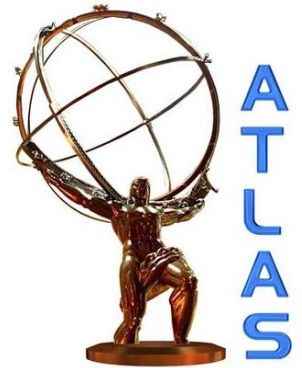
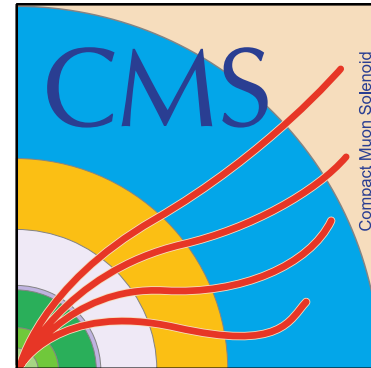


Higgs Searches at the LHC


Jake Anderson

Fermilab

on behalf of the CMS and ATLAS collaborations



- ✿ 2011 LHC run
- ✿ CMS and ATLAS
- ✿ Overview and motivations
- ✿ Higgs searches
 - $H \rightarrow WW \rightarrow \ell \nu jj$
 - $H \rightarrow WW \rightarrow \ell \nu \ell \nu$
 - $H \rightarrow ZZ \rightarrow 4\ell$
 - $VH \rightarrow (\ell \nu, \ell \ell, \nu \nu) b \bar{b}$
 - $H \rightarrow \gamma \gamma$
- ✿ Combined results
- ✿ Summary and outlook for 2012




45th Fermilab Users Meeting
June 12-13, 2012
Ramsey Auditorium, Fermilab

Showcasing recent experimental results in collider, astroparticle, and neutrino physics and presentations on future projects. Featuring talks and posters from outstanding young physicists.

Information & registration
www.fnal.gov/orgs/fermilab_users.org/users_mtg/2012

Public Lecture
 June 12 @ 8 pm
Dr. David Gross, 2004 Nobel Laureate

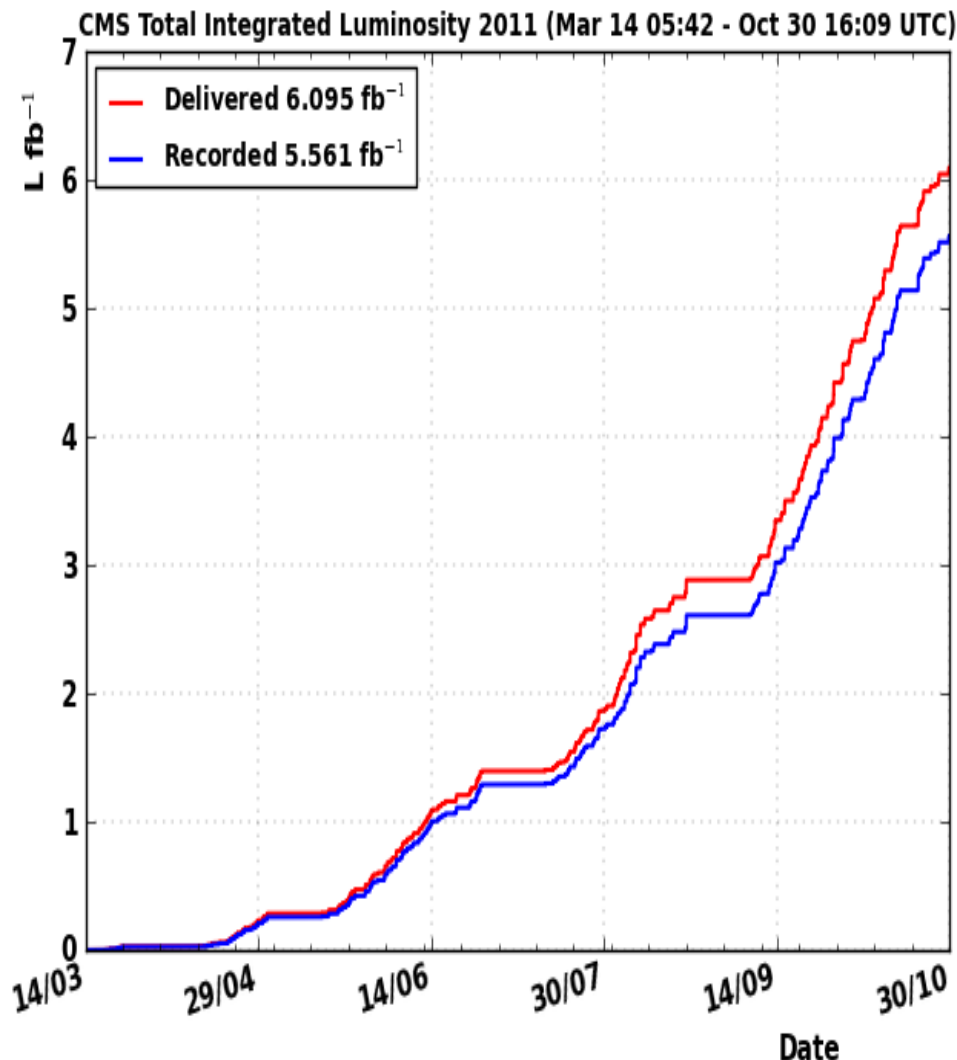
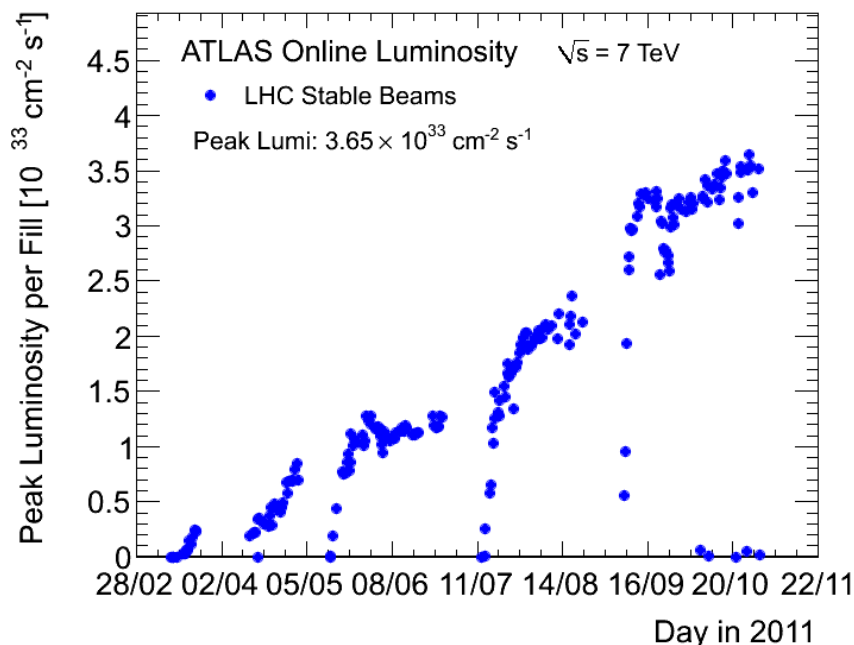
In conjunction with the Tevatron Impact Symposium on June 11



Fermilab ENERGY Office of Science Fermilab UEC Fermilab Research Alliance

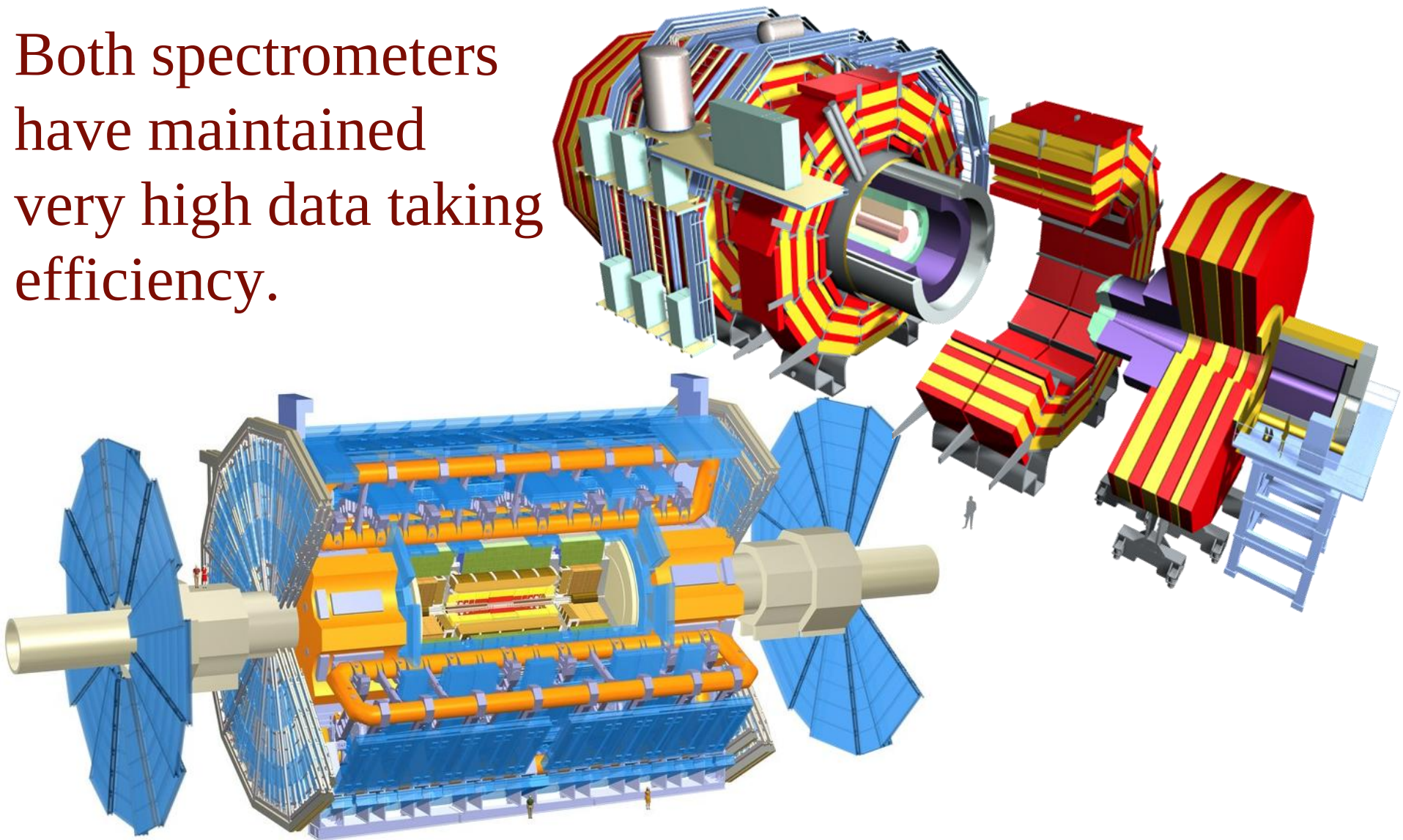
2011 LHC performance

- ✿ During 2011 the LHC performed extremely well.
 - delivered: $> 6 \text{ fb}^{-1}$
 - recorded: $> 5 \text{ fb}^{-1}/\text{experiment}$
- ✿ Luminosity (and pile-up) steadily increased throughout the year.

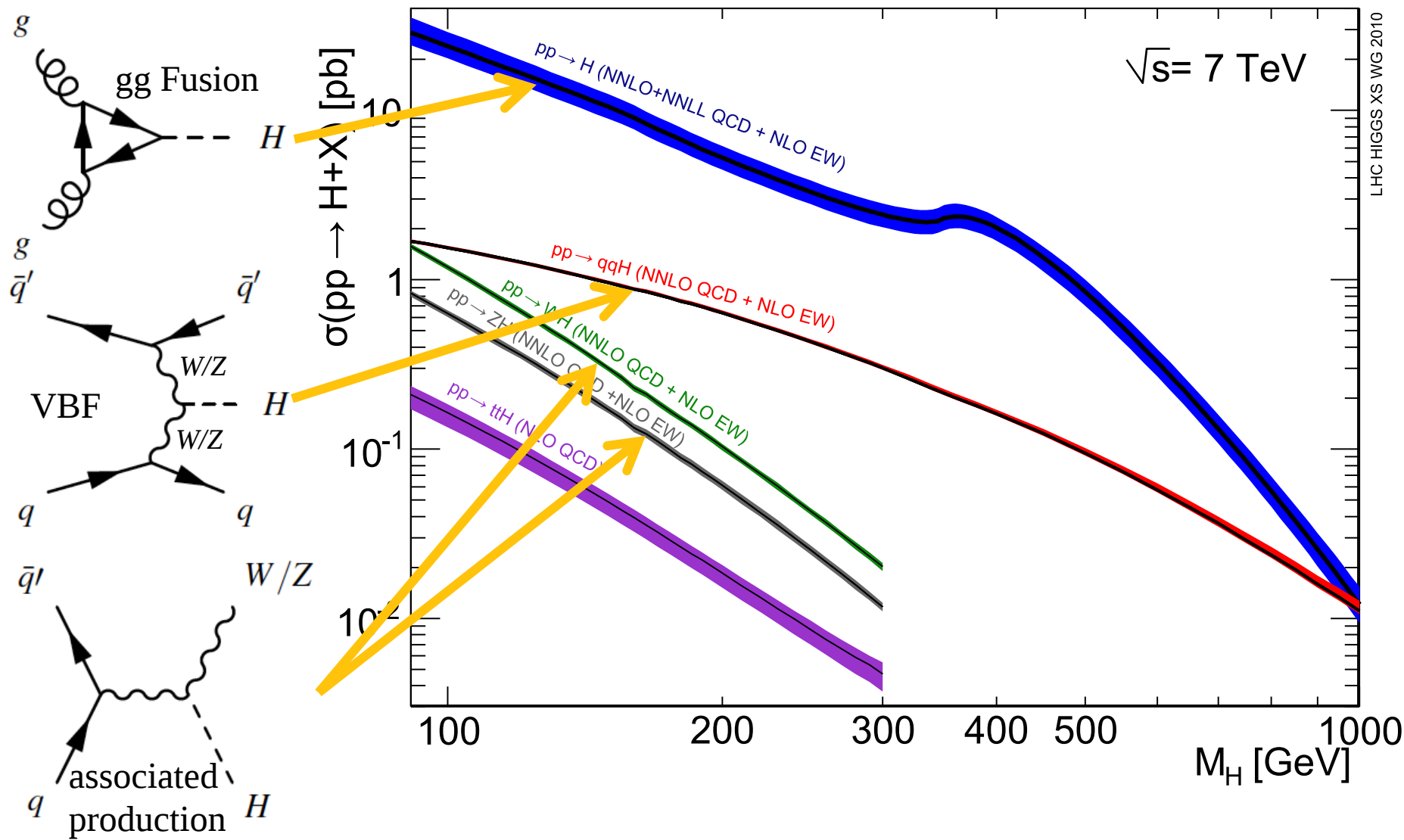


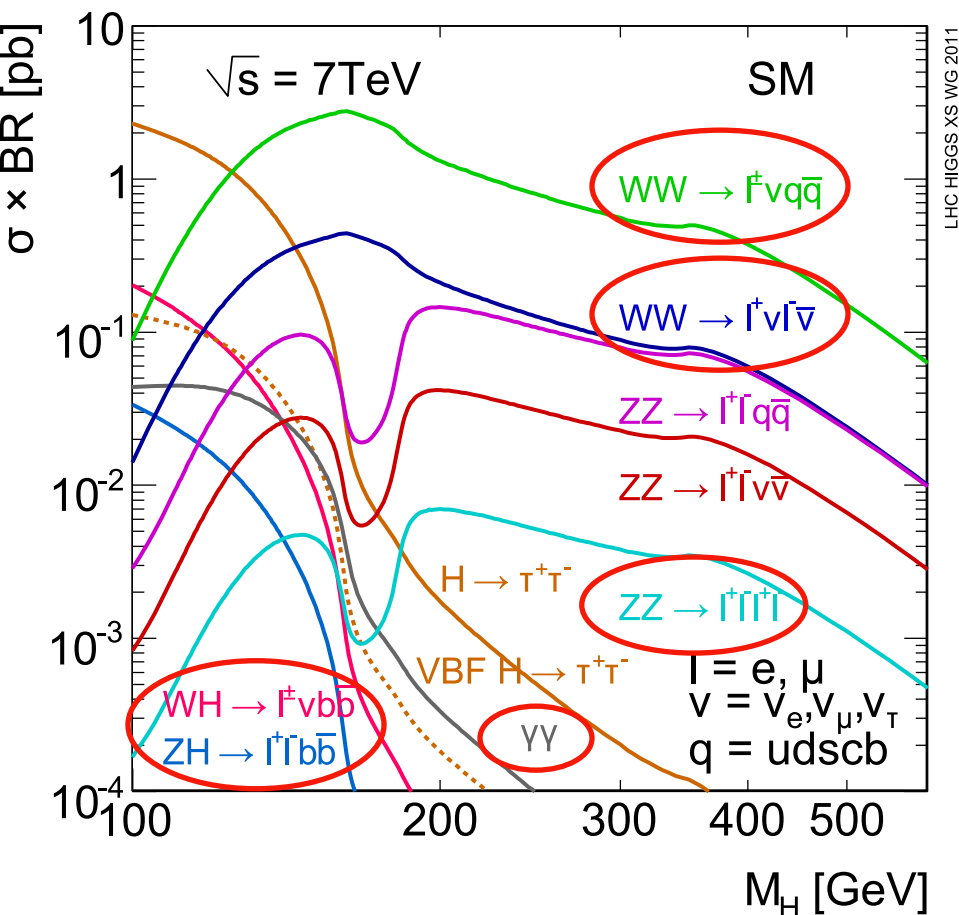
The CMS and ATLAS detectors

Both spectrometers have maintained very high data taking efficiency.



Higgs production





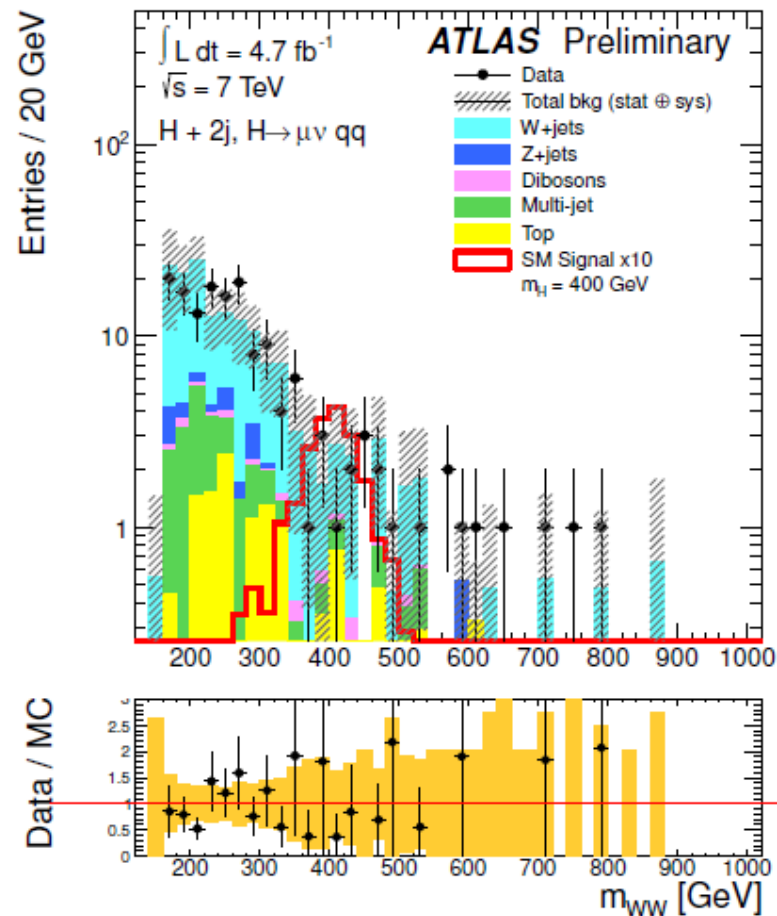
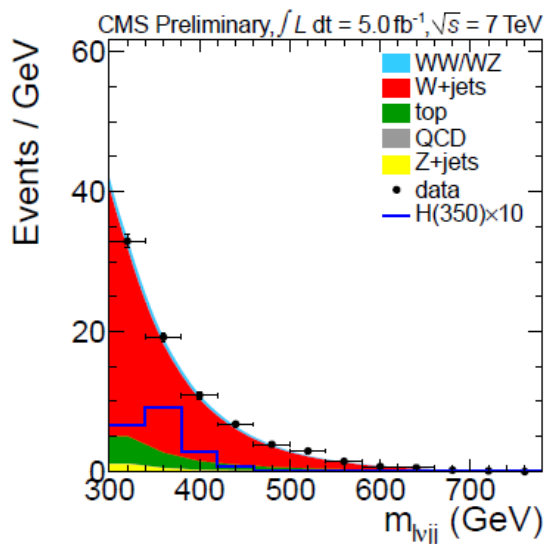
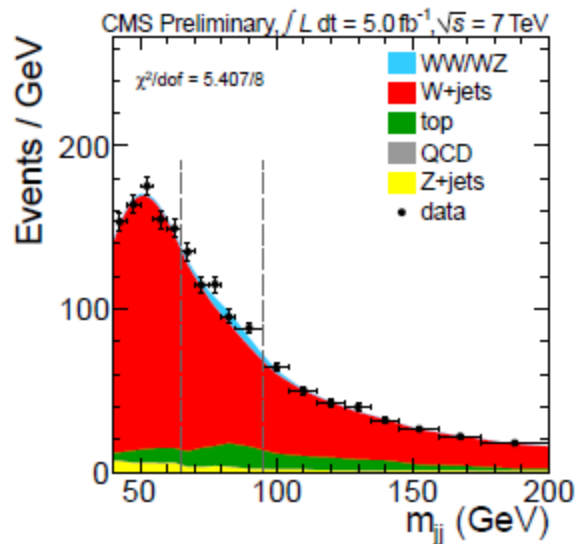
- ✿ There is not time to cover all the results on Higgs produced by CMS and ATLAS.
- ✿ I summarize some of the results.
- ✿ For a more complete list and treatment of results, please see:

<https://twiki.cern.ch/twiki/bin/view/AtlasPublic/HiggsPublicResults>

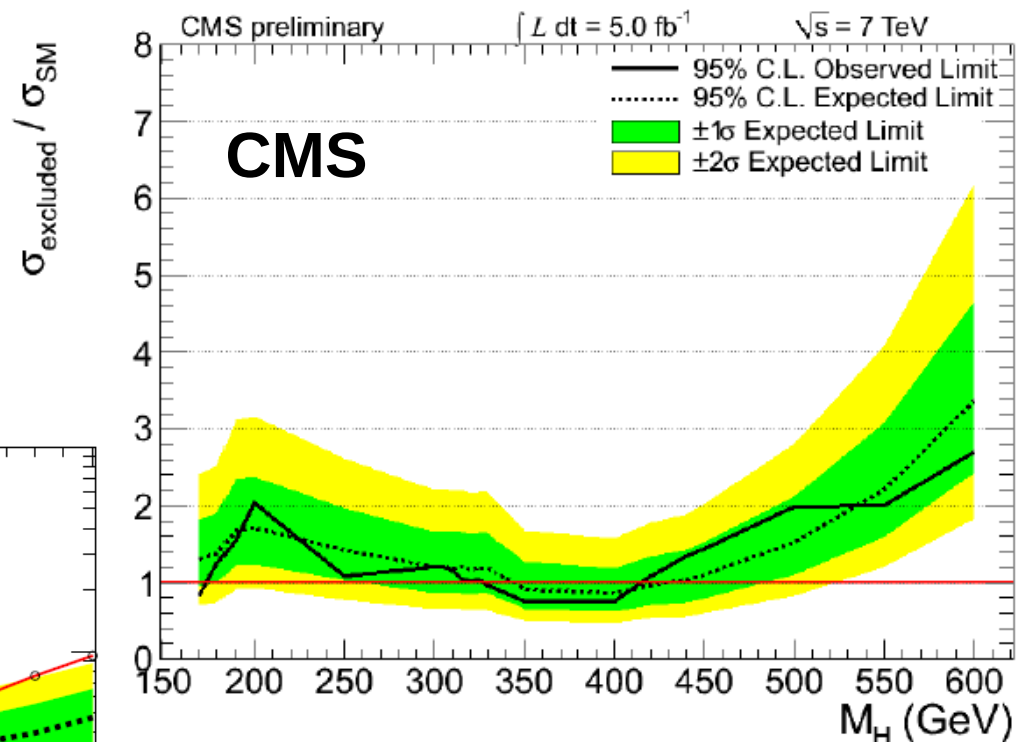
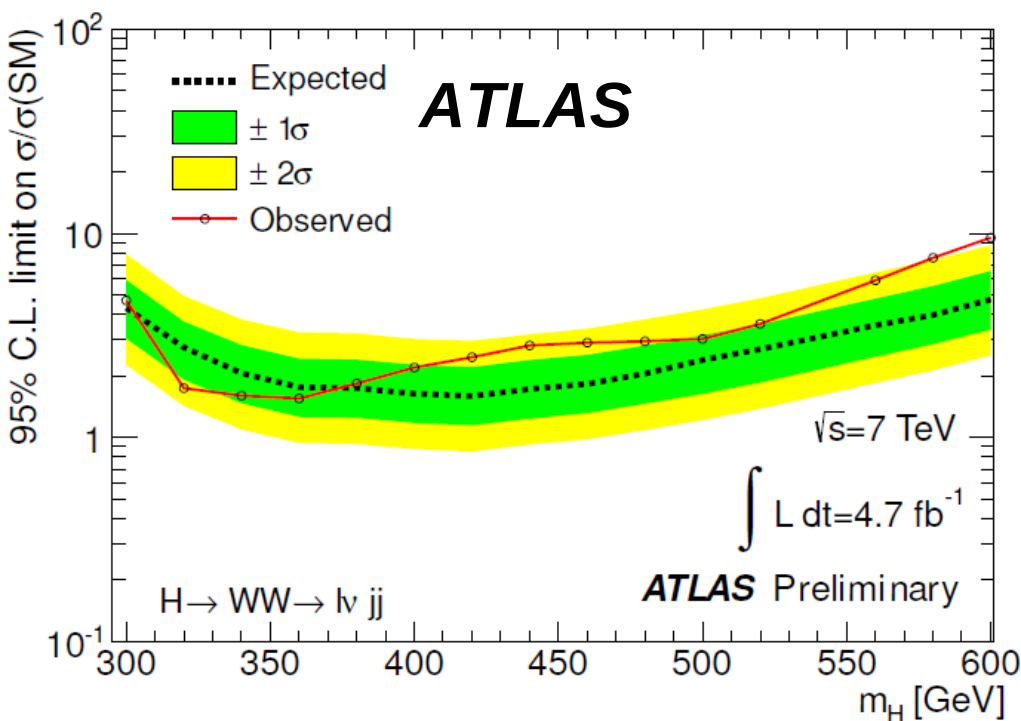
<https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsHIG>

$H \rightarrow WW \rightarrow \ell \nu jj$

- ✱ Largest $\sigma \times \text{BR}$ over much of the mass range.
- ✱ Use W mass to constrain neutrino p_z for a peak in the 4-body mass.
- ✱ Large W +jets background at LHC.



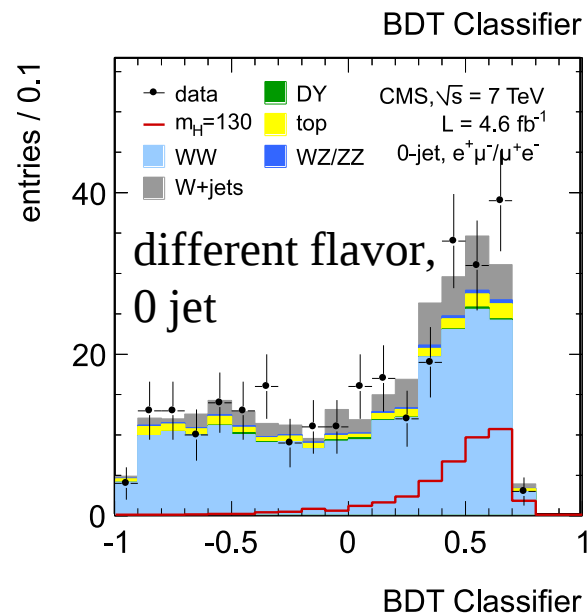
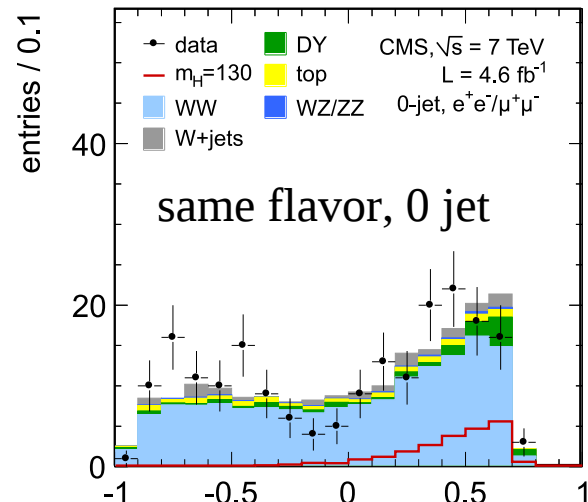
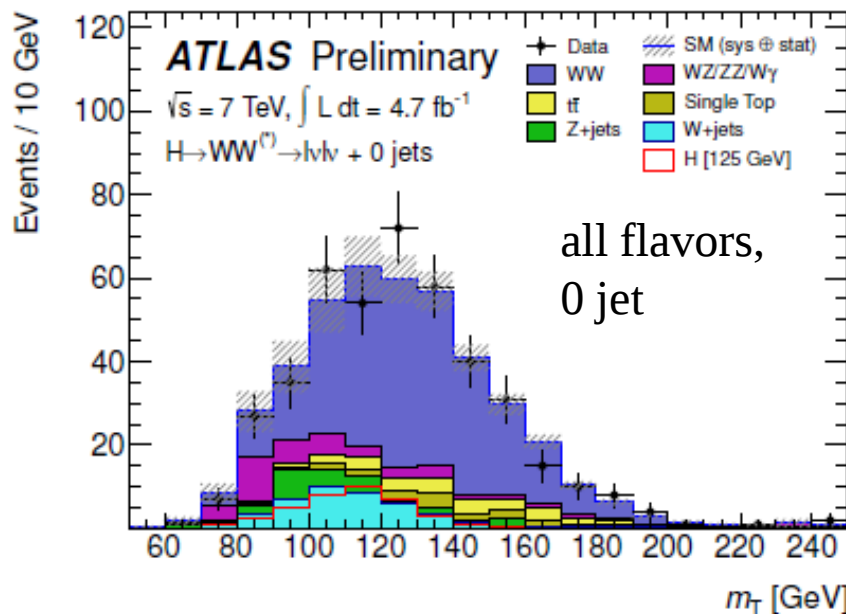
$H \rightarrow WW \rightarrow \ell \nu jj$ limits



CMS 95% C.L. Exclusion:
 327-415 GeV

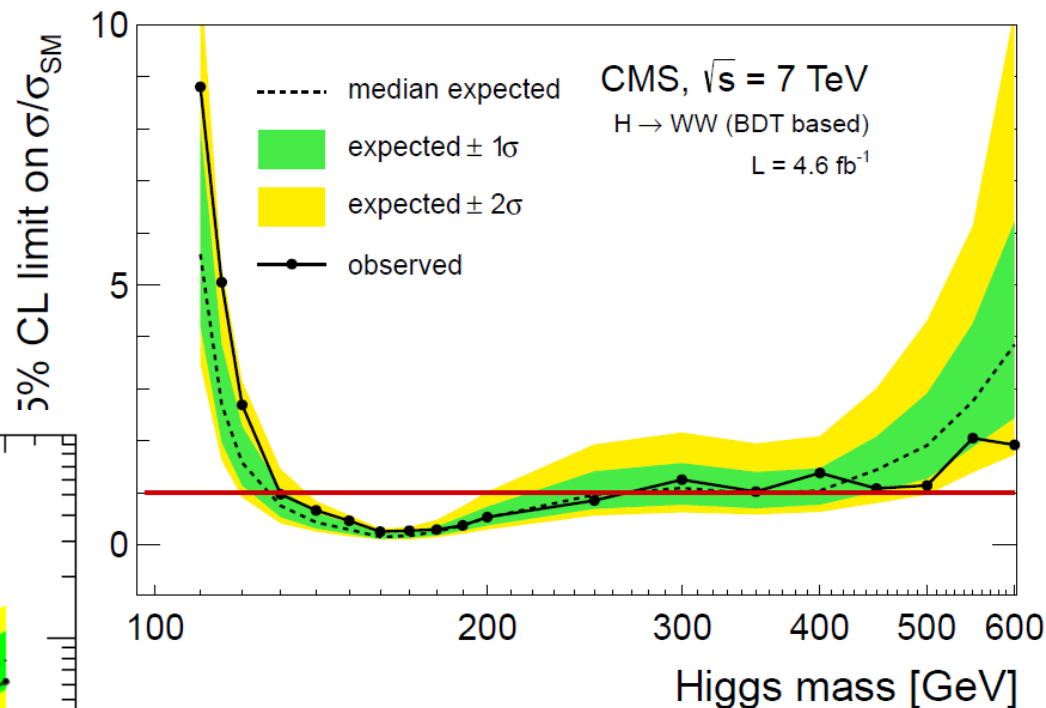
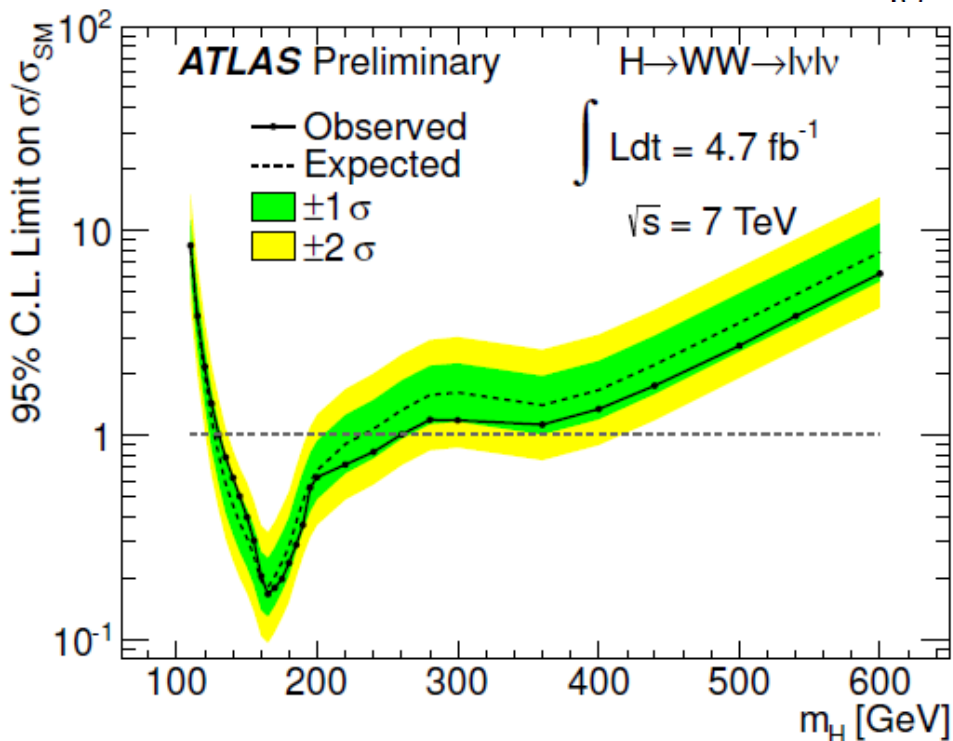
$H \rightarrow WW \rightarrow \ell\nu\ell\nu$

- ✿ Clean signature of two isolated leptons and large missing ET.
- ✿ Only irreducible background non-resonant WW production.
- ✿ Only a broad mass peak.



$H \rightarrow WW \rightarrow \ell\nu\ell\nu$ limits

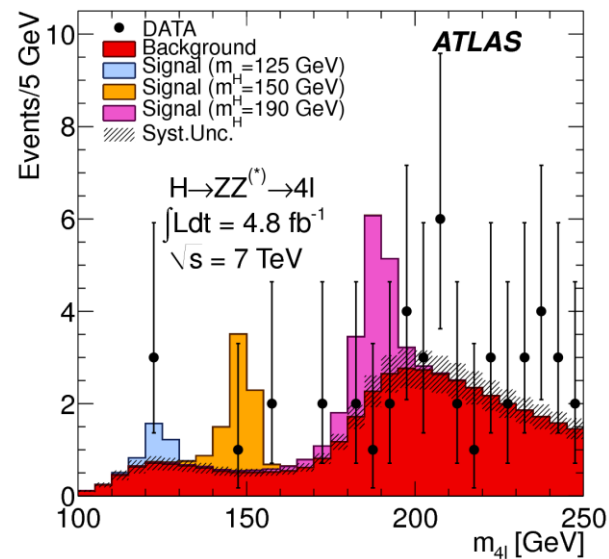
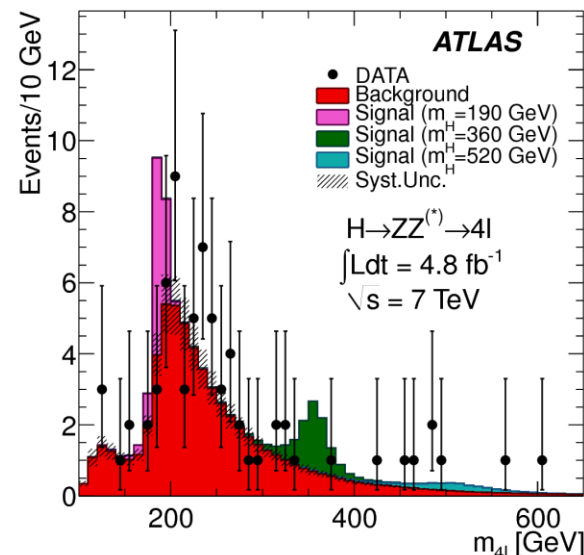
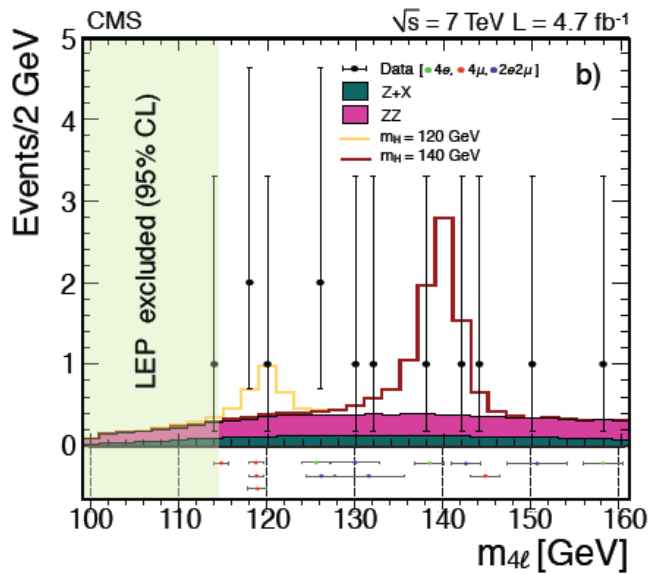
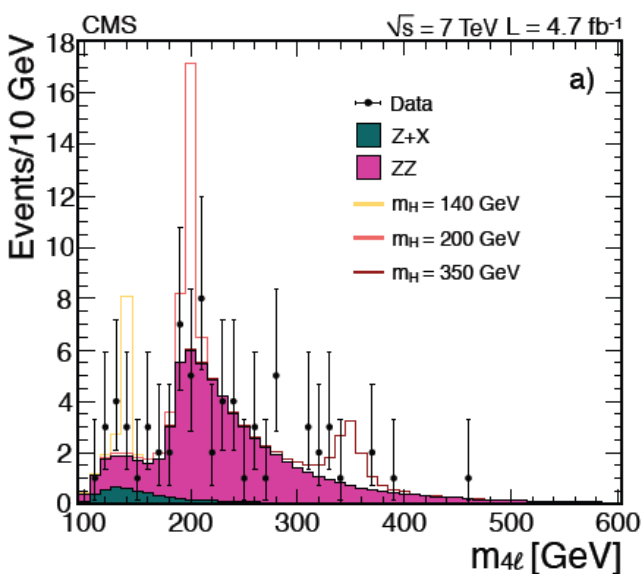
ATLAS 95% C.L. Exclusion:
127-234 GeV



CMS 95% C.L. Exclusion:
129-270 GeV

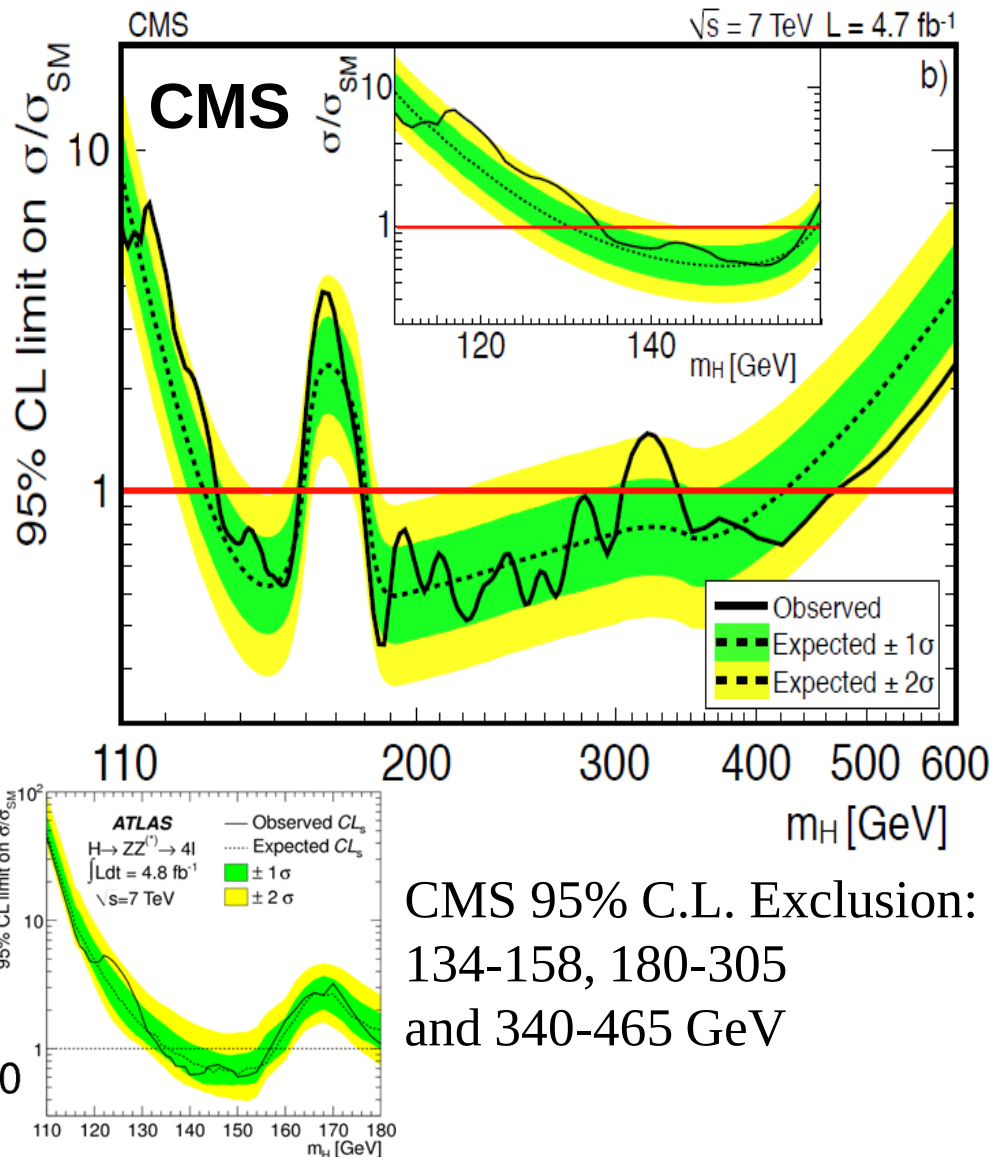
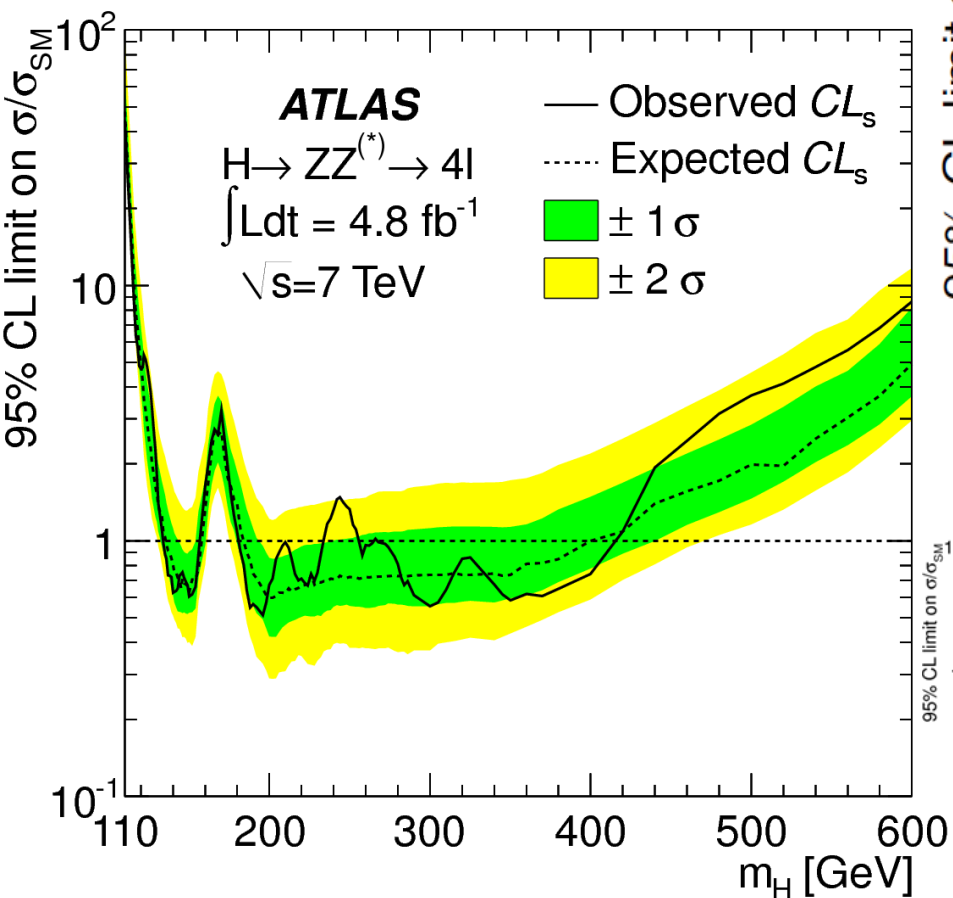
$H \rightarrow ZZ \rightarrow 4\ell$

- ✱ Very low backgrounds.
- ✱ Excellent resolution on the m_H (1-2%).
- ✱ Primary background from non-resonant ZZ production.
- ✱ Relatively small $\sigma \times \text{BR}$.



$H \rightarrow ZZ \rightarrow 4\ell$ limits

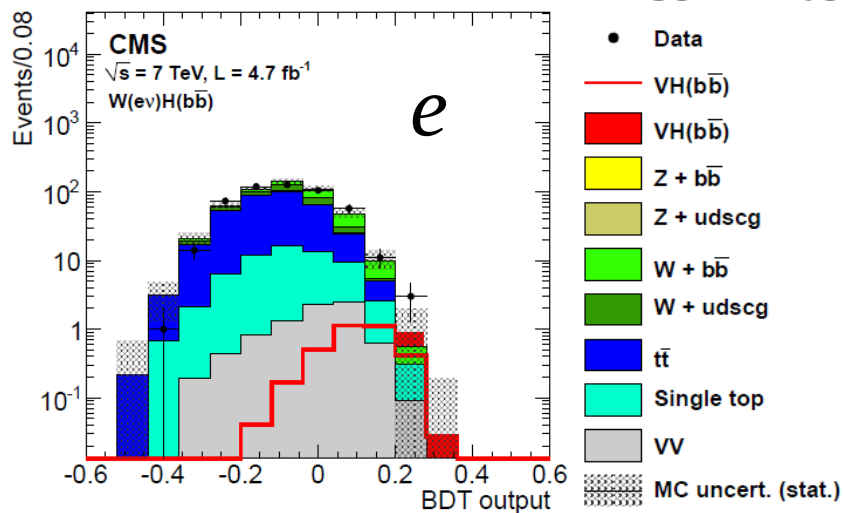
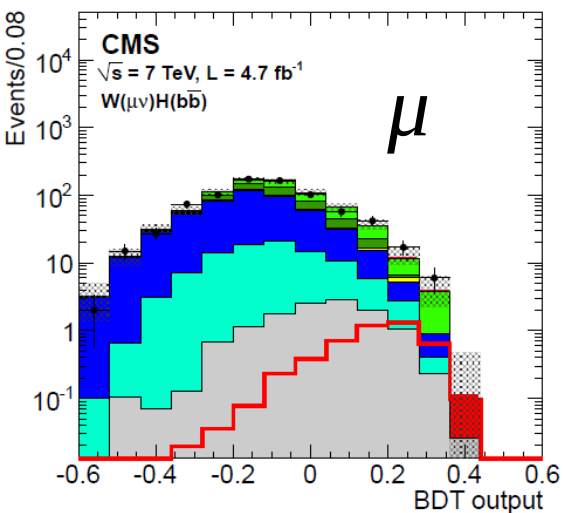
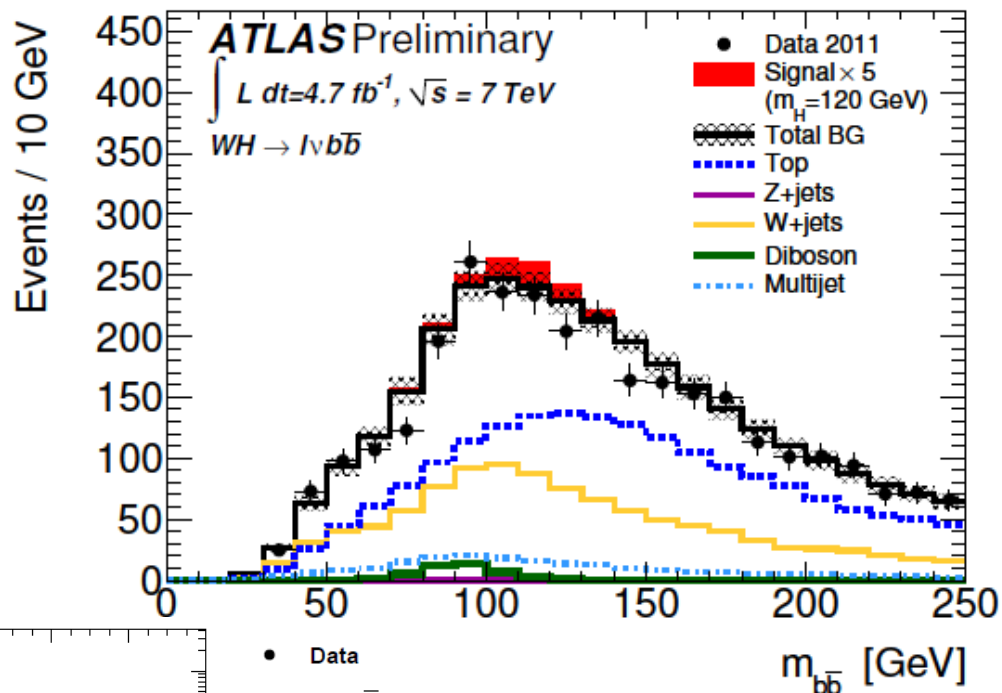
ATLAS 95% C.L. Exclusion:
134-156, 182-233, 256-265
and 268-415 GeV



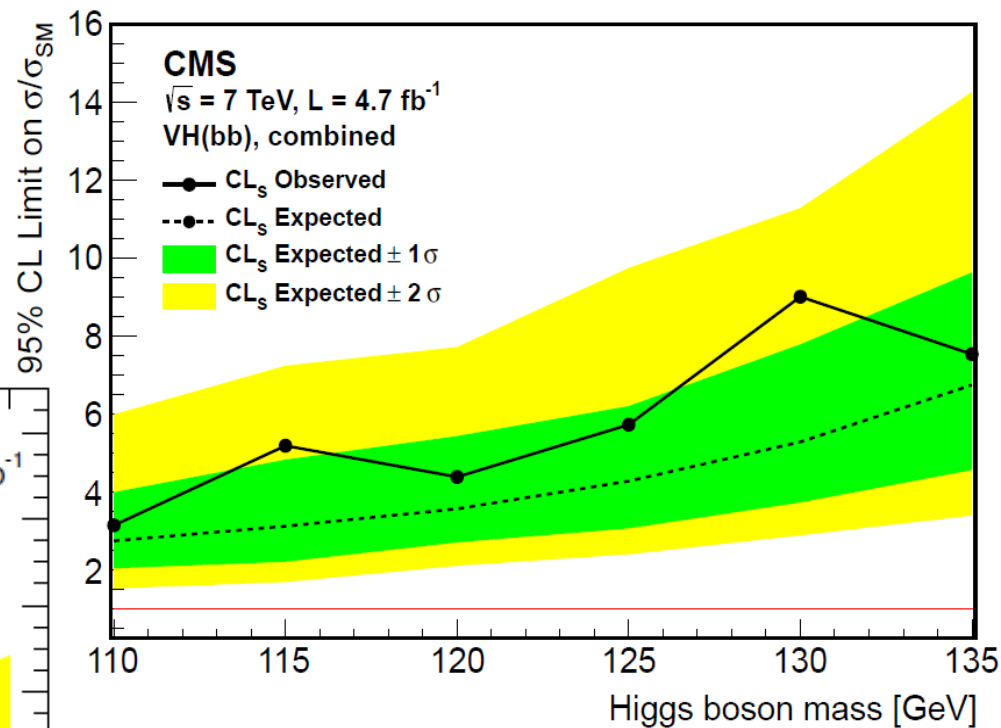
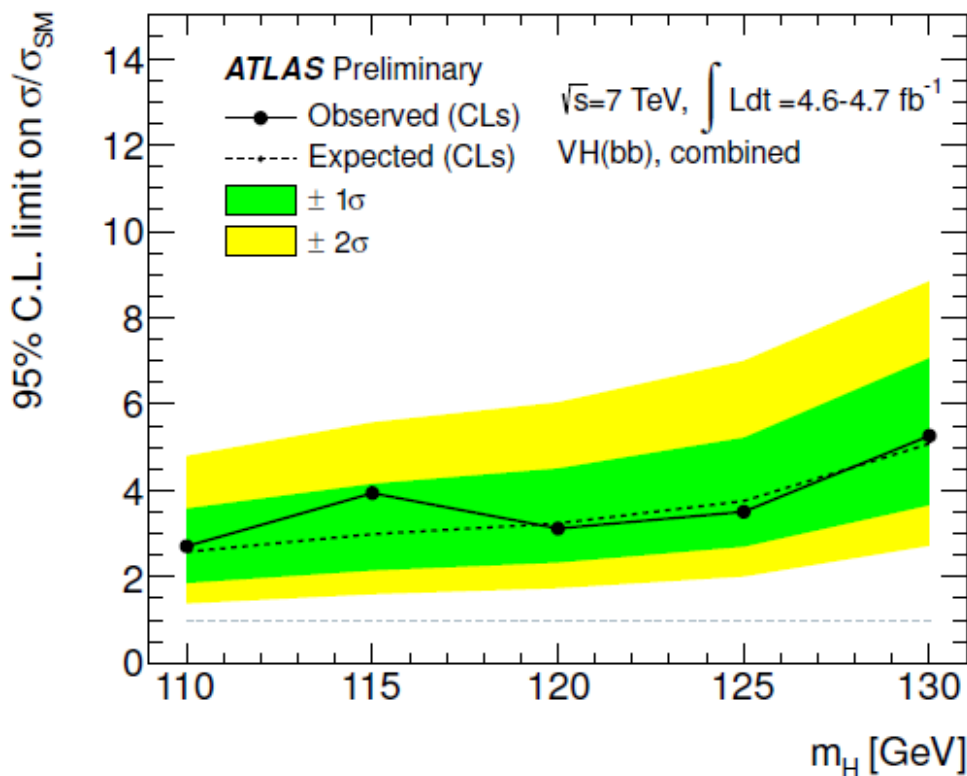
CMS 95% C.L. Exclusion:
134-158, 180-305
and 340-465 GeV

$VH \rightarrow (\ell\nu, \ell\ell, \nu\nu)bb$

- ✱ Large BR for low mass Higgs.
- ✱ Large backgrounds at LHC
 - move to boosted regime
 $p_T > \sim 100$ GeV

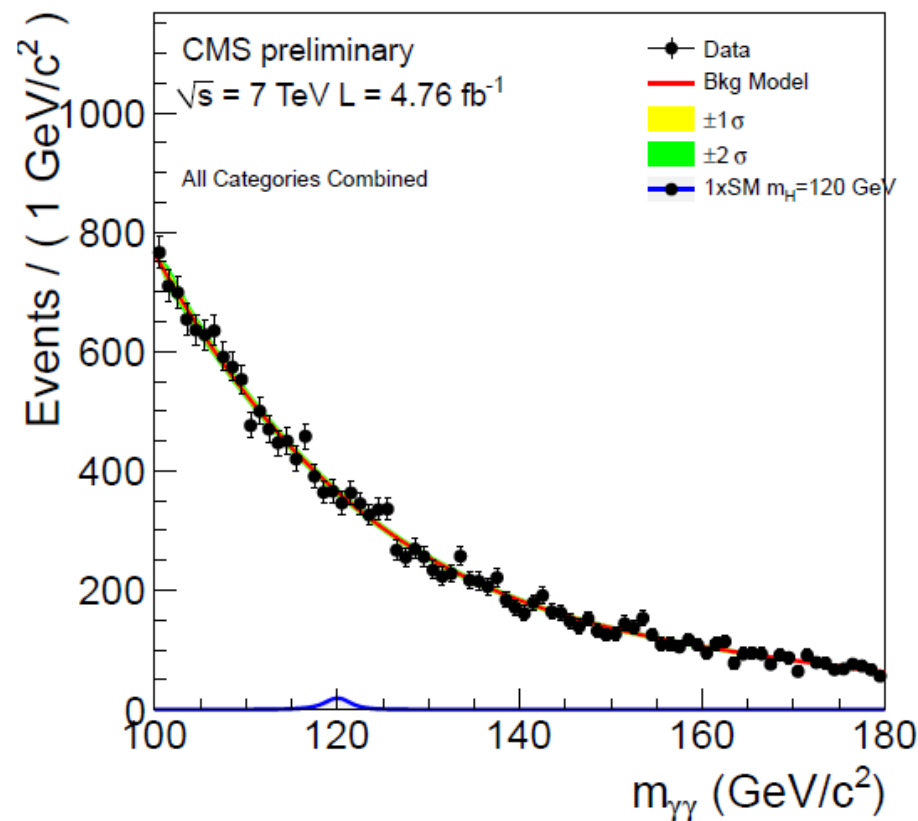
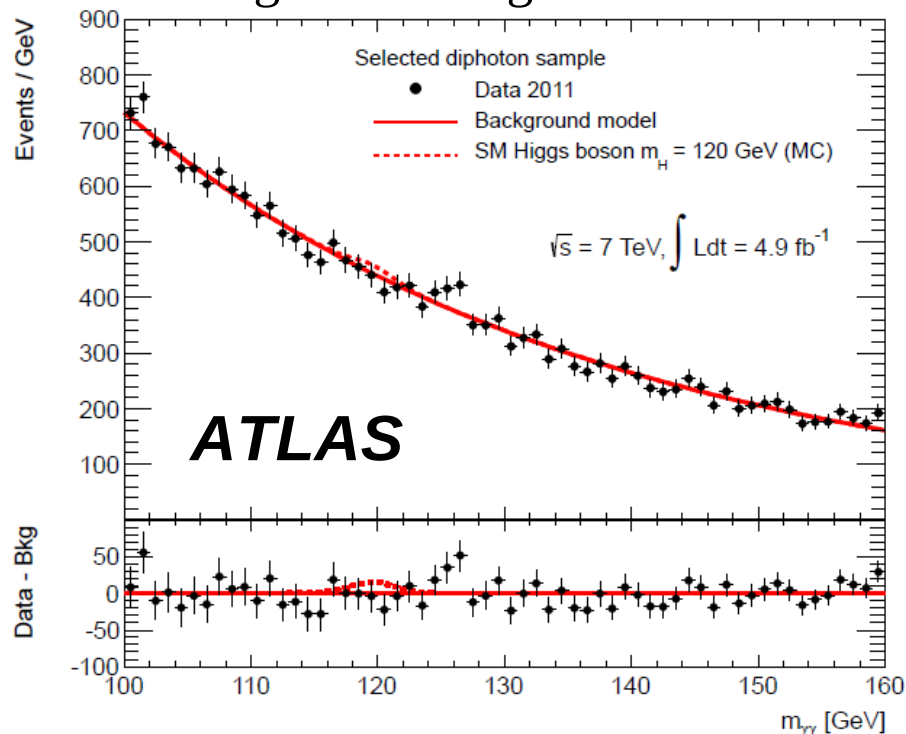


VH $\rightarrow (\ell\nu, \ell\ell, \nu\nu)bb$ limits



⚙ $H \rightarrow \gamma\gamma$ is a key decay for a low mass Higgs.

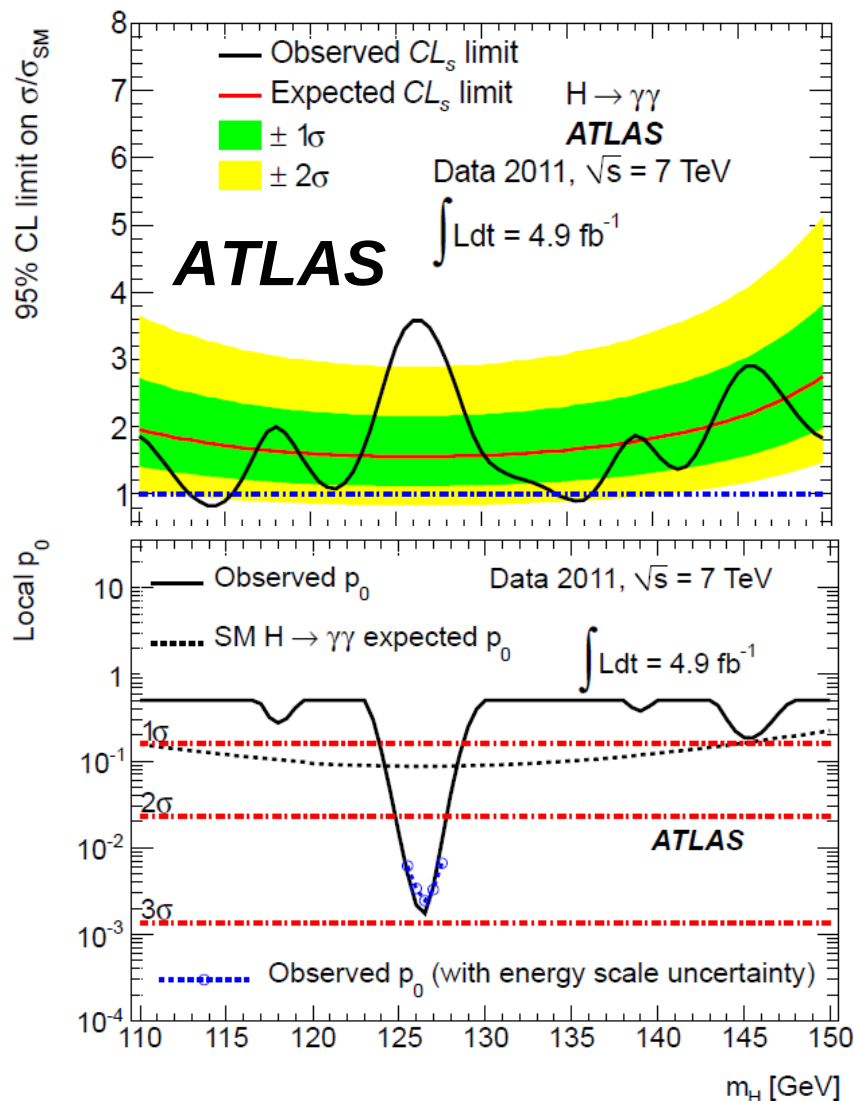
- excellent mass resolution (FWHM, 120 GeV)
 - ATLAS: 3.3-5.9 GeV
 - CMS: 2.6-4.9 GeV
- manageable backgrounds



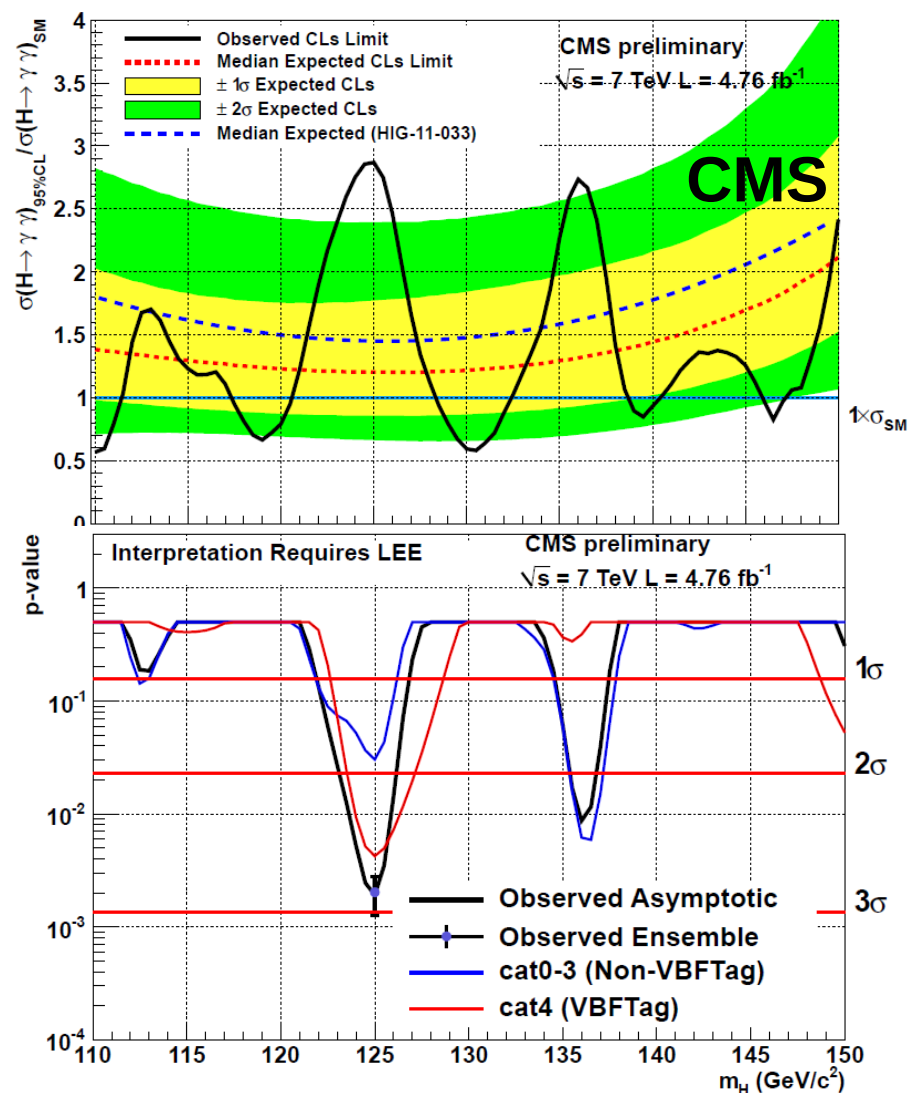
⚙ Minimal input from MC.

- looking for a narrow bump on a monotonic background

$H \rightarrow \gamma\gamma$ limits

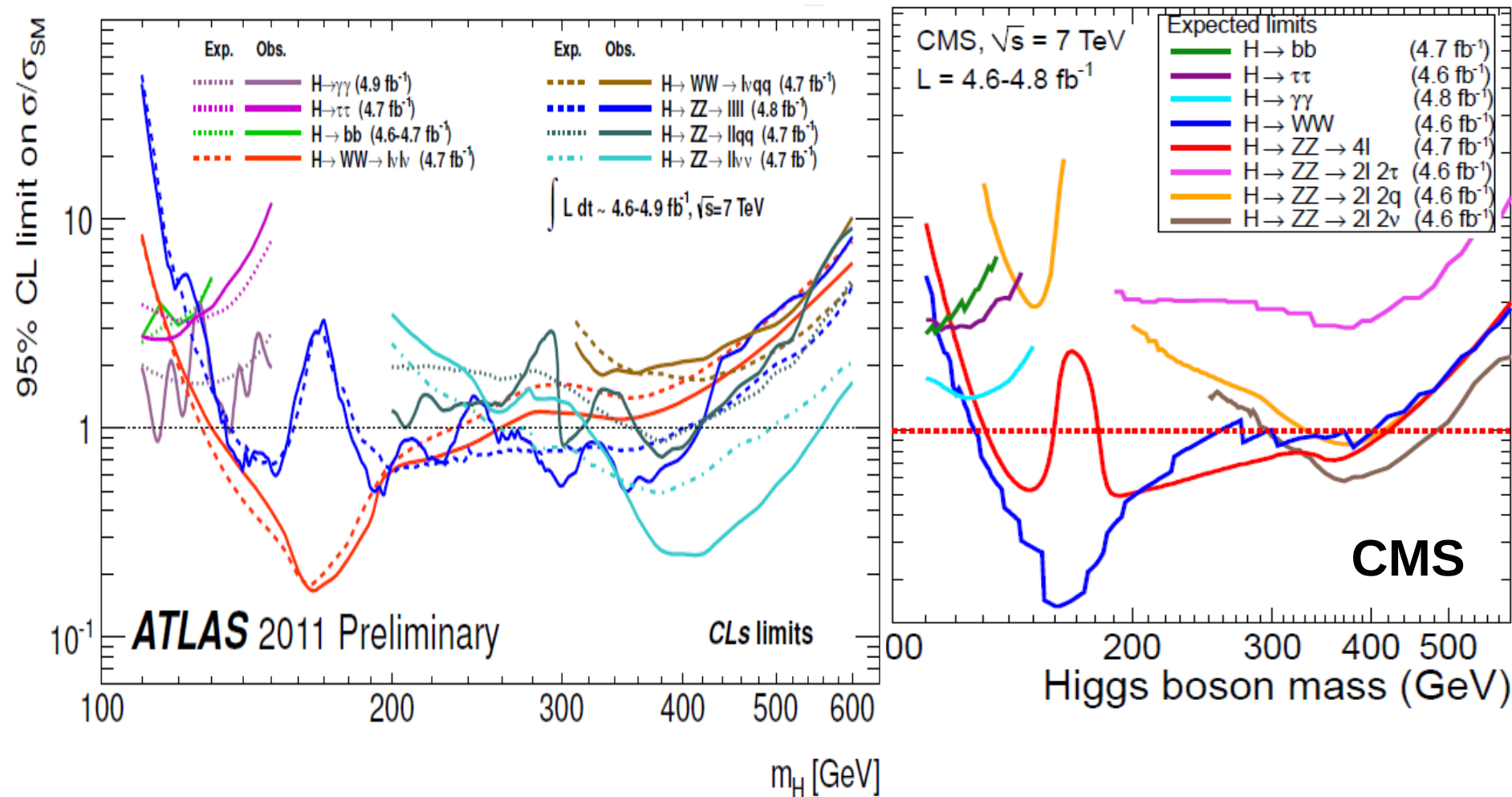


1.5 σ including look elsewhere effect (LEE)

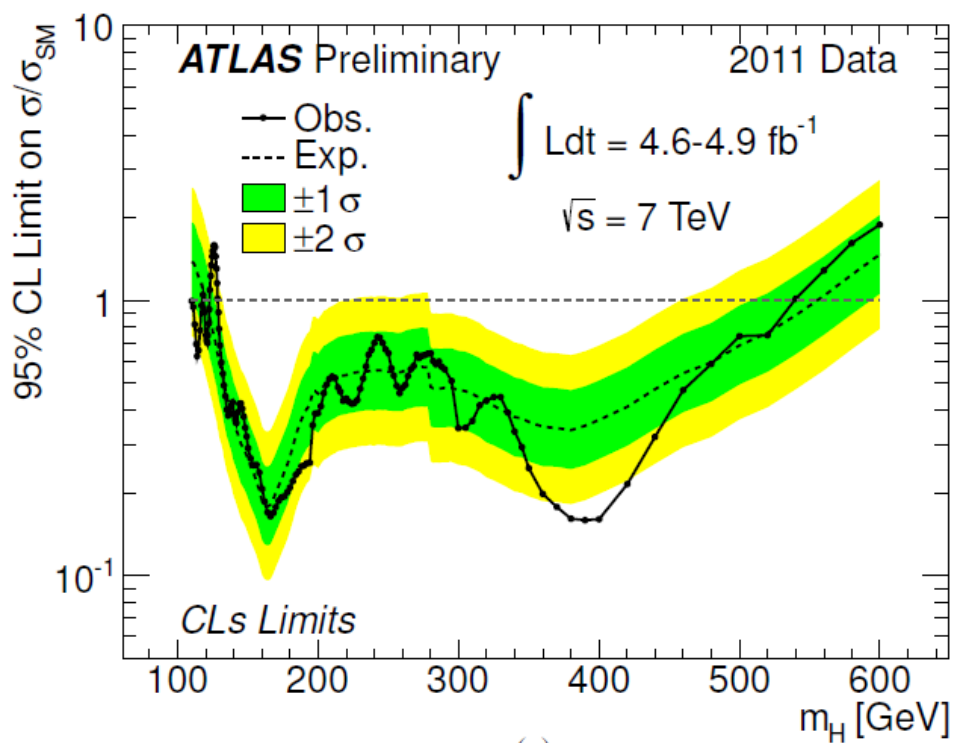


1.6 σ including LEE

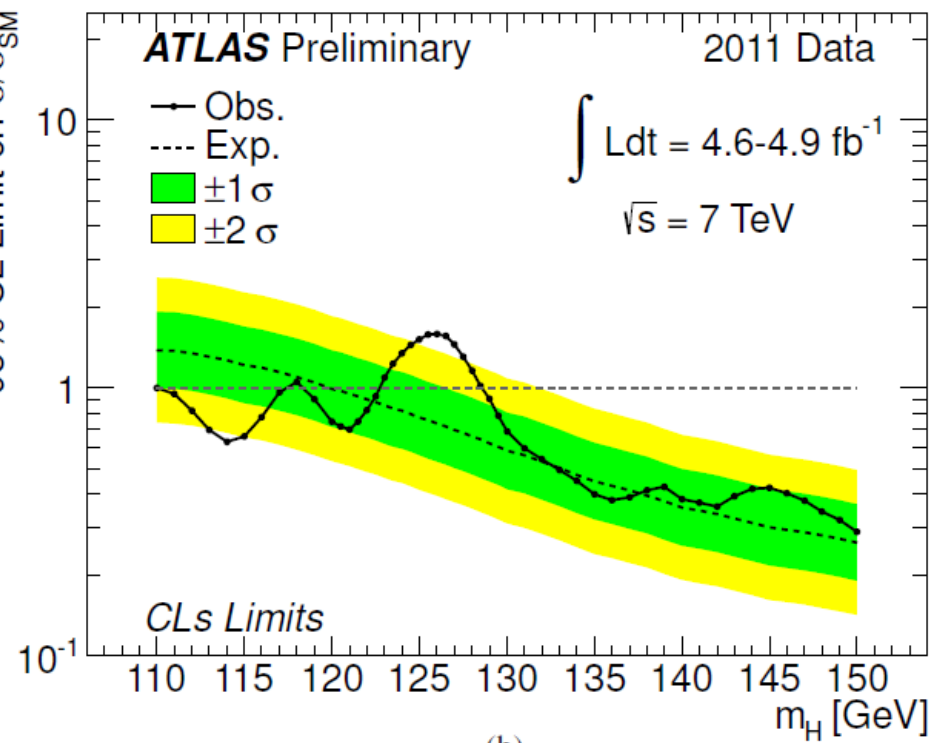
Each experiment has performed a combined search.



Combined limits (ATLAS)



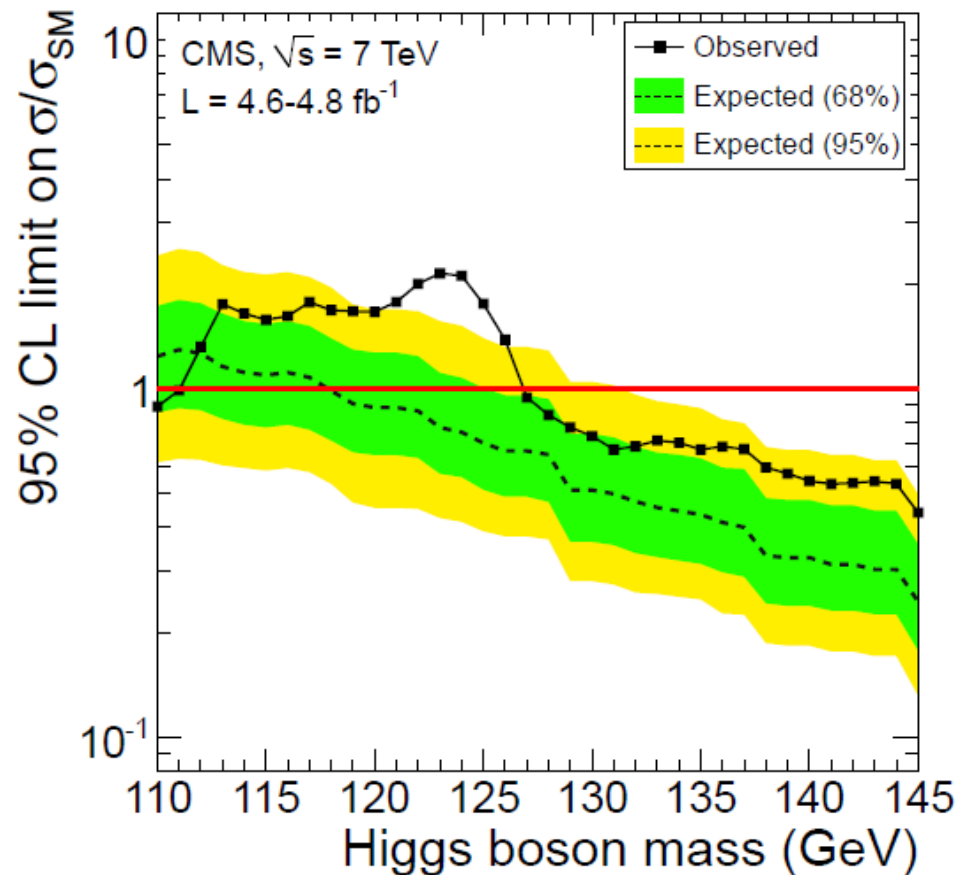
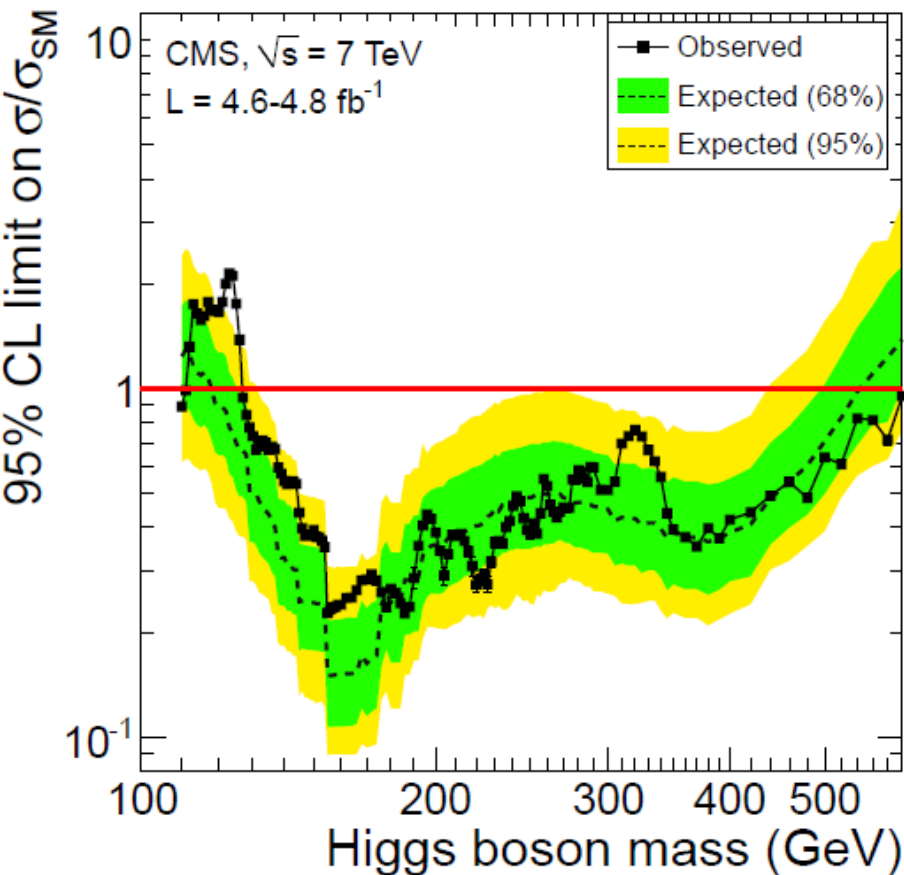
(a)



(b)

ATLAS 95% C.L. Exclusion:
 110-117.5, 118.5-122.5, 129-539 GeV

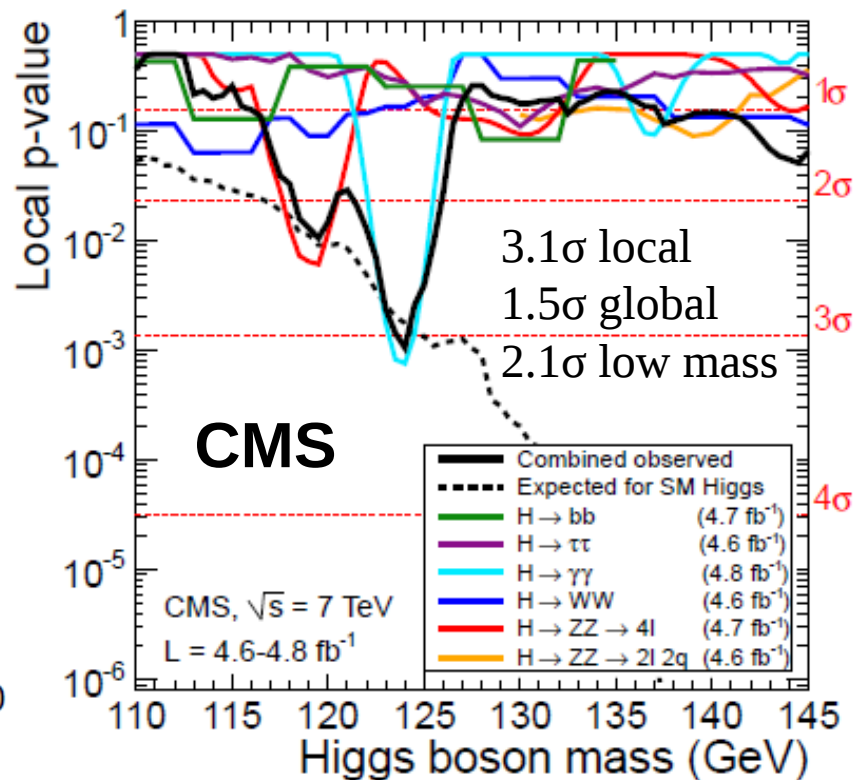
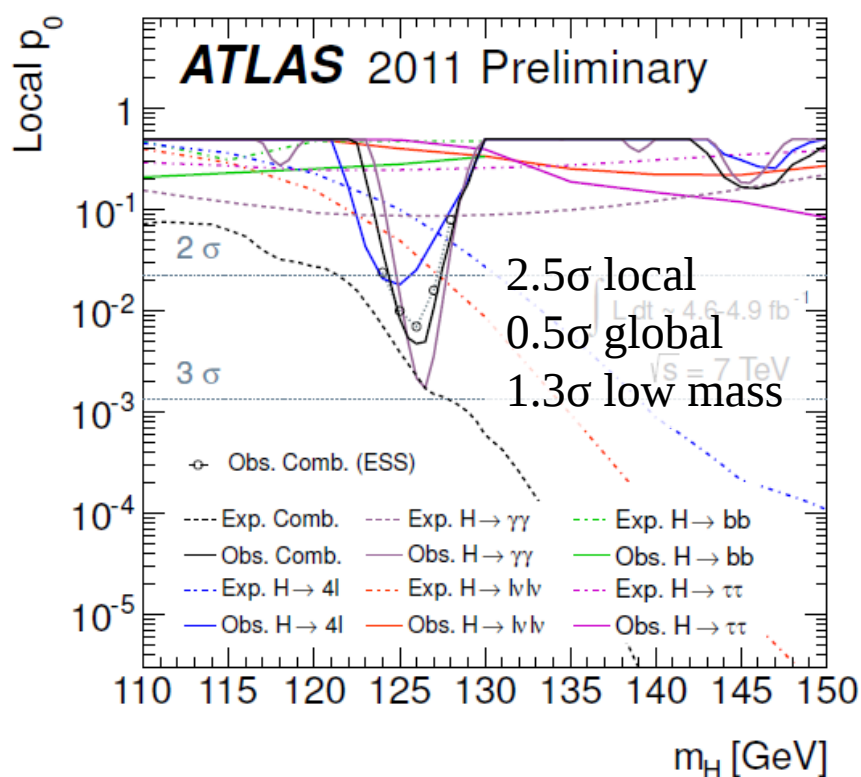
Combined limits (CMS)



CMS 95% C.L. Exclusion:
 127-600 GeV

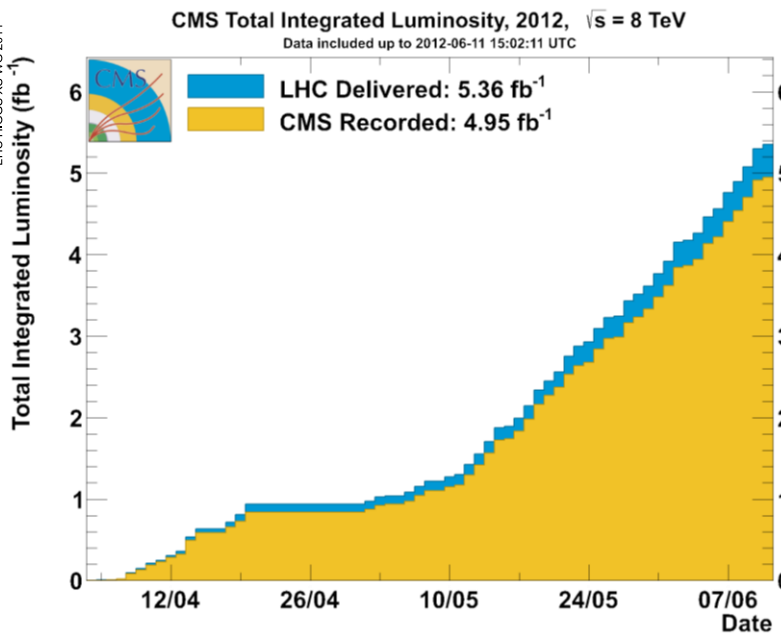
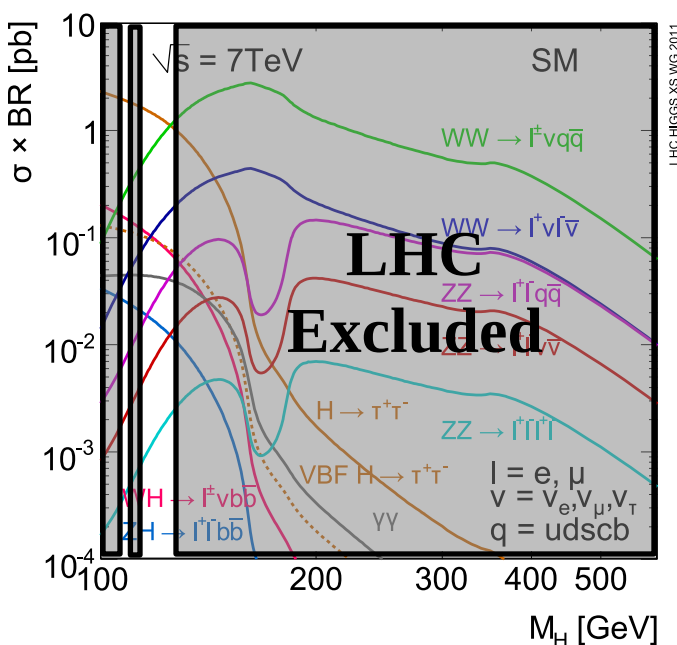
The most significant excess

- ✿ We can evaluate the most significant signal ~ 125 GeV.
- ✿ The $H \rightarrow \gamma\gamma$ channel dominates the measurements.
 - ATLAS also observes near-by signal in $H \rightarrow ZZ \rightarrow 4\ell$.



Conclusions and outlook

- Both ATLAS and CMS have aggressively searched for the Standard Model Higgs boson.
- So far there are no significant excesses observed.
- Experiments at the LHC exclude a SM Higgs boson at 95% C.L. over most of the mass range 110-600 GeV.
- Tantalizing hints have been seen, but aren't conclusive.



2012 LHC goal is 15 fb^{-1} at 8 TeV.

This may be the year of Higgs at the LHC!