Explanation of the ATLAS Z-peaked Excess in the NMSSM

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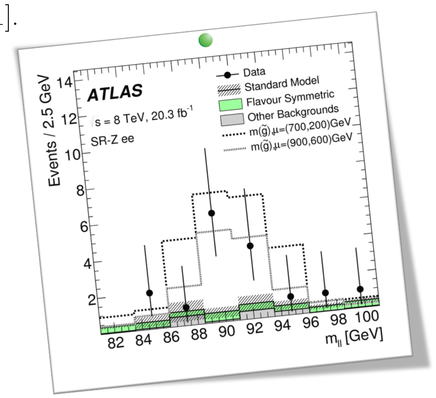
Introduction

The ATLAS collaboration reported a 3σ excess in the channel of two leptons with an invariant mass located around m_Z, large E_T^{miss} and at least two jets [1].



In this study, we explain this excess by production of gluino pair / squark pair in the Next-to Minimal Supersymmetric Standard Model (NMSSM) considering the current constraints.

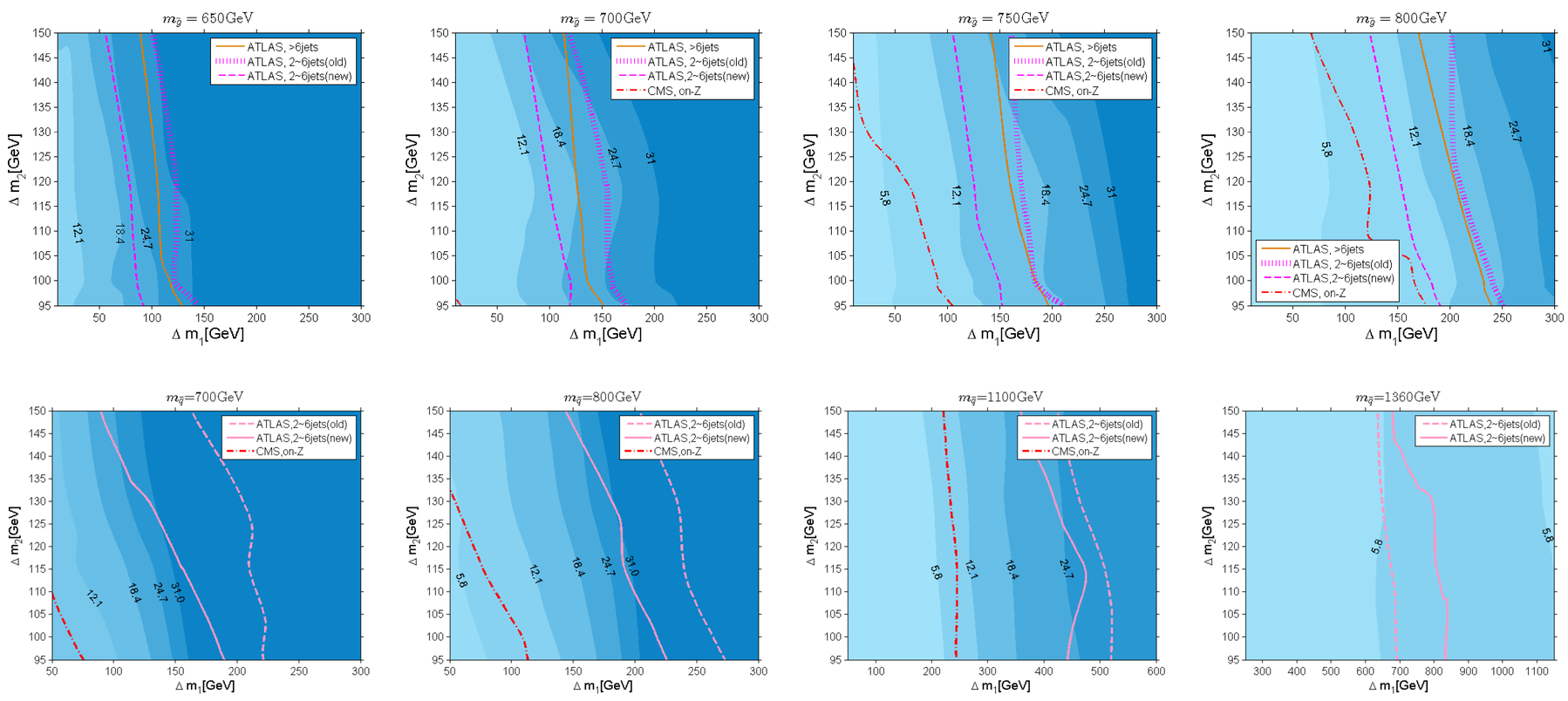
The scenarios in the NMSSM

To explain the leptonic-Z excess and escape the constraints from the other direct searches for SUSY at LHC, we use the scenarios as follows:

- The signal processes are
  $pp \to \tilde{g}\tilde{g} \to \tilde{\chi}_2^0 jj \tilde{\chi}_2^0 jj \to \tilde{\chi}_1^0 Zjj\tilde{\chi}_1^0 Zjj$ and
  $pp \to \tilde{q}\tilde{q} \to \tilde{\chi}_2^0 j\tilde{\chi}_2^0 j \to \tilde{\chi}_1^0 Zj\tilde{\chi}_1^0 Zj$ respectively.
- The LSP $\tilde{\chi}_1^0$ is singlino-like and the NLSP $\tilde{\chi}_2^0$ is bino-like.
  $\to$ BR$(\tilde{g} \to \tilde{\chi}_2^0 jj) = 100\%$ and
  BR$(\tilde{q} \to \tilde{\chi}_2^0 j) = 100\%$
- 90 GeV $< m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0} \leq 150$ GeV.
  $\to BR(\tilde{\chi}_2^0 \to Z\tilde{\chi}_1^0) = 100\%$.
- $m_{\tilde{g}} \sim m_{\tilde{\chi}_2^0} \sim m_{\tilde{\chi}_1^0} + m_Z$.
  $\to$ avoid the constraints from the LHC.
- The squarks $\tilde{q}$ only include the light-flavor ones and their masses $m_{\tilde{q}}$ are degenerate.
- All the irrelevant SUSY parameters are set to avoid corresponding experimental constraints.

Numerical Results and Discussions

In our scenarios, the event number of the gluino pair / squark pair production with the specific final states is solely determined by the masses, i.e. $m_{\tilde{g}}$ / $m_{\tilde{q}}$, $\Delta m_1 = m_{\tilde{g}} - m_{\tilde{\chi}_2^0}$ and $\Delta m_2 = m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0}$. In the following figures we show the contours of the event number for the ATLAS search for the leptonic-Z $+jets + E_T^{Miss}$ signal on the $\Delta m_1 - \Delta m_2$ plane for different gluino (upper panels) / squark (lower panels) masses. Considering that the signal processes not only generate the leptonic-$Z + jets + E_T^{miss}$ signal but also the multi-jets + E_T^{miss} signals, we take the ATLAS experimental constraints for these searches [2] into count, together with CMS analysis on the leptonic-$Z + jets + E_T^{miss}$ signal [3], which have the same physical origin as the ATLAS excess but observed no excess. Constraints from the those searches are plotted by different types of lines and the left sides of the lines stand for the allowed regions.



Gluino (Upper Panels)

- Fix $m_{\tilde{q}} = 4.5$ TeV.
- After exploring the relevant parameter space of the NMSSM by considering the constraints from the ATLAS searches for $jets + E_T^{miss}$ signals, the NMSSM is able to explain the excess at 1σ level.
- Under the CMS on-Z search limits, the event number of the ATLAS on-Z signal can still reach 11, which is about 1.2σ away from the measured central value.

Squark (Lower Panels)

- Fix $m_{\tilde{g}} = 1.5$ TeV.
- Considering the constraints from the ATLAS searches the central value of the excess can be obtained for $m_{\tilde{q}} = 1.2$ TeV, and if the constraint from the CMS is applied, more than 10 signal events are still attainable for $m_{\tilde{q}} = 750$ GeV.
- Compared with the gluino scenario, the squark explanation allows for a wider range of $m_{\tilde{q}}$ as well as a less compressed SUSY mass spectrum.

Tools: MG5_aMC, PYTHIA, CheckMATE, ...

References

[1] The ATLAS Collaboration, arXiv:1503.03290 [hep-ex].

[2] The ATLAS collaboration, ATLAS-CONF-2013-047, ATLAS-COM-CONF-2013-049, JHEP 1409, 176 (2014) [arXiv:1405.7875 [hep-ex]], JHEP 1310, 130 (2013) [arXiv:1308.1841 [hep-ex]].

[3] [CMS Collaboration], arXiv:1502.06031 [hep-ex].

∗ See arXiv:1504.07869 and arXiv:1507.08471 for details.