Karlsruher Institut für Technologie

Resonant di-Higgs production in the context of extended scalar sectors

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Based on results from: 2112.12515

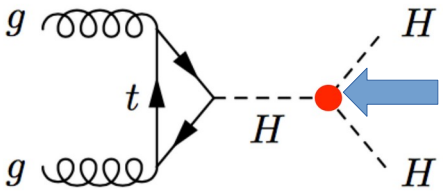
Defined tasks from pre-meeting with conveeners

- **Interest to extend resonant searches to include interference effects [motivated from several BSM models]**
- **Understanding interferences in a model independent way → dependence with trilinear, yukawas, masses, widths...**

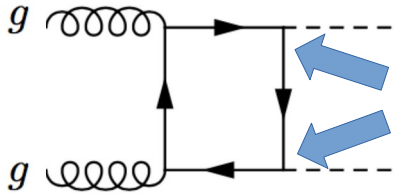
1) Get the allowed maximum resonant production cross-sections pp → H → h_SM h_SM at several mass values of the resonance, and ranges of pertinent parameters around these maxima. [covered in this presentation]
2) What is the differential distributions dependence on these parameters.
3) Implement models for MC generators to simulate these signals.

SM Di-Higgs production

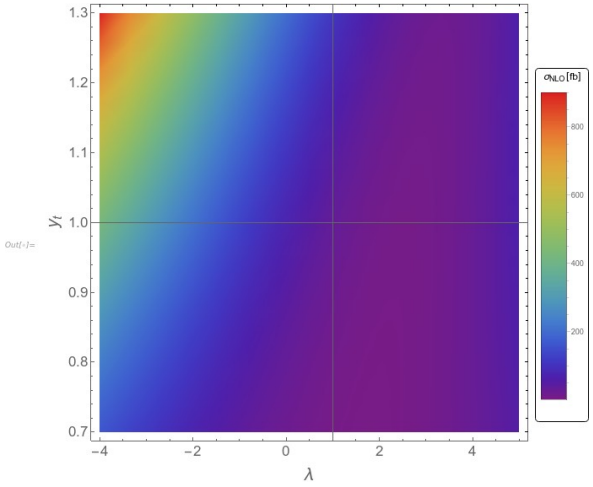
At LO



Trilinear
λ_{HHH}



Top Yukawa
y_t



$$\sigma_{hh}^{LO}[\text{fb}] = 5.22\lambda^2 y_t^2 - 25.1\lambda y_t^3 + 37.3 y_t^4 + \breve{\mathcal{O}}(y_b y_t^2) \approx 17.42 fb$$
$$\sigma_{hh}^{NLO}[\text{fb}] = 9.66\lambda^2 y_t^2 - 49.9\lambda y_t^3 + 70.1 y_t^4 + \mathcal{O}(y_b y_t^2) \approx 29.86 fb$$

(Internal note, NLO heavy top mass limit)

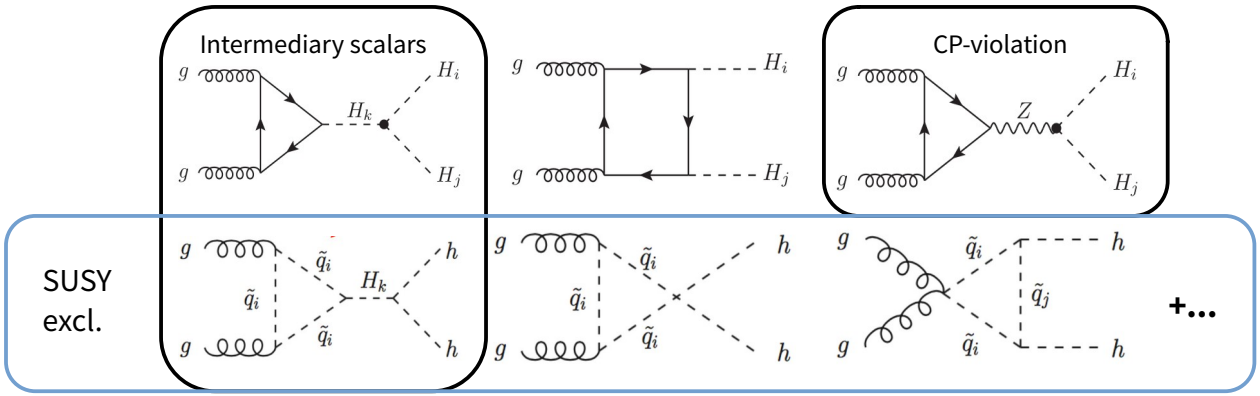
√s	7 TeV	8 TeV	13 TeV	14 TeV	27 TeV	100 TeV
$\sigma_{NNLO\ FTapprox}$ [fb]	6.572	9.441	31.05	36.69	139.9	1224

LHCXSWG

FT_{approx} : full NNLO QCD in the heavy-top-limit with full LO and NLO mass effects and full mass dependence in the one-loop double real corrections at NNLO

BSM Di-Higgs production

- Deviations from the SM trilinear coupling and top Yukawa.
- New particles:



- **Several new Yukawa coup., masses, widths, trilinear couplings. R2HDM: 6 parameters [SM tril./yuk + BSM tril/yuk/mass/width]**
- **In CP-violating scenarios, last diagram is expected to be small.**

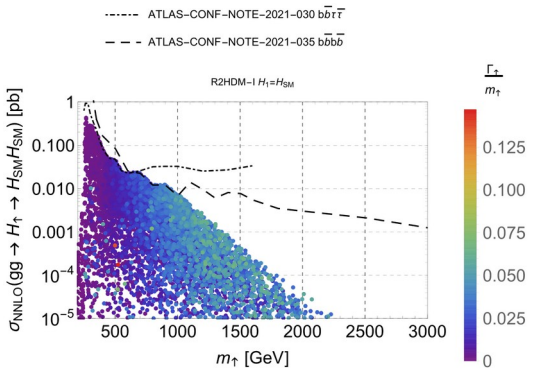
Allowed resonant production in prototypical models

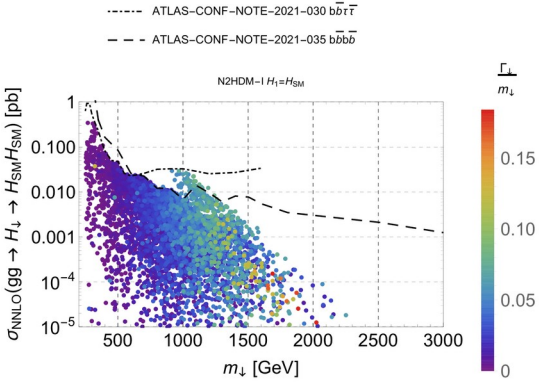
R2HDM

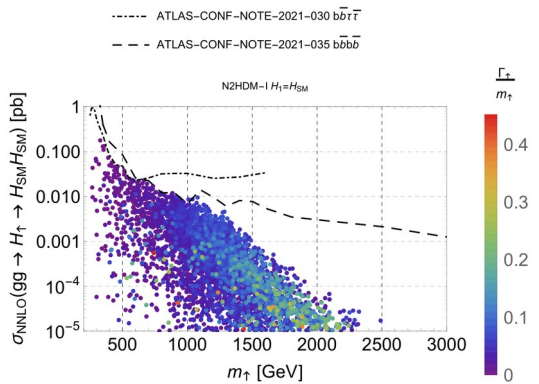
N2HDM

N2HDM

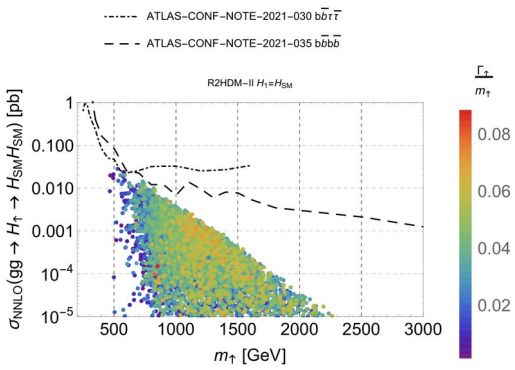
Type - I

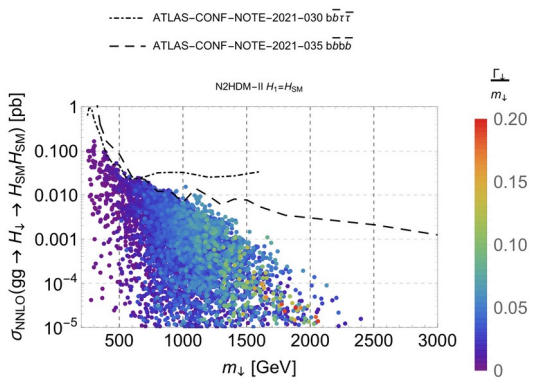




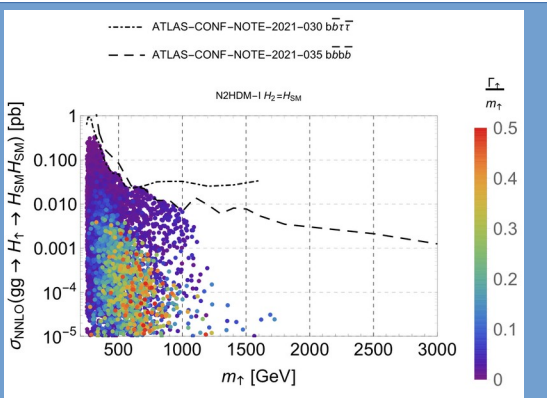


Type - II

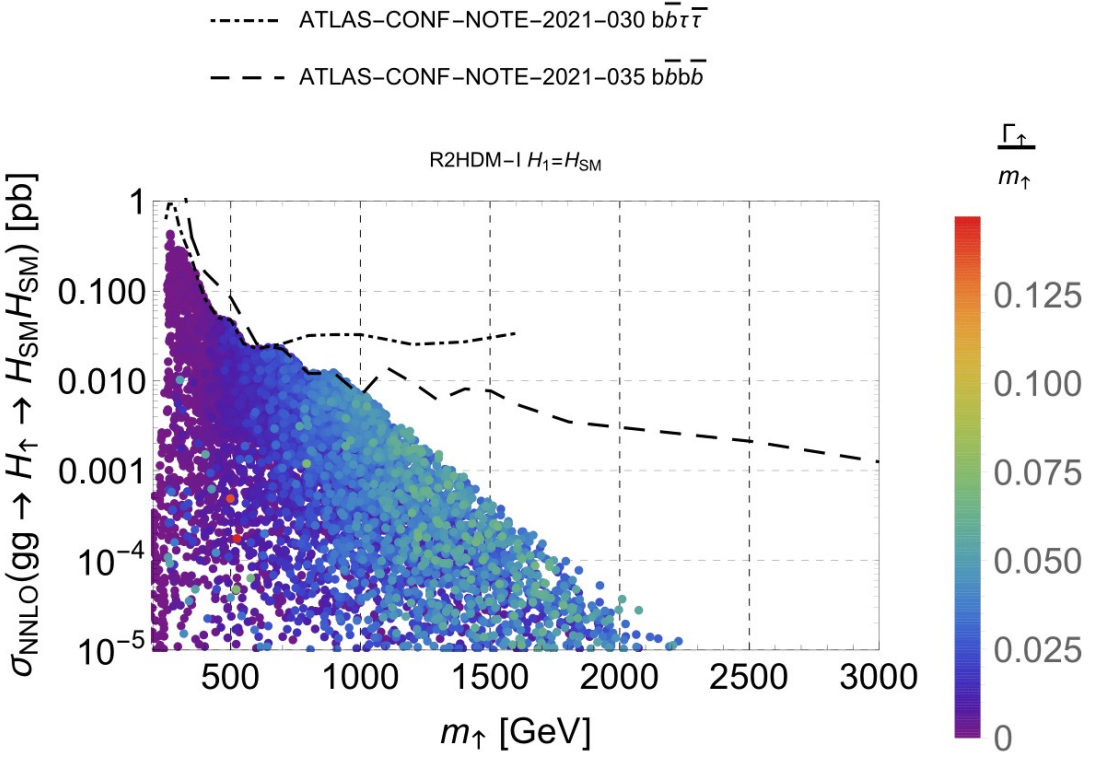




N2HDM-I H2 is SM-like



Allowed resonant production in prototypical models



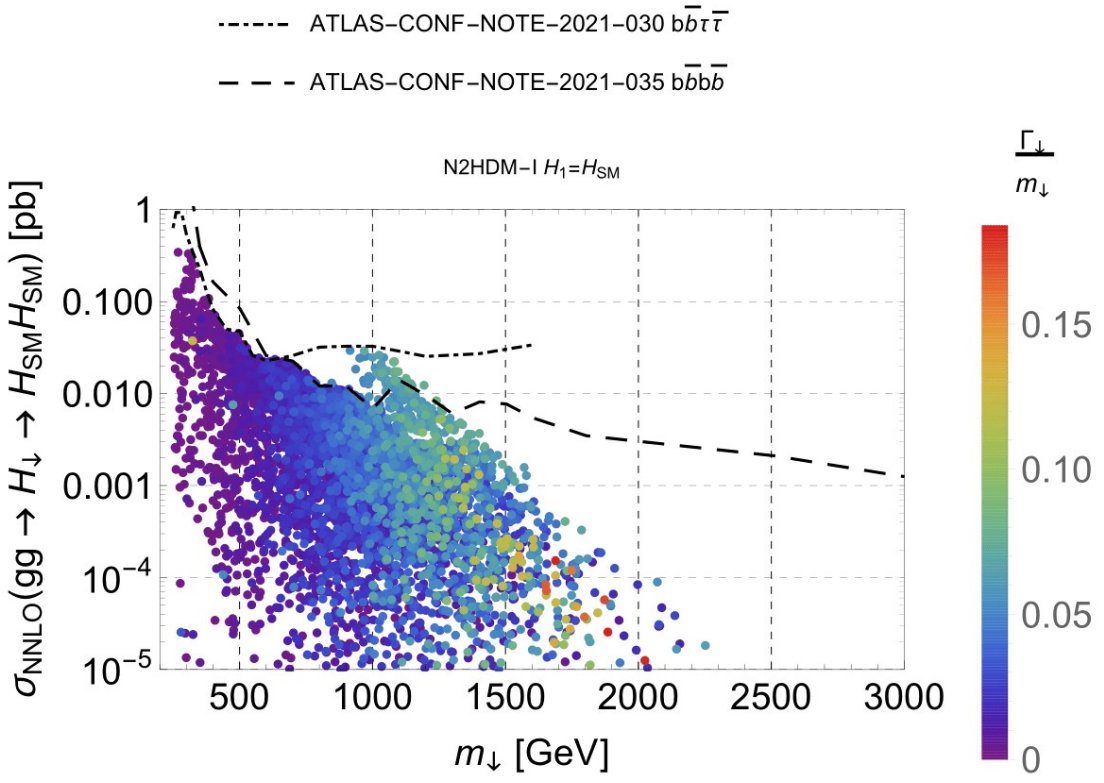
First task – preliminary results

- Look at res. masses of: 260, 500, 1000, 1500, 2000, 2500, 3000 GeV → Draw +/- 5 GeV window around.
- Look at maximum res. cross section → Draw -10% window [not possible due to sample size] → Draw – O(10^-1) window.

R2HDM-I:

Mass [GeV]	260	500	1000	1500	2000	2500
Res. XS [pb]	0.31	0.04	0.006	0.0004	0.00003	0.000004
k_lam	[0.8-1]	[0.7-1]	[0.6-1]	[0.7-1]	[0.9-0.9]	[0.9-1]
Lam_112 [GeV]	[-67;86]	[-73;215]	[-547;502]	[-702;524]	[683;684]	[-762;502]
Y_H2tt	[-0.3;-0.1]	[-0.7;-0.1]	[-1;-0.1]	[-1;-0.5]	[-1.1;-1.1]	[-1;-0.8]
w_H2/m_H2 [%]	[<1;<1]	[<1;1.4]	[<1;4]	[<1;5]	[5;5]	[2;4]

Allowed resonant production in prototypical models



First task – preliminary results

N2HDM-I (H2 as res. of interest):

Mass [GeV]	260	500	1000	1500	2000	2500
Res. XS [pb]	0.13	0.05	0.03	0.001	0.00008	0.000003
k_lam	[0.7;1]	[0.7;1]	[-0.6;1]	[0.3;0.9]	[0.5;0.5]	[0.9-1]
Lam_112 [GeV]	[-114;63]	[-432;89]	[-1390;1658]	[-1608;2538]	[1574;1574]	[-1938;1938]
Lam_113 [GeV]	[-336;285]	[-1165;4110]	[-1165;4110]	[-1831;4879]	[-3560;3560]	[2917;2917]
Y_H2tt	[-0.2;0.2]	[-0.1;0.7]	[0.2;0.9]	[0.3;1.1]	[0.5;0.5]	[0.2;0.2]
w_H2/m_H2 [%]	[<1;<1]	[<1;1.9]	[1;6]	[1;12]	[2;12]	[1;1]
m_H3 [GeV]	[578;2320]	[564;2462]	[1030;1912]	[1505;2900]	[2240;2240]	[2966;2966]

Conclusions

- First task will allow for easy comparable ranges of pertinent parameters for resonant production between BSM models
- Dedicated scans are needed to focus on specific parameter space regions
- In combination with the results from the other tasks → pertinent searches that can cover most scenarios/models.