Search for the Higgs Boson in the $H \rightarrow WW \rightarrow e\nu\mu\nu$ Channel at DØ

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Outline

1. Introduction
2. Analysis Strategy
3. Limits on the Higgs Cross Section
4. Summary
The most important production process is gluon fusion with 0.1-2.0 pb.

The associated production and vector boson fusion are one order of magnitude smaller.
For masses $> 135\text{GeV}$ the decay into $W^+W^-$ is dominant.

The analysis covers a mass region from 115 to 200 GeV.

The $H \rightarrow WW \rightarrow e\nu\mu\nu$ Channel has the highest sensitivity for the high mass region $> 135\text{ GeV}$ and has an impact for lower masses as well!
$pp$ collisions at $\sqrt{s} = 1.96$ TeV

8.1 fb$^{-1}$ are used in the current analysis
Signature of the $H \rightarrow WW \rightarrow e\nu\mu\nu$ Signal

One isolated electron and one isolated muon with high transverse momenta and missing transverse energy (neutrinos).

Selection:

- One isolated electron and muon.
- $p_T^e > 15$ GeV
- $p_T^\mu > 10$ GeV
- $\Delta R(e, \mu) = \sqrt{\Delta \eta^2 + \Delta \phi^2} > 0.3$
- $M_T^{min} > 20$ GeV
- $M_T^2 > 15$ GeV
- Analysis split by number of jets.
Final Discriminant - Training of the Multivariate Technique

discriminating variables:
  - object kinematics: $p_T^l$, $p_T^{jet}$, ...
  - event topology: $M_{e\mu}$, $\Delta \phi_{e\mu}$, ...
  - b identification
  - lepton quality

As a final discriminant for signal and background random forests (RF) are used.

For each mass point (115, 120, 125, ..., 200 GeV) 3 RF were trained.
  - 0, 1 and 2 or more jets
**Final Selection**

0 jets, \( M_H = 165 \text{ GeV} \)

- Data
- \( Z+\)jets
- Diboson
- \( W+\)jets
- Multijet
- \( t\bar{t} \)bar
- Sig Tot

\( M_H = 165 \text{ GeV} \)

1 jet, \( M_H = 165 \text{ GeV} \)

- Data
- \( Z+\)jets
- Diboson
- \( W+\)jets
- Multijet
- \( t\bar{t} \)bar
- Sig Tot

<table>
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<th>jets</th>
<th>data</th>
<th>sum bkgd</th>
<th>( H_{165} )</th>
<th>( tt )</th>
<th>diboson</th>
<th>( W+)jets</th>
<th>( Z+)jets</th>
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<td>0</td>
<td>881</td>
<td>949 ± 119</td>
<td>15.7</td>
<td>12.2</td>
<td>436</td>
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<td>1</td>
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<td>244 ± 38</td>
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<tr>
<td>2+</td>
<td>214</td>
<td>207 ± 30</td>
<td>3.0</td>
<td>174.5</td>
<td>7.7</td>
<td>21.0</td>
<td>3.6</td>
<td>0.1</td>
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No signal is observed.

A limit on the cross section is derived for each mass point using the modified frequentist method $\text{CL}_S$.

Best sensitivity for a SM Higgs boson mass of 165 GeV.

Exp. (Obs.): $1.31 \ (1.10) \times \text{SM}$
When combining the three most sensitive "high mass" channels ($H \rightarrow WW \rightarrow e\nu e\nu/e\nu\mu\nu/\mu\nu\mu\nu$) we are able to exclude a mass region for the SM Higgs boson at 95% CL.

- Expected exclusion 159 to 169 GeV.
- Observed exclusion 162 to 170 GeV.
DØ \((H \rightarrow WW)\) Combination: Upper Limits for the 4th Generation Model

Taking into account a model with a 4th generation of quarks leads to a higher gluon fusion cross section due to additional loops.

In this model the gluon fusion cross section is enhanced by a factor of 7 to 9.

The multivariate technique is retrained on gluon fusion signal only.

An exclusion of a Higgs boson in this model is obtained for masses between 140 GeV and 240 GeV at 95% CL.

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An exclusion of a Higgs boson in this model is obtained for masses between 140 GeV and 240 GeV at 95% CL.
The current $H \rightarrow WW \rightarrow l\nu l\nu$ analyzes are based on 8.1 fb$^{-1}$ of data.

The final dataset of the DØ experiment will about 10 fb$^{-1}$.

The additional data corresponds to 10-15% gain in sensitivity.

We expect to perform better than scaling with luminosity due to further improvements in analysis techniques.

The focus of our optimization is on the low Higgs masses.

These are very interesting times for Higgs searches. We may get an answer to an idea that has come up in the sixties soon.