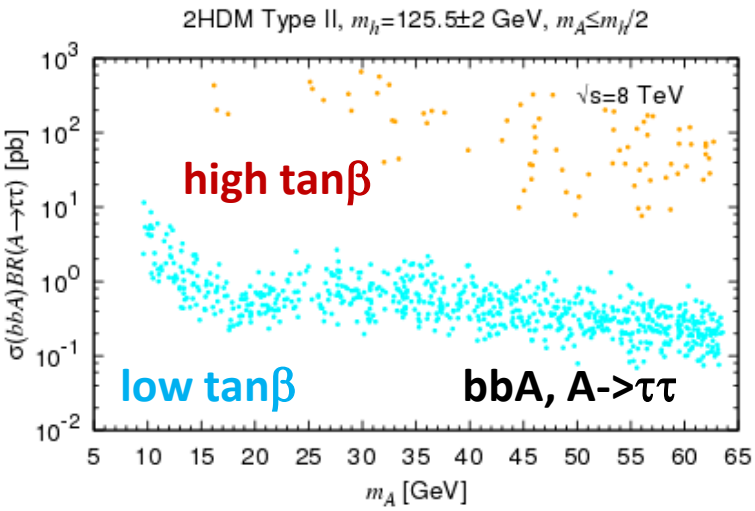
LE2015SummarySasha

2HDM: low mass pseudoscalar produced in association with bb_bar and decaying to μμ/ττ

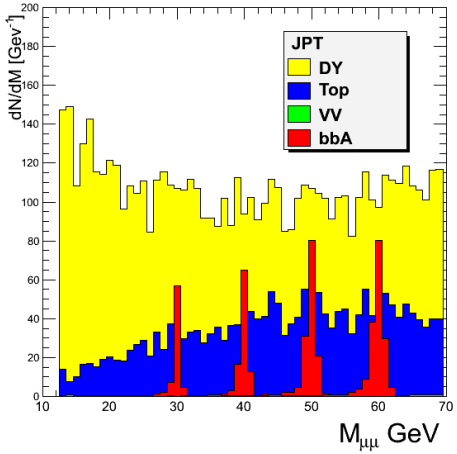
- **Responsible:** Alexandre Nikitenko
- **Members:** Eduard Boos, M. Spira, Jose Miguel No, Ken Mimasu, Jérémy Bernon, Daniele Barducci, Andreas Goudelis

bbA, A->μμ/ττ, mA=[20-60] GeV

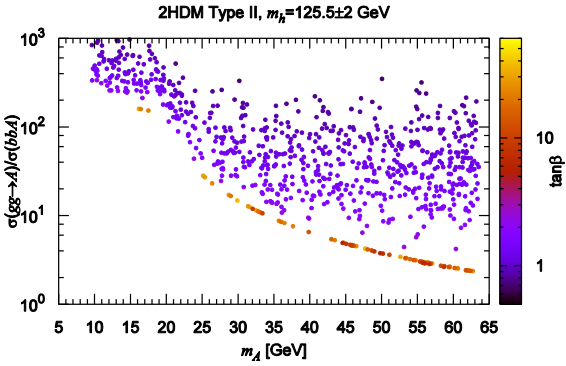
- **bbA, A->ττ/μμ cross-section in 2HDM Type II can be very large already at 8 TeV for light m_A in wrong sign Yukawa coupling scenario**
  - **J. Gunion, et al; arXiv:1412.3385**



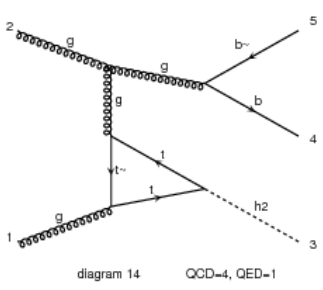
μμ +b analysis 8 TeV, assuming 100 pb for ττ mode

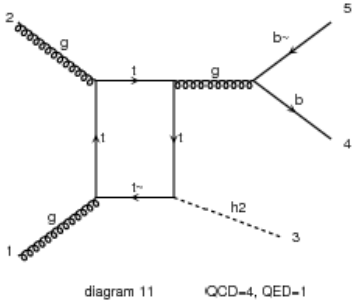


σ(gg->A)/σ(bbA)



Question addressed in Les Houches: how large is gg->A contamination in b-tag events





gg->A+gluon, gluon->bb

compare results with gluon->bb splitting from shower and with full ME gg->bbA

Full ME gg->bbA generation by Olivier Mattelaer

Selection efficiencies (at parton level) for bbA and gg->A processes for m_A=30 GeV

PY8 for showering

* Stat accuracy

	bbh with Q_{sh} variation 0.5, 2.0 of the nominal α=0.25 (small numbers in [])	gg->h with b-quark only in the loop + g->bb (in POWHEG generation Q_b is varied as 0.5, 2.0 of nominal scale Q_b=15 GeV: see small numbers in [])		
	MG5_aMC@NLO	aMC@NLO	POWHEG	aMC@NLO
		ME gg->bbA	g->bb from PY8 shower	
		R = 3.9 x 10^{-4}		
$p_T^{\mu 1,2}$> 25, 5 GeV $\lvert\eta^{\mu 1,2}\rvert$ < 2.1, 2.4	0.113 [0.105-0.124]	0.194	0.029 [0.021-0.038]	0.038
>=1 jet, p_T>30 GeV, $\lvert\eta\rvert$<2.4	0.375 [0.345-0.451]	0.378	0.160 [0.172-0.156]	0.108
>=1 b-jet, p_T^b > 30 GeV, $\lvert\eta^b\rvert$ < 2.4	0.789 [0.812-0.738]	0.524	0.032 (10%*) [0.030-0.027]	0.021 (10%)
total eff, ε	3.32x10^{-2}	1.5x10^{-5}	1.5x10^{-4}	0.9x10^{-4}
Ratio ε(gg->A)/ε(bbA)		4.5x10^{-4}	4.5x10^{-3}	2.7x10^{-3}

conclusion

- In wrong sign Yukawa coupling scenario contribution of gg->A process to b-tag category is small ~ 4 %
- Large difference (~ 30 %) in acceptance between gg->A in POWHEG and MG5_aMC@NLO
- Very large difference (factor 10) in acceptance for full ME and PY8 shower for g->bb in b-loop induced gg->bbA production
- Go for 13 TeV gg->A analysis with “normal sign Yukawa coupling” scenario

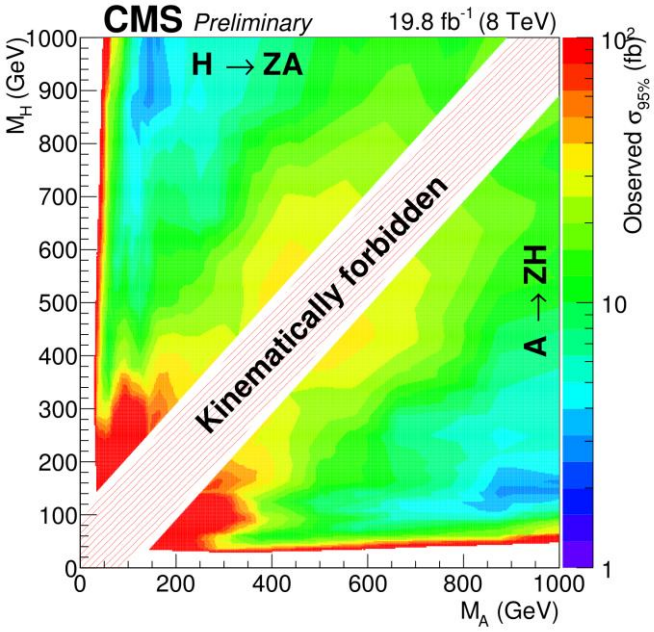
2HDM: Heavy Higgs decays for large splitting between Higgs partners

- **Responsible:** Jose Mi No
- **Members:** Ken Mimasu, Werner Porod, Jérémy Bernon, Andrey Katz, Dipan Sengupta

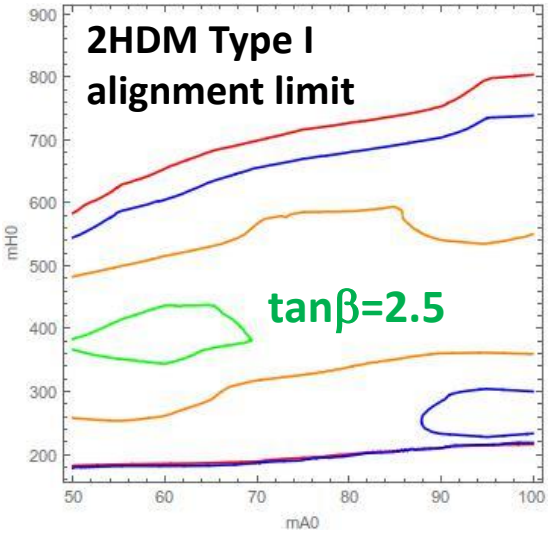
H->ZA, m_A=50-100 GeV

- Complementary to bbA, A->μμ/ττ analyses for m_A=[20-60] GeV

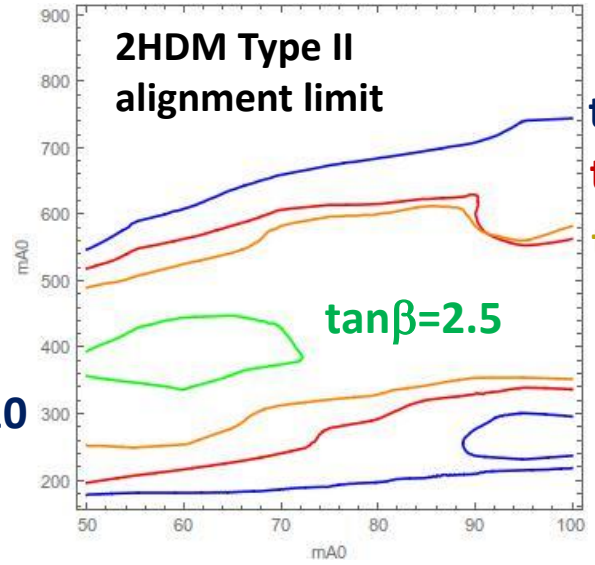
gg->A/H production
is generated for this CMS analysis



2HDM
interpretation



tanβ=0.5
tanβ=1.0
tanβ=1.5



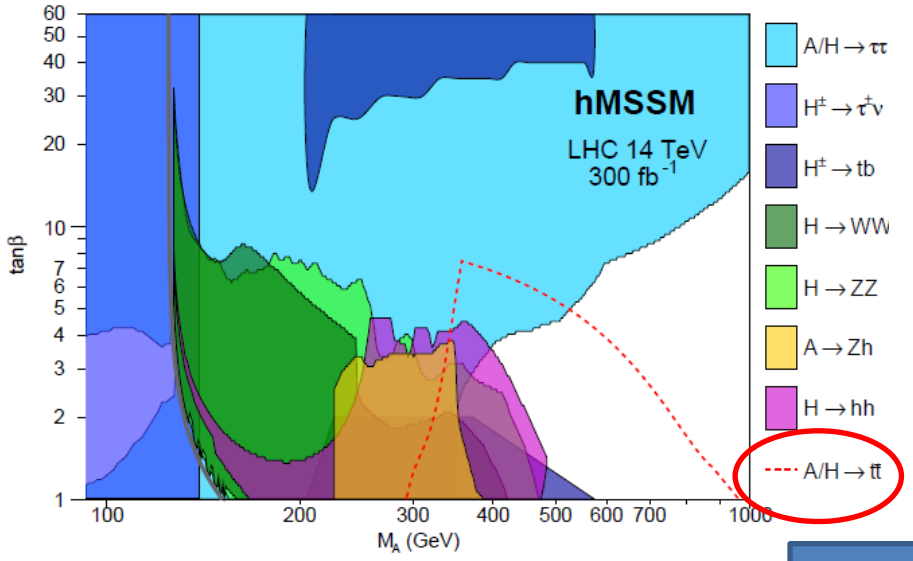
tanβ=1.0
tanβ=0.5
tanβ=1.5

- to complement bbA, A->μμ/ττ 8 TeV analyses one should make 2HDM interpretation for high tanβ >~ 10
- at Run II gg->A and H->ZA will complement each other at low tanβ

H->tt

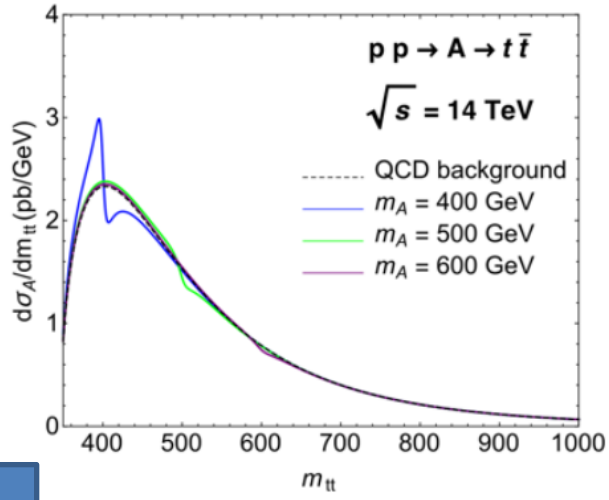
- **Responsible:** Ken Mimasu
- **Members:** Jose Mi No, Chris Pollard, Sanjoy Biswas, Adam Falkowski, Aurelio Juste, Andrey Katz, Aram Apyan

A. Djouadi et al arXiv:1502.05653: gg->H/A->tt analysis

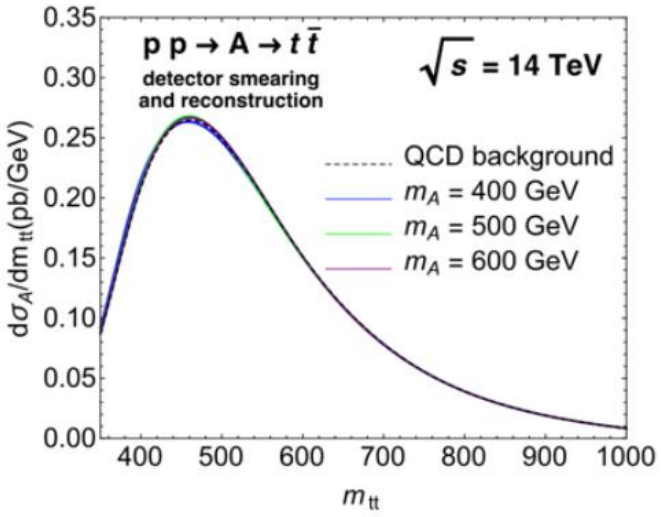


gg → H/A → tt

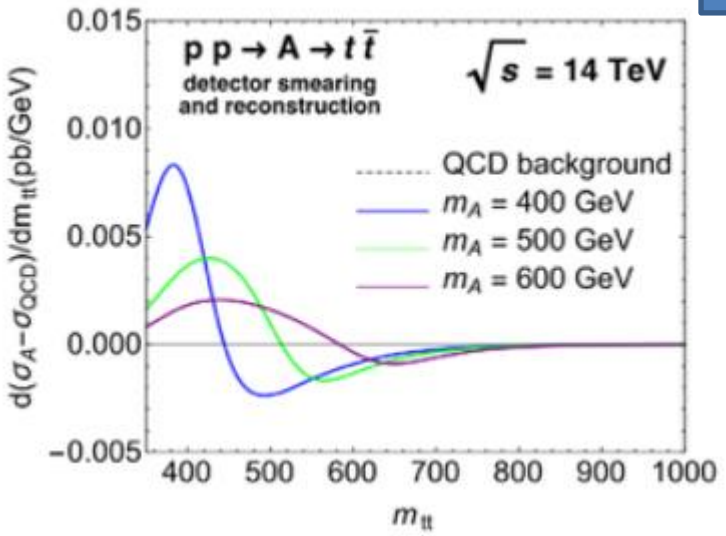
[Craig et al. arXiv:1504.04360]



gg->H ?



~ % deviation from bkg.



Try another idea: gg->tt(bb)H, H->tt

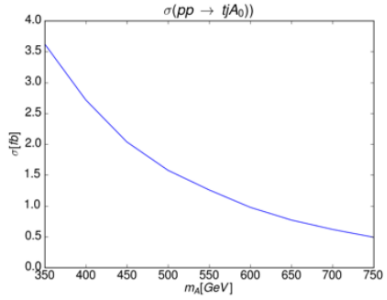
- **Recent analyses:**
  - **N. Craig et al arXiv:1504.04630 in 2HDM**
  - **J. Hajer et al. 1504.07617 in MSSM**

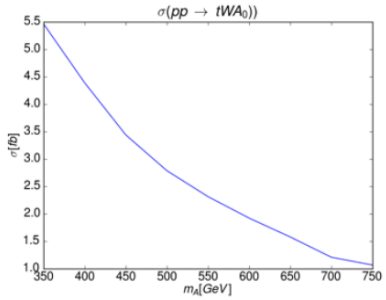
Associated production

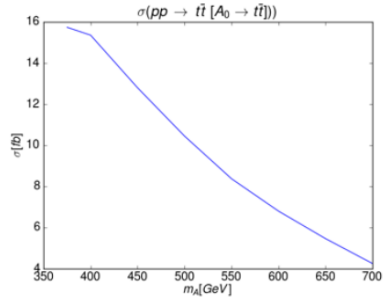
- tt/bb associated
  - Smaller cross sections ~ 20 fb ⇔ more manageable backgrounds
  - 4 top & ttbb final states
  - The latter also captures heavy charged Higgs production
  - Idea: Perform a detailed detector-level sensitivity study for LHC13
- single top associated
  - Accompanied by a forward light jet, W boson or b-jet
  - Relative sign of top and W coupling important for unitarity in the SM via the interference between top- and W-radiated Higgs diagrams
  - e.g. 2HDM allows for changes in relative sign, may lead to interesting features in production rates as a fucntion of heavy Higgs mass
  - Investigate this further in the 2HDM context as a function of tangent beta and deviation from alignment

- **cross-sections**

Associated production







LO A_0 associated production cross sections in fb for tangent beta = 1

- **Analysis setup**

- Assume the alignment limit with heavy degenerate states A/H/H± for types I and II
  - Determine mass tangent beta reach between ~ 400 & 700 GeV
  - Fast detector simulation & systematic uncertainty estimates
  - 300, 3000 fb^{-1}
- Main background: tt+jets
  - Large MC sample exists
- Preselection: 1 lepton, 6 jets, 2 b-tags
- Key variables: 4 b-tags, $M_{eff} = \sum|p_T|$ (leptons,jets,MET)
- Also investigate sensitivity to lighter states (< 2 Mt) for bb associated production using similar analysis

H/A->SUSY

- **Responsible:** Giacomo Polesello
- **Members:** Genevieve Bellanger, Suchita Kulkarni, Aram Apyan, Dipan Sengupta, Nicolas De Filippis, Daniele Barducci, Aoife Bharucha, Ulrich Goerlach, Ursula Laa

Long pre-LHC data history of these analyses:
F. Moortgat et al, A. Ketevi et. al

Mike Bisset et al, JHEP08 (2009) 037, arXiv:0709.1029

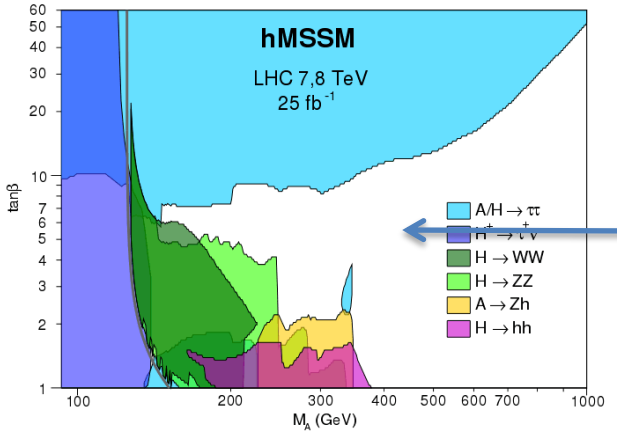
Are light charginons/neutralinos excluded in MSSM ?

- NO

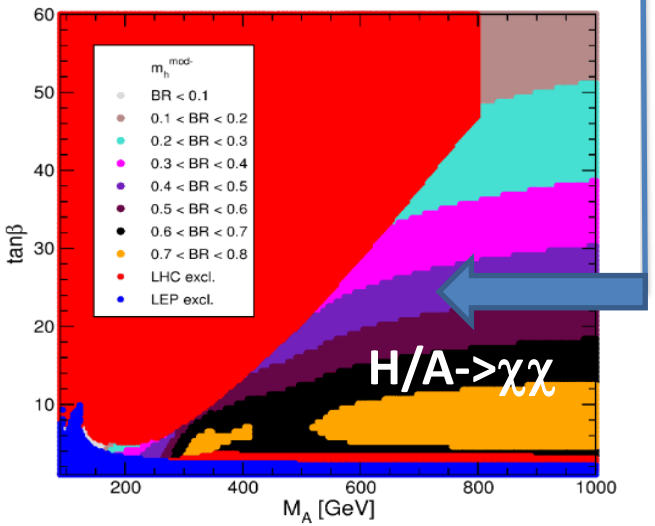
Choice of benchmark points:

- propose to fix m_A and tanβ
- find μ, M_1, $m_{slepton}$ within the present constraints with best σxBR
- Check with the data analysis if has sensitivity
  - if yes, expand in μ, M_1 , $m_{slepton}$
- Re-use 2ℓ, 3ℓ, 4ℓ LHC electrovikino searches

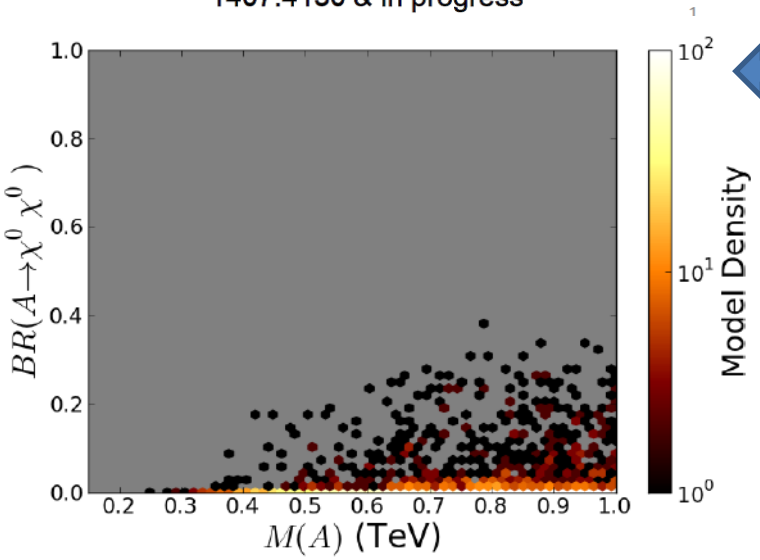
A. Djouadi et al arXiv:1502.05653



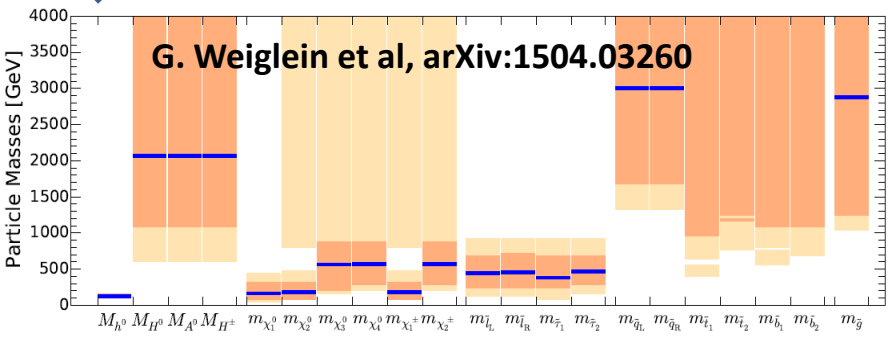
M. Carena et al arXiv:1302.7033



M.Cahill-Rowley, J. Hewett, A. Ismail & T. Rizzo
1407.4130 & in progress



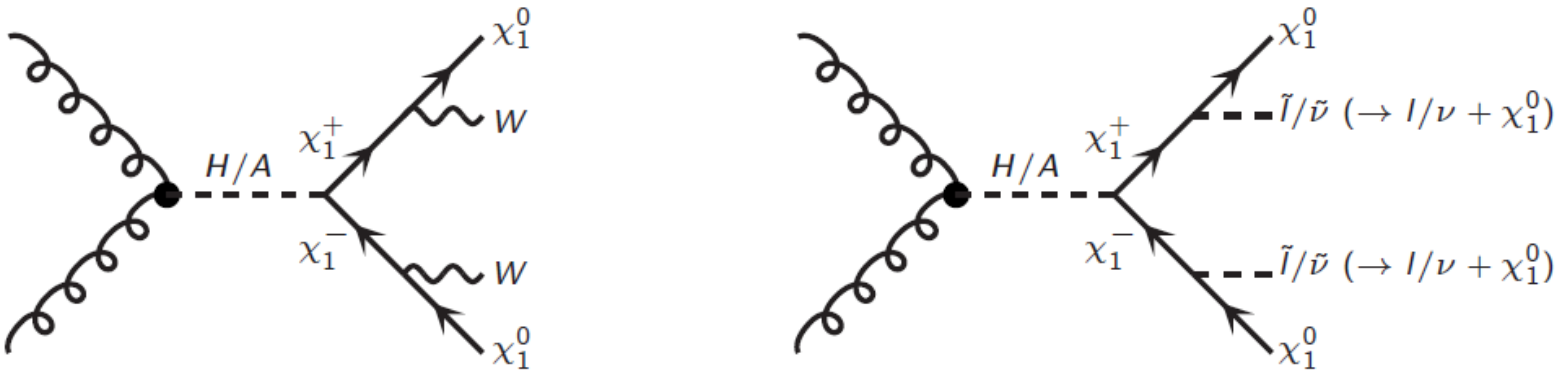
pMSSM scans



$H/A \to \chi\chi$ decay in the MSSM

- Is the LHC already sensitive to process like $gg \to H/A \to \chi\chi$?
- How different are $A \cdot \epsilon$ with respect to $pp \to W/Z \to \chi\chi$?
- $m_{H/A} \sim 500$ GeV, light χ and $\tilde{l}$, decouple $\tilde{q}$ and $\tilde{g}$.

First scenario: $2l + E_T^{\text{miss}}$ final state

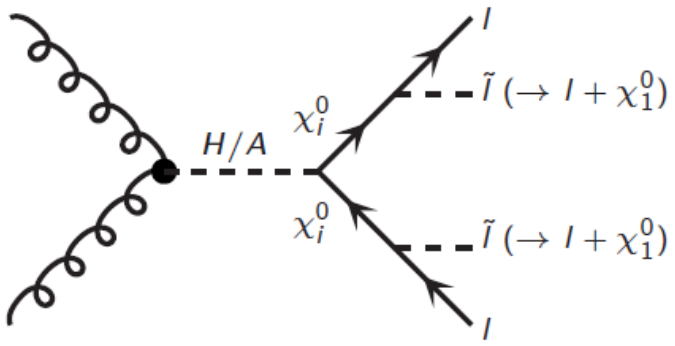


Also look for $\chi_2^+\chi_1^- \to Z\chi_1^+ W^*\chi_1^0 \to Z + E_T^{\text{miss}}$

Apyan, Barducci, Belanger, Bharucha, Godbole, Kraml, Laa, Polesello and Sengupta

$H/A \to \chi\chi$ decay in the MSSM

Second scenario: $3l + E_T^{\text{miss}}$ final state



$m_{\chi_1^0} < m_{\tilde{l}_R} < m_{\chi_{2,3}^0} < 250$ GeV

$\Delta M(\tilde{l}_r, \chi_1^0) \sim 10$ GeV

Possibility of 4 leptons?

- Can we say something for $H^{\pm}$ at LHC13?

Apyan, Barducci, Belanger, Bharucha, Godbole, Kraml, Laa, Polesello and Sengupta

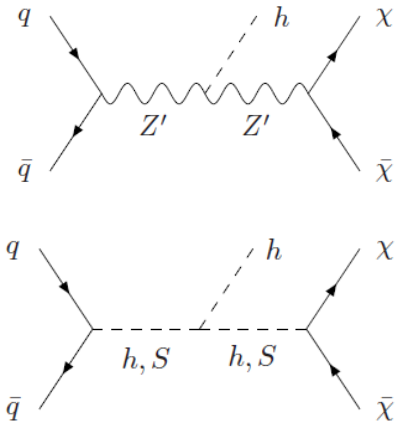
mono-Higgs

- **Chair:** Nicola De Filippis
- **Members:** Veronica Sanz, Harrison Prosper, Sabine Kraml, Daniel Schmeier, Sezen Sekmen, Jory Sonneveld, Nishita Desai, Camillo Carillo, Sanjoy Biswas, Monika Wielers, Ilaria Brivio, Jose Miguel No

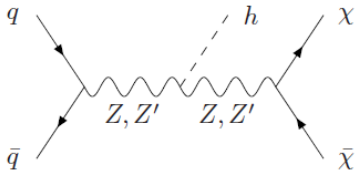
Mono-higgs models

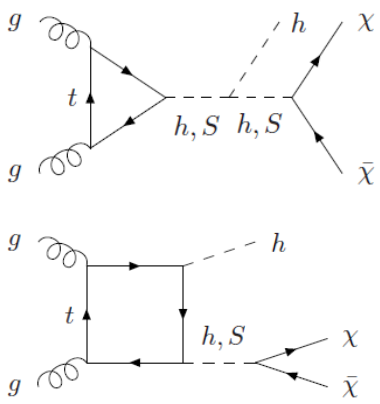
Simpified models:

- **reference papers:** ***arXiv:1312.2592v2 [hep-ph]***, arXiv:1404.3716v2 [hep-ph]

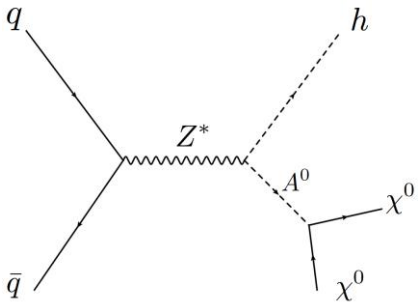


LHE files produced

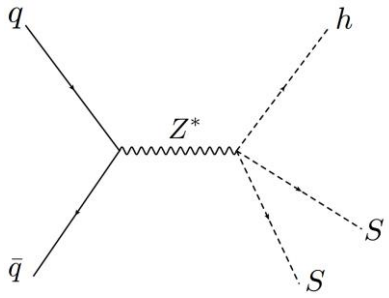




❑ **Input from Veronica Sanz, Jose Miguel No**



(N)MSSM



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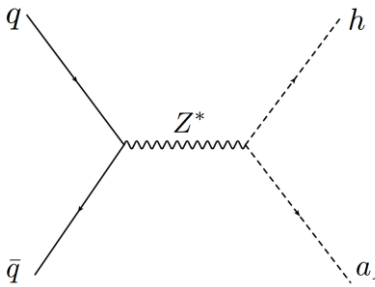


axion

Status of the work

- **Delphes-based analysis code available for 4ℓ and almost ready for γγ**

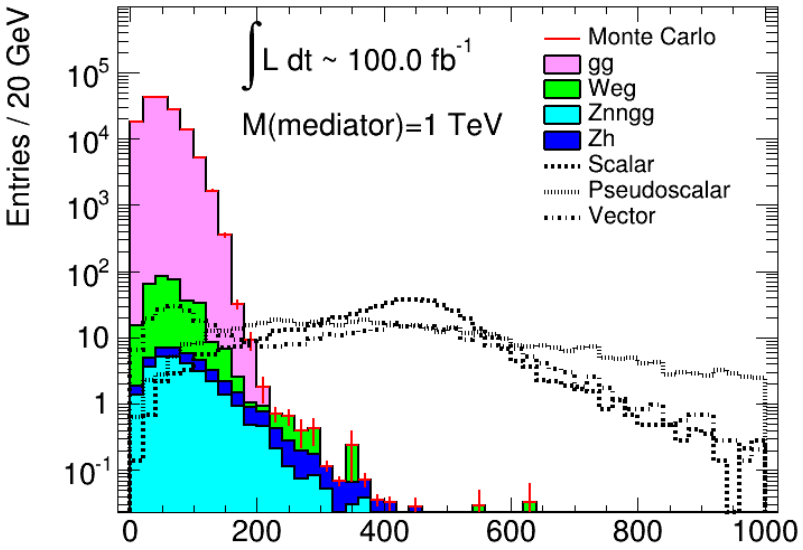
- **4ℓ +MET analysis:**
  - **signal with Z' and scalar mediator generated**
  - **Bkg: ggH, VBF H, ttH, Zh, WH, ZZ**

- **γγ +MET analysis:**
  - **signal with Z', scalar and pseudoscalar (V.S. model) mediator generated**
  - **Bkg: pp->γγ , Wγγ, Zγγ, …**

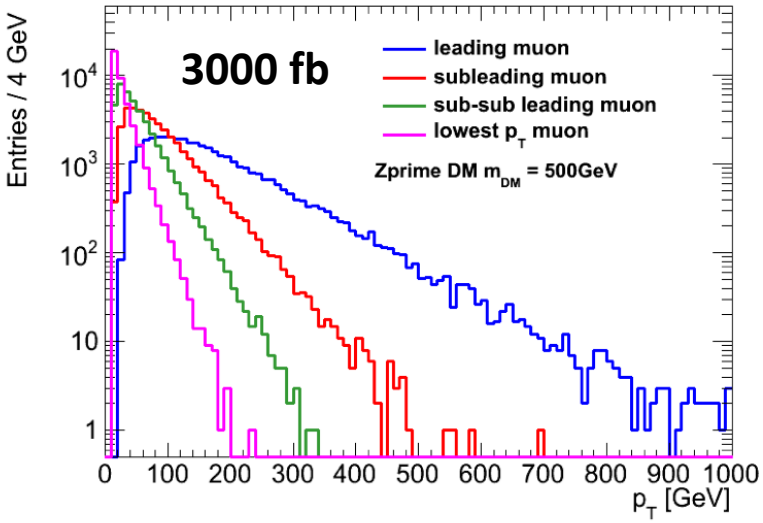
Some plots of the observables derived.

Code for statistical analysis ready

13 TeV, H→γγ



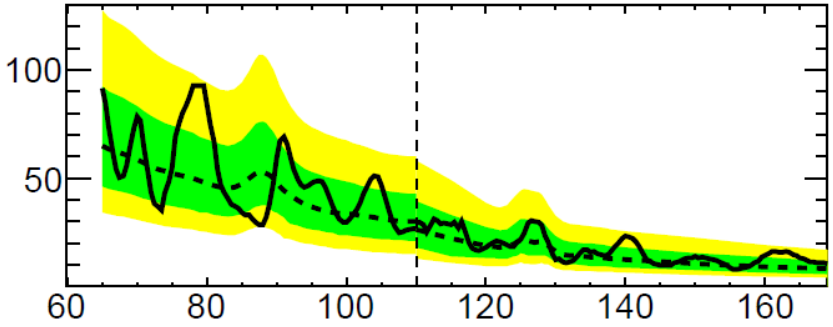
13 TeV, H→ZZ->4ℓ



Low mass scalar, $\phi \rightarrow \gamma\gamma$

- **Responsible:** Carrillo Camilo
- **Participants:** Berger Nicolas, Cacciapaglia Giacomo, Carrillo Camilo, Courbon Benoit, Deandrea Aldo, Gascon Susan, Goerlach Ulrich, Porod Werner, Sabes David

ATLAS, arXiv:1407.6583



Work in Les Houches:

- Consider a number of models with a light scalar decaying into γγ (LHE files are being produced)

- Set up and validate DELPHES for the analysis of the proposed topologies

Theory input for topologies with γs:

- NMSSM **by Werner Porod**
  - NMSSM the lightest $\chi^o\chi^\pm$ can be mainly the MSSM $\tilde{H}$. In case of a large singlet-doublet couplings, one gets sizable cross section for
    $$pp \to \chi\chi\, H_1$$
    Here $\chi\ \chi$ is the summation over all higgsinos which are mass degenerate within a few GeV.
  - The second interesting process ist $pp \to H_3 \to H_1\ H_1$ where the H_3 is the heaviest neutral Higgs boson.
  - The third is $pp \to tt \to W\ b\ H^\pm\ b$ where $H^\pm$ decays into $W\ H_1$ and the later to $\gamma\gamma$.

❑ **NMSSM, S. King at al, arXiv:1407.6583**

B.1 (Point ID Poi2a)	Scenario		
M_h, M_{H_s}, M_H	124.6 GeV	181.7 GeV	322.6 GeV
M_{A_s}, M_A	72.5 GeV	311.7 GeV	
$\lvert S_{H_2 h_s}\rvert^2, \lvert P_{A_1 a_s}\rvert^2$	0.90	1	
$\mu_{\tau\tau}, \mu_{bb}$	1.54	1.01	
$\mu_{ZZ}, \mu_{WW}, \mu_{\gamma\gamma}$	0.93	0.93	1.01
$\tan\beta, \lambda, \kappa$	1.9	0.628	0.354
$A_\lambda, A_\kappa, \mu_{\rm eff}$	251.2 GeV	53.8 GeV	158.9 GeV
M_1, M_2, M_3	890 GeV	576 GeV	1219 GeV
A_t, A_b, A_τ	1555 GeV	-1005 GeV	-840 GeV
$M_{Q_3} = M_{t_R}, M_{b_R}$	1075 GeV	1 TeV	
$M_{L_3} = M_{\tau_R}, M_{\rm SUSY}$	530 GeV	2.5 TeV	

Bug found in paper: 13 TeV σ(ggA) should be 4 time higher ! Ulrich G.

	13 TeV		8 TeV
X(ggHs)BR(Hs ! As As ! + b_ b)	67,33	fb	28,33
X(ggHs)BR(Hs ! As As ! + gg gg)	193,22	fb	81,29
X(ggH)BR(H ! hHs ! h + As As ! bb + 4gamma)	712,47	fb	247,41
X(ggH)BR(H ! hHs ! h + As As ! gamgam + 4 b)	248,02	fb	86,13
X(ggH)BR(H ! hHs ! h + As As ! tautau + 4gam)	74,6	fb	25,91
X(ggA)BR(A ! Hs As ! As As + As ! 6gam)	301,58	fb	103,45
X(ggA)BR(A ! Hs As ! As As + As ! bb + 4 gam)	157,64	fb	54,08

Rescaling states with γs to 8 TeV by Ulrich Goerlach

❑ **Composite Higgs, Giacomo Cacciapaglia, Aldo Deandrea:**

The model consists of a scalar which is pair produced by gauge interactions: qq → H' H', and VBF → H' H'. At low mass, the kinematically allowed decays are: W gamma (charged) and gamma gamma (neutral).