One-loop Corrections of Sparticles Widths in Light Stop Scenarios

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Outline

1. Motivation
2. SUSY parameters
3. Decay modes of gluino and stop1
4. One-loop corrections
5. Summary

1. Motivation

- **Large Yukawa coupling of top quark**

  ⇨ $M_{\tilde{t}_1} < M_{\tilde{q}(\neq\tilde{t}_1)}$ ⇨ **Light stop scenarios**

- **We assume the 126GeV new particle is the lighter CP-even Higgs (h^0) of the MSSM.**

  ⇨ **Are there possible SUSY parameters for light stop scenarios?**

- **How do we get some information of heavy particles through stop1 $(\tilde{t}_1)$ decay?**

2. SUSY parameters

- **Squark mixing matrix in EW interaction eigenstates for $\tilde{t}_L$, $\tilde{t}_R$**

$$\begin{pmatrix} M_Q^2 + m_t^2 + D_L & m_t X_t \\ m_t X_t & M_R^2 + m_t^2 + D_R \end{pmatrix}$$

$$D_L \equiv (T_{3f} - e_f \sin^2\theta_W) m_Z^2 \cos 2\beta \qquad D_R \equiv e_f \sin^2\theta_W m_Z^2 \cos 2\beta$$

$$m_{h^0}^2 \le m_Z^2 + \frac{3g^2 m_t^4}{8\pi^2 m_W^2}\left[\ln\left(\frac{M_S^2}{m_t^2}\right) + x_t^2\left(1 - \frac{x_t^2}{12}\right)\right]$$

at one-loop level

$$M_S^2 \equiv \tfrac{1}{2}(M_{\tilde{t}_1}^2 + M_{\tilde{t}_2}^2), \qquad x_t \equiv X_t / M_S$$

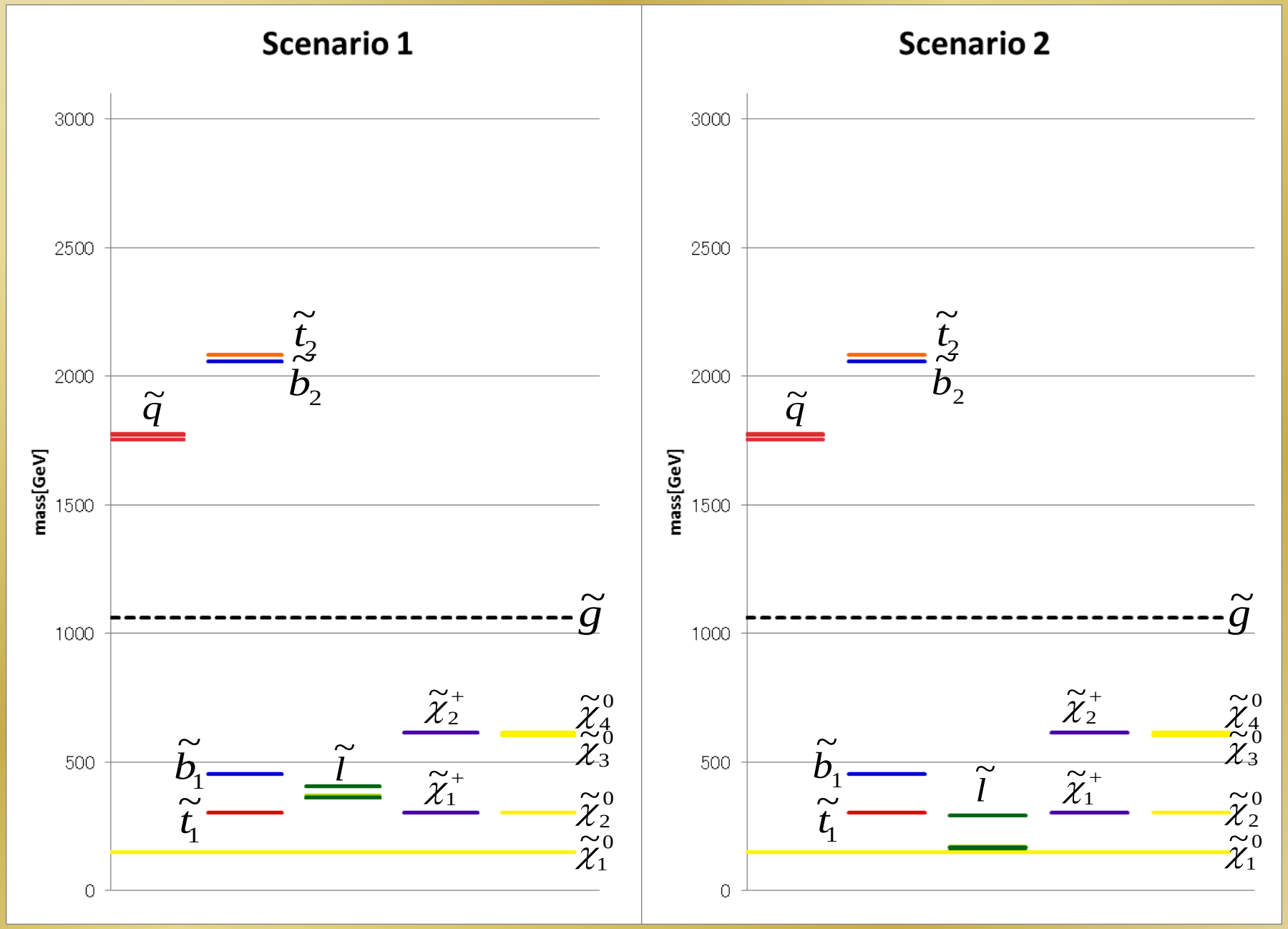
m_{h^0} reaches its maximum when $x_t = \sqrt{6}$

• Light stop scenarios:

Using hdecay for $m_{h^0} = 126\,\mathrm{GeV}$

Scenario 1 (heavy sleptons)			
$\tan\beta$	30	$m_{\tilde{t}_1}$	301GeV
μ	600GeV	$m_{\tilde{t}_2}$	2085GeV
M_2	310GeV	$\theta_{\tilde{t}}$	0.45π
$m_{\tilde{e}_1,\tilde{\mu}_1}$	363GeV	$m_{\tilde{b}_1}$	452GeV
$m_{\tilde{e}_2,\tilde{\mu}_2}$	368GeV	$m_{\tilde{b}_2}$	2057GeV
$\theta_{e,\mu}$	0.5π	$\theta_{\tilde{b}}$	0.5π
$m_{\tilde{\tau}_1}$	323GeV	m_A	800GeV
$m_{\tilde{\tau}_2}$	403GeV	$m_{\tilde{g}}$	1061GeV
θ_τ	0.19π	$m_{\tilde{\chi}_1^0}$	147GeV
$m_{\tilde{\nu}_{e,\mu}}$	359GeV	$m_{\tilde{\chi}_1^+}$	302GeV
$m_{\tilde{\nu}_\tau}$	359GeV		

Scenario 2 (light sleptons)			
$\tan\beta$	30	$m_{\tilde{t}_1}$	301GeV
μ	600GeV	$m_{\tilde{t}_2}$	2085GeV
M_2	310GeV	$\theta_{\tilde{t}}$	0.45π
$m_{\tilde{e}_1,\tilde{\mu}_1}$	166GeV	$m_{\tilde{b}_1}$	452GeV
$m_{\tilde{e}_2,\tilde{\mu}_2}$	172GeV	$m_{\tilde{b}_2}$	2057GeV
$\theta_{e,\mu}$	0.5π	$\theta_{\tilde{b}}$	0.5π
$m_{\tilde{\tau}_1}$	149GeV	m_A	800GeV
$m_{\tilde{\tau}_2}$	291GeV	$m_{\tilde{g}}$	1061GeV
θ_τ	0.19π	$m_{\tilde{\chi}_1^0}$	147GeV
$m_{\tilde{\nu}_{e,\mu}}$	152GeV	$m_{\tilde{\chi}_1^+}$	302GeV
$m_{\tilde{\nu}_\tau}$	152GeV		

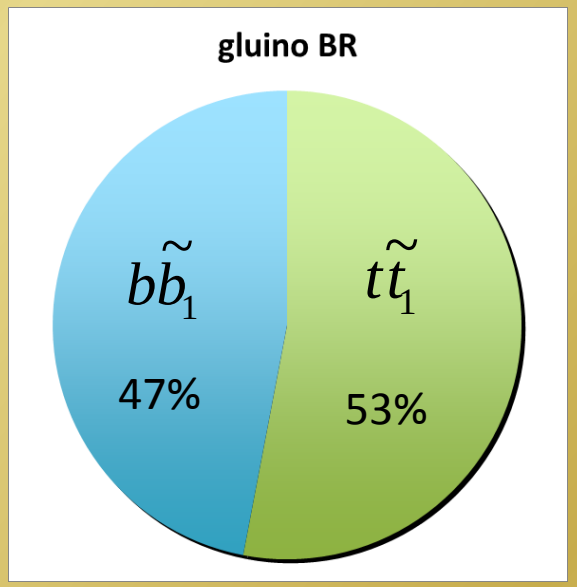

Scenario 1
Scenario 2
mass[GeV]
3000
2500
2000
1500
1000
500
0
$\tilde{q}$
$\tilde{t}_2$
$\tilde{b}_2$
$\tilde{g}$
$\tilde{b}_1$
$\tilde{t}_1$
$\tilde{l}$
$\tilde{\chi}_2^+$
$\tilde{\chi}_1^+$
$\tilde{\chi}_4^0$
$\tilde{\chi}_3^0$
$\tilde{\chi}_2^0$
$\tilde{\chi}_1^0$

3. Decay modes of gluino and stop1

- **gluino decay**

$$\tilde{g} \to t\tilde{t}_1$$

$$\tilde{g} \to b\tilde{b}_1$$



Cascade decays in $t\tilde{t}_1$ mode:

$$\tilde{g} \to t\tilde{t}_1 \to bW^+\bar{b}\tilde{\tau}_1^-\bar{\nu}_\tau \to b\bar{b}\ell^+\tau^-\nu\bar{\nu}\tilde{\chi}_1^0$$

$$bW^+\bar{b}\tilde{\tau}_1^-\bar{\nu}_\tau \to b\bar{b}q\bar{q}'\tau^-\bar{\nu}\tilde{\chi}_1^0$$

$$t\tilde{t}_1 \to bW^+\bar{b}W^-\tilde{\chi}_1^0 \to b\bar{b}\ell^+\ell^-\nu\bar{\nu}\tilde{\chi}_1^0$$

$$bW^+\bar{b}W^-\tilde{\chi}_1^0 \to b\bar{b}q\bar{q}q'\bar{q}'\tilde{\chi}_1^0$$

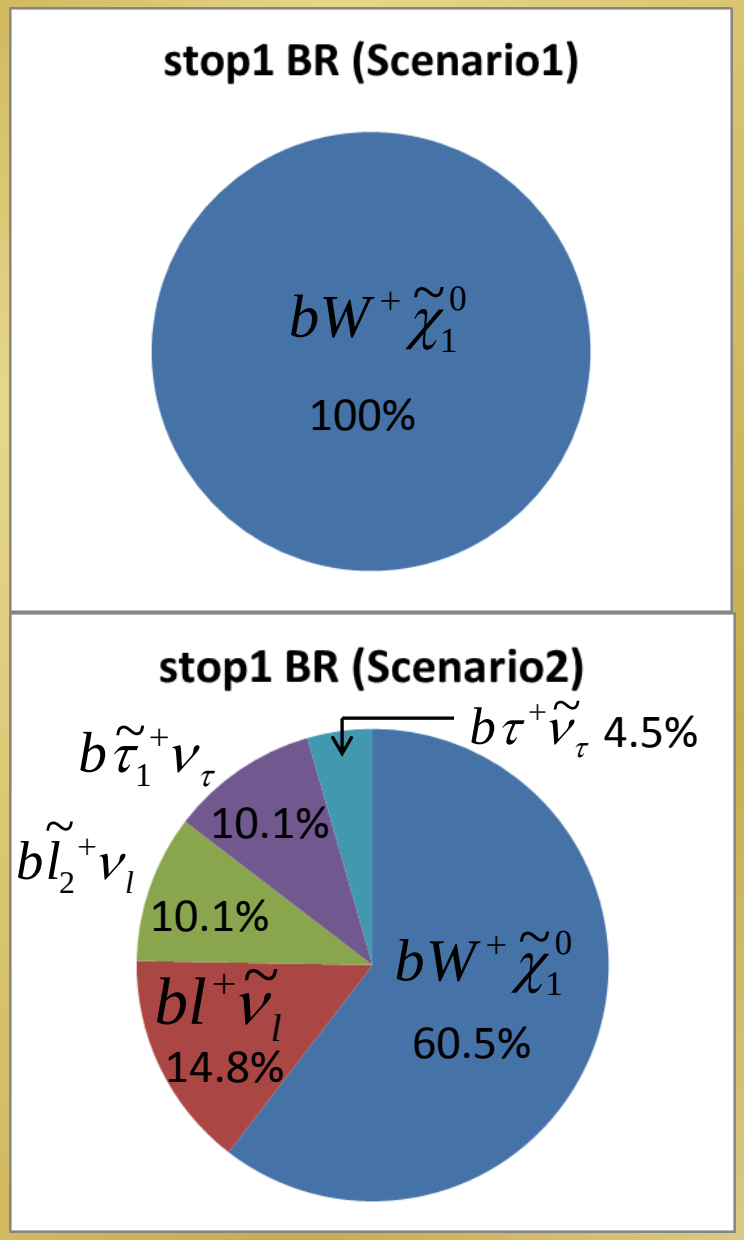
- **stop1 decay**

Scenario1

$$\tilde{t}_1 \to bW^+\tilde{\chi}_1^0$$

Scenario2

$$\tilde{t}_1 \to bW^+\tilde{\chi}_1^0$$
$$\tilde{t}_1 \to bl^+\tilde{\nu}_l \quad (l = e, \mu)$$
$$\tilde{t}_1 \to b\tilde{l}_2^+\nu_l \quad (l = e, \mu)$$
$$\tilde{t}_1 \to b\tilde{\tau}_1^+\nu_\tau$$
$$\tilde{t}_1 \to b\tau^+\tilde{\nu}_\tau$$



4. One-loop corrections

Results using GRACE/SUSY-loop

- **gluino decay widths** (in GeV)

$\tilde{g} \to$	$t\tilde{t}_1$	$b\tilde{b}_1$
Γ_{tree}	24.04	21.30
$\delta\Gamma_{\text{QCD}}$	-8.536	2.003
$\Gamma_{\text{tree}}+\delta\Gamma_{\text{QCD}}$	15.50	23.30

These modes exist only in Scenario2.

- **stop1 decay widths** (in GeV)

$\tilde{t}_1 \to$	$bW^+\tilde{\chi}_1^0$	$be^+\tilde{\nu}_e, b\mu^+\tilde{\nu}_\mu$	$b\tilde{e}_2^+\nu_e, b\tilde{\mu}_2^+\nu_\mu$	$b\tilde{\tau}_1^+\nu_\tau$	$b\tau^+\tilde{\nu}_\tau$
Γ_{tree}	4.354E-04	5.342E-05	3.641E-05	7.305E-05	3.220E-05
$\delta\Gamma_{\text{QCD}}$	2.037E-05	-7.979E-06	-4.037E-06	-1.347E-05	-5.765E-06
$\Gamma_{\text{tree}}+\delta\Gamma_{\text{QCD}}$	4.558E-04	4.544E-05	3.238E-05	5.960E-05	2.643E-05

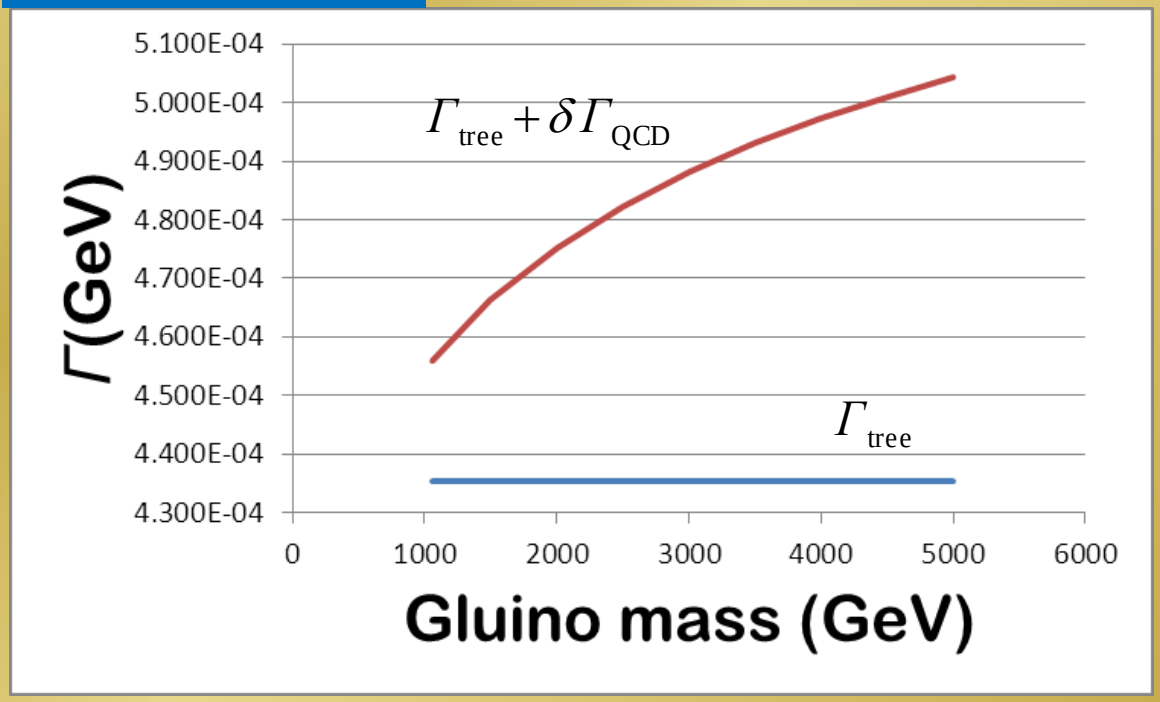
cf. 1-loop correction for other parameters:

K. Iizuka et al., PoS(RADCOR2009)068, (2010).

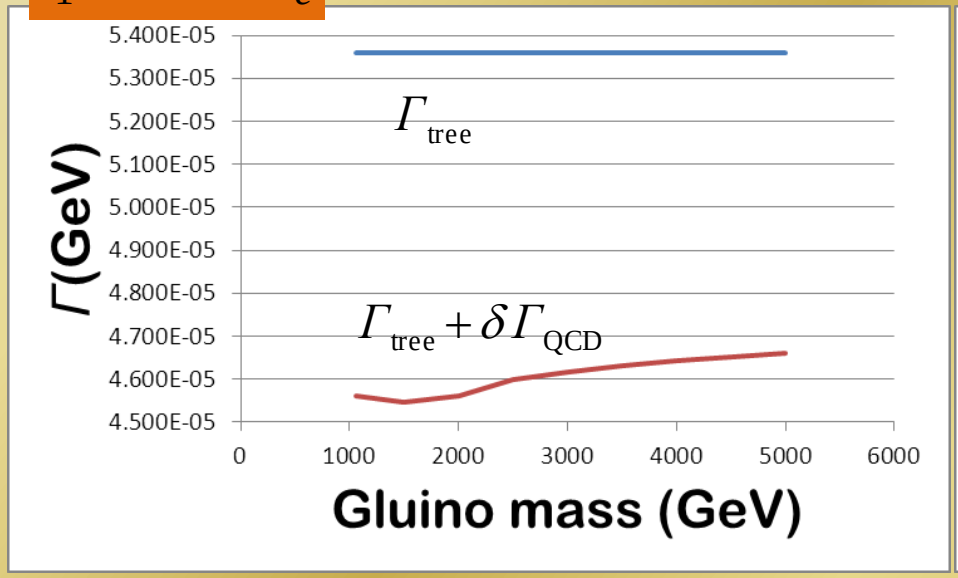
M. Jimbo et al., Talk at LCWS11, arXiv:1202.6295 [hep-ph].

- **Gluino mass dependence in stop1 decay widths**

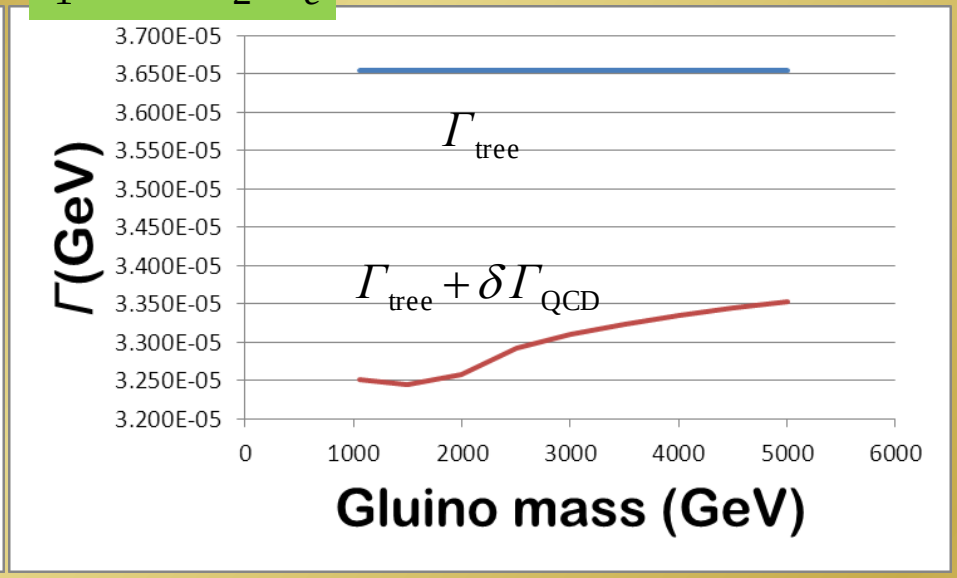
$$\tilde{t}_1 \to bW^+\tilde{\chi}_1^0$$



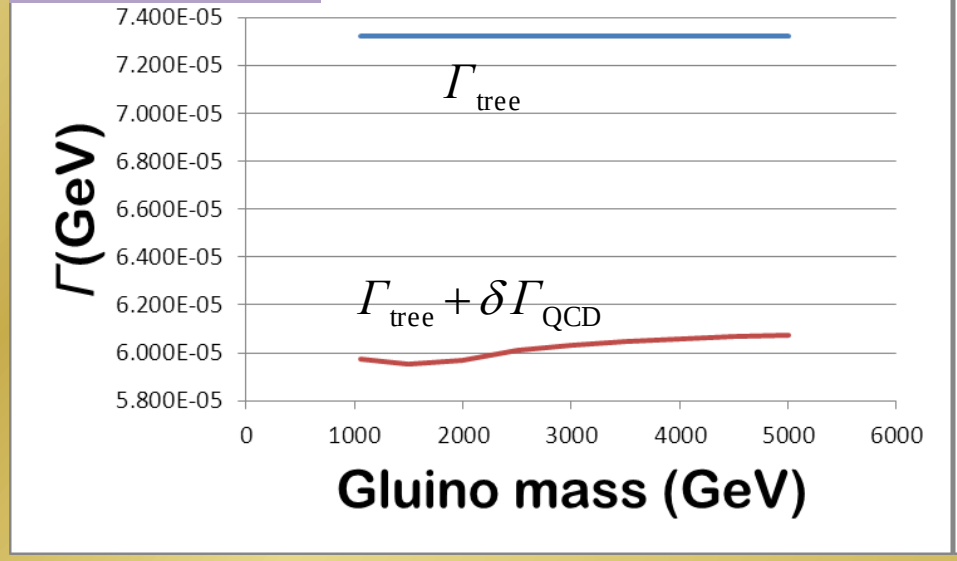
$\tilde{t}_1 \to b e^+ \tilde{\nu}_e$



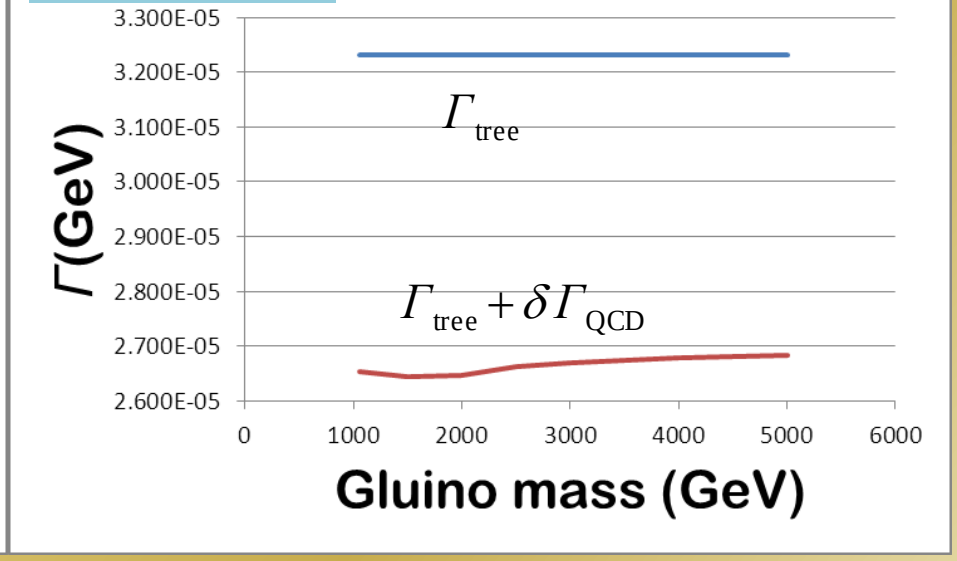
$\tilde{t}_1 \to b \tilde{e}_2^+ \nu_e$



$\tilde{t}_1 \to b \tilde{\tau}_1^+ \nu_\tau$



$\tilde{t}_1 \to b \tau^+ \tilde{\nu}_\tau$



5. Summary

- **We have found possible SUSY parameters for the assumption that the 126GeV new particle is the lighter CP-even Higgs of the MSSM.**
- **For these parameters, the mass of gluino is greater than 1TeV, and the lighter stop decays via three-body modes.**
- **Detailed study in one-loop order is necessary to get indirect information of heavy particles.**