Search for the SM Higgs Boson in lvqq Final States

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On the behalf of DØ Collaboration
The DØ detector

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

- Silicon Vertex Detector
- Scintillating Fiber Tracking
- LAr-U Compensating Calorimeter
- Muon System cover $|\eta| < 2$
The Higgs Production and Decay

Dominant Production at Tevatron

Main Decay Processes

\[ M_H < (\approx 135 \text{GeV}) \quad M_H > (\approx 135 \text{GeV}) \]
Search for the Higgs decays in $lvqq$ final state:

- $WH \rightarrow lvbb$
- $H \rightarrow WW \rightarrow lvjj$
- $WH \rightarrow WWW \rightarrow lvjjjj$

- Splitting data in orthogonal $b$-tagging samples
- Optimizing the search in each subchannels
Searching for Higgs in $lvqq$ Final State

**Signals**

- $WH \rightarrow lvbb$, $H \rightarrow WW \rightarrow lvjj$, $WH \rightarrow WWW \rightarrow lvjjjj$
- $ZH \rightarrow llbb$, $H \rightarrow ZZ \rightarrow lljj$, $ZH \rightarrow ZWW \rightarrow lljjjj$; $m_H = [90\text{GeV}, 200 \text{GeV}]$

**Signatures**

- Two High $P_T$ Jets
- One High $P_T$ Lepton
- Large MET

**Backgrounds**

- $W+\text{Jets}$, $Z+\text{Jets}$
- $WW$, $ZZ$, $WZ$
- Single-top, $t\bar{t}$
- MultiJets
B-Tagging: Separate b-jets and LF jets based on track and vertex information

Low Mass (m_H ≤150 GeV)

<table>
<thead>
<tr>
<th>Samples</th>
<th>2jet</th>
<th>3jet</th>
<th>4jet</th>
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</thead>
<tbody>
<tr>
<td>0tag</td>
<td>H→WW→lvjj</td>
<td>WWW→lvjjjj</td>
<td></td>
</tr>
<tr>
<td>1L</td>
<td>WH→lvjj</td>
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<tr>
<td>1T</td>
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<td>2M</td>
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High Mass (m_H >150 GeV)

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Tagging Categories:

- 2T: At least 2 Tight b-tagged jets
- 2M: At least 2 Med. b-tagged jets
- 2L: At least 2 Loose b-tagged jets
- 1T: Exact 1 tight b-tagged jet
- 1L: Exact 1 loose b-tagged jet
- 0tag: No signal

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

V+2 jets, 2 b-tags

Work in progress

2L  2M  2T

Data
- Multijet
- W+lf
- W+c
- W+b
- Z+lf
- Z+c
- Z+b
- tt
- single-top

Huong Nguyen, University of Virginia
WH → lvbb: Improvement in Signal Sensitivity

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

Separate the double b-tagged final states into three tagging categories (instead of two as before) contributes 6-10% improvements in expected limits.
• Splitting the search sample into 2 regions: W+Jets-like and Signal-like

Work in progress

MVA output

(Work in progress)
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
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. tt

Individual MVA outputs are used as input variables for the Final MVA training.
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
Motivation: Bkgs composition and signal shape depend on the Jet multiplicity

New Variable for 3jets events

\[ P_{j123} = P_{j1} + P_{j2} + P_{j3} \]

\[ \Delta \theta^i = \Delta \theta(P_{j1}, P_{j123}) \]

\[ \Delta \phi^i = \Delta \phi(P_{j1}, P_{j123}) \]

\[ \Delta R^i = \sqrt{ (\Delta \theta^i)^2 + (\Delta \phi^i)^2 } \]

\[ J_{123 - \text{sigma}} = \frac{\sum \Delta R^i \times |P_{j1}^i|}{\sum |P_{j1}^i|} \]
Figure 8: Relation between transverse mass and $E_T$ 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).