

## Top quark physics at DØ

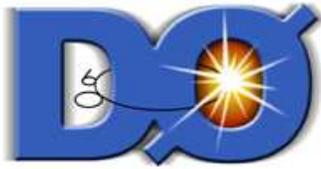


Yvonne Peters  
University of Wuppertal  
for the DØ collaboration

# Introduction

Results for top production

Results for top decay



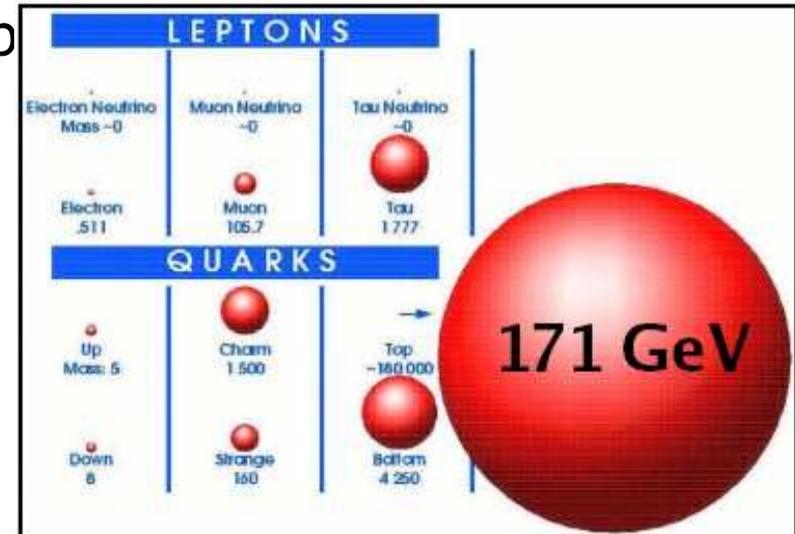
# The top quark



Top quark discovered 1995 at Fermilab by CDF and DØ  
at DØ:  $\sim 50 \text{ pb}^{-1}$  of integrated luminosity in Run I  
→ measured  $t\bar{t}$  cross section  $6.4 \pm 2.2 \text{ pb}$

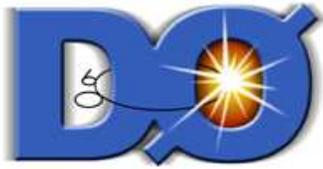
Current world average for top mass:  
 $170.9 \pm 1.1 \text{ (stat)} \pm 1.5 \text{ (syst) GeV}$

SM:  $t \rightarrow Wb$  with  $\sim 100\%$



Short lifetime of the top quark (expected to be  $\sim 0.5 \times 10^{-24} \text{ s}$ )  
→ no fragmentation of top quark before decay  
→ measure properties of bare quark

Will present analyses with  $\sim 1 \text{ fb}^{-1}$  integrated luminosity

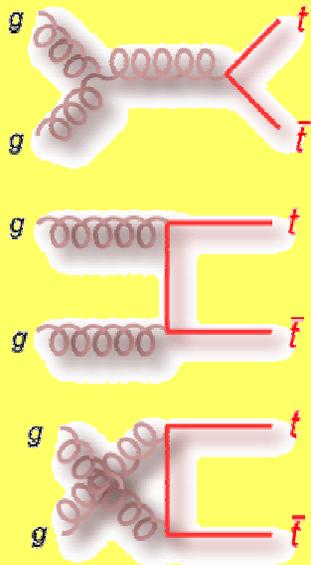


# Top production mechanism

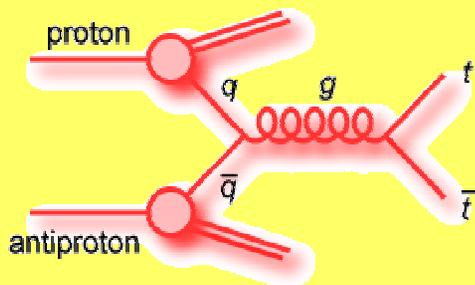


## top quark pair production

via strong interaction:  
15% gluon fusion



and 85%  $q\bar{q}$  annihilation



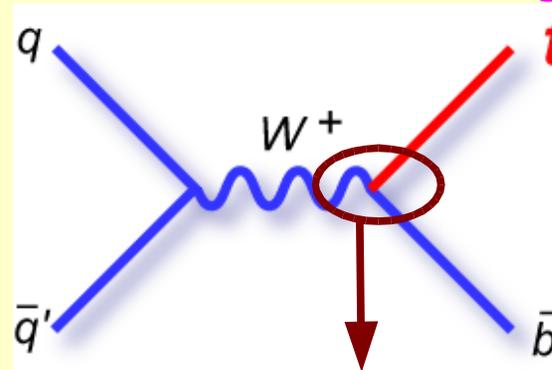
## single top quark production

via electroweak interaction

Phys. Rev Lett. 98, 181802 (2007)

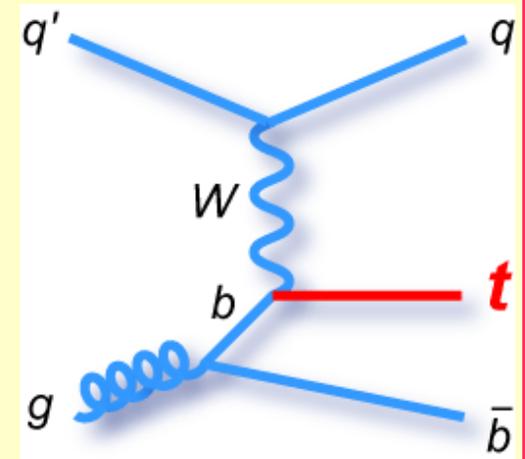
First evidence of single top  
reported by DØ in 2006!

$\sigma(tb+X, tqb+X) = 4.7 \pm 1.3 \text{ pb}$   
->3.6 std. dev. significance



direct measurement of  $V_{tb}$

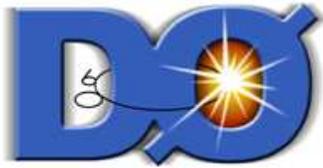
$|V_{tb}| > 0.68$  @95% C.L.



searches in single top channel:

$W'$  PLB 641, 423 (2006)

FCNC PRL 99, 191802 (2007)



# Top quark analyses at D0

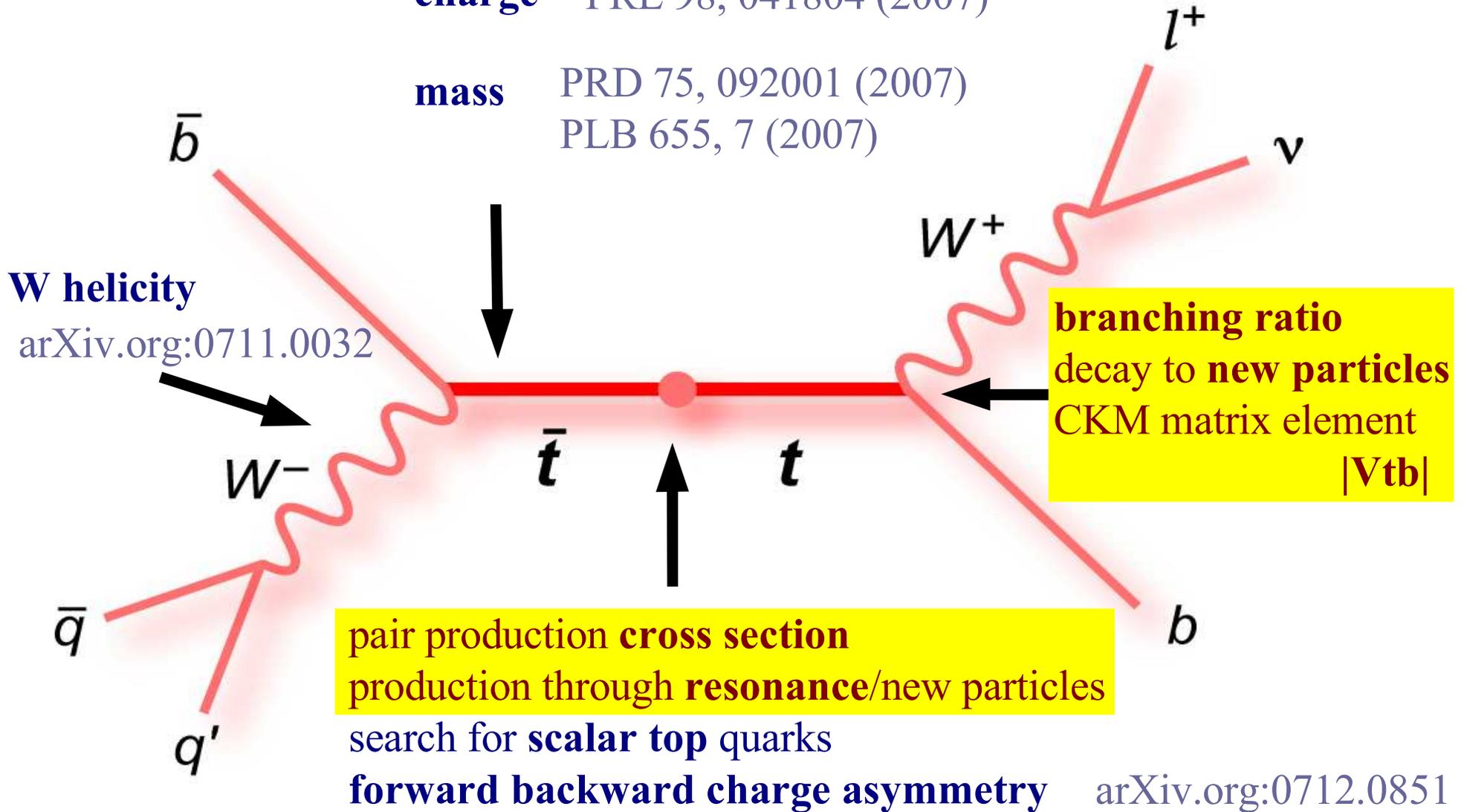


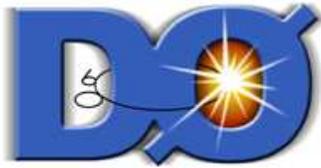
**charge** PRL 98, 041804 (2007)

**mass** PRD 75, 092001 (2007)  
PLB 655, 7 (2007)

**W helicity**

arXiv.org:0711.0032





# Top quark pair decay



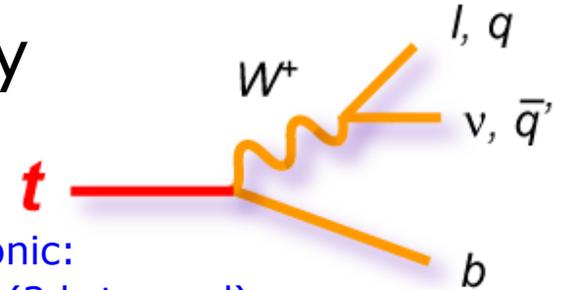
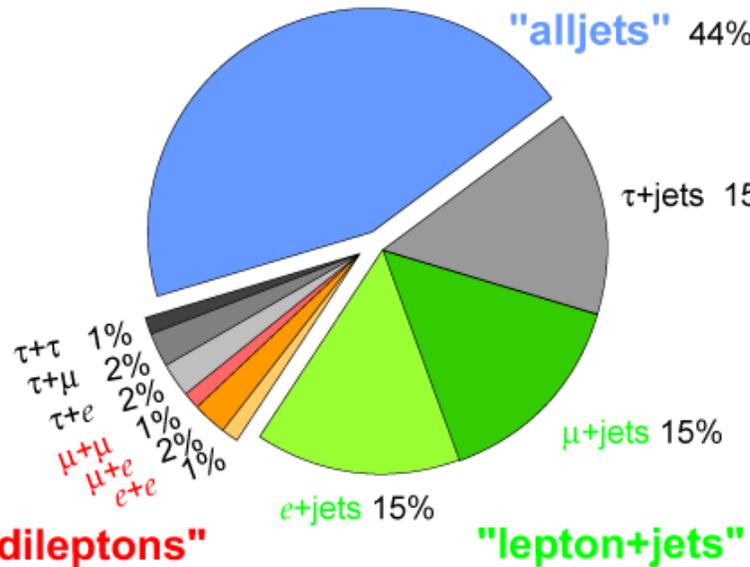
channels classified according to W decay

$\tau$ +lepton:  
 one isolated lepton  
 one hadronic  $\tau$   
 $\geq 2$  jets (b-tagged)  
 1 neutrino  
 $\rightarrow$  high missing  $E_T$

dilepton:  
 two isolated leptons  
 $\geq 2$  jets (b jets) "dileptons"  
 2 neutrinos  $\rightarrow$  high missing  $E_T$

experimental objects:  
 jets  
 (isolated) electrons and muons  
 missing  $E_T$

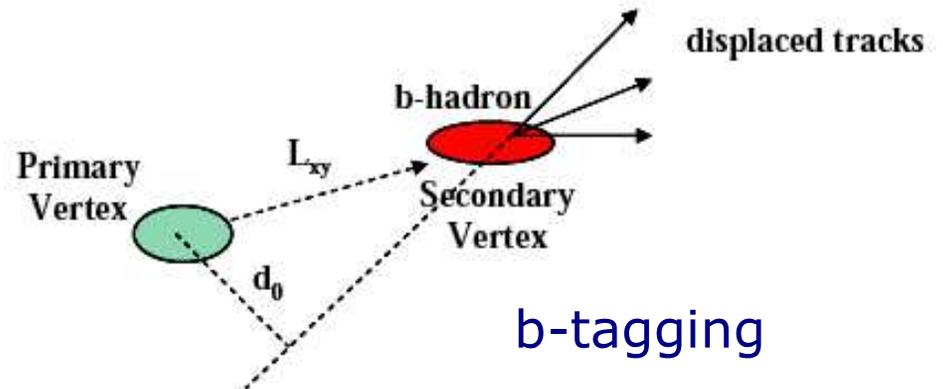
Top Pair Branching Fractions



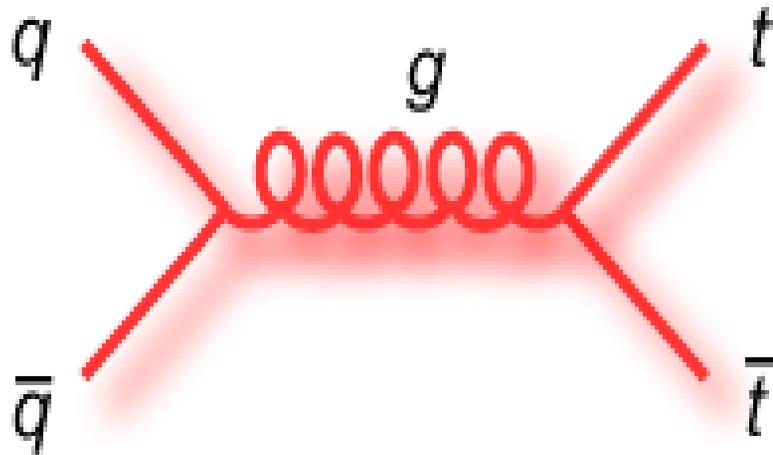
allhadronic:  
 $\geq 6$  jets (2 b-tagged)

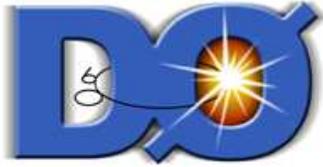
$\tau$ +jets:  
 one hadronic  $\tau$   
 $\geq 4$  jets (2b-tagged)

lepton+jets:  
 exactly one isolated lepton  
 $\geq 4$  jets (2 b-tagged)  
 1 neutrino  $\rightarrow$  missing  $E_T$



# Top production

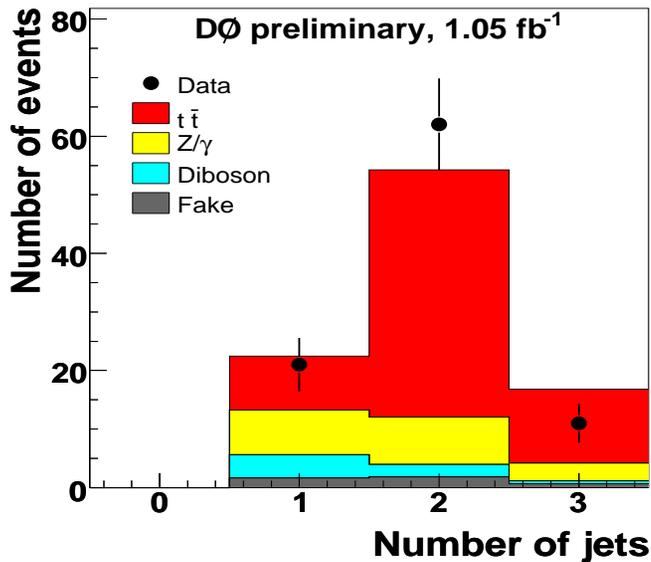
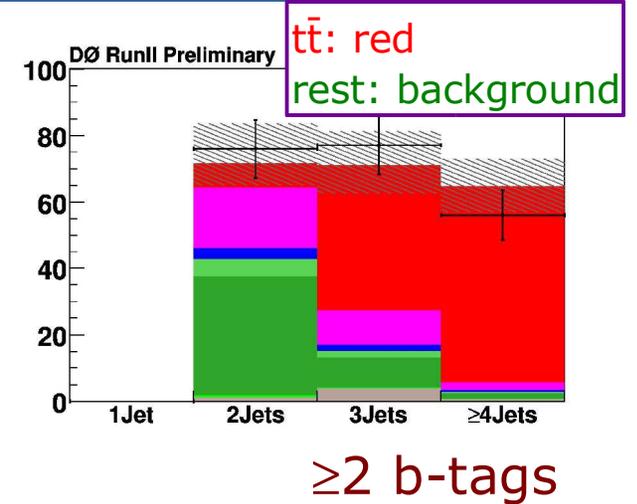
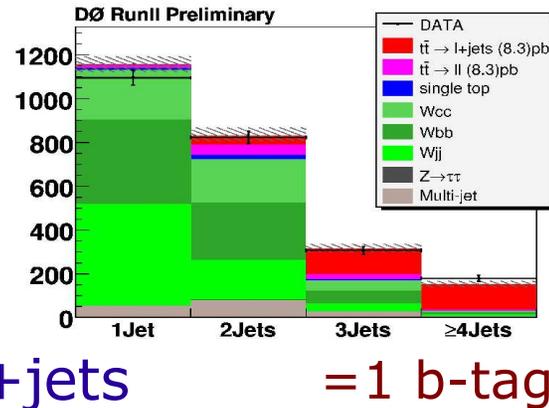




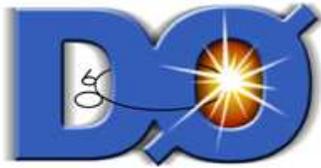
# Cross section



$t\bar{t}$  cross section with  
b-tag in l+jets channel  
high statistics  
main background: W+jets  
Signal/Background  $\sim 1$



$\sigma_{t\bar{t}}$  in dilepton & lepton+track channel  
 leptons give clear signature  
 $\rightarrow$  pure channel  
 main background: Z+jets  
 Signal/Background  $\sim 3$



# Cross section all results

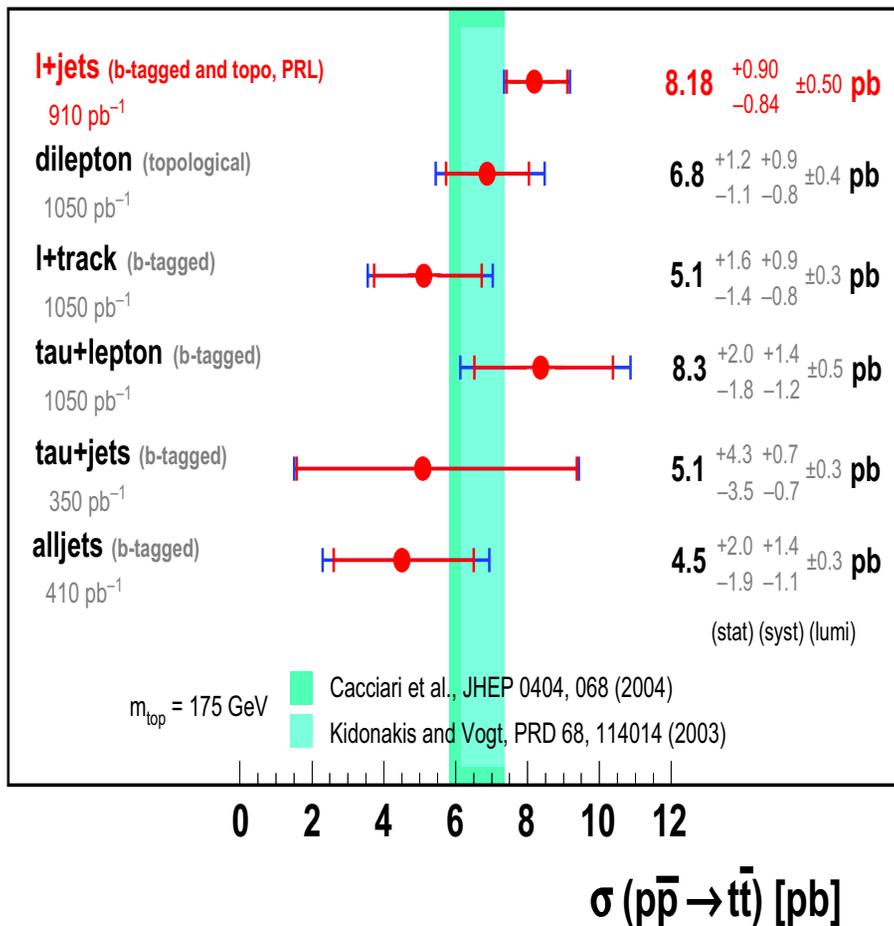


new results up to this winter with  $\sim 1 \text{ fb}^{-1}$

DØ Run II preliminary

Winter 2008

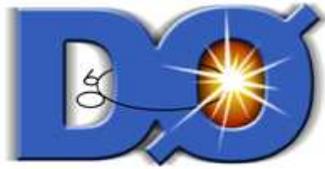
relative uncertainty



new physics may be hidden in one of the channels

→ measure  $\sigma_{t\bar{t}}$  in each channel, look for agreement

all channels agree within uncertainties



# Top quark mass from cross section

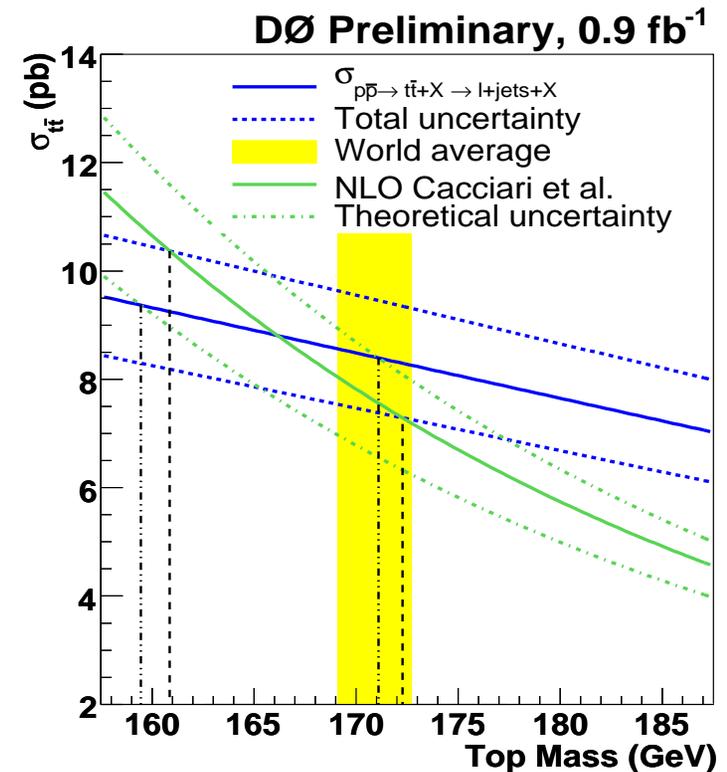


theoretical cross section:  
mass dependent

experimental cross section:  
acceptance slightly mass dependent

First extraction of top quark mass  
from measurement of  $\sigma_{t\bar{t}}$

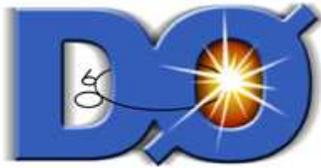
unambiguous interpretation:  
top mass in pole mass definition



e. g. using lepton+jets data and Cacciari et. al.

$$m_t = 166.1^{+6.1}_{-5.3} (stat + syst)^{+4.9}_{-6.7} (theory) GeV$$

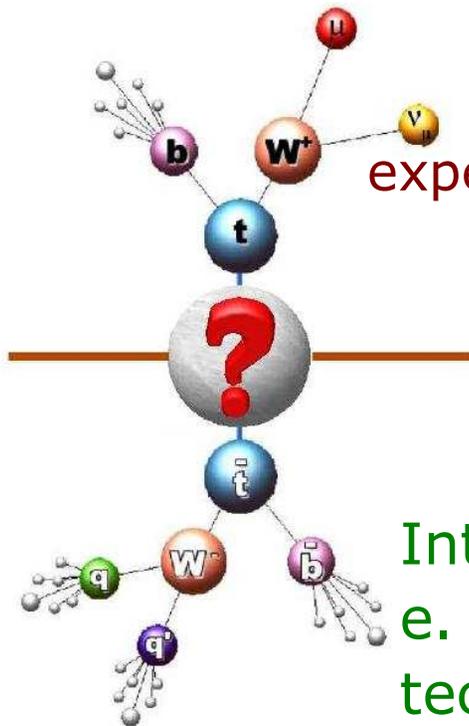
→ agrees with world average  $170.9 \pm 1.1 \pm 1.5 GeV$



# Top pair production through resonance



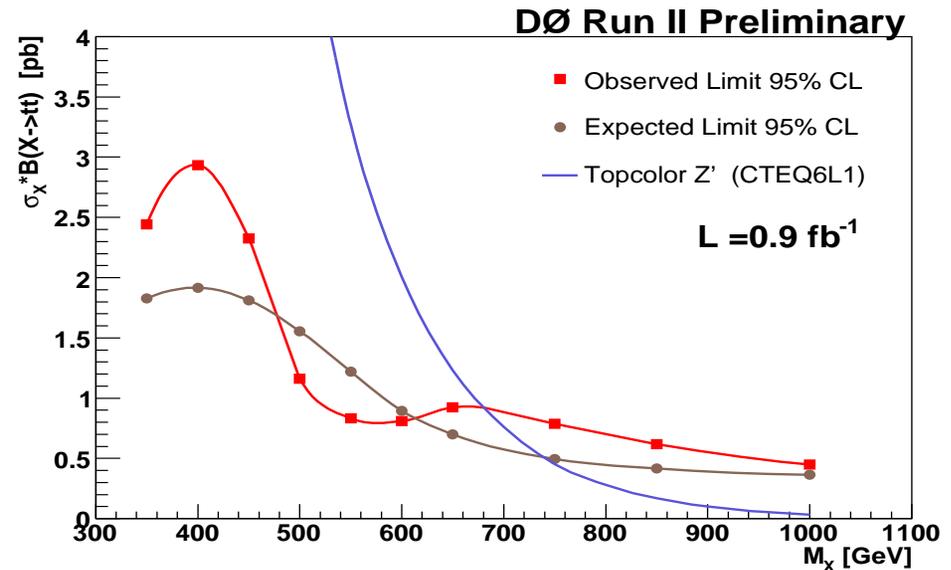
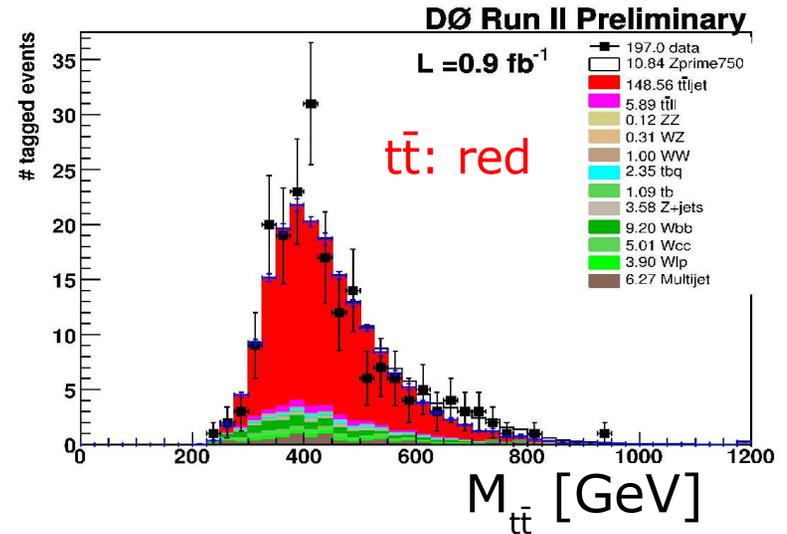
No resonant  $t\bar{t}$  production in SM  
 → search for new resonances  
 (for resonance narrower than resolution)



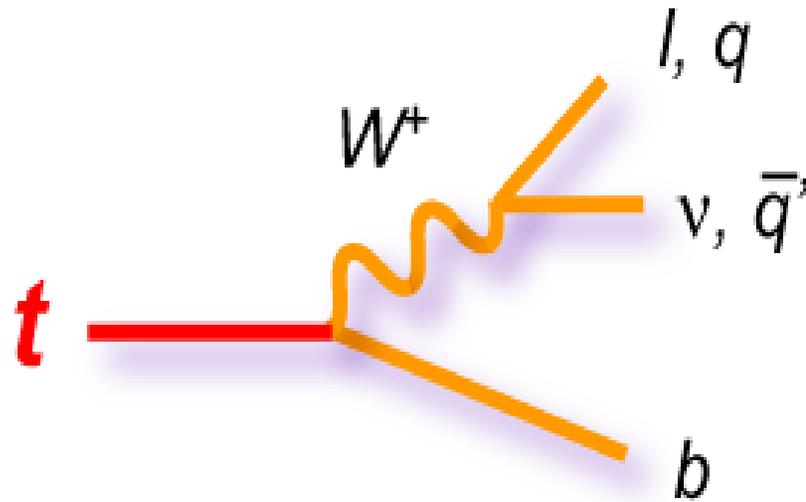
experimental signature:  
 bump in invariant  
 mass distribution  
 → generic search

Interpretation:  
 e. g. top assisted  
 technicolor  
 models: Z' boson

$M_{Z'} < 680 \text{ GeV}$  excluded @ 95% C.L.



# Top decay





# R and cross section

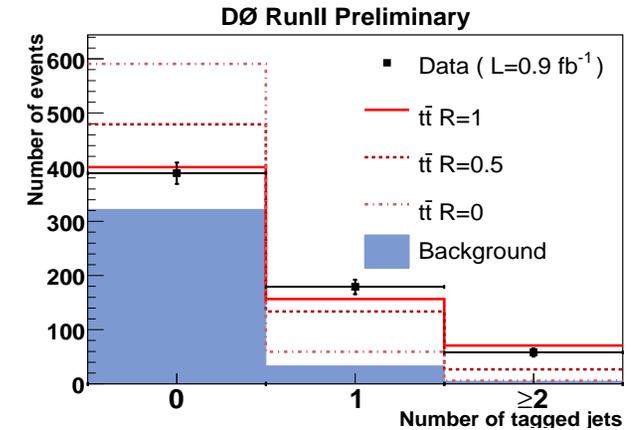


Simultaneously measure  $\sigma_{t\bar{t}}$  and R: no assumption of  $Br(t \rightarrow Wb) = 1$

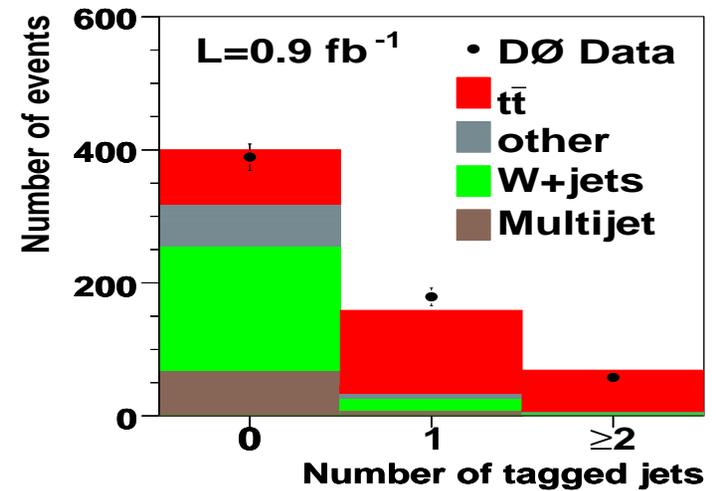
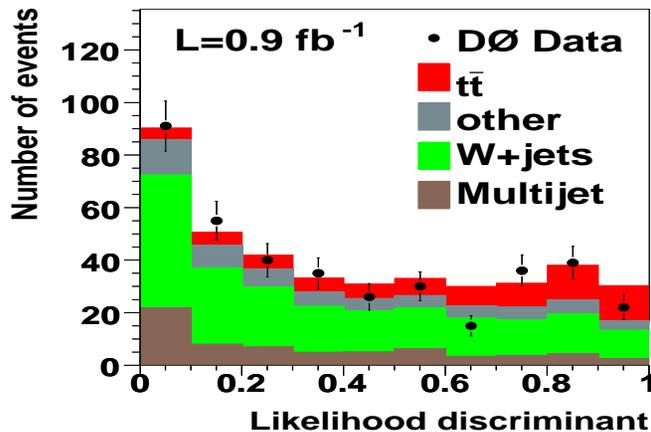
$$R = \frac{Br(t \Rightarrow Wb)}{Br(t \Rightarrow Wq)}$$

$R \approx 1$  in SM

number of identified b-jets depends quadratically on R



complementary information from topological discriminant in 0 b-tag bin





# R and cross section



$$\sigma_{t\bar{t}} = 8.18_{-0.84}^{+0.90} (stat + syst) \pm 0.5 (lumi) pb$$

11%

$$R = 0.97_{-0.08}^{+0.09} (stat + syst)$$

9% relative uncertainty

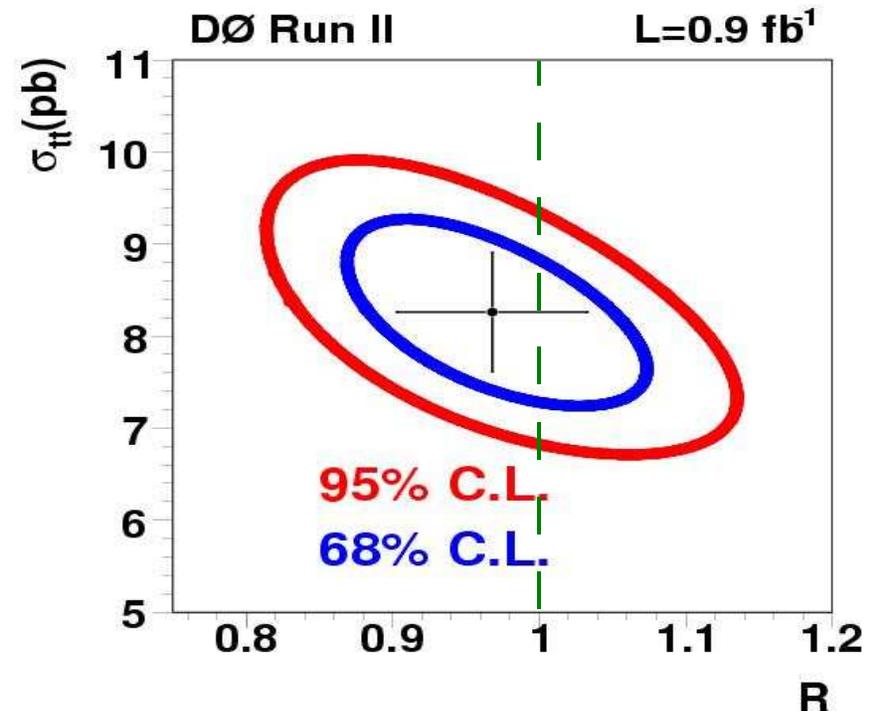
Limits on R and CKM  
matrix element  $|V_{tb}|$

$R > 0.79$  @95% C.L.

$|V_{tb}| > 0.89$  @95% C.L.

direct measurement from single top:

$|V_{tb}| > 0.68$  @95% C.L.



→ R measurement in agreement with the SM

arXiv.org:0801.1326



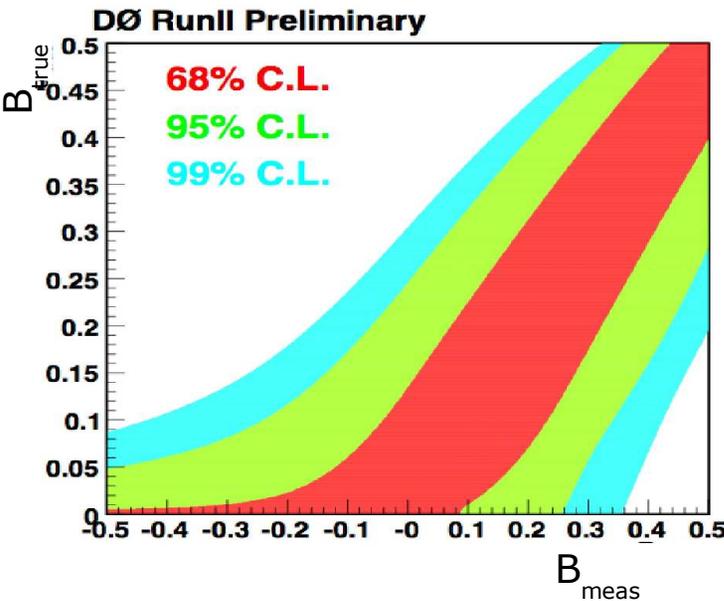
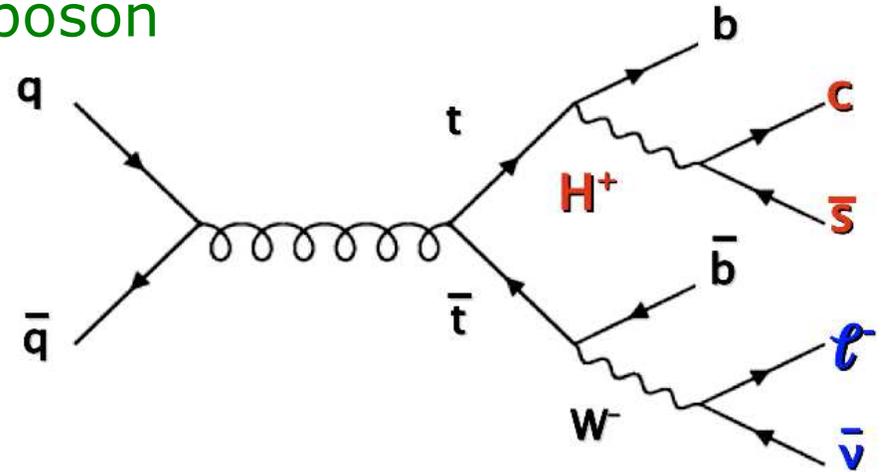
# Top pair production cross section ratio



Ratio of cross sections

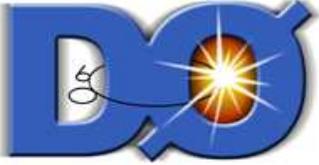
$$R_\sigma = \frac{\sigma(p\bar{p} \rightarrow t\bar{t})_{ljets}}{\sigma(p\bar{p} \rightarrow t\bar{t})_{dilepton}} = 1.21^{+0.27}_{-0.26} (stat + syst)$$

Interpretation: Upper limit on  $Br(t \rightarrow Xb)$  with X any other particle than W boson (results before: assumption of  $X=W$ )



Simple model: **charged Higgs**  $H^+$  with mass  $\sim$  W boson mass,  $Br(H^+ \rightarrow cs) = 100\%$ , similar event kinematics for  $t \rightarrow H^+ b$  and  $t \rightarrow W b$

$$B(t \rightarrow H^+ b) < 0.35 @ 95\% \text{ C.L.}$$



## Conclusion and outlook



- Recent results with  $1\text{fb}^{-1}$  of DØ data
  - ◆ measurements with high precision
  - ◆ some already systematically limited
    - ✦ e. g. top pair production cross section and top quark mass
- No evidence for new physics found in the top quark sector so far
- Coming soon: new results with up to  $2\text{fb}^{-1}$