Measurement of $B(t \to Wb)/B(t \to Wq)$ at DØ

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on behalf of the DØ collaboration

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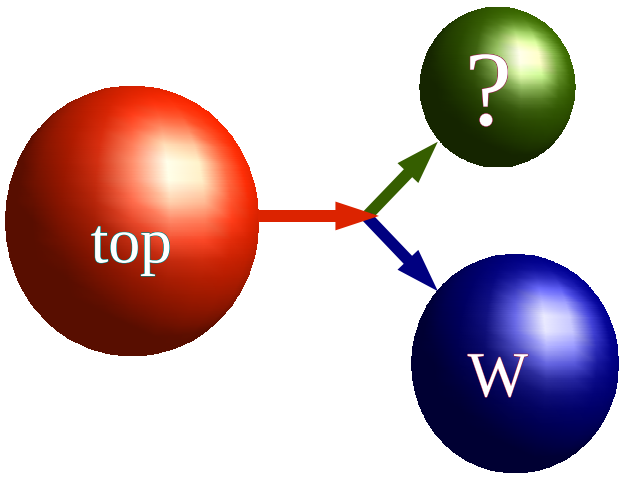
Outline

- Introduction
- Experimental Approach
- Tevatron and DØ detector
- Branching Ratio Measurement
- Conclusions

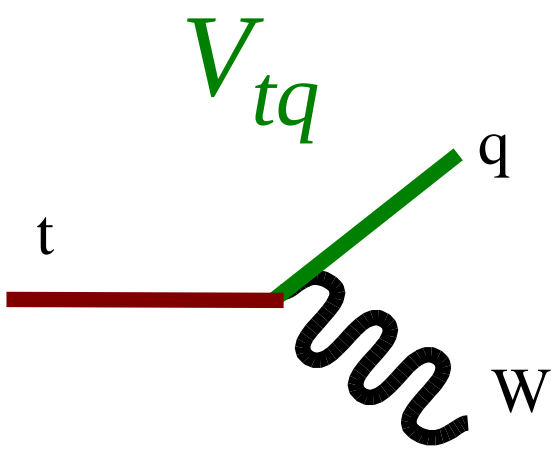
CKM Matrix element V_{tb}

b quark or other flavor?



- In SM: (3 generations, unitarity)
  - Top-quark CKM matrix elements indirectly constrained

$$\begin{pmatrix} 0.9739 \text{ to } 0.9751 & 0.221 \text{ to } 0.227 & 0.0029 \text{ to } 0.0045 \\ 0.221 \text{ to } 0.227 & 0.9730 \text{ to } 0.9744 & 0.039 \text{ to } 0.044 \\ 0.0048 \text{ to } 0.014 & 0.037 \text{ to } 0.043 & 0.9990 \text{ to } 0.9992 \end{pmatrix}$$



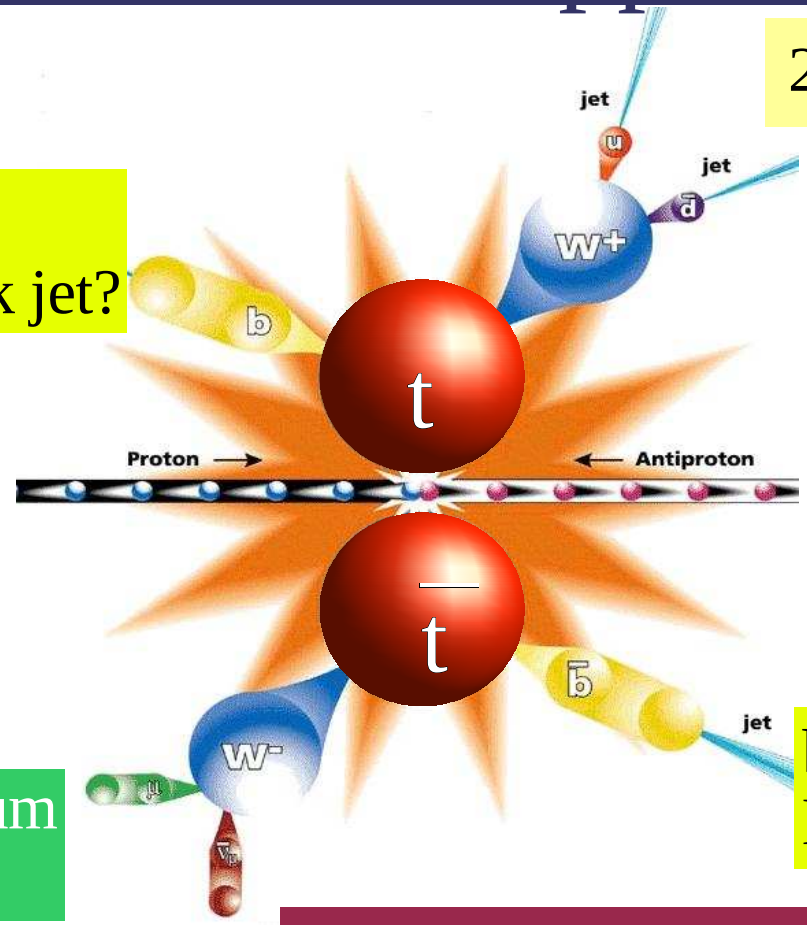
- New physics: >3 generations, ...
  - Almost no constraint on V_{tb}

$$\begin{pmatrix} 0.9730 \text{ to } 0.9746 & 0.2174 \text{ to } 0.2241 & 0.0030 \text{ to } 0.0044 \ldots \\ 0.213 \text{ to } 0.226 & 0.968 \text{ to } 0.975 & 0.039 \text{ to } 0.044 \ldots \\ 0 \text{ to } 0.08 & 0 \text{ to } 0.11 & 0.07 \text{ to } 0.9993 \ldots \\ \vdots & \vdots & \vdots \end{pmatrix}$$

Experimental Approach

2 light-quark jets

b-quark or light-quark jet?



b-quark or light-quark jet?

High-momentum lepton

Missing transverse energy

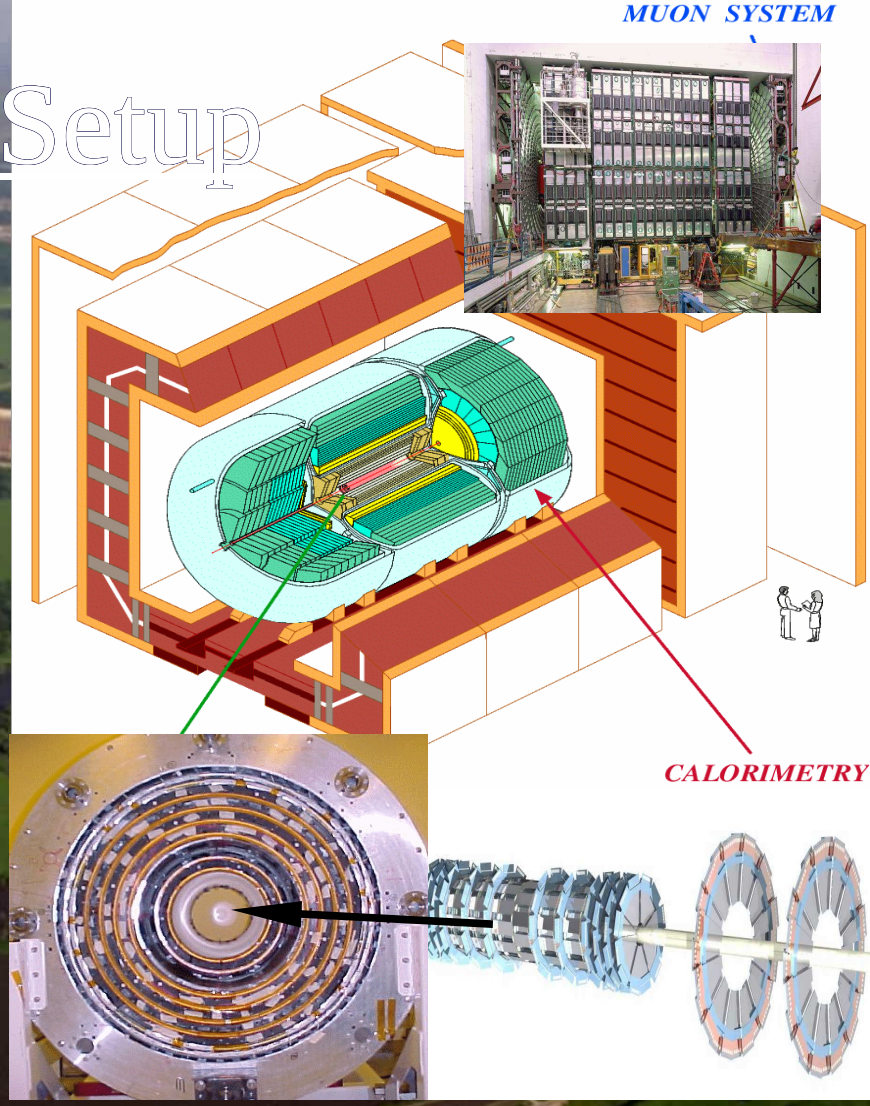
Measure fraction of top decays to b-quarks:

$$R = \frac{|V_{tb}|^2}{|V_{td}|^2 + |V_{ts}|^2 + |V_{tb}|^2} = B(t \to Wb) / B(t \to Wq)$$

Experimental Setup

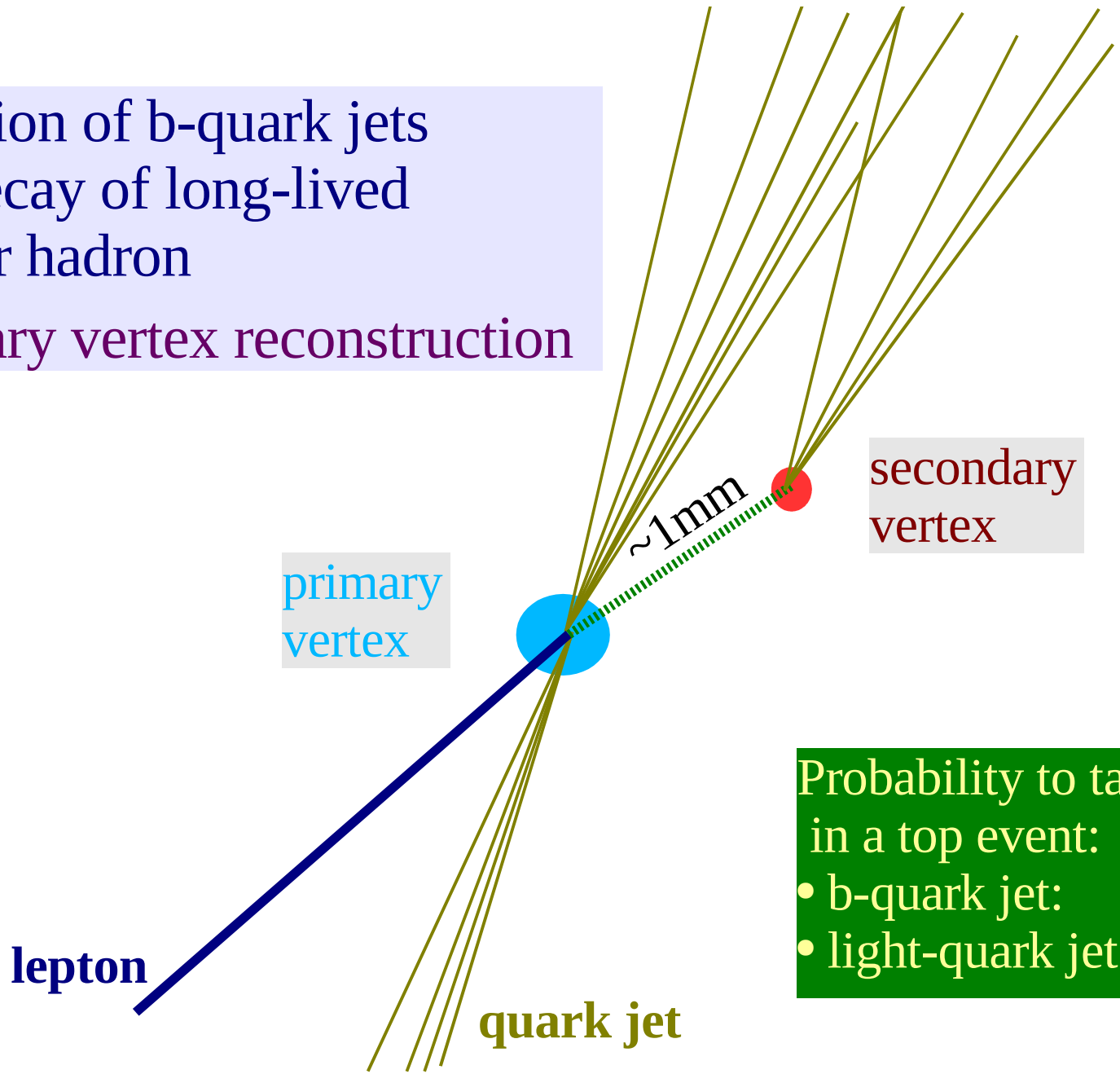
Fermilab Tevatron in Run II

Proton-Antiproton Collider
CM Energy 1.96TeV
→ ***Energy Frontier***



b-quark tagging

- Identification of b-quark jets through decay of long-lived b meson or hadron
  - secondary vertex reconstruction

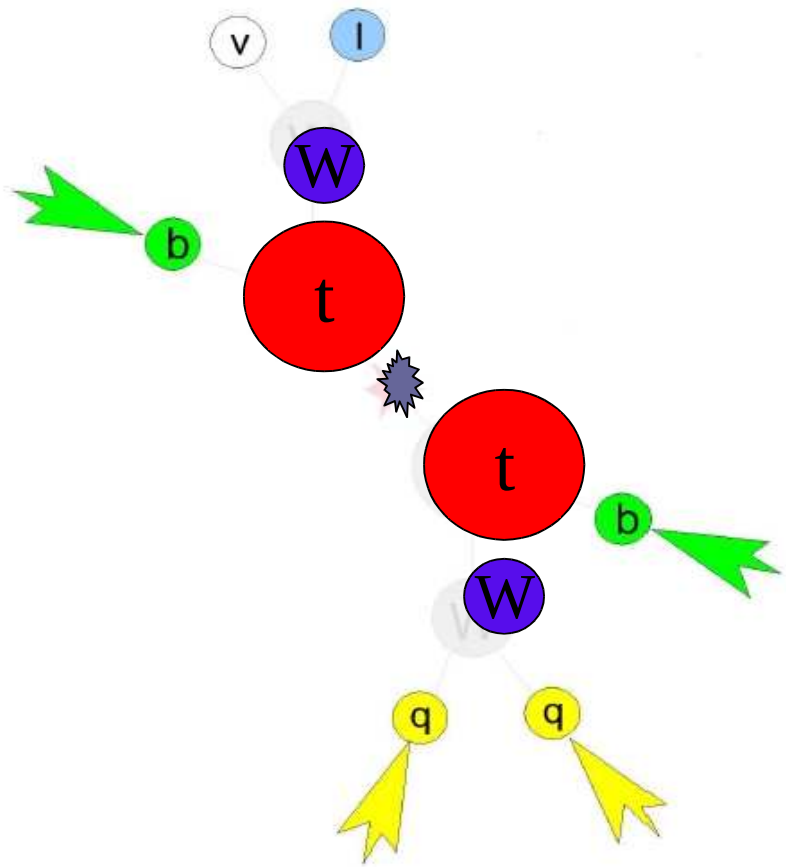


Probability to tag a jet in a top event:
- b-quark jet: ~55%
- light-quark jet: ~0.5%

230 pb^{-1}

Data Sample

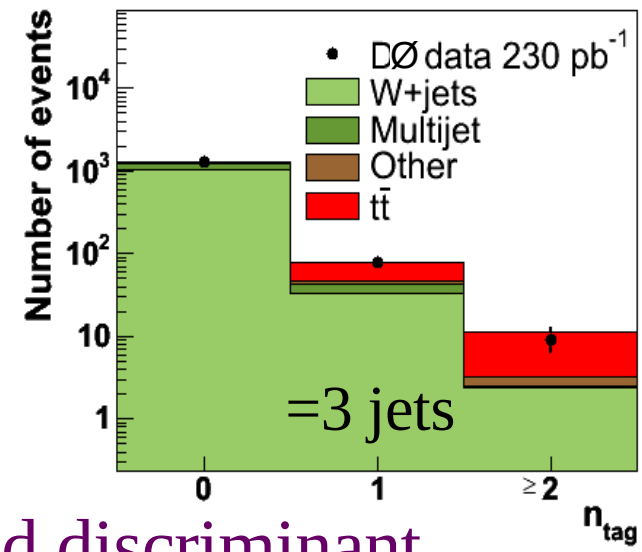
- Select μ+3 jets, μ +≥4 jets and e+3jets, e+≥4 jets final states with high MET
  - High p_T isolated lepton from W decay (> 20 GeV)
  - High missing transverse energy from neutrino (> 20 GeV)
  - 2 jets from hadronic W-decay
  - 2 jets from top decay (b?)
- Backgrounds:
  - W+jets
  - Multijet
  - Smaller backgrounds:
    - WW/WZ/ZZ, Z+jets, single top

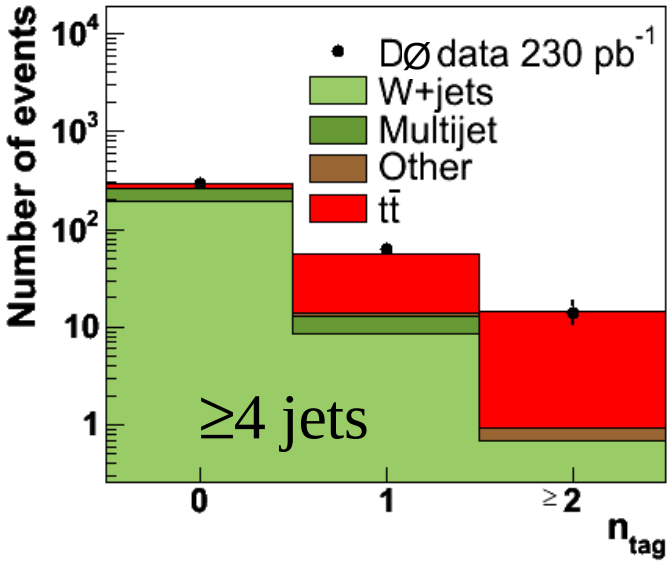


230 pb^{-1}

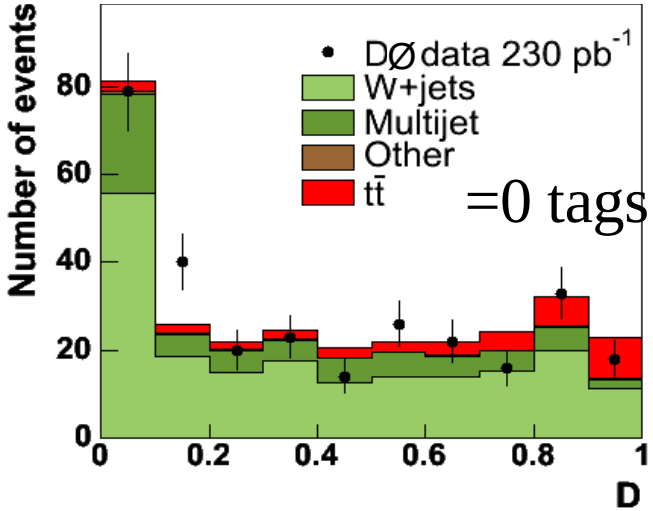
Analysis

- Count events with 0,1,2 b-tagged jets
  - Estimate SM background contributions
  - Measure top pair production above background
  - Simple event count for 1, 2-tags





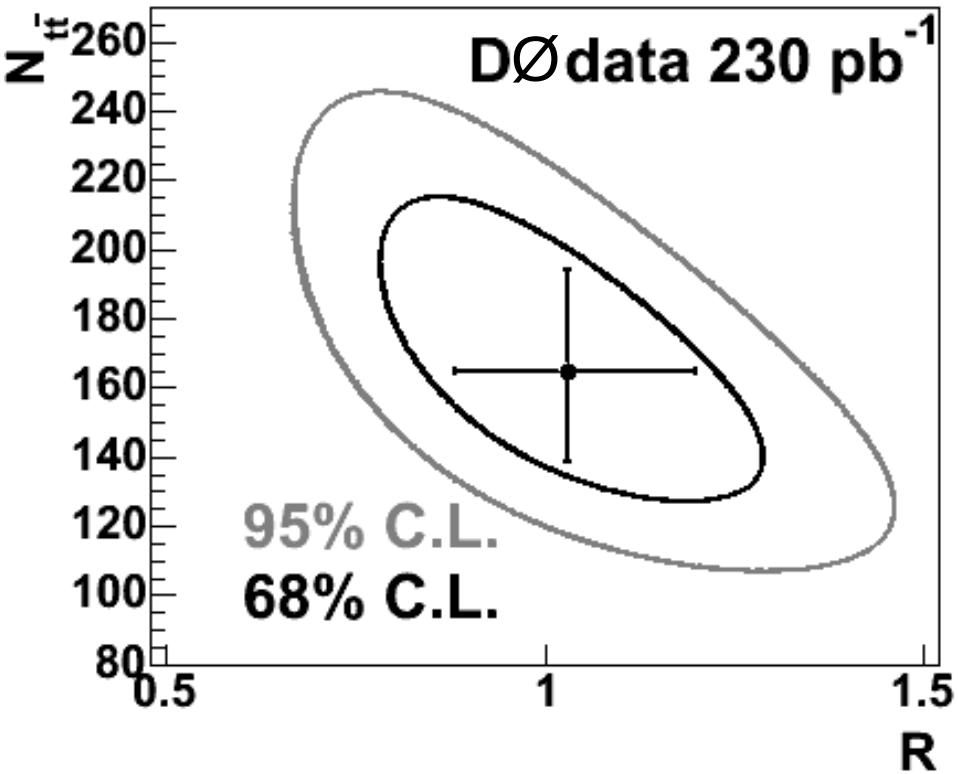
  - Likelihood discriminant in 0-tag sample



- Measure simultaneously: R and N(tt)

230 pb^{-1}

Result



95% CL limit:
R > 0.61
$|V_{tb}|$ > 0.78

($|V_{tb}| = \sqrt{R}$)

Submitted to PRL, hep-ex/0603002 (2006)

Conclusions

- The top quark decay branching fraction has been measured in 230 pb^{-1} of DØ data
  - $|V_{tb}| > 0.78$ at 95% CL
    - Consistent with SM expectation (~1)
  - World's best measurement
  - R and N(tt) measured simultaneously
    - No need to assume SM cross section
    - Reduced systematic uncertainty

One more piece in the top quark puzzle!

Backup Slides

Summary of Systematic Uncertainties

Uncertainties on R	
Statistical	$+0.17\ -0.15$
b-tagging efficiency	$+0.06\ -0.05$
Background modeling	$+0.05\ -0.04$
Jet identification	$+0.04\ -0.03$
Multijet background	± 0.02
Total error	$+0.19\ -0.17$

Uncertainties on $\sigma_{t\bar{t}}$ (pb)	
Statistical	$+1.4\ -1.3$
Background modeling	$+0.7\ -0.6$
Lepton selections	$+0.4\ -0.3$
Jet energy calibration	± 0.3
Jet identification	± 0.2
Multijet background	± 0.2
b-tagging efficiency	± 0.1
Light-jet tagging rate	± 0.1
Total error	$+1.7\ -1.5$

Topological variables...

- Sphericity

  $S = 3(\lambda_2 + \lambda_3)/2$, λ_2 and λ_3 are the smallest eigenvlues of the normalized momentum tensor M (isotropic events like ttbar S~ 1)

- K'_{Tmin}

  $K'_{Tmin} = R^{min}_{jj}/E^W_T$ with $E^W_T = E^l_T + MET$

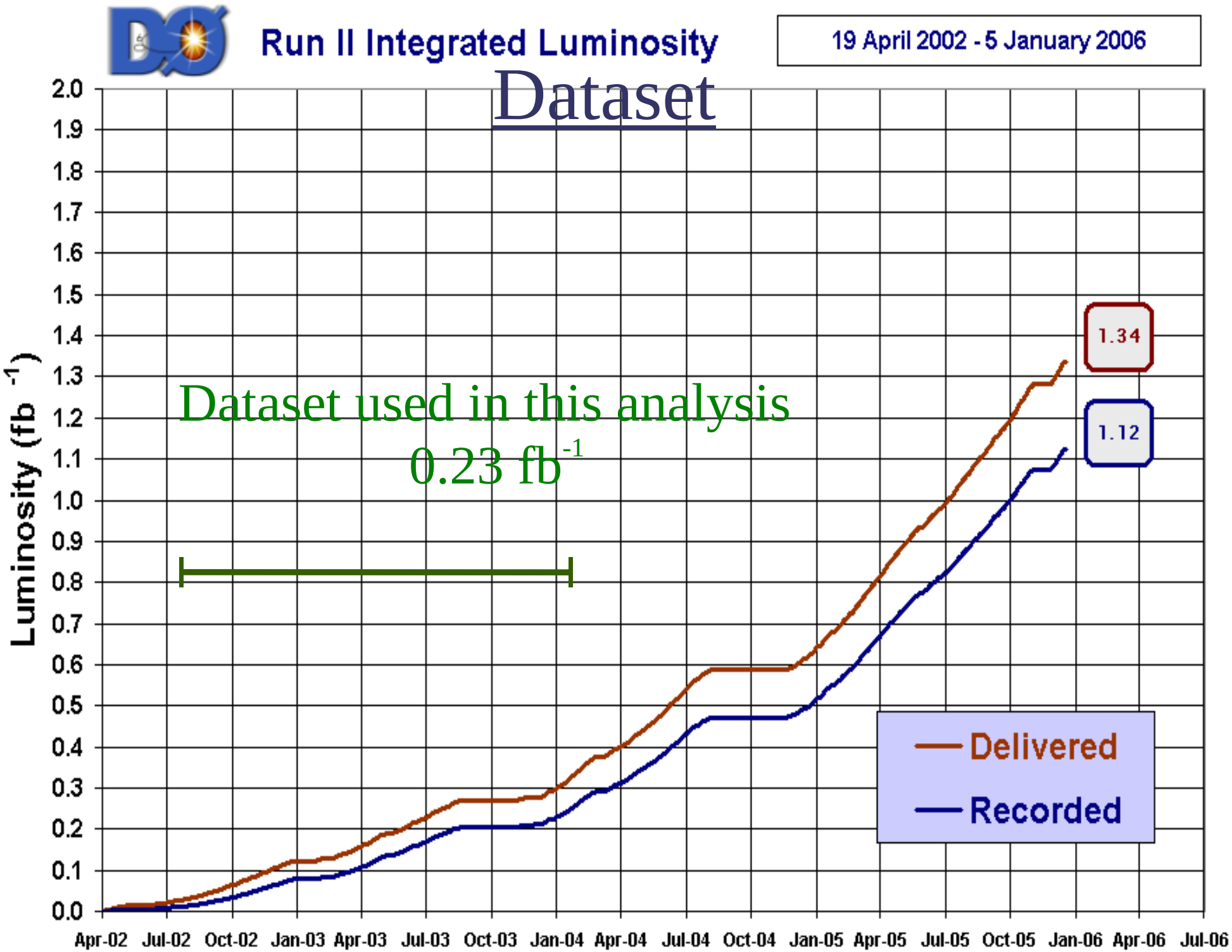
- Centrality

  $C = H_T/H$, H_T is scalar sum of jets E_T and h is the sum of the jet energies.

- H'_{T2}

  $H'_{T2} = H_{T2}/H_z$, H_{T2} is the p_T sum of ll jets except leading jet, Hz is the scalar sum of all jets $|E_z|$ plus $|E_z|$ of the neutrino (W-assumption)

Dataset


Run II Integrated Luminosity
19 April 2002 - 5 January 2006
Luminosity (fb -1)
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Apr-02
Jul-02
Oct-02
Jan-03
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05
Apr-05
Jul-05
Oct-05
Jan-06
Apr-06
Jul-06
1.34
1.12
Delivered
Recorded
Dataset used in this analysis
0.23 fb-1

Event Yield

ℓ + 3 jets	0-tag	1-tag	$\geq$ 2-tag
W+jets	1040±40	34±5	2.4±0.4
Multijet	192±23	8.3±1.5	$0.1^{+0.3}_{-0.1}$
Other bkg	18.4±1.3	4.3±0.3	0.7±0.1
$t\bar{t}$	29.5±1.6	28.2±1.6	6.9±0.5
Total expected	1280±44	75±5	10.1±0.8
Observed	1277	79	9

ℓ + $\geq$ 4 jets	0-tag	1-tag	$\geq$ 2-tag
W+jets	203±17	9.2±1.2	0.7±0.1
Multijet	65±9	4.1±1.1	0.0±0.4
Other bkg	2.9±0.4	1.2±0.2	0.21±0.01
$t\bar{t}$	32.5±3.0	36.3±3.3	11.4±1.4
Total expected	304±20	51±4	12.3±1.4
Observed	291	62	14