Recent ATLAS results on the search for a Standard Model Higgs boson decaying to a bb̄ pair

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The observation of a new 126 GeV boson by both ATLAS and CMS does not confirm yet the existence of a SM Higgs boson. To prove or discard this hypothesis, the coupling to fermions has to be measured, and H→bb̄ is an ideal candidate for this. This poster shows the analysis performed on the full √s=7 TeV dataset [1], a benchmark for future ATLAS analyses using this channel.

- ✧ In the case of a 126 GeV mass Higgs, the decay channel H→bb̄ has the highest branching ratio (~10×BR(H→τ⁺τ⁻)). However, it is difficult to discriminate between a Higgs decaying to a bb pair and the high rate of QCD multi-jet events.
- ✧ Therefore it is necessary to use the associated production of the Higgs with other particles, in particular vector bosons (V=W±,Z), which decay leptonically allowing us to exploit the cleaner signature in the detector from high p_t leptons.

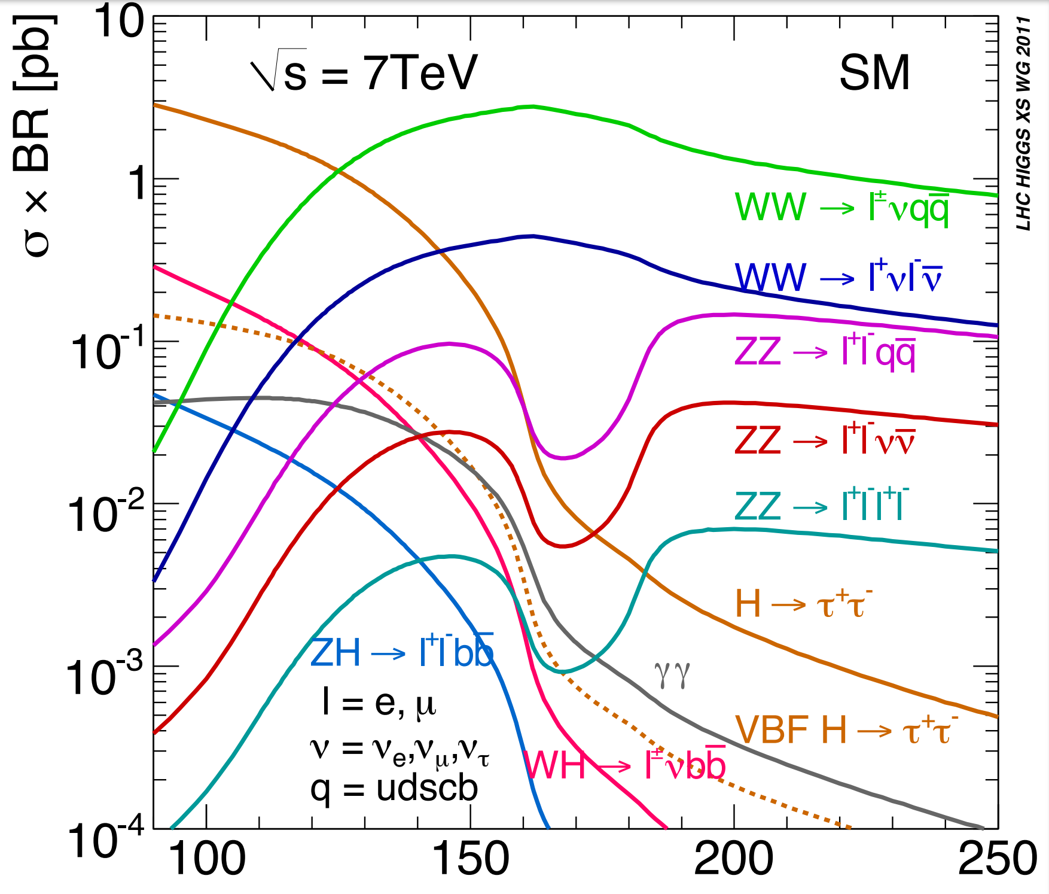

Figure 1. Cross section times Branching Ratio as a function of the Higgs mass for √s=7TeV

Three separate channels are considered: WH→lνbb̄, ZH→l⁺l⁻bb̄ and ZH→νν̄bb̄ **NB: l±=e±,μ±**

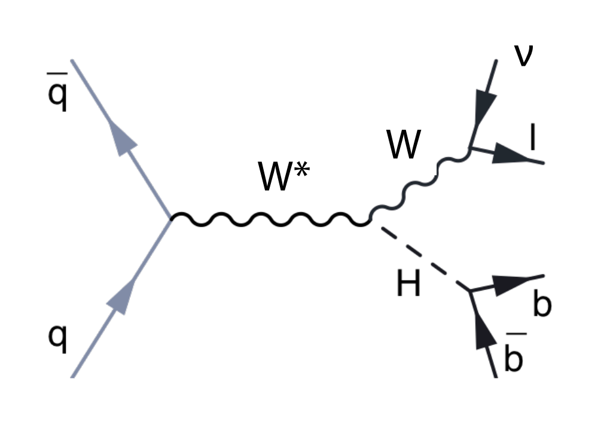

Figure 2. Feynman diagram for the process WH→lνbb̄

- ✧ single lepton trigger with low p_t threshold
- ✧ only one lepton with pt>25GeV
- ✧ W selection: E_t^{miss}>25GeV and M_t^W>40GeV
- ✧ exactly two jets, both b-tagged

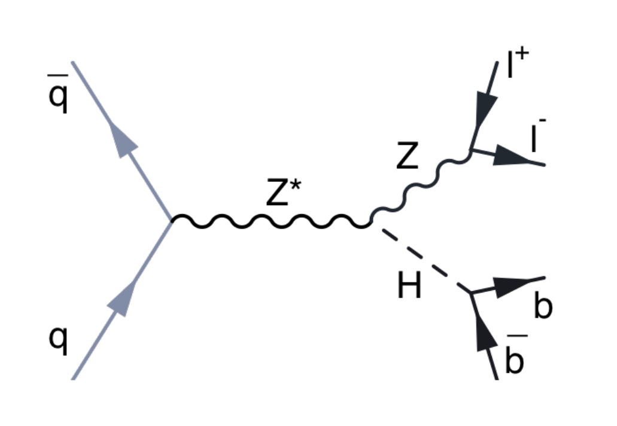

Figure 3. Feynman diagram for the process ZH→l⁺l⁻bb̄

- ✧ single lepton trigger + di-electron trigger with 12 GeV threshold
- ✧ exactly two opposite charged same flavour leptons with p_t>20GeV
- ✧ $|m_{ll}$-91GeV|<8GeV
- ✧ exactly two b-jets
- ✧ E_t^{miss}<50GeV.

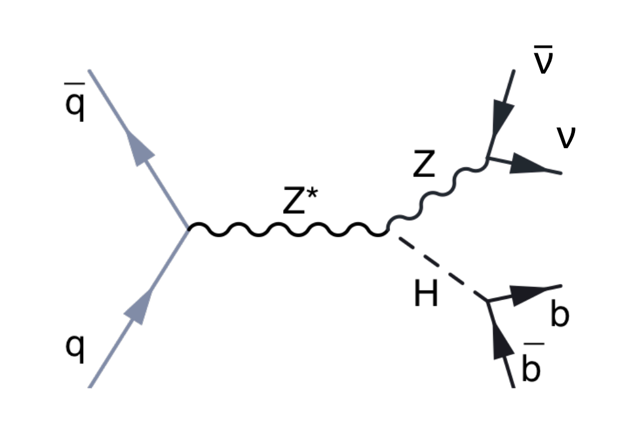

Figure 4. Feynman diagram for the process ZH→νν̄bb̄

- ✧ trigger on E_t^{miss}>70GeV
- ✧ reconstructed E_t^{miss}>120GeV (good trigger efficiency)
- ✧ exactly two b-tagged jets
- ✧ topological cuts on ΔR(bb̄) and Δφ(bb̄,E_t^{miss}) as a function of E_t^{miss}

Object Selection:

Electrons
Identified from calorimeter shower shapes and Inner Detector (ID) track match. Electrons up to |η| <4.5 are used to reject backgrounds .

Missing transverse energy
Obtained from calorimeter energy clusters in |η|<4.9 including muon corrections. Supplemented by track-based p_t^{miss} (only for ZH→ννbb̄ channel)

Muons
Combination of ID and Muon Chambers tracks. Muons from the muon system only (up to |η|<2.7) are used to suppress the background.

Jets
Reconstructed with anti-k_t algorithm with R=0.4 from calorimeter clusters. B-tagged if the flavour weight is higher than ~60%.

After performing the selection cuts, the strategy is to look for an excess in the distribution of the two b-jet invariant mass ($m_{b\bar{b}}$).
The mass hypothesis used for the plots shown is: **m_H=120 GeV**.
A shift of 1.05 on the $m_{b\bar{b}}$ distribution coming from jet mis-measurement due to losses from soft μ's and ν's is taken into account.

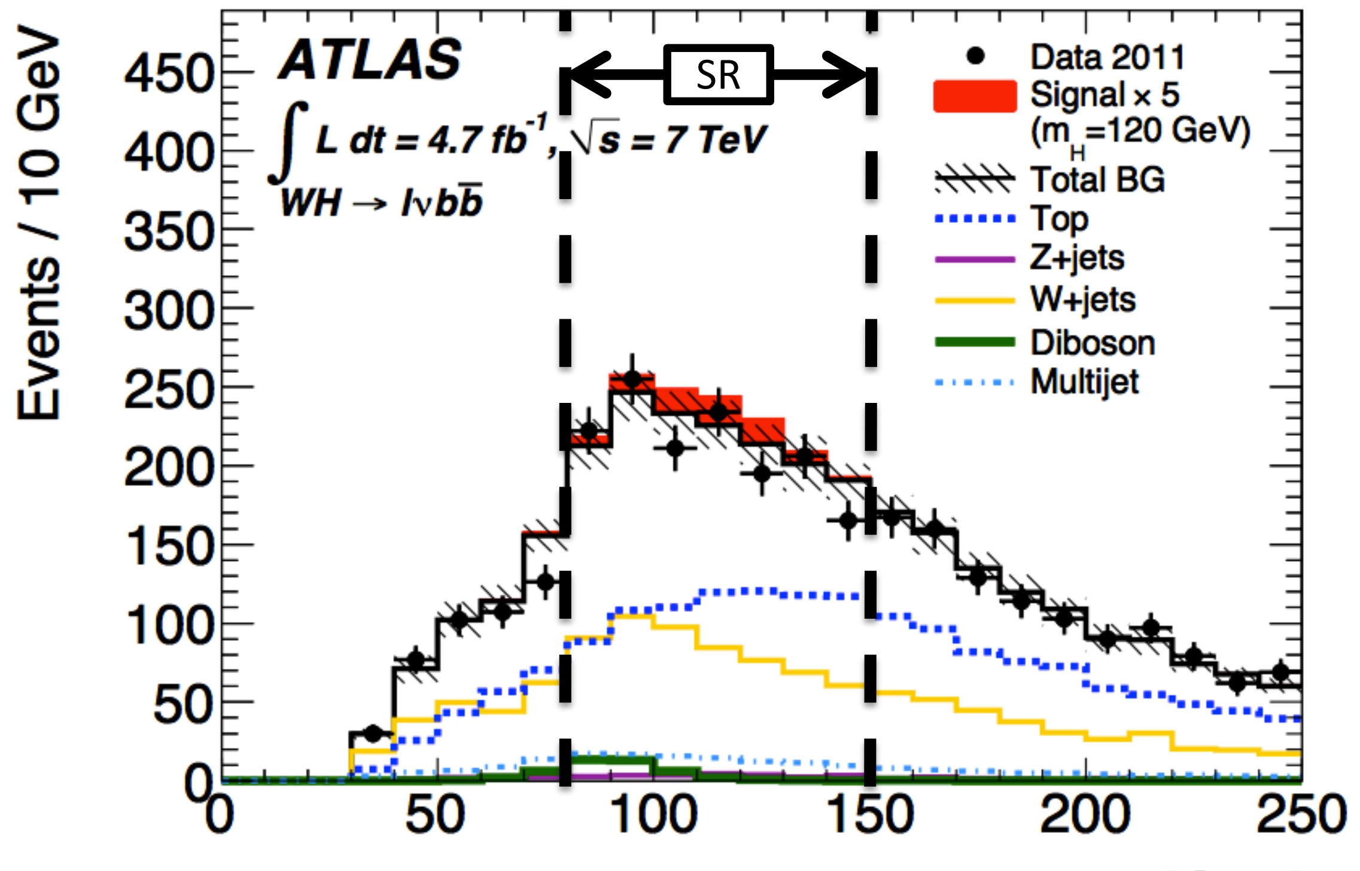

Figure 5. Invariant mass of the bb̄ pair for WH→lνbb̄

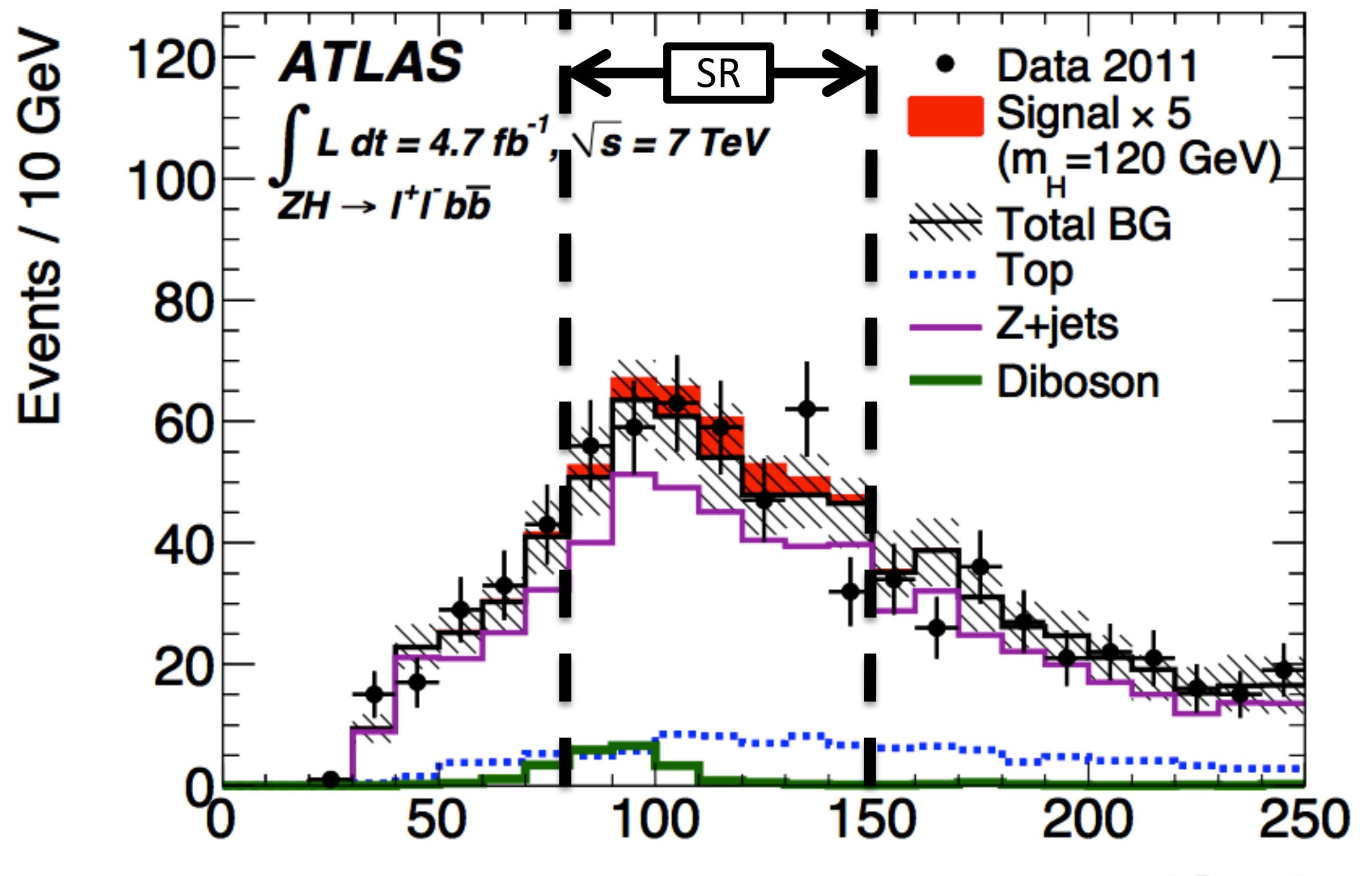

Figure 6. Invariant mass of the bb̄ pair for ZH→l⁺l⁻bb̄

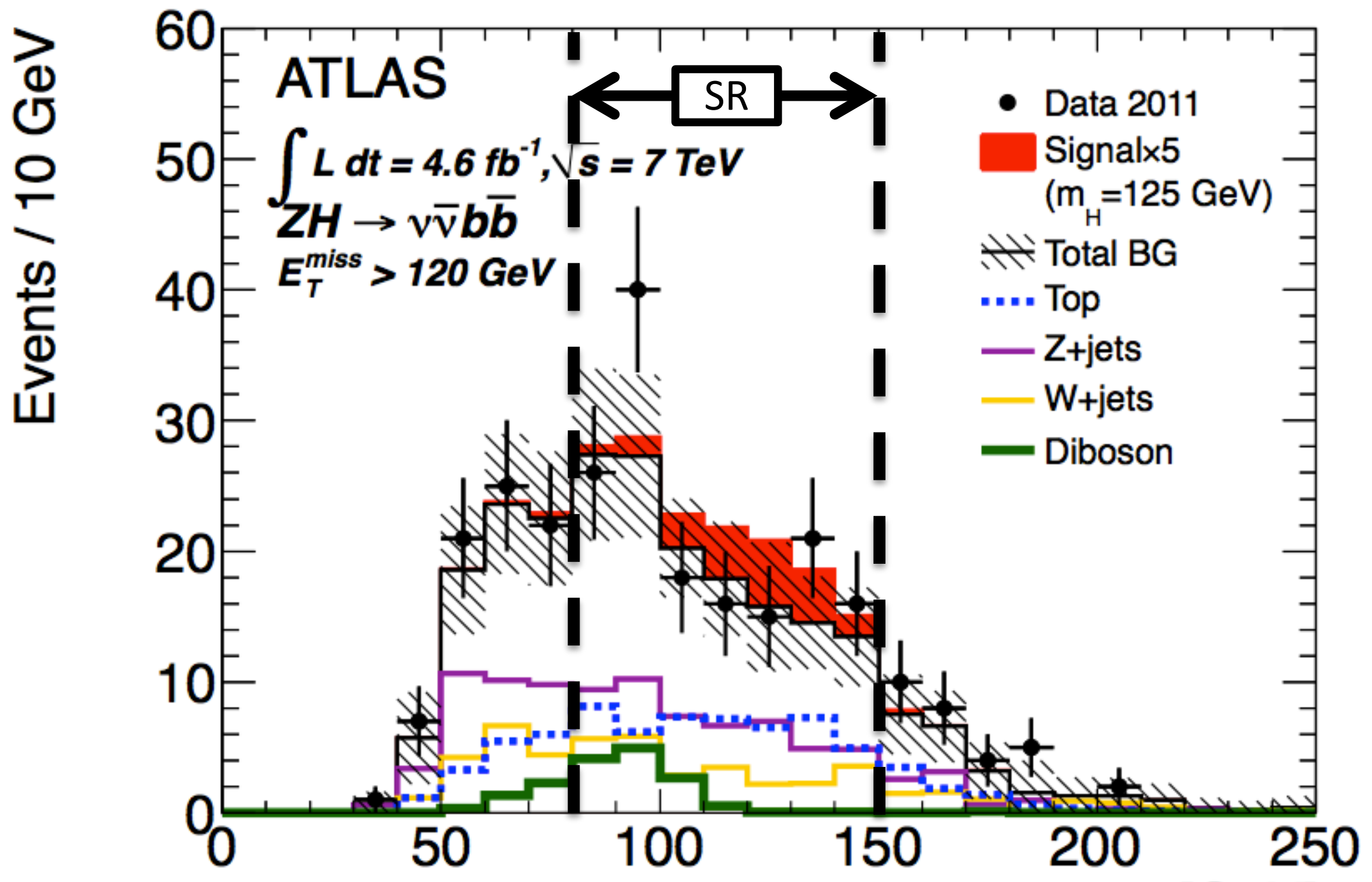

Figure 7. Invariant mass of the bb̄ pair for ZH→νν̄bb̄

- ✧ Main backgrounds: top (single+pair production), V+jets, VV and QCD in the WH case.
- ✧ For top and V+jets, the shape is taken from MC and normalisation from data **outside the Signal Region** (SR: 80<$m_{b\bar{b}}$/GeV<150). For VV, both the shape and the normalisation are evaluated with MC, while for QCD both are estimated using data.
- ✧ Quark flavour composition of V+jets background is estimated from data in a specific control region (exactly 2 jets, m_{jj}<80GeV) fitting templates of the flavour weight distribution in events with one or no b-tagged jets.
- ✧ The additional uncertainty for the modelling of p_t and $m_{b\bar{b}}$ distributions for the V+jets background is evaluated by comparing different MC predictions at LO and NLO.

- ✧ To **optimise** the analysis, the growth of Signal/Background as a function of the transverse momentum of the vector boson (p_t^V) is exploited. The analyses are performed in **bins of p_t^V**, three or four, depending on the channel. A correct modeling of the p_t^V spectrum is thus crucial.
- ✧ The total relative **systematic uncertainty** ranges from 3.4% to 19.6% on the background and from 9.1% to 16.5%, depending on p_t^V bin and channel.
- ✧ **Exclusion** limits are set using the expected signal and background and observed yields in the $m_{b\bar{b}}$ distribution.
- ✧ Five Higgs boson mass hypotheses are taken into account and tested by fitting the binned $m_{b\bar{b}}$ distribution in the SR. The upper limit on **$\mu=\sigma/\sigma_{SM}$ at 95% Confidence Level** is calculated using the CL_s method.
- ✧ The systematics are treated as nuisance parameters constrained by Gaussian terms. These can worsen the limit up to 40%. The **expected** exclusion limit ranges from 2.5 to 4.9×SM, and the **observed** ranges compatibly between 2.5 and 5.5×SM.
- ✧ The result is included in the ATLAS combination of the Higgs results presented on the 4th July 2012 [3],[4].

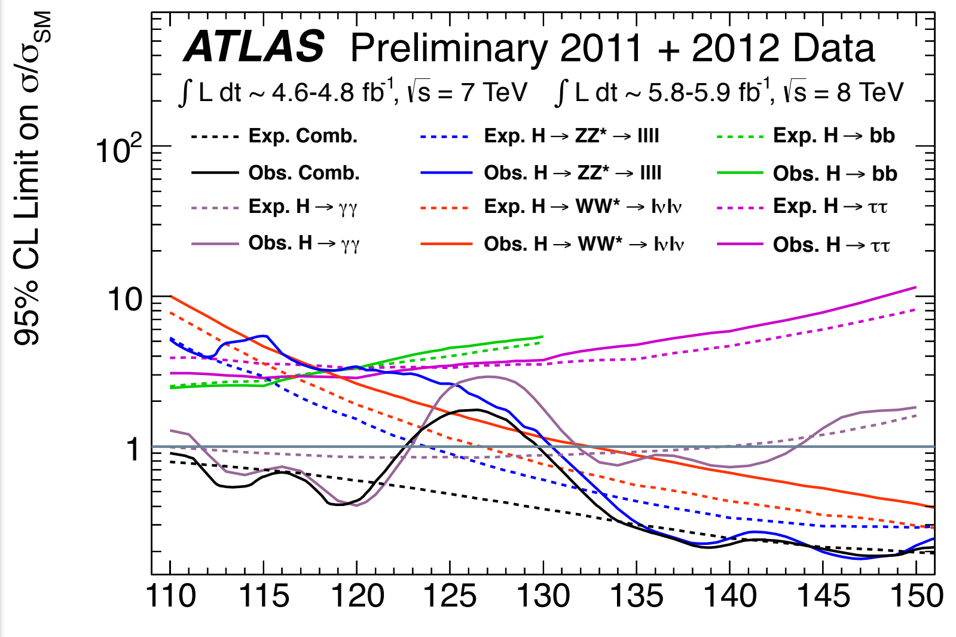

Figure 8. Combined exclusion limit for a SM Higgs boson [3]

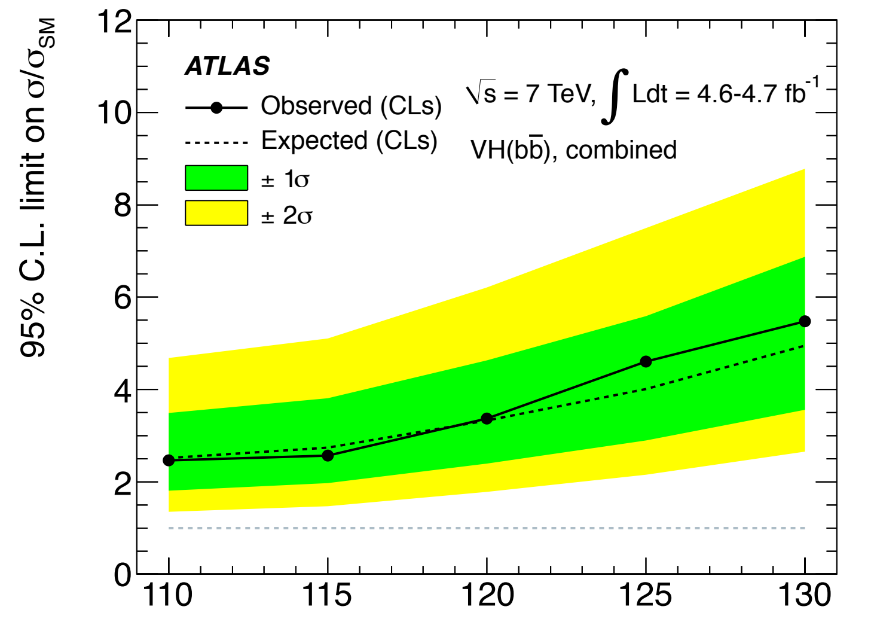

Figure 9. VH(bb) exclusion limit for a SM Higgs

What's next?

- ✧ The first **update** on data collected by ATLAS in 2012 dataset will be presented at Cracow in September 2012.
- ✧ It will provide a more complete picture on H→bb̄ with full 2012 dataset, with a cut-based analysis based on the illustrated 2011 one.
- ✧ Updates for Winter conferences, **multivariate techniques** under investigation for analysis optimisation.
- ✧ Possible alternative for sensitivity improvement: restriction to **high-p_t region**. More feasible with full 2011+2012 dataset because of significant statistics increase.
- ✧ Interesting approach, proposed in 2008: use of **jet substructure techniques** [2] to identify the Higgs candidate. High boost causes two b-jets to be very collimated, thus Higgs can be identified as a large-R jet, and its constituents studied. First study performed on MC at √s=14 TeV, with no pileup. Technique needs improvements. Work in progress.

References:

[1] arXiv:1207.0210
[2] arXiv:0802.2470v2
[3] ATLAS-CONF-2012-093
[4] arXiv:1207.7214v1