III. PARTICLE PHYSICS

DICOVERY POTENTIAL FOR NEW PHYSICS AT LEP2

P. Chiappetta

Centre de Physique Théorique, UPR 7061,
CNRS Luminy, Case 907, F-13288 Marseille Cedex 9.

We give an overview of the prospects for Standard Model Higgs and New Physics discovery at LEP2.

The present generation of high precision experiments imposes stringent tests on the standard model - hereafter denoted as SM - and on its extensions. The SM has been tested as the level of a few per mille [1] with already indirect evidence for self interaction among weak gauge bosons. The electroweak symmetry breaking relies on the existence of the Higgs boson, not yet discovered. The 2σ standard deviations on $R_b = \frac{\Gamma(Z \to b\bar{b})}{\Gamma_{hadronic}} = 0.2179 \pm 0.0012$ at LEP and on the left right asymmetry A_{LR} and fermionic asymmetries $A_f = \frac{2 v_f a_f}{v_f^2 + a_f^2}$ (v_f and a_f being the vector and axial vector couplings of Z to fermions) at SLC may indirectly reveal new physics, like supersymmetry - hereafter denoted as SUSY- or existence of a new gauge boson - the hadrophilic [2] or leptophobic Z' [3] or non commuting extended technicolor [4]. The observable $R_c = \frac{\Gamma(Z \to c\bar{c})}{\Gamma_{hadronic}}$ is now in agreement with the SM: $R_c = 0.1715 \pm 0.0056$. Concerning $p\bar{p}$ collider the CDF collaboration has observed an excess of jet events in the large P_T tail [5]. If these deviations from SM expectations remain, we will show that LEP2 has great potential for pinning down their origin. If LEP2 does not see deviations from the SM, this will indicate that the underlying theory, in its low energy limit, can only "softly" deviate from the SM: this will put severe constraints on SUSY or alternative models.

1. Electroweak symmetry breaking mechanism

In the SM the EWSB mechanism [6] is due to a complex isodoublet scalar field Φ which breaks $SU(2)_L \times U(1)_Y \to U(1)_{em}$ at a scale $v \simeq 250 GeV$. Since only three degrees of freedom are needed to generate masses for weak gauge bosons, we are left with a physical Higgs boson. Present direct LEP1 limits indicate that $M_H \geq 65.2 GeV$ [7]. For the moment the indirect sensitivity to the Higgs mass is weak: $65.2 GeV \leq M_H \leq 440 GeV$ [8], and the preference for small Higgs masses rely entirely on observables which differ from SM expectations by $2-3\sigma$ i.e. $R_b = \frac{\Gamma(Z \to b\bar{b})}{\Gamma_{hadronic}}$ and the left right asymmetry A_{LR}.

On the theoretical side [9] lower bounds come from vacuum stability whereas upper bounds are due to the strong interaction limit i.e. demanding that the SM particles remain weakly interacting up tp a scale Λ. In order to be more precise the renormalization group equation that the Higgs self coupling λ has to satisfy reads:

$$\frac{d\lambda}{dt} = \frac{1}{2\pi^2}(\lambda^2 + \lambda h_t^2 - h_t^4), \tag{1}$$

where h_t is the top Yukawa coupling and $t = \log\frac{Q^2}{\Lambda^2}$. Electroweak corrections have been omitted. If we arbitrarily fix Λ we get upper bound on the Higgs mass as a function of the top mass by imposing:

$$\frac{\lambda(\Lambda)}{4\pi} \leq 1. \tag{2}$$

The lower bound comes from the condition: $\lambda \geq 0$. This is explicitely shown in figure 1 from [9]. Thanks to the present limits on the top mass we can infer that for $\Lambda = 1TeV$ the bounds correspond moreless to the indirect LEP1 ones previously quoted, whereas if the SM is valid up to the Planck scale: $120 \leq M_H \leq 180GeV$.

The main production mechanism at LEP2 is $e^+e^- \to HZ$ with Z decaying into muons and the Higgs into massive fermions: $H \to b\bar{b}, \tau^+\tau^-$. The signal corresponds therefore to a four fermion final state. The simulations performed for LEP2 workshop-to which we refer for more details [10] - included initial state QED radiative corrections (of the order of $10-20\%$) and the $o(\alpha_s^2)$ corrections to $H \to b\bar{b}$. The results are summarized in figure 2. Assuming a luminosity per experiment of $150pb^{-1}$ at $\sqrt{S} = 192GeV$ leads to a 5σ discovery of $95GeV$ for the Higgs. One can infer from the theoretical plot of figure 1 that if a Higgs is found at LEP2, new physics is expected at a scale around $10TeV$.

As shown in this meeting [11] , for the SM Higgs, LHC will be able to discover the Higgs for masses $M_H \geq 80GeV$. The low mass Higgs is produced either directly from gluon-gluon subprocess and decays into two photons or in association with a W,Z or a $t\bar{t}$ pair. The signal corresponds to lepton(s) plus two photons or a $b\bar{b}$ pair according to the Higgs decay. Concerning associated production, by looking for a peak in the $b\bar{b}$ invariant mass one gets $\frac{S}{\sqrt{B}} \geq 5$ for $80GeV \leq M_H \leq 100GeV$.For the invariant diphoton mass $\frac{S}{\sqrt{B}} \geq 5$ only for $M_H \geq 100GeV$. Therefore there will be no hole in SM Higgs discovery.

If a Higgs is found at LEP2 the open question will be to pin down its origin: SM or SUSY [12]? In the MSSM (Minimal SuperSymmetric Model) two Higgs doublets are necessary to give masses to down type quarks and leptons on one hand and to up type quarks on the other hand. This leads to 5 Higgses: 2 charged H^+, H^- and 3 neutrals h_0, H_0 and the CP odd A. The two production processes $e^+e^- \to Zh$ and $e^+e^- \to Ah$ are complementary according to $\tan\beta = \frac{v_2}{v_1}$ values. For small (resp. large) $\tan\beta$ values $\sigma(e^+e^- \to Zh) \geq (resp. \leq)\sigma(e^+e^- \to Ah)$. The dominant decay modes are $h, A \to b\bar{b}$. The mass spectrum [13] has to take into account one loop radiative corrections:

$$m_h^2 = M_Z^2 \cos^2 2\beta + \frac{3m_t^4}{4\pi^2 v^2}\log(\frac{m_{\tilde{t}_1} m_{\tilde{t}_2}}{m_t^2}) + \frac{3m_t^4 \tilde{A}_t^2}{8\pi^2 v^2} f(m_{\tilde{t}_1}^2, m_{\tilde{t}_2}^2, \tilde{A}_t^2), \qquad (3)$$

where $\tilde{t}_i$ represents the stop ($i = 1, 2$) and $\tilde{A}_t = A_t - \mu \cot\beta$, A_t and μ being soft breaking terms related to the breaking of SUSY. The limits [10] on the SUSY Higgses depend on unknown parameters: soft breaking terms, common scalar and gaugino masses. For large $\tan\beta$ values the discovery limits on h_0 and A are degenerate: roughly $80GeV$ at $\sqrt{S} = 192GeV$ for an integrated luminosity of $150pb^{-1}$ and $90GeV$ at $\sqrt{S} = 205GeV$ for an integrated luminosity of $300pb^{-1}$. For $\tan\beta = 2$ discovery limits on (m_h, m_A) are at $\sqrt{S} = 192GeV$ resp. (95 GeV , 78 GeV) and at $\sqrt{S} = 205GeV$ (108 , 80 GeV).

The SUSY framework that LEP2 can exclude is the infrared fixed point solution [14]. Assuming at the GUT scale $h_b = h_\tau$ and determining the top mass as a function of $\tan\beta$ from the experimental values for b and τ masses, the top mass is attracted toward its infrared fixed point solution if $\frac{h_t^2(M_{GUT})}{4\pi} \simeq 0.1 - 1$. For top masses in the CDF range, $\tan\beta$ is either small or very large ($\simeq 50$). As an illustration for $m_t = 175GeV$ $m_h \leq 100GeV$ and the LEP2 option $\sqrt{S} = 192GeV$ excludes at 95% CL the IR fixed point solution [14].

A strong EWSB sector is strongly restricted but not excluded by present dataa[15]. The most solid scenario is the degenerate BESS, characterized by degenerate vector and axial-vector new resonances, since it evades LEP1 /SLC and CDF bounds. LEP2 will not improve present limits.

2. SUSY searches

SUSY is certainly the best motivated known extension of the SM, consistent with present experimental data. Moreover it offers, as we will show now, a possibility [16] to obtain larger values for R_b without altering the other LEP1 observables. The global fit to all electroweak data favours light stops and a lightest chargino below M_Z. The present LEP1 direct limits on SUSY partners lie around $\frac{M_Z}{2}$. LEP1.5 run has put limits on charginos: $M_{\chi^\pm} \geq 65GeV$. For low $\tan\beta$, R_b receives loop contributions from right stops and higgsino like charginos, whereas for large $\tan\beta$ the Higgs A contributes also. The deviations on R_b are more stringent when the the SUSY partners are as light as possible. SUSY can now accomodate the present world average R_b value. Moreover the SUSY partners are expected in the discovery range of LEP2.

LEP2 cannot compete with the Tevatron concerning the search for squarks and gluinos except for the stop. Since the top SUSY partners are expected to mix, they are sensitive to the soft SUSY breaking parameters. The decay modes are $\tilde{t}_1 \to c\tilde{\chi}_1^0$ and $\tilde{t}_1 \to b\tilde{\chi}_1^+$ and the stops are pair produced. As can be seen from figure 3 LEP2 [17] will appreciably extend the range excluded by the Tevatron.

Concerning neutralinos the most promising process is $e^+e^- \rightarrow \tilde{\chi}_1^0\tilde{\chi}_2^0$, depending on the parameters $\mu, \tan\beta$ and $M_{\frac{1}{2}}$ (the gaugino mass). The sleptons can be detected by looking for acoplanar lepton pairs and large missing transverse energy.

Since even in the minimal version the predictions depend on five parameters, it is not possible to derive independent limits but more convenient to express the results in terms of SUSY parameters regions explorable at LEP2. This is done in figure 4, where the comparison with Tevatron emphasizes the complementarity of the two colliders.

3. Trilinear gauge bosons couplings

Since the standard model- hereafter denoted as SM- has been tested at one loop level, we have now evidence that gauge bosons are self interacting. First evidence came already in 1994 when it was shown [18] that the $sin^2\theta_W(M_Z)$ value predicted without taking into account bosonic loops deviates from data by 7σ. As of today, the three dimensional plot shown in figure 5 [19] clearly indicates the need for bosonic loops to match the SM with precise data on $\frac{M_W}{M_Z}$, $sin^2\theta_W(M_Z)$ and the leptonic width Γ_l . There are seven independent ZWW form factors and six γWW besides the electric charge. Restricting our analysis to C and P conserving VWW couplings we parametrize the lagrangian as [20]:

$$\begin{aligned}
L_{VWW} &= -ie[A_\mu(W^{-\mu\nu}W^+_\nu - W^{+\mu\nu}W^-_\nu) + (1+\Delta\kappa_\gamma)F_{\mu\nu}W^+_\mu W^-_\nu \\
&+ \cot\theta_W(1+\Delta g_1^Z)Z_\mu(W^{-\mu\nu}W^+_\nu - W^{+\mu\nu}W^-_\nu) + (1+\Delta\kappa_Z)Z_{\mu\nu}W^+_\mu W^-_\nu \\
&+ \frac{1}{M_W^2}(\lambda_\gamma F^{\nu\lambda} + \cot\theta_W \lambda_Z Z^{\nu\lambda})W^+_{\lambda\mu}W^{-\mu}_\nu]. \qquad (4)
\end{aligned}$$

This lagrangian parametrizes the most general C and P conserving VWW vertex.

In the SM $\Delta g_1^Z = 0$, $\Delta\kappa_V = 0$ and $\lambda_V = 0$, whereas no self interaction among gauge bosons would lead to $\Delta\kappa_V = -1$ and $\lambda_V = 0$. Tevatron collider [21], assuming $\lambda_\gamma = \lambda_Z$ and $\kappa_\gamma = \kappa_Z$, has excluded $\Delta\kappa_V = -1$ since $-0.7 \leq \Delta\kappa \leq 0.89$ and $-0.44 \leq \lambda \leq 0.44$.

We will now introduce the notion of effective lagrangian, which gives a general description of the phenomenon without knowing precisely its origin or the underlying theory [22], [23]. The inputs are the known symmetries at low energies and the particle content. At the electroweak scale we have to keep $SU(2) \times U(1)$ invariance and the custodial $SU(2)$ symmetry- since $\Delta\rho \leq 410^{-3}$ indicates that weak isospin breaking effects are small. The residual interactions affecting the self couplings are described by operators O_i:

$$L_{eff} = \sum_n \sum_i \frac{f_i^{(n)}}{\Lambda^n} O_i^{(n+4)}, \qquad (5)$$

where Λ is the scale for new physics. The introduction of anomalous couplings leads to a violation of unitarity which is cured either by introducing form factors or imposing unitarity constraints on the couplings.

Some of these operators are already constrained at LEP1[24], since they affect gauge boson two point functions. We shall first discuss the scenario of a linear realization of EWSB through a Higgs doublet Φ. Precisely the operator $O_{\Phi,1} = (D_\mu\Phi)^+\Phi\Phi^+(D_\mu\Phi)$ is restricted by the parameter ϵ_1 whereas the variable ϵ_3 [25] restricts $O_{BW} = \frac{gg'}{4}\Phi^+B_{\mu\nu}W_{\mu\nu}\Phi$ (B being the $U(1)$ field and W the $SU(2)$ field). The coefficients $f_{\Phi,1}$ is of the order of 10^{-1} whereas f_{BW} is of the order of one [23]. The operators describing the self interactions which do not contribute to the two point functions are:

$$O_W = \frac{ig}{2}(D_\mu\Phi)^+\vec{\tau}.\vec{W}^{\mu\nu}D_\nu\Phi, \tag{6}$$

$$O_B = \frac{ig'}{2}(D_\mu\Phi)^+B^{\mu\nu}D_\nu\Phi \tag{7}$$

and

$$O_{WWW} = Tr[\frac{ig}{2}\vec{\tau}.\vec{W}_{\mu\nu}\frac{ig}{2}\vec{\tau}.\vec{W}^{\nu\rho}\frac{ig}{2}\vec{\tau}.\vec{W}^{\mu}_{\rho}]. \tag{8}$$

Their contribution to the parameters of [20] reads:

$$\Delta\kappa_\gamma = (f_B + f_W)\frac{M_W^2}{2\Lambda^2} \tag{9}$$

$$\Delta g_1^Z = f_W\frac{M_Z^2}{2\Lambda^2} \tag{10}$$

$$\Delta\kappa_Z = [f_W - \sin^2\theta_W(f_B + f_W)]\frac{M_Z^2}{2\Lambda^2} \tag{11}$$

$$\lambda_\gamma = \lambda_Z = f_{WWW}\frac{3g^2M_W^2}{2\Lambda^2}. \tag{12}$$

The present limits on the coefficients of these operators are:

$$f_i\frac{v^2}{\Lambda^2} \simeq 10. \tag{13}$$

Let us now consider the non linear realization of EWSB where the Higgs part of the lagrangian is replaced by:

$$L_{EWSB} = \frac{v^2}{4}Tr(D^\mu\Sigma^+D_\mu\Sigma), \tag{14}$$

where $\Sigma = \exp(i\frac{\vec{\tau}.\vec{\pi}}{v})$, the π being the goldstone bosons. LEP1, through ϵ_3, constrains the operator:

$$O_{10} = \frac{gg'}{16\pi^2}Tr(B_{\mu\nu}\Sigma^+W_{\mu\nu}\Sigma). \tag{15}$$

The coefficient L_{10} lies[26] in the range $-0.7 \leq L_{10} \leq 2.4$. Instead of O_W and O_B we have now to consider the operators:

$$O_{9R} = -\frac{ig'}{16\pi^2} Tr(B^{\mu\nu} D_\mu \Sigma^+ D_\nu \Sigma) \tag{16}$$

and

$$O_{9L} = -\frac{ig}{16\pi^2} Tr(W^{\mu\nu} D_\mu \Sigma^+ D_\nu \Sigma). \tag{17}$$

Their contribution to the trilinear gauge couplings parametrized according to [20] reads:

$$\Delta g_1^Z = L_{9L}(\frac{e^2}{\sin^2\theta_W})(\frac{1}{32\pi^2\cos^2\theta_W}) \tag{18}$$

$$\Delta\kappa_Z = (L_{9L} + L_{9R})(\frac{e^2}{\sin^2\theta_W})(\frac{1}{32\pi^2}). \tag{19}$$

Present limits are weak: $L_9 \simeq 10^3$.

LEP2 is now starting to operate and will probe directly the self interactions of electroweak gauge bosons. The most interesting reaction is $e^+e^- \to W^+W^-$. The calculations performed by the LEP2 working group [27] have taken into account initial state radiation, W width effects and the background from four fermion final state, since the optimal deaay channel is $jjl\nu$. At $\sqrt{S} = 190GeV$ and for an integrated luminosity of $500pb^{-1}$ limits on L_9 have improved: $-30 \leq L_{9L} \leq 30$ and $-300 \leq L_{9R} \leq 750$. The semi leptonic decay modes of the $W^\pm$ provide the most precise determination of the trilinear gauge couplings. At $\sqrt{S} = 192GeV$ and for $500pb^{-1}$ a 2% precision looks reachable, but with a $30-40\%$ degradation due to radiative corrections, acceptance and reconstruction procedures.

We shall discuss now technicolor models: only naive QCD scales versions are ruled out by present data. Due to the heavy top mass and precise LEP1/SLC data two attractive models have recently emerged: topcolor assisted technicolor[28] and the non commuting extended technicolor [4]. The first one differs from SM by a new interaction of type $SU(3) \times U(1)$ leading to colorons which affect top production, and to an extra Z which may affect diboson production if it couples strongly to light fermions[29]. The non commuting extended technicolor model is based on the assumption that the ETC group does not commute with $SU(2)_W$, this can be realized for example by assigning the technifermions in a right handed doublet. This model can explain the R_b deviations from SM. All technicolor models predict the existence of a rich spectrum of new particles like pseudogoldstone bosons, technirho, technieta. Their existence may affect diboson production [30]. Nevertheless a quantitative study of the phenomenological consequences for diboson production from those viable models is lacking.

4. New vector bosons

Owing to the already existing mass limits from Tevatron, a Z' would not be directly produced at LEP2, but its indirect effects on fermionic observables might be sizeable [31]. A model independent analysis allows to restrict rescaled Z' leptonic couplings defined as:

$$v_l = g'_{Vl}\sqrt{\frac{q^2}{M^2_{Z'} - q^2}}\sqrt{\frac{\alpha}{16c^2_w s^4_w}} \tag{20}$$

and

$$a_l = -g'_{Al}\sqrt{\frac{q^2}{M^2_{Z'} - q^2}}\sqrt{\frac{\alpha}{16c^2_w s^4_w}}. \tag{21}$$

In these equations g'_{Vl} and g'_{Al} are the vector and axial vector couplings of the Z' to leptons (with the normalization for the Z: $g_{Vl} = -\frac{1}{2} + 2s^2_w$ and $g_{Al} = -\frac{1}{2}$). For the configuration $\sqrt{S} = 175GeV$ with $500pb^{-1}$ one gets : $-0.01 \leq v_l, a_l \leq 0.01$. Concerning specific models [32], like E_6 or Left-Right ones, LEP2 and Tevatron with an integrated luminosity of $1fb^{-1}$ are complementary, pushing limits in the $800 - 900GeV$ range. A Z' is not expected to induce observable effects in the WW channel.

Let us now discuss the hadrophilic Z' [2], introduced a few months ago in order to explain LEP1/SLC and CDF anomalies. The existence of a Z', through mixing with the Z, induces a Z mass shift constraining the mixing angle ($|\Theta_M| \leq \sqrt{0}.005\frac{M_Z}{M_{Z'}}$) and a shift of the Z couplings to fermions. Any LEP1 observable O is therefore modified according to:

$$\frac{\Delta O}{O} = A_O\Theta^2_M\frac{M^2_{Z'}}{M^2_Z} + B_O\Theta_M. \tag{22}$$

From the various LEP1/SLC observables involving leptons and quarks one can derive the allowed bands at 2σ on the ratios ξ_{Vf} and ξ_{Af} between the $Z'f\bar{f}$ couplings and the $Zf\bar{f}$ ones. The values from LEP1 fit have to be taken with care now since they have recently changed but from SLC data a definite non zero value for ξ_{Ab} is suggested. An universal coupling to up and down type quarks is assumed: therefore the relative shifts in the partial widths Γ_u and Γ_d are predicted to be of opposite sign. The excess of dijet events with an invariant mass above 500 GeV seen by CDF, but not by D0, can be explained in terms of such an hadrophilic Z': the mass of the Z' should lie around 1 TeV and typical values for the couplings are $\xi_{Vb}, \xi_{Ab} \simeq 3 - 5$.

There are possible visible consequences at LEP2 if the Z' couples to leptons. The leptophobic option [3] assuming only a coupling through mixing will therefore escape any LEP2 constraint. Although there is no indication for large $Z'l\bar{l}$ couplings, LEP1/SLC precision data allow non zero values. Therefore the hadrophilic option can accomodate such couplings. If no deviation from the leptonic observables is seen at LEP2 for $\sqrt{S} = 175 GeV$, the leptonic ratios are limited according to:

$$|\xi_{Vl}| \leq 8.02(\frac{M_{Z'}}{1TeV}) \tag{23}$$

and

$$|\xi_{Al}| \leq 1.01(\frac{M_{Z'}}{1TeV}). \tag{24}$$

Using as input these upper bounds, values in the neighbourhood of $\xi_{Vb}, \xi_{Ab} \simeq 3$ induce an observable shift in the $b\bar{b}$ cross section, as shown in figure 6, and in the $b\bar{b}$ forward backward asymmetry.

5. Improved precision on the W mass

The present Tevatron [33] precision on M_W is $\Delta M_W = \pm 160 MeV$. Thanks to the large data sample from Run 1b with a luminosity of $100pb^{-1}$,Tevatron should reach $\Delta M_W = \pm 70 MeV$. Since the prediction on the W mass is sensitive to the top and Higgs masses, the interest of a precise determination is to constrain the allowed range for the Higgs boson mass and to confront direct M_W measurement with the indirect one obtained from a global fit. Varying the Higgs mass between 60 GeV and 1 TeV leads to $\Delta M_W = \pm 51 MeV$.

There are basically two methods for measuring M_W at LEP [34]. The threshold cross section measurement of $e^+e^- \rightarrow W^+W^-$ at $\sqrt{S} = 161 GeV$, assuming an integrated luminosity per experiment of $100pb^{-1}$, leads to $\Delta M_W = \pm 84 MeV$, including systematics. The direct reconstruction method from invariant mass of W decay products at $\sqrt{S} = 175 GeV$ with $500pb^{-1}$ leads to $\Delta M_W = \pm 44 MeV$. This conservative result relies only on semileptonic W decays. The addition of the configuration where the two W decay into jets, which leads to $\Delta M_W = \pm 34 MeV$, suffers from colour reconnection and Boson Einstein coherence uncertainties poorly known. LEP2 will certainly be able to discriminate between a light and an heavy Higgs.

6. Conclusions

The discovery potential of LEP2 is certainly beyond initial expectations. The precise determination of the W mass will clearly indicate if the Higgs is heavy or not. If a Higgs is found, the scale for new physics should be around 10 TeV. If by chance the present hints for deviations from SM remain, LEP2 is certainly well suited for pinning down its origin: SUSY partners around the M_Z scale or Z'.

Acknowledgements

This work has been partially supported by the EC contract CHRX-CT94-0579. I would like to thank J. Carr for enlightening discussions during the preparation of the written version of this report. I wish to thank the organizing comittee for the invitation and the pleasant stay in Protvino.

References

[1] A. Blondel, to appear in the Proceedings of the ICHEP conference, Warsaw, July 1996.

[2] P. Chiappetta, J. Layssac, F. M. Renard and C. Verzegnassi, Phys. Rev. **D54** (1996) 789.

[3] G. Altarelli, N. Di Bartolomeo, F. Feruglio, R. Gatto and M. Mangano, Phys. Lett. **B375** (1996) 292 .

[4] E. Simmons, R. Chivukula and J. Terning, Phys. Lett. **B331** (1994) 383 ; hep-ph/9606233.

[5] E. Buckley-Geer, in Proceedings of the International HEP Conference, Brussels 1995 (J. Lemonne, C. Vander Velde and F. Verbeure eds), World Scientific p 340.

[6] P. W. Higgs, Phys. Rev. Lett. **12** (1964) 132; Phys. Rev. **145** (1966) 1156.

[7] J. F. Grivaz, in Proceedings of the International HEP Conference, Brussels 1995 (J. Lemonne, C. Vander Velde and F. Verbeure eds), World Scientific p 827.

[8] W. Hollik, hep-ph/9602380, to appear in the Proceedings of the 5^{th} Corfou School.

[9] M. Lindner, Z. Phys. **C31** (1986) 295; G. Altarelli and I. Isidori, Phys. Lett. **B337** (1994) 141 ; J. A. Casas, J. R. Espinosa and M. Quiros, Phys. Lett. **B342** (1995) 171 .

[10] M. Carena, P. Zerwas et al, in Proceedings of Physics at LEP2, CERN 96-01, vol 1, p 351.

[11] N. Krasnikov, in these proceedings.

[12] J. F. Gunion, H. E. Haber, G. L. Kane and S. Dawson, The Higgs Hunter Guide, Addison-Wesley, 1990.

[13] A. Brignole, Phys. Lett. **B277** (1992) 313 and Phys. Lett. **B281** (1992) 284 .

[14] M. Carena, S. Pokorski and C. Wagner, Nucl. Phys. **B406** (1993) 59; S. Dimopoulos, L. Hall and S. Raby, Phys. Rev. **D45** (1992) 4192; V. Barger, M. Berger and P. Ohmann, Phys. Rev. **D47** (1993) 1093; M. Carena et al, Nucl. Phys. **B369** (1992) 33.

[15] R. Casalbuoni et al, Phys. Lett. **B349** (1995) 533 and Proceedings of Physics at LEP2, CERN 96-01, vol 1, p510.

[16] P. Chankowski and S. Pokorski, hep-ph/9603310.

[17] G. F. Guidice, M. L. Mangano, G. Ridolf, R. Ruckl et al, in Proceedings of Physics at LEP2, CERN 96-01, vol 1, p 463.

[18] P. Gambino and A. Sirlin, Phys. Rev. Lett. **73** (1994) 621.

[19] S. Dittmaier, D. Schildknecht and G. Weiglein, Nucl. Phys. **B465** (1996) 3.

[20] K. Hagiwara, R. Peccei, D. Zeppenfeld and K. Hisaka, Nucl. Phys. **B282** (1987) 253.

[21] CDF and D0 collaborations: Phys. Rev. Lett. **74** (1995) 1936, Phys. Rev. Lett. **75** (1995) 1017, Phys. Rev. Lett. **75** (1995) 1034; see also T. Yasuda and D. Neuberger, to appear in the proceedings of XI^{th} topical workshop on $p\bar{p}$ collider physics, Abano, 1996.

[22] W. Buchmuller and D. Wyler, Nucl. Phys. **B268** (1986) 621; B. Holdom, Phys. Lett. **B258** (1991) 156 ; A. de Rujula, M. Gavela, P. Hernandez and E. Masso, Nucl. Phys. **B384** (1992) 3.

[23] K. Hagiwara, S. Ishihara, R. Szalapski and D. Zeppenfeld, Phys. Rev. **D48** (1993) 2182.

[24] G. Altarelli, R. Barbieri, F. Caravaglios, Phys. Lett. **B314** (1993) 357 ; M. Peskin and T. Takeuchi, Phys. Rev. Lett. **65** (1990) 964.

[25] G. Altarelli, R. Barbieri and F. Caravaglios, Phys. Lett. **B349** (1995) 145 .

[26] P. Langacker, hep-ph/9511207 to appear in the Proceedings of SUSY 95.

[27] M. Bilenky, J. L. Kneur, F.M. Renard and D. Schildknecht, Nucl. Phys. **B409** (1993) 22; Nucl. Phys. **B419** (1994) 240; G. Gounaris, J. L. Kneur et al, in Proceedings of LEP2 workshop CERN 96-01 vol 1, p 525.

[28] C. Hill, Phys. Lett. **B345** (1995) 483 .

[29] D. Kominis, hep-ph/9605272 and private communication.

[30] K. Lane, hep-ph/9605257.

[31] P. Chiappetta, C. Verzegnassi et al, in Proceedings of Physics at LEP2, CERN 96-01, vol 1, p 577.

[32] L. Hewett and T. Rizzo, Phys. Rev. **C183** (1989) 193.

[33] F. Abe et al, Phys. Rev. Lett. **75** (1995) 11.

[34] Z. Kunszt, W. J. Stirling et al, in Proceedings of Physics at LEP2, CERN 96-01, vol 1, p 141.

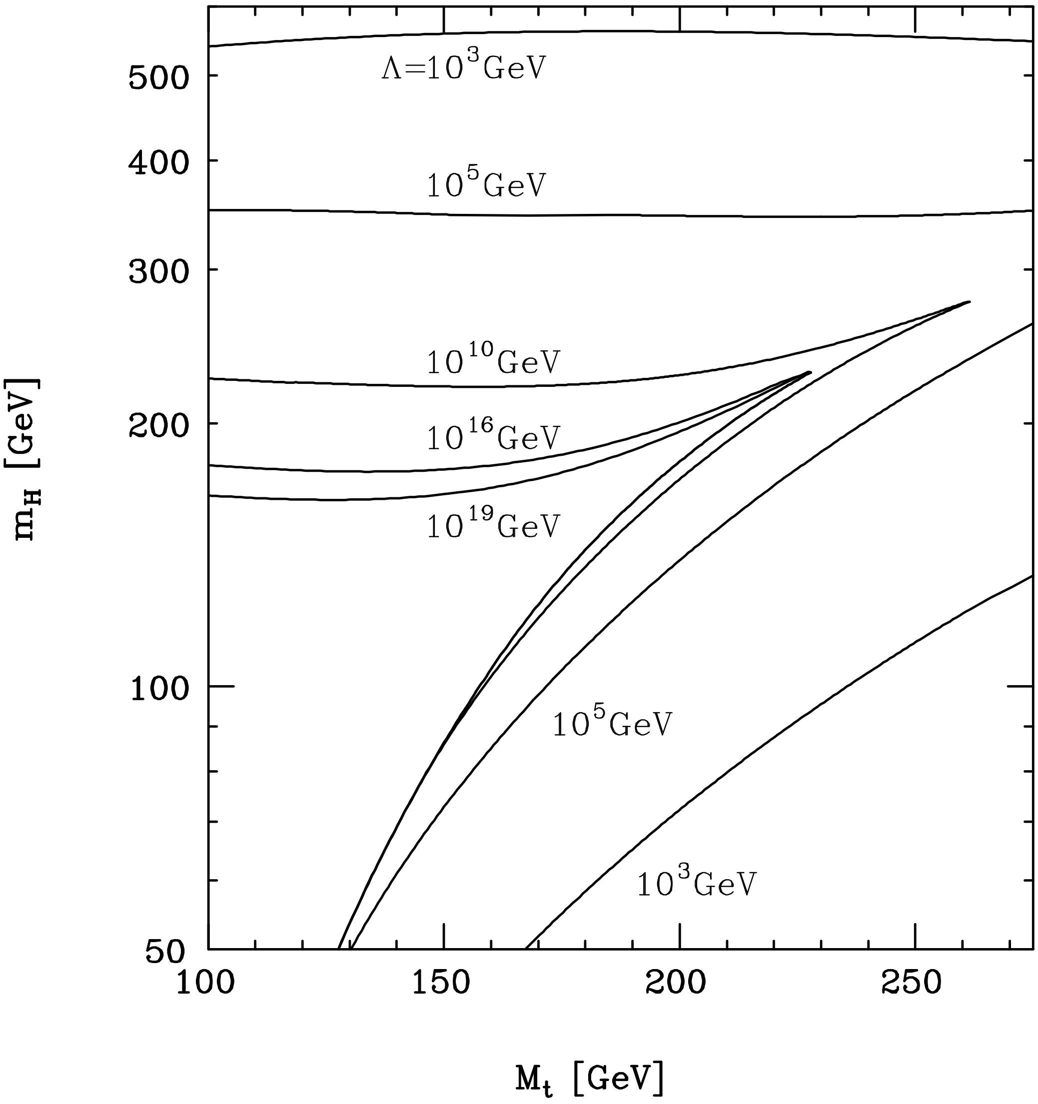


Figure 1: Theoretical bounds on the SM Higgs mass.

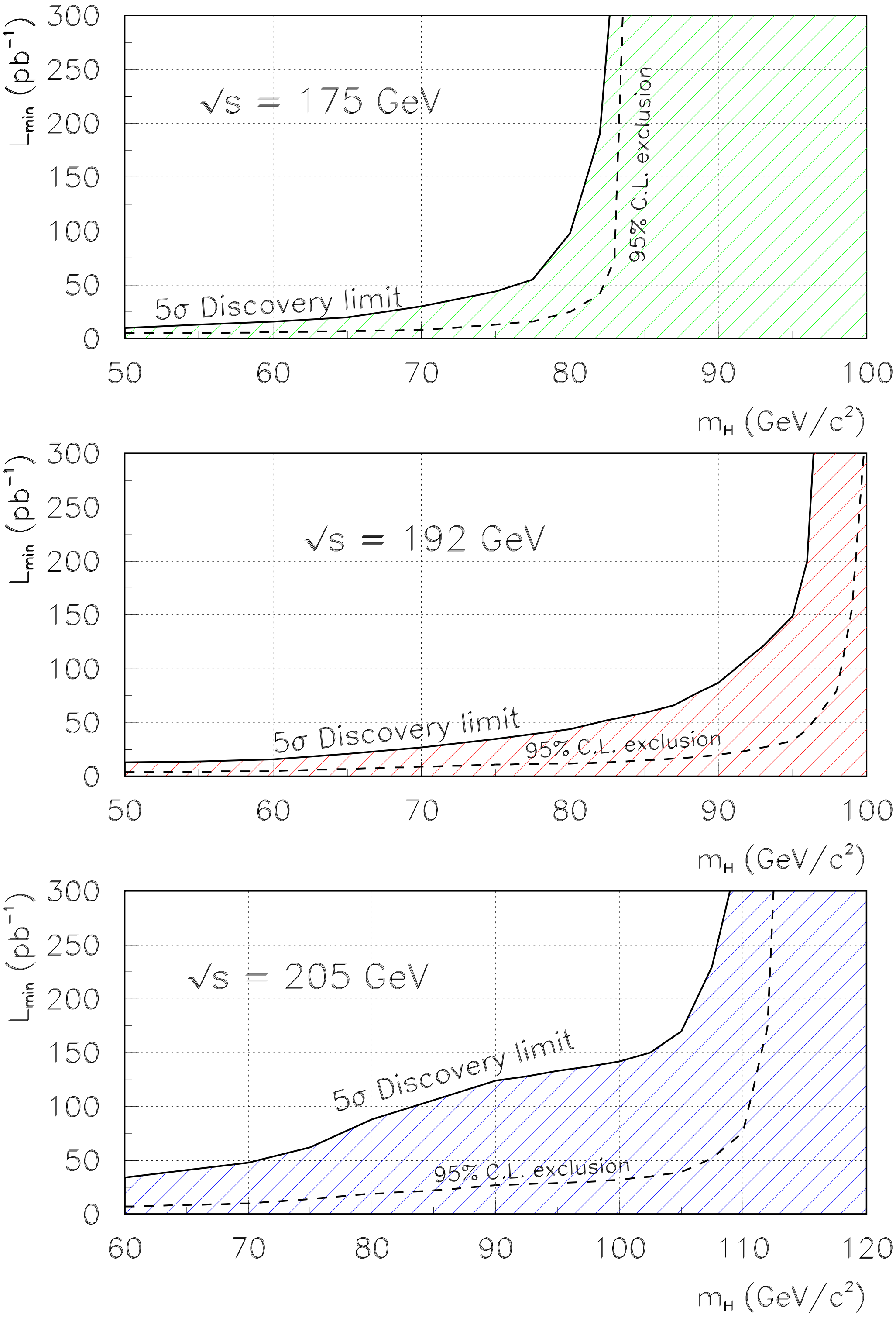
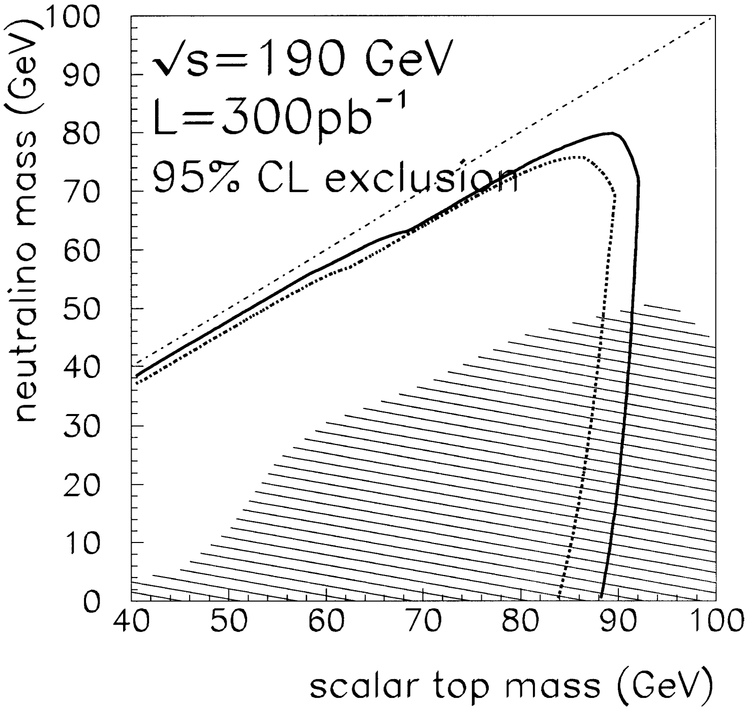


Figure 2: 5σ discovery limit (solid line) and 95 % CL exclusion limit (dashed line) on the SM Higgs boson as a function of the luminosity.



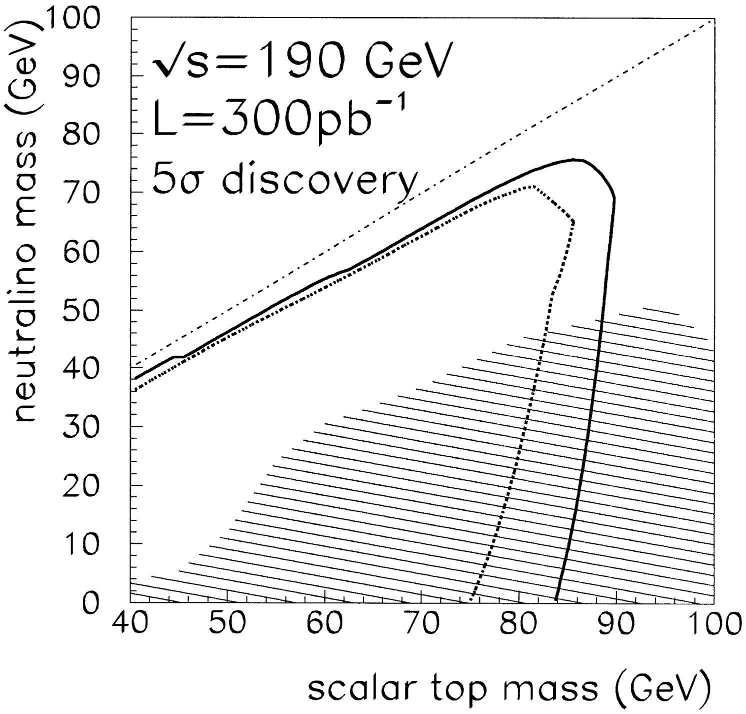


Figure 3: 5σ discovery limit and 95% CL exclusion limit on the stop. The solid(dashed) lines correspond to maximal (minimal) coupling to the Z. The shaded area coresponds to the 95% CL Tevatron limits.

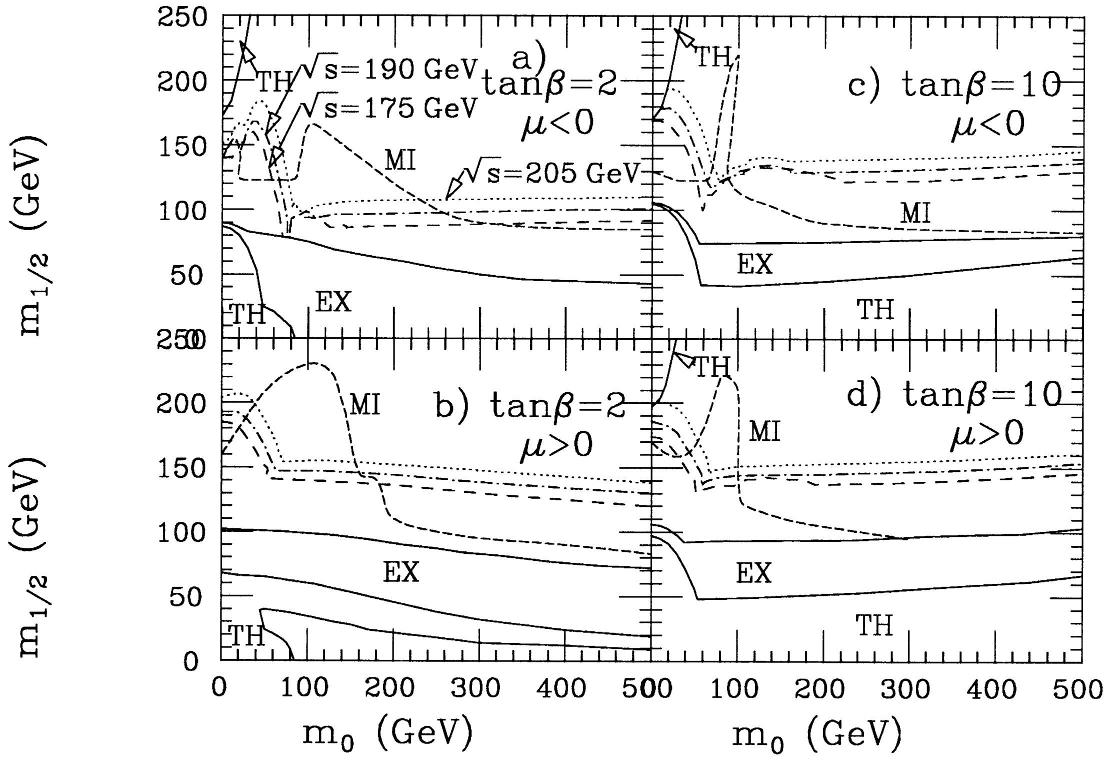


Figure 4: SUSY parameters domain explorable at LEP2 compared to Tevatron (denoted as MI). TH corresponds to the theoretical exclusion domain.

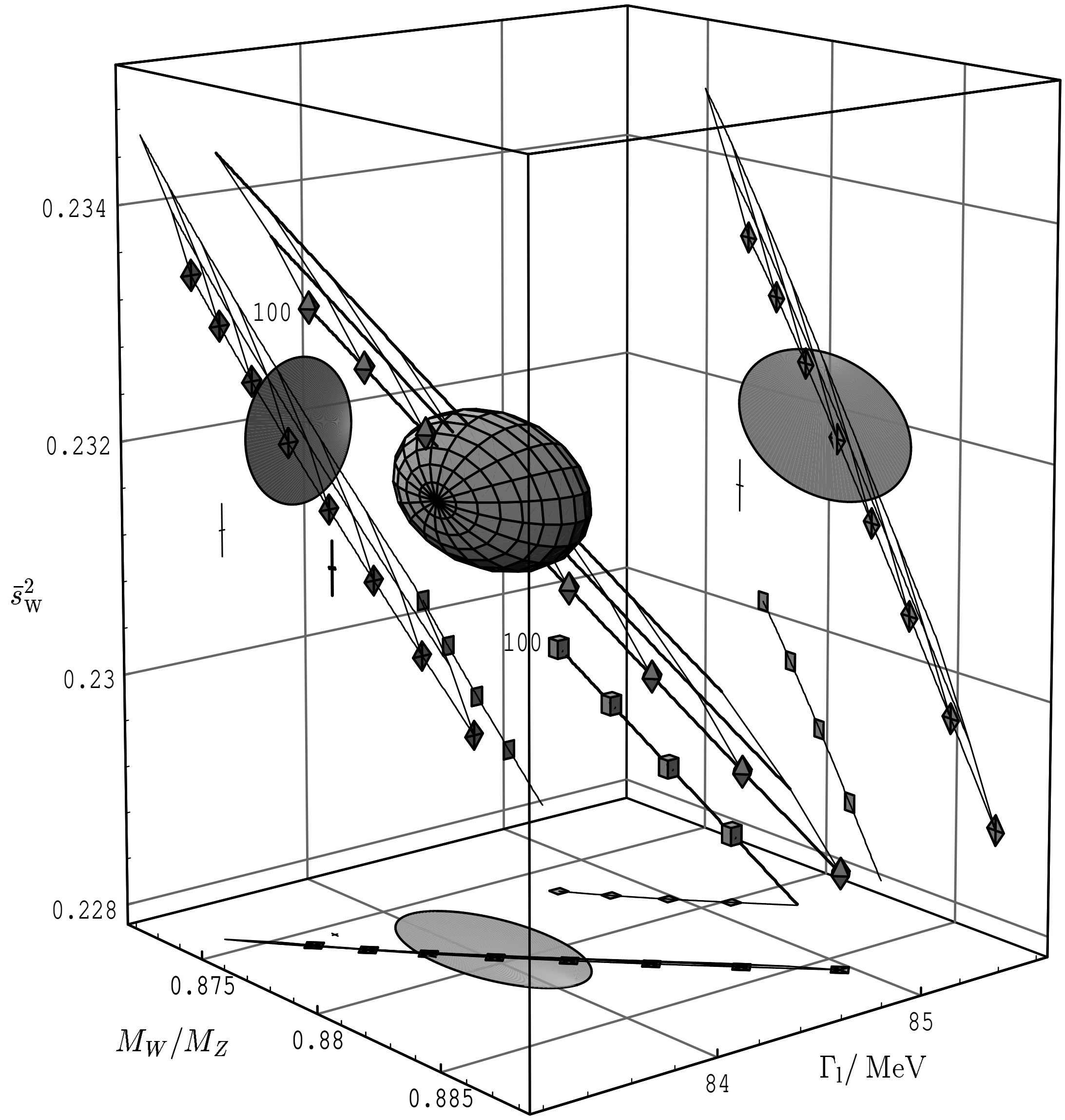


Figure 5: Need for bosonic loops from present electroweak data. The ball is the 68% CL of data. The net that the ball hints is the full SM prediction with a top mass varying from $100 GeV$ by steps of $20 GeV$ and a Higgs mass variation. The line with cubes corresponds to the purely fermionic contribution [19].

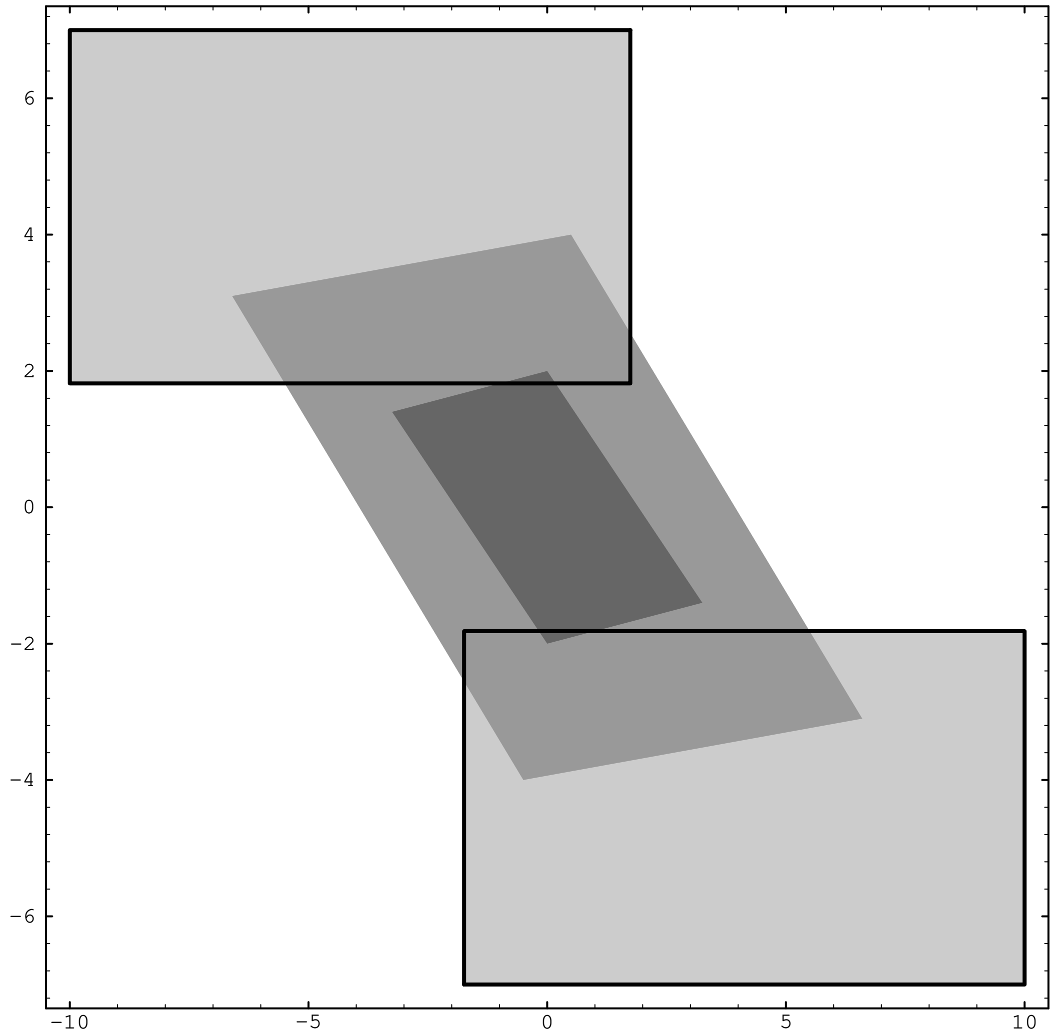


Figure 6: Observability limits from σ_b on $b\bar{b}$ vector (abcsissa) and axial vector (ordinate) couplings ratios between an hadrophilic Z' and the Z.The central dark region corresponds to a 5% accuracy and the central grey to a 10% accuracy. The two rectangles correspond to the SLC allowed domain [2].