What have we learned from LEP2?

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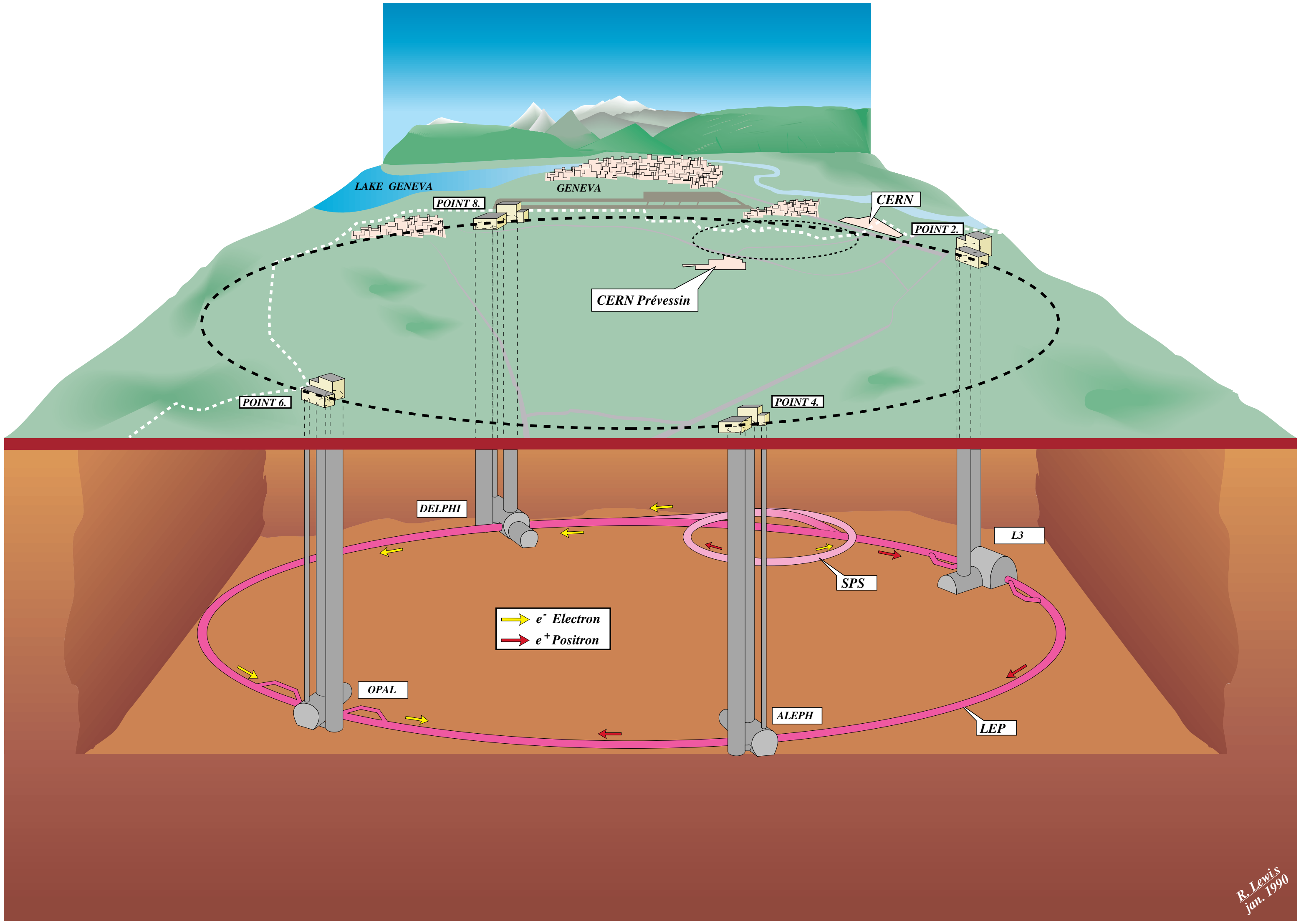
CERN/CIEMAT

November 14, 2001

- Introduction
- Four-fermion Physics
- Two-fermion Physics
- Higgs Searches
- Conclusions

LEP



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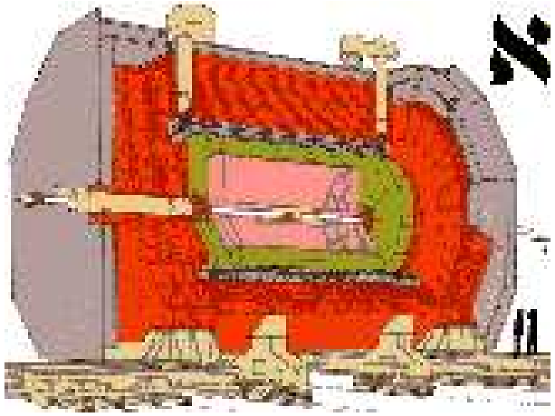
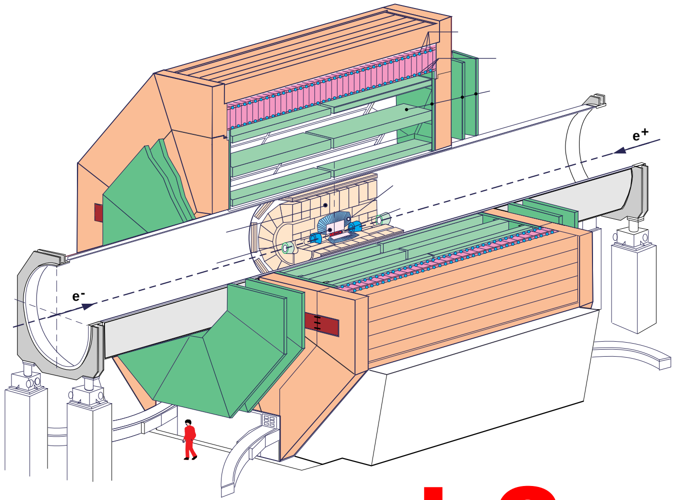
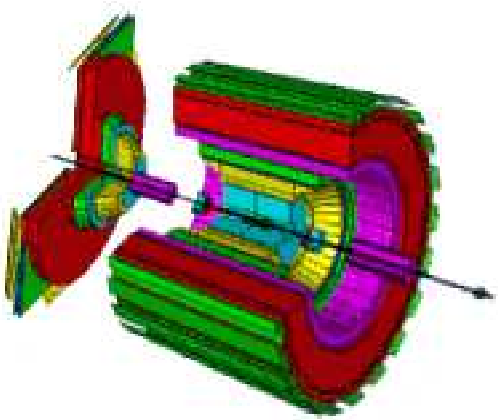
LEP detectors



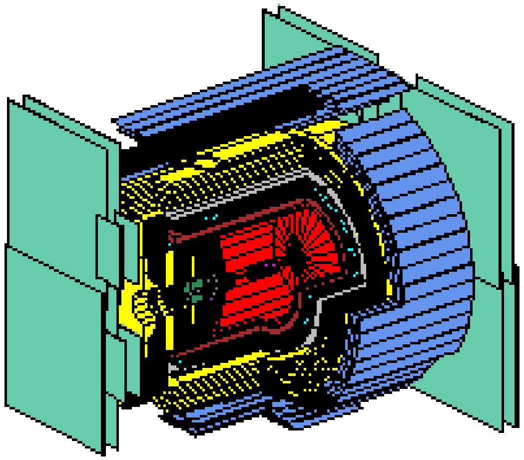
ALEPH



L3



DELPHI



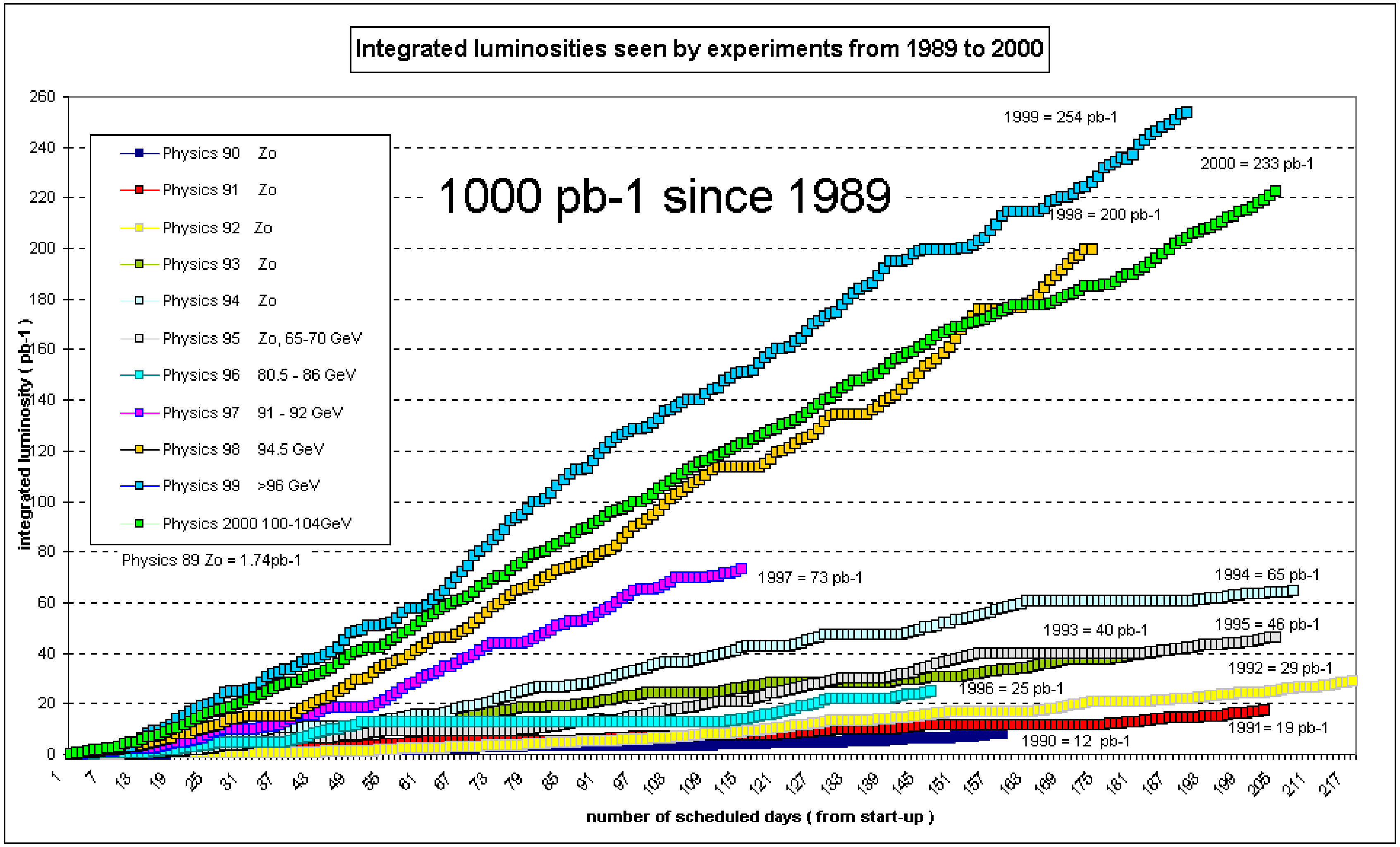
OPAL

Typical Energies and Luminosities at LEP2

L3 DATA COLLECTED IN 1996-2000				
Year	Bin Identifier	Beam Energy Range [GeV]	Mean Centre-of-Mass Energy [GeV]	Integrated Luminosity [1/pb]
1996	161 GeV	75.000 - 83.000	161.34	10.904
1996	172 GeV	84.000 - 100.000	172.13	10.250
1997	183 GeV	80.000 - 100.000	182.68	55.464
1998	189 GeV	80.000 - 100.000	188.64	176.773
1999	192 GeV	95.350 - 97.349	191.60	29.719
1999	196 GeV	97.350 - 99.349	195.54	83.690
1999	200 GeV	99.350 - 100.349	199.54	82.804
1999	202 GeV	100.350 - 102.349	201.75	37.042
2000	205 GeV	99.000 - 102.899	204.82	78.941
2000	207 GeV	102.900 - 103.699	206.48	130.067
2000	208 GeV	103.700 - 105.000	208.01	8.302

Total LEP2 luminosity collected at L3
$703.953\ \mathrm{pb}^{-1}$

LEP delivered luminosity 1990-2000



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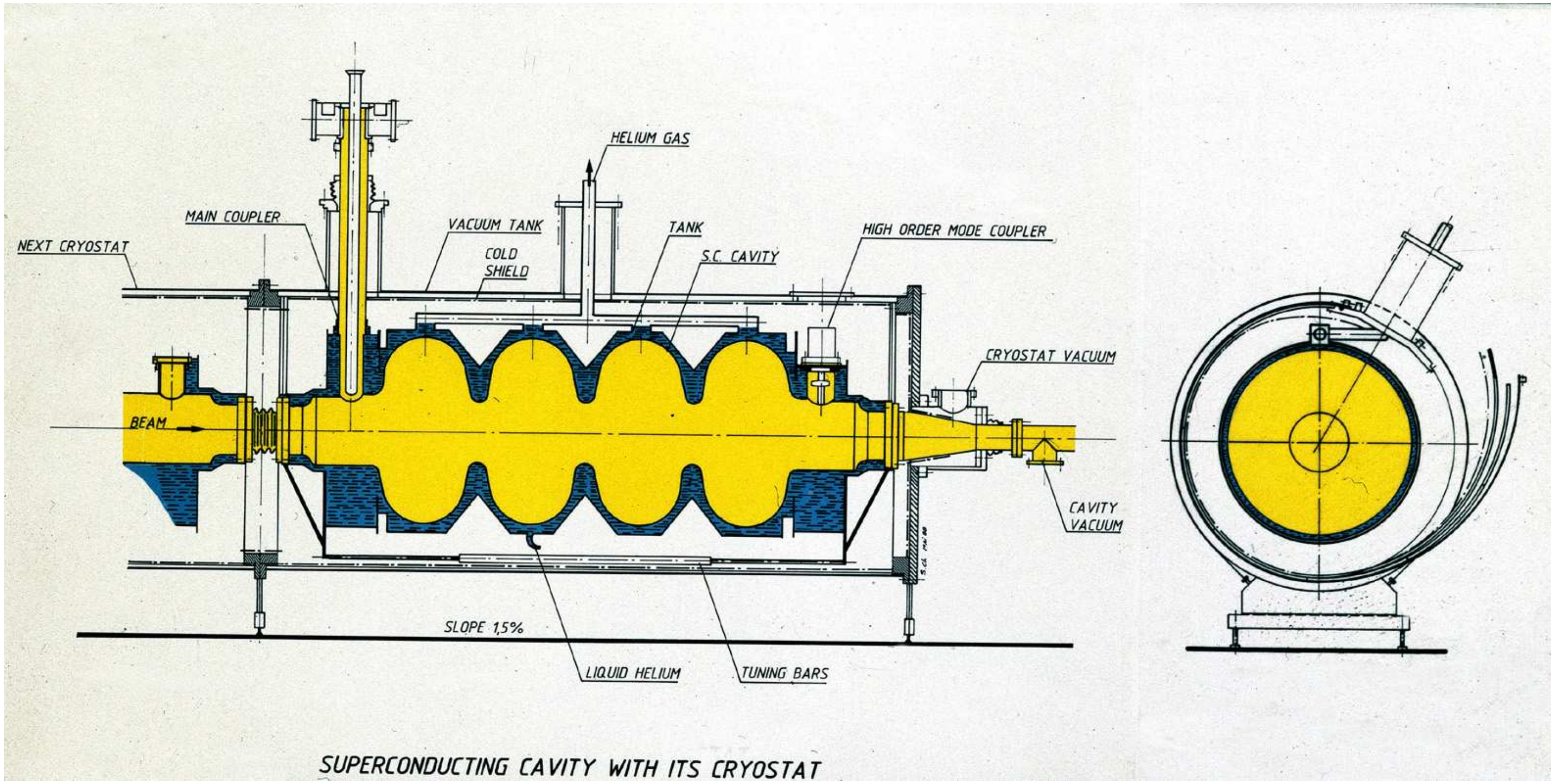
LEP2 Superconducting Cavities



- 262 Nb-Cu coated superconducting cavities, 7 MV/m
- 16 Nb superconducting cavities, 5 MV/m
- 56 room-temperature Cu cavities, 1 MV/m

... and in 2000 ?

- 56 copper cavities
  - re-install 8 copper cavities (adds 15-20 MV)
  - reasonable level 130 MV
- 4 Solid Niobium
  - reasonable level 110 MV

- Total voltage (MV) needed for 1 hour quantum lifetime
  - i_b 0.7mA, 102/90, J_x=1 (no frequency offset)
  - (Figures in parentheses are Nb film gradient in MV/m, assuming the above values for Cu and Solid Nb cavities)

	No reserve	1 klystron	2 klystrons
100 GeV	3180 (6.4)	3275 (6.6)	3370 (6.8)
101 GeV	3300 (6.6)	3395 (6.8)	3490 (7.0)
102 GeV	3430 (6.9)	3525 (7.1)	3620 (7.3)
103 GeV	3570 (7.2)	3660 (7.4)	3755 (7.6)

Have had this for extended periods

Maximum in 1999 operation

Maximum obtained in tests

Unknown territory

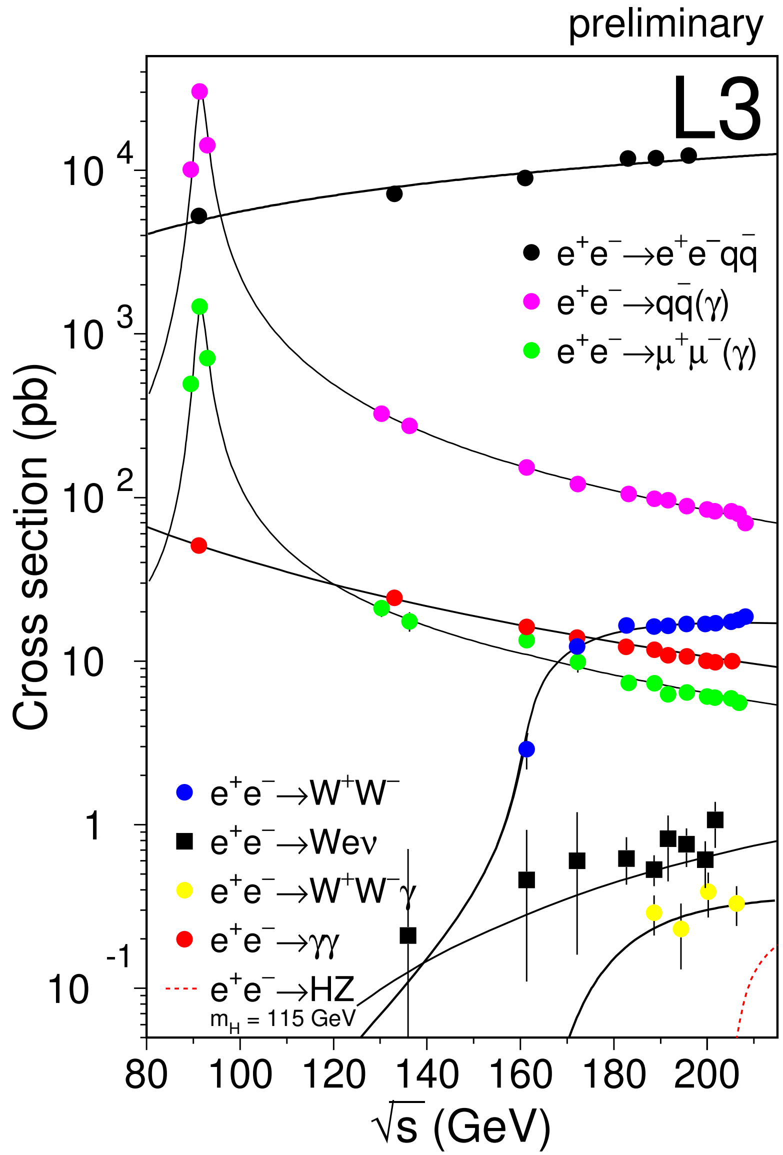
LEPC November 99

LEP2 Superconducting RF: more than $3.6\ \mathrm{GV}$ reached

LEP RF status | ON | OFF | ABNORMAL | BUSY | 10/05/2000 10:58:09

Unit	Heatrs	HV/kV	K1f/kW	K1r/kW	RF1/MV	K2f/kW	K2r/kW	RF2/MV
231	ON	82.3	646.8	8.2	32.9	574.6	3.1	
271	ON	82.3	734.5	1.1	33.9	703.4	2.8	
631	ON	82.3	538.4	2.7	30.0	638.9	3.6	
671	ON	82.0	684.7	5.7	32.8	644.3	19.3	
232	ON	82.0	587.0	239.1	102.9	505.2	146.9	102.3
233	ON	82.6	387.6	133.5	101.8	476.5	70.4	87.6
272	ON	82.1	595.4	259.3	102.7	642.3	283.1	102.7
273	ON	82.1	261.7	71.5	55.7	253.4	15.9	48.9
431	ON	81.5				469.9	140.3	100.1
432	ON	82.9	441.0	90.3	106.8	436.0	112.4	100.0
433	ON	82.0	336.5	192.0	100.7	449.8	132.8	105.9
471	ON	81.5	532.1	197.6	105.7			
472	ON	81.6	452.6	99.5	96.9	423.8	64.3	93.3
473	ON	81.3	429.6	120.3	93.8	376.8	197.5	93.8
632	ON	82.0	601.0	220.8	102.5	495.4	164.6	101.5
633	ON	82.2	484.0	194.5	89.2	408.2	122.4	102.4
672	ON	82.1	474.3	154.8	101.7	595.6	232.2	100.8
673	ON	81.7	606.0	129.8	93.3	498.1	128.8	94.7
831	ON	82.1				557.0	153.3	104.4
832	ON	82.0	455.1	103.7	101.7	525.0	112.1	105.6
833	ON	82.1	382.2	168.9	102.7	471.9	141.3	105.9
871	ON	82.1	597.1	200.2	105.7			
872	ON	81.8	466.8	100.4	103.7	442.3	100.6	106.6
873	ON	82.1	474.3	92.4	103.6	505.1	193.3	94.8

Total MV 3651



- Three orders of magnitude reduction with respect to LEP1:

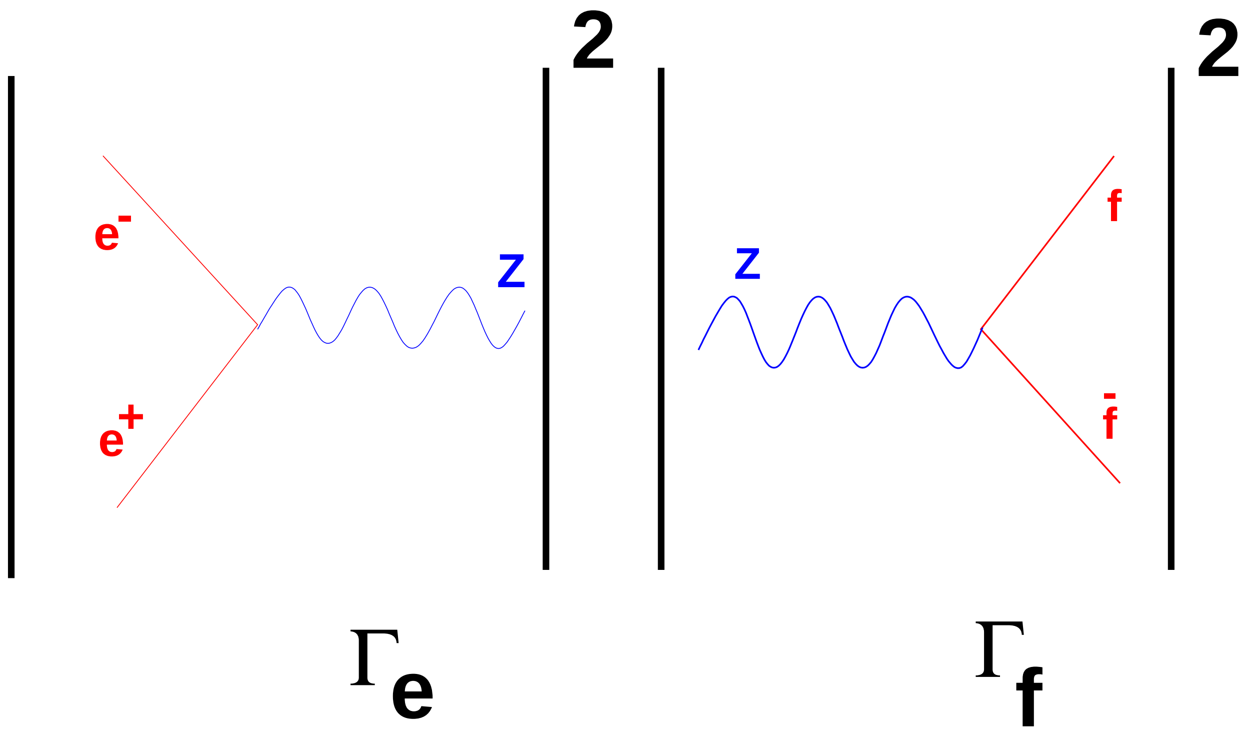
$$\mathrm{nb} \longrightarrow \mathrm{pb}$$

- Integrated luminosity $\simeq$ 5 times that of LEP1 $\Rightarrow$

$$\mathcal{L} \gtrsim 10^{34}\ \mathrm{cm}^{-2}\ \mathrm{s}^{-1}$$

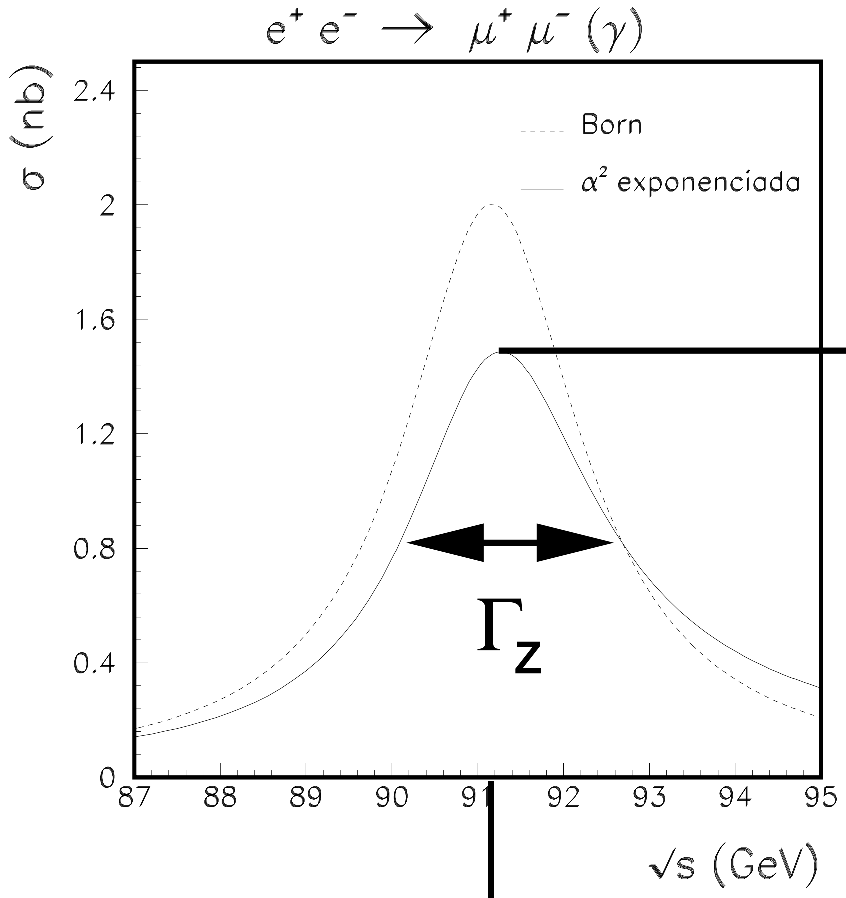
necessary at future $\mathrm{e}^+\mathrm{e}^-$ colliders

σ(e⁺e⁻->ff̄)
at LEP1 $\propto$



$$\sigma(\mathrm{e^+e^-} \rightarrow \mathrm{Z}^* \rightarrow \mathrm{f\bar{f}}) \propto \frac{\Gamma_\mathrm{e}\Gamma_\mathrm{f}}{m_\mathrm{Z}^2\ \Gamma_\mathrm{Z}^2}$$

LEP1 Physics: study of Z properties



Γ_Z

$$\Gamma_Z = \Gamma_{vis} + \Gamma_{inv}$$

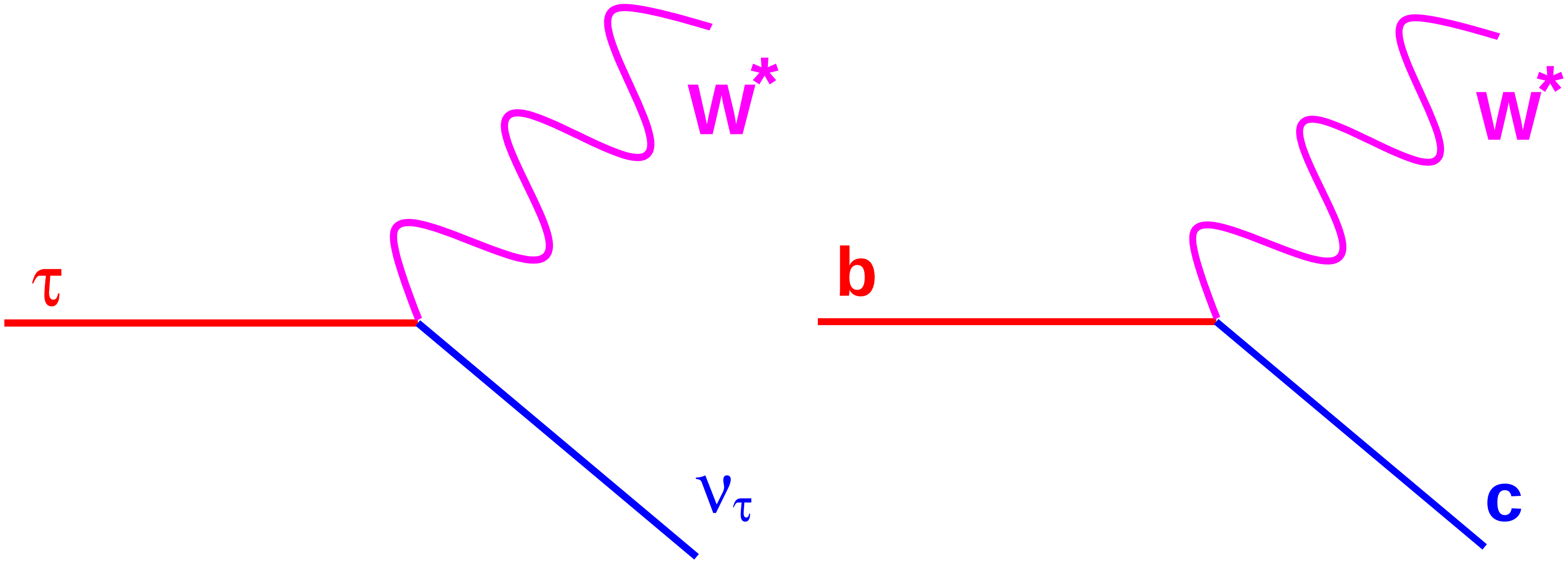
$$\Gamma_{vis} = \Gamma_e + \Gamma_\mu + \Gamma_\tau + \Gamma_{had}$$

$$\Gamma_{inv} = N_\nu \Gamma_\nu$$

m_Z

$$\frac{\Gamma_e \quad \Gamma_\mu}{m_Z^2 \quad \Gamma_Z^2}$$

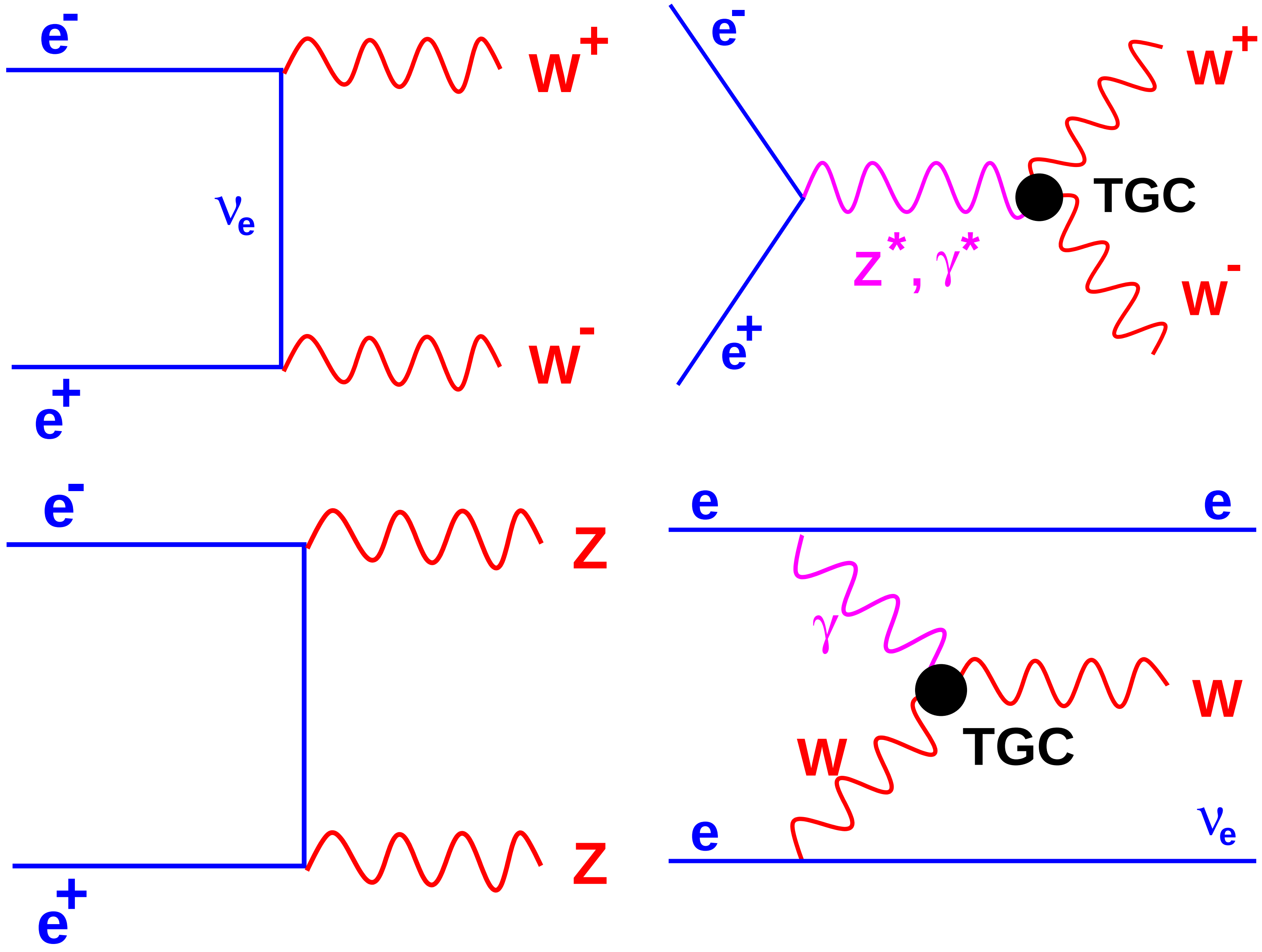
LEP1 Physics: study of $W \to \mathrm{f\overline{f'}}$ couplings

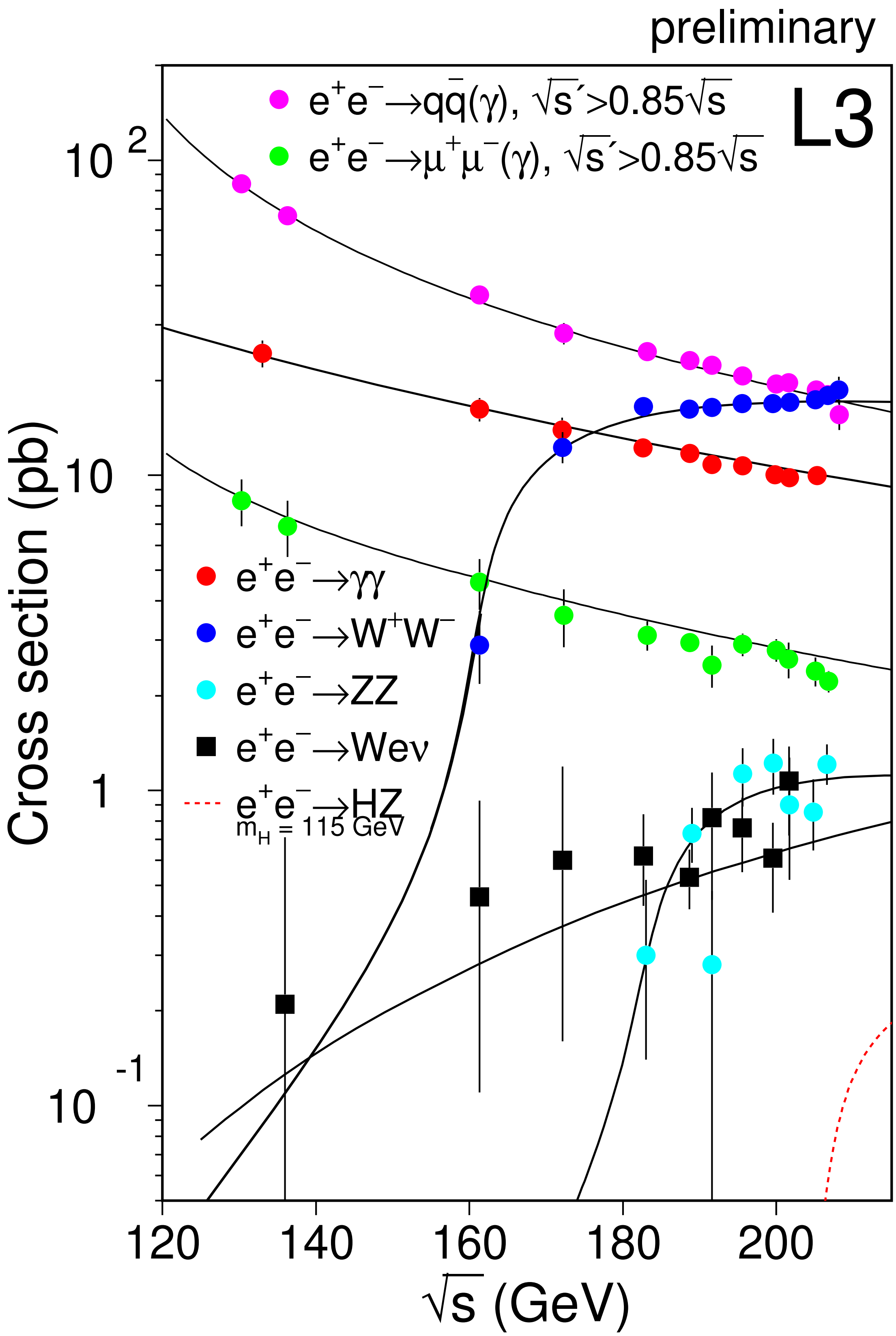


- τ lifetime,
- Γ_ℓ (α_s),
- exclusive and rare decays,
- topological BRs,
- Lorentz structure, . . .

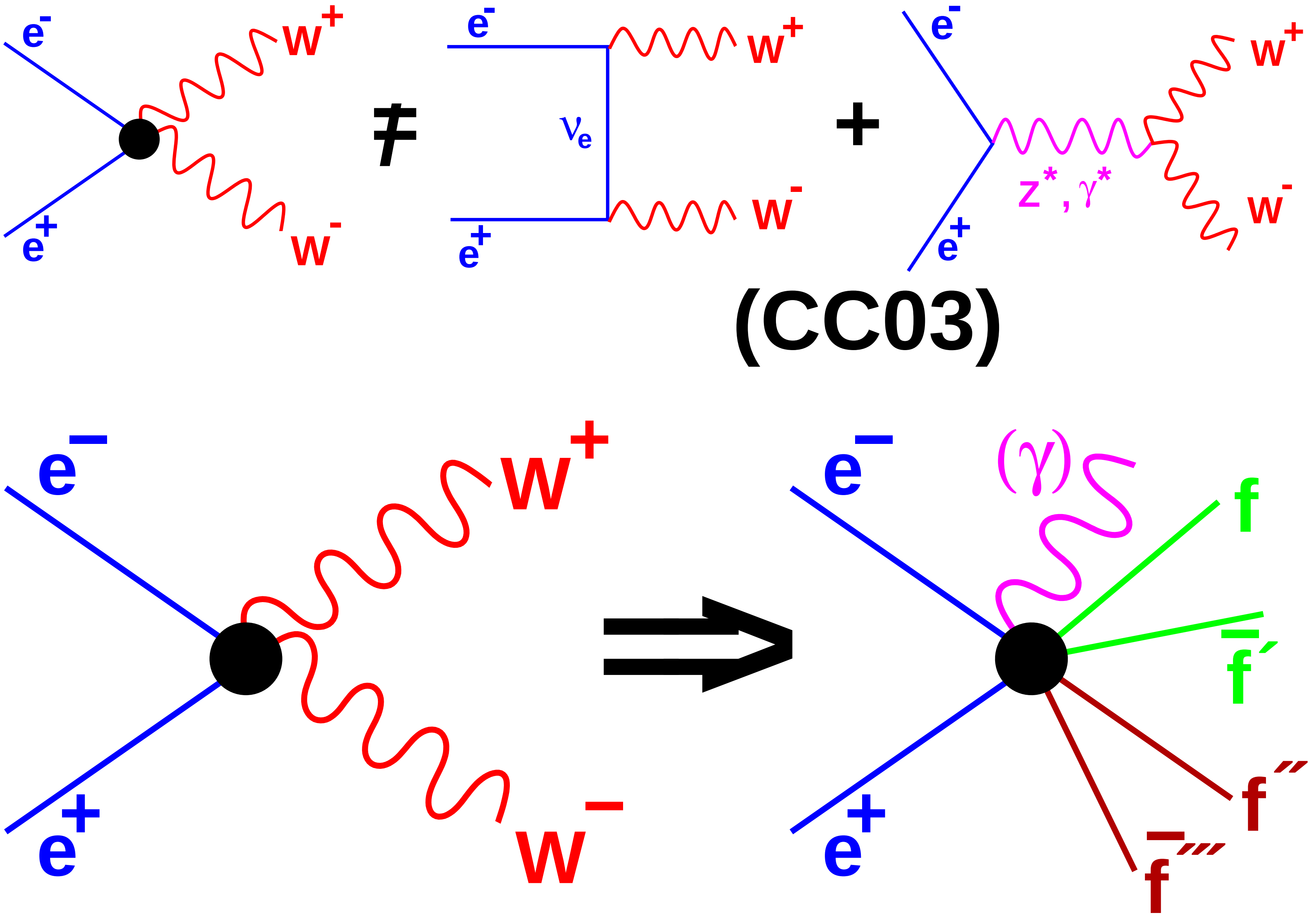
- b-lifetimes,
- $\mathrm{Br}(\mathrm{b} \to \ell\nu X)$,
- $|V_{cb}|$, $|V_{ub}|$,
- exclusive and rare decays,
- HQET studies, . . .

New at LEP2: four-fermion domain, interactions among bosons

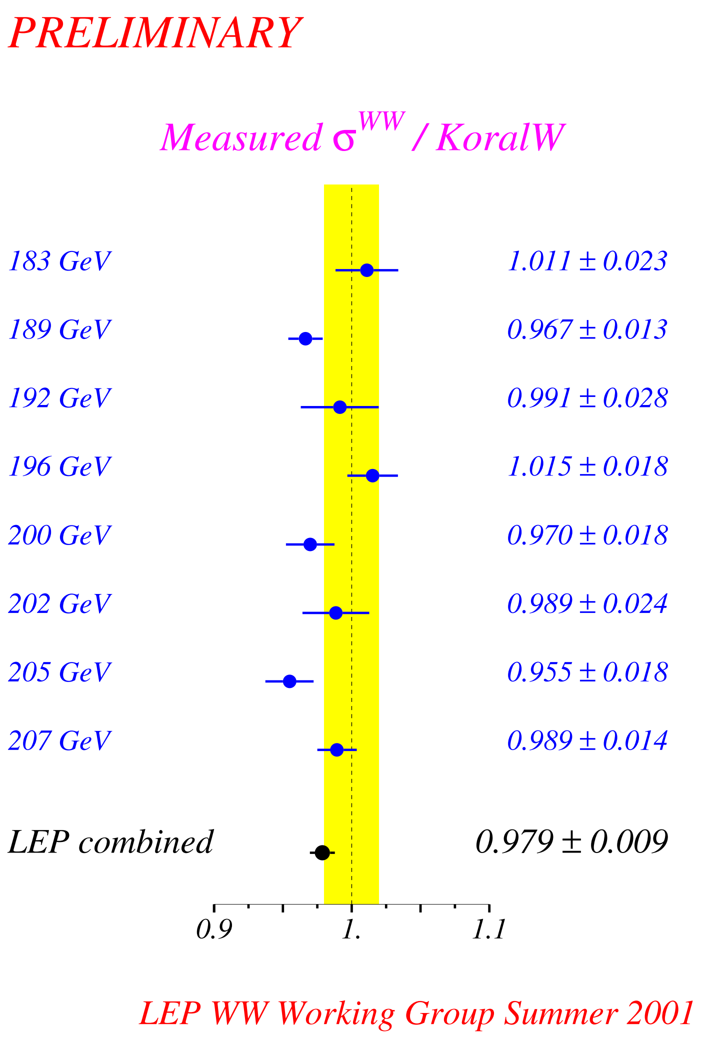


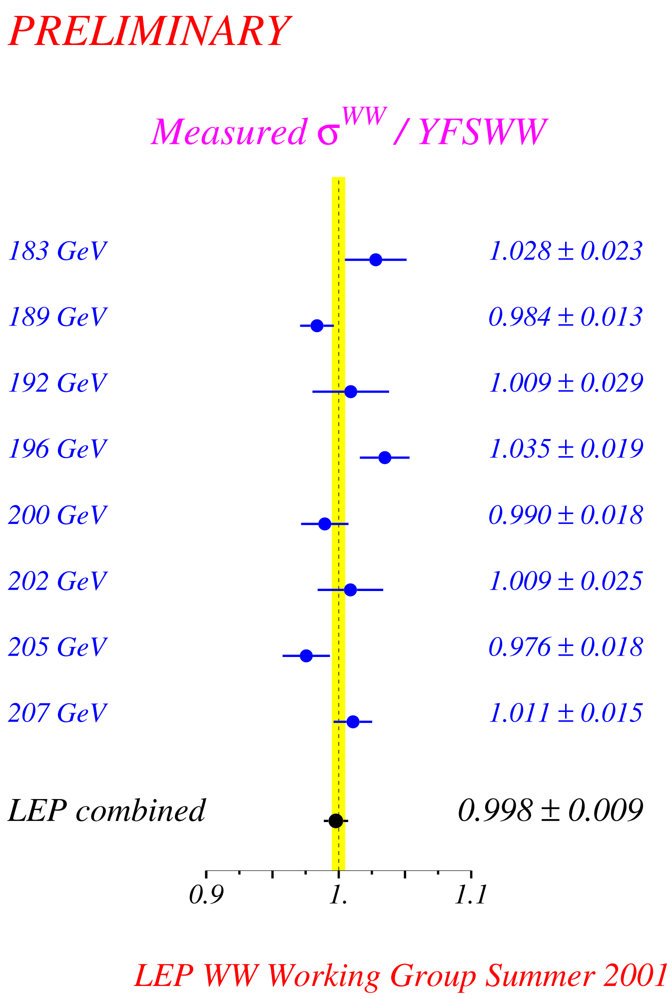

preliminary
L3
$e^+e^- \to q\bar{q}(\gamma)$, $\sqrt{s'}>0.85\sqrt{s}$
$e^+e^- \to \mu^+\mu^-(\gamma)$, $\sqrt{s'}>0.85\sqrt{s}$
$e^+e^- \to \gamma\gamma$
$e^+e^- \to W^+W^-$
$e^+e^- \to ZZ$
$e^+e^- \to We\nu$
$e^+e^- \to HZ$
m_H = 115 GeV
Cross section (pb)
$\sqrt{s}$ (GeV)
10^2
10
1
10^{-1}
120
140
160
180
200

LEP2: Four-fermion final states

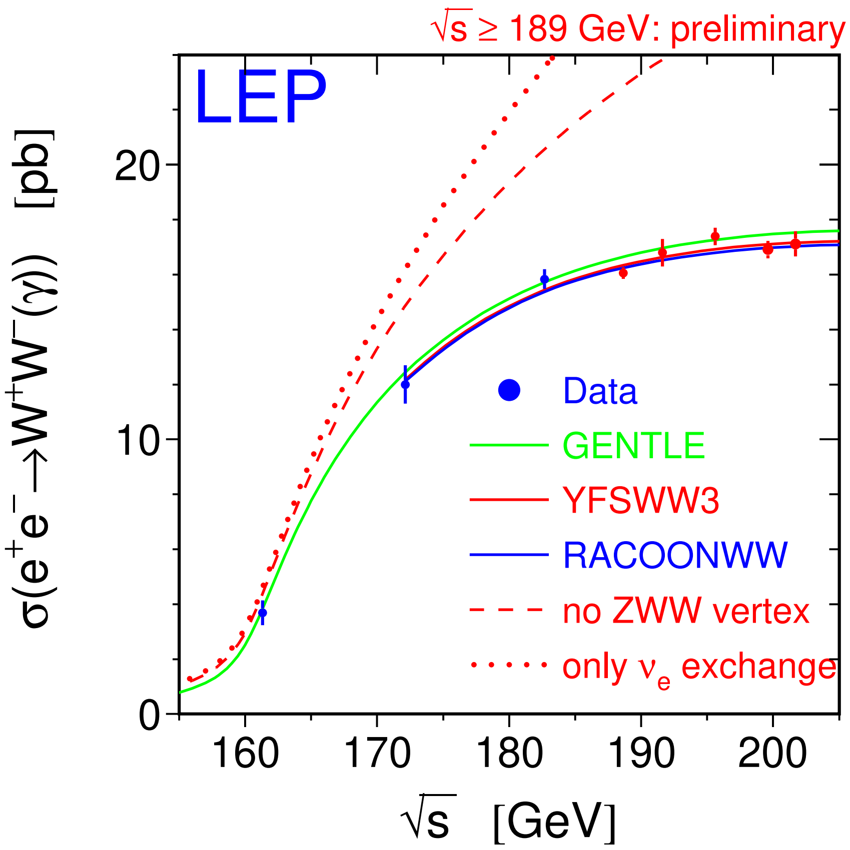


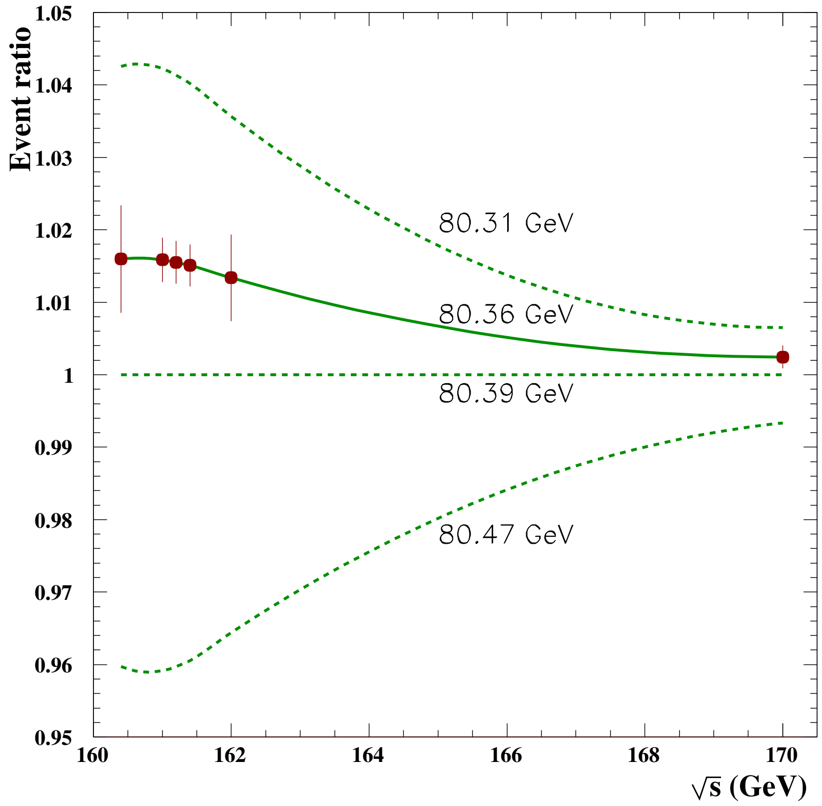
LEP2: precise calculations





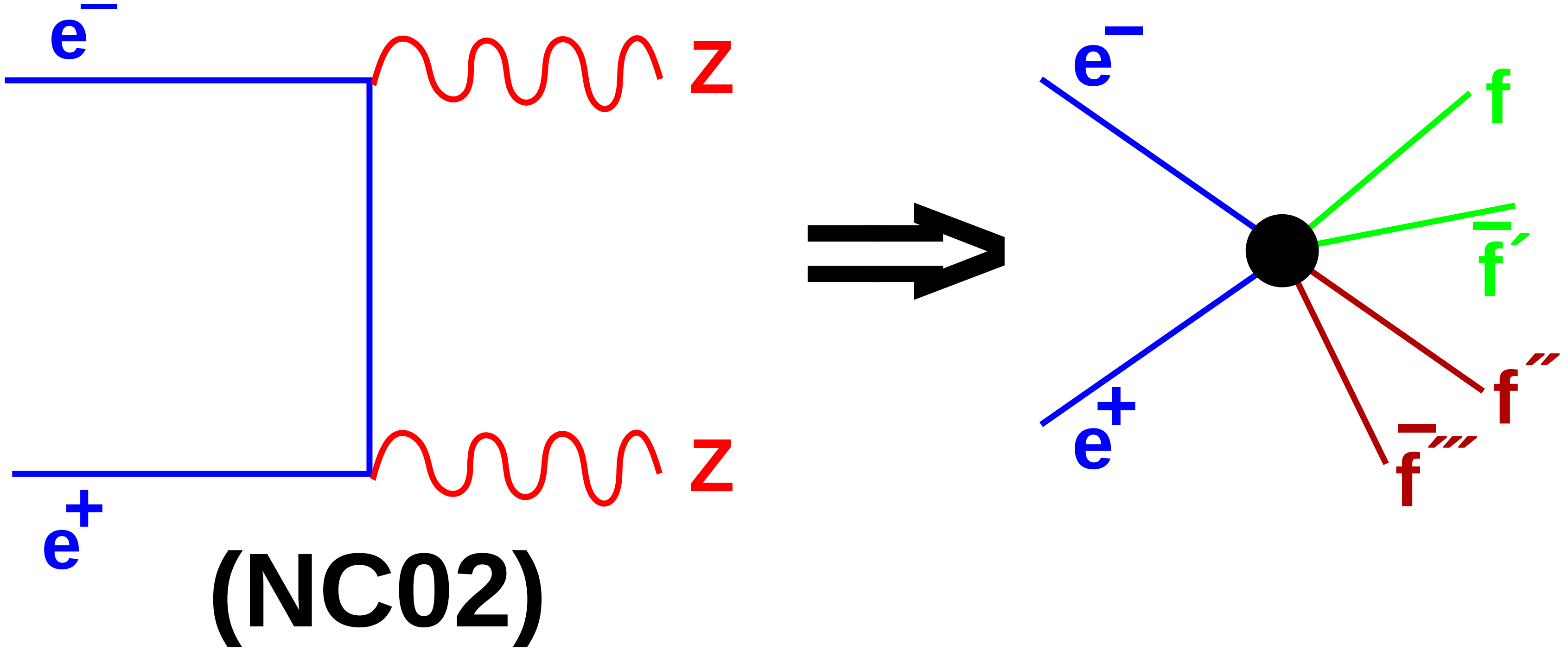
$2\% \rightarrow 0.5\%$ precision improvement . . . and reached!





Double Pole Approximation (DPA)
Main change: Coulomb correction for $\sqrt{s} \gg 2m_{\mathrm{W}}$

DPA not valid at $\sqrt{s} \approx 2m_{\mathrm{W}}$
$\Delta m_{\mathrm{W}} \approx 6$ MeV $\Rightarrow$ more theoretical efforts required at future linear colliders



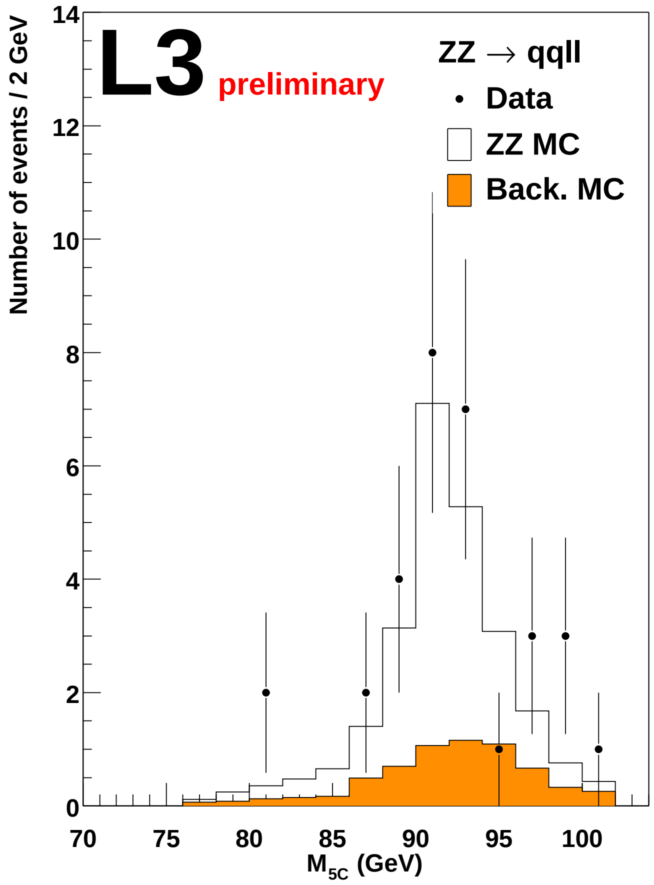
$$\sigma_{\mathrm{ZZ}} \simeq 1 \text{ pb}$$

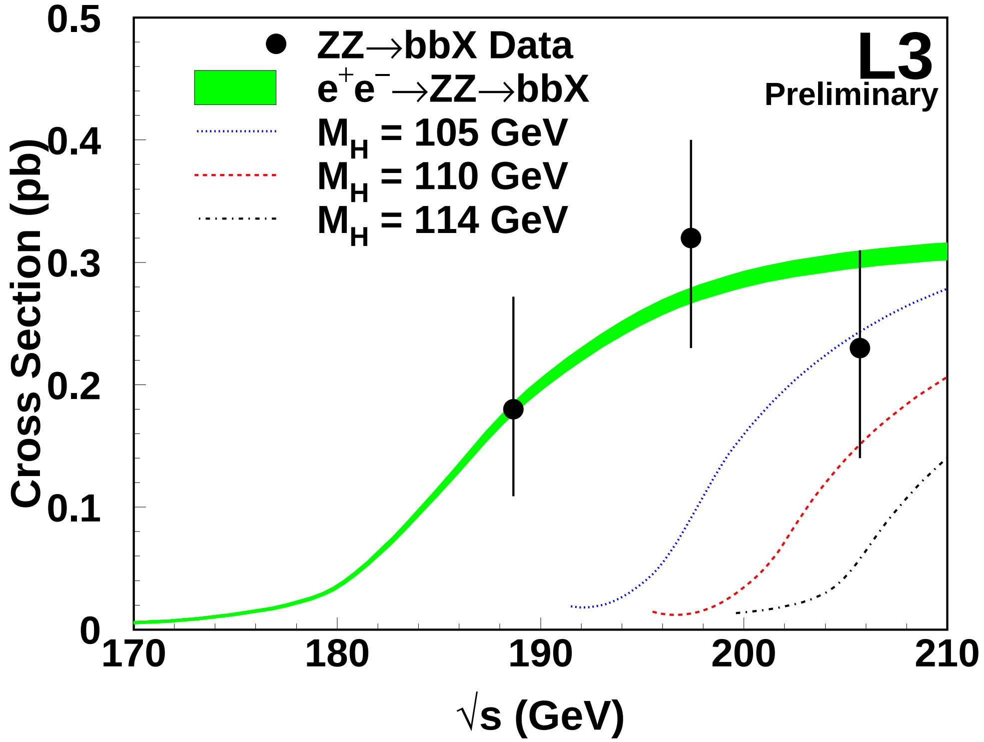
$4\mathrm{f}$ backgrounds on top of the ZZ signal!

This will not be cured at higher energies

$$(\sigma_{\mathrm{W^+W^-}} \approx 10\ \sigma_{\mathrm{ZZ}})$$

ZZ cross section



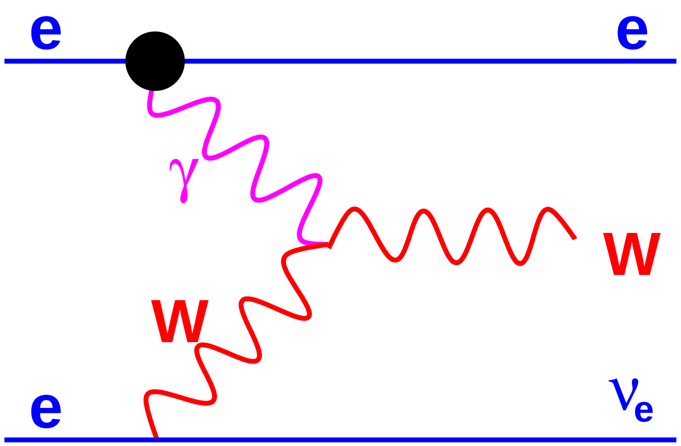


$q\bar{q}\ell^+\ell^-$ channel:cleanest signal

$q\bar{q}b\bar{b}$ channel: benchmark for Higgs searches

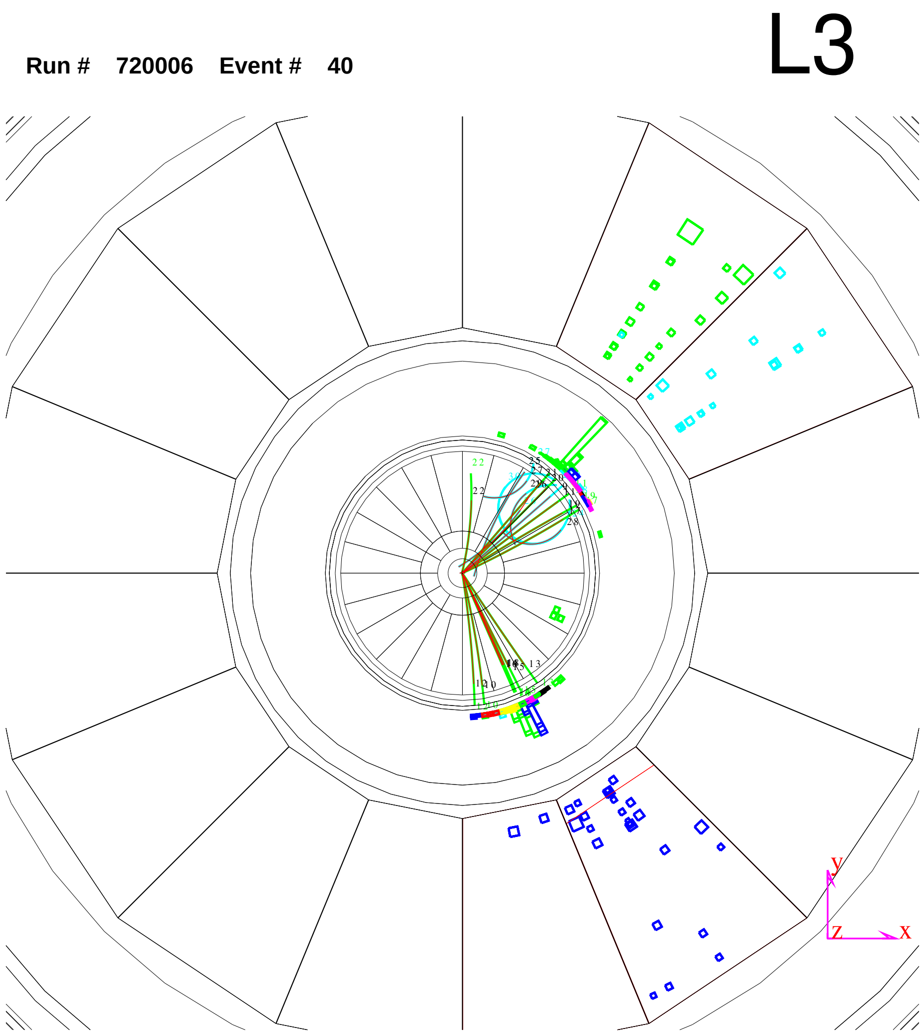
Single-W final states

NOT ENOUGH!!



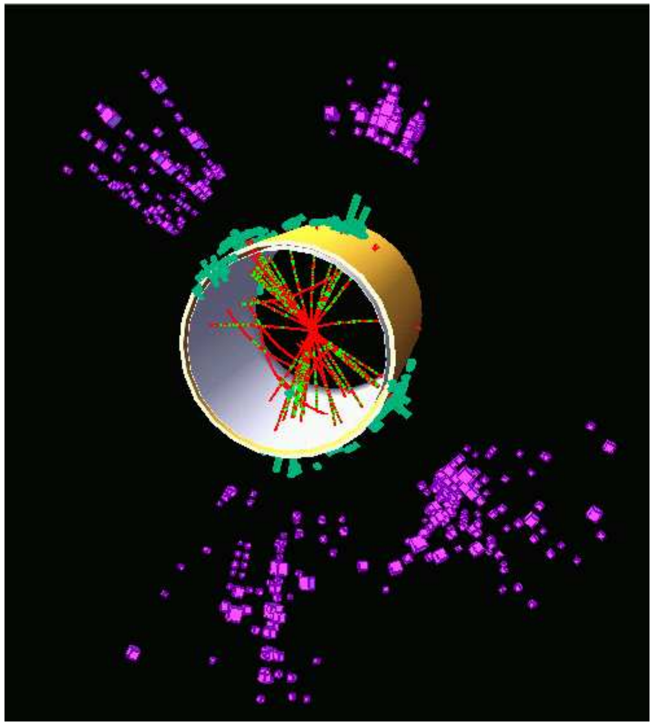
$$\alpha(m_Z^2) \rightarrow \alpha(-m_{\gamma^*}^2)$$

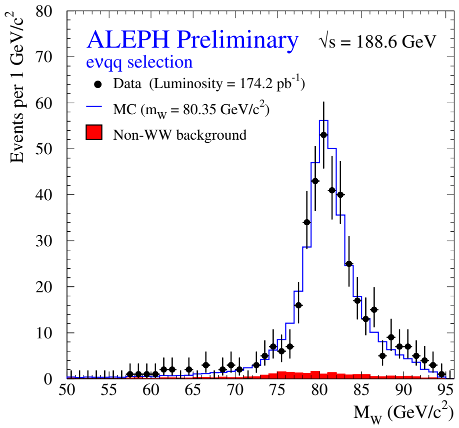
And stable generators at low angles for the electron, i.e. $e^+e^- \rightarrow e\nu W \rightarrow e\nu e\nu$

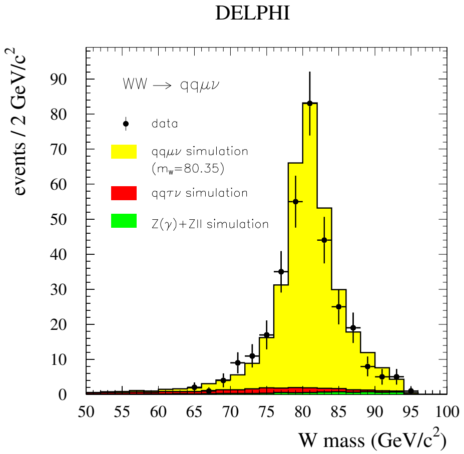


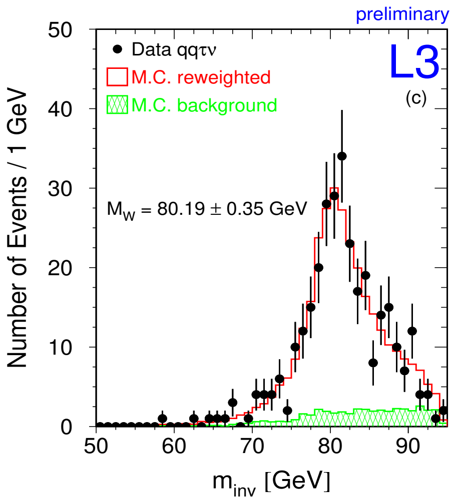
Transverse Imbalance :	.5264	Longitudinal Imbalance :	-.1792
Thrust : .8223	Major : .5562	Minor : .0407	
Event DAQ Time :	980827 194411		

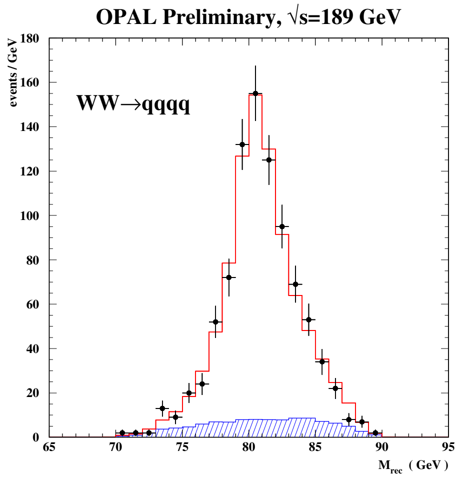
LEP2: W mass reconstruction





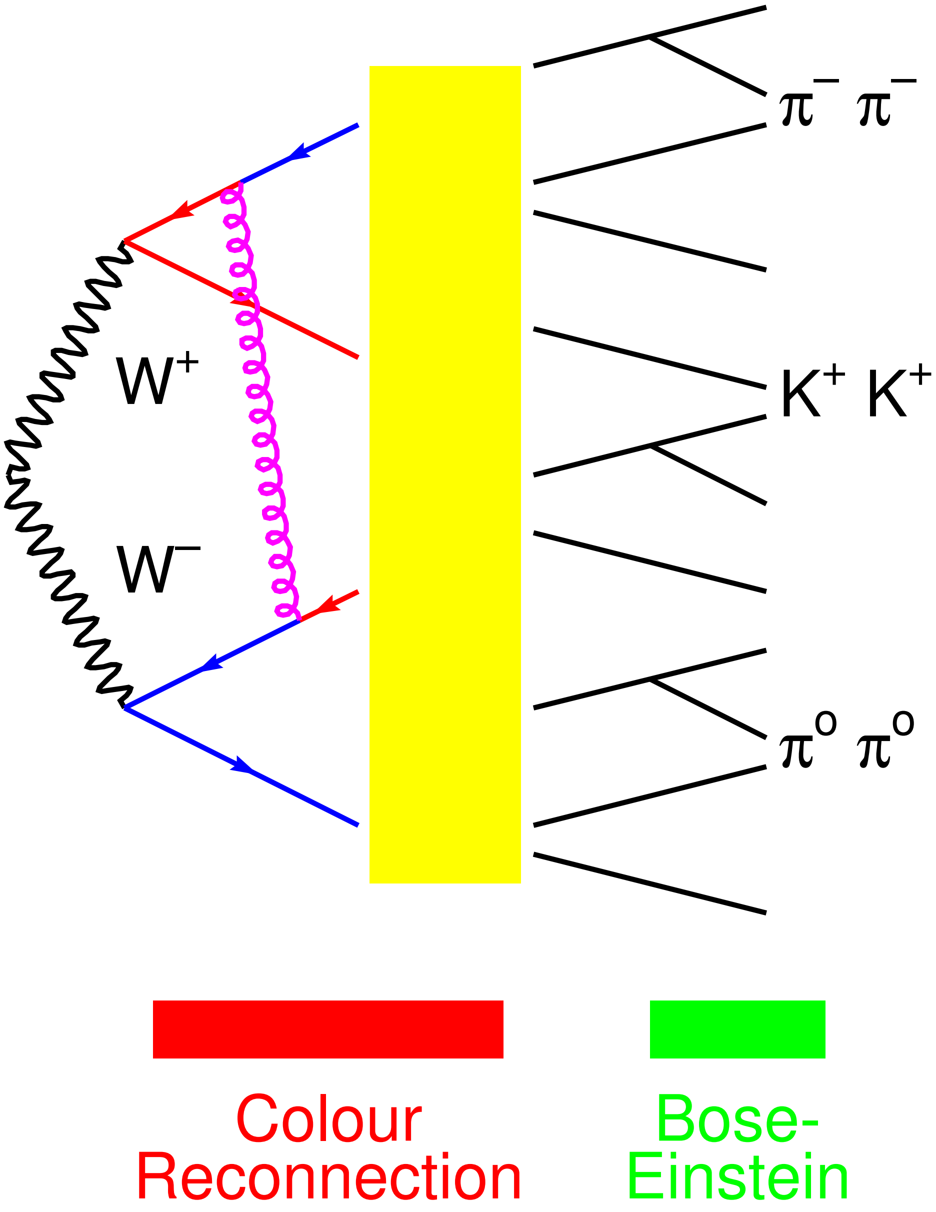






- Direct reconstruction is nice (higher statistics, kinematic fits), but . . .

$$\Gamma_W \gg \Lambda_{QCD}$$



- Together with fragmentation: dominant systematic uncertainties in the $W^+W^- \to 4q$ channel at LEP

Work in progress ...

Preliminary

Status of LEP W mass measurement

$m_W = 80.4496 \pm 0.0394$ GeV/c^2

χ^2/ndf = 32.5 / 39

4q channel $\rightarrow$ 26.4 %

(BR ~ 45 %)

$\Delta_{stat}\ m_W$ = 29.6 MeV

$\Delta_{syst}\ m_W$ = 54.3 MeV

2q channel $\rightarrow$ 71.5 %

(BR ~ 45 %)

$\Delta_{stat}\ m_W$ = 32.5 MeV

$\Delta_{syst}\ m_W$ = 29.2 MeV

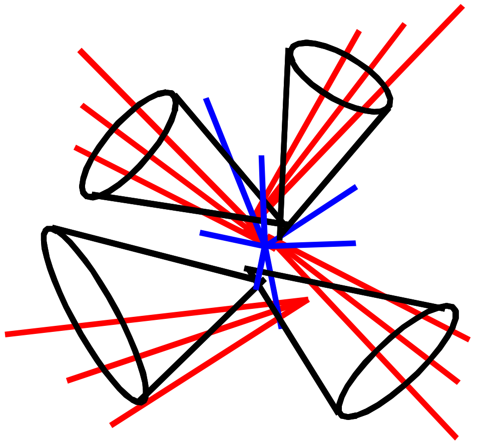
Δm_W (4q-2q) = 9.4 $\pm$ 64.5 MeV

χ^2/ndf = 31.1 / 34

Jorgen D'Hondt - DELPHI

Introduction:

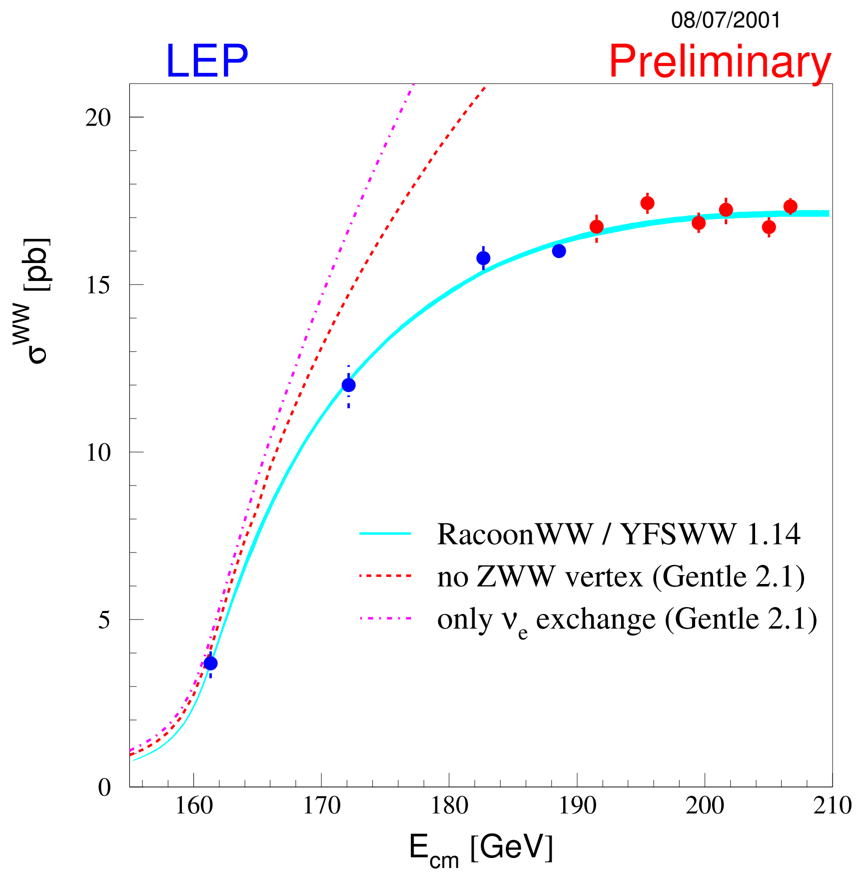
The 'new' jet algorithm...

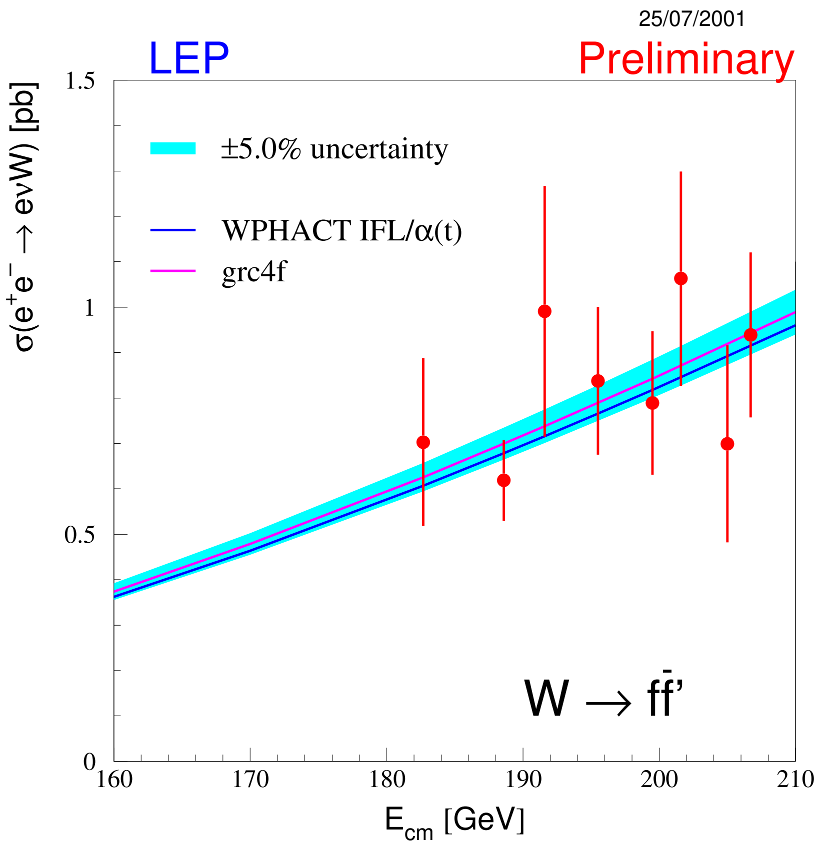


- Idea: FSI effects on m_W come mainly from *inter–jet* region, where
  - **Ambiguity in clustering** can occur.
  - **Momentum interchange** is possible between particles from different Ws.
  - **Multiplicity variations** are stronger (particle flow analysis, CR).

- Proposed solution:
  - Apply a jet algorithm that excludes information from the interjet region $\Rightarrow$ **cone algorithm.**
- Price to pay: loss of statistical power.

LEP2: trilinear gauge couplings seen

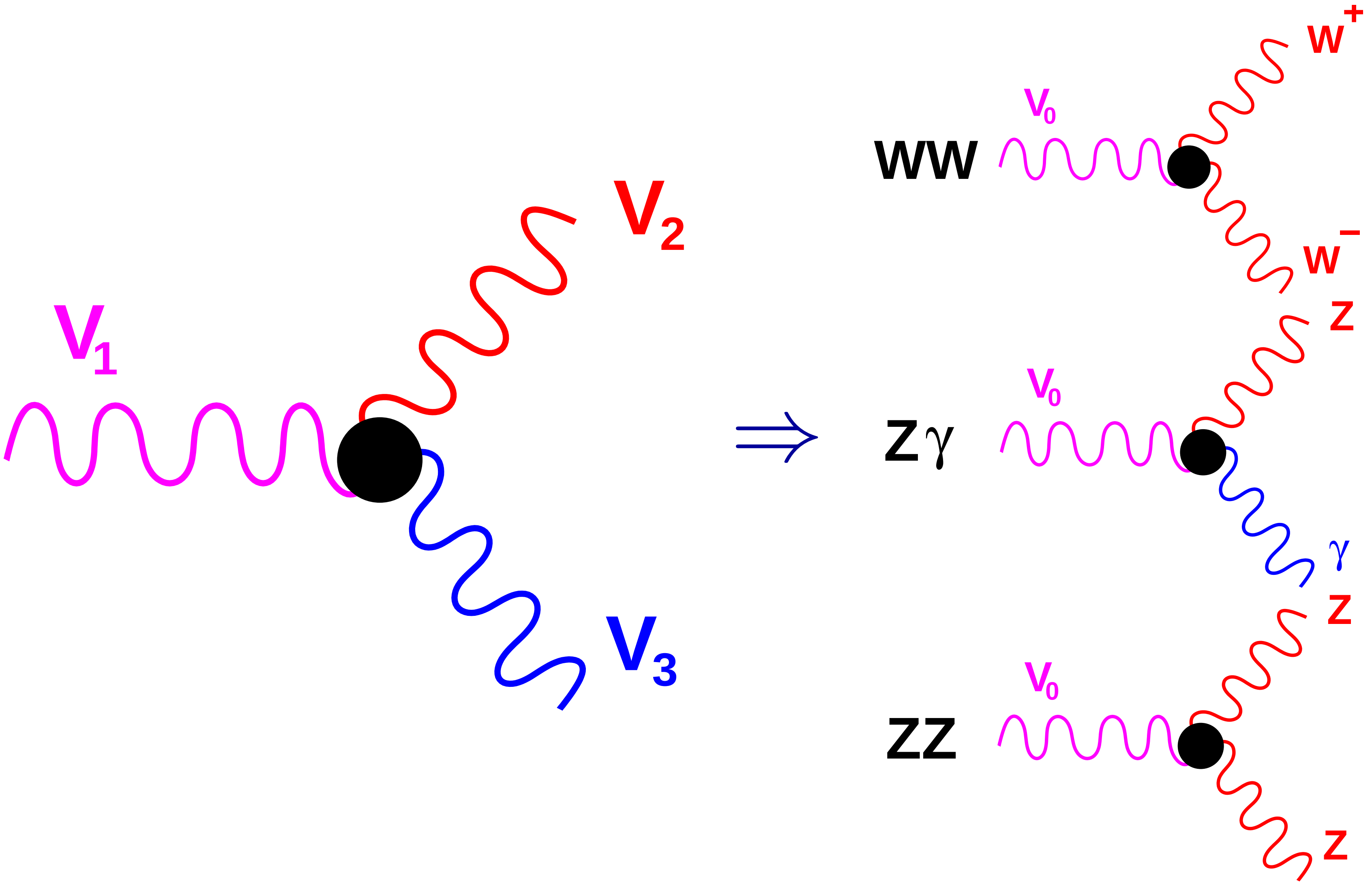


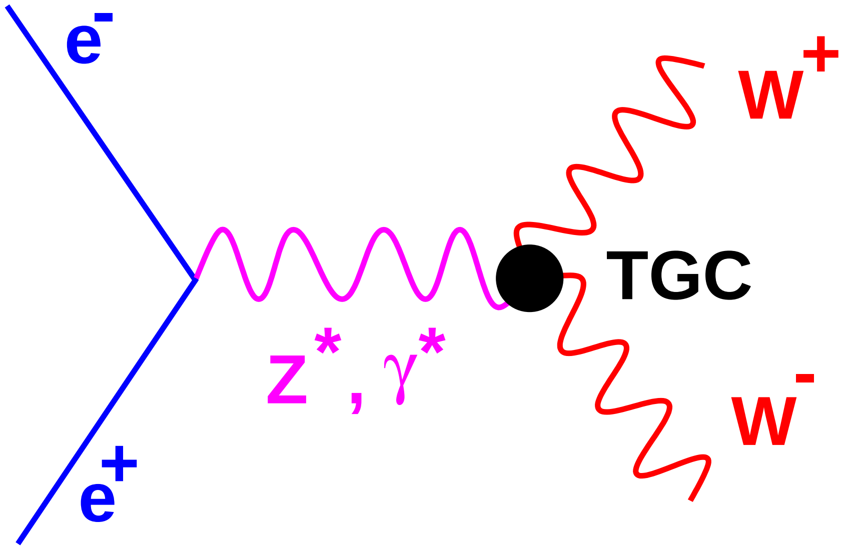


TGC structures predicted by the SM exist

Evidence at the level of $> 10\sigma$

Triple boson gauge couplings deserve precise studies . . .





Most general vertex structure assuming CP, on-shell W, neglecting scalar terms:

$$\begin{aligned}\Gamma_V^{\alpha\beta\mu} &= (1+\Delta g_1^V)[(q_1-q_2)^\mu g^{\alpha\beta} - q_1^\beta g^{\mu\alpha} + q_2^\alpha g^{\mu\beta}] \\ &+ (1+\Delta\kappa_V)[q_2^\alpha g^{\mu\beta} - q_1^\beta g^{\mu\alpha}] \\ &+ \frac{\lambda_V}{m_{\mathrm{W}}^2}\,(q_1-q_2)^\mu\,[\frac{s}{2}g^{\alpha\beta} - q_2^\alpha q_1^\beta] \\ &+ i\ g_5^V\ \epsilon^{\mu\alpha\beta\rho}\,(q_1-q_2)_\rho\end{aligned}$$

QED gauge invariance:

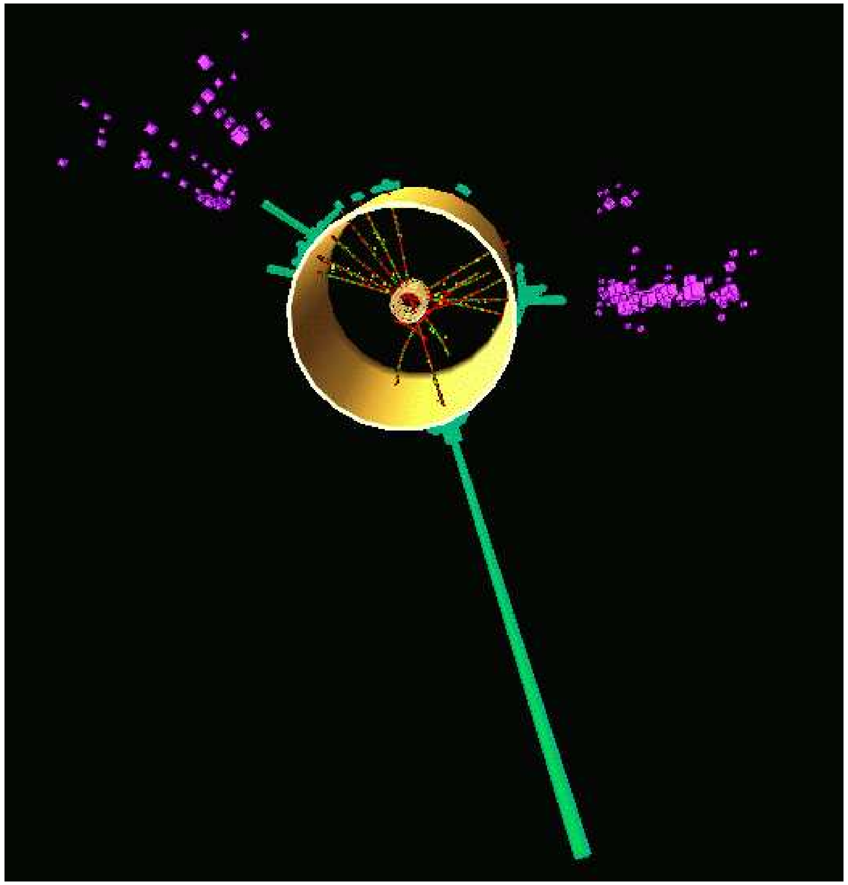
$$\Delta g_1^\gamma = g_5^\gamma = 0$$

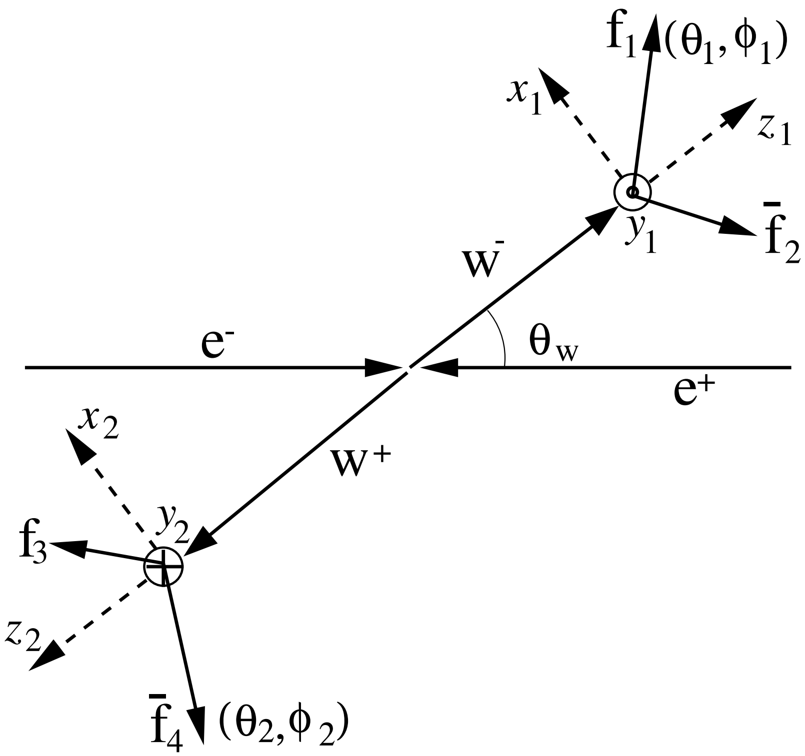
$SU(2)_L \times U(1)_Y$ invariance:

$$\frac{\Delta g_1^Z - \Delta\kappa_z}{\Delta\kappa_\gamma} = \tan^2\theta_w \quad \text{and} \quad \lambda_\gamma = \lambda_Z$$

Studying WWV anomalous structures in $e^+e^- \rightarrow q\overline{q'}\ell\nu \Rightarrow$

σ, $\cos\theta_W$, $\cos\theta_\ell^{CM}$, $\cos\theta_q^{CM}$, ϕ_ℓ^{CM}, ϕ_q^{CM}





There are ways to simplify the analysis: Optimal Observables (OO) for the coupling f

$$\left.\frac{d^2\sigma}{dO_1\ dO_2}\right|_f = \left.\frac{d^2\sigma}{dO_1\ dO_2}\right|_{f=0} \left(1 + f\ O_1 + f^2\ O_2\right)$$

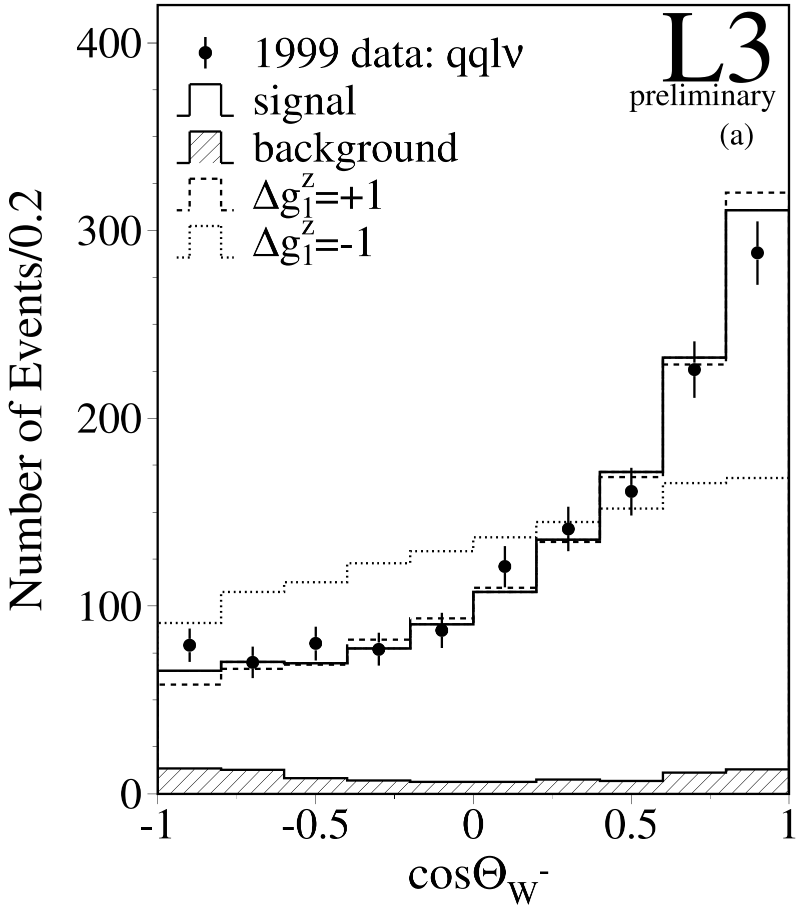
- The variables O_1, O_2 contain the full information on the process
- In the $f \to 0$ limit, σ and $< O_1 >$ keep all the sensitivity

- ALEPH, OPAL: $< O_1 >, < O_2 >, \sigma$
- DELPHI: Fit to O_1, O_2 distributions
- L3: Usual multidimensional likelihood fit (OO methods also employed)

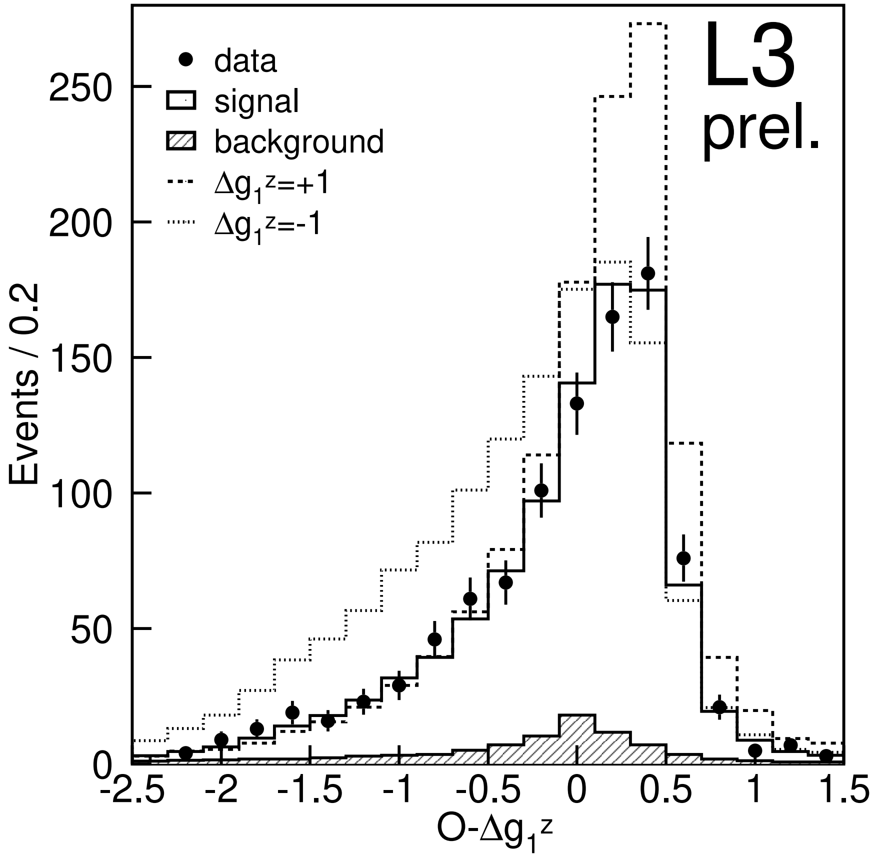
Delays due to old MC-new MC generator differences
WORK IN PROGRESS

Typical distributions for $e^+e^- \to q\overline{q'}\ell\nu$

$\cos\theta_W$ distribution



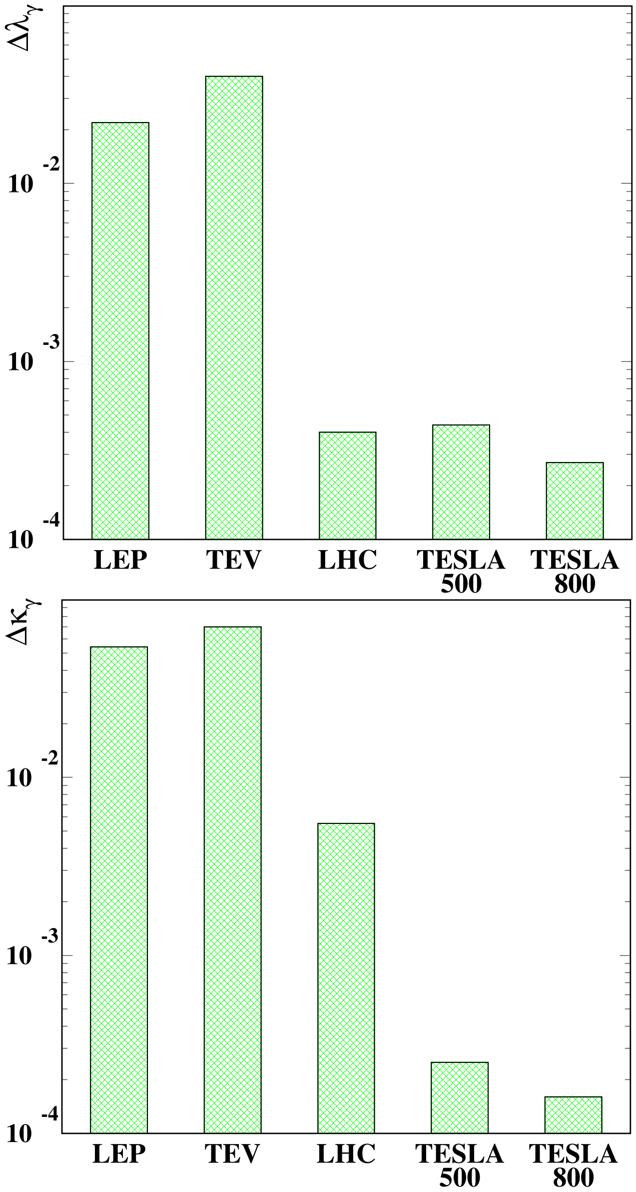
Most sensitive variable



$$-0.18 < \Delta g_1^Z < 0.04 \qquad (95\%\ \mathrm{CL},\ \ \mathrm{L3\ prel.\ 1999})$$

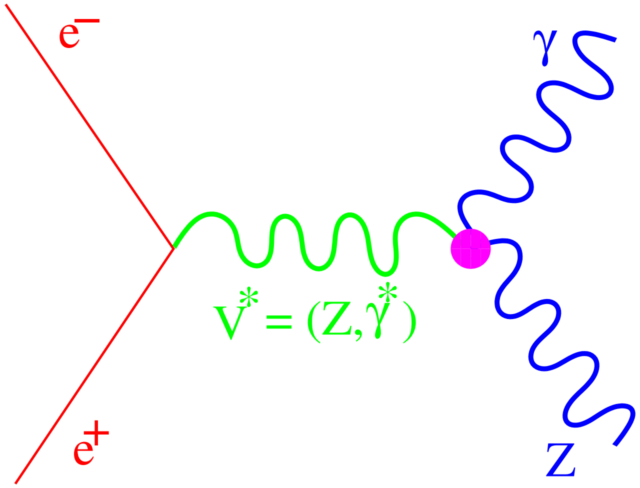
Anomalous Triple Gauge Couplings at large $\sqrt{s}$

- Sensitivity $\propto \left(\frac{\sqrt{s}}{\Lambda}\right)^n$
- Reconstructed level $\simeq$ Generator Level
- Beam Polarization is useful

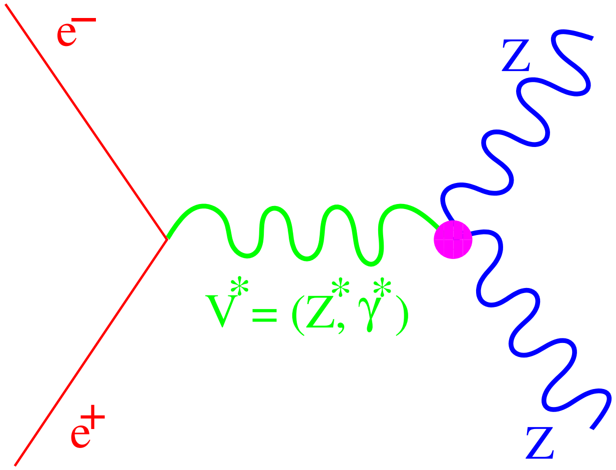


SM contributions to $\Delta\lambda_\gamma$, $\Delta\kappa_\gamma \sim 10^{-3}$

Test SM gauge structure. Are there hints of ZV_0V_0 couplings?



Most general vertex assuming: CP, on-shell Z,γ

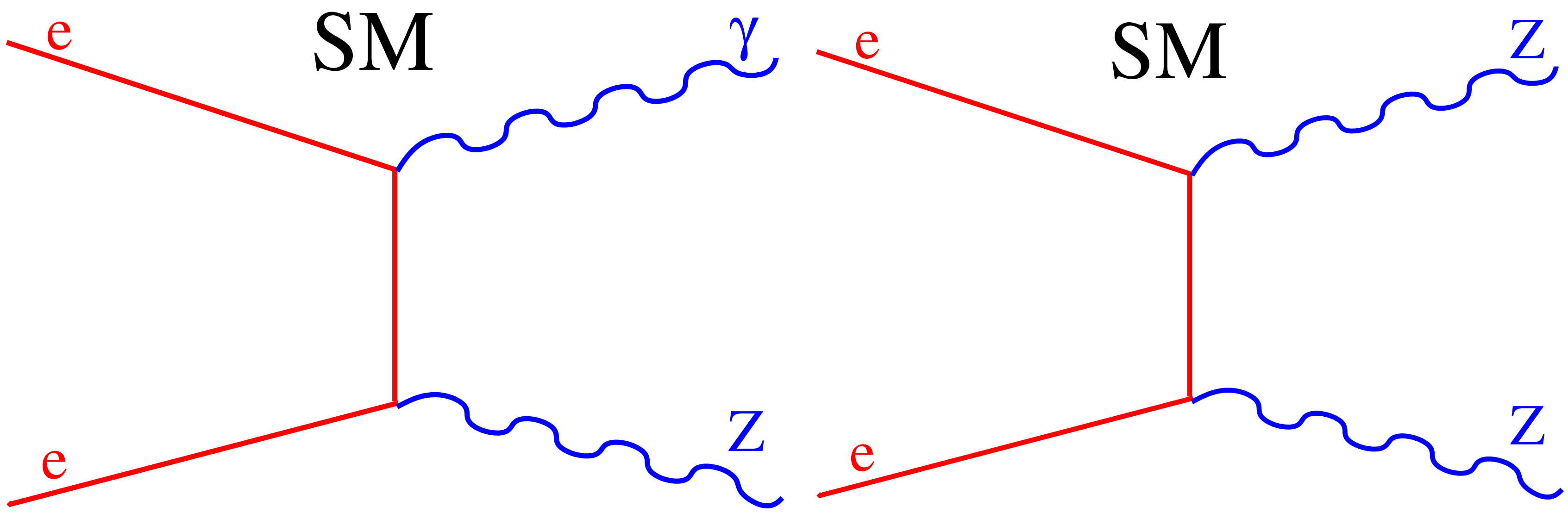


Most general vertex assuming: CP, on-shell Z

$$\Gamma^{\alpha\beta\mu}_{Z\gamma V} = i\frac{s-m_V^2}{m_Z^2}\left[\, h_3^V\ \epsilon^{\alpha\beta\mu\rho}\ q_{\gamma\rho} + h_4^V\ \frac{q_V^\alpha}{m_Z^2}\ \epsilon^{\mu\beta\rho\sigma}\ q_{V\rho}\ q_{\gamma\sigma}\,\right]$$

$$\Gamma^{\alpha\beta\mu}_{ZZV} = i\frac{s-m_V^2}{m_Z^2} f_5^V\ \epsilon^{\alpha\beta\mu\rho}\ (q_{Z_1\rho} - q_{Z_2\rho})$$

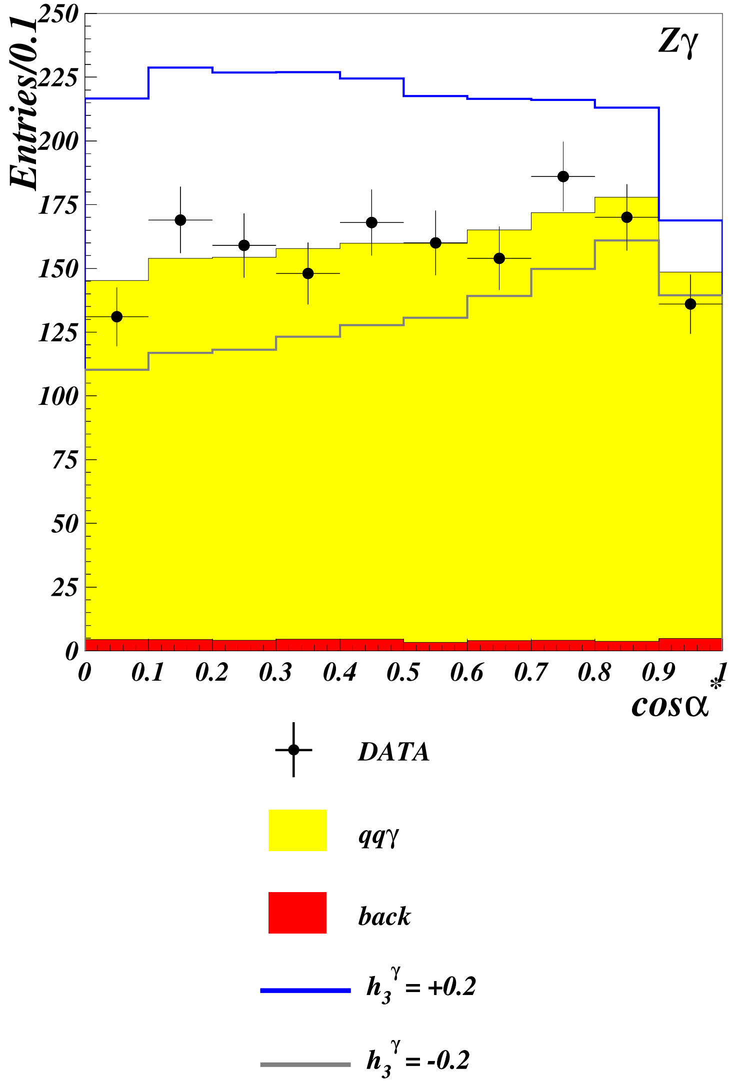
SM diagrams

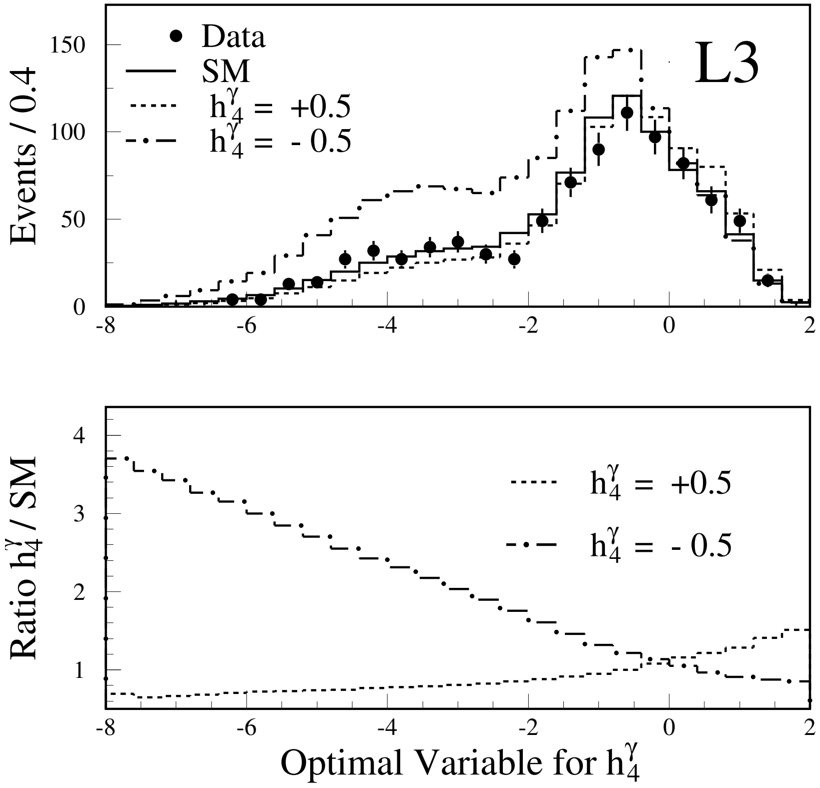


- $\sigma_{SM} \propto \frac{1}{s}$ when $\sqrt{s} \gg m_Z$
- $\frac{d\sigma_{SM}}{d\cos\theta} \propto \frac{1+\cos^2\theta}{1-\cos^2\theta}$ when $\sqrt{s} \gg m_Z$ (t-channel)
- Anomalous contributions increase with $\sqrt{s}$, may contribute at large polar angles and modify Z, γ helicities

Some $e^+e^- \rightarrow Z\gamma$ *distributions at LEP*

DELPHI preliminary





Adding likelihood functions

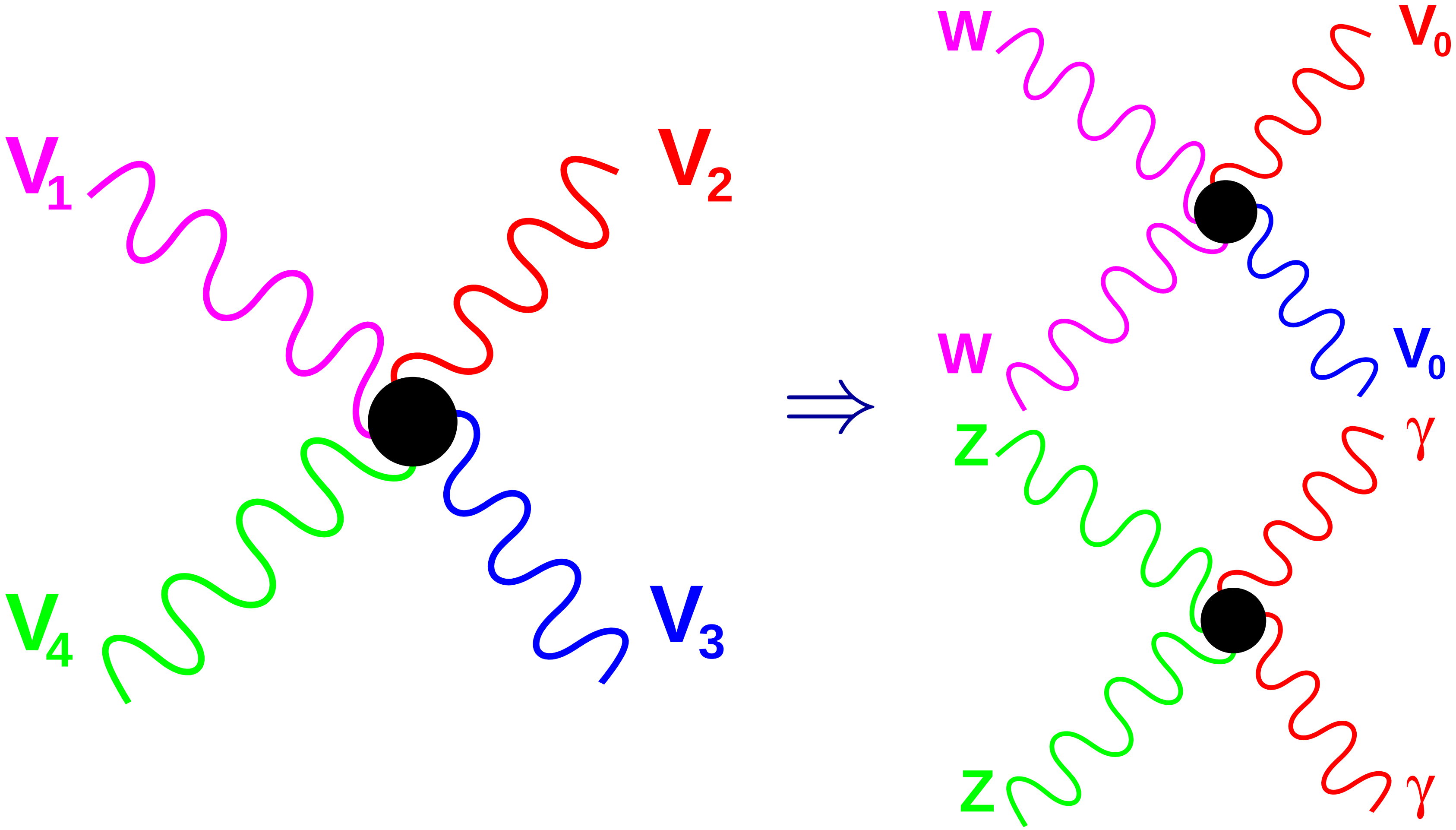
Parameter	95% CL
h_3^γ	$[-0.049, -0.008]$
h_4^γ	$[-0.002, +0.034]$
h_3^Z	$[-0.20, +0.07]$
h_4^Z	$[-0.05, +0.12]$

Agreement with SM expectations

LEP sensitivity on h_i^V couplings ~ 0.1

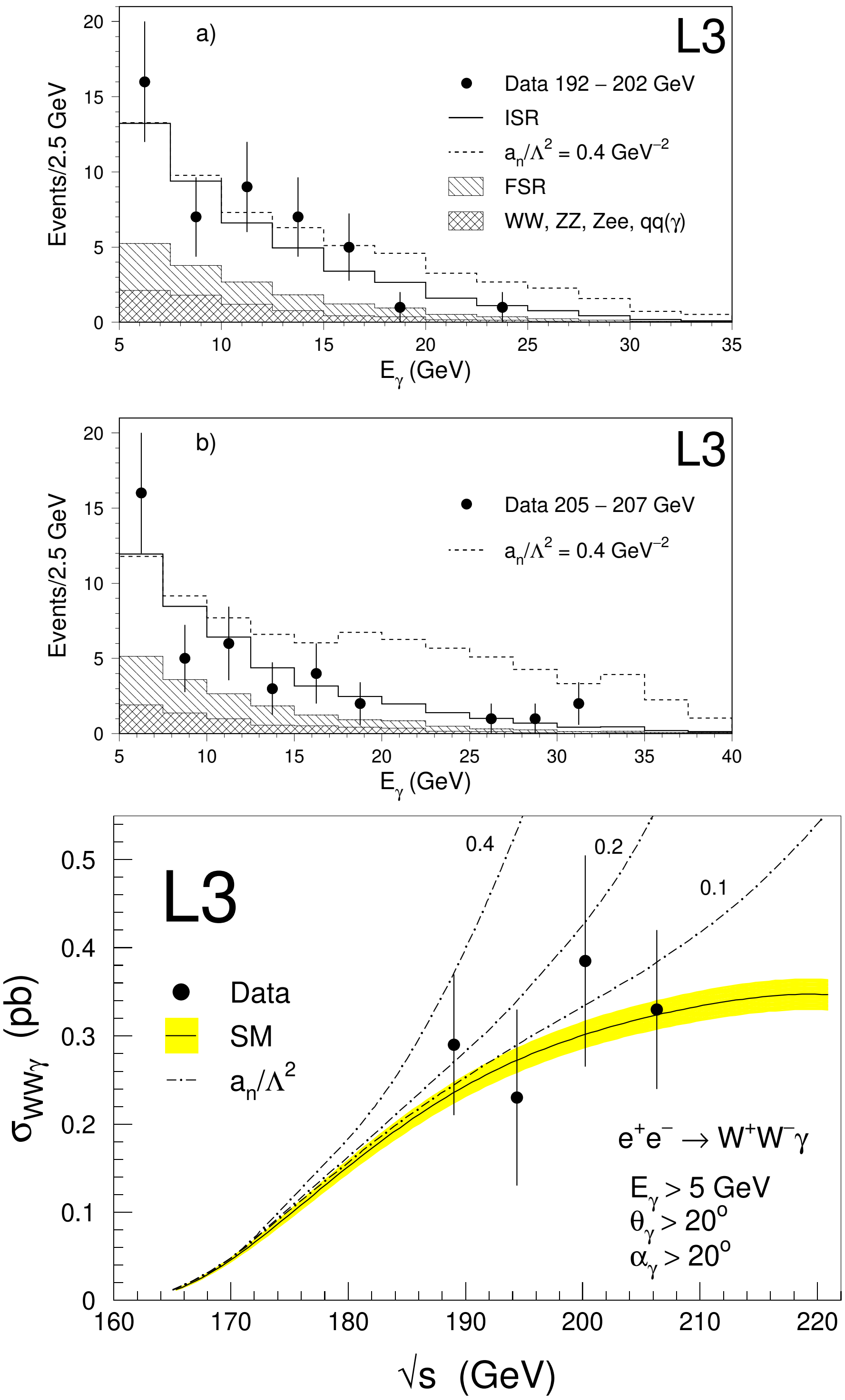
Window to new physics scales, maybe related to the symmetry breaking mechanism of the SM

These vertices are kinematically accessible at LEP2



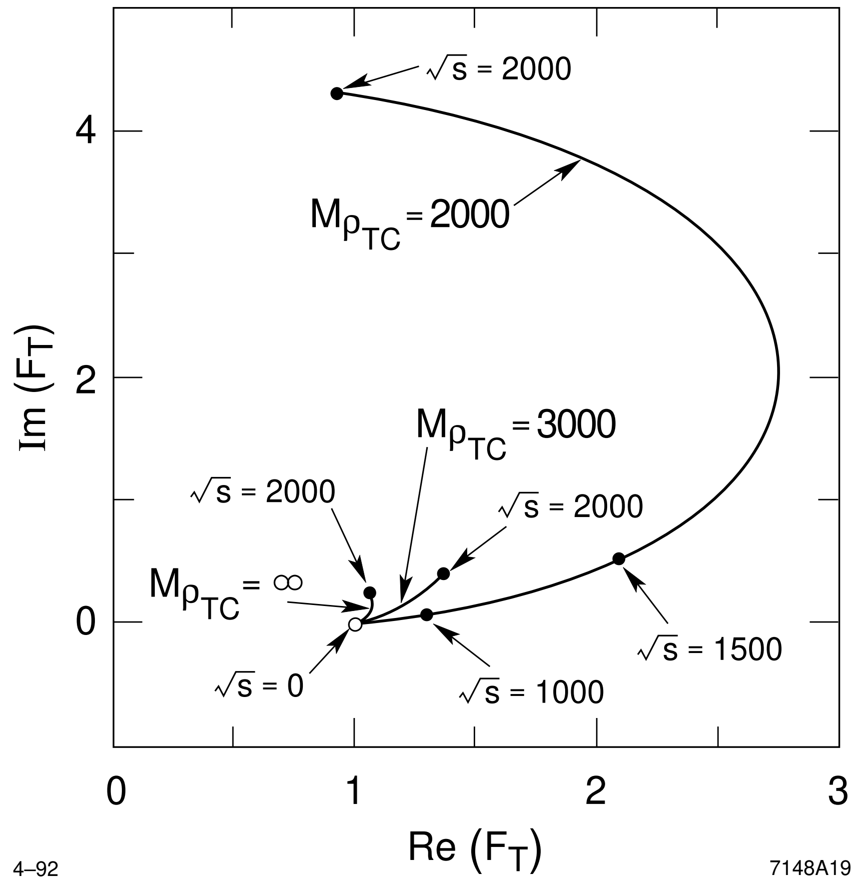
Unfortunately, SM predictions $\propto g^2$ (too small for LEP2)

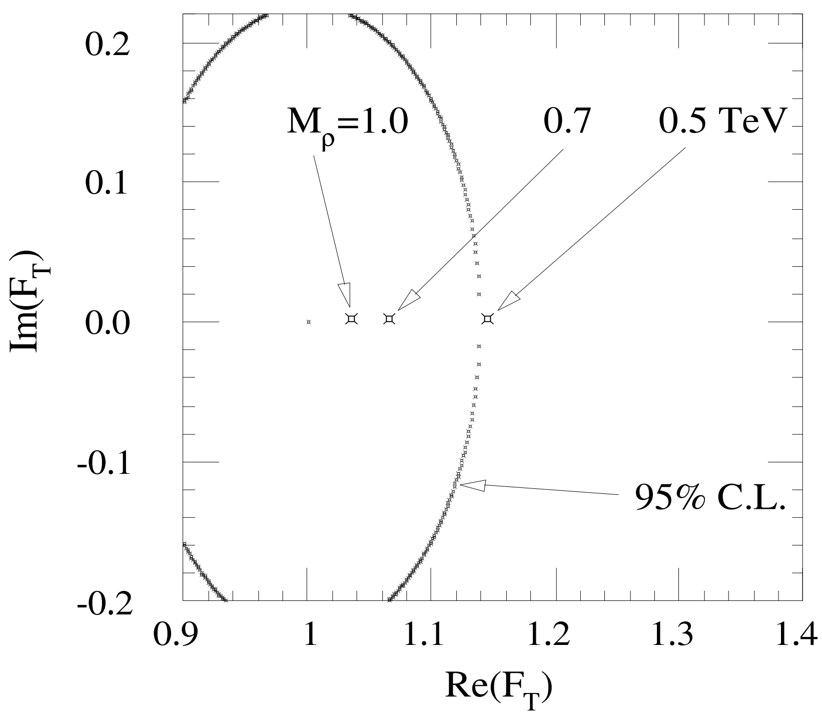
$WWV\gamma$ *coupling searches at LEP2*



- No anomalous quartic gauge couplings seen
- Poor limits: $\Lambda_{NP} \gtrsim 5$ GeV
- Catalyzed theoretical activity in this field

$W_L W_L \rightarrow W_L W_L$ *searches (T. Barklow)*





ρ_T effects: form factor F_T in the $\mathrm{e}^+\mathrm{e}^- \rightarrow \mathrm{W}^+\mathrm{W}^-$ process

$\rho_T \gtrsim 500$ GeV (ALEPH preliminary)

✥ Not obsessed by the Z peak anymore . . .

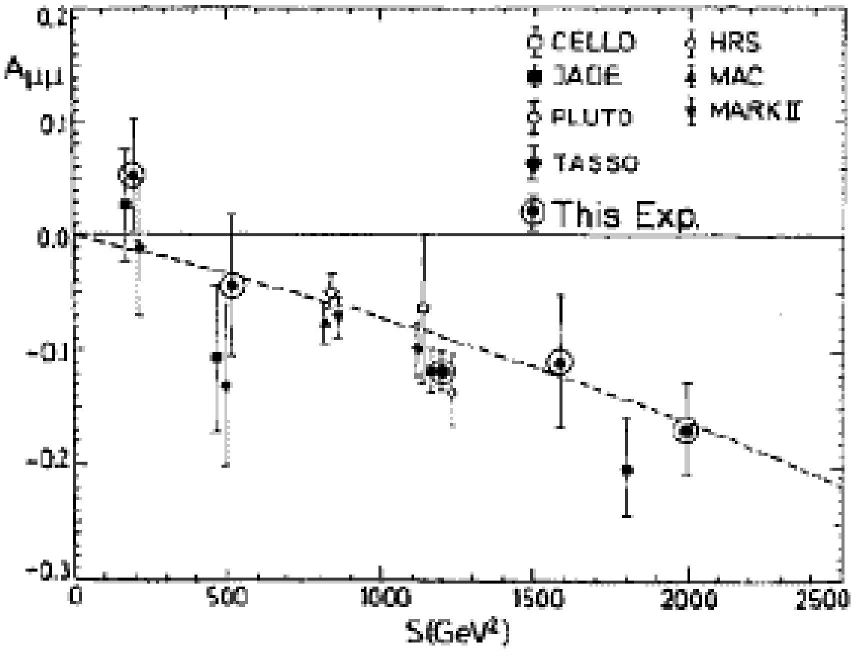
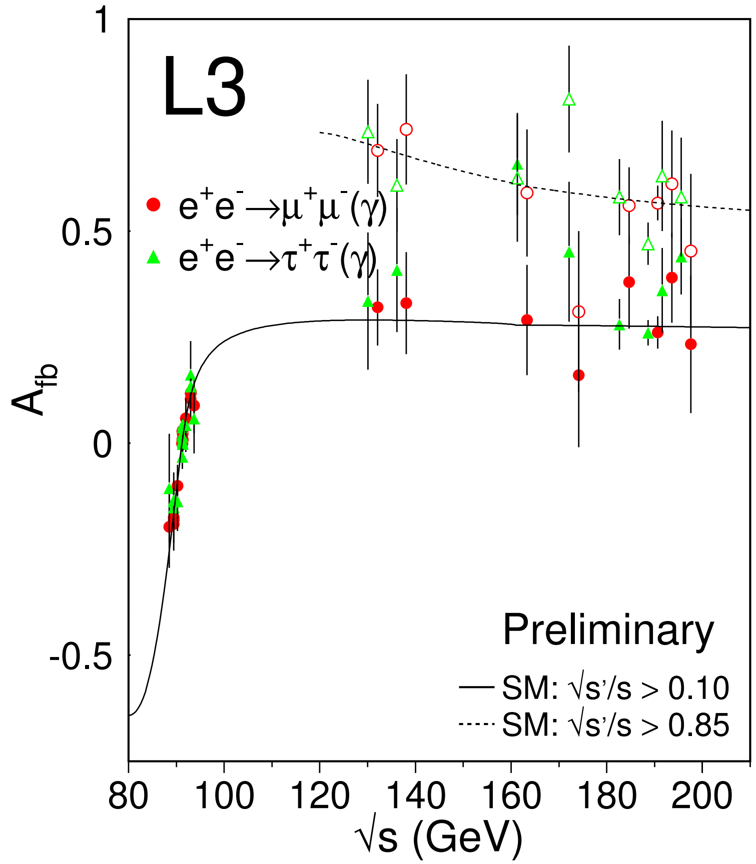
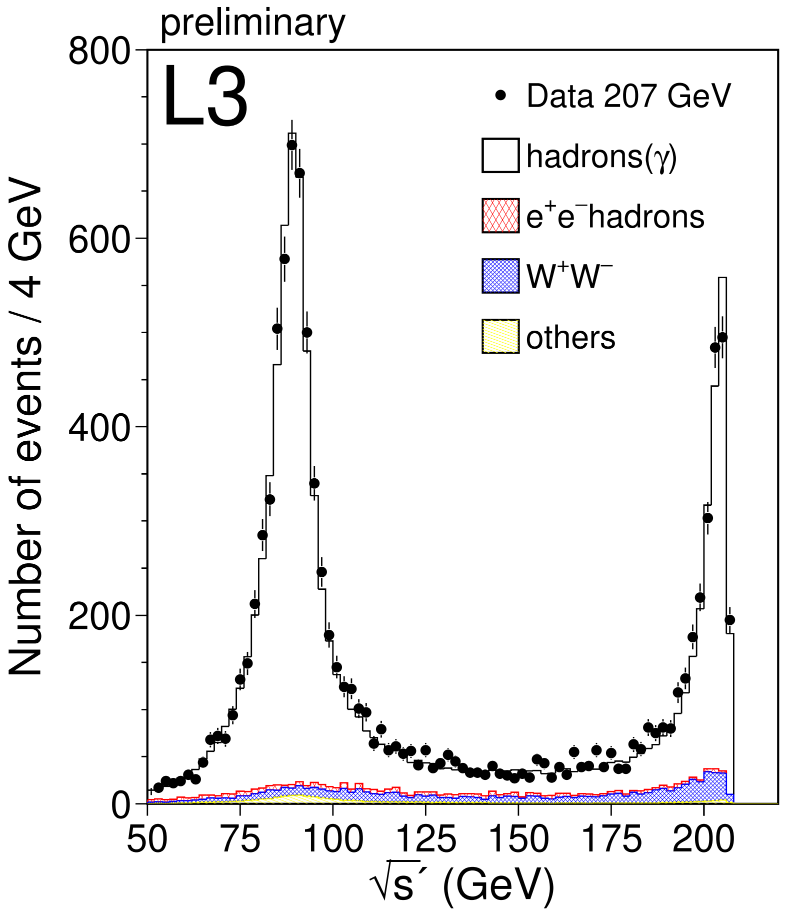
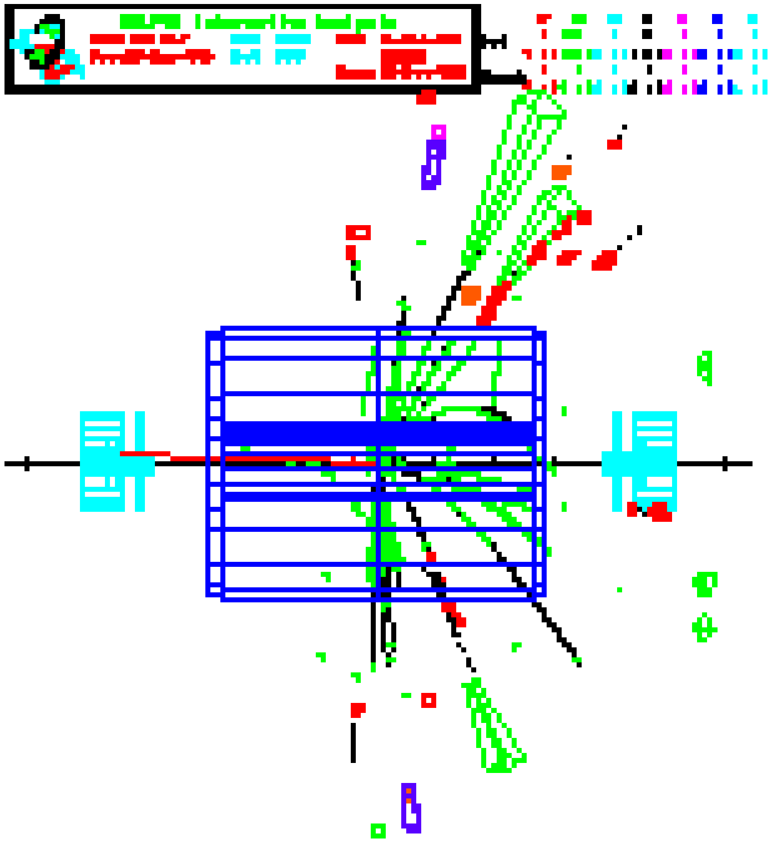


FIG. 1. $A_{\mu\mu}$ as a function of s. The dashed curve is the standard model prediction using $\sin^2\theta_W = 0.22$ and $m_{Z^0} = 93$ GeV.



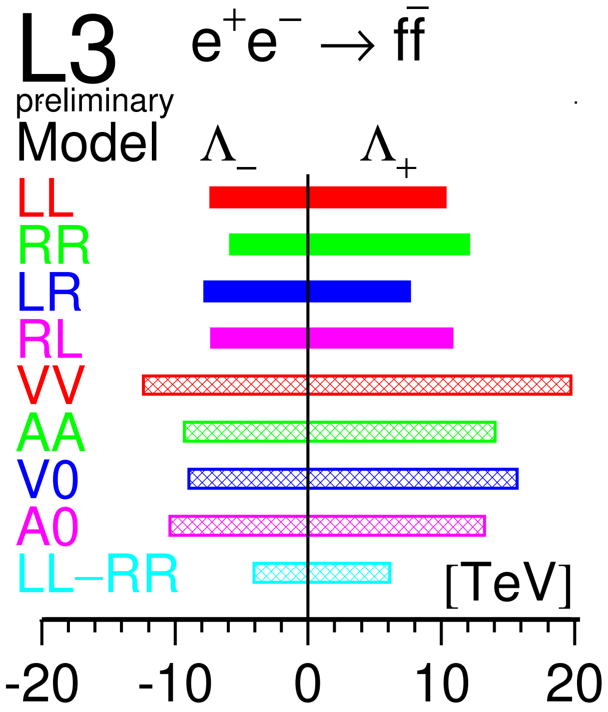
Throwing away the Z-recoil "background"



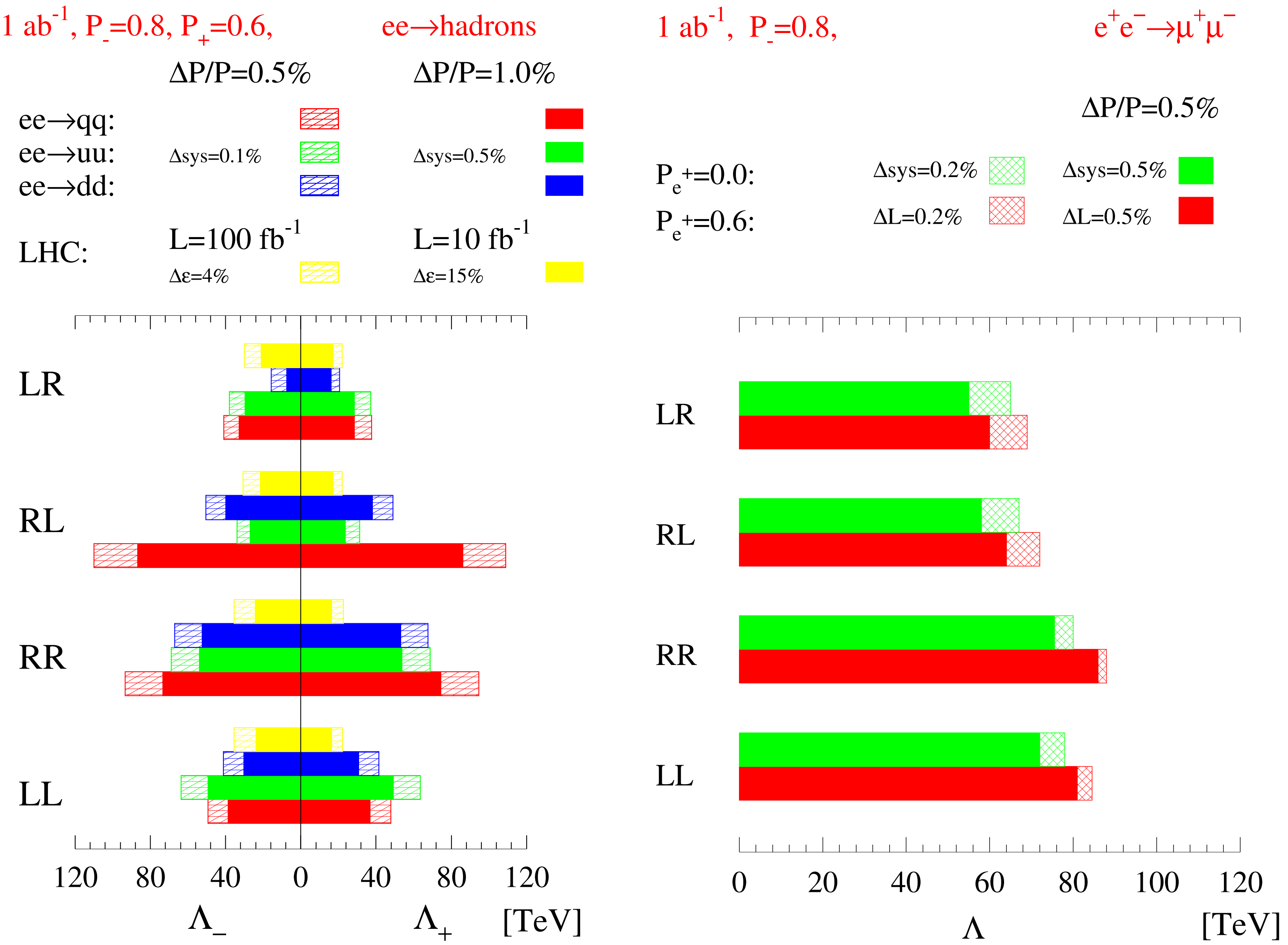


- If only the SM light Higgs boson is found, the most sensitive New Physics probes at future colliders will be dimension-six four-fermion contact operators:

$$\mathcal{L} = \frac{1}{1+\delta_{ef}} \sum_{i,j=\mathrm{L,R}} \eta_{ij} \frac{g^2}{\Lambda_{ij}^2} (\bar{\mathrm{e}}_i \gamma^\mu \mathrm{e}_i)(\bar{\mathrm{f}}_j \gamma_\mu \mathrm{f}_j)$$



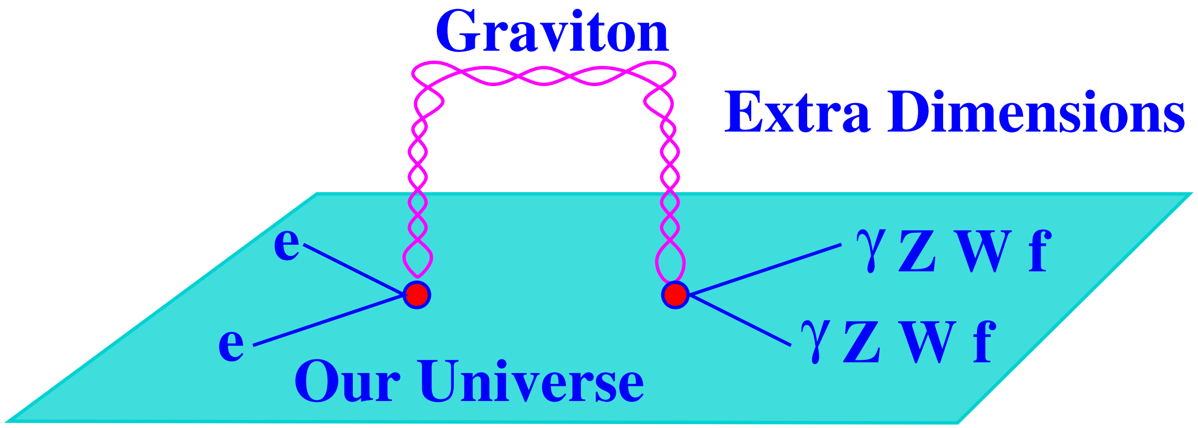
Contact $e^+e^- \to f\bar{f}$ *Interactions at future colliders*



J. Alcaraz

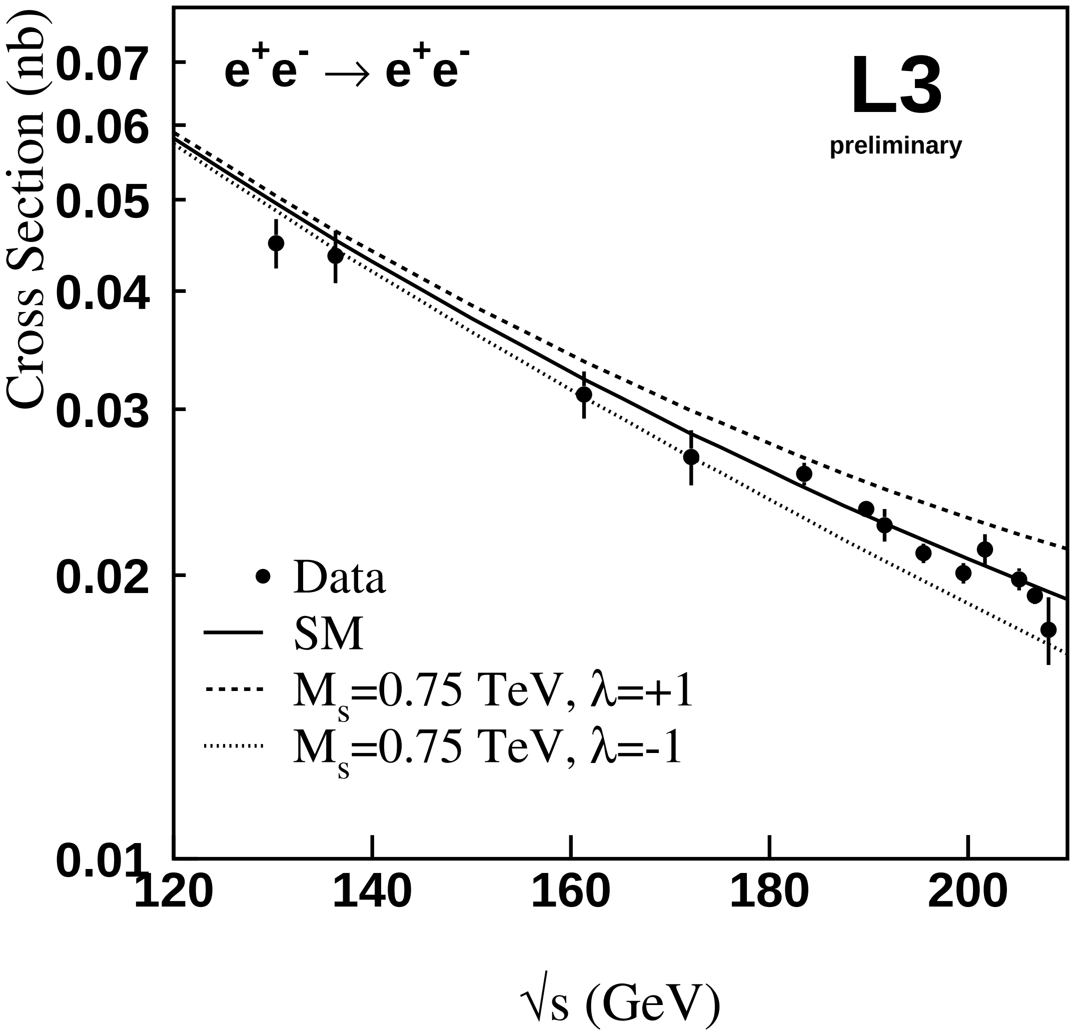
N extra large dimensions of size R for gravity?

$$M_P^2 \sim R^N \; M_S^{N+2}$$

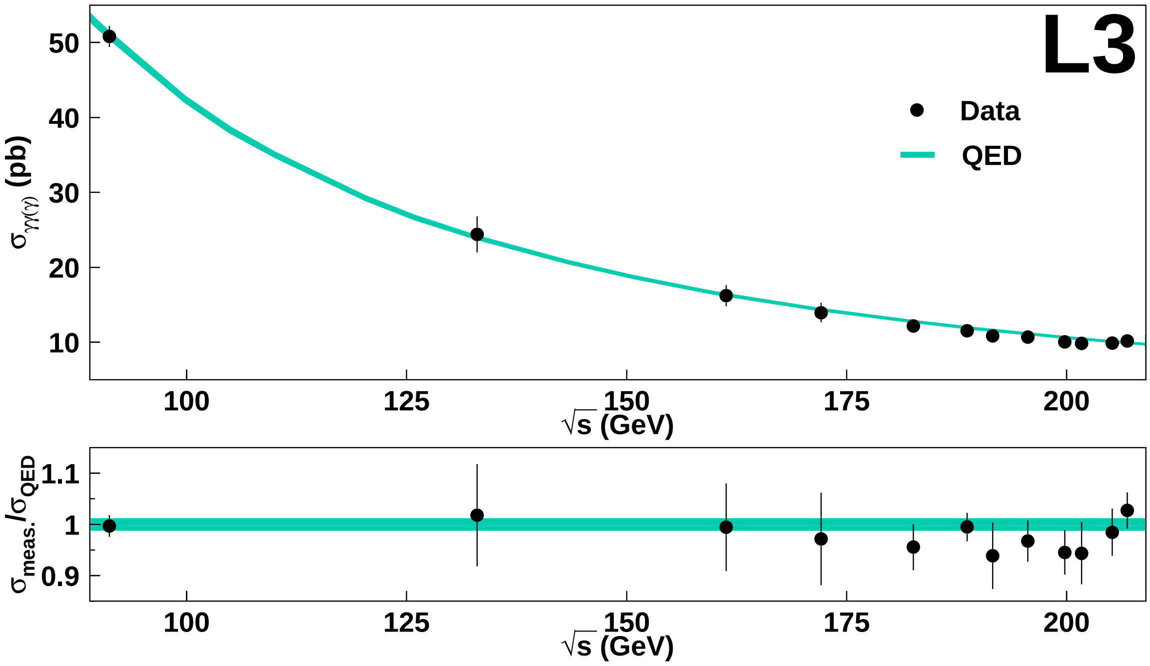


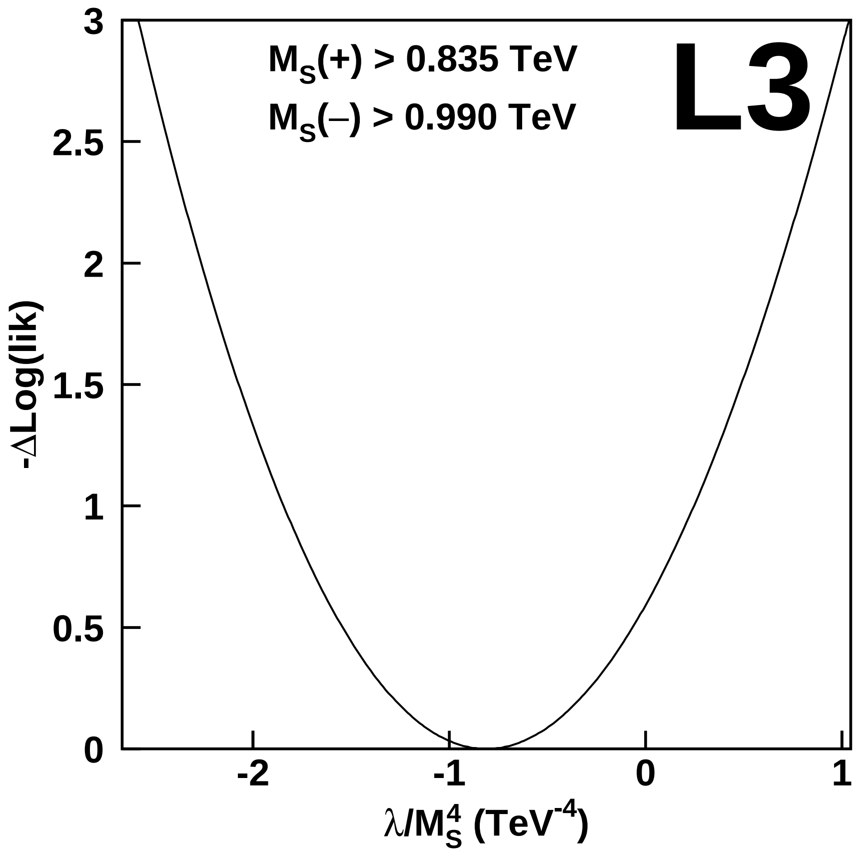
$$\mathcal{L} = \frac{\lambda}{M_S^4}(\bar{\mathrm{e}}\gamma^\mu \mathrm{e}) \; T_{\mu\nu} \; (\bar{\mathrm{f}}\gamma^\nu \mathrm{f})$$

✧ Tensorial contact interactions: Low Scale Gravity

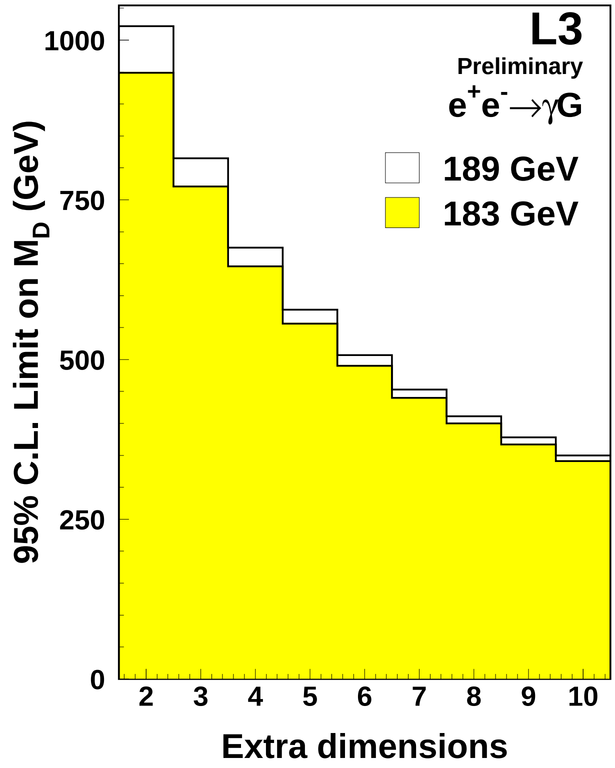


LEP2: QED tests in the $e^+e^- \to \gamma\gamma$ channel





Direct searches for LSG. Dimensions

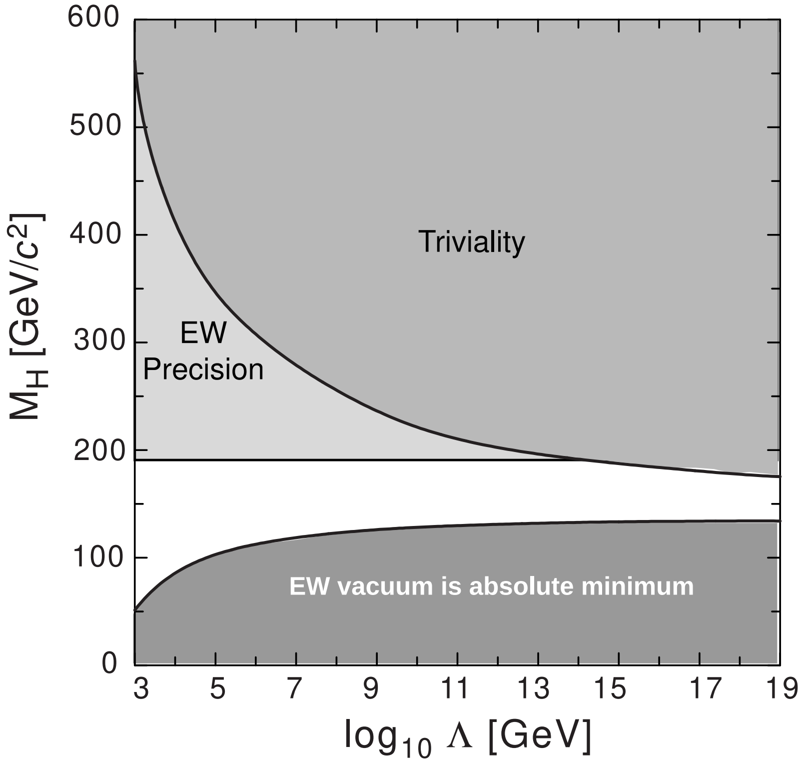


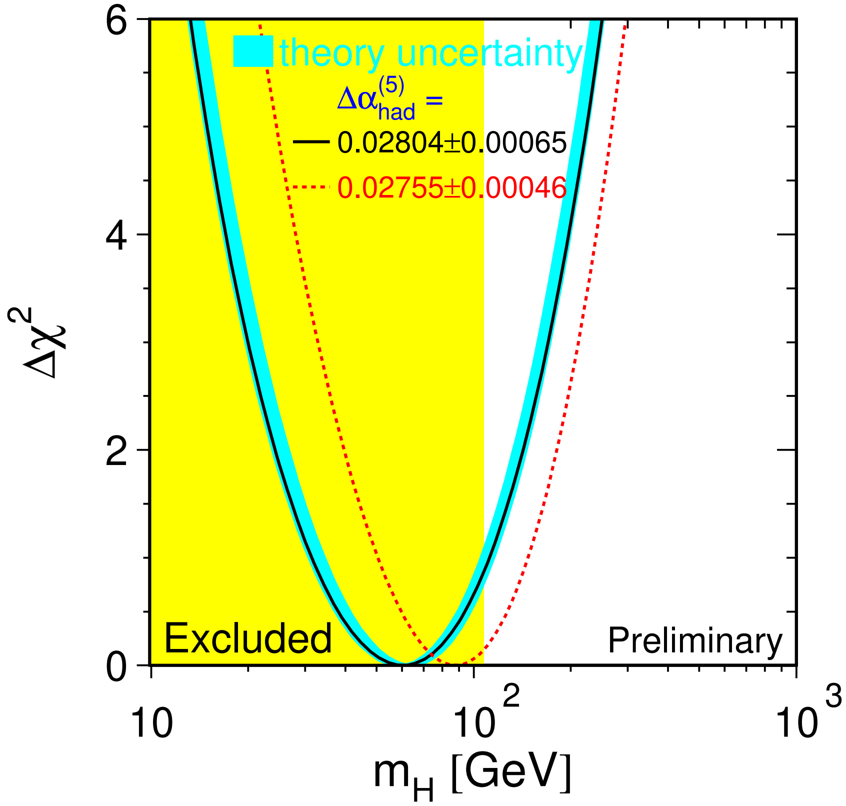
Excluded size of the Extra Dimensions from L3 Limits (E. Sanchez)

REFERENCE SIZES (IN METERS)

- 1 light Year ~ 10^{+16}
-  1 AU = $1.5 \times 10^{+11}$
-  Typical cell size ~ 10^{-5}
-  DNA Molecule size ~ 10^{-7}
- Typical Molecule size ~ 10^{-8}
-  Bohr Radius = 0.53×10^{-10}
- $\lambda_{COMPTON}$ of the electron = 3.8×10^{-13}
-  Typical Nucleus Size ~ 10^{-14}
- Proton Size ~ 2.8×10^{-15}
- electron or quark size ~ 10^{-18}

δ	$\lambda=+1$	$\lambda=-1$
1	$2.4 \times 10^{+13}$	$4.5 \times 10^{+13}$
2	2.1×10^{-3}	3.2×10^{-3}
3	9.3×10^{-9}	1.3×10^{-8}
4	1.9×10^{-11}	2.7×10^{-11}
5	4.9×10^{-13}	6.5×10^{-13}
6	4.1×10^{-14}	5.5×10^{-14}
7	7.1×10^{-15}	9.3×10^{-15}

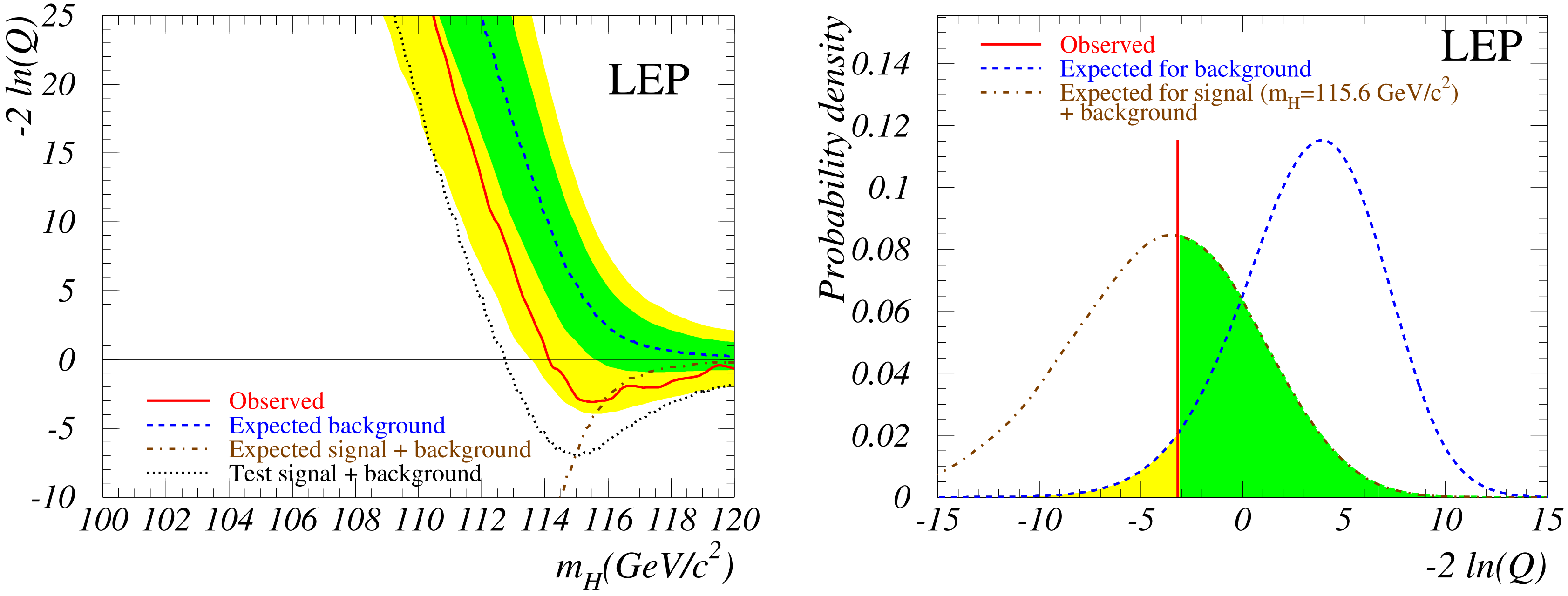




Only a narrow band is allowed if there is no new physics up to 10^{19} GeV

$m_{\rm H} \lesssim 200$ GeV at 95% CL

- The consistency of the data with a low mass SM Higgs ($m_{\rm H} \lesssim 200$ GeV) is just an indication, not a proof of its existence and of its production and decay properties



- We have to be prepared for surprises: non-existence, unexpected production and decay properties, . . .

Beyond the SM Higgs searches: a model independent approach

- If the SM is an approximately correct description of Nature, the "true theory" from a new physics scale Λ looks at low energies like (flavour violations are neglected):

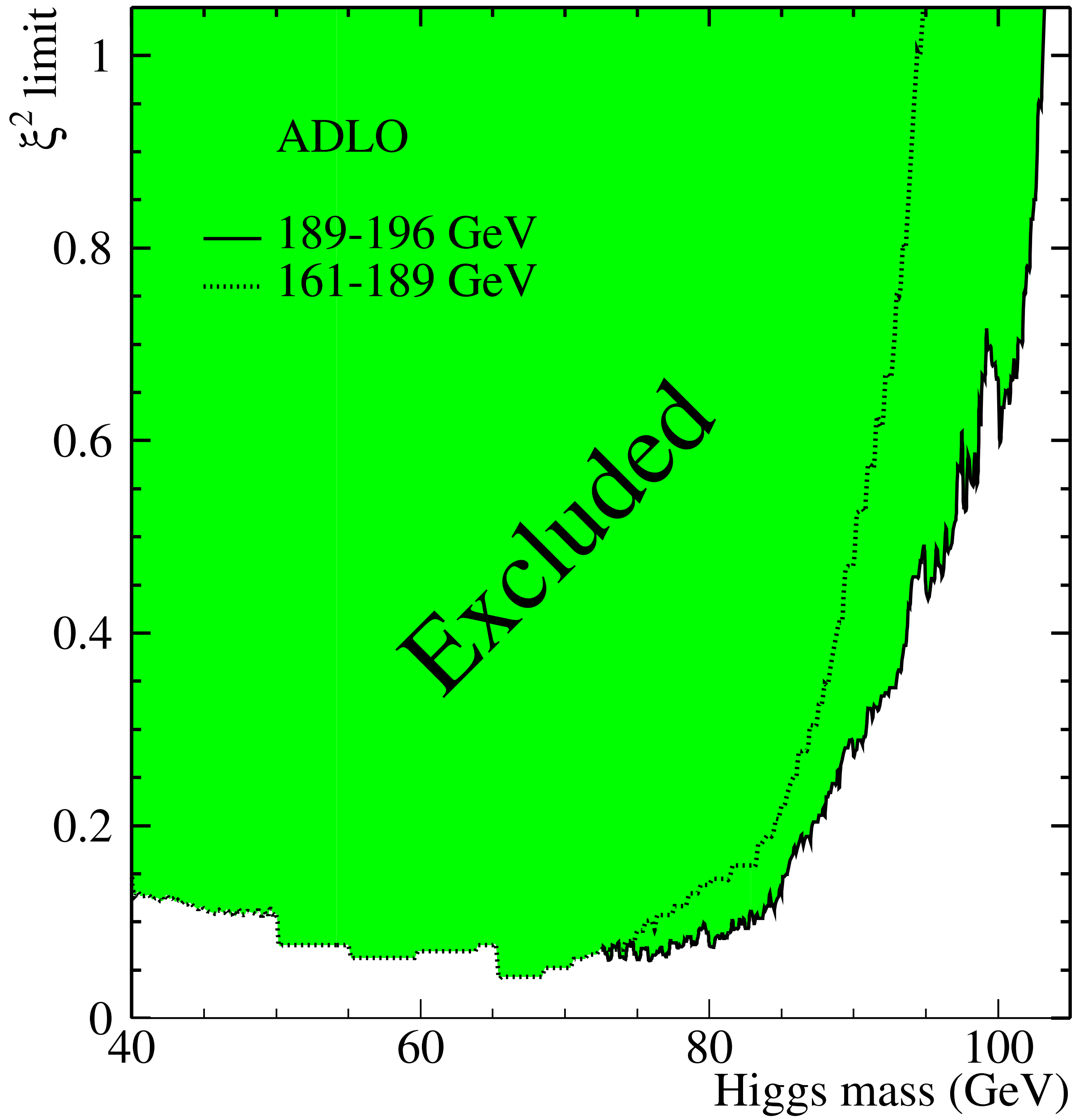
$$\mathcal{L} = \mathcal{L}_{SM} + \sum_{n=6}^{\infty} \frac{1}{\Lambda^{n-4}} \left(\sum_j f_{nj} \; \mathcal{O}_{nj} \right)$$

- Already at dimension 6 some CP conserving anomalous HVV couplings, not excluded by LEP1 or lower energy experiments, may appear:

$$\mathcal{L} = \mathcal{L}_{SM} + \frac{f_{\mathrm{WW}}}{\Lambda^2} \; \mathcal{O}_{\mathrm{WW}} + \frac{f_{\mathrm{BB}}}{\Lambda^2} \; \mathcal{O}_{\mathrm{BB}} + \frac{f_{\mathrm{W}}}{\Lambda^2} \; \mathcal{O}_{\mathrm{W}} + \frac{f_{\mathrm{B}}}{\Lambda^2} \; \mathcal{O}_{\mathrm{B}} + \frac{f_{\mathrm{B}}}{\Lambda^2} \; \mathcal{O}_{\Phi,2} + \ldots$$

$$\mathcal{L} = \mathcal{L}_{SM} + g_{\mathrm{H}\gamma\gamma} \; \mathrm{HA}_{\mu\nu}\mathrm{A}^{\mu\nu} \; + \; g^{(1)}_{\mathrm{HZ}\gamma} \; \mathrm{A}_{\mu\nu}\mathrm{Z}^{\mu}\partial^{\nu}\mathrm{H} \; + \; g^{(2)}_{\mathrm{HZ}\gamma} \; \mathrm{HA}_{\mu\nu}\mathrm{Z}^{\mu\nu}$$
$$+ \; g^{(1)}_{\mathrm{HZZ}} \; \mathrm{Z}_{\mu\nu}\mathrm{Z}^{\mu}\partial^{\nu}\mathrm{H} \; + \; g^{(2)}_{\mathrm{HZZ}} \; \mathrm{HZ}_{\mu\nu}\mathrm{Z}^{\mu\nu} \; + \; g^{(3)}_{\mathrm{HZZ}} \; \mathrm{HZ}_{\mu}\mathrm{Z}^{\mu} \; + \; \ldots$$

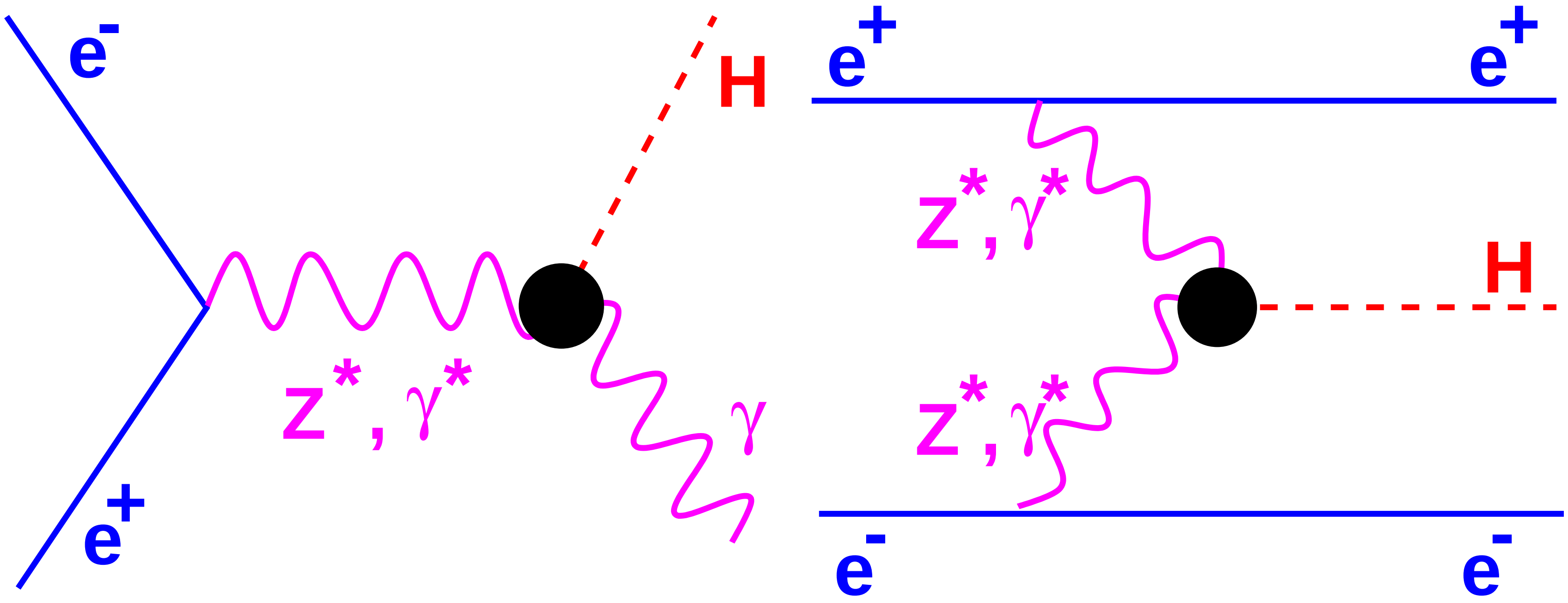
- These couplings modify the properties of the Higgs particle and are related to the anomalous WWV couplings:
  - $\mathrm{H}\gamma\gamma$, $\mathrm{HZ}\gamma$ couplings and $\mathrm{H} \rightarrow \gamma\gamma$, $\mathrm{H} \rightarrow \mathrm{Z}\gamma$ decays may become "observable"
  - $\frac{f_{\mathrm{W}}}{\Lambda^2}$ and $\frac{f_{\mathrm{B}}}{\Lambda^2}$ are the couplings leading to Δg_1^{Z}, $\Delta\kappa_\gamma$
  - $g^{(3)}_{\mathrm{HZZ}} \equiv \xi - 1 \Rightarrow$ Global factor with respect to SM Higgs couplings.



Example of ξ coupling: MSSM in the limit of large SUSY masses: $m_A >> v$

$$\frac{f}{\Lambda^2} \approx -\frac{v^2}{m_A^4}$$

New production channels

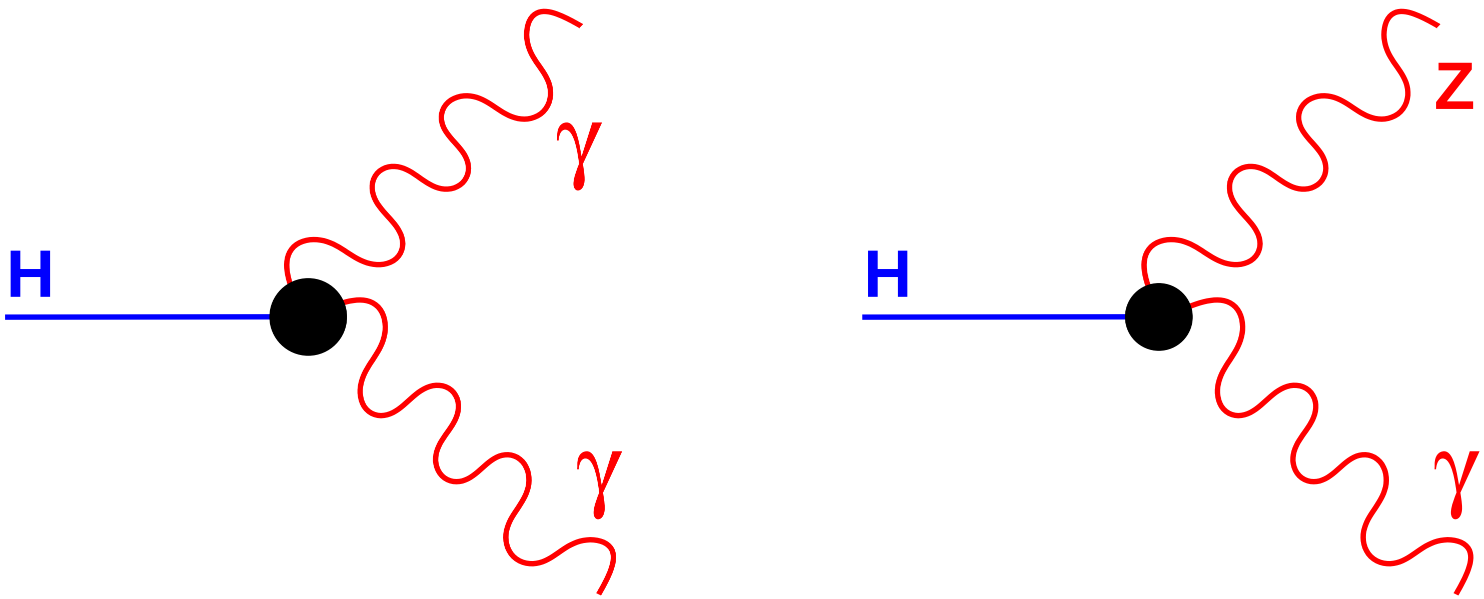


$$\Downarrow$$

Access to an unexplored region:

$$\sqrt{s} - m_{\mathrm{Z}} < m_{\mathrm{H}} < \sqrt{s}$$

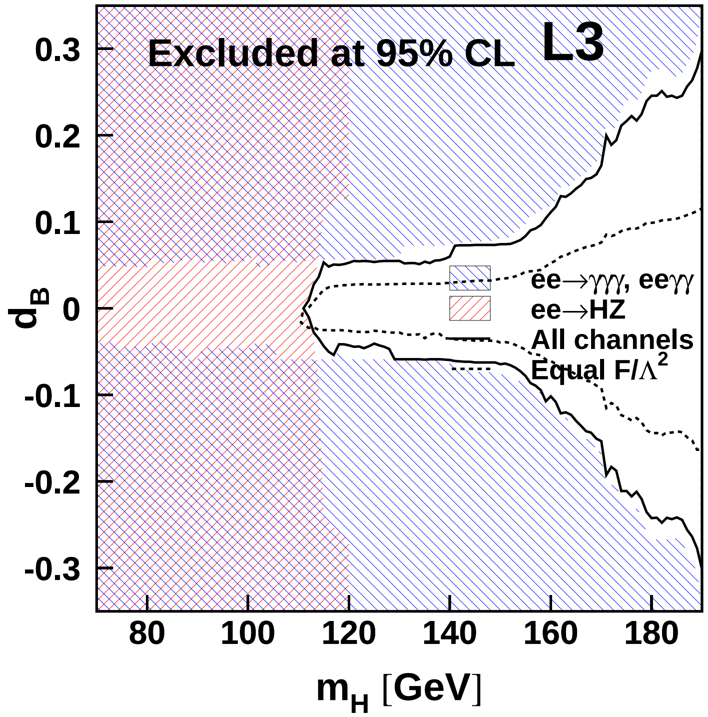
New decay channels

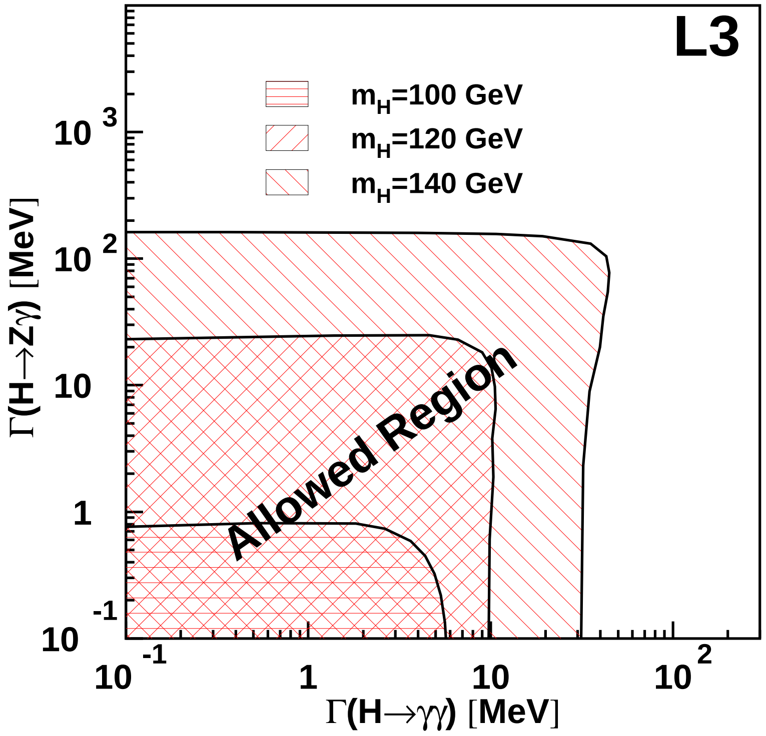


$\Downarrow$

- Clean final states
- If dominant: fermiophobic scenario
  (but different from the usual fermiophobic benchmark)

Non-standard Higgs searches: a model independent approach





- Limits comparable to those obtained for Δg_1^Z, $\Delta\kappa_\gamma$

- Limits to $\Gamma(\mathrm{H}\to\gamma\gamma)$ and $\Gamma(\mathrm{H}\to\mathrm{Z}\gamma)$ in the region of interest for LHC

Conclusions

- LEP2 is much more than a program for the precise measurement of m_{W} and the SM Higgs boson search
- LEP2 has opened the Pandora box at high energies: multi-fermion final states, boson self-couplings, FSI, . . .
- In the meantime we have learned about new things: optimal observable techniques, gravity in extra-dimensions, model-independent approaches via effective Lagrangians, . . .
- A substantial part of this experience will be beneficial for the next round of $\mathrm{e}^+\mathrm{e}^-$ colliders
- LEP2 is not over! Many analyses still in the pipeline . . .