

# Recent Theoretical Progress in the $t\bar{t}$ Threshold Analyses

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§1. Total Cross Section NNLO

(§2)  $1S$ -Resonance Mass NNLL

§3. Top Momentum Distribution NNLO

§4  $d\sigma(e^+e^- \rightarrow t\bar{t} \rightarrow b\bar{t}\nu\bar{b}W^-)$  NLO

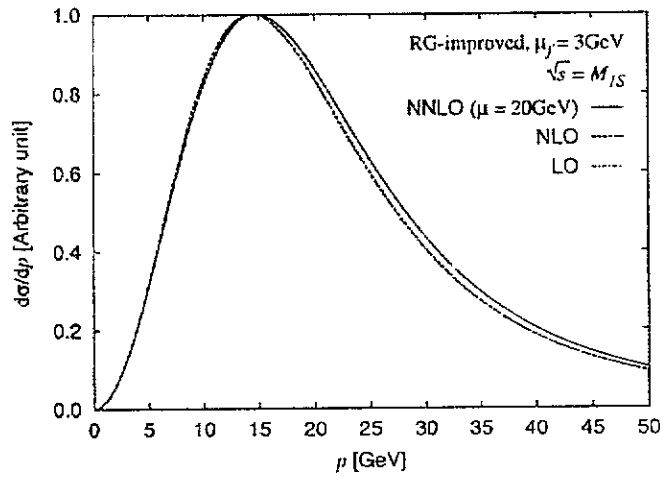
### §3. Top Momentum Distribution NNLO

$$\frac{d\sigma}{dp_t} \sim \left| \sum_n \frac{\psi_n^*(0) \phi_n(p_t)}{M_n - \sqrt{s} - i\Gamma_n} \right|^2$$

Normalized to unity at each distribution peak.  
 $\Downarrow$

NNLO corr.

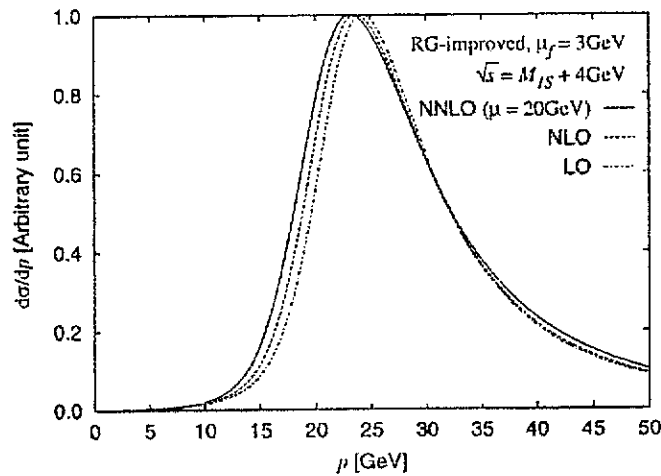
$$\frac{\delta p_{\text{peak}}}{p_{\text{peak}}} = +2.2\%$$



RG-improvement only in  $V_c(r)$

NNLO corr.

$$\frac{\delta p_{\text{peak}}}{p_{\text{peak}}} = -2\%$$

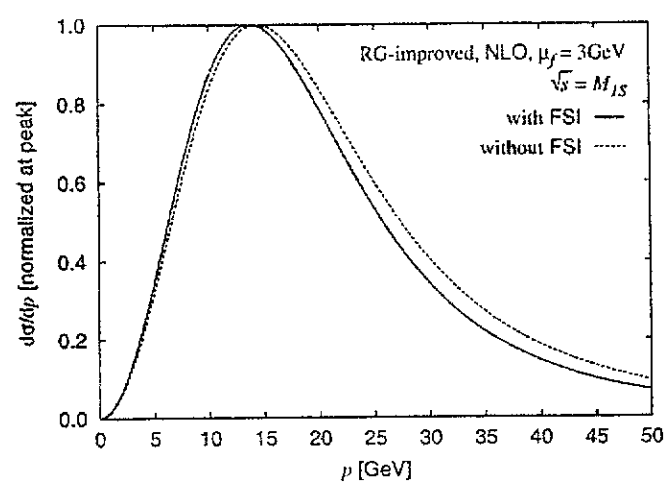


Final-state Interactions not included.

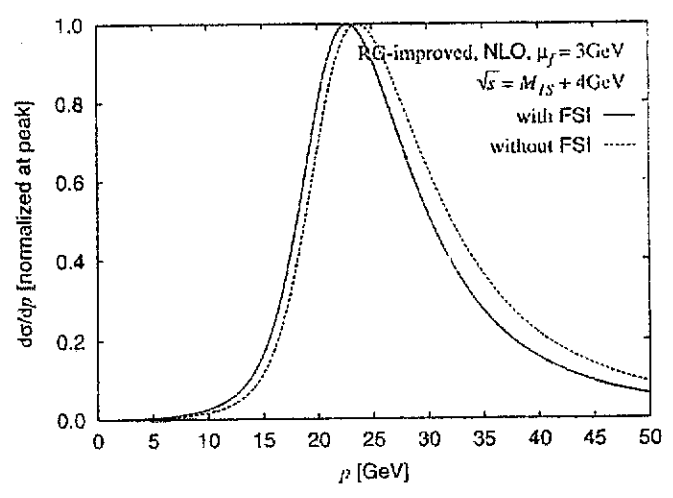
★ Comparison with Final-State Interaction Effects (one of NLO corrections)



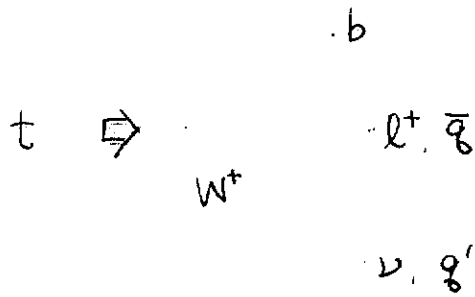
$$\frac{\delta p_{\text{peak}}}{p_{\text{peak}}} = -5\%$$



$$\frac{\delta p_{\text{peak}}}{p_{\text{peak}}} = -5\%$$



34.  $d\sigma(e^+e^- \rightarrow t\bar{t} \rightarrow b\ell^+\nu bW^-)$  NLO



t is highly polarized near threshold

Hortsmann, Jentsch, Kl...  
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- $\ell^+$  from free polarized top decay

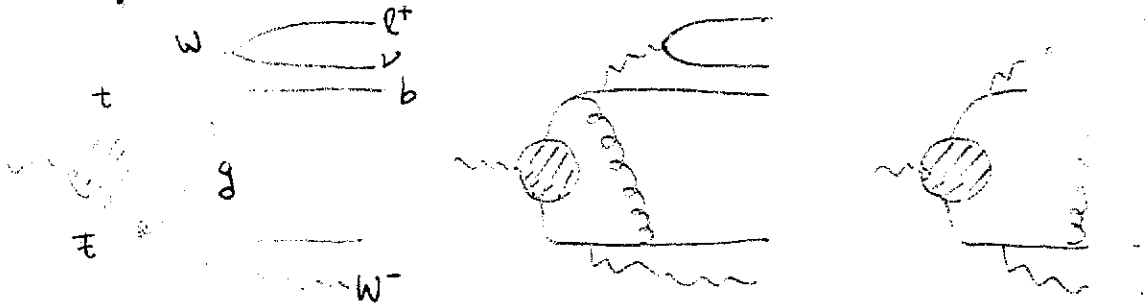
van Mechelen, Jentsch

$$\frac{d\Gamma(t_s \rightarrow b\ell^+\nu)}{dE_\ell d\cos\theta_\ell} = h(E_\ell) (1 + S \cos\theta_\ell) + \mathcal{O}(\alpha_s) \text{ corr.}$$

↑  
top polarization

Near threshold

- Boundstate effects
- Final-State Interactions



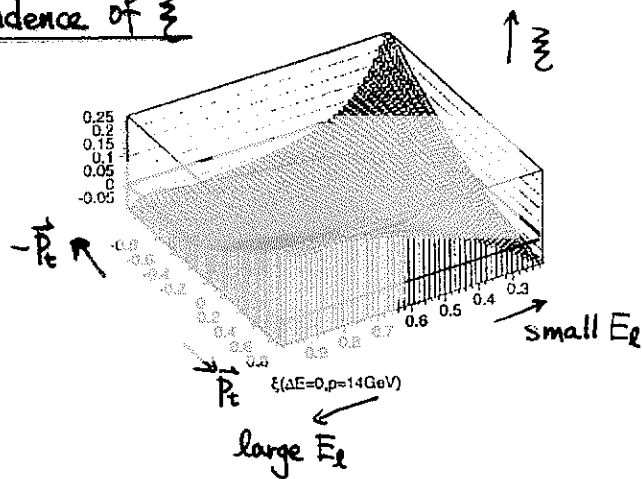
•  $\gamma$  or emission

$$\star \frac{d\sigma}{d^3\vec{p}_t dE_t d\Omega_t} = \frac{d\sigma(ee \rightarrow t\bar{t})}{d^3\vec{p}_t} (1 + \underline{\delta}_0 + \underline{\delta}_1 \cos\theta_t)$$

$$\times \frac{1}{\Gamma_t} \frac{d\Gamma(t_s \rightarrow b\ell^+\nu)}{dE_\ell d\Omega_\ell} \times \left[ 1 + \frac{\xi}{\text{non-factorizable corr.}}(\vec{p}_t, \sqrt{s}, E_\ell, \theta_{t\ell}) \right] + \mathcal{O}(\alpha_s^2)$$

$\vec{p}_t \rightarrow \vec{p}_s$

$\cos\theta_{t\ell}, E_\ell$  dependence of  $\xi$



A new observable dependent only on free polarized top decays.

$$\bar{A}(E_\ell, \cos\theta_\ell) = \frac{\left\langle \left[ \frac{d\sigma(ee \rightarrow t\bar{t} \rightarrow b\ell^+\nu bW)}{d^3\vec{p}_t dE_t d\Omega_t} \right]_{E_\ell, \vec{p}_t} \right\rangle}{\left\langle \left[ \text{''} \right]_{E'_\ell, \vec{p}'_t} \right\rangle}$$

$$\Rightarrow \frac{\left[ \frac{d\Gamma(t_s \rightarrow b\ell^+\nu)}{dE_\ell d\Omega_\ell} \right]_{E_\ell, \vec{p}_t}}{\left[ \text{''} \right]_{E'_\ell, \vec{p}'_t}} + \mathcal{O}(\alpha_s^2)$$

$\vec{p}_t \rightarrow \vec{p}_s$