Charged boson triple gauge couplings at LEP WWγ WWZ and W polarisation

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LAPP-EXP 2000-10
November 2000

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abstract

The study of WWZ and WWγ vertices is presented based on LEP2 data collected up to 202 GeV (475 pb^{-1} per experiment). WW pair and single W productions are used to measure possible deviations (quantified by the terms of a general Lagrangian) from the charged boson Triple Gauge Couplings (TGC) predicted by the Standard Model. In addition, the measurement of the W polarisation in W pair production gives access to deviations without using any model.

Talk given at ICHEP 2000, 27 july-2 august 2000, Osaka, Japan

CHARGED BOSON TRIPLE GAUGE COUPLINGS AT LEP $WW\gamma$ WWZ AND W POLARISATION

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The study of WWZ and WWγ vertices is presented based on LEP2 data collected up to 202 GeV (475 pb^{-1} per experiment). WW pair and single W productions are used to measure possible deviations (quantified by the terms of a general Lagrangian) from the charged boson Triple Gauge Couplings (TGC) predicted by the Standard Model. In addition, the measurement of the W polarisation in W pair production gives access to deviations without using any model.

1 Introduction

The most general Lagrangian being Lorentz invariant for the WWV (V=Z or γ) interaction is described in these papers[1,2,3,4]. It contains seven terms: (g_1^V, κ_V and λ_V) conserve C and P, g_5^V violates C and P but conserves CP and (g_4^V, $\tilde{\kappa}_V$ and $\tilde{\lambda}_V$) which violates CP. Taking into account LEP1 constraints, the base line analysis[1] at LEP2 measures 3 parameters (Δg_1^Z , $\Delta\kappa_\gamma$, λ_γ) which are the most likely to deviate from the Standard Model (C and P conservation, $U(1)_{em}$ gauge symmetry). They are equal to zero at the Standard Model. The $SU(2)_L \times U(1)_Y$ gauge symmetry implies the following constraint:

$$\Delta\kappa_Z = \Delta g_1^Z + \Delta\kappa_\gamma \tan^2\theta_w; \lambda_Z = \lambda_\gamma$$

This analysis supposes that only one, two or three terms are different from the Standard Model. The study is extended to the measurement of each of the 14 terms individually.

2 WW analysis

The selection of WW events is the same as for the cross section[5] but restricted to well reconstructed events[6]. S-channel for W pair production is sensitive to Δg_1^Z, $\Delta\kappa_\gamma$ and λ_γ contrary to the t-channel. Anomalous couplings affect quadratically the differential cross section. This effect is looked for through the total WW cross section and the angular distributions of the 5 angles of the event. Cross section are extracted from adjustement of the expected cross-section which is a function of couplings to the observed one. To have the most precise measurement of one/many couplings out of the angles, an unbinned maximum likelihood is used by ALEPH (analytical Particle Density Function convoluted with a detector resolution function) and L3 (PDF mapped from simulated events). A second solution is the Optimal Observable[7] method where the five kinematic variables are projected onto 1 or 2 parameters per TGC coupling. DELPHI does a binned maximum likelihood fit to $\mathcal{O}_i^1$ and $\mathcal{O}_{ij}^2$ while OPAL (resp. ALEPH) fits the $\mathcal{O}_i^1$ and $\mathcal{O}_{ij}^2$ (resp. $\mathcal{O}_{ii}^2$) average.

For the TGC measurement, there are four main systematics: the theoretical uncertainty on the WW cross section ($\pm$ 2 %), the fragmentation model of jets (comparison JETSET/HERWIG), the approximate models on final state interaction (Bose-Einstein and Color Reconnection effect).

3 Single W analysis

The single W channel is made of many s- and t-channel diagrams. The measured cross section up to 202 GeV for this definition is shown in figure 1. The theoretical uncertainty on the cross section (as defined during the LEP

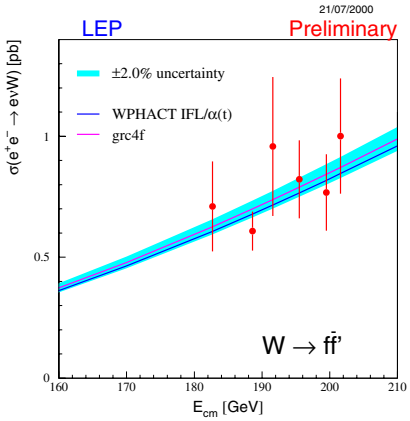

Figure 1. Measured and theoretical single W cross section at LEP2

Workshop[9]) was reduced to 5% but remains the main systematic for this channel.

This cross section measurement is translated into TGC[8] one ($\Delta\kappa_\gamma$ and λ_γ). ALEPH and OPAL improve the limits by including kinematic information based on visible energy and angle of the W.

4 Global results

The presented results[10] include all LEP data (except single W from OPAL for 99 data) up to 202 GeV (475 pb^{-1} per experiment). The likelihood of each measurement including statistical and uncorrelated errors were added. The table 1 shows the amplitude of the main systematics which are correlated between experiments and energies and no more negligible for the combination of LEP results. Because of non gaussian likelihood, the correlated errors were included with an approximate method: the likelihood curve is described as a gaussian with a width which is a function of the TGC value.

For the baseline analysis, supposing that only one parameter deviates from Standard Model, the results including all systematics are presented in table 2. The figure 2 presents one example out of three of exclusion contour for 2 free parameters analysis. In the note[10], the 3 parameter fit result is shown.

Table 1. Systematics

Systematics	Δg_1^Z	$\Delta\kappa_\gamma$	λ_γ
σ (WW)	0.012	0.055	0.014
Fragmentation	0.013	0.051	0.014
Color Reconnec.	0.003	0.012	0.005
Bose-Einstein	0.006	0.020	0.006
σ (Weν)	-	0.049	0.067

Table 2. Results for one free parameter with errors

Δg_1^Z	$-0.002^{+0.070}_{-0.067}$
$\Delta\kappa_\gamma$	$-0.024^{+0.028}_{-0.027}$
λ_γ	$-0.002^{+0.030}_{-0.030}$

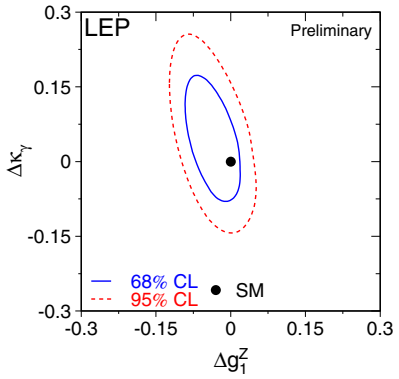

Figure 2. Exclusion contour plot for Δg_1^Z-$\Delta\kappa_\gamma$

Measurements are done on the other 14 parameters. ALEPH scanned individually the C, P or CP violating parameters. L3 looked at the CP conserving terms ($\Delta\kappa_Z$, λ_Z and g_5^Z). The result on $g_5^Z = 0.05\pm0.17\pm0.08$ is the ALEPH+L3 combination. OPAL measures the CP violating terms[11] with the Spin Density Method applying $SU(2)_L \times U(1)_Y$ constraint.

5 W Polarisation in WW pair production

W polarisation in WW pair production is measured independantly of any Lagrangian definition. L3[12] extracts the W helicity fractions from the $\cos\theta^*$ distributions of $W \to l\nu$ decays splitted in $\cos\theta_W$ bins (183-202 GeV data). The measured fraction of longitudinal W is $\sigma_L/\sigma_{tot} = 25.9 \pm 3.5$ % (24.8 % at the Standard Model). OPAL[11] applies the Spin Density Method on all W decays (183-189 GeV data) obtaining $\sigma_L/\sigma_{tot} = 21.0 \pm 3.3(stat.) \pm 1.5(syst.)$ % (25.7 % at the Standard Model).

6 Conclusion

The four LEP experiments have measured with the WW and single W events, the 3 parameters (Δg_1^Z, $\Delta\kappa_\gamma$ and λ_γ) independantly. The 95 % exclusion limits are : $-0.077 < \Delta g_1^Z < 0.030$, $-0.130 < \Delta\kappa_\gamma < 0.130$ and $-0.094 < \lambda_\gamma < 0.024$. They have been measured simultaneously too. These measurements become limited by systematics. Most of the other eleven parameters have been measured. None of these measurement has shown any deviation from the Standard Model. In W pairs, the distributions of W polarisation are consistent with the Standard Model expectation.

To improve these limits, the year 2000 LEP data will be included and systematics need to be reduced.

Acknowledgments

I want to thank my ALEPH, DELPHI, L3 and OPAL colleagues for making available their preliminary results, and the TGC LEP Working group for the combination results.

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