Top Pair Production Cross-Section in the All-Hadronic Channel

Daniel Wicke, Fermilab
on behalf of CDF and DØ

Outline

- Introduction
- Signal selection
- Background and efficiency determination
- Results
- Summary

Introduction

Top production

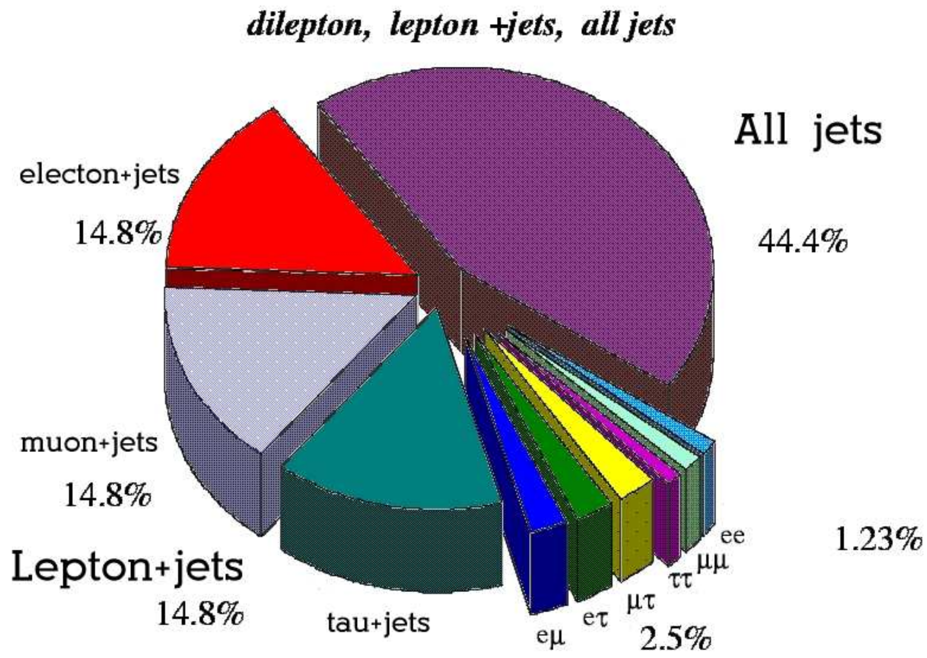
General signatures: $2b$-jets + missing E_T + lepton(s) "dilepton and l+jets"

$2b$-jets + at least 4 jets *"all hadronic"*

All hadronic channel

- Highest branching ratio: 44%
- Other quarks produced in the same process have many orders of magnitudes higher cross-section.

$\Rightarrow$ Overwhelming multijet background



The cross-section formula

$$\sigma_{t\bar{t}} = \frac{N - B}{\varepsilon \mathcal{L} \cdot \mathrm{BR}}$$

Signal Selection

Trigger

CDF

4 calorimeter cluster of $E_T \geq 15\,\text{GeV}$
$H_T \geq 125\,\text{GeV}$

DØ

4 Jets with $E_T > 12\,\text{GeV}$ [10 GeV]
3 with $E_T > 15\,\text{GeV}$ [–]
2 with of $E_T > 25\,\text{GeV}$ [20 GeV]
[$H_T \geq 90\,\text{GeV}$]

Preselection

CDF

4 or more jets of cone 0.4 with
$p_T \geq 15\,\text{GeV}$, $|\eta| < 3.0$, $z_{\text{vtx}} < 60\,\text{cm}$
no isolated high p_T leptons

DØ

6 or more jets of cone 0.5 with
$p_T \geq 15\,\text{GeV}$, $|\eta| < 2.5$, $z_{\text{vtx}} < 60\,\text{cm}$
no isolated high p_T leptons

Luminosity

CDF: $165\,\text{pb}^{-1}$

DØ: $162\,\text{pb}^{-1}$

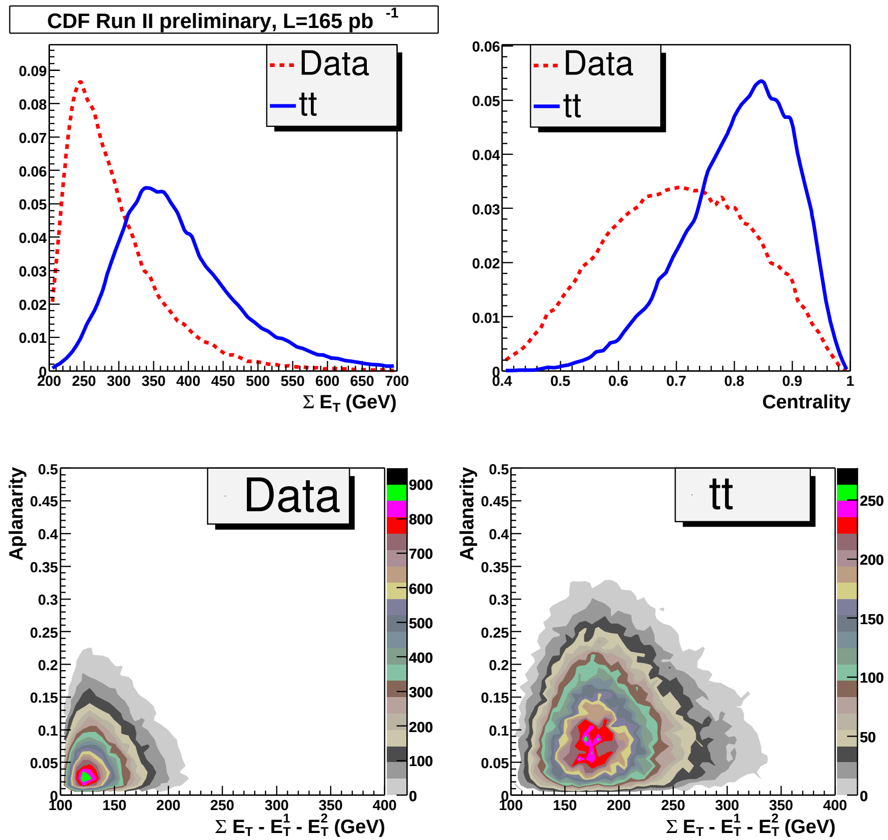
Kinematic observables

1. Energy scale
   H_T, $\sqrt{s}$

2. Soft non-leading jets
   H_T^{3j}, $E_{T_{4,5}}$, N_{jets}^A

3. Event shape
   Aplanarity, Sphericity

4. Rapitity distribution
   Centrality, $\langle \eta^2 \rangle$



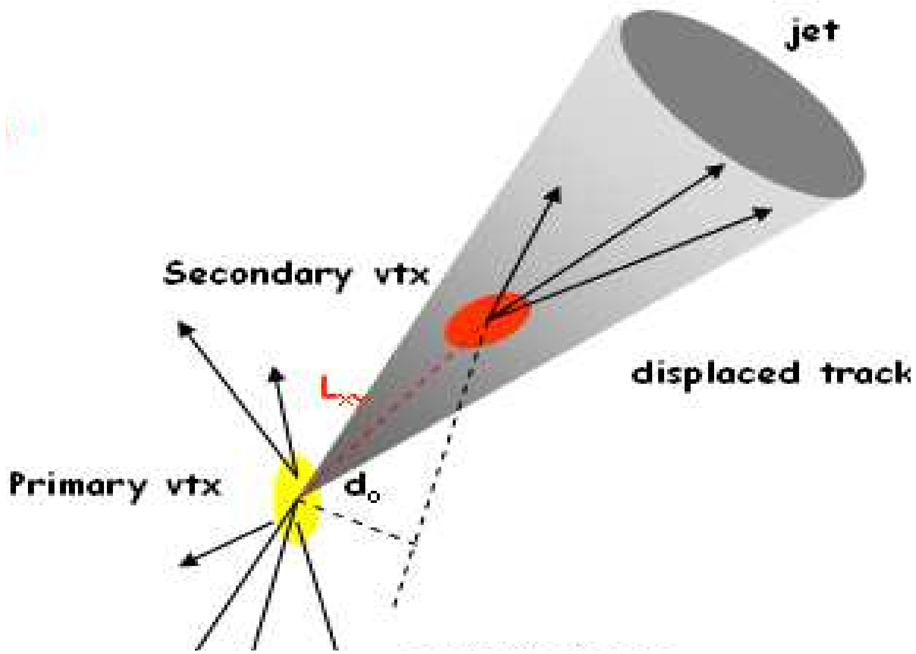
Some of these are correlated

5. Specific top properties
   W-χ^2 (consistency of reconstructed W-masses with theo. value)
   t-χ^2 (consistency of t-masses with each other)
   M_{WW}, M_{tt},
   $M_{1,2}^{\min}$, $M_{3,4}^{\min}$

B-tagging

Both experiments use b-tagging through reconstruction of secondary vertices:

- Find track-jets
- Find secondary vertices within jets.
- Determine distance between secondary and primary vertex.



Both experiments check the significance of the displacement of the sec. vertices:

CDF

Accepts tags with significance > 3.

DØ

Accepts tags with significance > 7.

Final signal selection

CDF

Preselection plus 4 straight cuts:

$6 \leq N_{\text{jets}} \leq 8$
$A + 0.0037 H_T^{3\text{j}} \geq 0.85$
$C \geq 0.77$
$H_T \geq 320$ GeV

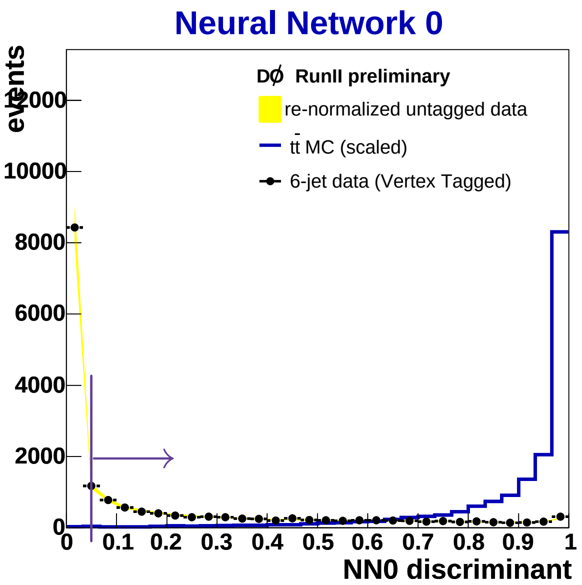
Counting secondary vertices

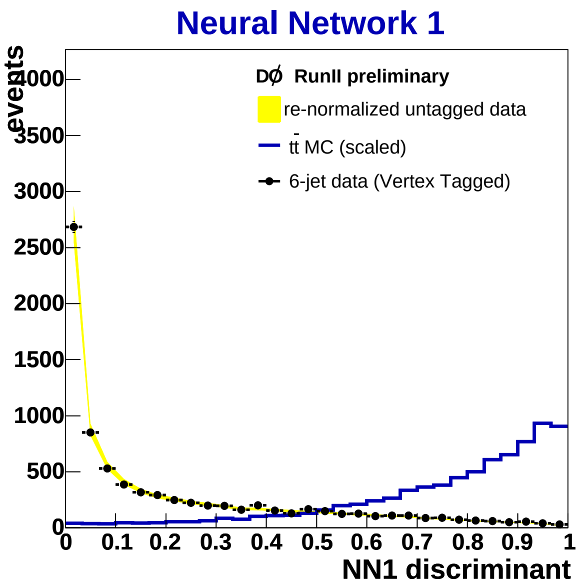
$\Rightarrow$ 326 b-Tags

DØ

3 artificial neural networks:

- NN0: Further preselection.
  Inputs: H_T, $\sqrt{s}$, N^A_{jets}, S, A and C.
- One secondary vertex tag
- NN1: Kinematics.
  Inputs: as NN0 plus $E_{T_{4,5}}$, $\langle \eta^2 \rangle$
  Result is fed into NN2





- NN2: Top properties:
  NN1 and rec. masses
  NN2≥ 0.75

Counting events:
$\Rightarrow$ 220 b-tagged events.

Background Description

- Tag Rate Functions (TRFs) parametrise probability to b-tag a jet.

- TRFs are measured after preselection (i.e. on background dominated sample)

CDF

uses only 4-jet events
parametrises in p_T, η,
$\#$ tracks at primary vertex,
N_{tracks} and Aplanarity.

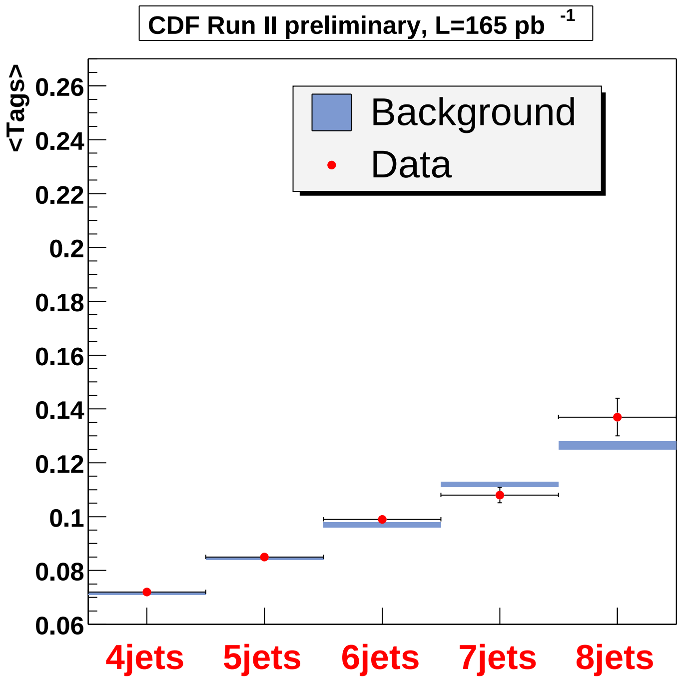
DØ

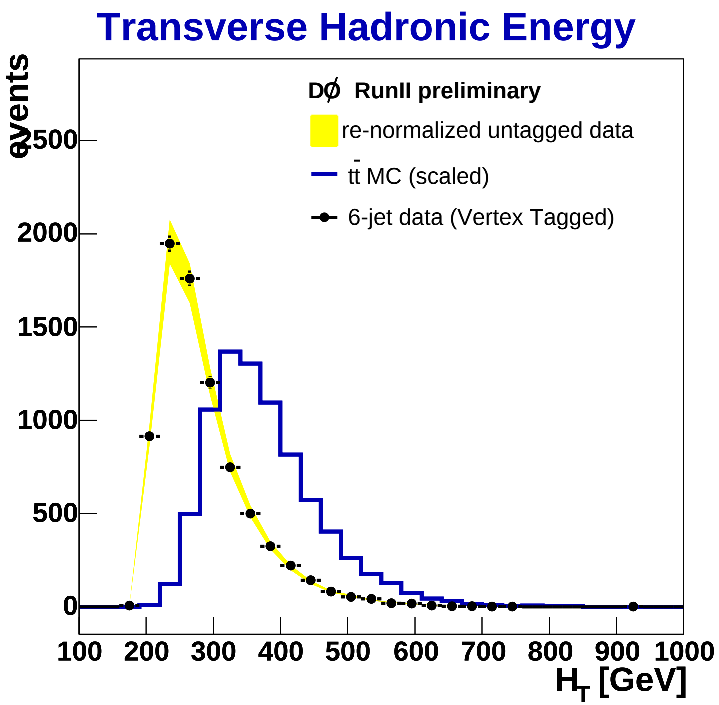
uses all preselected events (after NN0)
parametrises in p_T, η and 4 H_T bins.

- Replacing an actual b-tag with a weight computed from the TRFs simulates a b-tag as if the sample was all background.

Cross checks of TRFs

Both CDF and DØ prove that reweighted samples agree with tagged data:





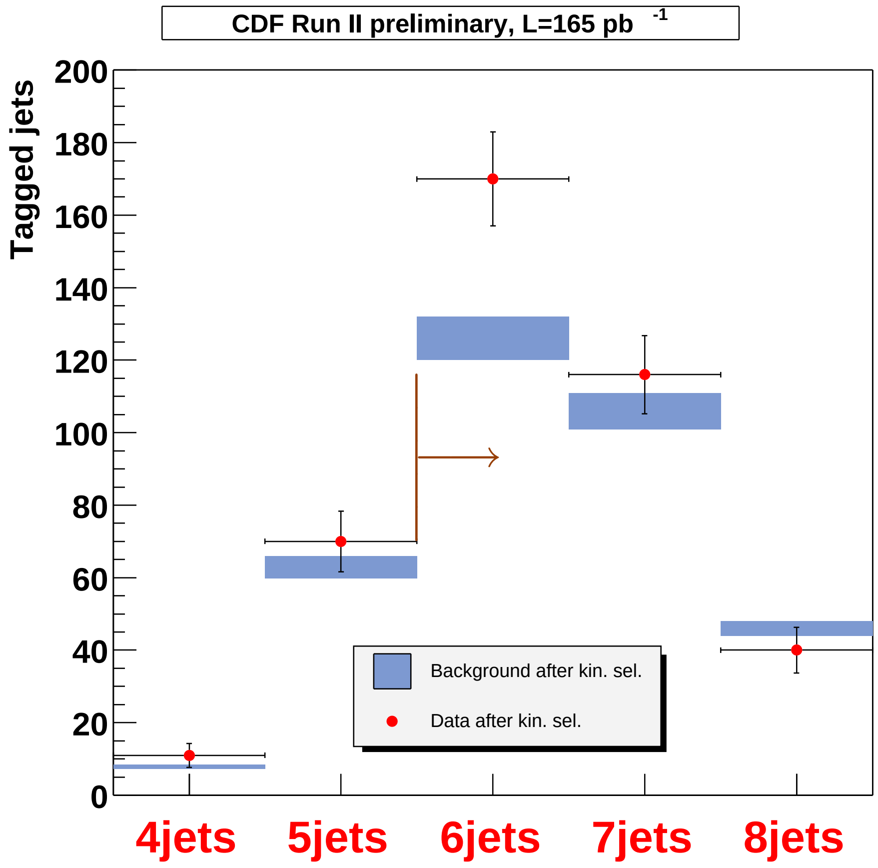
CDF

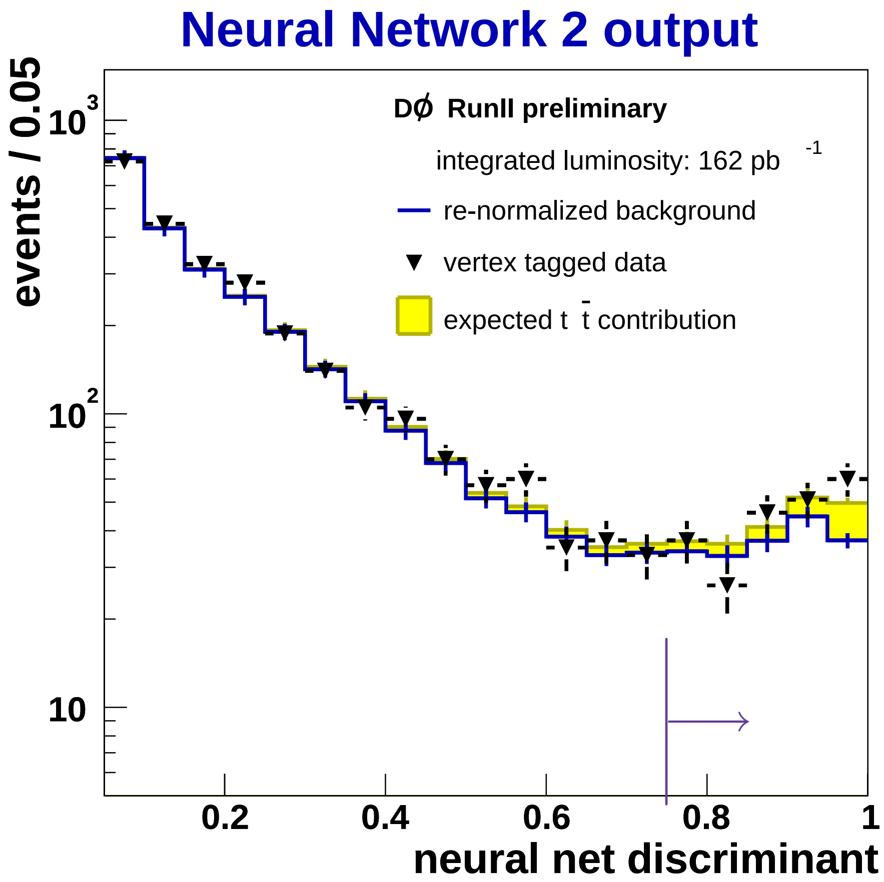
264.7 ± 17.2 background tags expected

DØ

186 ± 14.8 background events expected

Selected Signal





CDF

$326-265=61$ surplus *b-Tags*.

DØ

$220-186=34$ surplus tagged *Events*.

Signal Efficiencies

Signal efficiencies are obtained on $t\bar{t}$-simulation

CDF

kinematical select.	0.062 ± 0.012
trigger	1.00
mean # of b-tags	0.763 ± 0.065
Total	0.047

DØ

pre-selection	0.388 ± 0.003
trigger	0.737 ± 0.008
NN0> 0.05	0.997 ± 0.011
b-Tag	0.456 ± 0.005
NN2> 0.75	0.436 ± 0.007
Total	$0.058 \pm 0.001 \pm 0.018_{\mathrm{syst}}$

Systematic uncertainties investigated include:

CDF

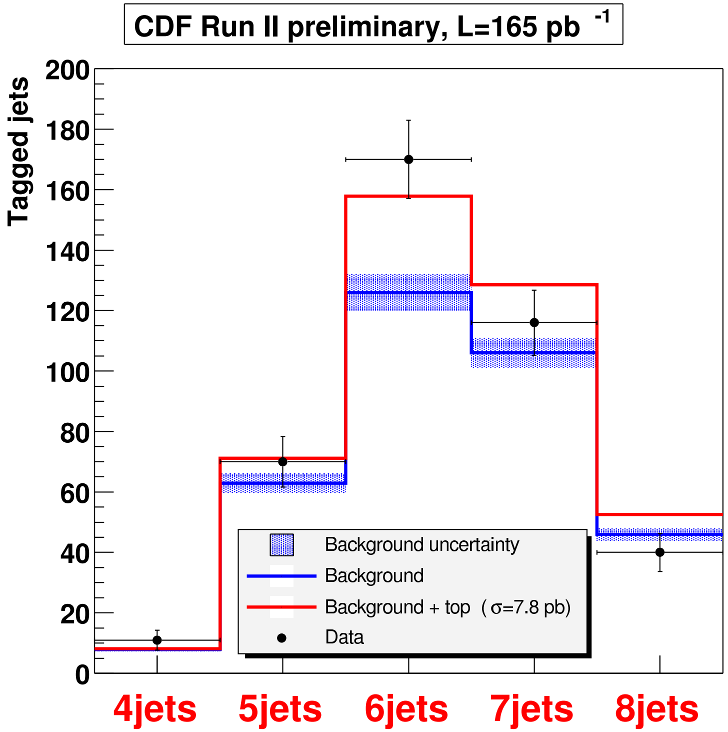
Generator	$\pm 2.9\%$
ISR/FSR	$\pm 4.0\%$
p.d.f	$\pm 7.4\%$
Jet Energy Scale	$\pm 28.8\%$

DØ

Jet Identification	-9.8%
Jet Energy Scale	$\pm 28.2\%$
Top Mass ± 5 GeV	$^{-7.6\%}_{+5.9\%}$
Trigger eff.	$\pm 4.0\%$

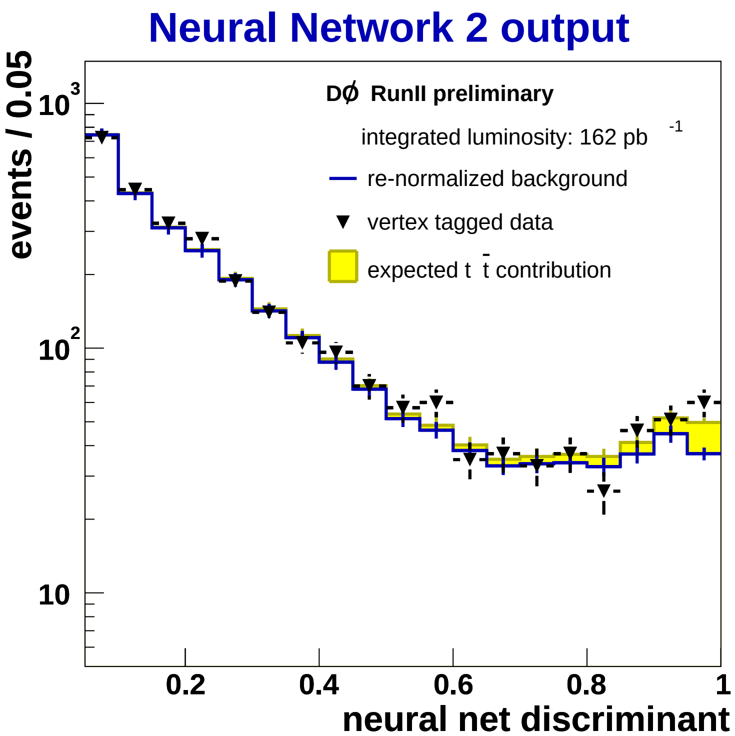
Results

CDF



$$\sigma_{t\bar{t}} = 7.8 \pm 2.5_{\text{stat}} \, {}^{+4.7}_{-2.3}\,{}_{\text{syst}}$$

DØ



$$\sigma_{t\bar{t}} = 7.7\, {}^{+3.4}_{-3.3}\,{}_{\text{stat}}\, {}^{+4.7}_{-3.8}\,{}_{\text{syst}} \pm 0.5\,{}_{\text{lumi}}$$

Dominating systematic uncertainties

- Efficiency: Jet Energy Scale: $\sim 30\%$ on ε.
- Background estimation from TRF: $\sim 7\%$ on B, $\Rightarrow 30\%$–40% in final result.

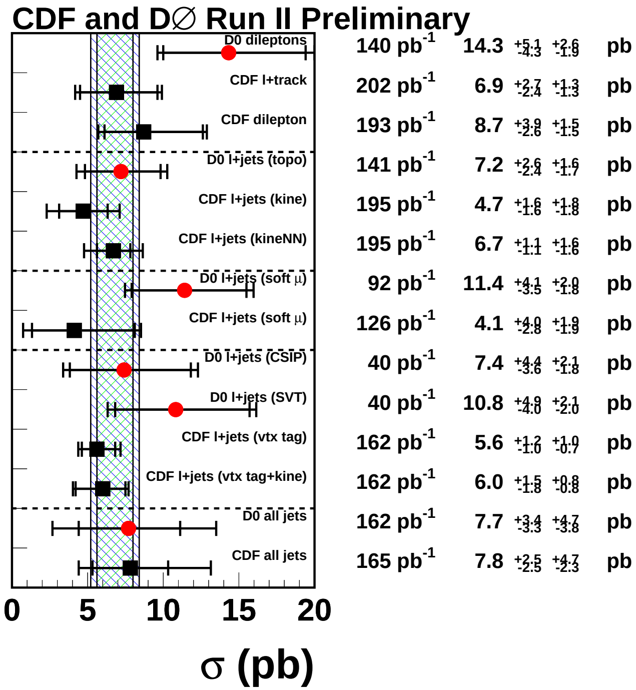
Summary

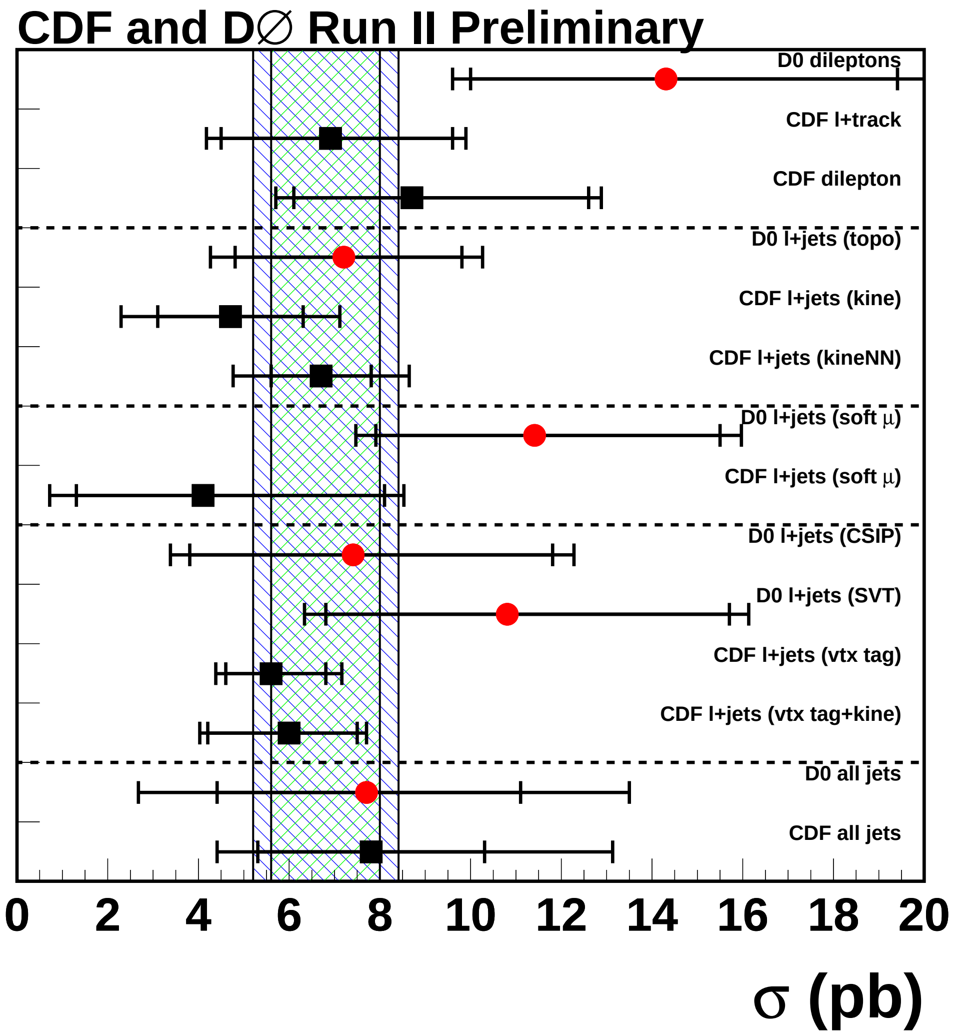
- Top pair production cross-section presented by both CDF and DØ
  - Luminosity $\sim 160\,\text{pb}^{-1}$
  - Signal is extracted using kinematical properties and b-tagging.
  - Background determination is done from data using TRFs.
  - Signal efficiencies from MC.

- Dominating systematic uncertainties:
  - Jet energy scale
  - Background estimation

- CDF: $\sigma_{t\bar{t}} = 7.8 \pm 2.5_{\text{stat}}\ {}^{+4.7}_{-2.3}\,{}_{\text{syst}}$

  DØ: $\sigma_{t\bar{t}} = 7.7\ {}^{+3.4}_{-3.3}\,{}_{\text{stat}}\ {}^{+4.7}_{-3.8}\,{}_{\text{syst}} \pm 0.5\,{}_{\text{lumi}}$




CDF and DØ Run II Preliminary
D0 dileptons
CDF l+track
CDF dilepton
D0 l+jets (topo)
CDF l+jets (kine)
CDF l+jets (kineNN)
D0 l+jets (soft μ)
CDF l+jets (soft μ)
D0 l+jets (CSIP)
D0 l+jets (SVT)
CDF l+jets (vtx tag)
CDF l+jets (vtx tag+kine)
D0 all jets
CDF all jets
0 2 4 6 8 10 12 14 16 18 20
σ (pb)