Gluinonia: Energy Levels, Production and Decay

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Overview

- Motivation

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- Introduction

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- Spectroscopy

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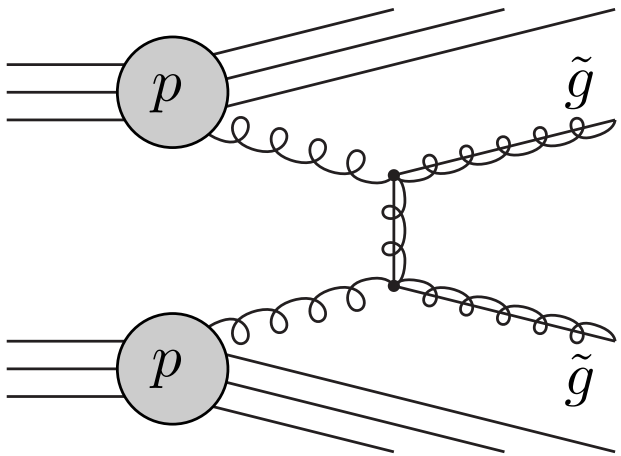

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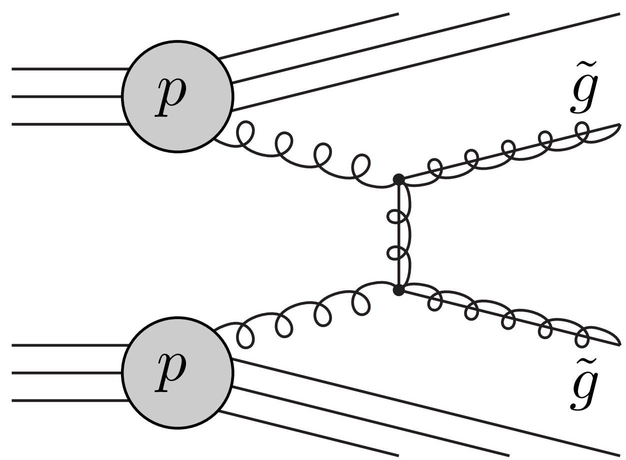

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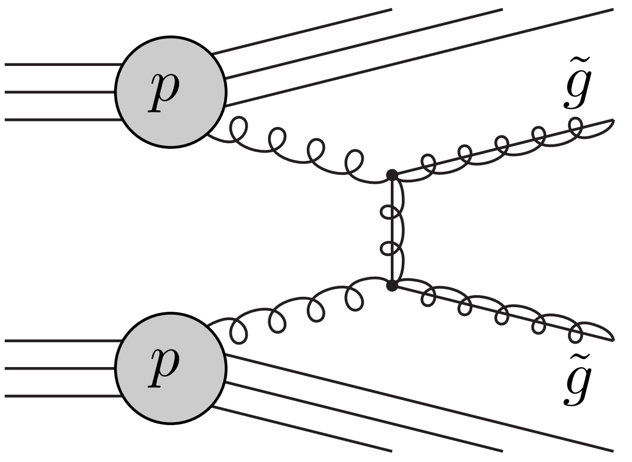

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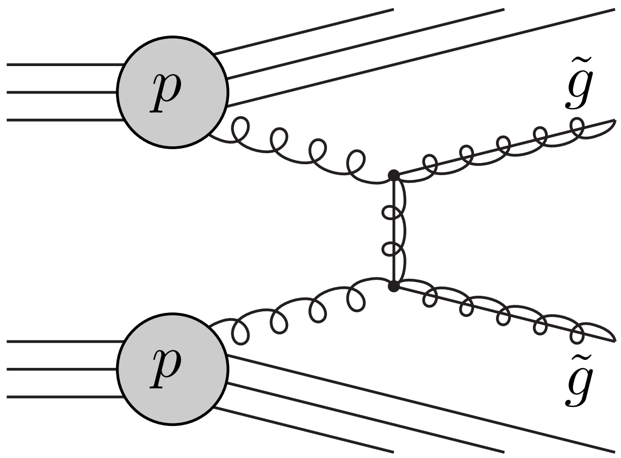

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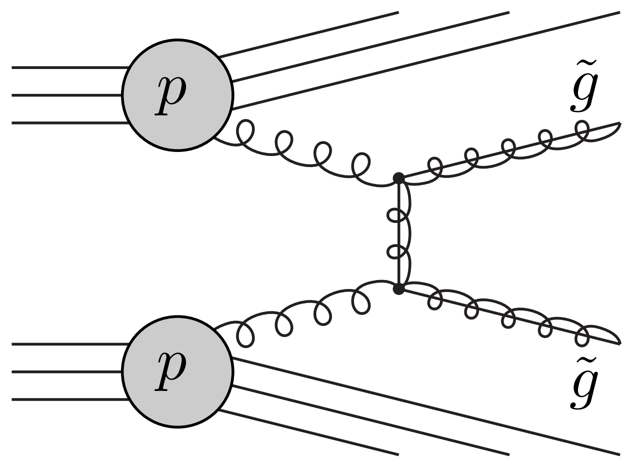

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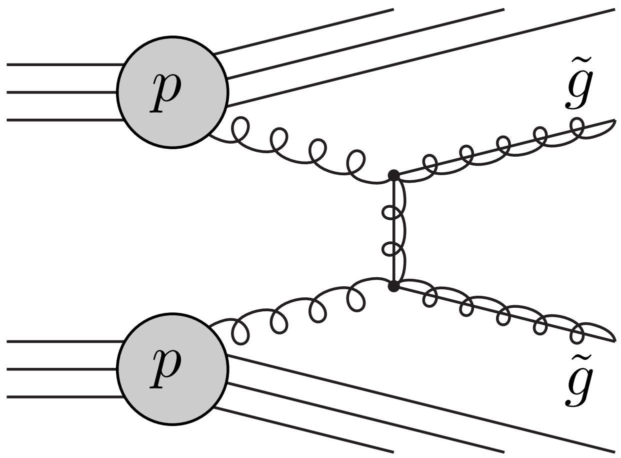

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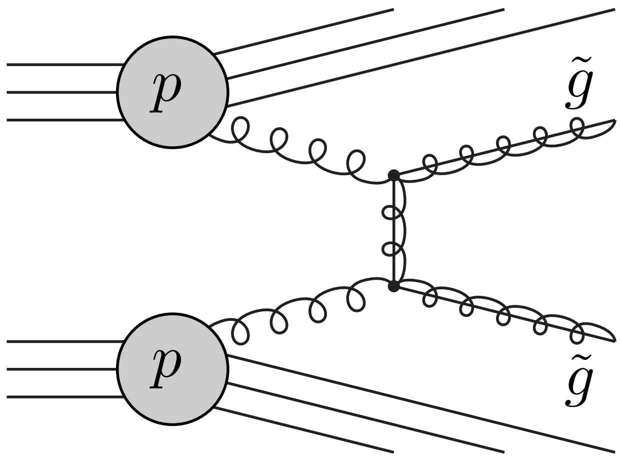

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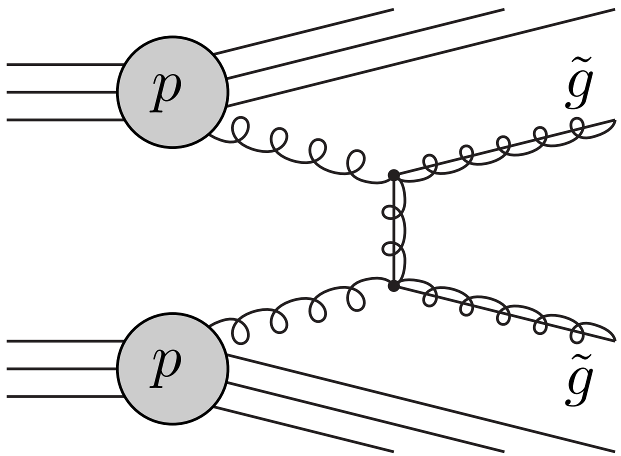

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– $m_{\tilde{g}} > 308$ GeV [PDG 2008]

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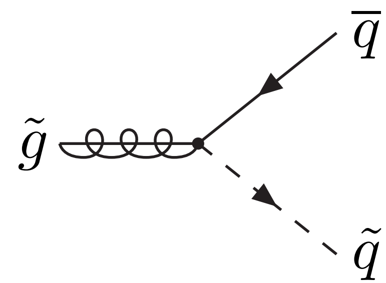

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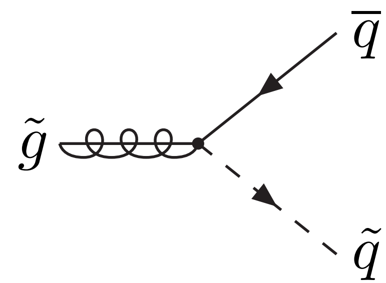

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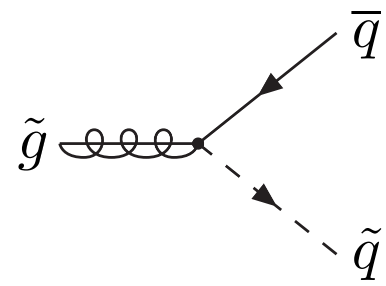

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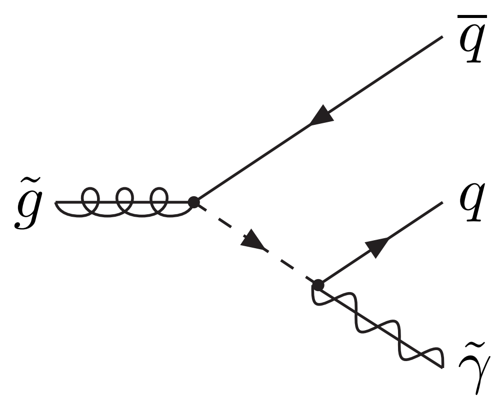

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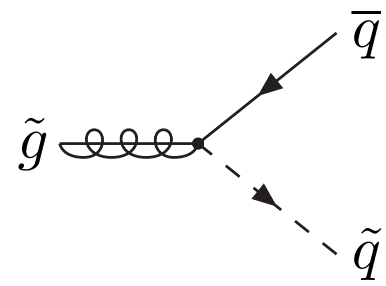

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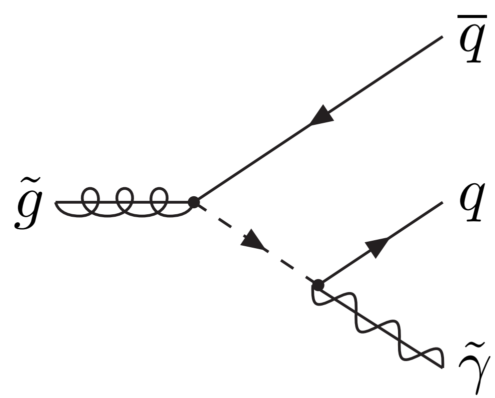

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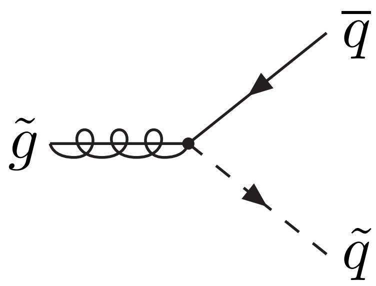

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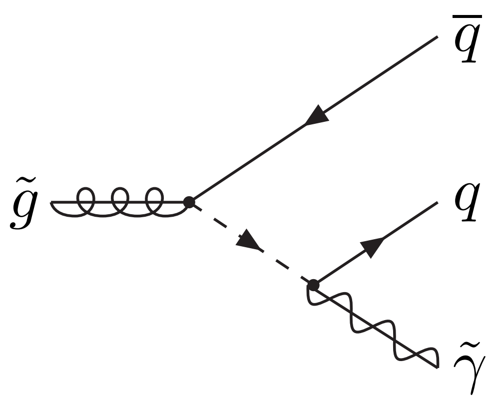

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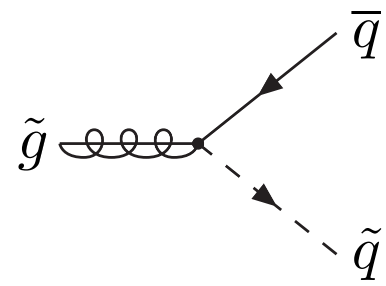

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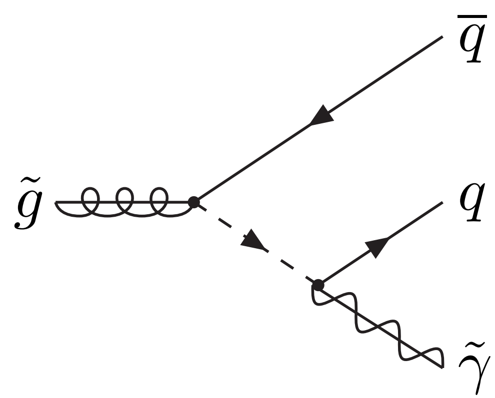

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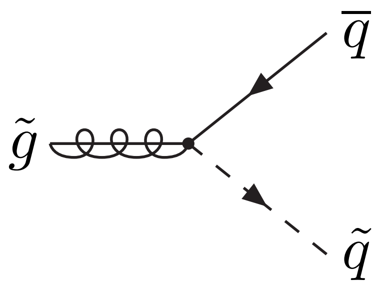

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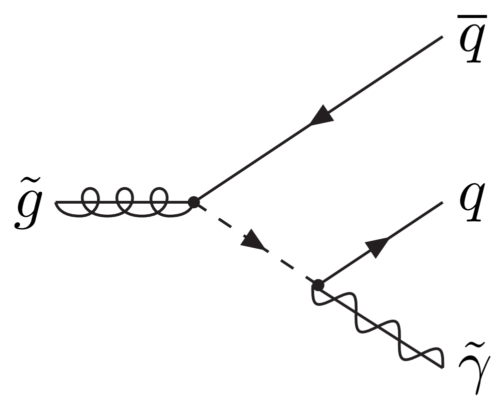

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similar to Quarkonia

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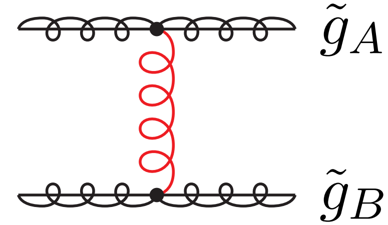

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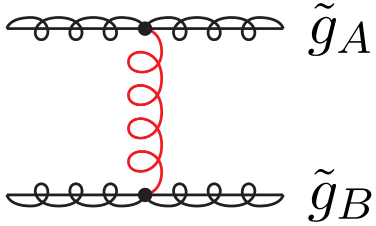

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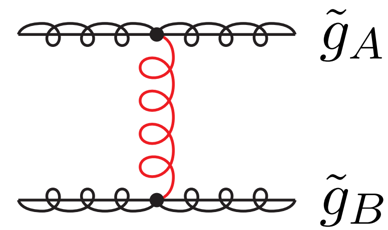

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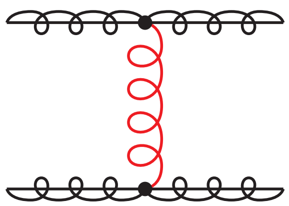

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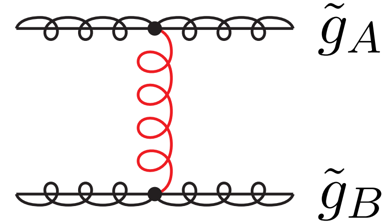

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[J.Kühn, J.Kaplan and E.Safiani '79; B.Guberina, J.Kühn, R.Peccei and R.Rückl '80]

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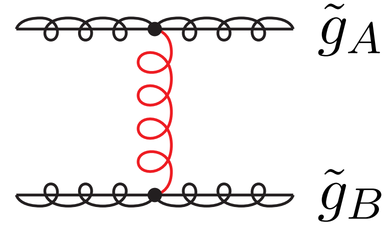

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in the following: 1_S state only $(S = L = 0)$

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- description of the force between the two constituents through an adequate potential

$\longrightarrow$ modification of existing $q\bar{q}$ potentials for $\tilde{g}\tilde{g}$

[W.Fischler '77; B.Kniehl, A.Penin, V.Smirnov and M.Steinhauser '02; . . .]

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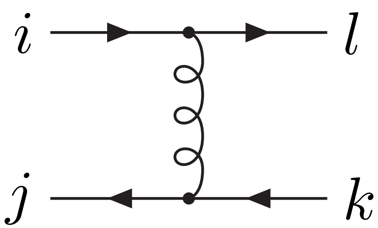

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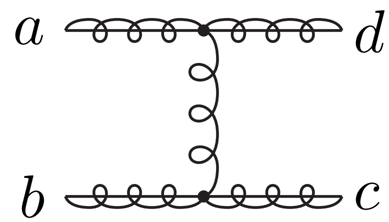

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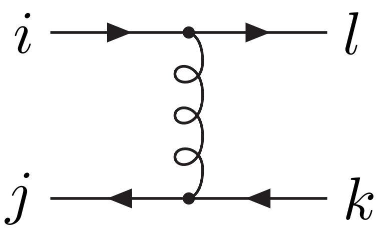

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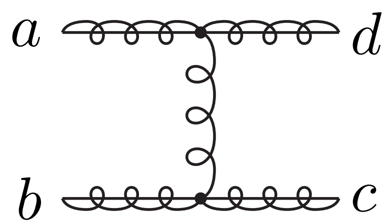

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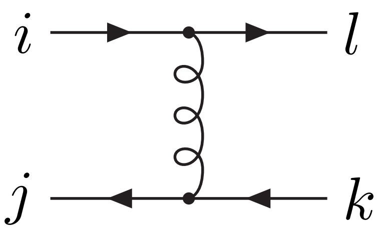

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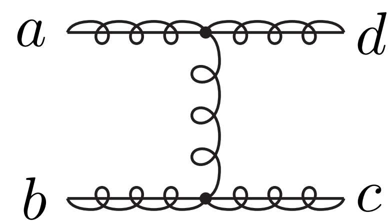

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[M.Kauth, J.Kühn, P.Marquard and M.Steinhauser '09]

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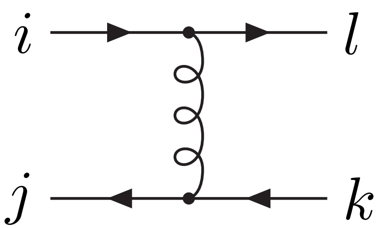

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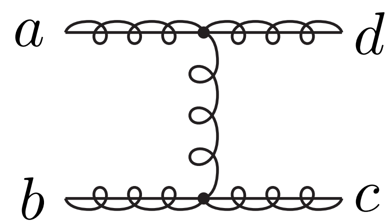

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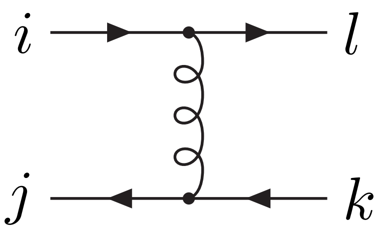
- solving the non-relativistic Schrödinger equation through numerics and perturbation theory

Spectroscopy I

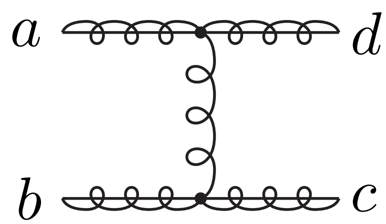
- description of the force between the two constituents through an adequate potential

  $\longrightarrow$ modification of existing $q\bar{q}$ potentials for $\tilde{g}\tilde{g}$

  [W.Fischler '77; B.Kniehl, A.Penin, V.Smirnov and M.Steinhauser '02; ...]



$$\times \frac{\delta_{ij}}{\sqrt{N_C}} \frac{\delta_{kl}}{\sqrt{N_C}} = C_F \qquad \longrightarrow$$



$$\times \frac{\delta_{ab}}{\sqrt{N_C^2-1}} \frac{\delta_{cd}}{\sqrt{N_C^2-1}} = C_A$$

- overall factor: $C_F \to C_A$ (up to NNLO)

$$\Rightarrow \quad V_{\tilde{g}\tilde{g}}(\vec{r}) \quad = \quad -\frac{C_A \alpha_s}{r} + \mathcal{O}(\alpha_s^2)$$

[M.Kauth, J.Kühn, P.Marquard and M.Steinhauser '09]

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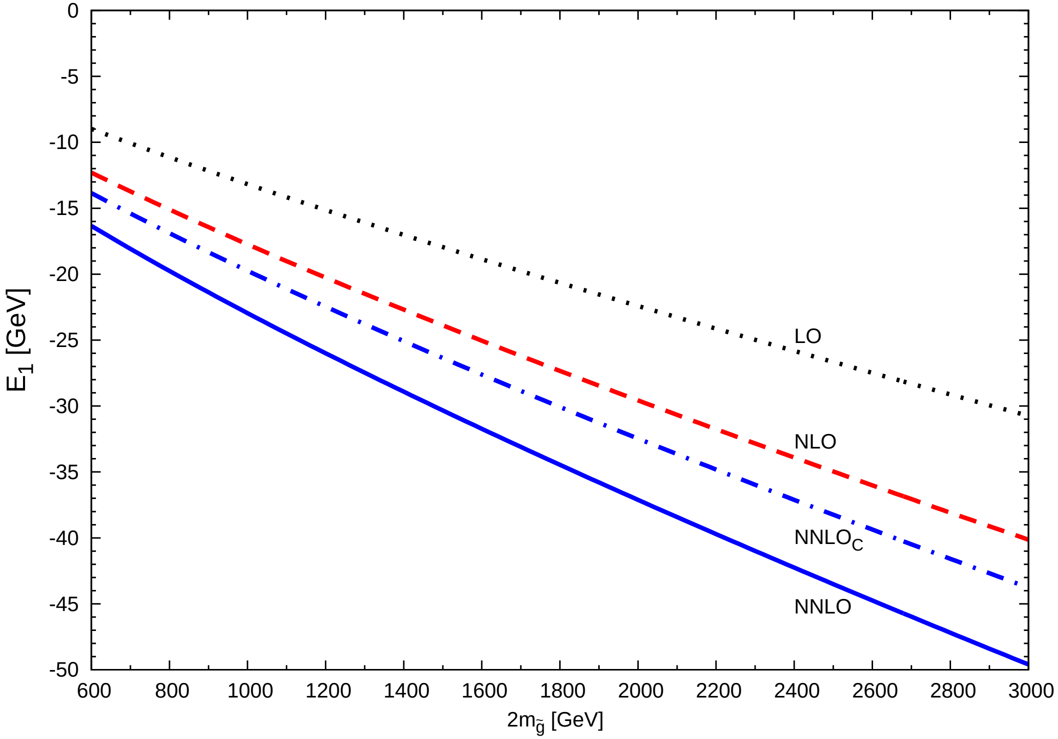
  1. wavefunction for decay and production

Spectroscopy II

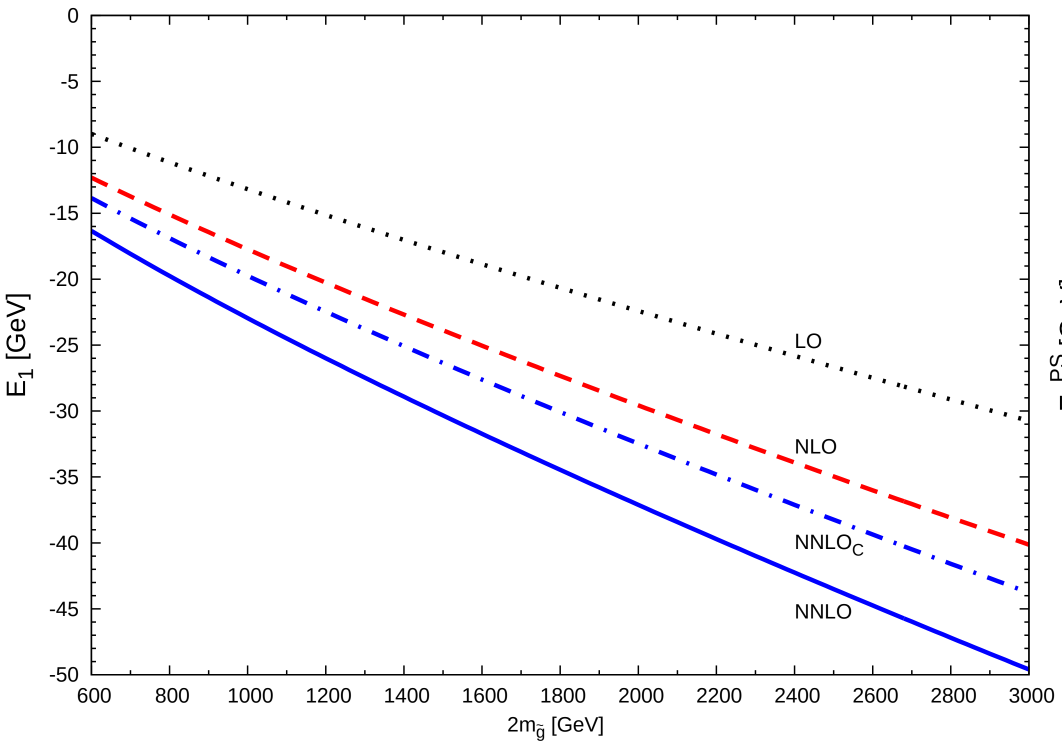
2. energy eigenvalues in the pole

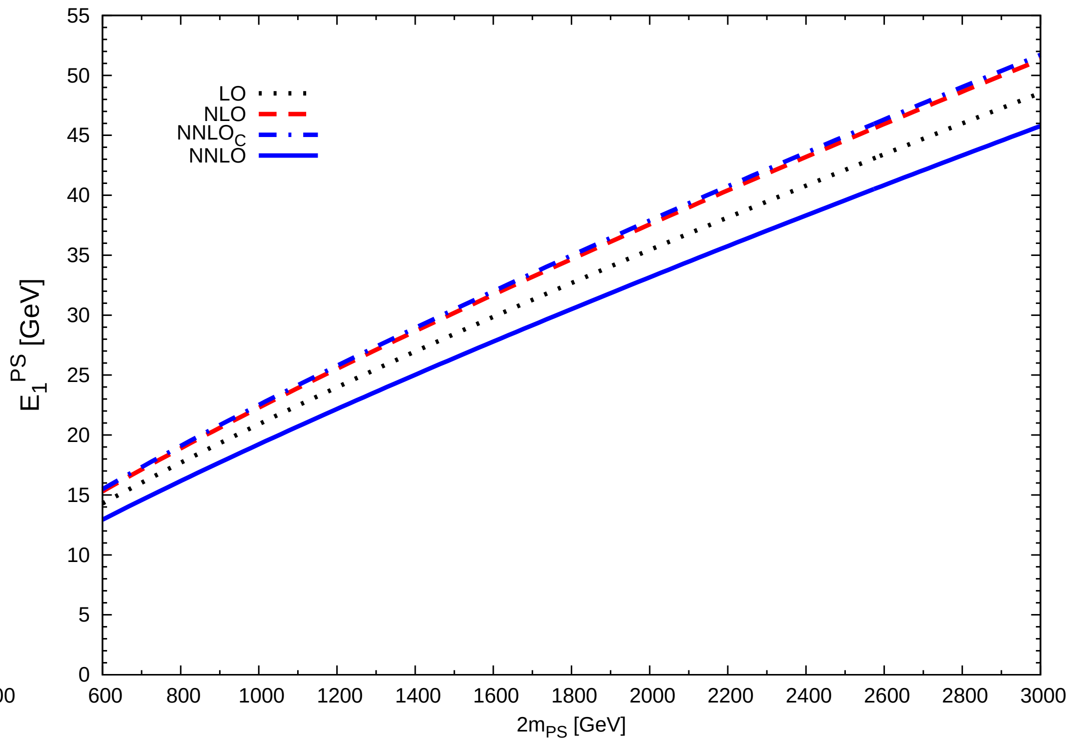


Spectroscopy II

2. energy eigenvalues in the pole and the PS scheme:

[M.Beneke '98]





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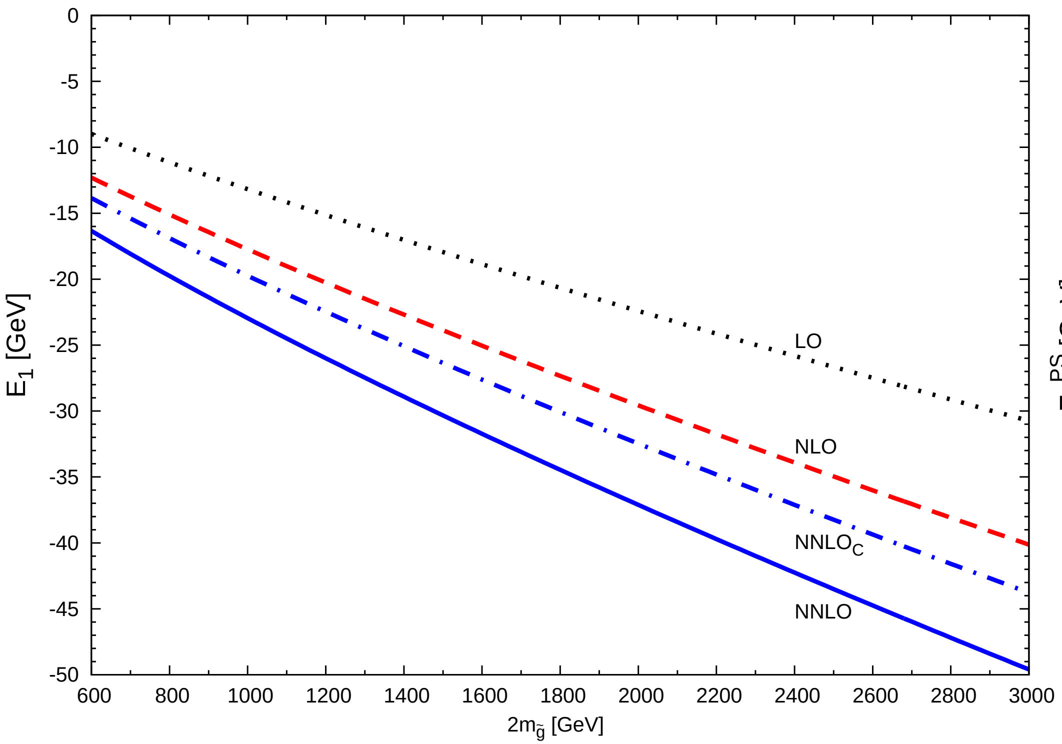

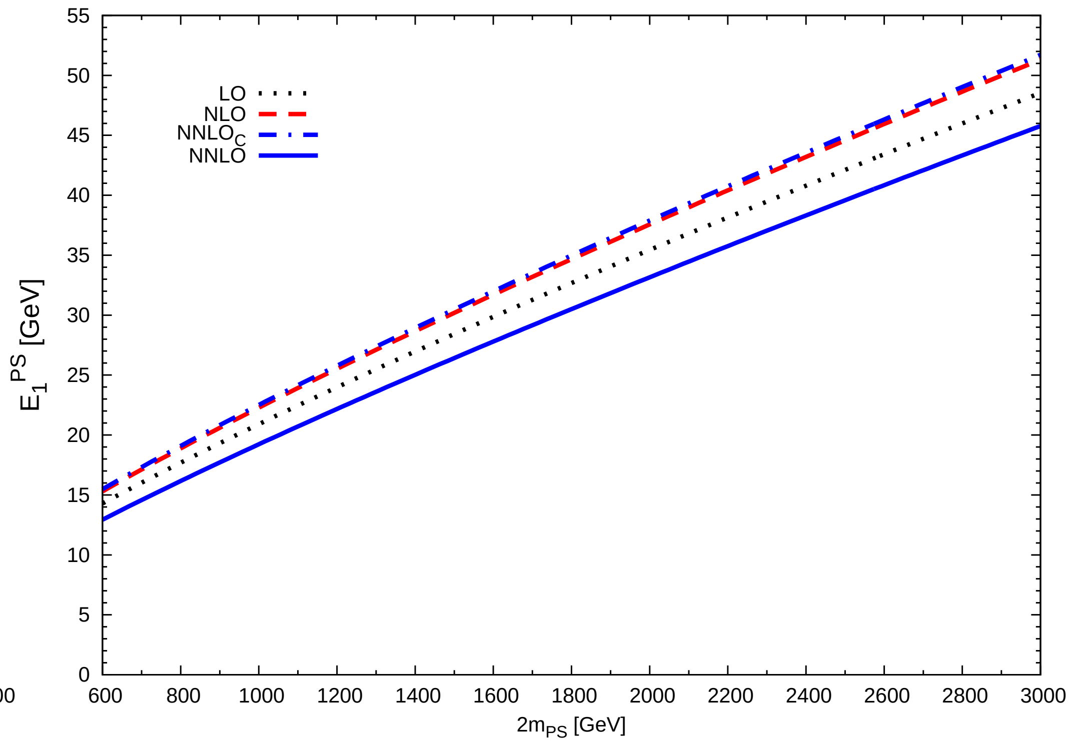

$$M_{(\tilde g \tilde g)_{1S}} = 2m_{\tilde g} + E_1 \quad \text{(Meson mass)}$$

$m_{\tilde g}$ and E_1 separately scheme dependant

Spectroscopy III

- excitation energy between the $1S$ and the $2S$ state

$$\Delta M = M(2S) - M(1S) = (1 - \tfrac{1}{4})\frac{C_A^2 \alpha_s^2}{4} m_{\tilde{g}}$$

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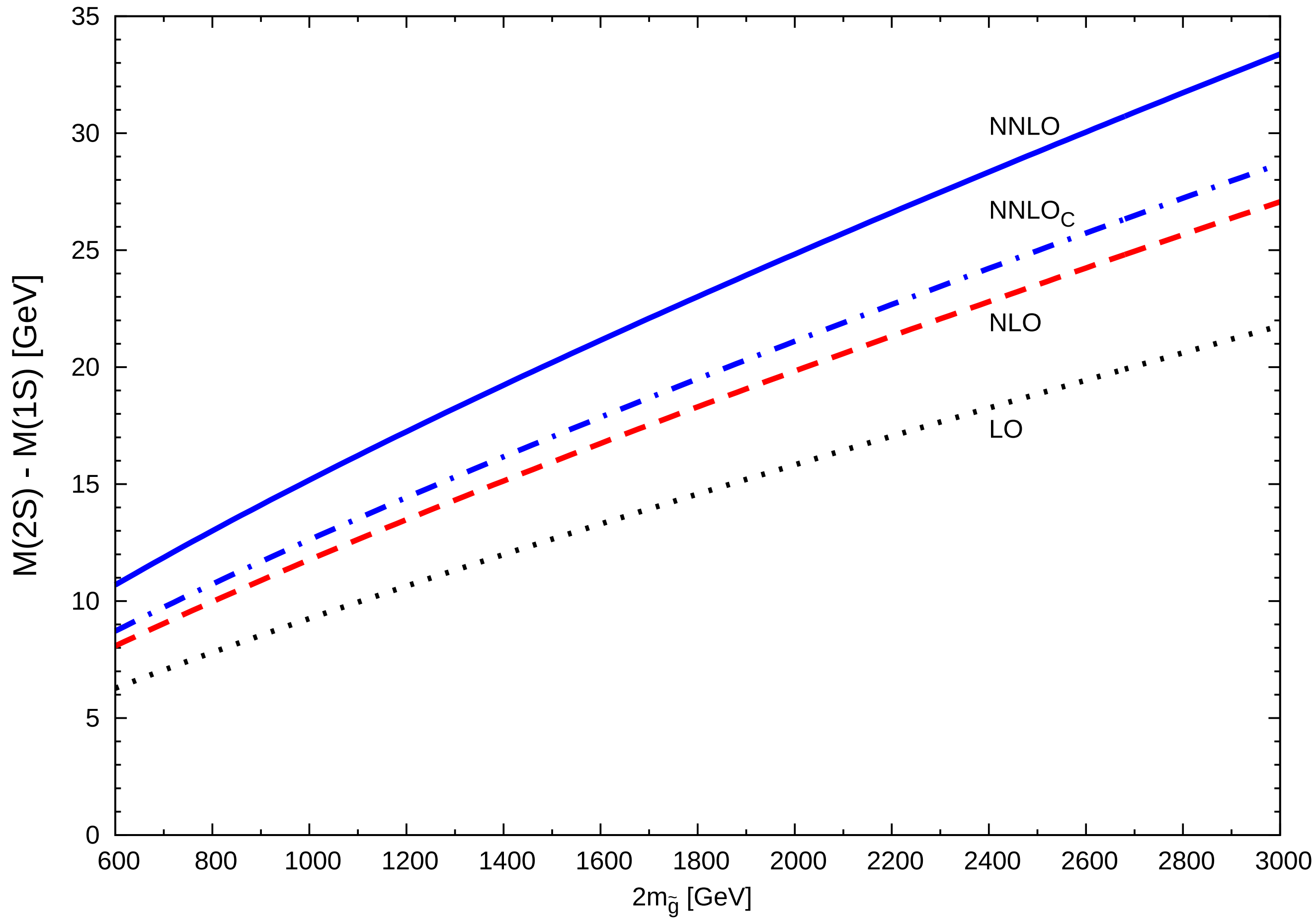
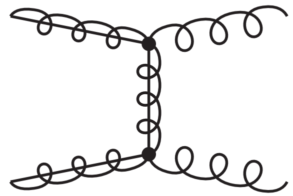
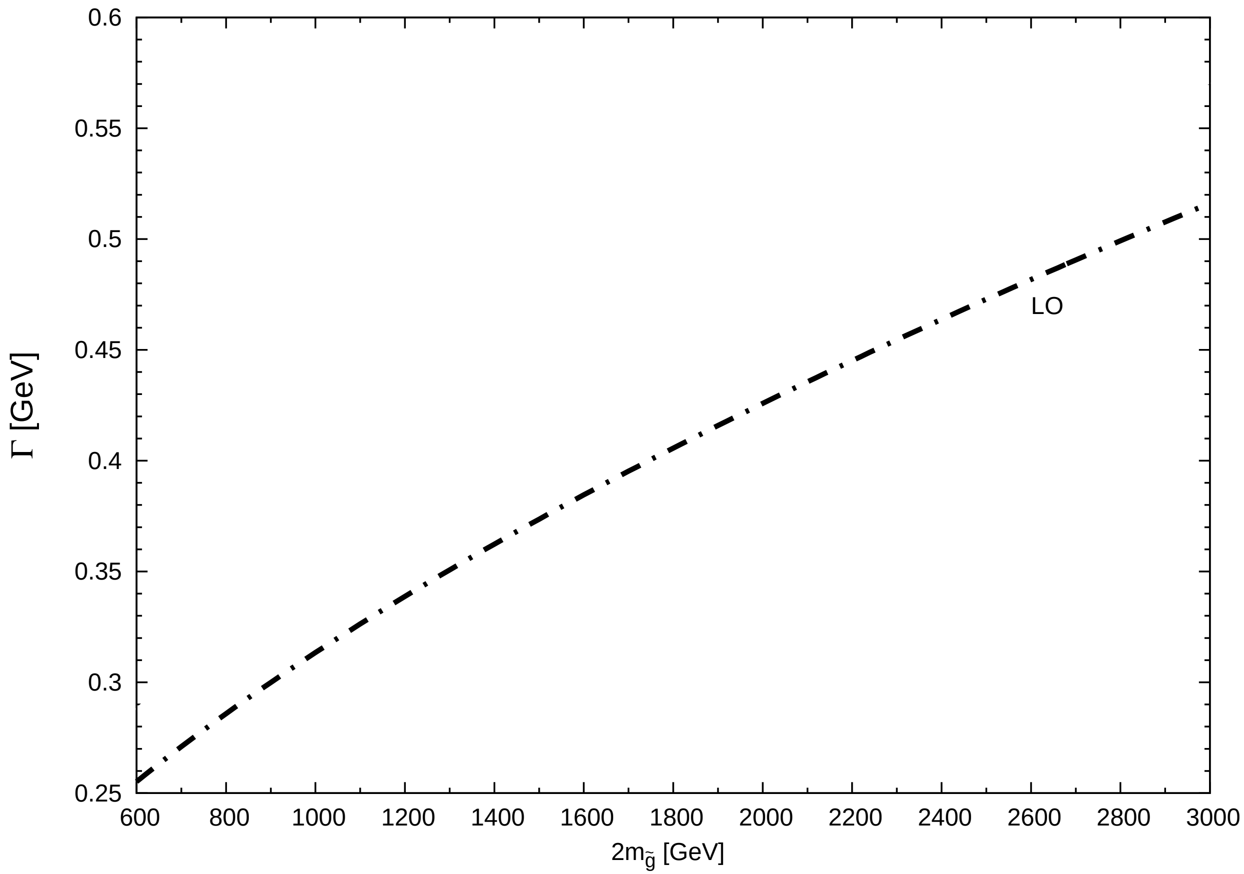


Decay I

- hadronic decay channel

$$\Gamma((\tilde{g}\tilde{g})_{1_s} \to gg) = |R(0)|^2 \frac{C_A^2 \alpha_s(\mu_r)^2}{2m_{\tilde{g}}^2}$$





	wavefunction	hard part
μ	$\mu_S = C_A \alpha_s m_{\tilde{g}}$	$\mu_H = 2m_{\tilde{g}}$
n_f	5	6

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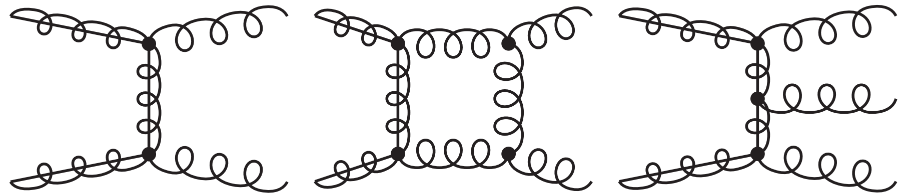

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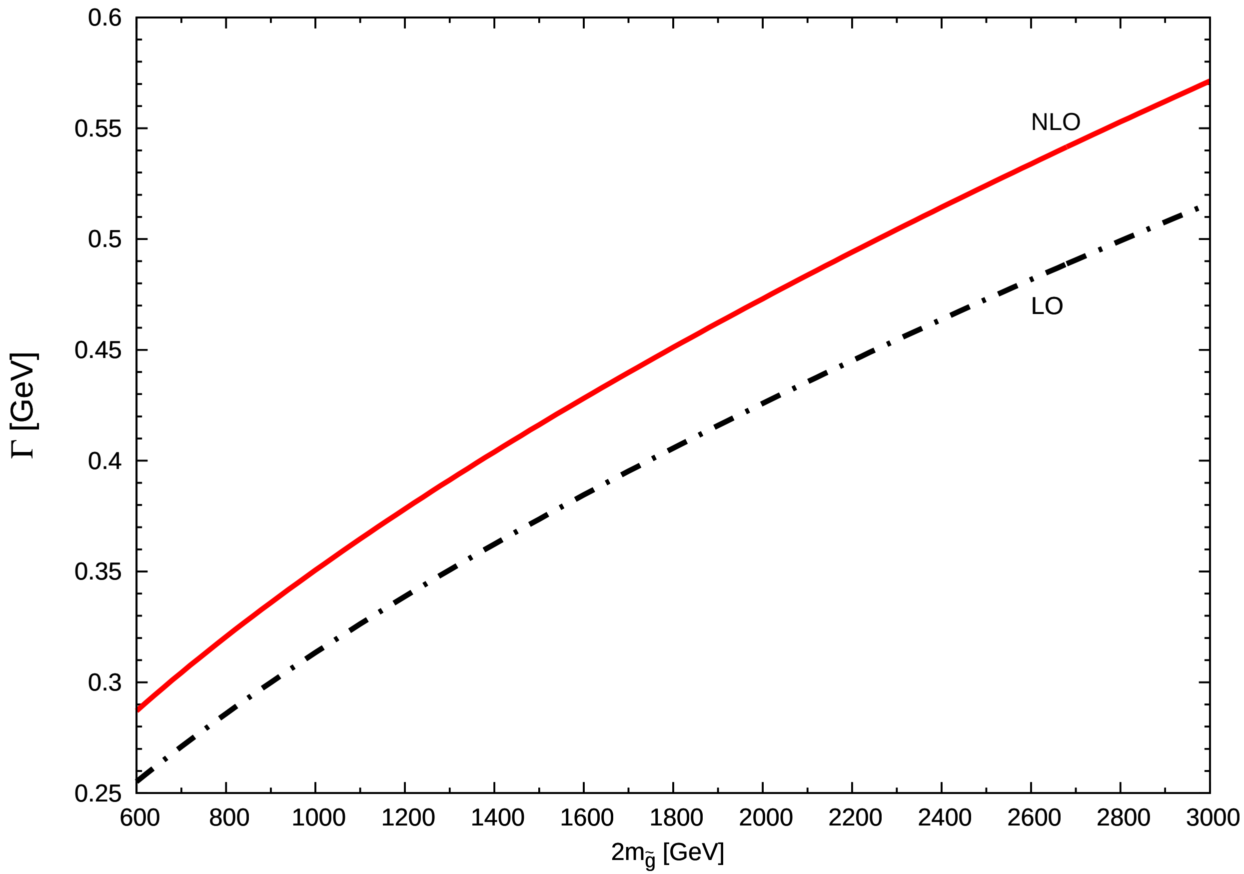
$$\times \left\{ 1 + \frac{\alpha_s(\mu_r)}{\pi} \left[C_A \left(\frac{108}{18} - \frac{7}{24}\pi^2 \right) - \frac{16}{9} n_f T_F + \left(\frac{11}{6} C_A - \frac{2}{3} n_f T_F \right) \ln\left(\frac{\mu_r^2}{4m_{\tilde{g}}^2} \right) \right] \right\}$$



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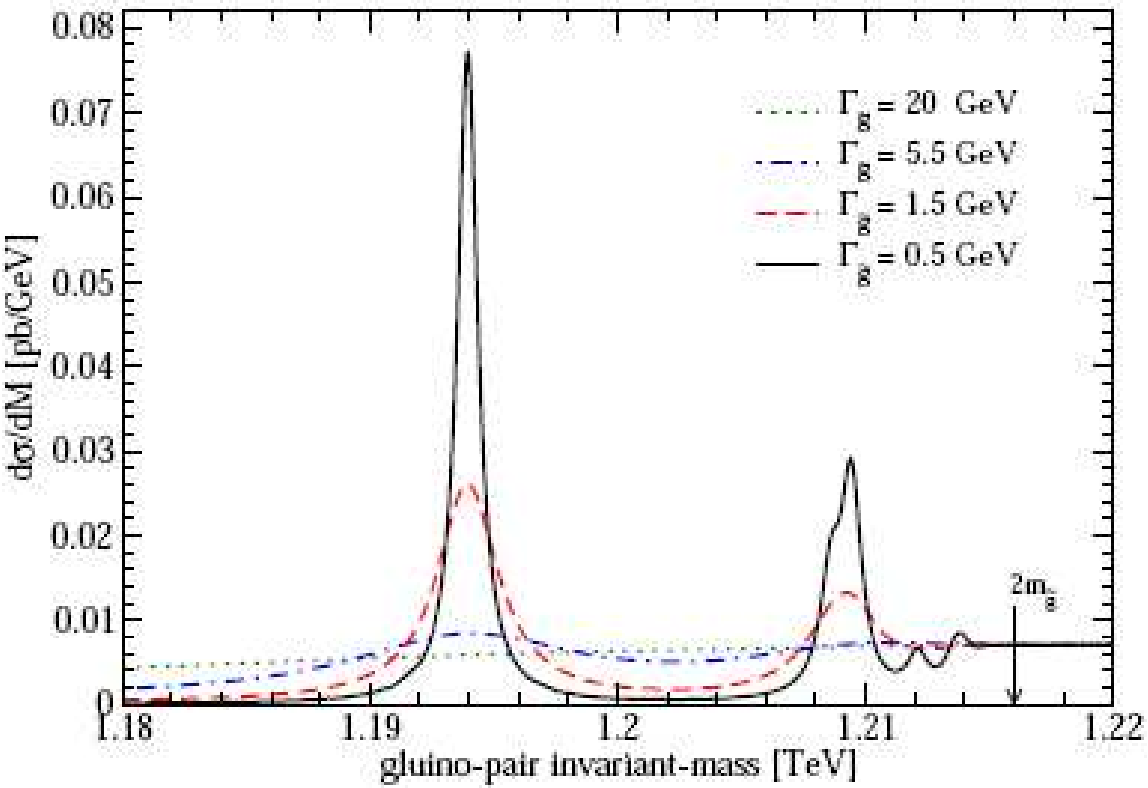
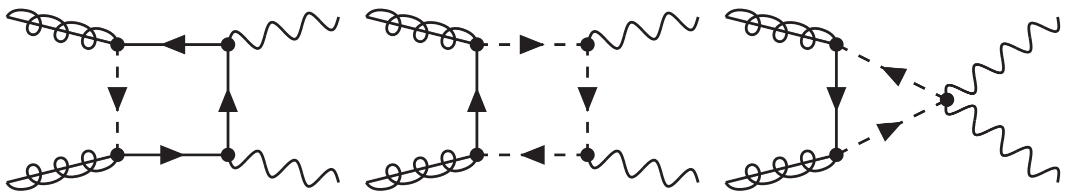


"Bound-state effects on gluino pair-production at hadron colliders"
[Hagiwara and Yokoya 2009]
arXiv : 0909.3204v2

$m_{\tilde{g}} = 608$ GeV

Decay III

- decay into 2 photons $\left(z = m_{\tilde{g}}^2/m_{\tilde{q}}^2\right)$



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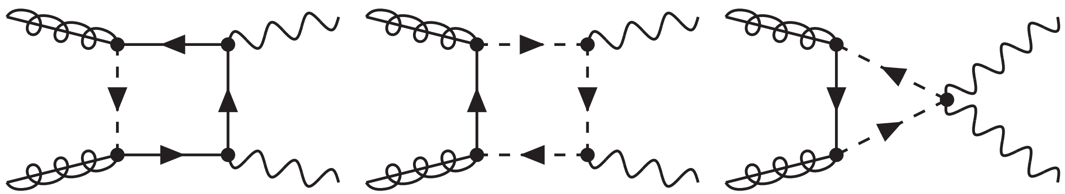

$$\mathrm{Br}(\gamma\gamma) = \frac{\Gamma((\tilde{g}\tilde{g})_{1_s} \to \gamma\gamma)}{\Gamma((\tilde{g}\tilde{g})_{1_s} \to gg)} = 4\frac{T_F}{C_A^2}\frac{\alpha^2}{\pi^2}\left(\sum_f Q_f^2\right)^2 (\mathrm{Li}_2(-z) - \mathrm{Li}_2(z))^2$$

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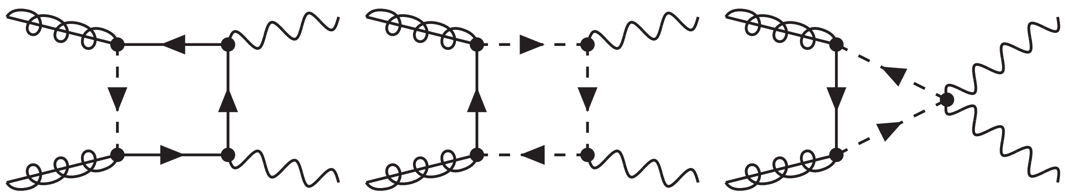

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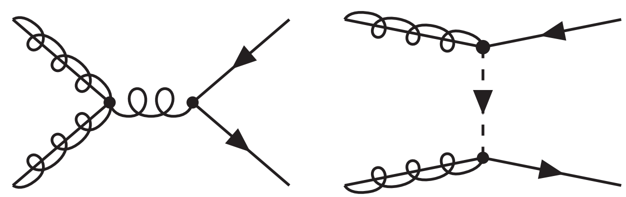

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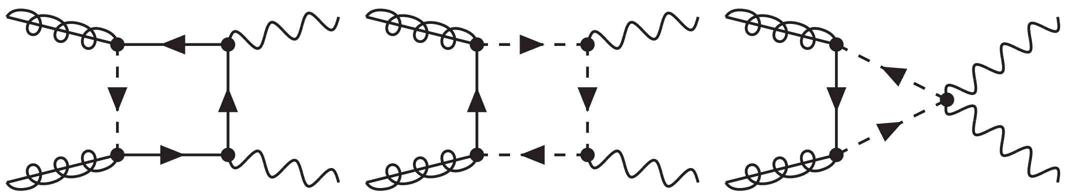

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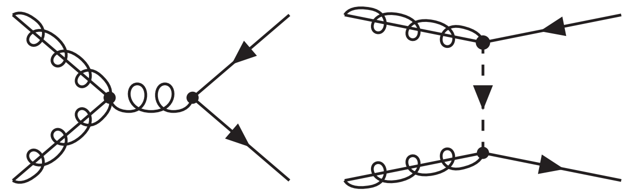

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$$\sim 0.05 \quad \text{for} \quad m_{\tilde{g}} \sim 300\,\text{GeV} \lesssim m_{\tilde{q}}$$

Production I

- hadronic production

$$\sigma(S) = \sum_{ab} \int_0^1 dx \int_0^1 dy\, f_a^p(x,\mu_f^2) f_b^p(y,\mu_f^2) \hat{\sigma}_{ab}(s = xyS)$$

with $\mu_f = \mu_r = \mu_H$ and $\sqrt{S} = 14$ TeV (LHC)

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PDF: MSTW2008(N)LO (formerly MRST)

[A.Martin, W.Stirling, R.Thorne and G.Watt '09]

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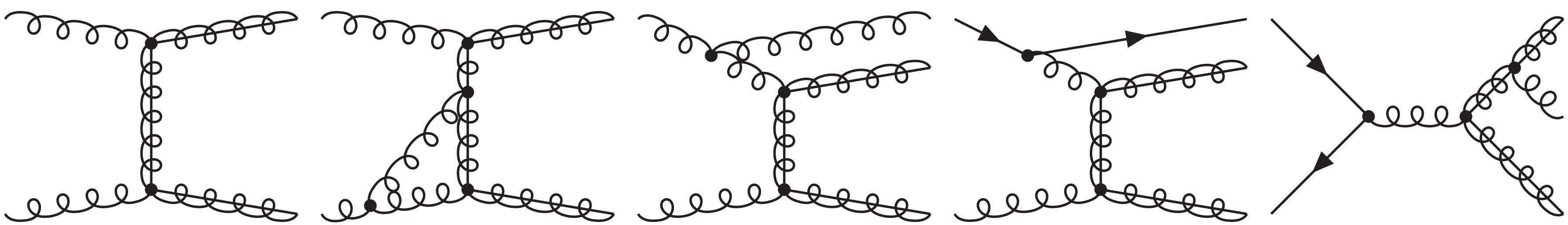

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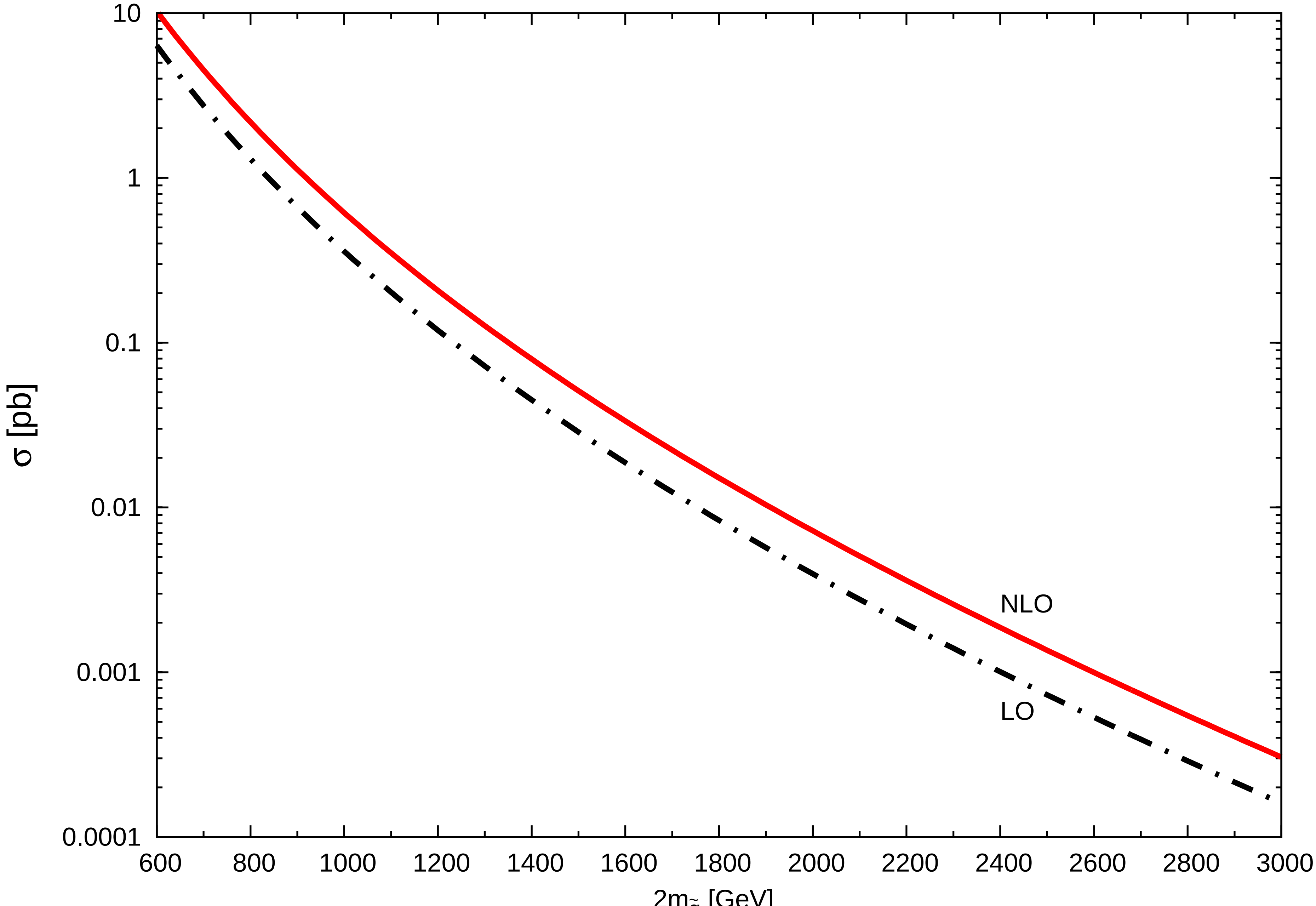

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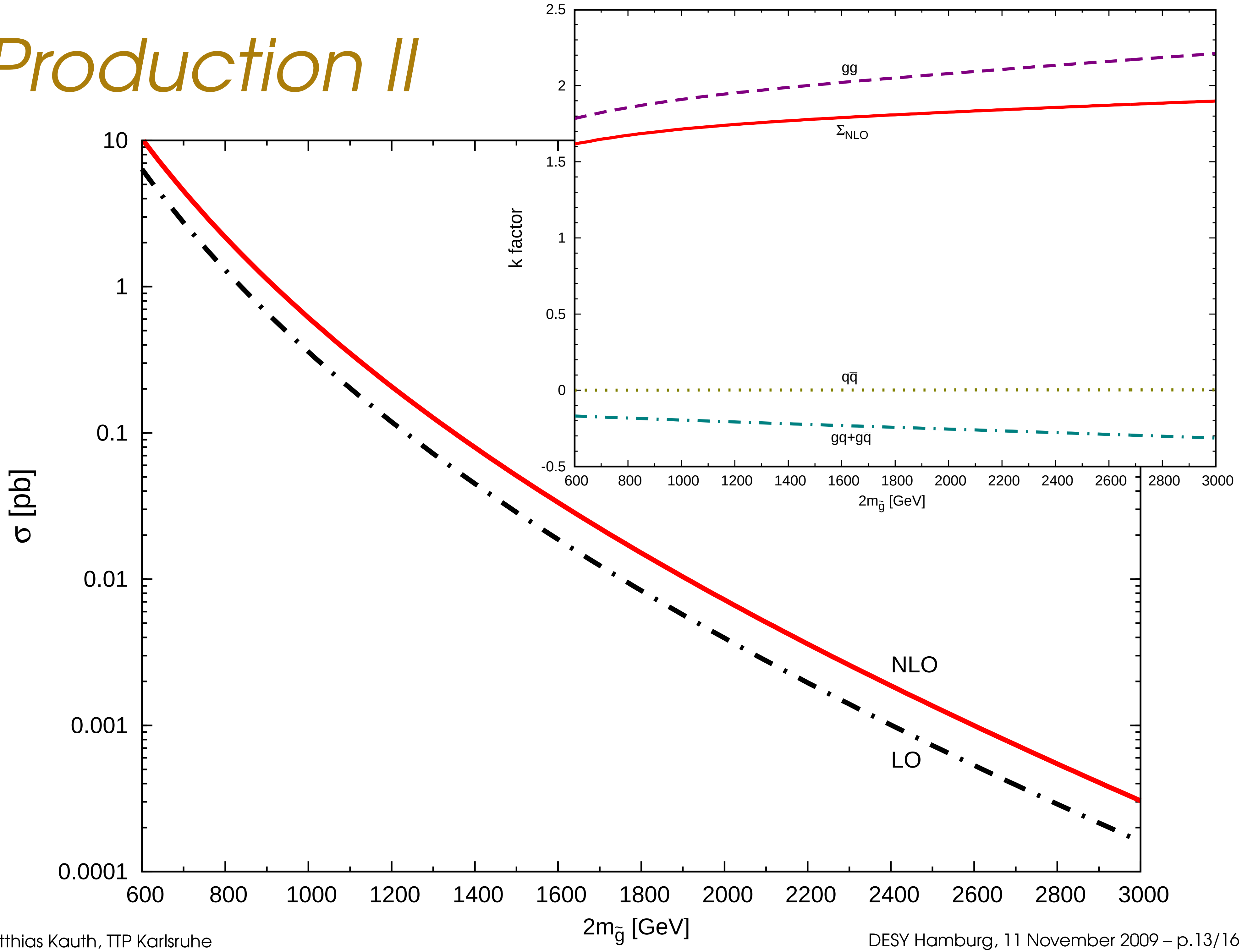
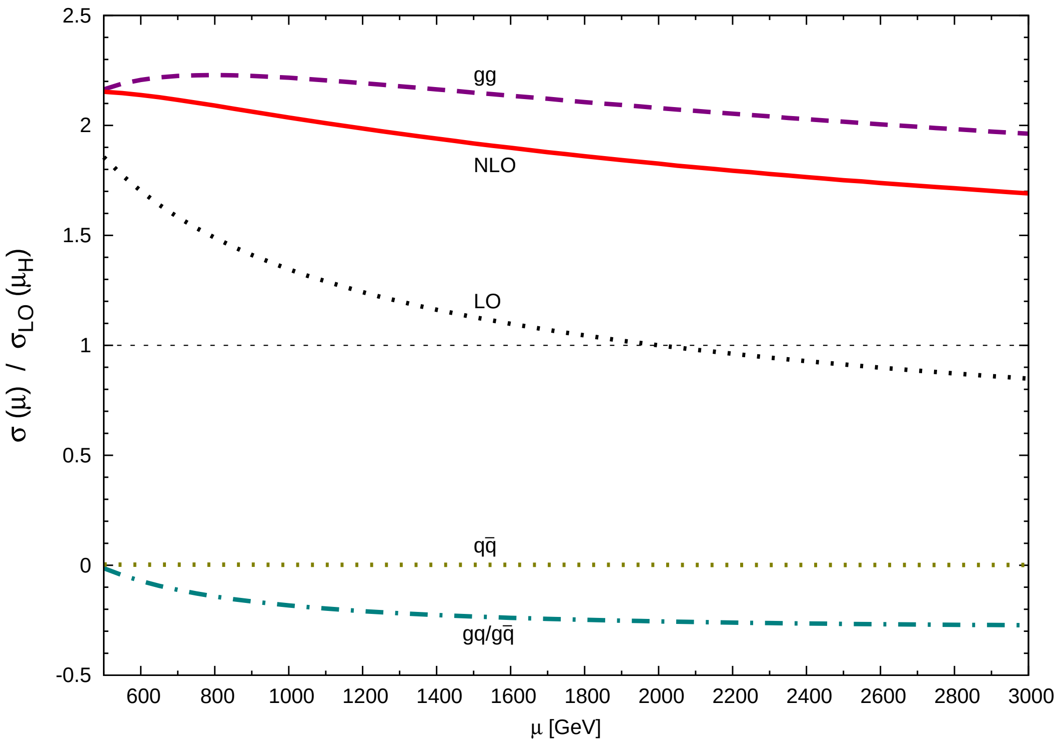


Production III

- scale dependence of the production cross section

for $m_{\tilde{g}} = 1000\,\text{GeV}$



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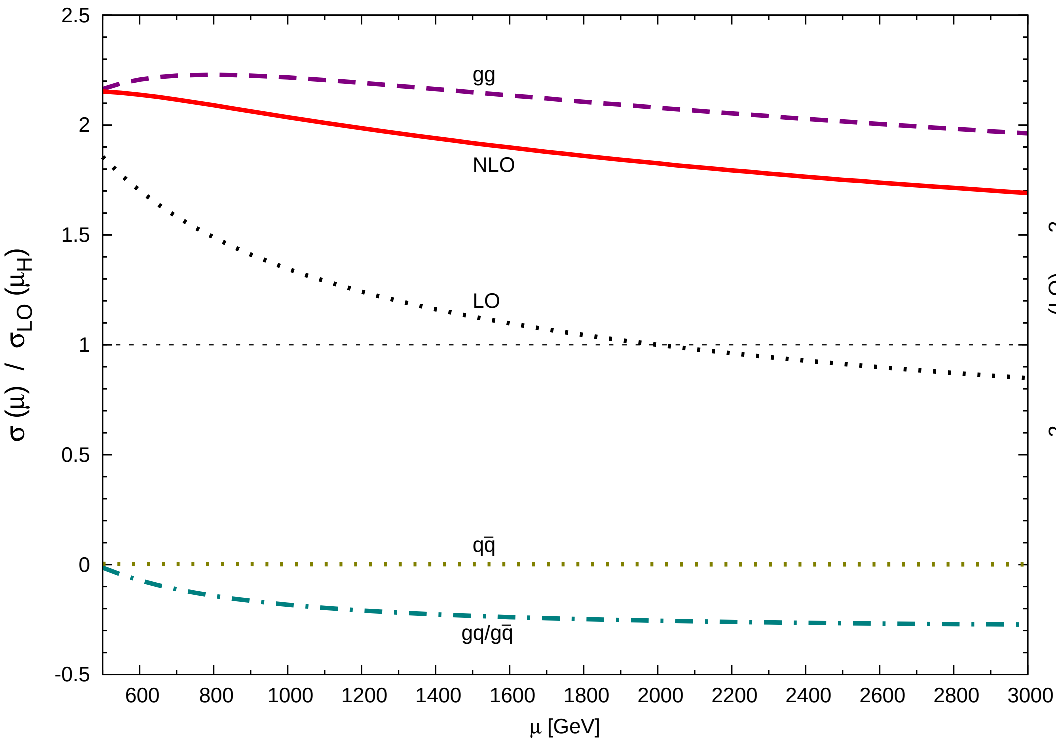

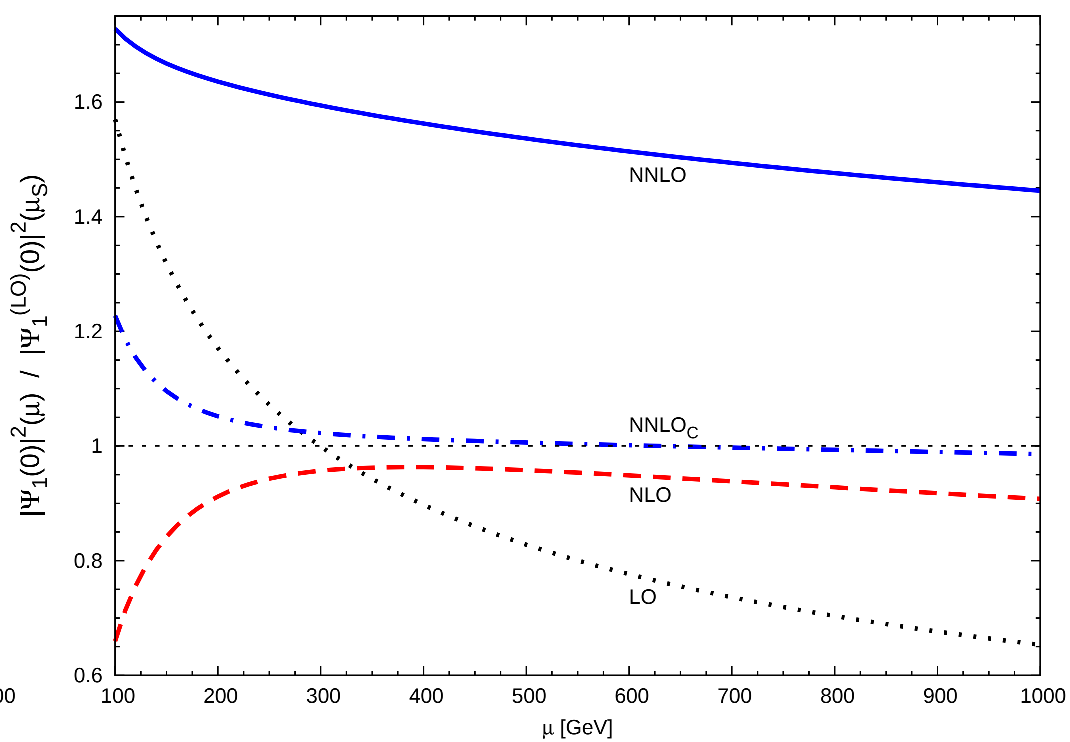

$$\mu_H = 2m_{\tilde{g}} = 2000\,\text{GeV}$$

$$\mu_S = C_A m_{\tilde{g}} \alpha_s(\mu_S) \simeq 300\,\text{GeV}$$

Background

- isolation of the signal from the two-jet continuum

$$\underbrace{\frac{d\sigma}{d\theta}\,(\,gg \to (\tilde{g}\tilde{g})_{1_s} \to gg\,)}_{\text{Signal}} \quad \text{versus} \quad \underbrace{\frac{d\sigma}{d\theta}\,(\,gg \to gg\,)}_{\text{Noise}}$$

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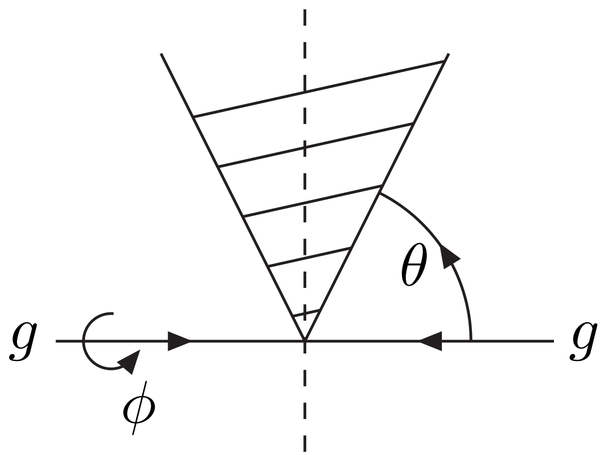

$$\longrightarrow \quad |\cos(\theta)| \leq z < 1$$

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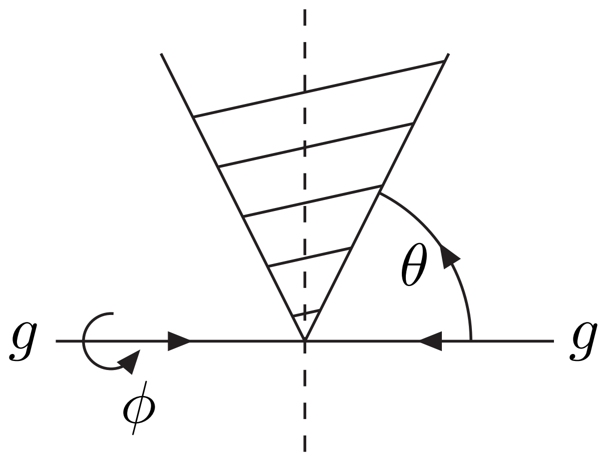

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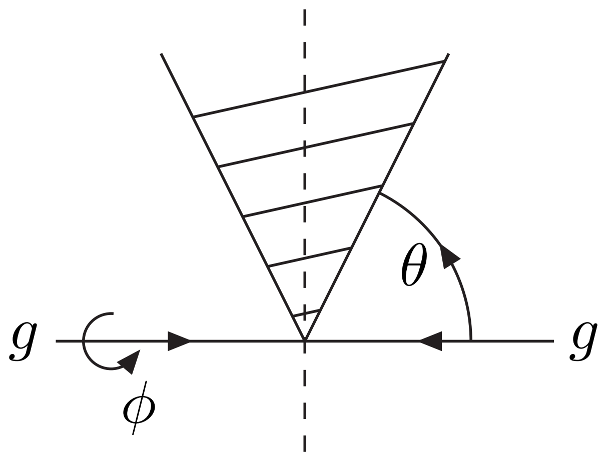

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$\Delta M / M_{jj} = 0.038 + 38/M_{jj}$ [CMS collaboration 2007]

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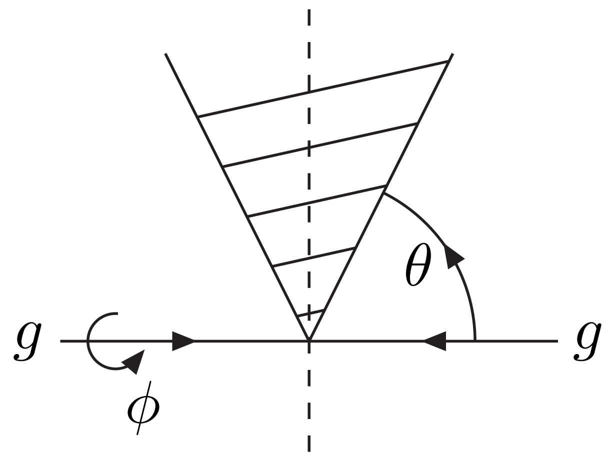

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$$\Delta M/M_{jj} = 0.038 + 38/M_{jj} \qquad [\texttt{CMS collaboration 2007}]$$

$\Rightarrow$ Signal/Noise $\sim 0.4 \ldots 0.7\,\%$ for $1/4 < z < 1/2$

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Thank you for your attention!