

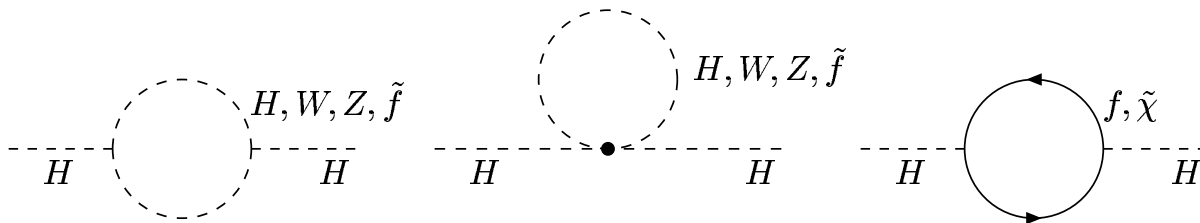
SUSY PARTICLE PRODUCTION AT HADRON COLLIDERS

Michael Spira (PSI)

- I Introduction
- II SUSY Particle Production
- III Conclusions

I INTRODUCTION

- SUSY: fermions \leftrightarrow bosons
- no quadratic divergences \Rightarrow solution to the hierarchy problem



$$\Delta M_H^2 \sim (\tilde{m}^2 - m^2) \log \frac{\Lambda^2}{m^2} \Rightarrow \tilde{m} \lesssim \mathcal{O}(1 \text{ TeV})$$

- SUSY-GUT: $\sin^2 \theta_W = 0.2334 \pm 0.0026$
LEP: $\sin^2 \theta_W = 0.2317 \pm 0.0002$

Langacker

LEP/SLC

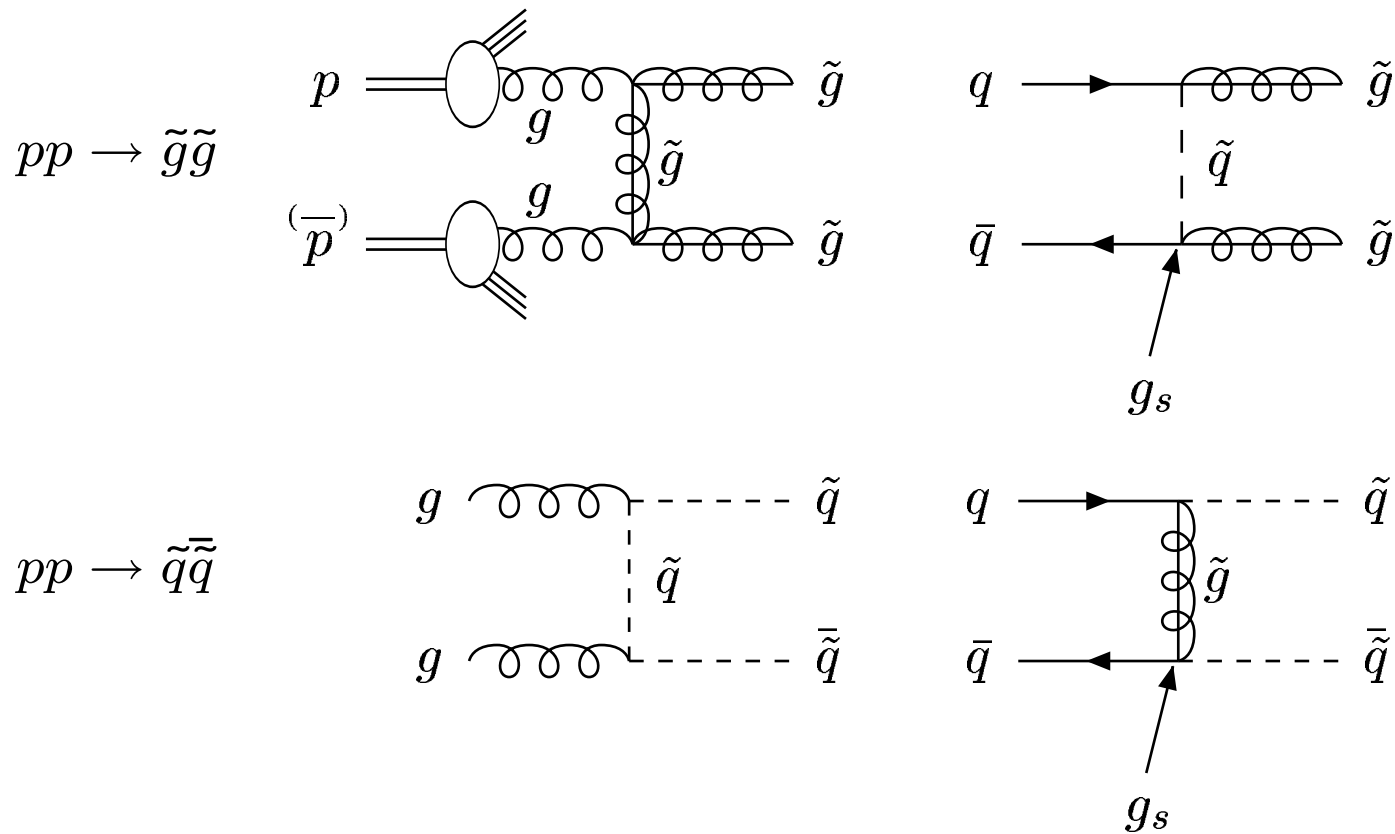
SUSY sector	particle	spin	d.o.f.	mass
	lepton $\ell_{L/R}$	1/2	1	0
	quark $q_{L/R}$	1/2	3	0
	top $t_{L/R}$	1/2	3	m_t
	gluon g	1	16	0
	Photon γ	1	2	0
	W^\pm	1	3	M_W
	Z	1	3	M_Z
	Higgs h, H, A, H^\pm	0	1	M_{h,H,A,H^\pm}
	slepton $\tilde{\ell}_{L/R}$	0	1	$m_{\tilde{\ell}}$
	squark $\tilde{q}_{L/R}$	0	3	$m_{\tilde{q}}$
	stop $\tilde{t}_{1/2}$	0	3	$m_{\tilde{t}_{1/2}}$
	gluino \tilde{g}	1/2	16	$m_{\tilde{g}}$
	chargino $\tilde{\chi}_{1/2}^\pm$	1/2	4	$m_{\tilde{\chi}_{1/2}^\pm}$
	neutralino $\tilde{\chi}_{1\dots 4}^0$	1/2	8	$m_{\tilde{\chi}_{1\dots 4}^0}$

- mixing, Majorana fermions

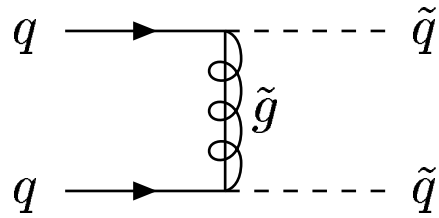
II SUSY PARTICLE PRODUCTION

3 classes of SUSY particle production processes:

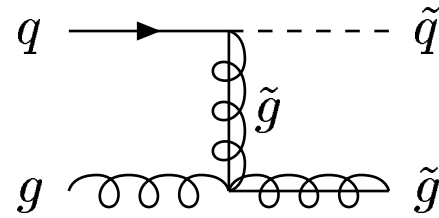
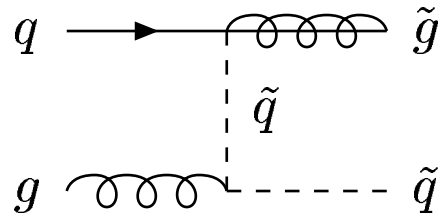
(i) strongly interacting particle pairs:



$pp \rightarrow \tilde{q}\tilde{q}$



$pp \rightarrow \tilde{q}\tilde{g}$



- $\sigma_{tot} \rightarrow$ mass determination

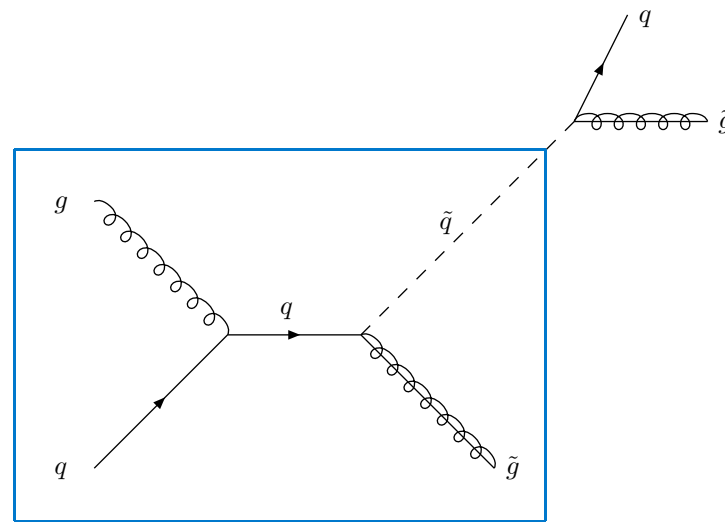
- $\frac{\Delta\sigma_{LO}}{\sigma_{LO}} \sim 100\% \Rightarrow$ NLO needed

- SUSY-QCD corrections:

α_s , PDF: $\overline{\text{MS}}$ scheme [5 active flavors]

$m_{\tilde{g}}, m_{\tilde{q}}$ on-shell

- **double counting:** $gq \rightarrow \tilde{g}\tilde{q} \rightarrow \tilde{g}\tilde{g}q$ [if $m_{\tilde{q}} > m_{\tilde{g}}$]



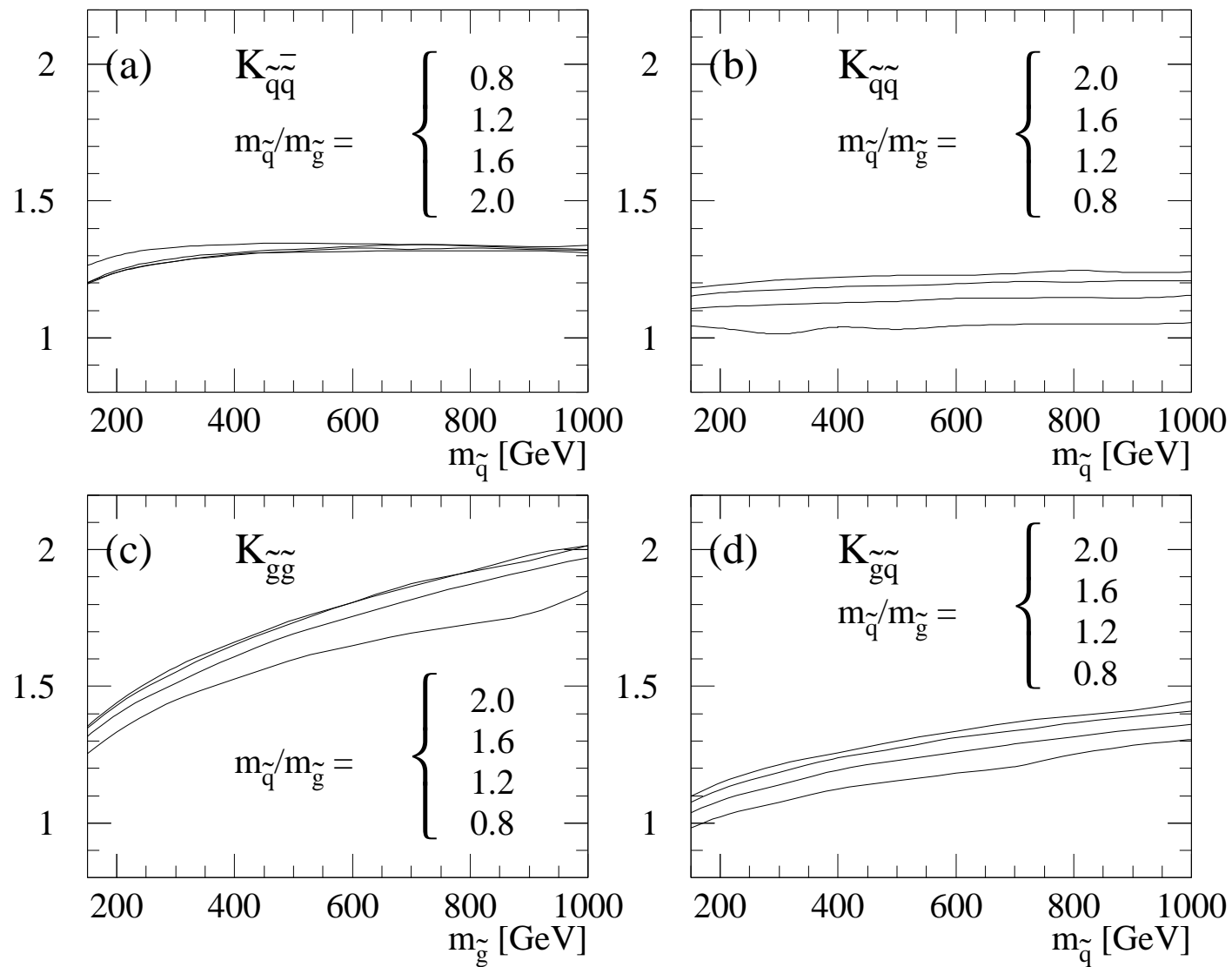
$$\frac{d\hat{\sigma}_{res}}{dM^2} = \hat{\sigma}(gq \rightarrow \tilde{g}\tilde{q}) BR(\tilde{q} \rightarrow \tilde{g}q) \underbrace{\frac{m_{\tilde{q}}\Gamma_{\tilde{q}}/\pi}{(M^2 - m_{\tilde{q}}^2)^2 + m_{\tilde{q}}^2\Gamma_{\tilde{q}}^2}}_{\rightarrow \delta(M^2 - m_{\tilde{q}}^2)}$$

to be subtracted

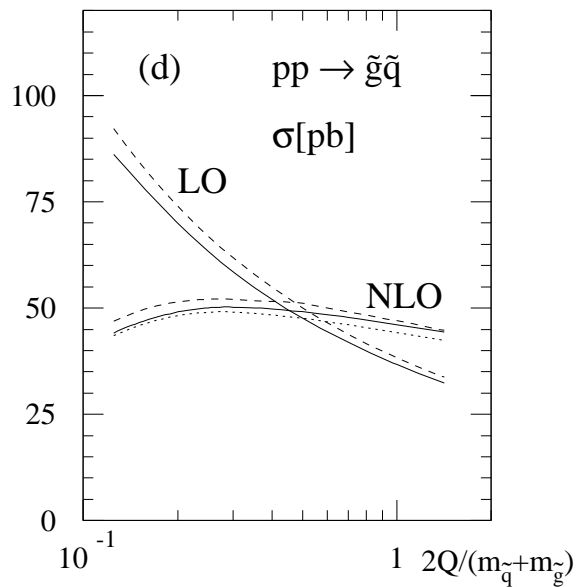
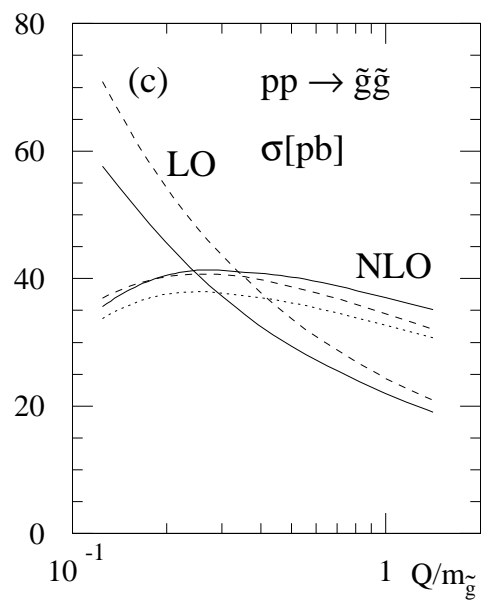
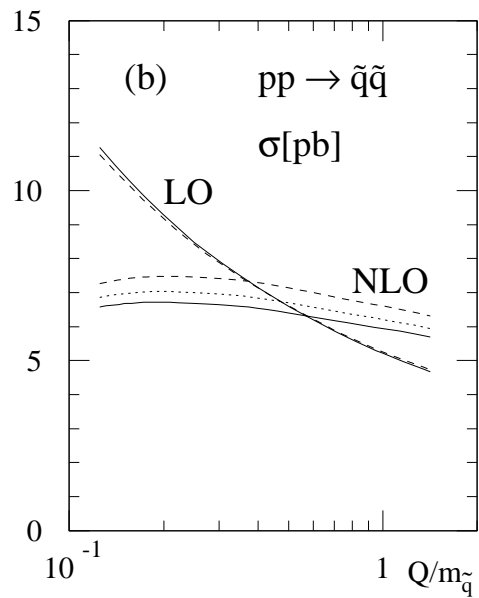
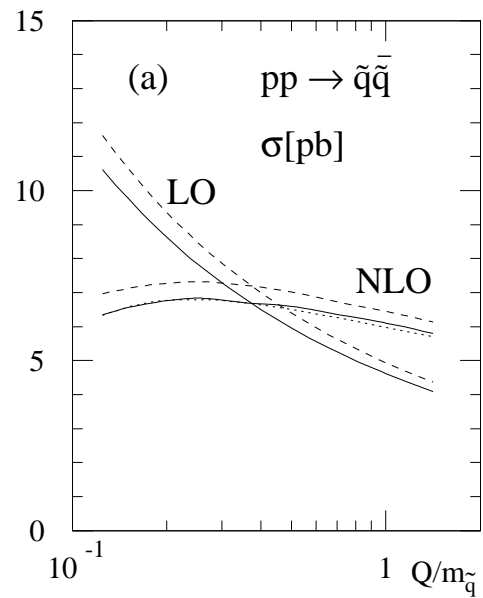
- corrections large: 10–100%
 $\rightarrow \frac{\Delta\sigma}{\sigma} \sim 10 - 15\%$
- only depending on $m_{\tilde{g}}, m_{\tilde{q}}$
- mass shifts @ LHC: $\sim 20 - 50$ GeV

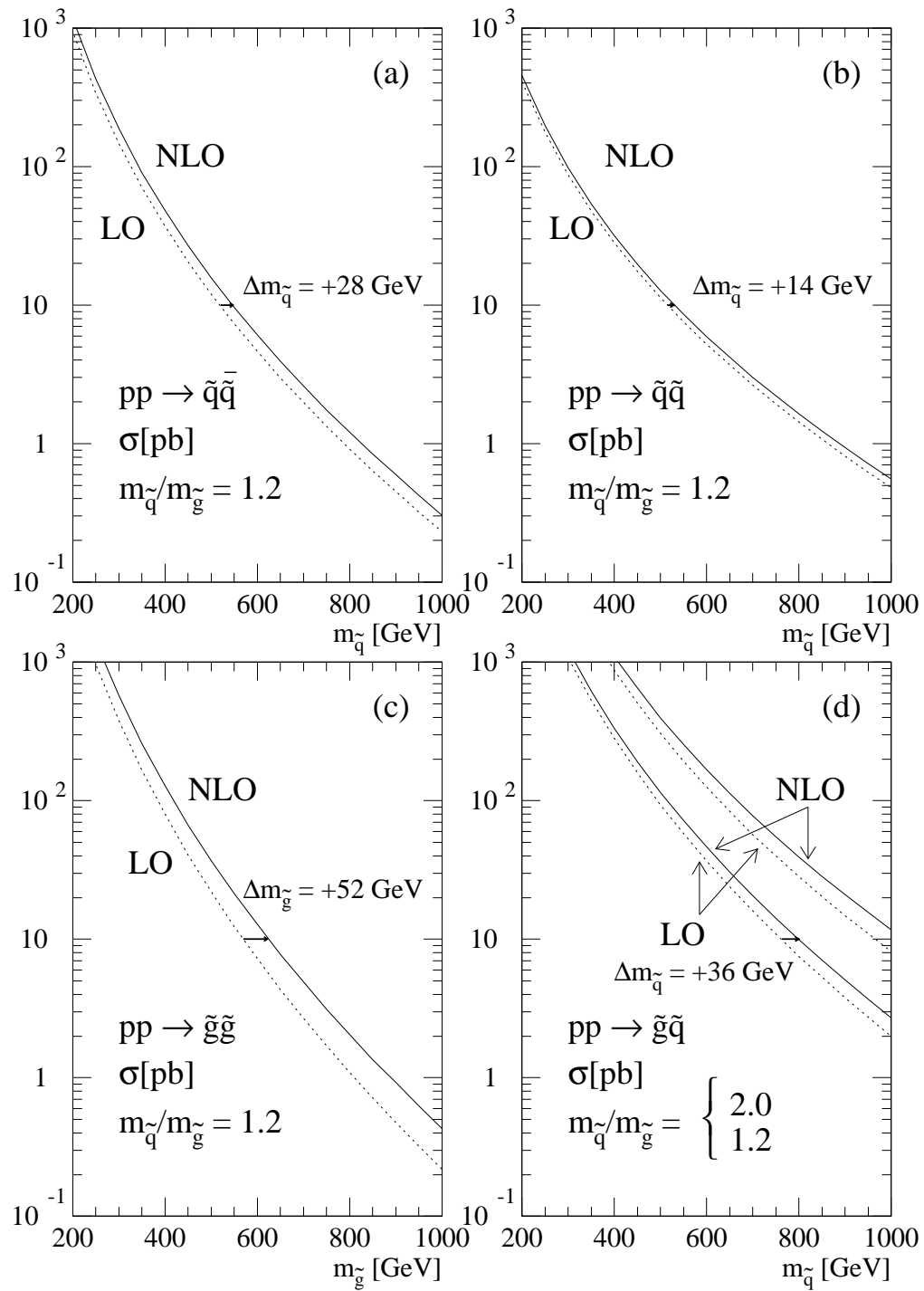
$pp \rightarrow t\bar{t}$: mixing effects $\tilde{t}_L, \tilde{t}_R \rightarrow \tilde{t}_1, \tilde{t}_2$

- SUSY-QCD corrections: $\sim 10 - 50\%$
- scale dependence $\lesssim 15\%$
- dependence on $\theta_{\tilde{t}}, m_{\tilde{g}}, m_{\tilde{q}}$ weak

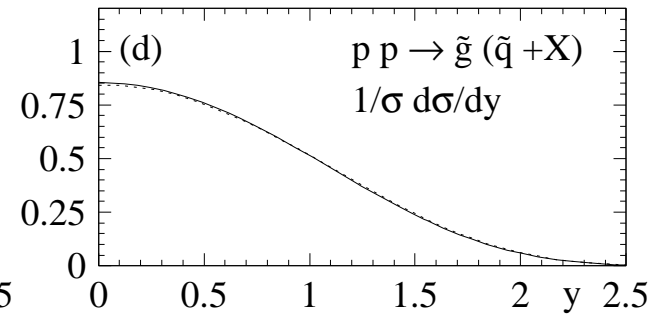
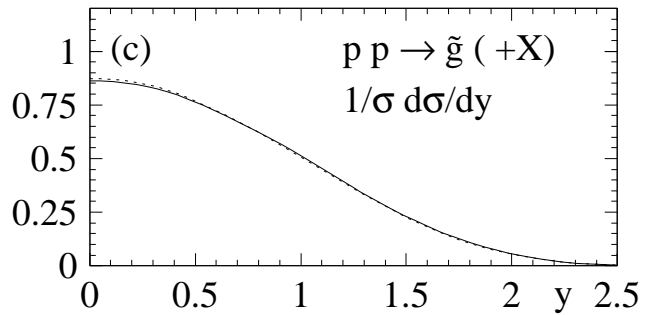
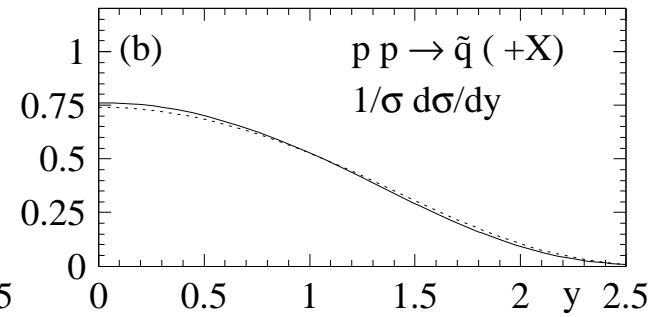
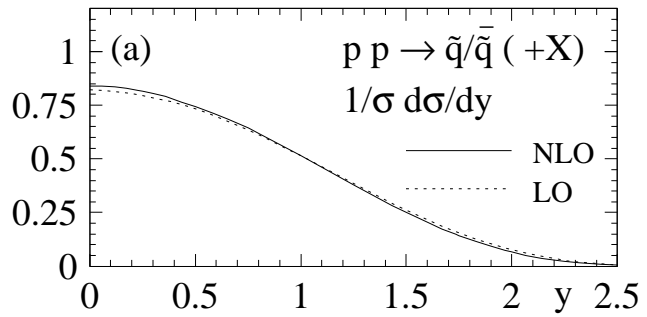
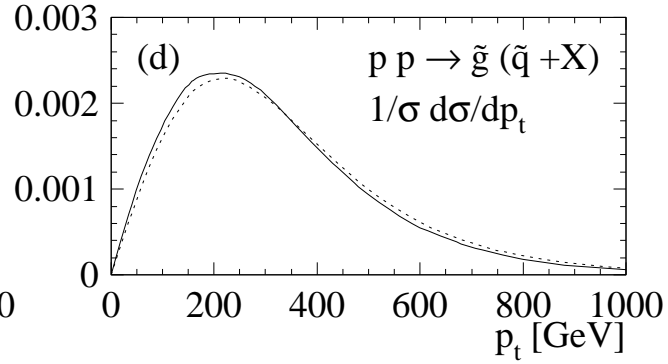
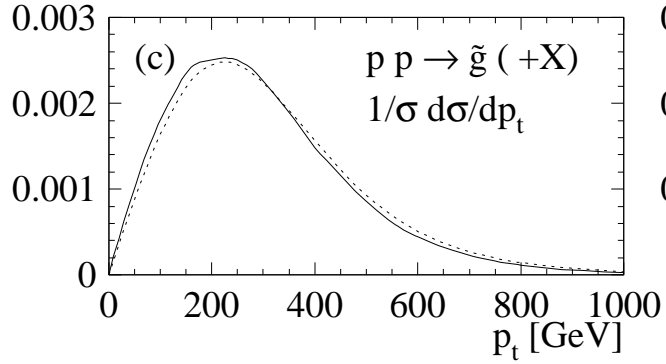
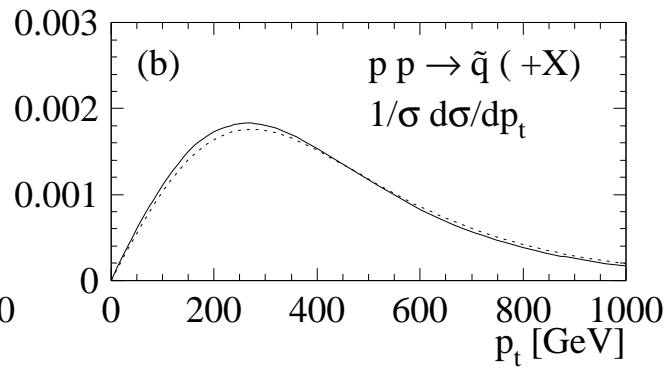
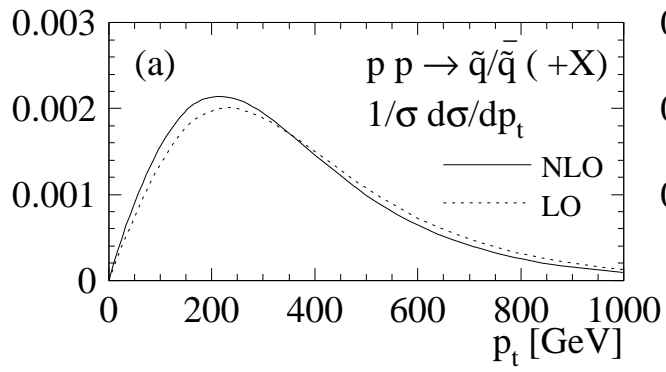


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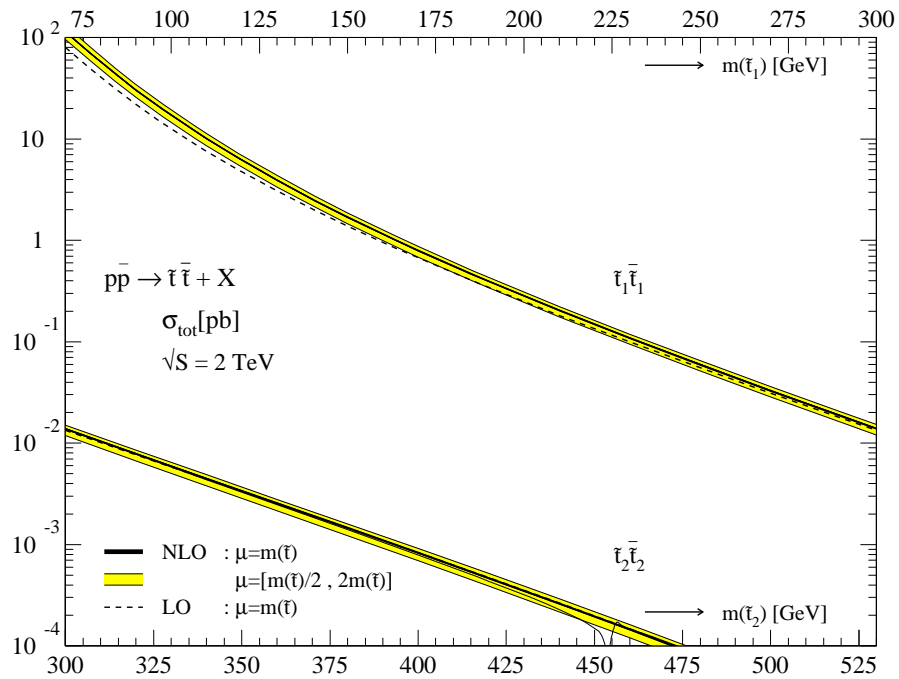
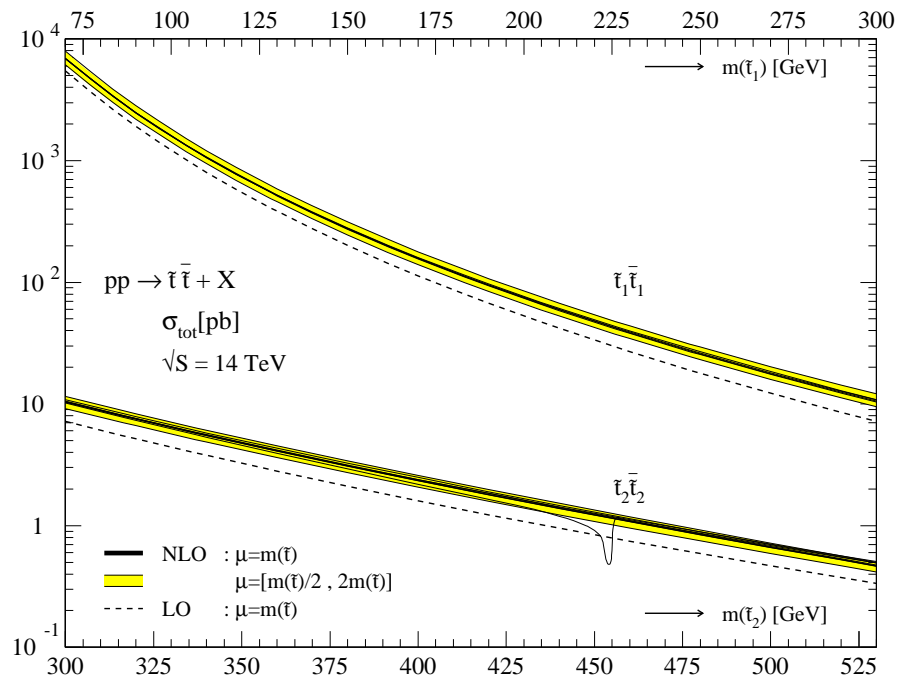




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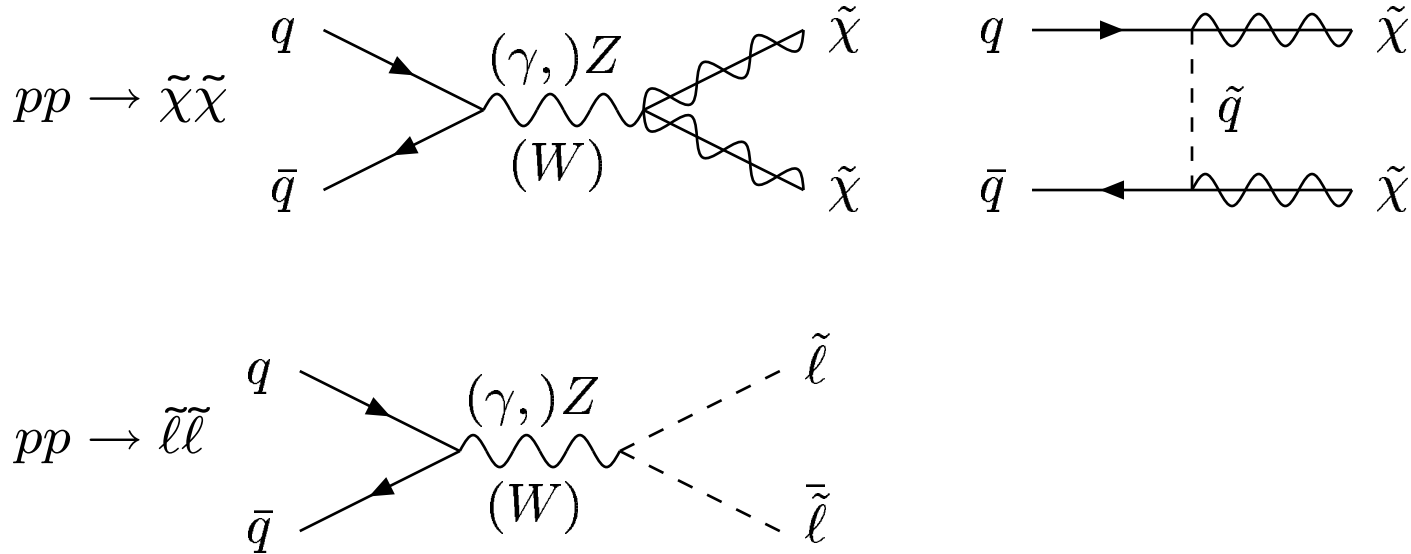


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(ii) weakly interacting particle pairs:



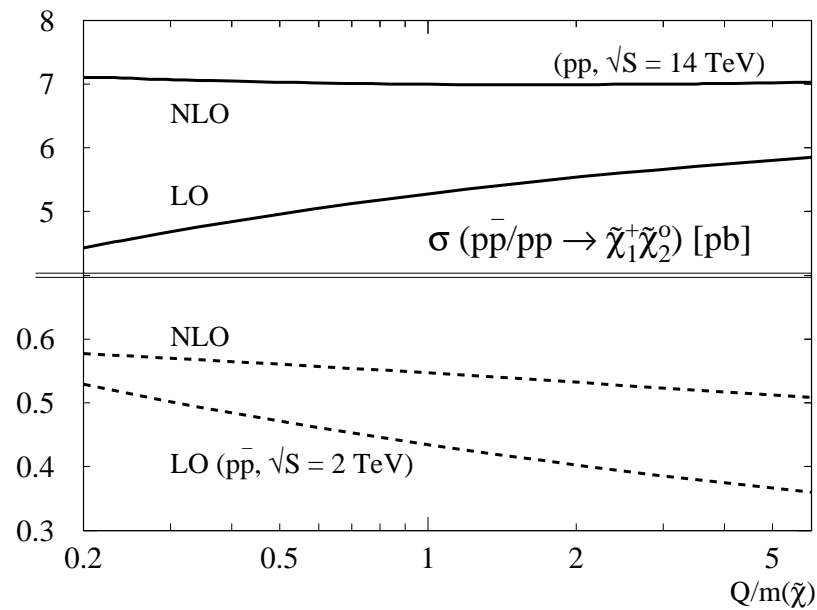
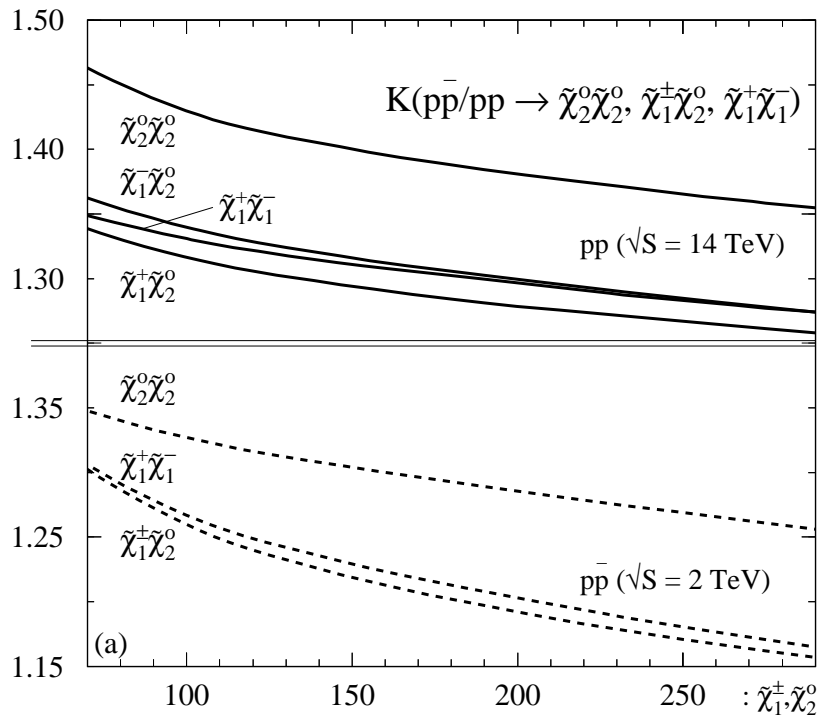
- several SUSY parameters involved: $M_1, M_2, \mu, \text{tg}\beta$

- SUSY-QCD corrections: $\sim 20 - 50\%$

F
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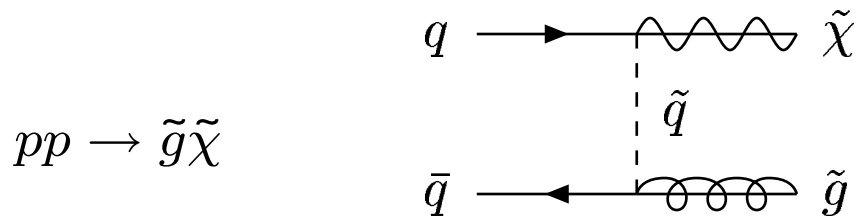
- scale dependence $\lesssim 10\%$

- resonance subtractions: $qg \rightarrow \tilde{\chi}\tilde{q} \rightarrow \tilde{\chi}\tilde{\chi}q$

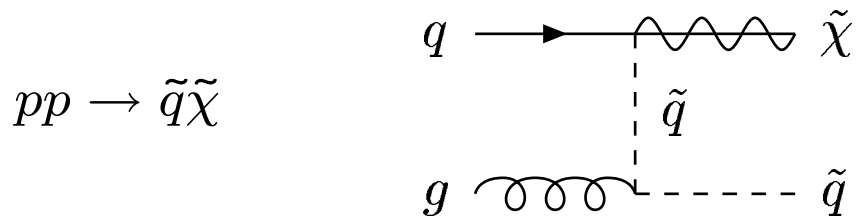


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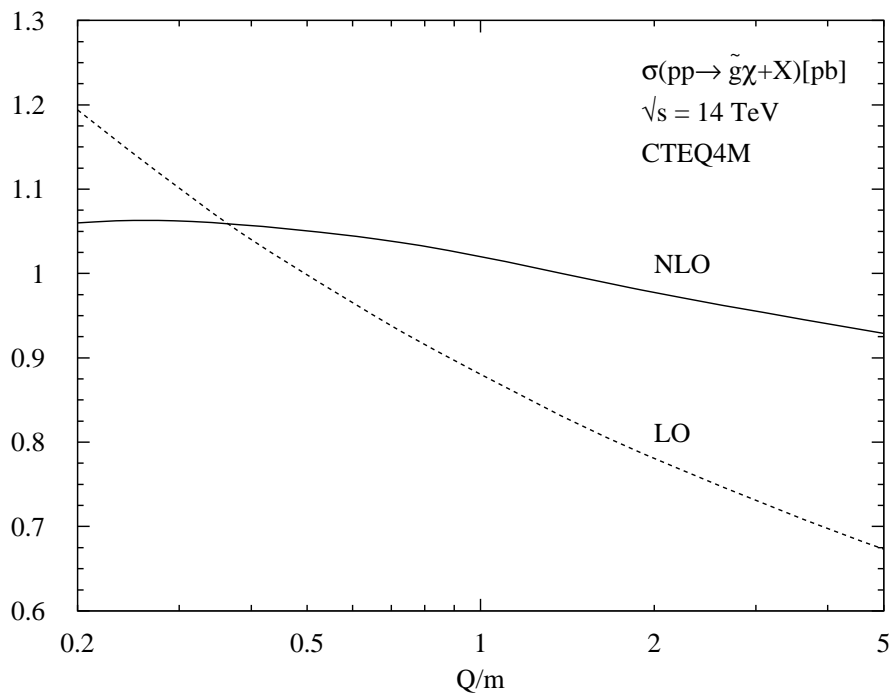
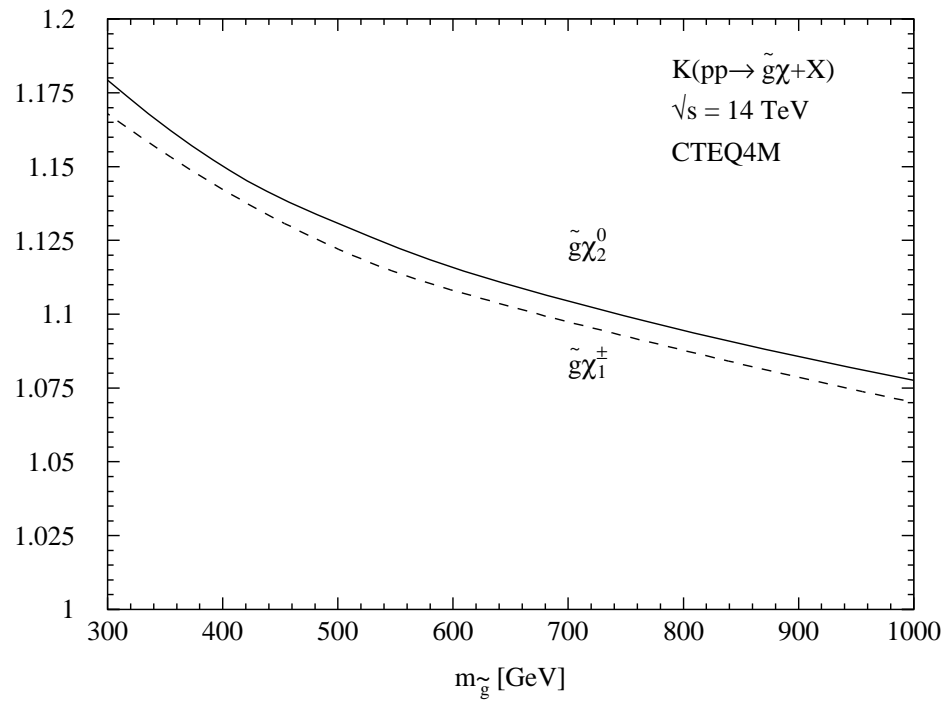
(iii) associated production:



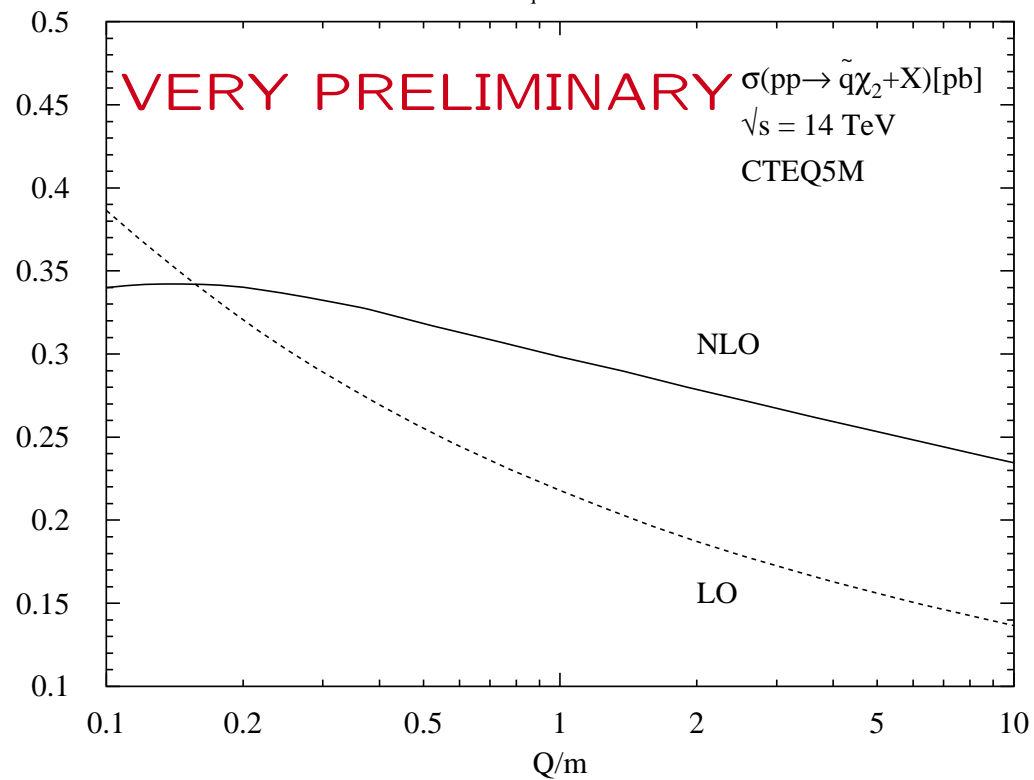
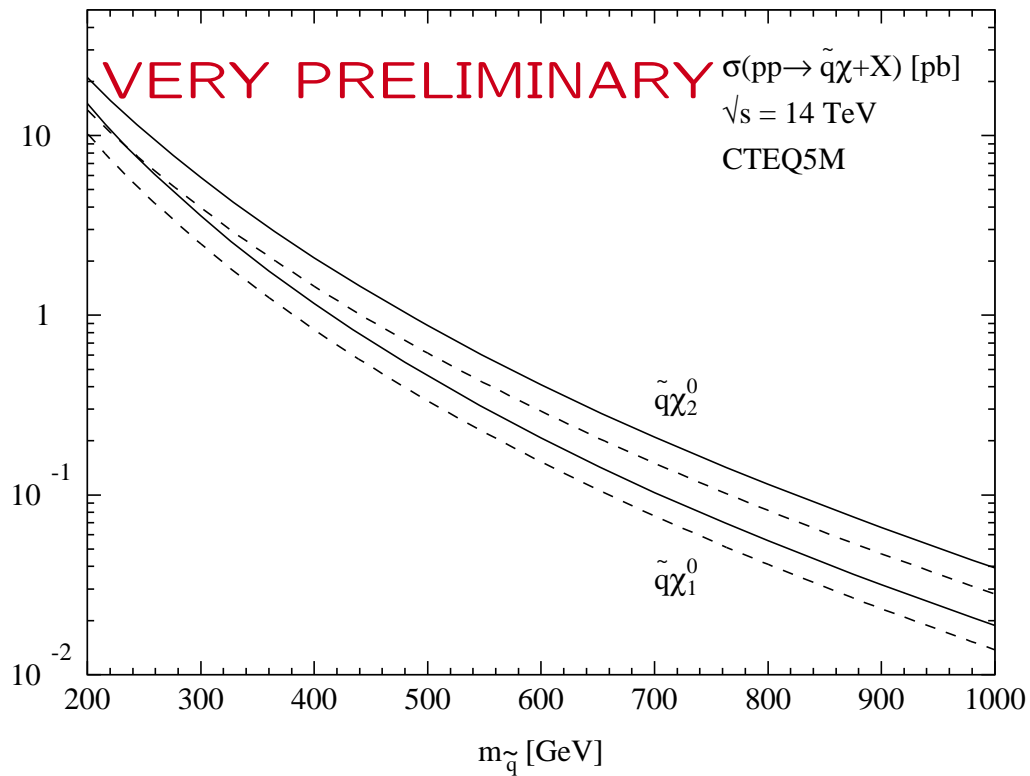
- sizeable cross section @ LHC
- SUSY-QCD corrections $\sim 10-20\%$ [agreement with Berger, Klasen, Tait] **F**
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- scale dependence $\lesssim 15\%$
- resonance subtractions: $qg \rightarrow \tilde{q}\tilde{g} \rightarrow \tilde{\chi}\tilde{g}q$, $qg \rightarrow \tilde{\chi}\tilde{q} \rightarrow \tilde{\chi}\tilde{g}q$



- first **very preliminary** results **F**
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- resonance subtractions: $q\bar{q}, gg \rightarrow \tilde{q}\tilde{q} \rightarrow \tilde{q}\tilde{\chi}\bar{q}$, $q\bar{q} \rightarrow \tilde{\chi}\tilde{g} \rightarrow \tilde{\chi}\tilde{q}\bar{q}$

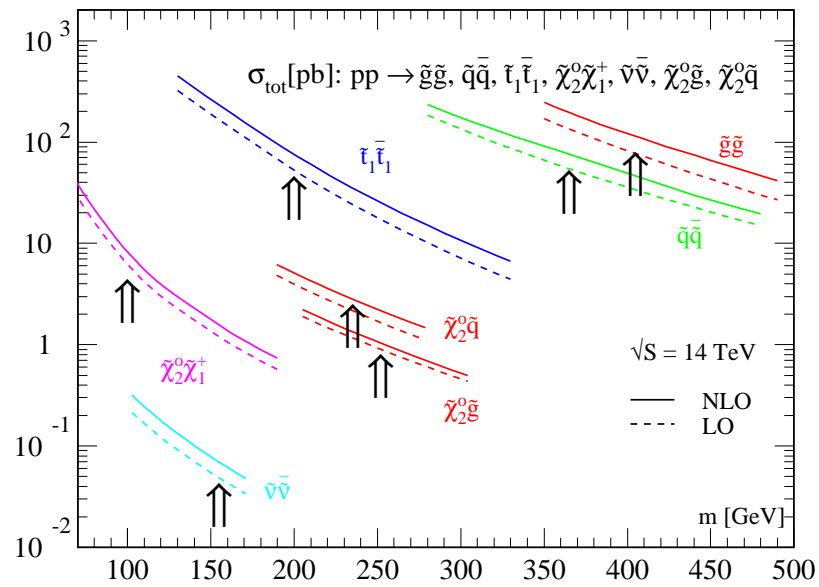
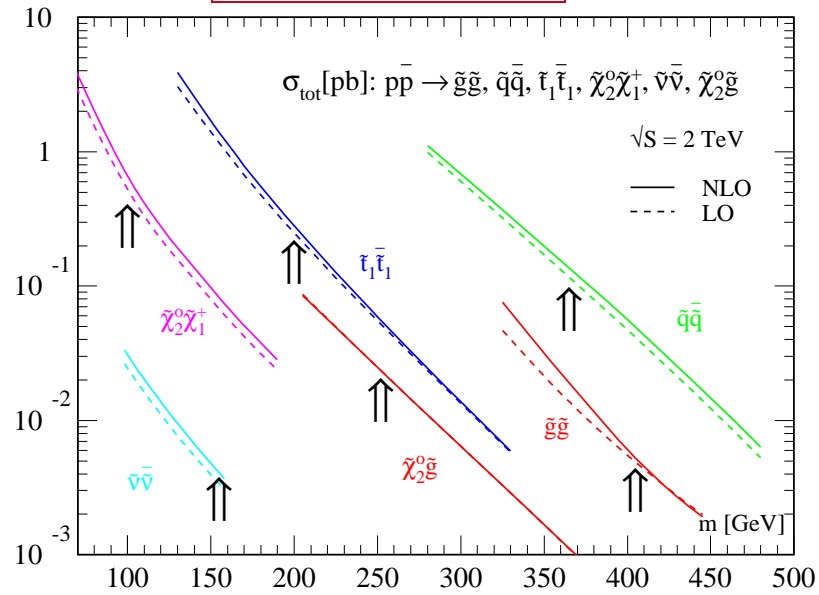


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PROSPINO



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III CONCLUSIONS

- SUSY particle searches at the Tevatron and LHC belong to major endeavours
- LHC has big potential to find SUSY particles
- SUSY–QCD corrections known \Rightarrow large corrections in several cases remaining theoretical uncertainties: $\sim 100\% \longrightarrow \lesssim 15\%$
- program available including these corrections: PROSPINO

<http://people.web.psi.ch/spira/>

<http://pheno.physics.wisc.edu/~plehn/prospino/prospino.html>

[PROSPINO 2.0]