CERN-TH.6274/91

USING τ POLARIZATION FOR THE CHARGED HIGGS SEARCH AT HADRON COLLIDERS

D.P. Roy*)

Theory Division, CERN
1211 Geneva 23, Switzerland

Abstract

The τ polarization has a fairly significant effect on the charged Higgs signature at the hadron colliders. It is best seen in the $\tau\mu$ channel followed by the pionic decay of τ. The average p^T of the pion originating from the W boson is only about half of that originating from a charged Higgs of comparable mass. This can be used to improve the signal/background ratio by a factor of ~ 3. It can also serves as an independent signature for the charged Higgs boson.

---

*) On sabbatical leave from the Tata Institute of Fundamental Research, Bombay-400005, India.

CERN-TH.6274/91
October 1991

From the direct top search experiment at the Tevatron [1] and from the indirect measurement of top quark induced radiative correction effects at LEP [2], a top quark mass range of 100–200 GeV is expected, with a central value of about 150 GeV. A top quark in this mass range is expected to be seen at the Tevatron upgrade and produced more copiously at the LHC/SSC colliders [3]. This will enable one to search for new particles in the t decay. There has been a good deal of current interest in the search of one such new particle, i.e. the charged Higgs boson of the two-Higgs doublet models and in particular the minimum supersymmetric standard model (MSSM) [4]-[6]. All these analyses are based on the preferential charged Higgs coupling to the τ channel vis-a-vis e and μ, in contrast to the universal W boson coupling to all three channels. Thus a departure from the universality prediction between these decay channels is used to separate the charged Higgs signal from the W boson background in

$$t \to bH(W) \to b\tau\nu \ . \tag{1}$$

Recently, it has been emphasized in Ref. [7] that a measurement of the τ polarization can serve as an independent signature for the charged Higgs boson, since

$$H^- \to \tau_R^- \bar{\nu}_R, \quad H^+ \to \tau_L^+ \nu_L \tag{2}$$

while

$$W^- \to \tau_L^- \bar{\nu}_R, \quad W^+ \to \tau_R^+ \nu_L \ . \tag{3}$$

However, there has been no quantitative investigation of this question so far in the context of a hadron collider. The present work is devoted to this exercise.

We shall concentrate on the charged Higgs–fermion coupling scheme of the MSSM [8], i.e.

$$\mathcal{L} = \frac{g}{\sqrt{2} m_W} H^+ \left\{ \cot\beta V_{ij} m_{ui} \bar{u}_i d_{jL} + \tan\beta V_{ij} m_{dj} \bar{u}_i d_{jR} + \tan\beta m_{\ell j} \bar{\nu}_j \ell_{jR} \right\} + \text{h.c.} \tag{4}$$

where V_{ij} are the KM matrix elements. The QCD corrections are taken into account in the leading log approximation by substituting the quark masses by the running masses, evaluated at the Higgs mass scale [5]. Perturbative limits on the tbH Yukawa couplings of Eq. (4), along with the limit coming from low-energy processes like $b \to s\gamma$ and B_d–$\bar{B}_d$ mixing, imply [9]

$$0.4 < \tan\beta < 120 \ . \tag{5}$$

In the most predictive form of MSSM, characterized by a common SUSY-breaking mass scale at the grand unification point, one gets stronger bounds [10], i.e.

$$1 < \tan\beta < m_t/m_b \ . \tag{6}$$

Such a lower bound also follows from requiring the perturbative limit on the tbH Yukawa coupling to hold up to the unification point [11]. We shall, however, assume only the least restrictive bounds of Eq. (5).

In the diagonal KM matrix approximation, one gets the decay widths

$$\Gamma_{t\to bW} = \frac{g^2}{64\pi m_W^2 m_t} \lambda^{1/2}\left(1, \frac{m_b^2}{m_t^2}, \frac{m_W^2}{m_t^2}\right) \left[m_W^2 (m_t^2 + m_b^2) + (m_t^2 - m_b^2)^2 - 2m_W^4 \right] \tag{7}$$

$$\Gamma_{t\to bH} = \frac{g^2}{64\pi m_W^2 m_t} \lambda^{1/2}\left(1, \frac{m_b^2}{m_t^2}, \frac{m_H^2}{m_t^2}\right) \left[(m_t^2 \cot^2\beta + m_b^2 \tan^2\beta)(m_t^2 + m_b^2 - m_H^2) - 4m_t^2 m_b^2 \right] \tag{8}$$

$$\Gamma_{H\to\tau\nu} = \frac{g^2 m_H}{32\pi m_W^2} m_\tau^2 \tan^2\beta \tag{9}$$

$$\Gamma_{H\to c\bar{s}} = \frac{3g^2 m_H}{32\pi m_W^2}(m_c^2 \cot^2\beta + m_s^2 \tan^2\beta). \tag{10}$$

From these, one can construct the relevant branching fractions

$$B_{t\to bH} = \Gamma_{t\to bH}/(\Gamma_{t\to bH} + \Gamma_{t\to bW}) \tag{11}$$

$$B_{H\to\tau\nu} = \Gamma_{H\to\tau\nu}/(\Gamma_{H\to\tau\nu} + \Gamma_{H\to c\bar{s}})\ . \tag{12}$$

The charged Higgs has to be observed in the τ channel in view of the large QCD background for the hadronic channel. It is thus the product of the two branching fractions (11) and (12) that controls the size of the observable charged-Higgs signal. The $t \to bH$ branching fraction has a pronounced dip at

$$\tan\beta = (m_t/m_b)^{1/2} \simeq 6\ , \tag{13}$$

where Eq. (8) has a minimum. Although this is partially compensated by the large value of the $H \to \tau\nu$ branching fraction in this region ($\simeq 1$), the product still has a significant dip. Note that this occurs right in the middle of the range (6), favoured by the MSSM. Thus the above value of $\tan\beta$ plays an important role in constructing a viable charged Higgs signal, as we shall see below.

The basic process of interest is $t\bar{t}$ production through gluon–gluon (or quark–antiquark) fusion [4]–[6] followed by their decay into charged Higgs or W boson channels, i.e.

$$gg \to t\bar{t} \to b\bar{b}(H^+H^-, H^\pm W^\mp, W^+W^-)\ . \tag{14}$$

The cleanest channels are the leptonic decay channels of both the charged bosons, i.e.

$$\begin{array}{cccccccccccc} H^+ & H^- & & H^+ & W^- & & W^+ & H^- & & W^+ & W^- & \\ \downarrow & \downarrow & , & \downarrow & \downarrow & , & \downarrow & \downarrow & , & \downarrow & \downarrow & , \\ \tau_L^+ & \tau_R^- & & \tau_L^+ & \tau_L^-, \mu^- & & \tau_R^+, \mu^+ & \tau_R^- & & \tau_R^+, \mu^+ & \tau_L^-, \mu^- & \end{array} \tag{15}$$

In the absence of polarization measurement, the 2τ channel gives the most favourable signal/background ratio because of the HH contribution and more importantly the enhancement of the WH contribution by a combinatorial factor of 2. This is true even if one includes the hadronic decay channel of W. In the region of $\tan\beta \simeq 6$ of course the signal is dominated by the WH contribution. As shown in Ref. [5], one expects a signal/background ratio $\gtrsim 1$ in this channel, throughout the allowed $\tan\beta$ range (5), up to $m_H \simeq 100$ GeV. Moreover, this ratio can be maintained right up to $m_H \simeq m_t - 20$ GeV by an appropriate kinematic cut on the accompanying b quark jets, i.e. $p_j^T < 30$ GeV [6]. With the large $t\bar{t}$ event rates expected at the LHC/SSC, it is possible to impose such a cut and get a viable charged Higgs signal to within 20 GeV of top quark mass. These considerations will be important in investigating the effect of τ polarization.

To see the effect of τ polarization one has to consider a channel where the signal and the background correspond to specific states of τ polarization. It is clear from (15) above that the best channel for this purpose is the $\tau\mu$ channel. This means of course a factor of 2 drop in the signal/background ratio. Further, one has to restrict to specific τ decay channels which are most sensitive to polarization, i.e.

$$\tau^\pm \xrightarrow{11\%} \pi^\pm \nu \tag{16}$$

and

$$\tau^{\pm} \xrightarrow{23\%} \rho^{\pm}\nu \, . \tag{17}$$

Consequently there will be an overall drop in the signal size. On the other hand, the effect of τ polarization can be used to improve the signal/background ratio significantly through appropriate cuts on the decay meson momentum. This momentum spectrum can also be used to distinguish the H signal from the W boson background and therefore serve as a charged Higgs signature.

We shall work in the collinear approximation, i.e. all the decay particles from τ emerge practically along the τ line of flight in the laboratory system. Nonetheless the momentum distribution of the decay particle can be used to measure the τ polarization. Indeed the τ polarization has been recently measured to an accuracy of ±5% with this method at LEP [12]. The average τ momentum for our process (14), (15) is similar to the LEP value ($\sim$ 40 GeV); but there is a considerable spread in the momentum distribution which dilutes the polarization effect appreciably vis-à-vis LEP. Nonetheless, it maybe feasible to measure the τ polarization to an accuracy of ±20%, say, which will be adequate for our purpose.

The formalism relating the τ polarization to the momentum distribution of its decay particles has been extensively studied since long before the discovery of the τ [13]. We shall only quote the formulae relevant to our analysis and shall concentrate on the π and ρ decay channels of Eqs. (16) and (17), which provided the most precise measurement of τ polarization at LEP [12]

$$\frac{d\Gamma_\pi}{\Gamma_\pi d\cos\theta} = \frac{1}{2}(1 + P_\tau \cos\theta) \tag{18}$$

$$\frac{d\Gamma_{\rho_L}}{\Gamma_\rho d\cos\theta} = \frac{1/2m_\tau^2}{m_\tau^2 + 2m_\rho^2}(1 + P_\tau \cos\theta) \tag{19}$$

$$\frac{d\Gamma_{\rho_T}}{\Gamma_\rho d\cos\theta} = \frac{m_\rho^2}{m_\tau^2 + 2m_\rho^2}(1 - P_\tau \cos\theta) \tag{20}$$

$$\cos\theta = \frac{2x - 1 - m_{\pi,\rho}^2/m_\tau^2}{1 - m_{\pi,\rho}^2/m_\tau^2} \tag{21}$$

where θ is the $\pi(\rho)$ direction in the τ rest frame relative to the τ line of flight; and x is the fractional τ momentum carried by it in the laboratory frame. By convention

$$P_\tau = P_{\tau^-} = -P_{\tau^+}, \quad P_{\tau^\pm} = \frac{\sigma_R - \sigma_L}{\sigma_R + \sigma_L} \, . \tag{22}$$

The above distributions can be simply understood in terms of angular momentum conservation. For $\tau^-_{R(L)} \to \nu_L \pi^-, \rho^-_{\lambda=0}$ it favours forward (backward) emission of π or longitudinal ρ meson; while it is the other way round for transverse ρ emission $\tau^-_{R(L)} \to \nu_L \rho^-_{\lambda=-1}$. As a result the π^- originating from the charged Higgs and the W boson peak at $x = 1$ and 0 respectively and $\langle x_{\pi^-}\rangle_H = 2\langle x_{\pi^-}\rangle_W = 2/3$. After convolution with the τ momentum the clear separation between the signal and the background peaks disappears; but one still gets a significantly harder π^- spectrum for the charged Higgs signal compared with the W boson background, as we shall see below. In particular, the ratio of the average π^- momenta remains unaffected by convolution; thus, for $m_H \simeq m_W$:

$$\langle p^T_{\pi^-}\rangle_H \simeq 2\langle p^T_{\pi^-}\rangle_W . \tag{23}$$

This can serve as an effective signature for the charged Higgs boson [1].

Similarly one sees from Eqs. (19)–(22) that the ρ^- spectrum originating from the charged Higgs decay would be harder than that from the W boson. But the sensitivity to the τ^- polarization is suppressed by a factor of $(m_\tau^2 - 2m_\rho^2)/(m_\tau^2 + 2m_\rho^2) \simeq 1/2$ owing to the admixture of the transverse ρ polarization. The longitudinal and transverse components of ρ polarization can be separated by looking at the energy distribution between the decay pions, i.e.

$$\frac{d\Gamma(\rho_T^- \to \pi^-\pi^0)}{\Gamma_{\pi\pi} d\cos\theta'} = \frac{3}{4}\sin^2\theta' \tag{24}$$

$$\frac{d\Gamma(\rho_L^- \to \pi^-\pi^0)}{\Gamma_{\pi\pi} d\cos\theta'} = \frac{3}{2}\cos^2\theta' \tag{25}$$

$$x' = \left[1 + \sqrt{1 - 4m_\pi^2/m_\rho^2}\cos\theta'\right]/2 \tag{26}$$

where x' and $(1 - x')$ are the fractions of the ρ laboratory momentum carried by π^- and π^0. The distributions (24) and (25) can again be understood in terms of angular momentum conservation, which forbids $\rho_T \to \pi^-\pi^0$ decay along its line of flight. Consequently ρ_T decay favours roughly equipartition of its momentum between the two pions while the ρ_L decay favours a large difference between the two pion momenta. Combining this with Eqs. (19)–(22), one expects a harder distribution in $|p_{\pi^-} - p_{\pi^0}|$ for the charged Higgs signal compared with the W boson background. In principle, this difference could be further enhanced by restricting to the large x $(= p_\rho/p_\tau)$ region. This cut will have little practical use in our case, however, because of the large spread in the τ momentum.

All the above results hold equally for $\tau^+_{H(W)} \to \pi^+, \rho^+$. For notational convenience, however, we shall continue to restrict our discussion to one (−ve) charged state only. But identical results hold for the charge conjugate case; and the charge averaged cross-sections are simply obtained by doubling those presented below.

We have computed the $t\bar{t}$ production and decay processes of (14)–(17) with a parton level Monte Carlo program using the QCD parameters of Ref. [14]. All the cross-sections presented below are calculated for the LHC energy of

$$\sqrt{s} = 16 \text{ TeV}. \tag{27}$$

But of course the only energy-dependent quantity is the overall normalization of the cross-section, which can only improve at the SSC energy.

Figure 1a shows the p^T distribution of pions coming from $W^-(H^-) \to \tau^-_{L(R)} \to \pi^-$. The normalizations correspond to $\tan\beta = 6$, i.e.to the minimum possible size of the charged Higgs signal. As remarked before, we see no clear separation between the signal and the background peaks anymore. Nonetheless the signal has a significantly harder p^T distribution, which can be used to improve the signal/background ratio by a factor of at least 3. Thus for $m_H = 80$–100 GeV ($\simeq m_W$), a $p^T_{\pi^-} > 30$ GeV cut gives a signal/background ratio > 1, while retaining 1/2 the signal size. It should be remembered of course that the overall cost to the signal size is a factor of ~ 10 after taking into account the pionic branching ratio of τ. Nonetheless one is left with a sufficiently large signal size of ~ 300 fb. However, we see from the bottom curve of Fig.

---

[1] An Identical relation holds for the ratio of average mommenta. But we shall generally work with transverse momenta since they are insensitive to beam energy and parton distribution function.

1a that the p^T_π-distribution alone cannot give a viable signal/background ratio for $m_H \simeq m_t$. This can be achieved with a $p^T < 30$ GeV cut on the accompanying b jets [6], as shown in Fig. 1b. With this cut one can achieve a signal/background ratio ≥ 1 up to $m_H \simeq m_t - 20$ GeV, i.e., up to 130 GeV for $m_t = 150$ GeV, going up to 180 GeV, for $m_t = 200$ GeV. In the last case, however, the signal size is only ~ 1 fb, corresponding to 10–100 events for the LHC luminosity range of 10–100 fb^{-1}. Thus it can be viable only for the high luminosity option of LHC (or SSC) [2].

Figure 2a shows the p^T distribution for $W^-(H^-) \to \tau^-_{L(R)} \to \rho^-$ events for $m_H = 80$ and 100 GeV. One clearly sees a significant dilution of the polarization effect compared with the pion channel. Figure 2b shows the corresponding distribution in the p^T difference between the π^- and π^0 coming from ρ^- decay. Here one sees a more significant difference between the charged Higgs signal and the W background. This figure also shows the effect of a large p^T_ρ cut on these distributions. As one sees it does not enhance the difference between the signal and background distributions further. Nonetheless the difference between the two distributions is sufficient to give a signal/background ratio $\gtrsim 1$ while retaining 1/2 the signal size for $m_H = 80$ to 100 GeV. One can supplement this by a p^T cut on the accompanying b jets to go to higher m_H values, as in the previous case. It should be remarked, however, that identifying the ρ^- channel and measuring the momentum difference between its decay pions would be considerably more difficult than the previous case.

We have seen above that the effect of τ polarization can be used to enhance the charged Higgs signal to W background ratio to $\gtrsim 1$ even for the most unfavourable value of $\tan\beta = 6$. Since the size of the W background is predicted via universality in terms of the dimuon channel, a significant excess over this prediction constitutes a signature for the charged Higgs boson. Let us see now if the effect of τ polarization can provide an effective charged Higgs signature by itself. For this we concentrate on the $W^-(H^-) \to \tau^-_{L(R)} \to \pi^-$ channel of Fig. 1, since it shows the strongest effect of τ polarization. In particular, the average $p^T_{\pi^-}$ for the H signal is seen to be about twice that of the W boson background for $m_H \simeq m_W$ (and marginally larger for higher values of m_H). As remarked earlier, this is a direct consequence of the τ polarization which remains unaffected by the p_τ convolution. This can be used as an effective charged Higgs signature provided the size of the signal is at least comparable to the W background. We have seen above that with appropriate kinematic cuts, this condition can be achieved up to $m_H \simeq m_t - 20$ GeV even for the most unfavourable value of $\tan\beta$. Thus the τ polarization effect can provide a viable charged Higgs signature throughout the allowed $\tan\beta$ range up to $m_H \simeq m_t - 20$ GeV. The obvious quantity to consider for this purpose is of course τ polarization

$$P_\tau = \frac{\sigma_R - \sigma_L}{\sigma_R + \sigma_L} = \frac{\sigma_H - \sigma_W}{\sigma_H + \sigma_W} \,. \tag{28}$$

Figure 3 shows the predicted polarization for $m_t = 150$ GeV ($m_H = 100, 130$ GeV) and $m_t = 200$ GeV ($m_H = 160, 180$ GeV), where the signal/background ratio has been enhanced in the last three cases by the $p_T > 30$ GeV cut on the accompanying b-jets as in Fig. 1b [3]. One sees that the predicted polarization always remains above -0.6 compared with the background value of -1. Thus a polarization measurement to within ±20% accuracy can provide an effective

---

[2] As discussed in Ref. [6], one can get a better signal size at the cost of a worse signal/background ratio by imposing a p^T cut on the second hardest b jet, instead of the hardest one.

[3] One does not need b identification for this purpose, since one expects only a tiny fraction of $t\bar{t}$ events to be accompanied by a QCD jet of $p^T > 30$ GeV [15]. Thus it is enough to ensure that the $\tau\mu$ events have no accompanying jets of $p^T > 30$ GeV

charged Higgs signature up to $m_H \simeq m_t - 20$ GeV. This seems feasible, considering that the p_π^T spectra of Fig. 1 for the background and signal + background correspond to $P_\tau = -1$ and -0.6 respectively. It should be noted here that the polarization prediction is practically independent of the $t\bar{t}$ production model as it depends only on the ratio σ_W/σ_H. On the other hand, one needs a production model for extracting τ polarization from the pion momentum spectrum since the τ momentum is not measurable. Note, however, that the momentum spectrum of the accompanying muon corresponds to that of the background τ, and hence can give a model independent estimate of the background pion spectrum. This should be of considerable help in extracting τ polarization from the observed pion spectrum [4].

Finally, the effect of τ polarization can also be useful in estimating the charged Higgs mass from the transverse mass distribution of the decay pion with the missing p^T. The softer pion spectrum for the W results is a softer transverse mass spectrum for the W background compared with a charged Higgs of similar mass with $\langle M_{tr}\rangle_W \simeq \langle M_{tr}\rangle_H/2$. Figure 4 shows the transverse mass distributions of the signal and background for the most unfavourable situation of $m_H \simeq m_W$ and $\tan\beta = 6$. Even in this case m_H has a discernible effect on the tail of the transverse mass distribution. Of course, the effect will be even clearer at higher m_H, provided the signal/background ratio is enhanced by the above-mentioned kinematic cut. Figures 4a and 4b refer to the $\tau + \mu$ channel and to the τ +multijet channel (corresponding to the hadronic decay of W). The latter channel has the advantage of a larger signal size and a sharp kinematic boundary at m_W (m_H). On the other hand, it suffers from a large background from $W + QCD$ jets and the problem of τ detection in a multijet environment.

In summary, τ polarization has a significant effect on the charged Higgs signature in $t\bar{t}$ decay at the hadron colliders. This is best seen in the $\tau\mu$ channel followed by pionic decay of τ. The average momentum (or p^T) of the pion originating from W is about half of that originating from a charged Higgs of comparable mass. This can be used to improve the signal/background ratio by a factor of 3, although the overall event rate is reduced by the small pionic branching fraction of τ. Along with a p^T cut on the accompanying b-jets, it can give a viable charged Higgs signal throughout the allowed coupling parameter ($\tan\beta$) space up to $m_H \simeq m_t - 20$ GeV. The τ polarization can also serve as an effective charged Higgs signature over this region, if it can be measured to an accuracy of ±20%.

I gratefully acknowledge discussions with G. Altarelli, S. Banerjee, M. Felcini, H.E. Haber and F. Zwirner.

---

[4] The polarization prediction of Fig. 3 is equally valid at SSC and Tevatron energies. In the latter case of course the low event rate would restrict the probe to a small part of the parameter space.

References

[1] CDF Collaboration: F. Abe et al., *Phys. Rev. Lett.* **64** (1990) 142 and 147;
A. Barbaro-Galtieri, Fermilab CONF-91/66-E (1991).

[2] See, e.g. J. Steinberger, *Phys. Rep.* **203** (1991) 345;
J. Ellis, Proc. LP-HEP Conference, Geneva, 1991 (to be published);
G. Altarelli et al., CERN preprint TH.6124/91 (1991).

[3] S. Gupta and D.P. Roy, *Z. Phys.* **C39** (1988) 417;
H. Baer, V. Barger and R.J.N. Phillips, *Phys. Rev.* **D39** (1989) 3310;
F. Cavanna, D. Denegri and T. Rodrigo, Proc. ECFA-LHC Workshop, CERN 90-10 (1990), Vol. II, p. 329.

[4] R.M. Barnett et al., Proceedings of the 1990 Summer Study in High Energy Physics, Snowmass (to be published);
V. Barger and R.J.N. Phillips, *Phys. Rev.* **D41** (1990) 884;
A.C. Bawa, C.S. Kim and A.D. Martin, *Z. Phys.* **C47** (1990) 75;
M. Felcini, Proc. ECFA-LHC Workshop, CERN 90-10 (1990), Vol. II, p. 414;
R.M. Godbole and D.P. Roy, *Phys. Rev.* **D43** (1991) 3640.

[5] M. Drees and D.P. Roy, *Phys. Lett.* **B269** (1991) 155.

[6] D.P. Roy, CERN preprint TH.6247/91 (1991).

[7] B.K. Bullock, K. Hagiwara and A.D. Martin, Durham preprint DTP/91/42 (1991).

[8] See, e.g., J.F. Gunion, H.E. Haber, G. Kane and S. Dawson, The Higgs Hunters' Guide, Addision Wesley, Reading, MA (1990);
H.E. Haber, Phenomenology of the Standard Model and Beyond, eds. D.P. Roy and Probir Roy, World Scientific, Singapore, (1989), p. 197.

[9] V. Barger, J.L. Hewett and R.J.N. Phillips, *Phys. Rev.* **D41** (1990) 3421;
J.F. Gunion and B. Grzadkowski, *Phys. Lett.* **B243** (1990) 301;
A. Buras et al., *Nucl. Phys.* **B337** (1990) 284.

[10] G. Ridolfi, G.G. Ross and F. Zwirner, Proc. ECFA-LHC Workshop, CERN 90-10 (1990), Vol. II, p. 608.

[11] J. Bagger, S. Dimopoulos and E. Masso, *Phys. Rev. Lett.* **55** (1985) 920.

[12] ALEPH Collaboration, D. Decamp et al., *Phys. Lett.* **B265** (1991) 430.

[13] Y.S. Tsai, *Phys. Rev.* **D4** (1971) 2841;
P. Aurenche and R. Kinnunen, *Z. Phys.* **C28** (1985) 261;
A. Rouge, *Z. Phys.* **C48** (1990) 75;
K. Hagiwara, A.D. Martin and D. Zeppenfeld, *Phys. Lett.* **B235** (1990) 198.

[14] M. Glück, F. Hoffman and E. Reya, *Z. Phys.* **C13** (1982) 119.

[15] M. Mangano, P. Nason and G. Ridolfi, Pisa preprint UPRF-91-308 (1991).

FIGURE CAPTIONS

Fig. 1: a) The p^T distribution of the decay pion from the process $t\bar{t} \to b\bar{b}W^+W^-(H^-)$ followed by $W^- \to \tau_L^- \to \pi^-(H^- \to \tau_R^- \to \pi^-)$.

b) Same as above, but with a $p_j^T < 30$ GeV cut on the accompanying b-jets. The charged Higgs coupling parameter is chosen at the most unfavourable value of $\tan\beta = 6$ in this and in Figs. 2 and 4 below.

Fig. 2: a) The p^T distribution of the decay ρ^- from $W^- \to \tau_L^- \to \rho^-$ (dashed line) and $H^- \to \tau_R^- \to \rho^-$ (solid line).

b) The corresponding distribution in the p^T difference between the decay pions from $\rho^- \to \pi^-\pi^0$. The effect of a $p_\rho^T > 20$ GeV cut on the W background and the 80 GeV charged Higgs signal are shown by dot-dashed and dotted lines respectively.

Fig. 3: The predicted τ^- polarization for $m_t = 150$ GeV($m_H = 100, 130$ GeV) and $m_t = 200$ GeV($m_H = 160, 180$ GeV). The curves correspond to signal + background while the background value is indicated at the bottom.

Fig. 4: The distribution in the transverse mass of the decay π^- and the missing p_T for (a) the $\tau\mu$ channel, (b) the τ + multijet channel.

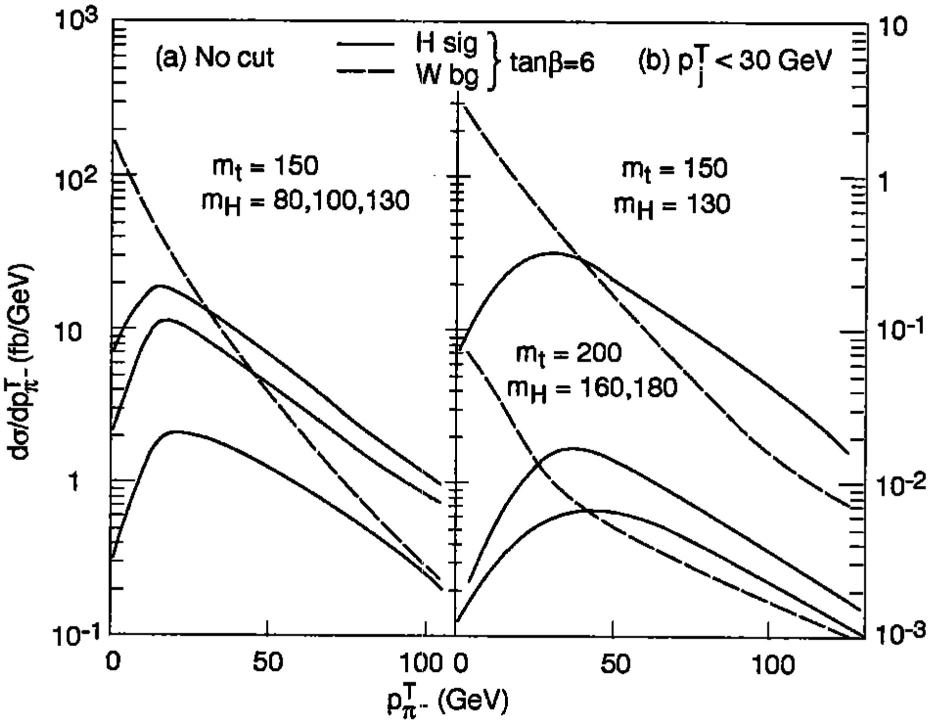

Figure 1

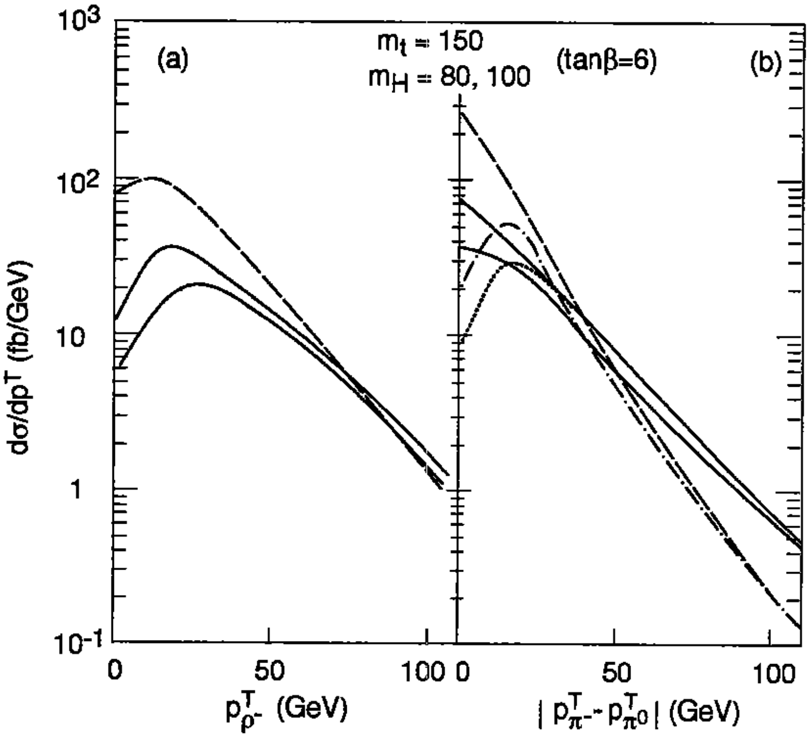

Figure 2

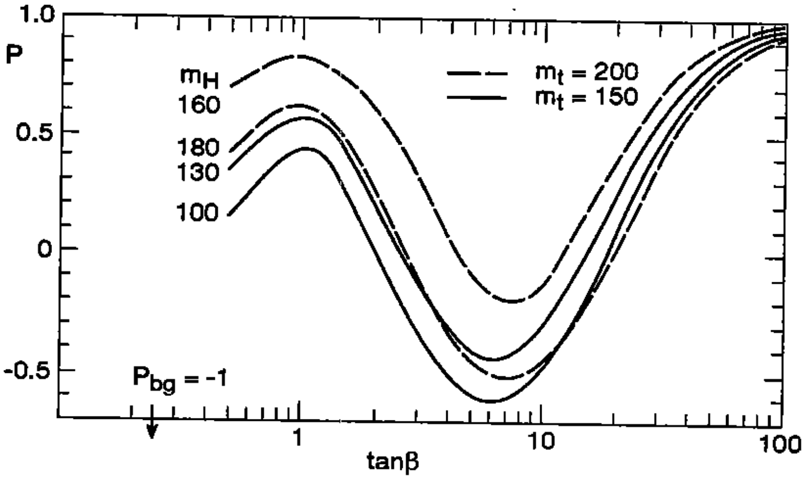

Figure 3

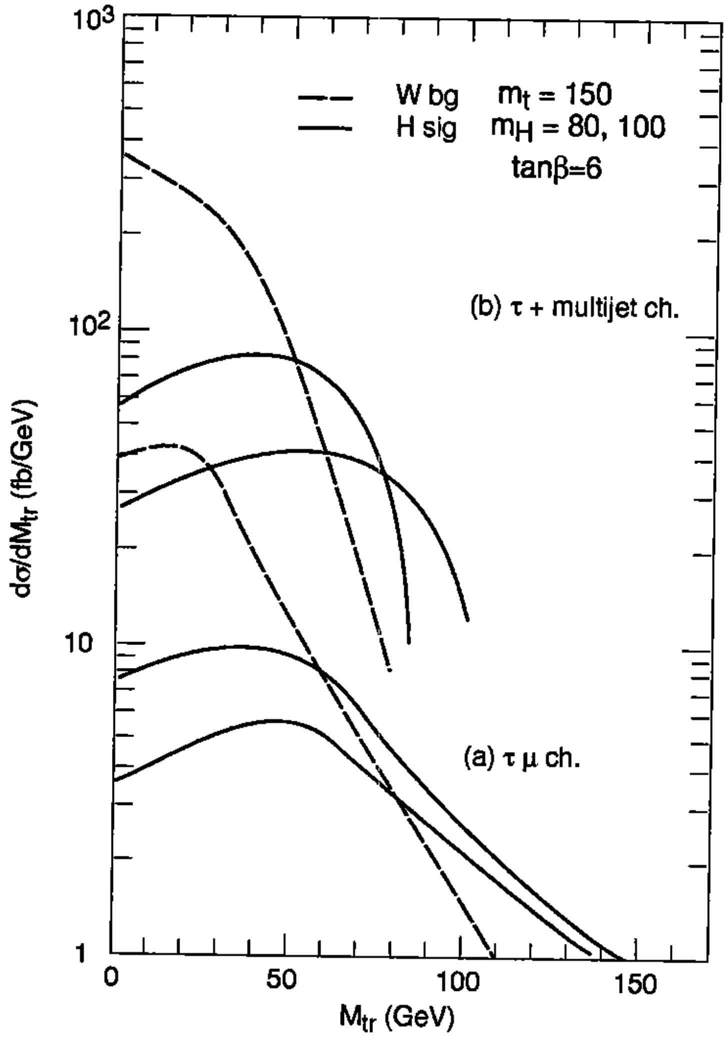

Figure 4