MEASUREMENT OF THE $t\bar{t}$ PRODUCTION CROSS SECTION IN $p\bar{p}$ COLLISIONS AT $\sqrt{s} = 1.96$ TeV USING LEPTON + JETS EVENTS WITH JET PROBABILITY AT CDF

Enrique Palencia Cortezón

Instituto de Física de Cantabria (CSIC-UC)

Fermilab, March 13, 2007

Outline

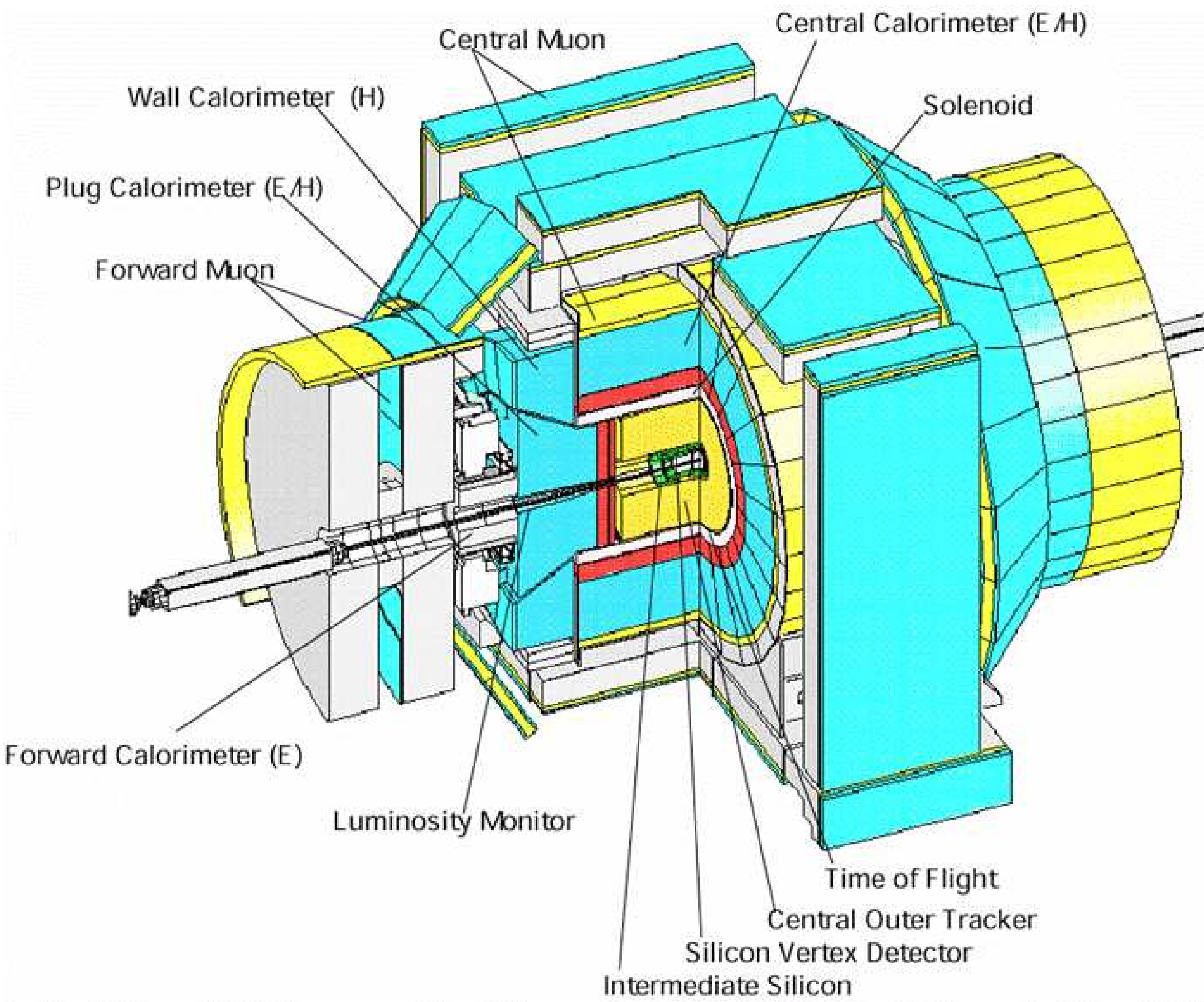
- Introduction/Motivation
- Jet Probability Tagging Algorithm
  - Description of the algorithm
  - Efficiency
  - Mistag rate
- $t\bar{t}$ Cross Section Measurement
  - Data sample and event selection
  - Acceptance and background estimate
  - Results
- Summary

The CDF Detector

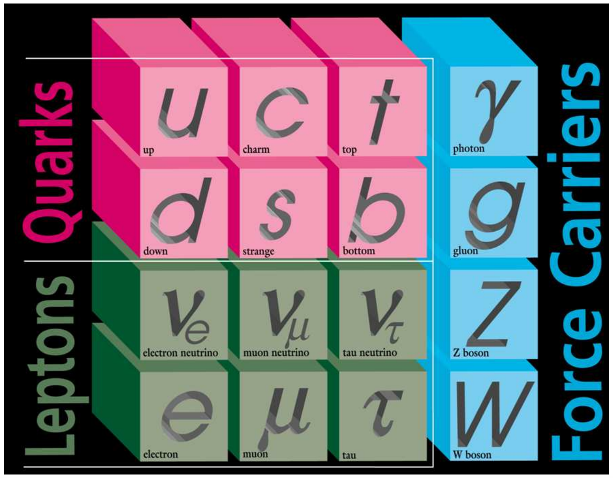
- General purpose particle detector. Cylindrical simmetry

- 3 subsystems: tracking (inside a $1.4\ T$ solenoidal magnetic field), calorimetry and muons systems

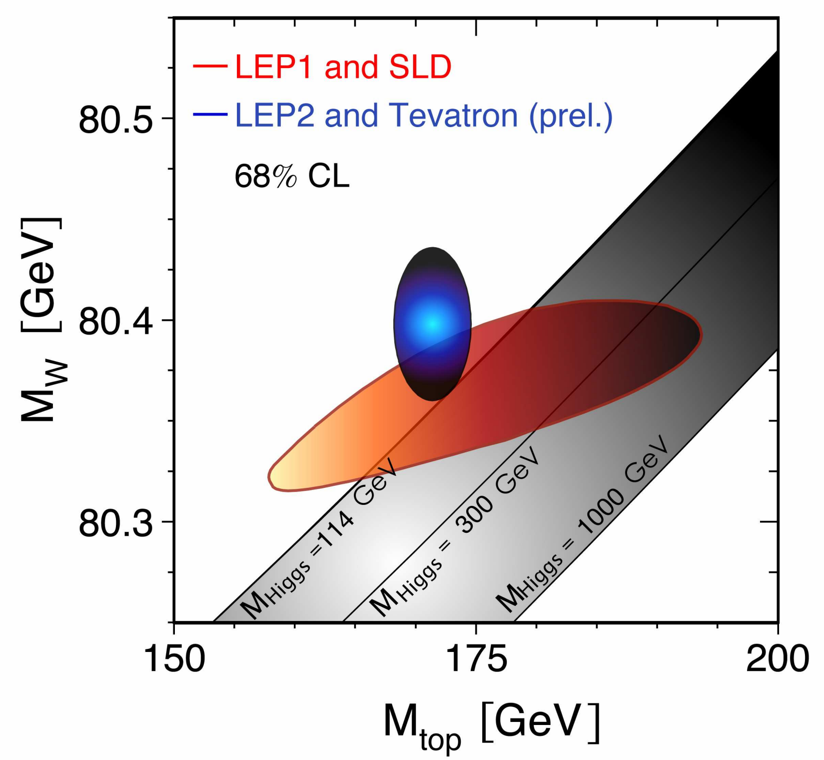
- For top physics, the full detector is needed



Why is the Top Quark so Interesting?

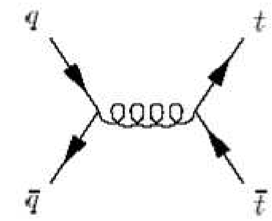


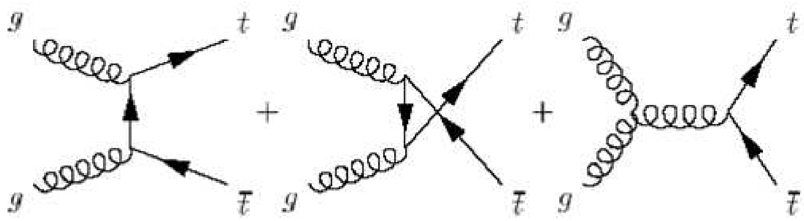
- Heaviest known fundamental particle ⇒ probe physics at much higher energy scale
- Decays before it can hadronize ($\tau_{top} \sim 10^{-25}$ sec) ⇒ momentum and spin pass to the decay products
- Look for new physics
- Top quark properties test SM
  - ◇ Higher x-sec than predicted could be a sign of non SM production mechanisms
- Top mass fundamental parameter in SM
  - ◇ M_t, along with the mass of the W, is related with the mass of the Higgs boson



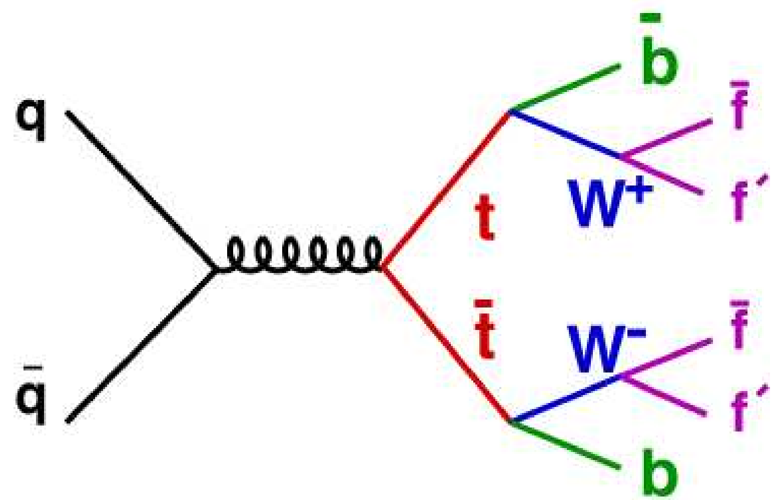
Top Production & Decay Modes

- At Tevatron energies ($\sqrt{s} = 1.96\ TeV$) top quark is mainly produced in pairs via strong interaction
  - ◇ $q\bar{q}$ annihilation (85%) or gluon fusion (15%)
  - ◇ $\sigma(p\bar{p} \to t\bar{t} \ @\ M_t = 178\ GeV) \approx 6.1\ pb$ $\Rightarrow$ one top event every 10 billion inelastic collisions





- Decays via electroweak interaction $t \to Wb$
  - ◇ BR($t \to Wb$)≈1 $\Rightarrow$ final state given by the $W^{\pm}$ decays
  - ◇ BR($W \to$ leptons) = 1/3, BR($W \to$ quarks) = 2/3

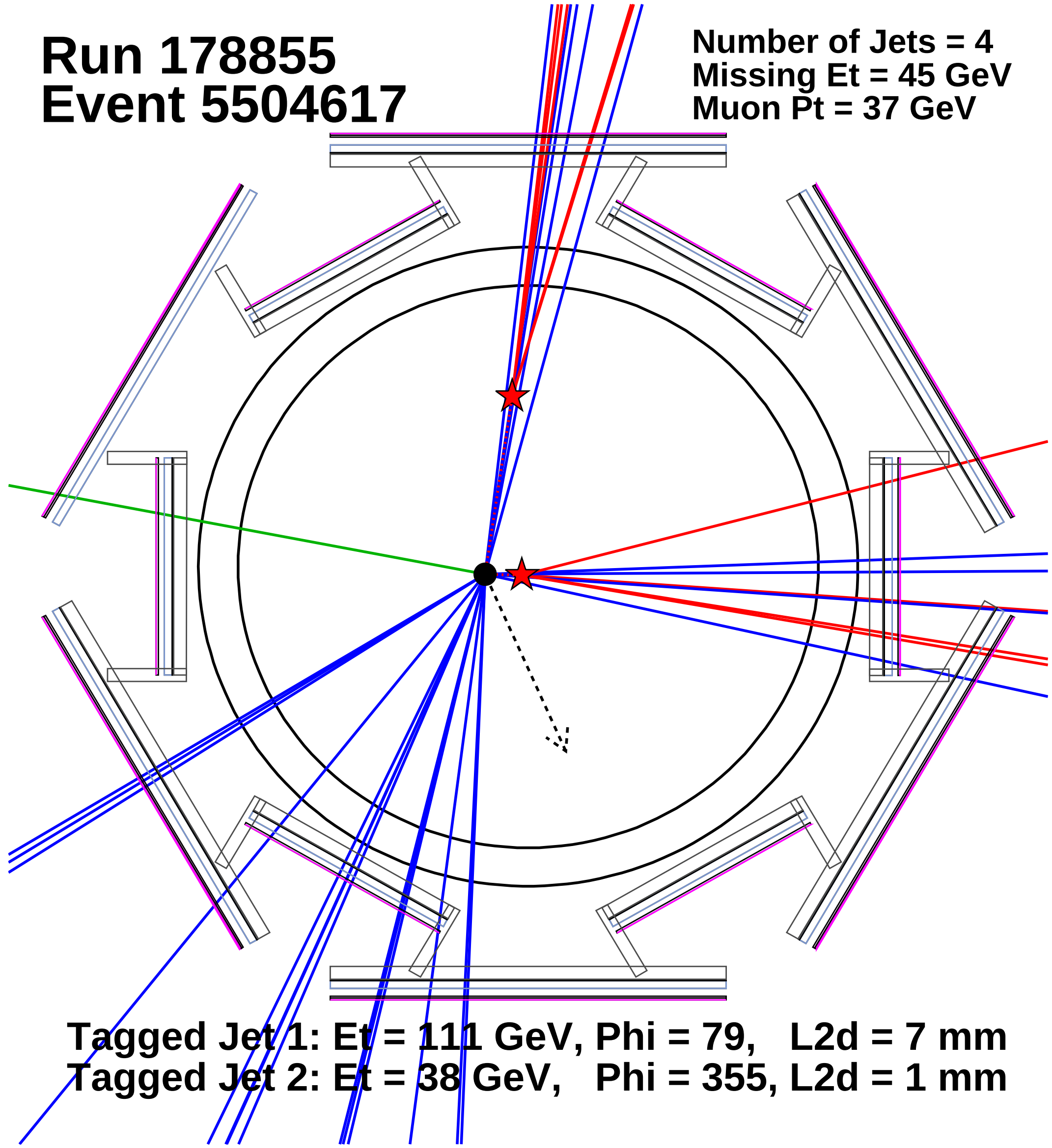


lepton $\equiv$ electron or muon

Final State	Dataset	BR	S/B
$l\nu\ l\nu\ bb$	dilepton	∼5%	4/1
$l\nu\ qq\ bb$	lepton+jets	∼30%	2/1
$qq\ qq\ bb$	hadronic	∼44%	1/4

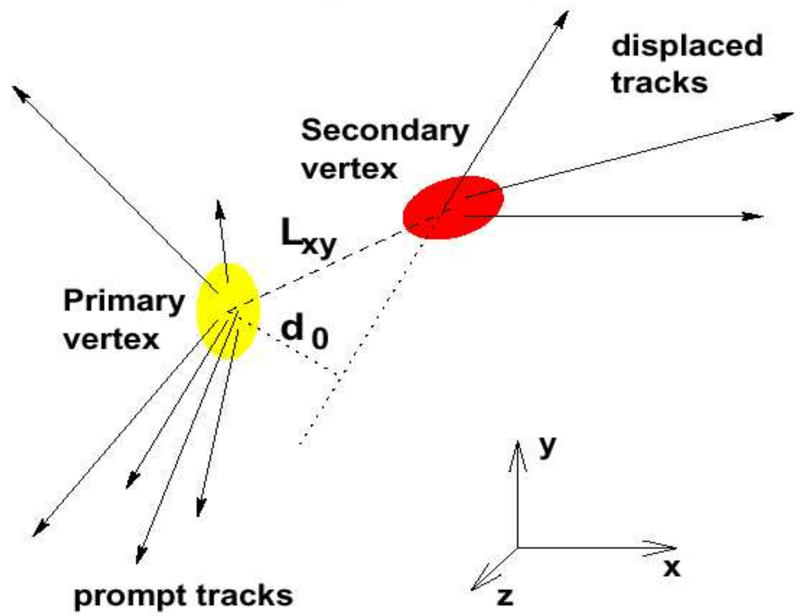
Detecting the Top Quark

- Top events:
  - are energetic, central and spherical
  - have $\not{E}_T$ from neutrinos in leptonic modes
  - have jets with high E_T
  - have two high E_T b-jets
- Main backgrounds:
  - Dilepton: $Z \to l^- l^+$
  - L+jets: $W + jets$ (few % have b or c)
- Identifying b-jets improves S/B
  - Secondary Vertex Tagger
  - Jet Probability Tagger
  - Soft Lepton Tagger



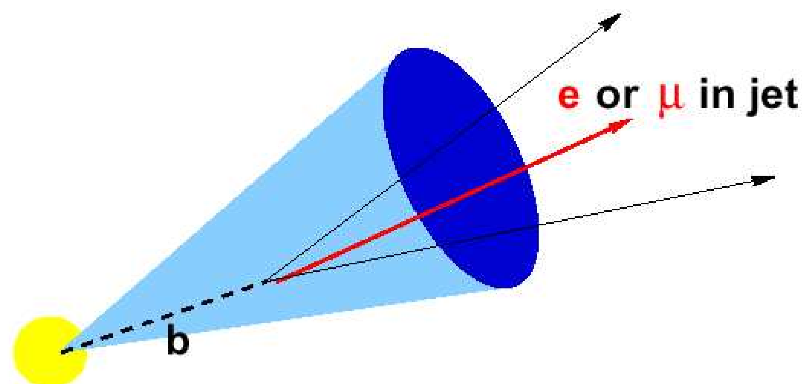
B-Tagging at CDF

- B decay signature has a displaced vertex (long lifetime) travels $\Rightarrow L_{XY}$ ~3 mm before decaying



- Secondary Vertex Tagger
  - Fit displaced tracks to a common vertex and cut on L_{XY} significance
  - Relies heavily on excellent performance and understanding of the silicon tracker

- Jet Probability Tagger
  - Joint probability for all tracks in a jet to come from a primary vertex



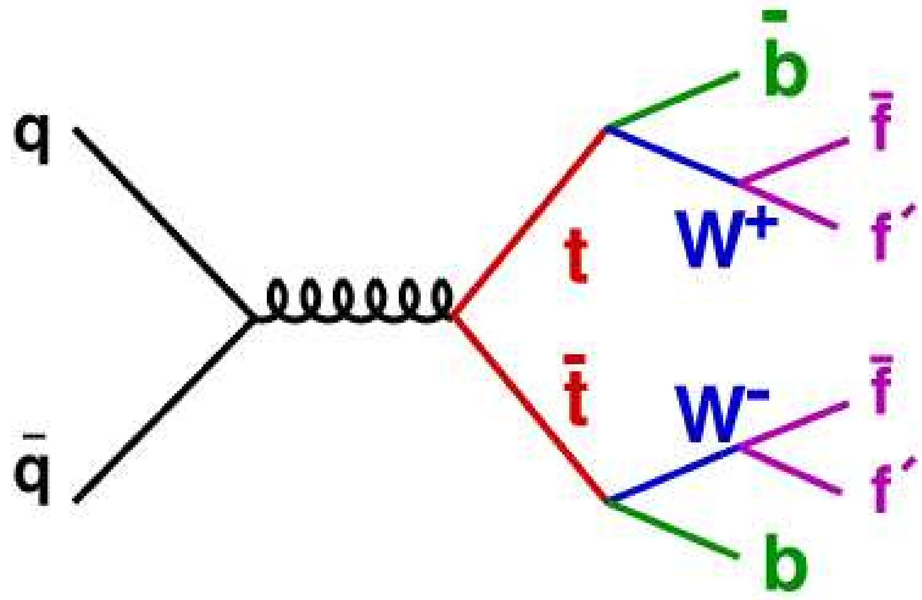
- Soft Lepton Tagger: looks for an energetic lepton inside a jet
  - B can decay semileptonically: $b \rightarrow l\nu c$

- $b \rightarrow \ell\nu c$ (BR $\sim$ 20%)
- $b \rightarrow c \rightarrow \ell\nu s$ (BR $\sim$ 20%)

Jet Probability... Why?

- ... heavy flavor (HF) tagging?
  - ◇ Top signal has 2 b's
  - ◇ $\sim$5% of the main backgrounds has HF

  $\Rightarrow$ S/B greatly increased



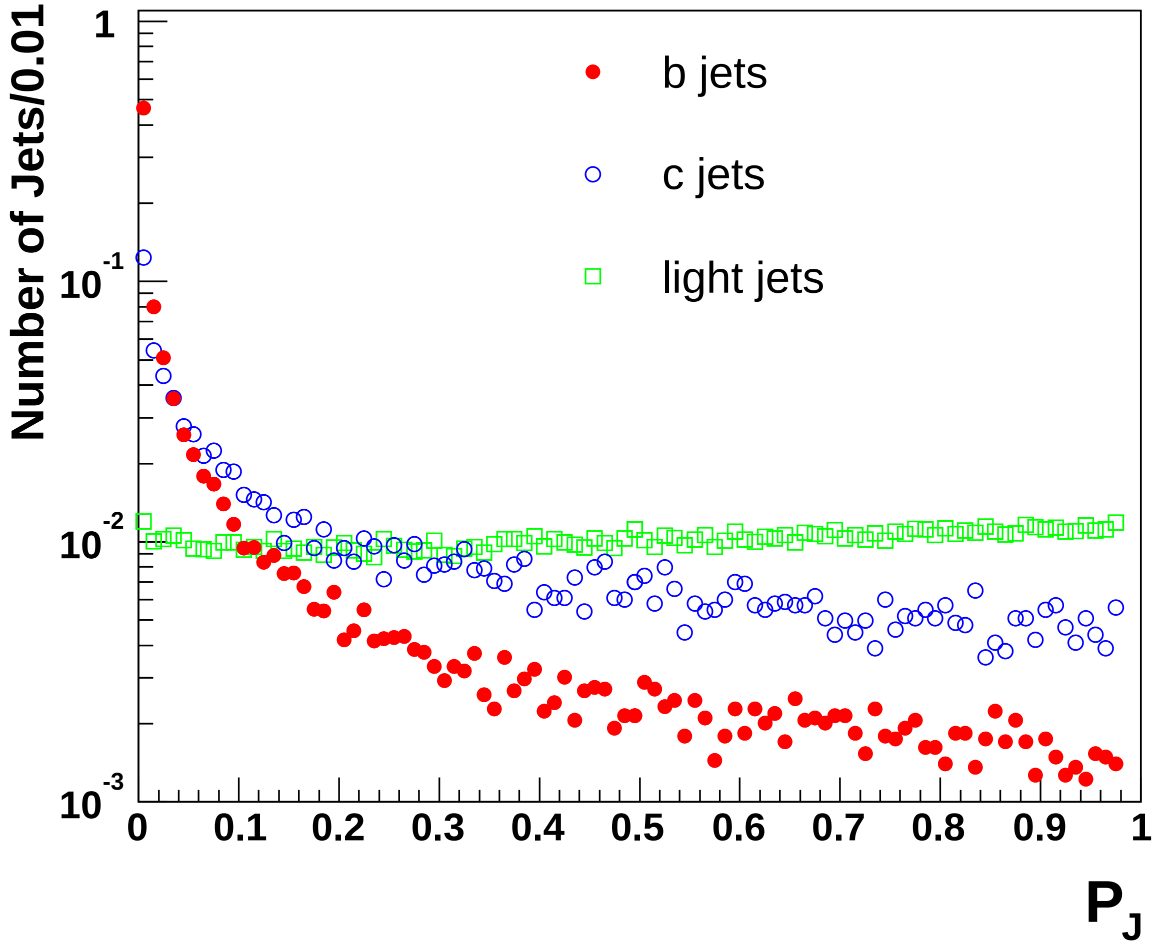
- ... Jet Probability?
  - ◇ Provides a continuous variable $\Rightarrow$ more flexible way to understand the composition of the tagged sample
  - ◇ Can be tuned/optimized differently for other kind of analyses
  - ◇ This method can be used to separate b and c heavy flavor contributions

Jet Probability Algorithm (I)

- HF hadrons have long lifetime $\Longrightarrow$ displaced vertices (and tracks) from the primary vertex

- Physically, probability for a jet to come from the primary vertex

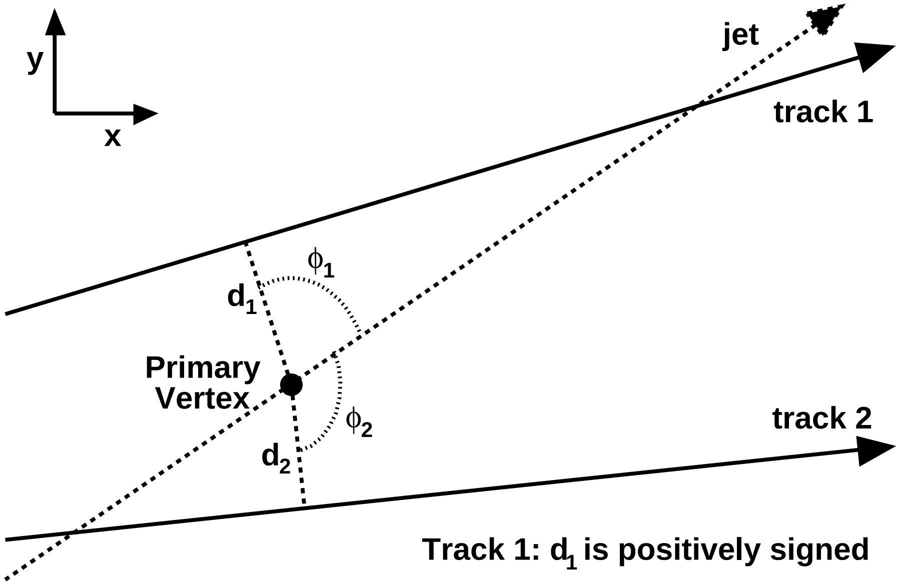
- Uniform for light quark or gluon jets. Peaks at 0 for jets containing displaced tracks from HF decays



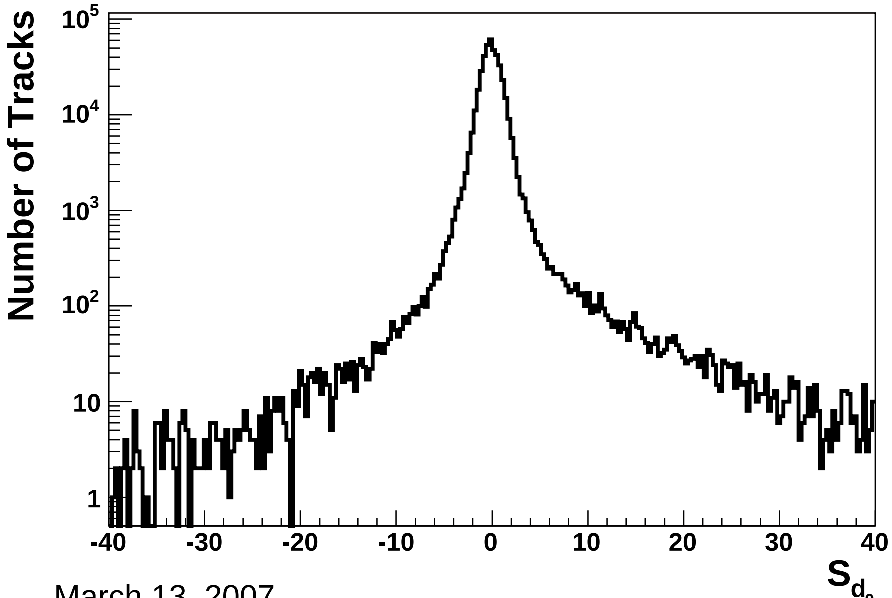
- For the analysis, $P_J < 1\%$ and $P_J < 5\%$

Jet Probability Algorithm (II)

- Signed impact parameter: $d_0 > 0$ if point of closest approach to the primary vertex lies in the same direction as the jet direction (cos $\phi > 0$)



- + (-) Jet Probability: only tracks with positive (negative) impact parameter
  - ◇ + Jet Probability ⇒ positive tags
  - ◇ - Jet Probability ⇒ mistags

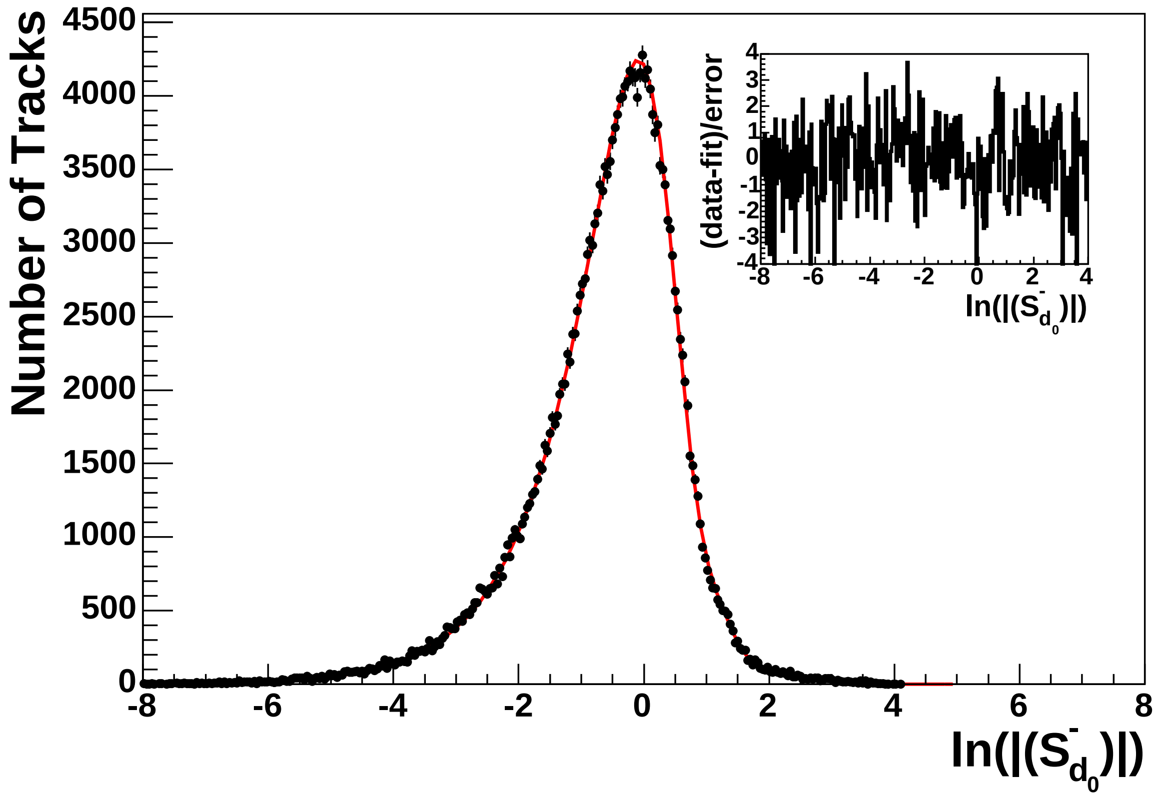


- Track impact parameter significance: $S_{d_0} = d_0/\sigma_{d_0}$

Jet Probability Algorithm (III)

- Fit the negative side of the track impact parameter significance distribution to obtain a resolution function $R(S)$ (different for data and MC)
- $R(S)$ used to determine the probability ($P_{tr}(S_{d_0})$) that the impact parameter significance of a given track is due to the detector resolution
- Probability that a jet is consistent with a zero lifetime hypothesis:

$$\prod_{l=1}^{N_{tr}} P_{tr} \times \sum_{k=0}^{N_{tr}-1} \frac{(-ln \prod_{l=1}^{N_{tr}} P_{tr})^k}{k!}$$

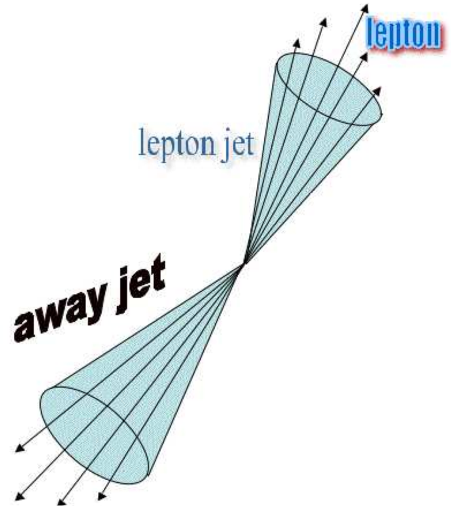


Jet Probability Efficiency

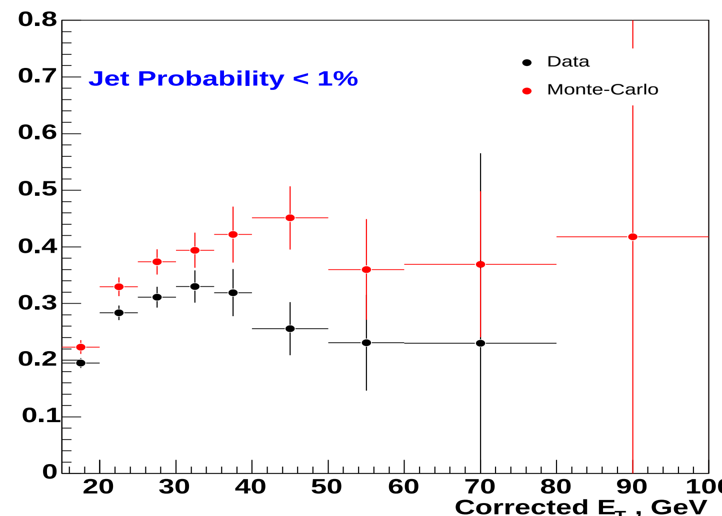
- Measured using an 8 GeV inclusive electron data sample (it is enriched with HF due to the semileptonic B decays)

- Double tag method: as heavy flavor quarks are mostly produced in pairs, heavy flavor content in one jet is enhanced requiring that the "other" jet (away jet) is tagged

- Efficiencies to tag a heavy flavor jet with $E_T > 15$ GeV and 318 pb^{-1}



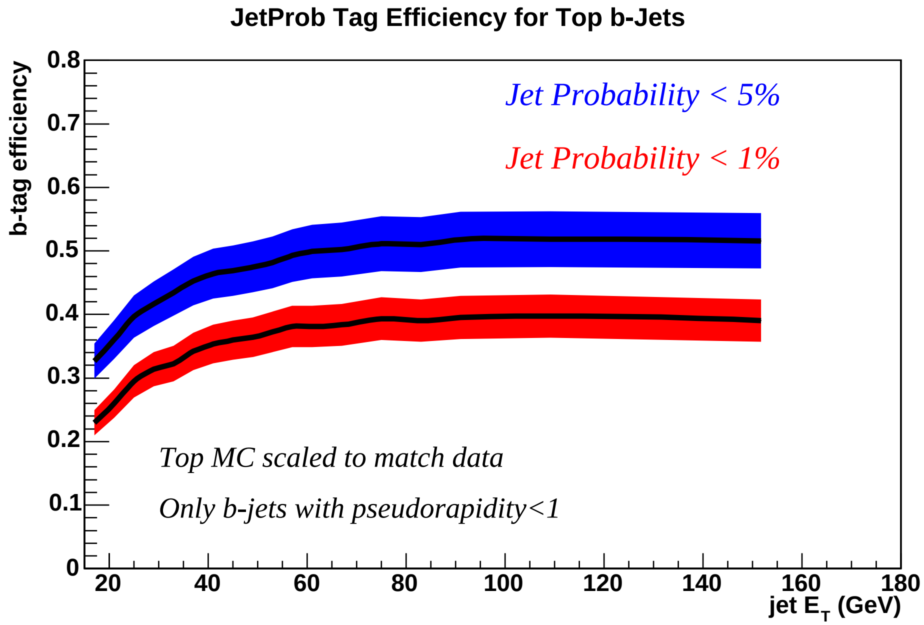
	$P_J < 1\%$	$P_J < 5\%$
ϵ^{data}	0.258 ± 0.018	0.334 ± 0.026
ϵ^{MC}	0.316 ± 0.021	0.392 ± 0.026
Scale Factor (SF)	0.817 ± 0.070	0.852 ± 0.072

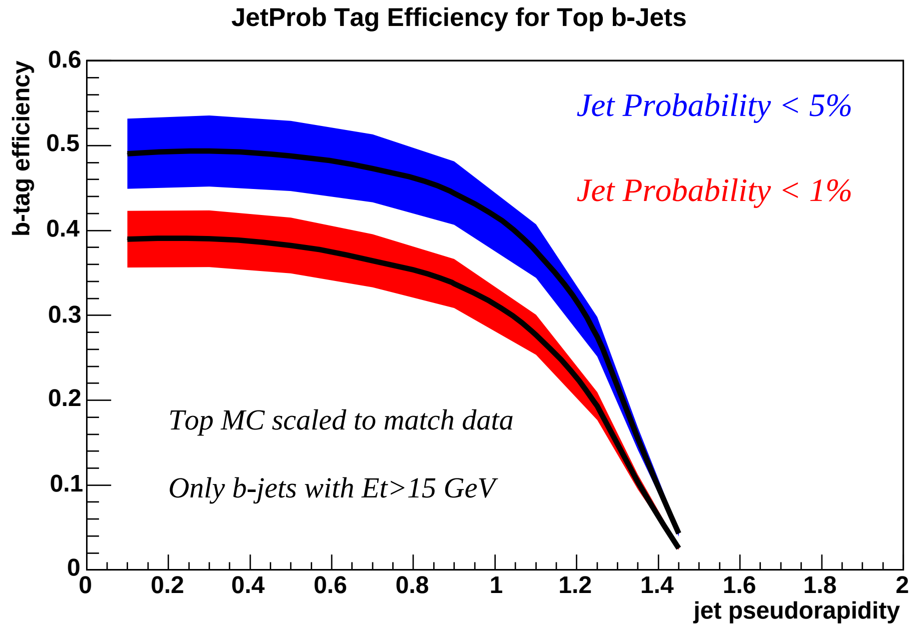


Efficiency vs E_T^{jet} (P_J <1%) in inclusive electron sample

Jet Probability Efficiency in $t\bar{t}$ Events

- b-tagging efficiency (tag rate $\times$ SF) per jet in a top Monte Carlo sample. Bands represent the systematic error due to the scale factor.

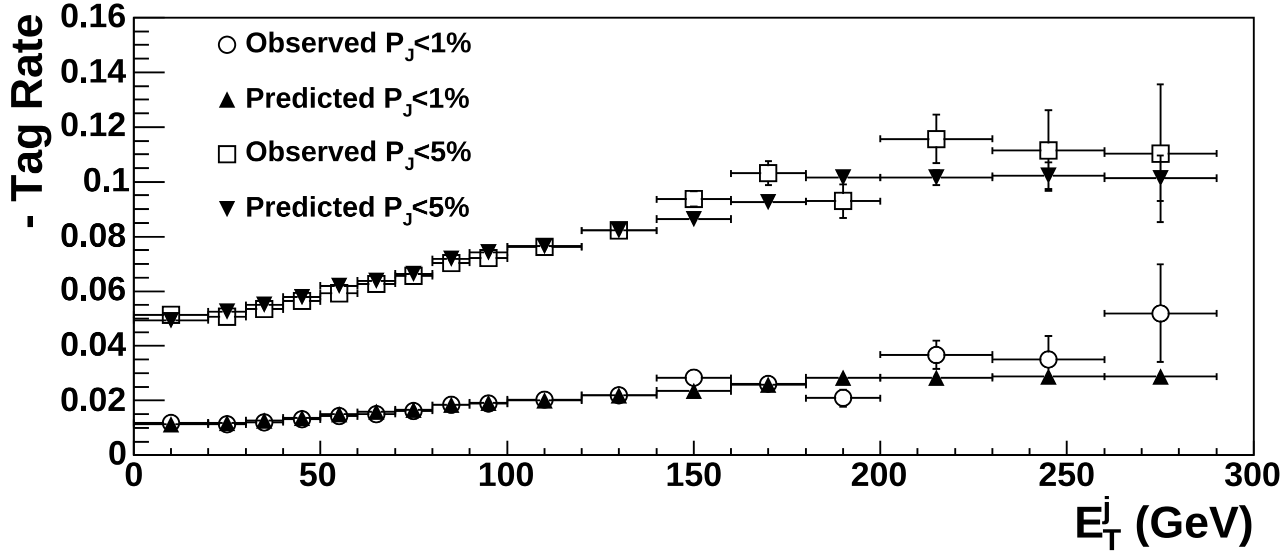




b-tagging efficiency (%)	$P_J < 1\%$	$P_J < 5\%$
per jet	35 ± 3	47 ± 4
per $t\bar{t}$ event	55 ± 4	69 ± 4

Jet Probability Mistag Rate

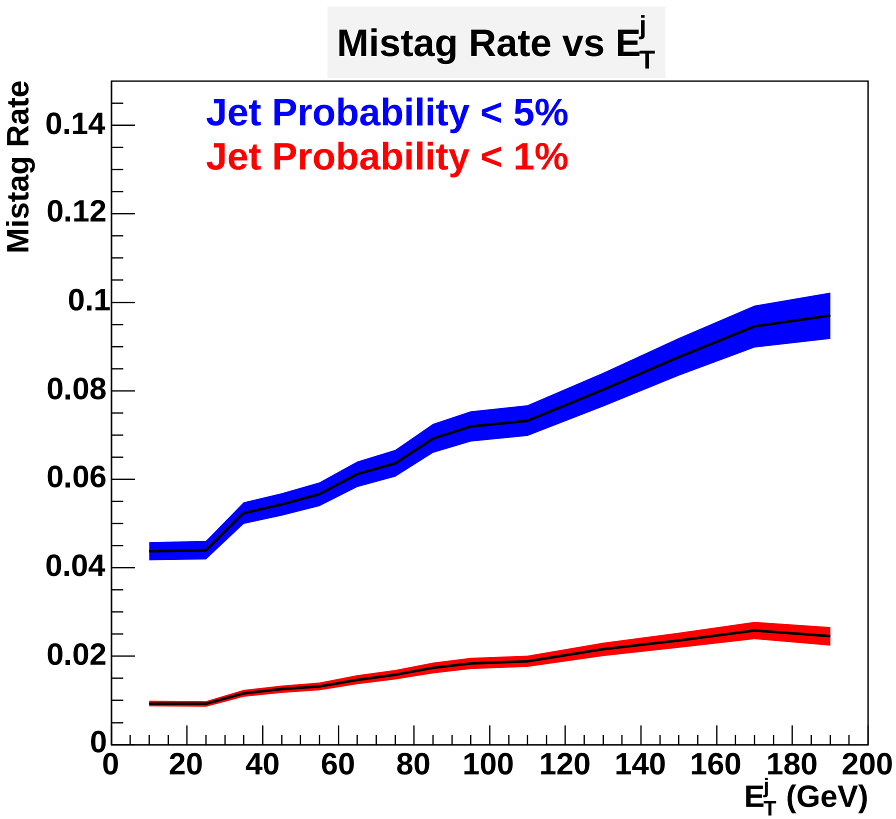
- Mistag rate: probability of tagging a light jet as a heavy flavor one
- Determined using inclusive jet data samples
- Parameterized as a 6 dimensional look-up table (mistag matrix): E_T, N_{trk}, $\sum E_T^j$, η, Z_{vtx}, ϕ

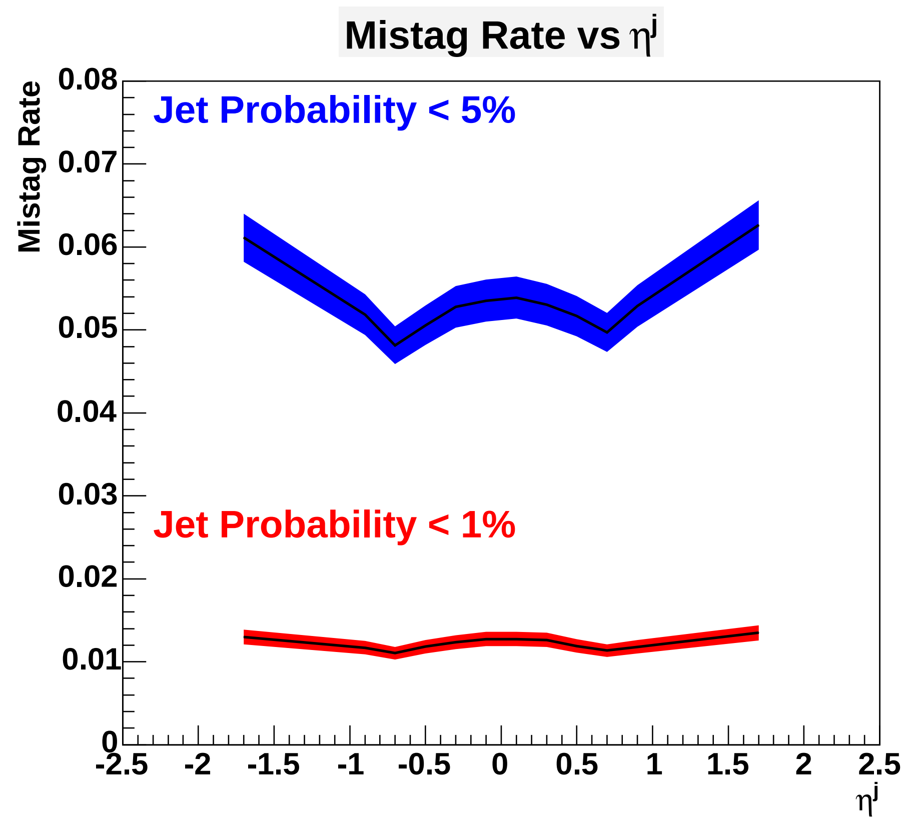


- Cross check independent samples: observed (multijet trigger) vs prediction (inclusive jet data)
- Results with 318 pb^{-1}

	$P_J < 1\%$	$P_J < 5\%$
Overall negative tag rate (%)	1.22 ± 0.08	5.30 ± 0.25

Jet Probability Mistag Rate vs E_T and η





- Bands represent the total uncertainty (statistical and systematic added in quadrature).

Comparison with other b-Tagging Algorithms

- Efficiencies and mistag rates for the b tagging algorithms used at CDF

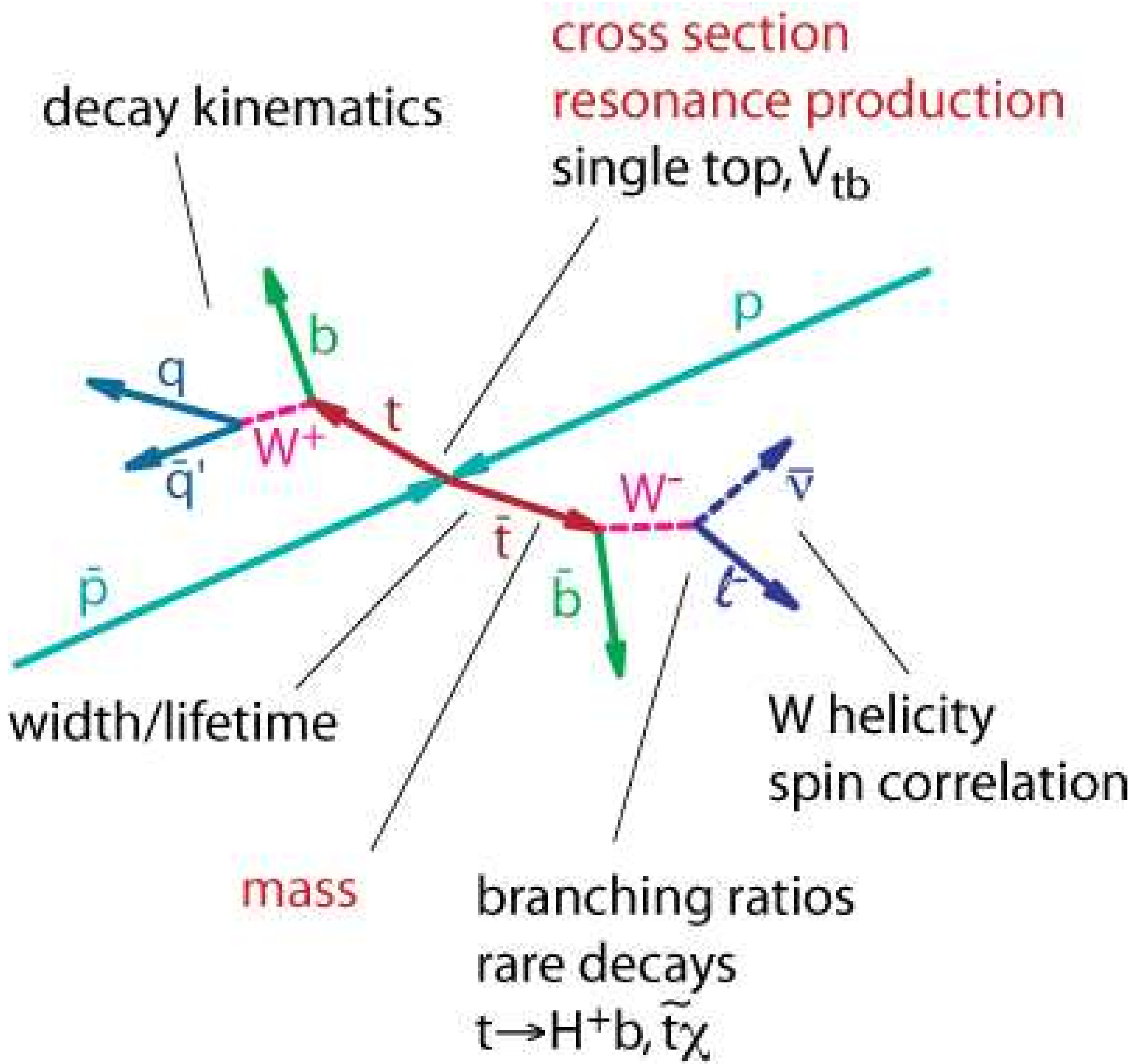
	$P_J < 1\%$	$P_J < 5\%$	SecVtx	SLT
Efficiency (%)	$\sim$55	$\sim$69	$\sim$60	$\sim$15
Mistag rate (%)	$\sim$1.2	$\sim$5.3	$\sim$0.5	$\sim$4

- Three different taggers that use different information

- Allow measure the same property using different taggers in order to reduce systematic effects

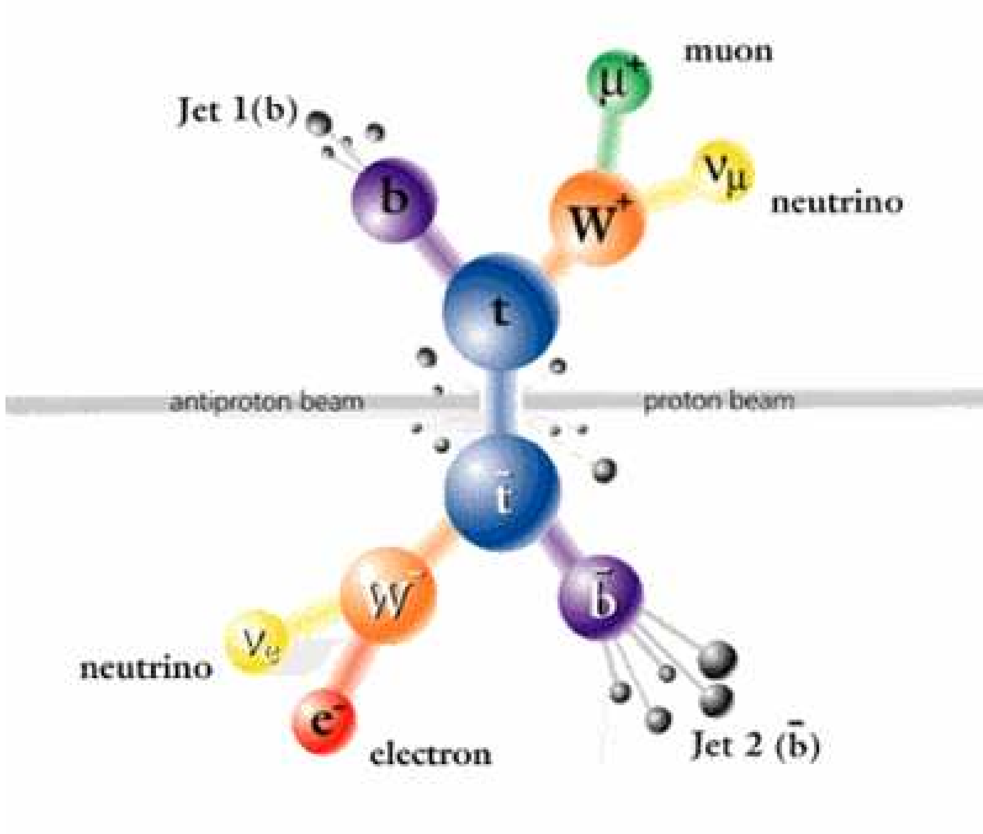
Physics analysis

TOP PHYSICS IS HUGE!!!



Why $t\bar{t}$ Production Cross Section?

- Test QCD in the high energies regime
- Test non-SM top production mechanism
- Look for new physics in the top samples
- Establish the sample for other top properties measurements
- Measuring with different methods in different channels will help reducing the systematic uncertainties



- Goal: demonstrate good understanding of backgrounds in control region and observe excess from top in signal region

$t\bar{t}$ Cross Section Measurement

- Counting experiment: $\sigma_{t\bar{t}} = \frac{N_{obs} - B_{bkg}}{\epsilon_{t\bar{t}} \times \int L dt}$

Data Sample

- Data sample based on Run II data taken untill September 2004
- Triggers based on the selection of a lepton with high p$_T$

	CEM (Central electrons, $\|\eta\| < 1$)	CMUP (Central muons, $\|\eta\| < 0.6$)	CMX (Extension muons, $0.6 < \|\eta\| < 1$)
Lum (pb^{-1})	318.5 $\pm$ 18.8	318.5 $\pm$ 18.8	305.2 $\pm$ 18.0

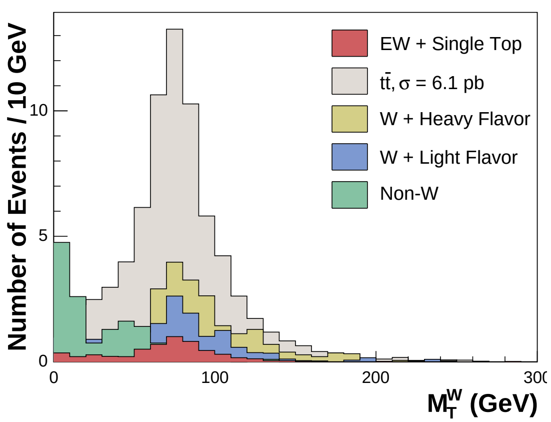
- Electron identification: track with p$_T$ $>$ 9 GeV that extrapolates to 3 CEM adjacent towers with E$_T$ $>$ 20 GeV
- Muon identification: isolated COT track with p$_T$ $>$ 20 GeV that extrapolates to a track segment in the muon chambers
- Jets are reconstructed from calorimeter towers using a cone algorithm with radius R $\leq$ 0.4

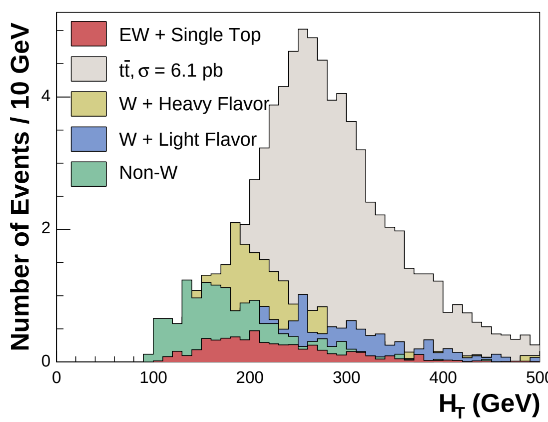
Event Selection

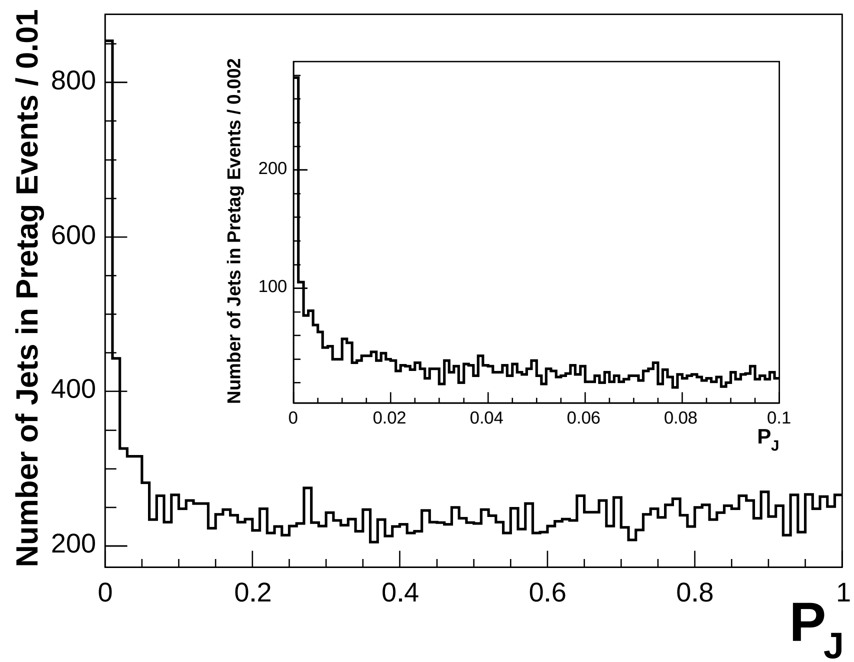
- 1 high p_T isolated lepton
- High missing transverse energy
- $\geq$ 3 energetic jets

Jet Multiplicity	1 jet	2 jets	3 jets	$\geq$ 4 jets
Before b-tagging				
# Events	29339	4442	300	166
After b-tagging ($P_J < 1\%$)				
# Events	350	191	52	68

- Vetoes (dilepton, cosmics, conversion, z_{vtx})
- $M_T^W > 20$ GeV and $H_T > 200$ GeV



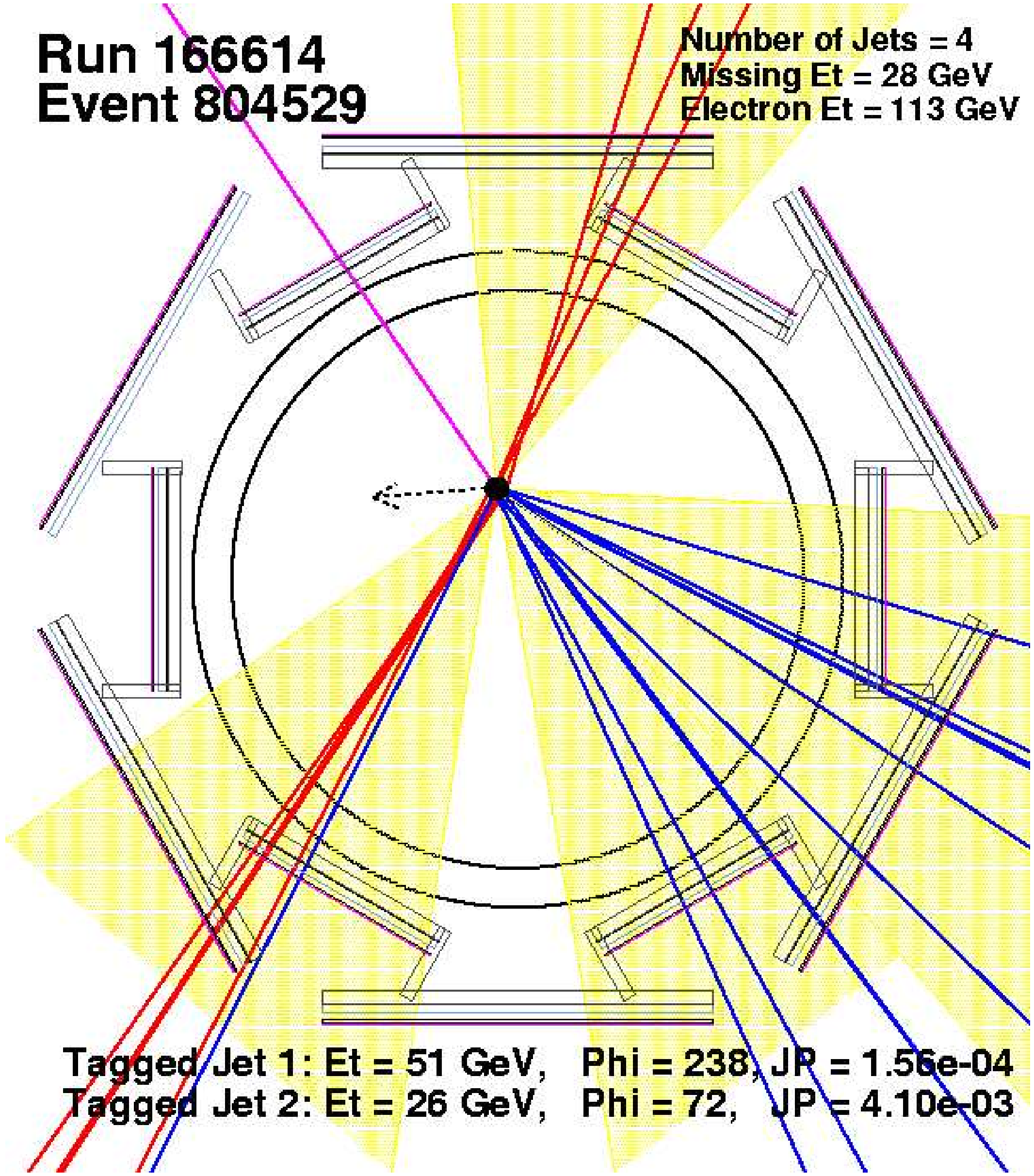




- $\geq$ 1 tagged jet (jet with positive $P_J < 1\%$)

A Top Candidate Event looks like this...

- Jets are represented by yellow hashed cones
- For tagged jets, positive impact parameter tracks are drawn red
- All other (good r-phi) tracks inside jet are drawn blue
- Missing transverse energy direction is the dotted arrow
- Electron track is magenta



Acceptance

- Jet Probability tagging efficiencies for $t\bar{t}$ events (PYTHIA Monte Carlo sample with M_t = 178 GeV/c^2)

$$\epsilon_{t\bar{t}} = (A_{t\bar{t}} \times K_{lep} \times \epsilon_{trig} \times \epsilon_{z_0}) \times \epsilon_{b-tag} = \epsilon_{t\bar{t}}^{\text{pretag}} \times \epsilon_{b-tag}$$

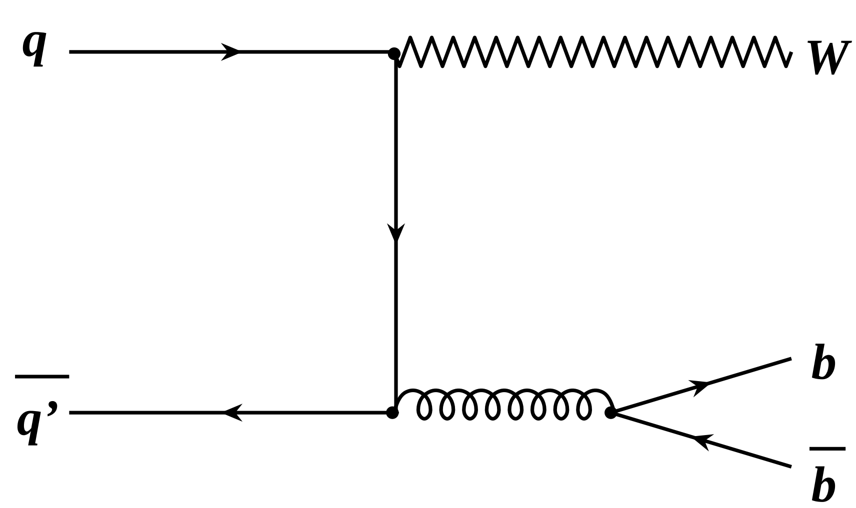
Quantity	CEM	CMUP	CMX
Single tag, JP<1% (SF = 0.82 $\pm$ 0.07)			
Acc. No Tag	3.67 $\pm$ 0.02 $\pm$ 0.22	1.92 $\pm$ 0.01 $\pm$ 0.12	0.751 $\pm$ 0.008 $\pm$ 0.046
Tag Eff.	54.7 $\pm$ 0.2 $\pm$ 3.6	54.1 $\pm$ 0.3 $\pm$ 3.5	55.2 $\pm$ 0.5 $\pm$ 3.6
Average Tag Eff.	54.5 $\pm$ 0.2 $\pm$ 3.6		
Acc. with Tag	2.00 $\pm$ 0.01 $\pm$ 0.18	1.04 $\pm$ 0.01 $\pm$ 0.09	0.41 $\pm$ 0.01 $\pm$ 0.04
$\epsilon_{t\bar{t}} \int$ L dt	6.38 $\pm$ 0.04 $\pm$ 0.68	3.30 $\pm$ 0.03 $\pm$ 0.36	1.32 $\pm$ 0.02 $\pm$ 0.14

Backgrounds

- W + heavy flavor jets
- W + light jets (mistags)
- Non-W
- Electroweak processes

Backgrounds: W + Heavy Flavor Jets

- Events with a real W in association with quarks or gluons

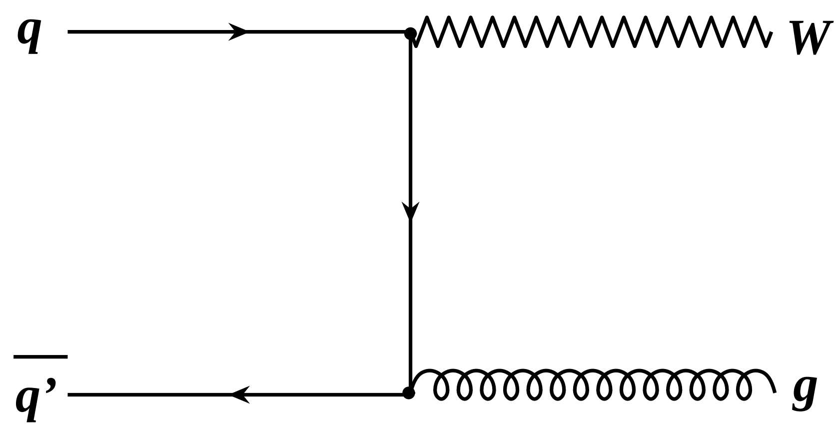


- Estimated using W + heavy flavor MC
  - Extract the HF fractions and the b-tag efficiencies from $\frac{W+HF}{W+Jets}$ MC
  - Normalized to W+jets pretag data
  - Contribution to the pretag sample: $N_{HF}^{pretag} = F_{HF} \times N_{obs}^{pretag}$
  - Contribution to the tagged sample: $N_{HF}^{tag} = N_{HF}^{pretag} \times \epsilon_{btag}$

- 12.3% of the lepton + jets tagged sample

Backgrounds: Mistags

- Jets from light partons or gluons that are tagged

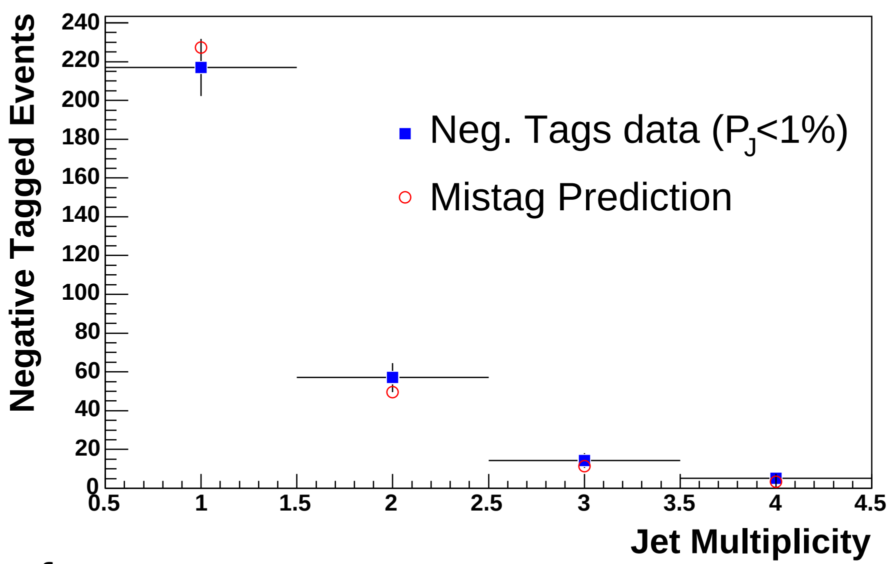


- Negative tags in data have large uncertainty

- Predicted, from data, by the negative tag rate matrix

  - Count events in the pretag sample

  - Weight by the probability of having one mistagged jet



- Accounts for 12.8% of the observed number of events

Backgrounds: non-W

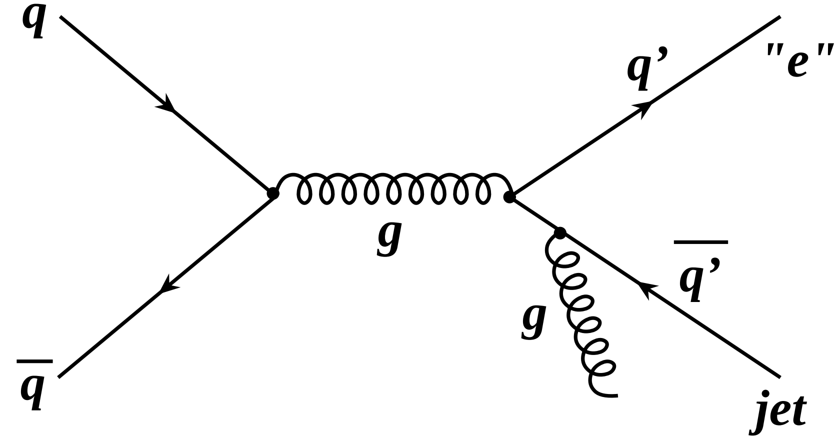
- Events for which the lepton+$\not\!\!E_T$ signature is not due to the decay of a W

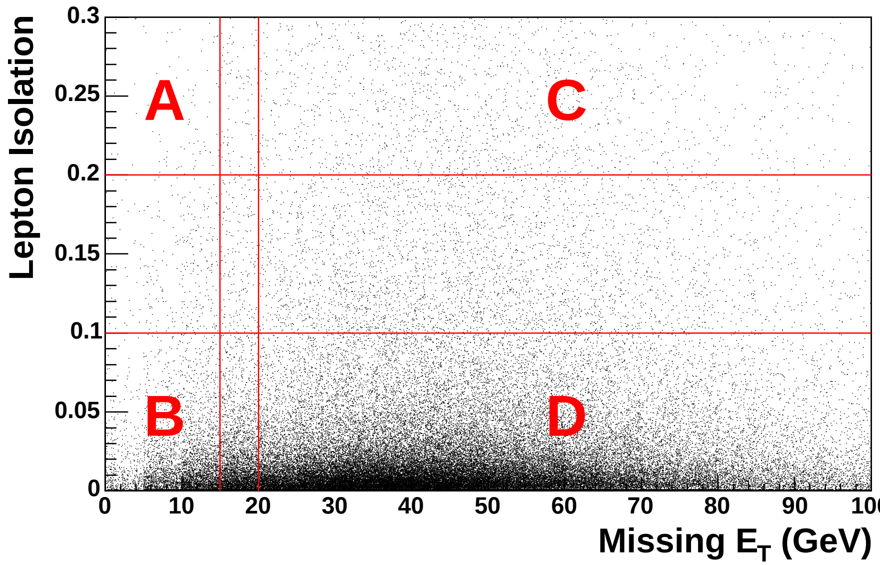
- QCD jet production where a jet fakes a lepton and the $\not\!\!E_T$ is due to a bad measurement of the jet energies

- Minimized with the cut in $M_T^W > 20$ GeV

- Derived from a control region in data
  - ◇ Assumes that the lepton isolation and the $\not\!\!E_T$ of the event are uncorrelated for QCD processess $\Rightarrow \frac{N_B}{N_A} = \frac{N_D}{N_C}$

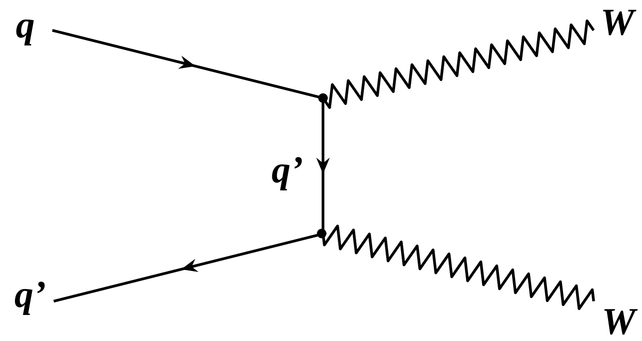
- 1.2% of the tagged sample

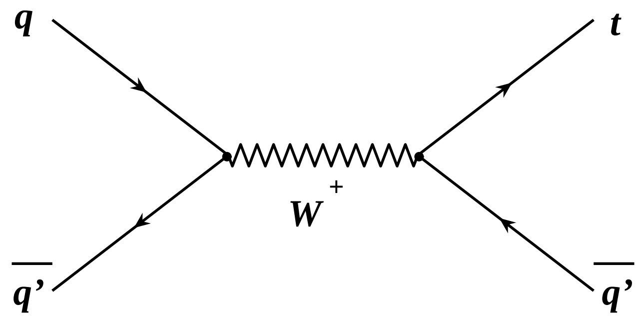




Backgrounds: Electroweak Processes

- Dibosons: One boson decays leptonically and the other hadronically producing a b tag
- Z $\rightarrow \tau\tau$: one τ fakes the W signature and the other one is tagged
- Single top: W (from the top) decays leptonically
- Predicted from MC using the theoretical cross sections (2.5%)



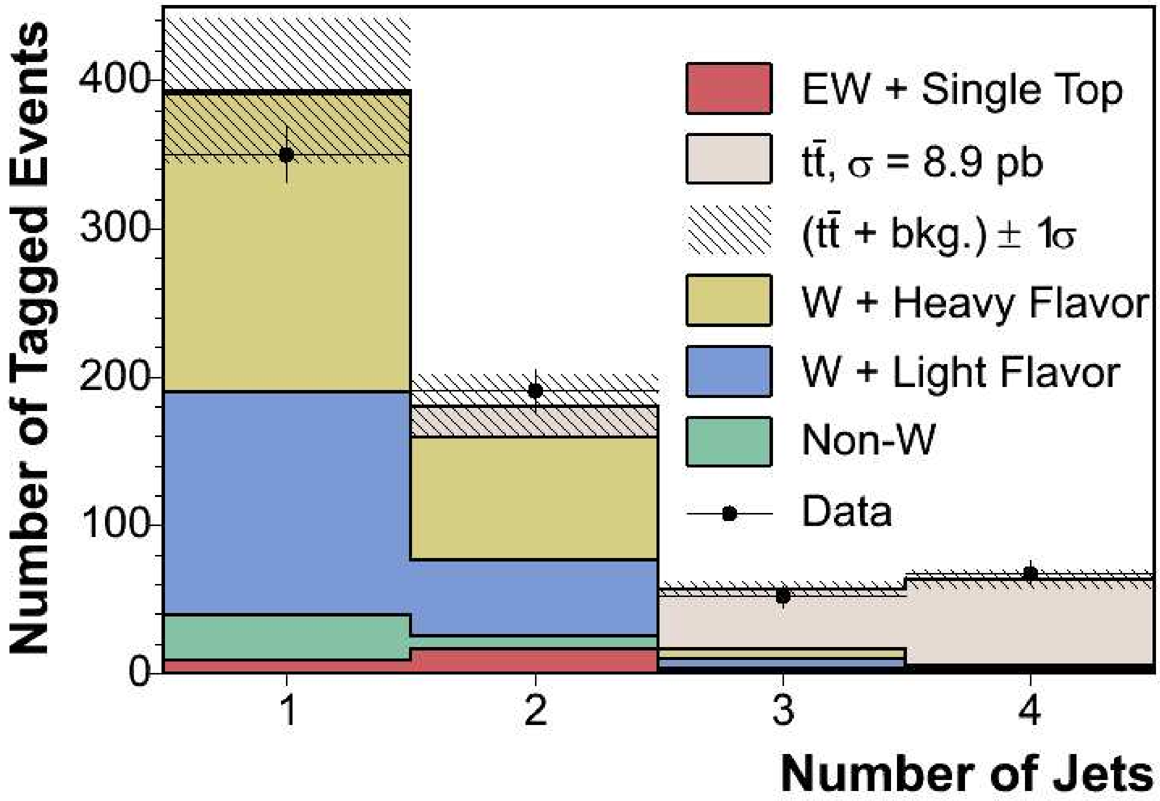


Process	Cross Section (pb)
WW	13.25 ± 0.25
WZ	3.96 ± 0.06
ZZ	1.58 ± 0.02
Single Top $W-g$ (t-channel)	1.98 ± 0.08
Single Top W^* (s-channel)	0.88 ± 0.05
$Z \rightarrow \tau^+\tau^-$	254.3 ± 5.4

Background Summary, $P_J < 1\%$

Jet Multiplicity	1 jet	2 jets	3 jets	$\geq$ 4 jets
Pretag Data	29339	4442	300	166
Electroweak	9.3 $\pm$ 1.1	16.6 $\pm$ 1.8	2.3 $\pm$ 0.3	0.71 $\pm$ 0.09
$Wb\bar{b}$	83 $\pm$ 23	47 $\pm$ 13	4.3 $\pm$ 1.2	1.1 $\pm$ 0.3
$Wc\bar{c}$	31 $\pm$ 9	17.3 $\pm$ 5.2	1.6 $\pm$ 0.5	0.4 $\pm$ 0.1
Wc	86 $\pm$ 21	19.0 $\pm$ 4.9	1.0 $\pm$ 0.3	0.21 $\pm$ 0.06
Mistag	149 $\pm$ 17	51 $\pm$ 6	6.1 $\pm$ 0.7	2.2 $\pm$ 0.3
Non-W	31 $\pm$ 16	8.6 $\pm$ 4.6	0.9 $\pm$ 0.6	0.5 $\pm$ 0.5
Total Background	389 $\pm$ 49	159 $\pm$ 22	16.3 $\pm$ 2.0	5.1 $\pm$ 0.7
$t\bar{t}$ (8.9 pb)	2.5 $\pm$ 0.5	20.6 $\pm$ 2.4	40.4 $\pm$ 4.5	58.1 $\pm$ 6.2
Data	350	191	52	68

Results for $P_J < 1\%$



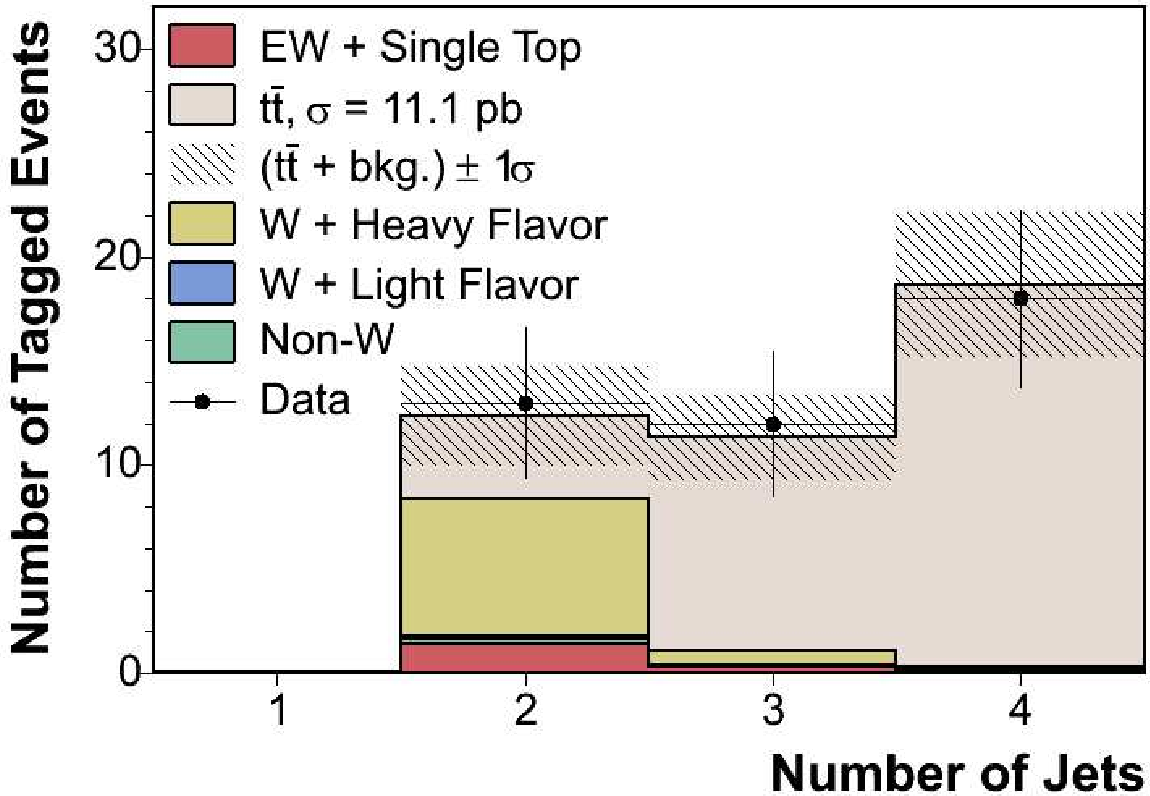
$\sigma_{t\bar{t}}$ (pb)	Single Tag
$P_J < 1\%$	8.9 ± 1.0 (stat) $^{+1.1}_{-1.0}$(syst)

Systematic Uncertainties ($P_J < 1\%$)

- Already systematically limited
- Largest uncertainties due to the tagging SF, jet energy scale and luminosity
- For future measurements, focused on reduce systematics
  - ◊ Tagging SF
  - ◊ Jet energy scale

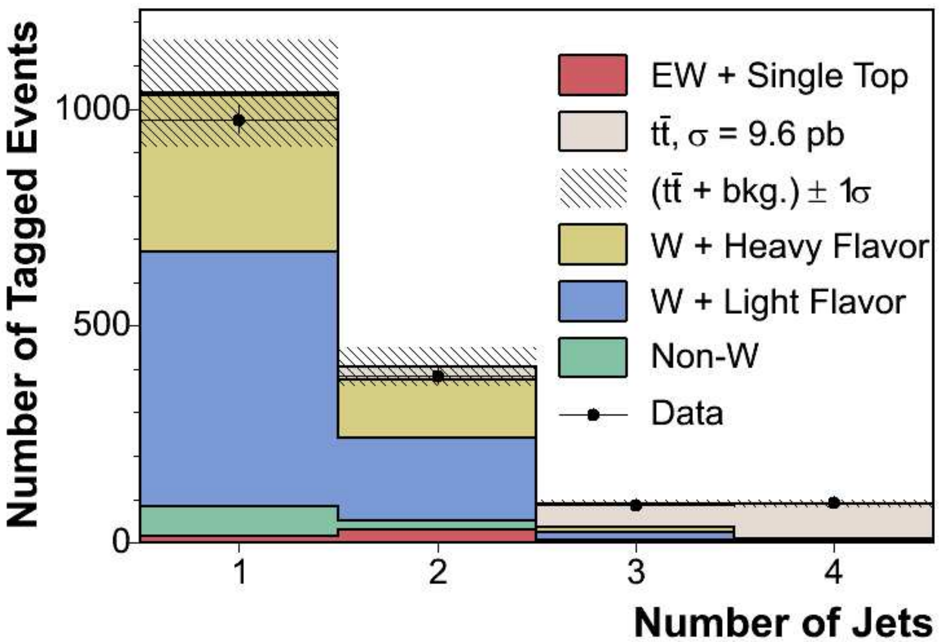
Source	Fractional Uncert. (%)	Contribution to $\sigma_{t\bar{t}}$ (%)
Central Electron ID	1.6	+0.99/-0.97
Central Muon ID	1.9	+0.61/-0.61
CMX Muon ID	1.8	+0.22/-0.22
PDF	2	+2.1/-2.0
Jet Energy Scale	4.2	+4.5/-4.2
ISR/FSR	1.3	+1.4/-1.3
MC Modeling	1.6	+1.7/-1.6
Z Vertex	2.0	+2.1/-2.1
Tagging SF (b's/c's)	8.6/12.9	+8.2/-7.2
Non-W Prediction	50	0.71
W+HF Prediction	30	2.6
Cross Sections Bkg.	1.8	0.056
Luminosity	5.9	+6.5-5.7
Total		+12.5/-11.3

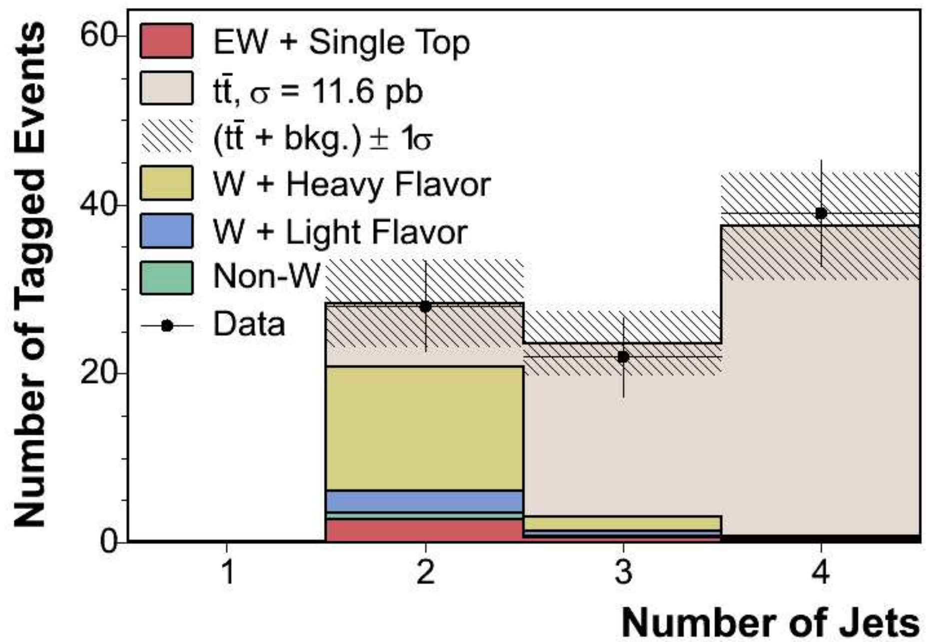
Cross Check (I): Double tag $P_J < 1\%$



$\sigma_{t\bar{t}}$ (pb)	Single Tag	Double Tag
$P_J < 1\%$	8.9 ± 1.0 (stat) $^{+1.1}_{-1.0}$ (syst)	$11.1^{+2.3}_{-1.9}$ (stat) $^{+2.5}_{-1.9}$ (syst)

Cross Check (II): $P_J < 5\%$





$\sigma_{t\bar{t}}$ (pb)	Single Tag	Double Tag
$P_J < 1\%$	8.9 ± 1.0 (stat) $^{+1.1}_{-1.0}$ (syst)	$11.1^{+2.3}_{-1.9}$ (stat) $^{+2.5}_{-1.9}$ (syst)
$P_J < 5\%$	$9.6^{+1.0}_{-0.9}$ (stat) $^{+1.2}_{-1.1}$ (syst)	$11.6^{+1.7}_{-1.5}$ (stat) $^{+2.4}_{-1.8}$ (syst)

Jet Probability at CDF

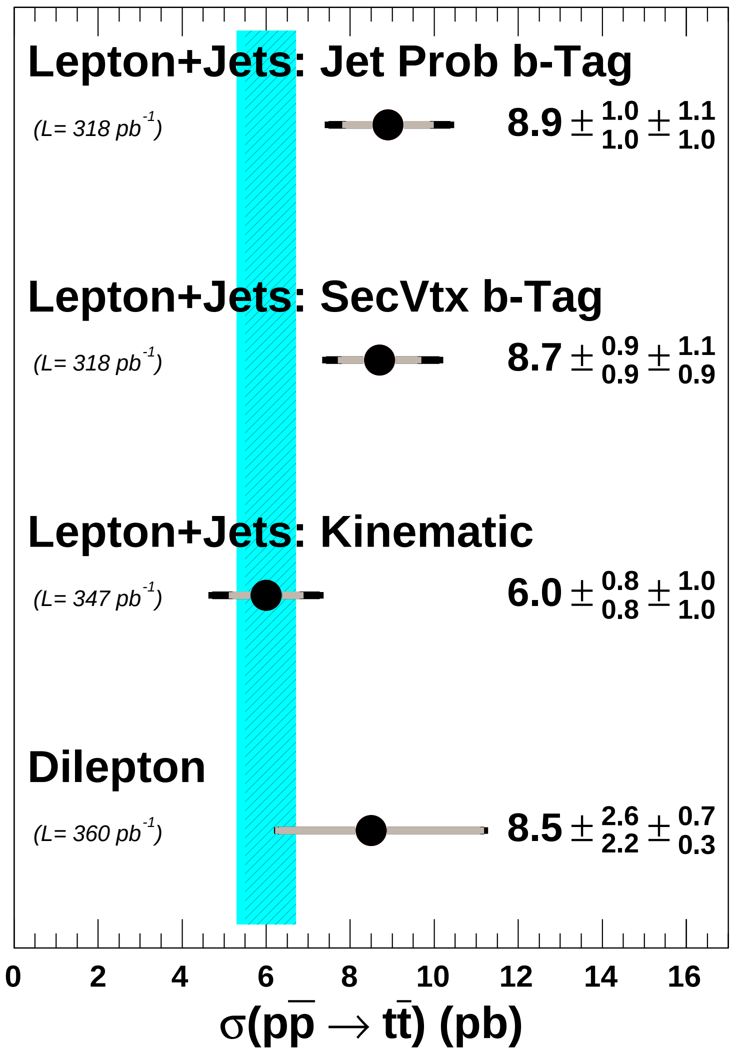
- Tagger has been used by other different analysis (top mass, b physics, exotics)

- Right now, measuring the efficiencies and mistag rate using 1.2 fb^{-1} of data
  - ◇ Using a new (and complementary) method for the scale factor
  - ◇ New parameterization of the mistag rate matrix

- Usefull to provide information in other tagging strategies
  - ◇ Combined tagger
  - ◇ Neural network tagger: the jet probability variable, P_J, is going to be introduced as an input variable with a high weight

Summary

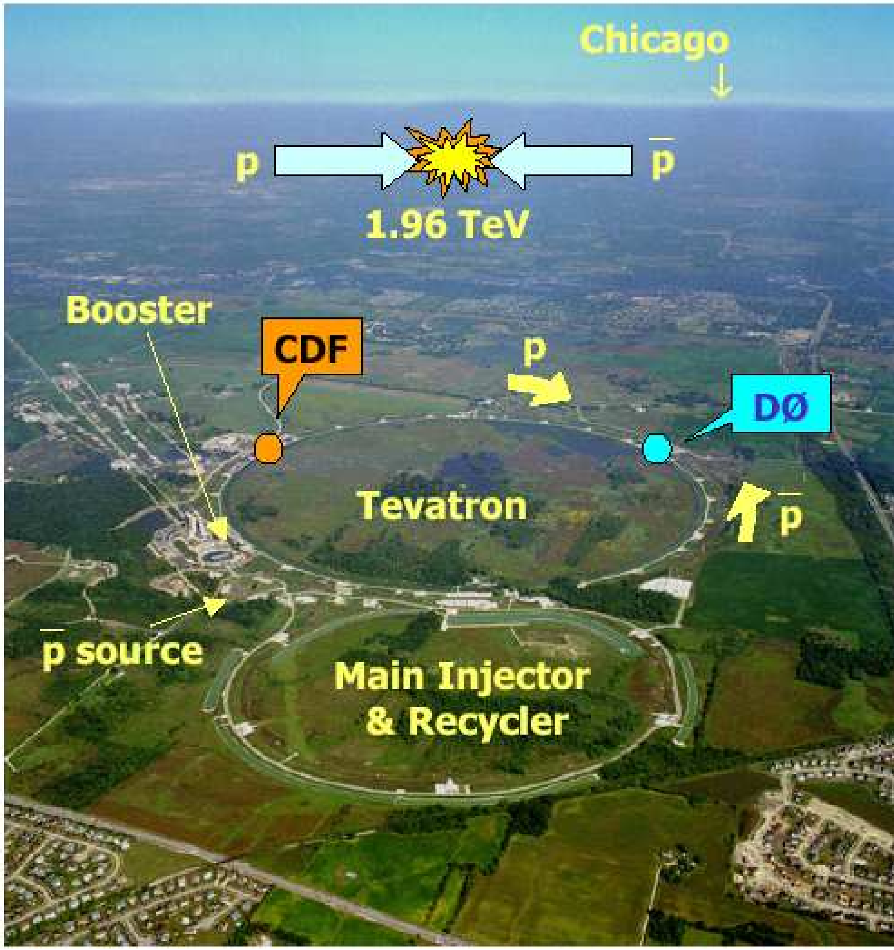
- We have developed the Jet Probability tagging algorithm for Run II
  - ◇ Based on the track impact parameter information
  - ◇ Continuous variable to discriminate heavy flavor jets
- Characterized the algorithm (efficiency and mistag rate) using data
  - ◇ $54.5 \pm 3.6\%$ efficiency for $t\bar{t}$ events
  - ◇ $1.22 \pm 0.08\%$ mistag rate
- Measured the $t\bar{t}$ production cross section in the Lepton+Jets sample ($M_{Top} = 178\ GeV/c^2$)
  - ◇ $\boldsymbol{\sigma = 8.9 \pm 1.0(stat)^{+1.1}_{-1.0}(syst)}$ pb
- Value consistent with other measurements (and also with the theoretical value)
  - ◇ Total uncertainty of 17%
- Published in Phys. Rev. D. 74, 072006.



BACK-UP SLIDES

The Tevatron

- Currently, the world's only top quark production machine
- Highest energy $p\bar{p}$ collider
  - Energy of the beam = $980\ GeV$
  - $\sqrt{s} = 1.96\ TeV$ (Run I $\rightarrow 1.8\ TeV$)
- Collisions every $396\ ns$ (Run I $3.5\ \mu s$)
- Run I: 1992 - 1996 (¡quark *top*!)
- Run II: 2001 - nowadays
  - Many improvements: *Main Injector*
  - $\mathcal{L}_{int}$: $100\ pb^{-1}$ (Run I) $\longrightarrow > 2\ fb^{-1}$ (Run II)



- Other achievements: quark *bottom* (1977), ν_τ (2000), B_s mixing, single top evidence

Deduction of the Jet Probability Formula

- If we have a jet with 2 tracks with positive impact parameter which probabilities are P_1 and P_2 and $K \equiv P_1 \cdot P_2$

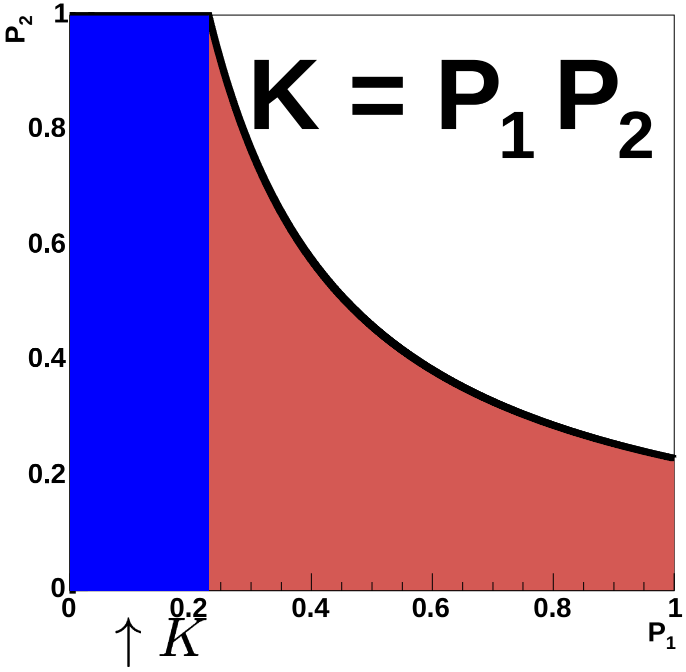
$$0 \leq P_i \leq 1 \text{ i=1,2} \Longrightarrow 0 \leq K \leq 1$$

- The area below and in the left of the curve of constant probability K is the set of combinations, for the 2 tracks, of having a probability less or equal than K. And this area is defined as Jet Probability, P_J

$\diamond\ P_J = A + B,\ A = K \cdot 1$

$\diamond\ B = \int_{x=K}^{x=1} f(x)dx = \int_{x=K}^{x=1} \frac{K}{x} dx = -K Ln K$

$\Longrightarrow P_J = K(1 - LnK)$



- In general, it can be shown that

$$P_J = \prod_{l=1}^{N_{tr}} P_{tr} \times \sum_{r=0}^{N_{tr}-1} \frac{(-ln \prod_{l=1}^{N_{tr}} P_{tr})^r}{r!}$$

Jet Probability Efficiency: Method

- Measured using an 8 GeV inclusive electron data sample and a generic 2→2 Herwig MonteCarlo sample
- Single tag method: $\epsilon = \frac{N_{ej}^{+} - N_{ej}^{-}}{N_{ej}} \cdot \frac{1}{F_B}$
  - ◇ Disadvantage: relays on the correct determination of the heavy flavor fraction in the sample
- Double tag method: sample of events with two jets

$$\epsilon = \frac{(N_{a+}^{e+} - N_{a+}^{e-}) - (N_{a-}^{e+} - N_{a-}^{e-})}{N_{a+} - N_{a-}} \cdot \frac{1}{F_B^a}$$

- Calculation of the heavy flavor content in the jet (F_B) has to be corrected for the contribution from charm (determined from MC): $F_B = F_b(1 + \lambda_{c/b})$
  - ◇ F_b from $D^0 \to K\pi$ decays: $F_b = \frac{N_{D^0}}{N_{ej}} \cdot \frac{1}{\epsilon_{D^0}}$
  - ◇ F_b from cascade muons: select b-hadrons with 2 semiletonic decays (b $\to$ c $\to$ X) emitting a pair e-μ with opposite charge:

$$F_b = \frac{1}{\epsilon_\mu} \frac{N_{ej}^{\mu}(OS) - N_{ej}^{\mu}(SS)}{N_{ej}}$$

Scale Factor Dependence with the Jet E_T

- Used two different samples with high energy jets (jet20 and jet50)
- Cannot calculate the SF since we do not know the content of HF
- ... but variations on HF fractions are small for a large range of E_T $\Rightarrow$ we can estimate the E_T dependence of the SF from the E_T dependence of the ratio of positive tag excess between data and MC
- We combined the slope obtained with the 3 samples
- Slope is consistent with a flat dependence $\Rightarrow$ SF is valid at any E_T

Sample	$P_J <$ 1%	$P_J <$ 5%
Inclusive Electron	-0.0082 $\pm$ 0.0037	-0.0081 $\pm$ 0.0044
Jet 20	-0.0008 $\pm$ 0.0019	-0.0028 $\pm$ 0.0024
Jet 50	0.0005 $\pm$ 0.0008	0.0005 $\pm$ 0.0009
Weighted Average	-0.00002 $\pm$ 0.00070	-0.00020 $\pm$ 0.00072

Tag Rate Matrix Definition

Bin	E_T (GeV)	Trk. Mult.	$\sum E_T^{\text{jets}}$ (GeV)	$\lvert\eta\rvert$	$\lvert Z_{\text{vtx}}\rvert$ (cm)	ϕ
1	[0,20)	2	[0,80)	[0,1.0)	[0,10)	$[\frac{-\pi}{12},\frac{\pi}{12})$
2	[20,35)	3	[80,140)	≥ 1.0	[10,20)	$[\frac{\pi}{12},\frac{3\pi}{12})$
3	[35,50)	4,5	[140,220)		[20,40)	$[\frac{3\pi}{12},\frac{5\pi}{12})$
4	[50,65)	6,7	≥ 220		[40,50)	$[\frac{5\pi}{12},\frac{7\pi}{12})$
5	[65,80)	8,9			[50,60)	$[\frac{7\pi}{12},\frac{9\pi}{12})$
6	[80,100)	10-13			≥ 60	$[\frac{9\pi}{12},\frac{11\pi}{12})$
7	[100,120)	≥ 14				$[\frac{11\pi}{12},\frac{13\pi}{12})$
8	[120,150)					$[\frac{13\pi}{12},\frac{15\pi}{12})$
9	[150,180)					$[\frac{15\pi}{12},\frac{17\pi}{12})$
10	≥ 180					$[\frac{17\pi}{12},\frac{19\pi}{12})$
11						$[\frac{19\pi}{12},\frac{21\pi}{12})$
12						$[\frac{21\pi}{12},\frac{23\pi}{12})$

Background Summary, $P_J < 5\%$

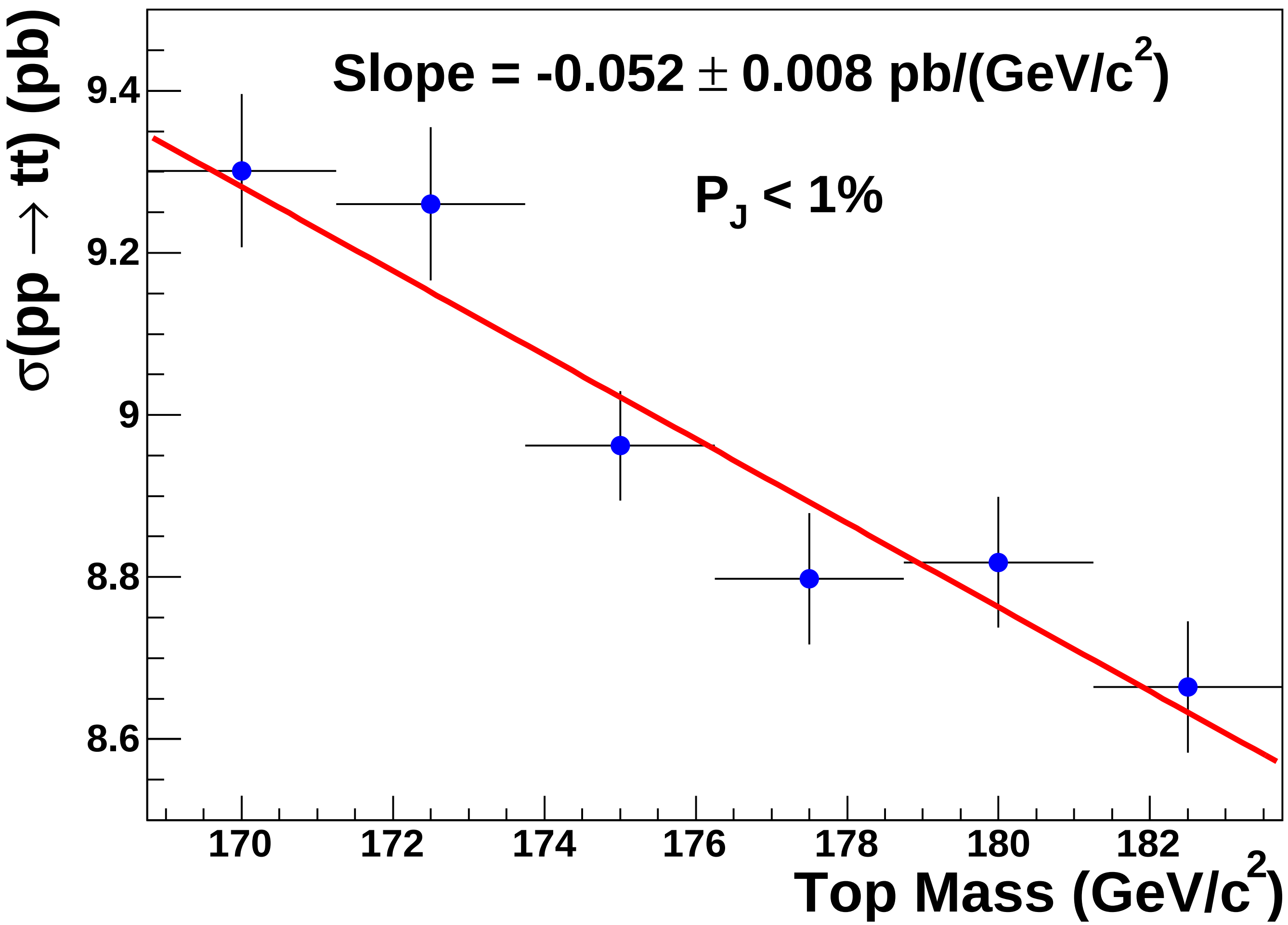
Jet Multiplicity	1 jet	2 jets	3 jets	$\geq$ 4 jets
Pretag Data	29339	4442	300	166
Electroweak	16.3 ± 1.8	28.8 ± 3.0	4.0 ± 0.4	1.4 ± 0.1
$Wb\bar{b}$	111 ± 31	60 ± 17	5.2 ± 1.4	1.1 ± 0.3
$Wc\bar{c}$	68 ± 20	36 ± 11	3.2 ± 1.0	0.76 ± 0.24
Wc	184 ± 45	40 ± 10	2.2 ± 0.6	0.5 ± 0.13
Mistag	585 ± 92	191 ± 30	19.6 ± 3.1	6.1 ± 1.0
Non-W	69 ± 35	21 ± 11	1.3 ± 0.9	0.8 ± 0.7
Total Background	1033 ± 125	377 ± 46	35.5 ± 4.2	10.6 ± 1.4
$t\bar{t}$ (9.6 pb)	3.6 ± 0.6	28.4 ± 3.1	55.1 ± 5.7	78.6 ± 7.8
Data	975	385	87	93

Background Summary, Double tag

Jet Multiplicity	2 jets	3 jets	$\geq$ 4 jets
Pretag Data	4442	300	166
	$P_J <$ 1%		
MC Derived	1.4 $\pm$ 0.3	0.33 $\pm$ 0.06	0.10 $\pm$ 0.02
$Wb\bar{b}$	6.1 $\pm$ 1.9	0.57 $\pm$ 0.19	0.10 $\pm$ 0.03
$Wc\bar{c}$	0.38 $\pm$ 0.17	0.09 $\pm$ 0.04	0.013 $\pm$ 0.008
Wc	0.12 $\pm$ 0.08	0.02 $\pm$ 0.02	0.003 $\pm$ 0.003
Mistag	0.21 $\pm$ 0.05	0.06 $\pm$ 0.01	0.019 $\pm$ 0.004
Non-W	0.19 $\pm$ 0.12	0.03 $\pm$ 0.02	0.05 $\pm$ 0.03
Total Background	8.4 $\pm$ 2.2	1.1 $\pm$ 0.3	0.28 $\pm$ 0.06
$t\bar{t}$ (11.1 pb)	3.9 $\pm$ 0.9	10.2 $\pm$ 2.0	18.4 $\pm$ 3.4
Data	13	12	18
	$P_J <$ 5%		
MC Derived	2.83 $\pm$ 0.51	0.70 $\pm$ 0.12	0.25 $\pm$ 0.05
$Wb\bar{b}$	11.4 $\pm$ 3.6	1.1 $\pm$ 0.3	0.16 $\pm$ 0.05
$Wc\bar{c}$	2.3 $\pm$ 0.9	0.38 $\pm$ 0.15	0.06 $\pm$ 0.03
Wc	0.97 $\pm$ 0.37	0.16 $\pm$ 0.07	0.03 $\pm$ 0.01
Mistag	2.7 $\pm$ 0.8	0.65 $\pm$ 0.20	0.15 $\pm$ 0.05
Non-W	0.63 $\pm$ 0.34	0.09 $\pm$ 0.05	0.14 $\pm$ 0.09
Total Background	20.9 $\pm$ 5.0	3.1 $\pm$ 0.6	0.80 $\pm$ 0.15
$t\bar{t}$ (11.6 pb)	7.5 $\pm$ 1.5	20.5 $\pm$ 3.7	36.6 $\pm$ 6.1
Data	28	22	39

$\sigma_{t\bar{t}}$ dependence with M$_t$

- Reevaluate signal acceptance using `HERWIG` Monte Carlo samples with different values of M$_t$



Single vs Double Tag Cross Section

- Measurements are statistically compatible but $\sigma_{2t}/\sigma_{1t} \simeq$ 1.2...
- We did 10,000 pseudoexperiments varying the total double tag background according to a Gaussian with a width equal to its uncertainty
- Add the background to the expected signal assuming σ_{1t} and vary the total number of events according to a Poisson distribution
- Count number of times in which the result is greater than σ_{2t}
- Prob($\sigma_{meas} > \sigma_{2t} \mid \sigma_{1t}$) = 13.2% (15.6%)