Searches for Heavy Resonances at the LHC

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These proceedings presents the results of several searches for heavy resonances using between 6 and 20 fb^{-1} of $\sqrt{s} = 8$ TeV proton-proton collision data collected by the ATLAS and CMS experiments at the LHC. No evidence of new heavy resonances is observed and limits are set at the 95% confidence level on various benchmark models.

1 Introduction

The Standard Model (SM) of particle physics has so far been a very successful theory, with experimental results being consistently in agreement with its predictions. Still it is conceivable that the SM is just an effective theory and that above some energy scale new physics emerges. Therefore there are various extensions to the SM which predict the presence of a new heavy resonances. These proceedings detail several of the most recent CMS and ATLAS searches for heavy resonances using 8 TeV proton-proton LHC data.

2 $Z' \to e^+e^-/\mu^+\mu^-$

Both CMS and ATLAS collaborations have searched for a heavy neutral spin-1 particle (Z') decaying into electron or muon pairs with approximately 20 fb^{-1} of data [3,4]. Figure 1 shows the measured mass spectra in the CMS dielectron and ATLAS dimuon channels. No significant excess is observed and limits are set at the 95% confidence level as shown in figure 2. Different conventions are used when setting cross-section limits, CMS models the signal as having zero intrinstic width while ATLAS uses the shape obtained from a Z'_{SSM} which does not interfere with the SM Z boson. Care must be taken when comparing the limits as a result. Both ATLAS and CMS exclude the benchmark Z'_{SSM} boson for masses below 2.9 TeV.

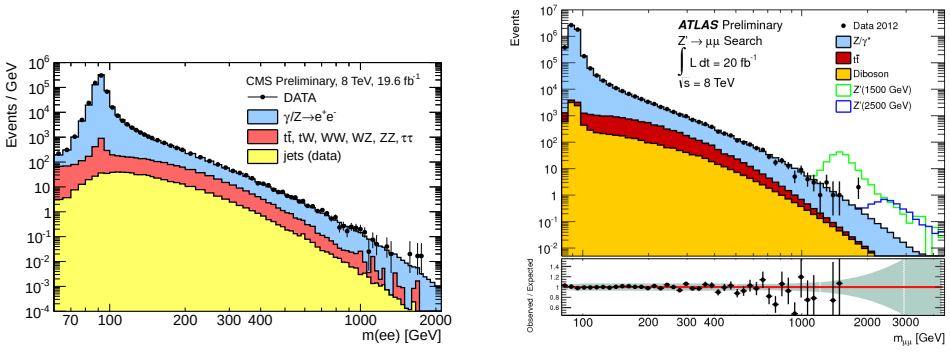

Figure 1: CMS dielectron (left) and ATLAS dimuon (right) mass spectra

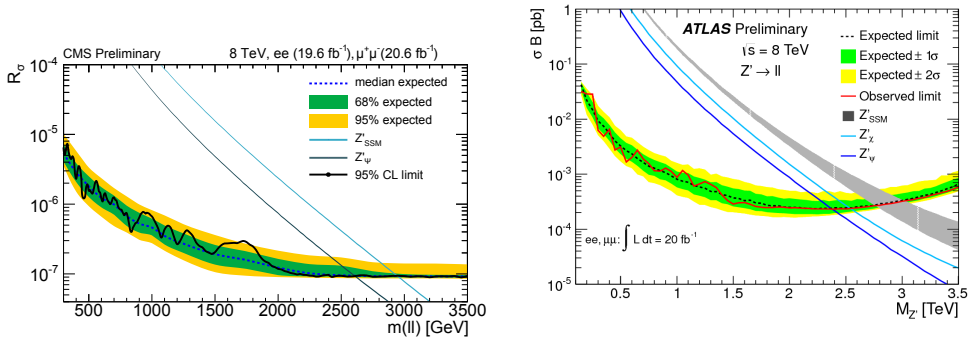

Figure 2: 95% confidence level limit on the σ.Br of a spin-1 boson vs mass using CMS (left) and ATLAS (right) dilepton mass spectra.

3 $W' \to e\nu/\mu\nu$

The CMS collaboration has searched for a charged spin-1 particle (W') decaying to $e\nu$ or $\mu\nu$ with 19.6 fb^{-1} of data [5]. The distribution of the observed transverse mass together with expected backgrounds is shown in figure 3. No significant excess is observed and as figure 4 shows, the M_T spectrum was used to set model independent limits vs M_T as well as on specific models, such as the W'_{SSM} and split UED. A W'_{SSM} boson is excluded below 3.35 TeV.

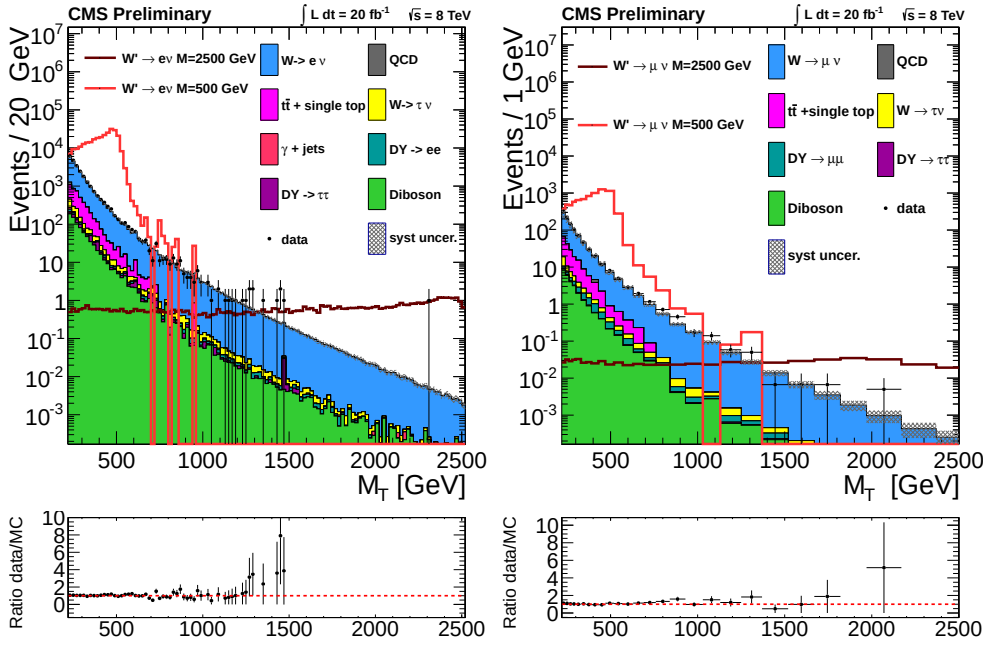

Figure 3: CMS transverse mass spectra for the electron (left) and muon (right) channels.

4 $W' \to tb$

The CMS collaboration has also searched for a W' decaying to top-bottom pairs where the top decays to either a muon or an electron using 19.6 fb^{-1} of data [6]. While not as sensitive as the lepton channel to a generic W', if the W' is right-handed and the right-handed neutrino is more massive than the W_R, the leptonic limits do not apply. Additionally, unlike the leptonic case, the W' mass can be reconstructed in this channel. Figure 5 shows the resulting mass spectrum. No significant excess is observed and limits are set on the cross-section times branching ratio.

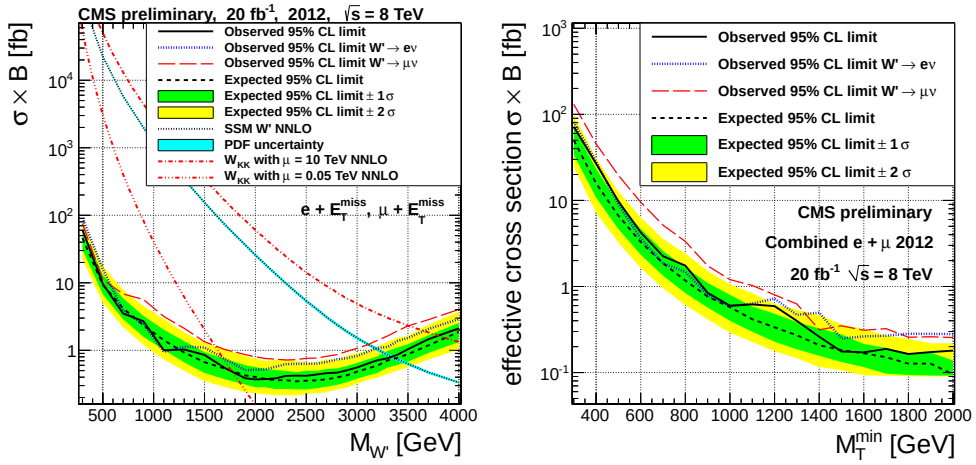

Figure 4: 95% confidence level upper limits on the $\sigma.Br$ of a W' vs transverse mass taking the signal shape into account (left) and on the effective $\sigma.Br$ above a minimum M_T threshold as a function of that threshold.

Figure 6 shows these cross-section limits vs mass and the reinterpretation of these limits into an exclusion plane of the W's coupling strength to left handed and right handed fermions.

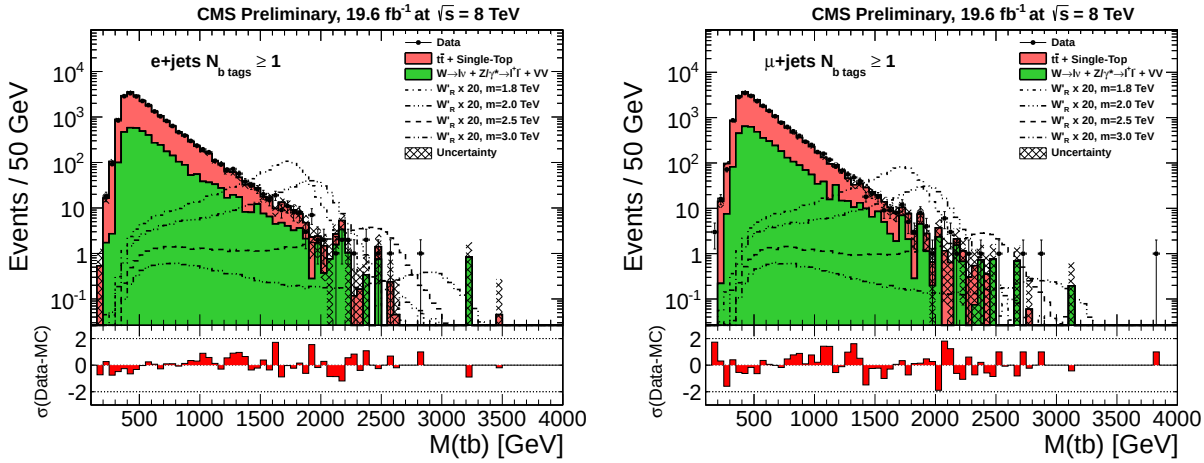

Figure 5: CMS observed top-bottom mass spectrum where the top decays to an electron (left) or a muon (right).

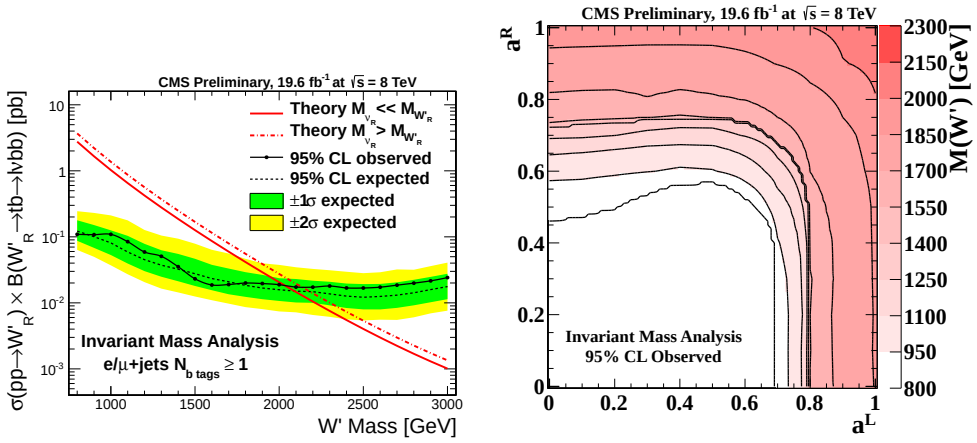

Figure 6: 95% confidence level upper limit on $\sigma(W').Br(W' \to tb)$ as a function of mass (left) and mass limits as as a function of W' coupling strength to left-handed and right-handed fermions (right).

5 Excited Leptons

The ATLAS collaboration has searched for excited electrons and excited muons using 13 fb^{-1} of data [7]. The leptons are pair produced, with one lepton in an excited state which then decays to the ground state lepton and a photon, giving a signature of two same flavor leptons and a photon. In order to generalize this search to objects other than excited leptons, the total mass of the photon and two leptons was measured rather than the mass of the excited lepton. No significant excess over the SM prediction was observed and limits were set on the excited lepton masses for various scales of compositeness. These limits are shown in figure 8.

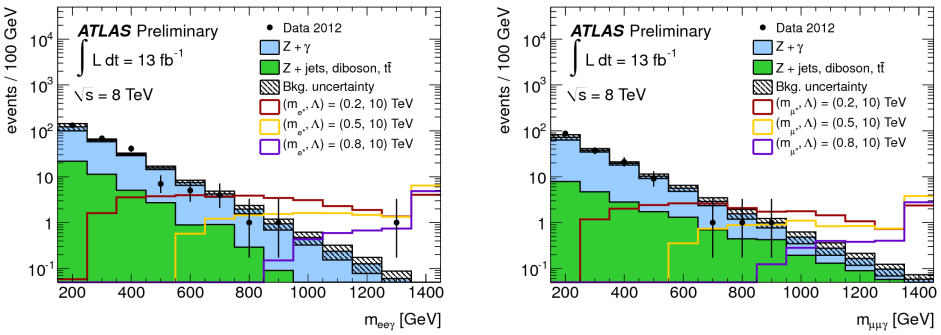

Figure 7: ATLAS observed total invariant mass of the 2 electron + 1 photon system (left) and 2 muon + 1 photon system (right).

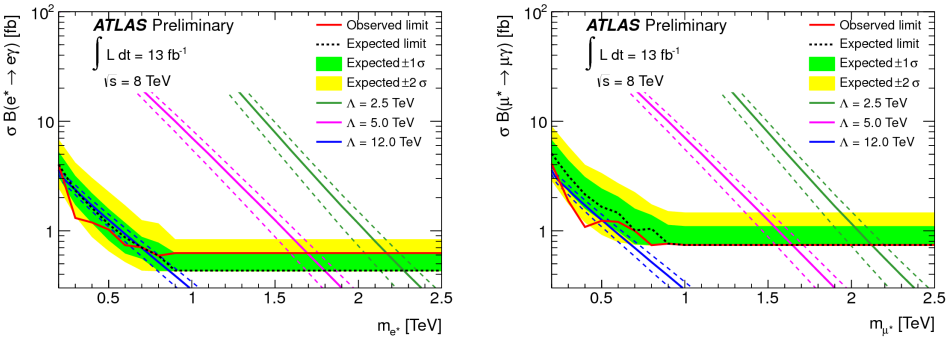

Figure 8: 95% confidence level upper limit on $\sigma.Br$ as a function of mass in for excited electrons (left) and excited muons (right).

6 Type III See-Saw

The ATLAS collaboration has searched for evidence of the lightest fermion triplet (N^+, N^-, N^0) postulated to generate neutrino masses by the type-III see-saw mechanism [8] using 5.8 fb^{-1} of data [9]. A 4 lepton final state resulting from the process $W \to N^{\pm}N^0; N^{\pm} \to l^{\pm}Z, N^0 \to l'^{\pm}W^{\mp}$, where the W and Z decay leptonically, is searched for. Only the $N^{\pm}$ mass is reconstructed, the lepton from the N^0 is solely used to tag the event to reduce background. The mass spectrum is shown in figure 9. No significant excess over the SM prediction was observed and limits were set on the cross-section times branching fraction vs fermion mass. These limits are shown in figure 10. For the $Br(N^{\pm} \to Zl^{\pm})$ and $Br(N^0 \to W^{\pm}l^{\mp})$ predicted by the type-III see-saw mechanism a lower mass bound on the N fermions is set at 245 GeV at 95% confidence level.

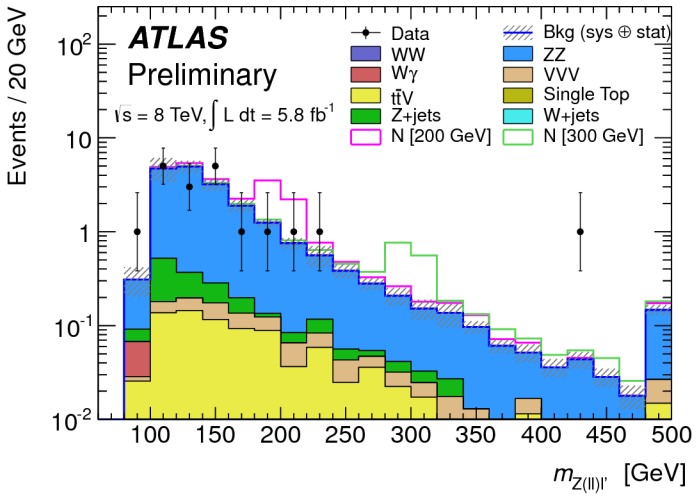

Figure 9: The ATLAS observed $Z(ll)+l$ mass spectrum where another lepton unrelated to the other three leptons is also present in the event.

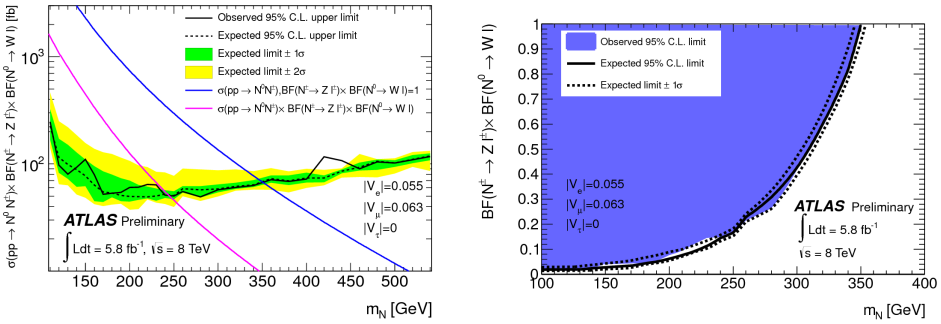

Figure 10: 95% confidence level upper limit on $\sigma.Br$ for $N^{\pm}N^{0}$ production as a function of mass (left) and $Br(N^{\pm} \to Zl^{\pm} \times Br(N^{0} \to W^{\pm}l^{\mp})$ vs mass exclusion plane (right).

7 Conclusion

The ATLAS and CMS collaborations have searched for several types of new heavy resonances using between 6 fb^{-1}and 20 fb^{-1}of proton-proton $\sqrt{s} = 8$ TeV collision data produced by the LHC. No significant excess has been observed and limits at the 95% confidence level have been set on a varity of models. Further searches for new heavy resonances are in more complicated final states are underway and will update over the coming year.

References

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