Constraints on the phenomenological MSSM from the LHC Higgs Results

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in collaboration with A Arbey, A Djouadi and F Mahmoudi

pMSSM Scans

R-parity conservation;
real soft SUSY breaking parameters;
diagonal sfermion mass matrices and trilinear coupling matrices;
universal first and second generation sfermions;
neutralino LSP;

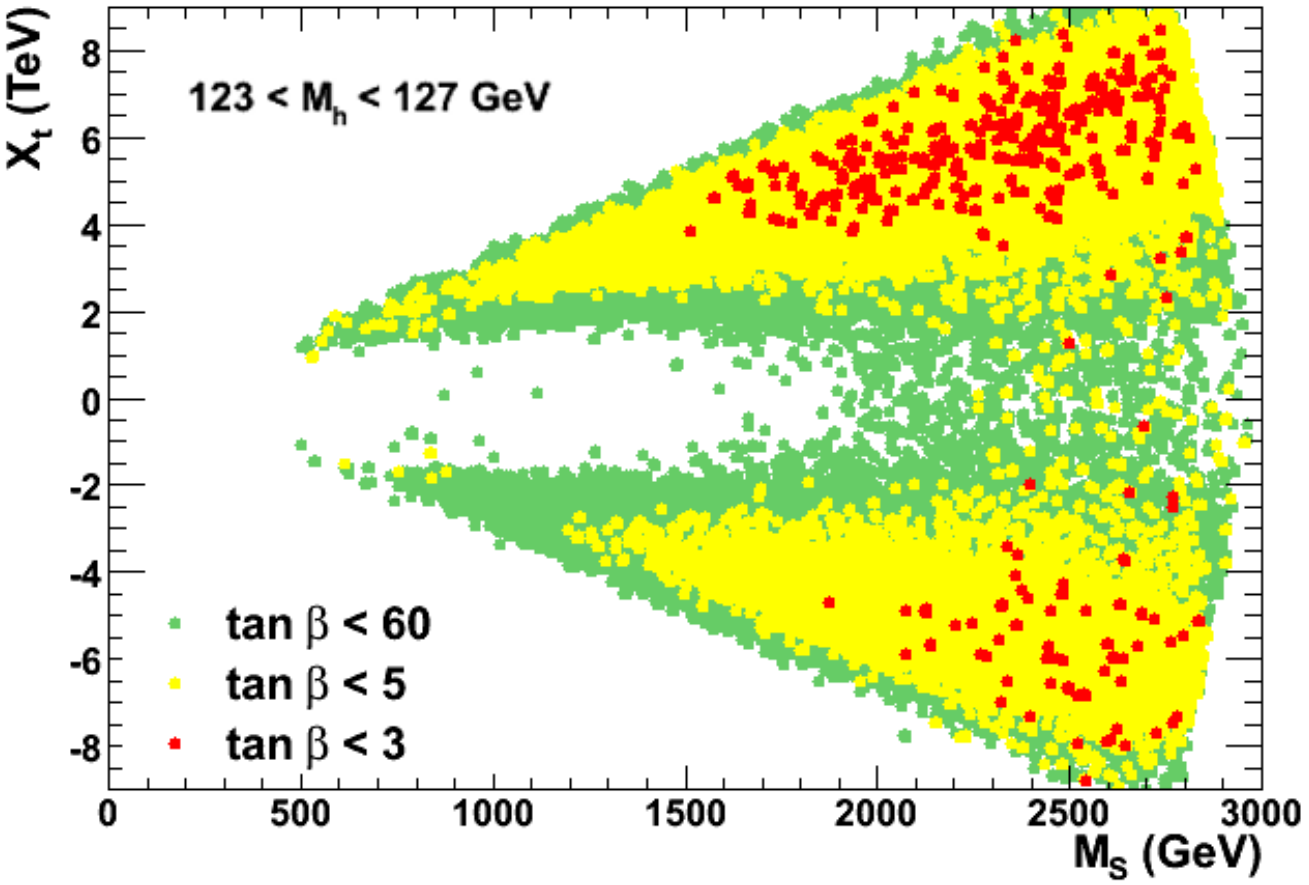
19 parameters flat scans

$$1 \leq \tan\beta \leq 60\,,$$
$$50\ \text{GeV} \leq M_A \leq 3\ \text{TeV}\,,$$
$$-10\ \text{TeV} \leq A_f \leq 10\ \text{TeV}\,,$$
$$50\ \text{GeV} \leq m_{\tilde{f}_L}, m_{\tilde{f}_R}, M_3 \leq 3.5\ \text{TeV}\,,$$
$$50\ \text{GeV} \leq M_1, M_2, |\mu| \leq 2.5\ \text{TeV}$$

Higgs Mass in the MSSM

One loop SUSY corrections to M_h

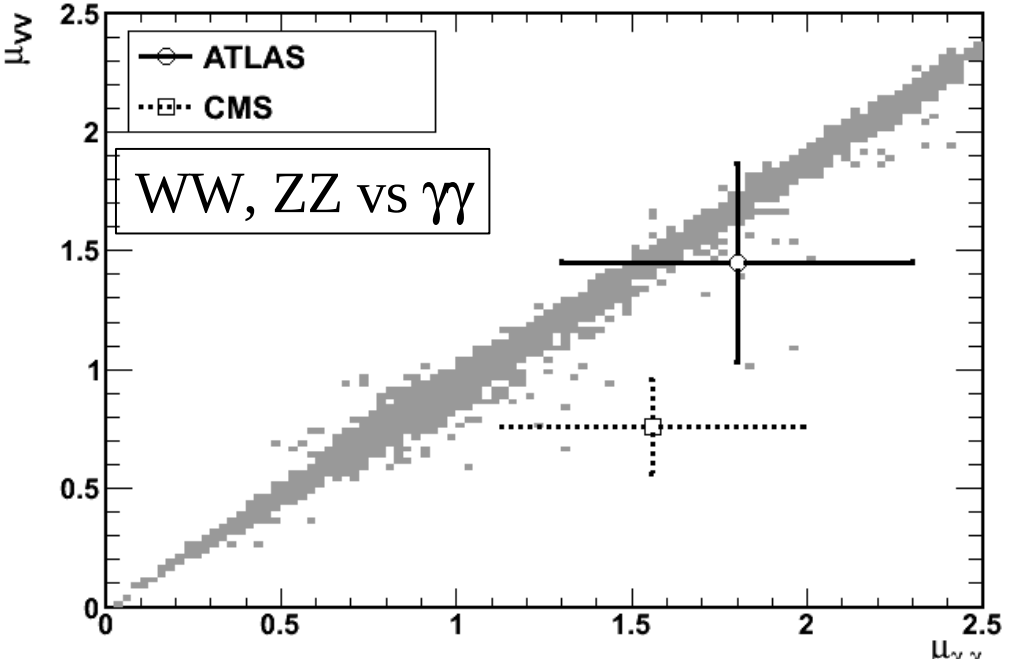
$$\frac{3\,\bar{m}_t^4}{2\pi^2 v^2 \sin^2\beta}\left[\log\frac{M_S^2}{\bar{m}_t^2}+\frac{X_t^2}{2\,M_S^2}\left(1-\frac{X_t^2}{6\,M_S^2}\right)\right]$$

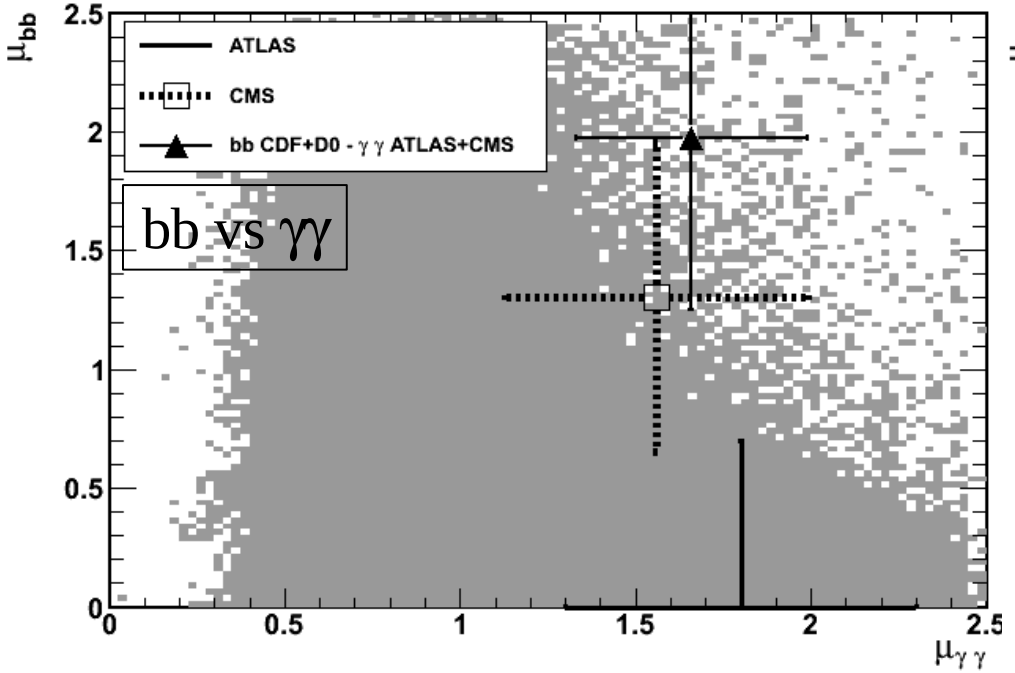


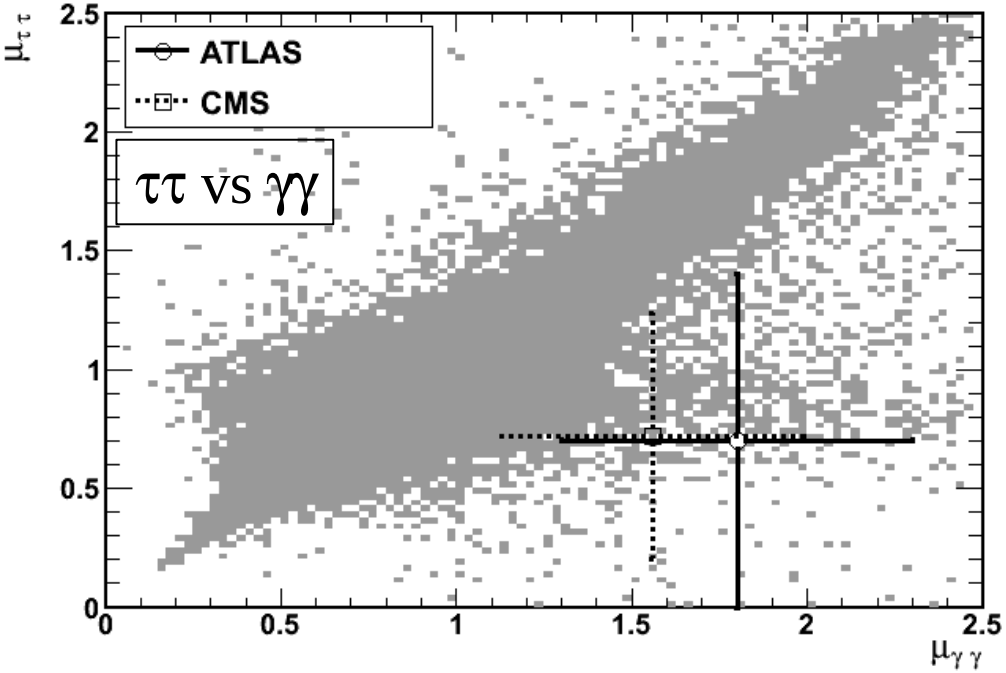
Arbey, MB, Djouadi, Mahmoudi, PLB 708 (2012) 162

μ values and MSSM

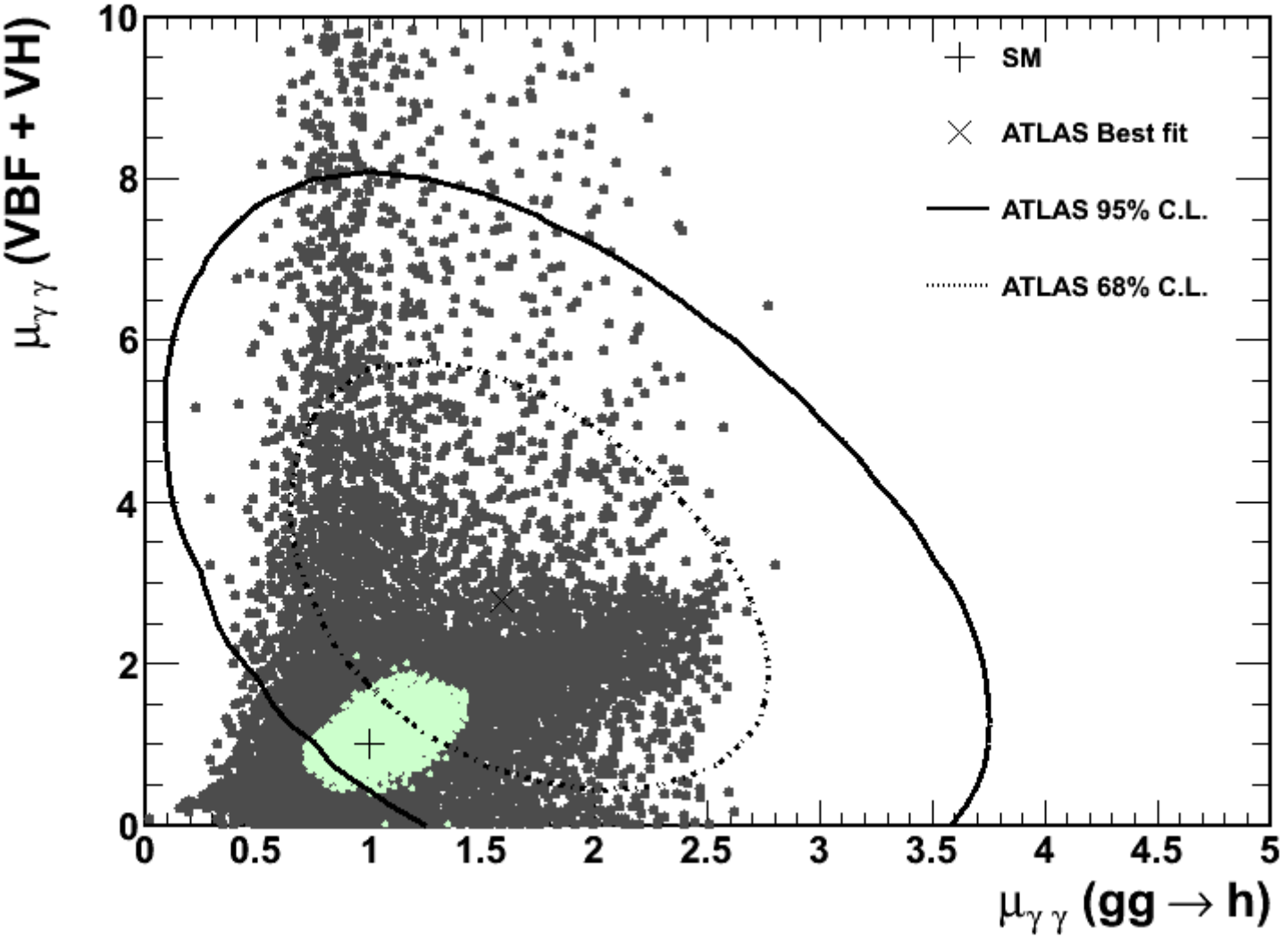
$$\mu_{XX} = \frac{\sigma(h)\times \mathrm{BR}(h\to XX)}{\sigma(H_{\mathrm{SM}})\times \mathrm{BR}(H_{\mathrm{SM}}\to XX)}$$







Arbey, MB, Djouadi, Mahmoudi, arXiv:1211.4004 [hep-ph]



Arbey, MB, Djouadi, Mahmoudi, arXiv:1211.4004 [hep-ph]

Constraints

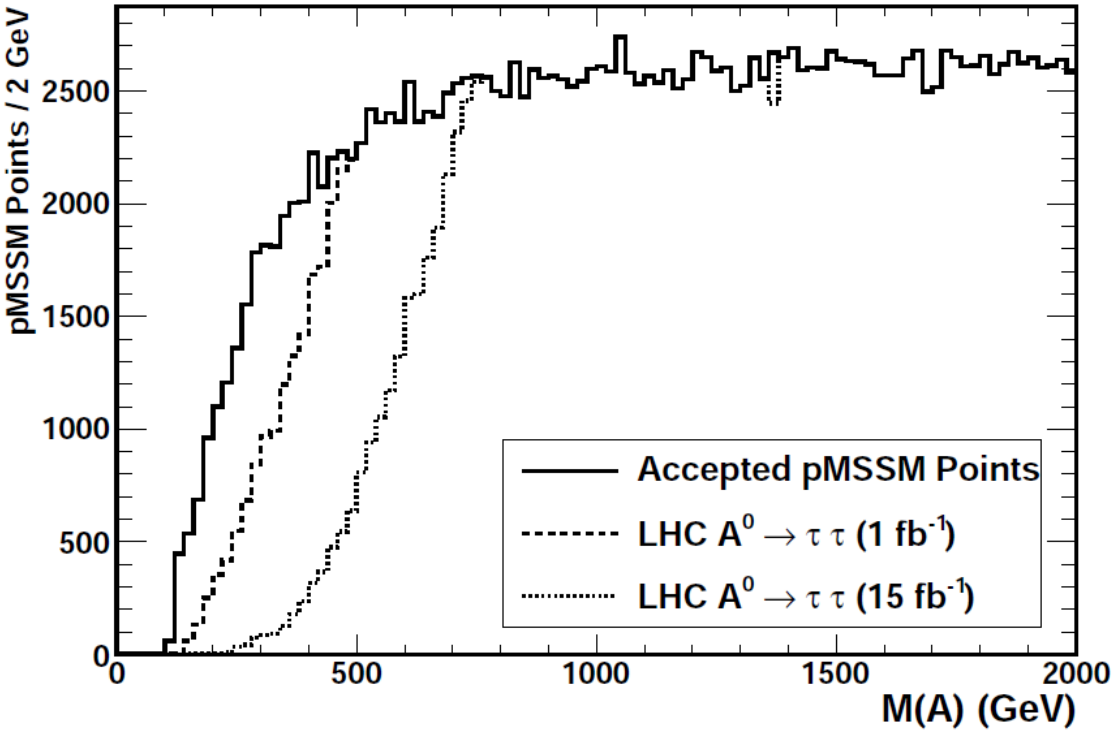
Limits from Z lineshape, LEP-2 and Tevatron searches,
LHC searches: jets + MET (CMS), leptons + MET, b-jets + MET (ATLAS)

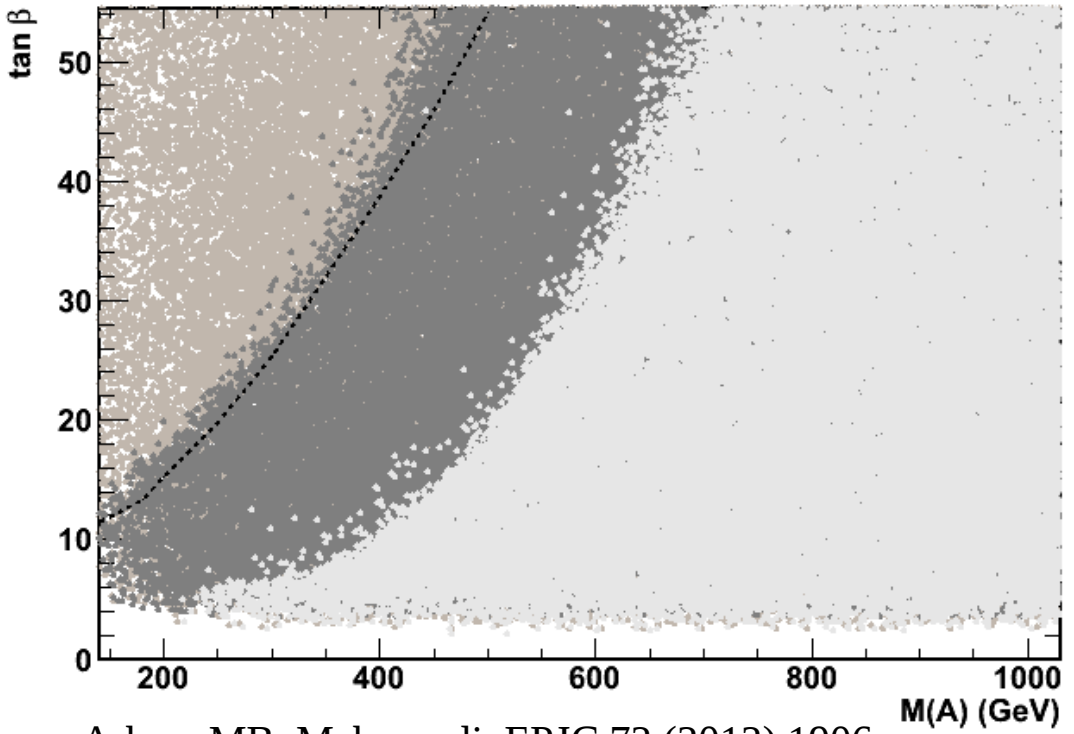
$$\mathrm{BR}(B_s^0 \to \mu^+\mu^-) = (3.2^{+1.5}_{-1.2}) \times 10^{-9}$$

$$10^{-4} < \Omega_\chi h^2 < 0.155$$

$$123\ \mathrm{GeV} \leq M_h \leq 129\ \mathrm{GeV}$$

H/A → τ τ





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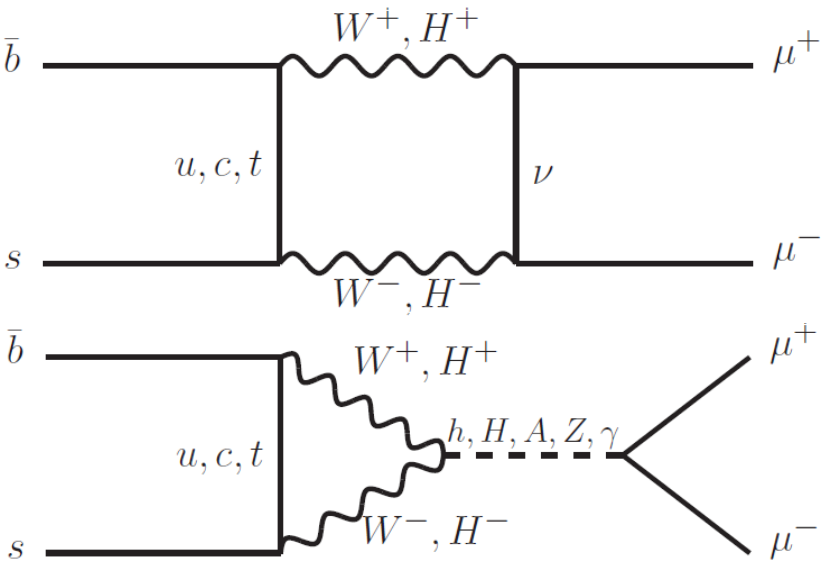
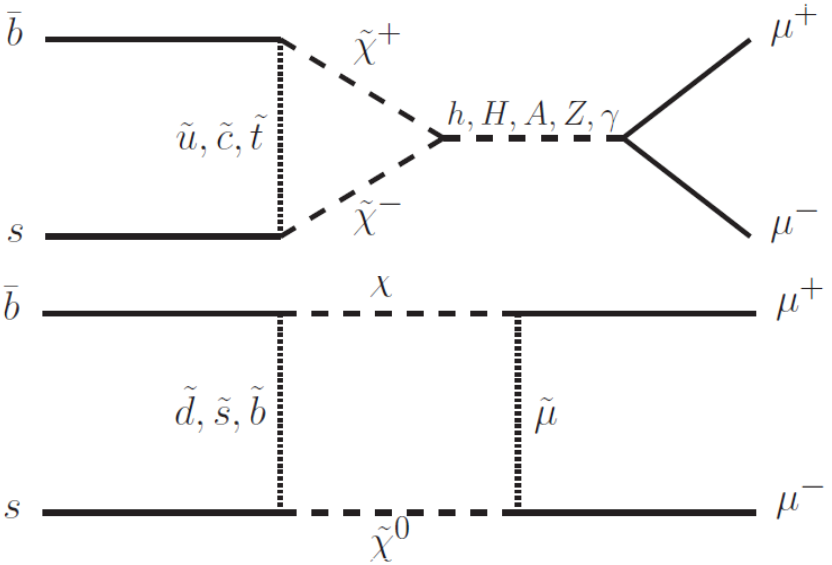
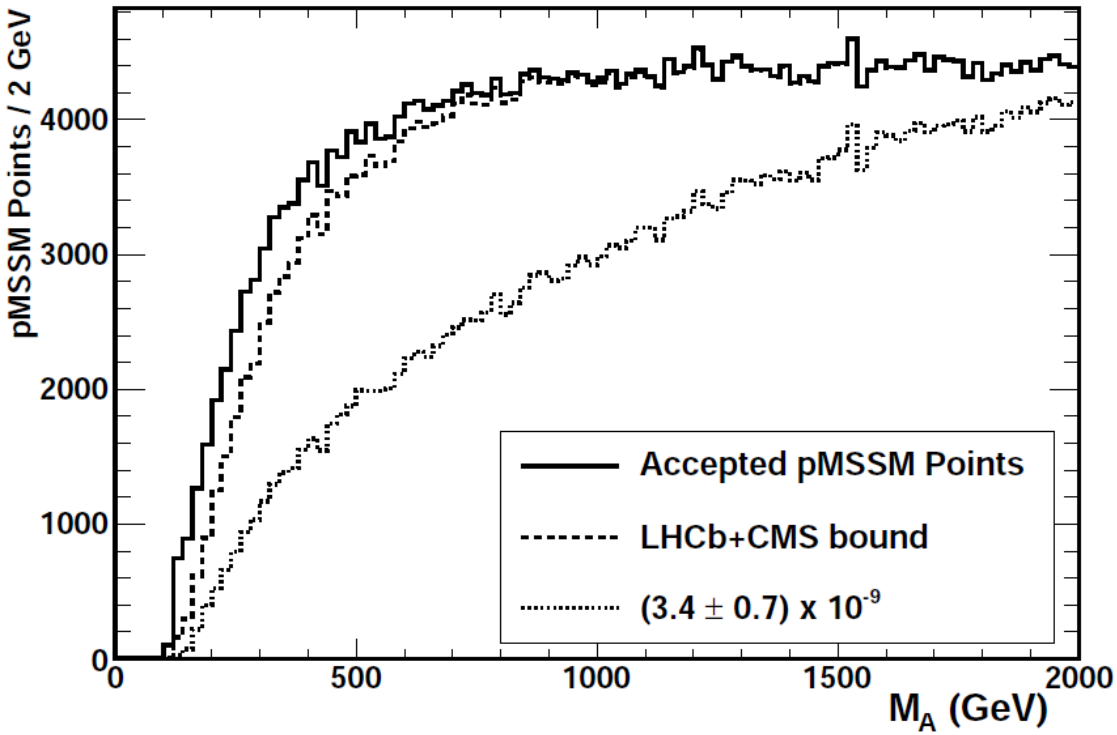
$B^0_s \to \mu\mu$

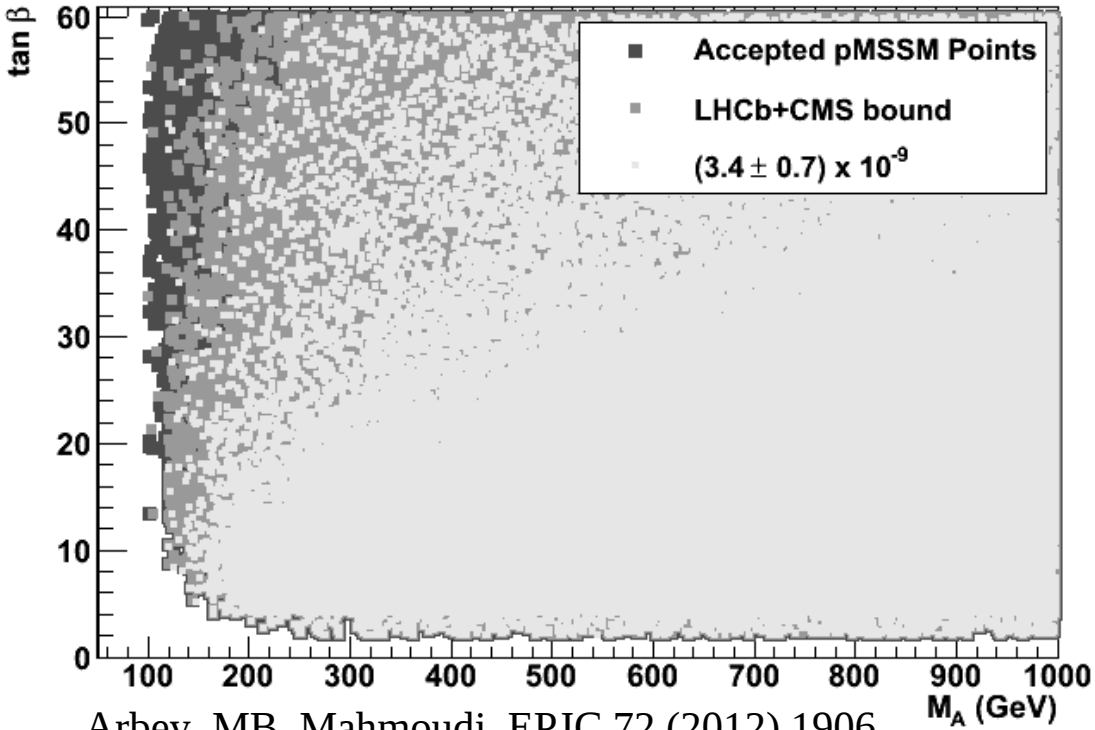


$$\mu A_t \frac{\tan^3\beta}{(1+\epsilon_b \tan\beta)^2} \frac{m_t^2}{m_{\tilde{t}}^2} \frac{m_b m_\mu}{4 s_W^2 M_W^2 M_A^2}$$



Haisch, Mahmoudi, arXiv:1210.7806 [hep-ph]





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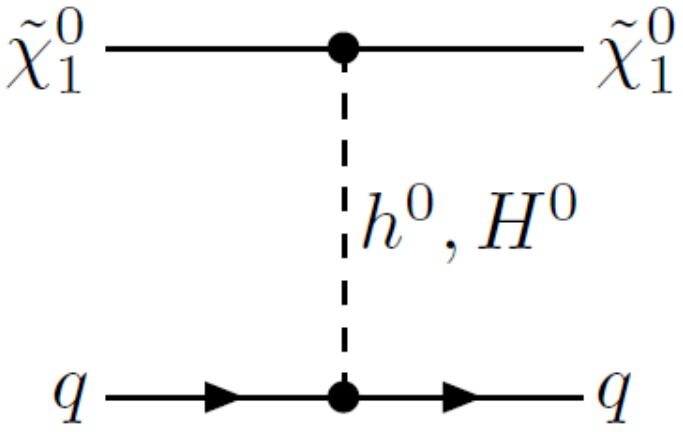
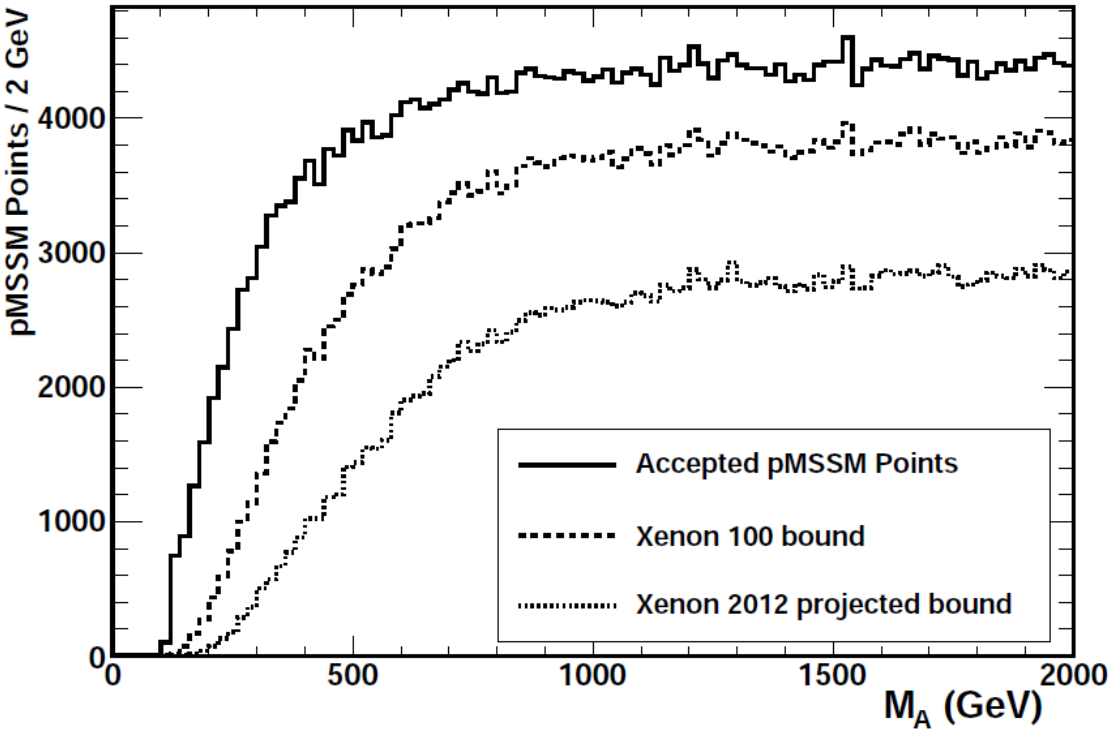
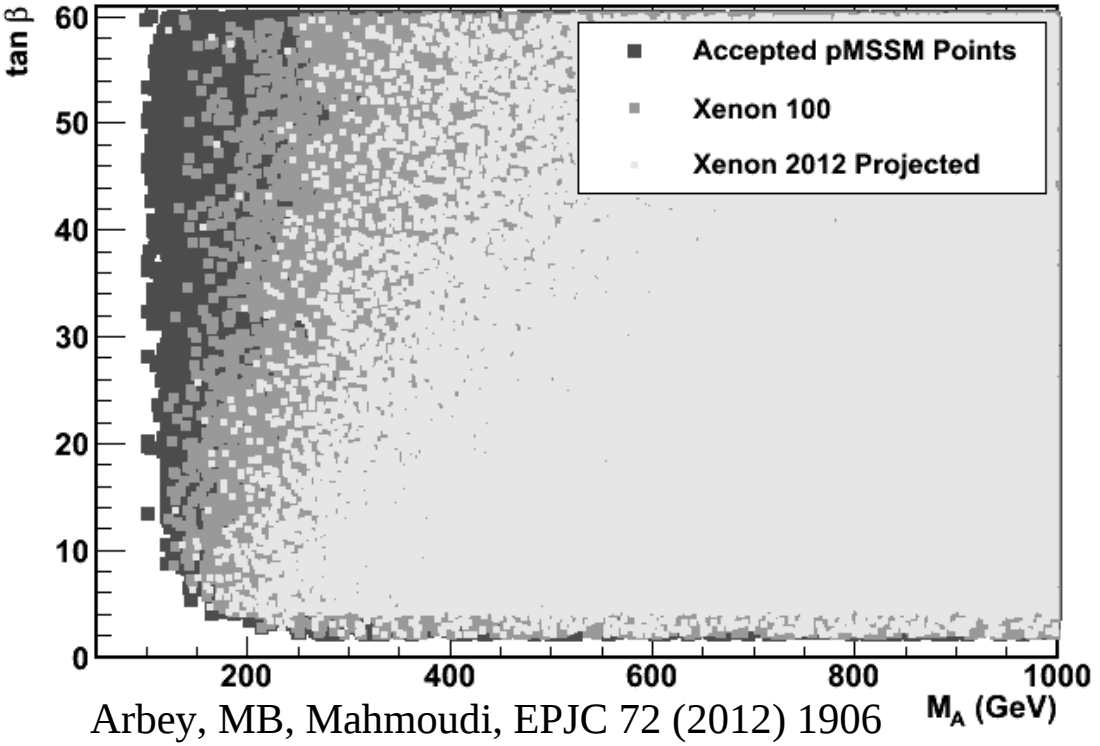
Direct DM Searches







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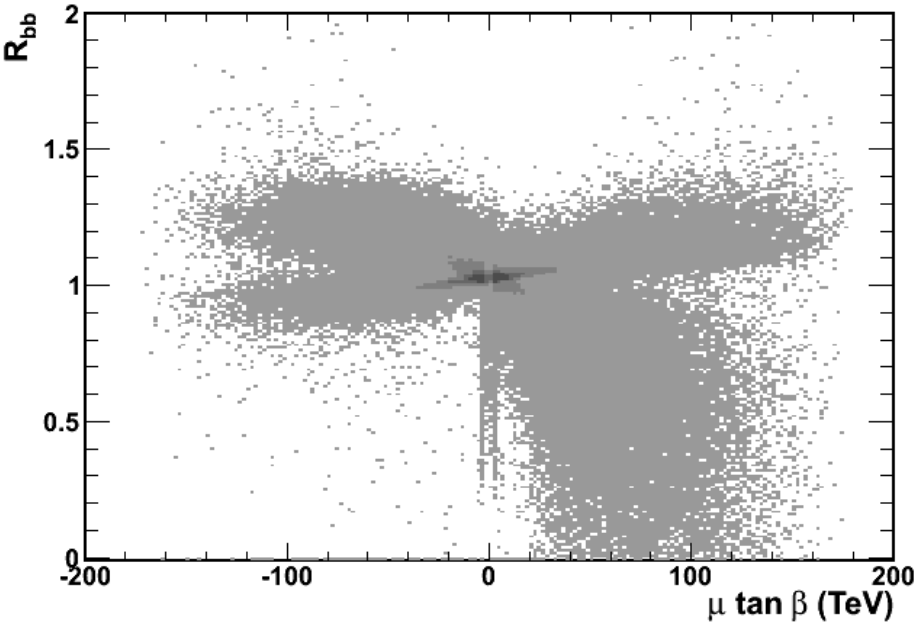
SUSY Effects to Higgs Rates

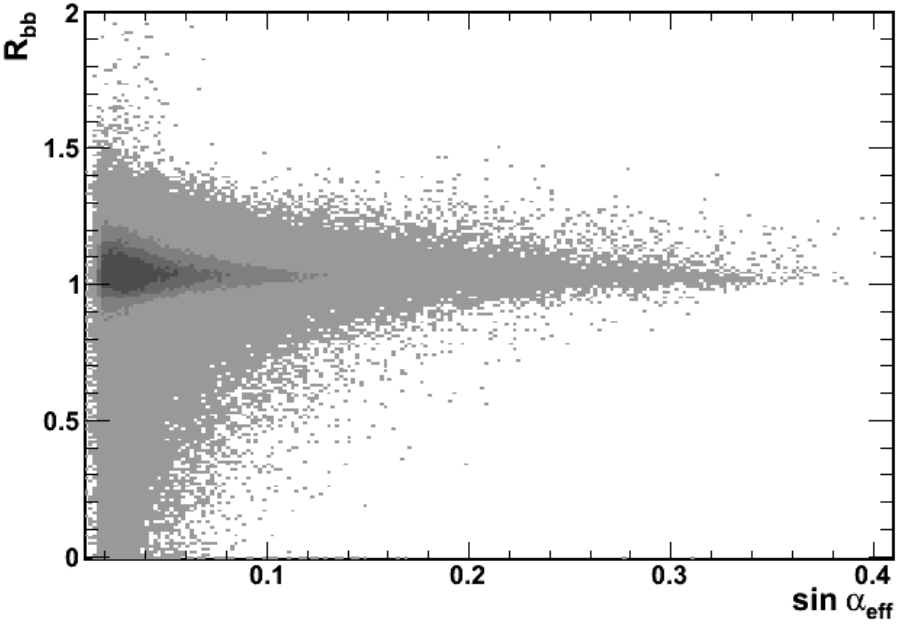
Modification of Higgs width
through bb suppression/enhancement

$$\Delta_b \approx \mu \tan\beta,$$



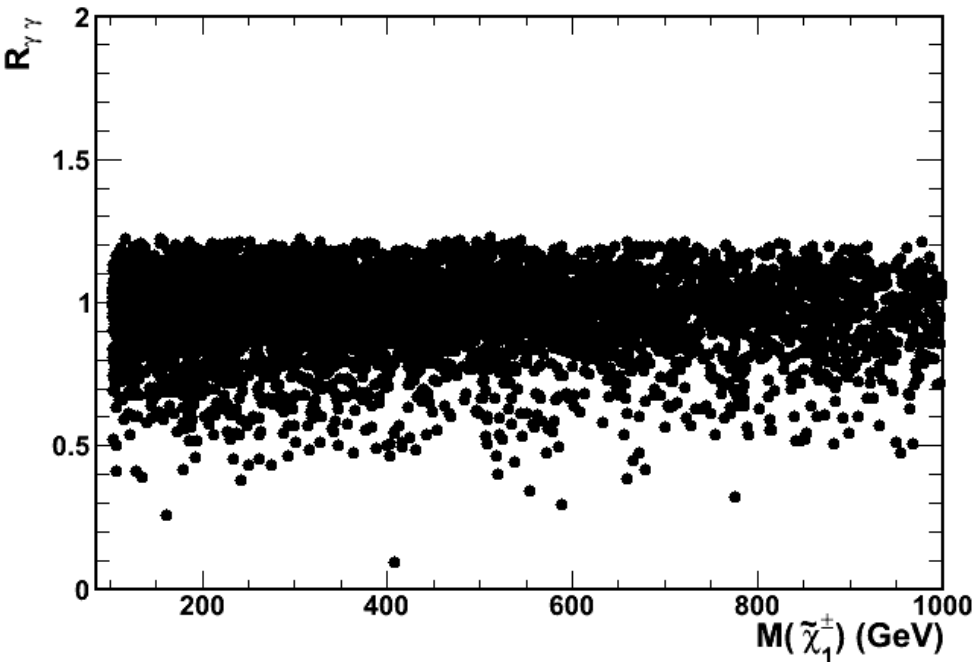
Vanishing coupling regime

$$g_{hb\bar{b}} \approx 1 - \Delta_b/(\tan\alpha_{\rm eff}\tan\beta)$$



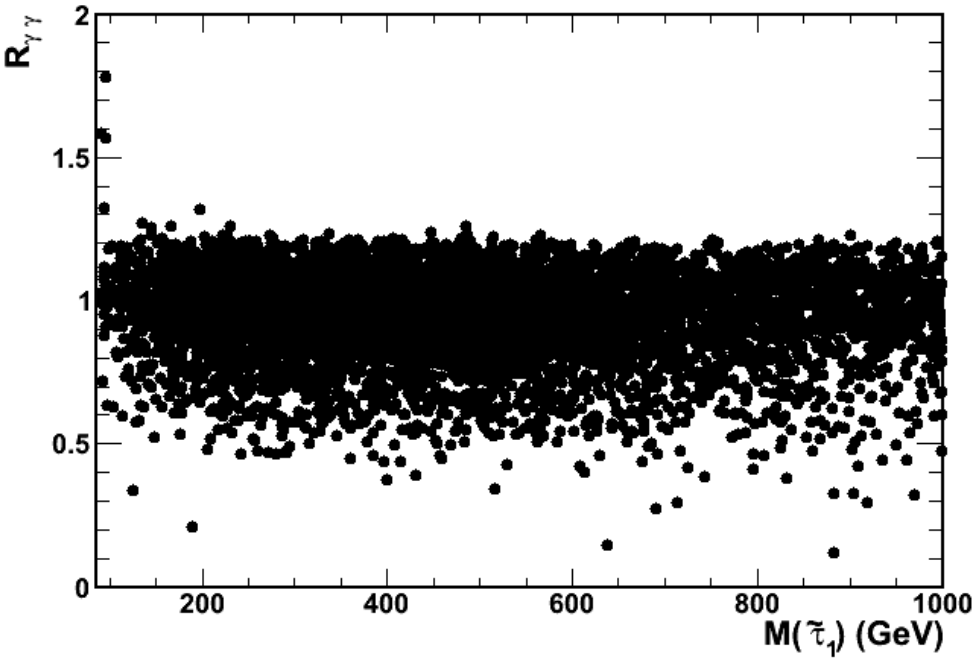
Arbey, MB, Djouadi, Mahmoudi, arXiv:1211.4004 [hep-ph]

Chargino contribution to h → γγ



Stau contribution to h → γγ

$$m_\tau^2 X_\tau^2 / m_{\tilde{\tau}_1}^2 m_{\tilde{\tau}_2}^2$$



Arbey, MB, Djouadi, Mahmoudi, JHEP 1209 (2012) 107

Statistical analysis

Parameter	Value
M_h	126±2 GeV
$\mu_{\gamma\gamma}$	1.66±0.33
μ_{ZZ}	0.93±0.28
μ_{WW}	0.85±0.23
$\mu_{b\bar{b}}$	1.28 ± 0.45
$\mu_{\tau\tau}$	0.71 ± 0.42

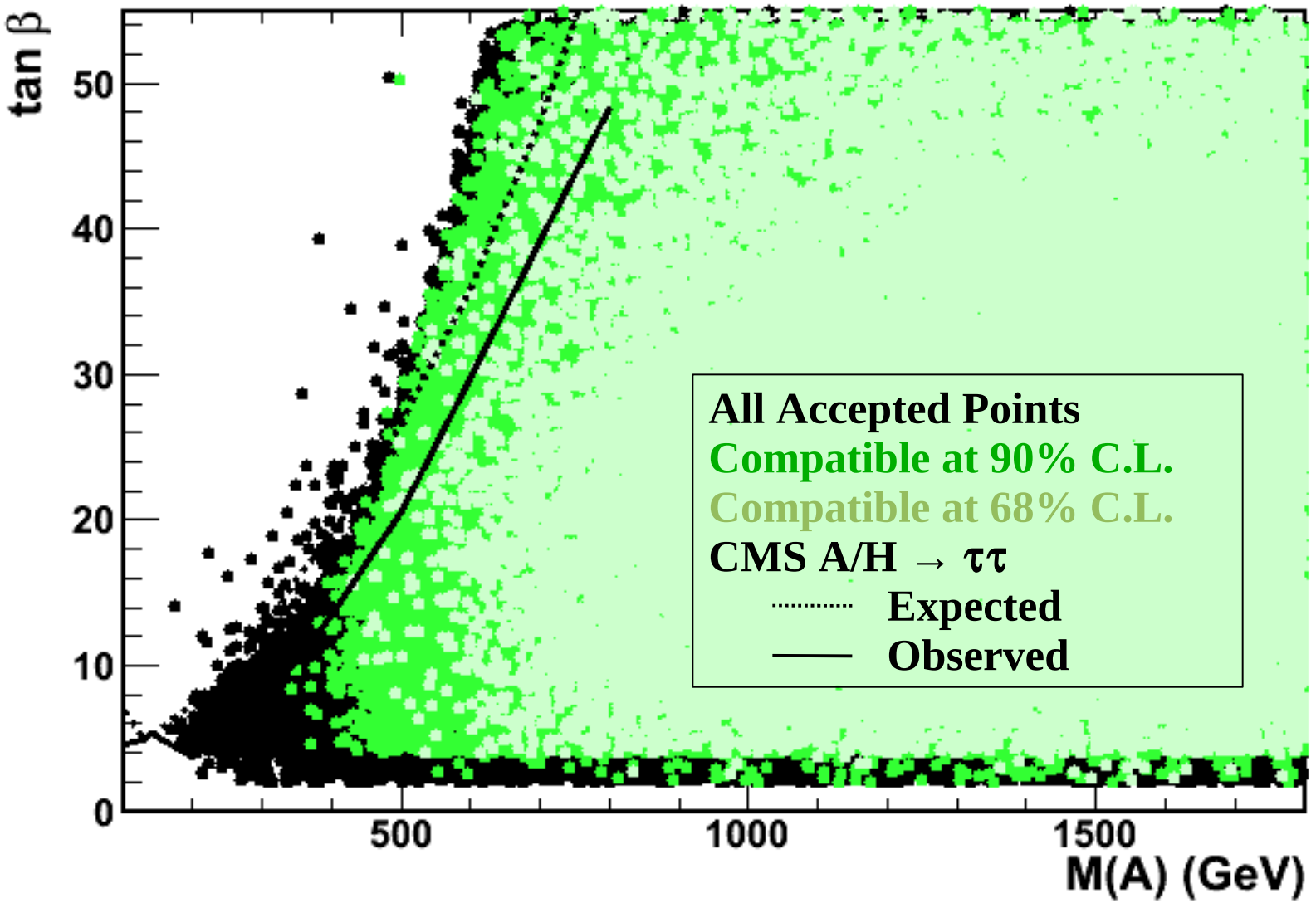
$$\chi^2 = \frac{(M_h(LHC) - M_h(i))^2}{\delta^2[M_h(LHC)] + \delta^2[M_h(th)]} + \sum_j \frac{(\mu_j(LHC) - \mu_j(i))^2}{\delta^2[\mu_j(LHC)] + \delta^2[\mu_j(th)]}$$

Higgs Data @ 90% C.L. 25%

Higgs Data @ 68% C.L. 5.5%

Higgs Data @ 68% C.L. (no syst.) 0.3%

$[M_A, \tan\beta]$



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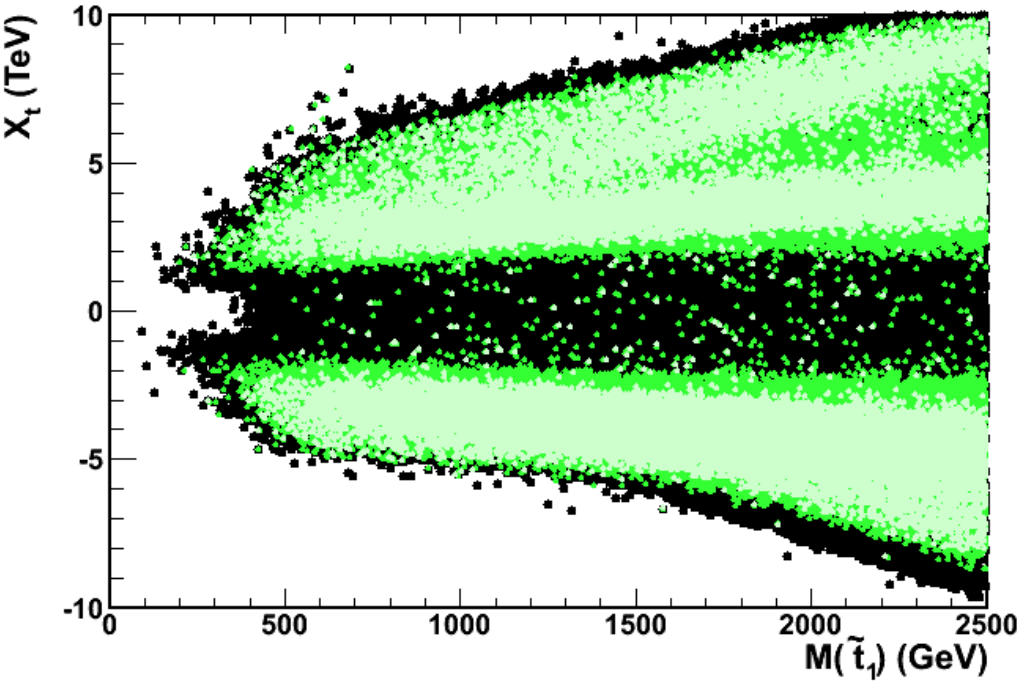
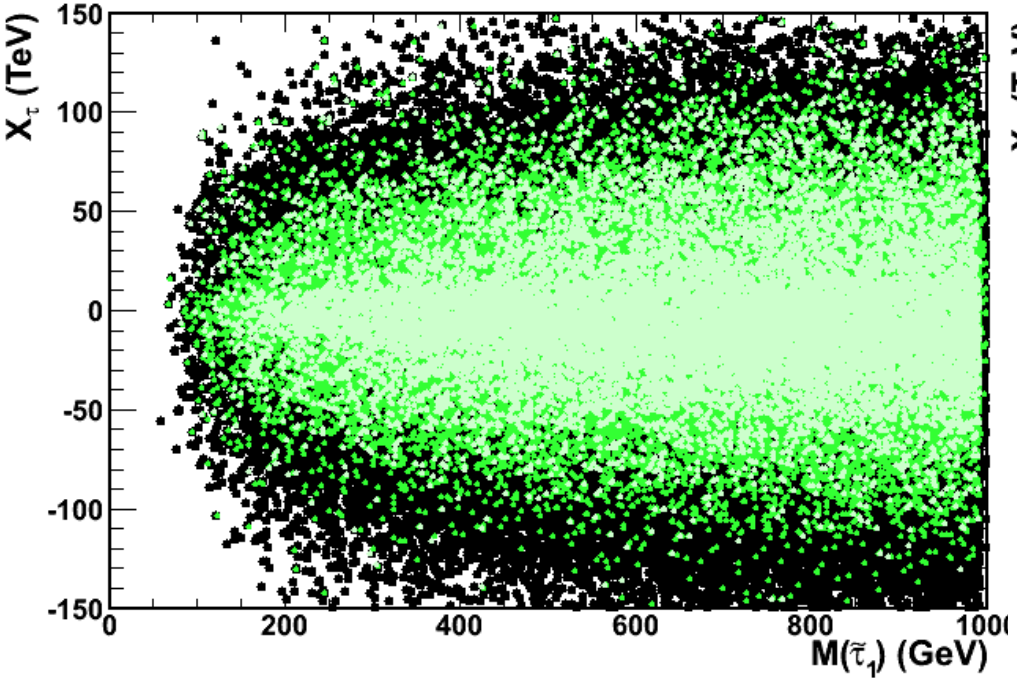
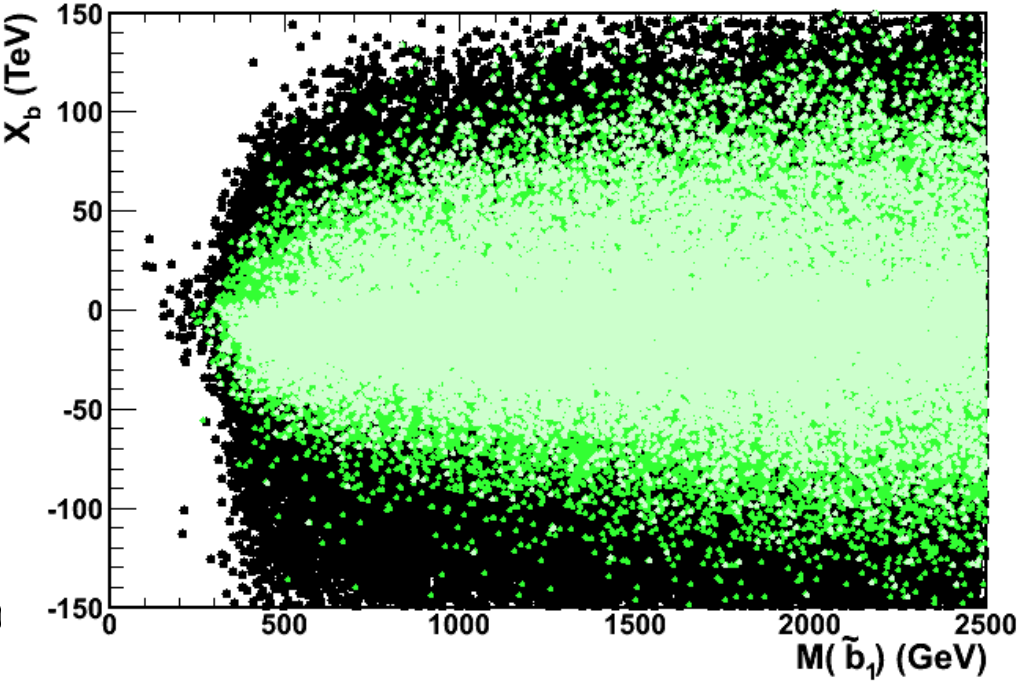
$[X_i, M_i]$ $(i = t, b, \tau)$







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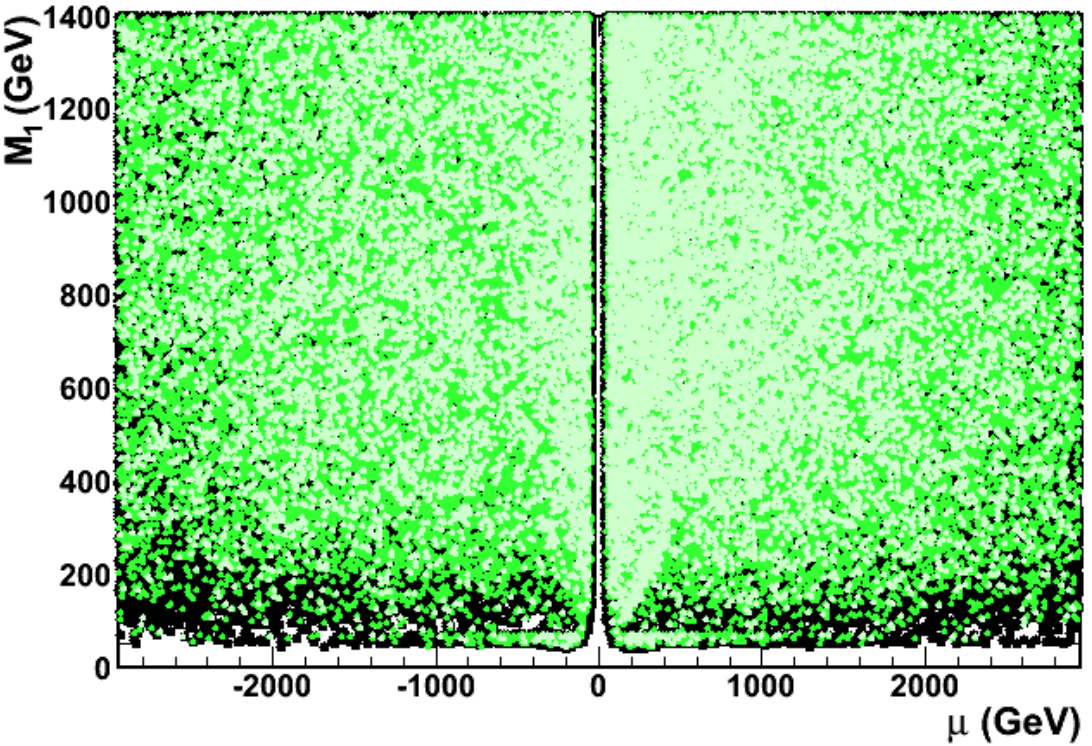
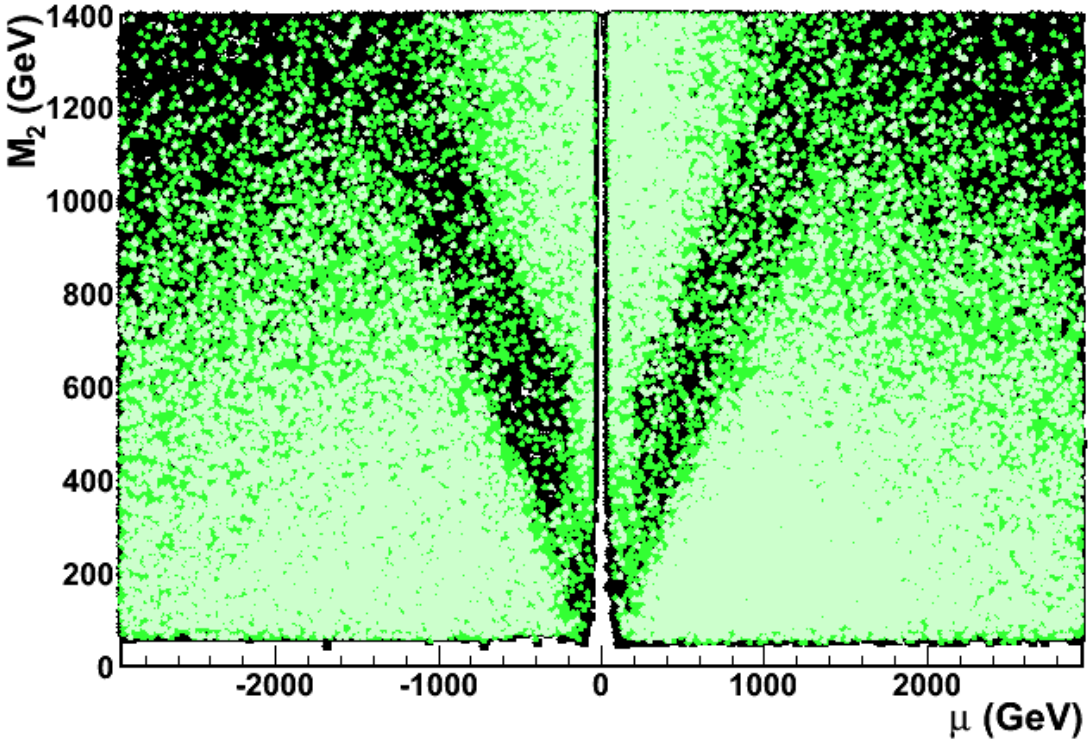
$[M_1, \mu]$

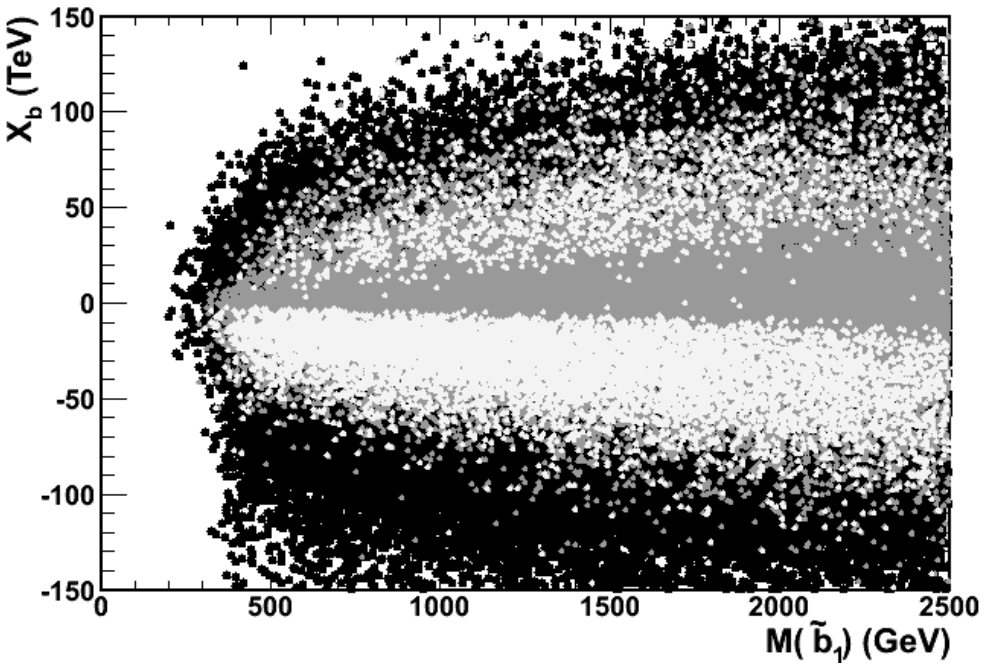

M1 (GeV)
1400
1200
1000
800
600
400
200
0
-2000
-1000
0
1000
2000
μ (GeV)

$[M_2, \mu]$


M2 (GeV)
1400
1200
1000
800
600
400
200
0
-2000
-1000
0
1000
2000
μ (GeV)

ICHEP 2012

Parameter	Value
M_H	125.7±2.1 GeV
$\mu_{\gamma\gamma}$	1.66±0.33
μ_{ZZ}	0.99±0.38
μ_{WW}	0.95±0.35
$\mu_{b\bar{b}}$	<1.64 (95% C.L.)
$\mu_{\tau\tau}$	<1.06 (95% C.L.)



Arbey, MB, Djouadi, Mahmoudi, JHEP 1209 (2012) 107

HCP 2012

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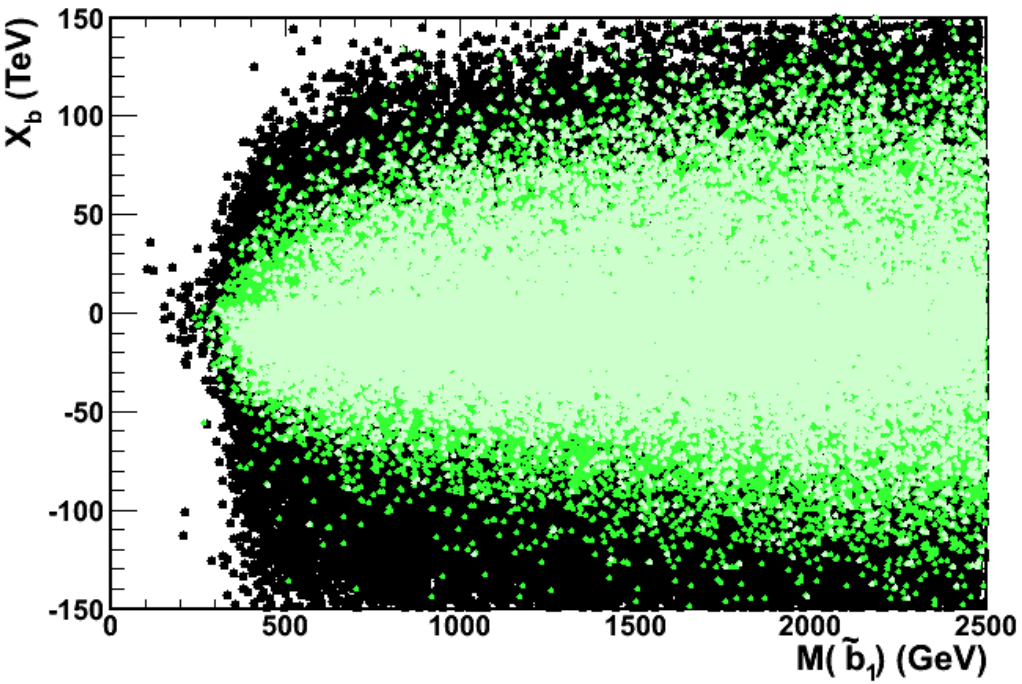

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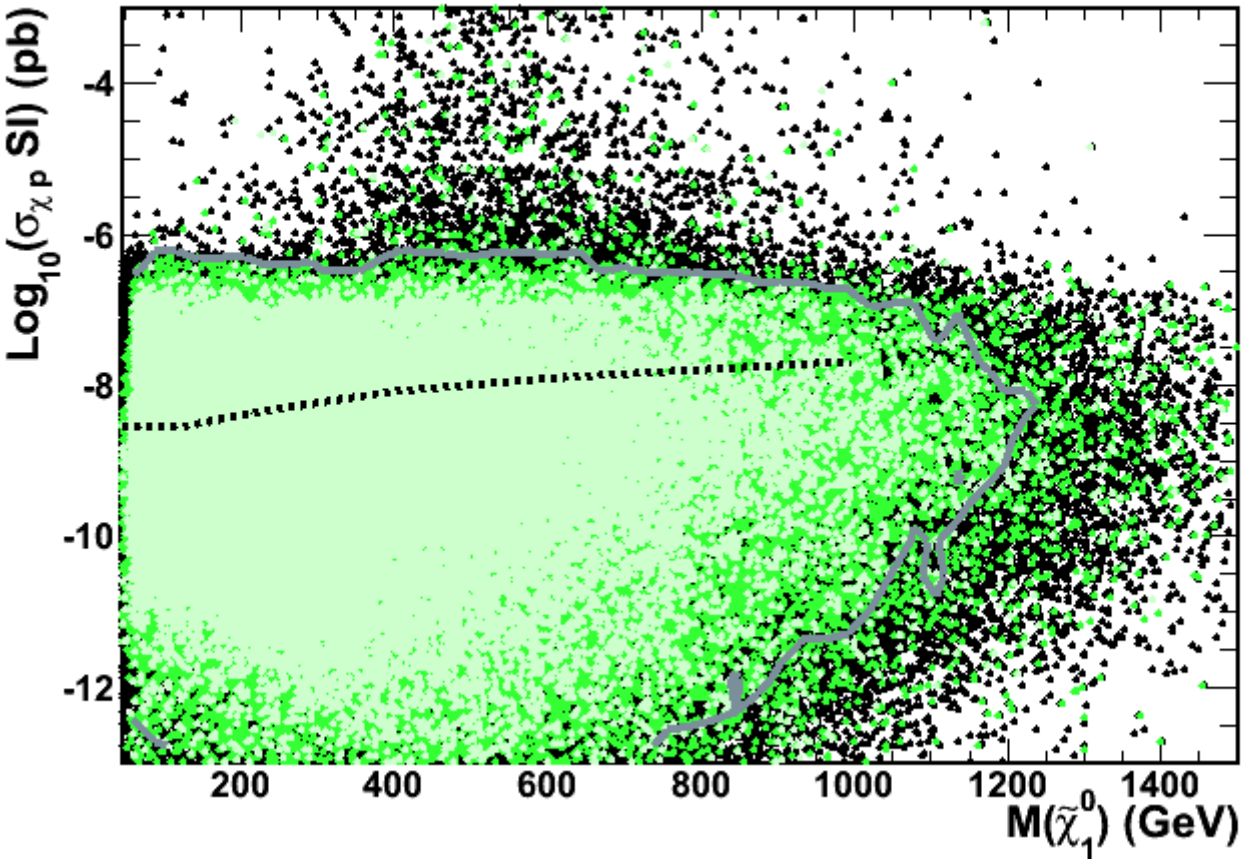
Higgs Results and Direct DM Searches



XENON 100 - 225 live days limit coverage of accepted pMSSM points

All accepted	28%
Higgs Data @ 90% C.L.	24%
Higgs Data @ 68% C.L.	15%

What have we learned so far ?

Higgs mass and signal strengths provide significant constraints on SUSY parameters if we interpret 126 GeVsignal as lightest SUSY h state;

Data on μ values not settled yet, discrepancies between experiments cover range of SUSY effects;

Possible enhancement of $\gamma\gamma$ rate interesting for its implications on Γ_h and/or chargino/stau contributions;

Data on bb and $\tau\tau$ channels essential for constraining width and understanding origin of (possible) enhancements;

Present data support SUSY in decoupling regime with heavy pseudo-scalar A^0, confirmed by limits of direct $H/A \rightarrow \tau\tau$ searches;

Important interplay of Higgs results with flavour physics ($B_s \rightarrow \mu\mu$) and dark matter direct detection experiments.

Many thanks for the hospitality !