LATEST RESULTS FROM TOP PRODUCTION AT THE TEVATRON

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We present recent results on top quark pair and single top production cross sections in several final states at the Tevatron $p\bar{p}$ collider operating at $\sqrt{s} = 1.96$ TeV. The most precise single $t\bar{t}$ cross section measurement is carried out in the lepton+jets final state using a Neural Network kinematic fit and considering the ratio of the top to the Z cross section. It yields a cross section value of 7.82 ± 0.38 (stat) ± 0.37 (syst) ± 0.15 (theory) pb for a mass of 172.5 GeV/c^2, using 4.6 fb^{-1} of CDF data. The total uncertainty is similar to those of the current best theoretical predictions. It is important to measure the $t\bar{t}$ cross section in as many different channels as possible as any significant discrepancy between them could be a sign of new physics. All current measurements are consistent with the standard Model predictions. Single top quark production is seen by many as the testing ground for the most complex analysis techniques that are needed in particular for Higgs searches. The first Tevatron single top production combination is presented as well as a measurement of the single top polarization. Searches in the top sector reveal no signs of new physics and limits are placed on fourth generation top-like quark production and on narrow resonances in $t\bar{t}$ production.

1 Top Quark Pair Production Cross Section

Many new $t\bar{t}$ cross section measurements from CDF and D0 were available for this conference. For the first time, CDF has used the ratio of the $t\bar{t}$ to the Z cross sections in order to cancel out the measurement uncertainty on the luminosity determination that was the dominant uncertainty. Essentially one replaces the luminosity uncertainty with the uncertainty on the measured Z cross section as well as the uncertainty on the theoretical prediction for this value, both of which are small. A combination of two measurements in the lepton+jets channel, one topological and one relying on heavy flavour tagging gives a measured $t\bar{t}$ cross section of $\sigma_{t\bar{t}} = 7.70 \pm 0.52$ pb for a top mass of 172.5 GeV/c^2 using 4.6 fb^{-1} of CDF data [1]. The individual measurements are $\sigma_{t\bar{t}} = 7.82 \pm 0.38(stat) \pm 0.37(sys) \pm 0.15(theory)$ pb and $\sigma_{t\bar{t}} = 7.32 \pm 0.36(stat) \pm 0.59(sys) \pm 0.14(theory)$ for the topological and b-tagged analyses,

respectively. Figure 1 (left) shows the Neural Network distribution used to fit the cross section in the topological analysis.

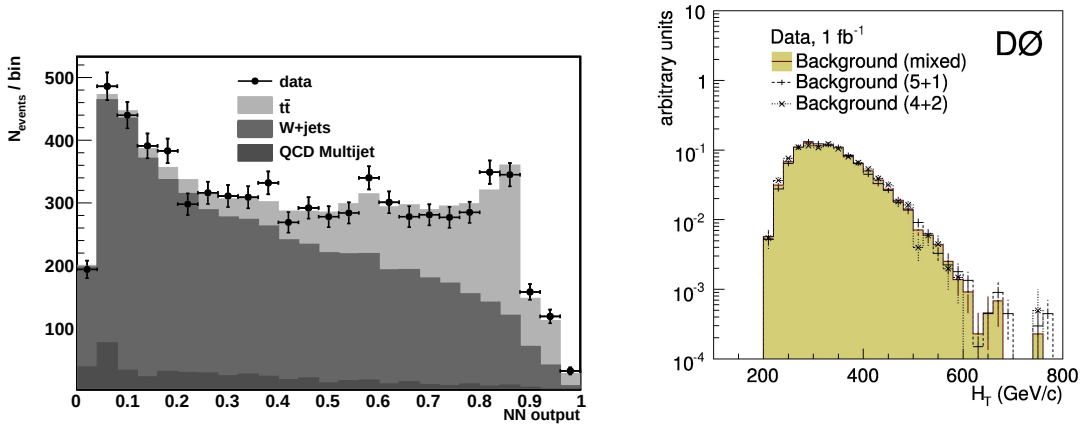

Figure 1: (left) Neural Network variables used to fit the $t\bar{t}$ cross section in the topological CDF analysis. (right) background model used for the D0 all hadron $t\bar{t}$ cross section measurement.

The all hadronic decay mode in $t\bar{t}$ production is notoriously difficult to measure due to the difficulty in measuring the multijet background reliably and due to the low signal to background ratio. D0 uses a novel approach to model this multijet background by looking at events with four jets, which have a negligible contribution from $t\bar{t}$, and attaching additional low p_T jets selected from events with six or more jets to events with four or five jets [2]. A reasonable distribution of the jets in the available phase space was ensured using a set of matching criteria. Good agreement in the background model, shown in Fig. 1 (right), is found between events with five jets to which one has added one jet and those with four jets to which one has added two jets. This analysis requires two of the jets to be b-tagged. This large multijet background is distinguished from the $t\bar{t}$ signal by exploiting differences in the kinematic and topological distributions of jets between $t\bar{t}$ and multijet events. The measured cross section, assuming a top quark mass of 175 GeV/c^2 , is $\sigma_{t\bar{t}} = 6.9 \pm 2.0$ pb.

Many other cross sections measurements are performed at both CDF and D0. A recent CDF $t\bar{t}$ cross section combination gives a total uncertainty of 6.4%, an improvement in precision of 9% relative to the most precise single measurement mentioned earlier [3].

2 Single Top Quark Production Cross Section

2009 saw the first observation of single top production, 14 years after the top quark discovery. Single top production is challenging due to is large backgrounds relative to its signal size, of the order of 20:1. We thus need to use sophisticated analysis techniques to extract the signal. Many different analyses techniques are carried out at both CDF and D0. For example D0 looks at 24 independent analysis channels, each containing combinations of up to 97 different variables [4]. CDF finds that adding all different lepton+jets analysis together into a single final super discriminant [5], then combining that with the missing transverse energy plus jets result [6] gains an additional 16% sensitivity. For the first time, a Tevatron combination was carried out for the combined s- and the t-channel production modes [7]. Figure 2 shows the results from the two experiments as well as the combination.

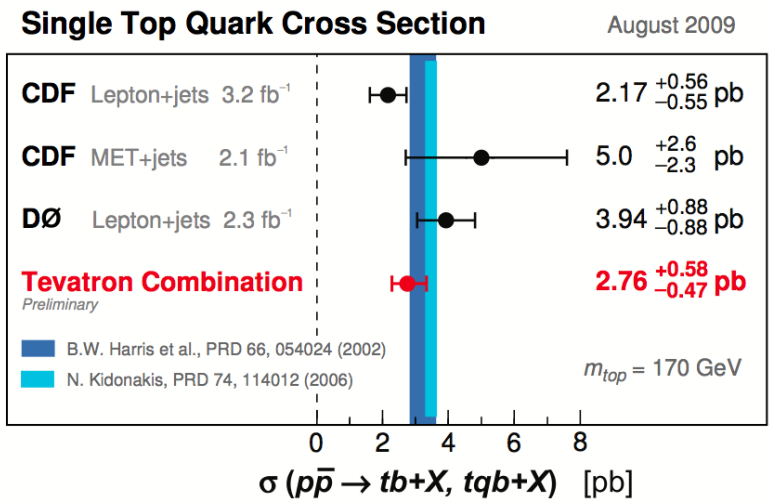

Figure 2: Tevatron combination of the single top production cross section.

3 Single Top Quark Polarization

Having ascertained that top quarks can be produced not only in pairs through strong production but also alone through weak production, one can begin to measure the properties of the top quark in single top production. In particular, as the top quark decays before it has time to hadronize, the polarization of the combination of its decay products will be the polarization of the top quark. Top quarks are produced almost 100% polarized due to the V-A nature of the weak coupling. By measuring the polarization of the top quark decay, one can study depolarizing effects and non-standard model mechanisms. By measuring simultaneously the V-A and the V+A components of the single top cross section, one can place limits on non-standard model contributions [8]. Figure 3 shows the result of this fit and the confidence level contours. TNo significany V+A cross section is measured.

4 Searches in the Top Sector

The sample of top quarks available at the Tevatron is large enough that we can look in it for signs of non standard model behaviour in the production or decay of the top quarks or to look for particles that have properties that resemble those of the top quark. Many beyond the standard model theories predict the presence of a fourth generation of top quarks. CDF has been looking into the lepton+jets final state to try and find the fourth generation equivalent of the top quark. We use a two-dimensional fit to the reconstructed mass of the quark (M_{reco}) and the sum of the transverse energy of all reconstructed objects of the event (H_T) [9]. No significant excess is found in 4.6 fb^{-1} of CDF data and thus limits are placed on fourth generation production; assuming 100% branching ratio of the t' to $W + q$, we place a lower limit, shown in Fig. 4, on $M_{t'}$ at 335 GeV/c^2.

D0 searches for narrow resonances, narrower than the detector resolution, in $t\bar{t}$ production. We reconstruct the invariant mass of the $t\bar{t}$ pair, shown in Fig. 5, and search for excesses in the spectrum. No significant excess is observed in 3.6 fb^{-1}. The limits on Z' production from top-assisted technicolor [10] exclude a Z' mass below 820 GeV/c^2 5.

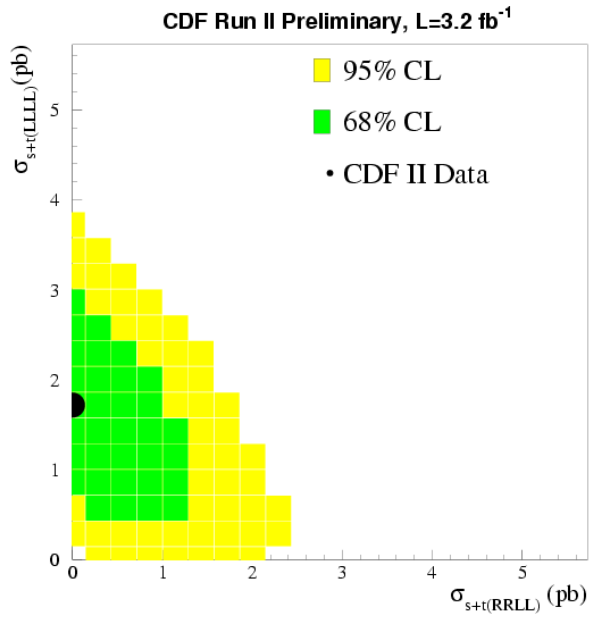

Figure 3: Fit to the standard model and inverted handedness coupling cross sections at CDF.

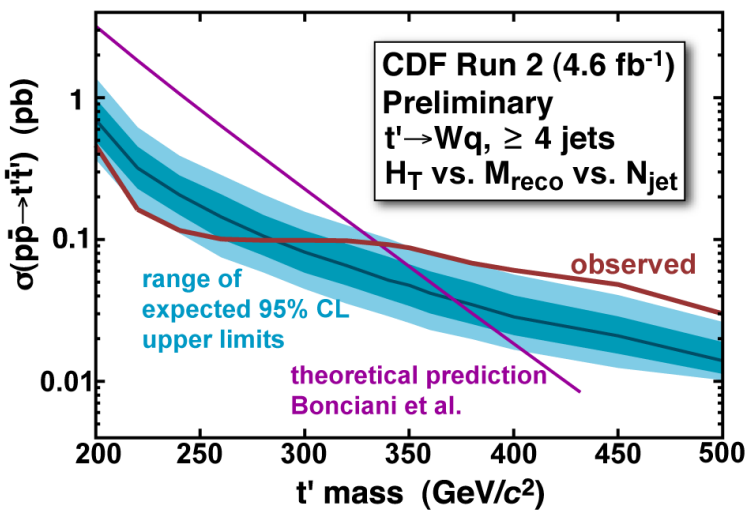

Figure 4: Observed (red) and expected (blue bands) limits on fourth generation top-like quark production as a function of its mass. The theoretical prediction for strong production is shown as the purple line.

Acknowledgments

We thank the Fermilab staff and the technical staffs of the participating institutions for their vital contribu- tions. This work was supported by the U.S. Department of Energy and National Science Foundation; the Italian Istituto Nazionale di Fisica Nucleare; the Ministry of Education, Culture, Sports, Science and Technology of Japan; the Natural Sciences and Engineering Research Council of Canada; the National Science Council of the Republic of China; the Swiss National Science Foundation; the A.P. Sloan Foundation; the Bundesministerium für Bildung und Forschung, Germany; the Korean Sci- ence and Engineering Foundation and the Korean Research Foundation; the Science and Technology Facilities Council and the Royal Society, UK;

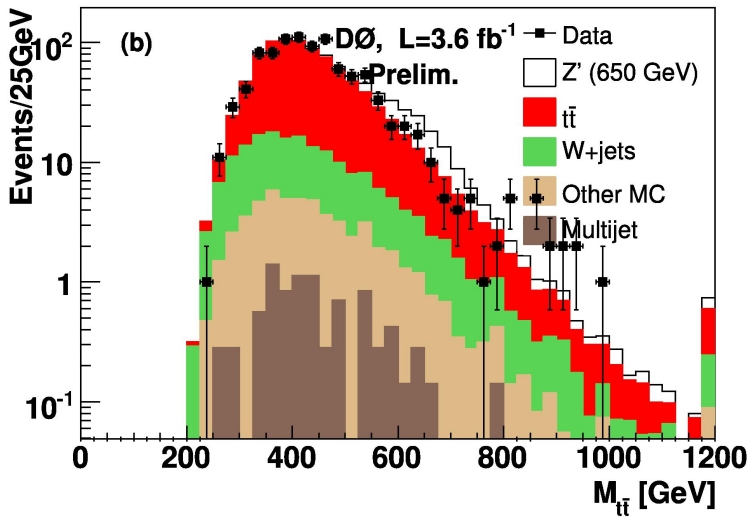

Figure 5: Invariant mass of the $t\bar{t}$ pairs at D0 comparing data (points) to the backgrounds (histograms).

the Institut National de Physique Nucleaire et Physique des Particules/CNRS; the Russian Foundation for Basic Research; the Comisión Interministerial de Ciencia y Tecnolog´a, Spain; the European Communitys Human Potential Programme; the Slovak R&D Agency; and the Academy of Finland.

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