

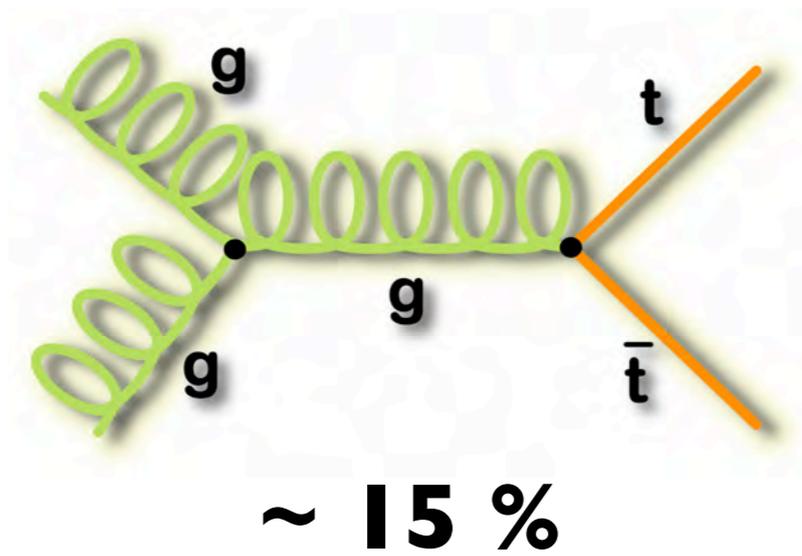
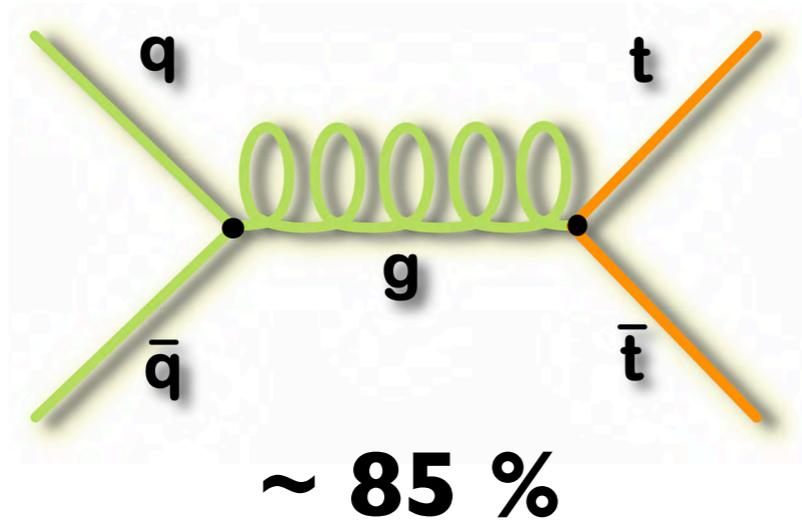
Measurements of Top Production and Decay at the Tevatron

Tom Schwarz
University of California Davis

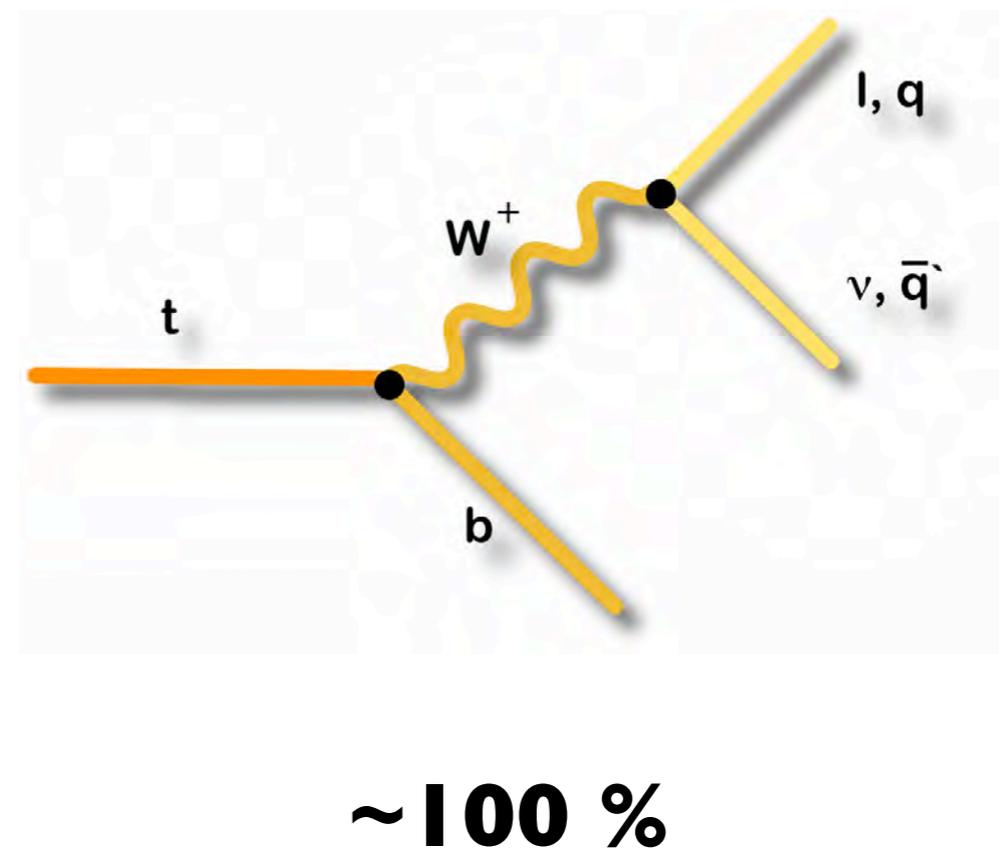


Rencontres de Moriond
Electroweak Interactions and Unified Theories
7-14 March, 2009

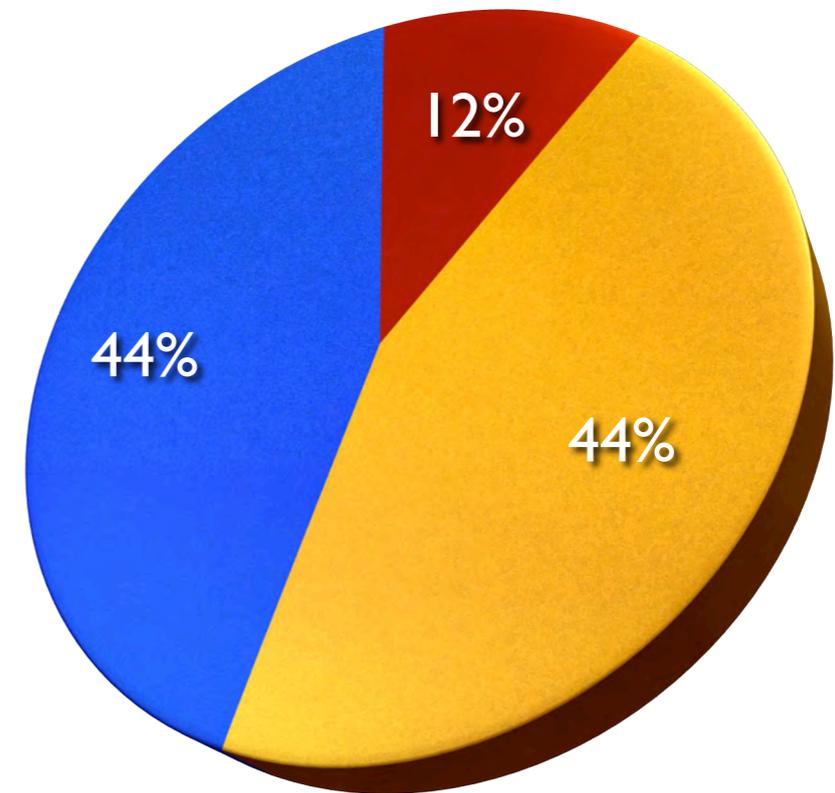
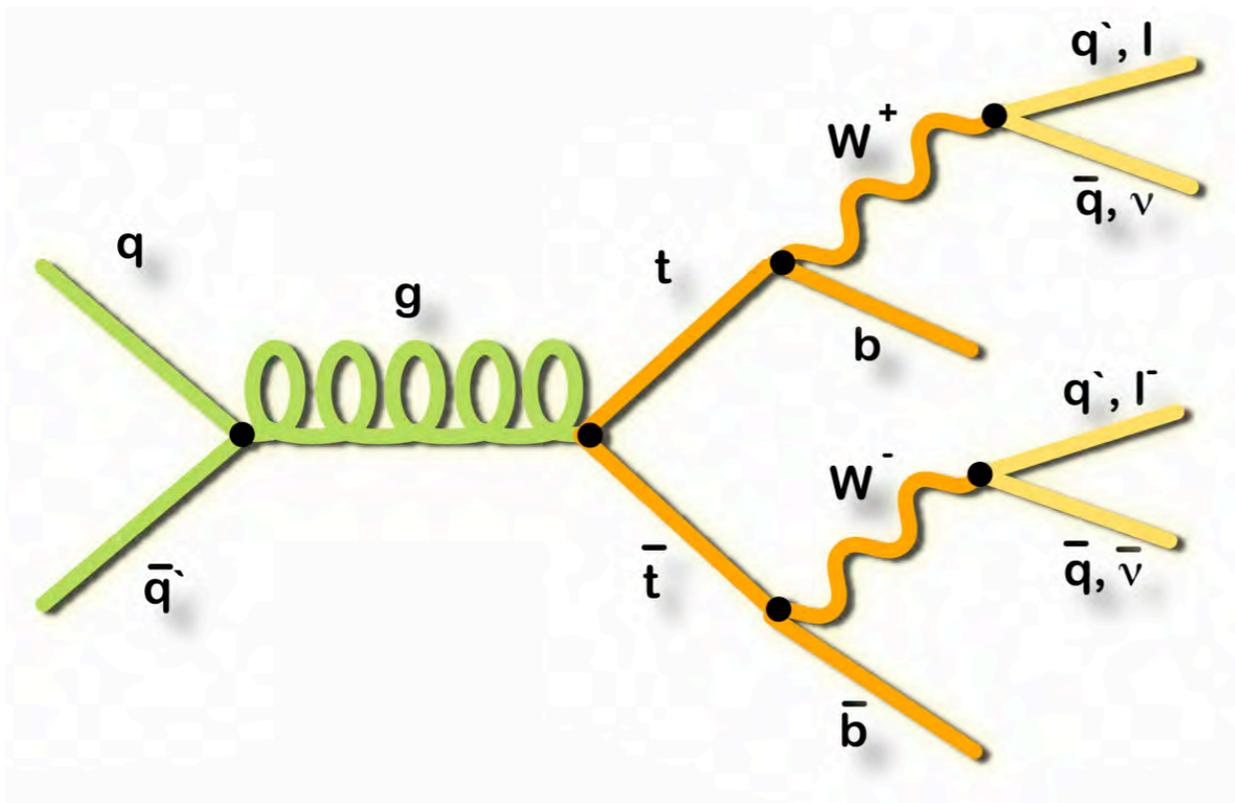
Production



Decay



Top Decay Channels



- Di-lepton ($W \rightarrow lv$ $W \rightarrow lv$)
- Lepton + Jets ($W \rightarrow lv$ $W \rightarrow qq$)
- All-hadronic ($W \rightarrow qq$ $W \rightarrow qq$)

Previous Talk

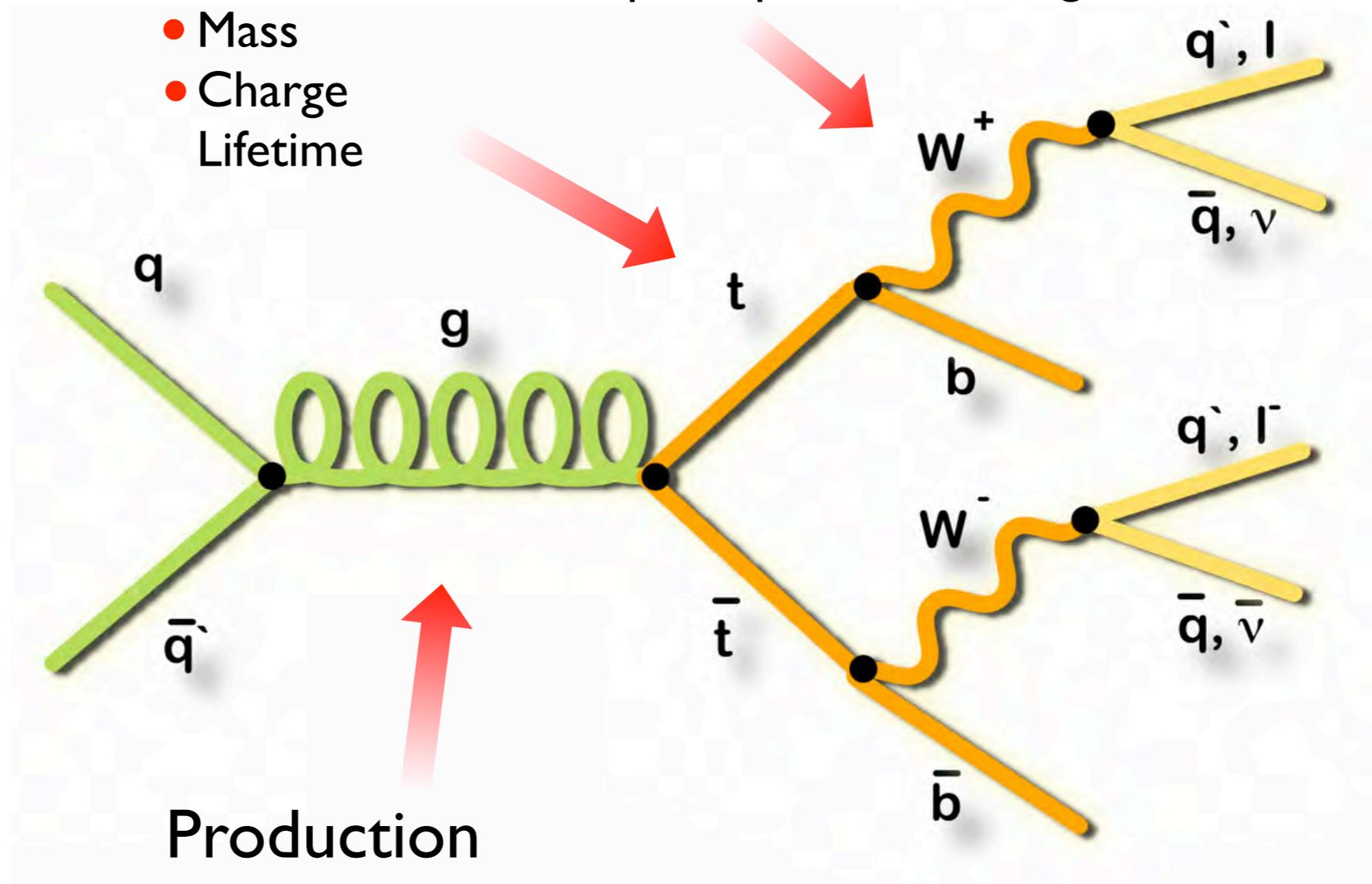
This Talk

Properties

- Mass
- Charge
- Lifetime

Decay

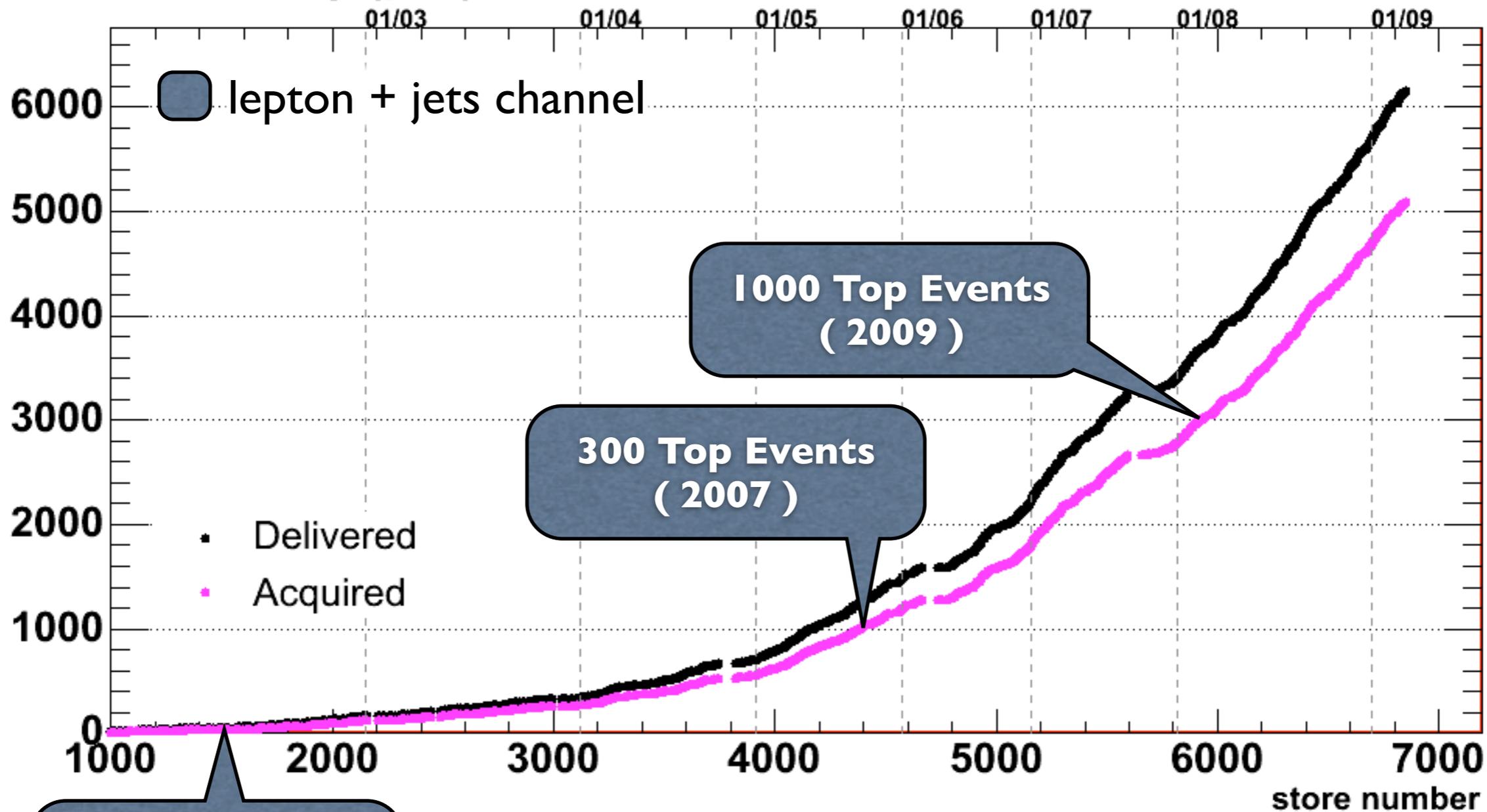
- W Helicity
- Non SM Decay
- Top-like particles - 4th gen



Production

- Cross Section
- Asymmetry
- Resonant Production

Luminosity (pb^{-1})

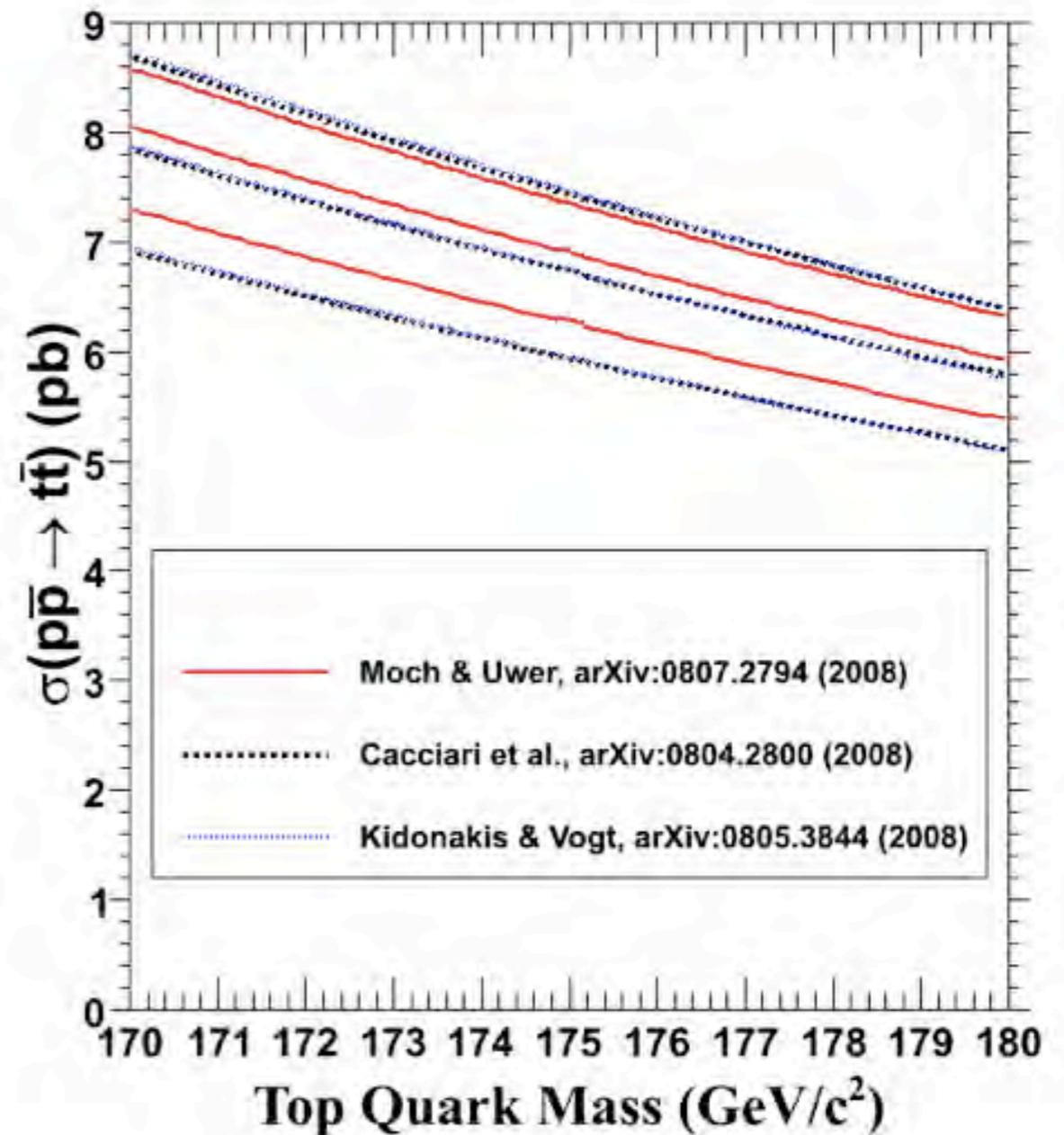
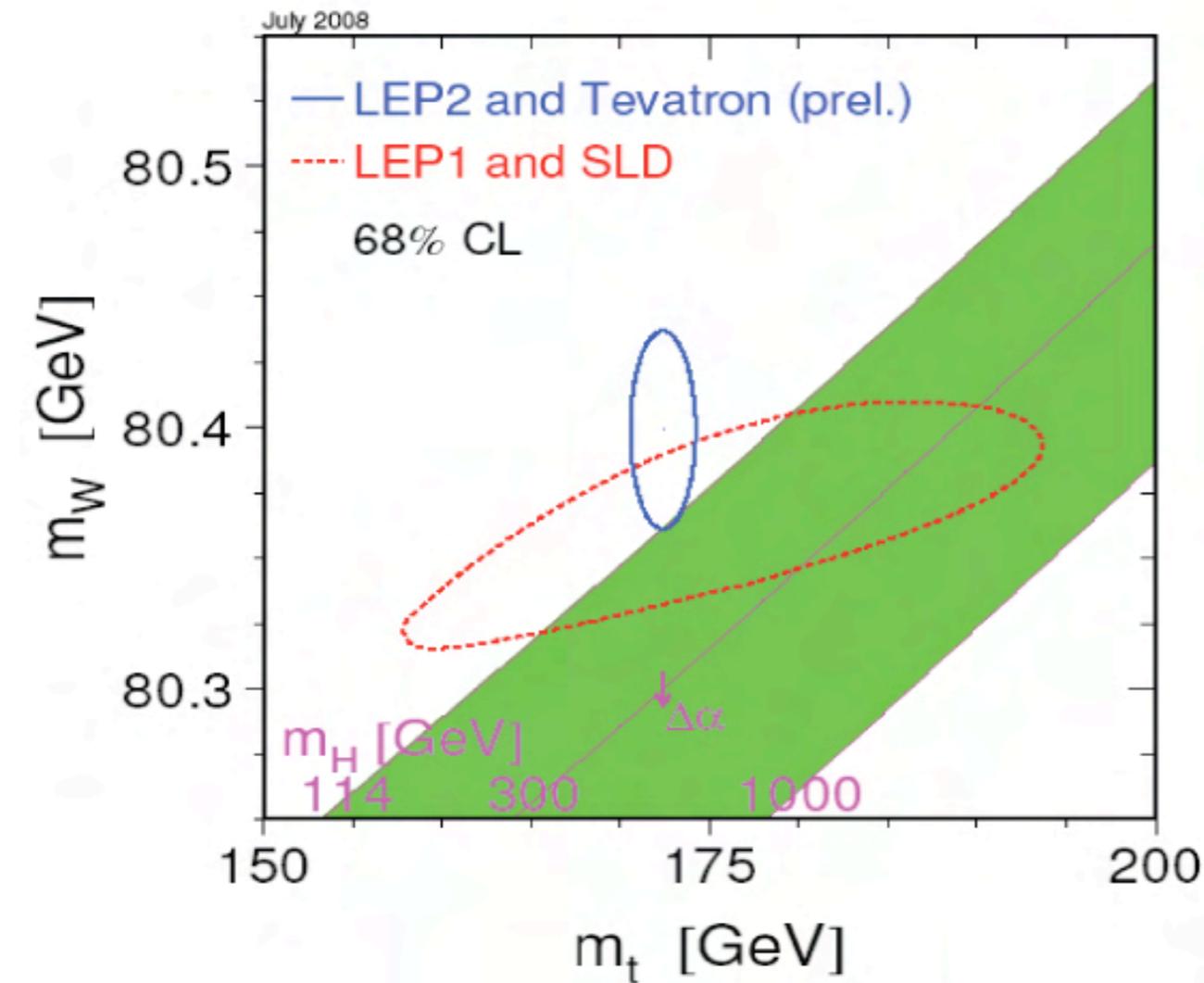


< 50 Top Events (2004)

~ 6 fb^{-1} delivered
~ 3 fb^{-1} in current analysis

Top Production

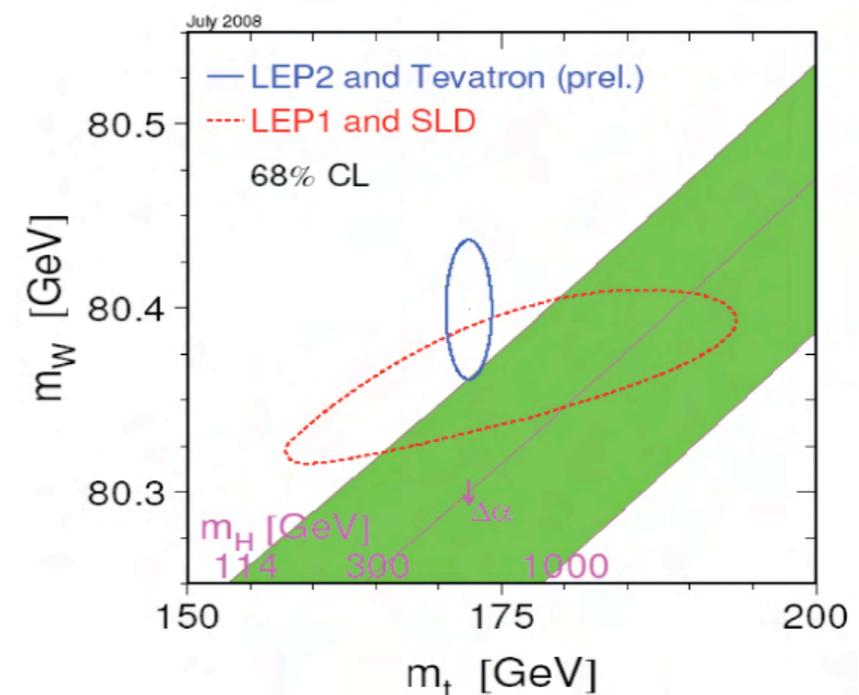
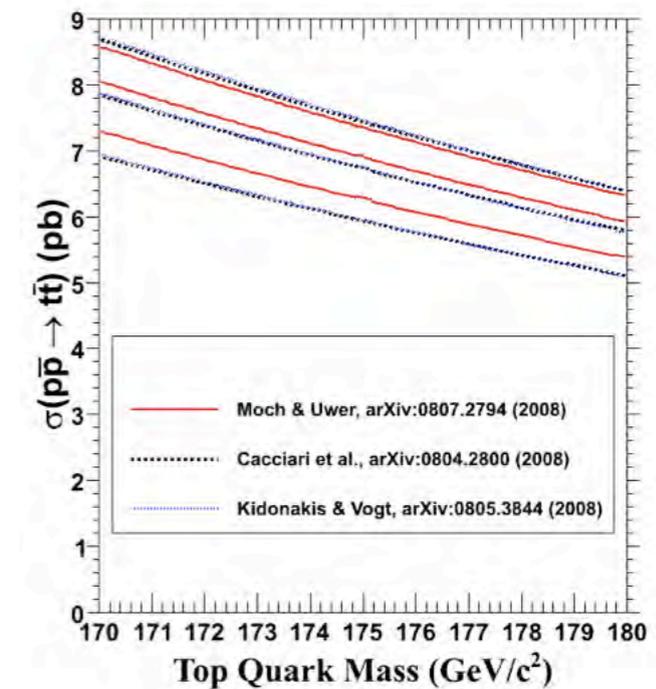
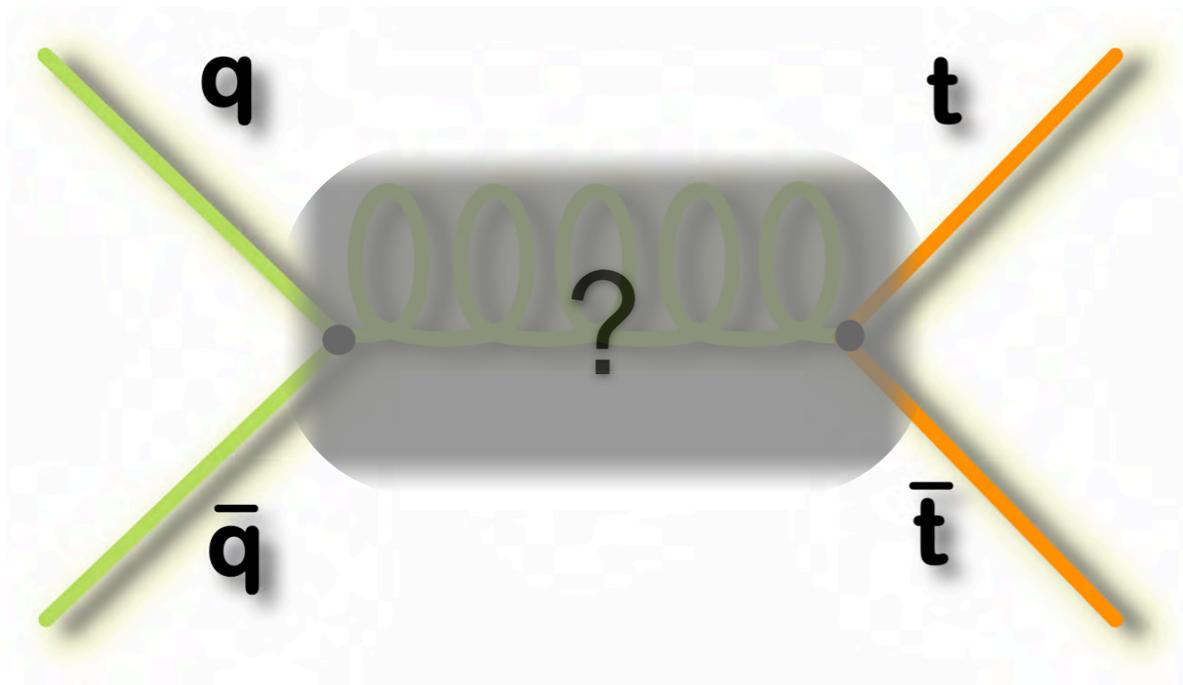
Looking for Consistency



Top Production

Looking for Consistency

- New production mechanisms can modify this picture - cross section, kinematics...
- Massive Gluons, Z' - remnants of some higher order symmetry breaking

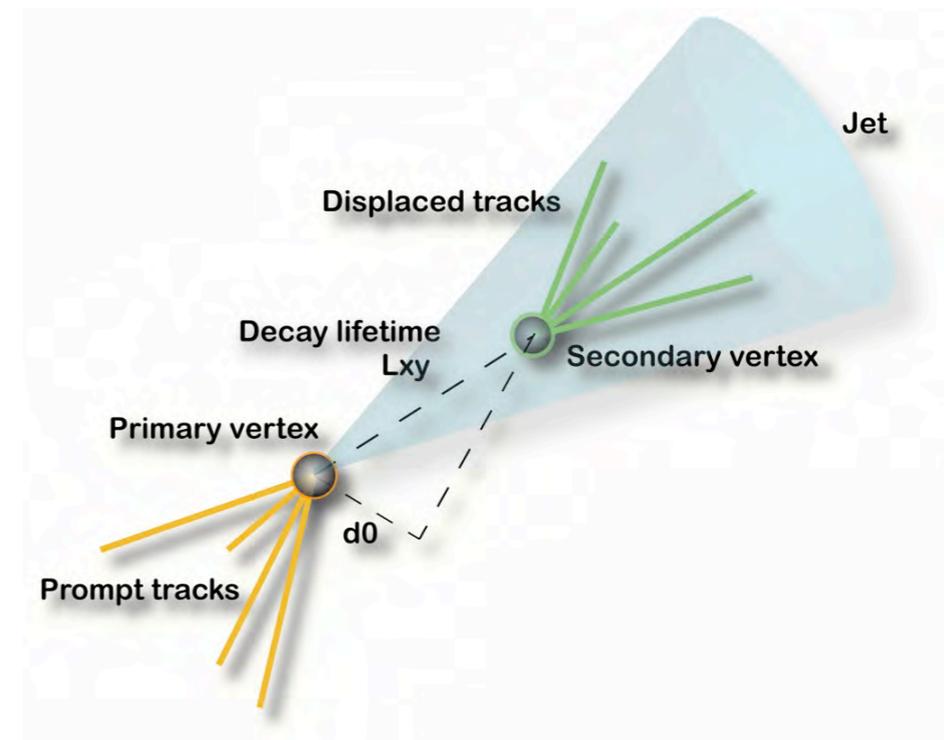




Cross Section by b-jet Identification

- Essentially a counting measurement
- Performed in the lepton + jets channel
- Require events to have a b-jet identified through secondary vertex (b-tagging)
- Rely on data as much as possible to derive backgrounds
- Largest backgrounds QCD and W-boson associated with Heavy Flavor jets

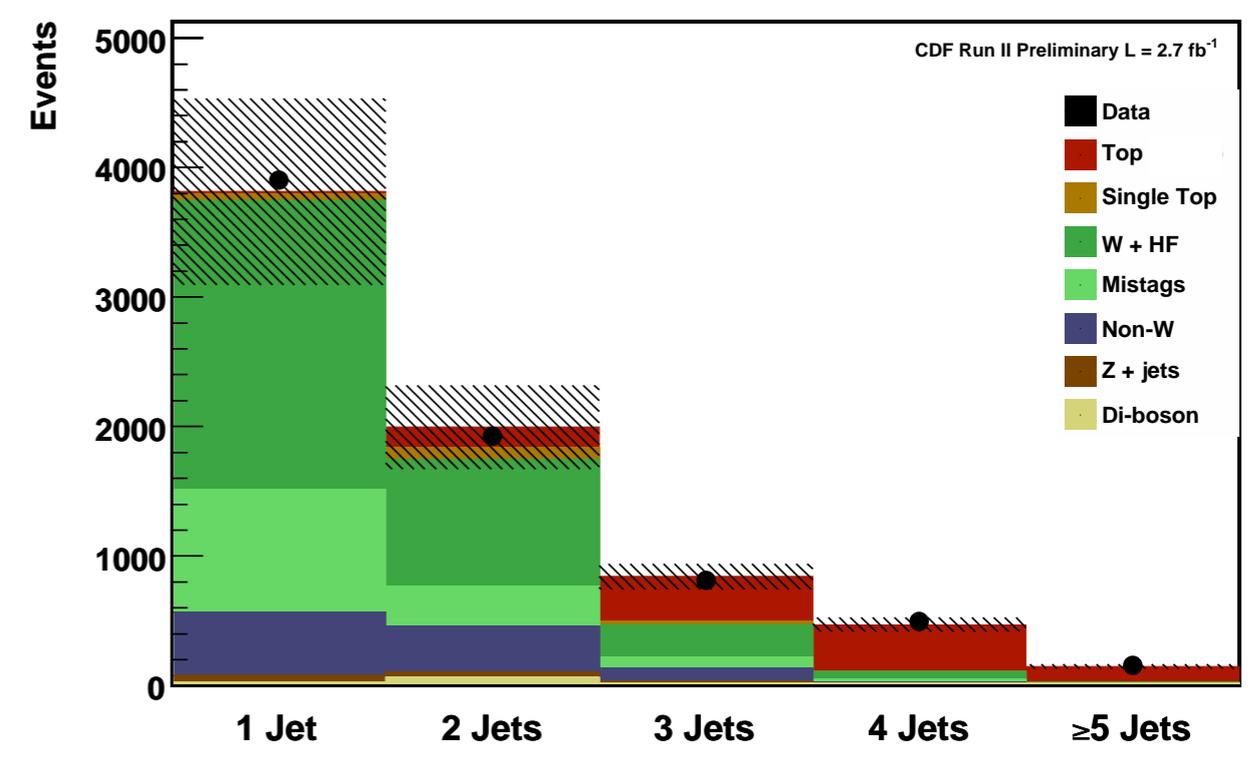
$$\sigma_{t\bar{t}} = \frac{N_{data} - N_{bkg}}{A \cdot \int \mathcal{L} dt}$$





Cross Section by b-jet Identification

- Background estimate is calculated as a function of jet multiplicity
- Events with 1 or 2 jets are a control region
- Cross Section calculated from events with ≥ 3 jets



$$\sigma_{t\bar{t}} = 7.1 \pm 0.4_{\text{stat}} \pm 0.6_{\text{sys}} \pm 0.4_{\text{lum}} \text{ pb}$$

@ $M_t = 175 \text{ GeV}/c^2$

$$\frac{\Delta\sigma}{\sigma} = 11.6\%$$



Cross Section by b-jet Identification

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Largest Systematics

- Correction on W+HF Monte Carlo (4%)
- Correction on b-tagging in Monte Carlo (6%)
- Luminosity (6%)

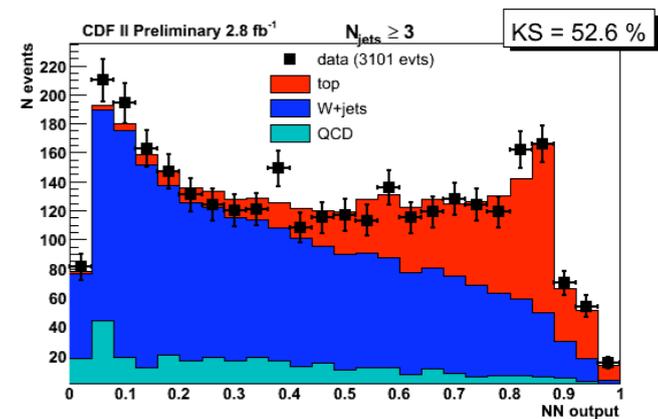
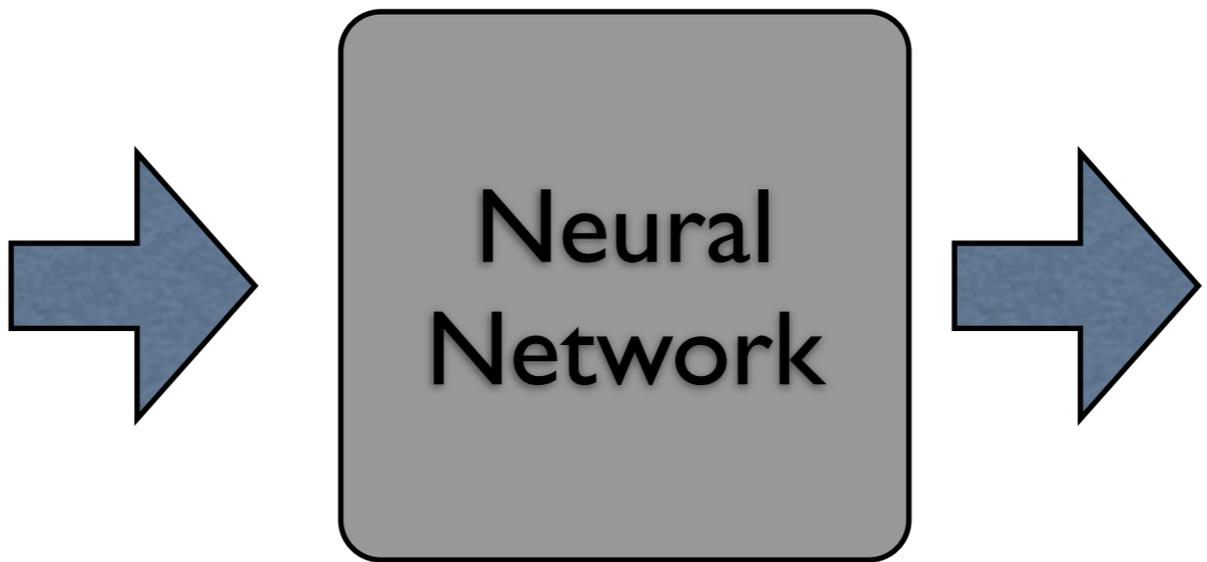
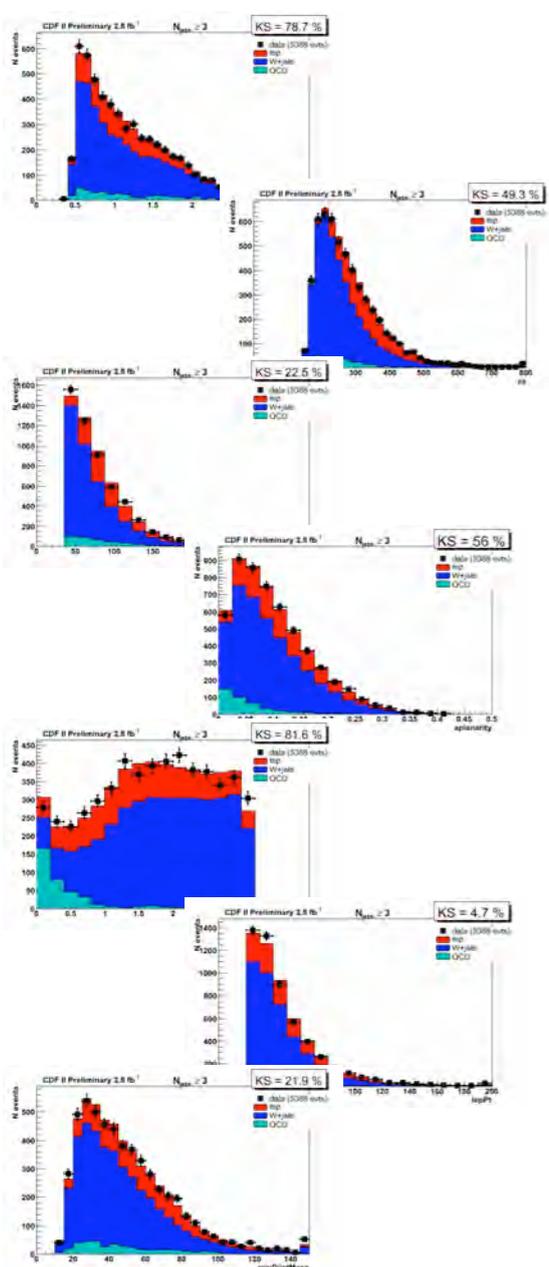


$$\sigma_{t\bar{t}} = 7.1 \pm 0.4_{\text{stat}} \pm 0.6_{\text{sys}} \text{ pb}$$

@ $M_t = 175 \text{ GeV}/c^2$

$$\frac{\Delta\sigma}{\sigma} = 11.6\%$$

Top Cross Section using Event Kinematics



- Rely on identifying top events through kinematics as opposed to b-jet identification
- Feed distributions into Neural Net, trained to distinguish signal from background and fit templates to data



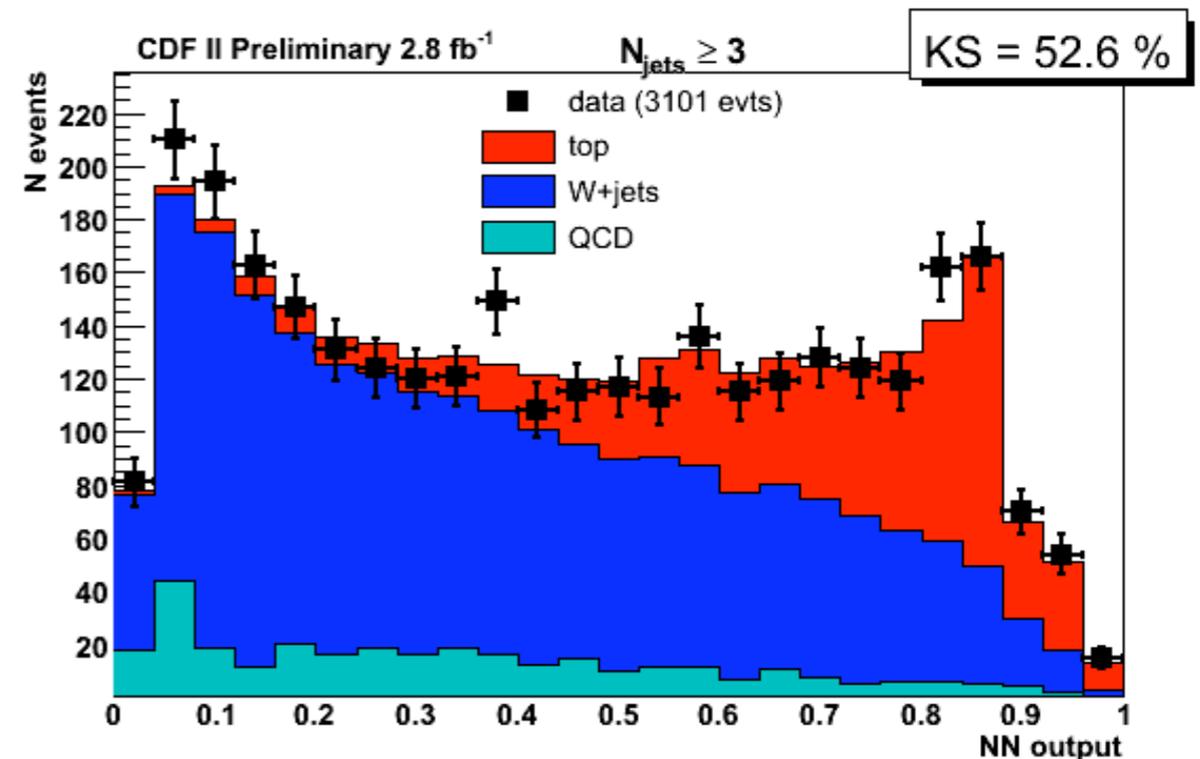
Top Cross Section using Event Kinematics

- Fit result yields cross section

$$\sigma_{t\bar{t}} = 7.0 \pm 0.4_{\text{stat}} \pm 0.4_{\text{sys}} \pm 0.4_{\text{lum}} \text{ pb}$$

@ $M_t = 175 \text{ GeV}/c^2$

$$\frac{\Delta\sigma}{\sigma} = 10\%$$



- Topological approach does not rely on b-jet identification, therefore eliminating the last measurements larger systematics
- Largest systematics - Luminosity (6%) and Jet Energy Scale (3%)



Reducing the Luminosity Systematic

- Luminosity is the largest systematic (6%) for both cross section measurements
- Can employ a common technique in electroweak physics and measure the top cross section relative to the Z cross-section
- Z Cross section measured with same amount of data

$$\sigma_{\gamma^*/Z} = 253.5 \pm 1.1_{\text{stat}} \pm 4.5_{\text{sys}} \pm 14.9_{\text{lum}} \text{ pb}$$

$$\sigma_{\gamma^*/Z}^{\text{theory}} = 251.3 \pm 5.0_{\text{scales/pdf}} \text{ pb}$$

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Top Cross Section

$$\sigma_{t\bar{t}} = R \cdot \sigma_Z^{theory}$$

b-jet

$$\sigma_{t\bar{t}} = 7.0 \pm 0.4_{\text{stat}} \pm 0.6_{\text{sys}} \pm 0.1_{\text{theory}} \text{ pb}$$

$$\frac{\Delta\sigma}{\sigma} = 10\%$$

Kinematic

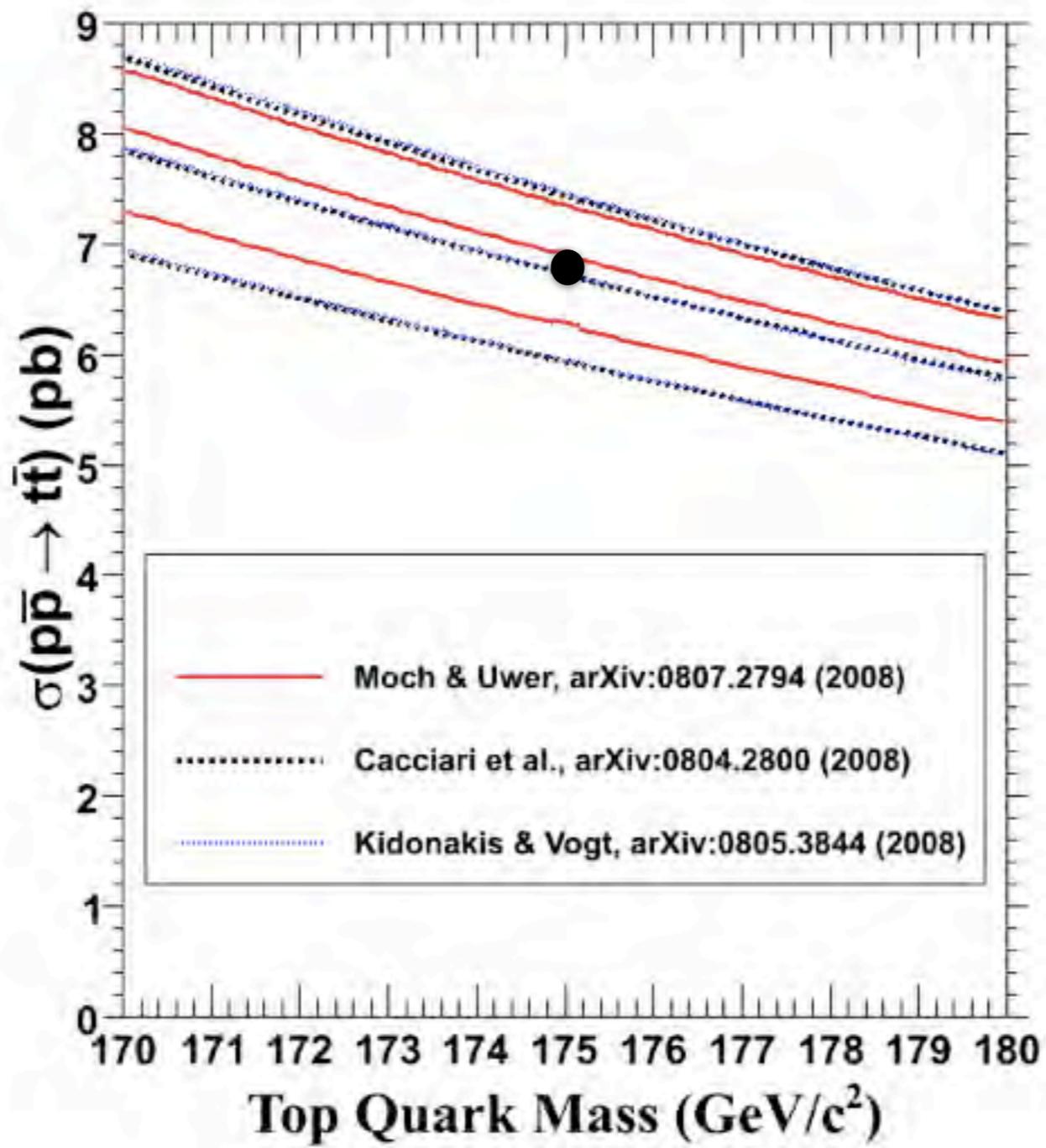
$$\sigma_{t\bar{t}} = 6.9 \pm 0.4_{\text{stat}} \pm 0.4_{\text{sys}} \pm 0.1_{\text{theory}} \text{ pb}$$

$$\frac{\Delta\sigma}{\sigma} = 8\%$$

Theory

$$\sigma = 6.73^{+0.72}_{-0.63} \text{ pb}$$

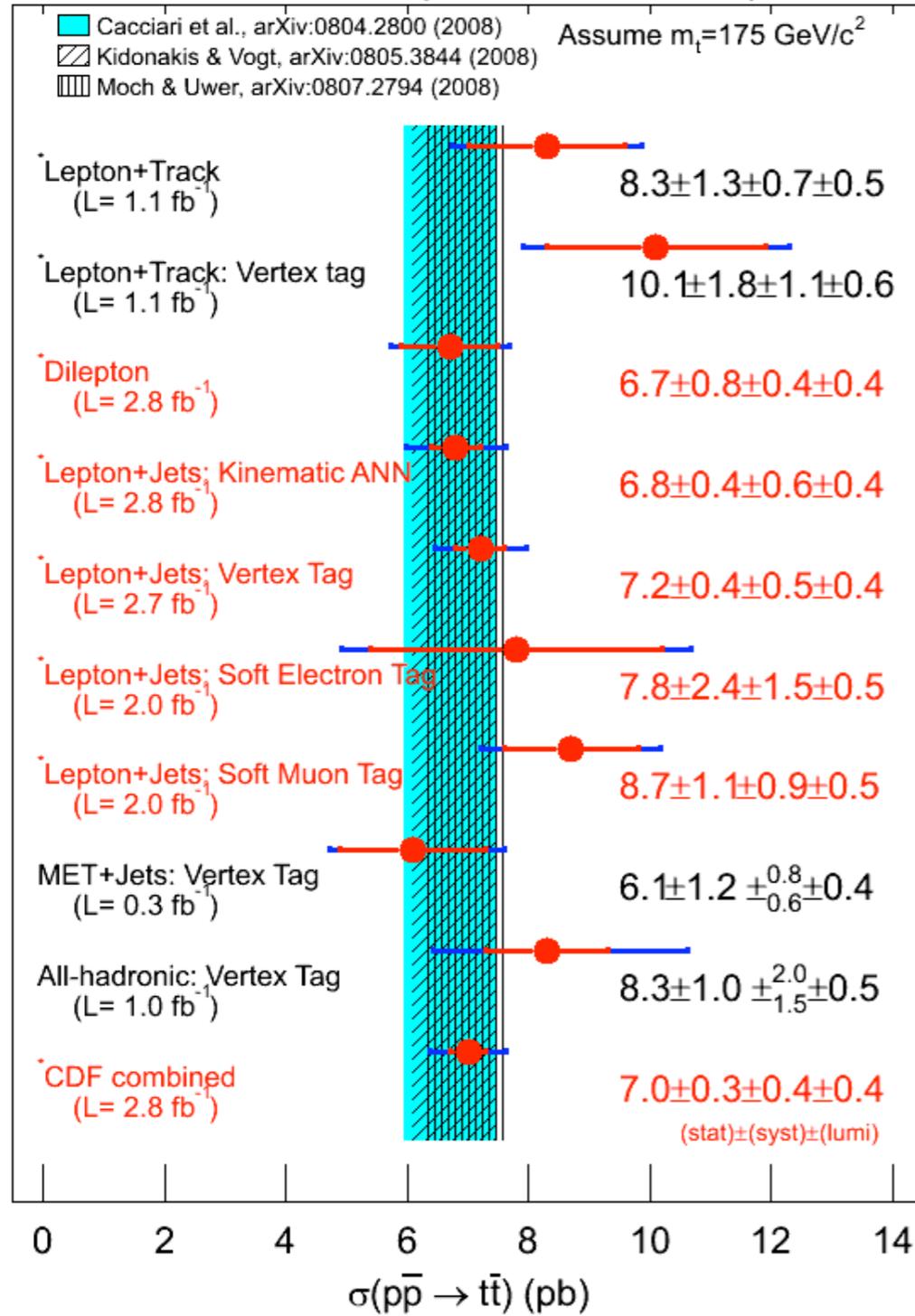
Cacciari et al, hep-ph/0804.2800 (2008)
@ $M_t = 175 \text{ GeV}/c^2$





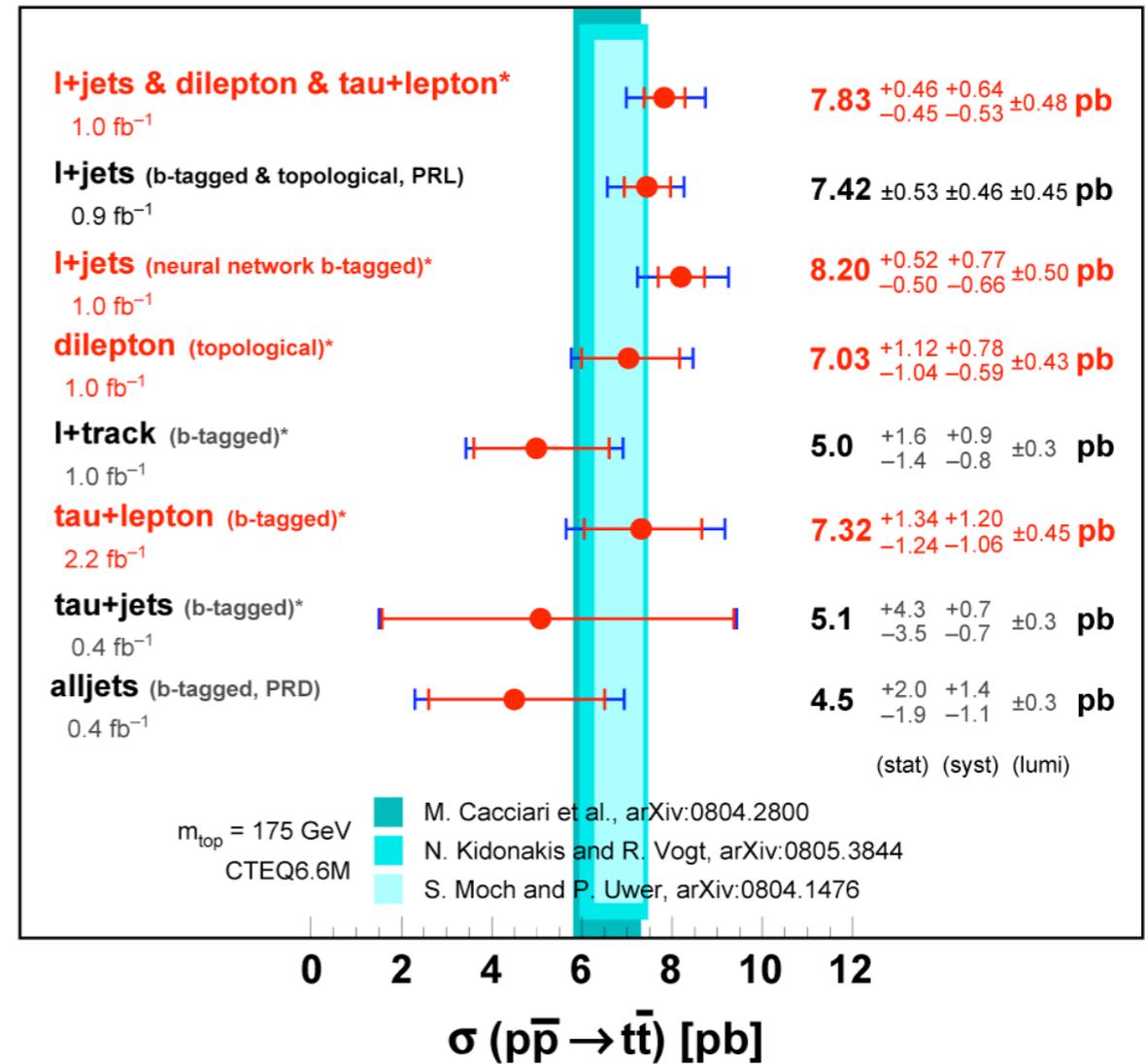
CDF Run II Preliminary

July 2008



DØ Run II * = preliminary

August 2008

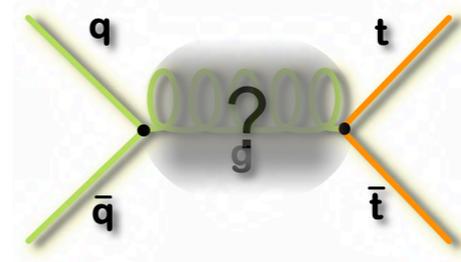


Good Agreement Across Channels & Experiment

Resonant Top Production

- Looking for Z' , Massive Gluon (new color octet)

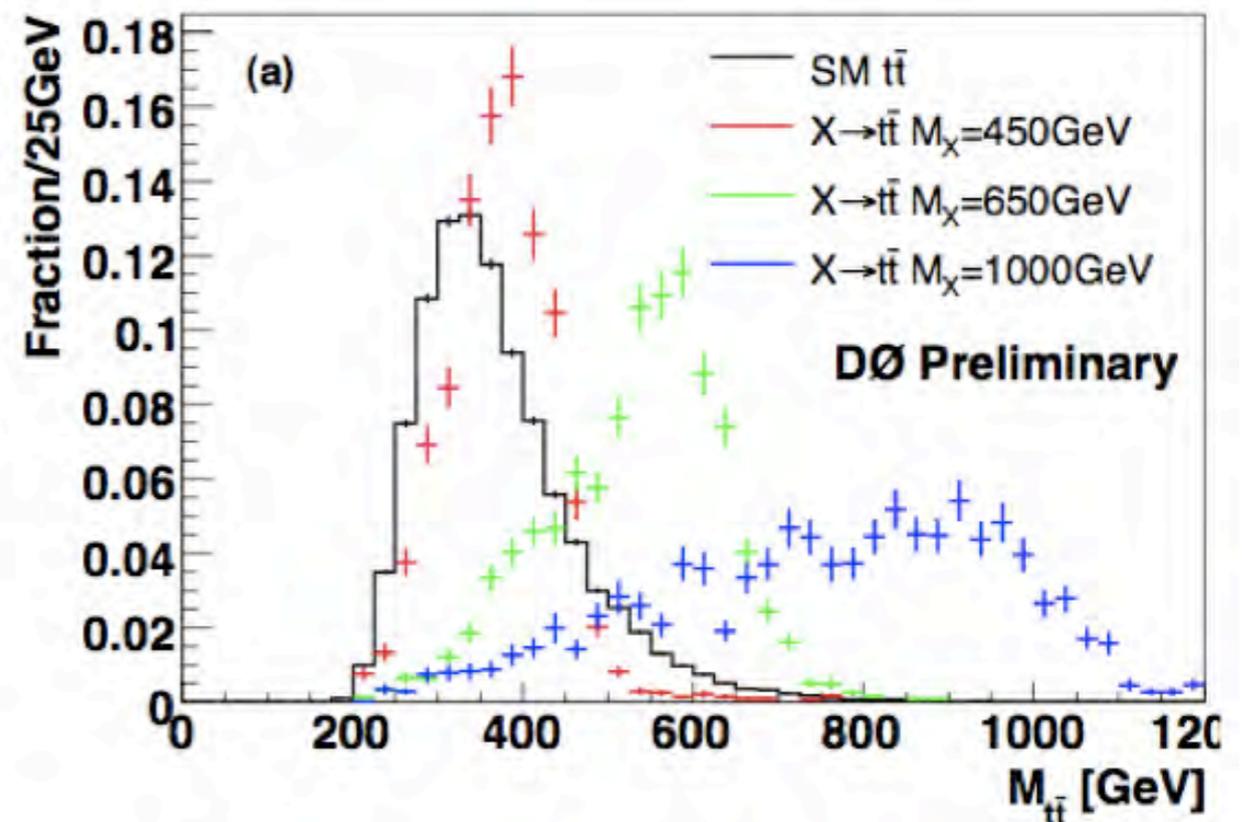
- More direct search then cross section



- Search in mass spectrum of the $t\bar{t}$ system

- Mass of the system fully reconstructed for each event

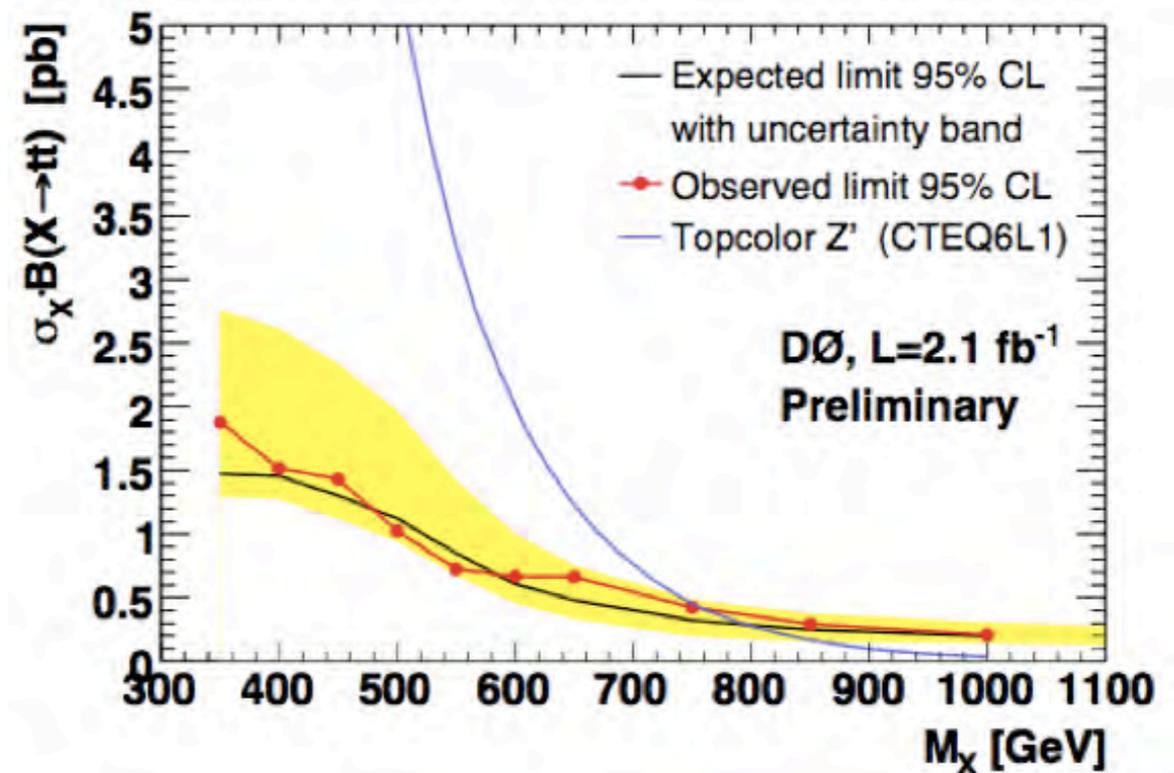
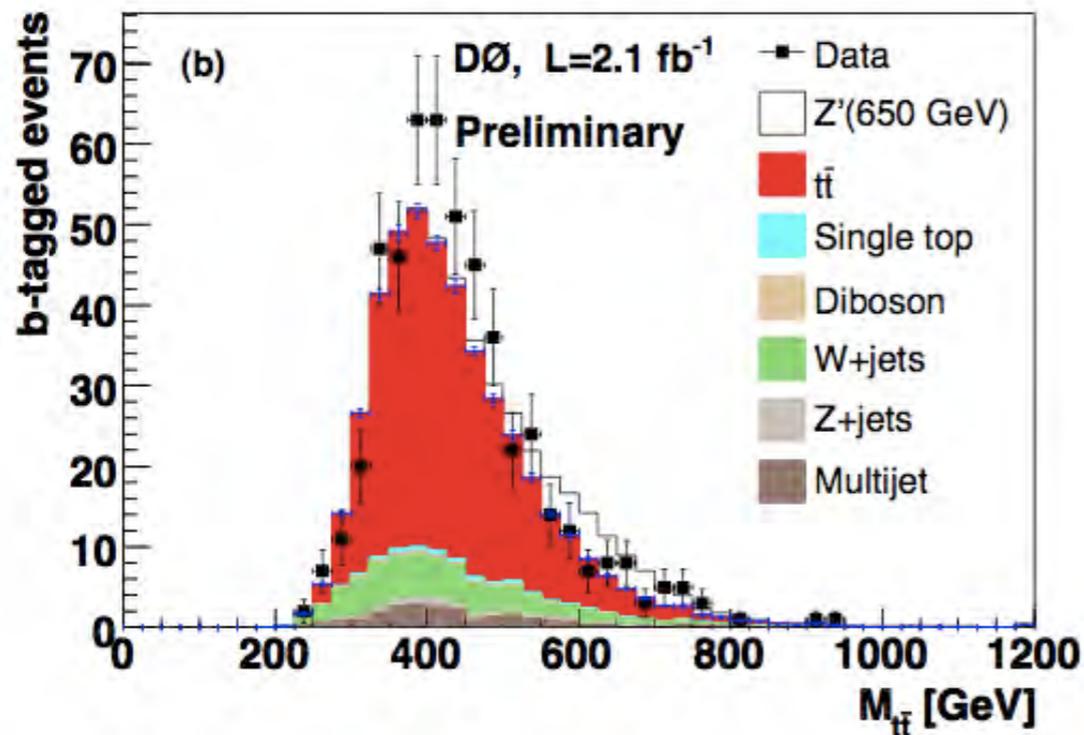
- Narrow resonance templates formed from Monte Carlo and fit to data



Resonant Top Production

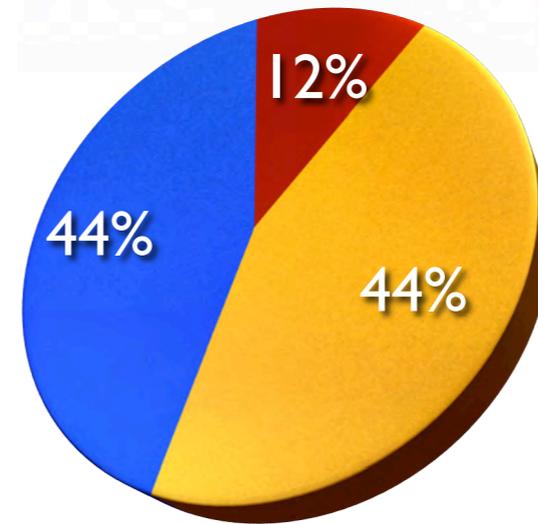
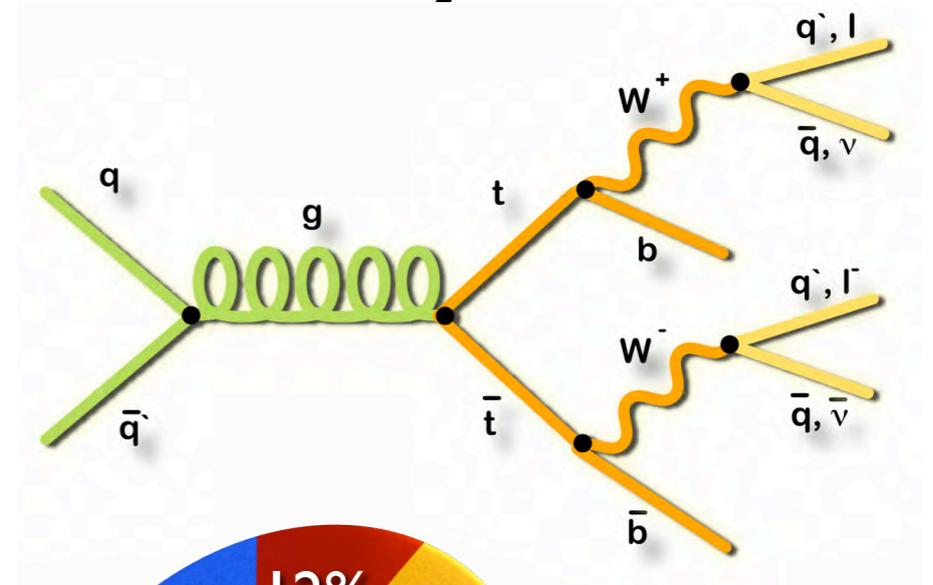
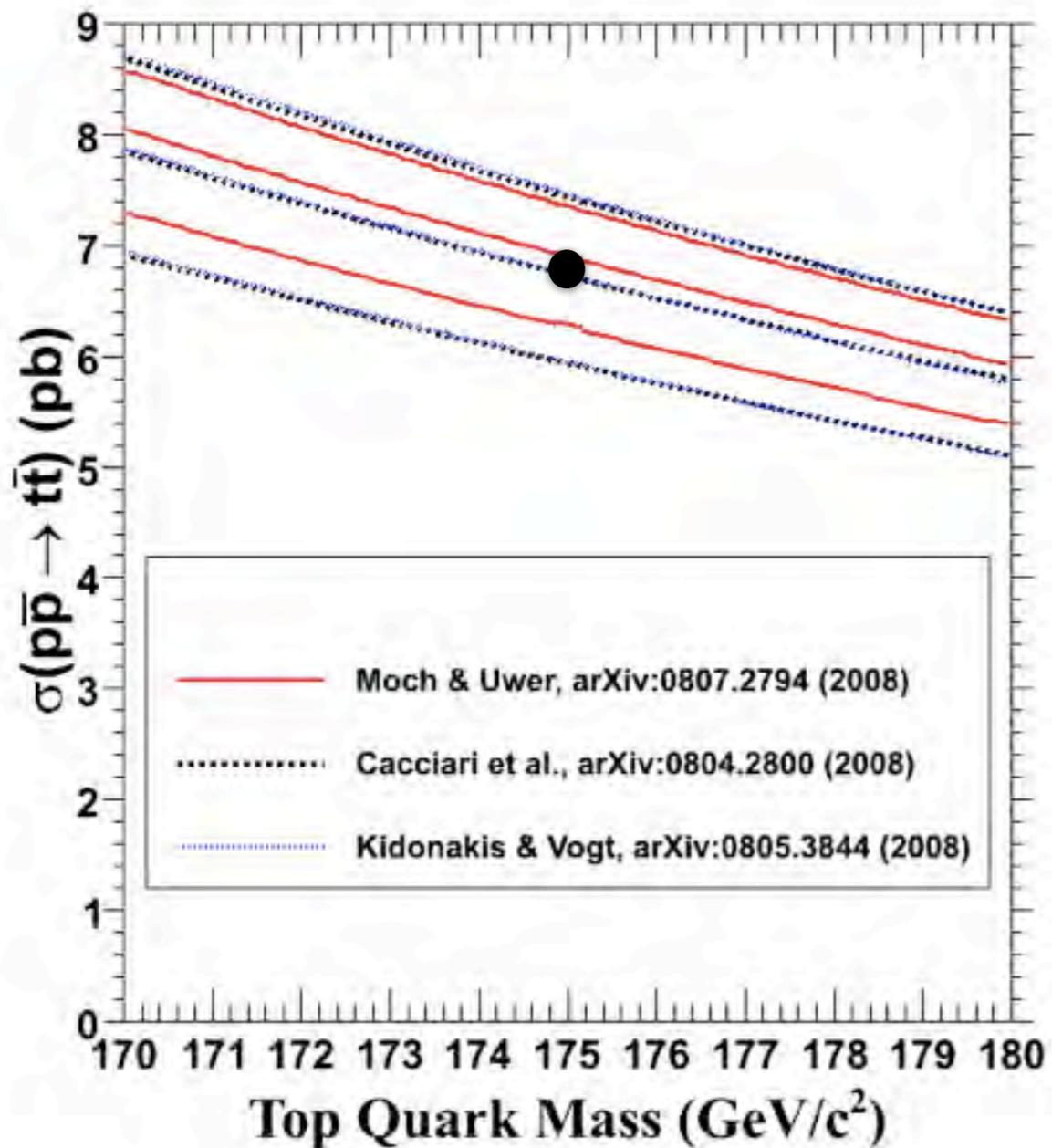
- Fit to data performed across several mass points
- Using narrow width topcolor model for expected cross section
- $M_{Z'} > 760$ GeV at 95% CL

CDF Result: $M_{Z'} > 720$ GeV at 95% CL in 0.9 fb⁻¹



Top Decay

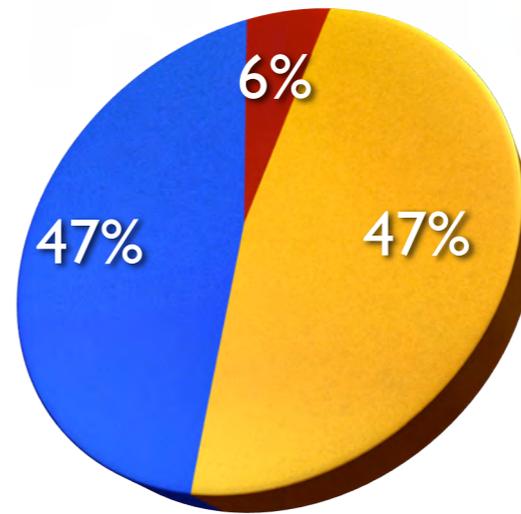
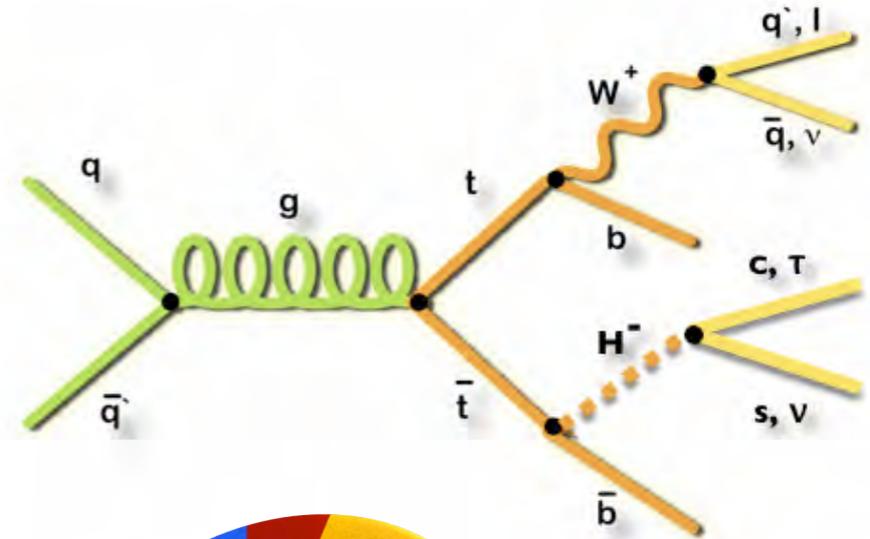
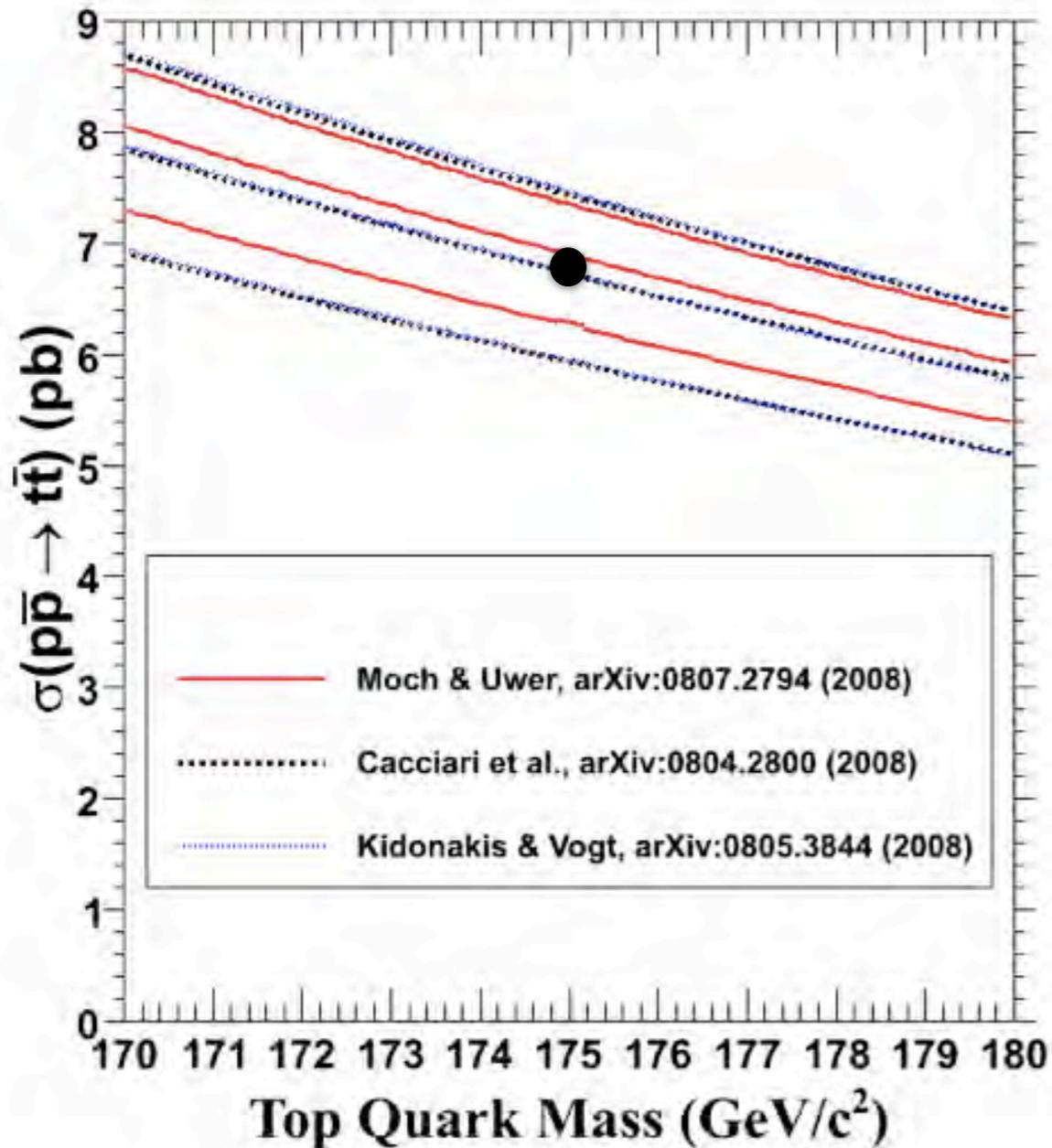
Looking for Consistency



- Di-lepton ($W \rightarrow lv \quad W \rightarrow lv$)
- Lepton + Jets ($W \rightarrow lv \quad W \rightarrow qq$)
- All-hadronic ($W \rightarrow qq \quad W \rightarrow qq$)

Top Decay

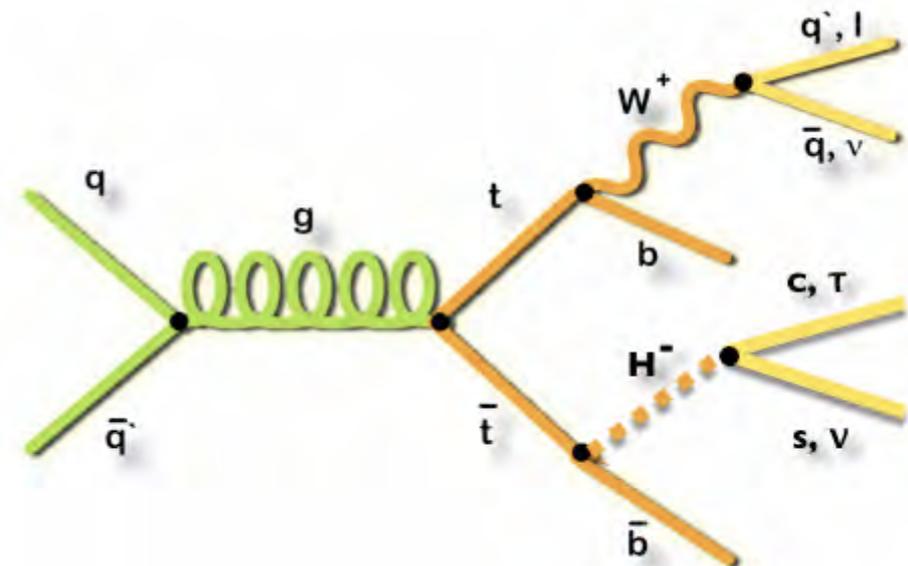
Looking for Consistency



- 6% Di-lepton ($W \rightarrow l\nu$ $W \rightarrow l\nu$)
- 47% Lepton + Jets ($W \rightarrow l\nu$ $W \rightarrow qq$)
- 47% All-hadronic ($W \rightarrow qq$ $W \rightarrow qq$)

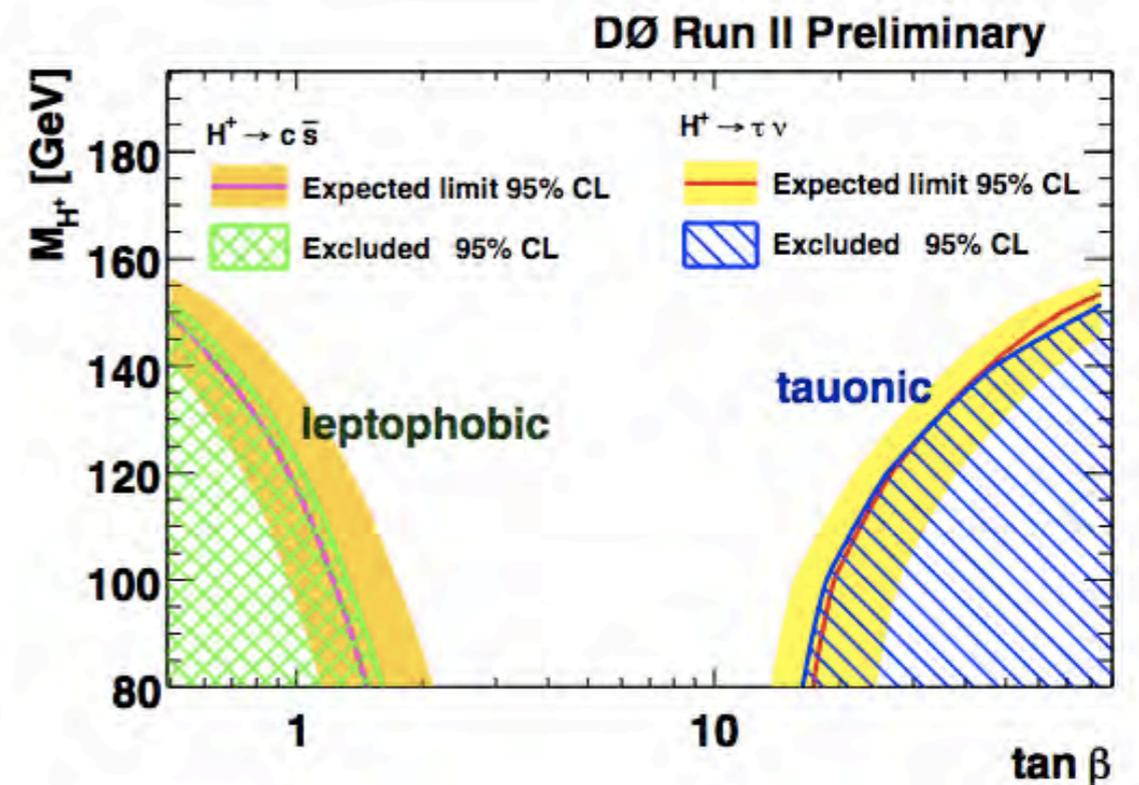
Search for Charged Higgs

- Relative rates of cross sections across decay channels could be modified if top is decaying to charged Higgs
- Use events across three channels: lepton + jets, dilepton, and τ + jets
- Consider two models: $H^+ \rightarrow \tau\nu$ and $H^+ \rightarrow cs$
- Compare cross sections in above three channels yields limit on models
- Limits placed on charged Higgs in pure leptophobic (MHDM) or tauonic models (MSSM $\gg \tan \beta$)



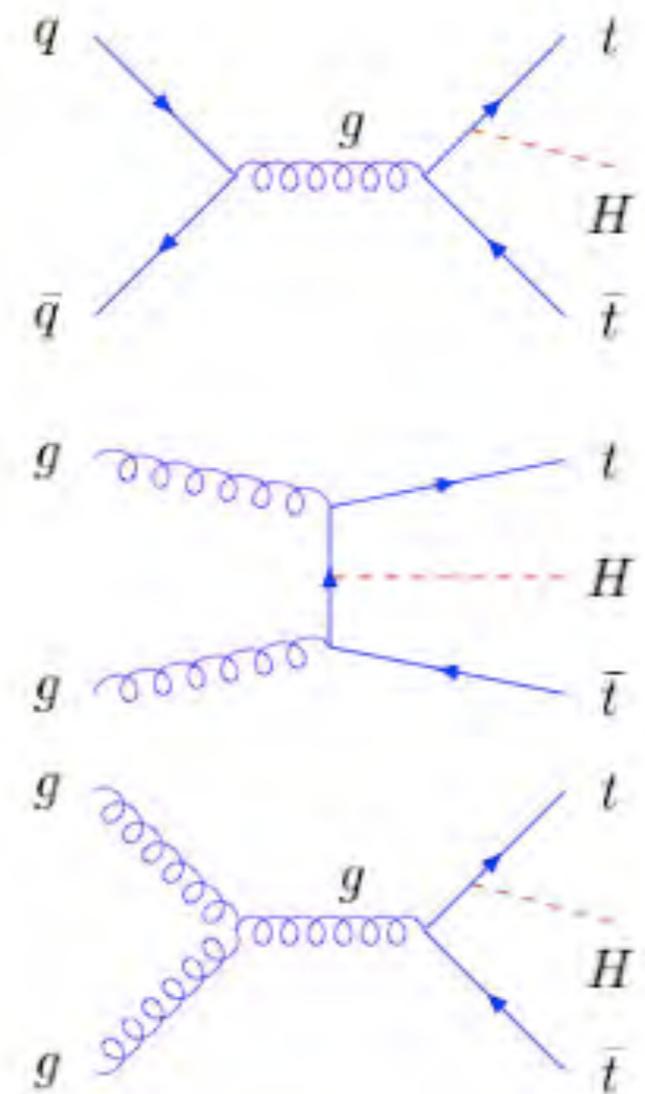
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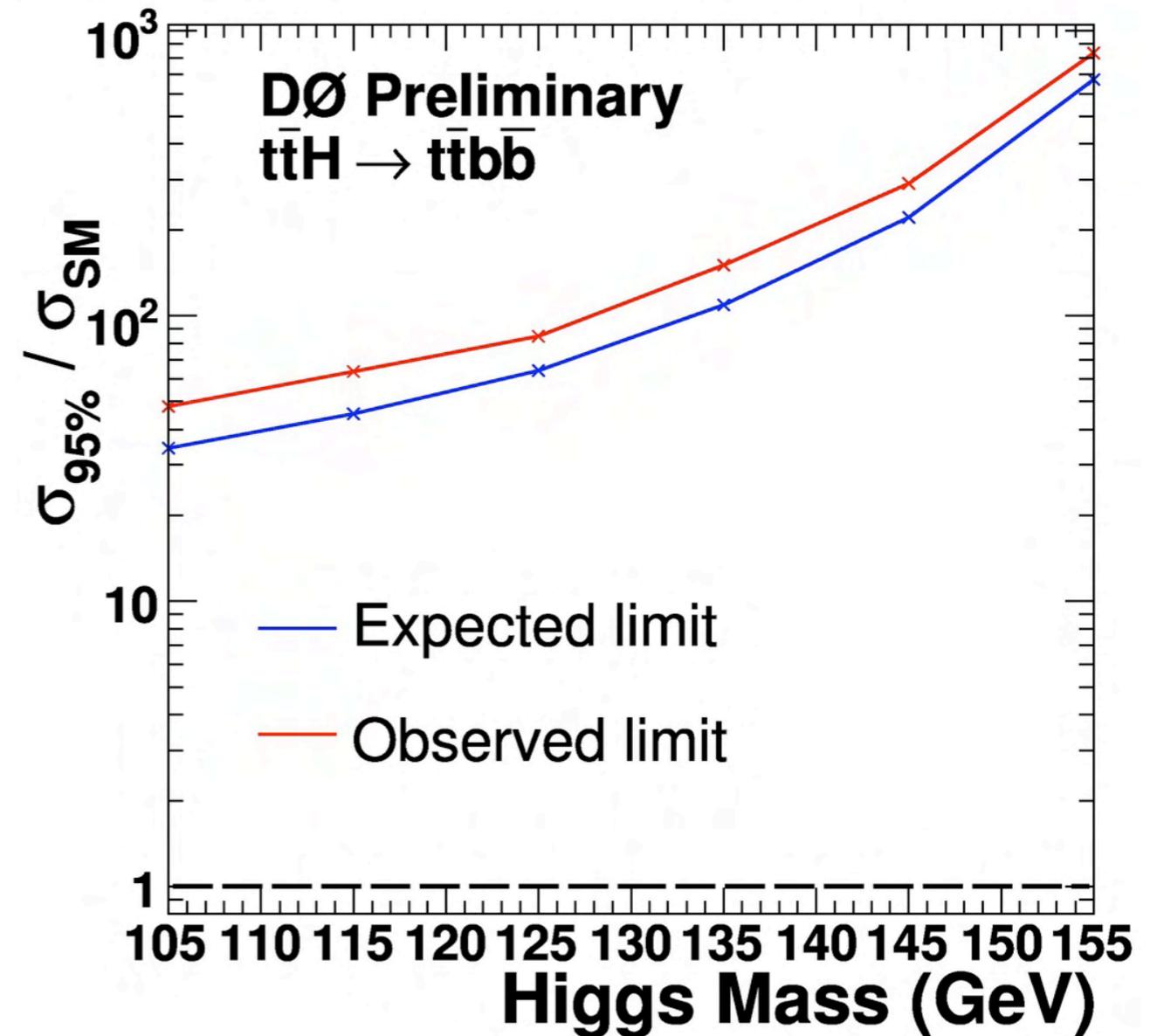
Search for $t\bar{t}H \rightarrow t\bar{t}b\bar{b}$

- Searching for Standard Model Higgs in association with top production
- $\sigma \cdot \text{BR}$ is very low, but interesting channel to search for deviations from SM
- Distinguish signal from background using:
 - Scalar sum of transverse energy - H_T
 - The number of jets
 - Track Parameters
 - The number of b-jets in the event (Neural Network Identification)



Search for $t\bar{t}H \rightarrow t\bar{t}b\bar{b}$

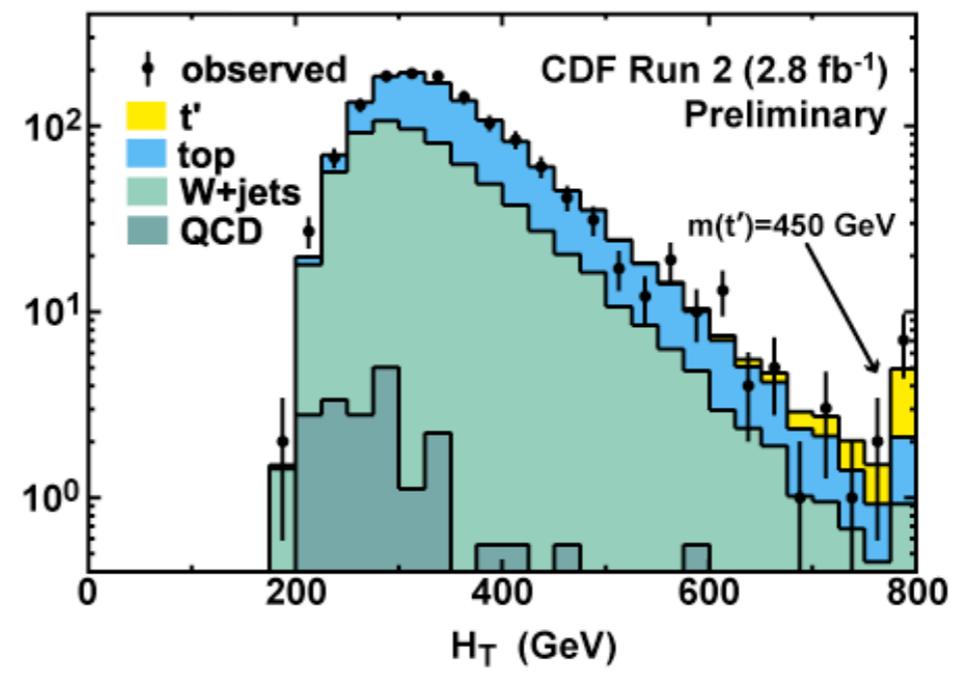
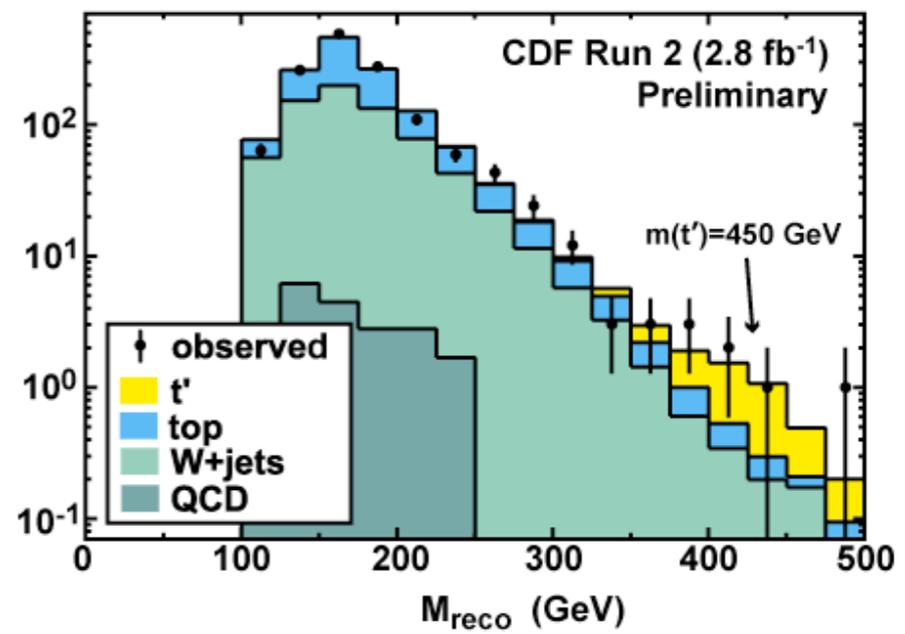
- No observed deviation from SM expectation
- Observed Limit at $M_H = 115$ GeV
64 times larger than SM prediction
- Result contributes in CDF/DØ combined search





Search for Fourth Generation Top

- Search for heavy top (t') quark decaying to Wq final state
- 4th generation present in little Higgs and beautiful mirrors models
- Reconstruct mass of top from kinematic constraints
- Use reconstructed mass and scalar sum of transverse energy in the detector (H_T) to discriminate top from t'



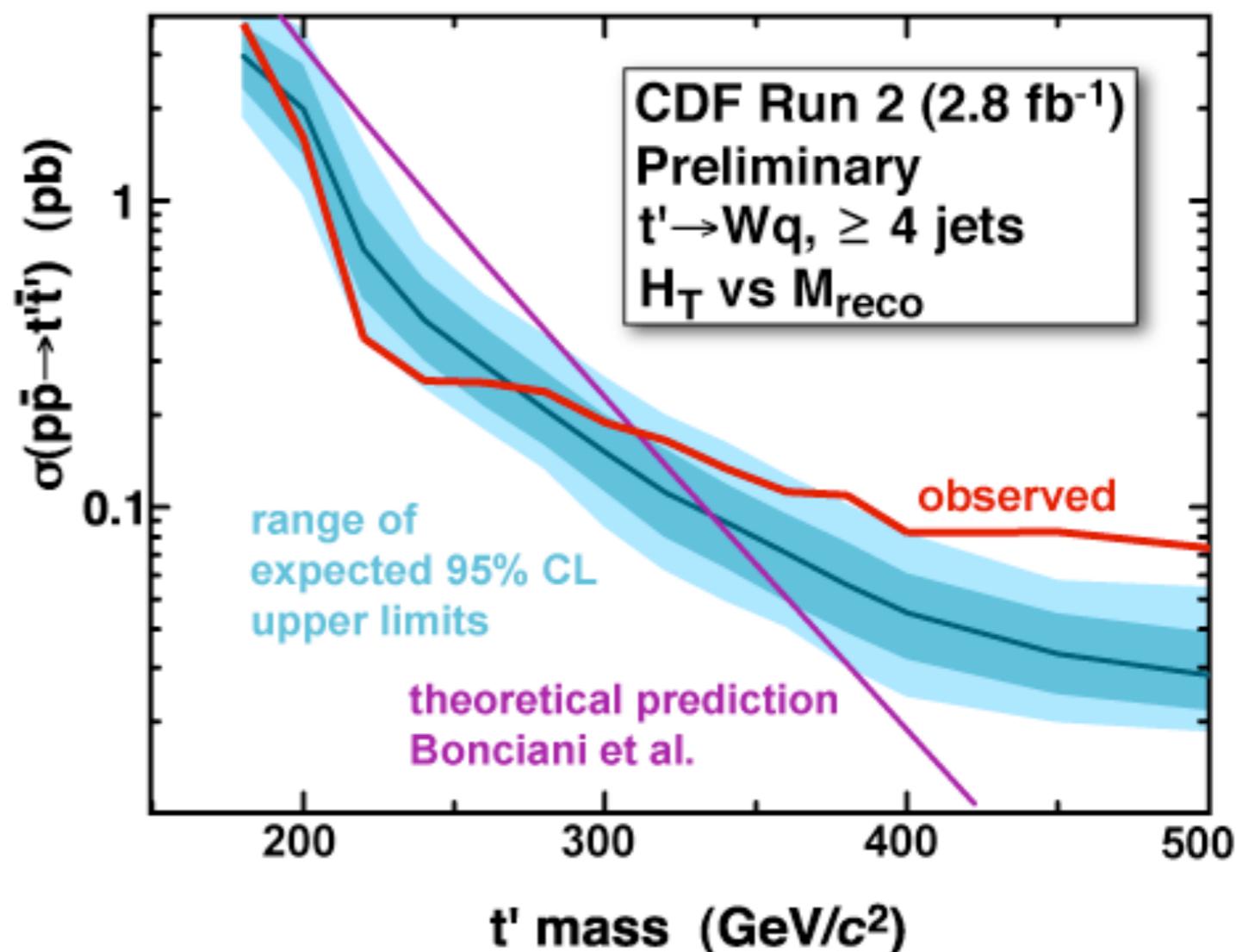


Search for Fourth Generation Top

- Perform 2D Likelihood fit using the reconstructed mass and H_T

Exclude

$M_{t'} < 311 \text{ GeV}$ at 95% CL

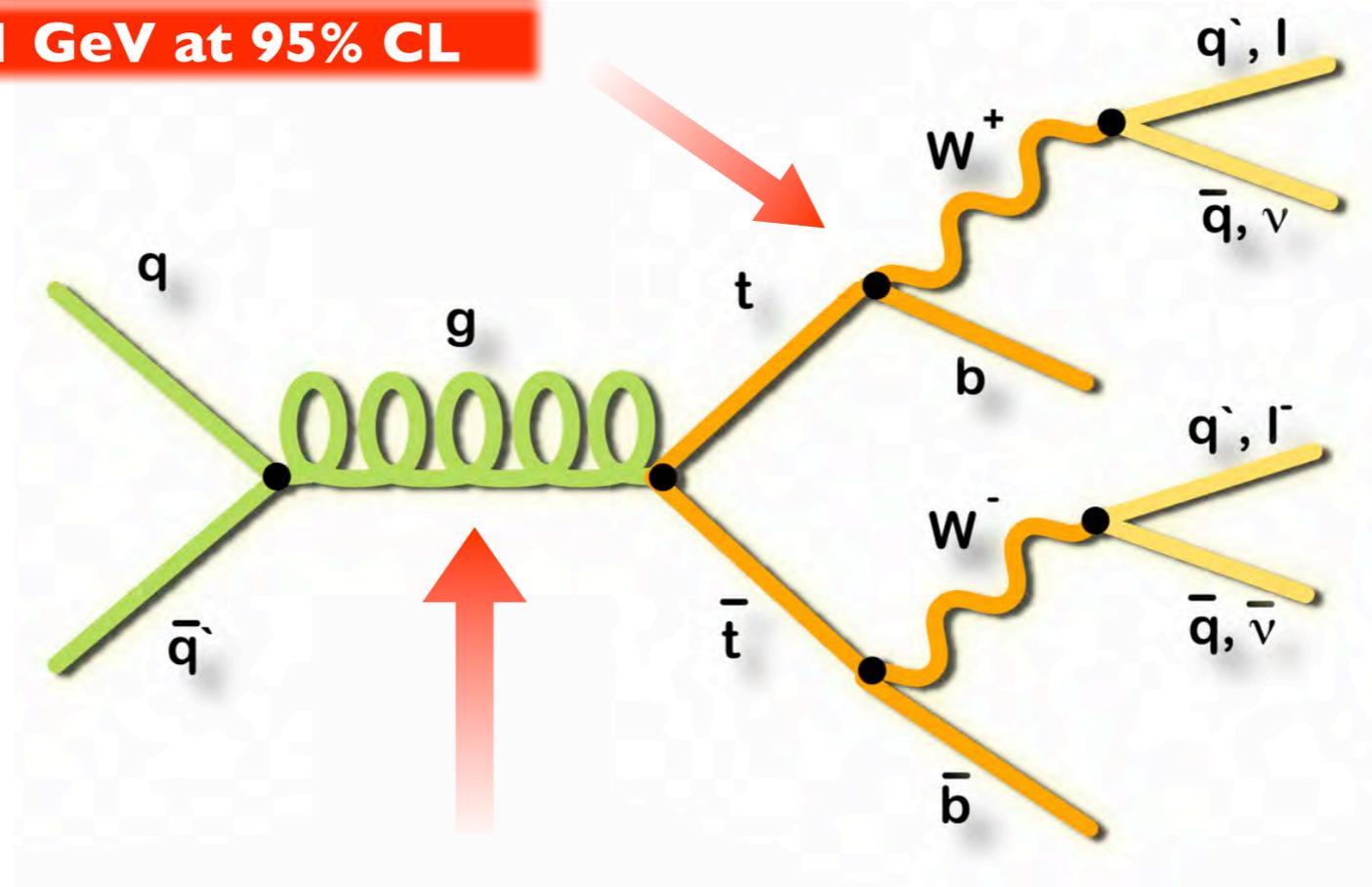




No evidence for top decay to H^+b

No evidence for ttH production

$M_t < 311 \text{ GeV}$ at 95% CL



$$\sigma_{t\bar{t}} = 7.0 \pm 0.4_{\text{stat}} \pm 0.6_{\text{sys}} \pm 0.1_{\text{theory}} \text{ pb}$$

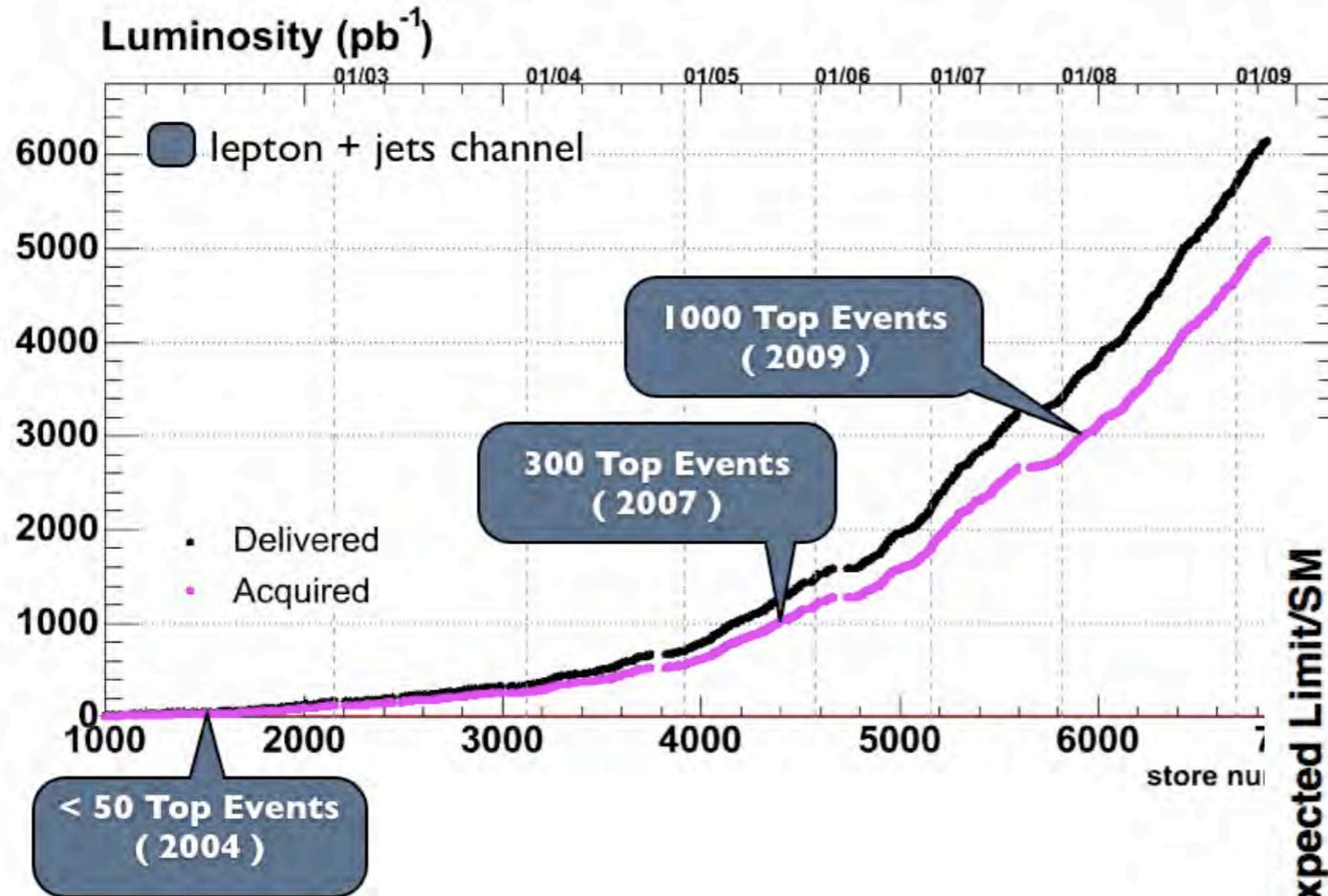
$$\sigma_{t\bar{t}} = 6.9 \pm 0.4_{\text{stat}} \pm 0.4_{\text{sys}} \pm 0.1_{\text{theory}} \text{ pb}$$

$M_Z > 760 \text{ GeV}$ at 95% CL



Visit the D0 & CDF public page for more results
http://www-d0.fnal.gov/Run2Physics/top_public_web_pages
<http://www-cdf.fnal.gov/physics/new/top/top.html>

On the Tevatron



8 weeks to get data
 < 9 months to turn an analysis

