

# Top Cross section and Production Measurements at the Tevatron

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I present recent results of  $t\bar{t}$  cross section and production measurements in  $p\bar{p}$  collisions at  $\sqrt{s} = 1.96$  TeV, based on  $1 \sim 2 \text{ fb}^{-1}$  of data collected by the CDF and DØ detector at the Fermilab Tevatron Collider.

## 1 Introduction

The top quark was discovered in 1995 by CDF and DØ collaborations [2, 3] with the mass predicted by the standard model. This completes the quark sector of the three generation structure in the standard model. The mass of top quark is 40 times heavier than the next heaviest quark and the lifetime is about  $4 \cdot 10^{25}$ s so that it is the only quark that decays before its hadronization which allows the study of the decay as an essentially free quark. The top quark plays an important role in Higgs boson coupling since the coupling is stronger than any other fermions. Therefore understanding the properties of the top quark is very important for Higgs boson search. Additionally the study of top quark provides a test of perturbative Quantum Chromo Dynamics and a crucial ingredient in the discovery of new physics beyond the standard model.

## 2 Measurements of the $t\bar{t}$ pair production cross section

The Tevatron collides protons and antiprotons at  $\sqrt{s} = 1.96$  TeV and most of top quarks at the Tevatron are created in pairs through the strong interaction. For a top quark mass of 175 GeV, the standard model predicts a  $t\bar{t}$  production cross section of about 6.7 pb [4, 5]. In the standard model the top quark always decays to a  $W$  boson and a  $b$  quark. The decay modes of the  $W$  boson define the possible final states. Since top pair production produces two  $W$ s and two  $b$ -s, we have classified as dilepton channel where both  $W$ s decay leptonically, lepton + jets channel where one  $W$  decays leptonically and the other  $W$  decays hadronically and finally all jets channel where both  $W$ s decay hadronically. The dilepton channel contains purest sample but less statistics and all jets channel contains high statistics but large backgrounds. The lepton + jets channel contains high statistics and manageable backgrounds.

CDF measured the top cross section using candidates events selected in dilepton channel with at least one SecVtx tagged jets [6]. The tagged backgrounds evaluated by applying the SecVtx positive tag rate matrix to the pretagged dilepton sample and validated by comparing observed and predicted number of tags in  $Z$  data events. Using  $2 \text{ fb}^{-1}$  of data collected by CDF detector, the cross section at top mass 175 GeV is

$$\sigma_{t\bar{t}} = 9.0 \pm 1.1(\text{stat.}) \pm 0.7(\text{syst.}) \pm 0.5(\text{lumi.}) \text{ pb}$$

DØ measured the  $t\bar{t}$  production cross section in the lepton+jets channel using two complementary methods which discriminate between signal and backgrounds, Neural Network  $b$ -tagging and a kinematic likelihood discriminant, based on  $0.9 \text{ fb}^{-1}$  of data collected by the DØ detector [7]. The cross section at top mass 175 GeV is

$$\sigma_{t\bar{t}} = 7.4 \pm 0.8 \text{ pb}$$

This is the world best measurement in  $t\bar{t}$  pair production. DØ determined top quark mass by comparing the cross section measurements with theory predictions and the top mass (see Fig. 1) is

$$M_{top} = 170 \pm 7 \text{ GeV}$$

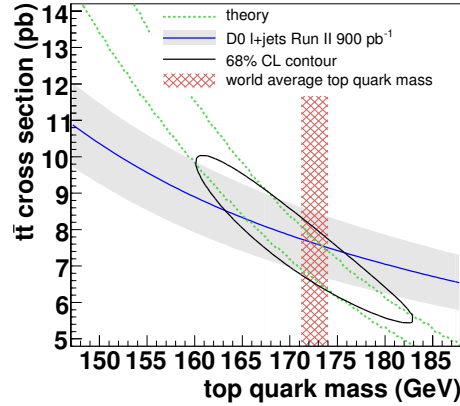


Figure 1: Comparison of measured cross section and theory prediction versus top quark mass.

Figure 2 summarizes recent results from both CDF and DØ based on approximately  $1 \sim 2 \text{ fb}^{-1}$  of data, together with the theoretical predictions.

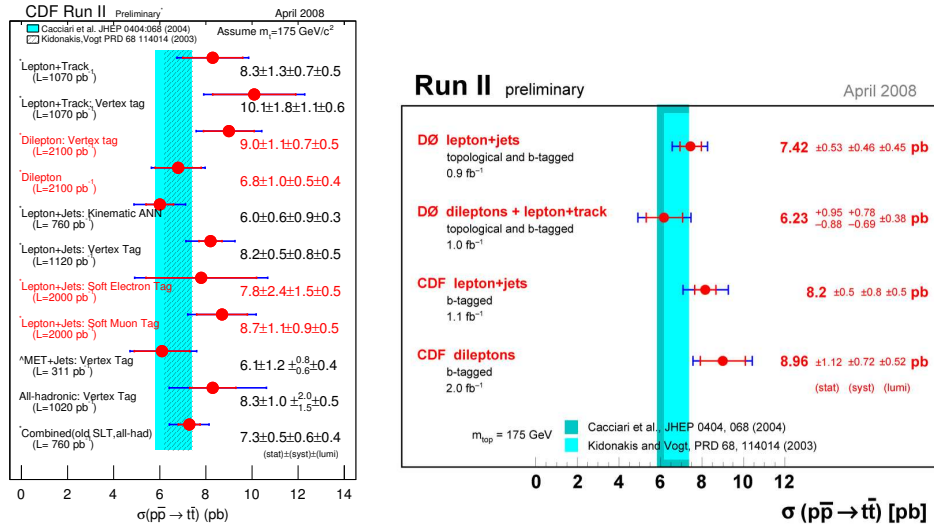


Figure 2: Summary of  $t\bar{t}$  pair production cross section measurements at  $\sqrt{s} = 1.96 \text{ TeV}$  from CDF (left), DØ(right) at top mass 175 GeV. Theoretical predictions are shown as vertical bands.

### 3 Measurements of the ratio $B(t \rightarrow Wb)/B(t \rightarrow Wq)$

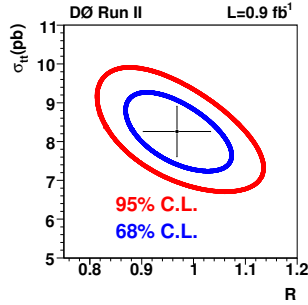


Figure 3:  $R = B(t \rightarrow Wb)/B(t \rightarrow Wq)$  versus  $\sigma_{t\bar{t}}$  (pb)

$$R = 0.97_{-0.08}^{+0.09}(\text{stat.} + \text{syst.})$$

$$\sigma_{t\bar{t}} = 8.2 \pm 0.9 \text{ pb}$$

### 4 Measurements of the relative fraction of $t\bar{t}$ events produced via gluon-gluon fusion

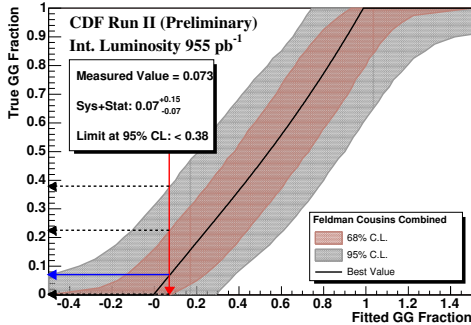


Figure 4: Feldman-Cousins plot of the combination. It shows the statistical+systematic 68% and 95% bands, the central value and its limits.

DØ has analyzed the ratio of branching fraction,  $R = B(t \rightarrow Wb)/B(t \rightarrow Wq)$ , with  $q$  being a  $d$ ,  $s$ , or  $b$  quark along with top pair cross section in the lepton + jets channel using  $0.9 \text{ fb}^{-1}$  of data collected by DØ detector [8]. The  $R$  and  $\sigma_{t\bar{t}}$  are measured using the sample of events with 0,1 and  $\geq 2$   $b$  jets by Neural Network  $b$ -tagging algorithm and the results (see Fig. 3) are

CDF has studied the relative fraction of  $t\bar{t}$  events produced via gluon-fusion to the total number of  $t\bar{t}$  events using a combined template method based on Neural Networks probabilities and low  $p_T$  track multiplicity [9]. Using  $0.9 \text{ pb}^{-1}$  of data collected by CDF detector, the fraction ( $C_f^{\text{true}}$ ) (see Fig. 4) was found to be

$$C_f^{\text{true}} = 0.07_{-0.07}^{+0.15}$$

### 5 Summary

The Tevatron has entered the era of precision measurements and the experimental precision on the top quark pair production cross section is approaching the theoretical uncertainty. New techniques has been developed and a large data have been available to make precision measurements of cross

section and properties. We found that all measurements agree with standard model predictions.

## 6 Acknowledgments

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