

SM low mass Higgs searches at D0

Yuji Enari

LPNHE, Paris Universites VI & VII

IN2P3-CNRS

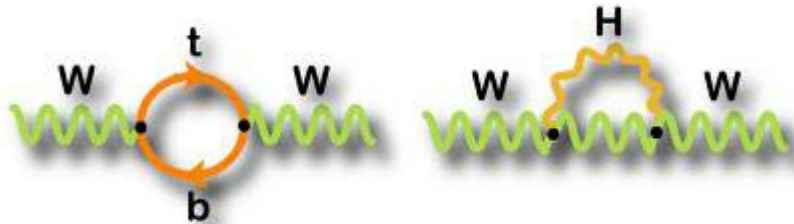


On behalf of Dzero collaboration

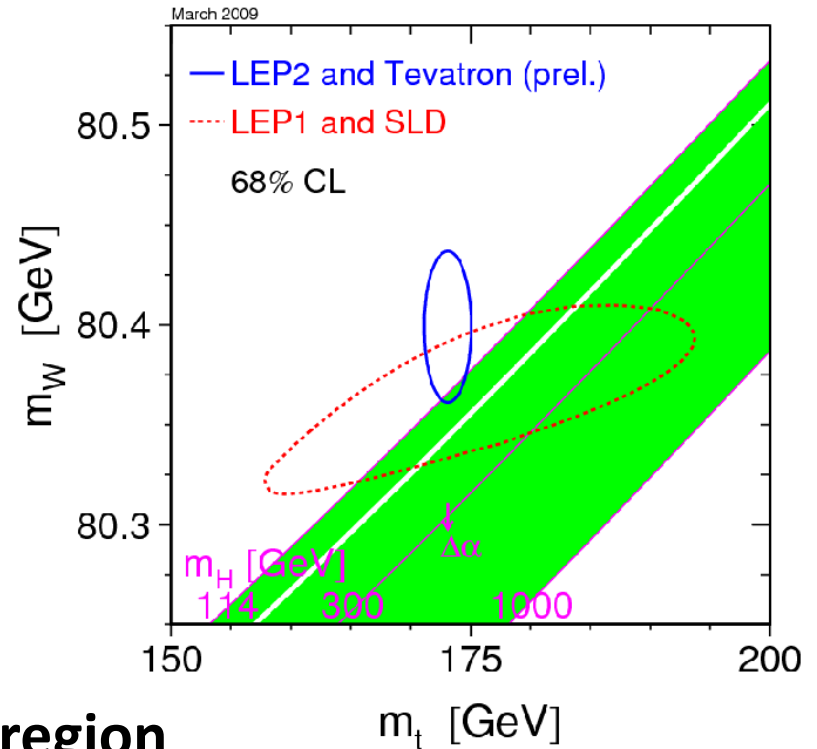
July 22nd 2010, ICHEP 2010



- Higgs boson is last missing piece in the SM
- Various Data favor light Higgs boson
 - LEP direct search $M_H > 114.4 \text{ GeV}$ @ 95% C.L.
 - EW global fitting



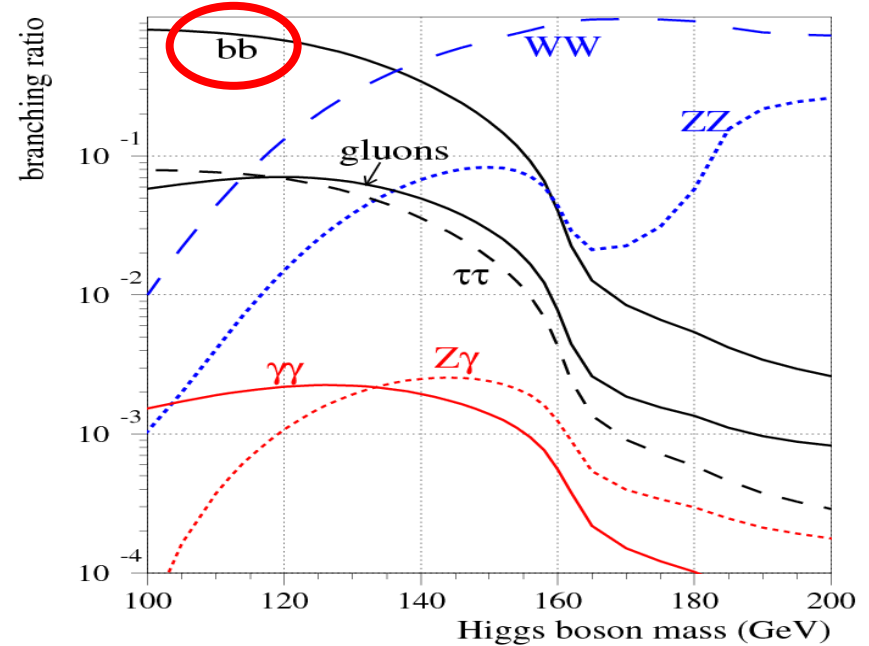
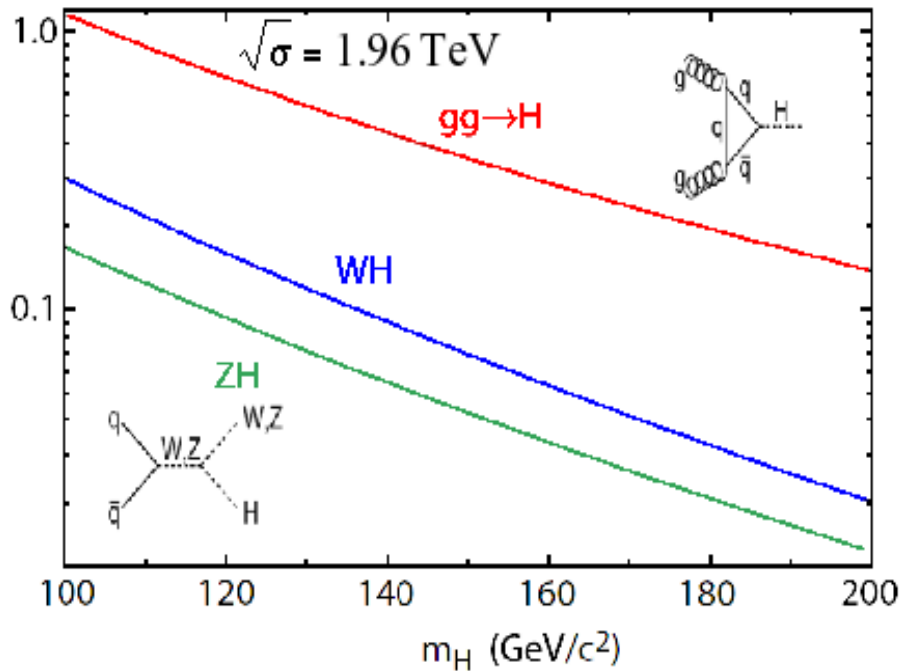
LEPEWWG @ 95% C.L.
 $m_H < 157 \text{ GeV}$



Tevatron is the place to explore this region



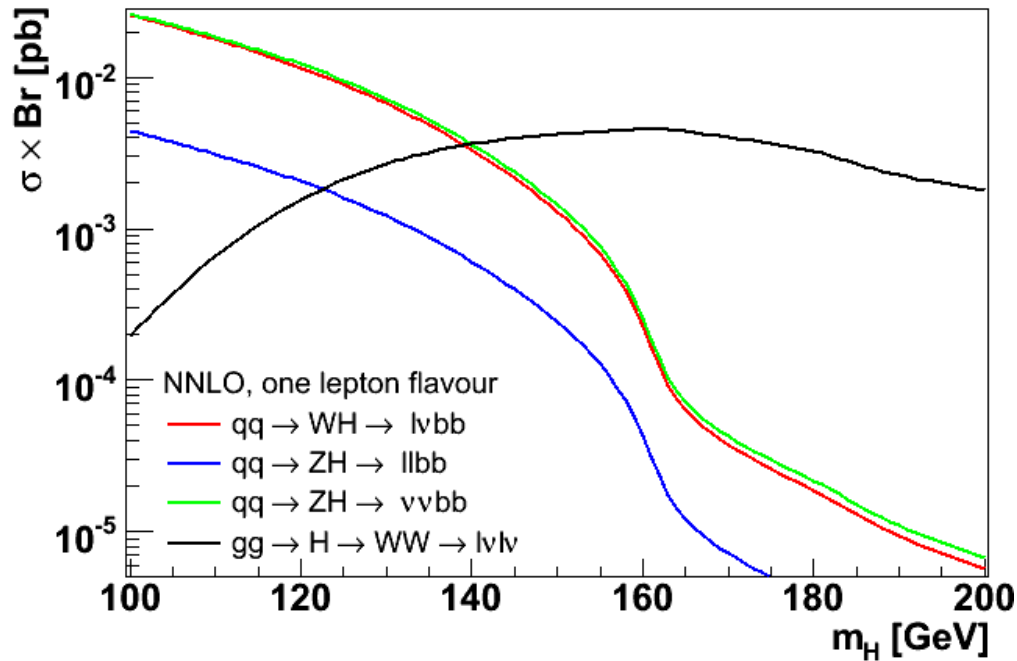
SM Higgs Production and Decay



- Highest cross section: $gg \rightarrow H$
 - H decays into $b\bar{b}$ at low mass region
 - Due to high multi-jet BG, almost impossible
- W or Z associated production
 - High pT lepton with $H \rightarrow b\bar{b}$ decay.



Main Channels for Low Mass Higgs



$ZH \rightarrow vv bb$
MET+bb

$WH \rightarrow lv bb$
l+MET+bb

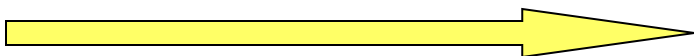
$ZH \rightarrow ll bb$
2l(e/ μ)+bb

Other SM Higgs search for low mass region

- $H \rightarrow \gamma\gamma$ (K. Peters)
- $VH \rightarrow \tau + \text{jets}$ (P. Totaro)
- Dzero combination (M. Mulhearn)

Multi-Jet (MJ) Background:

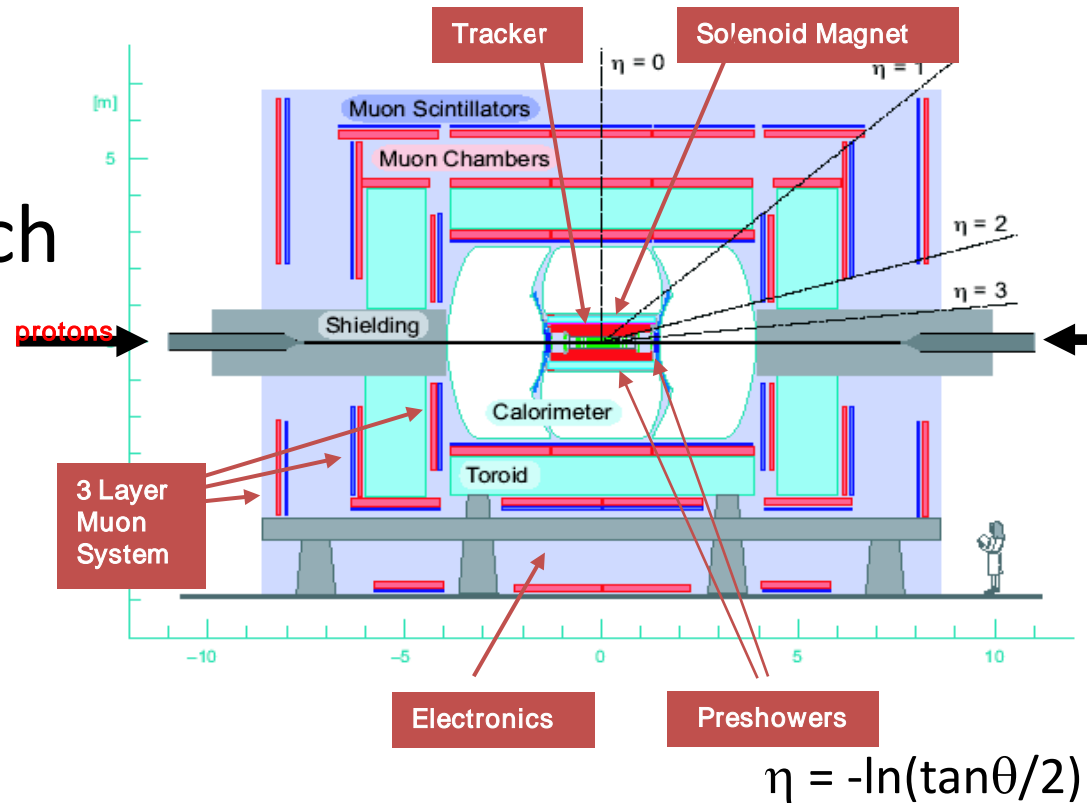
HIGH



LOW



- General purpose detector
- Low mass higgs search use all component.
 - Muon Detector
 - Electron ID
 - MET
 - Jet
 - Vertexing, Tracking
 - b-jet ID



Silicon inner tracker + Scinti. fiber tracker
EM and hadron Calorimeter (LAr-U)
Muon detector: $|\eta| < 2.0$

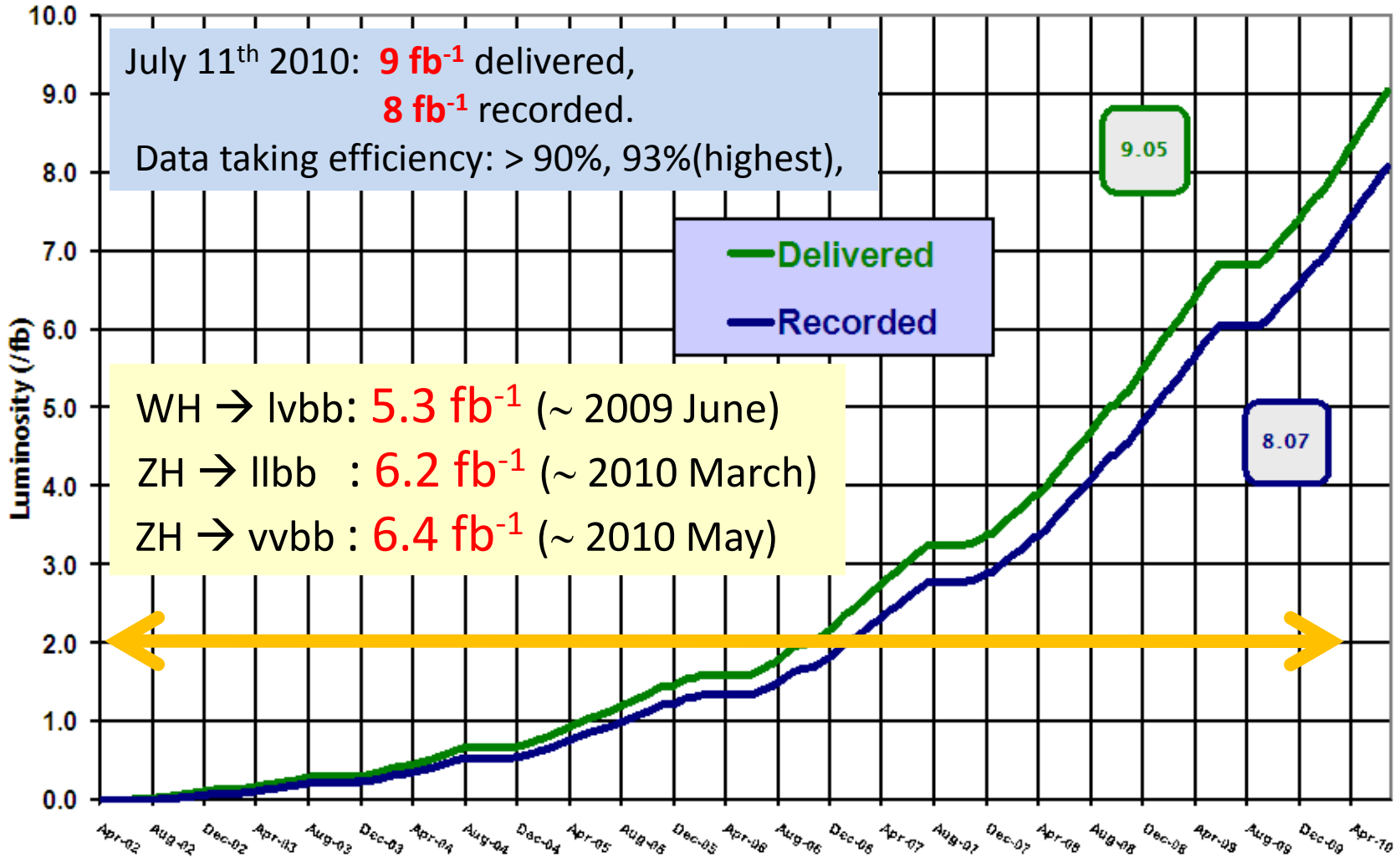


Data Set

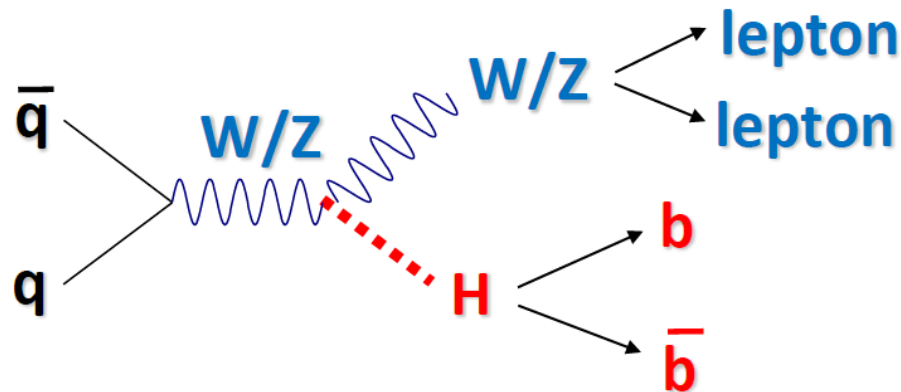


Run II Integrated Luminosity

19 April 2002 - 11 July 2010



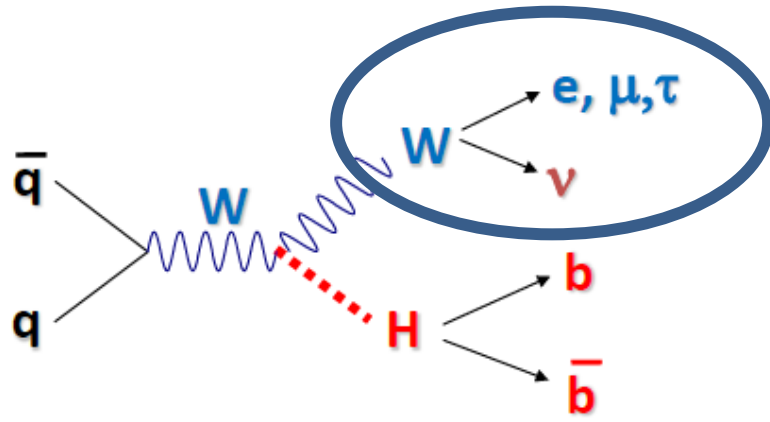
Thank Tevatron Accelerator Group for great effort !!



1. W or Z boson reconstruction
 $W \rightarrow l\nu, Z \rightarrow ll, Z \rightarrow \nu\nu$
2. Higgs candidate reconstruction
Dijet mass, b -jet tagging.
3. MultiVariate Analysis (MVA)
4. Result

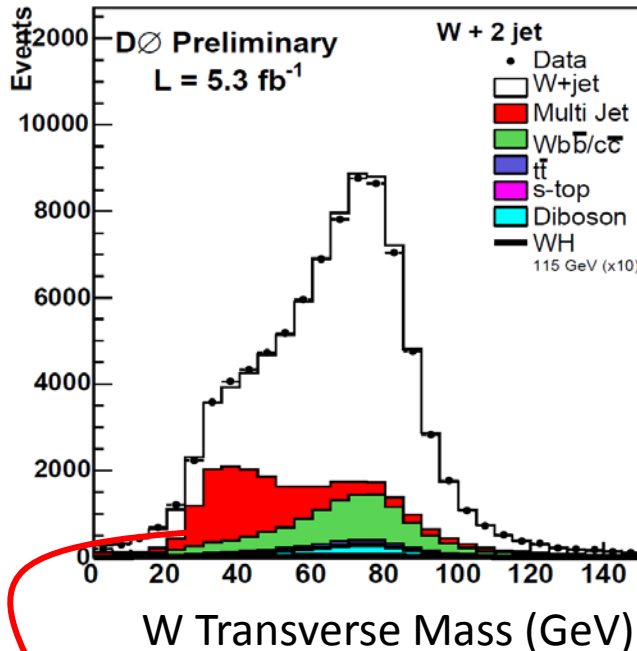
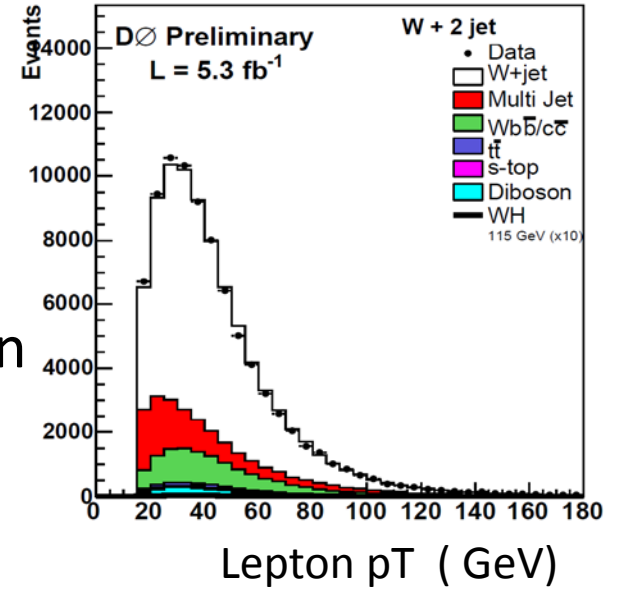


W boson Reconstruction



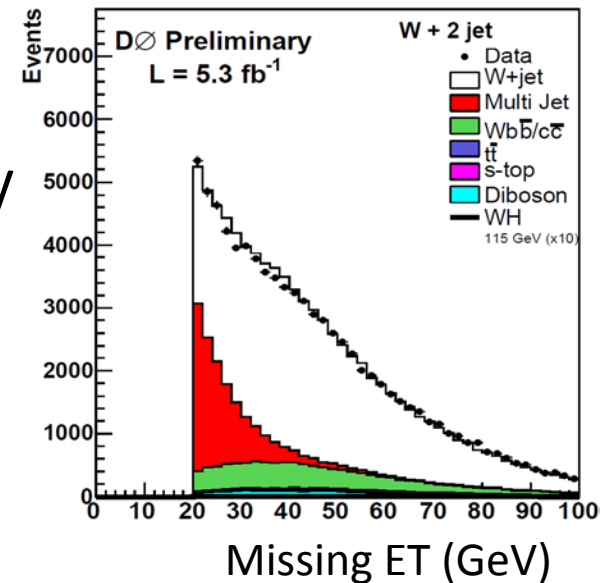
Lepton:

electron/ muon
 $p_T > 15 \text{ GeV}$



Missing E_T

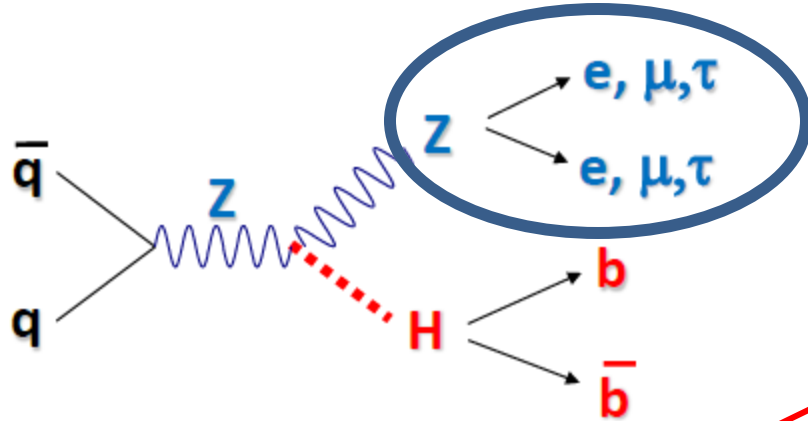
$MET > 20 \text{ GeV}$



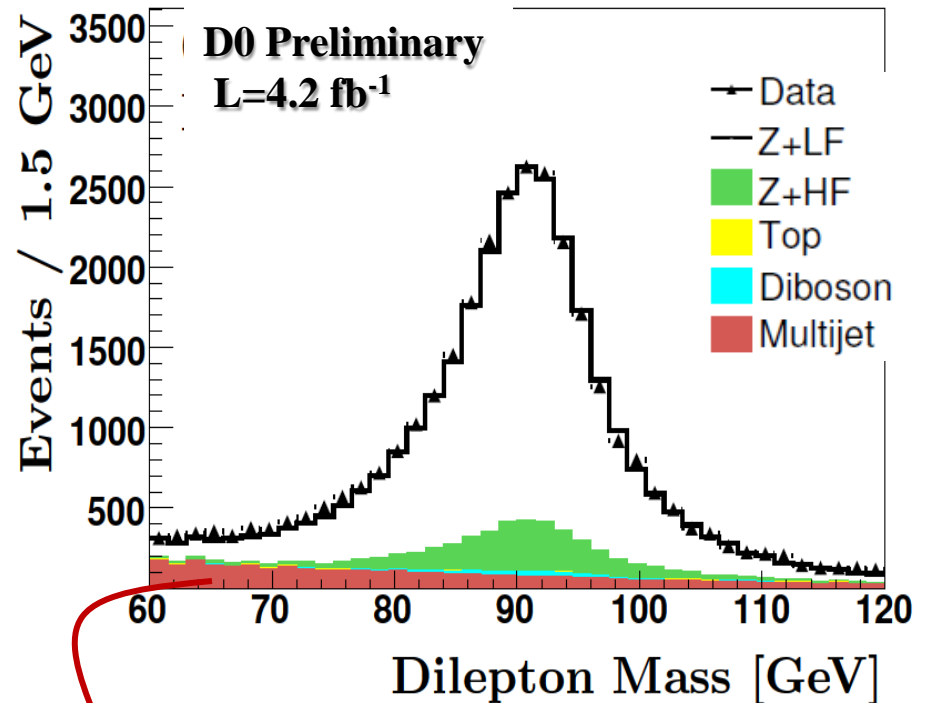
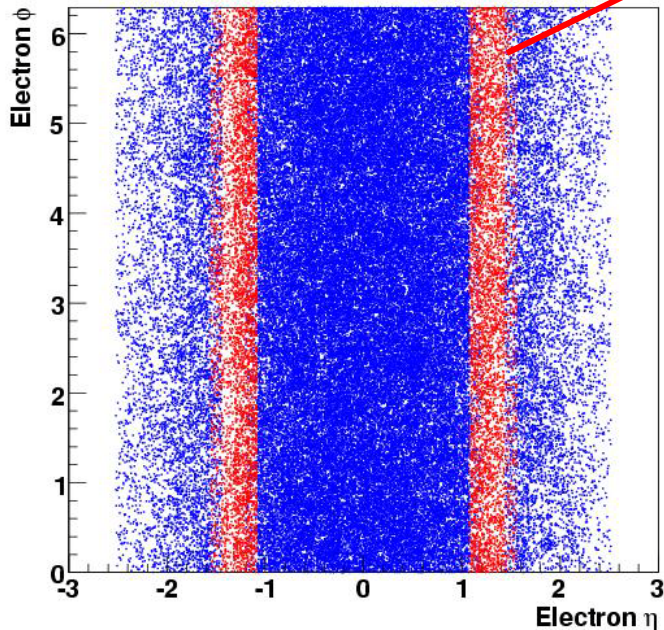
Multi-Jet Background is estimated from Data.



Z boson Reconstruction



- Increase signal acceptance
 - Inclusion of isolated tracks
 - Electron in GAP
 - Lowering pt cut on lepton

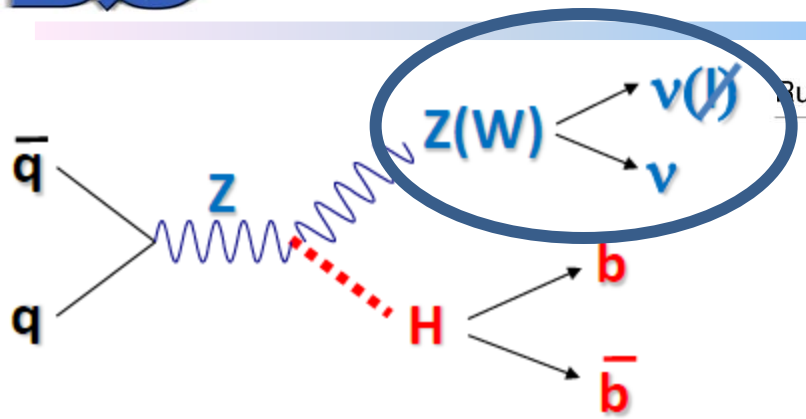


Multi-Jet BG is estimated from Data.

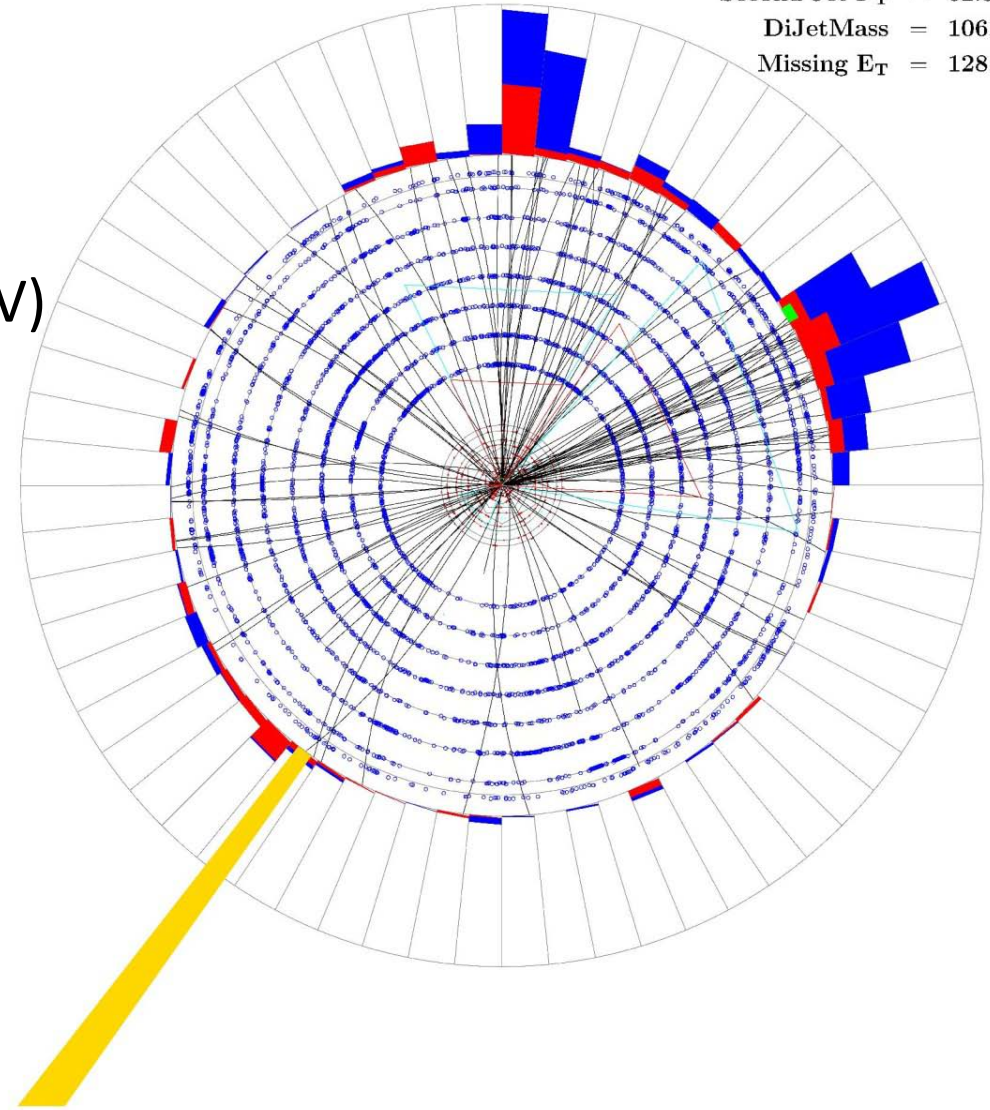


Z → νν reconstruction

Run 248968 Evt 48062268 Fri Jan 23 06:59:26 2009



Leading Jet $P_T = 85.6$ GeV
 Second Jet $P_T = 62.3$ GeV
 DiJetMass = 106.7 GeV
 Missing $E_T = 128.9$ GeV

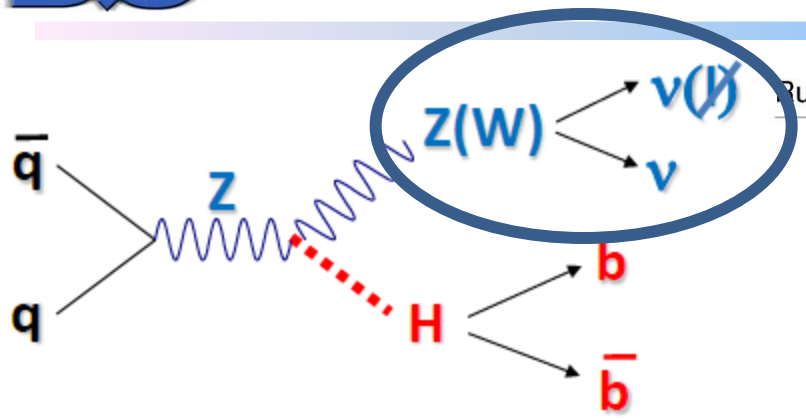


- Jets + large MET (>40 GeV)
- Expect high multi-jet Background
- **Signal sample**
- **Control sample**
- **Multi-Jet**
- **Electro-weak**

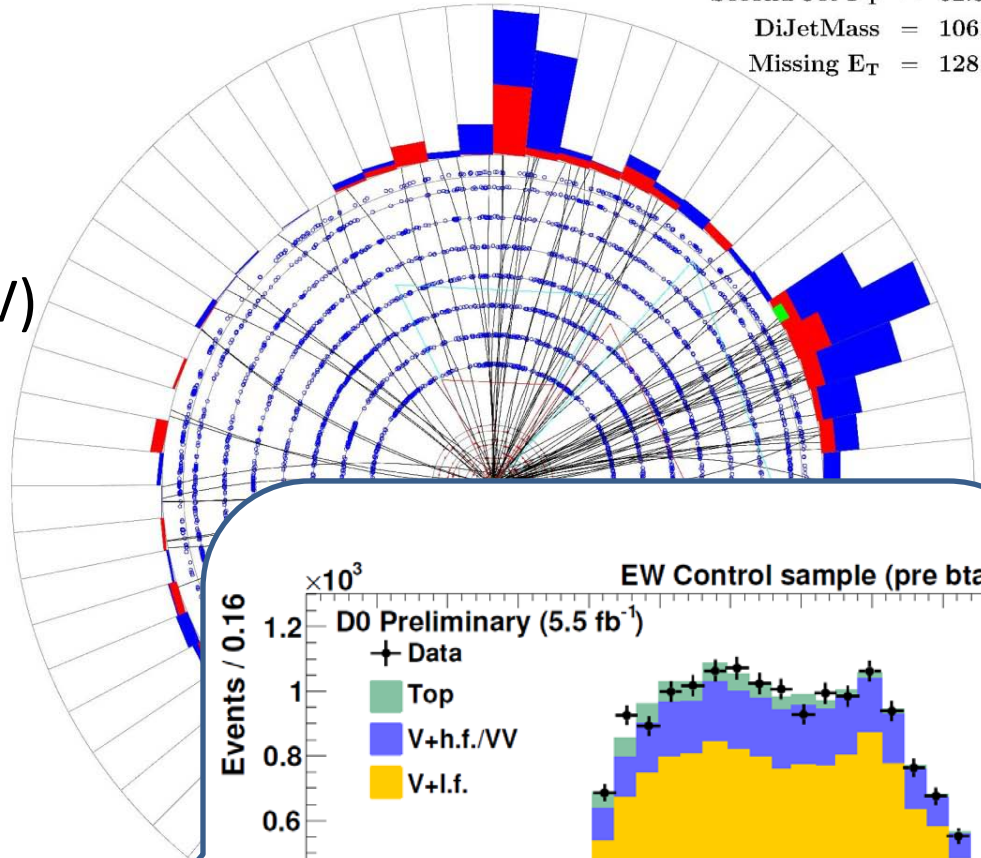


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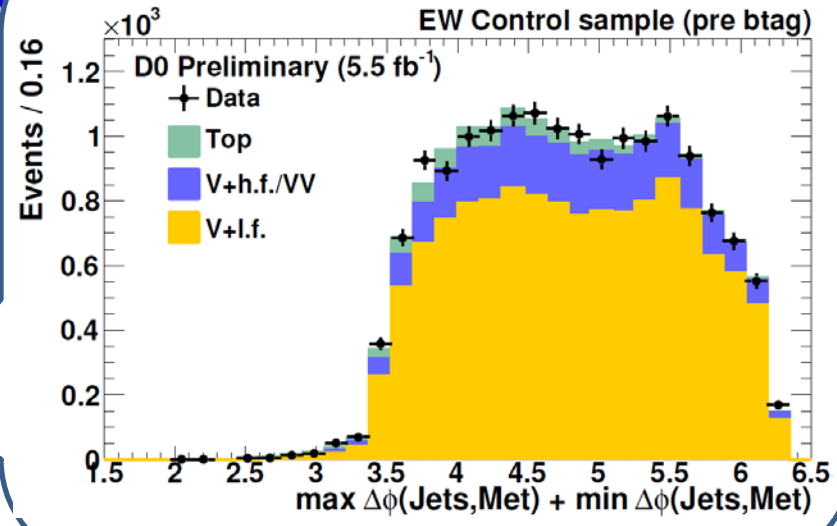
Expect high multi-jet
Background

- Signal sample
- Control sample

→ Multi-Jet

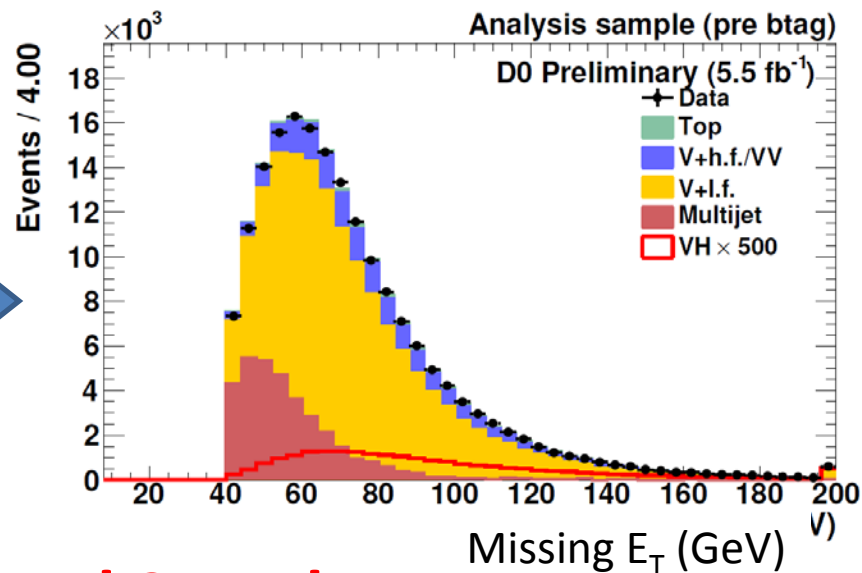
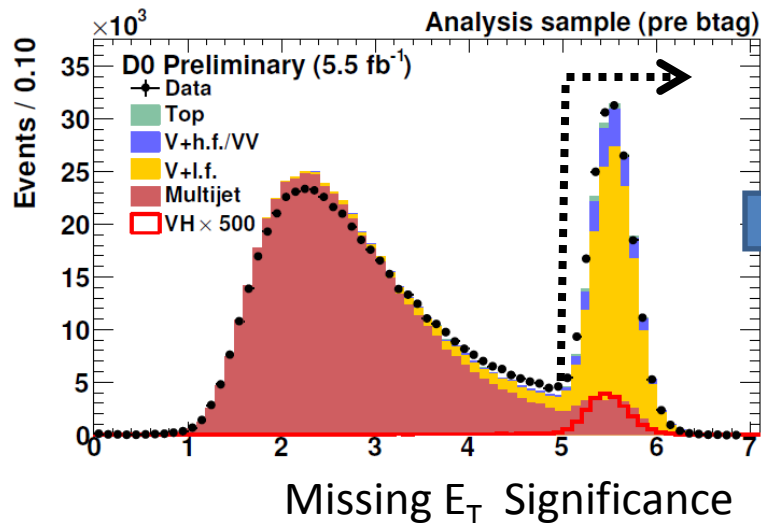
→ Electro-weak

W → μν, subtract muon pT





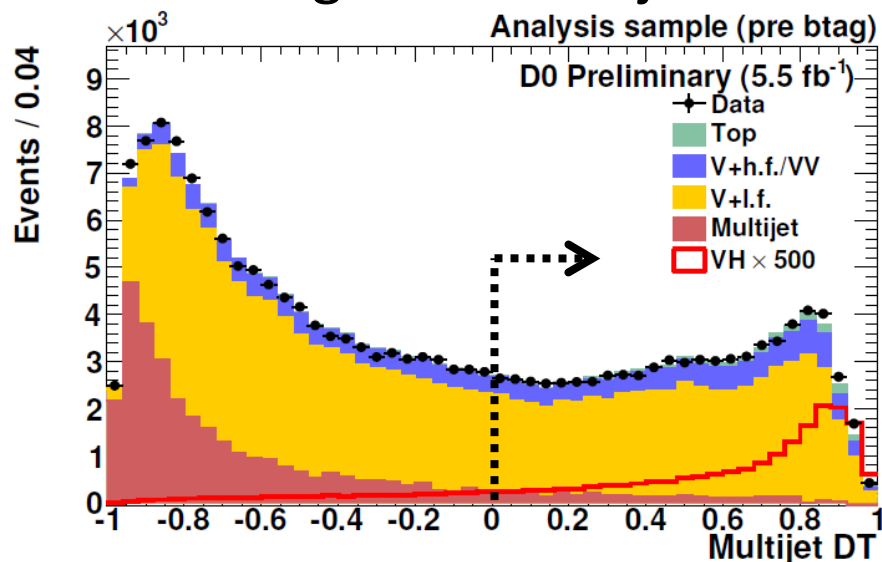
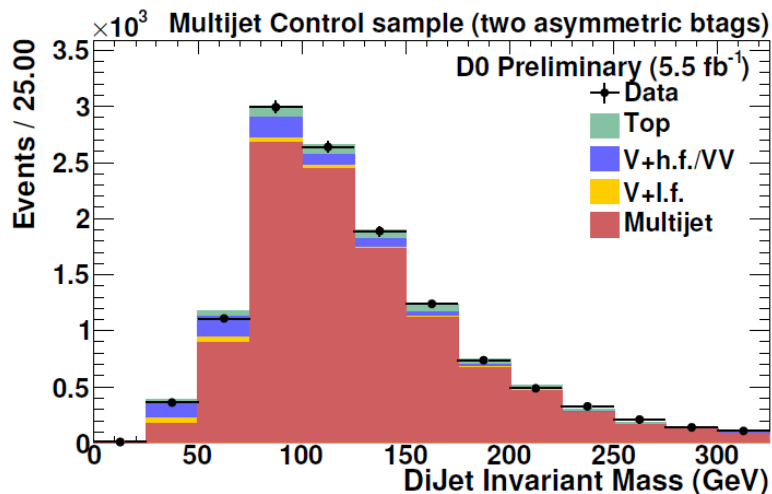
Multi-jet BG: mis-measurement in MET.



Signal Sample:

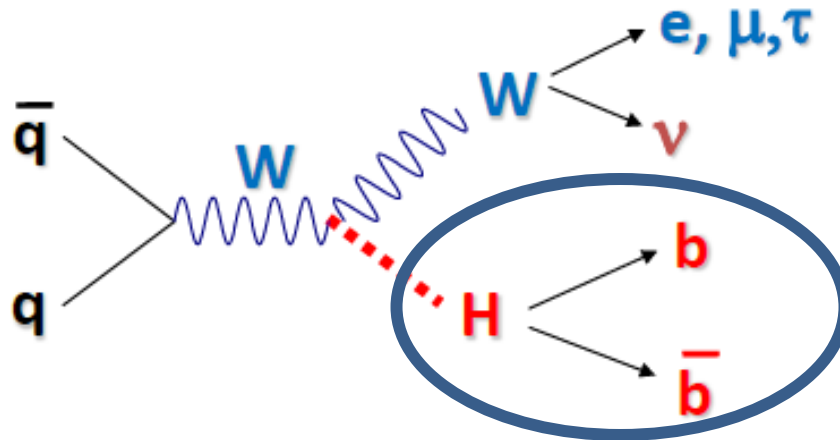
Train MVA against Multi-jet BG

Multi-Jet Control Sample

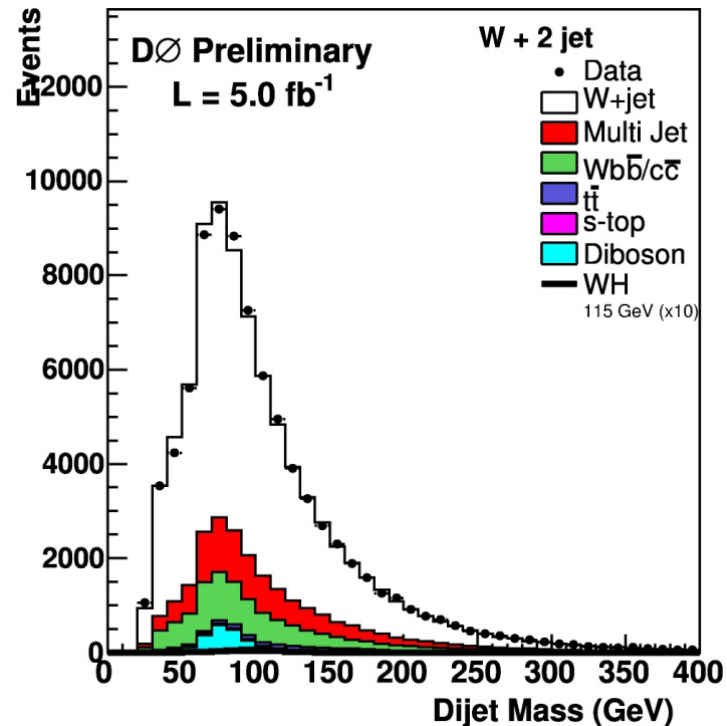
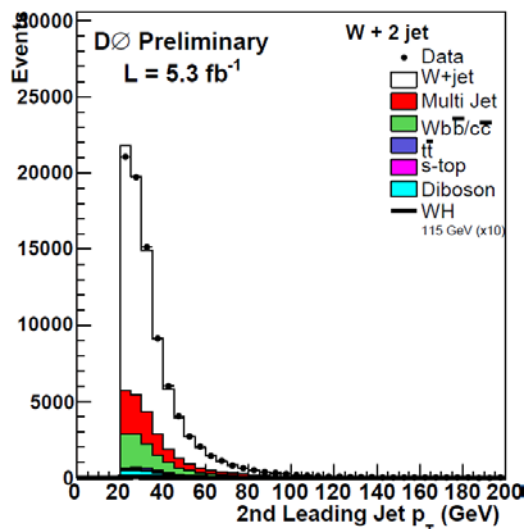
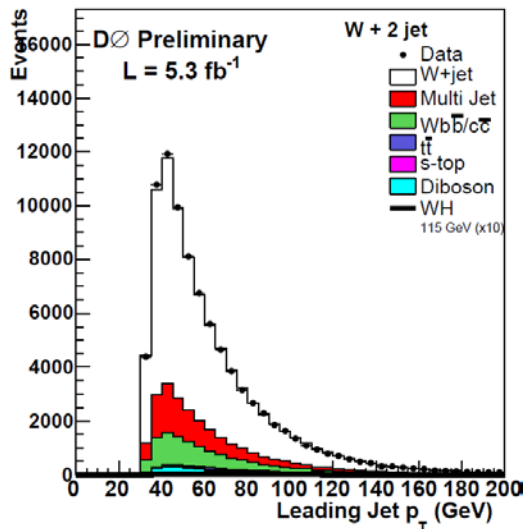




Higgs Candidate Reconstruction



- Jet : Jet with $R=0.5$ $R=\sqrt{(\phi^2+\eta^2)}$

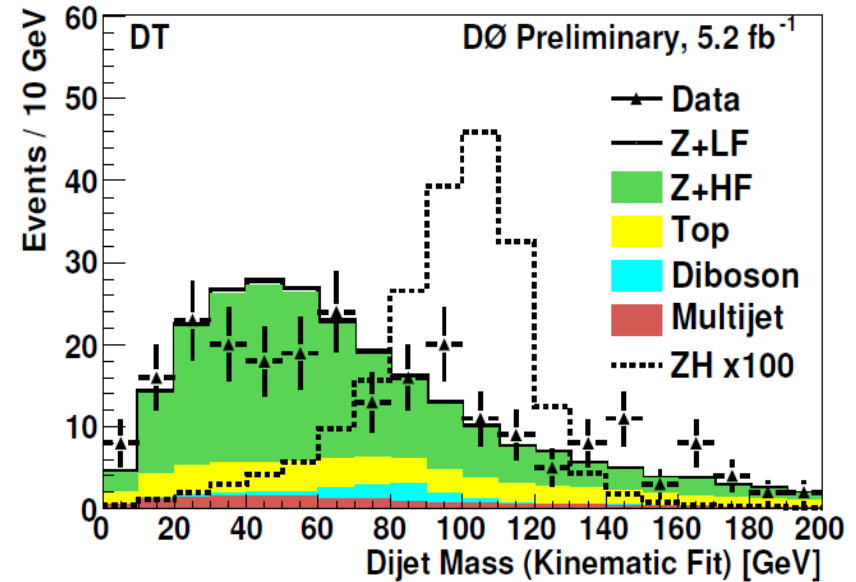
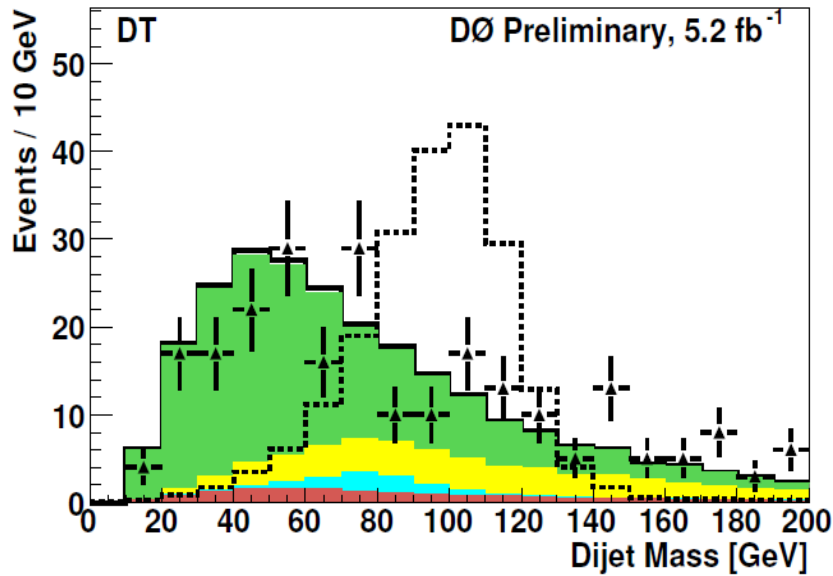
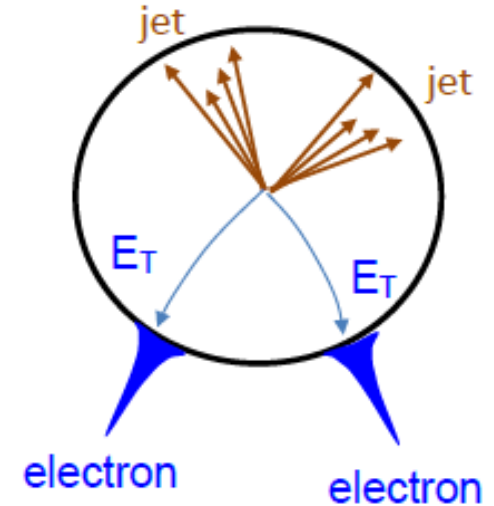




Dijet system in $ZH \rightarrow llbb$

- $ZH \rightarrow llbb$

- No real missing ET
- Use full kinematics information
 - Dijet Mass can be constrained



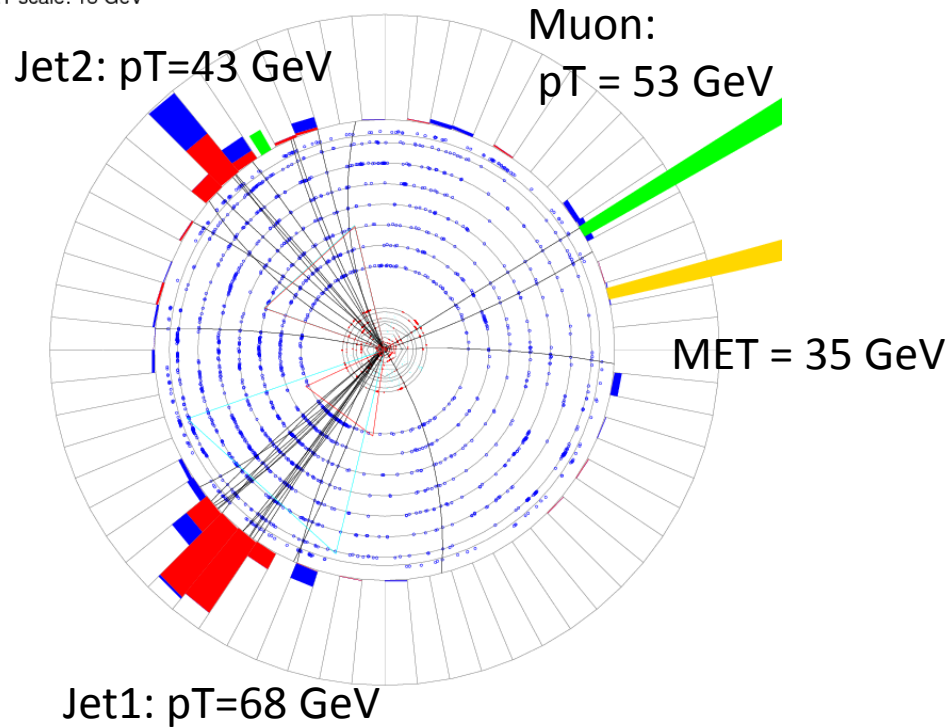
15 % improvement on Mass resolution



WH \rightarrow $\mu\nu b\bar{b}$ candidate event

Run 227895 Evt 117967657 Wed Nov 22 16:59:06 2006

ET scale: 18 GeV

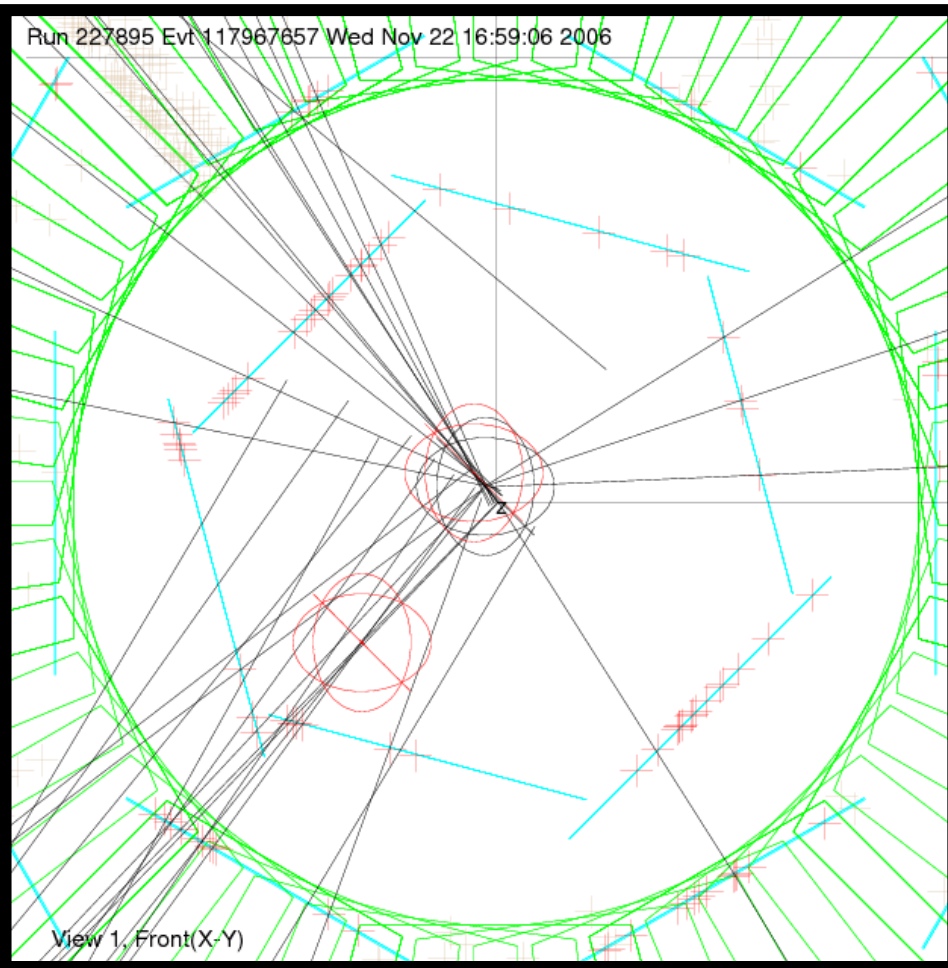
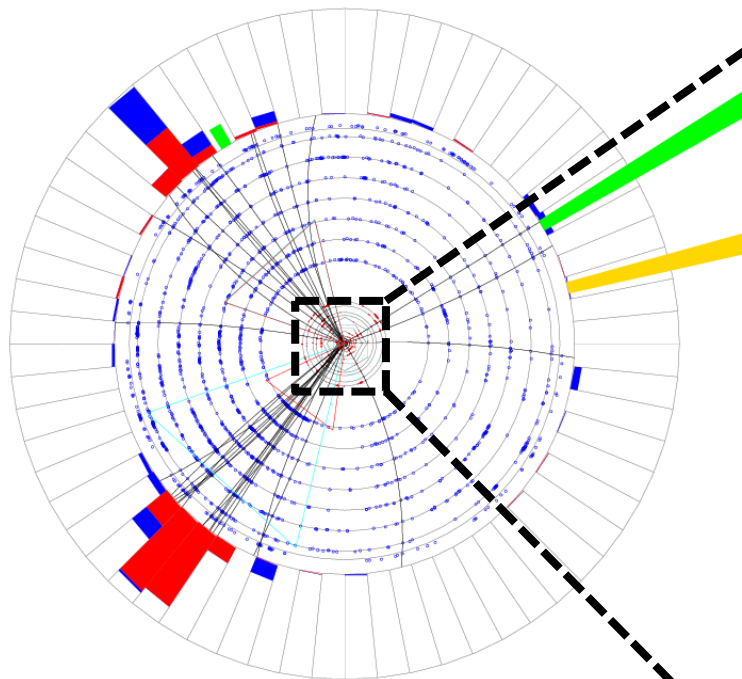




b-Jet Identification

Run 227895 Evt 117967657 Wed Nov 22 16:59:06 2006

ET scale: 18 GeV



Run 227895 Evt 117967657 Wed Nov 22 16:59:06 2006

View 1, Front(X-Y)

Vertex Tagging (transverse plane)

(Signed) Track Impact Parameter (dca)

Hard Scatter

Decay Length (L_{xy})

Neural Net b-tagger
 Combination of SV & dca
 Loose: 70% eff, 4.5% fake
 Tight : 50% eff, 0.3% fake



Usage of b-jet ID

Define orthogonal samples

if Two Loose (2-btag)

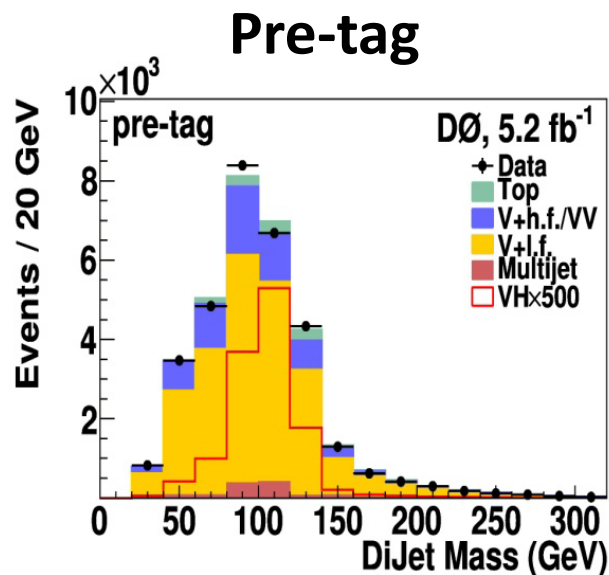
→ $S/N \sim 1:50$

else if 1 Tight (1-btag)

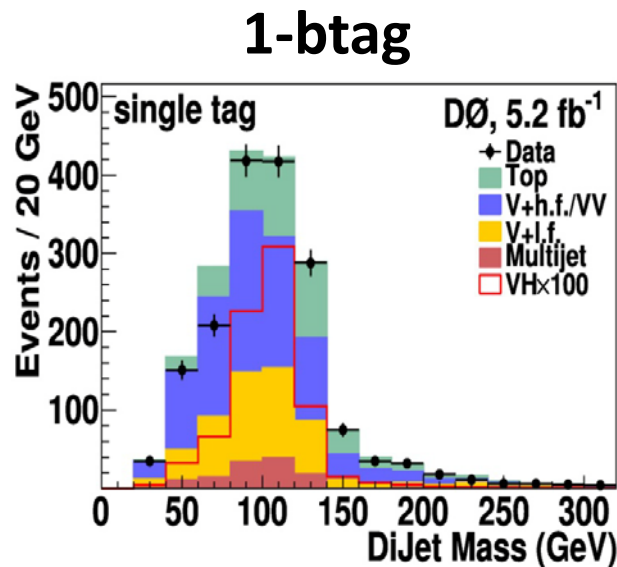
→ $S/N \sim 1:300$

Sample composition changes

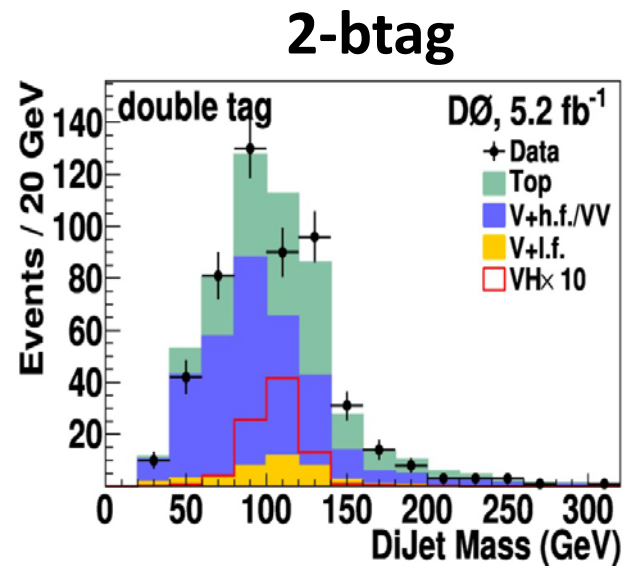
→ Optimize separately.



BG: **W+light**



W+light, W+bb/cc

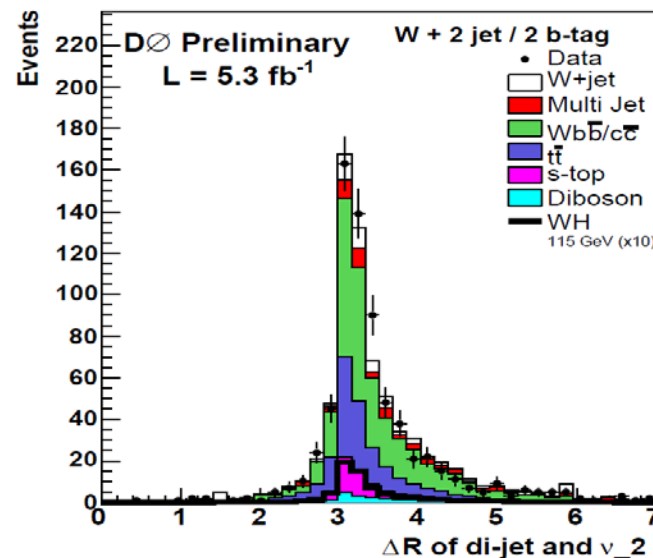
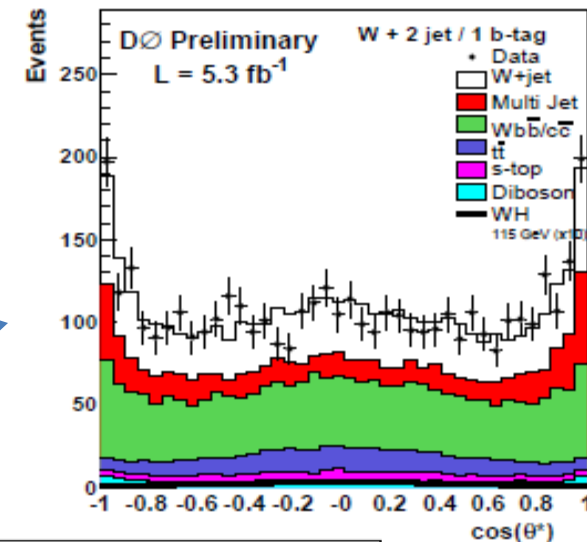
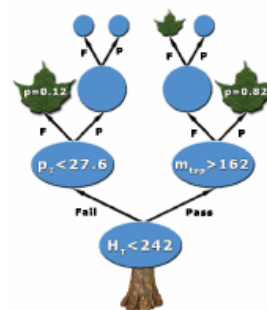


W+bb/cc, ttbar



MultiVariate Technique

- All three analysis using Decision tree based technique.
- The most sensitive input is dijet mass. And other sensitive variables are
 - Spin correlation
 - Neutrino direction
- Sensitivity gain: 15-20 % compared to dijet mass.
- Training:
 - 1-btag, 2-btag separately.
 - Use part of MC sample for train.



In total, ~ 20 input variables.



- In case of $WH \rightarrow l\nu b\bar{b}$ (%)

Source	$W \rightarrow e\nu$	$W \rightarrow \mu\nu$
Luminosity	6.1	6.1
BG X section	6-20	6-20
Lepton ID/Trigger	2-3	3-5
Jet ID	1-2	1-2
Jet Energy Scale	2-5	2-5
b-Jet ID	9-11	9-11
Multi-Jet BG	1.0	1.0
PDF, MC Model	2-3	2-3

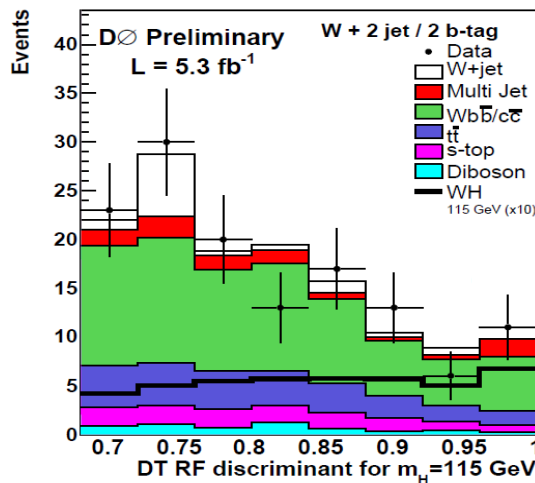
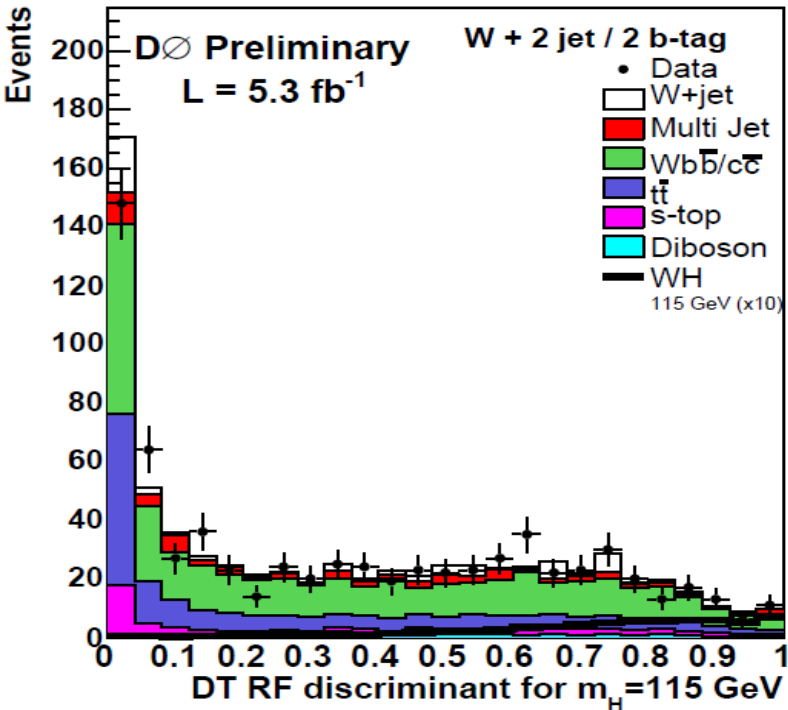
Flat Systematics

W+hf: 20%
Diboson : 6%
ttbar : 10%
Single top: 12%

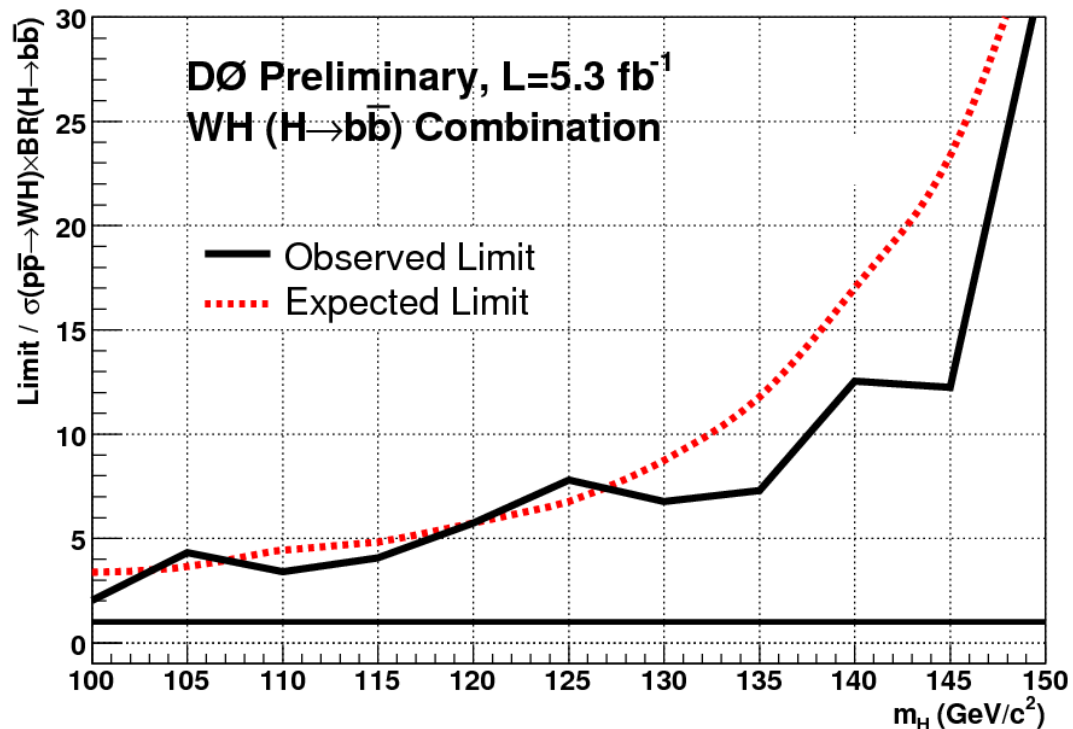
Shape Systematics



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

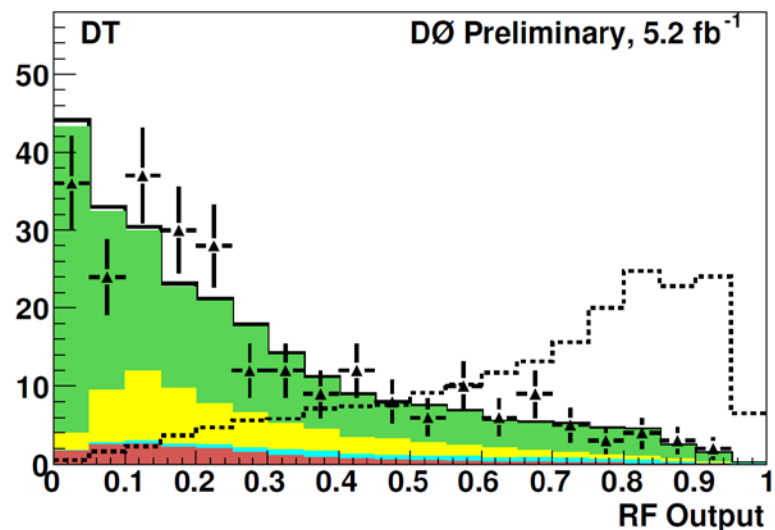
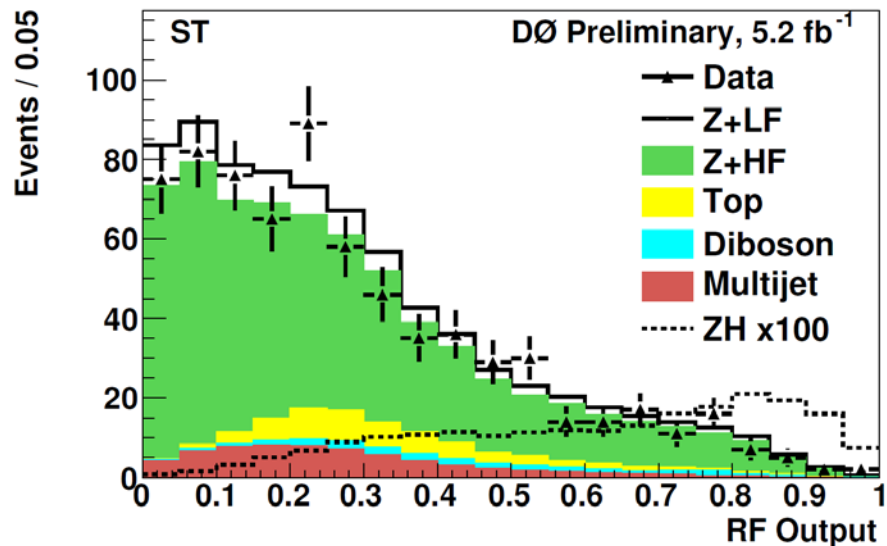


$\int \mathcal{L} dt = 5.3 \text{ fb}^{-1}$
 $M_H = 115 \text{ GeV}$
Exp./SM = 4.8
Obs./SM = 4.1
 @ 95% C.L.





ZH \rightarrow ll b \bar{b} Result



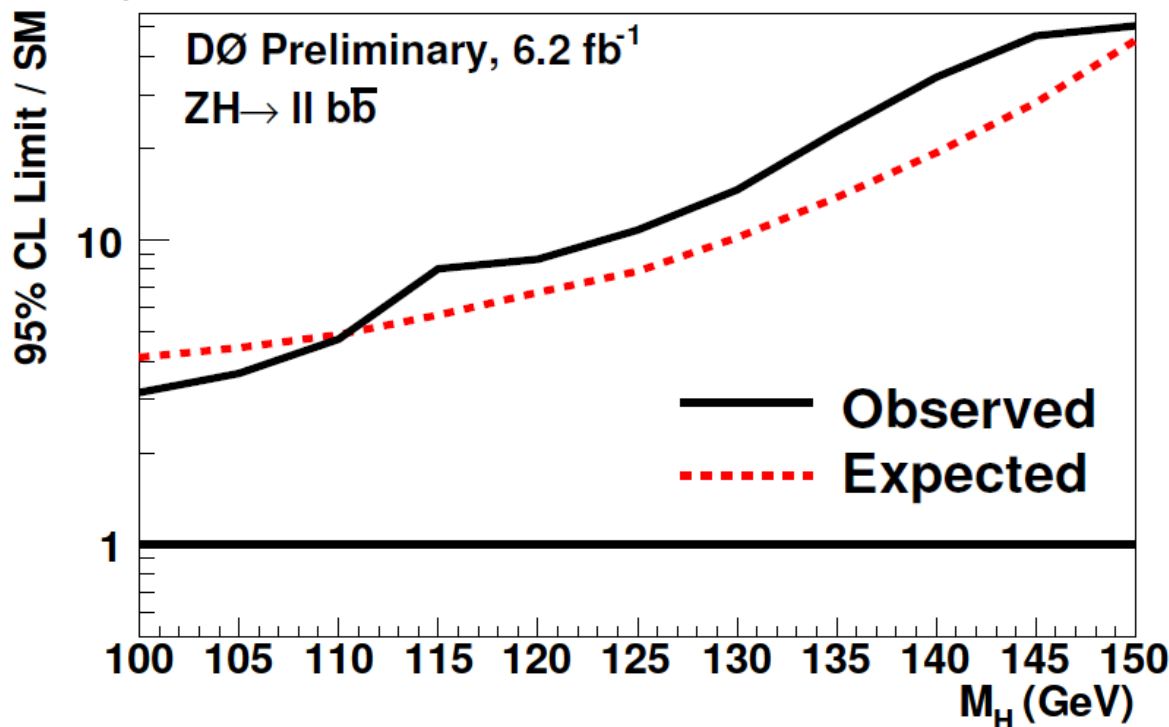
$$\int \mathcal{L} dt = 6.2 \text{ fb}^{-1}$$

$$M_H = 115 \text{ GeV}$$

$$\text{Exp./SM} = 5.7$$

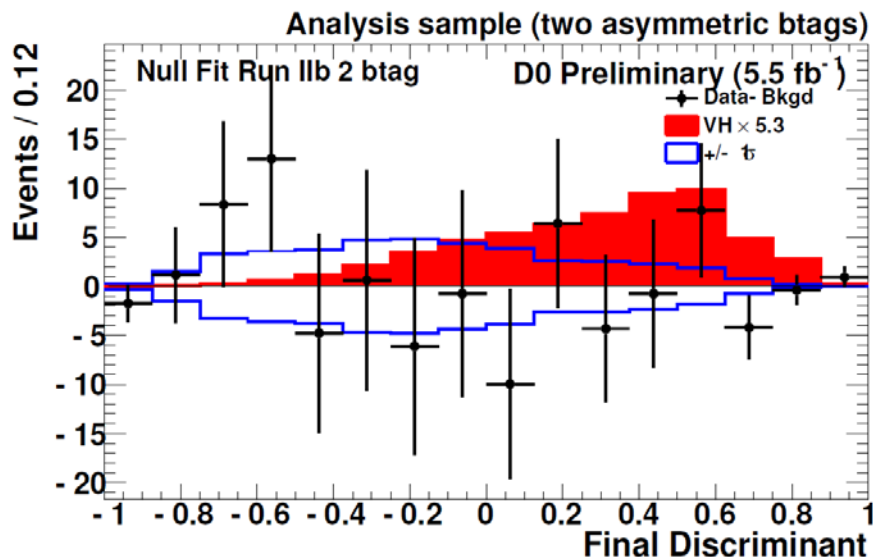
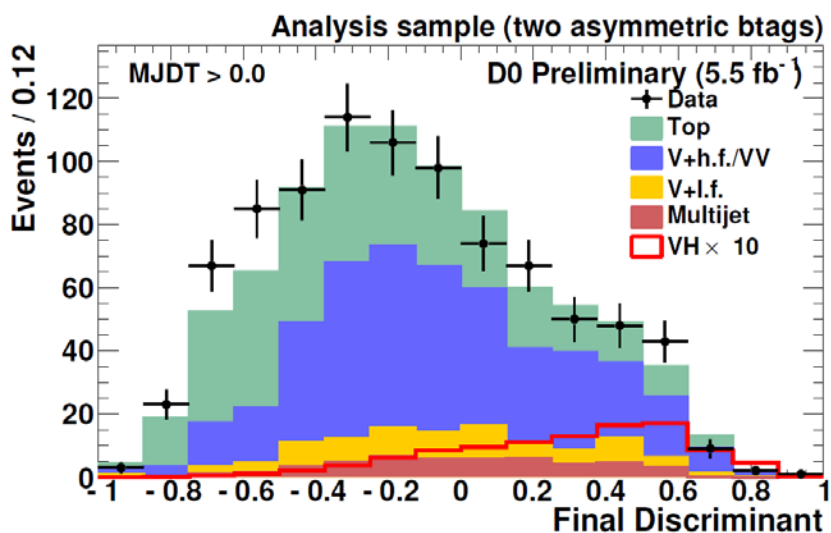
$$\text{Obs./SM} = 8.0$$

@ 95% C.L.





ZH → ννbb Result



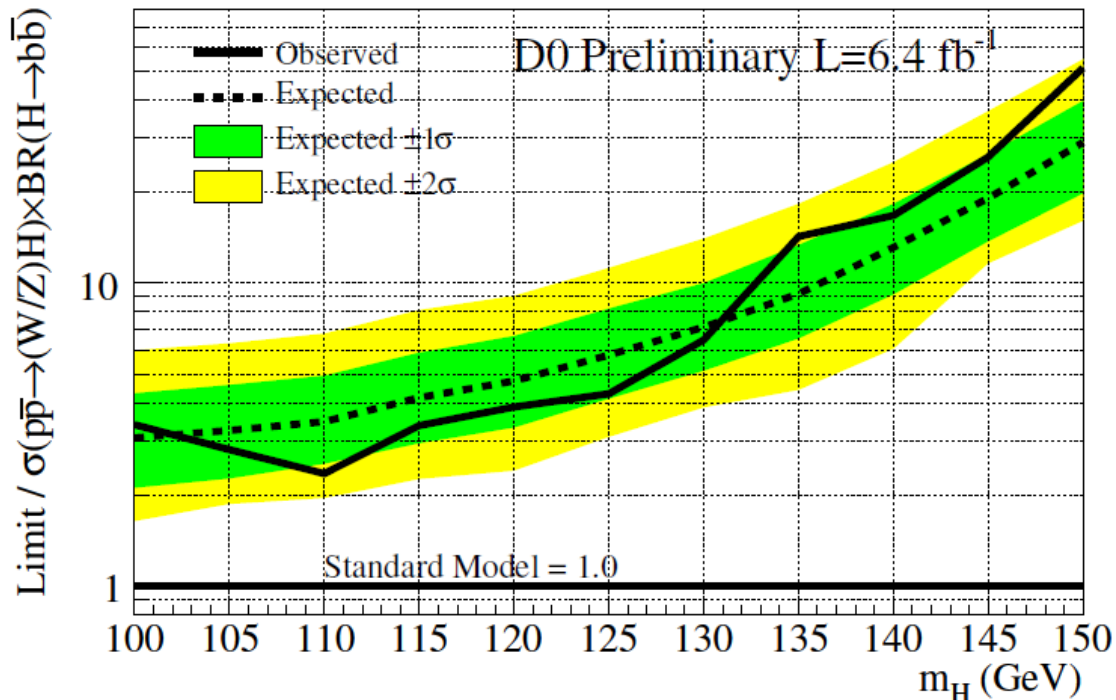
$$\int \mathcal{L} dt = 6.4 \text{ fb}^{-1}$$

$$M_H = 115 \text{ GeV}$$

$$\text{Exp./SM} = 4.2$$

$$\text{Obs./SM} = 3.4$$

@ 95% C.L.





- We release updated result on three main low mass Higgs searches.

Channel	Lumi.	Obs./SM	Exp./SM
WH \rightarrow lvbb	5.3 fb $^{-1}$	4.0	4.7
ZH \rightarrow llbb	6.2 fb $^{-1}$	8.0	5.7
ZH \rightarrow vvbb	6.4 fb $^{-1}$	3.4	4.2

40 % better
than last
result (2009
March)

Preliminary, at $M_H=115$ GeV, 95 % C.L.

- Combination result:
 - The Dzero combination: M. Mulhearn, tomorrow
 - The TeV combination: B. Kilminster, on Monday (plenary talk)
- More data, more improvements
 - 8 fb $^{-1}$ already recorded, 10 fb $^{-1}$ is expected in the future.
 - Various progress b-ID and MVA are coming!



BACK UP

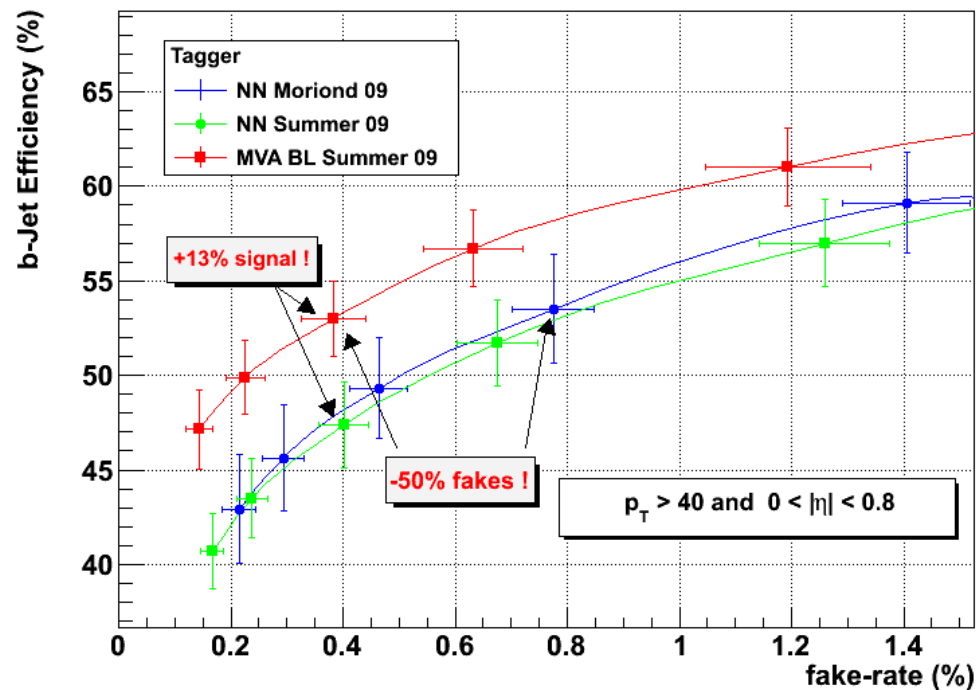
Y. Enari 24

Low Mass

Higgs @ Dzero



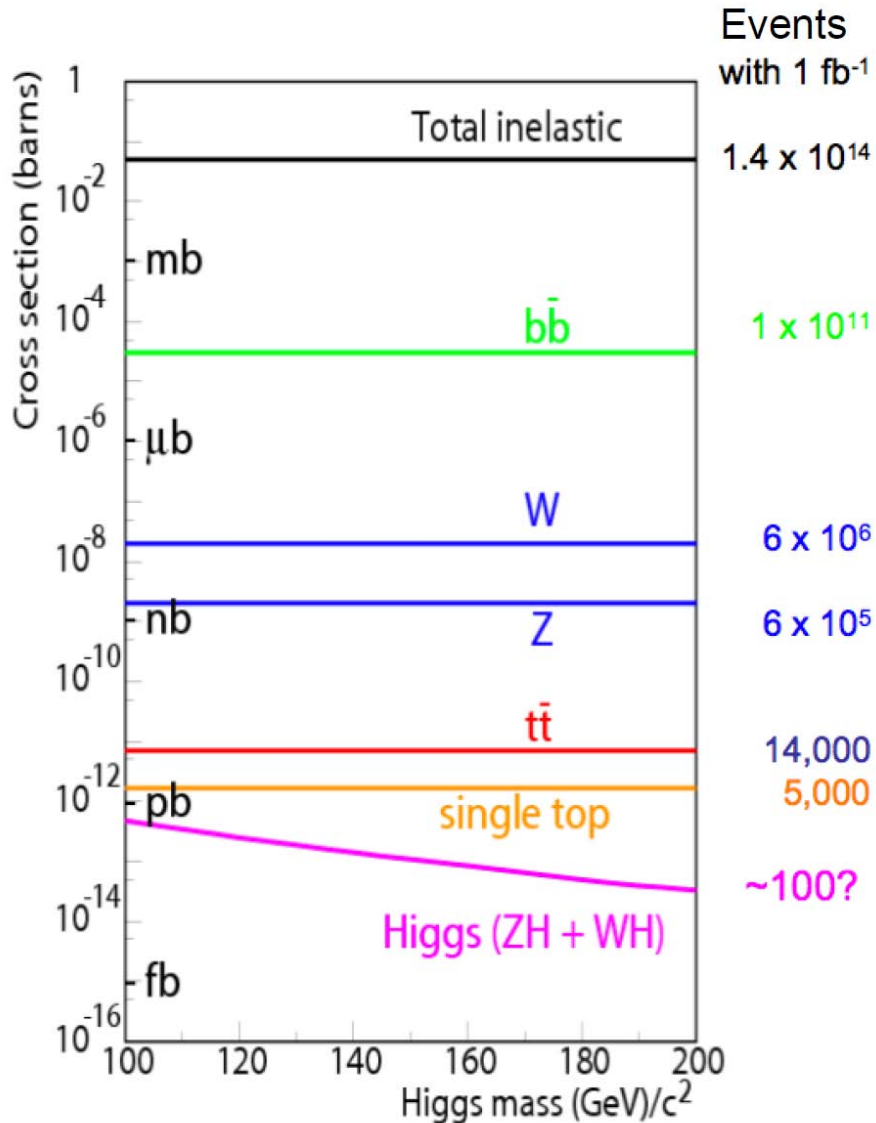
- New bID tagger
 - Re-optimization
- New Lepton ID
 - Re-optimization
 - Loosing operating point
- Re-optimizing MultiVariate Technique.
 - Against QCD (like $ZH \rightarrow \nu\nu b\bar{b}$)
 - How to train MVA, new algorithm.



Each points are expected to bring additional 5-10% gain in sensitivity.



- Cross section at $\sqrt{s} = 1.96$ TeV



9 order difference

Background Estimation

- Multi-Jet : from data
- W+Jet } ALPGEN/Pythia
- Z+Jets }
- ttbar, }
- Diboson } Pythia
- s-top } COMPHEP

Signal Estimation

- WH/ZH } Pythia