$t\bar{t}$ Asymmetry

Ph.D. seminar 2011

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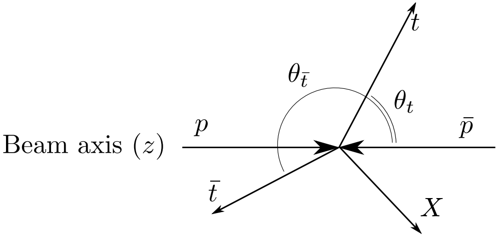

In any reference frame we may define the *total asymmetry* by

$$A = \int \mathrm{d}\cos\theta \frac{N_t(\cos\theta) - N_{\bar{t}}(\cos\theta)}{N_t(\cos\theta) + N_{\bar{t}}(\cos\theta)} = \int \mathrm{d}\cos\theta \frac{N_t(\cos\theta) - N_t(-\cos\theta)}{N_t(\cos\theta) + N_t(-\cos\theta)}.$$

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Remark: Charge asymmetry has here nothing to do with charge non-conservation, it is only a consequence of the asymmetry of the initial state.

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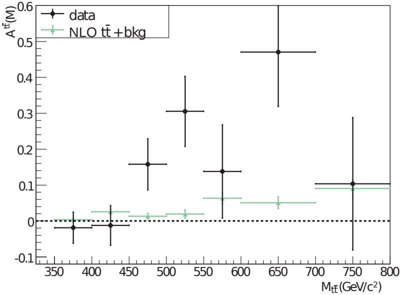
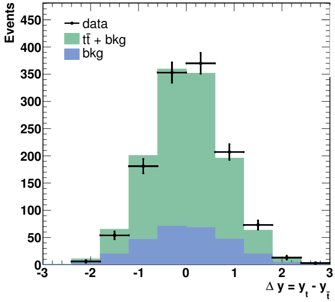
$$\text{CDF:} \qquad A^{t\bar{t}} = 0.158 \pm 0.075$$

$$\text{MC@NLO:} \qquad A^{t\bar{t}} = 0.058 \pm 0.009$$

[arXiv:1101.0034v1]





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$$\text{D}\emptyset: \quad A^{t\bar{t}} = 0.092 \pm 0.037$$

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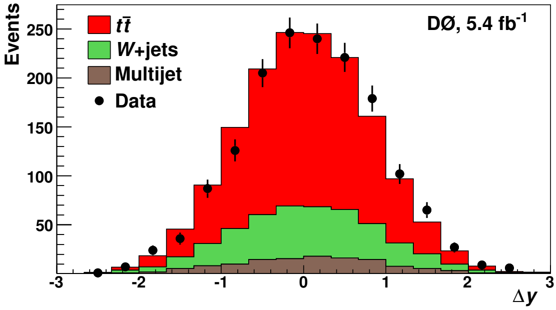
[arXiv:1107.4995v1]



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	Exp.	MC	Exp.	MC
$M_{t\bar{t}} \geq 450\,\text{GeV}$	0.475 ± 0.114	0.088 ± 0.013	0.115 ± 0.060	0.043 ± 0.013
$M_{t\bar{t}} < 450\,\text{GeV}$	-0.116 ± 0.153	0.040 ± 0.006	0.078 ± 0.048	0.013 ± 0.006
$\lvert\Delta y\rvert \geq 1$	0.611 ± 0.256	0.123 ± 0.008	0.213 ± 0.097	0.063 ± 0.016
$\lvert\Delta y\rvert < 1$	0.026 ± 0.118	0.039 ± 0.006	0.061 ± 0.041	0.014 ± 0.006
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Only a $\sim 2\sigma$ deviation seems to be confirmed by both experiments.

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I will only present here the details of the NLO QCD calculation and show that a lot of simplifications are possible compared to a fully differential NLO calculation.

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\end{aligned}
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and we see that indeed only the antisymmetric (under momentum exchange $p_3 \leftrightarrow p_4$) part of the amplitude squared $\overline{|\mathcal{M}|^2}$ is needed.

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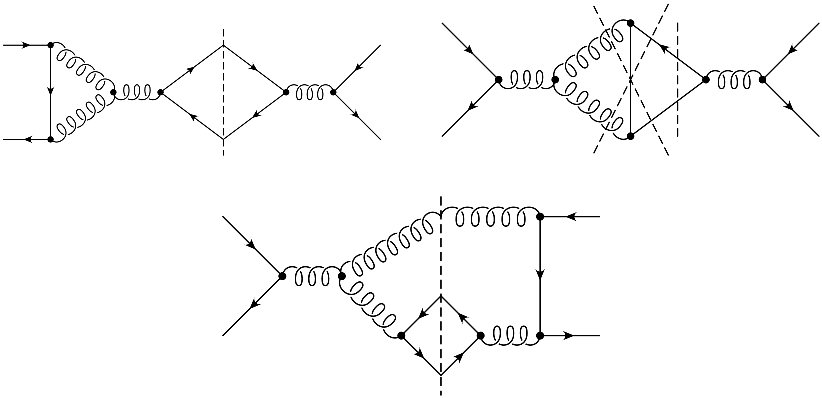
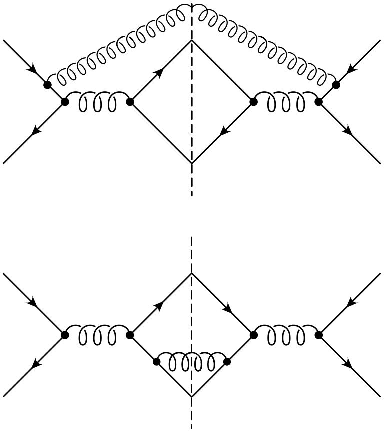


SYMMETRIC: Initial-initial and final-final radiations.



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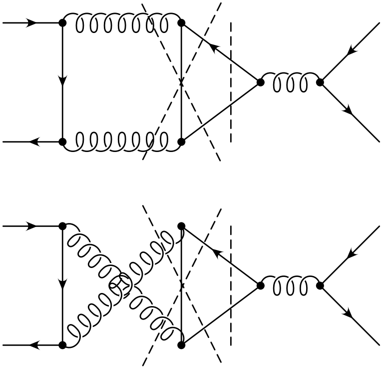

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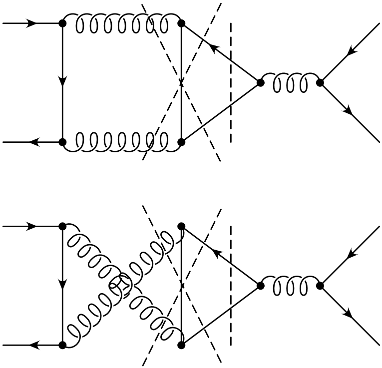

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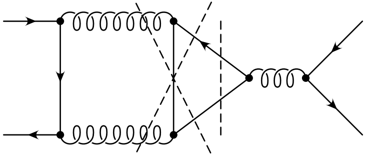

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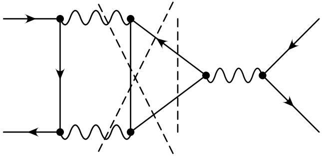

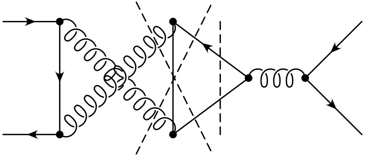

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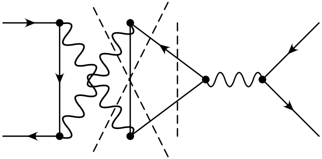

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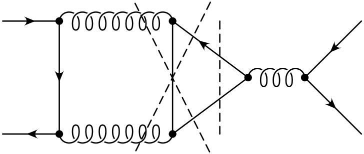

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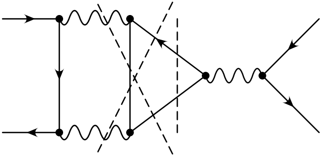

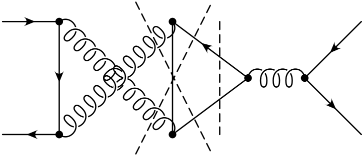

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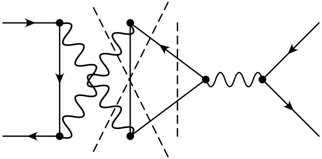

Where the color factors C_1 and C_2 are given by:

$$C_1 = \frac{1}{N_C^2} \mathrm{tr}\left(t^a t^b t^c\right) \mathrm{tr}\left(t^a t^c t^b\right) = \frac{1}{16 N_C^2}\left(f_{abc}^2 + d_{abc}^2\right)$$

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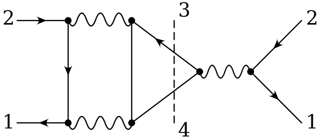

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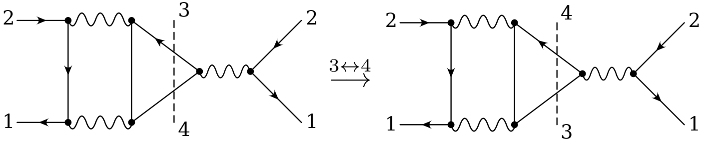

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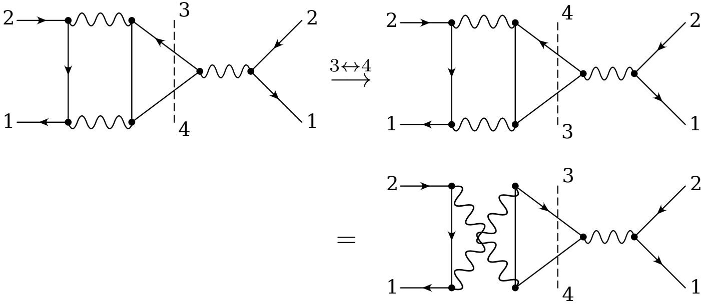

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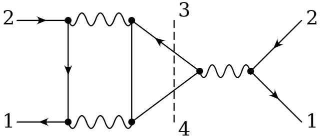

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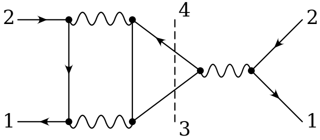

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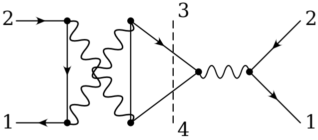

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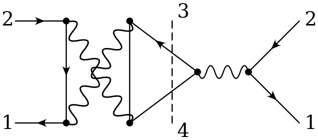

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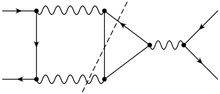
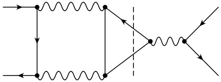
$\alpha_s^3 R(1,2,3,4,5) \equiv$ 

$\alpha_s^3 V(1,2,3,4) \equiv$ 

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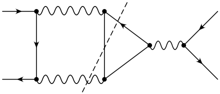
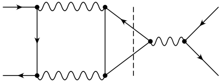
$\alpha_s^3 R(1,2,3,4,5) \equiv$ 

$\alpha_s^3 V(1,2,3,4) \equiv$ 

And then at $\mathcal{O}(\alpha)$ we obtain the following expression for the asymmetry:

$$A^{t\bar{t}} = \frac{\alpha_s}{\sigma_{Born}} \frac{d_{abc}^2}{16 N_C^2} \times \left[\int \mathrm{d}\Phi_2 V(1,2,3,4) + 2 \int \mathrm{d}\Phi_3 R(1,2,3,4,5) - (3 \leftrightarrow 4) \right]$$

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$$\int \mathrm{d}\Phi_3 R(1,2,3,4,5) \propto \left\{ \frac{1}{2\epsilon^2} - \frac{1}{\epsilon} \left(\log\left[\frac{2p_1 \cdot p_4}{\mu^2}\right] - \frac{1}{2} \log\left[\frac{m_t^2}{\mu^2}\right] \right) \right\} \sigma_{Born},$$

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and we see that the antisymmetric combination

$$\int \mathrm{d}\Phi_3 \left(R(1,2,3,4,5) - R(1,2,4,3,5) \right) \propto \frac{1}{\epsilon} \log\left[\frac{2p_1 p_4}{\mu^2}\right] \sigma_{Born}$$

is free from soft-collinear ϵ^{-2} divergences.

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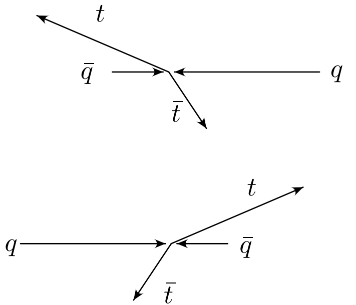

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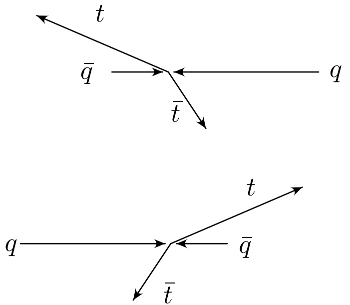

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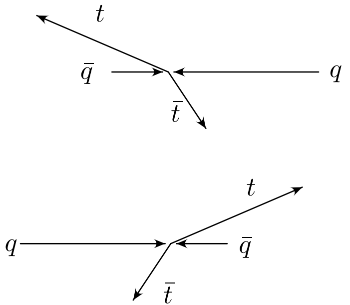

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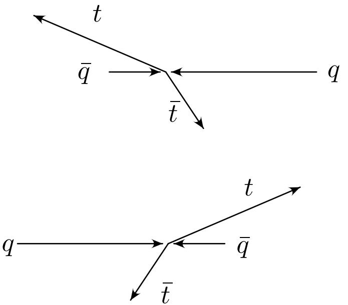

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Define in the lab frame the *central charge asymmetry*:

$$A_c(y_c) = \frac{N_t(|y| \leq y_c) - N_{\bar{t}}(|y| \leq y_c)}{N_t(|y| \leq y_c) + N_{\bar{t}}(|y| \leq y_c)}.$$

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THANK YOU