Studies of Electroweak Interactions and Searches for New Physics Using Photonic Events with Missing Energy at the Large Electron-Positron Collider

Thesis by

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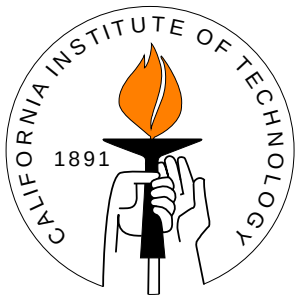

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Abstract

In this thesis I study the production of photonic events with missing energy in e^+e^- collisions at the Large Electron-Positron (LEP) Collider. My analysis was based on 619 pb^{-1} of data collected by the L3 detector between 1998 and 2000 at center-of-mass energies $\sqrt{s} = 189 - 208$ GeV, the highest energies ever attained in an e^+e^- collider.

I selected a high-purity sample of 2,022 well-reconstructed single- and multi-photon events with missing energy. I analyzed this sample to measure the cross section of the process $e^+e^- \to \nu\bar{\nu}\gamma(\gamma)$. The average ratio of the measured to expected cross section was found to be

$$\left\langle \frac{\sigma^{meas}_{\nu\bar{\nu}\gamma}}{\sigma^{exp}_{\nu\bar{\nu}\gamma}} \right\rangle = 0.987 \pm 0.022\,(stat) \pm 0.010\,(syst) \pm 0.010\,(theory)\,.$$

The number of light neutrino species was extracted:

$$N_\nu = 2.98 \pm 0.05\,(stat) \pm 0.04\,(syst)\,,$$

and the first direct evidence for the reaction $e^+e^- \to \nu_e\bar{\nu}_e\gamma$ was found. The experimental errors in these results are smaller than those of comparable previous measurements. My selection results are also given in the form of tables, which can be used to test any future models involving photonic signatures at LEP.

These measurements take advantage of the unique photon detection capability of the L3 Experiment. The performance and operation of the L3 electromagnetic calorimeter is discussed in detail, with an emphasis on its calibration and monitoring. In particular, I describe a novel calibration system based on a Radiofrequency Quadrupole accelerator, which allowed me to achieve a calibration precision of 0.5%.

Reactions of the type $e^+e^- \to \gamma(\gamma) + \textit{invisible particles}$ are predicted by a broad range of theories beyond the Standard Model, including Supersymmetry and models

with extra spatial dimensions and anomalous gauge-boson couplings. I found no evidence for such models and derived limits on the corresponding signal cross sections and model parameters. Among others, lower limits between 1.6 TeV and 0.66 TeV were set at the 95% confidence level on the new scale of gravity for the number of extra dimensions between 2 and 6.