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CHARGE ASYMMETRY in HADROPRODUCTION of HEAVY QUARKS

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HEP-PH/9802268,
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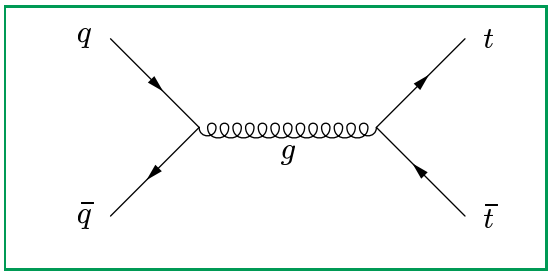
I MOTIVATION and MAIN IDEA

II RESULTS at PARTONIC LEVEL

III ASYMMETRIES at TEVATRON and LHC

I MOTIVATION and MAIN IDEA

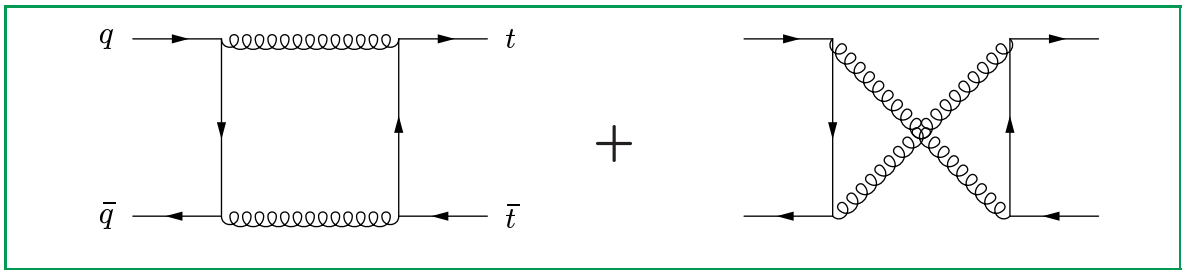


dominant process for $t\bar{t}$ production

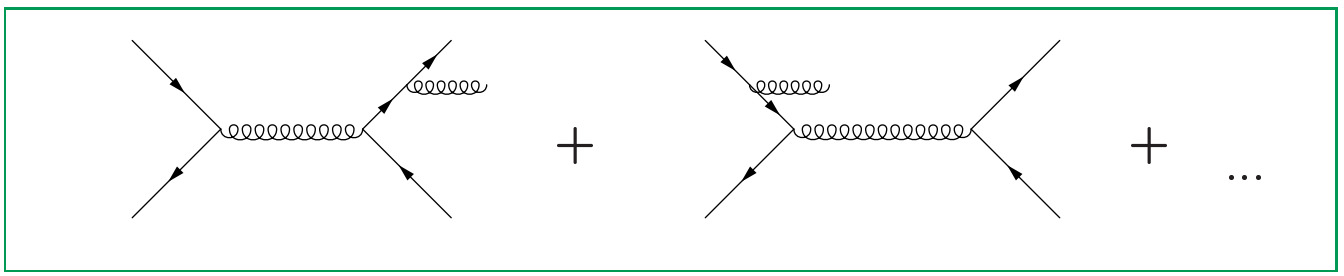
$$\frac{\mathrm{d}\sigma}{\mathrm{d}\cos\hat{\Theta}} \propto \left(1+\frac{4m^2}{Q^2}\right)+\left(1-\frac{4m^2}{Q^2}\right)\cos^2\hat{\Theta}$$

is symmetric!

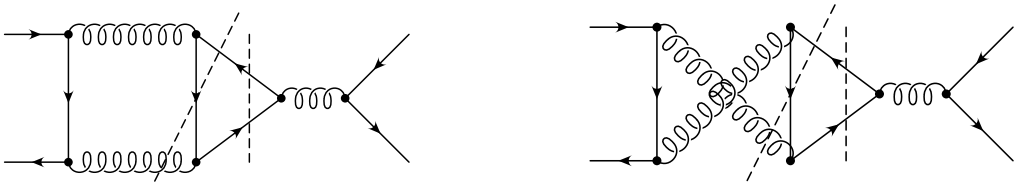
$\mathcal{O}(\alpha_s)$ corrections:
virtual gluons



real emission



Interference between C=+1 and C=-1 amplitudes

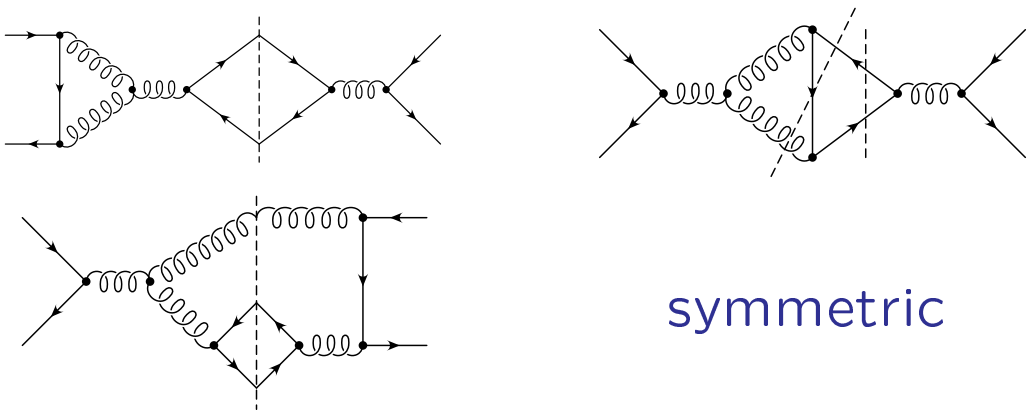


$\Longrightarrow$ charge asymmetry

$$\boxed{\mathrm{d}\sigma(q\bar{q} \to QX) - \mathrm{d}\sigma(q\bar{q} \to \bar{Q}X) \neq 0}$$

similar to QED!

Nonabelian terms:

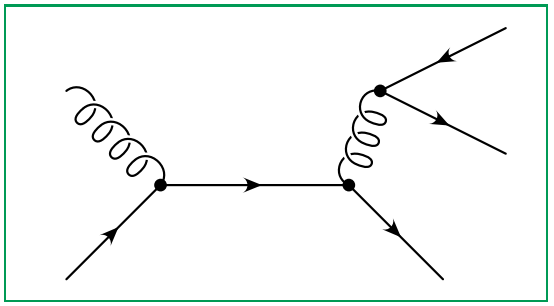


symmetric

similarly:

$$\boxed{\mathrm{d}\sigma(qg \to QX) - \mathrm{d}\sigma(qg \to \bar{Q}X) \neq 0}$$

numerically unimportant.



real and virtual corrections must be combined to obtain sensible (=IR–finite) result

$\Rightarrow$ forward–backward asymmetry of top quarks in $p\bar{p}$ collisions (TEVATRON)

$\Rightarrow$ difference in rapidity distributions between t and $\bar{t}$ in pp collisions (LHC)

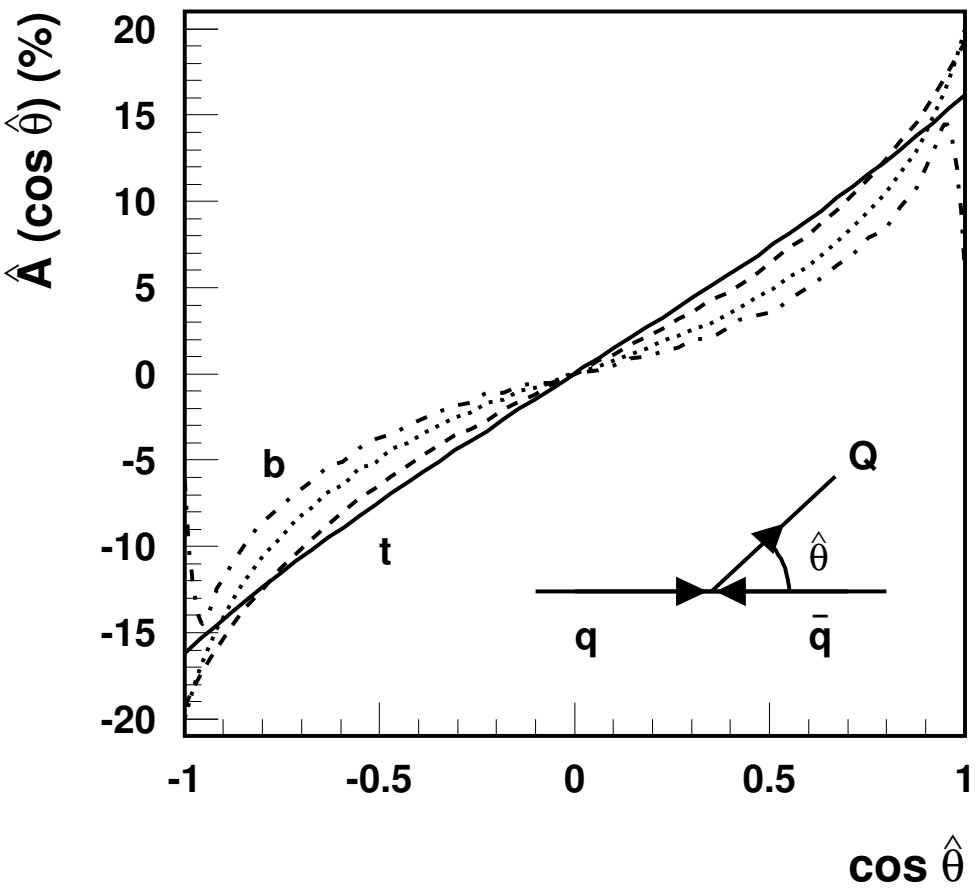
$\Rightarrow$ test of production mechanism

$\Rightarrow$ potential confusion with asymmetry from weak production avoided

II PARTONIC LEVEL

differential asymmetry ($q\bar{q}$ induced)

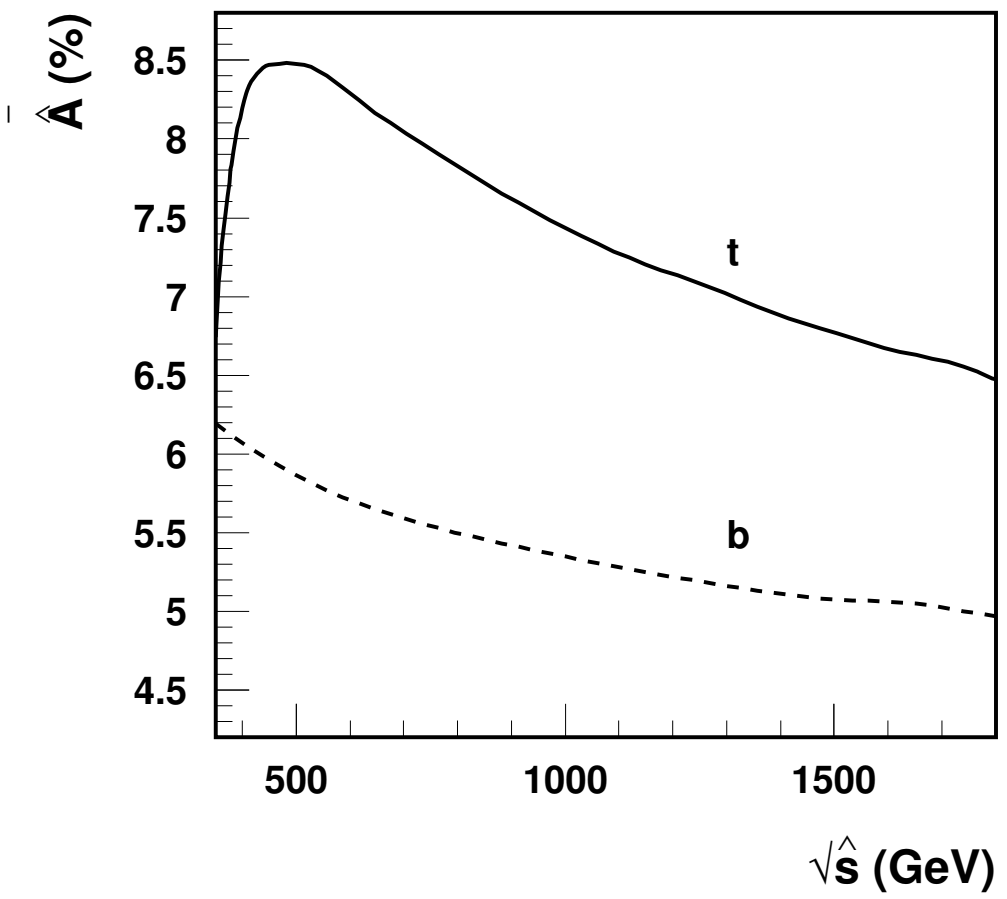
$$\hat{A}(\cos\hat{\Theta}) = \frac{N_t(\cos\hat{\Theta}) - N_{\bar{t}}(\cos\hat{\Theta})}{N_t(\cos\hat{\Theta}) + N_{\bar{t}}(\cos\hat{\Theta})} = \frac{N_t(\cos\hat{\Theta}) - N_{\bar{t}}(-\cos\hat{\Theta})}{N_t(\cos\hat{\Theta}) + N_{\bar{t}}(-\cos\hat{\Theta})}$$



integrated asymmetry (parton level)

$$\begin{aligned}\hat{A}(\cos\hat{\Theta}) &= \frac{N_t(\cos\hat{\Theta}\geq 0) - N_{\bar{t}}(\cos\hat{\Theta}\geq 0)}{N_t(\cos\hat{\Theta}\geq 0) + N_{\bar{t}}(\cos\hat{\Theta}\geq 0)} \\ &= \frac{N_t(\cos\hat{\Theta}\geq 0) - N_t(\cos\hat{\Theta}\leq 0)}{N_t(\cos\hat{\Theta}\geq 0) + N_t(\cos\hat{\Theta}\leq 0)}\end{aligned}$$

as function of $\sqrt{\hat{s}}$:

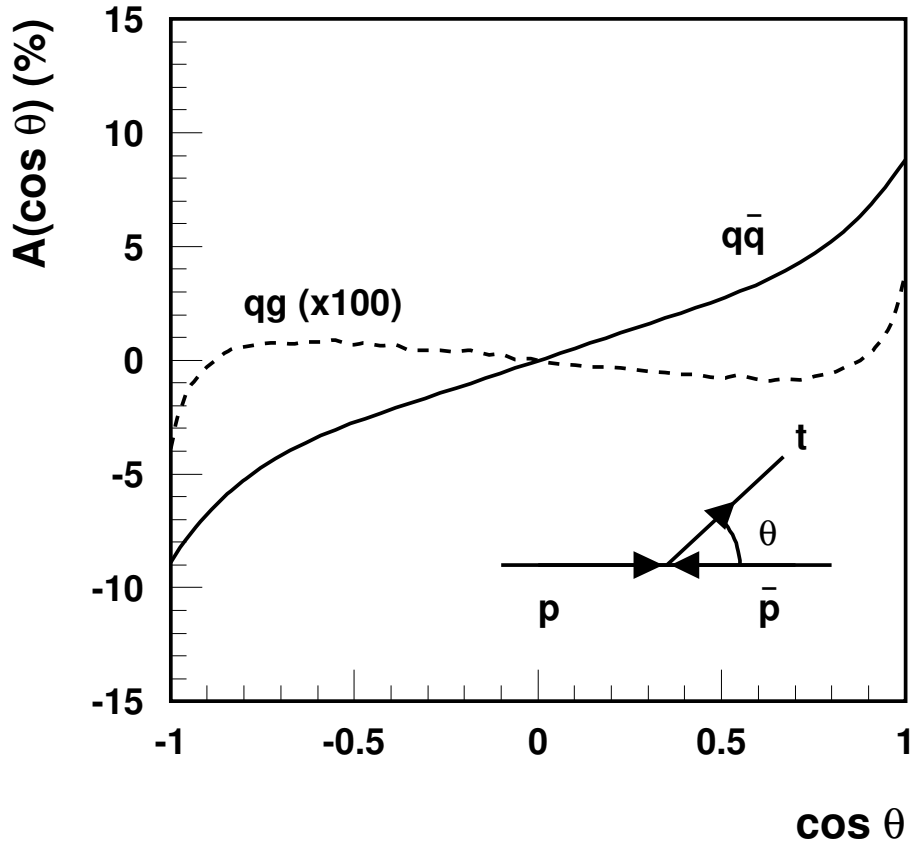


III HADRONIC COLLISIONS

$p\bar{p}$ 1.8 TeV

dominantly central production: $q\bar{q} \to t\bar{t}$

partonic asymmetry $\Rightarrow$ hadronic asymmetry

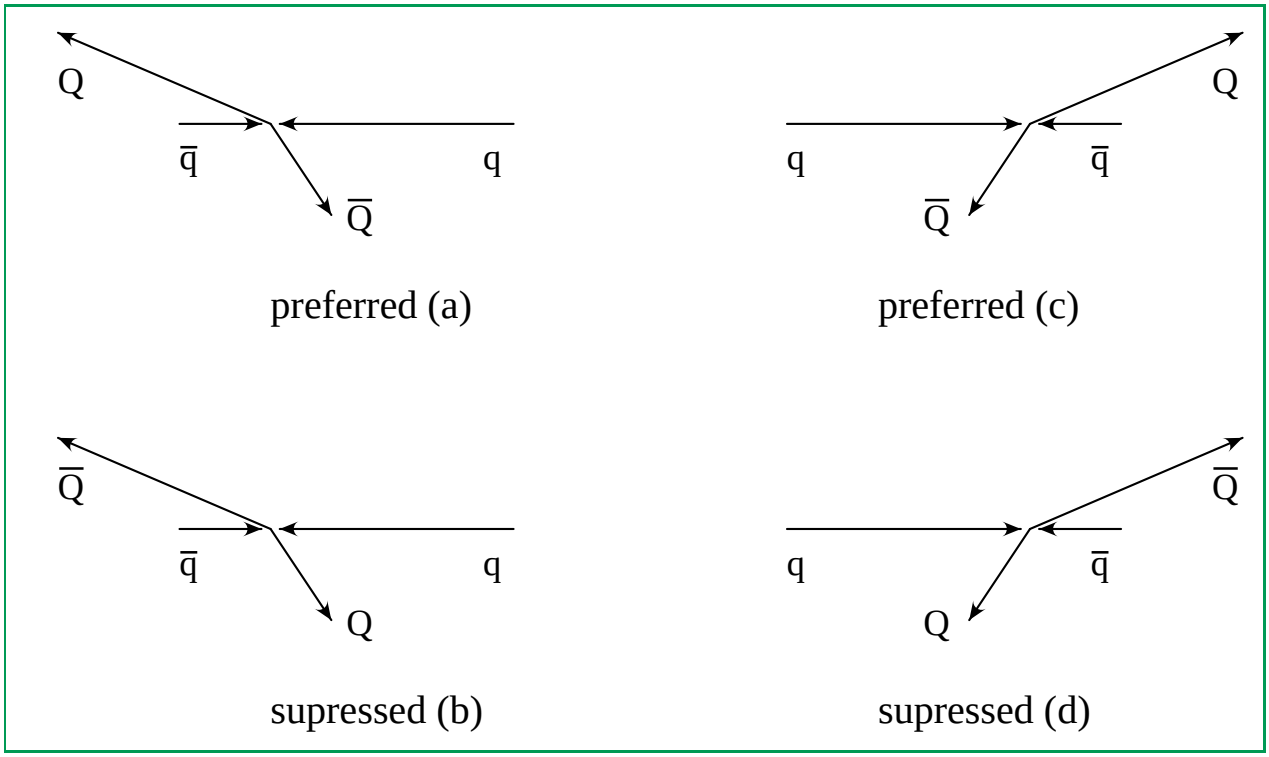


$\Rightarrow$ Integrated asymmetry

$$\bar{A}_{\text{fb}} = \begin{cases} 4.6 - 5.0\% & 1.8 \text{ TeV} \\ 4.3 - 4.7\% & 2.0 \text{ TeV} \end{cases}$$

pp 14 TeV

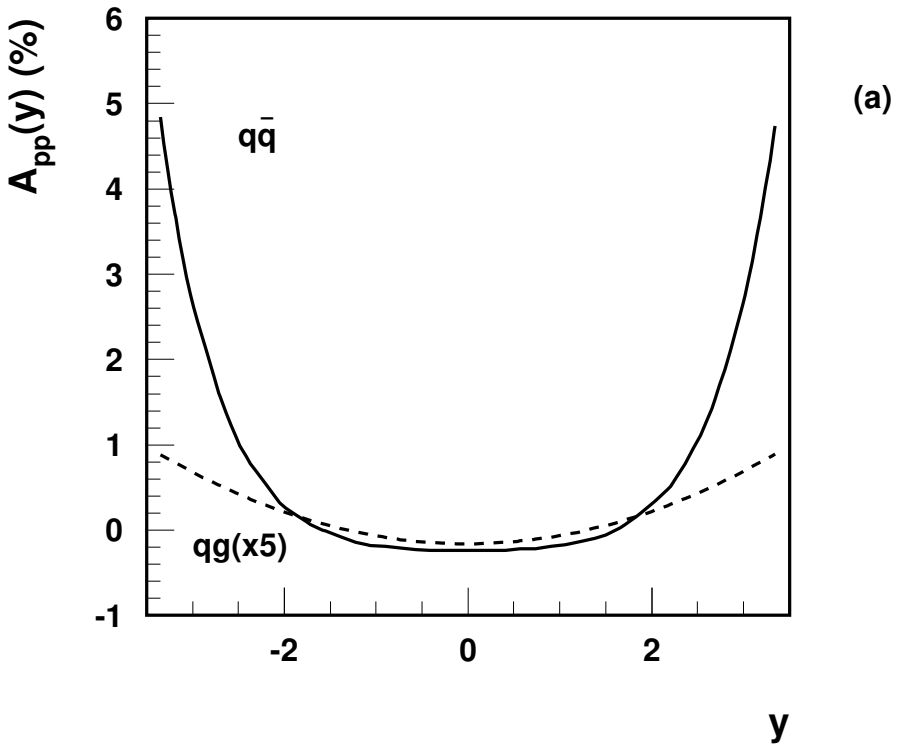
- no forward backward asymmetry
- slight difference between rapidity distributions of Q and $\bar{Q}$ from (small) admixture of $q\bar{q}$ processes



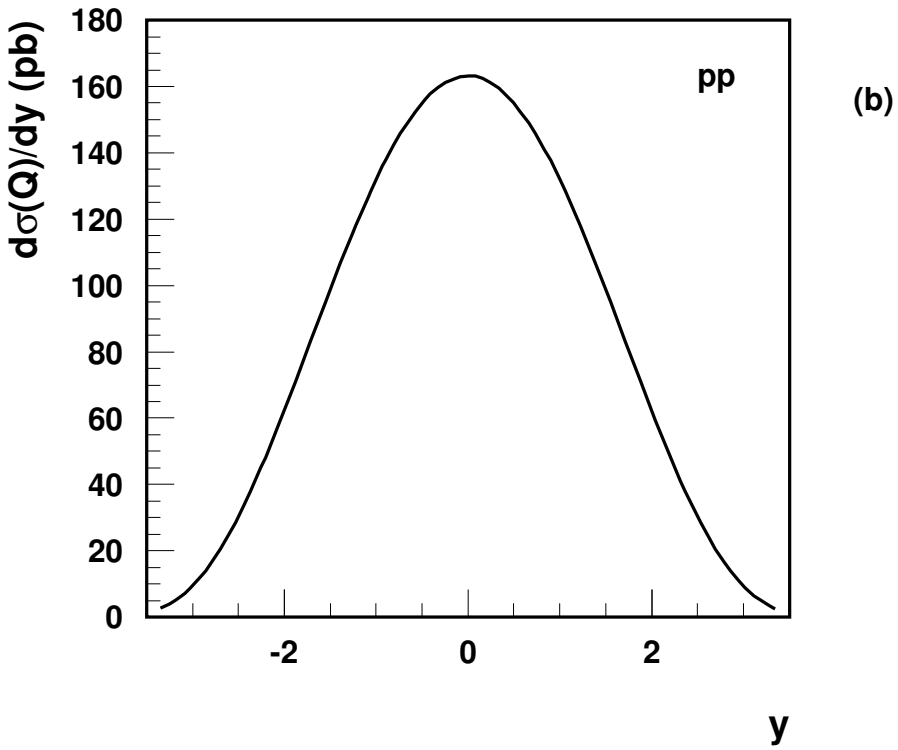
$\Rightarrow$ more t at large rapidity

$\Rightarrow$ more $\bar{t}$ at small rapidity

main effect in regions of small cross section



(a)



(b)

Leading order!

SUMMARY

- ⋆ forward backward asymmetry for t production at TEVATRON $\sim$ 4–5%
- ⋆ important test of production mechanism
- ⋆ differences between t and $\bar{t}$ distributions at LHC mainly in regions of small cross section (large rapidity!)
- ⋆ leading order prediction only
  scale and scheme dependent