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BOUNDS ON THE MASS AND MIXING OF Z' AND W' BOSONS DECAYING INTO DIFFERENT PAIRINGS OF W, Z OR HIGGS BOSONS USING CMS AND ATLAS DATA AT THE LHC

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A variety of theoretical extensions to the standard model of particle physics (SM) predict new phenomena in high-energy proton-proton collisions, the discovery of which is one of the main goals of the CERN Large Hadron Collider (LHC). The LHC allows to probe new phenomena, new particles and interactions, at energies of several TeV. A wide range of models predicts the production of new heavy, TeV-scale, resonances or vector bosons decaying to pairs of SM electroweak vector bosons (jointly referred to as V in the following, with V=W, Z), and SM Higgs (H) bosons. Models studied in the literature include extended gauge models (EGM) [1-2], models of warped extra dimensions, technicolourmodels associated with technirho and other technimesons, composite Higgs, and the heavy vector-triplet (HVT) model, which generalises a large number of models that predict spin-1 neutral (Z') and charged (W') resonances.

The extended gauge models are among the best motivated theoretical scenarios beyond the SM that predict the existence of new heavy neutral and charged vector bosons (Z' and W') [3]. These models are considered as benchmark scenarios for diboson resonances having spin 1 ($W' \to WZ$ or WH, $Z' \to WW$ or ZH), produced predominantly via quark-antiquark annihilation ($q\bar{q}' \to W', q\bar{q} \to Z'$). The neutral and charged massive resonance production at hadron level and its subsequent decay to pairs of electroweak gauge and Higgs bosons can be expressed as, $pp \to Z'X \to WWX$, $pp \to Z'X \to ZHX$ and $pp \to W'X \to WZX$, $pp \to W'X \to WHX$.

We present results as constraints on the relevant Z-Z' (W-W') mixing angle, $\xi_{Z-Z'}$ ($\xi_{W-W'}$) [4-5], and on the mass $M_{Z'}$ ($M_{W'}$) and display the combined allowed parameter space for the benchmark $M_{Z'}$ ($M_{W'}$) boson models, showing also indirect constraints from electroweak precision data (EW), previous direct search constraints from the Tevatron and from the LHC with 7 and 8 TeV in Run 1 (where available), as well as those obtained from the LHC at 13 TeV with the full CMS and ATLAS Run 2 data set of time-integrated luminosity of 137 fb^{-1} and 139 fb^{-1} in the semileptonic final states.

The total width $\Gamma_{Z'}(\Gamma_{W'})$ of the Z' (W') can be written as follows:

$$\Gamma_{Z'} = \sum_f \Gamma_{Z'}^{f\bar{f}'} + \Gamma_{Z'}^{WW} + \Gamma_{Z'}^{ZH}, \quad \Gamma_{W'} = \sum_f \Gamma_{W'}^{f\bar{f}'} + \Gamma_{W'}^{WZ} + \Gamma_{W'}^{WH} \qquad (1)$$

Different bounds on the Z' and W' parameter space are collected in Fig. 1 (left and right panel) for the EGM model, showing that at high masses, the limits on $\xi_{Z-Z'}$ ($\xi_{W-W'}$) obtained from the full Run 2 data set collected at $\sqrt{s} = 13$ TeV and recorded by the CMS and ATLAS detectors are substantially stronger than that derived from the global analysis of the precision electroweak data (EW), as well as the limits obtained from diboson data at the

Tevatron. Limits obtained separately with CMS and ATLAS from the two channels, $Z' \to W^+W^-$ ($W' \to WZ$) and $Z' \to ZH$ ($W' \to WH$), are shown for comparison. It turns out that the diboson channel in contrast to allows to place limits on $Z - Z'(W - W')$ mixing in the narrow mass ranges, whereas in the rest of the resonance mass both channels demonstrate comparable sensitivity to $\xi_{Z-Z'}$ ($\xi_{W-W'}$) mixing.

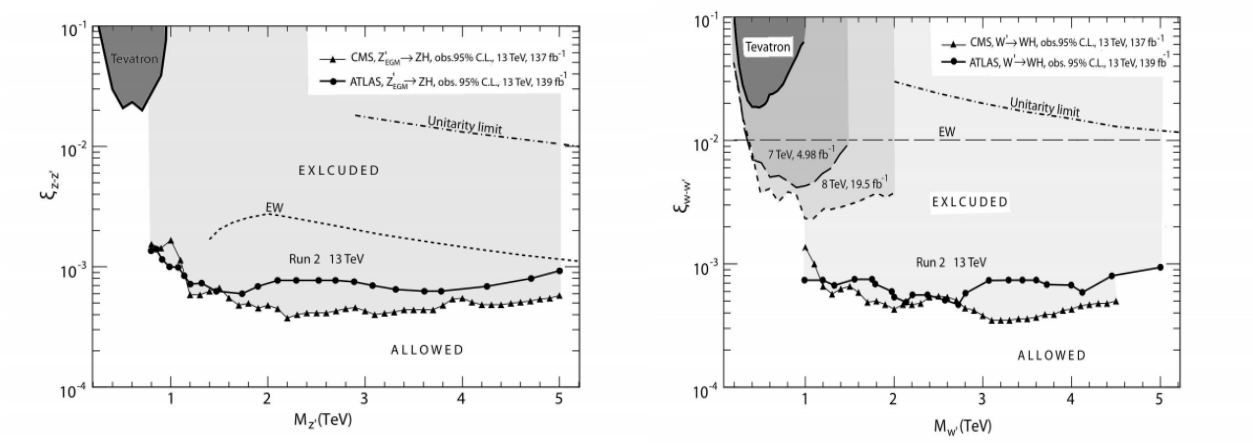

Fig1. Left panel: The Z'_{EGM} model: 95%*C.L.*exclusion regions in the two-dimensional $(M_{Z'}, \xi_{Z-Z'})$ plane obtained after incorporating indirect constraints from electroweak precision data (dashed curve labeled ``EW')' and direct search constraints from the Tevatron (dark shaded area) as well as from the LHC searches for and in semileptonic final states using the full Run 2 CMS and ATLAS data set. The region above the curves for the WW and ZH channels are excluded. Right panel: Same as in the left panel (W'_{EGM} model) but in the $(M_{W'}, \xi_{W-W'})$ plane.

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