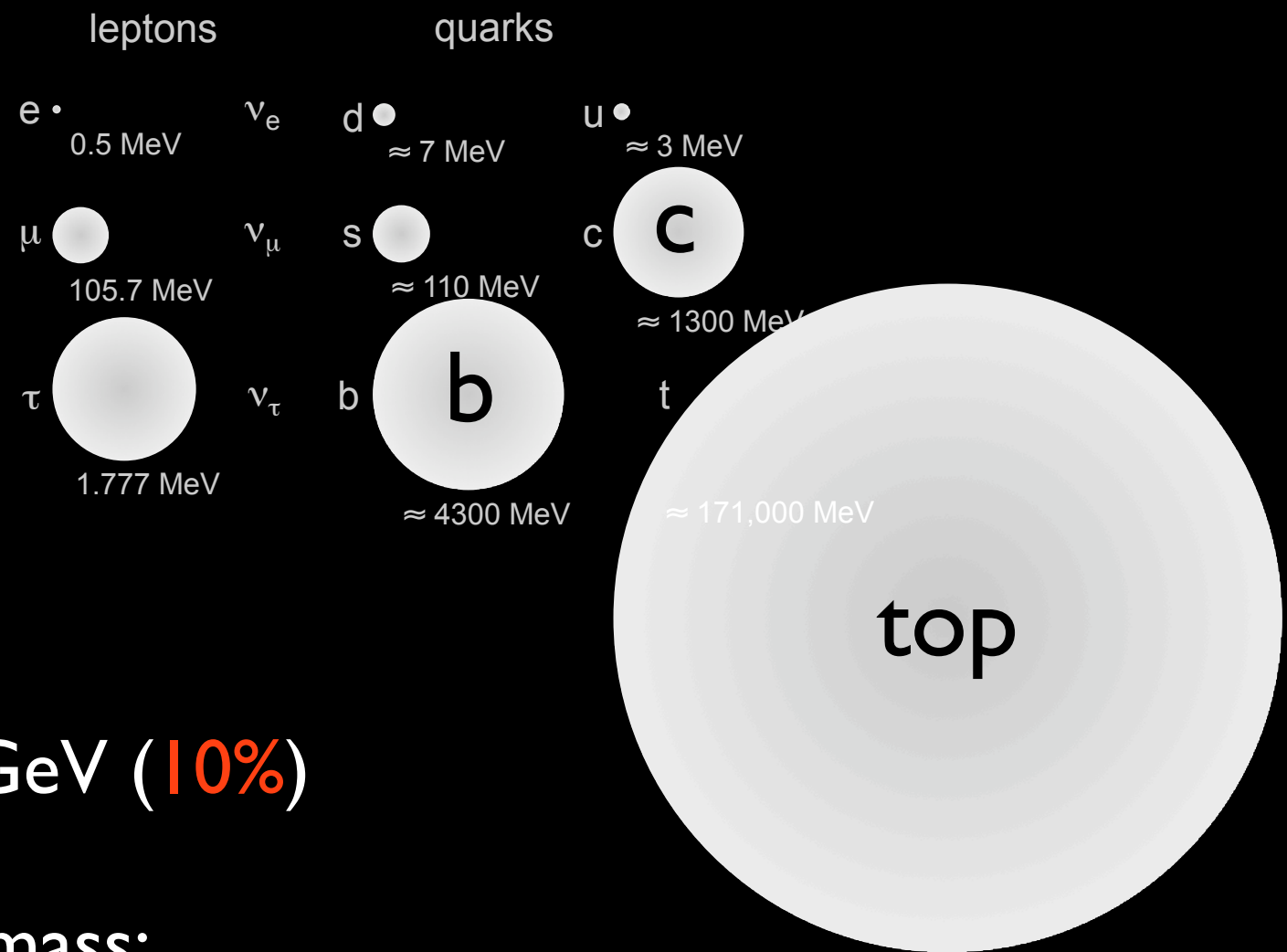


# Top Cross Section and Production Measurements at Tevatron

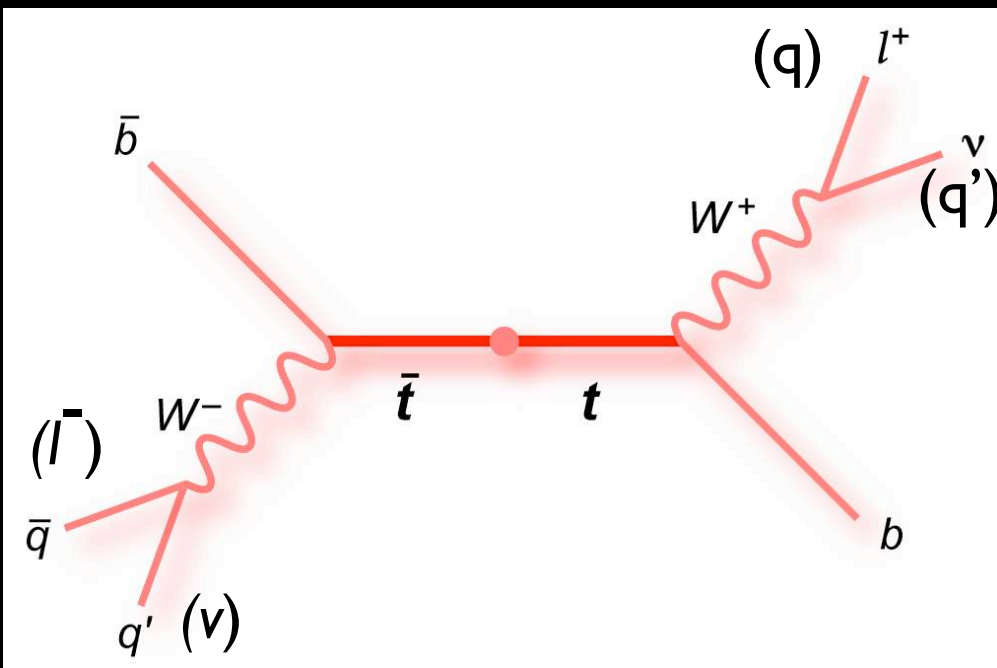
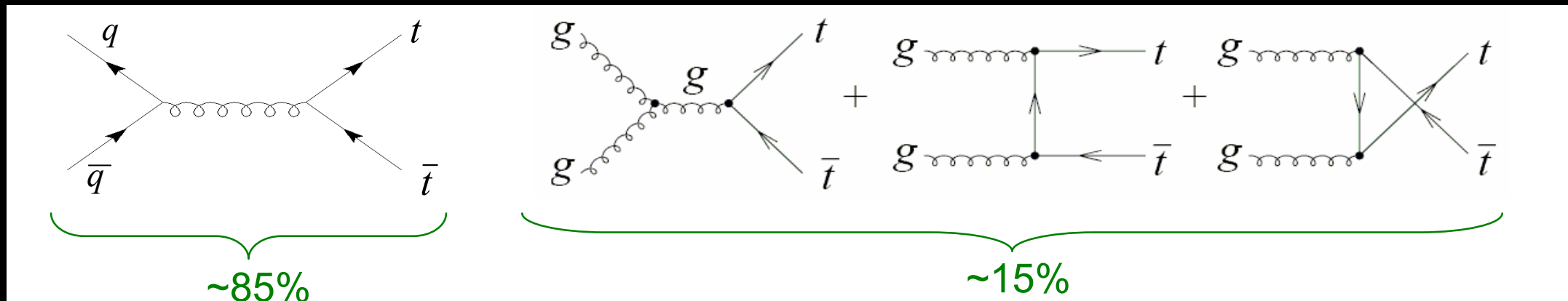
DooKee Cho  
Boston university  
on behalf of CDF and DØ collaborations

# Introduction

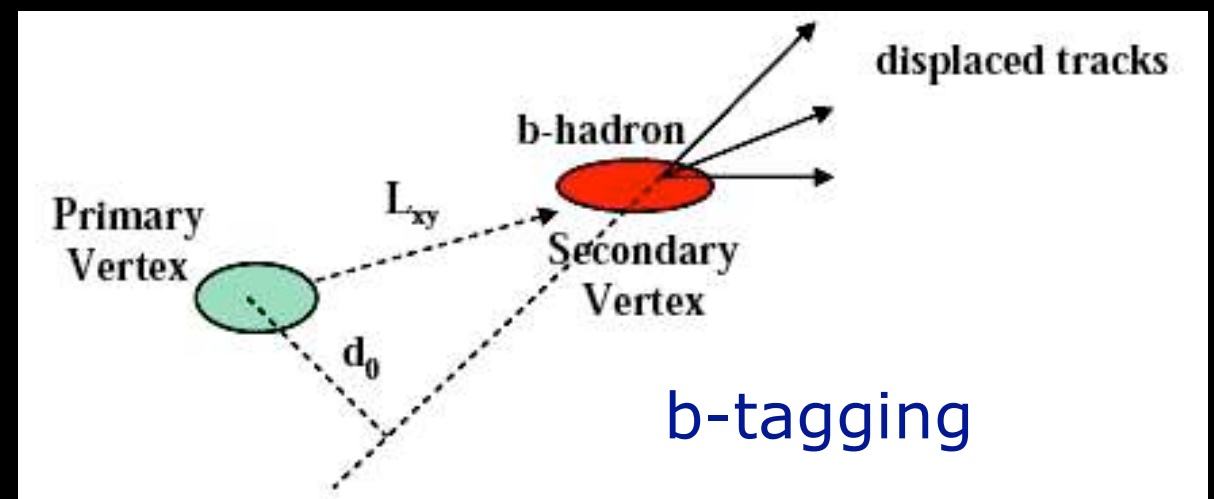
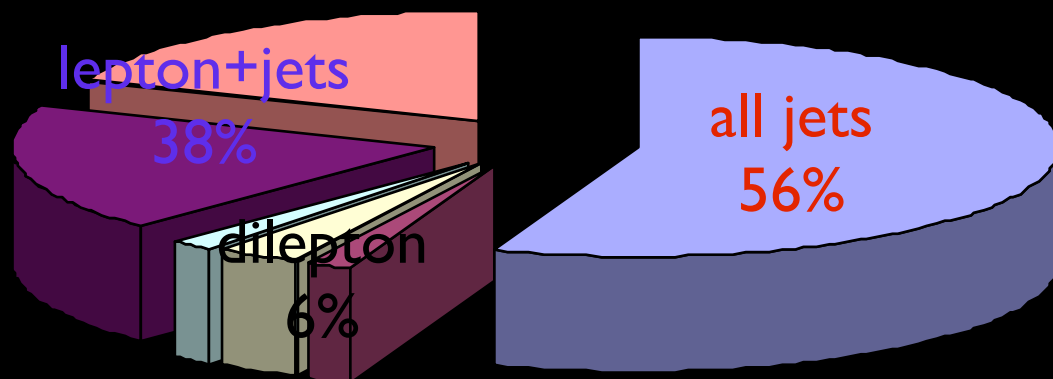
- top is the most massive fundamental particle
- discovered in 1995 at Fermilab by CDF and DØ
  - $\sigma = 6.4 \pm 2.2$  pb (34%)
- Theory prediction
  - 5.81 - 7.41 pb at  $M_{\text{top}} = 175$  GeV (10%)
- Current world average of top mass:
  - $172.6 \pm 1.4$  GeV (1%)



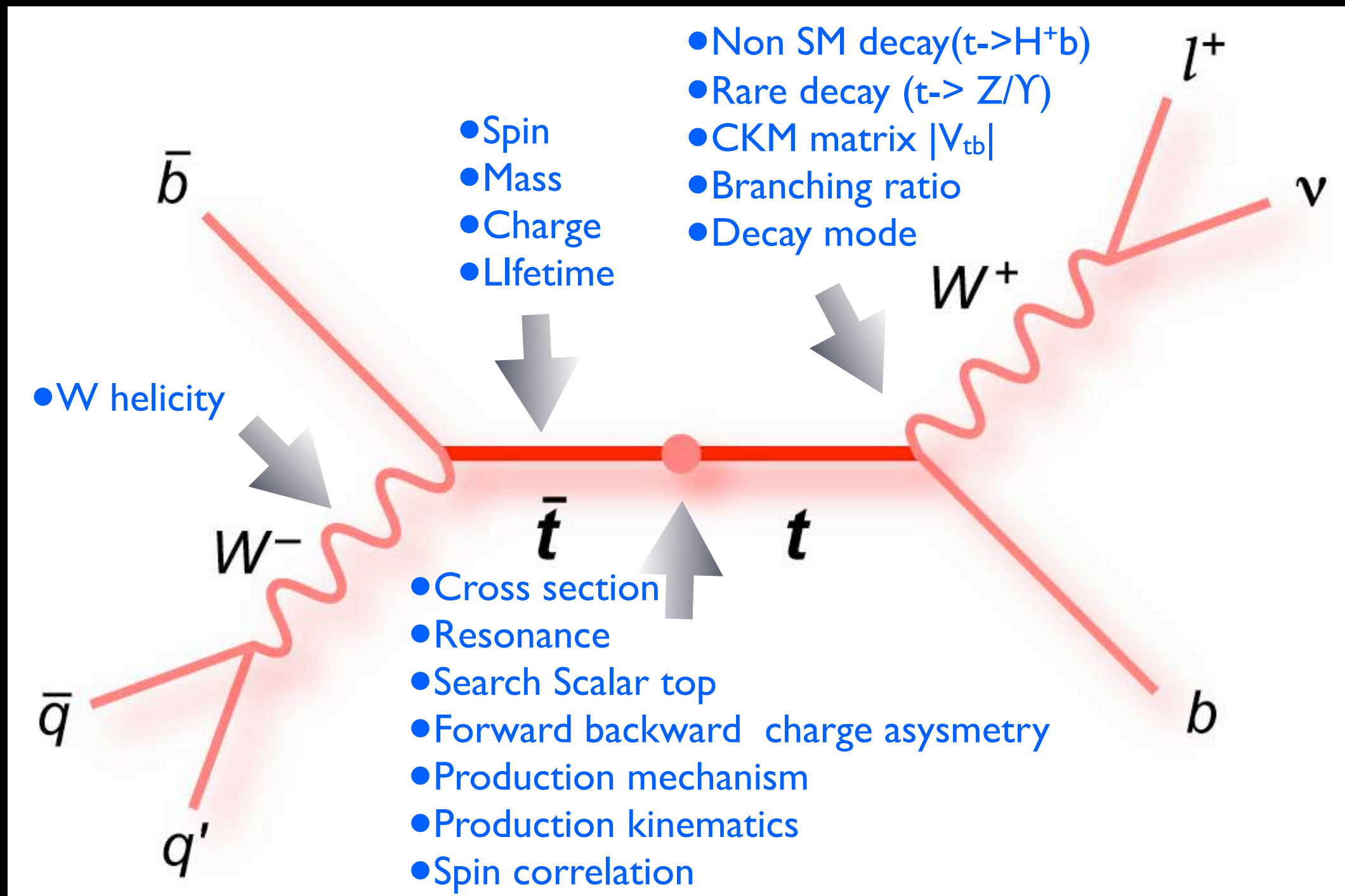
# Top pair production at Tevatron



- strong interaction
- 15% gluon fusion
- 85% qq annihilation
- short life time ( $\sim 0.5 \times 10^{-24} \text{s}$ )
- decay before hadronization
- signature - final state of W decay

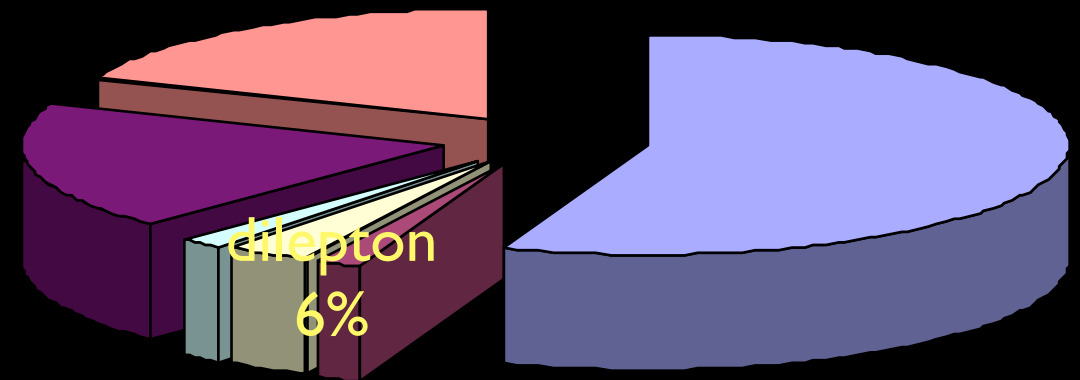


# Top physics in top pair production



# Dilepton cross sections

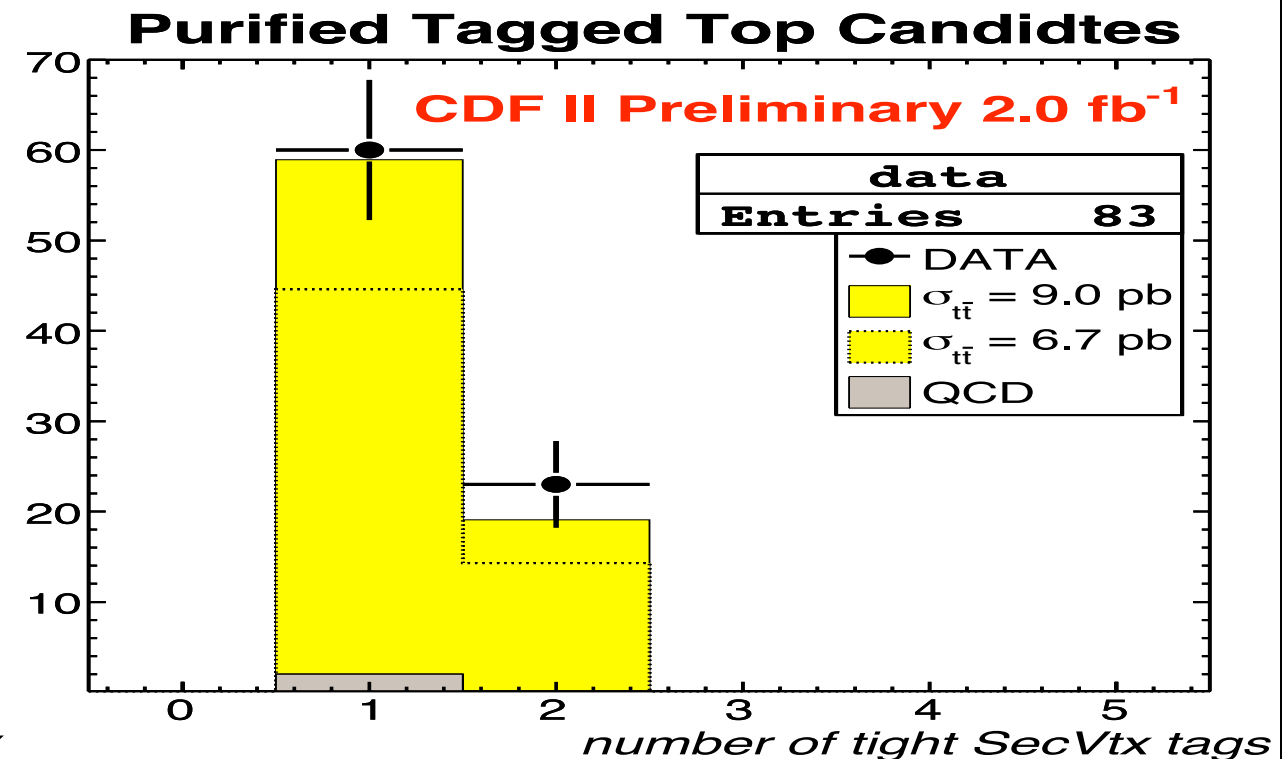
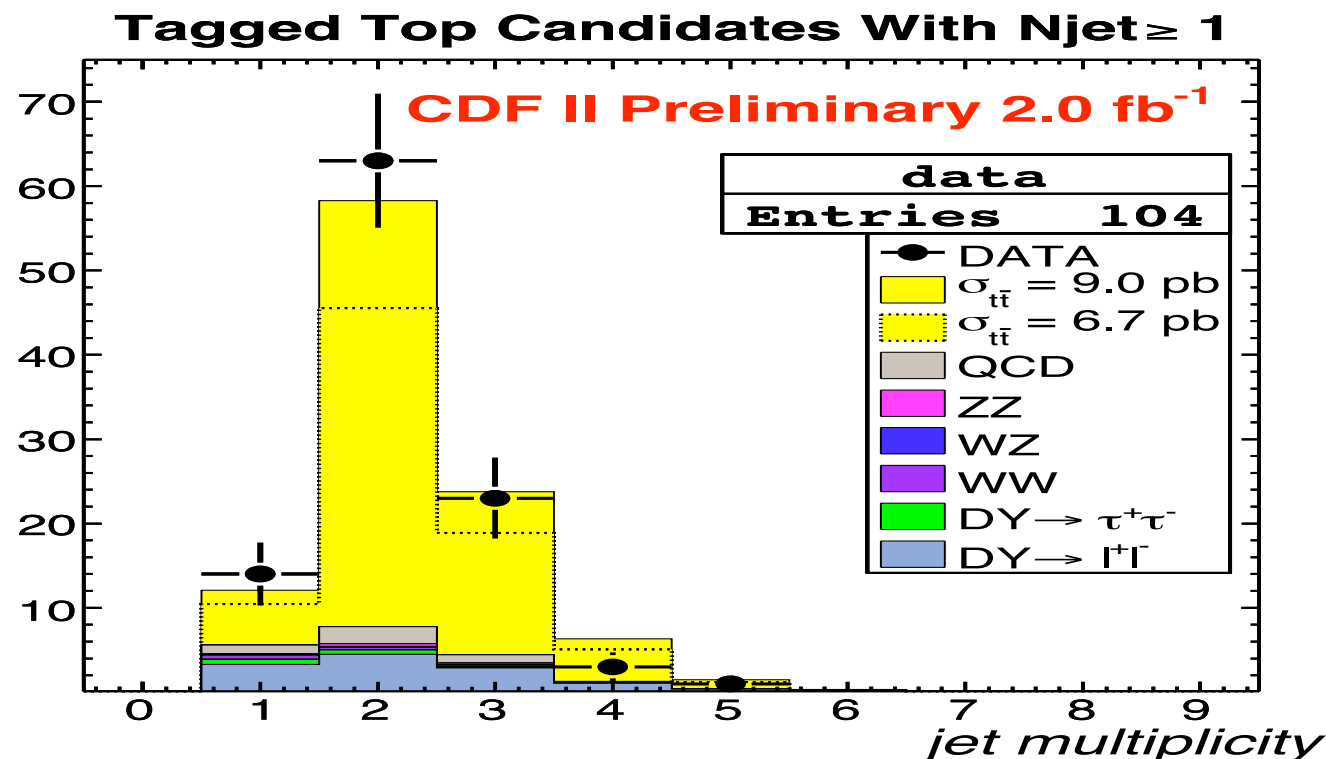
- Characteristics
  - pure sample (S:B=3:1)
  - small Branching ratio
  - two neutrinos
- Selection
  - two high  $p_T$  isolated leptons
  - $\geq 2$  jets
  - missing  $p_T$
  - Z rejection in  $ee/\mu\mu$  channels
- Backgrounds :  $Z+jets, WW/ZW/ZZ+jets$



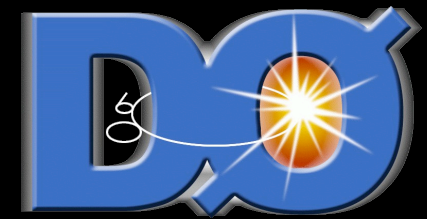
# Cross Section in Dileptons



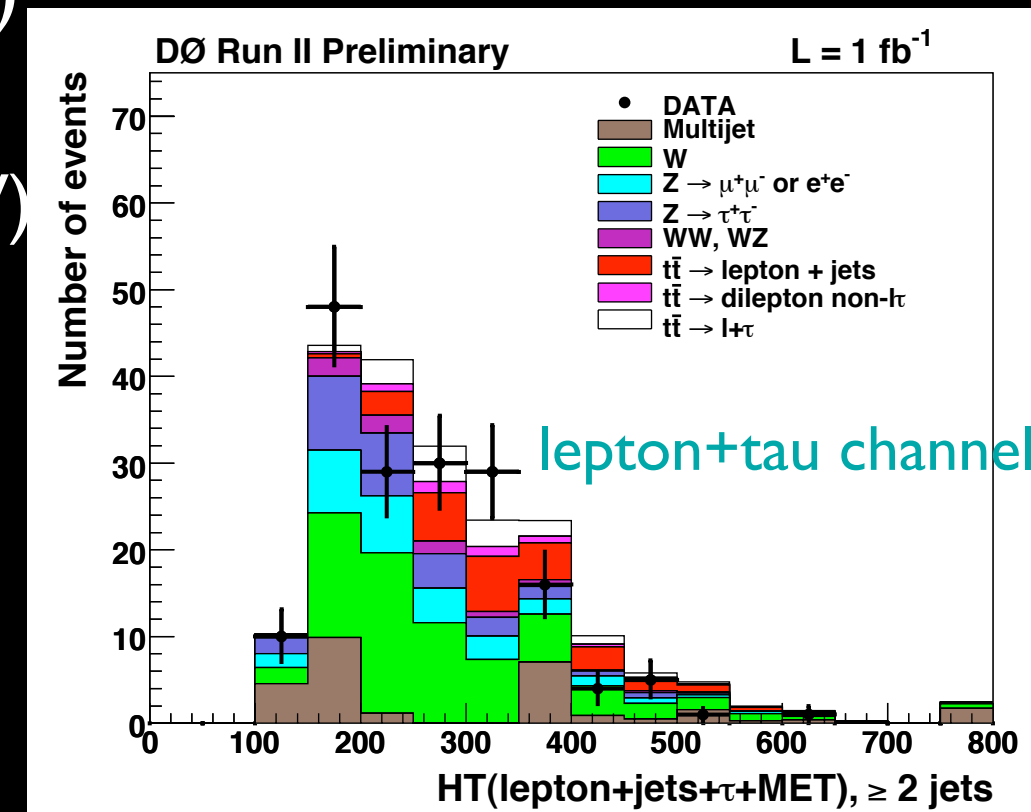
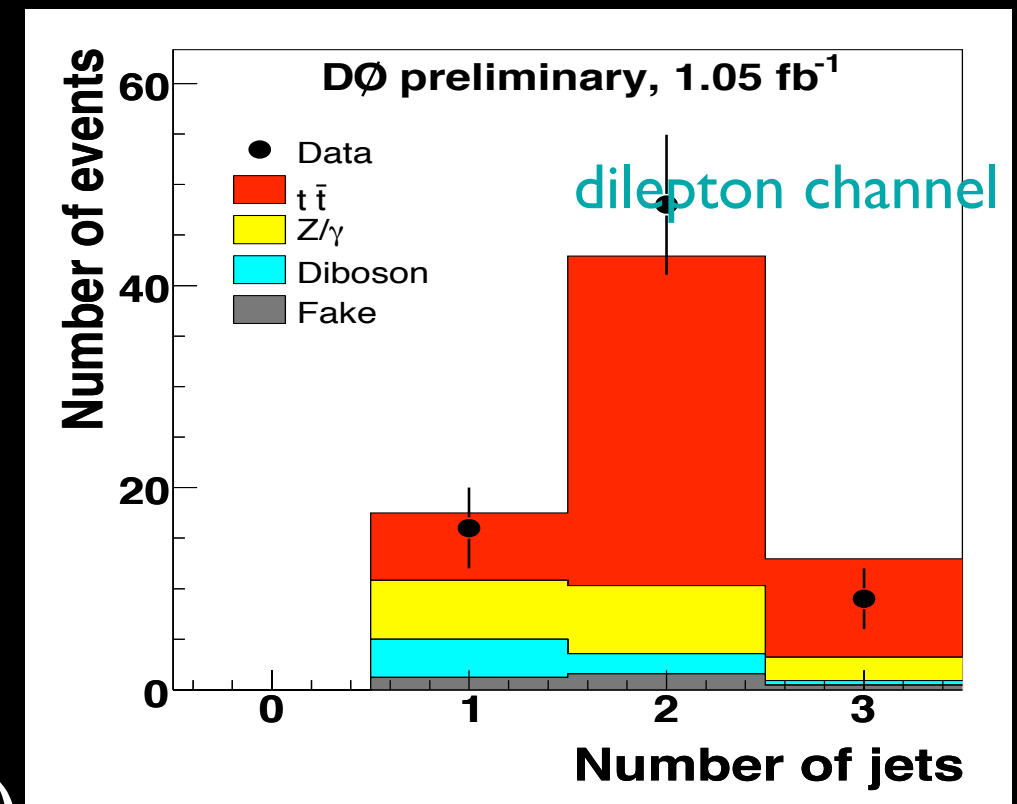
- $b\text{-tag} \geq 1$  (SecVtx tagger)
- background estimated by applying tag rate matrix to pretagged Drell-Yan and diboson sample
- main systematics : Jet energy scale, Drell-Yan tagged contribution, fake lepton background
- $\sigma = 9.0 \pm 1.1(\text{stat.}) \pm 0.7(\text{sys.}) \pm 0.5(\text{lumi}) \text{ pb } (2 \text{ fb}^{-1}) (M_{\text{top}} = 175 \text{ GeV})$  **16%**



# Cross Section in Dileptons

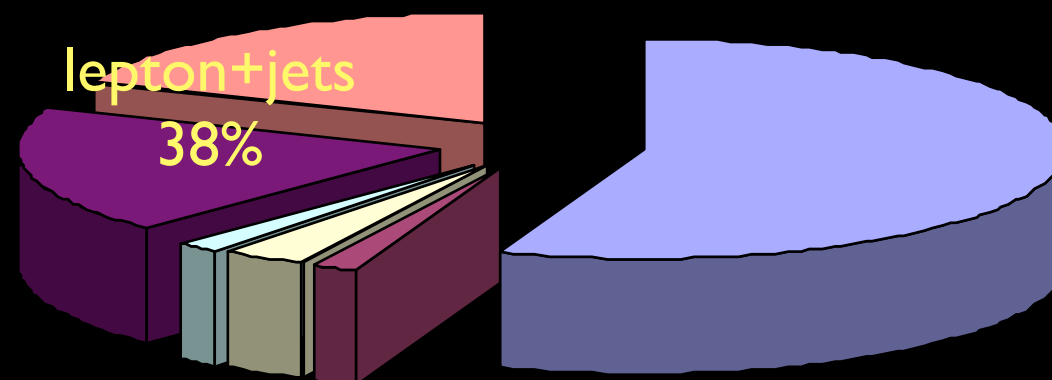


- $ee/\mu\mu$ : using kinematical information
- $e/\mu + \text{track}$  : one isolated lepton+one isolated track with 1 b-tagging
- $e/\mu + \tau$  : using Neural Network and one or more b-tagging (important for higgs search)
- combined :  $ee/\mu\mu + e/\mu + \text{track}$  ( $M_{\text{top}} = 175 \text{ GeV}$ )  
 $\sigma = 6.2 \pm 0.9(\text{stat.}) \pm 0.7(\text{sys}) \pm 0.5(\text{lumi}) \text{ pb}$   
(20%)
- combined :  $e\tau + \mu\tau$  ( $M_{\text{top}} = 175 \text{ GeV}$ )  
 $\sigma = 8.3 \pm 1.9(\text{stat.}) \pm 1.3(\text{sys.}) \pm 0.5(\text{lumi}) \text{ pb}$   
(28%)



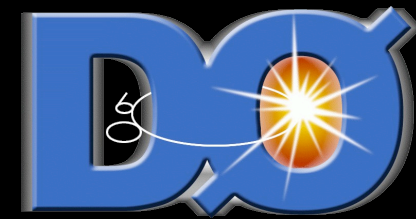
# Lepton+jets Cross sections

- Characteristics
  - large branching fraction
  - one neutrino
  - S:B=1:2 , 2:1 (btag)
- Selection
  - one isolated high  $p_T$  lepton
  - missing  $p_T$
  - 3 or more jets
  - (at least one b-tag)
- Backgrounds
  - W+jets
  - Multijets





# Cross Section in Lepton+Jets



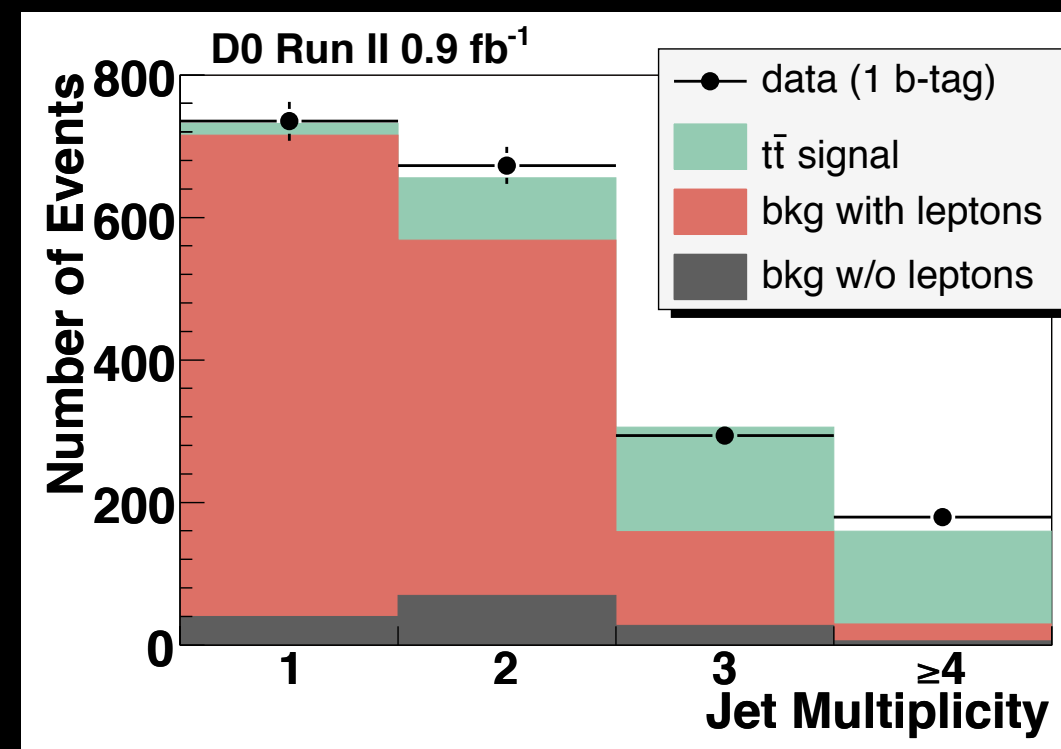
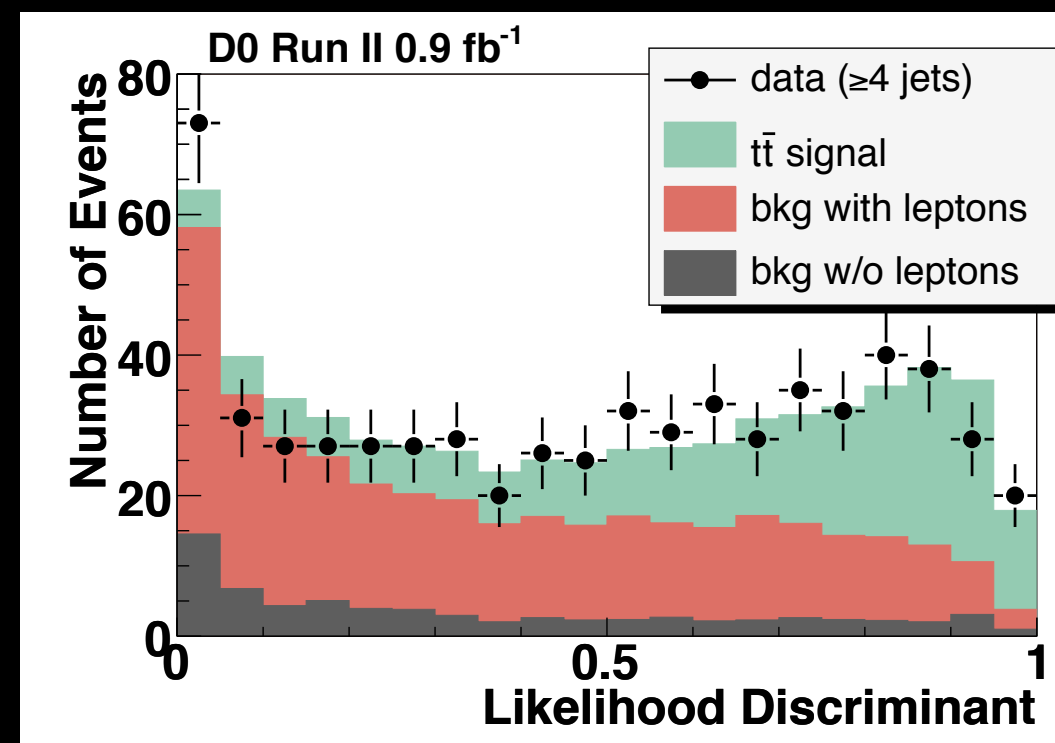
- simultaneous maximum likelihood fit of 4 channels (3/4 jets, e/μ)
- main systematics: lepton ID, template statistics

$$\sigma = 6.6 \pm 0.8(\text{stat}) \pm 0.4(\text{sys}) \pm 0.4(\text{lumi}) \text{ pb} \quad (15\%)$$

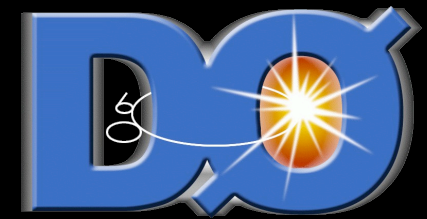
- B-tagging (NN tagger) of 8 channels (3/4 jets, e/μ, 1/2 tags)

- main systematics: b-tagging, JES, W hf fraction

$$\sigma = 8.1 \pm 0.5(\text{stat.}) \pm 0.7(\text{sys.}) \pm 0.5(\text{lumi}) \text{ pb} \quad (12\%)$$



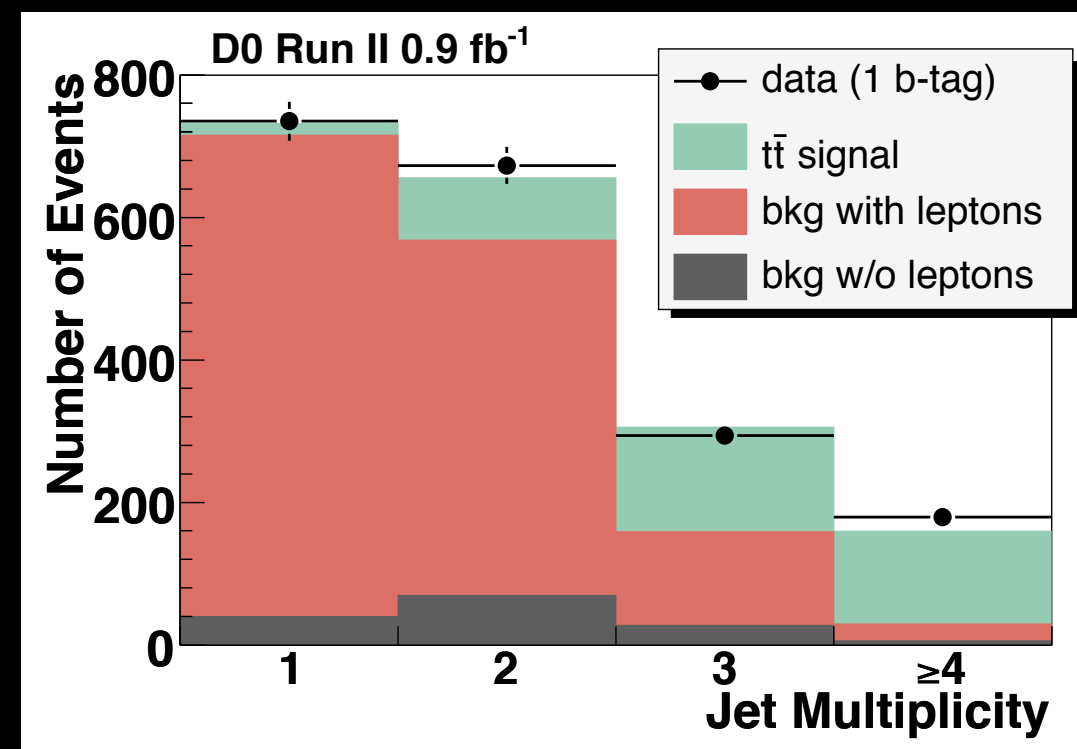
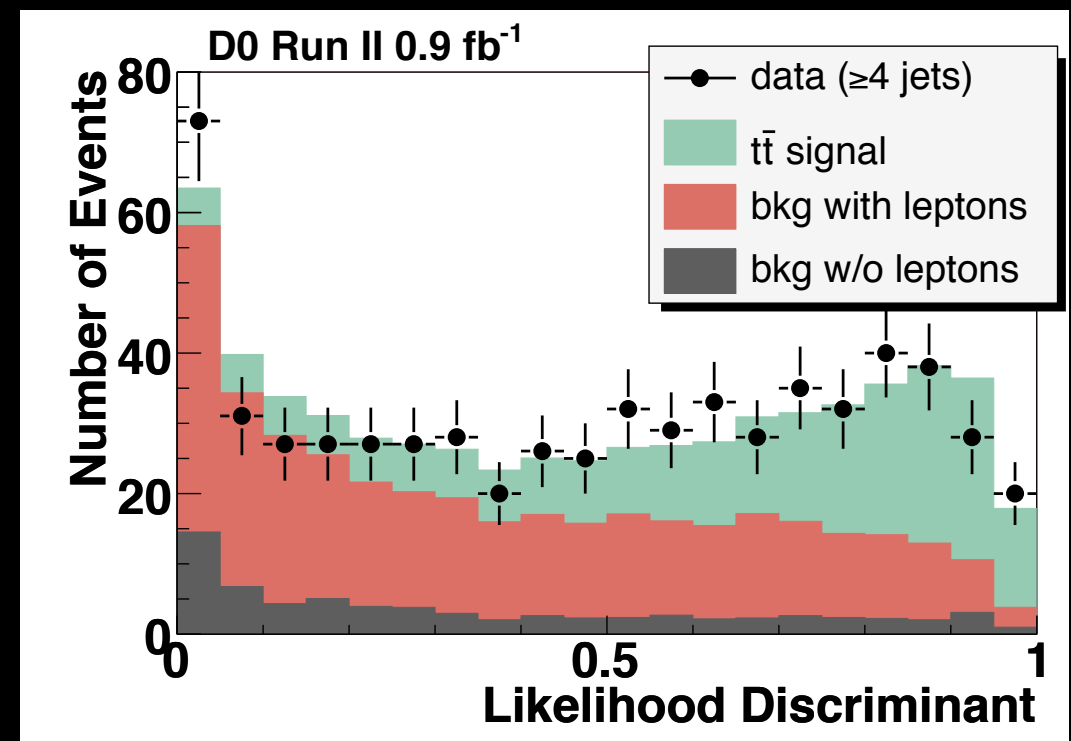
# Cross Section in Lepton+Jets



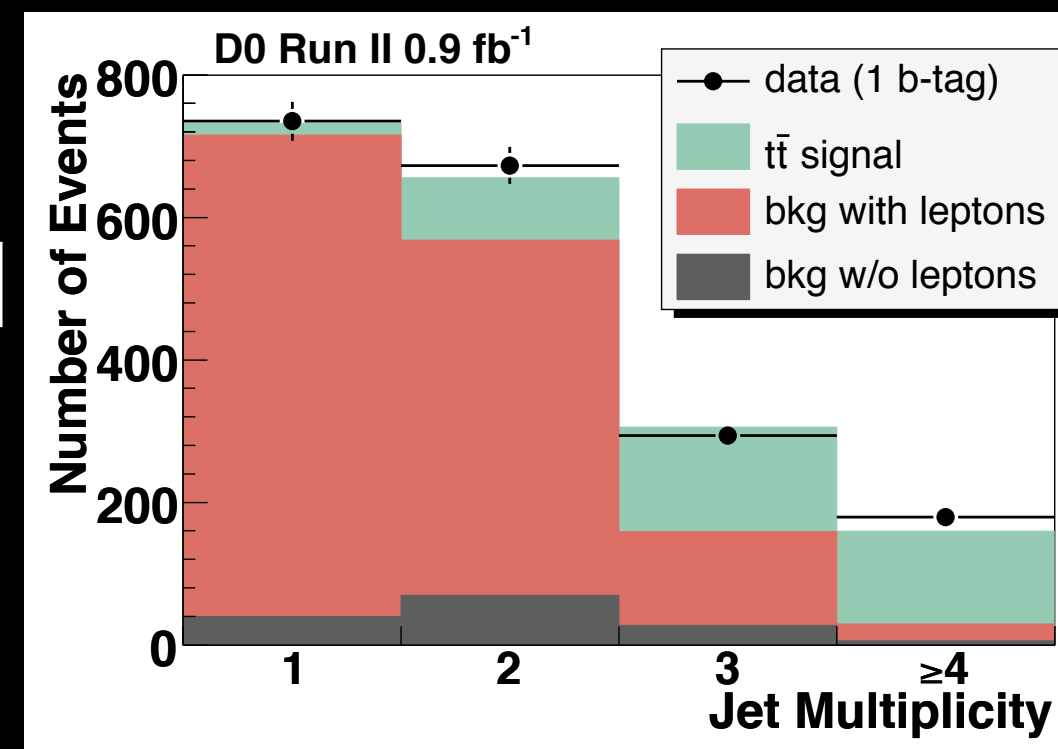
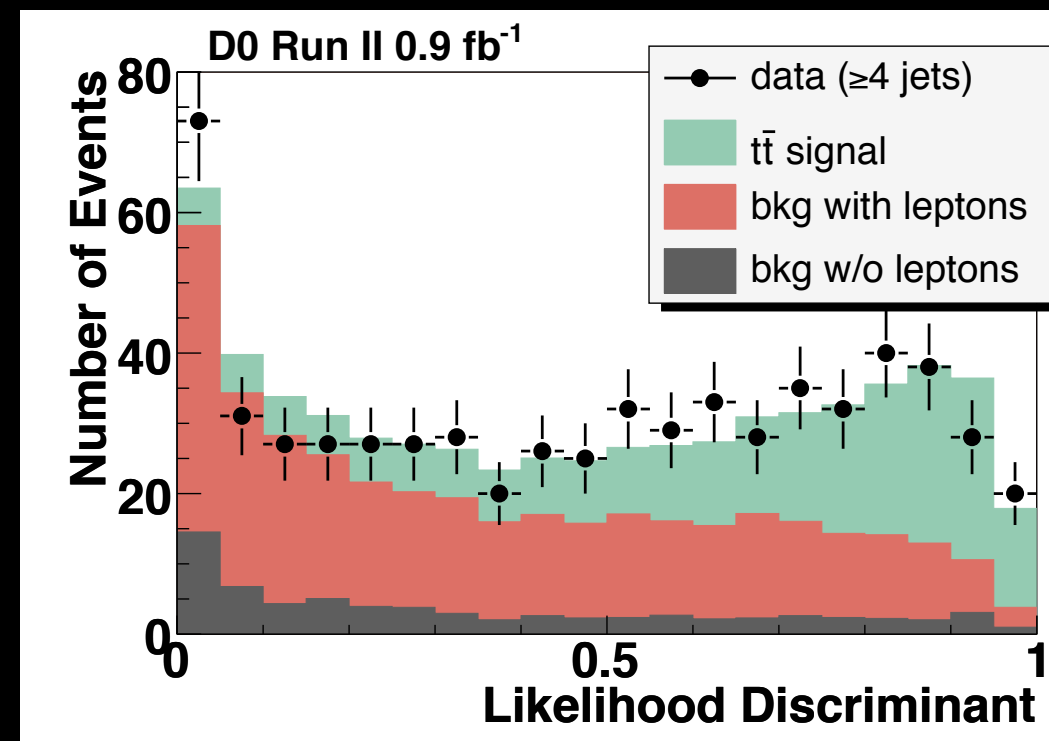
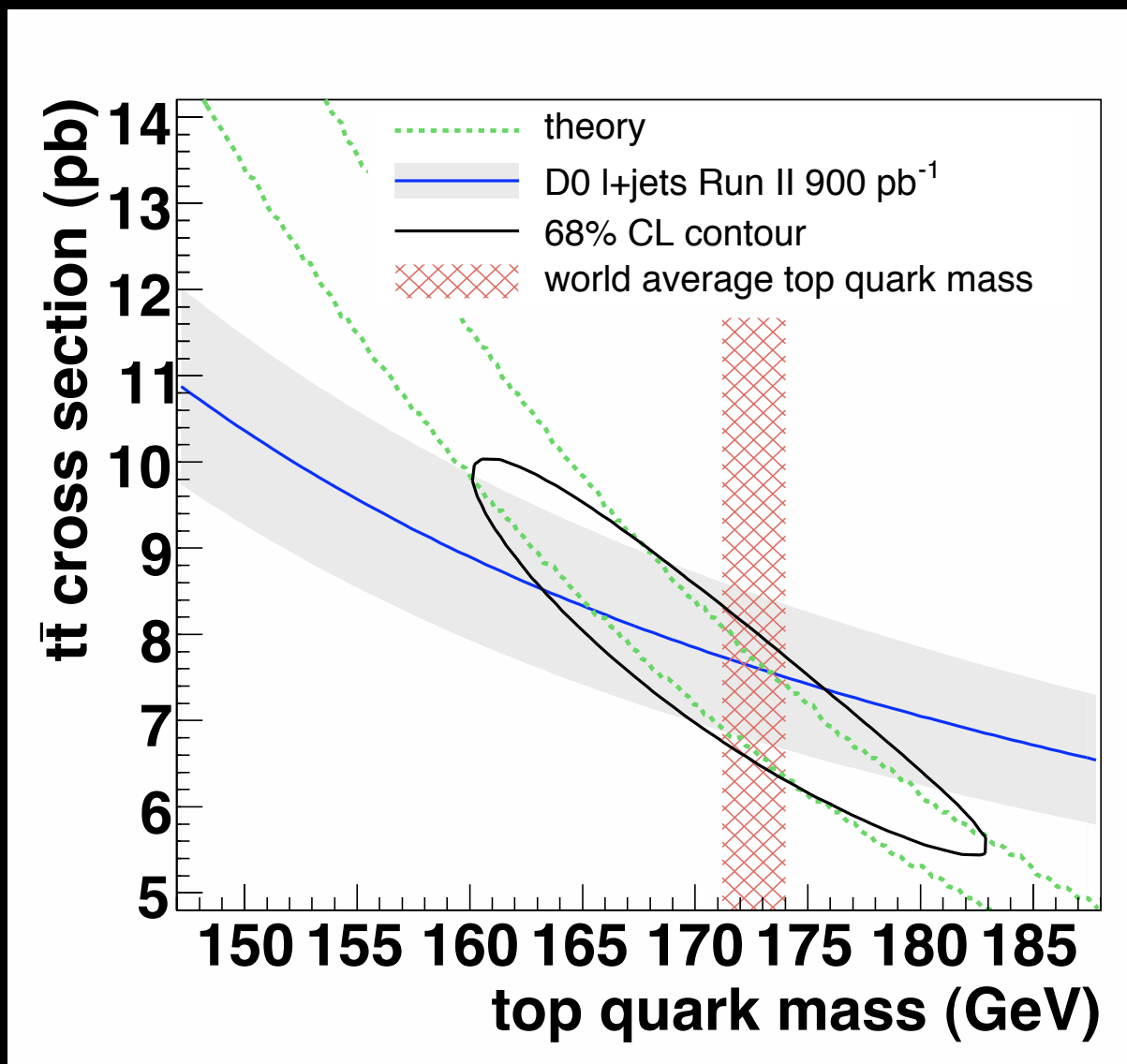
Combined: ( $M_{\text{top}} = 175 \text{ GeV}$ )  
 $7.42 \pm 0.52(\text{stat.}) \pm 0.46(\text{sys.}) \pm 0.45(\text{lumi}) \text{ pb}$   
(11%)

most precise measurement

PRL submitted

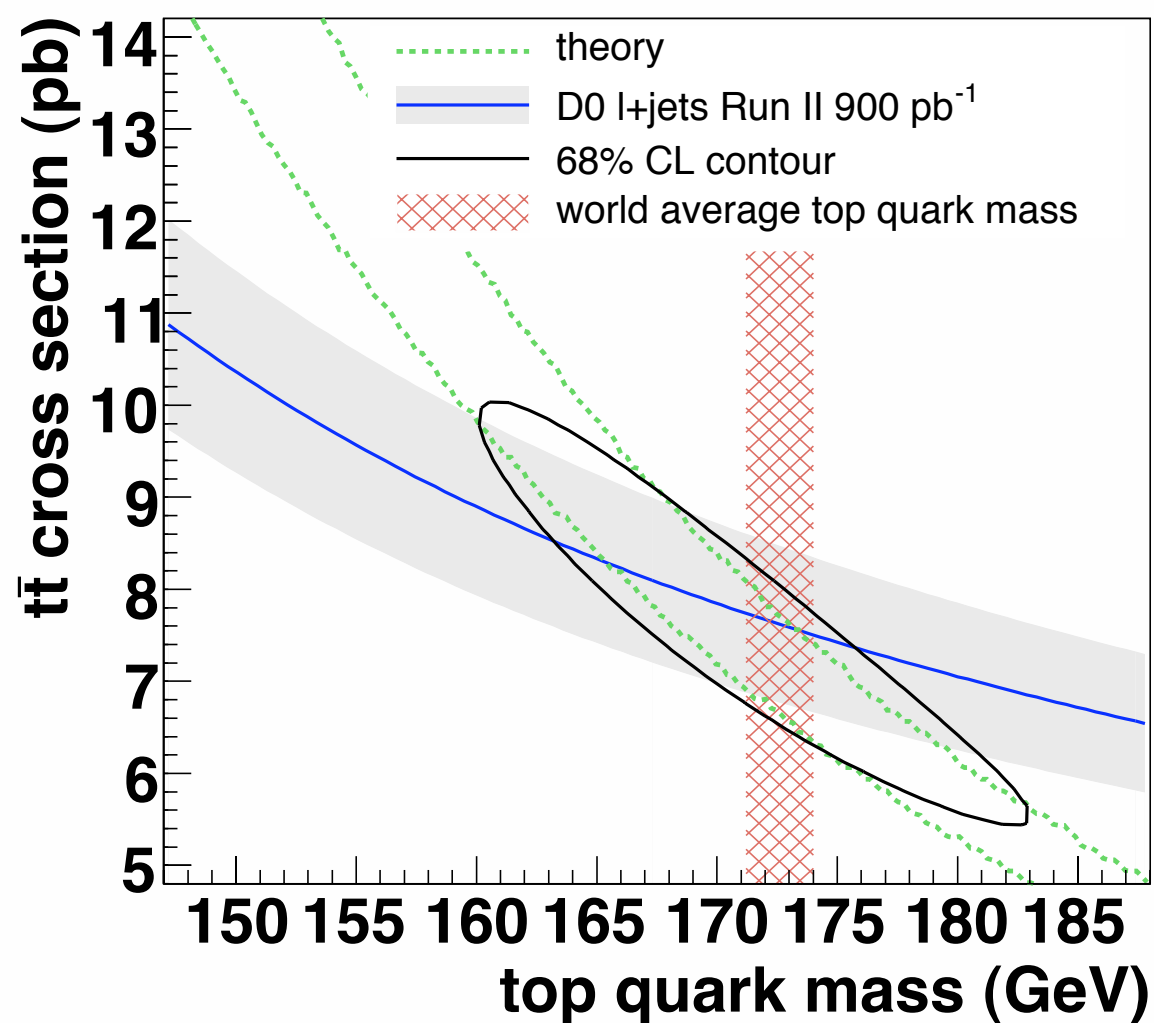


# Cross Section in Lepton+Jets



- Top mass measurement:  
 $M_{\text{top}} = 170 \pm 7 \text{ GeV @68\%CL}$   
 (  $172.6 \pm 1.4 \text{ GeV World Average}$  )

# Top Mass from Cross Section in Lepton+Jets



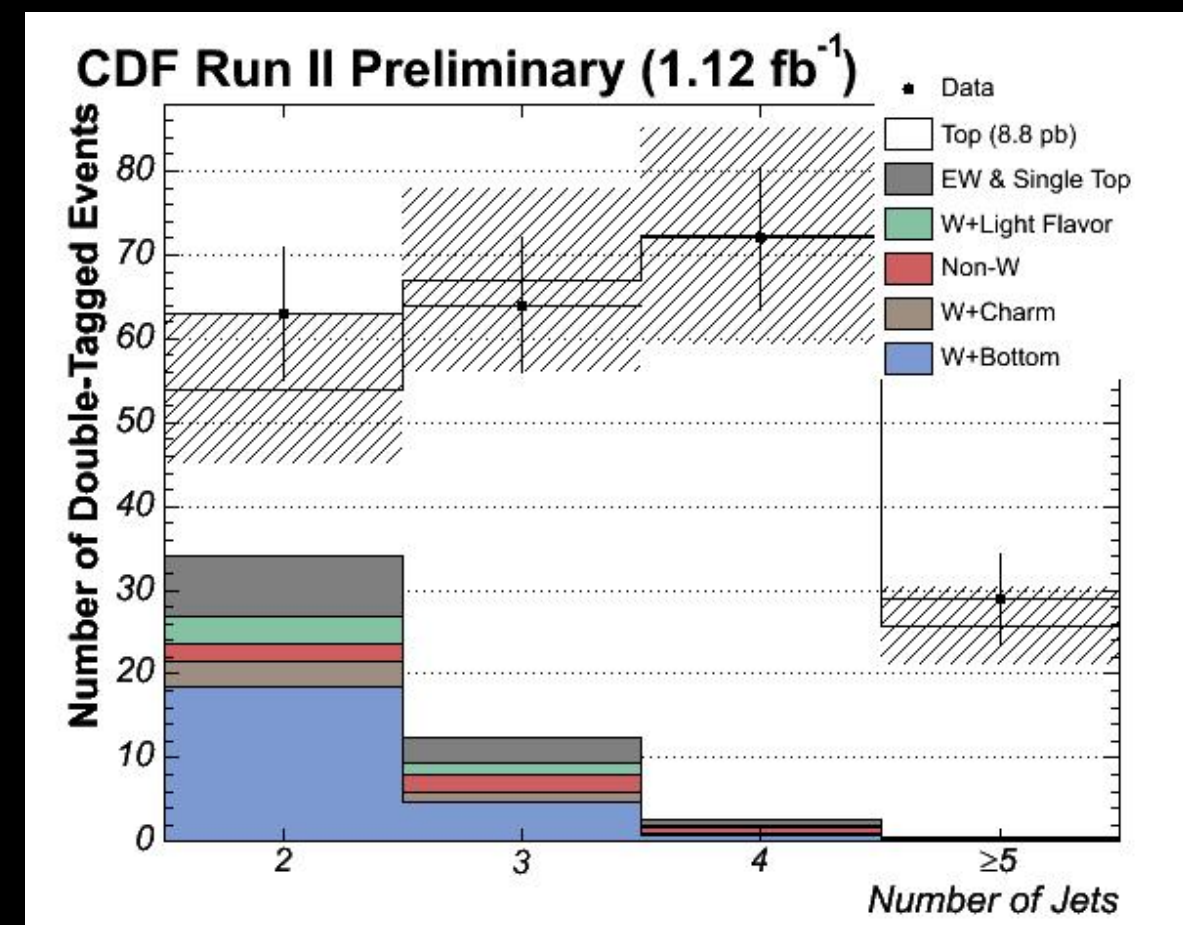
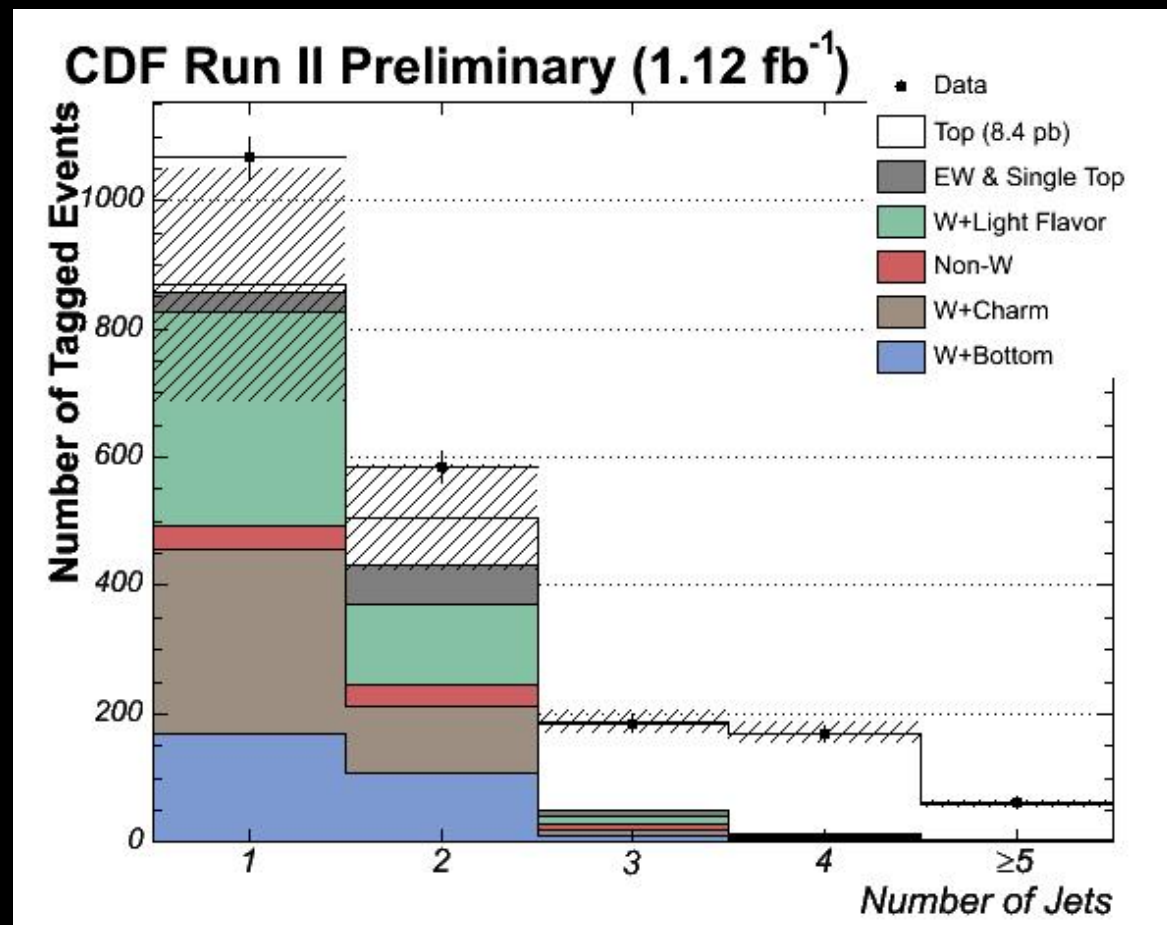
- Top mass measurement:  
 $M_{\text{top}} = 170 \pm 7 \text{ GeV @68\%CL}$   
(  $172.6 \pm 1.4 \text{ GeV}$  World Average)

- Using measured combined cross section + theory expectation with uncertainties:  
scales( factorization +renormalization) and PDFs  
via likelihood functions  
convolutions
- Theory from :
  - Cacciari et al. JHEP 0404:068
  - Kidonakis et al. PRD 68 114014

complementary measurement  
from normal top mass analysis

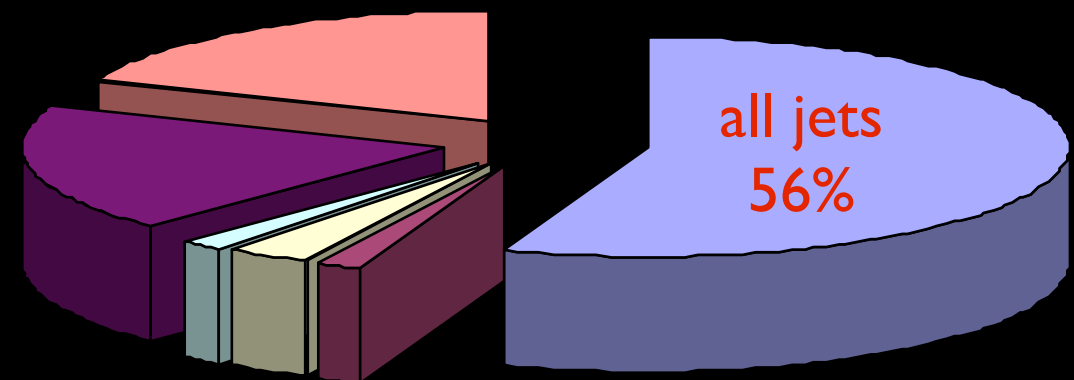
# Cross Section in Lepton+Jets

- B-tagging (SecVtx tagger) (jets  $\geq 3$ , e/ $\mu$ )
  - $\geq 1\text{tag}$ 
    - $\sigma = 8.2 \pm 0.5(\text{stat}) \pm 0.8(\text{sys}) \pm 0.5(\text{lumi}) \text{ pb}$  (13%)
  - $\geq 2\text{tag}$ 
    - $\sigma = 8.8 \pm 0.8(\text{stat}) \pm 1.2(\text{sys}) \pm 0.5(\text{lumi}) \text{ pb}$  (17%)



# Alljets Cross sections

- Characteristics
  - large branching fraction
  - no neutrino
  - S:B=1:16, 1:6(1 tag), 1:2(2tags)
- Selection
  - 6-8 well separated jets
  - no significant missing  $p_T$
  - at least one b-tag
  - Neural Network
- Backgrounds
  - Multijets
  - misidentified bjets

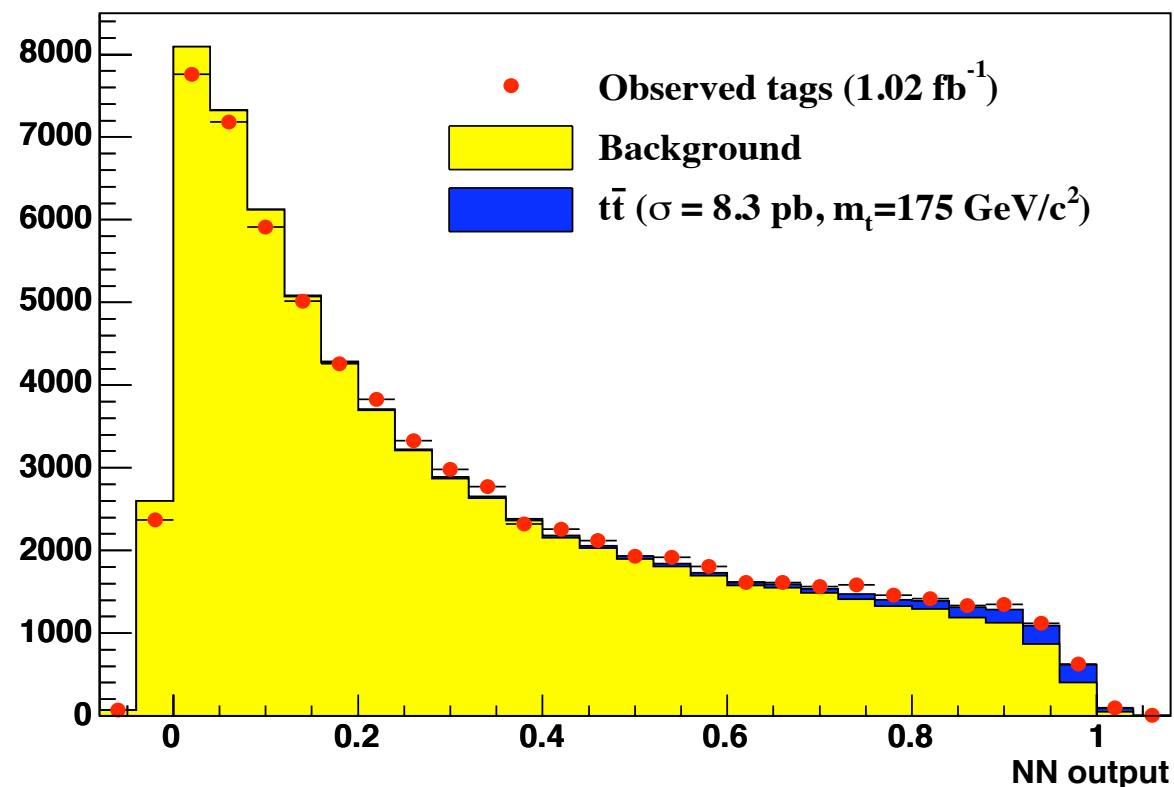




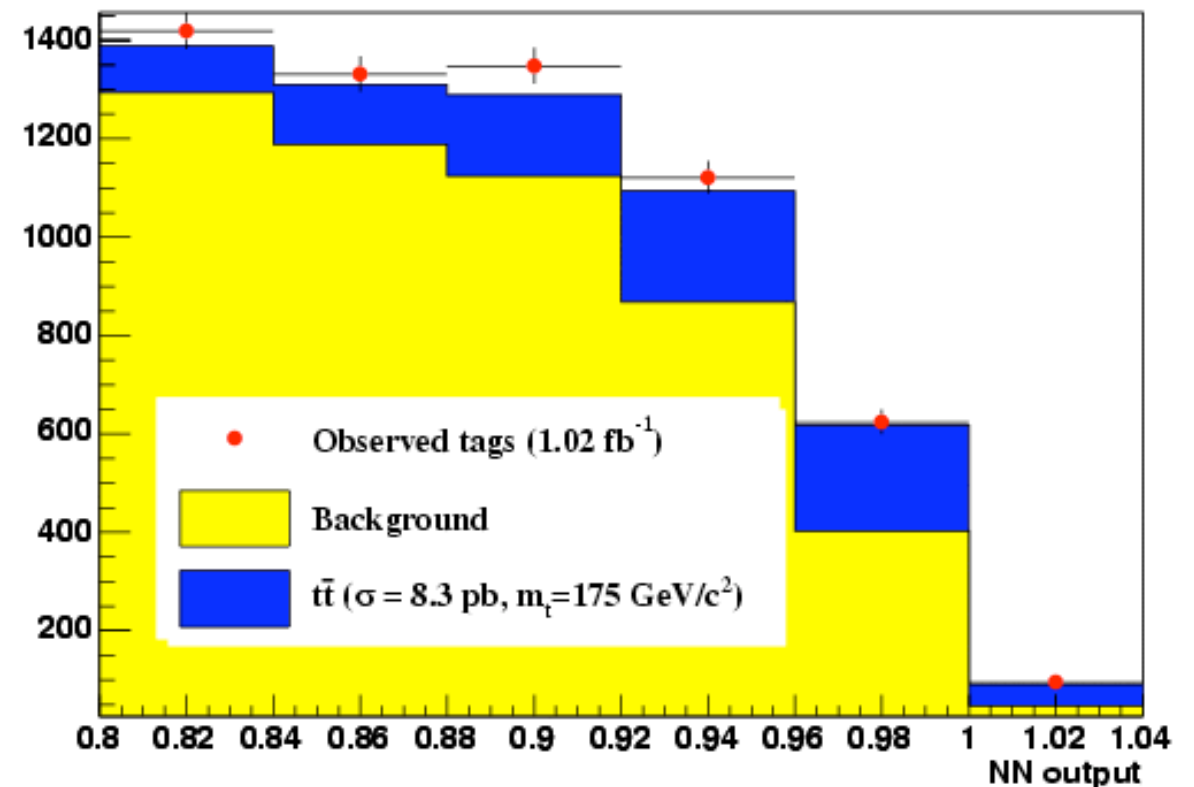
# Cross Section in Alljets

- NN with 11 kinematic variables  $\epsilon_{\text{NN}>0.94}=4.8\%$ , S:B=1:16
- Main systematics: jet energy scale
- $\sigma=8.3\pm 1.0(\text{stat})^{+2.0}_{-1.5}(\text{sys})\pm 0.5(\text{lumi})$  pb ( $\geq 1$  tag) (30%)

CDF Run II Preliminary

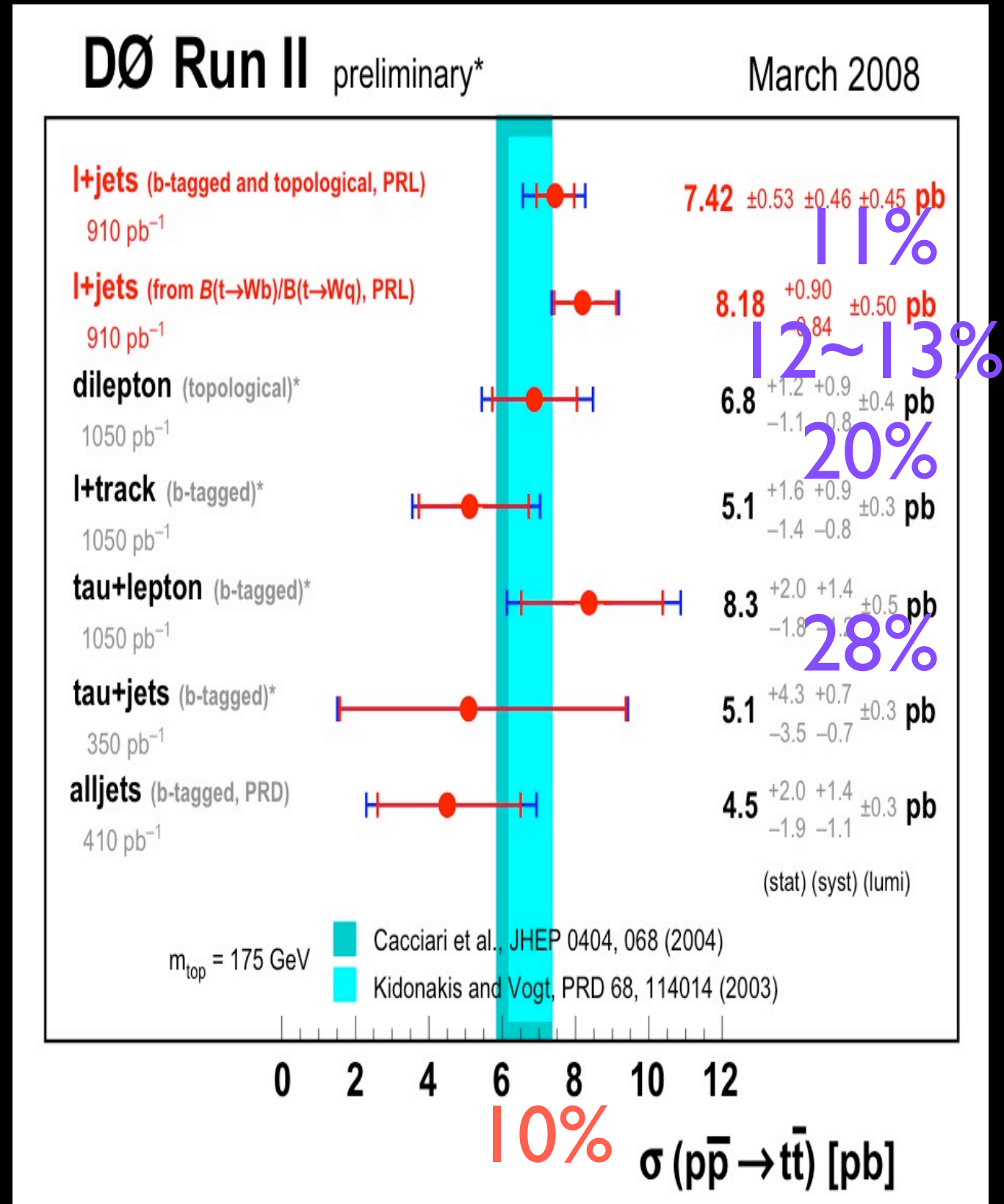
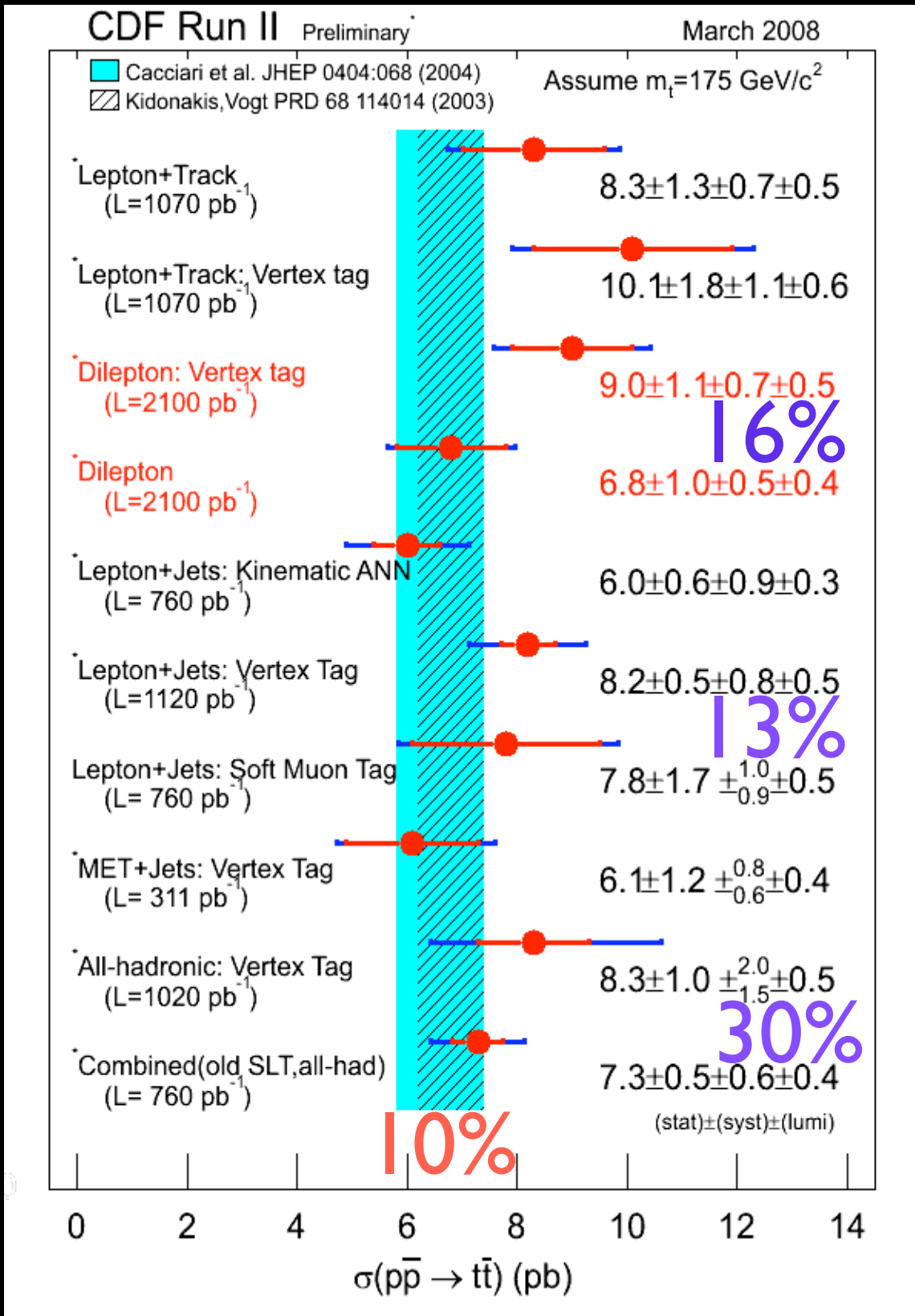


CDF Run II Preliminary

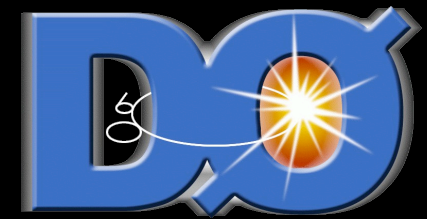


PRD D76 (072009) published

# Summary of cross sections







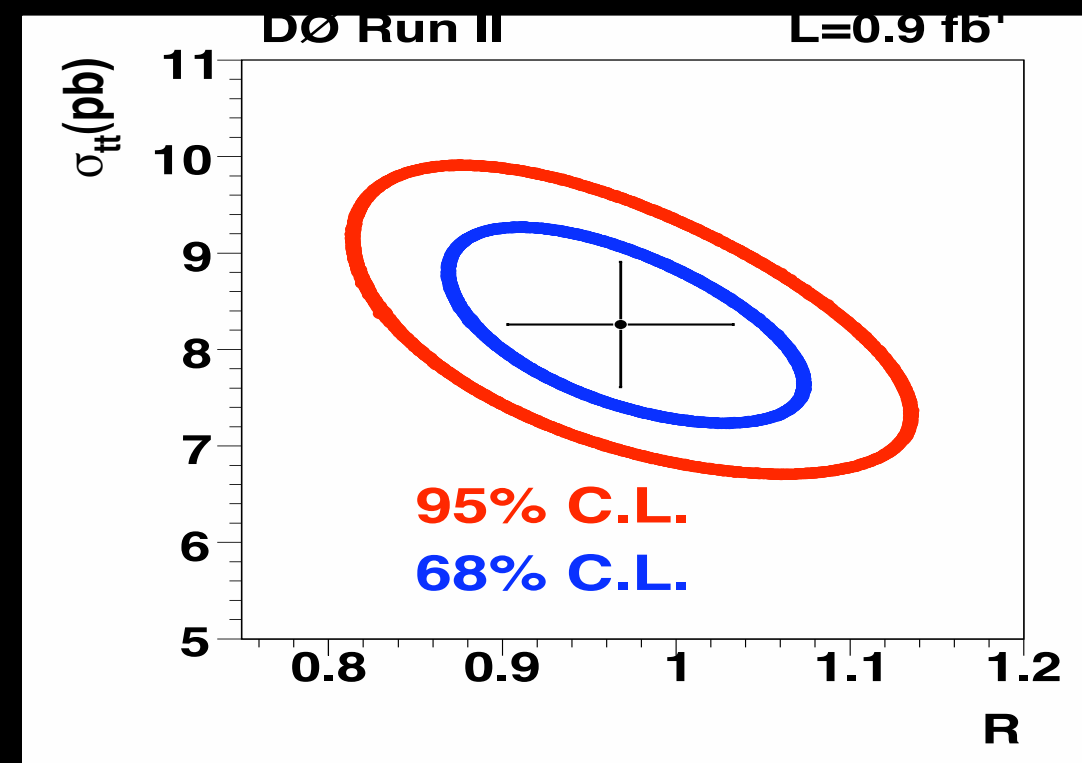
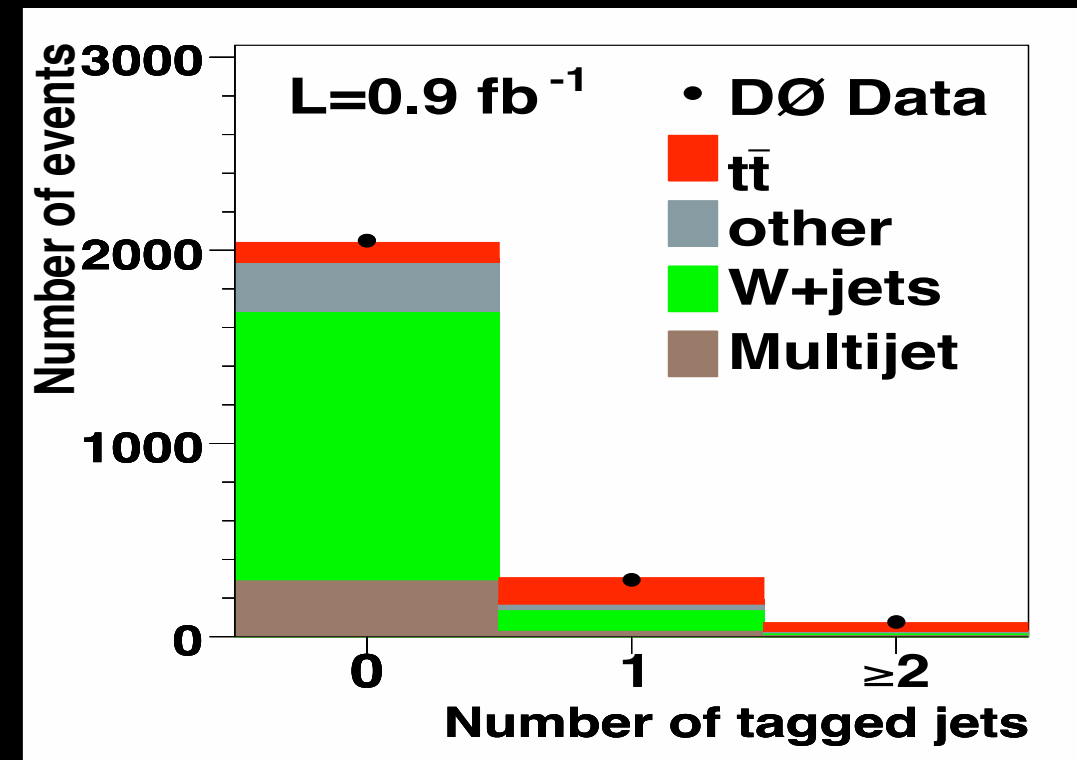
# Simultaneous measurements of the $B(t \rightarrow Wb)/B(t \rightarrow Wq)$ and Cross Section in Lepton+Jets

- Ratio of top branching ratios

$$R \equiv \frac{BR(t \rightarrow Wb)}{BR(t \rightarrow Wq)} = \frac{|V_{tb}|^2}{|V_{td}|^2 + |V_{ts}|^2 + |V_{tb}|^2}$$

- Measurement simultaneous with  $\sigma_{t\bar{t}}$  via tagging probability

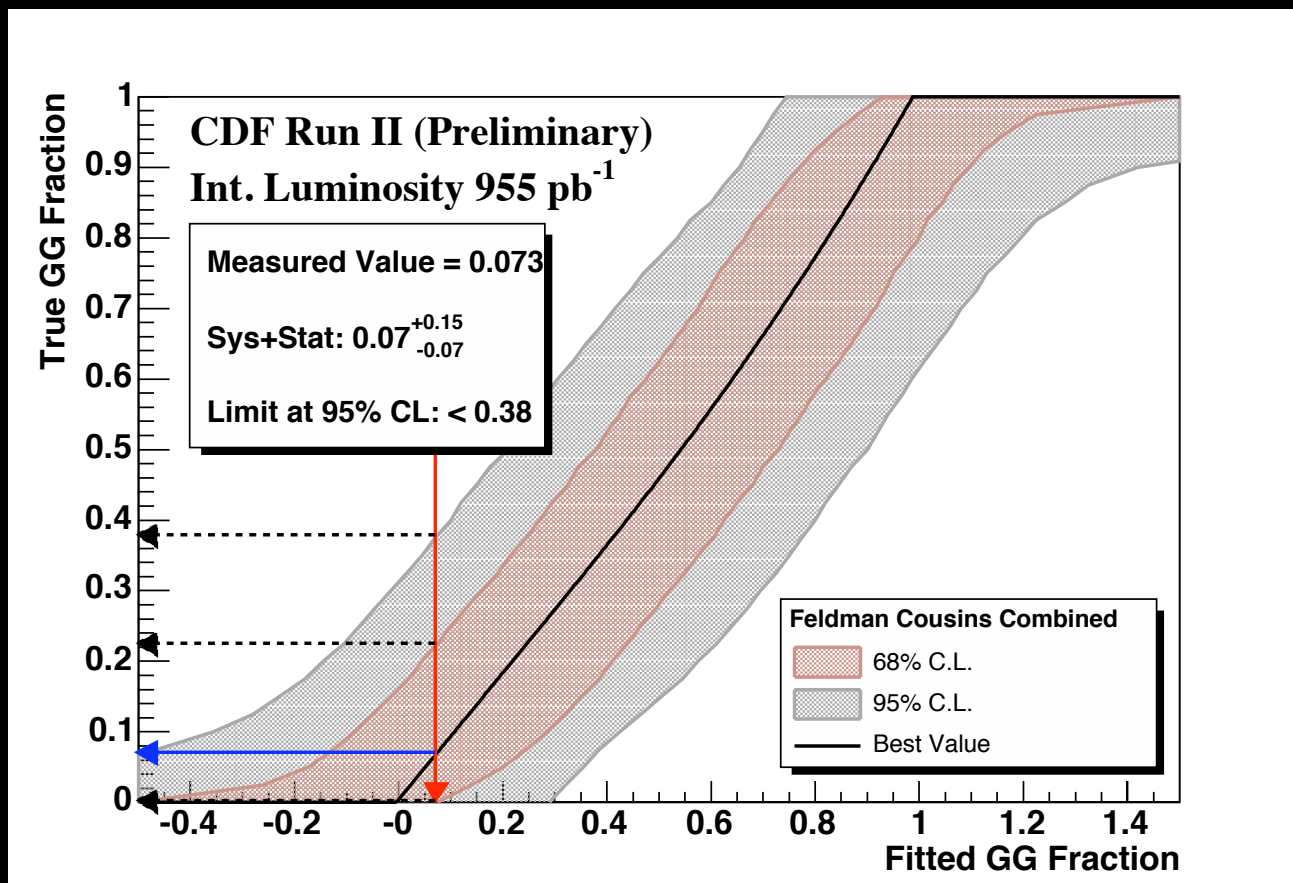
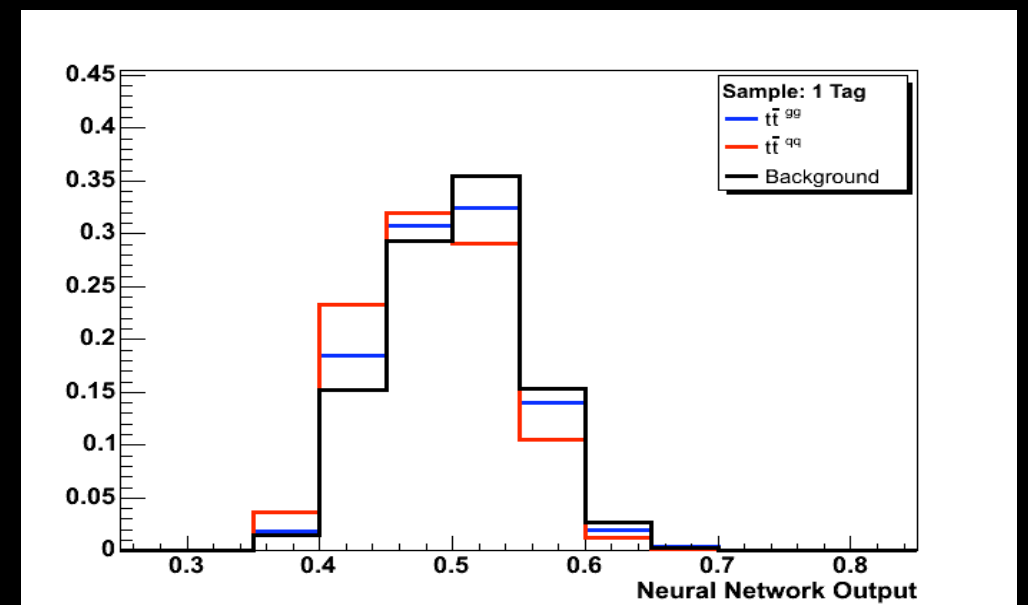
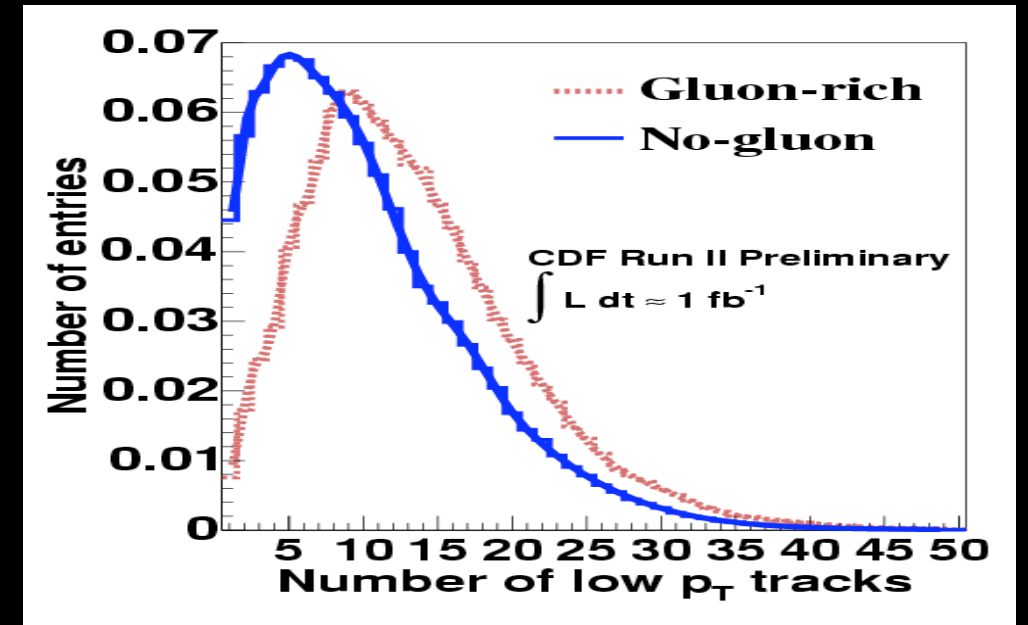
- $R = 0.97 \pm 0.09$  (stat+sys)
- $\sigma = 8.18^{+0.90}_{-0.84}$  (stat+sys)  $\pm 0.5$  pb  
**12~13%**
- $R > 0.79$  @95% C.L.
- $|V_{tb}| > 0.89$  @95% C.L.



PRL submitted

# Production Mechanism

- Measurement of the relative fraction of gg fusion (vs. qq annihilation) combining two complementary methods
- Combinations :
  - 1) using low Pt tracks: using shapes of gg (15%) and qq (85%) component derived from inclusive dijets samples shapes fit to data
  - 2) NN from kinematics: kinematic variables of gg and qq contributions to train NN



$$\frac{\sigma(gg \rightarrow t\bar{t})}{\sigma(pp \rightarrow t\bar{t})} = 0.07^{+0.15}_{-0.07} @ 68\% \text{ C.L.}$$

$$< 0.38 @ 95\% \text{ C.L.}$$

# Summary

- Entered era of precision measurements
- A lot of top physics have been analyzed using  $1 \text{ fb}^{-1} \sim 2 \text{ fb}^{-1}$  data (out of  $3 \text{ fb}^{-1}$ )
- The techniques of analysis have been improved to reduce systematics
- Top physics provide very important tests of the consistency of the Standard Model top quark parameters as well as tests of theoretical QCD calculations