Tevatron Results on SM Higgs Search in the High Mass Region

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On behalf of the CDF and D0 Collaborations
Lathuile 2012, La Thuile, Italy
February 27-March 3, 2012

Outline

● Search Foundation and Higgs detection modes
● CDF and D0 detection methods in High Mass
● Results, implications, next steps
Higher Physics Reach

Jet

Δm_s = 17.77 ± 0.10 ± 0.07

Build on mountain of measurements
SM Higgs Production and Decay

Gluon Fusion
(dominates)

Associated production

Vector Boson Fusion

- Trigger: 1 High Pt e or \( \mu \)
- Focus on Decays: \( WW \rightarrow ee, e\mu, \mu\mu, e\tau, \mu\tau + \nu\)’s
- Separate channels by dileptons (D0), \( N_{\text{jets}} \)
- Event Selection: High Pt Leptons, Missing \( E_T \)
HWW Production Features

- High Pt Leptons not back to back
- Spin 0 Higgs correlates spins of leptons: charged leptons (low $\Delta\phi_{ll}$), two neutrinos (High MET) tend to be closely aligned with one another.
Dileptons, Iso p_t > 15, 10 GeV/c

BDT or M_t(eµ) (0, 1, ≥2 Jet)

BDT 58 H^0

Z/γ

M_{ll}

Diboson

0J

1J

≥2J

Z/γ

ee

eµ

µµ

M_t = 165 GeV

Diboson

Z/γ
CDF Improvements

- 0,1 jet: $M_H$-dependent optimization of NN variables
- ≥2 jet: Alpgen model: use $M_{jj}$ for WH-$\rightarrow l\nu l\nu jj$ and rapidity diff for VBF.
- $M_{ll}<16$ GeV/c$^2$:
  - MadGraph $W\gamma$: $\Delta R \geq 0.1$ (was 0.2): 8.5% more Higgs at $M_H=160$ GeV/c$^2$
  - MadGraph Jets +Z: Better modeling of Drell Yan

Control Region: $15<\text{MetSpec}<25$ GeV
CDF 9.7 fb$^{-1}$ Expect 67 Signal Events → Total W/D0: 125

Fit Background

Search H

Improved

CDF Run II Preliminary

OS 0 Jets, High S/B
$M_H = 165$ GeV/c$^2$

$0J$

WW

S:31

$1J$

Hx10

S:18

CDF Run II Preliminary

OS 2+ Jets
$M_H = 165$ GeV/c$^2$

$>1 J$

tt

Hx10

S:14

CDF Run II Preliminary

OS 1 Jet, High S/B
$M_H = 165$ GeV/c$^2$

$1J$

WW

S:18

0,1 J

$M_{H} < 16$

WW

S:4
Control Region: Determine systematics, measure background rates:

- $W$+jet: $\Delta\phi_{l\tau} > 2$
- QCD: MET < 20 GeV
- DY $Z(\tau\tau)$: $\Delta\phi_{ll,MET} < 0.5$

Expected Signal: CDF $e,\mu$, 2.4; D0$\mu$: 5.3
Same sign Dileptons (CDF/D0), Trileptons (CDF)

No Rate? Too Low? No!

Different Channel
Different Systematics
Different Background

- Same Sign dileptons, Improved (CDF): optimized training:
  - WH
  - ZH
- Trileptons:
  - WH
  - ZH
- NEW (CDF): $l_1\tau_{\text{hadronic}}$: 

SameSign

Trileptons: $ll\tau$

S: 3.1

Low, Different Background (WZ)

Improved

S: 0.5

New

S: 0.36

ZHx10

S: 1.3

WHx10
H$\rightarrow$ZZ$^\ast$\rightarrow4l

- Four leptons, $p_T > 20, 10, 10, 10$ GeV/c
- $gg\rightarrow H\rightarrow ZZ$, $ZH\rightarrow ZWW\rightarrow ll l^\nu l^\nu$
- Bin in MET to see ZWW; 2d fit.

Improved

S:0.41 @150
CDF 9.7 fb$^{-1}$

- 8.2 – 9.7 fb$^{-1}$: 8.5% better
- 2Jet, $M_{ll} \leq 16$ GeV/c$^2$, $\tau$ trilepton, ZZ with MET, optimized $M_H$-dependent training on 0,1Jet
- All together: 12% better @165!
- CDF Sensitivity close to TeV sensitivity in July 2011.

New DØ Result, New Tev soon

CDF Run II Preliminary

- 148-180 GeV/c$^2$


SM Exclusion: 156-177 GeV/c$^2$

Summary

- “No channel too small” strategy successful: different, backgrounds, systematics, S/B and many channels.
- Combined Tevatron results coming next week. Up to now exclude the Standard Model Higgs at 95% CL for $156 \leq M_H \leq 177$ GeV/c$^2$.

<table>
<thead>
<tr>
<th>$M_H$ (GeV/c$^2$)</th>
<th>8.2 fb$^{-1}$</th>
<th>9.7 fb$^{-1}$</th>
<th>Improvement</th>
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<tr>
<td></td>
<td>Expected $\sigma/\sigma_{SM}$</td>
<td>Observed $\sigma/\sigma_{SM}$</td>
<td>Expected $\sigma/\sigma_{SM}$</td>
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<td>125</td>
<td>3.38</td>
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<td>165</td>
<td>0.78</td>
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CDF High Mass Higgs limits for Feb/March 2011

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<th>110</th>
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<td>5.39</td>
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<td>$+1\sigma/\sigma_{SM}$</td>
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