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- L3 Collaboration -

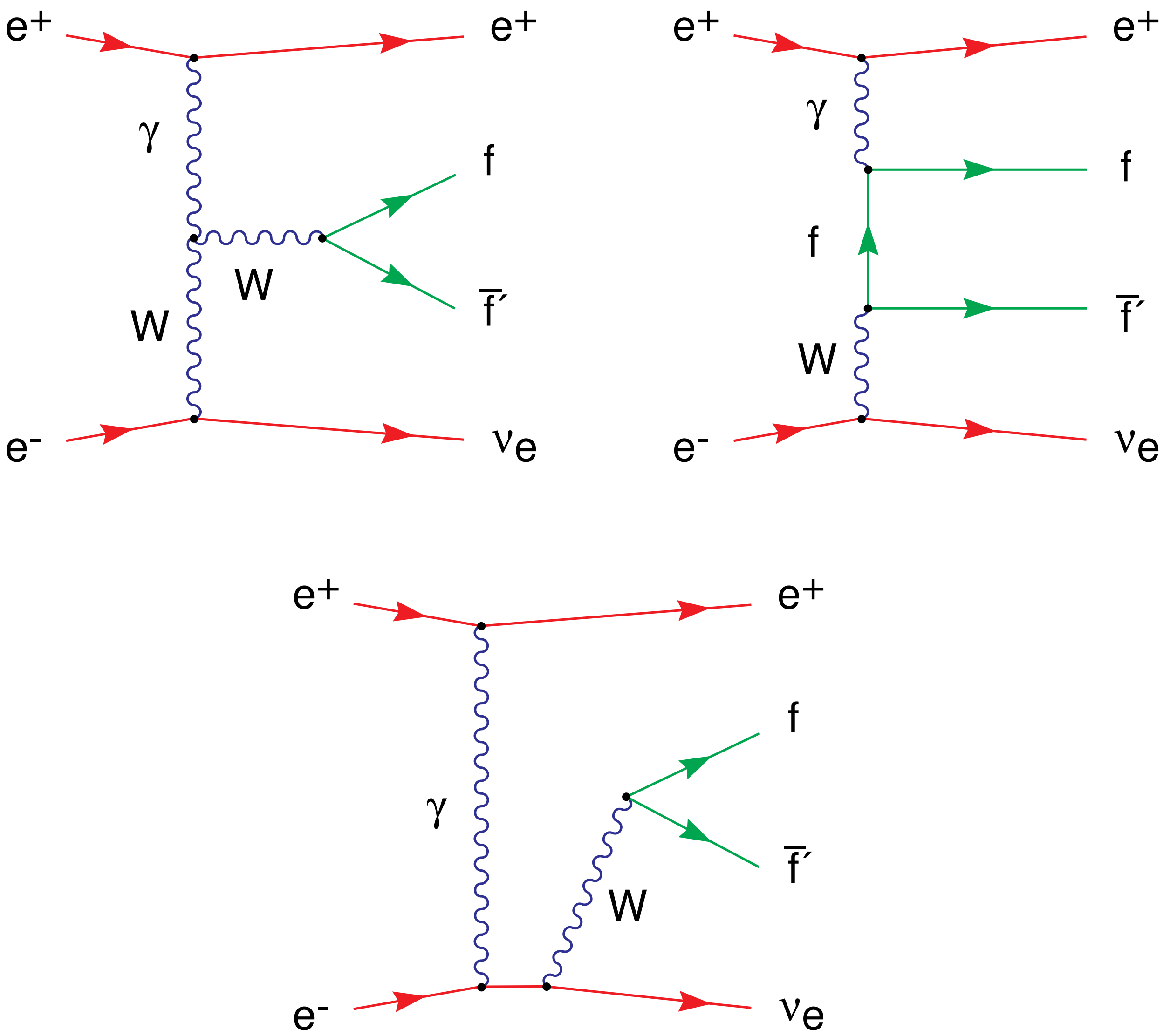
Observation of Single W Production at LEP

- Introduction
- Event Selection
- Results
- Interpretation
- Conclusions

XXXII$^{\mathrm{nd}}$ Rencontres de Moriond
ElectroWeak Interactions and Unified Theories
Les Arcs, France, March 15-22, 1997

Introduction

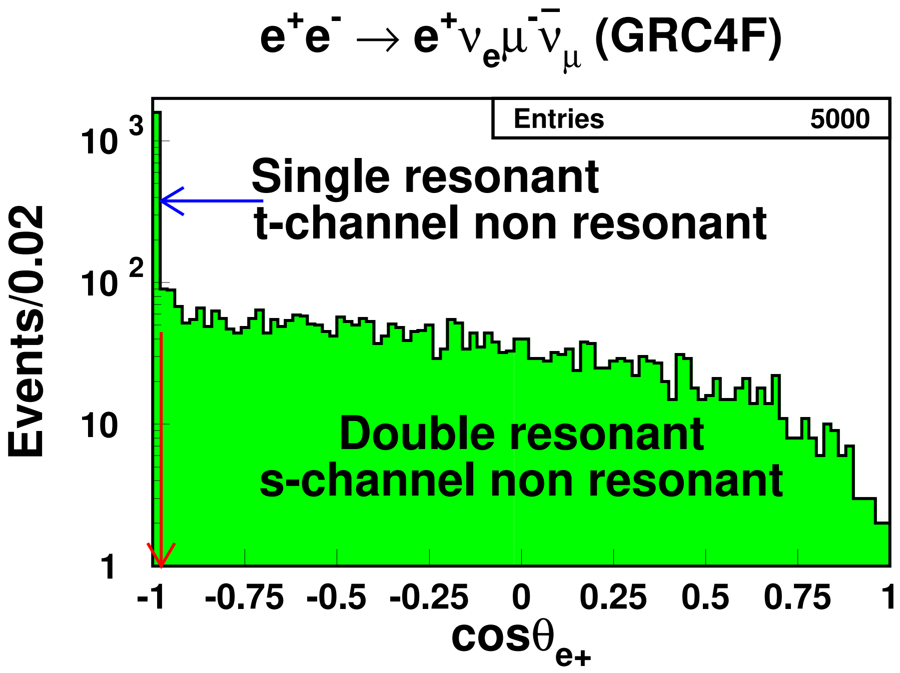
Several diagrams contribute to $e^+\nu_e f\bar{f}'$ ($f = \ell, q$) production besides $e^+e^- \rightarrow WW \rightarrow e^+\nu_e f\bar{f}'$:

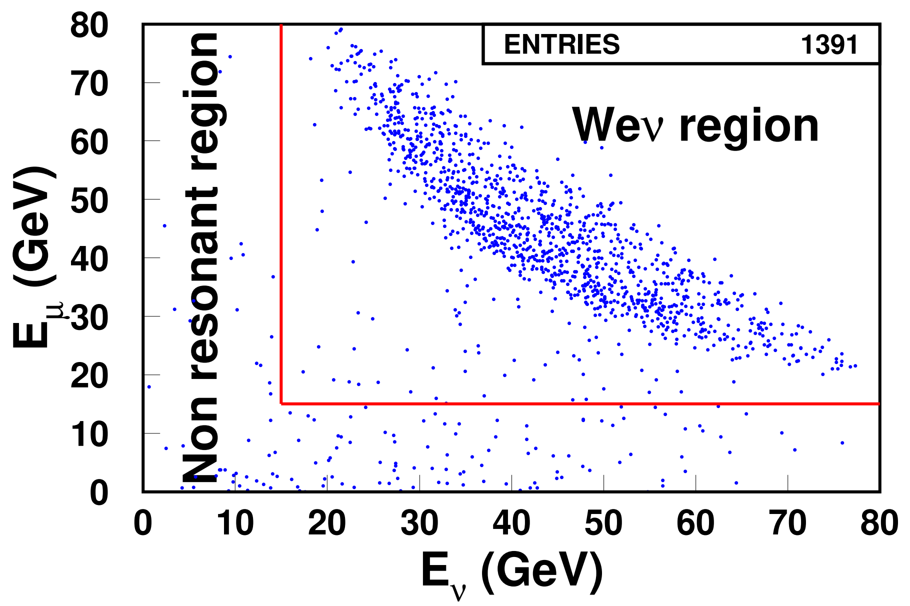


Single resonant diagrams ("single W") are of particular interest:

- Electron lost down beam pipe
- Background for New Particle searches
- Sensitive to anomalous $WW\gamma$ coupling

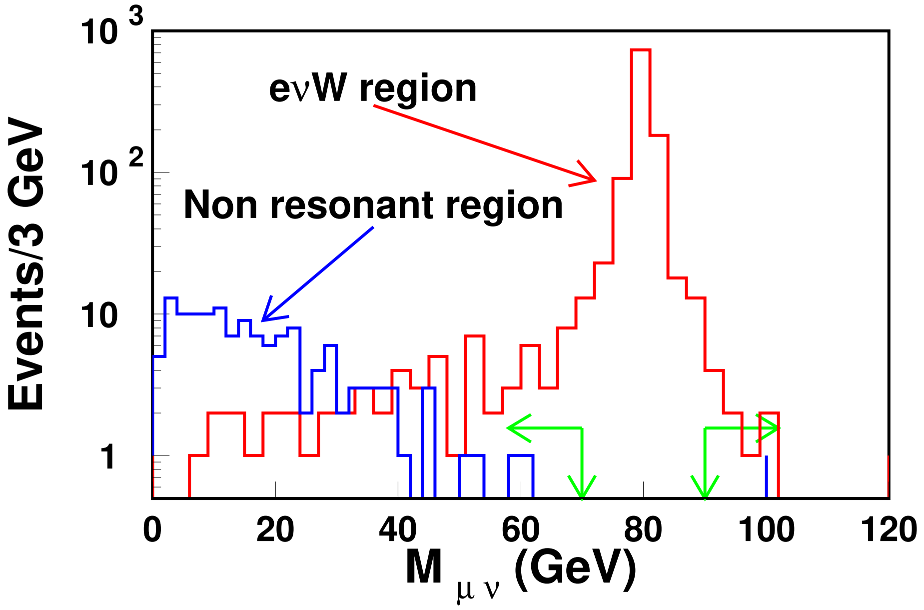
Generator study at $\sqrt{s} = 161\,\mathrm{GeV}$

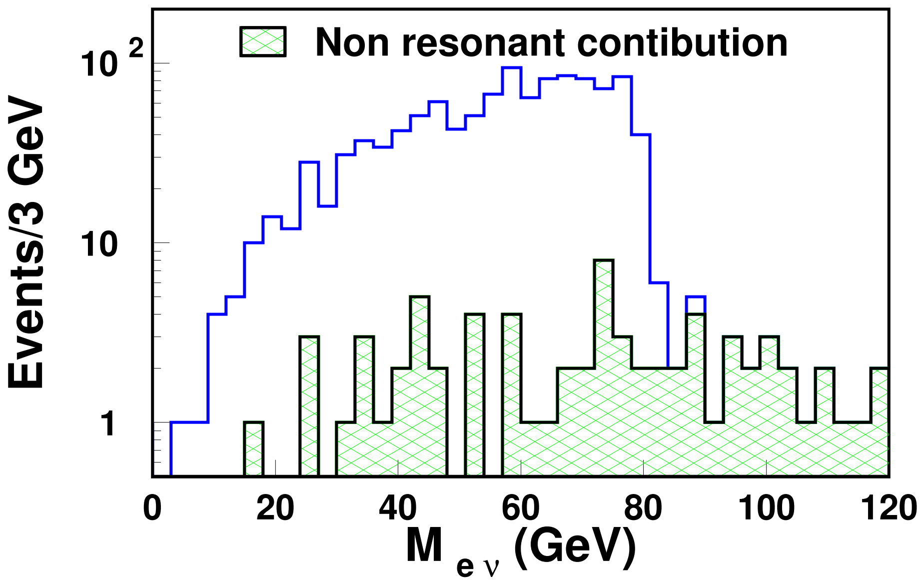




Definition of the signal:

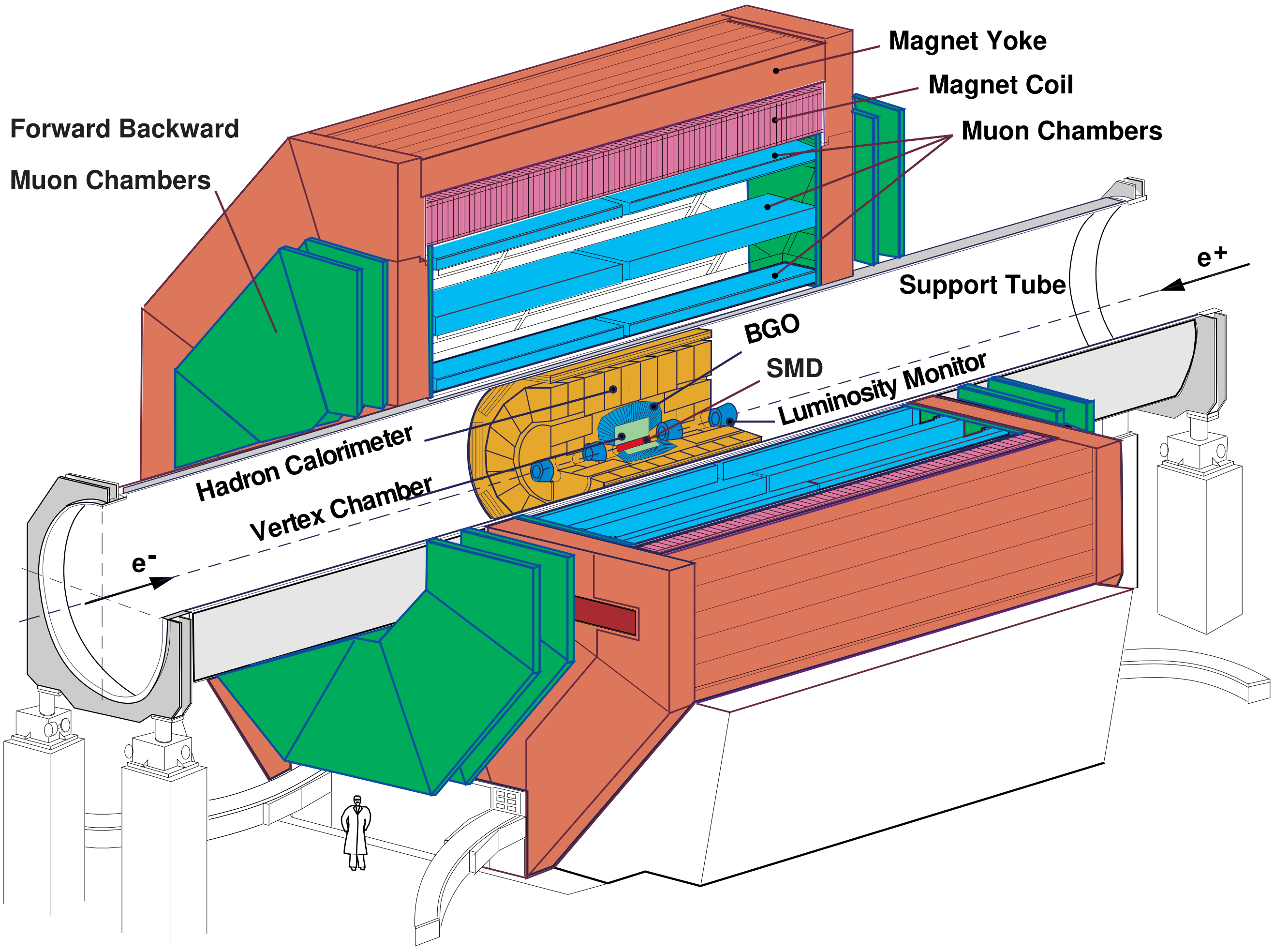
$$|\cos\theta_{e+}| \;>\; 0.997 \quad (\text{t channel, } vs. \text{ WW})$$
$$\mathrm{E_f},\ \mathrm{E_{\bar{f}'}} \;>\; 15\,\mathrm{GeV} \quad (\text{Single W, } vs. \text{ non res.})$$





- No single W outside the cuts
- Clear resonance structure in the selected sample
- No double resonance inside the cuts
- Irreducible 10% non resonant contribution

Event selection



Search for $e^+\nu_e W^- \to e^+\nu_e \ell^- \bar{\nu}_\ell / q\bar{q}'$

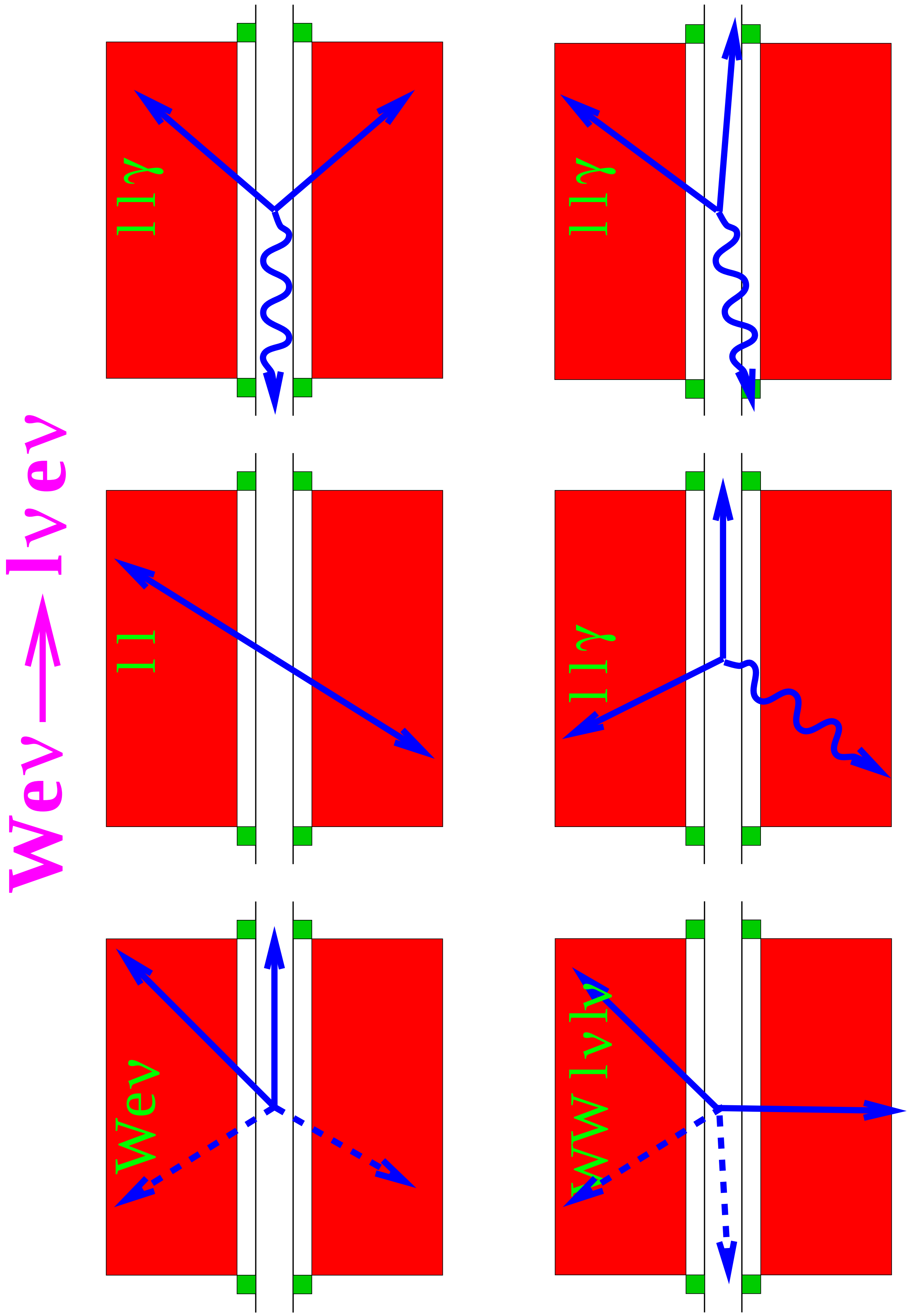
Electrons	:	tracks + e.m. calorimeter
Muons	:	tracks + muon chambers
Taus	:	tracks + calorimeters
Jets	:	tracks + calorimeters

Data sample:

$\sim 11\mathrm{pb}^{-1}$ @ $\sqrt{s} = 161\,\mathrm{GeV}$

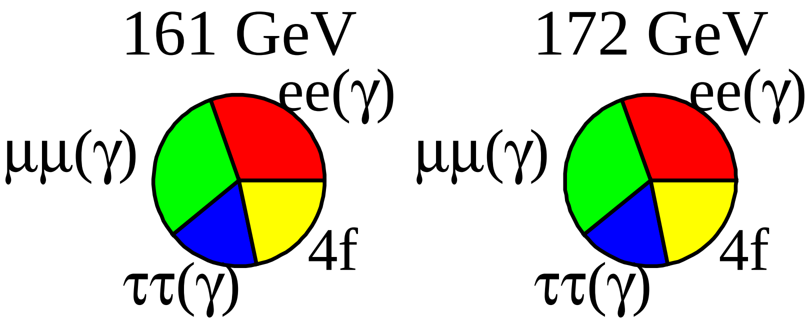
$\sim 10\mathrm{pb}^{-1}$ @ $\sqrt{s} = 170 - 172\,\mathrm{GeV}$

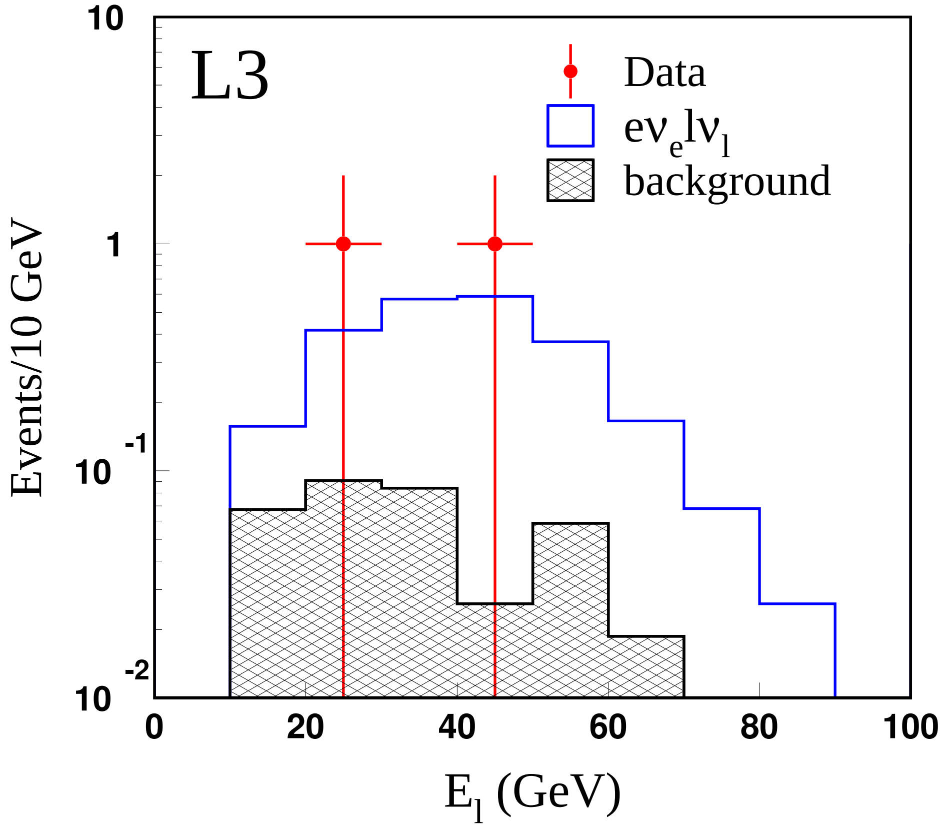
Event selection



Event selection

$\sqrt{s}$	Data events	Background
161 GeV	1	0.23 ± 0.08
170-172 GeV	1	0.26 ± 0.08

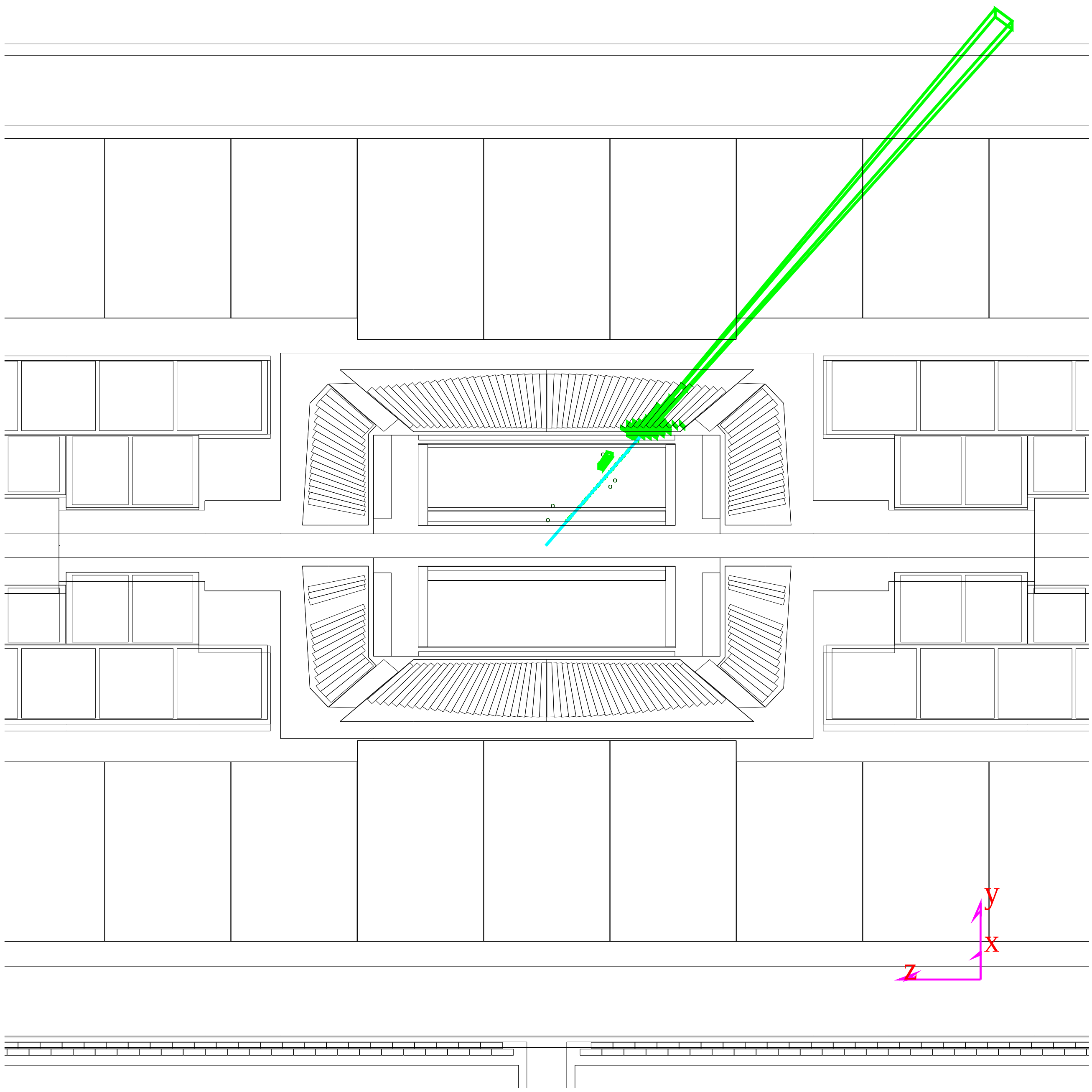


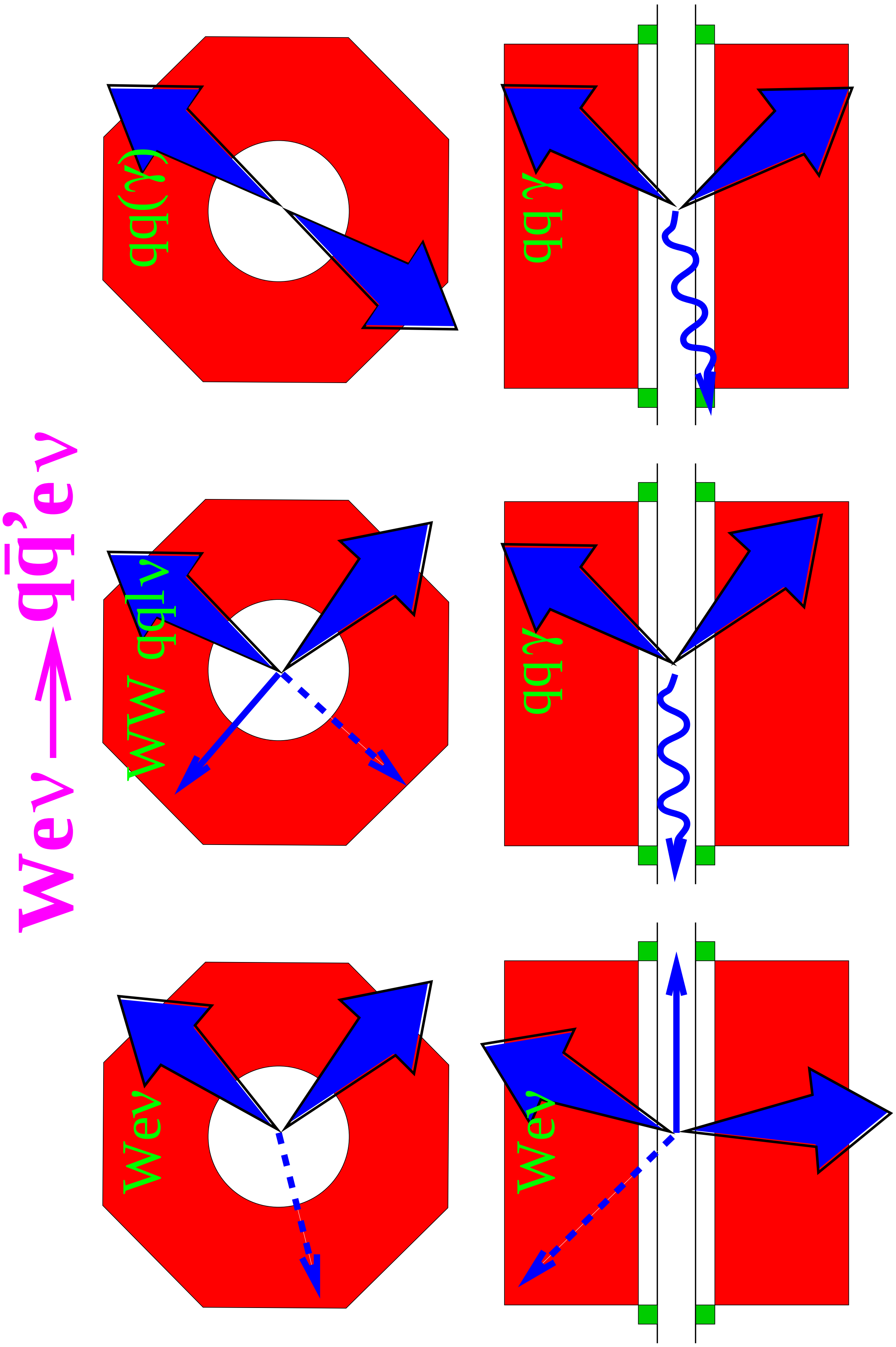


$\sqrt{s}$	$\varepsilon(e)$	$\varepsilon(\mu)$	$\varepsilon(\tau)$
161 GeV	$(80 \pm 4)\%$	$(55 \pm 2)\%$	$(30 \pm 2)\%$
170-172 GeV	$(76 \pm 4)\%$	$(51 \pm 2)\%$	$(26 \pm 2)\%$

Event selection

Run # 660201 Event # 5876

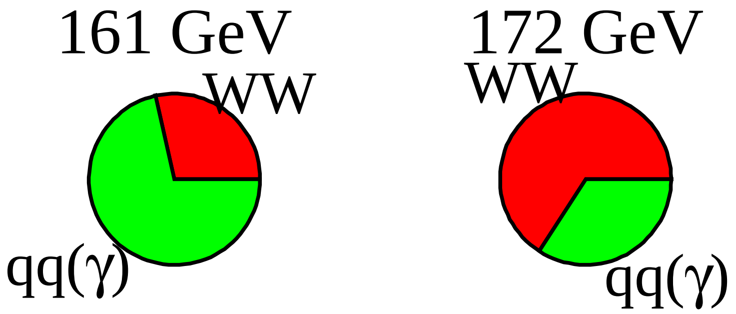


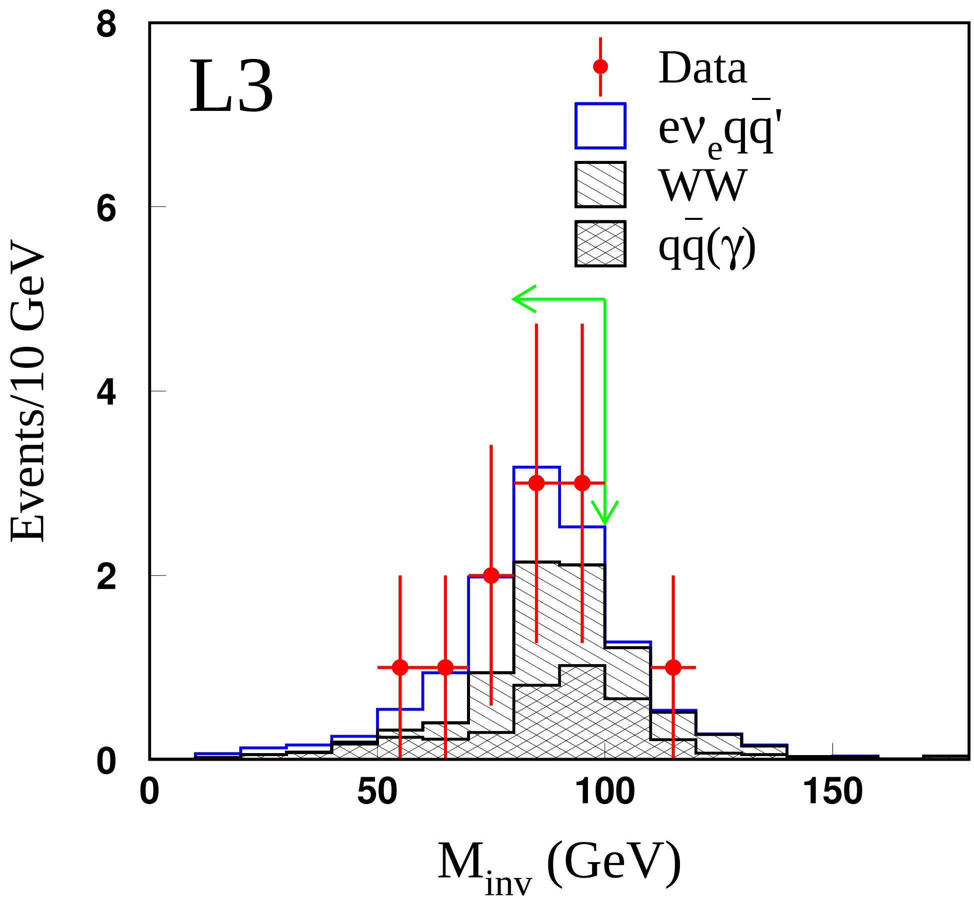


$q\bar{q}(\gamma)$
$q\bar{q}\gamma$
WW $q\bar{q}l\nu$
$q\bar{q}\gamma$
$We\nu \longrightarrow q\bar{q}'e\nu$
$We\nu$
$We\nu$

Event selection

$\sqrt{s}$	Data events	Background
161 GeV	4	2.1 ± 0.1
170-172 GeV	6	4.1 ± 0.2

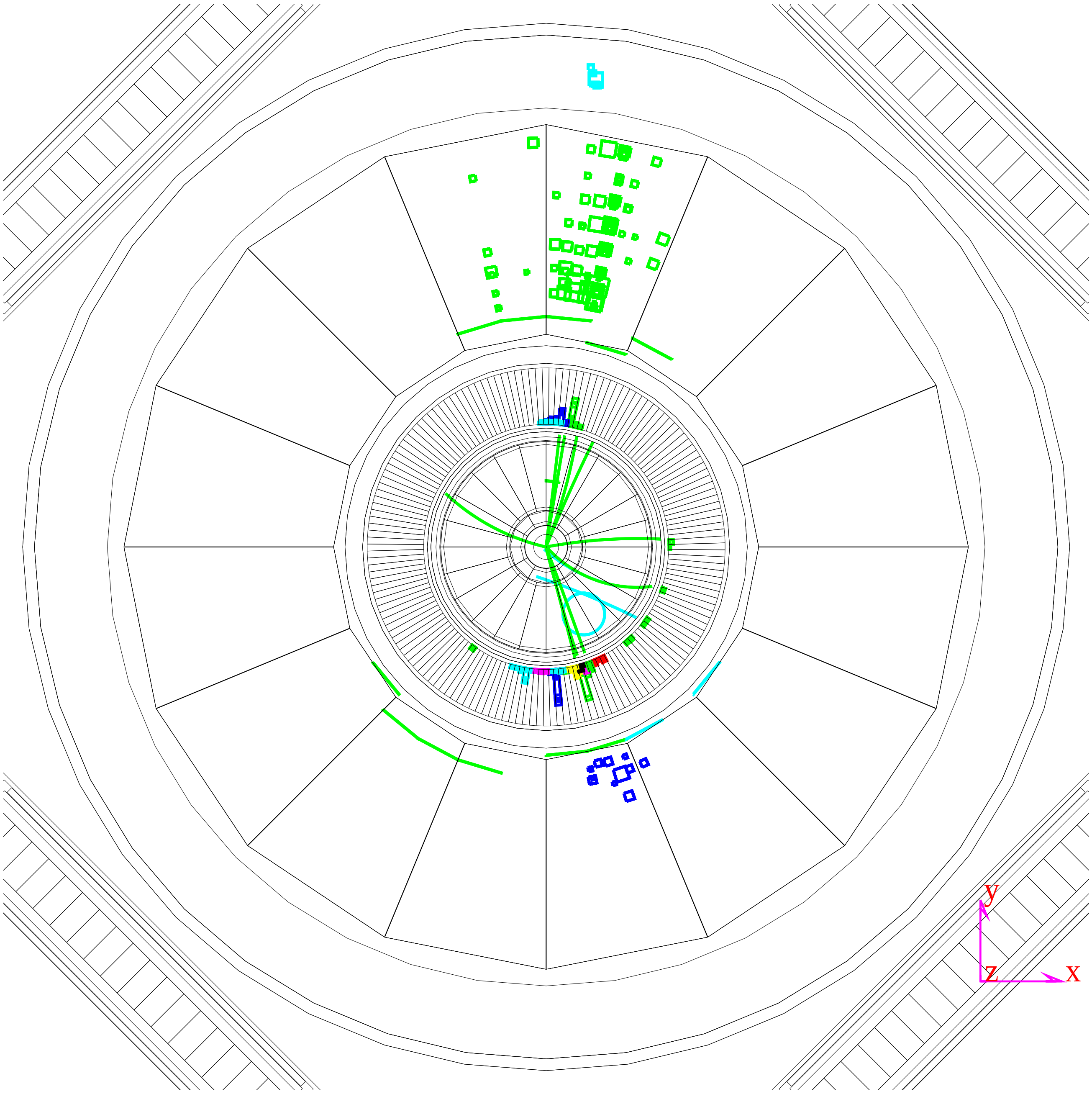




$\sqrt{s}$	ε
161 GeV	$(42 \pm 2)\%$
170-172 GeV	$(40 \pm 3)\%$

Event Selection

Run # 667611 Event # 920



Cross sections calculation @ $\sqrt{s} = 172\,\mathrm{GeV}$ using:
$\sigma(172\,\mathrm{GeV}) = 1.2\times\sigma(161\,\mathrm{GeV})$ (GRC4F).

Method: binned likelihood fit to E_l and M_{inv} fixing background shape and normalization as in Monte Carlo.

$$\sigma(e^+e^- \to \ell^-\bar{\nu}_\ell e^+\nu_e) = 0.17^{+0.20}_{-0.12} \pm 0.02\,\mathrm{pb}$$

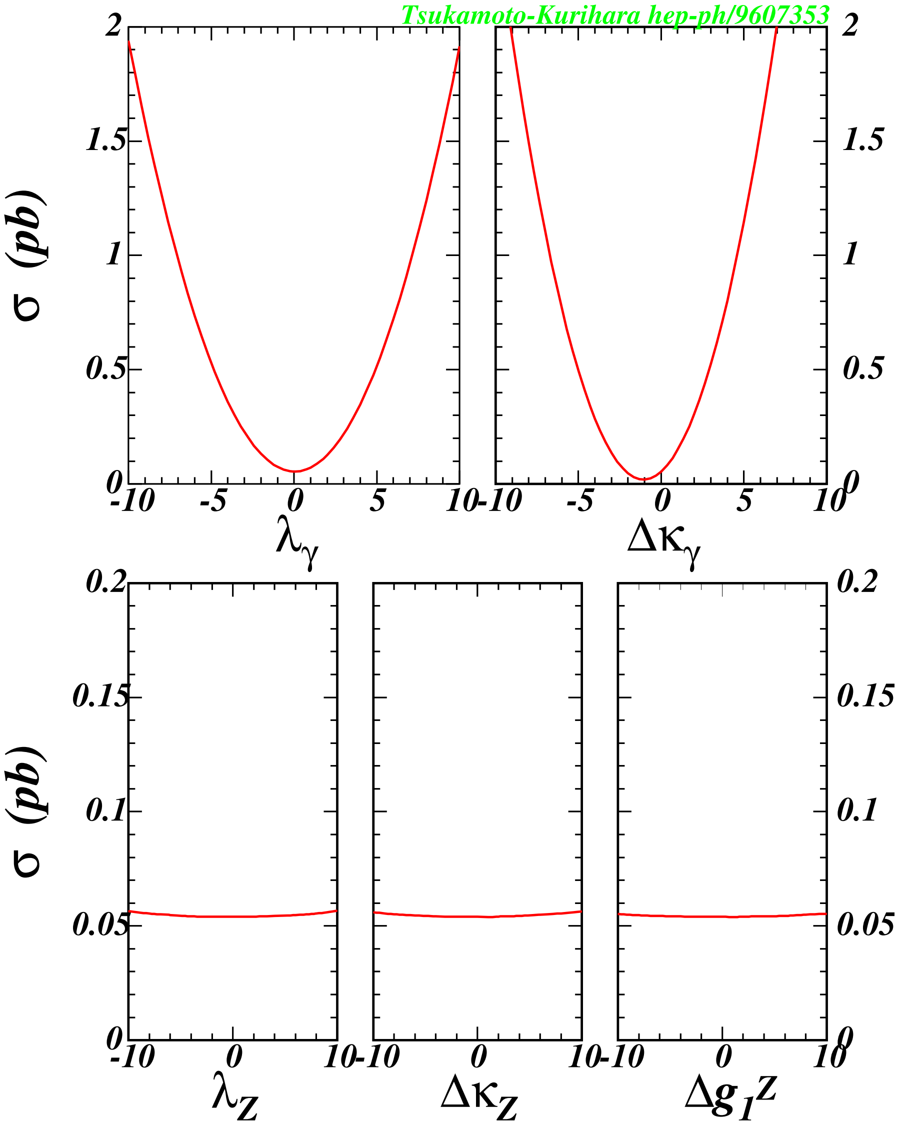
$$\sigma(e^+e^- \to q\bar{q}'e^+\nu_e) = 0.45^{+0.41}_{-0.32} \pm 0.04\,\mathrm{pb}$$

Using measured W branching fractions in a combined fit:

$$\boxed{\sigma(e^+e^- \to W^-e^+\nu_e) = 0.61^{+0.43}_{-0.33} \pm 0.05\,\mathrm{pb}}$$

Standard Model prediction : $0.35\,\mathrm{pb}$ (GRC4F).

Intepretation



$$i\mathcal{L}^{WWV} = g_{WWV}[\ g_1^V\left(W^\dagger_{\mu\nu}W^\mu V^\nu - W^\dagger_\mu V_\nu W^{\mu\nu}\right) + \kappa_V W^\dagger_\mu W_\nu V^{\mu\nu} + \frac{\lambda_V}{m_W^2} W^\dagger_{\rho\nu} W^\mu_\nu V^{\rho\nu}]$$

$$V = \gamma, Z, \quad W_{\mu\nu} = \partial_\mu W_\nu - \partial_\nu W_\mu, \quad V_{\mu\nu} = \partial_\mu V_\nu - \partial_\nu V_\mu,$$

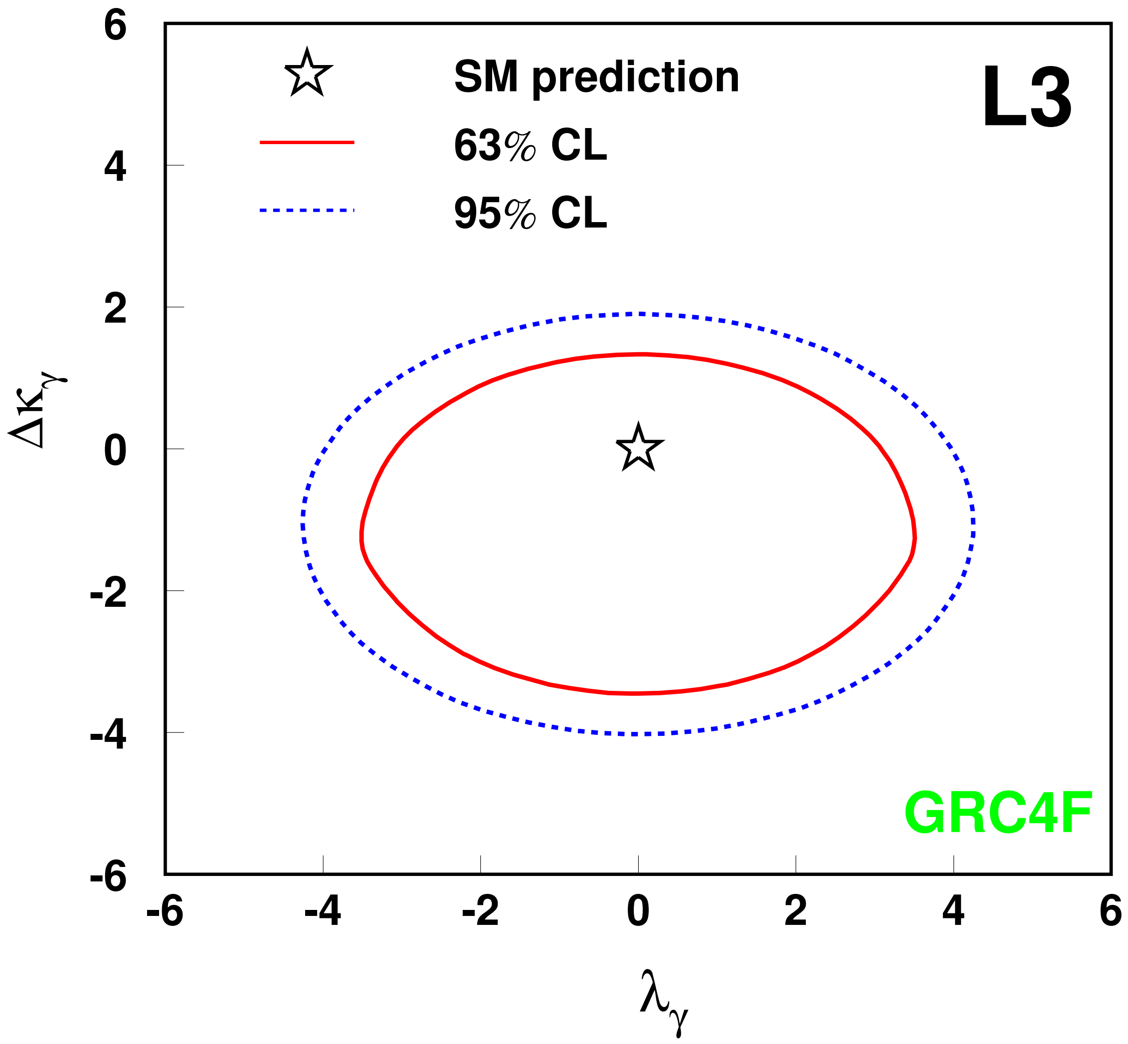
Deviations from the Standard Model:

$$\Delta g_1^Z \equiv (g_1^Z - 1), \quad \Delta\kappa_\gamma \equiv (\kappa_\gamma - 1), \quad \Delta\kappa_Z \equiv (\kappa_Z - 1), \quad \lambda_\gamma, \quad \lambda_Z$$

$$\mathrm{D0}: -0.33 < \lambda_\gamma < 0.31, \quad -0.98 < \Delta\kappa_\gamma < 1.01 \quad @ \quad 95\%\ \mathrm{CL}.$$

At LEP WWZ and WWγ couplings are difficult to disentangle in $e^+e^- \rightarrow W^+W^-$.

Limits on WWγ anomalous couplings from $\sigma(e^+e^- \rightarrow W^-e^+\nu_e)$:



$$-3.6 < \lambda_\gamma < 3.6 \quad @ \quad 95\% \text{ CL.}$$
$$-3.6 < \Delta\kappa_\gamma < 1.5 \quad @ \quad 95\% \text{ CL.}$$

Conclusions

First observation of single resonant W production at LEP in hadronic and leptonic final states in $\sim 21\mathrm{pb}^{-1} @ \sqrt{\mathrm{s}} = 161 - 172\,\mathrm{GeV}$.

$$\sigma(\mathrm{e^+e^-} \rightarrow \mathrm{W^-e^+}\nu_\mathrm{e}) = 0.61^{+0.43}_{-0.33} \pm 0.05\,\mathrm{pb}$$
$$@\sqrt{s} = 172\,\mathrm{GeV}$$

$$(\mathrm{Standard\ Model\ prediction:}\ 0.35\,\mathrm{pb}).$$

Good channel to study possible $\mathrm{WW}\gamma$ anomalous couplings:

$$-3.6 < \lambda_\gamma < 3.6 \quad @ \quad 95\%\ \mathrm{CL}.$$
$$-3.6 < \Delta\kappa_\gamma < 1.5 \quad @ \quad 95\%\ \mathrm{CL}.$$

Looking forward further integrated luminosity!