TOP QUARK PAIR PRODUCTION CROSS SECTION MEASUREMENTS IN $p\overline{p}$ COLLISIONS AT $\sqrt{S}$=1.96 TEV.

S. CABRERA *

on behalf of the CDF and DØ collaborations.
IFIC (CSIC-Universidad de Valencia)
Edificio Institutos de Investigación,
Apartado de Correos 22085
E-46071 Valencia - Spain
E-mail: Susana.Cabrera@ific.uv.es

The CDF and DØ experiments have measured the $t\bar{t}$ production cross section in $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV from different final states using a wide variety of techniques. CDF has combined 6 measurements using data samples with integrated luminosities up to 760 pb^{-1}:

$$\sigma_{t\bar{t}} = 7.3 \pm 0.5(stat) \pm 0.6(syst) \pm 0.4(lum) \;\; \text{pb}$$

in good agreement with the theoretical calculations: 6.7±0.8 pb for a top mass of 175 GeV/c^2. The experimental precision of the current CDF combined result is comparable for the first time to the accuracy of the QCD NLO theory: ∼12%

1. Introduction

Since the beginning of Run II, the Tevatron $p\overline{p}$ collider has delivered more than 1 fb^{-1}of $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV. With this increased data set the perturbative QCD theory can be exhaustively tested by measuring $\sigma_{t\bar{t}}$.

2. The dilepton channel

The dilepton analyses are focussed on selecting a sample enriched with $t\bar{t} \rightarrow W^+bW^-\bar{b}$ events where both W bosons decay leptonically. The CDF dilepton technique providing the $\sigma_{t\bar{t}}$ result with highest S/B ratio [1] searches for final states with two identified leptons, electrons (or muons), with opposite electric charge and $E_T(P_T)$ >20 GeV, $\not{E}_T$ above 25 GeV, and at least 2 jets with $E_T > 15$ GeV. The acceptance is $\mathcal{A} = 0.72 \pm 0.05\%$.

*Work partially supported by the grant FPA2005-25357-E of the Spanish Ministry of Science and Education.

The contributing backgrounds, in order of importance, are: Drell-Yan ($Z^*/\gamma \to e^+e^-, \mu^+\mu^-$), W boson production with associated jets with one jet misidentified as a lepton, massive diboson pairs WW and WZ and $Z^*/\gamma \to \tau^+\tau^-$ with associated jets. This technique provides a high signal to background ratio with no need of b-tagging (see figure 1). The main challenge is the determination of instrumental backgrounds $Z^*/\gamma \to e^+e^-, \mu^+\mu^-$ and *fake* lepton in W boson production, mostly driven by data.

In order to be sensitive to new physics two approaches have been followed. The DØ dilepton analysis [2] increases the acceptance by loosening the lepton identification requirements on the second lepton and by including events with one jet. The use of b-tagging is needed to control the increased background mainly from *fake* leptons. The main systematic source in both analyses [1] and [2] comes from the jet energy scale uncertainty. The measured $\sigma_{t\bar{t}}$ values for both analyses [1] and [2] are shown in figure 3. A new global high P_T dilepton analysis developed in CDF [3] fits all the Standard Model processes in the 2-D space $\not\!\!E_T$ versus N_{jets}. This method provides high statistical power with less purity but no dependence with the jet energy scale. The result obtained is $\sigma_{t\bar{t}} = 8.5^{+2.6}_{-2.2}(stat)^{+0.7}_{-0.3}(syst)$ pb with an integrated luminosity of $\mathcal{L} = 360$ pb^{-1}for a top mass 178 GeV/c^2.

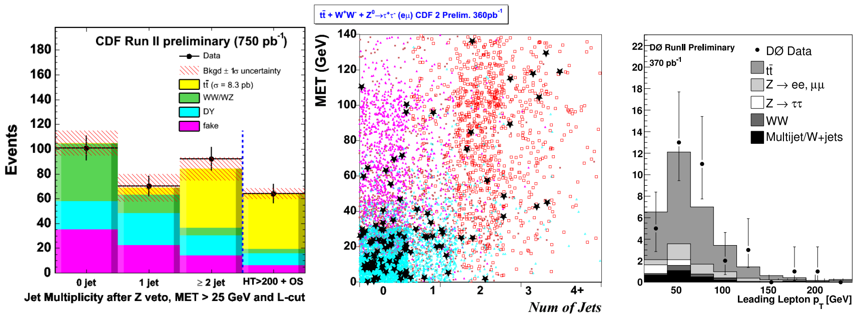

Figure 1. Left plot: Signal and background composition of the high P_T CDF dilepton sample (750 pb^{-1}) in different N_{jets} bins [1]. Central plot: 2-D $\not\!\!E_T$ versus N_{jets} distribution for CDF e-μ sample (360 pb^{-1}) [3]. Right plot: P_T distribution of the DØ *lepton plus track* sample after b-tagging [2]

3. The lepton plus jets channel

The lepton plus jets sample is enriched with $t\bar{t} \to W^+bW^-\bar{b}$ events where only one W bosons decay leptonically being the background moderate. The lepton plus jets signature consist of only one isolated electron (muon) with E_T (P_T) > 20 GeV, $\not\!\!E_T > 20$ GeV and 3 or more jets with $E_T > 15$

GeV. The dominant background is W boson production with associated jets followed by the QCD background. The most accurate $\sigma_{t\bar{t}}$ measurement is obtained by requiring at least one b-tagged jet with the secondary vertex technique and H_T[a]> 200 GeV [4].The signal to background ratio is almost 3. The acceptance is $\mathcal{A} = 3.4 \pm 0.2\%$. The QCD background evaluation relies 100% on data. $W +$ heavy flavour : $\mathrm{b}\bar{\mathrm{b}}, \mathrm{c}\bar{\mathrm{c}}, \mathrm{c}$ backgrounds are determined with data and MC and $W +$ light flavour are based on mistags found in data. The main systematic comes from the knowledge of the b-tagging efficiency.

An alternative approach [5] utilizes event kinematics. To discriminate against QCD background it is required $0.5 < \Delta\phi(\not{E}_T\ , jet_{E_T^{max}}) < 2.5$ if $\not{E}_T < 30$ GeV. To maximize the discrimination of $t\bar{t}$ production against $W +$jets an artificial neuronal network utilizes 7 topological variables: H_T, Aplanarity , $\min(M_{\mathrm{jet-jet}})$, $\min(\Delta R_{\mathrm{jet-jet}})$, $\eta_{\mathrm{jet}}^{max}$, $E_T^{\mathrm{2nd-jet}} + E_T^{\mathrm{3rd-jet}}$ and $\sum_{\mathrm{jets}} P_Z / \sum_{\mathrm{jets}} E_T$ keeping the correlations among them into account. The signal to background ratio is one to five. The $W +$jets background is driven 100% on $W +$ jets MC. Main systematics come from jet energy scale and Q^2 dependence of the $W +$jets MC.

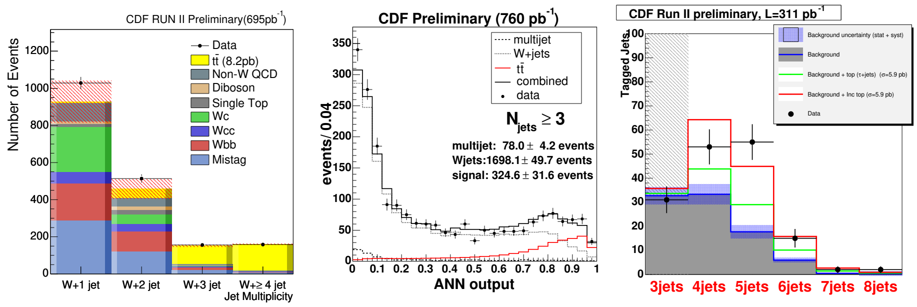

Figure 2. Left plot: Signal and background composition of the $W + \geq 3$jets sample with at least one btag (695 pb^{-1}) in different N_{jets} bins [4]. Central plot: output of the neural network for the $W + \geq 3$jets sample (760 pb^{-1}) [5]. Right plot: Signal and background composition of the $\not{E}_T$ plus jets sample in different N_{jets} bins [6] .

A third final state: $\not{E}_T$ plus jets, has been investigated in a multijet sample triggered in order to measure $\sigma_{t\bar{t}}$ using $t\bar{t}$ final states τ plus jets [6]. The main systematic comes from the background method determination: the probability of false btags or mistags is measured in the control sample $N_{jets} = 3$ and applied to the signal region $N_{jets} \geq 4$ before b-tagging. Third

[a] H_T is the scalar sum of all jets E_T, $\not{E}_T$ and lepton, electron (or muon) E_T (or P_T)

plot in figure 2 shows that part of the acceptance is also due to recovering of lepton plus jets events failing the lepton identification criteria.

All $\sigma_{t\bar{t}}$ measurements reported in this section are shown in figure 3.

4. Conclusions

All $\sigma_{t\bar{t}}$ measurements in different channels and different analysis techniques are in reasonable agreement each other (see figure 3). The CDF combined result, $\sigma_{t\bar{t}} = 7.3 \pm 0.5(stat) \pm 0.6(syst) \pm 0.4(lum)$ pb, improves 15% with respect to the best single measurement. Systematic and luminosity uncertainties slightly exceed the statistical one. All measurements are in good agreement with the NLO QCD predictions: 6.7±0.8 pb [8] for a top mass of 175 GeV/c^2. By combining with DØ and analizing the full dataset the theoretical accuracy can be superseded by the experimental precision.

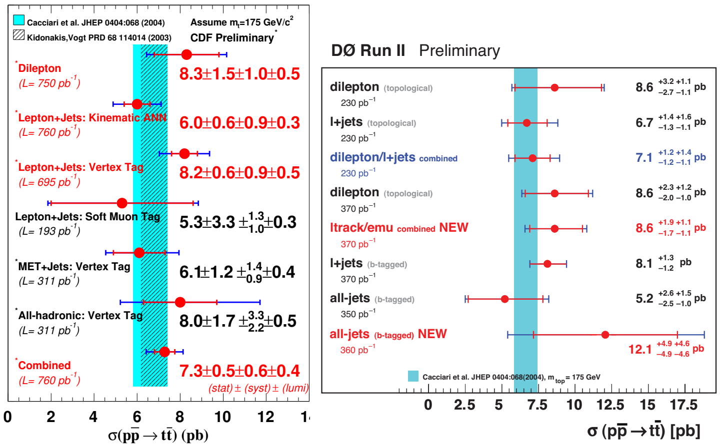

Figure 3. Summary of $\sigma_{t\bar{t}}$ measurements from CDF (left) and DØ (right)

References

1. The CDF collaboration. CDF conference note 8103 (2006).
2. The DØ collaboration. DØ conference note 5031 (2006).
3. The CDF collaboration. CDF conference note 7192 (2006).
4. The CDF collaboration. CDF conference note 8110 (2006).
5. The CDF collaboration. CDF conference note 8092 (2006).
6. A. Abulencia *et al.* CDF collaboration. *Phys. Rev. Lett.*, **96**, 202002.
7. The CDF collaboration. CDF conference note 8148 (2006).
8. M. Cacciari *et al.* , JHEP **404**,68 (2004).
   N. Kidonakis *et al.* *Phys. Rev. D.* **68**,114014 (2003).