Blessing: Study of ttbar Production Mechanisms

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Analysis Overview

Q&A

Plots, Results to Bless

Analysis Overview

- The goal is to measure $\sigma_{(gg \to t\bar{t})} / \sigma_{(p\bar{p} \to t\bar{t})}$
  - ✓ Test of pQCD
  - ✓ Unknown sources of physics beyond the SM
- To discriminate between gg and qq events, we take advantage of higher low pt track density in gluon-rich events
- There is no reliable MC calculations to predict low pt track multiplicities and as such, we use a data-driven analysis
- We use dijet samples with different leading jet Et and W events with different number of jets as calibration samples
- We show that there is a correlation between the average low pt track density and the average number of gluons present in a sample
  - ✓ We use MC calculations to find the average number of gluons in a sample

Analysis Overview

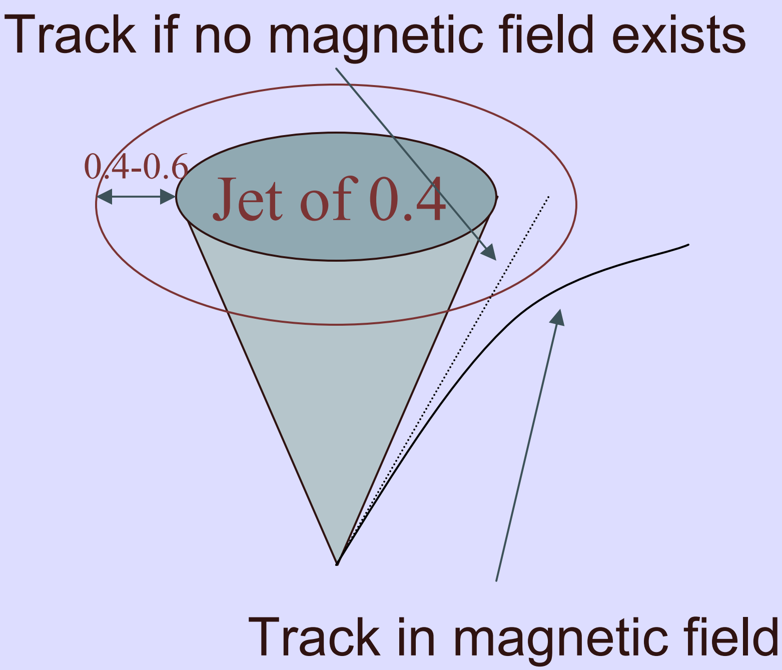
- We take advantage of the fact that W+0 jet sample is almost purely qq and that dijet sample with leading jet Et of 80-100 GeV has a large gluon content and define a gluon-rich and no-gluon distributions
- We use a binned likelihood fit with two free parameters to find the fraction of gluon-rich events present in a sample

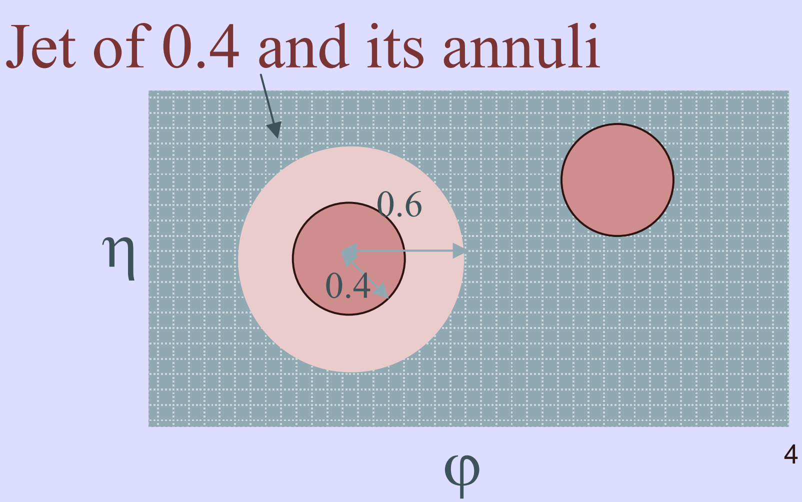
$$N[\, f_g F_g^{norm} + (1 - f_g) F_q^{norm} \,]$$

- For samples with similar gluon-content to the gluon-rich distribution (<Ng>~2 gluons), one can simply use the fit. In case of samples with much lower or much higher <Ng>, one can infer the <Ng> of the sample
- gg→ttbar events has an average gluon content similar to the gluon-rich distribution and as such we plan to use this method to make a measurement of the fraction of ttbar candidates produced through gluon-gluon fusion

Track multiplicity

- defTracks
  - ✓ p_T 0.3 – 2.9 GeV/c^2
  - ✓ $|\eta| \leq 1.1$
- Matched to the event vertex
  - ✓ 3cm
- Away from jets
  - ✓ ΔR=0.6, cor$E_T \geq$15 GeV
  - ✓ ΔR=0.4, 6 $\leq$ corE_T< 15 GeV
- Correct for area differences
- Correct for remaining contribution of high E_T jets
  - ✓ 0d: 0.90 ± 0.03
  - ✓ 0h: 0.97 ± 0.04
  - ✓ 0i: 0.96 ± 0.04





Qustions & Answers

Background

- Q Using L5 correction for the event selection, one expects larger background. Do you have an estimate for this? Or have you shown that this is not the case?

- A We changed the event selection criteria for the W+n jet samples, so that we use exactly the same cuts that is used in ttbar cross section analysis. We also require at least one good z vertex in the event as part of our track selection.
- A We also use a more recent background estimate from cross section measurement, CDF note 8037.

Background

Q Do you consider nonW background part of LF background? One expects them to have a sizeable HF events.

A Given the small background (13%), we do not expect to be very sensitive to the background composition. However, we took 2 extremes, nonW all LF and all HF, and our gluonrich fraction in ttbar signal was increased by 2%. Therefore, we decided to treat nonW as half HF and half LF and assign a 1% systematic uncertainty to the fgtt due to background composition.

<Ng> in ttbar sample

- Q Given that 80-100 GeV gluon-rich distribution has ~2.4 <Ng> and ttbar has about 2, is your choice of gluon-rich sample reasonable? It could be more useful if you use b bbar samples.

  - A We can't have a reliable <Ng> of bbbar sample, due to NLO effects, unless we use 2 and only 2 b-tagged jets in the sample, in which case most of the time at most we have 2 gluons in the event, however for the gg->ttbar sample we have 2+a small number of gluons, due to gluon radiation.

  - A In any event I used dijet 180+ GeV sample to define a gluon-rich distribution with ~2.1 gluons, to see the effect, however, we don't have enough statistics for a smooth parameterization.

  - A Using this sample, our final result changes by ~2%, however, due to large statistical uncertainties involved, we do not use this to assume a systematics effect.

<Ng> in dijets

Q How is the error on <Ng> determined? My concern is that the K-factor for gg or qg is larger than that of qq and it affects the <Ng>, given that you use LO MC to get this number.

A We require to have 2 and only 2 back to back jets in the dijet samples. This therefore should reduce the NLO effects on this calculation. We have an estimate of 3% uncertainty on the qq fraction in dijet sample with leading jet Et of about 100 GeV. We use this number, assuming all this 3% coming from qg processes or gg processes, we get an uncertainty of 0.06 or 0.12 gluon, respectively. As such, we use an uncertainty of 0.1 for <Ng> of dijet samples.

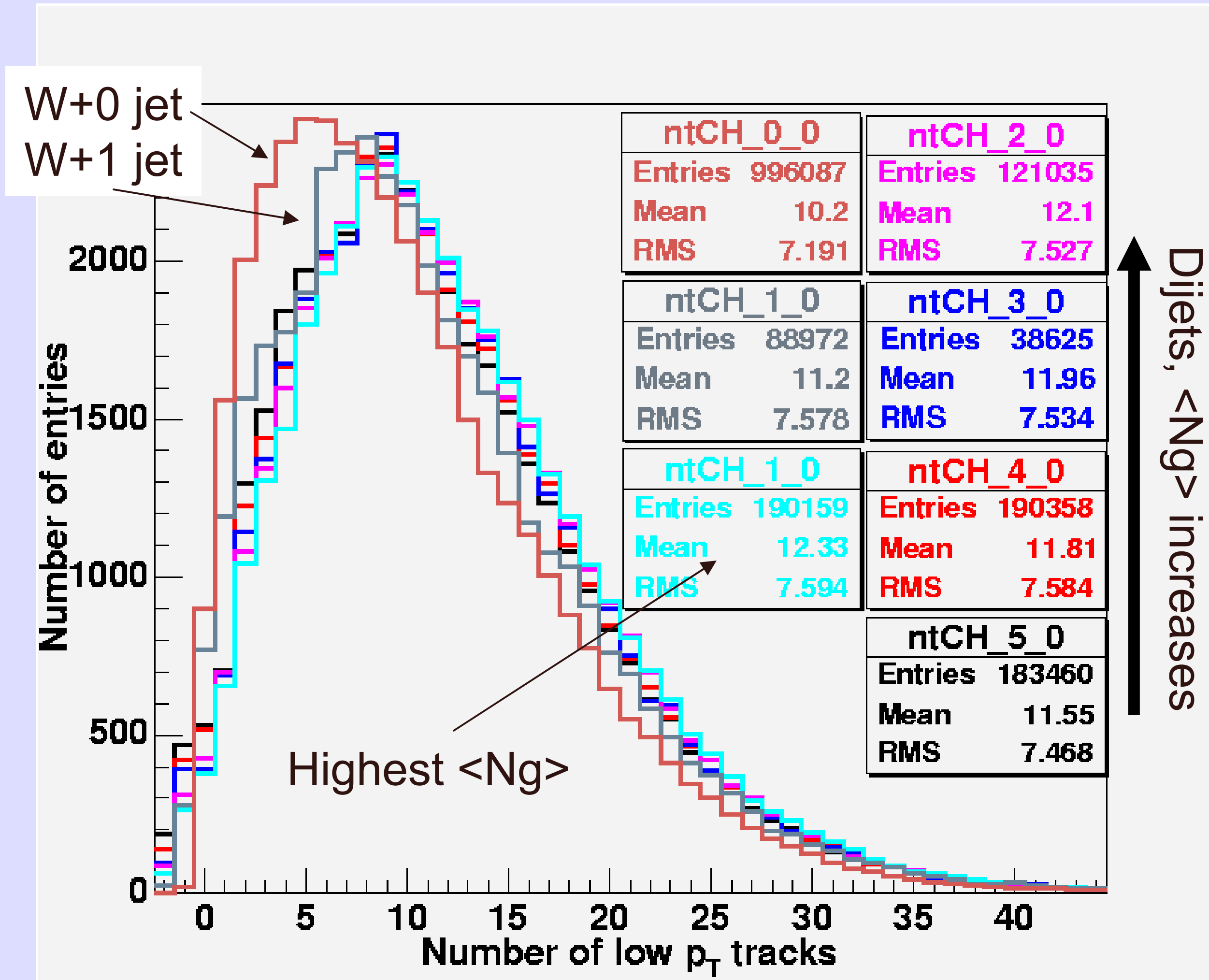
W+2 and W+3 jet

- Q We had two questions regarding the possible difference in the slope of W samples compared to dijet samples in <Ntrk> vs. <Ng> plot, mainly arising from W+2 jet point. Is this difference in slope affecting the fraction of gluon-rich events we find using parameterization of no-gluon and gluon-rich distributions we define from W+0 jet and dijet sample with leading jet Et of 80-100 GeV.

- A There are two points to consider
  - A The most important samples on this plot, affecting our measurement, are the W+0 jet and dijet samples. W+0 jet is almost purely qq process and is being used for our no-gluon distribution, as well as the dijet samples which have a more complicated quark-gluon composition and will be used for gluon-rich distributions. All these samples that I mentioned have a very small background and as such are more reliable.
  - A The gluon content of the background composition of W+2 and W+3 jet samples are not well defined and so there is a large uncertainty involved.

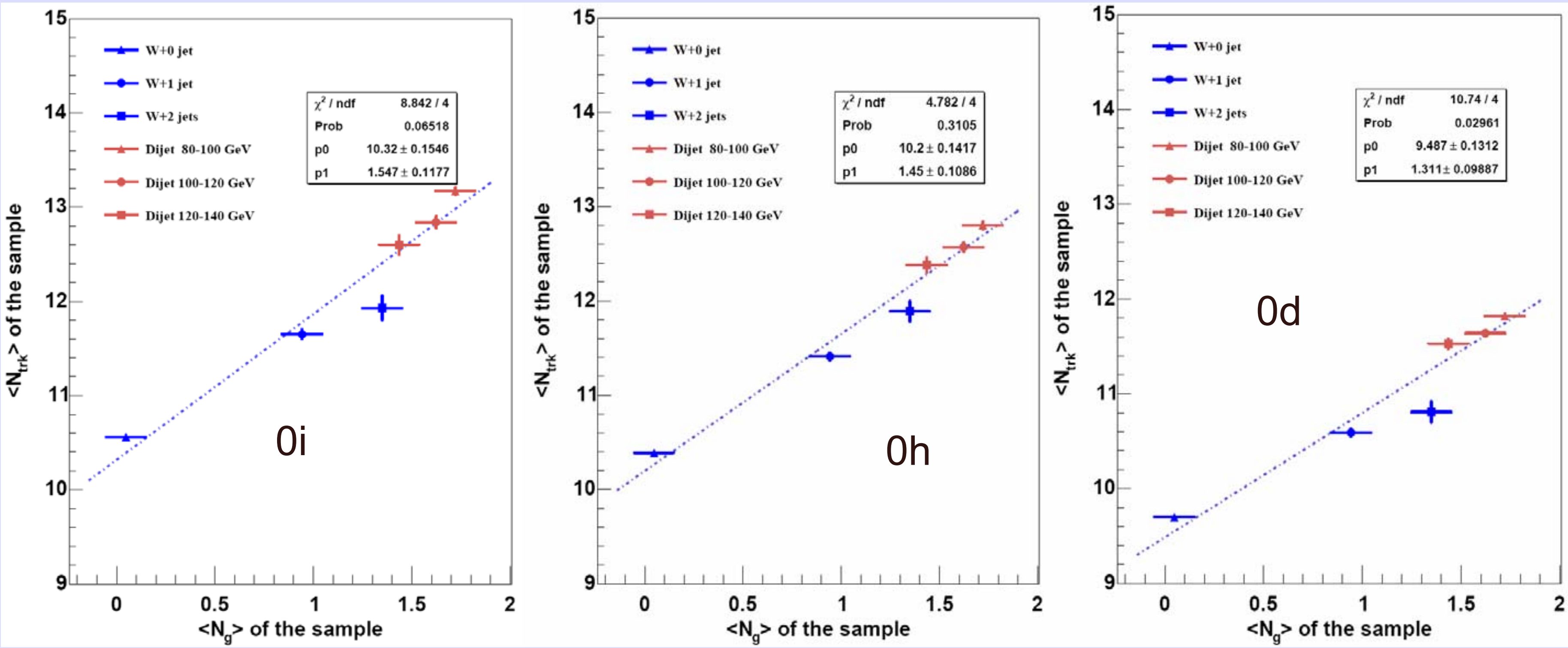
Systematics checks, <Ntrk> vs. <Ng>

- Are the slices of Ng or Ntrk shaped reasonably? Is a specific slice in Ng shaped differently if it comes from one (dijet) dataset or the other?



Systematic checks, <Ntrk> vs. <Ng> slope

- Q It would be nice to examine the <Ntrk>-<Ng> relationship as a function of somewhat unrelated variables.



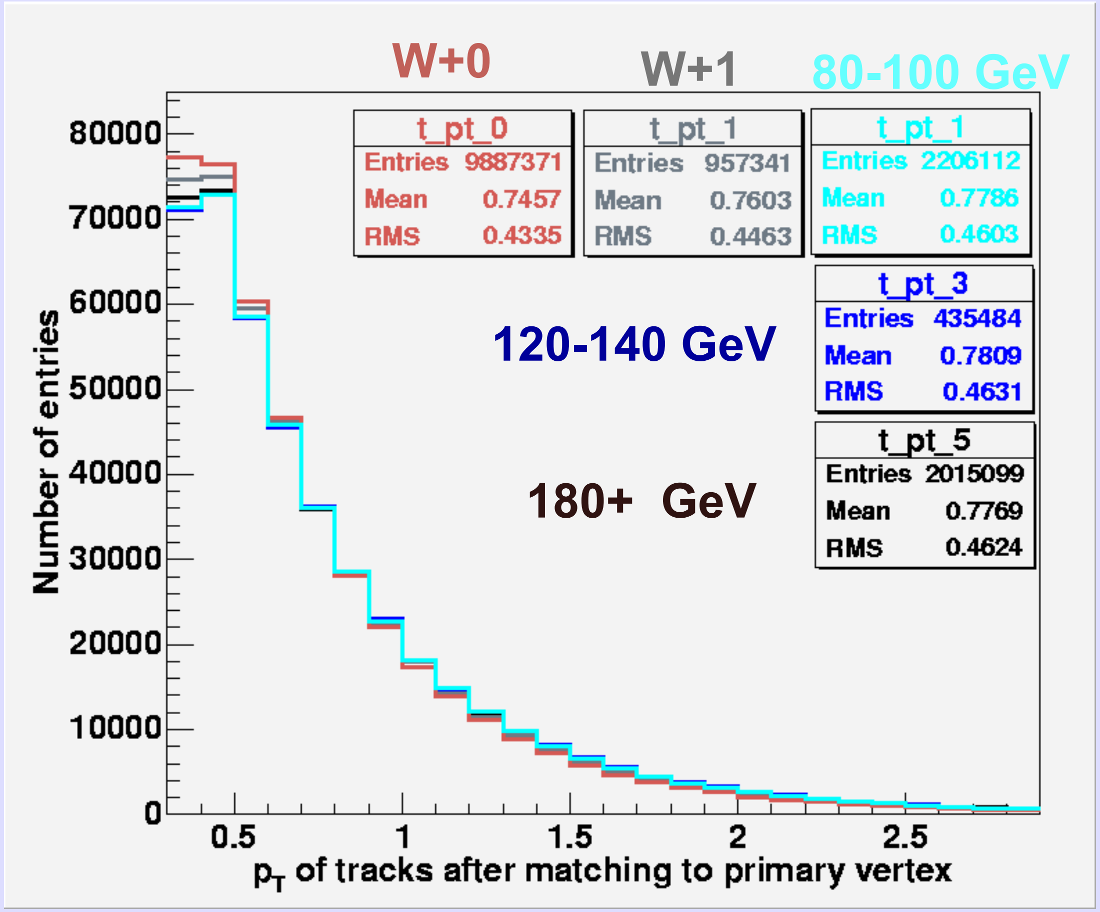
- A 0d has a different track reconstruction and efficiency, lower instantaneous luminosity (extra interaction)
- A 0i and 0h have same reconstruction, different instantaneous luminosity

Systematic checks, <Ntrk> vs. <Ng> slope

Q How sensitive is the slope to changes in the definition/selection of low pt tracks?

A All distributions are normalized to have the same number of events. The <Ng> decreases from cyan to brown.

A The distributions are fairly similar and as such one should not be very sensitive to a reasonable change in the track pt cuts.

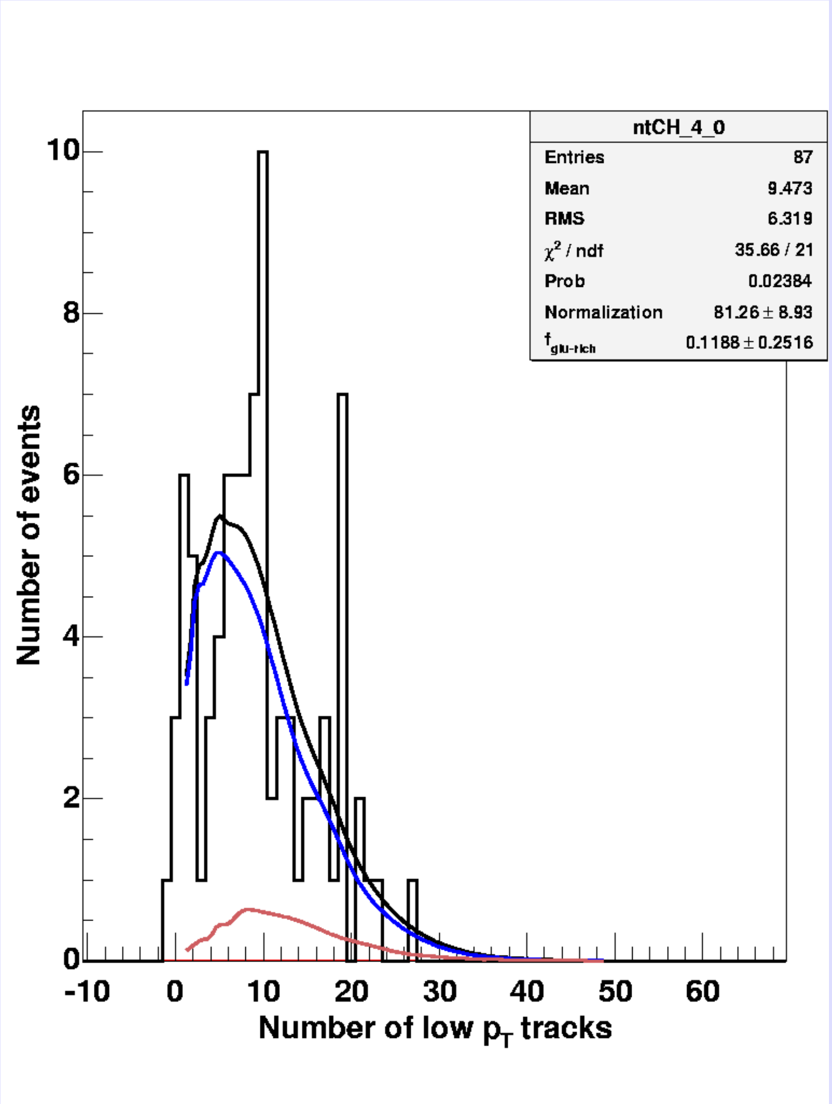


Systematic checks

Q How your result is affected if you were to use only 0d or 0i sample?

A Using only 0d dataset, we get a gluon-rich fraction of 0.12 +/- 0.25 compared to 0.11 +/- 0.15 we get from the combined dataset.

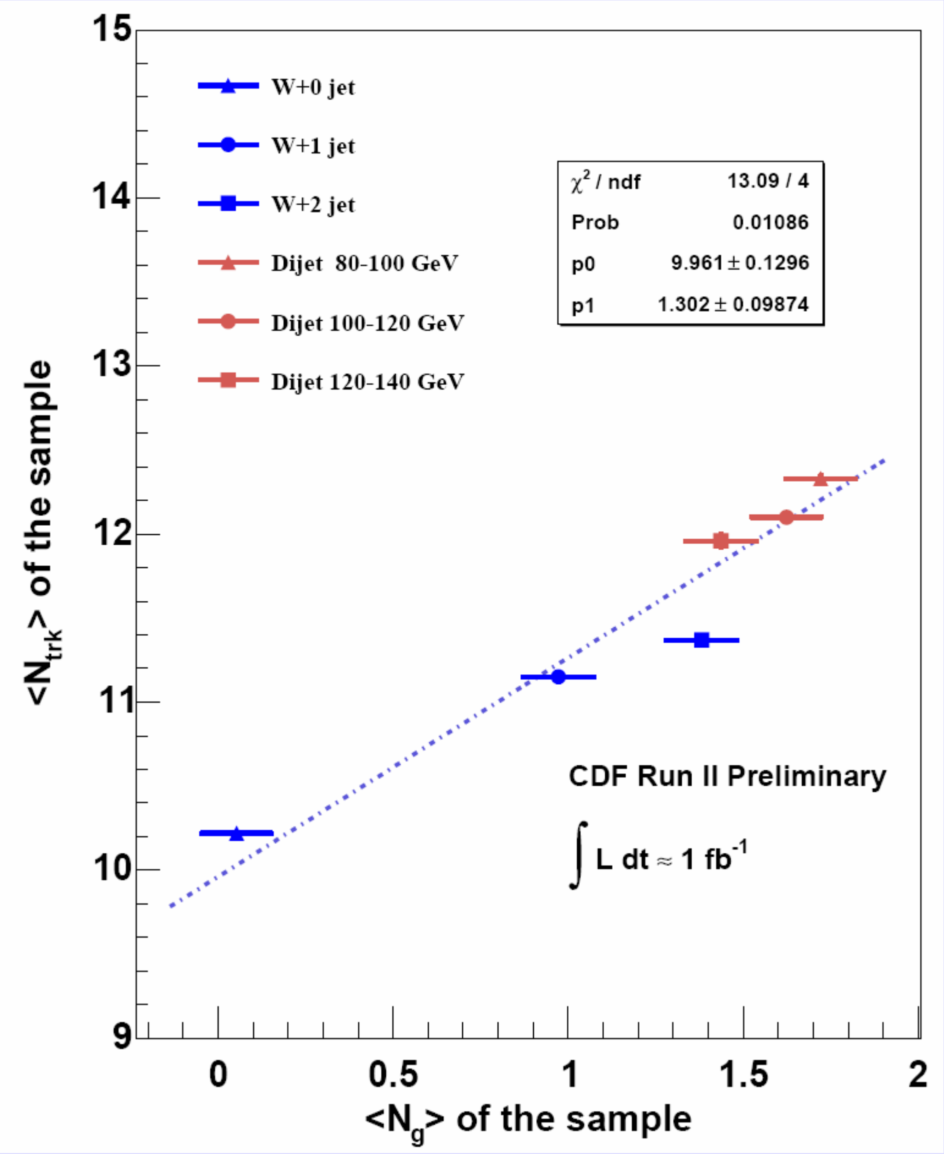
0d L5 selection compared to 0d+0h+0i L5 selection



Plots and Results to Bless…

Correlation between <N_g> and <N_{trk}>

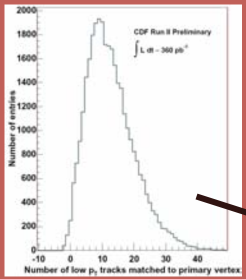
Sample	MC <N_g>	Data <N_{trk}>
W+0 jet	0.05 ±0.10	10.22±0.01
W+1 jet	0.97 ±0.10	11.15 ±0.03
W+2 jets	1.38 ±0.10	11.37 ±0.07
80-100 GeV	1.72 ±0.10	12.33 ±0.02
100-120 GeV	1.62 ±0.10	12.10 ±0.02
120-140 GeV	1.44 ±0.10	11.96 ±0.04



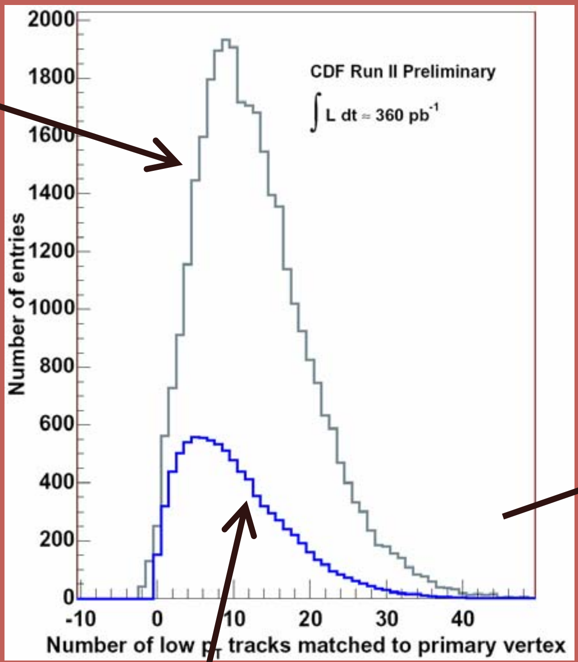
using the fit to find $<N_g>$ for other samples $<N_{trk}>$

Sample	MC prediction	Fit result
140-160 GeV	1.26 ±0.04	1.41+0.07-0.04
160-180 GeV	1.13 ±0.04	1.25+0.06-0.05
180-200 GeV	0.99 ±0.07	1.11+0.05-0.06
200-220 GeV	0.92 ±0.10	0.91+0.04-0.08
220+ GeV	0.67 ±0.10	0.68+0.04-0.10

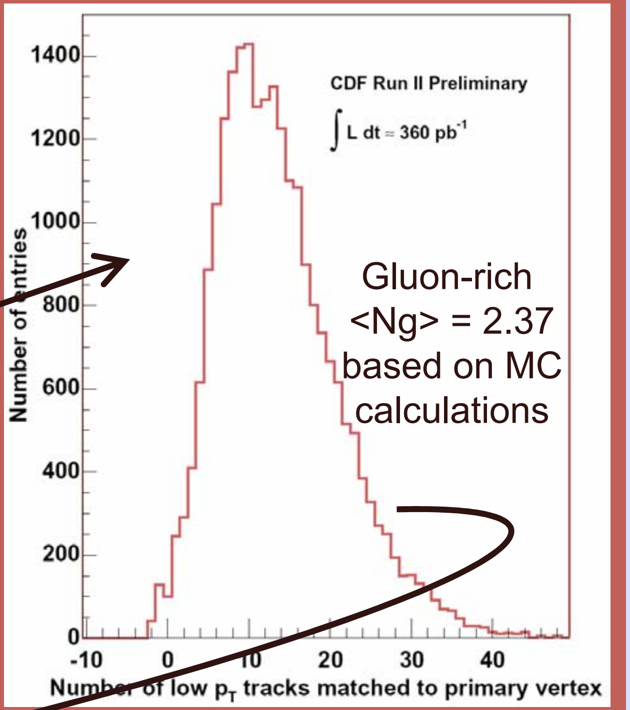
Gluon rich and 0-gluon distributions



DATA
dijet 80-100 GeV
Based on MC
27% qq → qq
<Ng> = 2.37
for the rest

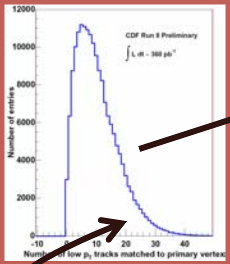


Subtract



Gluon-rich
<Ng> = 2.37
based on MC
calculations

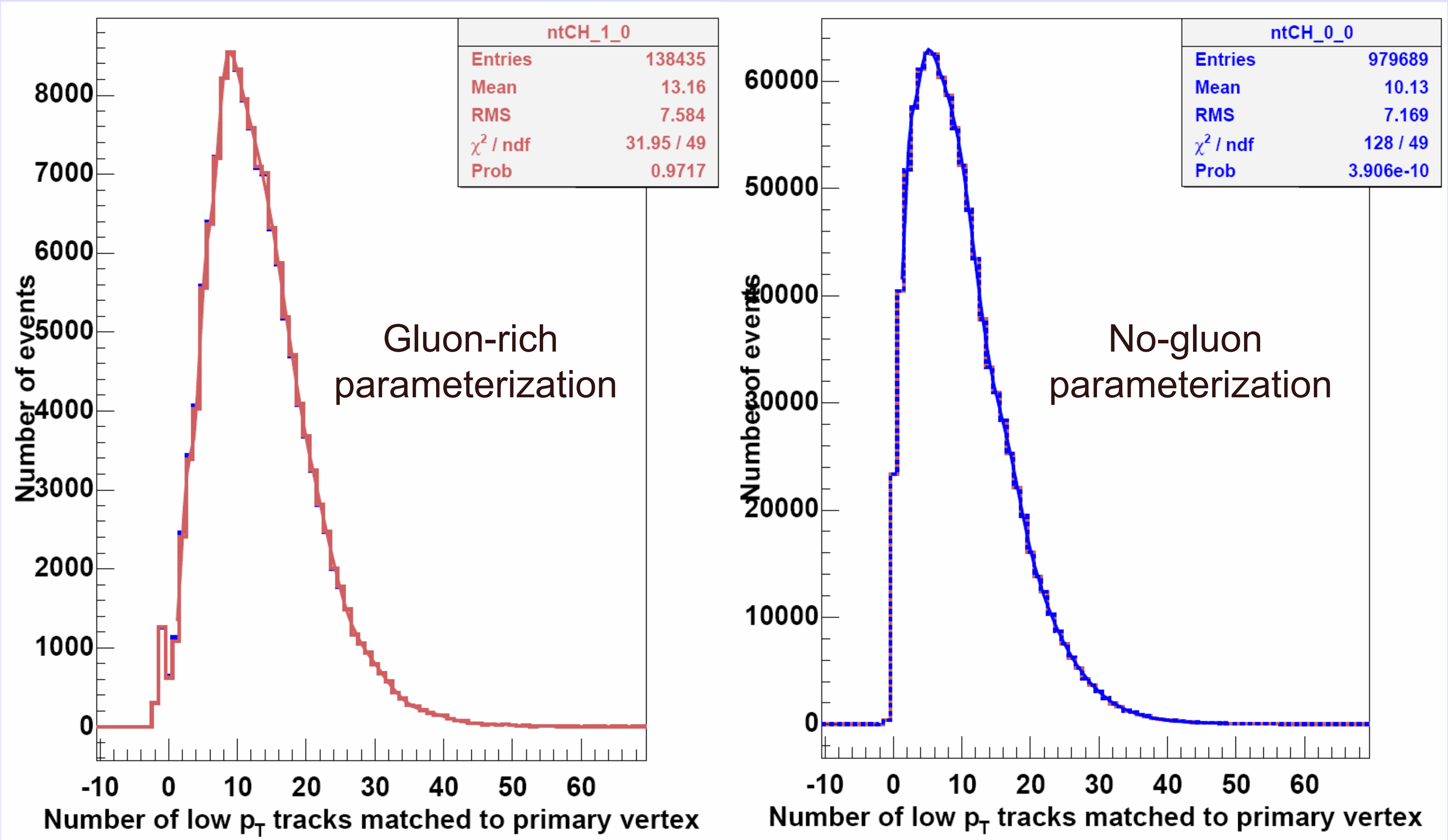
DATA
W+0 jet
Similar to
qq → qq



Normalized to dijet
80-100 GeV
Scaled by 0.27 to
represent qq → qq

Iterate to subtract gluon contributions
from W+0 jet data distribution

Parameterization



Fit and MC values for different calibration samples

Sample	f_g *from the fit*	MC prediction
80-100 GeV	0.733 ± 0.004	0.73 ±0.02
100-120 GeV	0.685 ± 0.006	0.69 ±0.02
120-140 GeV	0.655 ± 0.010	0.63 ±0.03
140-160 GeV	0.621 ± 0.005	0.57 ±0.03
160-180 GeV	0.565 ± 0.005	0.52 ±0.03
180+ GeV	0.481 ± 0.005	0.42 ±0.05

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 $f_g^{bkg} = 0.46 + 0.06 - 0.08$

- 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

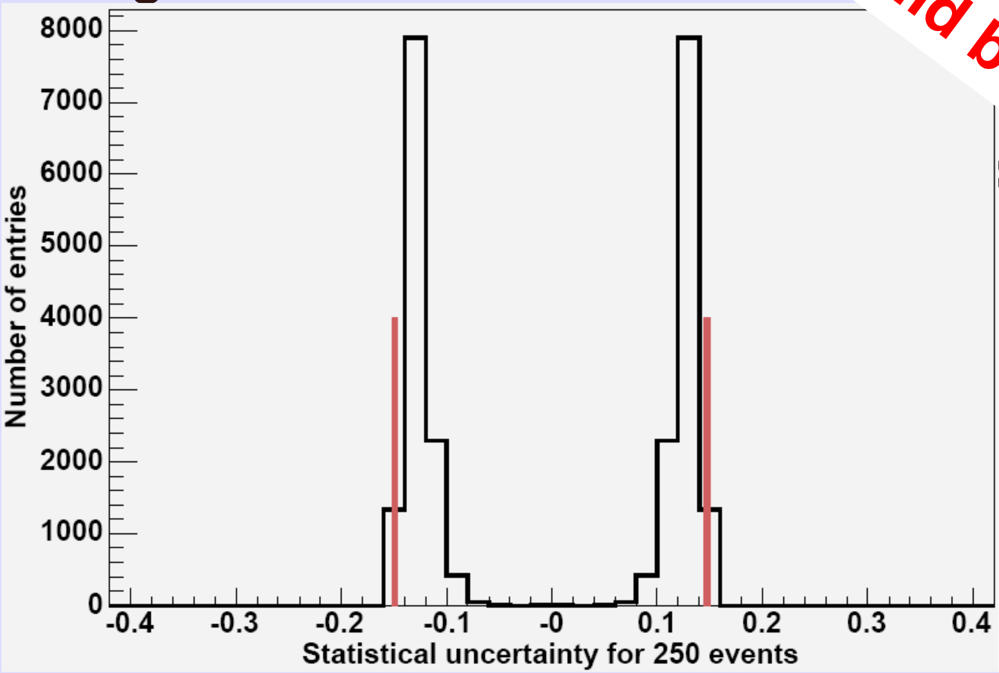
gg and qq to ttbar Acceptance

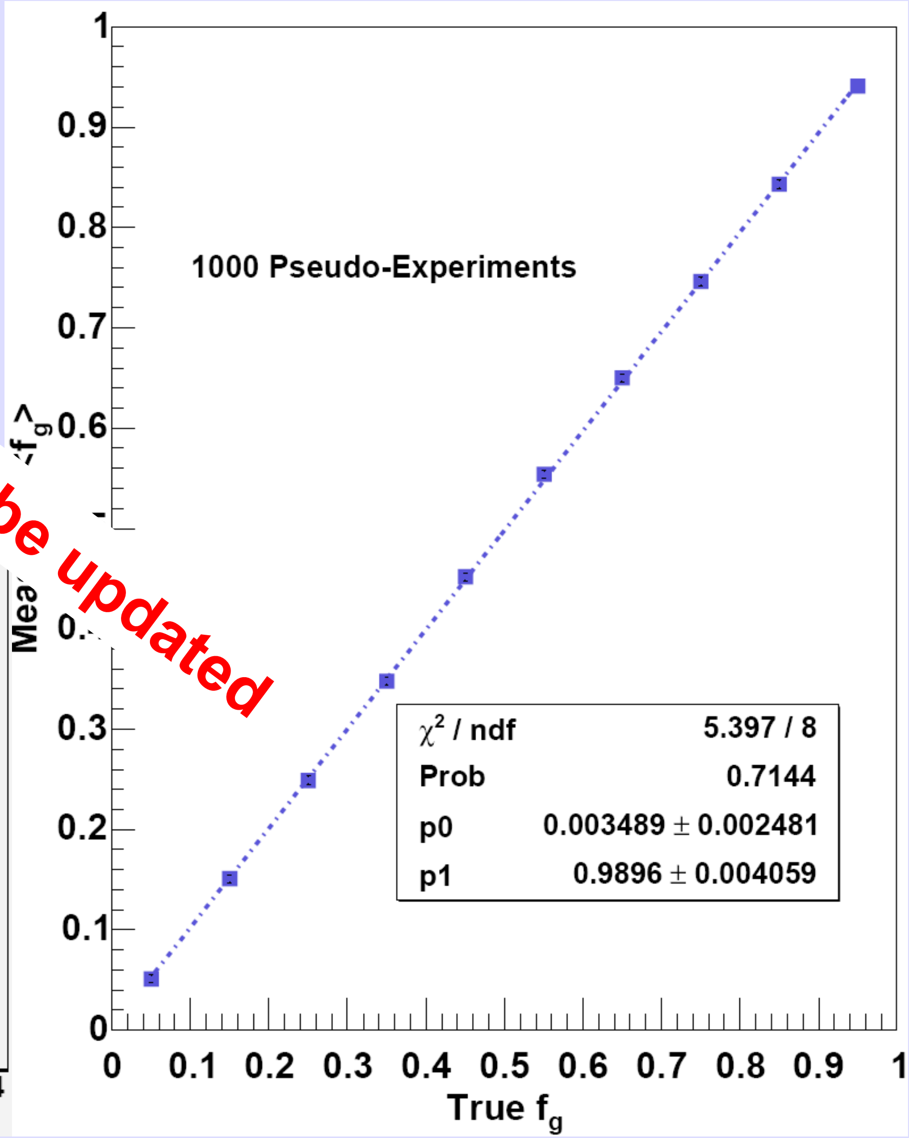
	$gg \rightarrow tt$, ≥4 jets	$qq \rightarrow tt$, ≥4 jets
A_{tagged}	0.0994 ±0.0013	0.0878 ±0.0003

Used ttop75 PYTHIA MC Sample

Pseudo-experiments

- Perform 1000 pseudo-experiments with 250 events, using the parameterizations to generate the track multiplicity distributions for different true gluon-rich fractions





L5, Should be updated

Systematic uncertainties-I

L5, Should be updated

- Uncertainties affecting track multiplicity
  - ✓ Change the central values and observe the changes in relevant variables

	f_g	f_g^{bkg}
Track/jet correction	±0.052	±0.015
Low jet E_T cut	±0.012	±0.034
Dijet qq→qq fraction	±0.004	±0.025
W+0 jet f_g	±0.034	±0.005
Total	±0.06	±0.042*

*This should be combined with ±0.08 uncertainty from f_g^{bkg} calculation described on slide 20

Systematic uncertainties-II

- Uncertainties due to f_g, f_g^{bkg} and f_b

L5, Should be updated

	f_g^{tt}
f_g	±0.07
f_g^{bkg}	±0.01
f_b	±0.01
Total	±0.07

Systematic uncertainties-III

- Uncertainties due to f_g^{tt} and acceptances

L5, Should be updated

	$\sigma(gg\rightarrow tt)/\sigma(pp\rightarrow tt)$
f_g^{tt}	±0.06
$\mathcal{A}_{gg\rightarrow tt}$	±0.002
$\mathcal{A}_{qq\rightarrow tt}$	±0.002
Total	±0.06

Result

- Using the values we found, and a background fraction of (13 ± 2)%, we get

$$f_g^{tt} = 0.02 \pm 0.17(stat) \pm ?(syst)$$

- And using a ttbar acceptance of 0.0994 ± 0.0013 and 0.0878 ± 0.0003 for gg fusion and qqbar respectively, we find

$$\frac{\sigma(gg \to t\bar{t})}{\sigma(p\bar{p} \to t\bar{t})} = 0.02 \pm 0.15(stat) \pm ?(syst)$$