

Higher-order corrections to single top production at the Tevatron and the LHC

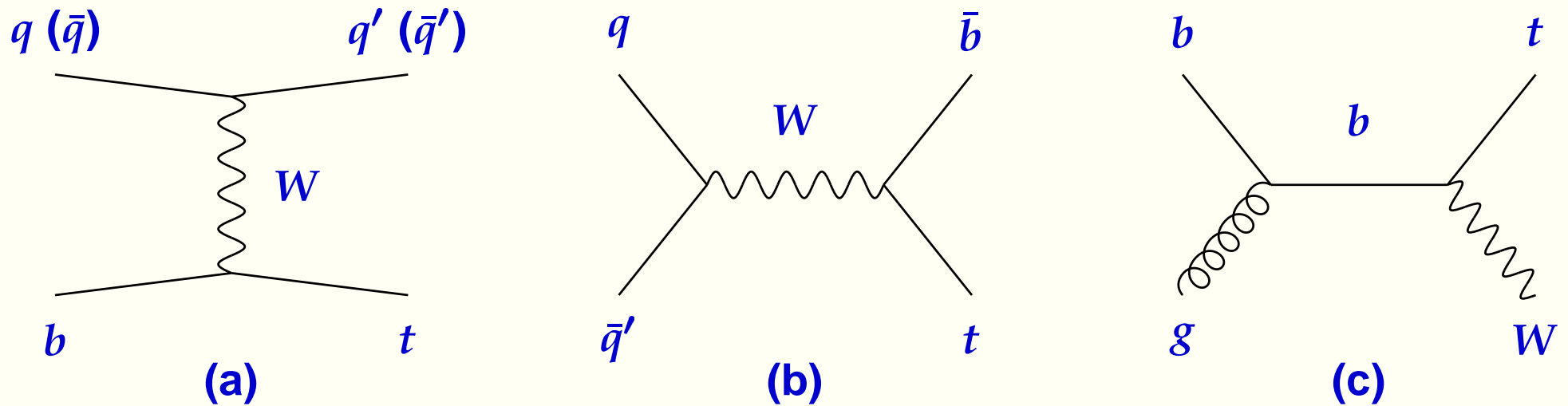
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- **Single top production -
 t and s channels and tW production**
- **Soft-gluon corrections**
- **Cross section at the Tevatron**
- **Cross section at the LHC**

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Single top quark production channels

Partonic processes at LO



(a) t channel: $qb \rightarrow q't$ and $\bar{q}b \rightarrow \bar{q}'t$ ($ub \rightarrow dt$ and $\bar{d}b \rightarrow \bar{u}t$, etc.)

(b) s channel: $q\bar{q}' \rightarrow \bar{b}t$ ($u\bar{d} \rightarrow \bar{b}t$, etc)

(c) associated tW production: $bg \rightarrow tW^-$

Soft gluon corrections

For the process $p_1 + p_2 \rightarrow p_3 + p_4$

define $s = (p_1 + p_2)^2$, $t = (p_1 - p_3)^2$, $u = (p_2 - p_3)^2$ and $s_4 = s + t + u - m_3^2 - m_4^2$

At threshold $s_4 \rightarrow 0$

Soft corrections $\left[\frac{\ln^l(s_4/m_t^2)}{s_4} \right]_+$

$l \leq 2n - 1$ for the $\mathcal{O}(\alpha_s^n)$ corrections

Resum these soft corrections

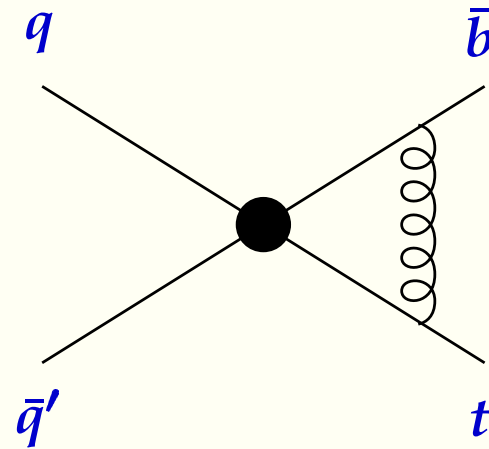
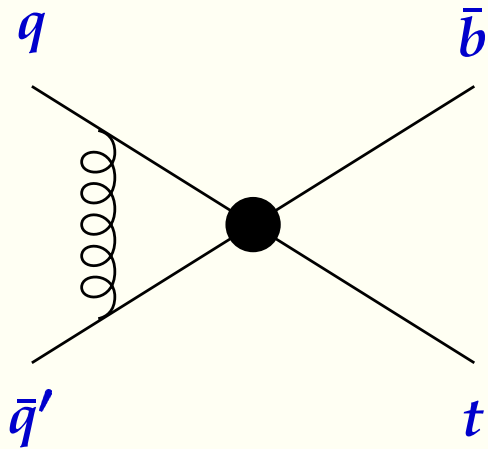
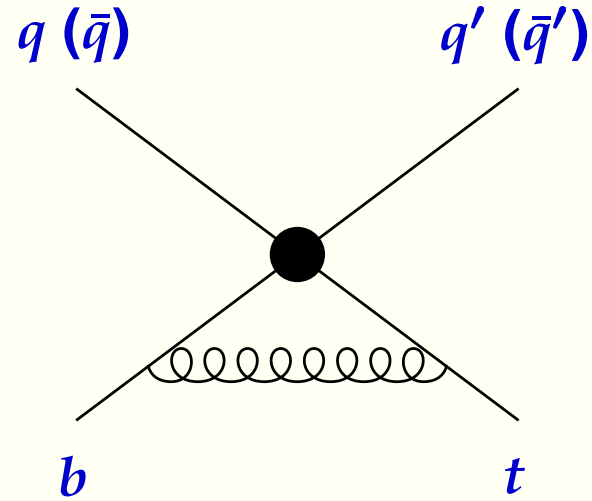
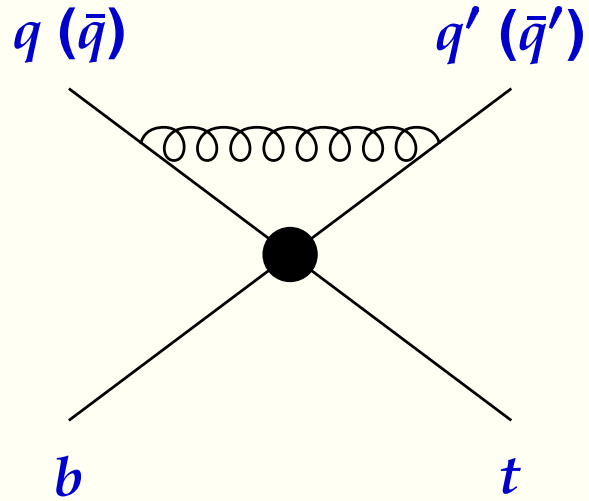
Expand cross section through NNNLO at NLL accuracy

Requires one-loop calculations in the eikonal approximation

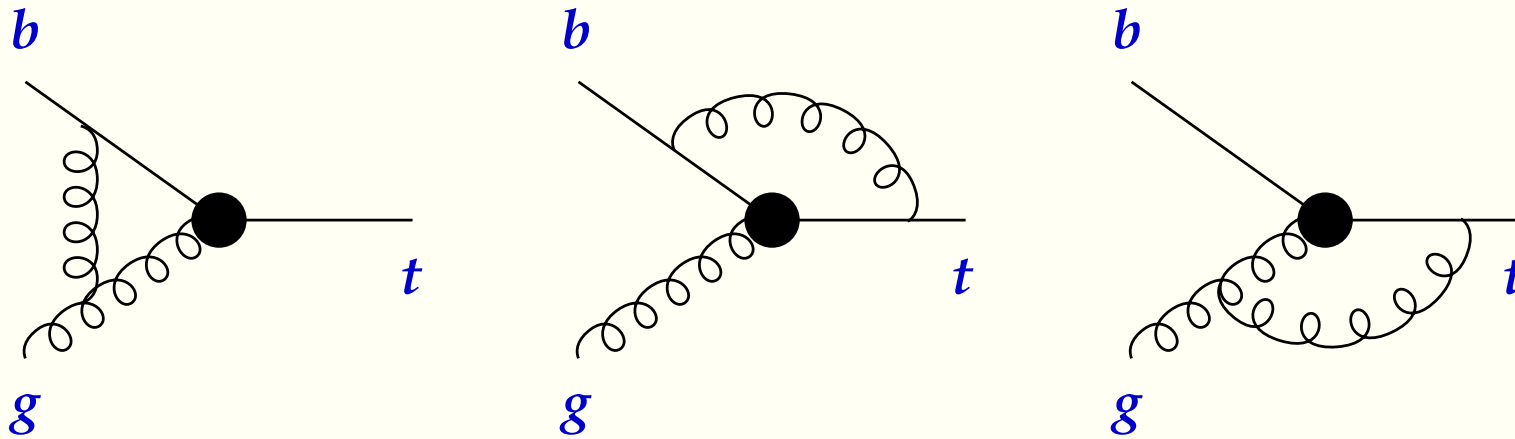
$$\sigma = \sum_f \int dx_1 dx_2 \phi_{f_1/p}(x_1, \mu_F) \phi_{f_2/\bar{p}}(x_2, \mu_F) \hat{\sigma}(s, t, u, \mu_F, \mu_R, \alpha_s)$$

MRST 2004 NNLO pdf are used for the numerical results

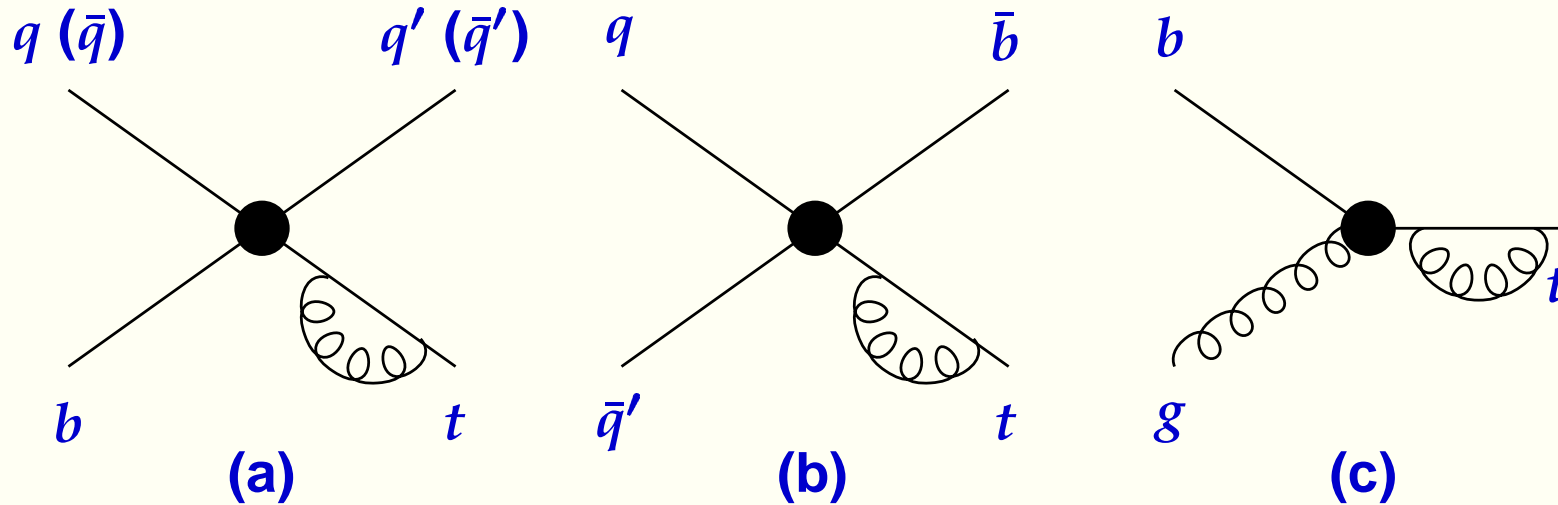
One-loop eikonal vertex corrections to the soft function in the t and s channels



One-loop eikonal vertex corrections to the soft function in the tW channel

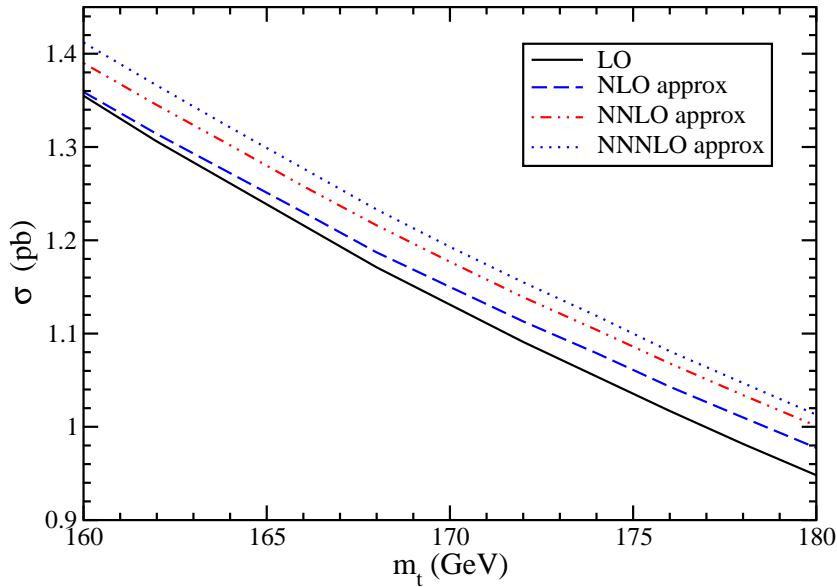


Top-quark eikonal self-energy one-loop corrections: (a) t channel; (b) s channel; (c) associated tW production

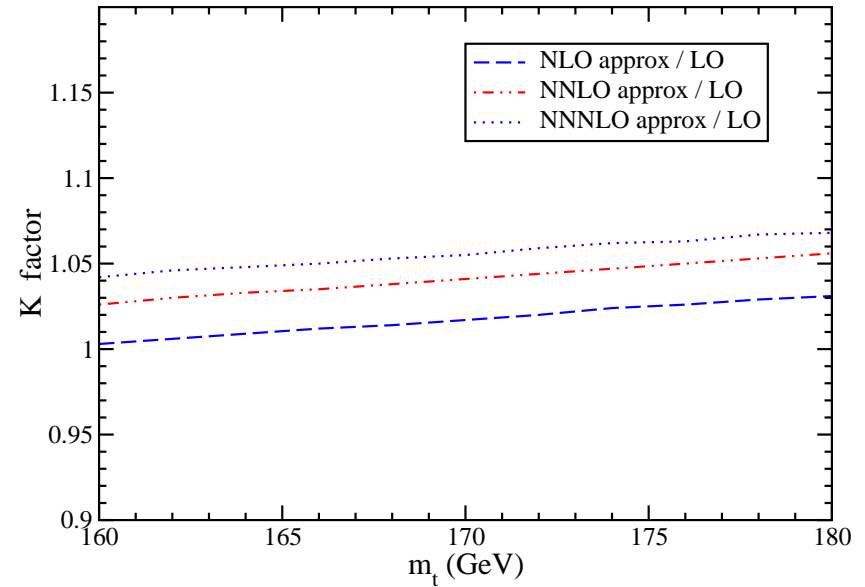


Single top production at the Tevatron - t channel

Single top at Tevatron t -channel $S^{1/2}=1.96$ TeV $\mu=m_t$



Single top at Tevatron t -channel $S^{1/2}=1.96$ TeV $\mu=m_t$



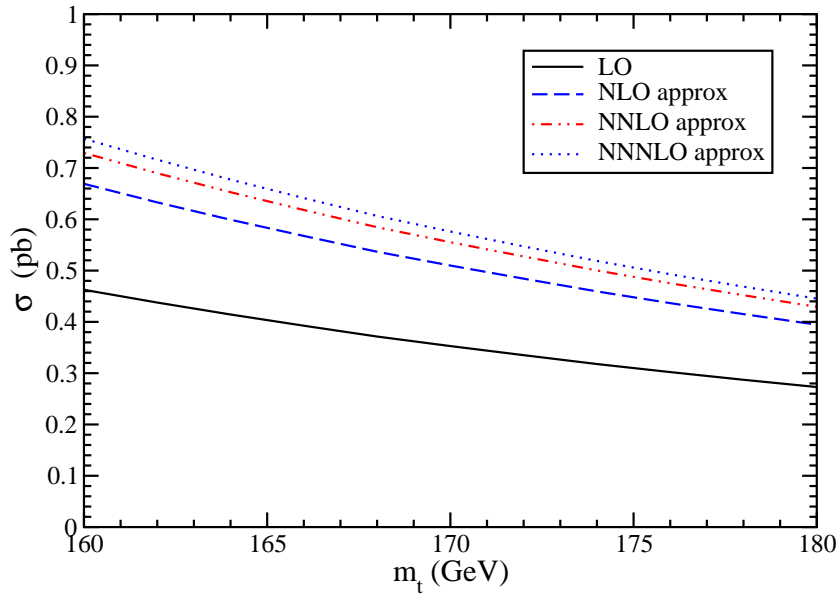
t channel	LO	NLO approx	NNLO approx	NNNLO approx
$m_t = 170$	1.131	1.150	1.177	1.193
$m_t = 172$	1.091	1.113	1.139	1.155
$m_t = 175$	1.035	1.060	1.085	1.100

$$\sigma^{t\text{-channel}}(m_t = 171.4 \pm 2.1 \text{ GeV}) = 1.15_{-0.02}^{+0.08} \pm 0.04 \pm 0.06 \text{ pb} = 1.15_{-0.07}^{+0.11} \text{ pb}$$

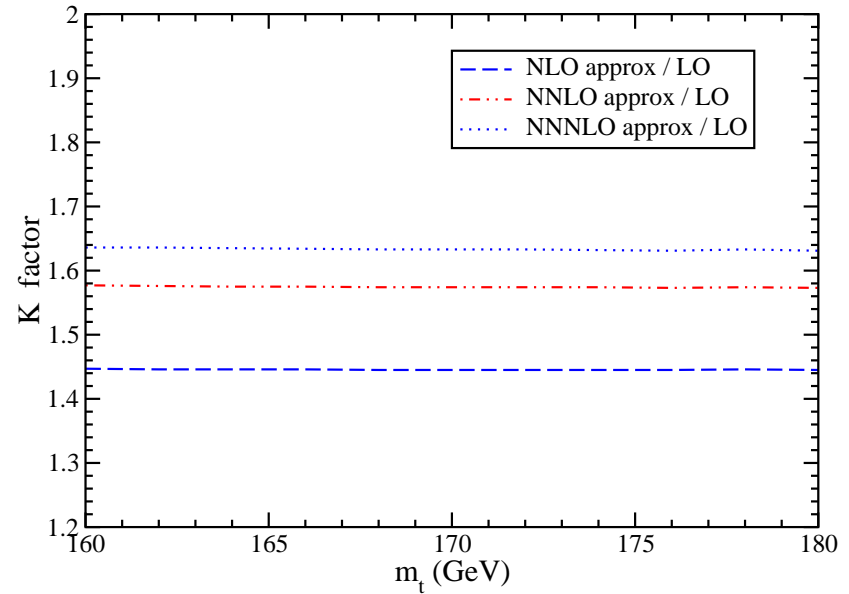
\uparrow scale \uparrow mass \uparrow pdf

Single top production at the Tevatron - s channel

Single top at Tevatron s-channel $S^{1/2}=1.96$ TeV $\mu=m_t$



Single top at Tevatron s-channel $S^{1/2}=1.96$ TeV $\mu=m_t$



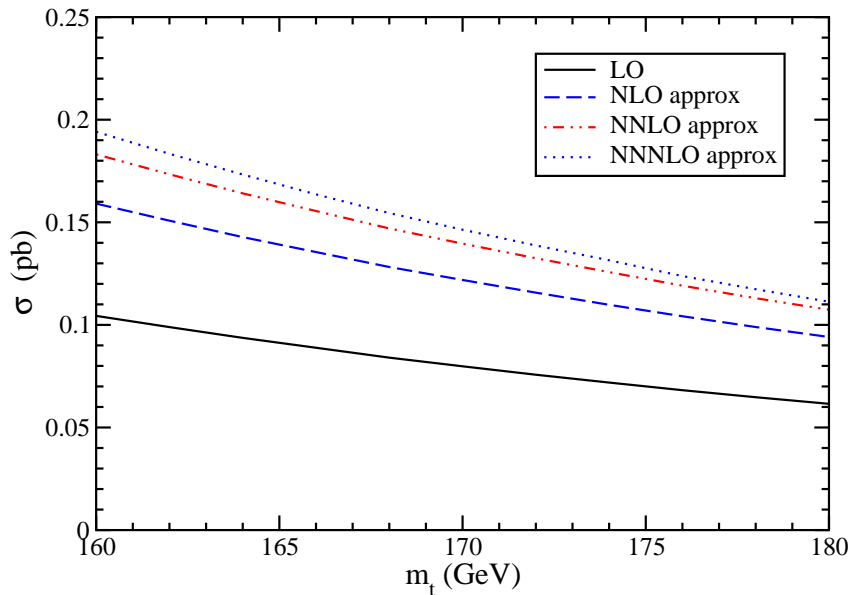
s channel	LO	NLO approx	NNLO approx	NNNLO approx
$m_t = 170$	0.353	0.510	0.555	0.576
$m_t = 172$	0.335	0.484	0.528	0.547
$m_t = 175$	0.310	0.448	0.488	0.506

$$\sigma^{s\text{-channel}}(m_t = 171.4 \pm 2.1 \text{ GeV}) = 0.54 \pm 0.02 \pm 0.03 \pm 0.01 \text{ pb} = 0.54 \pm 0.04 \text{ pb}$$

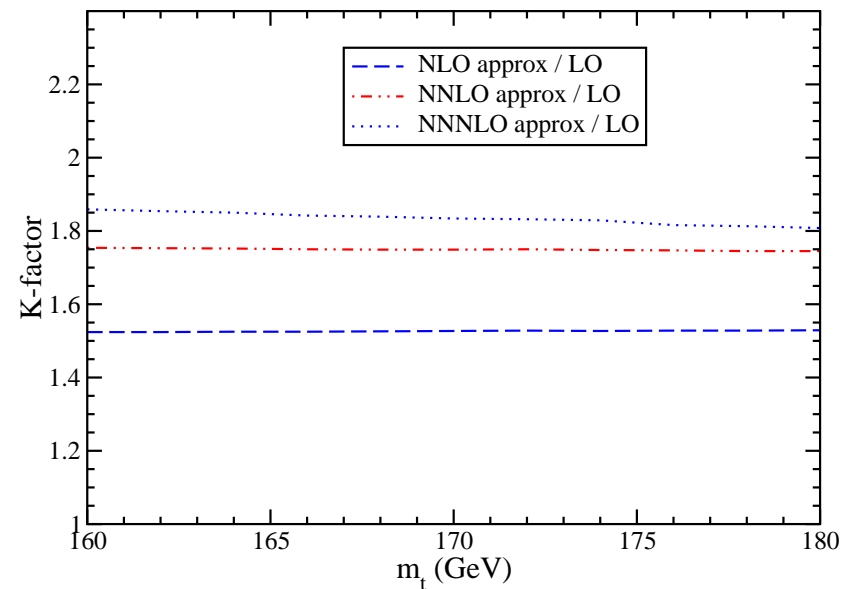
\uparrow \uparrow \uparrow
scale **mass** **pdf**

Single top production at the Tevatron - tW channel

bg \rightarrow tW^- at Tevatron $S^{1/2}=1.96$ TeV $\mu=m_t$



bg \rightarrow tW^- at Tevatron $S^{1/2}=1.96$ TeV $\mu=m_t$

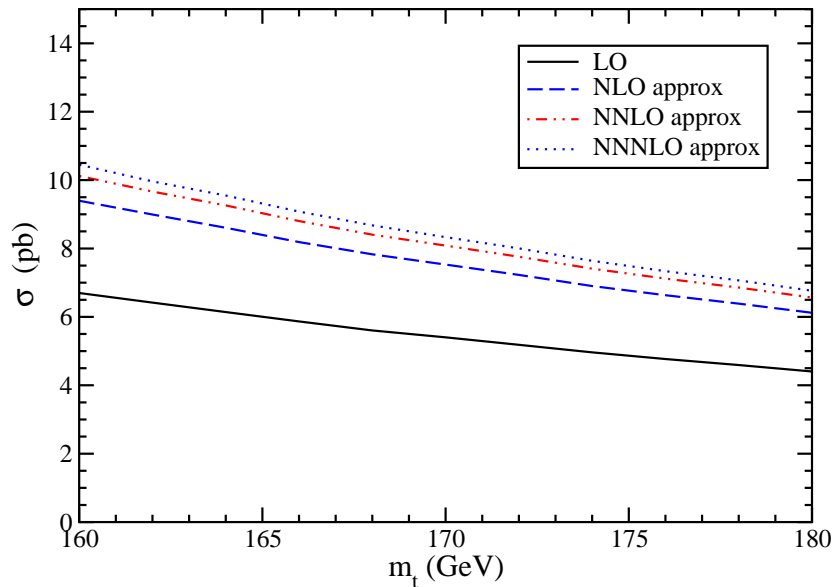


tW production	LO	NLO approx	NNLO approx	NNNLO approx
$m_t = 170$	0.080	0.122	0.140	0.146
$m_t = 172$	0.076	0.116	0.133	0.139
$m_t = 175$	0.070	0.107	0.122	0.127

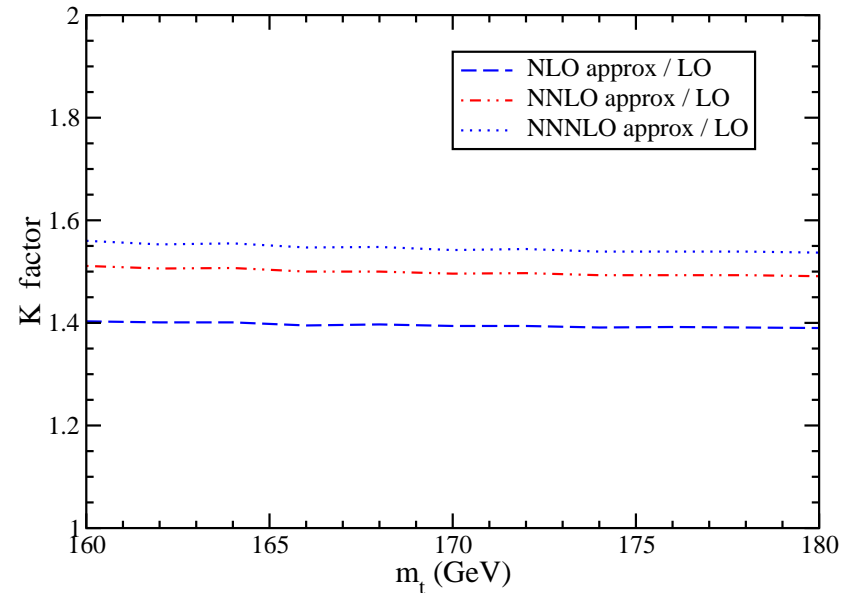
$$\sigma^{tW}(m_t = 171.4 \pm 2.1 \text{ GeV}) = 0.14 \pm \underset{\substack{\uparrow \\ \text{scale}}}{0.02} \pm \underset{\substack{\uparrow \\ \text{mass}}}{0.01} \pm \underset{\substack{\uparrow \\ \text{pdf}}}{0.02} \text{ pb} = 0.14 \pm 0.03 \text{ pb}$$

Single top production at the LHC - s channel

Single top at the LHC s-channel $S^{1/2}=14$ TeV $\mu=m_t$



Single top at the LHC s-channel $S^{1/2}=14$ TeV $\mu=m_t$



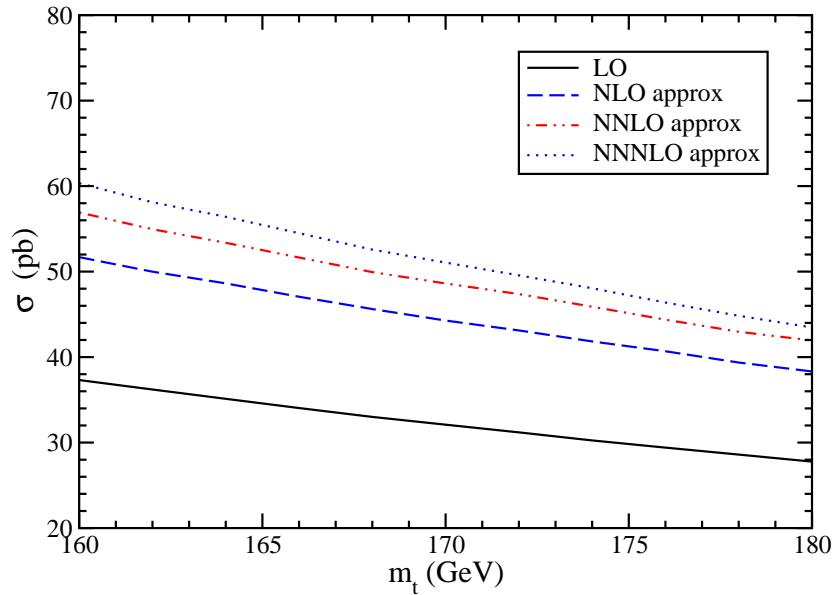
<i>s</i> channel	LO	NLO approx	NNLO approx	NNNLO approx
$m_t = 170$	5.40	7.53	8.08	8.33
$m_t = 172$	5.18	7.23	7.76	8.00
$m_t = 175$	4.87	6.79	7.29	7.52

$$\sigma^{s\text{-channel}}(m_t = 171.4 \pm 2.1 \text{ GeV}) = 7.80^{+0.58}_{-0.40}{}^{+0.36}_{-0.33} \pm 0.14 \text{ pb} = 7.80^{+0.70}_{-0.54} \text{ pb}$$

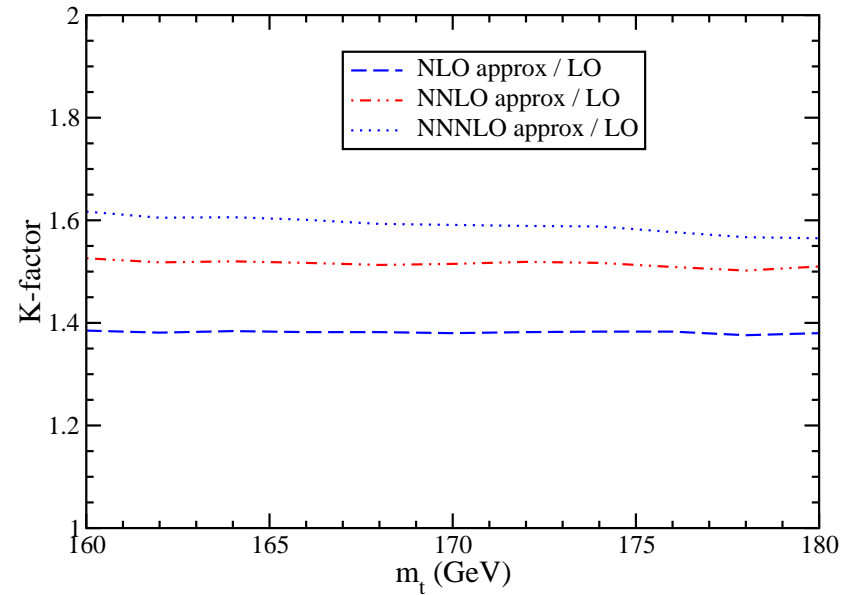
↑ scale
 ↑ mass
 ↑ pdf

Single top production at the LHC - tW channel

$bg \rightarrow tW^-$ at the LHC $S^{1/2}=14$ TeV $\mu=m_t$



$bg \rightarrow tW^-$ at the LHC $S^{1/2}=14$ TeV $\mu=m_t$



tW production	LO	NLO approx	NNLO approx	NNNLO approx
$m_t = 170$	32.1	44.3	48.6	51.0
$m_t = 172$	31.2	43.1	47.4	49.6
$m_t = 175$	29.9	41.1	45.0	47.0

$$\sigma^{tW}(m_t = 171.4 \pm 2.1 \text{ GeV}) = 43.5^{+4.4}_{-3.5} \pm 1.5 \pm 1.0 \text{ pb} = 43.5^{+4.7}_{-3.9} \text{ pb}$$

\uparrow \uparrow \uparrow
 scale mass pdf

Summary

- **Single top production via all Standard Model partonic processes**
- **t and s channels and associated tW production**
- **Soft-gluon threshold corrections**
- **At the Tevatron, threshold approximation works well - small corrections in t channel, large in s and tW channels**
- **At the LHC, threshold approximation works well in s and tW channels - large corrections**