Search for the Standard Model Higgs boson produced in association with vector bosons and decaying to $b\bar{b}$ using the ATLAS detector

Manuel Proissl on behalf of the ATLAS collaboration
University of Edinburgh

INTRODUCTION

A new neutral boson decaying into pairs of photons and W or Z bosons with an invariant mass of ~ 125 GeV has been observed and requires confirmation of its coupling to fermions in order to determine whether it is the Standard Model (SM) Higgs boson. A vital observation would be its decay into b quark pairs, which has a predicted branching ratio of 58% for m_H = 125 GeV. This poster presents an updated direct search with the ATLAS experiment for $b\bar{b}$ decays of the Standard Model Higgs boson produced in association with a W or Z boson using 4.7 and 20.3 fb^{-1} of LHC proton-proton data at centre-of-mass energies of 7 and 8 TeV, respectively. The search is performed in the three decay modes $ZH\to\nu\nu b\bar{b}$, $WH\to\ell\nu b\bar{b}$ and $ZH\to\ell\ell b\bar{b}$ with ℓ denoting either electrons or muons. No significant excess is observed. The observed (expected) 95% C.L. upper limit on the production cross section times the $pp\to(W/Z)(H\to b\bar{b})$ branching ratio for m_H = 125 GeV is found to be 1.4 (1.3) times the SM prediction. The diboson (W/Z)Z production with $Z\to b\bar{b}$ is used to validate the analysis. The ratio of the observed Higgs (diboson) cross section to the SM expectation is found to be μ = 0.2 ± 0.5 (stat.) ± 0.4 (syst.) (μ_{VZ} = 0.9 ± 0.2).

EVENT SELECTION

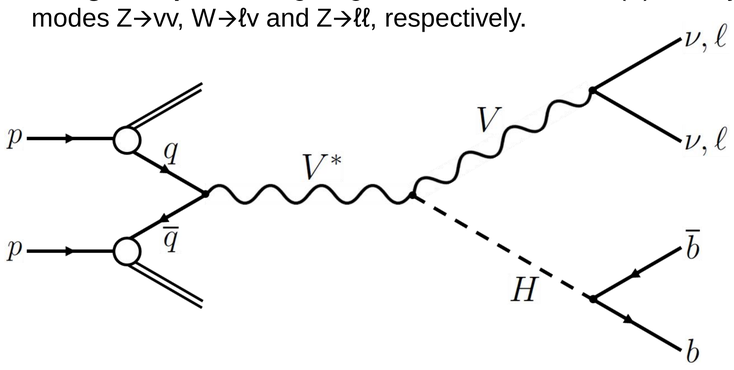
0 Lepton
- E_T^{miss} trigger
- E_T^{miss} > 120 GeV
- p_T^{miss} > 30 GeV

1 Lepton
- Single lepton trigger
- E_T^{miss} > 25 GeV
- m_T^W < 120 GeV

2 Lepton
- Single + di-lepton trigger
- 83 GeV < $m_{\ell\ell}$ < 99 GeV
- E_T^{miss} < 60 GeV

Common
- At least 2 jets p_T^1>45 GeV, p_T^2>20 GeV and |η|<2.5
- (Sub)Leading lepton p_T > 25 (10) GeV
- 2 b-tagged jets (70% eff.)

- The analysis is performed in events containing **0, 1 and 2 charged leptons** targeting the vector boson (V) decay modes $Z\to\nu\nu$, $W\to\ell\nu$ and $Z\to\ell\ell$, respectively.

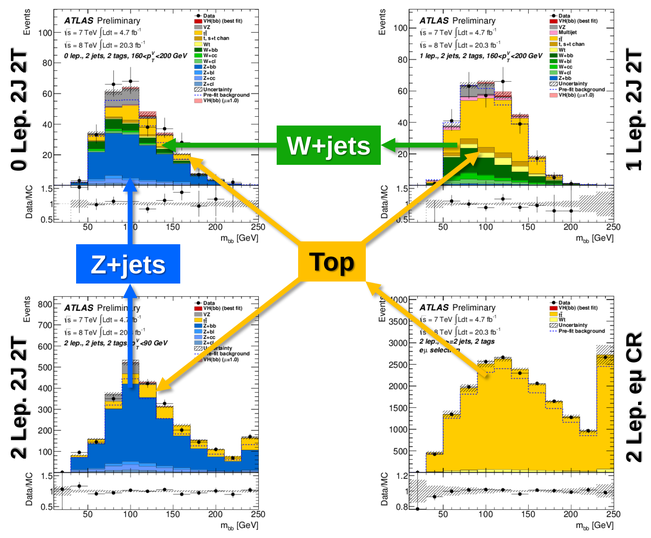


- Further QCD rejection cuts are applied in 0 and 1 lepton chn.
- Optimized cuts are applied in bins of the vector boson p_T and the number of jets to maximize the sensitivity.

p_T^V bin (GeV)	0-90	90-120	120-160	160-200	>200
ΔR(j,j)	0.7-3.4	0.7-3.0	0.7-2.3	0.7-1.8	<1.4

STATISTICAL TREATMENT

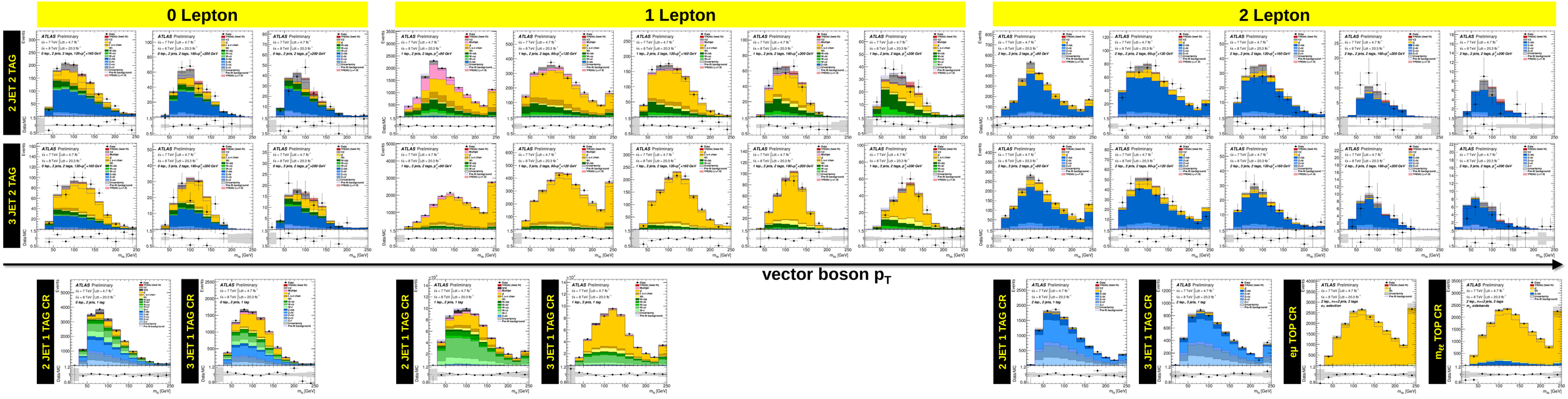
- A binned likelihood function is constructed as the product of Poisson probability terms with inputs from the **2-tag signal** regions, **1-tag control** regions and the 2 Lepton **eμ top control** region.
- Experimental (i.e. JES, b-tagging), background modelling and theoretical signal uncertainties affect normalizations and/or shapes of the **m_{bb}**, used as the main discriminating variable.



- Each source of systematic uncertainties is parameterised in the profile likelihood fit.
- **Common nuisance parameters** (NPs) across regions.
- Systematics on the extrapolation between background NPs
- The m_{bb} shape and normalisation are extracted from 2-tag regions; only the normalisation is used in the 1-tag and top control regions.

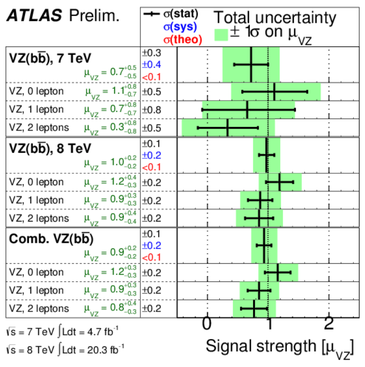
BACKGROUND COMPOSITION

- The **dijet mass distributions** for all signal (in Vp_T bins) and control (in Vp_T combined) regions after the profile likelihood "global fit". The signal included is for m_H = 125 GeV.

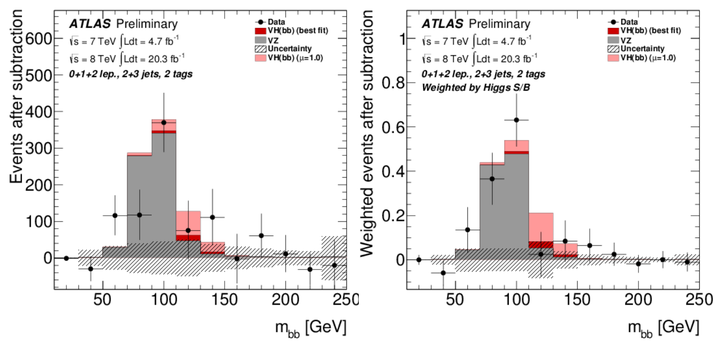


- The normalizations of V+jets and $t\bar{t}$ are floating in the fit. For 7+8 TeV, the scale factors obtained are: **$t\bar{t}$** (1.13±0.05), **Wb** (0.89±0.15), **Wcl** (1.05±0.14), **Zb** (1.30±0.07) and **Zcl** (0.89±0.48). [stat.+syst.]

DIBOSON OBSERVATION

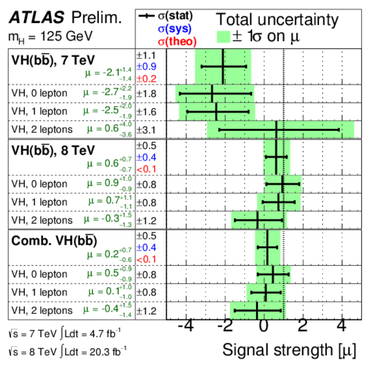


- The diboson (W/Z)Z production with $Z\to b\bar{b}$ has a similar signature to VH with a ~5 times larger cross section and thus is used to **validate the analysis procedure** ("Diboson fit").
- The combined **diboson signal strength μ_{VZ} = 0.9 ± 0.2** agrees well with the SM expectation of μ_{VZ} = 1 with an observed (expected) significance of 4.8σ (5.1σ).
- Higgs boson fit: the m_{bb} after subtraction of all backgrounds except for diboson and VH productions is shown.
- The diboson peak is clearly seen, located at the Z mass.



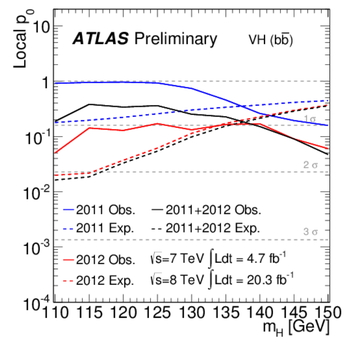
RESULTS

- The combined **Higgs signal strength is μ = 0.2 ± 0.5 (stat.) ± 0.4 (syst.)** for m_H= 125 GeV.

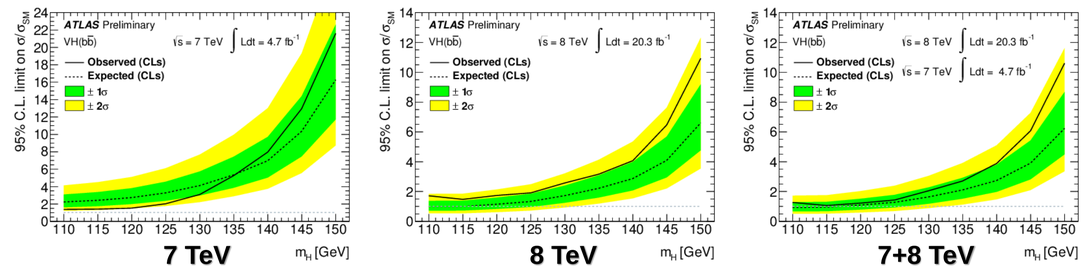


- The **observed (expected) limit is 1.4 (1.3)** times the SM expectation.
- If restricted to one dataset, the observed (expected) limits are:

7 TeV	**2.0 (3.3)**
8 TeV	**1.9 (1.3)**



- In the absence of signal the p_0 value is 0.36 and in the presence of a SM Higgs boson the expected p value is 0.05.
- The **95% C.L. upper limits**: 2σ deficit in 7 TeV data also observed in previous analysis, leading to a small excess in the combined result; an ~1σ excess is observed in 8 TeV data.



CONCLUSION

New results on associated SM Higgs production using the full 7 TeV and 8 TeV datasets are presented. The analysis achieved a **~35% gain in significance** beyond the increased integrated luminosity. No significant excess is observed. The diboson observation is consistent with the SM expectation with a 4.8σ excess over the background-only hypothesis. The ratio of the measured Higgs boson signal strength to the SM expectation is μ = 0.2 ± 0.5 (stat.) ± 0.4 (syst.).

Conference note: ATLAS-CONF-2013-079