Comparison of the standard theory predictions of M_{W} and sin^{2}θ_{eff}^{lept} with their experimental values

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$\Delta\alpha = \Delta\alpha_h^{(5)} + \Delta\alpha_l = 0.05907 \pm 0.00010$ [6], $\alpha_s(M_Z) = 0.1184 \pm 0.0007$ [7]. The fitting formulas employ $G_\mu = 1.16637 \times 10^{-5}$ GeV^{-2} rather than the most recent and accurate value $G_\mu = 1.1663788 \times 10^{-5}$ GeV^{-2} [8]. However, this difference is negligible to the accuracy of our calculations.

Inserting the input parameters in the fitting formulas of Ref. [3], we find the ST prediction:

$$M_W^{(\text{ST})} = 80.361 \pm 0.010 \text{ GeV}, \qquad (3)$$

The error in Eq. (3) has two components: ± 0.006 GeV arises from the errors in the input parameters, and ± 0.004 GeV is an estimate of the theoretical uncertainty from unknown higher order corrections [3]. In Eq. (3) we have combined the two errors linearly.

To evaluate $s_{\text{eff}}^2 \equiv \sin^2\theta_{\text{eff}}^{\text{lept}}$ we employ the fitting formulas given in Eqs. (48-49) and Table 5 of Ref. [9] which reproduce to high accuracy the complete calculation up to and including two-loop order. Inserting in these formulas the input parameters given above, we find the ST prediction

$$s_{\text{eff}}^{2(\text{ST})} = 0.23152 \pm 0.00010. \qquad (4)$$

Again, the error in Eq. (4) has two components, combined linearly: 0.00005 is the parametric error and 0.00005 is the estimated theoretical error from unknown higher order contributions [9].

It is interesting to note that Eqs. (3-4) are very close to the values obtained in recent global fits of the ST [10, 11]. This close agreement is related to the observation that M_W, s_{eff}^2 and their theoretical expressions play, as mentioned before, a dominant role in the indirect determination of M_H. In fact, the indirect estimates of M_H based on M_W and s_{eff}^2 are close to those obtained from the global fits of all the data (see, for example, Ref. [12] and refs. cited therein).

Eqs. (3-4) can be compared with the experimental val-

Assuming that the recently discovered particle at LHC is the Standard Theory (ST) Higgs boson (H), the aim of this report is to compare the ST predictions of the basic observables M_W and $\sin^2\theta_{\text{eff}}^{\text{lept}}$ with their experimental values. These observables are of particular interest because of three reasons: *i)* They have been measured accurately, *ii)* the theoretical formulas for their calculation include the full one and two-loop electroweak corrections, and *iii)* they play a dominant role in the indirect determination of M_H. The implications of this comparison for possible future developments at LHC and a future GigaZ linear collider are briefly discussed.

A crucial new input is the measurement of the mass of the new particle by the ATLAS collaboration [1]

$$M_H = 126 \pm 0.4 \pm 0.4 \text{ GeV},$$

and by the CMS collaboration [2]

$$M_H = 125.3 \pm 0.4 \pm 0.5 \text{ GeV}.$$

Combining the statistical and systematic errors, we have

$$M_H = 126.0 \pm 0.57 \text{ GeV} \qquad [\text{ATLAS}], \qquad (1)$$
$$M_H = 125.3 \pm 0.64 \text{ GeV} \qquad [\text{CMS}]. \qquad (2)$$

To the accuracy of our predictions, Eq. (1) and Eq. (2) give the same results, so that either value can be used.

To evaluate M_W, we employ the fitting formulas given in Eqs. (6-8) of Ref. [3], which include the complete two-loop result and the known higher-order QCD and electroweak corrections. These fitting formulas approximate the full result for M_W to better than 0.5 MeV for $10 \text{ GeV} \leq M_H \leq 1$ TeV. Our other input parameters are: $M_Z = 91.1876(21)$ GeV [4], $M_t = 173.2 \pm 0.9$ GeV [5],

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ues (see Ref. [13] and Ref. [14]):

$$M_W^{(\exp)} = 80.385 \pm 0.015 \text{ GeV}, \qquad (5)$$

$$s_{\text{eff}}^{2(\exp)} = 0.23153 \pm 0.00016. \qquad (6)$$

We remind the reader that, for a long time, there has been an intriguing difference, at the 3σ level, between the values of s_{eff}^2 derived from the leptonic asymmetries ($A_{\text{FB}}^{0,l}$, $\mathcal{A}_l(P_\tau)$, $\mathcal{A}_l(\text{SLD})$) and the hadronic asymmetries ($A_{\text{FB}}^{0,b}$, $A_{\text{FB}}^{0,c}$, $Q_{\text{FB}}^{\text{had}}$) [14]. In fact, one finds $(s_{\text{eff}}^2)_l = 0.23113(21)$ from the leptonic asymmetries and $(s_{\text{eff}}^2)_h = 0.23222(27)$ from the hadronic asymmetries. Since this issue has not been clarified, we follow here the standard procedure of employing the average value derived from all the asymmetries.

Comparing Eqs. (3, 5) we find a difference

$$\delta M_W = M_W^{(\text{ST})} - M_W^{(\exp)} = -0.024 \pm 0.018 \text{ GeV}, \quad (7)$$

or equivalently, $\delta M_W = -1.33 \ \sigma$.

Comparing Eqs. (4, 6):

$$\delta s_{\text{eff}}^2 = s_{\text{eff}}^{2(\text{ST})} - s_{\text{eff}}^{2(\exp)} = -0.00001 \pm 0.00019, \qquad (8)$$

or, equivalently, $\delta s_{\text{eff}}^2 = -0.053 \ \sigma$.

Thus, we see that the ST prediction of s_{eff}^2 is in excellent agreement with the experimental value, while the ST prediction for M_W shows a $-1.33 \ \sigma$ deviation.

For completeness, we note that the ST prediction of Eq. (4) differs from $(s_{\text{eff}}^2)_l$ and $(s_{\text{eff}}^2)_h$ (the values obtained separately from the leptonic and hadronic asymmetries) by $s_{\text{eff}}^{2(\text{ST})} - (s_{\text{eff}}^2)_l = 1.7 \ \sigma$ and $s_{\text{eff}}^{2(\text{ST})} - (s_{\text{eff}}^2)_h = -2.4 \ \sigma$.

In order to decide whether the δM_W deviation is a real effect or a statistical fluctuation, it would be very useful to improve the accuracy of the M_W measurement. The question of whether a future measurement of M_W at LHC may be possible with an error ~ 7 MeV [15], or even as low as 5 MeV [16], has been recently discussed. It would also be very useful to decrease the parametric and theoretical errors in Eq. (3). In connection with this remark, we observe that the theoretical error associated with the unknown higher order corrections (~ 4 MeV) is the second largest contribution to the uncertainty in Eq. (3), after the parametric one arising from the experimental error in the top quark mass (~ 5 MeV).

A future GigaZ linear collider may be able to measure s_{eff}^2 with an error of $\sim 1 \times 10^{-5}$. In order to find out whether the current agreement between the ST prediction of s_{eff}^2 and its experimental value will survive, or a deviation emerge, a decrease of the parametric end theoretical errors in Eq. (4) by a factor of ≈ 10 will be required. We observe that, in the calculation of s_{eff}^2, the theoretical error associated with the unknown higher order corrections is already the largest contribution to the uncertainty in Eq. (4).

It is important to note that the excellent agreement of the s_{eff}^2 comparison and the fact that the δM_W deviation is relatively small, of $\mathcal{O}(1\sigma)$, are consistent with the conjecture that the newly discovered particle is indeed the Higgs boson, the fundamental missing piece of the ST.

Very recently we learned that calculations of M_W and s_{eff}^2 based on the fitting formulas were also included in Ref. [11], and that they are in very close agreement with our results in Eq. (3) and Eq. (4). We thank R. Kogler for this valuable information. The authors are also indebted to Kyle Cranmer for very useful observations.

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