Prospects for SM Higgs at LHC at 7 TeV and Beyond

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(on behalf of the ATLAS and CMS Collaborations)

Higgs Hunting 2011, Orsay
29th July 2011
ATLAS Limits:
- Excess of events at (120 - 140 GeV) significance of \( \simeq 2.8 \sigma \).
- Excluded regions at 95% CL
  \[ 155 < m_H < 190 \text{ GeV and } 295 < m_H < 450 \text{ GeV} \]

CMS Limits (see next talk)
What Next?

- Still work needed to find and measure properties of SM Higgs or completely exclude it.
- How can we improve on existing limits?

- Luminosity
- Improve existing channels
- Add extra channels
- Increase beam energy

Also theory improvements:
Presently $\sim 17\%$ error on theory (for $gg \rightarrow H$).
Not a major factor on limits but improvements welcome.
\[ \simeq 1.5 \text{ fb}^{-1} \text{ taken so far (1.1 fb}^{-1} \text{ used for data analysis)} \]

4 fb\(^{-1}\) expected by end of year

Probably have \(> 10 \text{ fb}^{-1}\) expected by end of run 2012

Also possible increase in beam energy for 2012
Improving Existing Channels

- Expect improved systematics due to better understanding of detector and improved statistics of calibration channels
- Improve some channels with multi-variant techniques
- Other improvements possible:

**Example 1** $VH \rightarrow bb$: Can improve $S/B$ by asking for high $P_T$ $W$ or $Z$

$bs$ close together ⇒ reconstruct using sub-jet analysis

Data (1 $fb^{-1}$)  
(Boosted 30 $fb^{-1}$)

![Graphs showing data and boosted signal events](image)
Example 2 $H \rightarrow \gamma\gamma$: Improve $S/B$ by jet or $W$ tagging

### Inclusive

![Inclusive Graph](image)

### 1 lepton + MET

![MET Graph](image)

### 1 jet

![1 Jet Graph](image)

### 2 jets

![2 Jets Graph](image)
Adding Extra Channels

Some channels are yet to be included:

- \( H \rightarrow \tau\tau \) (VBF) - ATLAS

- \( H \rightarrow bb \) (VH) - CMS
- \( H \rightarrow bb \) (ttH) - ATLAS+CMS
- \( H \rightarrow WW \) (VH, VBF) - ATLAS+CMS

N.B. There may be other useful channels that are yet to have a MC study
New channels improved sensitivity at low mass.

Similar channels investigated by ATLAS with similar limits
- Expected Sensitivity - Combined

ATLAS Limits with all channels combined

**Exclusion**

- 95% CL limit on $\sigma/\sigma_{SM}$

**Observation**

- Median sensitivity

- 3$\sigma$ projections, $\sqrt{s}=7$ TeV

- Projections, $\sqrt{s}=7$ TeV

- 0.5 fb, 1 fb, 2 fb, 5 fb

- TeVatron, LEP

- ATLAS Preliminary (Simulation)

- Exclusion possible even at low mass with 5 fb$^{-1}$

- 3$\sigma$ evidence possible at all but lowest and highest masses at 5 fb$^{-1}$
Expected Sensitivity - Combined

Limits from CMS alone with all channels combined

- $3\sigma$ evidence possible at all but lowest and highest masses at 5 fb$^{-1}$ (same conclusion as for ATLAS)
- $3\sigma$ evidence possible at all masses with 10 fb$^{-1}$
- $5\sigma$ discovery possible at some masses
Possible to increase beam energy to 8 or 9 TeV in 2012
- Higgs $\sigma$ increases up to $\times 2$ at high mass for 9 TeV
- Increase only 1.3 for low mass at 8 TeV
- Most backgrounds increase more slowly than Higgs, but not $t\bar{t}$!
- For future running we expect $\sqrt{s} = 14$ TeV
Beam energy increase reduces luminosity required for discovery at high mass

Not so important at low mass, but every little helps!
Even higher energy

Going to 9 TeV means we need even less lumi
Potential for ATLAS/CMS combination at $\sqrt{s} = 8$ TeV

<table>
<thead>
<tr>
<th></th>
<th>5 fb$^{-1}$</th>
<th>10 fb$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>95% exclusion</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>$3\sigma$</td>
<td>Any</td>
<td>Any</td>
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<tr>
<td>$5\sigma$</td>
<td>120-500 GeV</td>
<td>Any</td>
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</tbody>
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Conclusions

- Major work undertaken by both collaborations to produce SM Higgs limits with 1 fb$^{-1}$ of data

- Limits can be improved by reducing systematics and optimizing selections

- Further gain can be made by adding more channels

- Biggest gain will be made by increased luminosity

- Further improvements if LHC can run at higher beam energy

- Combining ATLAS and CMS should have a 5$\sigma$ discovery potential with 10 fb$^{-1}$ of data per experiment at $\sqrt{s} = 8$ TeV over entire mass range