PROCEEDINGS OF SCIENCE

Status of the global fit to electroweak precisions data

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In this presentation Gfitter results from the global Standard Model (SM) fit to electroweak precision data are discussed. We have used the latest measurements of m_{top} and M_W and the most recent results for direct Higgs searches at LEP and Tevatron. We obtain $M_H = 121\,^{+17}_{-6}$ GeV and a 95% CL upper limit of 155 GeV for the SM Higgs mass. The forth-order result for the strong coupling constant is given by $\alpha_S(M_Z^2) = 0.1193 \pm 0.0028(\mathrm{exp}) \pm 0.0001(\mathrm{theo})$. In addition the electroweak fit has been performed with the top mass determined from the $p\bar{p} \to t\bar{t} + X$ cross-section as measured at Tevatron.

35th International Conference of High Energy Physics - ICHEP2010,
July 22-28, 2010
Paris France

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PoS(ICHEP 2010)570

1. Introduction

Precision measurements allow us to probe physics at much higher energy scales than the masses of the particles directly involved in experimental reactions by exploiting contributions from quantum loops. Prominent examples are the electroweak precision measurements, which are used in conjunction with the Standard Model (SM) to predict via multidimensional parameter fits unmeasured quantities like the Higgs mass. Such an approach has been used in the *Gfitter* analysis of the Standard Model (SM) in light of electroweak precision data [1].

In this paper updated results of the global electroweak fit are presented taking into account the latest experimental precision measurements and the results of direct Higgs searches from LEP and Tevatron.

2. Fit Inputs

The SM predictions for the electroweak precision observables measured by the LEP, SLC, and Tevatron experiments are fully implemented in *Gfitter*. 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], which exhibit the strongest constraints on the Higgs mass. The Gfitter library also includes the fourth-order (3NLO) perturbative calculation of the mass-less QCD Adler function [3], allowing the fit to determine the strong coupling constant with negligible theoretical uncertainty.

The experimental data used in the fit include the electroweak precision data measured at the Z pole including their experimental correlations [4], the latest W mass world average $M_W = (80.399 \pm 0.023)$ GeV [5] and width $\Gamma_W = (2.098 \pm 0.048)$ GeV [6], and the newest average of the Tevatron top mass measurements $m_{\rm top} = (173.1 \pm 1.3)$ GeV [7]. For the contribution of the five lightest quark flavours to the electromagnetic coupling strength at M_Z we use the evaluation from [8]. In addition, for some results we take also into account the information from the direct Higgs searches at LEP [9] and Tevatron [10].

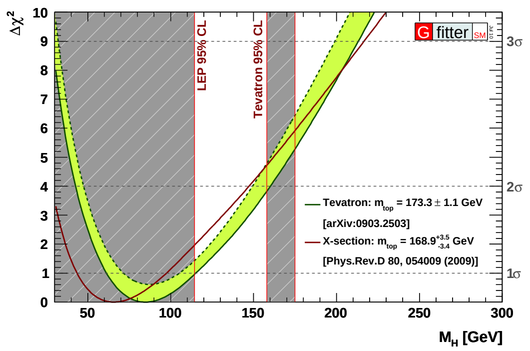

Fig. 1: $\Delta\chi^2$ as a function of M_H for a fit without the direct Higgs searches from LEP and Tevatron. The red solid line shows the result for a fit using the top mass as determined from the $t\bar{t}$ cross-section.

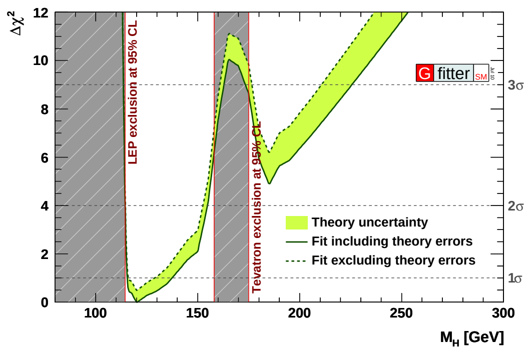

Fig. 2: $\Delta\chi^2$ as a function of M_H for a fit including the direct Higgs search results from LEP and Tevatron.

3. Fit Results

The minimum χ^2 value of the fit with (without) using the information of the direct Higgs searches amounts to 17.8 (16.4) which corresponds to a p-value of 0.23 (0.22). Figure 1 and fig. 2 show the corresponding profile curves of the $\Delta\chi^2$ estimator. We find for the most probable Higgs mass the value $M_H = 84\,^{+30}_{-23}$ GeV ($M_H = 121\,^{+17}_{-6}$ GeV). The 95% upper limits are 159 GeV (155 GeV).

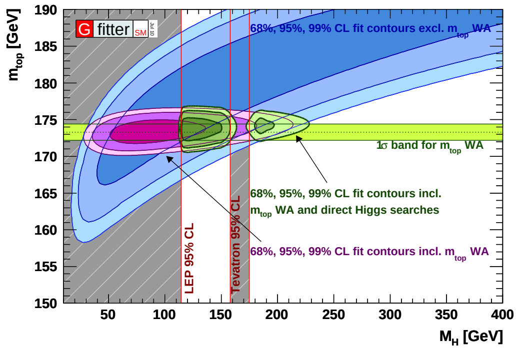

Fig. 3: Contours of 68%, 95% and 99% CL obtained from scans of fits with fixed variable pairs of m_{top} and M_H.

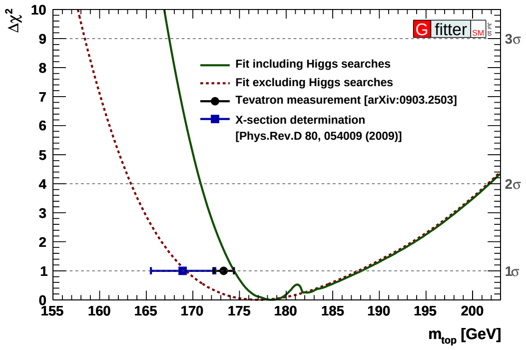

Fig. 4: $\Delta\chi^2$ as a function of m_{top} for a fit with and without the direct Higgs searches.

Figure 3 shows the 68%, 95% and 99% CL contours for the variable pairs of m_{top} vs. M_H. Three sets of fits are shown: the largest/blue (narrower/purple) allowed regions are derived from a fit excluding (including) the measured top mass value (indicated by the shaded/light green horizontal band). The fit providing the narrowest constraint (green) uses all available information, *ie.*, including the direct Higgs searches from LEP and Tevatron. The largest/blue contour show nicely the positive correlation factor between the Higgs and top mass, which can be determined to be 0.31. The importance of the top mass for the Higgs mass determination is clearly visible. However, an additional uncertainty for the top mass could arise due to ambiguities in the top mass definition at Tevatron [11]. In an alternative approach the top mass has been determined from the SM $p\bar{p} \to t\bar{t} + X$ cross-section [12], where the top mass is unambiguous once a renormalisation scheme is defined. The use of this top mass in the electroweak fit leads to a smaller value of M_H, but due the larger error of this top mass determination the 95% and 99% CL upper limits does not change significantly (see fig. 1). Figure 4 shows the $\Delta\chi^2$ as a function of m_{top}. For a comparison the direct Tevatron measurement and the determination from the $t\bar{t}$ cross-section are also shown.

In fig. 5 only the observable indicated in a given row is included in the fit. The four observables providing the strongest constraint on M_H are shown. The compatibility among these measurements can be estimated by repeating the global fit where the least compatible of the measurements (here $A_{\text{FB}}^{0,b}$) is removed, and by comparing the χ^2_{min} estimator obtained in that fit to the one of the full fit. To assign a probability to the observation, the $\Delta\chi^2_{\text{min}}$ obtained this way must be gauged with toy MC experiments to take into account the "look-elsewhere" effect introduced by the explicit selection of the outlier. We find that in (1.4 ± 0.1)% ("2.5σ") of the toy experiments, the $\Delta\chi^2_{\text{min}}$ exceeds the value observed in the current data.

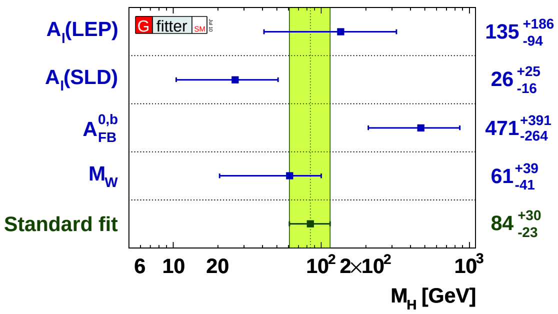

Fig. 5: Determination of M_H excluding all other sensitive observables from the fit, except for the one given.

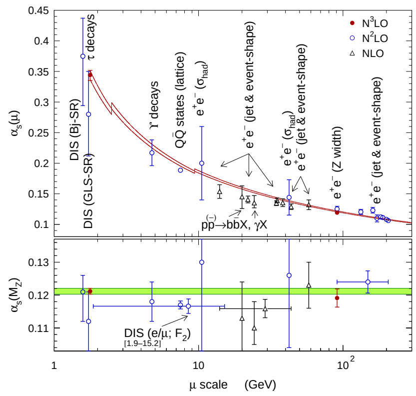

Fig. 6: Top: Collection of $\alpha_S(\mu)$ measurements at order 3NLO, 2NLO, and NLO [13]. Bottom: The corresponding α_s values evolved to M_Z [13].

From the fit including the direct Higgs searches we find for the strong coupling at the Z-mass scale $\alpha_s(M_Z^2) = 0.1193^{+0.0028}_{-0.0027} \pm 0.0001$, where the first error is experimental and the second due to the truncation of the perturbative QCD series. Figure 6 shows the excellent agreement between our result and 3NLO result from τ decays [13].

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