

# Constraints and scenarios at the end of the 7 TeV run from pMSSM scans

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**Thanks to A. De Roeck for discussions**

Implications of LHC results for TeV-scale physics - WG2 meeting  
CERN, 31 October 2011

# Motivations

## Going beyond constrained MSSM scenarios

- take the most general CP/R-parity conserving MSSM  
⇒ phenomenological MSSM (pMSSM) with 19 parameters  
see talks by: Marco Battaglia  
Tom Rizzo  
Sezen Sekmen  
in the previous meeting
- Allow for a more general study of SUSY features and signatures
- Interplay between low energy observables, relic density, direct dark matter searches and the LHC

# pMSSM scans

Flat scans over the pMSSM 19 parameters.

Using many codes: SuperIso Relic, SoftSusy, FeynHiggs, Hdecay, Sdecay, Higgsbounds, Micromegas, Prospino, Pythia and Delphes, with **SuperIso** as the central core.

$2.16 \times 10^{-4} < \text{BR}(B \rightarrow X_s \gamma) < 4.93 \times 10^{-4}$
$\text{BR}(B_s \rightarrow \mu^+ \mu^-) < 1.26 \times 10^{-8}$
$0.56 < R(B \rightarrow \tau \nu) < 2.70$
$4.7 \times 10^{-2} < \text{BR}(D_s \rightarrow \tau \nu) < 6.1 \times 10^{-2}$
$2.9 \times 10^{-3} < \text{BR}(B \rightarrow D^0 \tau \nu) < 14.2 \times 10^{-3}$
$0.985 < R_{\mu 23}(K \rightarrow \mu \nu) < 1.013$
$-2.4 \times 10^{-9} < \delta a_\mu < 4.5 \times 10^{-9}$
$10^{-4} < \Omega_\chi h^2 < 0.135$
+ sparticle mass upper bounds
+ Higgs search limits

Details of the scans and first results can be found in:

A. Arbey, M. Battaglia, F.M., [arXiv:1110.3726](https://arxiv.org/abs/1110.3726)

# In this talk:

- 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
  - Now approach the question from other directions
    - interplay between flavour, dark matter and direct searches in the Higgs sector
- Light neutralino scenario
  - Is it possible to have light neutralinos still compatible with the LHC results?
  - At the same time compatible with dark matter direct detection experiment results?
    - interplay between dark matter and direct searches

# Further constraints on the pMSSM

## Constraints on MSSM in the Higgs sector

- From  $\text{BR}(B_s \rightarrow \mu^+ \mu^-)$   
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  $A \rightarrow \tau\tau$   
and  $h^0 \rightarrow \gamma\gamma$  and  $h^0 \rightarrow WW$  searches.

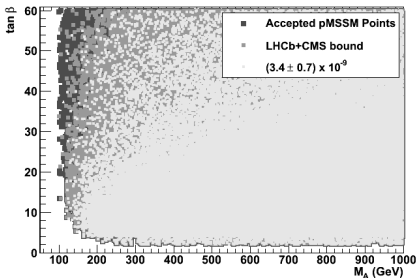
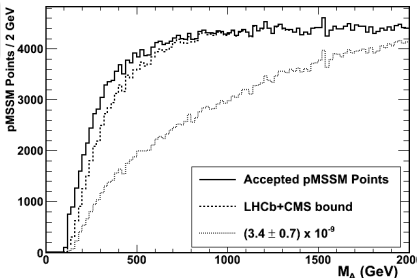
# Sensitivity to $M_A$ from $\text{BR}(B_s \rightarrow \mu^+ \mu^-)$

Considering 2 scenarios:

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

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

- SM like branching ratio with estimated 20% total uncertainty

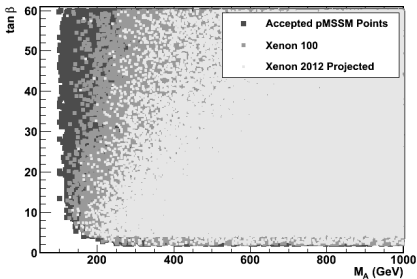
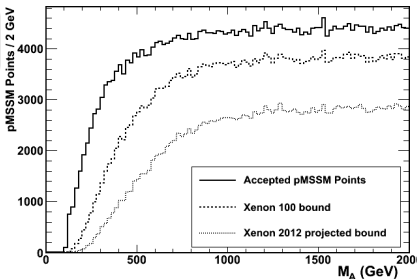


**Light  $M_A$  strongly constrained!**

# Dark matter direct detection

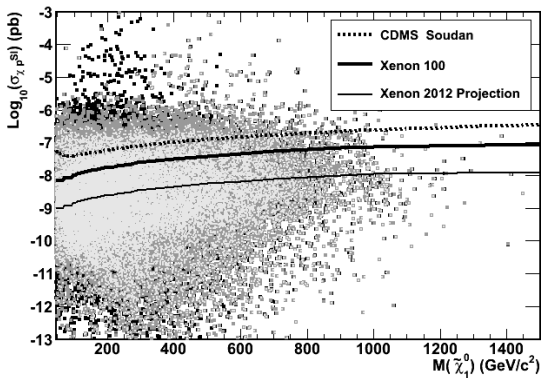
Considering 2 scenarios:

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



**Again light  $M_A$  strongly constrained!**

# Dark matter direct detection and LHC limits



arXiv:1110.3726

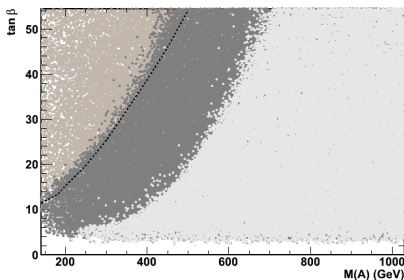


# Higgs searches

Direct searches for  $A \rightarrow \tau\tau$

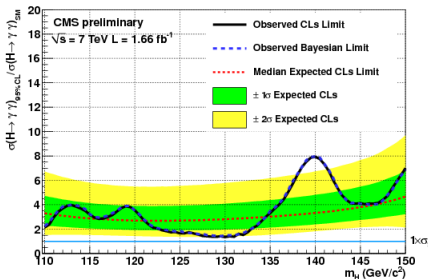
see CMS-PAS-HIG-11-009

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

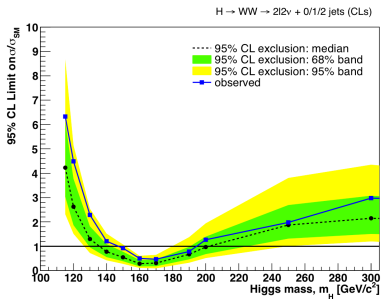


**Low  $M_A$  region below 350 GeV can be explored and excluded if no signal except a narrow strip around  $\tan\beta = 5$ .**

Interpretation of SM Higgs searches in the MSSM depends on the suppression of product of cross section  $\times$  BR in specific models which can affect the discovery exclusion limits expected from SM

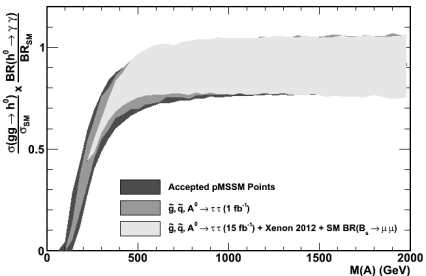


CMS-PAS-HIG-11-003

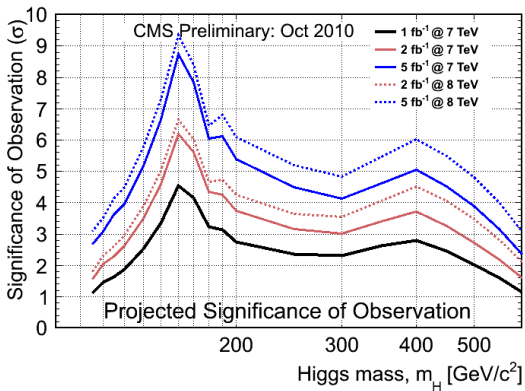


CMS-PAS-HIG-11-021

- Study of  $\sigma \times \text{BR}$  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  $1 \text{ fb}^{-1}$  LHC data ( $\tilde{g}, \tilde{q}$  and  $\text{BR}(B_s \rightarrow \mu^+ \mu^-)$ ) and XENON 100 results;
- And projected 2012 data assuming SM value for  $\text{BR}(B_s \rightarrow \mu^+ \mu^-)$ .

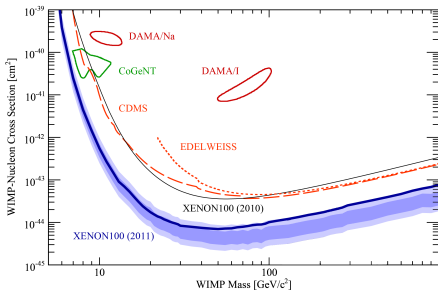


Similar behaviour for  $h \rightarrow WW$  but larger experimental systematics in the 120 GeV region



talk by W. Murray, LPCC Sept. 1st 2011

# Light neutralinos and dark matter direct detection

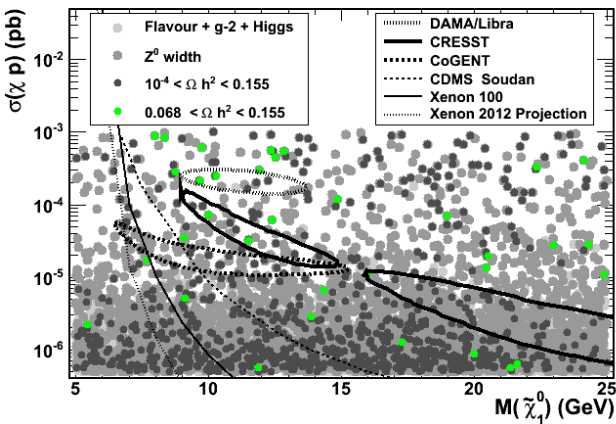


arXiv:1104.2549

The constrained MSSM scenarios provide no candidate compatible with DAMA, CoGeNT, CRESST and XENON data

# Light neutralinos and dark matter direct detection

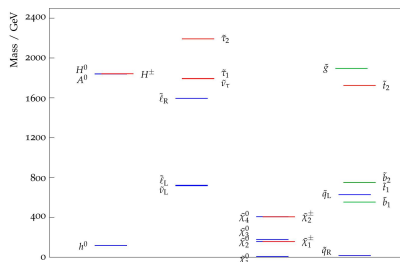
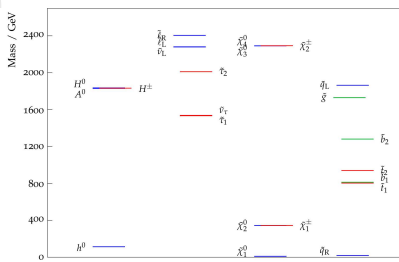
From a low mass pMSSM scan:  
more than 600k valid points with  $M_{\tilde{\chi}_1^0} < 100$  GeV



# Light neutralinos and dark matter direct detection

Scenarios with compressed gaugino spectrum and light Higgs bosons now removed by  $\Gamma(Z \rightarrow \chi_1 \chi_1)$ .

Interesting spectra:



One squark degenerate with the LSP, other squarks and charginos relatively heavy.

# Perspectives

## Status

- We have increased our statistics of standard pMSSM scan and have a dedicated low mass neutralino scan
- We started dedicated studies:
  - Higgs couplings and light neutralinos presented here
  - Others in progress

## Next steps

- Assess the impact of Higgs coupling suppression on discovery/exclusion at LHC
- Study in details the detectability of different scenarios of light neutralinos at LHC