Global SUSY Fits with the MasterCode Framework

Implications of 2010 Search results

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MASTERCODE

Outline

Aims

- Use broad range of observables to determine preferred phenomenology for constrained models of SUSY
- Understand the impact and scope of the first (2010) searches for SUSY from the LHC
- Combine with other results impacting SUSY parameter space
- Determine new preferred regions and probability of fit for these models

Models Covered

		Boundary Conditions
CMSSM	$m_0, m_{1/2}, A_0, tan(\beta), \mathrm{sign}(\mu)$	Unification +
VCMSSM	$m_0, m_{1/2}, A_0, \mathrm{sign}(\mu)$	$B_0 = A_0 + m_0$
MSUGRA	$m_0, m_{1/2}, A_0, \mathrm{sign}(\mu)$	$B_0 = A_0 + m_0; m_0 = m_{3/2}$
NUHM1	$m_0, m_{1/2}, A_0, m^2_{H_{1,2}}, \mathrm{sign}(\mu)$	$m_{1,2} = m_0 + \Delta m_{H_{1,2}}$

Observables

Examples

- Flavour Physics
  - $\mathrm{R}\,(b \to s\gamma)$
  - $\mathrm{BR}\,(B_s \to \mu\mu)$
  - $\mathrm{R}\,(B \to \tau\nu)$
- EWPOs
  - M_W
  - Γ_Z
  - $\mathrm{A}_{fb}(b)$,$\mathrm{A}_{fb}(c)$
- Nuisance parameters
  - M_Z, m_t, ...
- Cosmology
  - Ωh^2
  - σ_p^{SI}
- Particle Spectrum
  - M_{h^0} of particular interest
- Other indirect constraints
  - $\Delta(g_\mu - 2)$

In total we look at 36 individual measurements

Global Likelihood Function

$$\chi^2 = \sum_i^N \frac{(C_i - P_i)^2}{\sigma(C_i)^2 + \sigma(P_i)^2} \quad (1)$$

$$+ \quad \chi^2(M_h) + \chi^2(\mathrm{BR}(B_s \to \mu\mu)) \quad (2)$$

$$+ \quad \chi^2(\mathrm{SUSY\ search\ limits}) \quad (3)$$

$$+ \quad \sum_i^M \frac{\left(f_{SM_i}^{\mathrm{obs}} - f_{SM_i}^{\mathrm{fit}}\right)^2}{\sigma\left(f_{SM_i}\right)^2} \quad (4)$$

$$+ \quad \chi^2(\mathrm{LHC} + \mathrm{Xenon}) \quad (5)$$

ATLAS + CMS Direct Searches

Combination of

- CMS $35pb^{-1} \not{E}_t$
- ATLAS 0l and 1l combination

Assume

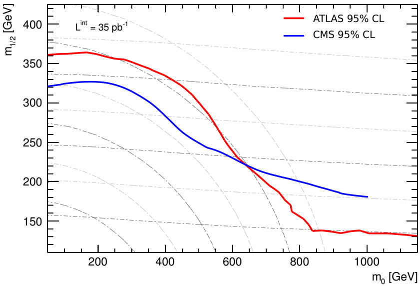
$n_{\mathrm{events}} \propto M^{-4} (M^2 \equiv m_0^2 + m_{1/2}^2)$

Then

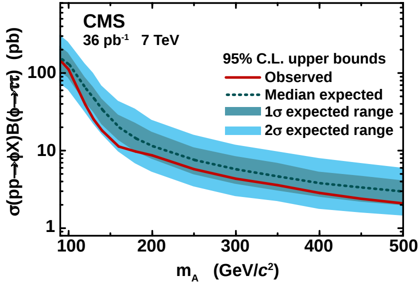
$$\chi^2 \sim \chi^2_{95\%} \left(\frac{M_p}{M_{95\%}} \right)^4$$

For each point in $(m_0, m_{1/2})$ we take

$Max\left(\chi^2\left(\mathrm{CMS}\right), \chi^2\left(\mathrm{ATLAS}\right)\right)$



CMS: SUSY Higgs



For fixed values of M_A assume

$$\chi^2 \propto (\sigma \times \mathrm{BR})^{p(M_A)}$$

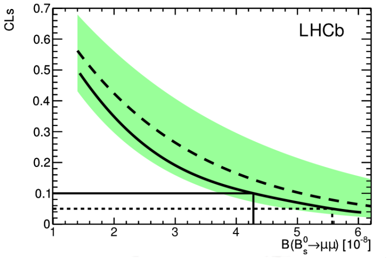
- use the three contours to fit for $p\,(M_A)$
- in the region of interest $(\sigma \times \mathrm{BR}) \propto \tan^2(\beta)$

$$\chi^2 \sim \left(\frac{\tan^2(\beta)}{\tan^2(\beta)_{95\%}}\right)^{p(M_A)}$$

LHCb, D0 and CDF: $BR(B_s \to \mu\mu)$

Combine LHCb (left) with the D0 and CDF results

- Use toy experiments to recreate the 90% CL upper limits from each experiment
- Toys recreate the 95% CL limits
- Combine using CL_s method: generate likelihood function.



Treat

- f_d/f_s
- $\mathrm{BR}\left(B^+ \to J/\psi\left(\mu^+\mu^-\right)K^+\right)$

as common errors

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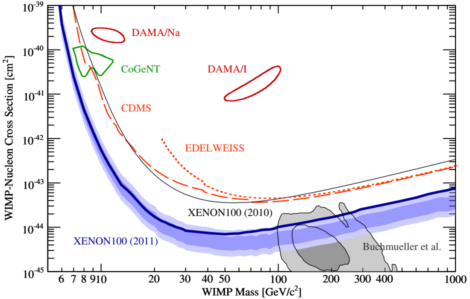
Xenon100



The uncertainty on the π-nucleon σ term is also accounted for, where we look at both

- $\Sigma_{\pi N} = 50 \pm 14$
- $\Sigma_{\pi N} = 64 \pm 8$

- Construct likelihood model for event numbers using CL_s method
- Close to a Gaussian with $\mu = 1.2$, $\sigma = 3.2$
- 90% CL corresponds to 6.1 events, rescale from contour (left)
- The excess in the Xenon experiments leads to a contribution $\chi^2 \sim 0.3$ for small σ_p^{SI}

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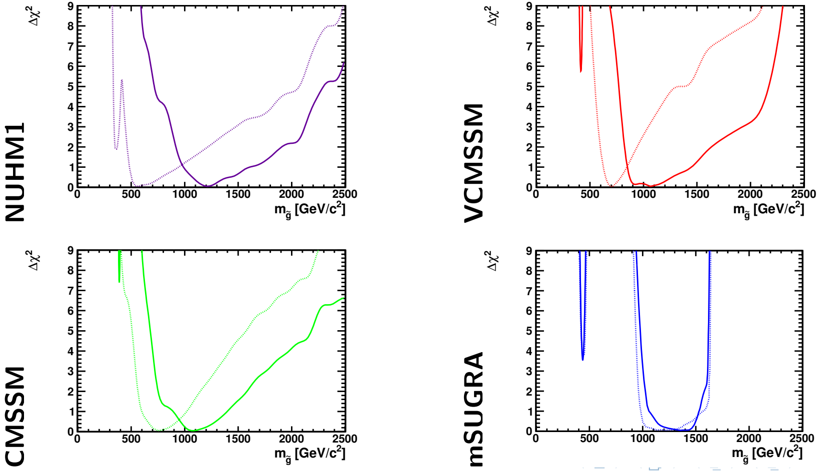
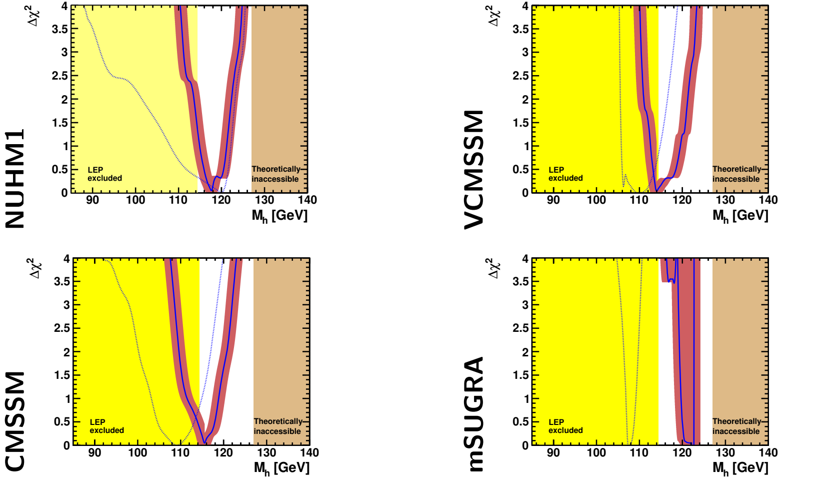
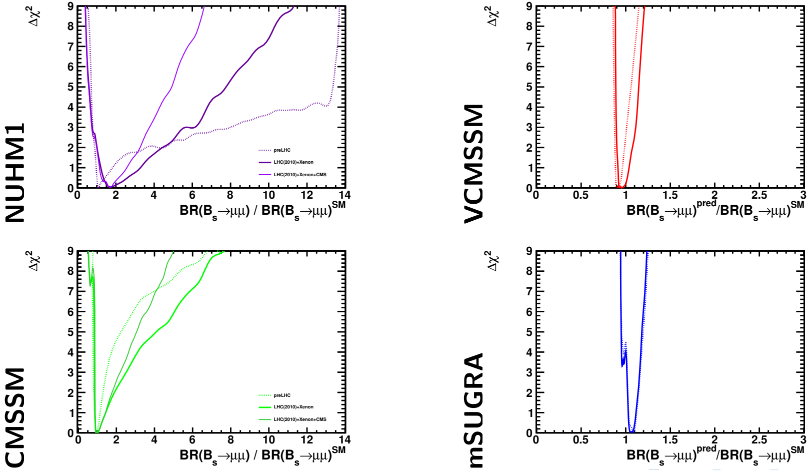
Sparticles



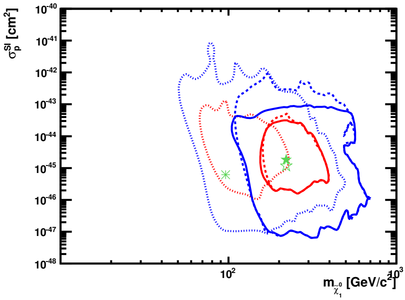
Lightest MSSM Higgs mass

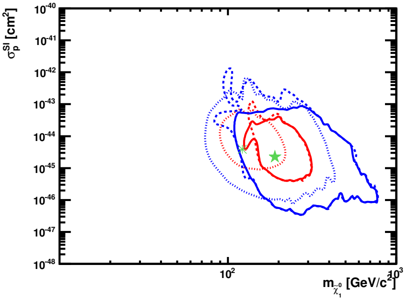


$\mathrm{BR}(B_s \to \mu\mu)$



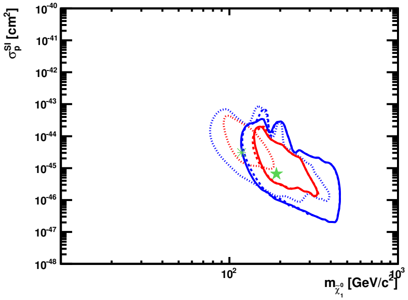
Dark Matter: σ_p^{SI}



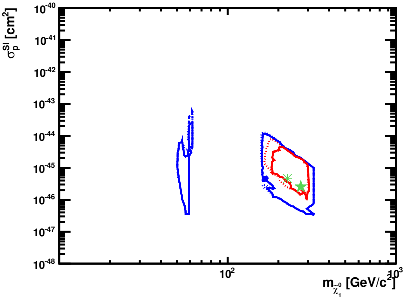


NUHM1 **CMSSM**

Dark Matter: σ_p^{SI}

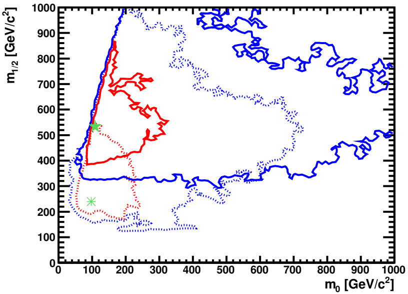


VCMSSM

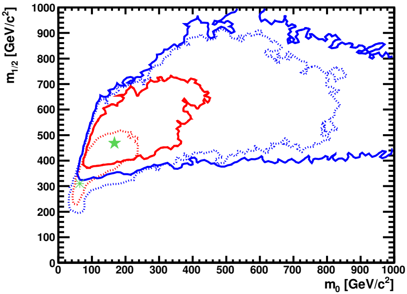


mSUGRA

Parameter Spaces

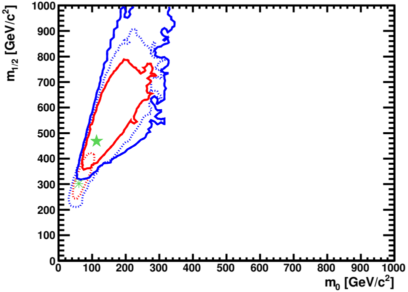


NUHM1

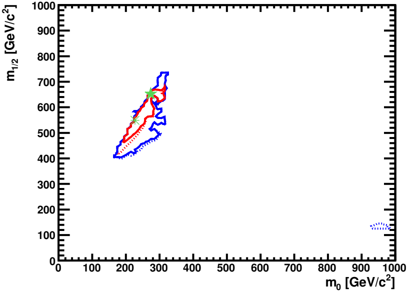


CMSSM

Parameter Spaces

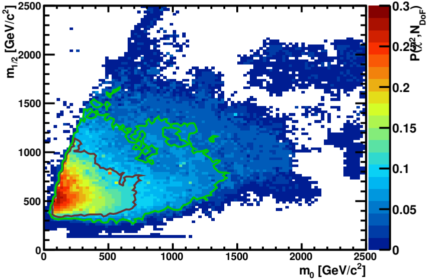


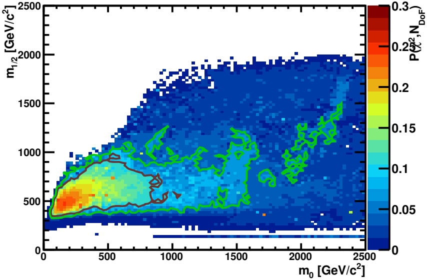
VCMSSM



mSUGRA

Model Probabilities





NUHM1 **CMSSM**

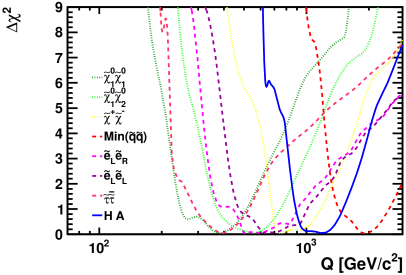
Model	Min χ^2	Prob	$m_{1/2}$	m_0	A_0	$\tan(\beta)$	$M_h^{\text{no LEP}}$
CMSSM	22.5/19	26%	310	60	-60	10	109
post-LHC/Xenon	26.2/20	16%	470	170	-780	22	116
NUHM1	20.5/17	25%	240	100	920	7	119
post-LHC/Xenon	24.2/19	19%	530	110	-370	27	118

Summary

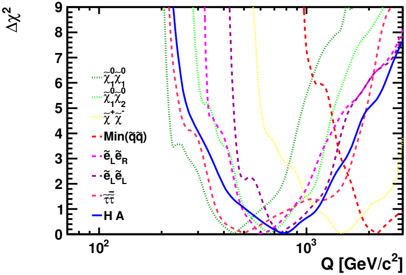
- $m_{\tilde{g}} > 1\text{TeV}$
- $m_{h^0} > 115\text{GeV}$
- $\text{BR}\,(B_s \to \mu\mu)$ preferred at $\sim 1 \times \text{SM}$: CMS 1.9e-8 ($5.5 \times \text{SM@95\%}$)
- $P\left(\chi^2, n_D\right)_{\text{model}}$ falling. $P \sim 0.1$. $1 fb^{-1}$ searches: expect to see $P < 0.05$.
- Air is starting to become very thin for these constrained models of SUSY

BACKUP SLIDES

Thresholds



$\Delta\chi^2$
0
1
2
3
4
5
6
7
8
9
$\tilde{\chi}^0_1\tilde{\chi}^0_1$
$\tilde{\chi}^0_1\tilde{\chi}^0_2$
$\tilde{\chi}^+\tilde{\chi}^-$
Min($\tilde{q}\tilde{q}$)
$\tilde{e}_L\tilde{e}_R$
$\tilde{e}_L\tilde{e}_L$
$\tilde{\tau}\bar{\tilde{\tau}}$
H A
10^2
10^3
Q [GeV/c^2]



$\Delta\chi^2$
0
1
2
3
4
5
6
7
8
9
$\tilde{\chi}^0_1\tilde{\chi}^0_1$
$\tilde{\chi}^0_1\tilde{\chi}^0_2$
$\tilde{\chi}^+\tilde{\chi}^-$
Min($\tilde{q}\tilde{q}$)
$\tilde{e}_L\tilde{e}_R$
$\tilde{e}_L\tilde{e}_L$
$\tilde{\tau}\bar{\tilde{\tau}}$
H A
10^2
10^3
Q [GeV/c^2]