order 10^{-6} for $Z \to e l_{\mathrm{h}}$ and 10^{-5} for $Z \to \tau\mu$. We concentrate on the most straightforward processes where LFV could be detected at the ILC: $e^+e^- \to \mu^- e^+$, $e^+e^- \to \tau^- e^+$, and $e^+e^- \to \tau^-\mu^+$, as well as the respective charge conjugates.

We computed the cross-sections and the decay widths for these LFV processes and used the experimental constraints to limit the possible range of the anomalous couplings. The range of values chosen for each of the coupling constants was $10^{-4} \leq |a/\Lambda^2| \leq 10^{-1}$ TeV^{-2}, where a stands for a generic coupling and Λ is in TeV. For $a \approx 1$ the scale of new physics can be as large as 100 TeV. This means that if the scale for LFV is much larger than 100 TeV, it will not be probed at the ILC unless the values of the coupling constants are unusually large. We then generate random values for all anomalous couplings (four-fermion and Z alike), and discard those combinations of values for which the several branching ratios we computed earlier are larger than the corresponding experimental upper bounds. The following figure shows us the example of the number of events occurring at the ILC for the process $e^+e^- \to \tau^- e^+$ in terms of the branching ratio BR$(\tau \to lll)$.

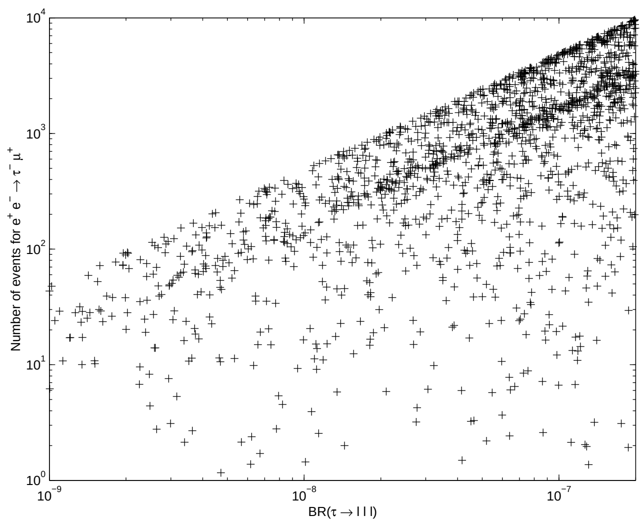

Fig. 1. Number of expected events with a center-of-mass energy of 1 TeV and a total luminosity of $1ab^{-1}$.

We have considered all planed future experiments on LFV. In the foreseeable future, the constraints on the four-fermion τ couplings could decrease one order of magnitude. Therefore, even in this case, the maximum number of events at the ILC would be $\sim$ 1000 and detection of LFV at the ILC would still be possible in that case. We also studied all possible SM backgrounds that could mask this signal. For example, for the signal process $e^+e^- \to \tau^+e^- \to \mu^+e^-\nu_\mu\bar{\nu}_\tau$ we have evaluated the two main backgrounds, $e^+e^- \to \mu^+e^-\nu_\mu\bar{\nu}_e$ and $e^+e^- \to \tau^+\tau^- \to \mu^+e^-\nu_\mu\bar{\nu}_e\nu_\tau\bar{\nu}_\tau$. With appropriate cuts on angular variables and transverse momentum, we were able to obtain a clear signal.

REFERENCES

[1] P.M. Ferreira, R.B. Guedes, R. Santos, *Phys. Rev.* **D75**, 055015 (2007).