Models with the triplet extended scalar sector - phenomenology

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AIM OF STUDIES:

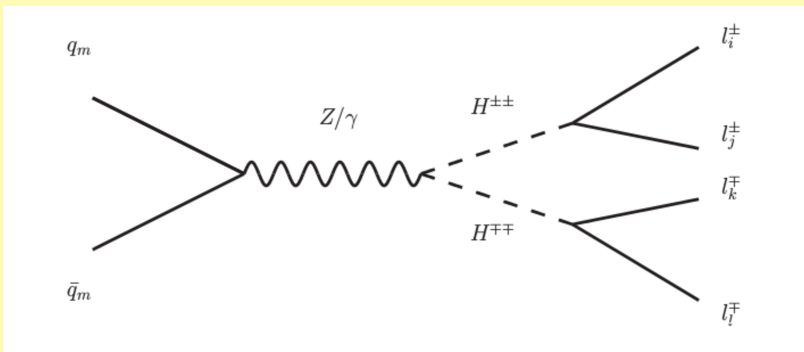
In 2012 CMS and ATLAS Collaboration announced discovery of a scalar boson. That discovery confirms the mass generation mechanism in the Standard Model theory. However, detection of the Standard Model-like Higgs particle does not exclude existence of other, more sophisticated theory with an extended scalar sector
There are many possibilities to build the more complex Higgs sectors. The simplest possibilities do not require extension of the SM $SU(2)_L$ x $U(1)_Y$ gauge group, for example Higgs Triplet Model (see−saw type II model). It is also possible to construct theories with an extended gauge group which includes scalar triplets. I will consider Left−Right Symmetric model, based on $SU(2)_R$ x $SU(2)_L$ x $U(1)_{B-L}$ gauge group. I will present some processes at the LHC and future collider energies in which doubly charged Higgs particles can emerge.

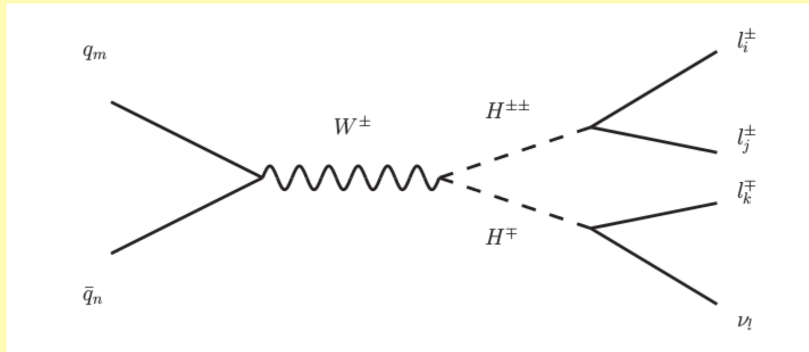
LEFT-RIGHT SYMMETRIC MODEL:

- **Model with extended gauge group: $SU(2)_R$ x $SU(2)_L$ x $U(1)_{B-L}$**
- **Right handed currents - suppressed thanks to the large mass of additional W_2 boson.**
- **In the most popular version for breaking the symmetry two additional scalar triplets are present.**
- **Doubly charged scalar particles are introduced.**
- **The parameter $\rho \simeq 1$ is preserved thanks to negligible VEV of the left-handed triplet.**
- **To suppress FCNC masses of relevant neutral scalars are at least at the range of 10 TeV [1].**

MOST RELEVANT PROCESSES:

Diagrams present the important ways of production doubly charged scalars at hadron colliders. The pair production and four lepton signal are especially interesting. The dominant contribution to these processes is via Z_1 and γ. Other contributions coming from s-channel H_0, H_0 and Z_2 are smaller [2].





$$H_{1,2}^{\pm\pm} \to l^\pm l^\pm$$
$$H_1^{\pm\pm} \to H_1^\pm W_1^\pm$$
$$H_2^{\pm\pm} \to H_2^\pm W_{1,2}^\pm$$
$$H_2^{\pm\pm} \to W_2^\pm W_2^\pm$$
$$H_2^{\pm\pm} \to H_{1,2}^\pm H_{1,2}^\pm$$

$$pp \to H^{\pm\pm} H^{\mp\mp} \to 4l \qquad pp \to H^{\pm\pm} H^{\mp} \to l^\pm l^\pm l^\mp \nu$$

RESULTS: pair production and 4-lepton channel

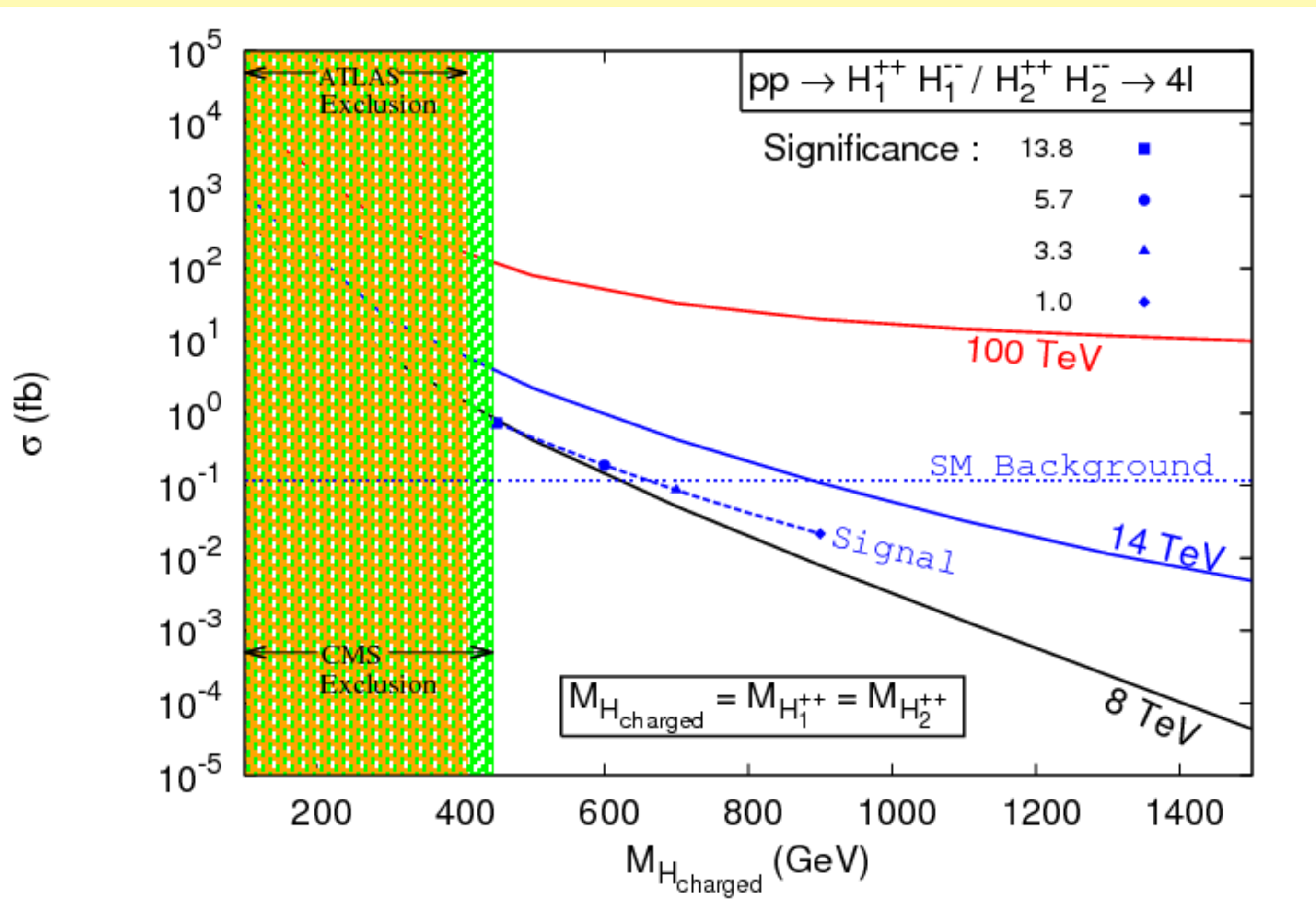


Fig. 3. Cross section for the pair production of doubly charged scalars decaying to four leptons in the MLRSM [3].

RESULTS: pair production $H^{++}H^{--}$ and 3-lepton channel

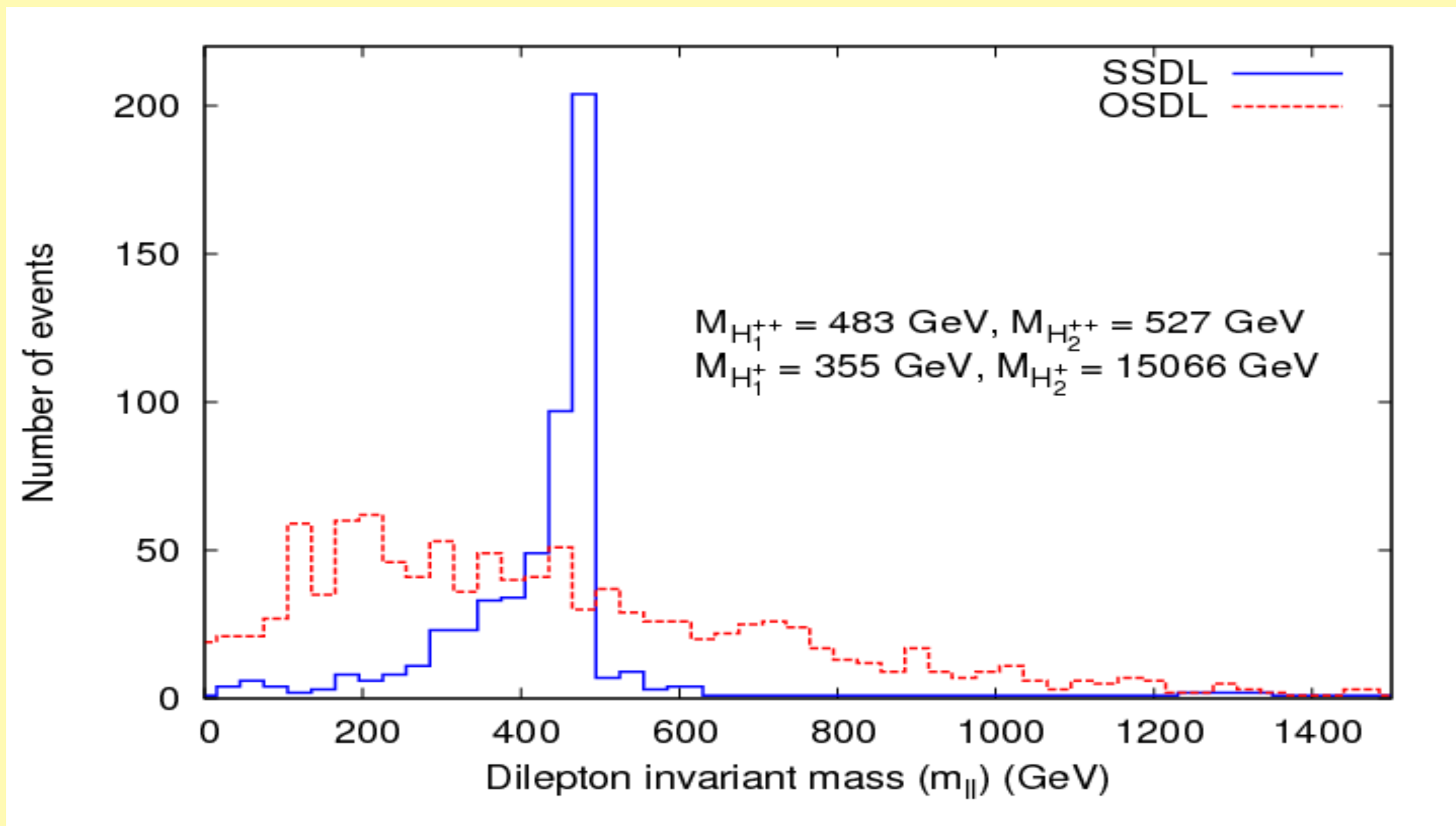


Fig. 1. Invariant mass plots for same sign di-leptons (SSDL) and opposite sign di-leptons (OSDL) for $pp \to l^\pm l^\pm l^\mp \not{p}_T$ with $\sqrt{s} = 14$ TeV and integrated luminosity 300 fb^{-1} [2]

RESULTS: signal, background and significance

Number of background and signal events at 25 fb^{-1} and 300 fb^{-1} as am anticipated integrate luminosity at next 14 TeV run of LHC. The tri-lepton signal is computed for following charged scalar masses: $M_{H1\pm\pm}$= 484 GeV, $M_{H2\pm\pm}$=527 GeV, $M_{H1\pm}$= 355 GeV, $M_{H2\pm}$= 15066 GeV. Scenario I reflects degeneracy of doubly charged scalar masses with (i) $M_{H1\pm\pm}$= $M_{H2\pm\pm}$= 400 GeV and (ii) $M_{H1\pm\pm}$= $M_{H2\pm\pm}$= 600 GeV, while Scenario II realises their non-degenerate spectrum namely $M_{H1\pm\pm}$= 400 GeV and $M_{H2\pm\pm}$= 500 GeV.
The significance of the signals is given using two definitions of significance: (i) $S/\sqrt{B}$, and (ii) $S/\sqrt{S+B}$, where S and B are the total nuber of signal and background events for 25 fb^{-1} and 300 fb^{-1} integrated luminosity, respectively. Here 'NA' implies that $S/\sqrt{B}$ can not be used as the definition of significance in these cases as $S \ll B$ is not justified.

	3l				4l						
						Scenario I			Scenario II		
Luminosity	Background events	Signal events	Significance		Background events	Signal events	Significance		Signal events	Significance	
			$S/\sqrt{B}$	$S/\sqrt{B+S}$			$S/\sqrt{B}$	$S/\sqrt{B+S}$		$S/\sqrt{B}$	$S/\sqrt{B+S}$
25 fb^{-1}	797.5	46.2	1.64	1.59	2.9	(i) 30 (ii) 4.4	NA	(i) 5.23 (ii) 1.63	24.8	NA	4.71
300 fb^{-1}	9569.7	554.0	5.66	5.51	34.8	(i) 360 (ii) 53	NA	(i) 18.11 (ii) 5.65	298	NA	16.34

OUTLOOK:

How to distinguish experimentally this mode from other BSM triplet models without right handed currents (e.q. Higgs Triplet Model - see saw type II, Georgi-Machacek model)?

REFERENCES:

[1] M. Pospelov, Phys. Rev. D 56, 259-264 (1997)
[2] G. Bambhaniya et al., JHEP 1405 (2014) 033
[3] G. Bambhaniya et al., Phys. Rev. D 90 (2014) 095003

ACKNOWLEDGMENTS:

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