Parton Distribution Functions and Top Quark Differential Cross Section at the D0 $\sqrt{s} = 1.96$ TeV and LHC $\sqrt{s} = 7, 13$ TeV

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The measurement of $t\bar{t}$ differential production cross sections provides a direct test of QCD. We present the comparison of top quark differential cross section in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV and predictions for LHC at $\sqrt{s} = 7, 13$ TeV as a function of transverse momentum using various PDFs. These cross sections are calculated in the next-to-next-to-leading order (NNLO) in QCD using DiffTop package. Our results are in good agreement with recent D0 experimental data from Fermilab Tevatron Collider.

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1. Introduction

Parton distribution functions (PDFs) are the probability of finding a quark or a gluon (parton) in a proton with a certain momentum fraction at a given energy scale. PDFs of the proton are extracted from a global analysis on deep inelastic data and hard scattering processes [1–11]. New measurements made at the Hadron Colliders can improve PDFs for high precision studies.

Top-quark pair $t\bar{t}$ events are widely created at the Hadron Colliders so it allows experimentalists to measure precise inclusive and differential top quark cross sections. High precision data of $t\bar{t}$ production have the potential to provide the opportunity to examine the perturbative QCD predictions and gain direct information on the gluon distribution at large momentum fractions (x_B) about 0.1-0.5 [12]. In this paper we investigate $t\bar{t}$ differential cross section based on QCD and the results are also compared to the data that released by D0 from Fermilab Tevatron Collider with various PDFs using DiffTop [13]. Moreover, we present our predictions for the $t\bar{t}$ differential cross sections at the LHC at $\sqrt{s} = 7, 13$ TeV.

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2. Top quark cross sections

The top quark is one of the strangest predictions of the Standard Model in particle physics. The top quark is an interesting subject of study because of two reasons. The first one is the huge mass of the top quark, which is about the same mass as an atom of Tungsten and the second one is it's decaying before hadronization. It is also of crucial importance in searches for signs of physics beyond the Standard Model. Recently, measurements declared that the Higgs boson mass is in this range $120 < M_H <$135 GeV, consequently the Higgs boson sector is twisted with the top quark physics.

The inclusive cross section for the $t\bar{t}$ production can be calculated with the computer programs Top++ [14] and Hathor [15]. The top quarks cross section in these programs are established in the on-shell approximation. The NLO calculations for top quark cross section where the final-state of top quarks decay into pairs of W bosons and b quarks can be found in Refs. [16–18]. Precise measurements of differential cross section of $t\bar{t}$ same as its inclusive cross section are beneficial for the comparison of QCD predictions with the data and phenomenological analyses. Available differential distributions are invariant mass distribution of $t\bar{t}$, transverse momentum, and rapidity distributions of the top quark or $t\bar{t}$. The QCD NLO calculations for total and differential cross sections of $t\bar{t}$ can be calculated with numerical codes MCFM [19], MC@NLO [20], POWHEG [21], and MadGraph/MadEvent [22, 23]. The NNLO approximation for $t\bar{t}$ differential cross section is implemented in DiffTop computer program [13]. In this code, calculations have established in the single-particle inclusive (1PI) kinematic for heavy-flavor production at the hadron colliders. Furthermore, because the lack of exact NNLO corrections for $t\bar{t}$ differential cross sections and to reach results beyond the NLO approximation, techniques of logarithmic expansion in QCD threshold resummation [25, 26] are implemented in this code. The threshold resummation technique utilize the logarithmic terms expansion of cross section to simplify cross-section calculations for higher order approximation beyond the NLO. So, this technique provides more facilities for phenomenology studies.

3. Results and conclusion

In this work, we use DiffTop package to study the predicted distributions of top-quark transverse momentum generated by using different PDF sets such as CT10 [2], MSTW [3] and NNPDF [4] and compare to the recent measurements by D0 collaborations [24]. The production of top quark-antiquark pairs $t\bar{t}$ at the Fermilab Tevatron Collider is dominated by the quark-antiquark $q\bar{q}$ annihilation process. The results of our comparison are illustrated in Fig. 1. According to this figure, the results are almost in a good agreement with D0 data. On the other hand, results related to different PDF sets are relatively close together, specially for the transverse momentum more than about 200 GeV and less than 25 GeV are quite the same. The only area which the results are clearly different is in the vicinity of 70 GeV. In this area, the CT10 PDFs give a better description of the data.

In addition in Fig. 2 the prediction for the $t\bar{t}$ differential cross section at the LHC at $\sqrt{s} = 7, 13$ TeV for various PDF sets are indicated.

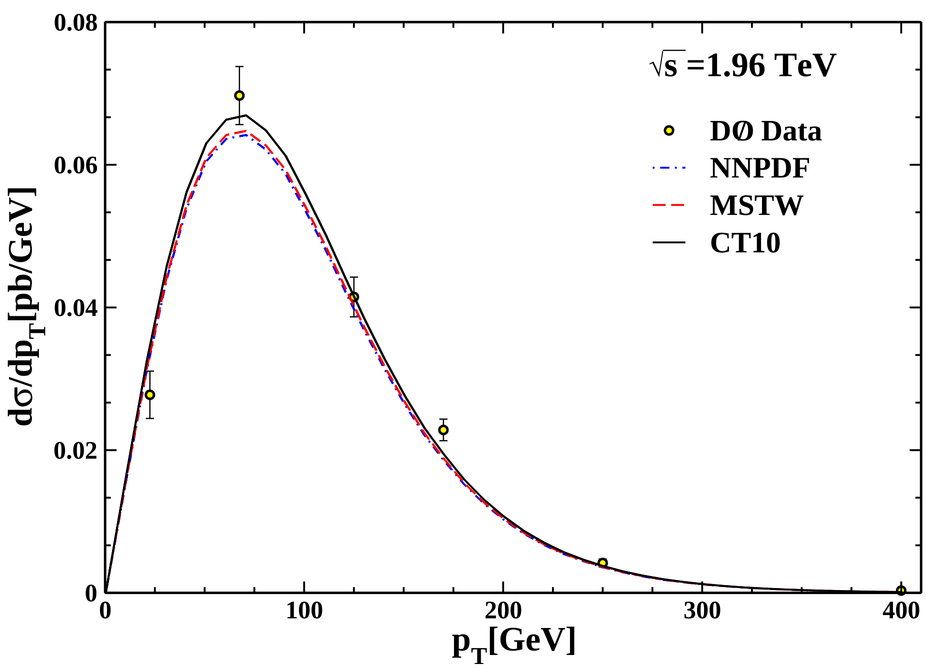

Figure 1: The comparison of top quark differential cross section in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV [24] as a function of the transverse momentum using various PDFs, CT10 [2], MSTW [3] and NNPDF [4]. These cross sections are calculated at the NNLO approximation in QCD using DiffTop package [13].

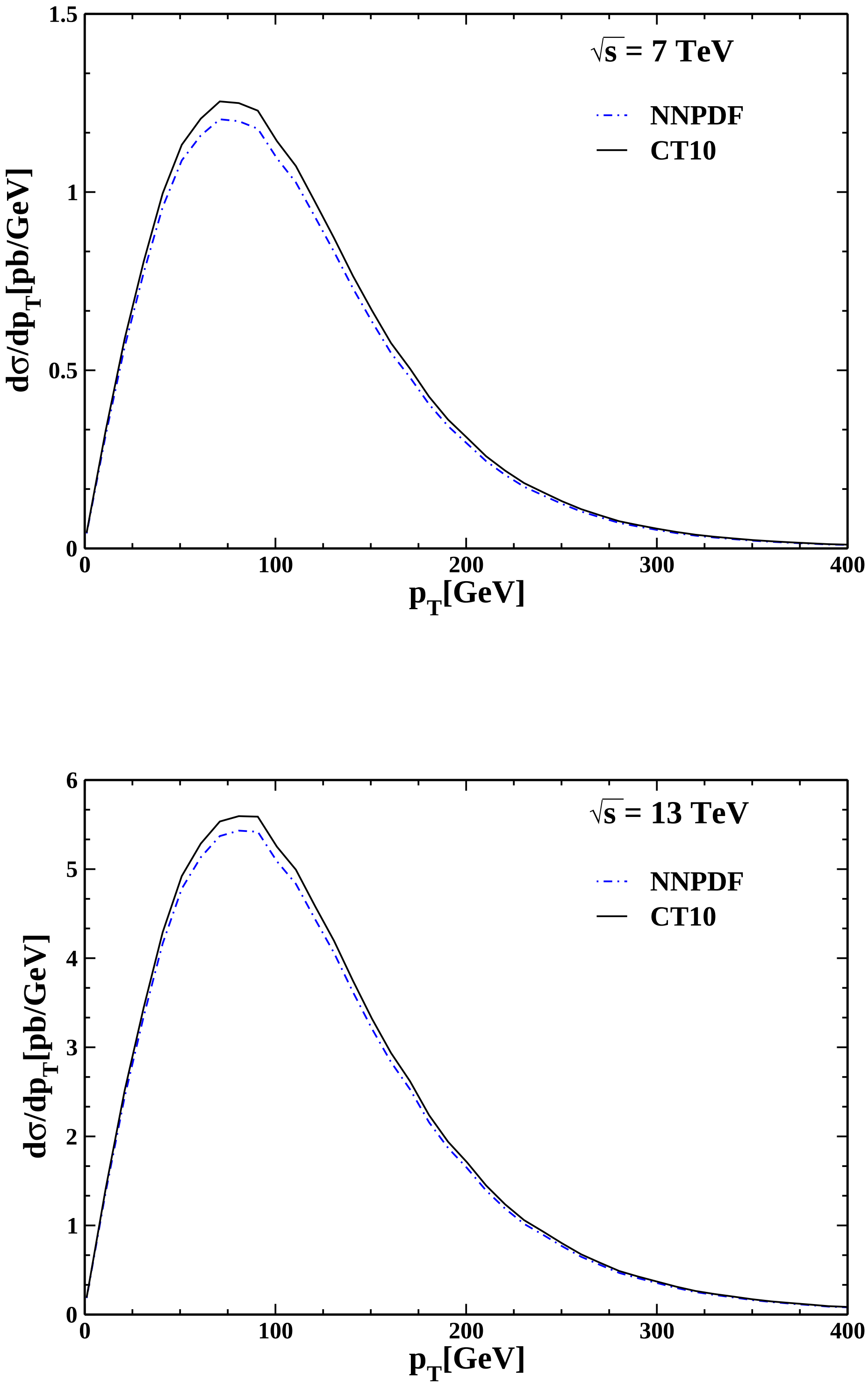

Figure 2: The prediction of top quark differential cross section in pp collisions at $\sqrt{s} = 7$ TeV and $\sqrt{s} = 13$ TeV as a function of transverse momentum using various PDFs, CT10 [2] and NNPDF [4]. These cross sections are calculated at the NNLO approximation in QCD using DiffTop package [13].

References

[1] L. A. Harland-Lang, A. D. Martin, P. Motylinski and R. S. Thorne, [arXiv:1412.3989 [hep-ph]].

[2] J. Gao, *et al.*, Phys. Rev. D **89** no. 3, (2014) 033009, [arXiv:1302.6246 [hep-ph]].

[3] A. D. Martin, W. J. Stirling, R. S. Thorne and G. Watt, Eur. Phys. J. C **63** (2009) 189, [arXiv:0901.0002 [hep-ph]].

[4] R. D. Ball, *et al.*, Nucl. Phys. B **867** (2013) 244, [arXiv:1207.1303 [hep-ph]].

[5] C. Bourrely and J. Soffer, [arXiv:1502.02517 [hep-ph]].

[6] S. Alekhin, J. Bluemlein and S. Moch, Phys. Rev. D **89**, no. 5 (2014) 054028, [arXiv:1310.3059 [hep-ph]].

[7] P. Jimenez-Delgado and E. Reya, Phys. Rev. D **89**, no. 7 (2014) 074049, [arXiv:1403.1852 [hep-ph]].

[8] H. Khanpour, A. N. Khorramian and S. A. Tehrani, J. Phys. G **40** (2013) 045002, [arXiv:1205.5194 [hep-ph]].

[9] A. Kusina, K. Kovarik, T. Jezo, D. B. Clark, F. I. Olness, I. Schienbein and J. Y. Yu, PoS DIS **2014** (2014) 047, [arXiv:1408.1114 [hep-ph]].

[10] F. Arbabifar, A. N. Khorramian and M. Soleymaninia, Phys. Rev. D **89**, no. 3 (2014) 034006 [arXiv:1311.1830 [hep-ph]].

[11] A. N. Khorramian, S. Atashbar Tehrani, S. Taheri Monfared, F. Arbabifar and F. I. Olness, Phys. Rev. D **83** (2011) 054017 [arXiv:1011.4873 [hep-ph]].

[12] M. Czakon, M. L. Mangano, A. Mitov, and J. Rojo, JHEP **07** (2013) 167 , [arXiv:1303.7215 [hep-ph]].

[13] Marco Guzzi, Katerina Lipka, Sven-Olaf Moch, JHEP **1501** (2015) 082, [arXiv:1406.0386 [hep-ph]].

[14] M. Czakon and A. Mitov, [arXiv:1112.5675 [hep-ph]], (2011).

[15] M. Aliev, *et al.*, Comput.Phys.Commun. **182** (2011) 1034, [arXiv:1007.1327 [hep-ph]].

[16] A. Denner, S. Dittmaier, S. Kallweit and S. Pozzorini, Phys.Rev.Lett. **106** (2011) 052001, [arXiv:1012.3975 [hep-ph]].

[17] G. Bevilacqua, *et al.*, JHEP **1102** (2011) 083, [arXiv:1012.4230 [hep-ph].

[18] A. Denner, S. Dittmaier, S. Kallweit and S. Pozzorini, JHEP **210** (2012) 110, [arXiv:1207.5018 [hep-ph]].

[19] J.M. Campbell and R.K. Ellis, Phys.Rev. **D62** (2000) 114012, hep-ph/0006304.

[20] S. Frixione, P. Nason and B.R. Webber, JHEP **0308** (2003) 007, hep-ph/0305252.

[21] S. Alioli, *et al.*, JHEP **1104** (2011) 081, [arXiv:1012.3380 [hep-ph]].

[22] J. Alwall, *et al.*, JHEP **0709** (2007) 028, [arXiv:0706.2334 [hep-ph]].

[23] R. Frederix, S. Frixione, F. Maltoni and T. Stelzer, JHEP **0910** (2009) 003, [arXiv:0908.4272 [hep-ph]].

[24] D0 Collaboration, Phys. Rev. D **90** (2014) 092006, [arXiv:1401.5785 [hep-ph]].

[25] G.F. Sterman, Nucl.Phys. B **281** (1987) 310.

[26] S. Catani and L. Trentadue, Nucl.Phys. B **327** (1989) 323.

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