High-Mass Higgs Searches at ATLAS

On behalf of the ATLAS Collaboration

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ATLAS Detector

A large Toroidal LHC Apparatus

- ATLAS is a multi-purpose detector built to observe a wide spectrum of events from the proton-proton (pp) collisions produced at the Large Hadron Collider (LHC), CERN, Geneva.
- Recorded $\sim 5/\text{fb}$ of pp data in 2010-2011 at $\sqrt{s} = 7\text{TeV}$.
- Coped with large number of interactions per crossing (pile-up).

Muon Spectrometer: $|\eta| < 2.7$

Air-core toroids with gas chambers.

Provides L1 trigger and standalone measurement.

$$\sigma/p_T < 10\% \text{ up to } p_T=1\text{TeV}$$

Hadronic Calorimeter:

Scintillating Fe tiles in barrel ($|\eta| < 1.7$)

Cu/W in LAr in forward region ($|\eta| < 4.9$)

Provides L1 trigger, jet measurement, and missing energy.

$$\sigma/E \sim 50\%/\sqrt{E} \oplus 3\%$$

Electromagnetic Calorimeter: $|\eta| < 3.2$

Pb in LAr with accordion geometry.

Provides L1 trigger, energy, identification, and position measurement.

$$\sigma/E \sim 10\%/\sqrt{E} \oplus 0.7\%$$

Inner Detector / Tracker: $|\eta| < 2.5$, $B=2\text{T}$

Si Pixels+Strips, Transition Radiation Tracker

Provides precise tracking, vertexing, em/hadron separation.

$$\sigma/p_T \sim 0.05\% p_T \oplus 1\%$$

[1] www.atlas.ch

Higgs Production at the LHC

gluon-gluon fusion: ggF

- Leading production at the LHC
- Theoretical uncertainty: 15-20%
- Discovery channel

- NNLO(QCD) + NNLL(soft-gluon resummation), Higgs p_T reweighted (HqT).

ttH

Higgs-strahlung

vector-boson fusion: VBF

- Uncertainty: 3-9%
- NLO(EW) + NNLO(QCD)
- Presence of forward jets in final state helpful for analysis

High-Mass Searches: Outline

Channels updated for full 2011 integrated luminosity

- 4.7-4.8 fb⁻¹

$ZZ \rightarrow ll\nu\nu$

$ZZ \rightarrow llqq$

$WW \rightarrow l\nu qq$

$ZZ \rightarrow ll ll, WW \rightarrow l\nu l\nu$

Combination

Summary and Outlook

[1] <https://twiki.cern.ch/twiki/bin/view/LHCPhysics/CrossSections>

Green, Yellow Bands, and Dashed Lines

Explanatory figure (not actual data)

Signal MC

- PowHeg+Pythia for ggF and VBF
- Higgs line shape and SM background interference
- uncertainties for $m_H > 300$ GeV:
 - $1.5 \times (m_H/\text{TeV})^3$ [1]
 - $\sim 30\%$ at $m_H = 600$ GeV

Measurements and Inputs

- Histogram shapes binned in m_H
- Likelihood fits of a discriminant distribution given m_H

Limit Extraction

- Profile likelihood ratio, hypothesis test with $\sigma/\sigma(\text{SM})$ [2]
- Exclusion limits on $\sigma/\sigma(\text{SM})$ are set at 95% confidence level (CL) using the CLs method [3]

[1] Handbook of LHC Higgs Cross Sections

[2] Eur.Phys.J.C71:1554,2011

[3] J. Phys. G 28 (2002) 2693-2704 [4] www.atlas.ch

$ZZ \rightarrow ll\nu\nu$

Features

- High cross-section $\times$ branching fraction.
- High- p_T leptons, large missing E_T
- Good background rejection with constraint to Z mass.

Status and References

- Updated to full 2011 statistics (4.7 fb^{-1}) at winter 2012.
- To be submitted to PLB.
- ATLAS-CONF-2012-016
- Phys. Rev. Lett. 107 (2011) 221802 (1.04 fb^{-1})

Main Result

- **Rejects:** 320-560 GeV
- **Expected:** 260-490 GeV
- Leading sensitivity at high mass!

ZZ → llvv

Lepton invariant mass and angular separation

Missing Transverse Energy (low-, high-pile-up)

Selection

- $Z \rightarrow ll$: 2 leptons with:
 - $p_T > 20$ GeV
 - $|m_{ll} - m_Z| < 15$ GeV
- $Z \rightarrow vv$:
 - $E_T^{\text{miss}} > 66$ GeV

Analysis

- Transverse mass discriminant:

$$m_T^2 \equiv \left[\sqrt{m_Z^2 + |\vec{p}_T^{\ell\ell}|^2} + \sqrt{m_Z^2 + |\vec{p}_T^{\text{miss}}|^2} \right]^2 - \left[\vec{p}_T^{\ell\ell} + \vec{p}_T^{\text{miss}} \right]^2$$

- Low/high pile-up separation: degradation of E_T^{miss} resolution.
- Low/high mass with boundary at 280 GeV:

$m_H \leq 280$ GeV	$m_H > 280$ GeV
• $E_T^{\text{miss}} > 66$ GeV	• $E_T^{\text{miss}} > 82$ GeV
• $1 < \Delta\phi_{ll} < 2.64$	• $\Delta\phi_{ll} < 2.25$
	• $\Delta\phi_{ll}, p_T^{\text{miss}} \geq 1$
• $\Delta\phi_{\text{jet}}, p_T^{\text{miss}} > 1.5$	• $\Delta\phi_{\text{jet}}, p_T^{\text{miss}} > 0.5$

ZZ → llvv

WZ

Z+jets, low pile-up

Top (eμ)

Z+jets, high pile-up

Backgrounds

- Diboson (WW, WZ, ZZ)
- Z+jets, Top, W+jets, QCD

Treatment

- Background shapes from MC
- Data control regions are used to validate and normalize the MC where needed.
 - WZ: 3 leptons
 - Top: m_{ll} sidebands + b-jet or e/μ pairs
 - Z+jets: reverted $\Delta\phi_{jet, p_T^{miss}}$ after E_T^{miss} cut
 - W+jets: m_{ll} sidebands + same sign $ee/e\mu$ + no b-jet
 - QCD multijet: relaxed electron ID
- ZZ and WW uses MC predictions

Shown: various control regions used to obtain normalization scale factors between data and MC.

ZZ → llvv

Low-mass, low pile-up

High-mass, low pile-up

High-mass, high pile-up

Low-mass, high pile-up

Source	low m_H search		high m_H search	
	Low pile-up data	High pile-up data	Low pile-up data	High pile-up data
Z	$41.1 \pm 5.2 \pm 4.9$	$249.4 \pm 12.4 \pm 43.7$	$0.9 \pm 0.3 \pm 1.2$	$11.1 \pm 2.0 \pm 3.0$
W	$4.7 \pm 2.2 \pm 4.7$	$5.6 \pm 1.8 \pm 5.6$	$1.5 \pm 0.8 \pm 1.5$	$2.2 \pm 1.3 \pm 2.2$
top	$23.3 \pm 1.3 \pm 2.5$	$27.1 \pm 1.2 \pm 2.8$	$15.7 \pm 1.0 \pm 1.7$	$17.0 \pm 0.9 \pm 1.6$
multijet	$0.4 \pm 0.1 \pm 0.2$	$0.6 \pm 0.1 \pm 0.3$	$0.0 \pm 0.0 \pm 0.0$	$0.1 \pm 0.0 \pm 0.0$
ZZ	$33.6 \pm 0.7 \pm 3.9$	$36.8 \pm 0.7 \pm 4.3$	$28.6 \pm 0.6 \pm 3.4$	$32.1 \pm 0.7 \pm 3.8$
WZ	$23.5 \pm 1.0 \pm 2.8$	$25.1 \pm 1.0 \pm 3.0$	$17.4 \pm 0.9 \pm 2.1$	$18.8 \pm 0.8 \pm 2.2$
WW	$25.9 \pm 0.8 \pm 3.0$	$32.4 \pm 0.9 \pm 3.8$	$9.5 \pm 0.5 \pm 1.1$	$13.4 \pm 0.5 \pm 1.6$
Total	$152.5 \pm 6.0 \pm 9.3$	$377.1 \pm 12.7 \pm 43.8$	$73.6 \pm 1.8 \pm 4.9$	$94.8 \pm 2.9 \pm 6.0$
Data	159	423	78	108

m_H [GeV]	Signal expectation	
200	$10.4 \pm 0.2 \pm 1.8$	$11.2 \pm 0.2 \pm 2.0$
300		$16.6 \pm 0.3 \pm 2.9$
400		$15.2 \pm 0.3 \pm 2.7$
500		$6.6 \pm 0.1 \pm 1.2$
600		$2.9 \pm 0.0 \pm 0.5$

$$m_T^2 \equiv \left[\sqrt{m_Z^2 + |\vec{p}_T^{\ell\ell}|^2} + \sqrt{m_Z^2 + |\vec{p}_T^{\text{miss}}|^2} \right]^2 - \left[\vec{p}_T^{\ell\ell} + \vec{p}_T^{\text{miss}} \right]^2$$

ZZ $\rightarrow$ llqq

95% CL limit on $\sigma/\sigma_{\text{SM}}$

Low-mass | High-mass (“boosted”)

Features

- High cross-section $\times$ BR
- Higgs-mass reconstruction.
- Good background rejection with constraint to Z mass.
- High backgrounds from Z+jets.

Status and References

- Updated to full 2011 statistics (4.7 fb^{-1}) at winter 2012.
- To be submitted to PLB.

- ATLAS-CONF-2012-017
- Phys.Lett.B 707 (2012) 27-45 (1.04 fb^{-1})

Main Result

- **Rejects:**
 - 300-310 GeV
 - 360-400 GeV
- **Expected:** 360-400 GeV

$ZZ \rightarrow llqq$

Untagged: 1 b-jet or none

Tagged: 2 b-jets

Selection

- $Z \rightarrow ll$: 2 leptons with $p_T > 20 \text{ GeV}$
 - $83 < m_{ll} < 99 \text{ GeV}$
- $Z \rightarrow qq$: at least 2 jets
 - $\Delta R_{jj} > 0.7$, with $E_T > 25 \text{ GeV}$
 - $70 < m_{jj} < 105 \text{ GeV}$,
- No neutrino: $E_T^{\text{miss}} < 50 \text{ GeV}$
 - reduces top background

Analysis

- Optimized by separating tagged and untagged
 - Smaller background in $Z \rightarrow bb$
- Low/high mass with boundary at 300 GeV
 - Improved sensitivity for $m_H > 300 \text{ GeV}$:
 - Jets with $p_T > 45 \text{ GeV}$,
 - $\Delta\phi_{ll} < \pi/2$ and $\Delta\phi_{jj} < \pi/2$
- Constrain m_{jj} to m_Z when setting the limits

$ZZ \rightarrow llqq$

Z+jets, untagged

Z+jets, tagged

Top, untagged

Top, tagged

Backgrounds

- Z+jets
- Top
- Diboson (WW, WZ, ZZ)

Treatment

- Background shapes from MC
- Data and control regions are used to validate and normalize the MC:
 - **Z+jets**: m_{jj} sidebands
 - **Top**: m_{ll} sidebands with E_T^{miss} reversed
 - Multijet QCD: relaxed electron ID
 - Diboson: uses MC predictions

Shown: various invariant-mass sidebands used to obtain normalization scale factors between data and MC.

ZZ → llqq

High-mass, untagged

Low-mass, tagged

High-mass, tagged

Low-mass, untagged

	Untagged		Tagged	
	Low- m_H	High- m_H	Low- m_H	High- m_H
Z+jets	$36770 \pm 80 \pm 950$	$1470 \pm 14 \pm 36$	$246 \pm 6 \pm 17$	$11 \pm 1 \pm 2$
Top	$87 \pm 3 \pm 9$	$7.3 \pm 0.7 \pm 1.1$	$23 \pm 1 \pm 3$	$1.8 \pm 0.4 \pm 0.5$
Multijet	$29 \pm 1 \pm 15$	$0.5 \pm 0.1 \pm 0.3$	< 0.2	< 0.1
ZZ	$350 \pm 3 \pm 47$	$25 \pm 1 \pm 3$	$23 \pm 1 \pm 4$	$2.3 \pm 0.3 \pm 0.4$
WZ	$444 \pm 4 \pm 70$	$46 \pm 1 \pm 7$	$0.7 \pm 0.2 \pm 0.6$	< 0.2
Total background	$37680 \pm 80 \pm 990$	$1550 \pm 14 \pm 40$	$293 \pm 6 \pm 21$	$15 \pm 1 \pm 3$
Data	38404	1505	292	20
Signal				
$m_H = 200 \text{ GeV}$	$118 \pm 2 \pm 19$		$6.9 \pm 0.4 \pm 1.7$	
$m_H = 300 \text{ GeV}$		$24 \pm 1 \pm 4$		$2.1 \pm 0.2 \pm 0.4$
$m_H = 400 \text{ GeV}$		$41 \pm 1 \pm 7$		$4.6 \pm 0.2 \pm 1.0$
$m_H = 500 \text{ GeV}$		$18.7 \pm 0.3 \pm 3.3$		$2.0 \pm 0.1 \pm 0.5$
$m_H = 600 \text{ GeV}$		$6.4 \pm 0.1 \pm 1.2$		$0.7 \pm 0.0 \pm 0.2$

WW $\rightarrow$ lvqq

> 300 GeV

+ 0,1 jet

+ 2 jets

Features

- Highest decay branching fraction
- Exclusive search lvqq + 0,1,2 jets
- Presence of missing E_T
- Reconstruction of W, and Higgs mass.

Status and References

- Updated to full 2011 statistics (4.7fb^{-1}) at winter 2012.
- To be submitted to PLB.

- ATLAS-CONF-2012-018
- Phys.Rev.Lett. 107 (2011) 231801 (1.04fb^{-1})

Main Result

- **Upper bounds** (SM cross-section)
 - **ggF:** ~ 2 (2.2 at $m_H = 400$ GeV)
 - **VBF:** ~ 6 (8.5 at $m_H = 400$ GeV)

WW → lvqq

VBF Selection

- Exactly 1 lepton with $p_T > 30$ GeV
- $E_T^{\text{miss}} > 30$ GeV (neutrino)
- At least 4 jets
- 2 closest jets to W mass
 - $71 < m_{jj} < 91$ GeV
- 2 other jets (VBF tag jets)
 - $\eta_1 \times \eta_2 < 0$ (opposite hemispheres)
 - $\Delta\eta > 3$ (well-separated)
 - $m_{jj} > 600$ GeV

2j + evqq

2j + μνqq

$ZZ \rightarrow IIII, WW \rightarrow l\nu l\nu$

Disclaimer

- Covered in more details in the Low-Mass Higgs Searches and dedicated talks.

Features

- Mostly sensitive to low-mass Higgs.
- **ZZ**: low background, good mass resolution $\rightarrow$ find m_H
- **WW**: broad mass resolution $\rightarrow$ set cross-section scale

Main Results

- In the high-mass range:
- **ZZ**: reject SM up to 415 GeV
- **WW**: reject SM up to 260 GeV

[1] Phys.Lett. B710 (2012) 383-402, arXiv:1202.1415

[2] ATLAS-CONF-2012-012

Channel-by-Channel Exclusion

Combination

Features

- Combine all low and high mass channels available.
- Expected exclusion: 120-555 GeV

Status and References

- Updated to full 2011 statistics ($4.6-4.9 \text{ fb}^{-1}$) at winter 2012.

- ATLAS-CONF-2012-019
- Phys.Lett. B710 (2012) 49-66

Main Result

- Observed exclusion (95% CL):
 - Low mass: 110-117.5, 118.5-122.5 GeV
 - **High mass: 129-539 GeV**

Summary

- Lots of analyses with 2011 $\sim 5\text{fb}^{-1}$ at 7TeV focusing on high-mass Higgs.
- High-mass SM Higgs searches in ATLAS:
 - $ZZ \rightarrow \ell\ell\nu\nu$ excludes $[320-560]$ GeV
 - $ZZ \rightarrow \ell\ell qq$ excludes $[300-310, 360-400]$ GeV
 - $WW \rightarrow \ell\nu qq$ can exclude from $2 \times \text{SM}$ production.
 - $ZZ \rightarrow \ell\ell\ell\ell$ excludes $[134-156, 182-233, 256-265, \text{and } 266-415]$ GeV
 - $WW \rightarrow \ell\nu\ell\nu$ excludes $[130-260]$ GeV.
 - **ATLAS combination excludes $[129-539]$ GeV.**
- Looking forward to 2012 data!
 - Improve all channels.
 - Explore possibilities to go beyond $m_H = 600$ GeV.

Extra Material

Decay Channels

ATLAS Combination Summary

Higgs Decay	Subsequent Decay	Additional Sub-Channels	m_H Range	L [fb ⁻¹]
$H \rightarrow \gamma\gamma$	–	9 sub-channels ($p_T, \otimes \eta_\gamma \otimes$ conversion)	110-150	4.9
$H \rightarrow ZZ$	$\ell\ell\ell'\ell'$	$\{4e, 2e2\mu, 2\mu2e, 4\mu\}$	110-600	4.8
	$\ell\ell\nu\bar{\nu}$	$\{ee, \mu\mu\} \otimes \{\text{low pile-up, high pile-up}\}$	200-280-600	4.7
	$\ell\ell q\bar{q}$	$\{b\text{-tagged, untagged}\}$	200-300-600	4.7
$H \rightarrow WW$	$\ell\nu\ell\nu$	$\{ee, e\mu, \mu\mu\} \otimes \{0\text{-jet, 1-jet, VBF}\}$	110-300-600	4.7
	$\ell\nu q\bar{q}'$	$\{e, \mu\} \otimes \{0\text{-jet, 1-jet}\}$	300-600	4.7
$H \rightarrow \tau^+\tau^-$	$\ell\ell 4\nu$	$\{e\mu\} \otimes \{0\text{-jet}\} \oplus \{1\text{-jet, VBF, VH}\}$	110-150	4.7
	$\ell\tau_{\text{had}} 3\nu$	$\{e, \mu\} \otimes \{0\text{-jet}\} \otimes \{E_T^{\text{miss}} \geq 20 \text{ GeV}\} \oplus \{e, \mu\} \otimes \{1\text{-jet, VBF}\}$	110-150	4.7
	$\tau_{\text{had}}\tau_{\text{had}} 2\nu$	$\{1\text{-jet}\}$	110-150	4.7
$VH \rightarrow b\bar{b}$	$Z \rightarrow \nu\bar{\nu}$	$E_T^{\text{miss}} \in \{120 - 160, 160 - 200, \geq 200 \text{ GeV}\}$	110-130	4.6
	$W \rightarrow \ell\nu$	$p_T^W \in \{< 50, 50 - 100, 100 - 200, \geq 200 \text{ GeV}\}$	110-130	4.7
	$Z \rightarrow \ell\ell$	$p_T^Z \in \{< 50, 50 - 100, 100 - 200, \geq 200 \text{ GeV}\}$	110-130	4.7

Shown: Summary of the individual channels contributing to the combination. The central number in the three-part mass ranges indicates the transition from low- m_H to high- m_H optimised event selections. The high-mass channels shown in this talk are highlighted.

Systematic Uncertainties

$ZZ \rightarrow ll\nu\nu$

- Background normalization (MC):
 - Diboson, ZZ: 11% (theory)
- Background normalization (data-driven):
 - Z : 2.5%
 - Top : 9%
 - W : 100%
 - QCD : 50%
- Signal acceptance: 3.4-8.4%

$ZZ \rightarrow llqq$

- Background normalization (MC):
 - Diboson: 11%
- Background normalization (data-driven):
 - Z+jets : 2.1-5.9%
 - Top : 2.5-3.6%
 - QCD : 50%
- b-tagging efficiency:
 - 14% (tagged channel)
- Jet energy scale:
 - 4% (untagged channel)
- Signal acceptance: 3-12%

$WW \rightarrow lvqq$

- Production cross-section: 19.4%
- Jet energy scale: 8-10%
- Jet energy smearing:
 - 10% (ggF) – 23% (VBF)
- $E_{\text{T}}^{\text{miss}}$ resolution due to pile-up: 10-16%
- b-tagging efficiency: 7%

Common

- ZZ: Signal production cross-section:
 - 15-20% (ggF) and 3-9% (VBF)
- Luminosity: 3.7 – 4.1%

Higgs Production at 8TeV

LHC in 2012

- Runs at $\sqrt{s} = 8\text{TeV}$
- Expect $10\text{-}20 \text{ fb}^{-1}$

Effect on Higgs Production

- Enhancement factor of 1.25-1.5 compared to 7TeV.
- Bigger effect at high mass.
- Reject faster for the same integrated luminosity.

ATLAS in 2012

- Improvements in analyses contribute to $\sim 20\%$ gain in sensitivity.
- Detector and reconstruction performances likely to be improved as well.

Prospects for High Mass Higgs

- Can we go much beyond $m_H = 600$ GeV in terms of predictions and theoretical uncertainties?
 - Workshops at CERN in May to discuss these various issues
 - Interference effects due to large width.
 - The case of a large-mass Higgs, CERN, May 14-15 2012
 - <https://indico.cern.ch/conferenceDisplay.py?confId=174430>
 - LHC Higgs Cross Section Working Group Workshop CERN, May 24-25 2012

$ZZ \rightarrow ll\nu\nu$

Shown: various missing E_T distributions in sidebands and control regions used to obtain normalization scale factors between data and MC.

Backgrounds

- Diboson (WW, WZ, ZZ)
- Z+jets, Top, W+jets, QCD

Treatment

- Background shapes from MC
- Data control regions are used to validate and normalize the MC where needed.
- WZ: 3 leptons
- Top: m_{ll} sidebands + b-jet or e/μ pairs
- W+jets: m_{ll} sidebands + same sign $ee/e\mu$ + no b-jet
- QCD multijet: relaxed electron ID
- Z+jets: reverted $\Delta\phi_{jet, p_T^{\text{miss}}}$ after E_T^{miss} cut
- ZZ and WW uses MC predictions

WW → lvqq

ggF Selection

- Exactly 1 lepton with $p_T > 40$ GeV
- $E_T^{\text{miss}} > 40$ GeV (neutrino)
- 2 or 3 jets
- 2 closest jets to W mass
 - $71 < m_{jj} < 91$ GeV
- Most energetic jet $E_T > 60$ GeV
- No b-tagged jets (top background)
- $\Delta R_{jj} < 1.3$ (W+jet background)
- $\Delta R_{lv} < 1.3$

0j + evqq

1j + μνqq

WW → lvqq

Backgrounds

- W+jets
- Z+jets
- QCD multijet
- Top, dibosons (WW, WZ, ZZ)

Treatment

- MC to motivate shape functions
- Data control samples used to validate background fit.
- MC and data-driven methods to estimate the background composition.

Background

$$f(x) = \frac{1}{1 + |a(x - m)|^b} e^{-c(x-200)}$$

Signal

$$f(x) = \frac{1}{a + (x - m_1)^2 + b(x - m_2)^4}$$

Shown: various sidebands used to fit the data to the background model.

$ZZ \rightarrow IIII, WW \rightarrow l\nu l\nu$

ZZ $\rightarrow$ IIII

Int. Luminosity	$\mu\mu\mu\mu$		$e\mu\mu\mu$		$eeee$	
	Low $m_{4\ell}$	High $m_{4\ell}$	Low $m_{4\ell}$	High $m_{4\ell}$	Low $m_{4\ell}$	High $m_{4\ell}$
4.81 fb ⁻¹			4.81 fb ⁻¹		4.91 fb ⁻¹	
$ZZ^{(*)}$	2.0±0.3	16.3±2.4	2.8±0.6	25.2±3.8	1.3±0.3	10.3±1.5
$Z, Zb\bar{b},$ and $t\bar{t}$	0.16±0.06	0.02±0.01	1.4±0.5	0.17±0.08	1.6±0.7	0.18±0.08
Total Background	2.2±0.3	16.3±2.4	4.2±0.8	25.4±3.8	2.9±0.8	10.5±1.5
Data	3	21	3	27	2	15
$m_H = 125$ GeV	0.58 ± 0.10		0.73 ± 0.13		0.25 ± 0.05	
$m_H = 130$ GeV	1.00 ± 0.17		1.22 ± 0.21		0.43 ± 0.08	
$m_H = 150$ GeV	2.1 ± 0.4		2.9 ± 0.4		1.12 ± 0.18	
$m_H = 200$ GeV	4.9 ± 0.7		7.7 ± 1.0		3.1 ± 0.4	
$m_H = 300$ GeV	2.9 ± 0.4		4.9 ± 0.6		2.1 ± 0.3	
$m_H = 400$ GeV	2.0 ± 0.3		3.3 ± 0.5		1.49 ± 0.21	
$m_H = 600$ GeV	0.34 ± 0.04		0.62 ± 0.10		0.30 ± 0.06	

WW $\rightarrow$ lνlν

	Signal	WW	WZ/ZZ/W γ	$t\bar{t}$	$tW/tb/tqb$	Z/ γ^* + jets	W + jets	Total Bkg.	Obs.
0-jet									
$m_H = 125$ GeV	25 ± 7	110 ± 12	12 ± 3	7 ± 2	5 ± 2	13 ± 8	27 ± 16	173 ± 22	174
$m_H = 240$ GeV	60 ± 17	432 ± 49	24 ± 3	68 ± 15	39 ± 9	8 ± 2	36 ± 24	607 ± 63	629
1-jet									
$m_H = 125$ GeV	6 ± 2	18 ± 3	6 ± 3	7 ± 2	4 ± 2	6 ± 1	5 ± 3	45 ± 7	56
$m_H = 240$ GeV	23 ± 9	99 ± 22	8 ± 1	73 ± 27	35 ± 19	6 ± 2	7 ± 7	229 ± 55	232
2-jet									
$m_H = 125$ GeV	0.4 ± 0.2	0.3 ± 0.2	negl.	0.2 ± 0.1	negl.	0.0 ± 0.1	negl.	0.5 ± 0.2	0
$m_H = 240$ GeV	2.5 ± 0.6	1.1 ± 0.7	0.1 ± 0.1	2.6 ± 1.3	0.3 ± 0.3	negl.	0.1 ± 0.1	4.2 ± 1.7	2