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Measurement of Single Photon Production in e^+e^- Collisions near the Z^0 Resonance

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Abstract

A measurement of the single photon production cross-section is presented based on a data-sample of 40.5 pb^{-1} collected with the OPAL detector at centre-of-mass energies within 3 GeV of the Z^0 mass. Single photon events arise from initial state radiation and the production of an "invisible" final state consisting of neutrinos or possibly particles such as sneutrinos or photinos. The single photon topology is also sensitive to new Z^0 decays such as $Z^0 \to \bar{\nu}\nu^* \to \bar{\nu}\nu\gamma$ or $Z^0 \to \gamma X$, $X \to$ invisible particles. A total of 447 single photon candidates were observed with energy exceeding 1.75 GeV in the polar angle region $|\cos\theta| < 0.7$. The estimated background from processes with visible reaction products, mainly $e^+e^- \to e^+e^-\gamma$, is 37 ± 6 events. Interpreting the cross-sections as being solely due to Z^0 decay to invisible particles and the expected W-contributions, the Z^0 invisible width is determined to be $539 \pm 26 \pm 17$ MeV corresponding to $N_\nu = 3.23 \pm 0.16 \pm 0.10$ light neutrino generations. The differential cross-section with photon energy is presented. Upper limits are set on additional invisible contributions to the Z^0 width, on possible non-resonant processes, and on Z^0 decays to single photons. The energy spectra are used to constrain exotic sources of high energy single photons. In particular, the radiative two-body decay of the Z^0 to a new particle X, with mass below 64 GeV and an invisible signature, has a Z^0 branching ratio of less than 4.3×10^{-6} at 95 % confidence level.

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