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ABSTRACT

Theoretical limits on the mass of the Higgs boson from vacuum stability and perturbative unitarity are examined. Search techniques for heavy Higgs bosons, $M_H > 200\ GeV$, are also reviewed.

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THE SEARCH FOR A HEAVY HIGGS BOSON

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Theoretical limits on the mass of the Higgs boson from vacuum stability and perturbative unitarity are examined. Search techniques for heavy Higgs bosons, $M_H > 200\ GeV$, are also reviewed.

1. INTRODUCTION

The electroweak sector of the standard model is inconsistent without the existence of a neutral Higgs boson or some similar object whose function is to give the W and Z gauge bosons their observed masses. Extentions of the standard model such as technicolor or supersymmetry also tend to have a neutral particle which plays the role of the Higgs boson. The standard model is incomplete, however, in that it gives no information about the mass of the Higgs boson. It therefore becomes important to search for the Higgs boson in all possible mass regimes.[1]

A particularly interesting mass region for the Higgs boson is $M_H > 2M_W$. In this mass region, the Higgs decays almost exclusively to vector boson pairs. In addition, as the Higgs boson mass approaches 1 TeV, its self couplings and its couplings to vector bosons become large, raising the possibility of anomalous strong interactions.

In Section 2, we review the basic theory for the production and decay of a heavy Higgs boson. We discuss production mechanisms and the total cross sections for Higgs boson production at the LHC and SSC. (The production of a heavy Higgs boson in an e^+e^- collider is not considered here.) We also discuss the theoretical issues associated with heavy Higgs bosons. Search techniques are examined in Section 3, where we consider both the 4- charged lepton and the 2 -charged lepton signals for heavy Higgs production. We also discuss the techniques necessary to search for the Higgs boson via the hadronic decay modes of the gauge bosons. Finally, in Section 4, we present our conclusions.

2. THEORETICAL ISSUES

In this section we discuss the theoretical issues associated with heavy Higgs bosons. We begin by discussing limits on the Higgs boson mass from vacuum stability arguments and from the requirement of perturbative unitarity. We emphasize the uncertainties and assumptions involved in these limits. Production and decay mechanisms for heavy Higgs bosons are then presented, along with the total cross sections for pp collisions at $\sqrt{s} = 17\ TeV$ (LHC) and at $\sqrt{s} = 40\ TeV$ (SSC).

Limits on the Higgs Mass From Vacuum Stability

The Higgs boson self interactions are described at tree level by a quartic potential,

$$V_0(H) = -\frac{\mu^2}{2}H^2 + \frac{\lambda}{4}H^4 \quad , \tag{2.1}$$

with $\mu^2 > 0$. The one-loop corrections can be easily calculated in the loop approximation,[2]

$$V_1(H) = -\frac{\mu^2}{2}H^2 + BH^4 \log\left(\frac{H^2}{M^2}\right), \tag{2.2}$$

where M is a mass scale chosen to absorb the λH^4 term of Eq. (2.1) and

$$B = \frac{3}{64}\left(\frac{\alpha}{\sin^2\theta_W}\right)^2\left[2 + \sec^4\theta_W - 4\left(\frac{m_t}{M_W}\right)^4\right] \quad . \tag{2.3}$$

This potential has two minima, $\langle H\rangle = 0$ and $\langle H\rangle = v$. The requirement that spontaneous symmetry breaking occur is $E(v) < E(0)$ which gives the limit,

$$M_H^2 > \frac{2B\sqrt{2}}{G_F} \sim (7\ GeV)^2\left[1 - \left(\frac{m_t}{M_W}\right)^4\right] \quad . \tag{2.4}$$

The important point is that for $m_t > M_W$, this bound vanishes.

However, as the top quark gets heavier and B becomes negative, it is clear that at some point the potential will become unbounded. For a large value of

H, the potential will turn over and go to negative infinity. In fact, the point at which the potential turns over is given approximately by,[3]

$$\frac{H}{v} \sim \sqrt{2}\exp\left(-\frac{8\lambda\pi^2}{B+9\lambda}\right) \quad . \tag{2.5}$$

However, this turnover occurs at such large values of H that it is necessary to use a renormalization group analysis in order to obtain reliable results. The resulting limit on the Higgs mass is,[3]

$$M_H(GeV) > \frac{5}{3}\left(m_t(GeV) - 95\ GeV\right). \tag{2.6}$$

For example, a 200 GeV top quark would require $M_H > 175\ GeV$. On the other hand, for a 60 GeV top quark, the relevant bound is that of Eq. (2.4), which gives $M_H > 6\ GeV$. Most extentions of the standard model, (for example the addition of more scalar particles), will cause the bounds of Eqs. (2.4) and (2.6) to be violated.

WW Scattering and Unitarity Bounds on the Higgs Mass

The other class of bounds on the Higgs mass comes from the requirement of perturbative unitarity. These bounds arise from considering the interactions of a heavy Higgs boson with longitudinally polarized vector bosons. It is completely possible, however, that the Higgs boson is heavier than the bound derived from perturbative unitarity. In this case, we no longer know how to calculate the interactions of the Higgs boson.

For $s >> M_W^2$, the interactions of the Higgs boson and the longitudinal gauge bosons can be calculated in an effective theory of interacting scalars. For a scattering process involving external longitudinally polarized W's and Z's, the amplitude can be calculated, to $\mathcal{O}(M_W^2/s)$, by replacing the external gauge bosons with the corresponding Goldstone bosons of the R_ξ gauge.[4] In the limit $M_H^2 >> M_W^2$, interactions of enhanced electroweak strength, $\mathcal{O}(G_F M_H^2)$, arise only from diagrams in which the internal particles are also Goldstone bosons or the Higgs boson. The calculations are simple since they involve only scalar particles. The effective theory has been used to calculate the Higgs decay width into vector boson pairs and also the one-loop corrections to longitudinal W boson scattering.

In the effective theory, the interactions of the Goldstone bosons and the Higgs scalar are given by

$$\mathcal{L} = -\lambda\left(w^+w^- + \frac{z^2}{2} + \frac{H^2}{2} + \sqrt{2}vH + v^2 - \frac{\mu^2}{2\lambda}\right)^2 \tag{2.7}$$

where $w^\pm$ and z are the Goldstone bosons, H is the physical Higgs scalar, and $\lambda =$

$G_F M_H^2/\sqrt{2}$ is the bare coupling of the λH^4 theory. (The last two terms, which cancel at tree-level, yield a tadpole counterterm which ensures that the physical Higgs field has zero VEV at one loop.) This form of the interaction demonstrates that large M_H corresponds to strong interactions between the longitudinal gauge bosons and the Higgs scalar. In the Landau gauge, the Goldstone bosons are massless and there is no $w - W$ mixing.

Since for large Higgs masses, the Hw^+w^- coupling grows as M_H^2/M_W, one might hope to find the effects of a heavy Higgs boson through anomalously large couplings to W bosons. However, this hope is foiled by a screening theorem due to Veltman.[5] In its simplest form, this theorem states that at $s << M_H^2$ there are no $\mathcal{O}(\lambda)$ corrections at one loop. For example, the W boson mass receives large corrections due to a heavy Higgs boson,

$$\frac{\delta M_W^2}{M_W^2} = \frac{\lambda}{16\pi^2} \quad . \tag{2.8}$$

The renormalization of a mass, however, is not a physical parameter. The ratio of W to Z boson masses is measurable, but the $\mathcal{O}(\lambda)$ corrections cancel in this ratio. The screening theorem is the direct result of the $O(3)$ symmetry of the Goldstone boson interactions. Thus to see possibly enhanced effects due to a very massive Higgs boson, we must go to high energy, $s >> M_H^2$.

The simplest place to search for enhanced electroweak effects of $\mathcal{O}(\lambda)$ is in the one loop corrections to the decay width for $H \rightarrow VV$, $(V = W, Z)$ which have been calculated by Marciano and Willenbrock.[6] They find,

$$\Gamma(H \rightarrow VV) = \Gamma_0 \left\{ 1 + \frac{\lambda}{\pi^2}\left[\frac{19}{16} - \frac{3\sqrt{3}\pi}{8} + \frac{5\pi^2}{48}\right]\right\} \tag{2.9}$$

where Γ_0 is the tree level width,

$$\begin{aligned} \Gamma_0(H \rightarrow W^+W^-) =& 2\Gamma_0(H \rightarrow ZZ) \\ & \sim 40\ GeV \left(\frac{M_H}{500\ GeV}\right)^3 \quad . \end{aligned} \tag{2.10}$$

The $\mathcal{O}(\lambda)$ corrections are actually quite small due to a cancellation between the terms of Eq. (2.9). For a Higgs mass of 1 TeV, the radiative corrections increase the width by about 15%. An indication of the scale where perturbation theory breaks down is given by looking at the place where the Higgs width is equal to its mass; at tree level, this occurs at 1.4 TeV, while at one loop it is at 1.3 TeV.

The classic example of large effects due to a heavy Higgs boson is elastic longitudinal W boson scattering, $W_L^+W_L^- \rightarrow W_L^+W_L^-$. The tree level matrix element is easily found in the limit $s, M_H^2 >> M_W^2$,

$$M_0(W_L^+W_L^- \rightarrow W_L^+W_L^-) = -2\lambda\left[\frac{M_H^2}{s-M_H^2} + \frac{M_H^2}{t-M_H^2} + 2\right] \quad . \tag{2.11}$$

The requirement that the theory satisy perturbative unitarity is often imposed on the longitudinal W scattering amplitude of Eq. (2.11). The $J = 0$ partial wave, a_0, can be extracted from the tree level matrix element with the result,

$$a_0 = -\frac{\lambda}{8\pi}\left[2 + \frac{M_H^2}{s-M_H^2} - \frac{M_H^2}{s}\log\left(1 + \frac{s}{M_H^2}\right)\right] \quad . \tag{2.12}$$

This result has been used to obtain two sets of limits on the theory. At high energies, $s >> M_H^2$, Lee, Quigg, and Thacker[7] obtained the bound,

$$M_H^2 < \frac{4\pi\sqrt{2}}{G_F} \sim (1.2\ TeV)^2 \tag{2.13}$$

from the requirement that $|\ a_0\ |< 1$. A complementary bound was found by Chanowitz and Gaillard.[8] By considering the low energy limit, $s << M_H^2$, they obtained a critical energy scale,

$$s_c \equiv \frac{16\pi\sqrt{2}}{G_F} \sim (2.5\ TeV)^2 \quad . \tag{2.14}$$

The one loop corrections of $\mathcal{O}(\lambda)$ to $W_L^+W_L^-$ scattering have recently been computed.[9] These results can be used both to study unitarity bounds and to do phenomenology.

By imposing the requirement of perturbative unitarity at one loop, the bounds of Lee, Quigg, and Thacker and of Chanowitz and Gaillard can be generalized. We will consider the low and high energy limits separately, (a discussion valid at any energy scale can be found in Ref. 9.) At high energy, $s >> M_H^2$, the contribution to the $J = 0$ partial wave to $\mathcal{O}(\lambda^2)$ is,[9]

$$a_0 = \frac{\lambda}{4\pi}\left[1 + \frac{\lambda}{8\pi^2}\left(6\log(\frac{s}{M_H^2}) - 4 - \frac{9\pi}{2\sqrt{3}}\right)\right] \quad . \tag{2.15}$$

The one loop amplitude grows logarithmically with energy and the coefficient of the logarithm is just the one loop beta function. In fact, we can improve our calculation by using the renormalization group to sum the leading logarithms,

$$a_0 = \frac{\lambda(s)}{4\pi}\left[1 - \frac{\lambda(s)}{8\pi^2}\left(4 + \frac{9\pi}{2\sqrt{3}}\right)\right] \tag{2.16}$$

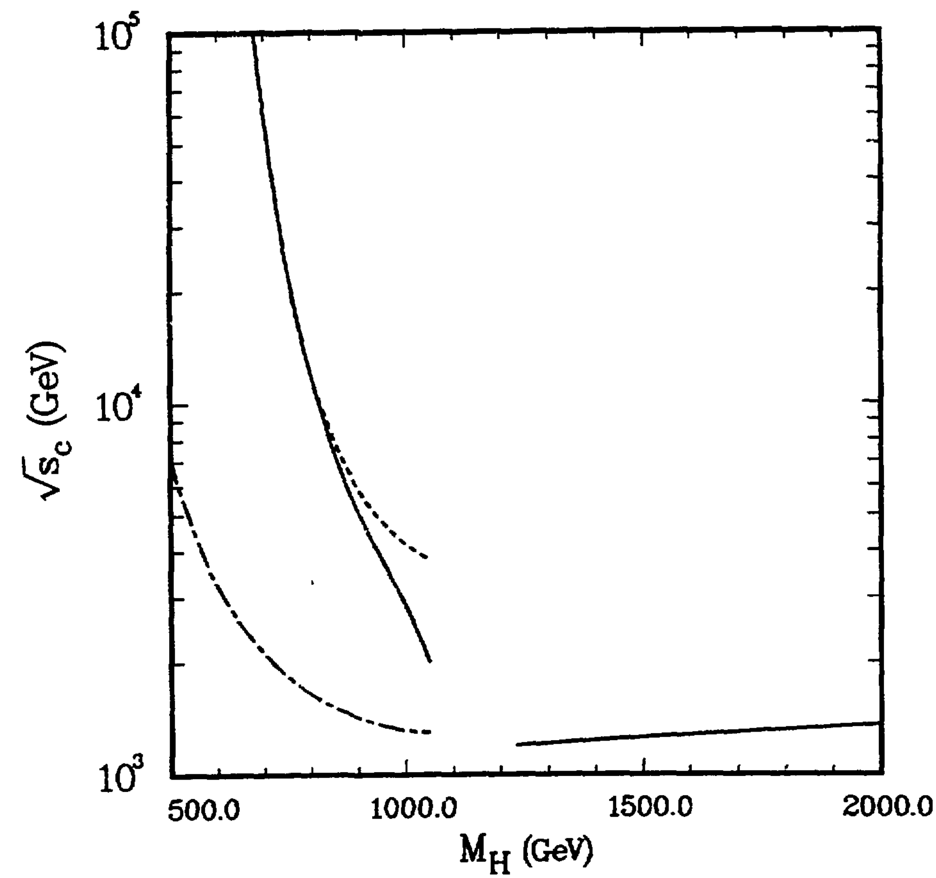

Fig. 1

Critical energy scale at which perturbative unitarity is violated. The solid curve is the complete one-loop result, the dashed curve is the high energy approximation, ($s >> M_H^2$), and the dot-dashed curve is the result of summing the leading logarithms using the renormalization group, ($\lambda(s)/4\pi < 1$). (The region $M_H \sim 1$ TeV is blank since in this region $M_H \sim \sqrt{s_c}$ and the calculation is unreliable.)

where the running coupling is

$$\lambda(s) = \frac{\lambda}{1 - \frac{3\lambda}{4\pi^2}\log\frac{s}{M_H^2}} \quad . \tag{2.17}$$

Notice that after summing the leading logarithms, the one loop correction is negative, which suggests that loop corrections could potentially help restore unitarity for light Higgs bosons. We can estimate the energy scale at which unitarity is violated by looking at the point where $\lambda(s)/4\pi$=1. This is the dot-dashed curve in Fig. 1.

At low energies, the amplitude also takes a simple form. The coefficients of the logarithms can be found by calculating the Goldstone boson interactions in an $O(4)$ non-linear σ model.[10] However, the non-logarithmic terms require the complete one loop calculation. We find, to $\mathcal{O}(\lambda^2)$, for $s << M_H^2$,[9]

$$\begin{aligned} Re\Big(\mathcal{M}(W_L^+W_L^- \rightarrow W_L^+W_L^-)\Big) = & 2\lambda\Bigg[\frac{-u}{M_H^2} + \frac{\lambda}{8\pi^2 M_H^4}\Bigg((\frac{st}{6}+\frac{5s^2}{6})\log(\frac{M_H^2}{s}) \\ & + (\frac{st}{6}+\frac{5t^2}{6})\log(\frac{M_H^2}{-t}) + \frac{u^2}{2}\log(\frac{M_H^2}{-u}) \\ & + (\frac{9\pi}{2\sqrt{3}} - \frac{76}{9})(s^2+t^2) - \frac{4}{9}u^2\Bigg)\Bigg] \quad . \end{aligned} \tag{2.18}$$

Note that $\lambda/M_H^2 = G_F/\sqrt{2}$, so that the expansion parameter is $G_F s$, rather than $G_F M_H^2$. This is a direct consequence of the screening theorem. The low- energy contribution to the $J=0$ partial wave is thus

$$a_0 = \frac{\lambda s}{16\pi M_H^2}\left[1 + \frac{\lambda}{8\pi^2}\frac{s}{M_H^2}\left(\frac{20}{9}\log(\frac{M_H^2}{s}) + \frac{12\pi}{\sqrt{3}} - \frac{2441}{108}\right)\right] \quad . \tag{2.19}$$

The one loop correction significantly reduces the energy at which unitarity is violated for a very massive Higgs boson, from 2.5 TeV to about 1.4 TeV, as is seen in Fig. 1.

Since we know that the Weinberg-Salam model is a unitary theory, the fact that unitarity is violated in perturbation theory is open to differing interpretations. The most logical interpretation is that new physics must occur before the critical energy scale. This new physics would then have the effect of restoring unitarity. The most interesting thing about the one loop corrections is the smallness of the critical energy scale, $\sqrt{s_c} \sim 1.4$ TeV. This is a scale which can certainly be probed at the SSC!

We turn now to the use of the matrix element for $W_L^+ W_L^-$ scattering to predict Higgs boson production in hadronic interactions.

WW Fusion and Higgs Boson Production Rates

For a Higgs boson mass near 1 TeV, the dominant production mechanism is WW fusion, (assuming $m_t > 150\ GeV$). The W bosons can be treated as partons in the proton and then the W boson structure functions are integrated with the appropriate WW scattering cross sections.[11]

Higgs boson production can be calculated naively by treating it as a resonant process, $W_L^+ W_L^- \rightarrow H$. For a heavy Higgs boson, only the longitudinal W's contribute to the production cross section since their interactions are enhanced by a factor of λ relative to the interactions of transverse W's, see Eq. (2.7). However, a heavy Higgs boson quickly decays to vector boson pairs. The s-channel Higgs exchange diagram alone is not gauge invariant and exhibits bad high energy behaviour. For $M_H \sim 1\ TeV$, it is necessary to include the full set of diagrams for $W_L^+ W_L^- \rightarrow W_L^+ W_L^-$ scattering, including γ and Z exchange.[12] Although the γ exchange diagram is not enhanced by a factor of λ, t-channel photon exchange has a pole at $\theta = 0$ and so gives an important contribution for $M_H > 1\ TeV$. The complete set of diagrams is shown in Fig. 2.

The invariant mass distribution of $W^+ W^-$ pairs at the SSC[13] is shown in Fig. 3 for $M_H = 500\ GeV$ and $M_H = 1\ TeV$. For $M_H = 500\ GeV$,we see that keeping only the s-channel pole is a reasonably good approximation, while for $M_H = 1\ TeV$, retaining only the s-channel Higgs exchange contribution is clearly a poor approximation, even for $M_{WW} \sim M_H$. Also shown is the background from continuum production of $W^+ W^-$ pairs from the $q\bar{q}$ parton sub-process.

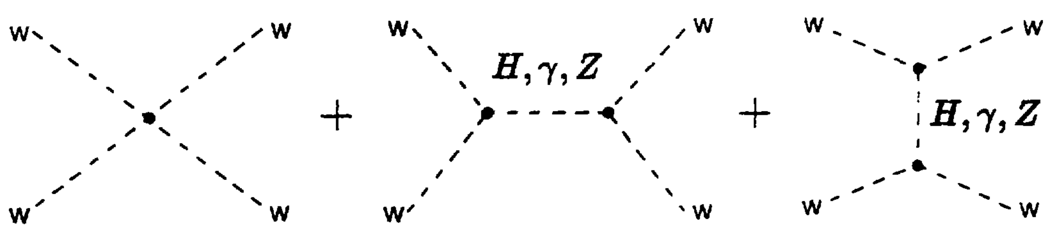

Fig. 2

Feynman diagrams contributing to $W_L^+ W_L^- \rightarrow W_L^+ W_L^-$ scattering.

Clearly, even under the best of circumstances, the number of events which are due to W^+W^- scattering (and hence sensitive to the Higgs boson mass) is small. Separating the tiny Higgs signal from the large $q\bar{q}$ continuum background is the challenge for heavy Higgs boson seekers.

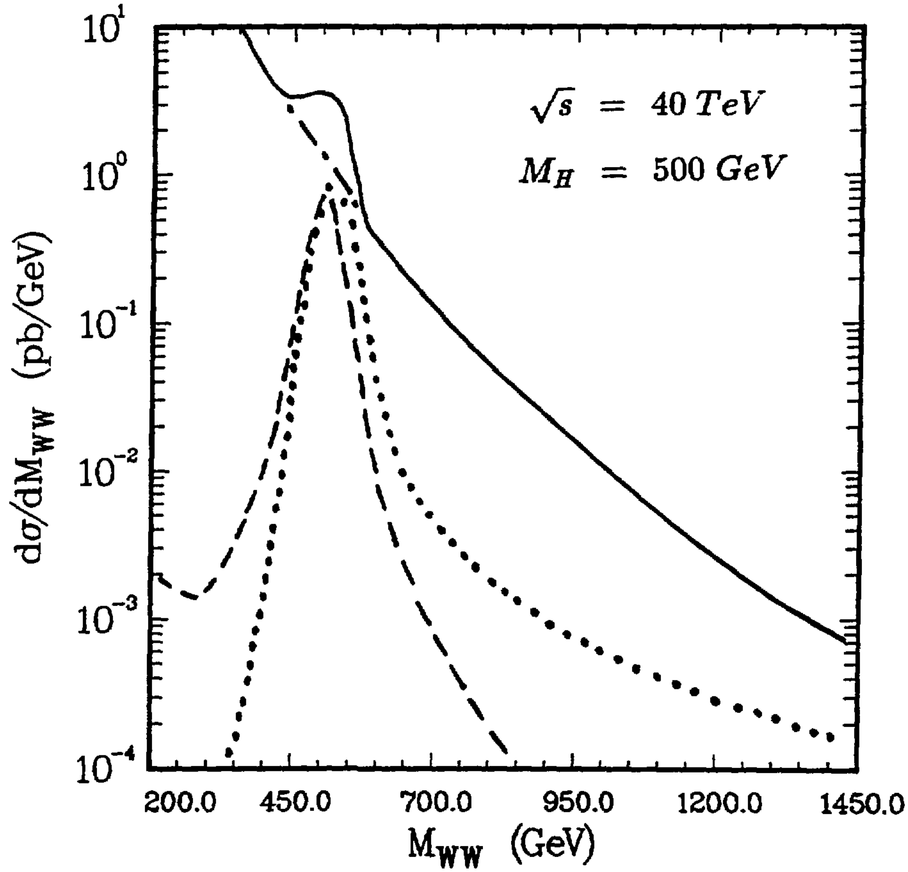

Fig. 3a

Invariant mass distribution for $pp \to W^+W^-$ at $\sqrt{s} = 40\ TeV$ for $M_H = 500\ GeV$ with a cut $|\ y_W\ | < 2.5$. The dot-dashed line is the background from $q\bar{q} \to W^+W^-$, the dashed line is the contribution from vector boson scattering, and the solid line is the sum of these two contributions. The dotted line is the contribution from s-channel Higgs exchange only. This figure is from Ref. 13.

Higgs bosons can also be produced from gluon-gluon fusion through a heavy quark loop. This production mechanism has a form factor like suppression and falls off rapidly with increasing Higgs mass. The total cross sections for Higgs production in pp collisions at $\sqrt{s} = 17\ TeV$ and $\sqrt{s} = 40\ TeV$[14] are shown in Fig. 4. At the SSC, vector boson fusion becomes the dominant production mechanism at $M_H \sim 600\ GeV$ for a top quark mass of $80\ GeV$. If $m_t > 150\ GeV$,

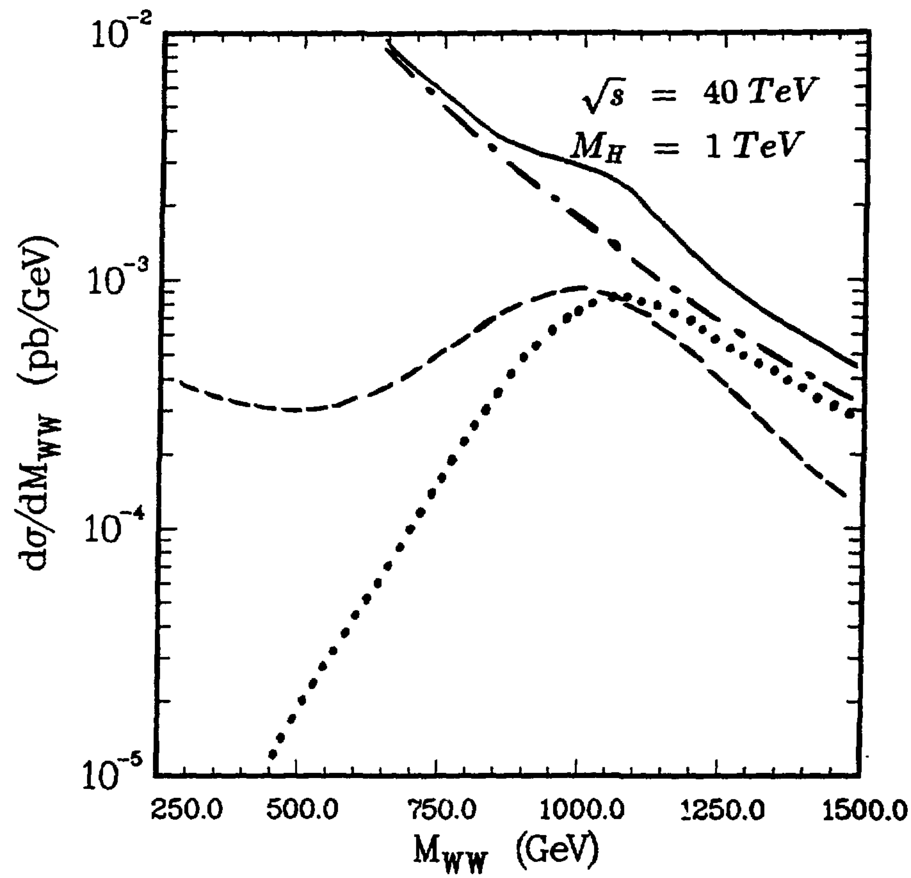

Fig. 3b

Invariant mass distribution for $pp \to W^+W^-$ at $\sqrt{s} = 40\ TeV$ for $M_H = 1\ TeV$ with a cut $\mid y_W \mid < 2.5$. The dot-dashed line is the background from $q\bar{q} \to W^+W^-$, the dashed line is the contribution from vector boson scattering, and the solid line is the sum of these two contributions. The dotted line is the contribution from s-channel Higgs exchange only. This figure is from Ref. 13.

the gluon fusion contribution always dominates over vector boson fusion at the SSC for $M_H > 2M_W$. The uncertainty due to the unknown top quark mass gives an uncertainty of at least a factor of two in the Higgs production cross section. Since the cross section increases with increasing top quark mass, conservative predictions can be found by taking $m_t = 40\ GeV$, which is the experimental lower limit on the top quark mass.

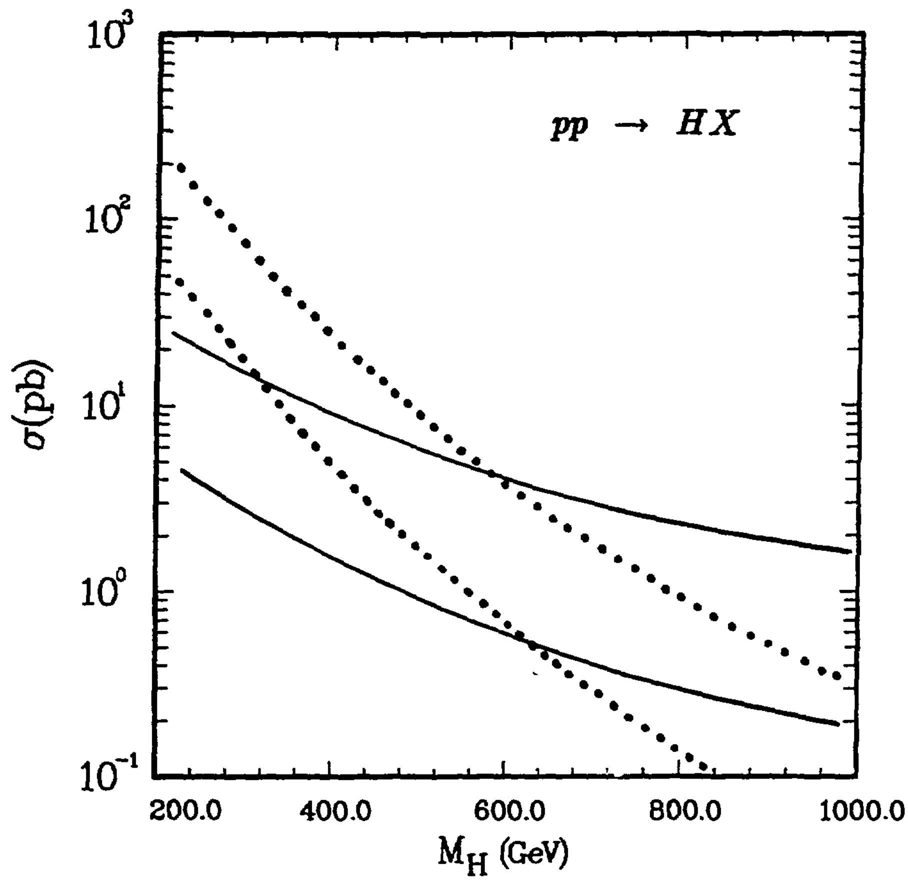

Fig. 4

Cross sections for Higgs production in pp collisions at the LHC, $\sqrt{s} = 17\ TeV$, and the SSC, $\sqrt{s} = 40\ TeV$. The solid lines are the contributions from vector boson fusion and the dotted lines are the contributions from gluon fusion for $m_t = 80\ GeV$. This figure is from Ref. 14.

3. SEARCH TECHNIQUES FOR HEAVY HIGGS BOSONS

In this section we consider Higgs boson searches using the various decay modes of the W and Z bosons.

Four-Charged Lepton Signal

The most straightforward method of searching for the Higgs boson is by its four-lepton decay modes, $H \rightarrow ZZ \rightarrow l^+l^-l^+l^-$. Summing over e's and μ's, the branching ratio is $\sim .8\%$. This process is therefore rate limited. For example, in a standard SSC year, $\int \mathcal{L} = 10^4/pb$, there will be ~ 10 events from the decay of a 1 TeV Higgs boson.

Detailed Monte Carlo studies have shown that it is possible to find a Higgs boson with a mass of up to about 600 GeV via bump-hunting.[18] Fig. 5 shows the ZZ invariant mass reconstructed from the $Z \rightarrow e^+e^-$, $\mu^+\mu^-$ decays at the SSC. This figure includes both continuum Z pair production and the contribution of a 600 GeV Higgs boson with $H \rightarrow ZZ$. The signal is clearly visible above the continuum background. At the SSC, the signal to background ratio for the four-charged lepton decay mode is ~ 3 for $M_H = 600$ GeV and ~ 5 for $M_H = 400$ GeV.[18] (At the LHC, these numbers are ~ 2 and ~ 3 respectively.) Hence both the SSC and LHC will find a Higgs boson with $M_H \sim 400$ GeV and the SSC can probably go to $M_H \sim 600$ GeV via this decay mode. As the Higgs boson mass becomes larger than about 600 GeV, not only does the number of events become small, but also the width of the Higgs boson becomes extremely large, (see Eq. (2.10)). Searching for a very massive Higgs boson by bump- hunting thus requires precise knowledge of the shape of the continuum ZZ background.

It is worth noting that, for a given Higgs mass, the production cross sections at the LHC are approximately an order of magnitude smaller than at the SSC. A high luminosity LHC, $\mathcal{L} \sim 5 \cdot 10^{34}/cm^2/sec$, is therefore roughly equivalent to the SSC with $\mathcal{L} \sim 10^{33}/cm^2/sec$ for the purpose of finding a heavy Higgs boson.

Two-Charged Lepton Signal

To reach Higgs masses higher than about 600 GeV, it is necessary to go to decay modes with larger branching ratios. A promising decay mode suggested by Cahn and Chanowitz[16] is,

$$H \rightarrow ZZ \rightarrow l^+l^-\nu\overline{\nu} \quad , \tag{3.1}$$

where $l = e$ or μ. This has an effective branching ratio of $\sim 5\%$. A significant background to this process is again from continuum Z pair production, $q\overline{q} \rightarrow ZZ$.

The idea is that the p_T of the Higgs boson is of order M_W and so the missing p_T does not balance the observed p_T for the Higgs signal. (Note that the effective W approximation cannot be used here since it does not give the Higgs boson any transverse momentum.)

Cahn and Chanowitz formed a transverse mass from the p_T of the observed Z, $M_T \equiv 2\sqrt{p_T^2 + M_Z^2}$. A cut on the transverse mass is efficient for eliminating

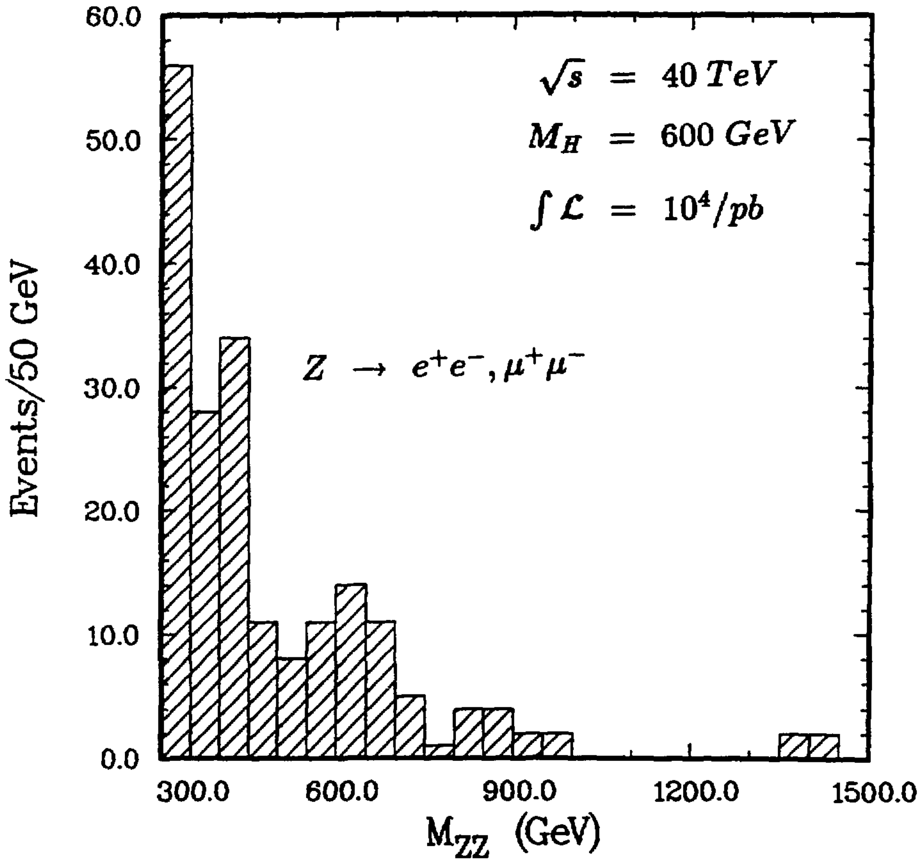

Fig. 5

Invariant mass spectrum for Z pair production in pp interactions at $\sqrt{s} = 40\ TeV$, with $ZZ \rightarrow l^+l^-l^+l^-$, $l = e$ or μ, assuming an ideal detector and $|\ y_Z\ | < 1.5$. Included are both continuum Z pair production and the contribution of a 600 GeV Higgs boson. This figure is from Ref. 15.

the $q\bar{q} \to ZZ$ background. For $M_H = 800\ GeV$ and $M_T > 400\ GeV$, there are 76 signal and 112 background events, while a cut $M_T > 700\ GeV$ leaves 54 signal and 17 background events in a standard SSC year.

Unfortunately, there is also a large background from $Z+$ jet production. With no cuts the signal to background ratio is approximately 1 : 100 for an 800 GeV Higgs boson. Kinematic cuts can eliminate the Z plus jet background, leaving 26 events/standard SSC year for a Higgs mass of 800 GeV. However, in order to eliminate this background, it is necessary to have good hadronic calorimetry down to about $\mid y \mid \sim 5.5$ with no cracks or dead cells.[16]

Higgs Signatures in Hadronic Decay Modes

It is interesting, however, to see if the 1 TeV mass scale can be approached experimentally since it is at this scale that unitarity violations begin to appear. To do this, it will be necessary to use the hadronic decay modes of the W or Z. A case which has been studied extensively is the decay chain,

$$H \to W^+W^- \to \text{ jets} + l^\pm \nu \tag{3.2}$$

where $l = e, \mu$. This decay chain has a branching ratio of about 20%, considerably larger than those for the purely leptonic signals considered above. With this decay chain, there are approximately 2000 events in a standard SSC year for a 1 TeV Higgs boson.

The backgrounds from $q\bar{q} \to W^+W^-, ZZ$ can be easily overcome. The pernicious background, however, is from single W plus jet production, $qg \to q'gW$, *etc.* Even assuming a 5% resolution in the jet-jet invariant mass is insufficient to eliminate this background. Several techniques have been applied in the attempt to beat down this background. The first is to note that when Higgs bosons are produced from WW fusion, the parton process is $q_1q_2 \to Hq_1'q_2'$ and so there are spectator jets present in the final state with $p_T \sim M_W$. The idea is to trigger on these spectator jets.[17] The other observation which may be useful is to note that the W plus jet background tends to produce jets of unequal energy, while the longitudinal W's produced in the decay of a heavy Higgs tend to decay into two jets with equal energy.[18] A combination of these two techniques yields a signal to background ratio of about 1 : 1 for a 1 TeV Higgs at the SSC. In a standard SSC year, there will be approximately 100 events remaining after these cuts.

It has also been observed that the Higgs signal and the W plus jet background may produce jets with significantly different multiplicities.[19] Unfortunately, jet multiplicities are notoriously difficult to predict and the final answer is not yet in as to whether this technique can be made to work.

4. CONCLUSIONS

The search for a heavy Higgs boson opens a window into physics beyond the standard model. For $M_H > 1\ TeV$, unitarity violations occur in the interactions of the Higgs boson with the W and Z gauge bosons. In such a case, deviations from standard model predictions may be seen at the SSC or LHC. Indeed, radiative corrections suggest that if $M_H >> 1\ TeV$, new physics should occur at the TeV energy scale. If the Higgs boson mass is less than $1\ TeV$ (but heavier than $2M_W$) then it should be possible to observe it directly in pp interactions at $\sqrt{s} = 40\ TeV$.

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