The Direct Limit on the Higgs Mass and the SM Fit

Michael S. Chanowitz

Lawrence Berkeley National Laboratory
University of California
Berkeley, California 94720

Abstract

Because of two 3σ anomalies, the Standard Model (SM) fit of the precision electroweak data has a poor confidence level, $CL = 0.02$. Since both anomalies involve challenging systematic issues, it might appear that the SM could still be valid if the anomalies resulted from underestimated systematic error. Indeed the CL of the global fit could then increase to 0.71, but that fit predicts a small Higgs boson mass, $m_H = 45$ GeV, that is inconsistent at 95% CL with the lower limit, $m_H > 114$ GeV, established by direct searches. The data then favor new physics if the anomalous measurements are both excluded or both retained, and the Higgs boson mass cannot be predicted until the new physics is understood. The validity of the SM could however be maintained by a propitious combination of statistical fluctuation and systematic error. The current data do not allow a definitive conclusion.

1 Introduction

A decade of beautiful experiments at CERN, Fermilab, and SLAC have provided increasingly precise tests of the Standard Model (SM). The data confirms the SM at the level of quantum effects and probes the Higgs boson mass. The global fit[1] has a poor confidence level $CL = 0.02$, due to two 3σ anomalies. One of these, $x_W^{\rm OS}[\nu N]$ from NUTEV[1], is recent. The other, the discrepancy between the effective leptonic mixing angle, $x_W^l = \sin^2\theta_W^l$, determined from three leptonic asymmetry measurements($x_W^l[A_L]$) versus its determination from three hadronic ($x_W^l[A_H]$) measurements, is dominated by the $\sim 3\sigma$ discrepancy between the two most precise, A_{LR}[2] and A_{FB}^b,[3] which has been a persistent feature of the data since the earliest days of LEP and SLC.

In this talk I focus on how the direct lower limit from LEP II, $m_H > 114.4$ GeV,[2] constrains the interpretation of these anomalies, and especially the asymmetry anomaly.[5]

[1] We fit only the observables that were considered by the EWWG prior to 2002, including neither APV nor Γ_W. Theoretical systematics are not clearly controlled for the former while the latter is $\simeq 30$ times less precise than the other observables. Including them the fit would yield $CL = 0.04$.

[2] N.B., the 95% lower limit from the direct searches does *not* imply a 5% chance that $m_H < 114.4$ but rather means that if the mass were actually 114.4 GeV it could have escaped detection with 5% likelihood. The likelihood for $m_H < 114.4$ GeV is $\ll 5\%$. See for instance section 5 of [4].

The central observation is that the only measurements which support m_H in the allowed region are precisely the ones with big pulls that drive the fit to a poor CL. Without the discrepant measurements the prediction for m_H is too low. In particular, the agreement of the SM with the data would not be improved if both anomalies were attributed to systematic error, since the resulting fit (with $x_W^{\rm OS}[\nu N]$ and $x_W^l[A_H]$ removed) predicts $m_H = 45$ GeV, with only a 5% likelihood that $m_H > 114$ GeV.

The W mass measurement plays a central role, discussed in more detail in [5]. In the SM fit, it favors the lower range of the leptonic asymmetries, $x_W^l[A_L] = 0.23113(21)$, over the larger hadronic result, $x_W^l[A_H] = 0.23217(29)$. Using the two loop result of [6] the new experimental result, $m_W = 80.426(34)$GeV,[7, 8] implies $x_W^l = 0.23095$ and a very light value for m_H. Essentially it is m_W which decides whether A_{LR} or A_{FB}^b will have the largest pull.

The interpretation of the data is not clear. All three generic possibilities are in play: new physics, statistical fluctuation, and underestimated systematic error. It is certainly possible that either anomaly is genuine evidence of new physics,[9] in which case the SM fit would be invalidated and we could not use the precision data to constrain the Higgs boson mass until the new physics were understood. Statistical fluctation is also a possible explanation, which is fairly represented by the global CL's. The new 23 MeV downward shift in m_W increases the global CL by a factor two, from 0.01 to 0.02, which still cannot be said to be "favored".

Concerning the possibility of underestimated systematic error, the three leptonic asymmetry measurements, $x[A_L]$, are theoretically clean and use three quite different experimental techniques, so that a large common systematic error is very unlikely. In contrast, both $x_W^{\rm OS}[\nu N]$ and $x[A_H]$ depend on subtle systematic issues, involving experimental technique and, especially, nontrivial applications of QCD. The three hadronic asymmetry measurements have important shared systematics, both theoretical and experimental. If the systematic uncertainties of the $x_W^{\rm OS}[\nu N]$ and $x[A_H]$ anomalies were much larger than current estimates, the CL of the global fit could increase to as much as 0.71. The SM might then appear to provide a good description of the data, however we would then encounter the conflict with the LEP II lower limit on m_H. This conflict would also signify new physics,[10] to raise the prediction for m_H into the allowed region above 114 GeV. Again m_H could not be predicted until the new physics is known. With oblique corrections it is possible to "dial in" essentially any value of m_H.[5]

It should be clear that the focus here on the possibility of underestimated systematic error is not based on the belief that it is the most likely explanation. In both cases the experimental groups have put great effort into understanding and estimating the systematic uncertainties, and the quoted systematic errors are too small to explain the anomalies.[1, 3] In fact, the situation is truly puzzling, and there is no decisive reason to prefer systematic error over new physics as the explanation of either anomaly. Rather we consider the systematic error hypothesis simply in order to understand what it implies and find that it also points to new physics.

Though it is an *a posteriori* observation, the grouping of the six asymmetry measurements into hadronic and leptonic clusters is a striking feature of the data. The leptonic asymmetries are the three lowest, combining to $x[A_L] = 0.23113(21)$ with $\chi^2/dof = 1.7/2$, $CL = 0.43$. The hadronic asymmetries are the three highest, tightly clustered around

$x[A_H] = 0.23217(29)$, with $\chi^2/dof = 0.05/2$, $CL = 0.97$. Combining all six measurements we have $x^l_W = 0.23148(17)$ with $\chi^2/dof = 10.2/5$ and $CL = 0.07$. It is unclear whether the grouping into leptonic and hadronic clusters is by chance or whether it is telling us something, either about new physics or about systematic effects. Since they are linked by common systematics, we consider the the three hadronic asymmetry measurements together when considering the systematic uncertainty hypothesis.

2 SM Fits

The SM radiative corrections are computed with ZFITTER v6.30,[11] but with the two loop m_W.[6] Experimental correlations are from [12] and $\Delta\alpha_5(m_Z)$ is from [13] as in [12]. Predictions for m_H are obtained using $\Delta\chi^2$[12] and also with a "Bayesian" likelihood method[5]. Both methods give very similar results, and only the former are reported here. When fitting the same observables the SM predictions and χ^2 results agree well with [8, 12], with small differences from our use of [6].

Table 1 summarizes χ^2 fits of four data sets, in which none, one, or both sets of anomalous measurements are excluded. We vary m_t and $\Delta\alpha_5(m_Z)$, which are constrained, and $\alpha_S(m_Z)$ and m_H, which are unconstrained. Fit A is our "all data"set, including the ten m_H-sensitive observables (the six x^l_W determinations, $x^{\rm OS}_W[\nu N]$, and three "non-asymmetry" observables, m_W, Γ_Z, and R_l) and five m_H-insensitive observables (σ_h, R_b, R_c, A_b, and A_c). The CL increases from 0.02 in fit A to 0.17 if $x^{\rm OS}_W[\nu N]$ is omitted (B), or to 0.08 if the hadronic asymmetries are omitted (C), to 0.71 if both are omitted (D).

Fits restricted to the m_H-sensitive sector, which determines the SM prediction for m_H, are also shown in table 1. Fit A$'$, with all ten m_H-sensitive observables, has $CL = 0.005$, while B$'$ and C$'$ are at 0.07 and 0.02 respectively, each substantially smaller than the corresponding global fits A,B,C. A fit of just the three most precise m_H-sensitive observables, A_{LR}, A^b_{FB}, and m_W, which together dominate the m_H prediction,[3] yields $\chi^2/dof = 10.2/2$ and $CL = 0.006$. The poor consistency of the m_H-sensitive sector is cause for concern in assessing the reliability of the SM prediction of m_H.

Table 1. Results for global fits A - D and for the corresponding fits restricted to m_H-sensitive observables, A$'$ - D$'$.

	All	$-x^{\rm OS}_W[\nu N]$
All	**A**	**B**
	$\chi^2/ = 25.7/13$, $CL = 0.019$	16.5/12, 0.17
$-x^l_W[A_H]$	**C**	**D**
	16.7/10, 0.081	6.3/9, 0.71
m_H-sensitive only:		
All	**A$'$**	**B$'$**
	22.2/8, 0.0046	13.2/7, 0.067
$-x^l_W[A_H]$	**C$'$**	**D$'$**
	13.2/5, 0.022	2.94/4, 0.57

[3]The fit to these three observables has $m_H = 94$ with $36 < m_H < 212$ (90% CL), compared with $m_H = 90$ and $39 < m_H < 205$ from the all-data global fit A.

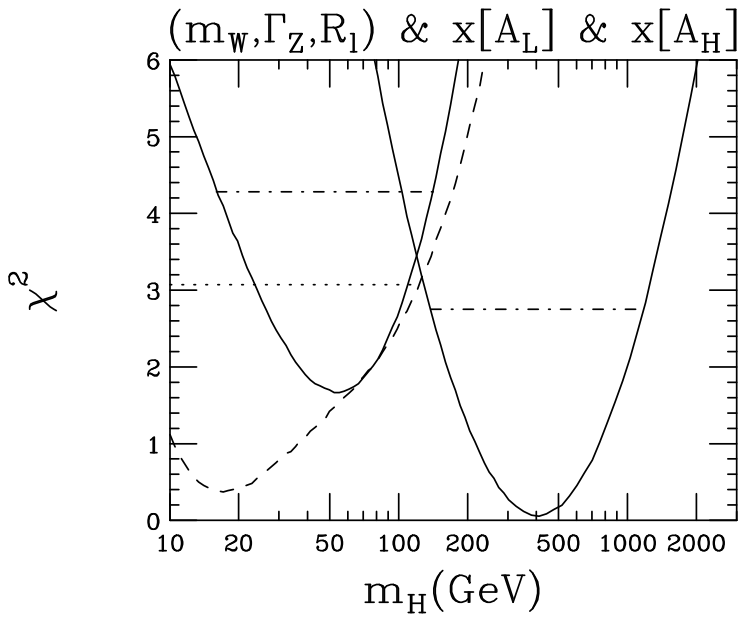

Figure 1: χ^2 distributions for $x_l^W[A_L]$ and $x_l^W[A_H]$ (solid lines) and for (m_W, Γ_Z, R_l) (dashed line). The symmetric 90% CL intervals are indicated by the dot-dashed lines for $x_l^W[A_L]$ and $x_l^W[A_H]$ and the dotted line for (m_W, Γ_Z, R_l).

The global CL's fairly reflect the likelihoods of the fits. Consider for example fit B, for which A_{FB}^b is the only significant outlyer, with a pull of 2.59. While 2.59σ corresponds to $CL = 0.0096$, in the context of fit B we should ask for the probability that at least one of 12 independent measurements would deviate by $\geq 2.59\sigma$. This is $1-(1-0.0096)^{12} = 0.11$, which appropriately reflects $CL = 0.17$ from the χ^2 global fit.

It is also instructive to consider the predictions of the m_H-sensitive observables, table 2. For A_{LR} the central value is $m_H = 39$ GeV, the 95% upper limit is 122 GeV, and the

Table 2. Predictions for m_H from the three highest precision m_H-sensitive observables, from the combined leptonic asymmetries $x[A_L]$, the combined hadronic asymmetries $x[A_H]$, and the three remaining (non-asymmetry) m_H-sensitive observables. The value of m_H at the χ^2 minimum is shown along with the symmetric 90% confidence interval and the likelihood for $m_H > 114$ GeV. Values indicated as 10− or 3000+ fall below or above the interval $10 < m_H < 3000$ GeV within which the fits are performed.

	m_H (GeV)	90% CL	$CL(m_H > 114)$
A_{LR}	39	$10- < m_H < 122$	0.062
A_{FB}^b	410	$130 < m_H < 1200$	0.97
m_W	35	$10- < m_H < 161$	0.12
$x_W^l[A_L]$	55	$16 < m_H < 143$	0.10
$x_W^l[A_H]$	410	$140 < m_H < 1200$	0.97
$m_W \oplus \Gamma_Z \oplus R_l$	17	$10- < m_H < 123$	0.057

likelihood for $m_H > 114$ GeV is $CL(m_H > 114) = 0.06$. The W mass also prefers small m_H. The only important contributor to large m_H is A_{FB}^b, with central value $m_H = 410$ GeV and symmetric 90% CL interval up to 1200 GeV. Also shown are the predictions of the three leptonic asymmetries which are similar to A_{LR}, the three hadronic asymmetries which are nearly identical to A_{FB}^b (since it has much greater precision than A_{FB}^c and Q_{FB}), and the non-asymmetry measurements (m_W, Γ_Z, R_l) which resemble m_W though with a stronger preference for light m_H. The χ^2 distributions are shown in figure 1.

Table 3 summarizes the m_H predictions of the four global fits for which $CL(\chi^2)$ is shown in table 1. Fit A is similar to the EWWG all-data fit[8], with the 95% CL upper limit at $m_H < 205$ GeV. The omission of $x_W^{\rm OS}[\nu N]$ from fit B increases $CL(\chi^2)$ appreciably but has little effect on m_H. Fits C and D, with the hadronic asymmetry measurements excluded, both have $m_H = 45$ GeV as central value, with 7% and 5% CL's respectively for $m_H > 114$ GeV. The $\Delta\chi^2$ distributions for fits A and D are shown in figure 2.

Since the internal consistency of the global fit, $CL(\chi^2)$, and the consistency of the fit with the search limit, $CL(m_H > 114)$, are independent, it is interesting to consider the combined probability, given by the product

$$P_C = CL(\chi^2) \times CL(m_H > 114). \tag{1}$$

The *relative* values of P_C for the different fits are especially interesting. From table 3 we see that P_C is approximately independent of whether the hadronic asymmetry measurements $x_W^l[A_H]$ are included, although the individual factors on the right side of eq. (1) are very sensitive to $x_W^l[A_H]$. For instance, for global fit A ('all' data), $CL(\chi^2) = 0.019$ and $CL(m_H > 114) = 0.35$ so that $P_C[A] = 0.019 \times 0.35 = 0.0066$.For fit C, with the three $x_W^l[A_H]$ omitted, we have $CL(\chi^2) = 0.081$, $CL(m_H > 114) = 0.068$, and $P_C[C] = 0.081 \times 0.068 = 0.0055 \simeq P_C[A]$. Similarly, $P_C[B] = 0.17 \times 0.29 = 0.049$ and $P_C[D] = 0.71 \times 0.049 = 0.035 \simeq P_C[B]$. If the hadronic asymmetry measurements are omitted, the increase in the global fit confidence level is compensated by a roughly equal decrease in the consistency with the direct search limit.

Table 3. Higgs boson mass predictions for global fits A - D. Each entry shows the value of m_H at the χ^2 minimum, the symmetric 90% confidence interval, the CL for consistency with the search limit, and the combined likelihood P_C, eq. (1), with the factors $CL(\chi^2)$ and $CL(m_H > 114)$ explicitly displayed.

	All	$-x_W^{\rm OS}[\overset{(-)}{\nu} N]$
All	**A**	**B**
	$m_H = 90$	$m_H = 90$
	$39 < m_H < 205$	$38 < m_H < 190$
	$CL(m_H > 114) = 0.35$	$CL(m_H > 114) = 0.29$
	$P_C = 0.019 \times 0.35 = 0.0066$	$P_C = 0.17 \times 0.29 = 0.049$
$-x_W^l[A_H]$	**C**	**D**
	$m_H = 45$	$m_H = 45$
	$18 < m_H < 123$	$18 < m_H < 114$
	$CL(m_H > 114) = 0.068$	$CL(m_H > 114) = 0.049$
	$P_C = 0.081 \times 0.068 = 0.0055$	$P_C = 0.71 \times 0.049 = 0.035$

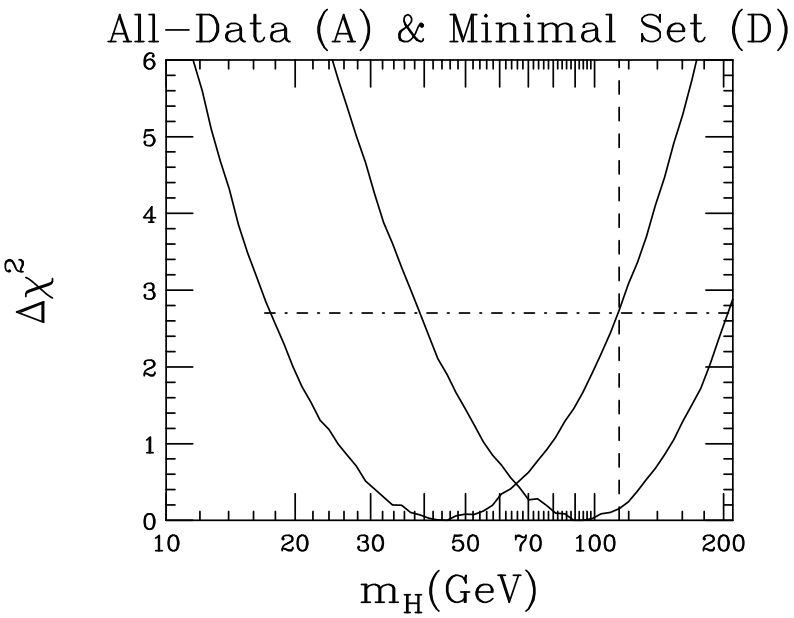

Figure 2: $\Delta\chi^2$ distributions for fits A and D. The dot-dashed line denotes the 95% CL upper and lower limits and the dashed line indicates the experimental lower limit on m_H.

It is easy to show that the product of n independent CL's has an expectation value of $1/2^n$ so that the expectation value of P_C is 0.25. Consider a continuous probability density function $f(x)$ defined for positive x, with normalization

$$\int_0^\infty dx f(x) = 1. \tag{2}$$

Then the CL for $x < y$ is

$$F(y) = \int_0^y dx f(x) \tag{3}$$

and the expected value of F is

$$< F >= \int_0^\infty dy F(y) f(y) = \frac{1}{2} \tag{4}$$

where equations (2) and (3) suffice to evaluate the integral. For a product of n independent CL's the expectation value of the combined product CL is then given by n factors of the form of equation (4), with the result $1/2^n$. In the case at hand P_C is the product of two χ^2 distributions: $CL(\chi^2, N)$ and $CL(m_H > 114) = CL(\Delta\chi^2, 1)/2$, where $\Delta\chi^2$ is the difference between the minimum at $m_H = 114$ and the global minimum. The factor $1/2$ in $CL(m_H > 114)$ is compensated by the fact that the domain of $\Delta\chi^2$ extends from $-\infty$ to $+\infty$; modifying equations (2-4) appropriately, the expected value is again $1/2$.

In addition to the pairings $P_C[A] \simeq P_C[C]$ and $P_C[B] \simeq P_C[D]$, the other prominent feature of table 3 is that $CL(m_H > 114)$ depends sensitively on whether $x[A_H]$ is retained but not on $x_W^{\rm OS}[\nu N]$, i.e., $CL(m_H > 114)_A \simeq CL(m_H > 114)_B$ and $CL(m_H > 114)_C \simeq CL(m_H > 114)_D$. For fits C and D, with $x[A_H]$ omitted, the consistency with the search limit is poor. Relative to 0.25, the value of P_C is marginal for all four fits.

3 New Physics to Increase m_H

The low values of $CL(m_H > 114)$ in fits C and D are either statistical fluctuations (e.g., of m_t) or they are signals of new physics. Examples of new physics that could do the job are the MSSM with light sneutrinos and sleptons (Altarelli *et al.* in [10]) or a fourth generation of quarks and leptons with a massive neutrino (Novikov *et al.* in [10]). An illustrative set of parameters for the latter is $m_N \simeq 50$ GeV, $m_E \simeq 100$ GeV, $m_U + m_D \simeq 500$ GeV, $|m_U - m_D| \simeq 75$ GeV, and $m_H \simeq 300$ GeV.

The prediction for m_H can be increased arbitrarily in models for which the dominant effect of the new physics is via the W and Z boson self energies, considered in the oblique approximation[14]. Figure 3 shows an S, T fit to the minimal data set, with the χ^2 minimum read to the left and S, T read to the right. In contrast to the SM fit with a distinct minimum at $m_H = 45$ GeV, also shown, the oblique fit is flat, with no preference for any range of m_H. The confidence level is $\simeq 0.5$ and the variation in χ^2 is very small, with $\Delta\chi^2 \leq 0.2$ for $m_H \geq 20$ GeV.

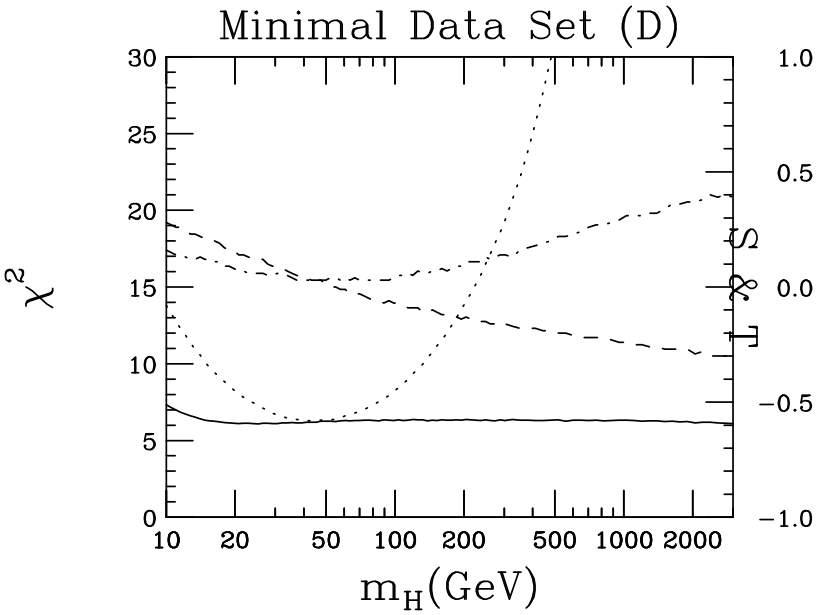

Figure 3: Minimal Data Set (data set D) χ^2 distributions for SM (dots) and S, T fit (solid). The values of S (dashed) and T (dot-dashed) are read to the right axis.

Values of m_H above 1 TeV cannot be interpreted literally as applying to a simple Higgs scalar. For $m_H > 1$ TeV symmetry breaking is dynamical, occurring by new strong interactions that cannot be analyzed perturbatively.[15] If the Higgs mechanism is correct, there are new quanta that form symmetry breaking vacuum condensates. Values of m_H above 1 TeV can be regarded only as a rough guide to the order of magnitude of the masses of the condensate-forming quanta.

The range of positive T needed in figure 3 occurs in models with custodial $SU(2)$ breaking, e.g., from nondegenerate quark or lepton isospin doublets. Negative S is less natural but there is not a no-go theorem, and models with $S < 0$ have been exhibited.

It is also possible to fit the data by varying T with $S = 0$ fixed — see figure 11 of [5]. Moderately large, postive T is again preferred. In this fit the confidence level for m_H above the LEP II lower limit is $CL(m_H > 114\,\mathrm{GeV}) = 0.21$, and the 95% upper limit extends to $m_H < 400$ GeV.

4 Discussion

Taken together the precision electroweak data and the direct searches for the Higgs boson create a complex puzzle with many possible outcomes. An overview is given in the "electroweak schematic diagram," figure 4. The diagram illustrates how various hypotheses about the two 3σ anomalies lead to new physics or to the conventional SM fit. The principal conclusion is reflected in the fact that the only lines leading into the 'SM' box are labeled 'Statistical Fluctuation.' That is, systematic error of both $x[A_H]$ and $x_W^{OS}[\nu N]$ cannot save the SM fit, since it implies the conflict with the search limit, indicated by the box labeled $CL(m_H > 114) = 0.05$, which in turn either implies new physics or reflects statistical fluctuation (e.g., of m_t). The problem is exhibited by the small value of P_C for

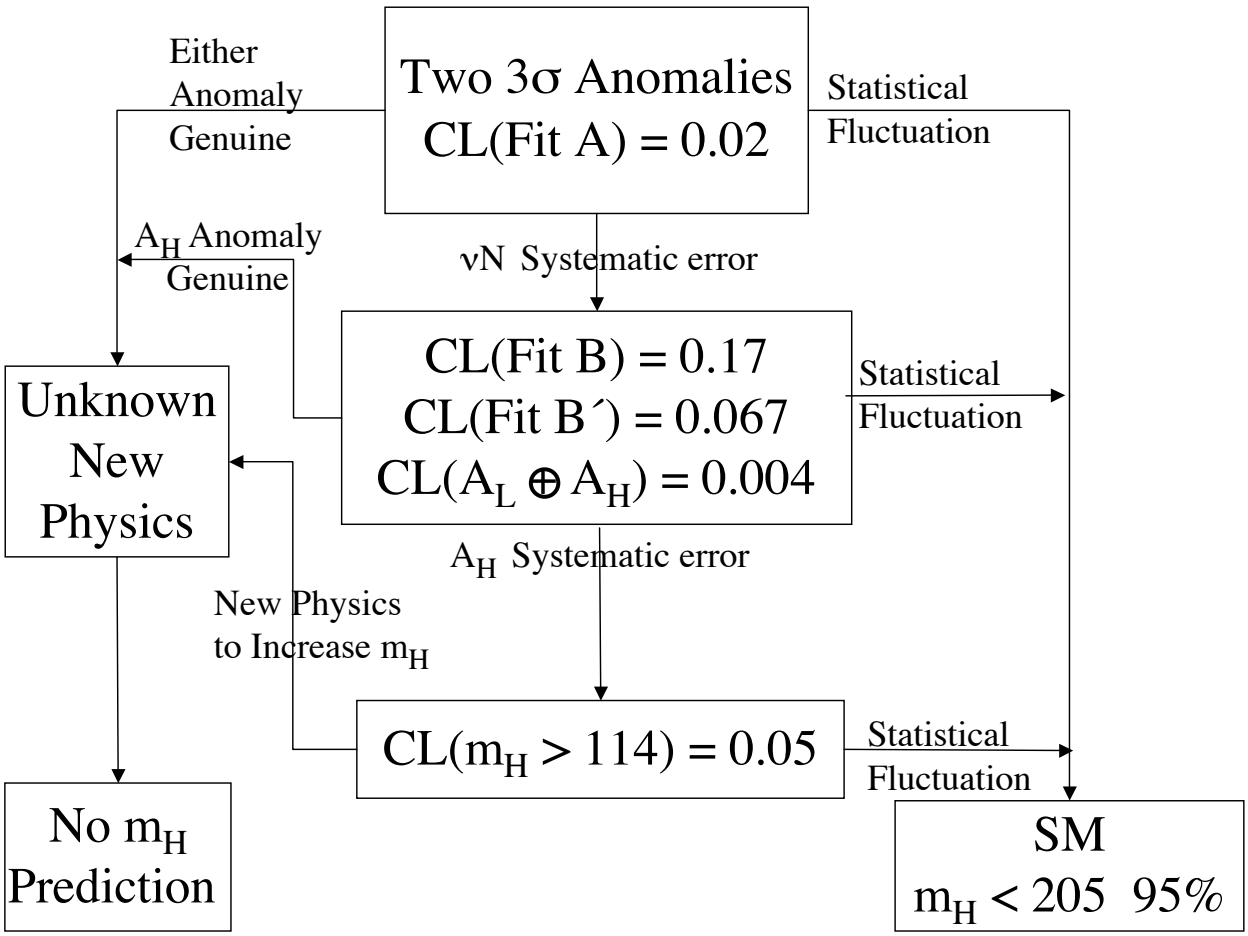

Figure 4: Electroweak schematic diagram.

each of the fits in table 3.

The 'New Physics' box in figure 4 is reached if either 3σ anomaly is genuine or, conversely, if neither is genuine and the resulting 95% CL conflict with the search limit is genuine. The global confidence levels of fits A and B fairly reflect the probability that they are due to statistical fluctuations. They do not favor the SM and they also do not exclude it: "It is a part of probability that many improbable things will happen."[16]

The smoothest path to the SM traverses the central box, fit B, and then exits via 'Statistical Fluctuation' to the SM. In this scenario QCD effects might explain the NuTeV anomaly and the 17% confidence level of fit B could be a statistical fluctuation. This is a valid possibility, but two other problems indicated in the central box should also be considered in this scenario. First, the consistency of the m_H-sensitive measurements is marginal, indicated by the 6.7% confidence level of fit B$'$. Second, the persistent conflict between the leptonic and hadronic asymmetry measurements, currently 2.9σ with $CL = 0.0037$, is at the heart of the determination of m_H. Thus even if we assume that the CL of the global fit is a statistical fluctuation, the reliability of the prediction of m_H depends on even less probable fluctuations.

The leptonic asymmetry measurements have been finalized. There are still some on-going analyses of the hadronic asymmetry data, but unless major new systematic effects are uncovered, large changes are unlikely. To do better we will need a second generation Z factory, such as the proposed Giga-Z project. However, to fully exploit the potential of such a facility it will be necessary to improve the precision of $\Delta\alpha_5(m_Z)$ by a factor of ~ 5 or better, requiring a dedicated program to measure $\sigma(e^+e^- \to \text{HADRONS})$ below ~ 5 GeV to $\simeq 1\%$.[17] The W boson and top quark mass measurements will be improved at the TeVatron, LHC, and, eventually, at a linear e^+e^- collider.

The issues raised by the data heighten the excitement of the moment in high energy physics. If both 3σ anomalies reflect systematic effects, the resulting SM fit is inconsistent with the LEP II limit. For the SM prediction of m_H to be valid the anomalies must be a propitious combination of systematic effect ($x_W^{\nu N}$) and statistical fluctuation ($x[A_L]$ vs. $x[A_H]$). The end of the decade of precision electroweak measurements leaves us with a great puzzle, that puts into question the mass scale at which the physics of electroweak symmetry breaking will be found. The solution of the puzzle could emerge at the TeVatron. If it is not found there it will emerge at the LHC, which at its design luminosity will be able to search for the new quanta of the symmetry breaking sector over the full range allowed by unitarity.[15, 18]

Acknowledgement: I wish to thank the organizers for the opportunity to attend this very interesting workshop and Peter Zerwas for kind hospitality beyond the call of duty.

References

[1] K. McFarland, these proceedings.

[2] M. Swartz, these proceedings.

[3] P. Wells, these proceedings.

[4] M. S. Chanowitz, Phys. Rev. D **59** (1999) 073005 [arXiv:hep-ph/9807452].

[5] M. S. Chanowitz, Phys. Rev. D **66** (2002) 073002 [arXiv:hep-ph/0207123]; Phys. Rev. Lett. **87** (2001) 231802 [arXiv:hep-ph/0104024].

[6] A. Freitas, S. Heinemeyer and G. Weiglein, arXiv:hep-ph/0212068.

[7] R. Hawkings, these proceedings.

[8] M. Grünewald, these proceedings.

[9] For new physics models of the anomalies see for instance X. G. He and G. Valencia, Phys. Rev. D **66** (2002) 013004 [Erratum-ibid. D **66** (2002) 079901]; D. Choudhury, T. M. Tait and C. E. Wagner, Phys. Rev. D **65** (2002) 053002 [arXiv:hep-ph/0109097]; W. Loinaz, N. Okamura, T. Takeuchi and L. C. Wijewardhana, arXiv:hep-ph/0210193.

[10] For new physics to increase m_H see for instance G. Altarelli, F. Caravaglios, G. F. Giudice, P. Gambino and G. Ridolfi, JHEP **0106** (2001) 018 [arXiv:hep-ph/0106029]; V. A. Novikov, L. B. Okun, A. N. Rozanov and M. I. Vysotsky, JETP Lett. **76** (2002) 127 [Pisma Zh. Eksp. Teor. Fiz. **76** (2002) 158] [arXiv:hep-ph/0203132]; Phys. Lett. B **529** (2002) 111 [arXiv:hep-ph/0111028].

[11] D. Bardin *et al.*, Comput. Phys. Commun. **133** (2001) 229 [arXiv:hep-ph/9908433].

[12] The LEP Collaborations ALEPH, DELPHI, L3, OPAL, the LEP Electroweak Working Group, and the SLD Heavy Flavour and Electroweak Groups, LEPEWWG/2002-02, December 10, 2002 [arXiv:hep-ex/0112036].

[13] H. Burkhardt and B. Pietrzyk, Phys. Lett. B 513, (2001) 46.

[14] M. E. Peskin and T. Takeuchi, Phys. Rev. D **46** (1992) 381.

[15] M. S. Chanowitz and M. K. Gaillard, Nucl. Phys. B **261** (1985) 379.

[16] Agathon, quoted by Aristotle in the *Poetics*, as translated by G. Eliot in *Daniel Deronda*.

[17] F. Jegerlehner, these proceedings.

[18] M. S. Chanowitz and W. B. Kilgore, Phys. Lett. B **347** (1995) 387 [arXiv:hep-ph/9412275];Phys. Lett. B **322** (1994) 147 [arXiv:hep-ph/9311336]; J. Bagger *et al.*, Phys. Rev. D **52** (1995) 3878 [arXiv:hep-ph/9504426].