# Gluino pair production
# in $\gamma\gamma$ collisions at Linear Collider

April 3, 2003

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# 1. Introduction:

- Supersymmetry: promising concept to extend the Standard Model(SM);
  MSSM: Every Standard Model particle is associated by a supersymmetrical particle, for QCD:

| | | | | |
|---|---|---|---|---|
| g | $\rightarrow$ | $\tilde{g}$ | Gluino | |
| $q_L$ | $\rightarrow$ | $\tilde{q}_L$ | Squarks, | mix to $\tilde{q}_1, \tilde{q}_2$ |
| $q_R$ | $\rightarrow$ | $\tilde{q}_R$ | | |

- Gluinos, if they exist and are not to heavy, will be produced in large numbers at LHC and the mass will be measured
- Since the Gluino only couples strongly the pair production cross section at a electron-positron Collider is suppressed and can not be measured
- Gluino production scattering processes at LC:

$$e^+e^- \rightarrow \tilde{g}\tilde{g}\,[1] \qquad \gamma\gamma \rightarrow \tilde{g}\tilde{g}[3]$$
$$e^+e^- \rightarrow q\tilde{q}\tilde{g}\,[2] \qquad \gamma\gamma \rightarrow q\tilde{q}\tilde{g}$$

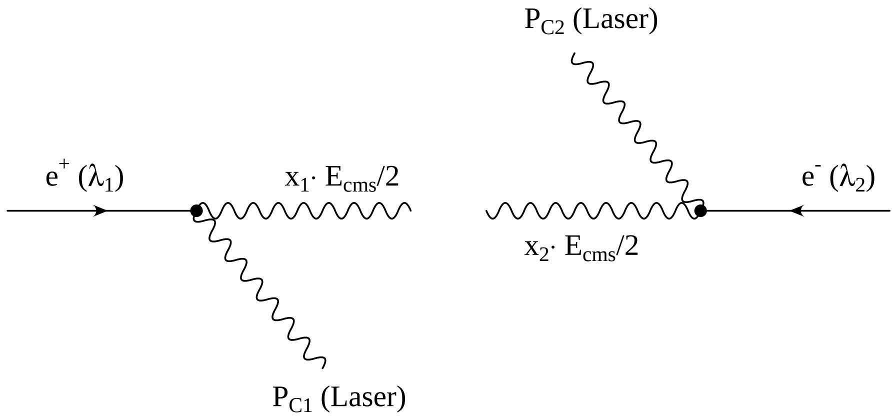

[1] B. Kileng, P. Osland, Z.Phys. C66 (1995) 503 ($m_{\tilde{g}} = 3.5$ GeV);
S.B., M. Klasen, hep-ph/0208212

[2] NLO, A. Brandenburg, M. Maniatis, M.M. Weber; hep-ph/0207278

[3] S.B., M. Klasen, hep-ph/0303032

## 2. Photon density function

- Scattering process:

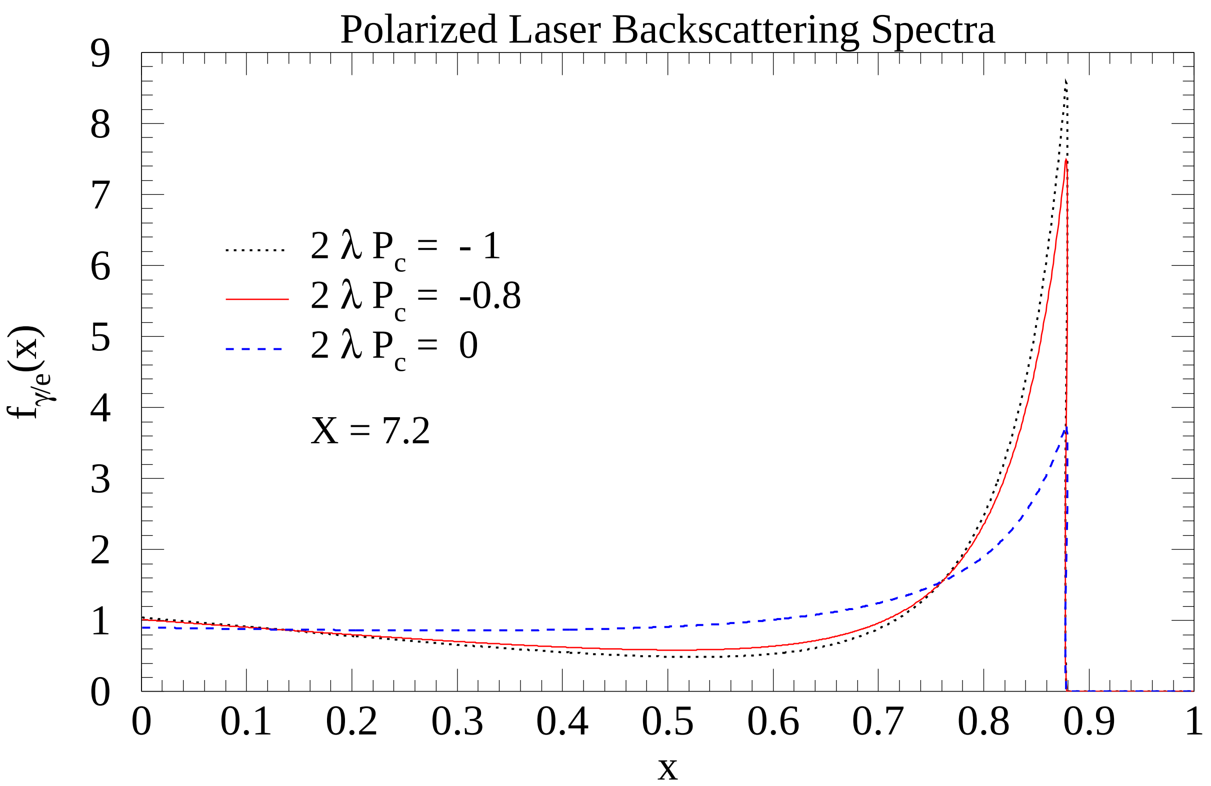



- $\sigma^{\lambda_1 \lambda_2}(S) = \int \mathrm{d}x_1 \mathrm{d}x_2 \sum_{\kappa_1,\kappa_2=\pm} f^{\kappa_1}(x_1,\lambda_1) f^{\kappa_2}(x_2,\lambda_2)\, \hat{\sigma}^{\kappa_1,\kappa_2}(x_1 x_2 S)$

- Density function:

$$\text{Direct}: \qquad f(x) = f_{\gamma/e}(x)$$

$$\text{Resolved}: \qquad f(x) = \int_x^1 \frac{\mathrm{d}y}{y} f_{\gamma/e}\left(\frac{x}{y}\right) f_{a/\gamma}(y)$$



- Model: Minimal supersymmetric standard model (MSSM):

  - assume R-Parity conservation
  - $m_{\tilde{g}}$ free parameter
  - $m^2_{\tilde{q}_{1,2}} = m^2_{\tilde{q}_{1,2}}(M_{Susy}, \tan\beta, \mu, A_q, m_q)$
    $\qquad\quad = m^2_{\tilde{q}_{1,2}}(M_{Susy},\ \theta_{\tilde{q}}, m_q)$
  - mass bounds:
    * $m_{\tilde{t}} > 97$ GeV, $m_{\tilde{b}} > 95$ GeV, $m_{\tilde{q}} > 250$ GeV
    * $m_{\tilde{g}} \geq 200$ GeV
  - $\Delta\rho^{Susy} < .0035$

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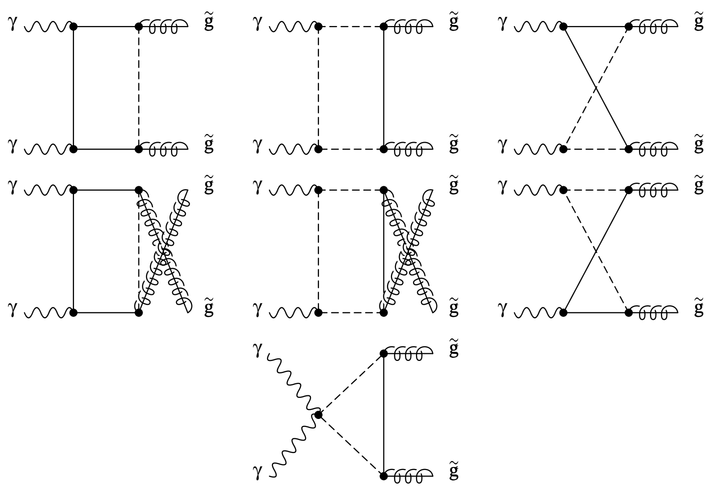
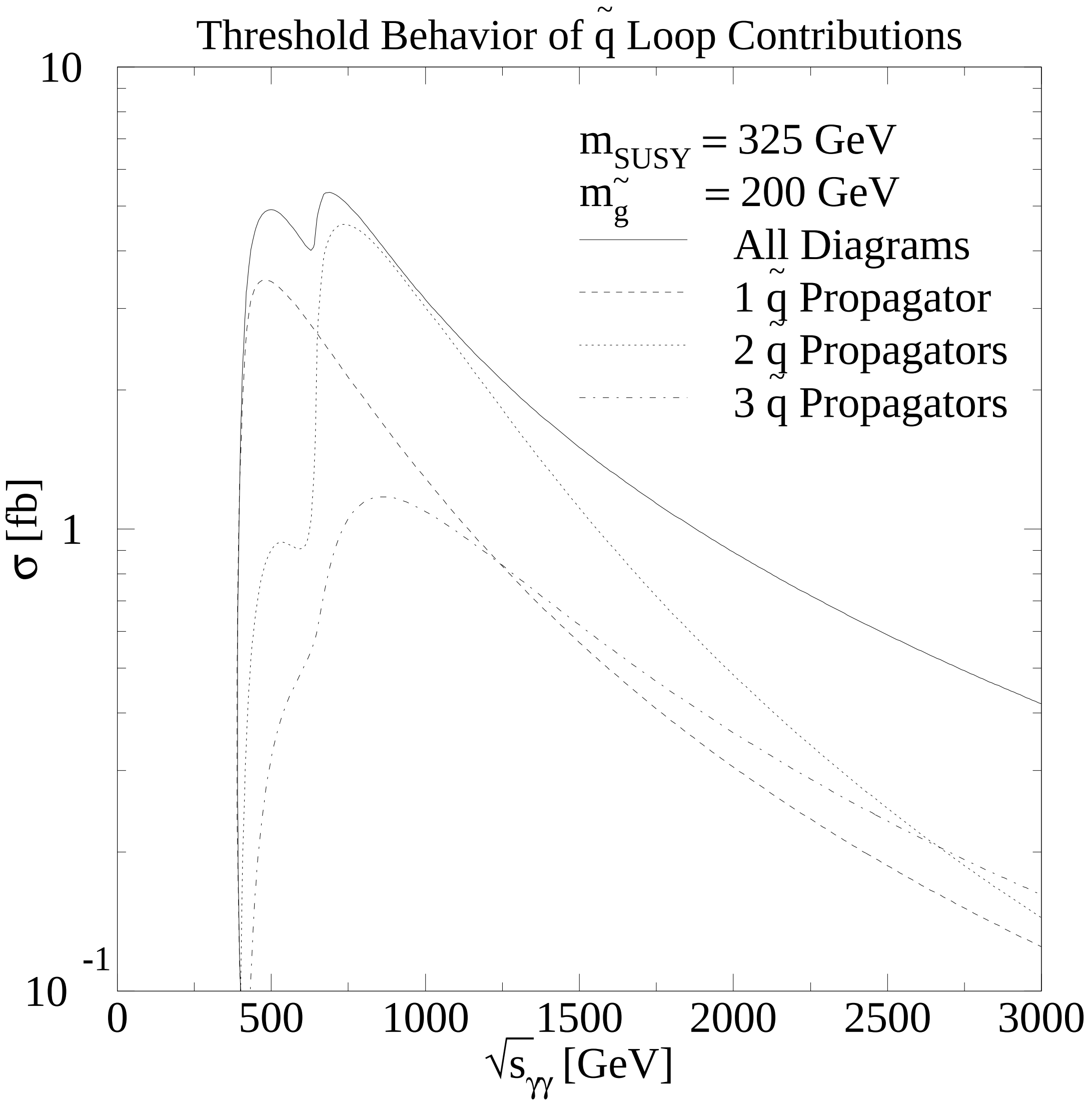
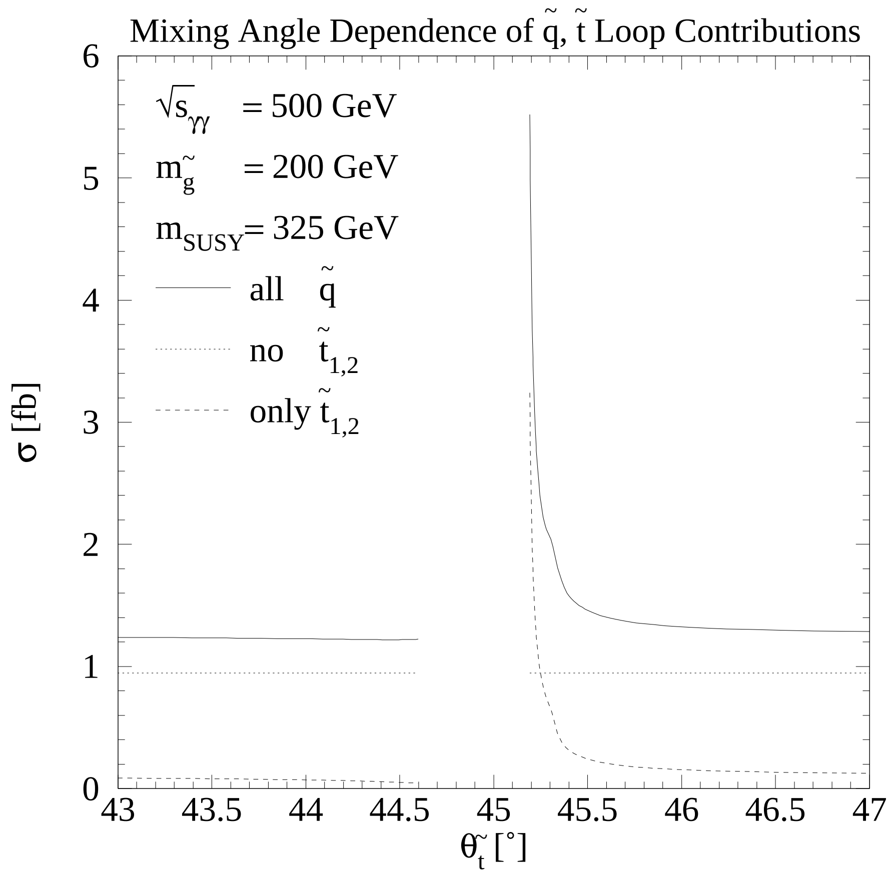
$$M^2_{\tilde{u}} = \begin{pmatrix} M^2_{\tilde{Q}} + M^2_Z \cos 2\beta\,(I^u_3 - Q_u s^2_w) + m^2_u & m_u(A^*_u - \mu \cot\beta) \\ m_u(A_u - \mu^* \cot\beta) & M^2_{\tilde{U}} + M^2_Z \cos 2\beta\, Q_u s^2_w + m^2_u \end{pmatrix}$$

## 3. Direct contribution to gluino pair production in $\gamma\gamma$ scattering

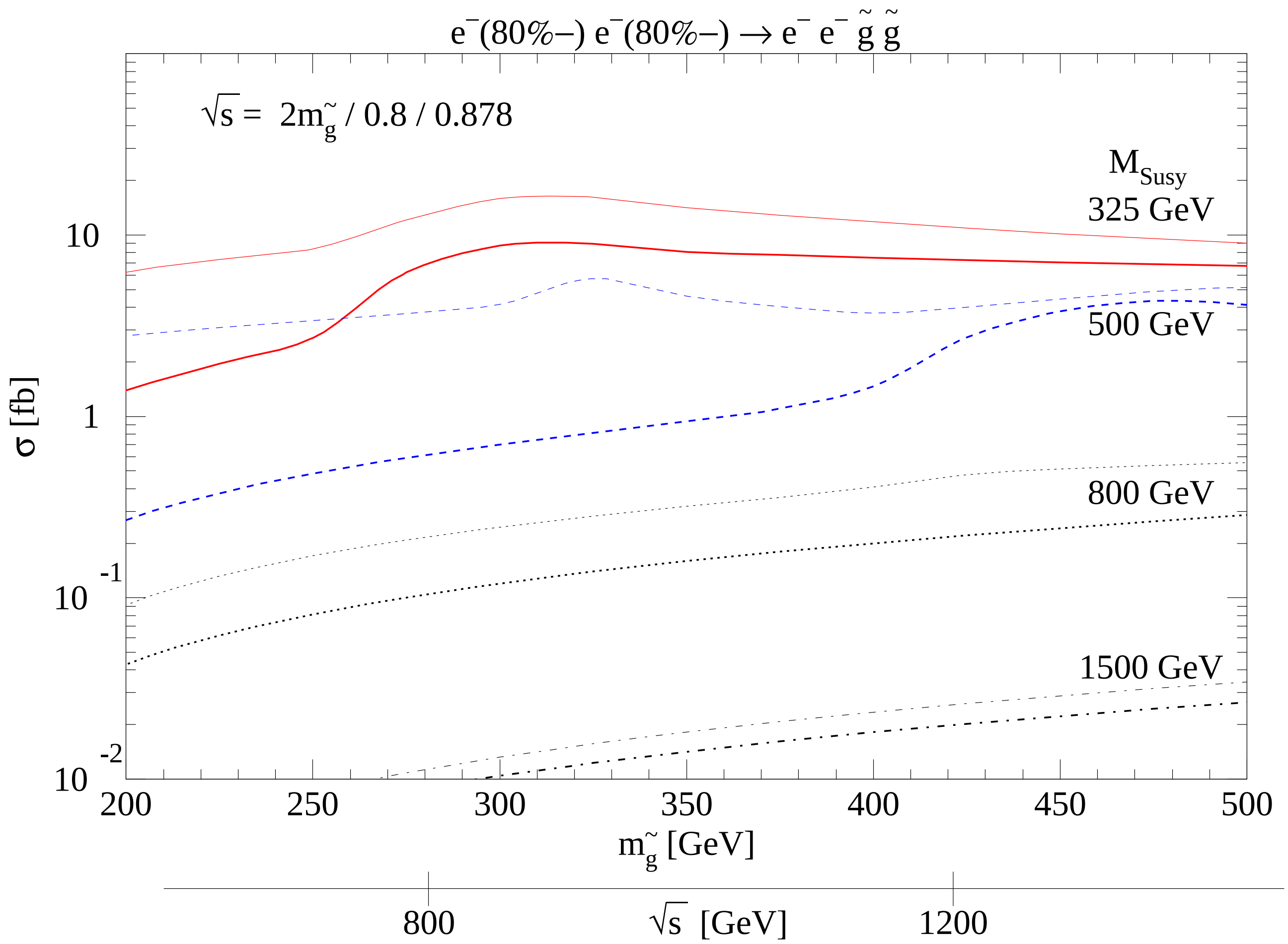
- Occurs only at one-loop level
- Sum over 6 flavours and $\tilde{q}_1$, $\tilde{q}_2$
- Flavor flow in 2 directions
- Diagrams are UV and IR finite
- Dependence on $m_q, m_{\tilde{g}}$, dependence on $\theta_{\tilde{q}}$
- Polarization increases $\sigma$ about a factor of 2
- $|M|^2 \sim Q_q^4$








Dependence of $\sigma$ in unpolarized photon-photon collisions on the top-squark mixing angle.



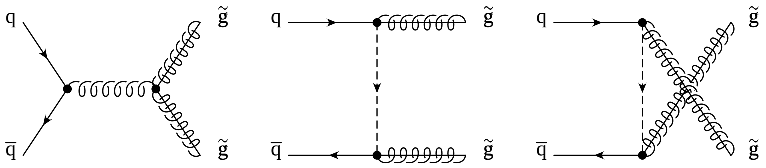

Dependence of the gluino pair production cross section in $\gamma\gamma$ collisions on the universal squark mass $M_{Susy}$ for no squark mixing (thick curves) and maximal top-squark mixing (thin curves).

## 4. Resolved contribution to $\gamma\gamma$ scattering

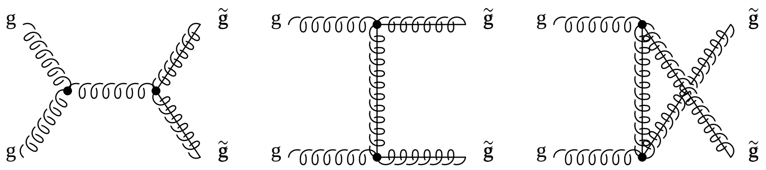
- Single resolved contributions: $g\gamma \longrightarrow \tilde{g}\tilde{g}$
  - Are loop induced, photon structure $[\mathcal{O}(\alpha)]$
  - Not included

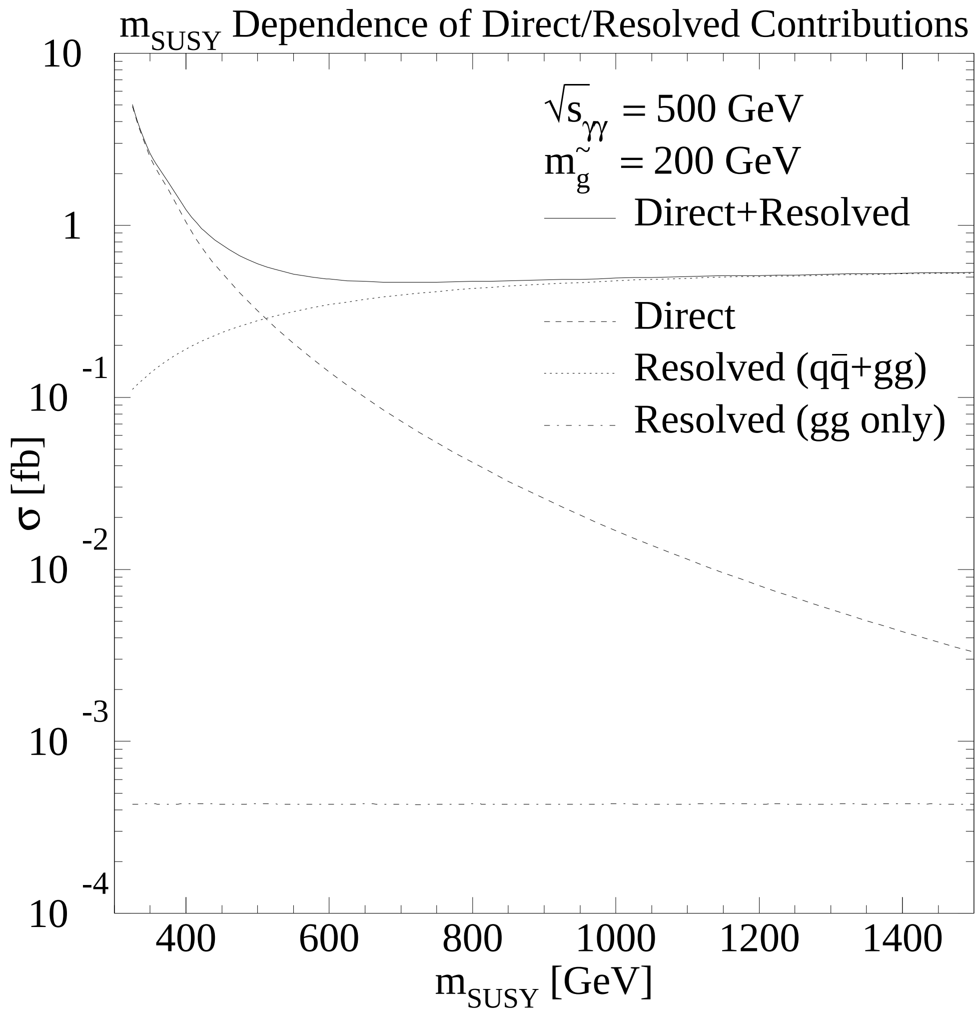
- Double resolved contributions are tree level diagrams

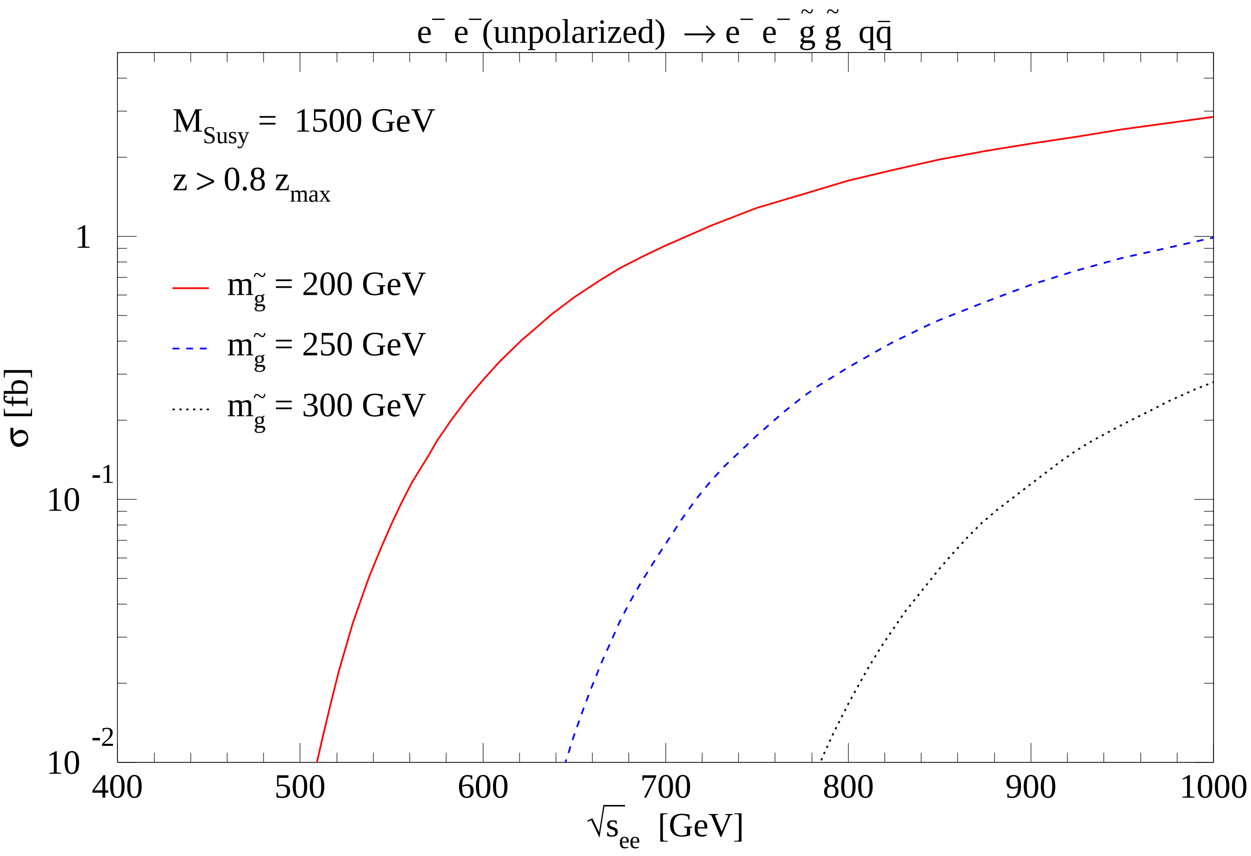
- $q\bar{q} \longrightarrow \tilde{g}\tilde{g}$ by gluon and squark exchange, depends on $m_{\tilde{q}}$ and $m_{\tilde{g}}$
- Destructive interference between s and t,u channel
  $\longrightarrow$ large $\sigma$ for large squark masses



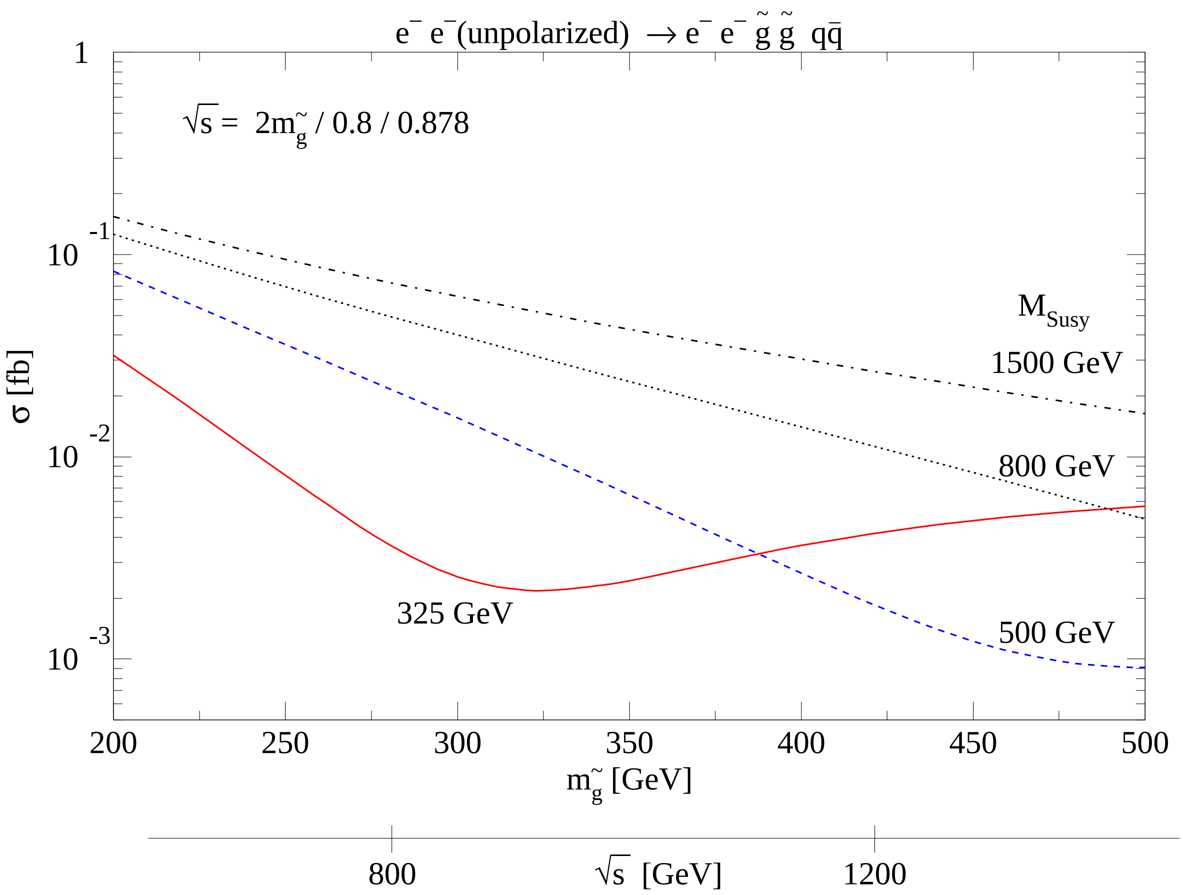

- $gg \longrightarrow \tilde{g}\tilde{g}$ by gluon and gluino exchange,
  depends only on gluino mass






Resolved contribution to the unpolarized electron-electron cross section.




Dependence of the resolved gluino pair production cross section in $\gamma\gamma$ collisions on gluino mass and the universal squark mass $M_{Susy}$.

## 6. Summary

- Assuming gluino masses up to 500 GeV and a photon luminosity of $\mathcal{L}_{\gamma\gamma} = 200 fb^{-1}$/year
- $E_{ee} = 2m_{\tilde{g}}/.8/.878$:
  - between 20 events for squarks of 800 GeV and 2000 events per year for light squarks of 325 GeV
  - about 20 events per year for heavy squarks (1500 GeV) by resolved contribution
- Resolved contribution O(1)fb for light gluinos (250 GeV) and heavy squarks for energies much larger than pair production threshold