University of Glasgow

Christoph Englert

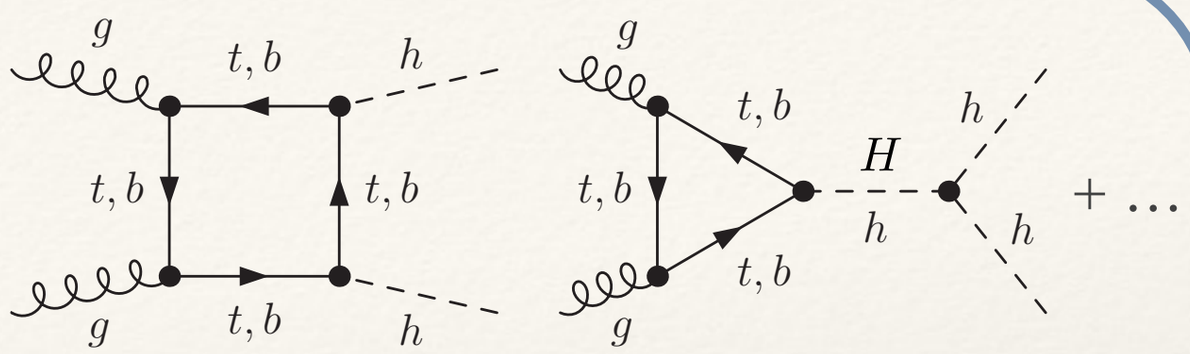
HH in weakly interacting models

Mainz, 28.03.2015

"HH in weakly interacting models" in this talk

- (non-)minimal Supersymmetry
- generic 2HDMs
- (non-)minimal Higgs portals
- (non-)custodial Higgs triplets and higher gauge representations

Theory



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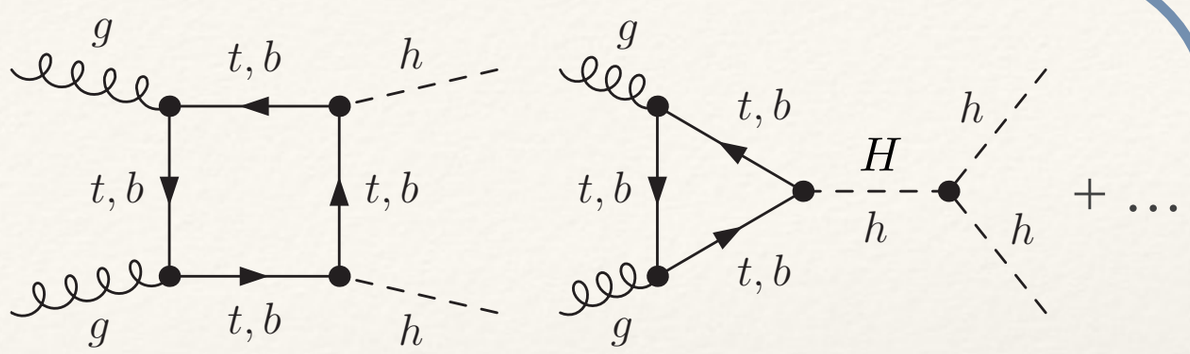

- exotic loop thresholds
- HH resonances
- modifications of SM-like couplings

Pheno

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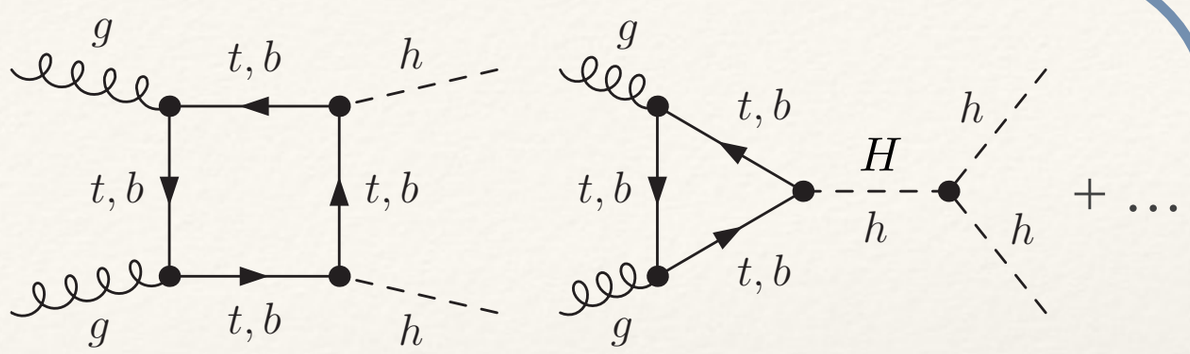

Pheno

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Analyses

- new technology?
- analysis strategies?
- information content?

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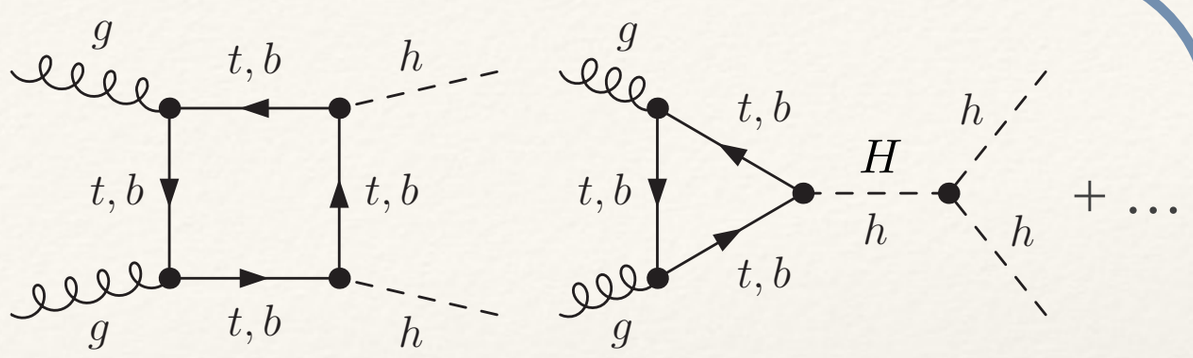

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[King, Mühlleitner, Nevzorv, Walz `14]

NMSSM

☛ complicated models = plethora of phenomenological signatures

B.3 (Point ID 210)	Scenario		
M_h, M_{H_s}, M_H	124.1 GeV	184.3 GeV	463.1 GeV
M_{A_s}, M_A	133.4 GeV	457.2 GeV	

B.3 (Point ID 210)	Signal Rates
$\sigma(ggH_s)$	390.38 fb
$\sigma(ggH_s)\mathrm{BR}(H_s \to b\bar{b})$	160.37 fb
$\sigma(ggH_s)\mathrm{BR}(H_s \to \tau\tau)$	18.46 fb
$\sigma(ggH_s)\mathrm{BR}(H_s \to WW)$	176.63 fb
$\sigma(ggH_s)\mathrm{BR}(H_s \to ZZ)$	29.00 fb
$\sigma(ggH)$	1.326 pb
$\sigma(ggH)\mathrm{BR}(H \to t\bar{t})$	684.96 fb
$\sigma(ggH)\mathrm{BR}(H \to hH_s)$	184.85 fb
$\sigma(ggH)\mathrm{BR}(H \to hH_s \to bb + bb)$	50.46 fb
$\sigma(ggH)\mathrm{BR}(H \to hH_s \to bb + \tau\tau)$	11.08 fb
$\sigma(ggH)\mathrm{BR}(H \to hH_s \to \tau\tau + \tau\tau)$	0.61 fb
$\sigma(ggH)\mathrm{BR}(H \to hH_s \to bb + \gamma\gamma)$	0.24 fb

D.1 (Point ID 5416)	Scenario		
M_{H_s}, M_h, M_H	9.6 GeV	124.2 GeV	793.4 GeV

D.1 (Point ID 5416)	Signal Rates
$\sigma(ggh)$	44.28 pb
$\sigma(ggh)\mathrm{BR}(h \to H_sH_s)$	4.22 pb
$\sigma(ggh)\mathrm{BR}(h \to H_sH_s \to \tau\tau + \tau\tau)$	3.58 pb
$\sigma(ggh)\mathrm{BR}(h \to H_sH_s \to \tau\tau + \mu\mu)$	31.64 fb
$\sigma(ggH_s)$	439.80 pb
$\sigma(ggH_s)\mathrm{BR}(H_s \to \mu\mu)$	1.79 pb
$\sigma(ggH_s)\mathrm{BR}(H_s \to \tau\tau)$	405.09 pb
$\sigma(ggH_s)\mathrm{BR}(H_s \to c\bar{c})$	5.17 pb
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[King, Mühlleitner, Nevzorv, Walz `14]

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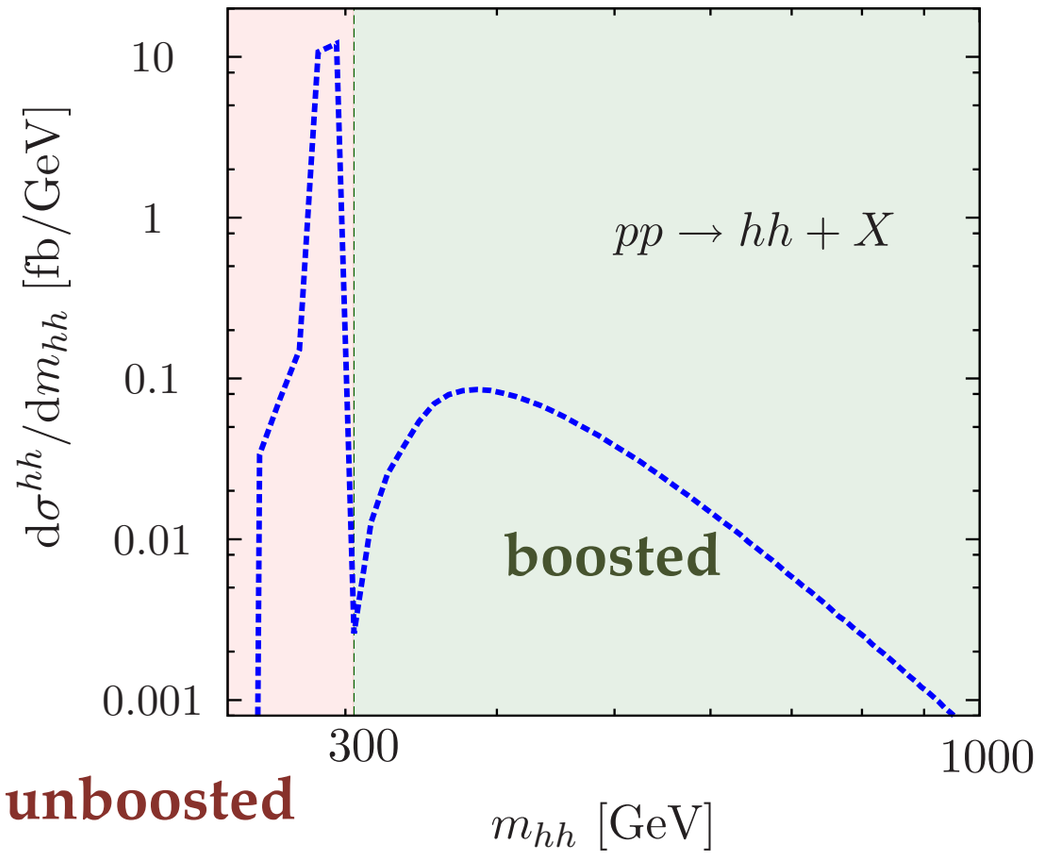
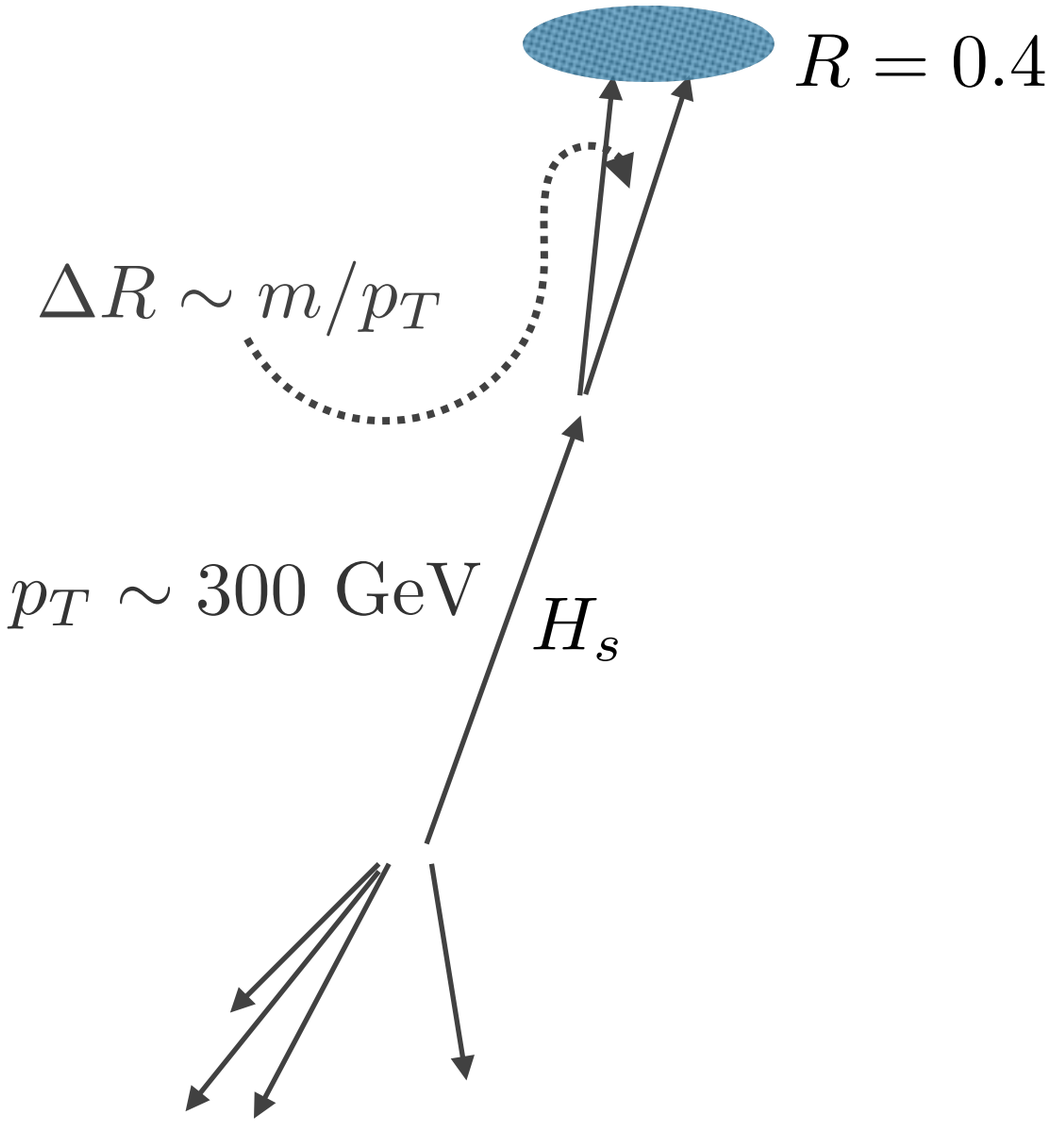
typical Higgs pair spectrum with resonances
(mini-split SUSY, portals, …)



[Dolan, CE, Spannowsky `12]

- correlation of on- and off-shell regions can provide complementary yet highly non-linear information to constrain model parameters
- experimental strategies differ (unboosted kinematics require rare decays)

ditaus decay leptonically 12.25%,
ditaus decay semi-leptonically 45.5%,
ditaus decay hadronically 42.25%.



exotics reconstruction, e.g. ditau jets, double b jets, ... **jet substructure**

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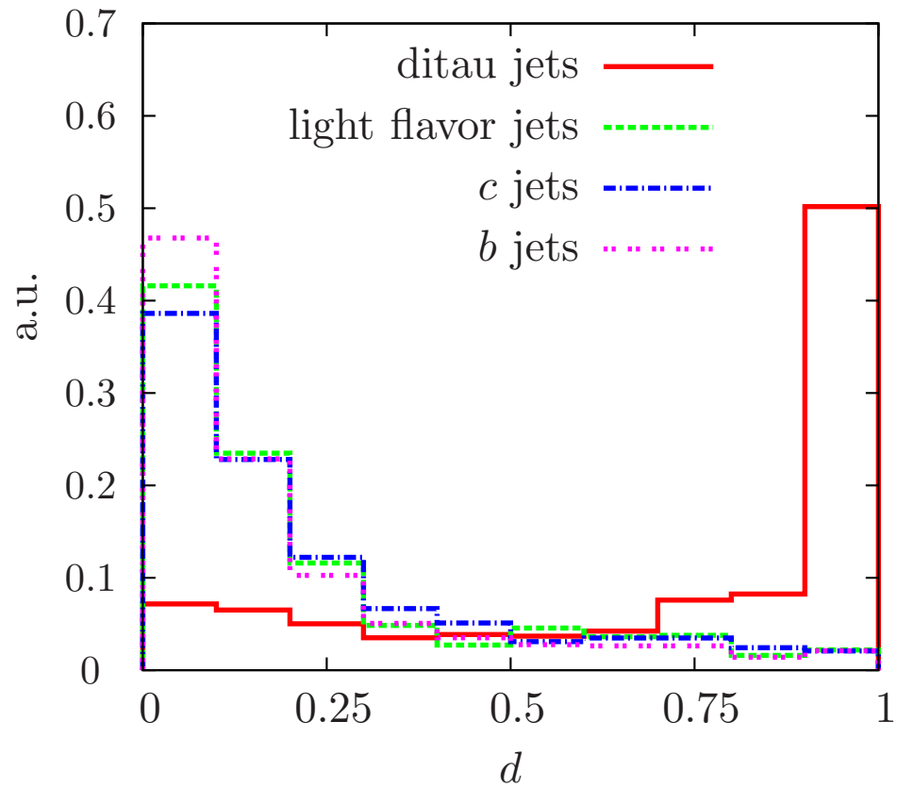
☛ hidden low lying states: exotic phenomenology!

[King, Mühlleitner, Nevzorv, Walz `14]

NMSSM



high discrimination taggers triggered by jet substructure development:

- pile-up & underlying event at LHC 13?
- general feasibility for model-dependent cross sections after fits?

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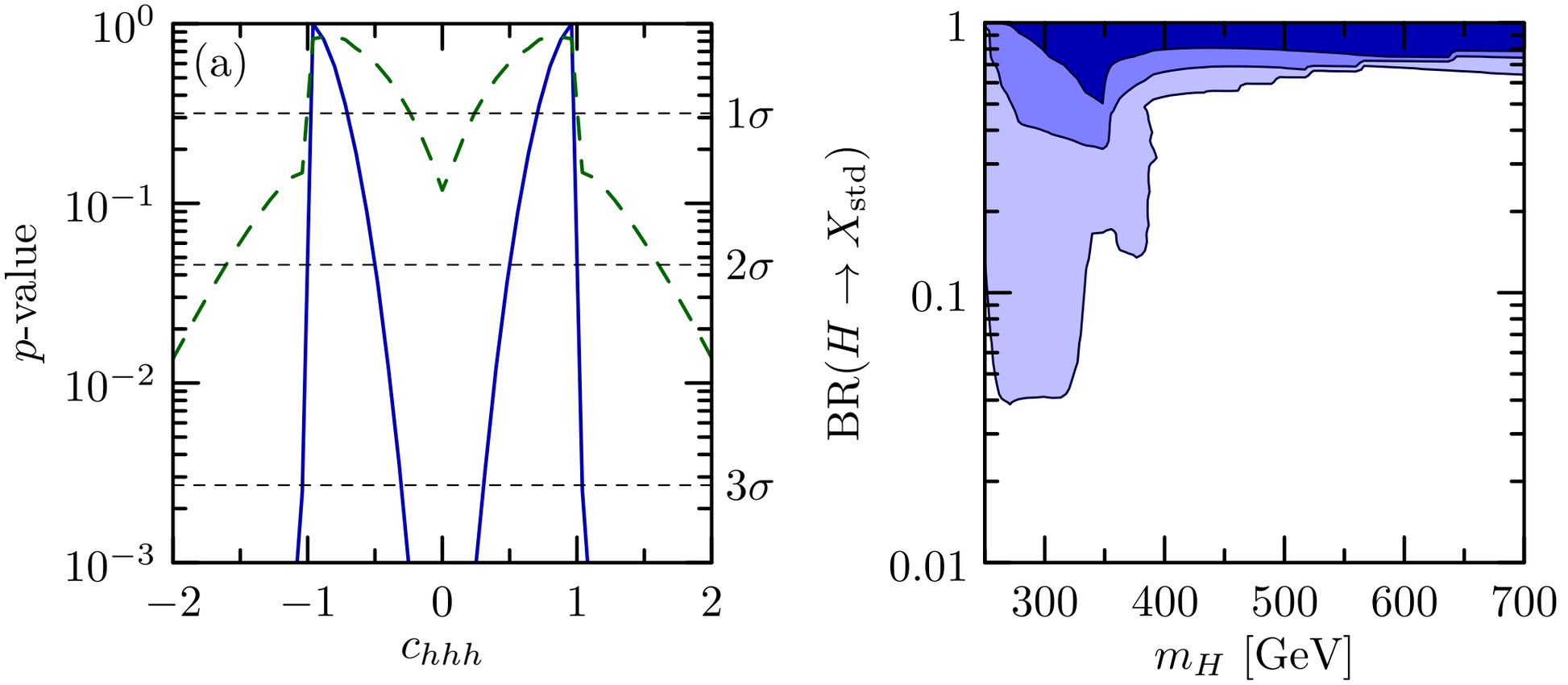
towards reconstructing model parameters

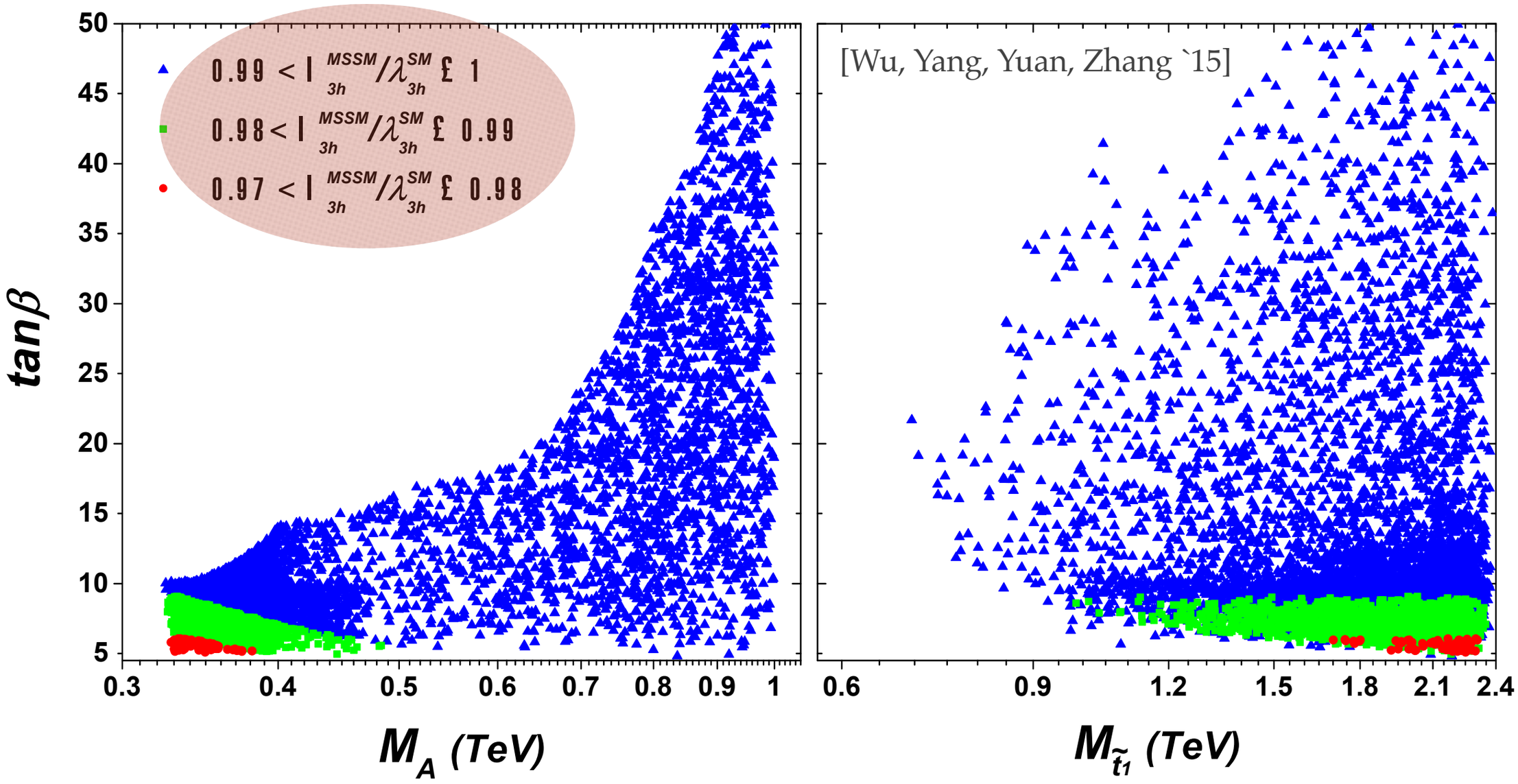
- hhh coupling expectation constrained by single Higgs measurements in concrete models (e.g. 2HDMs)

[Baglio, Eberhardt, Nierste, Wiebusch `14]



- single heavy Higgs phenomenology important (tuning in the MSSM?)

☛ situation similar in the MSSM



☛ What is the statistical pull of dihiggs final states?

reconstructing model parameters?

- concrete expectations for a concrete (most) simple scenario,
  i.e. singlet-extended Higgs sector?

$$\cos^2\chi = 0.9\,, \quad M_{1m}/M_{0m} = 2.5\,, \quad v_1/v_0 = 2$$

$$t^m_{000} = \tfrac{1}{2}\, M^2_{0m}\, \left(c^3_\chi/v_0 + s^3_\chi/v_1\right)$$

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single Higgs pheno

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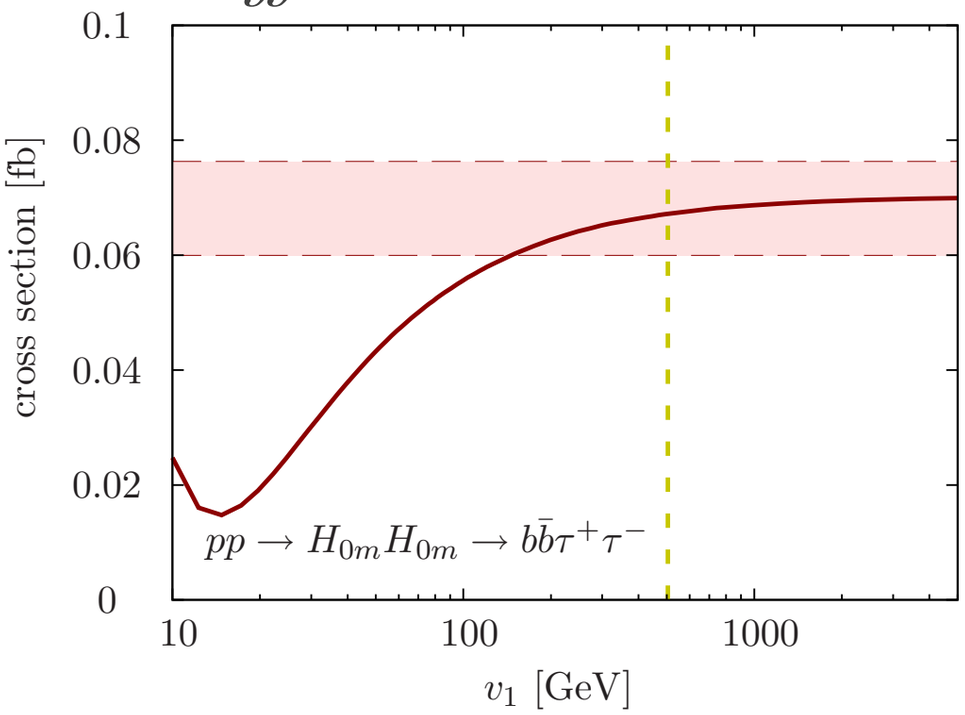
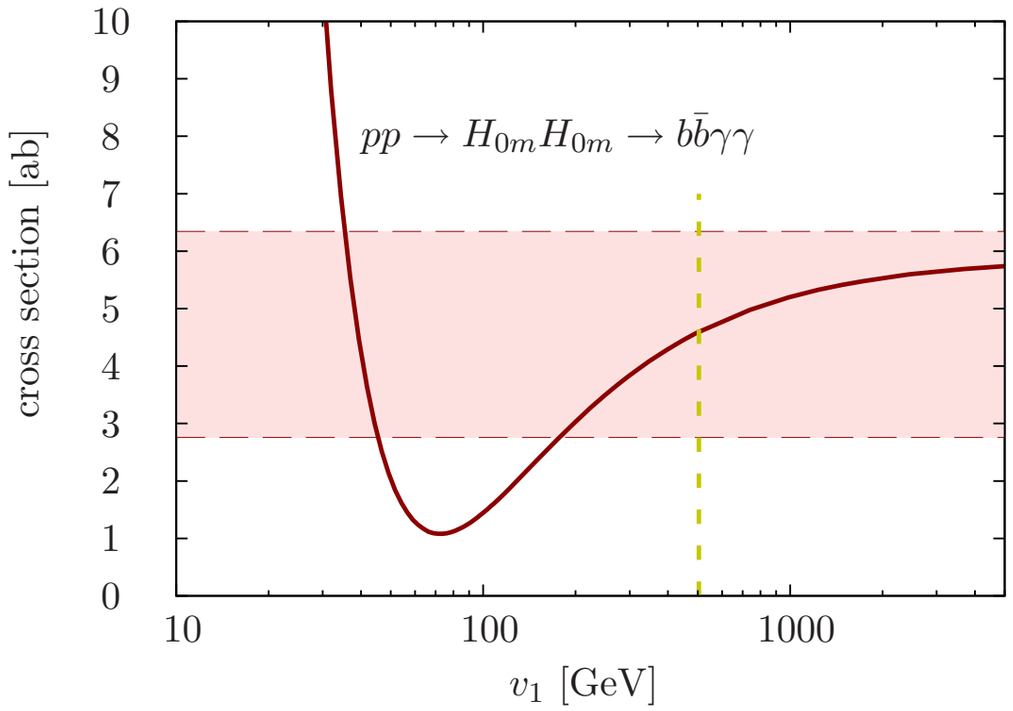
single Higgs pheno

LHC @ 3/ab

off-shell and boosted



inclusive and on-shell



[Choi, CE, Zerwas `13]

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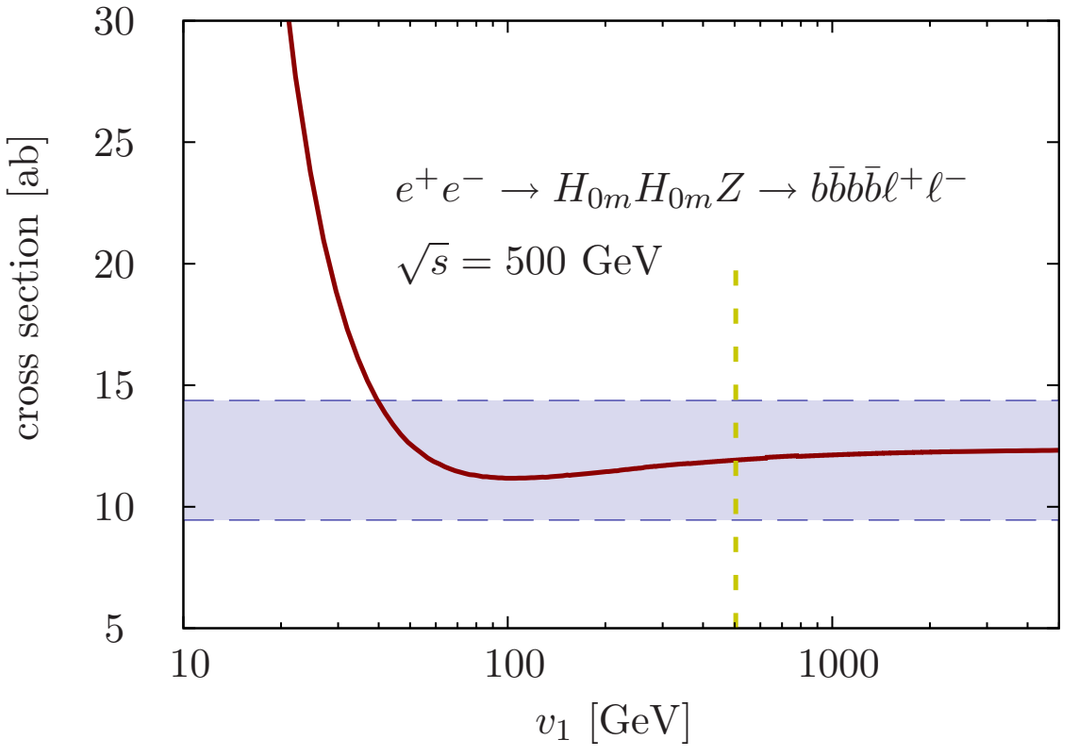
single Higgs pheno

ILC ?

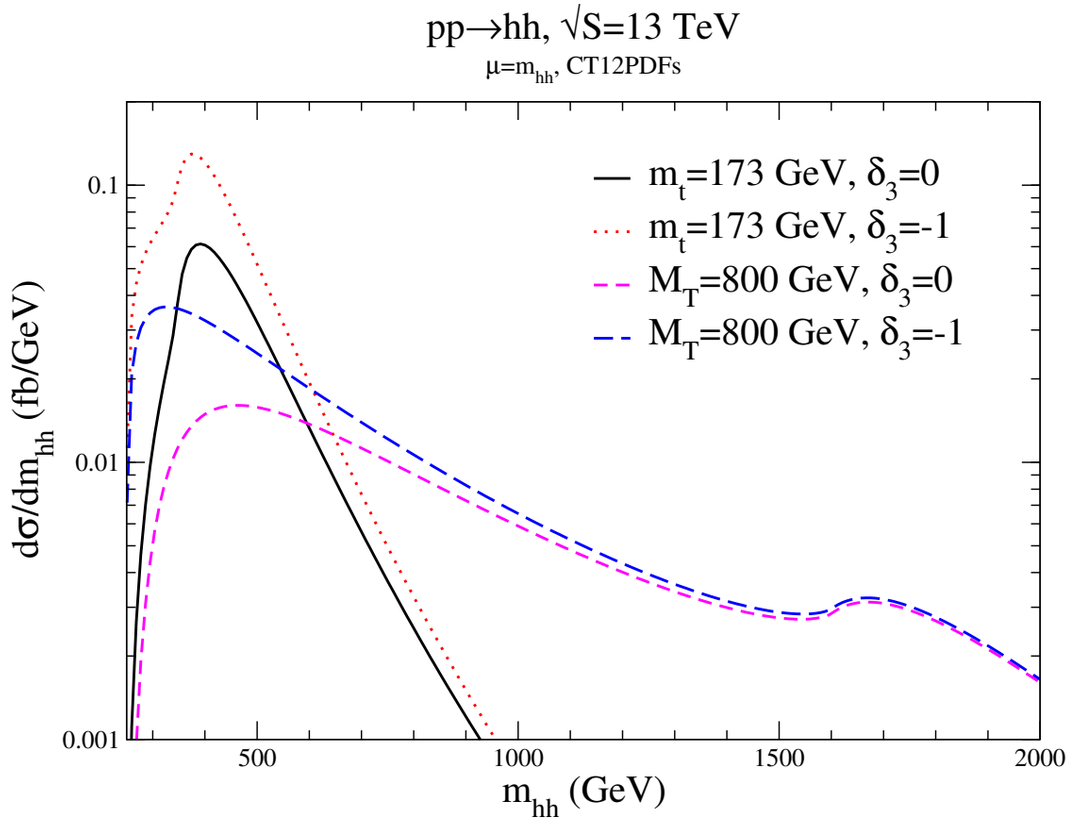


[Choi, CE, Zerwas `13]

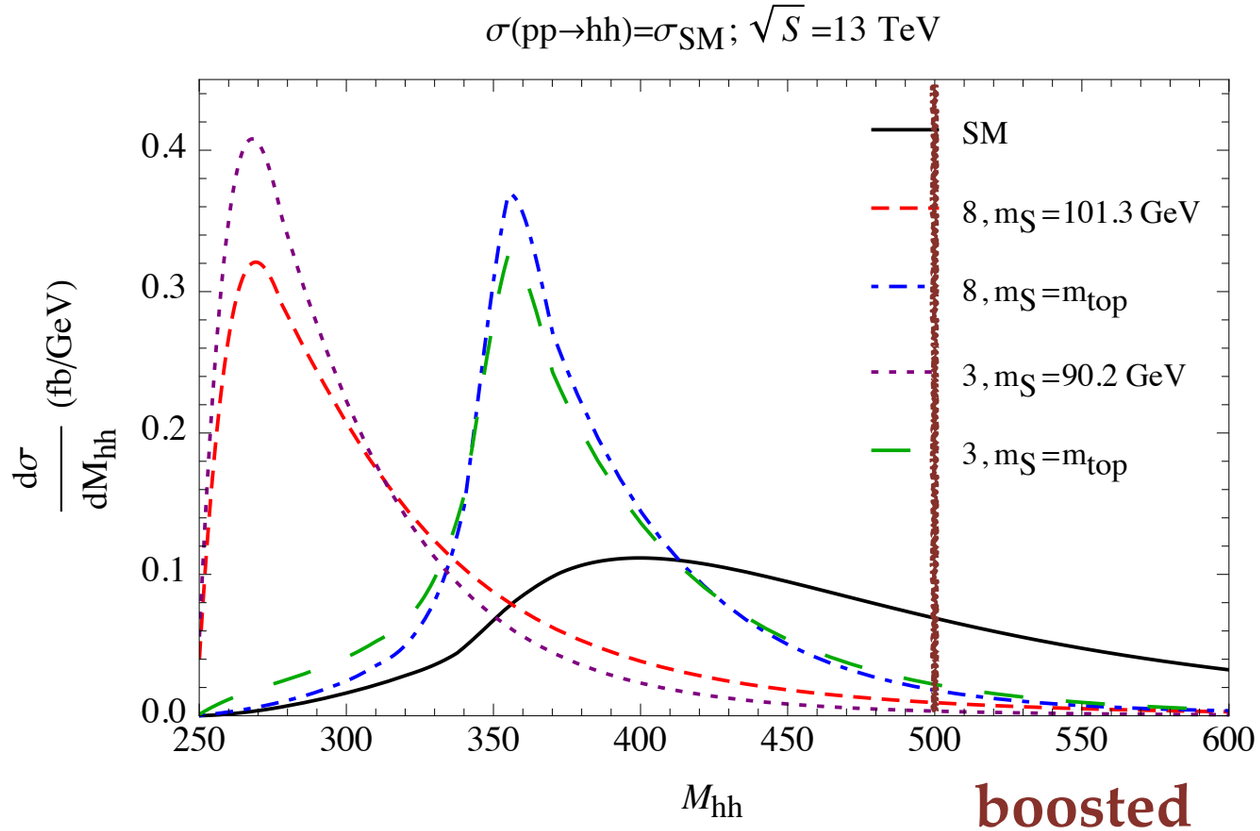
thresholds

☛ comprehensive analysis by Sally et al. few days ago [Dawson, Ismail, Low `15]

fermions



scalars

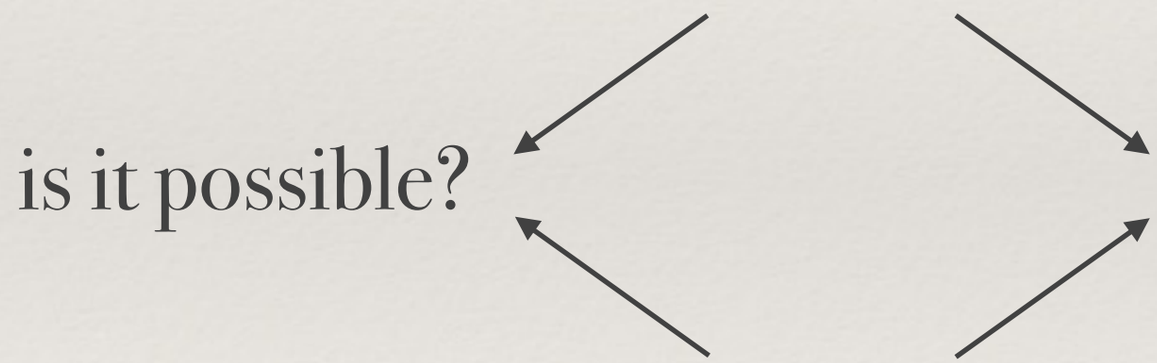


boosted

☛ differential distributions relevant. Can this be accessed?

Summary & Conclusions (if any)

- very hard to make generic statements at this stage: lots of models with exotics still viable, however hh does not exist in a vacuum
- lots of benchmarking underway
- need to validate strategies in different kinematic regimes and channels
- the role of hh for heavy Higgs searches (*will be model-dependent)*



first analyses available

➡ can be **the relevant discovery channel** (tuning?)

➡ complementary information, esp. through correlations

not yet attempted