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Search for Pair Production of Stop Quarks Mimicking Top Event Signatures at CDF

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Symposium

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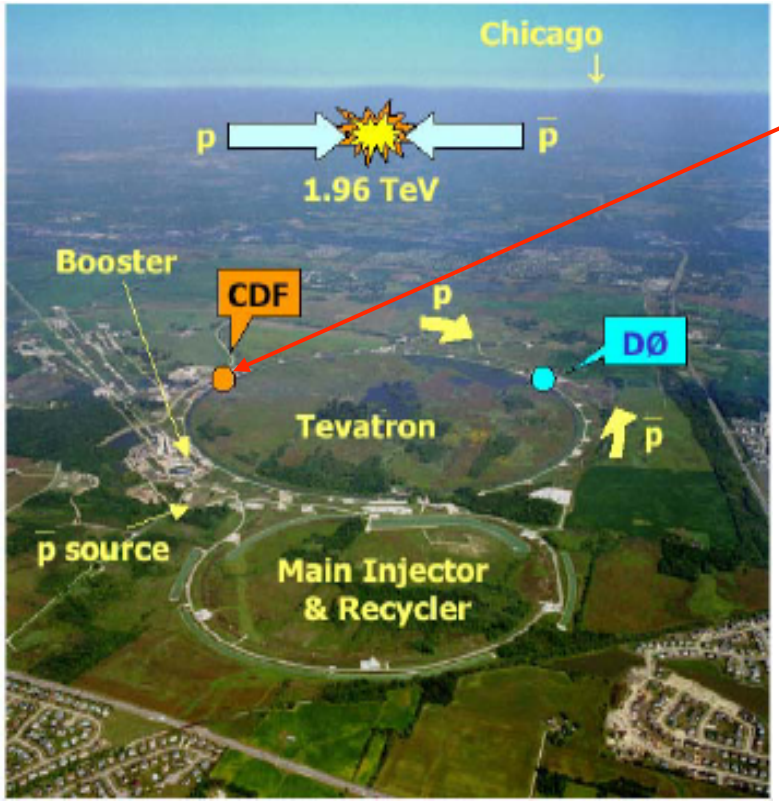
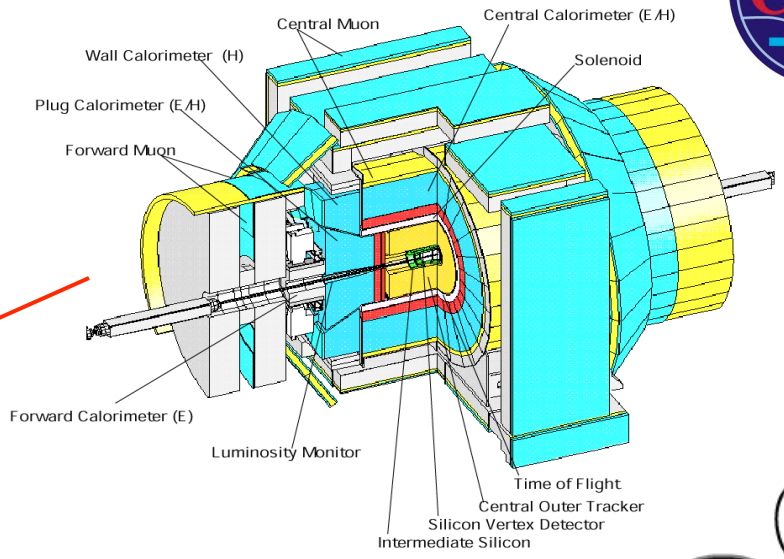
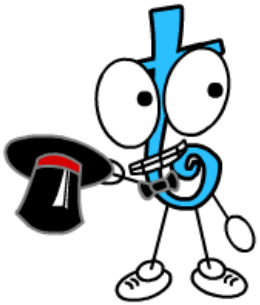
Tevatron and CDF detector

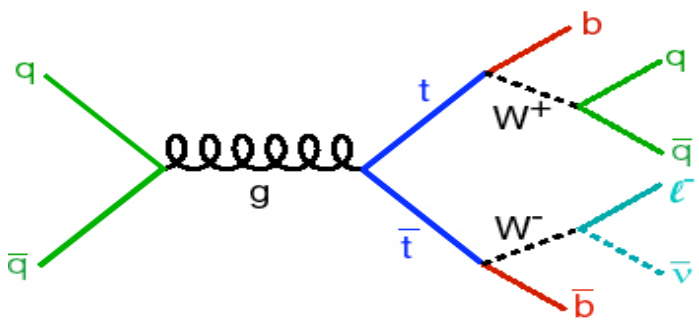






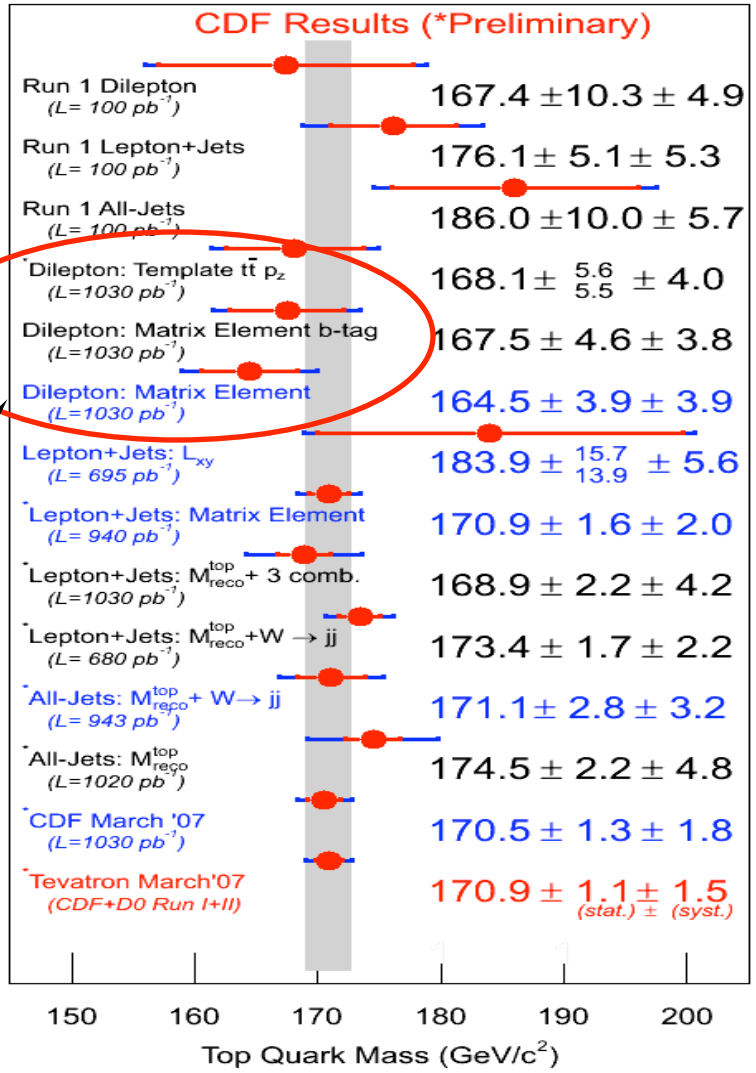
- Top quark has been discovered in 1995
- Standard Model particle, heaviest observed ~ 175 GeV
- We search for new physics in variety of channels
- But can it be hidden in the sample of top quarks?

Top Quarks

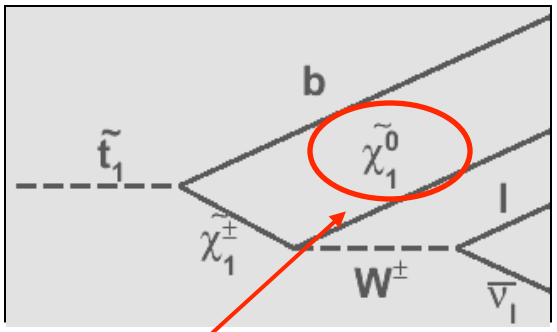


- We study top quark properties and measure its mass in all of its decay channels

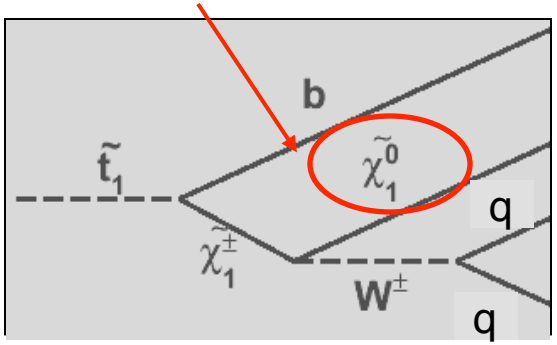
- There have been always apparent inconsistencies between the top mass measurements in the dilepton and lepton+jets channels



Stop in Top Data?



Extra particles in stop decays!



For top:

m(W) = m(lν) = m(qq)

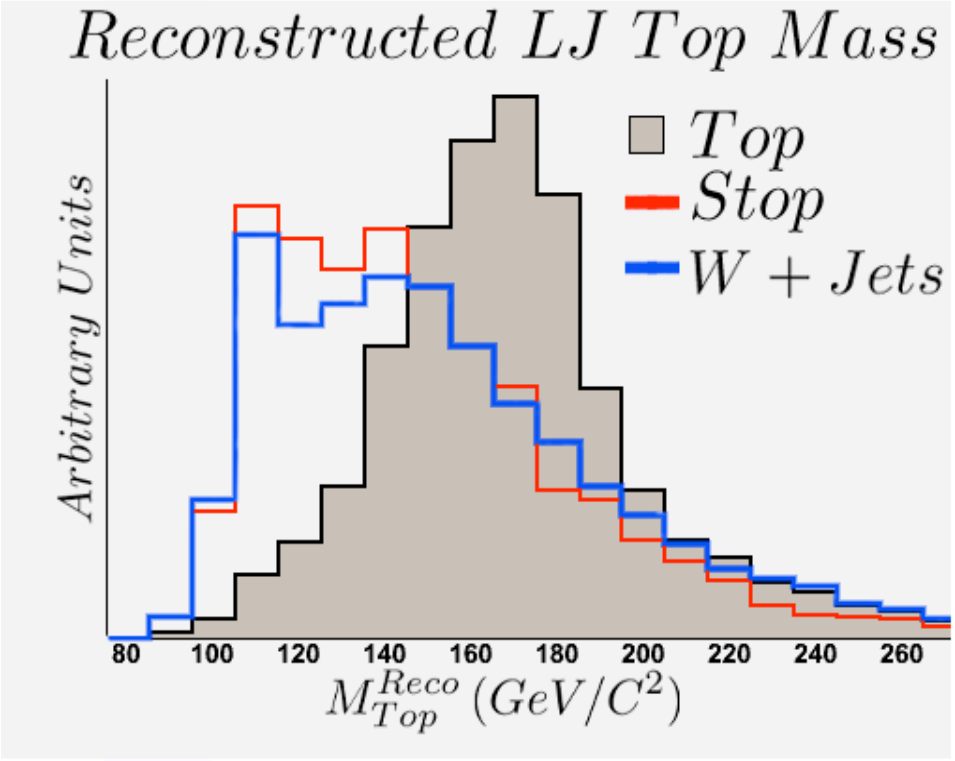
m(t) = m(blν) = m(bqq)

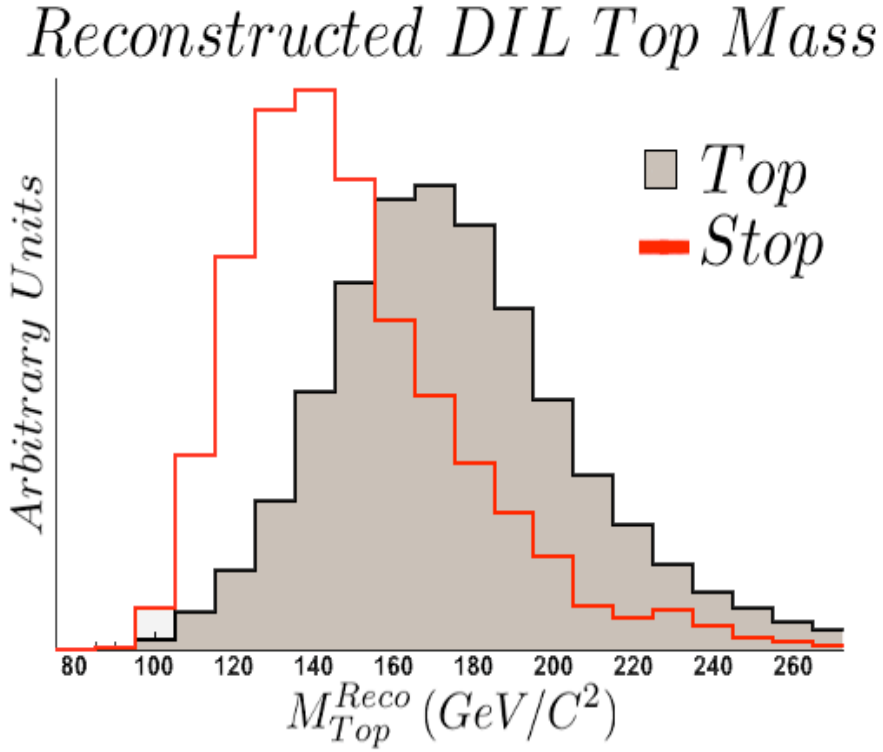
- We hypothesize that discrepancies in top mass measurements in different channels could be due to presence of light stop pair production with the subsequent decay chain:

$$\tilde{t_1} \rightarrow b\tilde{\chi_1}^{\pm} \rightarrow b\tilde{\chi_1}^{0} W^{\pm(*)}$$

- Event signature is identical to the signatures of top quarks!
- Stop is a scalar quark, cross section ~ 10 times smaller
- How do stop events behave under the top event reconstruction?
- Lepton+Jets channel: neutralino on hadronic side breaks the invariant mass constraints
- Dilepton channel: neutralinos are invisible, effect is minimal

Effect of Stop Presence in Lepton + Jets And Dilepton Channels

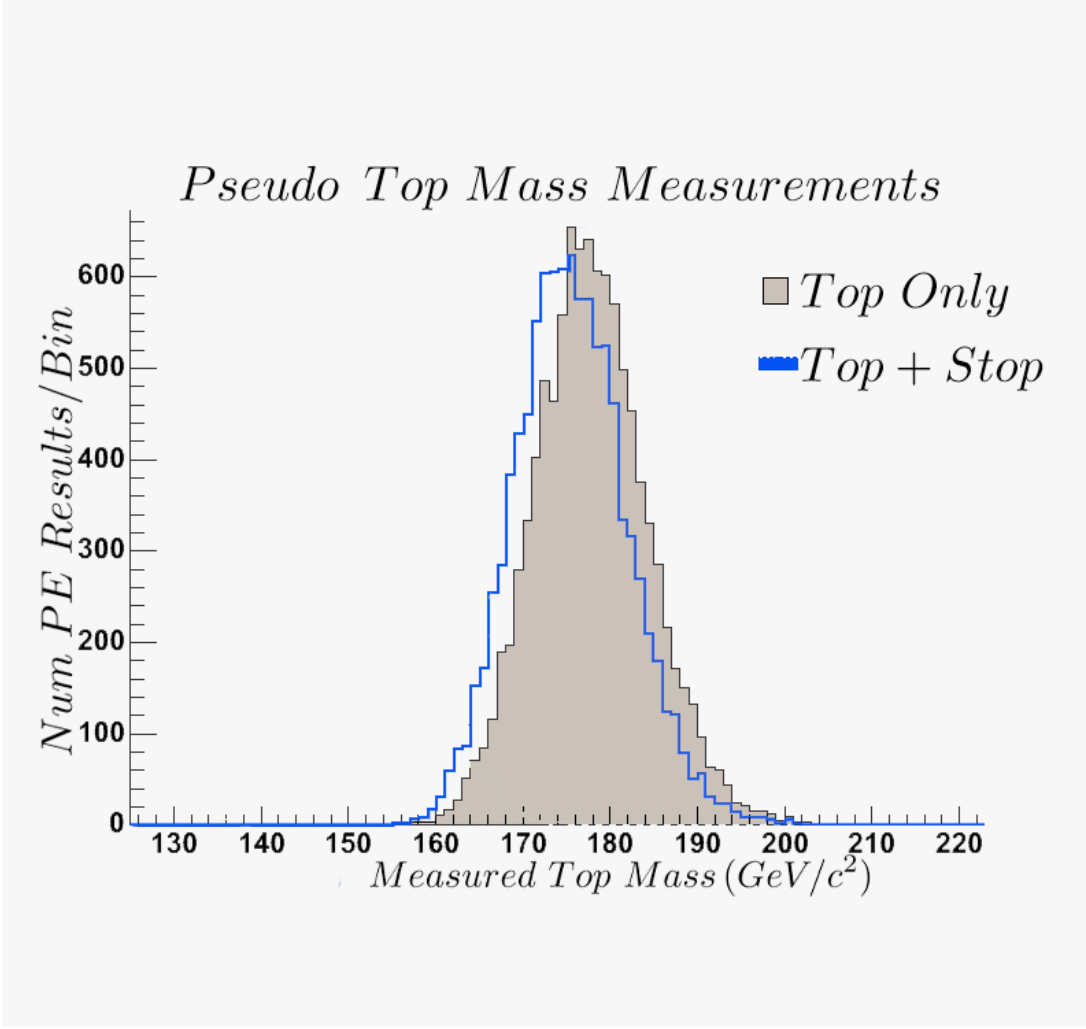




Would Presence of Stop Have an Effect on Top Mass Measurement?

Yes!

Would Bias the Top Dilepton Mass towards a value lower by a few GeV



Theoretical Assumptions

- Assumptions:

$\tilde{\chi}_1^0$ is the LSP, and $\tilde{q}, \tilde{\ell}, \tilde{\nu}$ are heavy

$m_{\tilde{t}_1} \lesssim m_t$

$m_{\tilde{\chi}_1^+} < m_{\tilde{t}_1} - m_b$

WMAP data

Electroweak Baryogenesis

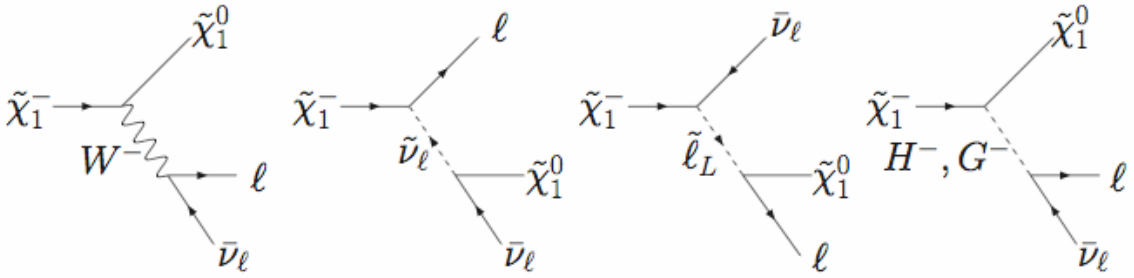
C. Balazs, M.Carena, C. Wagner, PRD 70 (2004) 015007

- Dominant decay mode (BR~ 100%):

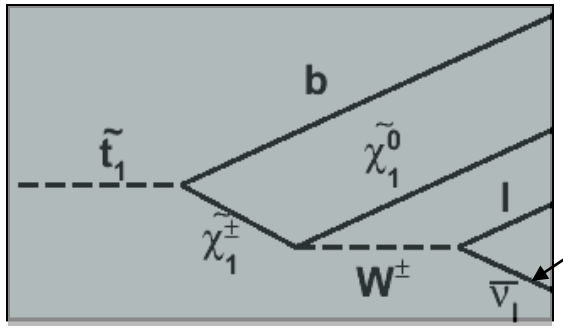
$$\tilde{t}_1 \rightarrow b\tilde{\chi}_1^{\pm} \rightarrow b\tilde{\chi}_1^0 W^{\pm} \rightarrow b\tilde{\chi}_1^0 l\nu$$

If $m(\chi_1^{\pm}) - m(\chi_1^0) < m(W)$
Dilepton branching ratio can be enhanced due to other SUSY particles off-shell:

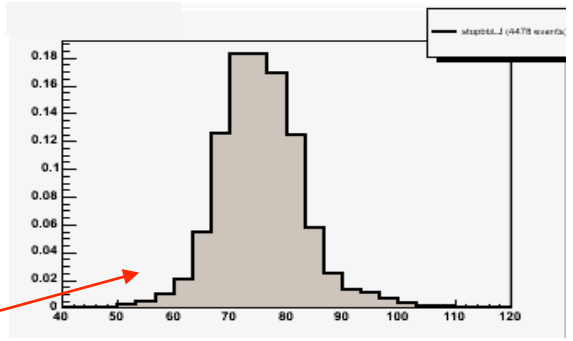
- We search in Dilepton Channel
- Event signature:
  - 2 leptons
  - >= 2 jets
  - + Missing E_T



Stop Mass Reconstruction



Pair invisible particles into PP, Fix mass=75 Gev and width= 5 GeV



- Consider all possible directions of sum of four-momenta of PP=neutralino +neutrino for each leg
- Minimize χ^2 for and construct sum:

$$M_{\tilde{t}} = \frac{1}{\sum_i e^{-\chi_i^2}} \sum_{direction\, i} M_i^{\tilde{t}} e^{-\chi_i^2}$$

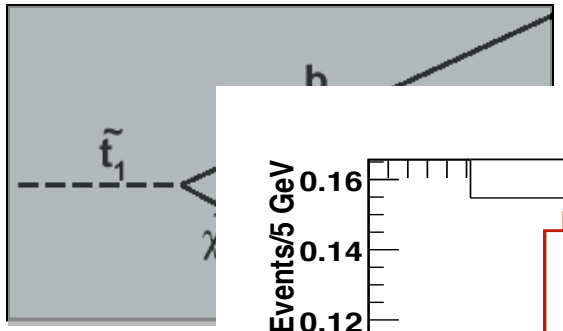
$$\chi^2 = \frac{\left(\vec{l}_{meas} - \vec{l}_{fit}\right)^2}{\sigma_l^2} + \frac{\left(\vec{\bar{l}}_{meas} - \vec{\bar{l}}_{fit}\right)^2}{\sigma_l^2} + \frac{\left(\vec{u}_{meas} - \vec{u}_{fit}\right)^2}{\sigma_{uncl}^2}$$

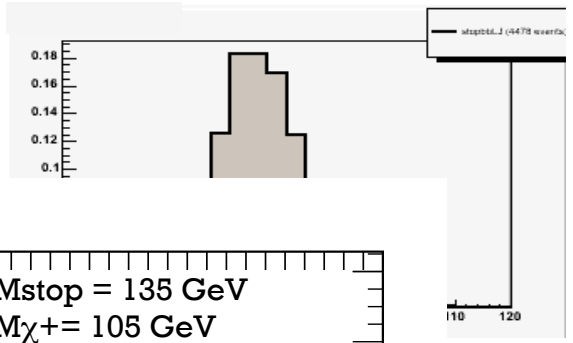
$$+ \sum_{jets\, i} \frac{\left(\vec{j}_{i_{meas}} - \vec{j}_{i_{fit}}\right)}{\sigma_{jet_i}^2} + \frac{\left(M_{PP_1}^{fit} - M_{PP}^{assume}\right)^2}{\Gamma_{PP}^{hepg}}$$

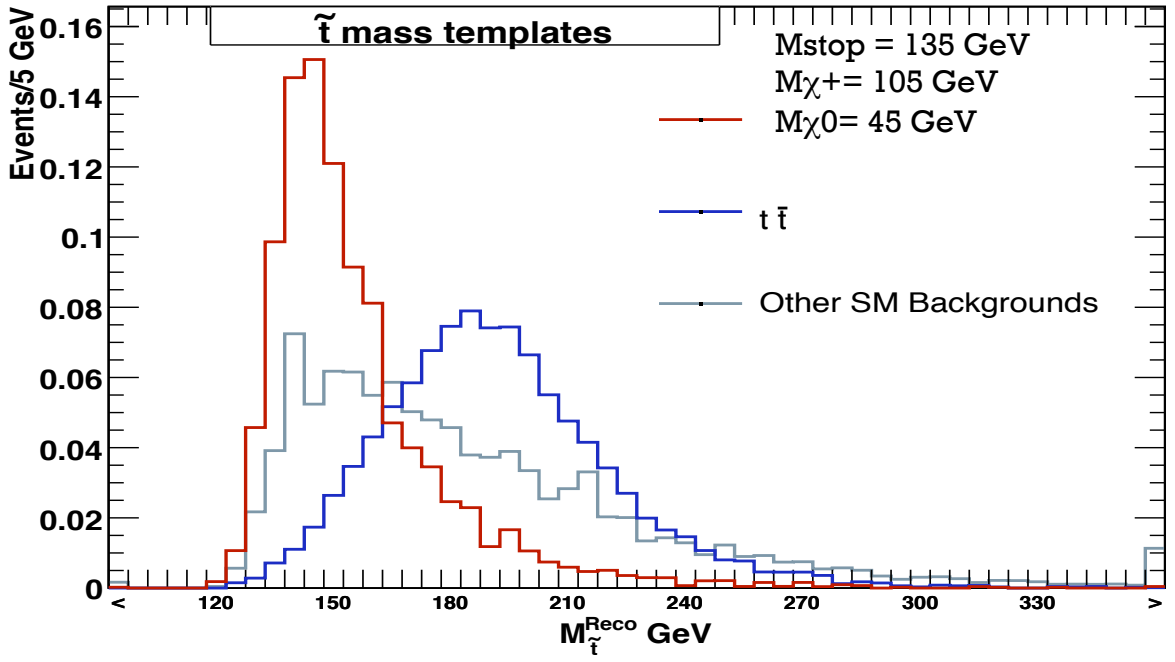
$$+ \frac{\left(M_{PP_2}^{fit} - M_{PP}^{assume}\right)^2}{\Gamma_{PP}^{hepg}} + \frac{\left(M_{PP_1,l} - M_{\tilde{\chi}^{\pm}}\right)^2}{\Gamma^{\tilde{\chi}^{\pm}}}$$

$$+ \frac{\left(M_{PP_1,\bar{l}} - M_{\tilde{\chi}^{\pm}}\right)^2}{\Gamma^{\tilde{\chi}^{\pm}}} + \frac{\left(M_{PP_1,\bar{l},b_{jet}} - M_{PP_2,l,\bar{b}_{jet}}\right)}{\Gamma^{\tilde{t}}}$$

Stop Mass Reconstruction







- Conside
  of four-
  +neutri
- Minimiz

$M_{}$

$$2$$

$$-+\frac{(\vec{u}_{meas}-\vec{u}_{fit})^2}{\sigma^2_{uncl}}$$

$$-M_{PP}^{assume}\Big)^2$$

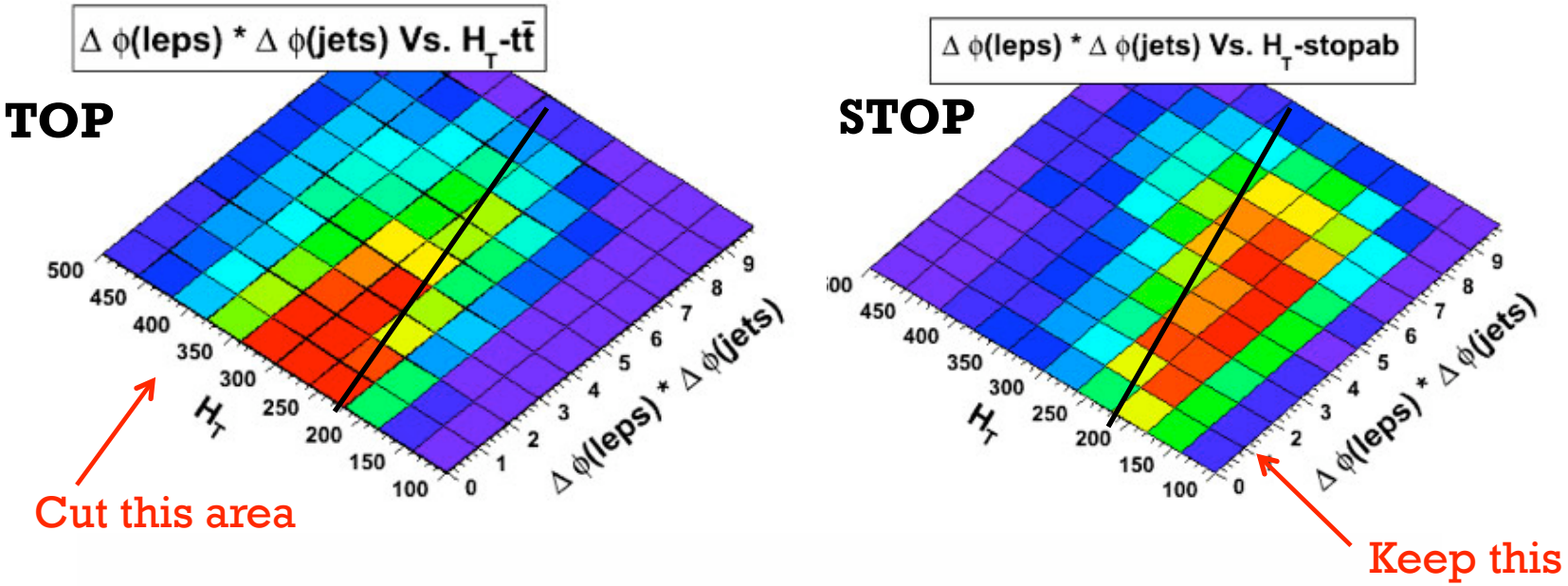
$$\Gamma_{PP}^{hepg}$$

$$\frac{P_1,l-M_{\tilde{\chi}^\pm}\Big)^2}{\Gamma\tilde{\chi}^\pm}$$

$$+\frac{\left(M_{PP_1,\bar{l}}-M_{\tilde{\chi}^\pm}\right)^2}{\Gamma\tilde{\chi}^\pm}+\frac{\left(M_{PP_1,\bar{l},b_{jet}}-M_{PP_2,l,\bar{b}_{jet}}\right)}{\Gamma\tilde{t}}$$

Top Killer

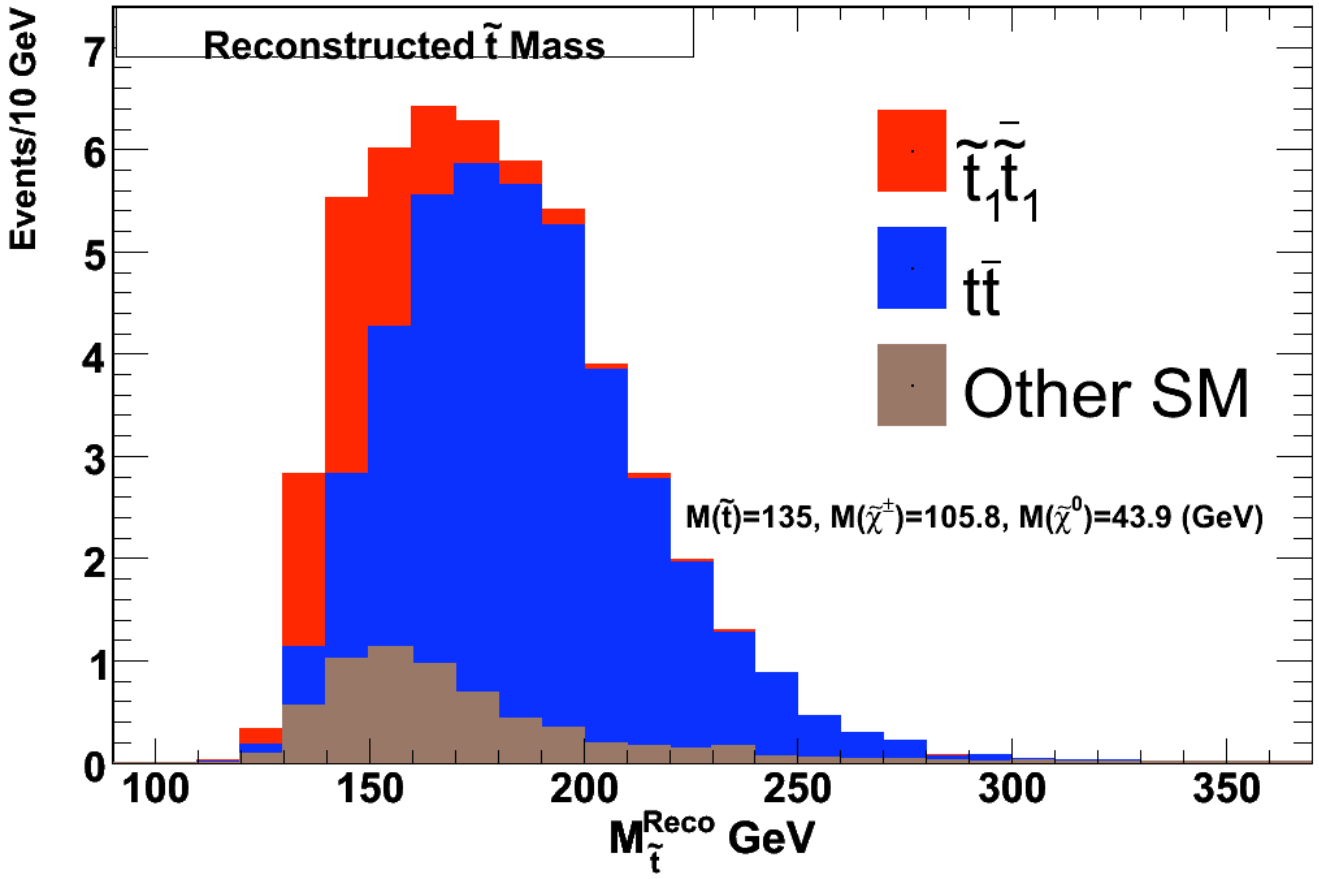
- Main background stop are top events



$$H_T \equiv \sum P_T < 215 \text{ GeV} + 325 \text{ GeV} \times \frac{\Delta\phi_{leps}\Delta\phi_{jets}}{\pi^2}$$

Kills about 50 % of top with
~ 15% loss of stop events

Can we see stop?



Event Yields in Signal Region

At least one of the jets has a b-tag

Events per 1900 pb^{-1} with Njet$\geq$ 2

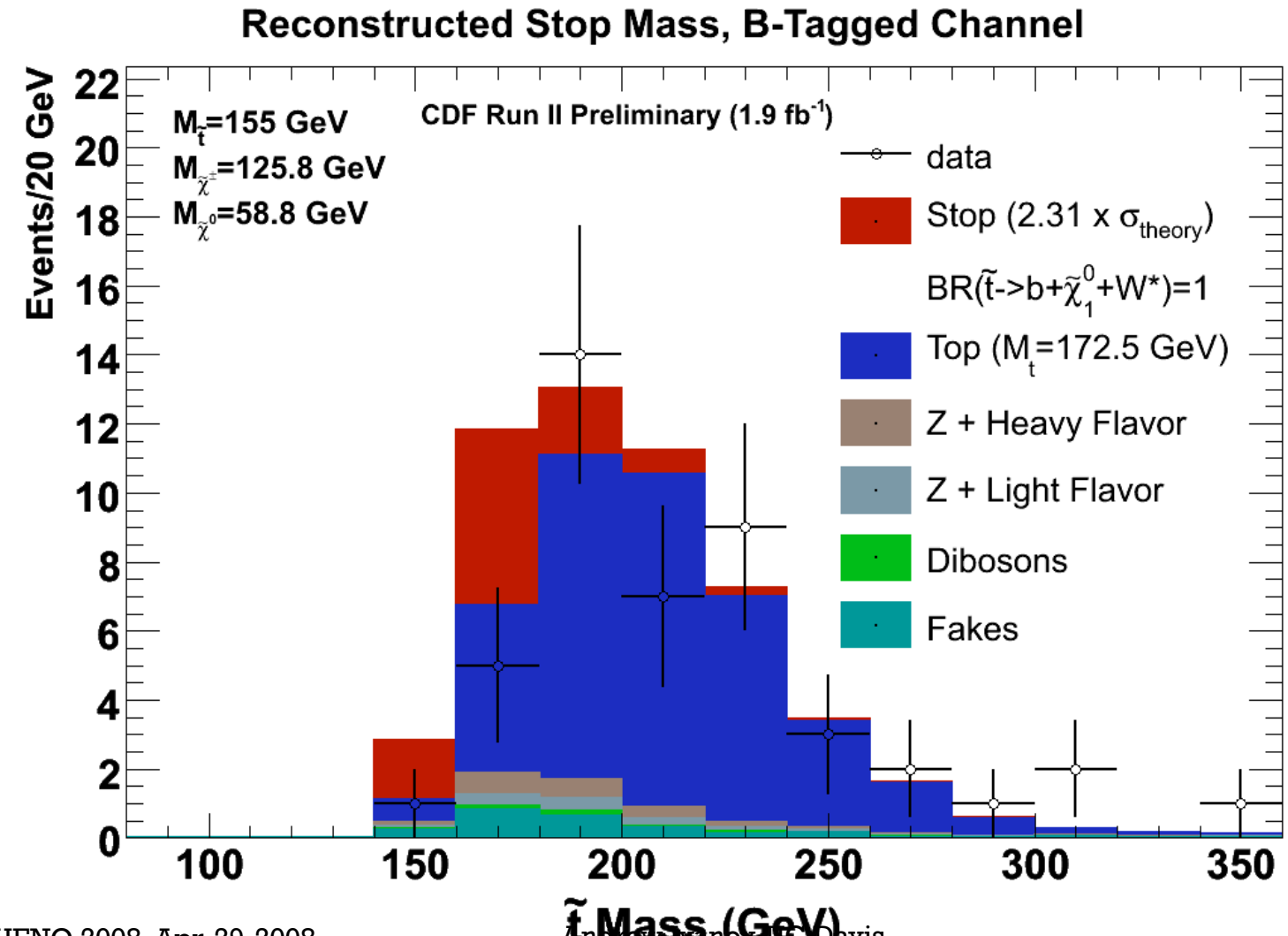
Source	ee	$\mu\mu$	$e\mu$	$\ell\ell$
Stop(155,105,60)	0.71 $\pm$ 0.14	0.89 $\pm$ 0.17	2.04 $\pm$ 0.39	3.65 $\pm$ 0.70
Top	8.43 $\pm$ 1.29	7.81 $\pm$ 1.20	20.26 $\pm$ 2.85	36.50 $\pm$ 5.27
Z+HF	1.02 $\pm$ 0.22	0.70 $\pm$ 0.15	0.27 $\pm$ 0.05	2.00 $\pm$ 0.43
Z+LF	0.63 $\pm$ 0.07	0.37 $\pm$ 0.07	0.24 $\pm$ 0.02	1.24 $\pm$ 0.12
Diboson	0.14 $\pm$ 0.02	0.10 $\pm$ 0.01	0.20 $\pm$ 0.03	0.44 $\pm$ 0.06
Fakes	0.39 $\pm$ 0.12	0.48 $\pm$ 0.14	1.48 $\pm$ 0.44	2.35 $\pm$ 0.70
SM Total	10.62 $\pm$ 1.49	9.46 $\pm$ 1.27	22.46 $\pm$ 2.88	42.53 $\pm$ 5.56
Data	10	11	24	45

No jets have a b-tag

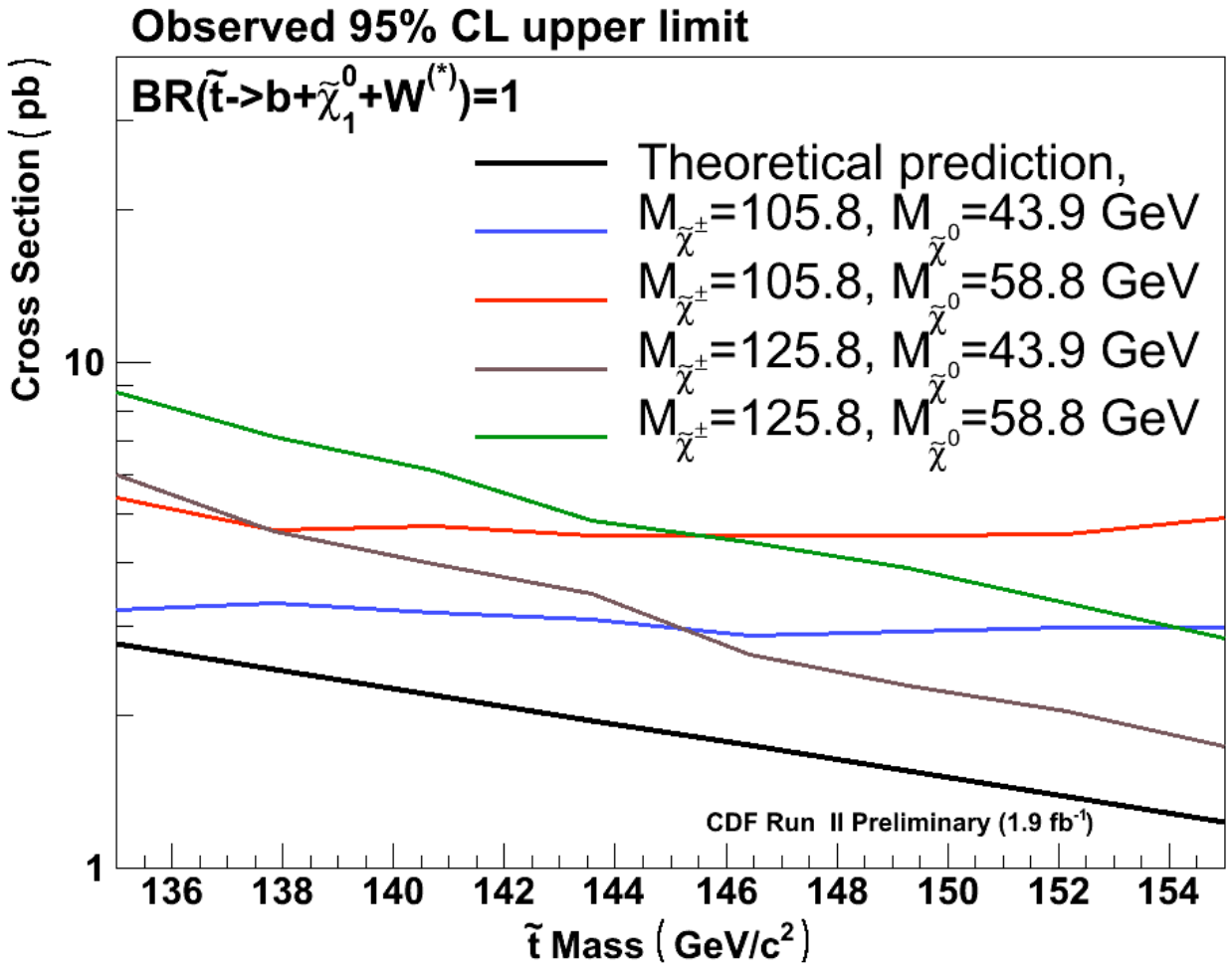
Events per 2000 pb^{-1} with Njet$\geq$ 2

Source	ee	$\mu\mu$	$e\mu$	$\ell\ell$
Stop(155,105,60)	0.29 $\pm$ 0.06	0.34 $\pm$ 0.06	0.83 $\pm$ 0.16	1.46 $\pm$ 0.28
Top	4.38 $\pm$ 0.64	4.45 $\pm$ 0.66	9.85 $\pm$ 1.36	18.68 $\pm$ 2.46
Z+HF	0.26 $\pm$ 0.05	0.20 $\pm$ 0.04	0.07 $\pm$ 0.01	0.54 $\pm$ 0.10
Z+LF	9.33 $\pm$ 2.57	6.77 $\pm$ 2.10	3.13 $\pm$ 0.25	19.23 $\pm$ 4.91
Diboson	1.40 $\pm$ 0.25	1.05 $\pm$ 0.21	2.46 $\pm$ 0.45	4.91 $\pm$ 0.91
Fakes	1.65 $\pm$ 0.49	1.98 $\pm$ 0.59	5.02 $\pm$ 1.51	8.66 $\pm$ 2.60
SM Total	17.02 $\pm$ 3.01	14.46 $\pm$ 2.59	20.54 $\pm$ 3.28	52.02 $\pm$ 8.04
Data	20	6	20	46

Reconstructed Stop Mass in Data



Observed Limits



Summary

- We performed a stop search in 1.9 fb^{-1} of CDF Run II data
- No evidence for stop signal is observed
- We set limits on stop pair production