Charge Asymmetry in $t\bar{t}$ Production and Threshold Resummation

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Outline

Charge Asymmetry in QCD

Threshold Resummation in $t\bar{t}$ Production

Threshold Behavior of Charge Asym.

Charge Asymmetry at LHC vs TeVatron

Threshold Resummation at fixed Pair Rapidity

Charge Asymmetry in QCD

$$\frac{d\Delta\sigma}{dM^2_{t\bar{t}}d\cos\theta} \equiv \frac{1}{2}\left\{\frac{d^2\sigma^{H_AH_B\to t\bar{t}X}}{dM^2_{t\bar{t}}d\cos\theta} - \frac{d^2\sigma^{H_AH_B\to \bar{t}tX}}{dM^2_{t\bar{t}}d\cos\theta}\right\},$$

$$\frac{d\bar{\sigma}}{dM^2_{t\bar{t}}d\cos\theta} \equiv \frac{1}{2}\left\{\frac{d^2\sigma^{H_AH_B\to t\bar{t}X}}{dM^2_{t\bar{t}}d\cos\theta} + \frac{d^2\sigma^{H_AH_B\to \bar{t}tX}}{dM^2_{t\bar{t}}d\cos\theta}\right\},$$

angle of top with proton in partonic cms

Inclusive Asymmetry

Differential: $A_c(M^2_{t\bar{t}}, \cos\theta) \equiv \frac{d\Delta\sigma}{d\sigma}$

Total: $A_T = \frac{\int dX d\Delta\sigma}{\int dX d\bar{\sigma}}$

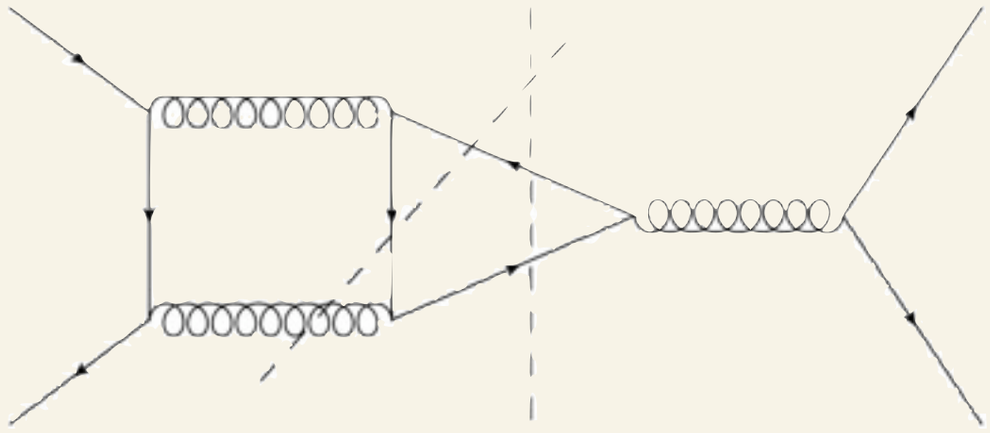
Exclusive Asymmetry $t\bar{t}j_1\cdots j_n$ Opposite sign to inclusive

(S. Dittmaier, P. Uwer and S. Weinzierl)

Contributions to Asymmetric x-section

(Kuhn, Rodrigo)

(M. T. Bowen, S. D. Ellis and D. Rainwater)



+ flavour excitation

xsec contributions $\sim d^2_{abc}\alpha_s^3 \cos\theta$

At Tevatron lead to sizable
Forward Backward Asymmetry

Incl. Asym. measured at CDF/D0:

0.24 ± 0.13 / 0.12 ± 0.08

SM ~ 0.08

Resum. ~1%

Threshold Corrections in $t\bar{t}$ Production

$$\frac{d^2\sigma^{H_A H_B \to t\bar{t}X}}{dM_{t\bar{t}}^2 d\cos\theta} = \sum_{ab} \int_0^1 dx_a \int_0^1 dx_b f_a^{H_A}(x_a, \mu^2) f_b^{H_B}(x_b, \mu^2) \frac{1}{s} \frac{d^2\hat{\sigma}_{ab}(\hat{\tau}, \cos\theta, \mu^2/s)}{d\hat{\tau} d\cos\theta}$$

(Kidonakis, Sterman)

$$\hat{\tau} = \frac{M_{t\bar{t}}^2}{\hat{s}} \quad \text{thus,} \quad \hat{\tau} \to 1 \quad \text{partonic threshold}$$

mis-cancelations will lead to large logarithmic corrections.

At α_S^3, one finds:

$$\frac{d^2\hat{\sigma}_{q\bar{q}}^{\mathrm{NLO}}(\hat{\tau}, \cos\theta)}{d\hat{\tau} d\cos\theta} = C_1(\theta)\delta(1-\hat{\tau}) + C_2(\theta)\left(\frac{1}{1-\hat{\tau}}\right)_+ + C_3(\theta)\left(\frac{\log(1-\hat{\tau})}{1-\hat{\tau}}\right)_+ + \ldots$$

Resummation of threshold logarithms

Mellin moment space: $$\frac{d\sigma^N}{d\cos\theta} \equiv \int_0^1 d\tau \tau^{N-1} \frac{d^2\sigma}{d\tau d\cos\theta}.$$

x-section factors $$\frac{d\sigma^N}{d\cos\theta} = \sum_{ab} f_a^{H_A,N}(\mu^2) f_b^{H_B,N}(\mu^2) \hat{\sigma}_{ab}(N,\theta)$$

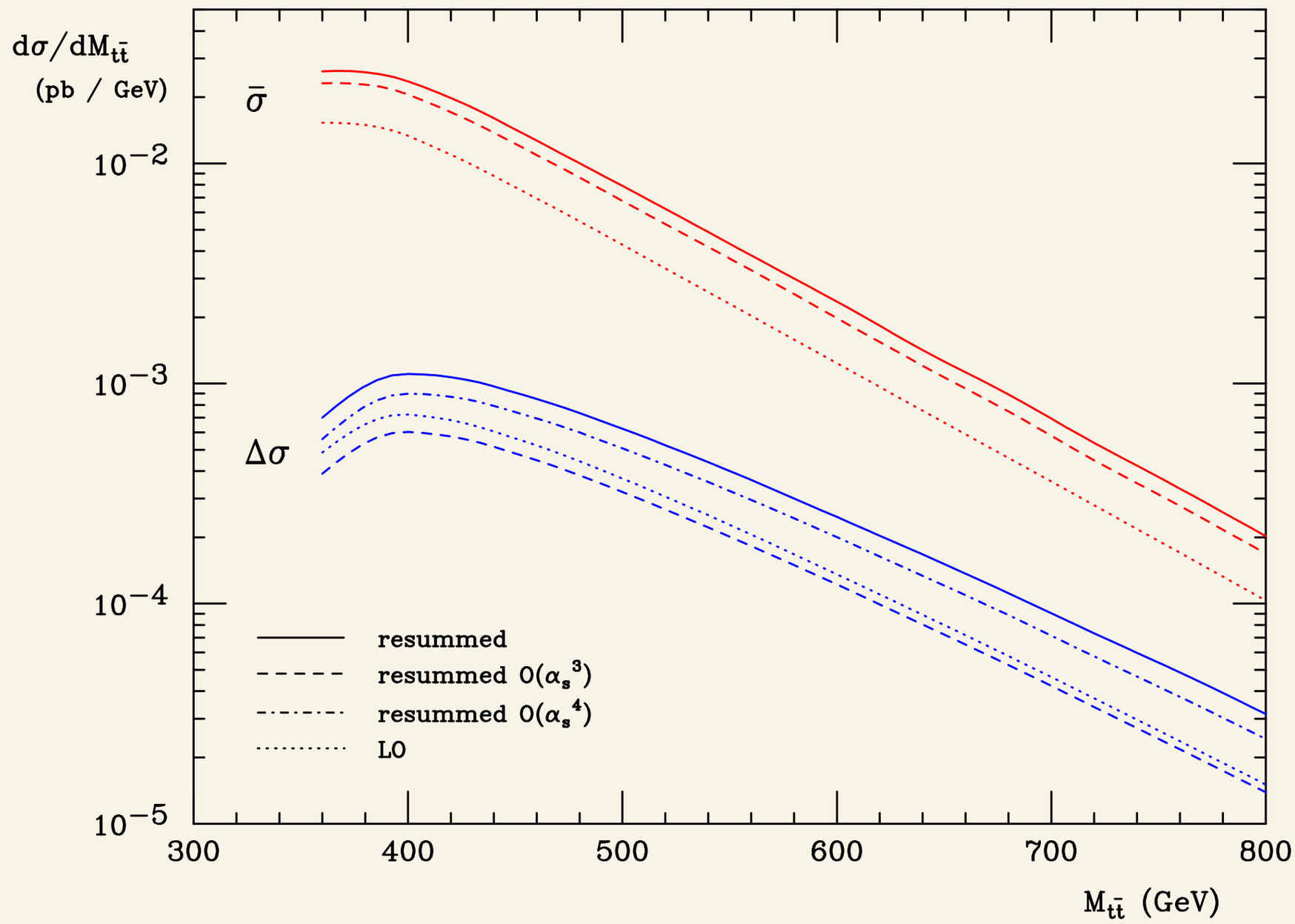
$$\hat{\sigma}_{ab}(N,\theta) = \int_0^1 d\hat{\tau} \hat{\tau}^{N-1} \frac{d^2\hat{\sigma}_{ab}(\hat{\tau},\cos\theta)}{d\hat{\tau} d\cos\theta}$$

Resumm. can be schematically written

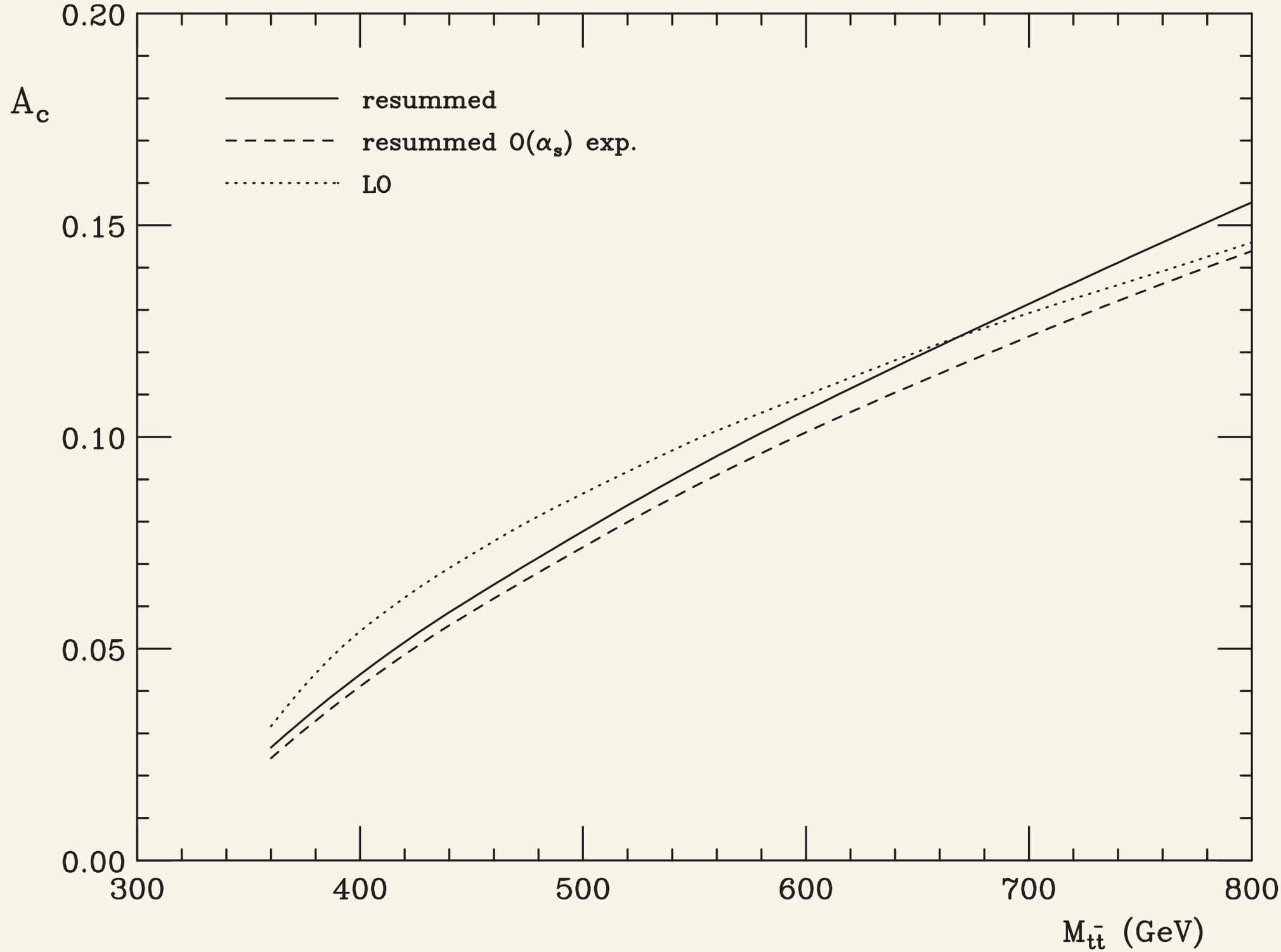
$$\hat{\sigma}_{ab}^{(\mathrm{res})}(N,\theta) = C_{ab}(\theta)\Delta_a(N)\Delta_b(N)\,\mathrm{Tr}\{H_{ab}^{(0)}(\theta)\,[\mathcal{S}_{ab}(N,\theta)]^\dagger S_{ab}^{(0)} \mathcal{S}_{ab}(N,\theta)\}$$

$$= \hat{\sigma}_{q\bar{q}}^{(\mathrm{Born})}(\theta)\ (\Delta_q(N))^2 \left\{1 + \frac{\beta\cos\theta(8C_F - 3C_A)\ln(1-2\lambda)}{\pi b_0}\right\} \mathrm{e}^{-\frac{C_A}{2\pi b_0}\ln(1-2\lambda)}$$

$M^2_{t\bar{t}}$ Dependence $\quad p\bar{p} \,@\, \sqrt{S} = 1.8 TeV$

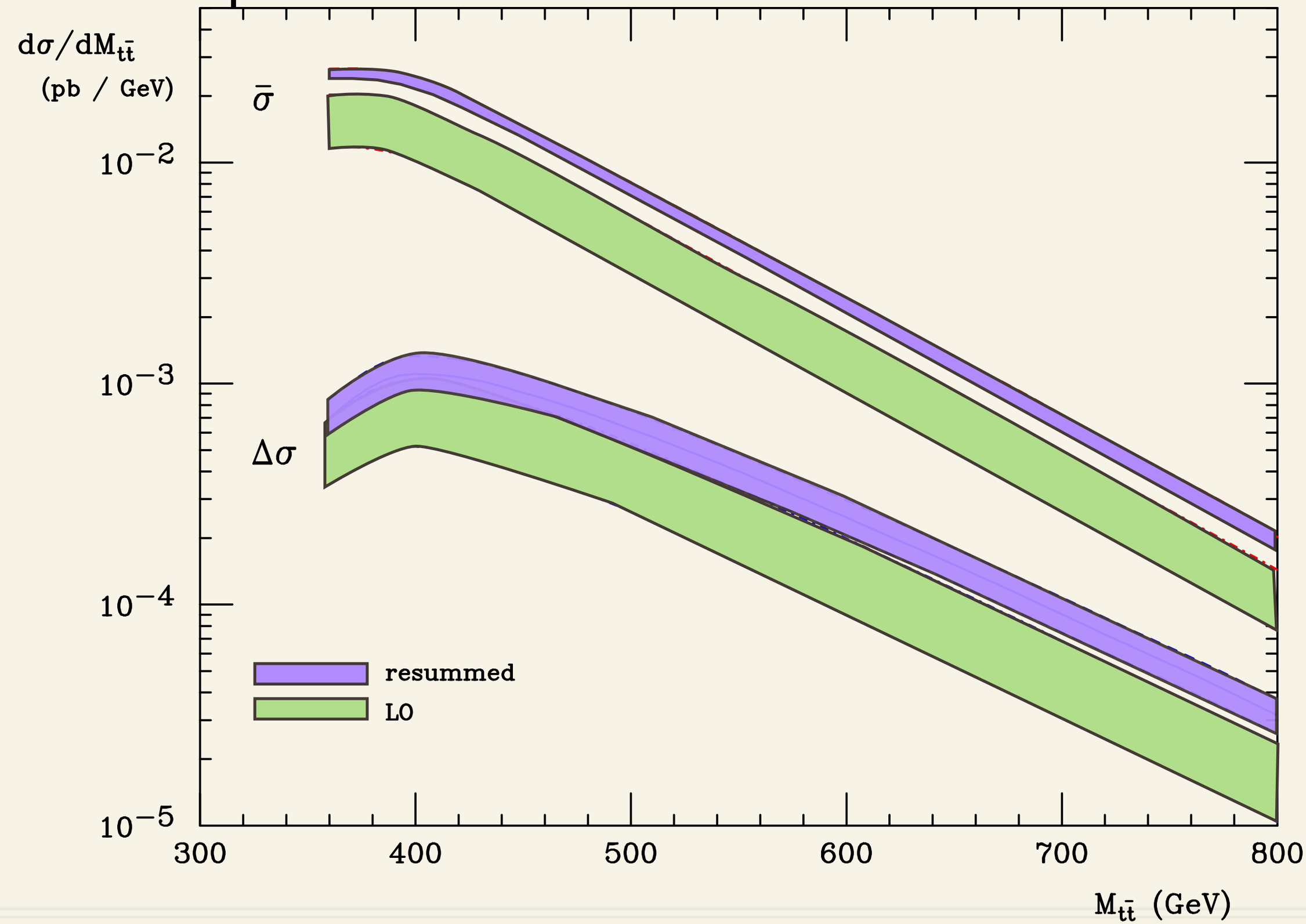


$M^2_{t\bar{t}}$ Dependence of Charge Asymmetry

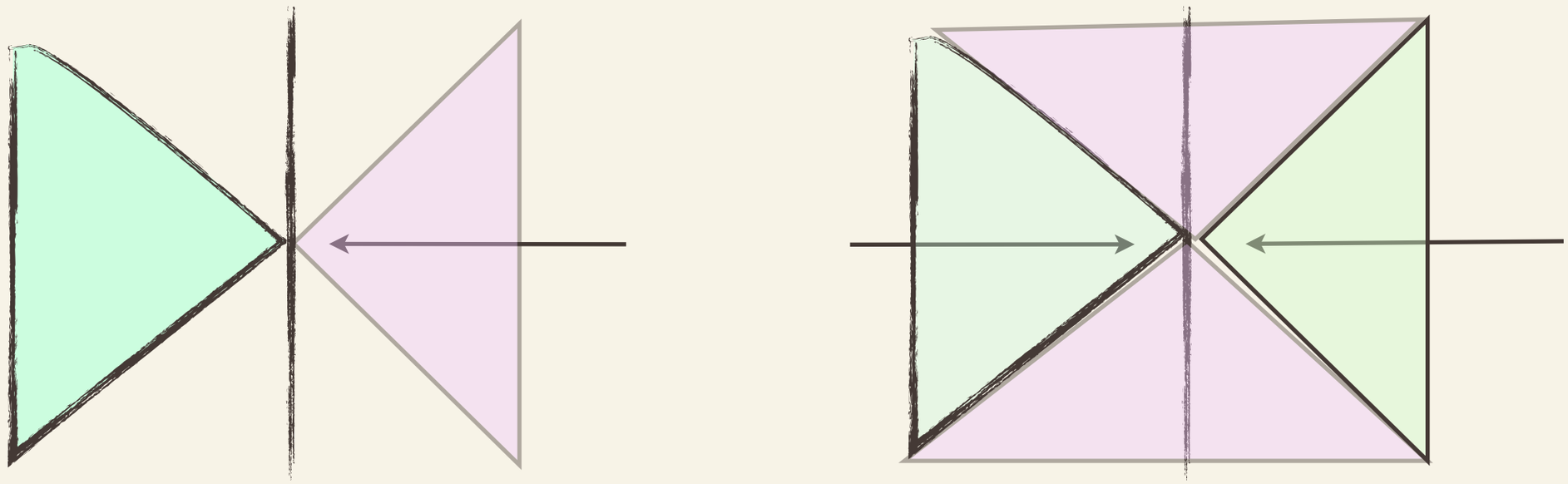


At high $M^2_{t\bar{t}}$ gg fusion is suppressed and CA increases

Scale Dependence:



pp VS $p\bar{p}$



@ LHC, Total FB Asymmetry Vanishes

However, the charge asymmetry in QCD still leads to the same sign asym. (Kuhn, Rodrigo)

More work needed to perform threshold resummation in this regime.

Summary

Charge Asymmetry in tt production
robust with respect to higher orders
generated by threshold resummation

Charge Asymmetries from QCD increase with

At LHC, need increased information on tops
to exploit differences in top distributions.