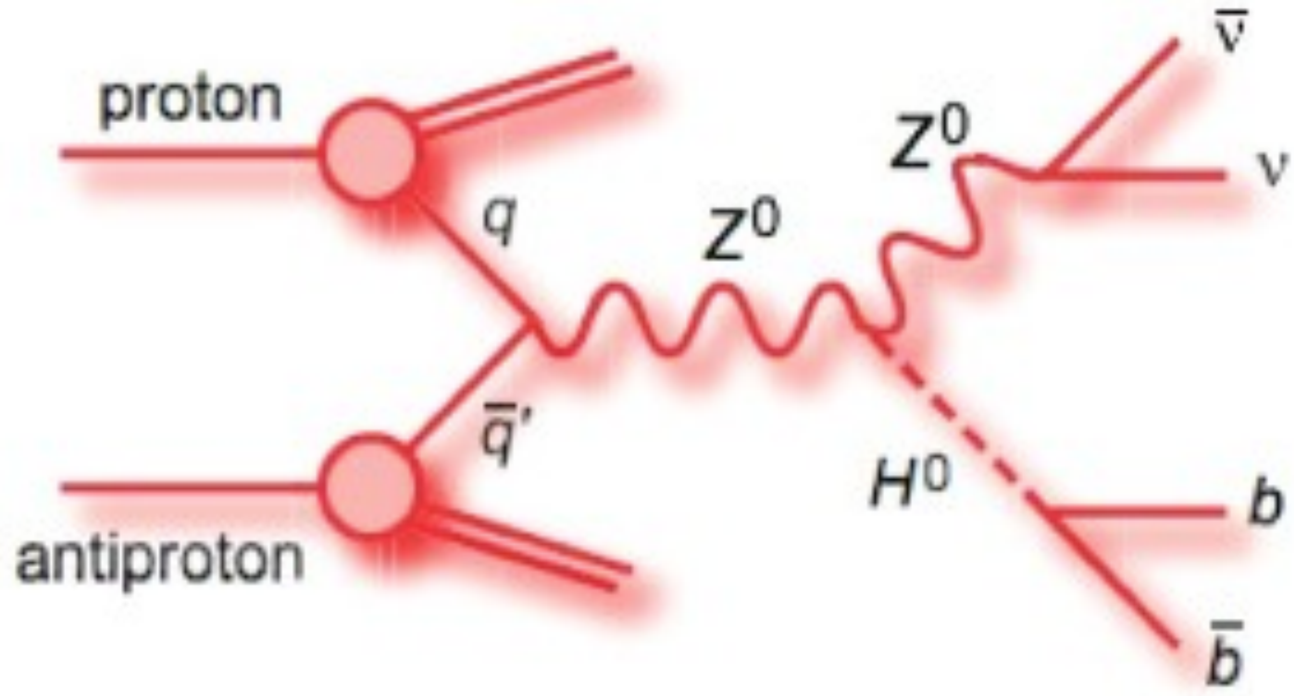
Search for the Standard Model Higgs Boson in $ZH \rightarrow \nu\bar{\nu}b\bar{b}$ channel at D0



Outline:

- Motivation
- Backgrounds
- Multijet Removal
- b-tagging/MVA
- Result

Abhinav Dubey

University of Delhi

Rencontres de Moriond EW 2012

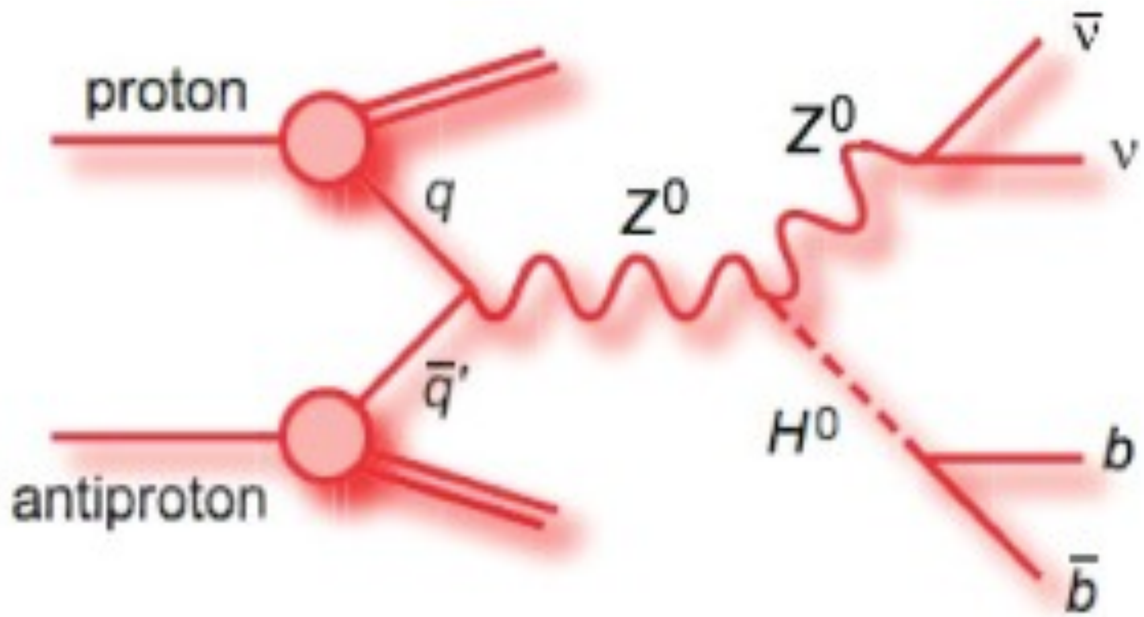
Motivation

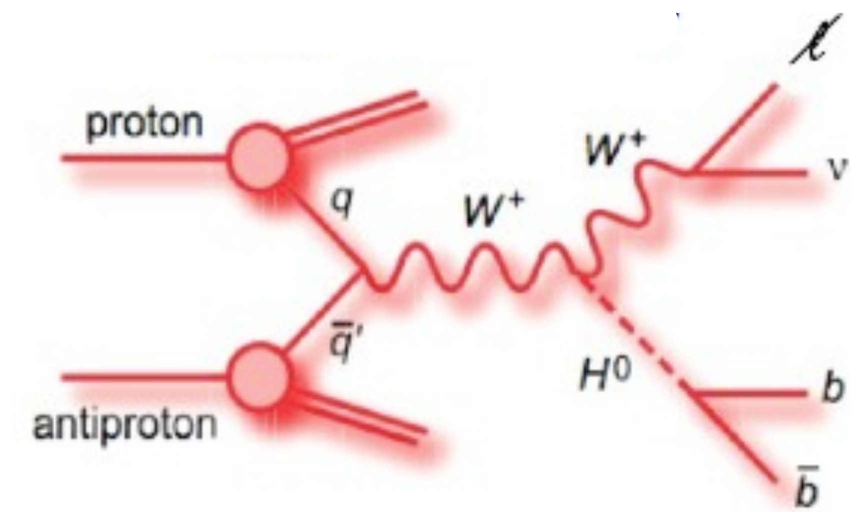
$Z \rightarrow \nu\bar{\nu}$ (~20%)

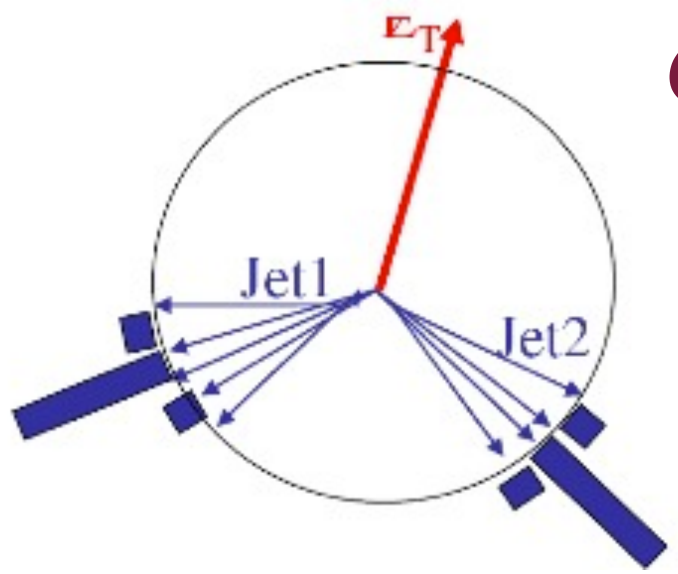
Also contribution from

$WH \rightarrow l\nu b\bar{b}$

when lepton is not identified.







Characteristic Signal:

- Large MET from invisible *Z* decay.
- Two boosted, high p_T b-tagged jets.
- No identified leptons.

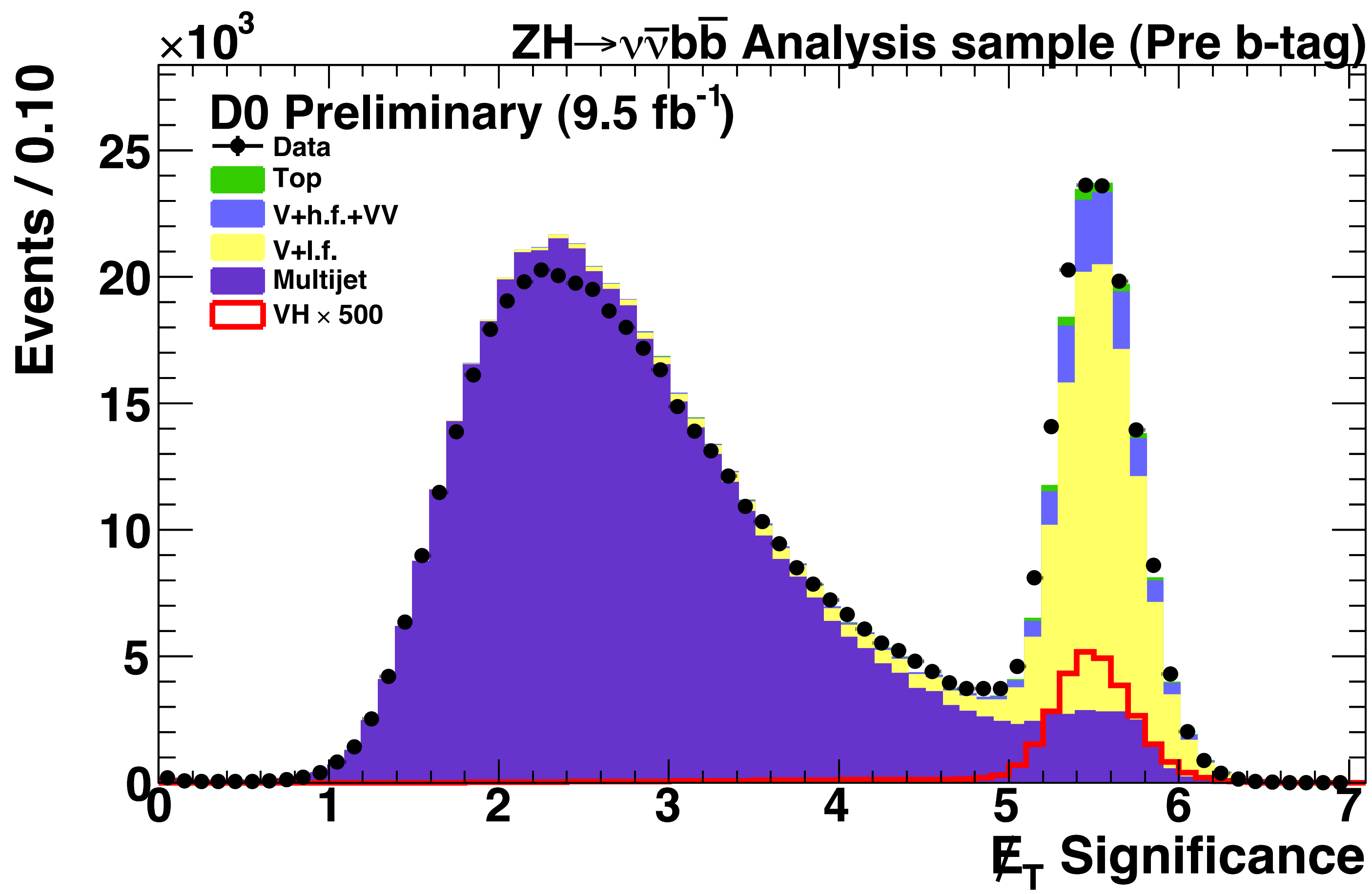
Very challenging due to large multijet background.

Backgrounds

SM backgrounds:

W/Z + jets
Diboson
Top

Simulated from
Monte Carlo



Instrumental backgrounds:

Multijet events from mis-measured jets.
Large and difficult to model, Data based modeling.

Background modeling validated in control regions.

Backgrounds

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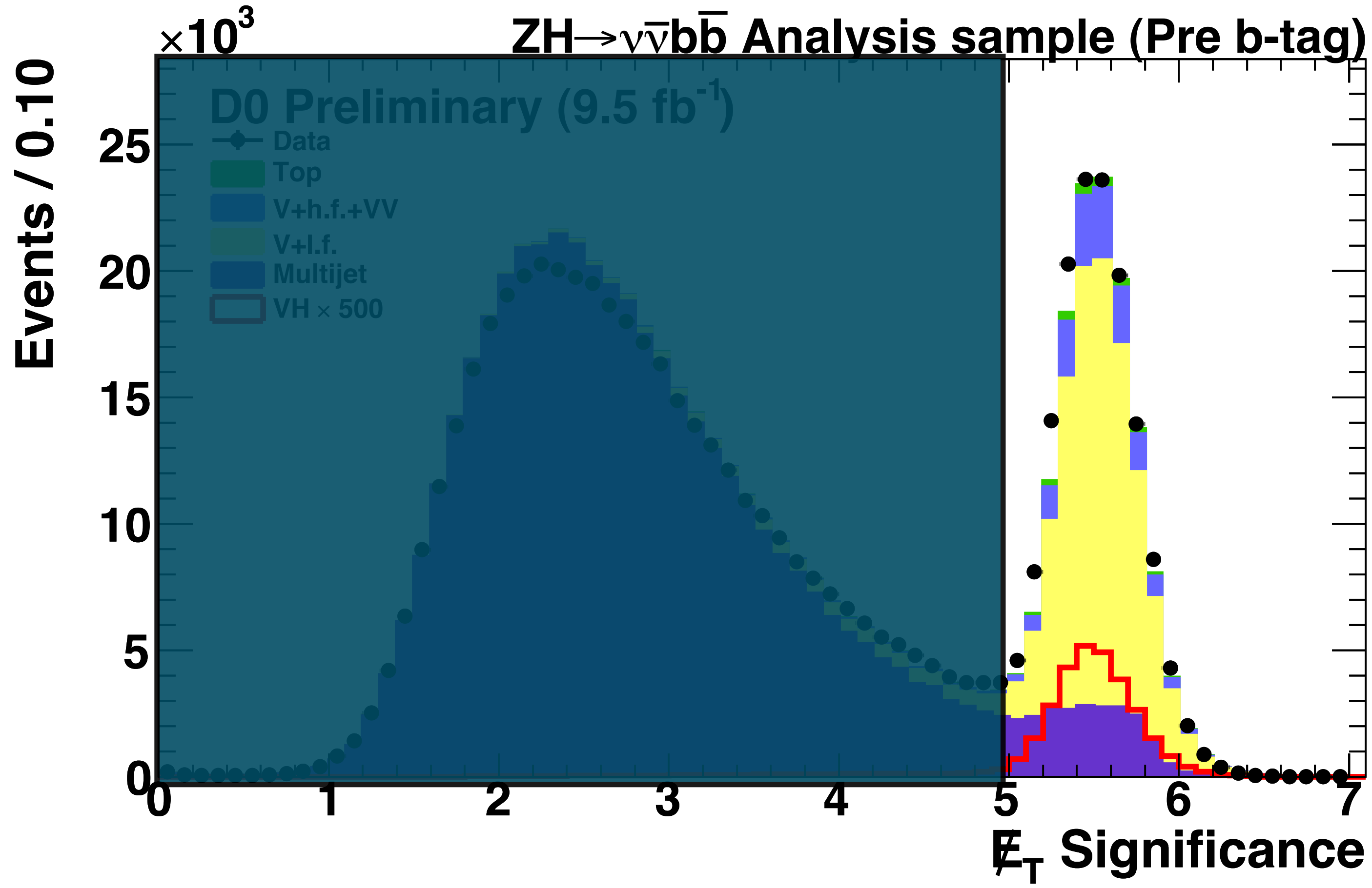

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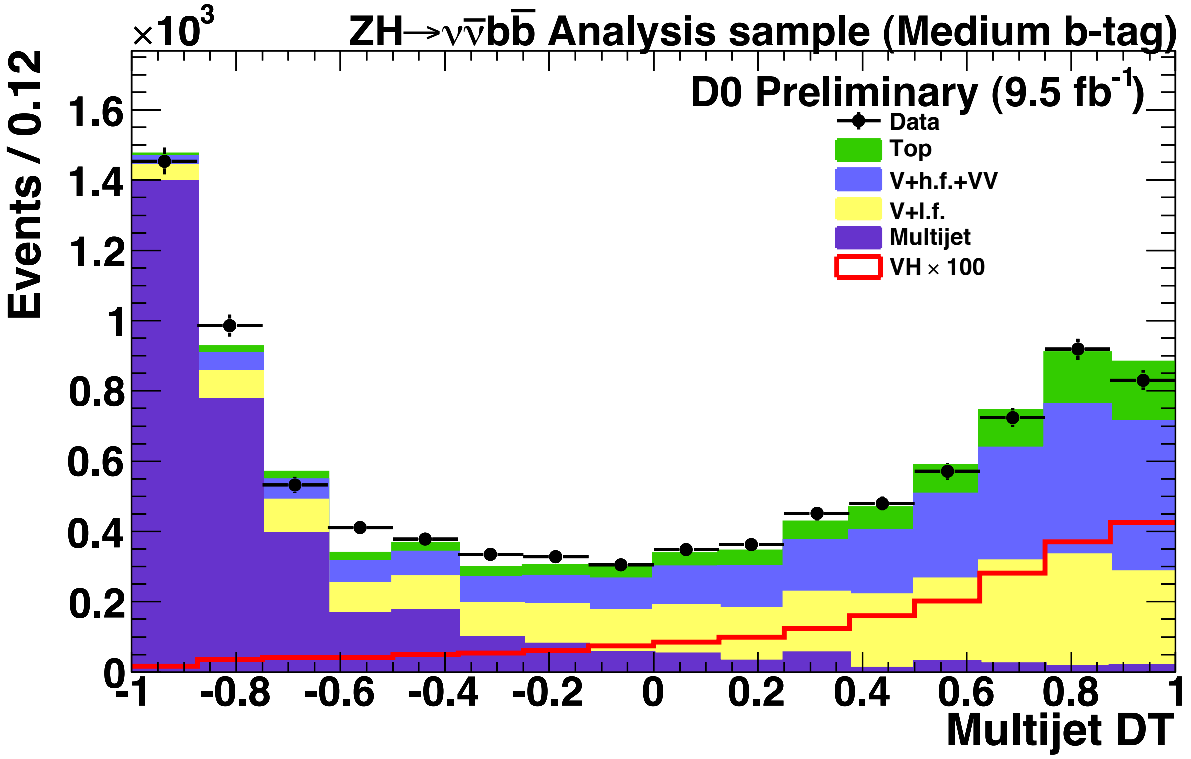
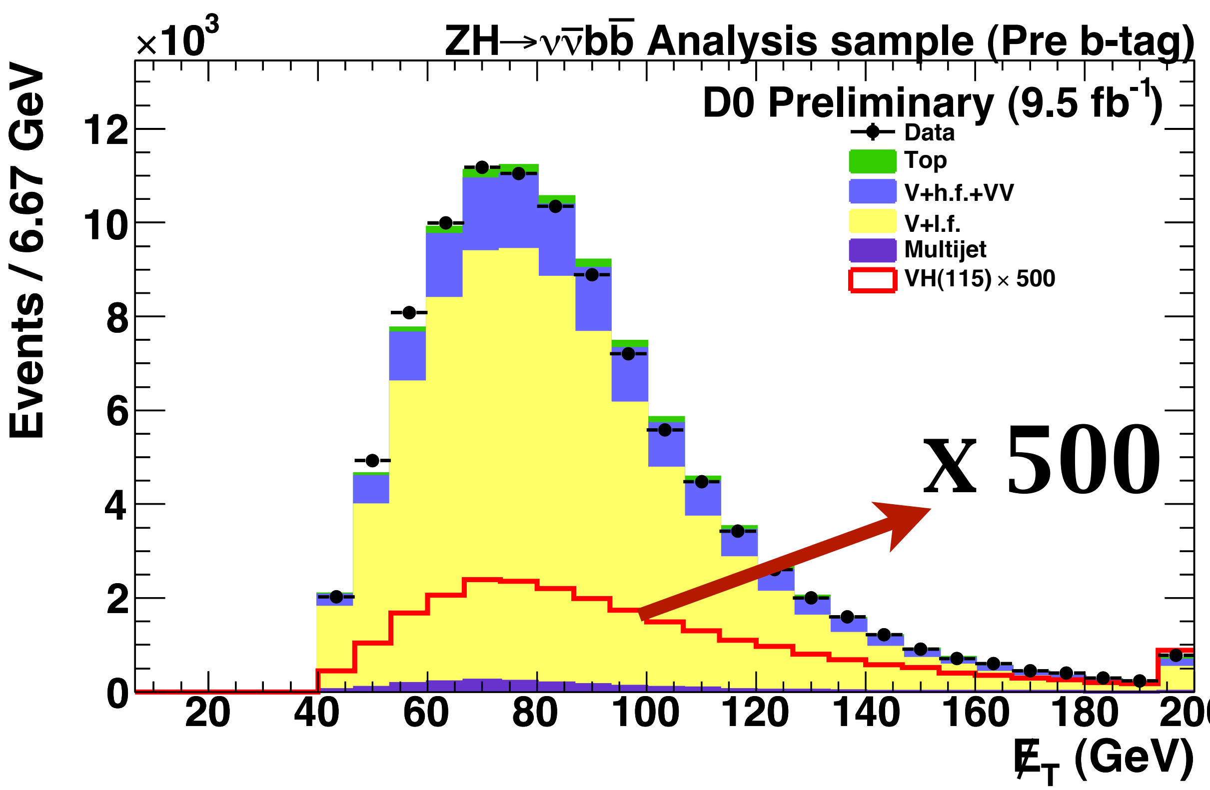
Multijet Removal



- Trained DT to separate signal from multijet background.
- Trained in untag channel of a sample of W/Z + heavy flavor jets events to avoid possible Higgs mass dependence.

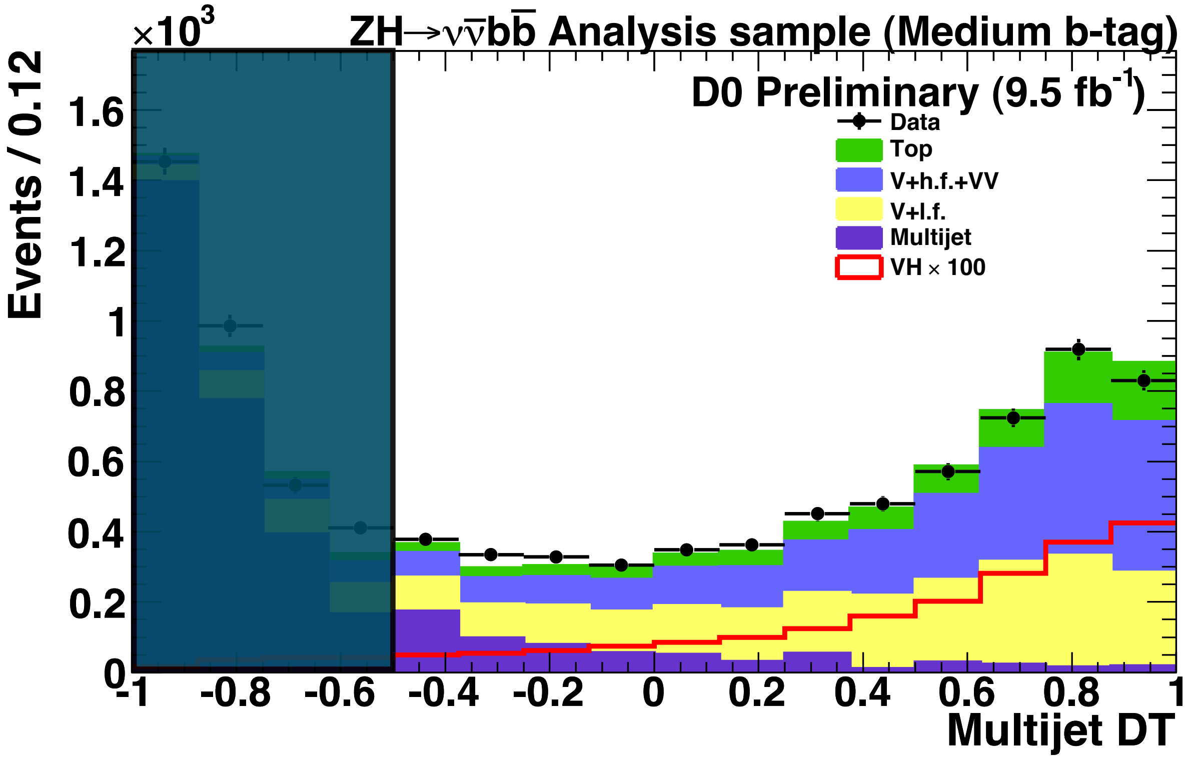
- 17 variables used.

MET, MET significance, angle between jets, jets pT sum etc.



Multijet rejection: ~94%
Signal efficiency: ~89%

Multijet Removal



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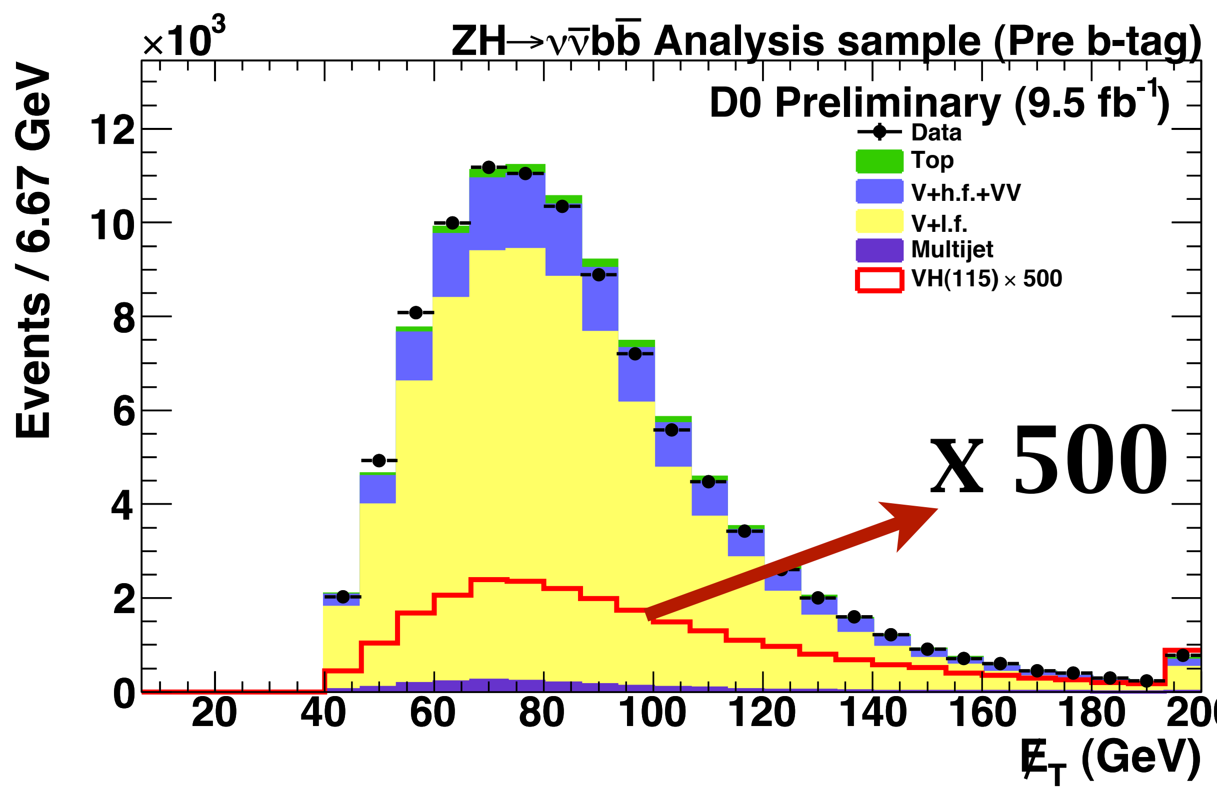
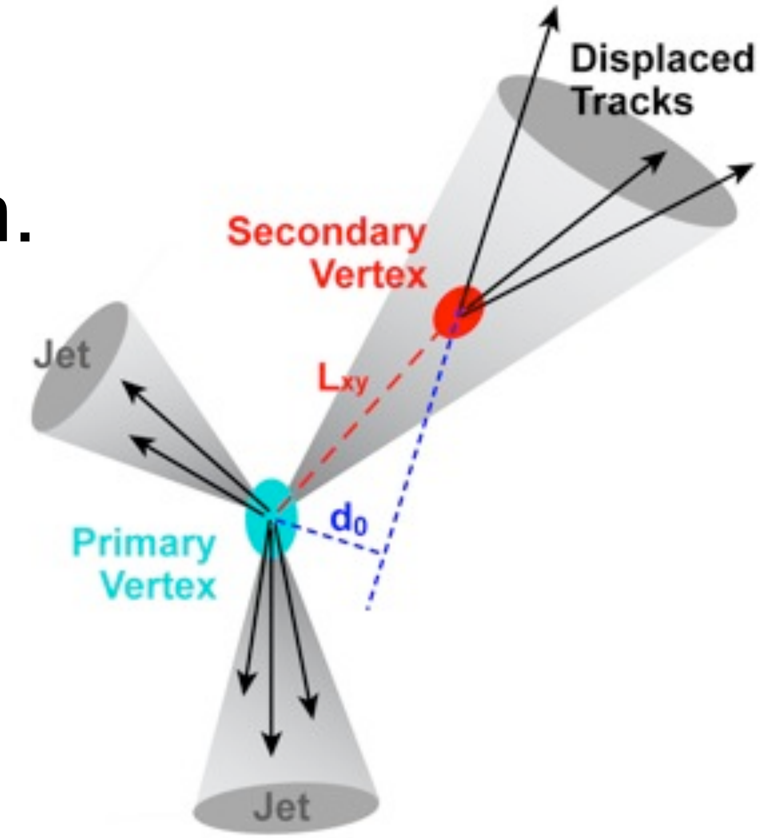


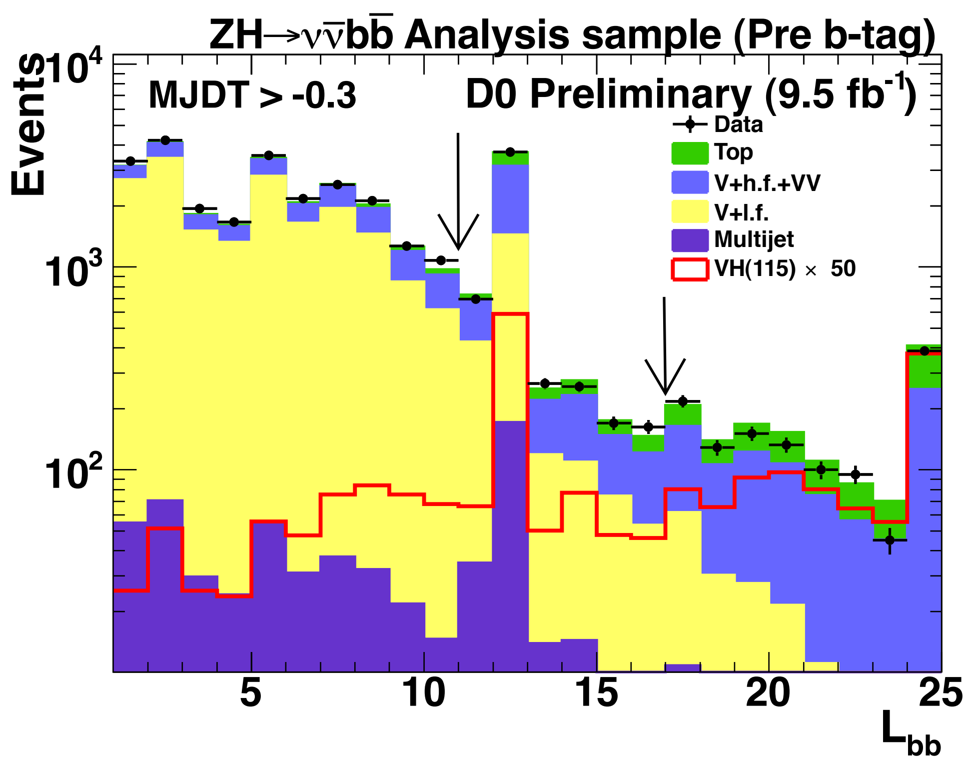
b-tagging

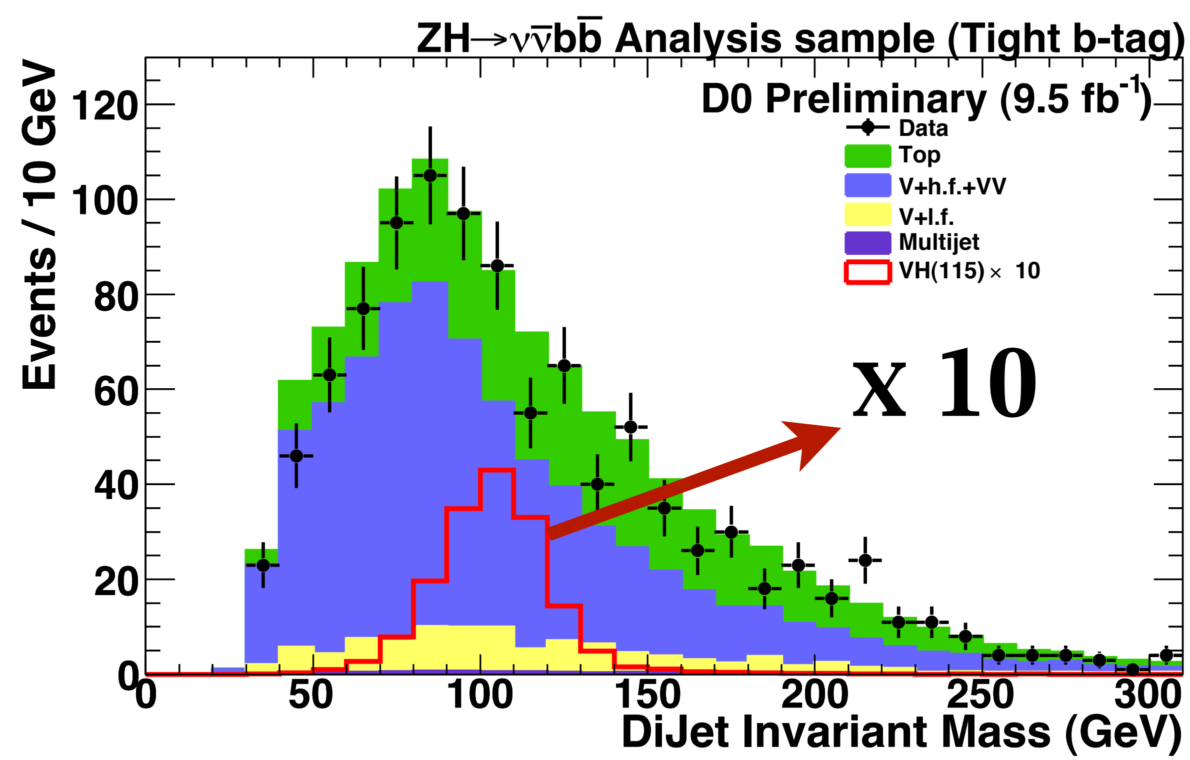
A multivariate b-tagging algorithm is used.

Uses secondary vertex information.



Based on multivariate discriminant we select two high purity b-tag channels:



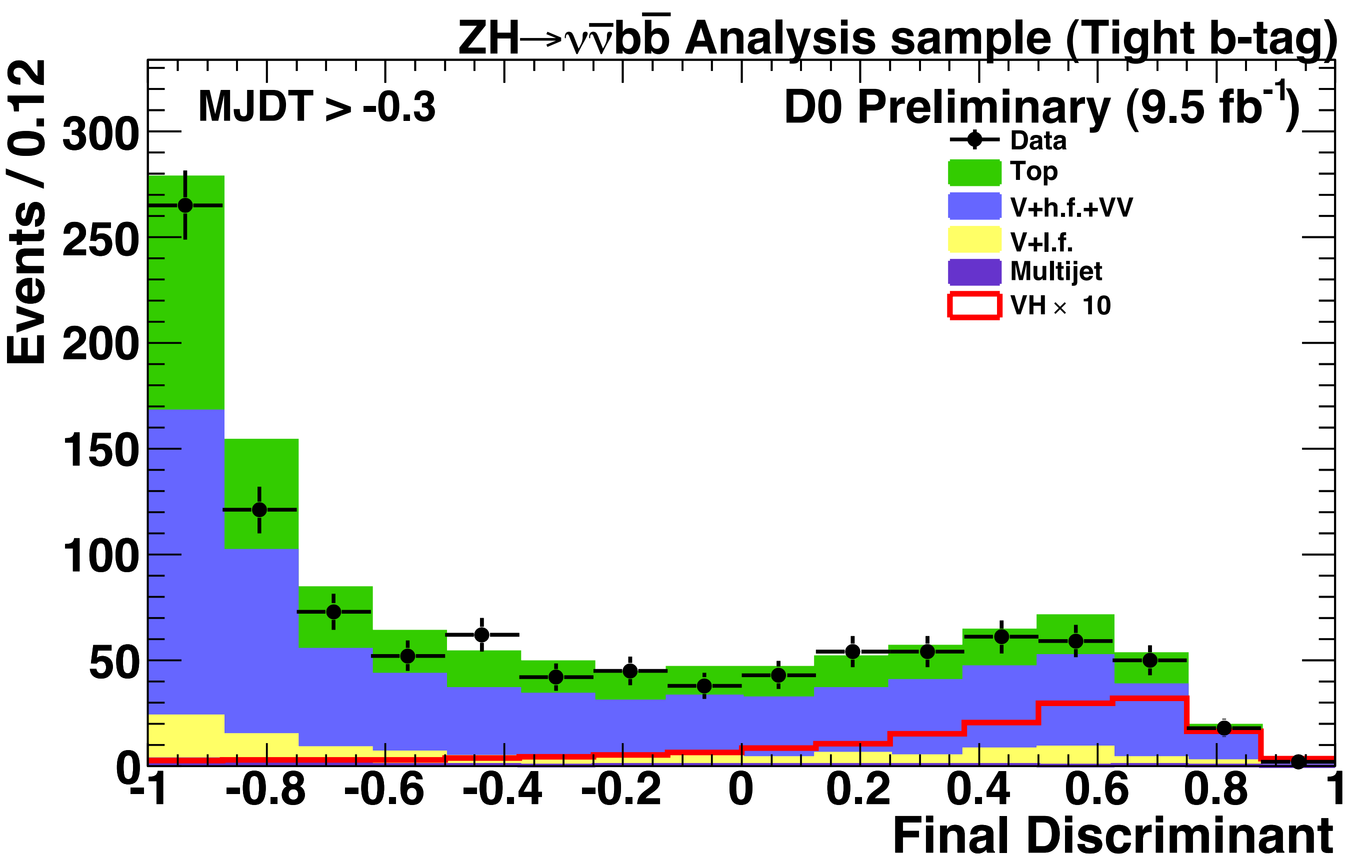


- a tight b-tag sample.
- a medium b-tag sample.

Final Discriminant

- Di-jet mass itself is not optimal for limit setting therefore we use a multivariate analysis for separation of remaining backgrounds.
- Trained DT to separate signal from signal like backgrounds in each b-tag channel.
- 22 variables used.

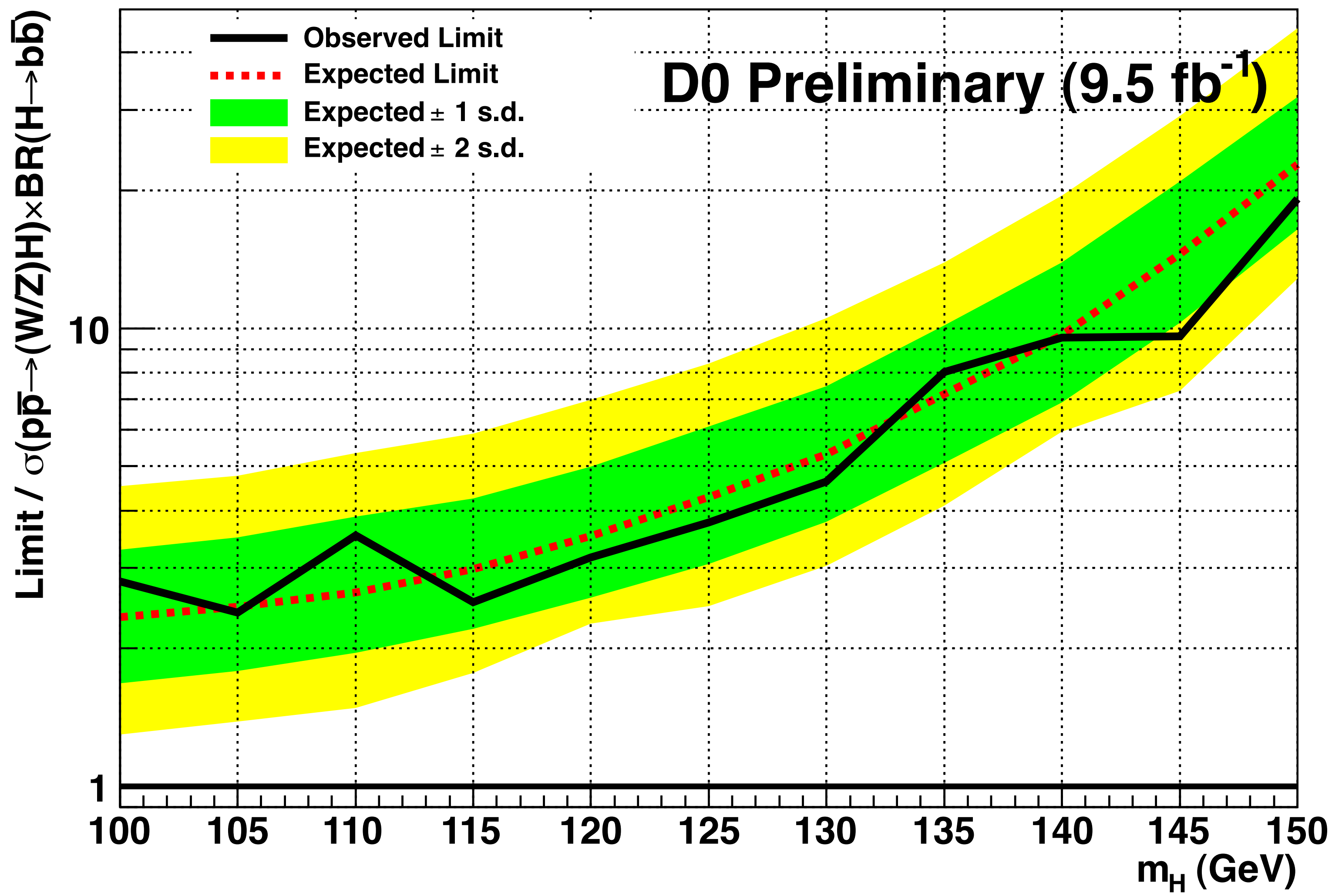
Di-jet mass, Event shapes, jets pT sum, relative position of jets and MET etc.



Final discriminant is used for limit setting.

Results

Upper limit on SM Higgs production cross-section at 95% CL as function of Higgs mass (relative to the SM value).



For m_H =115 GeV limit **Observed = 2.5**

Expected = 3.0


THANK YOU

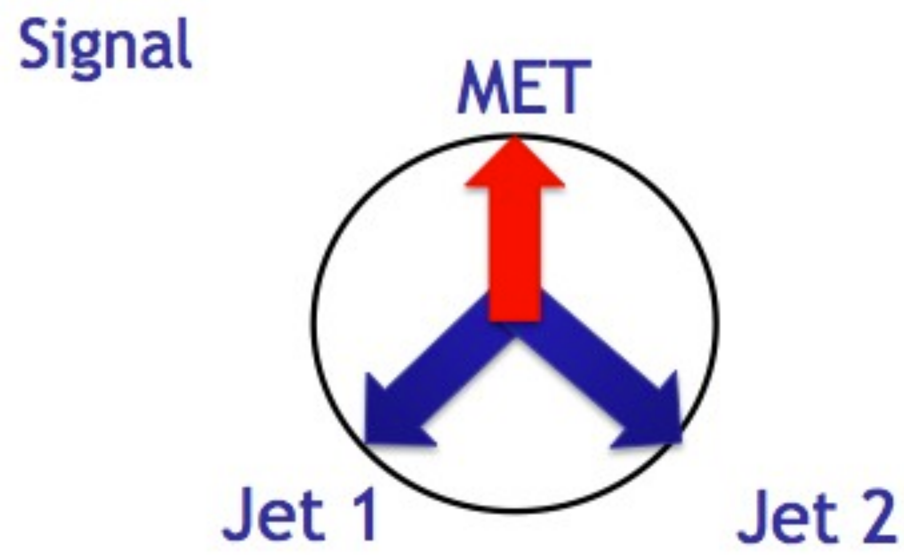
Multijet Modeling

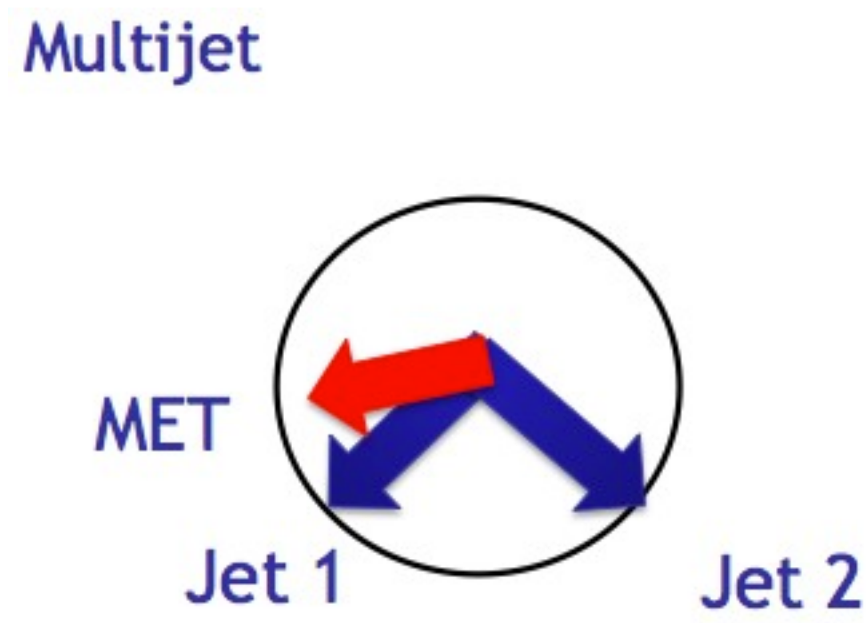
In Multijet events, MET tend to align with jets which is used for defining a sideband region.

We define a track based MET which is less sensitive to jet energy fluctuations.

- Signal Region:
  well separated jets and track MET in azimuthal plane.

- Sideband Region:
  track MET & jets closely aligned.

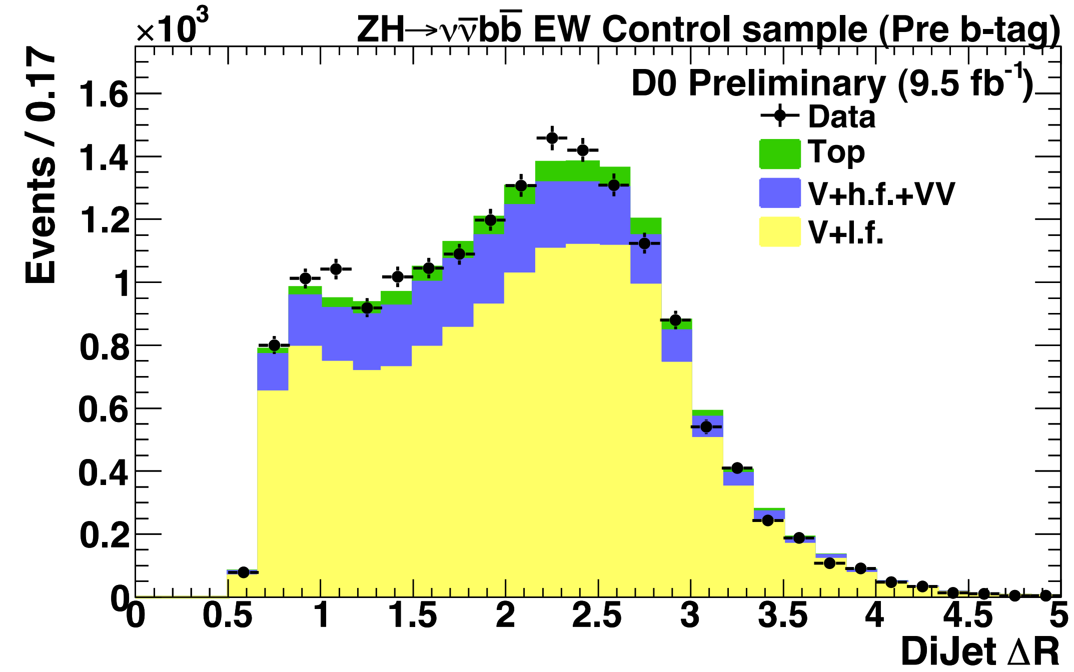


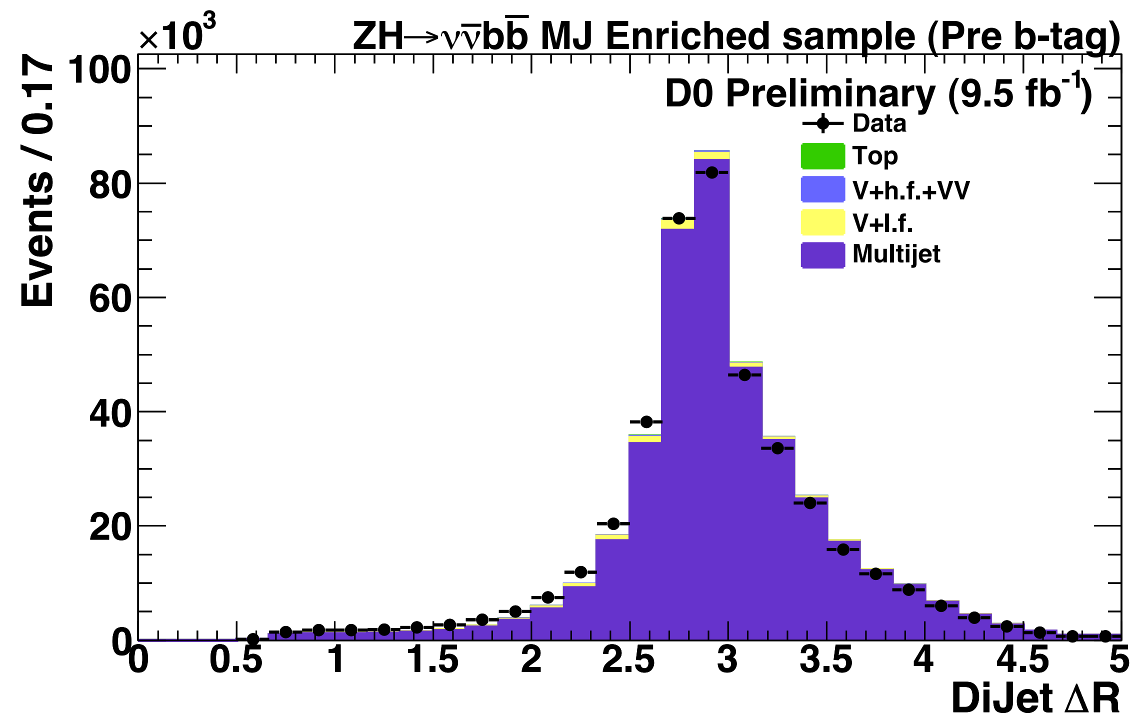


Sideband regions events are used as MJ in signal region.

Control Regions

EW Control Region:
- Invert muon veto
- W transverse mass cut





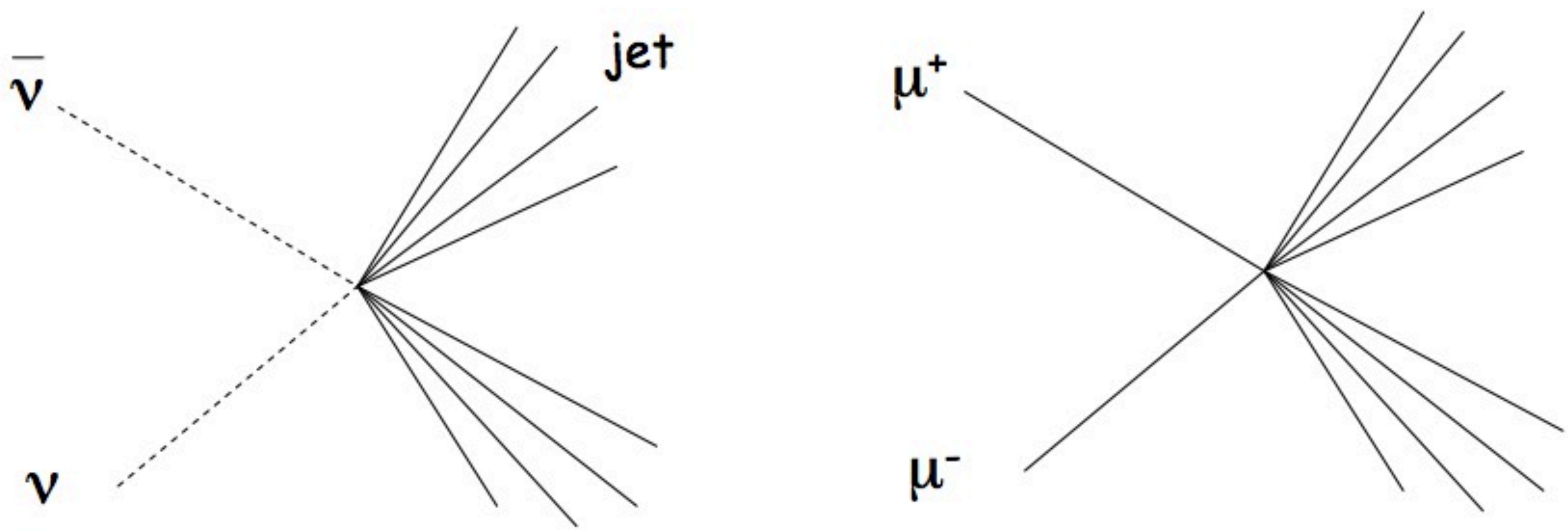
Multijet Control Region:
- Reduced MET cut
- Invert MET Significance cut

Trigger Parametrization

For MC, parametrization was done in events

$$Z \to \mu^+\mu^- + jets$$

with same jet topology as signal



Validation of parametrization was done in events

$$W \to \mu\nu + jets$$

Parametrization was tested in a control sample

Input to Multijet DT

Variables used in the MJ DT
$\Delta\phi(j_1, j_2)$
η of j_1
$\not\!\!E_T$
$\not\!\!E_T$ significance
$\min\Delta\phi(\not\!\!E_T, j_{\rm all})$
$\max\Delta\phi(\not\!\!E_T, j_{\rm all}) + \min\Delta\phi(\not\!\!E_T, j_{\rm all})$
$\max\Delta\phi(\not\!\!E_T, j_{\rm all}) - \min\Delta\phi(\not\!\!E_T, j_{\rm all})$
$\not\!\!H_T$(vectorial sum of $j_{\rm all}$ p_T)
$\not\!\!H_T/\ H_T$ (with H_T the scalar sum of $j_{\rm all}$ p_T)
Asymmetry between $\not\!\!E_T$ and $\not\!\!H_T$
$\not\!\!E_T$ component along the thrust axis
$\not\!\!E_T$ component perpendicular to the thrust axis
Sum of the signed components of the dijet and recoil momenta along the thrust axis
Sum of the signed components of the dijet and recoil momenta perpendicular to the thrust axis
Centrality (ratio of the scalar sum of j_1 and j_2 p_T to the sum of j_1 and j_2 energy)
θ angle of the dijet system
Polar angle of j_1 boosted to the dijet rest frame with respect to the dijet direction in the laboratory

Input to Physics DT

Variables used in the SM DT
Dijet mass
Dijet transverse mass
j_1 p_T
j_2 p_T
Scalar sum of j_1 and j_2 p_T
η of j_1
η of j_2
$\Delta\eta(j_1, j_2)$
$\Delta\phi(j_1, j_2)$
$\Delta R((j_1, j_2))$
p_T weighted $\Delta R(j_1, j_{\rm all})$
p_T weighted $\Delta R(j_2, j_{\rm all})$
H_T
$\not{H}_T$(vectorial sum of $j_{\rm all}$ p_T)
$\not{H}_T$/ H_T (with H_T the scalar sum of $j_{\rm all}$ p_T)
$\Delta\phi(\not{E}_T, \text{dijet})$
θ angle of j_1 boosted to the dijet rest frame
Polar angle of j_1 boosted to the dijet rest frame with respect to the dijet direction in the laboratory
$\min \Delta\phi(\not{E}_T, j_{\rm all})$
$\max \Delta\phi(\not{E}_T, j_{\rm all}) + \min \Delta\phi(\not{E}_T, j_{\rm all})$
Dijet p_T
$\Delta\phi(\not{E}_T, j_1)$

Event yields/Limits

TABLE II: The number of expected signal, expected background and observed data events after the multijet veto, for the pre , medium and tight b-tag samples. The signal corresponds to m_H = 115 GeV, "Top" includes pair and single top quark production, and VV is the sum of all diboson processes.

Sample	ZH	WH	W+jets	Z+jets	Top	VV	Multijet	Total Background	Observed
Pre b-tag	26.5	25.3	67098	25498	1885	3111	1815	99408	98980
Medium b-tag	9.8	9.2	3144	1071	742	234	261	5452	5453
Tight b-tag	8.6	8.1	444	252	373	55	8	1132	1039

TABLE IV: The observed and expected upper limits measured using 9.5 fb^{-1} of data on the $(W/Z)H$ production cross section relative to the SM expectation as a function of m_H.

m_H	100	105	110	115	120	125	130	135	140	145	150
Expected	2.3	2.5	2.7	3.0	3.5	4.3	5.3	7.2	9.7	14.5	22.8
Observed	2.8	2.4	3.5	2.5	3.2	3.8	4.6	8.0	9.6	9.6	19.2

Systematic Uncertainty

TABLE III: Systematic uncertainties in percent of the overall signal and background yields. "Jet EC" and "Jet ER" stand for jet energy calibration and resolution respectively. "Jet R&T" stands for jet reconstruction and taggability. "Signal" includes ZH and WH production and is shown for $m_H = 115$ GeV.

Systematic Uncertainty	Signal (%)	Background (%)
Medium b-tag		
Jet EC - Jet ER	0.9	1.9
Jet R&T	2.9	2.9
b Tagging	0.6	3.7
Trigger	2.0	1.9
Lepton Identification	0.9	0.9
Heavy Flavor Fractions	-	8.4
Cross Sections	7.0	9.8
Luminosity	6.1	5.8
Multijet Normalization	-	1.1
Total	10.0	14.2
Tight b-tag		
Jet EC - Jet ER	1.4	1.8
Jet R&T	2.7	3.0
b Tagging	7.8	7.4
Trigger	2.0	2.0
Lepton Identification	0.8	1.1
Heavy Flavor Fractions	-	11.0
Cross Sections	7.0	10.0
Luminosity	6.1	6.1
Multijet Normalization	-	0.2
Total	12.7	16.8