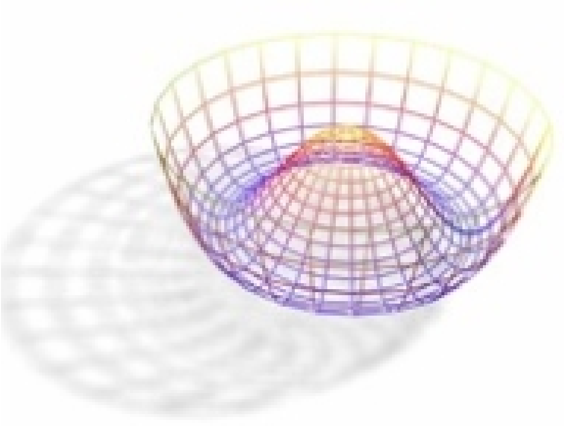
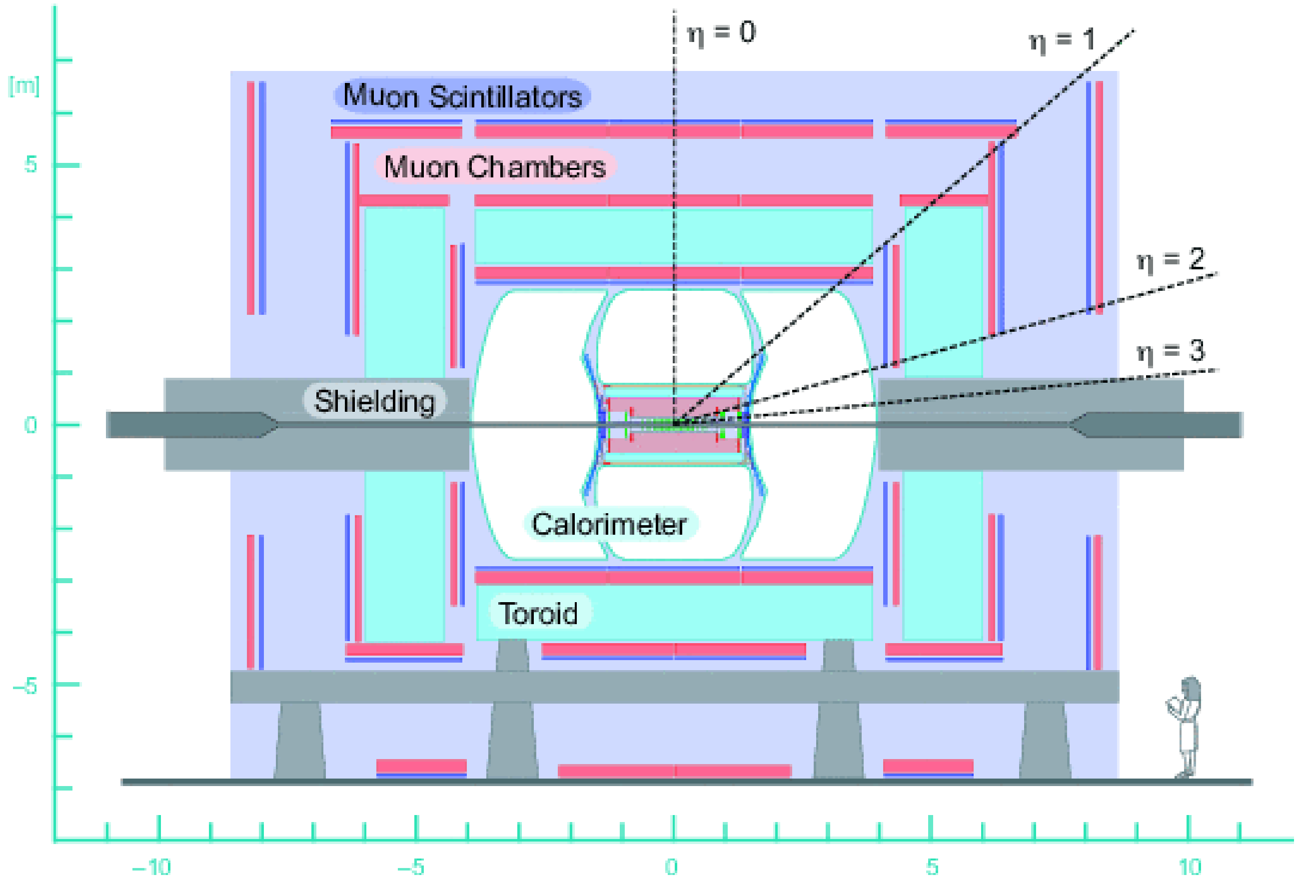
Search for the SM Higgs Boson in lνqq Final States



Huong Nguyen (UVa)
On the behalf of DØ Collaboration

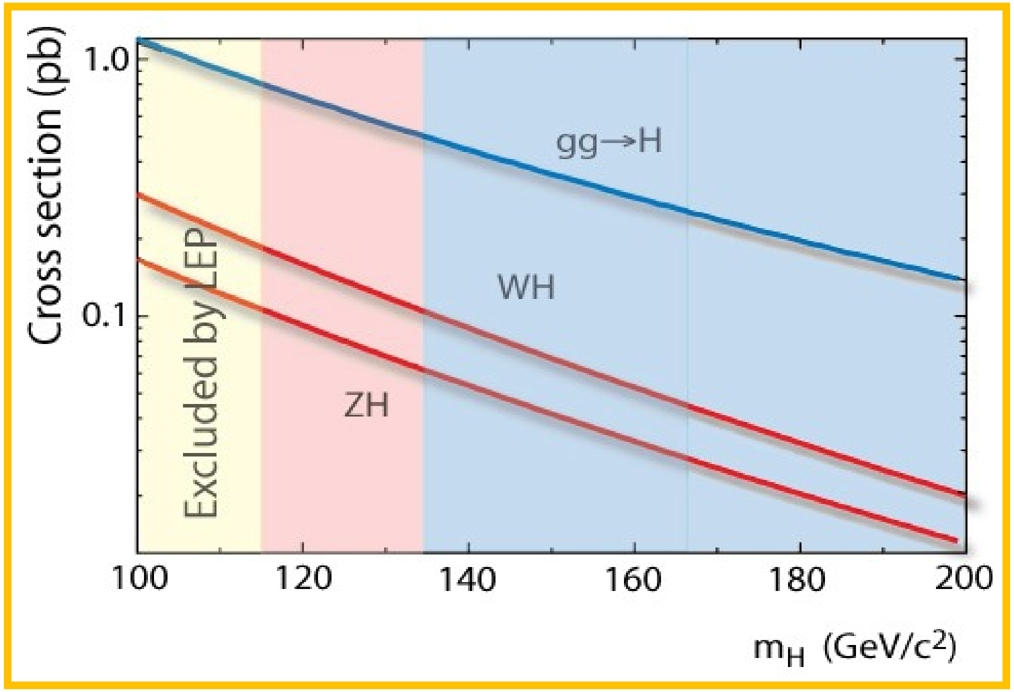
The DØ detector

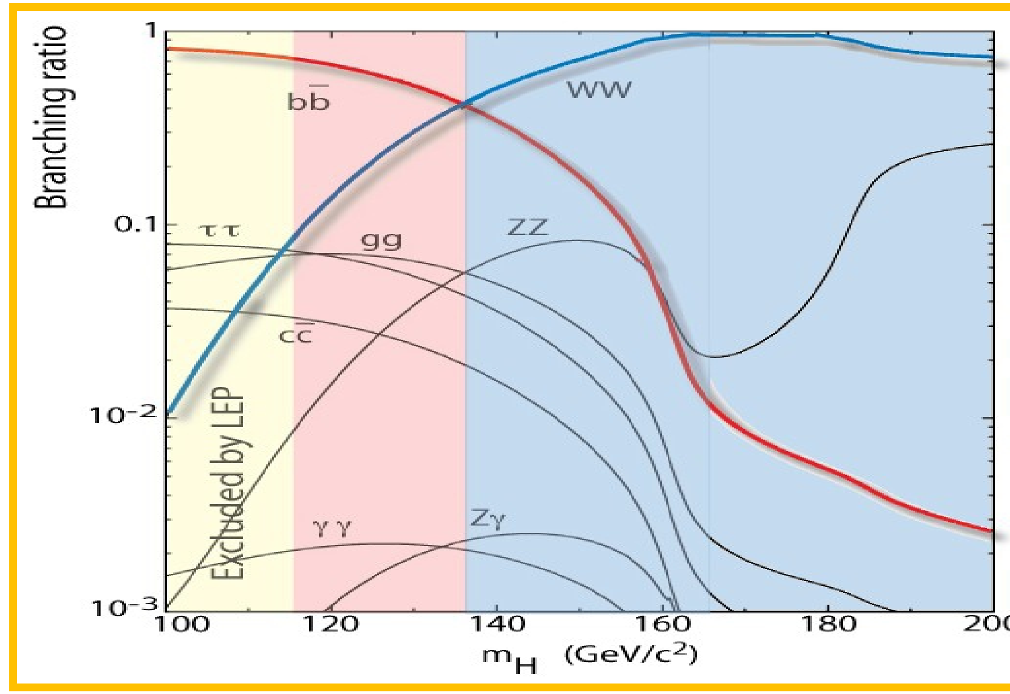
The Tevatron produces $p\bar{p}$ collisions at CM energy $\sqrt{s} =$ 1.96 TeV



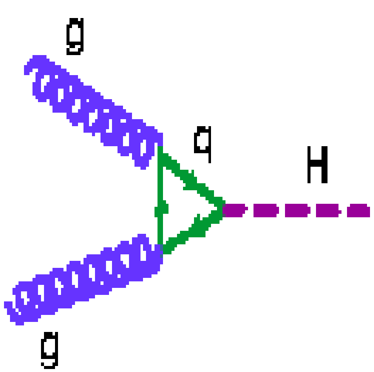
- Silicon Vertex Detector
- Scintillating Fiber Tracking
- LAr-U Compensating Calorimeter
- Muon System cover |η| <2

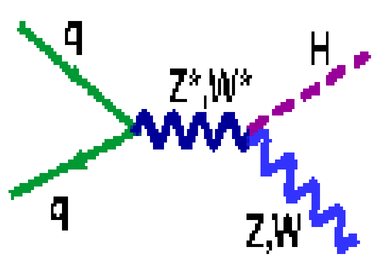
The Higgs Production and Decay





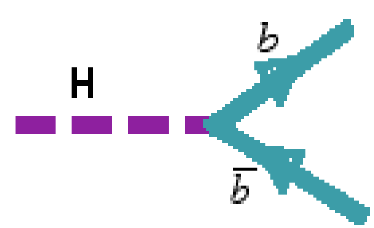
Dominant Production at Tevatron



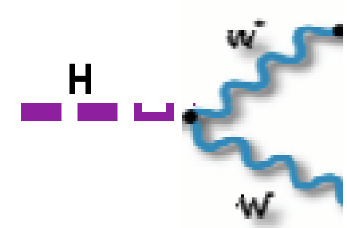


Main Decay Processes

$M_H < (\approx 135 GeV)$



$M_H > (\approx 135 GeV)$



What Will 10' Get Us ?

Search for the Higgs decays in lvqq final state :

- WH→lvbb
- H→WW→lvjj
- WH→WWW→lvjjjj

• Splitting data in orthogonal b-tagging samples

• Optimizing the search in each subchanels

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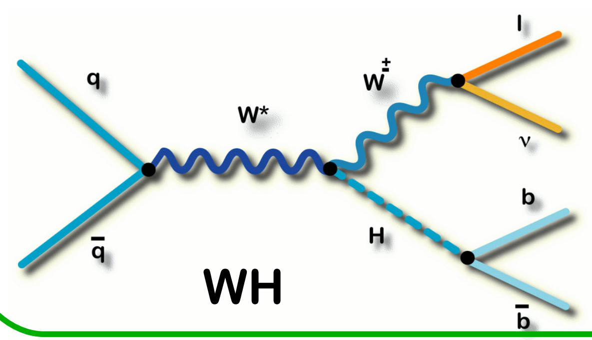
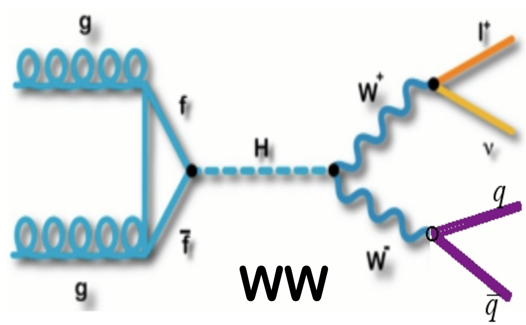
Searching for Higgs in lνqq Final State

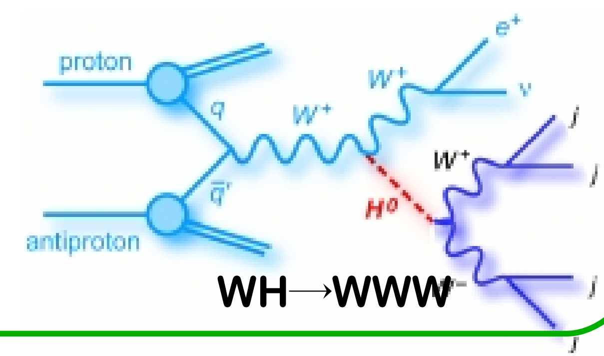
Signals

WH→lνbb , H→WW→lνjj , WH→WWW→ lνjjjj

ZH→llbb, H→ZZ→lljj , ZH→ZWW →lljjjj ; mH= [90GeV, 200 GeV])







Signatures

Two High P_T Jets

One High P_T Lepton

Large MET

Backgrounds

W+Jets, Z+ Jets

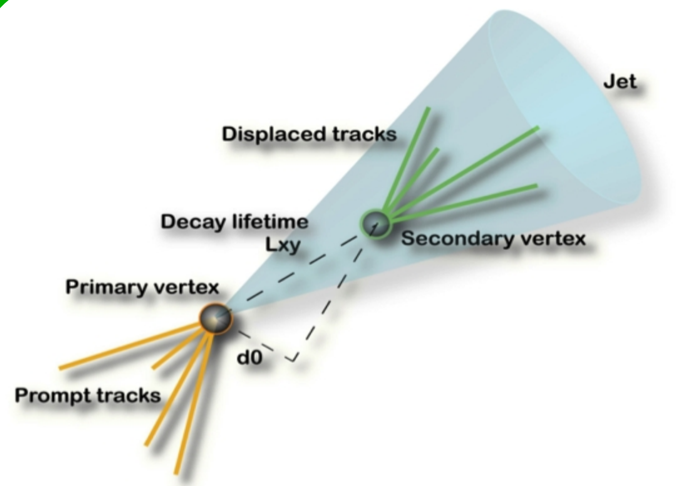
WW, ZZ, WZ

Single-top, $t\bar{t}$

MultiJets

Splitting Data via b-Tagging & Jet Mult.

B-Tagging: Separate b-jets and LF jets based on track and vertex information



Low Mass (mH <=150 GeV)

Samples	2jet	3jet	4jet
0tag	H→WW→lvjj	H→WW→lvjj	WWW→lvjjjj
1L	H→WW→lvjj	H→WW→lvjj	WWW→lvjjjj
1T	WH→lvbb	WH→lvbb	*ttbar bkgs*
2L	WH→lvbb	WH→lvbb	*ttbar bkgs*
2M	WH→lvbb	WH→lvbb	*ttbar bkgs*
2T	WH→lvbb	WH→lvbb	*ttbar bkgs*

Tagging Categories:

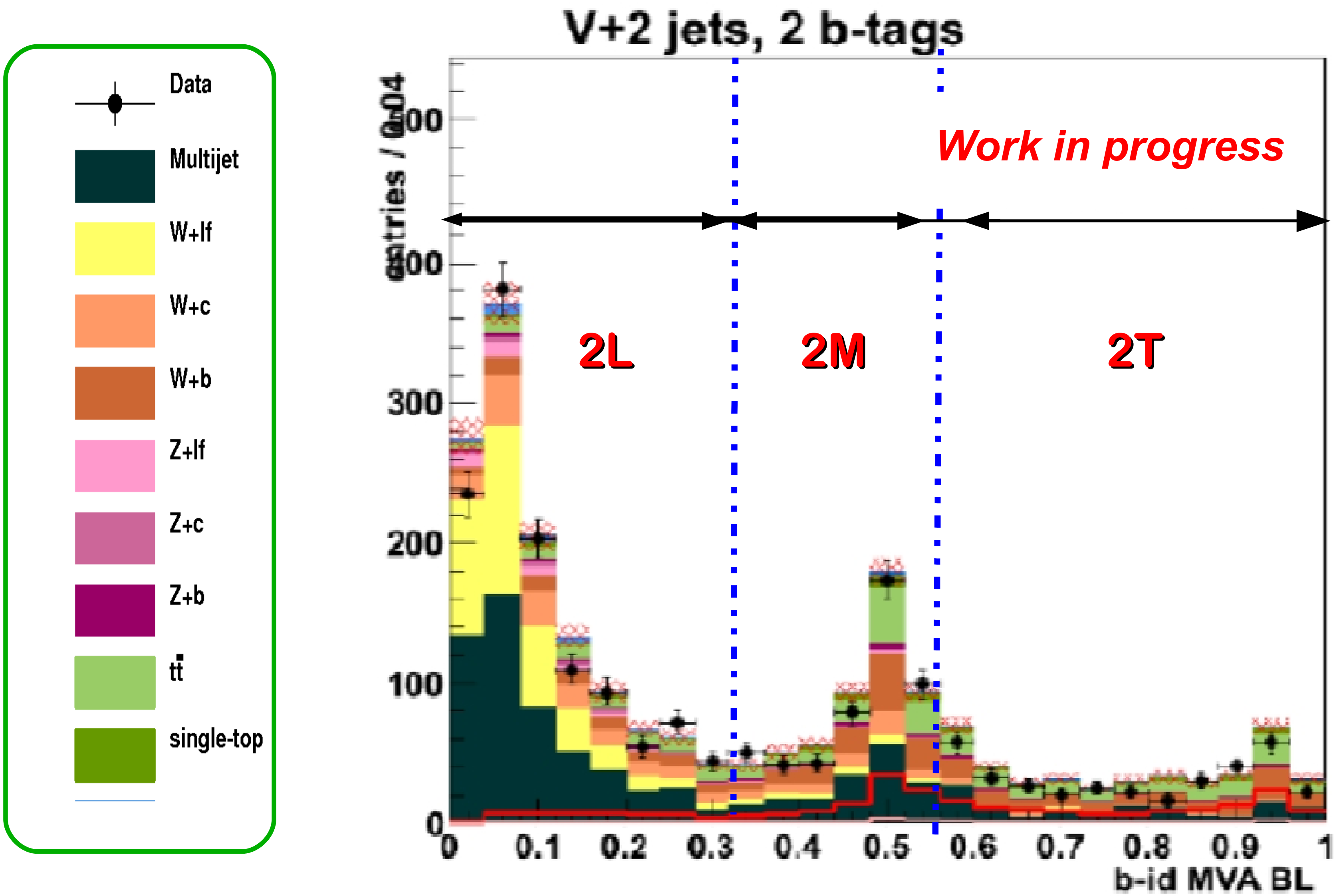
- **2T** At least 2 Tight b-tagged jets
- **2M** At least 2 Med. b-tagged jets
- **2L** At least 2Loose b-tagged jets
- **1T** Exact 1 tight b-tagged jet
- **1L** Exact 1 loose b-tagged jet
- **0tag**

High Mass (mH >150 GeV)

Samples	2jet	3jet	4jet
0tag	H→WW→lvjj	H→WW→lvjj	WWW→lvjjjj
1L	H→WW→lvjj	H→WW→lvjj	WWW→lvjjjj
1T	H→WW→lvjj	H→WW→lvjj	
2L	*Dominated by ttbar bkgs No Significant Signal*		
2T	*Dominated by ttbar bkgs No Significant Signal*		

WH→ lvbb: Categorizing data via B-tagging

* Separate b-jets from light flavor jets: BID Multivariate Analysis (bid_MVA)
* Dividing the sample based on bid_mva output



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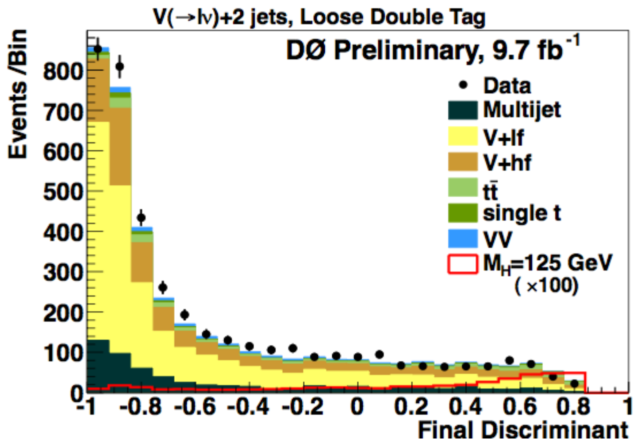
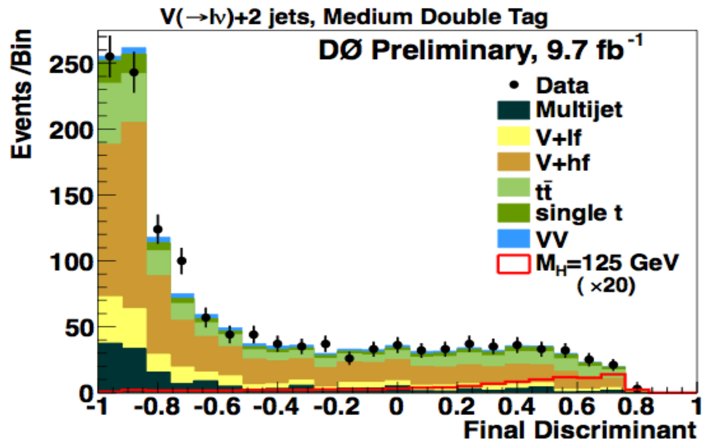
WH→ lνbb: Improvement in Signal Sensitivity

- Improving signal isolation by further splitting tagging samples
- Optimizing MVA training for each tagging samples

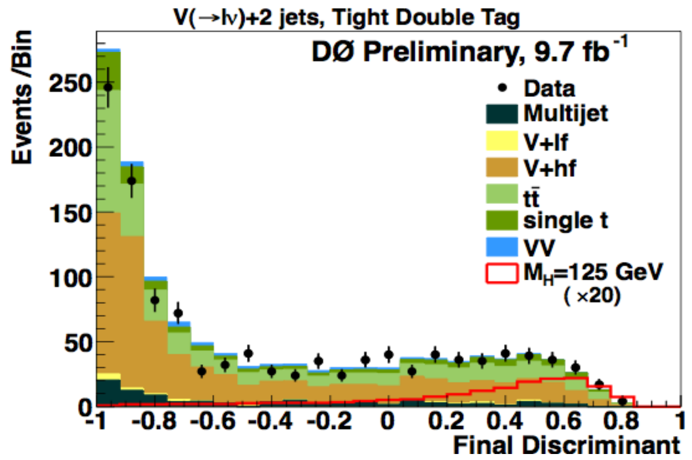
2 Loose b-tags



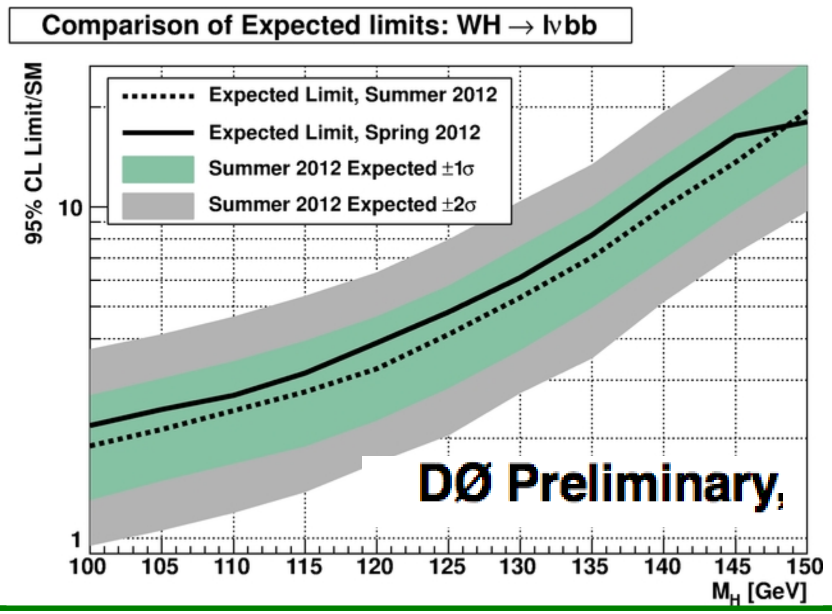
2 Medium b-tags



2 Tight b-tags

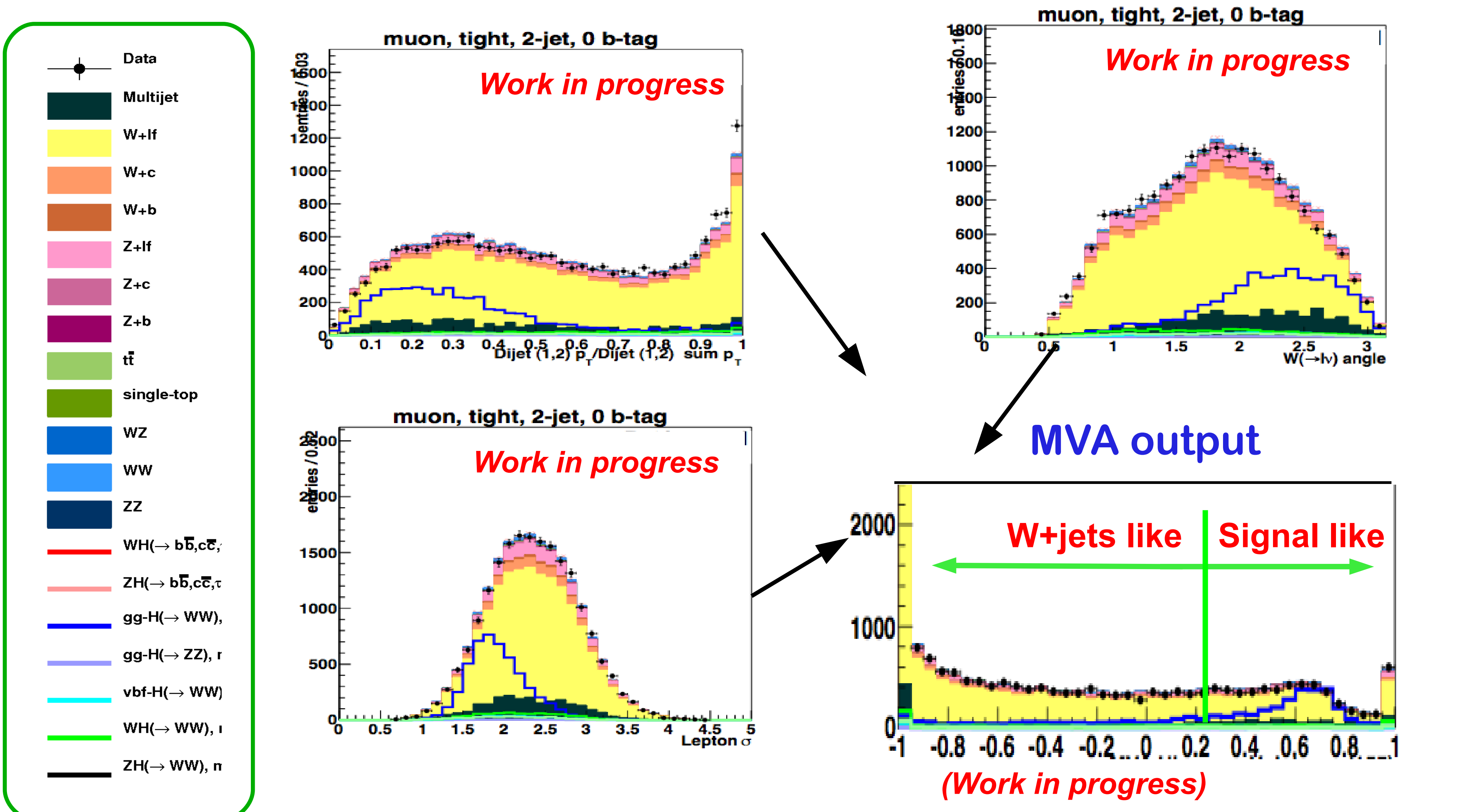


Separate the double b-tagged final states into three tagging categories (instead of two as before) contributes 6-10% improvements in expected limits



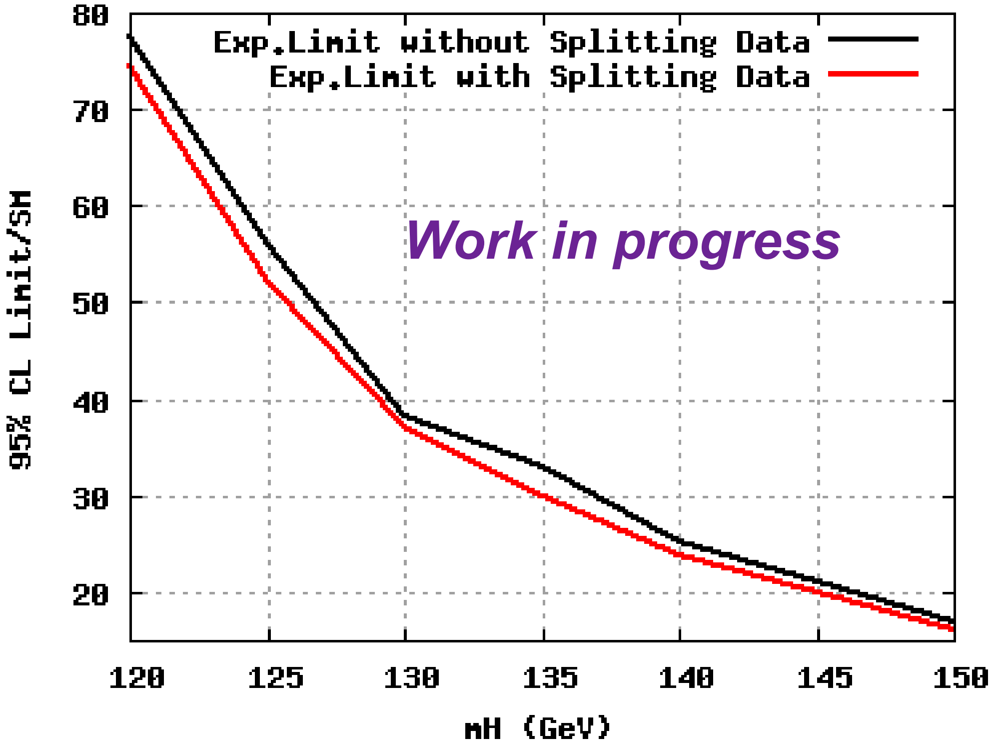
H→WW→ lνjj: Splitting data based on V+Jets bkg

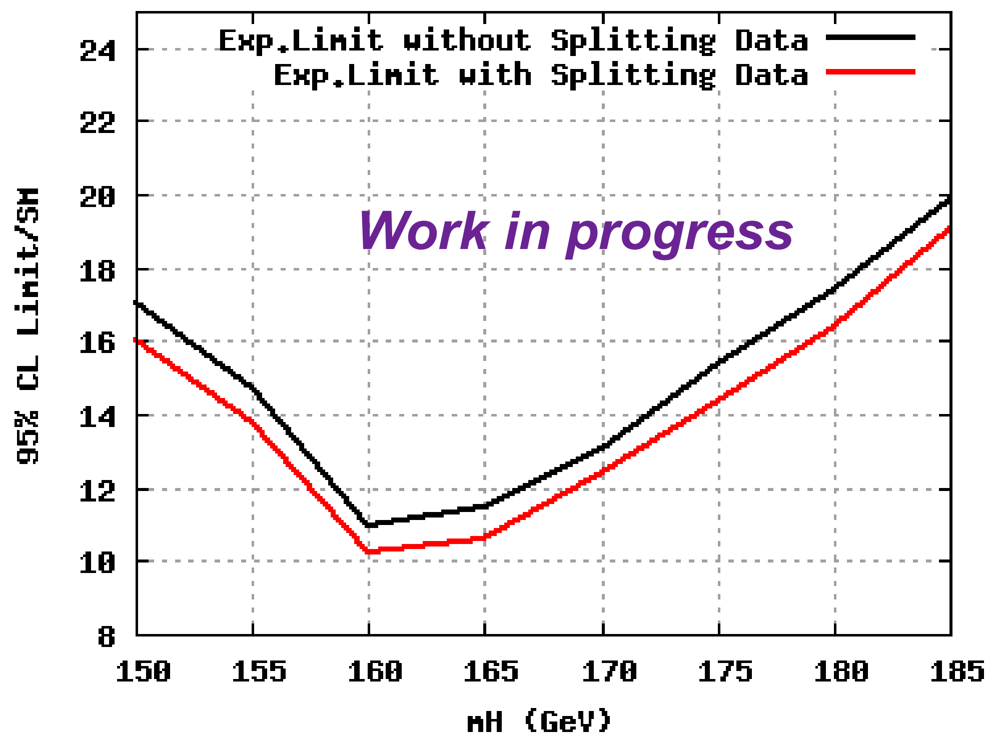
- Splitting the search sample into 2 regions: W+Jets-like and Signal-like



Improvement in Signal Sensitivity

- Splitting data into 2 orthogonal samples (W+Jets-like and Signal-like)
- Train MVA for each sample independently





Gain ~6% in signal sensitivity at all mass points by splitting the data based on W+Jets background*

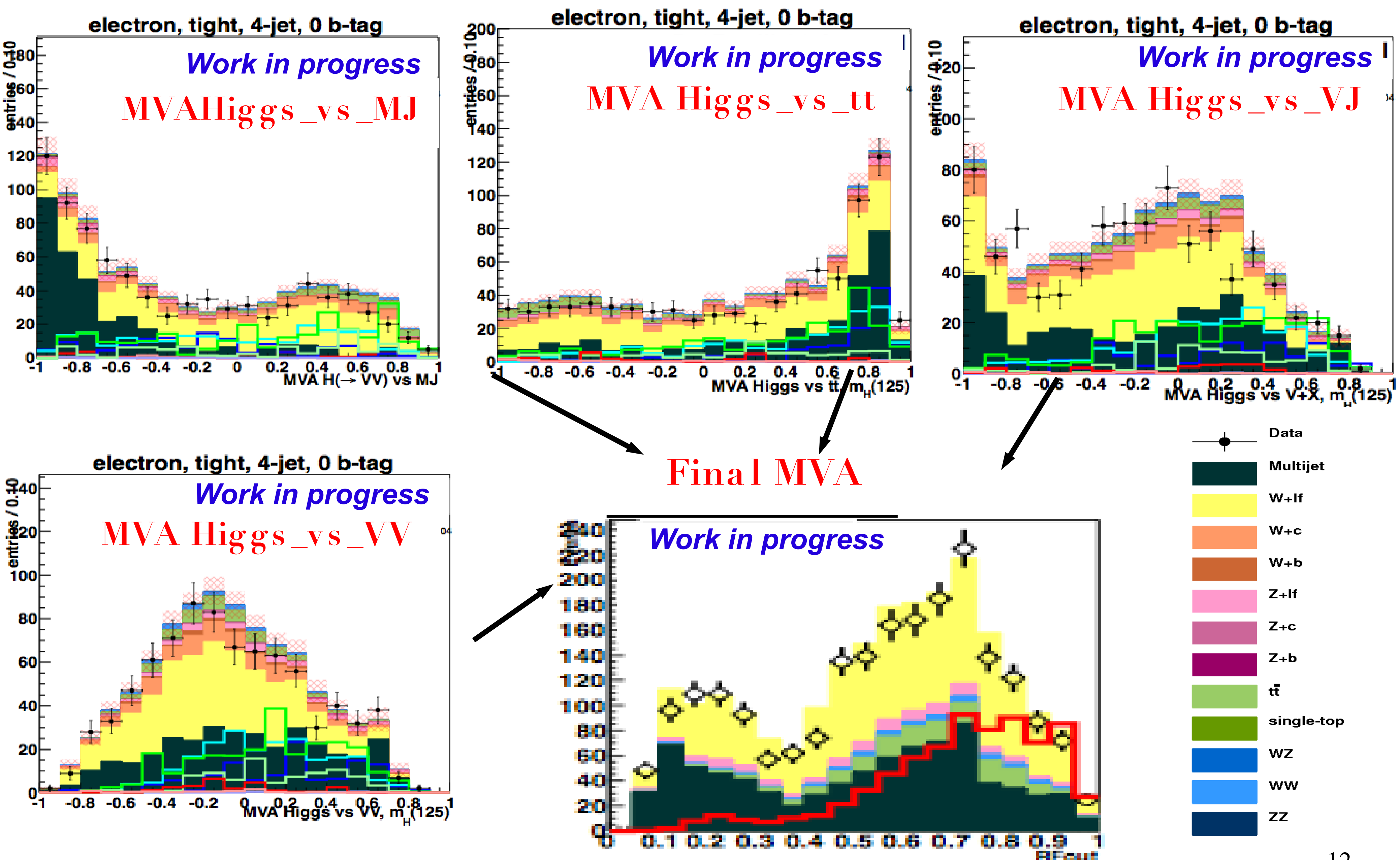
*Evaluated on small portion of full data set

$WH \rightarrow WWW \rightarrow l\nu jjjj$: Super MVA

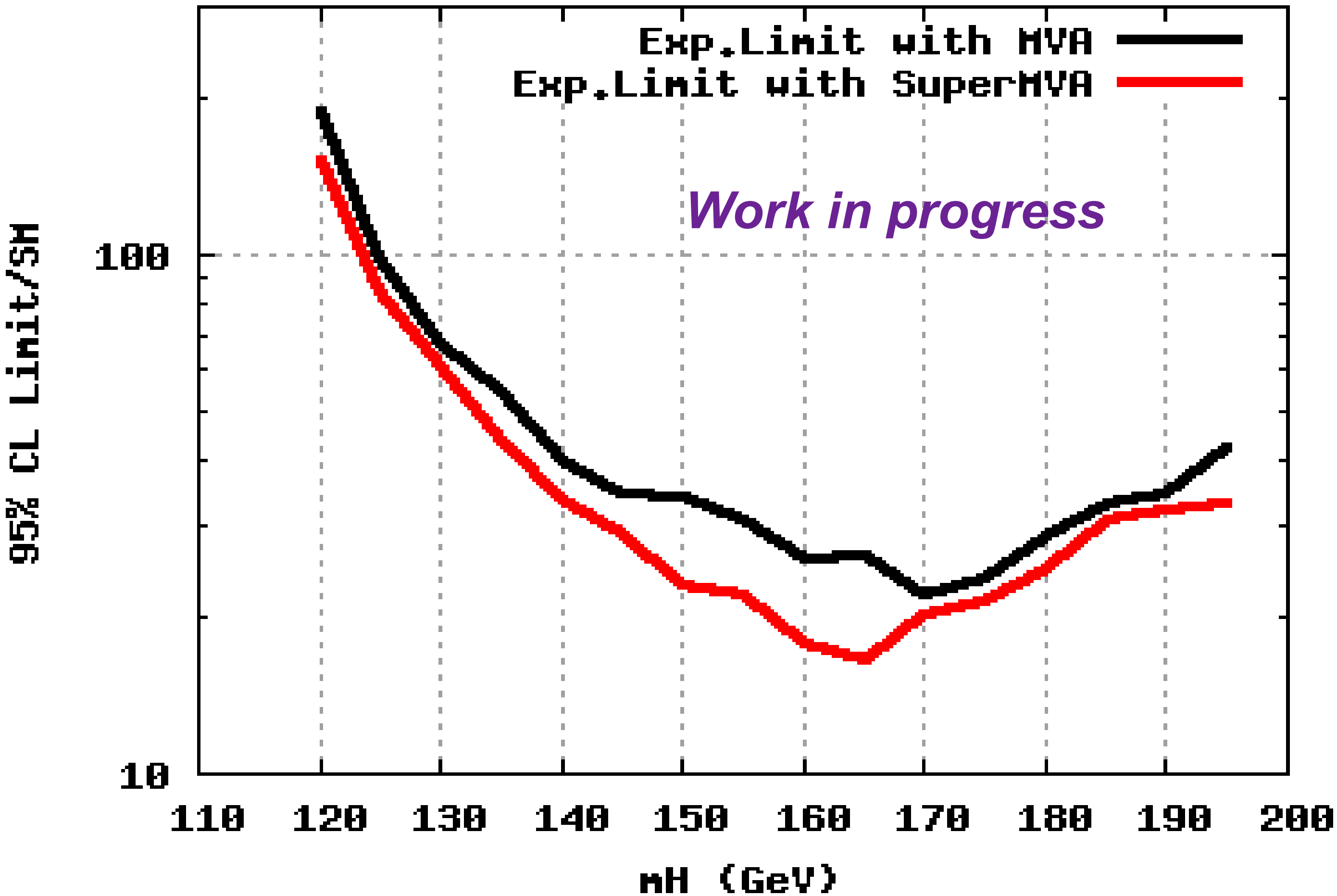
* Train MVA to discriminate signals from different groups of background
  - Higgs Signals vs. VJ (W+Jets, Z+ Jets)
  - Higgs Signals vs. VV (WW, ZZ, WZ)
  - Higgs Signals vs. MultiJets
  - Higgs Signals vs. $t\bar{t}$

* Individual MVA outputs are used as input variables for the Final MVA training

WH→WWW→ lνjjjj: Super MVA



Improvement in Signal Sensitivity



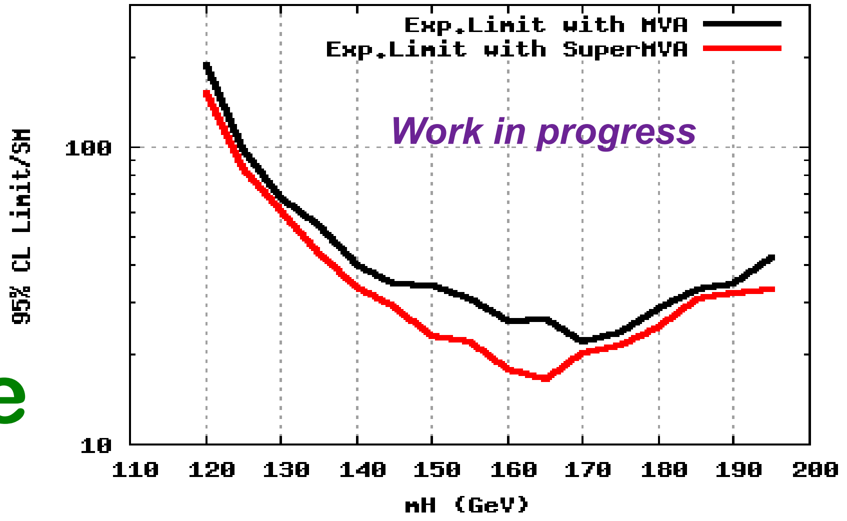
The primary results (using a subset of data) shows that SuperMVA technique improves the expected limit at mH=125 GeV is ~10%

*Evaluated on small portion of full data set

Summary

- Searching strategies for SM Higgs boson decays into **lvqq** final state

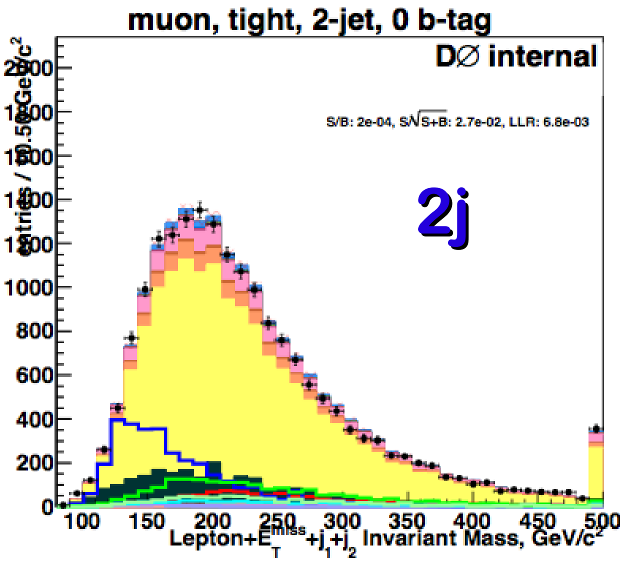
- Expected limits are improved by:
  - b-jets identification
  - Signal isolation
  - Super MVA technique

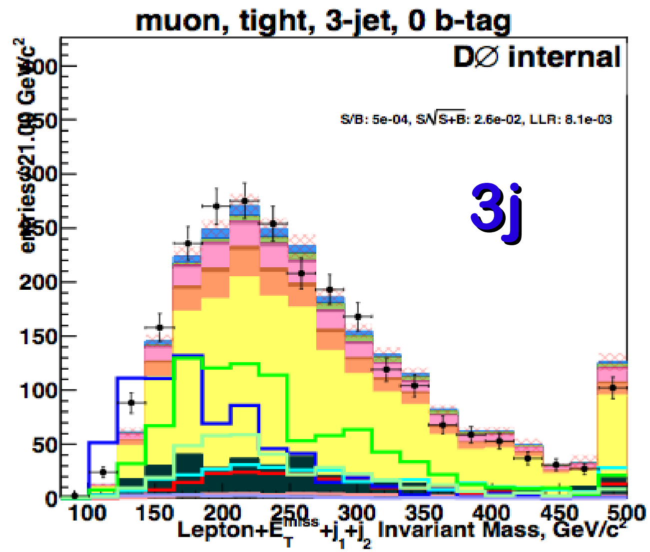


BACKUP

H→WW→ lν jj: Splitting data via Jet Multiplicity

Motivation: Bkgs composition and signal shape depend on the Jet multiplicity





New Variable for 3jets events

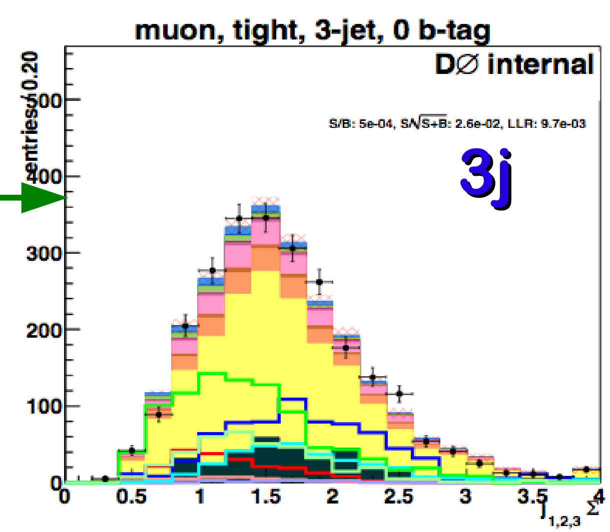
$$P_{j123} = P_{j1} + P_{j2} + P_{j3}$$

$$\Delta\theta^i = \Delta\theta(P_{ji}, P_{j123})$$

$$\Delta\varphi^i = \Delta\varphi(P_{j1}, P_{j123})$$

$$\Delta R^i = \sqrt{(\Delta\theta^i)^2 + (\Delta\varphi^i)^2}$$

$$J_{123}\_sigma = \frac{\sum_{i=1,2,3} \Delta R^i \times \left|P_{ji}^T\right|}{\sum_{i=1,2,3} \left|P_{ji}^T\right|}$$



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Triangular Cuts

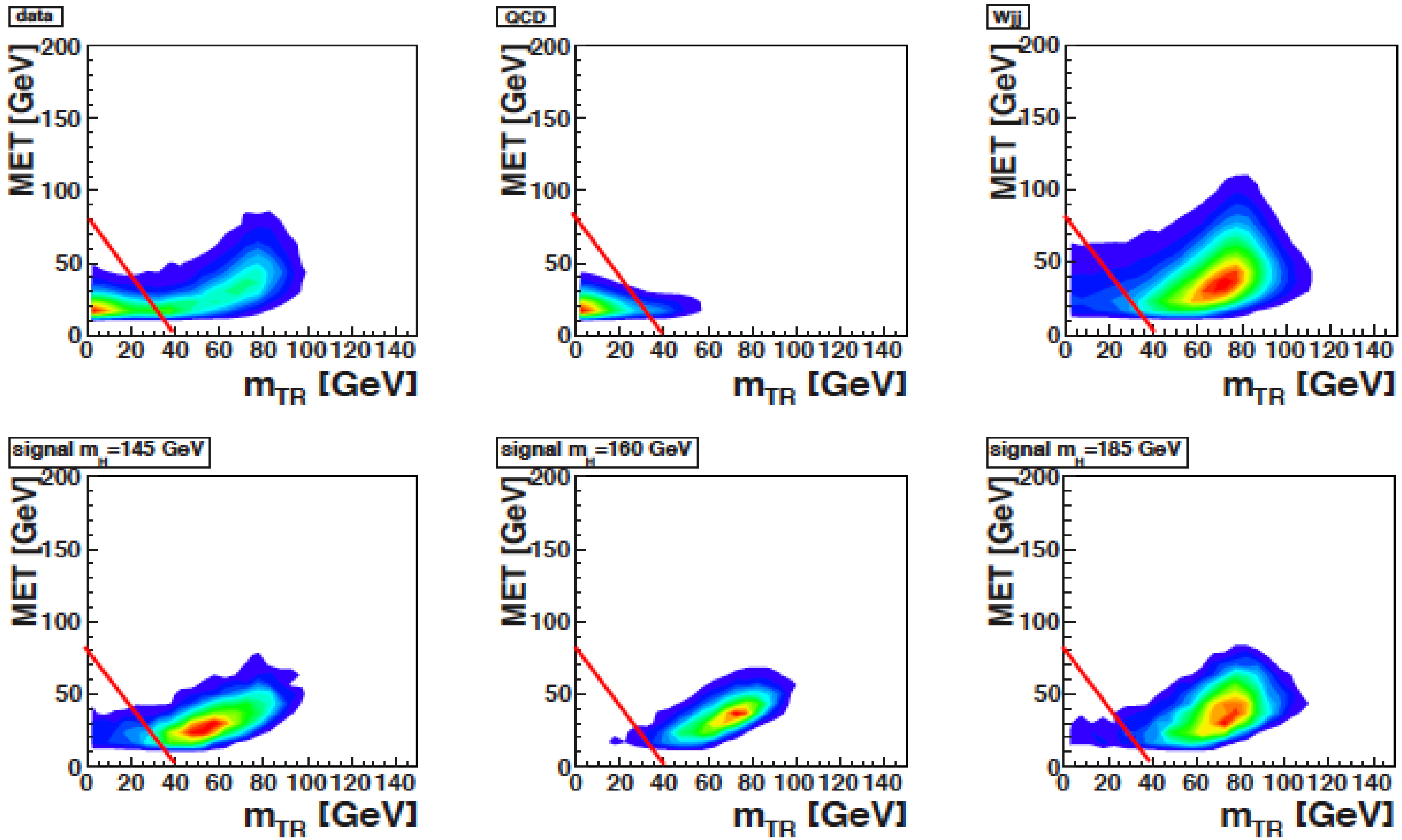

Figure 8: Relation between transverse mass and $\not\!\!E_T$ in the **p20 electron** channel for data (top left), QCD (top middle), $W + jets$ (top right), and three different Higgs signal masses, $m_H = 140$ GeV (bottom left), $m_H = 160$ GeV (bottom middle), and $m_H = 180$ GeV (bottom right).