Search for Lepton Flavour Violation in e^+e^- collisions at $\sqrt{s} = 189$ to 209 GeV

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The conservation of lepton number separately for each generation has no strong theoretical ground. In addition, recent data [1] present evidence for neutrino oscillations which necessarily violate lepton-flavour symmetry. Beyond the SM, lepton flavour violation (LFV) can occur in many supersymmetric (SUSY) extensions. An example is the SO(10) SUSY GUT model [2] where both the left- and right-handed supersymmetric lepton partners induce LFV, but none of the existing models predicts a measurable effect at LEP2 energies. Experimentally, no evidence for direct LFV has been reported so far. Upper bounds for muon decays are $\mathrm{BR}(\mu^- \to e^-\gamma) < 1.2 \times 10^{-11}$ and $\mathrm{BR}(\mu^+ \to e^+e^+e^-) < 10^{-12}$. Searches for neutrinoless τ decays such as $\tau^+ \to e^+e^+e^-$ and $\tau^+ \to \mu^+\mu^+\mu^-$ yield upper limits $\mathrm{BR}(Z \to e\tau) < 5.4 \times 10^{-5}$ and $\mathrm{BR}(Z \to \mu\tau) < 7.1 \times 10^{-5}$ at 90% confidence level (CL). Direct searches in e^+e^- annihilations at the Z peak yielded 95% CL limits $\mathrm{BR}(Z \to e\mu,\ e\tau,\ \mu\tau) < \mathcal{O}\ (1) \times 10^{-5}$.

This analysis [3] is based on the full data sample, corresponding to a total integrated luminosities larger than 500 pb^{-1}, collected with the OPAL detector since 1998 at centre-of-mass energies at and above 189 GeV. The SM background contributions are evaluated with a very large sample of Monte Carlo events processed through a full simulation of the OPAL detector and processed using the same reconstruction and selection programs as applied to the data. The SM sample comprised lepton pair final states with initial and final state radiations, $q\bar{q}(\gamma)$ events, four-fermion final states and two-photon scattering events. The efficiencies after the final event selection are almost independent of the considered centre-of-mass energy. They are on average 56%, 24% and 23% for $e\mu$, $e\tau$ and $\mu\tau$ channels respectively.

After applying the preselection criteria, events are subject to specific $e\mu$, $e\tau$ and $\mu\tau$ selection cuts. The cone jet finder is used to resolve two jets in each event and each jet is required to point to the barrel part of the OPAL detector (i.e. $|\cos\theta| \leq 0.82$). One jet should consist of a single identified electron or a single identified muon with a measured momentum close to the beam energy. The second jet should be narrow and consistent with a τ candidate or a single lepton different from the lepton of the first jet. The SM describes well the recorded data for each $\sqrt{s}$ and each step of the selection procedure except probably for the $e\mu$ channel at 189 GeV. There, one event remained after the $e\mu$ specific selection cuts and only 0.019 SM background events are expected. This particular event, shown on Figure 1, has the following characteristics: Total visible energy = 173.6 GeV ($\sqrt{s}$ = 189 GeV); electro-magnetic energy of the electron : 84.83 GeV; momentum of the Muon : 84.46 GeV; opening angle between the two tracks = 165°; one measured cluster in the forward detector with E = 7.2 GeV. We conclude that we have no clear evidence for production of lepton flavour violating events such as $e\mu$, $e\tau$ and $\mu\tau$ production in e^+e^- collisions between 189 GeV and 209 GeV. We observe one single $e\mu$ candidate, probably produced with initial state radiation, where, according to our Monte Carlo simulations, we expect 0.019 events to be produced from Standard Model processes. Assuming uniform final state angular distributions, we produce the first 95% confidence level on the upper limit of the production cross section of LFV events. They are displayed in Table 1 for different intervals of $\sqrt{s}$.

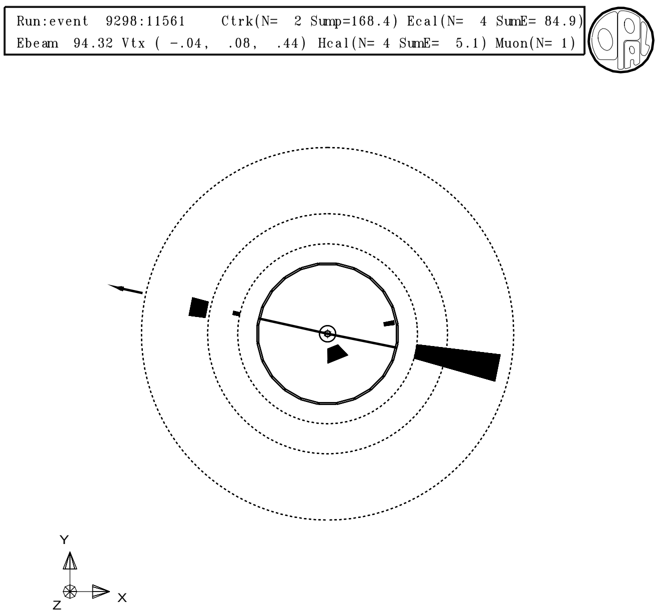

Fig. 1: An $r - \phi$ view of the $e\mu$ candidate at 189 GeV.

$\sqrt{s}$	$e\mu$ σ[fb]	$e\tau$ σ[fb]	$\mu\tau$ σ[fb]
189	58	95	115
$189 < \sqrt{s} < 200$	62	144	116
$200 \geq \sqrt{s} \leq 209$	22	78	64

Table 1: 95% **confidence level limits on** $\sigma(e^+e^- \to e\mu\ ,\ e\tau$ **and** $\mu\tau\ )$ **as a function of** $\sqrt{s}$

References

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