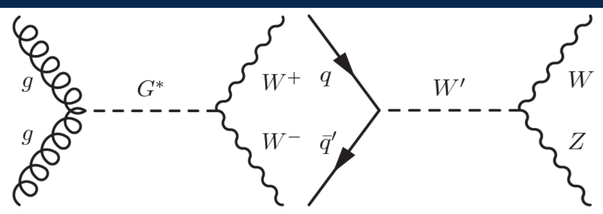
LHCP Poster Session – St. Petersburg, Russia, 1st September 2015

Semileptonic (lepton, neutrino and jets) *WW/WZ* resonance search at $\sqrt{s}$ = 8 TeV with the ATLAS detector at the LHC

Introduction

Physics models:
- Spin-2 Randall-Sundrum graviton (bulk RSG^*)
- Spin-1 Extended Gauge Boson (EGM W')

Data:
- 20.3 fb^{-1}, collected by ATLAS at the LHC in 2012



Final state:
- Leptonic decay: $W \rightarrow l\nu$ (l = e, μ)
- Hadronic decay: $W/Z \rightarrow jj$ (J)

Event selection

Preselection:
- 1 PV (max $\sum p_T^{track}$)
- $N_{track}^{PV} \geq 3$
- Single lepton trigger

+ Lepton:
- 1 "signal" lepton
- 0 "veto" lepton

+ Missing Energy:
- E_T^{miss} > 30 GeV

+ Jets:
- 2 small jets
- Or 1 Boosted Jet

Electron definition		Muon definition	
Signal	Veto	Signal	Veto
p_T > 25 GeV $\lvert\eta\rvert$ < 1.37, 1.52 < $\lvert\eta\rvert$ < 2.47 p_T^{cone20}/E_T < 0.15 E_T^{cone20}/E_T < 0.14 $\lvert d_0/\sigma(d_0)\rvert$ < 6 $\lvert z_0 \sin\theta\rvert$ < 0.5 mm Remove e if $\Delta R(\mu)$ < 0.1	p_T > 20 GeV $\lvert\eta\rvert$ < 1.37, 1.52 < $\lvert\eta\rvert$ < 2.47 p_T^{cone20}/E_T < 0.15 - $\lvert d_0/\sigma(d_0)\rvert$ < 6 $\lvert z_0 \sin\theta\rvert$ <e 2 mm Remove e if $\Delta R(\mu)$ < 0.1	p_T > 25 GeV $\lvert\eta\rvert$ < 2.5 p_T^{cone20}/E_T < 0.15 E_T^{cone20}/E_T < 0.14 $\lvert d_0/\sigma(d_0)\rvert$ < 3.5 $\lvert z_0 \sin\theta\rvert$ < 0.5 mm $\lvert (q/p)_{MS} - (q/p)_{ID}\rvert$ < 5σ	p_T > 20 GeV $\lvert\eta\rvert$ < 2.5 p_T^{cone20}/E_T < 0.15 - $\lvert d_0/\sigma(d_0)\rvert$ < 3.5 $\lvert z_0 \sin\theta\rvert$ < 2 mm $\lvert (q/p)_{MS} - (q/p)_{ID}\rvert$ < 5σ

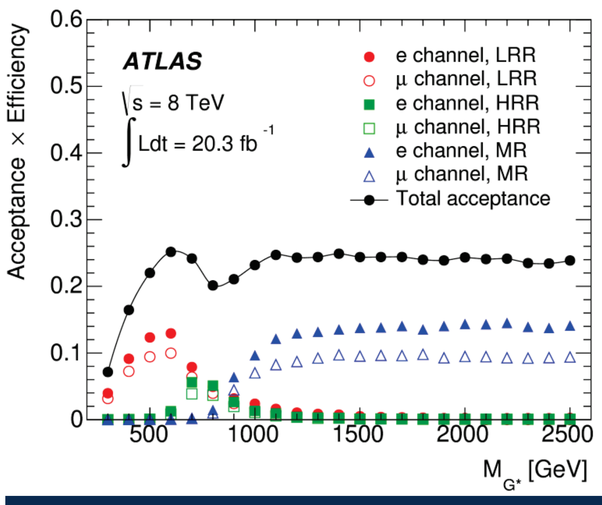
Lepton categories:
- "Signal" is used in the final analysis
- "Veto" is used to orthogonalize other final state topologies ($l\nu ll$, $lljj$)

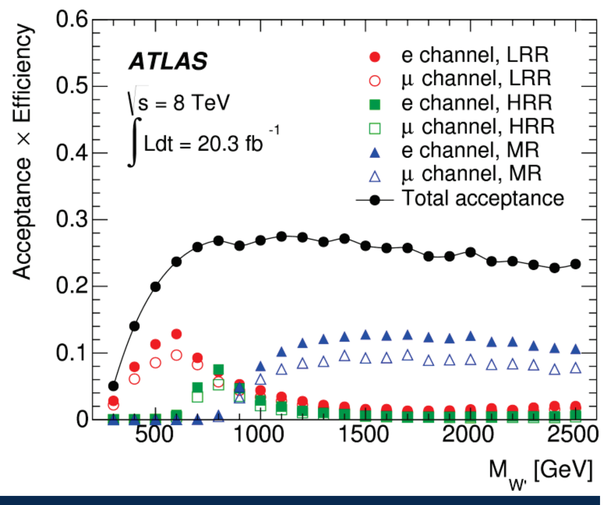
Low-p_T resolved region (LRR)	High-p_T resolved region (HRR)	Merged region (MR)
≥ 2 AntiKt4 jets (p_T > 30 GeV) $p_{T,jj}$ > 100 GeV $p_{T,W}$ > 100 GeV b-jet Veto (MV1, 70%) $\Delta\varphi$ (jet$_1$, E_T^{miss}) > 1 65 < m_{jj}< 105 GeV	≥ 2 AntiKt4 jets (p_T > 80 GeV) $p_{T,jj}$ > 300 GeV $p_{T,W}$ > 300 GeV b-jet Veto (MV1, 70%) $\Delta\varphi$ (jet$_1$, E_T^{miss}) > 1 65 < m_{jj}< 105 GeV	≥ 1 CA12 Jet $p_{T,J}$ > 400 GeV $p_{T,W}$ > 400 GeV b-jet Veto (MV1, 70%) $\Delta\varphi$ (jet$_1$, E_T^{miss}) > 1 65 < m_J< 105 GeV

Prioritization for signal regions

Low-p_T resolved region ← High-p_T resolved region ← Merged region

Signal efficiency in both channels and three signal regions.
The efficiency is expressed with respect to the total number of WW/WZ → ℓνjj events with ℓ = e, μ, τ.

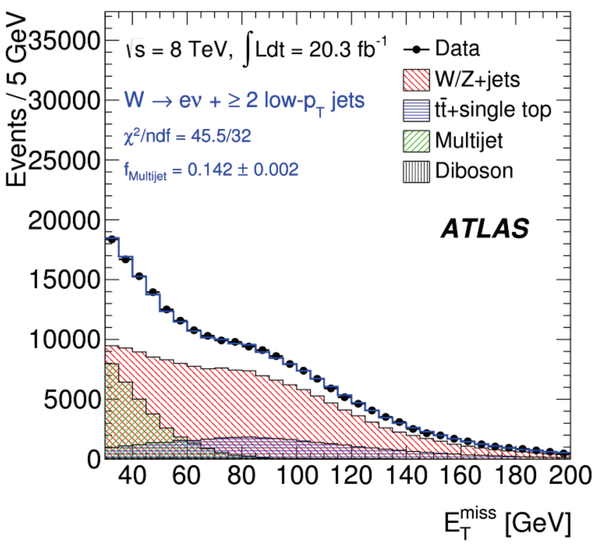


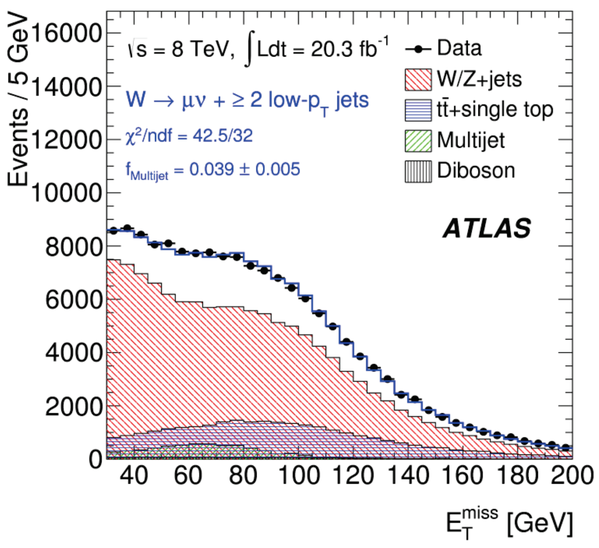


Background Estimation

BG	*W/Z* + jets	Single top, $t\bar{t}$	Multijet	Diboson
Shape	From MC	From MC	Data driven (enriched multijet ds)	From MC
Normalization	Data driven (CR)	From MC	Data driven (CR)	From MC
Control, Validation regions	CR: 40 < $m_{jj/J}$< 65 GeV 105 < m_{jj}< 200GeV	VR: ≥ 1 b-jet ≥ 4 jets (RR)	VR: E_T^{miss} < 30 GeV (e channel) 50 < E_T^{miss} < 80 GeV (μ channel)	

χ^2 fit performed to the E_T^{miss} distributions in CR to extract W/Z + jets and multijet normalizations.





Systematic Uncertainties

- Luminosity Uncertainty
- Trigger Efficiency

Electron:
- Electron Reconstruction, Energy Scale and Resolution

Muon:
- Muon Reconstruction, Momentum Scale and Resolution

MET:
- Missing Transverse Momentum Soft Terms

Jet:
- Jet Energy Scale and Resolution
- Jet Mass Scale and Resolution
- Jet Vertex Fraction Uncertainty
- Momentum Balance Scale and Resolution
- b-tagging

Background:
- Scale Uncertainty of the Backgrounds (W/Z+jets, Multijet, $t\bar{t}$, Diboson)
- Shape Uncertainty of the Backgrounds (W/Z+jets, Multijet, $t\bar{t}$, Diboson)
- Uncertainties due to Single top Production
- PDF Uncertainty of the $t\bar{t}$ Background
- ISR/FSR Uncertainty of the $t\bar{t}$ Background

Signal:
- Signal ISR/FSR Uncertainty
- Signal PDF Uncertainty

Limit setting

- In order to stabilize the combined fit, the low-p_T resolved, high-p_T resolved and merged regions are not all used for every mass point.
- A region is only used if it contributes more than 10% of the total signal sensitivity.

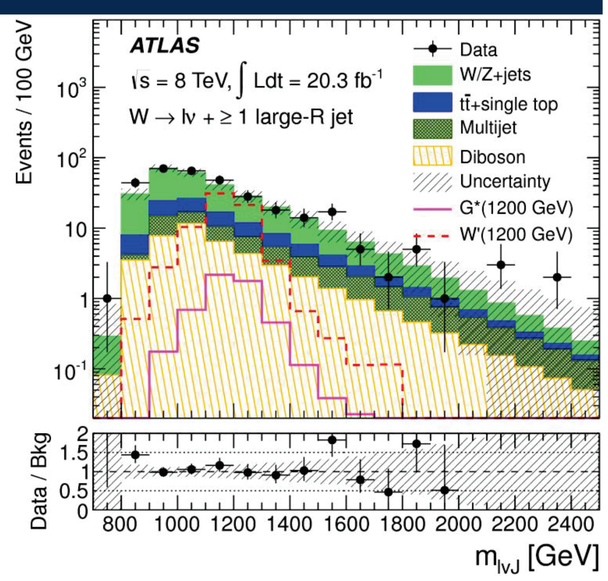
m, GeV	G^* signal	W' signal
300	low-p_T	low-p_T
400	low-p_T	low-p_T
500	low-p_T	low-p_T
600	low-p_T, high-p_T	low-p_T, high-p_T
700	low-p_T, high-p_T	low-p_T, high-p_T
800	L/H-p_T, merged	L/H-p_T, merged
900	high-p_T, merged	high-p_T, merged
1000	merged	high-p_T, merged
1100	merged	high-p_T, merged
1200	merged	merged
1300	merged	merged
1400	merged	merged
1500	merged	merged
1600	merged	merged
1700	merged	merged
1800	merged	merged
1900	merged	merged
2000	merged	merged
2100	merged	merged
2200	merged	merged
2300	merged	merged
2400	merged	merged
2500	merged	merged

Results and interpretation

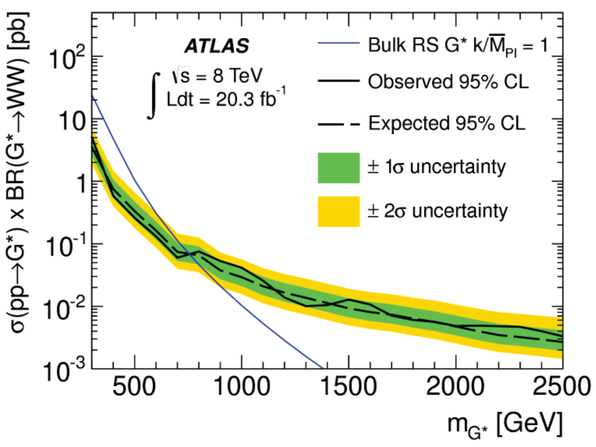
The number of events predicted for background and observed for data in each signal region.

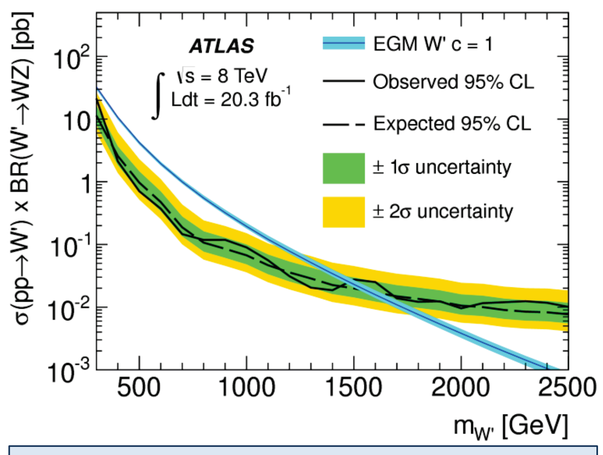
Sample	LRR	HRR	MR
W/Z + jets	104800 ± 1600	415 ± 10	180 ± 20
$t\bar{t}$ + single top	37700 ± 1600	271 ± 13	42 ± 7
Multijet	13500 ± 500	84 ± 9	29.3 ± 2.9
Diboson	5500 ± 270	96 ± 6	43 ± 7
Total	161500 ± 2300	870 ± 40	295 ± 22
Data	157837	801	323
G^* signal	7000 ± 500	36 ± 6	5.5 ± 2.3
W' signal	6800 ± 600	318 ± 21	70 ± 4

- The limits are calculated by performed fit of the likelihood to $m_{l\nu jj/J}$ by RooStats.
- It is done by CLs method using binned histograms (templates) derived from MC.
- The fit is performed simultaneously to the electron and muon channels.
- In each channel, five components are included in the fit for the lνjj/J final state: signal, W/Z+jets, multijet, top and diboson.
- Systematic uncertainties are include as nuisance parameters.

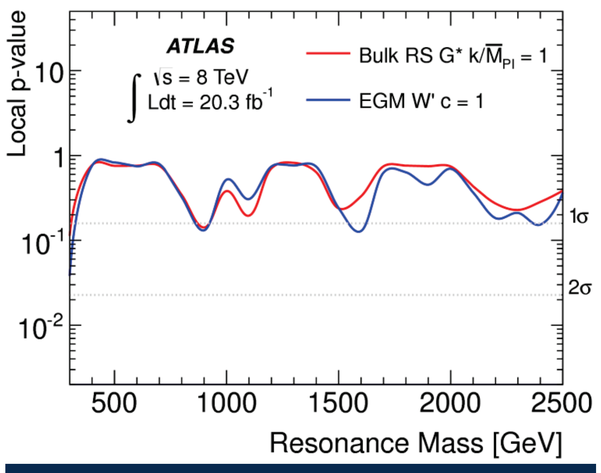


Expected and observed exclusion limits for RS G and EGM W' signals with statistic and systematic uncertainties.*





Observed p-value for the RS G and the EGM W' signals.*
No significant excesses are observed.



- All signal regions and channels are combined.
- The shoulder observed around 800 GeV is due to the transition between the high-p_T resolved and boosted selections.

Conclusion

- No evidence for resonant diboson production is observed.
- 95% CL upper limits on the production cross section times branching fraction of G^* and W' are determined.
- Resonance masses below 760 GeV and 1490 GeV are excluded for G^* and W' at 95% CL.

Analyses	$M(G^*)$	$M(W')$
ATLAS 8 TeV: $WW/WZ \rightarrow l\nu jj$ Eur. Phys. J. C (2015) 75:370 $WZ/ZZ \rightarrow lljj$ Eur. Phys. J. C (2015) 75:69 $WZ \rightarrow l\nu ll$ PLB 737 (2014) 223 $WW/ZZ/WZ \rightarrow JJ$ arXiv.org:1506.00962	<760 GeV <740 GeV – ~2 TeV 2.6σ ~2 TeV 2.9σ	<1490 GeV <1590 GeV <1520 GeV <1500 GeV ~2 TeV 3.4σ
CMS 8 TeV: $WW/WZ \rightarrow l\nu jj$ JHEP 08 (2014) 174 $WZ \rightarrow l\nu ll$ PLB 740 (2015) 83 $WW/WZ \rightarrow JJ$ JHEP 08 (2014) 173	No limit set – No limit set	– <1470 GeV <1700 GeV

Reference

$WW/WZ \rightarrow l\nu jj$ 8 TeV ATLAS EPJC(2015)75:370

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ATLAS EXPERIMENT