Top-antitop production in pbar-p collisions

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05/15/2013

Outline

- Motivations
- Identification of the $t\bar{t}$ signal
- Combined measurement of top pair production at the Tevatron
  - Combination within experiments
  - Combination between experiments
  - Treatment of systematics
  - Mass dependence
- Production mechanisms
- Mtt spectrum

Motivations

- Top is heavy – perturbative QCD should work
  - We are testing QCD prediction for ttbar production
  - But let's face it, it is always the other way around – QCD is testing us…
- Test different mechanisms of ttbar production – gg vs qqbar
  - Different balance from LHC – complementarity of the measurements
- Contributions from the new physics could affect the cross section measurement, e.g.
  - At production Z'→tt affects the overall rate, but even more prominent in differential distributions, e.g. Mtt
  - At decay t→bH^{+} affects the balance between channels, and in principle the overall rate through acceptance corrections
- Top may play a special role in the drama of ElectroWeak Symmetry Breaking
  - M_t=173.20 ± 0.51 (stat) ± 0.71 (syst) GeV/c^2
  - Top Yukawa coupling g_t=0.996±0.003±0.004 ← this is very close to 1.0!
  - Asymmetry in top production observed at Tevatron may hint at new physics

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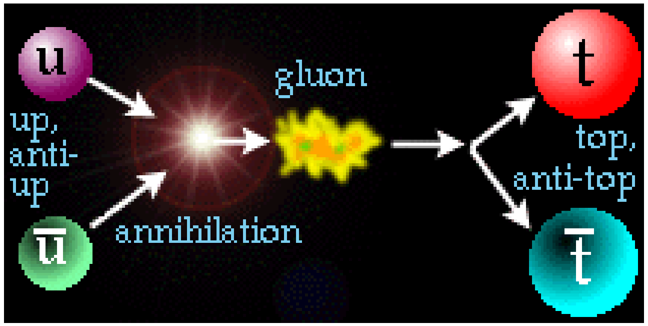
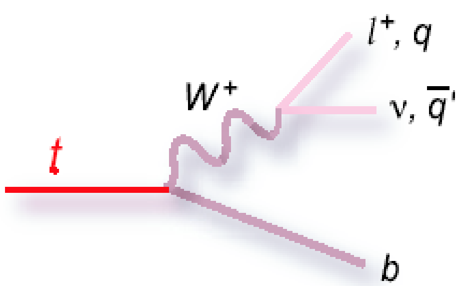
Top identification

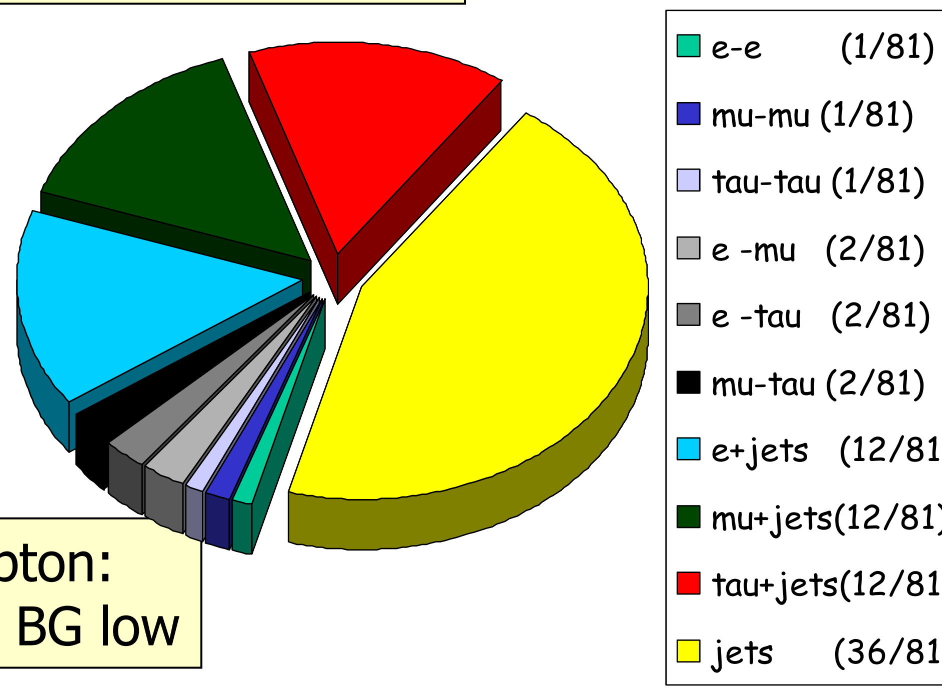


V_{tb}=~1   t→Wb in 99%



Need to reconstruct:
Electrons, muons, jets, b-jets and missing transverse energy

Lepton + jet:
BR and BG are OK
Best x-section measurement



di-lepton:
BR low, BG low

All jets:
highest BR, but high BG

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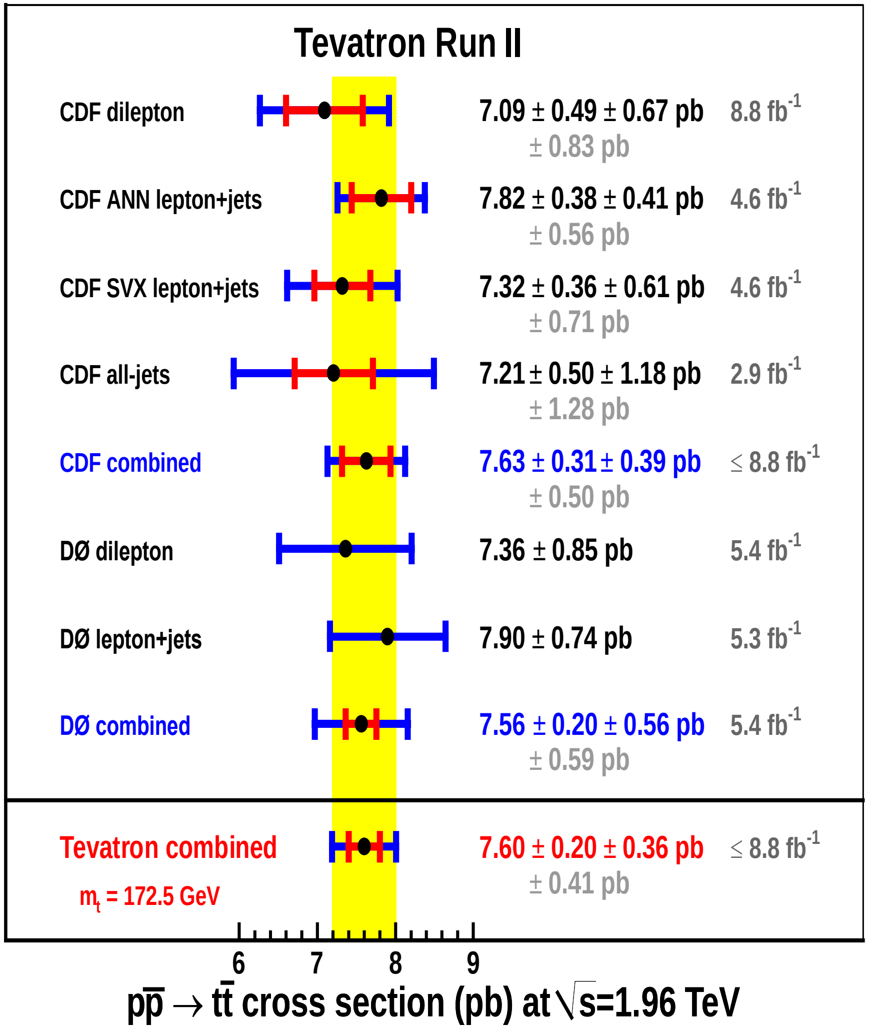

Theoretical calculations

Calculation	$\sigma_{t\bar{t}}$ (pb)	$\Delta\sigma_{\text{scale}}$ (pb)	$\Delta\sigma_{\text{PDF}}$ (pb)
NLO	6.85	$^{+0.37}_{-0.77}$	$^{+0.19}_{-0.13}$
NLO+NLL	7.09	$^{+0.28}_{-0.51}$	$^{+0.19}_{-0.13}$
NNLO+NNLL	7.35	$^{+0.11}_{-0.21}$	$^{+0.17}_{-0.12}$

P. M. Nadolsky, H. -L. Lai, Q. -H. Cao, J. Huston, J. Pumplin, D. Stump, W. -K. Tung and C. -P. Yuan, Phys. Rev. D **78**, 013004 (2008).
R. Bonciani, S. Catani, M. L. Mangano and P. Nason, Nucl. Phys. B **529**, 424 (1998) [Erratum-ibid. B **803**, 234 (2008)].
M. Cacciari, S. Frixione, M. L. Mangano, P. Nason and G. Ridolfi, JHEP **0404**, 068 (2004).

M. Cacciari, M. Czakon, M. L. Mangano, A. Mitov and P. Nason, Phys. Lett. B **710**, 612 (2012).
M. Czakon, P. Fiedler and A. Mitov, arXiv:1303.6254.

Some caveats:
1. statistically dependent measurements

- Two l+jets results from CDF
  - **LJ-ANN** –no use of b-tagging, artificial neural net based on 7 kinematic variables trained to discriminate against W+jets
    - Largest systematics due to JES and modeling of ttbar and W+jets
  - **LJ-SVX** – takes advantage of b-tagging.
    - Systematics due to W+heavy flavor scale factor (tuned on data)
  - For both channels the rate is measured wrt Z/γ^* production, thus minimizing the uncertainty due to luminosity measurement
- The statistical correlation between LJ-ANN and LJ-SVX was determined using ensemble testing to be 32%

Some caveats:
2. combinations within experiments

- CDF, relative weights:
  - LJ-ANN: 70%
  - Dileptons: 22%
  - LJ-SVX: 15%
  - All hadronic: -7%
  - Negative weights can occur if the correlation between the two measurements is larger than the ratio of their total uncertainty
  - **σ(CDF) = 7.63±0.31(stat)±0.36(syst)±0.15(lumi) pb**
- D0 – two channels - diletpton and single lepton:
  - **σ (D0) = $7.56^{+0.63}_{-0.56}$ (stat+syst) pb**

Some caveats:
3. combinations between experiments

- CDF relative weight 60%
- D0 relative weight 40%
- **σ(D0+CDF)=7.60±0.20(stat)±0.29(syst)±0.21(lumi) pb**
- Probability of agreement between channels – 92%

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Some caveats:
4. combinations of systematics

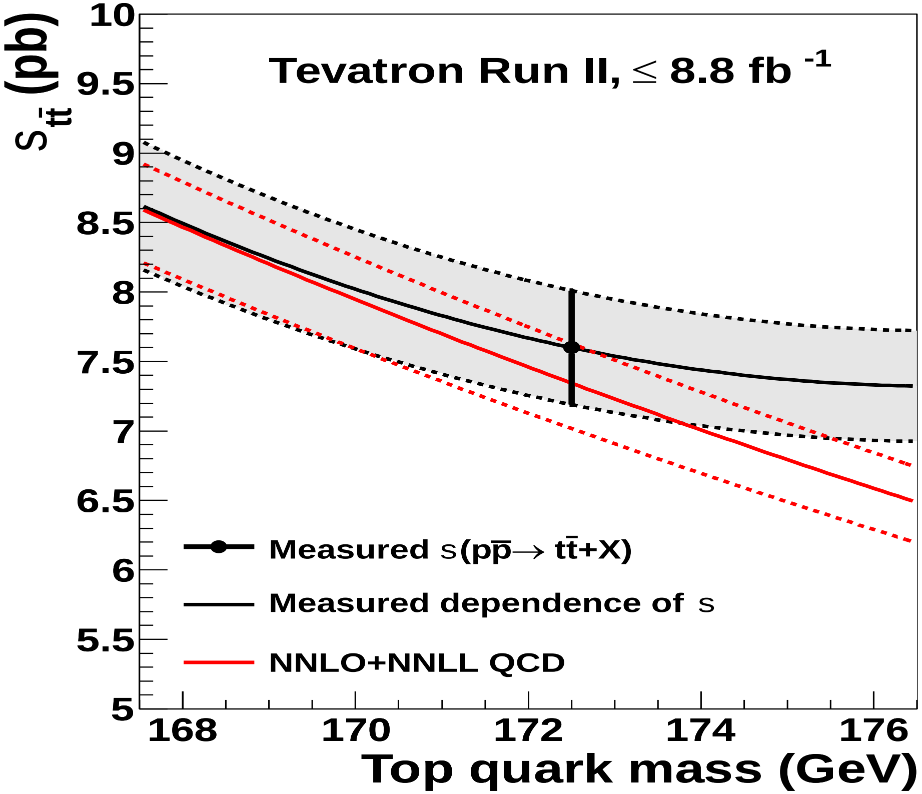
- Divide into sources that are either uncorrelated or **100% correlated**

	CDF	D0	
Central value of $\sigma_{\bar{t}t}$	7.63	7.56	
Uncertainties			Corr.
Statistics	0.31	0.20	no
Modeling detector	0.17	0.22	no
Modeling signal	0.21	0.13	yes
Modeling jets	0.21	0.11	no
Method of analysis	0.01	0.07	no
Background from theory	0.10	0.08	yes
Background based on data	0.08	0.06	no
Normalization Z boson cross section	0.13	–	no
Inelastic $p\bar{p}$ cross section	0.05	0.32	yes
Uncorrelated luminosity uncertainty	0.06	0.33	no
Total systematic uncertainty	0.39	0.56	

- Combined Tevatron systematic uncertainty 0.36 pb

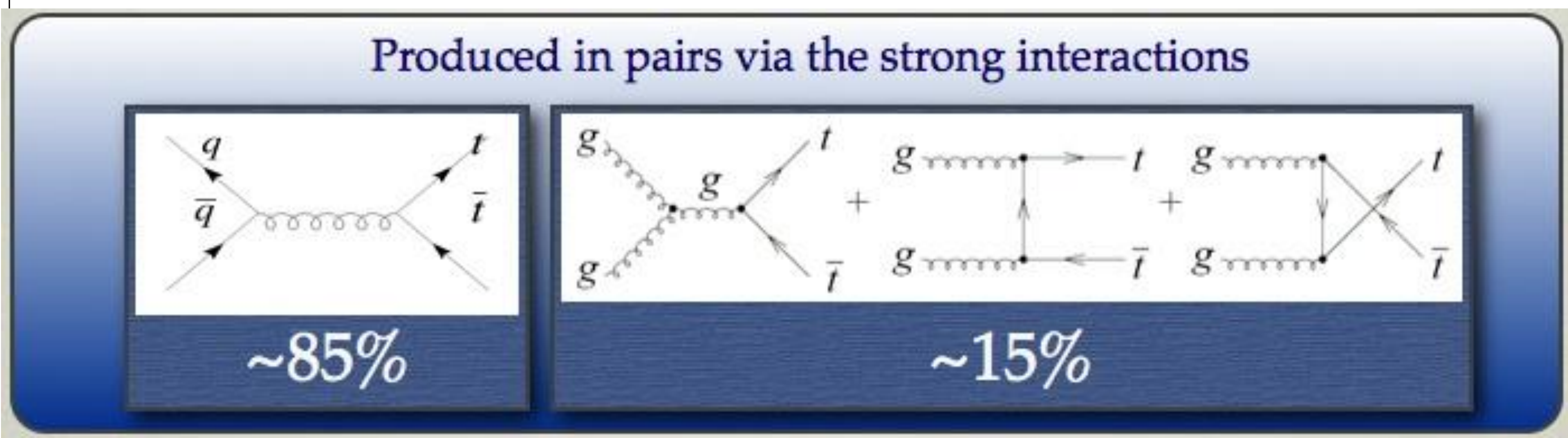
Some caveats:
5. dependence on top mass

- The measure ttbar cross section depends on the assumed value of the top mass → we therefore extract it for several values of top mass

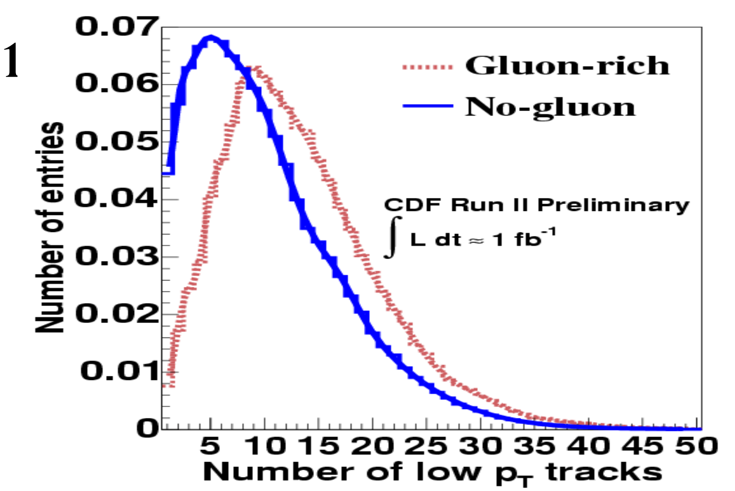


Production mechanisms

- Theoretical expectation

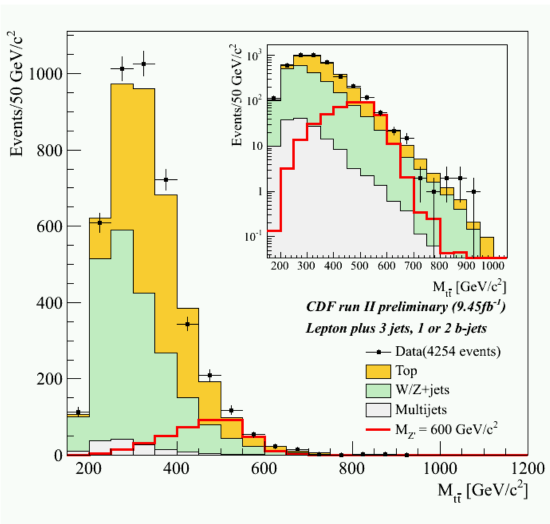


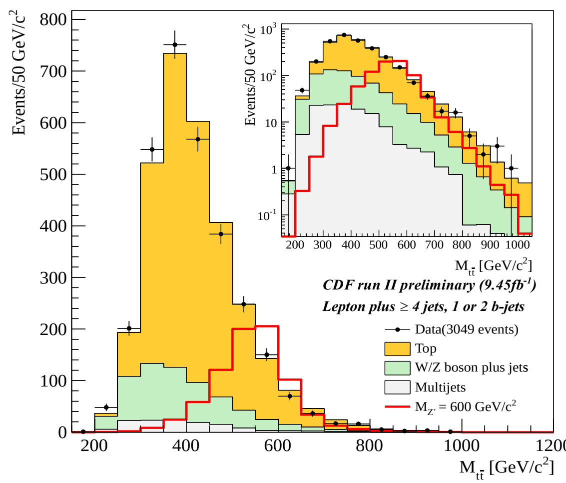
- **CDF's analysis based on ~1fb^{-1}**
- F(gg)=0.07+0.15-0.07(stat+sys)

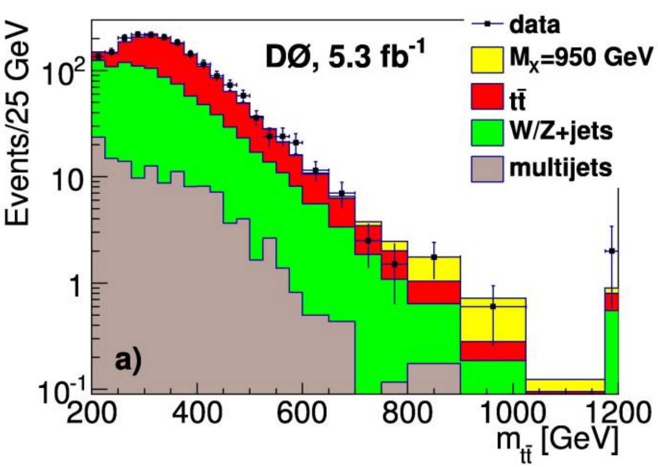


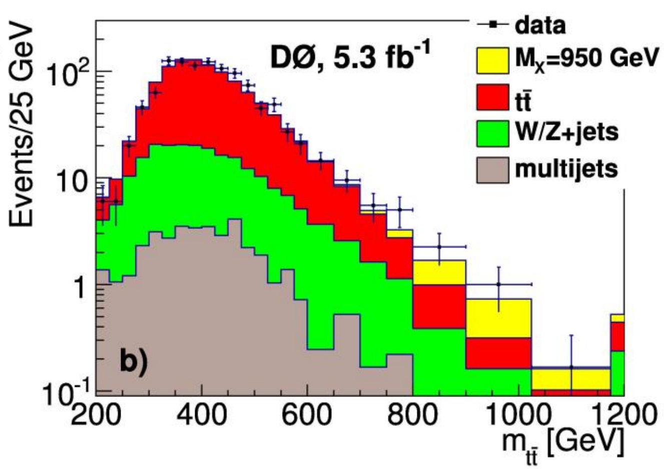
Search for narrow ttbar resonances

- No evidence for significant narrow ttbar resonances (Γ<15%Mtt)









Summary

- **Top-antitop cross section is in a good agreement with the Standard model prediction:**
- **σ(D0+CDF)=7.60±0.20(stat)±0.29(syst)±0.21(lumi) pb**
- **σ(NNLO)=7.35±0.24pb**