

Prospects for SM Higgs at LHC at 7 TeV and Beyond

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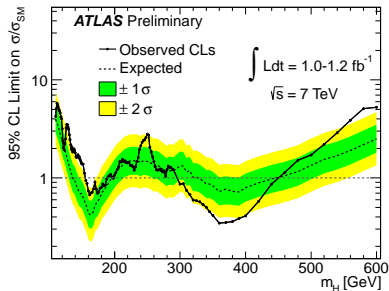
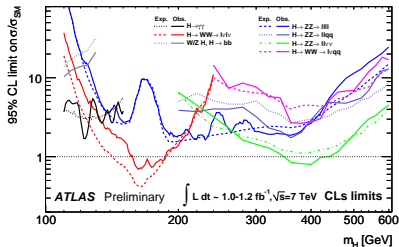
(on behalf of the ATLAS and CMS Collaborations)



Higgs Hunting 2011, Orsay
29th July 2011



Current Status



● 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?

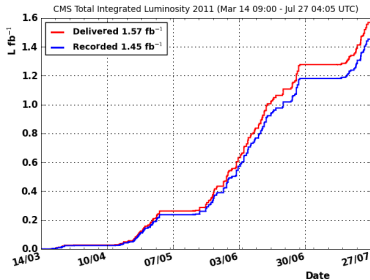
- Still work needed to find and measure properties of SM Higgs or completely exclude it.
- How can we improve on existing limits?
 - Luminosity
 - Improve existing channels
 - Add extra channels
 - Increase beam energy

Also theory improvements:

Presently $\sim 17\%$ error on theory (for $gg \rightarrow H$).

Not a major factor on limits but improvements welcome.

Integrated Luminosity

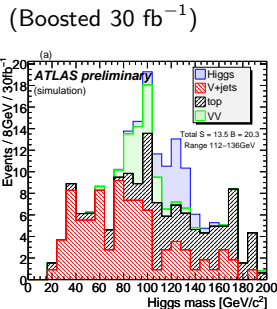
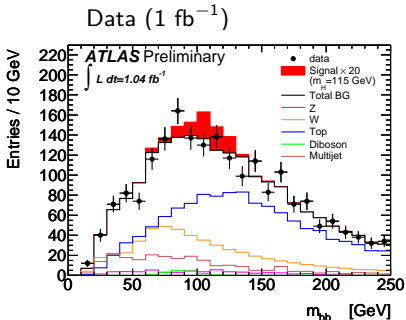


- $\simeq 1.5 \text{ fb}^{-1}$ taken so far (1.1 fb^{-1} used for data analysis)
- 4 fb^{-1} expected by end of year
- Probably have $> 10 \text{ fb}^{-1}$ expected by end of run 2012
- Also possible increase in beam energy for 2012

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:

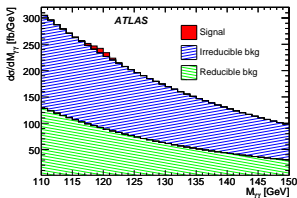
Example 1 $VH \rightarrow bb$: Can improve S/B by asking for high P_T W or Z bs close together \Rightarrow reconstruct using sub-jet analysis



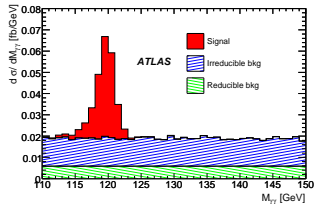
Improving Existing Channels

Example 2 $H \rightarrow \gamma\gamma$: Improve S/B by jet or W tagging

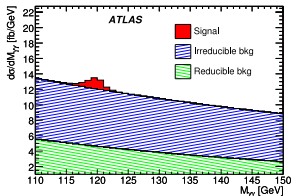
Inclusive



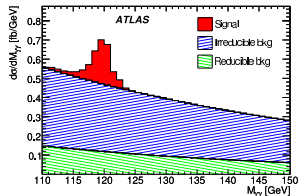
1 lepton + MET



1 jet



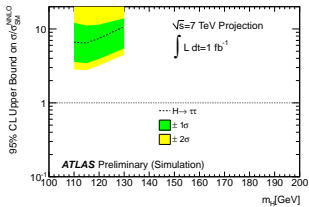
2 jets



Adding Extra Channels

Some channels are yet to be included:

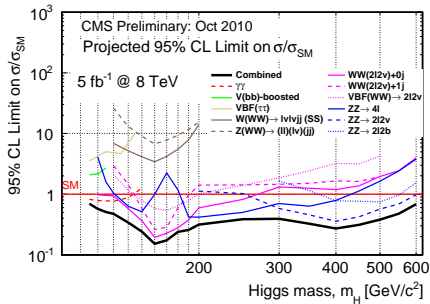
- $H \rightarrow \tau\tau$ (VBF) - ATLAS



- $H \rightarrow bb$ (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

Expected Sensitivity -Channels



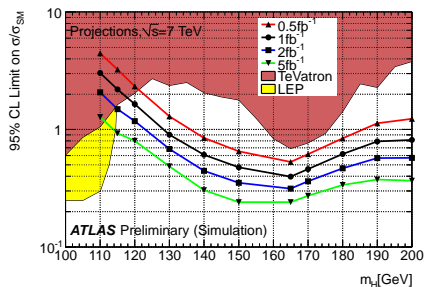
Channels included	Higgs mass range used in analyses (GeV)
H \rightarrow $\gamma\gamma$	115-150
VBF H \rightarrow $\tau\tau$	115-145
VH, H \rightarrow bb (highly boosted)	115-125
VH, H \rightarrow WW \rightarrow $l\nu jj$	130-200
H \rightarrow WW \rightarrow 2l2v + 0/1 jets	120-600
VBF H \rightarrow WW \rightarrow 2l2v	130-500
H \rightarrow ZZ \rightarrow 4l	120-600
H \rightarrow ZZ \rightarrow 2l2v	200-600
H \rightarrow ZZ \rightarrow 2l2b	300-600

- New channels improved sensitivity at low mass.
- Similar channels investigated by ATLAS with similar limits

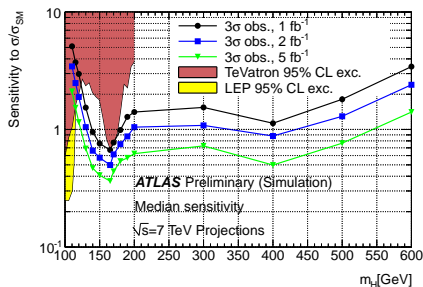
Expected Sensitivity - Combined

ATLAS Limits with all channels combined

Exclusion



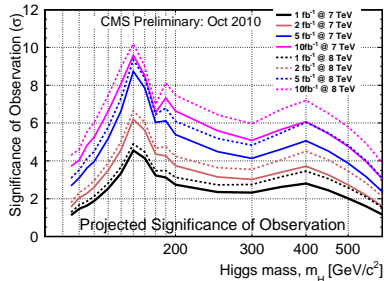
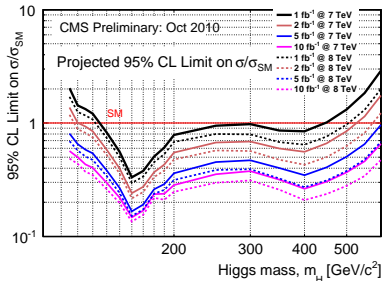
Observation



- Exclusion possible even at low mass with 5 fb⁻¹
- 3 σ evidence possible at all but lowest and highest masses at 5 fb⁻¹

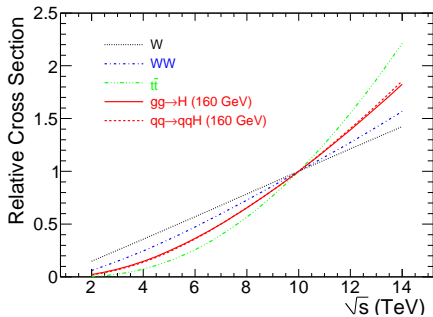
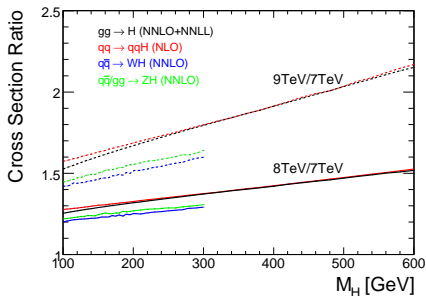
Expected Sensitivity - Combined

Limits from CMS alone with all channels combined



- 3σ evidence possible at all but lowest and highest masses at 5 fb^{-1} (same conclusion as for ATLAS)
- 3σ evidence possible at all masses with 10 fb^{-1}
- 5σ discovery possible at some masses

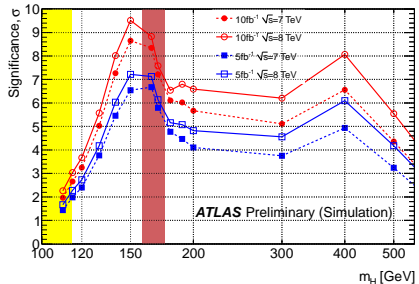
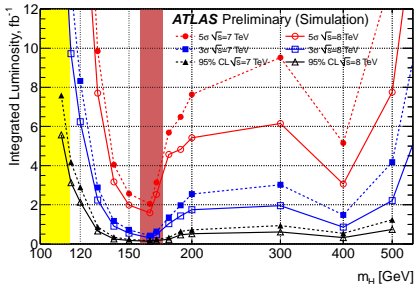
Increase of Beam Energy



- Possible to increase beam energy to 8 or 9 TeV in 2012
- Higgs σ 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

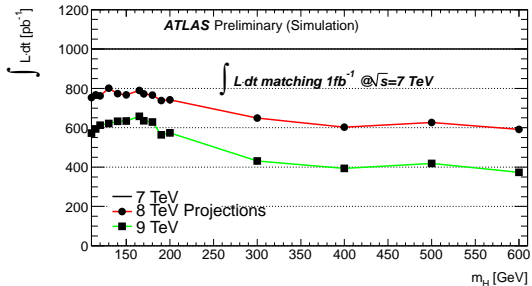
Increase of Beam Energy

Lumi/significance for different beam energies



- 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

ATLAS CMS Combination

Potential for ATLAS/CMS combination at $\sqrt{s} = 8$ TeV

	5 fb^{-1}	10 fb^{-1}
95% exclusion	Any	Any
3σ	Any	Any
5σ	120-500 GeV	Any

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 5σ discovery potential with 10 fb^{-1} of data per experiment at $\sqrt{s} = 8 \text{ TeV}$ over entire mass range