

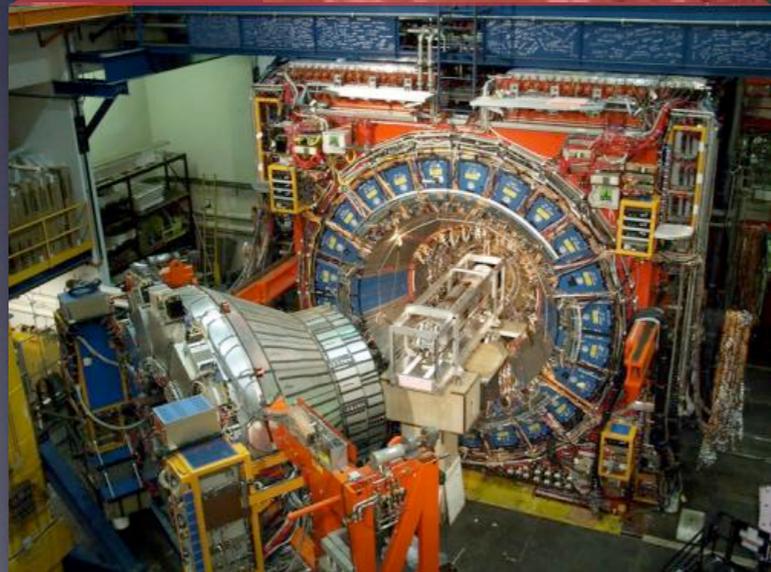
# Top Physics at CDF

Lake Louise Winter Institute  
February 18 2008



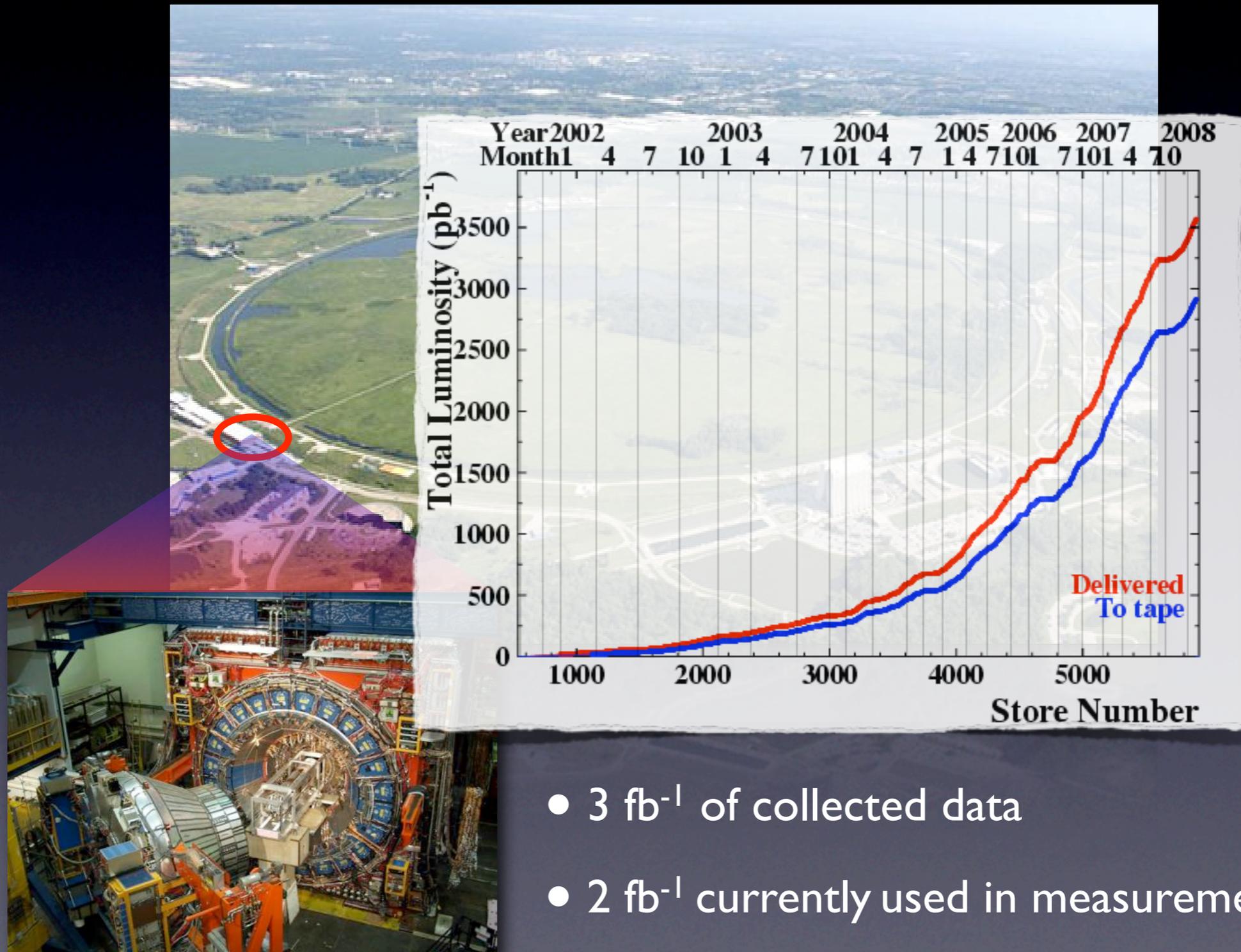
Tom Schwarz  
University of California Davis

# The Tevatron and CDF



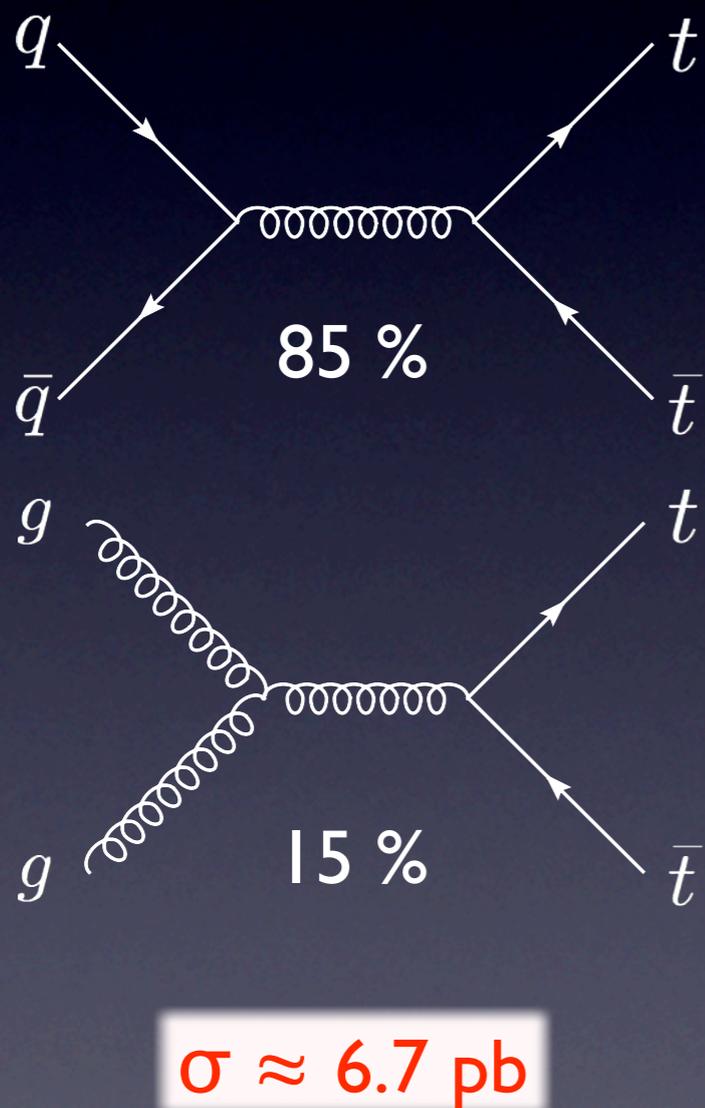
- Colliding protons and anti-protons at  $\sqrt{s} = 1.96 \text{ TeV}$

# The Tevatron and CDF

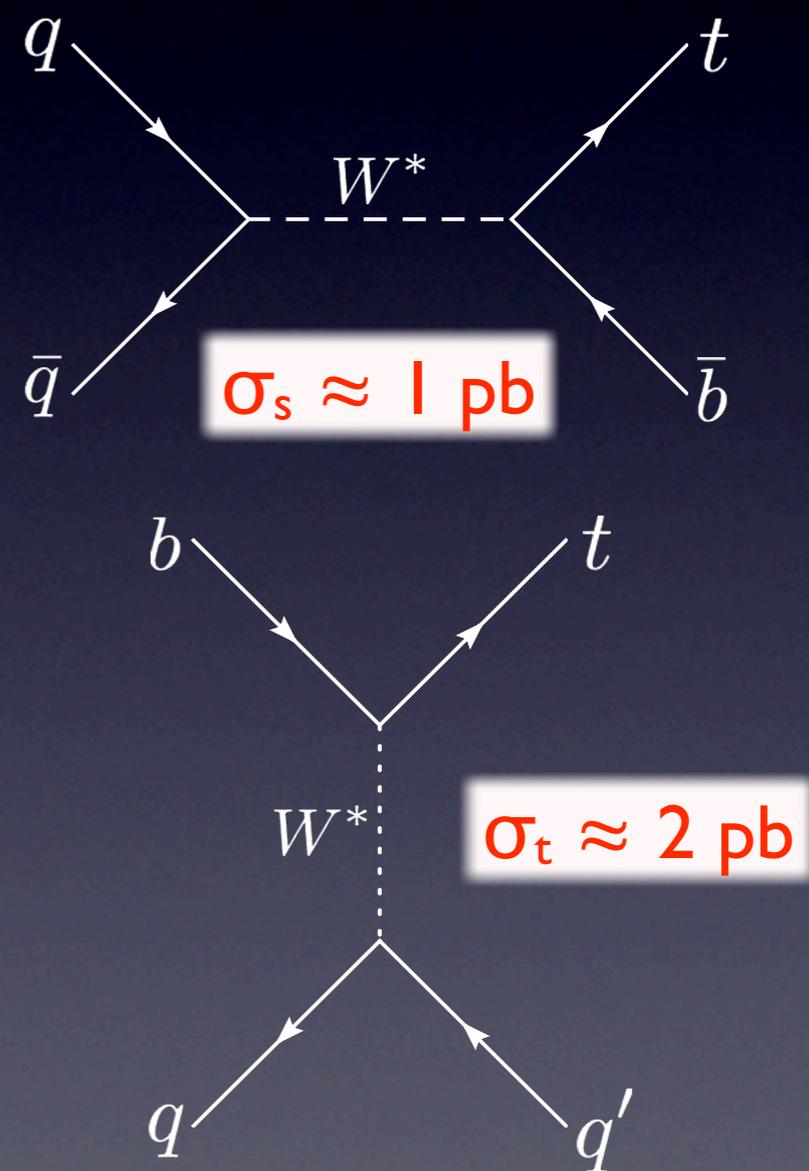


# How is Top Produced?

## Strong

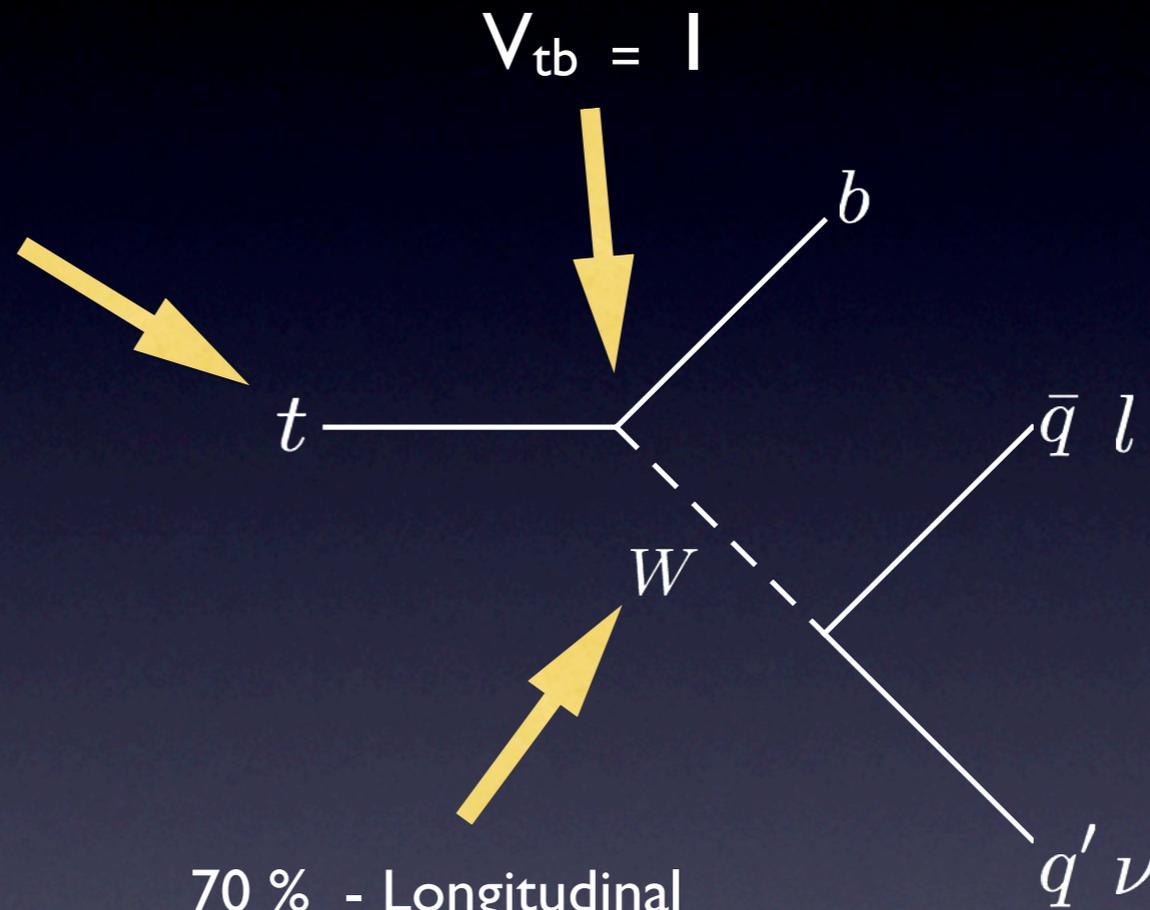


## Weak



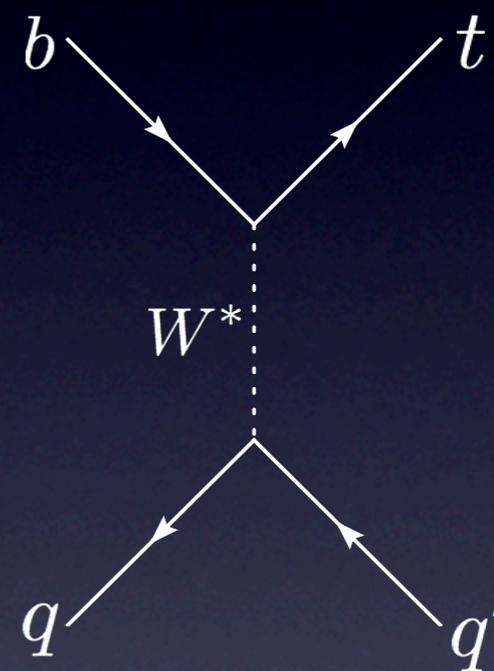
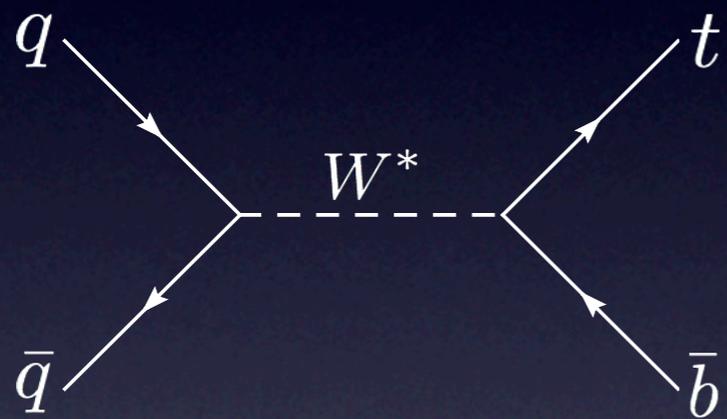
# How Does Top Decay?

Charge =  $2/3$   
Mass =  $175 \text{ GeV}$   
Spin =  $1/2$   
Width =  $1.5 \text{ GeV}$



70 % - Longitudinal  
30 % - Left handed  
0 % - Right handed

# Weak Production



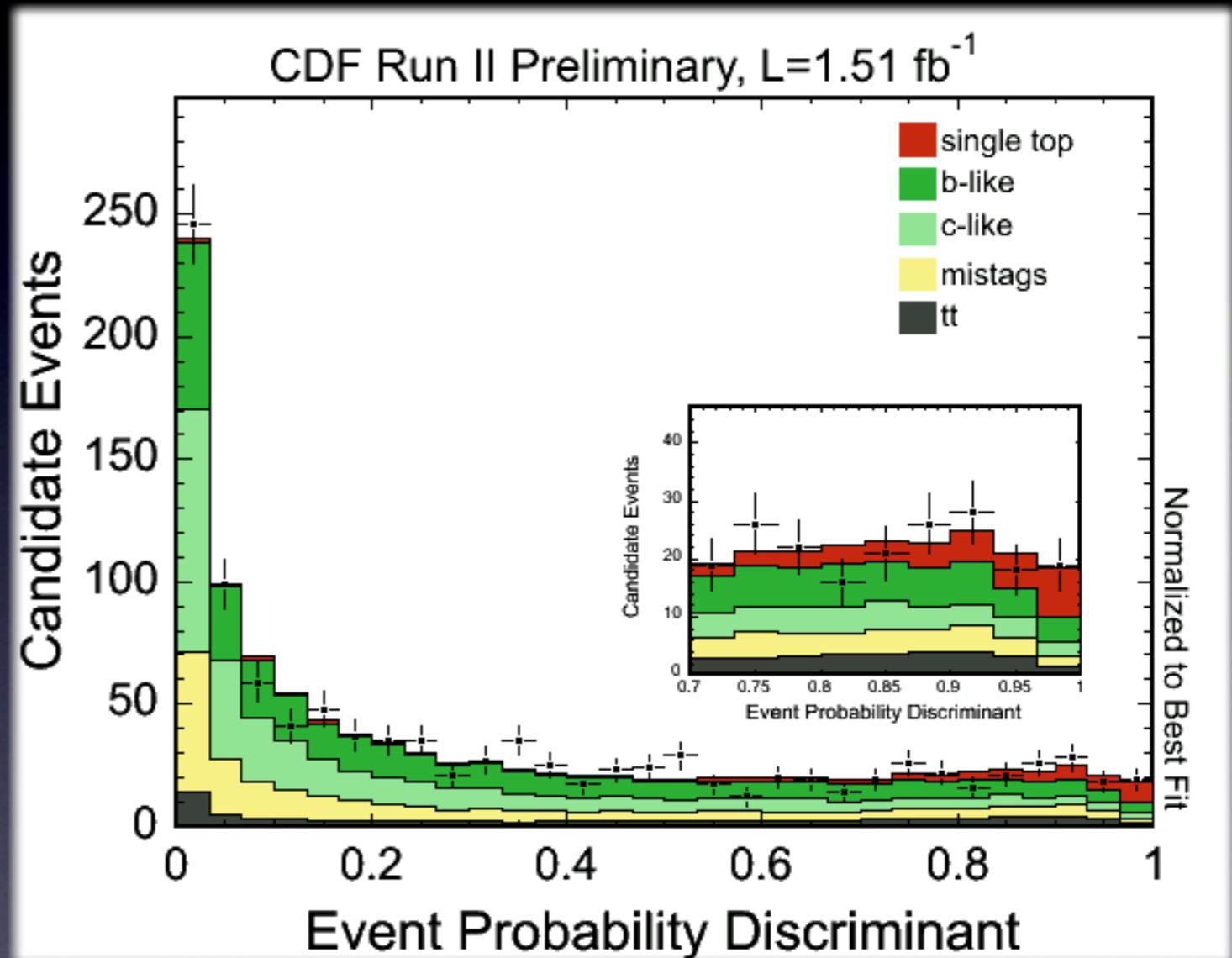
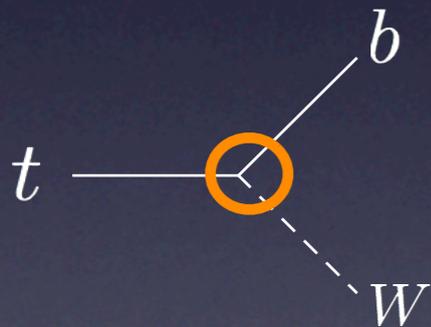
# Single Top & Measurement of $V_{tb}$

1.9 fb<sup>-1</sup>

- Recent evidence for single top at CDF

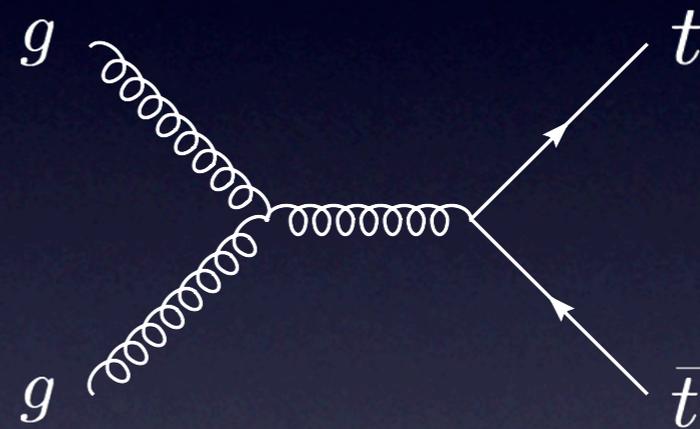
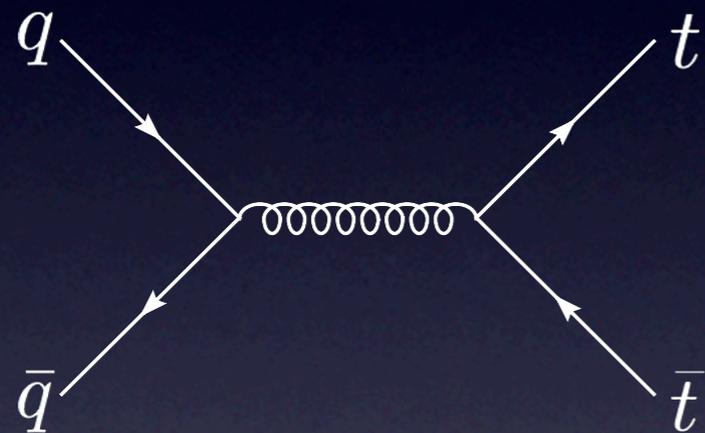
$$\sigma = 3.0^{+1.2}_{-1.1} \text{ pb}$$

- From single top x-section we can extract CKM element  $V_{tb}$



$$|V_{tb}| = 1.02 \pm 0.18_{\text{exp}} \pm 0.07_{\text{theory}}$$

# Strong Production

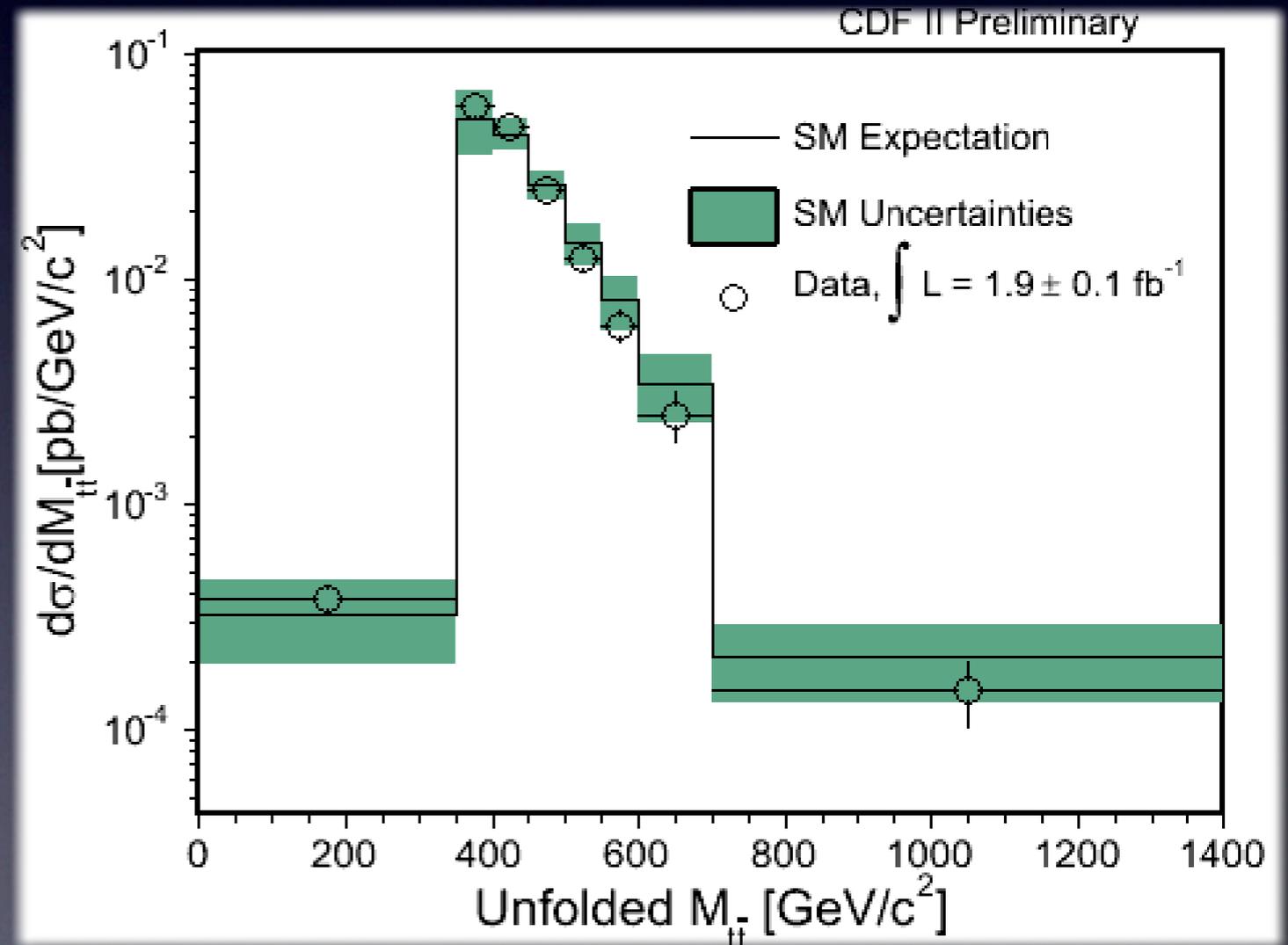


# $t\bar{t}$ Differential Cross-Section

1.9 fb<sup>-1</sup>

- Measuring the  $t\bar{t}$  differential cross-section as a function of  $M_{t\bar{t}}$
- Correct bin-to-bin smearing by regularized unfolding technique
- Very model independent search for new physics
- Unfolded distribution directly comparable to theory

**Consistent with SM**



# Search for Massive Gluon

1.9 fb<sup>-1</sup>

- Searching for massive gluon decaying to top pairs in  $M_{t\text{-}t\text{bar}}$  spectrum

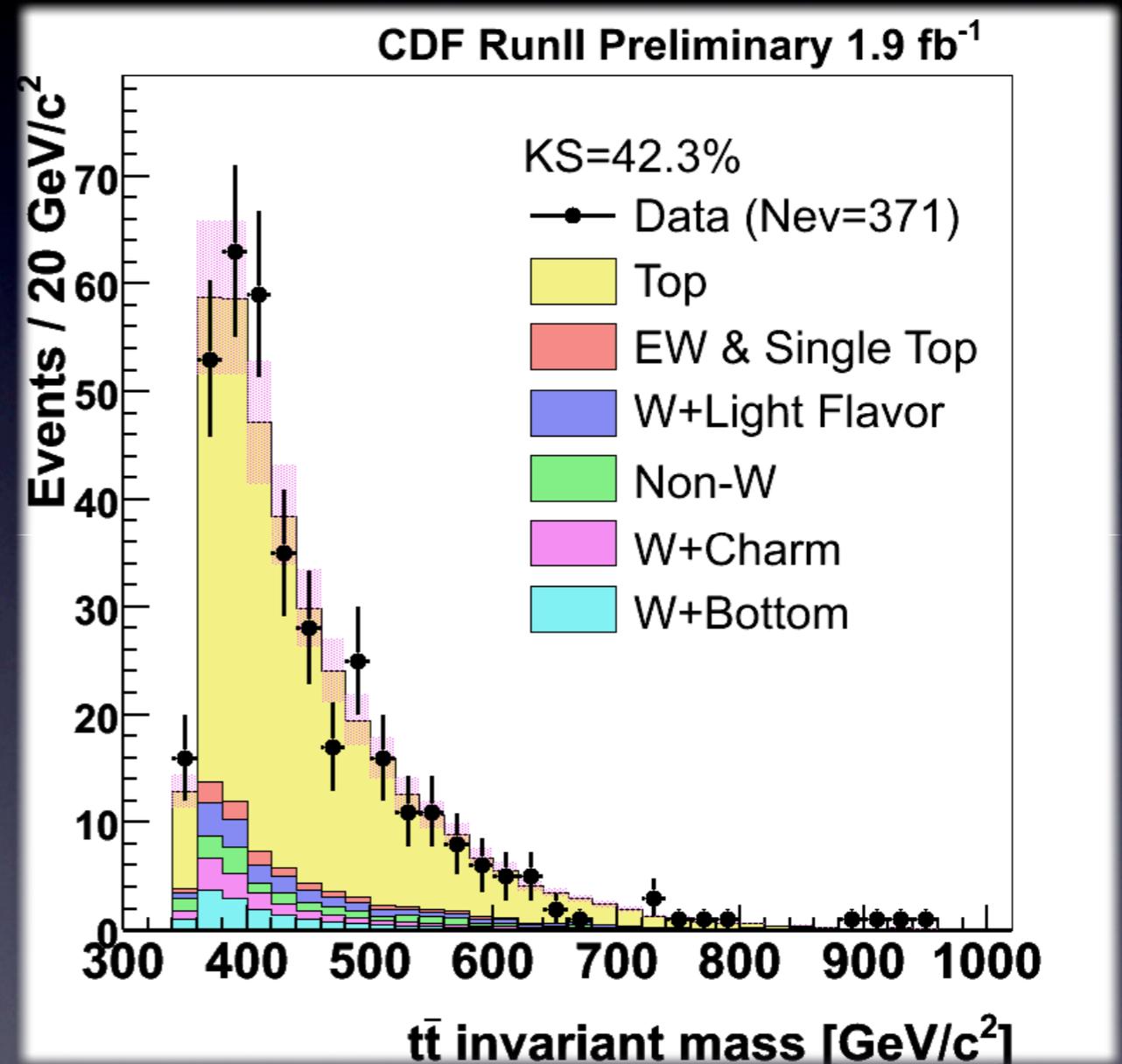
- Interferes with SM process

## *Not A Simple Bump Hunt*

- Set upper/lower limits on coupling strength for mass and width range

**Consistent with SM over Explored Range**

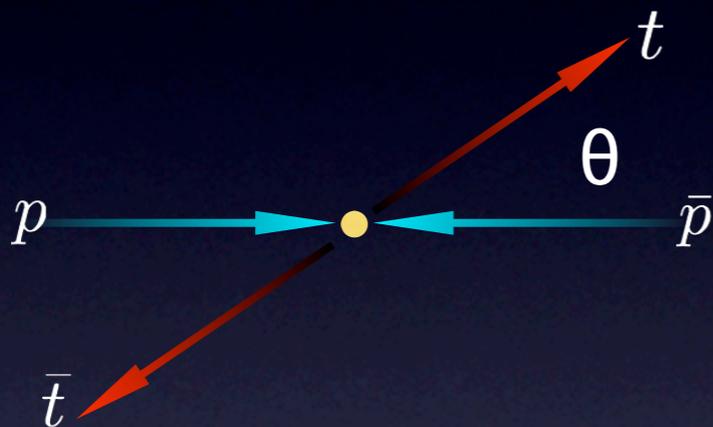
$500 < M_G < 800 \text{ GeV}$     $0.05 < \Gamma / M_G < 0.50$



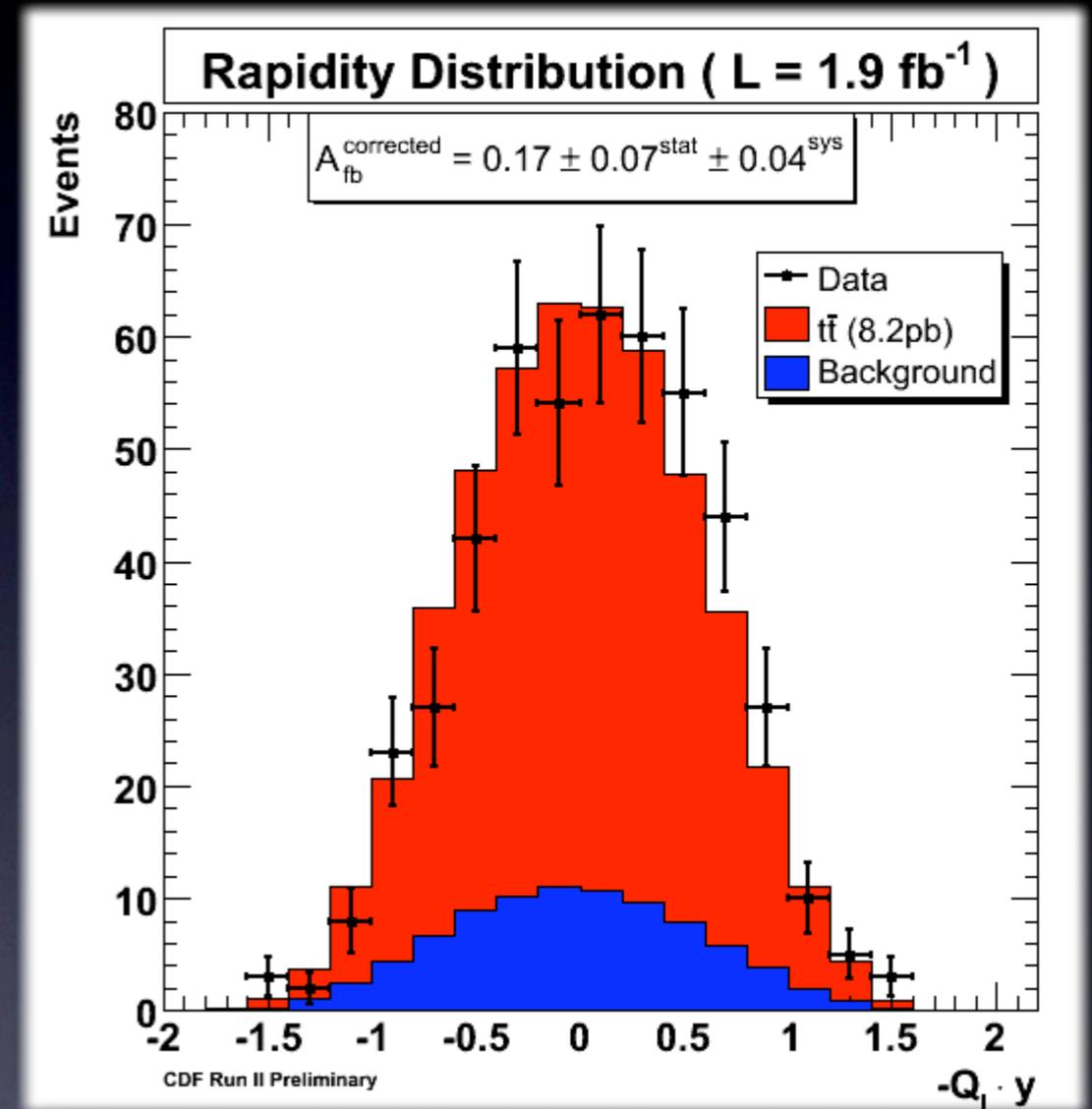
# Forward Backward Asymmetry

1.9 fb<sup>-1</sup>

- Measuring  $A_{fb}$  from production angle of top in  $p\bar{p}$  and  $t\bar{t}$  rest frame



- Measurement of discrete symmetries of the strong interaction at high energy
- QCD at NLO predicts a non-zero asymmetry



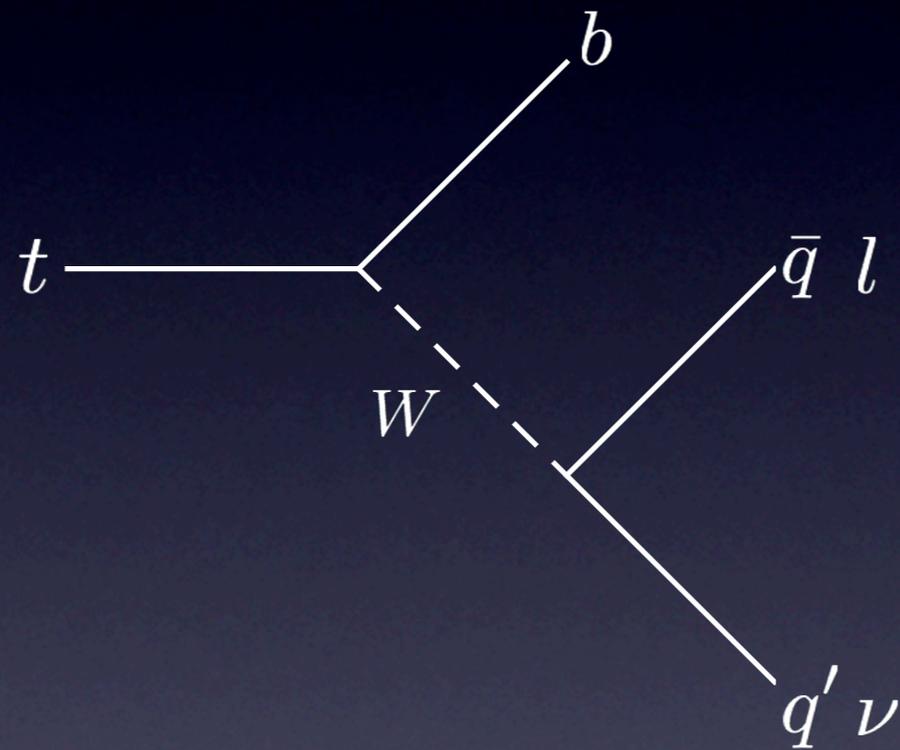
$$A_{fb}^{t\bar{t}} = 0.23 \pm 0.13_{\text{stat}} \pm 0.04_{\text{syst}}$$

$$A_{fb}^{t\bar{t}} \text{ theory} = 0.06 \pm 0.01$$

$$A_{fb}^{p\bar{p}} = 0.17 \pm 0.07_{\text{stat}} \pm 0.04_{\text{syst}}$$

$$A_{fb}^{p\bar{p}} \text{ theory} = 0.04 \pm 0.01$$

# Top Decay



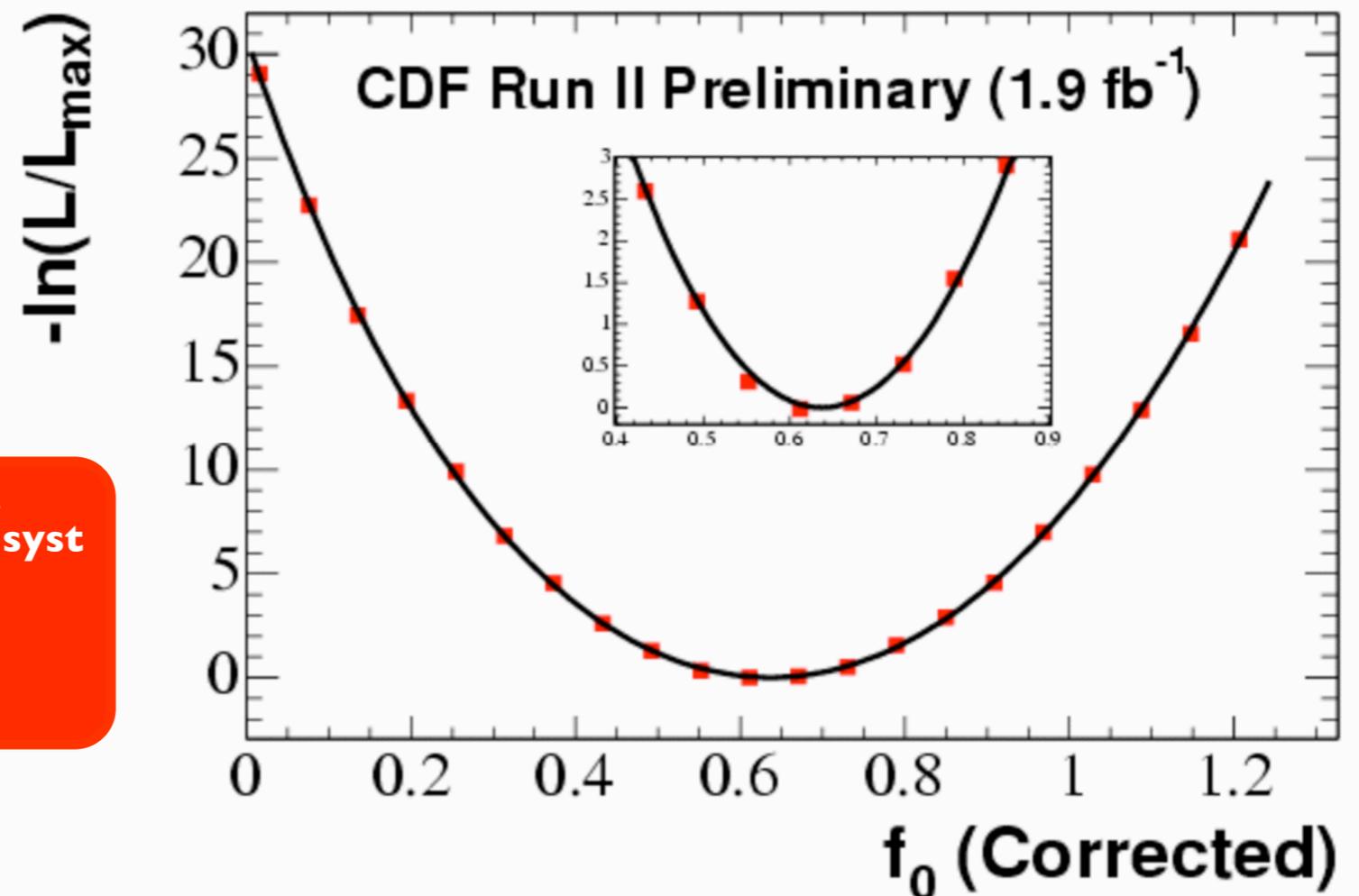
# W Helicity

1.9 fb<sup>-1</sup>

- Measuring the fraction of longitudinally polarized W bosons from top quark decay ( $F_0$ ) in the lepton plus jets channel
- Utilize a matrix element technique to calculate likelihood
- SM predicts  $F_0 = 0.70$

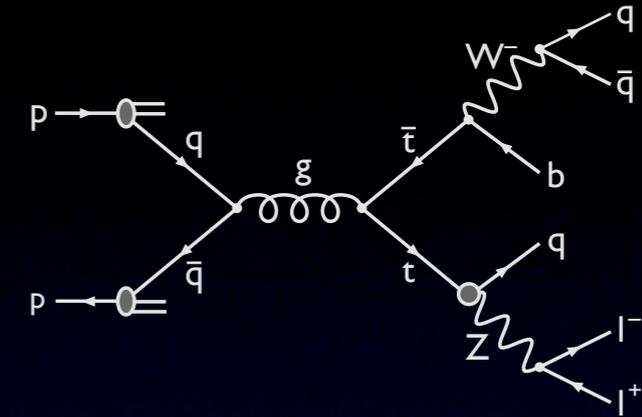
$$F_0 = 0.64 \pm 0.08_{\text{stat}} \pm 0.07_{\text{syst}}$$

Constraining  $F_+ = 0$



# Search For FCNC

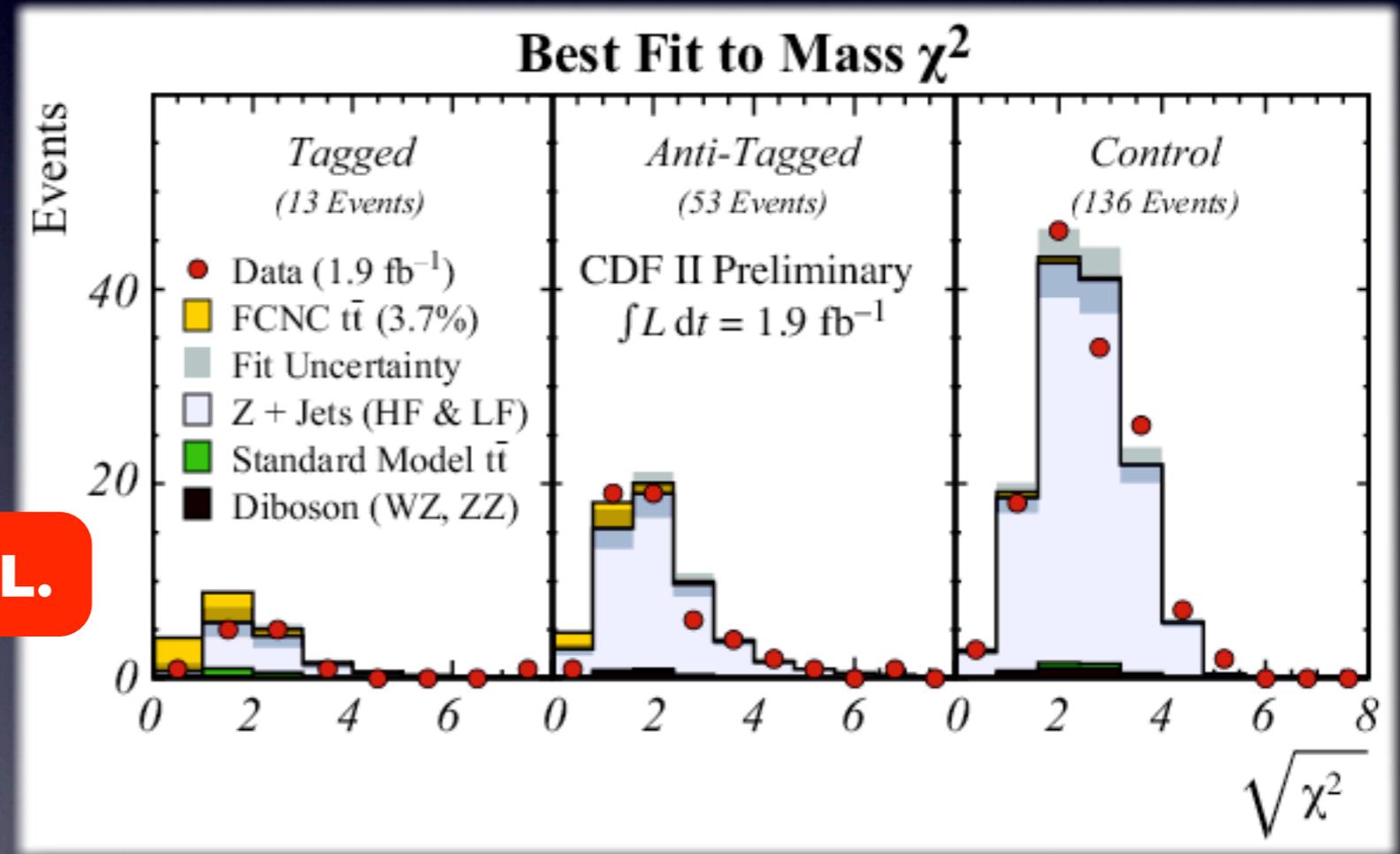
1.9 fb<sup>-1</sup>



- Top Flavor Changing Neutral Currents: very rare in SM  $B(t \rightarrow Zq) \approx 10^{-14}$
- Signature - Z + 4 jets
- Full event kinematics reconstructed
- Limit on  $B(t \rightarrow Zq)$  calculated

**$B(t \rightarrow Zq) < 3.7\% @ 95\% \text{ C.L.}$**

**World's Best Limit**



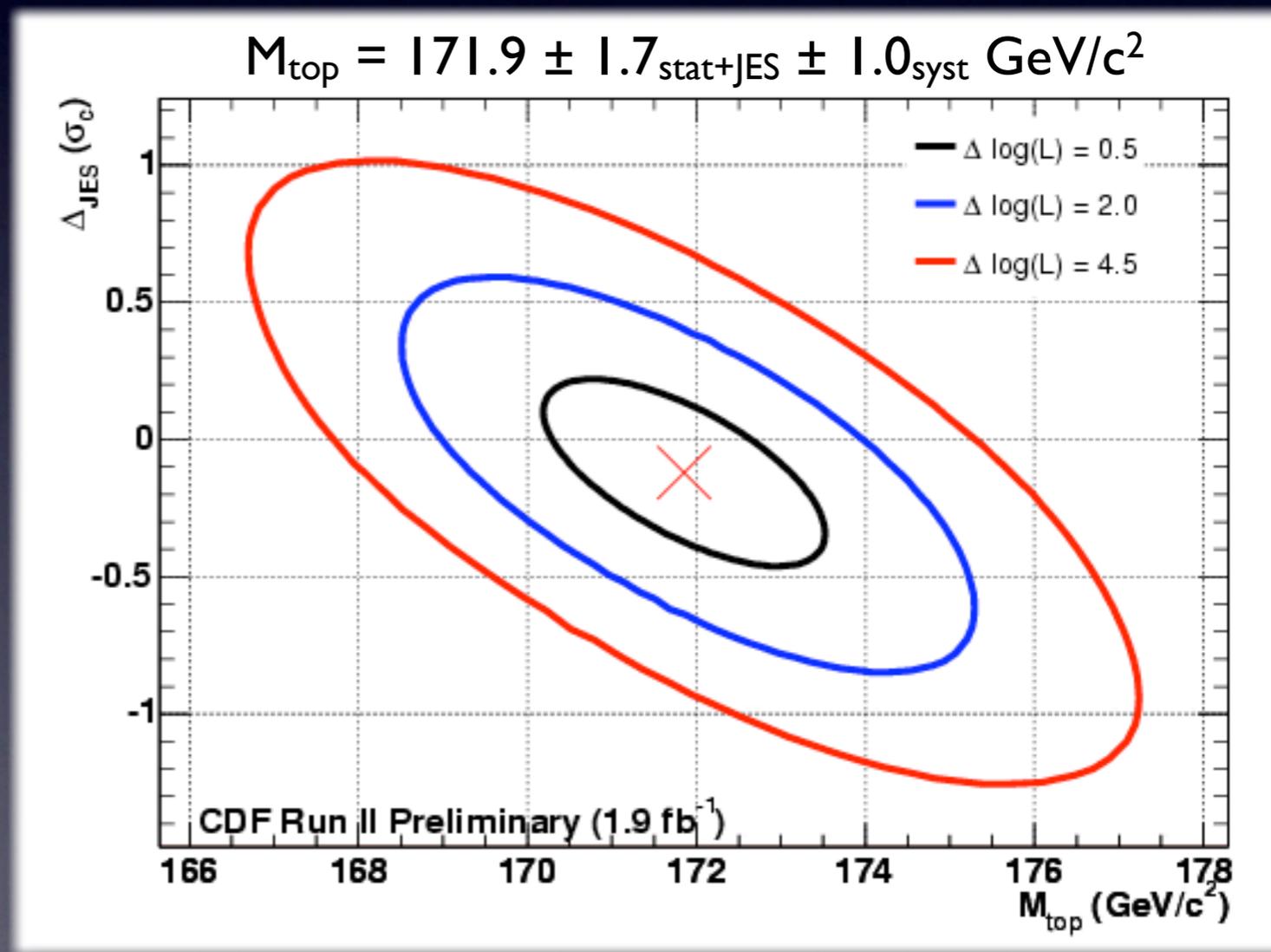
# Mass of the Top Quark

1.9 fb<sup>-1</sup>

- New result combines template mass measurements in the lepton plus jets and dilepton channels into a single likelihood
- Simultaneous fit to Jet Energy Scale (JES) and top mass constrains largest systematic
- In situ JES is transported to dilepton measurement

$$M_{\text{top}} = 171.9 \pm 2.0 \text{ GeV}/c^2$$

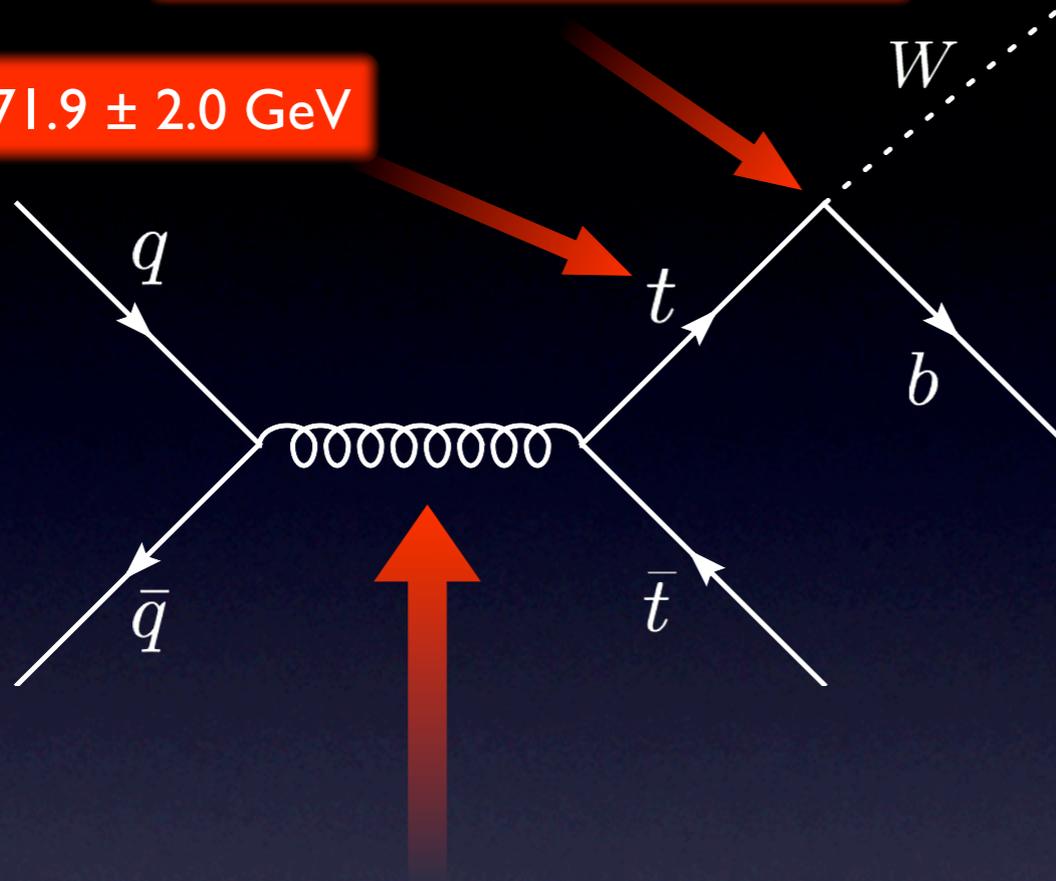
New World's Best



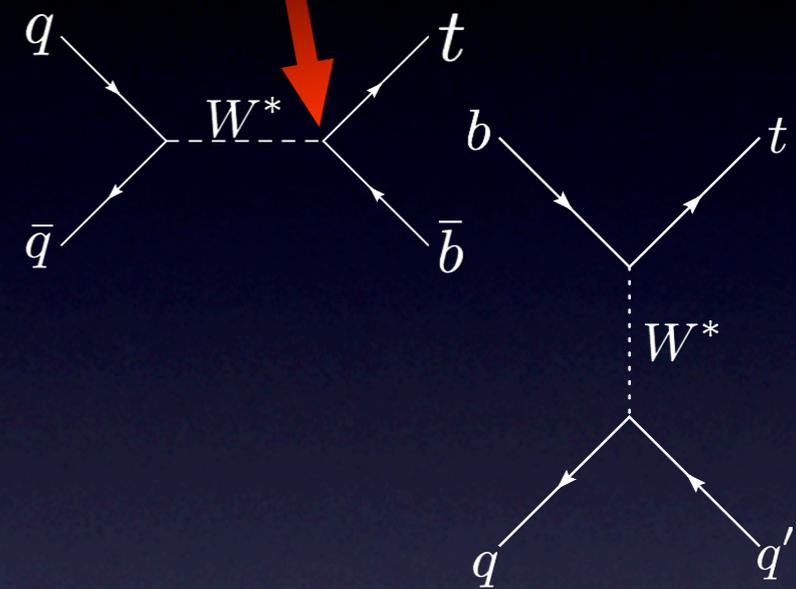
$$F_0 = 0.64 \pm 0.08_{\text{stat}} \pm 0.07_{\text{syst}}$$

$$B(t \rightarrow Zq) < 3.7\% \text{ @ } 95\% \text{ C.L.}$$

$$M_{\text{top}} = 171.9 \pm 2.0 \text{ GeV}$$



$$|V_{tb}| = 1.02 \pm 0.18_{\text{exp}} \pm 0.07_{\text{theory}}$$



No evidence for Massive Gluon

$$A_{\text{fb}}^{p\bar{p}} = 0.17 \pm 0.07_{\text{stat}} \pm 0.04_{\text{syst}}$$

$$A_{\text{fb}}^{t\bar{t}} = 0.23 \pm 0.13_{\text{stat}} \pm 0.04_{\text{syst}}$$

$$\frac{d\sigma}{dM_{t\bar{t}}} \text{ Measured - SM Consistent}$$

$$\sigma_{s+t} = 3.0^{+1.2}_{-1.1} \text{ pb}$$

Visit the CDF public page for more results

<http://www-cdf.fnal.gov/physics/new/top/top.html>