Scalar particles of the Higgs Triplet Model at the FCC with low energy constraints

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AIM OF STUDIES:

Discovery of the Higgs particle at the LHC confirmed the mechanism of mass generation predicted by the Standard Model. However the Standard Model leaves some problems unsolved and many attempts to construct more sophisticated theory are undertaken. This poster will concentrate on models with triplet scalar extension. Additional triplets in the scalar sector involve existence of new scalar particles, singly and doubly charged, depends on the hypercharge of the implemented triplet. Both types of particles can contribute to $(g-2)_\mu$ and LFV processes. Keeping in mind those low energy constrains it is possible to limit the parameters space and analyze signals which could be observed at the FCC collider.

THE HIGGS TRIPLET MODEL:

A Standard Model with an additional scalar triplet with hypercharge equal to 0 or 1. Following the convention $Q=Y+T_3$, triplets with Y=1 contain neutral, singly and doubly charged scalar fields. Multiplets higher than doublets contribute to the ρ parameter. The gauge group is not extended. The model is so-called *see-saw type II* model and it gives masses to the neutrinos without introducing the right handed components.

ADDITIONAL TRIPLET:

Model with a scalar triplet (Y=1). Additional neutral, singly and doubly charged scalar particles.

$$\Delta = \begin{pmatrix} \frac{\Delta^+}{\sqrt{2}} & \Delta^{++} \\ \Delta^0 & \frac{\Delta^+}{\sqrt{2}} \end{pmatrix}$$

THE ρ PARAMETER

The ρ parameter (v_Δ - triplet VEV) [1]. Current experimental limits [2]: $\rho^{exp} = 1.00037 \pm 0.00023$

$$\rho = \frac{1+2\frac{v_\Delta^2}{v_\phi^2}}{1+4\frac{v_\Delta^2}{v_\phi^2}}$$

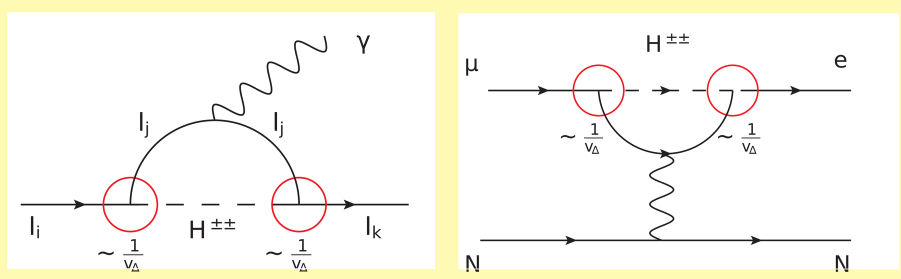
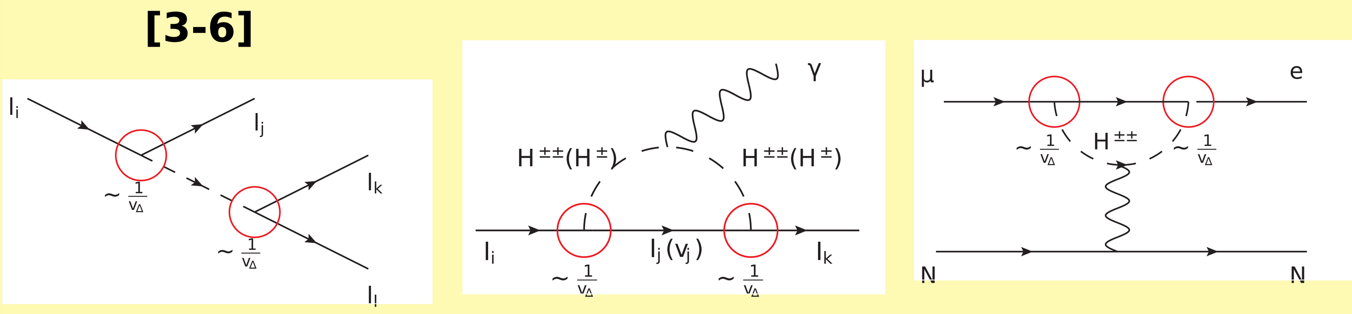
LFV EFFECTS

Contribution to $(g-2)_\mu$, neutrinoless double β decay, μ to e conversion (μ N → e N*), 3 body LFV decays ($l_i \to l_j l_k l_l$). Both singly and doubly charged scalars contribute to these processes.

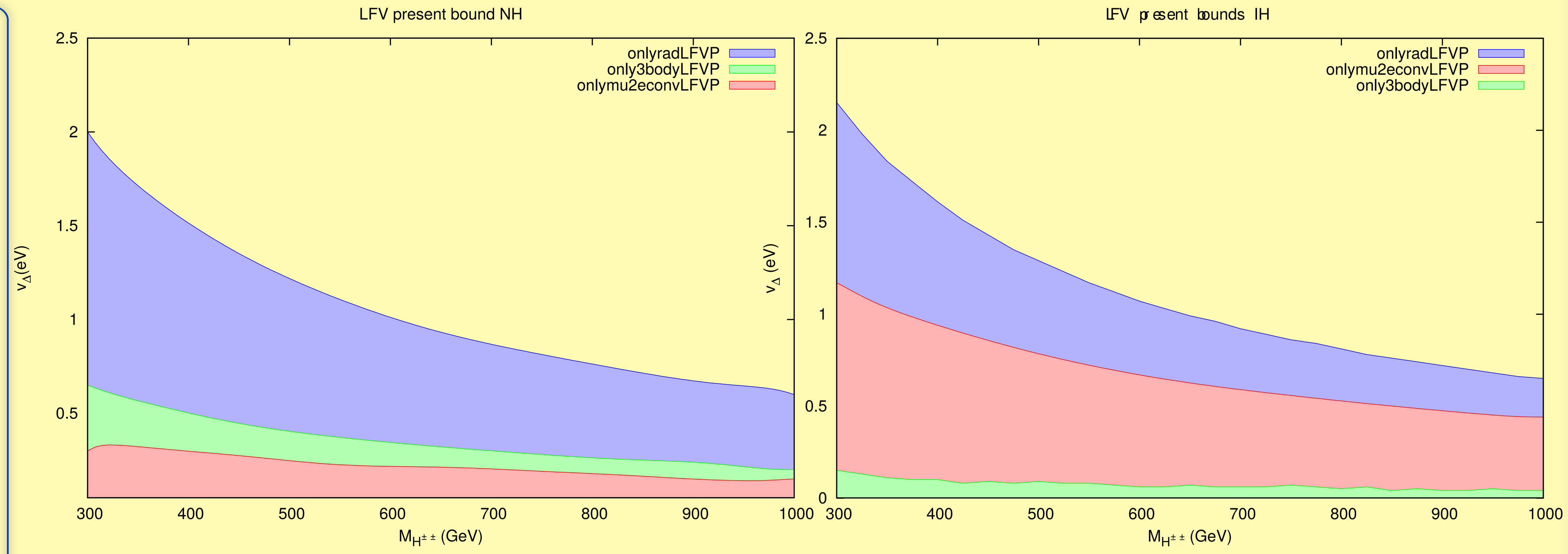
BOUNDS FROM LFV PROCESSES

Process:	Limits:
BR $(\mu \to e\gamma)$	5.7×10^{-13}
BR $(\tau \to e\gamma)$	3.3×10^{-8}
BR $(\tau \to \mu\gamma)$	4.4×10^{-8}
BR $(\tau \to 3\mu)$	2.1×10^{-8}
BR $(\tau \to e\mu\mu)$	2.7×10^{-8}
BR $(\mu N \to eN^*)$ (for Au)	7.0×10^{-13}

[3-6]

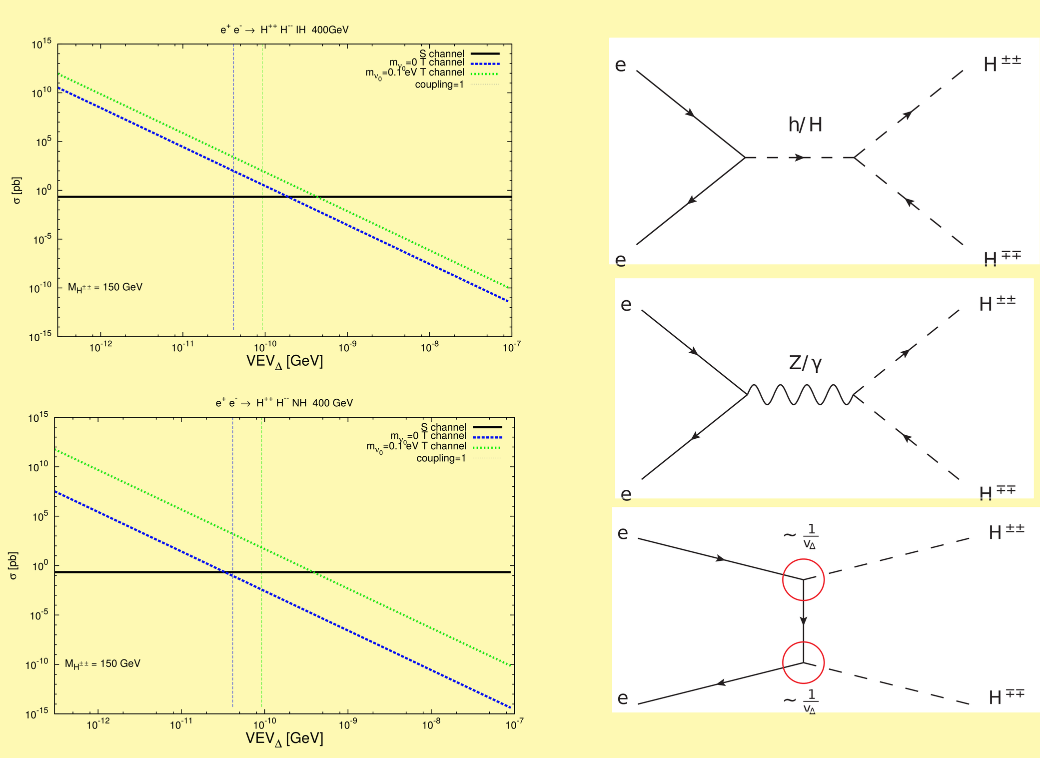



Experimental limits on LFV decays [3-6] and Feynman diagrams related to those processes. The $H^{\pm\pm}$-l_i-l_j vertex is inversely proportional to the triplet VEV.



Plots for v_Δ and $M_{H\pm\pm}$ dependence, using normal and inverted hierarchy. Shaded regions is excluded by limits from present LFV processes.

H±± IN e+e- COLLIDERS:

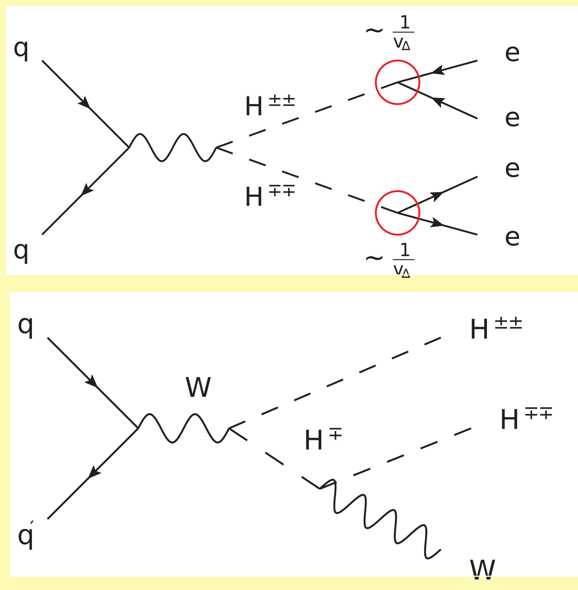


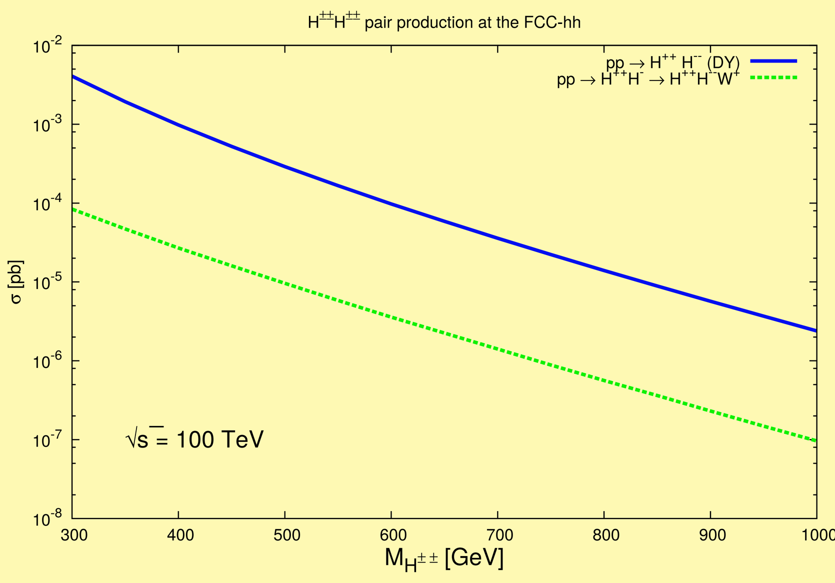
Doubly charged scalars pair production in e^+e^- collision. LEP has excluded doubly charged scalar's mass lower than 100 GeV [7], taking into account the S-channel. $H^{\pm\pm}$ also intermediate the Bhabha process in the T-channel.

H±± PAIR PRODUCTION IN HADRON COLLIDERS:

The most strict limits on the doubly charged scalars' masses given by LHC: 551 GeV (ATLAS [8]) and 382 GeV (CMS [9]). Those limits are calculated for Drell-Yan pair production, with subsequent decays into $e^+e^+e^-e^-$.
Other than the DY process which contributes to this 4 lepton signal is pair production through W boson [10]:

$$pp \to W^* \to H^{\pm\pm}H^{\mp} \quad , \quad H^{\mp} \to H^{\mp\mp}W^{+}$$

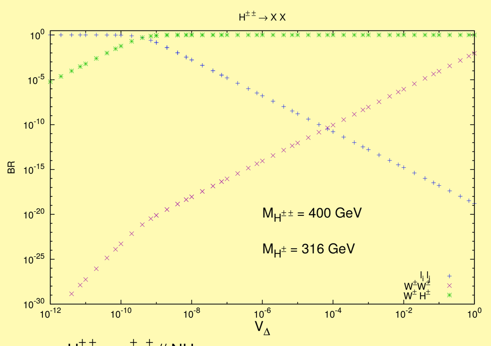


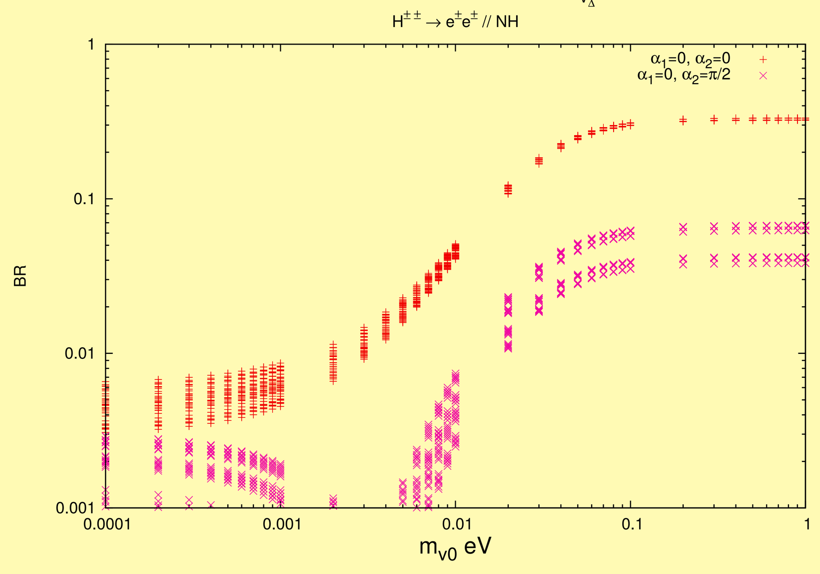


H±± DECAYS:

Lepton channel dominates for low v_Δ values. The $W^\pm H^\pm$ channel could be suppressed by changing $M_{H\pm}$.

$$H^{\pm\pm} \to W^\pm W^\pm$$
$$H^{\pm\pm} \to W^\pm H^\pm$$
$$H^{\pm\pm} \to l_i l_j$$





REFERENCES:

[1] T. G. Rizzo, Phys. Rev. D 21, 1404 (1980)

[2] M. Aoki, S. Kanemura, Phys. Rev. D 77, 095009 (2008)

[3] J. Adam et al. (MEG), Phys. Rev. Lett. 110, 201801 (2013), 1303.0754.

[4] B. Aubert et al. (BaBar), Phys. Rev. Lett. 104, 021802 (2010), 0908.2381.

[5] K. Hayasaka et al., Phys. Lett. B687, 139 (2010), 1001.3221.

[6] W. H. Bertl et al. (SINDRUM II), Eur. Phys. J. C47, 337 (2006).

[7] P.Achard et al. (L3 Collaboration), Phys.Lett.B576 (2008) 18-28

[8] G. Aad et al. [ATLAS Collaboration], JHEP 1503, 041 (2015)

[9] S. Chatrchyan et al. [CMS Collaboration], Eur.Phys.J.C 72, 2189 (2012)

[10] A.G. Akeroyd, H. Sugiyama, Phys. Rev. D 84, 035010 (2011)

OUTLOOK :

The poster presents the general information about doubly charged scalars' pair production in lepton and hadron colliders, their decay channels and low energy constraints in the context of HTM. We are planning to analyze these processes at one loop level and compare with other models with triplet extension.

This work was supported by the Polish National Science Center (NCN) under grant 2015/17/N/ST2/04067.