M_{top} and M_{Higgs} from EW fits

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L3 experiment

Moriond QCD
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Introduction

Measurements

The SM and radiative corrections

Fits

Results

Conclusions

Data from the following experiments are fitted to test the SM:

LEP $e^+e^- \rightarrow Z^\circ \rightarrow f\bar{f}$

SLD(linear collider) $e^+e^- \rightarrow Z^\circ \rightarrow f\bar{f}$
polarised e^- beam

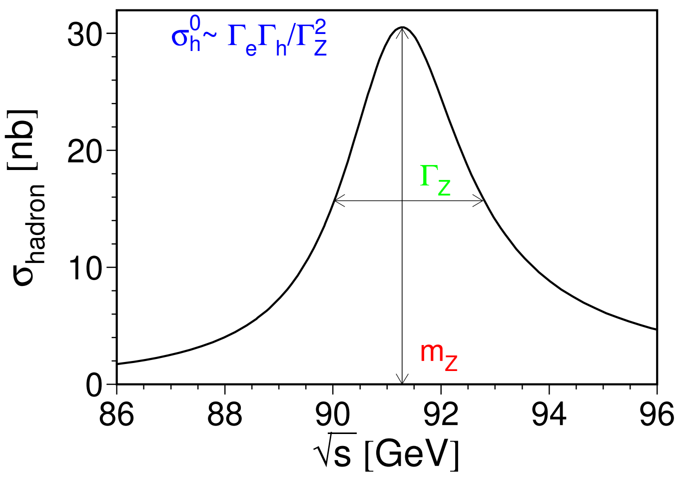
$p\bar{p}$ **experiments** m_W, m_t

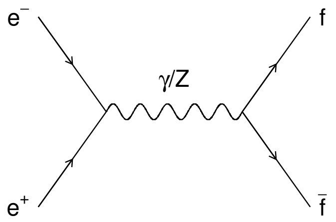
ν **N experiments** $1 - m_W^2/m_Z^2$

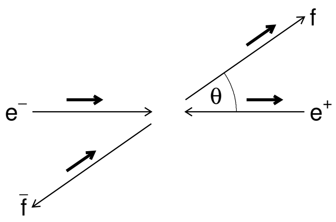
Most results are still preliminary

Fits from LEPEWWG
Thanks to C.Paus and B. Clare for the useful discussions.

Introduction







cross section:

$$\sigma^\circ_{f\bar{f}} \sim \frac{\Gamma_{ee}\,\Gamma_{f\bar{f}}}{\Gamma_Z^2} \qquad \Gamma_{f\bar{f}} = \frac{G_F\; m_Z^3}{6\;\pi\;\sqrt{2}}[g_A^2 + g_V^2](1+\delta_{QED})$$

forward-backward asymmetry:

$$A_{FB} = \tfrac{3}{4}\,A_e\,A_f \qquad A_f = 2\,\frac{\bar{g}_A^f \bar{g}_V^f}{(\bar{g}_A^f)^2+(\bar{g}_V^f)^2}$$

$$A_{LR} = \frac{\sigma(L)-\sigma(R)}{\sigma(L)+\sigma(R)} = A_e$$

$$A_{LR,FB}^f = \tfrac{3}{4}\,A_f$$

tau polarisation:

$$\bar{P}_t(cos\theta) = -\frac{(A_\tau + A_e F(\theta))}{1+A_\tau A_e F(\theta)} \qquad F(\theta) = \frac{2cos\theta}{(1+cos^2\theta)}$$

LEP measurements:

Lineshape and lepton asymmetries

$M_Z = 91.1863 \pm 0.0019\ GeV$

$\Gamma_Z = 2.4947 \pm 0.0026\ GeV$

$\sigma^0_{had} = 41.489 \pm 0.055\ nb$

$R_l = 20.783 \pm 0.029$ $(R_l = \Gamma_{had}/\Gamma_l)$

$A^{0,l}_{fb} = 0.00177 \pm 0.0010$

τ polarisation

$A_\tau = 0.1401 \pm 0.0067$ $(A_l = \frac{2\bar{g}_{vl}\bar{g}_{al}}{\bar{g}^2_{vl}+\bar{g}^2_{al}})$

$A_e = 0.1382 \pm 0.0076$

b and c quark results

$R_b = 0.2179 \pm 0.0011$ $(R_q = \Gamma_q/\Gamma_{had})$

$R_c = 0.1720 \pm 0.0056$

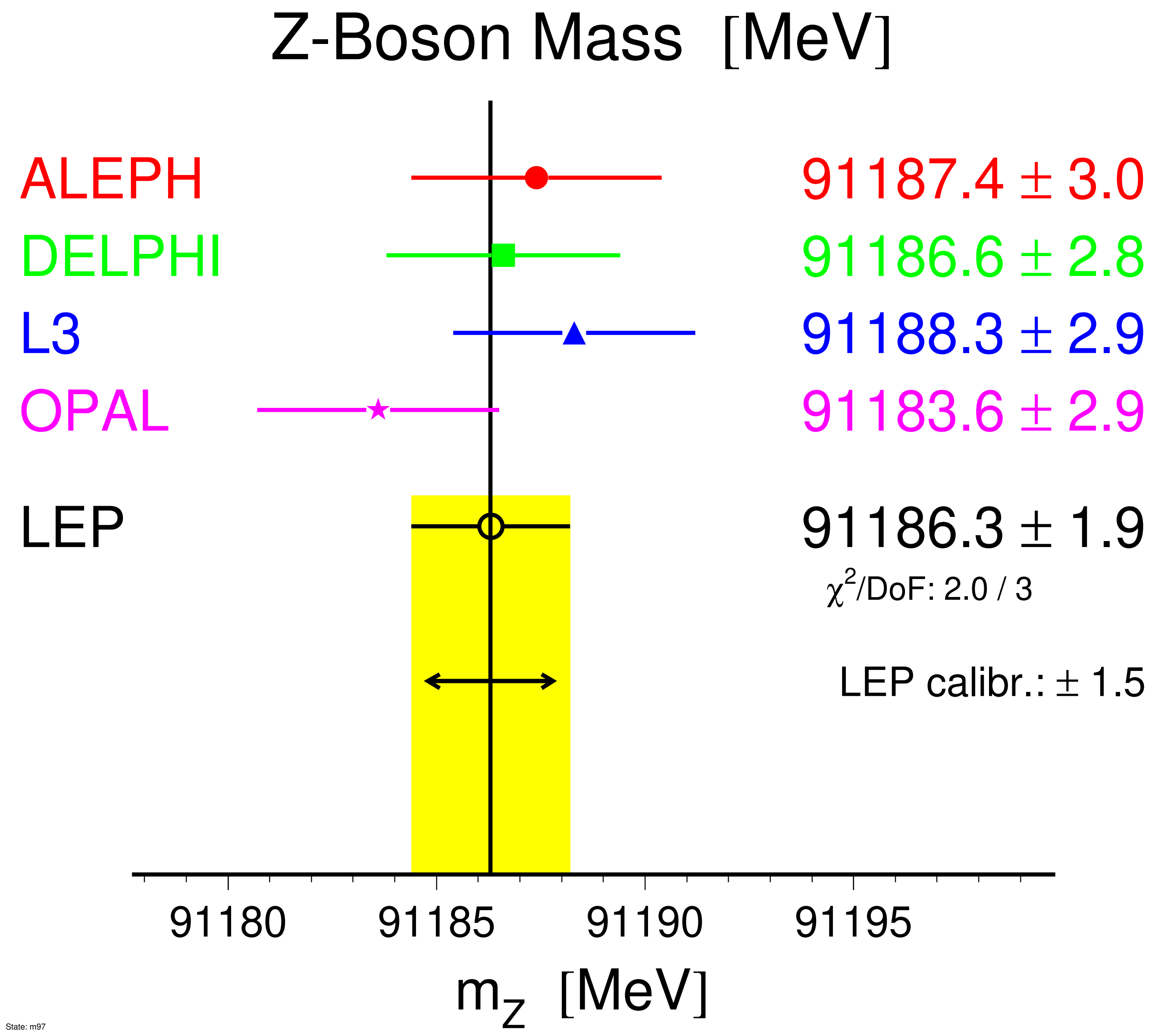
$A^{0,b}_{fb} = 0.0985 \pm 0.0022$

$A^{0,c}_{fb} = 0.0734 \pm 0.0048$

$q\bar{q}$ charge asymmetry

$sin^2\theta^l_{eff}(< Q_{fb} >) = 0.2322 \pm 0.0010$

Measurements



$$\Delta m_Z / m_Z = 22 \cdot 10^{-6}$$

$$\Delta G_F / G_F = 20 \cdot 10^{-6}$$

$$\Delta \alpha / \alpha = 700 \cdot 10^{-6} \; at \; m_Z^2$$

Measurements from other experiments:

$p\bar{p}$ experiments CDF, DØ, UA2:

$m_W = 80.37 \pm 0.10 GeV$

$m_{top} = 175.6 \pm 5.5 GeV$

νN experiments CCFR, CDHS, CHARM:

$1 - m_W^2/m_Z^2 = 0.2244 \pm 0.0042$

SLD:

from left right asymmetry

$sin^2\theta^l_{eff} = 0.23055 \pm 0.00041$

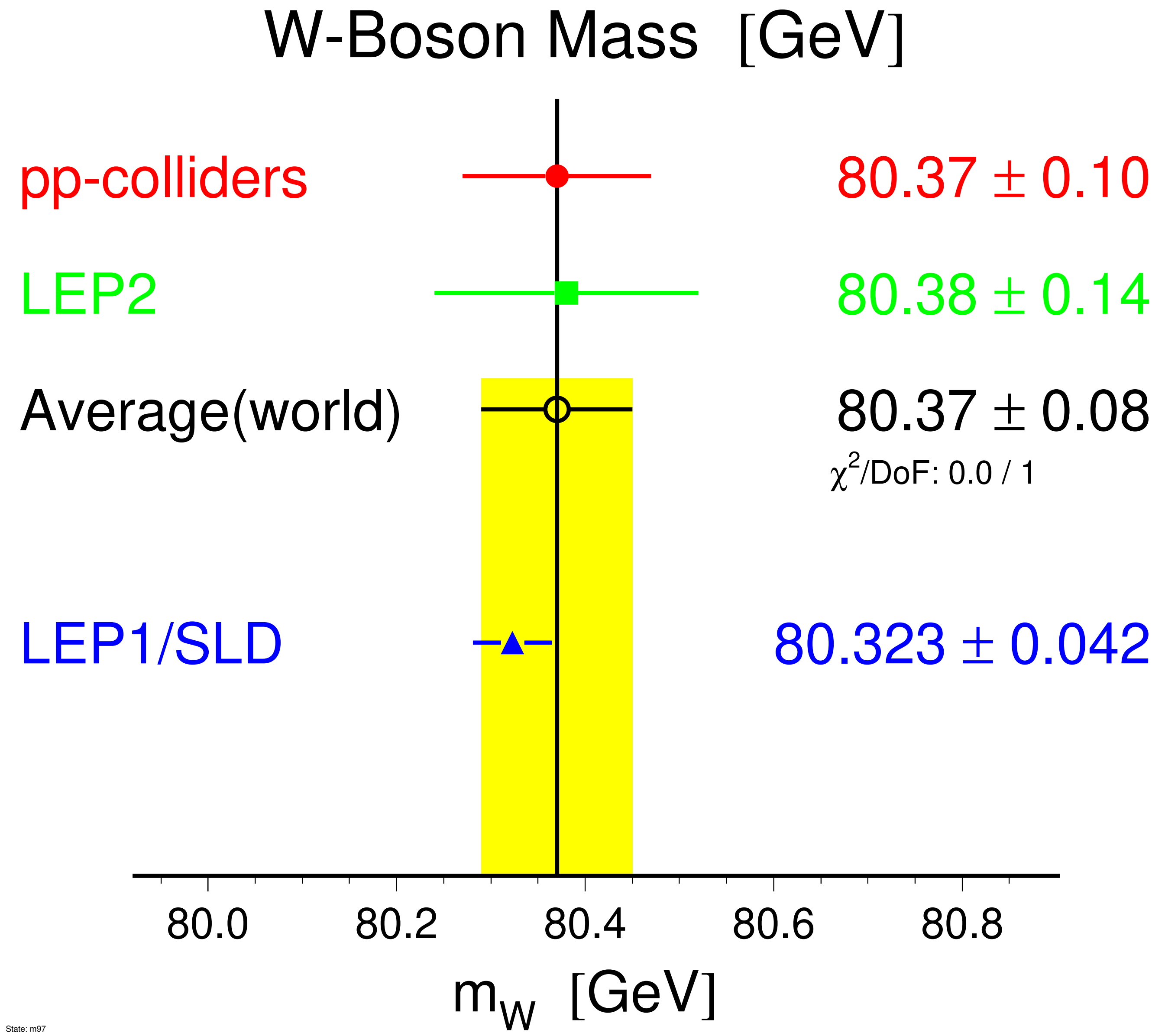
from b and c quark results

$R_b = 0.2149 \pm 0.0038$

$R_c = 0.1756 \pm 0.0181$

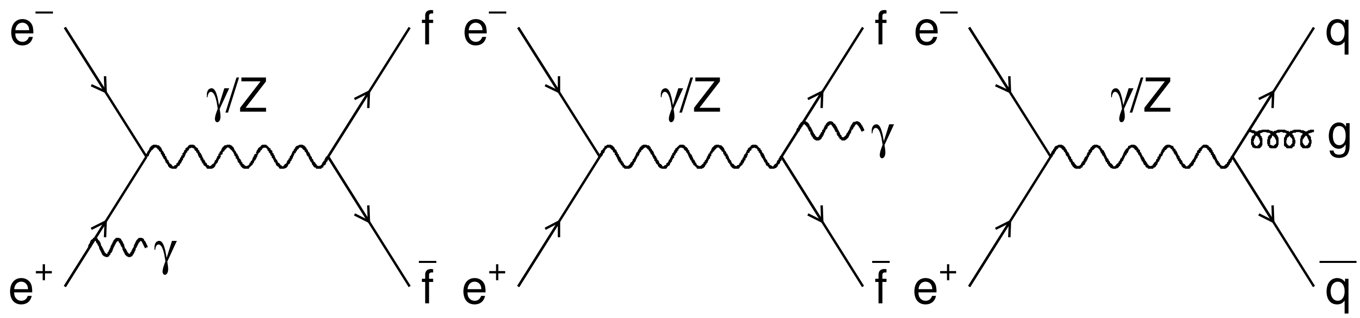
$A_b = 0.877 \pm 0.047$

$A_c = 0.623 \pm 0.085$


W-Boson Mass [GeV]
pp-colliders
80.37 ± 0.10
LEP2
80.38 ± 0.14
Average(world)
80.37 ± 0.08
χ2/DoF: 0.0 / 1
LEP1/SLD
80.323 ± 0.042
80.0
80.2
80.4
80.6
80.8
mW [GeV]
State: m97

The Standard Model can be parametrised:

- α, α_s QED and QCD coupling
- m_Z, m_W, m_H boson masses
- m_f, V_{ckm} fermion masses and CKM matrix (m_t)



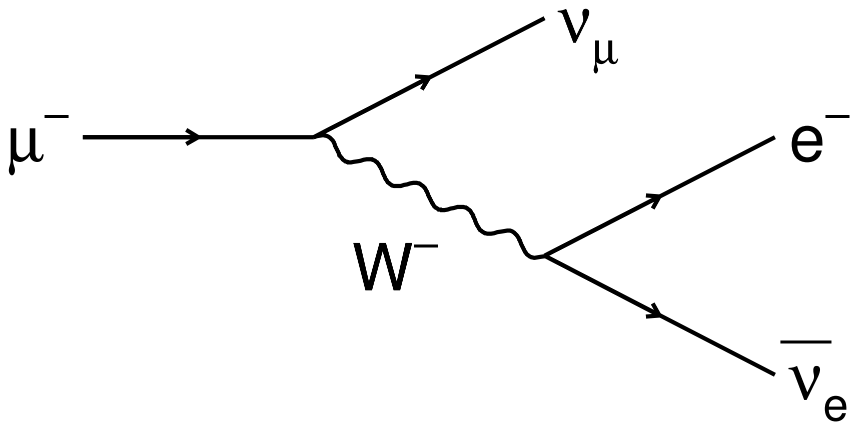
Two of these parameters are constrained using independent measurements:

1. **G_F, Fermi coupling constant, from the muon lifetime**
2. **α, QED coupling, from low energy measurements**

$$G_F = \frac{\pi\alpha(0)}{\sqrt{2}} \cdot \frac{m_Z^2}{m_W^2(m_Z^2 - m_W^2)} \cdot \frac{1}{1-\Delta r}$$

G_F measured in muon decay

$$G_F = (1.16639 \pm 0.00002) \cdot 10^{-5}\, GeV^{-2}$$

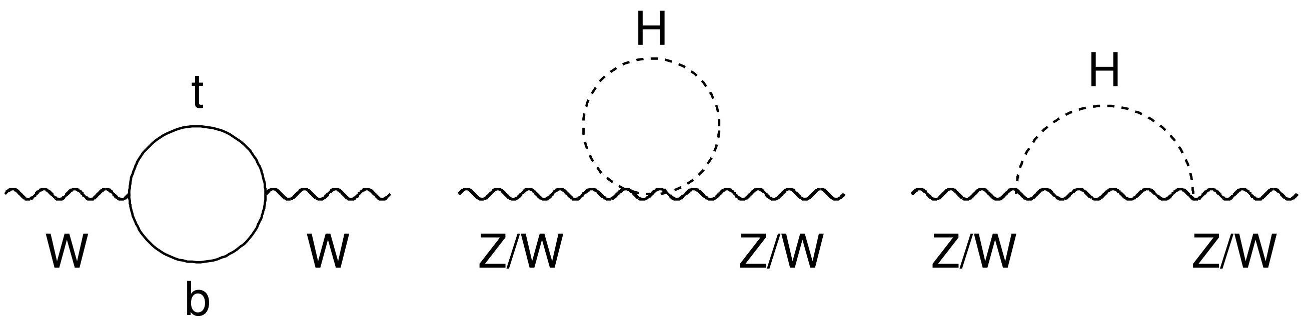


m_W enters directly in the expression of G_F and can be extracted from this measurement

α evolved to m_Z from low energy measurements:

$$1/\alpha = 128.896 \pm 0.090$$ **F.Jegerlehner et al.**

m_t and m_H from radiative corrections in the SM



$$\Delta r(m_t, m_H) = -a \cdot m_t^2 - b \cdot log\, m_t + c \cdot log\, m_H + h.o.$$

a, b, c positive coefficients

m_H and m_t enter in the expression of G_F only as radiative corrections:

m_t in a quadratic form and m_H in a logarithmic form

TEST the radiative corrections in the SM by extracting m_t and m_W
$\Rightarrow$ no direct measurements used

All the electroweak measurements are fitted together using the program ZFITTER: the results of the first fit (without fixing m_t and m_W)

$$m_t = 155^{+10}_{-9}\ GeV$$

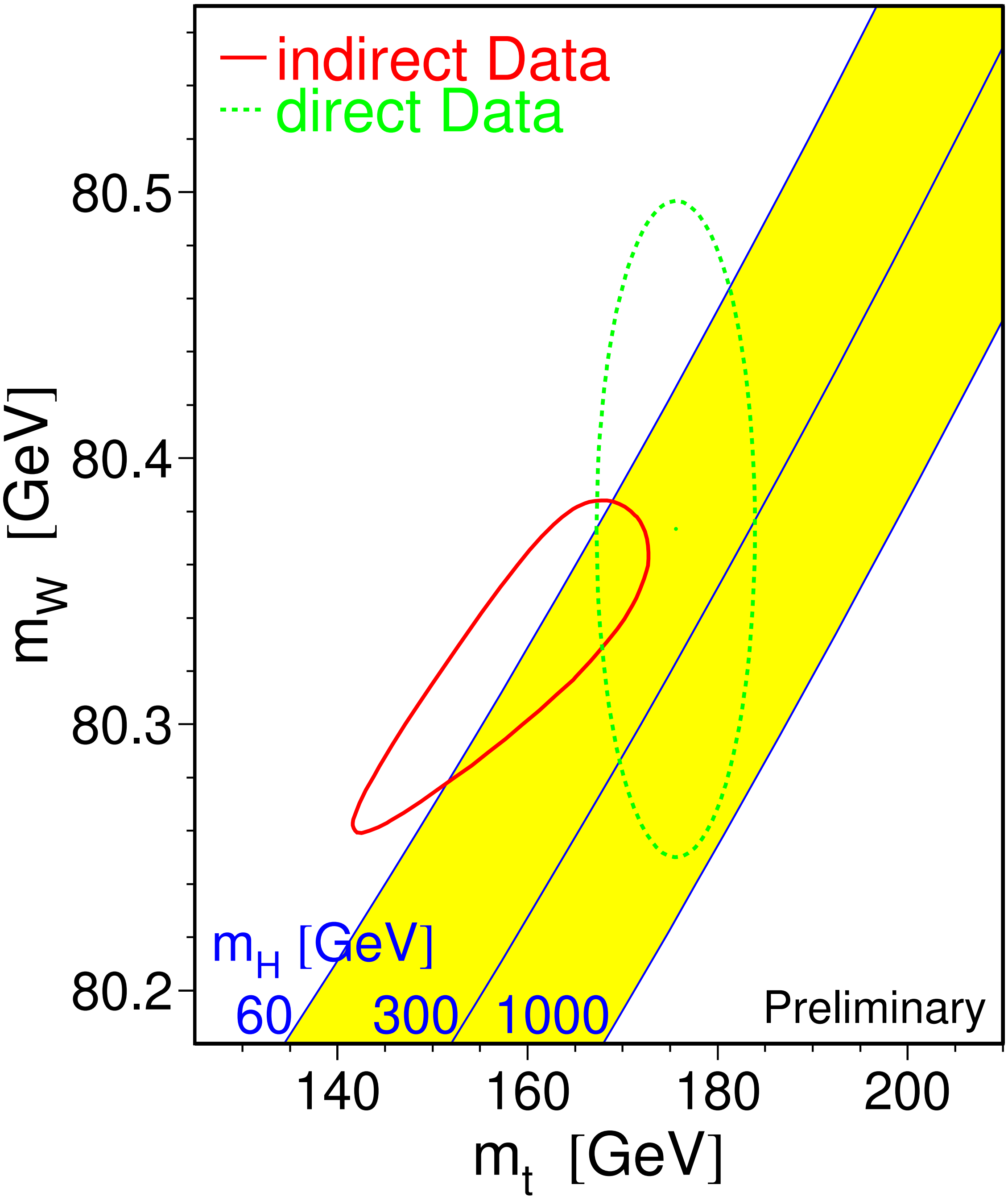
$$m_W = 80.323 \pm 0.042\ GeV$$

comparing these results with the direct measurements, m_t and m_W in good agreement with the mass values:

$m_t = 175.6 \pm 5.5\ GeV$	**CDF/DØ**
$m_W = 80.37 \pm 0.10\ GeV$	**CDF/DØ/UA2**
$m_W = 80.38 \pm 0.14\ GeV$	**LEP2**

PROOF OF THE PREDICTIVE POWER OF THE STANDARD MODEL

68% *c.l.* contours



Influence of G_F on the determination of m_W and m_t

- lost the sensitivity to m_t
- still sensitive to m_W but error factor $\sim$ 1.5 bigger
- error on α_s $\sim$ two times larger (0.003)

LEP(no m_W) + SLD + ν N

$$1/\alpha = 128.955 \pm 0.082$$

$$\alpha_s = 0.114^{+0.006}_{-0.009}$$

$$m_W = 80.12^{+0.15}_{-0.25}\ GeV$$

$$m_Z = 91.1862 \pm 0.0019\ GeV$$

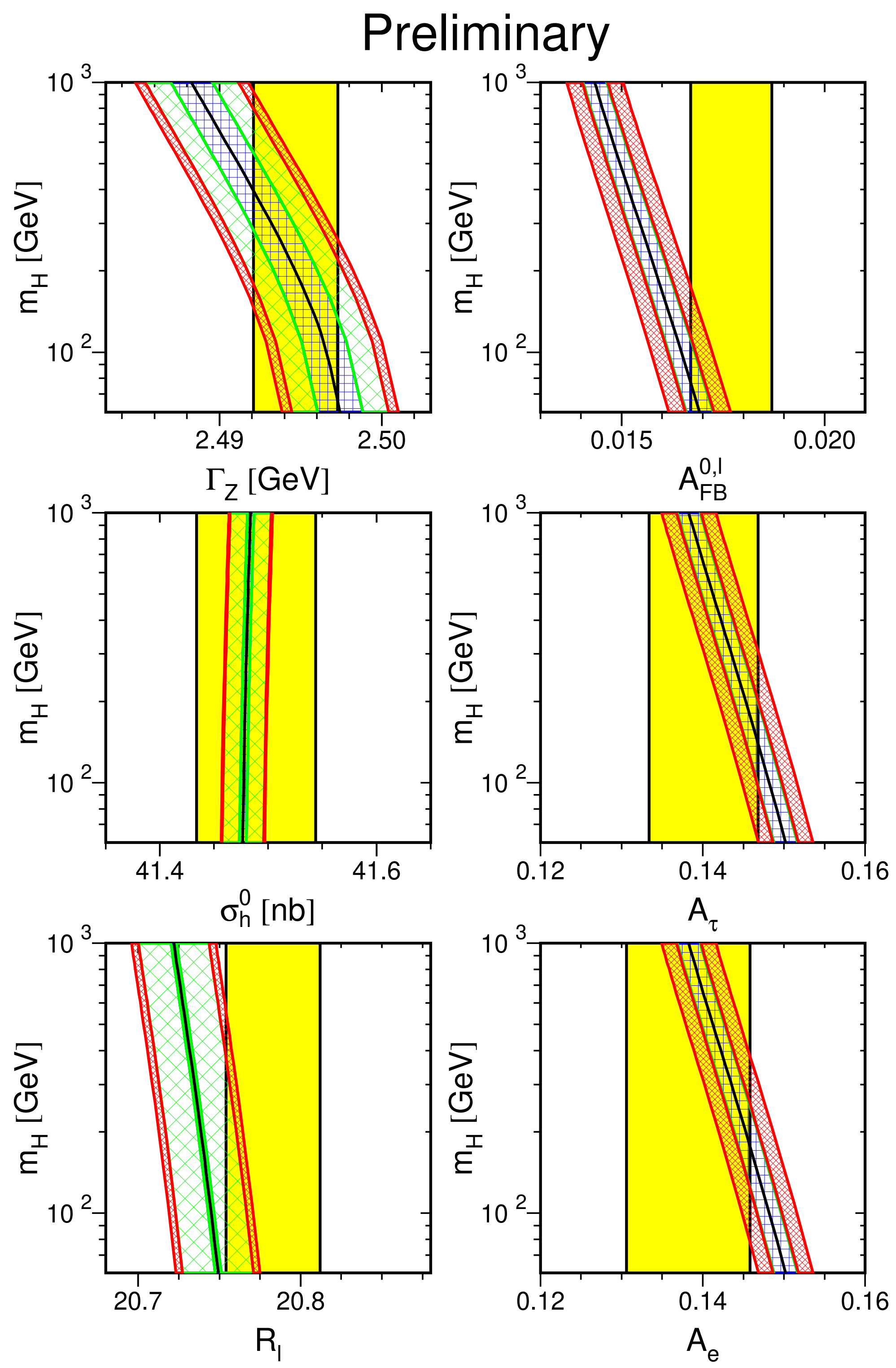
$$m_t = 123^{+36}_{-78}\ GeV$$

no G_F but $1/\alpha$ measurement included

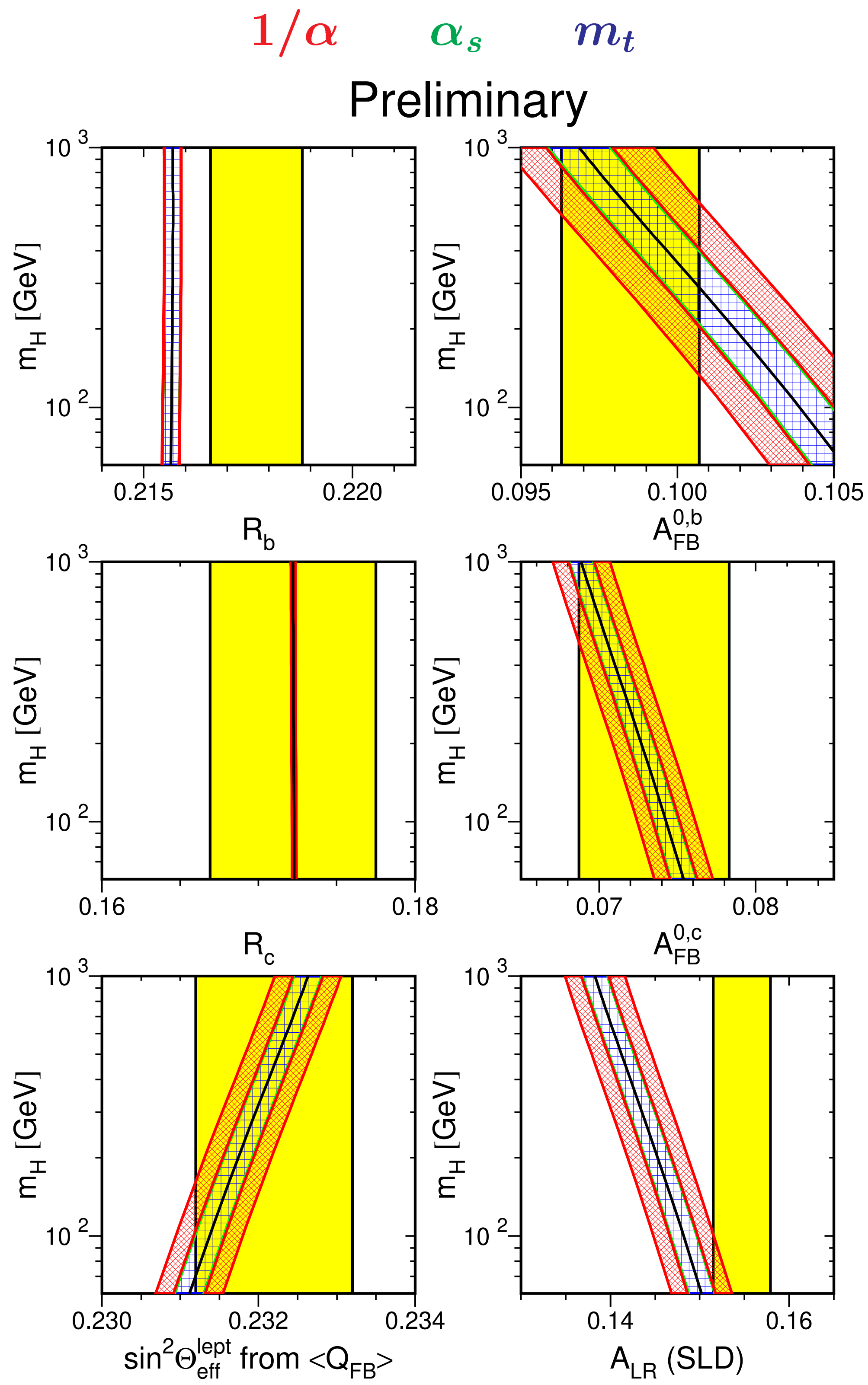
m_H fixed to 300 GeV

Fit for SM Higgs mass

$1/\alpha$ α_s m_t



Fit for SM Higgs mass



Global Standard Model fit

$$Pull = \frac{X - X_{SM}}{\Delta X}$$

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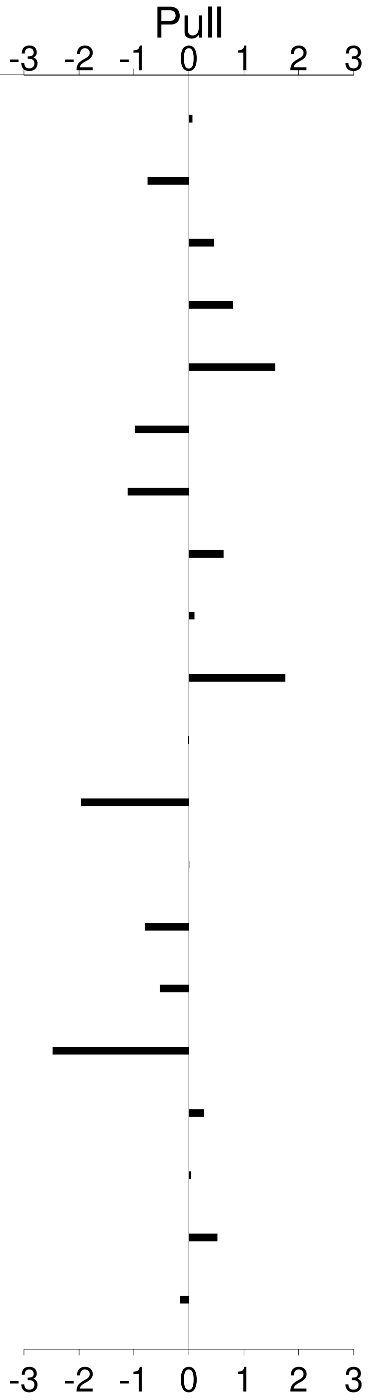
	Measurement	Pull
m_Z [GeV]	91.1863 ± 0.0019	.06
Γ_Z [GeV]	2.4947 ± 0.0026	-.75
σ^0_{hadr} [nb]	41.489 ± 0.055	.46
R_l	20.783 ± 0.029	.80
$A^{0,l}_{fb}$	0.0177 ± 0.0010	1.57
A_τ	0.1401 ± 0.0067	-.98
A_e	0.1382 ± 0.0076	-1.11
$\sin^2\theta^{lept}_{eff}$	0.2322 ± 0.0010	.63
m_W [GeV]	80.38 ± 0.14	.10
R_b	0.2177 ± 0.0011	1.75
R_c	0.1722 ± 0.0053	-.01
$A^{0,b}_{fb}$	0.0985 ± 0.0022	-1.96
$A^{0,c}_{fb}$	0.0735 ± 0.0048	.01
A_b	0.897 ± 0.047	-.80
A_c	0.623 ± 0.085	-.53
$\sin^2\theta^{lept}_{eff}$	0.23055 ± 0.00041	-2.48
$1 - m^2_W/m^2_Z$	0.2244 ± 0.0042	.28
m_W [GeV]	80.37 ± 0.10	.04
m_t [GeV]	175.6 ± 5.5	.52
$1/\alpha$	128.894 ± 0.090	-.16



$$\chi^2/d.o.f. = 21/15$$

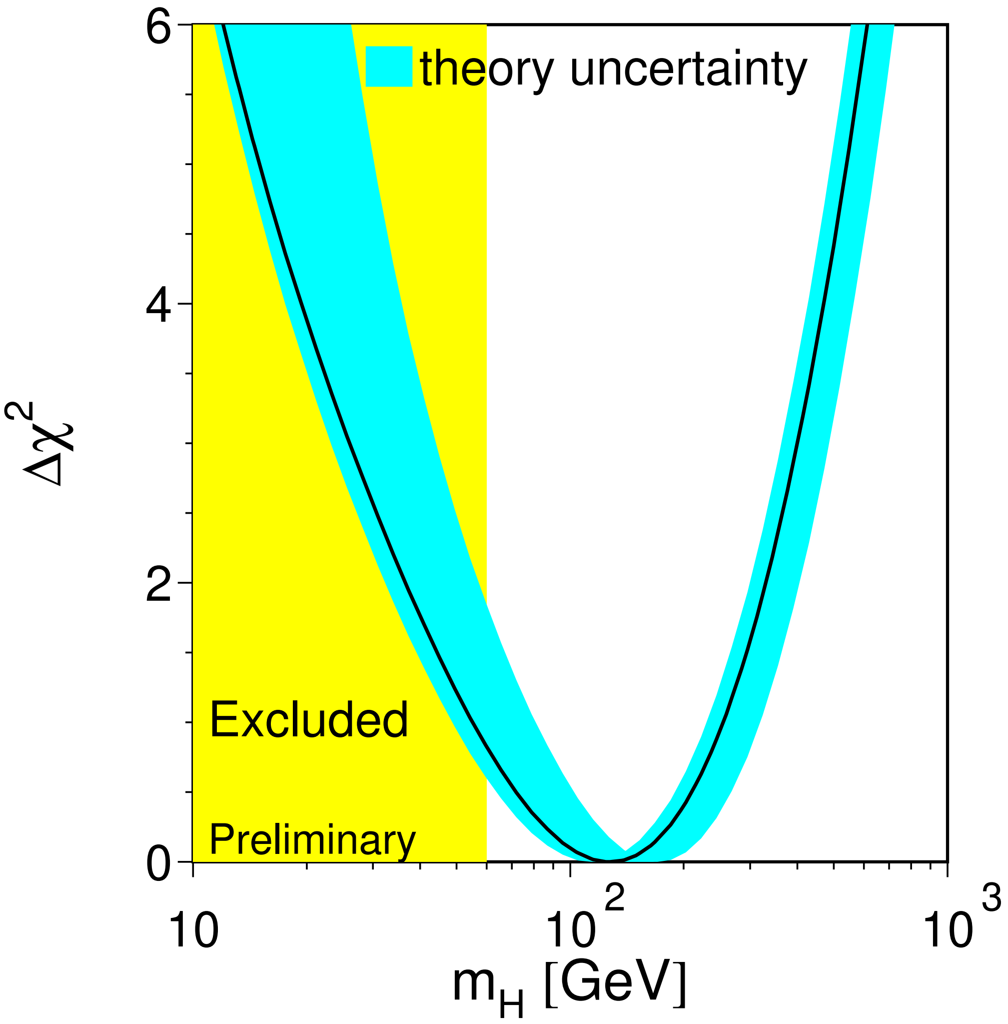
From previous fit including measurements of m_t and m_W in the fit

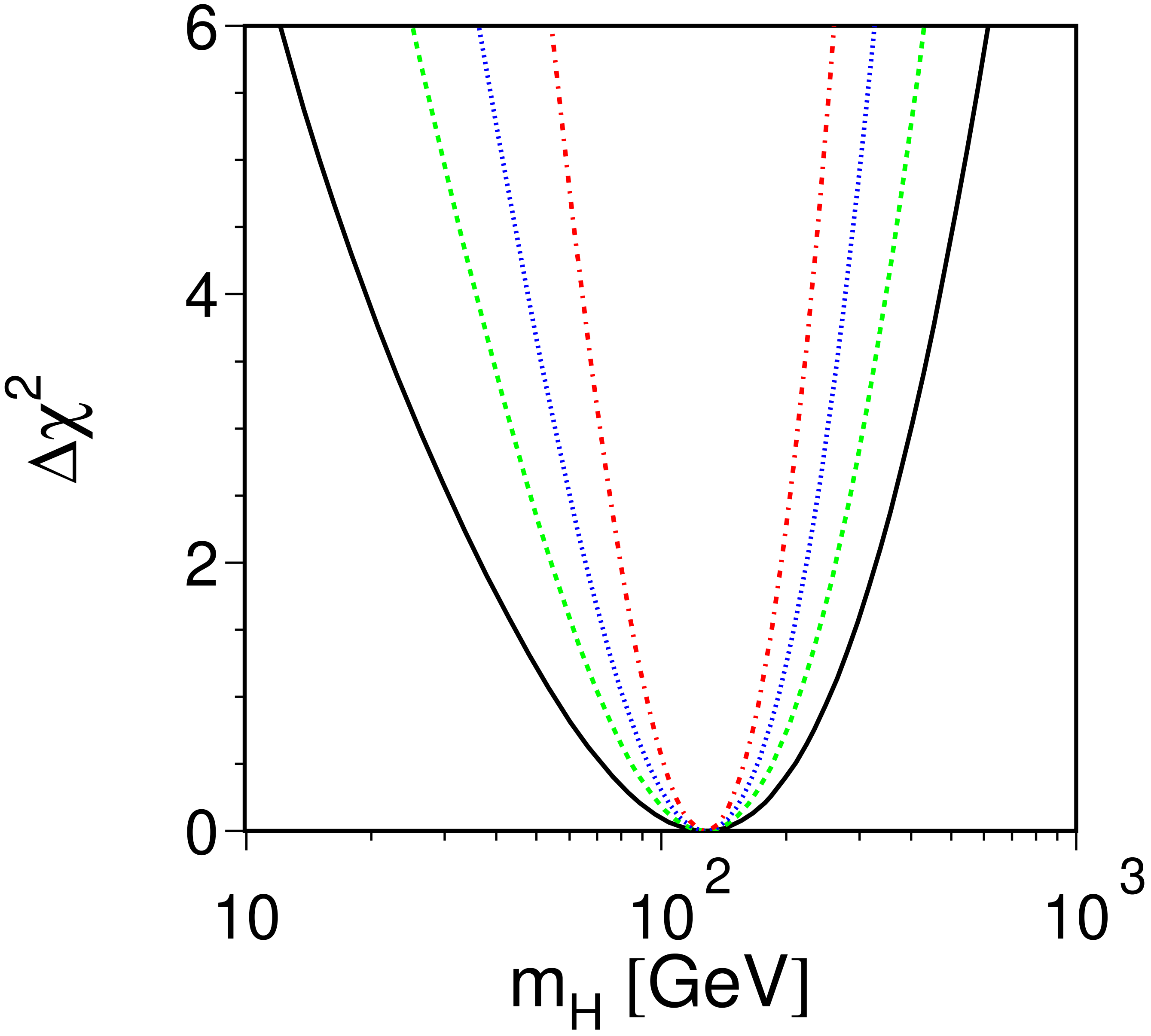
$\Rightarrow$ derive a prediction for m_H

$$m_H = 127^{+127}_{-72} \qquad log\, m_H = 2.10^{+0.30}_{-0.36}$$

Upper limit at 95% confidence level:

$$m_H < \underline{465\ GeV}$$





$\Delta m_t = 1GeV$ $(5.5\,GeV)$

$\Delta m_W = 30MeV$ $(80\,MeV)$

$\Delta 1/\alpha = 0.010$ (0.090)

Conclusions

- **Very good test of the Standard Model in particular of the radiative corrections:**
  m_W and m_t in good agreement with their direct measurements

- **Derive m_H using the measurements of m_W and m_t**

  $m_H < 465\ GeV$ at 95% c.l.

- **Waiting for improvements:**

$sin^2\theta_{eff},\ A_b$	**SLD**
m_t	**CDF and DØ**
m_W	**LEP2**
$1/\alpha$	**CMD(Russia) and BES (Beijing)**