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Search for the Standard Model Higgs boson decaying to a b-quark pair with ATLAS



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1. Motivations

- Fits to the parameters of the Standard Model favor a low mass Higgs boson ($m_{H} < 140 \text{ GeV}$)
- The decay H \rightarrow bb is dominant for m_H < 130 GeV
- The production of the Higgs in association with an electroweak vector boson provides clean signatures for reconstruction

2. Signal and Backgrounds

Experimental signature:

- isolated lepton(s) with high p_{T}
- 2 b-jets
- high E_{T}^{miss} (for WH events)

<u>Channels</u>: ZH \rightarrow llbb and WH \rightarrow lubb with l = e or μ





3. Event Selection

LEPTON IDENTIFICATION		$ZH \rightarrow llbb$				WH ightarrow l u bb					
		ION	electrons		muons		electrons	muons			
	no construction		match ID track and		match ID tracks a	and	match ID track and	match ID tracks and			
reconstruction			electromagnetic cluster		MS track (segmen	nts)	electromagnetic cluster	MS track (segments)			
	kinematic criteria		$E_T > 20 \text{ GeV}$		$p_T > 20 \text{ GeV}$		$E_T > 25 \text{ GeV}$	$p_T > 25 \text{ GeV}$			
			$ \eta < 2.47$		$ \eta < 2.5$		$ \eta < 2.47$	$ \eta < 2.4$			
	track isolation	track isolation		$\sum_{\rm track} p_T^{\rm track}(\Delta R < 0.2) < 0.1 \times p_T^{\rm lepton}$							
JET			JVF = fraction of the p_T sum of tracks in a jet								
RECONSTRUCTION					associated to the main interaction point						
identification		Anti	$-k_T$ with $R = 0.4$					Missing energy i			
kinematic criteria		$p_T >$	> 25 GeV	3 10 ⁶ ■ ATLAS Preliminarv							
		\eta <	$ \eta < 2.5$			4 Q	10 ⁵	$\int L dt = 1.04 \text{ fb}^{-1}$			
pile-up rejection		JVI	JVF > 0.75			SS/	10 ⁴				
Ī	EVENT					Intrie	10 ³	— M			
	SELECTION	ZH	$\rightarrow llbb$	WH	$\rightarrow l \nu b b$	ш	10 ²				
	trigger	sing	le/di-lepton	singl	e lepton	t					
Ī	number of leptons	exac	etly two	exac	tly one	1		╱╾┶╍╕╎╞╤╬╫╷║╷╽╺ <mark>╜┠┿╬┿╶╬╼╬</mark> ──┐╵╿╵╴╴╿┍┨╞╗╽┑╻ _┢ ╒╢╫╢			
	mass conditions	76 <	$< m_{ll} < 106 { m ~GeV}$	m_T :	$> 40 { m ~GeV}$		10 ⁻²				
	missing energy	E_T^{mi}	$^{\rm ss} < 50 { m ~GeV}$	$E_T^{\rm mis}$	$^{\rm s} > 25 { m ~GeV}$		0 5 0 1	150 200			
	jets	at le	east two	exac	tly two	ļ		E ^{miss}			
	b-tagged jets	two	highest p_T	exac	tly two						

Backgrounds:

- QCD multijet
- Wbb and Zbb
- tt and single-top
- di-bosons

4. Background Estimation

proton

proton

<u>Top quark (top pairs and single top)</u>:

- shape from MC simulation
- normalisation:

– <u>For ZH</u>: from MC. Checked with sidebands of m_{μ} : 60 < m_{μ} < 76 GeV / 106 < m_{μ} < 150 GeV – <u>For WH</u>: fit sidebands of m_{bb} distribution: $m_{bb} < 80 \text{ GeV} / 140 < m_{bb} < 250 \text{ GeV}$

• control sample: events with 2 b-tagged jets + 1 other jet (only on WH)

$\underline{Z + jets}$:

- shape from MC simulation
- \bullet normalisation: fit to m_{μ} in
- sidebands regions
- control sample: events with only one b-tagged jet

W + jets:





• shape of m_{ii} from data to model m_{ik} • normalisation: fit to m in sidebands regions

Di-bosons (ZZ/ZW/WW):

• irreducible background (not WW) • estimated from MC simulation

QCD multijet:

• shape from multijet enriched sample • normalisation: fit to m_{ij} for ZH and to E_{T}^{miss} for WH



m_I [GeV]

Missing energy in ZH:



Note: sidebands used for normalizing Z+jets are the same as for W+jets and tt (only for WH)

m_{bb} [GeV]

5. Systematic Uncertainties

DETECTOR RELATED:

Source of Uncertainty	Effect on ZH	$\rightarrow \ell\ell bb$ signal	Effect on $WH \rightarrow \ell \nu bb$ signal		
	$m_H = 115 \text{ GeV}$	$m_H = 130 \text{ GeV}$	$m_H = 115 \text{ GeV}$	$m_H = 130 \text{ GeV}$	
Electron Energy Scale	< 1%	< 1%	1%	1%	
Electron Energy Resolution	< 1%	< 1%	1%	1%	
Muon Momentum Resolution	1%	3%	4%	1%	
Jet Energy	9%	7%	1%	3%	
Jet Energy Resolution	< 1%	< 1%	1%	1%	
Missing Transverse Energy	2%	2%	2%	3%	
b-tagging Efficiency	16%	17%	16%	17%	
b-tagging Mis-tag Fraction	< 1%	< 1%	3%	3%	
Electron Efficiency	1%	1%	1%	1%	
Muon Efficiency	1%	1%	1%	1%	

6. Results and Conclusions



NON DETECTOR RELATED:

Source of Uncertainty	Treatment in analysis			
	ZH	WH		
Luminosity	3.7%	3.7%		
Higgs boson cross-section	5%	5%		
Background norm. and shape:				
Тор	9%	6%		
Z+jets	9% plus shape	9%		
W+jets	negligible	14% plus shapes		
ZZ	11%	negligible		
WZ	11%	11%		
WW	negligible	11%		
QCD multijets	100%	50%		

References: The ATLAS Collaboration note ATLAS-CONF-2011-103

VH, $H \rightarrow bb$ ±**2**σ ₩**100 ATLAS Preliminary** <u>ර</u> 80 115 120 Higgs mass [GeV]

• 95% C.L. limits on the cros-section combining muon and electron channels

• Exclusion limits range between 10 to 20 times the SM cross-section for m_H between 110 to 130 GeV

Acknowledgments:

