Search for leptonic resonances at CMS

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1 Introduction

We present the results of searches for new heavy gauge bosons (W' and Z') in the leptonic final states and excited leptons, using the *pp* collision data at 7 TeV collected with CMS [1] in 2010, which amounts to a luminosity of 36 pb^{-1}.

2 W' searches

Several BSM theories introduce new charged bosons, for instance, models with extra dimensions, Technicolor or extensions of the SM with enlarged gauge groups like the Left-Right symmetric models. Due to this variety, experimental searches consider a more general approach, where the W' is treated as a carbon copy of SM W with the additional decay channel $W' \to tb$. No interaction with the SM gauge bosons or with other heavy gauge bosons such as Z' is assumed.

The basis of this analysis is the efficient reconstruction of electrons and muons, respectively, along with transverse missing energy (E_T^{miss}), caused by the neutrino in the W' decay. Events are selected if there is just one central charged lepton with high momentum (p_T >25 GeV for muons and 30 GeV for electrons), well reconstructed and isolated. Given the two-body decay, the energy of the neutrino and charged lepton are expected to be mostly balanced in the transverse plane. Therefore, two dedicated kinematics requirements are applied: $0.4 < E_{lepton}/E_T^{miss} < 1.5$, $\Delta\phi$ >2.5. The primary sources of background include $W \to l\nu$ decays, QCD multijet events, $t\bar{t}$, Drell-Yan events and diboson processes with decays to electrons, muons or taus. In the muon channel cosmic ray muons are also considered.

The transverse mass (M_T) of the lepton-E_T^{miss} system is reconstructed, providing the main discriminating variable for the analysis, see Figure 1 left and middle plots. Since no excess is observed at high M_T in both channels, an upper limit on the W' production cross section times branching ratio is determined, which translates to a lower bound on the mass of the W' boson. For each mass point, a minimum M_T was chosen in such a way that provides the best expected limit. The M_T region above this threshold was used as the search window. The limits for the two individual channels result $M_{W'}$ >1.36 TeV [2] (electron) and $M_{W'}$ >1.40 TeV [3] (muon), and the one combining both, $M_{W'}$ >1.58 TeV, see Figure 1 right.

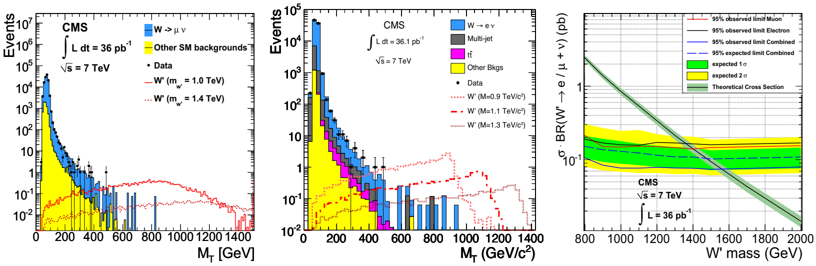

Figure 1: M_T distribution after all selection steps in data and in simulation for the muon (left) and electron (middle) channels. A W' signal with two different hypothetical masses is shown. Individual limits (right) as observed for the electron (black line), the muon channel (red line) and their combination (solid blue line).

3 Z' searches

Regarding the Z' searches the models used as benchmark were the Sequential Standard Model Z'_{SSM} with standard-model-like couplings, the Z'_{Ψ} predicted by grand unified theories and Kaluza-Klein graviton excitations arising in the Randall-Sundrum (RS) model of extra dimensions. The RS model has two free parameters: the mass of the first graviton excitation and the coupling k/M_{Pl}, where k is the curvature of the extra dimension and M_{Pl} is the reduced effective Planck scale.

The search for resonances is based on a shape analysis of dilepton mass spectra, in order to be robust against uncertainties in the absolute background level. The selection starts by identifying two high quality isolated leptons with high momentum (p_T >25 GeV for muons and p_T >20 GeV for electrons). In the muon channel opposite charge is enforced as charge misassignement is negligible, while for electrons this is not required because it would lead to a loss of efficiency of a few percent.

The invariant mass spectra, presented in Figure 3 for both channels, is consistent with the SM predictions. The dominant background is Drell-Yan (irreducible), followed by $t\bar{t}$-like events and jets (negligible for muons). Since no significant deviation is observed, we set limits in the ratio between the new gauge boson cross section and the Z SM cross section, see Figure 3 right. The combined upper limit on the ratio is compared to the theoretical cross section given by different models. By combining the two channels, the following 95% C.L. lower limits on the mass of a Z' resonance are obtained: 1140 GeV for the Z'_{SSM} and 887 GeV for Z'_{Ψ} models. RS Kaluza-Klein gravitons are excluded below 855 (1079) GeV for values of couplings 0.05 (0.10) [4].

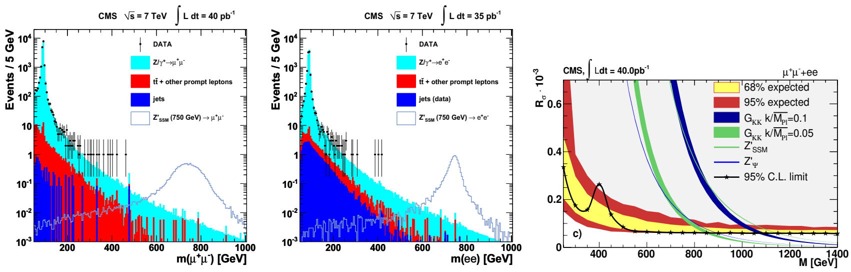

Figure 2: Invariant mass spectrum of $\mu^+\mu^-$ (left) and ee (right) events. The open histogram shows the signal expected for a Z'_{SSM} with a mass of 750 GeV. Upper limits (right) as a function of resonance mass M_{ll}, on the production ratio of $\sigma \times BR$ into lepton pairs for various models.

4 Excited leptons

CMS also searched for the production of an excited lepton l^* (μ^* or e^*) in association with an oppositely charged lepton of the same flavour via four-fermion contact interactions, followed by the electroweak decay $l^* \rightarrow l\gamma$. The two parameters of the model are the contact interaction scale, Λ, and the mass of the excited lepton, $M_{l\gamma}$. The presence of a l^* would be experimentally observed as an excess in data at high $M_{l\gamma}$.

For this analysis, events are selected by requiring an isolated photon and two good quality isolated leptons, with a minimun p_T of 20 GeV for photons and muons and of 25 GeV for electrons. The contribution of background events from SM processes containing the same signature is estimated from MC, while the number of background events due to jets faking photons or leptons is estimated from control samples in data. The final M_{μ^*} distribution is shown in Figure 3 left. The agreement between data and background processes is similar in the electron channel.

The search strategy is the same as in the W' analysis. A search window for the high invariant mass region is determined to compare the number of expected and observed events. The cut applied on M_{l^*} depends on the excited mass hypothesis. There are no signal candidates observed in data in the high mass region, so upper limits on $\sigma \times BR$ are set as a function of M_{l^*} at 95% CL. Interpreting the data in the context of the contact interaction model, a new region of the (Λ, M_{l^*}) parameter space can be excluded with each channel, see Figure 3 middle and right [5].

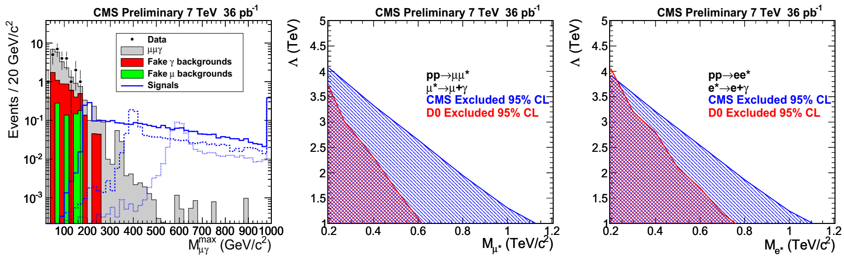

Figure 3: Invariant mass distribution of the chosen $l\gamma$ pair in the muon channel (left). (Λ, M_{l^*}) region excluded at the 95% CL, for muons (middle) and electrons (right), compared to previous most stringent limits by the D0 experiment.

5 Conclusions

CMS is looking for exotic signal of new physics, studying many different signatures to test several beyond the Standard Model theories. No excess of events above the standard model predictions has been found analysing the 2010 data set.

References

[1] CMS Collaboration, JINST 3:S08004 (2008).

[2] CMS Collaboration, Physics Letters B. **698**:21 (2011).

[3] CMS Collaboration, Physics Letters B. **701**:160 (2011).

[4] CMS Collaboration, J. High Energy Phys. 05 (2011) 093.

[5] CMS Collaboration, Physics Letters B. **704**:143 (2011).