Recent Top Quark Results at the D0

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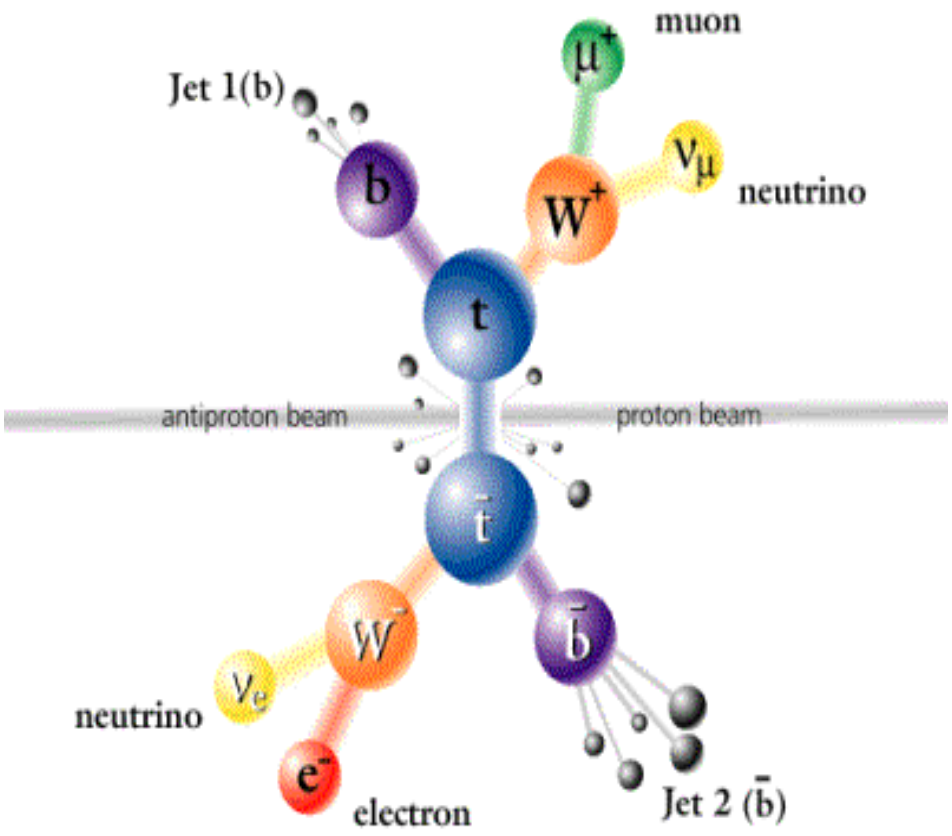
Top Quark Production overview

- Top quark is produced at the tevatron through
  - $q\bar{q}$ annihilation (90%)
  - gg fusion (10%)
- And decays predominantly into b and W (ll,jj)
- DØ recorded data set of 280 pb^{-1}
  - tt cross section is 30% higher in Run II than in Run I
- Work underway to measure
- tt cross section in all leptonic and all modes
- Top mass to a higher precision
- W helicity measurement
- Observation of single top production

Dilepton Event Signature

- 2 high pt leptons
- >= 2 jets
- Large $\not{E}_T$
- Backgrounds:
  - Physics
    - $WW \rightarrow ee, e\mu, \mu\mu$
    - $Z \rightarrow \tau\tau \rightarrow ee, e\mu, \mu\mu$
  - Instrumental
    - W + jets (jet fakes e,μ)
    - QCD (2 jets fake e,μ)
    - $Z \rightarrow ee$ and fake $\not{E}_T$



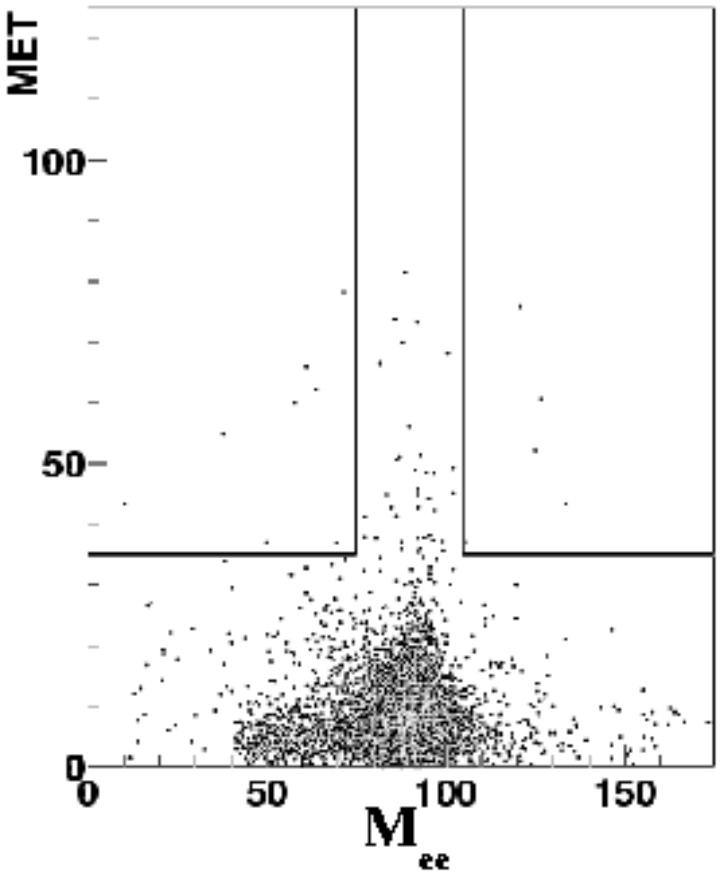
Background in the Dilepton channel

- $Z \rightarrow$ ee (μ,μ) is the largest background contribution to ee and μ,μ channels

- Remove Z mass window

- Require high MET (> 35 GeV)

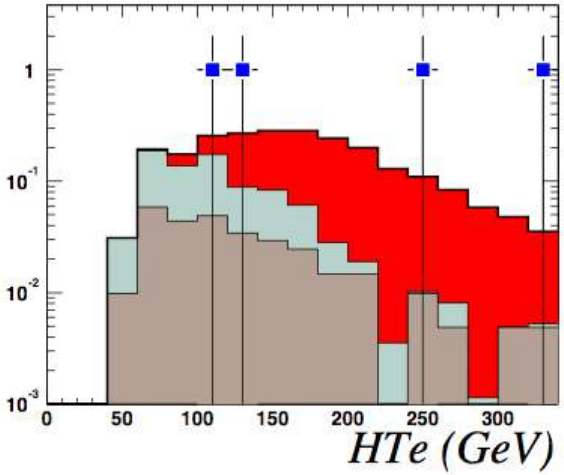
- H_T > 120 GeV

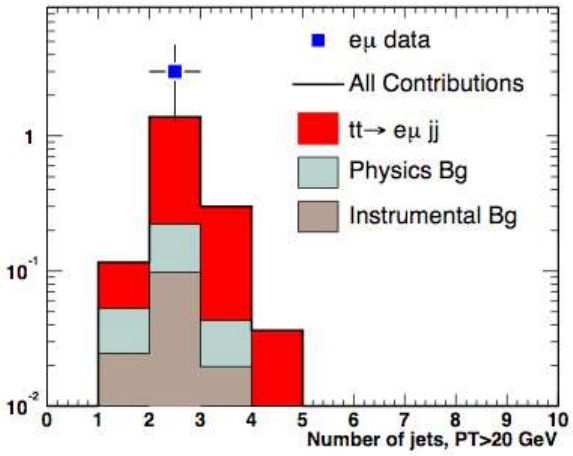


Top cross section in dilepton channel

Results from first 90 – 110 pb^{-1}

	ee	μμ	eμ
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
Signal+bkgd	1.2±0.5	1.2±0.5	2.3±0.5
Data	2	0	3

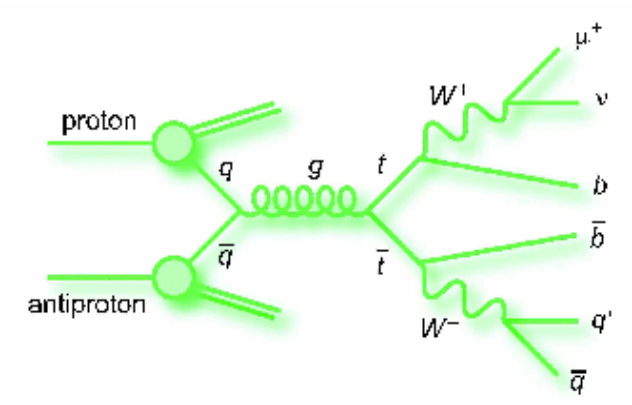




Combined cross section from all three channels yields :

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

Single lepton Channel



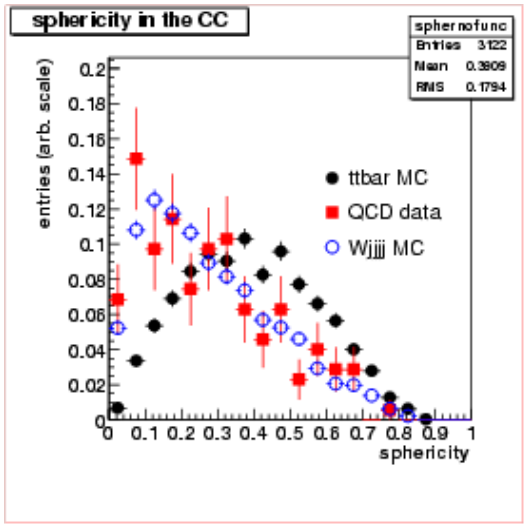
- Event selection :
- 1 high P_t isolated EM(Muon object
- High MET
- >=4 jets

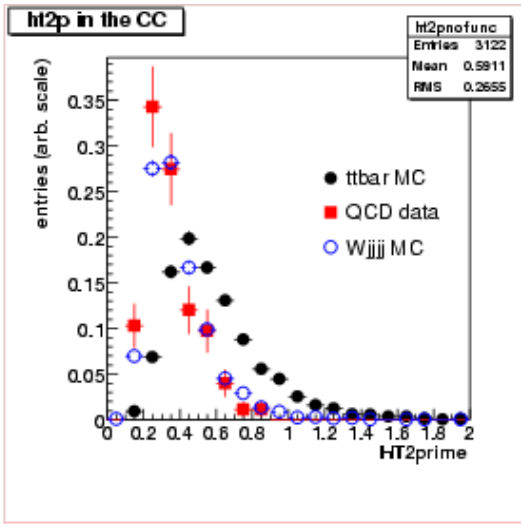
Branching ratio is much higher than a dilepton channel but with larger background contribution.

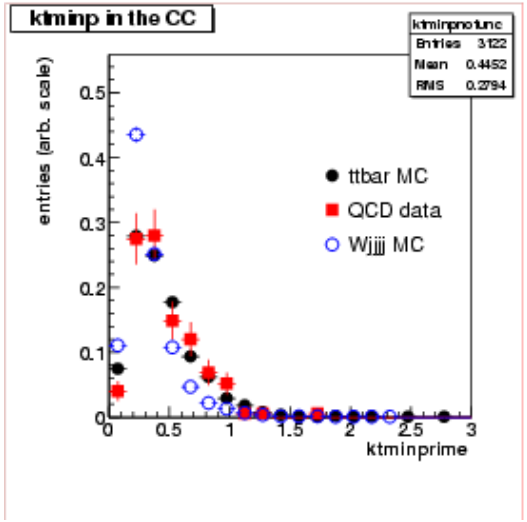
- Two sources if the background
- QCD events which fake an Electron or a isolated muon
- W+jets events

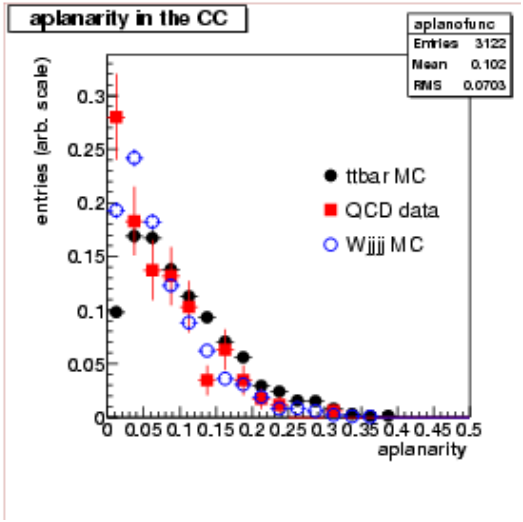
Topological Analysis

- For background rejection a top event likelihood is constructed using 4 topological errors.
  - **Jet Energy Scale systematic dominates earlier results**
- Use topological variables that depend on
  - **Angular quantities**
    - **sphericity**
    - **aplanarity**
  - **Ratios of energy-dependent quatities**
    - **H'_{T2}**
    - **K'_{Tmin}**





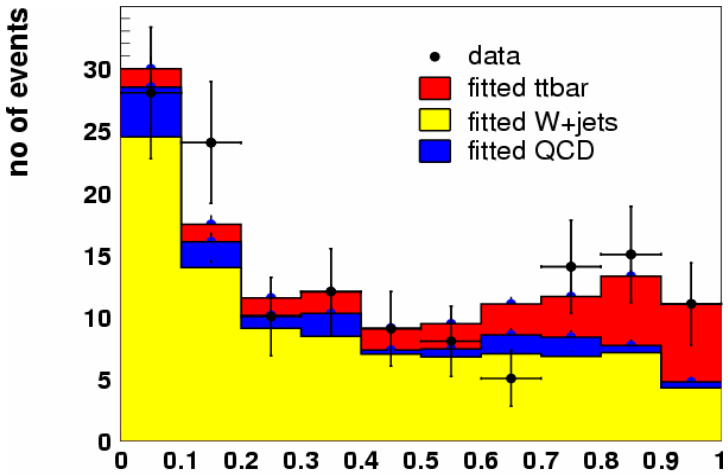




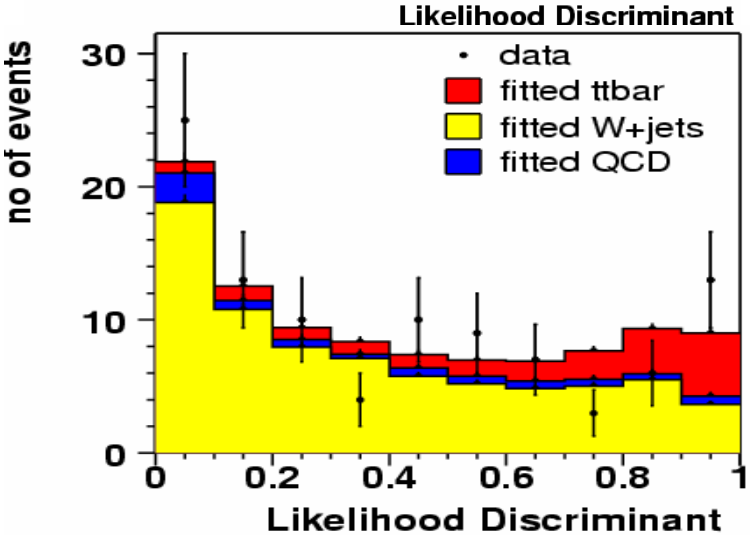
Likelihood fitting

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

- The likelihood shape for tt has very weak mass dependce
- $t\bar{t}$ shape is prediced by the MC at 175 GeV

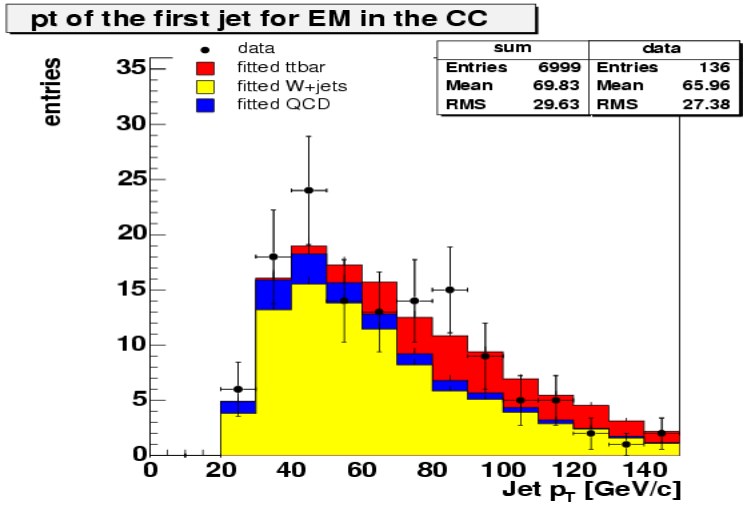


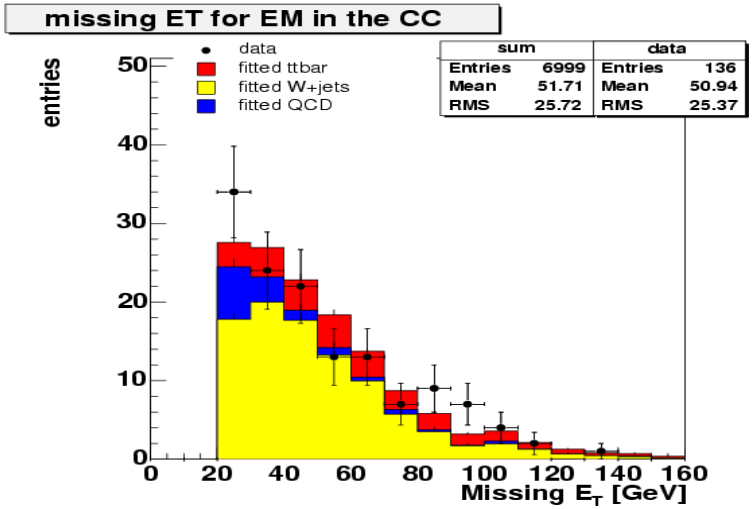
	e+jets	μ+jets
Inst Lum (pb^{-1})	141.2	143.9
QCD	14.1 ± 1.2	7.1 ± 0.9
W+jets	94.6 ± 15	74.7 ± 12
Bkgnd	108.7 ± 15	81.8 ± 12
Observed	136	100

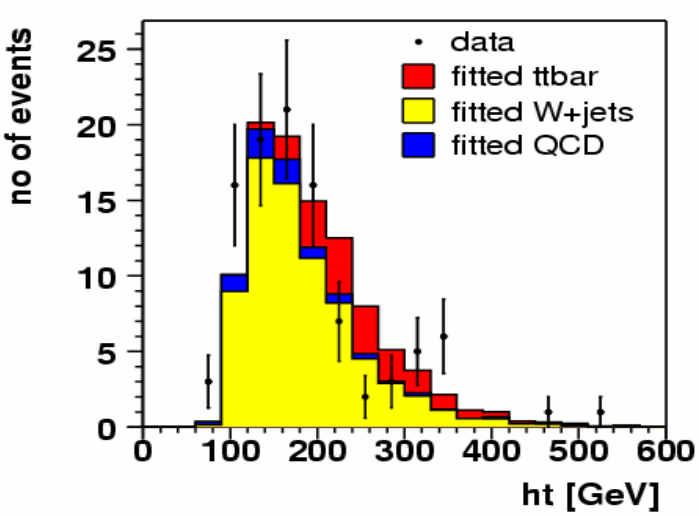


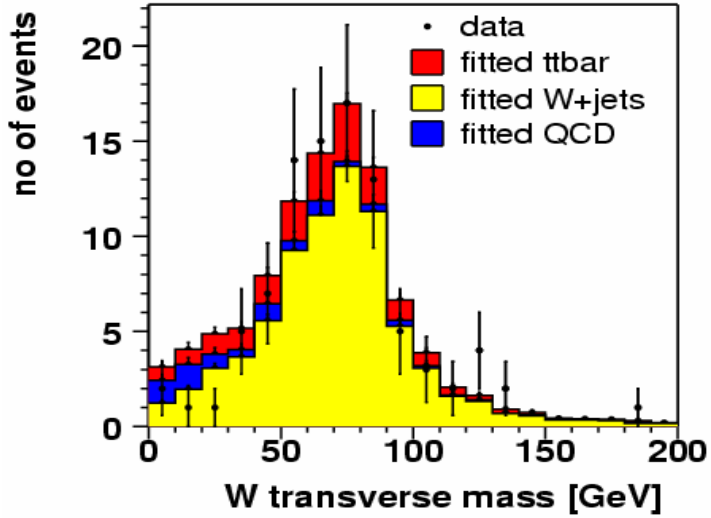
$$\sigma(t\bar{t}) = 7.20^{+2.58}_{-2.39}\ (\text{stat})\ ^{+1.36}_{-1.34}\ (\text{syst})\ \pm 0.47\ (\text{lumi})\ \text{pb}$$

Lepton + jets kinematic distributions

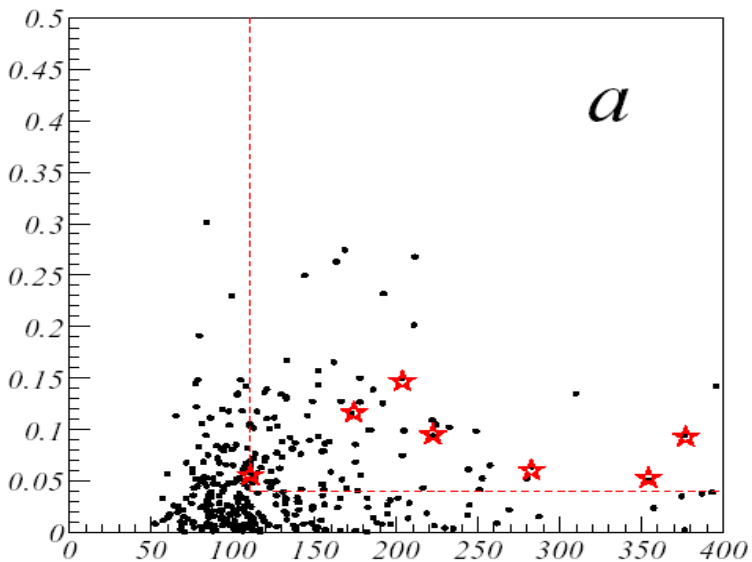








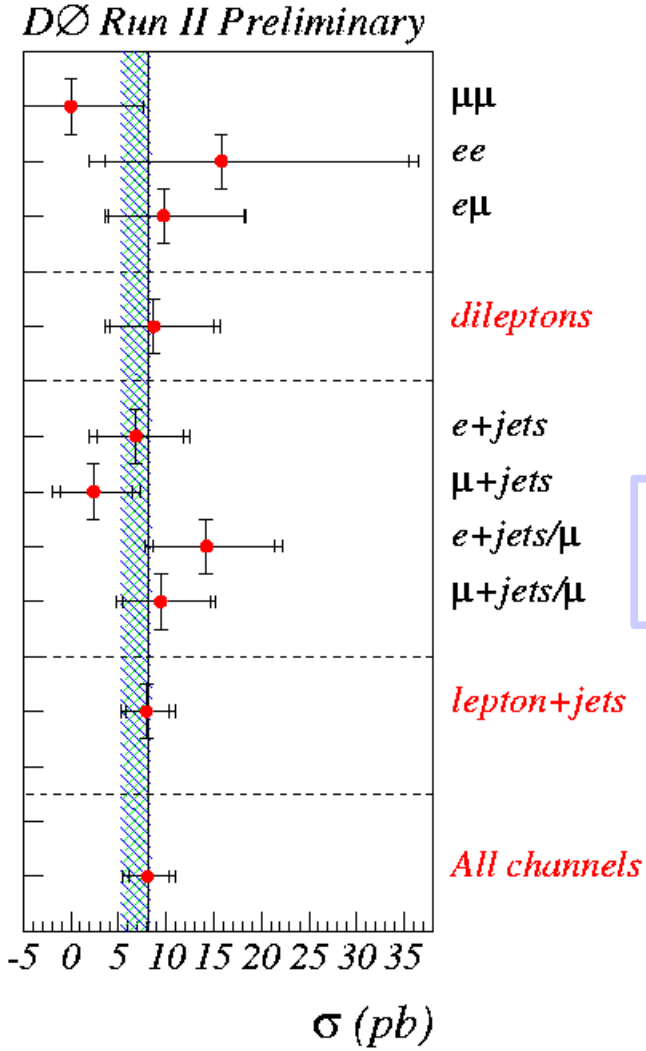
Single lepton with soft muon tagging



- <u>Soft Lepton Tag</u>
- In 40%, b quarks decay semi-leptonically
  - These leptons have a softer p_T spectrum than leptons from W/Z
  - They are not isolated
- same preselection as topological analysis
- ≥ 3 jets
- softer topological cut

- e+jets (94 pb^{-1}) :
  - **7 observed events**
  - **Background 1.1±0.9**
- μ+jets (94 pb^{-1}): $\sigma = 11.2 \pm 4.0\ (stat) \pm 1.3\ (sys) \pm 1.1\ (lumi)$
  - **8 observed events**
  - **Background 2.2±1.0**

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



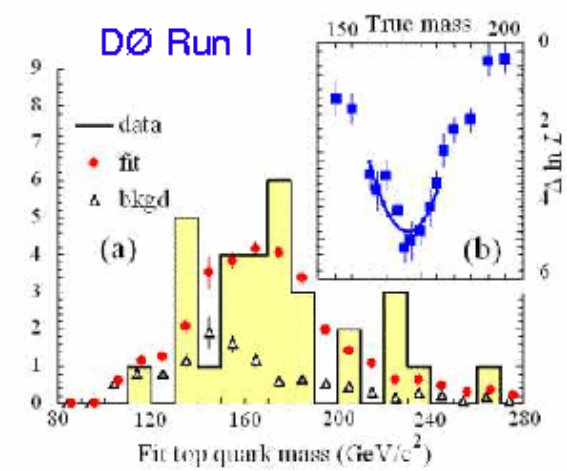
D0 Run II preliminary $t\bar{t}$ cross section result :

$$\sigma(t\bar{t}) = 7.20^{+2.58}_{-2.39}\ (\text{stat})\ ^{+1.36}_{-1.34}\ (\text{syst})\ \pm 0.47\ (\text{lumi})\ \text{pb}$$

New Run I top mass measurement

- Preselection [*PRD 58 (1998), 052001*]
  - **Isolated lepton: E_T>20 GeV,**
  - **$|\eta_e|<2, |\eta_\mu|<1.7$**
  - **Jets: ≥4, E_T>15 GeV, $|\eta|<2$**
  - **Missing E_T > 20 GeV**
  - **$|E_T^{lep}| + |E_T| > 60$ GeV ; $|\eta_W|<2$**
- **91 events selected,** 125 pb^{-1}

Run I DØ result (1998)
m_t = 172.1 ± 7.1 GeV/c^2



Run I approach :

- **Choose lowest χ^2 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, x : reconstructed 4-vectors

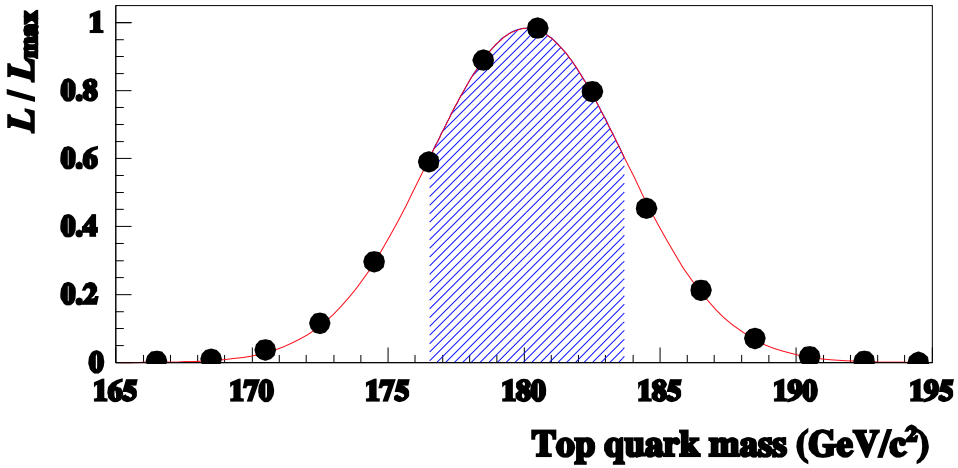
Differential Xsec (LO Matrix element + phase space)

PDF's

Transfer function Relating partonic Variables to Measured quantities

- Background probability
  - **Main component W+jets (85% of background)**
  - **P_{bkg} calculated from leading order matrix element from VECBOS**
  - **QCD is not not included in the Probability density matrix element**
  - **Only 4 jet events are considered**
- **Signal purity increased with cut on background probability: $P_{bkg} < 10^{-11}$ ·**
- **22 events remain**
- All jet-parton assignments considered
  - **Sum probabilities of all possibilities (12 total)**

- 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 to obtain M_t, c1, c2**

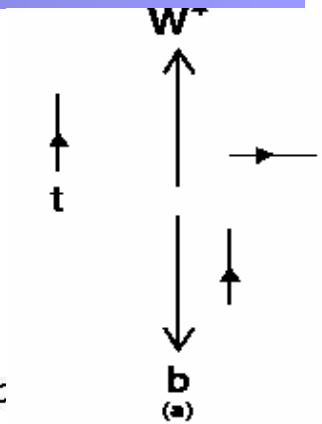


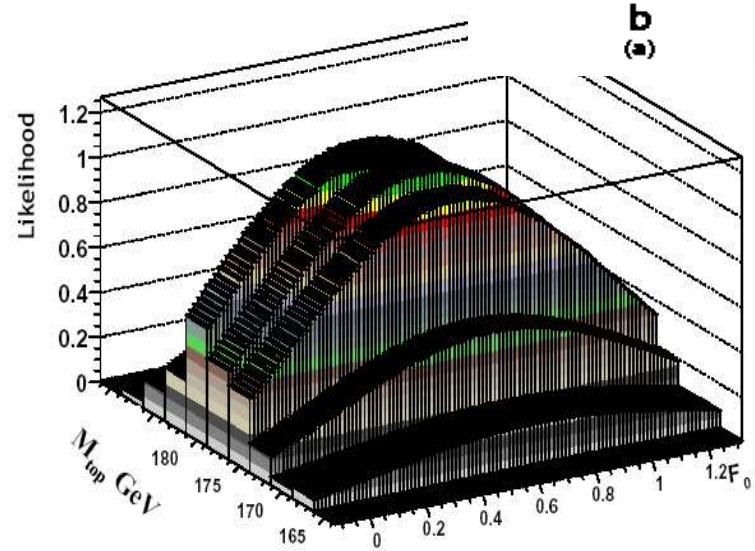
M_t = 180.1 ± 3.6 (stat) ± 3.9 (syst) GeV/c^2 = 180.1 ± 5.3 GeV/c^2

- 12 signal, 10 background events
- Improvement in statistical uncertainty equivalent to 2.4 times more data
- Dominant systematic error from JES (3.3 GeV/c^2)

Run I W helicity measurement

- The top decays before hadronization can occur
- Spin information transferred to daughters (*Wb*)
- SM: top decays via V-A current polarization for M_t = 175
  - **70% Longitudinal (F_0)**
  - **30% Left-handed(F_-)**
  - **Angular distribution of decay products in W rest frame probes this mixture**
- Same dataset, probability-based approach: allow F_0 to vary





F_0= 0.56 ± 0.31 (Statistical) ± 0.04 (Systematic)

The future developments

- Near term (~ 280 pb)
- New dilepton cross section results
- B tagging using total sample
- Top mass measurement using Run I original and matrix method approach

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- Longer term
- Top mass measurement with the 2 GeV precision
- Observation of single top quark production
- Detail study of prodution and decay properties
- Cross section is all decay channels
- Spin correlations
- W polarization
- Rare decays