PROCEEDINGS OF SCIENCE

PoS(EPS-HEP2011)254

Latest Results of the Global Electroweak Fit with Gfitter

Matthias Schott[*] **(for the Gfitter group)**
CERN, Switzerland
E-mail: `Matthias.Schott@cern.ch`

We present an update of the Standard Model fit to electroweak precision data. We include newest experimental results on the top quark mass and the W mass and width. We find for the Higgs boson mass $95^{+30[+74]}_{-24[-43]}$ GeV and $125^{+8[+21]}_{-10[-11]}$ GeV when not including and including the direct Higgs searches, respectively. In addition, we exploit the data to determine experimental constraints on the oblique vacuum polarisation parameters.

The 2011 Europhysics Conference on High Energy Physics-HEP 2011,
July 21-27, 2011
Grenoble, Rhône-Alpes France

---

[*] Speaker.

1. Introduction

The study of radiative corrections allows to gain information on physics processes at higher energy scales than those directly accessible by current experiments. Hence, using electroweak precision measurements with state-of-the-art SM predictions allows for example the estimation of a preferred mass range for the SM Higgs boson, as it is performed by the Gfitter package [1]. The SM predictions for the electroweak precision observables measured by the LEP, SLC, and Tevatron experiments are fully implemented in the Gfitter software. State-of-the-art calculations are used, in particular the full two-loop and leading beyond-two-loop corrections for the prediction of the W mass and the effective weak mixing angle [2][3][4], which exhibit the strongest constraints on the Higgs mass. The calculations of the partial and total widths of the Z and of the total width of the W boson have been integrated from the ZFITTER package [5][6] and are co-authored by both groups [7]. The Gfitter library also includes the fourth-order (3NLO) perturbative calculation of the massless QCD Adler function [8], allowing the fit to determine the strong coupling constant with very small theoretical uncertainty.

The SM parameters relevant for the prediction of the electroweak observables are the coupling constants of the electromagnetic α, weak G_F and strong interactions α_s, and the masses of the elementary bosons (M_Z, M_W, M_H) and fermions (m_f), where neutrino masses are set to zero. Electroweak unification results in a massless photon and a relation between the electroweak gauge boson masses and couplings, thus reducing the number of unknown SM parameters by two. The SM gauge sector is left with four free parameters taken to be α, M_Z, G_F and α_S. Simplification of the fit is achieved by fixing parameters with insignificant uncertainties compared to the sensitivity of the fit. The final list of floating fit parameters is: $M_Z, M_H, m_t, m_b, m_c, \Delta\alpha_{had}^{(5)}(M_Z^2)$, where only the latter parameter is kept fully unconstrained allowing an independent measurement. Theoretical uncertainties on the predictions of M_W and $sin^2\theta_{eff}$ are also taken into account.

Physics beyond the Standard Model can modify the relations between electroweak observables and their theoretical predictions. Such effects can be parametrized in terms of effective, so-called oblique parameters. A global fit of the electroweak SM, as performed with the Gfitter package [1], allows to determine the oblique parameters, to probe physics models and to set constraints on their free parameters

PoS(EPS-HEP2011)254

2. Global Electroweak Fit Results

In the global electroweak fit, predictions for precision observables are compared with the most recent measurements done by LEP, SLC, and Tevatron. A detailed list of all data used in the fit can be found in [12]. In particular, we use in this paper, the latest top mass combination from the Tevatron experiments $m_t = 173.2 \pm 0.9$ GeV presented at this conference [9]. In addition we make use of the latest Tevatron Higgs mass combination [10] and also first results from Higgs mass searches at the LHC from the ATLAS and CMS experiments in our fit [11].

Out fit converges at a χ^2 minimum of 17.6 and 16.7 when including and excluding information of the direct Higgs searches, respectively. The respective p-values based on toy Monte Carlo experiments are 0.21 and 0.23 where no individual pull value exceeds 3σ. One of the most important results of the electroweak fit is the estimation of Higgs mass. It is found at $M_H = 125^{+8[+21]}_{-10[-11]}$ GeV and $M_H = 95^{+30[+74]}_{-24[-43]}$ GeV when including and not including information of direct searches, respectively. Figure 1 (left) shows the corresponding $\Delta\chi^2$ profile as a function of M_H for the latter case. Also shown is the P-value dependence on M_H of the electroweak fit as obtained from pseudo-Monte Carlo simulations. The error band represents the statistical error from the MC sampling size. As an example we can assume a SM Higgs Boson mass of 140 GeV which in turn results in a P-value of $P = Prob(18.95, 14) = 0.17$.

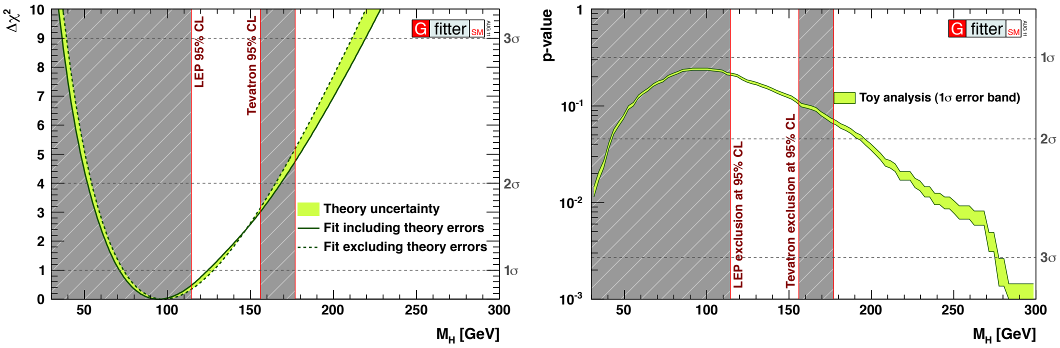

Figure 1: $\Delta\chi^2$ (left) and P-value (right) as a function of M_H for the standard fit.

Each parameter or observable can be also predicted, by scanning the profile likelihood without using the corresponding experimental or phenomenological constraint in the fit. Hence we can indirectly determine observables like M_W or m_t similar to the indirect M_H determination. We indirectly determine the W mass to be $M_W = 80.362 \pm 0.013$ GeV, which is 1.6σ below and exceeds the experimental world average in precision. The strong coupling constant at the Z pole to four loop perturbative order for the massless fermion propagators is found to be $\alpha_s(M_Z^2) = 0.1193 \pm 0.0028$ with negligible theoretical uncertainty due to the good convergence of the perturbative series at that scale. The top quark mass was indirectly determined to be $m_t = 177.2^{+2.9}_{-3.1}$ GeV.

3. Oblique Parameters

Provided that the new physics mass scale is high, beyond the scale of direct production, and that it contributes only through virtual loops to the electroweak precision observables, the dominant BSM effects can be parametrised by three gauge boson self-energy parameters named oblique parameters. We will focus here on the S, T, U parameters formalism, which are reparametrisations of the variables $\Delta\rho$, $\Delta\kappa$ and Δr. They absorb the radiative corrections to the total Z coupling strength, the effective weak mixing angle, and the W mass, respectively. By construction, the S, T, U parameters depend on a (somewhat arbitrary) SM reference point which is defined by fixed reference values for M_H and m_t.

The S, T, U parameters are determined from the fit by comparing the measured electroweak precision observables with the respective theory predictions of Eq. (11). Except for the fixed values of M_H and m_t all other SM fit parameters, including S, T and U, are free to vary in the fit. After fit convergence we find

$$S = 0.04 \pm 0.10, T = 0.05 \pm 0.11, U = 0.08 \pm 0.11.$$

Figures 2 shows by the orange ellipses the 68%, 95% and 99% confidence level (CL) allowed regions in the (S,T) planes. In addition the tighter constraints, found when fixing U = 0 (blue ellipses), are indicated. On the right, the individual constraints from the asymmetry measurements, Z partial and total widths, and W mass and width are displayed for $U = 0$. A detailed discussion including the tests of various BSM models can be found in [12]

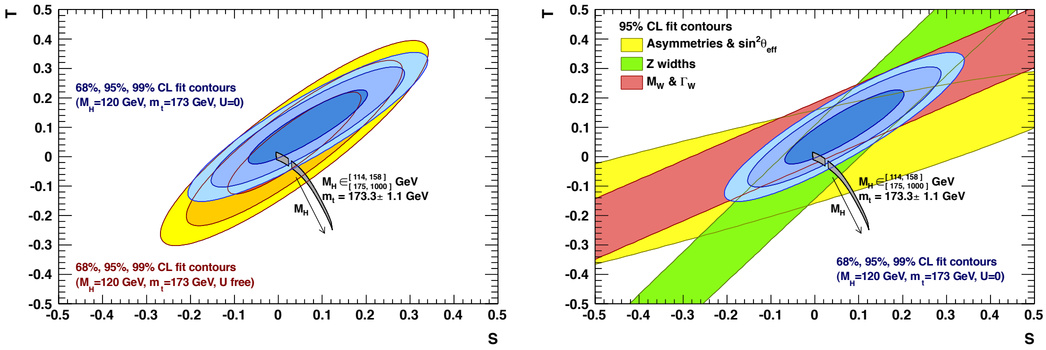

Figure 2: Experimental constraints on the S, T parameters with respect to the SM reference represented by $M_H = 120$ GeV and $m_t = 173$ GeV and the corresponding best fit values for the remaining SM parameters.

References

[1] Gfitter Group, H. Flaecher et al., Eur. Phys. J. C60, 543 (2009), [arxiv:0811.0009].

[2] M. Awramik, M. Czakon, A. Freitas and G. Weiglein, Phys. Rev. D69, 053006 (2004), [hep-ph/0311148].

[3] M. Awramik, M. Czakon, A. Freitas and G. Weiglein, Phys. Rev. Lett. 93, 201805 (2004), [hep-ph/0407317].

[4] M. Awramik, M. Czakon and A. Freitas, JHEP 11, 048 (2006), [hep-ph/0608099].

[5] A. B. Arbuzov et al., Comput. Phys. Commun. 174, 728 (2006), [hep-ph/0507146].

[6] D. Y. Bardin et al., Comput. Phys. Commun. 133, 229 (2001), [hep-ph/9908433].

[7] Gfitter/GSM sub-package, A. Akhundov, A. Arbuzov, M. Awramik, D. Bardin, M. Bilenky, P. Christova, M. Czakon, O. Fedorenko, A. Freitas, M. Goebel, M. Gruenewald, J. Haller, A. Hoecker, L. Kalinovskaya, K. Moenig, A. Olchevsky, S. Riemann, T. Riemann, public release in preparation.

[8] P. A. Baikov, K. G. Chetyrkin and J. H. Kuhn, Phys. Rev. Lett. 101, 012002 (2008), [arxiv:0801.1821].

[9] The Tevatron Electroweak Working Group, [arxiv:1107.5255]

[10] Tevatron New Phenomena, Higgs Working Group, [arXiv:1107.5518]

[11] The ATLAS and CMS Collaboration [arXiv:1106.2748] , [arXiv:1102.5429]

[12] Gfitter Group, M. Baak et al., [arXiv:1107.0975]