Special features of the complete one-loop MSSM SUSY effects in charged and neutral semi inclusive Higgs production at LHC.

Charged Higgs 2010, Uppsala 27/09.

C.Verzegnassi
Dept.of Physics, University, Trieste.

Terminology: follows Dawson, Jackson, Reina and Wackeroth (Mod.Phys.Lett. A21,89 -2006) for bottom- neutral Higgs

and Berger,Han, Jing Jiang and Plehn (Phys.Rev.D71,115012-2005) for top- charged Higgs ("semi-inclusive"="associated") production.

Apologies to the very large number of unquoted authors.....

The results that I will show have been obtained working in the 5FNS and considering the 4 “semi-inclusive” processes:

bg---> bh (h=ho, Ho, Ao MSSM)

bg---> tH (H=charged MSSM Higgs).

in the MSSM and also in the 2HDM, Type 2, approach, for MH>mtop.

The theoretical group that performed the calculations is mostly constitued by the members of the Italian INFN supported LE21 “Iniziativa Specifica” i.e.

Matteo Beccaria, Giacomo Dovier, Guido Macorini, Luca Panizzi, C.V. (green ones previously p.h.d. students of mine)
with the extra essential contribution of Fernand Renard, Edoardo Mirabella. and (for the last paper)
Abdelhak Djouadi.

At the lowest tree level order, the four considered processes are described by the following Feynman diagrams (next page):

To understand the main goals of the theoretical efforts to be described, a good starting point is to derive the MSSM expression of the relevant (t,b H=Higgs) Yukawa Lagrangian. In the notation of Carena, Garcia, Nierste and Wagner (Nucl.Phys.B577, 577-2000) this reads:

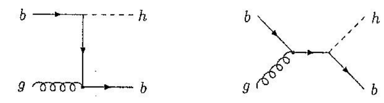


FIG. 2: Tree level Feynman diagram for $bg \to bh$ in the 5FNS.

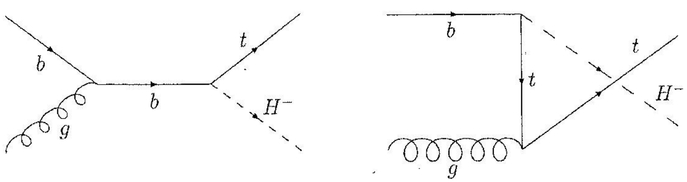


Figure 1: Born diagrams: s-channel bottom exchange and u-channel top exchange.

$$
-\mathcal{L}^{(0)}_{ya}(b,t,H) = \Bigg\{ \frac{\sqrt{2}}{v}\Big[m_b \, tg\beta \, \bar{t}_L b_R H^+ + \frac{m_t}{tg\beta} \bar{b}_L t_R H^- \Big] + h.c. \Bigg\}
$$

$$
+ \Bigg\{ \frac{m_b}{v\cos\beta}\Big[\bar{b} b \left(-\sin\alpha \, h_0 + \cos\alpha \, H_0 \right) - i \bar{b} \gamma_5 b A_0 \, tg\beta \Big]
$$

$$
+ \frac{m_t}{v\sin\beta}\Big[\bar{t} t \left(\cos\alpha \, h_0 + \sin\alpha \, H_0 \right) + i \bar{t} \gamma_5 t A_0 \cos\beta \Big] \Bigg\}
$$

Here β, α are the usual MSSM Higgs sector angles, $v \equiv \sqrt{v_1^2 + v_2^2} \simeq 174\,GeV$ and $\mathcal{L}^{(0)}$ does not contain (future) radiative corrections. The Yukawa couplings $h_{b,t}$ are defined as

$$
h_b = \frac{m_b}{v_1}, \quad h_t = \frac{m_t}{v_2}; \quad tg\beta \equiv \frac{v_2}{v_1}
$$

($v_{1,2}$ are the neutral Higgses vevs).

More precisely:

$$h_0 = \cos\alpha\, h_u^0 - \sin\alpha\, h_d^0$$
$$H_0 = \sin\alpha\, h_u^0 + \cos\alpha\, h_d^0$$

$$A_0 = \cos\beta\, \chi_u^0 + \sin\beta\, \chi_d^0$$
$$H^+ = \cos\beta\, h_u^+ + \sin\beta\, h_d^{-*}$$

h_u^0, χ_u^0, h_u^+ are the neutral (real and Imaginary) and charged members of the H_u doublet (coupled to up quarks)

The $(\ )_d$ fields are those coupled to down quarks.

In the previous expression (where I assumed Vtb=1), ho, Ho, Ao are the physical neutral CP even and odd Higgses (CP is assumed to be conserved), H+ is the physical charged Higgs. In principle, there are six free parameters (the four masses and the two angles).In the MSSM at this lowest order only two parameters are independent, usually taken as MAo and tgbeta.

In a model with one more (extra SM) Higgs Doublet and two different vevs like in the MSSM (2HDM) the six parameters are free.

Looking at the LO Lagrangian of page 7 one sees that taking large values (e.g. >10) of tanbeta the term proportional to Mt in the btH interaction can be ignored.

The four processes bg--->bh and bg--->tH are therefore described in this regime by the same parameters, tanbeta, MAo and mb. This suggests the criterion of making a common study and comparison of the four reactions, that must necessarily involve the higher order “radiative” corrections and, also, the “poor boy” small tanbeta (e.g. <10) region.

Moving to higher orders.

Moving to higher orders in the MSSM requires first of all a choice of the SUSY parameters description. Next, strong and EW interactions effects must be computed (in a possibly terrifying way, where a number N>>1 of infinities must be exactly cancelled) and suitable definitions for certain parameters must be adopted.

A particularly relevant example of the latter sentence is that of the choice of the bottom mass.

At the lowest order, page 7, mb is taken as the “pole mass”. But as soon as one moves to higher orders, this definition is not always safe and other renormalization schemes are preferable, see e.g. Beneke and Singer, Phys.Lett.B471, 233 (1999).

In the specific MSSM case, a particolarly convenient choice for mb is that of the Dimensional Reduction renormalization scheme, (Siegel,Phys.Lett.B84,193(1979)), as discussed in detail by Heinemeyer, Hollik, Rzehak and Weiglein, Eur.Phys.J C39,465 (2005). Different “mixed”choices are however allowed (with some care).

In the 5FNS treatment of the four considered ”semi-inclusive” production processes one finds two types of QCD corrections, that might be called of “diagrammatic” and “bottom pdf” origin.

The latter ones originate from the (known) fact that in the 5FNS the bottom parton is described by a proper pdf that resums collinear logarithms and is already of O(alphas) (see discussion and references of Dawson et al., page 2).
Moving to NLO replaces the LO version (CTEQ6L) with the NLO one ( ).

The SM and SUSY QCD NLO "diagrammatic" corrections for the considered "associated" processes in the 5FNS have been computed by a number of honourable authors, to my knoledge:

Zhu, Phys.Rev.D67,075006 (2003);
Plehn, Phys.Rev. D67, 014018, (2003)
Gao,Lu,Xiong, Yang, Phys.Rev.D66, 015007(2002);
Berger et al., page 2;
Campbell,Ellis,Maltoni and Willenbrock, Phys.Rev.D67,095002 (2003);
Dawson et al., page 2.

As a general feature, SM QCD corrections to the total rates are large and positive, while SUSY QCD effects are negative and sizeable for large values, e.g.>10, of tanbeta. This can be relatively easily understood as a consequence of the special large tanbeta parametrization of these effects originally proposed by Carena et al. (page 5), with the introduction of an "Effective" Yukawa Lagrangian replacing that of Page 7 and containing the "glorious" parameter Deltamb.

At the origin of the formalism there is the simple observation (Carena et al., page 5) that in the lowest order Yukawa Lagrangian (page 7) the bottom quark only interacts with d-type Higgses, while at higher MSSM order an interaction of SUSY QCD origin with u-type Higgses is introduced by the following diagram (next page).

Starting from this observation and after bright steps one is led to a description of the 4 processes valid in the large tanbeta range(in fact, the leading tanbeta effects are resummed to all orders) and based on an “effective” Yukawa Lagrangian where a modified bottom mass enters:

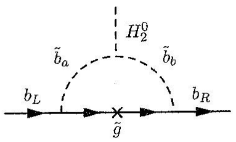


Figure 1: One-loop SUSY-QCD diagram contributing to the effective coupling Δh_b. The solid lines inside the loop denote the gluino propagator, the dashed lines correspond to sbottom propagators. The cross represents the $M_{\tilde{g}}$ insertion coming from the gluino propagator.

$$\mathcal{L}_{Yuk}^{(eff)} \underset{tg\beta \gg 1}{=} \frac{1}{v} \frac{\overline{m}_b(Q)}{1+\Delta m_b} \cdot$$

$$\Big\{ \left[\frac{\sin\alpha}{\cos\beta} - \Delta m_b \frac{\cos\alpha}{\sin\beta} \right] \bar{b} b h_0 +$$

$$+ \left[-\frac{\cos\alpha}{\cos\beta} + \Delta m_b \frac{\sin\alpha}{\sin\beta} \right] \bar{b} b H_0 +$$

$$+ \left[tg\beta \right] i \bar{b} \gamma_5 b A_0 +$$

$$+ \left[\sqrt{2}\, tg\beta \left(H^+ \bar{t}_L b_R + H^- \bar{b}_R t_L \right) \right]$$

where Q is the "typical" energy scale of the process ($\sim M_{H^\pm} + m_t$ or M_h) and $\overline{m}_b$ is computed in a safe renormaliz. scheme (e.g. $\overline{DR}$).

(V_{tb} assumed to be 1 .....) (in $H^+ V_{tb} \bar{t}_L b_R$ ...)

The SUSY QCD contribution to Deltab depends on the values of the involved MSSM parameters. For certain choices one sees that Deltab can be positive, proportional to tanbeta and thus large. The denominator (1+Deltab) therefore decreases the rates of the processes.

In conclusion, NLO QCD effects are known (with their related theoretical uncertainty, due to factorization and renormalization scale dependence, discussed in the quoted references).

What about NLO electroweak corrections?

For the considered processes, NLO MSSM EW radiative corrections have been computed in the following ways:

Dawson et al., page 2, (bh) have used a "generalized Deltab" approach. Beyond the gluino-sbottom graph of page 17, there are similar SUSY EW graphs, e.g. one with chargino-stop. This can be resummed and provides a "DeltabEW" effect which is also enhanced for large tanbeta and is supposed to be the dominant SUSY EW contribution. Numerical results are given in this approximation.

Berger et al., page 2, add to the SUSY QCD Deltab term other NLO “Supersymmetric contributions”. In the (usual) large tanbeta limit, these extra MSSM “non SUSY QCD Deltab” effects are small and negligible. MSSM EW effects seem not to be relevant.

The “dignity” of MSSM EW effects is reconsidered in the”fully inclusive” process of h production by bottom fusion in a paper By Dittmaier,Kramer,Muck and Schluter (JHEP 0703, 114(2007)).

This paper performs the complete NLO MSSM EW calculation for the process and separates the resummed extra “ EW Deltab” effects (wino-higgsino-stop, wino-higgsino-sbottom,..) from the “remaining” ones.

The result is that the EW Deltab effects are well competitive with the SUSY QCD ones, and of opposite sign. The “remaining” ones give a smaller (relative few percent) effect.

Our conclusion is that these NLO MSSM EW effects must be accurately computed.

This is what we did.

For top-charged Higgs calculation: Beccaria,Macorini,Panizzi,Renard, C.V., Phys.Rev.D80,053011,(2009).

For bottom-neutral Higgs calculation Beccaria,Dovier,Macorini,Mirabella, Renard, C.V.,arXiv:1005.0759(hep-ph). A more recent version with extra calculations and the same authors exists, arXiv:

For the top polarization in tH production , a preliminary version exists,Beccaria,Djouadi,Dovier, Macorini,Renard,C.V.

In all papers, the complete one-loop MSSM EW effects (including QED) have been computed.

NLO QCD has not been included (it already exists).

The resummed SUSY QCD Deltab term has been inserted in the bh production processes, and omitted in the tH production case.

The EW calculation is valid for all tanbeta values, including the usually neglected “small” ones. SM entry alpha, MW,MZ.

For bh we chose the Dimensional Reduction Renormalization scheme, with the (kinematical) bottom mass defined in the OS system.

For tH we chose the Wan,Ma,Zhang, Yang (Phys.Rev. D 64,115004-2001-) Renormalization scheme, with the b,t masses on shell.

The bottom pdf has been computed in the MSbar system at scale (Mt+ MH) or Mh.

All the definitions of the various counterterms can be found in the two first quoted papers (a partial illustrative set of figures is enclosed).

We have calculated invariant mass distributions and total rates with only EW (and SUSY QCD for bh) NLO effects for different parameter space scenarios ,for the MSSM and for the 2HDM.

tH

The c.t. appearing in the above expressions are obtained in terms of self-energies as follows:

b and t quark

$$\delta Z_L^b = \delta Z_L^t \equiv \delta Z_L = -\Sigma_L^b(m_b^2) - m_b^2[\Sigma_L'^b(m_b^2) + \Sigma_R'^b(m_b^2) + 2\Sigma_S'^b(m_b^2)] \quad \text{(A16)}$$

$$\delta Z_R^b = -\Sigma_R^b(m_b^2) - m_b^2[\Sigma_L'^b(m_b^2) + \Sigma_R'^b(m_b^2) + 2\Sigma_S'^b(m_b^2)] \quad \text{(A17)}$$

$$\delta Z_R^t = \delta Z_L + \Sigma_L^t(m_t^2) - \Sigma_R^t(m_t^2) \quad \text{(A18)}$$

$$\delta\Psi_t = -\{\Sigma_L^t(m_t^2) + \delta Z_L + m_t^2[\Sigma_L'^t(m_t^2) + \Sigma_R'^t(m_t^2) + 2\Sigma_S'^t(m_t^2)]\} \quad \text{(A19)}$$

$$\delta m_b = \frac{m_b}{2} Re[\Sigma_L^b(m_b^2) + \Sigma_R^b(m_b^2) + 2\Sigma_S^b(m_b^2)] \quad \text{(A20)}$$

$$\delta m_t = \frac{m_t}{2} Re[\Sigma_L^t(m_t^2) + \Sigma_R^t(m_t^2) + 2\Sigma_S^t(m_t^2)] \quad \text{(A21)}$$

gauge boson

$$\delta Z_1^W - \delta Z_2^W = \frac{\Sigma^{\gamma Z}(0)}{s_W c_W M_Z^2} \quad \text{(A22)}$$

$$\delta Z_2^W = -\Sigma'^{\gamma\gamma}(0) + 2\frac{c_W}{s_W M_Z^2}\Sigma^{\gamma Z}(0) + \frac{c_W^2}{s_W^2}[\frac{\delta M_Z^2}{M_Z^2} - \frac{\delta M_W^2}{M_W^2}] \quad \text{(A23)}$$

$$\delta M_W^2 = Re\Sigma^{WW}(M_W^2) \qquad \delta M_Z^2 = Re\Sigma^{ZZ}(M_Z^2) \quad \text{(A24)}$$

Higgs boson

We need δZ_{j1}^* which means $\delta Z_{H^-H^-}^*$ and $Z_{G^-H^-}^*$. We use the on-shell procedure of Wan et al [18] in which

$$\delta Z_{H^-H^-} = -\Sigma_{H^-}'(p^2 = m_{H^-}^2) \quad \text{(A25)}$$

and

$$\delta Z_{G^-H^-}^* = \delta Z_{G^+H^+} = -\frac{2\Sigma_{H^-W^-}^*(m_{H^-}^2)}{M_W} = \frac{2\Sigma_{H^+W^+}(m_{H^+}^2)}{M_W} \quad \text{(A26)}$$

Couplings

The Yukawa btH^- coupling leads to the c.t. δc^L and δc^R, computed in terms of δg, $\delta m_{t,b}$, δM_W (given above) and $\delta\tan\beta$. For the latter, we have adopted the renormalization scheme of [18].

calculation are collected in Appendix B.

Higgs sector

As anticipated we performed the calculation using two different renormalization schemes: the $\overline{\mathrm{DR}}$ scheme [14] is defined by the following renormalization conditions

$$
\begin{aligned}
\delta Z_{H_1}^{\overline{\mathrm{DR}}} &= -\left[\mathrm{Re}\frac{\partial\Sigma_{H^0}(k^2)}{\partial k^2}|_{k^2=M^2_{H^0},\alpha=0}\right]_{\mathrm{div}} \\
\delta Z_{H_2}^{\overline{\mathrm{DR}}} &= -\left[\mathrm{Re}\frac{\partial\Sigma_{h^0}(k^2)}{\partial k^2}|_{k^2=M_{h^0},\alpha=0}\right]_{\mathrm{div}} \\
\delta T_{h^0} &= -T_{h^0} \\
\delta T_{H^0} &= -T_{H^0} \\
\delta M^2_{A^0} &= \mathrm{Re}\Sigma_{A^0}(M^2_{A^0}) - M^2_{A^0}\Sigma'_{A^0}(M^2_{A^0}) \\
\delta\tan\beta^{\overline{\mathrm{DR}}} &= \frac{1}{2}\left(\delta Z_{H_2}^{\overline{\mathrm{DR}}} - \delta Z_{H_1}^{\overline{\mathrm{DR}}}\right)\tan\beta.
\end{aligned}
\qquad (10)
$$

$\delta Z_{H_i}^{\overline{\mathrm{DR}}}$ define the wave function renormalization costant of the Higgs field H_i, the third and fourth line fix the tadpole renormalization and the last one the $\tan\beta$ renormalization constant. $[\mathcal{A}]_{\mathrm{div}}$ means keeping the UV divergent part of $\mathcal{A}$, discarding the finite contribution. In the DCPR scheme [15, 16] the independent parameters are the same, and the renormalization conditions of the Higgs wavefunctions change as follows

$$
\begin{aligned}
\delta Z_{H_1}^{\mathrm{DCPR}} &= -\mathrm{Re}\frac{\partial\Sigma_{A^0}(k^2)}{\partial k^2}|_{k^2=M^2_{A^0}} - \frac{1}{\tan\beta M_Z}\mathrm{Re}\Sigma_{A^0Z}(M^2_{A^0}) \\
\delta Z_{H_2}^{\mathrm{DCPR}} &= -\mathrm{Re}\frac{\partial\Sigma_{A^0}(k^2)}{\partial k^2}|_{k^2=M^2_{A^0}} + \frac{\tan\beta}{M_Z}\mathrm{Re}\Sigma_{A^0Z}(M^2_{A^0}) \\
\delta T_{h^0} &= -T_{h^0} \\
\delta T_{H^0} &= -T_{H^0} \\
\delta M^2_{A^0} &= \mathrm{Re}\Sigma_{A^0}(M^2_{A^0}) - M^2_{A^0}\Sigma'_{A^0}(M^2_{A^0}) \\
\delta\tan\beta^{\mathrm{DCPR}} &= \frac{1}{2}\left(\delta Z_{H_2}^{\mathrm{DCPR}} - \delta Z_{H_1}^{\mathrm{DCPR}}\right)\tan\beta
\end{aligned}
\qquad (11)
$$

We choose to impose on-shell (OS) condition for the mass of CP-odd A^0 Higgs in both schemes.

The renormalization constants of the Higgs bosons wavefunctions and of the $c^\eta(bb\mathcal{H}^0)$ couplings can be written in terms of the of the renormalization constants defined above.

A few illustrative Figures.

In the bh process we have (also) determined the EW K factor, defined as the ratio of the computed one-loop (BORN +SUSY QCD + MSSM EW) rate to the (BORN +SUSY QCD) one. We have considered a “SPP2” scenario with fixed MA=250 GEV and input parameters shown in next Table. The sparticle masses and mixing angles have been obtained with the code FeynHiggs. The results for Ao,Ho,ho production are shown in the next Figure.

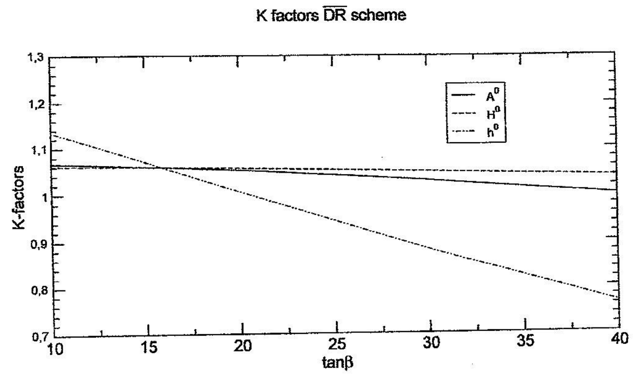


FIG. 14: K-factors for A^0, H^0 and h^0 production, $\overline{\text{DR}}$ scheme. $M_{A^0} = 250$ GeV, $p_{b,T} > 20$ GeV, $|y_b| < 2$.

Scenario	$\tan\beta$	M_{A^0}	$M_{\tilde{q},1}$	$M_{\tilde{q},2}$	$M_{\tilde{q},3}$	M_1	M_2	$M_{\tilde{g}}$
SPP_1	15	350	350	350	250	90	150	800
SPP_2	variable	250	500	500	400	90	200	800

TABLE I: Inputs parameters for the SUSY scenarios considered in our numerical discussion. $M_{\tilde{q},j}$ is the common value of the breaking parameters in the sector of the squarks belonging to the j^{th} generation. The dimensionful parameters are given in GeV.

What about tH?

We have computed the purely EW (no SUSY QCD) MSSM K factor in two mSugra scenarios +SUSPECT (tables).

The EW effect is modest for tanbeta =10. For tanbeta = 50,
it reaches a relative 20 percent size (to be compared with possible 30-40 percent effects for Berger et al.)

Again, it appears that MSSM EW NLO effects can be relevant and should be fully computed.

As one sees from the Figure, the NLO MSSM EW effect is indeed “modest” (a few percent) for Ao and Ho. But for ho it becomes large and negative (a relative 20 percent) when tanbeta approaches 40, and is of opposite sign (a relative 10 percent) and apparently increasing when tanbeta approaches 10 (smaller tanbeta values are being computed…).

Certainly, for bh0 production the NLO MSSM EW effect should not be “assumed” to be negligible.

mSUGRA scenario	m_0	$m_{1/2}$	A_0	$\tan\beta$	sign μ	H^-	$\alpha_s(Q)$
LS2	300	150	-500	50	+	229.6	0.0965325
SPS1a	100	250	-100	10	+	412.1	0.0922963

Table II: input parameters for the mSUGRA benchmark points and mass of the charged Higgs H^- (all values with mass dimension are in GeV)

mSUGRA scenario	σ_{Born}	SUSY		2HDM	
		σ_{1-loop}	K-factor	σ_{1-loop}	K-factor
LS2	5.589	4.545	0.813	5.867	1.050
SPS1a	0.04207	0.04145	0.985	0.04170	0.991

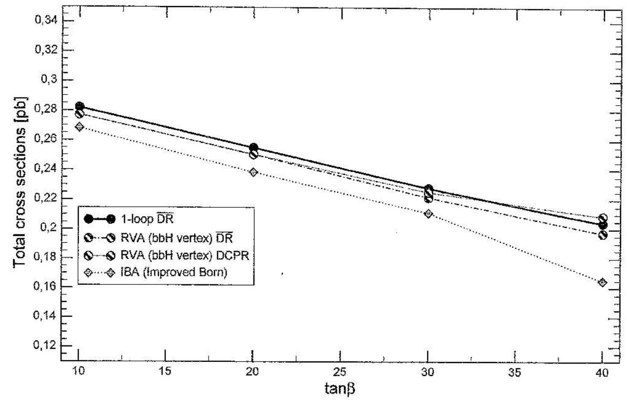
Table III: Total cross sections (in pb) at Born and loop level and K-factors

A reasonable question that arises at this point, having verified the possible relevance of the complete NLO EW MSSM effects, is the following one:

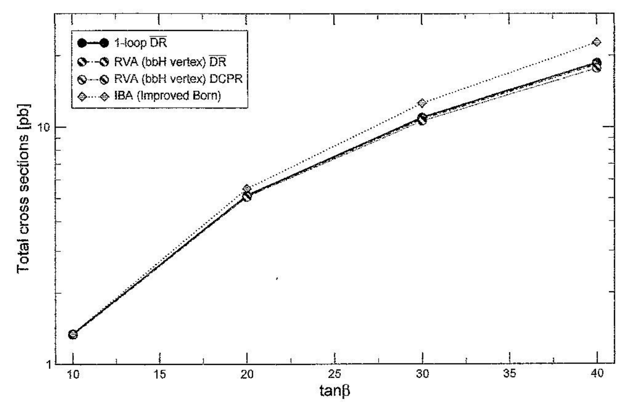
Are the EW effects of “non Deltab type” really important? In other words, could one use the (much simpler) “Improved Born Approximation” with only resummed SUSY QCD and (all) EW Deltab terms, like in the Dittmaier et al. b-fusion paper, where these contributions seem to be by far the leading ones?

To find an answer to this question, we have compared our full one-loop calculation with the mentioned IBA, keeping in both terms the full resummed SUSY QCD Deltab term and allowing as in the previous example tanbeta to vary in the SPP2 scenario with MA= 250 GEV. The results are shown in the following Figures.

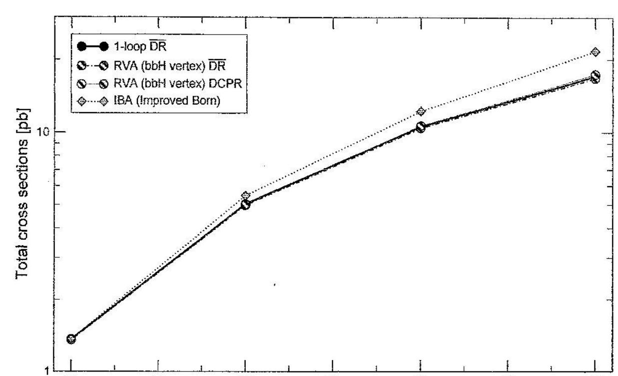
h_0 production, total cross sections, NLO $\overline{DR}$ and approximations



H_0 production, total cross sections, NLO $\overline{DR}$ and approximations



A_0 production, total cross sections, NLO $\overline{DR}$ and approximations



As one sees from the Figure, there is a rather strong difference between the complete one-loop calculation and the IBA, that reaches a relative 25 percent size for large tanbeta.

In the same Figures, one sees the result of a different “Reduced Vertex Approximation”, RVA, that sums at one loop effects of a larger number of bottom vertices and reproduces much better the complete calculation.

So for bh IBA seems to be in trouble.

Which special information can be obtained by NLO MSSM effects?

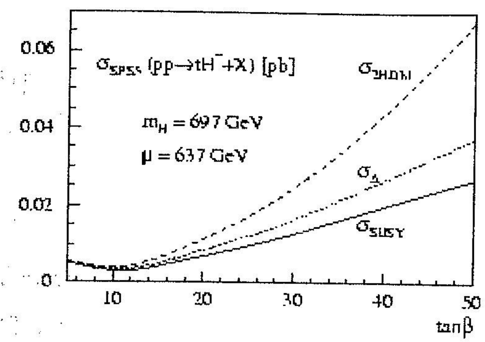
As a first example, we considered the ratio of the MSSM and 2HDM rates at variable tanbeta (with another parameter e.g. MAo kept fixed).

This ratio should be SM QCD independent, and would therefore provide the size of the “Genuine” SUSY content (including SUSY QCD) of the MSSM with reasonable accuracy.

This ratio has already been computed for tH by Berger et al. in a certain scenario and has provided a Figure containing only a part of the MSSM EW NLO with the SUSY QCD Deltab term. (see next page).

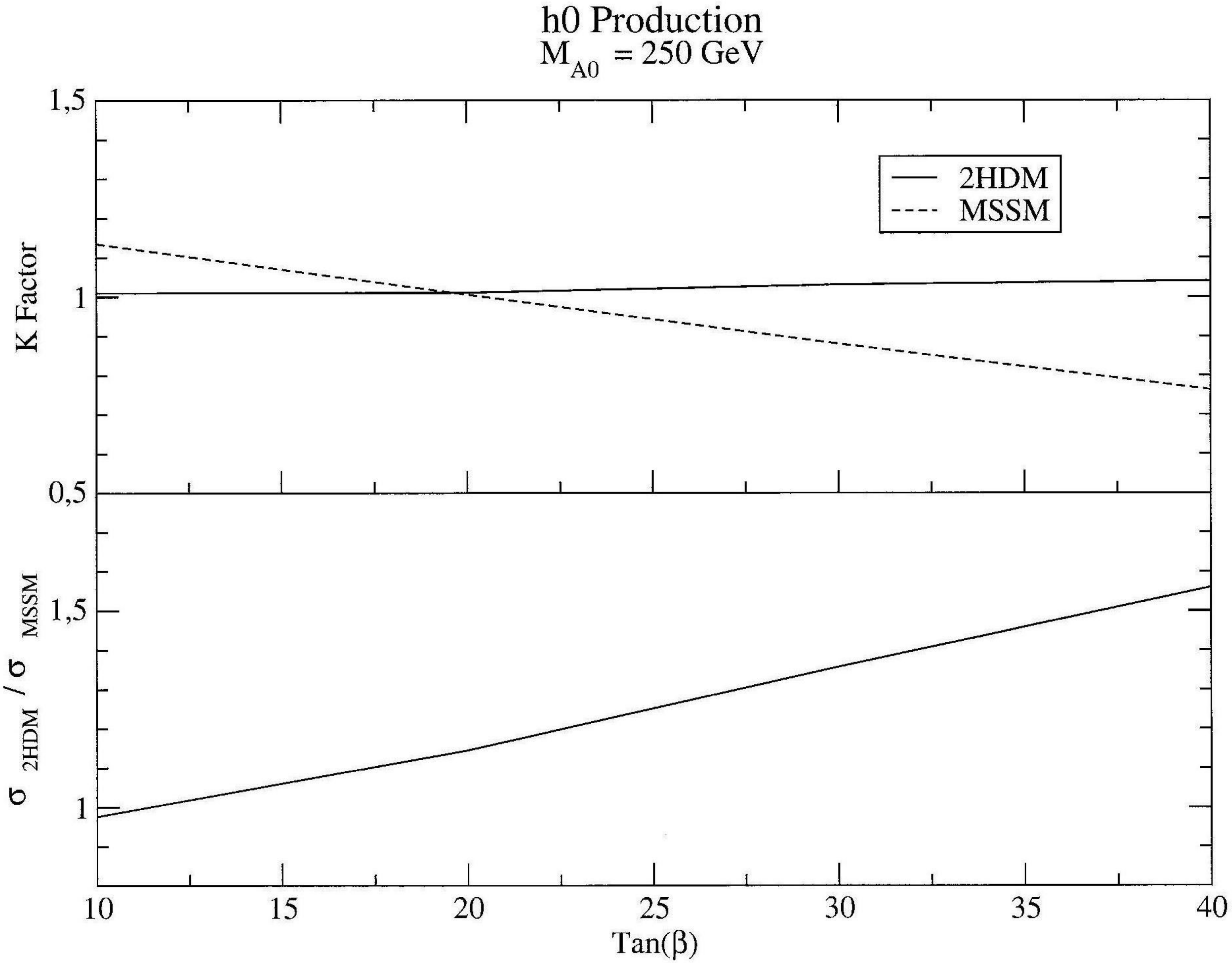
As one sees, the 2HDM rate is much larger for large tanbeta (almost a factor 2 for tanbeta =40) but coincides with the MSSM when tanbeta becomes smaller.

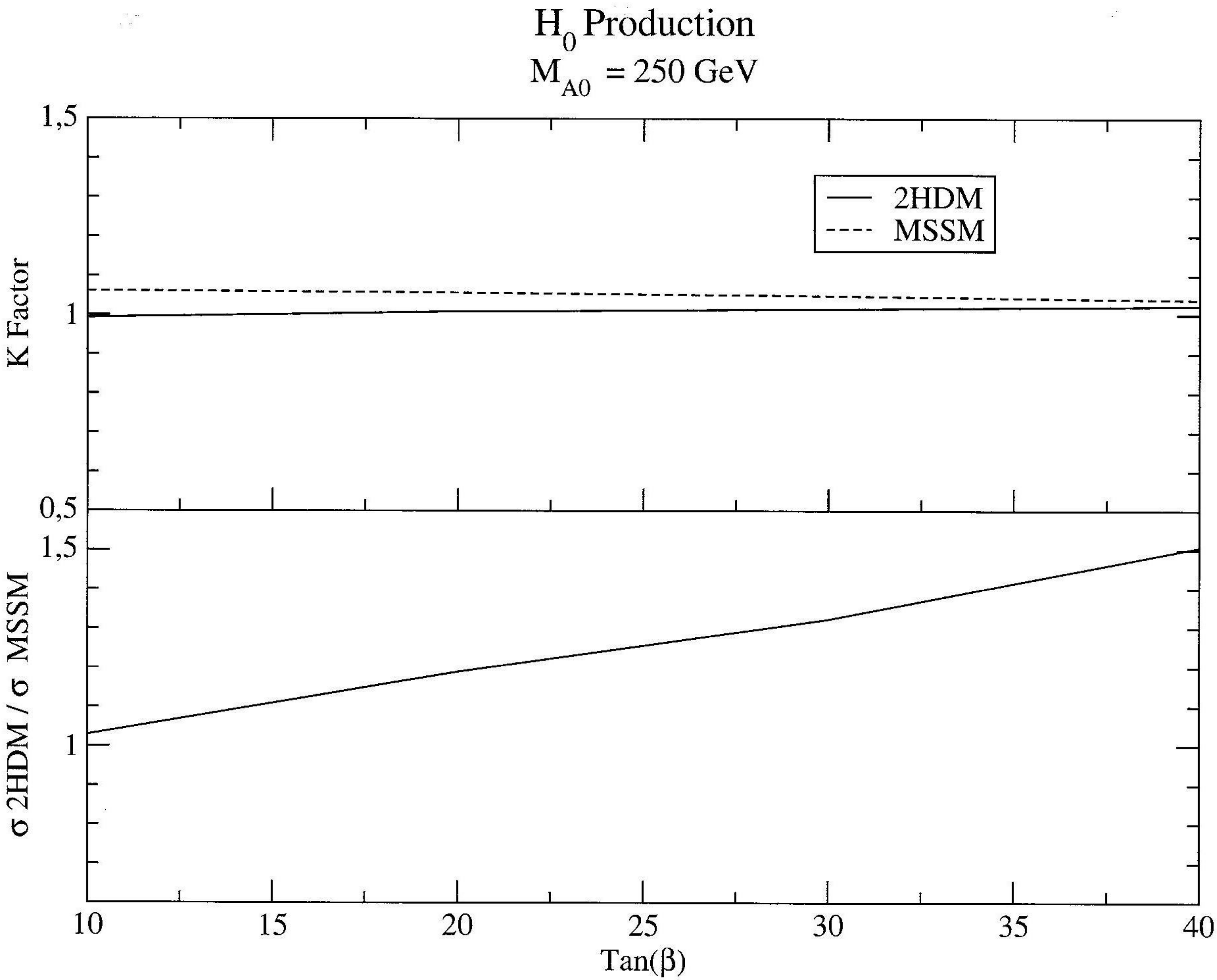
This is what one would expect from the presence of the Deltab term.



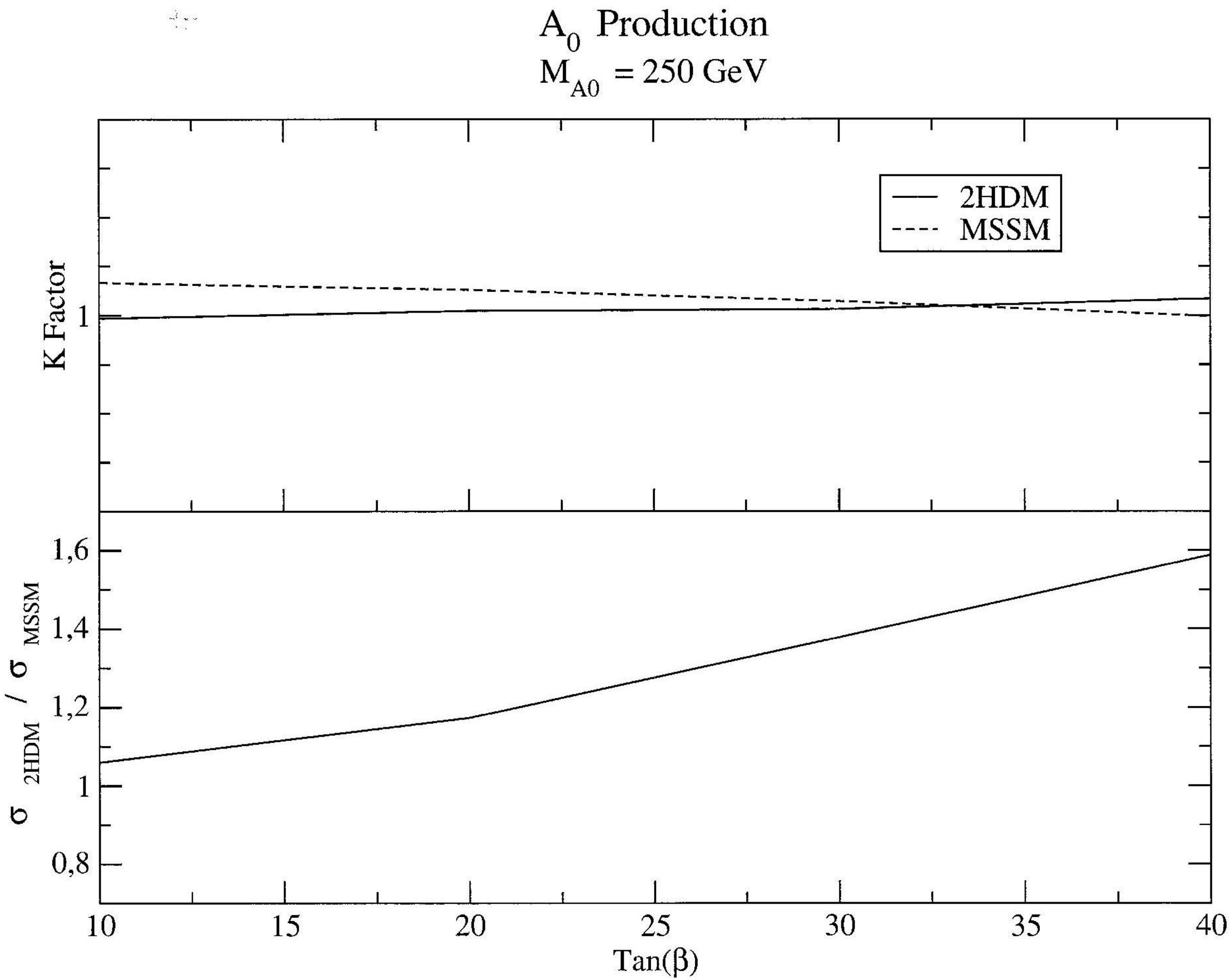
σ_{SPS5} (pp→tH⁻+X) [pb]
m_H = 697 GeV
μ = 637 GeV
σ_{2HDM}
σ_A
σ_{SUSY}
0.06
0.04
0.02
0
10
20
30
40
50
tanβ

We have performed the same comparison for bh, again allowing tanbeta to vary for fixed MA at different values. Only the MA=250 Figures are shown.


h0 Production
M_{A0} = 250 GeV
2HDM
MSSM
K Factor
1,5
1
0,5
1,5
1
$\sigma_{2HDM} / \sigma_{MSSM}$
10
15
20
25
30
35
40
Tan(β)



H0 Production
MA0 = 250 GeV
K Factor
2HDM
MSSM
σ 2HDM / σ MSSM
Tan(β)
1,5
1
0,5
1,5
1
10
15
20
25
30
35
40



A0 Production
MA0 = 250 GeV
2HDM
MSSM
K Factor
1
1,6
1,4
1,2
1
0,8
σ 2HDM / σ MSSM
10
15
20
25
30
35
40
Tan(β)

As one sees from the Figures, the 2HDM provides a rate whose ratio with the MSSM one follows the identical tanbeta behaviour in all neutral Higgs cases. For large tanbeta the 2HDM rate is definitely larger, moreless like in the Berger plot.

If tanbeta were known, it might be possible to identify the “true” Model.

This leads to the last question of my presentation: could tanbeta be measured?

A problem to identify SUSY parameters is the presence of strong interactions that introduce in the theoretical estimate a “scale” uncertainty that is sometimes as large as the SUSY effect to be measured.

On the other hand, strong interactions increase the value of the rates, which produces more statistics----> they are “useful”.

The situation appears to me somehow similar to the old case of LEP1 Hadron production at the Z resonance.

The idea was to define an observable that was independent of strong interactions (Lynn, C.V., Phys.Rev-D35,3326-1987)

i.e.:

The Longitudinal Polarization Asymmetry (Alr(MZ)).

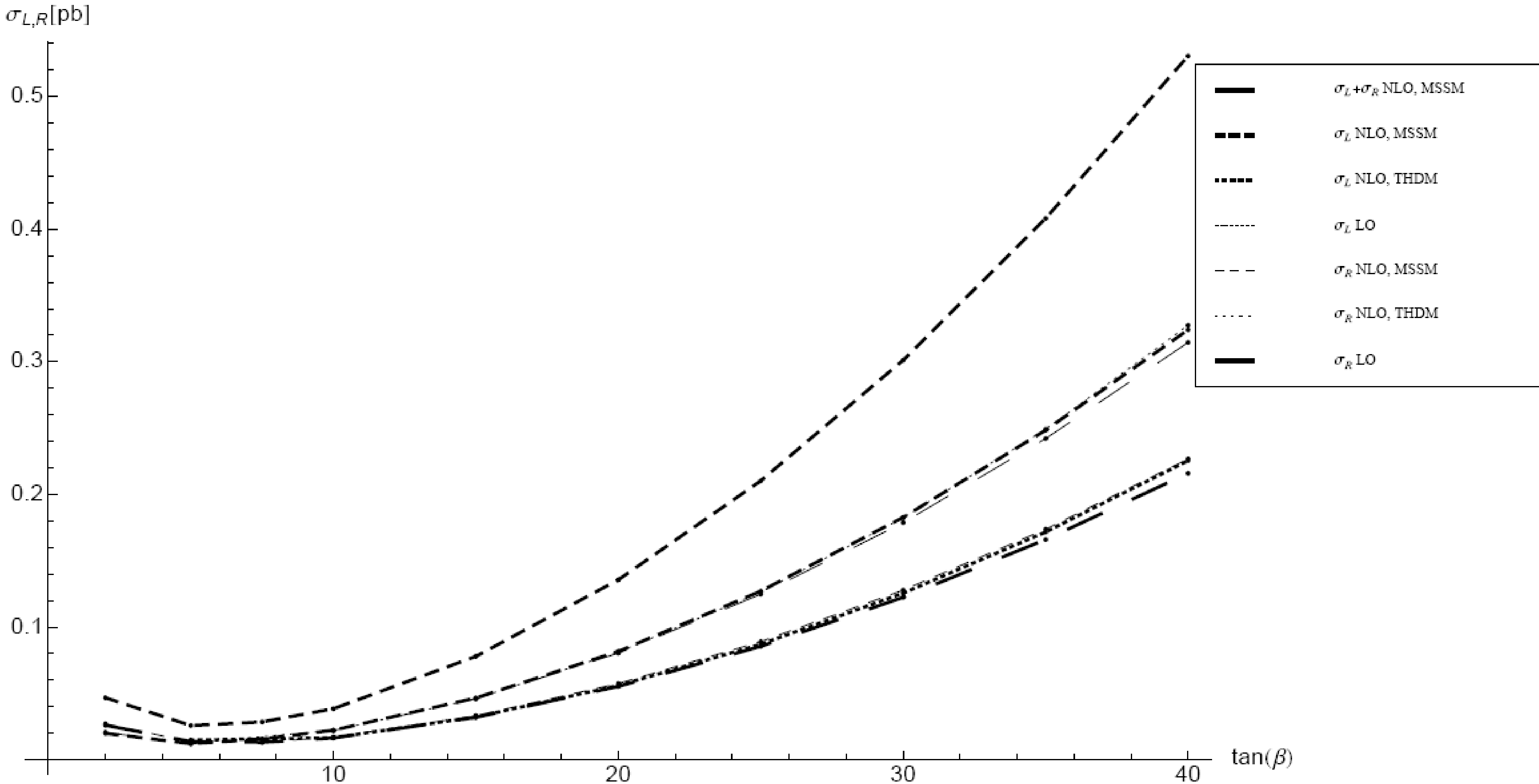
First question: does such an observable exist in one of the considered processes? In principle, Yes for the tH process (rates for tl and tr production are certainly different).

A detailed discussion of possible measurements of top polarization asymmetry from charged slepton production, suggesting the “natural extension” of the work to the process of tH production, has very recently been provided by

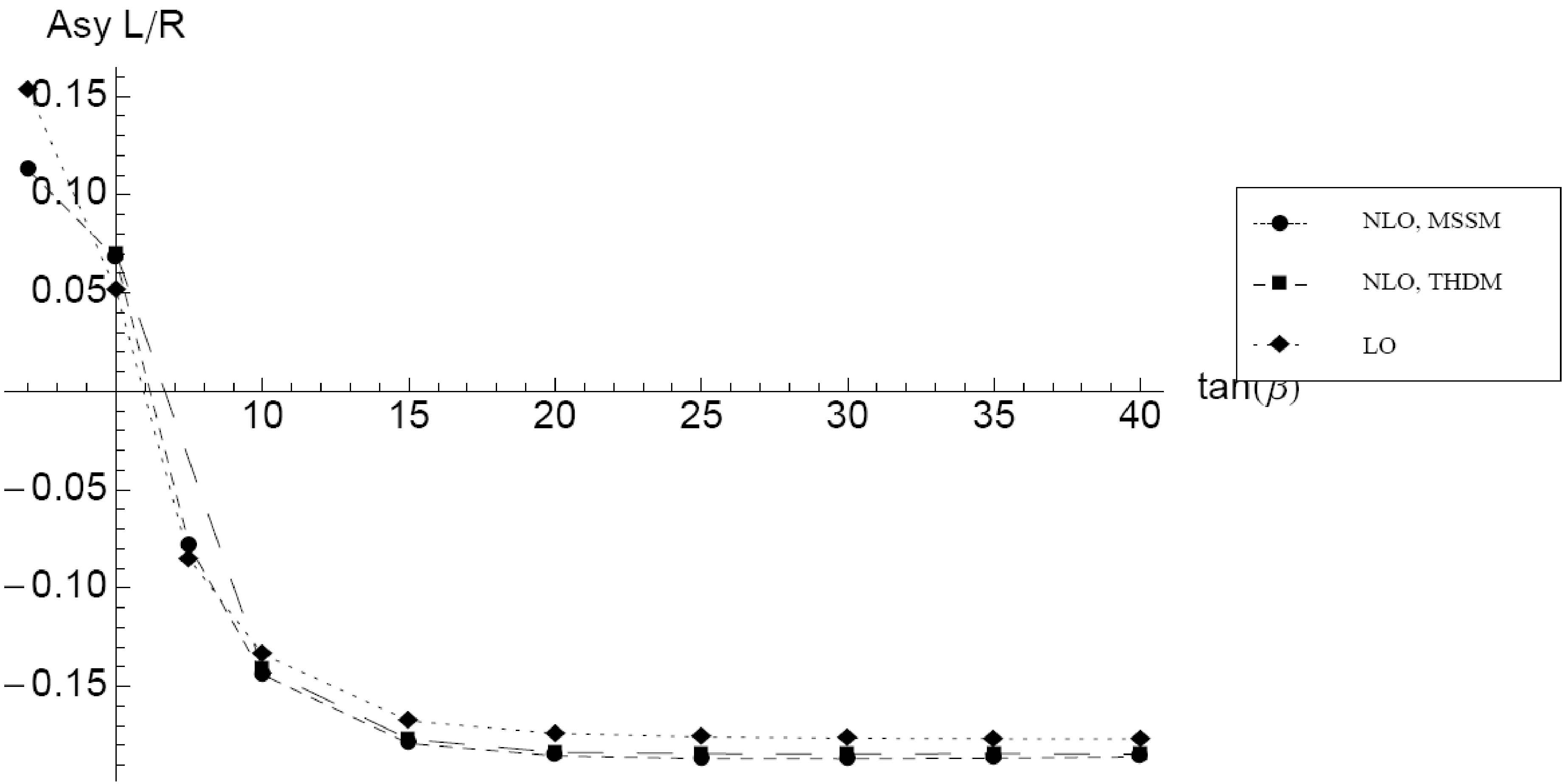
Arai, Huitu, Rai and Rao,
ArXiv: 1003.4708V2, (August 2010).

Could a certain longitudinal polarization asymmetry be SM QCD independent (i.e. SUSY detector)?

Before tackling this problem, we computed the purely EW NLO value of this asymmetry, defined as the ratio of difference and sum of the polarized rates, starting from the previously defined tH benchmark point(SPS1) and allowing tanbeta to vary with SUSPECT .Next (preliminary!!) Figures show the tH rates and left-right asymmetry.



$\sigma_{L,R}$[pb]
0.5
0.4
0.3
0.2
0.1
10
20
30
40
tan(β)
$\sigma_L+\sigma_R$ NLO, MSSM
σ_L NLO, MSSM
σ_L NLO, THDM
σ_L LO
σ_R NLO, MSSM
σ_R NLO, THDM
σ_R LO


Asy L/R
0.15
0.10
0.05
−0.05
−0.10
−0.15
10
15
20
25
30
35
40
tan(β)
NLO, MSSM
NLO, THDM
LO

Qualitatively : one sees a potentially relevant feature in the low tanbeta region (2<tanbeta<10) , with a drastic change of sign. But SUSY QCD could be also relevant, and should be computed(Beccaria,Djouadi,Dovier, Macorini,Renard,C.V., in progress).

Our hope: SM QCD might cancel in the ratio (to be checked).
Then Alr might be considered as a possible“ SUSY measurement” in the all tanbeta region, if combined with measurements of all tH and bh rates.

Conclusions.

The role of the NLO MSSM SUSY corrections appears to be relevant both at the QCD and at EW level in the production of tH and bh.

It seems appropriate to compute the Deltab QCD effect , correctly resummed, independently of the complete NLO EW contribution: no separation of “priviledged” resummed DeltabEW terms and “poor people” remaining NLO EW ones:

DEMOCRACY MUST WIN!!!

A lot of work on these processes has been done.

A lot of work on these processes has still to be (and is being) done.