Search Light Higgs and new physics in associate production with Top Quark Pairs at CDF

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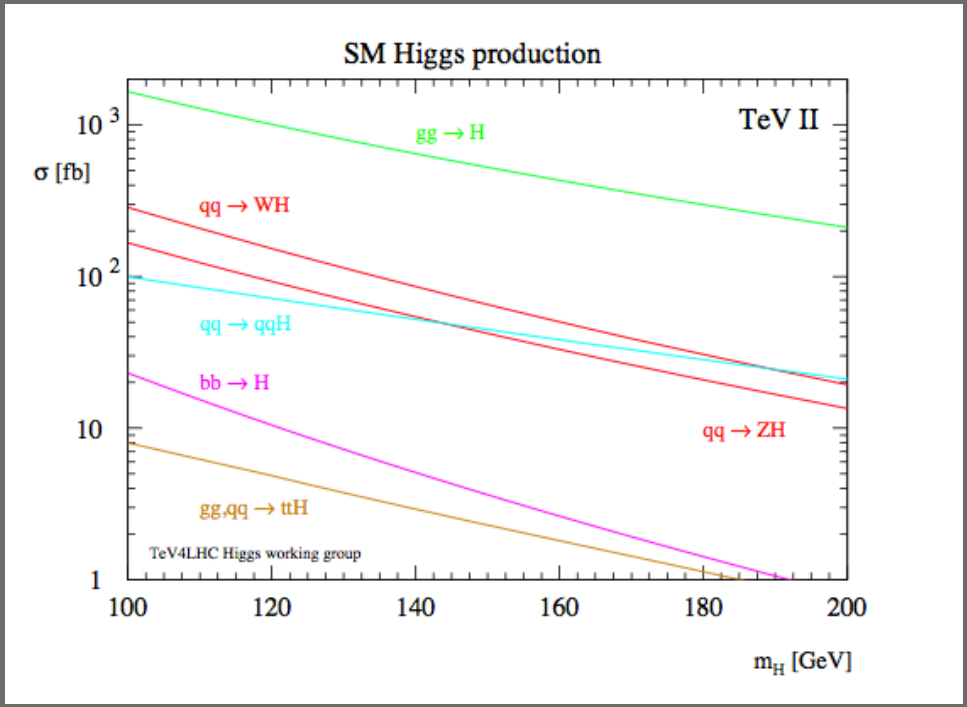
On going Analysis Outline

- Introduction
- Standard model Events CDF results
- Non SM Events with same FS
- Analysis strategy
- Further Work

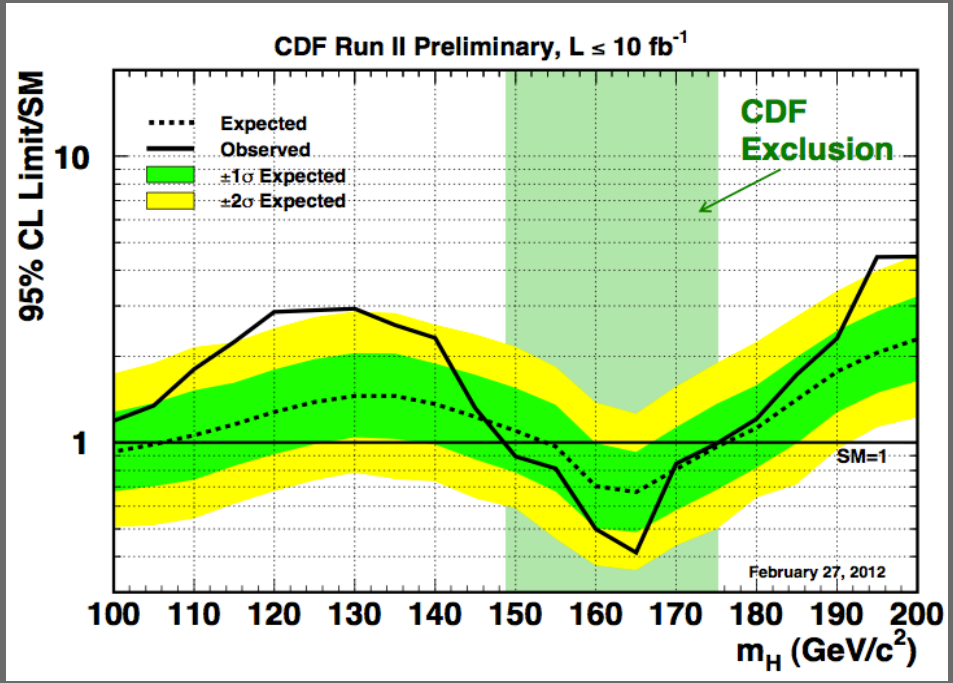
Introduction:

- Higgs, the last unobserved particle postulated by the SM in order to explain the origin of mass is produced at Tevatron by several processes originated by gluon-gluon fusion and $q\bar{q}$ processes



Introduction:

- The last analysis presented by CDF exclude in large mass intervals the presence of a new particle but for an interval between 120-135 Gev/c^2 where there is a strong indication of the presence of the particle.

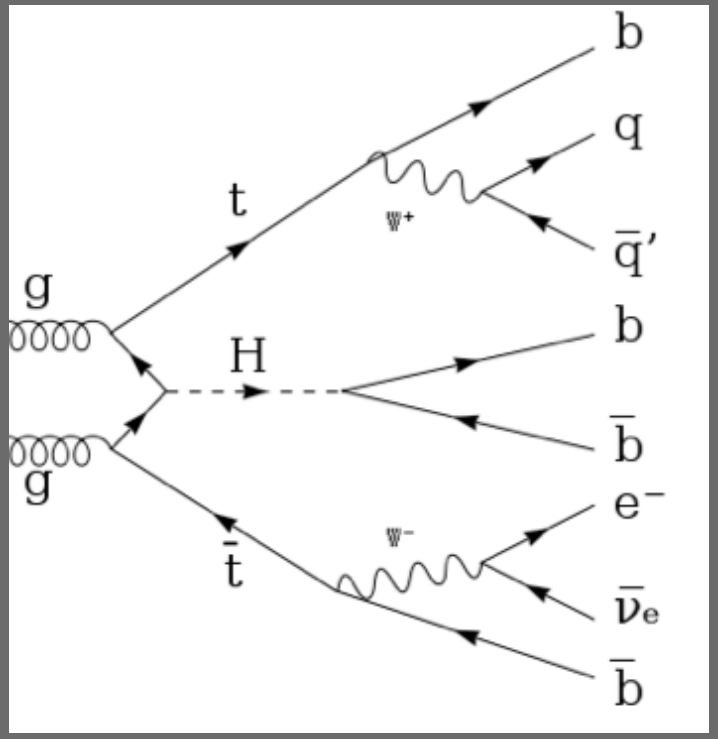


Introduction:

- The data include the combination of several analysis with $b\bar{b}$ in the final state except those in witch the production of the Higgs is associated with $t\bar{t}$, because this kind of studies has been performed at CDF, on a limited integrated luminosity only.

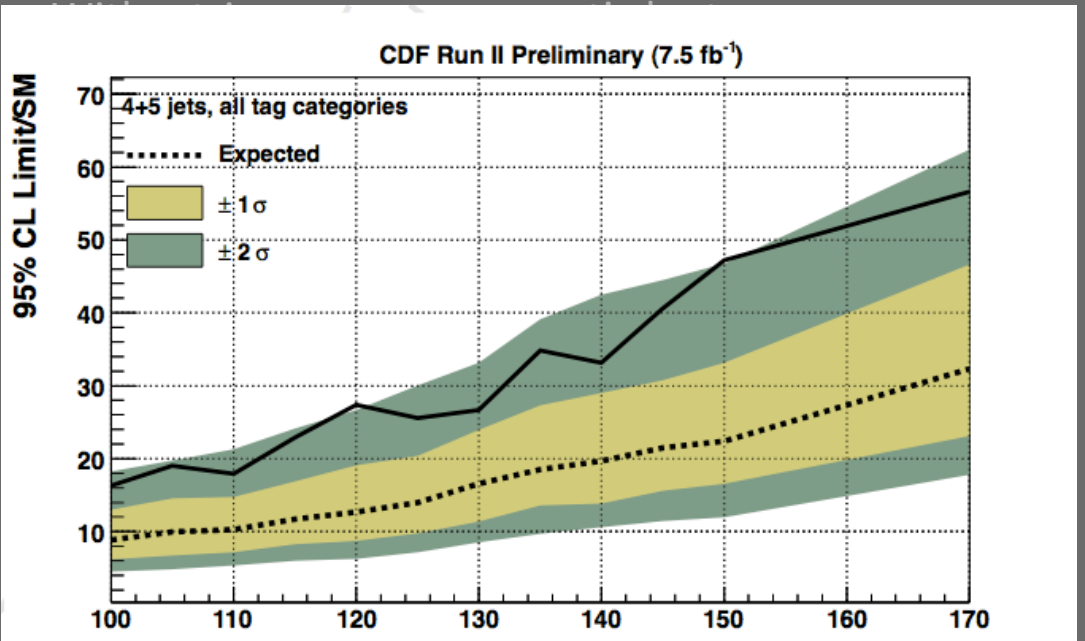
Introduction:

In this sector ($t\bar{t}$ associate production) two different channel have been studied:



$$gg \rightarrow t\bar{t}H \rightarrow 2j + 4j_b + l + \not{E}_T$$

This channel has been studied by Jon Wilson, Homer Wolfe, Jake Connors, Richard Hughes and Brian Winer over 7.5fb^{-1}



The results of the first kind of analysis Show a significant deviation of 2 σ in 2 regions; ~ 120 GeV and ~150 GeV

Introduction:

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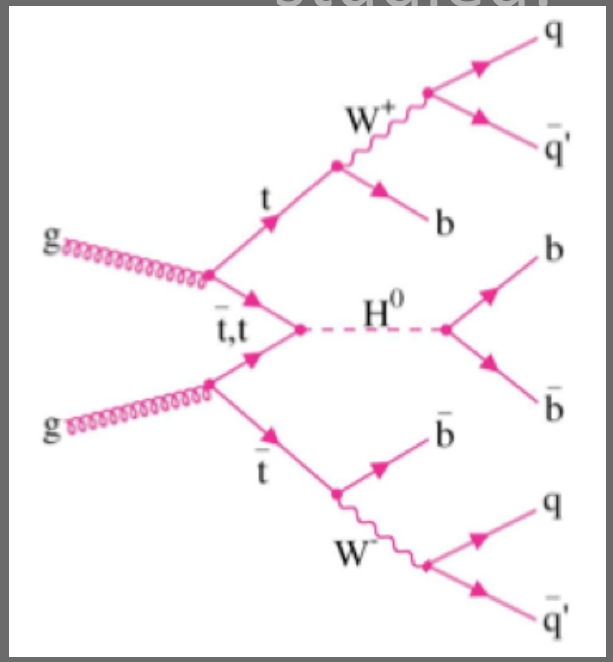
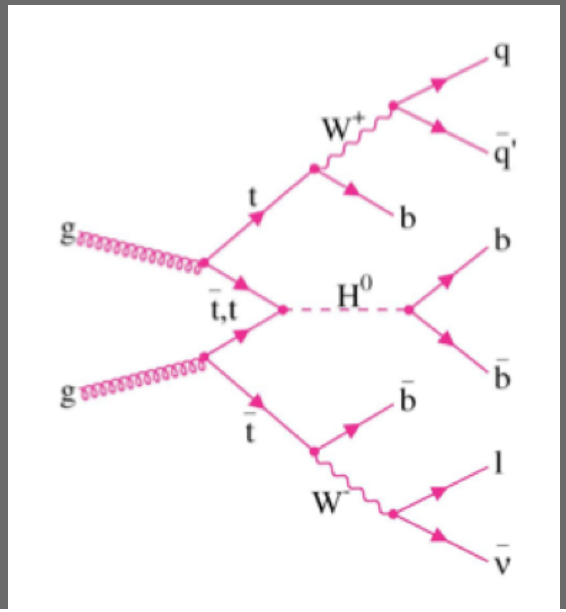


$$gg \rightarrow t\bar{t}H \rightarrow 4j + 4j_b$$

This channel has been studied by
Hyun Su Lee, Wesley Ketumn and Young-Kee Kim
Over 5.7 fb^{-1}
With a multijet trigger.



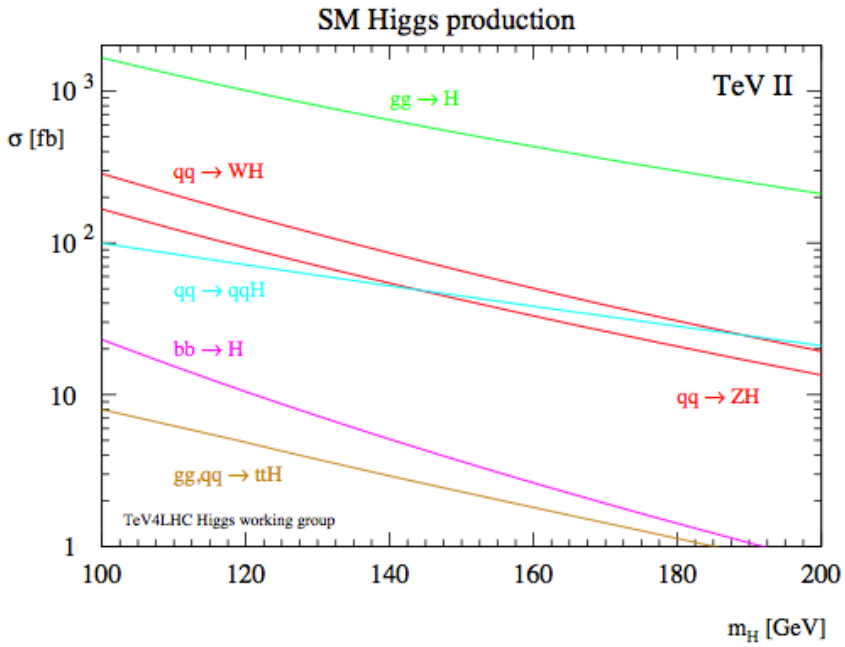
Standard model Events CDF results

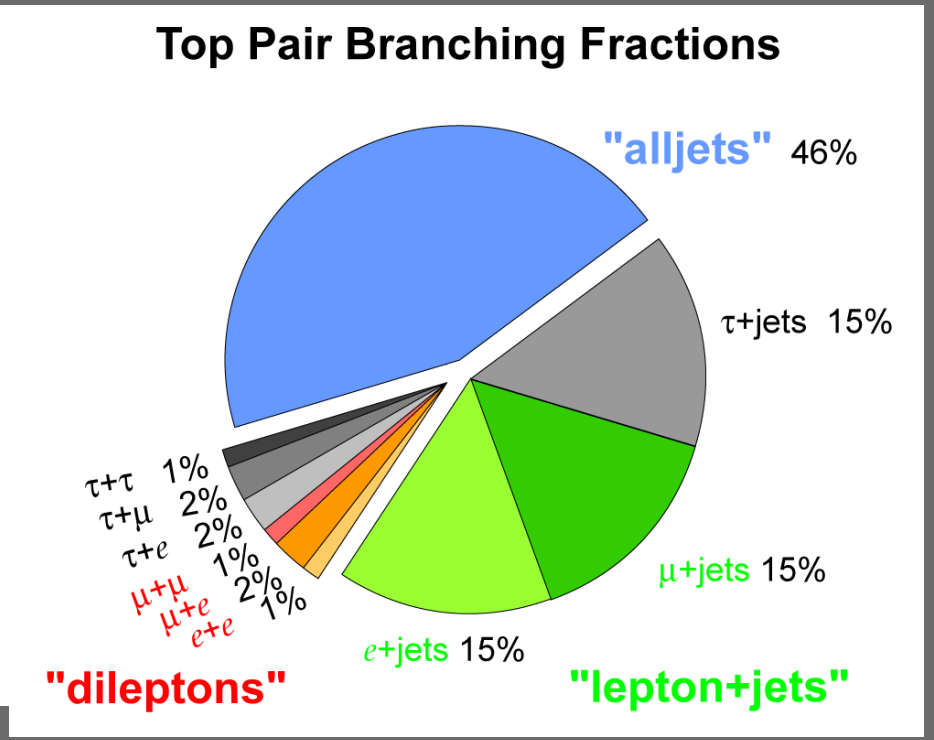
•A new analysis on the same channels with full luminosity extension could be interesting especially if implemented with new tools coming from all hadronic top mass and new tagging of the b jets in order to improve the efficiency and the exclusion of the background at the same time.

• Since there in fact the new tagging Hobbit has been introduced and a very efficient method of selecting all jet top events by a NN has been tested in measurement of the top mass.

Standard model Events CDF results

- Even if the production is relatively depressed in the SM respect to associated production with W or Z the BF can be large and interesting if we use the same event structure of the top all jet analysis





Non SM Events with same FS

- Vectorlike quarks (spin-1/2, color triplets; same electroweak charges for LH and RH components) predicted in top-quark seesaw, little-Higgs, E6 GUT, extra dimensions,…

- P. H. Frampton, P. Q. Hung and M. Sher, "Quarks and leptons beyond the third generation," Phys. Rept. 330, 263 (2000) [arXiv:hep-ph/9903387]
- D. Choudhury, T. M. P. Tait and C. E. M. Wagner, "Beautiful mirrors and precision electroweak data," Phys. Rev. D 65, 053002 (2002) [arXiv:hep-ph/0109097]
- T. Han, H. E. Logan and L. T. Wang, "Smoking-gun signatures of little Higgs mod- els," JHEP 0601, 099 (2006) [arXiv:hep-ph/0506313].
- S. Abdullin et al, "Tevatron-for-LHC report: Preparations for discoveries," hep-ph/0608322, Section 3.4.
- Bogdan A. Dobrescu, Kyoungchul Kong, Rakhi Mahbubani, Prospects for top-prime quark discovery at the Tevatron, April 10, 2009Fermilab-Pub-08-571-T;
- Bogdan A. Dobrescu –Private comunication April 2012

Non SM Events with same FS

- Color-octet spin-1 particles: G′ μ "gluon-prime" (topgluon,coloron, Kaluza-Klein gluon, techni-ρ, ...) predicted in topcolor, extra dimensions, technicolor,...

- B. A. Dobrescu and C. T. Hill, "Electroweak symmetry breaking via top condensation seesaw," Phys. Rev. Lett. 81, 2634 (1998) [hep-ph/9712319];
- H. Collins, A. K. Grant and H. Georgi, "The phenomenology of a top quark seesaw model," Phys. Rev. D 61, 055002 (2000) [hep-ph/9908330];
- H. J. He, C. T. Hill and T. M. P. Tait, "Top quark seesaw, vacuum structure and electroweak precision constraints," Phys. Rev. D 65, 055006 (2002) [arXiv:hep-ph/0108041];
- H. C. Cheng, B. A. Dobrescu and C. T. Hill, "Electroweak symmetry breaking and extra dimensions," Nucl. Phys. B 589, 249 (2000) [arXiv:hep-ph/9912343];
- M. S. Carena, E. Ponton, J. Santiago and C. E. M. Wagner, "Light Kaluza-Klein states in Randall-Sundrum models with custodial SU(2)," Nucl. Phys. B 759,20202 (2006) [hep-ph/0607106].

Non SM Events with same FS

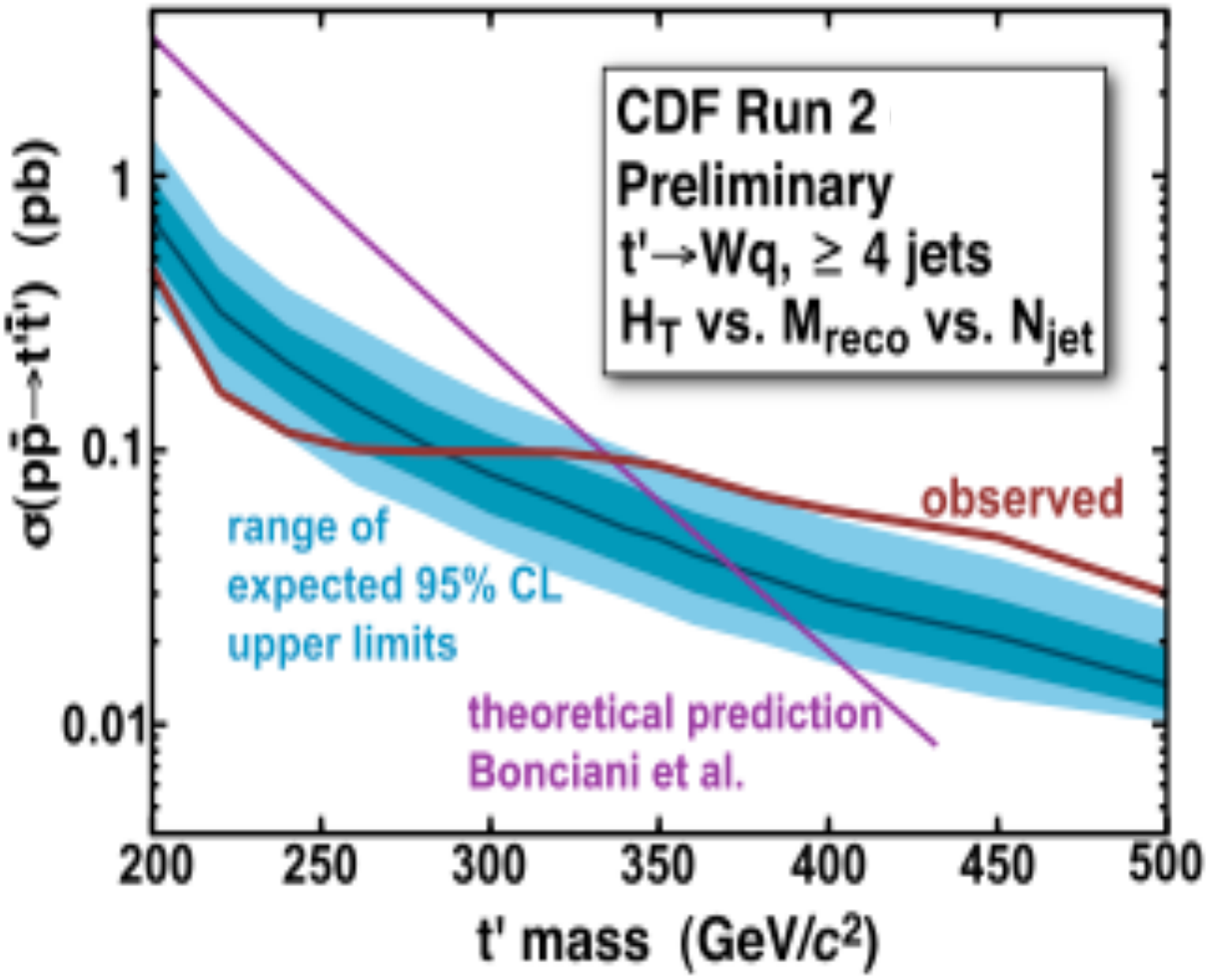
- Search for t' has been already performed at CDF in the channel :

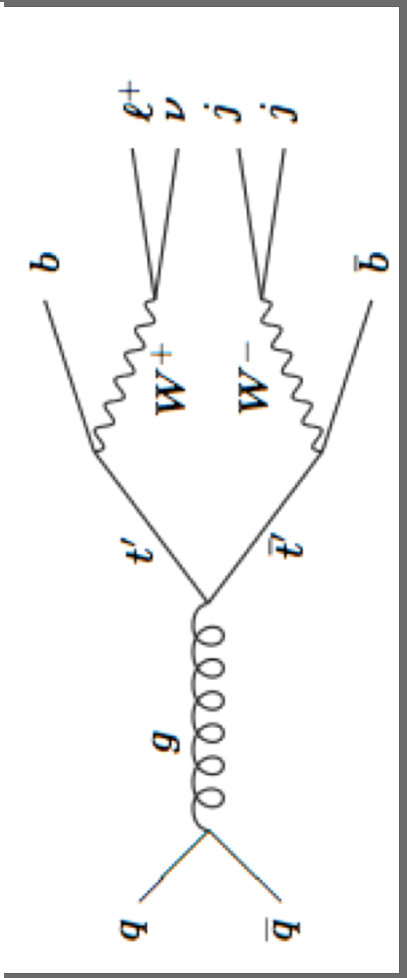
$$t'\bar{t}' \rightarrow Wq + W\bar{q} \rightarrow q_1 + \bar{q}_2 + q + l + \bar{q} + \not{E}_T$$

- Using only event kinematics this method avoids imposing the b tagging and allows various decays of the t' and at the same time has a larger acceptance

- CDF Collaboration, "Search for t' → W q in lepton plus jets events", note 9446, July 2008;
- A. Lister [CDF Collaboration], "Search for heavy top-like quarks t' → Wq using lepton plus jets events", hep-ex/0810.3349.

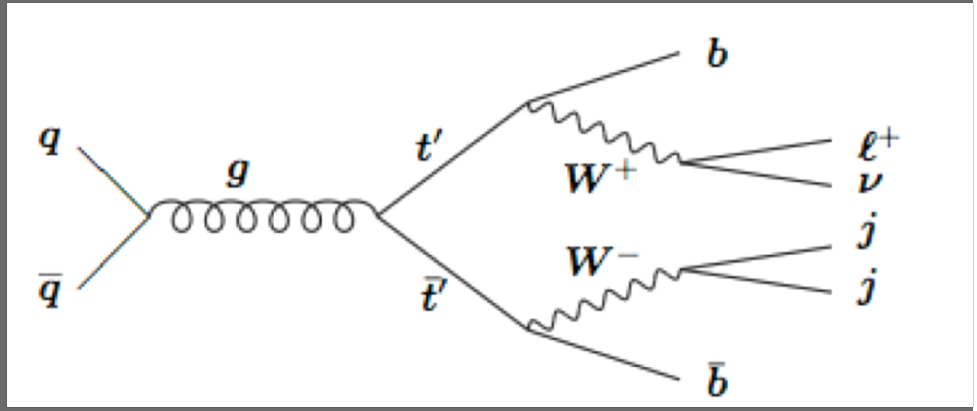
Non SM Events with same FS





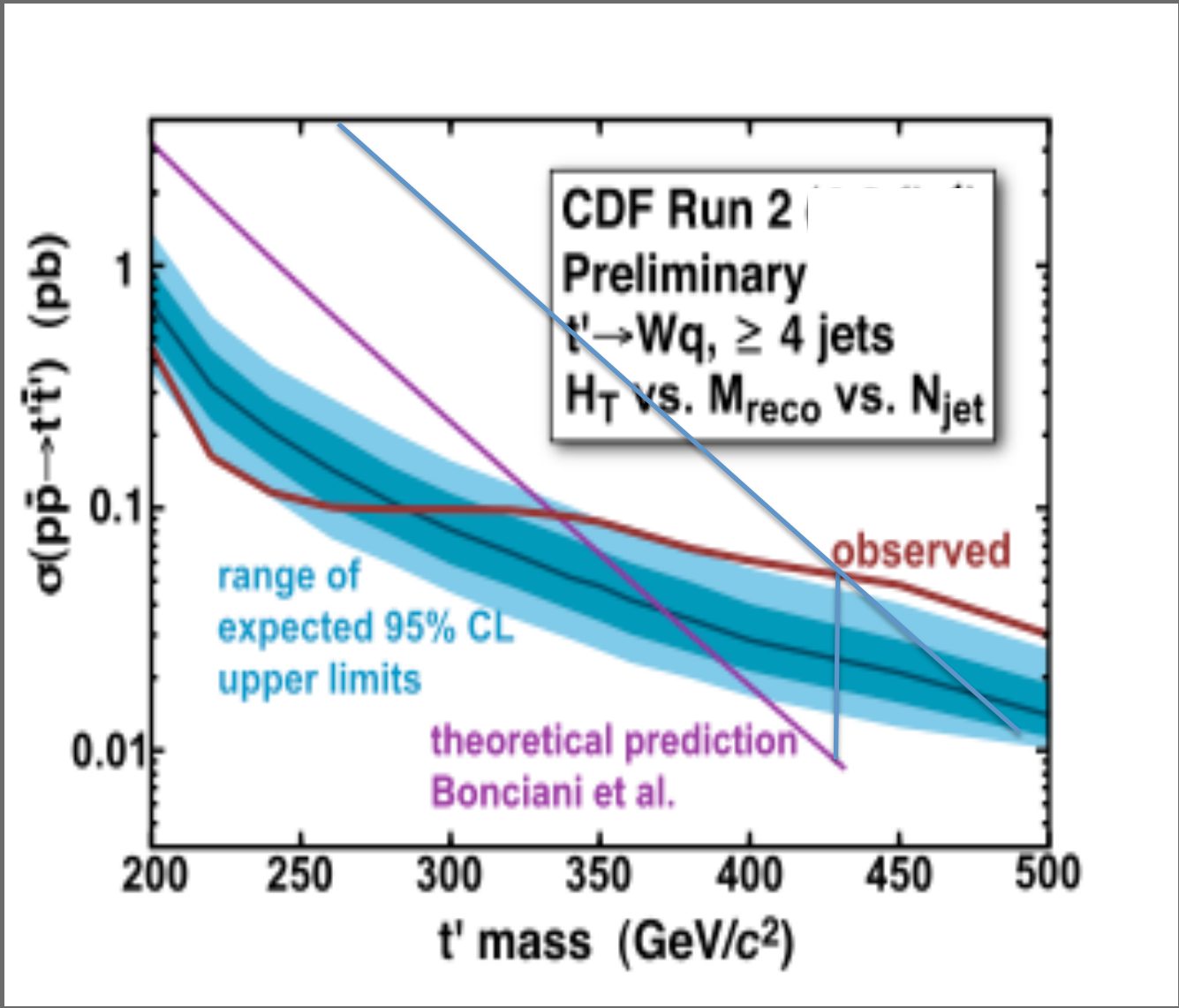
Non SM Events with same FS

With a choice of only hadronic + Hadronic and missing E_T we can have a better result of a factor:

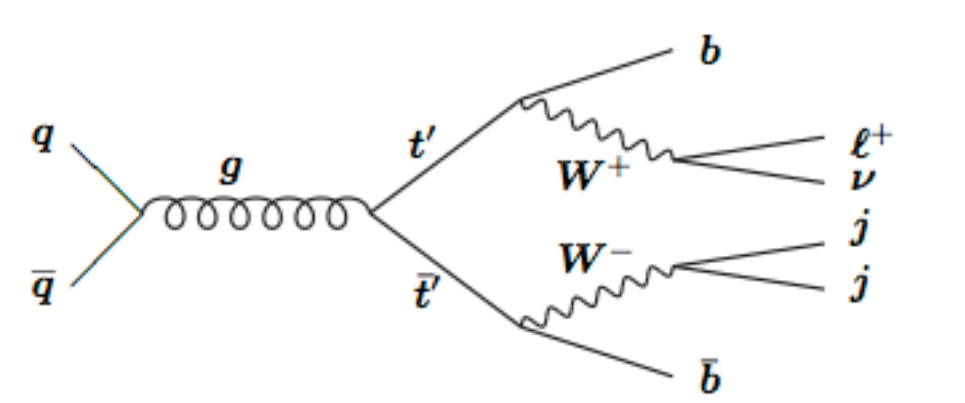


$$\sqrt{\frac{L_{new}}{L_{old}}} \times \frac{BF_{new}}{BF_{old}} = 5.6$$

Non SM Events with same FS

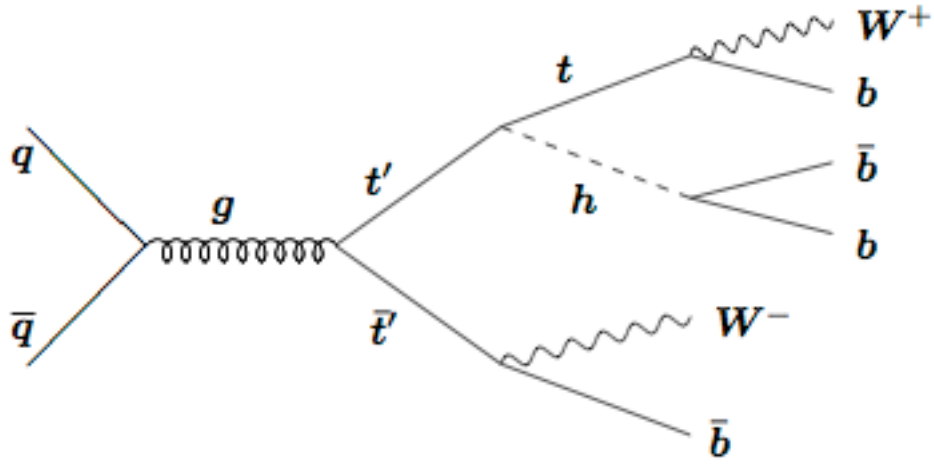


Non SM Events with same FS

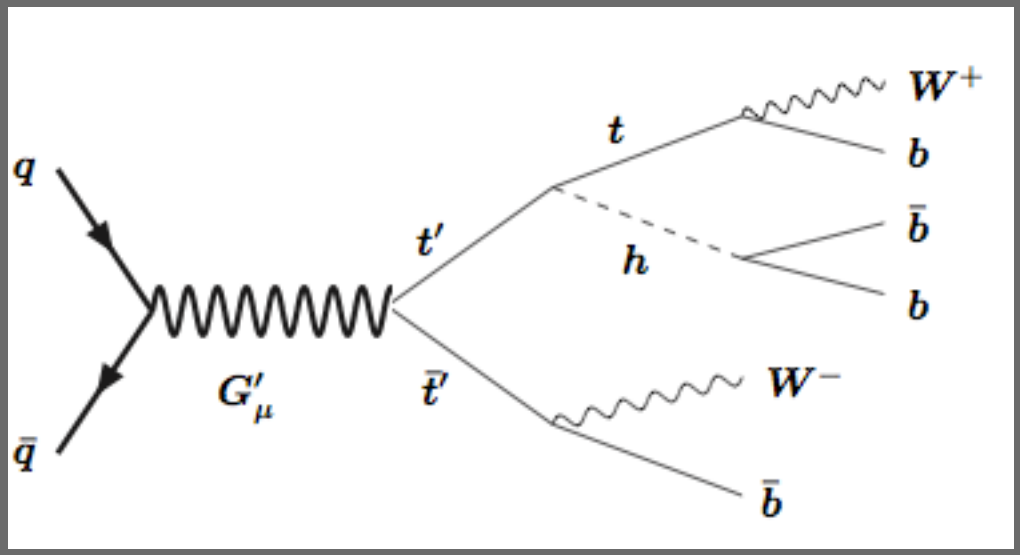


- A t' can decay as a SM t or radiating a Higgs or a Z

We could take advantage of the experience in the measurement of the top mass in the pure hadronic channel in order to explore this new Physics signals

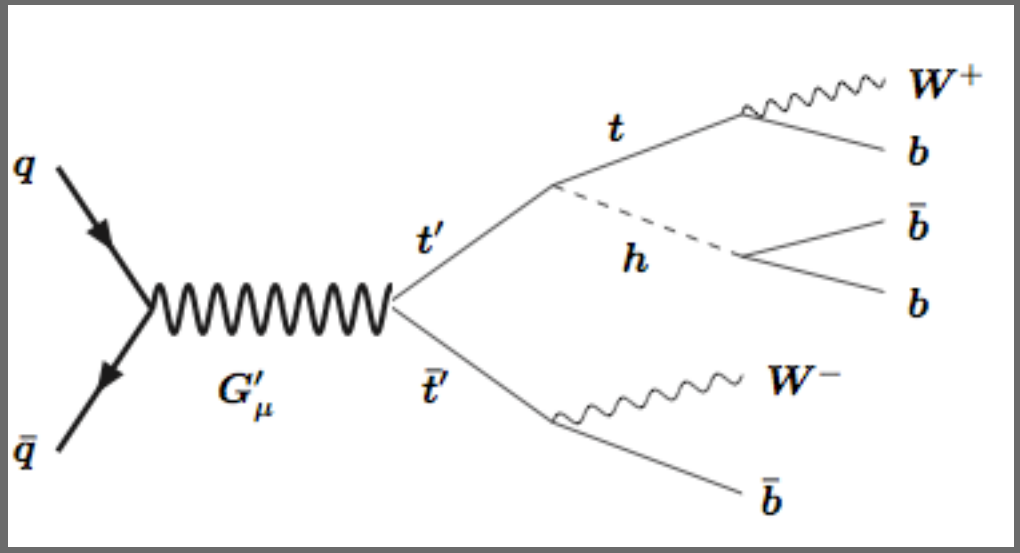


Non SM Events with same FS



G'_μ "gluon-prime" (topgluon,coloron, Kaluza-Klein gluon, techni-ρ, ...)
predicted in topcolor, extra dimensions, technicolor,...

Non SM Events with same FS



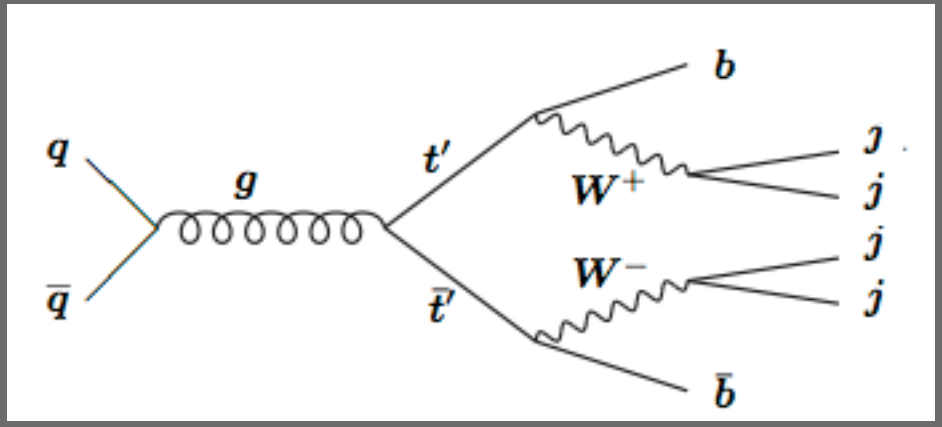
So the analysis could be sensitive also to G'_μ

Strategy

- We plan to make use of the machinery used in the all hadronic top mass;
- All the events we are looking for have tops in final state so b and W;
- We have plan to use the NN of the all hadronic top with improved by including Hobbit;
- We can fully reconstruct the kinematic of the processes.

Strategy

- As an example we can consider the event of following the kind:



- We first select the events with the NN.
- The QCD background modeling will be based on the data-driven method

Strategy

$$t'\bar{t}' \to b\bar{b}W^+W^- \to b\bar{b}q_1\bar{q}_2q_3\bar{q}_4$$

$$p^\mu_{t'} = p^\mu_{W^+} + p^\mu_b$$
$$p^\mu_{\bar{t}'} = p^\mu_{W^-} + p^\mu_{\bar{b}}$$
$$p^\mu_{W^+} = p^\mu_{q_1} + p^\mu_{\bar{q}_2}$$
$$p^\mu_{W^-} = p^\mu_{q_3} + p^\mu_{\bar{q}_4}$$

$$(\mu = 0,1,2,3)$$

There are 13 unknown quantities:
The three-momenta of the t' those of the W and the t' mass.
We have 16 equations so the System is over constrained

Strategy

We make a $\chi^2 - like$ fit as follows:

$$\chi^2 = \frac{\left(m_{jj}^{(1)} - M_W\right)^2}{\Gamma_W^2} + \frac{\left(m_{jj}^{(2)} - M_W\right)^2}{\Gamma_W^2} + \frac{\left(m_{jjb}^{(1)} - M_{t'}^{m}\right)^2}{\Gamma_{t'}^2} + \frac{\left(m_{jjb}^{(2)} - M_{t'}^{m}\right)^2}{\Gamma_{t'}^2} + \sum_{i=1}^{6} \frac{\left(p_{T,i}^{Fit} - p_{T,i}^{m}\right)^2}{\sigma^2}$$

- We have 30 or 6 permutations in function of the number of taggings we minimize in function of the seven parameters the 6 transverse momenta and the t' mass.

Strategy

- Similar strategies are possible for all the other event configuration and can be explored in series/ parallel following the progress of the analysis

Conclusion

- We can study several interesting channels with the same machinery;
- We can put limits on important parameters of competitive models;
- The analysis is peculiar of the Tevatron for the qqbar resonant production of the new particles;
- We have local theoretical assistence (Dobrescu);
- We can extend old analysis to a larger luminosity

Backup slides

Non SM Events with same FS