Measurement of the relative fraction of the gg fusion in $t\bar{t}$ production process at 1.96 TeV $p\bar{p}$ collisions using CDF

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for the CDF Collaborations

Rencontres de Moriond EW 2009

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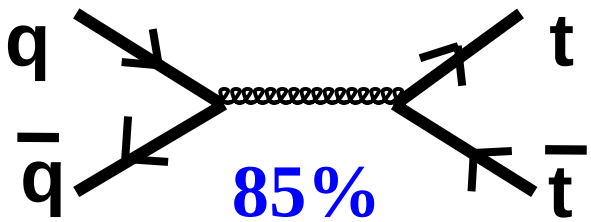
Motivation

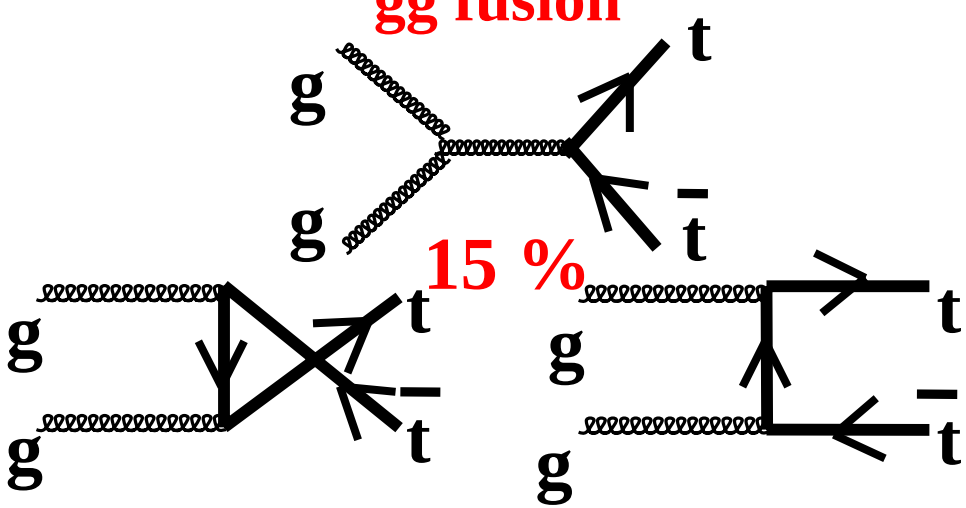
The $t\bar{t}$ production processes in 1.96 TeV $p\bar{p}$ colisions

$q\bar{q}$ annihilation



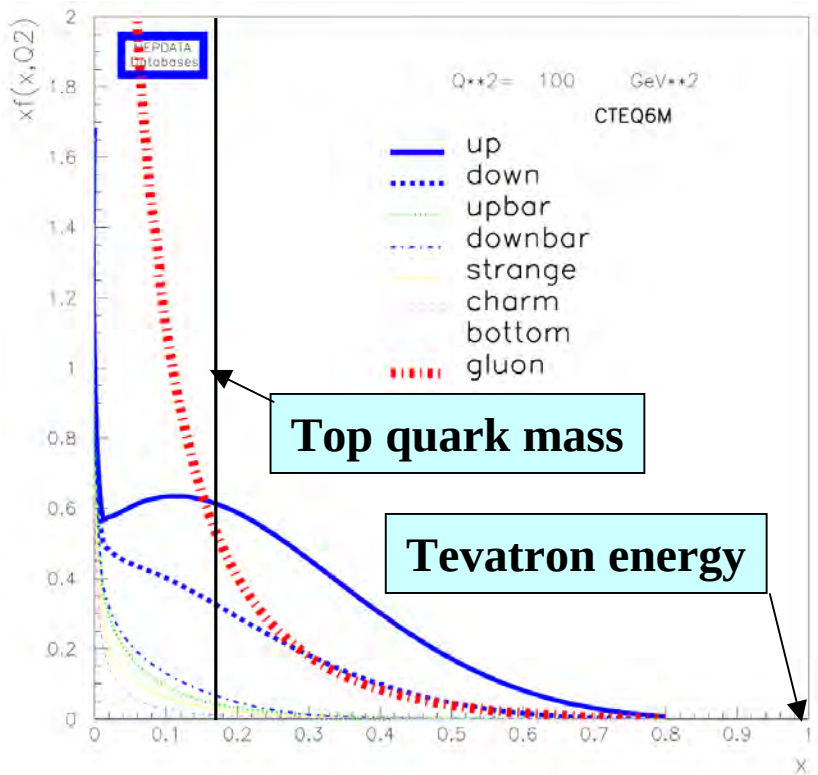
85%

gg fusion



15 %

Parton distribution function

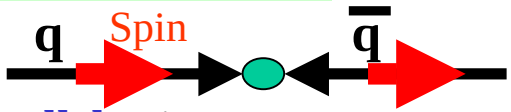


We are going to measure this ratio in experimentally to verify the perturbative QCD calculation and search for new physics.

Analysis methodology

• $q\bar{q} \rightarrow t\bar{t}$ and $gg \rightarrow t\bar{t}$ have different spin configuration

$q\bar{q}$ annihilation

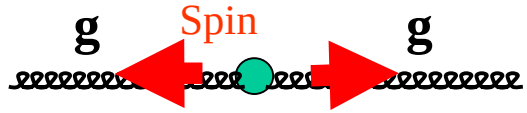


parallel spin state

J = 1 Jz = ±1

At threshold ttbar production

gg fusion



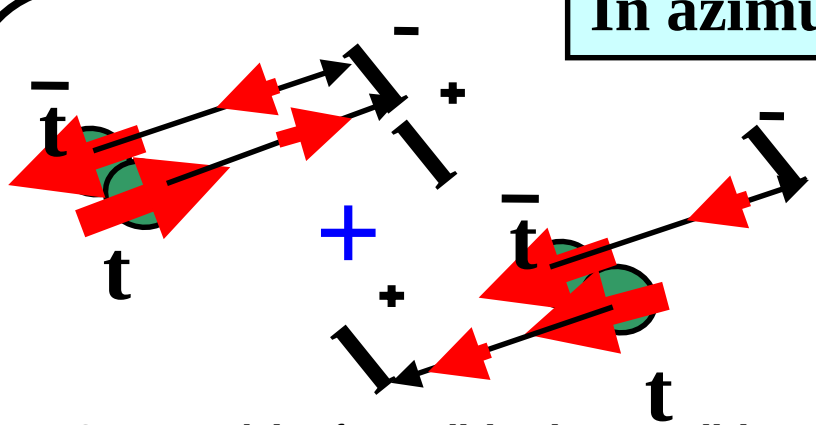
anti-parallel spin state

J = 0 Jz = 0

• **top quark is the only quark that we can use spin correlation. Top quark decay before hadronization.**

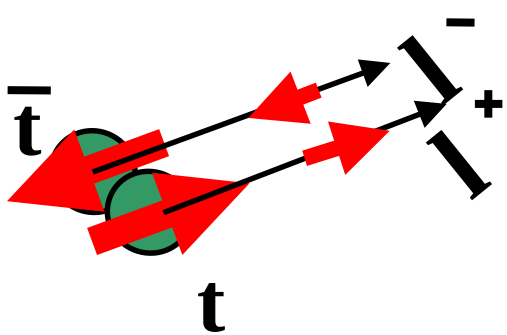
•**We measure the gg fusion fraction using the distribution of the azimuthal angle between l^+ and l^- ($\Delta\phi$) in top dilepton channel ($t\bar{t}$ -> WbWb - >lvlvbb).**

In azimuthal plane



Same possibility for parallel and anti-parallel

no correlation in flight direction between l^+ and l^-

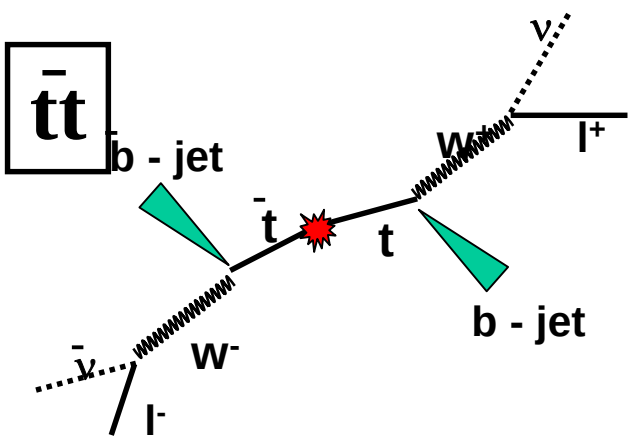


t̄/t spin is in anti-parallel

same flight direction of l^+ and l^- is favored

Event Selection

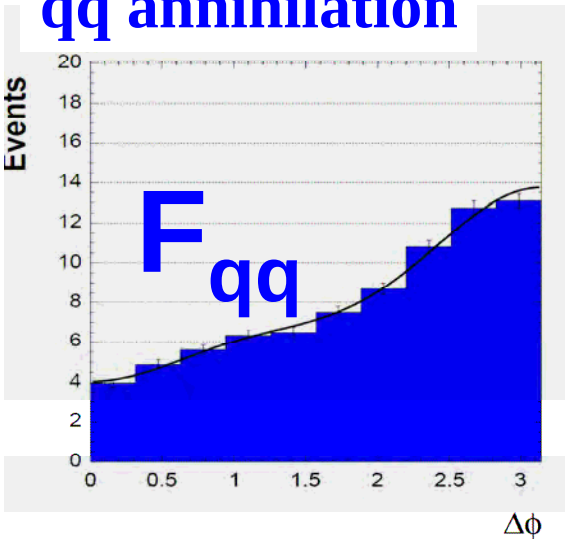
- **Signal selection:**
  - **2 leptons with E_T>20 GeV**
  - **At least 2 tight jets with E_T>15 GeV, |Eta|<2.5**
  - **MET>25 GeV**
- **Background rejection:**
  - **L-cut (MET>50 GeV if the minimum angle between MET and any lepton or jet is less than 20^0)**
  - **Z-veto**
  - **H_T>200 GeV**
  - **Oppositely charged leptons**



Process	Number of expected events
WW	6.81 ± 1.17
WZ	1.59 ± 0.26
ZZ	1.09 ± 0.85
$W\gamma$	0.17 ± 0.18
Drell-Yan($Z \rightarrow ee, \mu\mu$)	12.78 ± 2.17
$Z \rightarrow \tau\tau$	5.26 ± 1.02
Fakes	21.75 ± 6.33
Total background	49.45 ± 7.83
$t\bar{t}(\sigma = 6.7$ pb)	93.86 ± 7.14
Total SM expectation	143.31 ± 13.09
Data (2.0 fb^{-1})	145

Δϕ distribution of leptons

$q\bar{q}$ annihilation



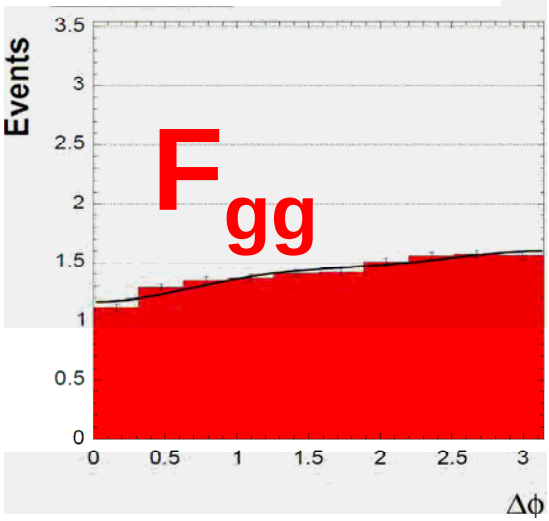
We make the Δϕ distribution of leptons using Monte Carlo simulation. And we could find different distribution between qq annihilation and gg fusion ttbar production processes.

After all check, we perform unbinned likelihood fit to data as a function of gg fraction using following function.

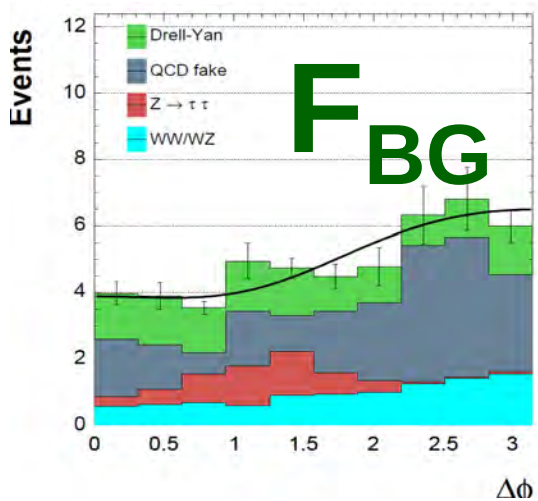
$$F(\Delta\varphi)_{all} = (f_{gg}\, F(\Delta\varphi)_{gg} + (1-f_{gg})\, F(\Delta\varphi)_{qq}) \times f_{sig} + F(\Delta\varphi)_{bg} \times (1-f_{sig})$$

$$L = \Pi F_{all}$$

gg fusion



background



Results and Summary

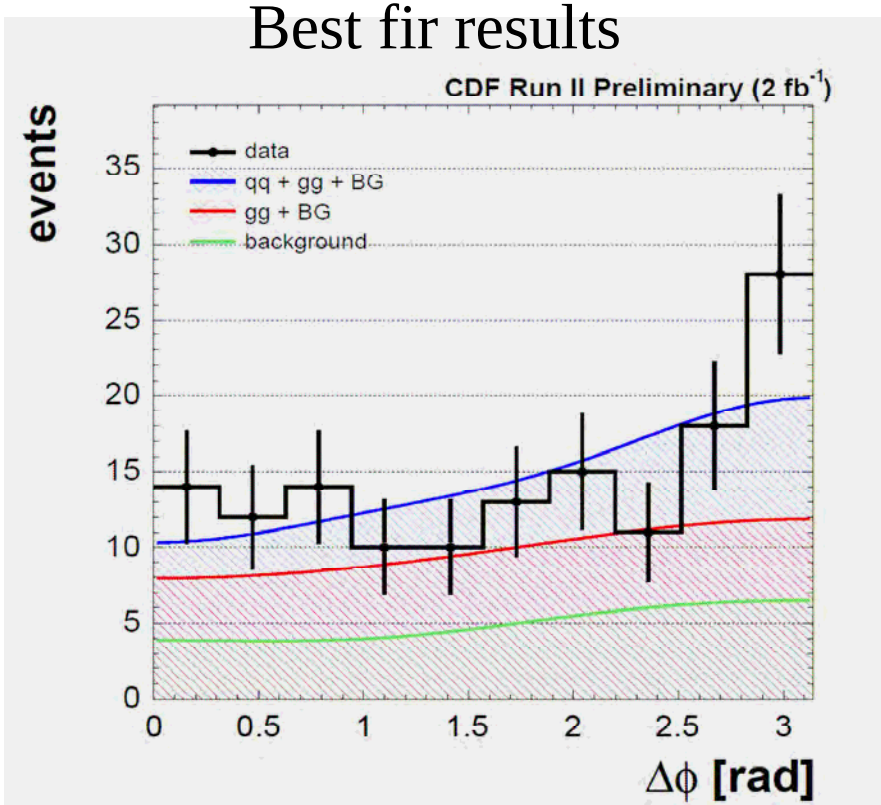
- **We presented a measurement of gg fraction in ttbar production using dilepton channel spin correlation.**

$$F_{gg} = 0.53\ ^{+0.36}_{-0.38}\ \left(\ ^{+0.35}_{-0.37}\ (Stat.)\ ^{+0.07}_{-0.08}\ (Syst.)\right)$$

Standard Model Prediction

$$F_{gg} = 0.15 \pm 0.05$$

Best fir results



- **The results is consistent with Standard Model prediction.**
- **Tevatron keep running and we improving our analyses, we are aiming at the about 10% uncertainty finally.**
  - four times data from Tevarton
  - combine other channel and method
  - multi validate analysis

Backup

Analysis methodology (cont.)

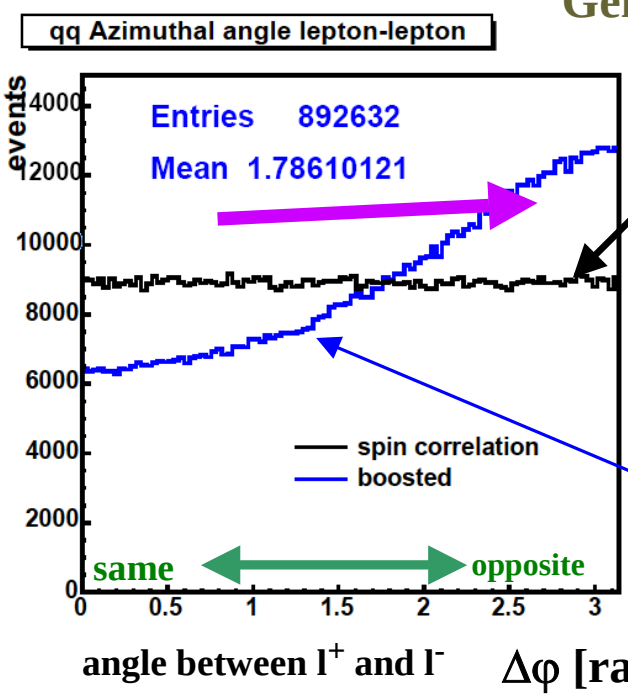
In actual $p\bar{p}$ collisions, $t/\bar{t}$ are produced with $p_T > 0$

Enhance opposite flight directions of l^+ and l^-

In $q\bar{q}$ annihilation

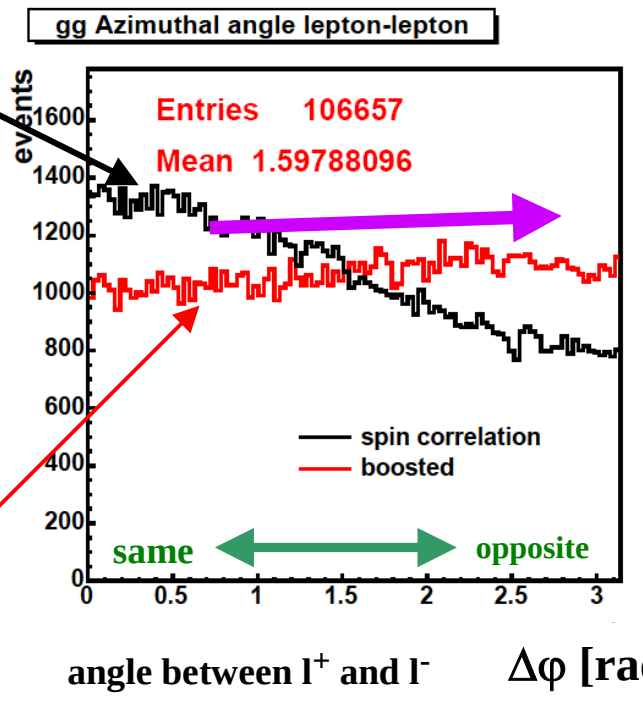
In gg fusion

Generator level (HERWIG)



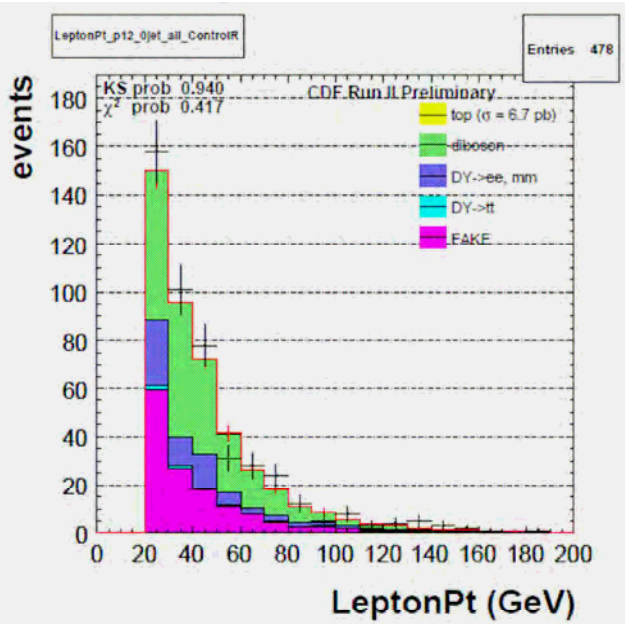
Without t and tbar Pt effect

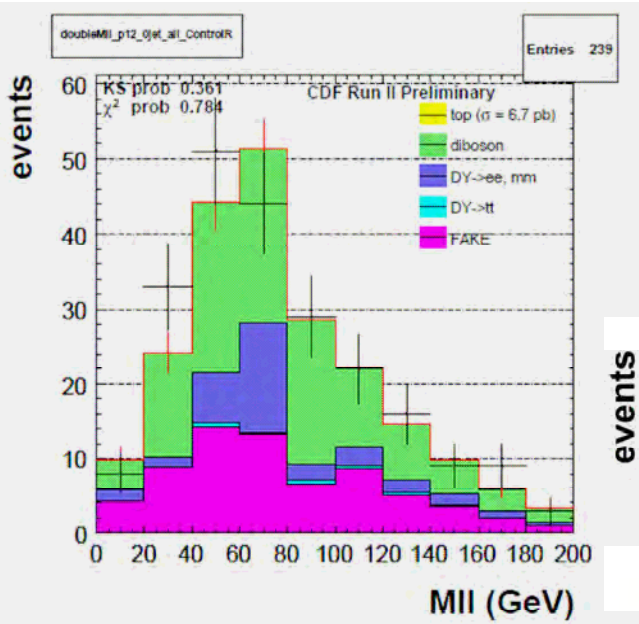
$t\bar{t}$ product in actual collisions

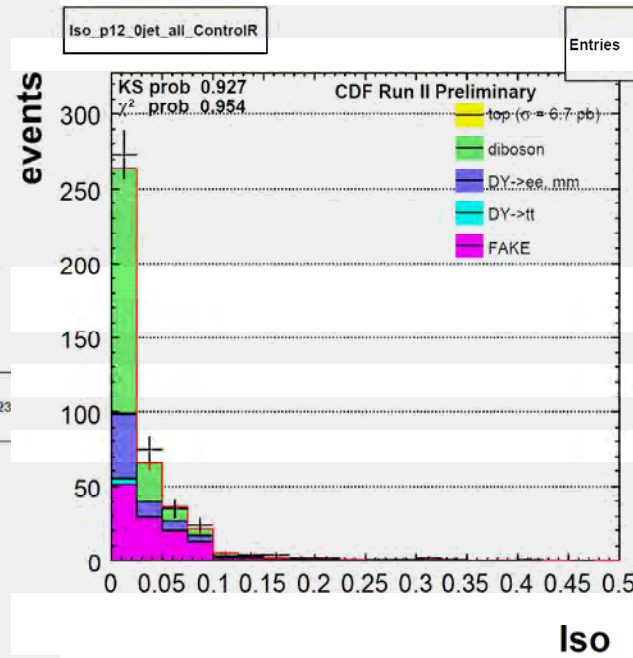


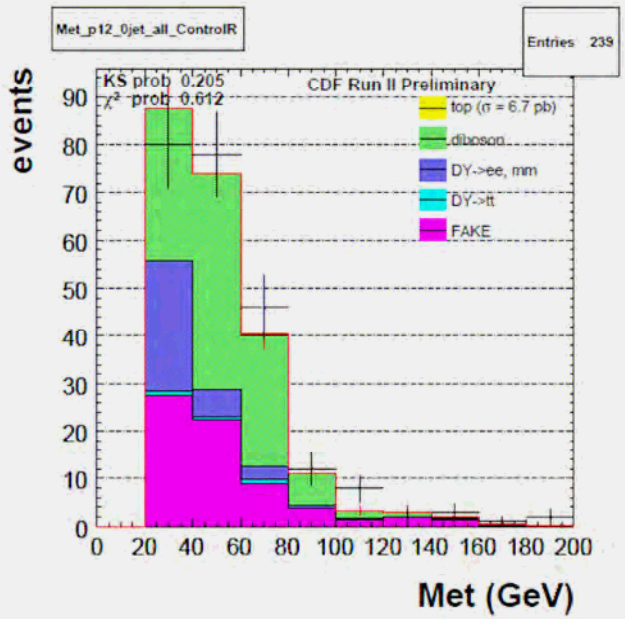
The qq fraction can be determined with $\Delta\varphi$ distribution

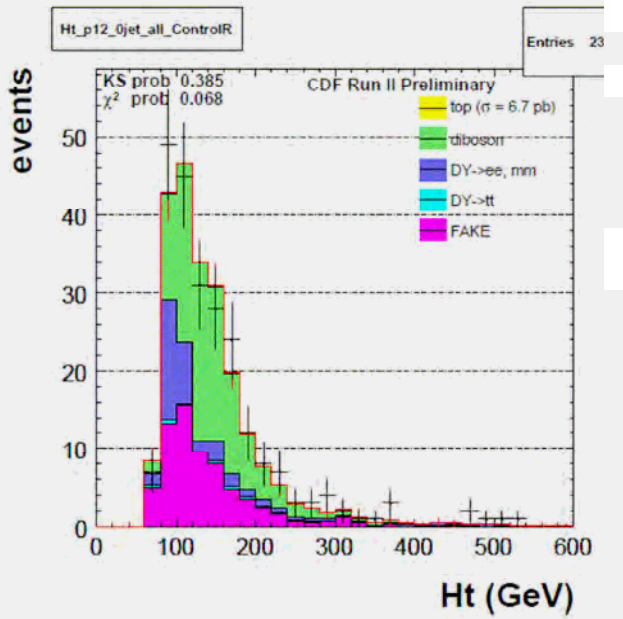
0 jet control region







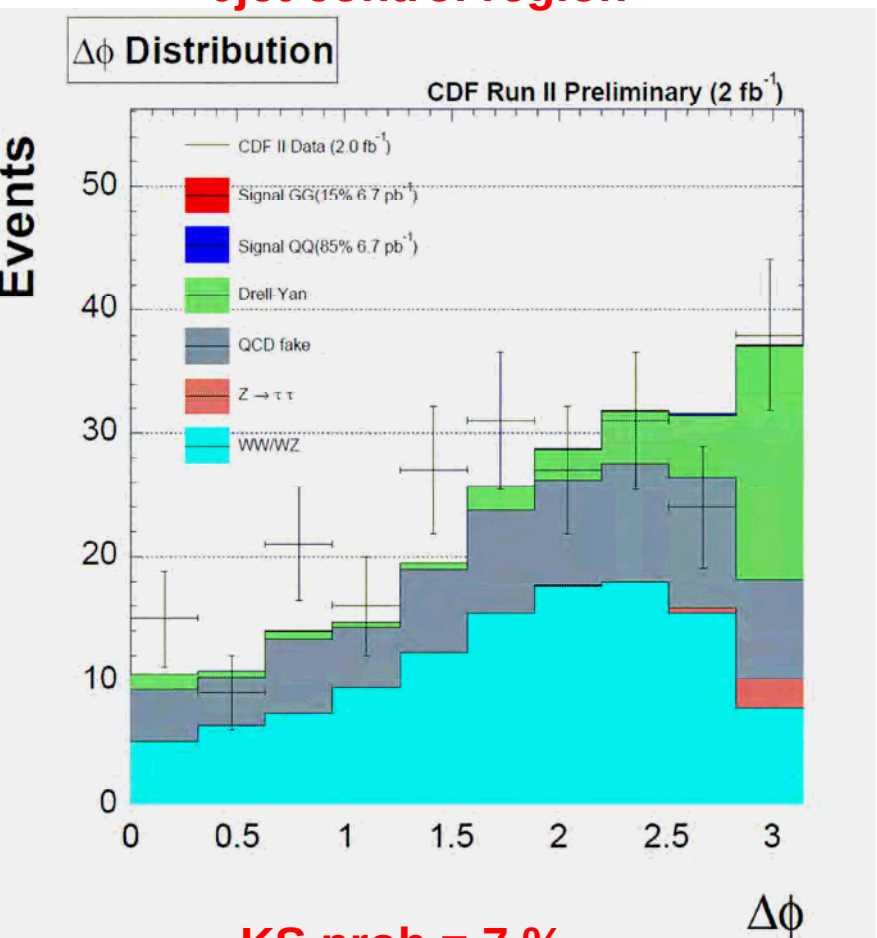




Background distribution check using 0jet and 1jet control region

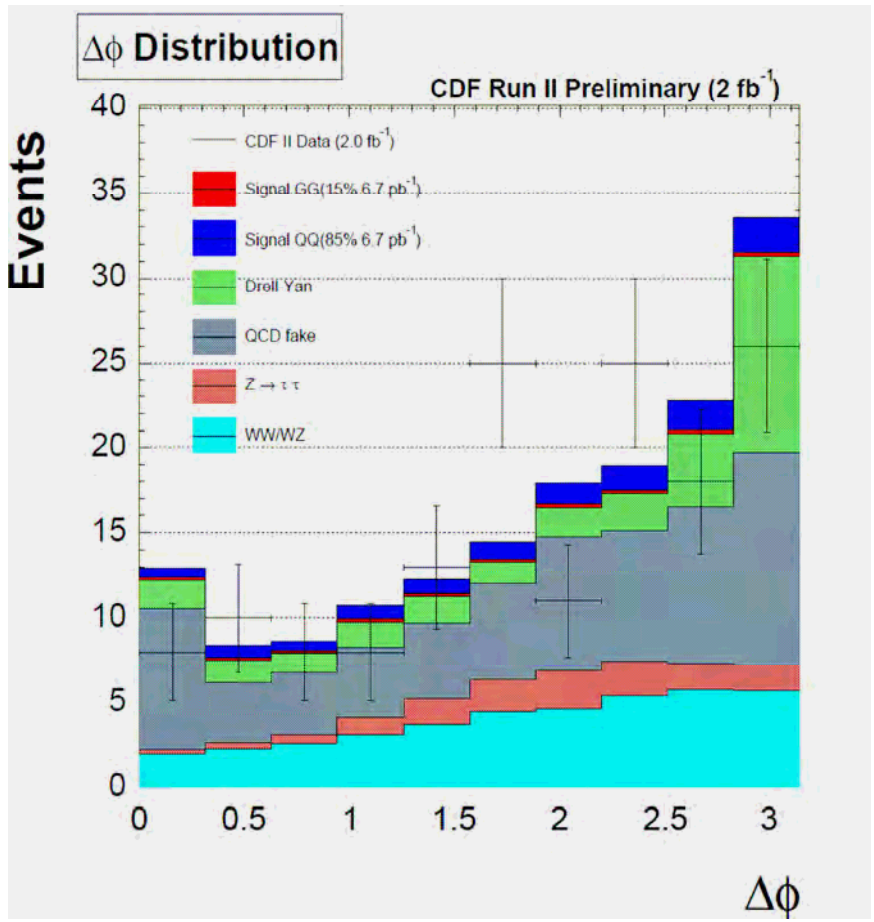
Before HT and Opposite Sign lepton cut

0jet control region



KS prob = 7 %

1jet control region



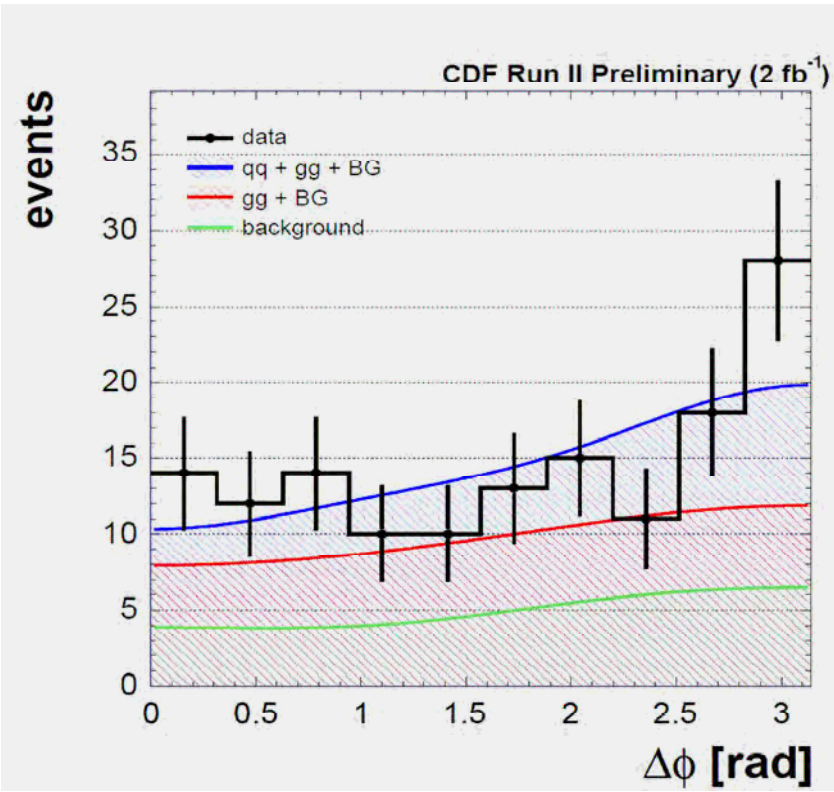
KS prob = 37 %

Summary of uncertainty

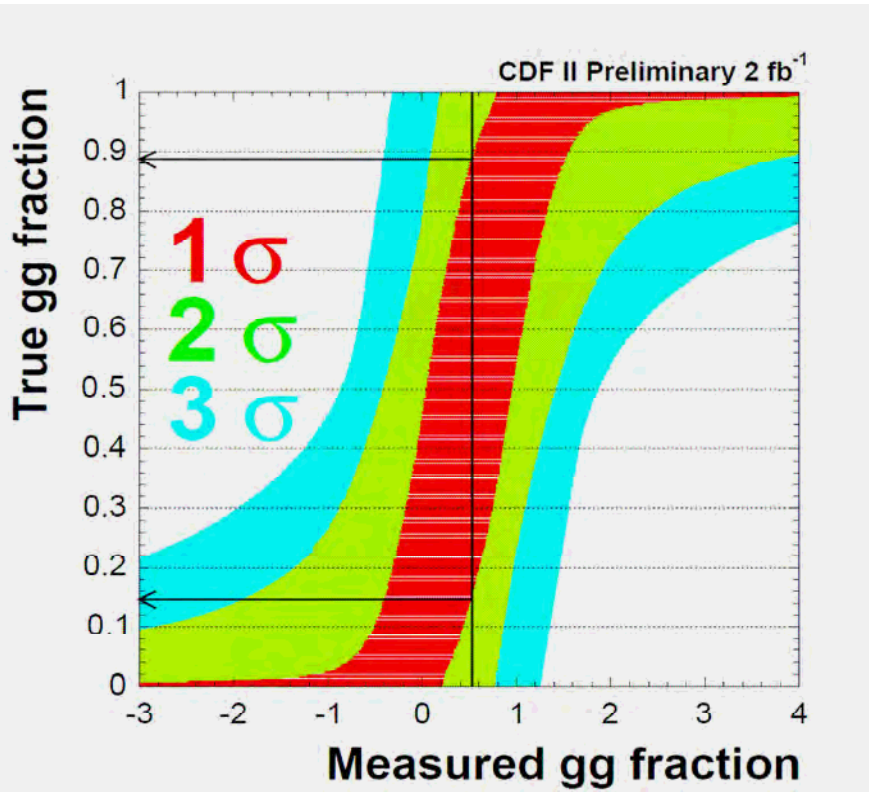
Source	Positive Uncertainty in $\mathcal{F}_{gg}^{\text{measured}}$	Negative Uncertainty in $\mathcal{F}_{gg}^{\text{measured}}$
Statistics	0.448	0.448
$\Delta\phi$ template and		
Expected number of bkg	0.049	0.049
$A_{gg}/A_{q\bar{q}}$	0.014	0.014
Estimation method		
of Systematic	0.020	0.020
Other	0.03	0.03
(top P_t PYTHIA vs HERWIG)		
	if Positive value	if Negative value
NLO matrix element	$0.032 \times F_{gg}^2 + 0.080 \times F_{gg} - 0.008$	$0.032 \times F_{gg}^2 + 0.080 \times F_{gg} - 0.008$
PDF	$0.068 \times F_{gg}^2 - 0.009 \times F_{gg} + 0.027$	$-0.046 \times F_{gg}^2 + 0.009 \times F_{gg} - 0.040$
	$\pm$ half of the largest	
ISRFSR more	$-0.054 \times F_{gg}^2 - 0.067 \times F_{gg} + 0.049$	$-0.054 \times F_{gg}^2 - 0.067 \times F_{gg} + 0.049$
ISRFSR less	$-0.004 \times F_{gg}^2 - 0.061 \times F_{gg} + 0.098$	$-0.004 \times F_{gg}^2 - 0.061 \times F_{gg} + 0.098$

Results

Data Fitting



Feldman-Cousins Bands



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