Stop hadronisation in SUSYGEN

$$\tilde{t}_1 \longrightarrow c\ \widetilde{\chi}_1^0$$

The stop hadronisation, why ?

- The stop decay $\tilde{t}_1 \longrightarrow c\ \widetilde{\chi}_1^0$
- The decay width

Hard gluon emission :

- Introduction at the matrix element level

Non-pertubative hadronisation:

- Peterson function
- Fragmentation step at the matrix element level

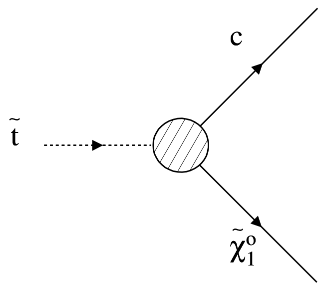
FORTRAN code :

- $\Longrightarrow$ http://home.cern.ch/~verdier/

Why this decay channel ?

- The decay : $\tilde{\mathrm{t}}_1 \rightarrow \mathrm{t}\widetilde{\chi}^0_1$ is not allowed at LEP2.
- The decay : $\tilde{\mathrm{t}}_1 \rightarrow \mathrm{b}l\widetilde{\nu}$ is disfavored in view of existing limits on the chargino masses.

The decay $\tilde{\mathrm{t}}_1 \rightarrow \mathrm{c}\widetilde{\chi}^0_1$ happens through radiative corrections :



$$\Gamma(\tilde{t}_1 \rightarrow c\widetilde{\chi}^0_1) = \frac{\alpha_{em}}{4}|\epsilon|^2|F|^2 m^2_{\tilde{t}_1}\left(1 - \frac{m^2_{\widetilde{\chi}^0_1}}{m^2_{\tilde{t}_1}}\right)$$

with $\epsilon \sim 10^{-4}$, $\tau_{\tilde{t}_1} \gg \tau_{QCD}$

$\Longrightarrow$ The stop hadronises before its decay.

Hard-gluon emission

Diagrams :

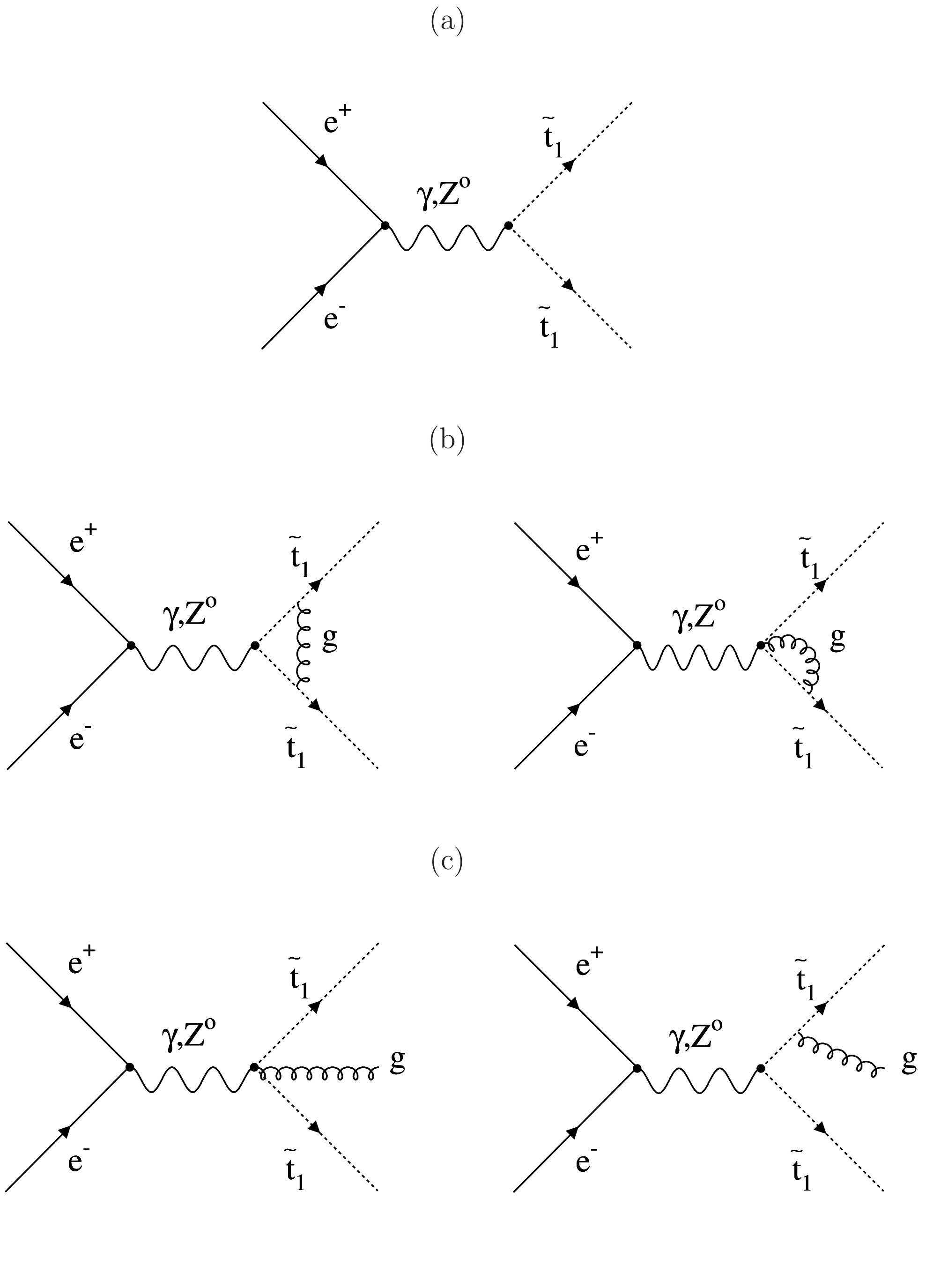


Figure 1: (a) Born level (b) virtual QCD corrections (c) gluon radiation.

Hard-gluon emission

It is important to separate the final states : $\tilde{t}_1\tilde{t}_1$ and $\tilde{t}_1\tilde{t}_1g$:

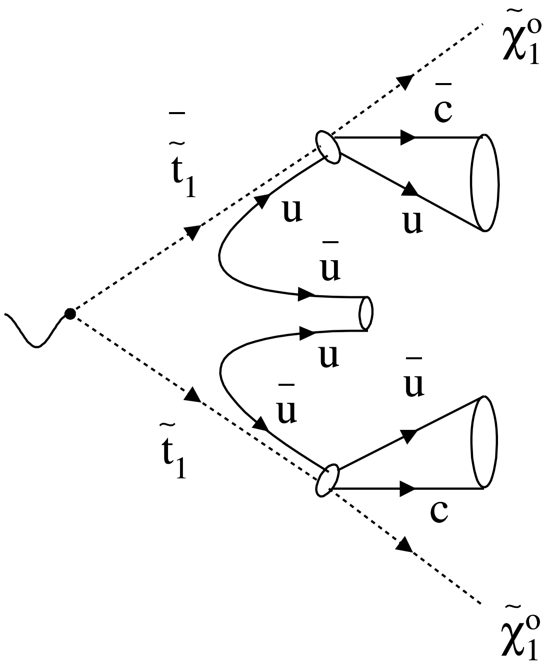
- I introduce a cut-off : E_g^{min} on the minimum gluon energy
- Virtual and soft-QCD correction are included in the $\tilde{t}_1\tilde{t}_1$ process
- 2 cross-sections are computed : $\sigma(\tilde{t}_1\tilde{t}_1)$ et $\sigma(\tilde{t}_1\tilde{t}_1g)$
- Monte-Carlo events are generated w.r.t. these cross-sections

$\Longrightarrow$ hep-ph/9902391 - M. Drees, O. eboli

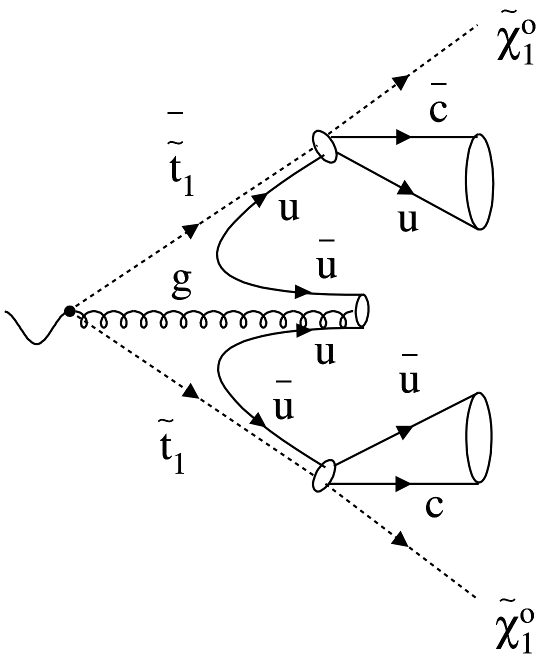
Non-pertubative hadronisation

Hadronisation scheme :

(a)



(b)



Peterson function :

They are introduced at the matrix element level :

$$D_{\tilde{t}}(x,\epsilon) = \frac{1}{N}\frac{1}{x(1-\frac{1}{x}-\frac{\epsilon_{\tilde{t}}}{1-x})^2} \; , with \;\; \epsilon_{\tilde{t}} = \frac{\epsilon}{m^2_{\tilde{t}_1}}$$

is the energy fraction taken by the stop-meson. It is possible to tune the value of the ϵ parameter by extrapolating the ϵ_b value :

$$\epsilon_b \, m^2_b \;\; = \epsilon_{\tilde{t}} \, m^2_{\tilde{t}}$$

Fragmentation :

It is impossible to "decay" the $\tilde{\mathrm{t}}_1$ ($M_{\tilde{t}^0_1}$) into a stop-meson ($M_{\tilde{t}_M} > M_{\tilde{t}^0_1}$) : I generate off-shell stop masses (x is still the Peterson function parameter)

$$m^2(x) = m^2_{\tilde{t}_1} + 2E^2_{\tilde{t}_1}(1-x)\left(1 - \sqrt{1 - \frac{m^2_{\tilde{t}_1}}{E^2_{\tilde{t}_1}}}\right)$$

Non-pertubative hadronisation

Then, the $\tilde{t}_1$ can be fragmented into a stop-meson + a fragmented jet (colinear kinematic).

I generate a gaussian distribution to give a mass $M_{\tilde{t}_M}$ to the stop-meson ($P_f \sim 0.35$ GeV) :

$$\phi(p) = \frac{2}{\sqrt{\pi}\, P_f} \exp\left(-p^2/P_f^2\right)$$

$$m_{\tilde{t}_M} = m_{\tilde{t}_1} \sqrt{1 + \frac{p^2}{m_{\tilde{t}_1}^2}} + p$$

The kinematic is then fixed by the 3 masses : $M_{\tilde{t}_M}$, $M_{\tilde{t}_1^0}$ and the mass of the fragmentation jet = 0.

Stop-meson decay :

It is done in 2 steps :

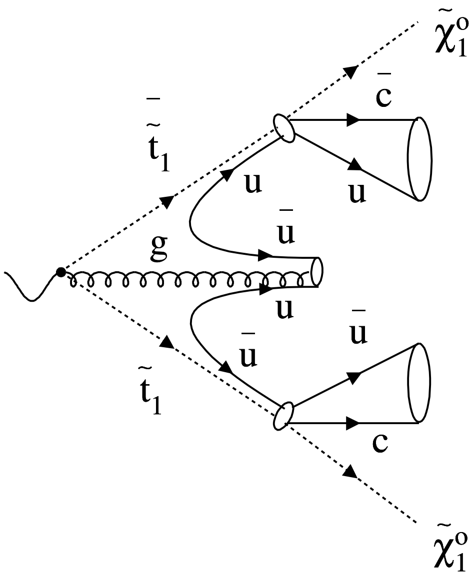
- stop-meson decay into $\tilde{t}_1$ ($M_{\tilde{t}_1^0}$) + a spectator quark
- $\tilde{t}_1$ decay into $c\tilde{\chi}_1^0$

JETSET interface :

Final partons forming a color singlet are joined by a string in JETSET :

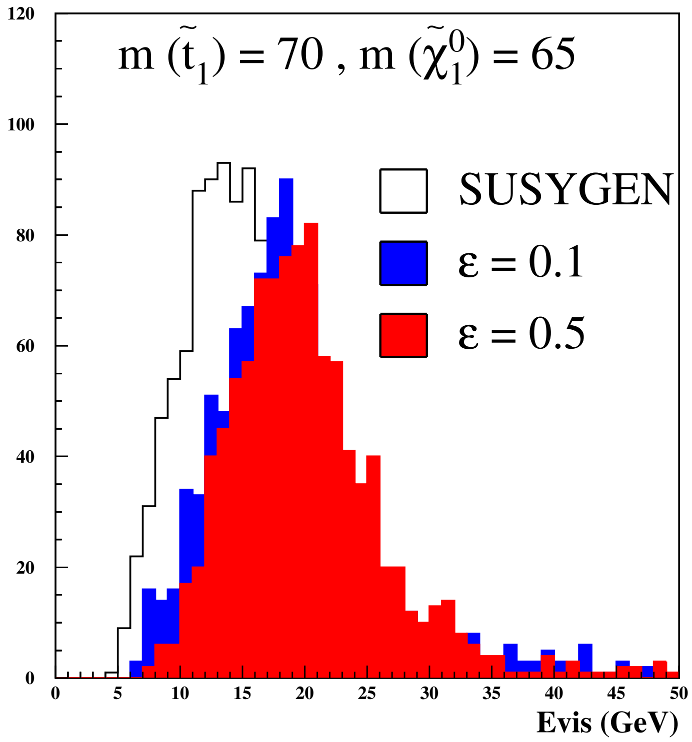
- "c" quark, coming from the stop decay with the corresponding spectator quark
- The 2 fragmentation jets (+ hard gluon)

All spectator quarks and fragmentation jets are treated as "up" quarks.

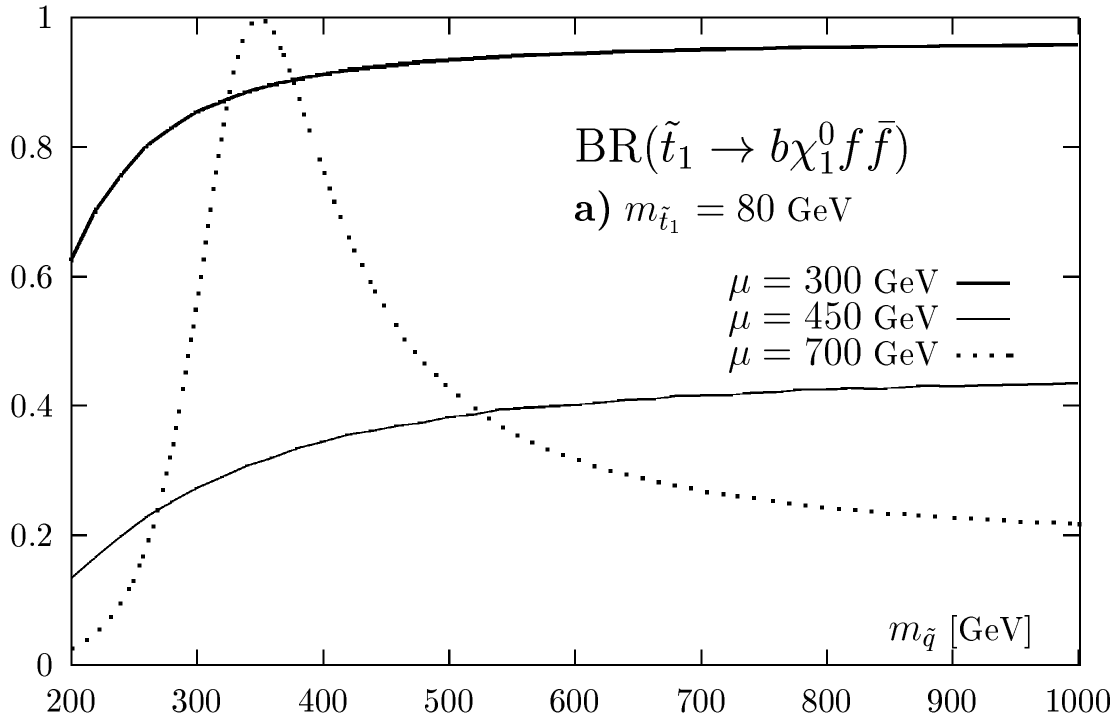


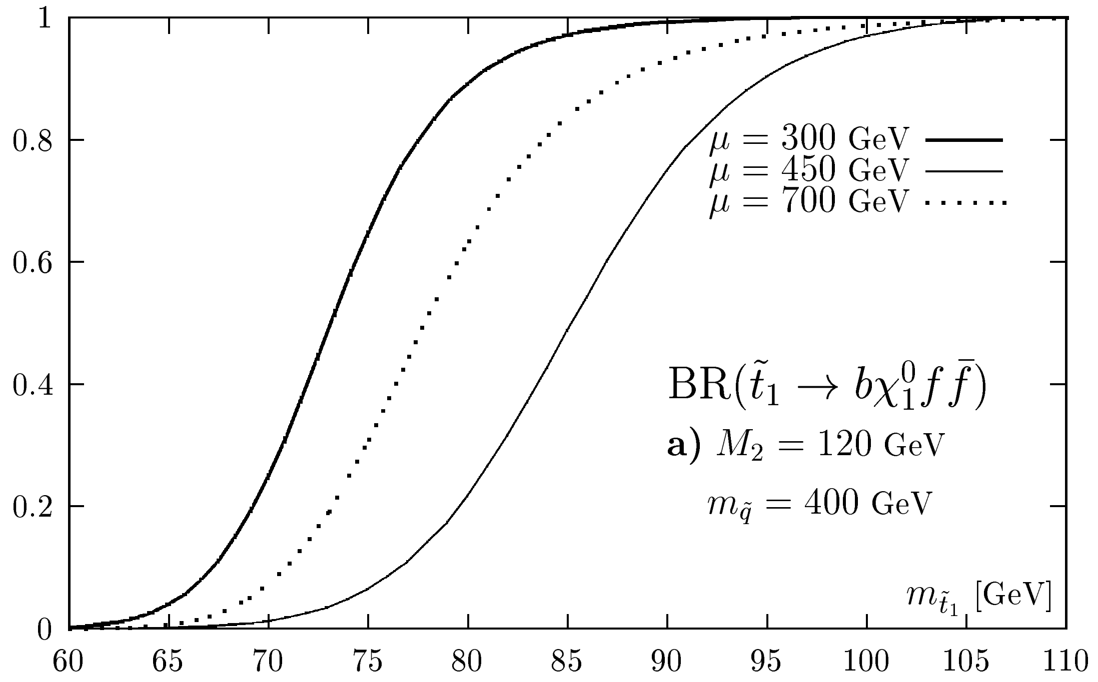
Conclusion :

- ISR are also included
- A very preliminary version is available
- I would like to compare it with OPAL and ALEPH generator
- It will be in SUSYGEN as soon as possible
- Systematic studies :



$\Longrightarrow$ **http://www.home.cern.ch/ verdier/**


BR($\tilde{t}_1 \to b\chi_1^0 f \bar{f}$)
a) $m_{\tilde{t}_1} = 80$ GeV
$\mu = 300$ GeV
$\mu = 450$ GeV
$\mu = 700$ GeV
$m_{\tilde{q}}$ [GeV]
0
0.2
0.4
0.6
0.8
1
200
300
400
500
600
700
800
900
1000


$\mu = 300$ GeV
$\mu = 450$ GeV
$\mu = 700$ GeV
BR($\tilde{t}_1 \to b\chi_1^0 f \bar{f}$)
a) $M_2 = 120$ GeV
$m_{\tilde{q}} = 400$ GeV
$m_{\tilde{t}_1}$ [GeV]
0
0.2
0.4
0.6
0.8
1
60
65
70
75
80
85
90
95
100
105
110

4 body decay:

$m_{\tilde{t}_1}$	M_2	μ	$m_{\chi_1^0}$	$m_{\chi_1^+}$
80	120	300	50.2	96
		450	53.6	106
		700	55.4	112

- a general MSSM (not mSUGRA) where the squark masses are not unified at the GUT scale.
- If $\tilde{t}_1$ is a pure right squark, moderate values of A_b can supress the decay $\tilde{t}_1 \rightarrow c\widetilde{\chi}_1^0$. A high mass for $\tilde{c}$ reinforces this supression.
- In mSUGRA with special values of $\tan\theta_{\tilde{t}}$:

4 body decay:

$$\epsilon = \frac{\Delta_L c_{\theta_t} - \Delta_R s_{\theta_t}}{m^2_{\tilde{c}_L} - m^2_{\tilde{t}_1}}$$

$$F = \frac{\alpha}{4\pi s^2_W} \log\left(\frac{\Lambda^2_{\mathrm{GUT}}}{M^2_W}\right) \frac{V^*_{tb} V_{cb}\, m^2_b}{2M^2_W \cos^2\beta}$$

$$\begin{aligned} \Delta_L &= F(m^2_{\tilde{c}_L} + m^2_{\tilde{b}_R} + m^2_{H_1} + A^2_b) \\ \Delta_R &= F m_t A_b \end{aligned}$$

$\Longrightarrow$ **It will be implemented in STOPGEN for january**
$\Longrightarrow$ **New analysis :**

- 6 jets + missing energy
- 4 jets + missing energy
- 2 jets + 2 leptons + missing energy (already done in DELPHI ?)
- 2 jets + 4 leptons + missing energy