Single W Physics in L3

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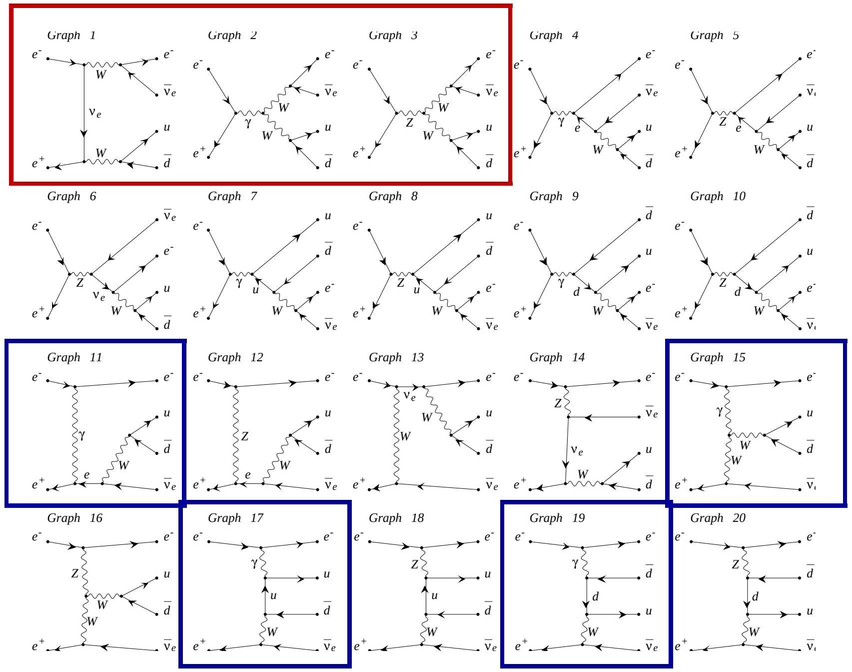
Les Rencontres de Physique de la Vallée d'Aoste – La Thuile

- Signal definition
- Experimental signatures
- Selections
- Cross section measurement and comparison with theory
- Trilinear gauge couplings with single W
- Conclusions and outlook

Signal definition

The f f$'$eν_e final state is obtained, within the SM, via 96 charged and neutral current diagrams:
(only some of them are shown here)

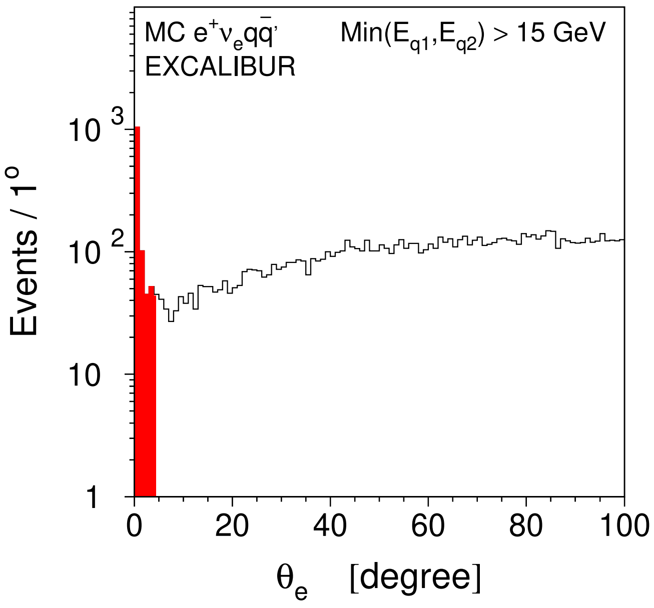


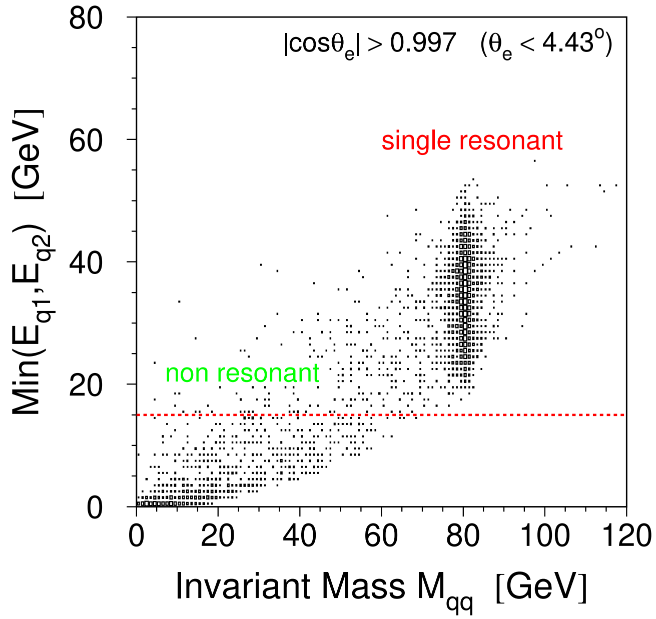
W-pair production

Single W production:
the f f$'$ pair is clearly identified to come from a W decay

Signal definition

The single W signal ($e^+e^- \rightarrow e^+\nu_e\, f\, f'$) is defined on the basis of either phase space cuts (L3 approach), or graphs content.

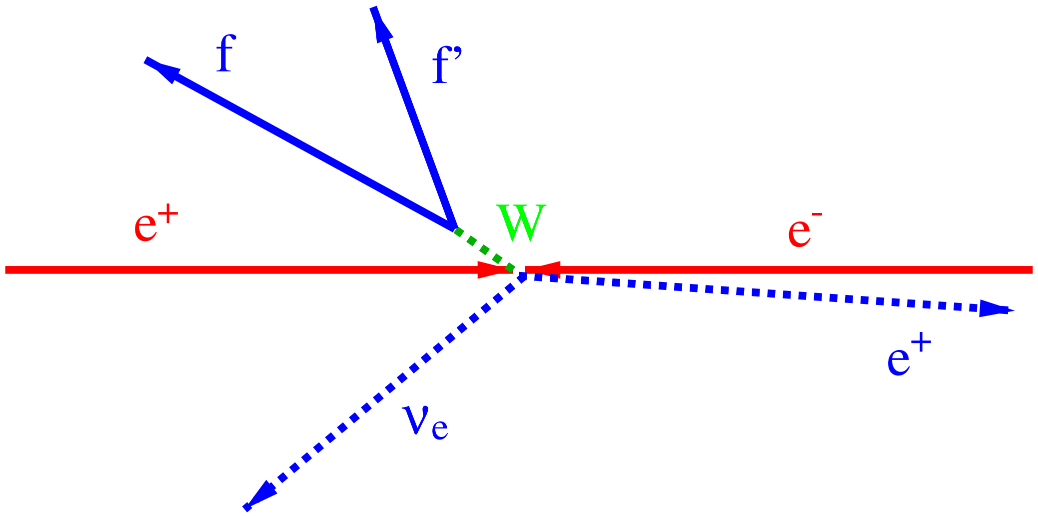




$$
\begin{array}{rcl}
|\cos\theta_{e^+}| & > & 0.997 \\
\min(E_f, E_{f'}) & > & 15\ \mathrm{GeV} \\
|\cos\theta_{e^-}| & < & 0.75,\ \text{for } e^+\nu_e e^-\bar{\nu}_e \text{ events only} \\
 & & \quad\text{(to reject Zee events)}
\end{array}
$$

Experimental signatures

- The presence of an iso-doublet pair $(\mathrm{qq}', \ell\nu_\ell)$ with high energy fermions and invariant mass close to M_W (qq' case).
- The electron, lost along the beam pipe, produces a large component of missing momentum parallel to the incoming particles.
- The neutrino, scattered against the W boson, produces a large transverse component for the missing momentum

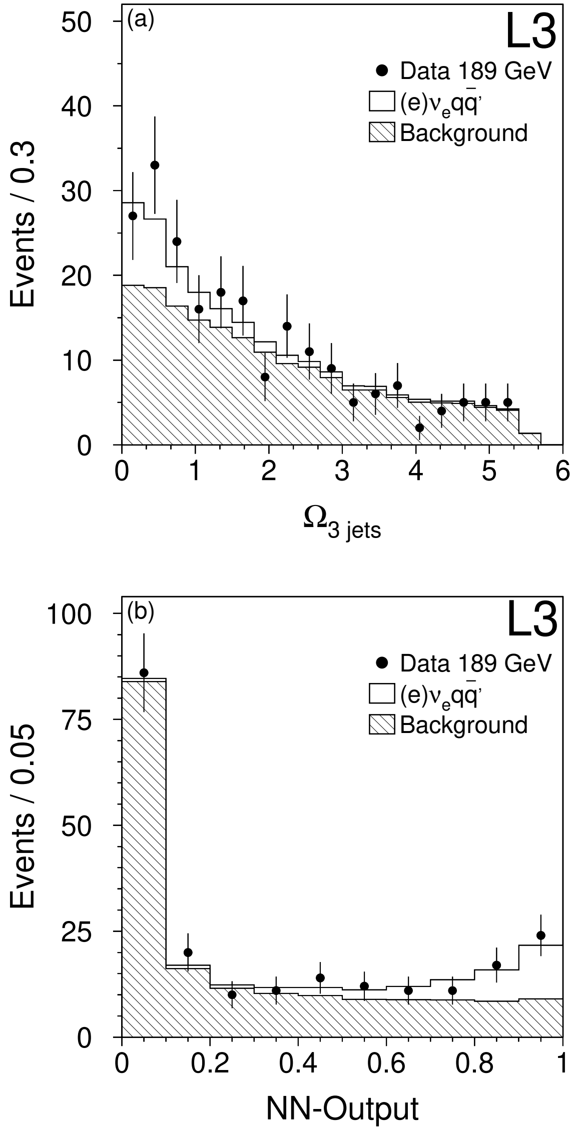


- $\Rightarrow$ Two reconstructed jets ;
- $\Rightarrow$ Large acoplanarity ;
- $\Rightarrow$ Invariant mass compatible with W mass ;
- $\Rightarrow$ Large missing momentum pointing inside the detector ;

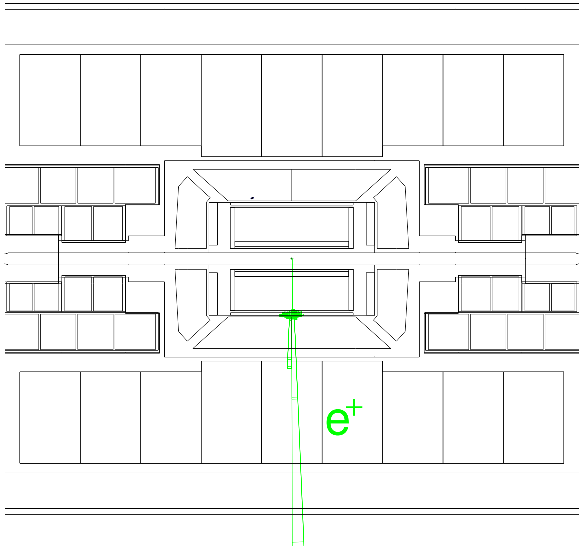
In order to maximise the discriminating power of the selection, a neural network, based on event shape variables + invariant mass + Ω_{3jets} + ..., is applied.

The signal over background ratio after preselection is of the order 1/6.

The neural network improves this ratio up to 3/2 in the signal region.



Selections: $e\nu_e (e\nu_e)$



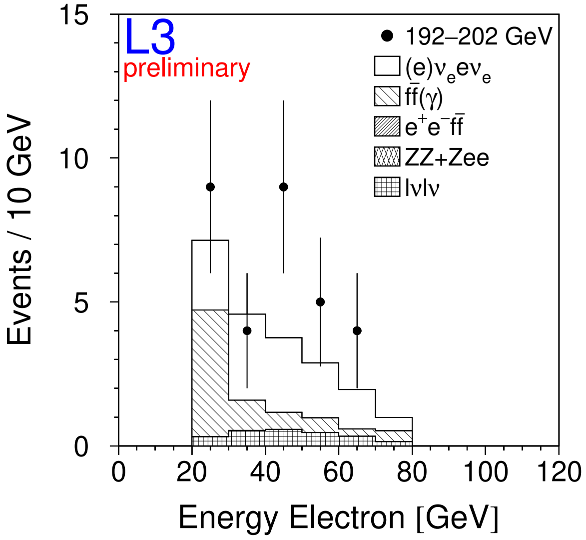
⇒ A high energy reconstructed electron in the barrel region;

⇒ No other activity in the rest of the detector ;

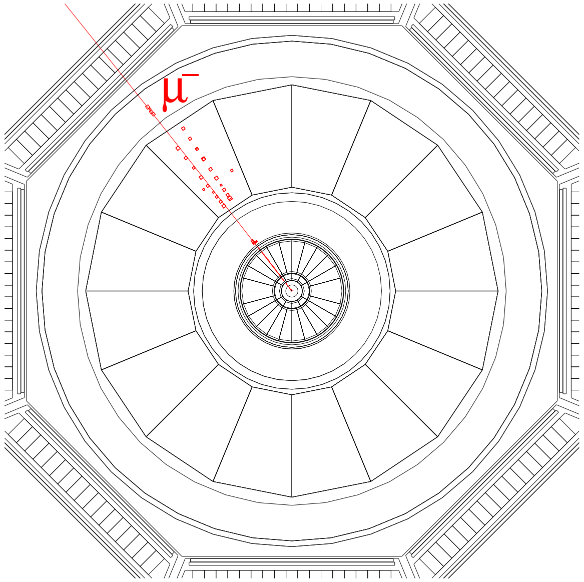
Because of the peculiar event topology, a key point for this selection is the understanding of the trigger efficiency.

A 90 % total trigger efficiency has been independently estimated giving in total

Efficiency = 75 %
Purity = 62 %



Selections: $\mu\nu_\mu(e\nu_e)$



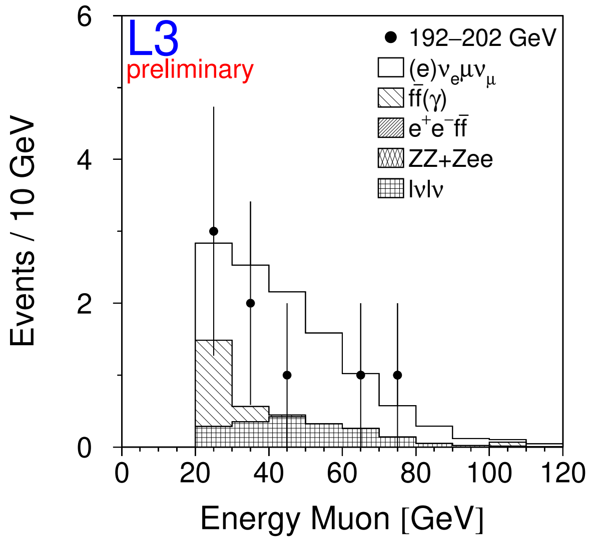
⇒ A high energy reconstructed muon inside the fiducial volume of the trigger ;

⇒ No other activity in the rest of the detector ;

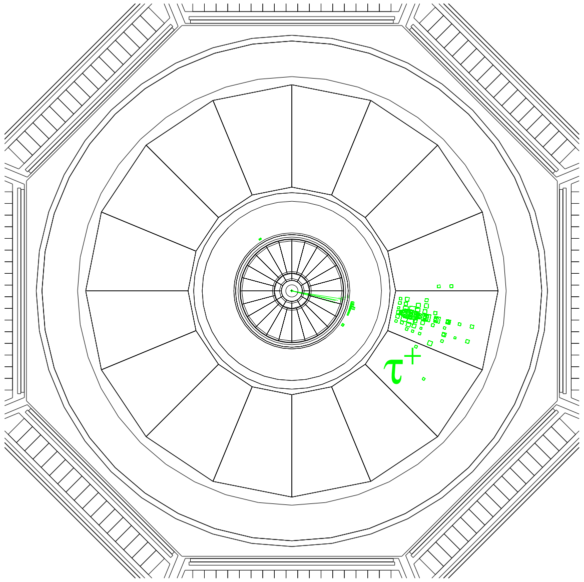
The trigger efficiency is evaluated to be 95 %.

The relatively low efficiency, w.r.t. the electron case, is due to the detector angular coverage:

Efficiency = 54 %
Purity = 75 %



Selections: $\tau\nu_\tau(\mathrm{e}\nu_\mathrm{e})$

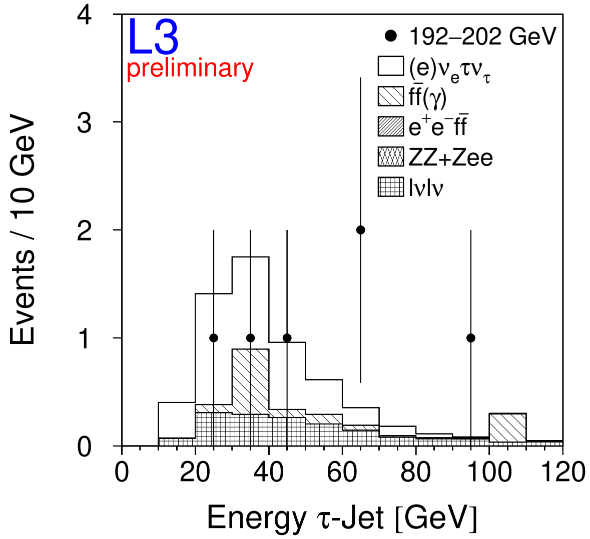


- ⇒ A high energy jet ;
- ⇒ Charged multiplicity = 1 or 3 ;
- ⇒ No other activity in the rest of the detector ;

The estimated trigger efficiency is 98 %.

This selection accepts only τ hadronic decays. The leptonic decays are accepted by the previous selections.

Efficiency = 31 %
Purity = 58 %

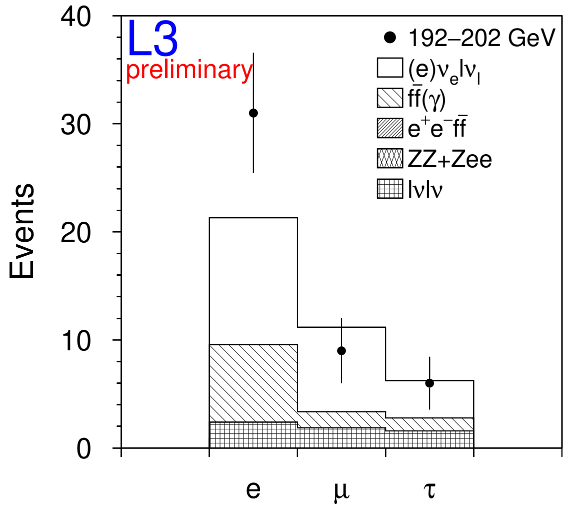


Cross section measurement

Data sets

All results are preliminary!

$\sqrt{s}$ (GeV)	$\int \mathcal{L}dt$ (pb^{-1})
189	176.4
192–202	233.3

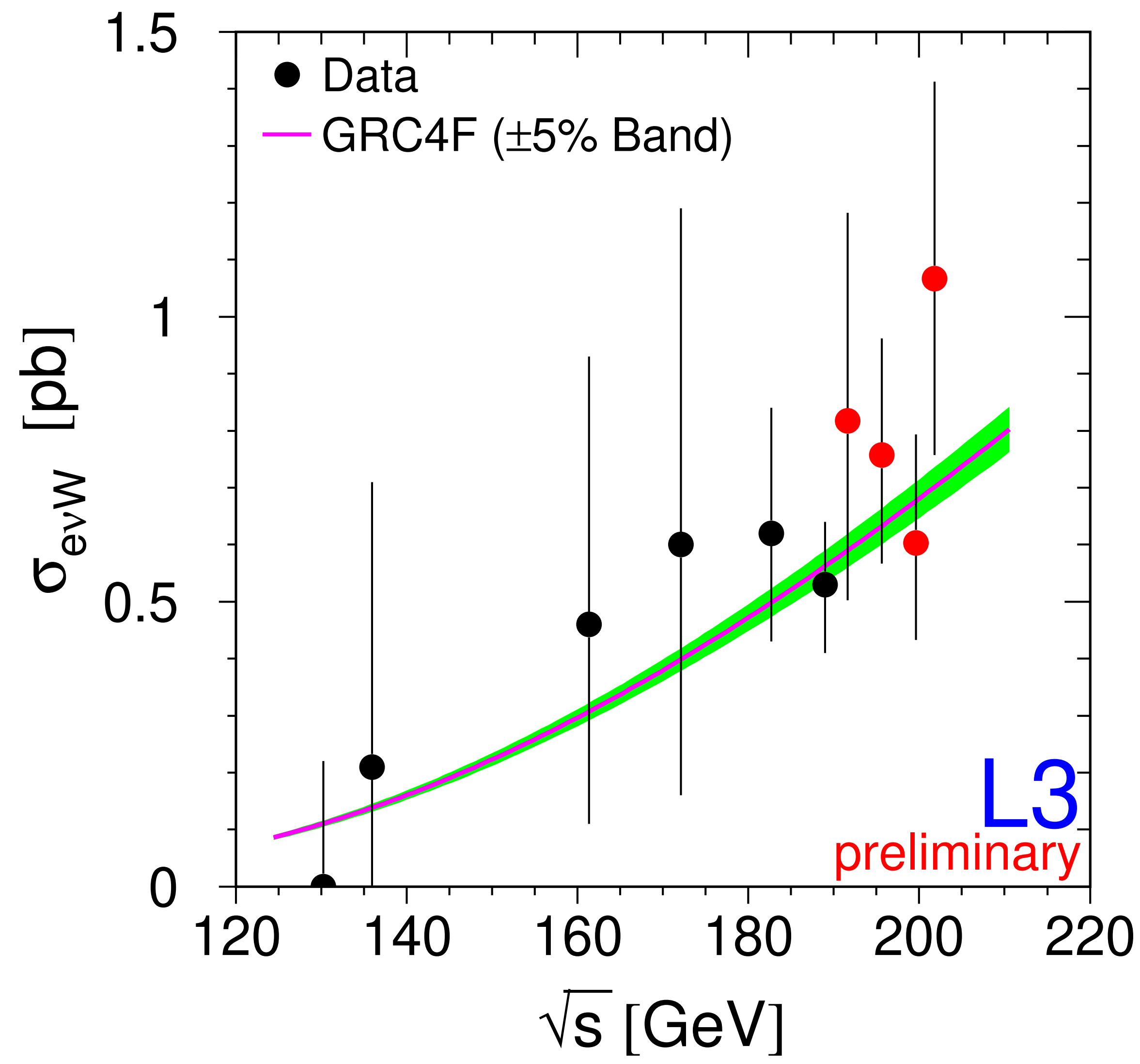


The cross section measurement is derived from a global log-likelihood fit to the neural network output distribution ($qq'e\nu_e$ case) and to the lepton energy spectra ($\ell\nu_\ell e\nu_e$ case).

The background contamination is fixed (both in quantity and shape) to the SM expectation.

Systematics sources:	Signal modelling (EXCALIBUR vs GRC4F)	~ 4 %
	Neural network	~ 3 %
	Background estimation	~ 2 %

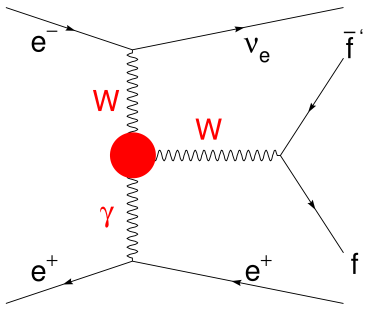
Cross section measurement



$$\boldsymbol{\sigma(\sqrt{s} = 189\ \mathrm{GeV}) = 0.53^{+0.12}_{-0.11} \pm 0.03\ \mathrm{pb}}$$

$$\sigma(\mathrm{SM\ -\ EXCALIBUR}) = 0.559\ \mathrm{pb}$$
$$\sigma(\mathrm{SM\ -\ GRC4F}) = 0.565\ \mathrm{pb}$$

Trilinear Gauge Couplings



- Both differential and total cross sections are sensitive to the γWW coupling

The differential and total cross sections are parametrised in function of κ_γ and λ_γ ([a]) which are related to the magnetic dipole and to the electric quadrupole moments of the W.

SM expectations are: $\kappa_\gamma = 1$ and $\lambda_\gamma = 0$.

The other gauge couplings, g_1^Z, κ_Z and λ_Z, affecting the WW background, are parametrised assuming $SU(2) \times U(1)$ gauge invariance:

$$\kappa_Z = \left[g_1^Z - \tan^2\theta_W \cdot (\kappa_\gamma - 1)\right] \quad \text{and} \quad \lambda_Z = \lambda_\gamma$$

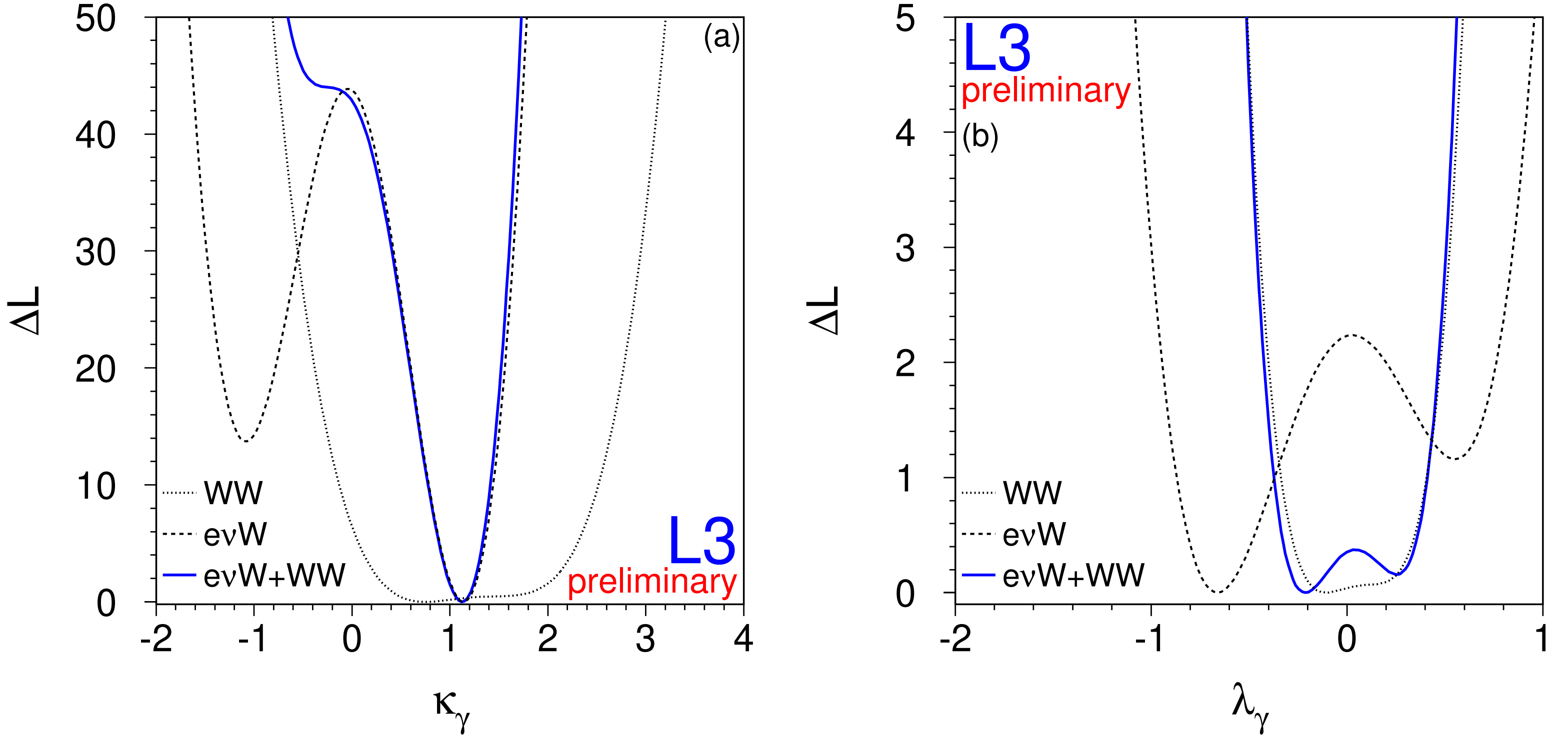
with g_1^Z fixed to 1.

[a] K. Hagiwara, R.D. Peccei, D. Zeppenfeld and K. Hikasa, Nucl. Phys. **B 282** (1987)

Trilinear Gauge Couplings

1-dimensional fit

(The other coupling is fixed to the SM expectation)

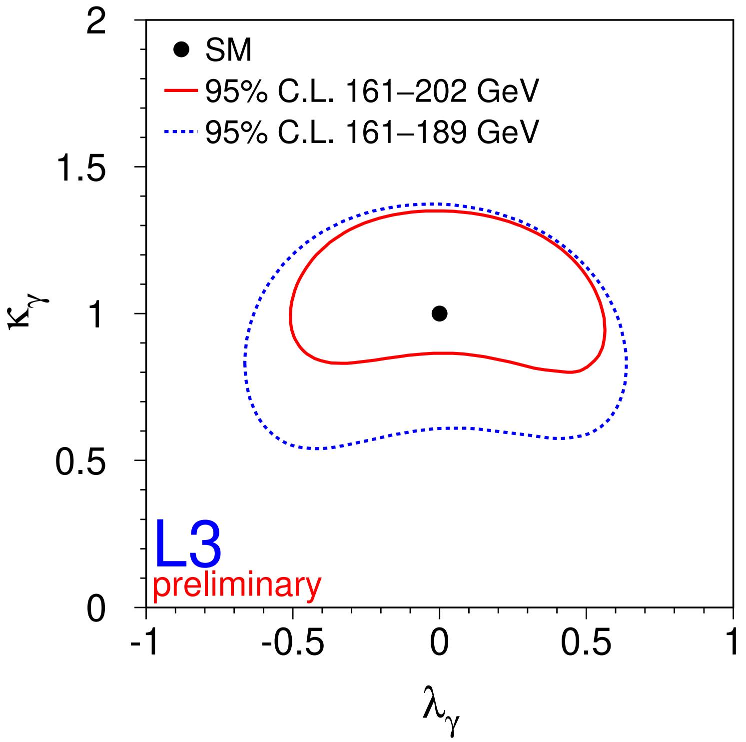


$0.89 < \kappa_\gamma < 1.32 \qquad -0.50 < \lambda_\gamma < 0.54$

(@ 95 % C.L.)

2-dimensional fit

(Both couplings are left free to vary)



From all L3 data collected in the energy range $\sqrt{s} = 161 - 202$ GeV:

$$\kappa_\gamma = +1.12^{+0.10}_{-0.11} \pm 0.08$$

$$\lambda_\gamma = -0.09^{+0.39}_{-0.22} \pm 0.11$$

with a correlation of 29.2 %.

Systematics sources:	Signal modelling	~ 6 %
	Normalization effects	~ 4 %

Conclusions and outlook

- Also single W events confirm the existence of trilinear gauge couplings
- The accuracy in the cross section measurement is approaching the theoretical uncertainty
- A combination of single W cross sections from the LEP experiments is foreseen in the near future (few days).
  It will be performed on a common signal definition based on a gauge-invariant t-channel subset of diagrams.
- Despite its low statistics, the sensitivity of single W processes on anomalous TGC's (in particular κ_γ) is comparable with W-pair analyses at LEP and $p\bar{p}$ colliders:

Tampere 1999