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TRIPLE GAUGE COUPLINGS AT LEP

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The status of Triple Gauge Coupling measurements from the LEP experiments is reported, with the main focus on the combined LEP fits. Preliminary results are given for single- and multi-parameter fits to the parameters λ_γ, g_1^Z and κ_γ.

1 Introduction

The measurement of Triple Gauge Boson Couplings (TGC) and the search for possible anomalous contributions due to the effects of new physics beyond the Standard Model are among the principal physics aims at LEP2 [1]. The W-pair production process, $e^+e^- \to W^+W^-$, is the main source of information for TGCs. It involves charged Triple Gauge Boson vertices between the W^+W^- and the Z or photon. The TGC parameters proposed in [1] and commonly used by the LEP experiments are g_1^Z, λ_γ and κ_γ.

Single W ($e\nu W$) and single photon ($\nu\bar{\nu}\gamma$) production at LEP are also sensitive to the $WW\gamma$ vertex. Results from these channels are also included in the combination for some experiments; the individual references should be consulted for details.

2 Data and Monte Carlo Samples

During LEP2 operation, about 10,000 W-pair events were collected by each experiment at centre-of-mass energies ranging from the W-pair production threshold up to 209 GeV. For the charged TGCs, Monte Carlo calculations (RacoonWW [2] and YFSWW [3]) incorporating an improved treatment of $O(\alpha_{em})$ corrections to the WW production have become our standard by now. The corrections affect the measurements of the charged TGCs in W-pair production. Results, some of them preliminary, including these $O(\alpha_{em})$ corrections have been submitted from all four LEP collaborations ALEPH [4], DELPHI [5], L3 [6] and OPAL [7].

3 Analyses

The analyses from the four LEP experiments use different channels, typically the semileptonic and fully hadronic W-pair decays. The full data set is analysed by ALEPH, L3 and OPAL, whereas DELPHI presently uses all data at 189 GeV and above. Anomalous TGCs affect both the total production cross-section and the shape of the differential cross-section as a function of the polar W^- production angle. The relative contributions of each helicity state of the W bosons are also changed, which in turn affects the distributions of their decay products. The analyses presented by each experiment make use of different combinations of each of these quantities. In general, however, all analyses use at least the expected variations of the total production cross-section and the W^- production angle. Results from eνW and $\nu\bar{\nu}\gamma$ production are included by some experiments. Single W production is particularly sensitive to κ_γ, thus providing information complementary to that from W-pair production.

4 Results

The LEP TGC combination is based on the individual likelihood functions from the four LEP experiments. As input to the combination, each experiment provides the negative log likelihood, $\log \mathcal{L}$, as a function of the coupling parameters to be combined. At the heart of the combination lies a joint minimisation of statistical and systematic uncertainties. For details, the LEP Gauge Couplings Report [8] should be consulted.

The individual $\log \mathcal{L}$ curves for single-parameter TGC fits and the corresponding LEP combination are shown in Figure 1, together with the numerical results of the combination. Figure 2 shows the results from two-parameter fits. The errors in both cases include both statistical and systematic effects.

A list of the systematic errors treated as fully correlated between the LEP experiments, and their shift on the combined fit result are given in Table 1. The uncertainty in the radiative corrections, labelled $O(\alpha_{em})$ correction, is of particular interest: it was the dominant systematic error in the previous combination [9], where a conservative estimate, the full effect from applying the $O(\alpha_{em})$ corrections, was used. New preliminary analyses on the subject are now available from several LEP experiments, based on comparisons of fully simulated events using two different leading-pole approximation schemes (LPA-A and LPA-B) [10]. In addition, the availability of comparisons of both generators incorporating $O(\alpha_{em})$ corrections (RacoonWW and YFSWW [2,3]) makes it now possible to perform a more realistic estimation of this effect. In general, the TGC shift measured in the comparison of the two generators is found to be larger than the effect from the different LPA schemes. This improved estimation, whilst still being conservative, reduces the systematic uncertainty from $O(\alpha_{em})$ corrections significantly, and renders the charged TGC measurements statistics dominated.

5 Conclusions

A precision measurement of the Triple Gauge Coupling parameters λ_γ, g_1^Z and κ_γ has been performed, based on the individual analyses from the LEP experiments. The LEP-wide combination gives total uncertainties of about 2% for the couplings λ_γ and g_1^Z, and 5% for κ_γ from single-parameter fits. No deviation from Standard Model values is found.

Source	g_1^Z	λ_γ	κ_γ
$O(\alpha_{em})$ correction	0.010	0.010	0.020
σ_{WW} prediction	0.003	0.005	0.014
Hadronisation	0.004	0.002	0.004
Bose-Einstein Correlation	0.005	0.004	0.009
Colour Reconnection	0.005	0.004	0.010
$\sigma_{singleW}$ prediction	-	-	0.011

Table 1. The systematic uncertainties considered correlated between the LEP experiments in the charged TGC combination and their effect on the combined fit results.

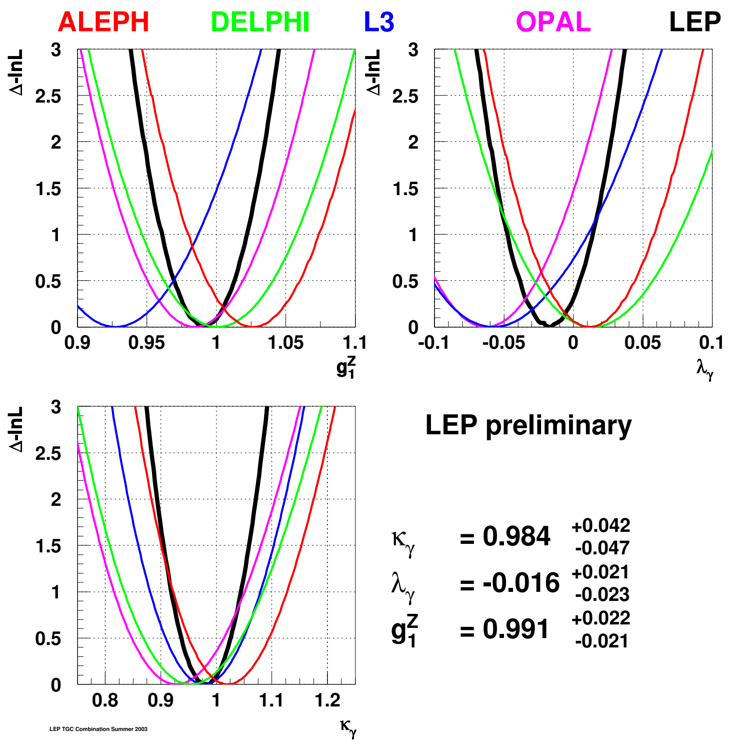

Figure 1. The log $\mathcal{L}$ curves of the four experiments (thin lines) and the LEP combined curve (thick line) for the three charged TGCs g_1^Z, κ_γ and λ_γ. In each case, the minimal value is subtracted.

References

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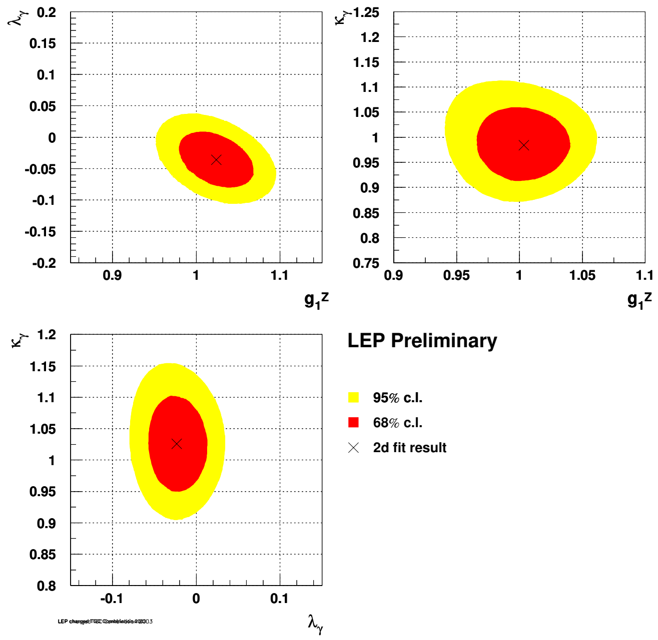

Figure 2. The 68% and 95% confidence level contours for the three two-parameter fits to the charged TGCs g_1^Z-λ_γ, g_1^Z-κ_γ and λ_γ-κ_γ. The fitted coupling value is indicated with a cross; the Standard Model value for each fit is in the centre of the grid. The contours include the contribution from systematic uncertainties.

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