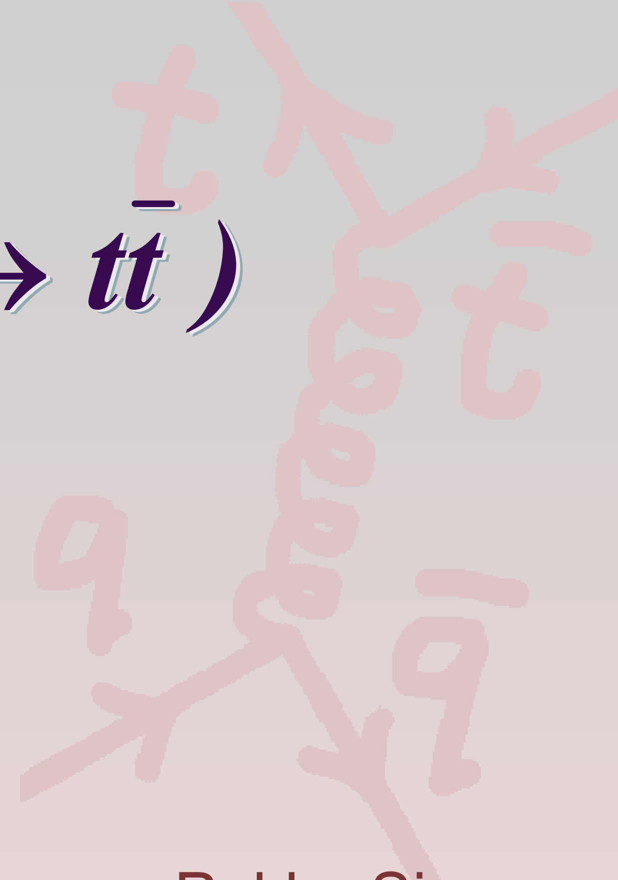
First Measurement of $\sigma(gg \to t\bar{t}) / \sigma(p\bar{p} \to t\bar{t})$ in $p\bar{p}$ Collisions at E_{CM} of 1.96 TeV



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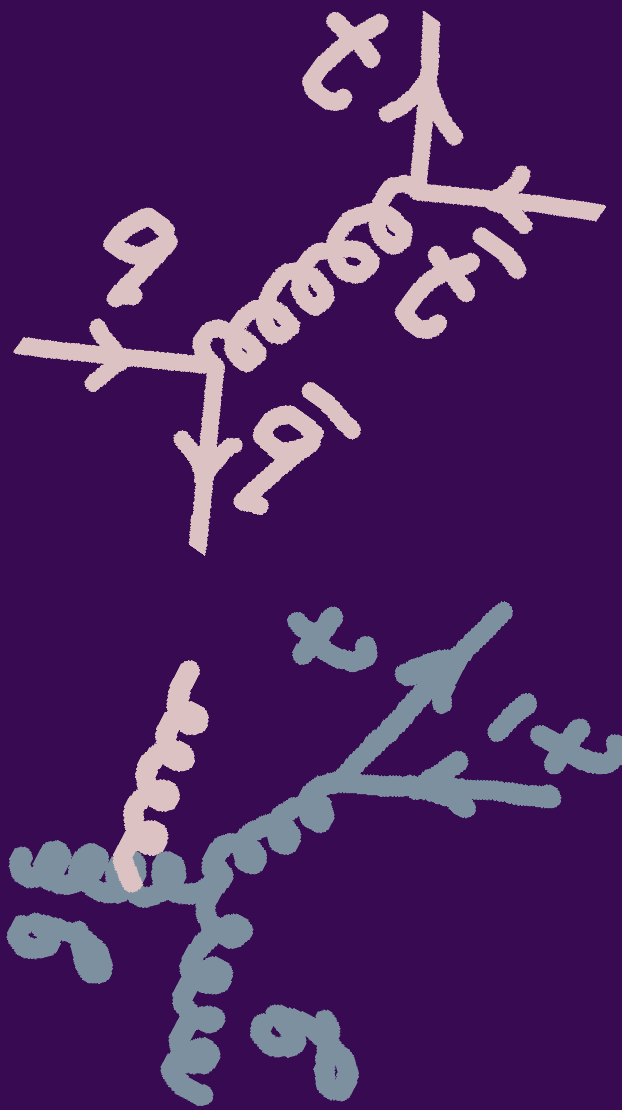
CAP Congress
June 19, 2007

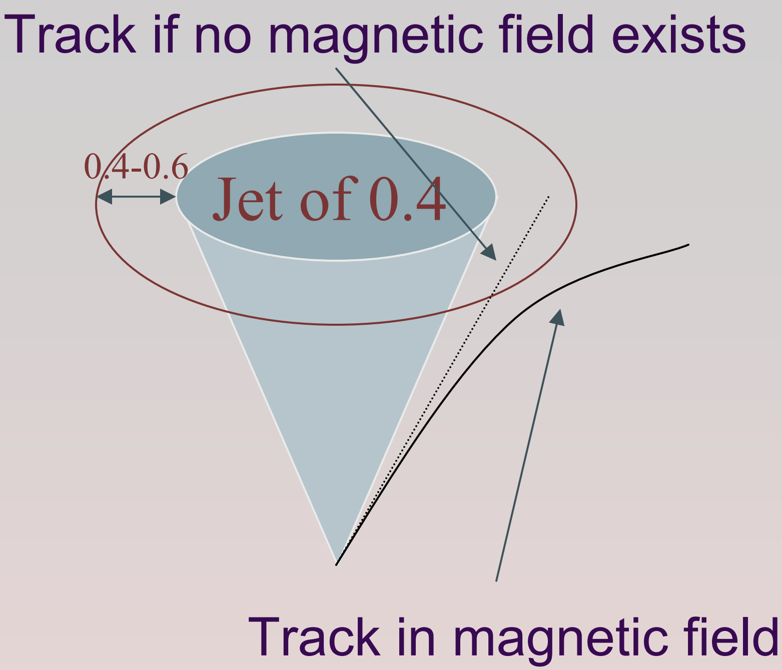
Introduction

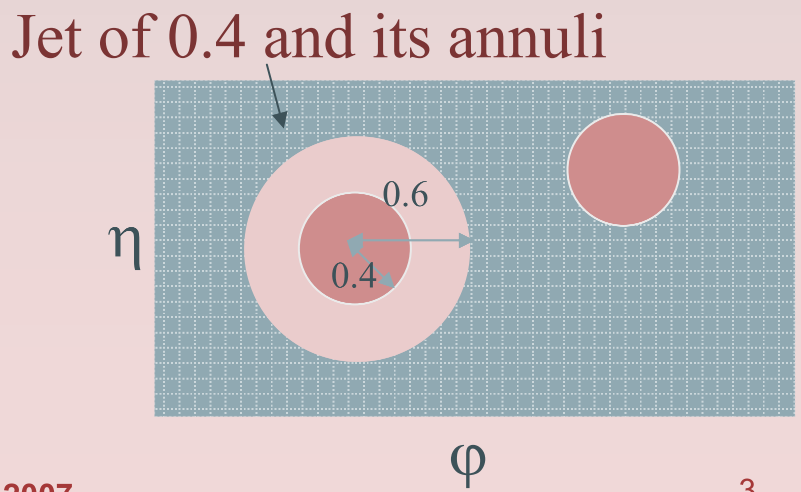
- According to SM, in $p\bar{p}$ collisions at $\sqrt{s} \sim 2$ TeV
  - $gg \rightarrow t\bar{t}$ (10-20)%
  - $q\bar{q} \rightarrow t\bar{t}$ Almost the rest
- Measure $\sigma_{(gg \rightarrow t\bar{t})} / \sigma_{(p\bar{p} \rightarrow t\bar{t})}$
  - Test of pQCD calculations
  - Gluon momentum distribution
  - Non-SM mechanisms
- Processes differ in underlying activity



The Difference

- Gluons radiate more gluons than quarks do
  - More charged particles in gg channel
- Track Multiplicity
  - Low p_T
  - $|\eta| \leq 1.1$
  - Matched to the event vertex
  - Away from jets
  - Correct for area differences





Calibration Samples

- Can not rely on the modeling of gluon radiation
- Therefore calibrate using data
  - W + n jet events
    - W with no jet is mainly $q\bar{q}'$
    - As jet multiplicity increases, the gluon-content increases
  - Dijet events
    - Gluon-content decreases as the leading jet E_T increases
- Show a correlation exists between $\langle N_{trk} \rangle$ and $\langle N_g \rangle$

Jet in W+ n jet categories:

- $E_T \geq 20$
- $|\eta| \leq 2$

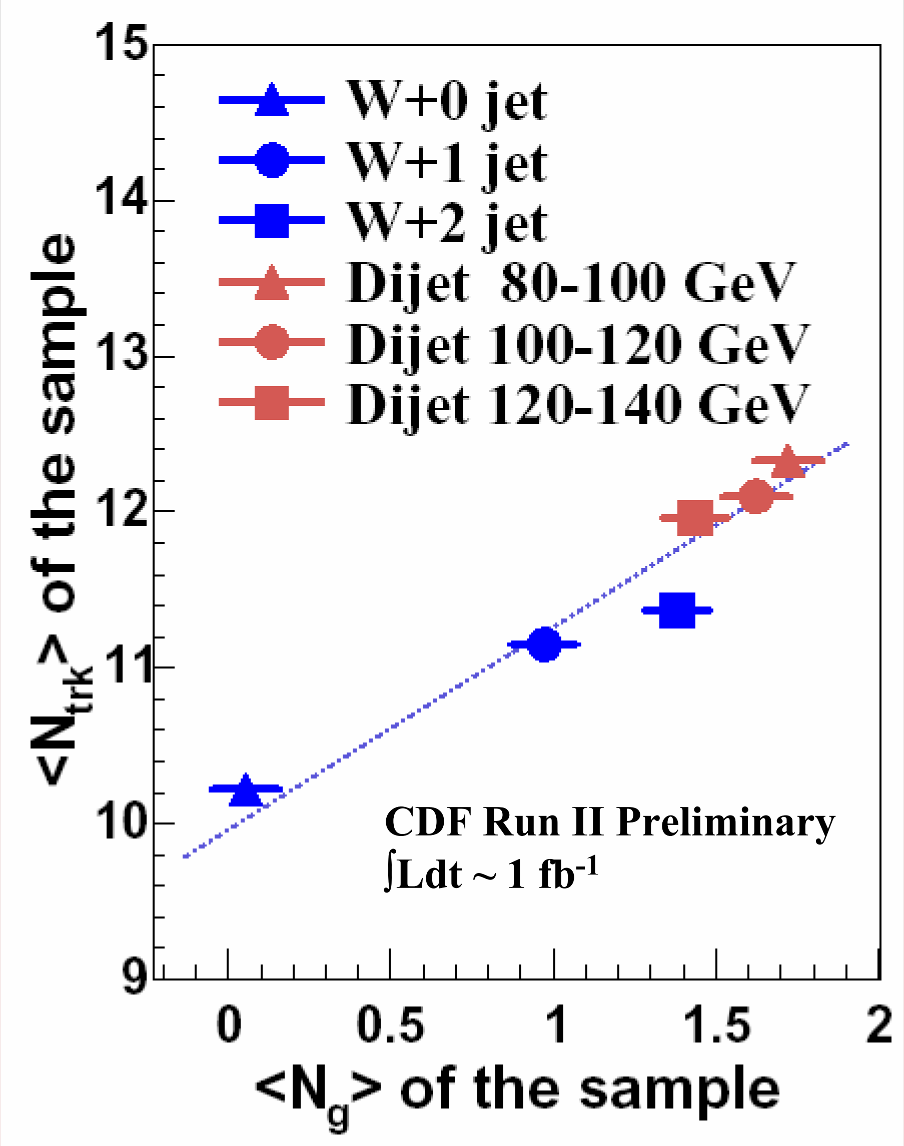
Leading jet in dijet categories:

- starting from 80 GeV
- bins of 20 GeV
- up to 220 GeV or more

- $\langle N_{trk} \rangle \equiv$ Average number of low p_T tracks
- $\langle N_g \rangle \equiv$ Average number of gluons in the scattering process

Correlation of <N_{trk}> and <N_g>...

Sample	X-axis, MC, <N_g>	Y-axis Data, <N_{trk}>
W+0 jet	0.05 ±0.10	10.22±0.01
W+1 jet	0.97 ±0.10	11.15 ±0.03
W+2 jets	1.38 ±0.10	11.37 ±0.07
80-100 GeV	1.72 ±0.10	12.33 ±0.02
100-120 GeV	1.62 ±0.10	12.10 ±0.02
120-140 GeV	1.44 ±0.10	11.96 ±0.04

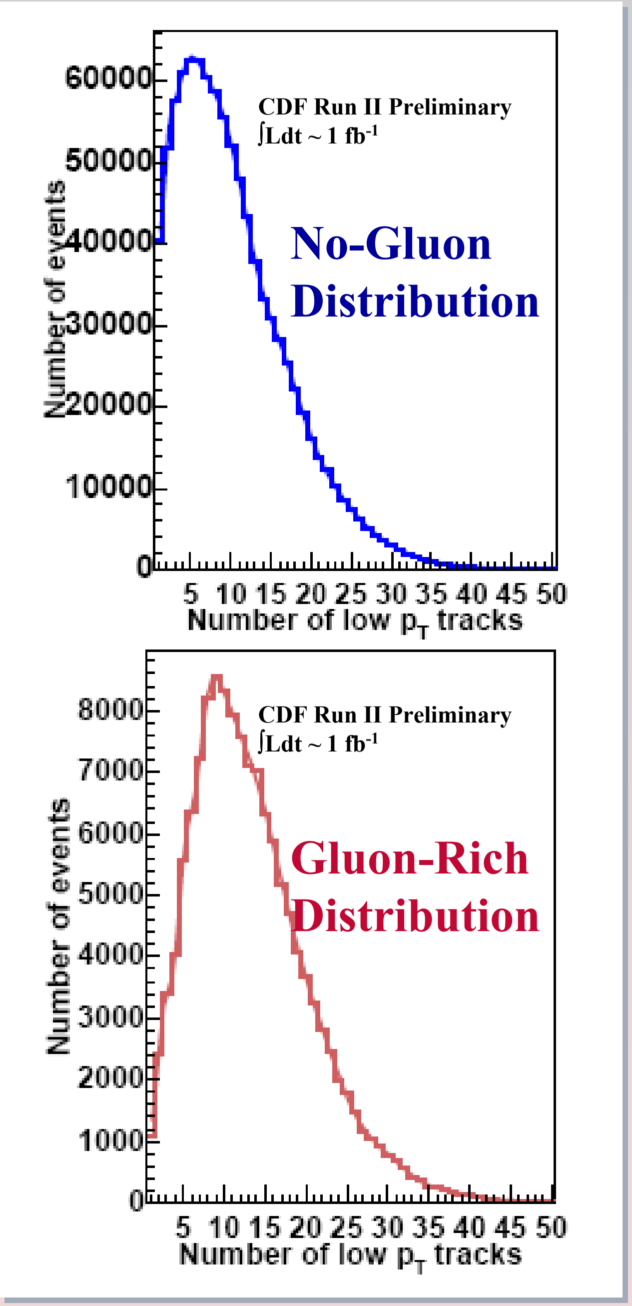


Measuring Gluon-Rich Fraction

- Define and parameterize two distributions representing no-gluon and gluon-rich samples
  - F_q, W+0 jet which is almost purely $qq \to W$
  - F_g, dijet sample with leading jet E_T of 80-100 GeV after we subtract the qq component from it
- Use the normalized parameterization of the two distributions in a fit to the low p_T track multiplicity distribution in any other sample

$$N[f_{glu-rich} F_g^{norm} + (1 - f_{glu-rich}) F_q^{norm}]$$

- Using the calibration samples, we show that the method works well



Estimating Gluon-Rich Fraction in Background

Sample	f_{g} - no tag	f_{g} - tagged
W+1 jet	0.37 ± 0.01	0.55 ± 0.06
W+2 jet	0.48 ± 0.02	0.34 ± 0.09
W+3 jet	0.50 ± 0.05	0.28 ± 0.13
Extrapolated W+4^{+} jet, (f_g^{LF}) (f_g^{HF})	0.69 ± 0.06	0.002 ± 0.22
LF fraction in background (f_b^{LF})	-	0.55 ± 0.11
HF fraction in background (f_b^{HF})	-	0.45 ± 0.09

- We calculate f_g^{bkg} assuming Gaussian distributions for the variables used in the following equation using the above values

$$f_g^{bkg} = f_b^{LF} f_g^{LF} + f_b^{HF} f_g^{HF}$$

- We find $f_g^{bkg} = 0.46 \pm 0.07$

- HF background is anything that can have a real tag (Wc, Wcc, Wbb, Single Top and half of nonW) and the rest is what we consider LF

Systematic Uncertainties

- We use $\pm 1\sigma$ difference of the cuts and corrections we use to find the low p_T track multiplicity to find the systematic uncertainties in different variables and propagate them to the final result

	f_g^{tt}		$\sigma(gg\to tt)/\sigma(pp\to tt)$
f_g	± 0.08	f_g^{tt}	± 0.07
f_g^{bkg}	± 0.02	$\mathcal{A}_{gg\to tt}$	$< \pm 0.001$
f_b	± 0.01	$\mathcal{A}_{qq\to tt}$	$< \pm 0.001$
Total	± 0.08	Total	± 0.07

Results

- Using

$$f_g^{W+4\,jet} = 0.07 \pm 0.15(stat) \pm 0.07(syst),$$

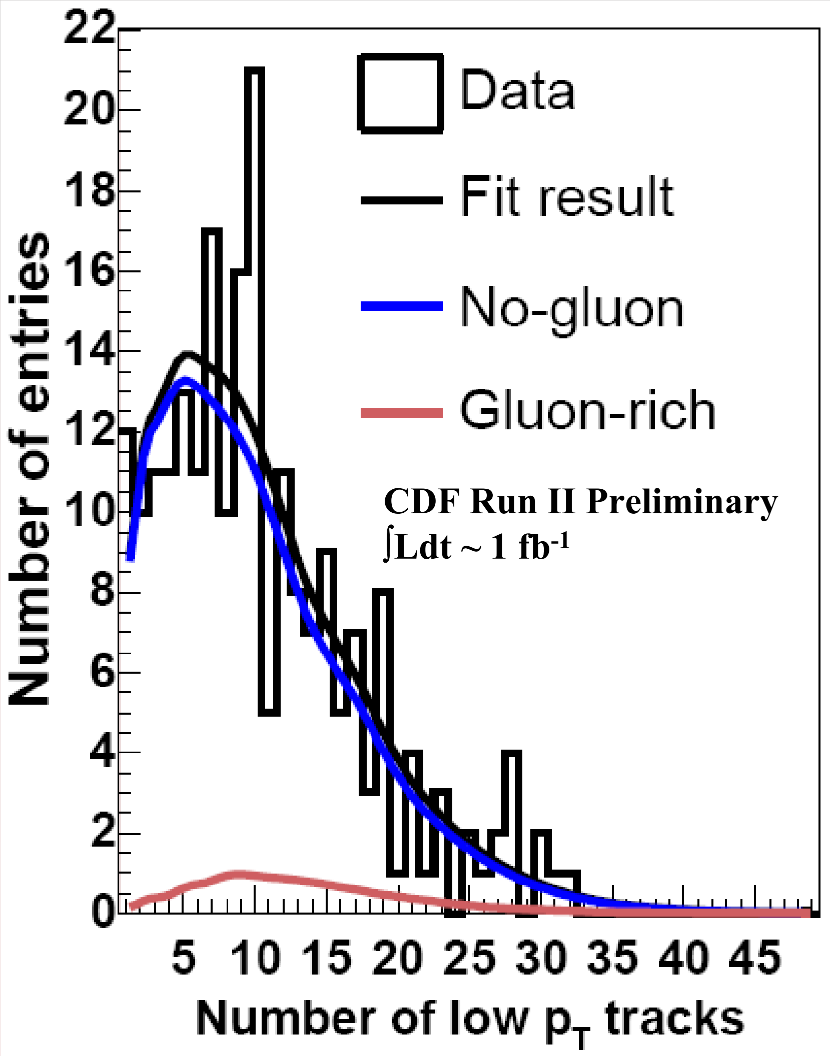
$$f_g^{bkg} = 0.46 \pm 0.11(stat + syst)$$

and a background fraction of (13 ± 2)%, we get

$$f_g^{tt} = 0.01 \pm 0.18(stat) \pm 0.08(syst)$$

- and using a ttbar acceptance of 0.099 ± 0.002 and 0.088 ± 0.002 for gg fusion and qqbar respectively, we find

$$\frac{\sigma(gg \to t\bar{t})}{\sigma(p\bar{p} \to t\bar{t})} = 0.01 \pm 0.16(stat) \pm 0.07(syst)$$



Summary

- Using about 1 fb^{-1} data collected at CDF, we show
  - There exists a clear correlation between the $\langle N_g \rangle$ and $\langle N_{trk} \rangle$
  - Gluon-rich fraction in a given sample can be determined using low p_T track multiplicity distribution of the sample, using only one input value from Monte Carlo
  - $$\frac{\sigma(gg \to t\bar{t})}{\sigma(p\bar{p} \to t\bar{t})} = 0.01 \pm 0.16(stat) \pm 0.07(syst)$$
  - The result is limited by statistics