THE UNIVERSITY OF CHICAGO

Top quark properties at CDF

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On behalf of the CDF collaboration

Why we study Top properties?

- Top quark lifetime is short
  - Decaying before hadronizing
  - Studying bare quark
- Fundamental question
  - Why top quark is so heavy? Is it related with EWSB?
  - Is it SM top or mimic with non-SM top like particles?
  - Is it decaying to non-SM particles or non-allowed final states from SM?
- However it's still little known particle
- Top quark is an ideal place to study new physics

Study of top properties at CDF

95% CL upper limit on BR:90<H^+<150GeV

BR(t→Zq) < 3.7% at 95% CL

W helicity : F_0=0.62±0.11 & F_+=-0.04±0.05

Spin correlation

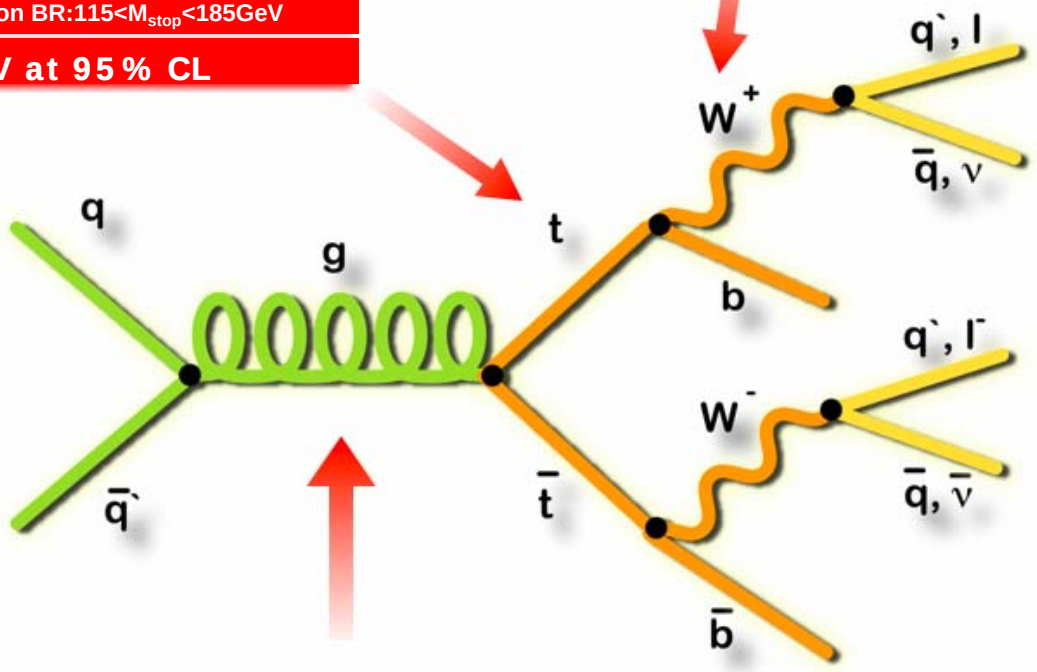
$M_t = 172.6 \pm 0.9_{stat} \pm 1.2_{sys}$ GeV/c^2

Γ_t < 13.1 GeV at 95% CL

Exclude q = -4/3 at 87% CL

95% CL upper limit on BR:115<M_{stop}<185GeV

M_t' <311 GeV at 95% CL



$\sigma_{l+jets} = 6.9 \pm 0.4_{stat} \pm 0.4_{sys} \pm 0.1_{z\text{-}theory}$ pb

$\sigma_{dil} = 6.7 \pm 0.8_{stat} \pm 0.4_{sys} \pm 0.1_{lumi}$ pb

$\sigma_{all\text{-}jets} = 7.2 \pm 0.5_{stat} \pm 1.4_{sys} \pm 0.4_{lumi}$ pb

$F_{gg} = 0.07^{+0.15}_{-0.07}$ (stat+sys)

$A_{fb}^{lab} = 0.19 \pm 0.07_{stat} \pm 0.02_{sys}$

$M_{Z'} > 805$ GeV at 95% CL

Study of top properties at CDF

Costas's talk tomorrow

$M_t = 172.6 \pm 0.9_{stat} \pm 1.2_{sys}$ GeV/c^2

Γ_t < 13.1 GeV at 95% CL

Exclude q = -4/3 at 87% CL

95% CL upper limit on BR:115<M_{stop}<185GeV

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David's talk tomorrow

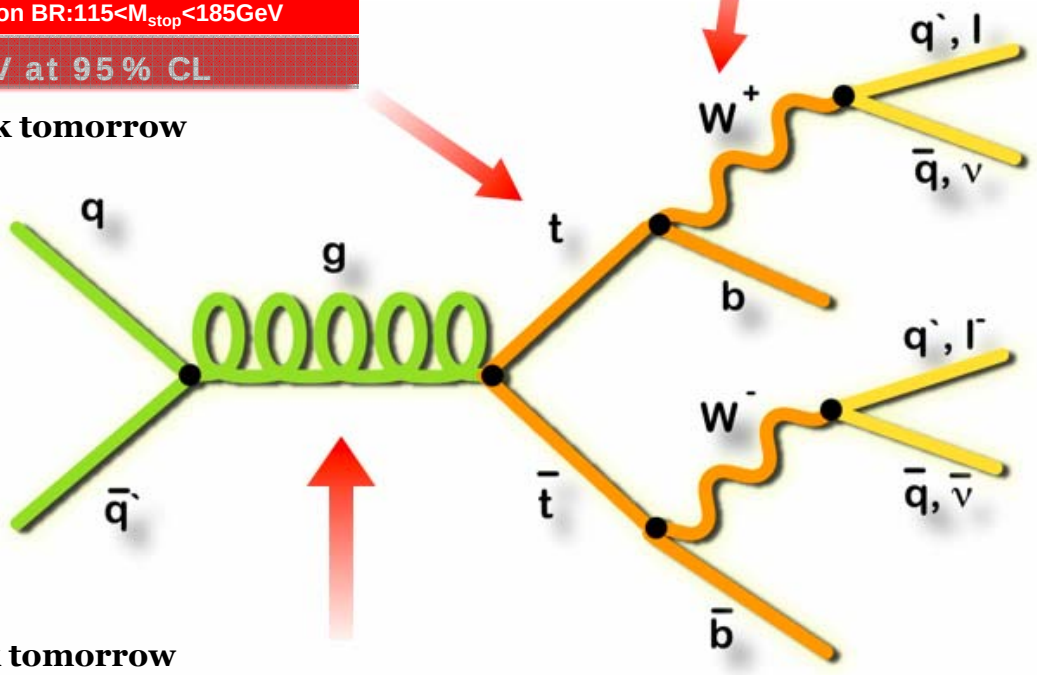
95% CL upper limit on BR:90<H^+<150GeV

BR(t→Zq) < 3.7% at 95% CL

W helicity : F_0=0.62±0.11 & F_+=-0.04±0.05

Spin correlation

Alexei's talk today



Tom's talk tomorrow

$\sigma_{l+jets} = 6.9 \pm 0.4_{stat} \pm 0.4_{sys} \pm 0.1_{z\text{-}theory}$ pb

$\sigma_{dil} = 6.7 \pm 0.8_{stat} \pm 0.4_{sys} \pm 0.1_{lumi}$ pb

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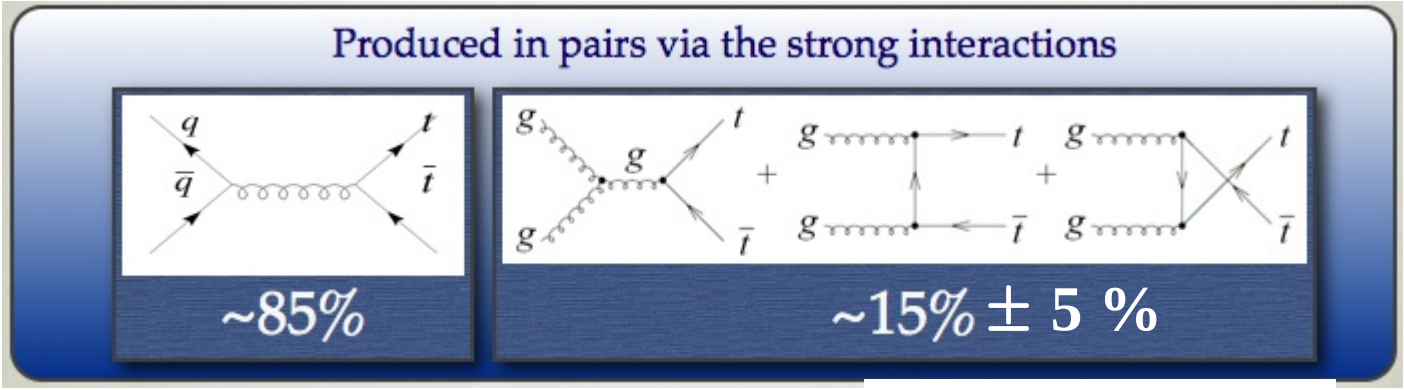
$M_{Z'}$ > 805 GeV at 95% CL

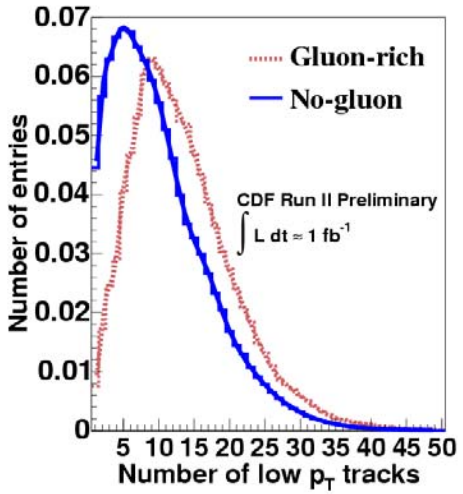
Glenn and Monica's talk today

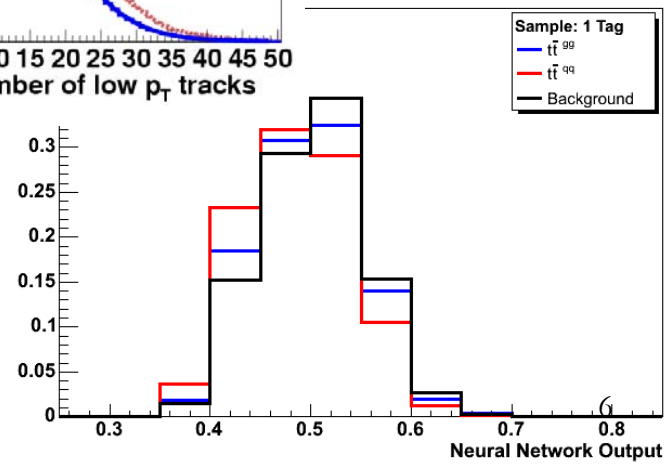
Production

Top production mechanism in lepton+jet (1 fb^{-1})



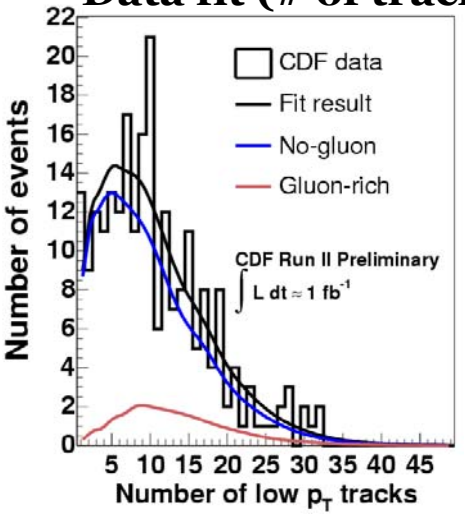
- Gluon radiate more gluon than quarks do
  - # of low pt charged track can be discriminant
- Various kinematic variable
  - Artificial neural net



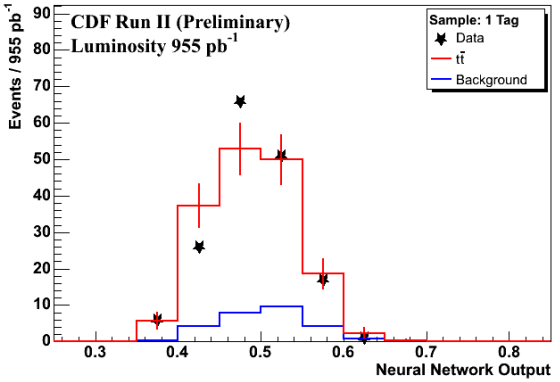


Top production mechanism in lepton+jet (1 fb^{-1})

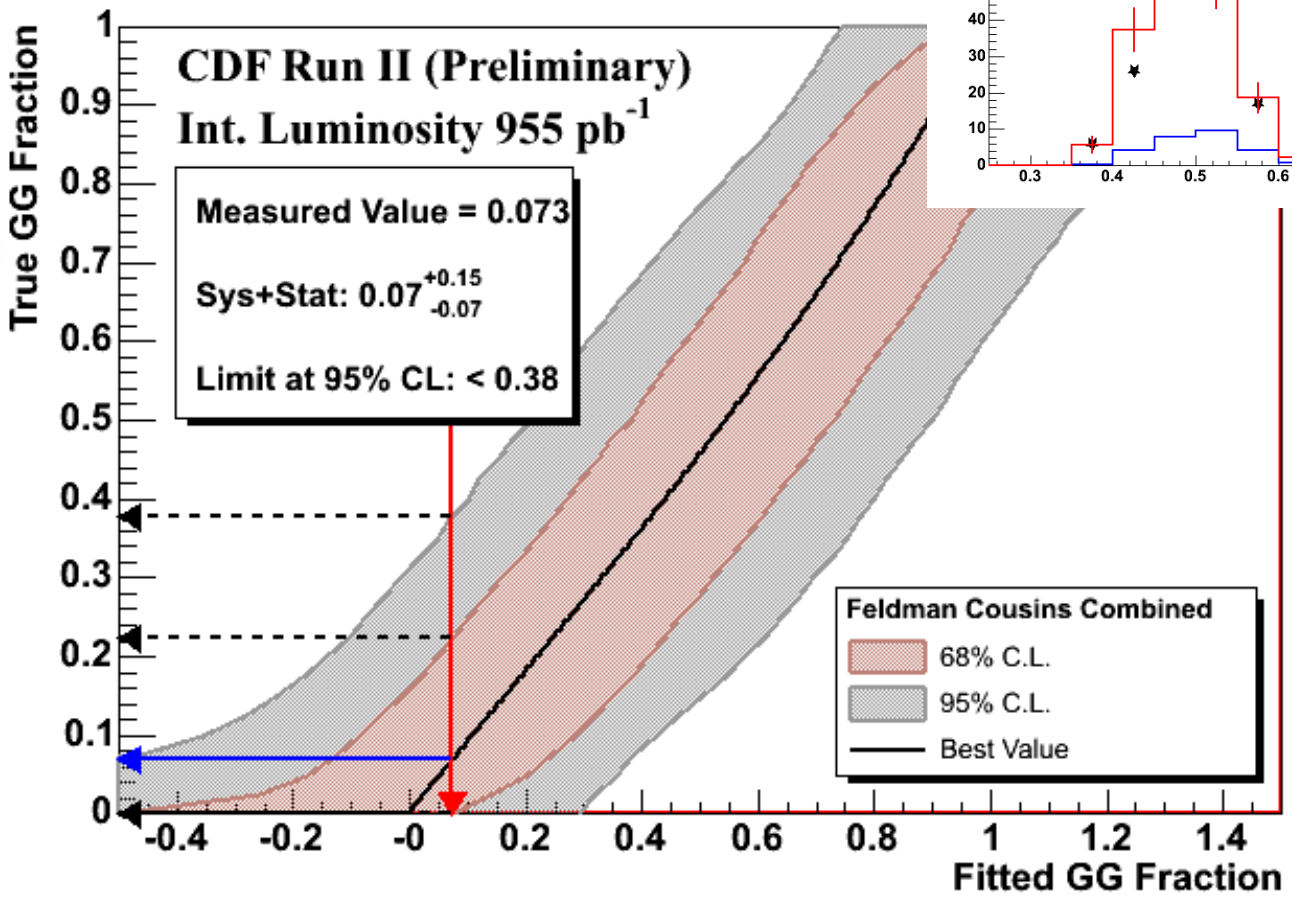
Data fit (# of track)



Data fit (Neural net)

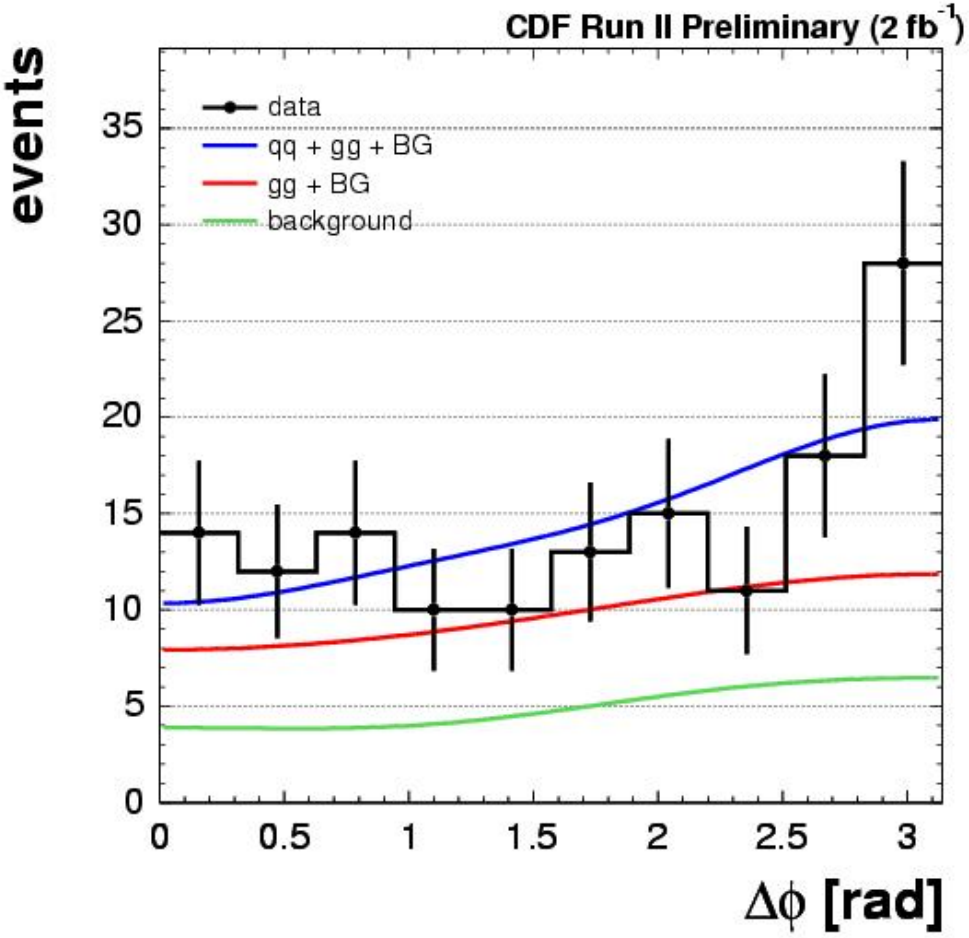


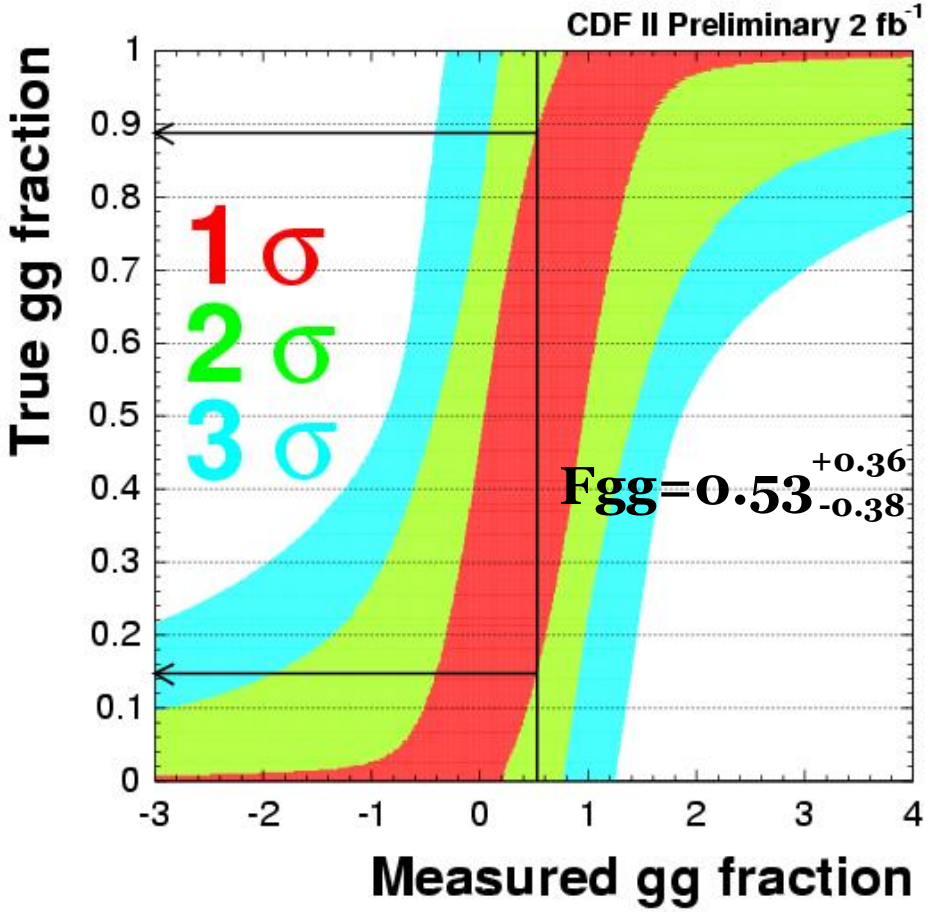
Combined result



Top production mechanism in dilepton channel (2 fb^{-1})

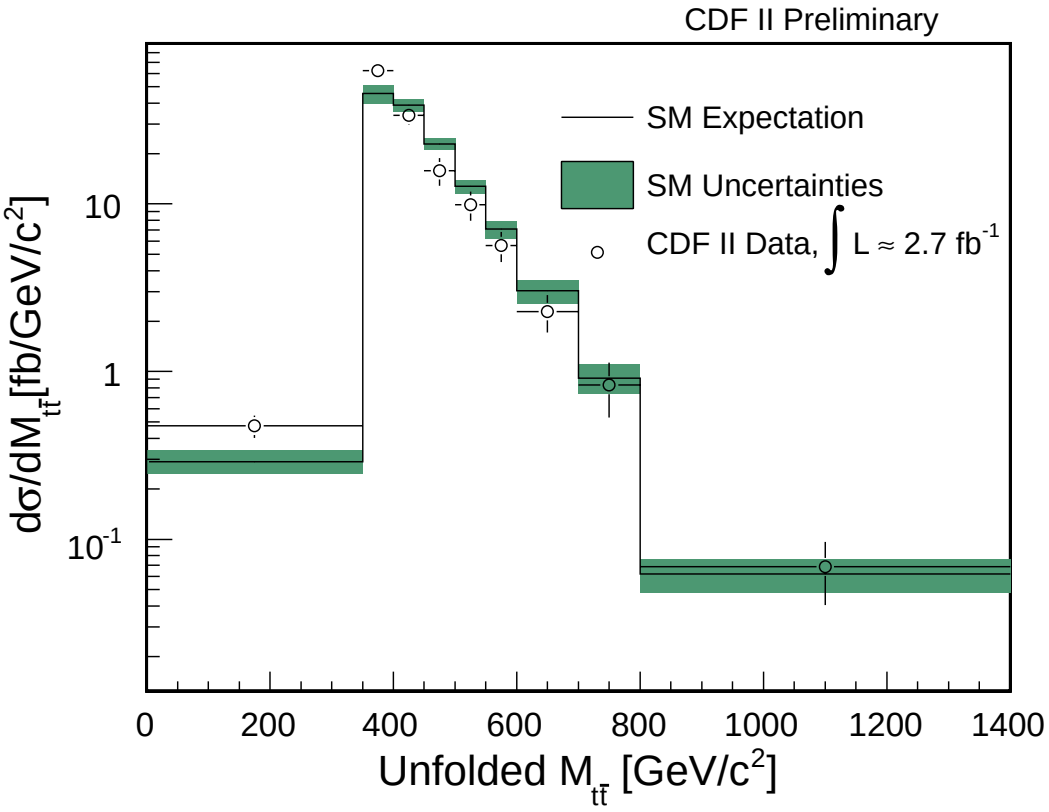
- Azimutal angle between charged lepton can be used as discriminant





$d\sigma/dm_{ttbar}$ in lepton+jet channel (2.7 fb^{-1})

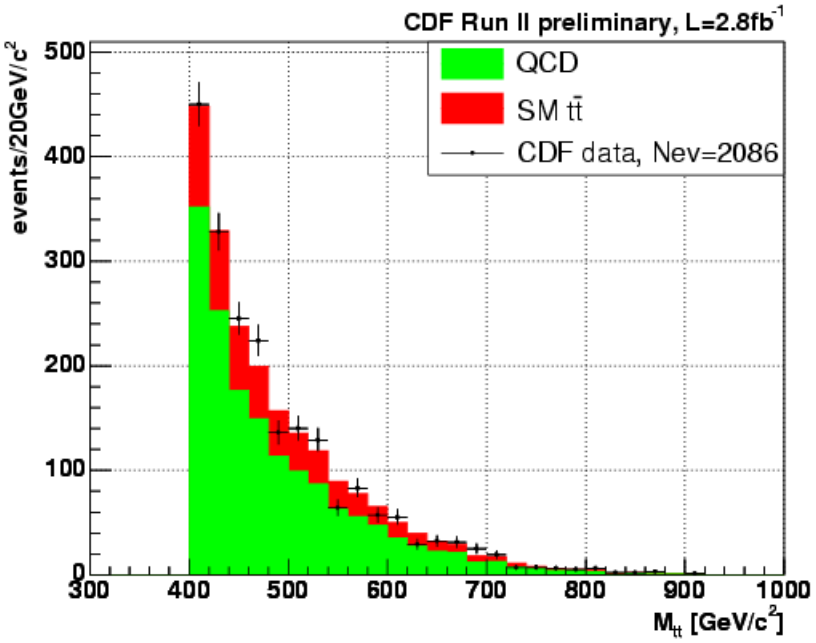
- $d\sigma/dm_{ttbar}$ is sensitive to a broad class of models
- In situ JES calibration significantly reduce dominant JES systematics

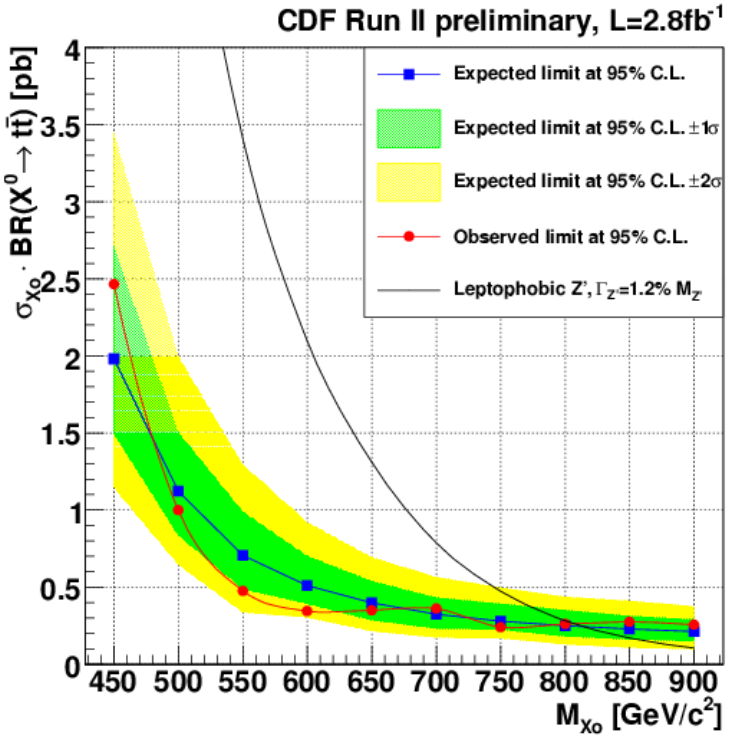


- No evidence of inconsistency with SM

M_{tt} resonance in all hadronic channel (2.8 fb^{-1})

- Various BSM theories predict resonance ttbar production from massive Z like boson





- Consistent with SM prediction
- Set a 95% CL limit of Z' = 805 GeV

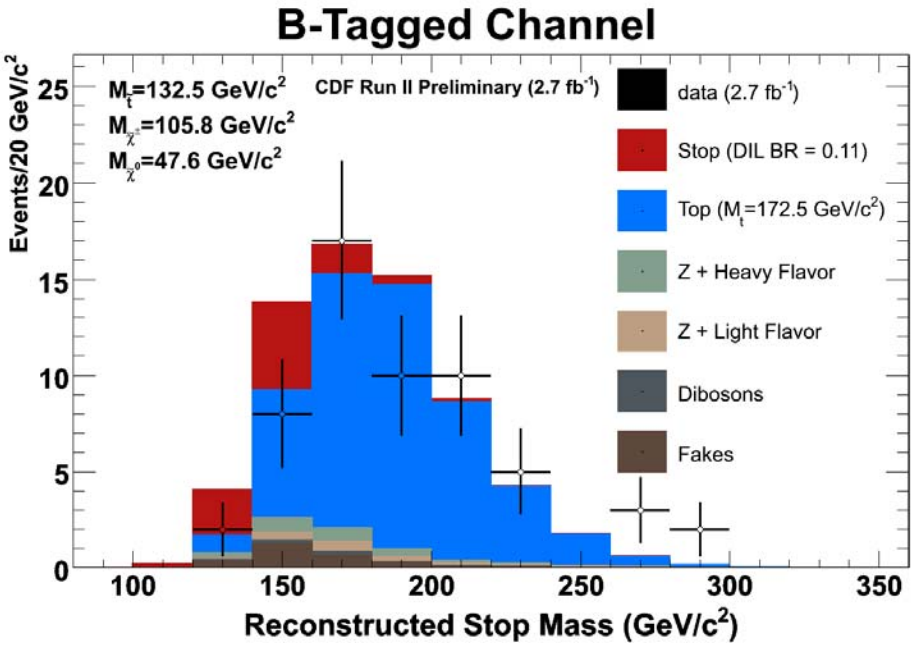
Top like particle

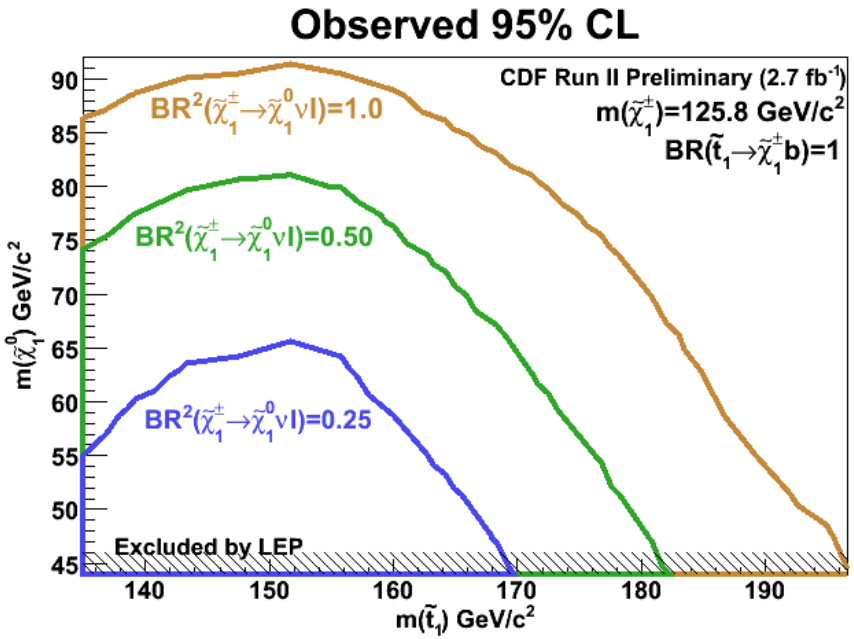
Stop search (2.7 fb^{-1})

- Similar signature with a top dilepton event

$$\tilde{t}_1\bar{\tilde{t}}_1 \rightarrow b\bar{b}\tilde{\chi}_1^+\tilde{\chi}_1^- \rightarrow b\bar{b}\ell\bar{\ell}\tilde{\chi}_1^0\tilde{\chi}_1^0\nu\bar{\nu}$$

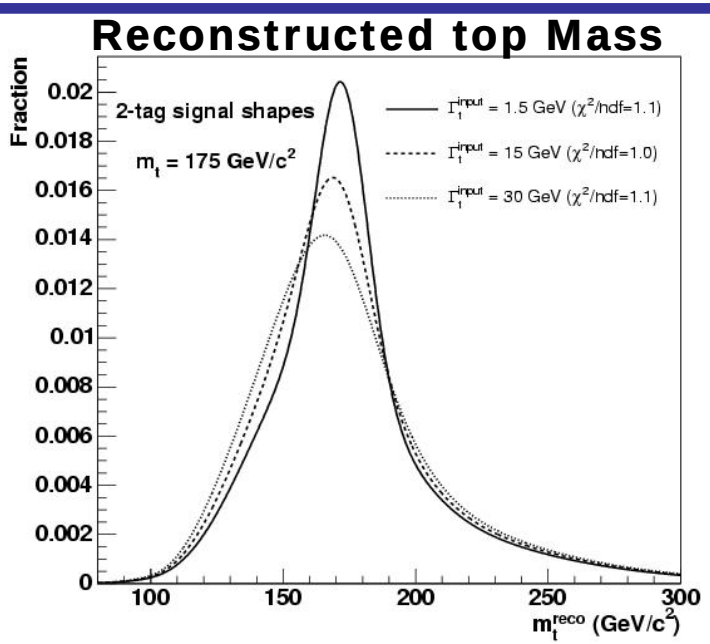
- Dilepton branching ratio is determined by SUSY parameters like tan β, and mass of SUSY particles

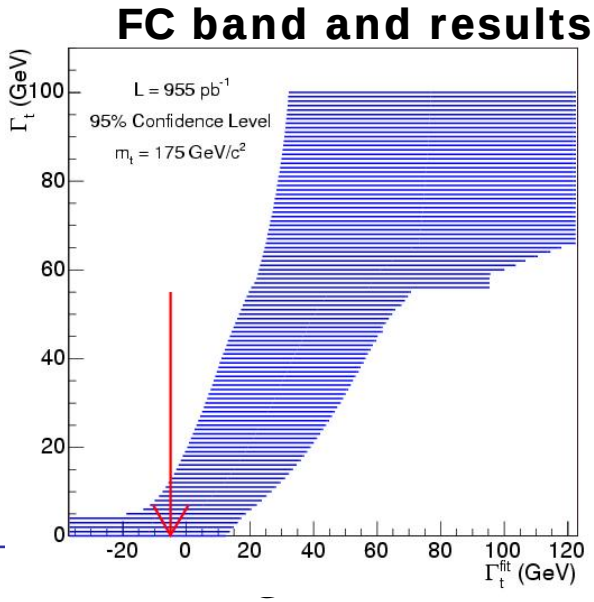


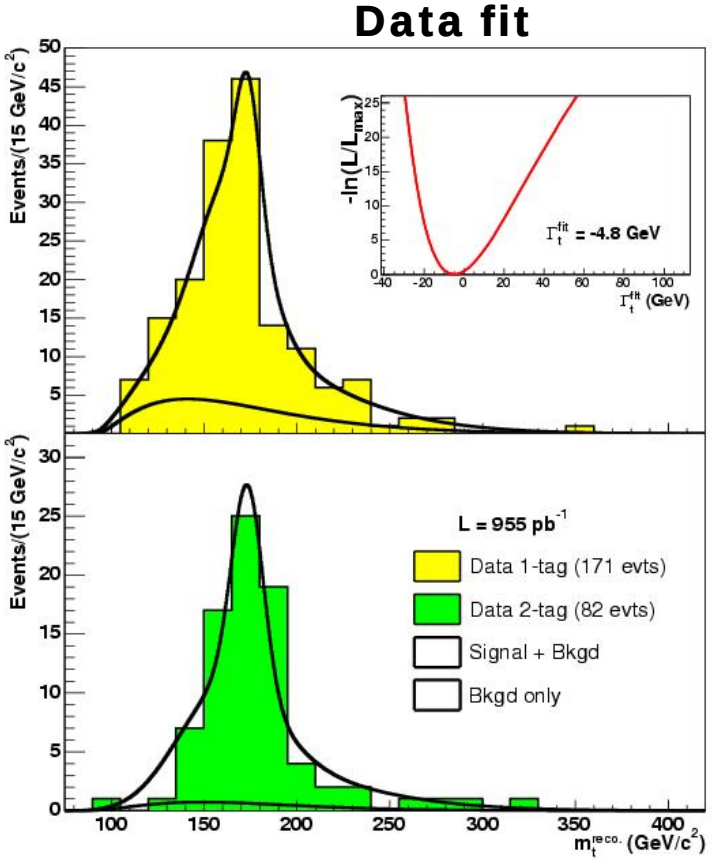


Properties

Top quark width (1 fb^{-1})





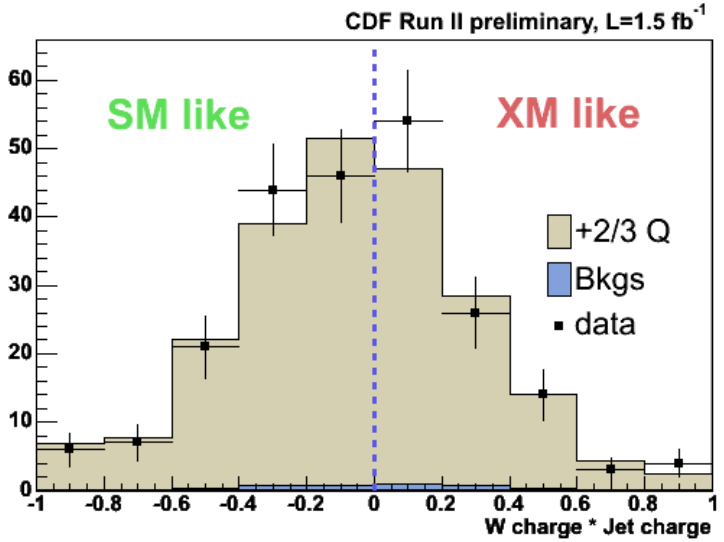


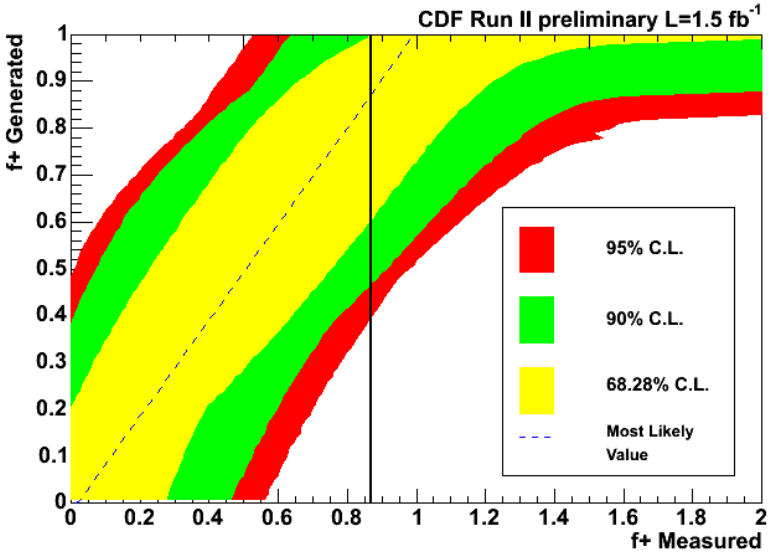
$\Gamma_{Top} <$ 13.1 GeV at 95 % CL

Consistent with SM (1.5GeV)

Top charge (1.5 fb^{-1})

- Is it +2/3e as SM predicts?
- Exotic model predict -4/3e of top charge
  - t ->W^- b (SM W^+ b)
- Measurement
  - Measuring W charge
  - Assigning b quark to W
  - Determining the flavor of b (is it a b or anti-b?)
- Reject XM with 87%CL
- f+ (signal fraction of SM)>0.4 (95%CL)
  - center=0.87

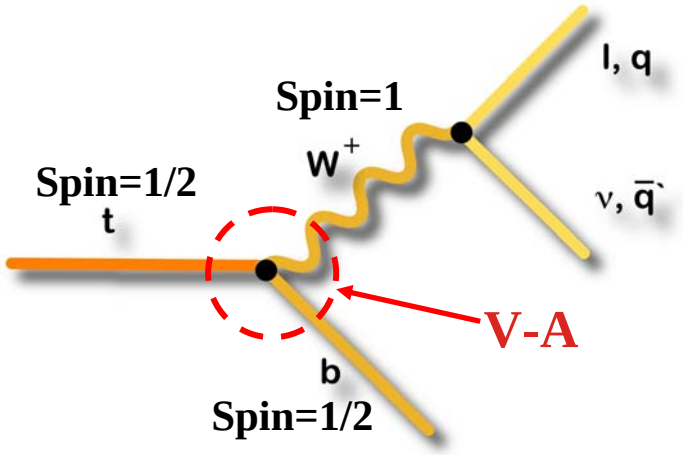




Decay

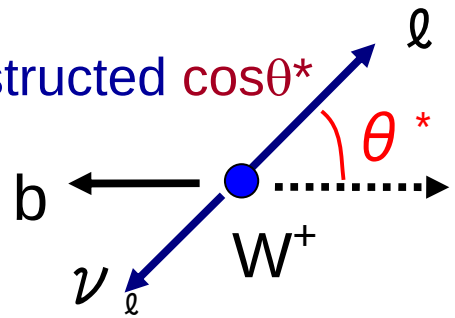
W Hilicity (1.9 fb^{-1})

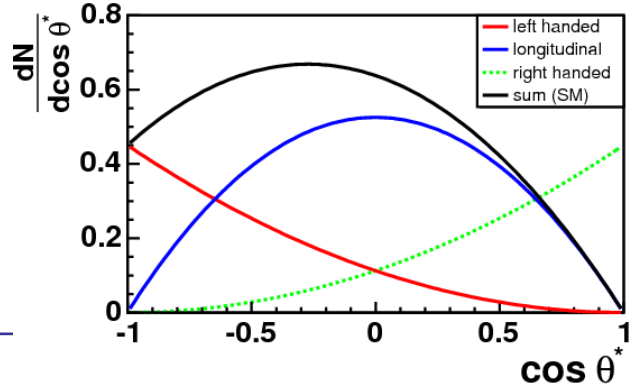
- The SM top decays via EW interaction
  - Top decays as a bare quark ⇒ spin information transferred to final state particles



- V-A coupling predict
  - f_0 = 0.7 (longitudinal)
  - f_+ = 0 (right handed)
  - f_- = 0.3 (left handed)

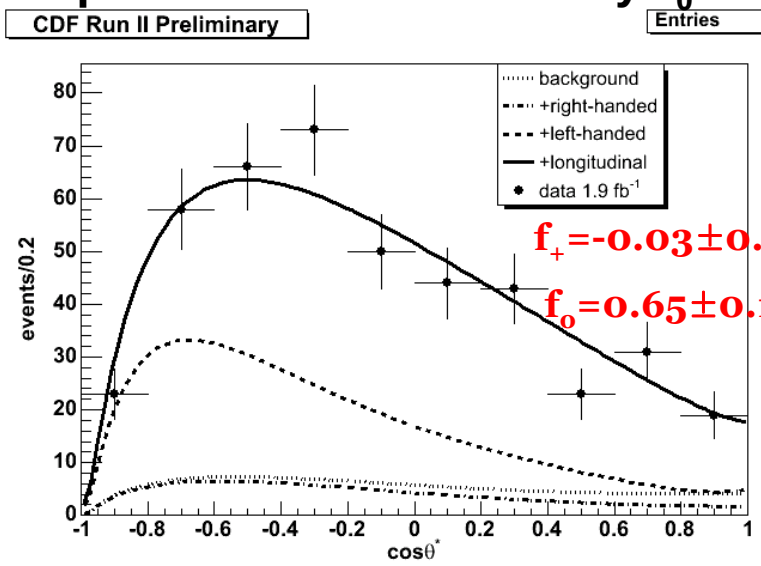
- Measuring the fraction of longitudinally polarized W bosons
  - Reconstructed cosθ*





W-Helicity (1.9 fb^{-1})

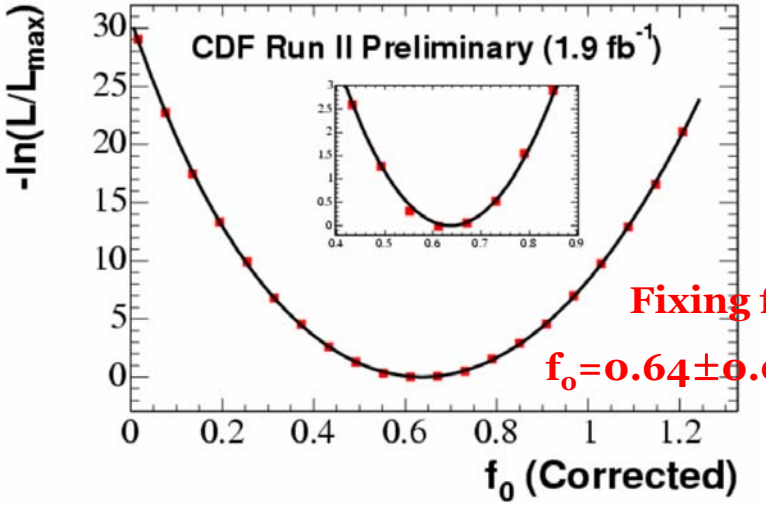
Template fit simultaneously f_0 and f_+



f_+=-0.03±0.07±0.03

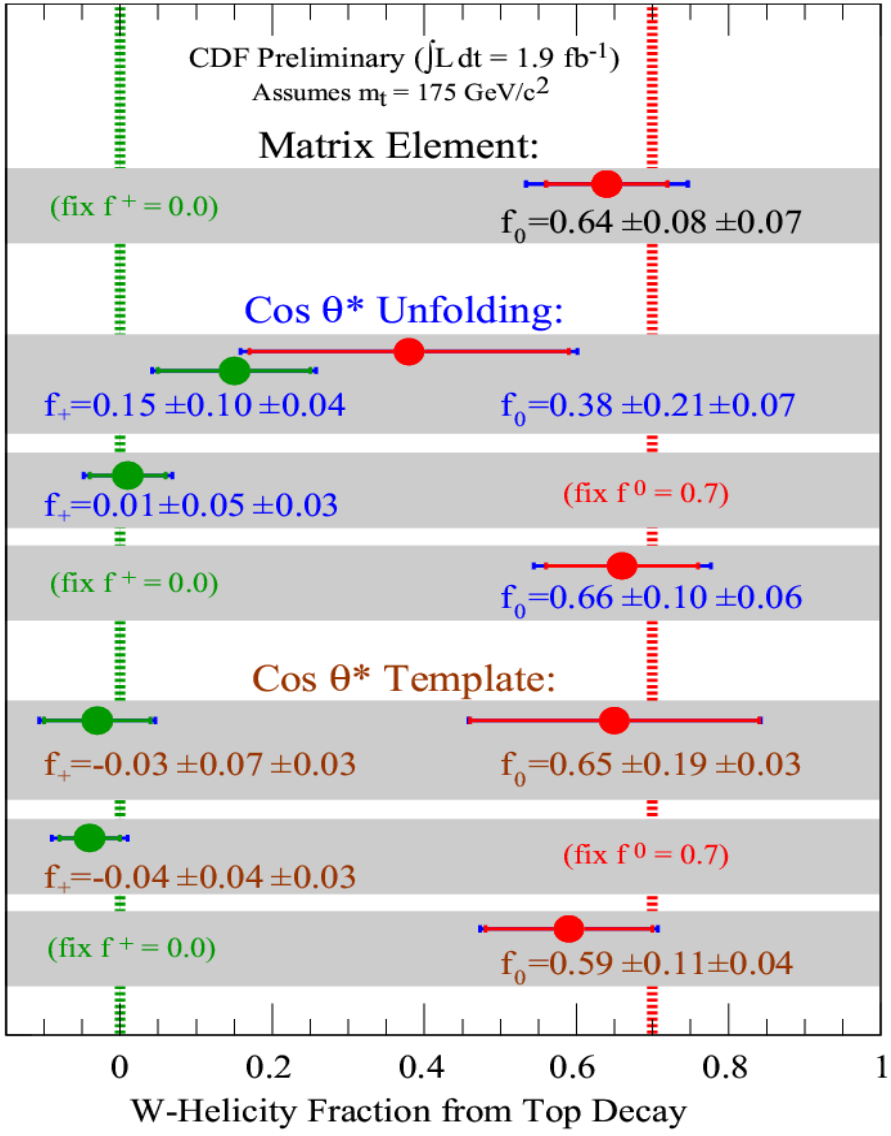
f_0=0.65±0.19±0.03

Matrix element based technique

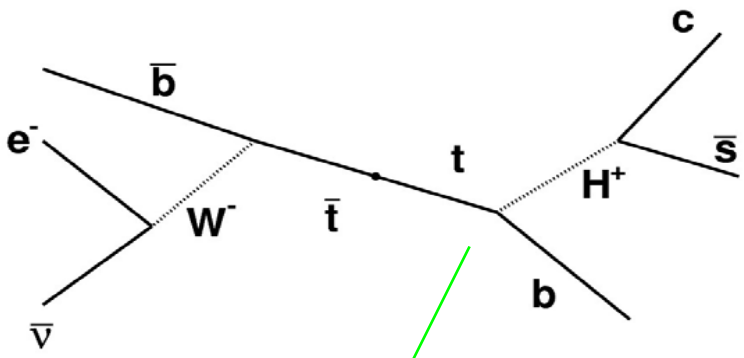


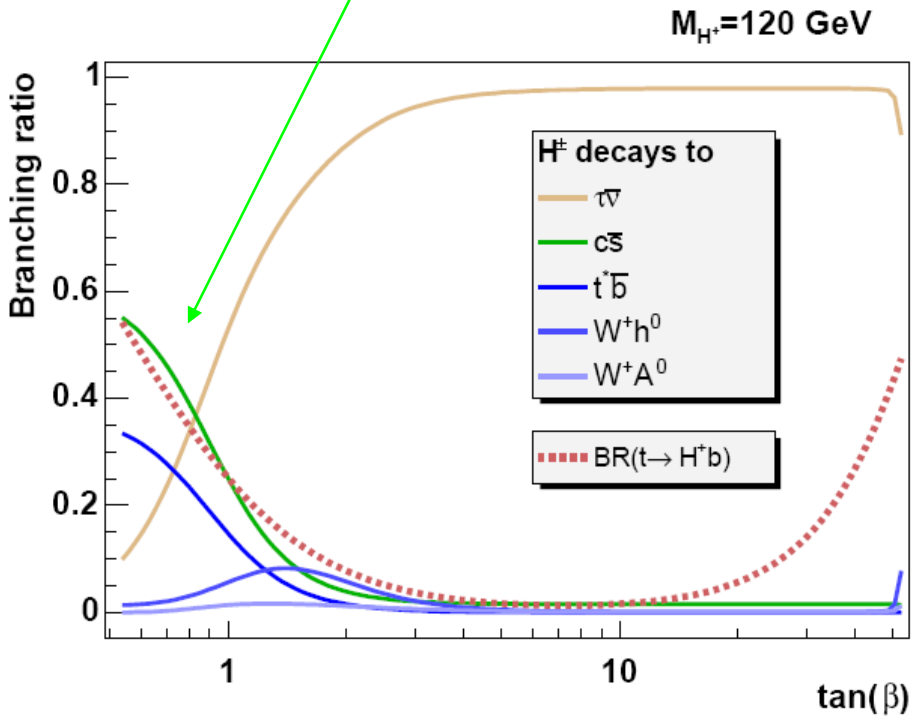
Fixing f_+=0

f_0=0.64±0.08±0.07



Charged Higgs Search (2.2 fb^{-1})



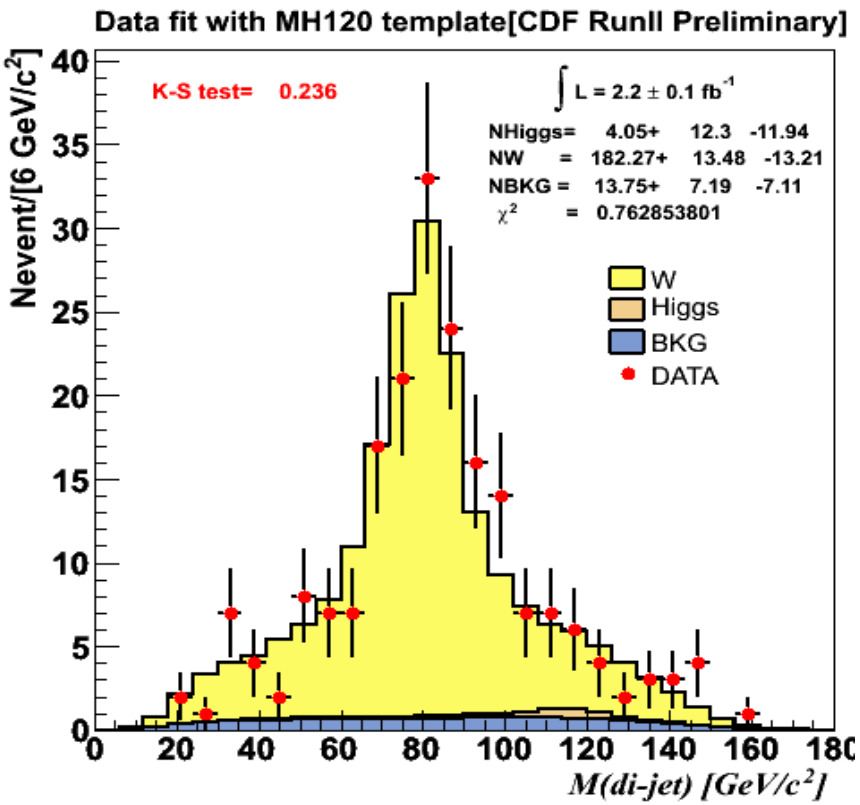


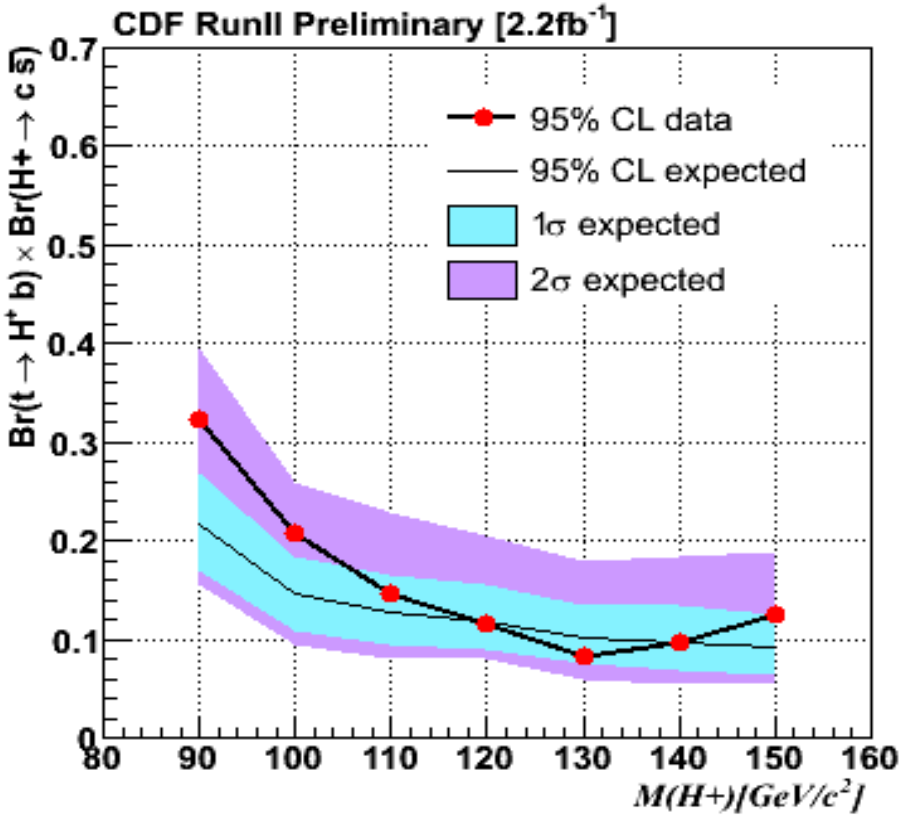
- Search for $H^+ \rightarrow cs$ from $t \rightarrow H^+ b$
  - In the low tanβ, this process is enhanced
- Event Reconstruction using kinematic fit

$$\chi^2 = \sum_{i=l,4jets} \frac{(p_T^{i,fit} - p_T^{i,meas})^2}{\sigma_i^2} + \sum_{j=x,y} \frac{(p_j^{UE,fit} - p_j^{UE,meas})^2}{\sigma_{UE}^2}$$
$$+ \frac{(M_{l\nu} - M_W)^2}{\Gamma_W^2} + \frac{(M_{jj} - M_H^{reco})^2}{\Gamma_H^2} + \frac{(M_{bl\nu} - M_t)^2}{\Gamma_t^2} + \frac{(M_{bjj} - M_t)^2}{\Gamma_t^2}$$

  - Here H^+ replaced W^+ from standard model top kinematics
  - Reconstructed dijet mass distribution can be useful to extract charged Higgs

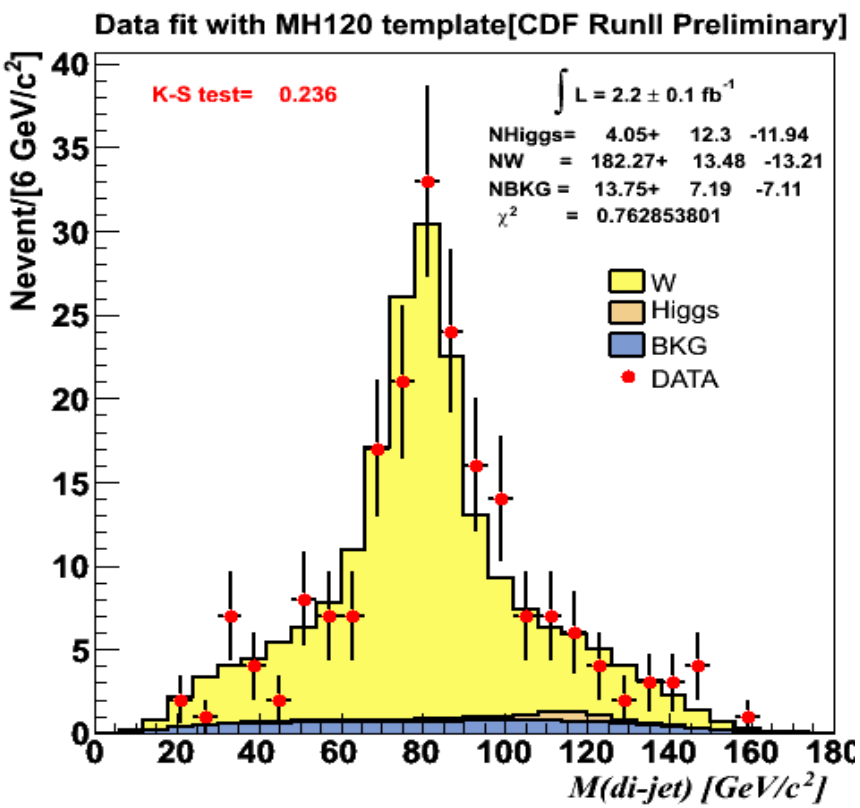
Charged Higgs Search (2.2 fb^{-1})

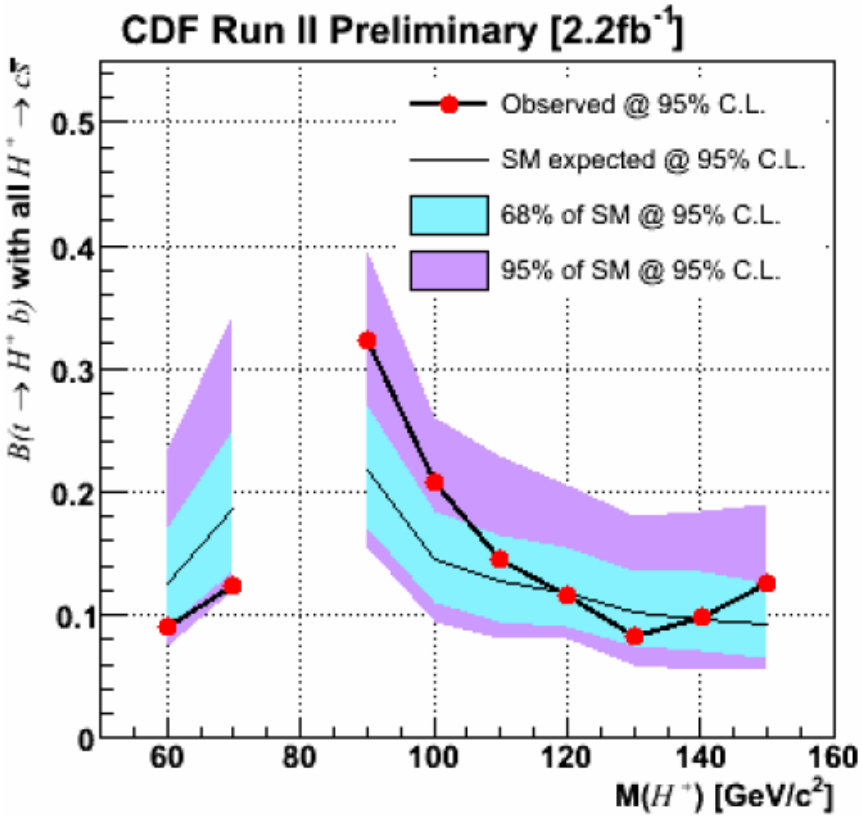




Template fit to the dijet invariant mass in Lepton+Jets channel

Generic Charged boson Search

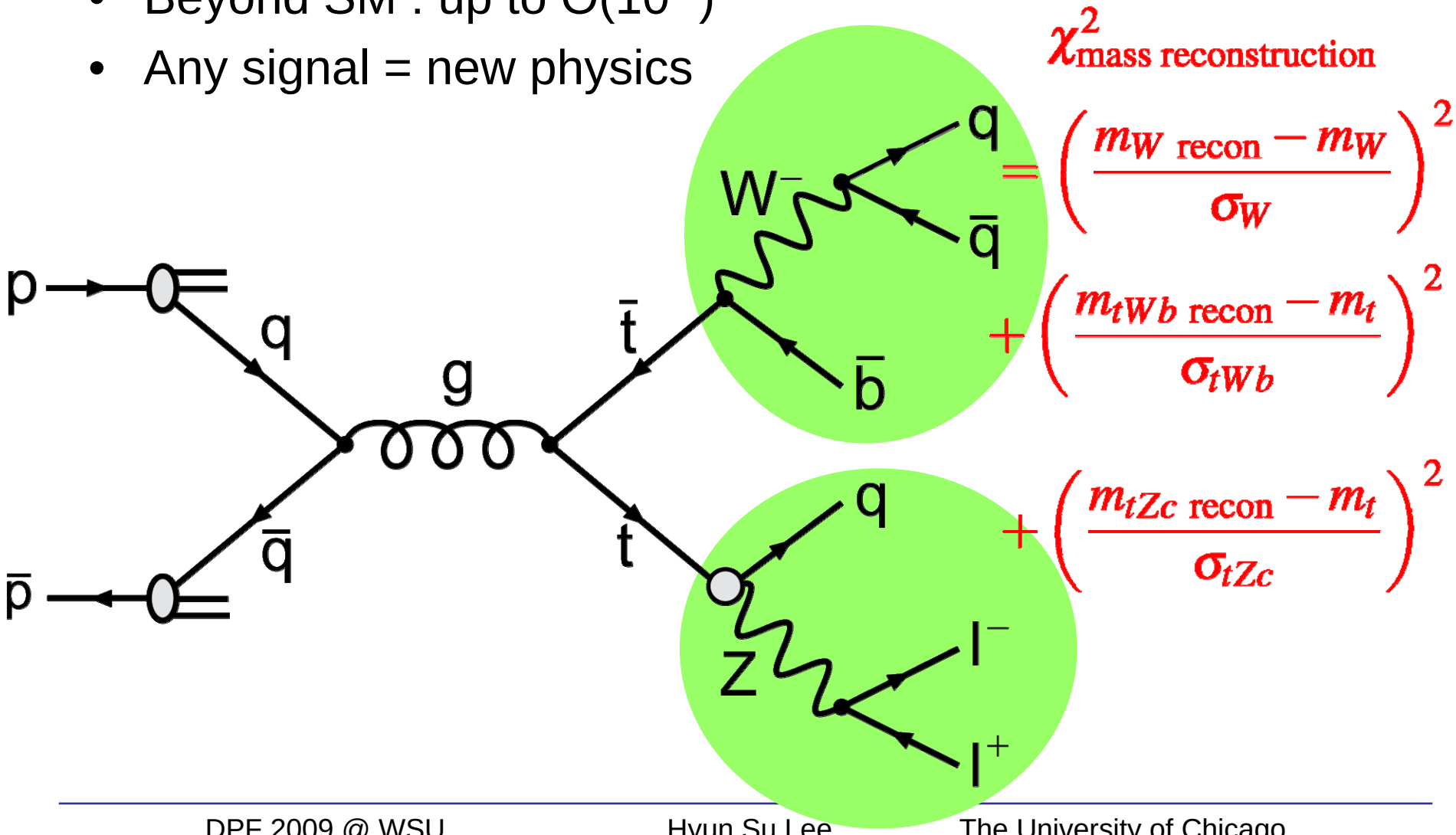




It can be interpreted as generic charged boson search extending below W boson mass

Search for the Top FCNC Decay $t \rightarrow Zq$ (1.9 fb^{-1})

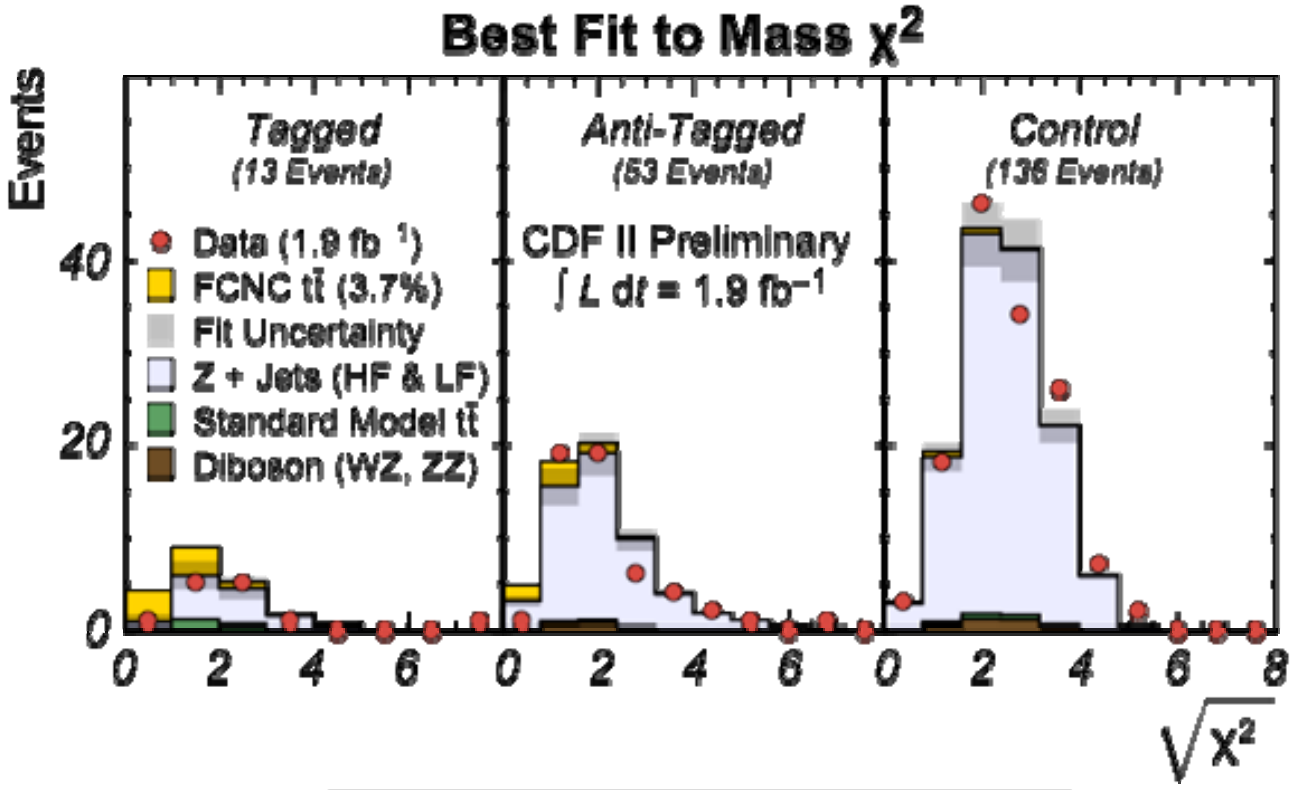
- Top FCNC is extremely small in SM ~ O(10^{-14})
- Beyond SM : up to O(10^{-4})
- Any signal = new physics



$$\chi^2_{\text{mass reconstruction}} = \left(\frac{m_{W\ \text{recon}} - m_W}{\sigma_W}\right)^2 + \left(\frac{m_{tWb\ \text{recon}} - m_t}{\sigma_{tWb}}\right)^2 + \left(\frac{m_{tZc\ \text{recon}} - m_t}{\sigma_{tZc}}\right)^2$$

Search for the Top FCNC Decay $t \rightarrow Zq$ (1.9 fb^{-1})

- Data fit for signal (tagged and anti-tagged) events region
- Background constraints in the control region
  - (Z+jets dominant region)



B(t→Zq) < 3.7% (95% C.L.)

Conclusion & Outlook

- CDF are studying the top quark in various angle
- So far top quark seems to be standard model top quark
- Still a lot of measurement are limited by statistics
  - Much larger sample can give more interest
  - We already have more than 6 fb^{-1}
  - End of 2011 ~ 10 fb^{-1}
  - LHC will be top factory – can be apply same technique