

Search for $t\bar{t}H$ production in $p\bar{p}$ collisions at 1.96 TeV



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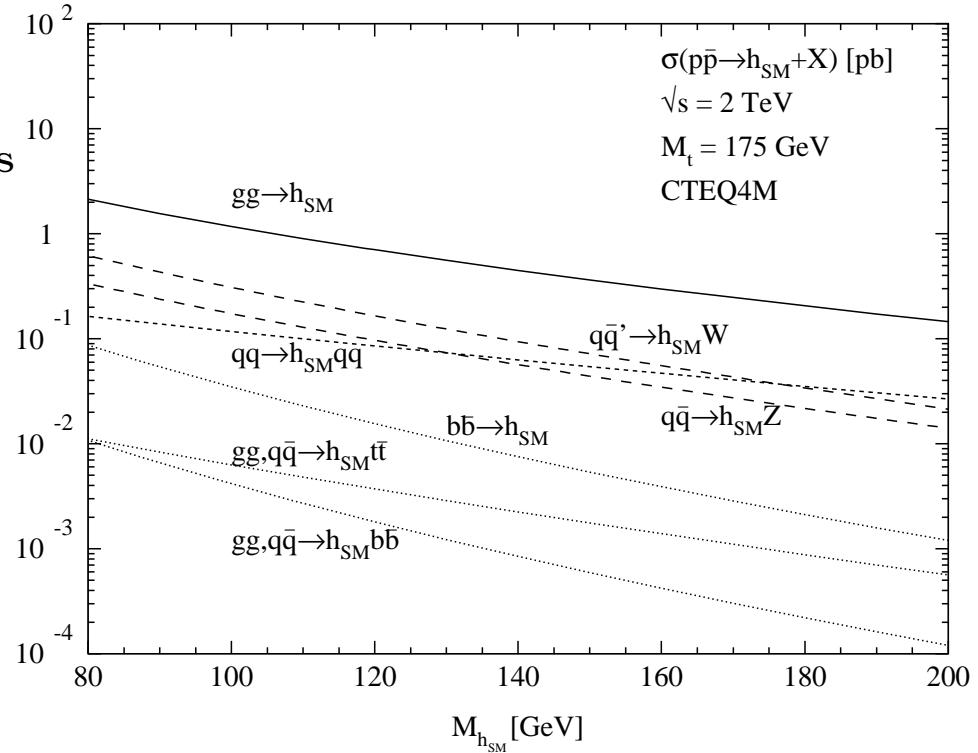
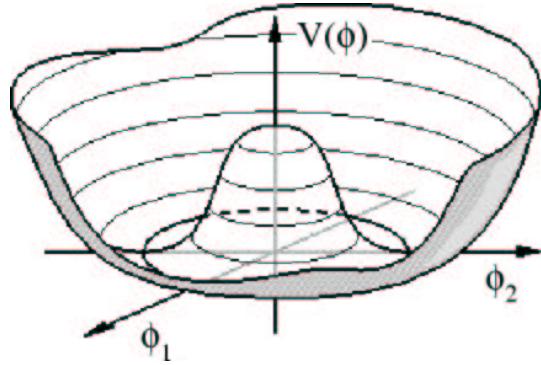


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Introduction to $t\bar{t}H$

Higgs mechanism gives rise to:

- Masses for W^\pm and Z^0 bosons
- Masses for SM fermions
- **The Higgs Boson**



Tevatron collides $p\bar{p}$ at 1.96 TeV

- Search channels include $H \rightarrow W^+W^-$, $W^\pm H$, ZH
- $t\bar{t}H$ production has low cross-section, but spectacular signature
- For low mass Higgs, final state signature $W^+W^- b\bar{b}b\bar{b}$

Event Selection for $t\bar{t}H$

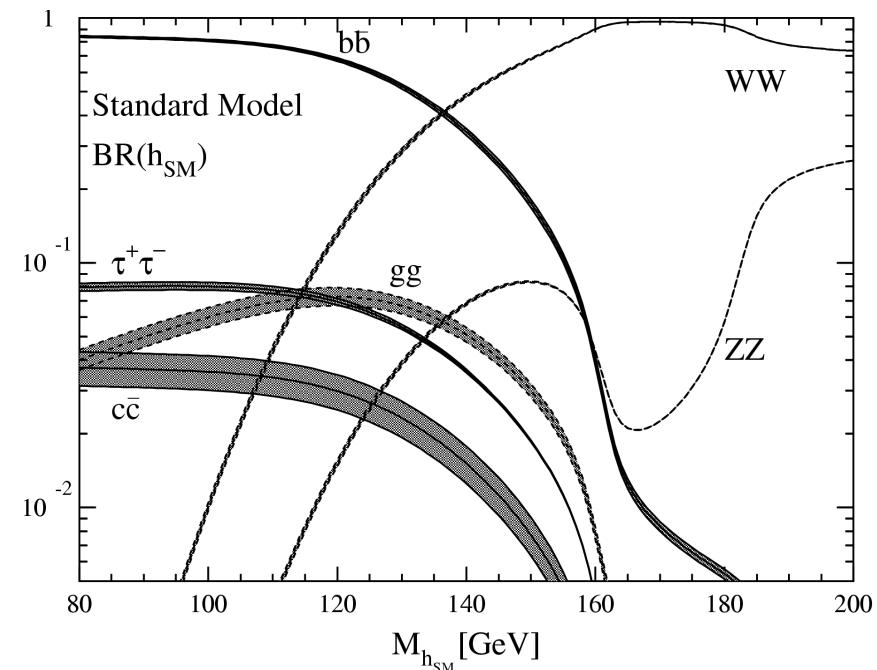
Final state signature: $W^+ W^- b\bar{b}b\bar{b}$

Event Selection:

- Exactly 1 identified electron or muon ($p_T > 20$ GeV)
- 5 or more jets ($E_T > 15$ GeV, $|\eta| < 2.0$)
- $\cancel{E}_T > 10$ GeV
- Veto events consistent with Z boson
- ≥ 3 jets that originate from Secondary Vertex

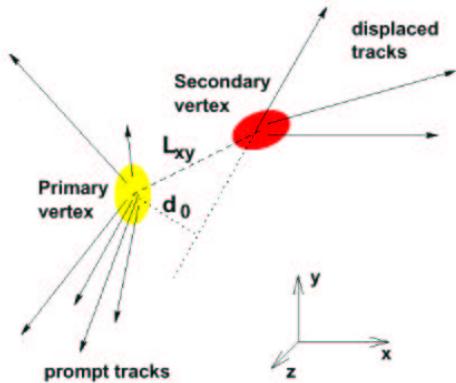
Data sample: 320 pb^{-1}

Signal region blinded while evaluating background components

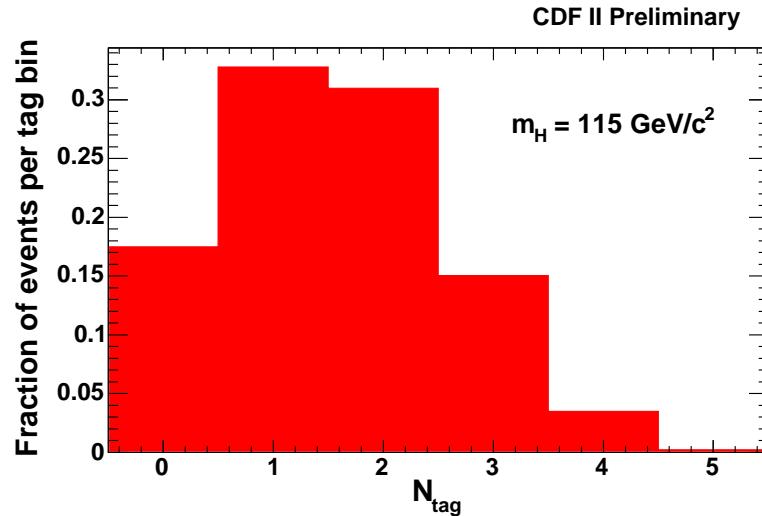


Identification of b -jets

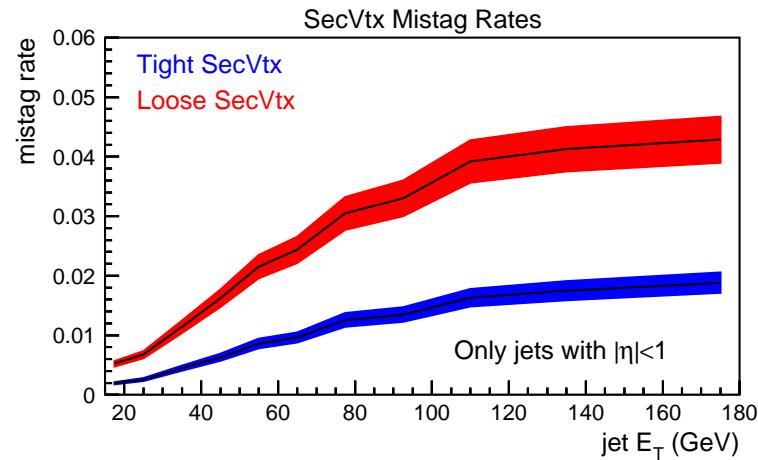
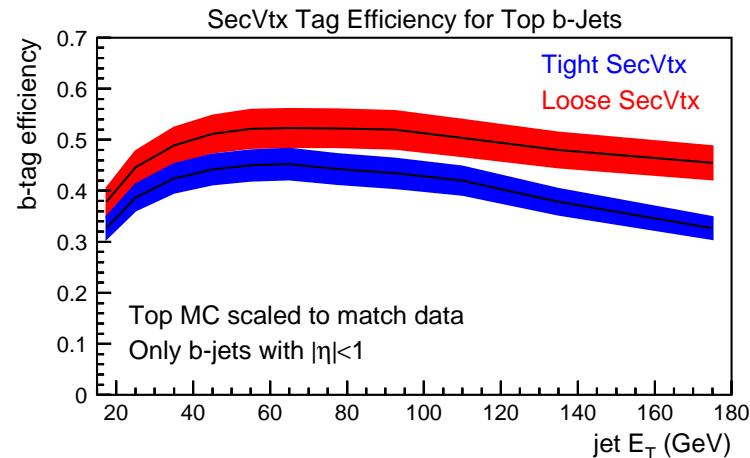
b -jets identified using secondary vertices



Tag multiplicity distribution for $t\bar{t}H$ events

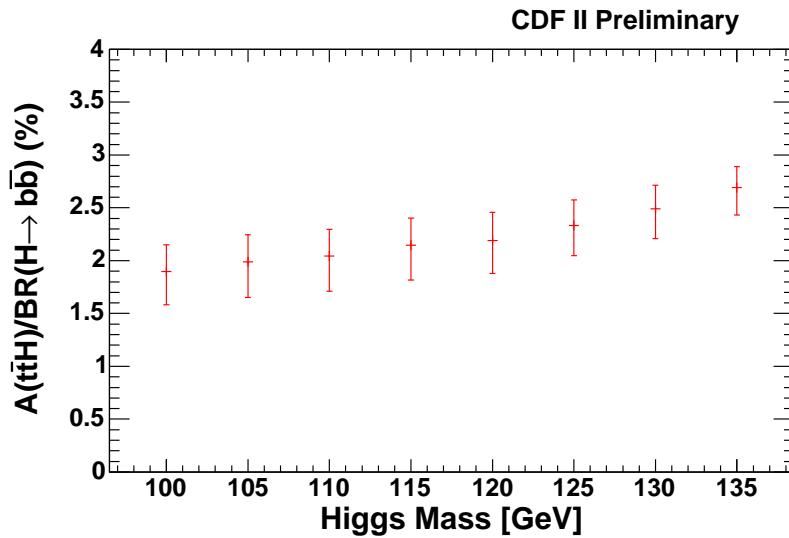


b -tagging performance



Loose tagging is used in this analysis

Detector Acceptance for $t\bar{t}H$



Systematic uncertainties on
Event Acceptance

Source	Uncertainty (%)
Jet Energy Scale	4.2
PDF	1.0
ISR/FSR	1.6
MC Modelling	0.5
Lepton ID Efficiency	5.1
BTag Efficiency	18
MC Stats	1
Total	19

- Event acceptance factors out $BR(H \rightarrow b\bar{b})$ but not $BR(W \rightarrow l\nu)$
- $A(t\bar{t}H)/BR(H \rightarrow b\bar{b}) \sim 2.0(2.5)\%$ for $m_H = 110(135)$ GeV
- Dominant systematic uncertainty comes from the b -tagging efficiency

Background Estimation

Three major sources of background:

- Mistag background: arises from misidentification of b -jets
- Multijet background: arises from misidentification of lepton
- Irreducible background: states with same final state signature as $t\bar{t}H$

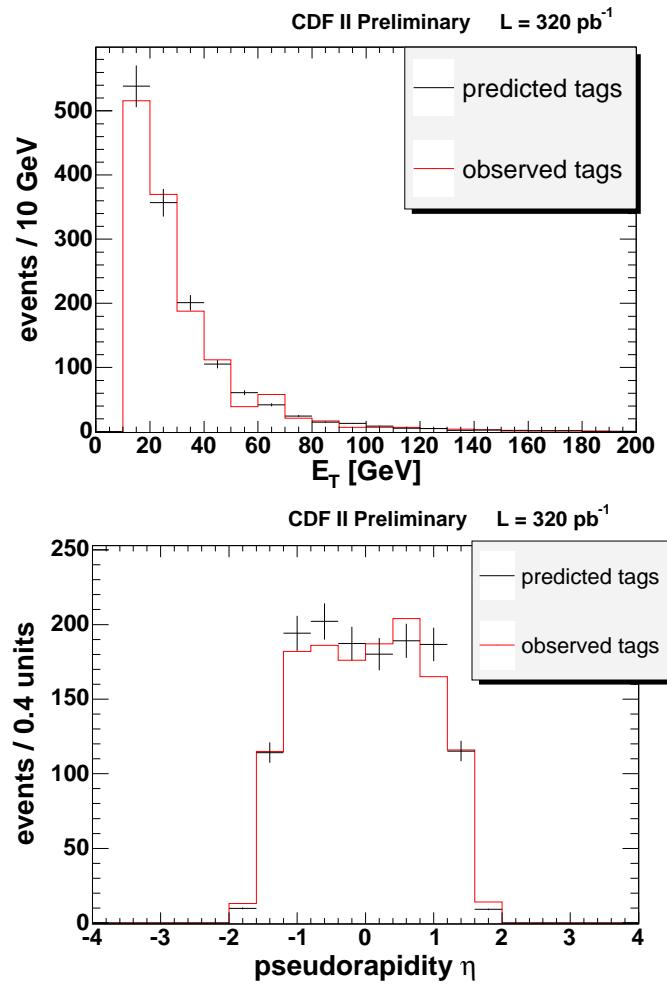
Background	Estimation Method	Estimated Yield
Mistag	Parametrization of jet mistag rates	0.49 ± 0.10
Irreducible	Combination of data and MC	0.36 ± 0.07
Multijet	Estimate in control region of non-isolated leptons and low \cancel{E}_T	0.04 ± 0.04

Misidentification of b -jets

Measure likelihood of mistag by forming secondary vertices with negative impact parameter tracks.

Use jet samples to construct probability of mistag as function of 5 variables:

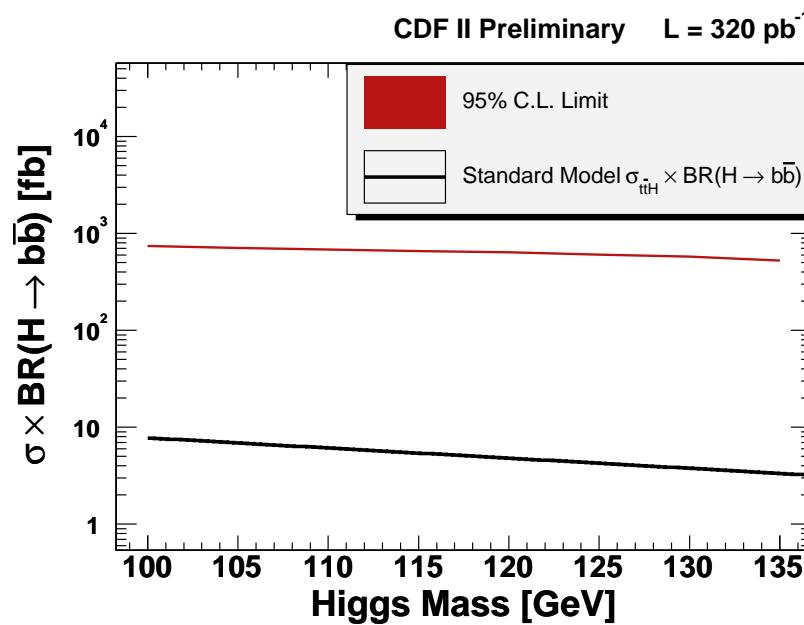
- jet E_T
- jet η
- jet ϕ
- jet N_{tracks}
- event $\sum_{jet} E_T$



Mistag component contribution 0.49 ± 0.10

Event Tally and Result

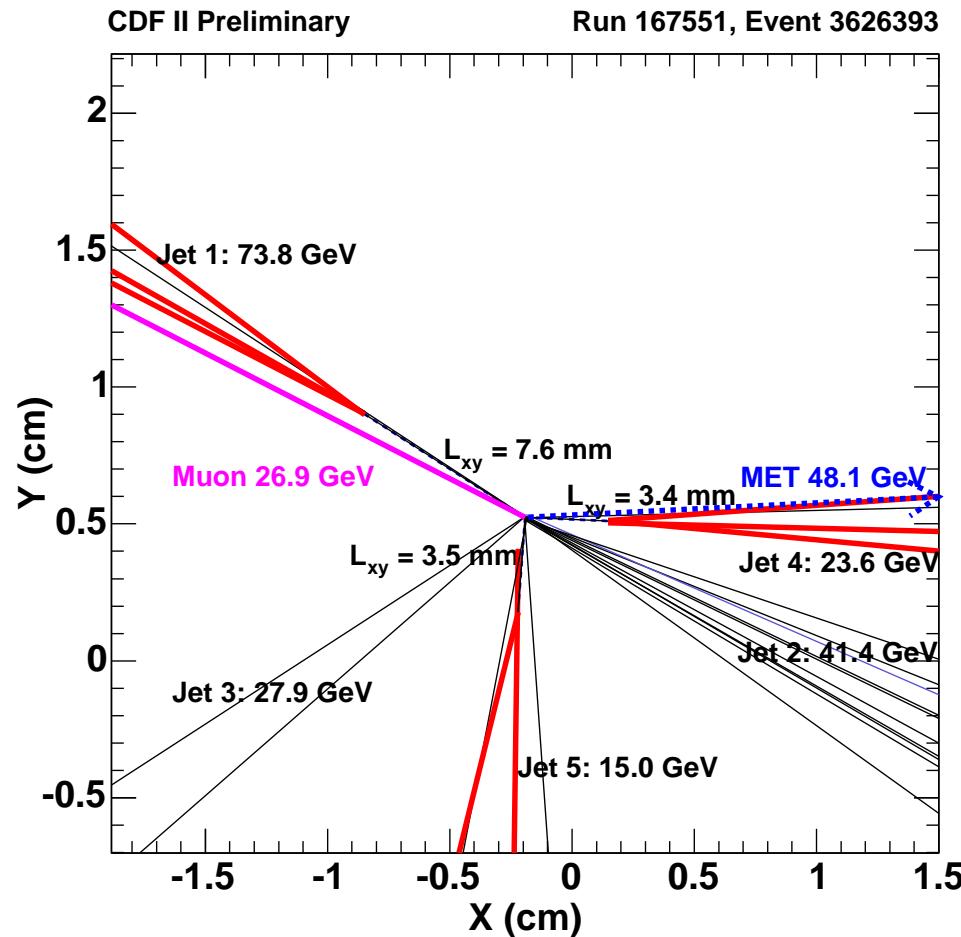
Source	Yield (events)
Mistag	0.49 ± 0.10
Irreducible	0.36 ± 0.07
QCD	0.04 ± 0.04
Total Background	0.89 ± 0.12
Signal ($m_H = 115$ GeV)	0.024 ± 0.005
Observed	1



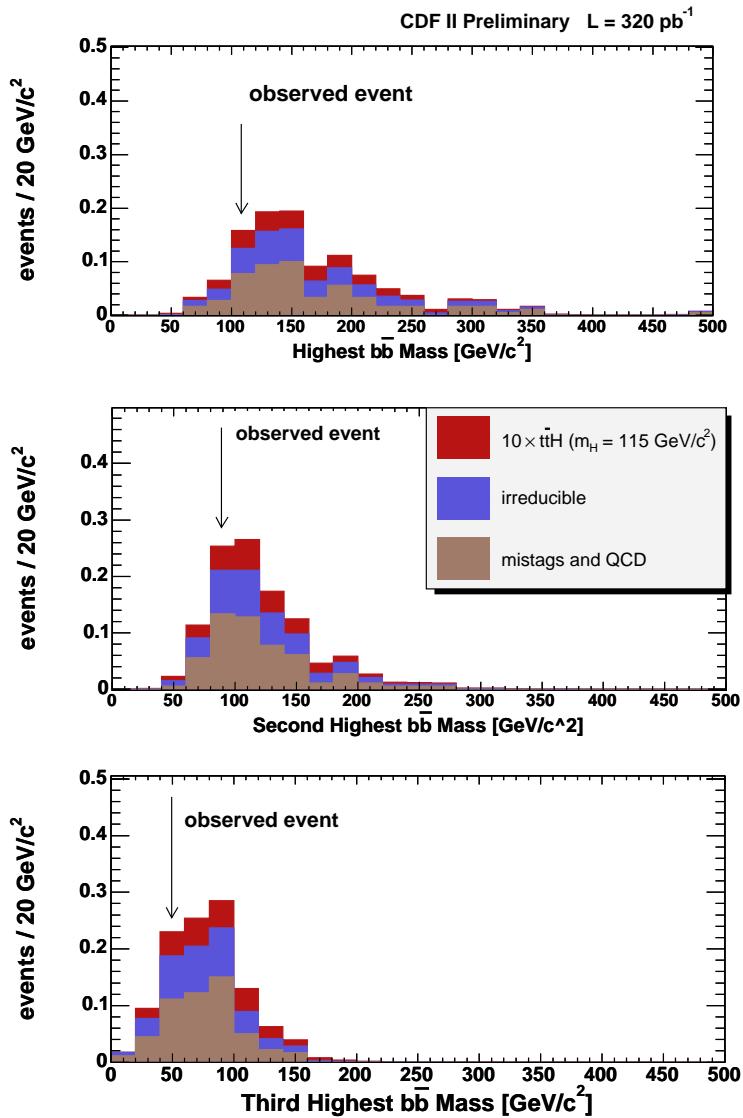
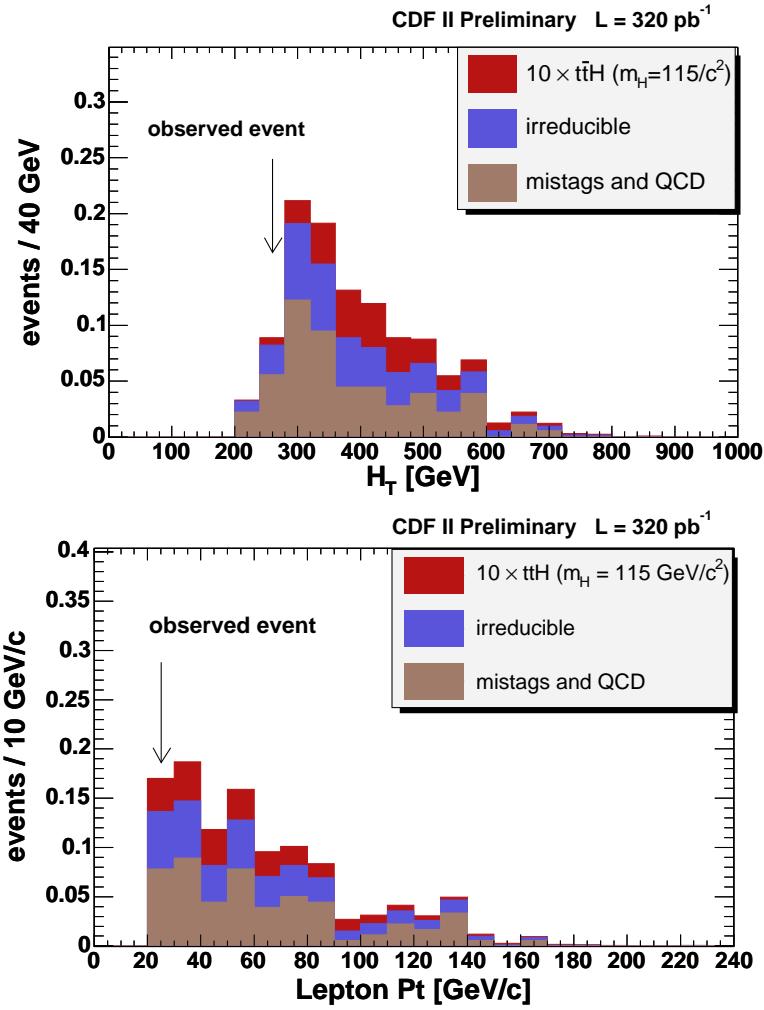
- Once backgrounds estimates finalized, the signal region was unblinded
- One event observed in the signal region
- 95% C.L. Limit ($m_H = 115$ GeV) on $\sigma_{t\bar{t}H} \times BR(H \rightarrow b\bar{b})$ is 660 fb .
- For 95% C.L. limit σ_{limit} we find $\frac{\sigma_{limit}}{\sigma_{t\bar{t}H}^{115}} = 168$.

Observed Event - Kinematics

Event with an identified, central muon and three b -tagged jets:



Event Distributions



Summary and Outlook

1. First Limits set on $t\bar{t}H$ production

- Investigate spectacular signature: high p_T lepton and 3 b -tagged jets
- One event observed on background of 0.89 ± 0.12 events
- Limit set at 660 fb, 168 times above SM expectation for $\sigma_{t\bar{t}H}^{115}$.

2. Future Prospects at CDF/Tevatron

- Measurement is statistics limited: better result with more data!
- Better b -tagging algorithms also improve limit
- At 1 fb^{-1} and above, can be a helpful complementary search channel to WH , ZH production

3. Future Prospects at LHC

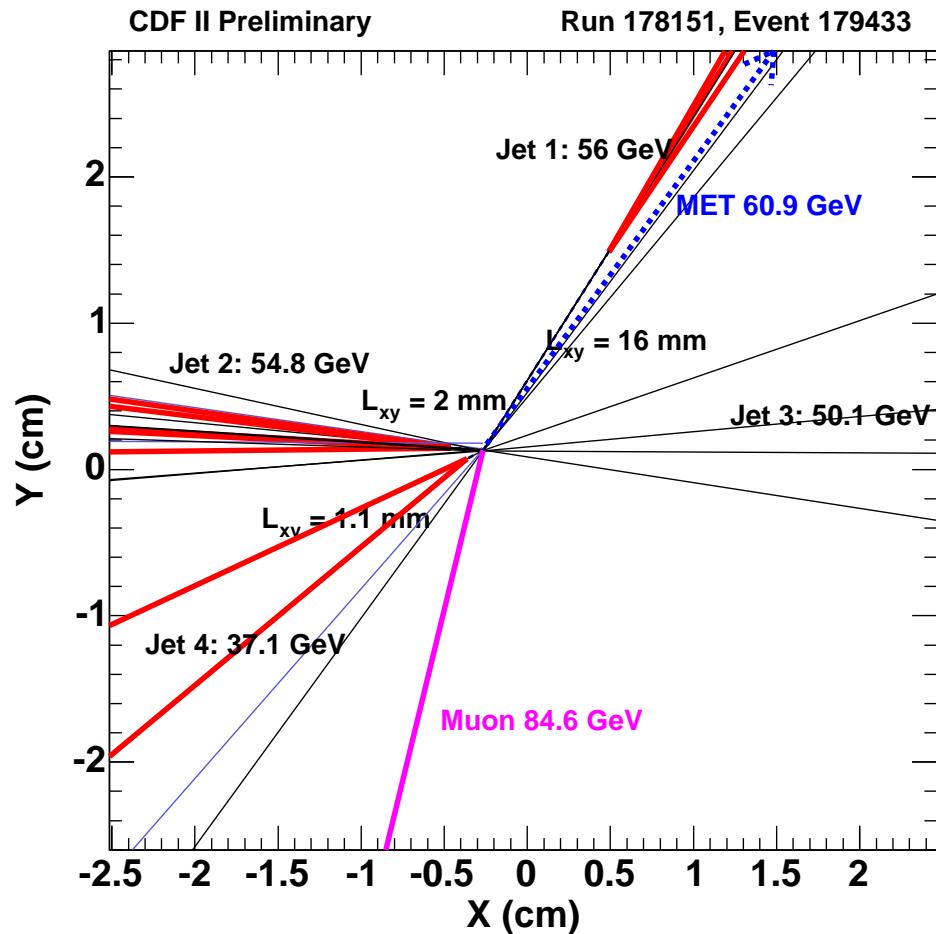
- Very important search channel for low mass Higgs range
- Misidentification of b -jets must be controlled
- May require the b -tagging of four jets in final state signature

This channel is not just interesting for finding the Higgs, but exploring the large Higgs-top Yukawa coupling!

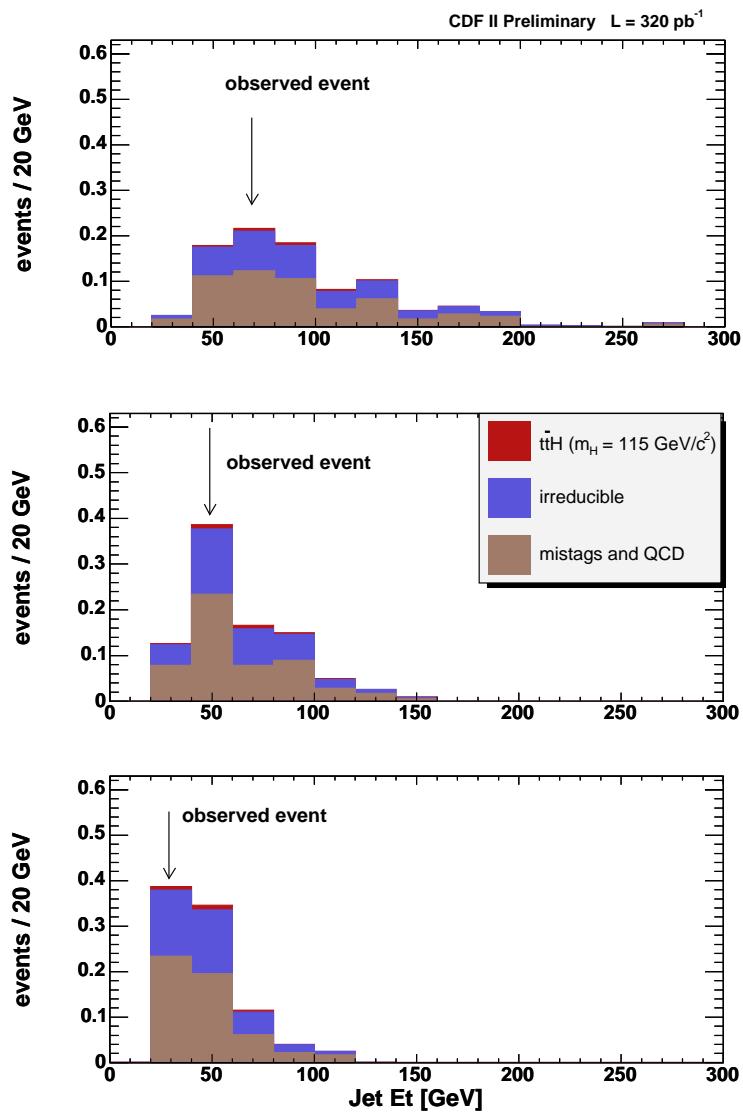
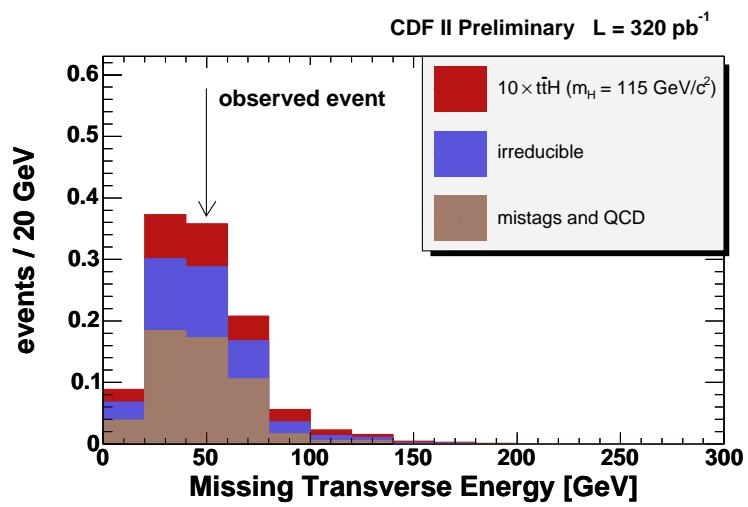
Backup Slides

Event with muon and three b -tags

Event with a muon and three b -tagged jets, but only 4 jets:



Event Distributions



CDF Limits on Higgs Production

