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Combined fit to the Electroweak data and constraints on the Standard Model

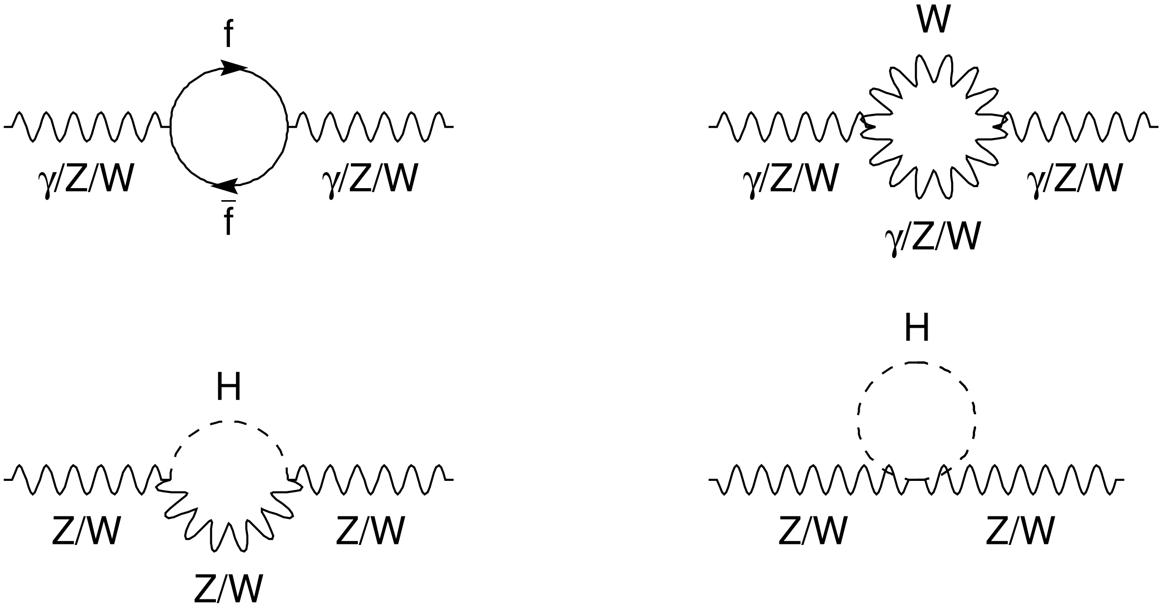
- (Short) Introduction
- Inputs
- Results
- (My) Conclusions

On behalf of the LEP/SLD collaborations and the LEP Electroweak working group

Numbers & plots in `http://www.cern.ch/LEPEWWG`

EPS-HEP 2001, Budapest, July 12-18

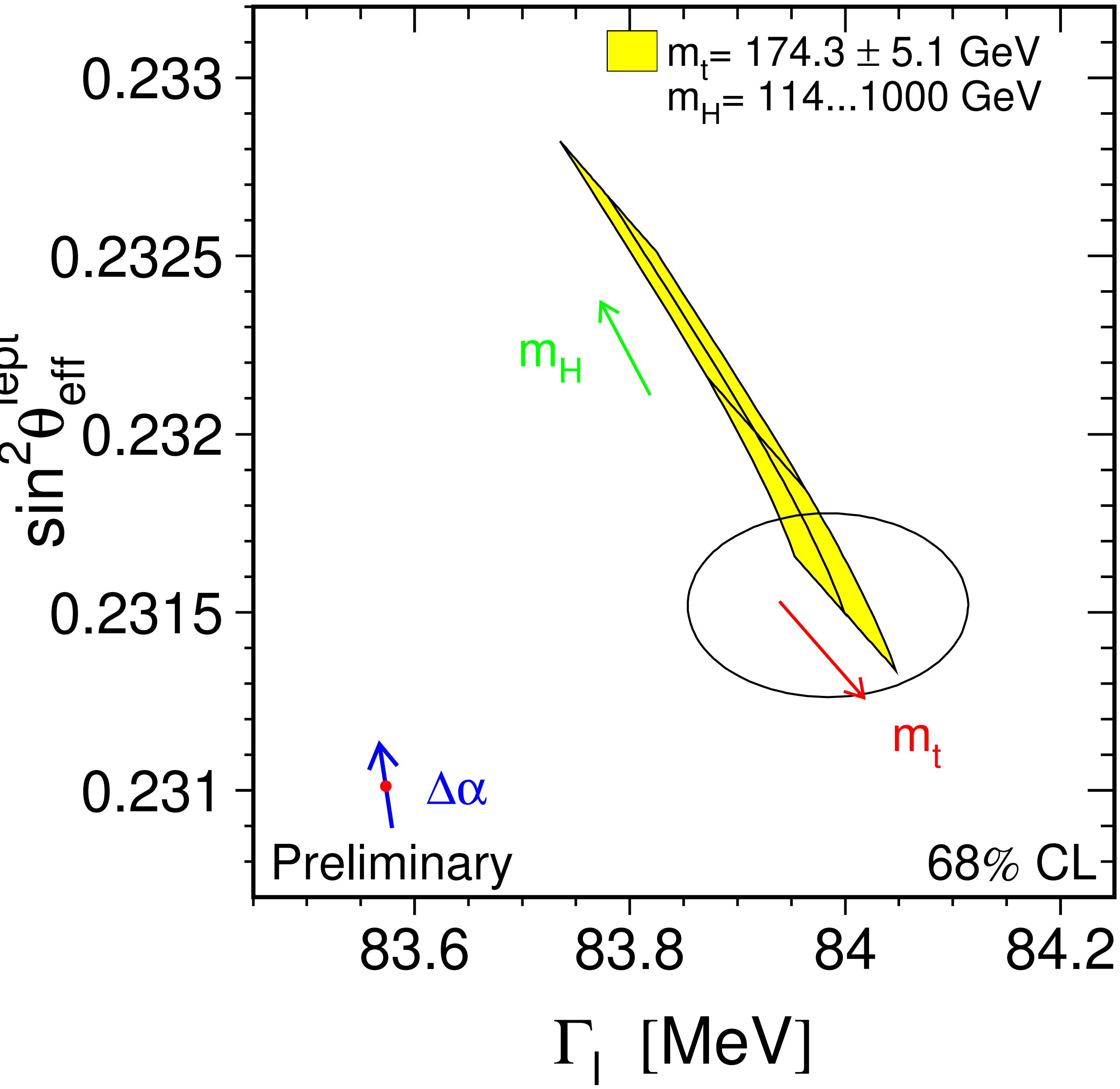
Precision Electroweak measurements test and constrain the Standard Model through the mechanism of radiative corrections.



Boson and fermion loops in boson propagators

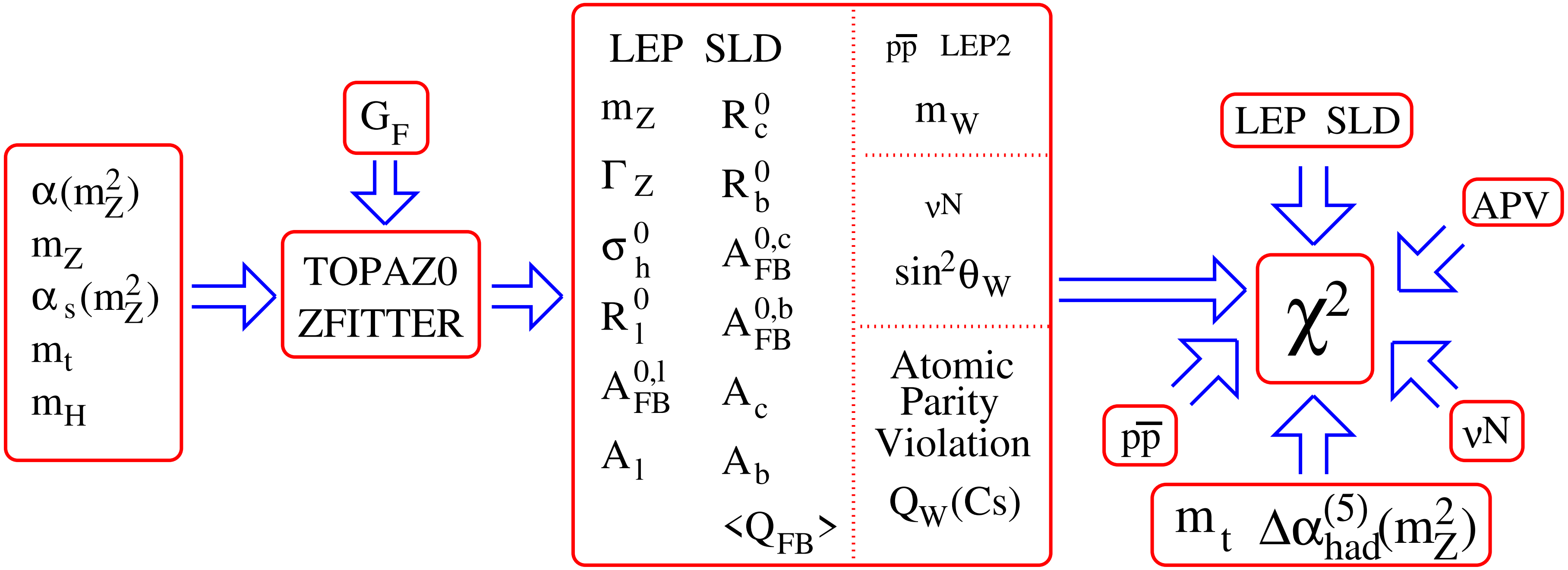
$$\frac{1}{\alpha(0)} \longrightarrow \frac{1-\Delta\alpha}{\alpha(0)}$$

Electroweak corrections $= f(m_{\mathrm{t}}^2, \log m_{\mathrm{H}}, \ldots)$



Evidence of Electroweak corrections beyond the running of α.

(Short) Introduction



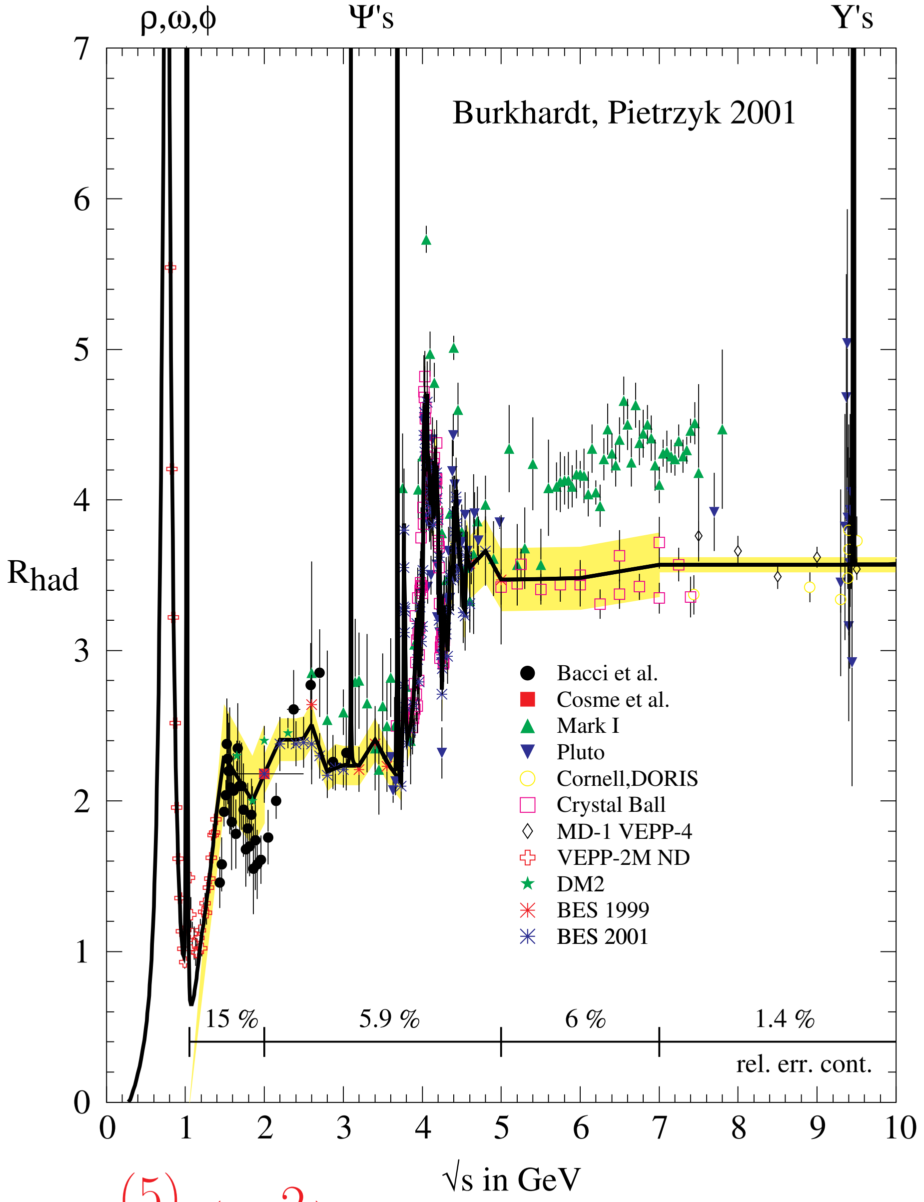
NEW:

–Inclusion of Atomic Parity Violation

–Inclusion of Electroweak corrections on m_W

$$\alpha(s) = \frac{\alpha(0)}{1 - \Delta\alpha_\ell(s) - \Delta\alpha_{\text{top}}(s) - \Delta\alpha^{(5)}_{\text{had}}(s)}$$

$\Delta\alpha_\ell(s)$ and $\Delta\alpha_{\text{top}}(s)$ are calculable, $\Delta\alpha^{(5)}_{\text{had}}(s)$ has QCD uncertainties.
Determine it from measurements of $R_{\text{had}} = \frac{\sigma(e^+e^- \to \text{hadrons})}{\sigma(e^+e^- \to \mu^+\mu^-)}$ (BES updates)



$$\Delta\alpha^{(5)}_{\text{had}}(m_Z^2) = 0.02761 \pm 0.00036$$

Previous value, Eidelman, Jegerlehner ZP **C67** (1995) 585:

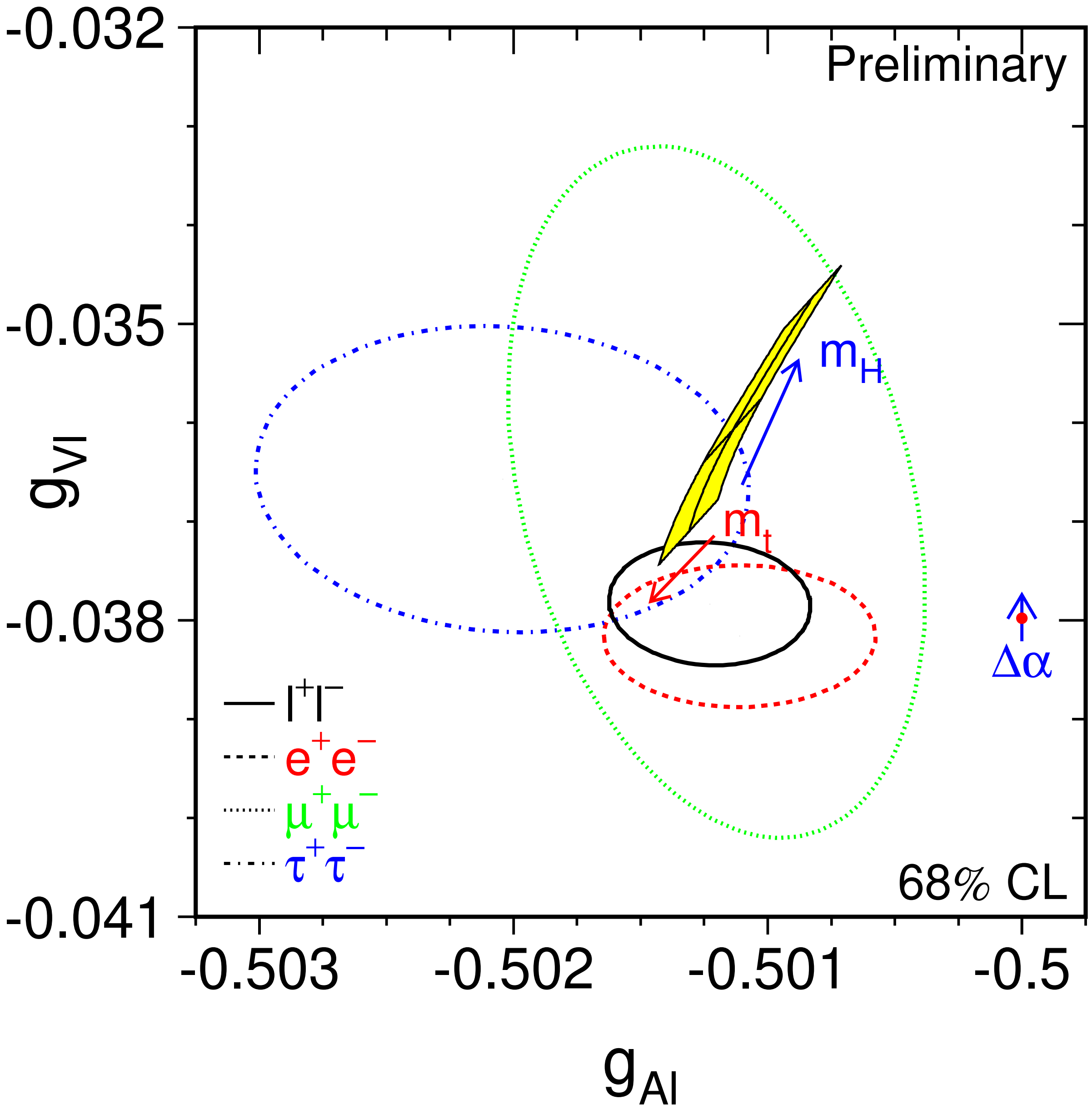
$$\Delta\alpha^{(5)}_{\text{had}}(m_Z^2) = 0.02804 \pm 0.00065$$

With perturbative QCD and BES data, Martin *et al* PL **B492** (2000) 69:

$$\Delta\alpha^{(5)}_{\text{had}}(m_Z^2) = 0.02378 \pm 0.00020$$

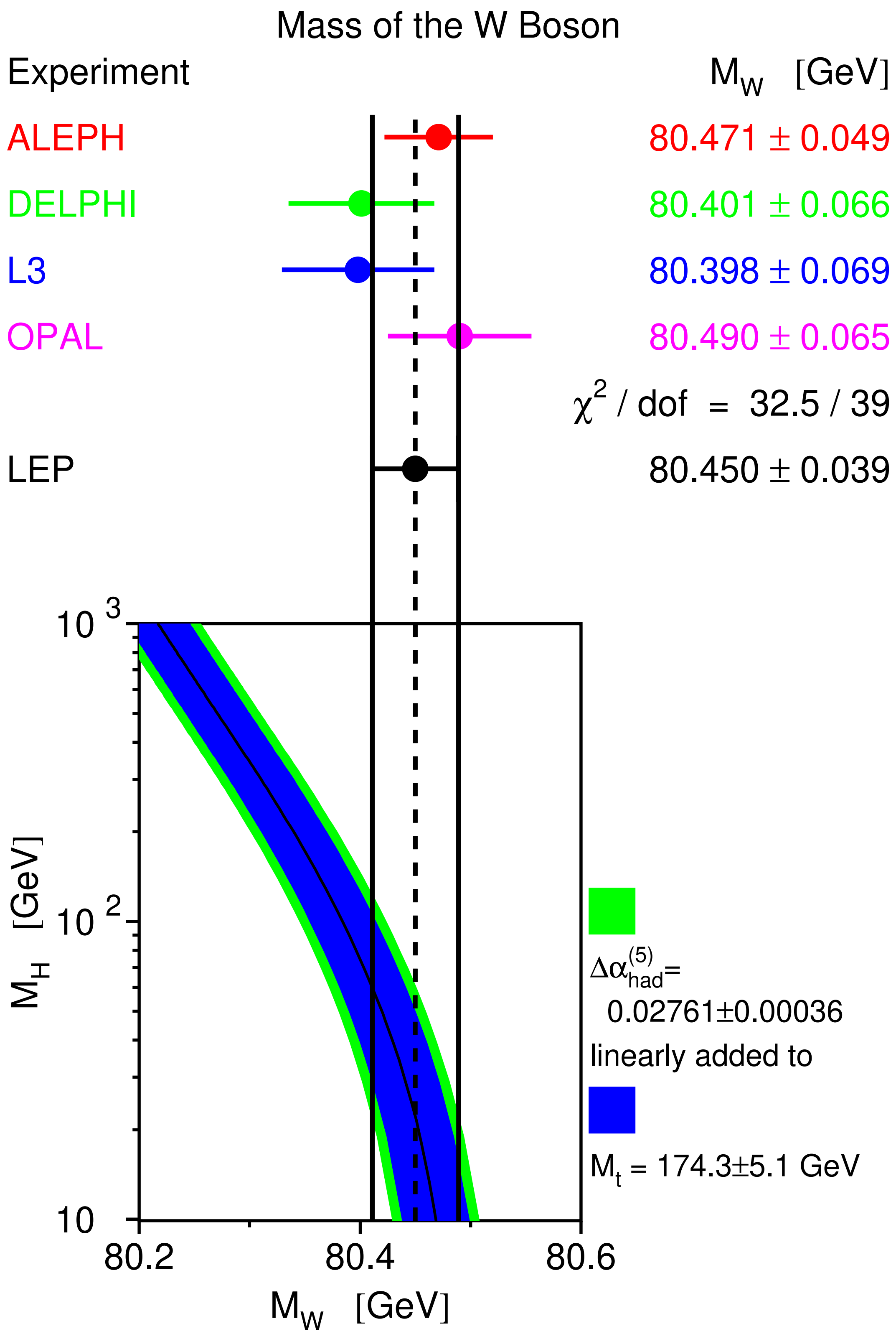
Inputs

Standard Model predictions from:
$m_t = 174.3 \pm 5.1$, $m_H = [114.1, 1000]$



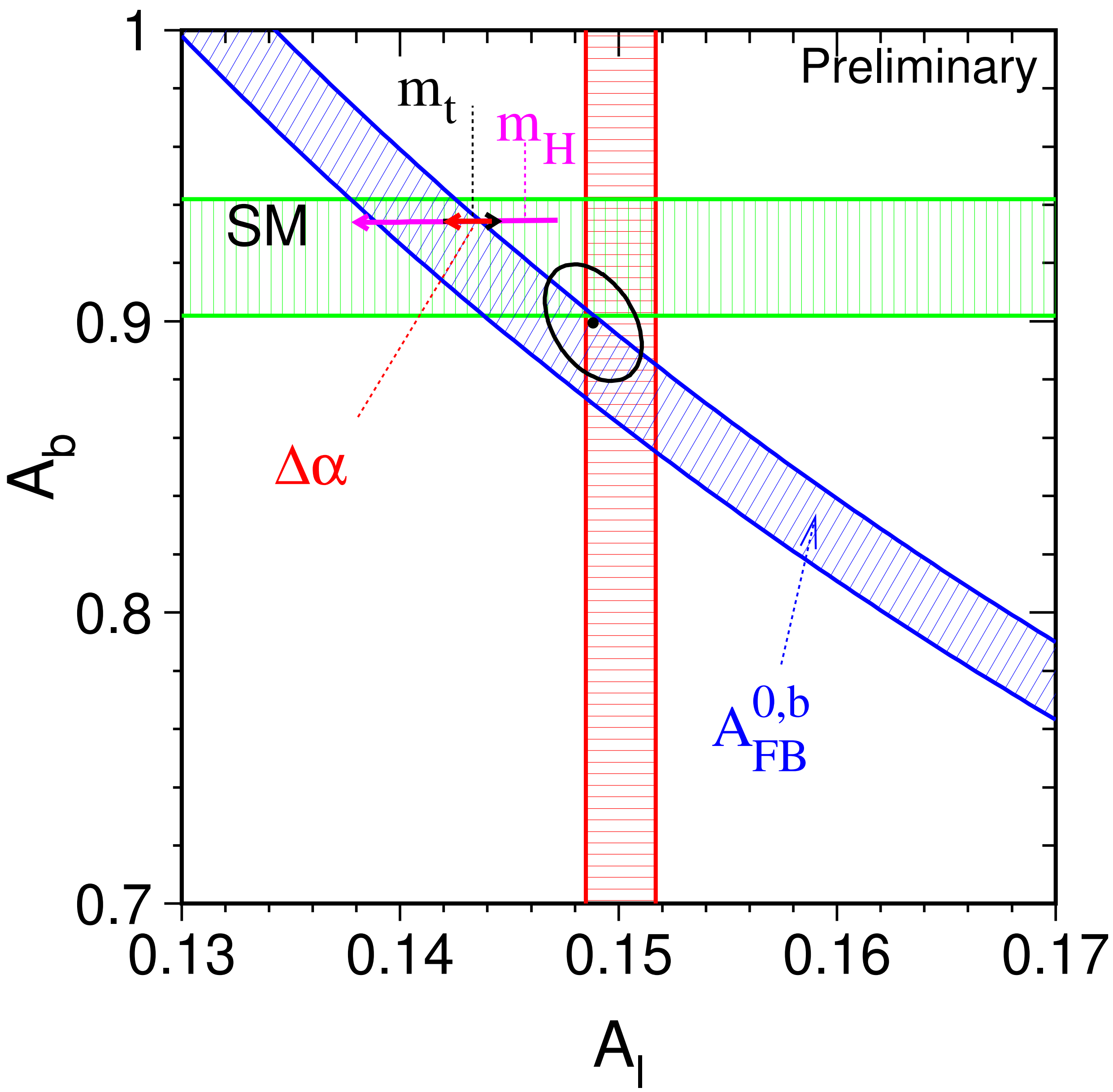
Internal consistency in the leptonic sector
LOW m_H are favoured

Inputs

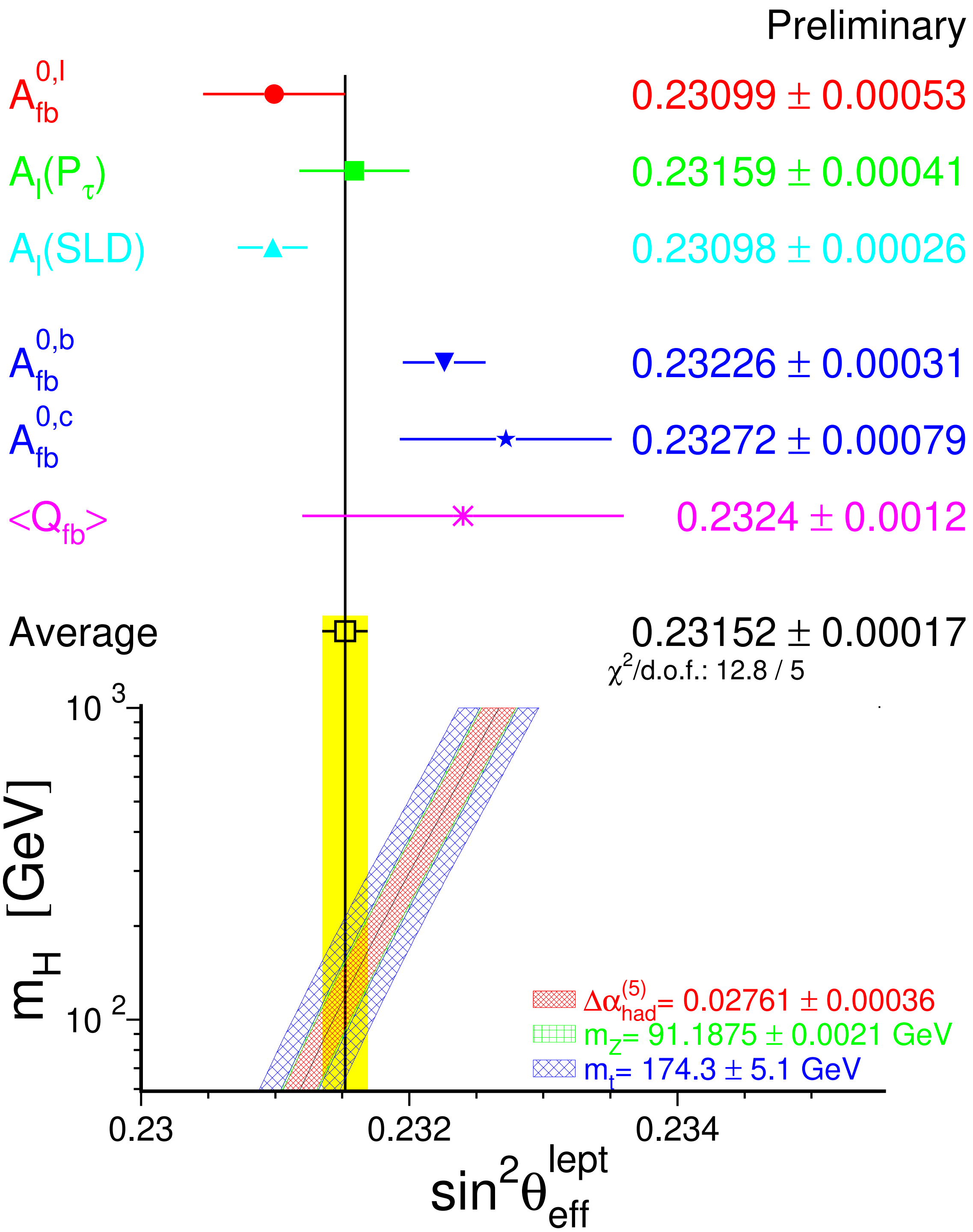


Other observables also prefer **LOW** m_H

Standard Model predictions from:
$m_{\mathrm{t}} = 174.3 \pm 5.1$, $m_{\mathrm{H}} = [114.1, 1000]$



The heavy quark favour **HIGH** m_{H}



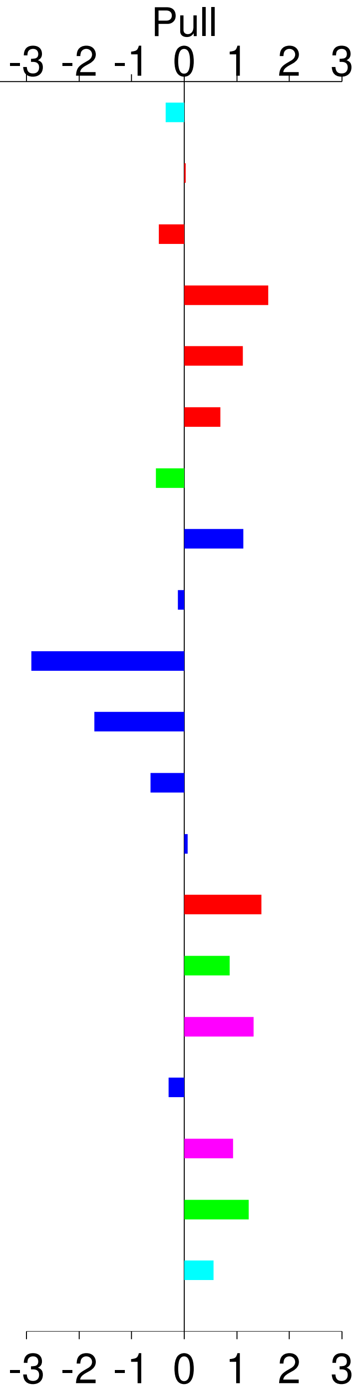
$$\chi^2(\text{leptons})/d.o.f. = 1.6/2\ (44.3\%)$$
$$\chi^2(\text{hadrons})/d.o.f. = 0.3/2\ (84.6\%)$$
$$\chi^2(\text{total})/d.o.f. = 12.8/5\ \ (2.5\%)$$

Difference of 3.3σ between hadrons and leptons

Results

Summer 2001

	Measurement	Pull
$\Delta\alpha^{(5)}_{had}(m_Z)$	0.02761 ± 0.00036	-.35
m_Z [GeV]	91.1875 ± 0.0021	.03
Γ_Z [GeV]	2.4952 ± 0.0023	-.48
σ^0_{had} [nb]	41.540 ± 0.037	1.60
R_l	20.767 ± 0.025	1.11
$A^{0,l}_{fb}$	0.01714 ± 0.00095	.69
$A_l(P_\tau)$	0.1465 ± 0.0033	-.54
R_b	0.21646 ± 0.00065	1.12
R_c	0.1719 ± 0.0031	-.12
$A^{0,b}_{fb}$	0.0990 ± 0.0017	-2.90
$A^{0,c}_{fb}$	0.0685 ± 0.0034	-1.71
A_b	0.922 ± 0.020	-.64
A_c	0.670 ± 0.026	.06
A_l(SLD)	0.1513 ± 0.0021	1.47
$\sin^2\theta^{lept}_{eff}(Q_{fb})$	0.2324 ± 0.0012	.86
$m_W^{(LEP)}$ [GeV]	80.450 ± 0.039	1.32
m_t [GeV]	174.3 ± 5.1	-.30
$m_W^{(TEV)}$ [GeV]	80.454 ± 0.060	.93
$\sin^2\theta_W(\nu N)$	0.2255 ± 0.0021	1.22
Q_W(Cs)	-72.50 ± 0.70	.56

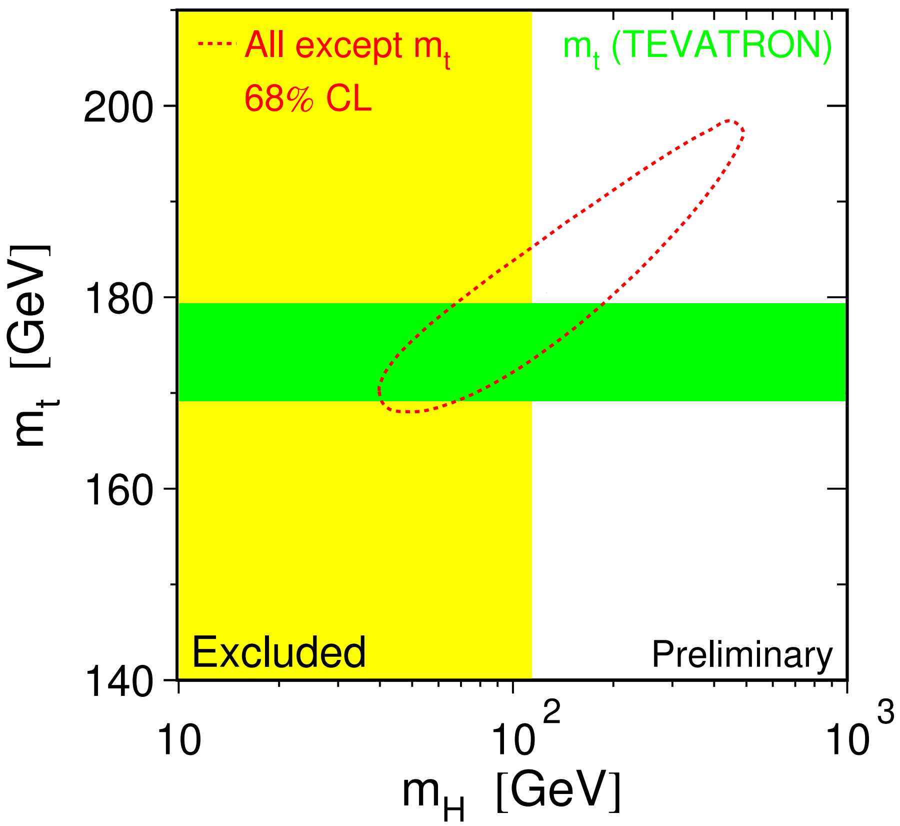


$$\text{Pull} = \frac{\mathcal{O}_{\text{meas}} - \mathcal{O}_{\text{fit}}}{\sigma \mathcal{O}_{\text{meas}}}$$

$$\chi^2/d.o.f. = 22.9/15 \quad \mathcal{P}(\chi^2) = 8.6\%$$

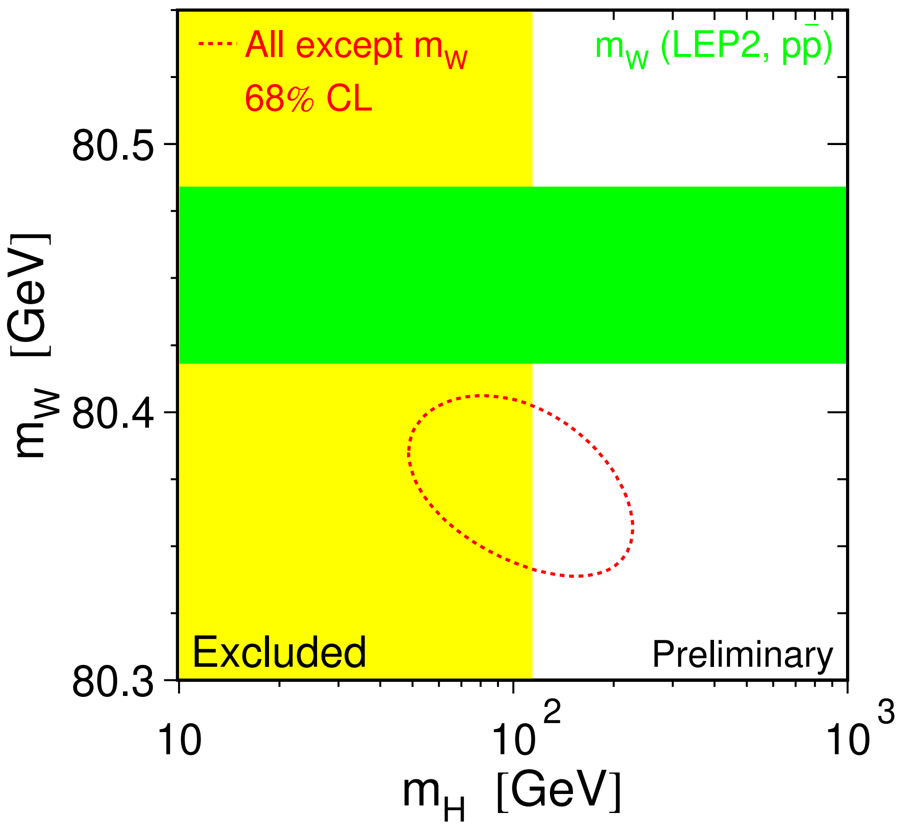
Release m_{t} constraint

$$m_{\mathrm{t}}^{\mathrm{Fit}} = 180.5^{+11.3}_{-8.8}\ \mathrm{GeV}$$
$$m_{\mathrm{t}}^{\mathrm{Meas}} = 174.3 \pm 5.1\ \mathrm{GeV}$$

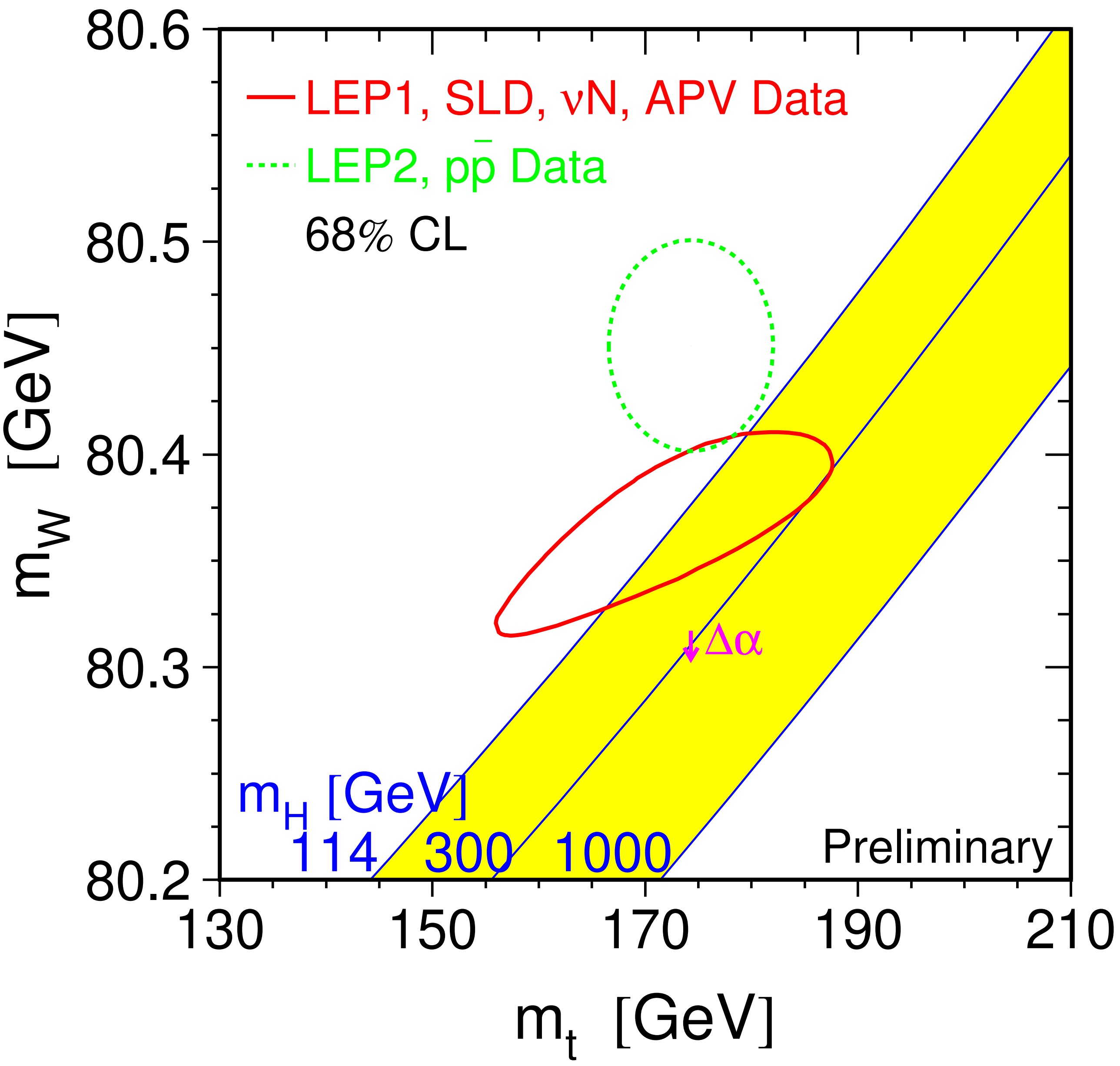


Release m_{W} constraint

$$m_{\mathrm{W}}^{\mathrm{Fit}} = 80.373 \pm 0.023\ \mathrm{GeV}$$
$$m_{\mathrm{W}}^{\mathrm{Meas}} = 80.451 \pm 0.033\ \mathrm{GeV}$$



Releasing both the m_t and m_W constraints

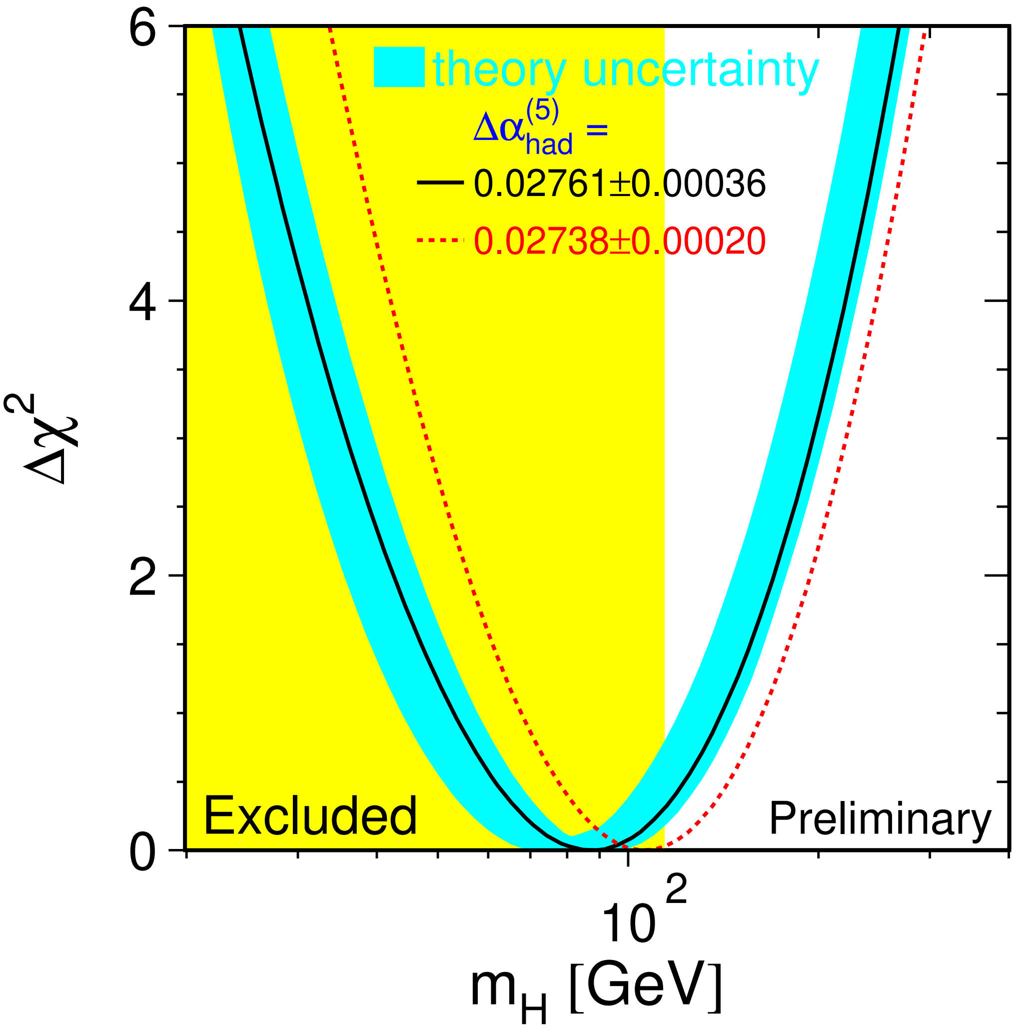


$$m_t^{\rm Fit} = 169.0^{+11.5}_{-8.9}\ {\rm GeV} \qquad m_W^{\rm Fit} = 80.363 \pm 0.032\ {\rm GeV}$$
$$m_t^{\rm Meas} = 174.3 \pm 5.1\ {\rm GeV} \qquad m_W^{\rm Meas} = 80.451 \pm 0.033\ {\rm GeV}$$

Results

$$m_{\mathrm{H}} = 88^{+53}_{-35}\ \mathrm{GeV}$$
$$m_{\mathrm{H}} < 196\ \mathrm{GeV}\ @95\%\mathrm{C.L.}$$

$m_{\mathrm{H}} < 222$ GeV @95%C.L. for $\Delta\alpha^{5}_{\mathrm{had}}(m_{\mathrm{Z}}) = 0.02378 \pm 0.00020$



The theory uncertainty follows from:

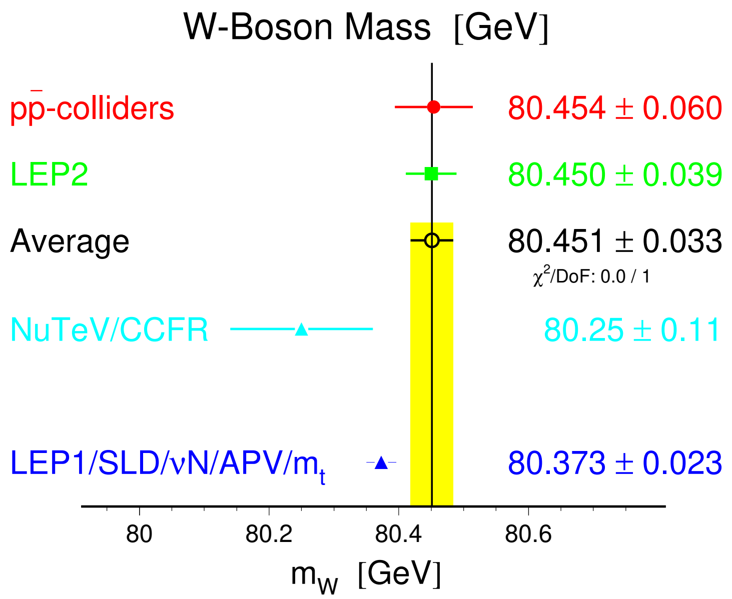
- Propagation of new Electroweak corrections on m_{W} to $\sin^2\theta_{\mathrm{eff}}$
- Estimation of higher order corrections

(My) Conclusions

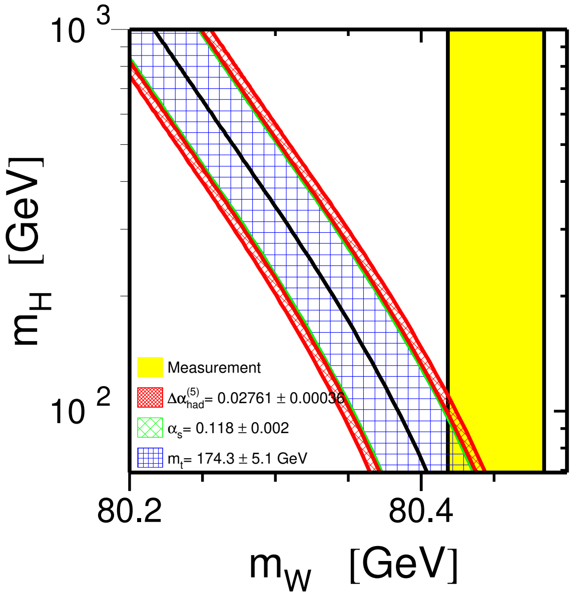
- "Almost" all the measurements are consistent
- The Higgs boson is light
- The χ^2 of the fit gives a probability of 8.6%
- This low probability follows from $A_{FB}^{0,b}$

- We shall finalise the $A_{FB}^{0,b}$ measurements:
- We shall improve the m_W measurement:

To test internal consistency



To constrain m_H



(m_t measurement $\Rightarrow$ high predictive power)