

Top production and properties

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for the CDF collaboration



DIS 2004

Outline

- Run I recapitulation
- Improvements in Run II
- Top production on Tevatron
- Cross section results
- Single top searches
- Top mass results
- Outlook

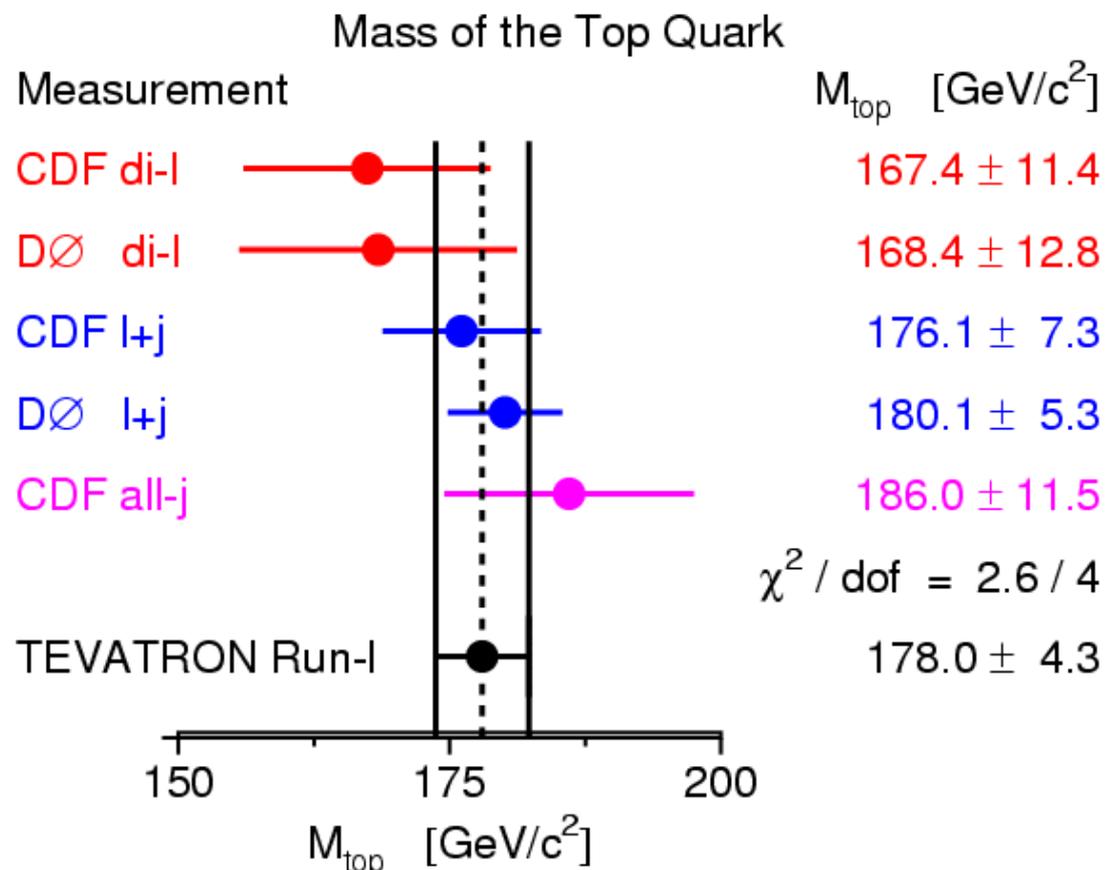
Summary of Run I top results

- Observed in first 70 pb⁻¹ of Run I in 1995
- Final Run I analyses based on 110 pb⁻¹

➤ $t\bar{t}$ cross-section:
 $6.5^{+1.7}_{-1.4}$ pb (1.8 TeV)

➤ Single top production:
 < 13.5 pb @ 95% C.L.

➤ Overall agreement with SM,
 but small statistics
 (~100 events)



world average:

$$M_{\text{top}} = 178.0 \pm 4.3 \text{ GeV}$$

Run II improvements

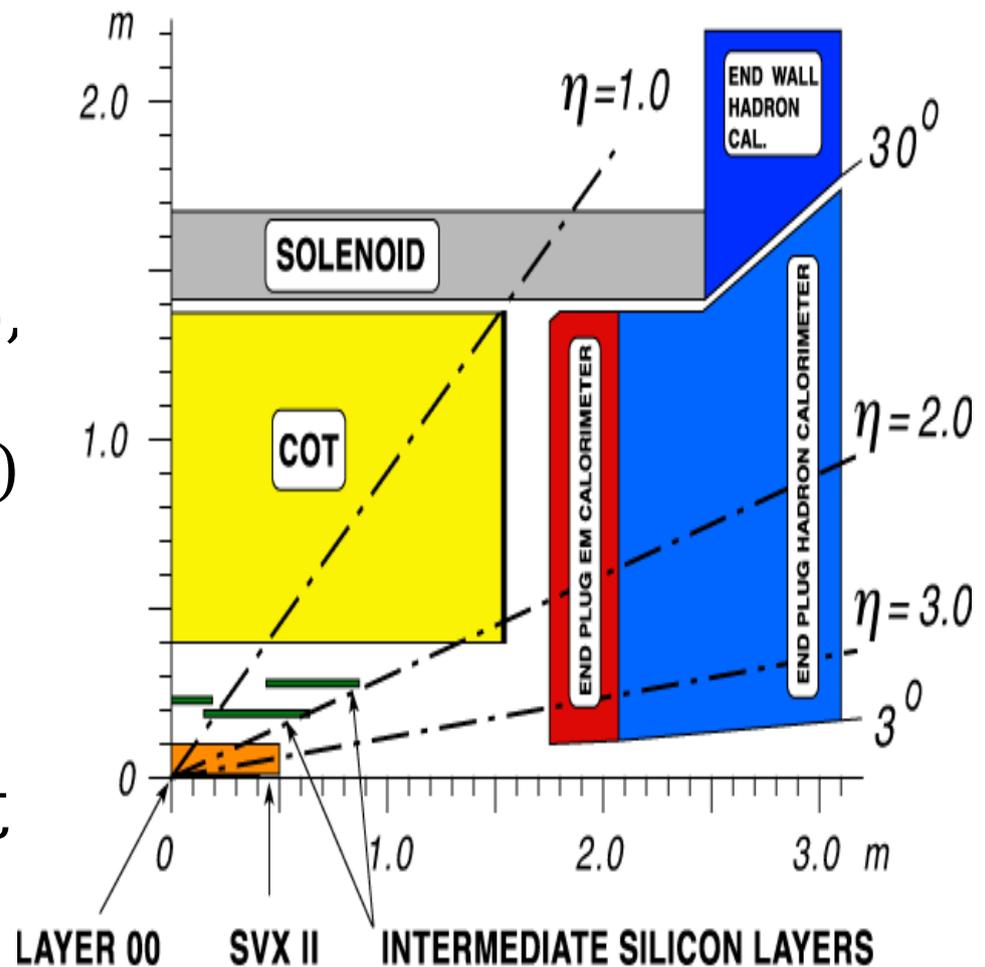
Accelerator: \sqrt{s} 1.8 TeV \longrightarrow 1.96 TeV

it gives 30%-40% increase in top cross-section

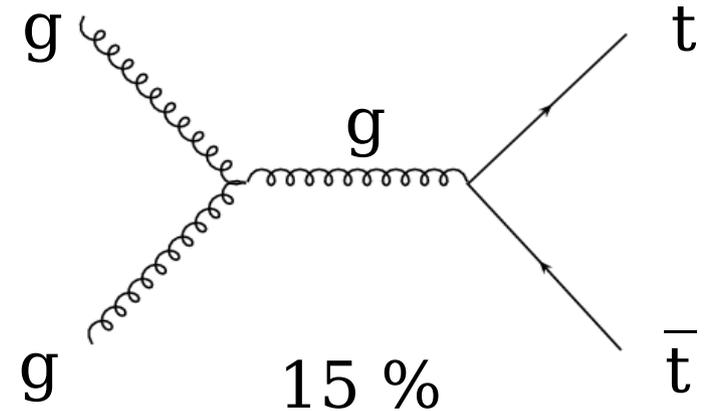
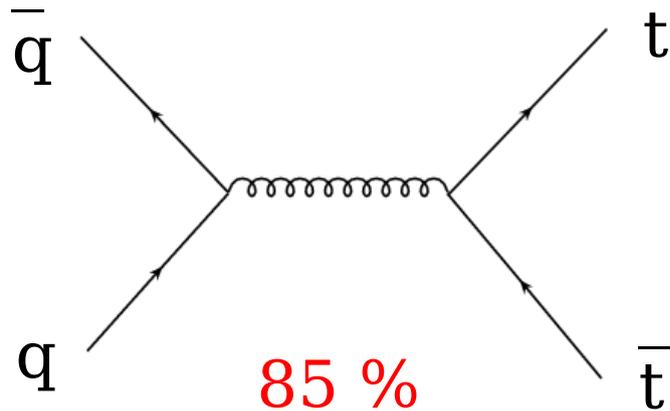
CDF Detector upgrades:

- › new silicon system ($|\eta| < 2$),
 \longrightarrow improved b-tagging
- › extended muon system ($|\eta| < 1.5$,
 filled gaps)
- › plug calorimeter ($1.0 < |\eta| < 3.6$)
- › upgraded trigger and DAQ system

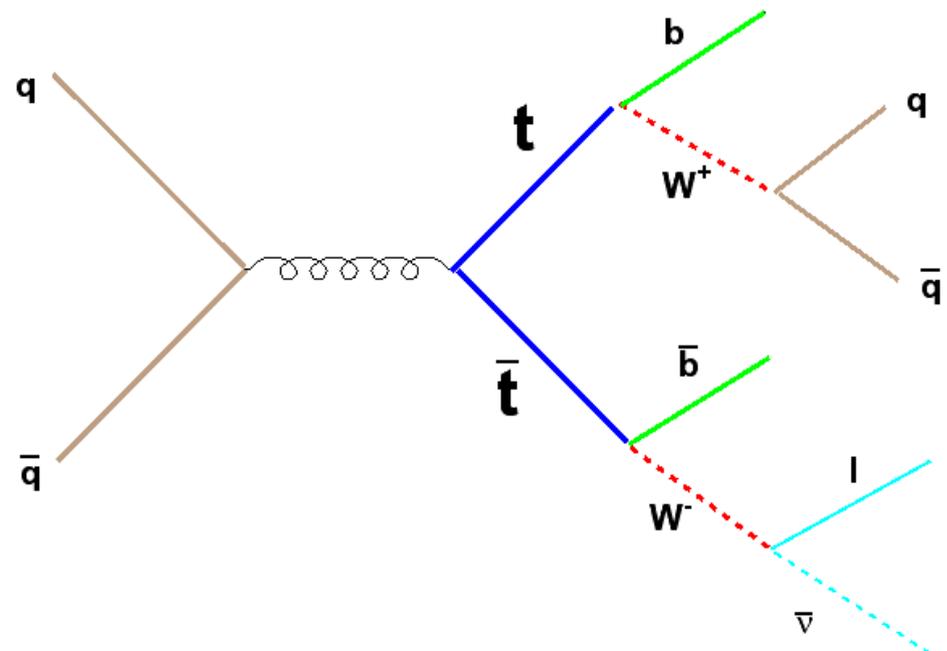
ALL together big impact
on top physics



Top pair production on Tevatron



- ▶ Dilepton: BR = 11%
 2-high pt leptons, 2 b-jets,
 missing E_t
- ▶ Lepton+jets: BR=44%
 lepton, 4(2 b)-jets,
 missing E_t
- ▶ All hadronic: BR=45%
 6 jets , no missing E_t



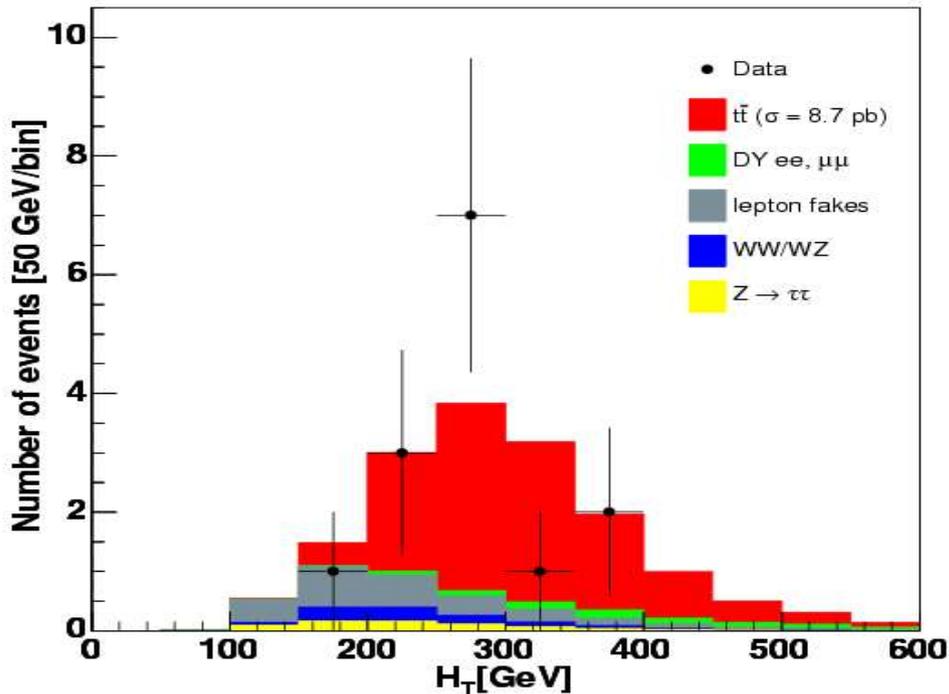
$BR(t \rightarrow Wb) \approx 100 \%$

Dilepton-mode cross-section

two analysis:

2 tight leptons

CDF Run II Preliminary $\int L dt = 193 \text{ pb}^{-1}$

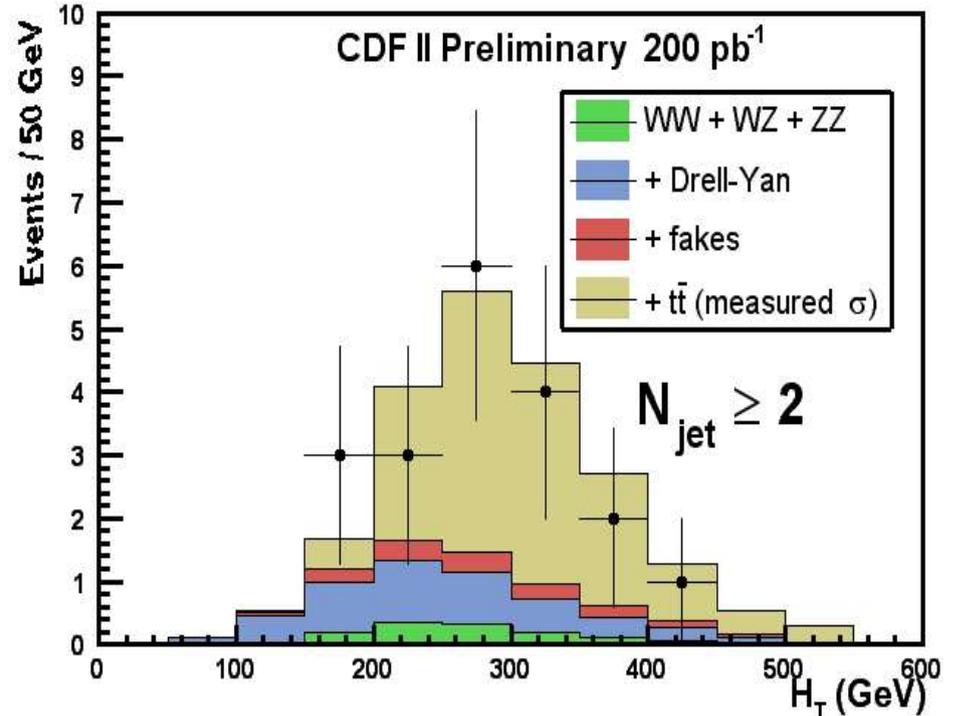


13 events (1 $e\bar{e}$, 3 $\mu\bar{\mu}$, 9 $e\bar{\mu}$)
with expected background 2.4

$$\sigma = 8.7^{+3.9}_{-2.6} \pm 1.5 \text{ pb}$$

Tight lepton + isolated track

Total Transverse Energy (scalar sum)



19 events (11 e-track, 8 μ -track)
with expected background 7.1

$$\sigma = 6.9^{+2.7}_{-2.4} \pm 1.3 \text{ pb}$$

Lepton+jets mode cross-sections

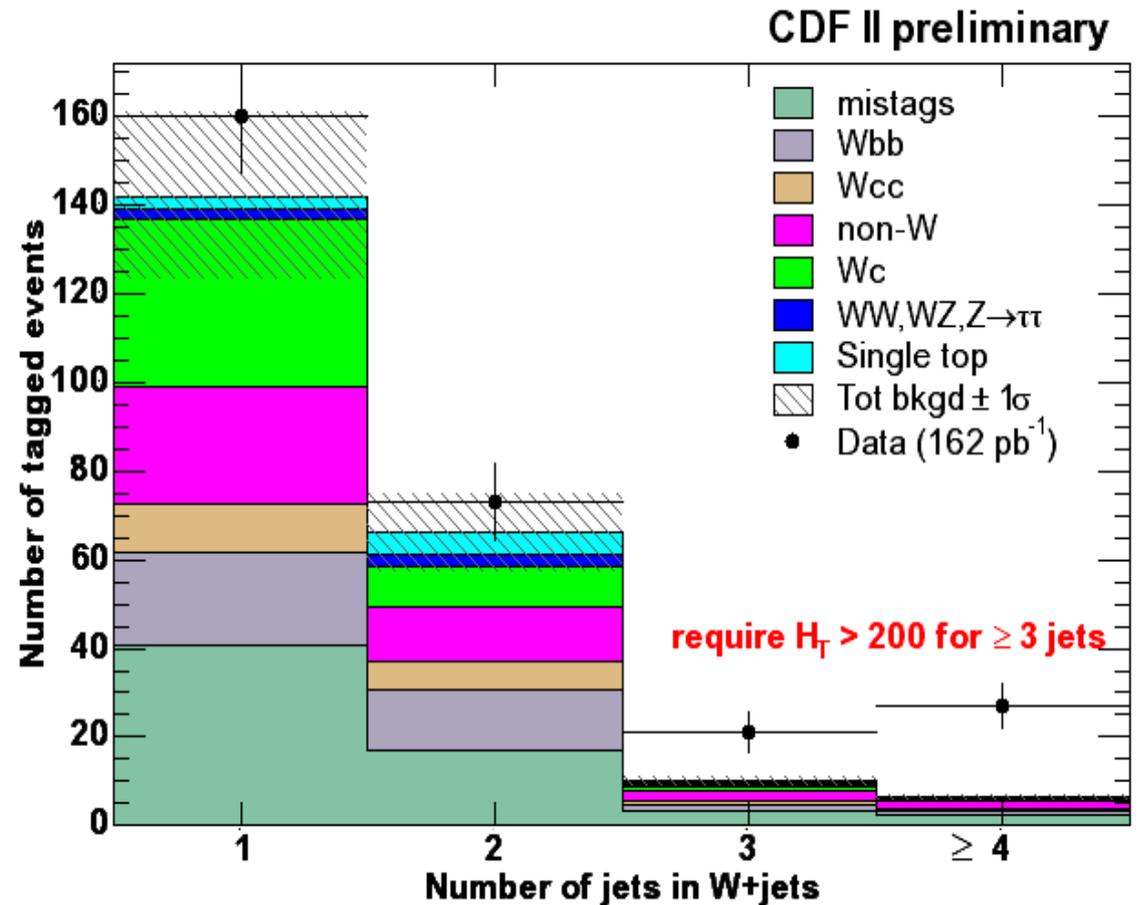
many different analysis in progress !

Using secondary vertex tag (counting method):

Predict the rates of non-top processes in tagged W+jets,

the excess in ≥ 3 jets is top !

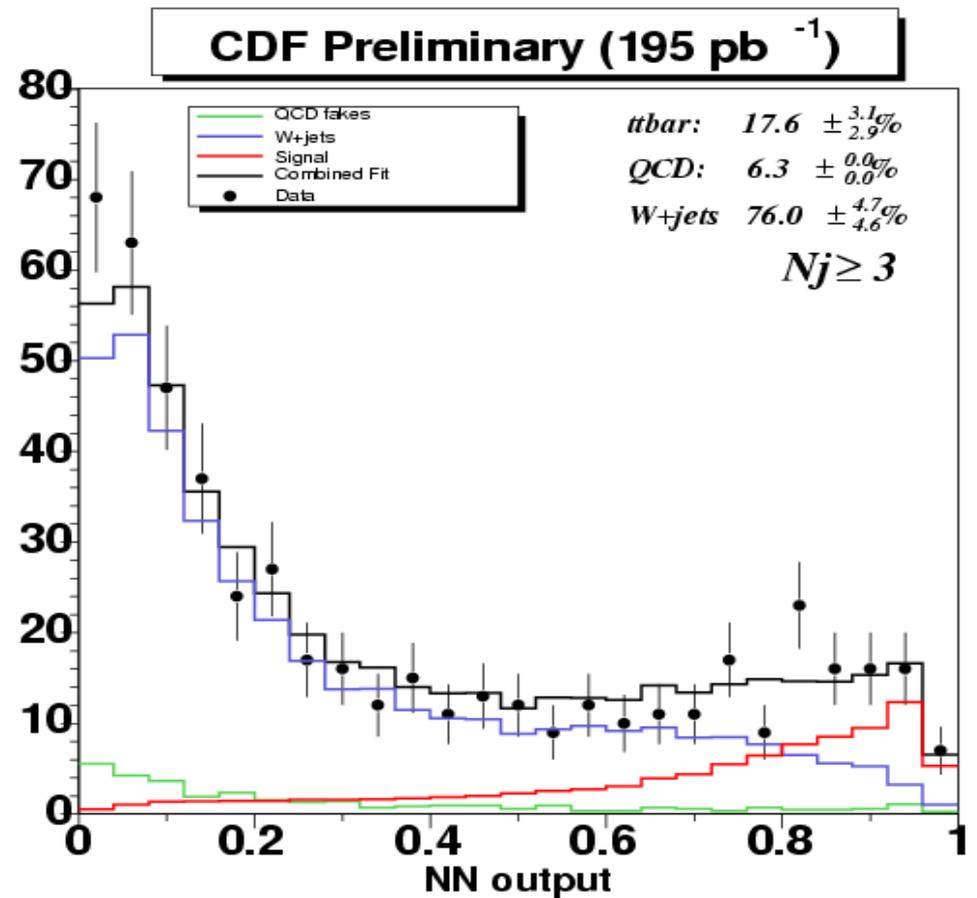
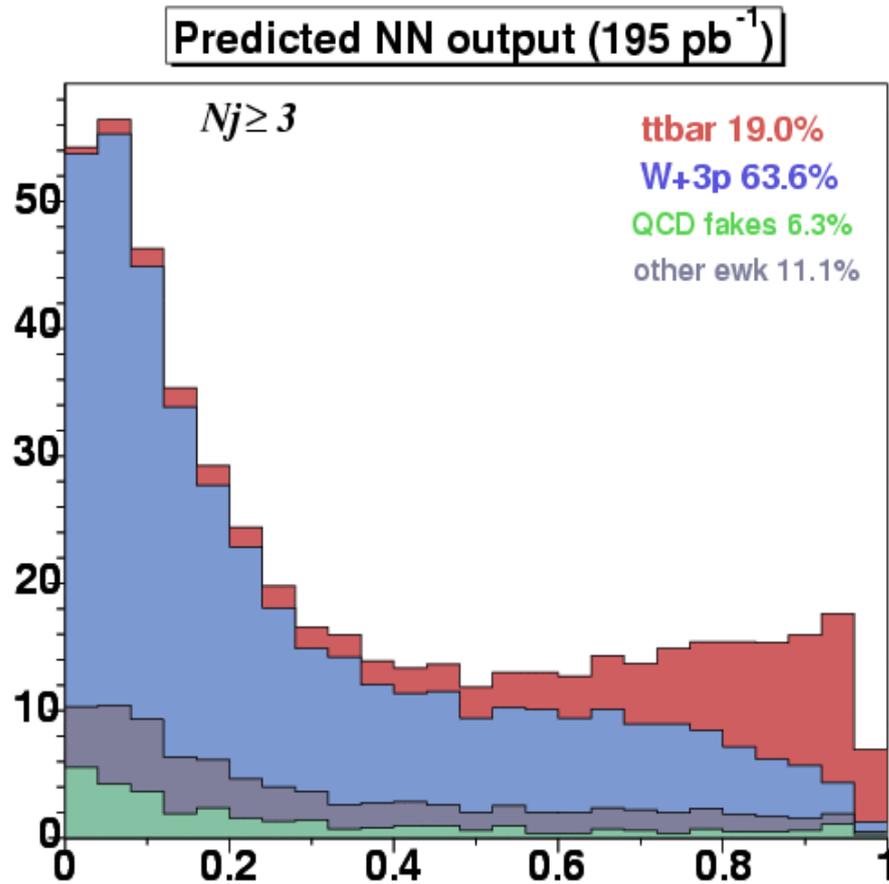
48 events on 13.8 ± 2.0 background



$$\sigma = 5.6^{+1.2}_{-1.0} {}^{+1.0}_{-0.7} \text{ pb}$$

Using event kinematics and neural net(NN):

$t\bar{t}$ and W +jets kinematically differ in many variables \rightarrow
pick uncorrelated variables \rightarrow develop neural net
NN gives good separation of signal and background

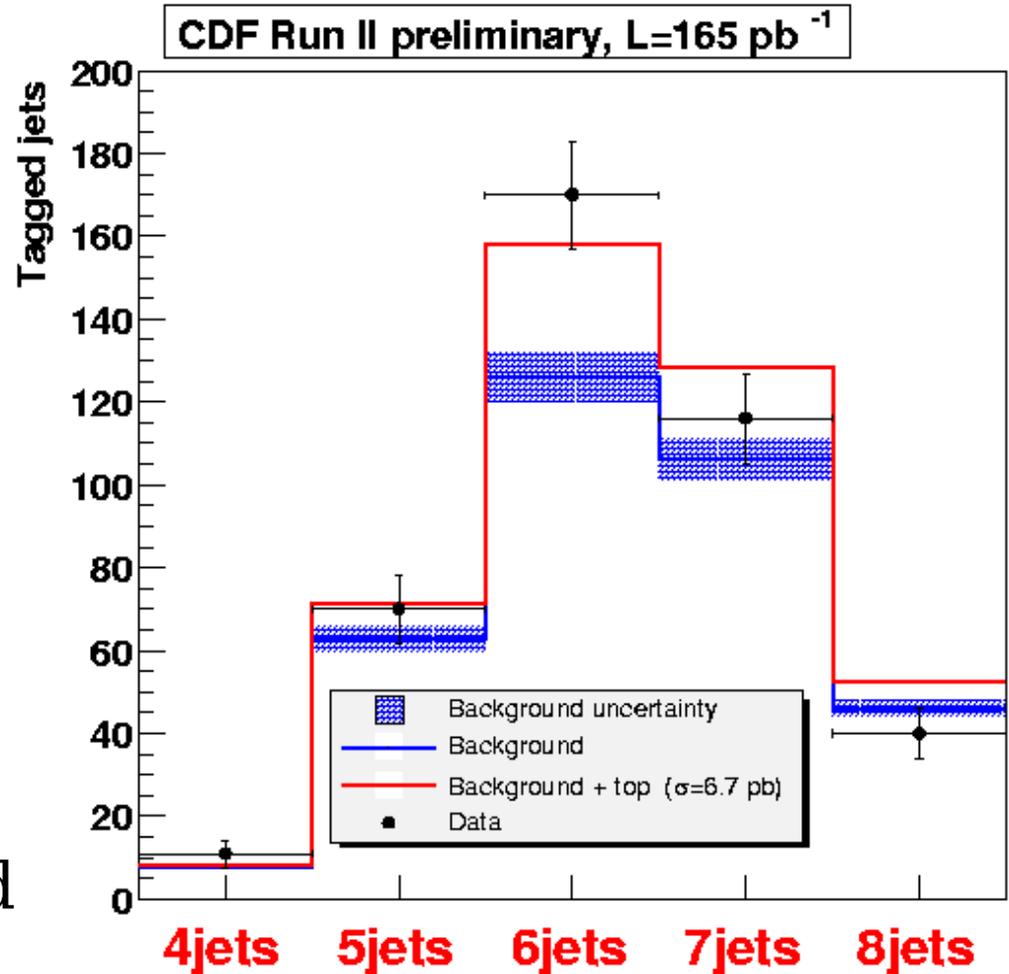


$$\sigma = 6.7 \pm 1.1 \pm 1.6 \text{ pb}$$

All hadronic cross-section

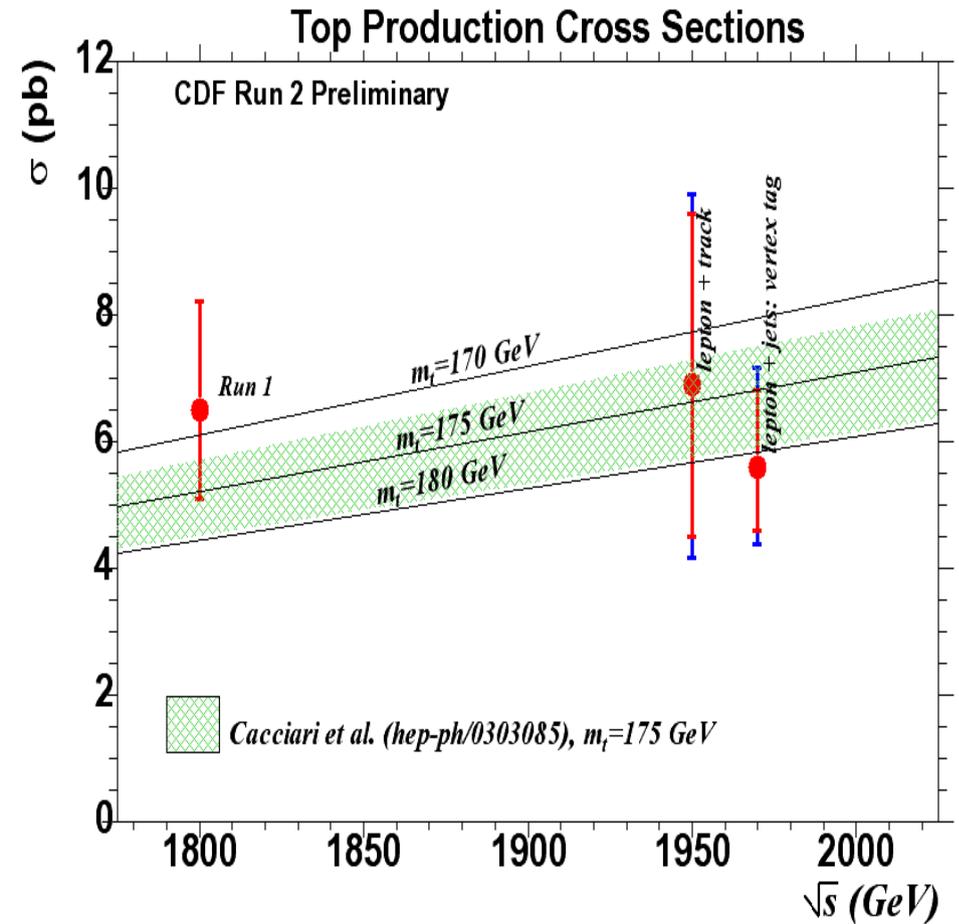
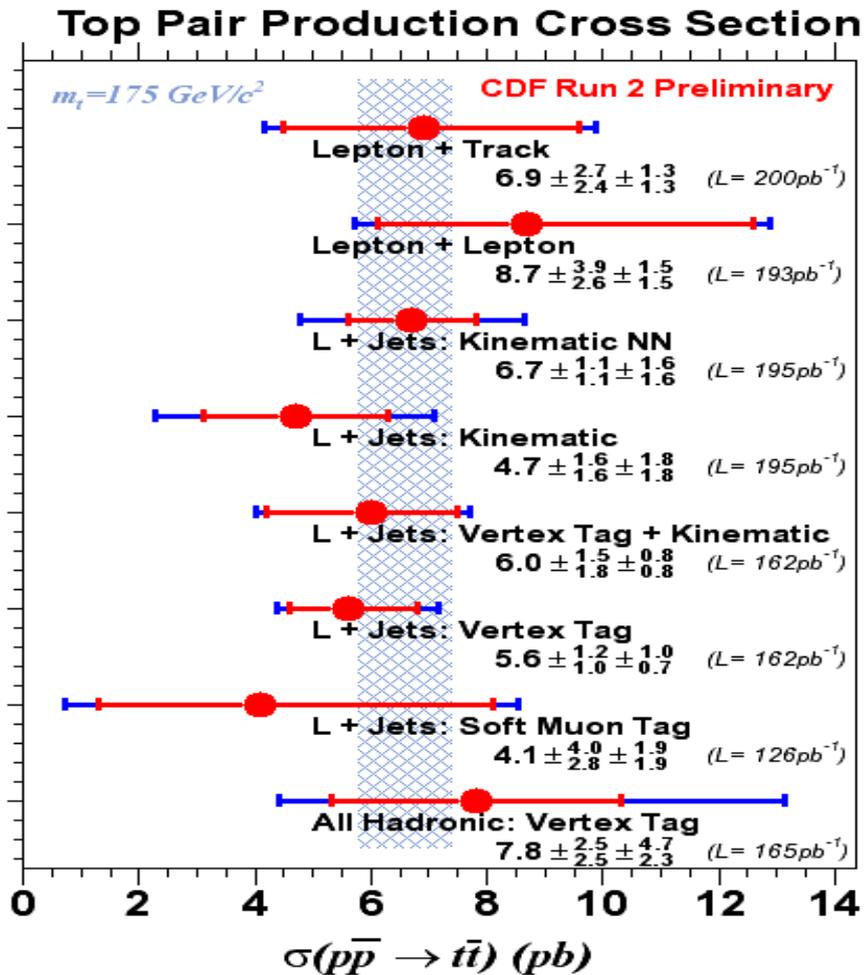
- › Counting method
- › Kinematical selection complemented with b-tagging (≥ 1 tagged jet)
- › cross-section **measured from excess of tagged jets**
- › Luminosity: 165 pb^{-1}

Observed **326 tags**
on 264.7 ± 17.2 background



$$\sigma = 7.8 \pm 2.5 \text{ (stat.) } {}^{+4.7}_{-2.3} \text{ (syst.) pb}$$

Cross section summary



Many analysis ongoing
all within SM expectations

Single-top search

Searching for $W+2\text{jets}$,
1 jet tagged

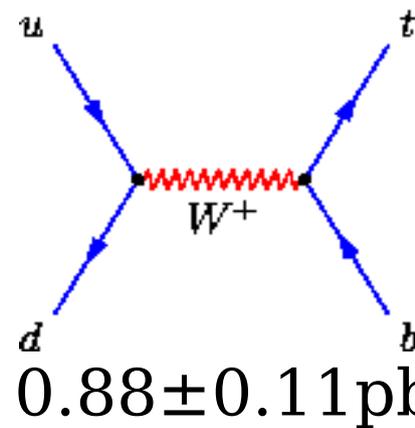
Perform likelihood
fit to:

H_T (combined)

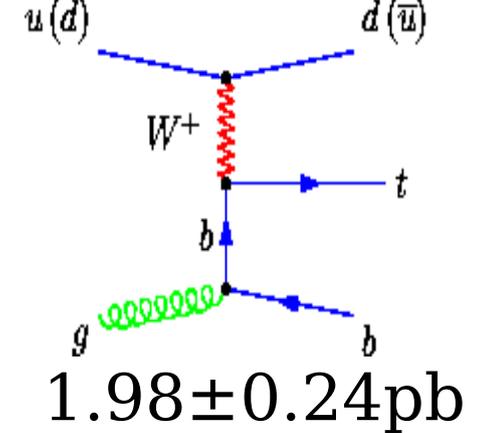
$Q^*\eta$ (t-channel)

Q of lepton, η of light quark jet

s-channel



t-channel



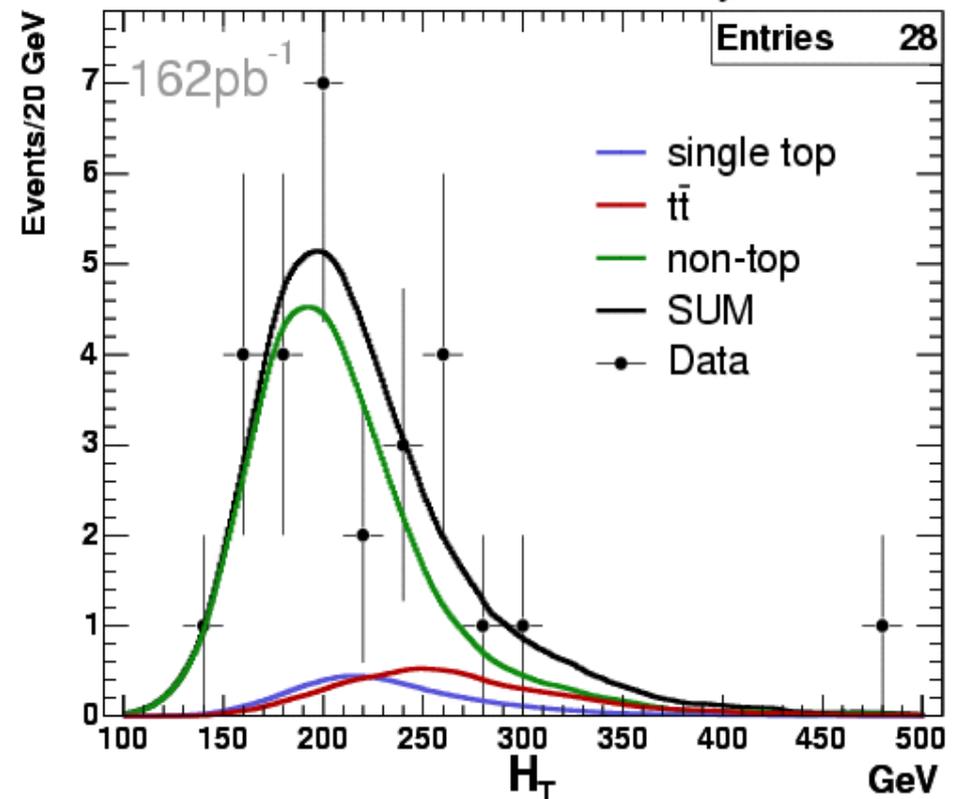
Process	N events	
	Combined Search	t-channel search
t-channel	2.39 ± 0.56	2.34 ± 0.54
s-channel	1.19 ± 0.25	1.16 ± 0.24
$t\bar{t}$	3.47 ± 1.04	3.39 ± 1.02
non-top	20.7 ± 4.1	17.4 ± 3.3
Sum	27.8 ± 4.3	24.3 ± 3.5

Data: **28** **25**

95% C.L. limits:

Combined (s+t) : $\sigma < 13.7 \text{ pb}$
t-channel: $\sigma < 8.5 \text{ pb}$

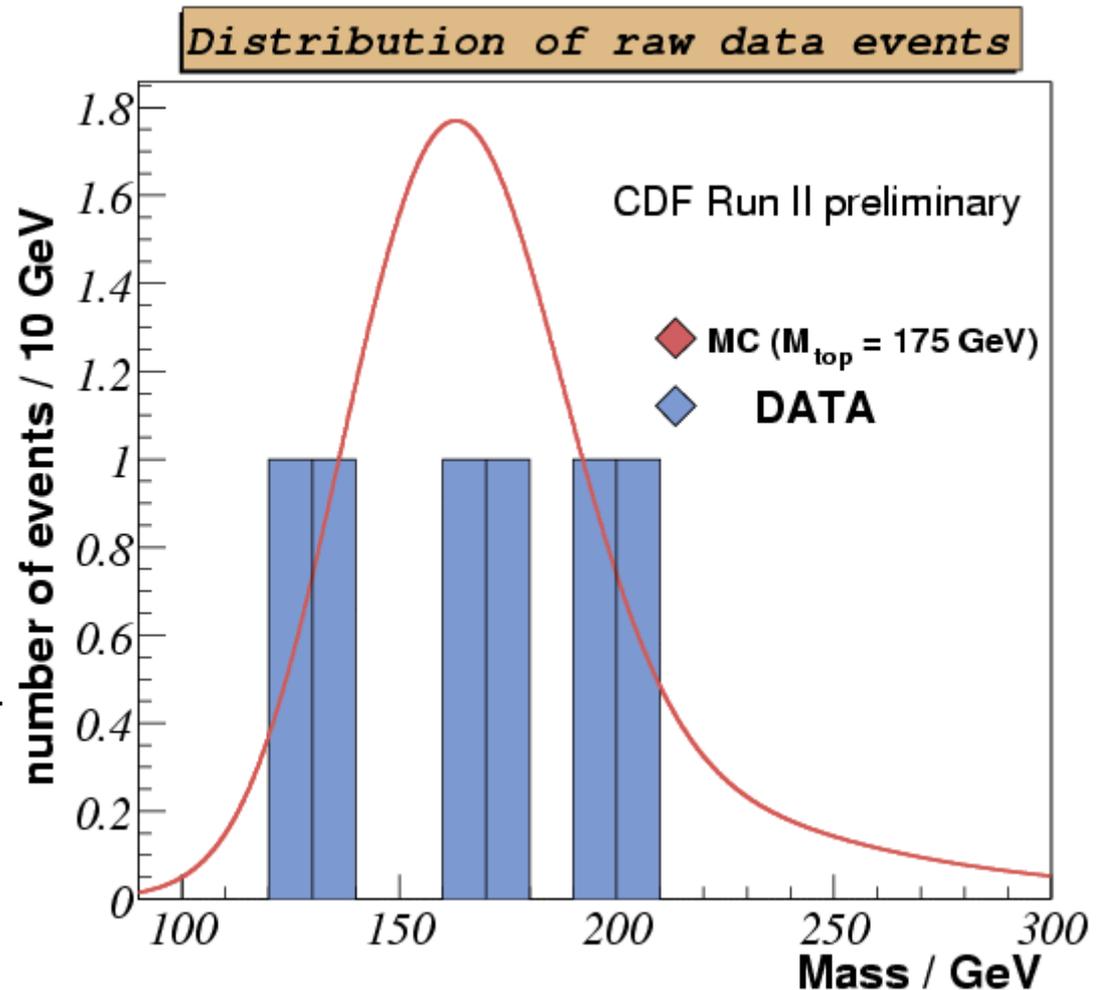
CDF Run II Preliminary



Top mass: dilepton

Underconstrained system,
need one more variable

- Dynamic variable used: $P_z t\bar{t}$ system
- Template method
- **6 events** in 126 pb^{-1}
- Systematic uncertainty dominated by jet energy scale

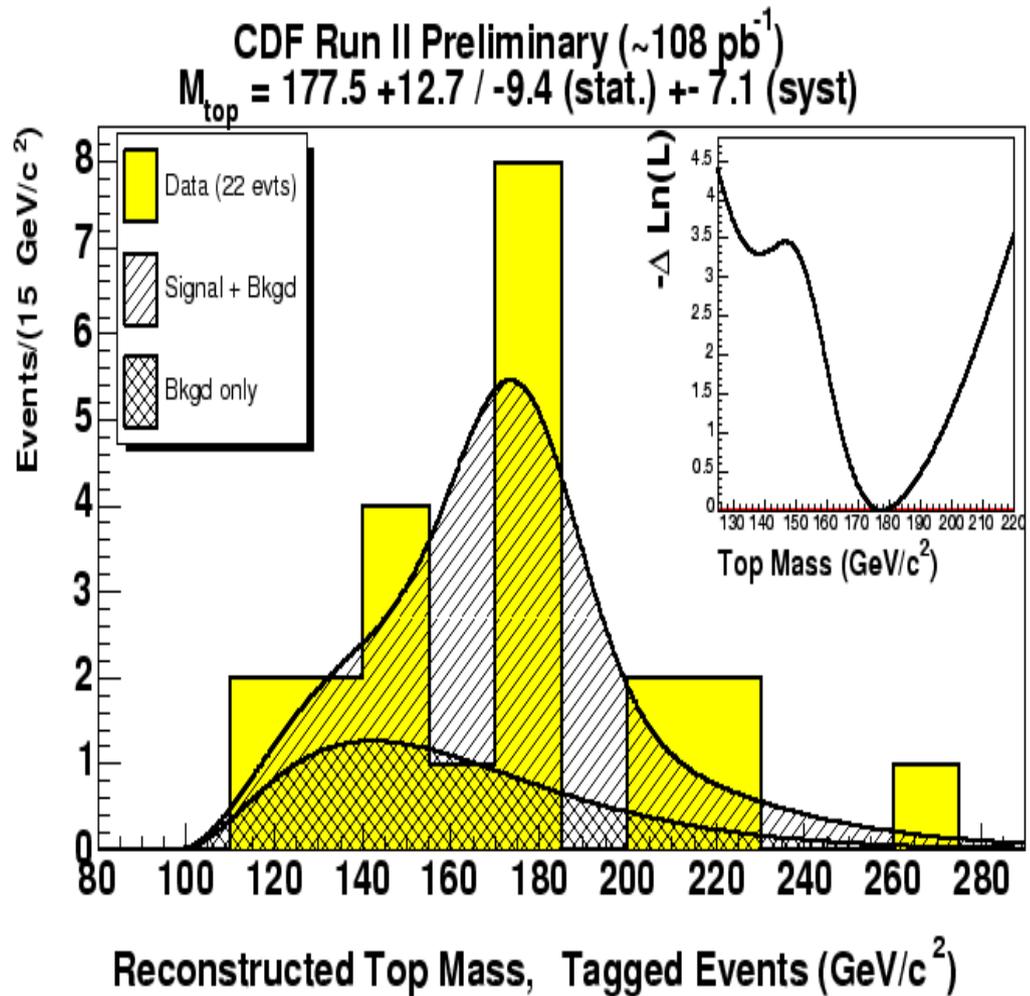


$$M_{\text{top}} = 175 \pm 17(\text{stat.}) \pm 8(\text{syst.})$$

Top Mass: lepton+ jets

Overconstrained system,
minimalization of ' χ^2 '

- Events with 4 jets,
 ≥ 1 vertex tag
- Template method
- Select combination
most consistent with
ttbar hypothesis in
kinematic fit
- **22 events** in 108 pb^{-1}
- Systematic dominated
by jet-energy scale



$$M_{\text{top}} = 178^{+13}_{-9} (\text{stat.}) \pm 7 (\text{syst.}) \text{ GeV}$$

Dynamic Likelihood method

For i-th event:

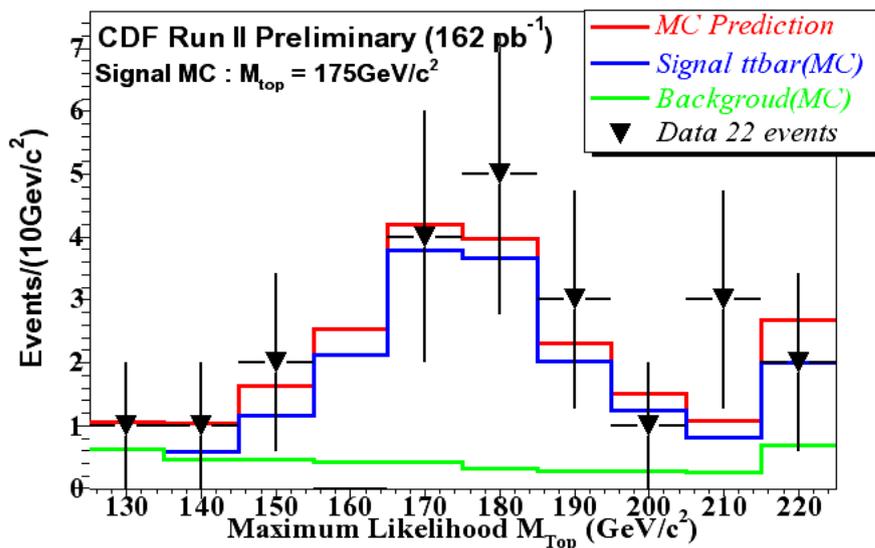
$$L^i(M_{top}) = \sum_{comb} \int \frac{(2\pi)^4}{4\sqrt{(a \cdot b)^2 - m_a^2 m_b^2}} |\mathcal{M}|^2 f_{a/A}(z_1) f_{b/B}(z_2) f_T(p_T) w(\mathbf{x}, \mathbf{y}) d\mathbf{x}$$

Differential cross-section (function of M_{top}) multiplied by transfer function w (jets \leftrightarrow partons)

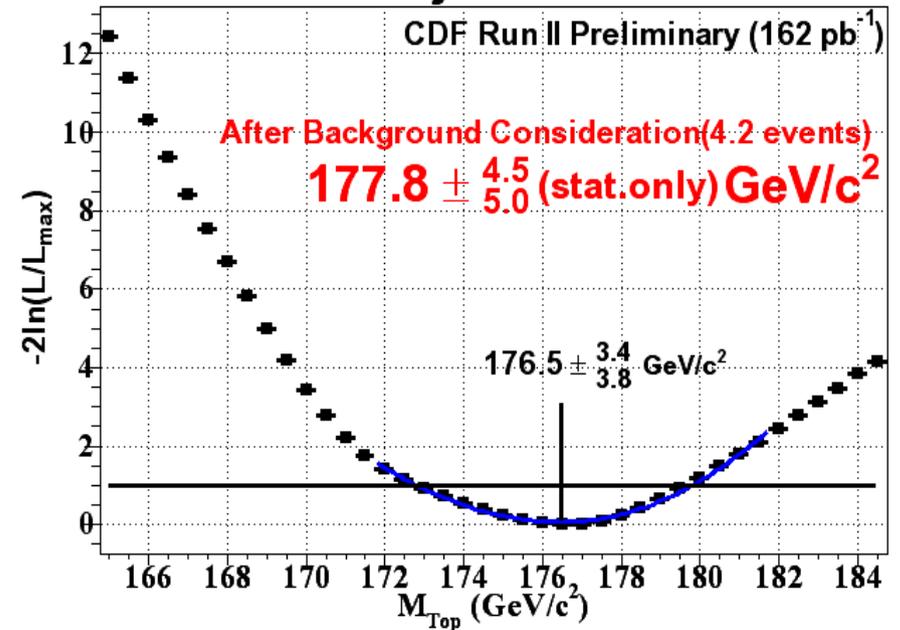
$$\prod_{event} L^i(M_{top}) \rightarrow M_{top} = M_{max\ likelihood}$$

- applied to lepton+ jets sample
- 22 4-jets events with at least one b-tag, 4.2 expected bckg

Maximum Likelihood Mass



22 events joint likelihood



$$M_{top} = 177.8 \text{ (stat.)} \pm 6.2 \text{ (syst.)}$$

Outlook:

- next few weeks:
 - all analysis updated with $\sim 200 \text{ pb}^{-1}$
- Next months:
 - analysis pushing towards publications!
- At the end of this year:
 - total integ. luminosity $\sim 500 \text{ pb}^{-1}$ (on tapes)
 - Lots of precise + new (W helicity,...) results ahead !