Signatures at One-loop Order of Split Stops Scenarios using GRACE/SUSY

T.Kon, Y.Kouda, K.Kato, T.Ishikawa, Y.Kurihara, M.Jimbo and M.Kuroda

LCWS13
Nov 2013, Tokyo

Outline

- *Introduction*
- *Split stops scenarios*
- *GRACE/SUSY*
- *Results*
- *Summary & Conclusion*

Introduction

- *Discovered Higgs with mass 126GeV*
  : lighter CP even Higgs in MSSM

$$m_h^2 \le m_Z^2 + \frac{3g^2 m_t^4}{8\pi^2 m_W^2}\left[\ln\left(\frac{M_{\tilde{t}}^2}{m_t^2}\right) + x_t^2\left(1-\frac{x_t^2}{12}\right)\right]$$

$$M_{\tilde{t}}^2 = \frac{1}{2}\left(m_{\tilde{t}_1}^2 + m_{\tilde{t}_2}^2\right)$$

$$x_t = X_t / M_{\tilde{t}}$$

$$\begin{pmatrix} M_{\tilde{t}_L}^2 & m_t X_t \\ m_t X_t & M_{\tilde{t}_R}^2 \end{pmatrix}$$

Mass Matrix

$$\left(\tilde{t}_L, \tilde{t}_R\right)$$

Simple split scenario

Scenario 0			
$\tan\beta$	*30*	m_h	*126 GeV*
μ	*400 GeV*		
M_2	*380 GeV*	$x_t/\sqrt{6}$	*0.05*
M_1	*177 GeV*		
$m_{\tilde{\chi}_1^0}$	*174 GeV*	$m_{\tilde{g}}$	*1.5 TeV*
$m_{\tilde{\chi}_1^+}$	*336 GeV*	$m_{\tilde{q}}$	*1.6 TeV*
$m_{\tilde{\ell}}$	*365 GeV*	$m_{\tilde{t}_1}$	*1.5 TeV*
$m_{\tilde{\tau}_1}$	*334 GeV*	$m_{\tilde{t}_2}$	*1.5 TeV*
$m_{\tilde{\tau}_2}$	*394 GeV*	$m_{\tilde{b}_1}$	*1.5 TeV*
m_A	*1.5 TeV*	$m_{\tilde{b}_2}$	*1.5 TeV*

Low Energy / LEP Constraints	
$\Delta\rho$	0.233×10^{-4}
$g_\mu - 2$	0.251×10^{-8}
$Br(b\to s\gamma)$	0.349×10^{-3}
$Br(B_s\to\mu\mu)$	1×10^{-13}

Suspect 2.4

G.Kane et al.
hep-ph/0310042v1

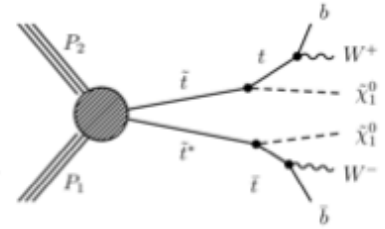
Split stops scenarios

Scenario 1			
$\tan\beta$	30	m_h	126 GeV
μ	400 GeV		
M_2	380 GeV	$x_t/\sqrt{6}$	0.9
M_1	177 GeV		
$m_{\tilde{\chi}_1^0}$	174 GeV	$m_{\tilde{g}}$	1.5 TeV
$m_{\tilde{\chi}_1^+}$	337 GeV	$m_{\tilde{q}}$	1.7 TeV
$m_{\tilde{\ell}}$	365 GeV	$m_{\tilde{t}_1}$	0.33 TeV
$m_{\tilde{\tau}_1}$	336 GeV	$m_{\tilde{t}_2}$	2.1 TeV
$m_{\tilde{\tau}_2}$	393 GeV	$m_{\tilde{b}_1}$	0.8 TeV
m_A	1.5 TeV	$m_{\tilde{b}_2}$	2.1 TeV

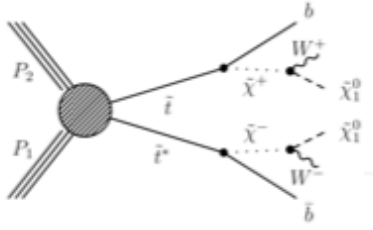
Low Energy / LEP Constraints	
$\Delta\rho$	0.898×10^{-4}
$g_\mu - 2$	0.249×10^{-8}
$Br(b\to s\gamma)$	0.243×10^{-3}
$Br(B_s\to\mu\mu)$	4×10^{-11}

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

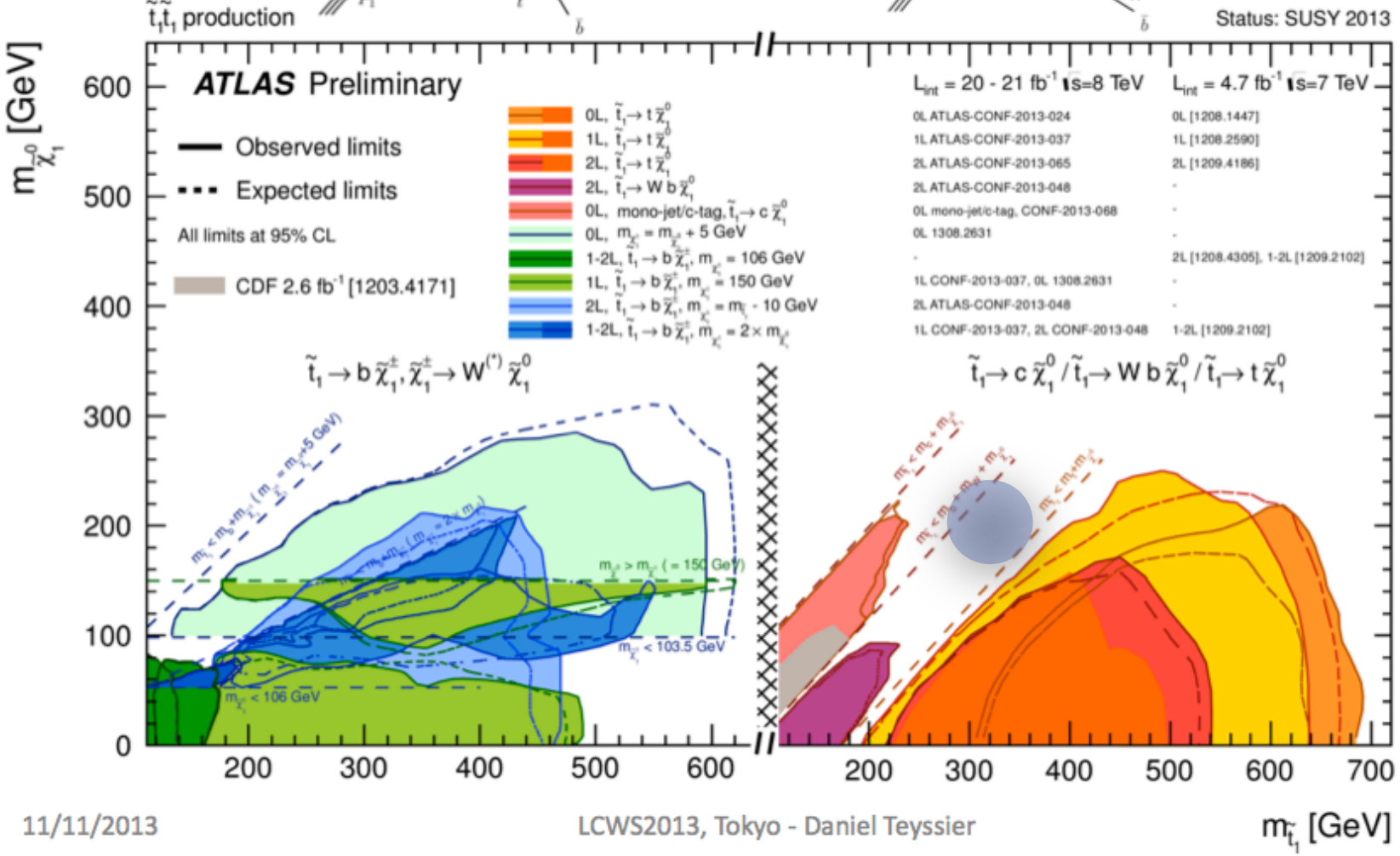
• Simplified Models $\tilde{t}$-$\tilde{t}$ production (Rp conserved):



T2tt



T2bW

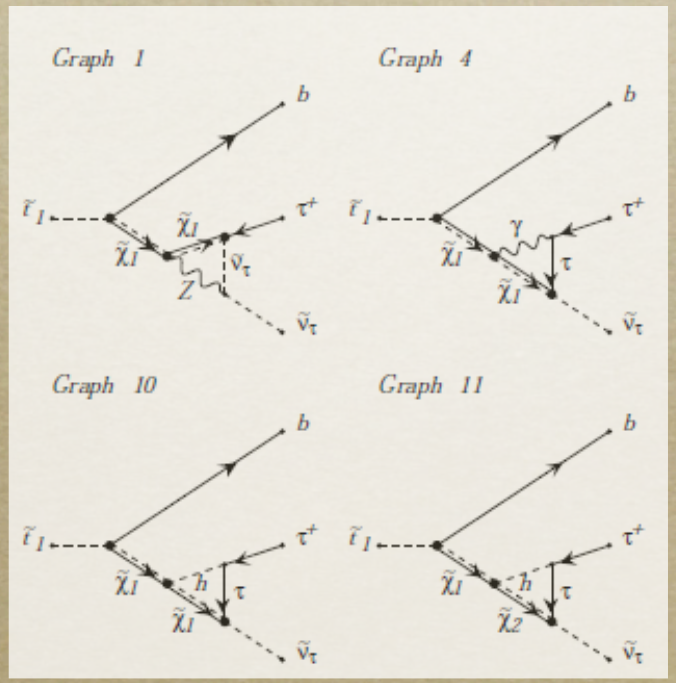


GRACE/SUSY

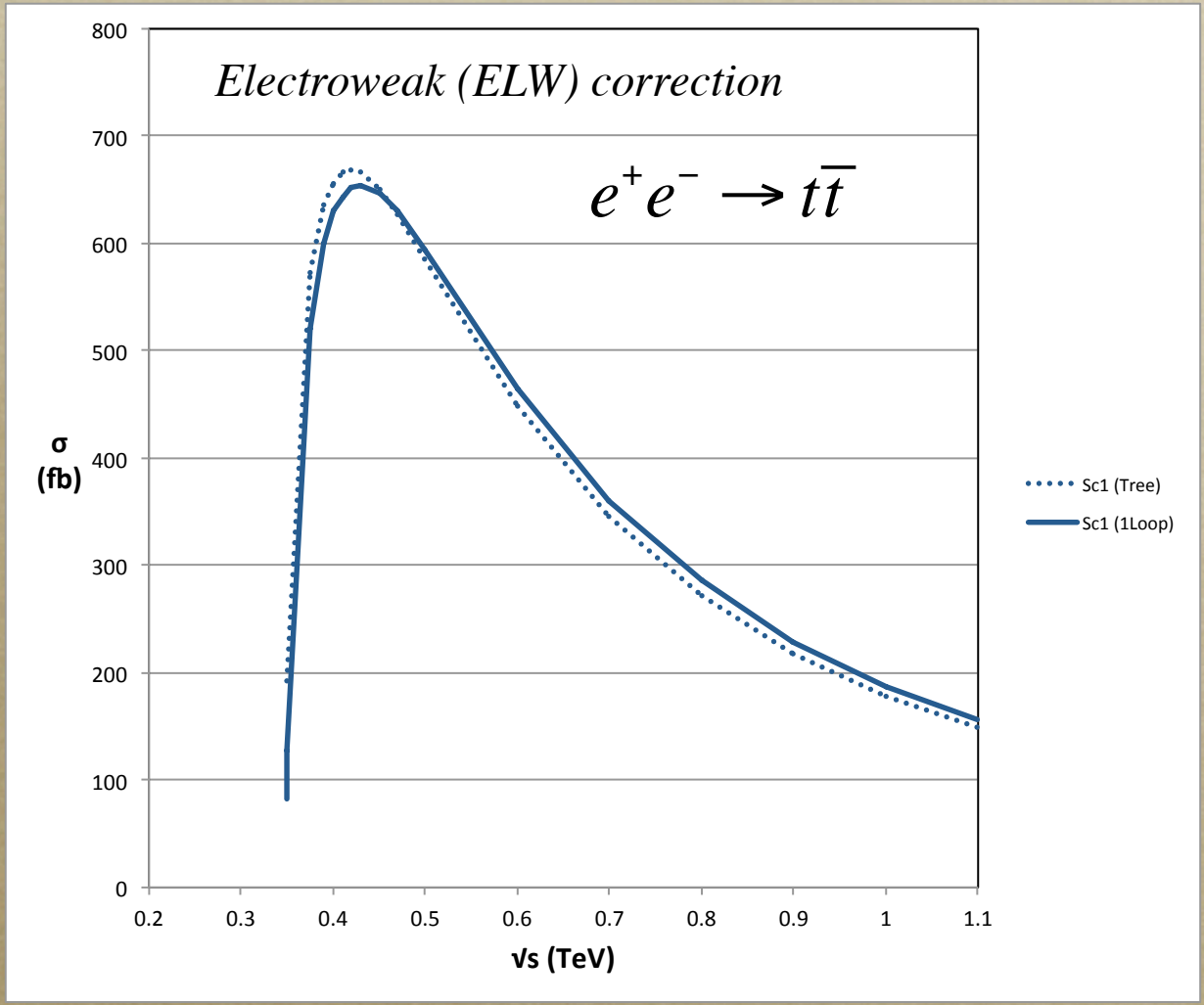
* Tree ver. Ref. **Comput.Phys.Commun.153 : 106, 2003**
download : http://minami-home.kek.jp/

* 1-loop ver. Ref. **Phys.Rev.D75 : 113002, 2007**

1. Feynman diagrams
2. Physical amplitudes
3. Phase space Integration
4. Event generation
5. Various Self-checks

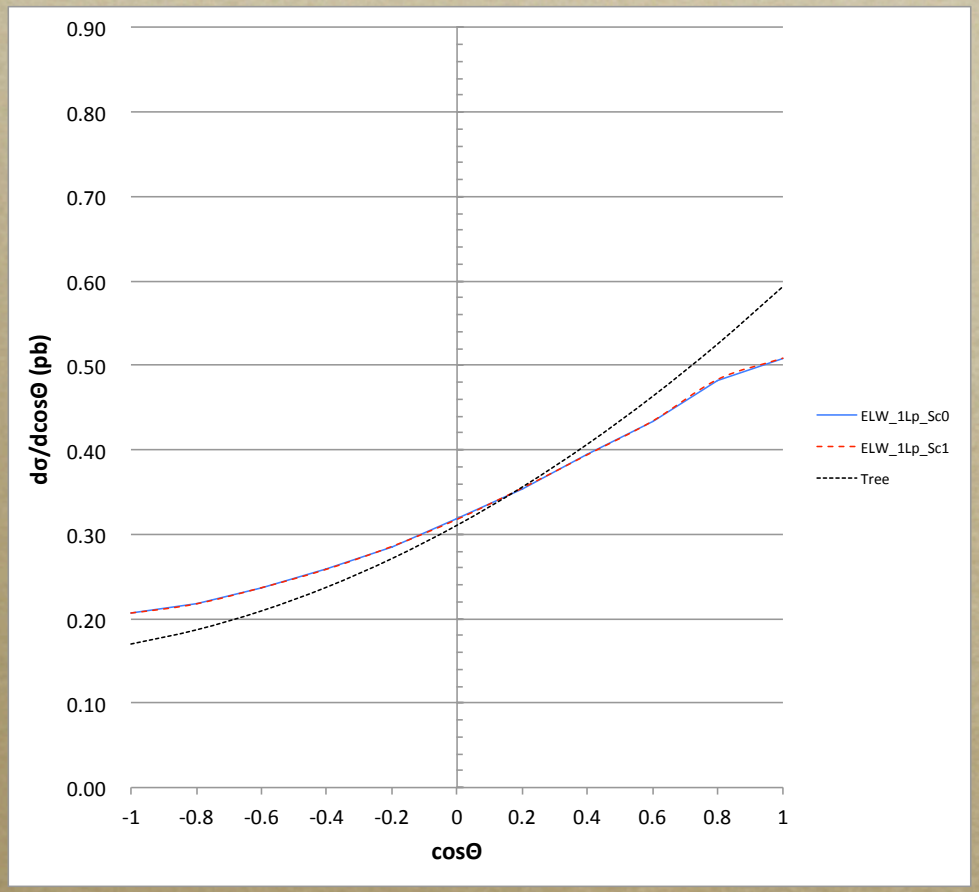


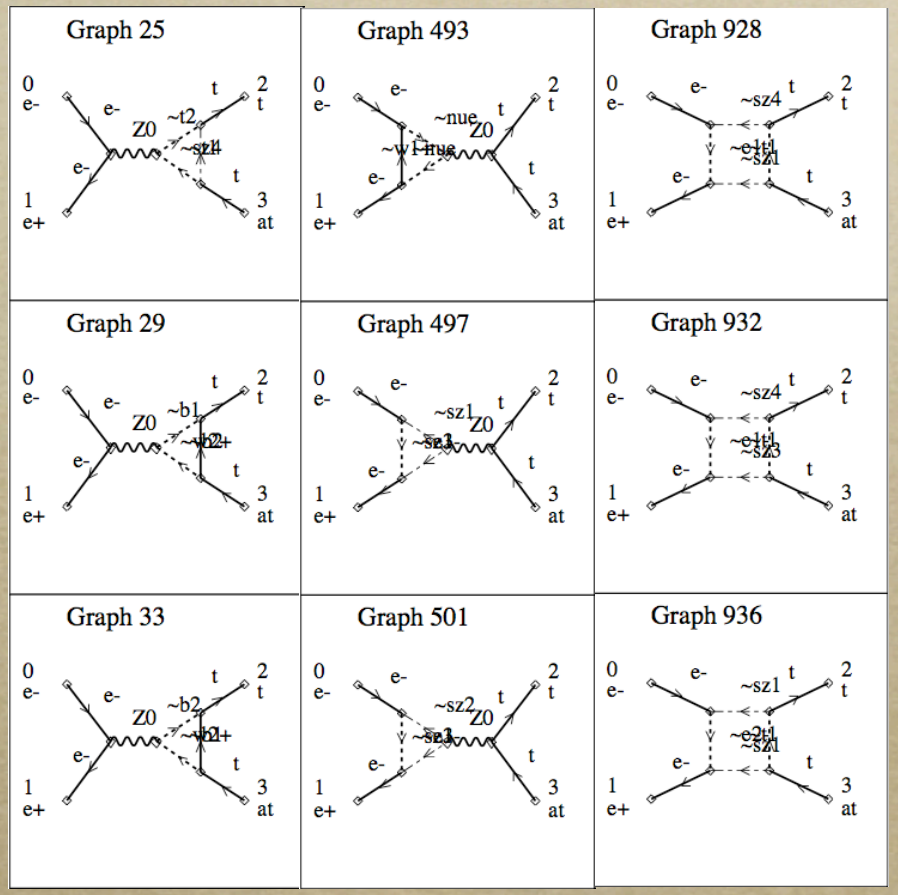
Results


Electroweak (ELW) correction
$e^+e^- \rightarrow t\bar{t}$
σ (fb)
800
700
600
500
400
300
200
100
0
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
√s (TeV)
Sc1 (Tree)
Sc1 (1Loop)

$\sqrt{s} = 420\,GeV$

ELW correction $e^+e^- \to t\bar{t}$ *1114 diagrams*



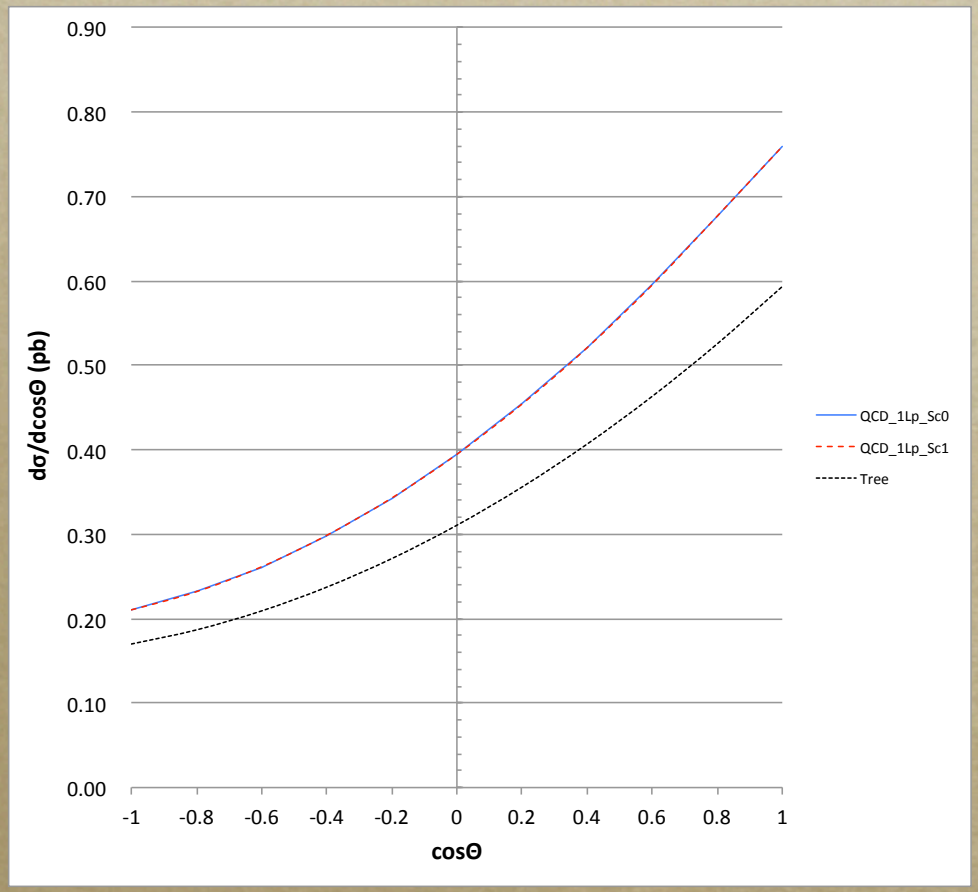


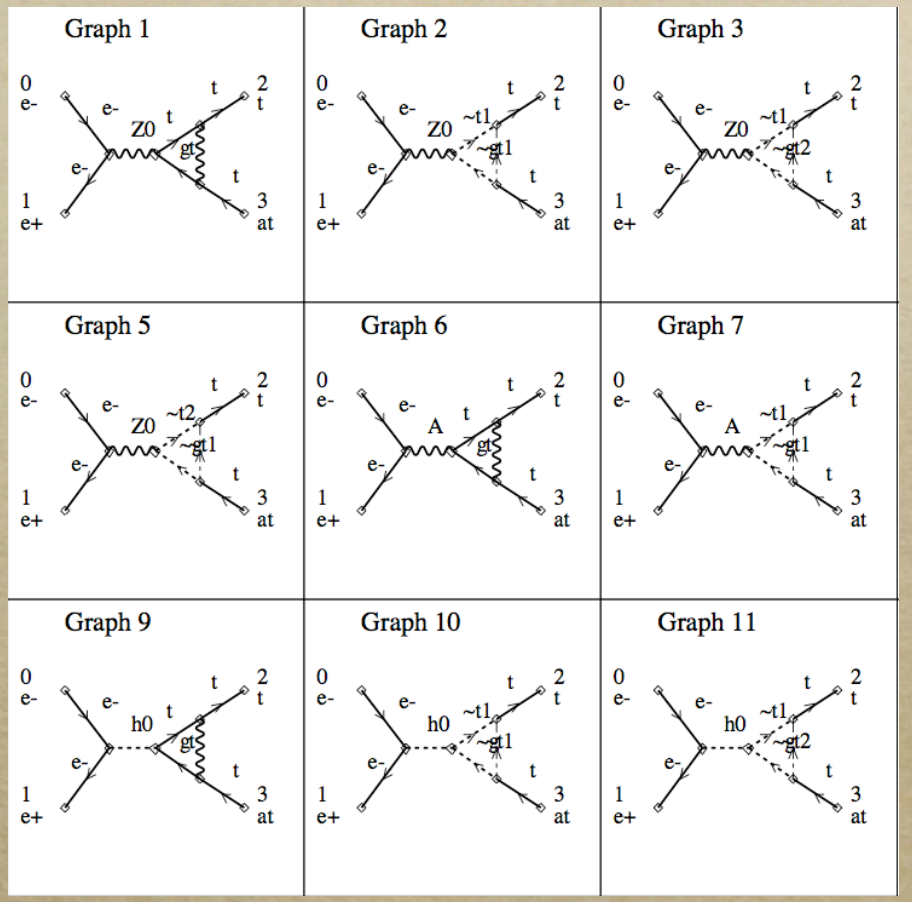
$\sqrt{s} = 420\,GeV$

QCD correction

$e^+e^- \rightarrow t\bar{t}$

30 diagrams

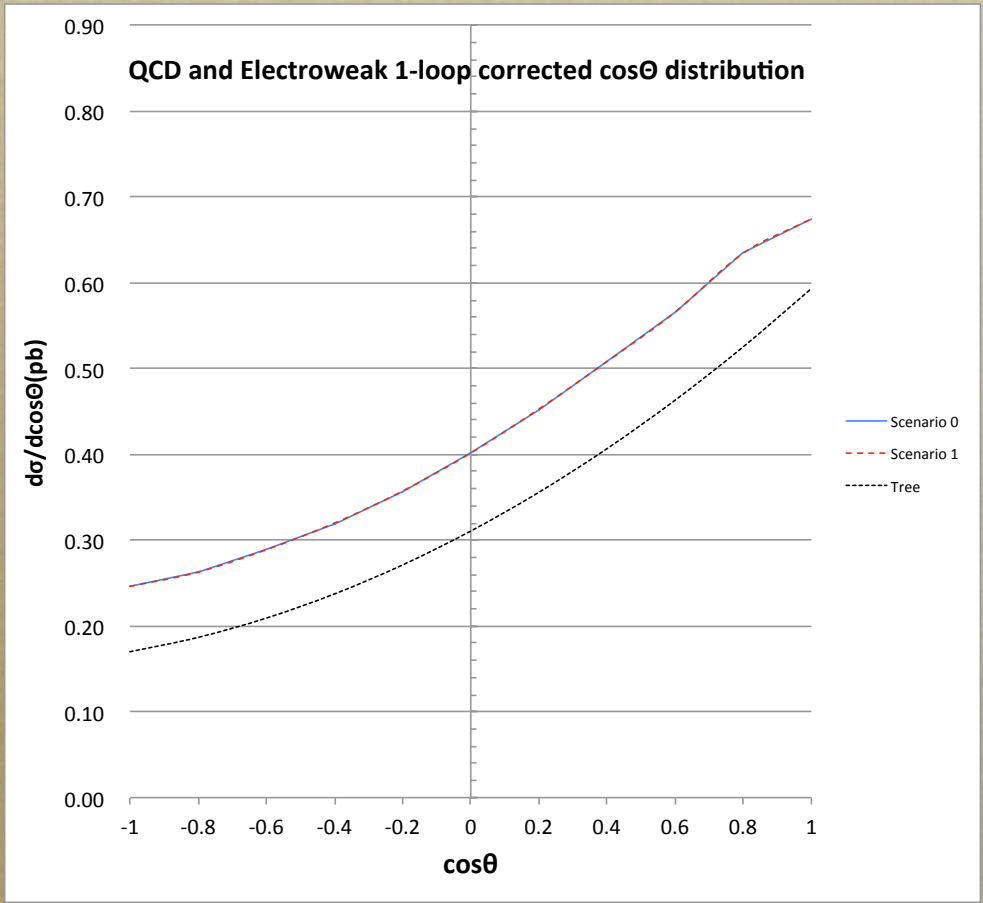


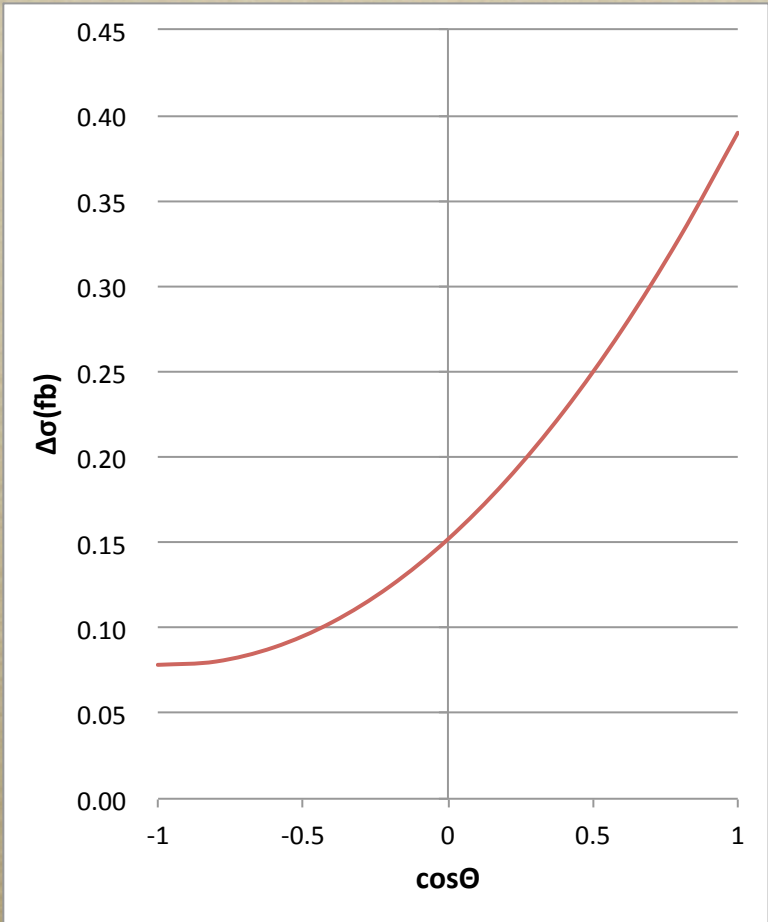


$$\sqrt{s} = 420\,GeV$$

ELW & QCD correction

$$\Delta\sigma \equiv \frac{d\sigma(Sc1)}{d\cos\theta} - \frac{d\sigma(Sc0)}{d\cos\theta}$$





Summary

- *126GeV Higgs in MSSM*

$$M_{\tilde{t}}^2 = \frac{1}{2}\left(m_{\tilde{t}_1}^2 + m_{\tilde{t}_2}^2\right) \geq O(1TeV)$$

- *Constraint from* $g_\mu - 2$

O(100GeV) sleptons & gauginos

Split scenarios

$m_{\tilde{\ell}}, m_{\tilde{\chi}} << m_{\tilde{q}}, m_{\tilde{g}}$

?

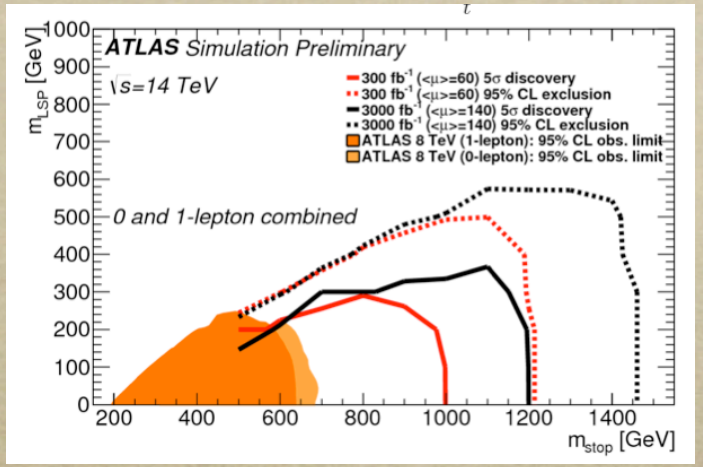
- *We considered the case*

$$m_{\tilde{\ell}}, m_{\tilde{\chi}} << m_{\tilde{g}}, m_{\tilde{u},\tilde{d},\tilde{c},\tilde{s}} \quad \text{and} \quad m_{\tilde{t}_1}, m_{\tilde{b}_1} << m_{\tilde{t}_2}, m_{\tilde{b}_2}$$

Split stops scenarios

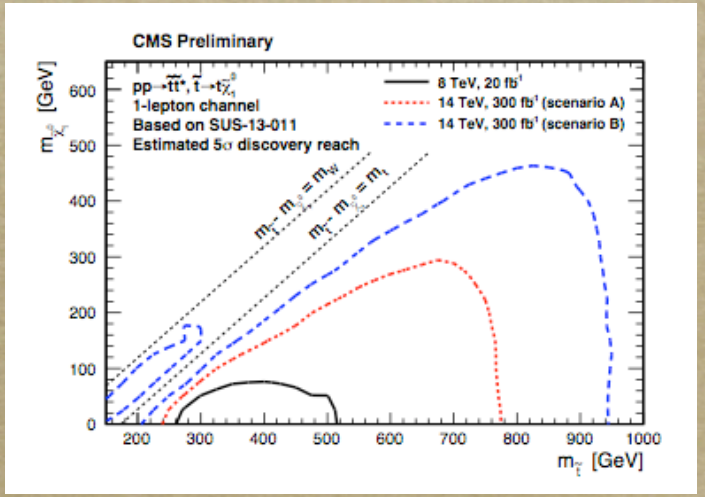
Conclusions

- *Detailed study of Top pair production at ILC will be possibly important for us to distinguish Simple split and Split stops scenarios*



Daniel LCWS13

Particular, when upgraded LHC can not exclude 300-500GeV stop, it can be one of important target of ILC



Ulmer DPF2013