Dileptons searches for electroweakinos

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The hallmark way to search for electroweakinos in natural supersymmetry at the LHC involves the trilepton plus missing energy ($\not{E}_T$) final state. This approach assumes an electroweakino mass hierarchy that allows for cascade decays leading to a final state of $W^{\pm}Z^0$ plus $\not{E}_T$. There are, however, situations when that decay pattern may not exist, such as when a chargino is the lightest electroweakino and the lightest supersymmetric particle is the gravitino. In regions of the parameter space where this ordering occurs, the production of any combination of neutralino/chargino leads to a $W^+W^-+\not{E}_T + X$ final state, where X could be additional jets or leptons. If X is soft, then all neutralino/chargino production modes fall into the same experimental final state, $\ell^+\ell^-+\not{E}_T$. ATLAS [1] and CMS [2] have $W^+(\ell^+\nu)W^-(\ell^-\bar{\nu})+\not{E}_T$ searches, but their interpretation assumes a spectrum consisting of an isolated charged state. A spectrum that does not occur in the MSSM.

One can identify the circumstances under which natural supersymmetry models can avoid $W^{\pm}Z^0 + \not{E}_T$ bounds. For scenarios that escape $W^{\pm}Z^0 + \not{E}_T$, then one can recast the latest ATLAS $W^+W^- + \not{E}_T$ search, taking into account all the states that contribute to the same signal. Assuming the lightest supersymmetric particle is massless, a bound of 460 GeV [3] for a higgsino-like degenerate doublet is found instead of the 410 GeV quoted by ATLAS and CMS.

This is just one example of a more general statement, realistic and complete spectra are far more complicated than simplified models. In some extreme cases simplified spectra never appear in complete models. Stronger collaboration among theorists and experimentalist is needed to find a more complete way of presenting bounds. One possibility could be to provide both exclusion plots of different masses along with the cross-sections being exluded.

References

[1] The ATLAS collaboration [ATLAS Collaboration], ATLAS-CONF-2019-008.

[2] A. M. Sirunyan *et al.* [CMS Collaboration], JHEP **1811**, 079 (2018) doi:10.1007/JHEP11(2018)079 [arXiv:1807.07799 [hep-ex]].

[3] A. Delgado and A. Martin, Phys. Rev. D **101**, no.3, 035014 (2020) doi:10.1103/PhysRevD.101.035014 [arXiv:1912.03215 [hep-ph]].