CDF note 8416

First Measurement of $\sigma(gg \rightarrow t\bar{t})/\sigma(p\bar{p} \rightarrow t\bar{t})$ Using Low p_T Charged Particle Multiplicity in $p\bar{p}$ Collisions at $\sqrt{s}$ =1.96 TeV

The CDF Collaboration
URL http://www-cdf.fnal.gov
(Dated: July 25, 2006)

We present the first measurement of $\sigma(gg \rightarrow t\bar{t})/\sigma(p\bar{p} \rightarrow t\bar{t})$ using the low p_T track multiplicity in lepton+jet channel to discriminate between the two initial states. We show that the average number of low p_T tracks scales with the gluon content of the sample. We take advantage of the fact that the gluon composition of the gluon rich fraction of the standard model $t\bar{t}$ processes is close to that of the gluon-rich fraction of dijet samples with relatively high leading jet E_T values, and that the W+0 jet sample is dominated by qq initial states. We extract the gluon rich fraction and measure $\sigma(gg \rightarrow t\bar{t})/\sigma(p\bar{p} \rightarrow t\bar{t})$. We find a value of 0.25±0.24(stat)±0.10(syst) for $\sigma(gg \rightarrow t\bar{t})/\sigma(p\bar{p} \rightarrow t\bar{t})$ using 330 pb^{-1} of data.

Preliminary Results for Summer 2006 Conferences

I. INTRODUCTION

According to the standard model(SM) in ppbar collisions of center-of-momentum of about 2 TeV, top quark pairs are expected to be produced through gluon gluon fusion (∼15%) and quark-antiquark annihilation (∼85%) [1]. In this study, we make a measurement of the $t\bar{t}$ cross section fraction through gg fusion over $q\bar{q}$ annihilation. This can provide a test of the perturbative Quantum Chromo Dynamics(pQCD). Also, it may reveal the existance of unknown $t\bar{t}$ production and top quark decay mechanisms, where the new decay mechanism denies the excess due to new production mechanism over the SM prediction [2]. Thus, there is an interest in studying the ttbar production mechanisms independent of the ttbar final state channels.

In order to make this measurement, one needs to discriminate between the two production channel. In this study, we take advantage of the fact that gluons are more likely to radiate a gluon with a low fraction of their momentum than quarks, as such we expect to see larger number of low energy particles in gg than in $q\bar{q}$ production channel. To be able to observe this difference, we use the low p_T charged particle multiplicity. The CDF detector is described in detail in [3]. As there are large uncertainties associated with the monte carlo (MC) prediction for the soft gluon radiation, we cannot rely on MC for this analysis and so define a number of calibration samples that are similar to the gg and $q\bar{q}$ processes.

II. DATA SAMPLE & EVENT SELECTION

This analysis is based on an integrated luminosity of 330 pb^{-1} collected with the CDFII detector between March 2002 and August 2004. We use both data and MC samples for dijet and W+n jet processes as explained in the following subsections. These samples have different gluon contents based on their leading jet E_T range or jet multiplicity, respectively. The MC samples are used to find the average number of gluons present in each sample while data samples are used to find the average number of charged particles in a sample.

A. W+n Jet Samples

The W+n jet data are collected with an inclusive lepton trigger that requires an electron or muon with E_T >18 GeV (P_T >18 GeV/c for the muon). From this inclusive lepton dataset we select events offline with a reconstructed isolated electron E_T (muon P_T) greater than 20 GeV, missing E_T >20 GeV. Jets have E_T >15 GeV. W+n jet samples where n = 0, 1, 2, or 3 constitute part of our calibration sample. As this sample has large background coming from QCD interactions, if the $\not\!\!E_T$ is less than 30 GeV, we require $\Delta\phi$ between the leading jet and the $\not\!\!E_T$ to be between 0.5 to 2.5 rad. We remove any event that is a $t\bar{t}$ dilepton or a Z boson candidates and veto any event where the electron is consistent with coming from a conversion. The MC sample used for the W+n jet is MADGRAPH+PYTHIA, tuned to reproduce underlying events correctly, CKKW [4] $k_T = 15$ for W($\rightarrow e\nu$) + 0, 1, 2, 3 and 4 partons, where each sample is added with the appropriate weight based on their luminosities. The same event selection criteria is applied to both data and MC. Jets are defined using a cone algorithm with a cone of 0.4 and are corrected for energy calibration, calorimeter η dependence and multiple interactions.

B. Dijet Samples

The dijet data are collected using two inclusive jet triggers that require a jet with E_T of 50 and 100 GeV. The MC samples are generated using PYTHIA [5] with minimum p_T of 40 and 90 GeV tuned to reproduce the underlying events. For both data and MC, following event selection criteria is used.

- To avoid any trigger bias, we require a minimum uncorrected leading jet E_T of 75 and 130 GeV for Jet50 data (Jet40 MC) and Jet100 data (Jet90 MC), respectively.
- We remove any event that has any electron or muon with E_T >18 GeV (P_T >18 GeV/c for the muon).
- We require 2 and only 2 jets within $|\eta| \leq 2$ with a minimum corrected E_T of 20 GeV in the event.
- The two jets should be back-to-back in ϕ within 35^o.

Jets are defined the same way as in W+n jet except that they are also corrected for any non-linearity and energy loss in the un-instrumented regions of the calorimeter.

C. $t\bar{t}$ Candidates

To define $t\bar{t}$ candidates, we look at the W+4 or more jet bin. This sample has a noticeable background coming from the W boson production in association with jets, to reduce this background, we require at least one of the jets in the event to be identified as coming from a b-quark (b-tagged) jet. Our selection criteria for $t\bar{t}$ candidates is similar to the standard $t\bar{t}$ cross section measurements. Jets are defined the same way they are defined in the W + n jet sample.

III. TRACK MULTIPLICITY

We would like to show that there is a correlation between number of gluons and number of low p_T tracks in a given sample. We find the average number of low p_T tracks, $< N_{trk} >$, using data and the average number of gluons in the sample, $< N_g >$, using MC as explained in the following subsections.

A. Track Selection

In this section, we describe the selection criteria for including a track in our definition of track multiplicity. The goal is to have a track multiplicity that best represents the presence of the soft gluons radiated from the "matrix element" partons in the event and therefore it should be independent of the number of extra interactions and number of jets present in the event. One would also like to reduce the contribution from the final state partons. These are explained in more detail in the following.

- We use tracks with p_T in the range 0.3-2.9 GeV/c and $|\eta| \leq 1.1$, where we expect to have good tracking coverage.
- The tracks should not be part of the jets present in the event. We therefore require the tracks not to fall within $\Delta R = 0.6$ of the high E_T jets (15 GeV or more) and within $\Delta R = 0.4$ of the low E_T (6-15 GeV) jets in the event. These cuts are set as such due to the fact that we expect higher E_T jets to generate larger number of wide-angle, low p_T particles than low E_T ones.
- The track should match the primary vertex of the event within ± 3 cm or $\pm 3\sigma$. This requirement reduces the contribution from other interations.
- We also check that the track will not match a second vertex better than it does match the primary vertex.
- The fact that we exclude regions around the jets provides different tracking area available for different events and samples. To have a comparable track multiplicity, we find the track density for each event by dividing the track multiplicity by the available tracking area. Then, we multiply this density with the total central area, 4.4π, to get our tracking multiplicity.
- The track multiplicity, even though tracks from jets are excluded, still has a dependency on the number of high E_T jets in the event. We, therefore, have some further contribution from each high E_T jet present in the central ($|\eta| \leq 1.1$) region.

For both W + n jet and dijet samples, the jets used here for the track counting procedure are defined as the jets in dijet sample.

B. Counting Gluons

We apply the same event selection cuts as data to MC samples. Then using the generator-level information, we count the number of gluons in each event, taking into consideration the 2 incoming and all the outgoing partons. We define the outgoing partons as the immediate daughters of the 2 incoming partons. For all dijet samples, we have 2 incoming and 2 outgoing partons. In the W samples, depending on the type of generated event, we have 2 incoming and 0, 1, 2, 3 or 4 (excluding the W boson) outgoing partons corresponding to the W+0, 1, 2, 3 or 4 parton samples used to create the W+njet MC sample. To get the average number of gluons in a sample, we sum over the number of gluons in each event of our MC sample and divide the sum by the total number of events in the sample.

C. $< N_{trk} >$-$< N_g >$ Correlation

The correlation between $< N_{trk} >$ (measured from data) and $< N_g >$ (MC calculations) as well as the linear χ^2 fit to W+0, 1 and 2 jet samples along with the dijet samples with leading jet E_T range 80-100, 100-120 and 120-140 GeV are shown in Fig. 1. This correlation can be used to measure $< N_g >$ in a given data sample. The comparisons of the measured and the expected $< N_g >$ are shown in Table I.

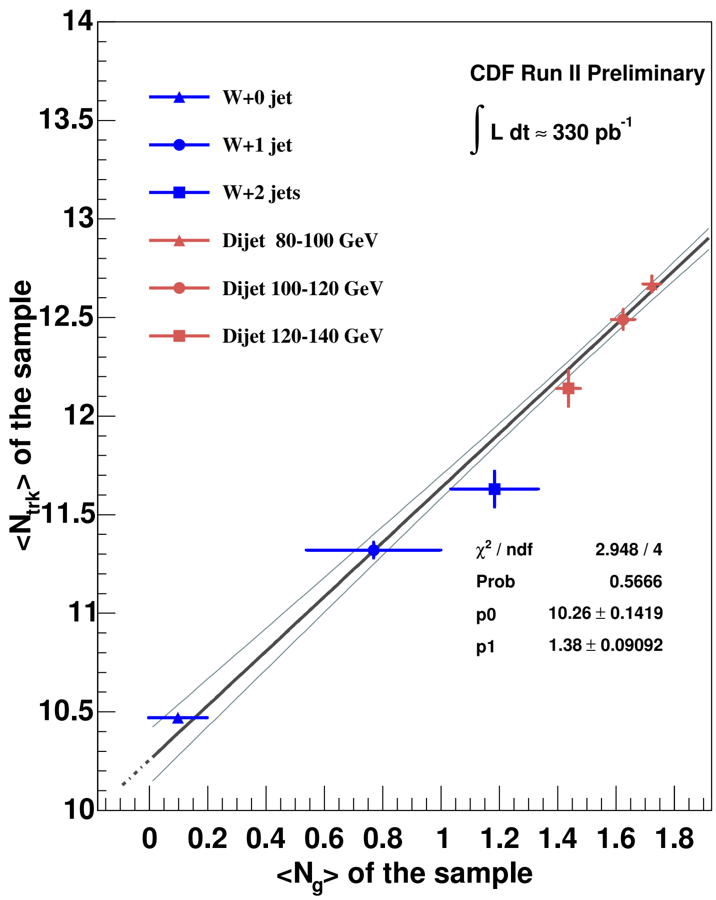

FIG. 1: Using three W and three dijet samples, we find the correlation between the average low p_T track multiplicity and the average number of gluons. $< N_g >$ is predicted using MC for each sample and $< N_{trk} >$ is measured using data. Different samples are shown with different markers and colors. The lighter grey(red) corresponds to dijet samples and the darker grey(blue) represents W samples. Solid circles, squares and triangles are used to distinguish different subsamples as specified in the legend.

IV. MEASUREMENT METHOD

The $< N_{trk} >$ and $< N_g >$ correlation enables us to define low p_T track multiplicity distributions representing specific average number of gluons. Most importantly, we can define gluon rich distributions and distributions with no gluon content. The latter can be defined using the W+0 jet data sample. This sample is almost purely a quark-quark process with a small QCD background of order 1%. It also includes some gluon content coming from W production in association with other partons when we fail to observe these partons in form of jets, (we call this the "feed-down background"). We use MC calculations to predict the composition of this background and alternatively

Sample	Expected $< N_g >$ MC	Fit$_{correlation}$ $< N_g >$	Fit$_{distribution}$ $< N_g >$
W+0 jet	0.10 ± 0.10		
W+1 jet	0.77 ± 0.23		0.87 ± 0.03
W+2 jet	1.18 ± 0.15		1.06 ± 0.05
dijet 80-100 GeV	1.72 ± 0.03		
dijet 100-120 GeV	1.62 ± 0.04		1.61 ± 0.03
dijet 120-140 GeV	1.44 ± 0.04		1.49 ± 0.05
dijet 140-160 GeV	1.26 ± 0.04	1.19 ± 0.04	1.30 ± 0.03
dijet 160-180 GeV	1.13 ± 0.04	1.06 ± 0.05	1.18 ± 0.03
dijet 180-200 GeV	0.99 ± 0.07	0.93 ± 0.05	1.06 ± 0.05
dijet 200-220 GeV	0.92 ± 0.10	0.75 ± 0.07	0.95 ± 0.07
dijet 220+ GeV	0.67 ± 0.10	0.60 ± 0.07	0.76 ± 0.07

TABLE I: The average number of gluons in each sample as predicted by MC calculations, the average number of gluons as found using the correlation fit and the average number of gluons as found using the distribution fit. All data and fitted uncertainties are statistical.

its contribution to the average number of gluons present in the W+0 jet sample. To define the gluon rich distribution, we use our dijet sample with the lowest jet E_T range, 80-100 GeV. In order to have as pure as possible no-gluon distribution and a gluon rich distribution with a comparable gluon content to that of the $t\bar{t}$, we iteratively subtract the gluon component from W+0 jet sample and $qq \rightarrow qq$ contribution from the dijet sample with a leading jet E_T of 80-100 GeV. The $qq \rightarrow qq$ is estimated to be about 27% using PYTHIA MC calculations. We first normalize the W+0 jet sample to our dijet sample and then subtract it from the dijet sample by a factor of 0.27. This will give us the first gluon rich sample. We then use this subtracted, gluon rich sample to subtract the gluon content contribution to the W+0 jet distribution. We have an $< N_g >$ estimate of 0.15 for the W+0 jet sample, where about 0.13 is the feeddown background contribution and about 0.02 is the QCD background contribution, as we have less than 1% QCD background and we assume it has a similar gluon content as that of the gluon rich sample. Using the estimated gluon composition of the dijet sample, from PYTHIA MC calculations, we then subtract the gluon content of the W+0 jet. This subtracted version of the W+0 jet sample is what we consider as our no gluon distribution. Finally, we subtract the $qq \rightarrow qq$ contribution from dijet 80-100 GeV track multiplicity distribution using our no gluon distribution, normalized and scaled to the appropriate fraction of 27%. The remaining distribution is what we consider our gluon rich sample. Changes to the distributions due to subsequent iterations are indistigushable. We use the normalized parameterizations of these distributions in a simple binned likelihood fit with two free parameters to find the fraction of gluon rich components or alternatively $< N_g >$ in a given sample. Figure 2 shows the parameterizations of the no gluon and gluon rich distributions, and also overlays them with the first iteration subtracted distributions for comparison. The gluon rich fraction of a given low p_T track multiplicity distribution can be found using the following fit

$$N[f_g\mathcal{F}_g + (1 - f_g)\mathcal{F}_q] \tag{1}$$

where, N is the normalization factor and one of the free parameters, f_g is the fraction of gluon rich components of the sample and the other free parameter and $\mathcal{F}_g$ and $\mathcal{F}_q$ are the normalized gluon rich and 0-gluon parameterizations, respectively.
The fraction f_g can be used as the fraction of gluon rich components for samples with similar gluon compisition or can be used to find the $< N_g >$ in a given sample by multiplying it with the estimated $< N_g >$ in the gluon rich distribution, ~ 2.36, based on its gluon composition. Table I summerizes the $< N_g >$ measured using the fit to the calibration sample distributions and estimated $< N_g >$ from MC calculations. It is worth noting that in the case of the samples with comparable average number of gluons in the gluon rich fraction, one can use the f_g value itself to predict the gluon fraction of the sample, as the gluon rich distribution changes slightly. This is the case of $t\bar{t}$ events as one expects a value of $2 + \epsilon$, where ϵ is small for the average number of gluons in $gg \rightarrow t\bar{t}$. The small ϵ value takes into account the contribution of higher order processes.

A. $t\bar{t}$ Gluon Rich Fraction

The measured gluon rich fraction in the tagged W+4 or more jet sample, consists of two components, the $t\bar{t}$ gluon rich fraction and the background gluon rich fraction. Therefore, knowing the background fraction in our sample and

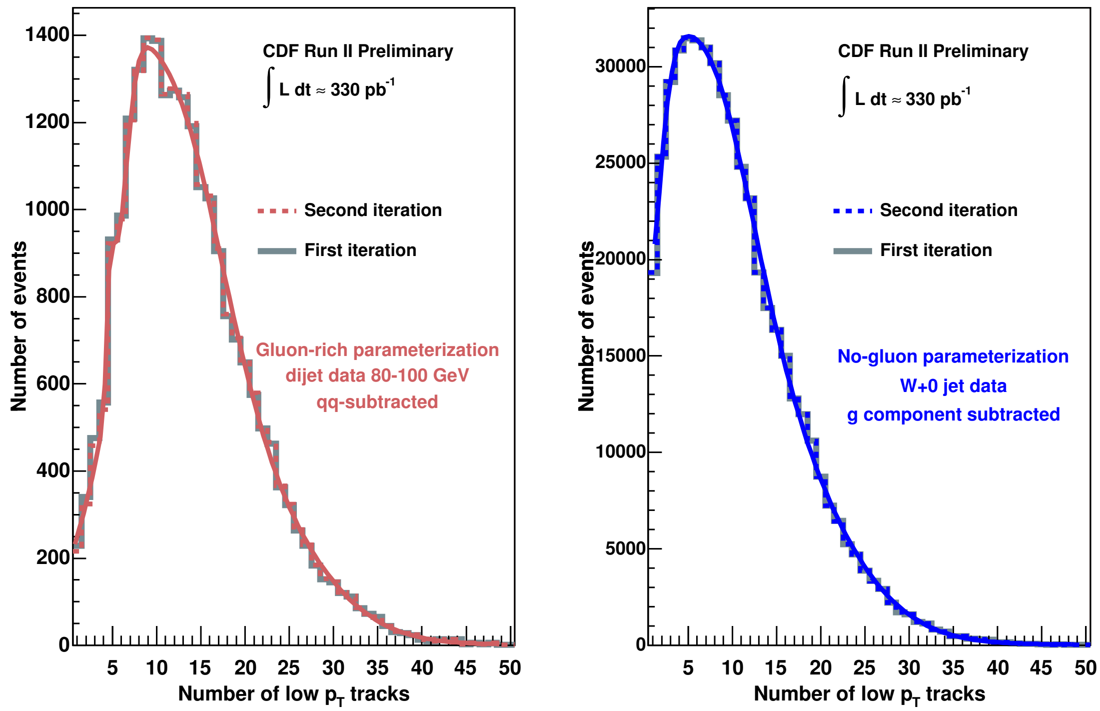

FIG. 2: The plot on the left shows a comparison between dijet with jet E_T range 80-100 GeV data first and second iteration to subtract $qq \rightarrow qq$ along with its final parameterization. The plot on the right shows a similar comparison between W+0 jet data sample between its forst and second iteration to subtract the gluon contribution along with its final parameterization. In both plots, the solid (light gray) histogram shows the first iteration.

the measured f_g from the fit, we can write

$$f_g = f_b f_g^{bkg} + (1 - f_b) f_g^{t\bar{t}}, \tag{2}$$

where, f_b is the background fraction and f_g^{bkg} and $f_g^{t\bar{t}}$ are the gluon rich fraction of the background and $t\bar{t}$ signal, respectively. The latter is what we want to measure, while f_b can be estimated for the 4 or more jets tagged sample as done for $t\bar{t}$ cross section measurements. Fig. 3 shows the fit to the tagged W+4 or more jets sample. We need to find the fraction of gluon rich components in the background. In order to do so, we take advantage of the W+n jet sample. We expect the gluon fraction to scale with the number of jets and as such we can extrapolate the gluon rich fraction of the background in the 4 or more jet bin from the gluon rich fraction of W+0, 1 and 2 jet samples with no b-tagged jet. The requirement of having no b-tagged jet will reduce the fraction of $t\bar{t}$ events in the W+2 and W+3 jet samples, so that they more closely represent backgrounds. To use the extrapolated fraction from no b-tagged sample to estimate f_g^{bkg}, we make the assumption that the gluon rich fraction of a sample is independent of the existance of a b-tagged jet. To test this assumption, we compare the gluon rich fraction of the samples with no b-tagged jet with the gluon rich fraction of the sample with at least 1 b-tagged jet. The gluon fractions found by the fit for each jet bin for b-tagged or no b-tagged samples are consistent within the uncertainties. As such, we believe the extrapolated value for the background gluon fraction is a reasobanle estimate for the gluon rich fraction of background in the sample, even more so given the small background fraction in the tagged sample. Additionally, Fig. 4 shows a clear rise in the no tag sample gluon fraction as we go to higher jet multiplicity, as expected. The trend in the tagged sample as we move to higher jet bins is consistent with being flat and as such, it might be possible to get the fraction by taking the average of the 3 tagged samples. The tagged sample has a large $t\bar{t}$ fraction in 3 jet bin and as such, assuming SM prediction for $t\bar{t}$, one would expect the gluon rich fraction to be lower than what it is if we take into account the contribution from $gg \rightarrow t\bar{t}$. This is also the case for W + 2 jet b-tagged sample.

Extrapolating the gluon rich fractions of the W+1, W+2 and W+3 jet no b-tagged sample gives an estimate for the W+4 or more jet sample. We use the $t\bar{t}$ cross section measurement estimates [6] to get the background event

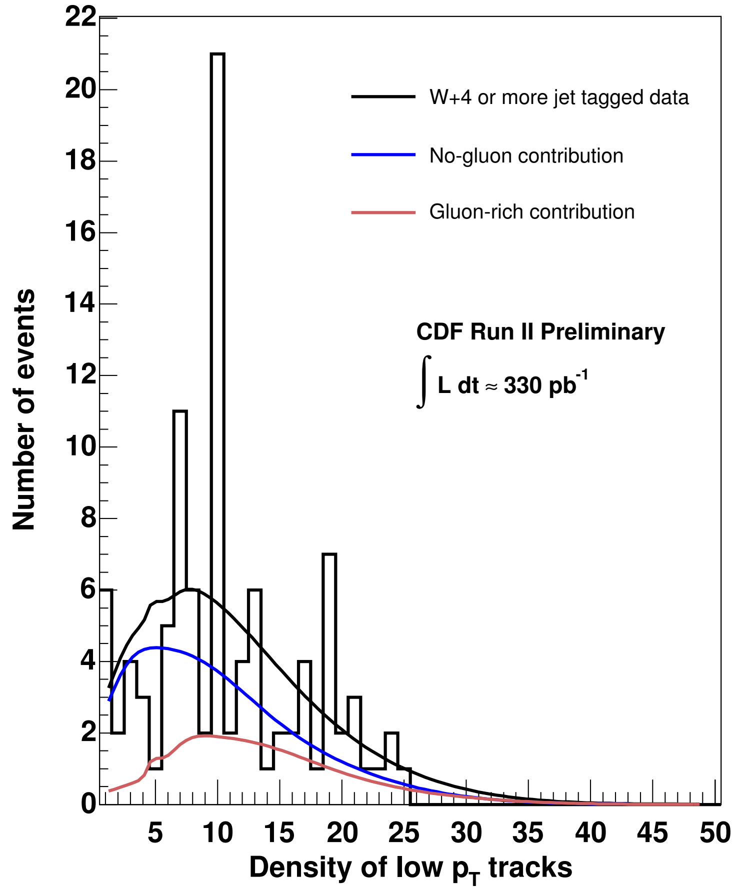

FIG. 3: The fit result for the tagged W+4 or more jet sample. The two components of the fit (gluon rich and 0-gluon) contributions are also shown.

fractions. Using $f_b = 0.13 \pm 0.03$, $f_g^{bkg} = 0.65 \pm 0.06$ and measured $f_g = 0.32 \pm 0.22$, we get $f_g^{t\bar{t}} = 0.28 \pm 0.25$. The systematics uncertainties will be discussed in the next section.

B. $\sigma(gg \to t\bar{t})/\sigma(p\bar{p} \to t\bar{t})$

The last step to measure $\sigma(gg \to t\bar{t})/\sigma(p\bar{p} \to t\bar{t})$ is to estimate the relative acceptance of $gg \to t\bar{t}$ and $p\bar{p} \to t\bar{t}$. To do so, we use HERWIG [7] MC calculations. We use 10 sets of about 100K $t\bar{t}$ events with an almost equal fraction of gg fusion and $q\bar{q}$ annihilation. The fraction of $gg \to t\bar{t}$ events that falls in 4 or more jet bins is higher than that of the $q\bar{q} \to t\bar{t}$, as expected due to higher gluon radiation probability for gluons. Using the MC calculations, we find $(6 \pm 1)\%$ of $gg \to t\bar{t}$ and $(5 \pm 1)\%$ of $p\bar{p} \to t\bar{t}$ events passing our tagged sample criteria. These numbers do not have the lepton+jet branching fraction and b-tag SF incorporated in them, however as we are interested in the relative acceptance, the effects of these factors cancel out. We find

$$\frac{\sigma(gg \to t\bar{t})}{\sigma(p\bar{p} \to t\bar{t})} = \frac{1}{1 - (\mathcal{A}_{gg\to t\bar{t}}/\mathcal{A}_{q\bar{q}\to t\bar{t}}) + (\mathcal{A}_{gg\to t\bar{t}}/\mathcal{A}_{q\bar{q}\to t\bar{t}}(1/f_g^{t\bar{t}}} = 0.25 \pm 0.24(\text{stat}), \quad (3)$$

where $\mathcal{A}_{gg\to t\bar{t}}$ and $\mathcal{A}_{p\bar{p}\to t\bar{t}}$ are the acceptance for $gg \to t\bar{t}$ and $p\bar{p} \to t\bar{t}$, respectively.

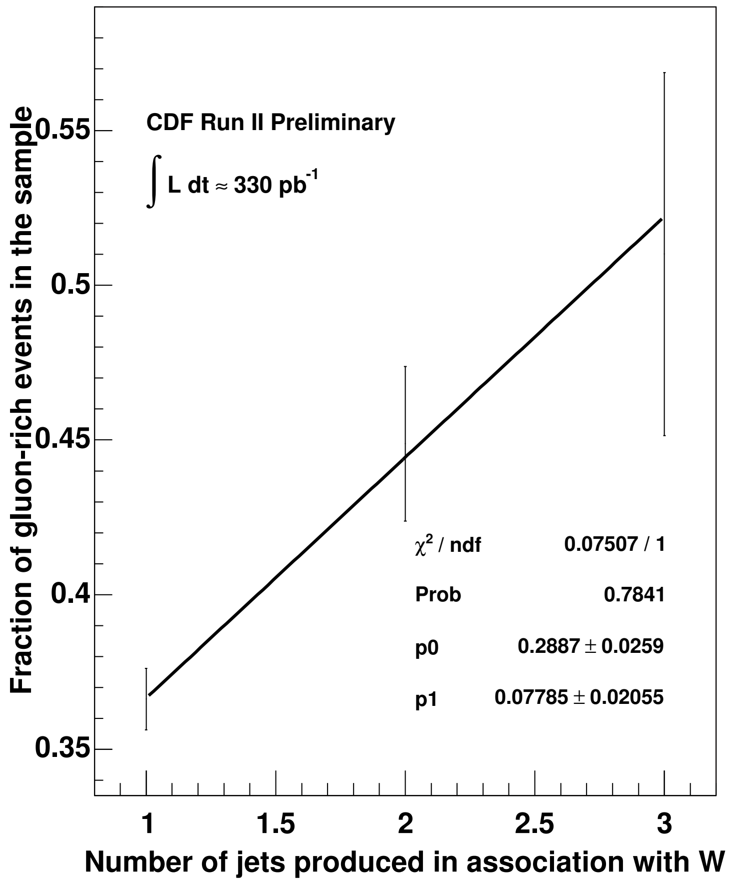

FIG. 4: This plot shows the linear fit used to extrapolate the no tag gluon rich fraction to estimate the gluon rich fraction of the $t\bar{t}$ in the tagged 4 or more jet bin.

V. SYSTEMATIC UNCERTAINTIES

There are several sources of systematics uncertainties on this measurement.

- The estimation of f_g^{bkg}.

  As mentioned before, we estimate this value by extrapolation in the no positive b-tag sample. Alternatively we can average the f_g fractions in tagged W+1,2 and 3 jet bins corrected for the presence of $t\bar{t}$ events in 2 and 3 jet bins. We take half of the difference between these two estimates, 0.13, as our systematics on f_g^{bkg}.

- The process composition of W+0 jet and dijets with E_T of 80-100 GeV

  We have used MADGRAPH+PYTHIA with $\mathrm{K_T} = 15$ and PYTHIA jet40 MC calculations for the process composition of W+0 jet and dijet events with E_T of 80-100 GeV samples, respectively. These calculations are used to make low p_T track multiplicity distributions associated with the 0-gluon and gluon rich processes. It is important to check the effect of these using different MC calculations. We use jet40 HERWIG MC calculations for dijet sample and find a value of about 26% for the $qq \rightarrow qq$ process. However, to be conservative we assign 5% uncertainty for this fraction and so find the gluon-rich fraction values for gluon-rich samples found assuming 22% and 32% $qq \rightarrow qq$ events in the 80-100 GeV dijet sample. We use different $\mathrm{K_T}$ values for W=0 jet sample to estimate the systematic uncertainties associated with the process compositions and we find a 2% effects due to ths uncertainty. We also use different average number of gluons for the contribution of gluon rich QCD background in the W+0 jet sample. We assume we have 2 or 4 gluons on average for this contribution. These values are the two extreme cases, as we expect these QCD backgrounds to be dijet events where one jet fakes a lepton and the other is not obsereved and as such for the gluon rich composition, we only get 2 or 4 as the possibilities for each event. However, we do not expect the QCD background composition in W+0 jet sample to be an important factor, due to its very small fraction.

- The choice of jet E_T threshold

  One expects higher number of jets coming from initial or final state gluon radiation in events with higher gluon content. As we exclude the low p_T tracks that fall within a radius of 0.4 from the centroid of low E_T jets (6-15 GeV), our low p_T track multiplicity distribution might be changed differently for the gluon rich and no gluon events. To estimate the effect of this cut, we measure f_g and estimate f_g^{bkg} using a low E_T cut of 8 GeV instead of 6 GeV.

- The track multiplicity correction per high E_T jet

  To reduce contributions to $< N_{trk} >$ from the high E_T jets present in the event, we make an additional correction of 0.89 ± 0.03 to the track multiplicty of the event for each jet. As we use a binned likelihood, with bin size of 1 starting from 0.5, $\pm 1\sigma$ change of this value does not change the distribution for events with 1 or 2 high E_T jets. However, it may change our low p_T track multiplicity distributions for samples with higher high E_T jet multiplicities. We estimate the systematics associated with this correction by making the correction of $\pm 1\sigma$ of 0.89.

- The acceptance for $t\bar{t}$ events

  We associate a systematics uncertainty of 4% for the acceptance due to the parton distribution function (PDF) and MC generator differences. This value is based on the uncertainties due to PDF (2%) and choice of MC generator (2%) in $t\bar{t}$ production cross section measurement.

- The pseudo-experiments

  We perform 1000 pseudo-experiments with 0.15, 0.25, 0.35, 0.45, 0.55 and 0.65 gluon-rich fractions using a total number of events equal to our ttbar candidate sample (104 events). Each entry in the distributions for these "true" fractions is randomly generated from the dijet 80-100 and W+0 jet track density distributions. The gg fraction is underestimated by about 5% at "true" gg fraction of about 25% and as such we associated an extra 5% systematic uncertainty to f_g.

  The systematics uncertainties associated with f_g and f_g^{bkg} are summerized in Table II.

Taking into account these systematics effects, we find

- $f_g = 0.32 \pm 0.22(stat) \pm 0.10(syst)$,
- $f_g^{bkg} = 0.65 \pm 0.06(stat) \pm 0.14(syst)$ and
- $\frac{\mathcal{A}_{gg\to t\bar{t}}}{\mathcal{A}_{q\bar{q}\to t\bar{t}}} = 1.16 \pm 0.28(stat) \pm 0.04(syst)$,

and then determine

$$\frac{\sigma(gg \to t\bar{t})}{\sigma(p\bar{p} \to t\bar{t})} = \frac{1}{1 - (\mathcal{A}_{gg\to t\bar{t}}/\mathcal{A}_{q\bar{q}\to t\bar{t}}) + (\mathcal{A}_{gg\to t\bar{t}}/\mathcal{A}_{q\bar{q}\to t\bar{t}})(1/f_g^{t\bar{t}})} = 0.25 \pm 0.24(\text{stat}) \pm 0.10(\text{syst}). \quad (4)$$

VI. CONCLUSION

The first measurement of $\sigma(gg \to t\bar{t})/\sigma(p\bar{p} \to t\bar{t})$ using an integrated luminosity of 330 pb^{-1} is presented. We have shown that the low p_T track multiplicity distribution in a given sample can be used to find the gluon composition of the sample. As there is no reliable MC calculations to predict the low p_T track multiplicity of a sample, we employe a data-driven method and define the shape of the low p_T track multiplicity distributions for 0-gluon process and gluon rich process. These parameterizations are used to find the fraction of $gg \to t\bar{t}$. Using this fraction we find a value of $0.25 \pm 0.24(\text{stat}) \pm 0.10(\text{syst})$ for $\sigma(gg \to t\bar{t})/\sigma(p\bar{p} \to t\bar{t})$. MC calculations are used to predict the composition of a given process. Sources of sustematic effects are explained and their estimated uncertainties are given.

Type of systematics effect	source	f_g^{bkg}	f_g	$\mathcal{A}_{gg\to t\bar{t}}/\mathcal{A}_{q\bar{q}\to t\bar{t}}$
3*Quark-gluon composition	$qq \to qq$	±0.02	±0.02	-
	K_T	$^{+0.00}_{-0.02}$	±0.02	-
	QCD bkg composition	$^{+0.00}_{-0.02}$	$^{+0.00}_{-0.01}$	-
3*Track counting	low E_T cut	$^{+0.02}_{-0.00}$	$^{+0.00}_{-0.03}$	-
	trk/jet correction	$^{+0.00}_{-0.01}$	$^{+0.03}_{-0.02}$	-
	trk-vtx matching	-	-	-
3*Others	the pseudo-experiments comparisons	±0.05	-	-
	f_g^{bkg} estimate method	±0.13	-	-
	PDF and MC	-	-	±0.04
Total		±0.14	±0.04	±0.04

TABLE II: Sources of systematics effects and their effects on different variables

Acknowledgments

We thank the Fermilab staff and the technical staffs of the participating institutions for their vital contributions. 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 fuer Bildung und Forschung, Germany; the Korean Science and Engineering Foundation and the Korean Research Foundation; the Particle Physics and Astronomy Research Council and the Royal Society, UK; the Russian Foundation for Basic Research; the Comision Interministerial de Ciencia y Tecnologia, Spain; and in part by the European Community's Human Potential Programme under contract HPRN-CT-20002, Probe for New Physics.

[1] J.H. Kühn, Lectures presented at the XXIII SLAC Summer Institute on Particle Physics, *The Top Quark and the Electroweak Interaction*, hep-ph/9707321, July 10-21, 1995, SLAC, Stanford, USA.

[2] G.L. Kane and S. Mrenna, Phys. Rev. Lett. **77**, 3502-3505 (1996).

[3] F. Abe, et al., Nucl. Instrum. Methods Phys. Res. A **271**, 387 (1988); D. Amidei, et al., Nucl. Instum. Methods Phys. Res. A **350**, 73 (1994); F. Abe, et al., Phys. Rev. D **52**, 4784 (1995); P. Azzi, et al., Nucl. Instrum. Methods Phys. Res. A **360**, 137 (1995); The CDFII Detector Technical Design Report, Fermilab-Pub-96/390-E

[4] `http://home.fnal.gov/~mrenna/Matched_Dataset_Description.html`

[5] T. Sjostrand et al., High-Energy-Physics Event Generation with PYTHIA 6.1, Comput. Phys. Commun. **135**, 238 (2001).

[6] Salvatore Rappoccio, *Measurement of the ttbar Production Cross Section*, Harvard University (August 2005).

[7] G. Corcella et al., HERWIG 6: An Event Generator for Hadron Emission Reactions with Interfering Gluons (including supersymmetric processes), JHEP **01**, 10 (2001).