8-1-2010

Top Quark Pair and Single Top Production at Tevatron and LHC Energies

Nikolaos Kidonakis
Kennesaw State University, nkidonak@kennesaw.edu

PROCEEDINGS OF SCIENCE

Top quark pair and single top production at Tevatron and LHC energies

Nikolaos Kidonakis[*†]
Kennesaw State University, USA
E-mail: nkidonak@kennesaw.edu

I present the latest calculations of total and differential cross sections for top-antitop pair production and single top quark production via all main partonic channels. Higher-order corrections from the resummation of soft gluons are added through NNLL accuracy. Detailed numerical results are presented for approximate NNLO cross sections and top quark transverse momentum distributions at the Tevatron and LHC colliders.

35th International Conference of High Energy Physics
July 22-28, 2010
Paris, France

[*]Speaker.

[†]This work was supported by the National Science Foundation under Grant No. PHY 0855421.

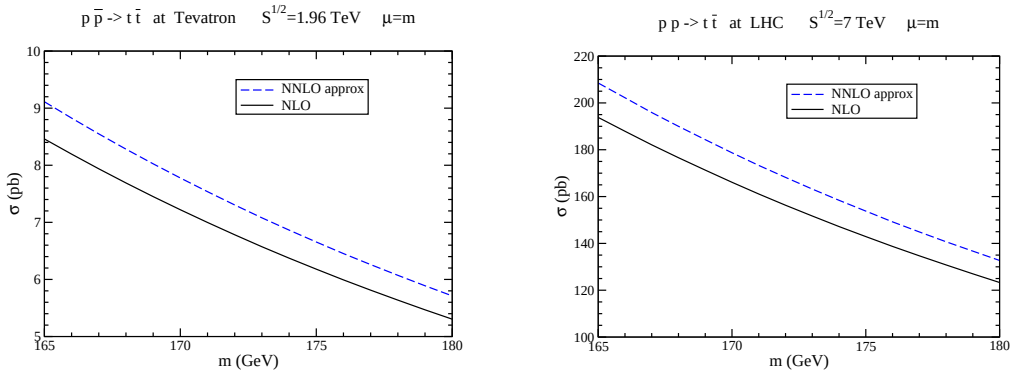

Figure 1: Top-antitop pair cross section at the Tevatron (left) and the LHC (right).

1. Top quark production and NNLL resummation

Top quarks can be produced at hadron colliders via top-antitop pair [1] and single top [2] production channels. For $t\bar{t}$ production the leading-order (LO) partonic processes are $q\bar{q} \to t\bar{t}$, which is dominant at Tevatron energies, and $gg \to t\bar{t}$, dominant at LHC energies. For single top quark production the corresponding processes are $qb \to q't$ and $\bar{q}b \to \bar{q}'t$ (t-channel), dominant at both Tevatron and LHC energies; $q\bar{q}' \to \bar{b}t$ (s-channel), which is small at both Tevatron and LHC; and associated tW production, $bg \to tW^-$, which is very small at the Tevatron but significant at the LHC. A related process is $bg \to tH^-$.

QCD corrections are significant for both $t\bar{t}$ and single top production. Higher-order corrections from threshold resummation of soft-gluon contributions further enhance the total cross section and top quark differential distributions [3, 4, 5]. Recently these corrections have been resummed to next-to-next-to-leading logarithm (NNLL) accuracy, involving two-loop calculations of the soft anomalous dimensions. Approximate next-to-next-to-leading order (NNLO) total and differential cross sections have been derived from the NNLL resummed expressions [6, 7, 8]. Below I show numerical results for the $t\bar{t}$ cross section and the top quark p_T distribution at Tevatron and LHC energies, and for single top production via s-channel or via associated production with a W^- or H^- at Tevatron and LHC energies [7, 8].

2. $t\bar{t}$ cross section and top quark p_T distribution at the Tevatron and the LHC

We first study the total cross section for $t\bar{t}$ production (Fig. 1). We derive an approximate NNLO cross section from the expansion of the NNLL resummed cross section. Using the MSTW2008 NNLO pdf [9], we find at Tevatron and LHC energies

$$\sigma_{t\bar{t}}^{\rm NNLOapprox}(m_t = 173\,{\rm GeV}, 1.96\,{\rm TeV}) = 7.08^{+0.00\,+0.36}_{-0.32\,-0.27}\,{\rm pb}\,,$$

$$\sigma_{t\bar{t}}^{\rm NNLOapprox}(m_t = 173\,{\rm GeV}, 7\,{\rm TeV}) = 163^{+4\,+9}_{-8\,-9}\,{\rm pb}\,.$$

At 14 TeV LHC collisions, we find $920^{+50\,+33}_{-45\,-35}$ pb. The first uncertainty is from scale variation by a factor of 2 around $\mu = m_t$ while the second is from the pdf [9] uncertainties.

The top quark transverse momentum distribution at the Tevatron and LHC is shown in Fig. 2.

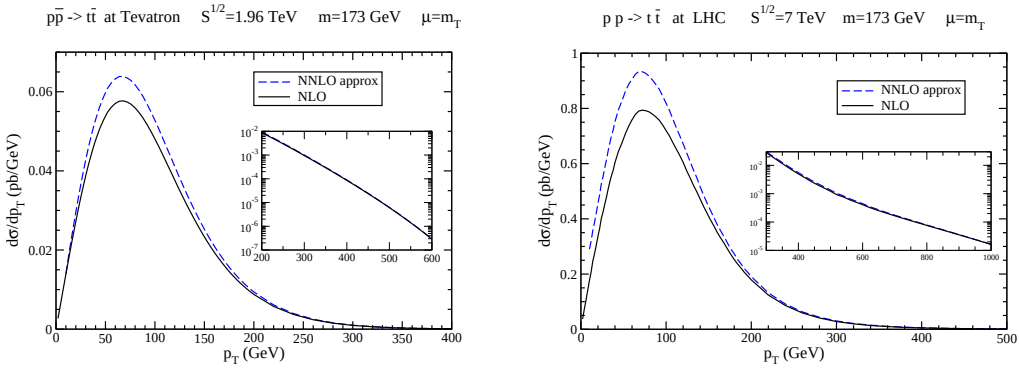

Figure 2: Top quark p_T distribution at the Tevatron (left) and the LHC (right).

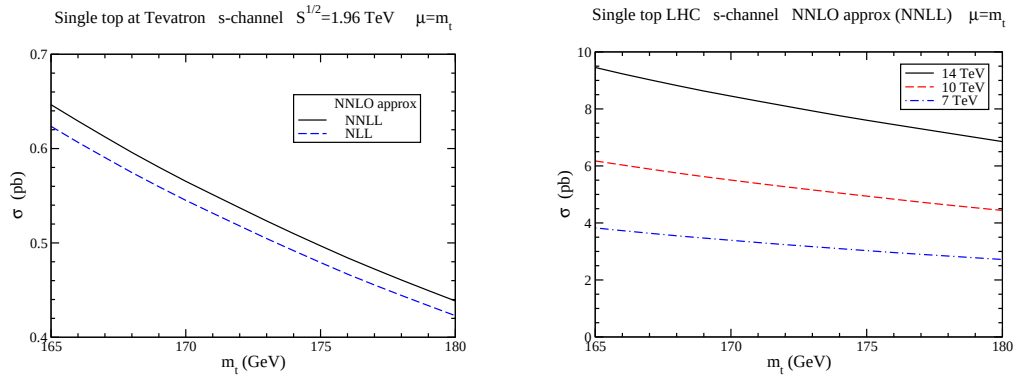

Figure 3: *s*-channel single top cross section at the Tevatron (left) and LHC (right).

3. Single top quark production: *s*-channel and associated production

We continue with the *s*-channel single top cross section at the Tevatron (Fig. 3, left). We find

$$\sigma_{s-\mathrm{channel}}^{\mathrm{NNLOapprox,top}}(m_t = 173\,\mathrm{GeV}, 1.96\,\mathrm{TeV}) = 0.523^{+0.001\,+0.030}_{-0.005\,-0.028}\,\mathrm{pb}\,.$$

The cross section for single *s*-channel anti-top production at the Tevatron is identical.

The single top production cross section at the LHC in the *s*-channel (Fig. 3, right plot) is

$$\sigma_{s-\mathrm{channel}}^{\mathrm{NNLOapprox,top}}(m_t = 173\,\mathrm{GeV}, 7\,\mathrm{TeV}) = 3.17 \pm 0.06^{+0.13}_{-0.10}\,\mathrm{pb}\,.$$

At 14 TeV, the result is $7.93 \pm 0.14^{+0.31}_{-0.28}$.

For single antitop production at the LHC in the *s*-channel we find $1.42 \pm 0.01^{+0.06}_{-0.07}$ pb at 7 TeV; and $3.99 \pm 0.05^{+0.14}_{-0.21}$ pb at 14 TeV.

The cross section for tW^- production at the LHC (see Fig. 4, left) is

$$\sigma_{tW}^{\mathrm{NNLOapprox}}(m_t = 173\,\mathrm{GeV}, 7\,\mathrm{TeV}) = 7.8 \pm 0.2^{+0.5}_{-0.6}\,\mathrm{pb}\,.$$

At 14 TeV, we have $41.8 \pm 1.0^{+1.5}_{-2.4}$ pb. The NNLO approximate corrections increase the NLO cross section by $\sim 8\%$. The cross section for $\bar{t}W$ production is identical.

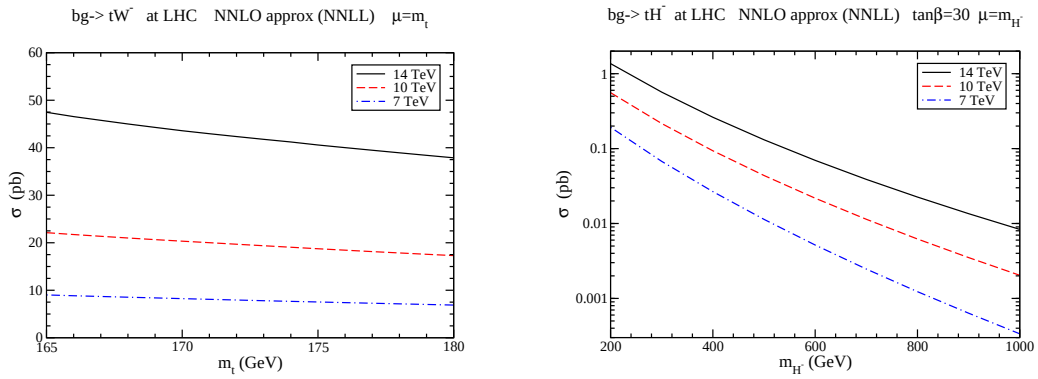

Figure 4: tW^- (left) and tH^- (right) cross sections at the LHC.

For tH^- production (Fig. 4, right) the NNLO approximate corrections increase the NLO cross section by ~ 15 to $\sim 20\%$.

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