

Recent Top Quark Results at D0

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On Behalf of the D0 Collaboration

Overview of latest top quark measurements at D0

- **Top quark pair production at the tevatron**
 - Through $q\bar{q}$ annihilation
 - gluon fusion
 - Top quark decays through $bW(\ell,qq)$ channel
- **Latest Run II measurements**
 - $t\bar{t}$ cross section in dilepton mode
 - $t\bar{t}$ cross section in lepton+jets (Presented for the first time)
 - $t\bar{t}$ cross section in lepton+jets with soft muon tagging
- **Recent Run I measurement with the new technique**
 - Top quark mass measurement
 - W helicity in top decays measurement

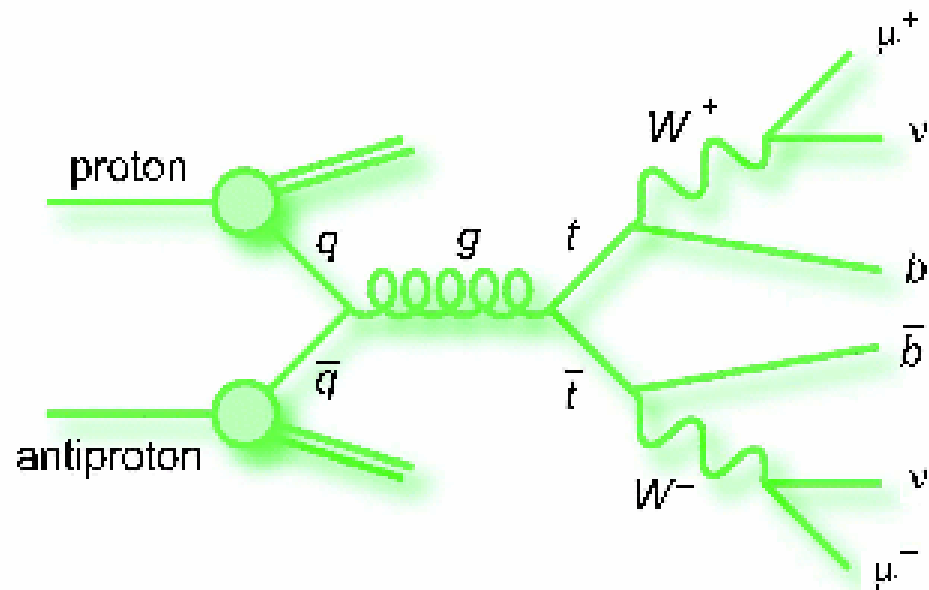
Dilepton Event Signature

Event Selection

- 2 high P_T leptons
- Large Missing Transverse Energy (\cancel{E}_T)
- Large total transverse jet momentum (H_T)

Background

- Physics
- $WW \rightarrow ee, e\mu, \mu\mu$
- $Z \rightarrow \tau\tau \rightarrow ee, e\mu, \mu\mu$



- Instrumental
- $W + \text{jets}$ (jet fakes e, μ)
- Multijet events (2 jets fake e, μ)
- $Z \rightarrow ee$ (fake \cancel{E}_T)

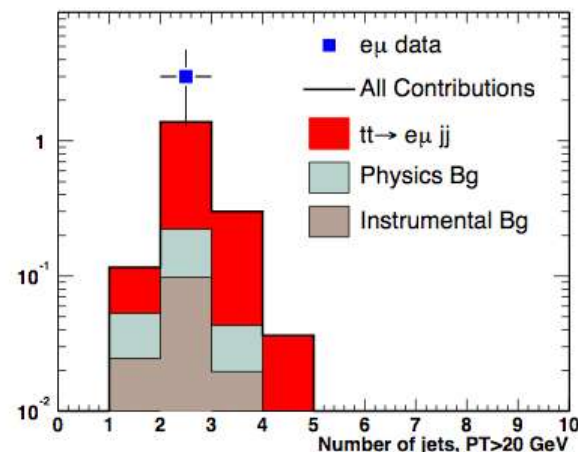
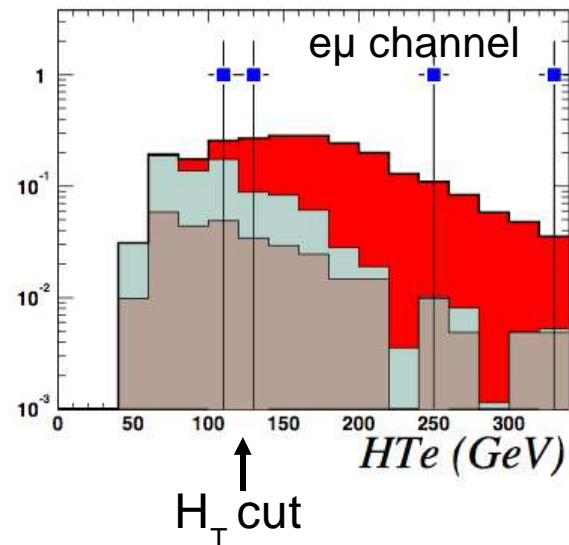
$t\bar{t}$ cross section in dilepton channel

Combined cross section from all three channels yields :

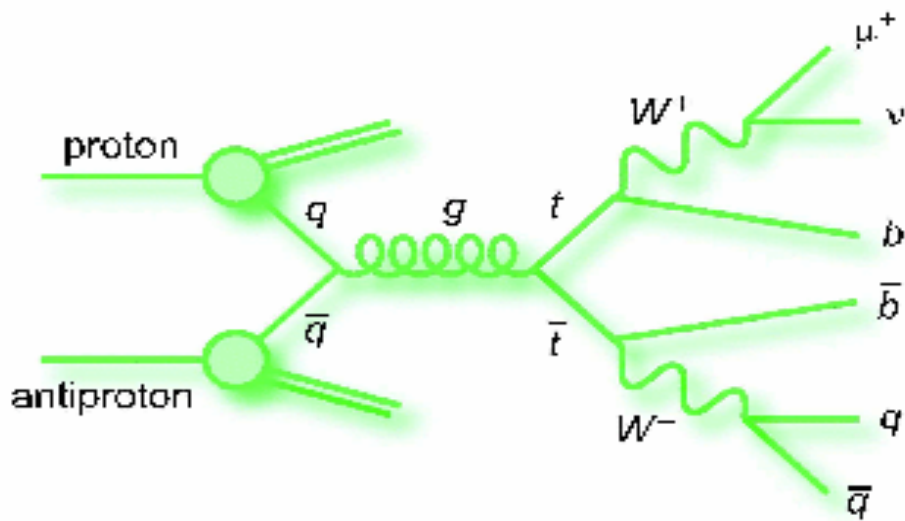
$$\sigma(t\bar{t}) = 8.7^{+6.4}_{-4.7} (\text{stat.})^{+2.7}_{-2.0} (\text{syst.}) \pm 0.9 (\text{lumi}) \text{ pb}$$

- Larger luminosity results will be shown next week

	ee	$\mu\mu$	$e\mu$
Int. Lum (pb^{-1})	107	90.4	97.7
Background	0.6 ± 0.5	0.7 ± 0.4	0.6 ± 0.4
Expected signal	0.6 ± 0.1	0.5 ± 0.1	1.7 ± 0.3
Data	2	0	3



Lepton + jets Channel



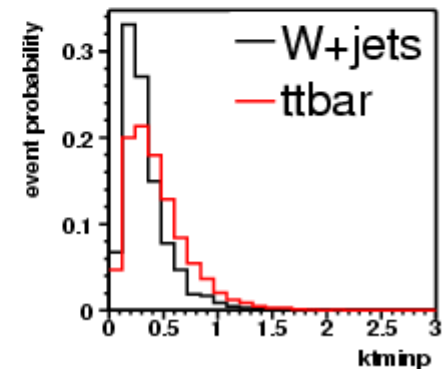
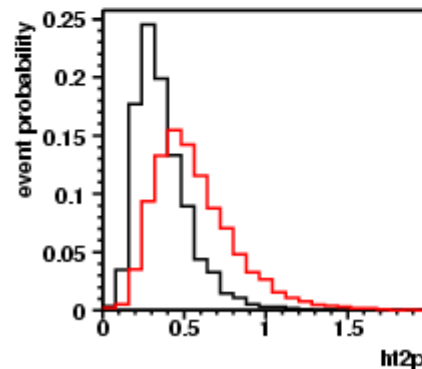
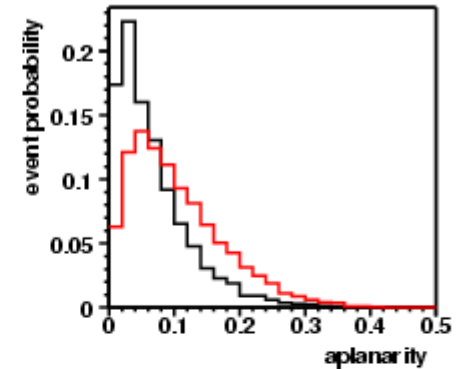
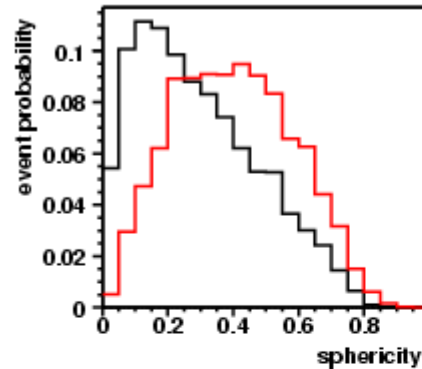
- Event selection :
- 1 high P_T isolated Lepton
- High (\cancel{E}_T)
- ≥ 4 jets

- Branching ratio is much higher than in dilepton channels but with larger background contribution.
- Two sources of the background
 - Multijet events which fake Electron or isolated muon
 - W +jets events

Topological Analysis

- For background separation a top event likelihood is constructed using 4 topological variables
- Jet Energy Scale systematic dominates earlier results
- Use topological variables that depend on
 - Angular quantities
 - Ratios of energy dependent quantities

$$H'_{T2}, K'_{Tmin}$$



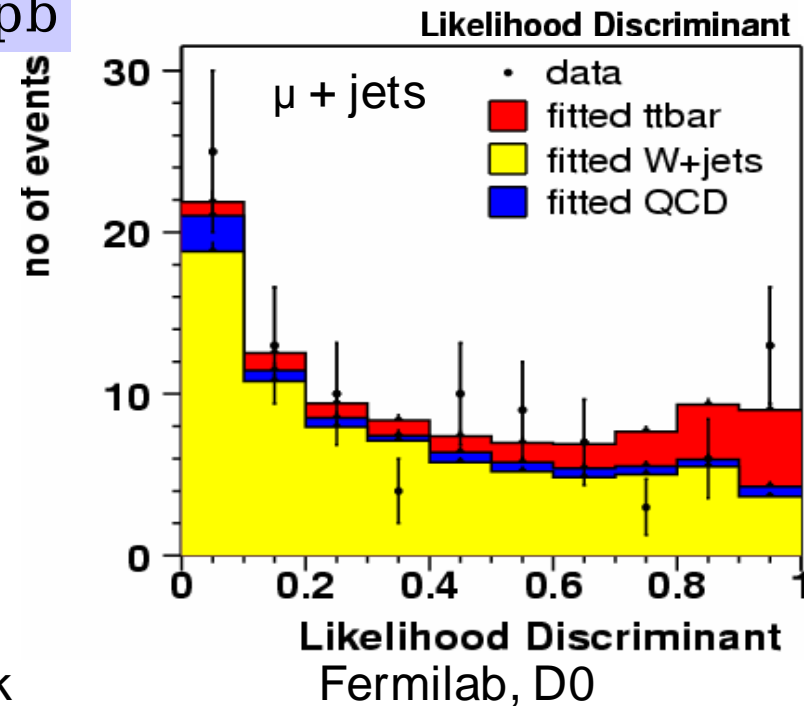
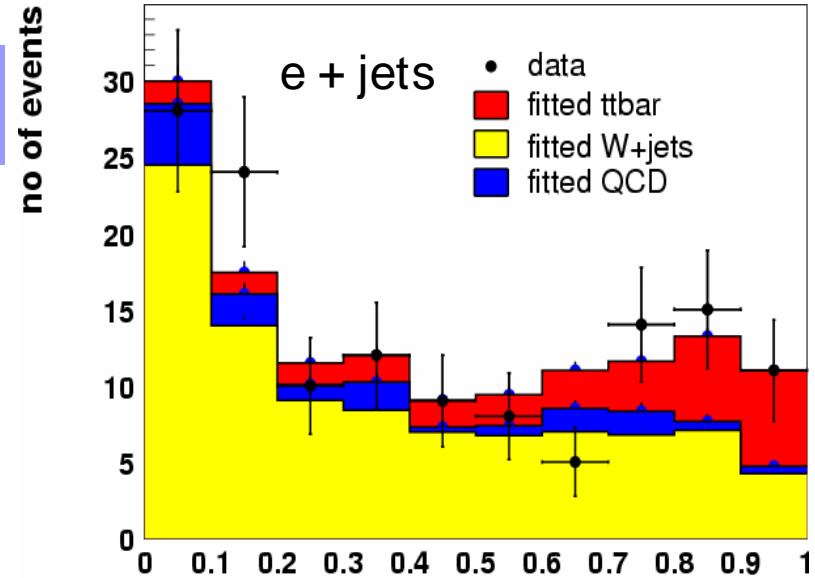
Likelihood fitting

Number of $t\bar{t}$ events is extracted directly from the likelihood fit

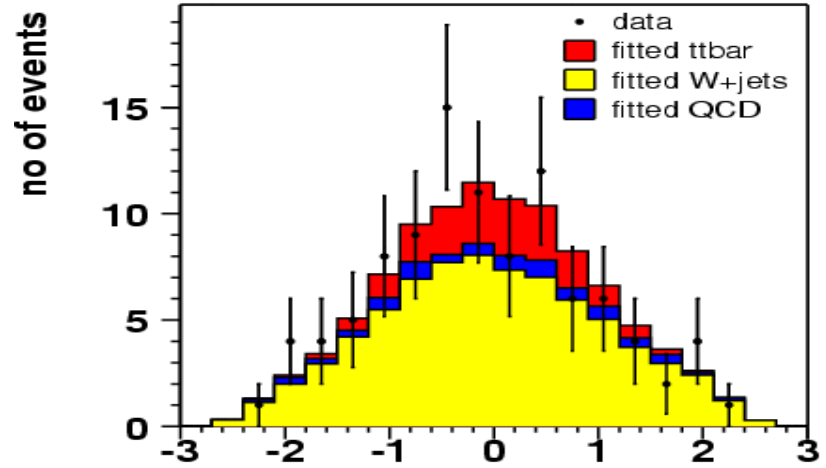
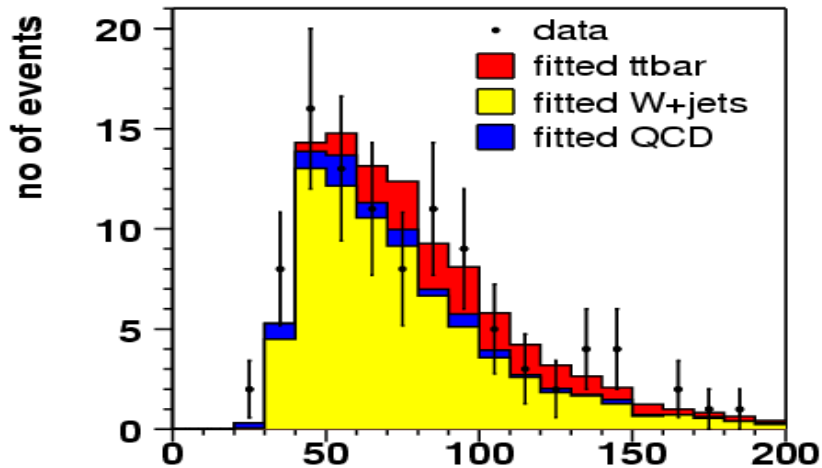
- The likelihood shape for $t\bar{t}$ has very weak mass dependence
- $t\bar{t}$ shape is predicted by the MC

$$\sigma(t\bar{t}) = 7.2^{+2.6}_{-2.4} (\text{stat})^{+1.6}_{-1.7} (\text{sys}) \pm 0.5 (\text{lumi}) \text{ pb}$$

	e+jets	μ +jets
Inst Lum (pb^{-1})	141.2	143.9
QCD	14.1 ± 1.2	7.1 ± 0.9
W+jets	95 ± 15	75 ± 12
Fitted ($t\bar{t}$)	28 ± 12	17.8 ± 9.3
Observed	136	100

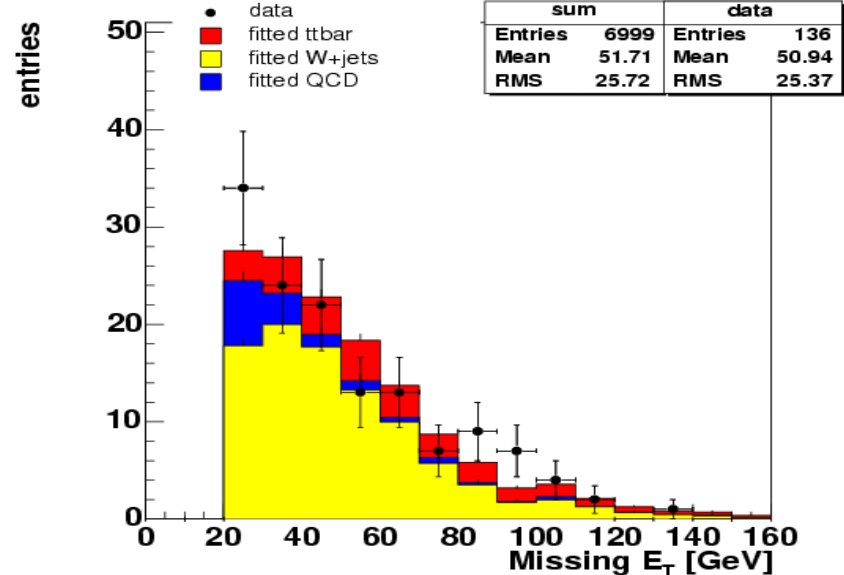
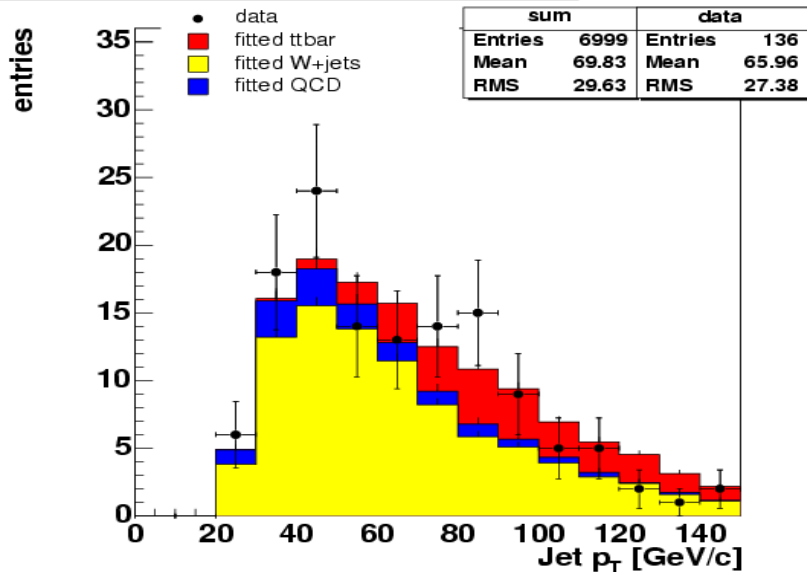


Lepton + jets kinematic distributions

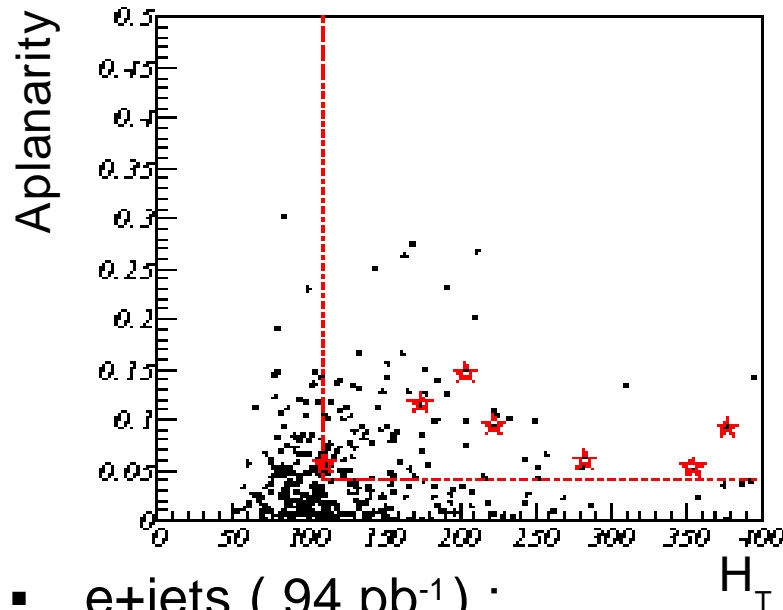


pt of the first jet for EM in the CC

missing ET for EM in the CC



Lepton + jets with soft muon tagging



- e+jets (94 pb⁻¹) :
- 7 observed events
- Background 1.1 ± 0.9
- μ+jets (94 pb⁻¹):
- 8 observed events
- Background 2.2 ± 1.0

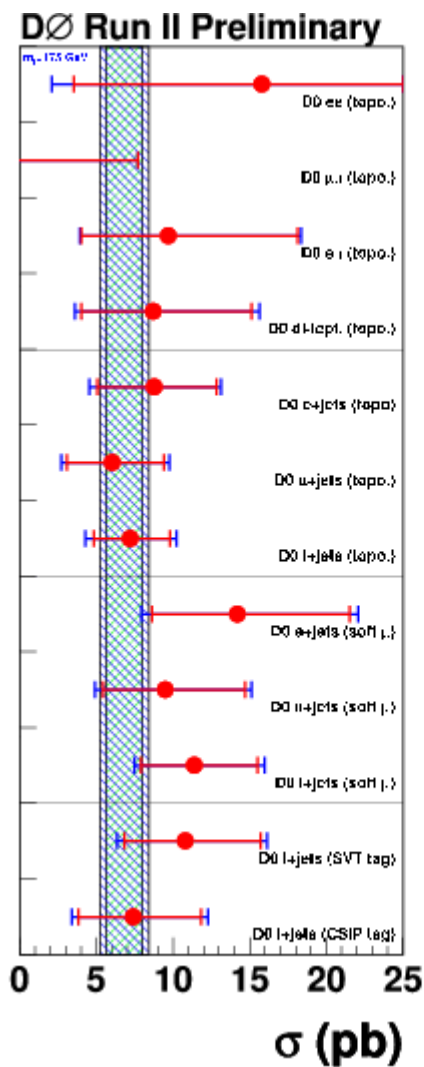
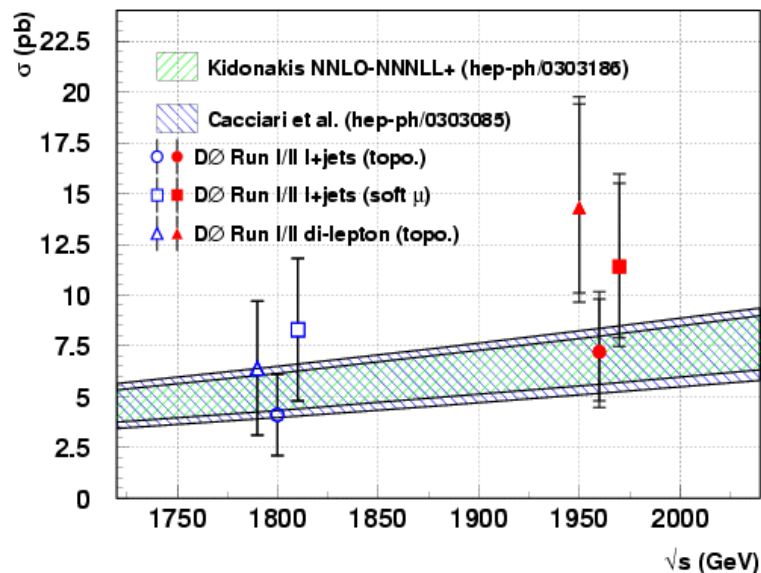
▪ Soft Lepton Tag

- In 40% of $t\bar{t}$ event, b quarks decay through muon channel
- These muons have a softer P_T spectrum than leptons from W/Z
- They are not isolated
- Same preselection a topological analysis
- 3 jets
- Softer topological cut

$$\sigma(t\bar{t}) = 11.2 \pm 4.0(\text{stat}) \pm 1.3(\text{sys}) \pm 1.1(\text{lumi}) \text{ pb}$$

Combined $t\bar{t}$ cross section from all channels

D0 Run II preliminary $t\bar{t}$ cross section results.



107 pb ⁻¹	15.8 ^{+19.8} _{-12.3} ^{+6.5} _{-6.1}
90 pb ⁻¹	< 7.7
98 pb ⁻¹	9.7 ^{+8.4} _{-5.7} ^{+2.1} _{-1.9}
90 pb ⁻¹	8.7 ^{+6.4} _{-4.7} ^{+2.7} _{-2.0}
141 pb ⁻¹	8.8 ^{+4.1} _{-3.7} ^{+1.6} _{-2.1}
144 pb ⁻¹	6.0 ^{+3.4} _{-3.0} ^{+1.6} _{-1.6}
141 pb ⁻¹	7.2 ^{+2.6} _{-2.4} ^{+1.4} _{-1.3}
92 pb ⁻¹	14.2 ^{+7.3} _{-5.6} ^{+2.9} _{-2.8}
94 pb ⁻¹	9.5 ^{+5.2} _{-4.1} ^{+2.1} _{-2.1}
92 pb ⁻¹	11.4 ^{+4.1} _{-3.5} ^{+2.0} _{-1.8}
40 pb ⁻¹	10.8 ^{+4.9} _{-4.0} ^{+2.1} _{-2.0}
40 pb ⁻¹	7.4 ^{+4.4} _{-3.6} ^{+2.1} _{-1.8}

New Run I top mass measurement

Previous (Published) Run I method

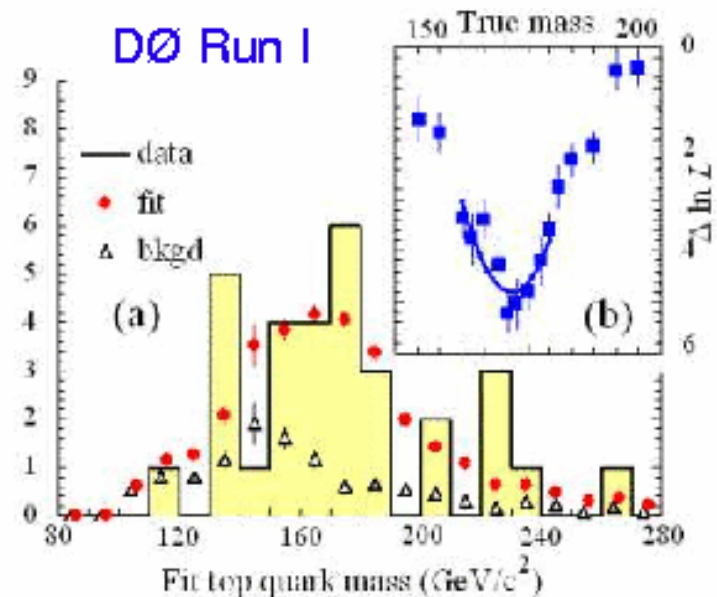
- Preselection [*PRD 58 (1998), 052001*]
 - Isolated, high P_T lepton
 - ≥ 4 Jets
 - Large \cancel{E}_T
- 91 events selected, 125 pb^{-1}

Run I DØ result (1998)

$$m_t = 172.1 \pm 7.1 \text{ GeV}$$

Run I approach :

- Choose lowest solution from constrained kinematic fit ? fitted mass
- Topological discriminant used to separate signal and background
- Mass estimate made with 2D fit in fitted mass and discriminant



New Approach is to calculate per event probability to be a $t\bar{t}$ event. Probability density

$$P(x, M_t) = \frac{1}{\sigma(x)} \int d\sigma(y, M_t) dq_1 dq_2 f(q_1) f(q_2) W(y, x)$$

Mass-dependent,
reconstructed
4-vectors

Differential Xsec
(LO Matrix element +
phase space)

PDF's

Transfer function
Relating partonic
Variables to
Measured quantities

Event Probability $P(x; c_1, c_2, M_t) = c_1 P_{t\bar{t}}(x; M_t) + c_2 P_{\text{bkgd}}(x)$

Background probability

- Main component W+jets (85% of background)
- P_{bkg} calculated from leading order matrix element from VECBOS

All jet-parton assignments considered

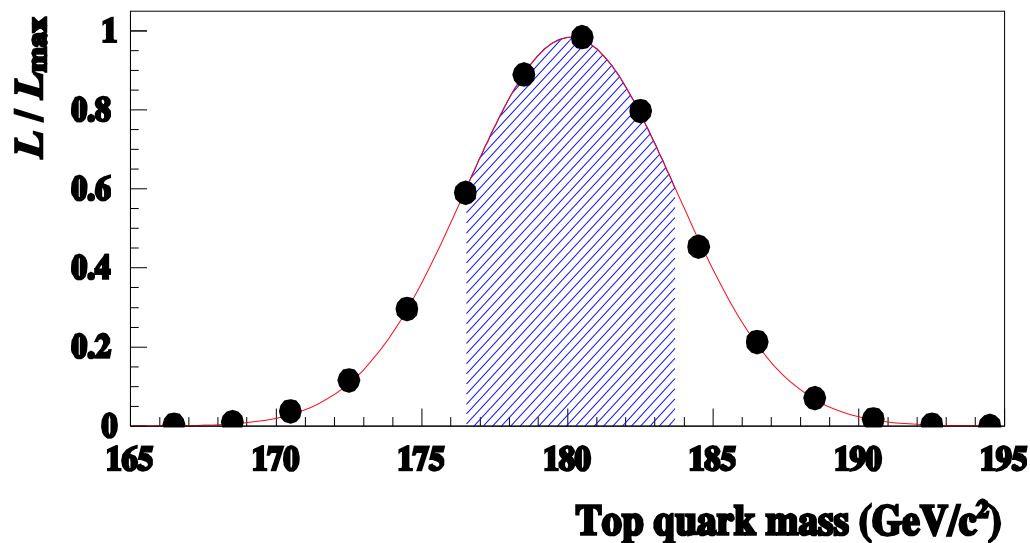
- Sum probabilities of all possibilities (12 total)

Signal purity increased with cut on background probability: $P_{\text{bkg}} < 10^{-11}$

Only 4 jet events are considered

22 events remains

- Event probability $P(x; c_1, c_2, M_t) = c_1 P_{t\bar{t}}(x; M_t) + c_2 P_{\text{bkgd}}(x)$
Likelihood formed, maximized with respect to M_T

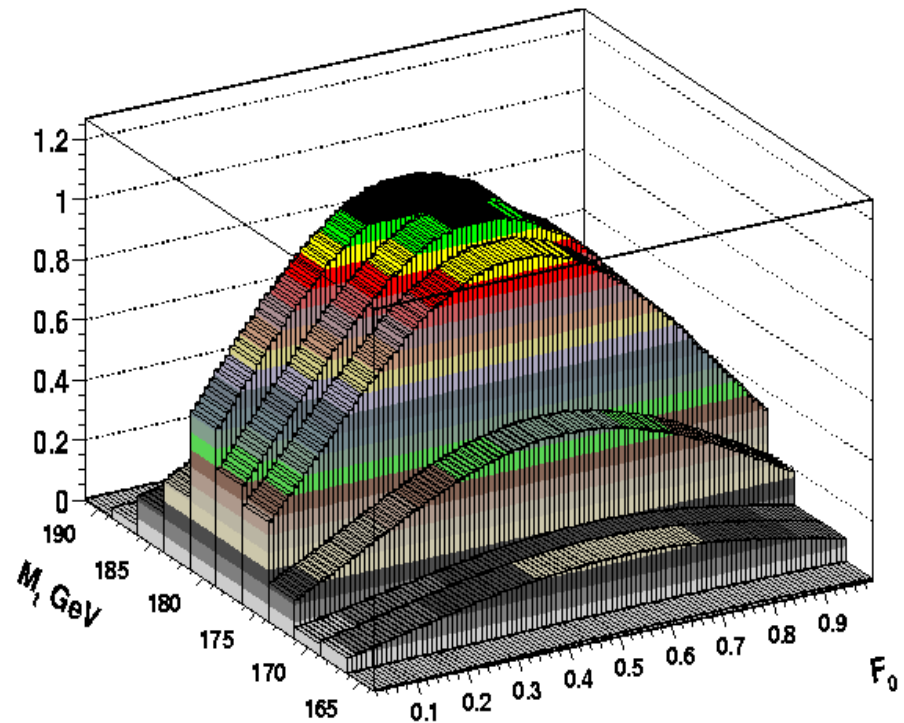


$$M_T = 180.1 \pm 3.6 \text{ (stat)} \pm 3.9 \text{ (syst)} \text{ GeV}$$

- 12 signal events, 10 background events
- Improvement in statistical uncertainty is equivalent to 2.4 time more data
- Dominant systematic error from Jet Energy Scale (3.3 GeV)
- Result is submitted to "Nature"

New Run I W helicity measurement

- The top decays before hadronization can occur
- Spin information transferred to decay products (Wb)
- Standard Model: top decays via V-A current polarization
 - 70% Longitudinal (F_0)
 - 30% Left-handed (F_L)
 - Angular distribution of decay products in W rest frame probes this mixture
- Same dataset, probability based approach: allow F_0 to vary



D0 Preliminary : $F_0 = 0.56 \pm 0.31 (stat.) \pm 0.04 (syst.)$

Outlook

- **More results to come in the near future :**
- tt cross section measurement with larger data sets :
 - Cross section with b lifetime and soft muon tagging
 - Cross section in dilepton channel (next week)
 - Cross section in all jet channel with lifetime tagging
- **Top quark mass measurement with Run II data set**
 - With standard Run I method
 - With the New Matrix Element method
- **W helicity measurement with the Run II data set**
- **Single top production search**