Top Quark Cross Sections

Frédéric Déliot

CEA-Saclay

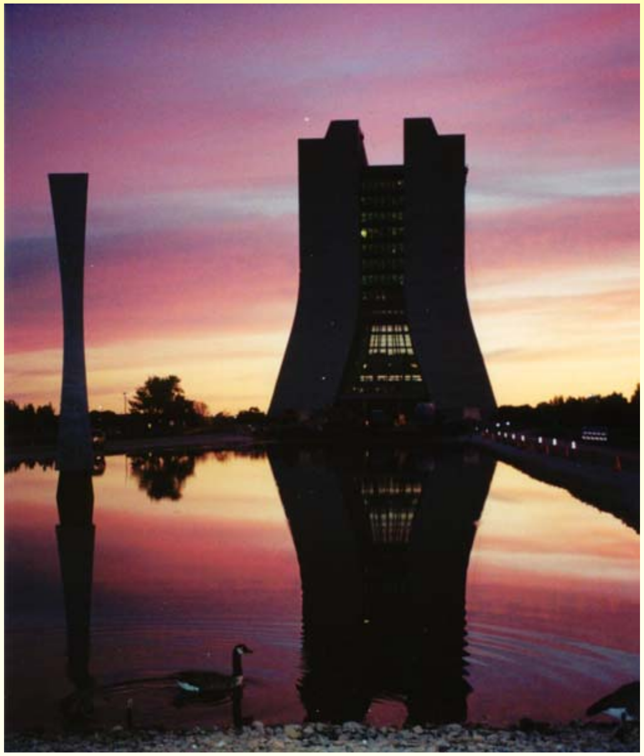
On behalf of the CDF and D0 Collaborations

XXVIII Physics In Collision

Perugia, 26 June 2008

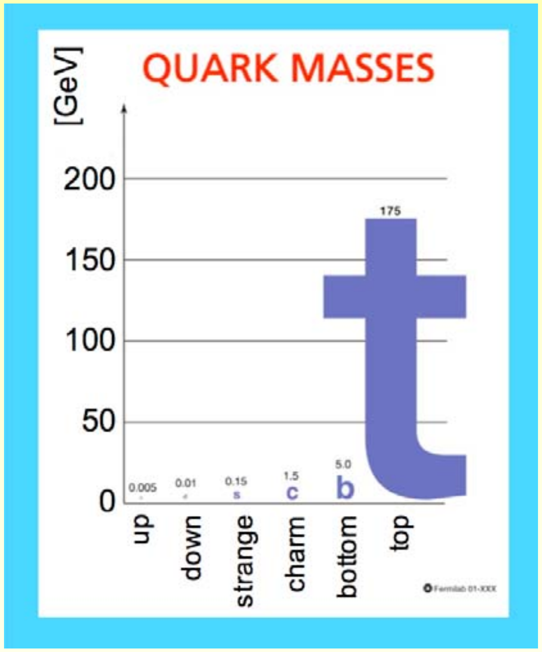
Outline

- Introduction
- The Tevatron, the CDF and D0 Detectors
- Top Production at Hadron Colliders
- Pair Production Cross Section
  - $\rightarrow$ $t\bar{t}$ Decay Channels
  - $\rightarrow$ Results
- Single Top Cross Section
  - $\rightarrow$ Search Strategy
  - $\rightarrow$ Results
- Conclusion and Perspectives



What Make The Top Quark So Special ?

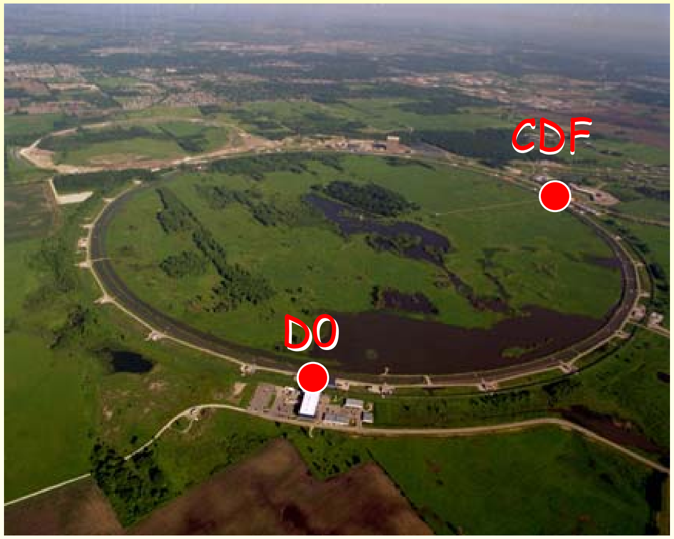
- That's the « youngest » quark of the Standard Model
  - → discovered in 1995 during the Run I of Tevatron
  - → many of its properties need to be studied in detail
- That's the heaviest elementary particle
  - → ~ 40 times heavier than its weak isospin partner, the b quark
  - → Yukawa Coupling to the Higgs ~ 1
  - → Large contribution in virtual fermionic loops
  - → Only quark to decay before hadronizing: « nude » quark
  - → Does it play a special role ?



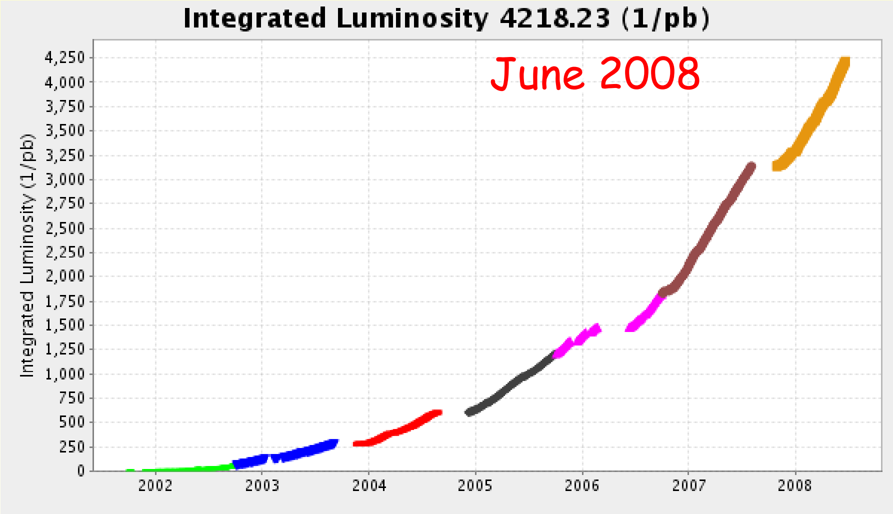
- The top quark physics is a rich, still developing field
  - → The top quark is currently only directly produced at Tevatron

The Tevatron

- $p\bar{p}$ collider at $\sqrt{s}$ = 1.96 TeV
  - → 36x36 bunches, bunch crossing every 396 ns
  - → 2 experiments : CDF and D0
- Data taking periods:
  - → Run I (1993-1996): $\mathcal{L}_{delivered}$ ~ 120 pb^{-1} / experiment
  - → Run IIa (2002 - March 2006): $\mathcal{L}_{delivered}$ ~ 1.5 fb^{-1}
  - → Run IIb (August 2006 – 2009/2010): $\mathcal{L}_{delivered}$ ~ 6 to 8 fb^{-1}

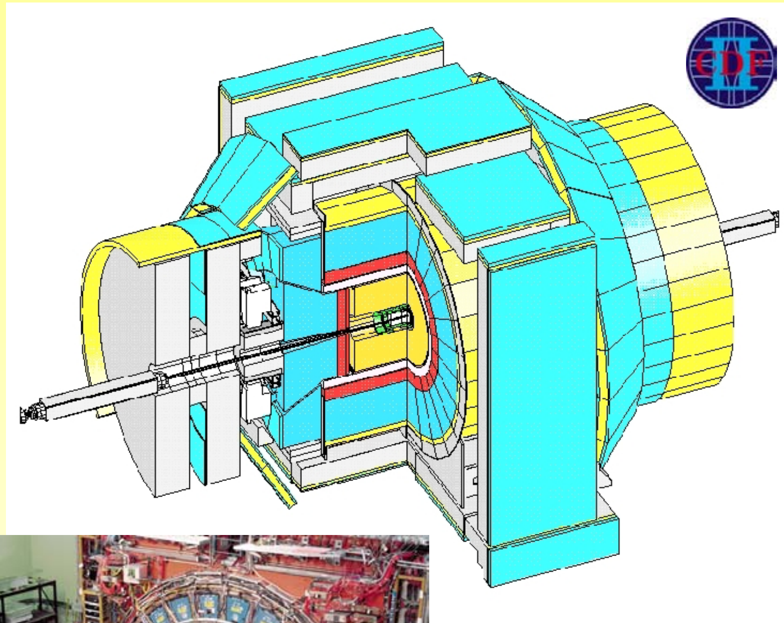


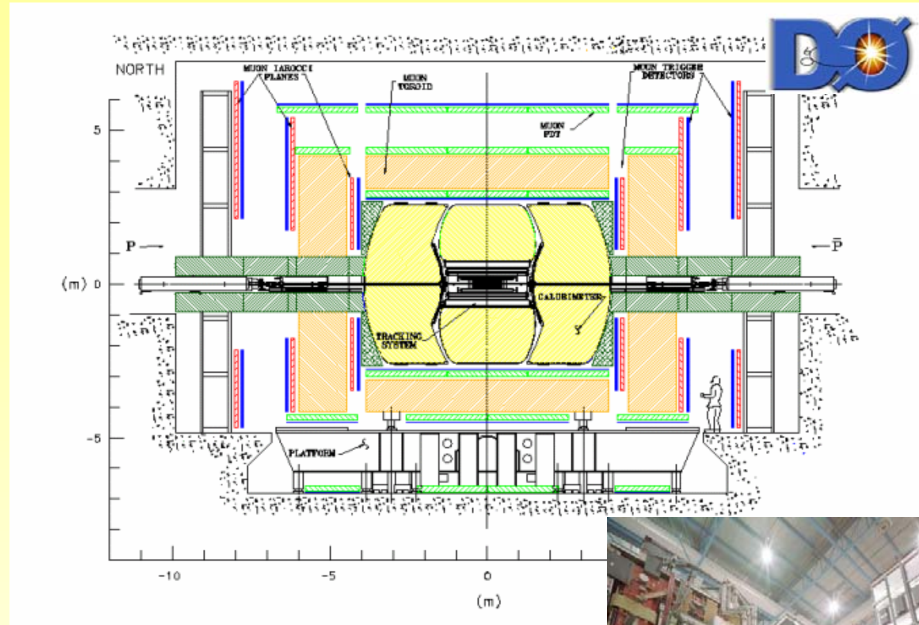
Typical data taking efficiency: > 85%

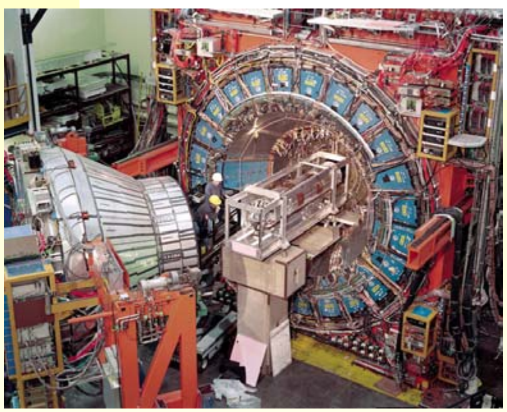


In this talk:
results with 0.8 $fb^{-1} \leq \mathcal{L}_{recorded} \leq$ 2.2fb^{-1}

The RunII CDF and D0 Detectors







- Top physics utilizes every subdetector:

→ tracking (vertexing, momemtum measurement, b tagging)

→ calorimetry (jets, electron, missing transverse energy)

→ muon detection

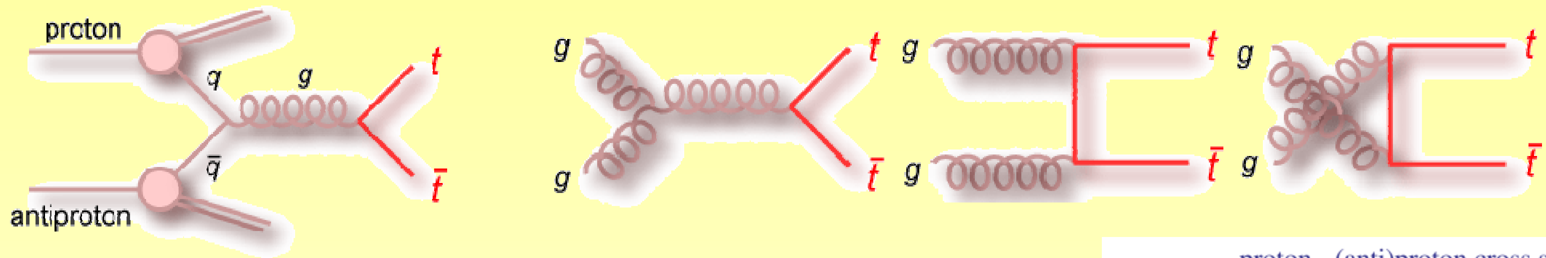
Pair Production

$t\bar{t}$ Cross Section

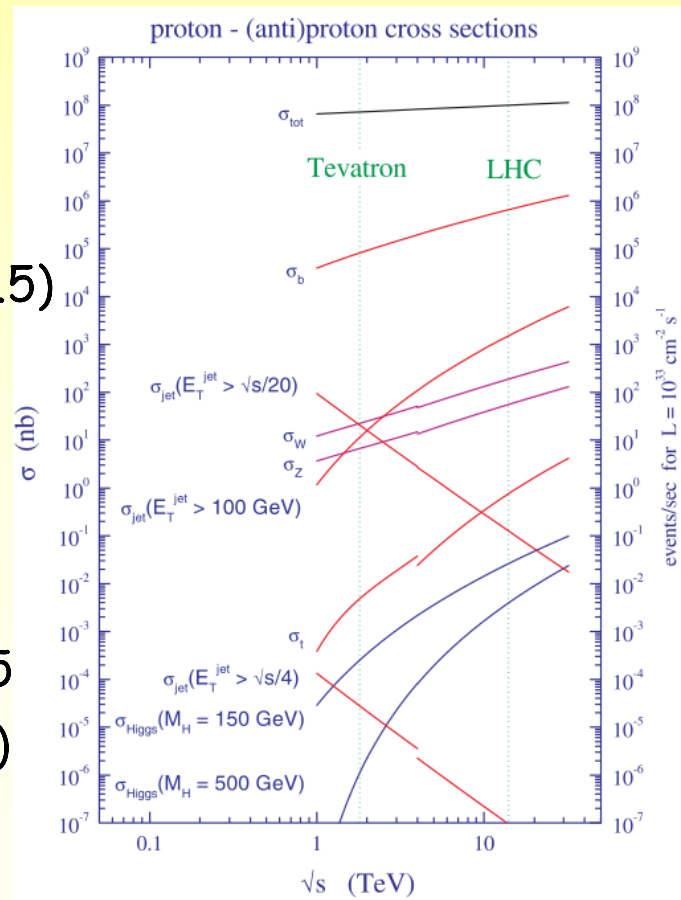
Top Quark Pair Production

- Strong Interaction Production Mode:

Pair ($t\bar{t}$) production: dominant at hadron collider



Tevatron :	85%	15%
LHC:	13%	87%



→ Theoretical prediction: M_{top} = 175 GeV (CTEQ6.5)

Cacciari et al. arXiv/08042800, NLO+NLL

Tevatron: σ = 6.73 pb $\pm$ ~ 10 %

LHC: σ = 908 pb $\pm$ ~ 10 %

→ Typically :

Tevatron : for 1 fb^{-1} , σxBrxA = 7600x0.3x0.15

~ 300 evts (lepton +jets)

LHC : same number of events with 10 pb^{-1}

Why Do We Want to Measure the $t\bar{t}$ Cross Section ?

- $\sigma(t\bar{t})$ is an inclusive quantity that allows:

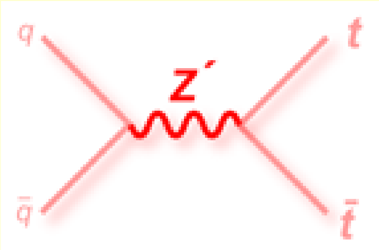
→ test the SM :

compare the experimental measurement with the QCD NLO prediction

→ extract the top quark mass comparing theory with measurement

→ probe new physics :

- anomalous $t\bar{t}$ production rate
- compare cross-sections in different top decay channels



→ background for Higgs and new phenomena searches

How Do We Measure the ($t\bar{t}$) Cross Section ?

Event counting or fit of discriminating variable shape

Number of expected background events

Using Monte Carlo or data

$$\sigma_{t\bar{t}}(M_t) = \frac{\overbrace{N_{observed} - N_{background}}}{\varepsilon_{t\bar{t}}(M_t)L}$$

Signal selection efficiency

using $t\bar{t}$ Monte Carlo samples

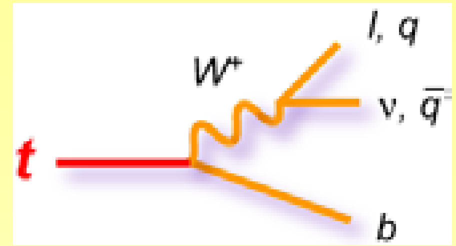
Pythia or Alpgen

Recorded luminosity

Channel dependent

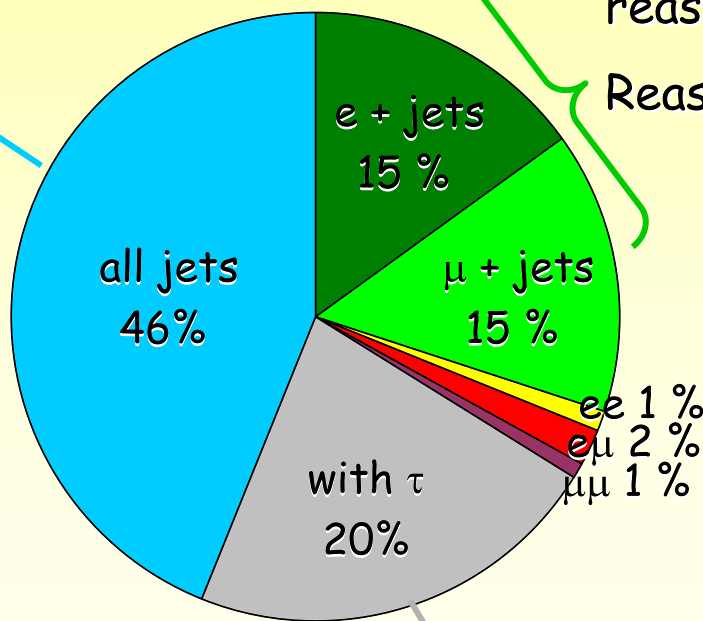
$t\bar{t}$ Production Final States

- Top Decay in the Standard Model:
  BR($t \to Wb$) ~ 100 %
- Final State driven by the W decay modes



large statistics

large bkg: multijets



reasonable statistics

Reasonable bkg: W/Z +jets, multijets

low statistics

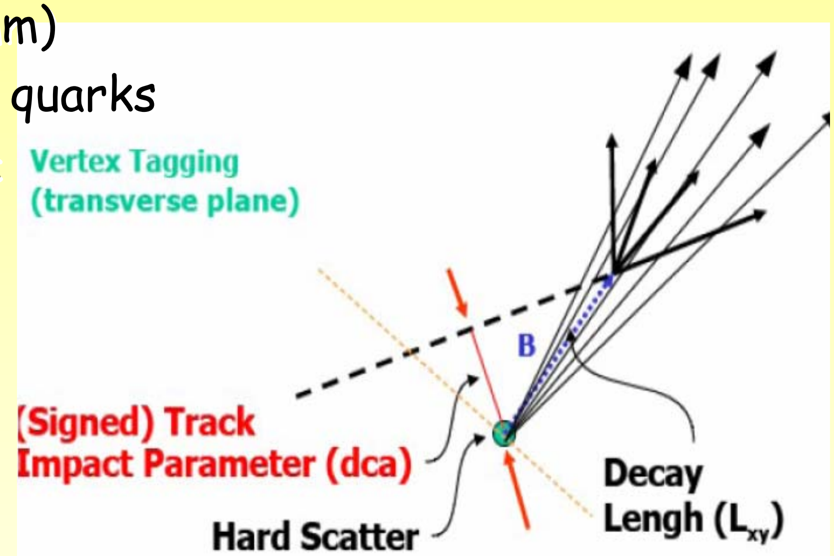
low bkg:

Z+jets, Diboson +jets, Z(ττ)+jets

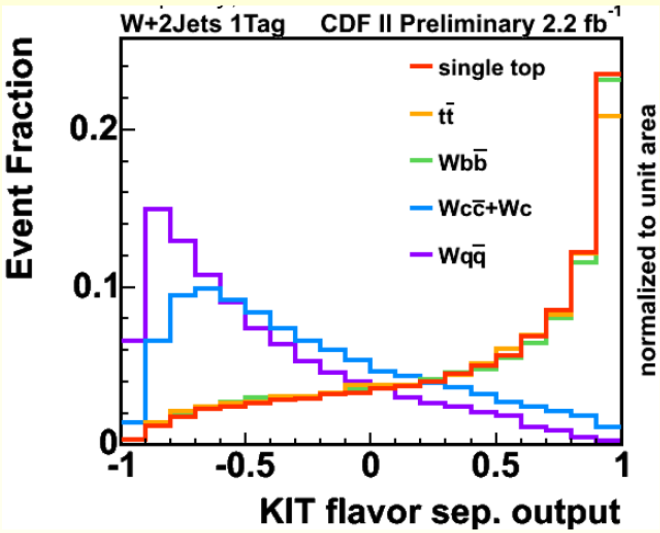
Challenging to identify

b Jet Tagging

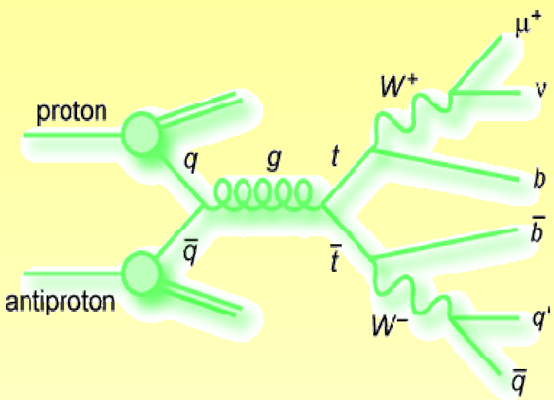
- utilize b-jets special properties to separate them from light/gluon jets: (reduce multijet and W+jets bkg)
  - → long b-hadrons decay length ($c\tau$~0.5mm)
  - → high b quark mass compared the light quarks
  - → b-hadrons semileptonic decay: $b \rightarrow \mu\nu c$



- 3 main b-tagging algorithms:
  1) impact parameter based
  2) secondary vertex reconstruction
  3) soft lepton tag
- D0: 1 & 2 combined into a neural network (NN):
  - → $\varepsilon \approx$ 55% for fake rate ~1%
- CDF: 2 & NN jet separator



Lepton + jets Channel

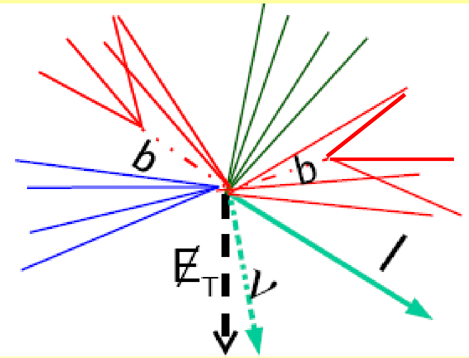


• Signature:

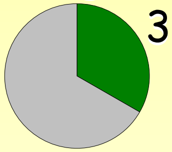
High Pt isolated lepton

High $\not{E}_T$

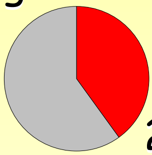
4 jets (2 b jets)



Branching ratio



Signal/Bkg (4jets)



2:3 w/o btag

4:1 w/ btag

• 2 analysis strategy:

→ topological: likelihood using kinematic variables

(aplanarity, sphericity, H_T, angles, invariant masses, …)

→ b-tagging

•Background:

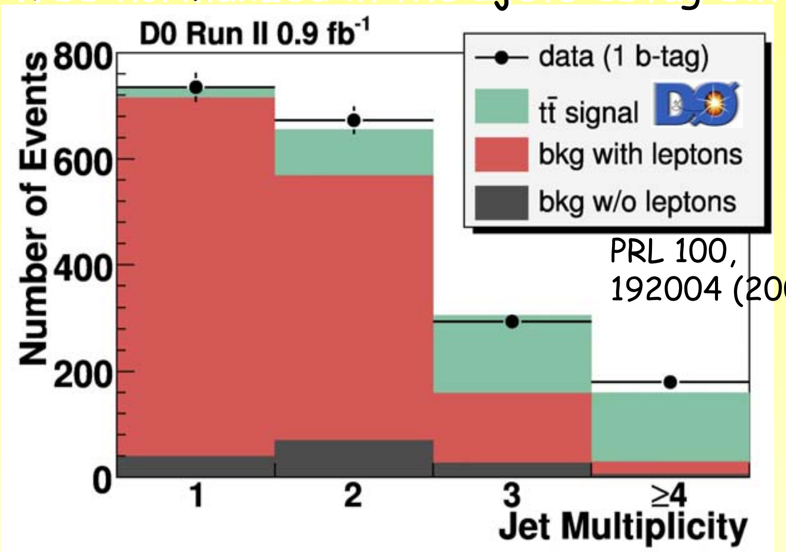
→ W + jets : MC, normalized to data (before b-tagging)

→ non-W (multijets) : fake lepton, estimated from data

→ diboson, Z+jets, single top : MC

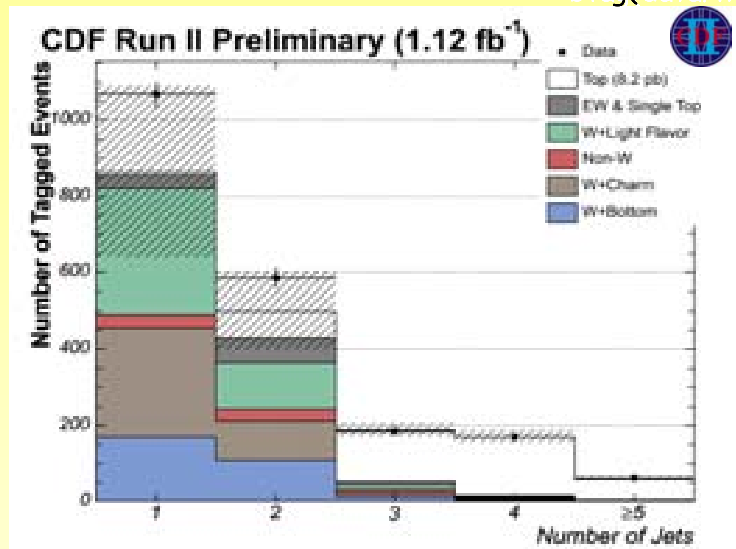
Lepton + jets With b-Tagging

Wbb normalized in the 2jets-1btag bin



PRL 100, 192004 (2008)

Wbb from MC corrected for $\varepsilon_{btag(data/MC)}$



8 channels: 2 lepton flavors
x 3 jets-4jets x 1btag-2btag

data: 596, expected bkg: 208 ± 10

$\sigma(t\bar{t})$ = 8.0 ± 0.5 (stat) ± 0.7 (sys) ± 0.5 (lumi) pb

data: 416, expected bkg: 75 ± 15

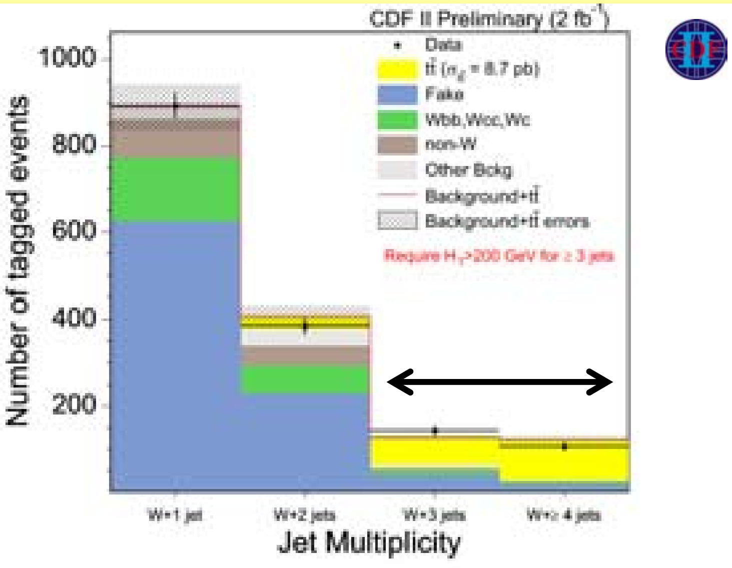
$\sigma(t\bar{t})$ = 8.2 ± 0.5 (stat) ± 0.8 (sys) ± 0.5 (lumi) pb

- dominant systematics: (luminosity : 6%)
  - → b-tagging : 6 % (b-tag)
  - → MC Modeling: (W+jets, PDF, …) : ~4%
  - → Jet Energy Scale : ~ 4%

$\Delta\sigma/\sigma$ ~ 12%

Lepton + jets With Soft Lepton Tagging

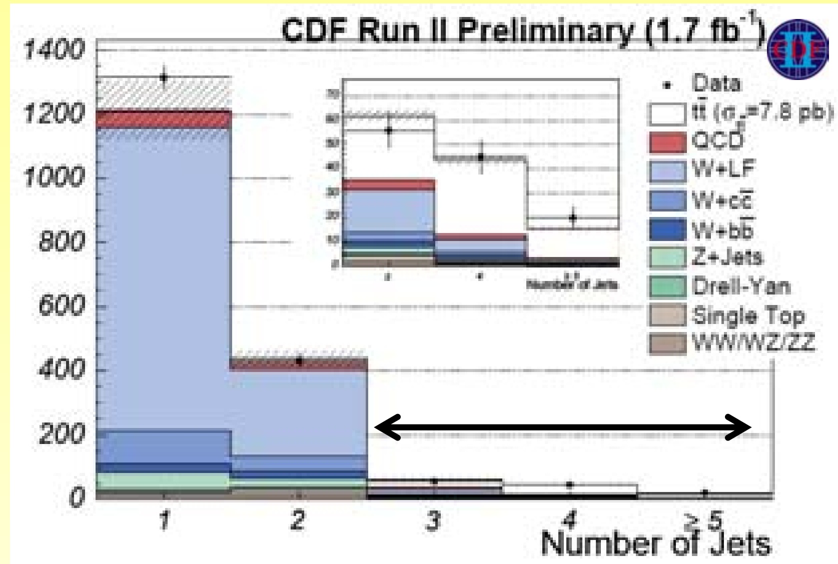
soft μ tag



data: 248, expected bkg: 87 ± 6

$\sigma(t\bar{t})$ = 8.7 ± 1.1 (stat) ± 0.9 (sys) ± 0.6 (lumi) pb

soft e tag



data: 121, expected bkg: 52 ± 3

$\sigma(t\bar{t})$ = 7.8 ± 2.4 (stat) ± 1.5 (sys) ± 0.5 (lumi) pb

(M_{top} = 175 GeV)

- dominant systematics: (luminosity : 6%)
  - → ℓ-tag acceptance/ε : 8-15 %
  - → ℓ-tag fake rate: ~ 5%
  - → W+HF prediction: ~4%

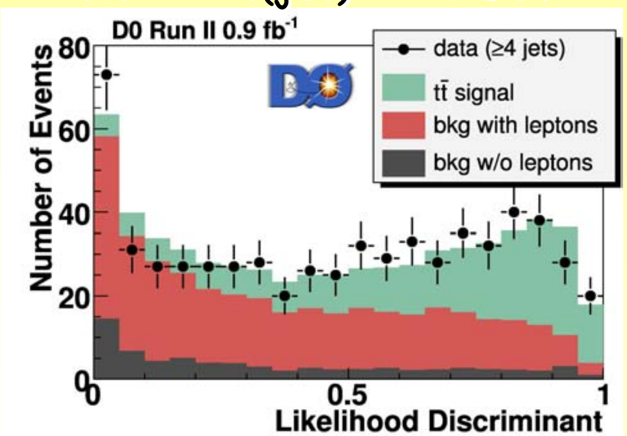
Lepton + jets with Kinematic Discriminant

Likelihood discriminant

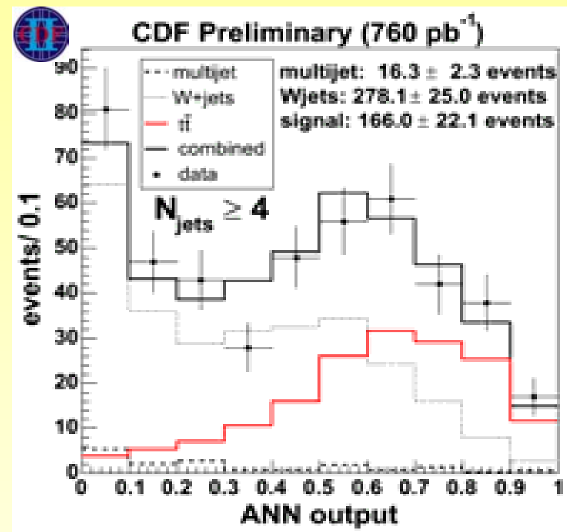
Neural Network

Fit the discriminant output in all channel to extract the cross section

Additionnal selection:
Ht = Σ Pt(jet) > 120 GeV



PRL 100, 192004 (2008)



4 channels: 2 lepton flavors x 3 jets-4jets

data: 2386, expected bkg: 1912 $\pm$ 70

$\sigma(t\bar{t})$ = 6.6 $\pm$ 0.8 (stat) $\pm$ 0.4 (sys) $\pm$ 0.4 (lumi) pb

$\sigma(t\bar{t})$ = 6.0 $\pm$ 0.6 (stat) $\pm$ 0.9 (sys) $\pm$ 0.3 (lumi) pb

(M_{top} = 175 GeV)

- D0: combination with the b-tagging analysis:

$\sigma(t\bar{t})$ = 7.4 $\pm$ 0.5 (stat) $\pm$ 0.5 (sys) $\pm$ 0.5 (lumi) pb

$\Delta\sigma/\sigma$ ~ 11%
Correlation: 31%

Top Mass Extraction From the Cross Section

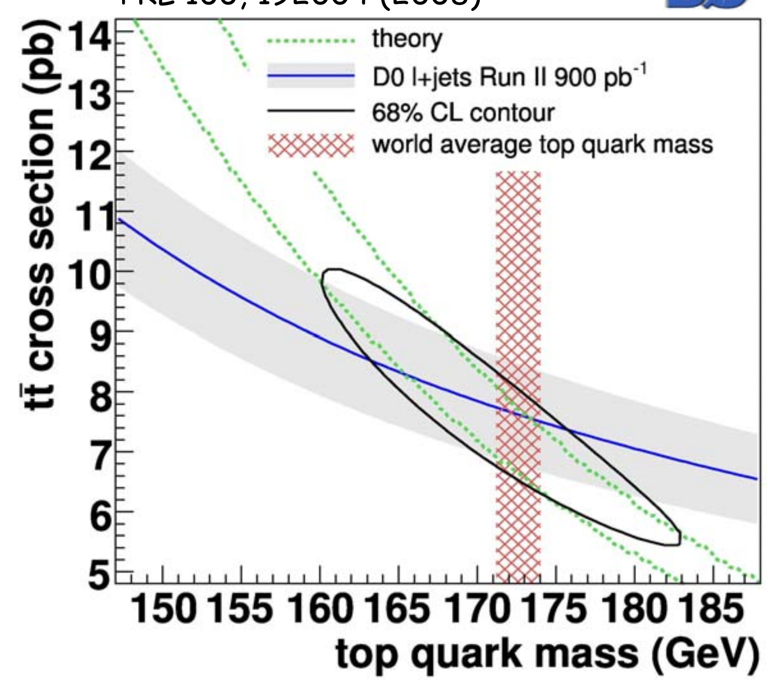
- interest
  - → top mass in a well defined renormalization scheme
- compare cross-section measurement with theory computation
  - → for each Mtop, construct a joint likelihood = theory likelihood (scale and PDF uncertainty) × experimental likelihood (total uncertainty)
  - → integrate over the cross-section

M_{top} = 170 ± 7 GeV

in agreement with the world average value:

M_{top} = 172.6 ± 1.4 GeV

PRL 100, 192004 (2008)



Simultaneous R and Cross Section Measurement

- Previous measurement assumed Br($t \to Wb$)=1

$\to$ fit simultaneously and R and $\sigma(t\bar{t})$ w/o this assumption

$$R = \frac{Br(t \to Wb)}{Br(t \to Wq)_{q=(d,s,b)}} = \frac{|V_{tb}|^2}{|V_{tb}|^2 + |V_{ts}|^2 + |V_{td}|^2}$$

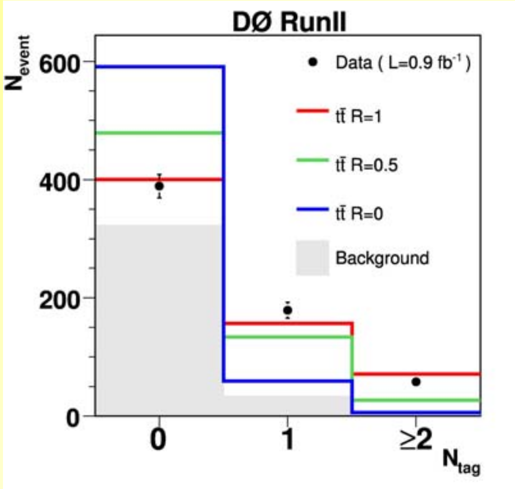
- channels: 0, 1, 2 b-tag, $\geq$ 4 jets

$\sigma(t\bar{t}) = 8.2^{+0.9}_{-0.8}$ (stat+sys) $\pm$ 0.5 (lumi) pb

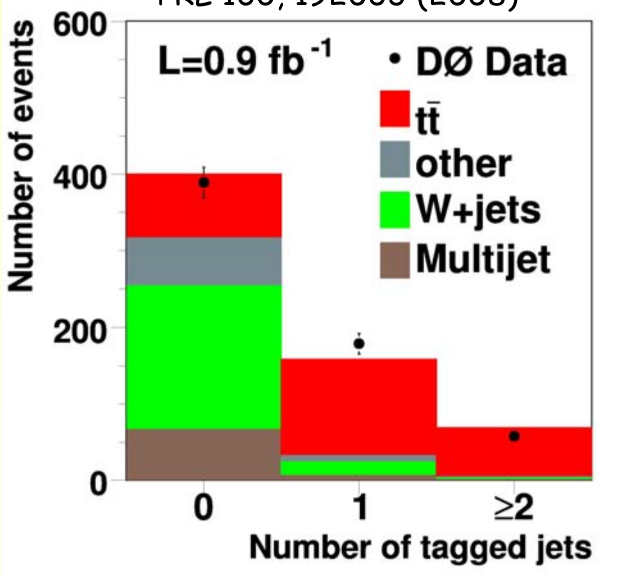
$R = 0.97^{+0.09}_{-0.08}$ (stat+sys)

Correlation: -58%

R $\approx$ 1 in the SM



PRL 100, 192003 (2008)



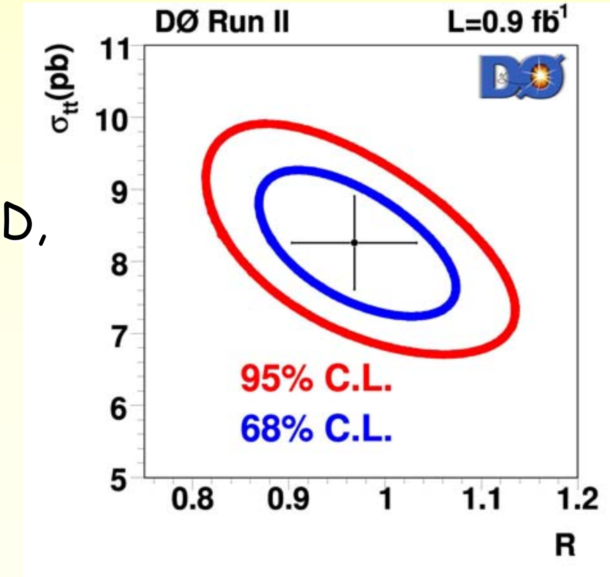
- dominant uncertainty:

$\to$ R: statistics + b-tagging

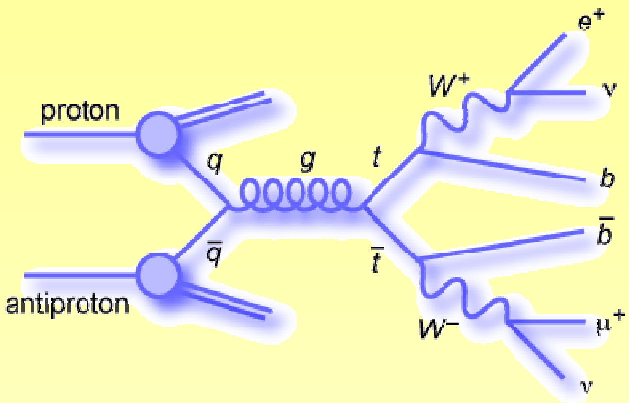
$\to$ $\sigma(t\bar{t})$: statistics, lepton ID, jet energy scale

$|V_{tb}|$> 0.89 @ 95% CL

(unitarity + 3 families)



Dilepton Channel

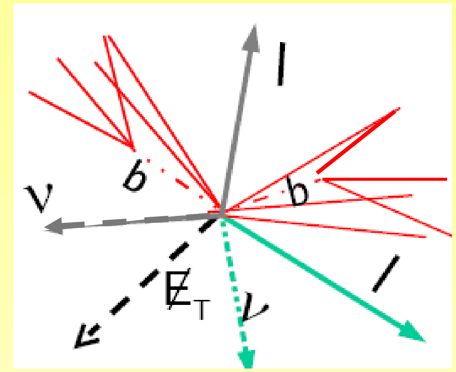


- Signature:

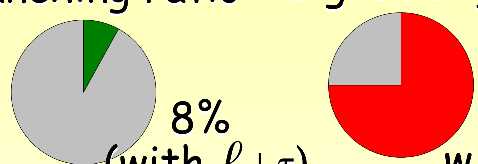
2 high Pt isolated leptons

High $\not{E}_T$

2 b jets



Branching ratio   Signal/Bkg



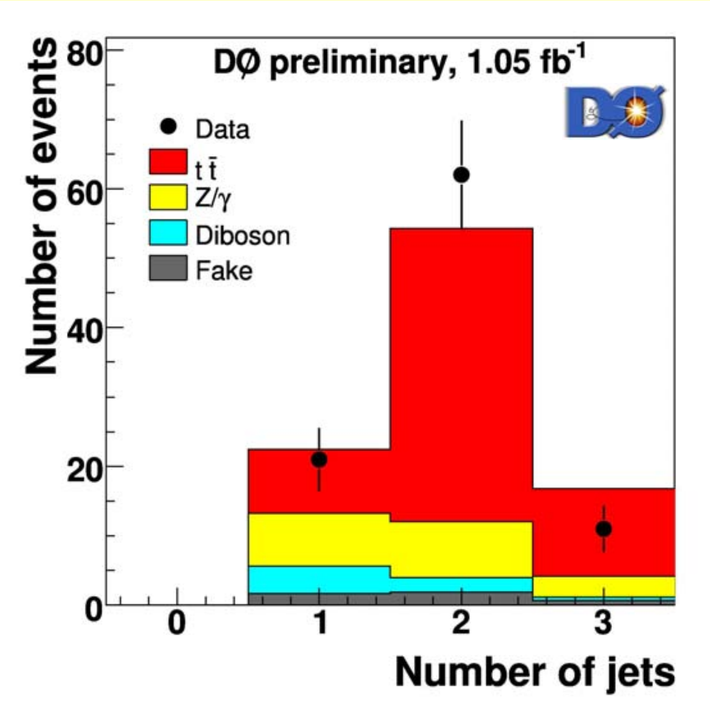
8% (with $\ell+\tau$)   3:1 w/o btag

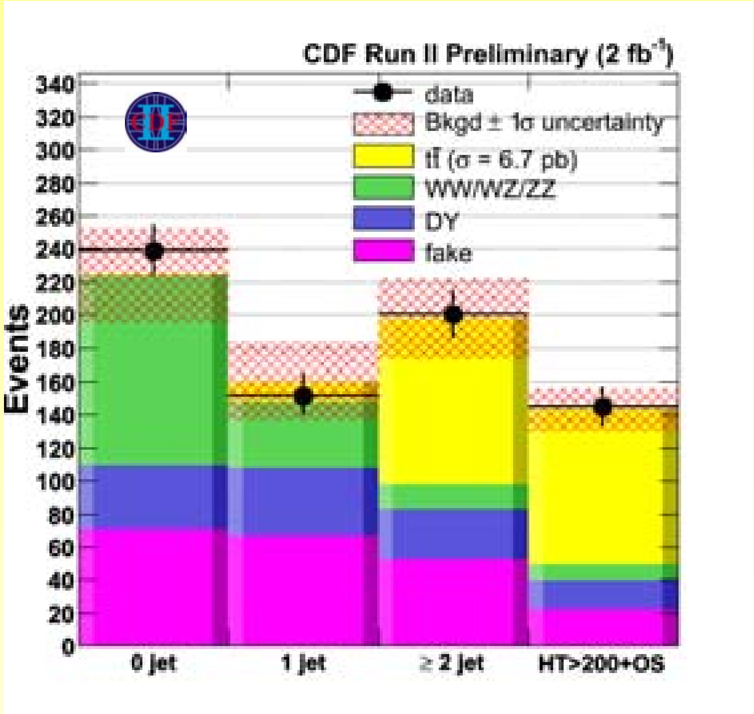
- complementary strategy:

$\rightarrow$ lepton + isolated track : need b-tagging to enhance purity

- Background:
  - $\rightarrow$ Z + jets : Z $\rightarrow \ell\ell$ +fake $\not{E}_T$: MC or data
  - $\rightarrow$ fake lepton (multijets) : estimated on data
  - $\rightarrow$ diboson (WW,WZ) +jets : MC

Dilepton Channel Results





1.05 fb^{-1}: ℓℓ + ℓ-isolated track (w/ btag):

$\sigma(t\bar{t})$ = 6.2 ± 0.9 (stat) ± 0.8 (syst) ± 0.4 (lumi) pb

(M_{top} = 175 GeV)

- dominant systematics:
  - → Jet energy scale : ~ 3%
  - → MC normalization : ~ 3%
  - → others of the order of 2-3%

2 fb^{-1}: ℓℓ (w/o btag): Δσ/σ ~ 17%

$\sigma(t\bar{t})$ = 6.8 ± 1.0 (stat) ± 0.4 (sys) ± 0.4 (lumi) pb

2 fb^{-1}: ℓℓ (w/ btag):

$\sigma(t\bar{t})$ = 9.0 ± 1.1 (stat) ± 0.7 (sys) ± 0.5 (lumi) pb

1.1 fb^{-1}: ℓ+track (w/o btag):

$\sigma(t\bar{t})$ = 8.3 ± 1.3 (stat) ± 0.7 (sys) ± 0.5 (lumi) pb

1 fb^{-1}: ℓ+track (w/ btag):

$\sigma(t\bar{t})$ = 10.1 ± 1.8 (stat) ± 1.1 (sys) ± 0.6 (lumi) pb

ℓ+jets/ℓℓ Cross Section Ratio

- using the measured ℓ+jets/ℓℓ cross sections:

$$R_\sigma = \frac{\sigma_{t\bar{t}}(\ell + jets)}{\sigma_{t\bar{t}}(\ell\ell)}$$

→ in the SM: $R_\sigma = 1$

→ deviation from 1 sensitive to the W disappearance : B(t → Xb)

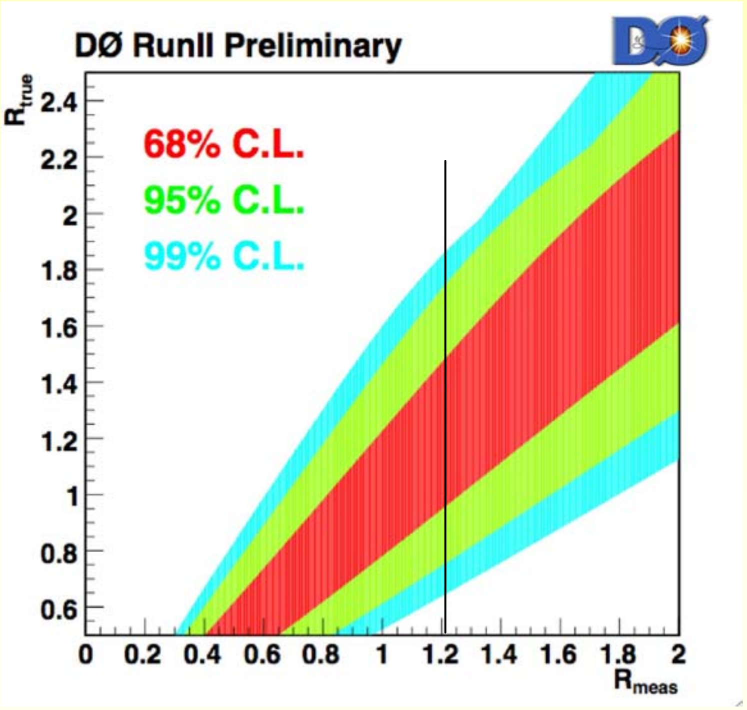
ex: t → Hb with $H^+ \to c\bar{s} \Rightarrow$ R>1

- using the Feldman Cousins method:

$R_\sigma = 1.21^{+0.27}_{-0.26}$ (stat+sys)

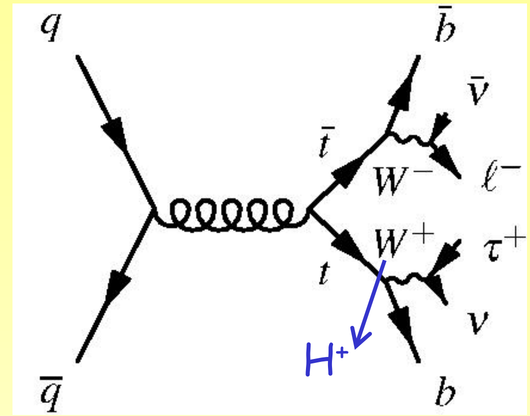
→ assuming $m_{H\pm}$=80 GeV and Br($H^\pm \to$ cs)=1

Br(t→Hb) < 0.35 @ 95% CL

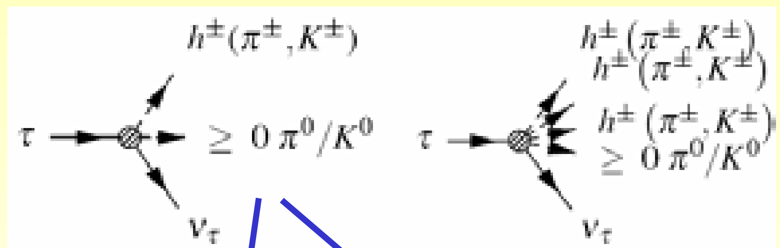


Lepton + τ Channel

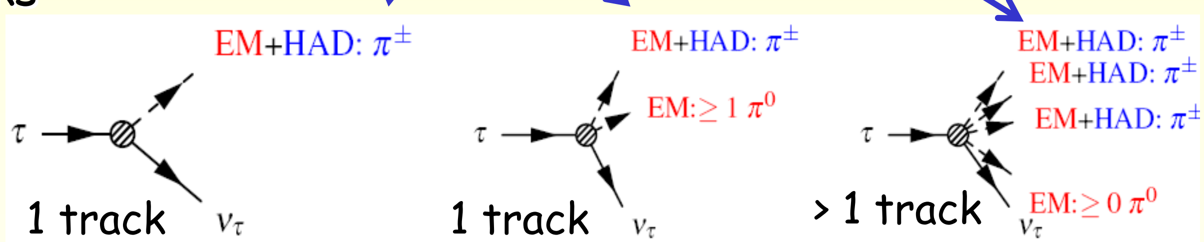
- final state with taus:
  - $\rightarrow$ challenging to identify
  - $\rightarrow$ but most sensitive channel to new physics
    ex: MSSM: if $m_{H+} < m_t$: $t \rightarrow H^+ b$, $H^+ \rightarrow \tau\nu$



- tau identification:
  - $\rightarrow$ hadronic tau decays :

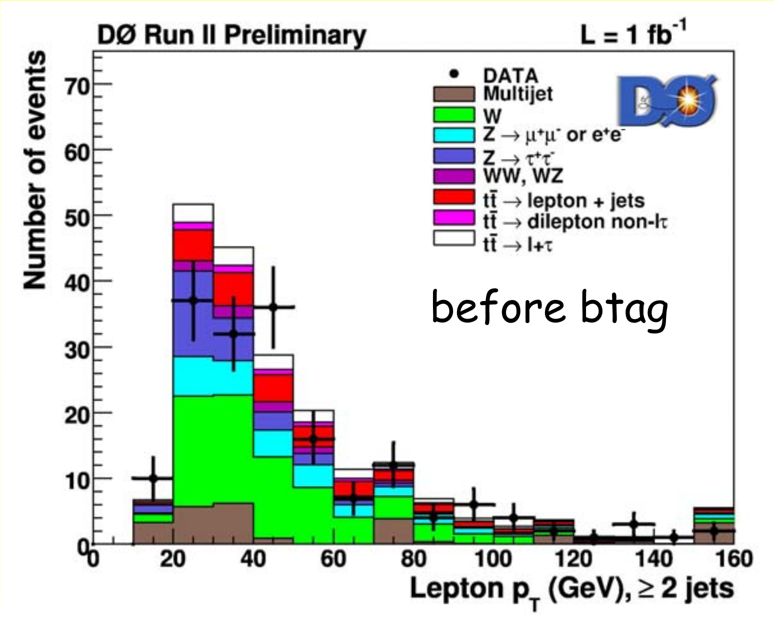


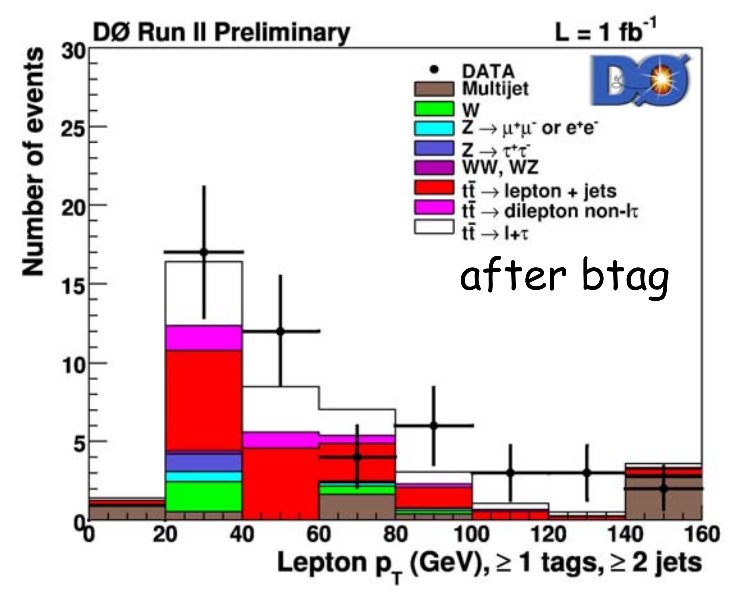
  - $\rightarrow$ hadronic tau reconstruction :
    3 neural networks
    to identify
    separately



Lepton + τ Channel Results

- background estimation:
  - → W+jets: normalized to data
  - → multijet: from same sign events
  - → other from MC





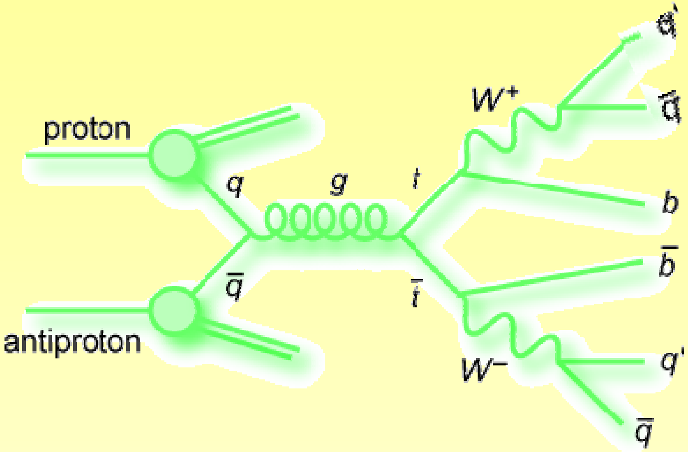
1 fb^{-1}: (M_{top}=175GeV)

$\sigma(t\bar{t}) = 8.3^{+2.0}_{-1.8}$ (stat) $^{+1.4}_{-1.2}$ (syst) ± 0.5 (lumi) pb

$\Delta\sigma/\sigma \sim 28\%$

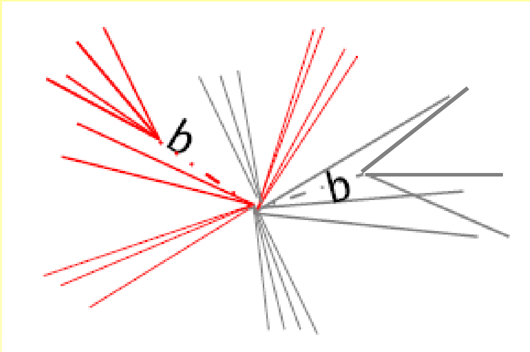
- dominant systematics: (luminosity : ~ 6%)
  - → bkg/MC statistics : ~ 20%
  - → b-tagging : ~ 6%
  - → tau fake rate : ~ 4%

Full Hadronic Channel

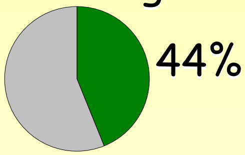


• Signature:

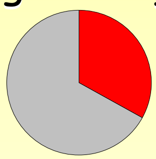
6 jets (2 b jets)



Branching ratio



Signal/Bkg



b-tagging necessary

Important combinatoric background

• Selection:

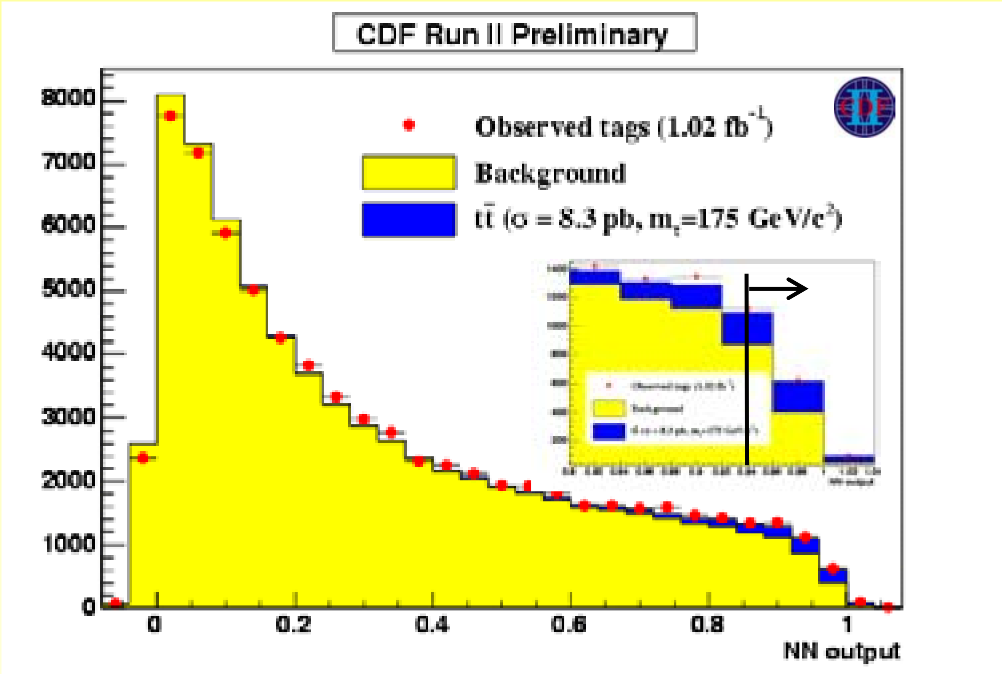
→ $6 \leq$ Njet ≤ 8

→ signal/bkg separation: using a neural network (jet invariant masses, sphericity, aplanarity, …)

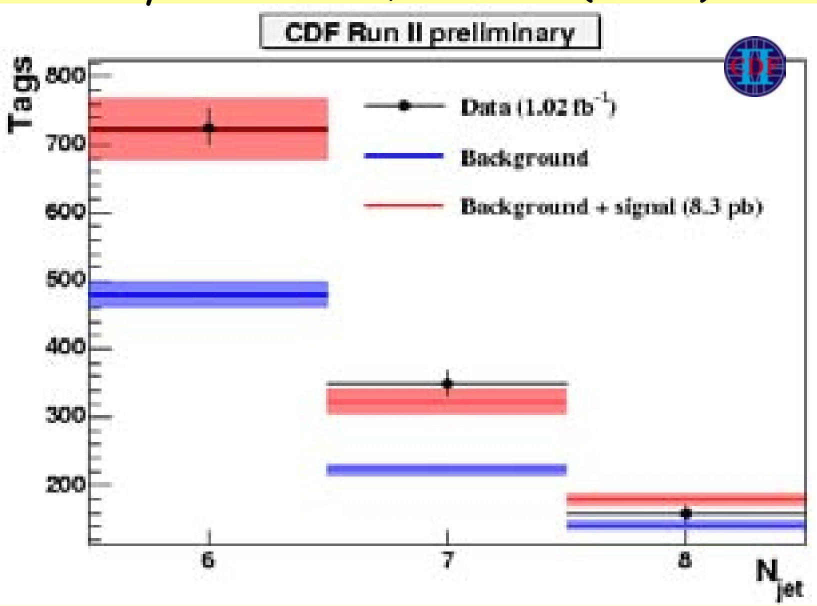
• Background:

→ multijets : estimated on data (tag rate in the N_{jet}=4 bin)

Full Hadronic Channel Results



Phys. Rev. D76, 072009 (2007)

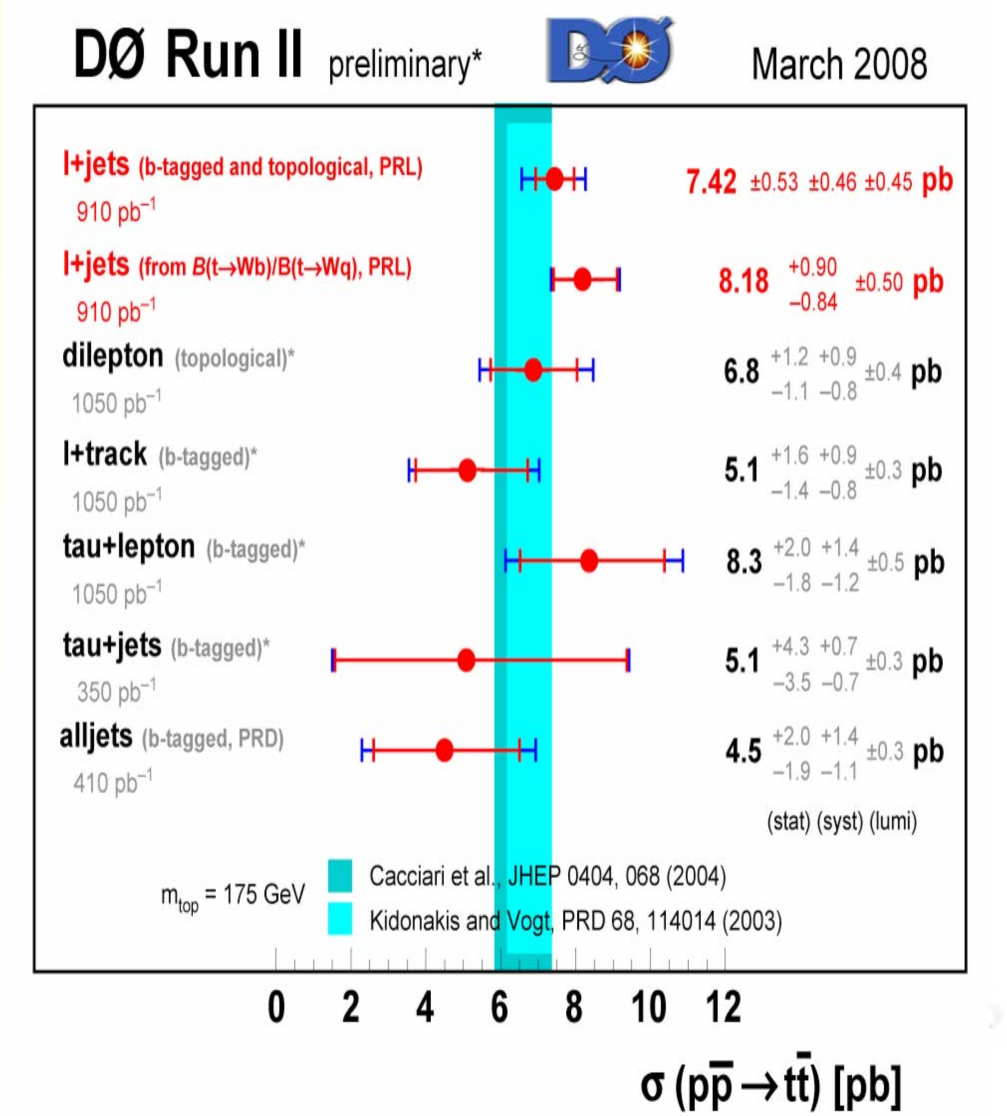


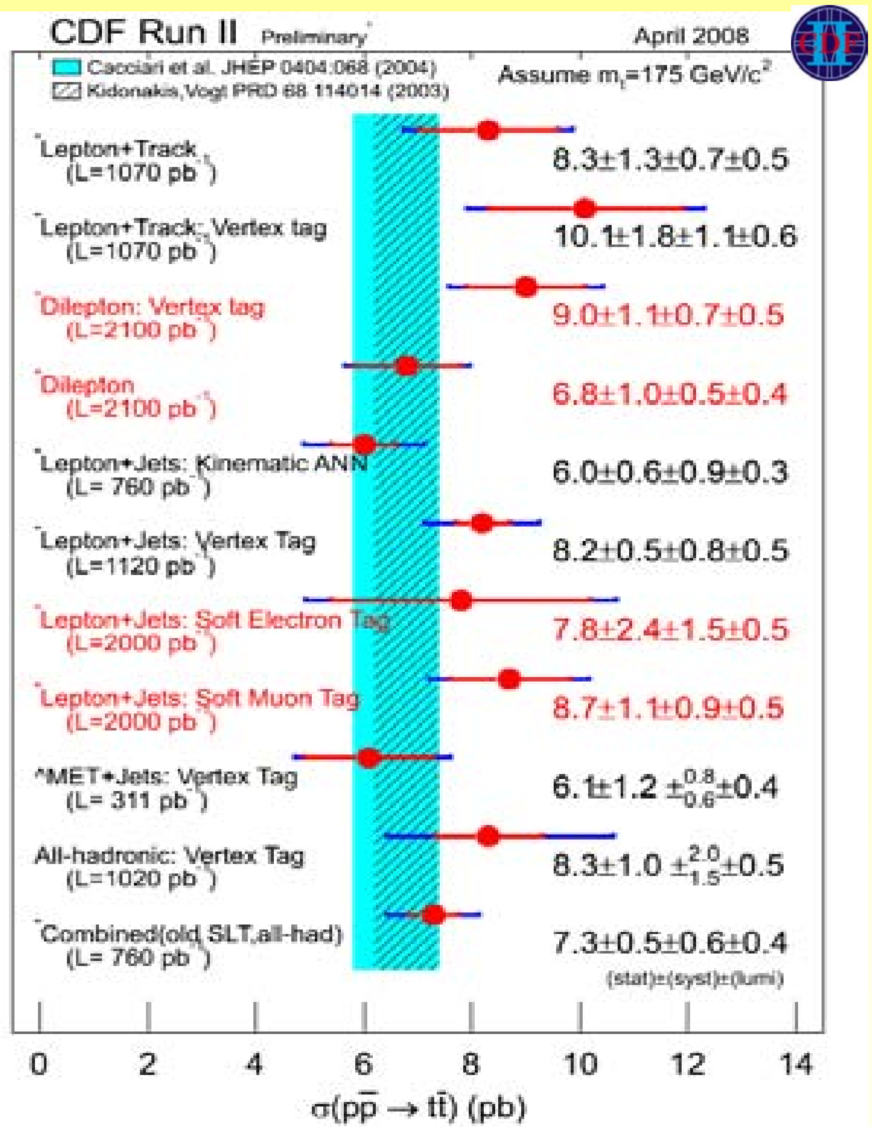
data: 1233, expected bkg: 856 $\pm$ 23

$\sigma(t\bar{t})$ = 8.3 $\pm$ 1.0 (stat) $^{+2.0}_{-1.5}$ (sys) $\pm$ 0.5 (lumi) pb (M$_{top}$ = 175 GeV)

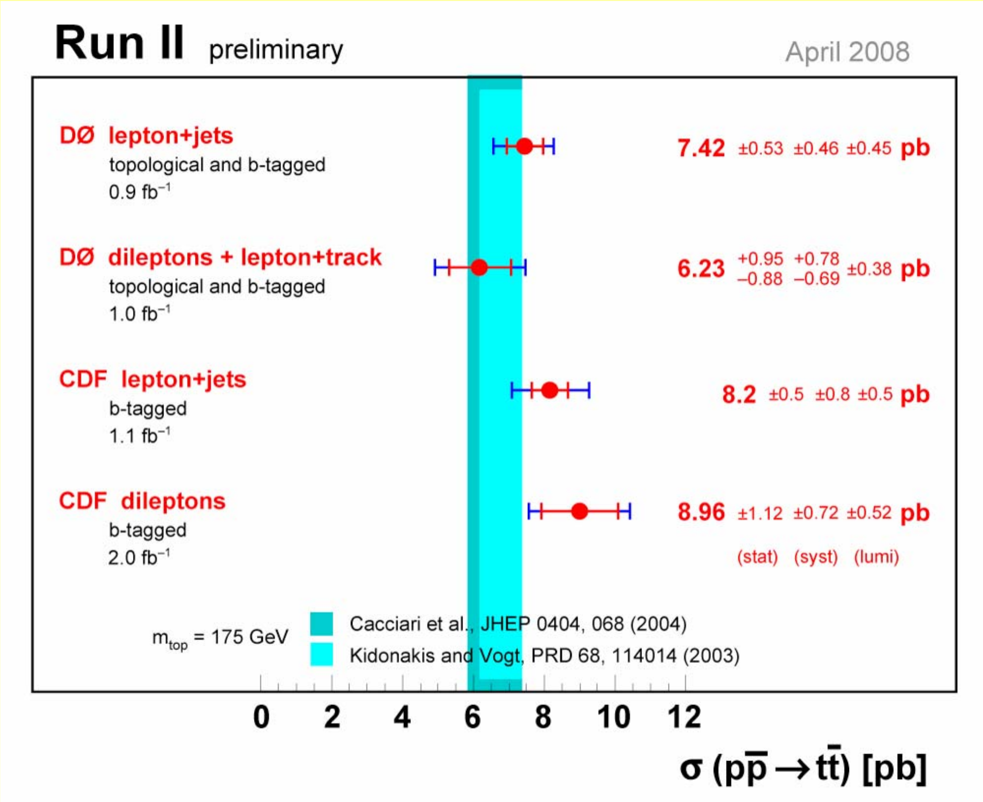
- dominant systematics: (luminosity : ~ 6%) $\Delta\sigma/\sigma$ ~ 25%
  - $\rightarrow$ Jet energy scale : ~ 16%
  - $\rightarrow$ b-tagging : ~ 7%

Summary of $t\bar{t}$ Cross Section Measurements





Perspectives



$\rightarrow$ better current result: $\Delta\sigma(t\bar{t})/\sigma$ ~ 11 % (~ theory uncertainty)

$\rightarrow$ systematic dominated (ℓ +jets, full hadronique)

$\rightarrow$ perspective: end of runII

a 6 % uncertainty could be achieved (need to improve systematics)

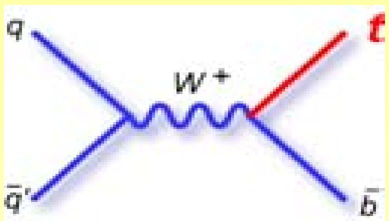
$\rightarrow$ LHC: 5-10% with 10 fb^{-1} (luminosity uncertainty 5%-10%)

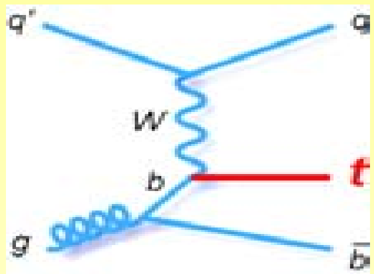
Single Top Quark Cross Sections

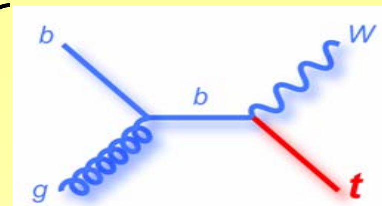
Single Top Quark Production

- Electroweak Production Mode

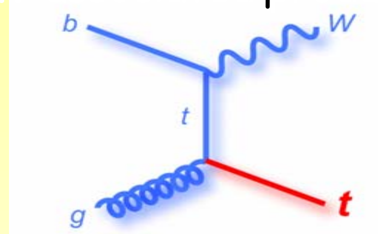
single top production





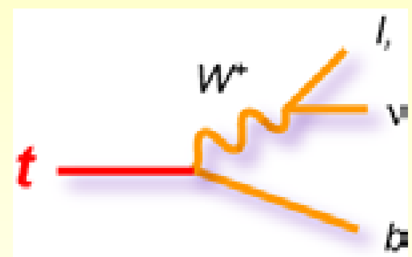


W associated production



	s-channel	t-channel	W associated production
Tevatron :	30%	65%	5%
(LHC:	3%	77%	20%)
NLO σ :	0.88 ± 8% pb	1.98 ± 12% pb	0.09 ± 26% pb
Final state:	$\ell\nu b\bar{b}$	$\ell\nu b\bar{b}q$	

Leptonic decay of the W



→ Theoretical prediction: M_{top} = 175 GeV (CTEQ5M1)

Sullivan, Phys. Rev. D70:114012,2004, NLO

Tevatron: σ = 2.9 pb ± ~ 14 % (typically: for 1 fb^{-1} , ~ 50 evts)

LHC: σ = 315 pb ± ~ 20 %

Why Do We Want to Measure the Single Top Cross Section ?

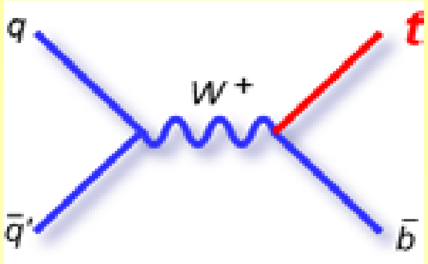
- Single top cross section:

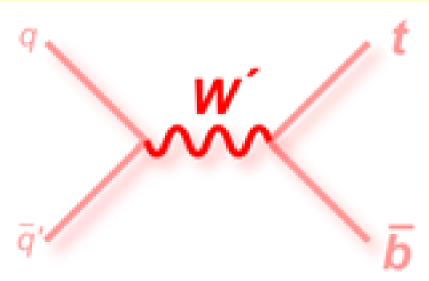
→ predicted by the standard model:
  need to measure it

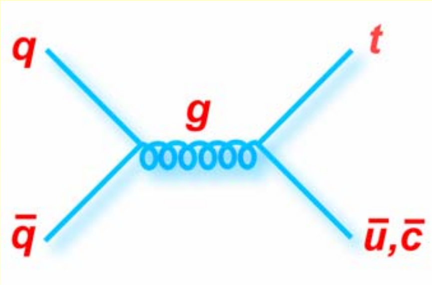
→ direct measurement of V_{tb} ($\sigma \propto |V_{tb}|^2$)
  test the unitarity of the CKM matrix

→ sensitive to non standard process:
  W' or charged Higgs, FCNC: tug, …
  anomalous Wtb coupling: V+A

→ background for Higgs searches:
  same final state as $WH \to Wb\bar{b}$







- Difficult measurement:

→ low cross-section, high background ($Wb\bar{b}$, $t\bar{t}$, multijets)
  S/B ~ 1/15
  need multivariate techniques

Event Selection and Background Estimation

- Event Selection:

→ one isolated electron or muon (Pt>15-20GeV)

→ $\not{E}_T$ > 15-25 GeV

→ 2, 3 or 4 jets with 1 or 2 b-tag (Pt>15-25GeV)

- Background estimation:

→ from MC: diboson, Z+jets and $t\bar{t}$ (+ single top)

→ from MC and Data:

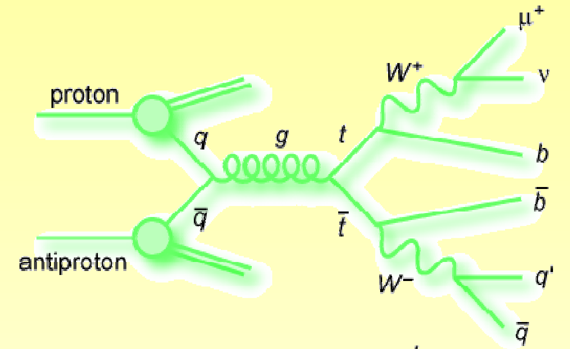
kinematics and flavor composition from MC

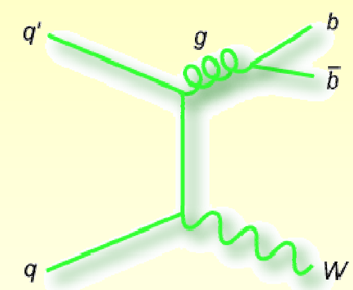
(+ additional scale factor for $Wb\bar{b}$ and $Wc\bar{c}$)

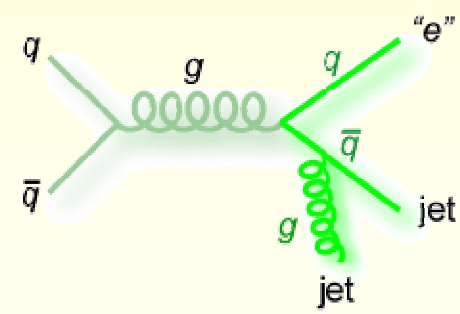
W+jets normalized from data before b-tagging

→ from data: multijets

using sideband or non isolated lepton sample







Event Yields

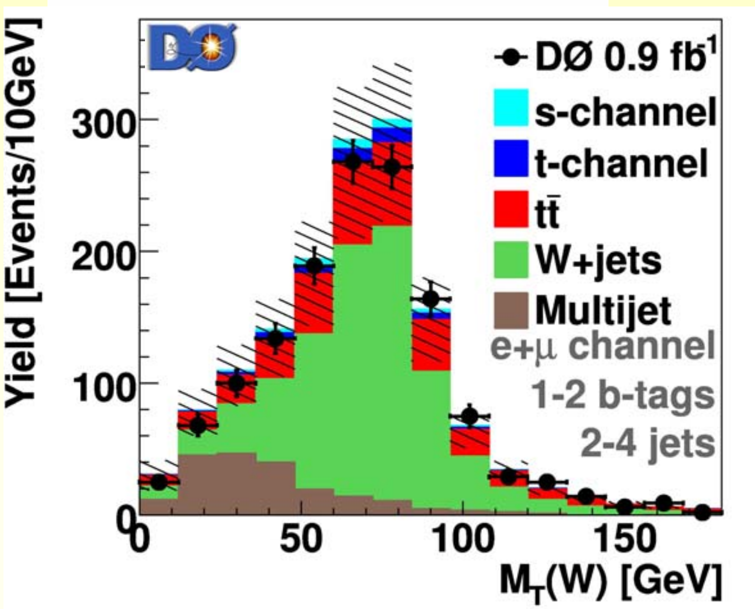
After b-tagging

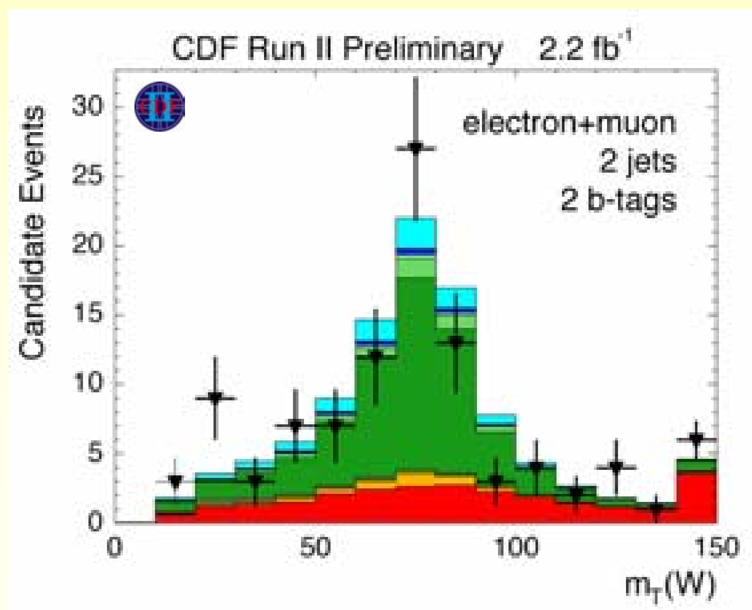
DØ PRD 0.9 fb^{-1}		
1,2 b-tags	2-jets	3-jets
s-channel tb	16	8
t-channel tqb	20	12
W+light-jets	119	43
W+charm	151	85
W+bottom	261	120
$t\bar{t}\to$dileptons	39	32
$t\bar{t}\to$lepton+jets	20	103
Multijets	95	77
Total prediction	721	480
Data	697	455

Signal Acceptances	CDF	DØ
s-channel *tb*	2.8%	3.2%
t-channel *tqb*	1.8%	2.1%

multivariate discriminant needed

CDF preliminary 2.2 fb^{-1}	2-jets	3-jets
s-channel tb	41	14
t-channel tqb	62	18
W+light-jets	340	102
W+charm	395	109
W+bottom	462	141
Z+jets	27	11
Dibosons	63	22
$t\bar{t}$	146	339
Multijets	60	21
Total prediction	1,595	777
Data	1,535	712





Systematic Uncertainties

- systematics affect the normalization and/or the shapes

→ correlation between channels taken into account

Source of Uncertainty	Size
Top pairs normalization	18%
W+jets & multijets normalization	18–28%
Integrated luminosity	6%
Trigger modeling	3–6%
Lepton ID corrections	2–7%
Jet modeling	2–7%
Other small components	Few %
Jet energy scale	1–20%
Tag rate functions	2–16%

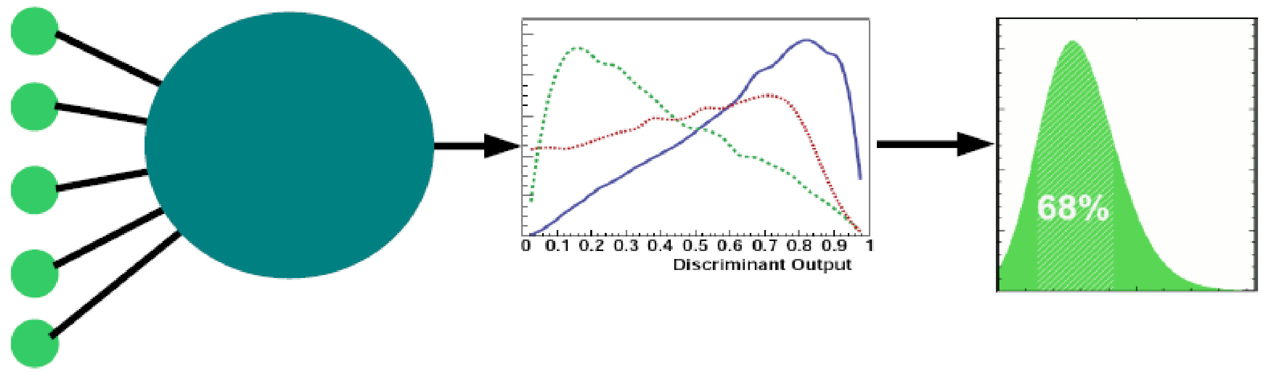
Syst. Uncertainty	Rate	Shape
Jet Energy Scale	0...16%	☑
Initial state radiation	0...11%	☑
Final state radiation	0...15%	☑
Parton Distribution Function	2...3%	☑
MC Generator	1...5%	
Event Detection Efficiency	0...9%	
Luminosity	6%	
NN Flavor-Separator		☑
Mistag model		☑
Q2 scale in ALPGEN MC		☑
Input variable mismodeling		☑
Wbb+Wcc normalization	30%	
Wc normalization	30%	
Mistag normalization	17...29%	
Top-pair normalization & mtop	23%	☑

- the cross section uncertainty is dominated by the statistical uncertainty

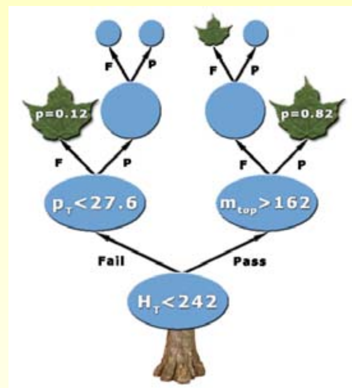
Multivariate Techniques

Discriminating variables | multivariate discriminant | Statistical analysis

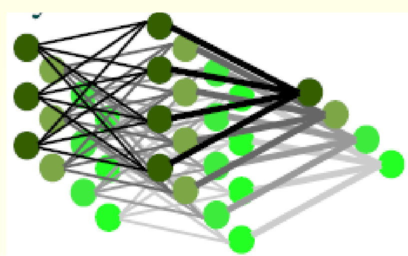
Event kinematics
Object properties
Reconstructed top mass
Angular correlations
…

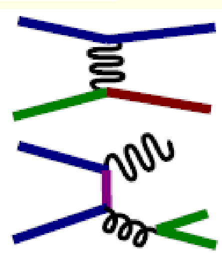


→ Boosted Decision Tree
→ Bayesian Neural Network
→ Matrix Elements



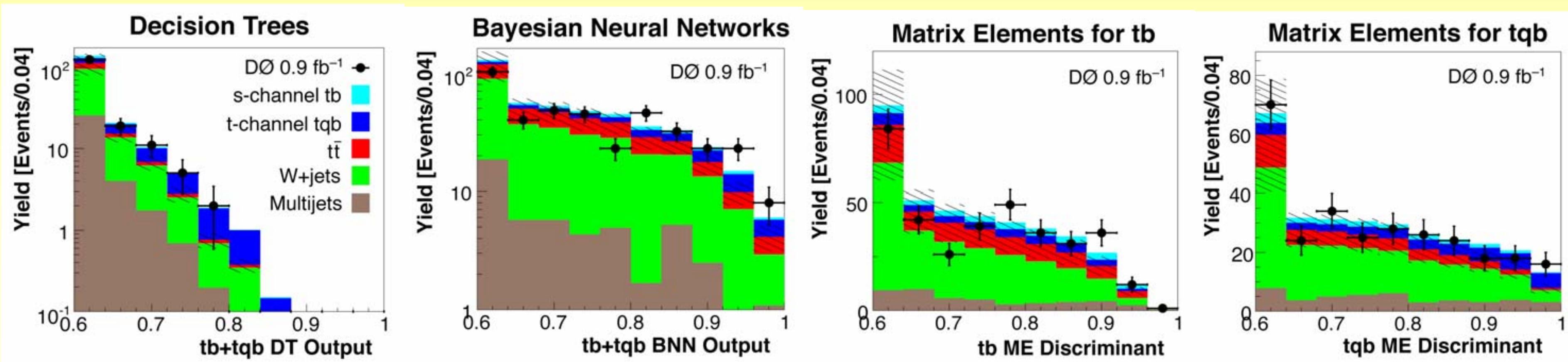
→ Boosted Decision Tree
→ Neural Network
→ Matrix Elements
→ Likelihood Functions





D0 Results

- First evidence for single top production in December 2006: PRL 98, 181802 (2007)
- 3 analyses: Boosted decision tree, Bayesian Neural Network, Matrix Elements (0.9 fb^{-1}) combined s and t channel searches (assume SM ratio between them)

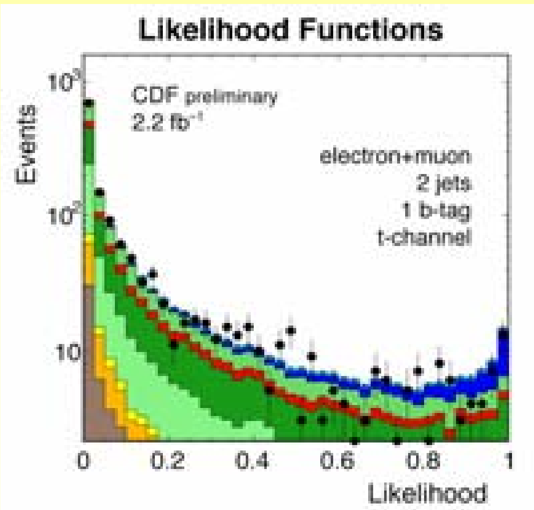


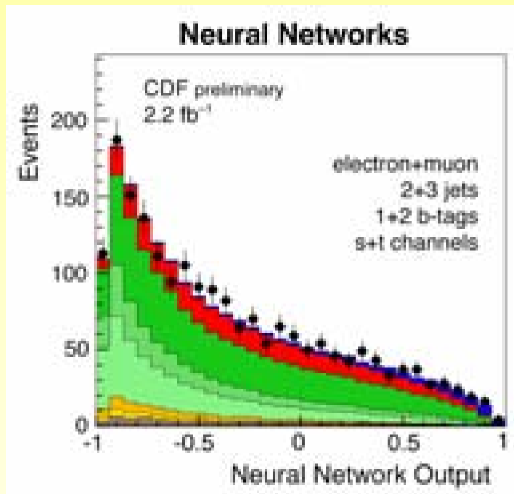
tb+tqb Results	DØ PRD 0.9 fb^{-1}		
	DT	BNN	ME
Expected significance	2.1 σ	2.2 σ	1.9 σ
Observed significance	3.4 σ	3.1 σ	3.2 σ
Cross section	$4.9^{+1.4}_{-1.4}$ pb	$4.4^{+1.6}_{-1.4}$ pb	$4.8^{+1.6}_{-1.4}$ pb

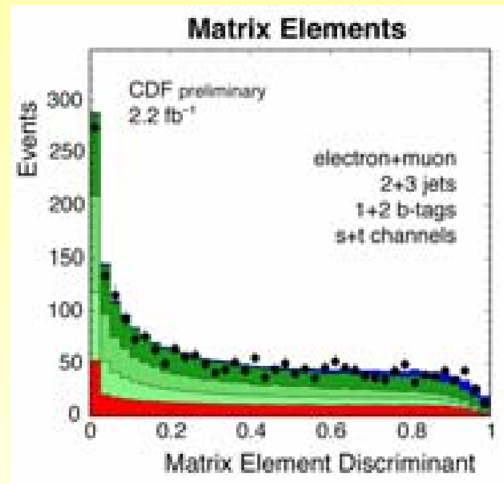
(M_{top} = 175 GeV)

CDF Results

- Large dataset analyzed : 2.2 fb^{-1}
- 4 analyses: Likelihood function, Neural Network, Matrix Elements
  Boosted Decision Tree (new)

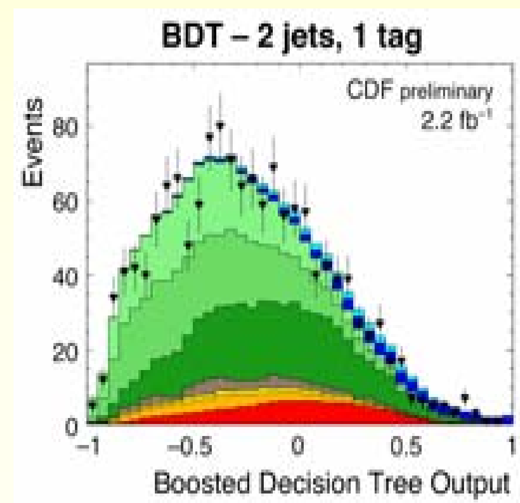






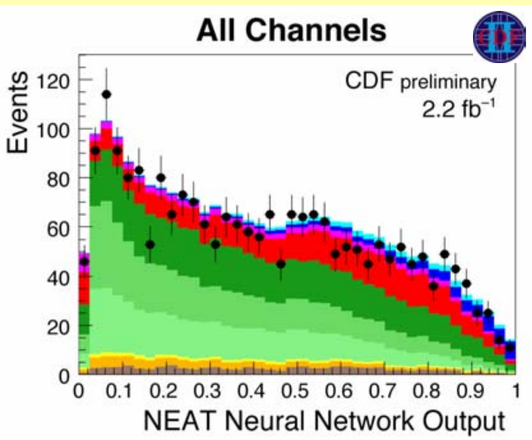
tb+tqb **Results**	**CDF preliminary 2.2 fb^{-1}**			
	LF	**NN**	**ME**	**BDT**
Expected significance	3.4 σ	4.4 σ	**4.5 σ**	**4.6 σ**
Observed significance	2.0 σ	3.2 σ	**3.4 σ**	**2.8 σ**
Cross section	$1.8^{+0.9}_{-0.8}$ pb	$2.0^{+0.9}_{-0.8}$ pb	**$2.2^{+0.8}_{-0.7}$ pb**	**$1.9^{+0.8}_{-0.7}$ pb**

(M_{top} = 175 GeV)



Combining the Results

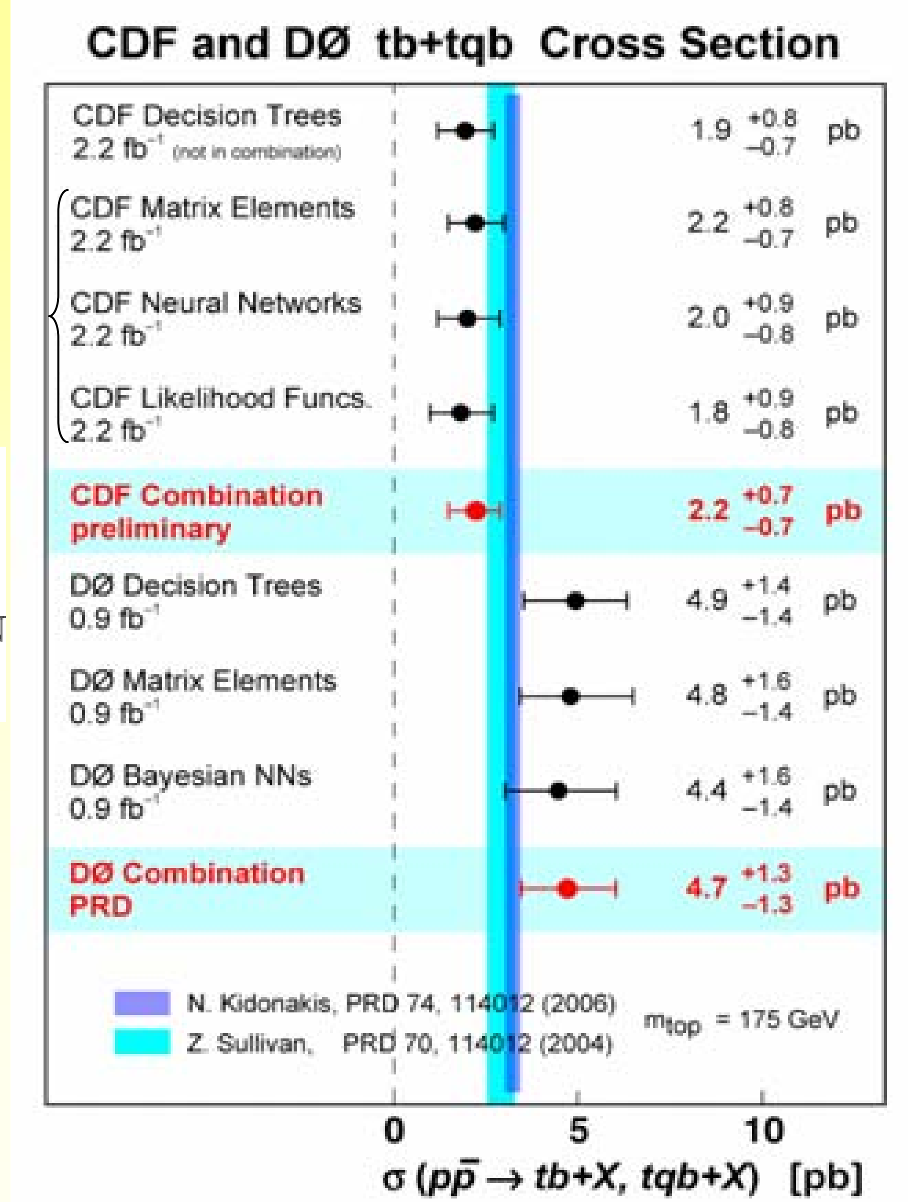
- CDF: Neural network optimized using neuro-evolution of augmentation topologies (NEAT)
- D0: Best Linear Unbiased Estimate (BLUE) method



D0 correlation matrix

$$\begin{array}{cc} \begin{array}{ccc} \text{DT} & \text{BNN} & \text{ME} \end{array} & \\ \begin{pmatrix} 1 & 0.66 & 0.64 \\ 0.66 & 1 & 0.59 \\ 0.64 & 0.59 & 1 \end{pmatrix} & \begin{array}{c} \text{DT} \\ \text{BNN} \\ \text{ME} \end{array} \end{array}$$

tb+tqb Combined Results		
	DØ PRD 0.9 fb^{-1}	CDF prelim. 2.2 fb^{-1}
Expected significance	2.3 σ	5.1 σ
Observed significance	3.6 σ	3.7 σ
Cross section	4.7 ± 1.3 pb	2.2 ± 0.7 pb

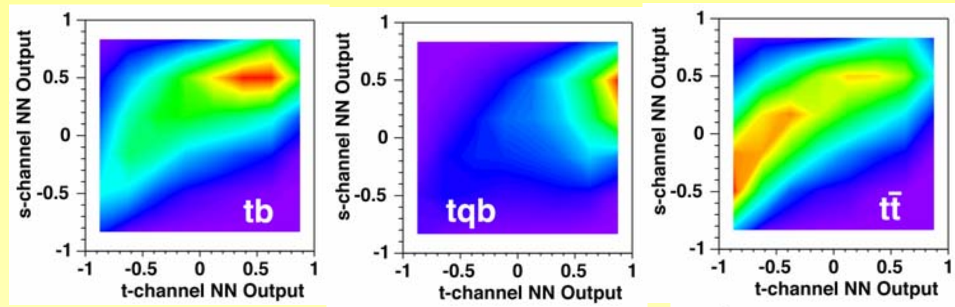


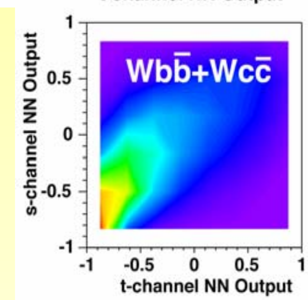
Separate Measurements of s and t Channels

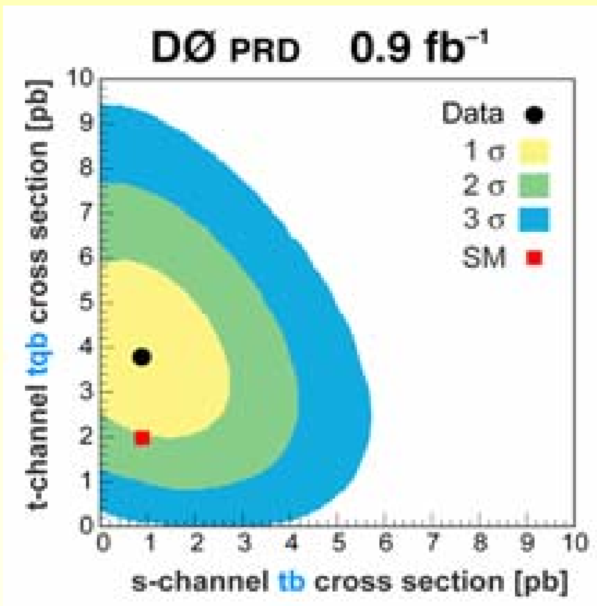
- DØ: s+t channel decision tree where the s and t channel cross sections are allowed to float

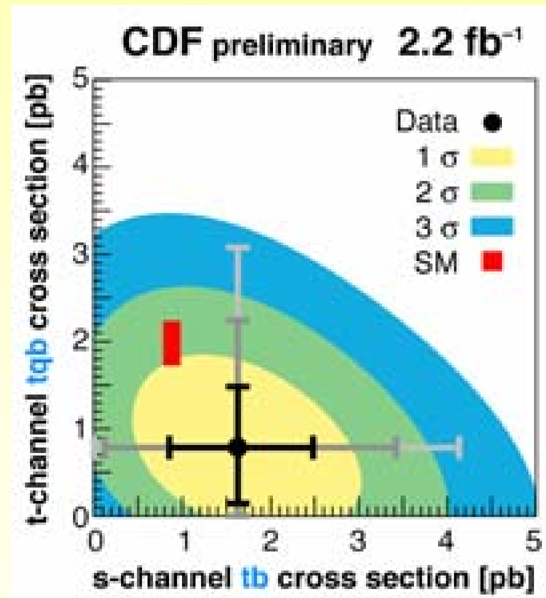
- CDF: Neural network output templates for s and t channels separately

2jet 1btag: 2D NN discriminant









s-channel $\sigma(tb) = 0.9$ pb
t-channel $\sigma(tqb) = 3.8$ pb

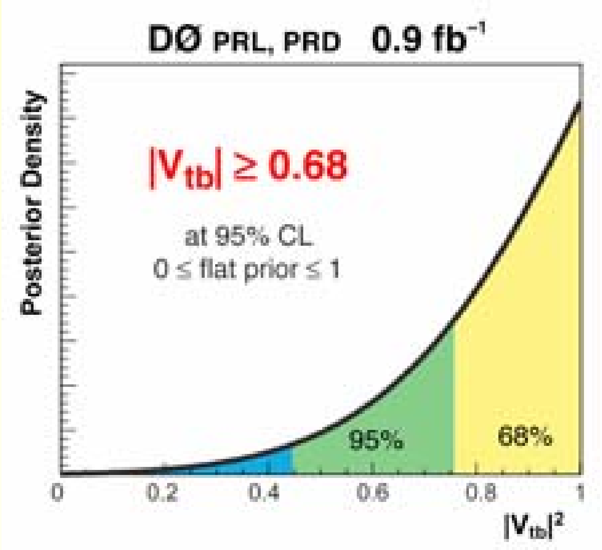
s-channel $\sigma(tb) = 1.6^{+0.9}_{-0.8}$ pb
t-channel $\sigma(tqb) = 0.8^{+0.7}_{-0.8}$ pb

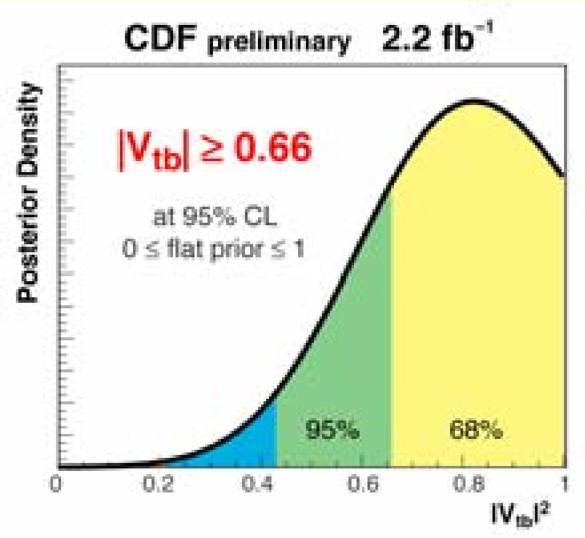
Measurement of the CKM Matrix Element V_{tb}

- Wtb vertex:

$$\Gamma^{\mu}_{Wtb} = -\frac{g}{\sqrt{2}} V_{tb} \; \gamma^{\mu} \left[f_1^L P_L + f_1^R P_R \right]$$

- Extraction of V_{tb} from the cross section measurement: $\sigma \propto |V_{tb}|^2$
- Assumptions:
  - $\rightarrow$ single top production with W interaction (no FCNC, …)
  - $\rightarrow$ SM top decay: $|V_{td}|^2 + |V_{ts}|^2 \ll |V_{tb}|^2$
  - $\rightarrow$ pure V-A: $f_1^R=0$
- No assumption on the number of quark families or CKM unitarity





Summary of Single Top Cross Section Measurements

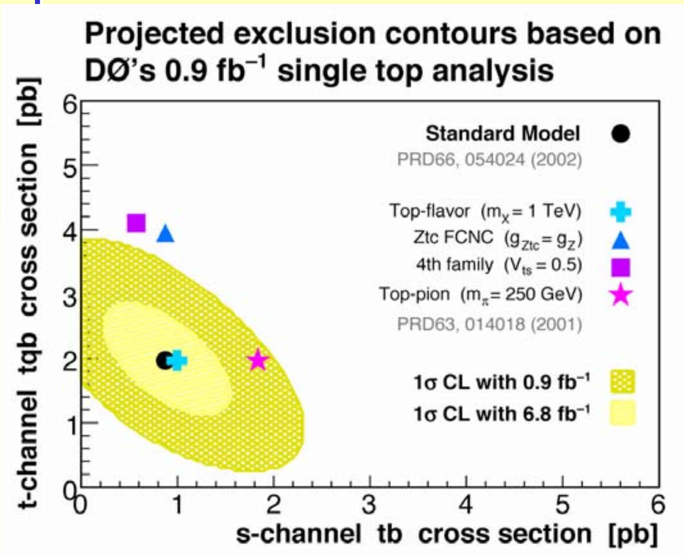
- Challenging measurements
- Both D0 and CDF report evidence for single top production:

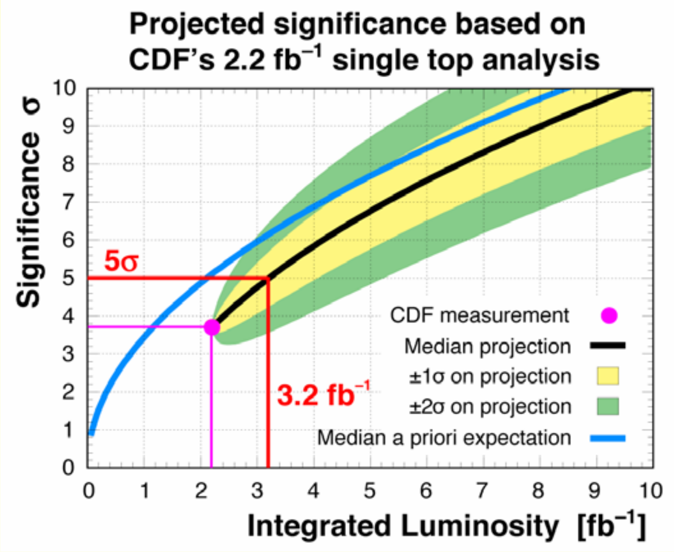
D0 (0.9 fb^{-1}): σ(s+t channel) = 4.7 $\pm$ 1.3 pb (3.6 σ significance)

CDF (2.2 fb^{-1}): σ(s+t channel) = 2.2 $\pm$ 0.7 pb (3.7 σ significance)

(M_{top} = 175 GeV)

- Perspectives:





LHC experiments will need ~ 10 fb^{-1} to see the t-channel and to discover the Wt channel. The s-channel will be more difficult.

Conclusion

- At Tevatron Run II, top physics has entered the precision area.

$\rightarrow$ statistics is not the limiting factor anymore for the $t\bar{t}$ cross-section measurements (ℓ +jets, full hadronique) : $\Delta\sigma(t\bar{t})/\sigma$ ~ 11 %

- Test of the Standard Model:
  - $\rightarrow$ $t\bar{t}$ cross section in all the possible channels
  - $\rightarrow$ evidence for single top (>3σ)

- The Tevatron will deliver 6-8 fb^{-1} by 2009/2010
  - $\rightarrow$ dilepton $t\bar{t}$ cross section limited by systematics
  - $\rightarrow$ work on reducing systematics
  - $\rightarrow$ single top discovery (s and t channels)
  - $\rightarrow$ surprises in the top sector?

see next talk for top properties results