Top Quark Physics at DØ

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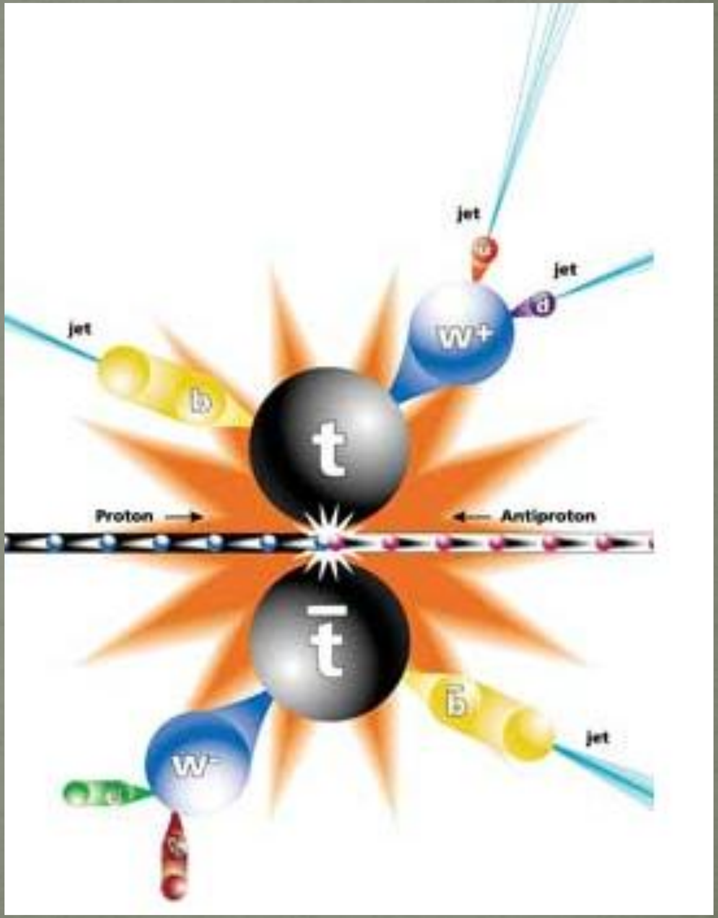
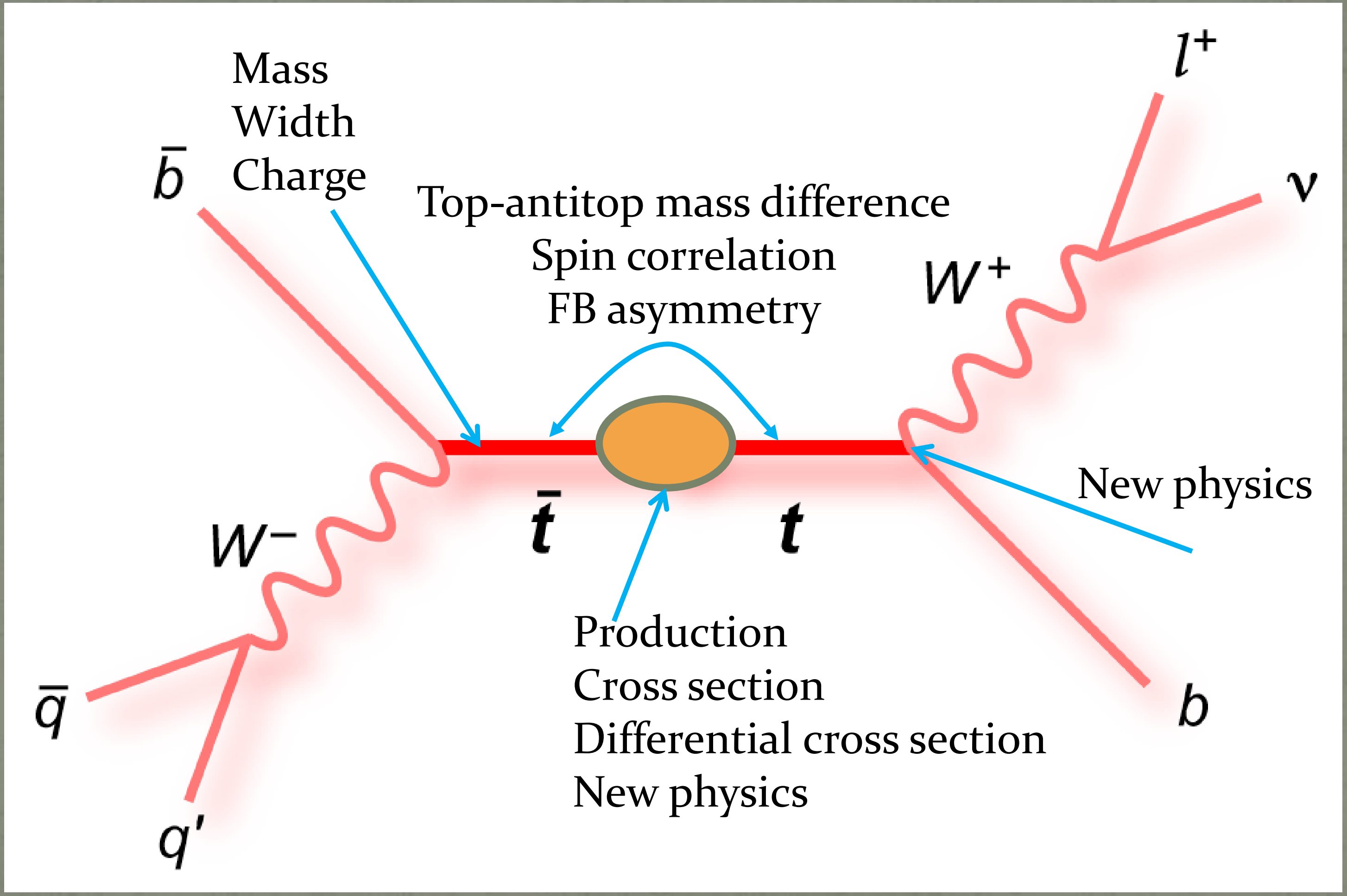
On behalf of the DØ collaboration

Outlook

- Top quark production
  - L+jets
  - Dilepton
  - Single top
- Properties
  - Mass
  - Forward backward asymmetry
  - Spin correlation
  - Top-antitop mass difference
- Searches
  - t'

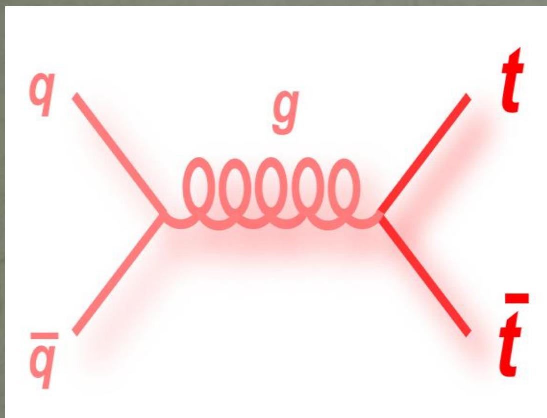


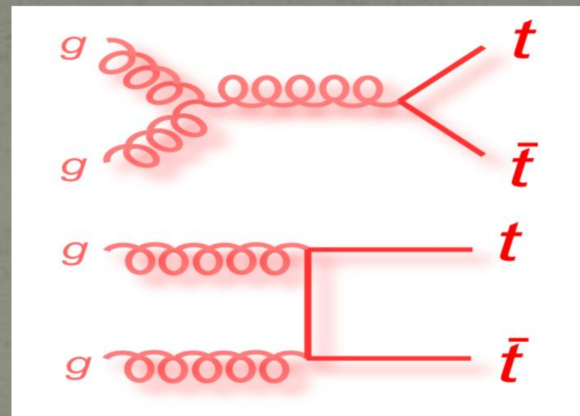
Top Quark Analyses



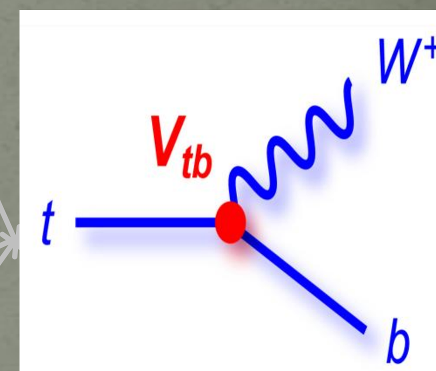
Top Production and Decay

Top pair production

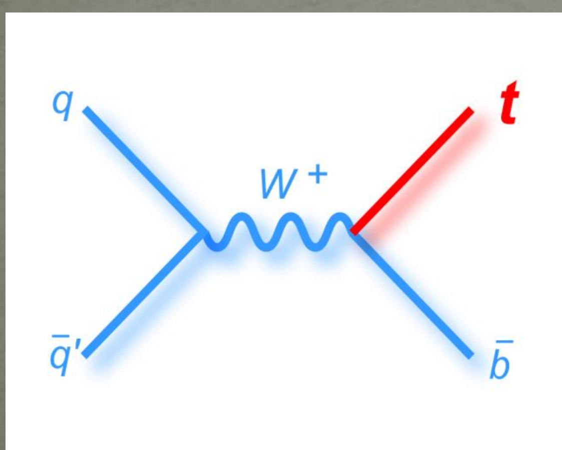


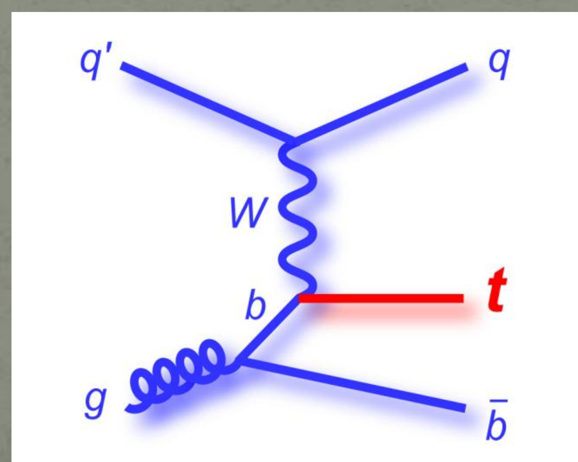


Top decay



Single top production

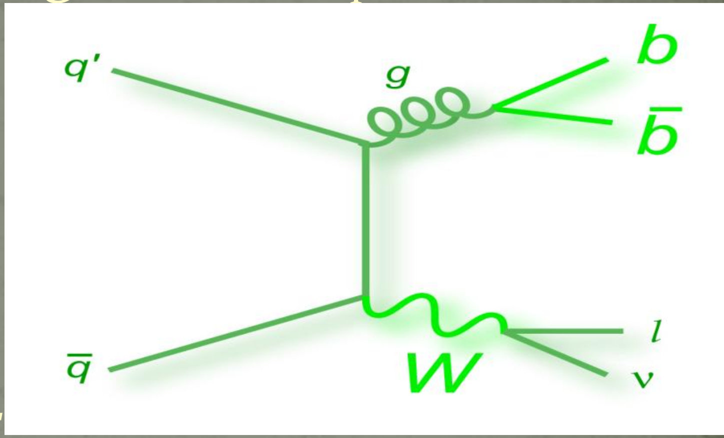




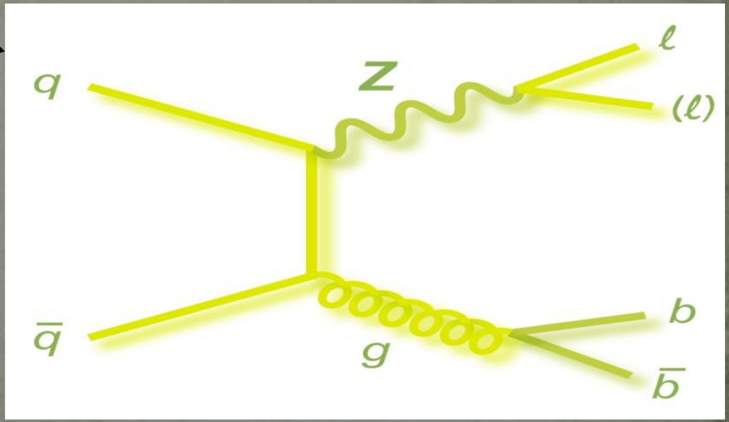
Top Quark Production

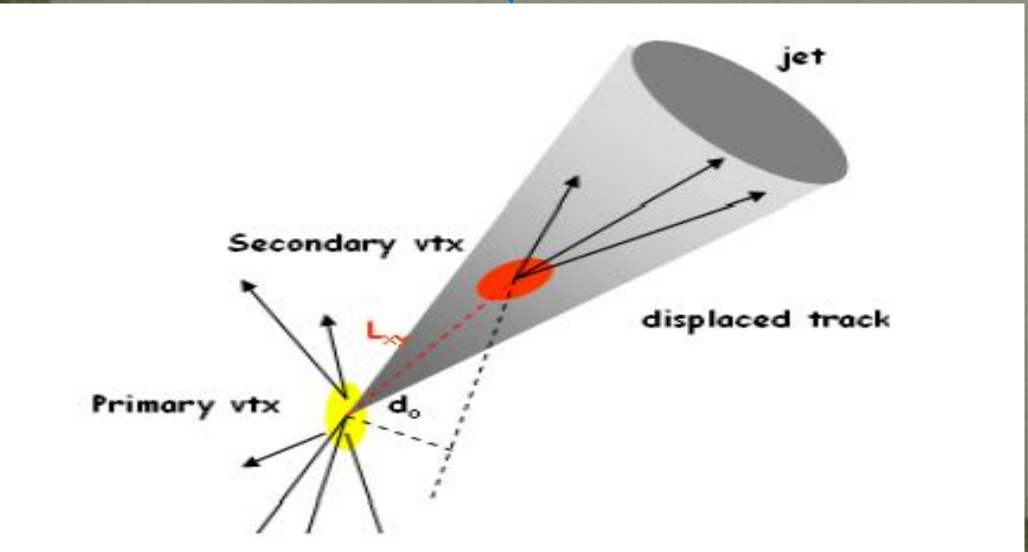
Selection and backgrounds

- L+jets
  - One isolated lepton, at least 4 jets, significant $\not{E}_T$
  - B tagging
  - Main background W + jets



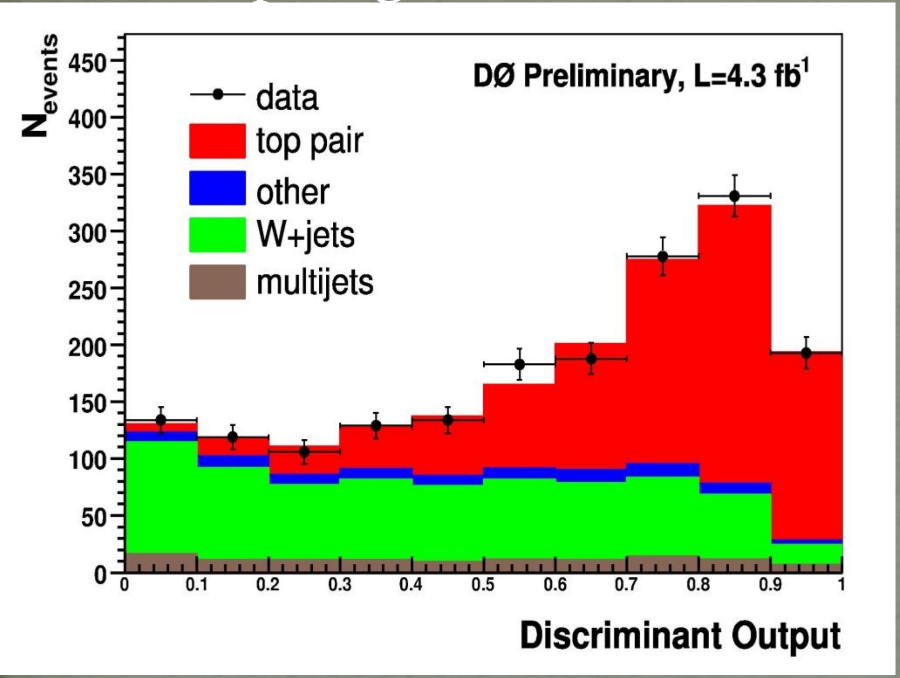
- Dilepton
  - Two isolated leptons, significant $\not{E}_T$
  - Main background Z + jets



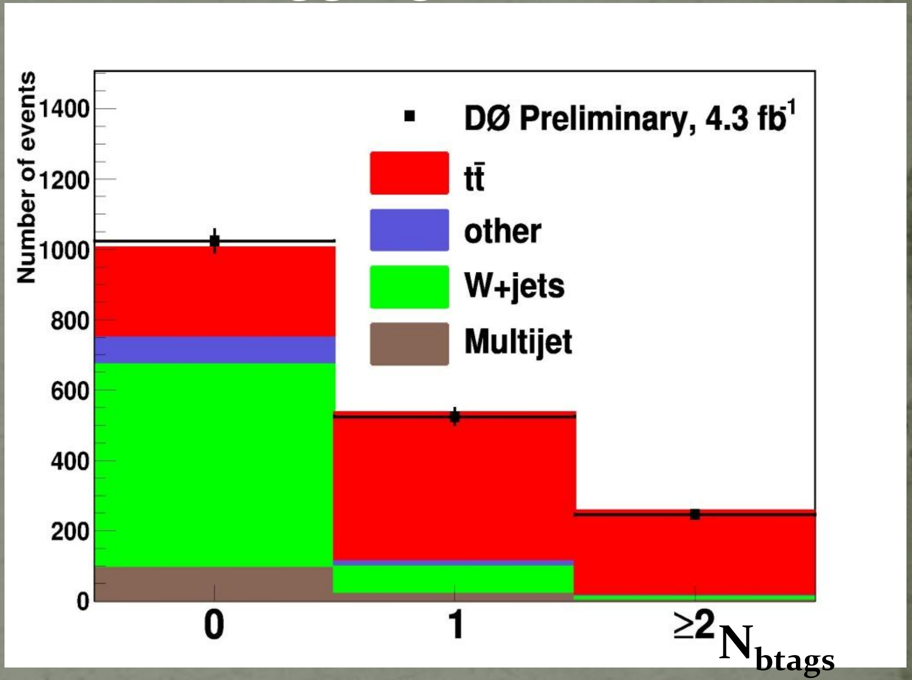


Top Quark Production Cross Section l+jets channel

topological



b-tagging



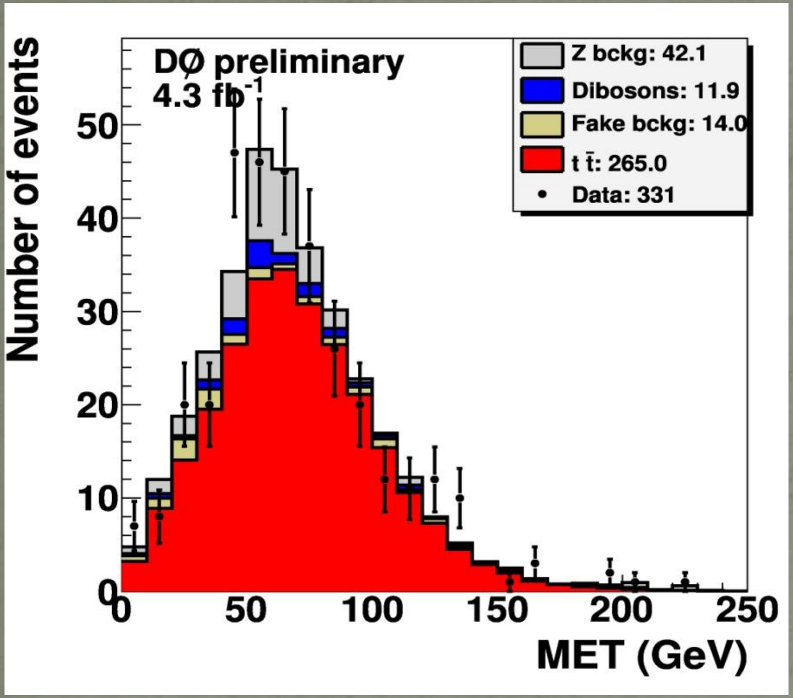
σ_{tt}= 7.70 ± 0.79 (stat+syst+lumi) pb

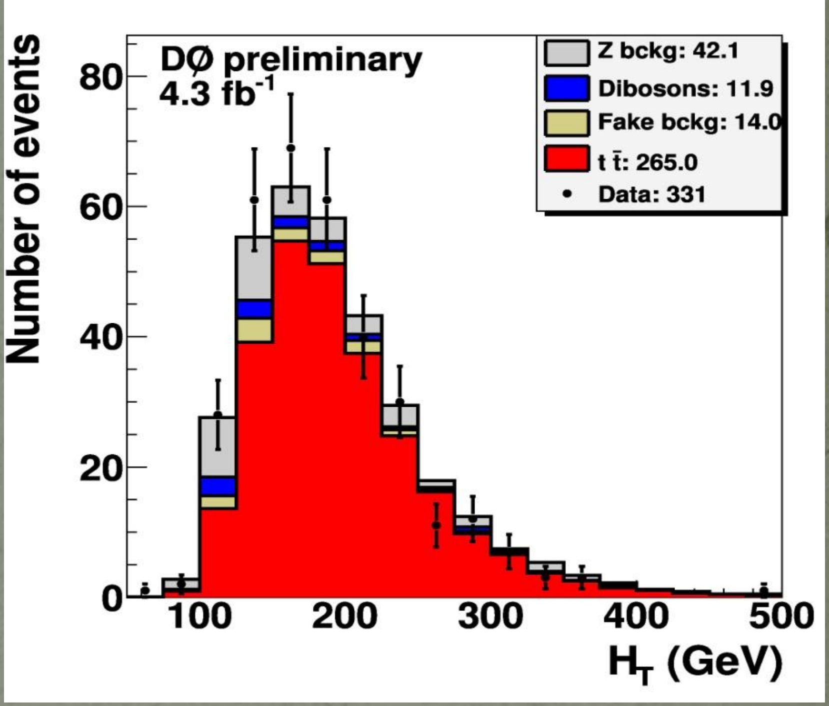
σ_{tt}= 7.93 ± 0.91 (stat+syst+lumi) pb

systematics limited!

Phys.Rev.Lett.105:012001,2010

Top production Cross Section in Dilepton Channel





σ_{tt} = 8.23 ± 0.52 (stat) ± 0.83 (syst) ± 0.61 (luminosity) pb

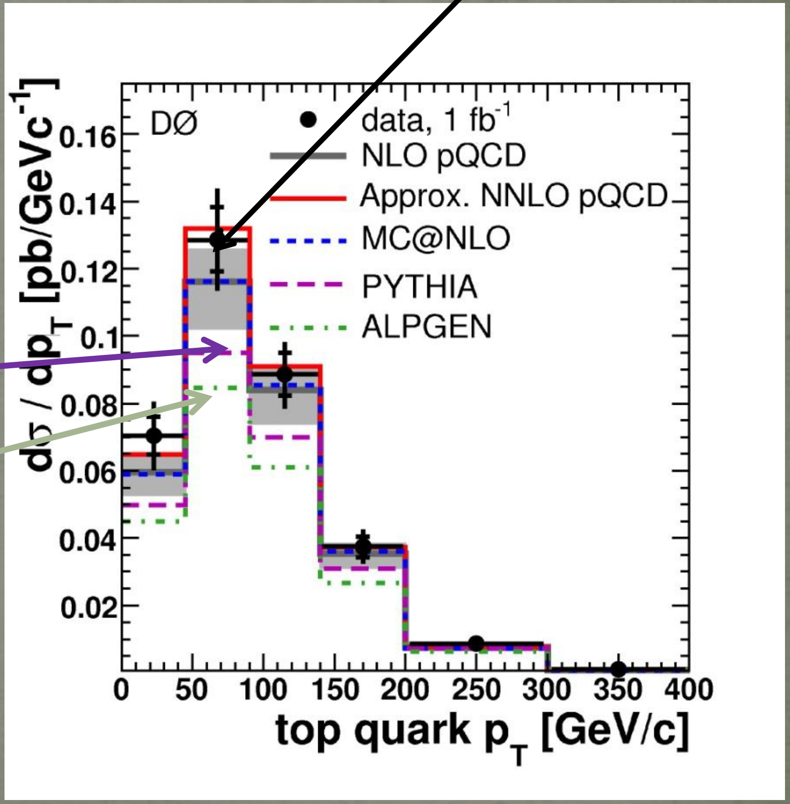
Differential cross section

- Unfolding of p_T spectrum
- Important to test NLO QCD
  - Used for normalization
  - Data prefers NLO

Data

Pythia

Alpgen

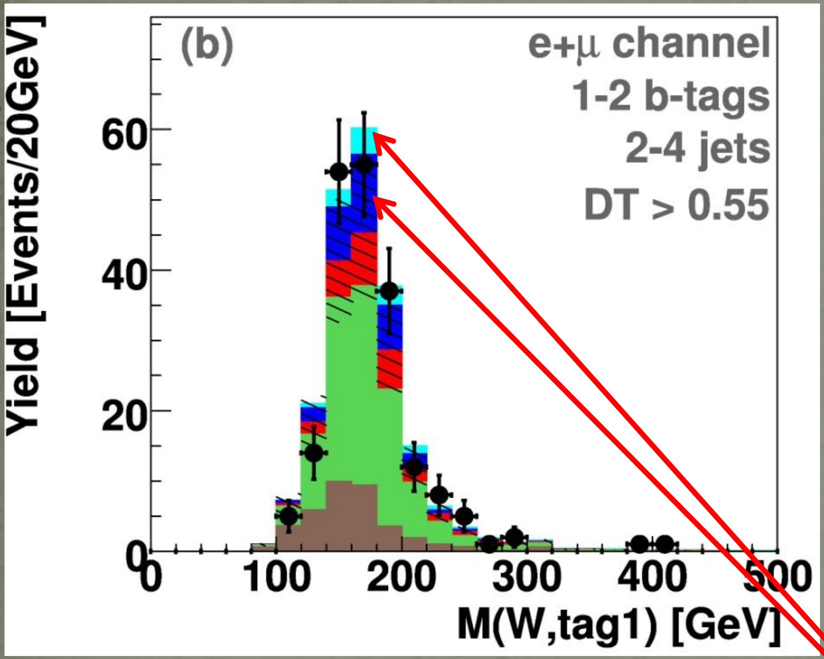


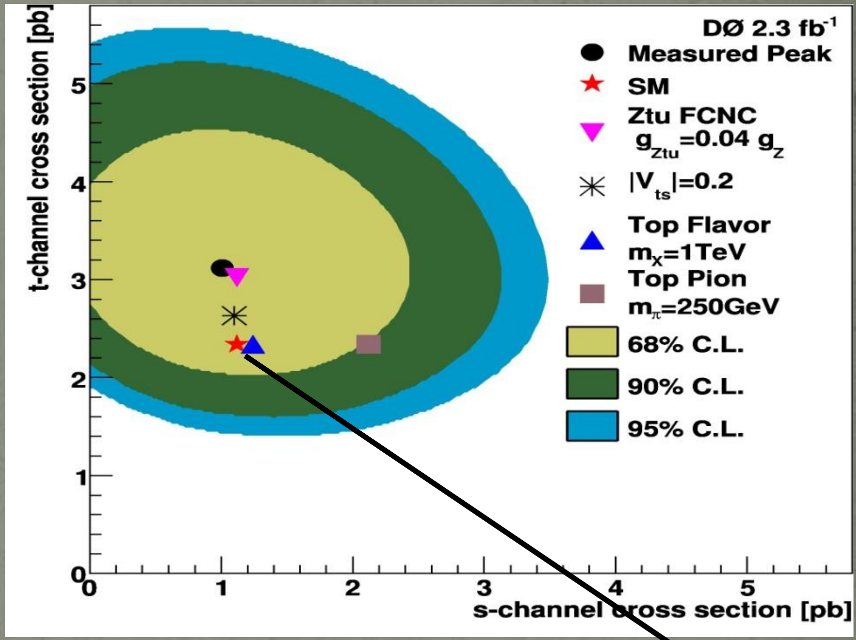
arXiv:1001.1900 [hep-ex]

Single Top Discovery

Expected 4.5 σ
Observed 5.0 σ

- Challenging – significant W+jets background.
- Employed three techniques:
  - Boosted Decision Tree, Neural Network, Matrix Elements





$\sigma_t = 3.94 \pm 0.88$ pb

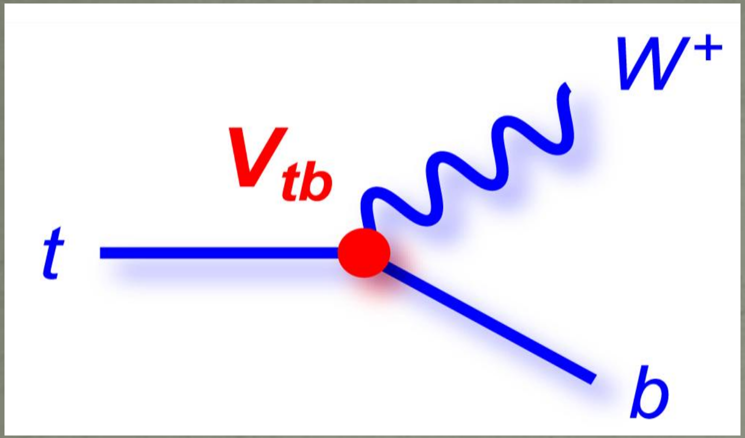
Single top

SM

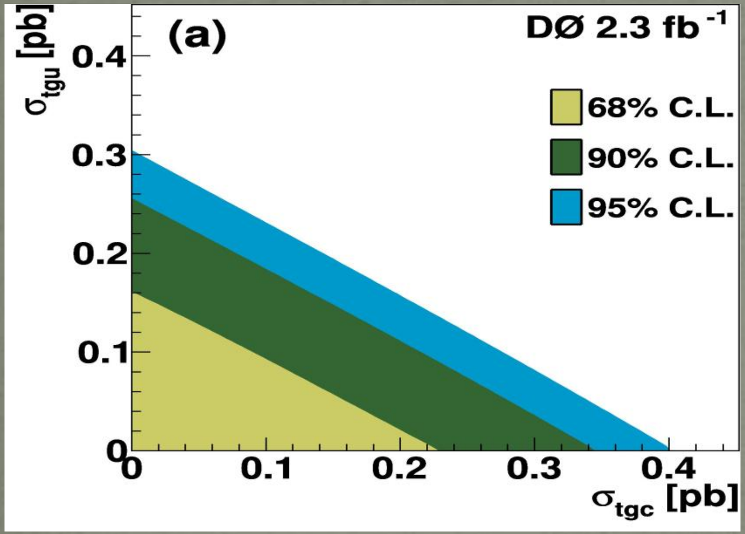
t-channel evidence 4.8σ

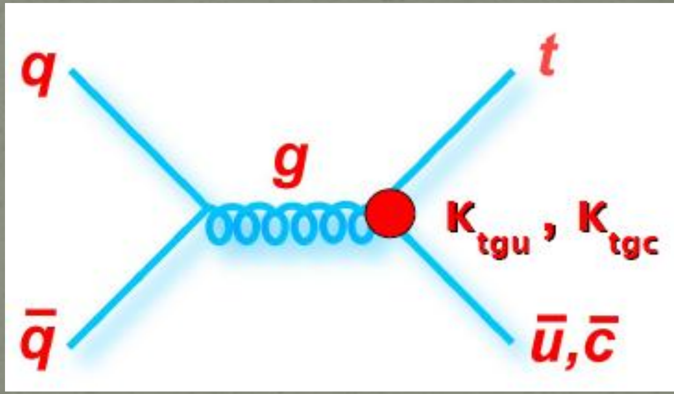
PRD 74, 114012 (2006)

V_{tb} measurement



V_{tb}=1.07 ± 0.12

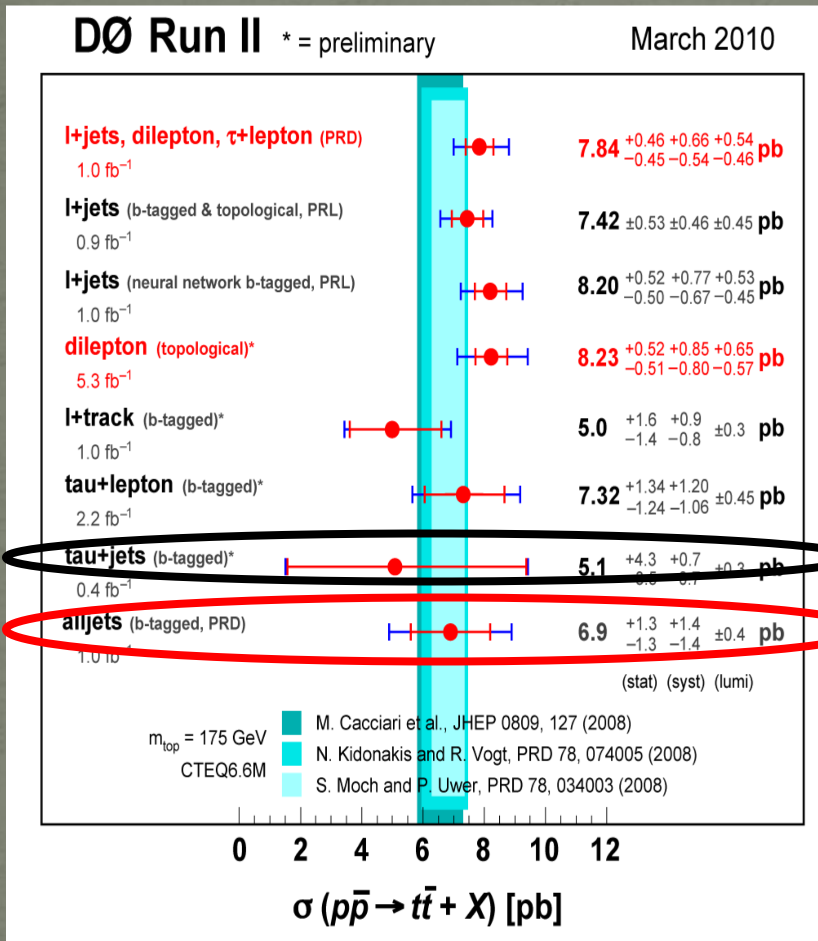


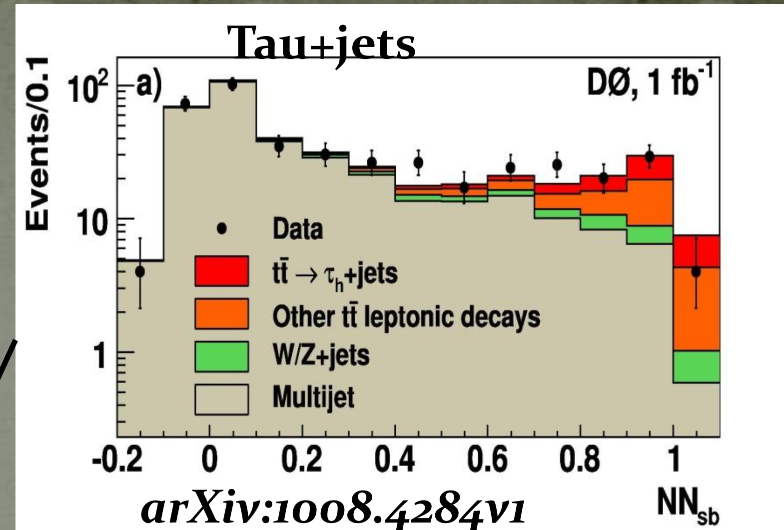


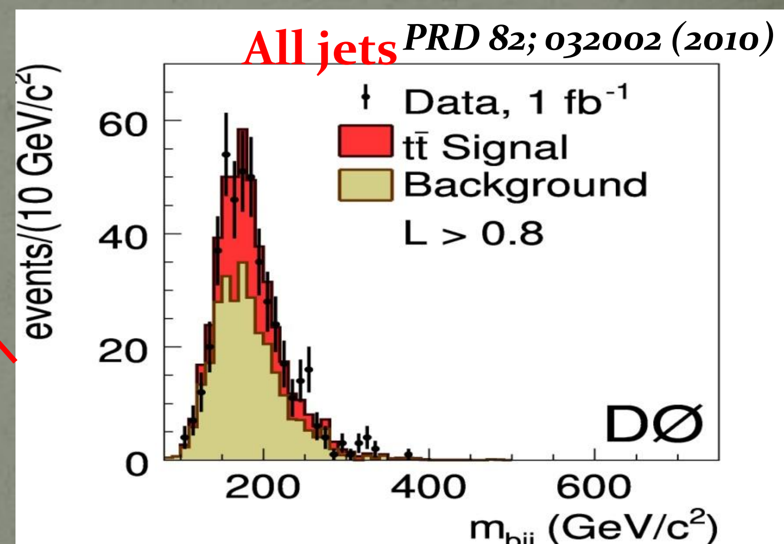
$\sigma_{tgc} < 0.20$ pb
$\sigma_{tgu} < 0.27$ pb

PLB **693**, *81 (2010)*

Cross Section







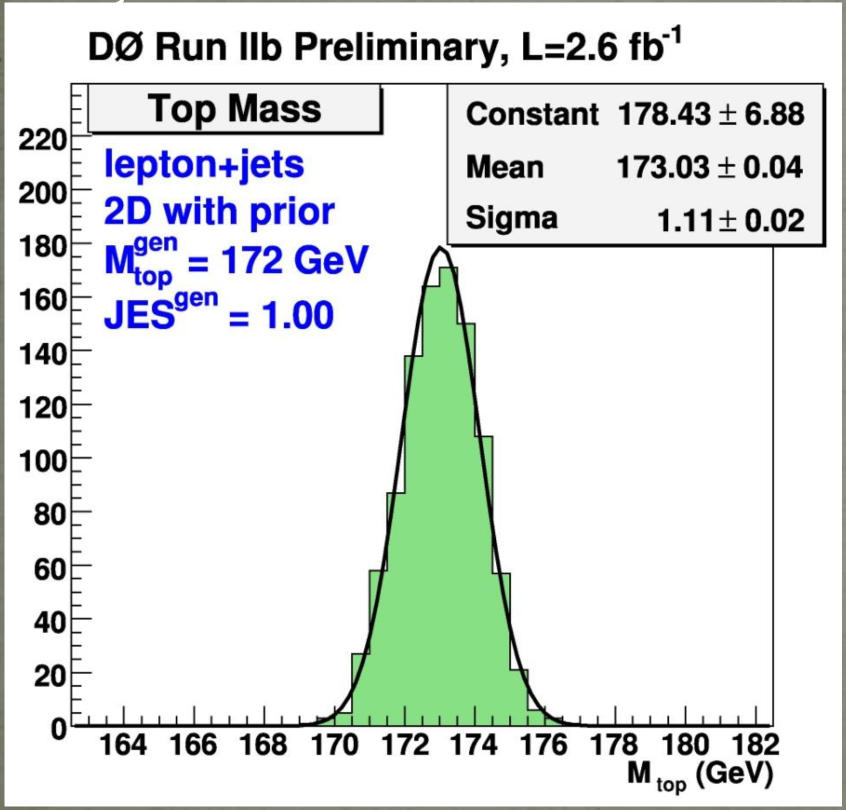
Good agreement with SM

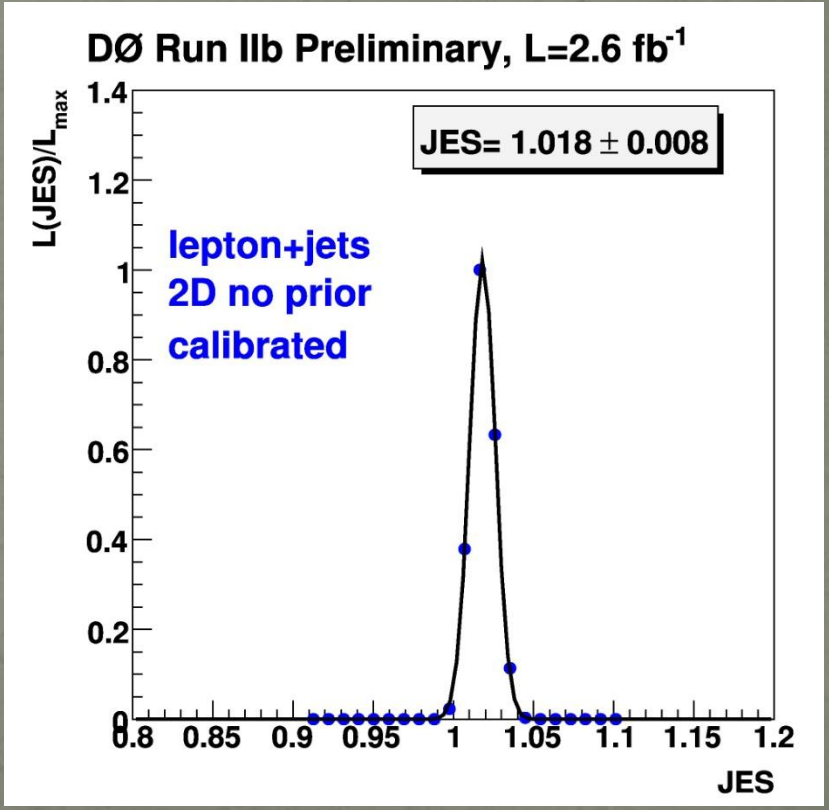
Top Quark Mass

Top Quark Mass. l+jets

- Matrix Element technique
- Get a probability for an event to be consistent with the given m_t
  - Integrate over Parton Density Functions
  - For a data sample with N events, multiply the probabilities
  - Find the most probable mass
- In-situ measurement of Jet Energy Scale (JES), thus reducing the JES systematic

m_t=173.7 ± 0.8(stat) +-1.6(syst)

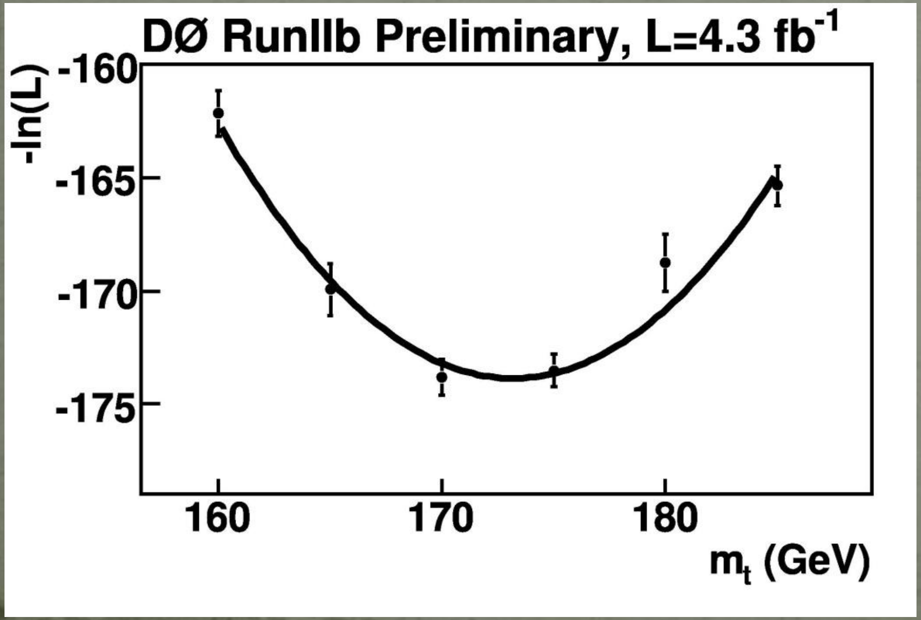




Top Quark Mass. Dilepton

We also measure
m_t with ME in dilepton

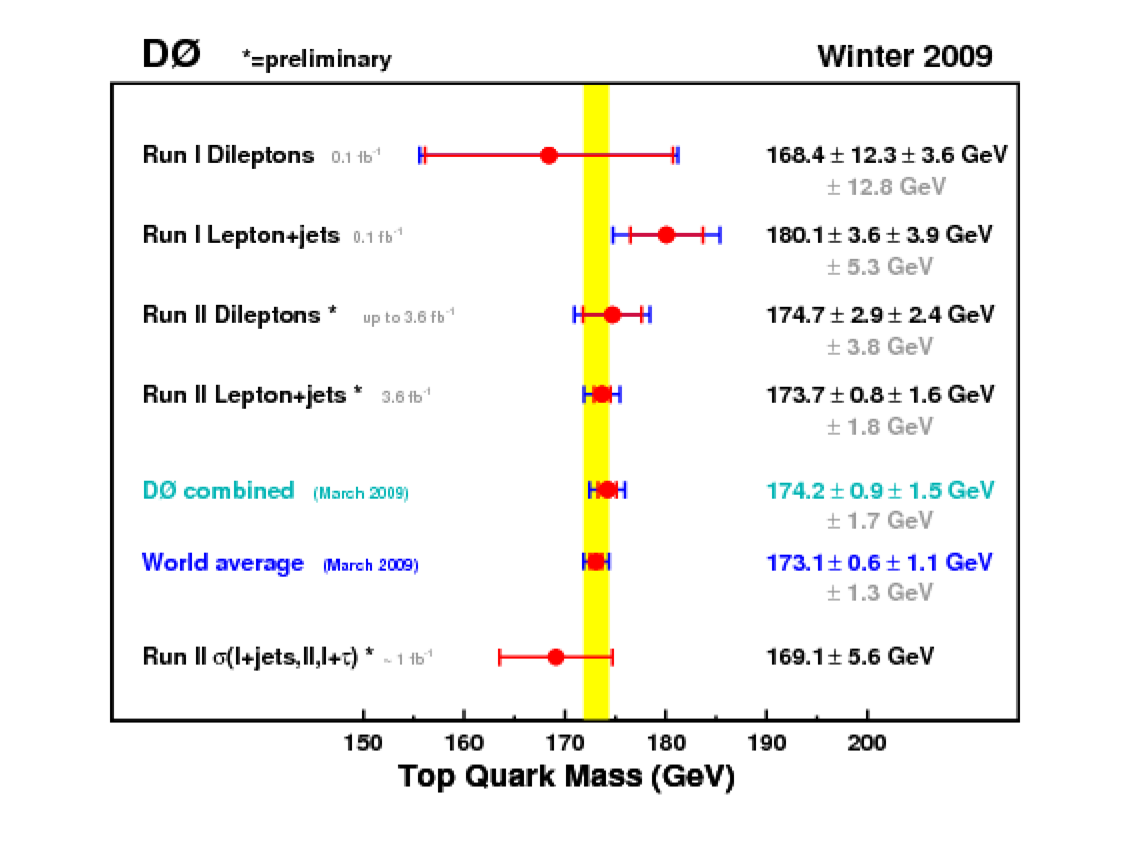
- Template method
  - Compare reconstructed mass in data and MC for different m_t and find the best m_t
  - Two neutrinos in the final state – under constrained fit
    - Integrating over neutrino rapidities to find the reconstructed mass
  - Best m_t measurement in the dilepton channel



$m_t = 173.3 \pm 2.4$ stat ± 2.1 syst

$\Delta m_t \,/\, m_t = 1.8\%$

Top quark mass



Systematics dominated!

Top Quark Properties

Top width

• Can not measure directly better than our detector resolution

•Determine the width of the top quark indirectly from the single top t-channel cross section measurement

•Most precise measurement of Γt

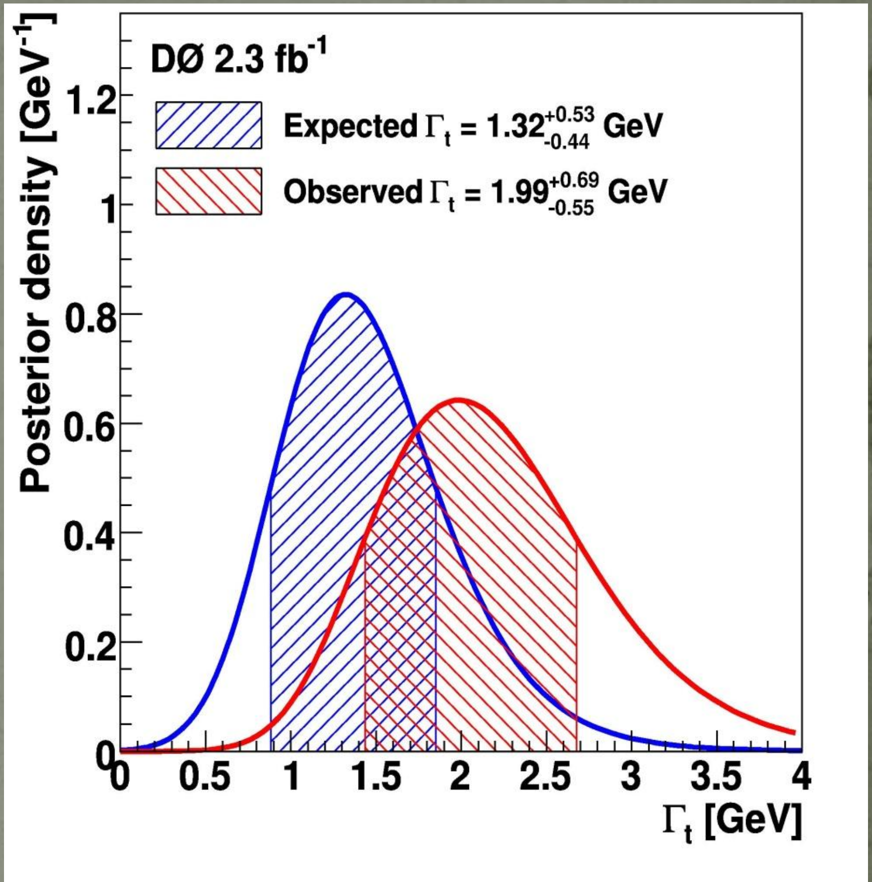
$$\Gamma_t = \frac{\sigma(t\text{-channel})\ \Gamma(t \to Wb)_{SM}}{\mathcal{B}(t \to Wb)\ \sigma(t\text{-channel})_{SM}}\ .$$

$$\mathcal{B}(t \to Wb) = 0.962^{+0.068}_{-0.066}(\text{stat})\ ^{+0.064}_{-0.052}(\text{syst})$$

$\Gamma_t = 1.99^{+0.69}_{-0.55}$ GeV

$\tau_t = (3.3^{+1.3}_{-0.9})\ 10^{-25}$ s

$\Gamma_t^{SM} = 1.3$ GeV



arXiv:1009.5686v1

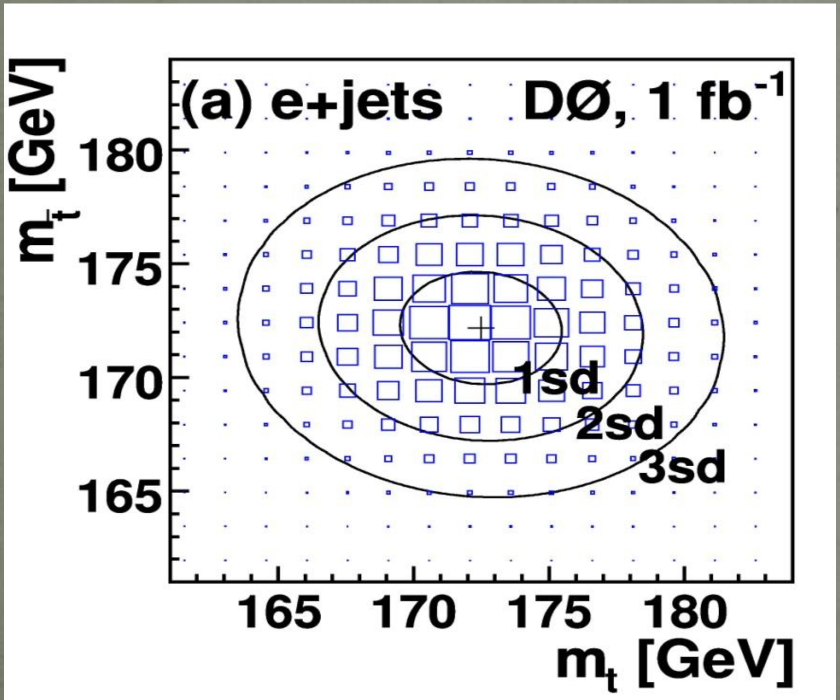
Phys. Rev. Lett. 103, 132001 (2009)

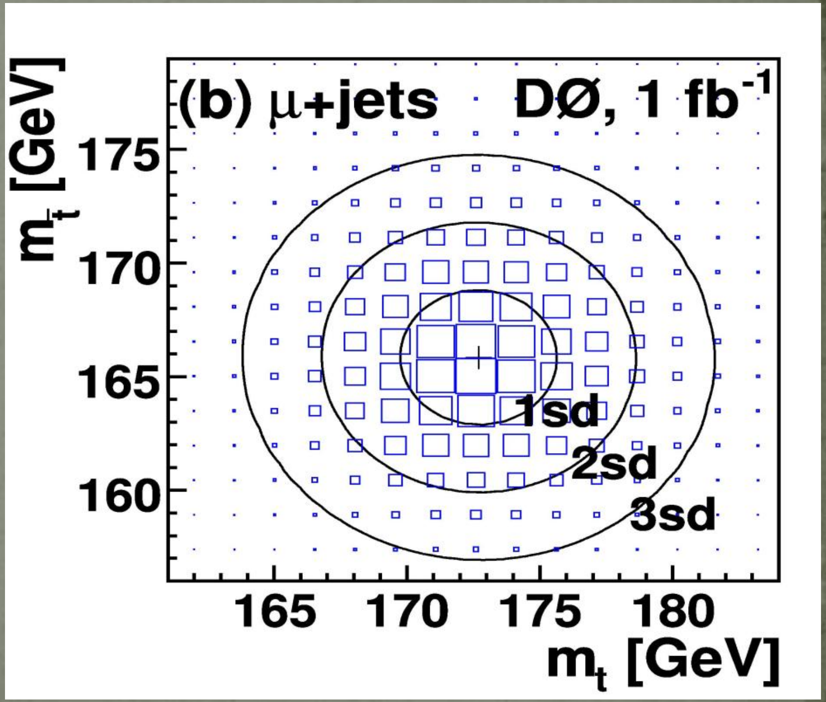
Top-Antitop mass difference

Advertised in Nature!

- With CPT conserved $m_t = m_{\bar{t}}$
  - Measuring $m_t = m_{\bar{t}}$ tells us about CPT conservation
- Matrix Element for the mass extraction

$m_t - m_{\bar{t}} = 3.8 \pm 3.7$ **GeV with 1 fb^{-1}**

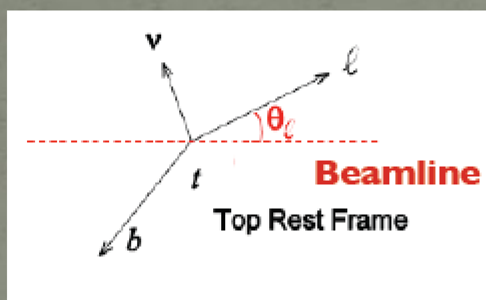




Spin Correlations

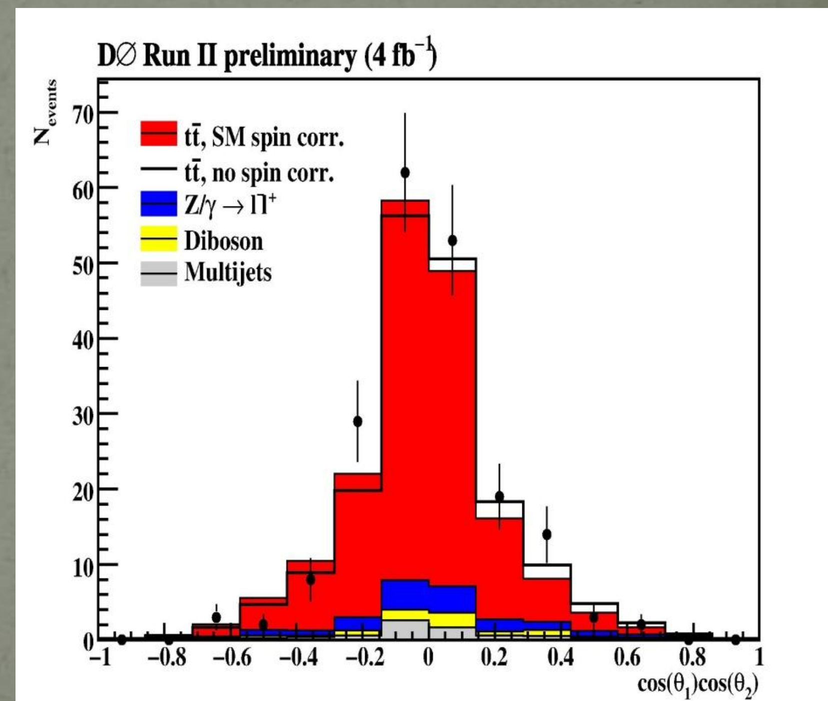
- Top quark decays before hadronization – spin information preserved.
- Differentiate between spin/no spin hypothesis

$$\kappa = \frac{N_{\downarrow\uparrow} + N_{\uparrow\downarrow} - N_{\uparrow\uparrow} - N_{\downarrow\downarrow}}{N_{\downarrow\uparrow} + N_{\uparrow\downarrow} + N_{\uparrow\uparrow} + N_{\downarrow\downarrow}} \approx 0.78$$



$$\frac{1}{\sigma}\frac{d^2\sigma}{d\cos\theta^+ d\cos\theta^-} = \frac{1 + \kappa\cos\theta^+\cos\theta^-}{4}$$

$K_{SM}=0.777$
$K=-0.2^{+0.6}_{-0.5}$



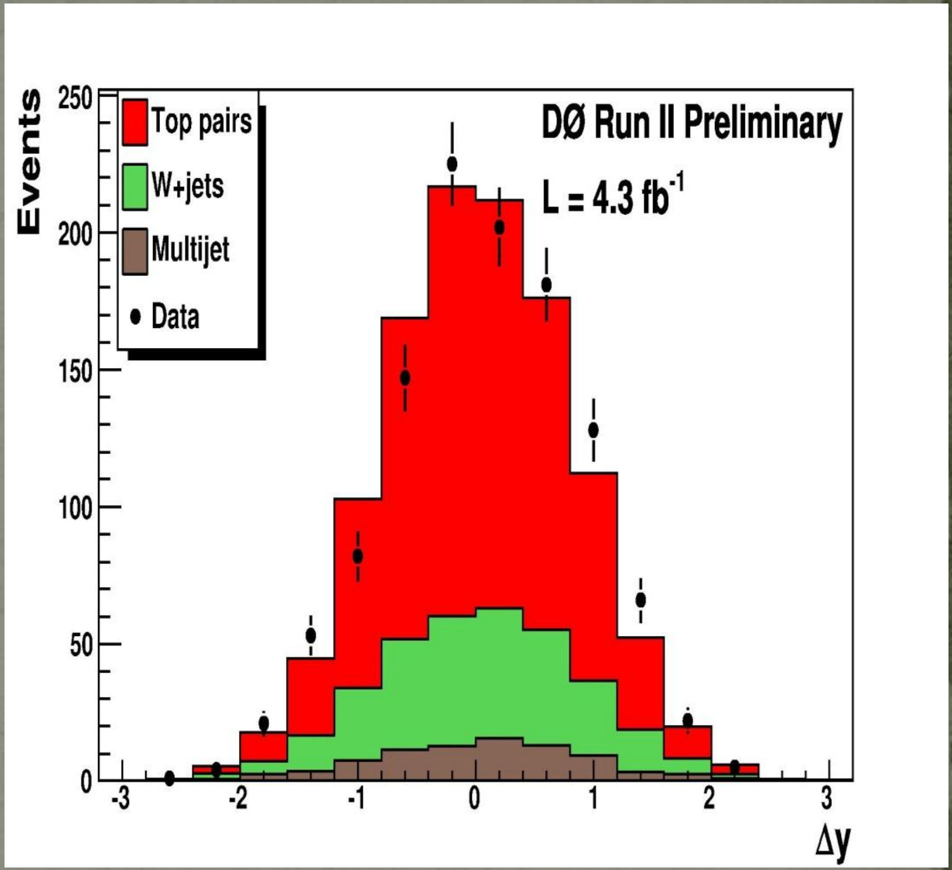
Forward Backward Asymmetry

- Tevatron is a $p\bar{p}$ collider
- Expect a small forward backward asymmetry at NLO

$$\Delta y \equiv y_t - y_{\bar{t}}$$

$$A_{fb} = \frac{N^{\Delta y>0} - N^{\Delta y<0}}{N^{\Delta y>0} + N^{\Delta y<0}}.$$

A_{FB}=8 ± 4(stat) ± 1(syst)%
$A_{FB}^{SM,NLO} = 1^{+2.0}_{-1.0}$ %

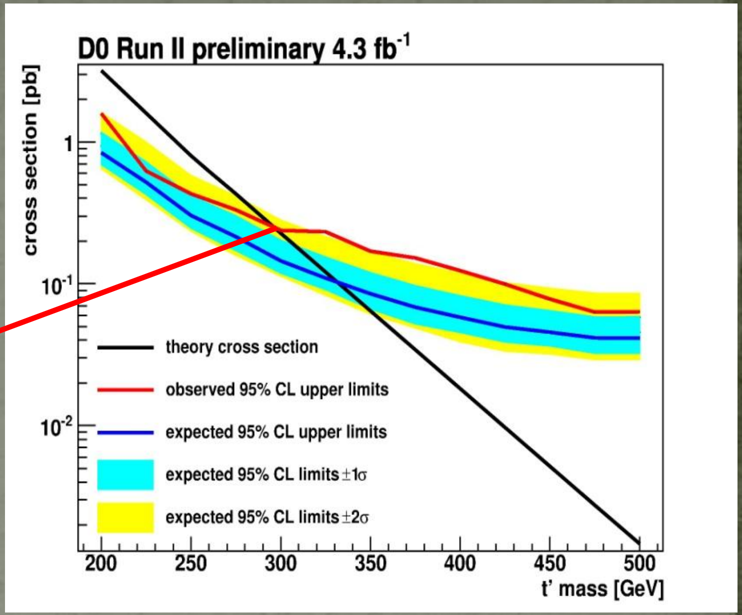


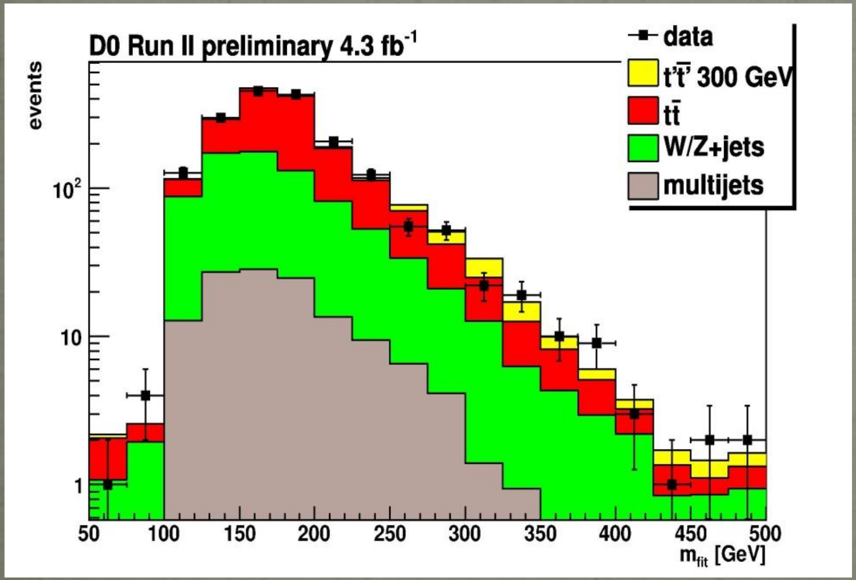
- **Z` → tt and warped extra dimensions predict higher A_{FB} ?**

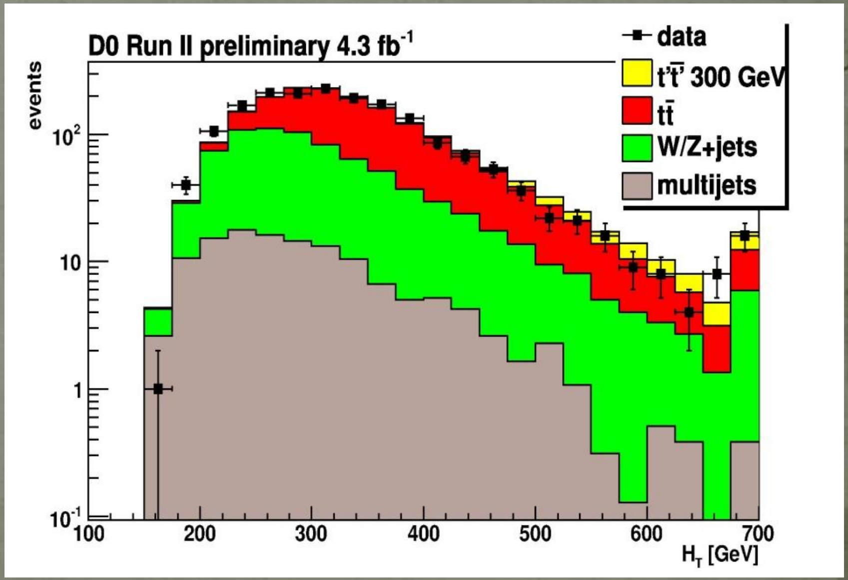
Searches for New Particles

Search for t`

- Why three generation?
  - Looking for the fourth.
- t` → Wb
  - m(t`)<m(W)+m(b`)
- Use reconstructed $m_{t`}$ and $H_T = \Sigma p_T$
- Exclude $m_{t`}$<296 GeV at 95% CL







Conclusion

- Many top quark measurements
  - Exciting era
- Top production cross section
  - 6% precision
- Mass
  - <1% precision
- Single top discovery!
  - Direct measurement of V_{tb}
- Testing NLO QCD
- More exciting measurements to come!