Search for new particles in events with one lepton and missing transverse momentum in *pp* collisions at $\sqrt{s}$ = 8 TeV

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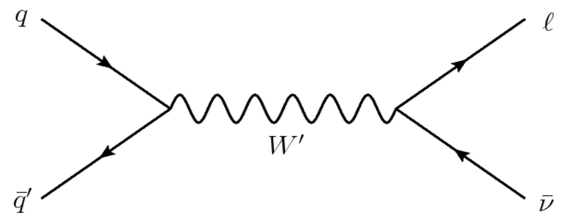
Introduction

A search for new particles in events with one lepton (electron or muon) and missing transverse momentum using 20.3 fb^{-1} of proton-proton collision data at $\sqrt{s}$ = 8 TeV recorded by the ATLAS experiment[1].



$$W' \rightarrow l\nu$$

Many models predict the existence of heavy gauge bosons.

The first new physics scenario that is investigated is the Sequential Standard Model (SSM), the extended gauge model of ref. [2]. This model proposes the existence of additional heavy gauge bosons, of which the charged ones are commonly denoted as W'. The W' has the same couplings to fermions as the SM W boson and a width that increases linearly with the W' mass.

The second new physics scenario that is investigated originates from ref. [3] and proposes the existence of charged partners, denoted W*, of the chiral boson excitations described in ref. [4]. The anomalous (magnetic moment-type) coupling of the W* leads to kinematic distributions significantly different from those of the W'.

Search Strategy

Search for high mass states that decay into a lepton and E_T^{miss}.

The observable is transverse mass:

$$m_T = \sqrt{2\, p_T^l E_T^{miss} (1 - \cos\varphi_{l\nu})}$$

Look for significant excess above background expectations. If no excess is observed, set limit on the **σ·B.**

Mass [GeV]	$W' \rightarrow \ell\nu$ σB [pb]	$W^* \rightarrow \ell\nu$ σB [pb]
300	149.0	
400	50.2	37.6
500	21.4	16.2
600	10.4	7.95
750	4.16	3.17
1000	1.16	0.882
1250	0.389	0.294
1500	0.146	0.108
1750	0.0581	0.0423
2000	0.0244	0.0171
2250	0.0108	0.00700
2500	0.00509	0.00290
2750	0.00258	0.00120
3000	0.00144	4.9×10^{-4}
3250	8.9×10^{-4}	2.0×10^{-4}
3500	5.9×10^{-4}	8.0×10^{-5}
3750	4.2×10^{-4}	3.2×10^{-5}
4000	3.1×10^{-4}	1.3×10^{-5}

Predicted values of the cross-section times branching fraction (**σ·B**) for W' → lν and W* → lν. The **σ·B** for W' are at NNLO while those for W* are at LO.

Background

- ***W→ℓ+ν*** (Irreducible and the dominant one)
- ***Z→ℓℓ*** (One of the leptons is not reconstructed)
- ***Diboson*** (WW, WZ, ZZ, $W\gamma$)
- ***Top quarks*** (Single top and ttbar → ℓ X)
- **Events with multijets - QCD** (Data estimated)

Process	σB [pb]
$W \rightarrow \ell\nu$	12190
$Z/\gamma^* \rightarrow \ell\ell$ ($m_{Z/\gamma^*} > 60$ GeV)	1120
$t\bar{t} \rightarrow \ell X$	137.3

Candidate selection

- ***Primary Vertex –*** pp collision
  - at least 3 tracks, |z|<200 mm
- ***Impact Parameter –*** cosmics rejection
  - $|d_0^{PV}| < 0.2$ mm
  - $|z_0^{PV}| < 1$ mm
- ***Jet Cleaning –*** avoid events with spurious E_T^{miss}
- ***E_T^{miss} > 125 GeV (e) or 45 GeV (μ) –*** enhancement of associated neutrino production

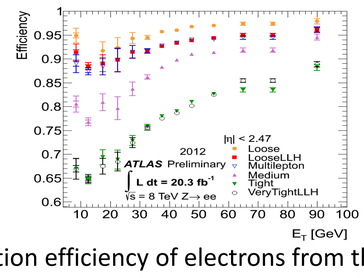
Electron

- Central electrons
  - E_T > 125 GeV
  - |η| < 2.47
- Medium electron identification
- ID hits
- Trigger matching
  - Reconstructed electron with trigger track
- Isolation
  - QCD rejection

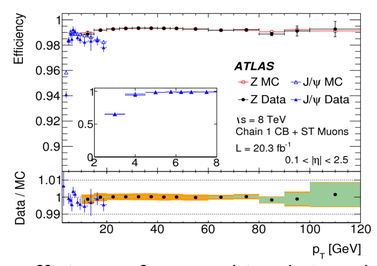
Muon

- Combined muons
  - p_T > 45 GeV
  - Combined = ID + MS tracks loosely matched
- ID and MS hits
- Trigger matching
  - Reconstructed muon with trigger track
- Isolation
  - QCD rejection
- ID-MS momentum
  - Remove muons with mismeasured momentum

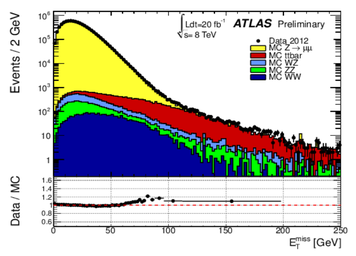
Performance in ATLAS – e, μ, E_T^{miss}



The identification efficiency of electrons from the Z → ee decay for the Loose, Multilepton, Medium and Tight set of cuts as well as the Loose, VeryTight Likelihood is shown as a function of E_T for -2.47 < η < 2.47 [5].



Reconstruction efficiency for Combined+Standalone muons as a function of muon p_T, for muons with 0.1<|η|<2.5. The result obtained with Z → μμ and J/ψ → μμ events is also shown. The insert shows the detail of the efficiency as a function of p_T in the low p_T region. The lower part of the figure shows the ratio between data and MC distributions [6].



Distribution of E_T^{miss}, as measured in a data sample of Z → μμ candidates. The expectation from Monte Carlo simulation is superimposed and normalized to data, after each MC sample is weighted with its corresponding cross-section. The lower part of the figure shows the ratio between data and MC distributions [7].

References

[1] ATLAS Collaboration, JINST 3 (2008) S08003
[2] G. Altarelli, B. Mele, and M. Ruiz-Altaba, Searching for new heavy vector bosons in pp colliders, Z. Phys. C 45(1989) 109.
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[4] M. Chizhov, V. Bednyakov, and J. Budagov, Proposal for chiral bosons search at LHC via their unique new signature, Phys. Atom. Nucl. 71 (2008) 2096–2100
[5] ATLAS Collaboration, Electron reconstruction and identification efficiency measurements with the ATLAS detector using the 2011 LHC proton-proton collision data [arXiv:1404.2240v3 [hep-ex]]
[6] ATLAS Collaboration, Measurement of the muon reconstruction performance of the ATLAS detector using 2011 and 2012 LHC proton–proton collision data ,[Eur.Phys.J. C74 (2014) 3130]
[7] ATLAS Collaboration, Reconstruction and Calibration of Missing Transverse Energy and Performance in Z and W events in ATLAS Proton-Proton Collisions at √s=7 TeV [ATLAS-CONF-2012-101]
[8] ATLAS Collaboration, Search for new particles in events with one lepton and missing transverse momentum in pp collisions at √s = 8 TeV with the ATLAS detector [arXiv:1407.7494v1 [hep-ex]]

Acknowledgments

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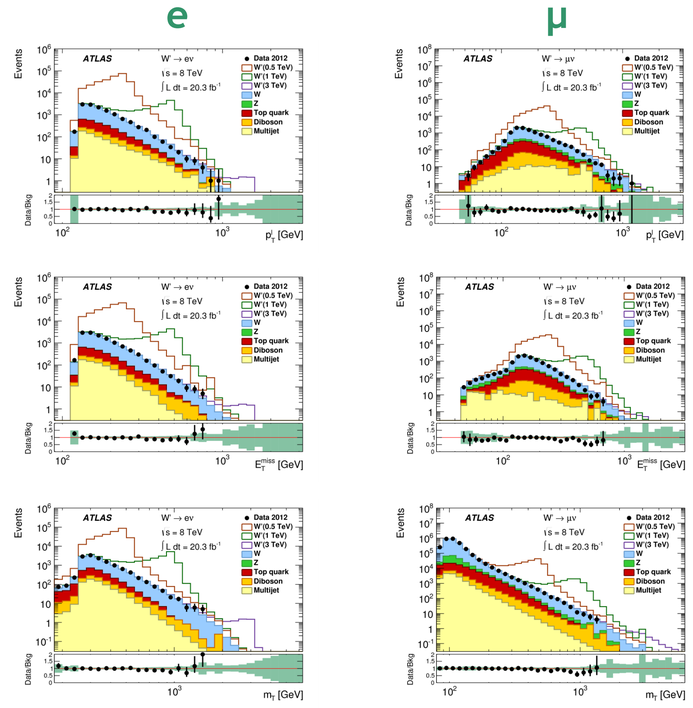
Results

e μ



- ✓ Select a high-p_T lepton
- ✓ Require E_T^{miss} that balances the lepton p_T
- ✓ Search the m_T distributions for excesses

Source	ε_{sig} eν	ε_{sig} μν	N_{bkg} eν	N_{bkg} μν
$W' \rightarrow \ell\nu$				
Reconstruction and trigger efficiency	2.5%	4.1%	2.7%	4.1%
Lepton energy/momentum resolution	0.2%	1.4%	1.9%	18%
Lepton energy/momentum scale	1.2%	1.8%	3.5%	1.5%
E_T^{miss} scale and resolution	0.1%	0.1%	1.2%	0.5%
Beam energy	0.5%	0.5%	2.8%	2.1%
Multi-jet background	-	-	2.2%	3.4%
Monte Carlo statistics	0.9%	1.3%	8.5%	10%
Cross-section (shape/level)	2.9%	2.8%	18%	15%
Total	4.2%	5.6%	21%	27%
$W^* \rightarrow \ell\nu$				
Reconstruction and trigger efficiency	2.7%	4.1%	2.6%	4.0%
Lepton energy/momentum resolution	0.4%	0.9%	3.0%	17%
Lepton energy/momentum scale	2.4%	2.4%	3.1%	1.5%
E_T^{miss} scale and resolution	0.1%	0.4%	3.1%	0.6%
Beam energy	0.1%	0.1%	2.5%	1.9%
Multi-jet background	-	-	1.8%	2.6%
Monte Carlo statistics	1.2%	1.8%	6.7%	8.6%
Cross-section (shape/level)	0.2%	0.2%	17%	15%
Total	3.9%	5.1%	19%	25%

Relative uncertainties on the selection efficiency ε_{sig} and expected number of background events N_{bkg} for a W' and W* with a mass of 2000 GeV.

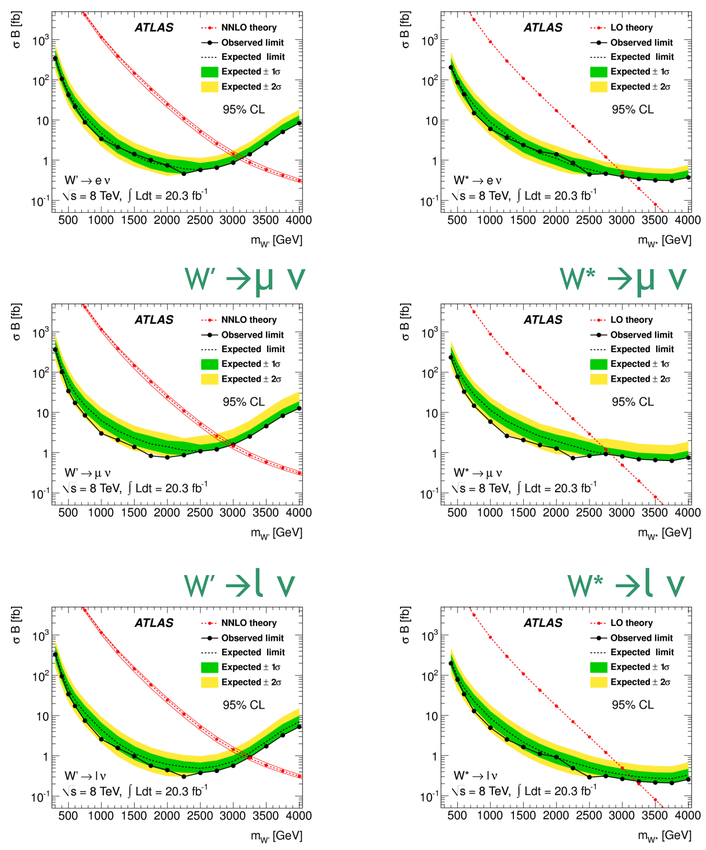
Conclusions - Limits

No significant excess beyond Standard Model expectations is observed. A W' with SSM couplings is excluded at the 95% confidence level for masses up to 3.24 TeV. Excited chiral bosons (W*) with equivalent coupling strengths are excluded up to a mass of 3.21 TeV [8].

W' →e ν W* →e ν

W' →μ ν W* →μ ν

W' →l ν W* →l ν



Decay	$m_{W'}$ [TeV] Exp.	$m_{W'}$ [TeV] Obs.	m_{W^*} [TeV] Exp.	m_{W^*} [TeV] Obs.
$e\nu$	3.13	3.13	3.08	3.08
$\mu\nu$	2.97	2.97	2.83	2.83
Both	3.17	3.24	3.12	3.21