Search for Massive Top at CDF

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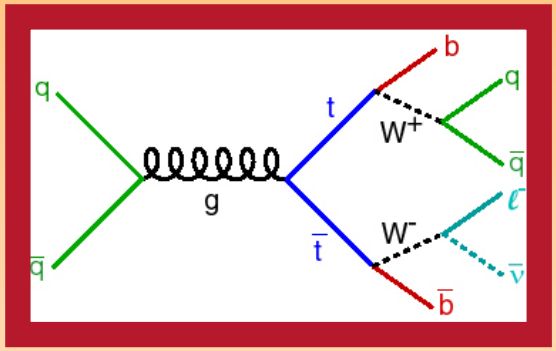
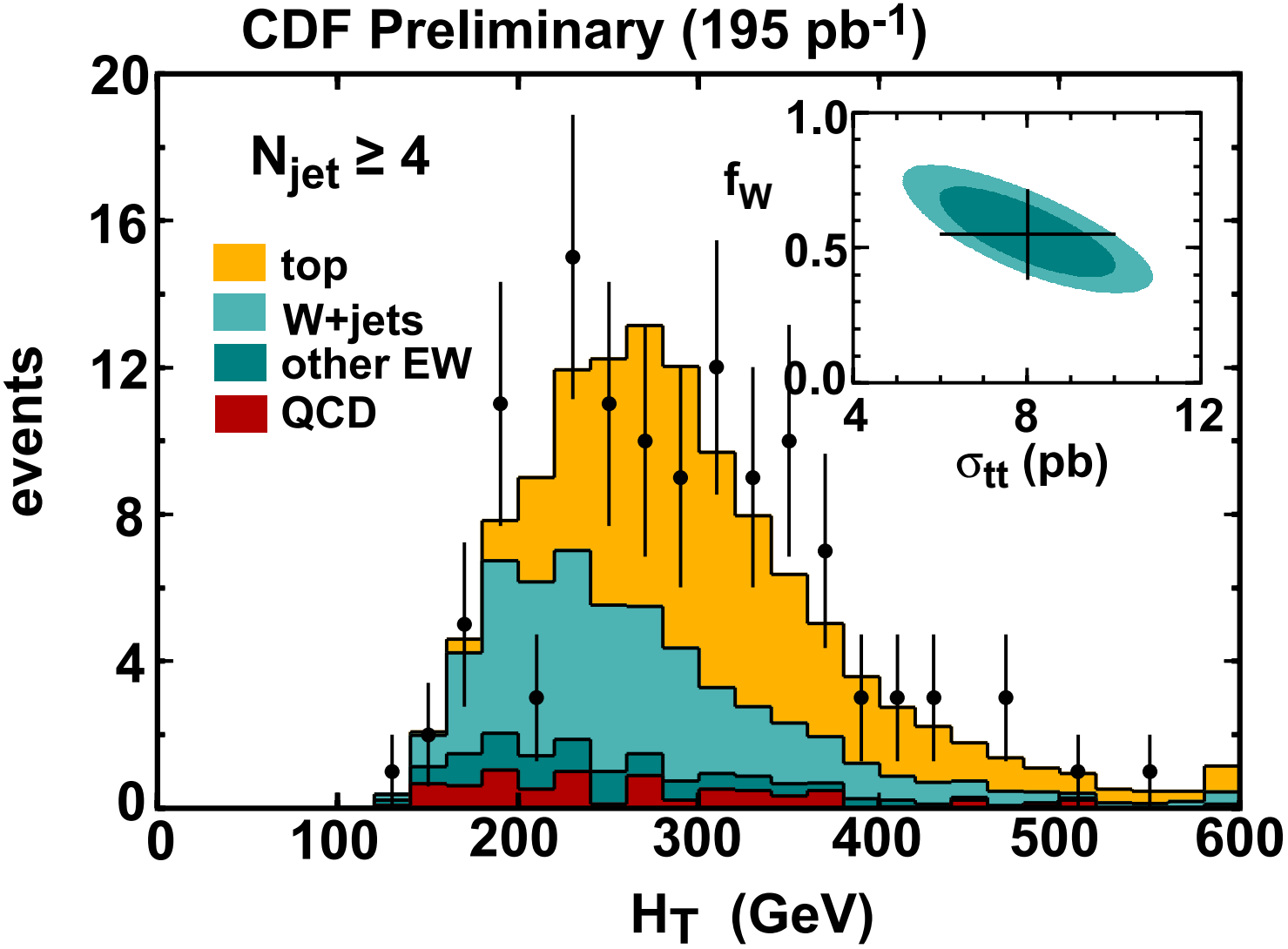


Aspen Winter Conference *-- January 9, 2007*

New physics in top samples

- While on the energy frontier, we look for interesting events on the tails of the top quark distributions
- Can a t′ exist? Can it mimic top?
- Generic 4th chiral generation is consistent with EWK data; can accommodate a heavy Higgs (500 GeV) without any other new physics
  - Masses of 4th generation quarks ~ few hundreds of GeV
  - Oblique corrections drive Higgs Mass to ~ 500 GeV
  - Almost degenerate b′ and t′ masses: M(t′) - M(b′) < M(W)
  - Two Higgs Doublets N=2 SUSY (C.He et al, hep-ph/0102144)

Total Transverse Energy (Scalar)



New physics in top samples

- While on the energy frontier, we look for interesting events on the tails of the top quark distributions

- Little Higgs models predict a heavy t' -like particle

- Several SUSY models provide for a 4th generation t' or mimic top-like signatures *(Beautiful Mirrors: Choudhury, Tait, Wagner)*

New physics in top samples

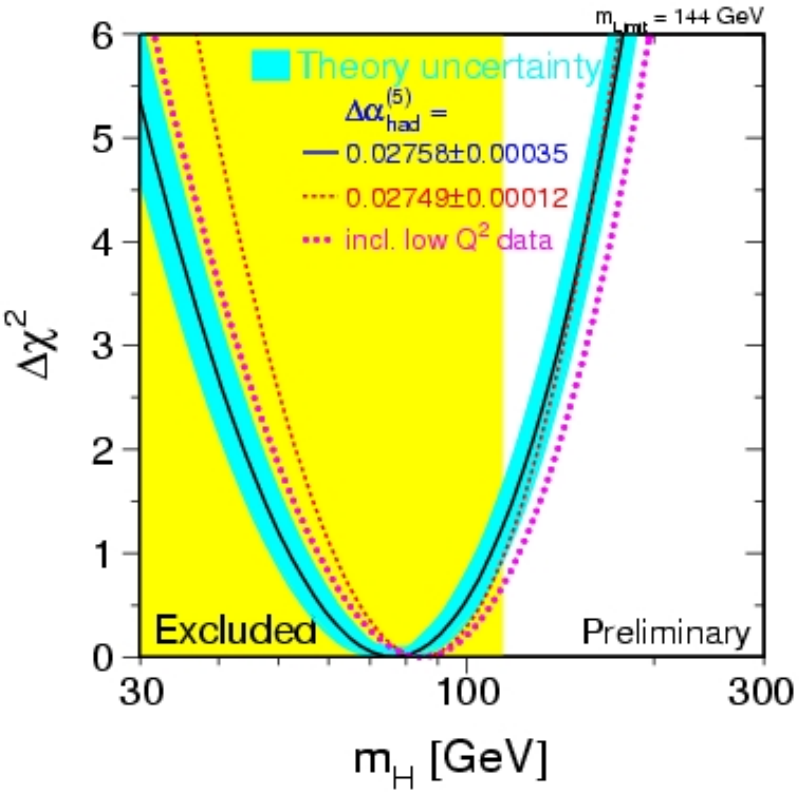
- Discrepancy with the SM!
- $A_{FB}{}^{b}$ - b-quark forward-backward asymmetry

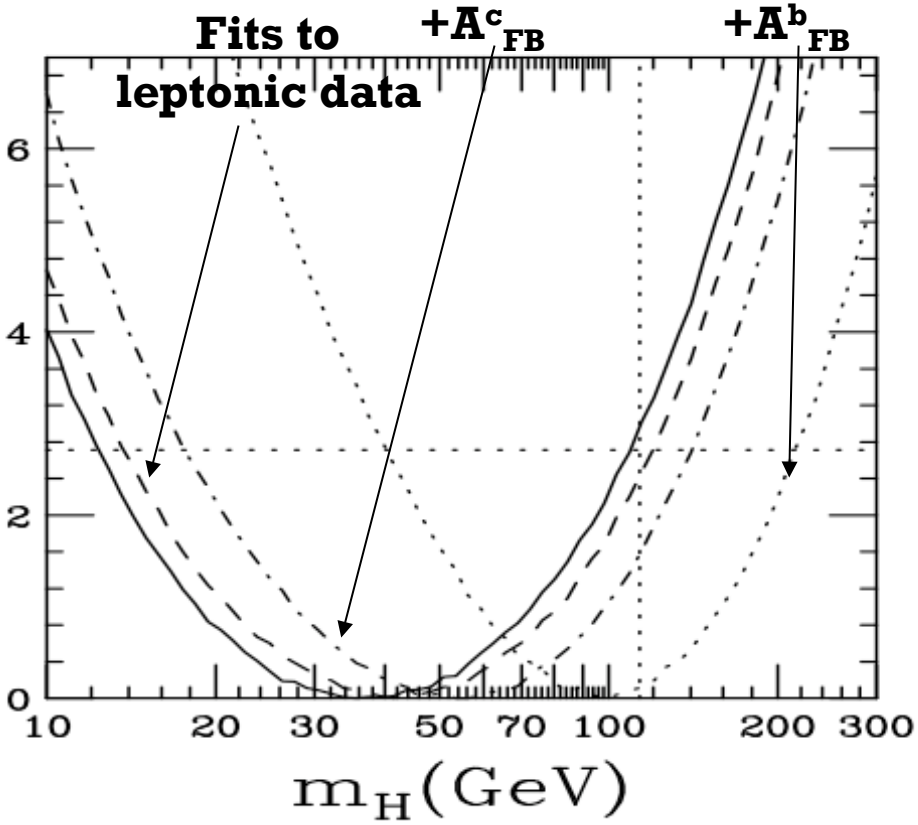
  ~2.9 σ away (LEP)
- As a result:

  sin $\theta_{W,\,lep}$ is ~3.6 σ away from sin $\theta_{W,\,had}$
- Assumptions on mistakes in the LEP measurements:
  - underestimated systematic uncertainty
  - systematical shift in the measured value

  are not satisfactory

New physics in top samples



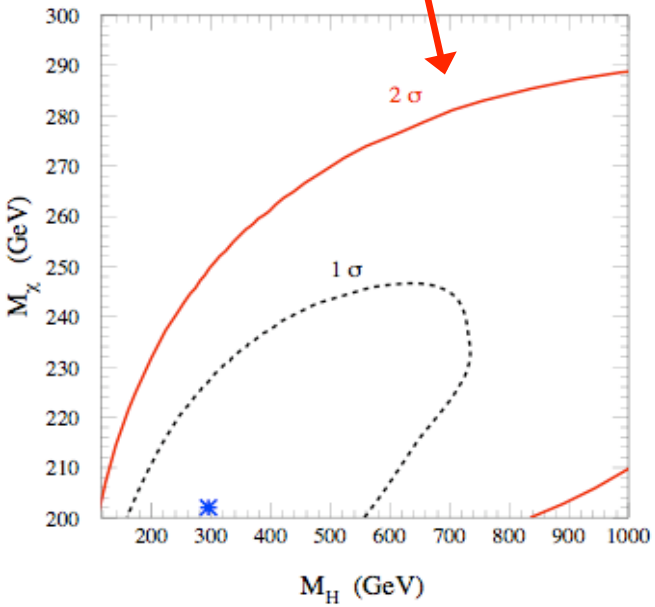


With sin θ_W value averaged over leptonic and hadronic measurements

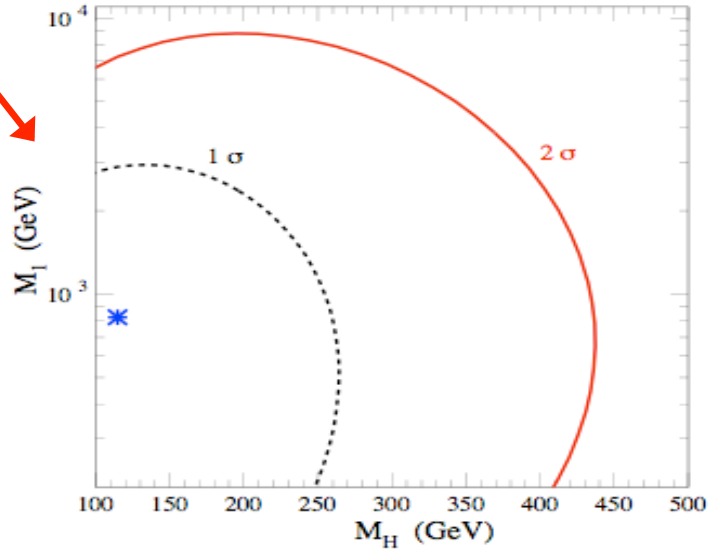
With sin $\theta_{W,\,lep}$ and sin $\theta_{W,\,had}$ alone
M. Chanowitz, hep-ph/0104024

New physics in top samples

- New physics in Z->bb? (C. Wagner et al, hep-ph/0109097)
- Mirror quarks of b-quarks improve the EWK fit
- Two scenarios: with and without top mirror quarks



Perfect for Tevatron searches



Difficult at Tevatron

This Analysis ~2.8 fb^{-1}

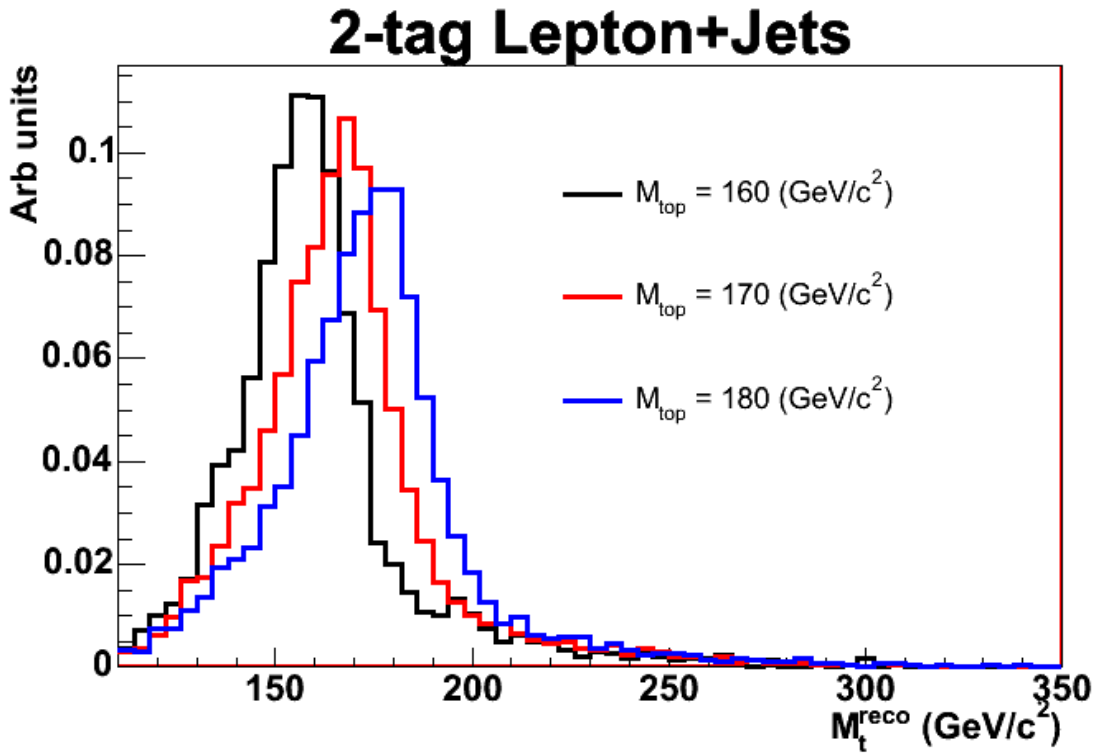
Idea: use kinematics again to separate t′ from t

- We search for new quark decays into Wq: t´ -> Wq
  - t´ ->Wb´ is kinematically suppressed and $V_{t'b} \sim V_{t'q}$
- Use lepton+jets events (no b-tagging requirements)
- Assume BR(t'->Wq) ~ 100%
- Model new signal with 4-generation t´ quark pair production (Pythia)
- Assume strong t´ pair production with strong SM couplings

Reconstructed Mass

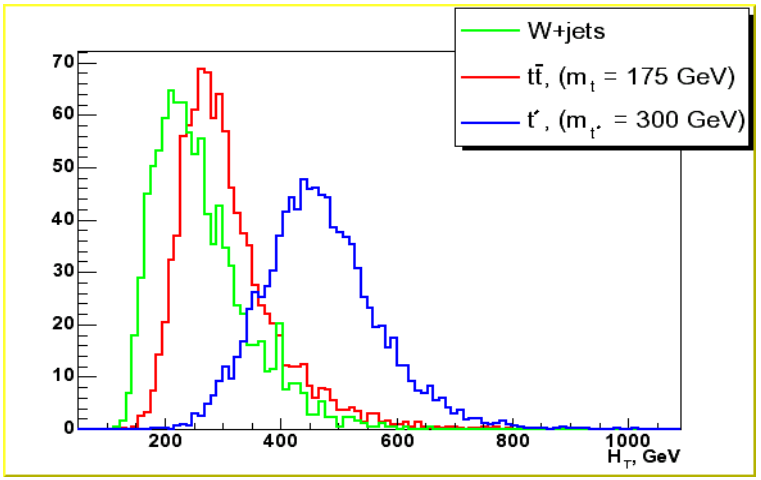
$$\chi^2 = \sum_{i=l,jets} \frac{(p_t^{i,meas} - p_t^{i,fit})^2}{\sigma_i^2} + \sum_{j=x,y} \frac{(p_j^{UE,meas} - p_j^{UE,fit})^2}{\sigma_j^2}$$

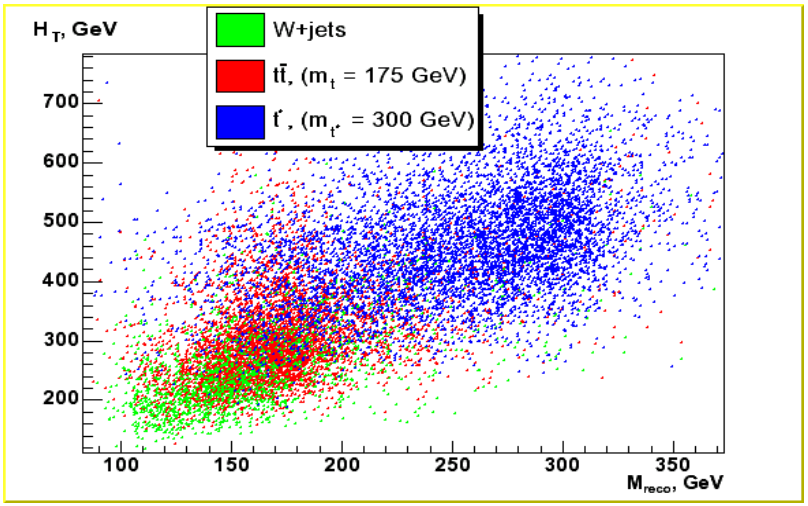
$$+ \frac{(M_{jj} - M_W)^2}{\Gamma_W^2} + \frac{(M_{lv} - M_W)^2}{\Gamma_W^2} + \frac{(M_{bjj} - M_{fit})^2}{\Gamma_t^2} + \frac{(M_{blv} - M_{fit})^2}{\Gamma_t^2}$$

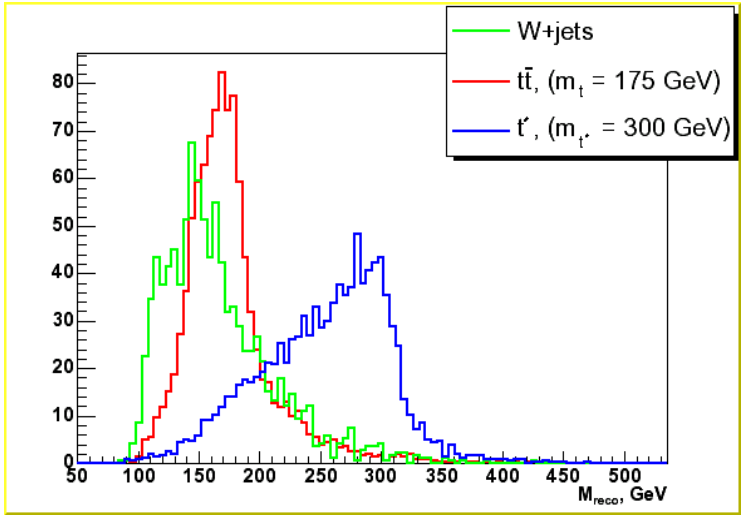


Search for massive top

- We use the top mass fitter, and fit observed 2D data distribution of H_T vs M_{recon}

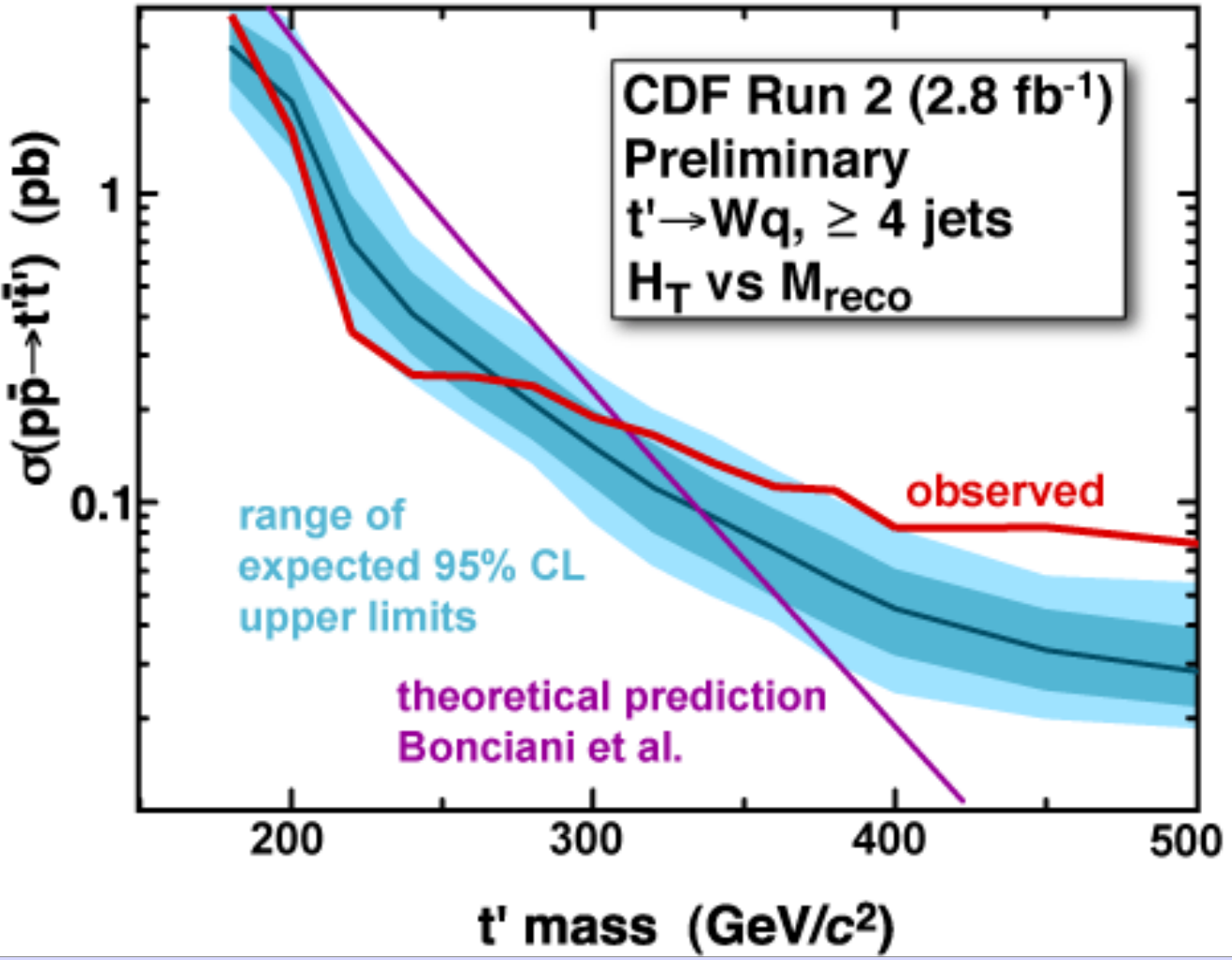






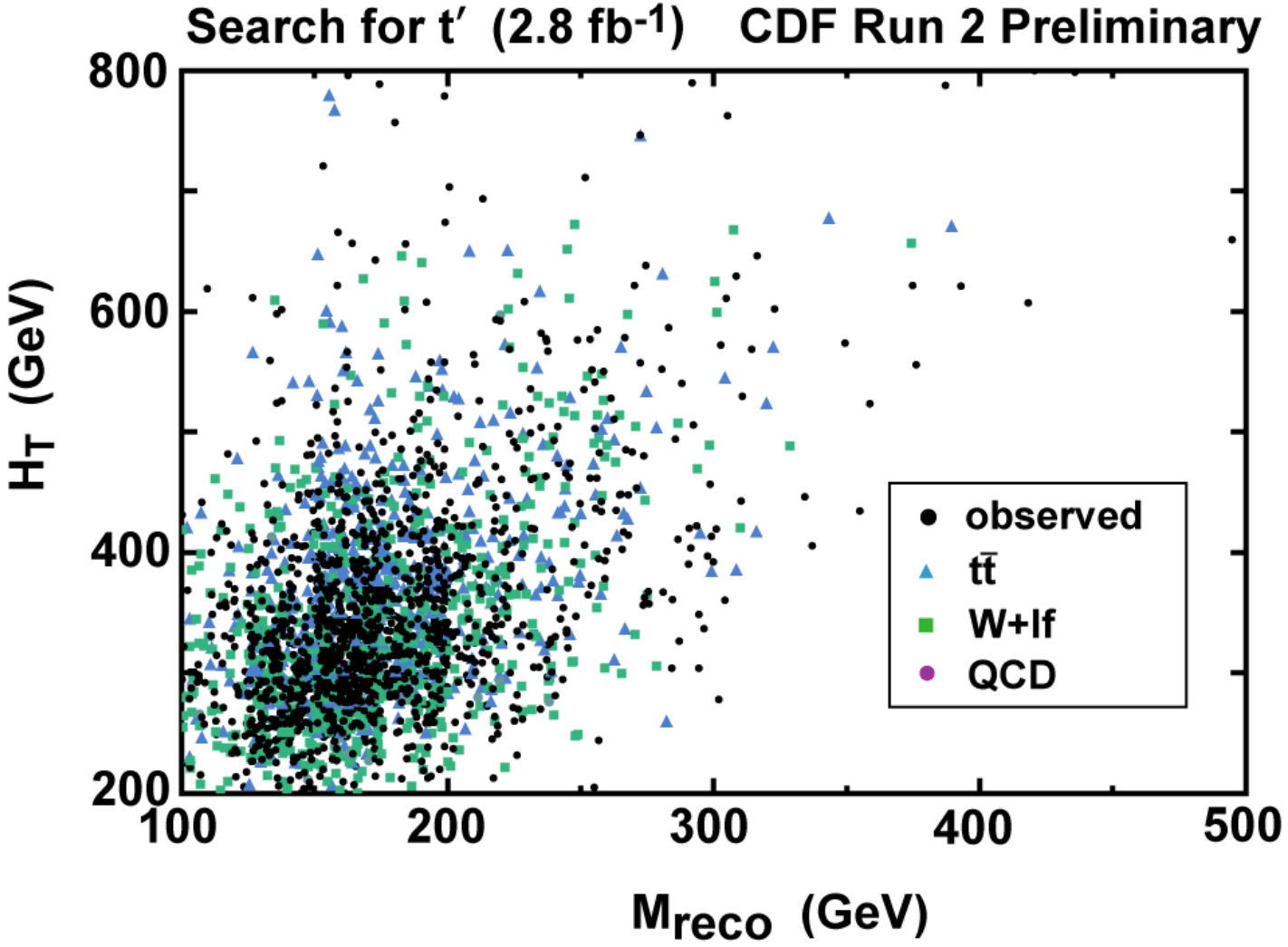
Variables are ~model-independent, to maintain sensitivity to many BSM scenarios

Limits on t'



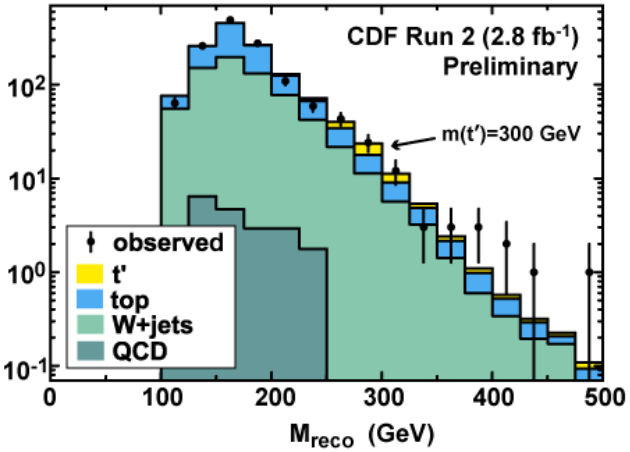
Exclude with 95%CL region of t′ masses below 311 GeV

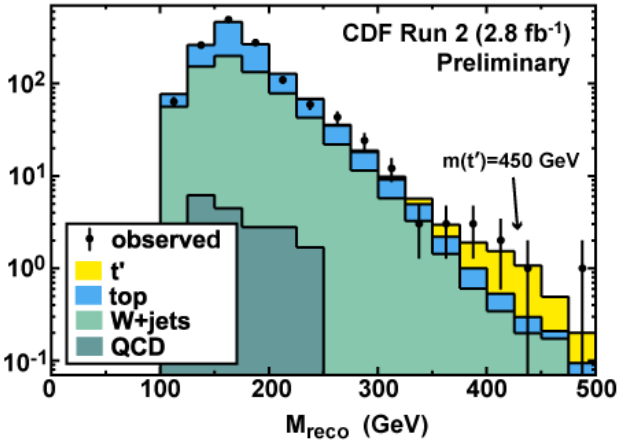
2-D Scatter Plot

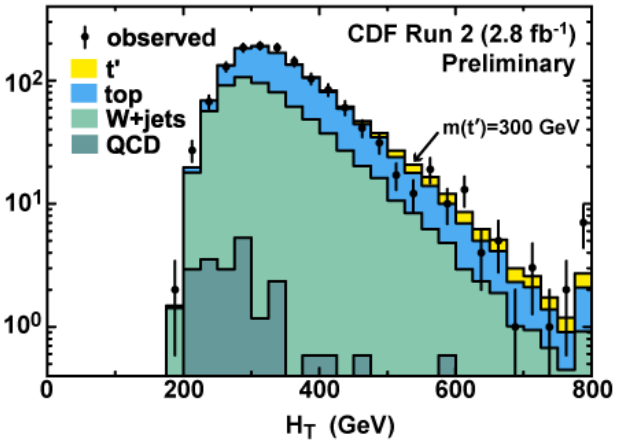


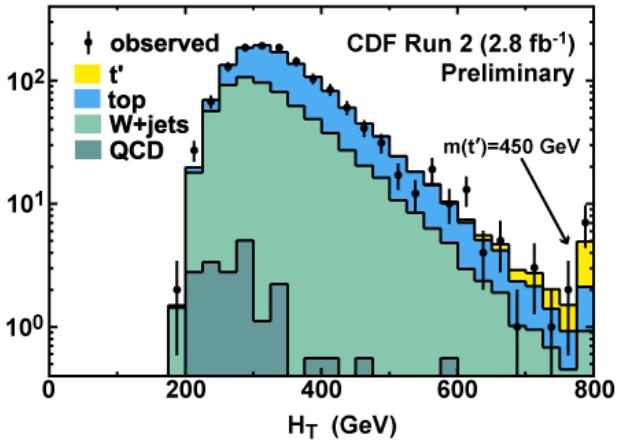
Expected (MC) v. data (black)

Data v. Projections



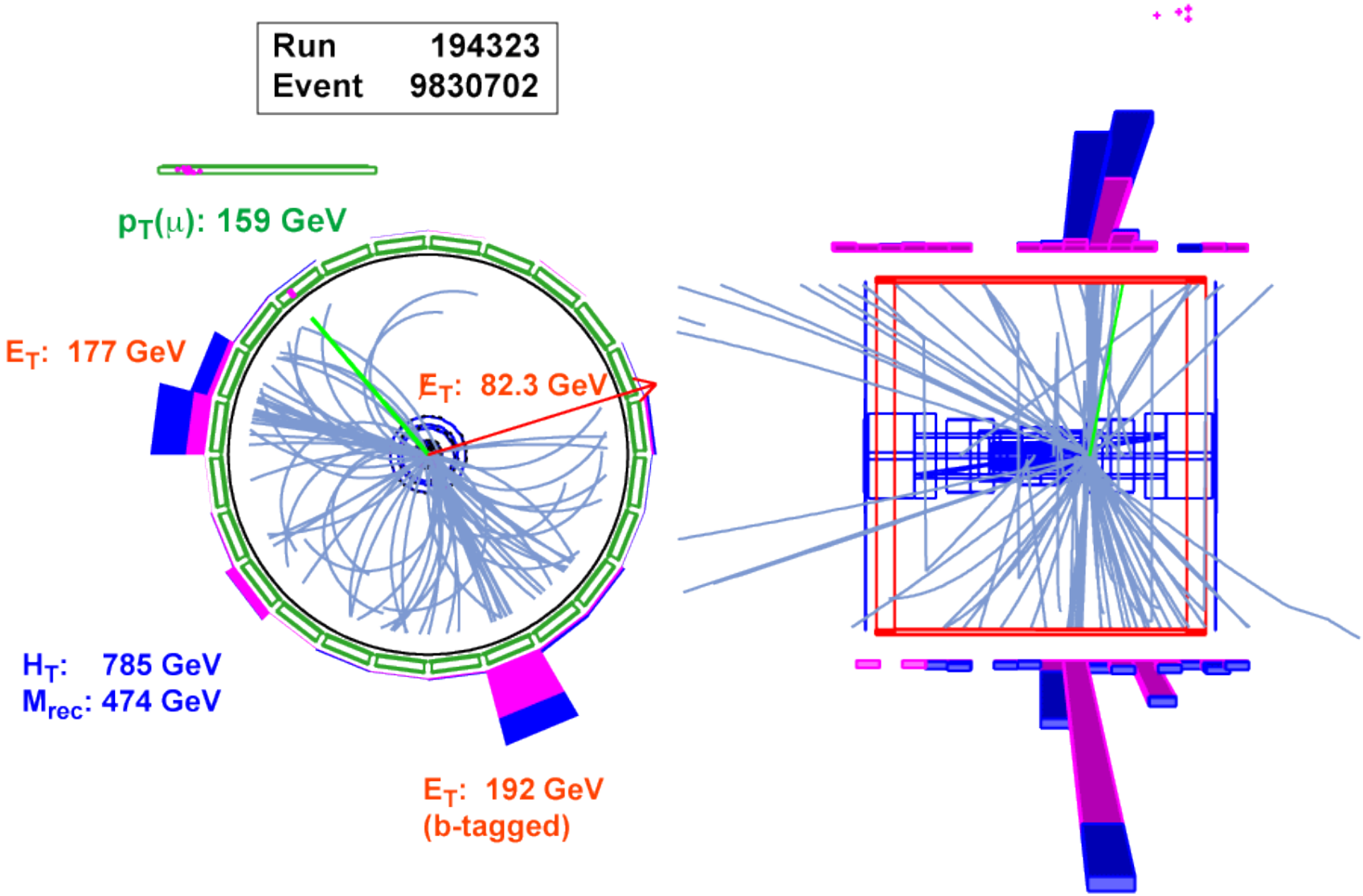






1-d Projection: Fit results for M(t′) = 300, 450 GeV

Couple of strange ones…



Significance Test nxn

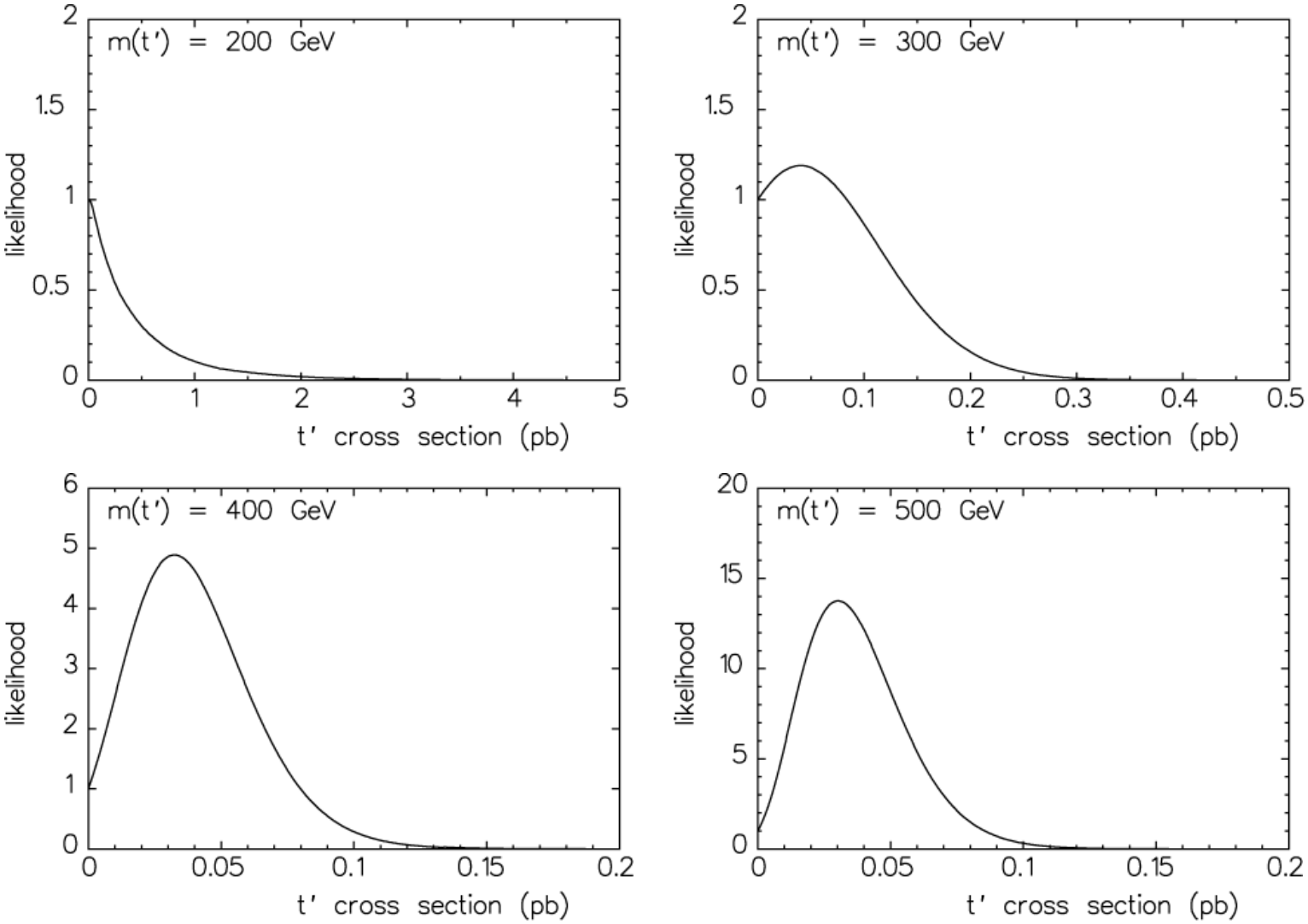
- measure significance of excess by looking at upper-right-most n x n bins
- let n increase from n=1,2,… and find the n x n region with most significant excess
- then ask "how probable is it that we get such a most significant excess?"

CDF Run 2 (2.8 fb^{-1}) Preliminary

n	Min M_{rec} [GeV/c^2]	Min H_T [GeV]	observed	expected	p-value
1	475	775	0	0.021	1.000
2	450	750	0	0.116	1.000
3	425	725	1	0.228	0.2040
4	400	700	2	0.371	0.0540
5	375	675	3	0.718	0.0364
6	350	650	4	1.503	0.0660
7	325	625	4	2.876	0.3251
8	300	600	12	5.498	0.0110
9	275	575	14	9.885	0.1273
10	250	550	29	18.03	0.0105
11	225	525	41	31.34	0.0555
12	200	500	58	52.05	0.2219
13	175	475	92	91.14	0.4779
14	150	450	152	158.7	0.7141
15	125	425	222	231.0	0.7318

Backup Slides

Likelihoods



Limits

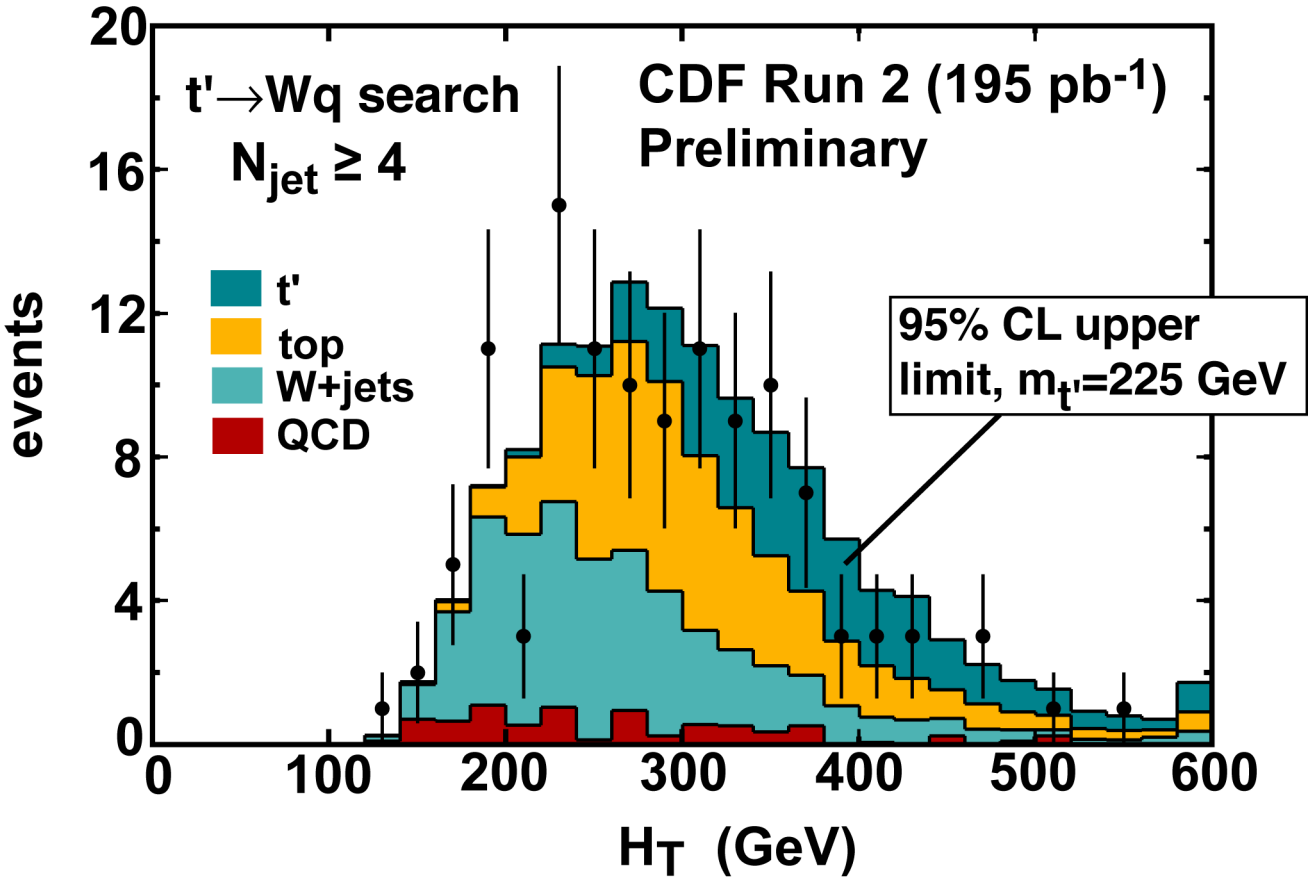
CDF Run 2 (2.8 fb^{-1}) Preliminary

	expected limit (pb)					**observed limit (pb)**
$m(t')$ **(GeV)**	-2σ	-1σ	**median**	$+1\sigma$	$+2\sigma$	
180	1.900	2.362	2.954	3.772	4.540	3.759
200	1.066	1.434	1.959	2.828	3.682	1.595
220	0.360	0.486	0.693	1.002	1.579	0.355
240	0.248	0.306	0.406	0.558	0.743	0.258
260	0.183	0.216	0.288	0.390	0.498	0.254
280	0.135	0.161	0.208	0.280	0.370	0.237
300	0.089	0.116	0.150	0.202	0.268	0.188
320	0.063	0.081	0.112	0.156	0.202	0.165
340	0.050	0.064	0.088	0.120	0.164	0.133
360	0.041	0.050	0.070	0.096	0.128	0.112
380	0.031	0.040	0.056	0.077	0.103	0.109
400	0.024	0.032	0.045	0.062	0.083	0.081
450	0.020	0.025	0.033	0.045	0.058	0.083
500	0.019	0.022	0.028	0.039	0.055	0.073

Modeling

- Model t' as heavy version of top in Pythia
  - Generate samples with masses 180-400 GeV/c^2 every 20 GeV + 450 and 500 GeV
- Top with Mass 175 GeV
  - Assume SM cross-section of 6.7pb^{-1}
- W+lf
  - ALPGEN 0p up to 4p
  - Merged as per top group specifications
- Other backgrounds
  - W+heavy flavour, Z+heavy flavour, diboson, single top
  - As per standard Top Group

H_T from First Result



Plot for fit result with t' signal (M(t') =225 GeV) included at 95% CL limit

[σ(ttbar) →6.12 pb in this fit]

Other ideas: Top plus missing E_T

- Search for anomalous events that look like top+MET.
  - →SUSY cascades, T→A_ht *(L. Wang)*, …
- Similar (*based on*) t' search but optimize for extra MET.
- Search underway at CDF.