Light doubly charged Higgs search via WW* mode at the LHC

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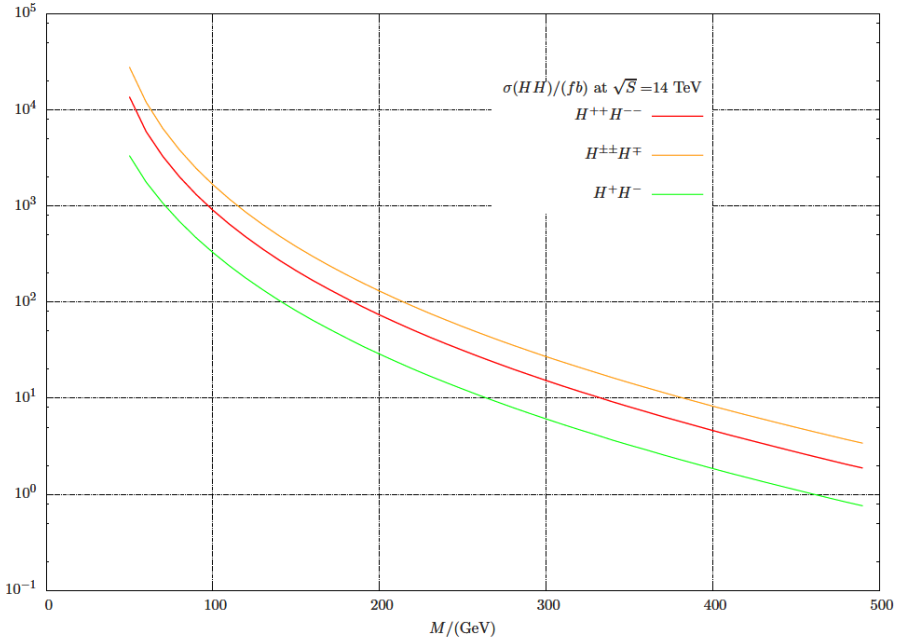
Outline of the paper

- Production and decay of H++
- Background studies for the same-sign di-lepton final state
- Event generation
- Signal region optimization
- Conclusions

Production of H^{++}

- pp-> gamma/Z -> H++H—
  - Cross sections can be increased by 20-30% if NLO QCD corrections are considered.
  - Two-photon fusion process contribution comparable to NLO QCD contributions.
- pp->W*+->H++H-
  - Mass degeneracy is assumed.



Decays

- l+l+ mode
  - Neglegible due to small yukawa terms
- WW* mode
  - Major contribution
- WH mode
  - Depends on the mass splitting between H+ and H++
  - Mass splitting study on the next slide

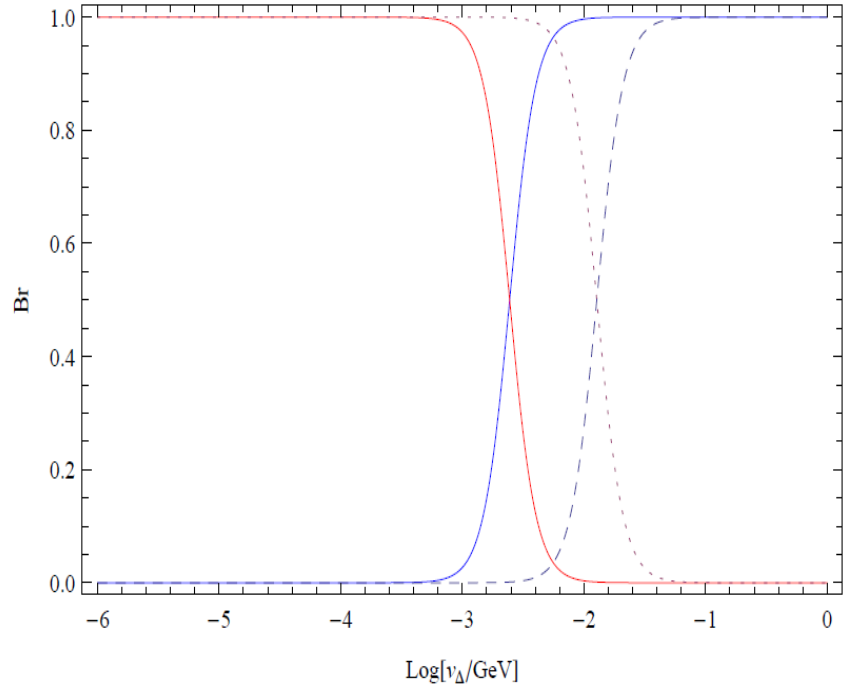


FIG. 2: The branching ratios of the doubly charged Higgs boson decay versus v_Δ for $M_{H^{\pm\pm}} = 100\text{GeV}$ (dash line) and $M_{H^{\pm\pm}} = 150\text{GeV}$ (solid line). The red and blue lines are for the LNV decays and WW^* mode, respectively.

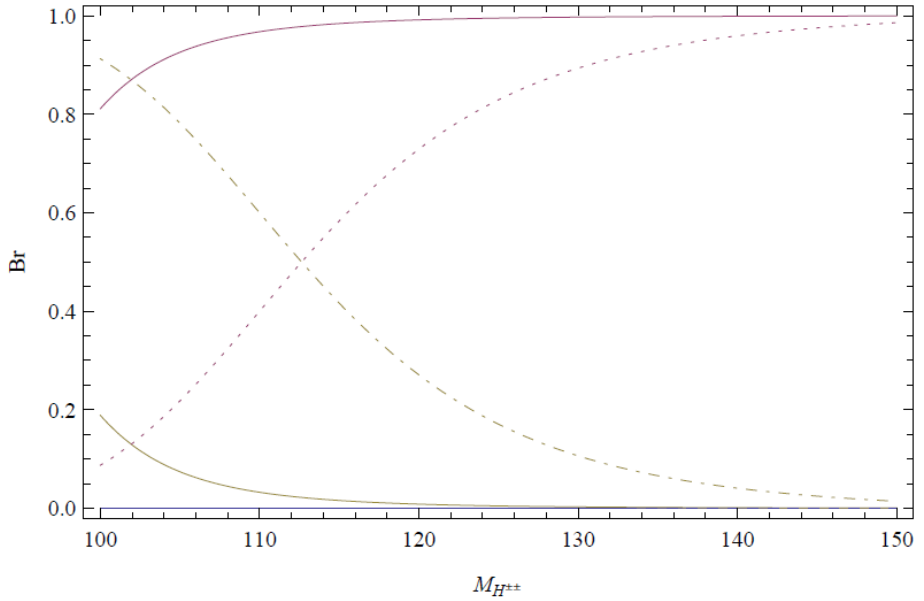


FIG. 3: The branching ratios of the doubly charged Higgs boson decay versus $M_{H^{\pm\pm}}$ for $\Delta M =$ 2GeV (solid line) and $\Delta M = 5$GeV (dash line) with $v_\Delta = 1$GeV. The yellow, red, and blue lines are for the cascade decays, di-W mode, and LNV decays, respectively.

- Even a splitting of 5 GeV can help cascade decays overcome WW mode.
  - This needs to be checked for our masses and different splittings.
  - This plot considers mH++ > mH+ i.e. $\lambda_5 < 0$

Background studies

	$t\bar{t}$	$W_l^+ Z_l$	$W_l^- Z_l$	$Z_l Z_l$	$t\bar{t}W_l^+$	$t\bar{t}W_l^-$	$t\bar{t}Z_l$	$W_l^+ W_l^+ jj$	$W_l^- W_l^- jj$
Events Number	8433380	4278.0	2629.7	729.9	1080.9	558	733	162.1	70.7
2SSL	1978.6	499.7	314.1	56.5	88.4	52.4	35.7	56.1	26.1
$N_j > 0$, N_b=0	698.4	380.3	245.4	47.9	14.7	8.0	5.8	53.5	24.7
$E_T^{miss} > 20$	639.1	336.3	214.0	17.2	14.0	7.7	5.3	50.7	22.7
$H_T > 100$ GeV	621.7	244.0	155.6	10.5	13.9	7.6	5.3	49.5	22.1
m_{ll} <75 GeV	367.3	102.2	58.6	5.5	4.5	2.3	1.7	14.2	5.1
$\Delta R(l,l) < 1.5$	137.2	49.3	29.2	2.9	2.2	1.4	1.1	6.2	2.7
$\Delta\phi(ll, p_T^{miss}) < 1.5$	74.9	16.6	8.9	0.7	1.0	0.4	0.4	2.3	0.8
$N_j > 2$, $m_{jjj} < 150$ GeV	6.9	0.6	0.5	0.03	0.06	0.03	0	0.05	0.02

TABLE II: The cuts flow for backgrounds. The number has normalised to 10 fb^{-1}. W_l and Z_l represent the leptonic decays of the gauge bosons.

Signal significance

	100	110	120	130	140	150
Ratio required to be excluded	4.5	4.0	4.2	4.3	4.5	4.3
Events Number	2608	1864	1365	1024	786	612
2SSL	126.3	123.3	102.9	84.5	70.2	57.8
$N_j > 0$, N_b=0	114.0	112.9	94.7	78.1	64.6	53.1
$E_T^{miss} > 20$	104.1	103.7	87.5	72.4	60.8	50.4
$H_T > 100$ GeV	95.5	95.0	82.5	69.5	59.2	49.4
m_{ll} <75 GeV	95.5	95.0	81.5	65.8	53.2	41.6
$\Delta R(l,l) < 1.5$	76.4	72.2	59.5	46.5	37.7	30.0
$\Delta\phi(ll, p_T^{miss}) < 1.5$	61.3	56.8	46.5	36.6	29.7	23.4
$N_j > 2$, $m_{jjj} < 150$	11.2	16.3	14.4	13.6	11.3	8.8
σ	3.89	5.64	4.98	4.70	3.91	3.04

TABLE III: Cut flow for signal benchmark points. The events number has been normalised to 10 fb^{-1}. The first row shows the ratios needed for the production rate so that the benchmark points can be excluded by the CMS search [39]. In the last row, we show the corresponding signal significances for those benchmark points in our search.

Conclusion

- Their work is still not entirely overlapping with ours.
- Still makes sense to go on with analysis kind of the study for higher masses.
  - Effect of mass splitting on H++ decay mode should be studied carefully!
- Ongoing:
  - Experimental work: Fake estimation of Z+jets
  - Phenomenology: Contamination of Associated production into the pair-production signal region.
  - Focus right now on the experimental work.