Searches for $t\bar{t}$ Resonances at the Tevatron

Azeddine Kasmi
Baylor University
On behalf of the CDF and D0 Collaborations
ICHEP 2012, Melbourne, Australia

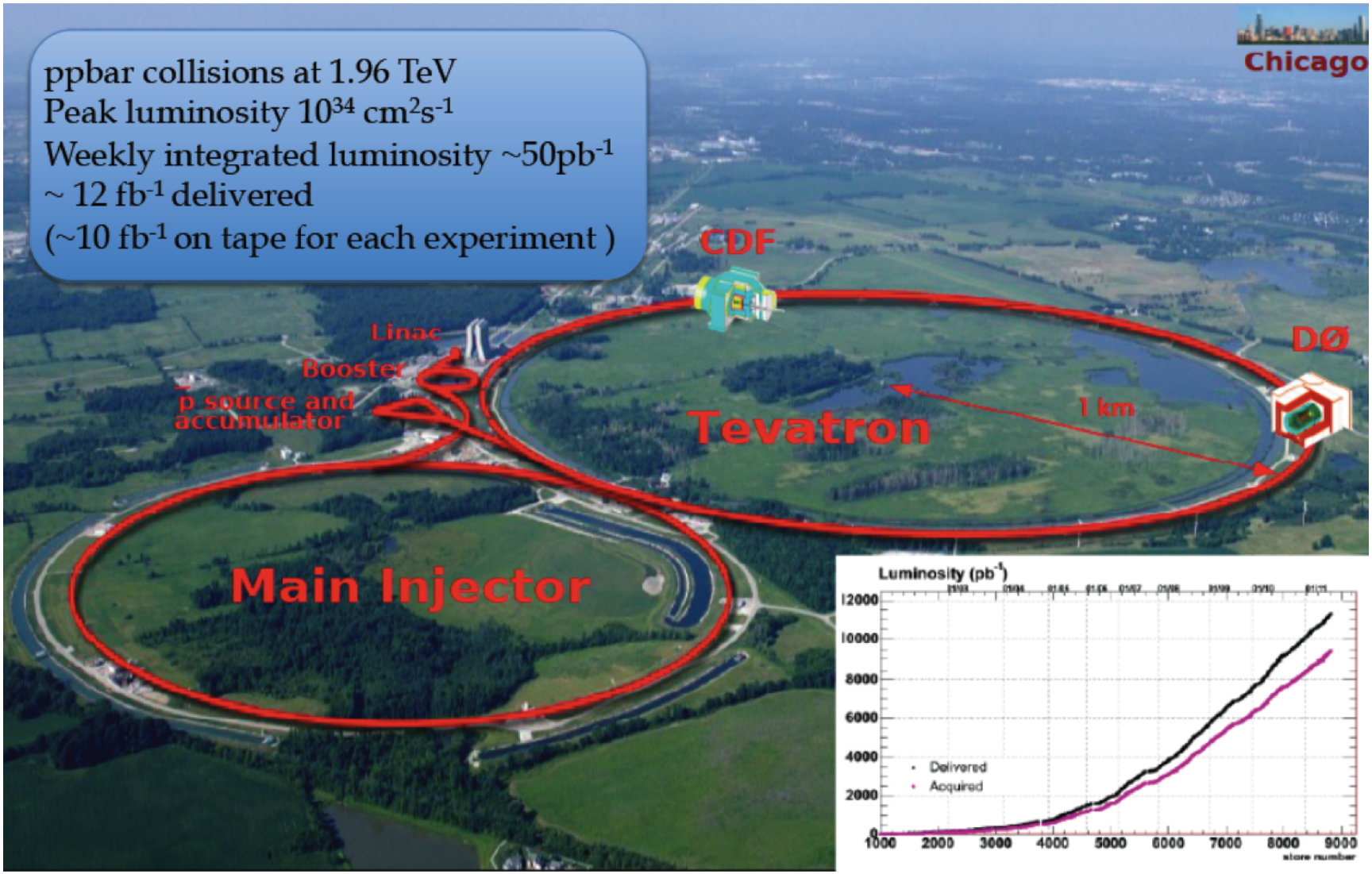
July 6, 2012

Table of Contents

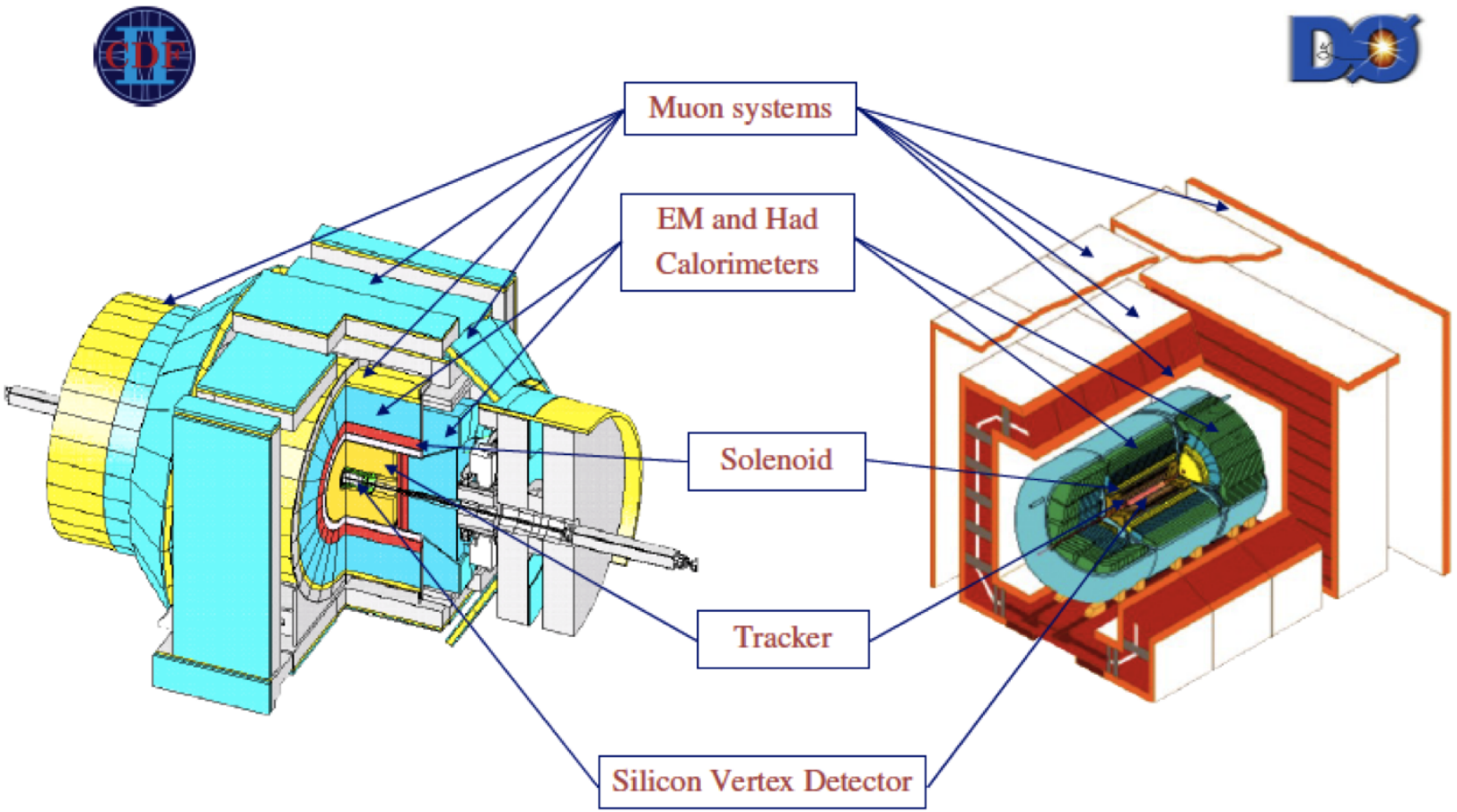
Introduction

- Top is the heaviest fundamental particle
  - In EWSB
  - In BSM scenarios
- Large radiative correction to the Higgs:
  - Need to cancel
  - New particles: Top partners (SUSY), Fermions (Little Higgs), Extra Dimensions
- How are $t\bar{t}$ pairs produced?
  - Only by SM QCD?
  - Or is there New Physics?
  - Are $t\bar{t}$ produced by massive resonances?
- At the Tevatron, we investigate these

Tevatron

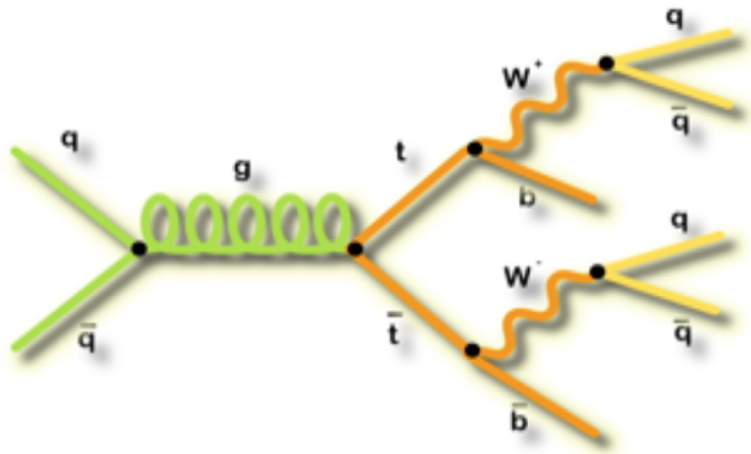

ppbar collisions at 1.96 TeV
Peak luminosity 10^{34} cm^2s^{-1}
Weekly integrated luminosity ~50pb^{-1}
~ 12 fb^{-1} delivered
(~10 fb^{-1} on tape for each experiment)
Chicago
CDF
DØ
Linac
Booster
p source and accumulator
Tevatron
1 km
Main Injector
Luminosity (pb^{-1})
12000
10000
8000
6000
4000
2000
0
Delivered
Acquired
1000
2000
3000
4000
5000
6000
7000
8000
9000
store number

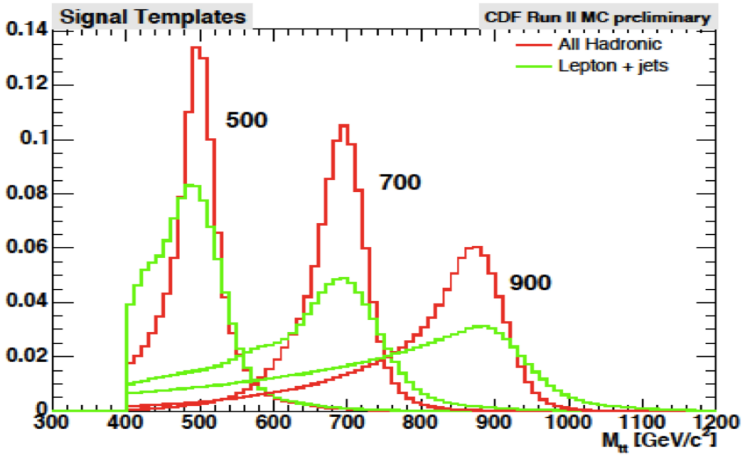
The CDF and the D0 Detectors



All Hadronic Channel at CDF (2.8 fb^{-1})

- Advantages
  - Highest branching ratio
    - Most events are here
  - No missing information like neutrino
    - Better signal templates
  - Mass resolution is much improved over lepton+jets
  - Cross-check for a possible discovery
- Disadvantages
  - Large QCD background
  - More combinations

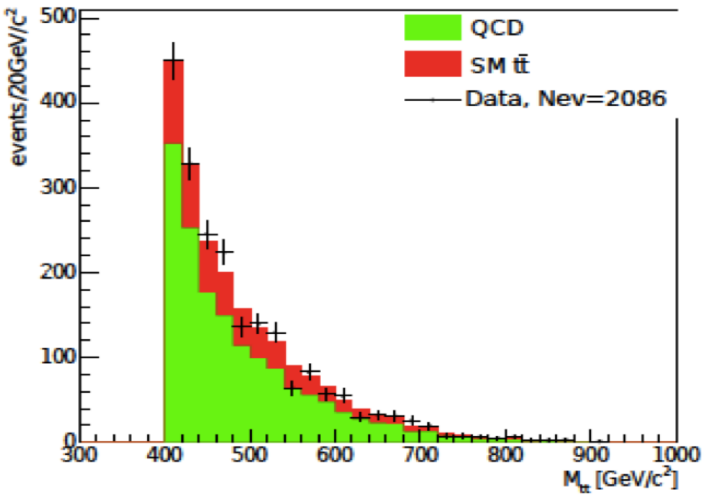


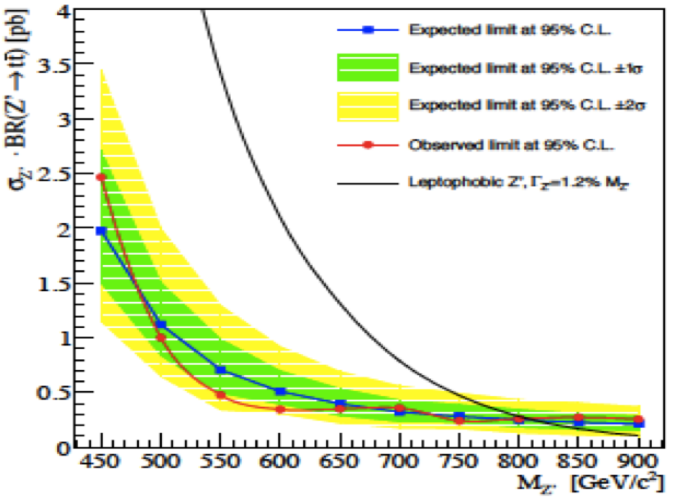


All Hadronic Results at CDF (2.8 fb^{-1})

- The leptophobic model predicts a vector particle (Z'), which couples primarily to the third generation of quarks and has no significant couplings to leptons.
- Exclusion limit on leptophobic topcolor at 95% C.L.
  - $m_{Z'} < 805$ GeV/c^2
  - Width assumption, $\Gamma_{Z'} = 0.012 M_{Z'}$

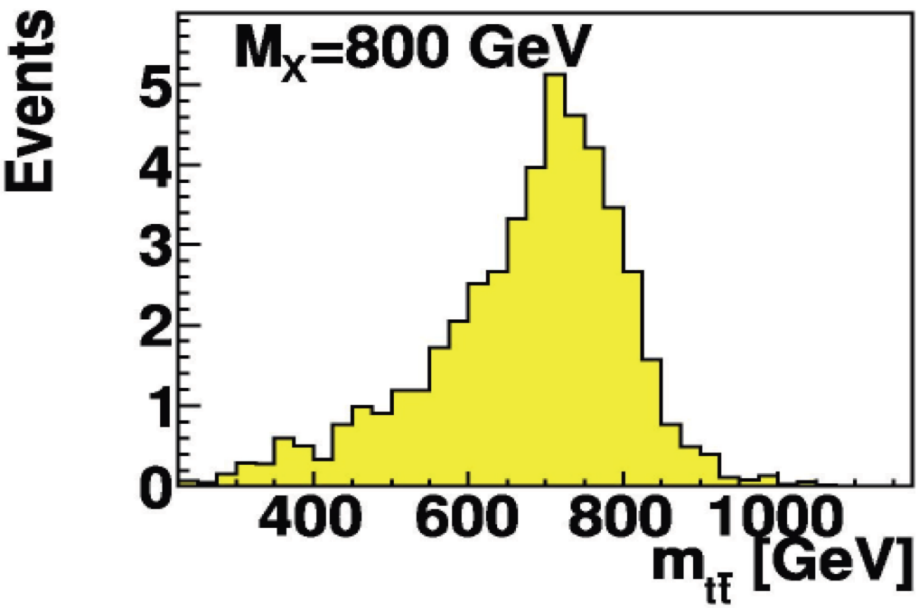
Phys. Rev. D 84, 072003 (2011)



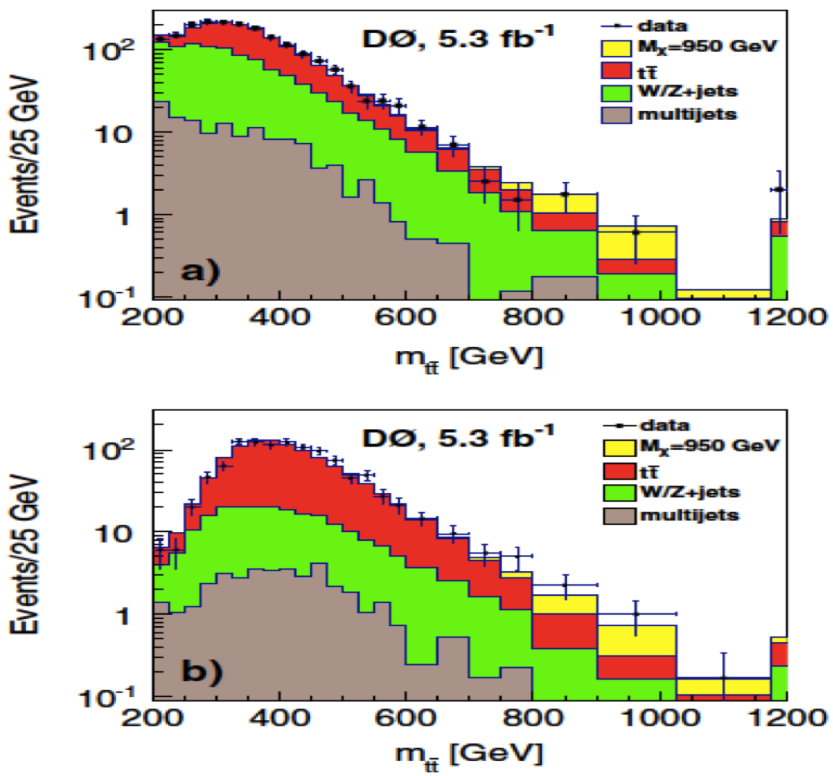


Lepton + Jets Channels at D0 (5.3 fb^{-1})

- W decays to an e or μ
- NN b tagger to reduce background
- Reconstruct neutrino momentum by using measured $\not\!\!E_T$ and W mass constraint for the lepton-neutrino pair

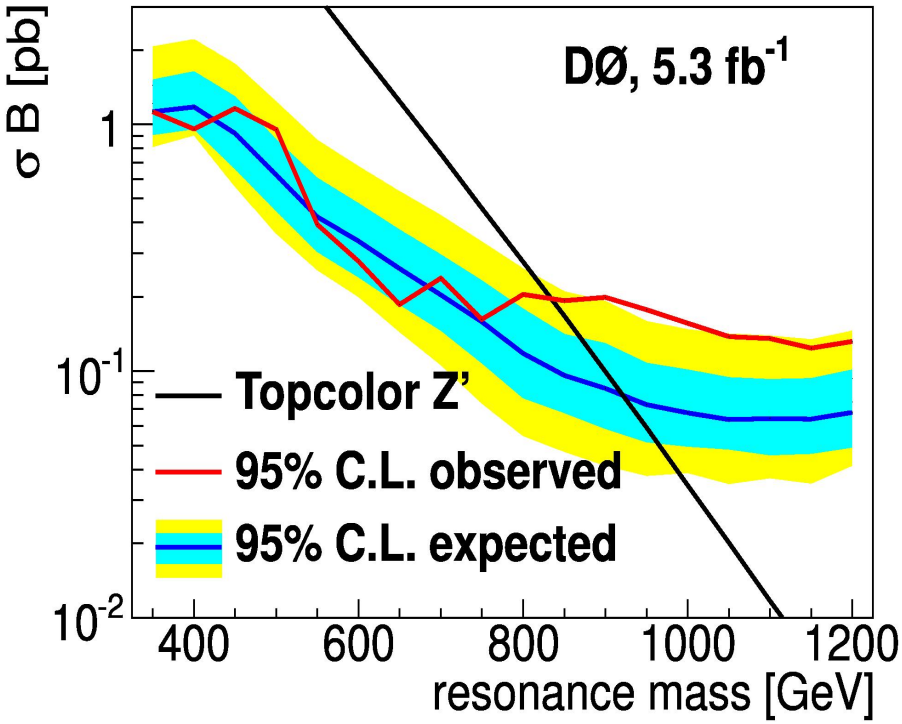


(a) exactly 3 jets
(b) at least 4 jets



Lepton + Jets Channels at D0 (5.3 fb^{-1})

- Exclude leptophobic topcolor Z' ($\Gamma_{Z'} = 0.012 M_{Z'}$) at 95% C.L. below
  - 835 GeV/c^2 (observed)
  - 920 GeV/c^2 (expected)



Phys. Rev. D 85, 051101 (2012)

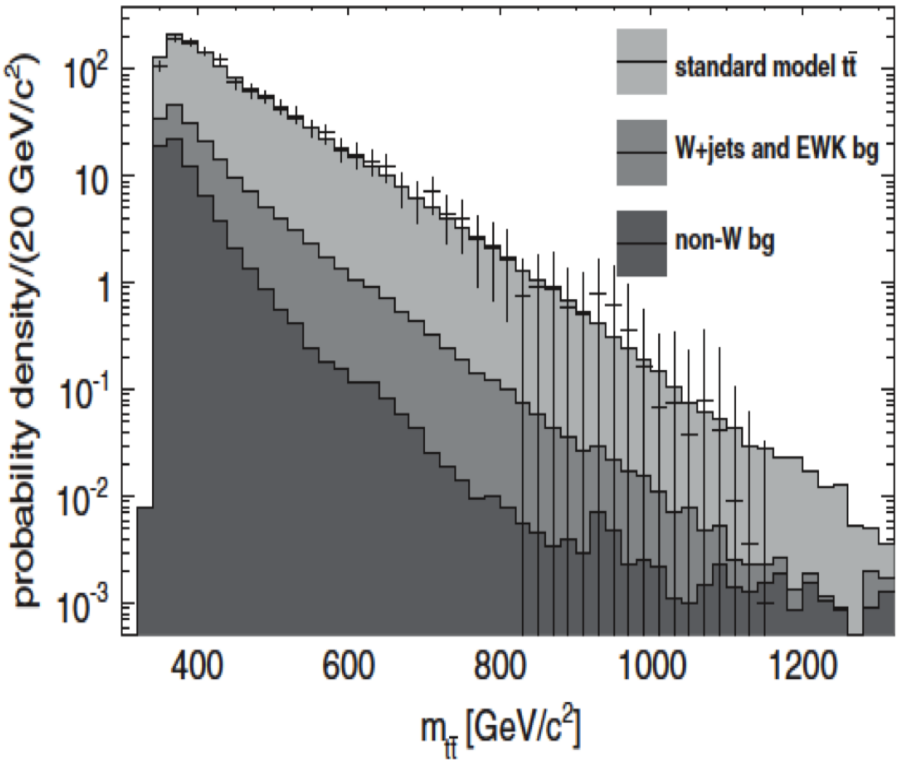
Lepton + Jets Channels at CDF (4.8 fb^{-1})

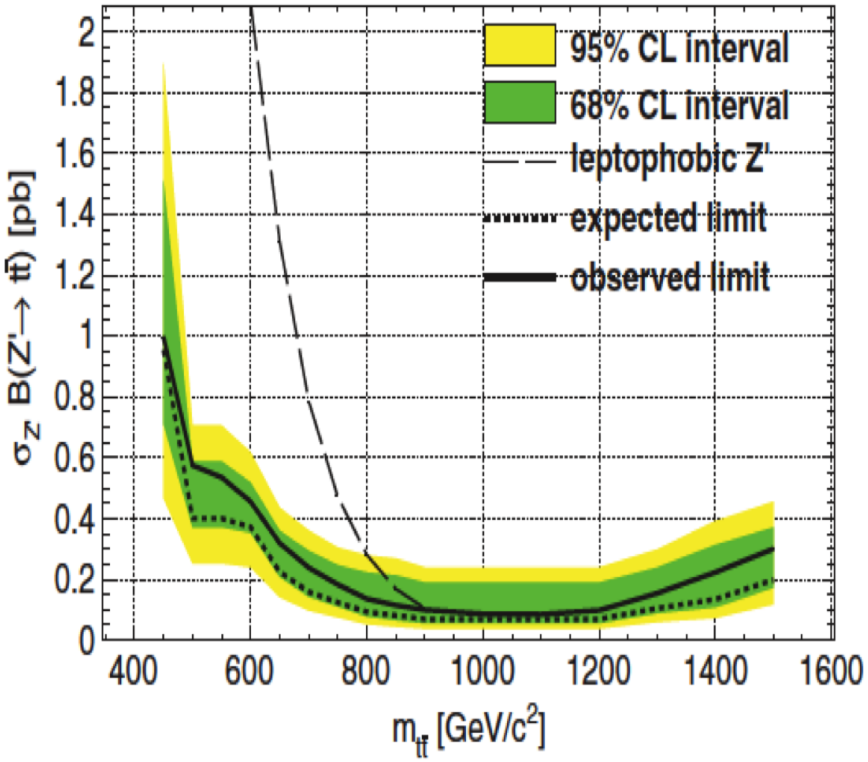
- For each event: apply $t\bar{t}$ hypothesis: observed event kinematics mapped to parton level using the Matrix Element for $t\bar{t}$ production and decay
- L+J Backgrounds (treatment same as for σ measurements)
  - W+Jets (HF, LF) (get tag rate, etc)
  - QCD (data driven)
  - EWK (diboson, single top)

component	4 jets	$\geq$ 5 jets
non-W	46.1 ± 35.7	15.7 ± 12.2
Z+light flavor	6.4 ± 0.5	1.6 ± 0.1
W+light flavor	32.9 ± 8.5	7.4 ± 3.1
$Wb\bar{b}$	51.5 ± 12.6	12.4 ± 3.7
$Wc\bar{c}$	27.7 ± 6.6	7.3 ± 2.1
Wcj	14.0 ± 3.3	3.0 ± 0.9
single top	8.9 ± 0.4	1.4 ± 0.0
diboson	9.1 ± 0.6	2.4 ± 0.1
total non-$t\bar{t}$	196.6 ± 39.5	51.2 ± 13.3
SM $t\bar{t}$	667.1 ± 61.8	225.2 ± 21.0
Data:	996	370

tt/non-tt:3.6
Data/Bkg:1.2

Lepton + Jets Channels at CDF (4.8 fb^{-1})

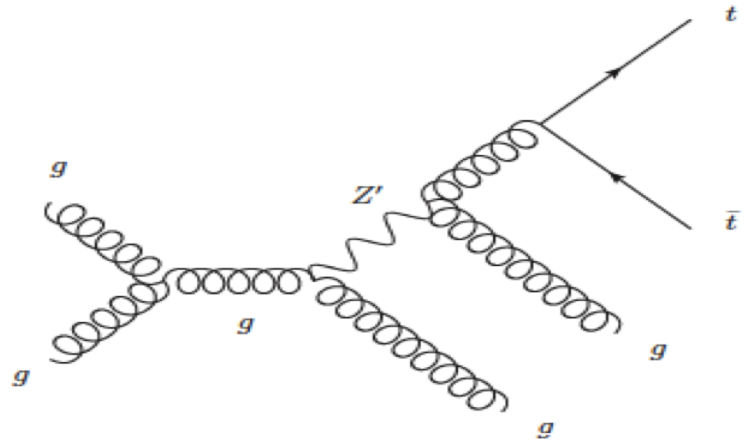


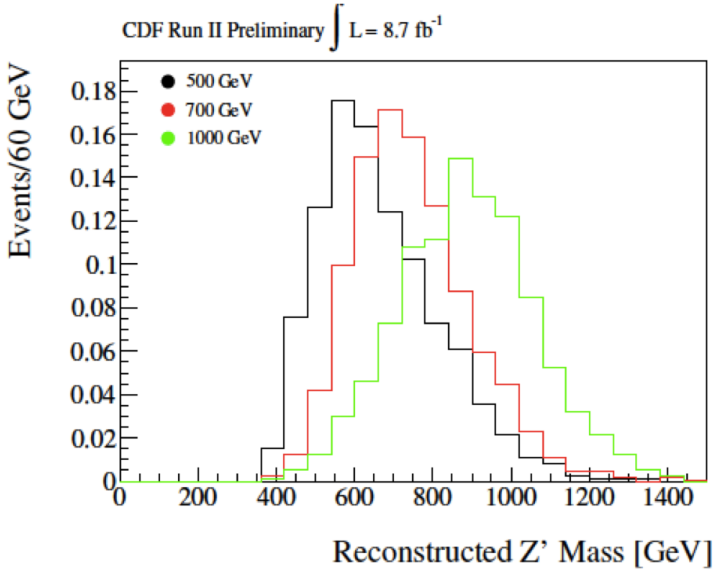


95 CL limit on top-color-assisted technicolor Z':
$m_{Z'} > 900$ GeV/c^2 for $\Gamma_{Z'} = 0.012 M_{Z'}$
Phys. Rev. D 84, 072004 (2011)

Chromophilic Z' Resonance in Lepton + Jet at CDF

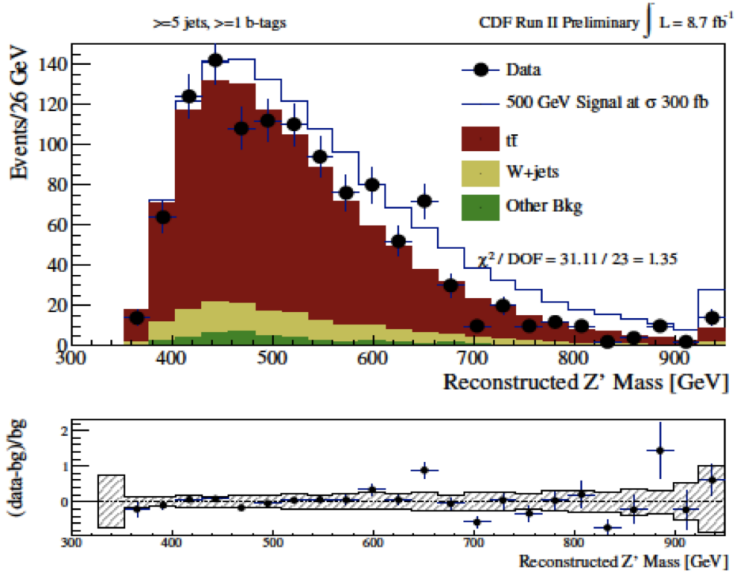
- The chromophilic Z' couples only to two gluons
- A dominant decay mode of $Z' \to q\bar{q}g$
- Cross section grows with $m_{Z'}$ for a fixed coupling
- We consider the decay mode:
  - $Z' \to t\bar{t}g \to W^+bW^-\bar{b}g$
  - One W decays leptonically and the other hadronically
  - leptons include leptonic τ decays





Chromophilic Z' Resonance in Lepton + Jet at CDF

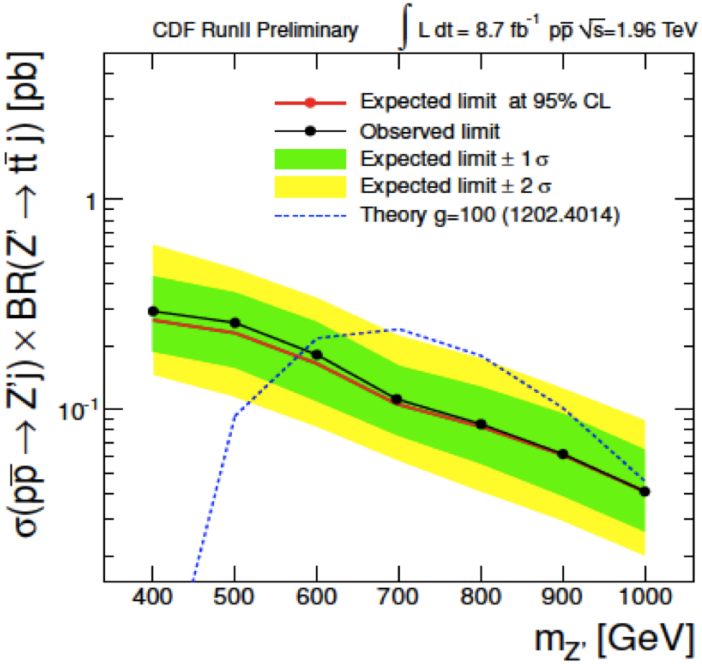
- Fit the most likely value of the sum of the Z' cross section by performing a binned maximum-likelihood fit in $m_{t\bar{t}j}$
- Allow for systematic and statistical fluctuations
- No evidence for the presence of Z' in $t\bar{t}j$ events, so we set upper limits on Z' production at 95% C.L.

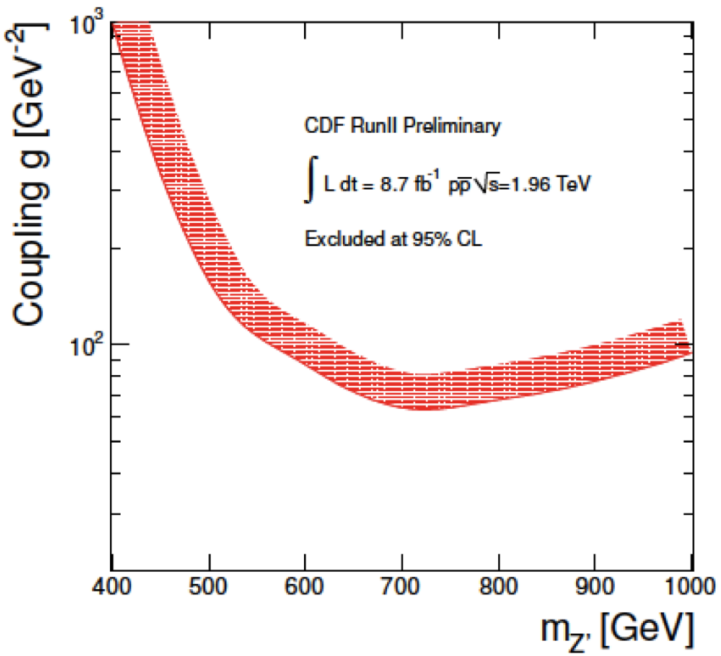


CDF Run II Preliminary 8.7 fb^{-1}

Process	e+jets	μ+jets	total
$t\bar{t}$	206 ± 44	271 ± 61	477 ± 103
W+jets	31 ± 10	36 ± 12	67 ± 21
Single Top	2 ± 1	3 ± 1	6 ± 2
Z+jets	1 ± 1	2 ± 1	3 ± 1
Diboson	2 ± 1	2 ± 1	4 ± 1
QCD	11 ± 11	< 1	11 ± 11
Total	254 ± 47	314 ± 62	568 ± 105
Data	261	325	586
Signal($\sigma = 300$ fb): 500 GeV/c^2	55 ± 2	89 ± 4	144 ± 7

Chromophilic Z' Resonance in Lepton + Jet at CDF

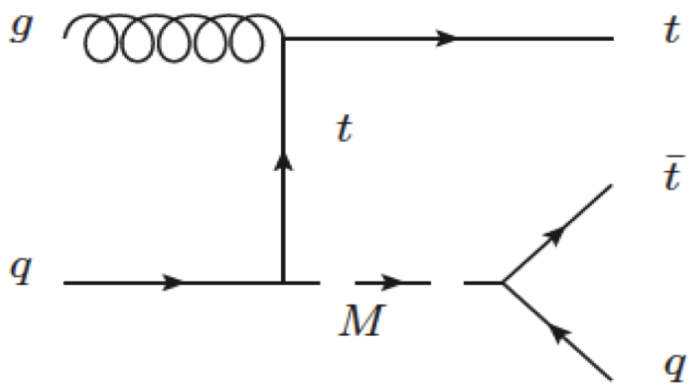




We set cross-section upper limits on the production of this chromophilic Z' at 95% C.L. from 300 fb to 40 fb for Z' masses ranging from 400 GeV/c^2 to 1000 GeV/c^2, respectively.

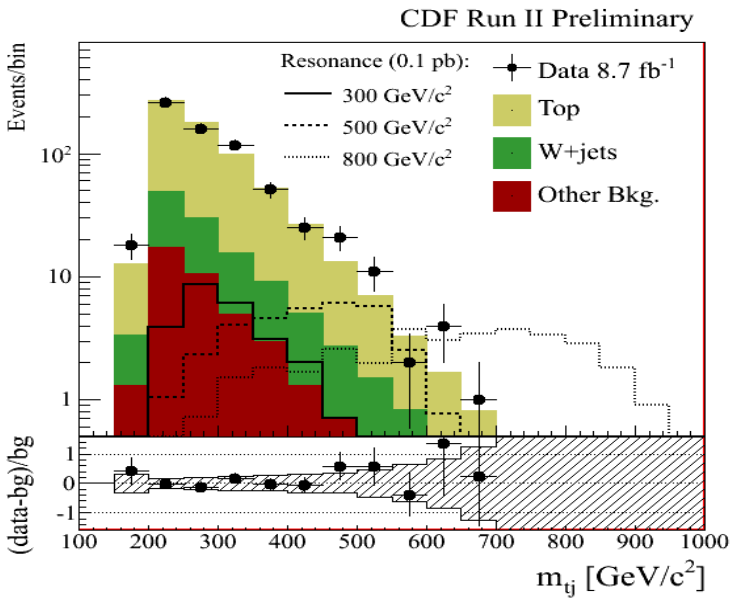
Search For Top + Jet Resonances in Lepton + Jet at CDF

- CDF and D0 reported a forward-backward asymmetry (A_{FB}) that is significantly larger than predicted by the SM
- Can be explained via models involving the production of a new heavy mediating particle M that enhances A_{FB}
- Such new particles may also be singly produced in association with a t ($\bar{t}$) and further decay to $\bar{t}$ (t) and an additional jet, $p\bar{p} \rightarrow Mt(\bar{t}) \rightarrow \bar{t}jt(tj\bar{t})$

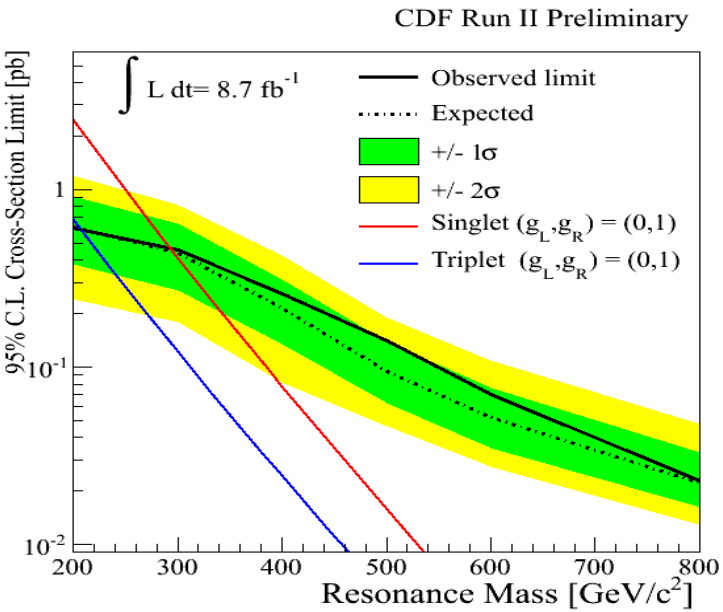


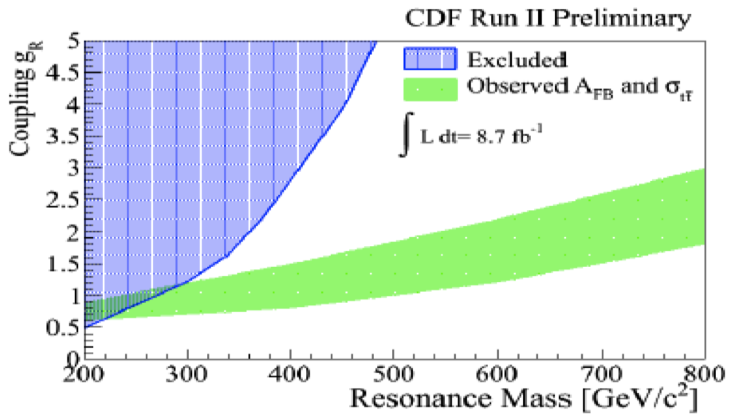
Search For Top + Jet Resonances in Lepton + Jet at CDF

- We search for lepton + jet signature
- Detector signature $l + \nu + qq' + bb' + q$
- Exactly one e or μ with $p_T > 20$ GeV
- At least 5jets with $E_T > 20$ GeV and $|\eta|$ <2.0
- At least one b tag
- $\not\!\!E_T \geq 20$ GeV

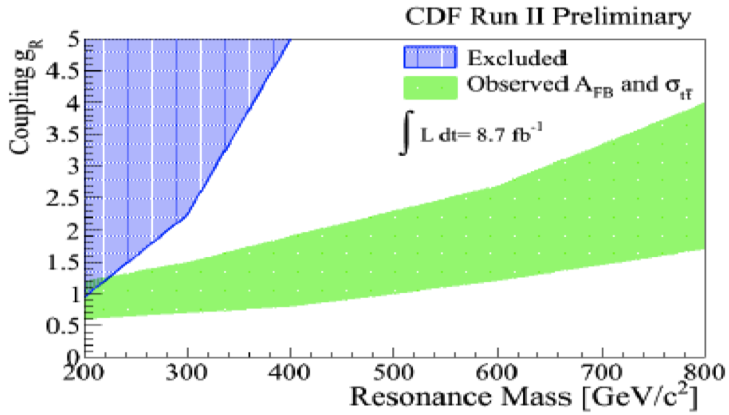


Search For Top + Jet Resonances in Lepton + Jet at CDF





(a) Singlet models.



(b) Triplet models.

- Data are consistent with the SM
- Set σ limits from 0.61 pb to 0.02 pb for resonances ranging from 200 GeV/c^2 to 800 GeV/c^2

Conclusion

- Reported on $t\bar{t}$ resonant production results from the Tevatron
- No evidence for resonant production of $t\bar{t}$ and top+jets at the Tevatron
- Tevatron searches in some cases have better reach than LHC at low masses (below 1 TeV)
- The LHC will carry the torch to reach masses above 1 TeV