Tevatron Searches in Top Decays

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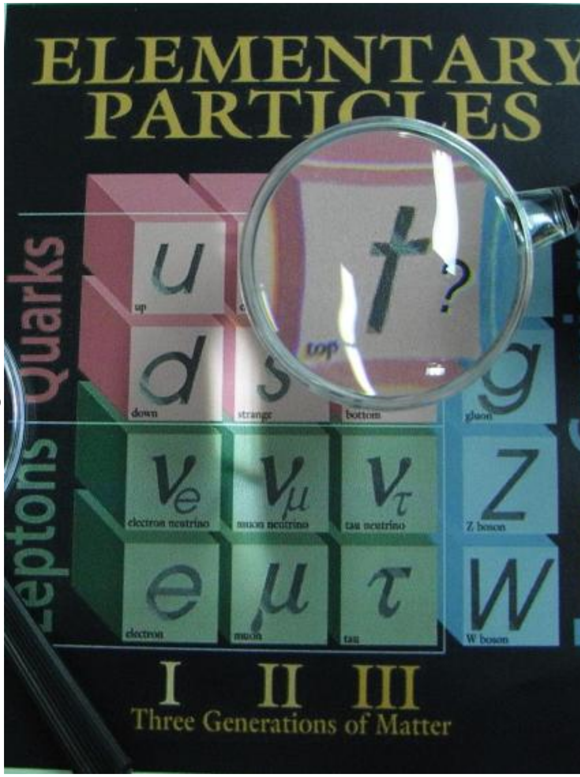
DIS 2008, London, April 09, 2008

Why Searches in Top Sample?

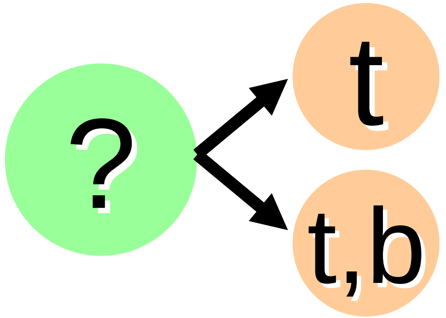
- **Top quark is really massive.**
  - Mt = 172.6 $\pm$ 1.4 GeV/c^2: arXiv:0803.1683
- **Mass of order electroweak scale**
  - Special role in Electroweak Symmetry Breaking?
- **Smallest data size in the quark sector**
  - Plenty of room for unexpected phenomena.
  - Currently, only Tevatron can make top quarks.



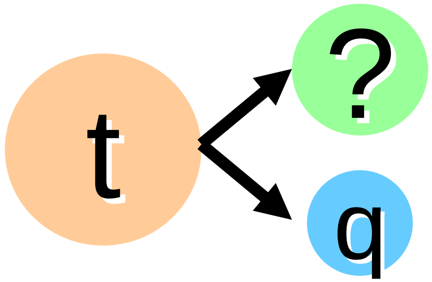
- **Many models include new physics coupling to top quark**
  - Could be sensitive to physics beyond SM.

Tevatron Searches in Top Quark

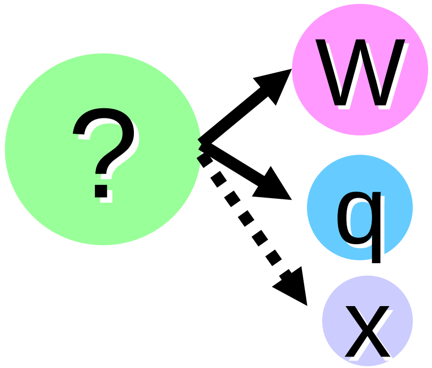
- **In SM, top quarks are dominantly produced in pairs at the Tevatron, and decay quickly to Wb.**
- **But there are lots of theoretical predictions beyond the Standard Model:**
- **Resonances decaying to top**
  - tt decay (next talk by J. Meyer)
  - tb decay: CDF & D∅



- **Exotic top quark decay**
  - Flavor Changing Neutral Current: CDF
  - Charged Higgs: D∅



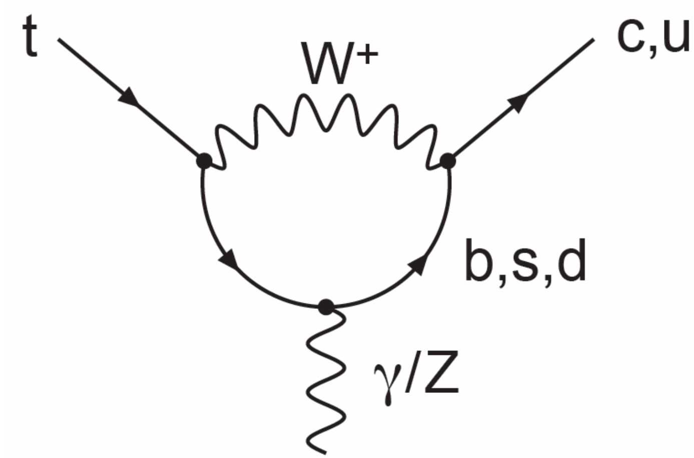
- **Mimics in top decays** **(Admixture in top sample)**
  - Heavy Top-like Quark (t’): CDF
  - Scalar Top: D∅



Top Flavor Changing Neutral Currents

- No FCNC at tree level in SM.
  - Further suppressed by GIM mechanism and CKM suppression
- Occur rarely via penguin diagrams
  - SM: BR($t \to Zq$)=$O(10^{-14})$
- Beyond SM models predict higher branching fractions
  - up to $O(10^{-4})$
- Best published limit from LEP (L3)
  - BR($t \to Zq$): 13.7%
- Any signal at the Tevatron
  $\to$ New Physics

Top FCNC Decay via Penguin Diagram

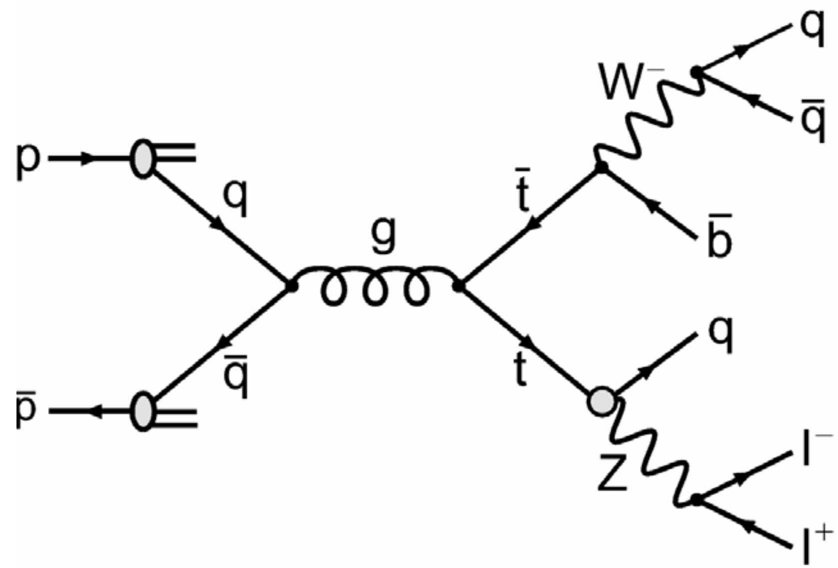


Model	BR($t \to Zq$)
Standard Model	$\mathcal{O}(10^{-14})$
$q = 2/3$ Quark Singlet	$\mathcal{O}(10^{-4})$
Two Higgs Doublets	$\mathcal{O}(10^{-7})$
MSSM	$\mathcal{O}(10^{-6})$
R-Parity violating SUSY	$\mathcal{O}(10^{-5})$

[after J.A. Aguilar-Saavedra, Acta Phys. Polor **B35** (2004) 2695]

Top FCNC Search in CDF

- Search in $t\bar{t} \to ZqWb$
  - $Z \to ee, \mu\mu$ (clean signature)
  - 4 jets (large BR of $W \to qq'$)

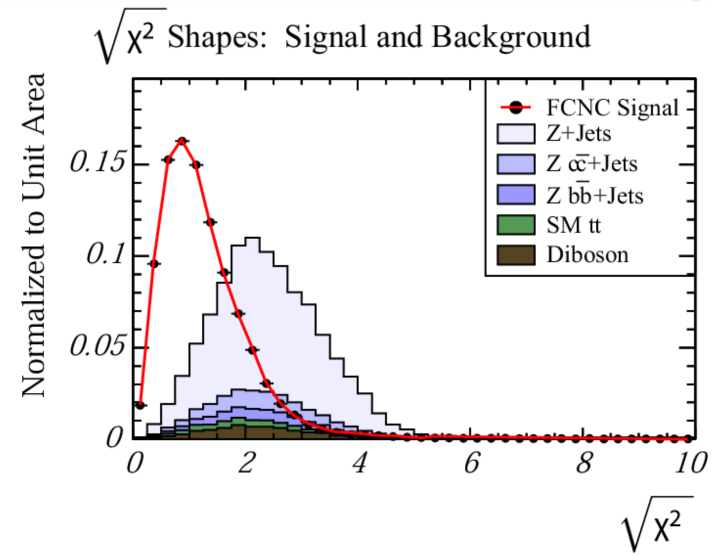


- SM backgrounds
  - Dominant: Z + jets
  - Small: $t\bar{t}$ and diboson

- Full event kinematics reconstructed

  mass χ^2 variable is used as discriminant.

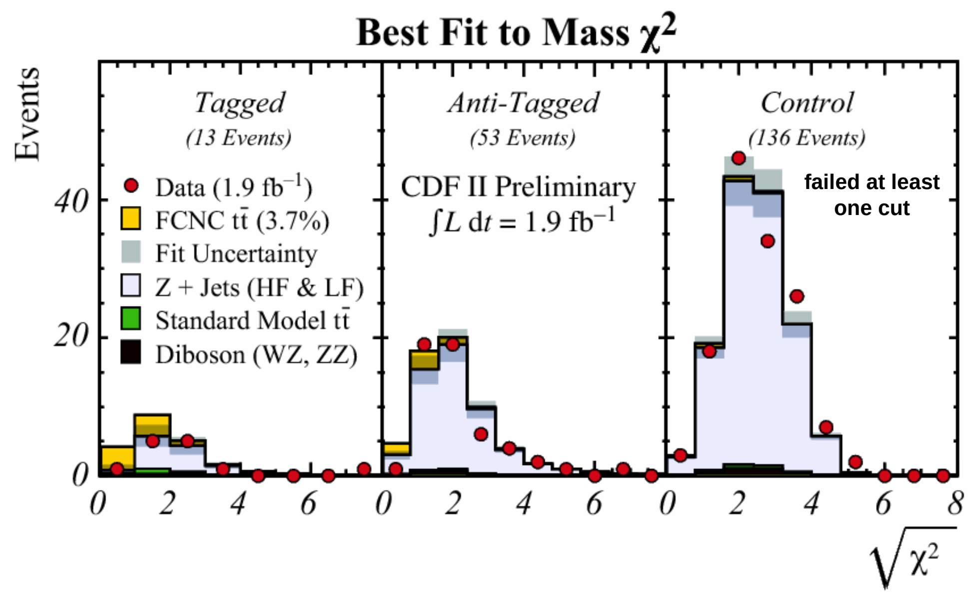
$$\chi^2 = \left(\frac{m_{W,rec} - m_{W,PDG}}{\sigma_W}\right)^2 + \left(\frac{m_{t\to Wb,rec} - m_t}{\sigma_{t\to Wb}}\right)^2 + \left(\frac{m_{t\to Zq,rec} - m_t}{\sigma_{t\to Zq}}\right)^2$$

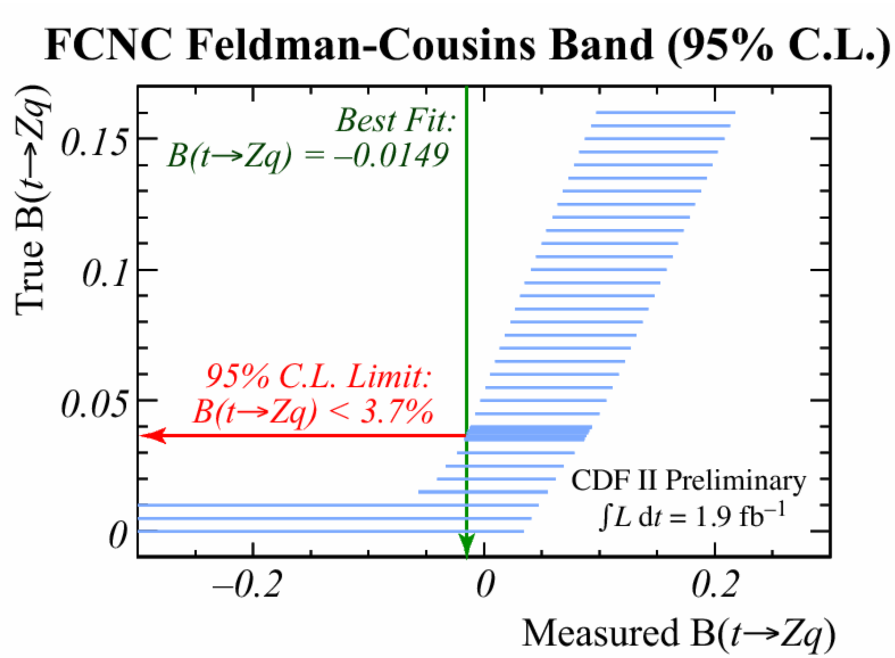


Top FCNC Search: Results

1.9 fb^{-1}

- Limit on B(t→Zq) obtained from template fit to mass χ^2.
  - Simultaneous fit to two signal regions and one control region
  - Feldman-Cousins limit with systematic uncertainties

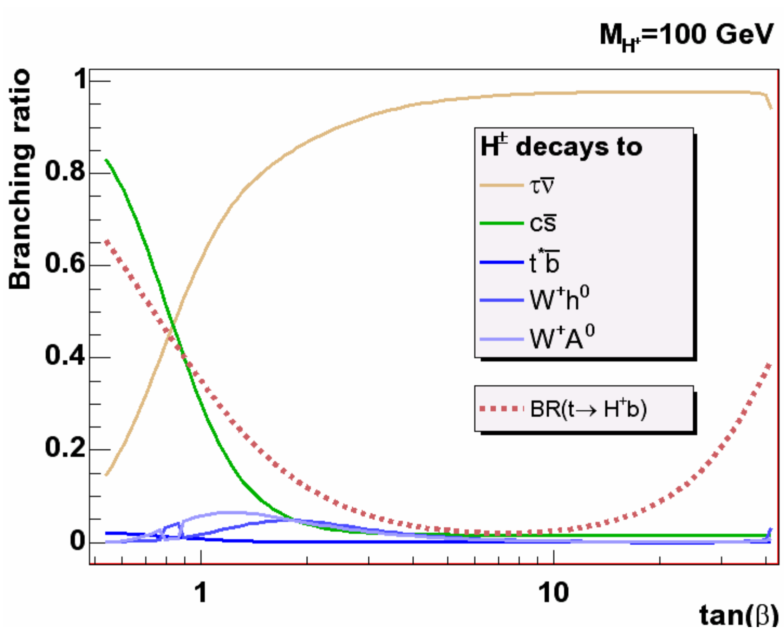


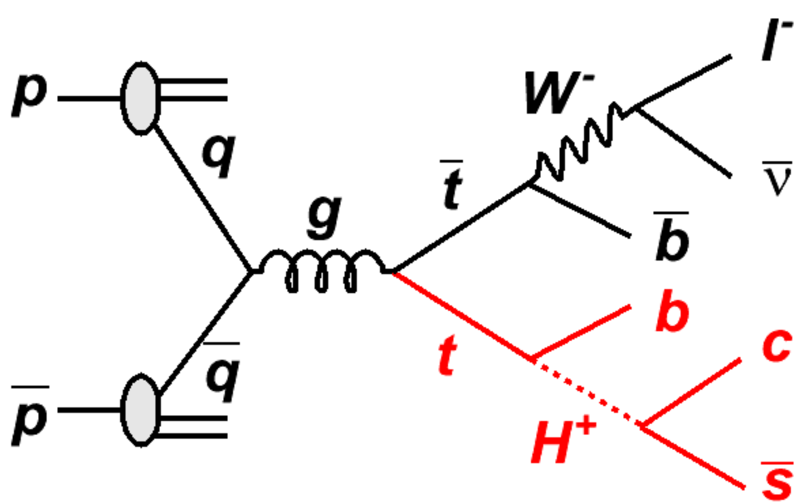


- World's best limit on B(t→Zq): **B(t→Zq) < 3.7% @ 95% C.L.**
- Best published limit (13.7%) improved by factor of 3.5.

Charged Higgs Search in Top Decay

- MSSM predicts large BR($t \rightarrow H^+ b$)>10% for small and large $\tan\beta$, if $M(H^+)<M(t)$.
- H^+ decays differently than W^+:
  - $H^+ \rightarrow \tau^+ \nu_\tau$ if large $\tan\beta$
  - $H^+ \rightarrow t^* b \rightarrow W^+ bb$ for high $M(H^+)$ if low $\tan\beta$
  - $H^+ \rightarrow cs$ if small $\tan\beta$





Charged Higgs Search in D∅

1 fb^{-1}

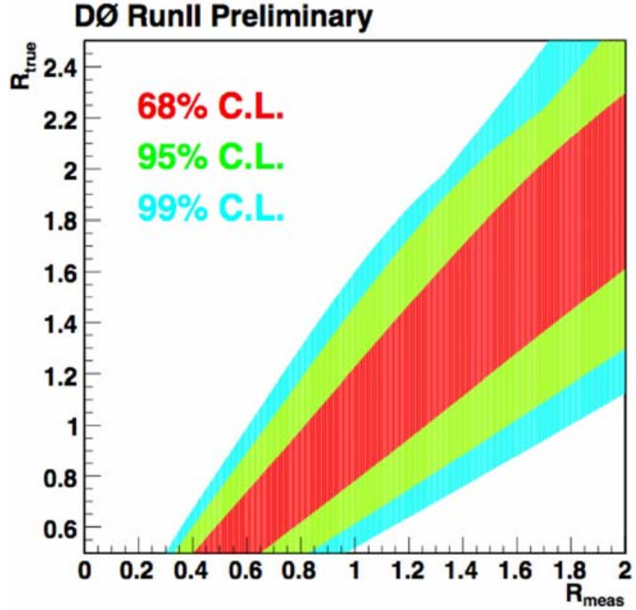
In SM, cross section ratio expectation:

$$R_\sigma = \frac{\sigma(p\bar{p} \to t\bar{t})_{\ell+jets}}{\sigma(p\bar{p} \to t\bar{t})_{\ell\ell}} = 1$$

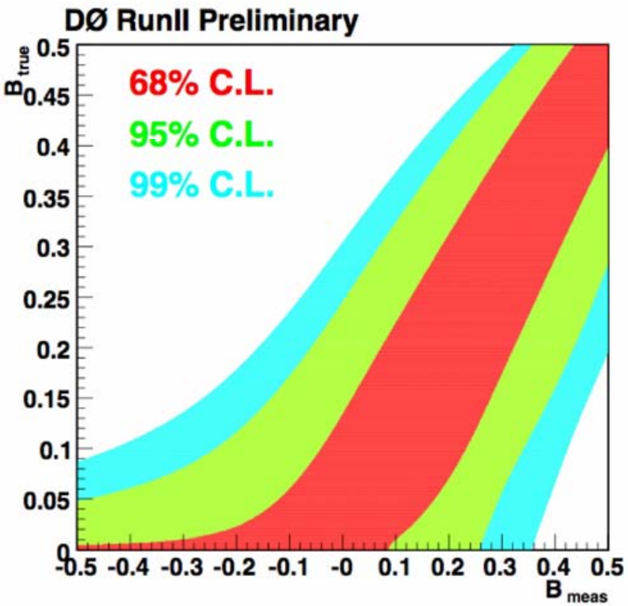
Measurement in agreement with SM:

$$\mathbf{R}_\sigma = \frac{\sigma(\mathbf{p\bar{p}} \to \mathbf{t\bar{t}})_{\ell+\text{jets}}}{\sigma(\mathbf{p\bar{p}} \to \mathbf{t\bar{t}})_{\ell\ell}} = \mathbf{1.21}^{+0.27}_{-0.26}(\textbf{stat} + \textbf{syst})$$

R_σ confidence interval



BR($t \to H^\pm b$) confidence interval



- Translate R_σ into BR($t \to H^\pm b$) by assuming
  - M($H^\pm$) ~ M(W): not ruled out by LEP
  - $H^\pm$ decays exclusively to cs

  (in a general multi-Higgs-doublet model)

BR($t \to H^\pm b$) < 35% @ 95% C.L.

Expected limit: BR($t \to H^\pm b$) < 25%

Heavy Top-like Quark (t’) Search

- Consider possible contribution to top sample from top-like particle (t’)

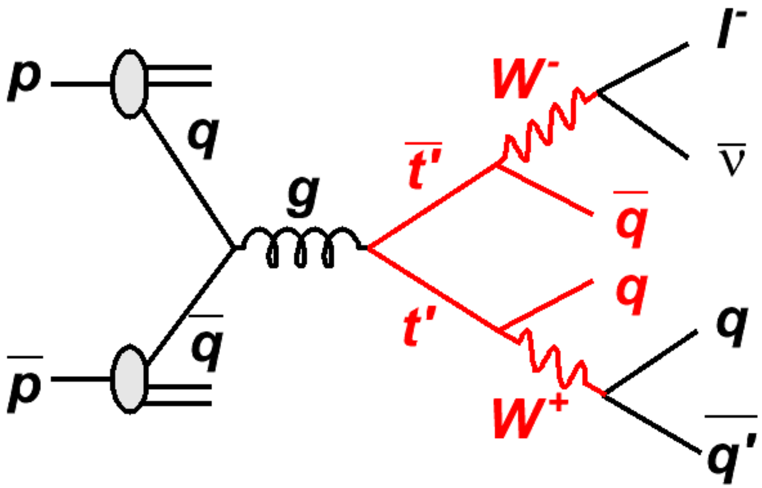
- Examples
  - 4^{th} chiral generation consistent with precision EWK data
    [Phys. Rev. D64, 053004 (2001)]
  - “Beautiful Mirrors” Model: additional generation of quarks that mix with 3^{rd} generation
    [Phys. Rev. D65, 053002 (2002)]
  - Little Higgs model with T-parity conservation: suggests a heavy top
    [Phys. Lett. B563, 191 (2003)]

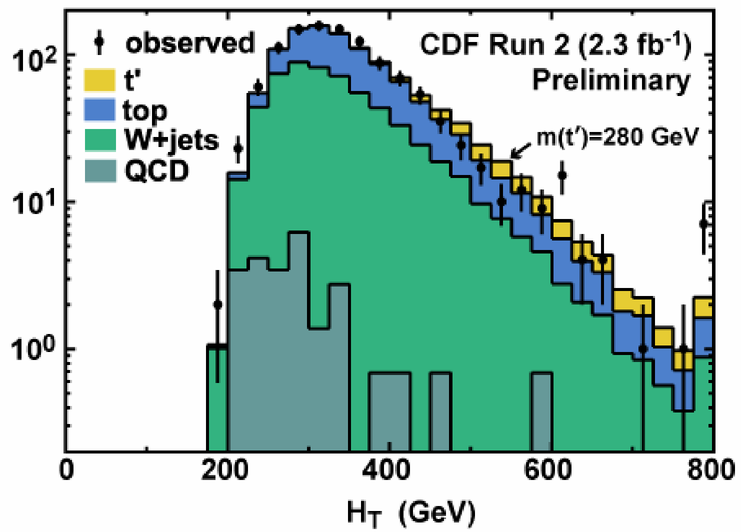
- Assumptions
  - t’ is pair-produced strongly
  - t’ is heavier than top quark
  - t’ decays promptly to Wq
    - Happens when M(t’) < M(b’) + M(W)
    - Precision EWK data suggests small mass splitting between b’ and t’

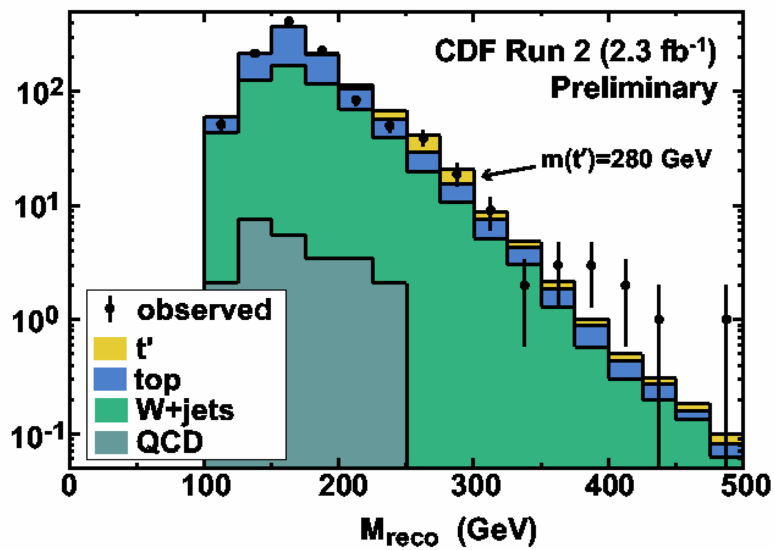
t' Search in CDF

2.3 fb^{-1}

- Search in lepton+jets channel
  - No b-tagging requirement
- Background
  - Dominant: W+jets
  - Smaller: top pair, QCD multi-jets
- 2D fit in H_T vs M_{reco}
  - $H_T = \Sigma P_T$ of all objects
  - M_{reco} = Wq mass reconstructed with a χ^2 fitter used in Mt measurements





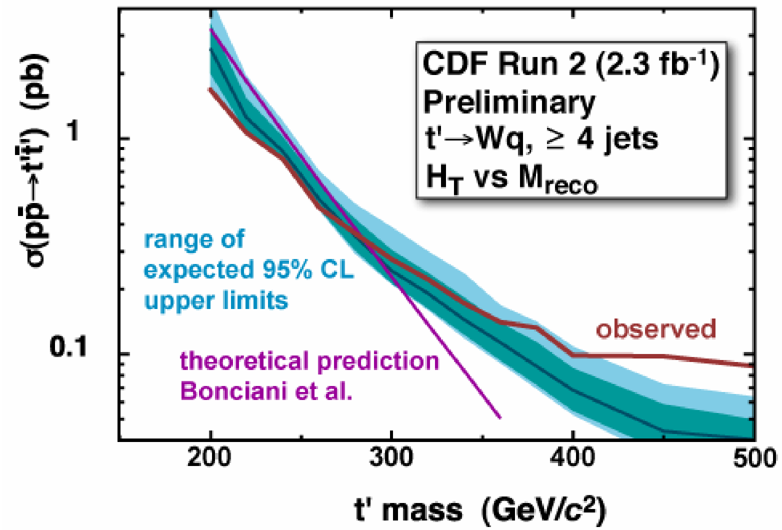


t' Search: Result

2.3 fb^{-1}

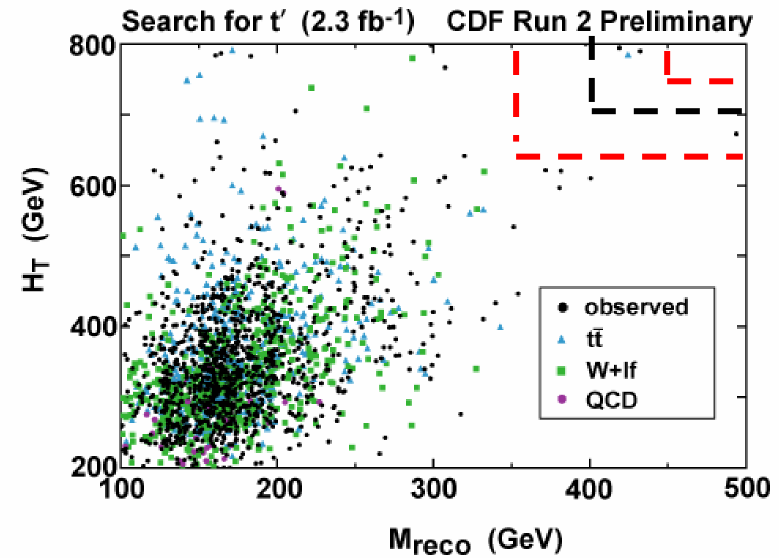
- Set 95% C.L. upper limits on σ(t't')

M(t') > 284 GeV/c^2 @ 95% C.L.



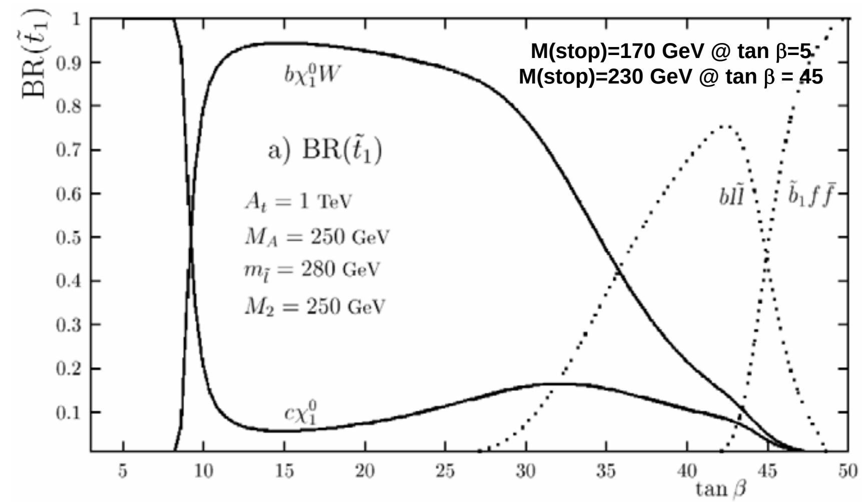
Model Independent Search

- Counting experiment in n×n box
- Find a region with a max. excess
- 4.7 events expect, 11 observed
- Apply a trial factor to obtain an overall p-value
- p-value = 2.8% (~2σ)



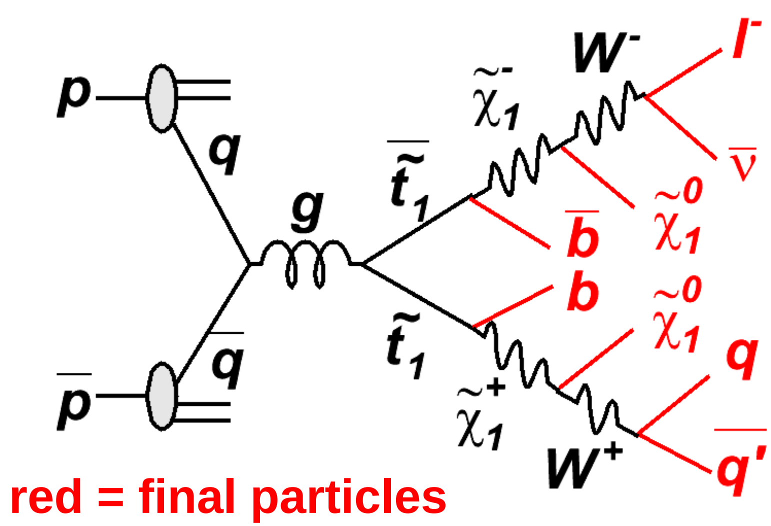
Scalar Top (stop) Search

- Search for superpartner of top
- At Tevatron, stops are produced in pairs,
  $\tilde{t} \rightarrow b\tilde{\chi}_1^+ \; (\tilde{\chi}_1^+ \rightarrow W^+\tilde{\chi}_1^0)$ decay mode can be mixed in top sample with additional Met by neutralino.



- Consider:
  - M(stop) ≤ M(top)
  - MSSM parameters with 100% $\tilde{t} \rightarrow b\tilde{\chi}_1^+$
  - M(stop) = 145 ~ 175 GeV
  - M(chargino) = 105 ~ 135 GeV
  - M(neutralino) = 50 GeV

- Search in lepton+jets channel
  - Dominant bkg: ttbar
  - Smaller bkg: W+jets, etc.



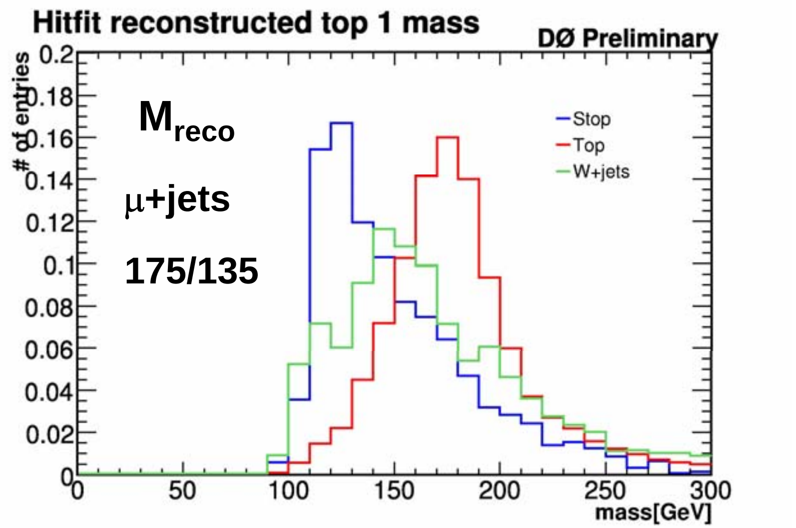
Stop Search in D∅

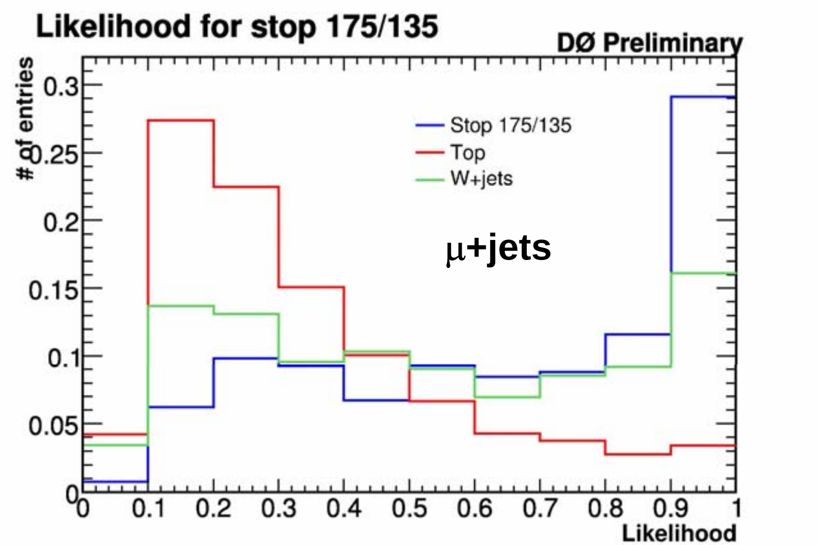
0.9 fb^{-1}

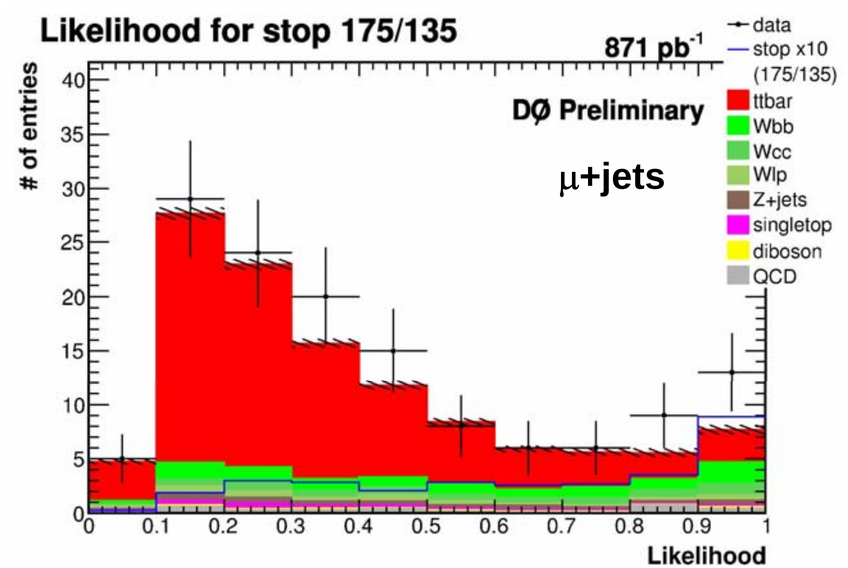
- Define likelihood discriminant:

$$L(\mathbf{x}) = \frac{\prod_{i=1}^{N\mathrm{var}} P_{\mathrm{sig}}(x_i)}{\prod_{i=1}^{N\mathrm{var}} P_{\mathrm{sig}}(x_i) + \prod_{i=1}^{N\mathrm{var}} P_{\mathrm{bkg}}(x_i)}$$

- Chose appropriate variables at each stop/chargino mass to separate signal from background.



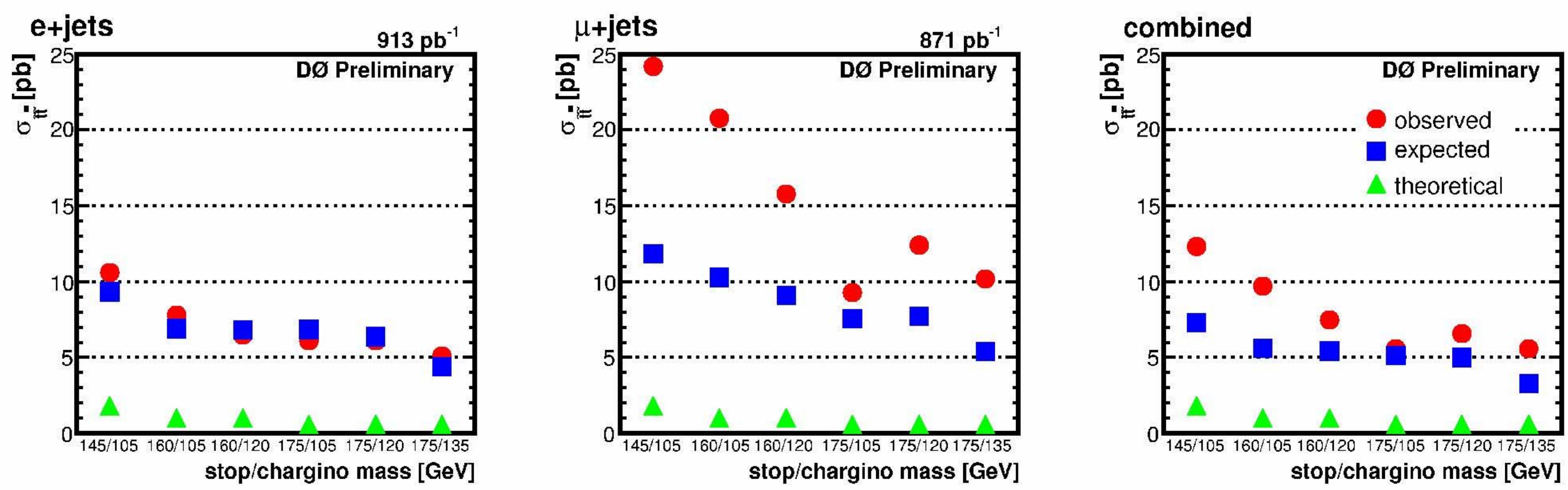




Stop Search: Result

0.9 fb^{-1}

- No evidence for scalar top is observed.
- Set the cross section upper limit at 95% C.L. for electron, muon channel separately.
- The limits are a factor of 7-12 higher than MSSM expectations.

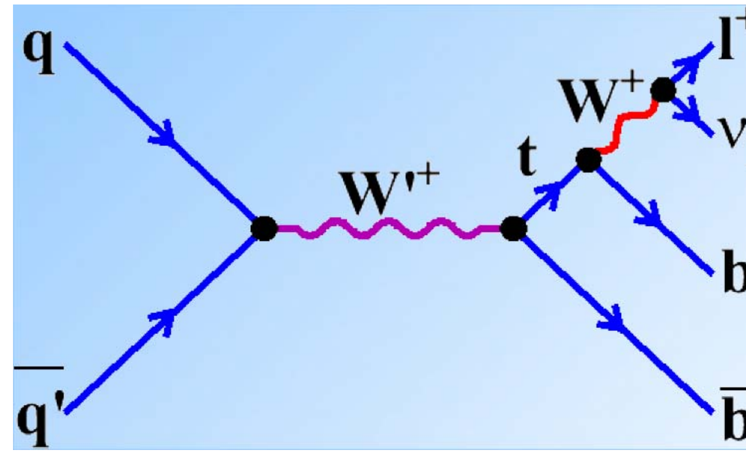


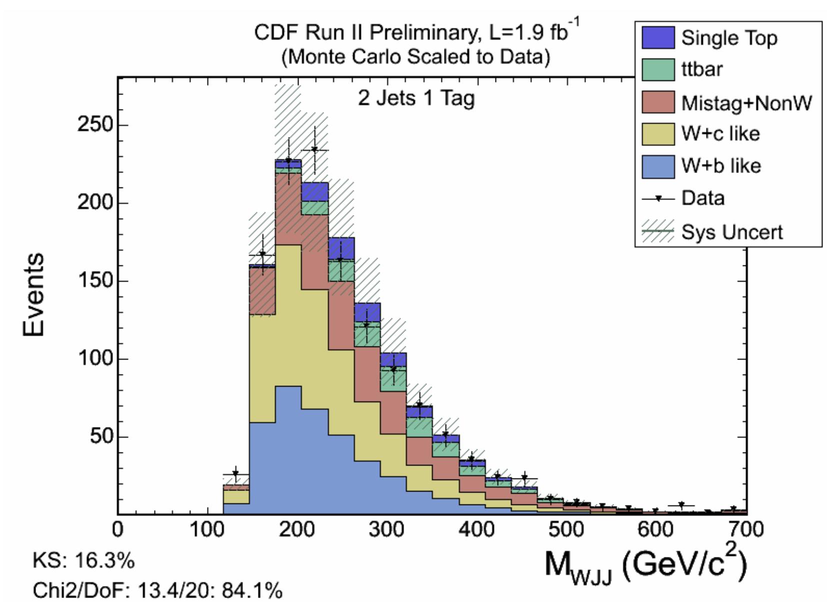
1.9 fb^{-1}

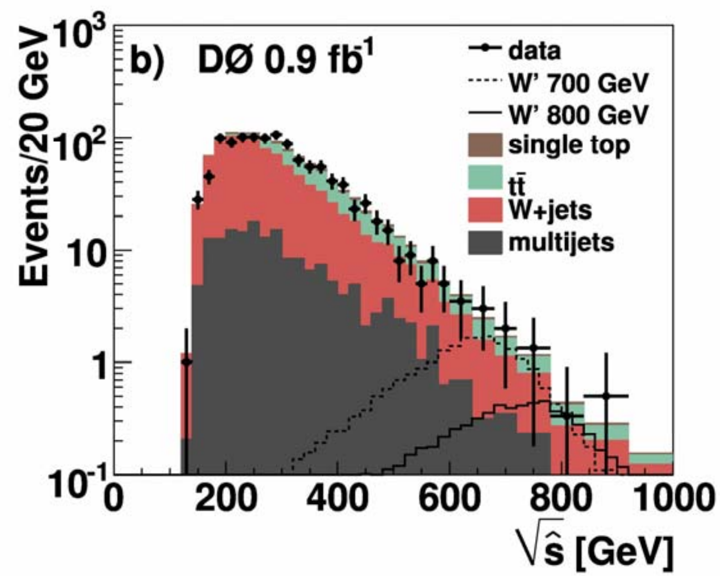
Search for W'→tb

0.9 fb^{-1}

- W' occurs in some extensions of the SM with higher symmetry.
- Complementary to searches in W'→e(μ)ν (e.g. W' of leptophobic nature).
- Same event selection and background estimate as single top analysis.
- Use M(lνjj) as discriminant
- W'_L : Interference with SM W boson.
  W'_R : No interference



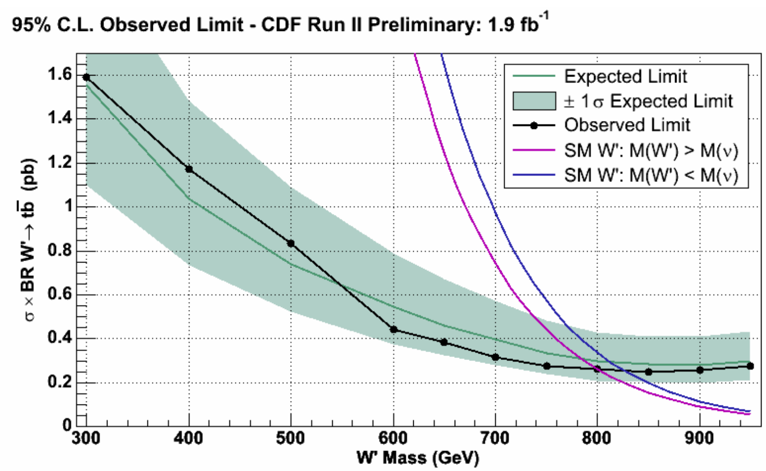


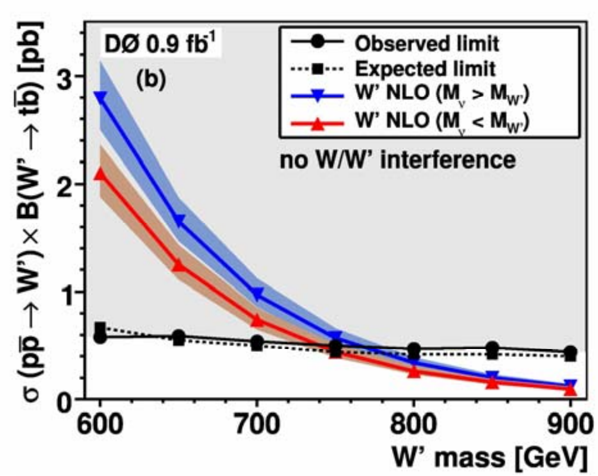


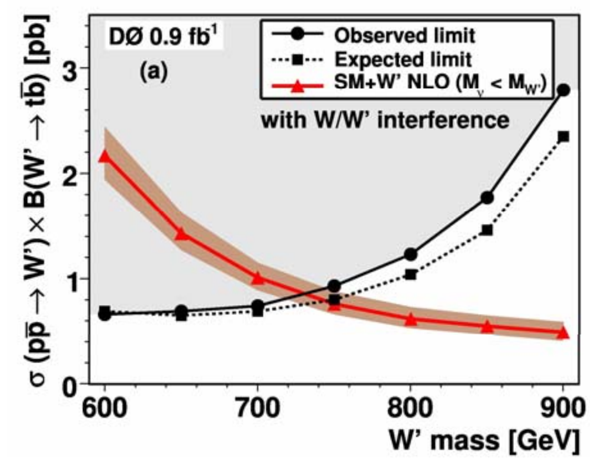
W’ Search: Results

1.9 fb^{-1} 0.9 fb^{-1}

Observe no evidence for resonant W’ production.
Mass limits: Based on the theoretical cross section prediction
(Z. Sullivan, Phys. Rev. D 66, 075011, 2006)







Mass limits:

CDF:
M(W’)>800 GeV if $M(W'_R)>M(\nu_R)$
M(W’)>825 GeV if $M(W'_R)<M(\nu_R)$

DØ:
M(W’)>739 GeV if $M(W'_R)>M(\nu_R)$
M(W’)>768 GeV if $M(W'_R)<M(\nu_R)$
M(W’)>731 GeV if W'_L

D0 Results: arXiv:0803.3256 (submitted to Phys. Rev. Lett.)

Conclusions

- **Many searches in top decays have been done at Tevatron**
  - FCNC, Charged Higgs, t', stop, W'
- **No evidence is obtained so far.**
  - Just pushing the world's best limits

- **Tevatron will provide more than a factor of 3 data for**
  - more precise measurements
  - high energetic tail region
  - unique opportunity in qq$\rightarrow$tt mode, unlike LHC

- **Top quark have lots of motivation for physics BSM**
  - could open the window to physics BSM with more data

- **Other searches not covered in this talk**
  - Charged Higgs (CDF: 190 pb^{-1})
  - Single top via FCNC (D0: 230 pb^{-1})

Backup

CDF FCNC Event Selection

Base selection:

- **Z + $\geq$4 jets**
- **OS lepton + track with 76GeV< M(Z) < 106 GeV**
- **jets with ET>15 GeV & |η|<2.4**

TABLE I: Event selection criteria.

Kinematic Variable	Optimized Cut
Transverse Mass	$\geq$ 200 GeV
Leading Jet E_T	$\geq$ 40 GeV
Second Jet E_T	$\geq$ 30 GeV
Third Jet E_T	$\geq$ 20 GeV
Fourth Jet E_T	$\geq$ 15 GeV

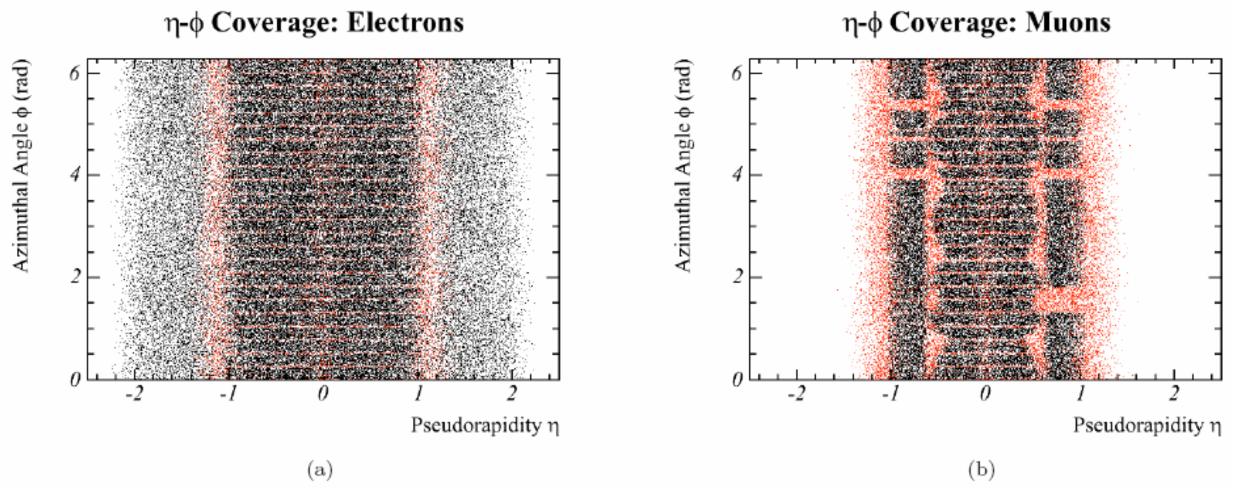


FIG. 2: Improved lepton η–ϕ coverage using track leptons for (a) electrons and (b) muons. The black points show the coverage with tight leptons only, the red points show the additional coverage gained by using track leptons.

CDF FCNC Acc. & Backgrounds

$$N_{\text{signal}} = \{\mathcal{P}(t\bar{t} \to WbZq) \cdot \mathcal{A}_{WZ} + \mathcal{P}(t\bar{t} \to ZqZq) \cdot \mathcal{A}_{ZZ}\} \cdot \sigma_{t\bar{t}} \cdot \int \mathcal{L}\,\mathrm{dt}$$

$$= \mathcal{B}_Z \cdot (N_{\text{LJ}} - B_{\text{LJ}}) \cdot \frac{\mathcal{A}_{WZ}}{\mathcal{A}_{WW,\text{LJ}}} \cdot \frac{2 \cdot (1 - \mathcal{B}_Z) + \mathcal{R}_{ZZ/WZ} \cdot \mathcal{B}_Z}{(1 - \mathcal{B}_z)^2 + 2 \cdot \mathcal{B}_z \cdot (1 - \mathcal{B}_z) \cdot \mathcal{R}_{WZ/WW,\text{LJ}} + \mathcal{B}_z^2 \cdot \mathcal{R}_{ZZ/WW,\text{LJ}}}$$

parameters are

$$\begin{aligned}
\mathcal{B}_Z &\equiv \mathcal{B}(t \to Zq) = 1 - \mathcal{B}(t \to Wb), \\
N_{\text{LJ}} &\equiv \text{Lepton+Jets Event Yield}, \\
B_{\text{LJ}} &\equiv \text{Lepton+Jets Background}, \\
\mathcal{A}_{WZ} &\equiv \text{FCNC Acceptance for } t\bar{t} \to Zq\,Wb, \\
\mathcal{A}_{ZZ} &\equiv \text{FCNC Acceptance for } t\bar{t} \to Zq\,Zq, \\
\mathcal{A}_{WW,\text{LJ}} &\equiv \text{Lepton+Jets Acceptance for SM } t\bar{t} \to Wb\,Wb, \\
\mathcal{A}_{WZ,\text{LJ}} &\equiv \text{Lepton+Jets Acceptance for } t\bar{t} \to Zq\,Wb, \\
\mathcal{A}_{ZZ,\text{LJ}} &\equiv \text{Lepton+Jets Acceptance for } t\bar{t} \to Zq\,Zq, \\
\mathcal{R}_{ZZ/WZ} &\equiv \mathcal{A}_{ZZ}/\mathcal{A}_{WZ}, \\
\mathcal{R}_{WZ/WW,\text{LJ}} &\equiv \mathcal{A}_{WZ,\text{LJ}}/\mathcal{A}_{WW,\text{LJ}}, \\
\mathcal{R}_{ZZ/WW,\text{LJ}} &\equiv \mathcal{A}_{ZZ,\text{LJ}}/\mathcal{A}_{WW,\text{LJ}}.
\end{aligned}$$

smaller bkg:

Source	Cross Section (pb)	Events Tagged	Events Anti-Tagged	Events Control
Standard Model $t\bar{t}$	8.8±1.1	1.7±0.2	0.7±0.1	1.8±0.2
Diboson WZ	3.96±0.06	0.2±0.1	1.4±0.1	2.1±0.1
Diboson ZZ	3.40±0.25	0.3±0.1	1.1±0.1	1.8±0.1

Z+jets: Float in the fit

CDF FCNC Systematic Uncertainties

Signal Acceptance:

Systematic Uncertainty: Signal Acceptance Ratio	Base Sel. (%)	Tagged Region (%)	Anti-Tagged Region (%)	Control Region (%)
Lepton Scale Factor	0.5	0.5	0.5	0.6
Trigger Efficiency	0.2	0.2	0.2	0.2
ISR/FSR	1.8	4.8	5.5	4.0
Helicity Re-Weighting	3.5	3.4	3.6	4.0
Parton Distribution Functions	0.9	0.9	0.9	0.9
Jet Energy Scale		— *Fit Parameter* —		
Total Correlated	3.9	6.2	6.1	5.9
B-Tagging Scale Factor	10.2	5.6	16.1	10.2
Mistag Parameterization	0.6	0.4	1.0	0.6
$\mathcal{B}(t \to Zc)$ versus $\mathcal{B}(t \to Zu)$	0.0	4.5	4.5	0.0
Total Anti-Correlated	10.2	7.2	16.7	10.2

Background Rate:

Systematic Uncertainty: Small Backgrounds	Base Sel. (%)	Tagged Region (%)	Anti-Tagged Region (%)	Control Region (%)
Luminosity	6.0	6.0	6.0	6.0
Lepton Scale Factor	1.3	1.4	1.4	1.3
Trigger Efficiency	0.4	0.4	0.4	0.4
Jet Energy Scale		— *Fit Parameter* —		
Total Correlated	6.2	6.2	6.2	6.2
B-Tagging Scale Factor	0.0	3.1	2.4	0.0
Mistag Parameterization	0.0	0.8	0.7	0.0
Total Anti-Correlated	0.0	3.2	2.5	0.0

Shape Uncertainties:

- **Jet Energy Scale Uncertainties: Signal & Background**
- **Z+jets Q2 scale (Alpgen): Z+jets processes**

D0 Charged Higgs

- Measured cross sections:
  - Lepton+Jets: 8.27 +0.96-0.95 (stat+syst) ± 0.51 (lumi) pb
  - Dilepton: 6.8 +1.2-1.1 (stat) +0.9-0.8 (syst) ± 0.4 (lumi) pb
- How to calculate

$$R_\sigma = \frac{\sigma(t\bar{t})_{\ell+\mathrm{jets}}}{\sigma(t\bar{t})_{\mathrm{dilepton}}} = 1 + \frac{B}{1-B} \cdot \frac{1}{B(W \to qq) + 1/2 \cdot k \cdot A}$$

where,

$$k = \varepsilon(\ell\ell\ell j)/\varepsilon(\ell j\ell j)$$

$\varepsilon(\ell\mathrm{j}\ell\mathrm{j}) = \varepsilon_{\mathrm{sm}}(\ell + \mathrm{jets})$ is the selection efficiency in the ℓ+jets channel for $t\bar{t}$ ℓ+jets

$\varepsilon(\ell\ell\ell\mathrm{j})$ is the selection efficiency in the ℓ+jets channel for $t\bar{t}$ dilepton

$$A = \left[1 - B(W \to qq)\right]^2 / B(W \to \ell\nu)$$

Then,

$$\boxed{B = B(t \to Hb) = W \cdot (R_\sigma - 1)/(1 + W \cdot (R_\sigma - 1))}$$

$$W = B(W \to qq) + 1/2 \cdot k \cdot A$$

CDF t': Selection & Systematics

- **Event selection**
  - lepton (e or mu) pT > 20 GeV
  - MET > 20 GeV
  - ≥ 4jets (ET>20GeV)
  - For QCD veto
    - $\Delta\phi$(lepton,met) ≥ 4.408 – (1/6.11)Met
    - $\Delta\phi$(1st jet, met) ≥ 1.888 – (1/21.6)Met
    - ET(1st jet) ≥ 60 GeV

Mass χ2

$$\chi^2 = \sum_{i=\ell,4jets} \frac{(p_T^{i,fit} - p_T^{i,meas})^2}{\sigma_i^2} + \sum_{j=x,y} \frac{(p_j^{UE,fit} - p_j^{UE,meas})^2}{\sigma_j^2} + \frac{(m_{jj} - m_W)^2}{\Gamma_W^2} + \frac{(m_{\ell\nu} - m_W)^2}{\Gamma_W^2} + \frac{(m_{bjj} - m_t)^2}{\Gamma_t^2} + \frac{(m_{b\ell\nu} - m_t)^2}{\Gamma_t^2}$$

Systematics

$m(t')$	Q^2 scale		IFSR	
	offset	slope	offset	slope
180	0.61	0.016	0.125	0.026
200	0.72	0.018	0.125	0.024
220	0.48	0.025	0.125	0.022
240	0.36	0.022	0.110	0.020
260	0.20	0.027	0.080	0.018
280	0.12	0.028	0.060	0.017
300	0.093	0.022	0.035	0.014
320	0.072	0.021	0.025	0.011
340	0.055	0.016	0.015	0.009
360	0.043	0.014	0.010	0.008
380	0.033	0.011	0.007	0.007
400	0.025	0.011	0.005	0.006
450	0.015	0.007	0.004	0.005
500	0.013	0.006	0.003	0.004

PDF uncertainties

	top	
175	+0.0110	-0.0112
	tprime	
180	+0.007	-0.008
200	+0.004	-0.005
220	+0.005	-0.005
240	+0.003	-0.003
260	+0.003	-0.003
280	+0.002	-0.003
300	+0.001	-0.003
320	+0.001	-0.002
340	+0.002	-0.002
360	+0.003	-0.002
380	+0.002	-0.002
400	+0.005	-0.002
450	+0.004	-0.005
500	+0.015	-0.013

Shape uncertainties
- Jet Energy Scale
- Q2 Scale (Alpgen)

CDF t': Counting Experiment

counting in NxN bin in HT vs. Mreco

n	Min M_{rec} [GeV/c^2]	Min H_T [GeV]	observed	expected	p-value
1	475	775	0	0.0159	1.000
2	450	750	0	0.0626	1.000
3	425	725	1	0.1655	0.1525
4	400	700	2	0.2909	0.0349
5	375	675	3	0.5861	0.0218
6	350	650	4	1.231	0.0365
7	325	625	4	2.443	0.2302
8	300	600	11	4.694	0.0089
9	275	575	14	8.467	0.0501
10	250	550	23	15.52	0.0447
11	225	525	34	26.93	0.1055
12	200	500	49	44.77	0.2826
13	175	475	81	76.79	0.3304
14	150	450	128	133.2	0.6846
15	125	425	190	193.8	0.6159

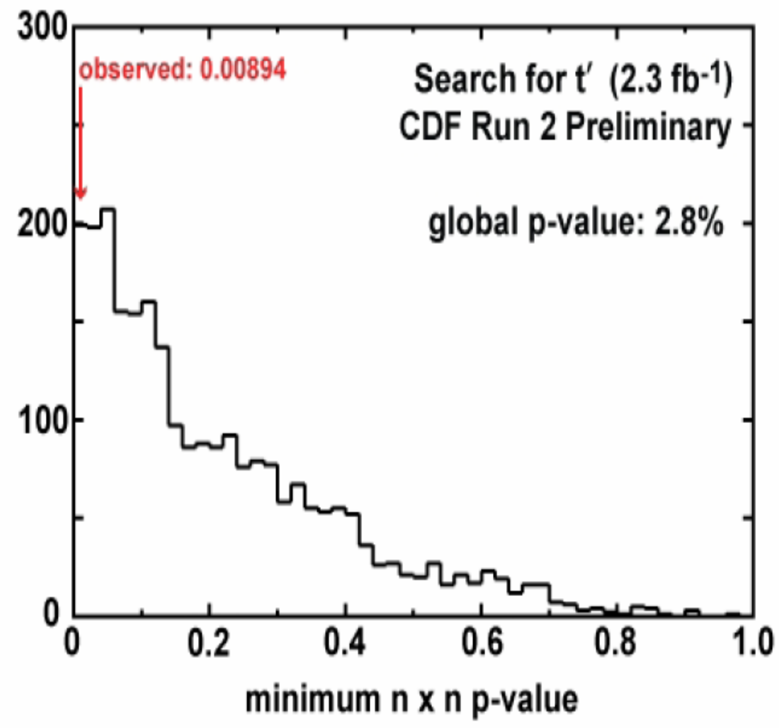


FIG. 5: Pseudoexperiment distriubtion of the smallest p-value of all of the nxn bins. The integral of this distribution from zero up to the observed minimum p-value 0.0089 gives the global p-value, 0.028.

D0 Stop: MSSM Parameters

The $\tilde{t}_1\bar{\tilde{t}}_1$ signal events in the lepton+jets topology were generated using Pythia v6.323 [13] in its general MSSM mode. The neutralino $\tilde{\chi}_1^0$ is the LSP and the MSSM parameters are chosen as follows:

- $\tan\beta = 20$, $\mu = 225$ GeV, $M_A = 800$ GeV, $M_1 = 53$ GeV, $M_3 = 500$ GeV,
- Trilinear couplings $A_b = A_\tau = 200$ GeV,
- Scalar lepton masses $M_{\tilde{l}_L} = M_{\tilde{l}_R} = M_{\tilde{\tau}_L} = M_{\tilde{\tau}_R} = 200$ GeV,
- Scalar quark masses $M_{\tilde{q}_L} = M_{\tilde{q}_R} = M_{\tilde{b}_R} = M_{\tilde{t}_R} = 250$ GeV.

Mass point	$\sigma_{\tilde{t}_1\bar{\tilde{t}}_1}$	A_t	$m_{\tilde{t}_1}$	M_2	$m_{\tilde{\chi}_1^\pm}$	M_1	$m_{\tilde{\chi}_1^0}$
Stop 175/135	0.579 pb	357 GeV	175 GeV	164 GeV	135 GeV	53 GeV	50 GeV
Stop 175/120	0.579 pb	357 GeV	175 GeV	144 GeV	120 GeV	53 GeV	50 GeV
Stop 175/105	0.579 pb	357 GeV	175 GeV	125 GeV	105 GeV	53 GeV	50 GeV
Stop 160/120	1.00 pb	387 GeV	160 GeV	144 GeV	120 GeV	53 GeV	50 GeV
Stop 160/105	1.00 pb	387 GeV	160 GeV	125 GeV	105 GeV	53 GeV	50 GeV
Stop 145/105	1.80 pb	414 GeV	146 GeV	125 GeV	105 GeV	53 GeV	50 GeV

D0 Stop: Selection&Bkg&Syst.

Event selection:

- **e+jets**
  - pT(e)>20GeV, |eta|<1.1
  - ≥4 jets (pT>15GeV, |eta|<2.5)
  - pT (1st jet) > 40 GeV
  - Met>20GeV, Δφ(e,Met)>0.7π - 0.045Met
- **mu+jets**
  - pT(mu) > 20 GeV, |eta|<2.0
  - ≥4 jets (pT>15GeV, |eta|<2.5)
  - pT(1st jet) > 40 GeV
  - Met>25 GeV, Δφ(mu,met)>2.1-0.035Met

systematics

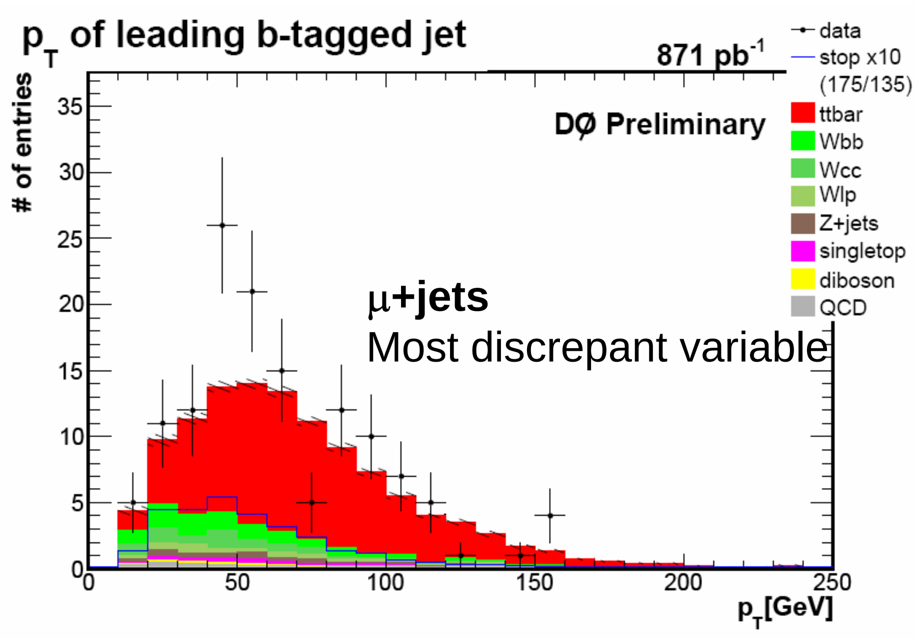
Source	e+jets	μ+jets
Luminosity [20]	6.1%	6.1%
Monte Carlo Cross Section $t\bar{t}$	18.0%	18.0%
Monte Carlo Cross Section single top	12.6%	12.6%
Monte Carlo Cross Section Z+jets	15.0%	15.0%
Monte Carlo Cross Section diboson	6.8%	6.8%
Top Quark Mass	4.9%	4.2%
Multijet Background Estimation	21.1%	54.2%
W+jets Background Normalization	70.3%	30.1%
Primary Vertex	2.0%	2.0%
Lepton	5.5%	7.4%
Trigger	1.2%	2.7%

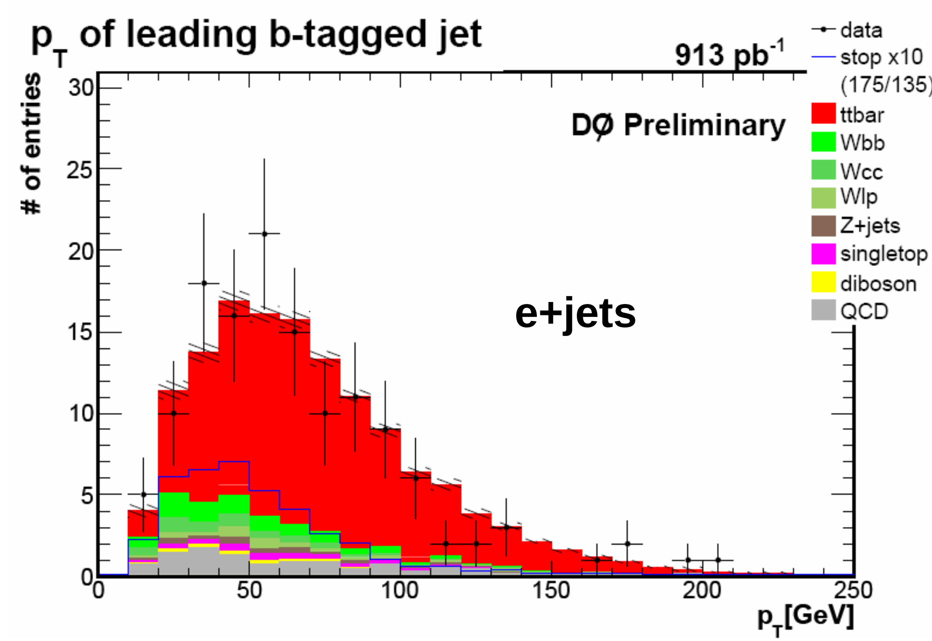
background

Sample	e+jets					μ+jets				
	=1 jet	=2 jets	=3 jets	≥4 jets	HITFIT	=1 jet	=2 jets	=3 jets	≥4 jets	HITFIT
α_W	1.42	1.46	1.32	0.86	0.86	1.48	1.60	1.62	1.25	1.25
$N_{t\bar{t}}$	4.9	39.3	77.6	108.3	103.0	3.1	27.8	58.5	89.8	84.2
$N_{Wb\bar{b}}$	70.6	86.0	35.4	9.1	8.5	56.5	79.8	36.1	12.2	11.1
$N_{Wc\bar{c}}$	39.5	46.8	20.1	5.0	4.8	27.2	39.6	22.2	6.9	6.5
N_{Wjj}	124.5	59.0	13.2	4.0	3.8	89.0	51.3	19.3	4.4	4.0
N_{Z+jets}	2.9	7.5	5.2	3.0	2.8	14.3	14.8	6.9	3.9	3.3
$N_{singletop}$	5.1	19.3	9.3	3.6	3.1	3.7	15.2	7.5	2.9	2.5
$N_{diboson}$	3.1	11.6	4.2	1.4	1.4	2.8	10.2	3.8	1.4	1.2
$N_{multijet}$	16.2	41.1	22.3	11.1	10.7	6.6	12.0	3.0	2.9	3.2
N_{SUM}	266.8	310.7	187.2	145.6	138.1	203.1	250.7	157.5	124.3	116.0
N_{data}	255	329	193	145	133	189	265	163	146	135

D0 Stop: Variable Choice, etc.

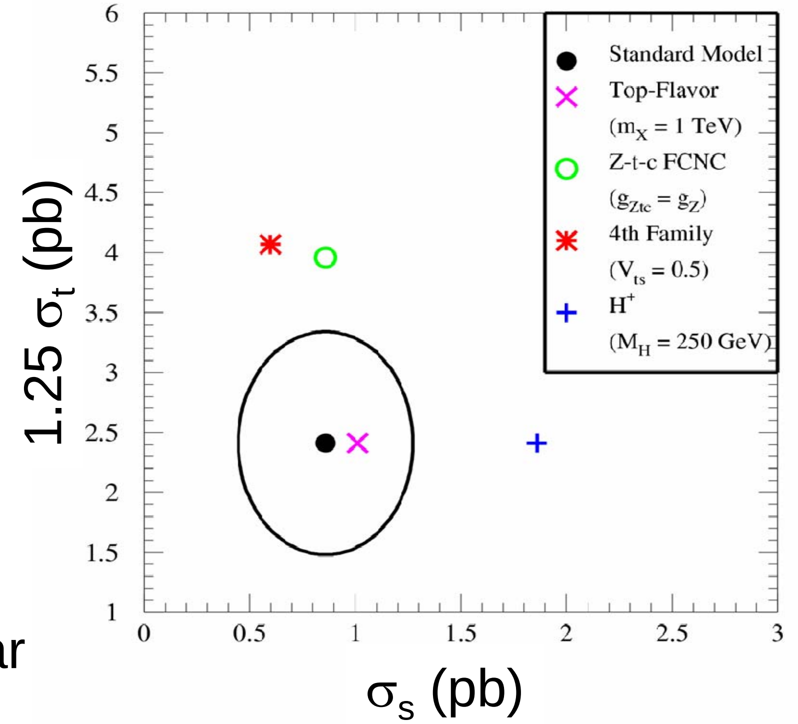
$m_{\tilde{t}_1}$	$m_{\tilde{\chi}_1^\pm}$	Variables in Likelihood Discriminant
175 GeV	135 GeV	$p_T(b\text{-jet})$, $\Delta R(b, lead)$, m_t^{hf}, $\cos\theta^*(b,b)^{hf}$
175 GeV	120 GeV	$p_T(b\text{-jet})$, $m(j,j)$, m_t^{hf}, $\Delta R(W,b)^{hf}_{wrong}$
175 GeV	105 GeV	$M_T(W)$, $m(j,j)$, K_{Tmin}, m_t^{hf}, $m^{hf}(b,b)$
160 GeV	120 GeV	$p_T(b\text{-jet})$, $m(j,j)$, m_t^{hf}, $\Delta R(W,b)^{hf}_{corr}$
160 GeV	105 GeV	$p_T(b\text{-jet})$, $M_T(W)$, $m(j,j)$, $\Delta R(lep,b)$, m_t^{hf}
145 GeV	105 GeV	$p_T(b\text{-jet})$, $M_T(W)$, $m(j,j)$, $\Delta R(lep,b)$, m_t^{hf}





Searches in Single Top Sample

- Interesting signal -- *s* and *t*-channel rates are differently sensitive to new interactions
- Can search for FCNC's involving top quarks
- Single top quarks are ~100% polarized in the SM
  - Can test this with angular distributions of decay products
- Can test CP-violation -- single t vs. single tbar
- A check of the b PDF of the proton
- Can search for heavy W′ bosons (L or R-handed), contributing to s- and t-channel production modes



T. Tait and C. P. Yuan, Phys.Rev.**D63**:014018 (2001)