H/A->SUSY (in MSSM)

A. Nikitenko

discussion

Search for heavy A/H->χχ decays could complement direct searches χχ searches:

Les Houches project CMS exp.:

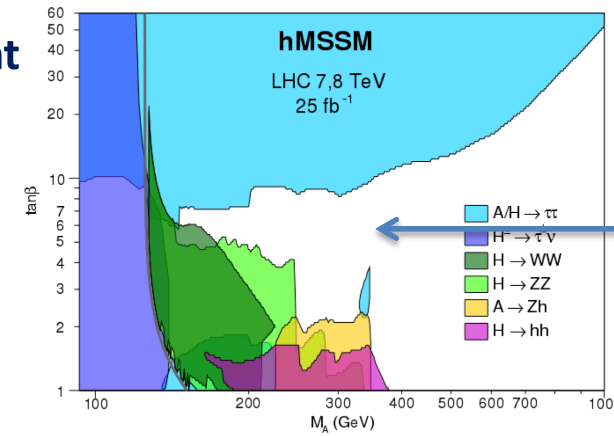
Apyan Aram (CMS), $H^+ \to \chi\chi$

A. Nikitenko (CMS), A/H->χχ->4ℓ+MET

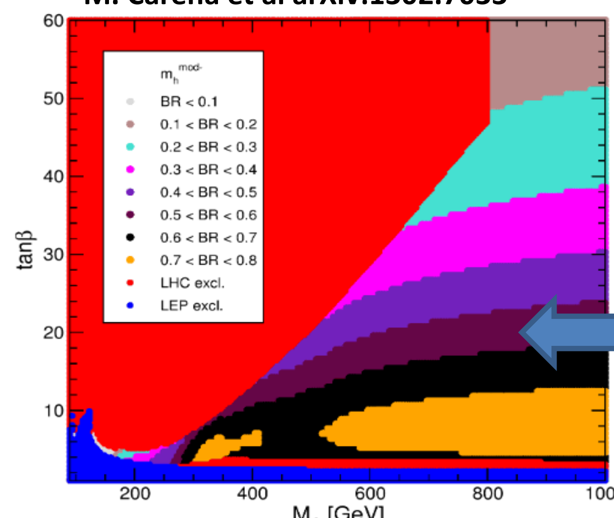
Long pre-LHC data history of these analyses:

F. Moortgat et al, A. Ketevi et. al

A. Djouadi et al arXiv:1502.05653



M. Carena et al arXiv:1302.7033

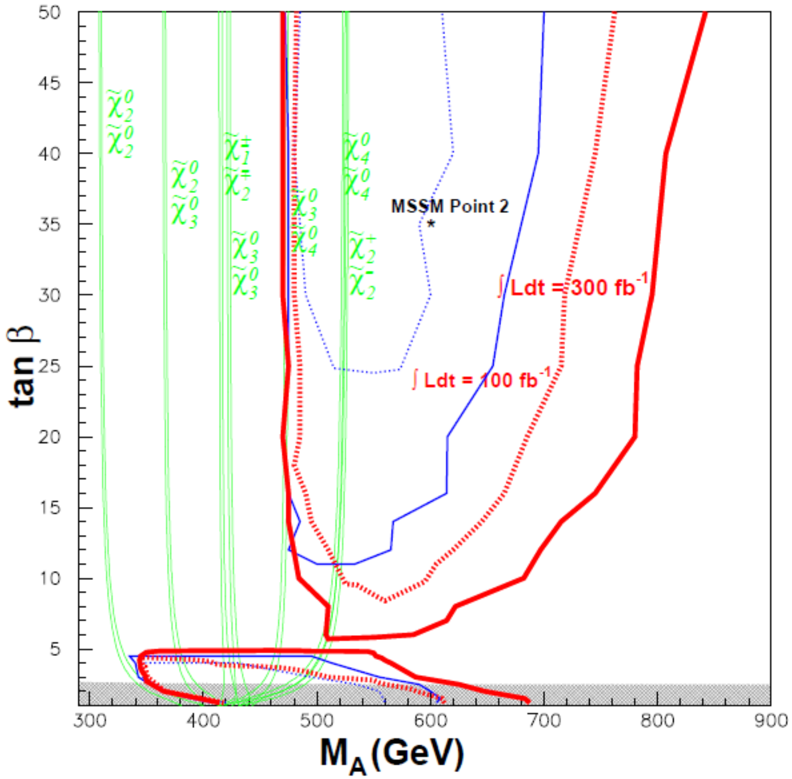


H/A->χχ

Four-lepton LHC events from MSSM Higgs boson decays into neutralino and chargino pairs

TUHEP-TH-07161
SCUPHY-07002
SHEP-07-12
DFTT 40/2009

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



'igure 8: Discovery region in red in $(M_A, \tan\beta)$ plane for –ino/slepton parameters $\mu =$ -200 GeV, $M_2 = 200$ GeV, $M_1 = 100$ GeV, $m_{\tilde{\ell}_{soft}} = 150$ GeV, $m_{\tilde{\tau}_{soft}} = 250$ GeV as in MSSM 'oint 2 (whose location is marked by an black asterisk). Here Higgs boson decays to a variety 'f higher mass –inos (see text) constitute the majority of the signal events. Solid (dashed) ed border delineates the discovery region for $L_{int} = 300\,\mathrm{fb}^{-1}$ ($100\,\mathrm{fb}^{-1}$). The green curves are $M_A, M_H - m_{\tilde{\chi}_i^0} m_{\tilde{\chi}_j^0}$ and $M_A, M_H - m_{\tilde{\chi}_k^{\pm}} m_{\tilde{\chi}_2^{\mp}}$ $(i, j = 2, 3, 4;\ k = 1, 2)$. The blue contours add he extra cut on the four-lepton inv. m. for the nominal cut-off value of 240 GeV.

	Point 1	Point 2
M_A	500.0	600.0
M_H	500.7	600.8
$\tilde{\chi}_1^0$	89.7	93.9
$\tilde{\chi}_2^0$	176.3	155.6
$\tilde{\chi}_3^0$	506.9	211.8
$\tilde{\chi}_4^0$	510.9	262.2
$\tilde{\chi}_1^{\pm}$	176.5	153.5
$\tilde{\chi}_2^{\pm}$	513.9	263.2
$m_{\tilde{\nu}}$	241.6	135.5
$m_{\tilde{e}1}$	253.8	156.3
$m_{\tilde{\mu}1}$	252.0	154.3
$m_{\tilde{e}2}$	254.4	157.2
$m_{\tilde{\mu}2}$	256.2	159.2
$m_{\tilde{e}2} - m_{\tilde{e}1}$	0.59	0.96
$m_{\tilde{\mu}2} - m_{\tilde{\mu}1}$	4.20	4.81

questions

- **Are light neutralinos excluded ?**
- **Choice of benchmark points ?**
  - **shell we still use m_A-tanβ plane for fixed M_1, M_2, μ, $m_{slepton}$ as used in 2009 analysis ?**

Are light neutralinos excluded ?

The pMSSM10 after LHC Run 1

K.J. de Vries[a], E.A. Bagnaschi[b], O. Buchmueller[a], R. Cavanaugh[c,d], M. Citron[a], A. De Roeck[e,f], M.J. Dolan[g], J.R. Ellis[h,e], H. Flächer[i], S. Heinemeyer[j], G. Isidori[k], S. Malik[a], J. Marrouche[e], D. Martínez Santos[l], K.A. Olive[m], K. Sakurai[h], G. Weiglein[b]

arXiv:1504.03260

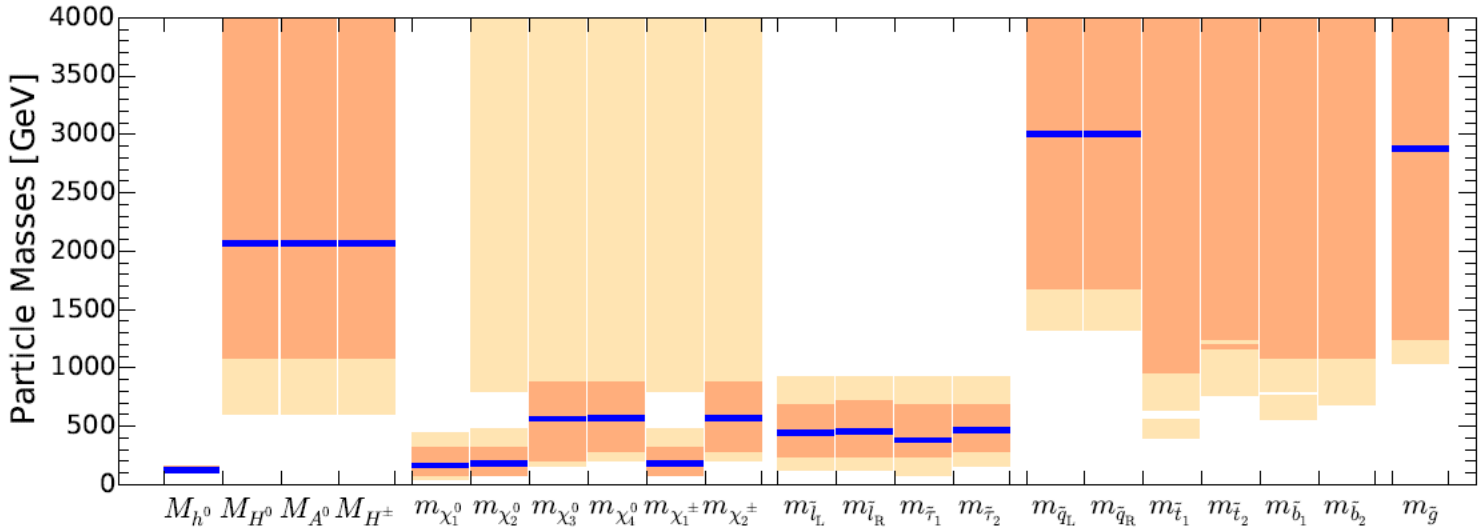
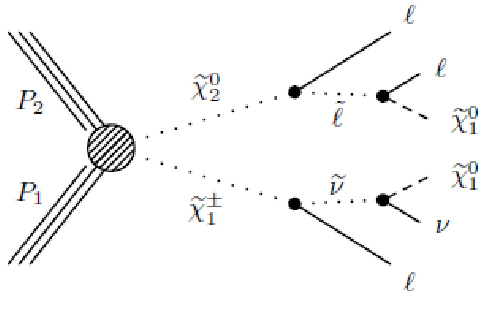
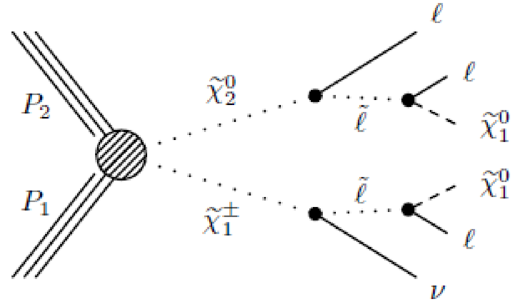
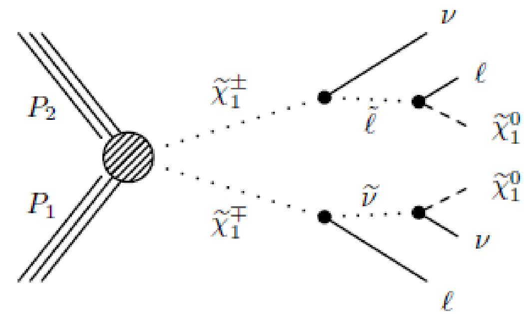
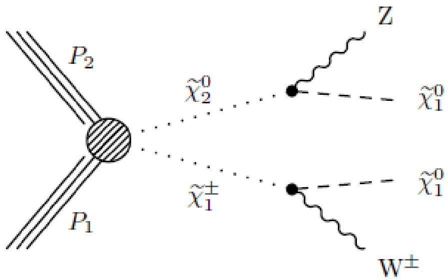


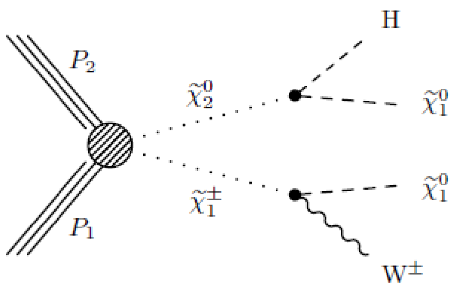
Figure 12. *Summary of mass ranges predicted in the pMSSM10. The light (darker) peach shaded bars indicate the 95% (68%) CL intervals, whereas the blue horizontal lines mark the values of the masses at the best-fit point.*

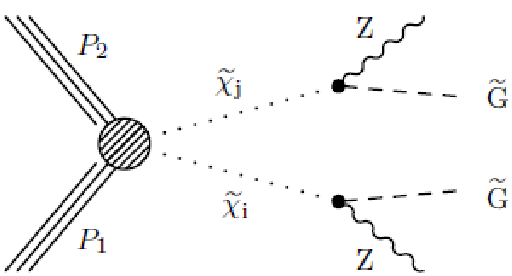


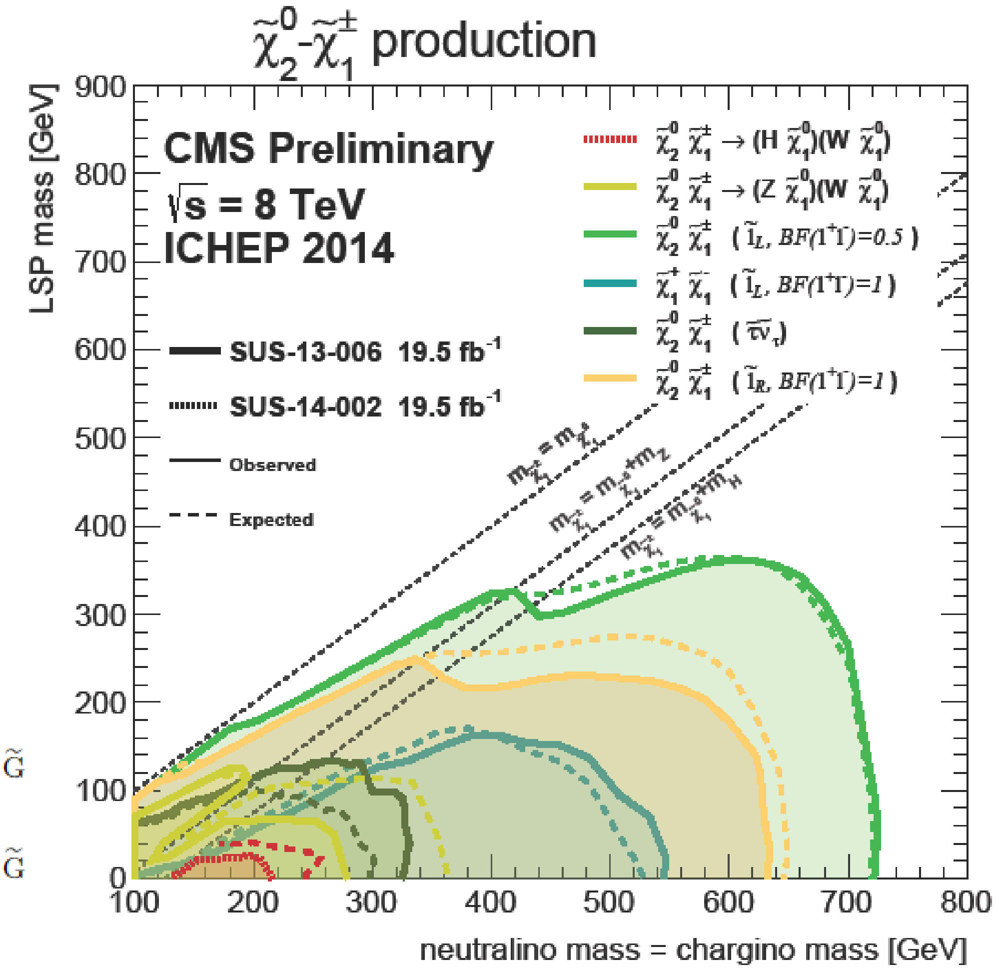




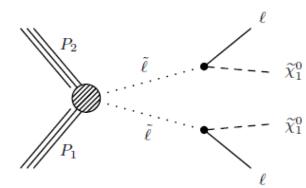








$\tilde{\chi}_2^0$-$\tilde{\chi}_1^\pm$ production
CMS Preliminary
$\sqrt{s}$ = 8 TeV
ICHEP 2014
SUS-13-006 19.5 fb^{-1}
SUS-14-002 19.5 fb^{-1}
Observed
Expected
$\tilde{\chi}_2^0 \tilde{\chi}_1^\pm \rightarrow (H\ \tilde{\chi}_1^0)(W\ \tilde{\chi}_1^0)$
$\tilde{\chi}_2^0 \tilde{\chi}_1^\pm \rightarrow (Z\ \tilde{\chi}_1^0)(W\ \tilde{\chi}_1^0)$
$\tilde{\chi}_2^0 \tilde{\chi}_1^\pm$ ($\tilde{l}_L$, BF(l^+l^-)=0.5)
$\tilde{\chi}_1^+ \tilde{\chi}_1^-$ ($\tilde{l}_L$, BF(l^+l^-)=1)
$\tilde{\chi}_2^0 \tilde{\chi}_1^\pm$ ($\tilde{\tau}\tilde{\nu}_\tau$)
$\tilde{\chi}_2^0 \tilde{\chi}_1^\pm$ ($\tilde{l}_R$, BF(l^+l^-)=1)
$m_{\tilde{\chi}_1^\pm} = m_{\tilde{\chi}_1^0}$
$m_{\tilde{\chi}_1^\pm} = m_{\tilde{\chi}_1^0}+m_Z$
$m_{\tilde{\chi}_1^\pm} = m_{\tilde{\chi}_1^0}+m_H$
LSP mass [GeV]
neutralino mass = chargino mass [GeV]
0
100
200
300
400
500
600
700
800
900



- Choice of benchmark points
  - shell we still use m_A-tanβ plane for fixed M_1, M_2, μ, $m_{slepton}$?
  - discussed a bit with Sven Heinemeyer

- **propose to fix m_A and tanβ**
- **Find μ, M_1, $m_{slepton}$ within the present constraints which maximizes σxBR**
- **Check with the data analysis if has sensitivity**
  - **if yes, expand in μ, M_1 , $m_{slepton}$**

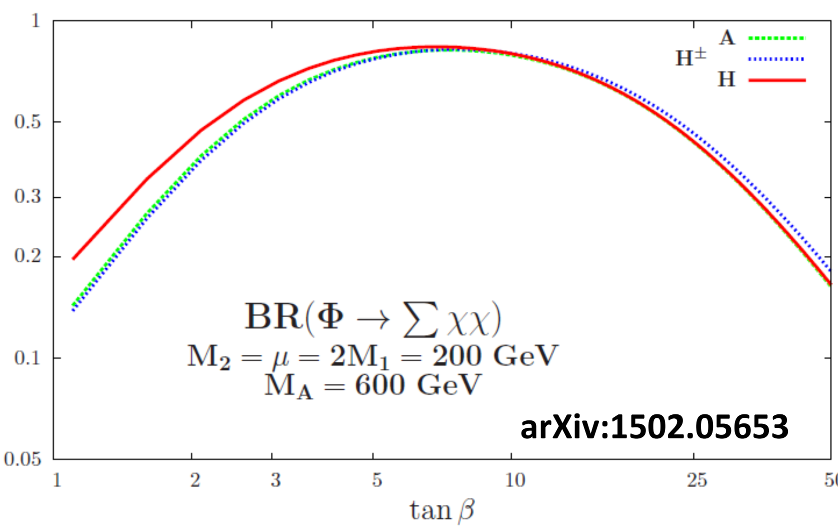
Fully covering the MSSM Higgs sector at the LHC

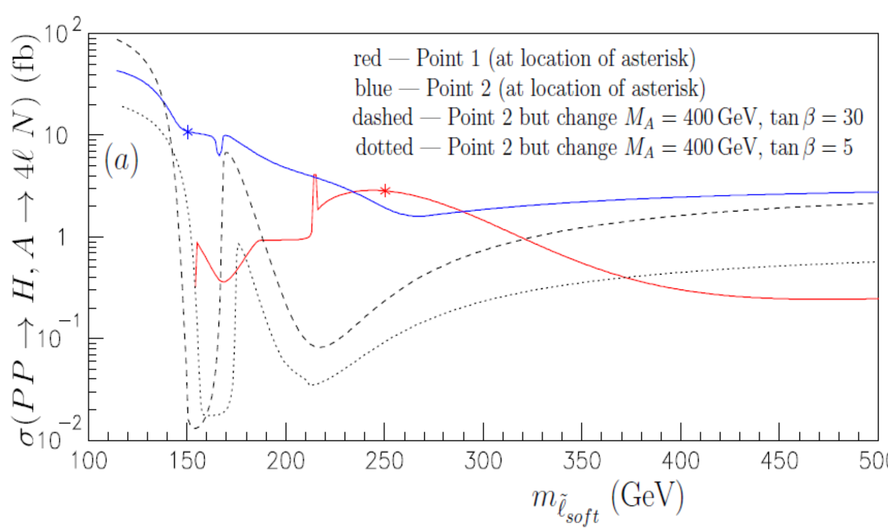
A. Djouadi[1], L. Maiani[2], A. Polosa[2], J. Quevillon[3] and V. Riquer[2]

regime $M_\Phi \gg 2m_\chi$ where phase space effects can be neglected.

$$\text{BR}(\Phi \to \sum_{i,j} \chi_i\chi_j) = \frac{(1+\frac{1}{3}\tan^2\theta_W)\,M_W^2}{(1+\frac{1}{3}\tan^2\theta_W)\,M_W^2 + \overline{m}_t^2\cot^2\beta + (\overline{m}_b^2 + m_\tau^2)\tan^2\beta} \quad (3.21)$$

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





BACKUP

$$m^2_{\tilde{\chi}^\pm_{1,2}} = \frac{1}{2}\left[M_2^2 + \mu^2 + 2M_W^2 \mp \sqrt{(M_2^2-\mu^2)^2 + 4M_W^2(M_W^2 c_{2\beta}^2 + M_2^2 + \mu^2 + 2M_2\mu s_{2\beta})}\right] .$$

In the limit $|\mu| \gg M_2,\, M_W$, the masses of charginos could be simplified as

$$m_{\tilde{\chi}^\pm_1} \simeq M_2 - \frac{M_W^2}{\mu^2}\left(M_2 + \mu s_{2\beta}\right) , \quad m_{\tilde{\chi}^\pm_2} \simeq |\mu| + \frac{M_W^2}{\mu^2}\mathrm{sign}(\mu)\left(M_2 s_{2\beta} + \mu\right) .$$

$|\mu| \gg M_{1,2}, M_Z$, the relations can be simplified as [24]

$$\begin{aligned}
m_{\tilde{\chi}^0_1} &\simeq M_1 - \frac{M_Z^2}{\mu^2}\left(M_1 + \mu s_{2\beta}\right) s_W^2 , \\
m_{\tilde{\chi}^0_2} &\simeq M_2 - \frac{M_Z^2}{\mu^2}\left(M_2 + \mu s_{2\beta}\right) c_W^2 , \\
m_{\tilde{\chi}^0_3} &\simeq |\mu| + \frac{1}{2}\frac{M_Z^2}{\mu^2}\epsilon_\mu(1 - s_{2\beta})\left(\mu + M_2 s_W^2 + M_1 c_W^2\right) , \\
m_{\tilde{\chi}^0_4} &\simeq |\mu| + \frac{1}{2}\frac{M_Z^2}{\mu^2}\epsilon_\mu(1 + s_{2\beta})\left(\mu - M_2 s_W^2 - M_1 c_W^2\right) .
\end{aligned}$$