Measurement of charged triple gauge-boson couplings at LEP2

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On behalf of the LEP experiments

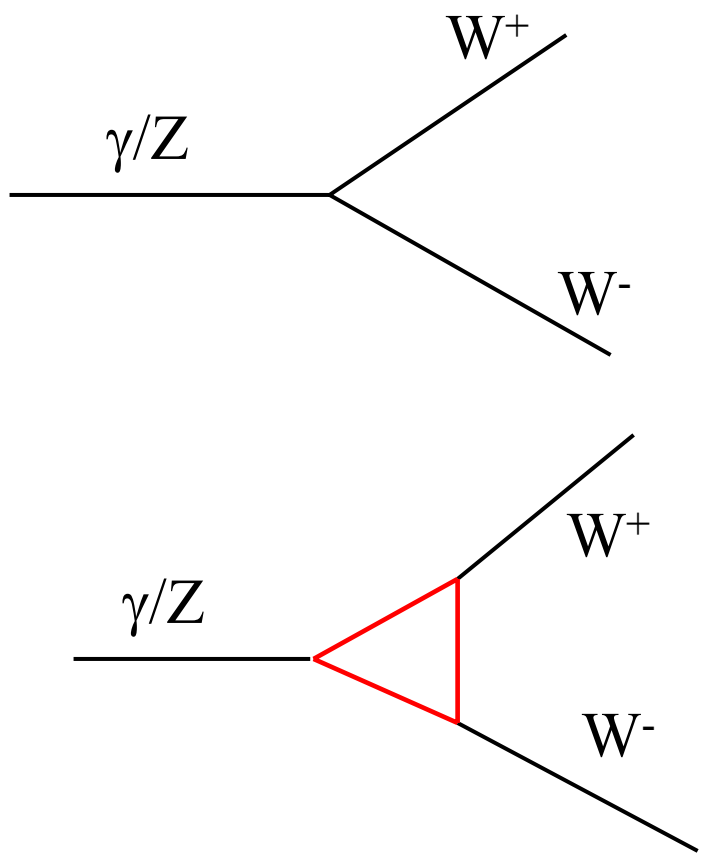
Outline

- Characteristics of charged triple gauge-boson coupling (cTGC)
- Analysis
  - Single W channel
  - W^+W^- channel
- LEP combination of cTGC results
  - ❖ *All results are preliminary for all experiments*
- Conclusion

Characteristics of cTGC

- cTGC are related to WWγ and WWZ vertices
- Non-Abelian nature of $SU(2)_L \times U(1)_Y$ WWγ and WWZ exist at tree level in the Standard Model
- S.M. loop correction ~ 10^{-3}

- Deviation from Standard Model prediction would indicate new physics at larger scale than LEP energy
- Expectation from New Physics like MSSM ~ few 10^{-3}



Characteristics of cTGC (2)

⇒The most general Lagrangian describing interactions between WWV (V=Z,γ) contains 2×7 terms:

- $g^1_V, \kappa_V, \lambda_V$: C and P conserving
- g^5_V : C, P violating but CP conserving
- $g^4_V, \tilde{\kappa}_V, \tilde{\lambda}_V$: CP violating

❑No new LEP combined result on each individual couplings

❑Most constrained analysis

(C and P conservation , $U(1)_{em}$, $SU(2)_L \times U(1)_Y$)

3 free parameters :

g^1_Z (=1 in the S.M.)

κ_γ (=1 in the S.M.)

λ_γ (=0 in the S.M.)

Others are fixed at their S.M. value except :

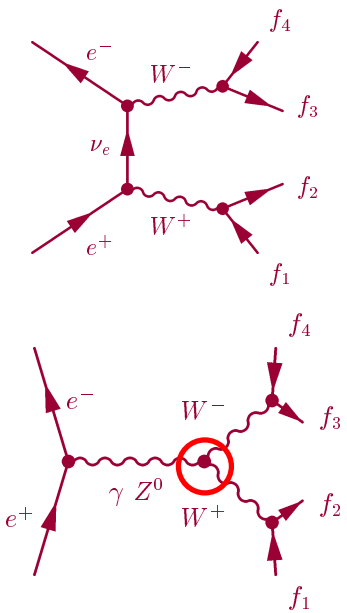
$\kappa_Z = g^1_Z + (\kappa_\gamma - 1).\tan^2\theta_W$

$\lambda_Z = \lambda_\gamma$

κ_γ and λ_γ : realeted to electric dipole and quadrupole moments of W

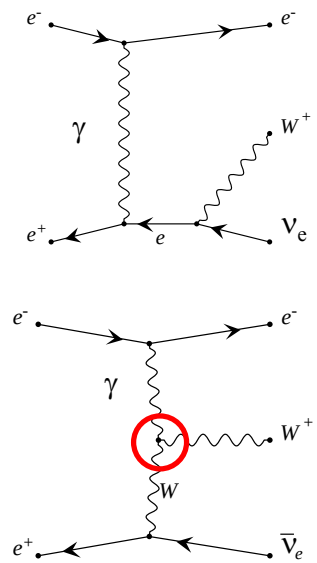
Sensitive channels to cTGC

- $e^+e^- \rightarrow W^+W^-$ (CC03)



g^1_z,κ_γ and λ_γ

- $e^+e^- \rightarrow We\nu_e$

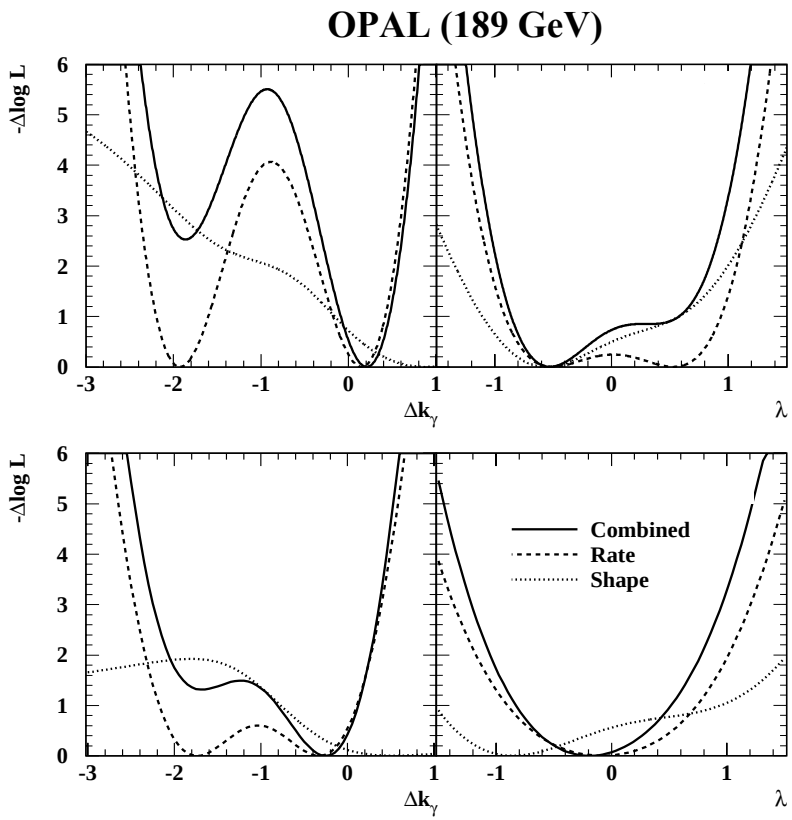


κ_γ and λ_γ

•Single γ not used for LEP combination

cTGC with single W

- Same selection as for the single-W cross section
- Main sensitivity through its cross section
- Kinematic information improves the measurement using :
  - Pt_W,$|\cos\theta_{jet1} - \cos\theta_{jet2}|$, NN output for W→2 jets
  - E_l,$\cos\theta_l$,Pt_l for W→lν



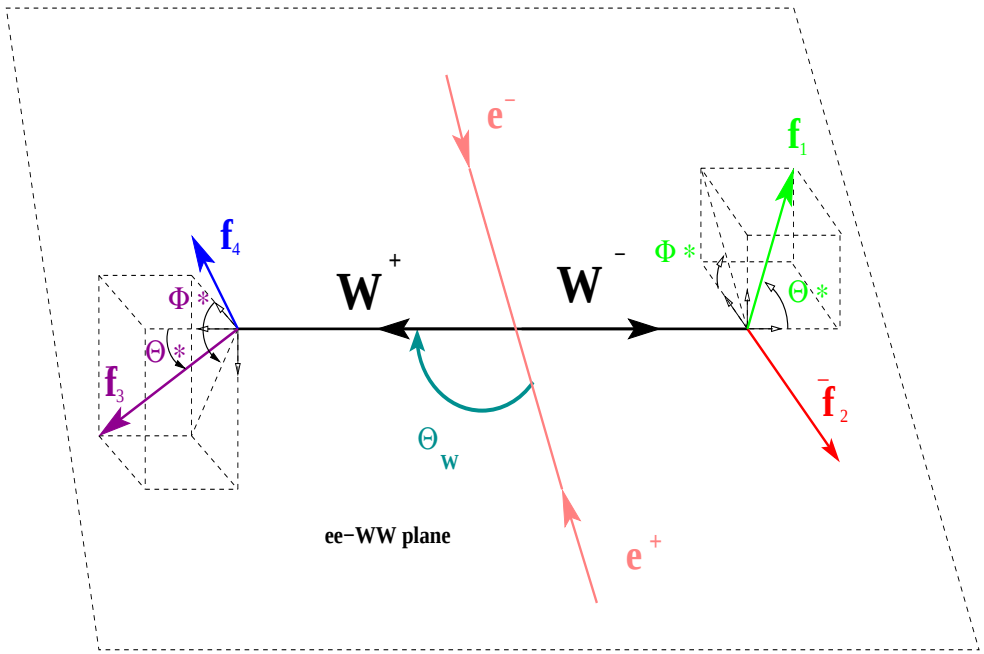
W→qq

W→lν

$\Delta\kappa_\gamma=\kappa_\gamma-1$ λ_γ

W^+W^- reconstruction for cTGC

- **Selection** : same as W^+W^- cross section restricted to well measured four fermion events
- **Kinematics of WW events**



- **Reconstruction**
  - Start from jets (q), lepton (l) and missing momenta (ν)
  - Tagging particles as fermion or antifermion possible only for lepton (electrical charge)

W^+W^- reconstruction for cTGC(2)

- Pairing of particles of Ws
  - $WW \rightarrow l\nu qq$

    W_1 = jet pair,

    W_2=lepton-neutrino
  - $WW \rightarrow qqqq$

    Highest CC03 Matrix Element of the three possible pairings (~80% efficiency)
- Charge of Ws
  - $WW \rightarrow l\nu qq$

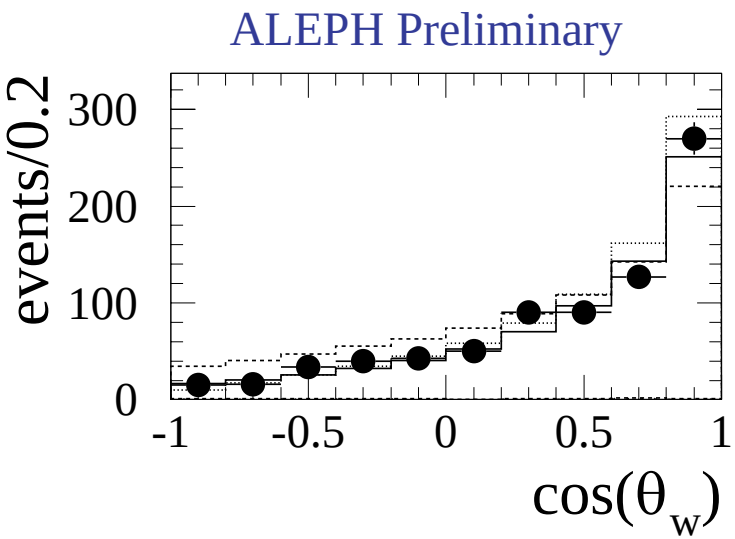
    Tagged by the lepton charge
  - $WW \rightarrow qqqq$

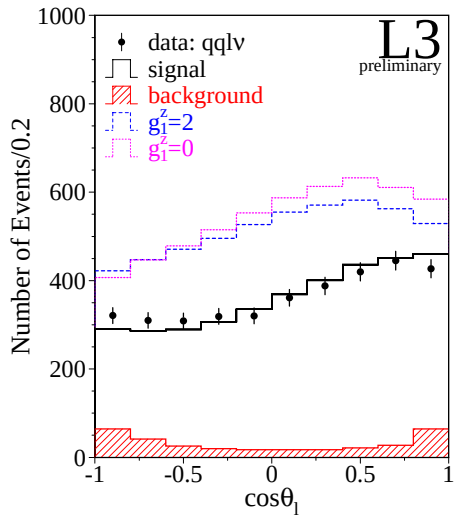
    Estimated from $Q(W_1)$-$Q(W_2)$ (~80 % efficiency) where

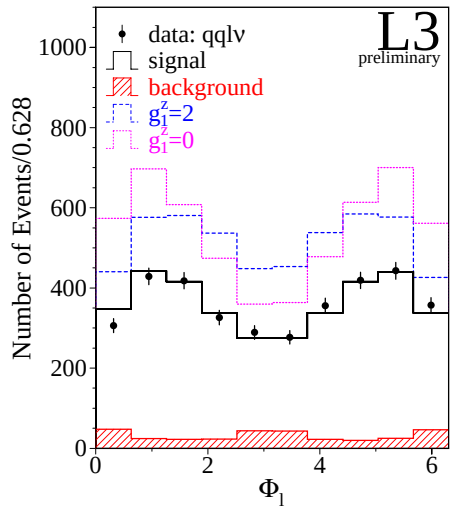
    $Q(W)=\Sigma$jet charge

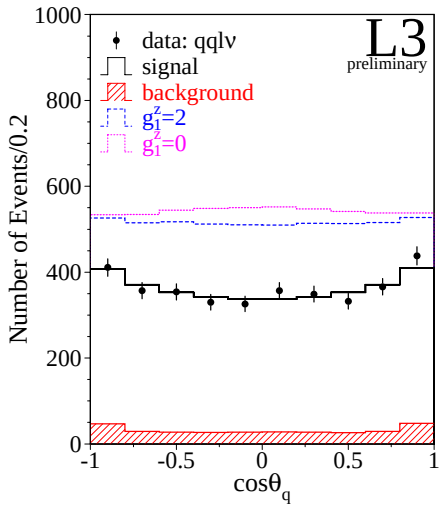
➢ $WW \rightarrow l^+\nu l^-\nu$: 2 possible solutions for neutrinos (or Ws) assuming 4-momenta conservation and equal masses

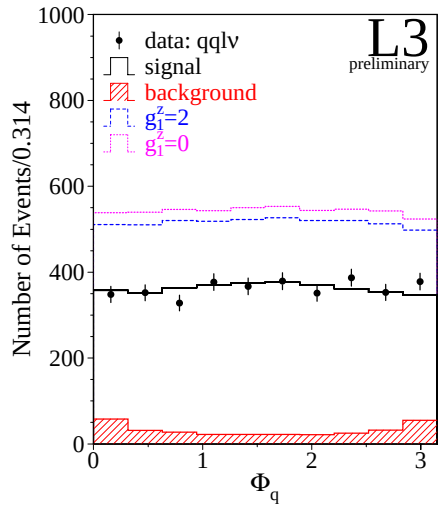
Examples of angle distributions











➢lνqq channel

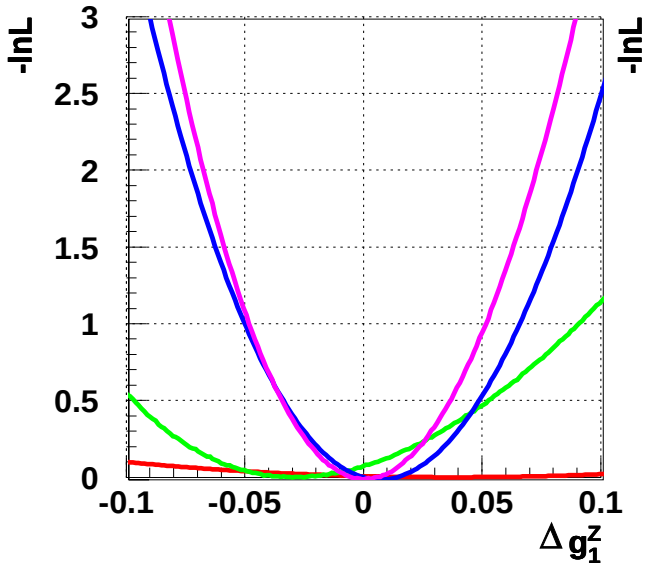
Extraction of cTGC for W^+W^- events

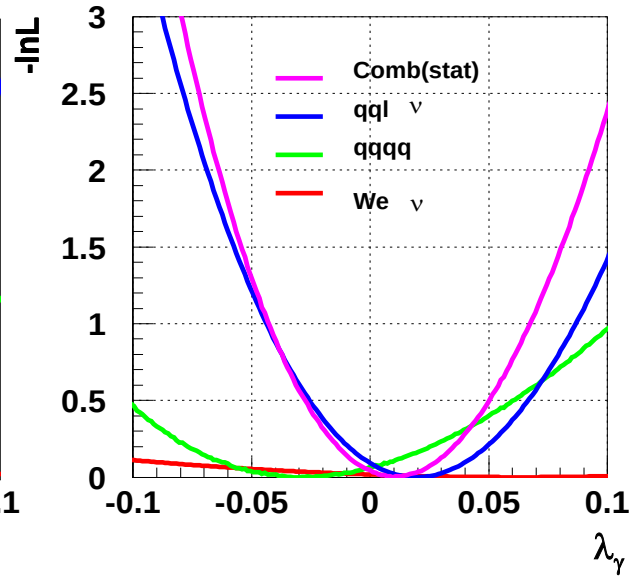
- Cross-section :
  - Adjust expected cross-section from simulation to the number of observed data
- Angular information
  - Problem : Extract the most precise measurement of one/many couplings out of 5 (or less angles)
  - Solution 1 : Unbinned likelihood method
    - ALEPH : Computed PDF ⊗ detector resolution function
    - L3, DELPHI : PDF from simulated events
  - Solution 2 : Optimal Observable
    - ✓ Project 5 kinematics variables onto 1 (2) parameter per TGC coupling

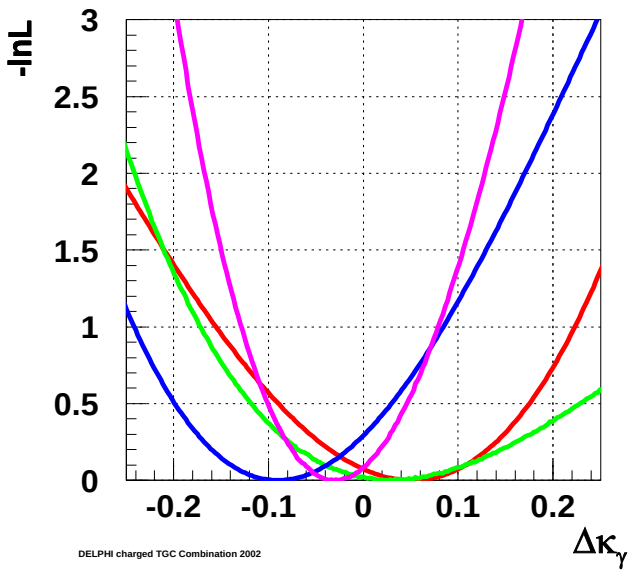
$$d\sigma(\Omega,\alpha)= S^0(\Omega) +\Sigma\alpha_i.\ S_i^1(\Omega)+ \Sigma\alpha_i.\alpha_j.S_{ij}^2(\Omega) \quad \text{with } \alpha_i= g^1_z,\kappa_\gamma \text{ and } \lambda_\gamma$$
$$O_i^1=S_i^1(\Omega)/S^0(\Omega) \text{ and } O^2_{ij}=S^2_{ij}(\Omega)/S^0(\Omega)$$

- χ^2 fit to O_i^1 and O^2_{ij} averages (OPAL, ALEPH)

Contribution of channels to cTGC







$o\Delta g_1^z = g_1^z - 1$

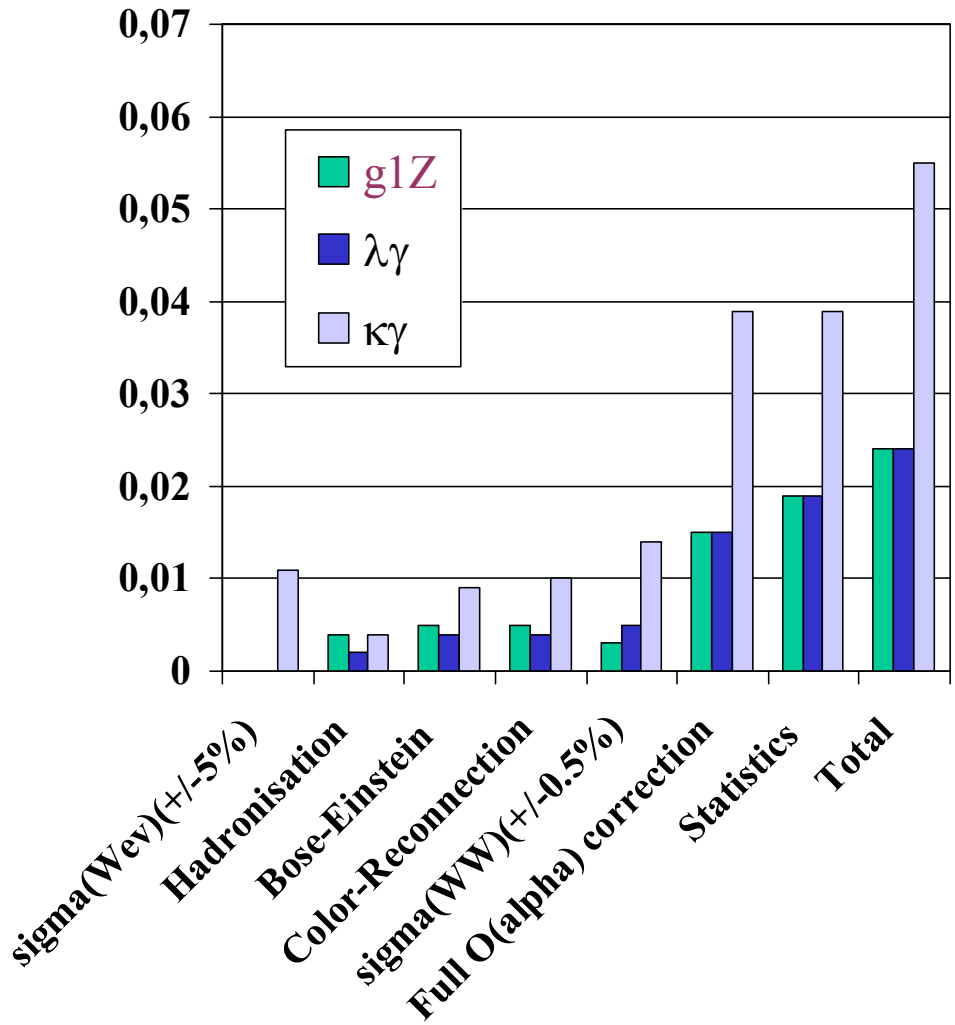
$o\Delta\kappa_\gamma = \kappa_\gamma - 1$

DELPHI preliminary

Systematics

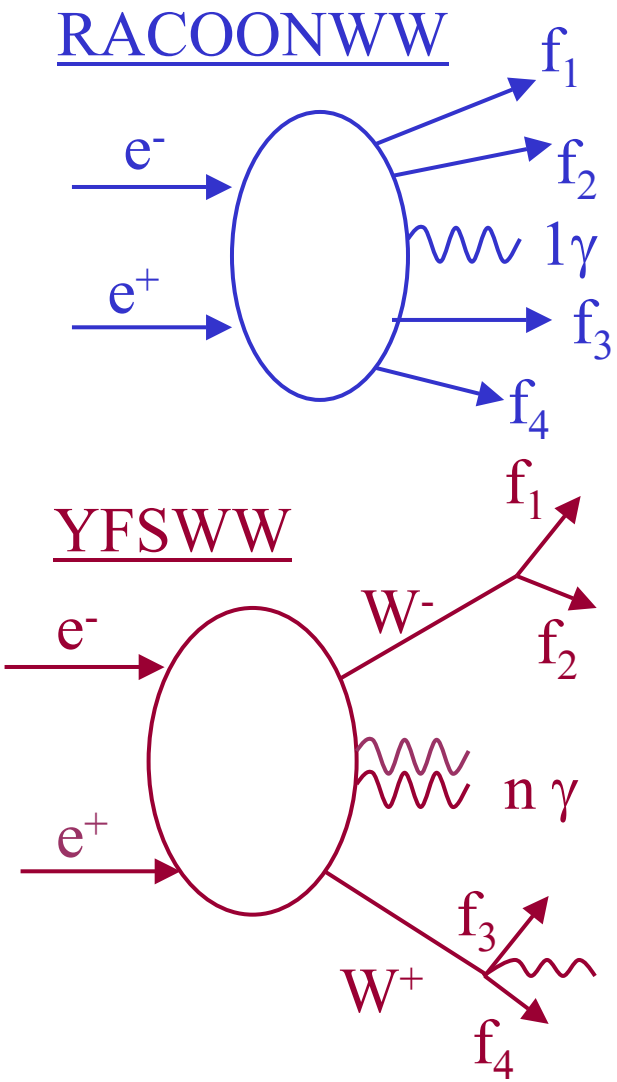
- All main systematics are correlated between energies and experiments
- The main single W systematic is its theoretical cross section uncertainty (+/- 5%)
- All other systematics affect W^+W^- channel and are at 1% level except full O(α) correction
- Full O(α) correction on the angular distribution is taken as systematic (*conservative assumption*)

⇒same amplitude as the statistical error

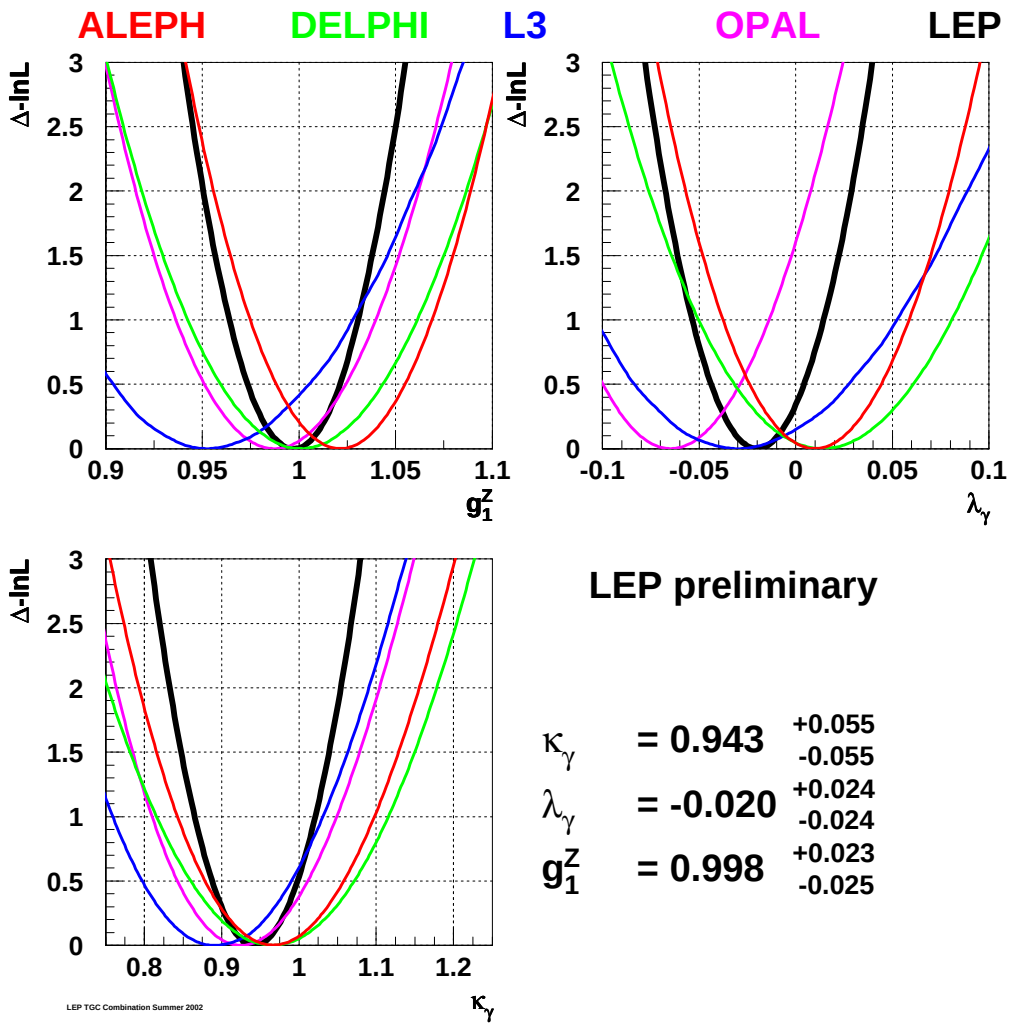


More on O(α) corrections

- Generators applying full O(α) corrections to WW CC03 graphs: RacoonWW and YFSWW
- Common paper have been written for comparison and extraction of systematic on the correction: **Phys.Lett. B533:75-84,2002**
  - The two generators predict similar O(α) correction for angular distribution shifting λ_γ by **$1.5.10^{-2}$**
  - The uncertainty on the correction was studied for λ_γ varying cos θ_W distributions.
    - ✓ Main contribution comes from different schemes for the EW effective couplings and is estimated to **$0.5.10^{-2}$**
    - ✓ Checked with parameterized variations of reconstructed cos θ_W distributions within the ALEPH detector
- LEP experiments are now checking results with the full simulation of detectors



Combination of experiments : 1D

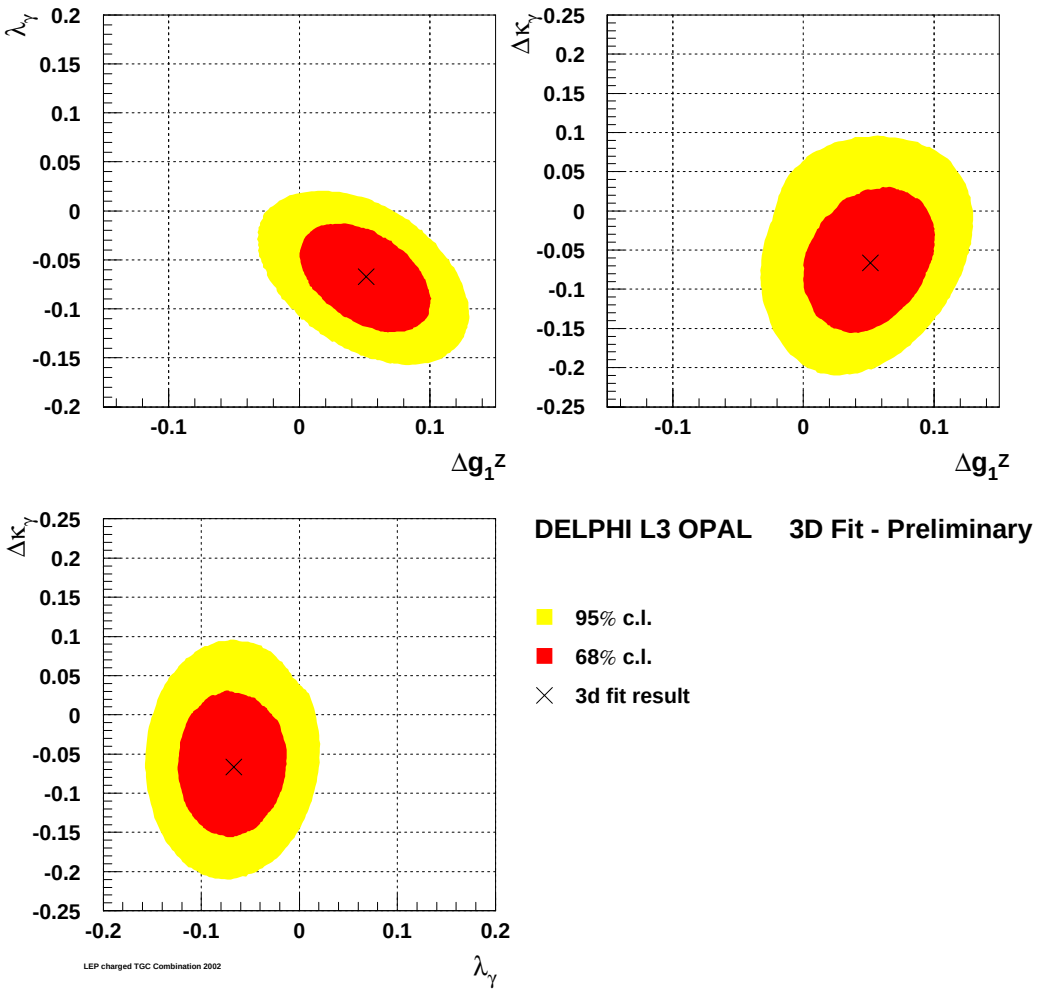


❖New compared to Winter2002 : Complete OPAL result for Year 2000 data

Good agreement with Standard Model prediction

Combination of experiments : 3D

➢Third parameter fixed at the minimum χ^2



❖First combination since ICHEP2000

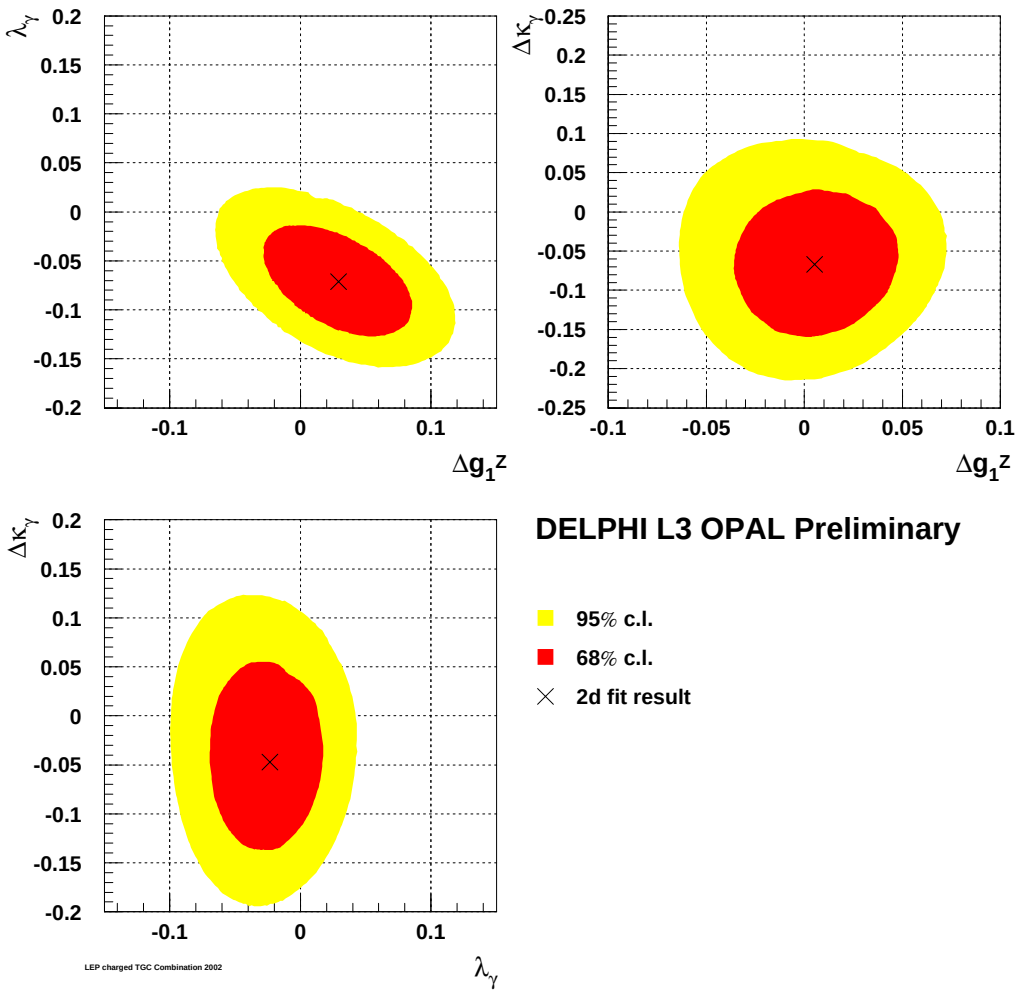
✓O(α) correction which increases systematics

✓Improved treatment of correlated systematic errors necessary

Agreement with Standard Model prediction

Combination of experiments : 2D

- Third parameter fixed at S.M. expectation



Agreement with Standard Model prediction

Conclusion

$0.951 < g^1_z < 1.043$

$0.835 < \kappa_\gamma < 1.052$

$-0.067 < \lambda_\gamma < 0.028$

95 % C.L.

cTGC in agreement with S.M. expectation

- Since almost all LEP2 data have been analyzed, no significant statistical improvement is foreseen
- LEP sensitivity on cTGC is limited by $O(\alpha)$ systematic
- Work devoted to reduce the $O(\alpha)$ correction uncertainty to 0.005 and to finalize results
- LEP2 data exclude new physics giving effect on cTGC greater than few %