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

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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}:

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

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 $\mathcal{A} = 0.72 \pm 0.05\%$.

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The contributing backgrounds, in order of importance, are: Drell-Yan ($Z^*/\gamma \rightarrow e^+e^-, \mu^+\mu^-$), W boson production with associated jets with one jet misidentified as a lepton, massive diboson pairs WW and WZ and $Z^*/\gamma \rightarrow \tau^+\tau^-$ 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 $Z^*/\gamma \rightarrow e^+e^-, \mu^+\mu^-$ 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.

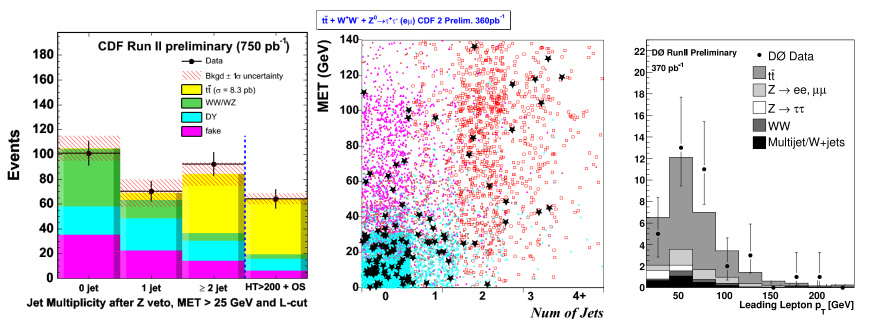

Figure 1. Left plot: Signal and background composition of the high P_T CDF dilepton sample (750 pb^{-1}) in different N_{jets} bins [1]. Central plot: 2-D $\not{E}_T$ versus N_{jets} distribution for CDF e-μ sample (360 pb^{-1}) [3]. Right plot: P_T distribution of the DØ *lepton plus track* sample after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

3. The lepton plus jets channel

The lepton plus jets sample is enriched with $t\bar{t} \rightarrow W^+bW^-\bar{b}$ 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 : $\mathrm{b\bar{b}, c\bar{c}, c}$ 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.

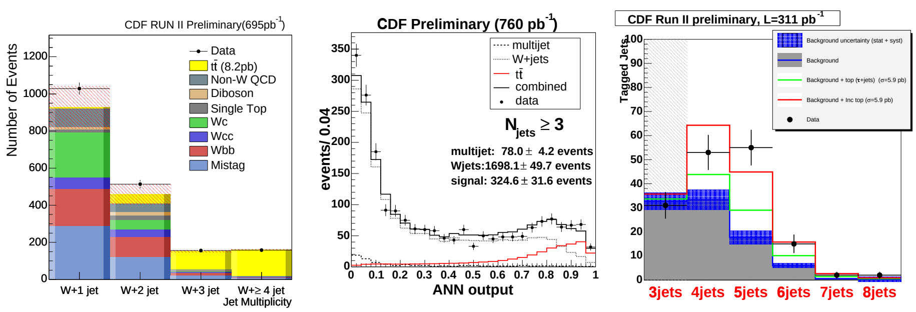

Figure 2. Left plot: Signal and background composition of the $W + \geq$3jets sample with at least one btag (695 pb^{-1}) in different N_{jets} bins [4]. Central plot: output of the neural network for the $W + \geq$3jets sample (760 pb^{-1}) [5]. Right plot: Signal and background composition of the $\not{E}_T$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

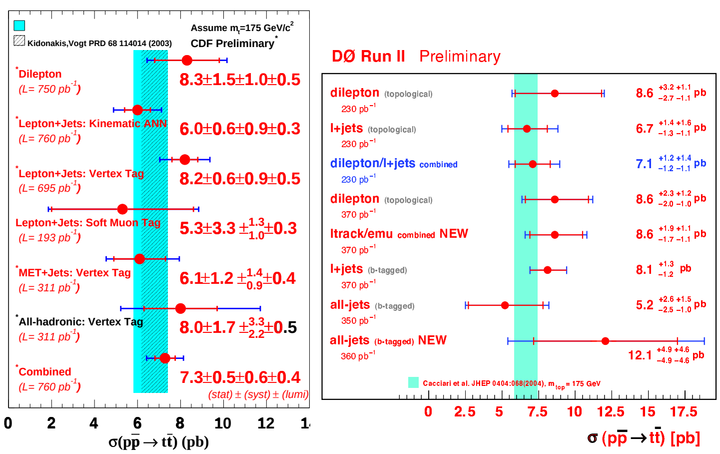

Figure 3. Summary of $\sigma_{t\bar{t}}$ measurements from CDF (left) and DØ (right)

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