TRIPLE COUPLINGS OF ELECTROWEAK GAUGE BOSONS AT LEP2

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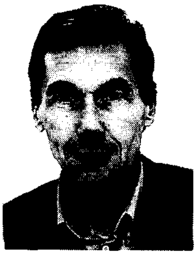

The non-abelian self-couplings of electroweak gauge bosons (TGC) $\gamma W^+ W^- Z^0$ is one of the most important consequences of the $SU(2)_L \times U(1)_Y$ symmetry of the standard model. Their measurements and the search of possible anomalous values is one of the main physics goal at LEP2.
From the data collected in 1997 the four LEP collaborations have improved the limits already stated for the couplings values. The results presented here correspond to a total integrated luminosity of $80pb^{-1}$/experiment at 161($9.9pb^{-1}$), 172($10.4pb^{-1}$), 183($57pb^{-1}$) GeV

1 Introduction

The most general Lorentz invariant WWV ($V = \gamma$ or Z) vertex observable in processes where the vector bosons couple to effectively massless fermions has 7 independent terms for each γ or Z couplings.
Electromagnetic gauge invariance and $\mathcal{CP}$ conservtion reduces the effective Lagrangian to 5 parameters: g_1^Z, κ_Z, κ_γ, λ_Z, λ_γ with $\kappa_\gamma = \kappa_Z = g_1^Z = 1$ $\lambda_\gamma = \lambda_Z = 0$ expected in the standard model. The number of parameters can be reduced to three by requiring $SU(2)_L \times U(1)_Y$ gauge invariance and two common set of parameters can be defined, one of them is $\delta_Z, \Delta\kappa_\gamma, \Delta\kappa_Z, \lambda = \lambda_\gamma = \lambda_Z$ the other set proposed [1] and used hereafter is:

$$\alpha_{W\Phi} = \Delta g_Z^1 \cos^2\theta_W$$
$$\alpha_W = \lambda_\gamma$$
$$\alpha_{B\Phi} = \Delta\kappa_\gamma - \Delta g_Z^1 \cos^2\theta_W$$

In the multidimensional space of the TGC these parameters correspond to the directions where the constraints from LEPI are weak.

2 Access to triple gauge bosons couplings

2.1 Selection of WW production

The production of W pairs is sensitive to the triple gauge couplings which affect the total cross-section and the angular distributions of θ_{W-} the angle of production and θ_l^* $\phi*_l$ the polar and azimuthal angles of its decaying particles. As either W can decay in $l\bar{\nu}$ or $q\bar{q}'$ there is three final sates to be studied:

- $q\bar{q}'l\bar{\nu}$ final state has been largely used for the couplings determination. It give access unambiguously to the W^- production angle with the charge of the reconstructed lepton, and to the right decay angles of the leptonically decaying W products. It correspond to 43% of the final sates
- $q\bar{q}q'\bar{q}'$ final state include 46% of the final states but it give access only to the W production angle and, if the W charge is not determined, it is neccessary to sum the distributions over the charge of the two W. The signal over background ratio is enhanced by using multivariables selection methods.
- $l_1\bar{\nu}_1\bar{l}_2\nu_2$ has a rather poor branching ratio (11% including the τ final state) but a clear signature. It has been used to complement the results from other final states.

2.2 Single W and single γ

The γWW vertex can be probed with single photon and single W production [2] [3], the cross-section depending only of $\Delta\kappa_\gamma$ and λ_γ parameters.

2.3 Determination of TGC

The access to the different quantities related on TGC parameters either kinematic quantities or optimal observable depends strongly on each W decay mode. In $W^+W^- \to q\bar{q}q'\bar{q}'$ reconstructed as four hadronic jets one has to identify which jet-pair came from W^- and which from the W^+. Jet charge information is generally used statistically to separate the W^+ and W^- contributions. In $W^+W^- \to q\bar{q}l\bar{\nu}$ the access to production and decay angles θ_W, θ_l^*, ϕ_l^* is most easily achievable. In a $W^+W^- \to l\bar{\nu}l\bar{l}'\nu_{l'}$ event there are at least two undetected neutrinos but the angles can still be reconstructed for $l = e$ or μ.

3 Results of TGC determination

3.1 Previous results with 161GeV and 172GeV

The data recorded at these energies by the four LEP experiments correspond to $\int \mathcal{L}dt \simeq 20.\,pb^{-1}$ per experiment, the strongest information comes from $qql\bar{\nu}$ but $q\bar{q}q'\bar{q}'$ and $l\bar{\nu}l\bar{l}'\nu_{l'}$ has been used too for total cross-section and additionnal angular information. Single W and single γ production results has been combined with the results of the WW pairs[4]. The results are summarized table [1]

Table 1: Combined LEP results with 161 GeV and 172 GeV data

Parameter	Results with $\int \mathcal{L}dt \simeq$ 20. pb^{-1}
$\alpha_{B\Phi}$(95% C.L.)	0.45, [+ 1.50 − 0.81]
$\alpha_{W\Phi}$(95% C.L.)	−0.02, [+ 0.33 − 0.28]
α_{W}(95% C.L.)	0.15, [+ 0.68 − 0.37]

3.2 Results with data recorded at 183 GeV

All experiments [5] [6] [7] [8] have used the four quarks channel, with W charge assignement, and the semi-leptonic channel. Opal have used in addition the fully leptonic channel information. Example of distributions are given in figures [1], [2] and [3].

The WW pairs results from Delphi, L3 and Opal have been combined with those of single W

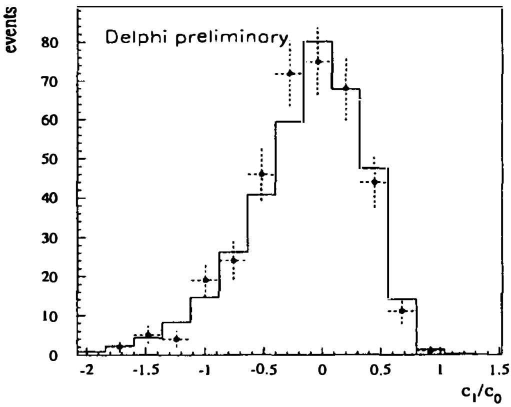

Figure 1: Optimised observable distribution in the four quarks channel.

from Aleph and L3 [7] and single γ from Aleph figures [4] by the Lep-TGC working group. The combined 95% limits are displayed table [2]

Table 2: Combined 95% C.L. results (the systematics errors have been included)

Parameter	Results with $\int \mathcal{L}dt \simeq$ 80. pb^{-1}
$\alpha_{B\Phi}$(95% C.L.)	−0.04, [+ 1.10 − 0.43]
$\alpha_{W\Phi}$(95% C.L.)	−0.05, [+ 0.14 − 0.12]
α_{W}(95% C.L.)	−0.09, [+ 0.27 − 0.21]

4 Conclusion

The final combination give $\alpha_{B\Phi}$, $\alpha_{W\Phi}$, α_{W} compatible with the standard model predictions with limits tightened by the new set of 183 data.

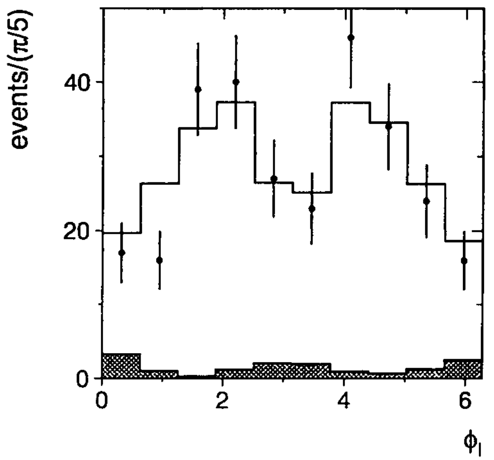

Figure 2: Distribution of the ϕ_l angle in the semi-leptonic channel from L3

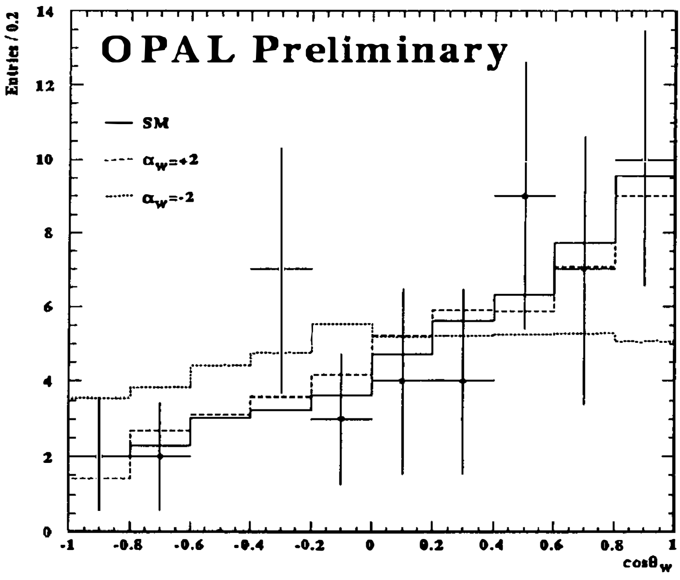

Figure 3: Distribution of the W production angle in the fully leptonic channel

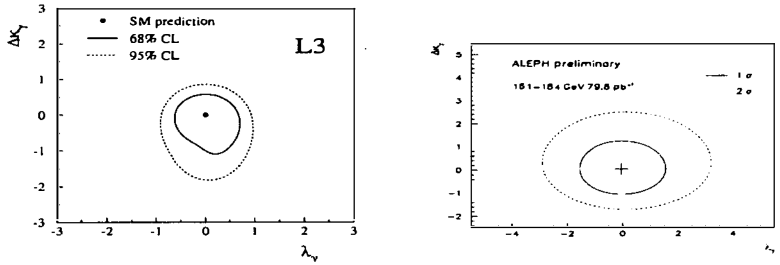

Figure 4: Results on Single W and single γ

Acknowledgments

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