The search for the SM Higgs boson in $pp \to WH \to \ell\nu b\bar{b}$ events at ATLAS/LHC/CERN

Alberto Palma
on behalf of the LIP/ATLAS group

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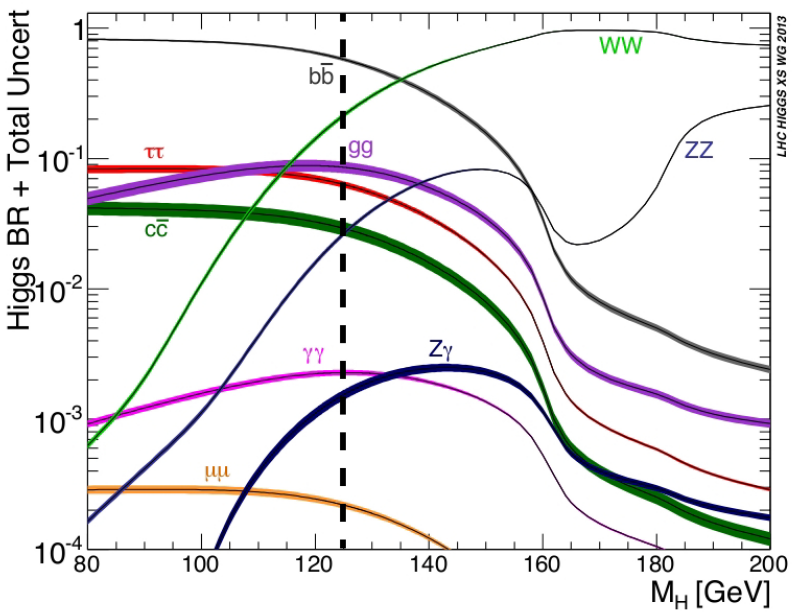
Why $H \to bb$ and associated production?

The discovery and study of the Higgs boson has been driven mainly by analysis using the bosonic decay modes: $H \to \gamma\gamma$, $H \to ZZ \to 4\ell$, $H \to WW \to \ell\nu\ell\nu$

Is also essential to study the decays into quarks and leptons to:

- direct probe the Yukawa coupling predictions;
- measure the dominant decay mode ($H \to bb$, $BR \sim 58\%$), and test for potential BSM physics



To study $H \to bb$:

- background is overwhelming (high p_T b-jets production is $\sim 10^6$ times larger)
- require leptons to reduce background:

  $\Rightarrow$ use W, Z or tt in associated production:

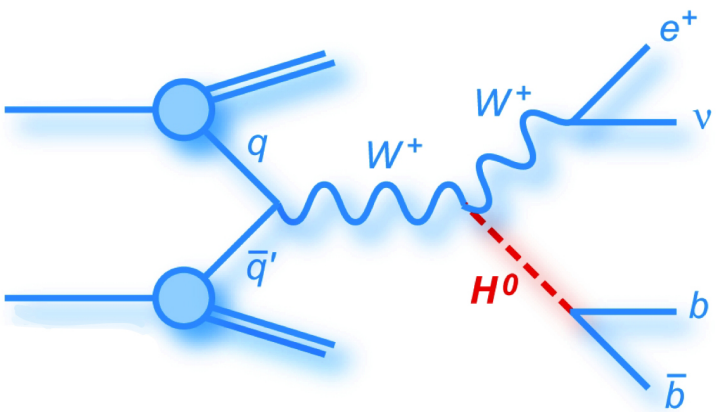
$$\sigma_{ggF} = 19.52 \text{ pb}$$
$$\sigma_{WH} = 1.09 \text{ pb}$$
$$\sigma_{ttH} = 0.13 \text{ pb}$$

Introduction $VH(H \to bb)$

3 channels explored and combined to increase sensitivity:

WH (1-lepton) and ZH (0 and 2-leptons)

(lepton = electron or muon)
At least 2 independent analysis/groups per channel



- 1 good isolated lepton:
  $p_T > 25$ GeV and $|\eta^{\mu(e)}| < 2.5(2.47)$
- 2 b-tagged jets:
  $p_T^{\text{leading(sub-leading)}} > 45(20)$ GeV and $|\eta| < 2.5$
- $\not{E}_T > 25$ GeV and $m_T^W < 120$ GeV
- use ΔR_{jj} to exploit different signal and background kinematics
- analysis binned in p_T^V to extract extra sensitivity

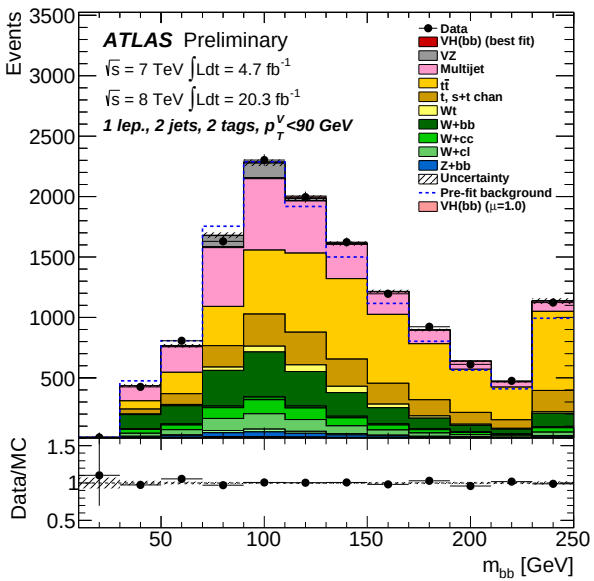
m_{bb} is the discriminating variable

Backgrounds

Control regions (CR) are used to constrain main backgrounds

Signal & control regions	1tag2jets	1tag3jets	2tag2jets	2tag3jets	top e/μ
0-leptons, 3 p_T^V bins	CR	CR	SR	SR	–
1-leptons, 5 p_T^V bins	CR	CR	SR	SR	–
2-leptons, 5 p_T^V bins	CR	CR	SR	SR	CR

- simultaneous fit to m_{bb} distribution in 26 SR and 31 CR to get the yield
  - shape template from MC, except QCD
  - normalization of top and W/Z + jets free to float



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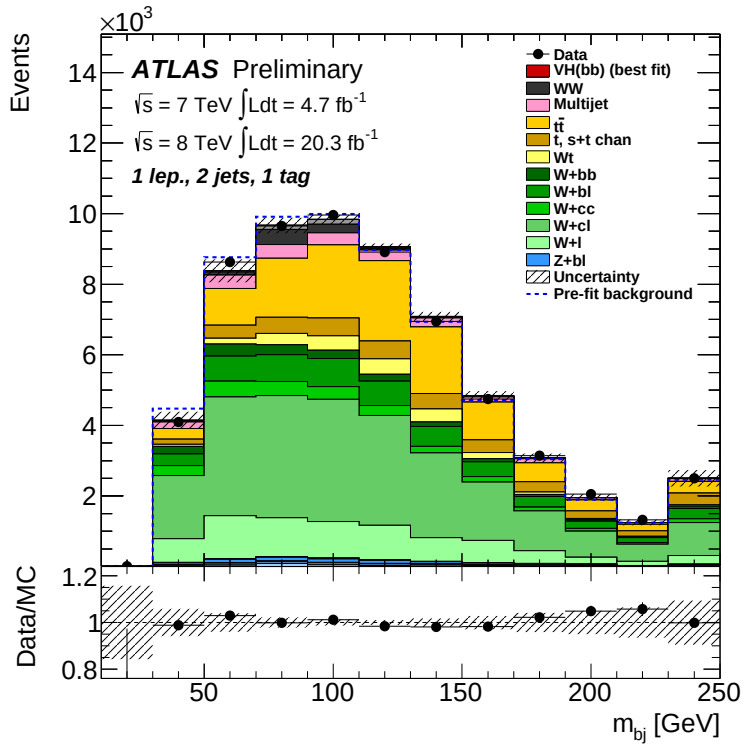
- QCD multi-jet estimated separately from data:
  - revert isolation cuts in data
  - subtract the EW contribution
  - use this template to get the QCD yield

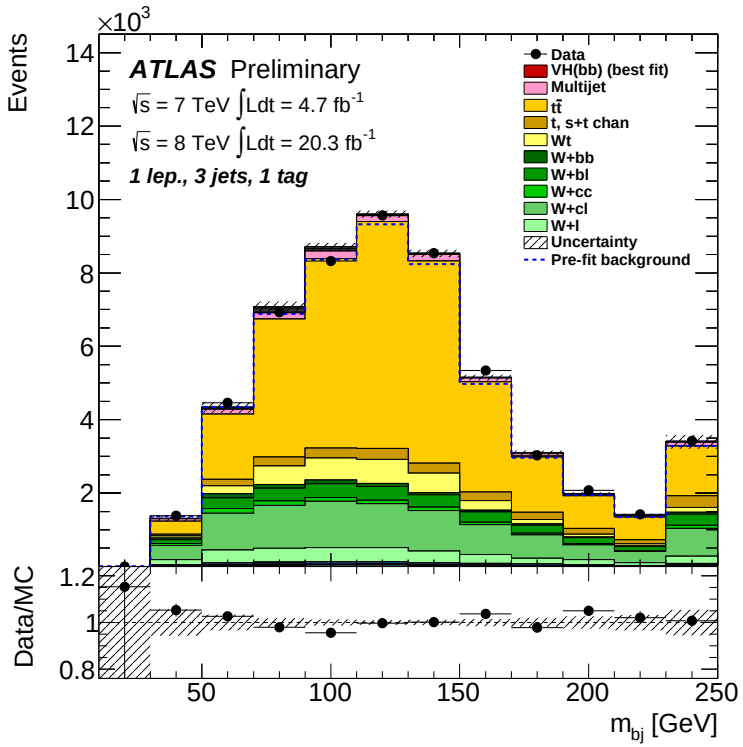
QCD contribution can be of the order of $\sim 15\%$ in the low p_T^W bin

Backgrounds

Signal & control regions	1tag2jets	1tag3jets	2tag2jets	2tag3jets	top e/μ
0-leptons, 3 p_T^V bins	CR	CR	SR	SR	–
1-leptons, 5 p_T^V bins	CR	CR	SR	SR	–
2-leptons, 5 p_T^V bins	CR	CR	SR	SR	CR

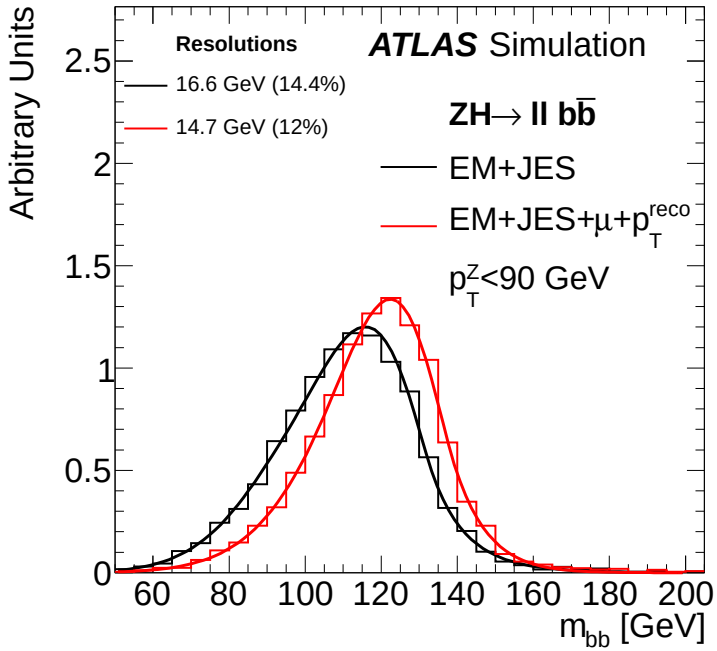


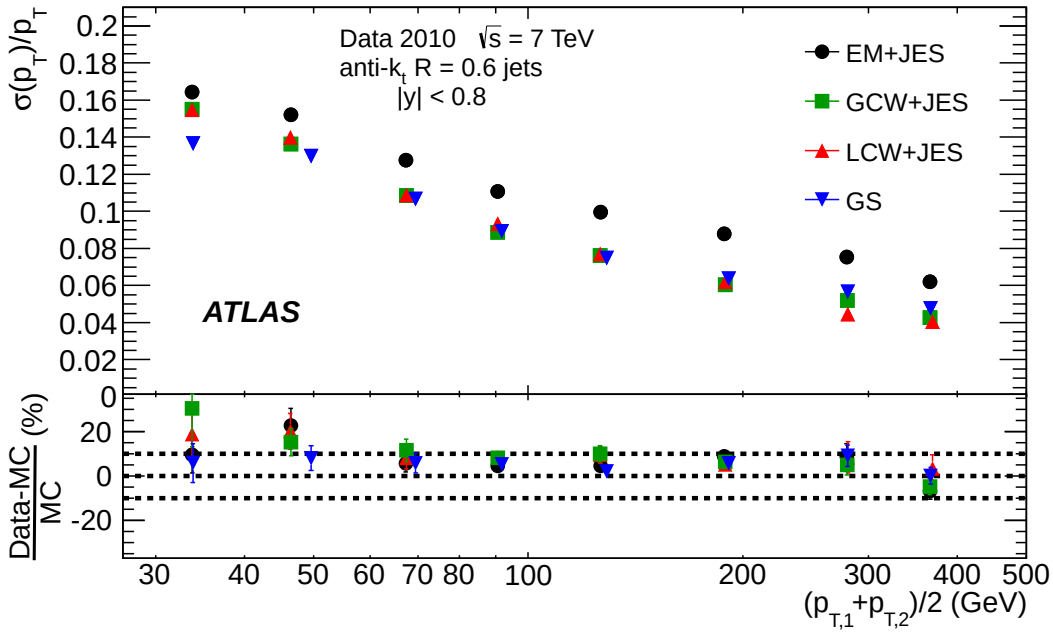
W + jets CR



top CR

Dedicated jet calibration to improve m_{bb} resolution





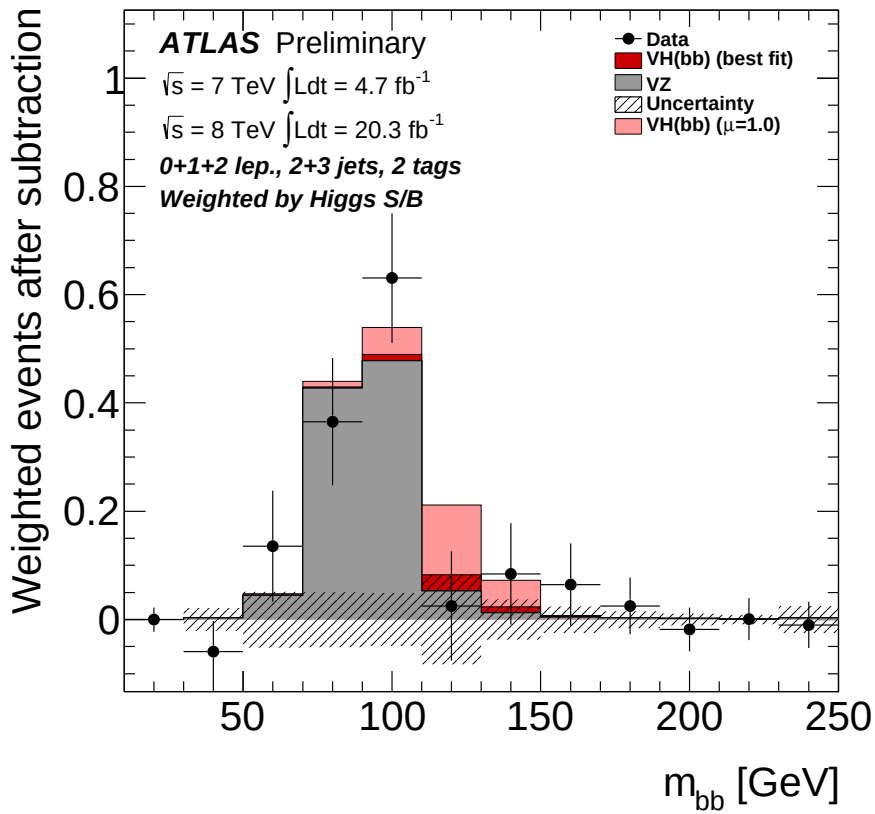
- Correct for muons inside jets
- Correct for migration of events between p_T bins
- In preparation: detailed jet calibration that improves resolution and reduces flavor dependence

Test potential to observe $H \to bb$ with $Z \to bb$

- VZ has a similar signature with $\sim 5 \times$ larger cross-section then VH:
  - perfect to validate VH analysis
- "Search" for $Z \to bb$:
  - subtract all SM backgrounds, except dibosons
  - fix Higgs yield to SM value

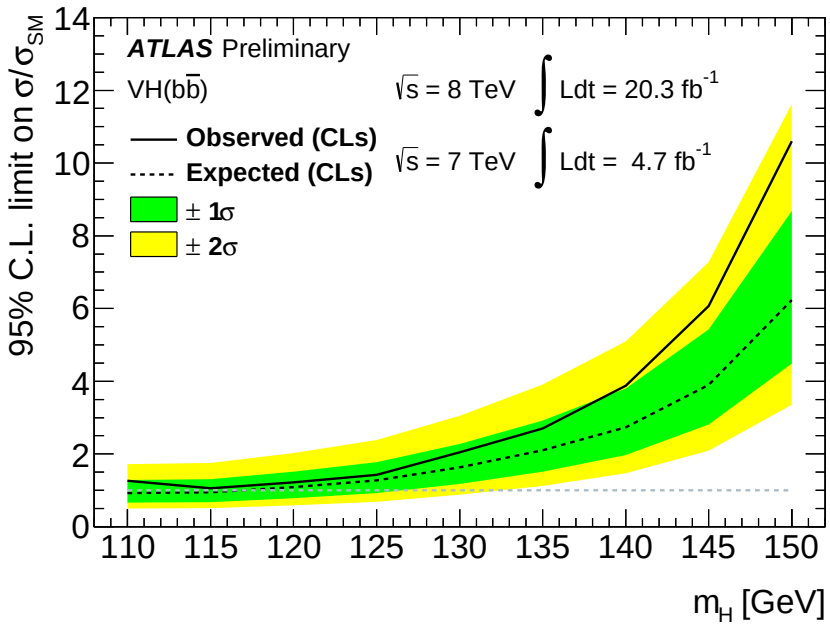
- Expected significance: 5.1σ
- Observed significance: 4.8σ
- Signal strength with respect to SM:

$$\mu_{VZ} = 0.9 \pm 0.2$$

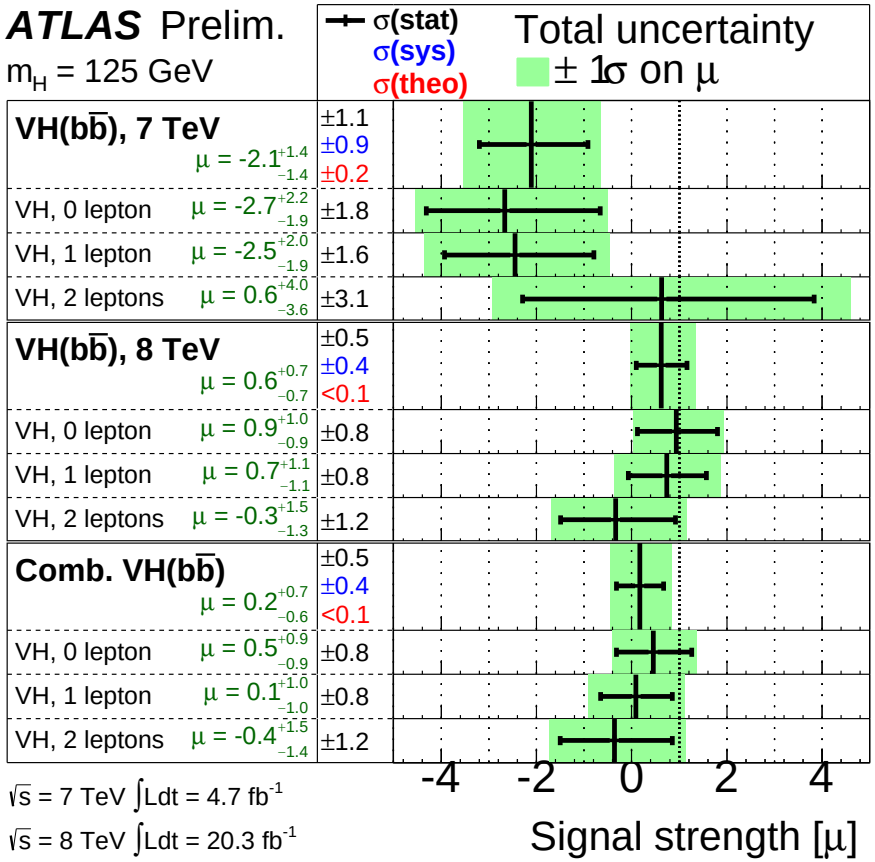


ZZ and WZ processes clearly visible and compatible with SM (gray); no excess of $H \to bb$ observed

Results



- 95% CL limit @ 125 GeV:
  - Observed: 1.4× SM
  - Expected: 1.3× SM



- Signal strength with respect to SM:

$$\mu = 0.2 \pm 0.5(stat.) \pm 0.4(syst.)$$

Results compatible with both background-only hypothesis and SM $H \to bb$ hypothesis

Conclusions

- $H \rightarrow$ essential to probe SM Higgs predictions
- ATLAS has performed a search for $H \rightarrow bb$ in the VH channels:
  - at $m_H = 125$ GeV, a 95% CL limit of 1.4$\times$ SM expectation is set on the $\sigma_{WH} \times BR$
- Working on improvements:
  - better b-jet energy calibration
  - QCD and single top backgrounds modeling and systematics
  - LIP provides one of the 2 analysis contributing to the WH channel

Acknowledgments:

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