Single W production in ee collision

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Sitges 1999

Introduction

Situation at LEP2

At high energy Linear Collider

A study with M.Verzocchi

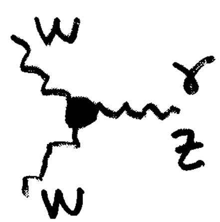
Single W production

$e^+e^- \to e\nu_e W$

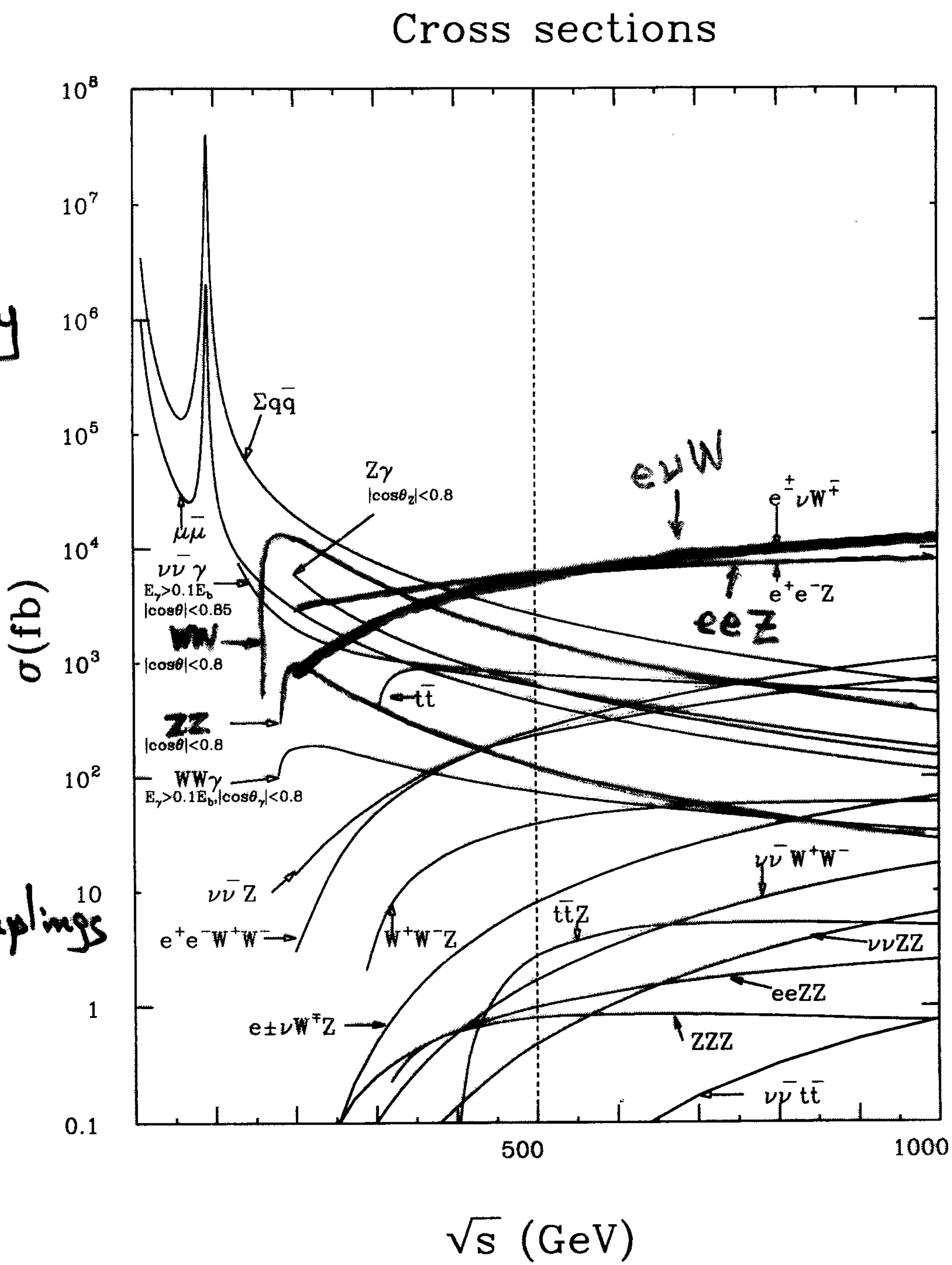
- A major process at high energy
  - Want to measure anyway
  - $\longleftrightarrow$ check with S.M.

- Composes a background for other measurements/searches

- Sensitive to TGC
  - Anomalous Triple Gauge boson Couplings

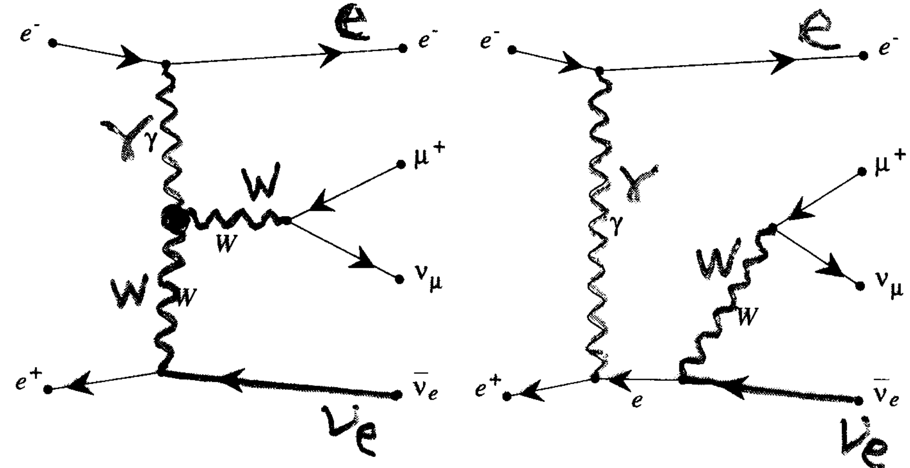


Cross sections



Properties of single W

Dominant diagrams



≈ C.C version of Compton scattering

- t-channel γ propagator prefers small q^2
- W propagator does not care much

→
- $\Theta_e \approx 0°$
- ν_e of large P_T

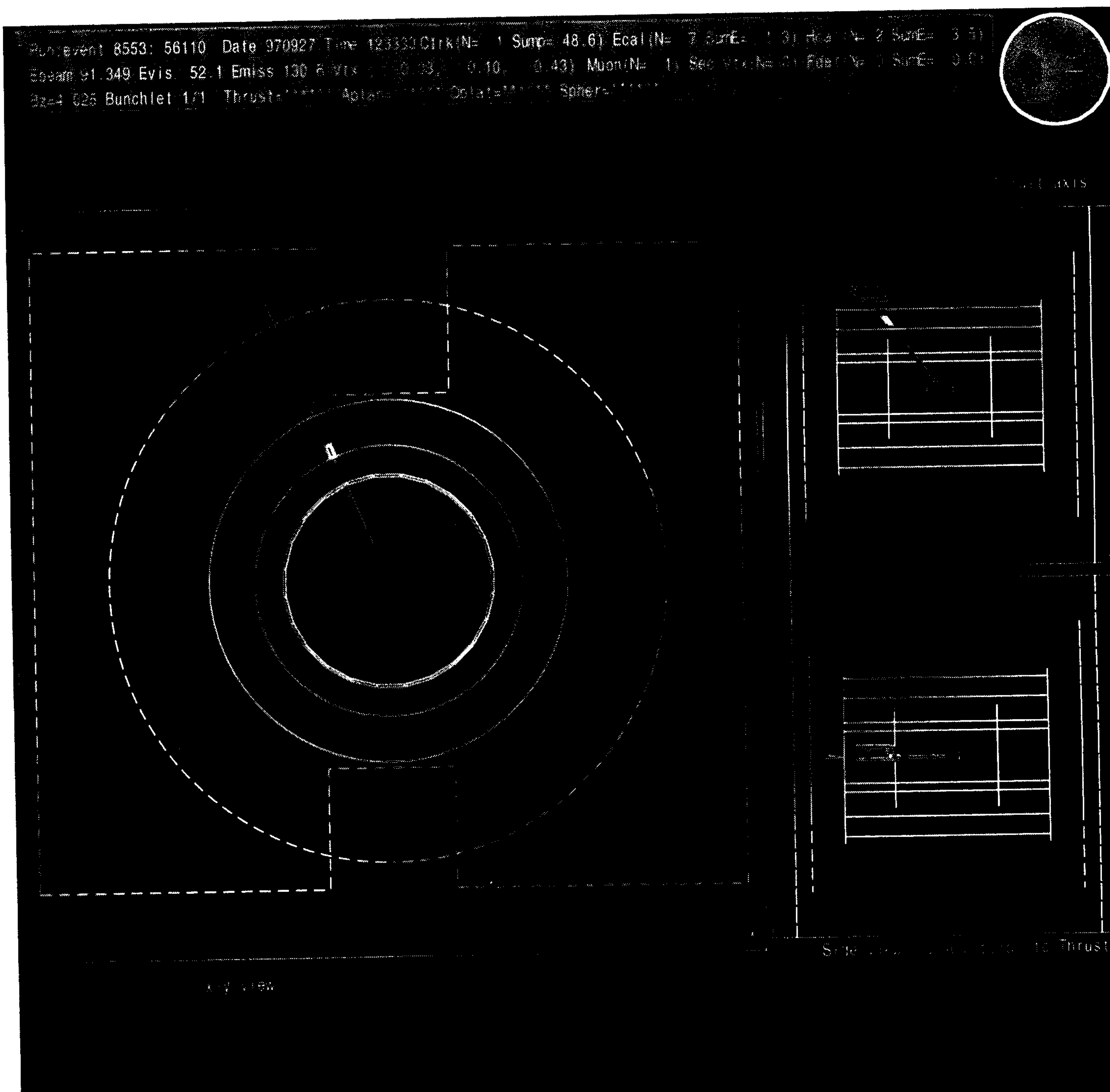
W needs mass

↓ This involves $WW\gamma$ vertex
Interesting diagram

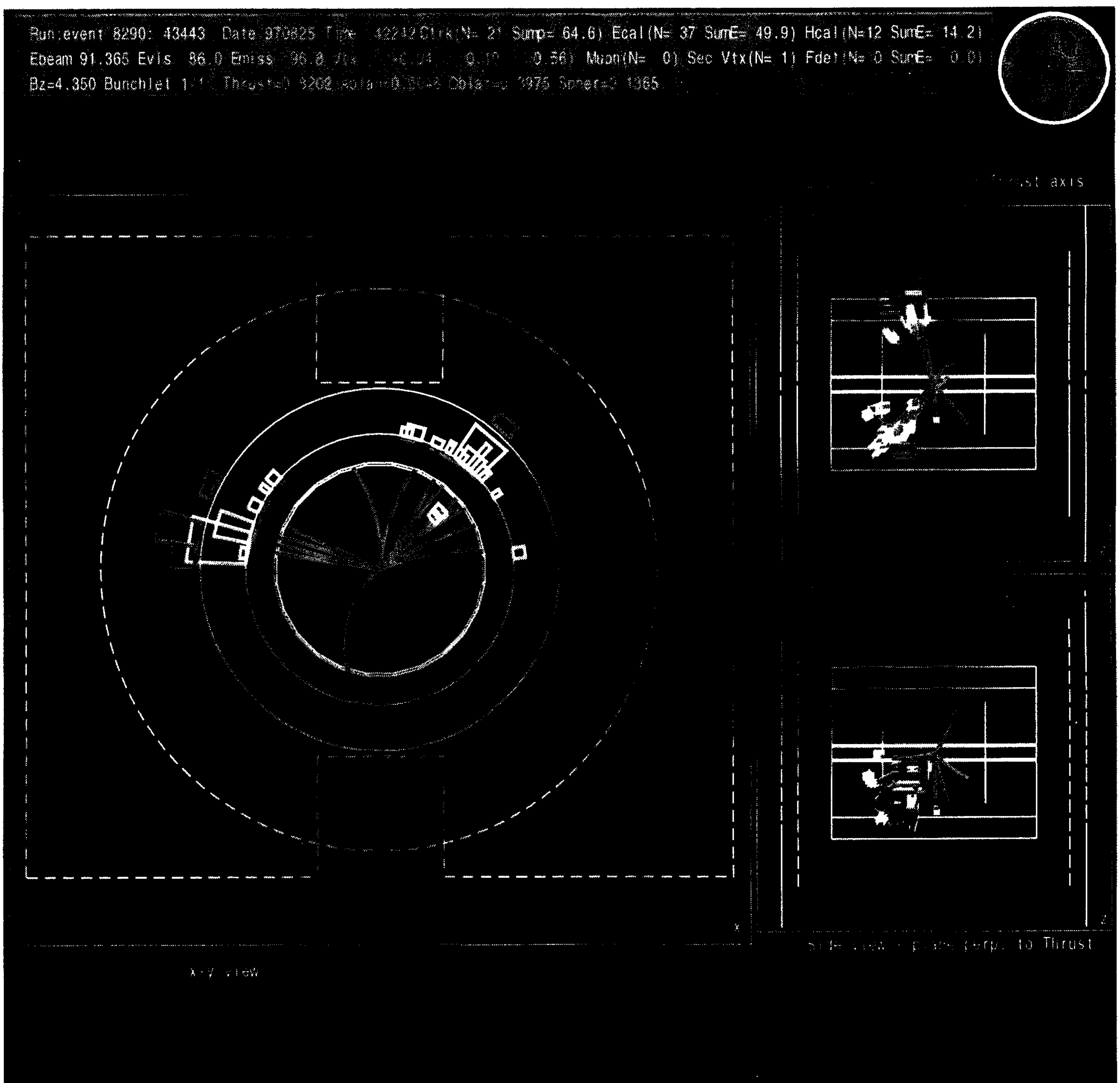
- e in the beam pipe
- $W \to \ell\nu \Rightarrow$ single high P_T lepton, missing energy

$W \to qq' \Rightarrow$ 2 jet, high P_T, acoplanar, missing energy

A single μ candidate

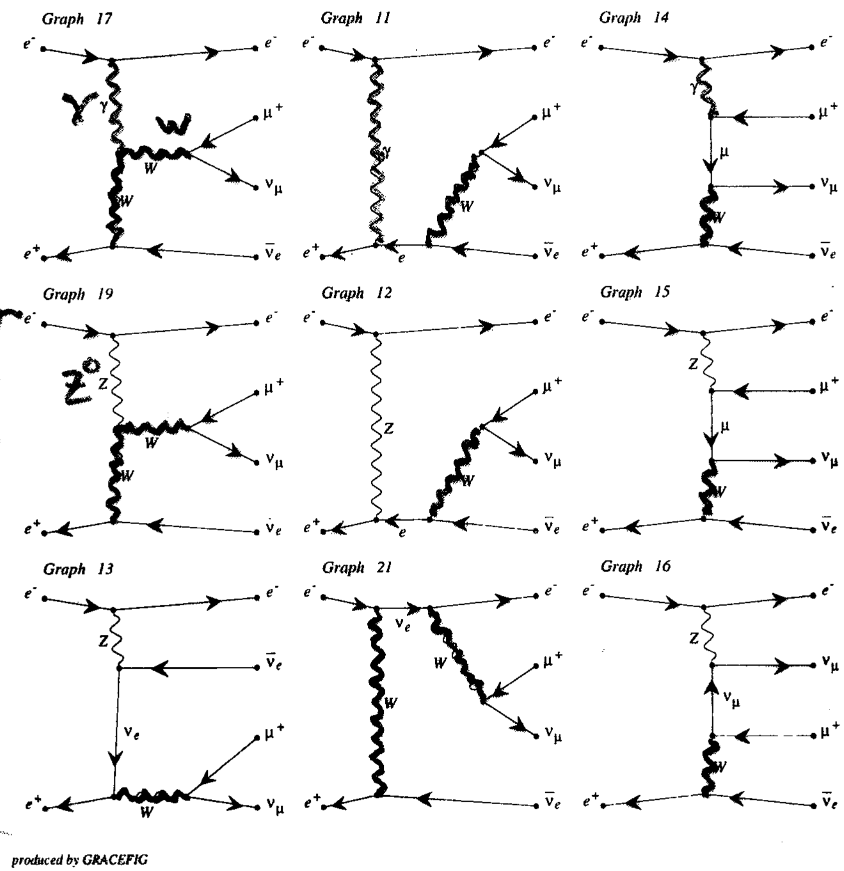


Acoplanar 2 jet



$e\nu_e W$ is a part of 4-fermion process

ex. complete 4f diagrams for $e\nu_e\mu\nu_\mu$



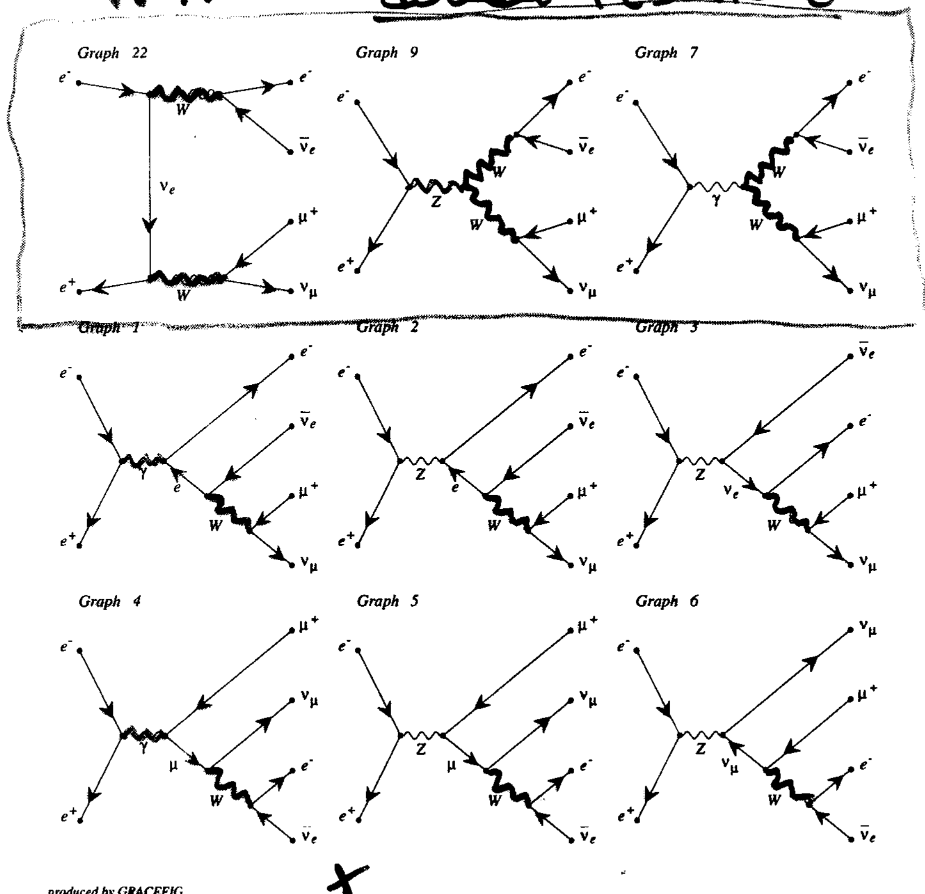
Z exchange + Small

single resonant

multiperipheral

t-channel

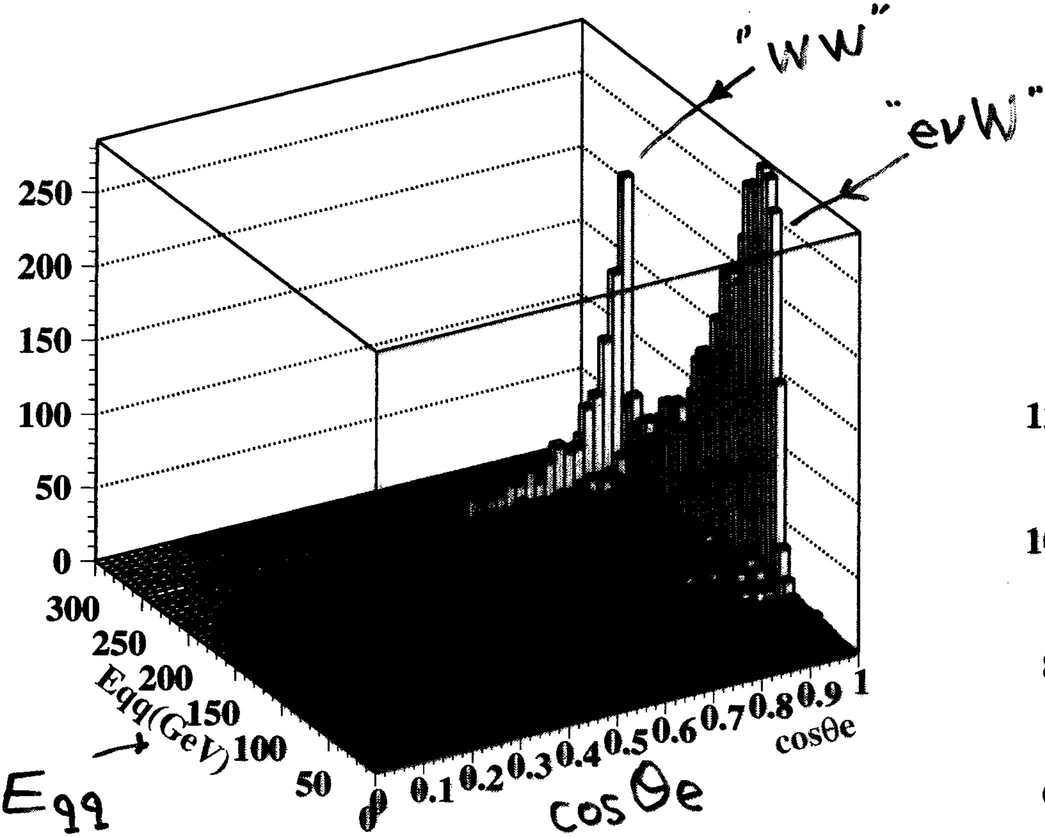
WW double resonant



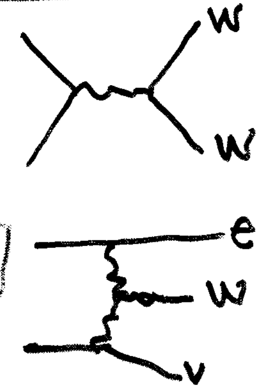
non resonant

S-channel

Kinematic separation



WW

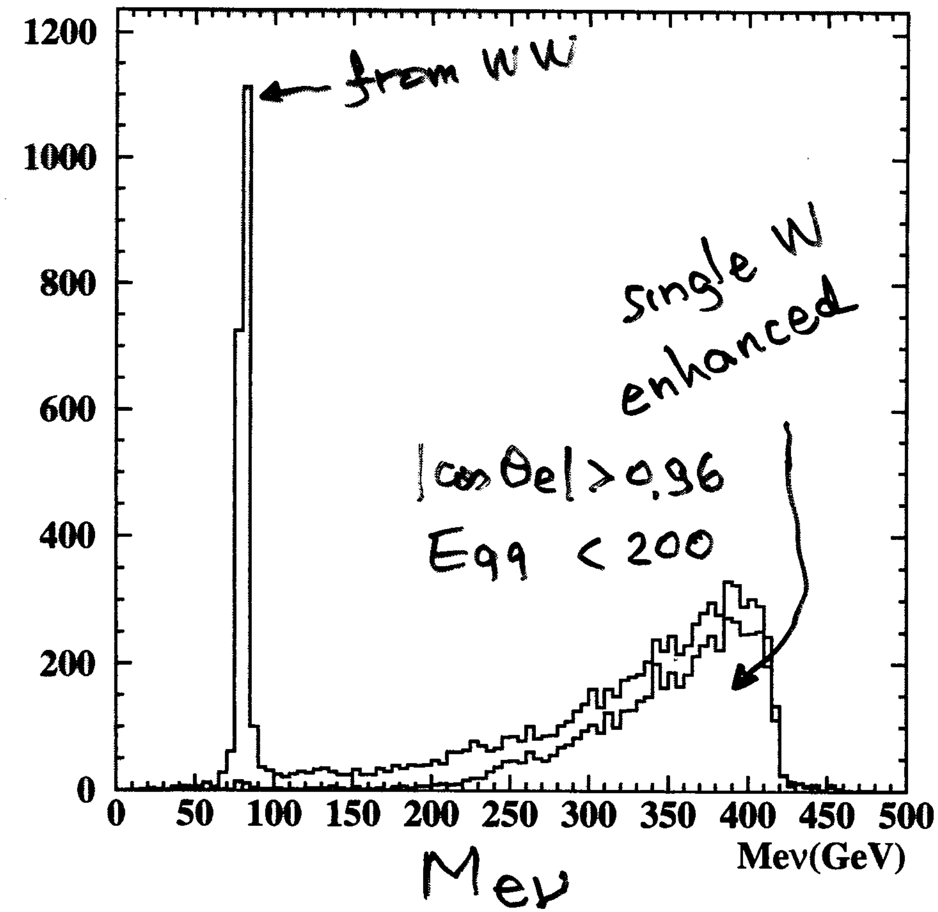


eνW

$E_W \approx \frac{\sqrt{s}}{2}$

$\theta_e \approx 0°$

$E_W \approx M_W$



$e^+e^- \to e\nu_e u d$
at $\sqrt{s} = 500$ GeV
grc4f

Anomalous TGC

Lorentz invariant, C and P conserving effective Lagrangian.

EM gauge invariance.

- 5 parameters to parametrize anomalous TGC

$$\boxed{g_1^Z,\ \kappa_\gamma,\ \kappa_Z,\ \lambda_\gamma,\ \lambda_Z}$$

in SM: $g_1^Z = \kappa_\gamma = \kappa_Z = 1$, $\lambda_\gamma = \lambda_Z = 0$

$\Delta g_1^Z = g_1^Z - 1$, $\Delta\kappa = \kappa - 1$

- Often further reduced to 3 parameters ← Motivated by constraints from
  - * Low energy data
  - * $SU(2)\times U(1)$ invariance

$$\boxed{\Delta g_1^Z,\ \Delta\kappa_\gamma,\ \lambda_\gamma}$$

$$\begin{cases} \Delta\kappa_Z = -\Delta\kappa_\gamma \tan\theta_W + \Delta g_1^Z \\ \lambda_Z = \lambda_\gamma \end{cases}$$

Experimental tests of anomalous TGC

$e^+e^- \to WW$

controlled by all 5 parameters $\underline{\Delta g_1^Z}$, $\underline{\Delta K_\gamma}$, ΔK_Z, $\underline{\lambda_\gamma}$, λ_Z
or 3 parameters with constraints

→ σ_{WW}, W angle, W decay angle

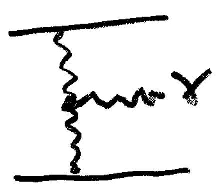
Channel of main TGC analysis

$e^+e^- \to e\nu W$

$WW\gamma$ coupling dominates
controlled effectively by 2 parameters $\underline{\Delta K_\gamma}$, $\underline{\lambda_\gamma}$

→ $\sigma_{e\nu W}$

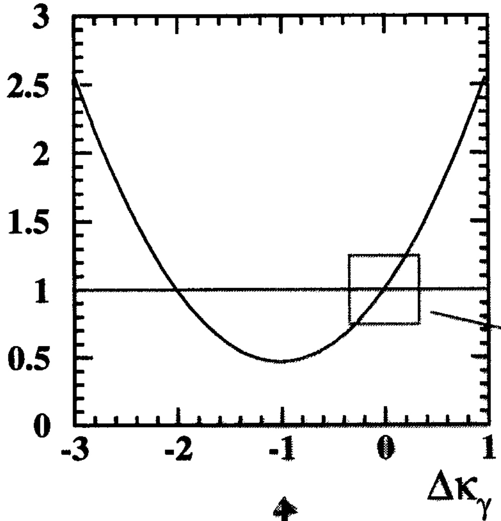
$e^+e^- \to \gamma\nu\nu$



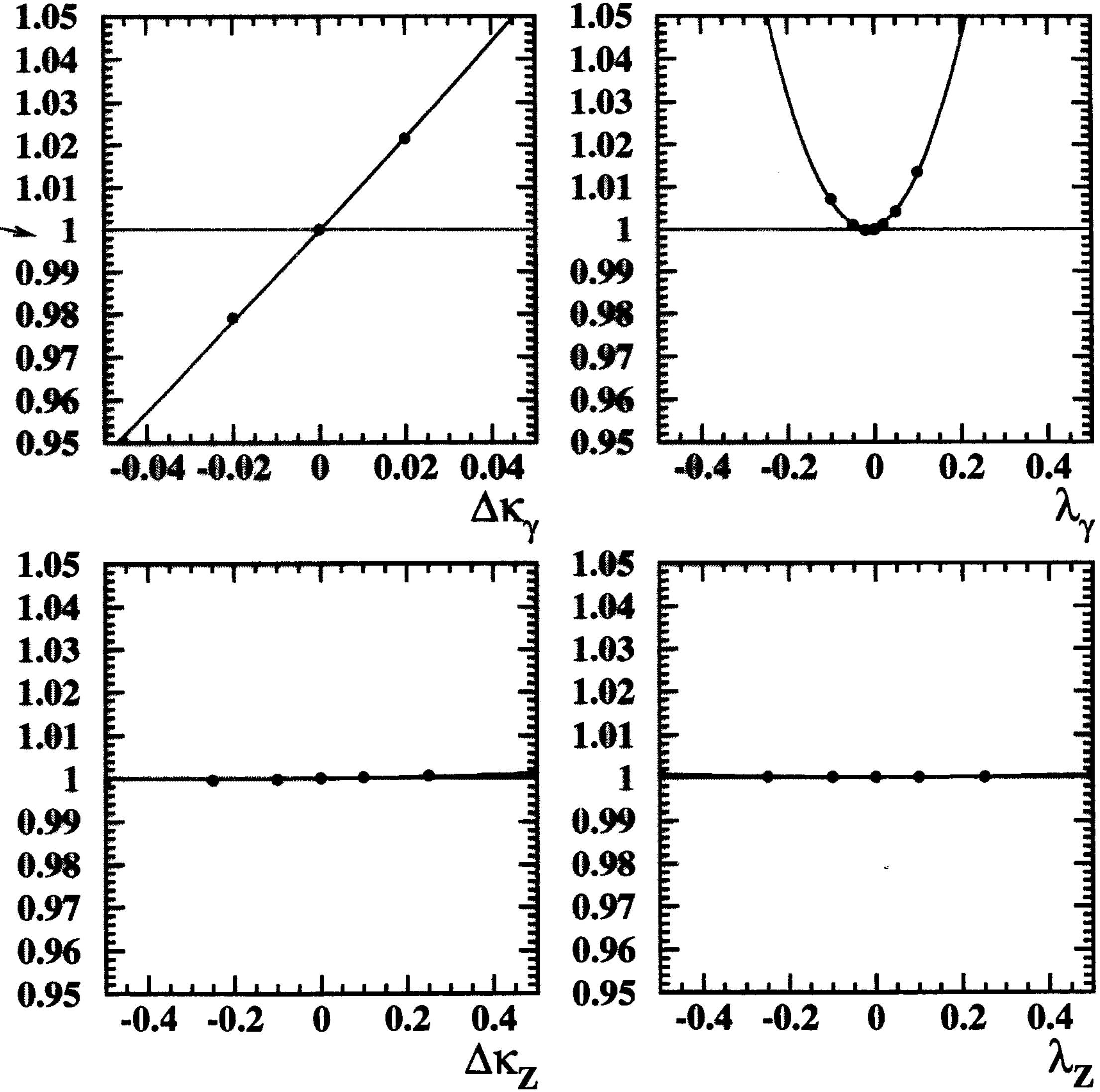
single γ
Another channel sensitive to $WW\gamma$

Dependence of $\sigma_{e\nu W}$ on TGC

σ/σ_{SM} vs TGC parameters



minimum at
$\Delta\kappa_\gamma = -1$
$(\kappa_\gamma = 0)$



Very small dependence
on $\Delta\kappa_Z$, λ_Z

$e^+e^- \to e\nu ud$
$\sqrt{s} = 500$ GeV
grc4f

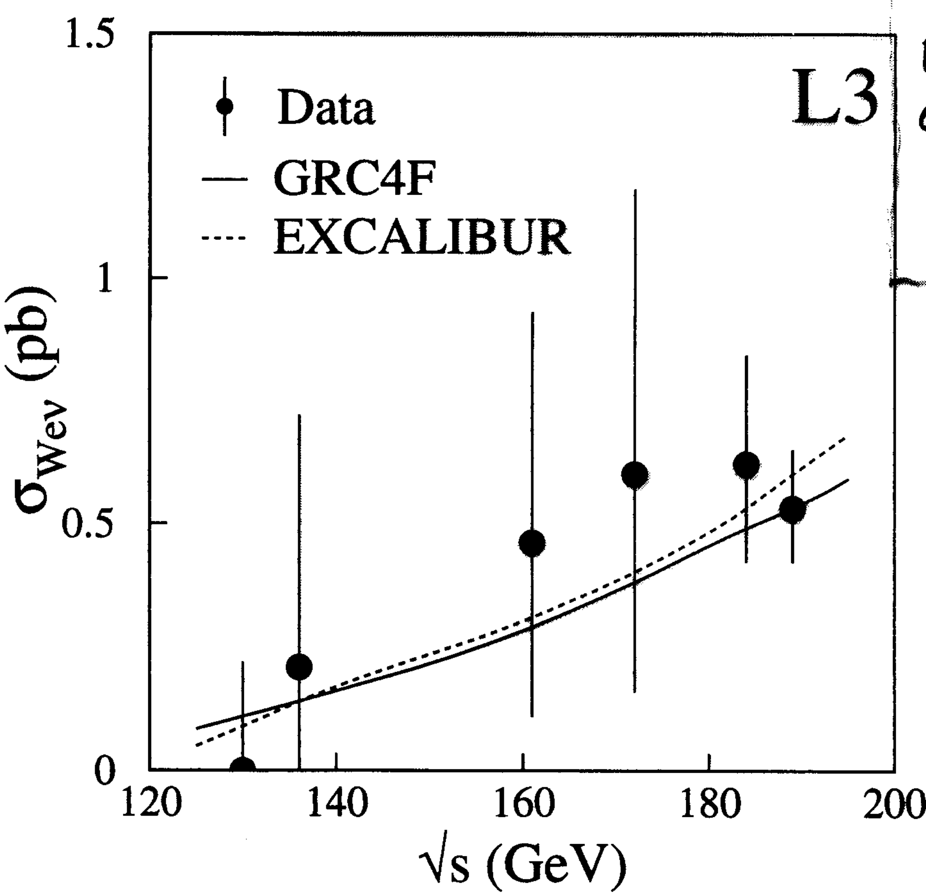
Measurements at LEP2

- Cross-section : small
- Modest int. Lumi.

mostly prelim.

	$\sqrt{s}$ (GeV)	L (pb^{-1})	$W \to \ell\nu$ obs.	$W \to \ell\nu$ expected		$W \to qq'$ obs.	$W \to qq'$ expected	
Aleph	161-183	79	11	11.1	7.3	21	21.5	8.8
Delphi	161-183	73	9	5.4	5.2	44	52.6	19.9
L3	130-183	89	12	10.2	6.0	109	103	14.7
OPAL	161-172	20	2	2	0.8	4	2.5	1.3
L3	189	176	22	26	17	216	215	35.9

(from $e\nu W$ → the second "expected" values, 17 and 35.9)



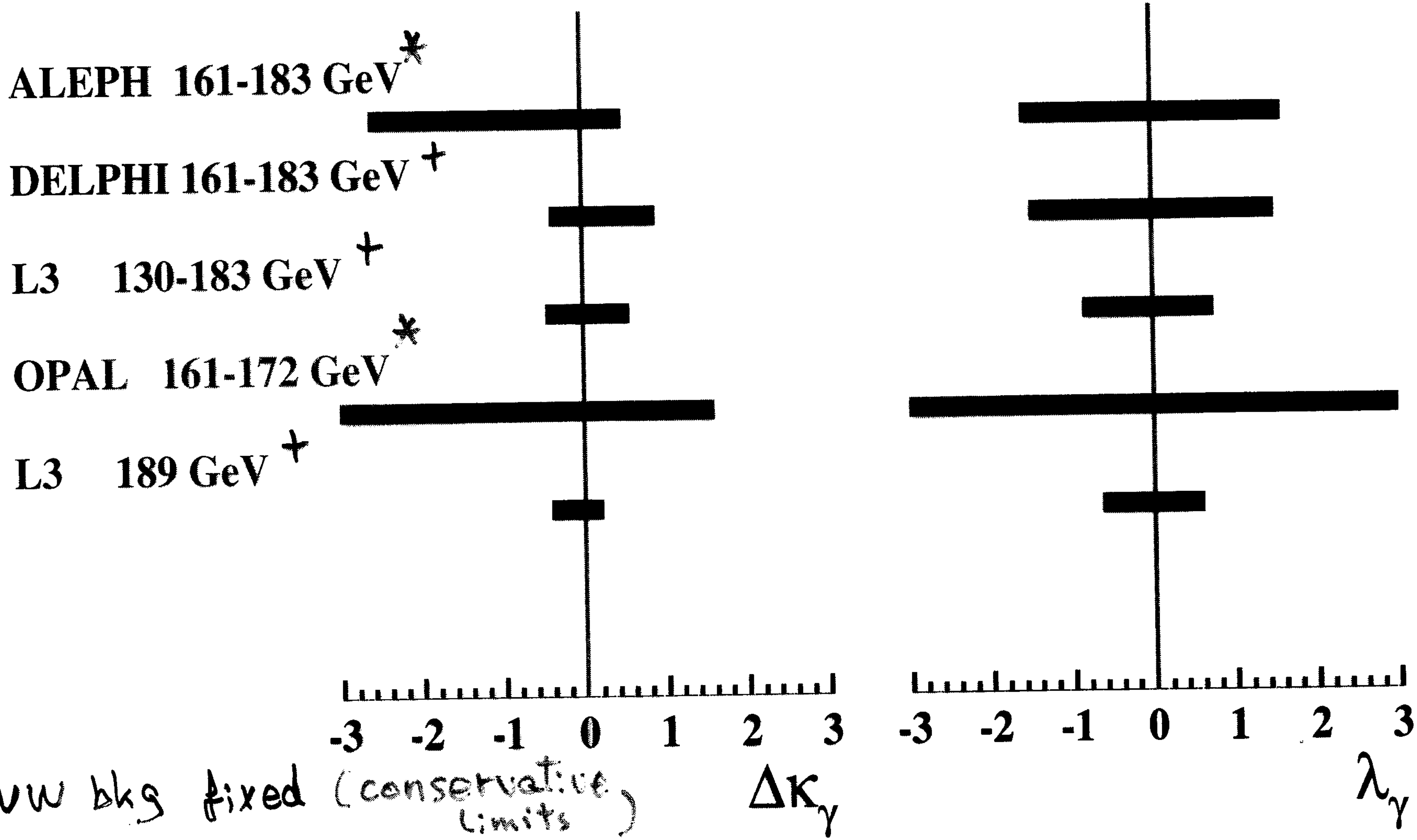
Large bkg, esp. in qq' channel
↑ includes WW

- signal $e\nu W$ depends only on $\Delta\kappa_\gamma$, λ_γ
- bkg WW depends also on g_1^Z, κ_Z, λ_Z

TGC Limits from single W at LEP2

95 % CL

mostly prelim.



* WW bkg fixed (conservative limits)

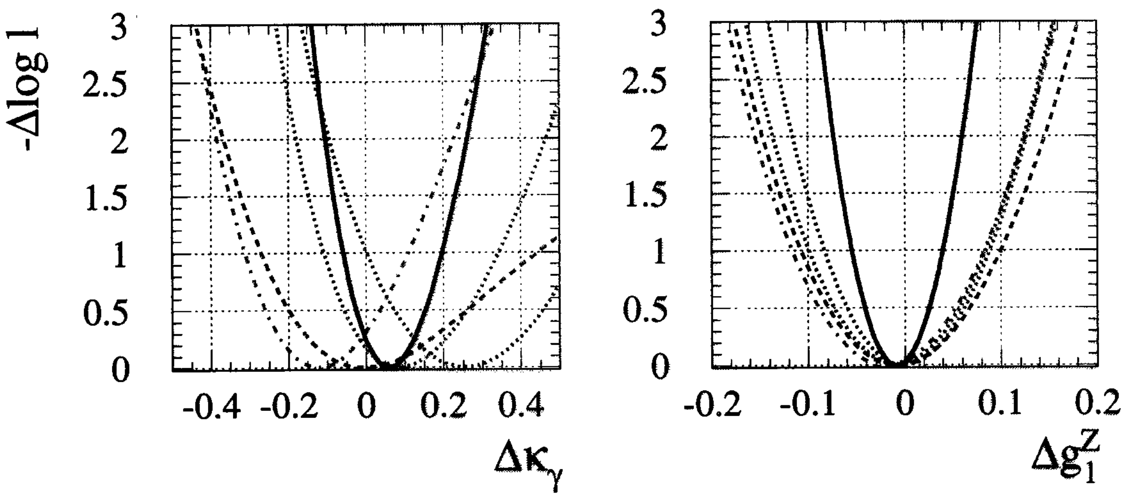
\+ WW bkg varied

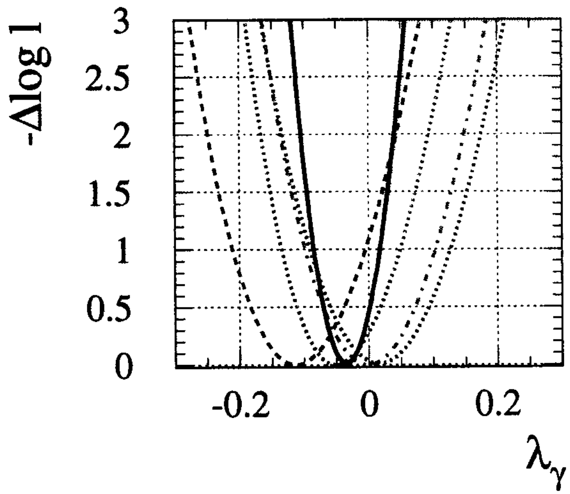
2 parameters ($\Delta g_1^Z = 0$)

Combined LEP TGC measurements

Primarily from WW

ALEPH + DELPHI + L3 + OPAL





$\Delta\kappa_\gamma = 0.06\ ^{+0.09}_{-0.09}$

$\Delta g_1^Z = -0.01\ ^{+0.03}_{-0.03}$

$\lambda_\gamma = -0.03\ ^{+0.04}_{-0.04}$

↳ 1σ

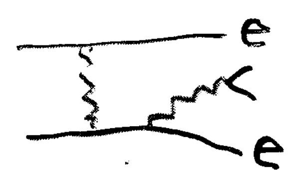
Single W event selection at linear collier

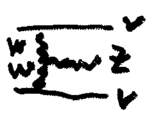
will be easier than LEP2 (in particular $W \to q\bar{q}'$)

- $\sigma_{e\nu W}$ ↗
  σ_{WW} ↘
- $E_{WW} \approx \frac{\sqrt{s}}{2}$
  $E_{e\nu W} \approx M_W$ better separation in E_{qq}

  σ_{ZZ} ↗ $E_Z \sim \frac{\sqrt{s}}{2}$

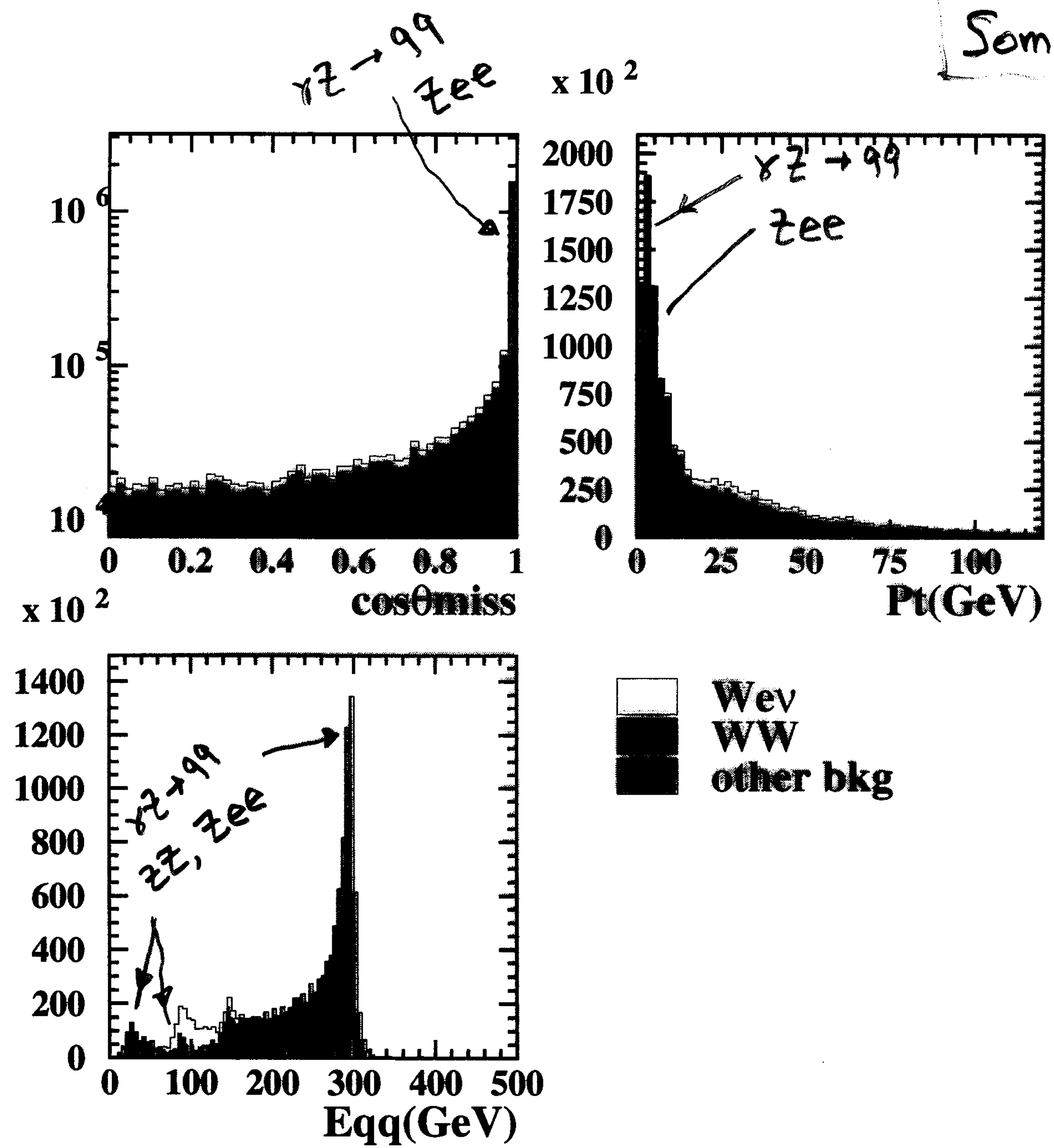
  σ_{Zee} ↗ similar t-channel process as $e\nu W$

  + e is visible (ν is invisible) 

  $\nu\nu Z$  can be a problem, xsec small

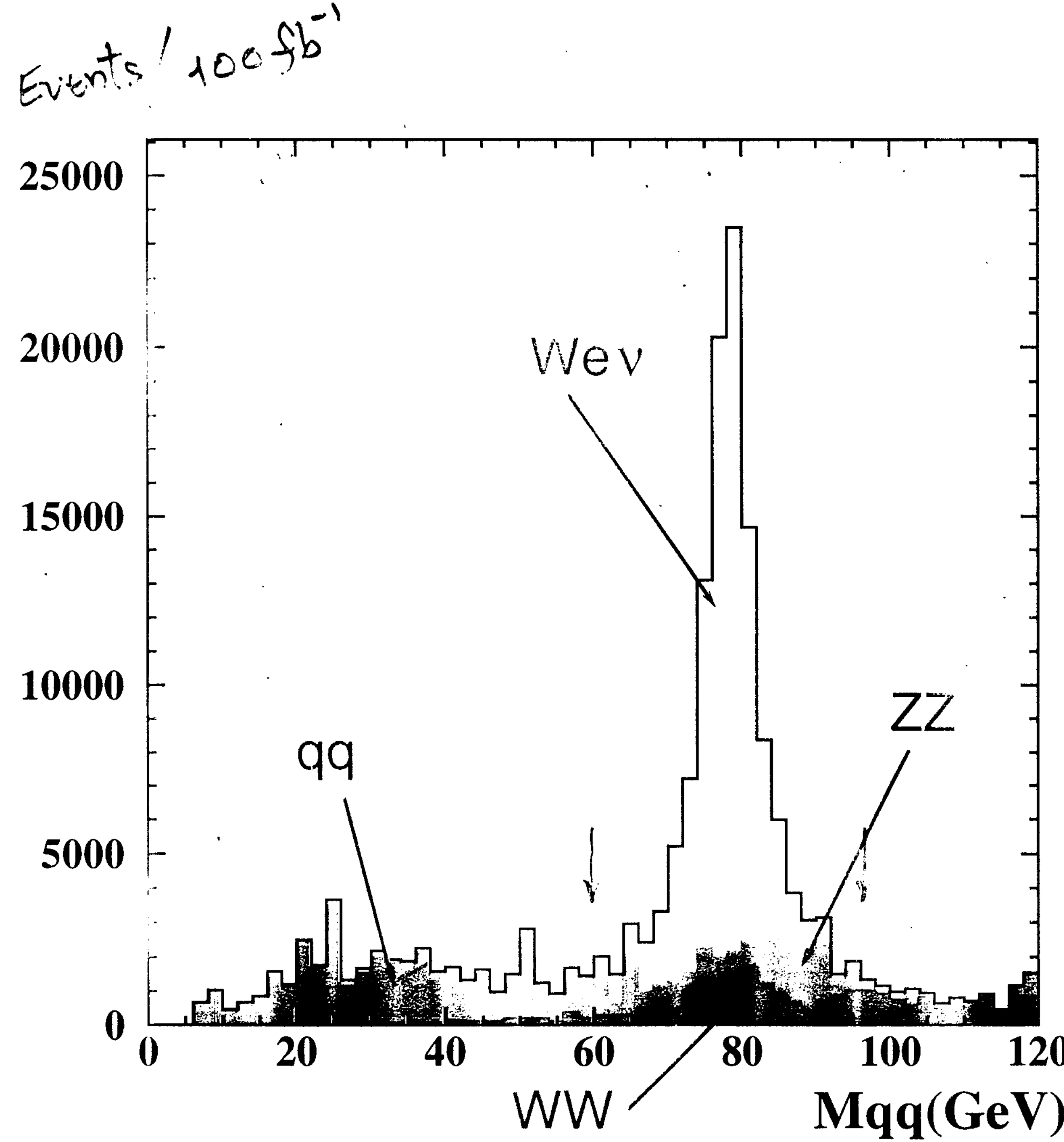
- However
  - Beam strahlung
  - event overlap ?

Some distributions with detector simulation



- High multiplicity sample
- 2 jets ($y_{23} < 0.2$)
- $|\cos\theta_{miss}| < 0.96$
- $P_T > 10$ GeV
- $E_{vis} < 140$ GeV

$\sqrt{s} = 300$ GeV
pythia
JLC detector simulation



- High multiplicity
- 2 jet ($y_{23} < 0.2$)
- $|\cos\theta_{mis}| < 0.96$
- $P_T > 10$ GeV
- $E_{vis} < 140$ GeV

- $60 < M_{qq} < 96$ GeV

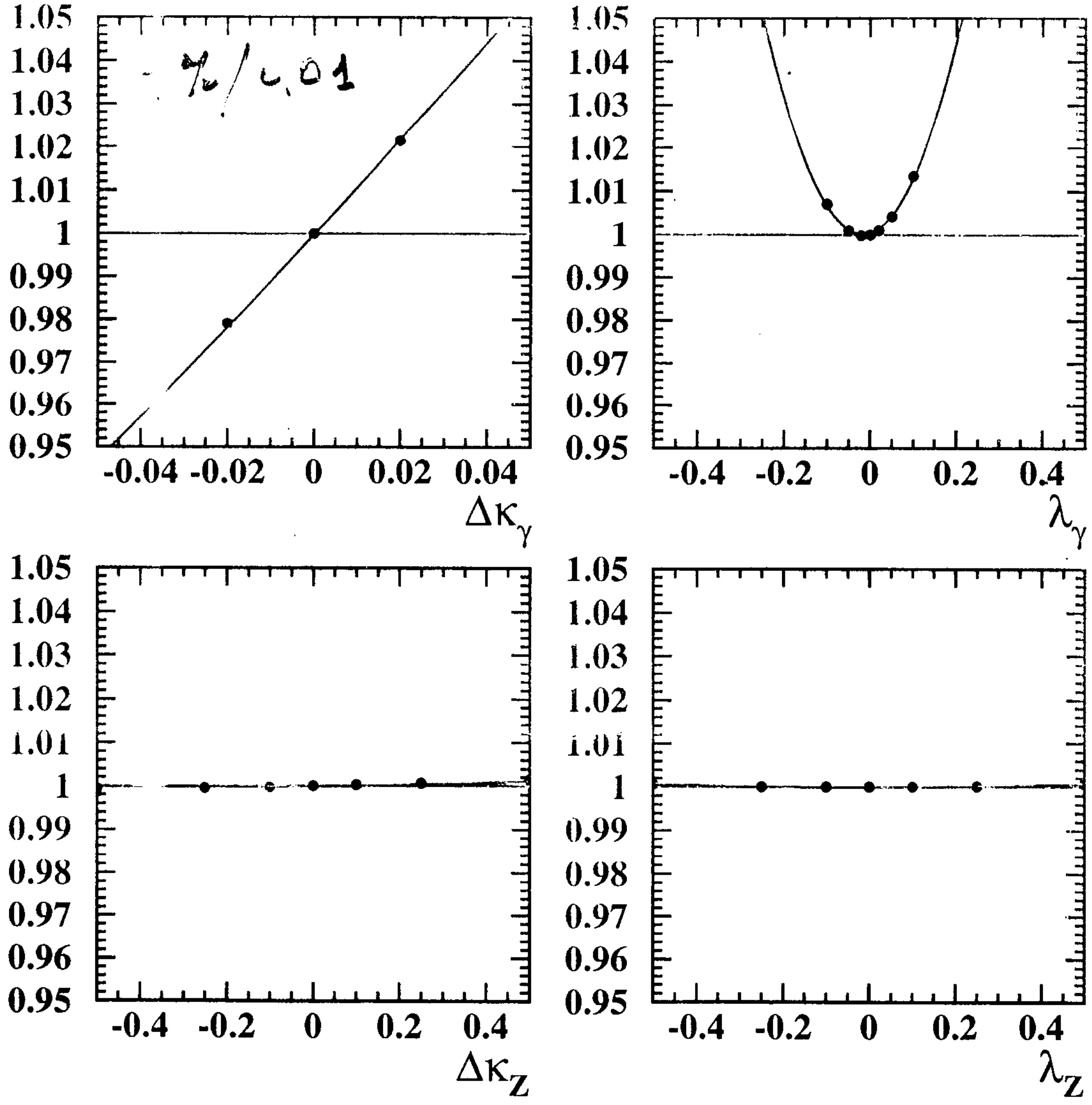
$\varepsilon = 62\%$

Purity $= 73\%$

bkg

$\gamma Z \to f\bar{f}$	9%
WW	12%
ZZ	6%
Zee	1%

$\approx$ 100K $e\nu W$ candidates @ 300 GeV for 100 fb^{-1}



From σ_{WW} measurement:

100 fb^{-1} 300 – 500 GeV

- stat. error 0,2–0,3 %

  $\Delta\kappa_\gamma$ to ≈ 0,002 (1σ)

  (0.004 at 95% CL)

[w.o. SU(2)×U(1) constraint]

- sys. error is important
  - Lumi
  - eff, bkg estimation
  - Theory uncertainty

    ISR, $\alpha(Q^2)$, H.O corr. ...

- Next:

  How bad is beamstrahlung / event overlap ?

  Polarization helps ?

  Event distribution helps ?

  Fit → $\Delta\chi^2$, $\Delta \ln L$