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TOP PRODUCTION AND PROPERTIES

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A summary of recent results from CDF on top production and its properties is presented.

1 Introduction

The top quark was for the first time observed by CDF and D0 collaborations in Run I in 1995 [1] [2]. The final analyses were based on 110 pb^{-1} of data. The measurements of $t\bar{t}$ cross-section[3] and top mass[4] were in agreement with Standard Model, however the results were limited by statistics.

Run II started in 2001. There were made several improvements which have big impact on top physics. First of all, the energy of interaction of colliding proton and anti-proton increased from 1.8 TeV to 1.96 TeV, which raised the top cross-section by 30%-40%. Secondly, the detector was upgraded. Mainly, that were the silicon system ($|\eta| < 2.0$), extension of the muon system ($|\eta| < 1.5$) and adding plug calorimeters ($1.0 < |\eta| < 3.6$).

The presented results are based on data collected during Run II until the end of year 2003 (~ 200 pb^{-1}). It is almost twice as much as in Run I. But, over the last year (2004) another more than 200 pb^{-1} was collected, so the next results (winter 2005) will be based roughly on 400 pb^{-1}!

In this paper, recent measurements of top cross-section, mass and single top searches from CDF are presented.

2 Top pair production on Tevatron

At the energy of interaction of 2 TeV the top quark is mainly produced in pairs. There are two contributions from $q\bar{q} \to g \to t\bar{t}(85\%)$ and $gg \to g \to t\bar{t}(15\%)$.

Consequently, top decays (almost in 100% of cases) into b-quark and W boson, where W boson can decay leptonically($W \to \ell\nu$) or hadronically($W \to qq$). We study 3 different channels, which corresponds to the number of leptons being observed in the event: dilepton channel (both W's decay into leptons, BR=11%), lepton+jets channel (one W decay into lepton, second one into quark, BR=44%) and hadronic channel (W's decay into pair of quarks, BR=45%). All channels have some advantages and disadvantages. In the dilepton channel, there is the purest sample with almost no background, however the statistics is small in this case. In the hadronic channel, you have the largest sample but also a huge background. The lepton+jets channel is a compromise between the other two channels.

The cross-section for $t\bar{t}$ production was measured in all three channels. In dilepton channel two analysis measured the cross-section. First one uses two very well identified leptons (Et > 20 GeV, isolated) with $\not{E}_T > 20$ GeV, while the second one uses just one well identified lepton and one isolated track. Both analysis get results in agreement with the Standard Model. The number of observed events was 13 and 19 respectively, with expected number of background events to be 2.7 ± 0.7 and 6.9 ± 1.7 respectively. Their combined result on top pair production cross-section is $\sigma(t\bar{t}) = 7.0^{+2.4}_{-2.1}(\mathrm{stat.})^{+1.7}_{-1.2}(\mathrm{syst.})$ pb [5] (fig. 1).

In lepton+jets channel, there are many analysis ongoing on cross-section measurement, see fig. 1. Currently, the best is the one which requires at least one jet to be identified as b-jet by the secondary vertex algorithm. The number of observed events is 48 with estimated background to be 13.8 ± 2.0 events which results in the top pair production cross-section $\sigma(t\bar{t}) = 5.6^{+1.2}_{-1.0}(\mathrm{stat.})^{+1.0}_{-0.7}(\mathrm{syst.})$ pb. The plot of the number of jets per bin is in fig. 2. The first two bins for 0 and 1 jet are used as control of the background estimation, while the other bins are used for the estimate of the $t\bar{t}$ cross-section. The dependence of the $t\bar{t}$ production cross-section on center of mass energy is in fig. 3.

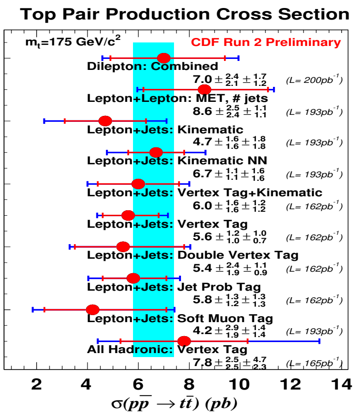

Figure 1. All the latest measurements of top pair production cross-section from CDF in Run II.

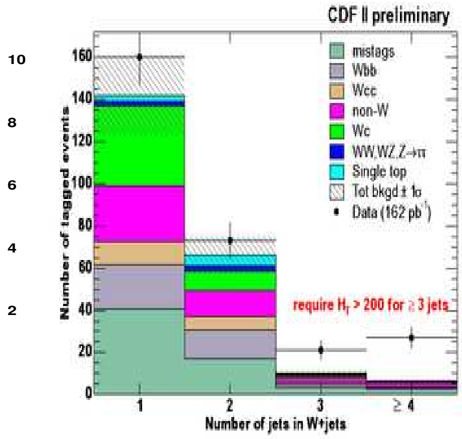

Figure 2. Background contributions and results from data as a function of event jet multiplicity, after the H_T requirement has been applied to events with 3 or more jets.

Also in the handronic channel there is already a Run II result. After the application of an optimized kinematical selection it is observed the excess of the events with 6 or more jets, relative to background expectation. Based on the excess of the 'tags' (jets with secondary vertices), the production cross-section in hadronic channel is measured to be $\sigma(t\bar{t}) = 7.8 \pm 2.5(\mathrm{stat.})^{+4.7}_{-2.3}(\mathrm{syst.})$ pb (fig. 1).

3 Single top searches

The search for single top production is performed on W + 2 jets events in t-channel(Wg fusion) and s-channel (W^*) as well as in combined channel of the two processes. There is found no evidence for single top production thus the upper limits on production cross-sections are set: 10.1 pb for the t-channel, 13.6 pb for the s-channel and 17.8 for the combined cross-section of t- and s-channel. All the numbers are valid for 95 % confidence level. On fig. 4 is a comparison of data with SM expectations for pseudorapidity of the b-jet multiplied by charge of the lepton.

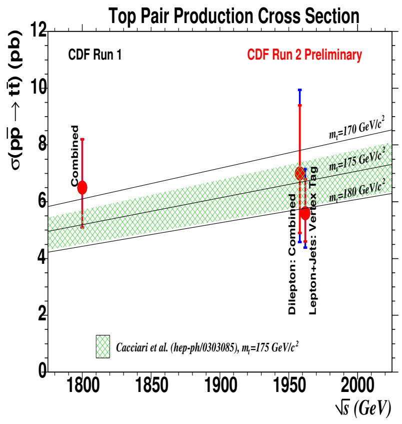

Figure 3. Selected measurements of top pair production cross-section as a function of the center-of-mass energy.

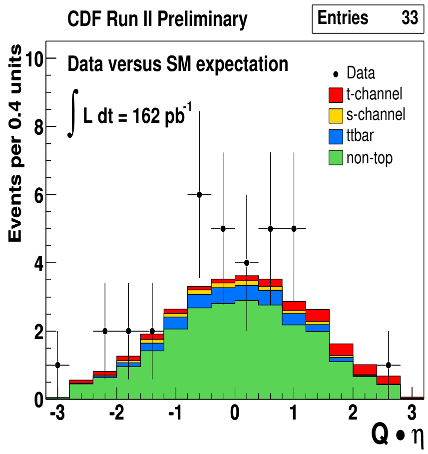

Figure 4. Comparison of the data and SM expectation for single top events and background

4 Top mass measurements

CDF has been exploring several different techniques for the top mass measurement. The best single number is from a dynamic likelihood technique in the lepton+jets channel ($t\bar{t} \to \ell\nu bqqb$). The top quark mass measured there is $M_{top} = 177.8^{+4.5}_{-5.0}(\text{stat}) \pm 6.2(\text{syst})$ GeV/c^2 (fig 5). This is done by maximizing the likelihood, which is defined as the differential cross-section as a function of M_{top} per unit phase space volume of the final partons multiplied by the transfer function from jets to parton quantities.

The analysis use 162 pb^{-1} of Run II data (March 2002-September 2003). The systematic is dominated by the modeling of the calorimeter response (new forward calorimeter, extra material in new tracking system) and is expected to go down soon as a result of improvements in the CDF calorimeter simulation.

The top mass was also measured by other techniques in lepton+jets channel as well as in dilepton channel (fig. 6).

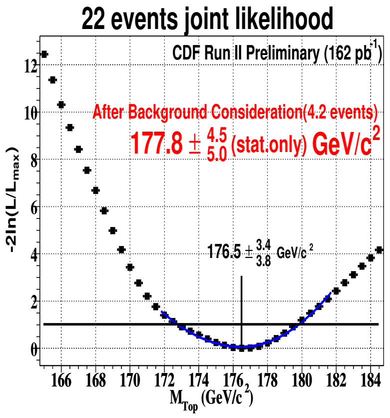

Figure 5. Joint Likelihood of 22 observed data (at least one btag jet, and exactly 4 tight jets) from dynamical likelihood method.

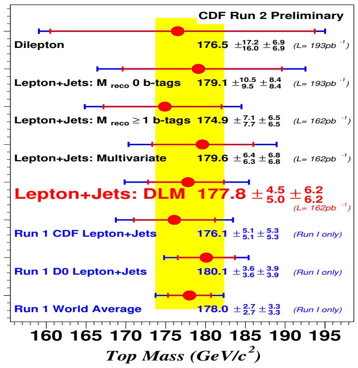

Figure 6. All the measurements of top mass from CDF in Run II together with Run I CDF and D0 measurements.

Acknowledgments

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References

1. CDF Collaboration, F. Abe et al., Phys. Rev. Lett. **74**, 2626 (1995).
2. D0 Collaboration, S. Abachi et al., Phys. Rev. Lett. **74**, 2632 (1995).
3. CDF Collaboration, T. Affolder et al., Phys. Rev. **D 64**, 032002 (2001)
4. CDF Collaboration, T. Affolder et al., Phys. Rev. D 63, 032003 (2001)
5. CDF Collaboration, D. Acosta et al., hep-ex/0404036 (Submitted to PRL in April 2004)