Implications of Higgs searches for MSSM

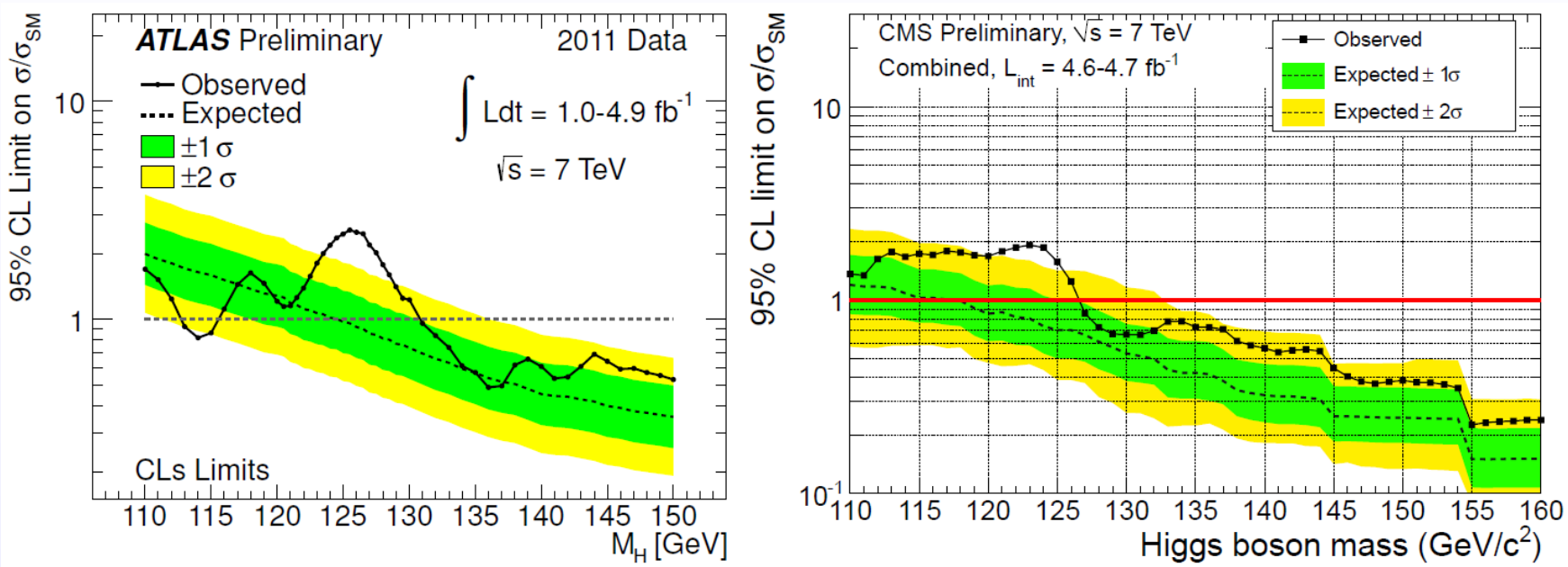
Nazila Mahmoudi

CERN TH & LPC Clermont-Ferrand (France)

In collaboration with A. Arbey, M. Battaglia & A. Djouadi

LPSC, January 30, 2012

ATLAS and CMS excess around 125 GeV



ATLAS-CONF-2011-163, CMS PAS HIG-11-032

Excess around 125 GeV seen by both ATLAS and CMS

No evidence however...

ATLAS exclusion at 95% C.L.: 112.7–115.5 ; 131–237 ; 251–468 GeV

CMS exclusion at 95% C.L.: 127–600 GeV

Two possible scenarios

We consider two scenarios:

- The light Higgs boson is discovered with a mass of about 125 GeV.
- No Higgs is discovered by the end of 2012.

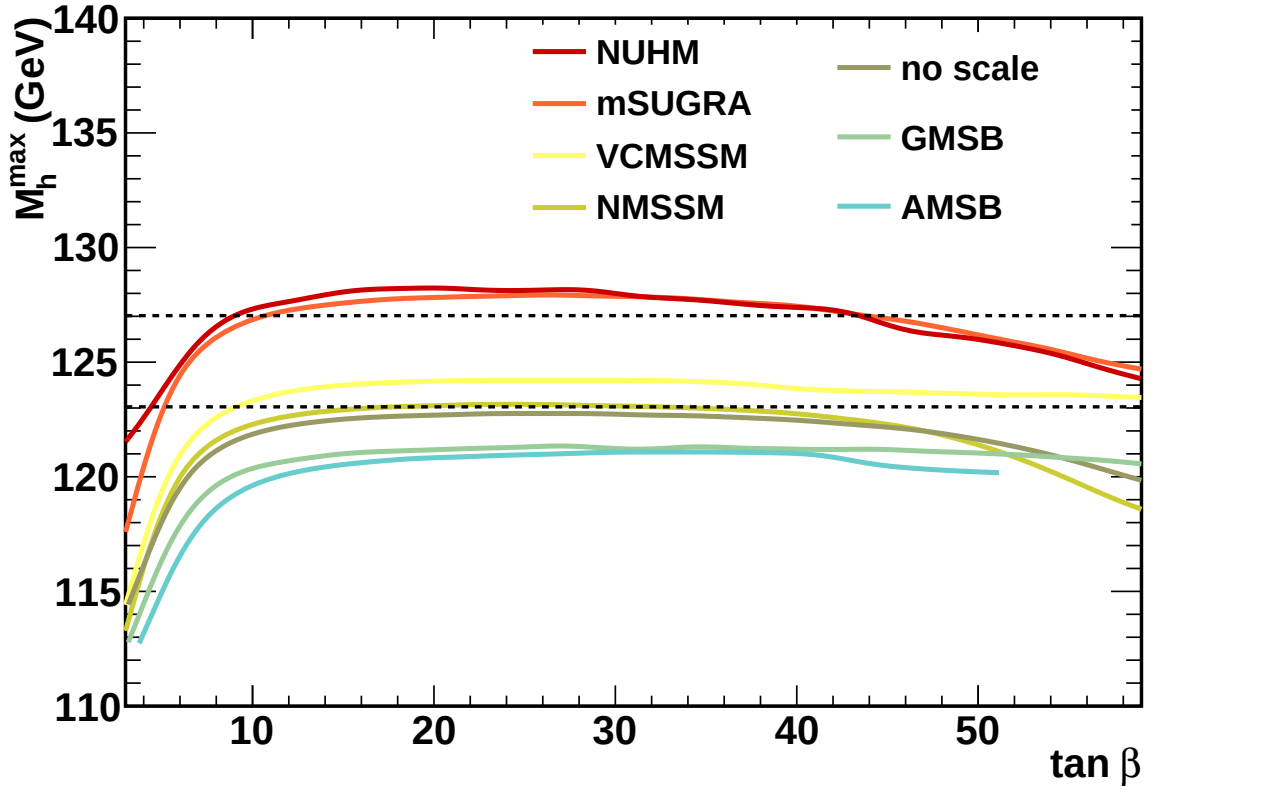
Case 1: the light Higgs is discovered at 125 GeV.

- In the SM, the Higgs mass is essentially a free parameter
- In the MSSM, the lightest CP-even Higgs particle is bounded from above:
  $M_h^{max} \approx M_Z |\cos 2\beta| +$ radiative corrections $\lesssim 110 - 135$ GeV
- Imposing M_h places very strong constraints on the MSSM parameters through their contributions to the radiative corrections

  $\rightarrow$ Calculation of M_h^{max} in different constrained scenarios

- Important parameters for MSSM Higgs mass:
  - $\tan\beta$ and M_A
  - the SUSY breaking scale $M_S = \sqrt{m_{\tilde{t}_1} m_{\tilde{t}_2}}$
  - the mixing parameter in the stop sector $X_t = A_t - \mu \cot\beta$
- M_h^{max} is obtained for:
  - a decoupling regime with a heavy pseudoscalar Higgs boson, $M_A \sim \mathcal{O}(\text{TeV})$
  - large $\tan\beta$, *i.e.* $\tan\beta \gtrsim 10$
  - heavy stops, *i.e.* large M_S
  - maximal mixing scenario, *i.e.* $X_t = \sqrt{6} M_S$
- In contrast, much smaller M_h^{max} values for the no-mixing scenario, *i.e.* $X_t \approx 0$.

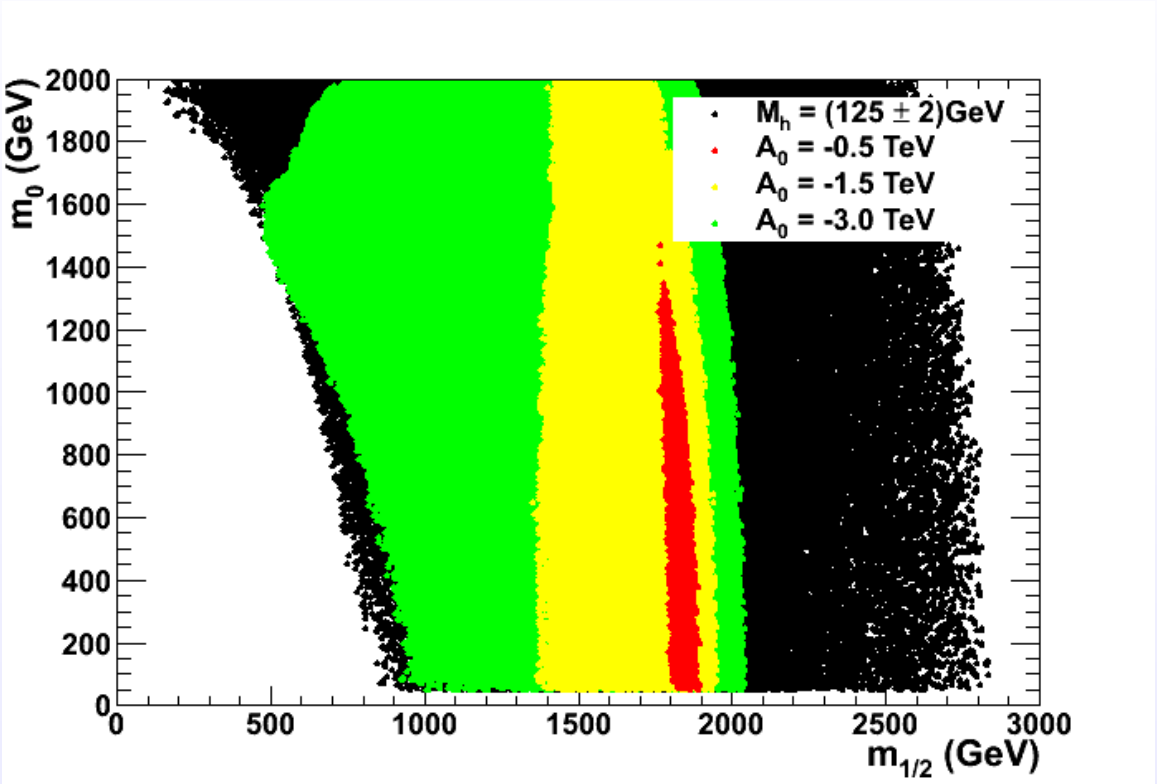
Maximal Higgs masses



A. Arbey, M. Battaglia, A. Djouadi, F.M., J. Quevillon, Phys.Lett. B708 (2012) 162

End of AMSB and GMSB in their minimal versions

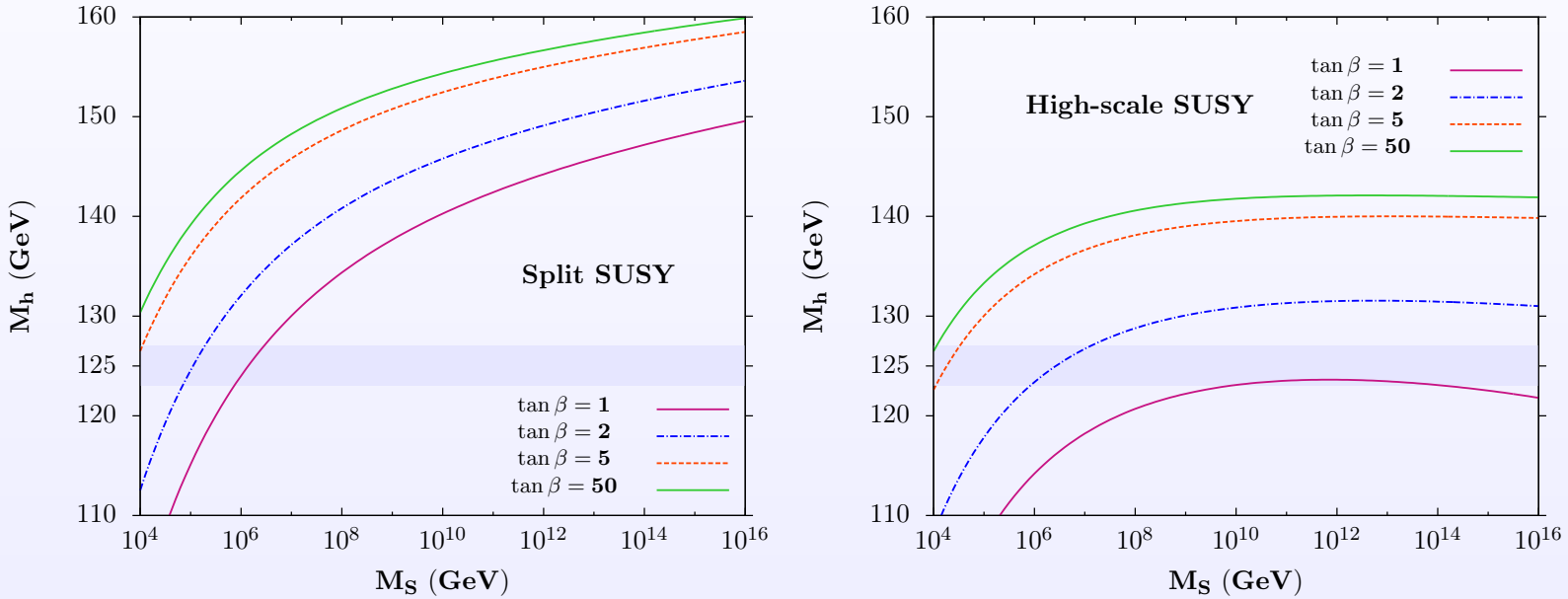
Higgs mass between 123 and 127 GeV in the CMSSM



A. Arbey, M. Battaglia, A. Djouadi, F.M., J. Quevillon, Phys.Lett. B708 (2012) 162

mSUGRA/CMSSM still survives, but only for negative values of A_0

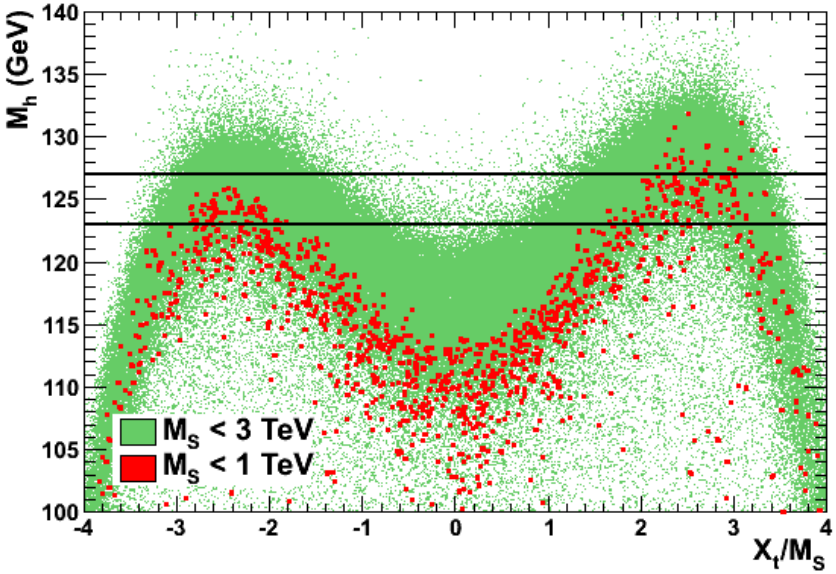
Consequences of a 125 GeV Higgs boson on high scale SUSY scenarios

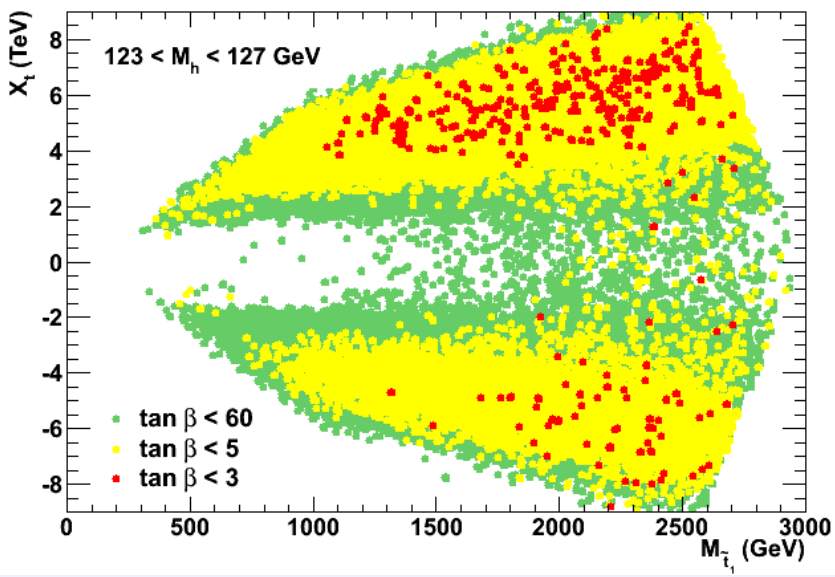


A. Arbey, M. Battaglia, A. Djouadi, F.M., J. Quevillon, Phys.Lett. B708 (2012) 162

Very strong constraints on Split-SUSY and High-scale SUSY

Consequences of a 125 GeV Higgs boson on pMSSM





A. Arbey, M. Battaglia, A. Djouadi, F.M., J. Quevillon, Phys.Lett. B708 (2012) 162

A large part of the pMSSM still survives

No mixing cases ($X_t \approx 0$) excluded for $M_S < 1$ TeV

Small stop masses still allowed

Case 2: no Higgs is discovered by the end of 2012

Constraining the pMSSM through the Higgs sector

- Previous studies addressed constraints on SUSY through squark and gluino searches.
- Viable solutions for masses well above sensitivity of 7 TeV run
- Not sufficient, approach the question from other directions

  $\rightarrow$ interplay between flavour, dark matter and direct searches in the Higgs sector

Constraints on MSSM in the Higgs sector

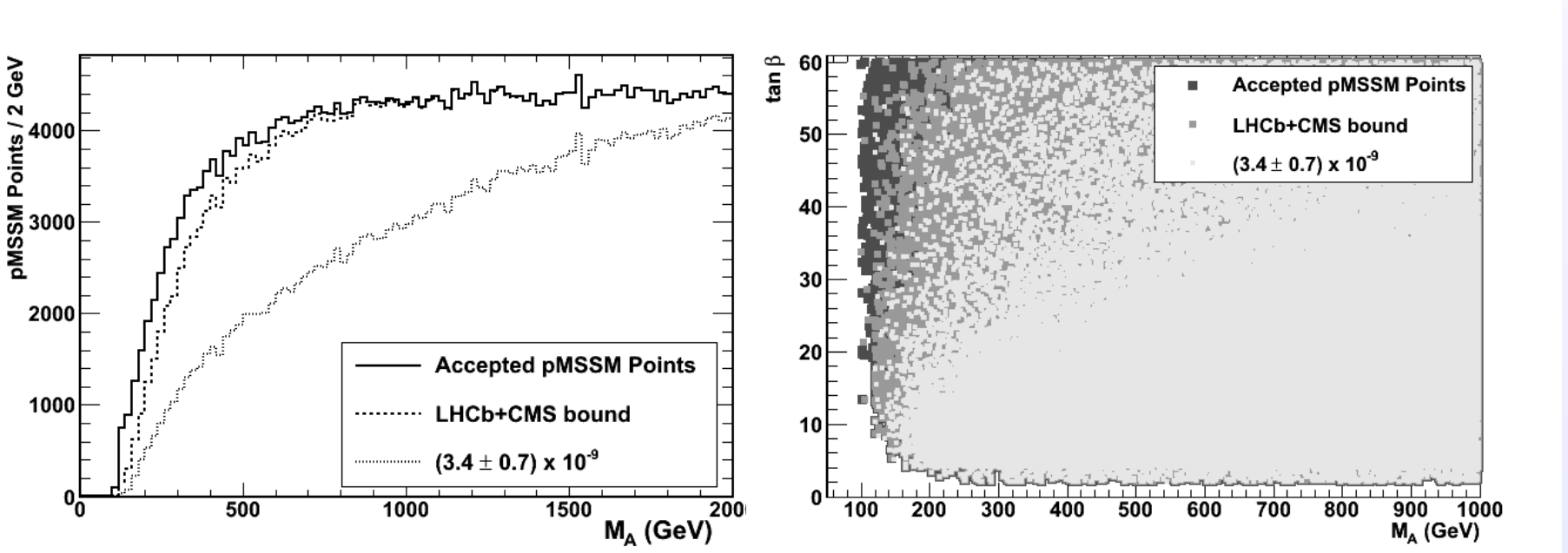
- From BR($B_s \to \mu^+\mu^-$)
  very sensitive to M_A and $\tan\beta$
  very promising experimental situation
- From dark matter direct detection
  also sensitive to M_A
  many results from independent experiments
- From Higgs searches
  direct constraints on M_A from $A \to \tau\tau$
  and $h^0 \to \gamma\gamma$ and $h^0 \to WW$ searches.

Considering 2 scenarios:

- Current bound from LHCb+CMS + estimated th syst:

$$\mathrm{BR}(B_s \to \mu^+\mu^-) < 1.26 \times 10^{-8}$$

- SM like branching ratio with estimated 20% total uncertainty

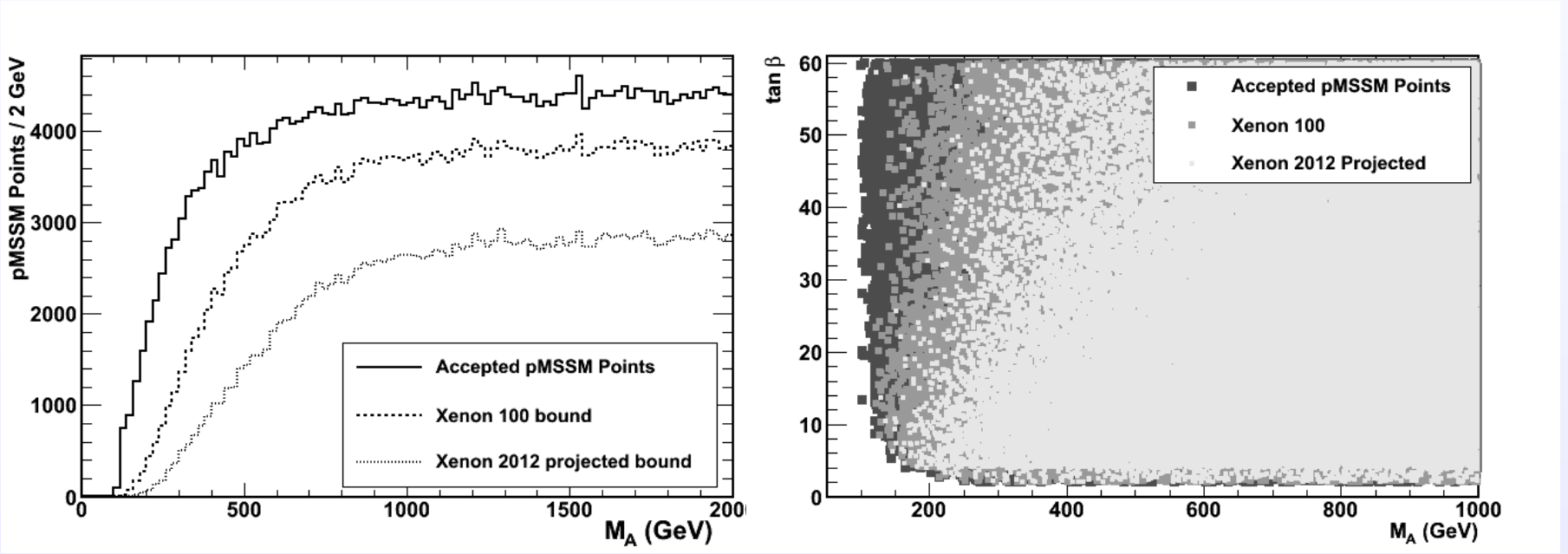


A. Arbey, M. Battaglia, F.M., arXiv:1112.3032

Light M_A strongly constrained!

Considering 2 scenarios:

- Current Xenon 100 limit
- Projected 2012 90% C.L. upper limit

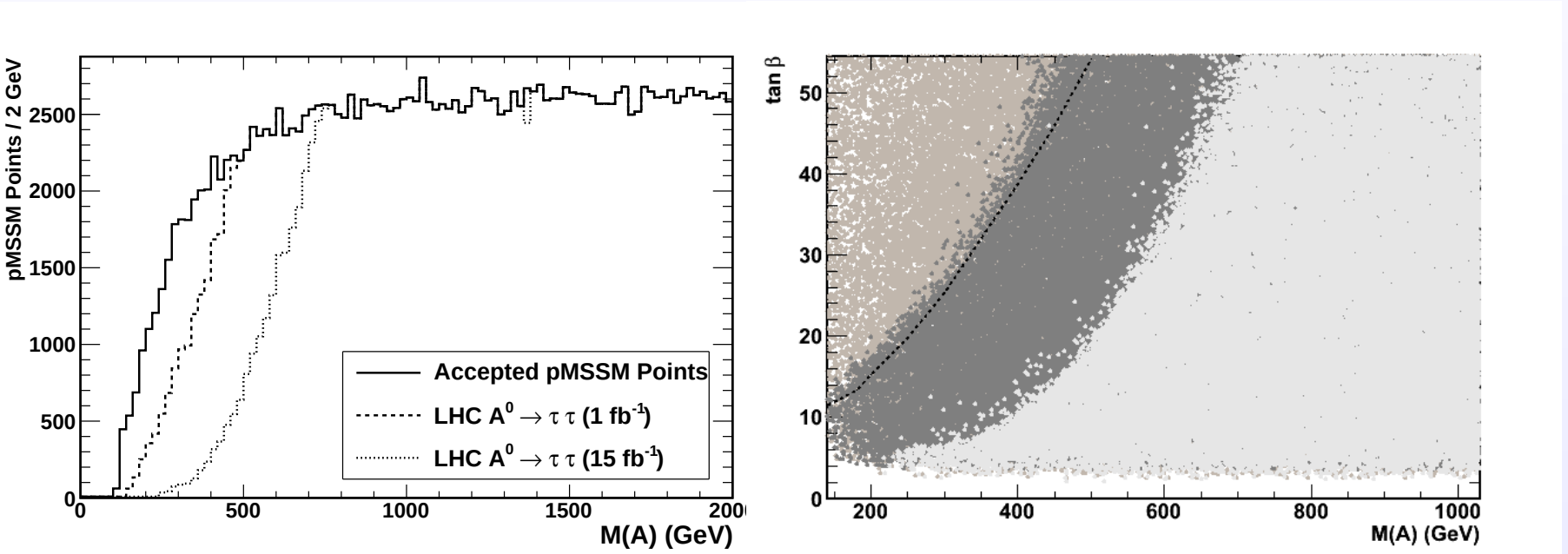


A. Arbey, M. Battaglia, F.M., arXiv:1112.3032

Again light M_A strongly constrained!

Direct searches for $A \to \tau\tau$ CMS-PAS-HIG-11-009

Allowed region of $(M_A, \tan\beta)$ from full pMSSM scans for 1.1 and 15 fb^{-1} compared to published CMS expected limit



A. Arbey, M. Battaglia, F.M., arXiv:1112.3032

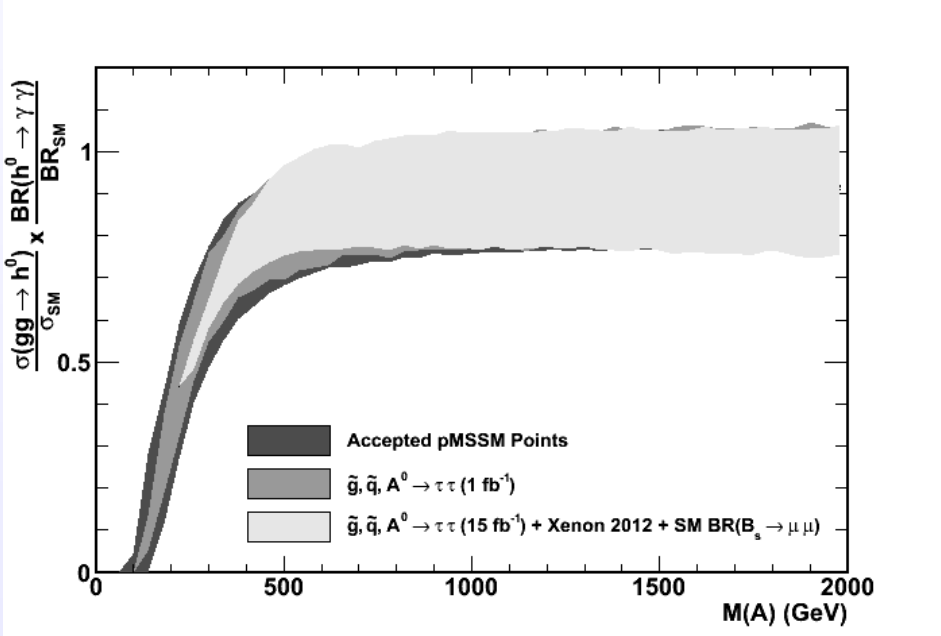
Low M_A region below 350 GeV can be explored and excluded if no signal except a narrow strip around $\tan\beta$ =5.

Higgs coupling suppression

- Study of $\sigma\times$ BR suppression wrt SM with pMSSM scans (with $M_{\chi_1^0} > 46$ GeV) for $\gamma\gamma$ and WW final states

- Present suppression factor vs M_A for all accepted pMSSM points compatible with 1 fb^{-1} LHC data ($\tilde{g}, \tilde{q}$ and BR($B_s \to \mu^+\mu^-$)) and XENON 100 results;

- And projected 2012 data assuming SM value for BR($B_s \to \mu^+\mu^-$).

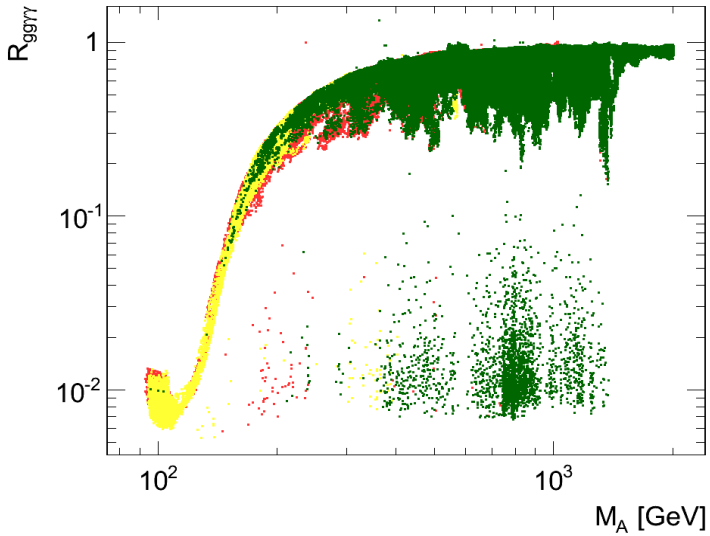


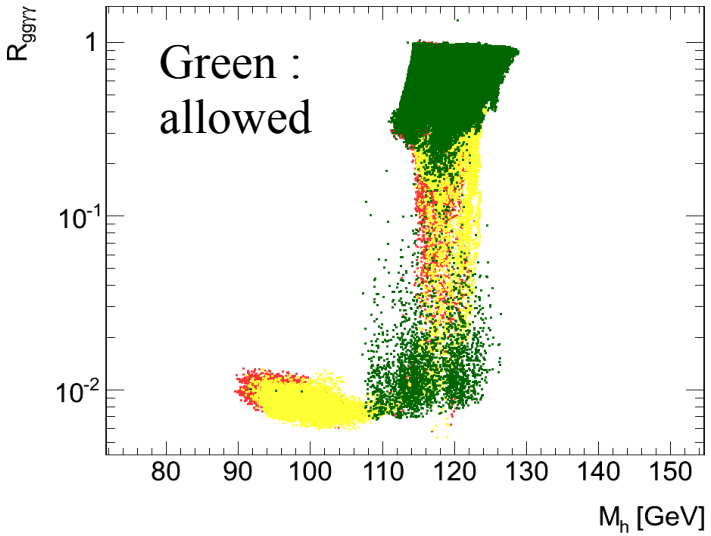
A. Arbey, M. Battaglia, F.M., Eur.Phys.J. C72 (2012) 1847

Similar behaviour for $h \to WW$ but larger experimental systematics in the 120 GeV region

MSSM - light neutralinos

- Invisible decays of the Higgs can lead to large reduction in ggɣɣ
- MCMC fit to MSSM (11 parameters) including DM constraints (WMAP+Xenon100+FermiLAT)





Albornoz Vasquez et al, 1112.2200

1

Conclusion

- The Higgs sector can play an important role in constraining SUSY
- Several constrained MSSM scenarios can be ruled out by a Higgs discovery at 125 GeV
- The CMSSM still provides viable solutions with $A_0 < 0$
- General MSSM: A lot of viable model points survive, but combining with flavour and dark matter sector information, one can squeeze the parameter space