Aspects of the same-sign diboson signature from wino pair production in natural SUSY at LHC

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May 09, 2017

Introduction

- Standard Model(SM) has certain drawbacks like gauge hierarchy, inability to explain Dark Matter etc.
- Supersymmetry or SUSY is a highly motivated extension of SM where quadratic divergences are neatly cancelled and is also supported indirectly by experimentally obtained values of gauge couplings, m_t, m_h.
- But **no** sparticles have been seen in LHC yet.

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Is SUSY Unnatural?

- Supersymmetric models with **radiatively-driven naturalness** enjoy modest electroweak fine-tuning while respecting LHC sparticle and Higgs mass constraints.

One such Radiatively- driven Natural SUSY (RNS) model is the two-extra-parameter non-universal Higgs model (NUHM2) which we have used with parameters as follows :

$m_0 = 5$ TeV, $A_0 =$ -1.6m_0, $tan\beta = 10$, $m_A =$1500 GeV, $\mu = 150$ GeV, $m_{1/2} = 800$ GeV

This spectrum has $\tilde{m_g} = 2007.40$ GeV, $\tilde{m_{t1}} = 1470.30$ GeV, $m_h = 124.38$ GeV and $\Delta_{EW} = 9.3$ for just 10.75% finetuning.

The Electroweak fine-tuning parameter (Δ_{EW}) is defined as

$$\Delta_{EW} = max_i|C_i|/(M_Z^2/2) \quad (1)$$

Where, C_i is any one of the parameters on the RHS of the following equation :

$$\frac{M_Z^2}{2} \approx -m_{H_u}^2 - \mu^2 - \Sigma_u^u(\tilde{t}_{1,2}) \quad (2)$$

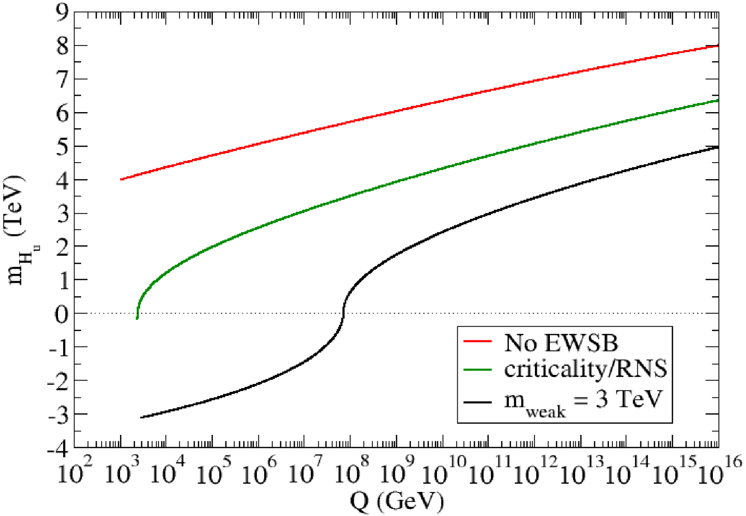

FIG 1: Evolution of the term $sign(m^2_{H_u})\sqrt{m^2_{H_u}}$ for the case of *No EWSB*, criticality as in *RNS* and $m_{weak} = 3$ TeV as in *arXive : 1602.07697*

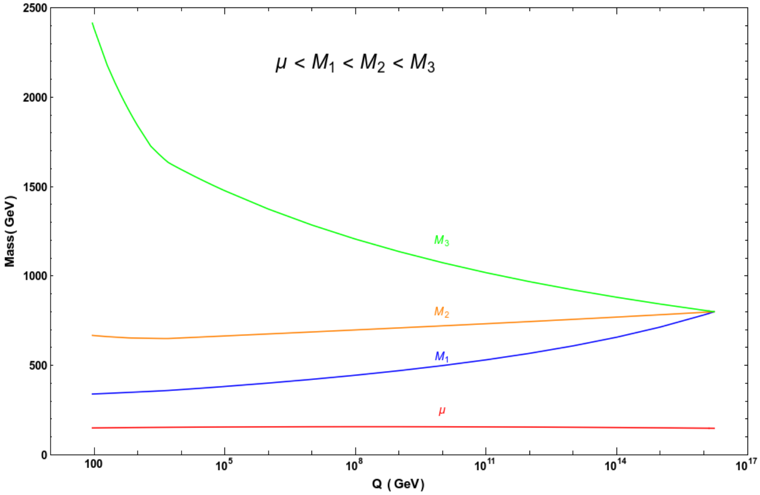

FIG 2

This hierarchy leads to a novel, rather clean same-sign diboson signature from wino pair production at hadron colliders.

Signal Process

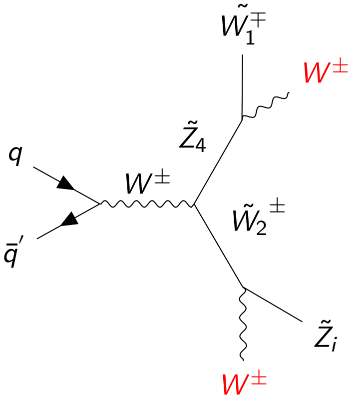

FIG 3 : Same-sign diboson production at LHC in SUSY models with light higgsinos.Here, $\tilde{Z}_4$ and $\tilde{W}_2^{\pm}$ in the intermediate step are winos and $\tilde{W}_1^{\mp}$ and $\tilde{Z}_i$ in the final step are light higgsinos.

NLO contribution in signal from prospino

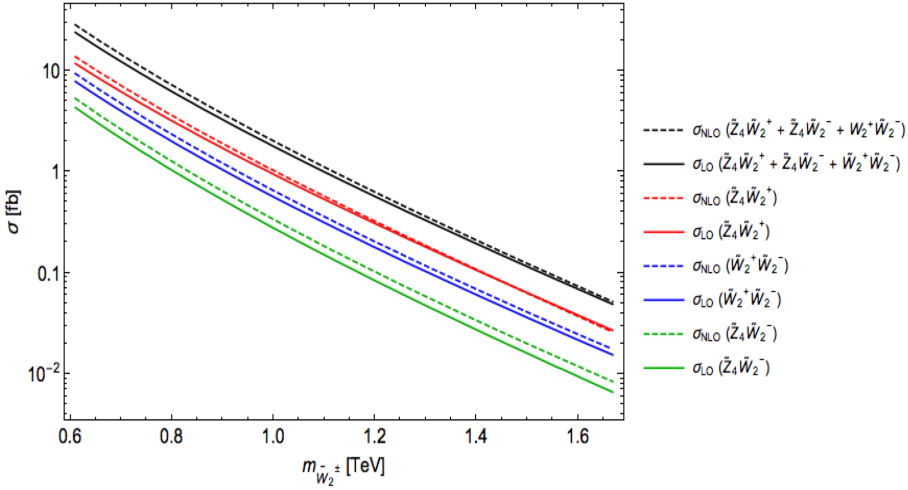

FIG 4

Cut-Flow Table

Sigma (in fb)			
Process	Without cuts	With NLO Effects	*After cuts*
Signal($m_{1/2} = 800$ GeV)	12.39	14.63	0.016
$t\bar{t}$	553300	887000	0
$W^{\pm}Z$	27670	52260	0
$t\bar{t}W^{\pm}$	419.1	513.26	0.007
$t\bar{t}Z$	631.1	769.94	0.00154
$W^{\pm}W^{\pm}W^{\mp}$	128.9	128.9*	0.0012
$t\bar{t}t\bar{t}$	8.428	8.428*	1.69E-05
$W^{\pm}W^{\pm}jj$	372.1	372.1*	0.0007
Total BG	581557.33	941052.63	0.0106

The Signal has been adjusted to include the NLO contribution as well according to the prospino result.

The Background processes includes a k-factor as obtained using MCFM.

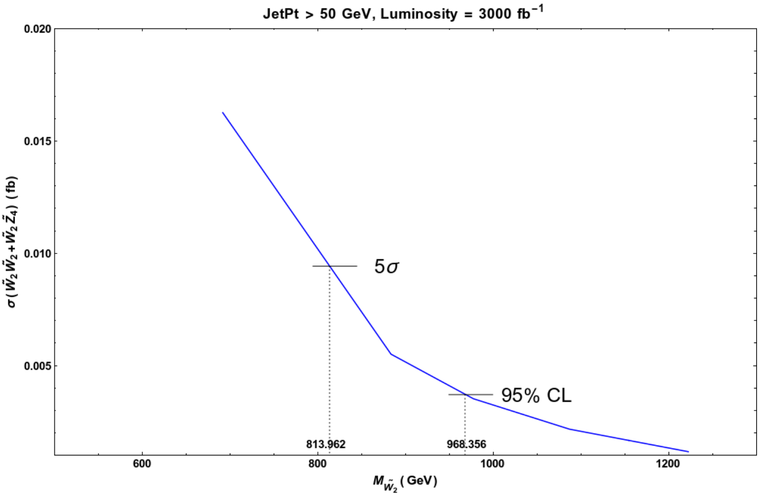

FIG 5 : Production cross-section of $\tilde{W}_2\tilde{W}_2 + \tilde{W}_2\tilde{Z}_4$ vs Mass of wino.

Conclusion

- In this project we have used a radiatively-driven natural Supersymmetric Model with light higgisino, thereby giving rise to a clean same-sign diboson signal from wino pair production.
- Certain cuts have been selected in order to efficiently reduce the background so that the signal is clean enough to be detected experimentally.
- For an integrated luminosity of 3000 fb^{-1} this Same-Sign diboson signal should be observable at LHC14 for wino mass upto 968 GeV.
- Assuming gaugino mass unification, this result is consistent with the predicted gluino mass ($\approx$ 2.8 TeV) in the paper arXiv : 1612.00795 (H.Baer *et.al.*)
- Since this is an ongoing project, there are some more things that we aim to attain in it.

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Now, let us have a look of those parts of the project which are still *"under construction"*

Future Goals

- One of most important part that we wish to attain in this project is to extract the wino mass.
- Since the diboson signature is produced from wino pair production is it possible to extract the wino mass from the distributions like invariant mass or minimum transverse mass of same-sign lepton pairs?
- Can we extract the wino mass via counting ?
- However, these can be done only after we have reduced the background enough to get a clean signal for a given integrated luminosity.
- We are still trying to figure out some better cuts so that most of the signal is retained while removing the background effectively.

THANK YOU

QUESTIONS ?