MEASUREMENTS OF SINGLE W PRODUCTION AT LEP2

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In the energy region of LEP2 and above, four fermion final states in e^+e^- collisions can be produced by Feynman diagrams involving two, one, or zero resonant bosons. The four fermion process $e^+e^- \to e\nu f\bar{f}'$ is an interesting reaction because it involves t-channel diagrams, whose contribution is enhanced when the electron is scattered at very low angles and escapes experimental detection along the beam pipe. Under these conditions, the process is commonly referred to as single W production, $e^+e^- \to e\nu W$, as it is dominated by diagrams involving one single resonant heavy W boson.

The interest of the experimental study of single W production at LEP2 is twofold. First, this process is a powerful probe of possible physics beyond the Standard Model, thanks to its strong sensitivity to anomalous triple gauge boson couplings (TGCs) [1]. Secondly, the experimental signature of single W events, with large missing energy and transverse momentum due to the undetected electron and neutrino, is also characteristic in the searches for new particles, and its measurement provides a useful check of the validity of the background estimation for these analyses.

Measurements of single W production cross sections

Single W cross sections at LEP2 have been measured by the four LEP experiments at energies between 130 and 207 GeV [2], in both the hadronic and leptonic decay channels of the W boson. Hadronic single W events, characterised by two acoplanar jets of high invariant mass accompanied by large transverse missing energy, are typically selected with 40% efficiency and 40% purity, with large $WW \to q\bar{q}\tau\nu$ and $ZZ \to q\bar{q}\nu\bar{\nu}$ backgrounds. Leptonic single W events, with a single isolated electron or muon (or thin jet for τ decays) of high p_T, are typically selected with 60% efficiency and 60% purity, the largest backgrounds being Zee or radiative Z events with $Z \to \nu\bar{\nu}$, as well as radiative Bhabha events. At 189 GeV, 60 (30) events per experiment are typically accepted by the hadronic (leptonic) analyses. Both measurements are limited by statistical errors.

The combined values of the single W cross sections measured by the four LEP experiments between 183 and 207 GeV [2] are compared in Figure 1 to several theoretical

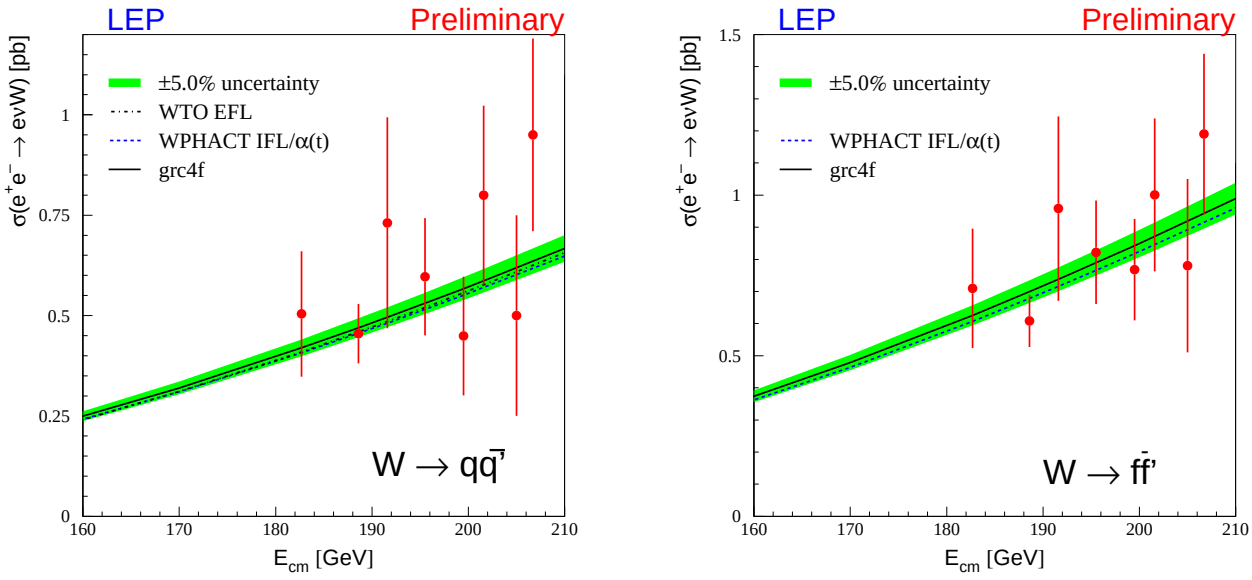

Figure 1: LEP measurements of the hadronic (left) and total (right) single W production cross section, compared to the predictions of WTO, WPHACT and `grc4f` [3]. The shaded areas represent the ±5% uncertainty on the predictions [4].

predictions [3, 4]. No deviation of the measurements from the expectations is observed. The values in the figures represent single W cross sections according to the common LEP definition [2], where single W production is considered as the complete t-channel subset of Feynman diagrams contributing to $e\nu_e f\bar{f}'$ final states, with additional kinematic cuts to exclude the regions of phase space dominated by multiperipheral diagrams.

Sensitivity to triple gauge boson couplings

Triple gauge boson couplings, usually described in terms of the three parameters Δg_1^Z, $\Delta\kappa_\gamma$ and λ_γ [5], are measured at LEP2 [6] primarily from the analysis of W pair events, $e^+e^- \to W^+W^-$. Since this process is sensitive to both the WWZ and the WWγ vertices, it is difficult to disentangle the two effects and large correlations exist between the fitted values of the couplings from these analyses. Single W production at LEP2 is especially interesting because it is sensitive to the WWγ vertex alone [1], the contribution of the WWZ vertex being suppressed by the t-channel exchange of a Z, thus providing useful constraints complementary to those from W pair events.

Measurements of $\Delta\kappa_\gamma$ and λ_γ from the analysis of single W events have been performed by ALEPH at 161–202, DELPHI at 189–202, L3 at 130–202 and OPAL at 189 GeV [7]. TGCs are extracted via maximum likelihood fits to total event rates and differential distributions, most of the sensitivity coming from event rates. As expected [1], for a given integrated luminosity, the sensitivity of single W production to $\Delta\kappa_\gamma$ is comparable to that obtained from W pair events, in spite of the much lower cross section. This can be seen, for instance, in Figure 2, where the ALEPH measurements of λ_γ and $\Delta\kappa_\gamma$ at energies up to 202 GeV [8] from W pair, single W and single γ events are compared and combined. As the figure also shows, W pair events have a considerably higher sensitivity to λ_γ compared to single W events. Combined LEP results for TGCs from W pair, single γ and single W events have been presented in Ref. [6].

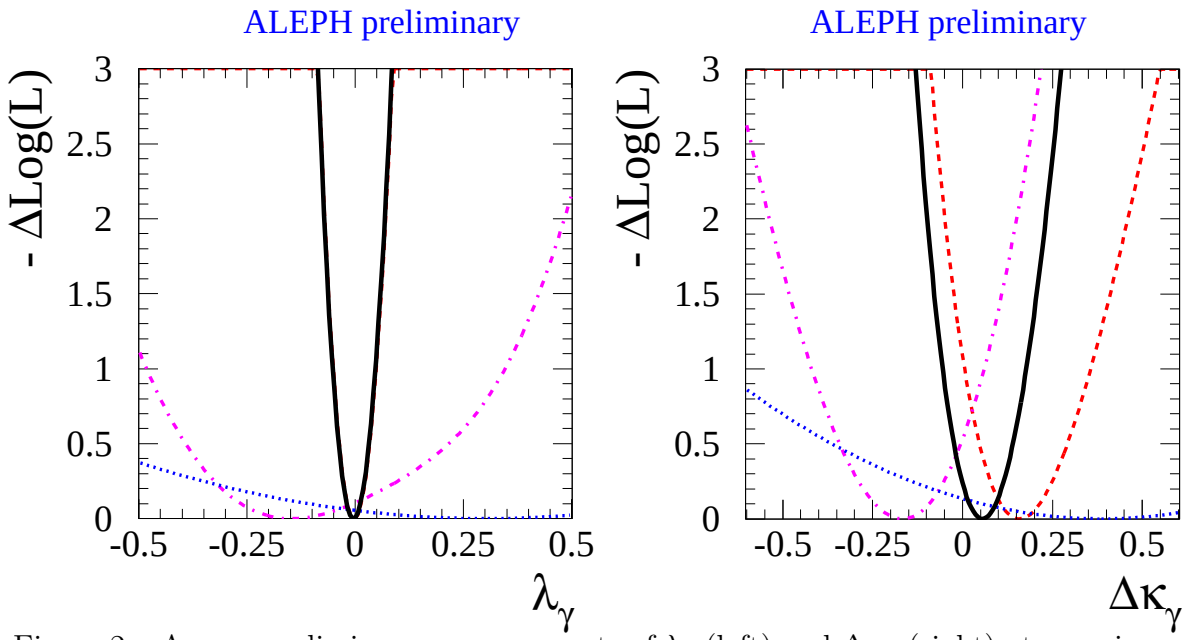

Figure 2: ALEPH preliminary measurements of λ_γ (left) and $\Delta\kappa_\gamma$ (right) at energies up to 202 GeV [8], from W pair (dashed red), single γ (dotted blue) and single W events (dashed-dotted purple) and their combination (solid black).

Conclusions and acknowledgements

Single W production has been studied by the four LEP experiments at all LEP2 energies between 130 and 207 GeV. The process is sensitive to anomalous triple gauge boson couplings, especially to the WWγ coupling $\Delta\kappa_\gamma$. No deviation of the measured cross sections from the theoretical predictions of the Standard Model has been observed.

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References

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