DPF, Riverside
August 2004

Top Quark Mass in The Lepton + Jets Channel: Template Method

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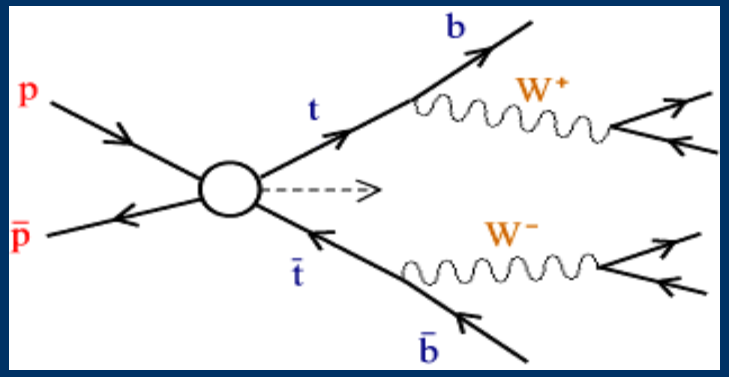
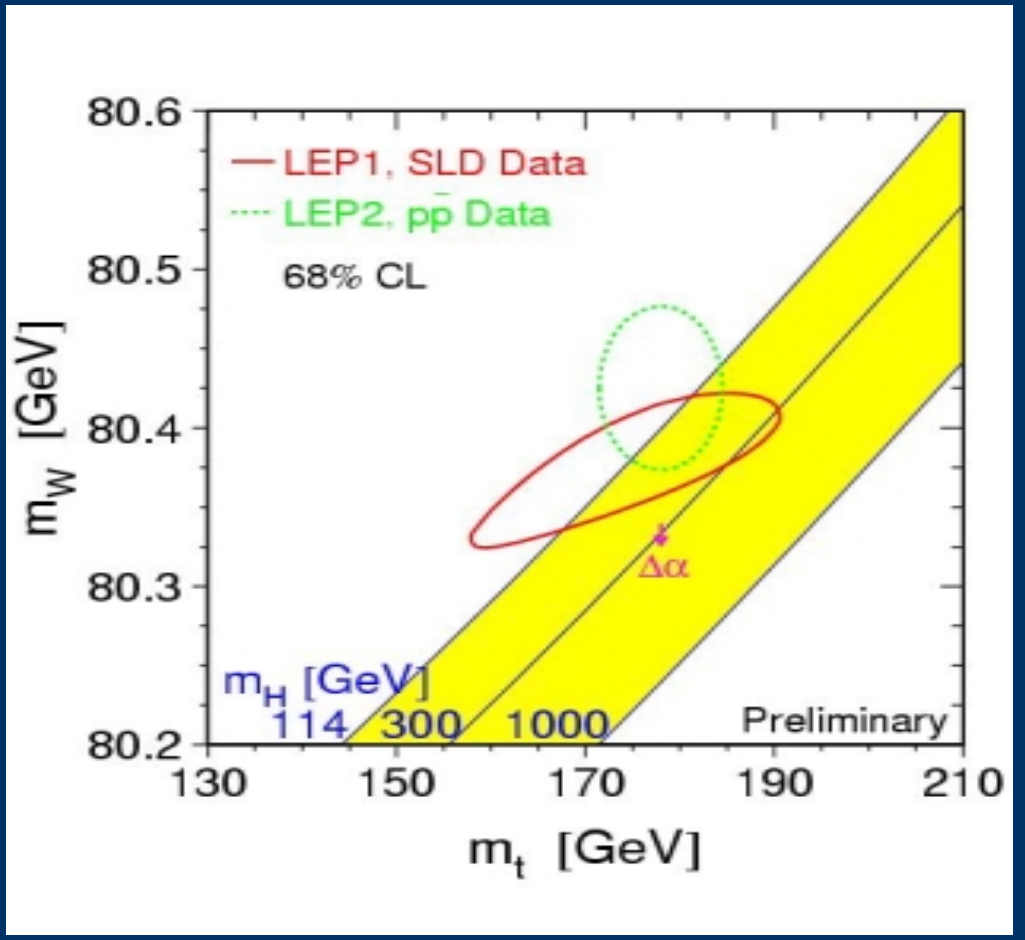
for the DØ Collaboration

Overview

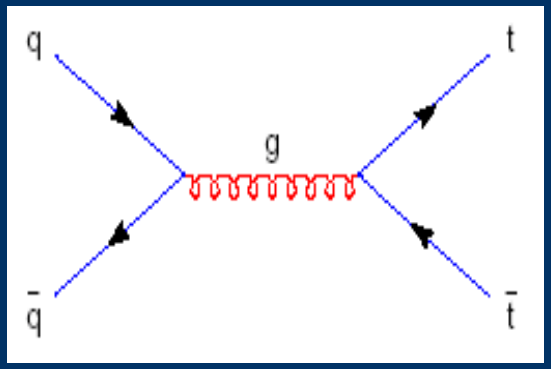


- Motivation
- DØ Detector
- Data Sample and Event Selection
- Measurement Technique
- Preliminary Results

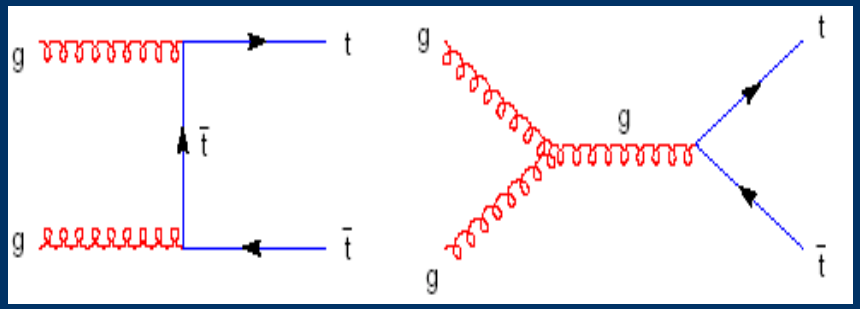


Top Quark Production and Decay

At the Tevatron $\sqrt{s}$ = 1.96 GeV, top quarks are primarily produced in pairs

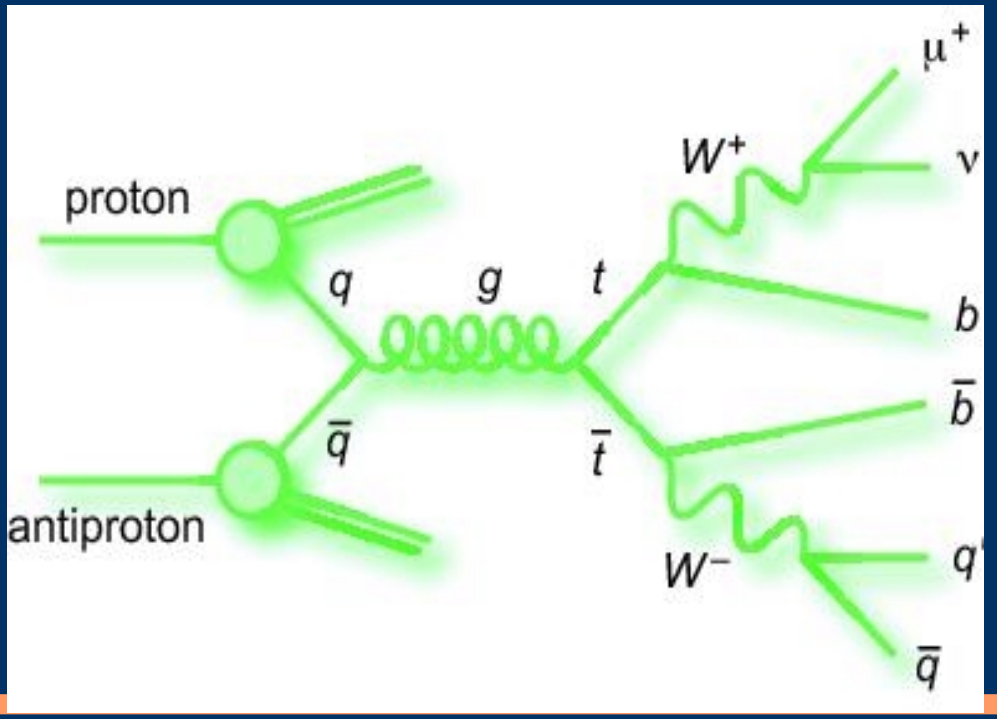


$q\bar{q}$ annihilation (85%)

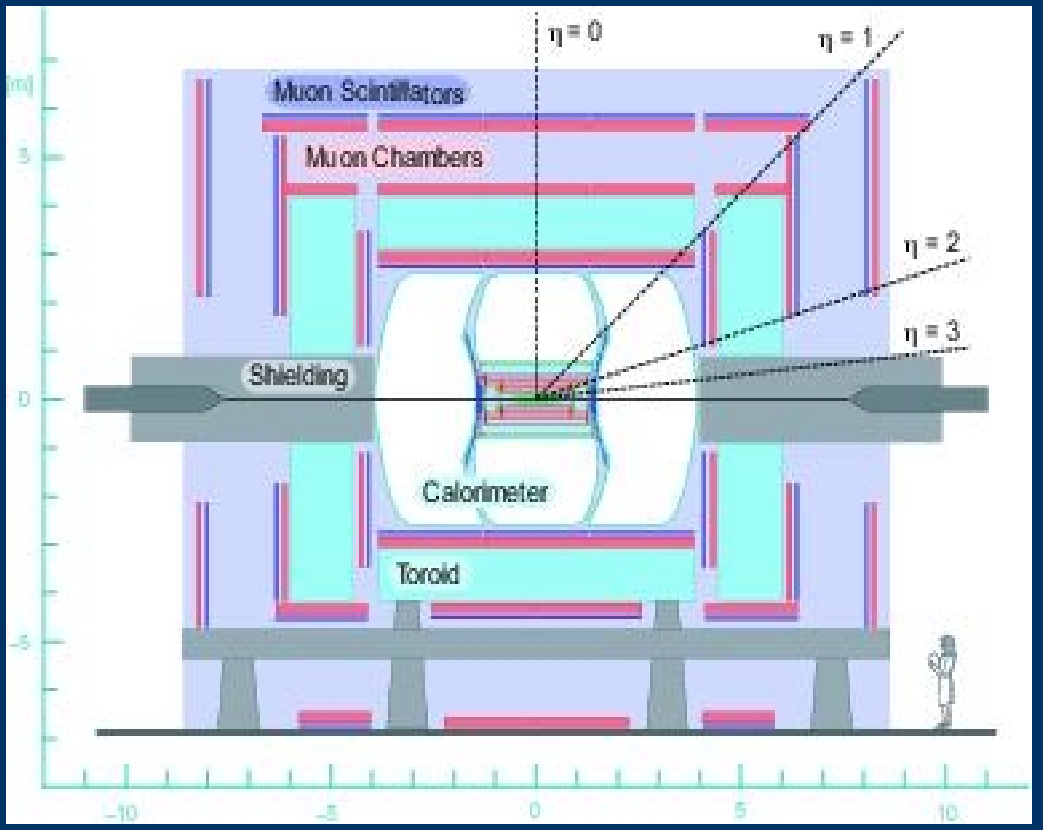


gluon fusion (15%)

- Since $|V_{tb}| \sim 1$, the top quark almost always decays to Wb.
- Event topology depends on the W boson decay mode:
  - **Dilepton:** 2 high p_T leptons, 2 b-jets, large E_T^{mis}. BR(ee, μμ, eμ) = 5%.
  - **Lepton + Jets**: 1 high p_T lepton, 4jets (2 b-jets), large E_T^{mis}. BR(e,μ) = 30%.
  - **All hadronic**: 6 high p_T jets (2 b-jets). BR = 44%.



DØ Detector



- Central Tracking (Silicon/Scintillating Fiber Tracker)- Solenoid 2 Tesla field
- Liquid Argon/Uranium Sampling Calorimeter
- Excellent Muon Coverage $|\eta| < 2.0$

Data Sample and Event Selection

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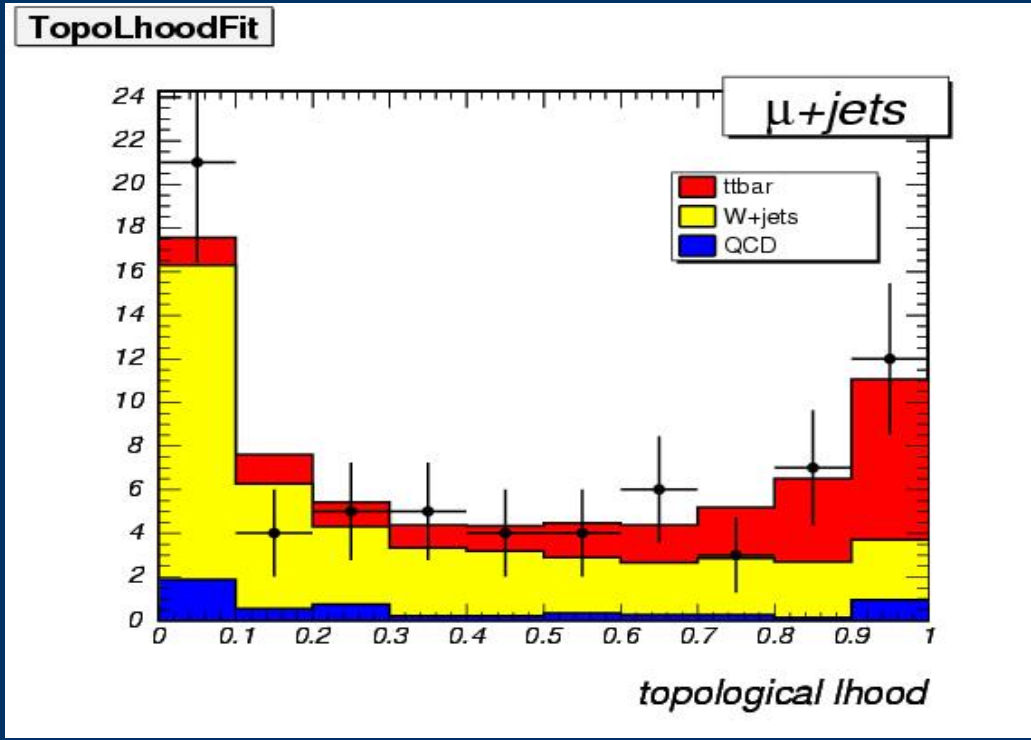
159 pb^{-1} μ +jets

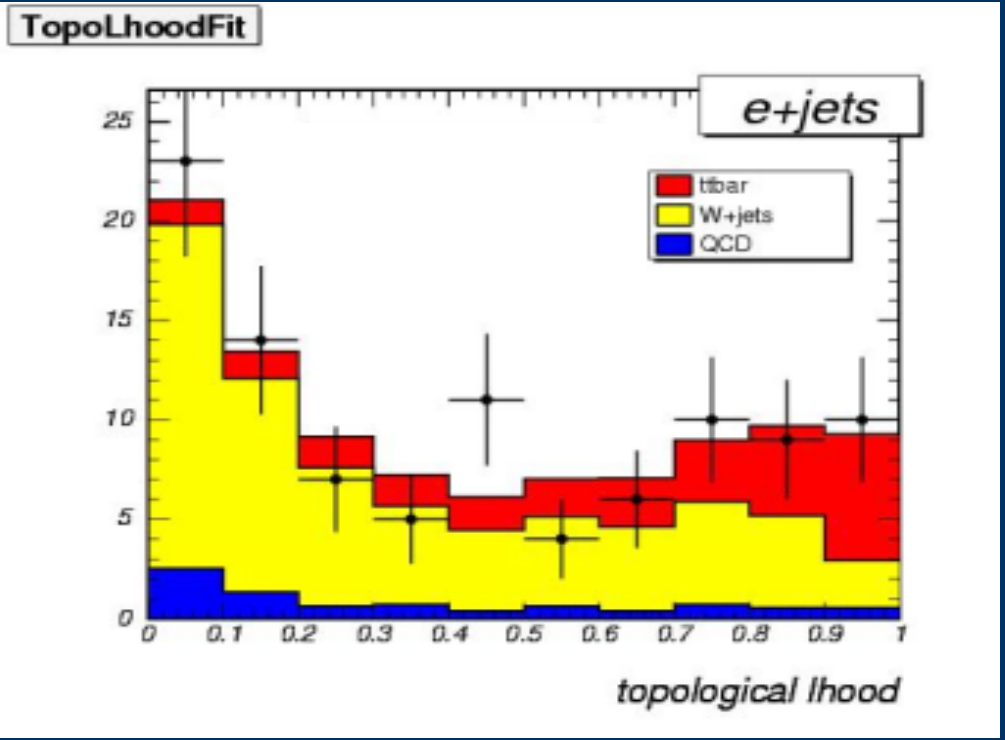
- Primary Vertex within SMT fiducial region with at least 2 tracks
- 3 Leading Jets with $|\eta| < 2.5$, $P_T > 20$ GeV
- 4th leading jet with $|\eta| < 2.5$, $P_T > 15$ GeV
- 20 GeV < Muon P_T < 150 GeV
- Isolated Muon
- $\not\!\!E_T > 17$ GeV
- Triangle $\not\!\!E_T$,φ cuts
- Second high pt muon veto
- Sum of P_T of jets (excluding leading jet) > 90 GeV

148 pb^{-1} e+jets

- Primary Vertex within SMT fiducial region with at least 2 tracks
- 3 Leading Jets with $|\eta| < 2.5$, $P_T > 20$ GeV
- 4th leading jet with $|\eta| < 2.5$, $P_T > 15$ GeV
- Electron $P_T > 20$ GeV
- Isolated well identified Electron
- $\not\!\!E_T > 20$ GeV
- Triangle $\not\!\!E_T$,φ cuts
- Reject if there is a second tight high P_T electron
- Sum of P_T of Jets (exluding leading jet) > 90 GeV
- $|\not\!\!E_T| + |P_T^e| > 65$ GeV

Sample Composition

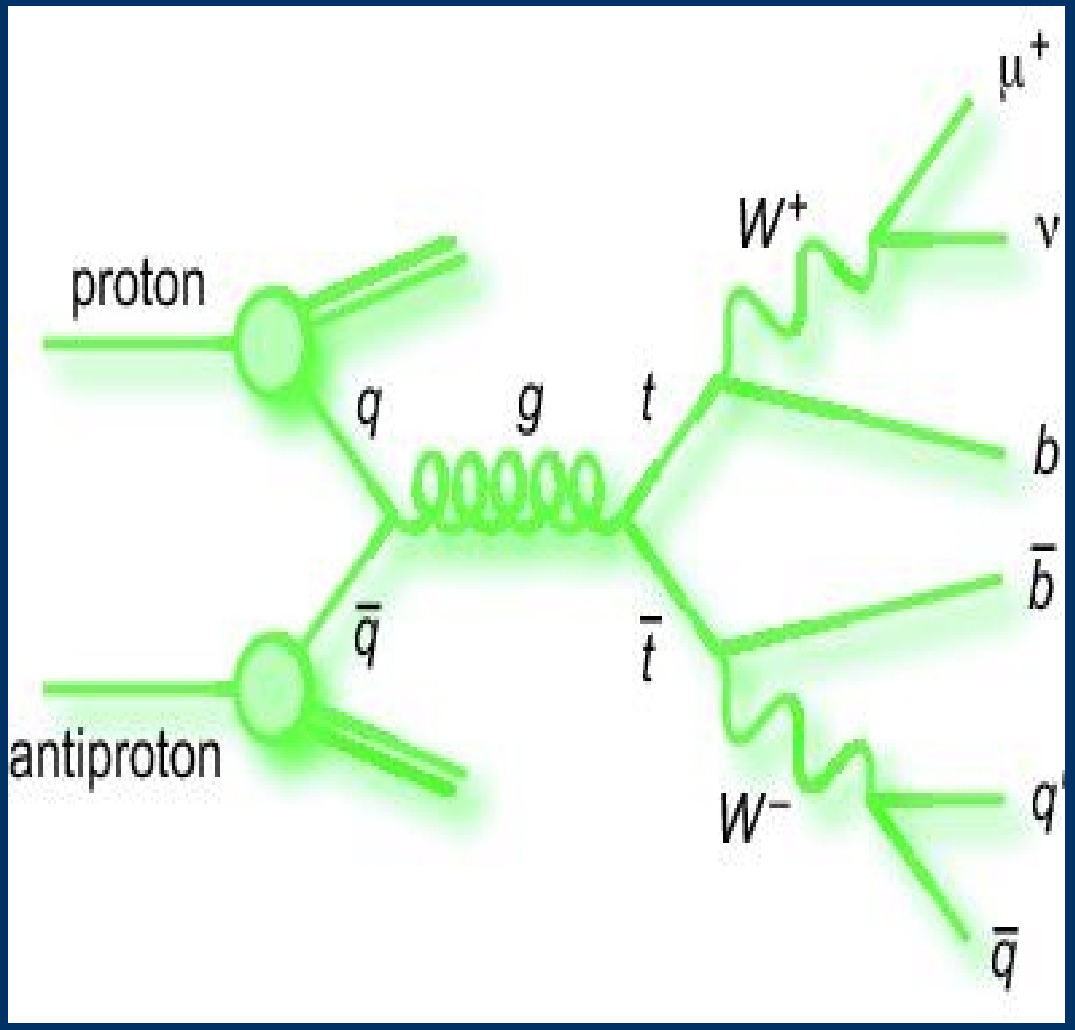




~ 30% ± 8% $t\bar{t}$

- Construct Likelihood from topological information
- Likelihood fit to template to select most likely sample composition

Kinematic Fit



- Kinematic Fit:
  - 1 unknown: longitudinal momentum of the neutrino
  - 3 constraints
    - t and $\bar{t}$ have the same mass
    - 2 jets have the invariant mass of the W boson
    - lepton+neutrino have invariant mass of the W boson
  - 2C fit for top quark mass
- Use Templates From MC
  - Different Top quark Masses
  - Background Fit as Signal
- Fit for most likely top quark mass and signal purity using likelihood fit

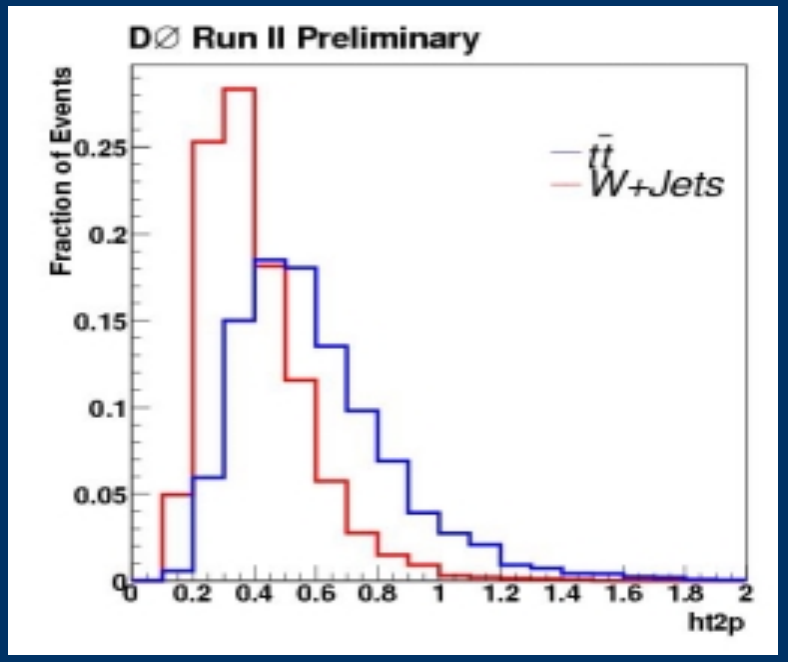
Topological Variables

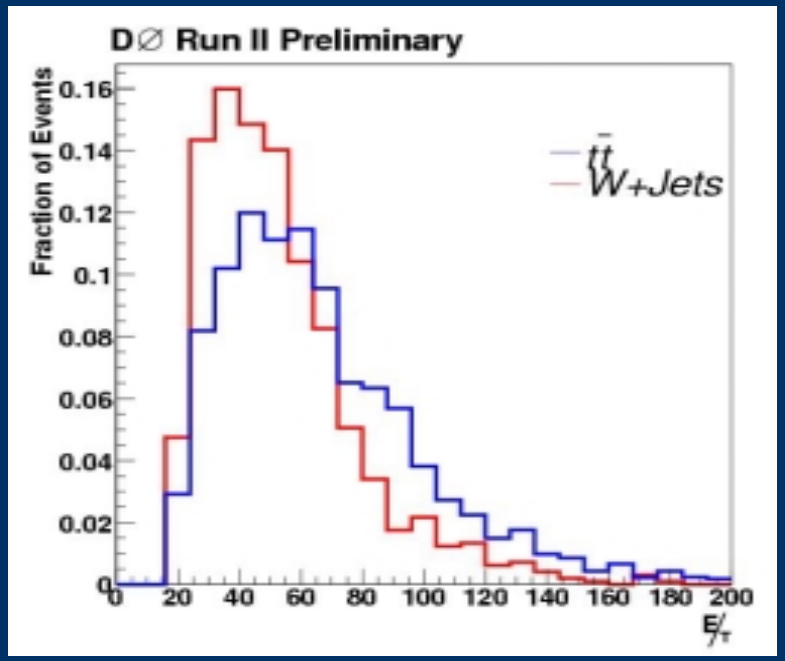
- Low Bias ("LB") discriminant is built from 4 topological variables to give extra discrimination between top and background
- Form log likelihood of signal over background for each variable and combine
- Designed to be uncorrelated with mass

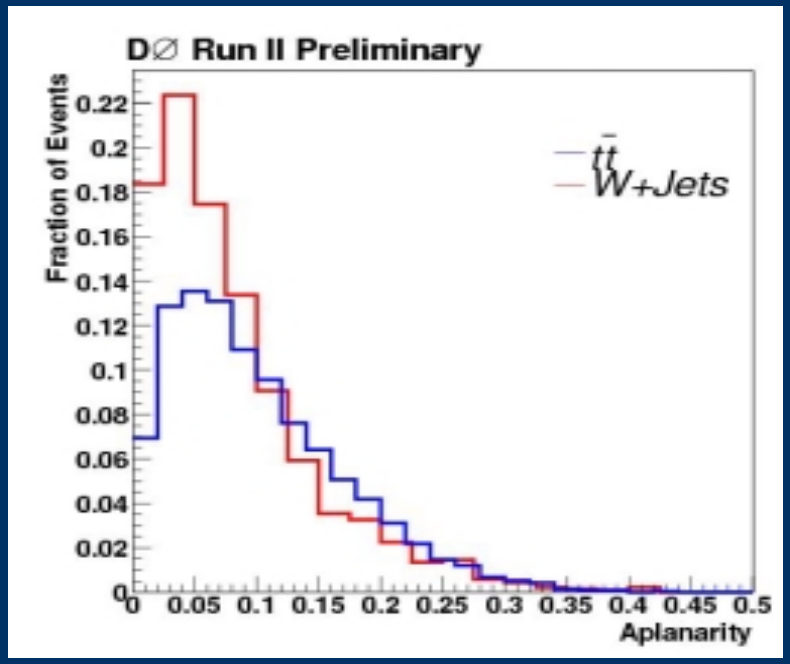
1. The reconstructed $\not{P}_T$.
2. $\mathcal{A} \equiv \frac{3}{2} \times$ smallest eigenvalue of $\mathcal{P}$
3. $H'_{T2} \equiv \frac{H_{T2}}{H_{\parallel}}$
4. $K'_{Tmin} \equiv \frac{(min\ of\ 6\ \Delta R_{jj}) \cdot P_T^{lesser\ j}}{P_W^T}$

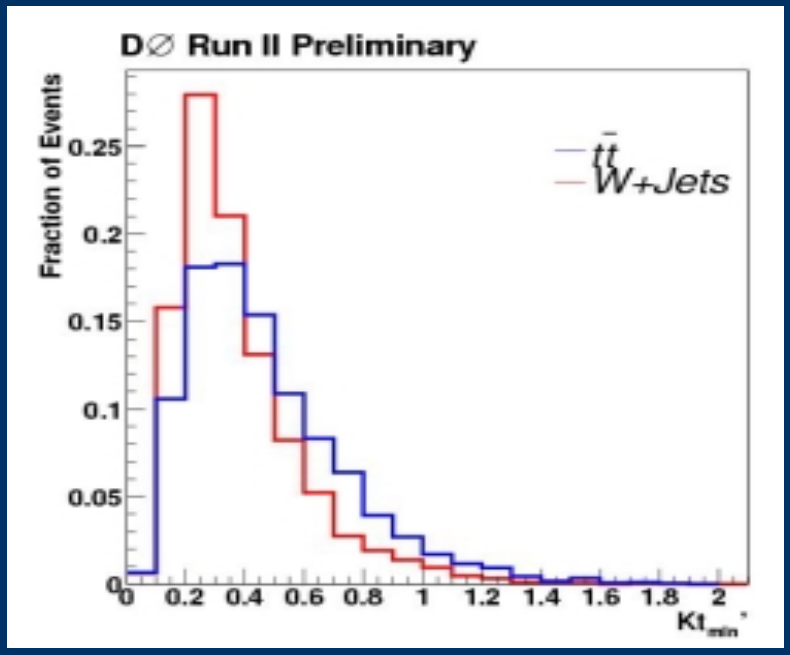
$$\mathcal{P}_{ij} \equiv \frac{\sum_a p_{a,i} p_{a,j}}{\sum_a |\vec{p}_a|^2}$$

Topological Variables









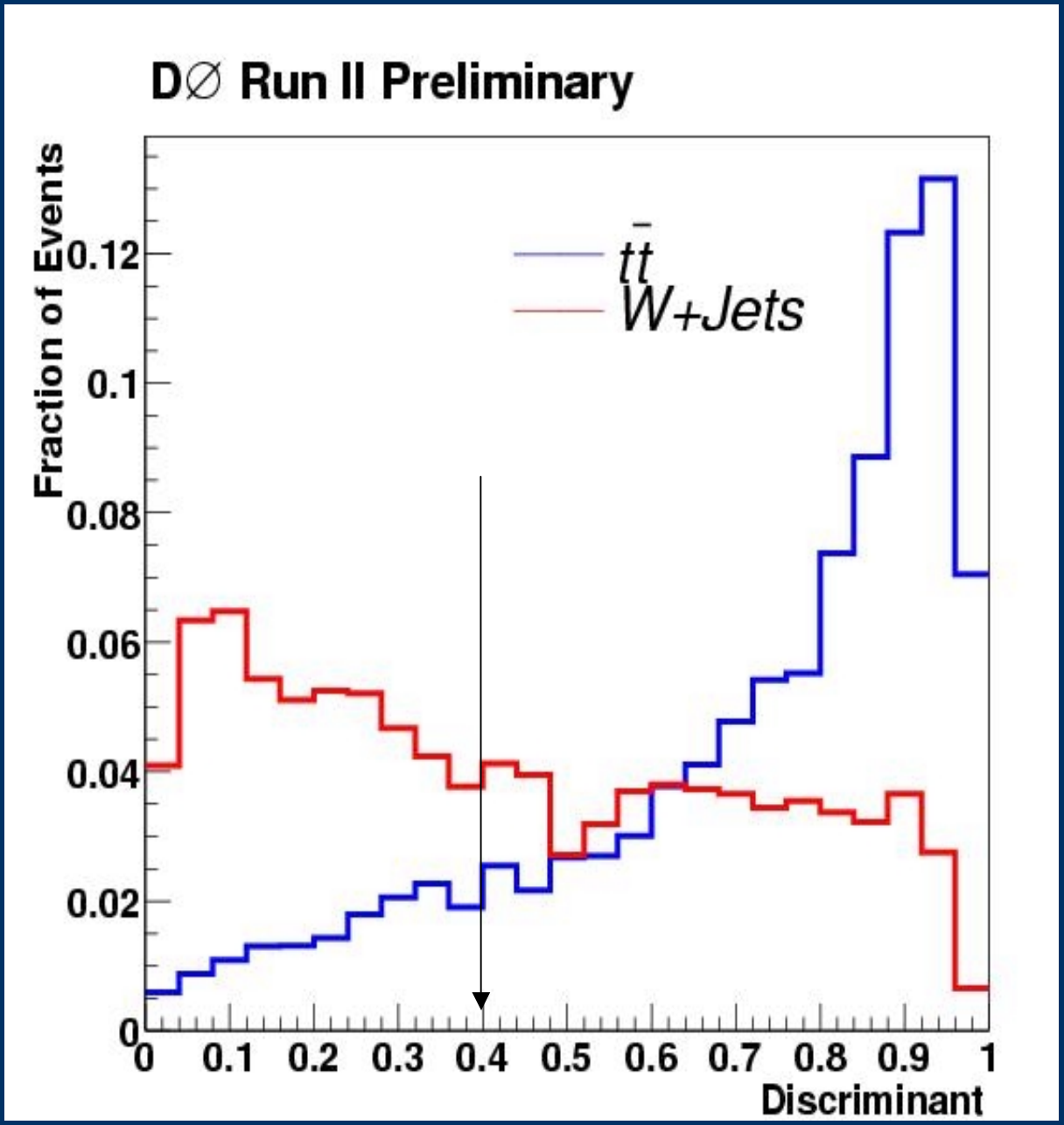
Topological Likelihood

Use a discriminant cut of 0.40:

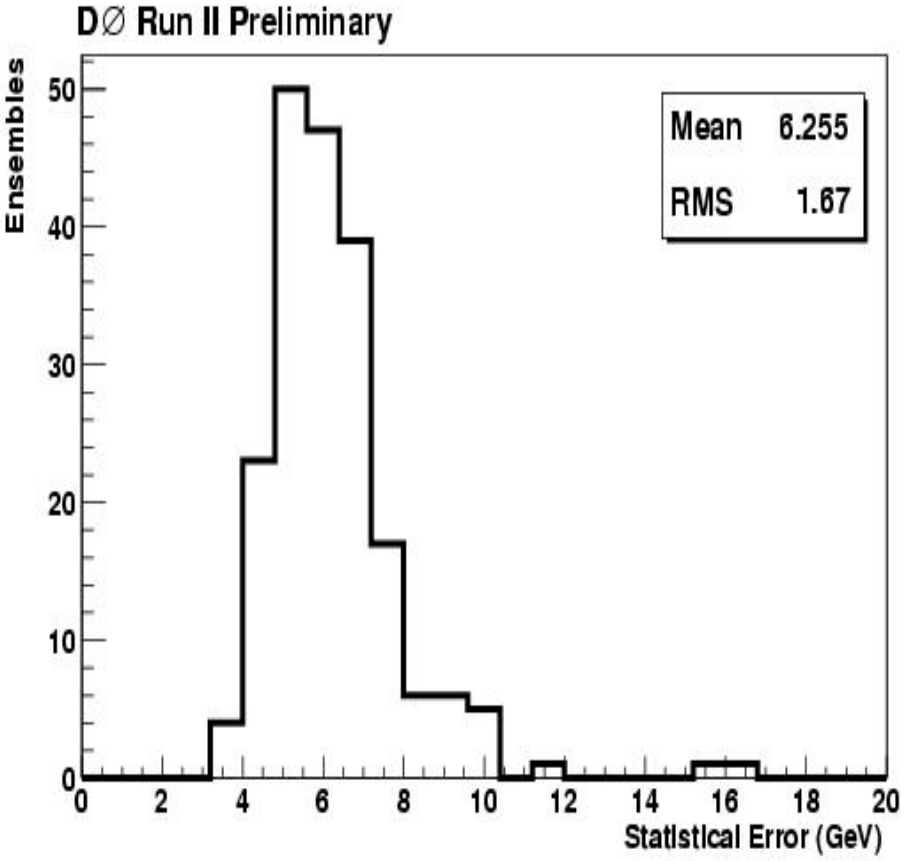
- minimizes expected statistical error from ensemble tests
- retains ~85% of signal
- removes ~50% of background

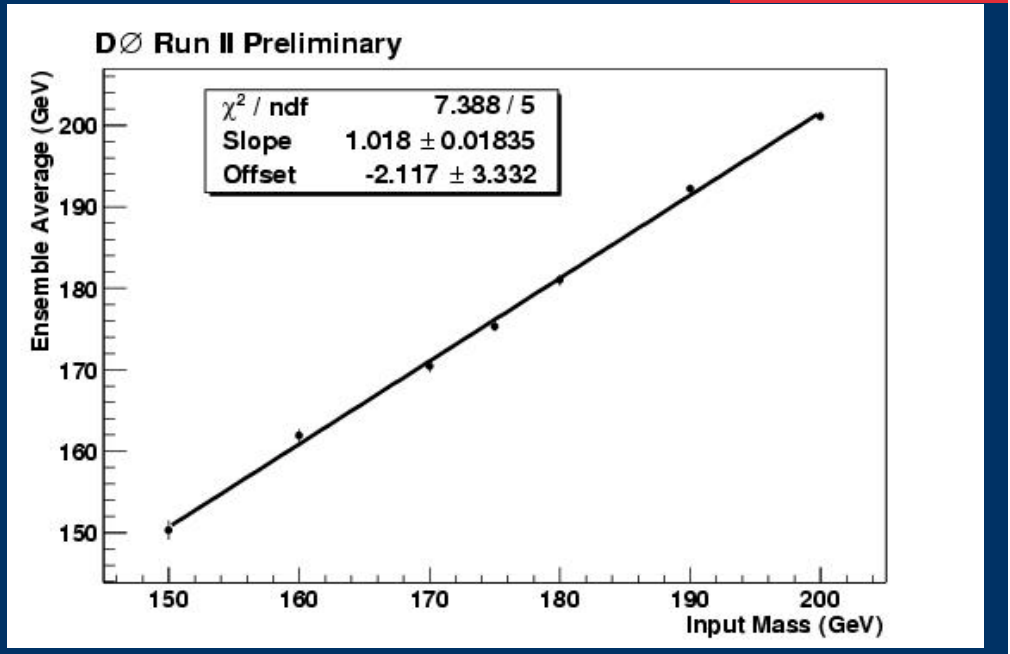
$$L^{tb} = \sum_{i=1}^{4} L_i^{tb}(f_i)$$

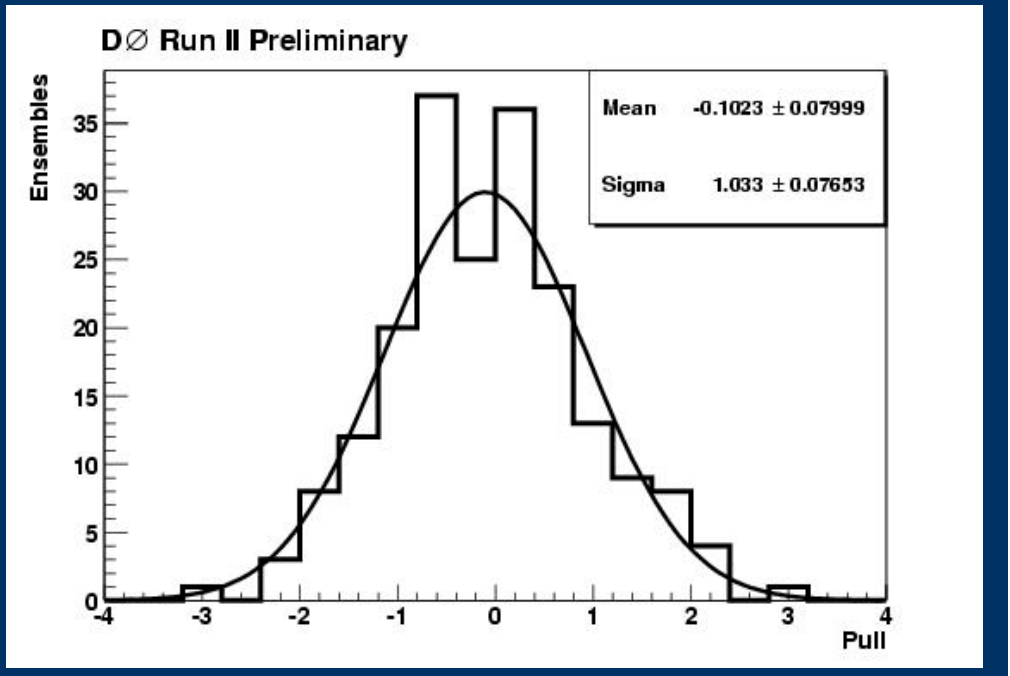
$$\mathcal{D}_{LB} = \frac{1}{1+1.25e^{-L^{tb}}}$$



Performance of the Method

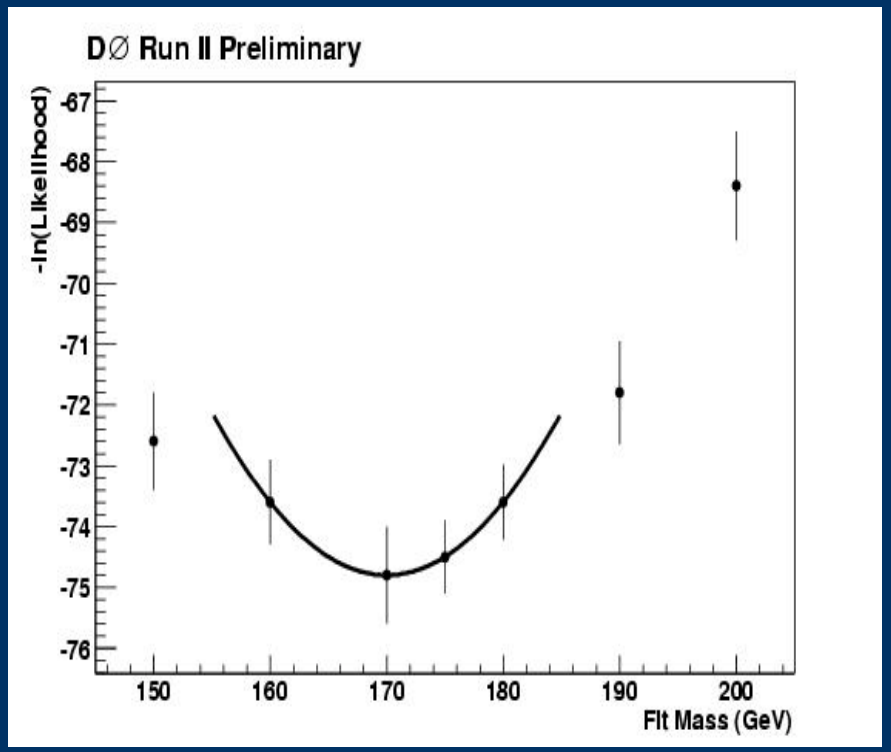


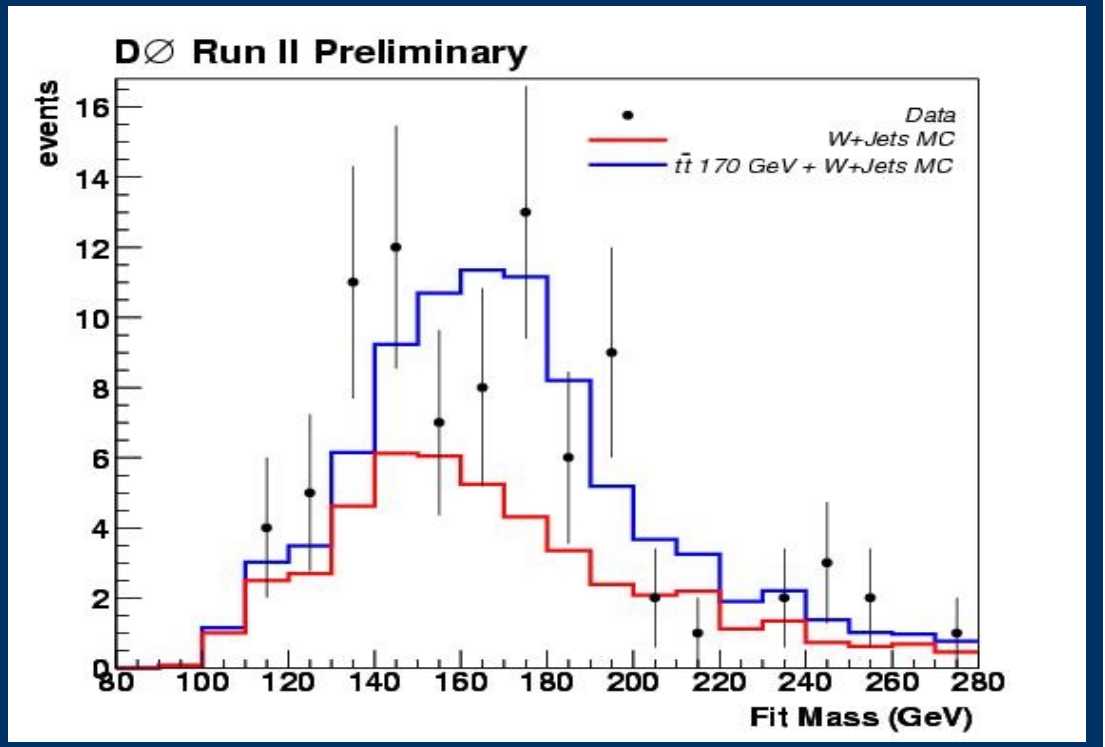




* unbiased, linear measurement
* errors consistent with statistical spread
* most likely error ~5-6 GeV

Results on Data





$170.0 \pm 6.5\ \text{GeV (stat)}^{+10.5}_{-6.1}\ \text{(sys)}$

38 ± 8 Top Quark Events

Source	-1σ	+1 σ
JES	4.0 GeV	9.0 GeV
Jet Resolution	1.5 GeV	3.0 GeV
Underlying Event	-	3.0 GeV
Limited MC	3.0 GeV	3.0 GeV
Trigger Bias	1.0 GeV	1.0 GeV
Calibration	0.5 GeV	0.5 GeV
Signal Model	4.8 GeV	4.8 GeV

Summary

- First Preliminary Measurement of the Top Quark Mass in Run II at DØ
- Analysis uses ~150 pb^{-1}, by the end of 2004 expect ~500 pb^{-1}
- Reduction of Systematic Errors (coming soon)
  - Jet Energy Scale being evaluated and improved
- Use of b-tagging to reduce background, and increase resolution due to reduction of jet permutations