

H/A- \rightarrow SUSY (in MSSM)

A. Nikitenko
discussion

Search for heavy $A/H \rightarrow \chi\chi$ decays could complement direct searches $\chi\chi$ searches:

Les Houches project CMS exp.:

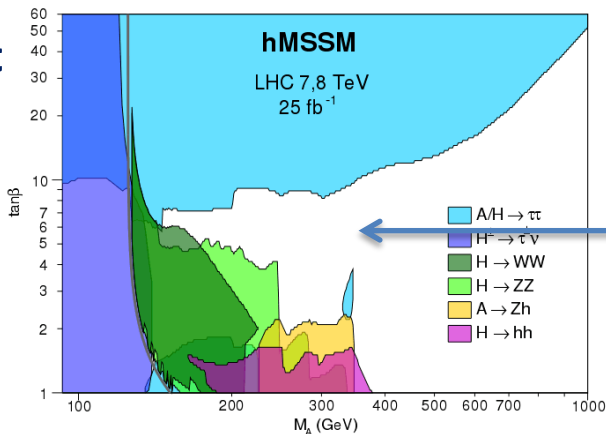
Apyan Aram (CMS), $H^\pm \rightarrow \chi\chi$

A. Nikitenko (CMS), $A/H \rightarrow \chi\chi \rightarrow 4\ell + MET$

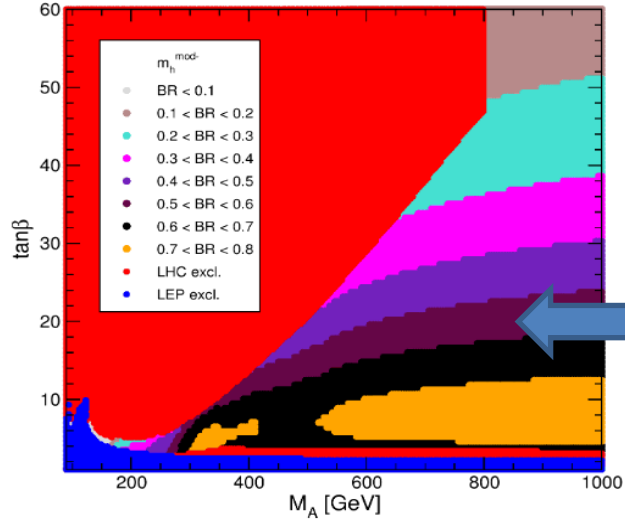
*Long pre-LHC data history of these analyses:
F. Moortgat et al, A. Ketevi et. al*



A. Djouadi et al arXiv:1502.05653



M. Carena et al arXiv:1302.7033



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

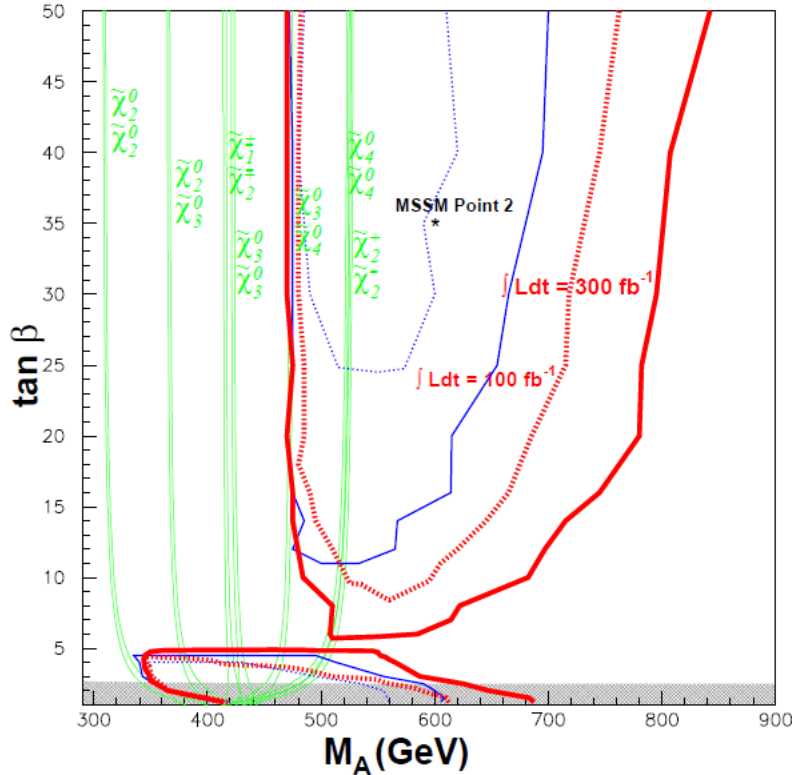


Figure 8: Discovery region in red in $(M_A, \tan \beta)$ plane for $\tilde{m}_0 = 200$ GeV, $M_2 = 200$ GeV, $M_1 = 100$ GeV, $m_{\tilde{t}_{soft}} = 150$ GeV, $m_{\tilde{\tau}_{soft}} = 250$ GeV as in MSSM Point 2 (whose location is marked by a black asterisk). Here Higgs boson decays to a variety of higher mass $\tilde{\chi}$ -inos (see text) constitute the majority of the signal events. Solid (dashed) border delineates the discovery region for $L_{int} = 300$ fb $^{-1}$ (100 fb $^{-1}$). The green curves are $M_A, M_H - m_{\tilde{\chi}_i^+} m_{\tilde{\chi}_j^0}$ and $M_A, M_H - m_{\tilde{\chi}_k^+} m_{\tilde{\chi}_l^0}$ ($i, j = 2, 3, 4; k = 1, 2$). The blue contours add the 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 ?
 - shall we still use m_A - $\tan\beta$ 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. Flächerⁱ, 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

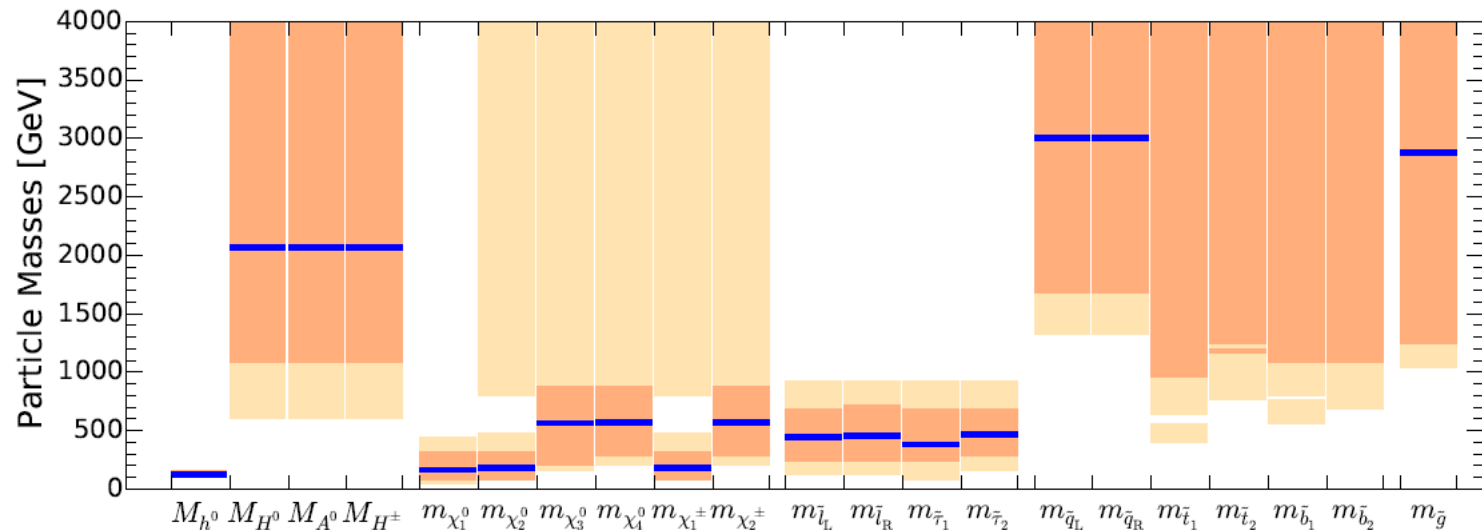
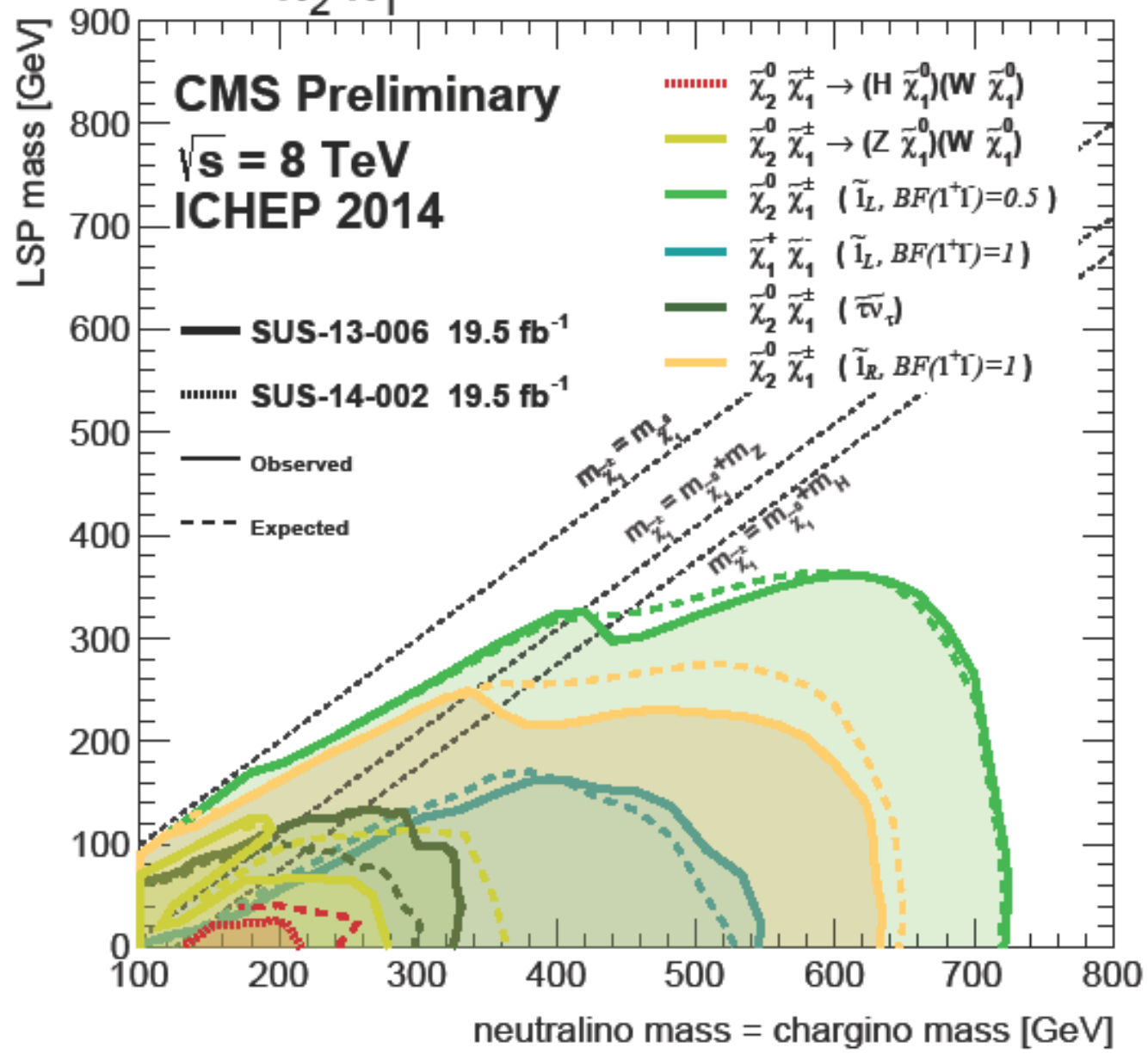


Figure 12. Summary of mass ranges predicted in the pMSSM10. The light (darker) peach shaded bars indicate the 95% (68%) CL intervals, whereas the blue horizontal lines mark the values of the masses at the best-fit point.

$\tilde{\chi}_2^0 - \tilde{\chi}_1^\pm$ production



- **Choice of benchmark points**
 - shell we still use m_A - $\tan\beta$ plane for fixed $M_1, M_2, \mu, m_{\text{lepton}}$?
 - discussed a bit with Sven Heinemeyer



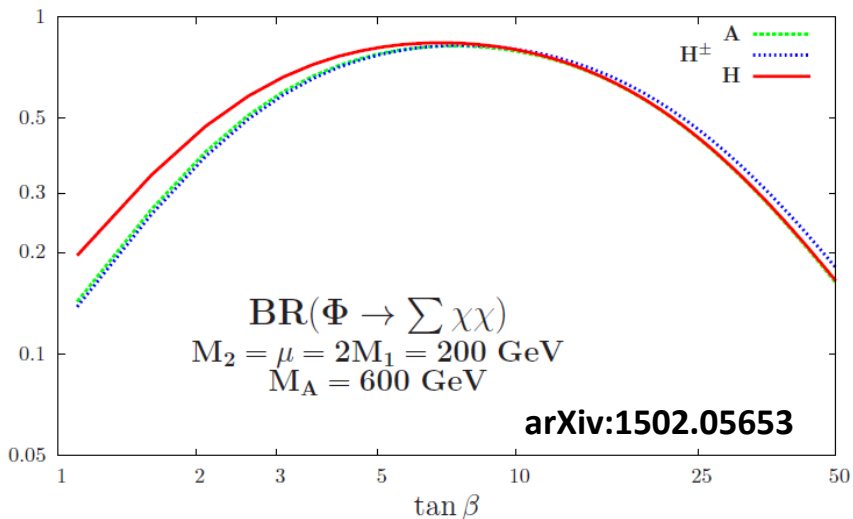
- propose to fix m_A and $\tan\beta$
- Find $\mu, M_1, m_{\text{slepton}}$ within the present constraints which maximizes σBR
- Check with the data analysis if has sensitivity
 - if yes, expand in $\mu, M_1, m_{\text{slepton}}$

Fully covering the MSSM Higgs sector at the LHC

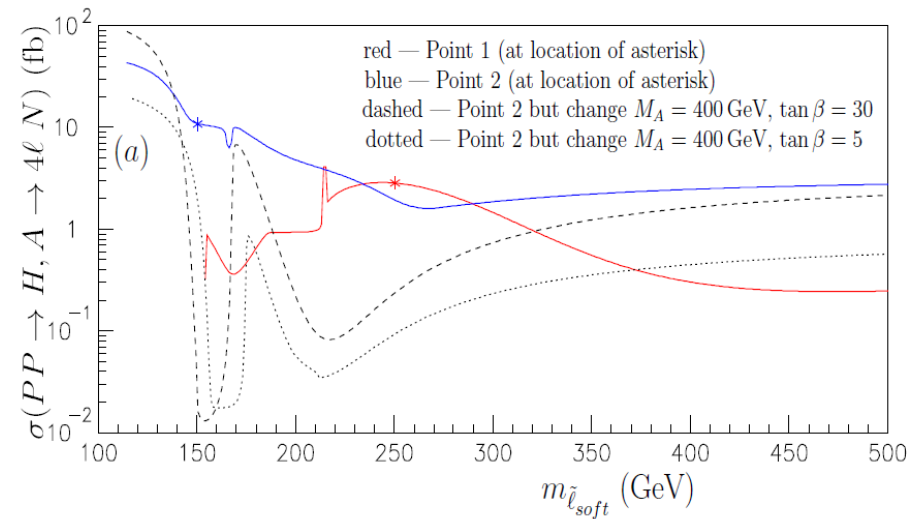
A. Djouadi¹, L. Maiani², A. Polosa², J. Quevillon³ and V. Riquer²

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

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



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



BACKUP

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

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

$$m_{\tilde{\chi}_1^\pm} \simeq M_2 - \frac{M_W^2}{\mu^2} (M_2 + \mu s_{2\beta}), \quad m_{\tilde{\chi}_2^\pm} \simeq |\mu| + \frac{M_W^2}{\mu^2} \text{sign}(\mu) (M_2 s_{2\beta} + \mu).$$

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

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