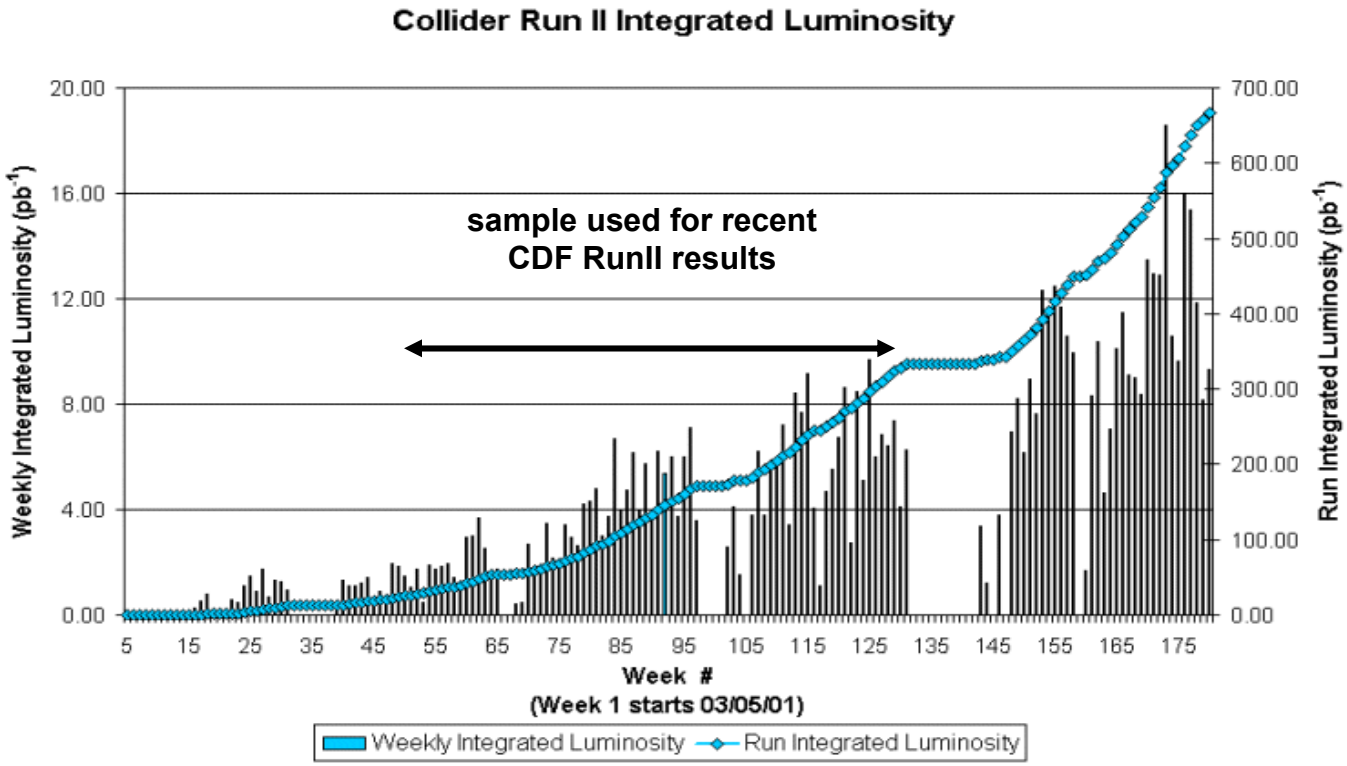
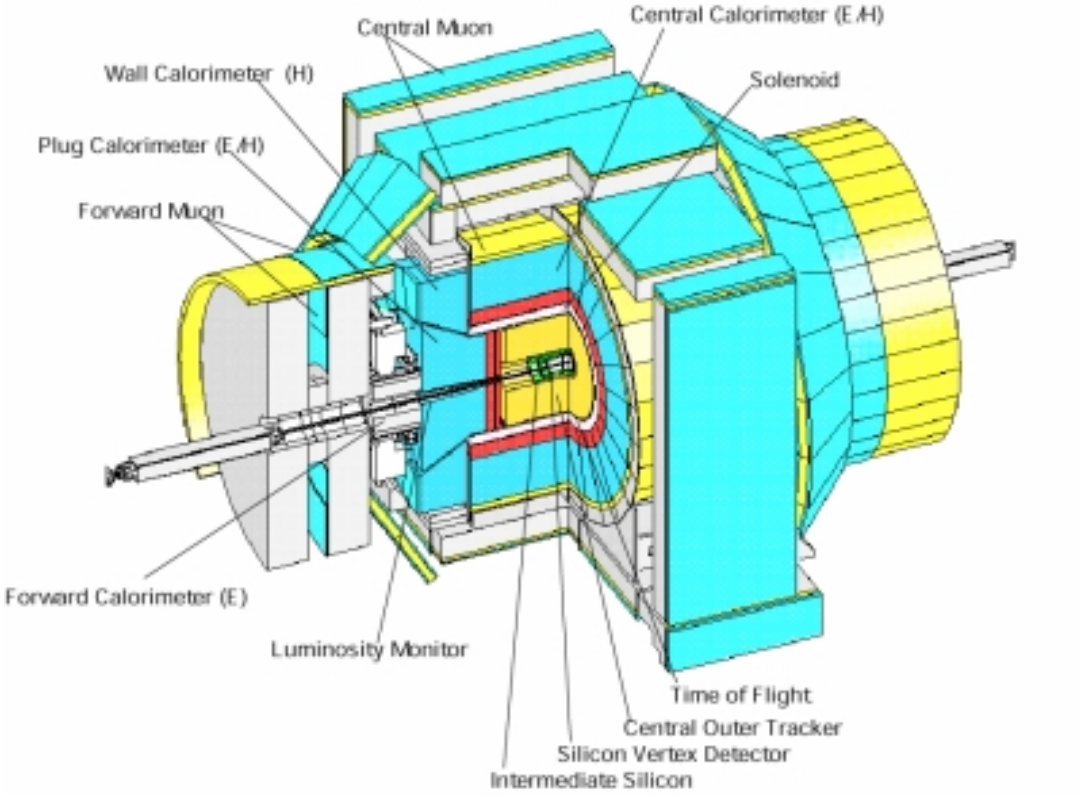
Measurement of top pair production in the *lepton+jets* channel at CDF using event kinematics and neural networks

Radu Marginean for the CDF Collaboration



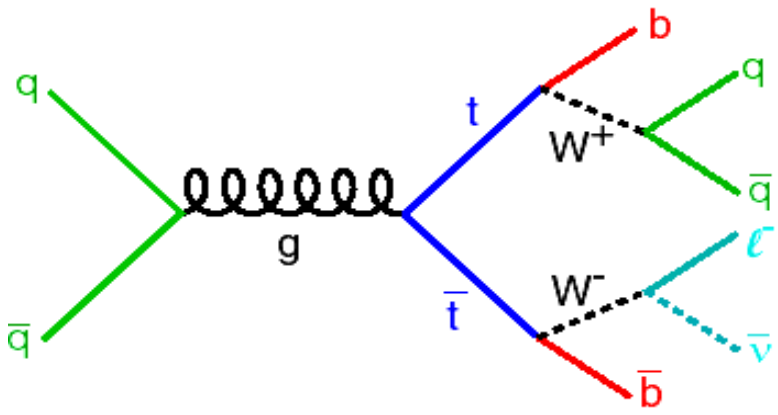
- Luminosity record 10.3×10^{31} cm^{-2} s^{-1}.
- CDF integrated luminosity so far: ~400 pb^{-1}.
- Data Sample: 193.5 pb^{-1} accumulated at CDF between March 2002 – September 2003.

The CDF detector



- Improved Silicon coverage: $|\eta| < 2$ (**SVXII**) .
- New Central Drift Chamber (**COT**): 8□12 layers.
- Time of Flight.
- Expanded muon coverage.
- Improved calorimetry.
- Trigger on displaced tracks .

Top pair detection in the Lepton+Jets channel



- √s = 1.96 TeV
- e+μ BR ~ 24/81

Event selection:

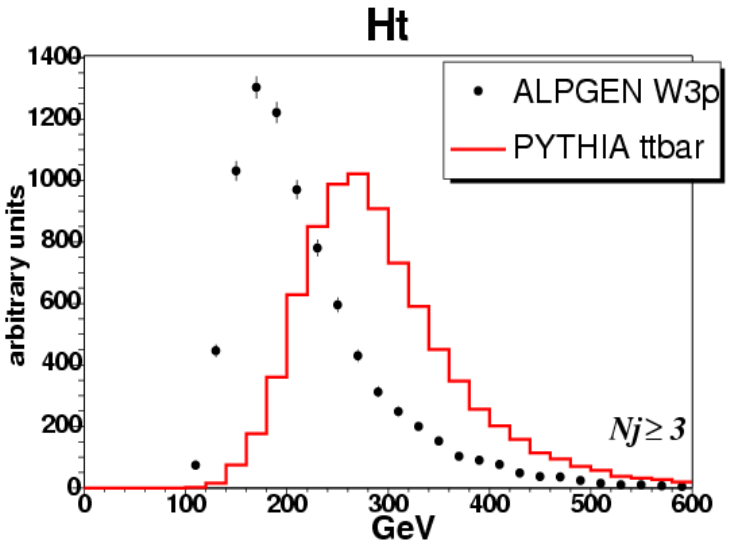
- One isolated lepton (e,μ):
  - E_T >20.0 GeV, Iso<0.1.
- At least 3 jets:
  - E_T > 15.0 GeV, |η|<2.0.
- Missing energy:
  - Met > 20 GeV.
- clean up QCD fakes,
  if 20.0<Met<30.0 (GeV) require:
  0.5<ΔΦ(Met-1stJet)<2.5
- veto dilepton events.
- veto lepton+track near Z mass.
- No b-tagging requirement.

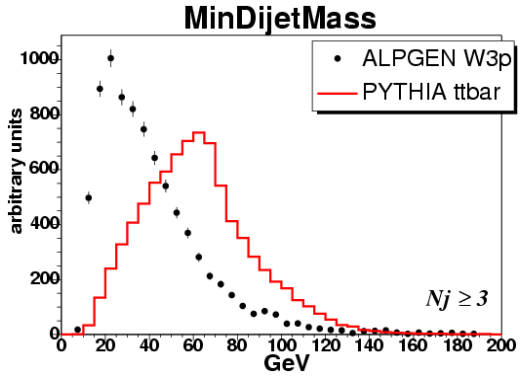
Acceptance for ttbar: 7.11%

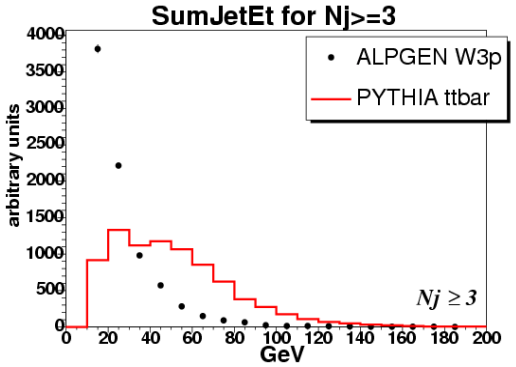
Kinematic signatures for top pair production

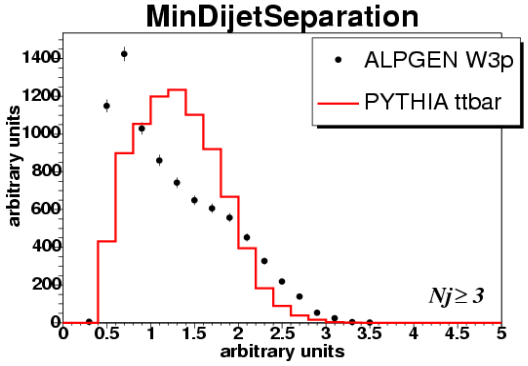
Central, spherical events.
Large transverse energy.

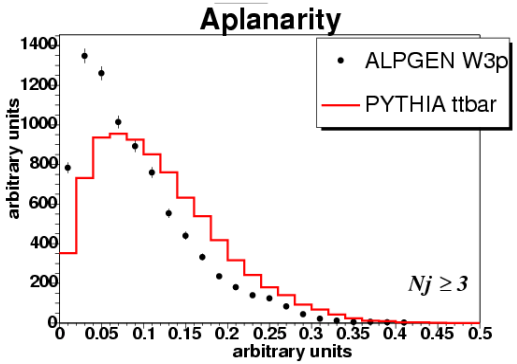
Signal: PYTHIA (M_{top}=175 GeV)
W+jets model: ALPGEN
Multijet fakes: data
Z+jets,WW,WZ+jets: ALPGEN

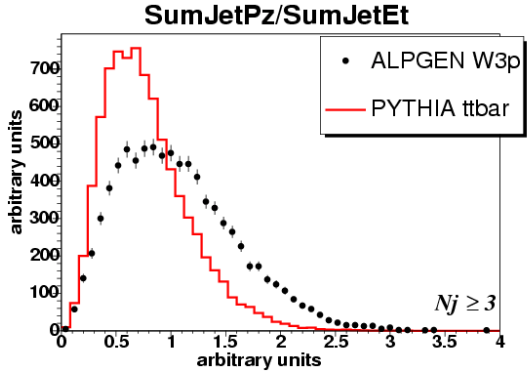


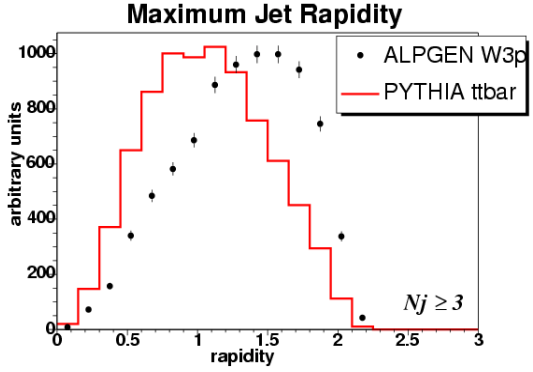




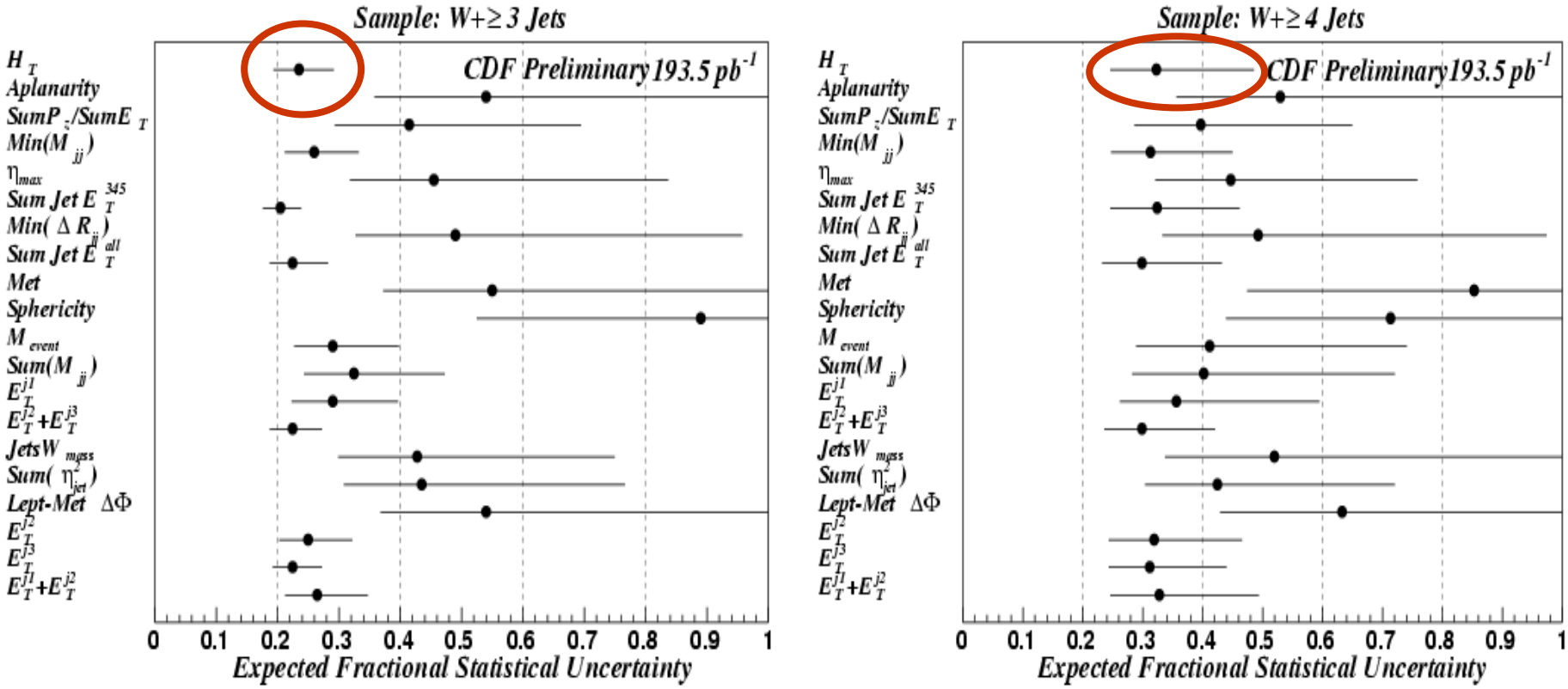








Sensitivity for single variable fits



Points: median for relative error distribution from pseudo-experiments. Error bars: 68% interval.

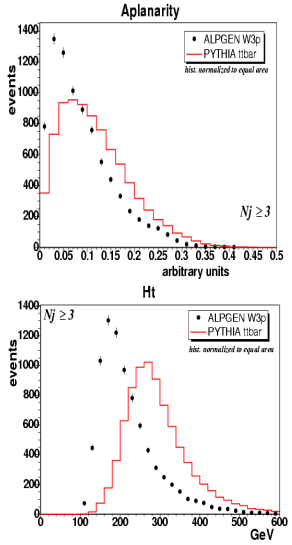
Using NN to enhance signal/bkg separation

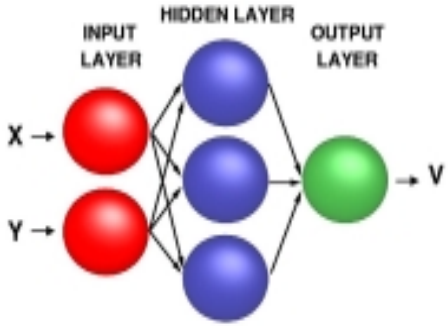
- Feed Forward NN.
- 1 hidden layer, 1 output in [0,1] range.
- Training/testing: JETNET

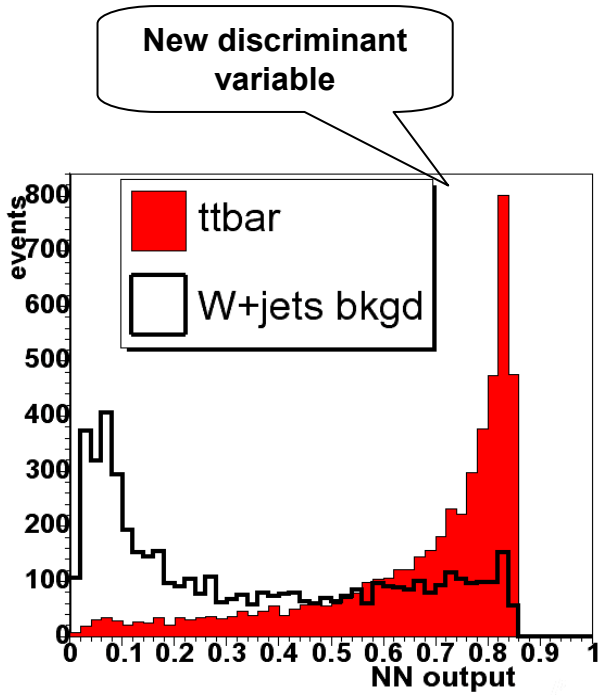
(Peterson et al. CERN-TH/7135-94)

- Typical error function: $E = \frac{1}{N}\sum_{i}^{N}(O_i - t_i)^2$

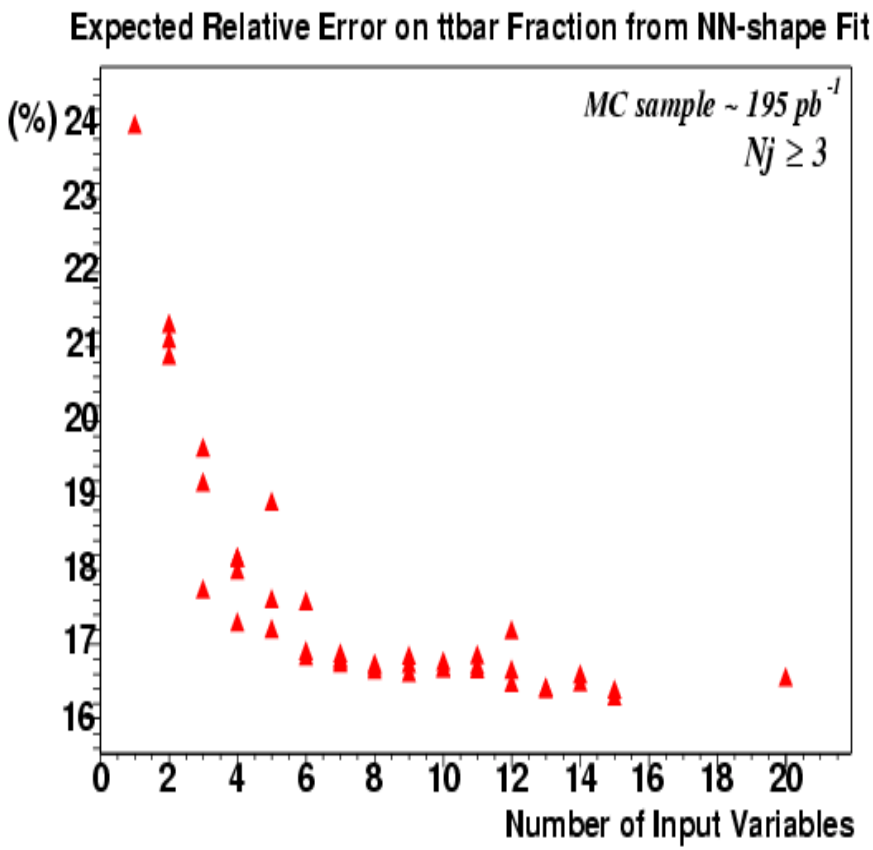
NN are composed of simple nonlinear processing units (neurons). By exposure to information (learning) they are able to adapt their function.

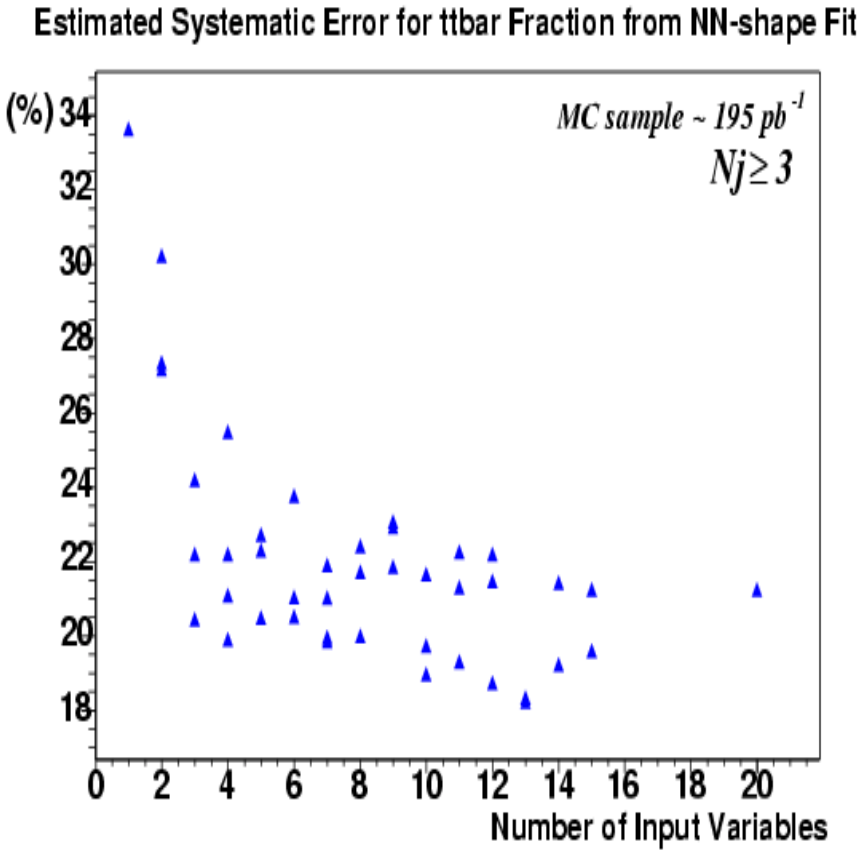






Choosing the NN configuration





Perform pseudo-experiments to estimate statistical/systematic errors.
Optimum NN architecture: 7in X 7hid X 1out .

Systematic errors: Ht and NN fit

Effect	Acceptance (%)	Shape (%)	Total (%)
Jet E_T Scale	4.7	21.4	26.1
W+jets Q^2 Scale	-	24.6	24.6
QCD fraction	-	2.4	2.4
QCD shape	-	4.5	4.5
Other EWK	-	1.8	1.8
ttbar PDF	1.5	2.2	4.7
ttbar ISR	2.1	1.1	2.9
ttbar FSR	1.7	1.5	3.7
ttbar generator	1.4	1.0	2.4
Lepton ID/trigger	2.0	-	2.0
Lepton Isolation	5.0	-	5.0
Luminosity	-	-	5.9
Total	-	-	37.8

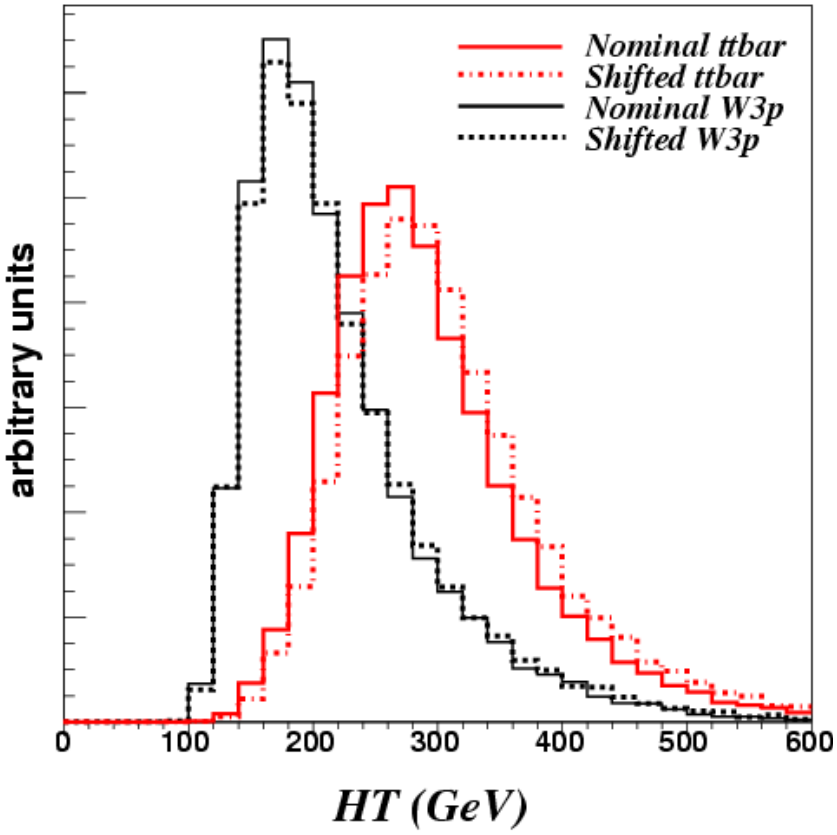
Ht fit

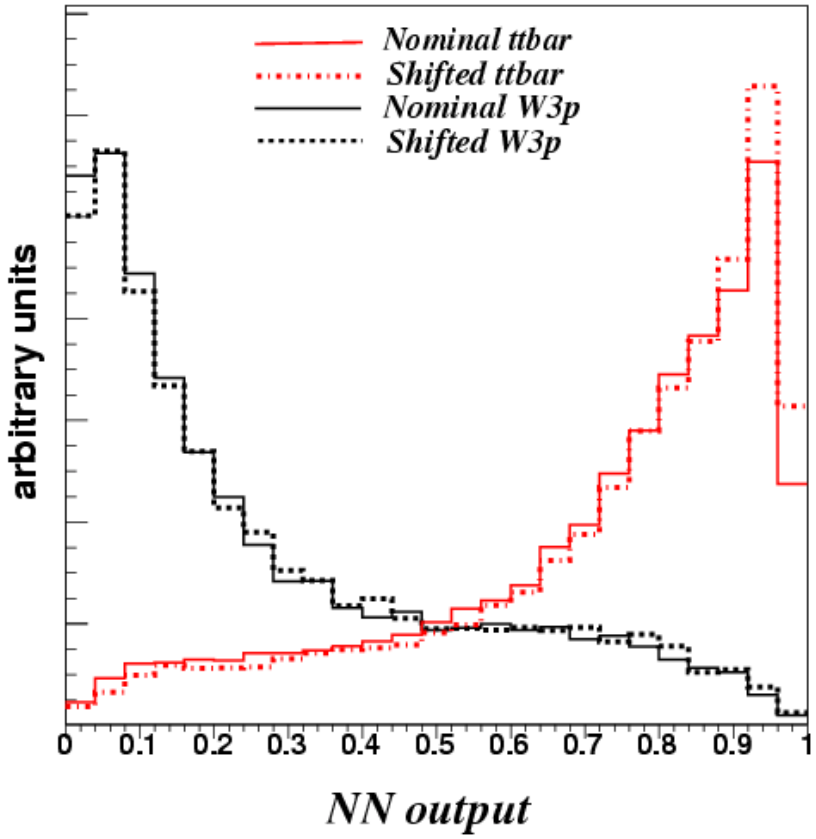
Effect	Acceptance (%)	Shape (%)	Total (%)
Jet E_T Scale	4.7	12.2	16.9
W+jets Q^2 Scale	-	10.2	10.2
QCD fraction	-	0.6	0.6
QCD shape	-	1.1	1.1
Other EWK	-	2.0	2.0
ttbar PDF	1.5	2.9	4.4
ttbar ISR	2.1	1.9	3.0
ttbar FSR	1.7	1.0	2.7
ttbar generator	1.4	0.3	1.7
Lepton ID/trigger	2.0	-	2.0
Lepton Isolation	5.0	-	5.0
Luminosity	-	-	5.9
Total	-	-	22.3

NN shape fit

NN produce a significant reduction of the systematics.

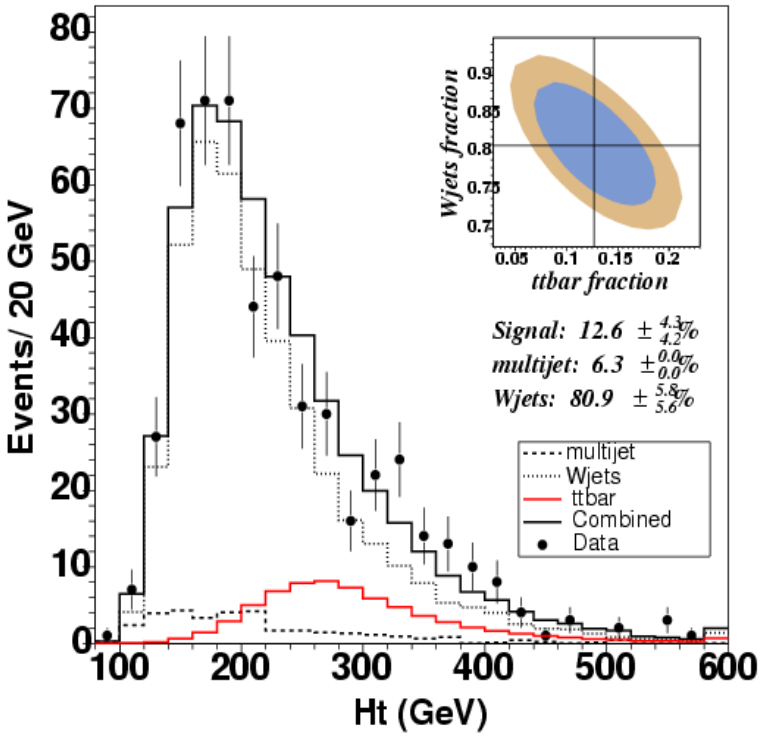
A closer look at the systematic errors

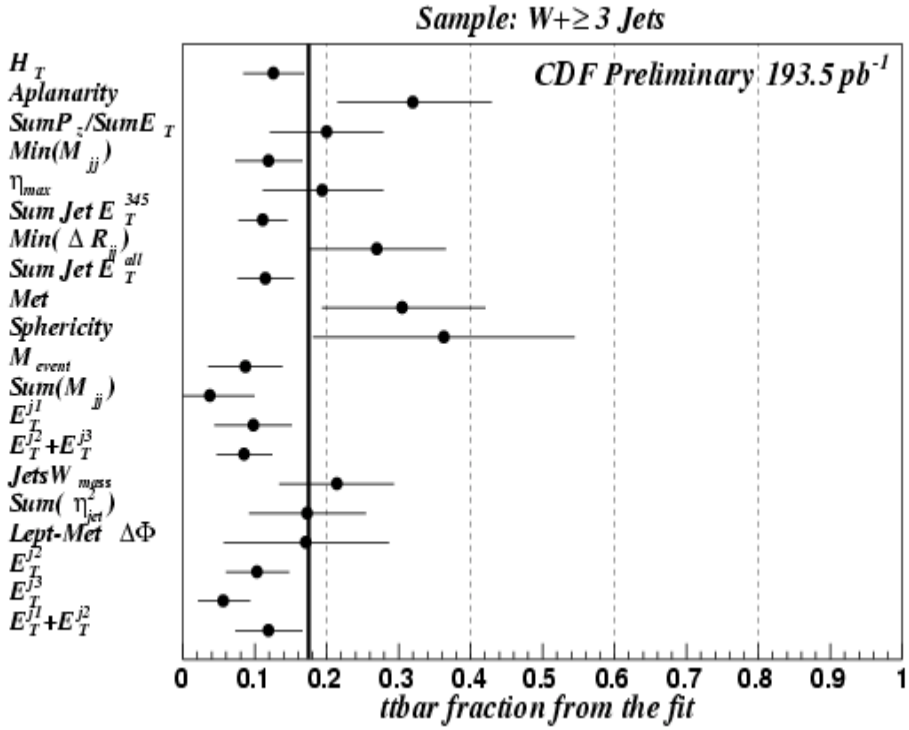




Behavior of the Ht and NN output templates under a positive shift in the jet energy scale.

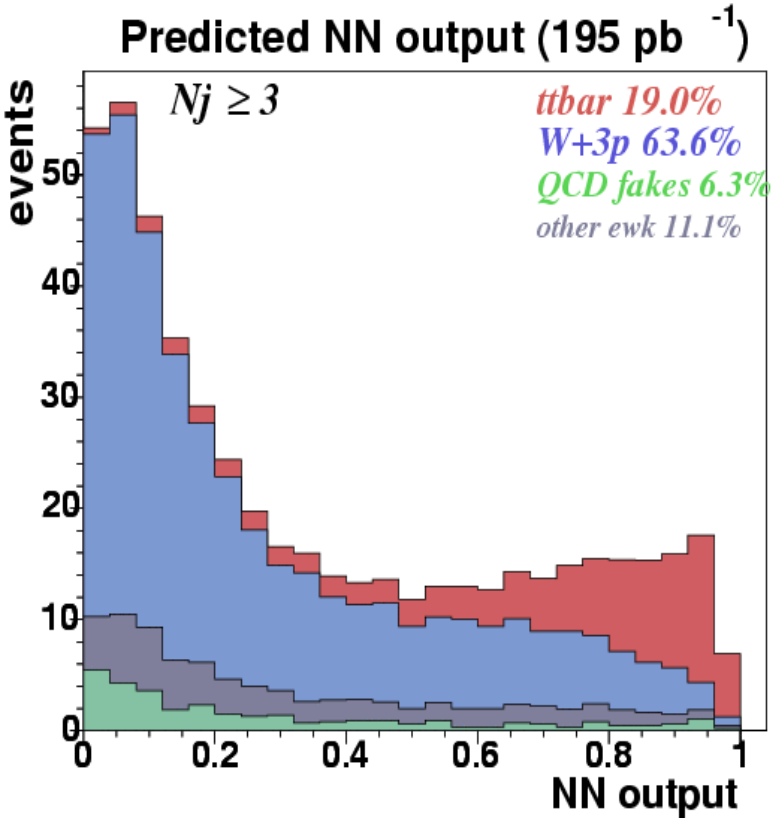
Single variable kinematic fits : Nj≥3



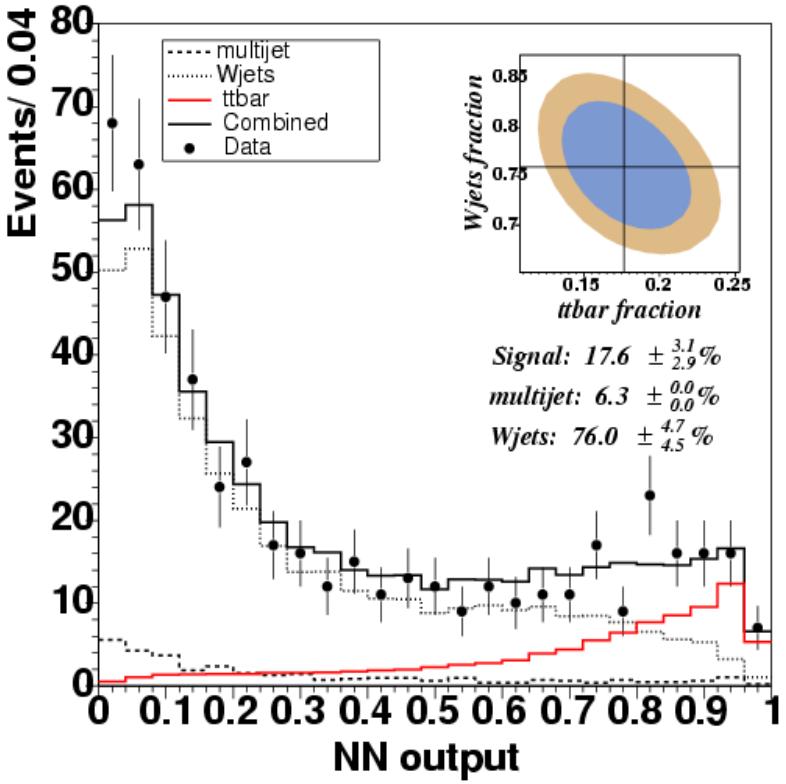


CDF Preliminary: $\sigma_{t\bar{t}} = 4.7 \pm 1.6(stat) \pm 1.8(sys)\, pb$

NN fit result in the Nj>=3 mode



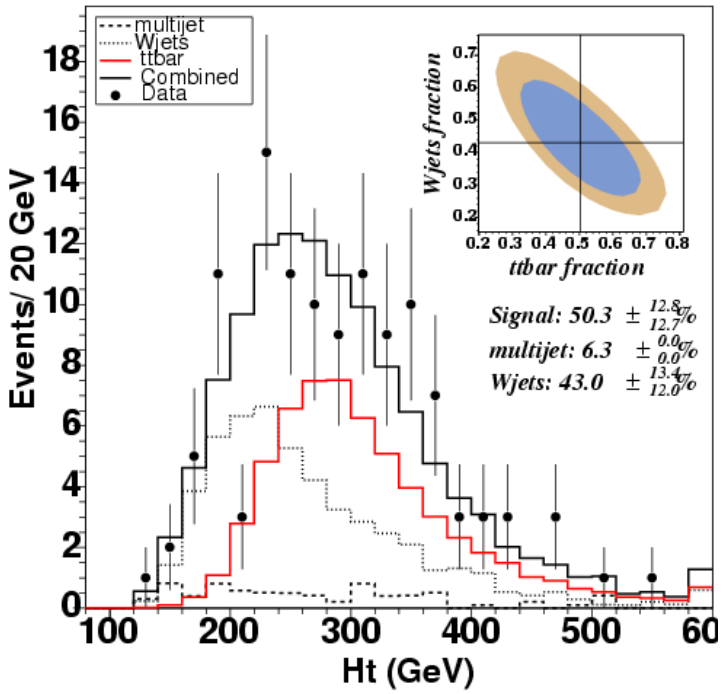
CDF Preliminary

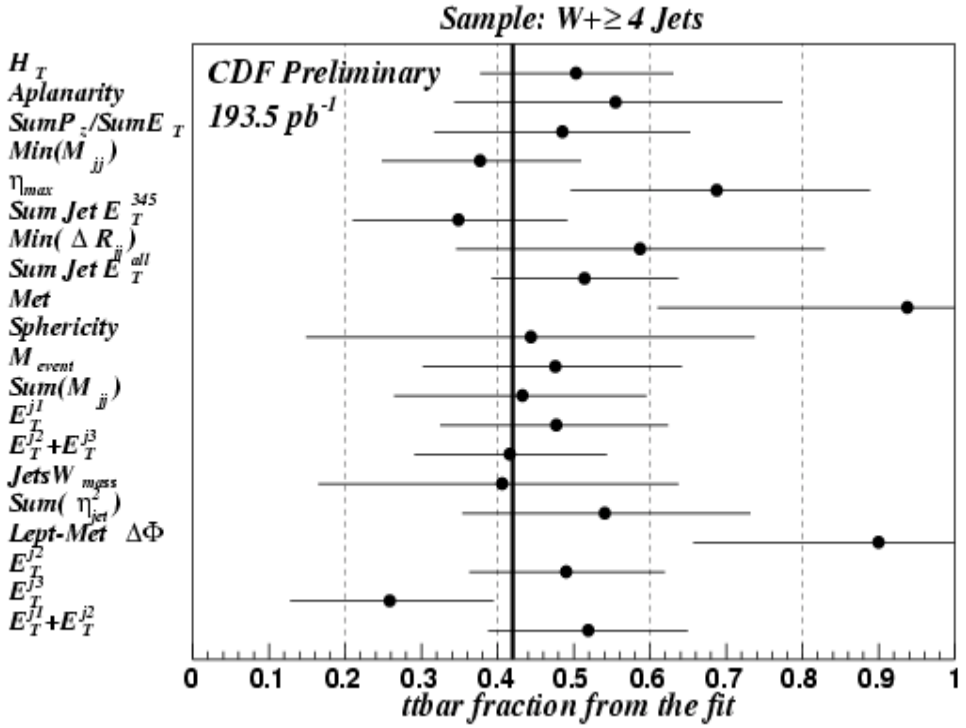


CDF Preliminary: $\sigma_{t\bar{t}} = 6.7 \pm 1.1(stat) \pm 1.6(sys)\, pb$

Single variable kinematic fits: Nj≥4

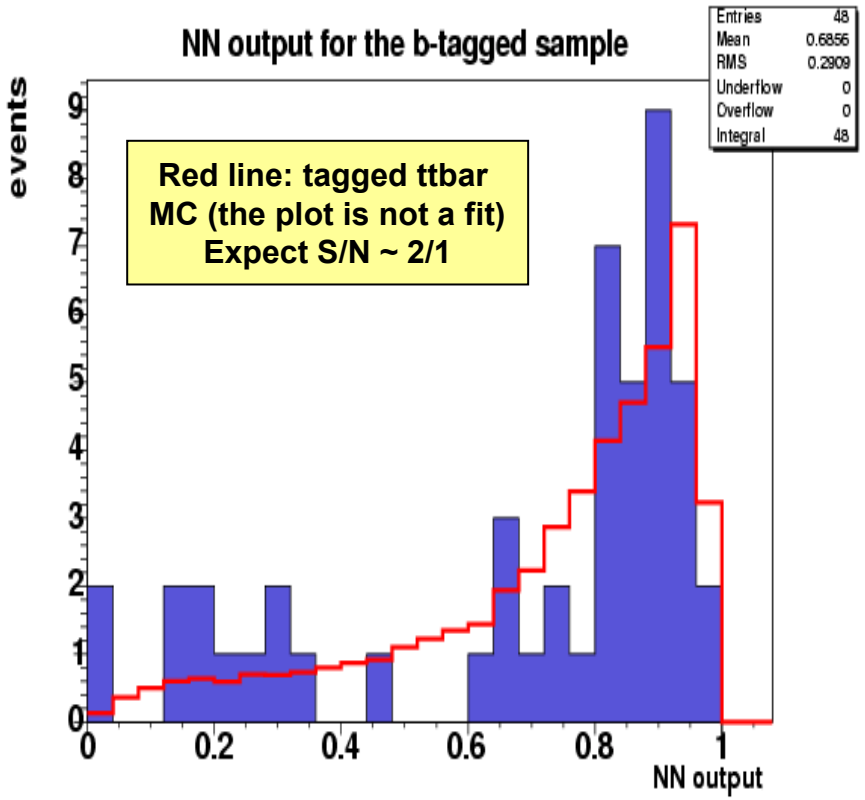
CDF Preliminary



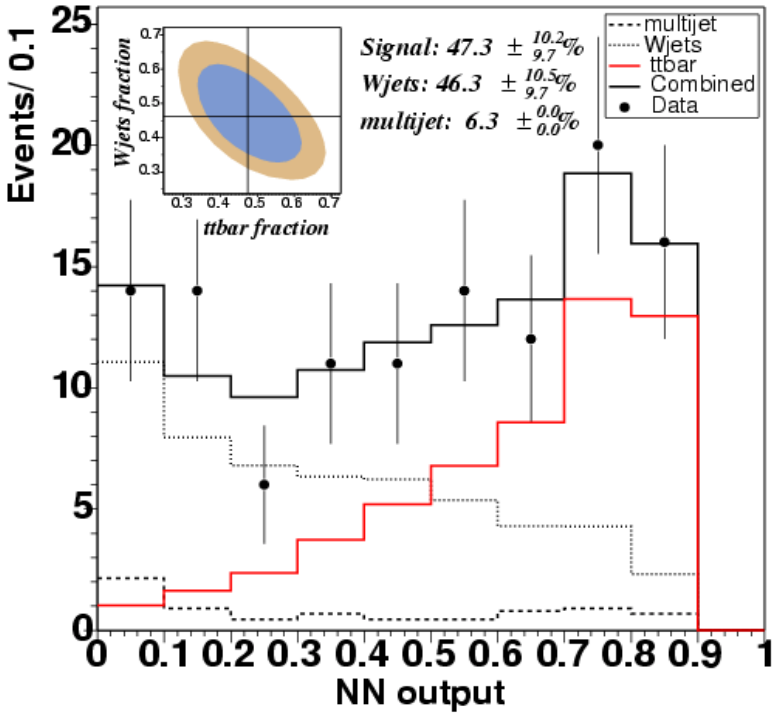


CDF Preliminary: $\sigma_{t\bar{t}} = 8.0 \pm 2.0(stat) \pm 3.0(sys)\, pb$

Crosschecks



CDF Preliminary



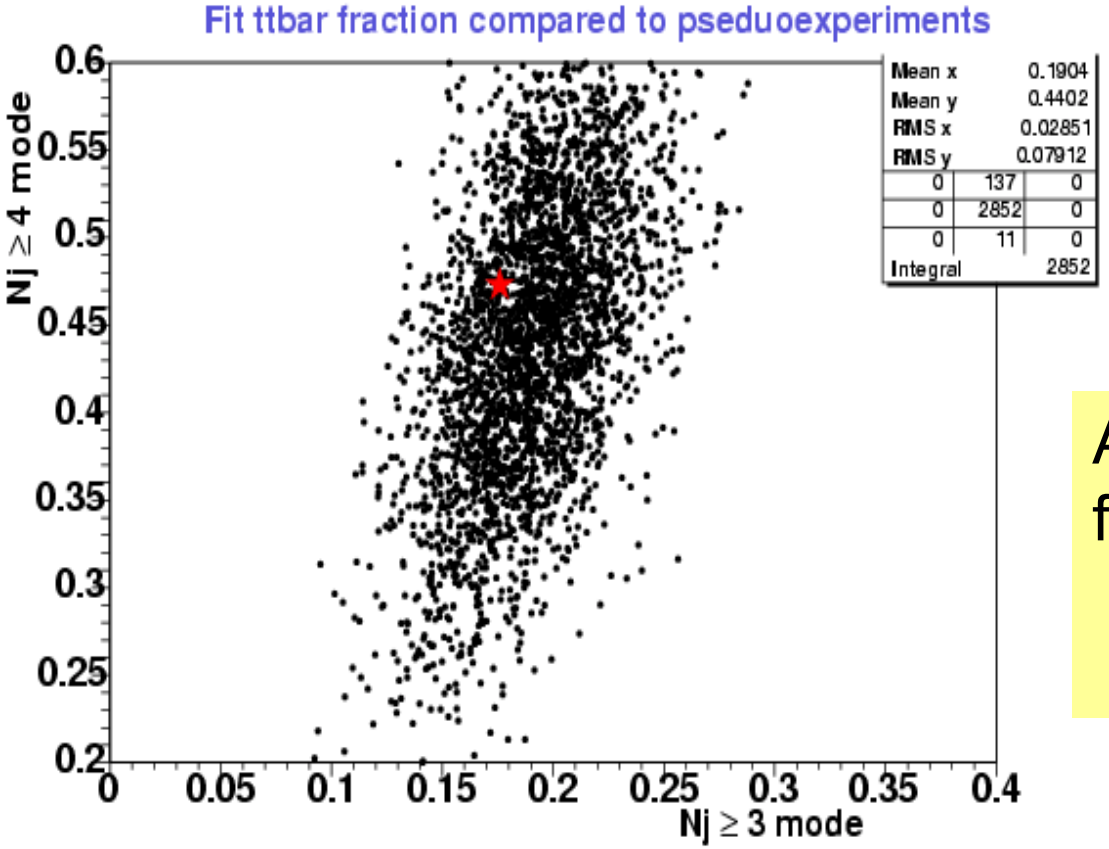
CDF Preliminary: $\sigma_{t\bar{t}} = 7.5 \pm 1.6(stat) \pm 1.8(sys)\, pb$

Summary

- Event kinematic variables combined with a multivariate approach can be used to select an enriched top sample.
- First we used a single best kinematic to measure the cross section.
- NN fit: measure a ttbar cross section of 6.7±1.1±1.6 pb.
- As expected the NN output for the b-tagged sample is consistent with an enhanced top content.

Back-up Slides

Sample	Observed Evts	$t\bar{t}$ fraction	$\sigma(t\bar{t})$
W+≥3 Jets	519	0.176 ± 0.030	$6.7 \pm 1.1 \pm 1.6$ pb
W+≥4 Jets	118	0.473 ± 0.100	$7.5 \pm 1.6 \pm 1.8$ pb

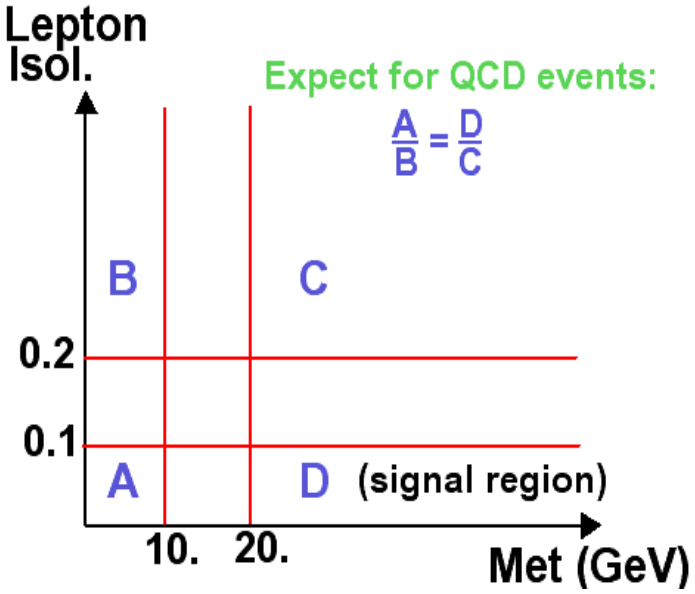


Cross Section Measurement

Apriori our best result is for the Nj>=3 mode:

$$\sigma_{t\bar{t}} = 6.7 \pm 1.1 \pm 1.6\, pb$$

Treatment of the QCD background



To remove QCD fakes,
if 20.0<Met<30.0 require:
0.5<ΔΦ(MetLeadingJet)<2.5

Without Jet-Met Cut:

W+n jets	Electron background	Muon backgroud	Total back-ground
1	9.6±0.3%	5.1±0.2%	7.6 ±0.4%
2	12.6±0.8%	4.0±0.4%	8.7±0.9%
≥3	15.0±1.9%	5.6±1.2%	11.7±2.%

After Jet-Met Cut:

W+n jets	Electron background	Muon backgroud	Total back-ground
1	3.8±0.2%	2.9±0.2%	3.4 ±0.3%
2	6.1±0.5%	2.0±0.2%	4.3±0.5%
≥3	8.9±1.5%	3.4±0.9%	7.0±1.7%