NMSSM impact on the diphoton signal rate:

1) Recall:

$$BR(H \to \gamma\gamma) = \frac{\Gamma(H \to \gamma\gamma)}{\Gamma(H \to bb) + \ldots}$$

($\Gamma(H \to bb)$ gives $\sim 58\%$ of the total width for a 125 GeV scalar mass)

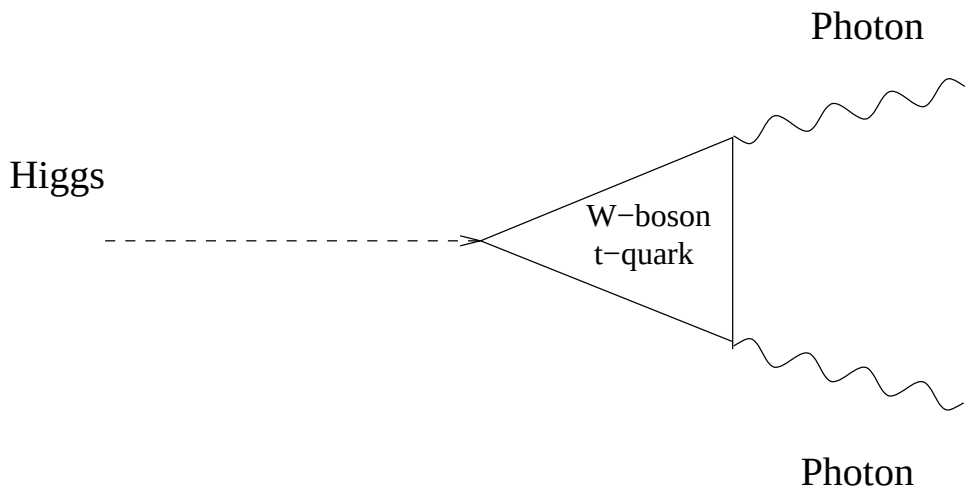
$\to$ Due to the mixing of H_u, H_d, S it is easily possible that, in the NMSSM, the mostly SM–like scalar h_{SM} has

— a reduced coupling to bb, and hence a reduced width $\Gamma(h_{SM} \to bb)$
$\longrightarrow$ an enhanced $BR(h_{SM} \to \gamma\gamma)$

— nearly SM–like couplings to the top quark (whose loops induce the coupling to gluons) and to the electroweak gauge bosons
$\longrightarrow$ the production rates in gluon fusion and/or VBF are hardly reduced

$\to$ The diphoton signal rate is enhanced (U.E. 2010)

2) Recall: In the SM, $\Gamma(H \to \gamma\gamma)$ is induced via W-boson (and top quark) loops:



In the NMSSM, the singlet S couples to the (charged) higgsinos Ψ_{H_u}, Ψ_{H_d}:

$\lambda S \Psi_{H_u} \Psi_{H_d}$ (recall the generation of the μ–term through $\langle S \rangle$)

$\longrightarrow$ If h_{SM} has a S-component, charged higgsinos contribute to the loop and to $\Gamma(h_{SM} \to \gamma\gamma)$ unless λ is small or the higgsinos are heavy

If h_{SM} mixes strongly with another mostly singlet-like scalar: The mass of this mostly singlet-like scalar should be not too far from $M_{h_{SM}} \sim 125$ GeV

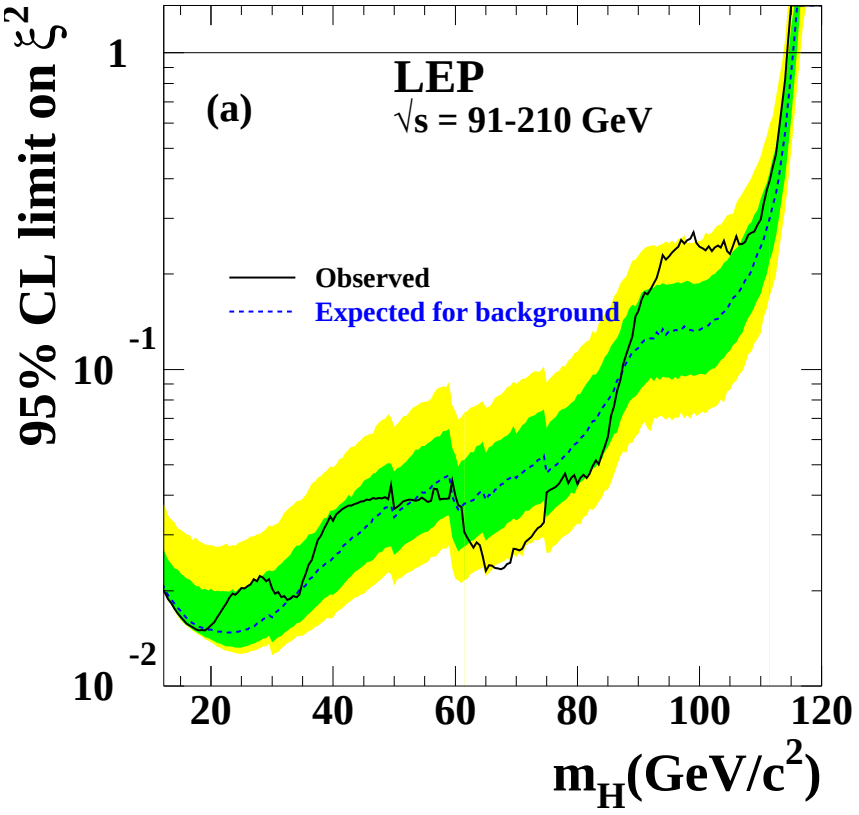
$\longrightarrow$ Are there hints for (at least weak bounds on) such a state?

Unfortunately: The couplings/signal rates of such a state are typically reduced relative to the ones of h_{SM}, but it can still be visible

If this state has a mass below 114 GeV:

Study the bounds on the signal rate ξ^2 in $Z^* \to Z + h_{SM}$ at LEP:

$\longrightarrow$ If $\xi^2(H_1) \sim 0.2$:
Compatible with the
weak bounds around 95 GeV
(R. Dermisek, J.-F. Gunion)



Or: could be very close to 125 GeV?

see Gunion, Jiang, Kraml, 1207.1545 and 1208.1817

If this state has a mass above 125 GeV:

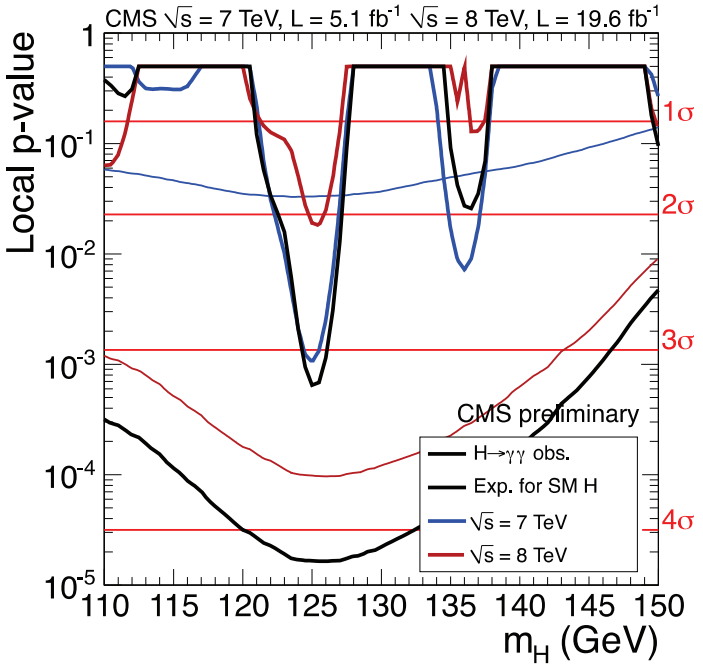
CMS $H \to \gamma\gamma$ (Moriond QCD 2013, Orchando): Additional excesses around $M_H \sim 137$ GeV

H□□□: Results (p-values)

CMS-HIG-13-001

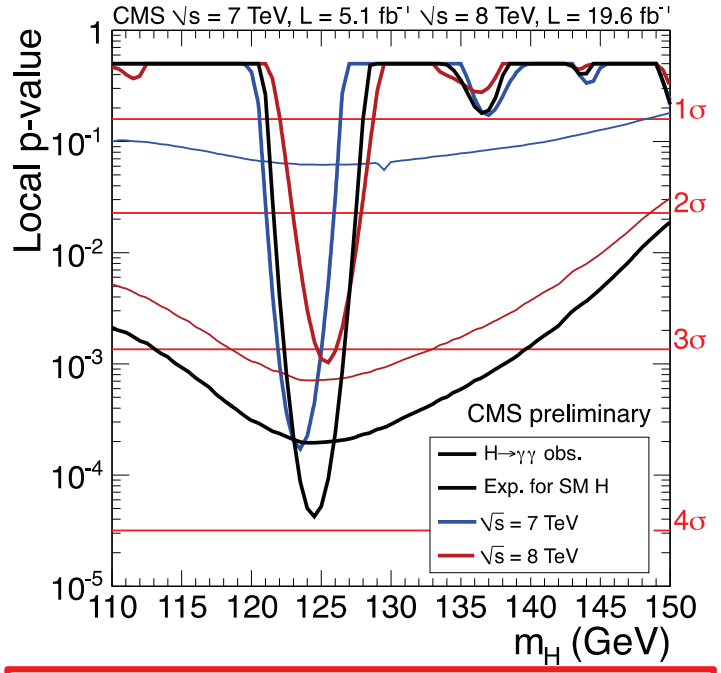
ø In the following: results of the two analyses are shown side by side

MVA mass-factorized



Significance @ 125.0 GeV: 3.2 □ (4.2 exp.)

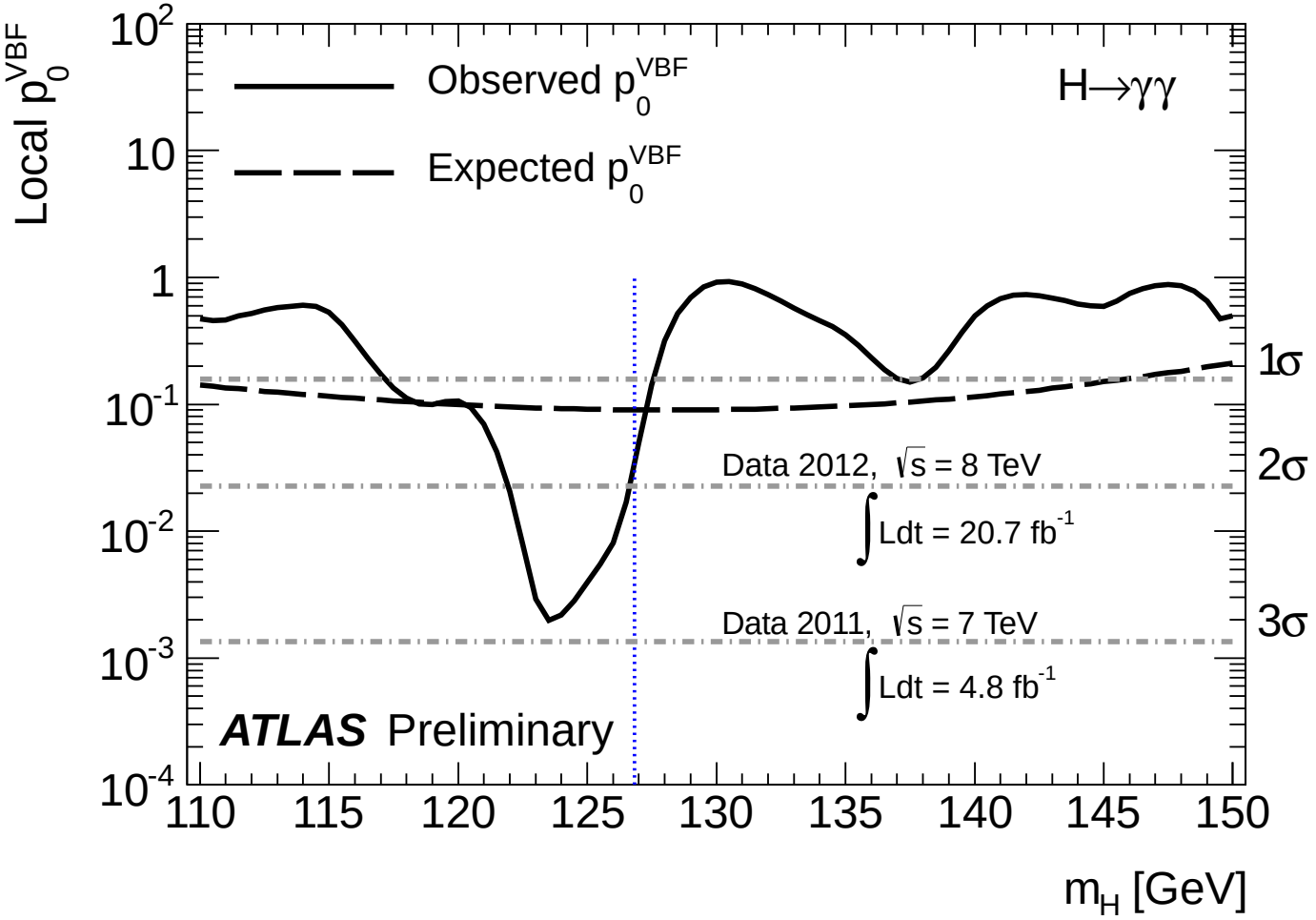
Cut-based



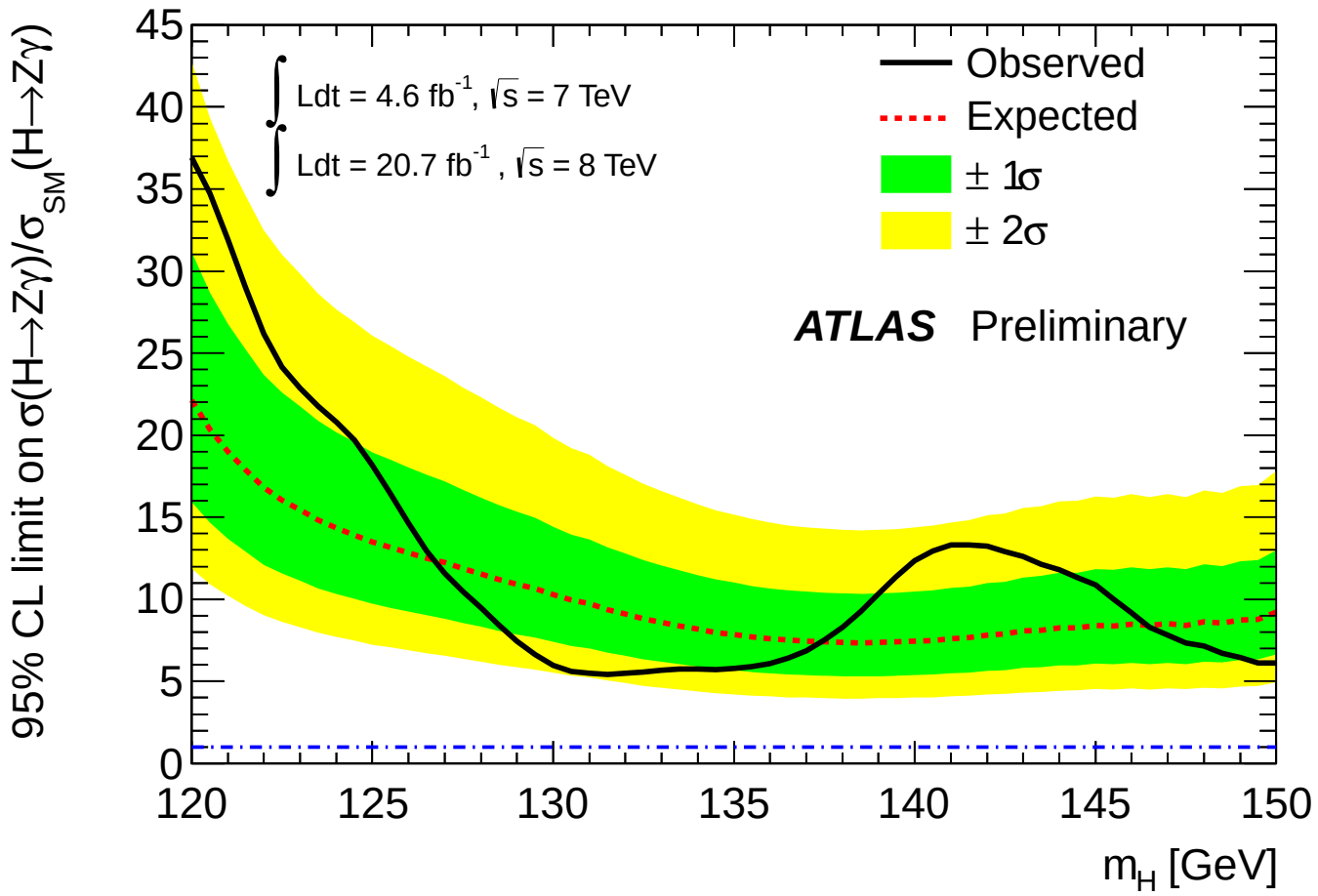
Significance @ 124.5 GeV: 3.9 □ (3.5 exp.)

With additional data and new analysis: significance decreased compared to the published results

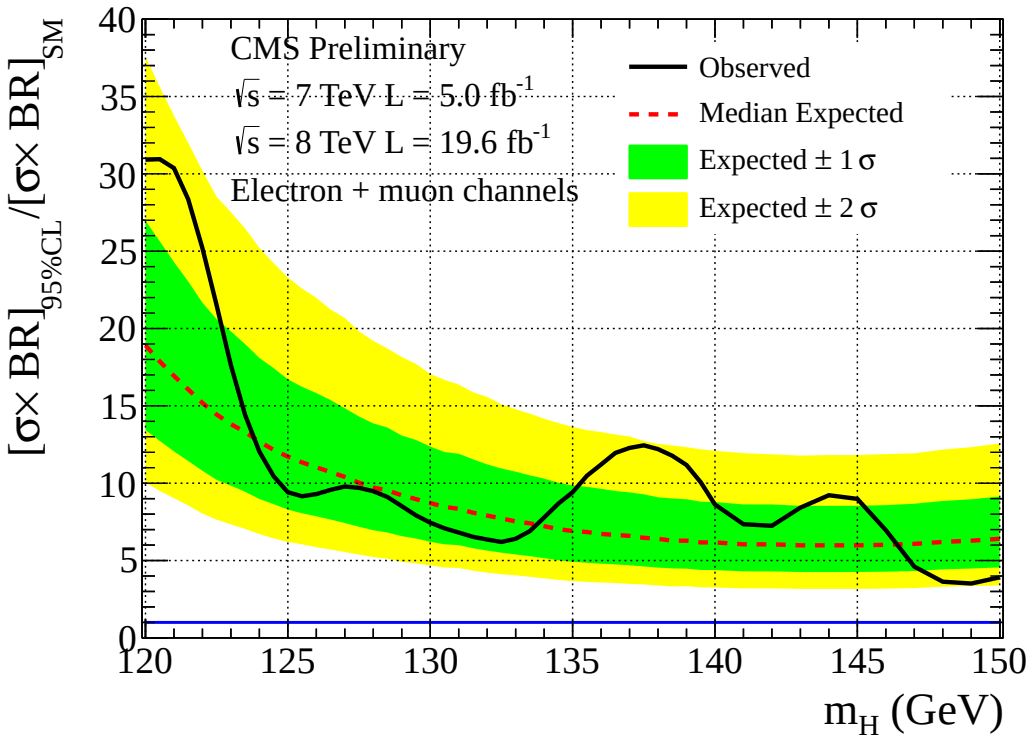
ATLAS $H \to \gamma\gamma$ in VBF (ATLAS-CONF-2013-012):
small additional excess around $M_H \sim 137$ GeV



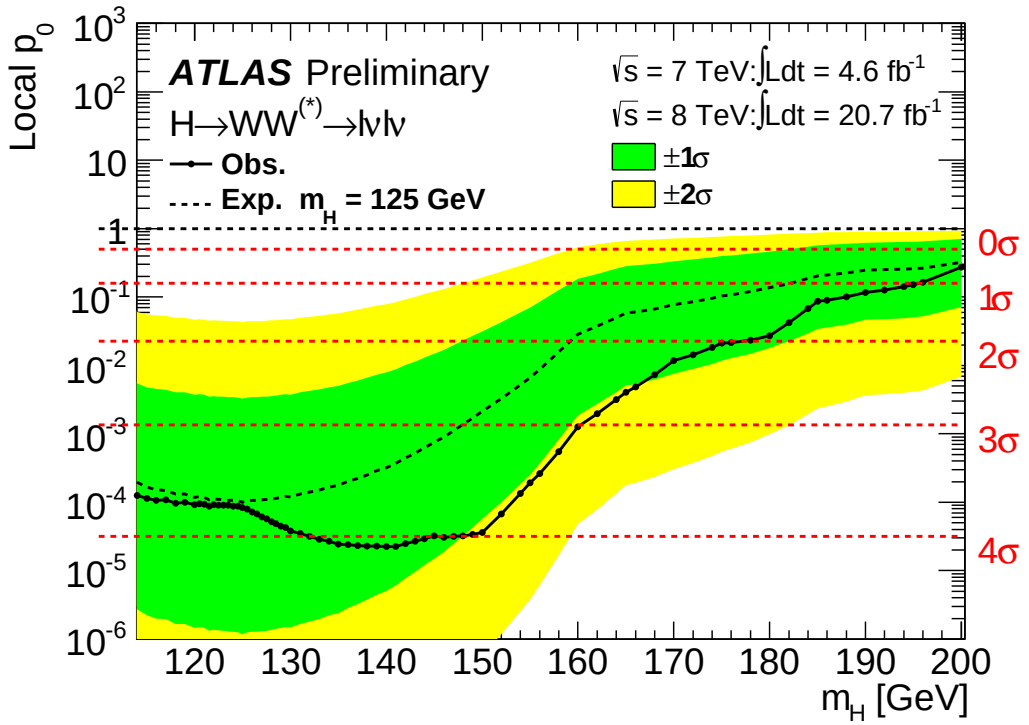
ATLAS $H \to \gamma Z$:



CMS $H \to \gamma Z$:

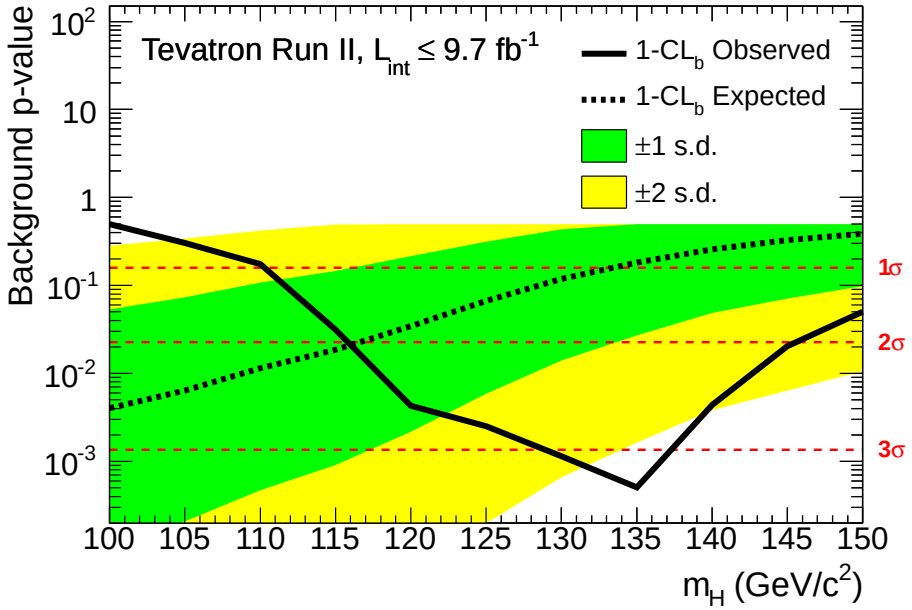


ATLAS $H \to WW$:

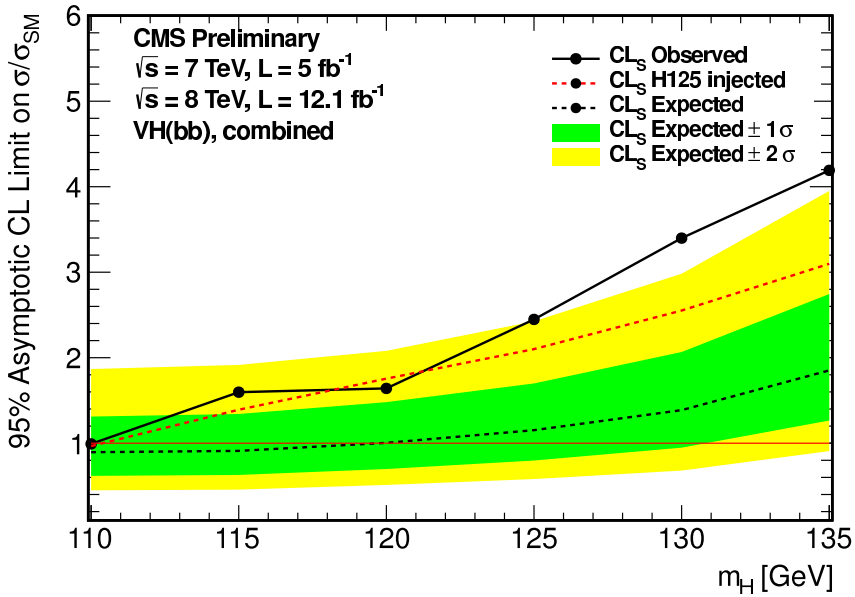

Local p_0
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
ATLAS Preliminary
$H \to WW^{(*)} \to l\nu l\nu$
Obs.
Exp. m_H = 125 GeV
$\sqrt{s}$ = 7 TeV: $\int$Ldt = 4.6 fb^{-1}
$\sqrt{s}$ = 8 TeV: $\int$Ldt = 20.7 fb^{-1}
$\pm 1\sigma$
$\pm 2\sigma$
0σ
1σ
2σ
3σ
4σ
120 130 140 150 160 170 180 190 200
m_H [GeV]

Best fits of M_H in VH with $H \to bb$ (low mass resolution):

Tevatron (1207.6436, PRL):



CMS (pre-Moriond):



→ For $M_H \sim 135$ GeV!? Due to the low mass resolution in $H \to bb$, the excesses could be a superposition of two states at 125 + 135 GeV!

→ Possible in the NMSSM! (See arXiv:1208.4952)
let's see...