PROCEEDINGS OF SCIENCE

Top Quark Pair Production Cross Section in the Lepton+Jets Final State at DØ

Jean-Roch Vlimant[*†]
LPNHE, University of Paris VI, France
E-mail: vlimant@in2p3.fr

Preliminary and published results obtained by the DØ Collaboration on the top quark pair production cross-section in $p\bar{p}$ collisions at a center-of-mass energy of $\sqrt{s} = 1.96$ TeV are presented. The measurements are obtained using the *lepton+jets* final states with two methods : in the first one, signal is discriminated from background using event kinematics and in the other method signal events are enumerated in a sample purified using b-lifetime tagging.

International Europhysics Conference on High Energy Physics
July 21st - 27th 2005
Lisboa, Portugal

*Speaker.
†on behalf of the DØ Collaborations

1. Introduction to top quark physics at the Tevatron

Top Quark Production

Since its discovery in 1995 the Top quark can only be studied at Fermilab with the Tevatron which produces $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV. At the Tevatron *Run II*, Top pairs are produced mostly by quark annihilation (85%) and gluon fusion (15%). The theoretical prediction for the pair production is 6.7±0.8 pb [1] with the mass assumption[1] of 175 GeV. The electroweak production of Top quark (single Top) has not yet been observed.

In order to study Top quark properties, Top enriched samples are used, which are controlled with the cross section measurement. Top pair production measurements allow to test the Standard Model (SM) and perturbative QCD predictions. Moreover, since Top pair production is a major background in analysis seeking for more rare decays such as light Higgs production, it has to be measured precisely.

Top Quark Pair Decay

The Top quark has a relatively short lifetime (10^{-25} s) compared to the other quarks and to the typical hadronisation time (10^{-23} s). Within the SM prediction, the Top decays predominantly ($\sim$100%) into a b quark and a W boson, therefore Top pair events contain at least 2 b-jets.

This SM assumption is made only in the b-lifetime tagging analysis which uses an algorithm to distinguish heavy (b and c quarks) from light flavor jets (u, d, s quarks and gluon). Charged tracks, primary and secondary verticies are utilized as input of this algorithm. They are reconstructed with the inner tracking system, which consists of a silicon micro-strips tracker and a scintillating fi ber tracker both inside a superconducting solenoid creating a longitudinal magnetic fi eld of 2 Tesla.

Top pair decay channels are completely determined by the W boson decay modes. They are : all hadronic channel (45%), dilepton channels (2.4% and 1.2 %) and *lepton+jets* channels (15%). The *Lepton+jets* channel analysis for electron and muon are reported in this paper.

2. Lepton plus jets channel

In the *lepton+jets* channels presented, one of W boson decays hadronically and the other in a lepton/neutrino pair, with the additional requirement that the fi nal lepton measured in the detector be a muon or an electron, including those from $W \to \mathrm{tau} + \mathrm{X} \to \mathrm{lepton} + \mathrm{X}$ decay[2].

Event Signature

Selected events consist of one isolated high p_T lepton, large missing transverse energy ($\not{E}_T$) due to neutrinos escaping the detector, 2 b-jets and some other jets from W decay and initial state radiation. Only events with at least four reconstructed jets are taken into account in the event kinematic analysis, while events with three and more jets are used in the b-lifetime tagging analysis.

Electrons are measured in the fi nely granulated, electromagnetic region of the DØ calorimeter. In addition, the hadronic region of the DØ calorimeter is used to measure the energy deposition of jets. Muons are measured with the muon spectrometer and the inner tracking system.

[1]The best measurement of the Top mass is 174±3.4 GeV [2], it is the most massive of the six SM quarks.

[2]Branching ratio is of the order 17% with the use of the *tau→lepton* possible decay.

Backgrounds

The two main backgrounds in both analysis are

- the W boson production with additional jets radiated from the initial state (*W+jets*). The flavor fraction of additional jets in simulation is applied[3] to data in the b-tagging analysis.
- *Multijet* events where one of the jets fakes[4] the identification of the lepton. Since the simulation of these particular events is not available, *multijet* background is evaluated from data.

Additional backgrounds are taken into account in the b-tagging analysis because of their relatively increased expected size due to the use of b-lifetime tagging : di-boson production with one or two leptons in the final state, single Top production events, and Top pair decays with two leptons in the final state. Backgrounds with two leptons in final states are considered because one of the lepton can escape detection and fake the *lepton+jets* signature.

3. Event Kinematics Method Analysis in the Lepton+Jets Channel

A two-class likelihood function is build out of six kinematic variables that were chosen to optimize the expected uncertainty on the cross section. This discriminant distinguishes between Top like events and backgrounds which appear to have similar discriminant shape.

The number of signal events is estimated using a likelihoof fit build out of the estimation of the *multijet* background from data and the distribution of the discriminant function (see figure 1). Using **230 pb**$^{-1}$ of DØ data, we measure [3]:

$$\sigma^{Kine.\ lepton+jets}_{p\bar{p}\to t\bar{t}+X} = 6.7^{+1.4}_{-1.3}(\mathrm{stat})^{+1.6}_{-1.1}(\mathrm{syst}) \pm 0.4(\mathrm{lumi})\ \mathrm{pb}$$

where the systematical uncertainty (20%) is mainly due to jet energy calibration (18%).

4. b-Lifetime Tagging Method Analysis in the Lepton+Jets Channel

This is a counting experiment in which the *multijet* background is also estimated from data, the *W+jets* flavor fraction is taken from the simulation and is normalized to data, the other backgrounds are normalized to their expected cross section. The number of signal events is fitted simultaneously in 8 independent samples at a time (see figure 2). Using **365 pb**$^{-1}$ of DØ data, we obtain the preliminary result :

$$\sigma^{b-tag.\ lepton+jets}_{p\bar{p}\to t\bar{t}+X} = 8.1^{+1.3}_{-1.2}(\mathrm{stat}+\mathrm{syst}) \pm 0.5(\mathrm{lumi})\ \mathrm{pb}$$

Systematical and statistical uncertainties are quoted together because of the fitting method which allows sources of systematics to shift the cross section value. The systematics (11%) is dominated by the flavor composition uncertainty (5%) and by the b-tagging efficiency measured in data (5%). Using only **230 pb**$^{-1}$ of DØ data, we measure [3]:

$$\sigma^{b-tag.\ lepton+jets}_{p\bar{p}\to t\bar{t}+X} = 8.6^{+1.6}_{-1.5}(\mathrm{stat}+\mathrm{syst}) \pm 0.6(\mathrm{lumi})\ \mathrm{pb}$$

[3] However, the prediction of the cross section is not reliable, *W+jets* is thus normalised to data.

[4] A jet can fake an electron when it mainly deposits its energy in the electromagnetic region (eg. $\pi^0 \to 2\gamma$). It can fake a muon when it contains an electroweak decay into a muon which happens isolated.

PoS(HEP2005)075

5. Summary

We have presented the measurement of the Top quark pair production cross section in the *lepton+jets* channel using an event kinematics method and a b-lifetime tagging method. Results are in agreement with SM expectation. Analysis based on **230 pb**$^{-1}$ have been submitted to Phys. Lett. B journal [3]. Analysis exhibit good precision ($\sim$20% more precise than previous results) and even more precise measurements are foreseen with more than 1 fb^{-1} delivered by the Tevatron before March 2006 and improvements of data analysis technics.

Acknowledgments

I would like to thank the DØ Top group conveners for their trust, support and work. I would like to thank the organizing committee for this fruitful and interesting conference.

References

[1] M. Cacciari *et al.*, JHEP **404**,68 (2004).
[2] Top quark mass measurements at Tevatron, Koji Sato, this conference.
[3] V.M. Abazov *et al.*, **hep-ex/0504043** and **hep-ex/0504058**, submitted to Phys.Lett.B.

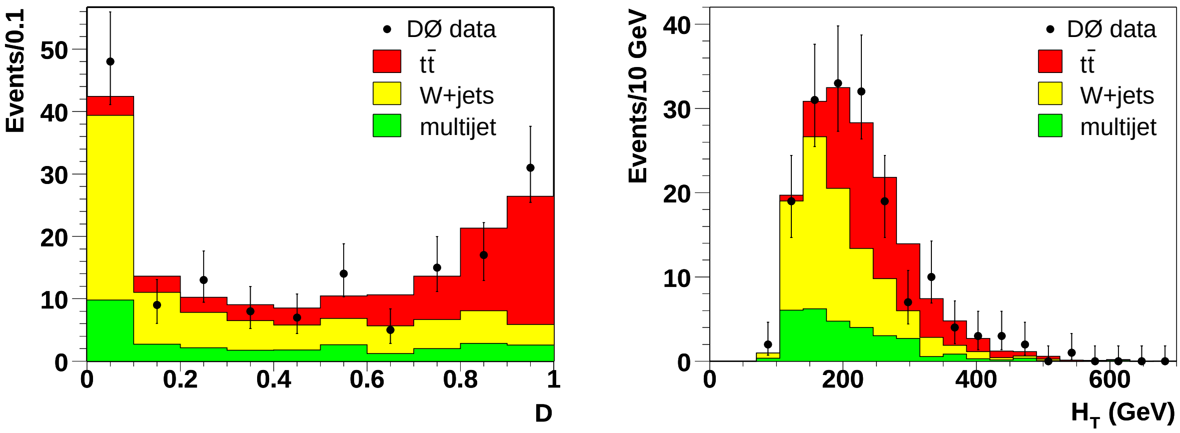

Figure 1: Kinematic discriminant D and H_T distribution for *lepton+jet* data (**230 pb**$^{-1}$) overlaid with the result of the fit. The combined sample contains 38% of signal, 44% of *W+jets*, and 18% of *multijet* events.

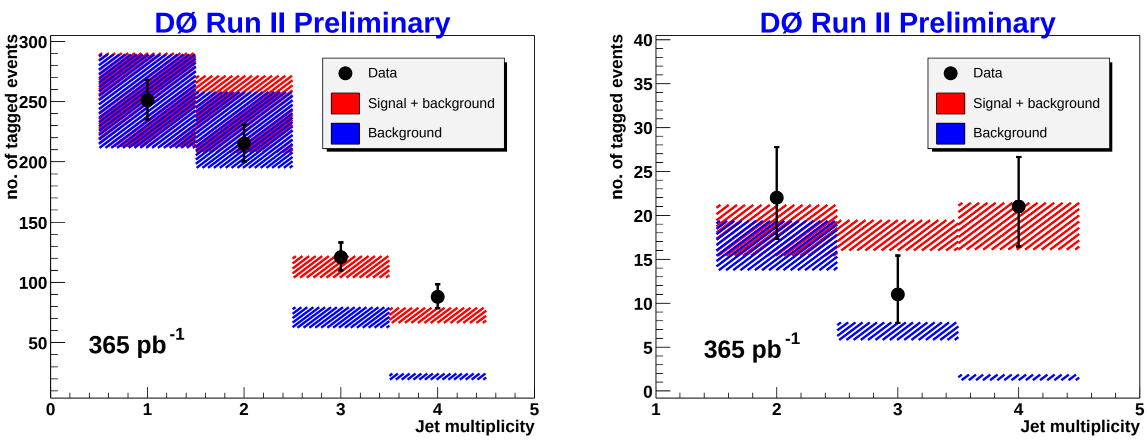

Figure 2: Observed and predicted number of single (left) and double (right) tagged events in *lepton+jet* data (**365 pb**$^{-1}$). The fit is carried on in the jet multiplicity bins 3 and $\geq$ 4, others serve as backgrounds control.