XXXIXth Recontres de Moriond
LaThuile, 28 March - 4 April 2004

Standard Model Fits

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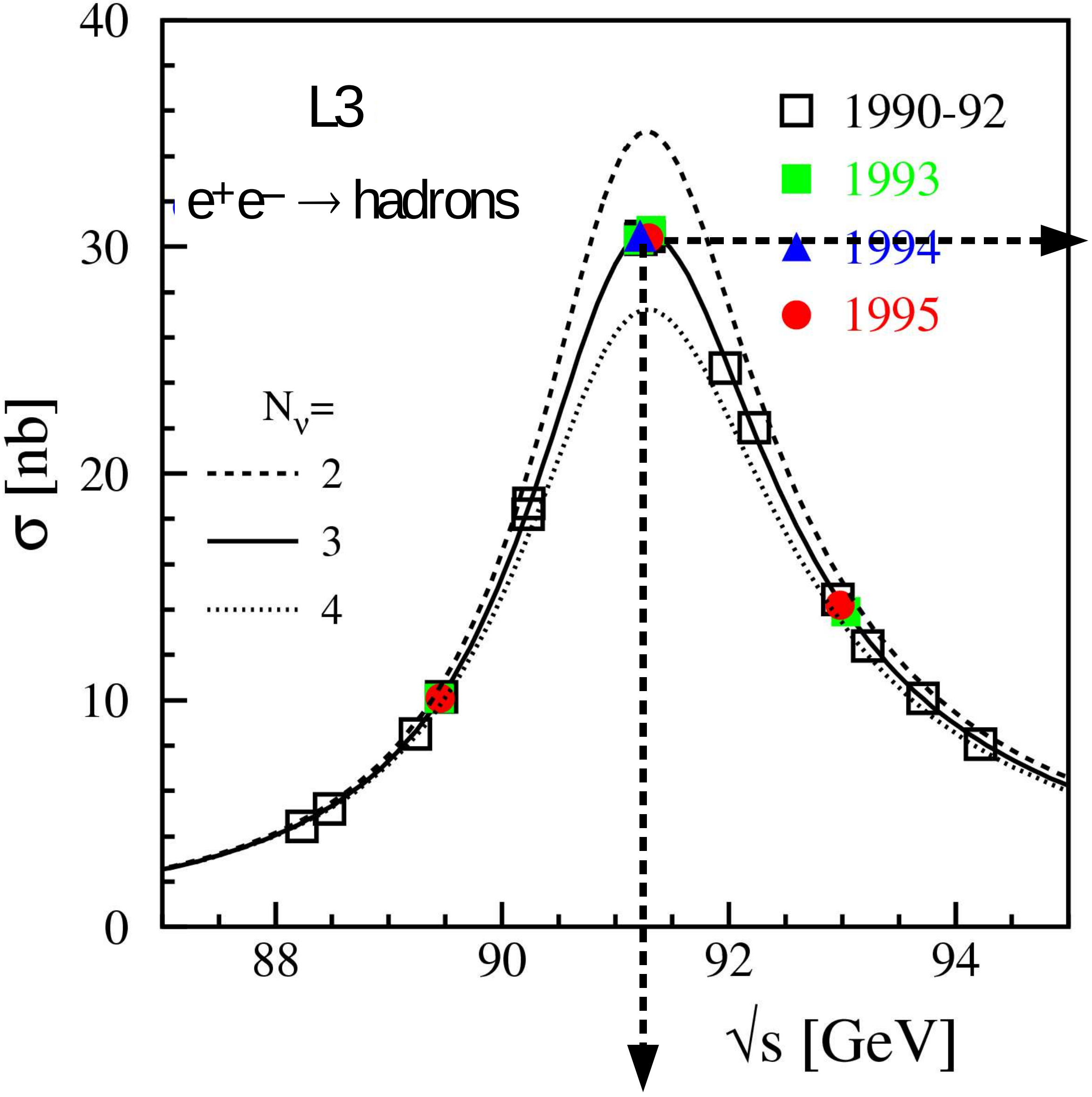
L3 Collaboration

Outline:

- Measurements at the Z pole
- Measurement of the W mass
- Other observables
- Interpretation within the SM – Higgs mass analysis

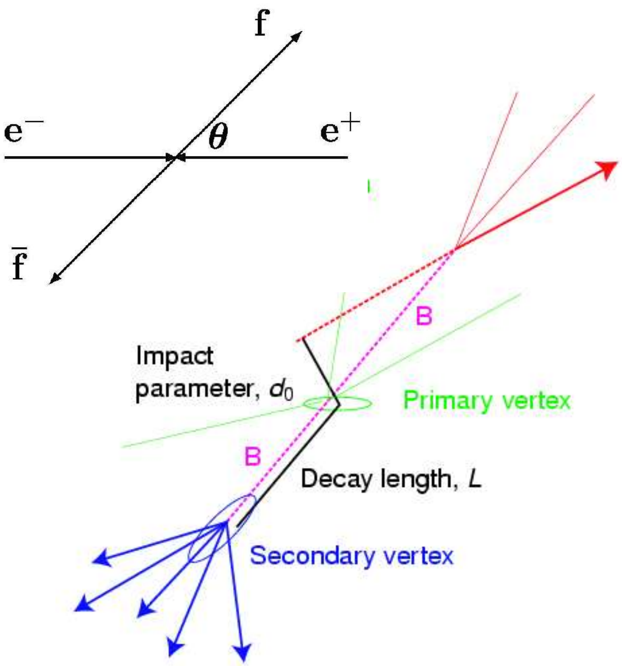
Z-Lineshape



$N_\nu = 3 \times (0.9947 \pm 0.0028)$

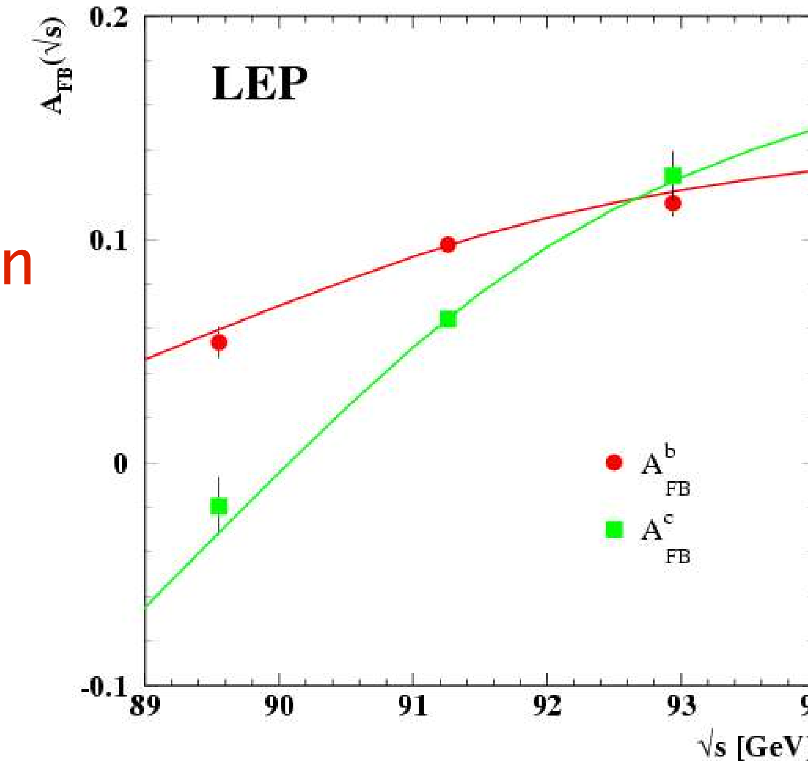
$m_Z = 91.1875 \pm 0.0021$ GeV

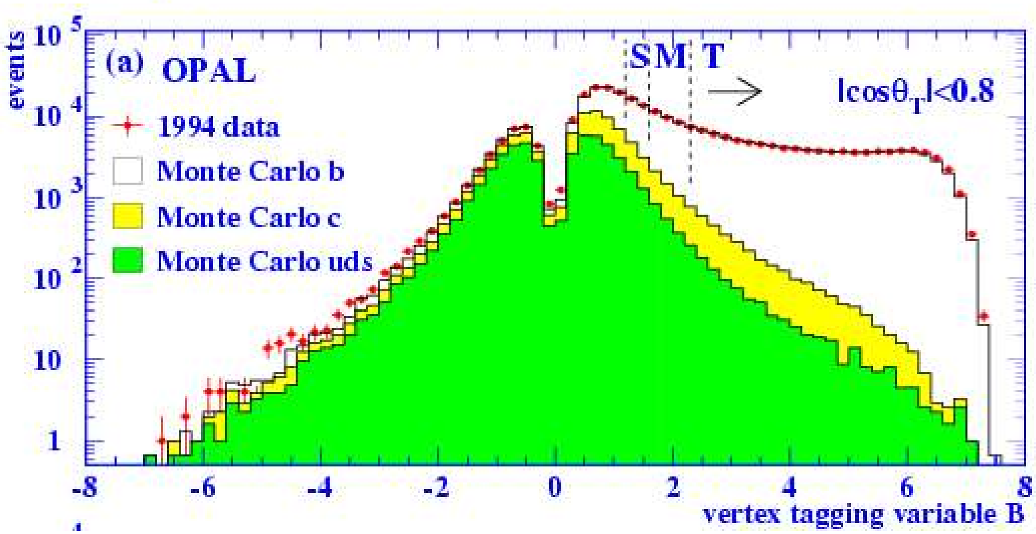
Forward-Backward Asymmetry



- jet direction
- b tagging
- tag jet charge
- Corrections for
  - fragmentation
  - charge confusion
  - b mixing

$$\mathcal{A}_{\mathrm{FB}} = \frac{N(\theta > 90^\circ) - N(\theta < 90^\circ)}{N(\theta > 90^\circ) + N(\theta < 90^\circ)}$$





Measurement of A_{FB}(b) translates into weak mixing angle:

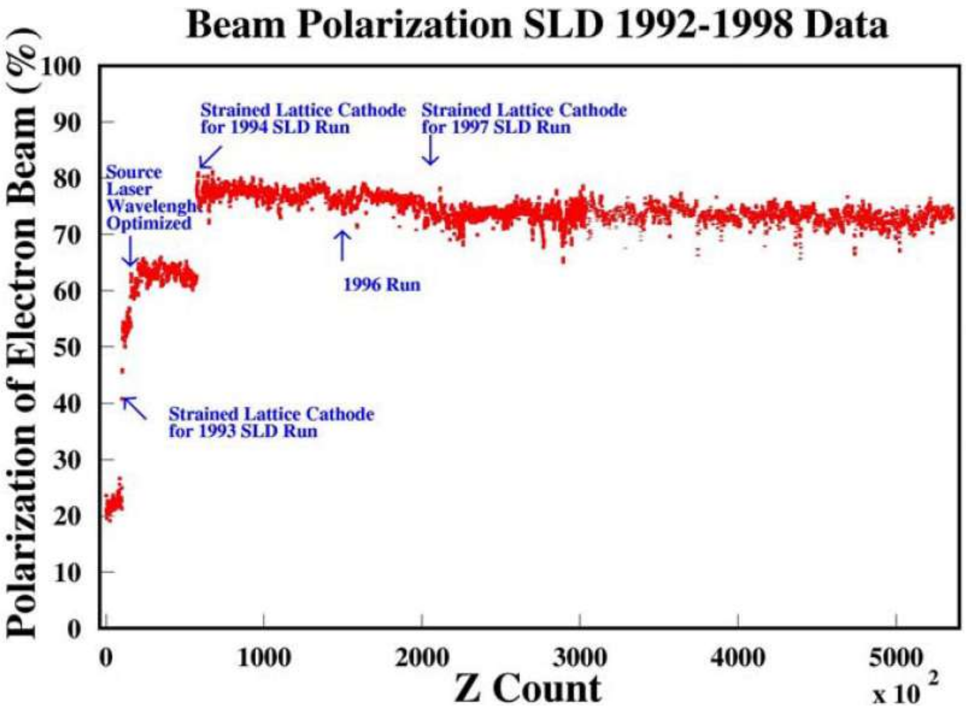
$$\sin^2\theta_{eff} = 0.23212 \pm 0.00029$$

Left-Right-Asymmetry at SLC

Count Z events N_Z for both polarizations of electron beam :

$$\mathcal{A}_{\mathrm{LR}} = \frac{N_{\mathrm{Z}}(L) - N_{\mathrm{Z}}(R)}{N_{\mathrm{Z}}(L) + N_{\mathrm{Z}}(R)} = \mathcal{P}_e \, A_e$$

Measurement of couplings g_L and g_R of the electron to the Z :



Parity violation !

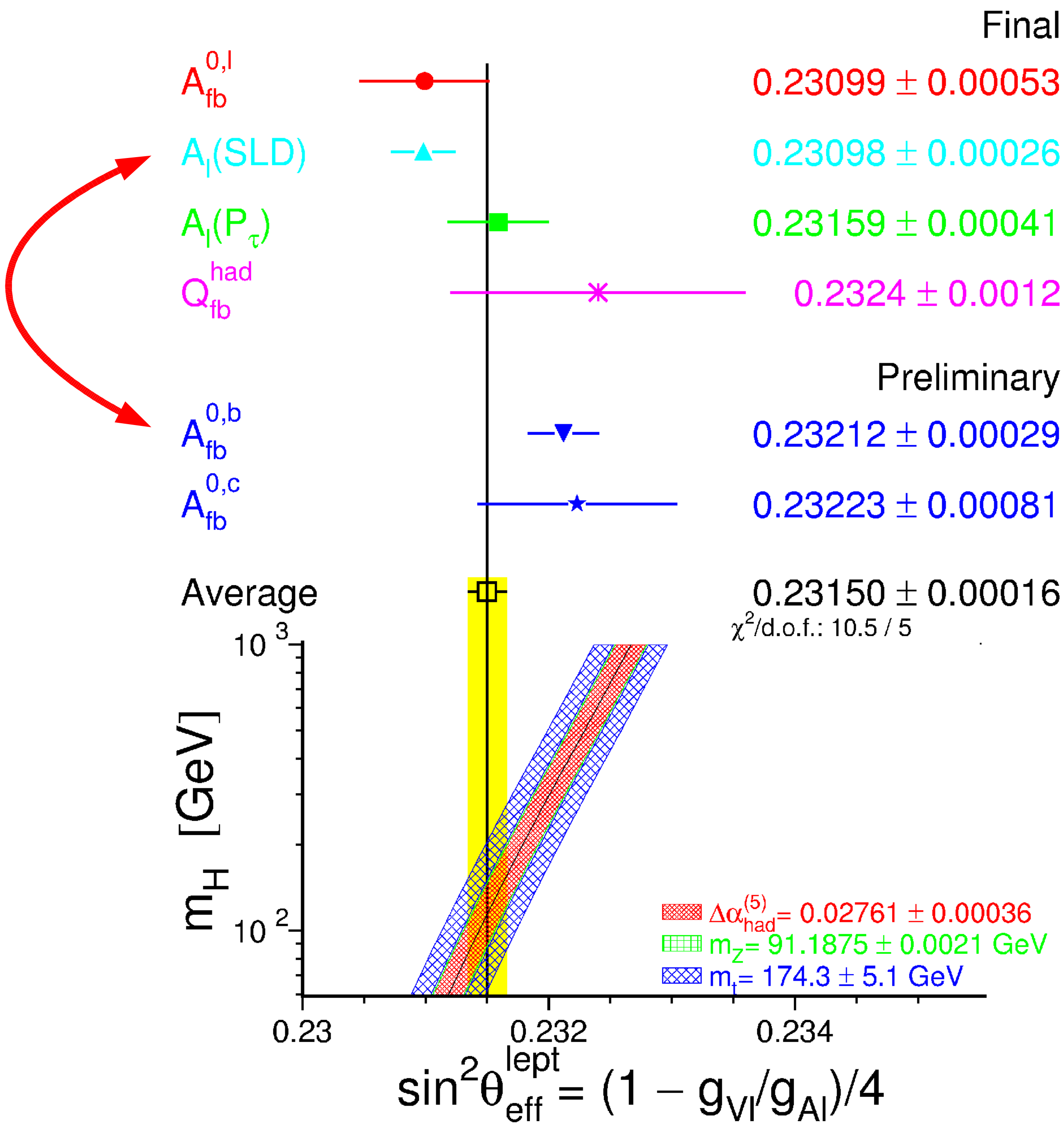
Important:
Precise Measurement of beam polarisation

Large Polarisation of 75%, with only 500 000 Z bosons:

$\sin^2 \theta_{eff} = 0.23098 \pm 0.00026$

Weak Mixing Angle

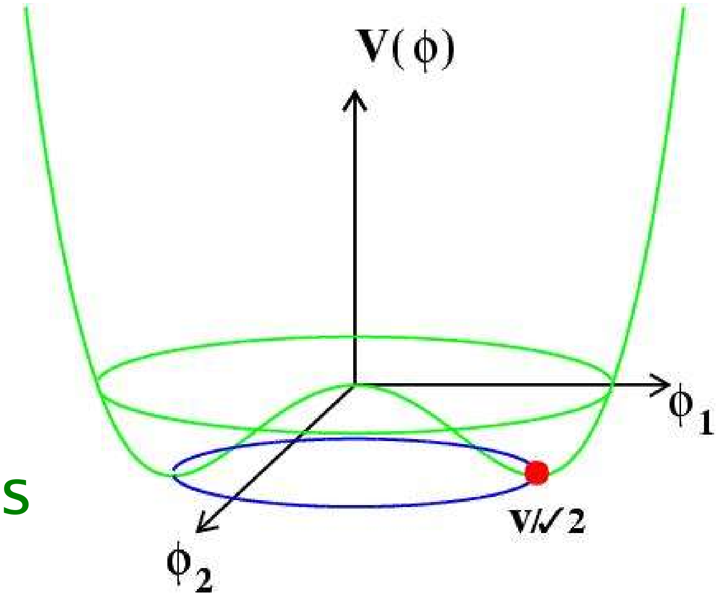
Between most precise measurements
2.9 σ difference !



Light Higgs preferred

Higgs Mechanism

$$V(\Phi) = \mu^2 \Phi^\dagger \Phi + \lambda(\Phi^\dagger \Phi)^2$$



Spontaneous symmetry breaking:

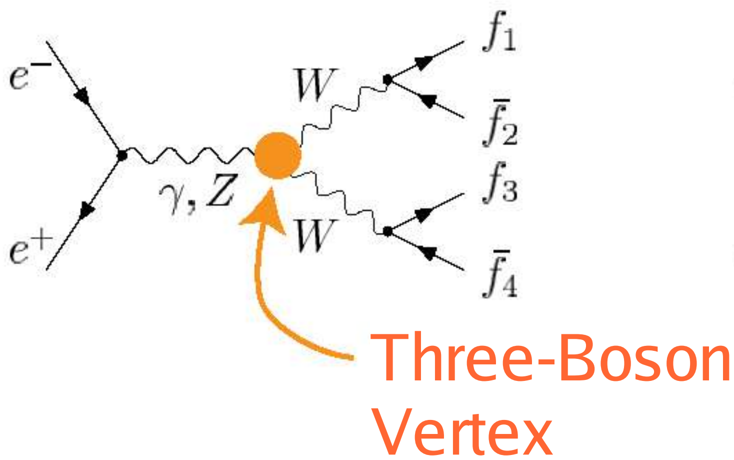
- Scalar field *Φ* with electroweak coupling
- Potential V(*Φ*) with non-vanishing vacuum expectation value *v* /√2
- Coupling to Higgs field gives W and Z mass

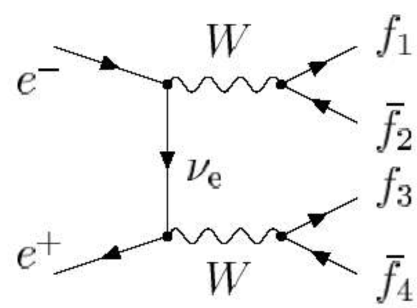
$$m_\mathrm{W} = \frac{1}{2}\frac{e}{\sin\theta_w}\, v$$

$$m_\mathrm{Z} = \frac{1}{2}\frac{e}{\sin\theta_w \cos\theta_w}\, v$$

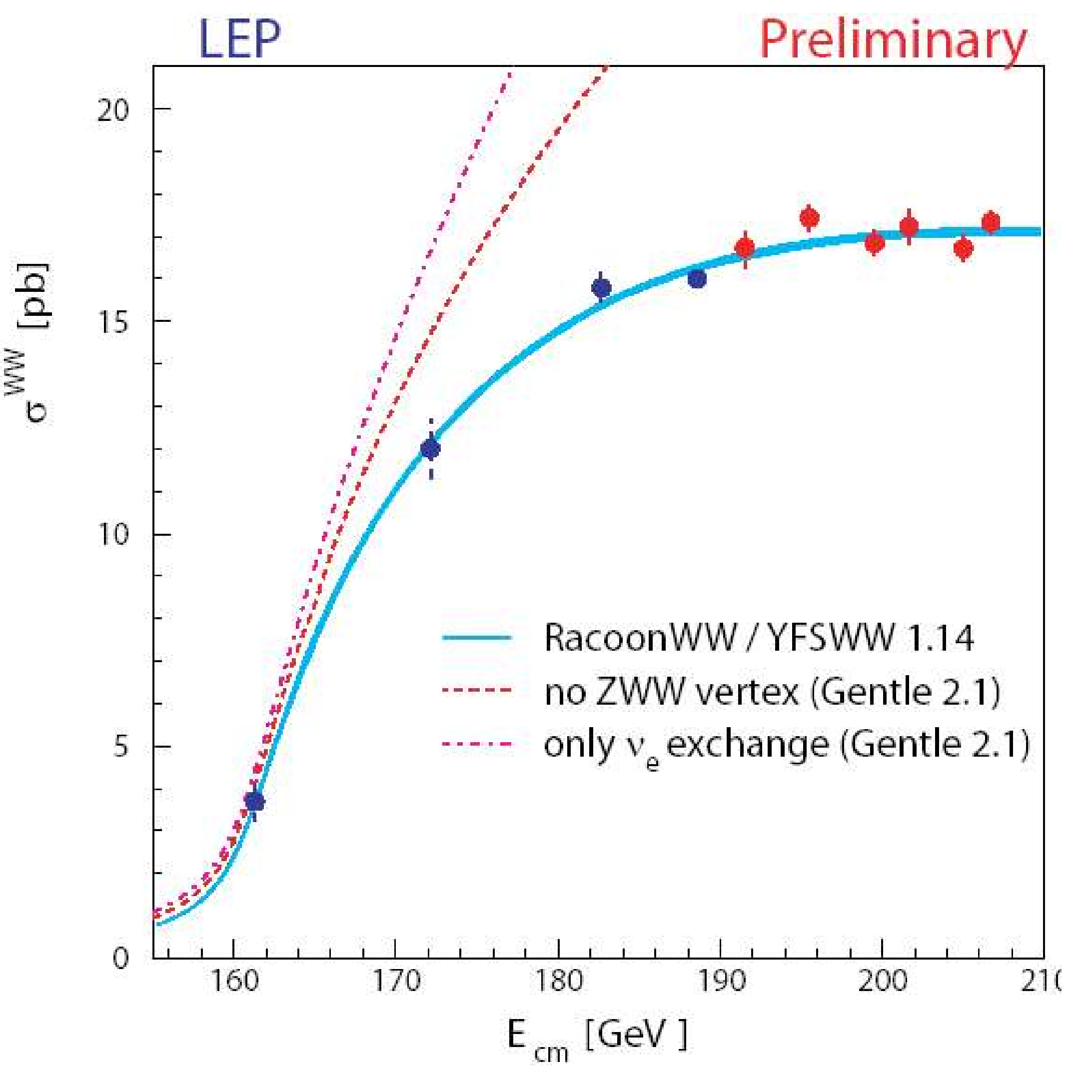
$$\frac{m_\mathrm{W}}{m_\mathrm{Z}} = \cos\theta_w$$

W pair production at LEP



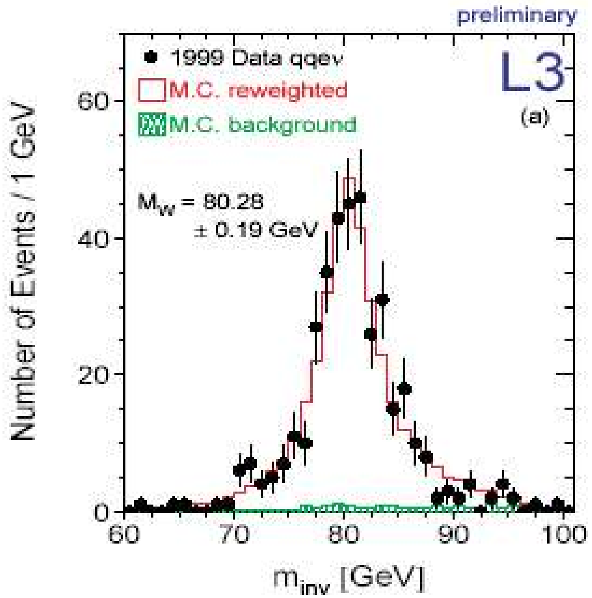


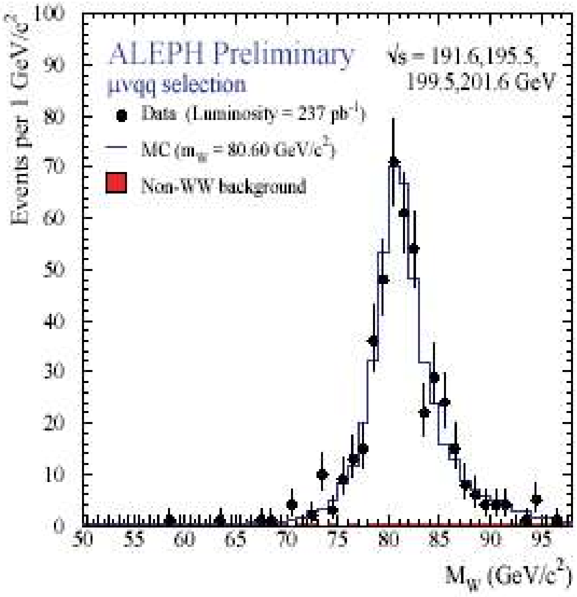
Individual contributions from ν, γ and Z exchange violate unitarity!



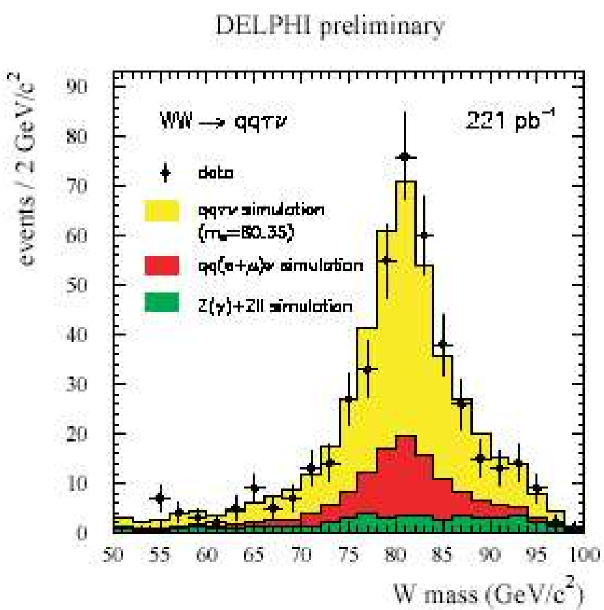
W mass distributions

qq eν

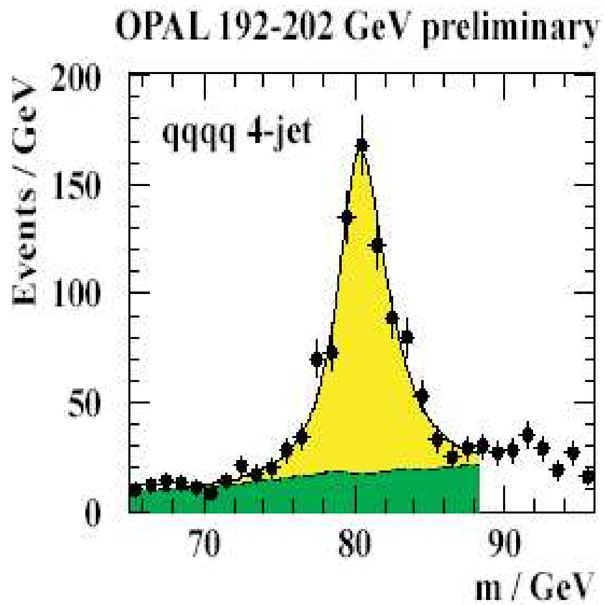




qq $\mu\nu$



qq $\tau\nu$

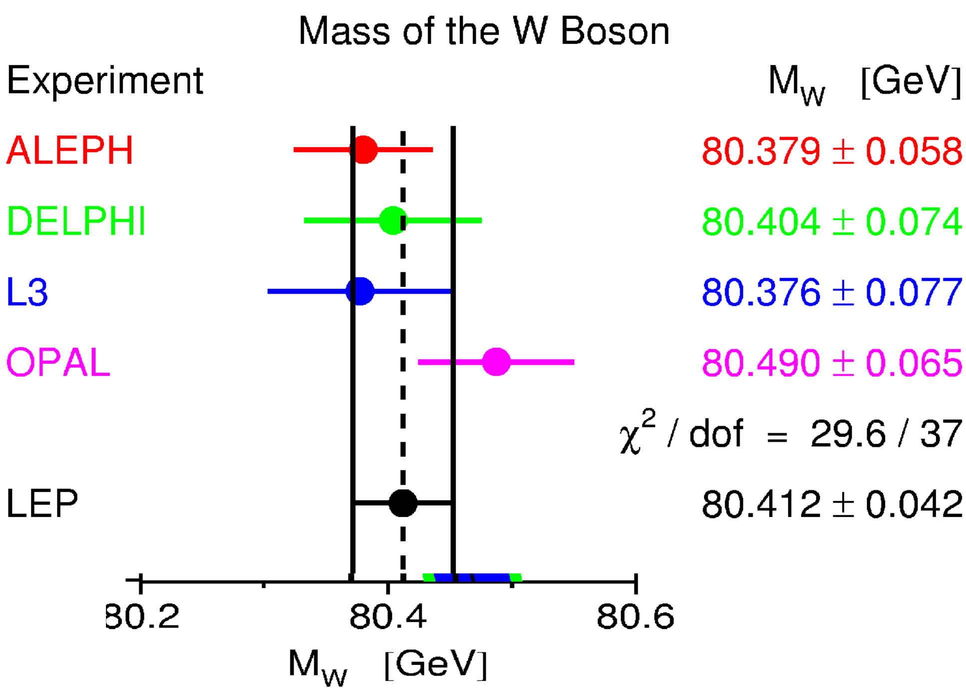


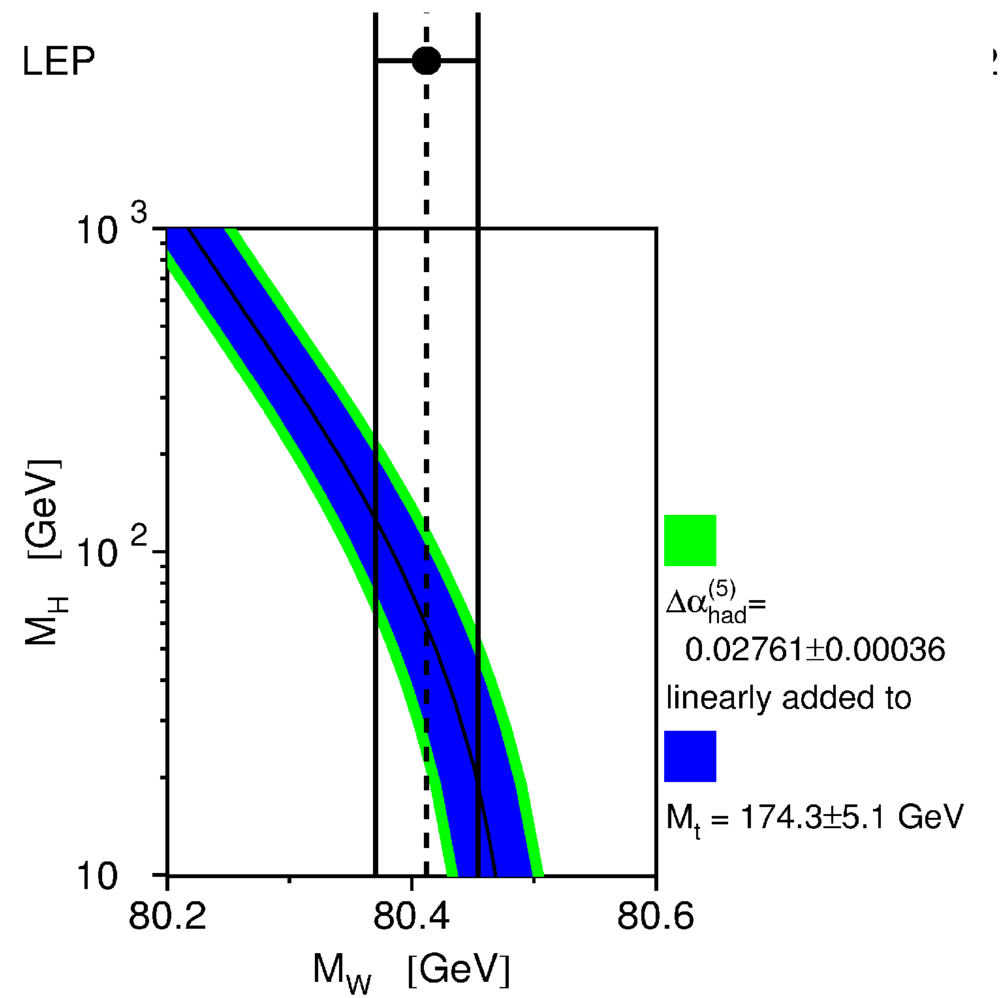
qq qq

(see talk A. Moutoussi)

W mass at LEP

Light Higgs preferred





Combination of the 4 experiments

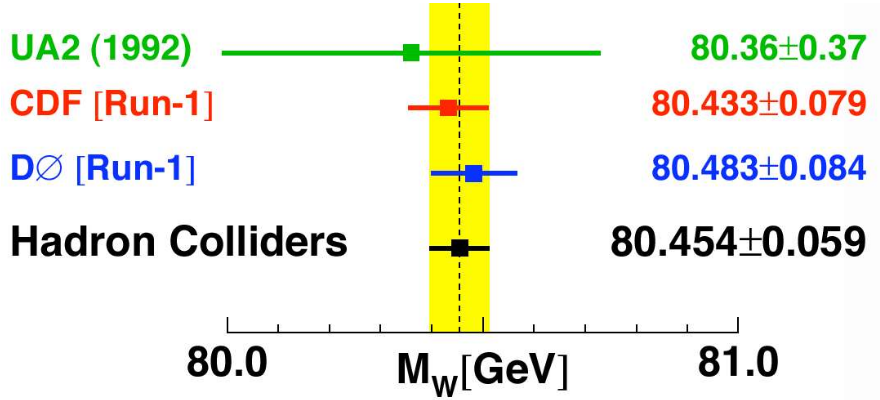
$m_W = 80.412 \pm 0.029(\text{stat}) \pm 0.031(\text{syst})$ GeV

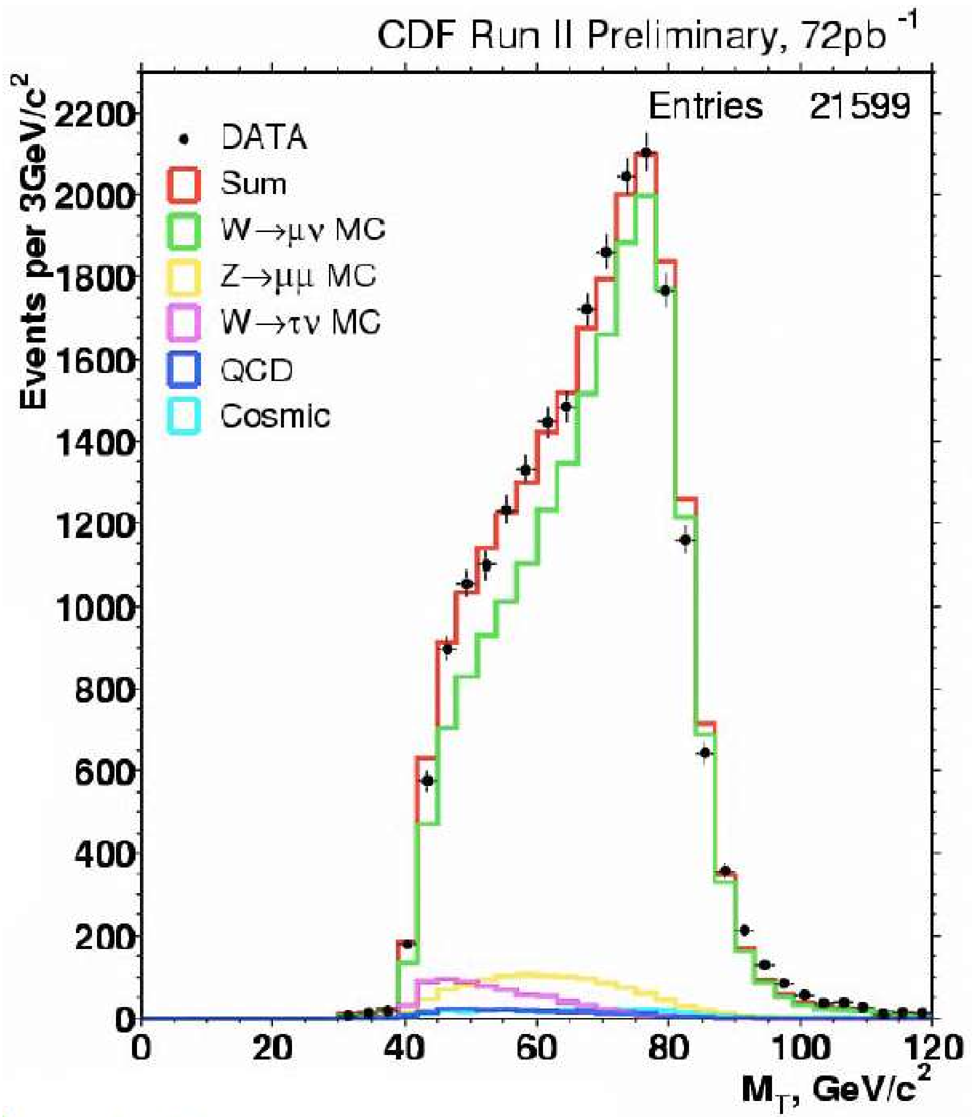
W mass at Tevatron

CDF and D0 fit transverse mass

Energy scale given by Z decays

Systematics will decrease with increased statistics

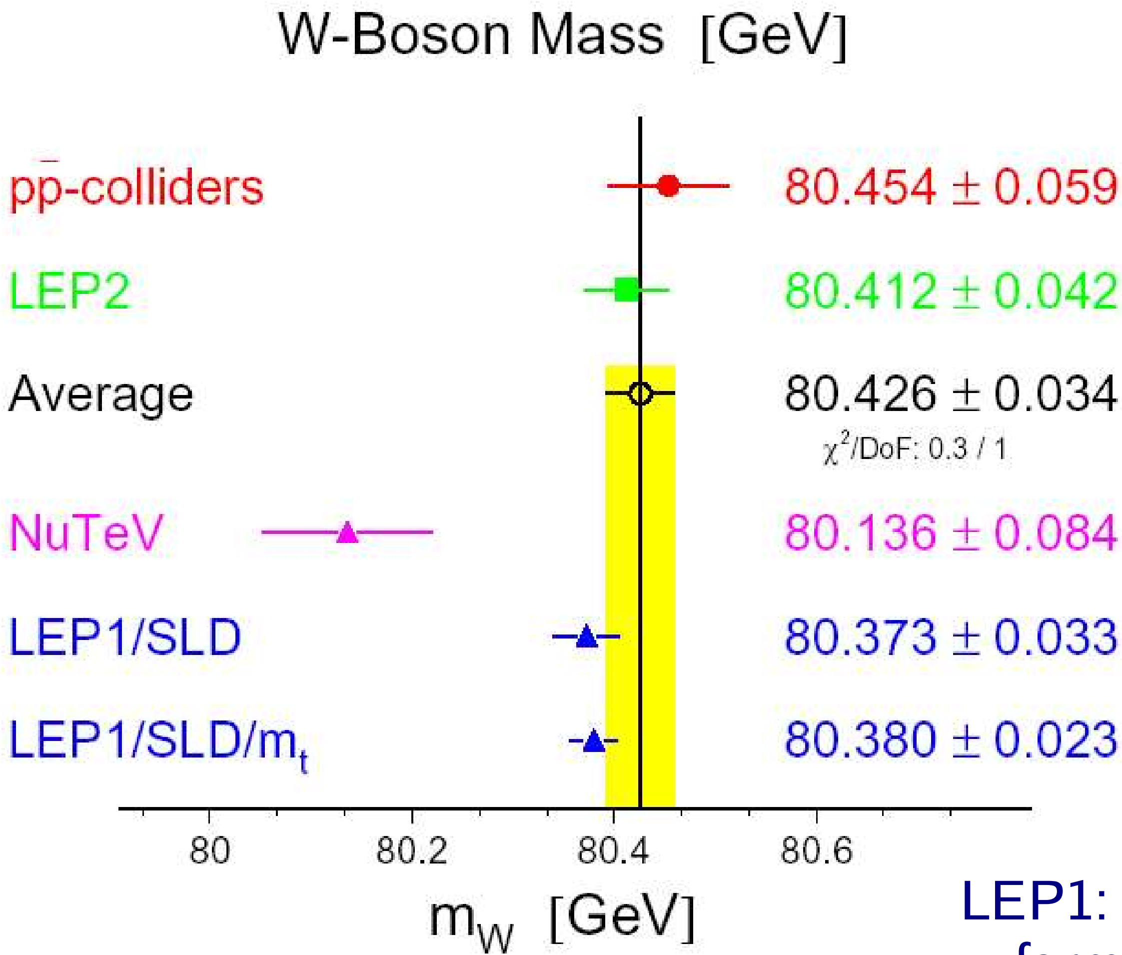




Combination of CDF and D0

$m_W = 80.454 \pm 0.059$ GeV

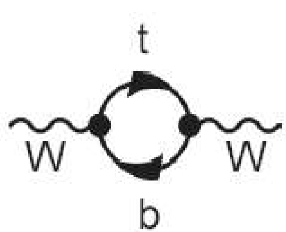
World average of W mass



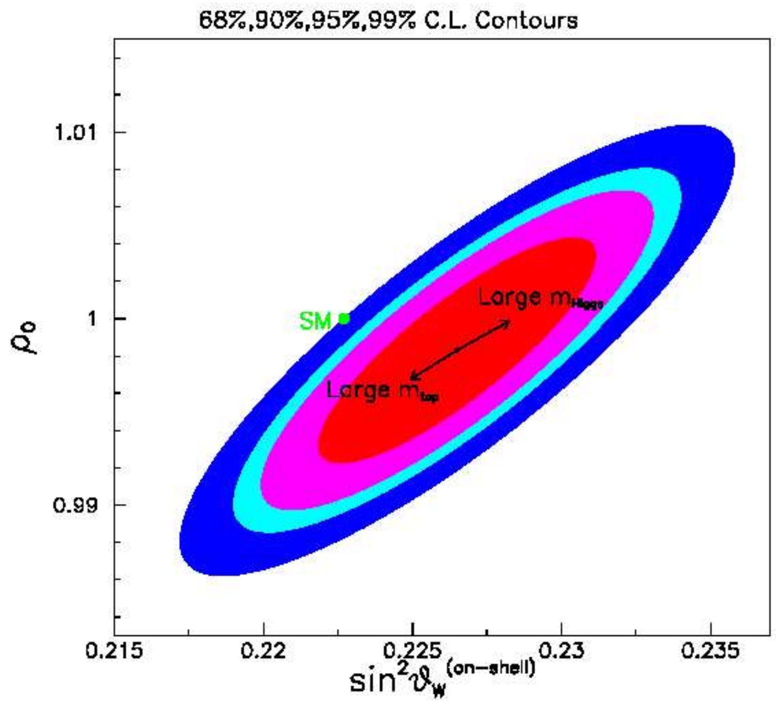
LEP1: Couplings of fermions to the Z $\sin^2\theta_w$

Relation to boson masses via the Higgs mechanism $m_\mathrm{W} = m_\mathrm{Z}\cos\theta_w$

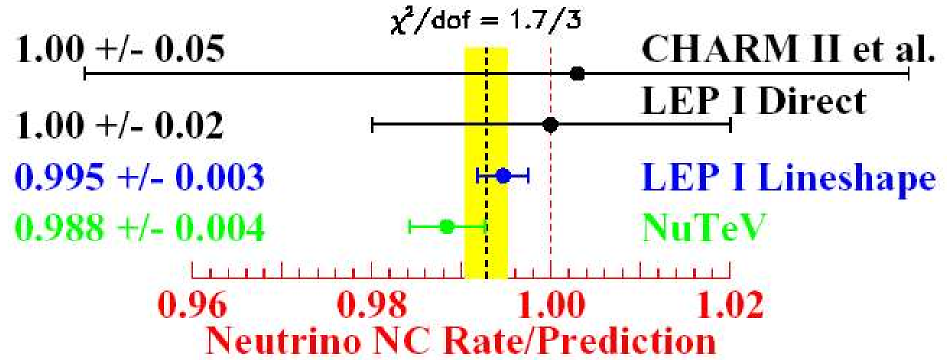
Additional dependence on the top mass due to radiative corrections



NuTeV Result



$$\frac{\sigma_{NC}^{\nu}-\sigma_{NC}^{\bar{\nu}}}{\sigma_{CC}^{\nu}-\sigma_{CC}^{\bar{\nu}}} = \rho^2\left(\frac{1}{2}-\sin^2\theta_W\right)$$



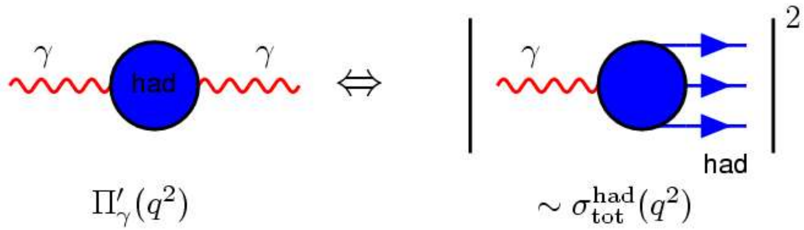
Could be explained by smaller NC coupling of neutrinos compared to SM

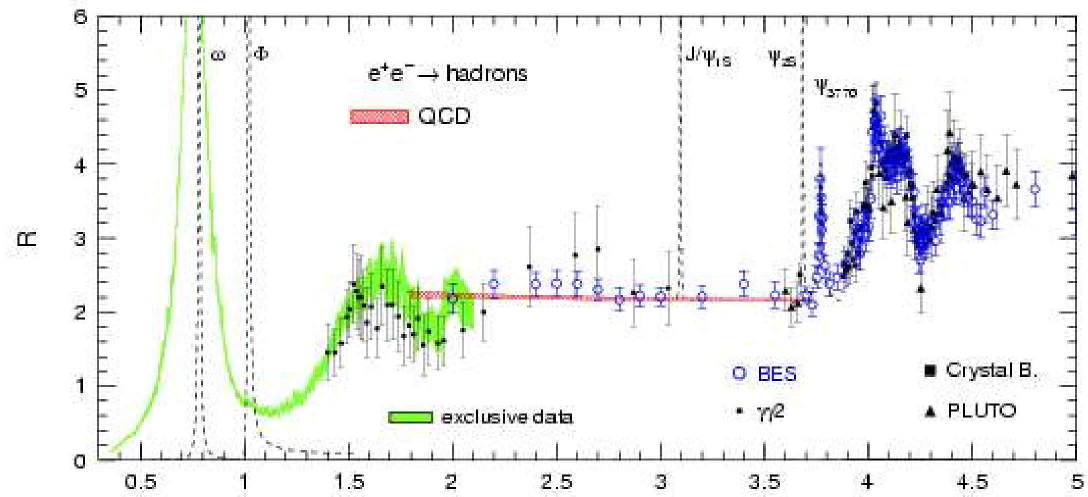
Other (more probable) explanations:

- QCD effects: non-isoscalar contributions, asymmetry in strange-sea, improved PDF's (see talks/discussion S. Kretzer, D. Mason)
- New electroweak corrections by Diener, Dittmaier, Hollik
  - differences to old calculations (Bardin et al)
  - result depends strongly on photon treatment in final state
  - uncertainty order of magnitude higher than assumed by NuTeV

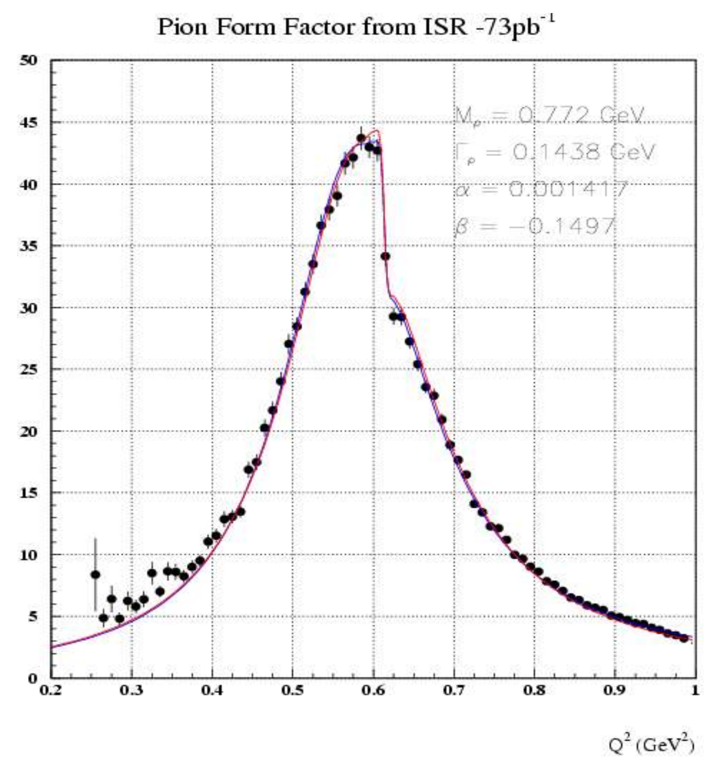
Calculation of $\alpha(m_Z)$

Uncertainty in $\alpha(m_Z)$ dominated by hadronic vacuum polarisation





Measurement of $e^+e^- \rightarrow$ hadrons



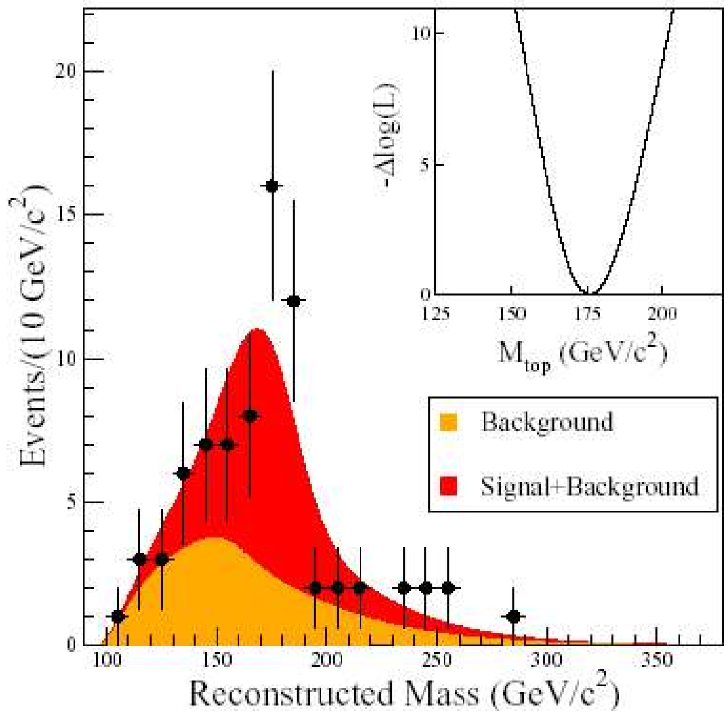
Important region at ω resonace (782 MeV):

- CMD-2 detector at VEPP Novosibirsk
- Measurement from KLOE (rad. return from ϕ) (see talk A. Denig)
- Rad. return from Υ at BaBar (see talk F. Anulli)

Most recent CMD-2 result changes $\alpha(m_Z)$ from 0.02761 ± 0.00036 to 0.02768 ± 0.00036 (Burkhard and Pietrzyk)

Measurement of Top Mass

Tevatron (CDF,D0): $p\bar{p} \rightarrow t\bar{t}X, \;\; t\bar{t} \rightarrow b\bar{b}WW$



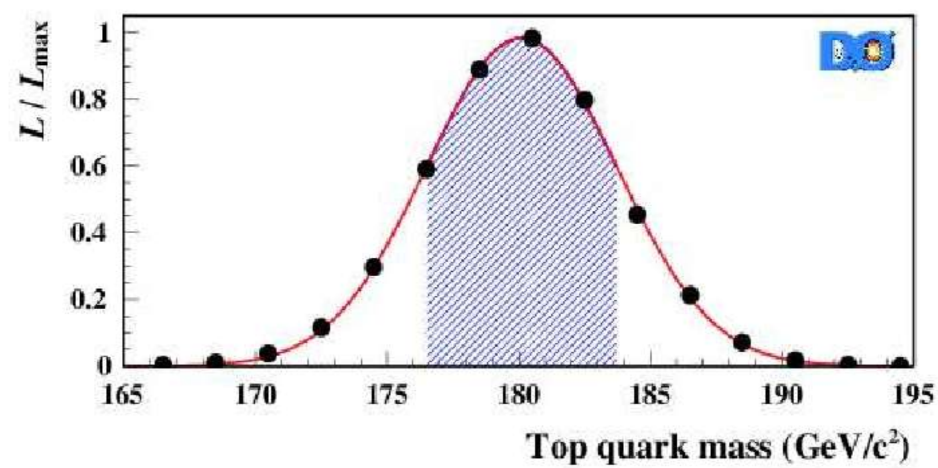
m_t = 174.3 ± 3.2(stat) ± 4.0(syst) GeV

(until yesterday)

Systematics dominated by:

- Energy scale
- Monte Carlo model

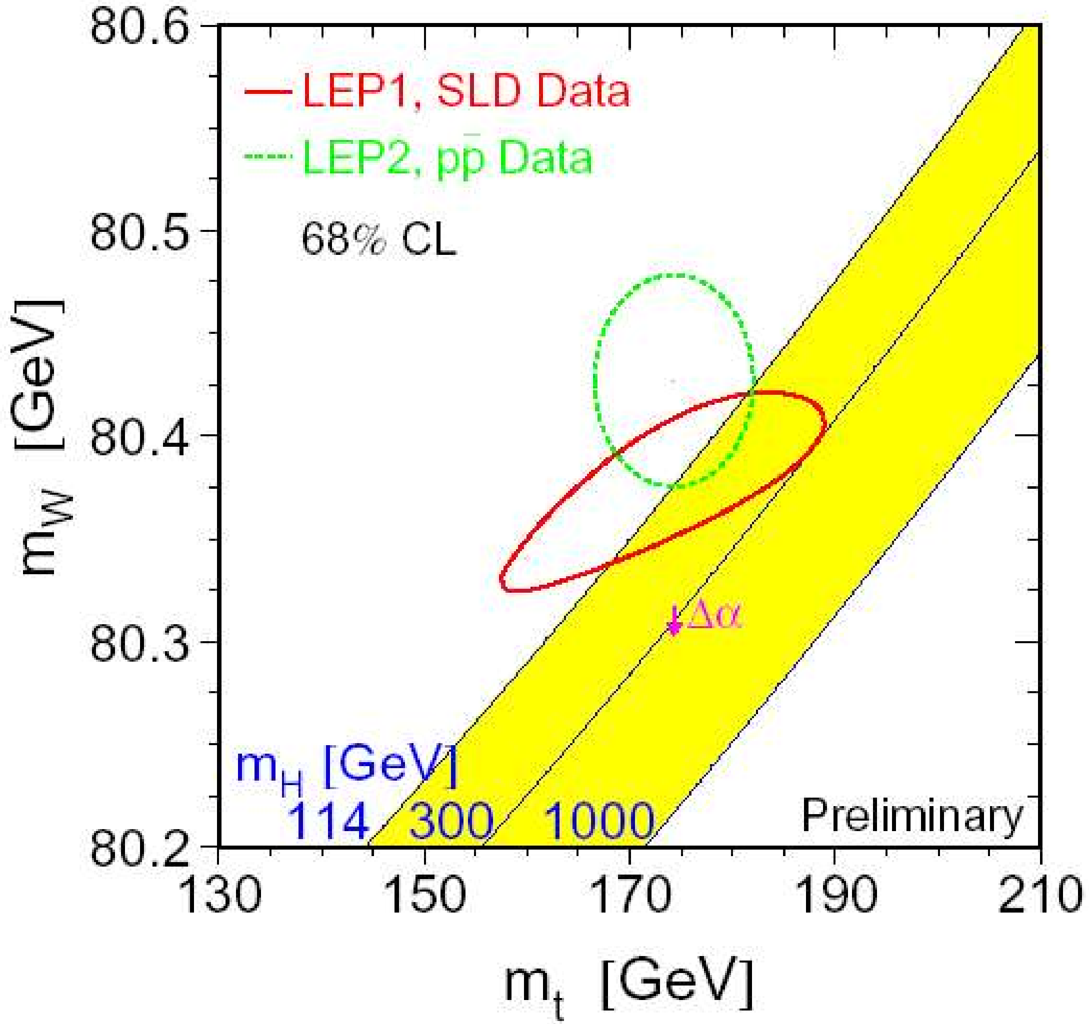
will improve with data statistics



Recent updates (see talk L. Cerrito)

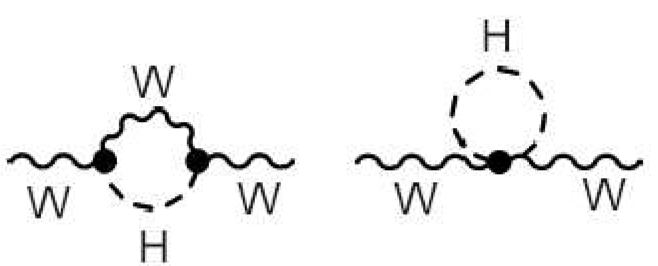
- Improved D0 analysis of Run I data: m_t now 7 GeV higher
- First results from Run II, prospects: $\delta\, m_t < 3$ GeV
- New Combination gives m_t = 178.0 ± 2.7(stat) ± 3.3(syst) GeV

Measurements vs Standard Model



old top mass !

Dependence on Higgs mass :

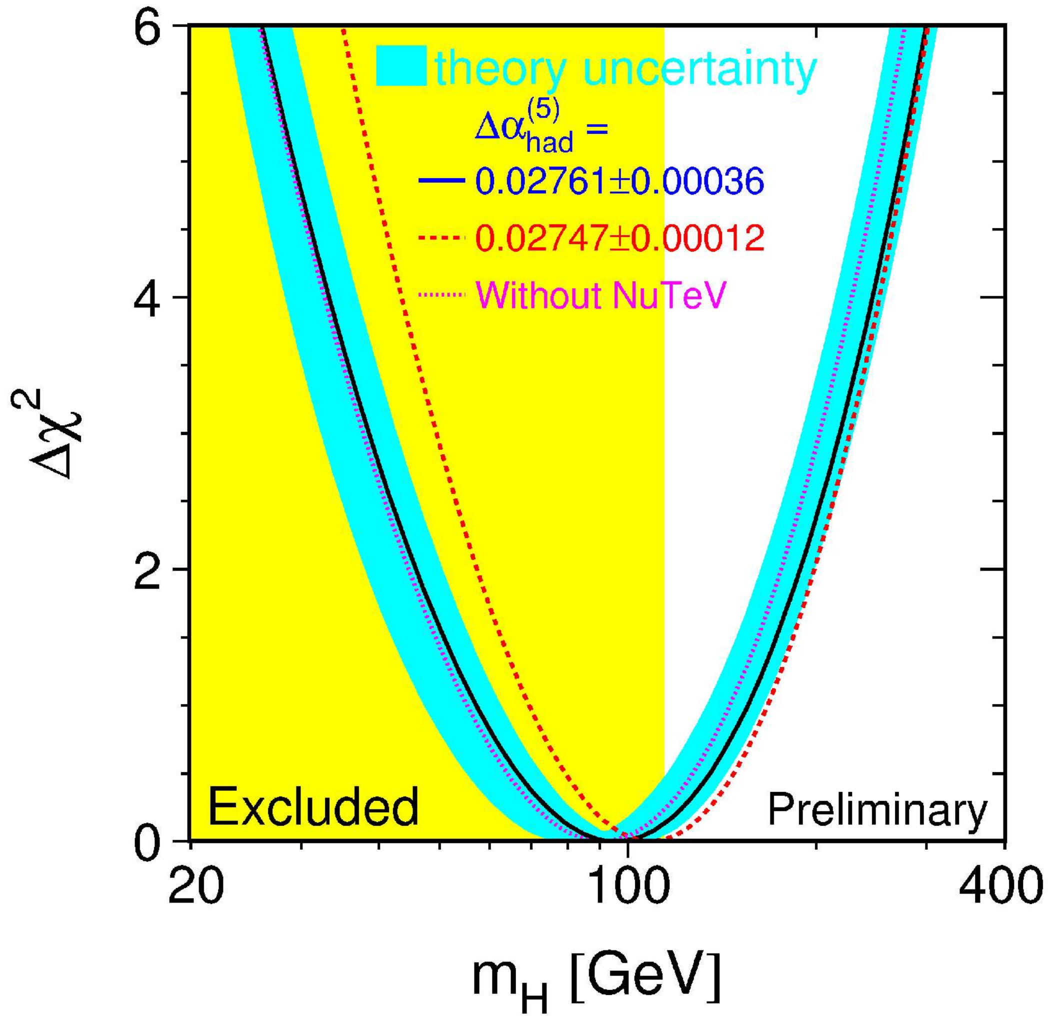


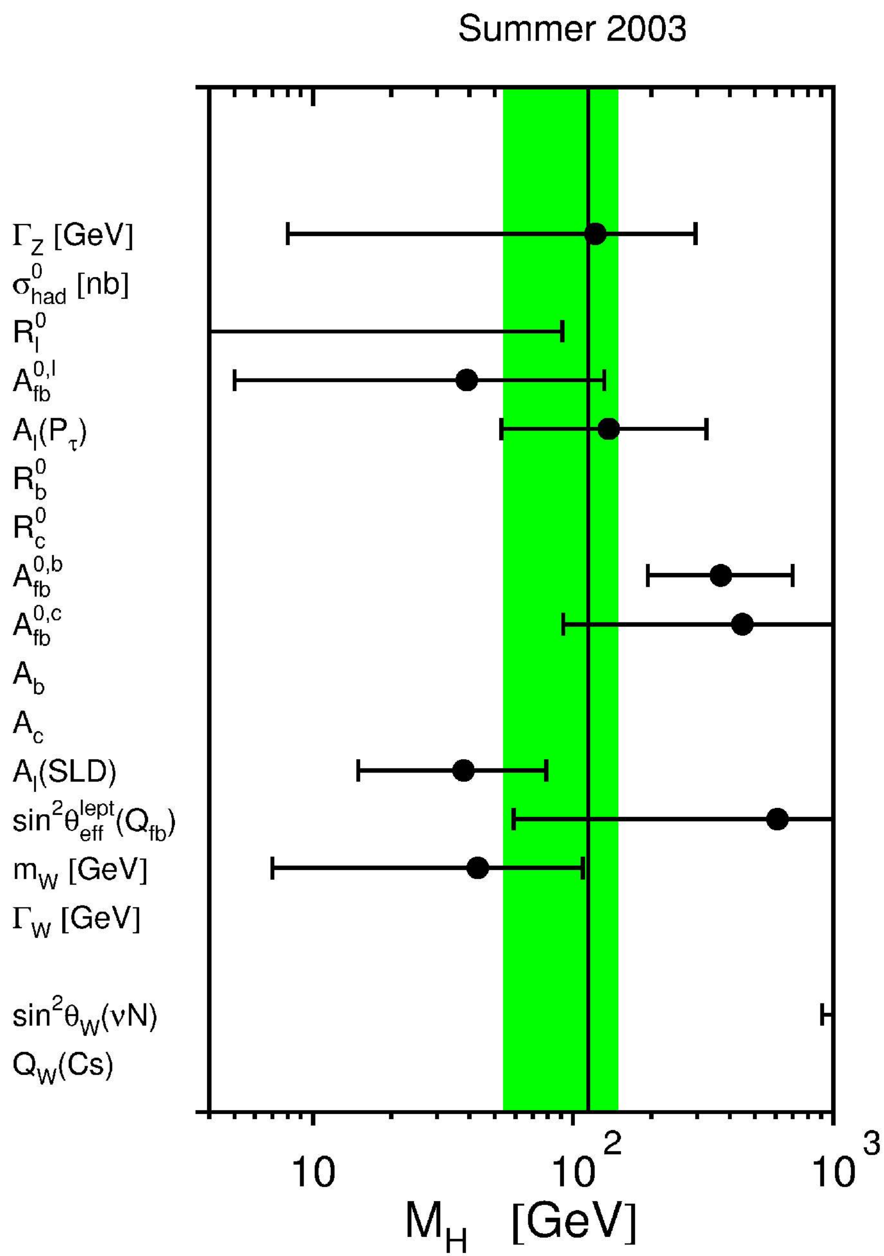
$$\propto \log\left(\frac{m_H}{m_W}\right)$$

Higgs mass upper bound: $m_H < 219$ GeV at 95% C.L.

Prediction of Higgs mass

old top mass !



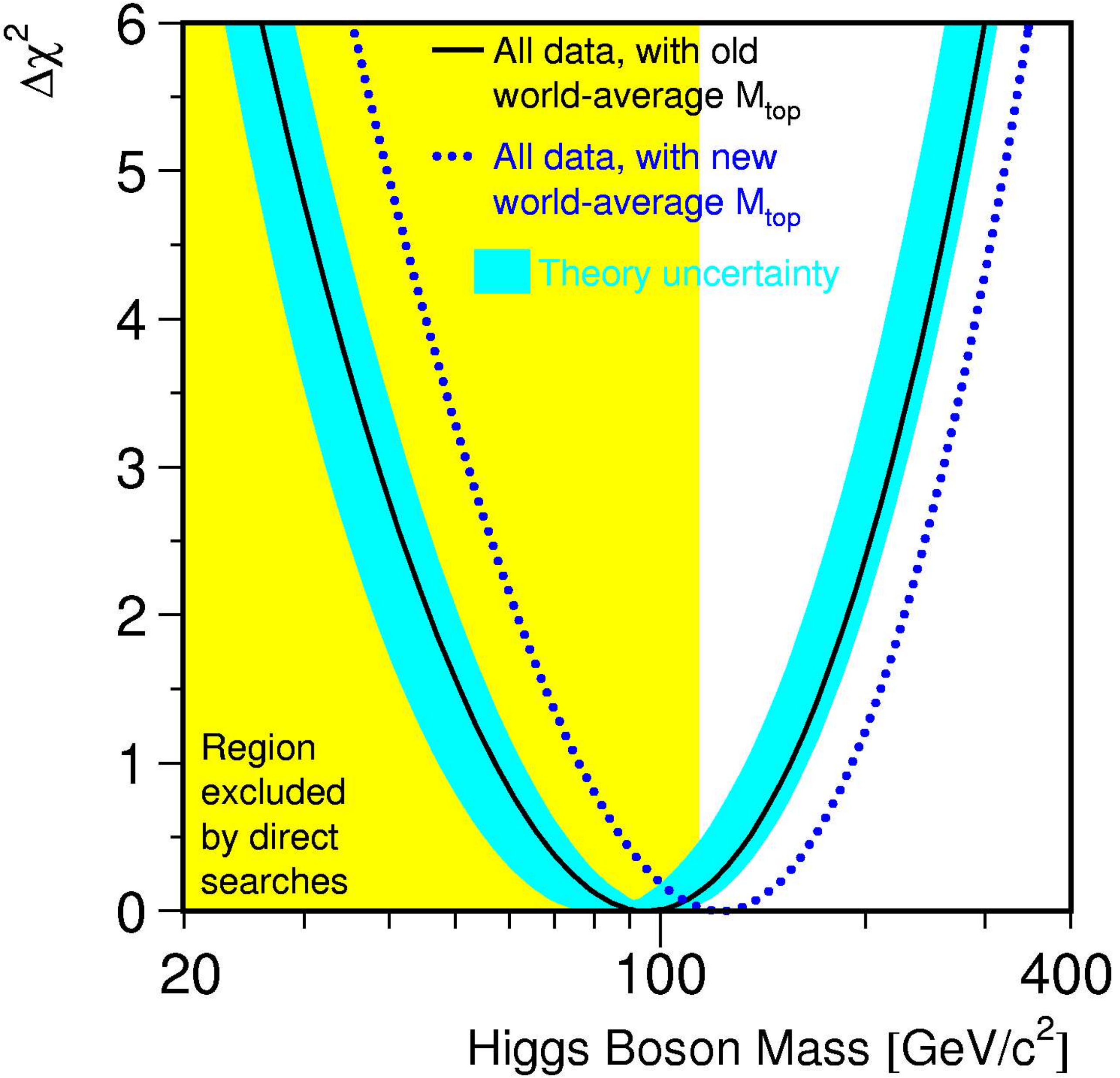


$m_H < 219$ GeV at 95% C.L.

Higgs mass for new Top mass

Tevatron (CDF,D0): new combination gives

$m_t = 178.0 \pm 4.3$ GeV

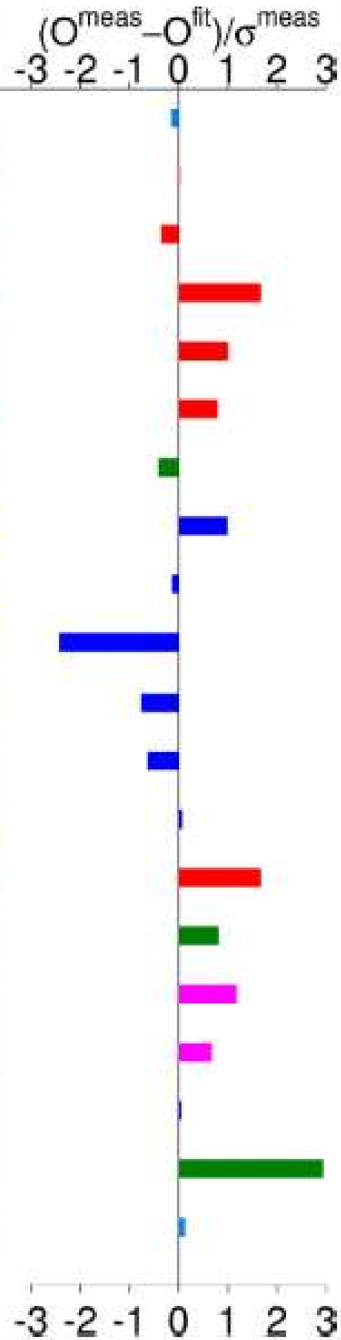


New fit for Higgs mass :

- Central value:
  96 GeV → 117 GeV
- Bound:
  219 GeV → 251 GeV

Global SM Fit

	Measurement	Pull
$\Delta\alpha^{(5)}_{had}(m_Z)$	0.02761 ± 0.00036	-0.16
m_Z [GeV]	91.1875 ± 0.0021	0.02
Γ_Z [GeV]	2.4952 ± 0.0023	-0.36
σ^0_{had} [nb]	41.540 ± 0.037	1.67
R_l	20.767 ± 0.025	1.01
$A^{0,l}_{fb}$	0.01714 ± 0.00095	0.79
$A_l(P_\tau)$	0.1465 ± 0.0032	-0.42
R_b	0.21644 ± 0.00065	0.99
R_c	0.1718 ± 0.0031	-0.15
$A^{0,b}_{fb}$	0.0995 ± 0.0017	-2.43
$A^{0,c}_{fb}$	0.0713 ± 0.0036	-0.78
A_b	0.922 ± 0.020	-0.64
A_c	0.670 ± 0.026	0.07
A_l(SLD)	0.1513 ± 0.0021	1.67
$\sin^2\theta^{lept}_{eff}(Q_{fb})$	0.2324 ± 0.0012	0.82
m_W [GeV]	80.426 ± 0.034	1.17
Γ_W [GeV]	2.139 ± 0.069	0.67
m_t [GeV]	174.3 ± 5.1	0.05
$\sin^2\theta_W(\nu N)$	0.2277 ± 0.0016	2.94
$Q_W(Cs)$	-72.83 ± 0.49	0.12



Fit to all data:

χ^2/dof = 25.5 / 15 (4.4%)

Fit without NuTeV:

χ^2/dof = 16.7 / 14 (27%)

fitted parameters almost unchanged

Conclusions

Reasonable agreement between experiment and theory in global Standard Model Fit

Light Higgs mass is preferred

Future prospects:

- Final W mass from LEP
- Improved top and W mass from Tevatron
- Find Higgs and measure its mass at LHC
- Electroweak precision tests at LC (GigaZ...)