Search for the Associated Production of Z and Higgs Bosons in ννbb *final state*

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Outline

- Introduction
- D0 detector
- Backgrounds
- Analysis outline
- B-jet identification
- Multivariate discriminant
- Previous Result
- Conclusion

Introduction

Motivation

High branching ratio for $Z \rightarrow \nu\bar{\nu}$

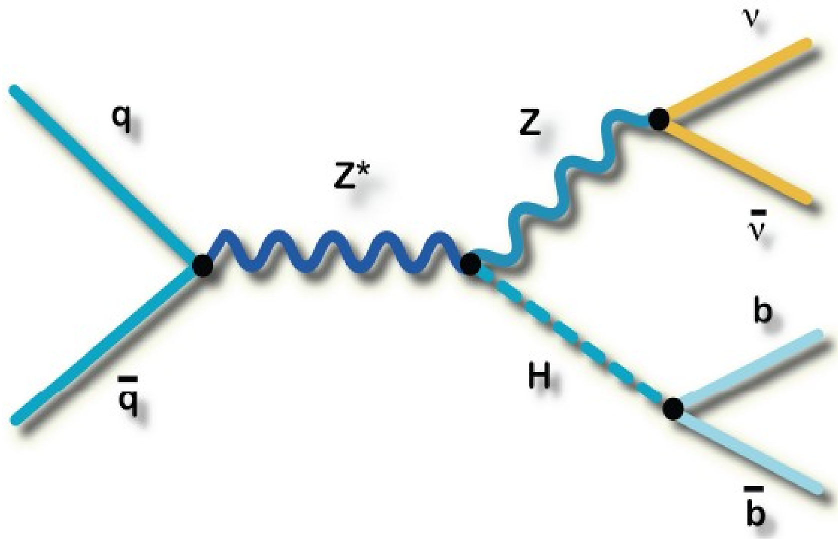
$\sigma(qq \rightarrow ZH) \times Br(Z \rightarrow \nu\bar{\nu}, H \rightarrow b\bar{b})$ ~0.015pb

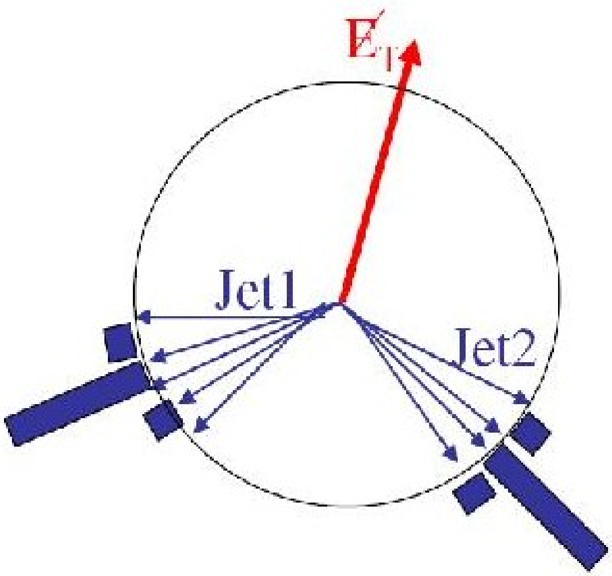
(m_H=115GeV)

Also contribution from

$\sigma(qq \rightarrow WH) \times Br(W \rightarrow \not{l}\nu, H \rightarrow b\bar{b})$ ~0.014pb

Challenging at Hadron Colliders

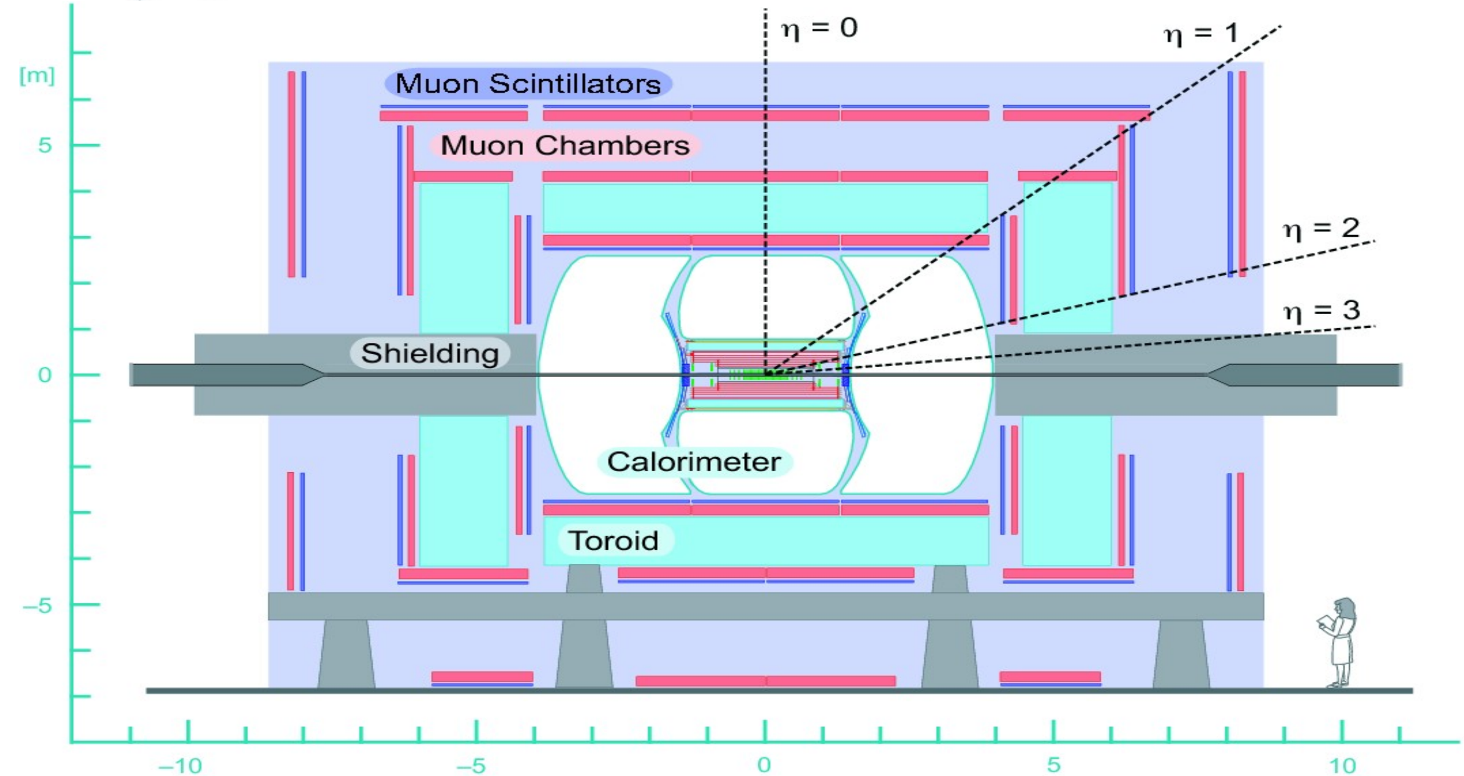




Characteristic signal

- Large Missing E_T(need good calorimeter)
- Two high P_T b-tagged jets(tracking,b tagging)
- Jets boosted(not back to back)
- Dijet mass of b jets
- Veto on isolated leptons

The DØ Detector

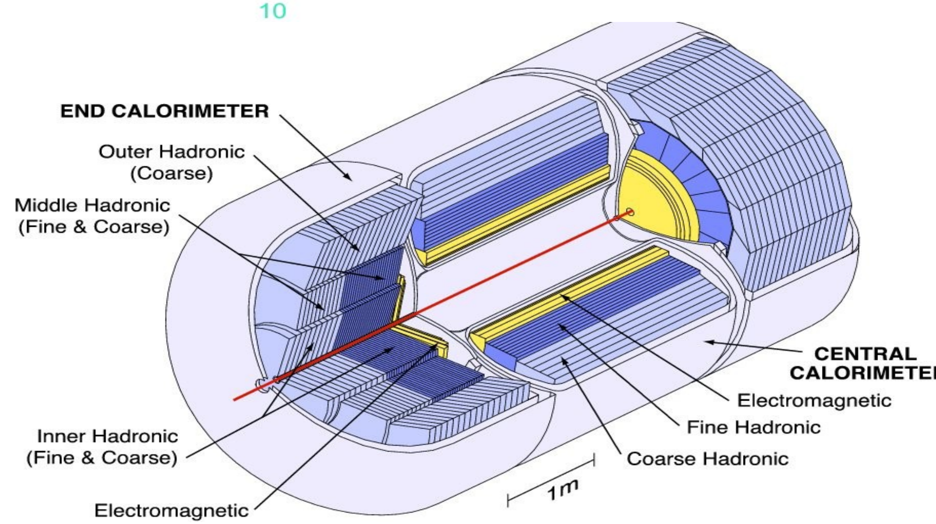


Tracking
Silicon Microstrip Tracker (SMT)
Central Fiber Tracker (CFT)

Surrounded by 2T Solenoid

Uranium/ Liquid-Argon Calorimeter

- Hermetic coverage |η| < 4.2.
- Online and offline monitoring.
- Algorithms to scan data from contaminated events.
- Daily pedestals performed.
- Stability ~99.8%.



Backgrounds

Physics Backgrounds (from Monte Carlo)

- W/Z+jets - $W/Z + b\bar{b}$ $W/Z + (non\ b\ jets)$
- Top - $t\bar{t} \rightarrow l\nu\, bq\bar{q}'\bar{b}$ $t(q)b \rightarrow l\nu\, b(q)\bar{b}$
- Di-boson - $WZ \rightarrow qq'\, l\nu$ $ZZ \rightarrow \nu\nu\, b\bar{b}$

Instrumental Backgrounds (from Data)

Multijet events with mis-measured and fake jets.
Generally low acceptance but x-section is much larger.
Shape and magnitude of multijet background is estimated from data.

Multijet Modeling

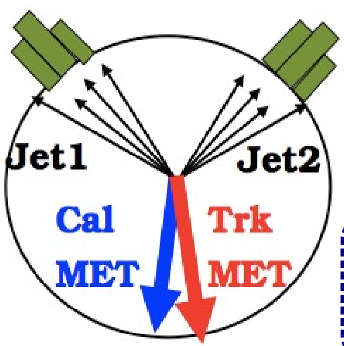
In Signal like events missing E_T from calorimeter and tracks is aligned.

In multijet events where jet energies are mis-measured, direction of the missing E_T from calorimeter and track is random.

Multijet modeling is done from data sideband region where missing E_T from track and calorimeter is not aligned.

Signal Region

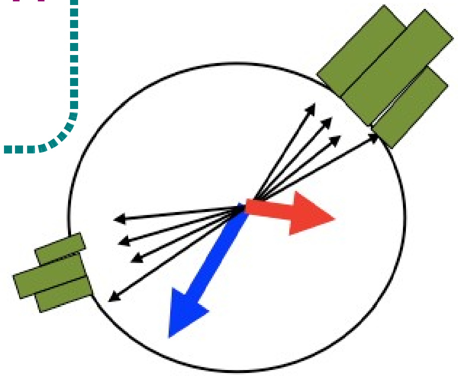
$\Delta\phi(\not{E}_T, \not{P}_T^{trk}) < \pi/2$



Sideband Region

$\Delta\phi(\not{E}_T, \not{P}_T^{trk}) > \pi/2$

$\not{P}_t^{trk} = |\Sigma P_T(tracks)|$



Physics MC sideband contribution is subtracted from data sideband. For normalization remaining multijet background contribution is scaled to match the data observed in signal region.

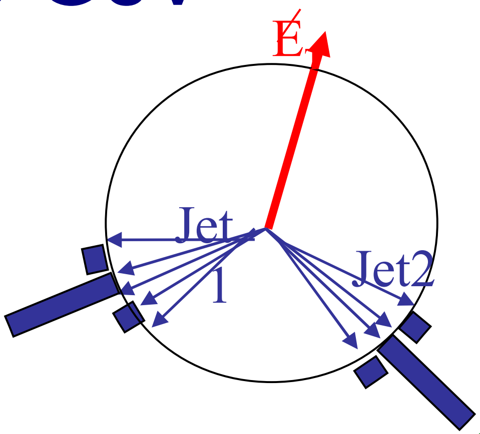
Analysis Outline

Signal Selection

- Using $4 fb^{-1}$ of data
- Trigger on Jets and missing E_T
- Require 2 or 3 jets with P_T>20 GeV and $|\eta| < 2.5$

  two charged particle tracks must be associated with each jets for effective b-tagging
- Require calorimeter missing E_T> 40 GeV
- Boosted jets are expected from the Higgs decay - so we require

  $\Delta\phi$(leading jets) < 165°



Analysis Outline

Background Rejection

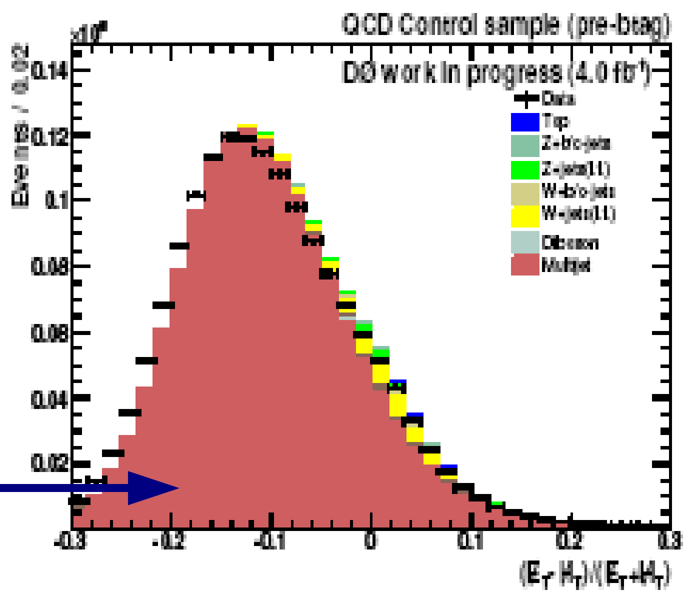
- Missing E_T(GeV) > - 40*min$\Delta\phi$(missing E_T, jet) is required in case of missing E_T direction being closely aligned to that of the jet.

- Missing Asymmetry cut

$$-0.1<(\not{E}_T - \not{H}_T)/(\not{E}_T + \not{H}_T)<0.2$$

$$\not{H}_T = |\Sigma P_T(\text{jets})|$$

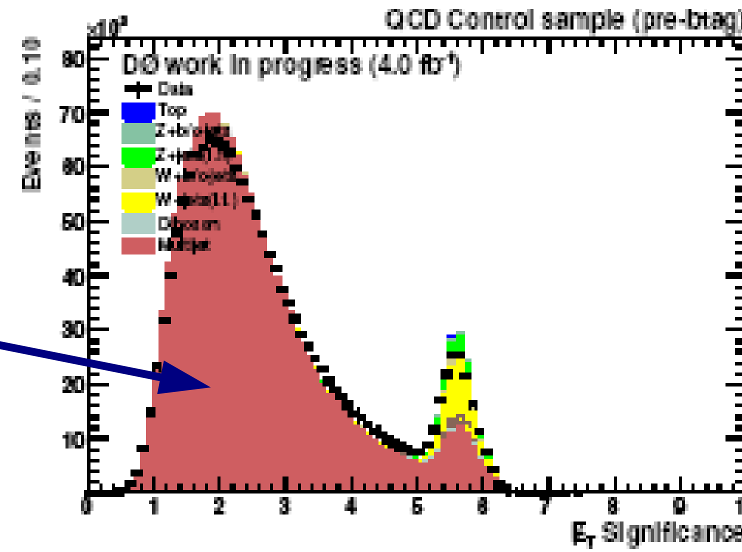
reject multijet background



Analysis Outline

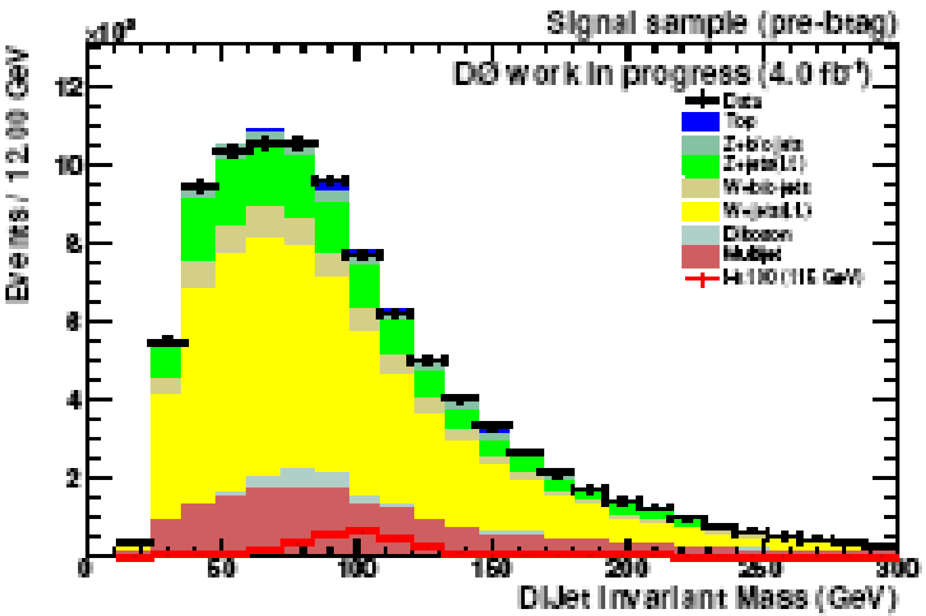
Background Rejection contd.

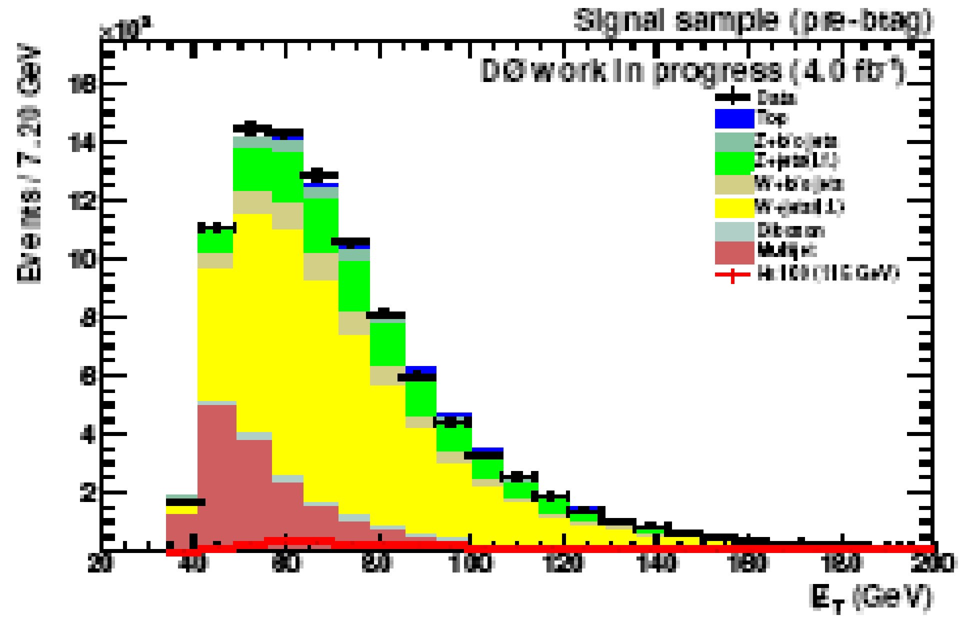
- Missing E_T Significance cut – consistency check for missing E_T based on the jet energy resolution and jet energy fluctuations.
  reject multijet background

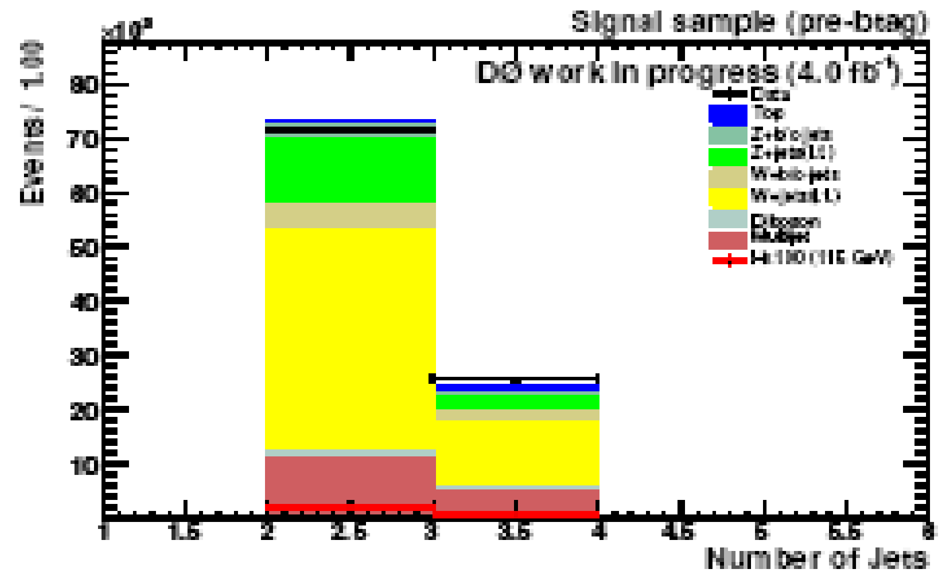


- Veto on isolated lepton
  to be orthogonal to $WH \rightarrow l\nu b\bar{b}$

Pre B-tag Plots

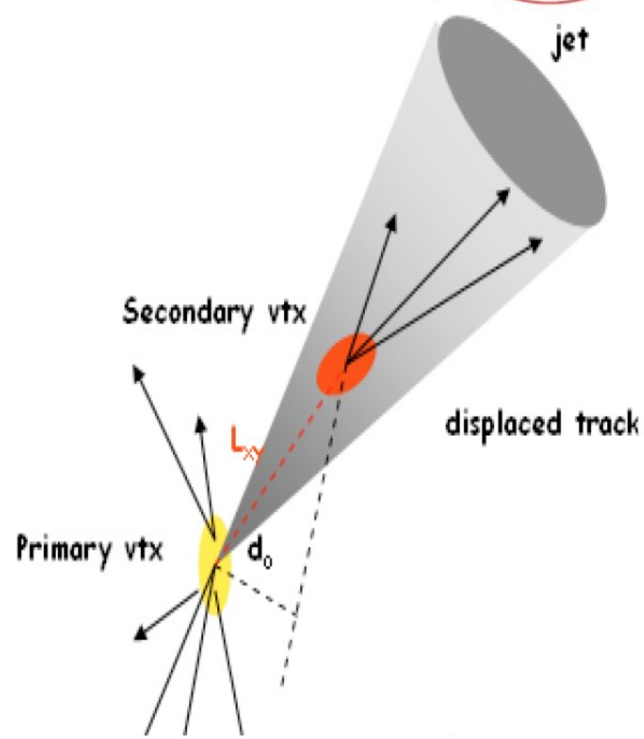






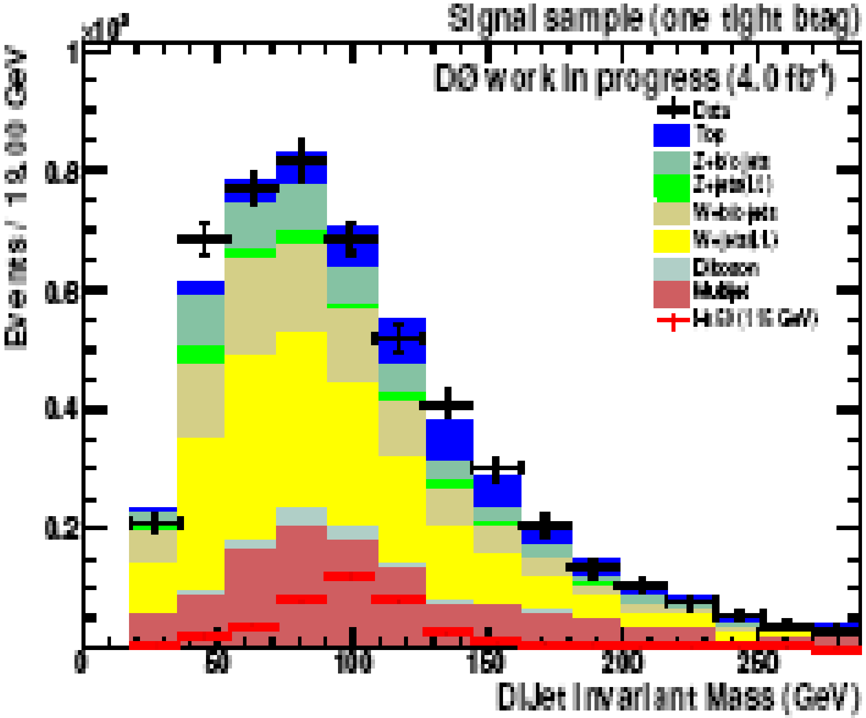
B-jet Identification

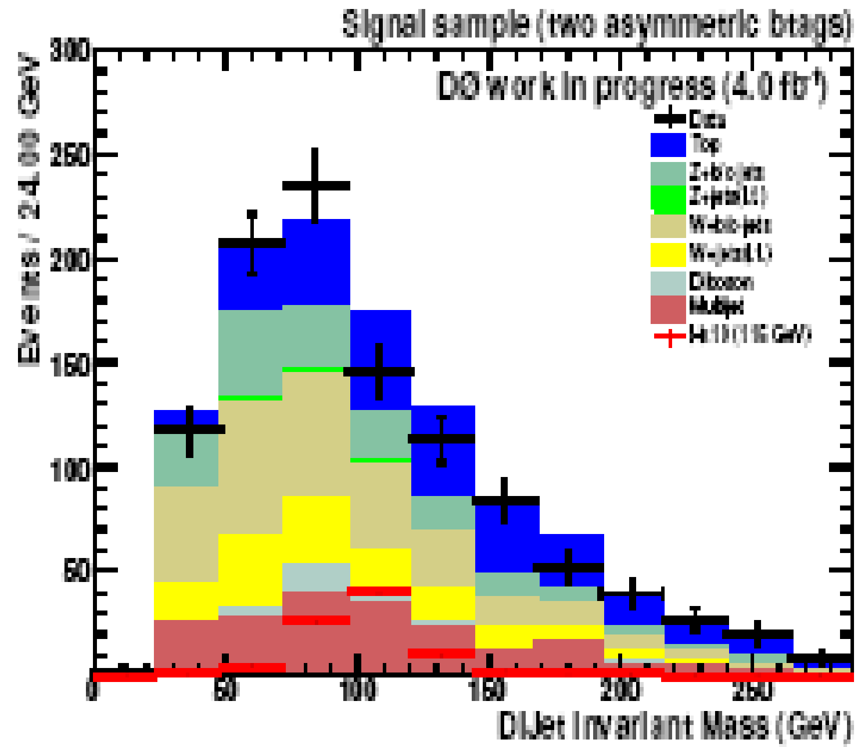
- High branching fraction of $H \rightarrow b\bar{b}$
- **Used a Neural Net(NN) b-tagger algorithm:**
  combines variables from the displaced vertex (e.g. decay length L_{XY}), primary vertex association probability and track impact parameters(d_0).



- Asymmetric tagging, provides best sensitivity to a Higgs signal:
  one jet is tightly tagged and another is loosely tagged.
- Enhance search sensitivity with an independent orthogonal sample:
  one tightly tagged jet and no other loosely tagged jet.

Post B-tag Plots





	Pre Btag	One tight Btag	Two asymmetric Btag
Signal yield (ZH115)	13.82	3.95	4.22
Signal yield (WH115)	14.04	4.07	4.20
S/√(B)	0.08	0.11	0.25

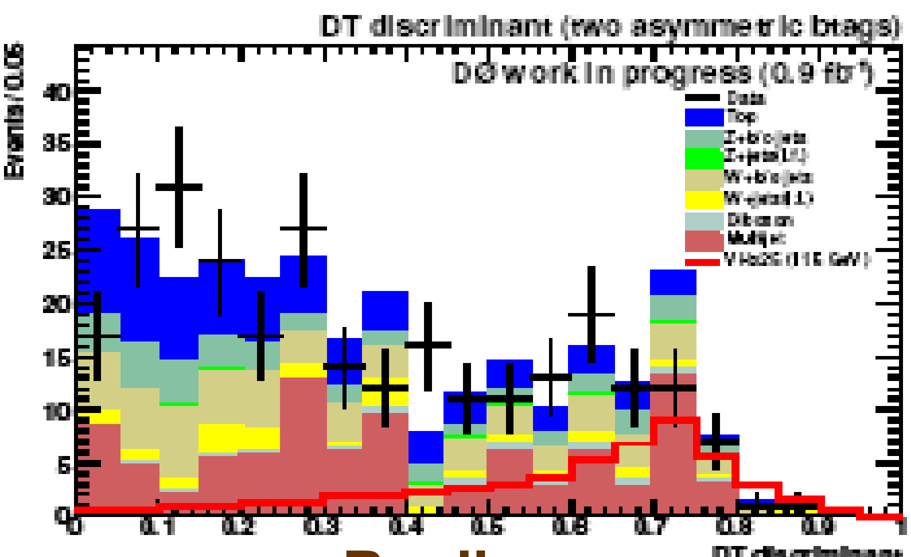
After b-tagging: top and W/Z + heavy flavor are main backgrounds

Multivariate Discriminant

A “Boosted Decision Tree” technique was used for the final separation between data and remaining backgrounds.
Combined for WH and ZH signals, 13 variables were used.
A separate decision tree was trained for each Higgs mass probed, for each data period, RunIIa and RunIIb.

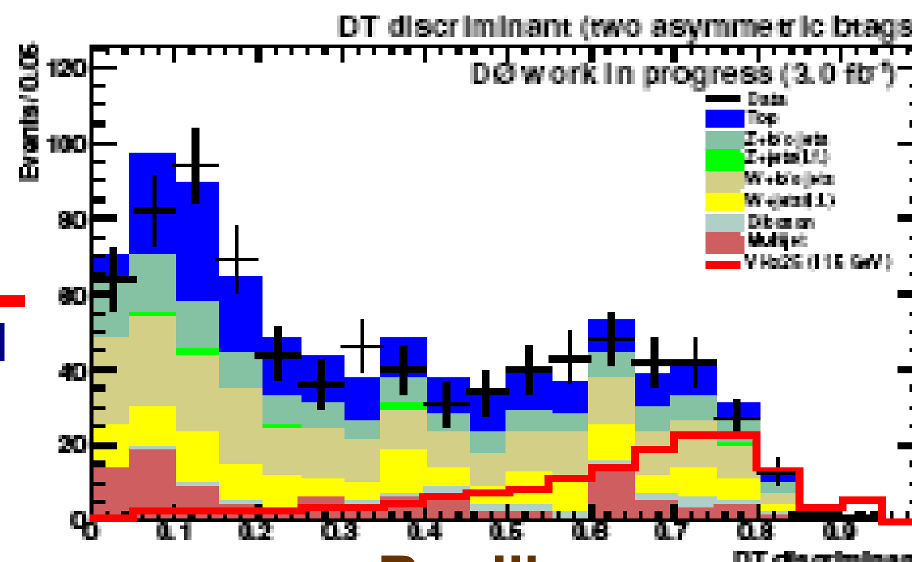
DT discriminant output: Higgs signal with m_H = 115 GeV

two asymmetric Btags



RunIIa

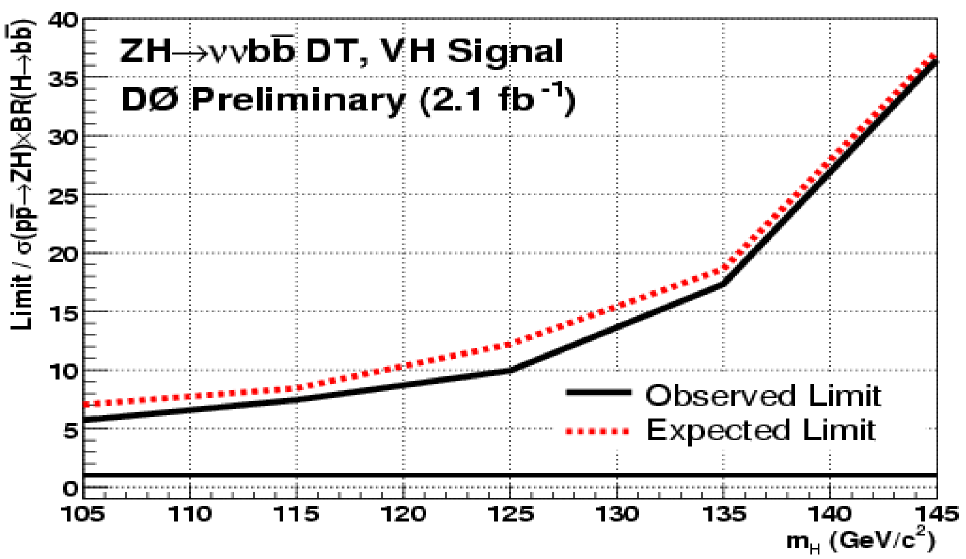
Signal



RunIIb

Previous Result

Based on 2.1 fb^{-1} of data.
No deviation from the Standard Model expectation was observed.
Using Boosted Decision Tree technique an upper limit on the SM Higgs boson production "σ*BR(H→bb)" (relative to SM value) was derived.



For m_H= 115 GeV limit is a factor 7.5 larger than the SM cross section.
(expected limit ~ 8.4)

Conclusion

- Search is on for Higgs boson using 4 fb^{-1} of data.
- Sensitive to $ZH \rightarrow \nu\nu b\bar{b}$ and $WH \rightarrow l\nu b\bar{b}$ where lepton is not identified.
- Used NN technique for b-tagging and multivariate discriminant.
- With full data set we expect improvement of current limit.
- Extracting cross section limit as a function of Higgs mass using the analysis technique presented here.