4F final states with forward electrons

Andrei Kounine / L3
on behalf of the 4 LEP experiments

OUTLINE:

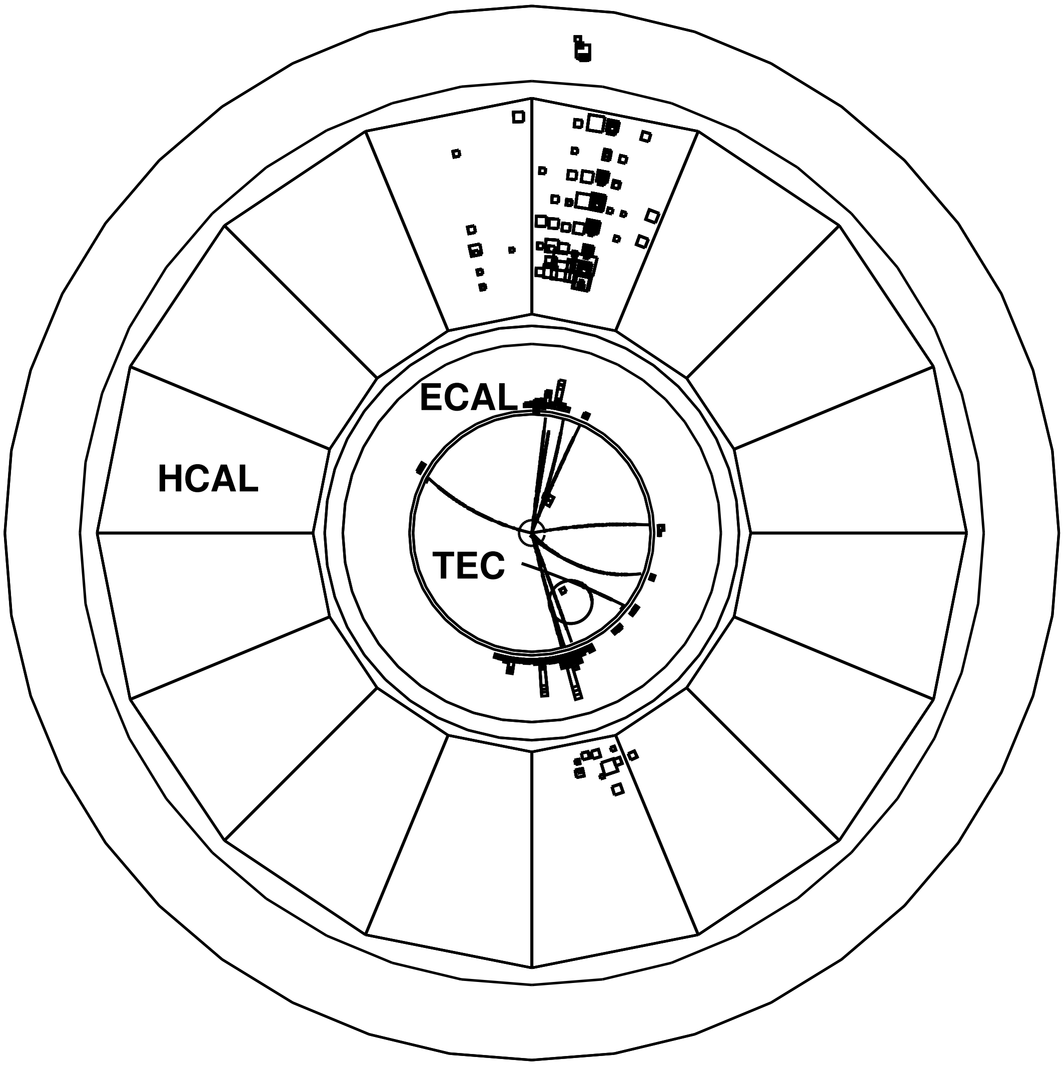
- Introduction
- Single W production at LEP
- Physics with Single Ws
- Single W generators
- Single Z/γ* production at LEP
- Single Z/γ* generators
- Questions to be addressed.

Introduction

Background to searches:

L3 – several H$\nu\bar{\nu}$–like candidates at 161 GeV

Run # 667611 Event # 920

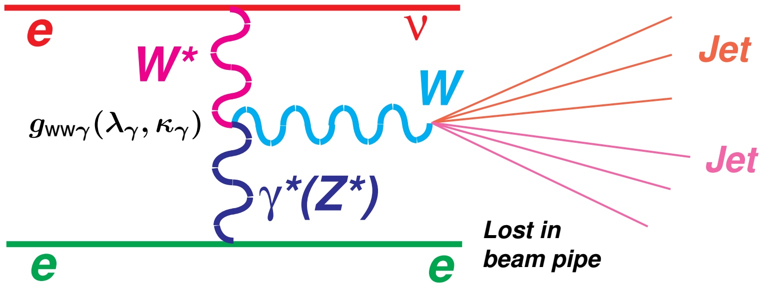


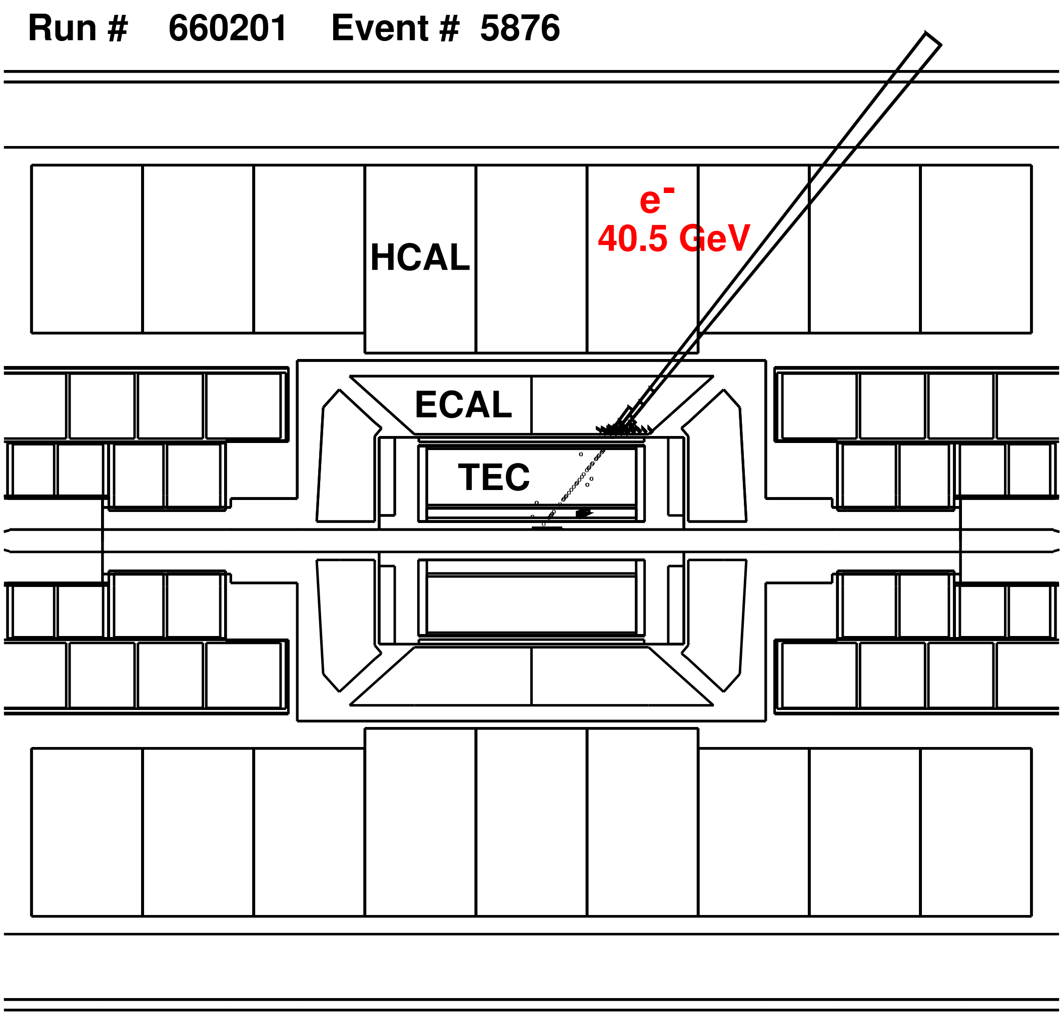
Discovery?

Introduction

Interesting physics: $e^+e^- \to W^-e^+\nu_e$

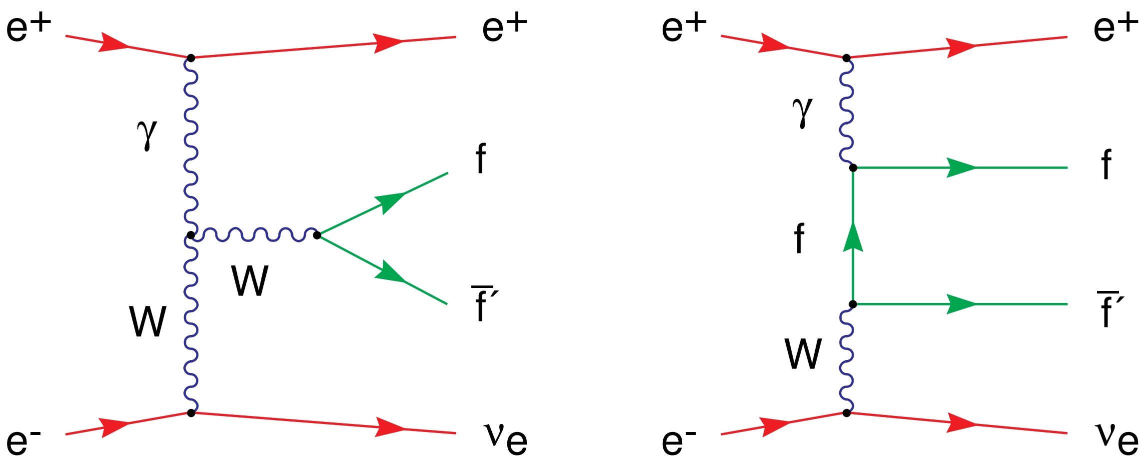
L3 Collab., Phys.Lett **B 403** (1997) 168

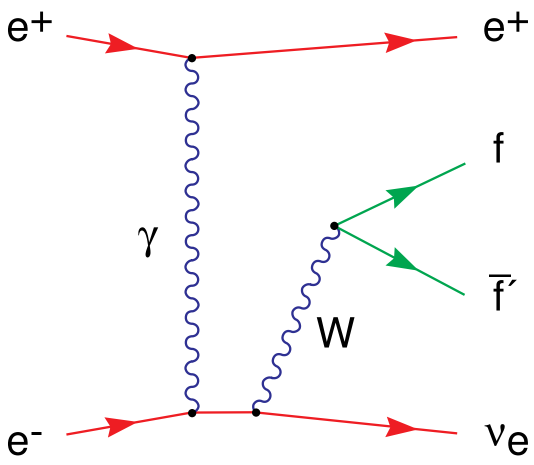




Single W production at LEP

Dominant diagrams:





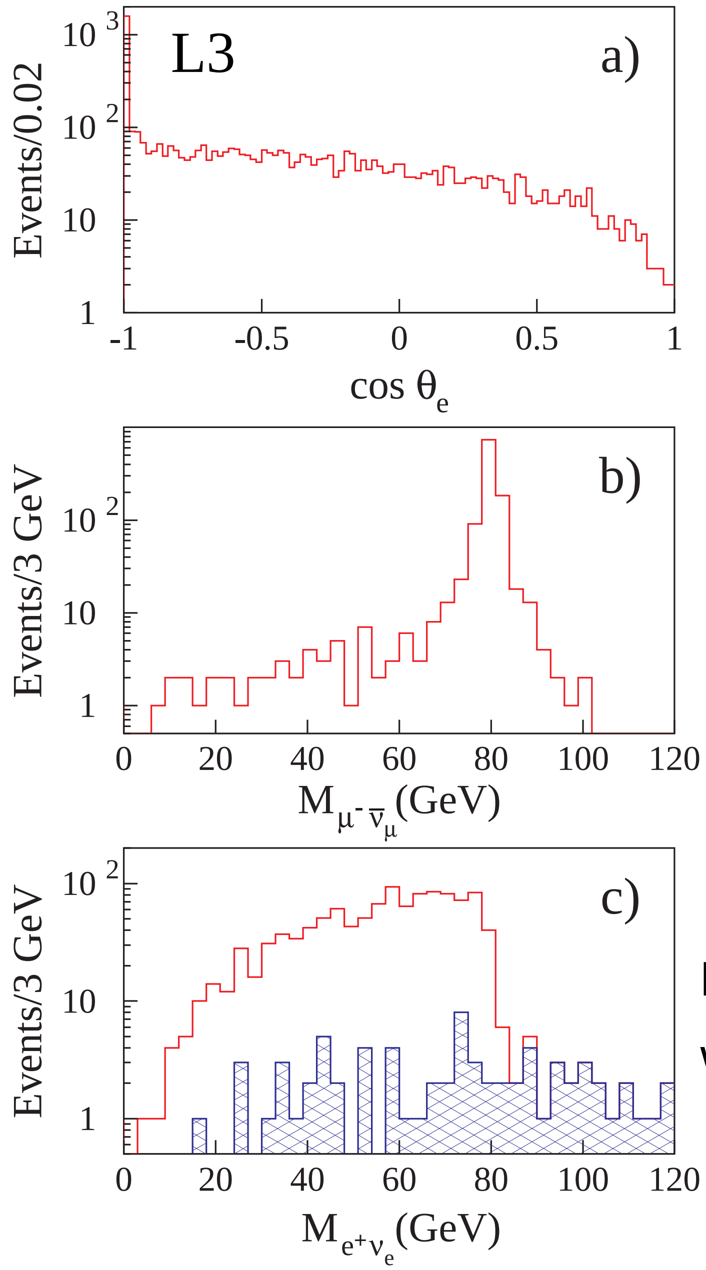
Sensitive probe of WWγ couplings!

For the WW production both WWZ and WWγ couplings contribute.

Single W production at LEP

Signal definition (L3):

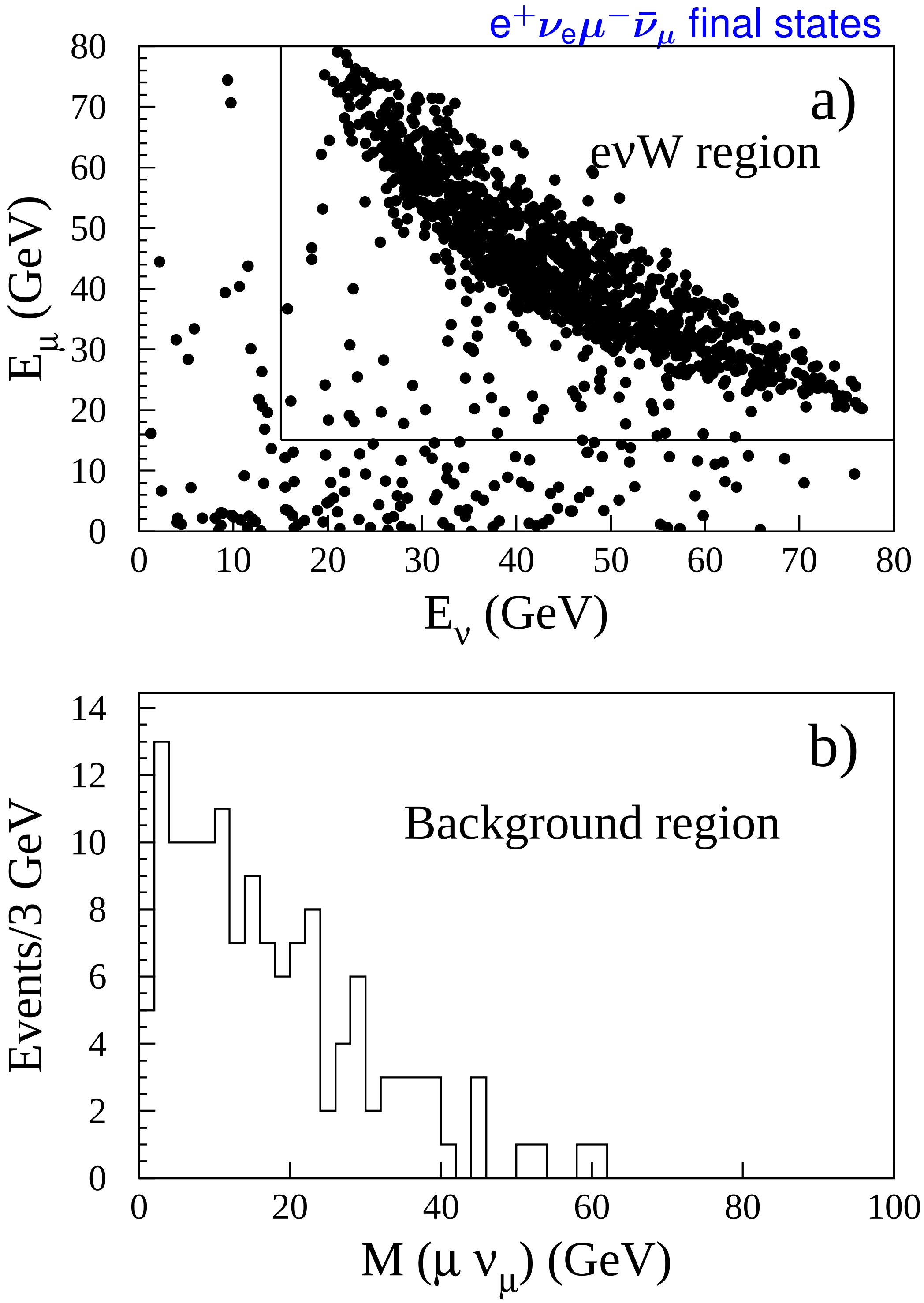
$$|\cos\theta_{e^+}| > 0.997$$
$$\min(E_f, E_{\bar{f}'}) > 15\ \mathrm{GeV}$$
$$|\cos\theta_{e^-}| < 0.75,$$ for $e^+\nu_e e^-\bar{\nu}_e$ events only



Hatched area – events with $M_{\mu^-\bar{\nu}_\mu} < 60$ GeV

Single W production at LEP

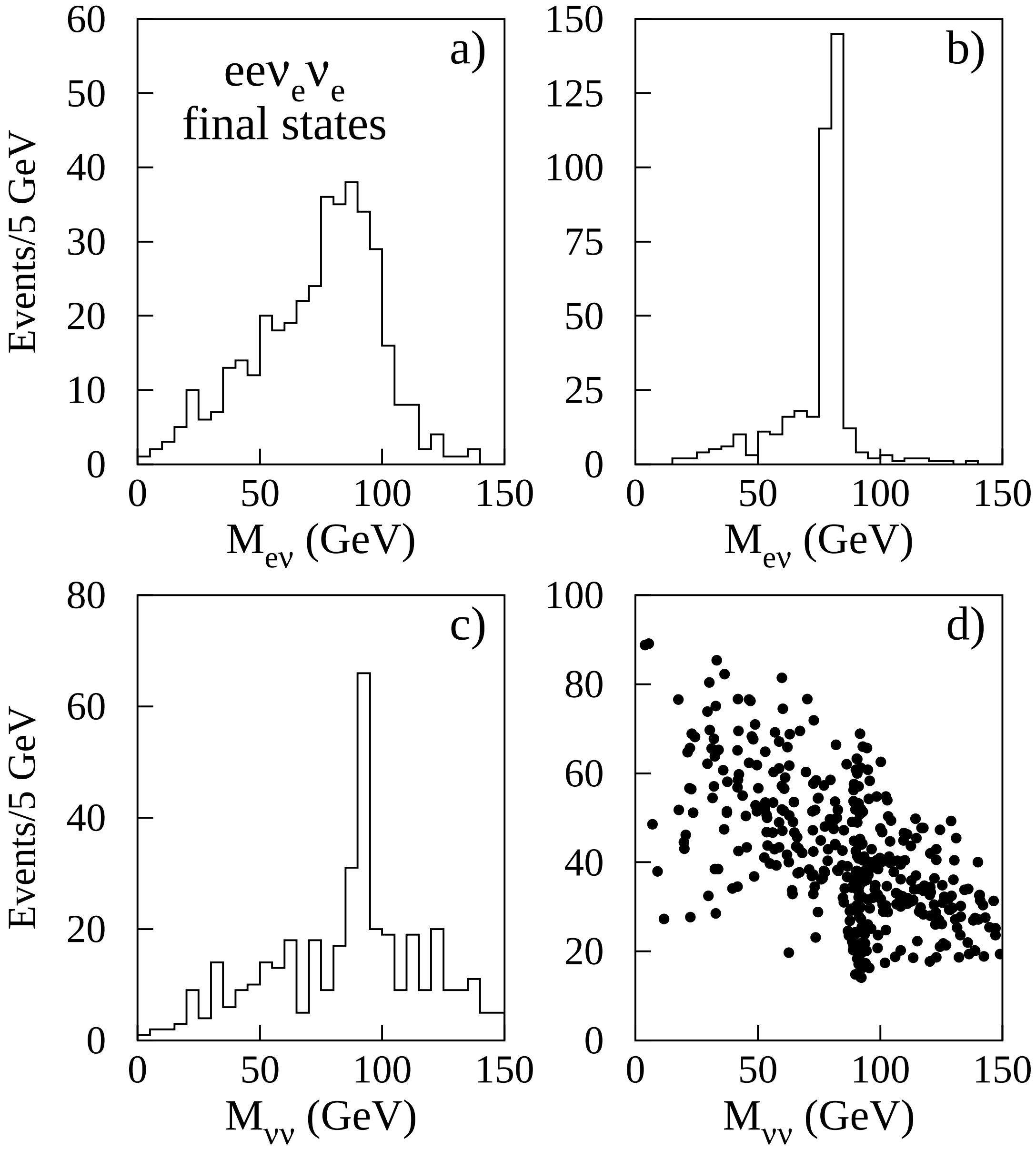
Signal definition (L3):



Single W production at LEP

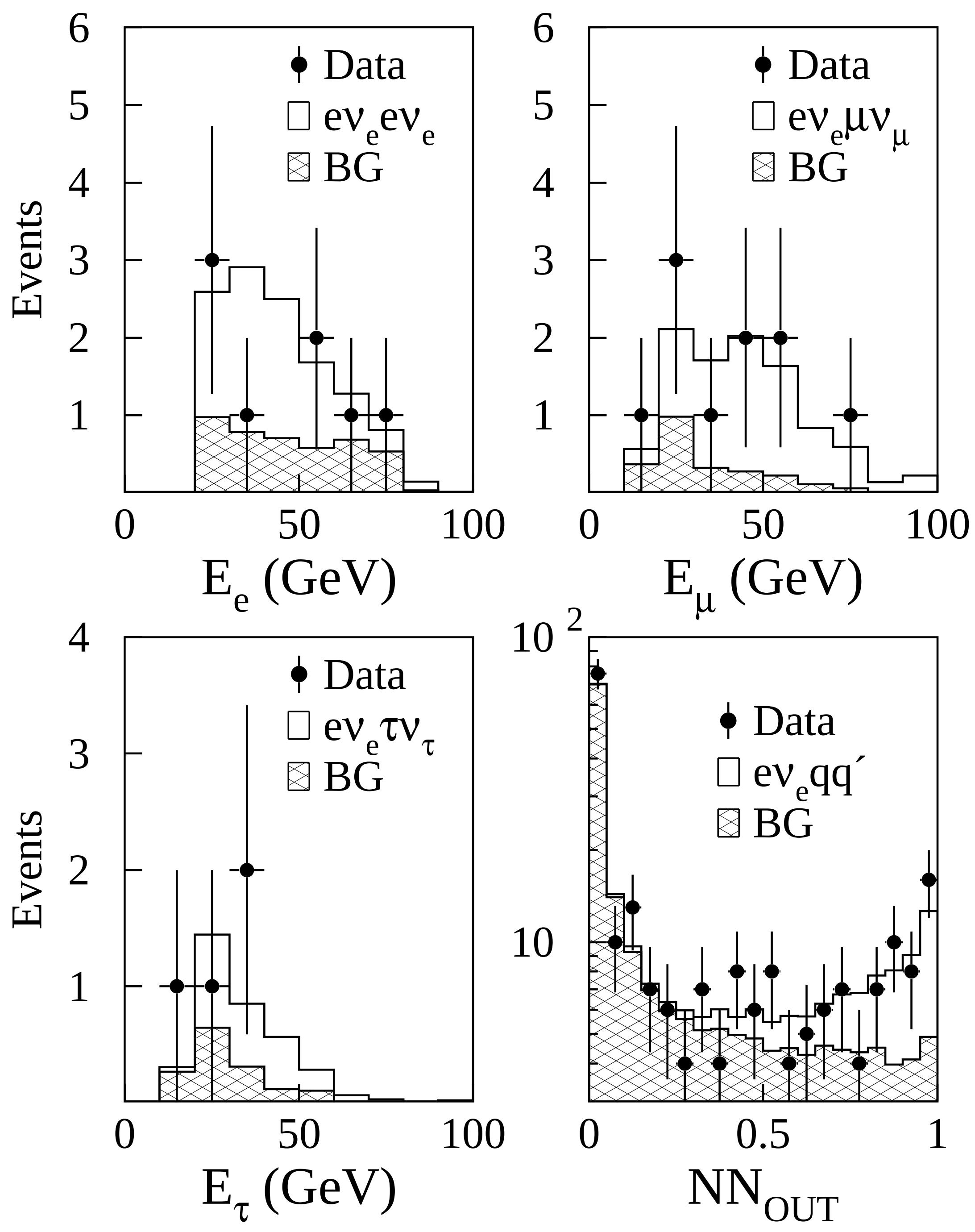
Purity depends on the final state (70-90%)

For $e^+\nu_e e^-\bar{\nu}_e$ final states other (Z/γ) resonant states also contribute:



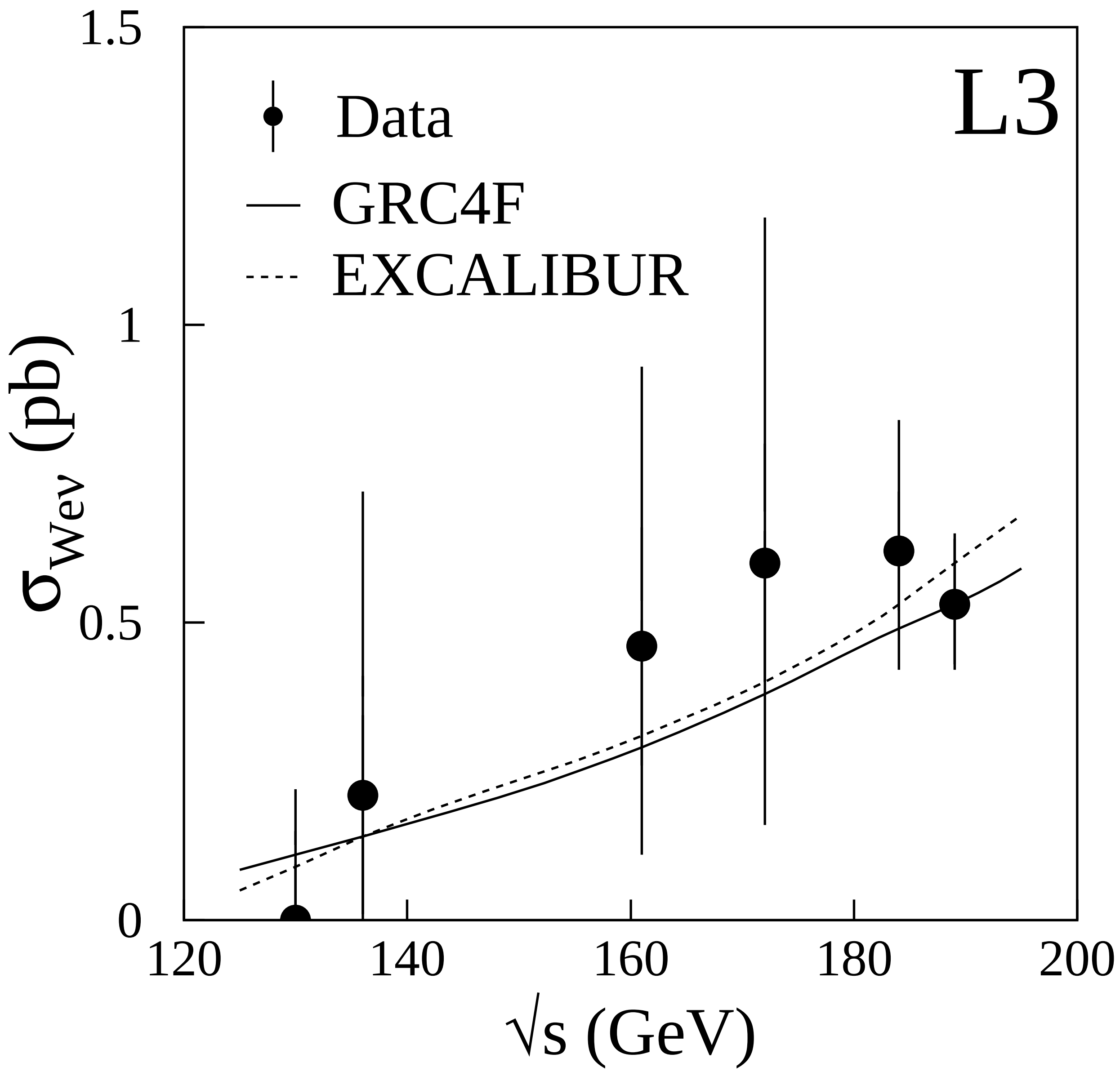
Physics with Single Ws

L3 results from 189 GeV data:



Single W signal as predicted by EXCALIBUR

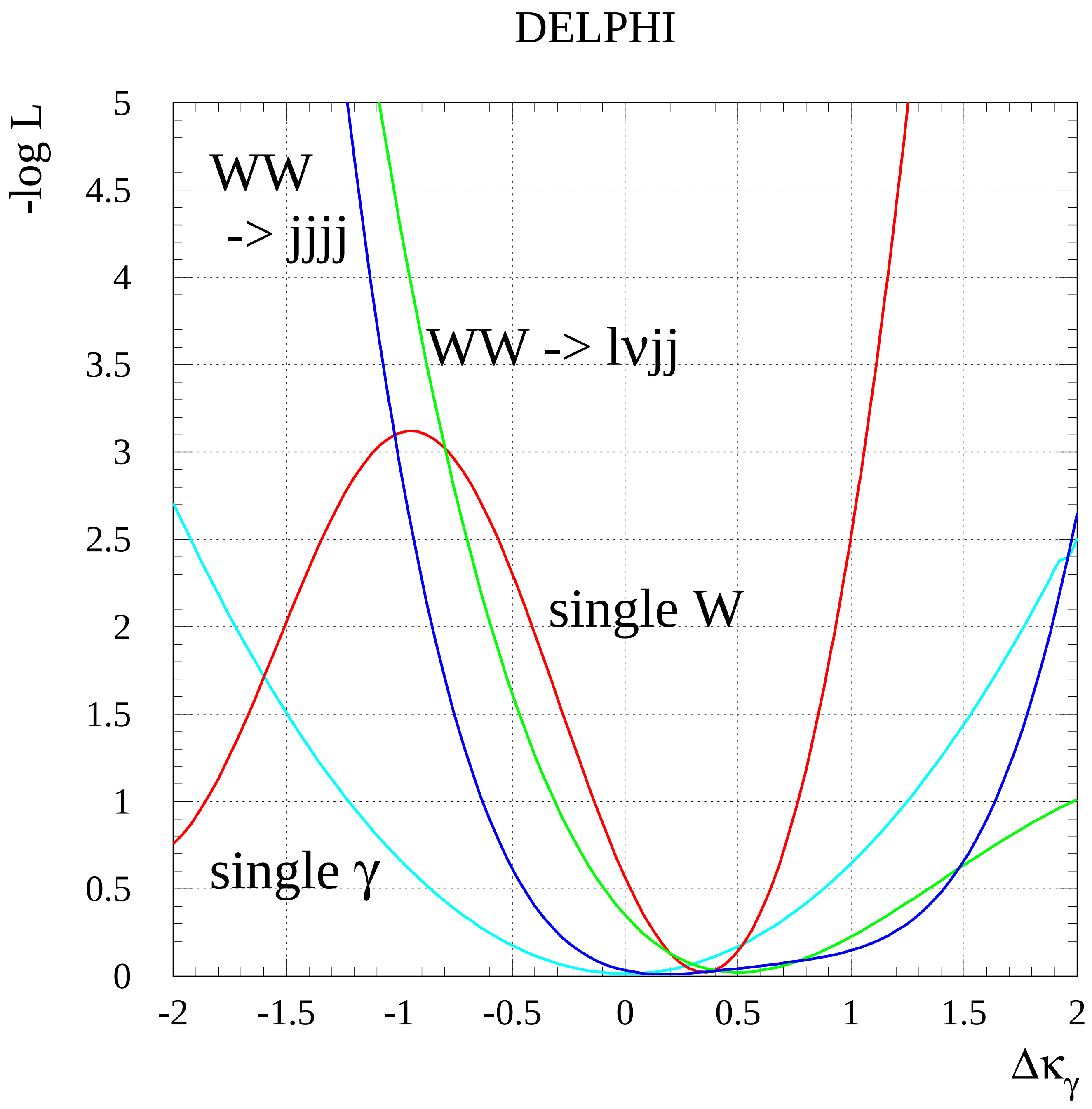
Physics with Single Ws



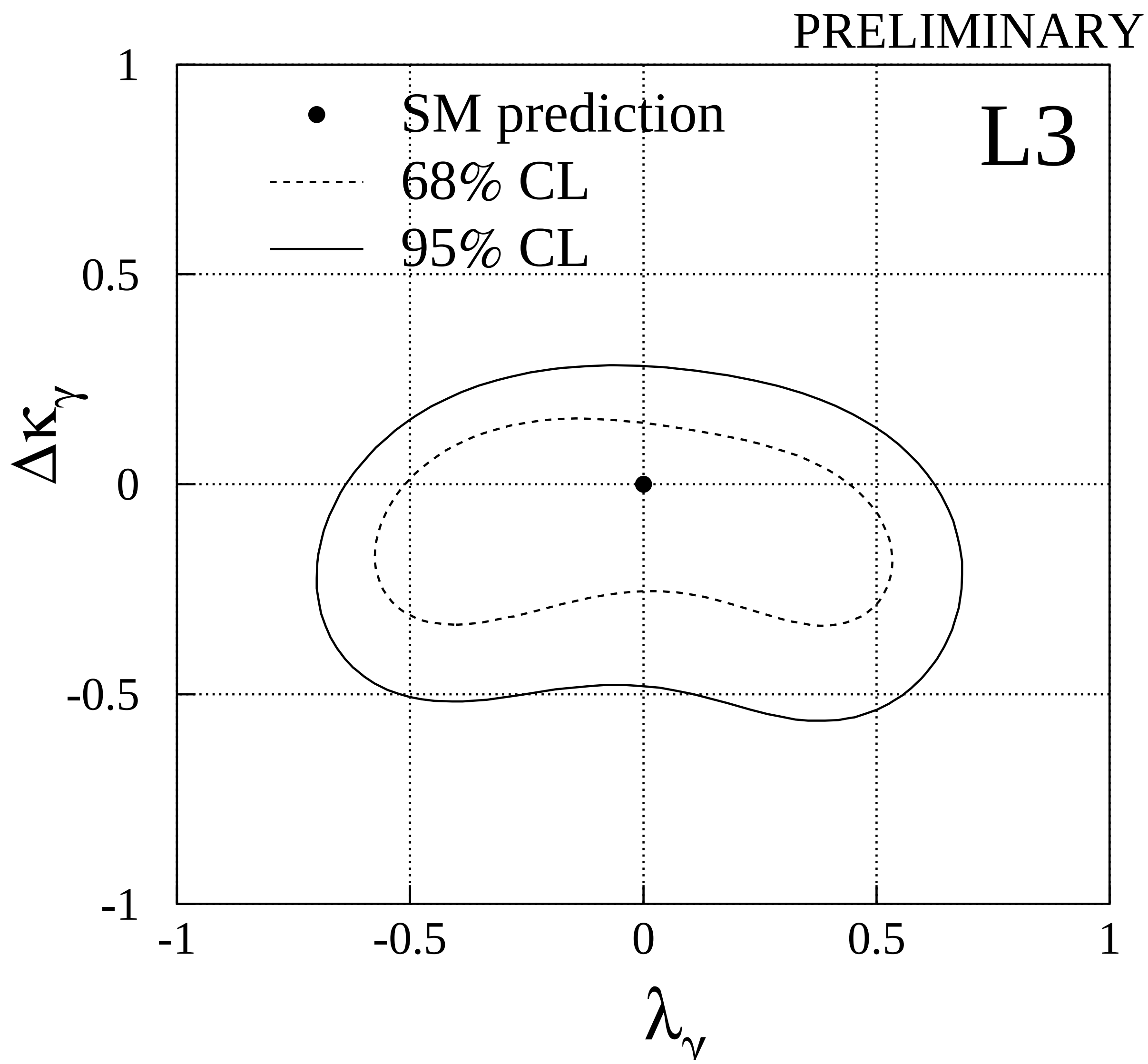
What is the accuracy of the SM prediction?

Physics with Single Ws

Significant sensitivity of Single Ws to κ_γ:



Physics with Single Ws



Two parameter fit at 95% CL:

$$
\begin{aligned}
-0.42 &< \Delta\kappa_\gamma < 0.22 \\
-0.64 &< \lambda_\gamma < 0.61
\end{aligned}
\tag{1}
$$

Single W generators

Available four-fermion generators:

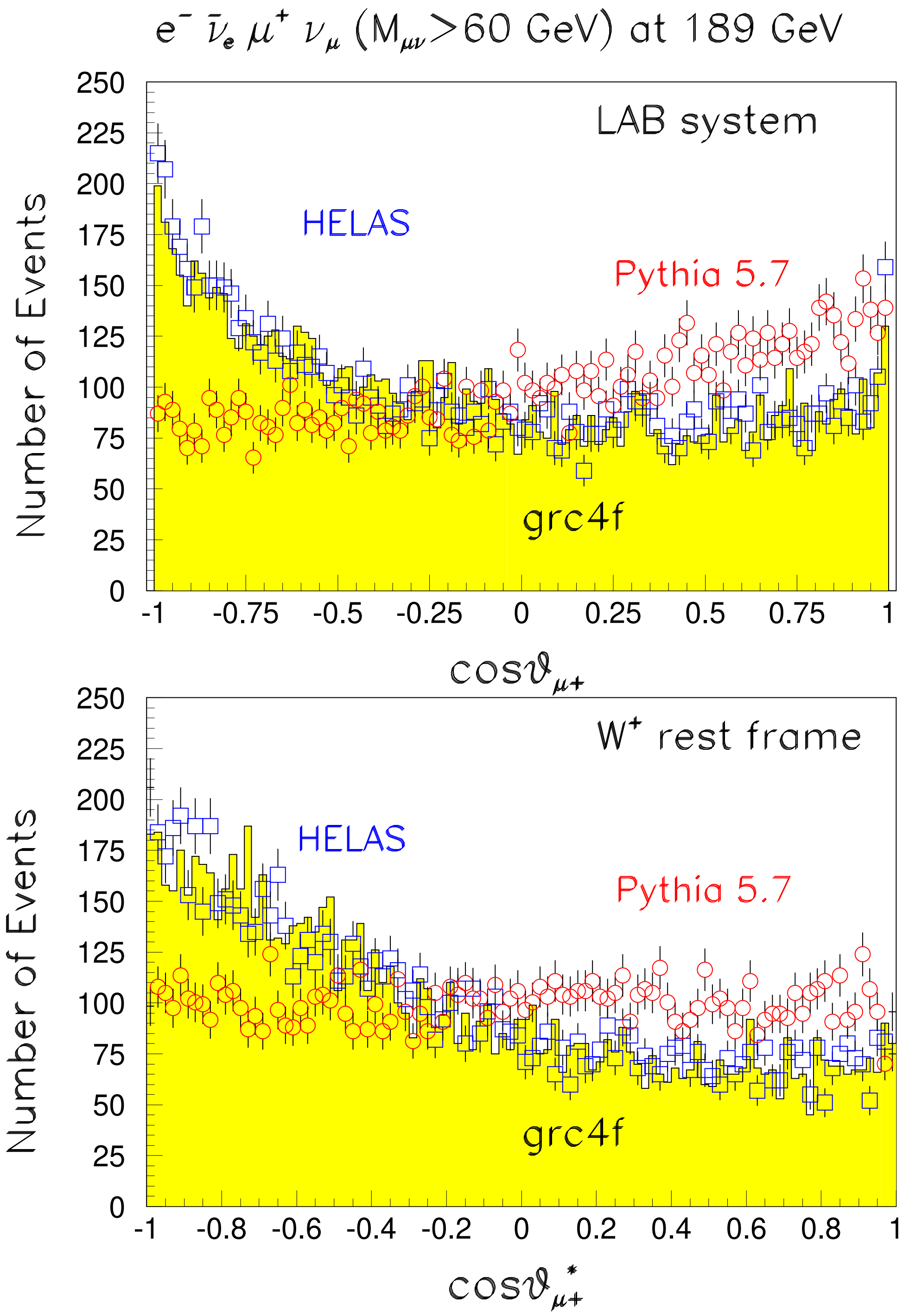
- PYTHIA
- EXCALIBUR
- GRC4F
- ERATO
- WTO
- ...

Tested by the all 4 LEP experiments:

- PYTHIA
- EXCALIBUR
- GRC4F

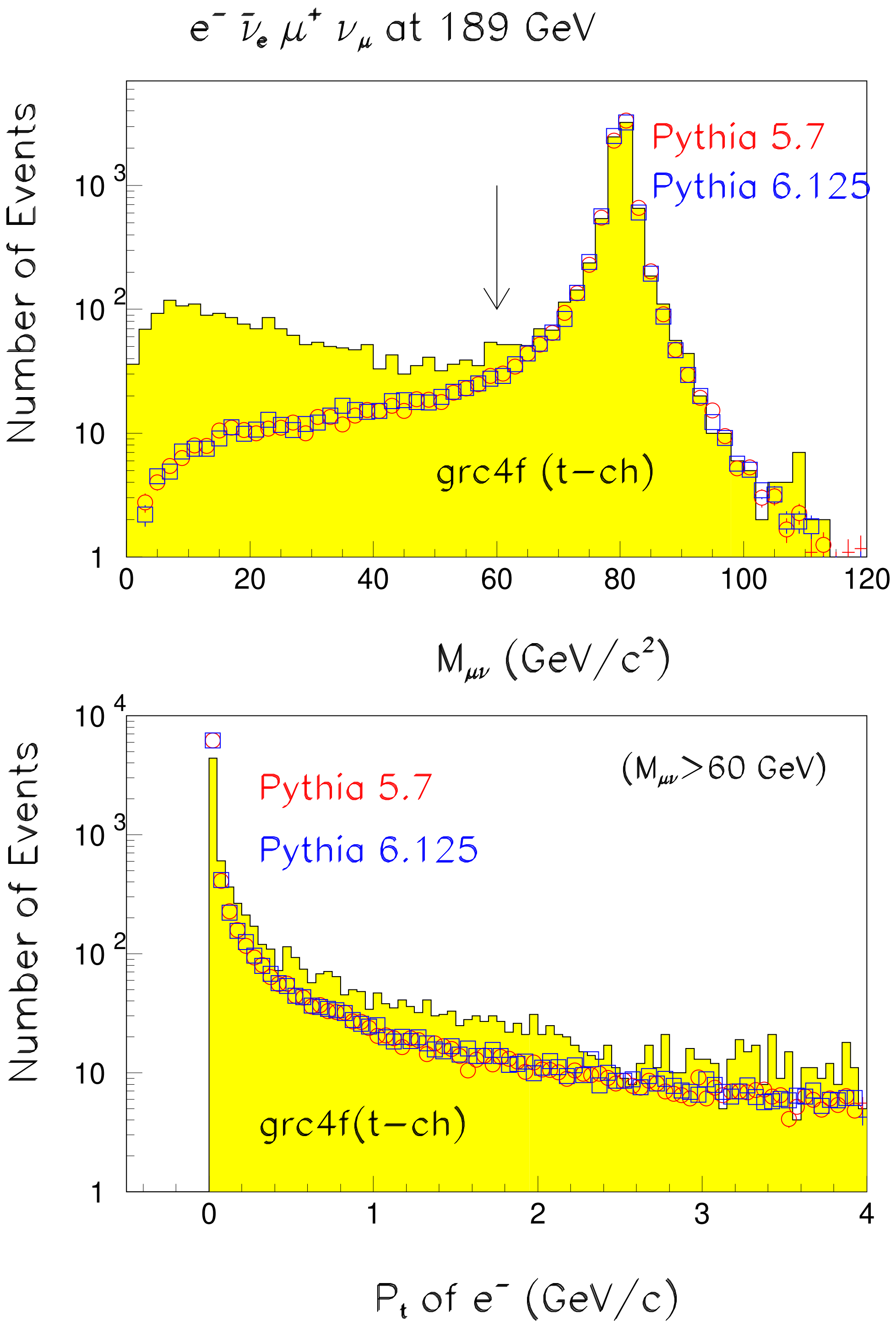
Single W generators

PYTHIA–GRC4F comparison by ALEPH:



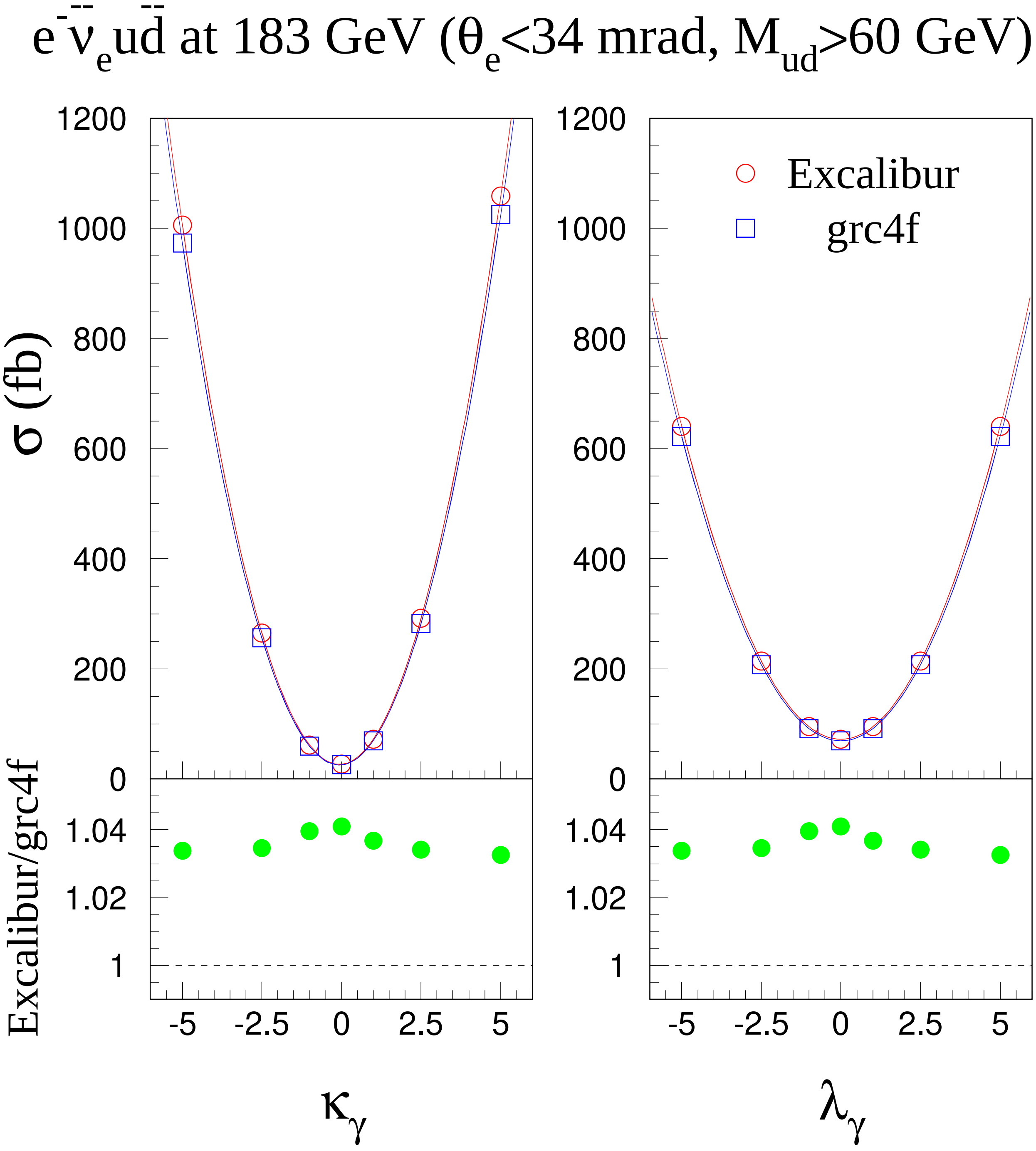
Single W generators

PYTHIA–GRC4F comparison by ALEPH:



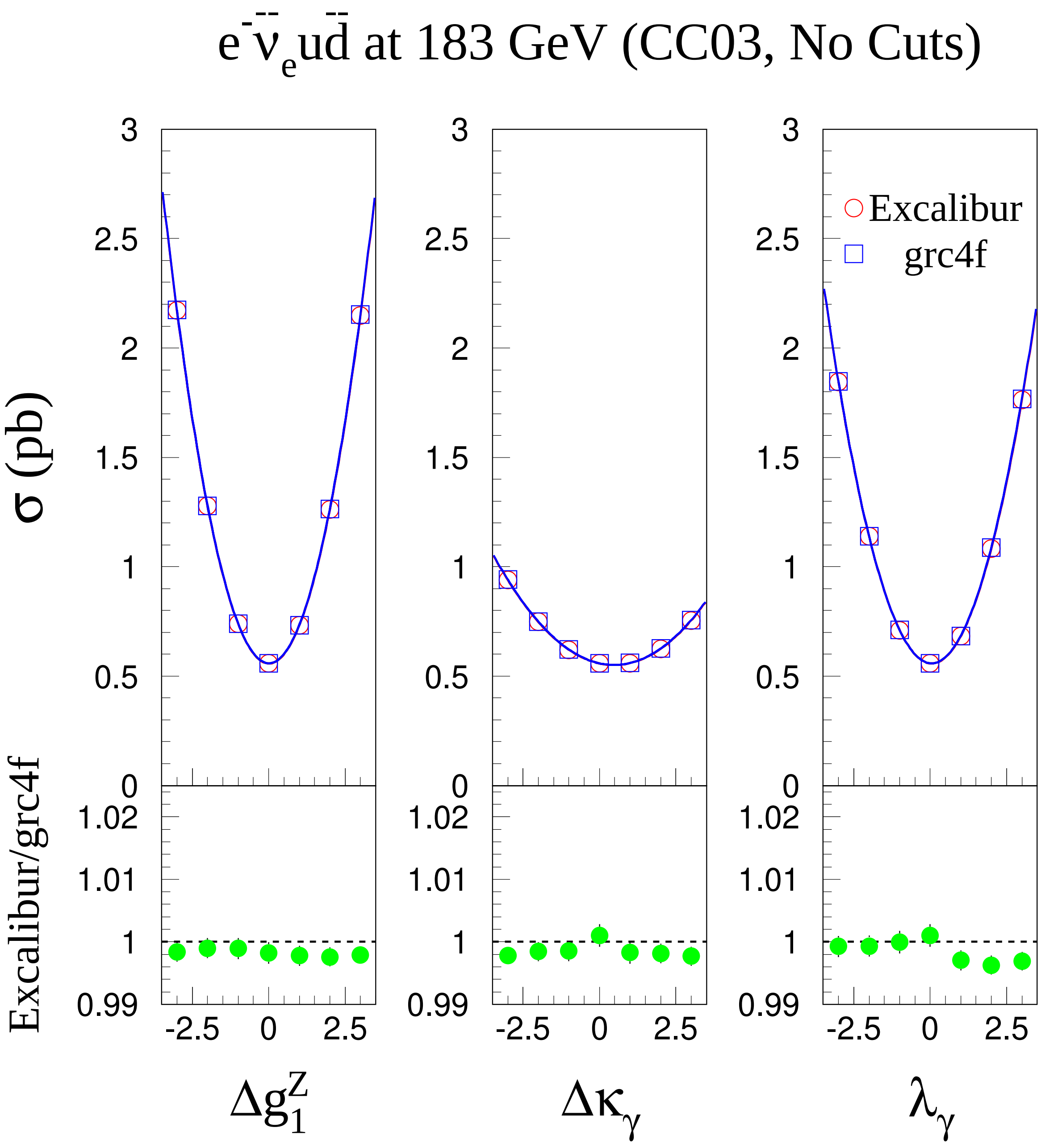
Single W generators

EXCALIBUR–GRC4F comparison by ALEPH:

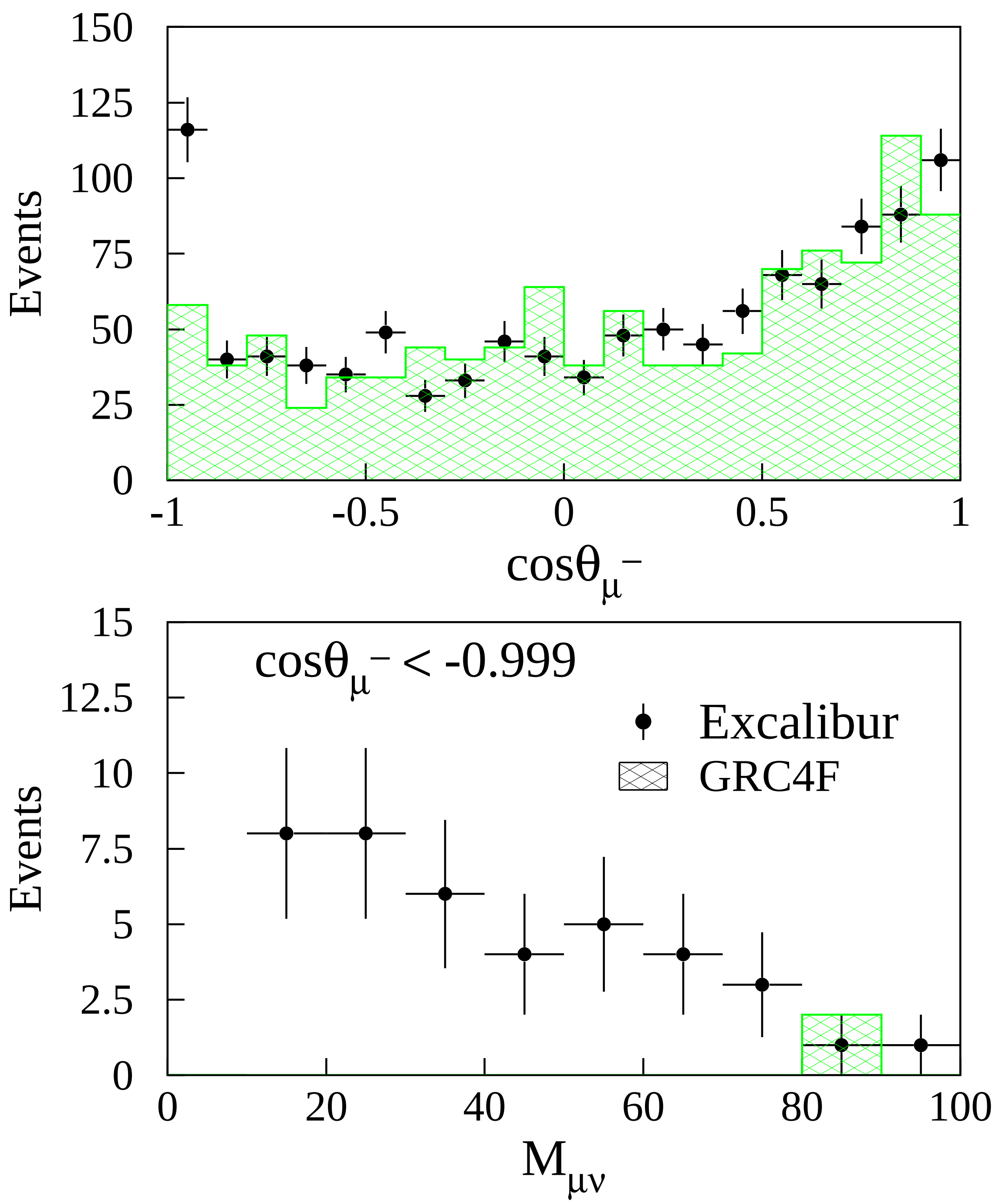


Single W generators

EXCALIBUR–GRC4F comparison by ALEPH:



EXCALIBUR–GRC4F comparison by L3:



Single W generators

ISR/FSR treatment in GRC4F
and EXCALIBUR:

- Collinear photon approximation for $\mathrm{e}^{+}\nu_{\mathrm{e}}\mathrm{ff}'$ final states.
- Uncertainty on the cross section due to this.
- Uncertainty in the efficiency calculation, as the p_t^{e} spectrum is modified

How large these uncertainties are?

Running α vs effective α?

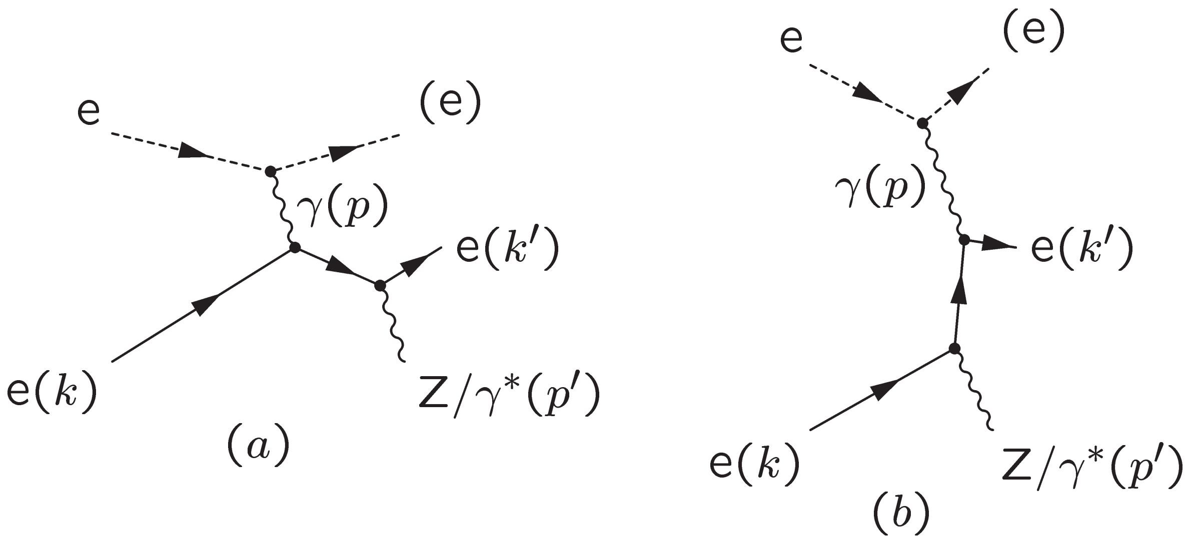
What uncertainty to be associated to that?

Single Z/γ^* production at LEP

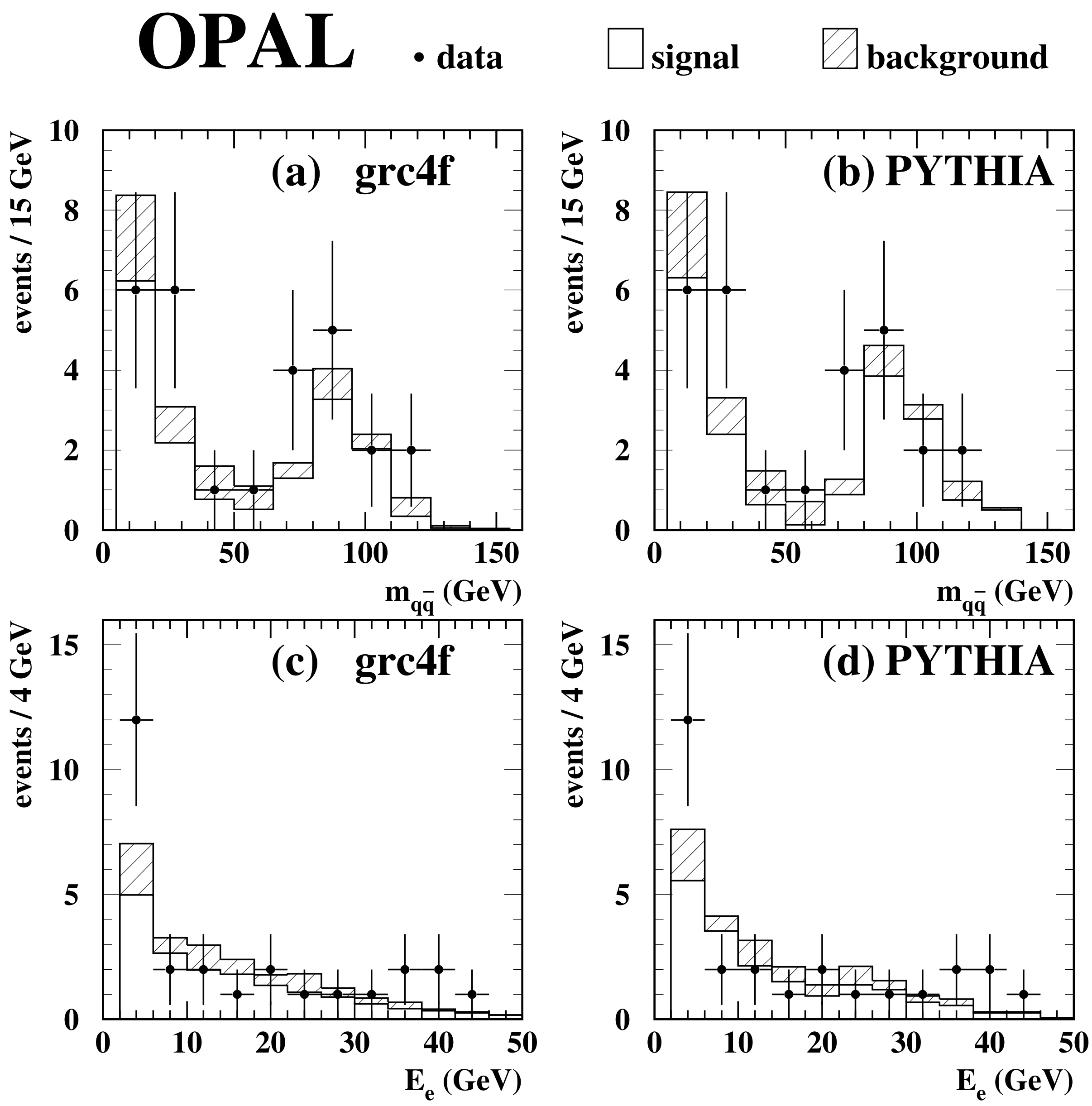
OPAL analysis of Single Z/γ^* production.

Signal definition for $\mathrm{e^+e^-q\bar{q}}$ final states:

$$
\begin{aligned}
|\cos\theta_{\mathrm{e}+}| &> 0.99995 \\
|\cos\theta_{\mathrm{e}-}| &< 0.985 \\
|\cos\theta_{\mathrm{q}}| &< 0.985 \\
M_{\mathrm{q\bar{q}}} &> 15\ \mathrm{GeV}
\end{aligned}
$$

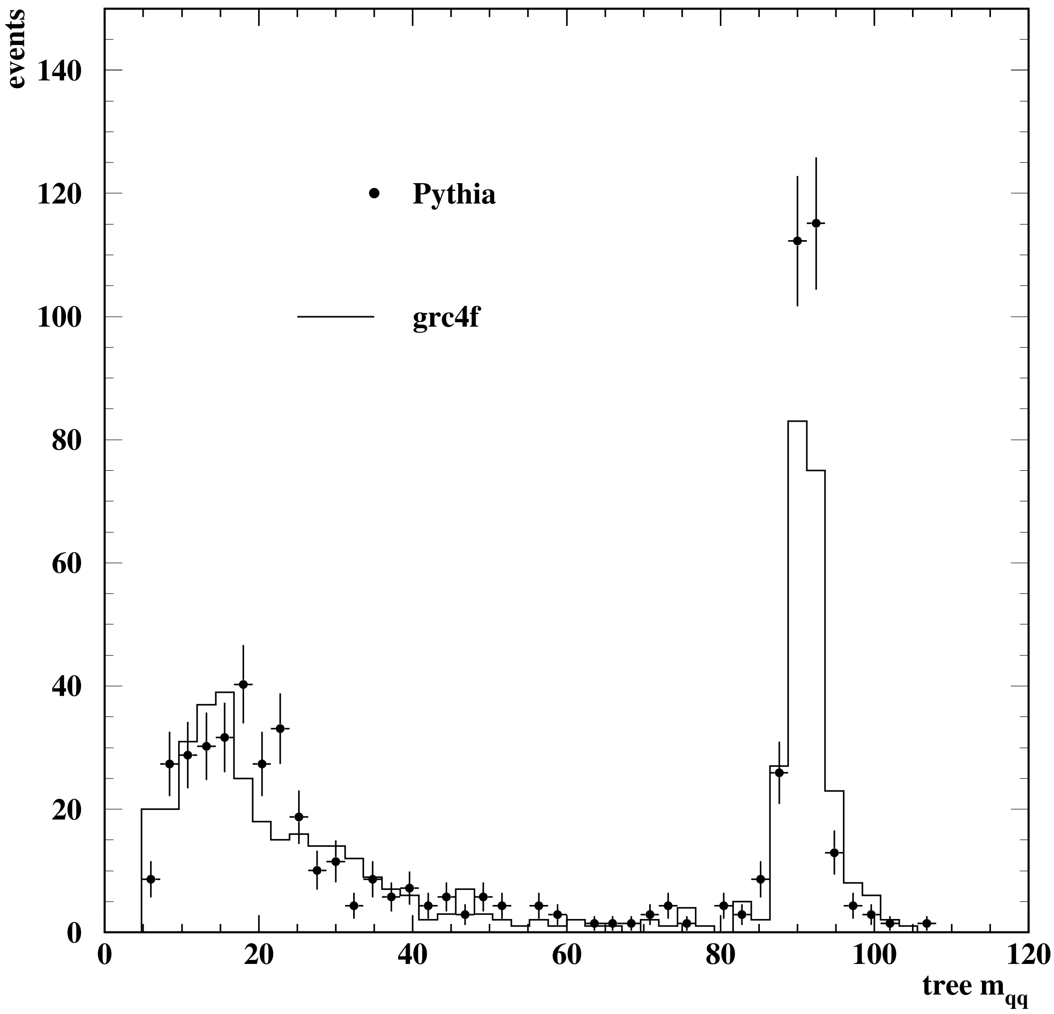


OPAL analysis of Single Z/γ^* production at $\sqrt{s} = 183$ GeV



Single Z/γ^* generators

OPAL analysis of Single Z/γ^* production at $\sqrt{s} = 183$ GeV



20% discrepancy in the cross section for $M_{q\bar{q}} > 60$ GeV

At $\sqrt{s} = 500$ GeV effect is opposite.

Remaining questions

So far (i.e. $\mathcal{L} \sim 100\text{pb}^{-1}$ of data) the accuracy of the SM predictions was adequate to the experimental precision

We expect 5-10 fold increase in statistics of final states with forward electron/positron

To be addressed

– Effects (and uncertainties) of ISR on four–fermion cross–section?

– Effects (and uncertainties) of ISR on p_t of small–angle electron?

– Effective vs running α – what is the uncertainty?

– Can discrepancy between GRC4F and EXCALIBUR be understood and corrected? (With 189 GeV data it becomes comparable to experimental errors)

– New programs available to be checked against the data

Remaining questions

Wish list:

- Matrix element from every generator is available as a stand–alone program.
- CPU time needed to generate $\mathrm{e}^{+}\nu_{\mathrm{e}}\mathrm{e}^{-}\bar{\nu}_{\mathrm{e}}$ with GRC4F is finite and integration is stable at the same time.
- Precision of SM prediction for the final states with forward electrons is 1%.
- Uniform treatment of ISR/FSR by the experiments

Many thanks for help in preparing this talk to:

- Reisaburo Tanaka (ALEPH)
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- Marco Verzocchi (OPAL)