

# $t\bar{t}$ Production in the Alljets Channel @ DØ

Top Quark Pair Production @ Tevatron  
Decay Signature & Preselection  
Plain Cut Analysis  
Neural Net Analysis  
Summary



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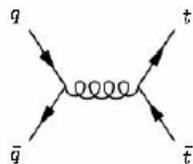
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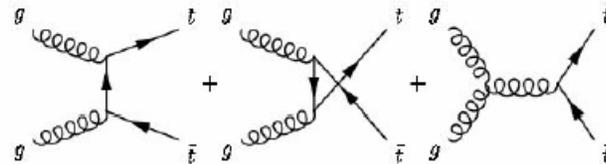
Annual APS April Meeting, April 24 2006

# Top Quark Pair Production & Decay

- Top Quark Pair production in  $p\bar{p}$  collisions at the Tevatron (1.96 TeV):



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



15%  $gg$  fusion

- SM top decay  $\approx 100\%$   $Wb \Rightarrow$  Final states determined by W decay mode

$t\bar{t}$  decay modes

$\Rightarrow$  **2 b-jets**

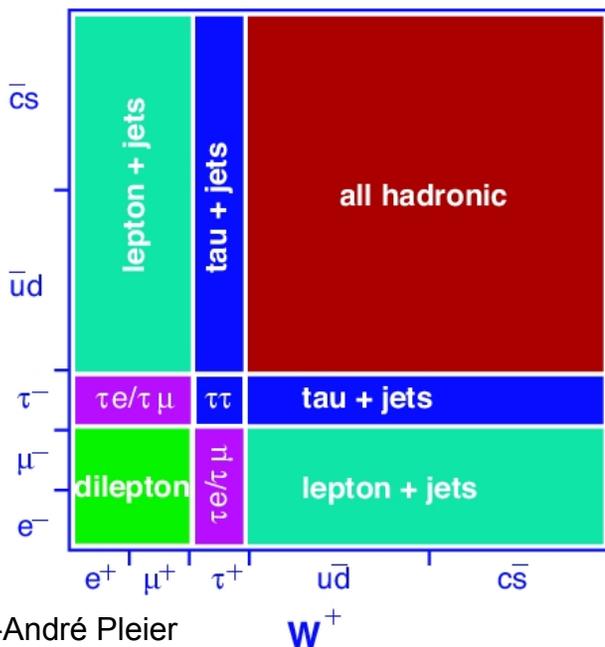
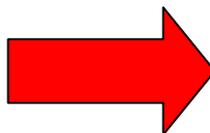
$\Rightarrow$  Up to two charged leptons/neutrinos

$\Rightarrow$  Up to **four additional jets**

**all hadronic  $\approx 46\%$** , 1+jets  $\approx 44\%$ , dilepton  $\approx 10\%$

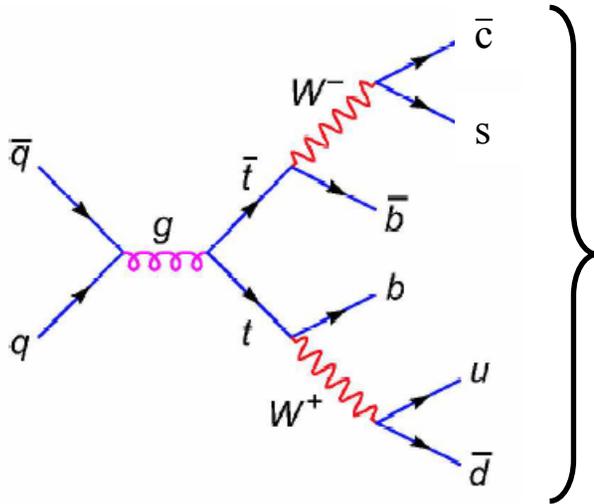
Need to reconstruct/identify:

- Electrons, muons, taus,
- Missing transverse energy
- Jets/b-jets**



# Decay Signature & Preselection

- require primary vertex:  
 $\geq 3$  tracks,  $|z| < 50 \mid 60$  cm



- high branching fraction
- all decay products “visible”
- no energetic vs produced  
 $\Rightarrow$  no cut on  $E_T$

## Plain Cut Analysis:

- 6 Jets within  $|\eta| < 2.4$ :
- $\geq 2$  **b-tagged** jets,  
 $p_T > 45$  GeV/c
- $\geq 4$  non-b jets,  
 $\geq 2$  jets,  $p_T > 20$  GeV/c  
 $\geq 2$  jets,  $p_T > 15$  GeV/c
- $\geq 2$  tracks per jet cone  
point to primary  
vertex

## Neural Net Analysis:

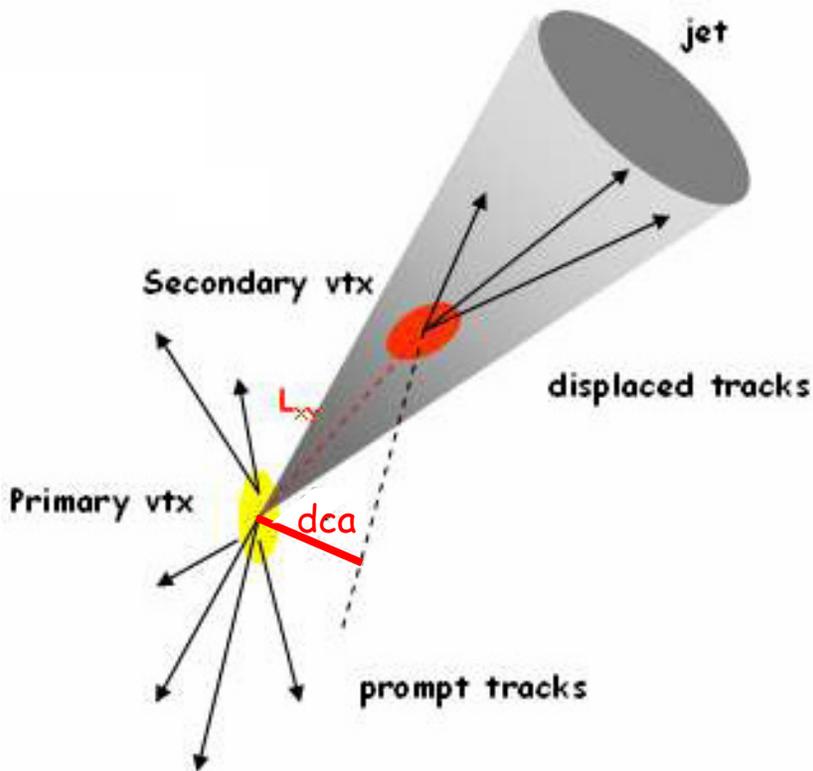
- $\geq 6$  Jets with  $|\eta| < 2.5$ ,  
 $p_T > 15$  GeV/c
- $\geq 1$  **b-tagged** jet
- veto isolated leptons  
(Orthogonality wrt.  
lepton+jets)
- reject events including  
two distinct multijet  
events

## Main background:

- overwhelming “QCD” multijet production
- jets from multiple interactions

**need b-jet  
identification**

# Lifetime b-Tagging at DØ



(dca = distance of closest approach)

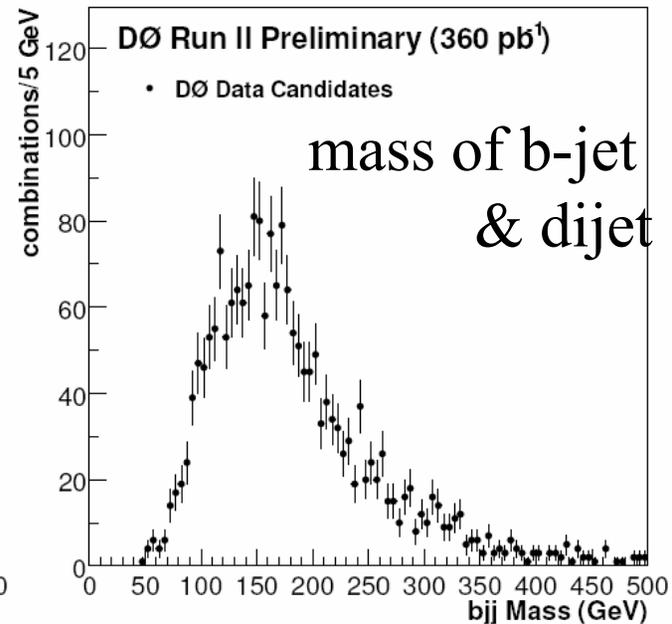
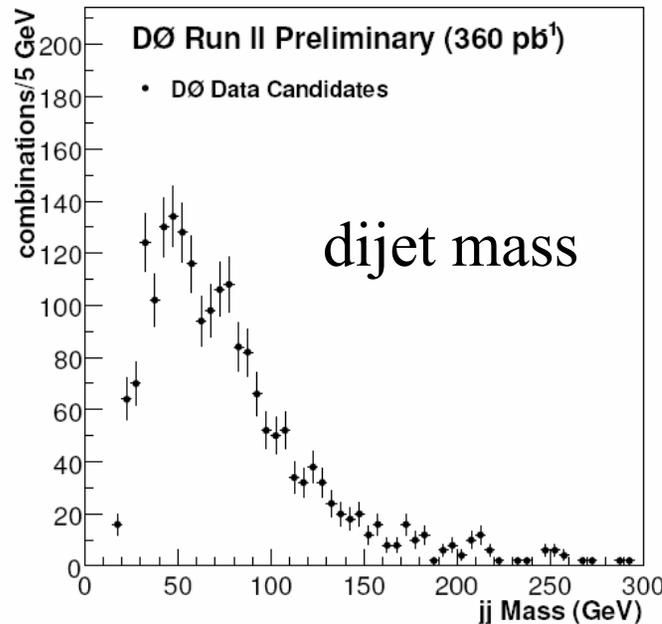
## Secondary Vertex Tagger (SVT)

- Reconstruct vertices which are significantly ( $7\sigma$ ) displaced from the primary vertex
- $V^0$  Filter:  
Remove track pairs in the mass windows corresponding to  $K_S$ ,  $\Lambda$  and photon conversions ( $\gamma \rightarrow e^+e^-$ )

# Plain Cut Analysis (I)

- Signal preselection: see previous slide.

look for W and top candidates in mass spectra, using all jet combinations



- Background derived from *untagged* data:
  - assign b-flavoured jets at random for each event
  - if b-jet kinematics are fulfilled, define it a b-jet
  - if not, define it a non-b-jet if kinematic condition is fulfilledKeep event if desired multiplicity is reached and treat it like a signal event.

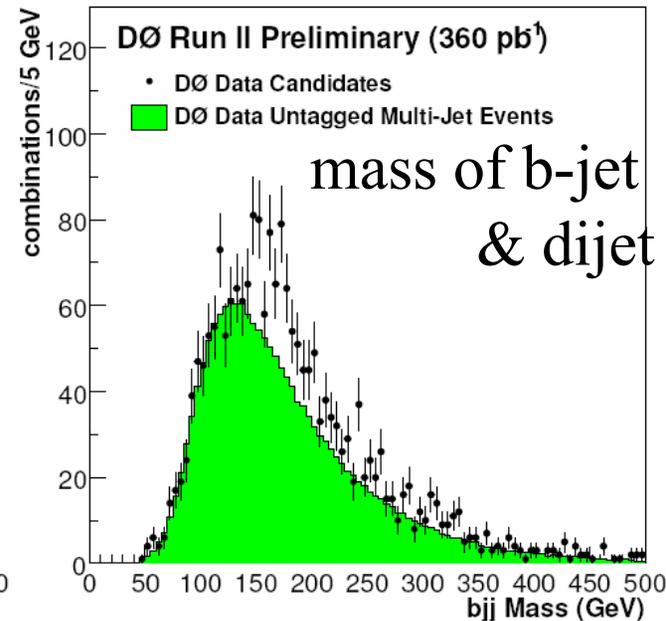
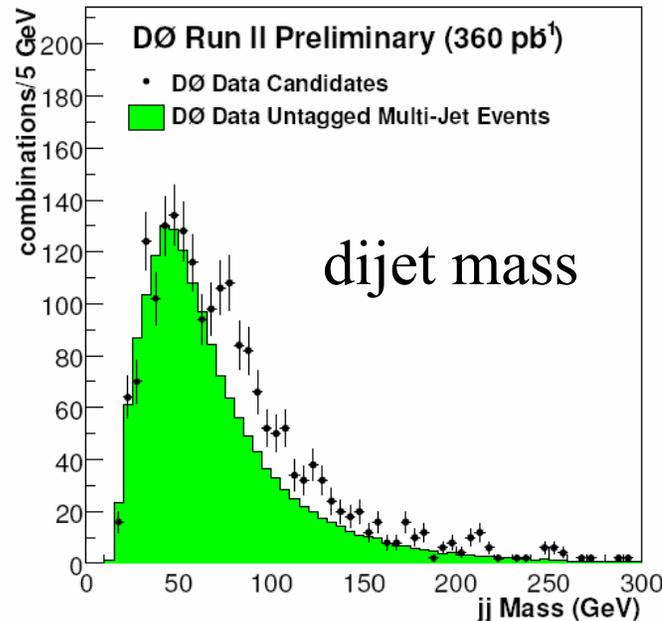
# Plain Cut Analysis (II)

- Normalize background sample to candidate distribution in area  $M_{jj} < 65\text{GeV}$
- Add weights to background sample for proper kinematic correlations of b-jets in b-jet  $p_T$  spectrum and angular correlation between b-jets  $\Delta R_{bb}$ .

significant excess  
of W and top  
candidates in mass  
spectra



(Use W mass peak fit  
to fix jet energy scale)



## To extract cross-section:

- Determine selection efficiency  $\epsilon_{tt}$  from signal MC
- Use data-MC scalefactor for b-jet identification  $S_{SVT}$
- Determine efficiency of background subtraction procedure  $\epsilon_{SB}$

# Plain Cut Analysis (III)

$$\sigma_{t\bar{t}} = \frac{1}{\mathcal{L}} \frac{(N^{\text{candidates}} - N^{\text{background}})}{\epsilon_{t\bar{t}} \epsilon_{SB} S_{\text{SVT}}}$$

$$N^{\text{candidates}} = 173 \pm 13$$

$$N^{\text{background}} = 140.4 \pm 0.8$$

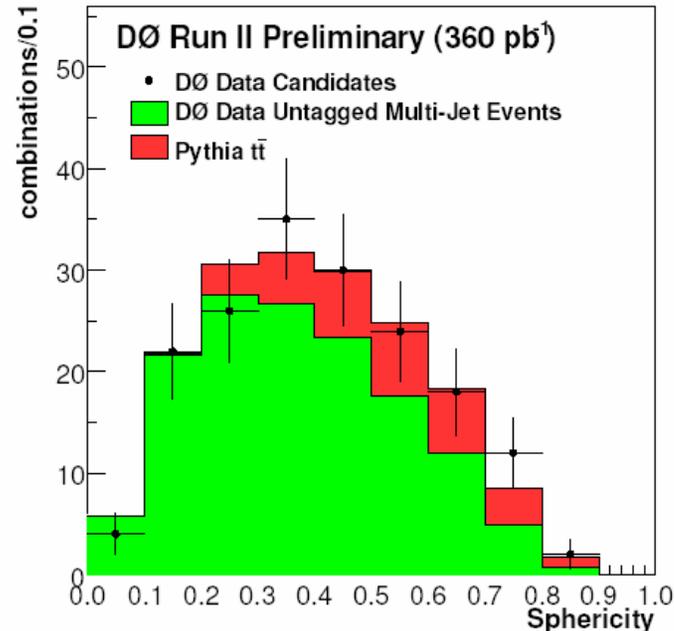
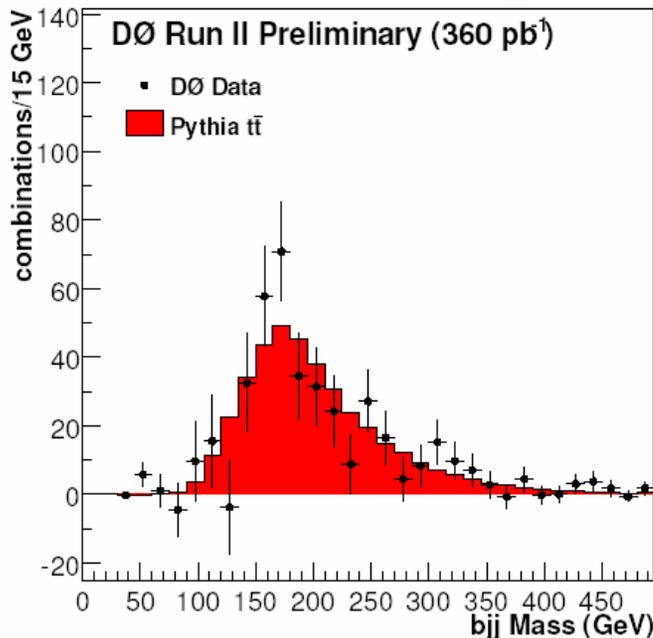
$$\epsilon_{t\bar{t}} = 1.51\%$$

$$\epsilon_{SB} = 80\%$$

$$S_{\text{SVT}} = 62\%$$

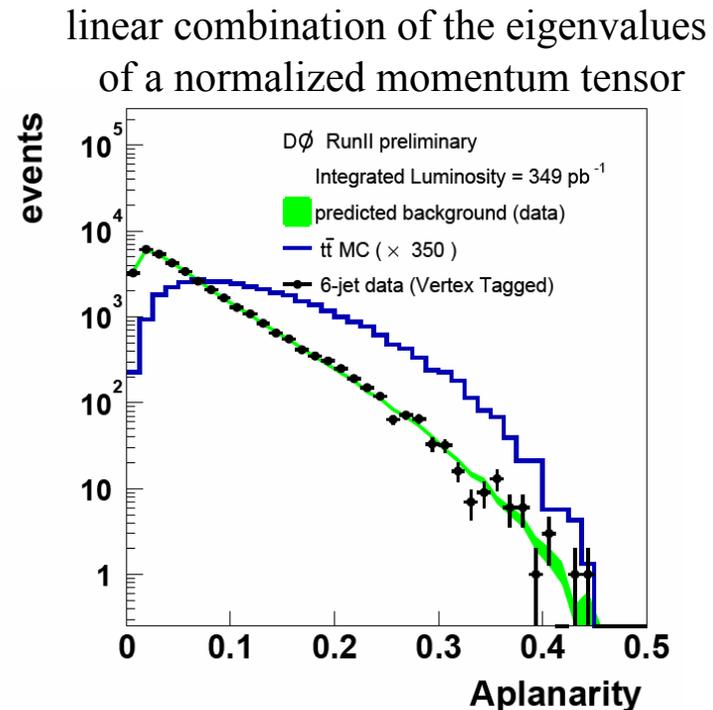
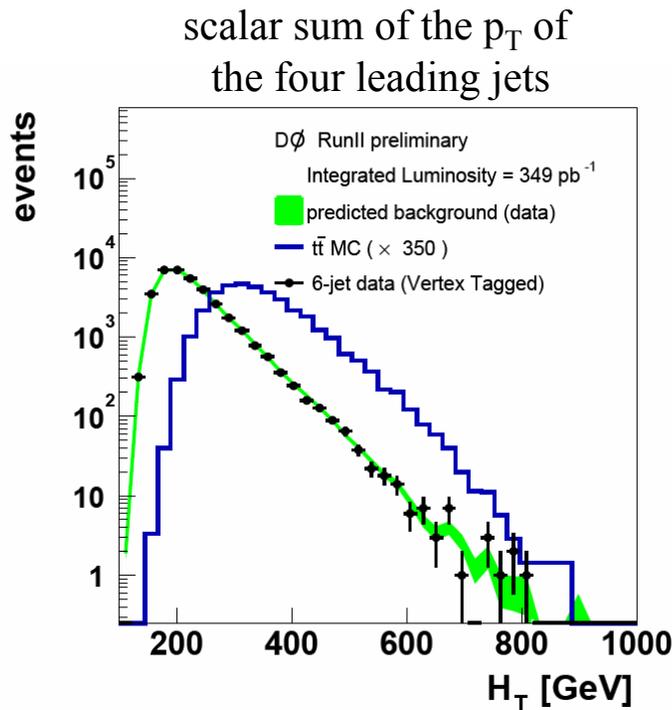
$$\sigma_{t\bar{t}} = 12.1 \pm 4.9 \text{ (stat.)} \pm 4.6 \text{ (sys.) pb}$$

## Comparisons with signal MC:



# Neural Net Analysis (I)

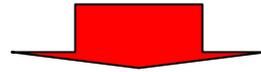
- **Kinematic variables** allow separation of signal and background.
- Choose variables for **separation power** and if possible **low sensitivity to systematics** (jet energy scale).



Obtain background prediction from *untagged* preselected data and probability to tag an event based on per-jet tagging probability.

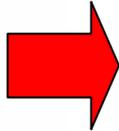
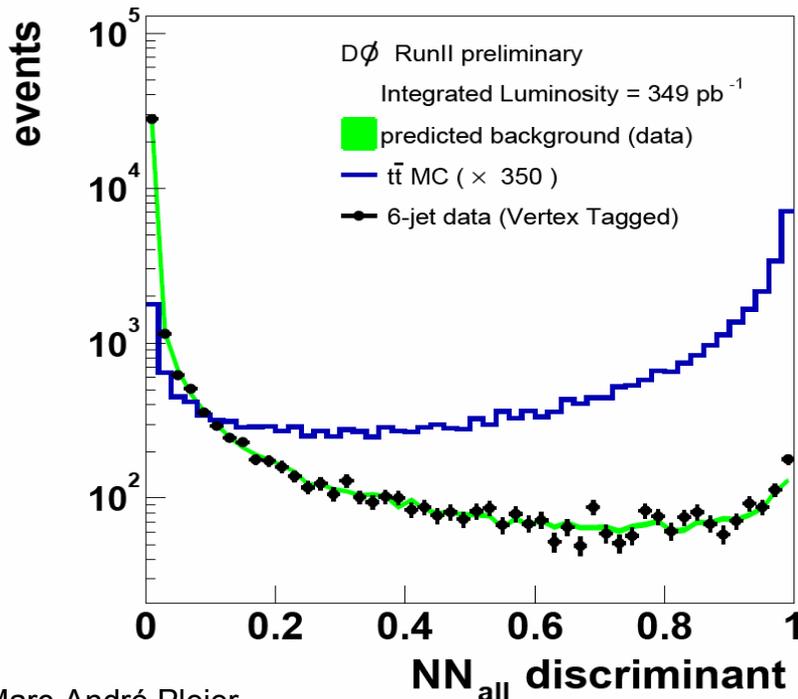
# Neural Net Analysis (II)

Single variables after rather “loose” preselection  
don’t show significant excess due to signal



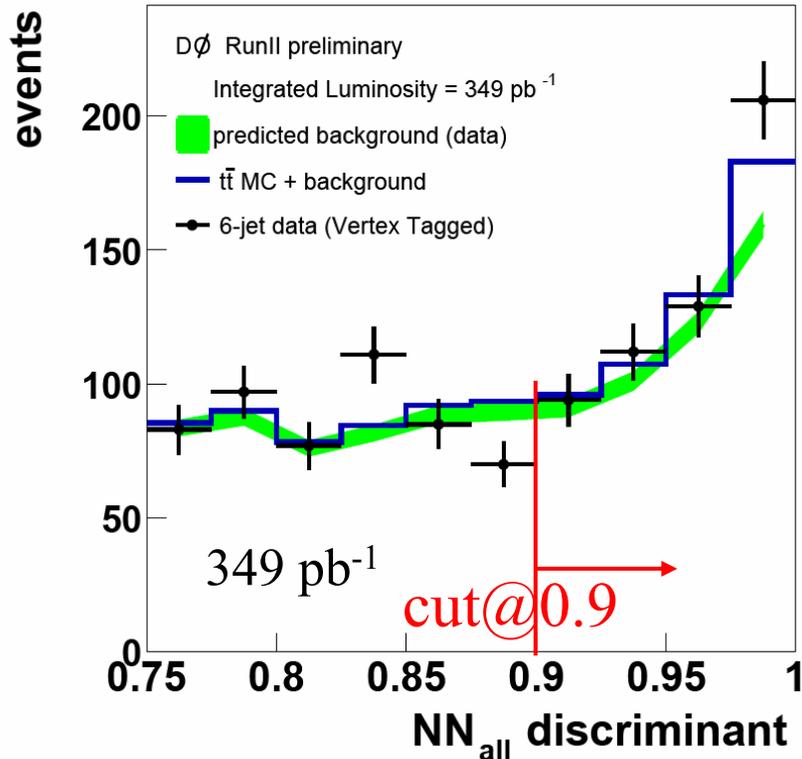
Combine into Neural Network:

(NN is trained on subset of untagged data for background,  $t\bar{t}$  MC for signal.  
6 kinematic variables are used.)



- Obtain signal enriched sample by cut on  $NN > 0.9$
- Cut value is optimized for expected analysis significance

# Neural Net Analysis (III)



events observed in data: 541  
 predicted background: 494

$$\sigma_{t\bar{t}} = \frac{N^{\text{candidates}} - N^{\text{background}}}{L \epsilon_{t\bar{t}} \epsilon_{\text{corr}}}$$

$$\sigma_{t\bar{t}} = 5.2^{+2.6}_{-2.5}(\text{stat})^{+1.5}_{-1.0}(\text{syst}) \pm 0.3(\text{lumi}) \text{ pb}$$

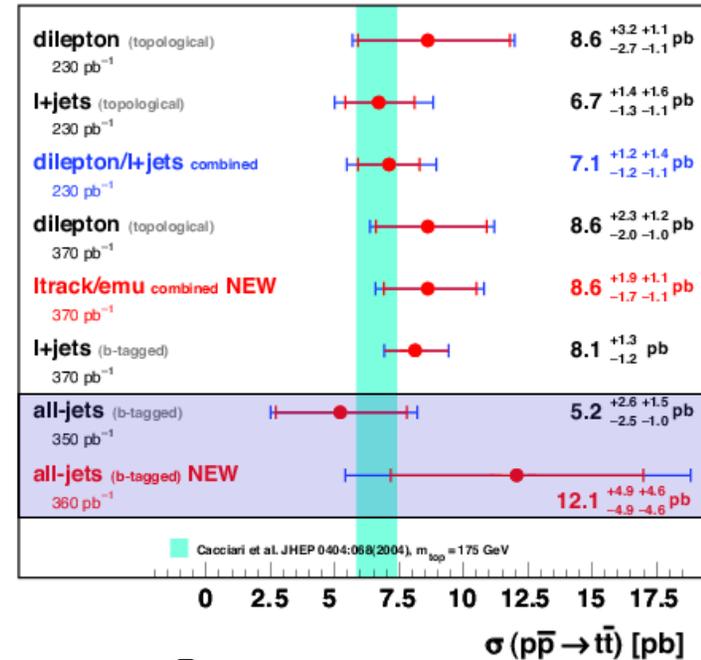
Source	Effect on cross section [pb]	
Jet energy calibration	+1.12	-0.73
Jet Identification	+0.68	-0.42
Trigger	+0.27	-0.05
Background prediction	+0.52	-0.50
$t\bar{t}$ tagging probability	+0.34	-0.29
total	+1.48	-1.02

Future improvements: split up analysis in single/double tagged events

# Summary

- Measurements agree with SM expectations and each other
- First direct observation of top mass peak
- Ongoing analyses use almost three times more data and improved methods/calibration
- Improved jet energy scale precision
- Tevatron is making good progress (4-8 fb<sup>-1</sup> until 2009)

DØ Run II Preliminary



Stay tuned!



non?  
Standard-  
Model