PROCEEDINGS OF SCIENCE

Top quark cross section and properties at DØ

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In this review we present updated results of top quark production cross section as well as new properties measurements performed by the DØ experiment using up to 4.2 fb^{-1} of RunII data collected at the Tevatron collider at Fermilab.

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1. Introduction

The top quark is dominantly produced in $t\bar{t}$ pairs at the Tevatron. In the Standard Model (SM), it decays into a W boson and a b quark with a branching ratio of ≈100%. Final states signature of $t\bar{t}$ pairs are subsequently characterized by the hadronic or leptonic decay of the W bosons and are classified as *dilepton*, *lepton+jets and all-jets*.
A peculiar property of the top quark is its short lifetime, $\Gamma_t \approx 1.4$ GeV. As a consequence, it decays before hadronizing and the spin of the top quark is thus efficiently transmitted to its decay products. It is thus possible to investigate directly the structure of the W-t-b vertex and the top *spin-spin* interaction.

This document, summarizing the latest results of the DØ experiment shown during the SM session, is structured as follow: Section 2 will review the measurements of the of the $t\bar{t}$ pairs production cross sections, Section 3 will present a measurement of the W boson helicity in $t\bar{t}$ pairs decays and an investigation of anomalous couplings of the top quark, finally Section 4 will present a measurement of the $t\bar{t}$ spin-spin correlation strength.

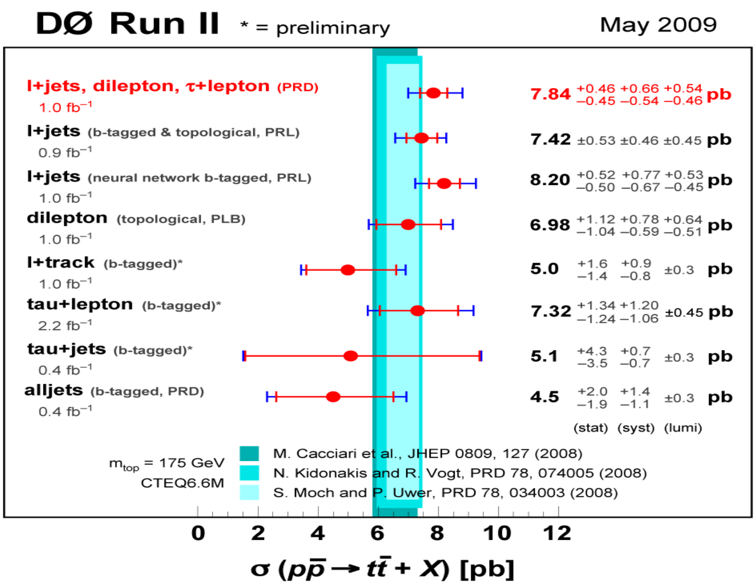

Figure 1: Summary of $t\bar{t}$ production cross sections at $\sqrt{s}$ = 1.96 TeV. The vertical bands represent various theoretical predictions [1, 2, 3].

2. $t\bar{t}$ production cross sections

At the Tevatron, the production cross section of top quark pairs originating from $p\bar{p}$ collisions is a function of the top quark mass m_t. In the SM, for m_t = 172.5 GeV, the expected cross section is $\sigma_{t\bar{t}} = 7.45^{+0.50}_{-0.70}$ pb [1]. Any observed deviation from the theoretical predictions could indicate effects beyond QCD perturbation theory such as new production mechanisms or decay channels. All recent measurements performed in the dilepton (ee, $\mu\mu$, $e\mu$), lepton+jets and all-jets channels are summarized in Fig. 1. They are all in good agreement with the SM prediction. The overall errors in the cross section measurements which are systematics limited, are of the order of $\Delta\sigma_{t\bar{t}}/\sigma_{t\bar{t}} \approx 11\%$ at the same level than the theoretical uncertainty.

3. Investigating the Lorentz structure of the W-t-b interaction

In the SM, only left-handed particles couple to the W boson through an axial-vector $(V-A)$ charged-current interaction. New physics could alter the Lorentz structure of the W-t-b interaction by changing the W boson helicity fractions from their SM values: f_0 = 0.697 $\pm$ 0.012 (longitudinal), f_+ = 3.6 10^{-4} (right-handed)[4]. Using dilepton and lepton+jets data samples [5], both fractions have been measured in a model independent approach. The result which is statistics limited agrees with the SM predictions within 23%: f_0 = 0.490$\pm$0.106 (stat.)$\pm$0.085 (syst.), f_+ = 0.110$\pm$0.059 (stat.)$\pm$0.052 (syst.).

The structure of the W-t-b interaction could be altered by the presence of anomalous couplings such as left/right vector $f_1^{L/R}$ and tensor $f_2^{L/R}$ components. In the SM, where the W-t-b coupling is purely left-handed, the values of the coupling form factors are $f_1^L \approx 1$, $f_2^L = f_1^R = f_2^R \approx 0$. Variations in the coupling form factors would alter both the production rate and the kinematic of electro-weak single top-quark processes and the helicity fractions of W bosons from top-quark decays. Fig. 2 shows the 95% C.L limits for pairs of coupling form factors. They are found to be consistent with SM predictions and provide a significant improvement over previous results [6].

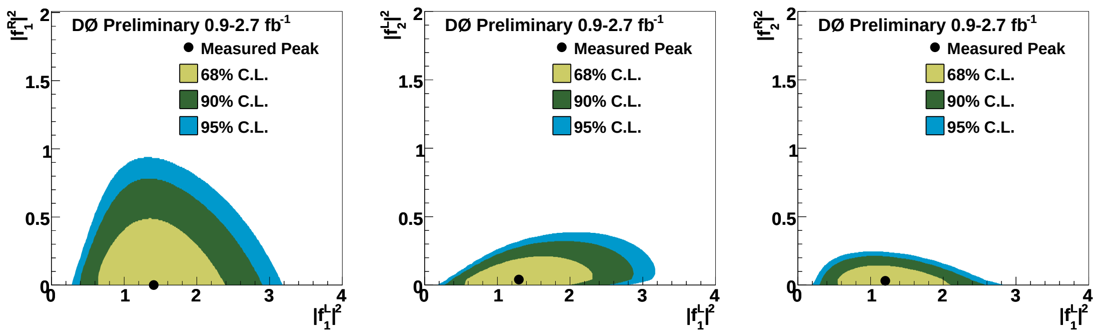

Figure 2: Final posterior densities for right- vs left-handed vector coupling (left), left-handed tensor vs left-handed vector coupling (center), and right-handed tensor vs left-handed vector coupling (right).

4. Spin correlations in $t\bar{t}$ in dilepton final states

The spin correlation in $t\bar{t}$ events has been investigated with a 4.2 fb^{-1} dilepton data sample from the double differential distribution:

$$\frac{1}{\sigma}\frac{d\sigma}{d\cos\theta_1 d\cos\theta_2} = \frac{1}{4}(1 - C\cos\theta_1\cos\theta_2) \qquad (4.1)$$

where σ denotes the cross section of the channel under consideration and C is a free parameter between -1 and 1 that depends on the choice of the spin basis. Here $\theta_{1(2)}$ describes the angle between the direction of flight of the lepton in the $t(\bar{t})$ rest frame and the direction of flight of one of the colliding hadrons in the $t\bar{t}$ zero momentum frame (ZMF). The numerical value for the coefficient C is 0.928 (0.777) at LO(NLO) [7]. A strength of the spin correlation of C = -

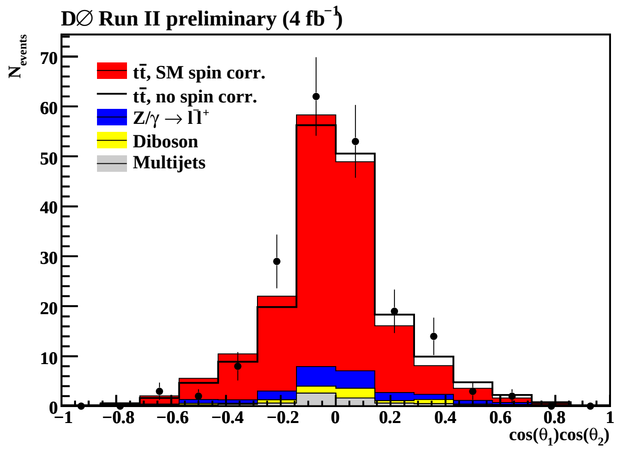

Figure 3: The $\cos\theta_1 \cos\theta_2$ distribution using the mean of the weight distribution per event for the full dilepton event sample. The sum of $t\bar{t}$ signal including NLO QCD spin correlation (C = 0.777) (red) and multijet (grey), diboson (yellow) and Drell-Yan (blue) background is compared to data. The open black histogram shows the prediction without $t\bar{t}$ spin correlation (C = 0).

$0.17^{+0.64}_{-0.53}$(stat.+syst.) has been measured. It agrees within two standard deviations with the above mentioned NLO calculation.

5. Conclusion

The current experimental precision of top quark pair production cross section is now at the level of theoretical uncertainty. The era of precision top physics has started with a new set of properties measurements and searches. At present both CDF and DØ experiments have about 6 fb^{-1} of data on tape which represents 1.5 to 5 times the data used in these results. Refinement of the current measurements and increased data samples are expected which will further improve our understanding of the top quark physics.

References

[1] S. Moch and P. Uwer, PRD 78, 034003 (2008) [hep-ph/0804.1476]

[2] N. Kidonakis and R. Vogt, PRD 78, 074005 (2008) [hep-ph/0805.3844]

[3] M. Cacciari, S. Frixione, M. Mangano, P. Nason and G. Ridolfi, JHEP 09, 127 (2008) [hep-ph/0804.2800]

[4] G. L. Kane, G. A. Ladinsky, and C.-P. Yuan, Phys. Rev. D 45, 124 (1992);

[5] DØ Collaboration: http://www-d0.fnal.gov/Run2Physics/WWW/results/prelim/TOP/T69/T69.pdf

[6] Search for Anomalous Top-Quark Couplings with the DØ Detector, Phys. Rev. Lett. 102, 092002 (2009)

[7] W. Bernreuther, A. Brandenburg, Z. G. Si and P. Uwer, Nucl. Phys. B 690, 81 (2004).