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The Search for Single Top Quark Production in the Muon plus Jets Channel at DØ

Leonard Christofek
University of Kansas, Lawrence, Kansas 66045, USA
E-mail: leonard@fnal.gov

(For the DØ Collaboration)

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We have performed a search for the electroweak production of single top quarks in $p\overline{p}$ collisions at the Fermilab Tevatron at a center of mass energy of $\sqrt{s} = 1.96$ TeV. The search was performed in the muon plus jets decay channel requiring at least one b-tagged jet. The data were collected using the DØ detector between August 2002 and September 2003 corresponding to an integrated luminosity of 158 pb^{-1}. The resulting 95% C.L. upper limits on the production cross sections are 27 pb in the s-channel, 41 pb in the t-channel, and 36 pb in the combined $s + t$ channel using the secondary vertex tagger (SVT) algorithm. We also present results from the combined electron and muon channel search using the DØ detector.

Keywords: single top; top quark; top production.

1. Introduction

The top quark was discovered in 1995 at the Fermilab Tevatron by both the DØ and CDF collaborations. [1,2] At the Tevatron, top quarks are produced predominately in pairs via the strong interaction, but single top quarks can be produced through the electroweak interaction. [3] The dominant Feynman diagrams at the Tevatron for single top production are shown in Figure 1. The single top production cross section has been calculated at next-to-leading order (NLO) in QCD. The NLO cross section

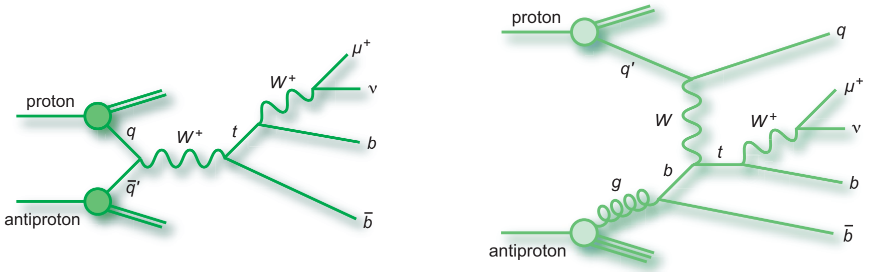

Fig. 1. The dominant Feynman diagrams for s-channel (left) and t-channel (right) single top quark production.

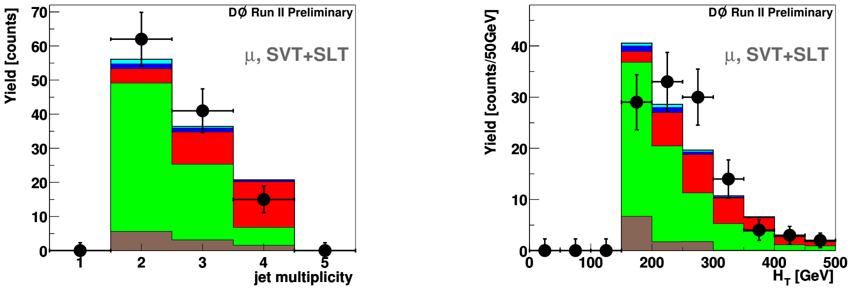

Fig. 2. Distribution for the number of jets and the scalar transverse energy, H_T, for the muon channel.

for the s-channel process is $\sigma = 0.88^{+0.07}_{-0.06}$ pb at $\sqrt{s} = 1.96$ TeV with $m_t = 175$ GeV.[4] Similiarly, the NLO cross section for the t-channel process is $\sigma = 1.98^{+0.23}_{-0.18}$ pb. [5] Observation of single top production will allow direct measurement of the CKM mixing angle $\mid V_{tb} \mid$ and the top quark polarization, as well as serving as a probe for physics beyond the Standard Model.

In Run I at the Tevatron, DØ set upper limits of 17 pb for the s-channel and 22 pb for the t-channel at the 95% C.L. using 90 pb^{-1} of data.[6,7] CDF also set upper limit with the same confidence level of 18 pb in the s-channel, 13 pb in the t-channel and 14 pb in the combined $s + t$ channel search.[8,9]

2. Event Selection and Backgrounds

The event is required to have exactly one isolated muon with $P_T > 15$ GeV and $\mid \eta_{detector} \mid < 2.0$, missing transverse energy of $E_T > 15$ GeV, and between two to four jets with $E_T > 15$ GeV and $\mid \eta_{detector} \mid < 3.4$. The leading jet must have an $E_T > 25$ GeV and $\mid \eta_{detector} \mid < 2.5$. There must be at least one b-tagged jet in the event using one of several different b-tagging algorithms. Events with a soft lepton tag (SLT) are analyzed separately from events with a lifetime tag and then later combined in the final result. The two lifetime taggers used are the Secondary Vertex Tagger (SVT) which is based on the reconstruction of a secondary vertex and the Jet LIfetime Probability algorithm (JLIP).

The final event requirement used to separate single top from background events, especially W+jets, is the scalar sum of the transverse energies of the muon, missing energy, and the two leading jets ($H_T > 150$ GeV). We show the jet multiplicity and the H_T distribution after final event selection are applied in Figure 2.

The dominant background is from W+jets and Z+jets, particularly $Wb\bar{b}$. Additional backgrounds are from the misreconstruction of multijet events and $t\bar{t}$ production. The backgrounds from multijet production and W/Z+jets events are modeled using data and those from $t\bar{t}$ and single top are estimated using Monte Carlo.

The largest sources of uncertainties come from the jet energy scale, modeling of the taggers and triggers, and vary between $20 - 25\%$ for the different backgrounds and signals.

3. Summary

We have performed a search for the electroweak production of single top quarks in $p\overline{p}$ collisions at the Fermilab Tevatron at a center of mass energy of $\sqrt{s} = 1.96$ TeV. We present the combined results of the muon and electron plus jets decay channels requiring at least one b-tagged jet. The resulting 95% C.L. upper limits on the production cross sections using Bayesian statistics for the combined SLT and SVT analyses are 19 pb in the s-channel, 25 pb in the t-channel, and 23 pb in the combined $s + t$ channel. Table 1 shows the observed and the expected limits for the different taggers used in this search. See Ref. 10 for more information on the electron plus jets decay channel.

Table 1. The 95% C.L. observed(expected) upper limits (in pb) for the single top production cross sections.

	Tagger	s-channel	t-channel	$s + t$ channel
μ only	SVT	27(24)	41(35)	36(39)
	JLIP	21(26)	29(37)	26(32)
	SLT	35(33)	59(56)	49(45)
$\mu + e$	SVT	14(17)	20(24)	18(20)
	JLIP	15(20)	21(27)	19(23)
	SLT	40(22)	67(37)	57(30)

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