Search for the Higgs boson decaying to b quark pairs in the W/Z associated production channels with ATLAS

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The $H \to b\bar{b}$ decay has the largest SM branching ratio for a 125 GeV Higgs boson (58%) and its measurement is fundamental to:

- Measure the Higgs decay width and couplings
- Confirm the SM hypothesis

The W/Z associated production provides clear signatures for trigger and backgrounds rejection.

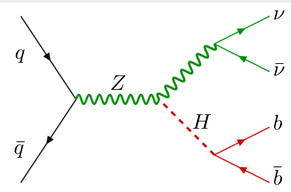
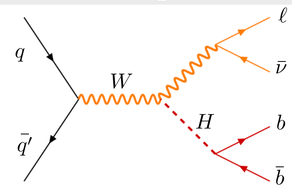
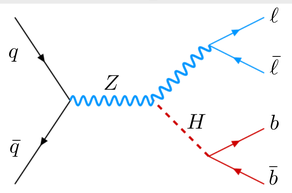
DATA SAMPLE

The results from the VH (V=W,Z) channels analysis with the Run1 pp collision data are presented:

- $4.7 fb^{-1}$ at $\sqrt{s} = 7$ TeV
- $20.3 fb^{-1}$ at $\sqrt{s} = 8$ TeV

EVENT SELECTION

The analysis explores 3 channels to maximize the sensitivity: 0, 1 and 2 leptons ($\ell = e, \mu$).

0-Lepton	1-Lepton	2-Lepton
		
no leptons	exactly 1 lepton	2 same flavor leptons
$p_T^{miss} > 30,\ E_T^{miss} > 120$ (GeV)	$H_T > 180\ GeV$	$71 < m_{\ell\ell} < 121\ (GeV)$
$\Delta\phi(E_T^{miss}, p_T^{miss}) < \pi/2$	$E_T^{miss} > 20$ ($p_T^W > 120$) (GeV)	
$min[\Delta\phi(E_T^{miss}, jet_i)] > 1.5$		

In addition: p_T^V-dependent $\Delta R(b_1, b_2)$ cuts and jets p_T cuts

b-tagging weight (MV1c) in 3 categories: 50, 70 and 80% efficiency

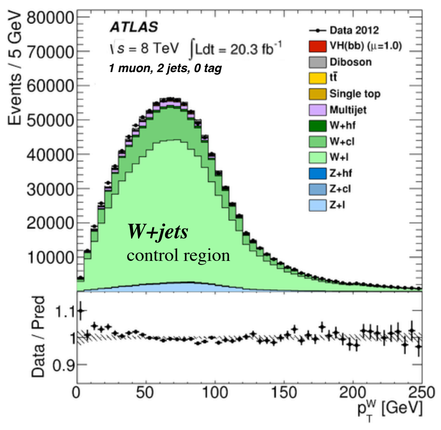
Events categorized based on the number of jets (2 or 3), p_T^V and *b*-tag type

BACKGROUNDS

Process	Generator
$t\bar{t}$	POWHEG+PYTHIA
Z + jets	SHERPA 1.4.1
W + jets	SHERPA 1.4.1
Dibosons	POWHEG+PYTHIA8
top t-channel	ACERMC+PYTHIA
top s-channel	POWHEG+PYTHIA
top Wt	POWHEG+PYTHIA
Multi-jet	data-driven

Modeling uncertainties are derived by comparing different generators and simulation with data.

Special regions designed to control backgrounds.



MULTIVARIATE ANALYSIS

The sensitivity is improved by exploring event properties with a Boosted Decision Tree (BDT) trained for different Higgs mass hypothesis for each event class:

- 0, 1 or 2 lepton channels
- 2 or 3 jets
- p_T^V intervals

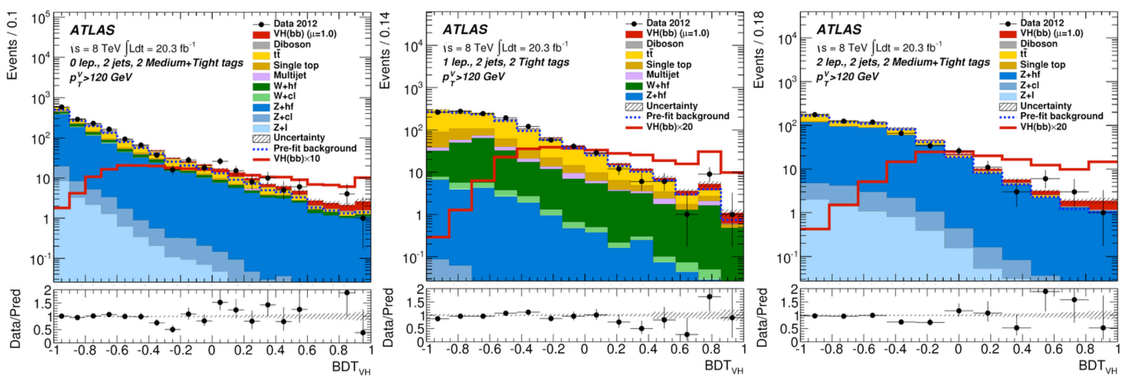
Input variables optimized for each event category.

p_T^{j3}, m_{bbj} only used for 3 jet events.

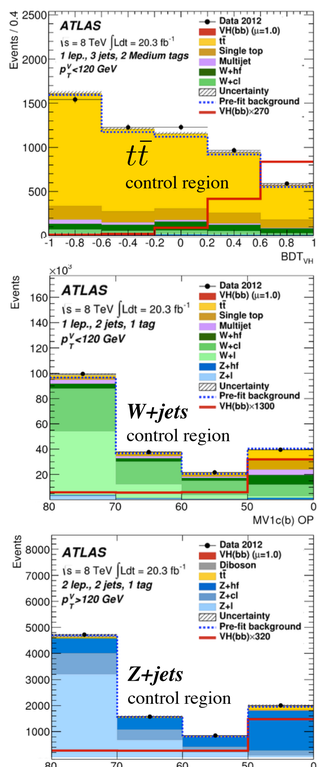
Variable	*0ℓ*	*1ℓ*	*2ℓ*
p_T^V -Vector Boson Transverse Momentum		●	●
E_T^{miss} - Missing Transverse Energy	●	●	●
$p_T^{j_i}$ - Jet Transverse Momentum	●	●	●
m_{bb} and m_{bbj} - Invariant Mass of the jets system	●	●	●
$\Delta R(b_1, b_2)$ - Radial Distance between the 2 jets	●	●	●
$\lvert\Delta\eta(b_1, b_2)\rvert$ - η difference between the 2 jets	●		●
$\Delta\phi(V, bb)$ - ϕ between the V and the bb system	●	●	●
$\lvert\Delta\eta(V, bb)\rvert$ - η between the the V and the bb system			●
H_T - Scalar sum of E_T^{miss}, $p_T^{j_i}$ and p_T^{ℓ}	●		
$min[\Delta\phi(\ell, b^i)]$ - ϕ between the lepton and closest *b*-jet		●	
m_T^W - Vector Boson Transverse Mass		●	
$m_{\ell\ell}$ - Invariant Mass of the leptons system			●
$MV1c(b_i)$ - Jet flavor (*b*-tagging) weight	●	●	●

FIT METHOD

A maximum likelihood binned fit is performed simultaneously on the 3 channels using 38 regions. Input distributions are the BDT output (2 tag regions) and the *b*-tagging weight (1 tag regions).

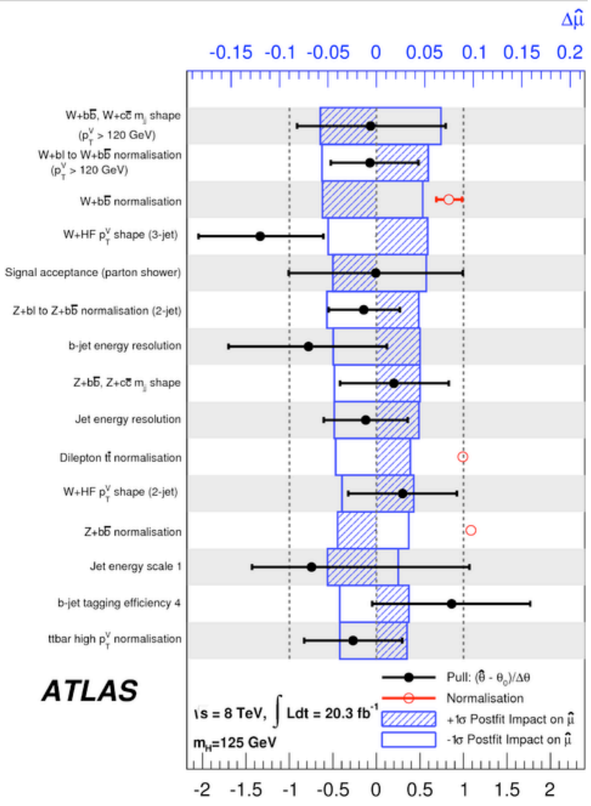


Experimental and systematic uncertainties are parsed as a set of nuisance parameters. The impact of each uncertainty on the signal strength uncertainty ($\Delta\mu$) is evaluated independently (right plot).



Largest backgrounds are allowed to float and their scale is constrained by the data.

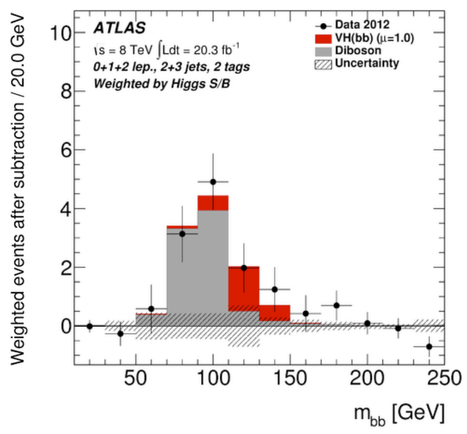
Process	Scale factor
$t\bar{t}$ 0-lep	1.36 ± 0.14
$t\bar{t}$ 1-lep	1.12 ± 0.09
$t\bar{t}$ 2-lep	0.99 ± 0.04
Wbb	0.83 ± 0.15
Wcl	1.14 ± 0.10
Zbb	1.09 ± 0.05
Zcl	0.88 ± 0.12



VALIDATION

The analysis is validated by the VZ ($Z \to b\bar{b}$) yield measurement:

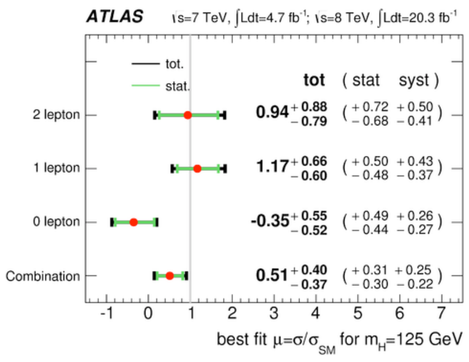
$$\mu_{VZ} = 0.74 \pm 0.09(\text{stat}) \pm 0.14(\text{syst})$$



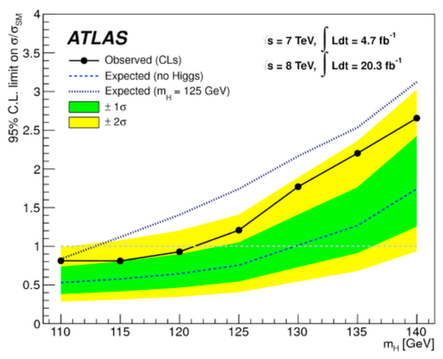
RESULTS

The observed (expected) deviation from the background-only hypothesis corresponds to a significance of 1.4 (2.6) σ.

Signal strength μ for the 3 channels and combination.



Observed and expected 95% CL on σ upper limits.



BIBLIOGRAPHY

ATLAS Collaboration. JHEP01(2015)069

XXXV Physics in Collision - September 15th-19th 2015 - Warwick University - England