SUSY: Constraints, fitting and the future

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Recap

Yesterday,

- SM - discrepancies and problems
  - W scattering cross-section
  - $\Delta(g_\mu - 2)$
  - Dark Matter candidate
  - Hierarchy problem
- SUSY
  - Solves most of these problems
  - Testable
  - Models: CMSSM, NUHM1, mSUGRA

CMSSM

5 parameter model

$$m_0, m1/2, A_0, \tan(\beta), \mathrm{sign}(\mu) \tag{1}$$

- $m_0, m_{1/2} > 0$: As $m_{0,1/2} \to \infty$ SUSY decouples
- $\tan(\beta) > 0$: Why? What other bounds?
- A_0: Any boundaries?

NUHM1

Same as the CMSSM with an extra parameter, m_H or Δm_H

- Can anything be said about these?
- Any "intuitive" limit on m_H?
- Does freeing the m_H values allow us to fix things that the CMSSM can't?

mSUGRA

Last time I didn't give a full description, SUGRA is what was described yesterday ($m_{3/2}$ at the electroweak scale).
Minimal Supergravity (mSUGRA) has slightly different conditions:

- $m_{3/2} = m_0$
- Commonly a second boundary condition is applied, $B_0 = A_0 + m_0$
- Removes a degree of freedom - now $\tan(\beta)$ is an output

Still have the same problem as the CMSSM - relatively free parameters.

Constraints

How can we constrain SUSY,

- W cross-section
- Higgs mass?
- $(g-2)_\mu$

But SUSY (should) contribute to everything

Other areas

There are an enormous number of measurements out there

- Flavour physics
  - $R(b \to s\gamma)$
  - $BR(B_s \to \mu\mu)$
  - $R(B \to \tau\nu)$
- Higgs searches (LEP)
- Cosmology
  - Ωh^2
  - σ_p^{SI}
- Direct searches (Tevatron, now CMS, soon ATLAS)

Attacking SUSY parameter space

While there aren't any proper limits on SUSY-parameters.

- For each $\{m_0, m_{1/2}, A_0, \tan(\beta)\}$ there is a uniquely defined spectrum of particles
- Infact for any $\{\ldots\}$ all other parameters are uniquely defined (as you'd expect)

Constraints

Considering we know the phenomenology for any particular set of input parameters is well defined:

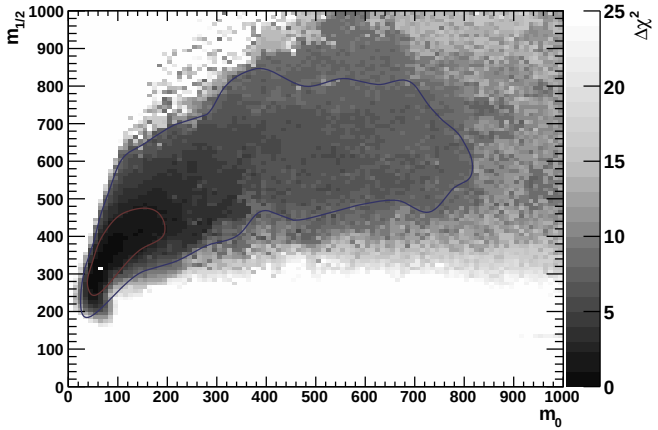
- Calculate spectrum and couplings
- Calculate contributions and final values of various parameters
- Compare to current experimental value and accuracy

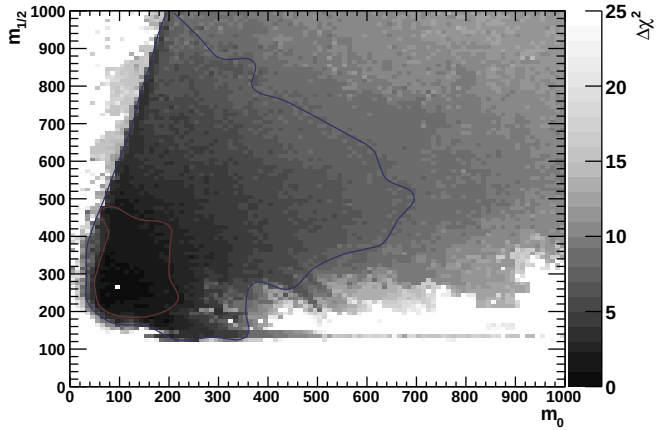
In this way we can construct a method for determining the likely parameter space of any given SUSY model

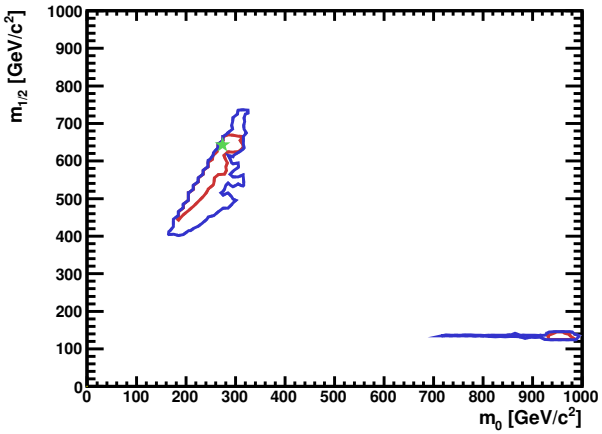
Quantification

- 1-D Likelihood: $\chi^2 = \frac{x-\mu}{\sigma_x}$
- Pick as many values to measure as you like
- How well does SUSY actually predict the whole range of measurements

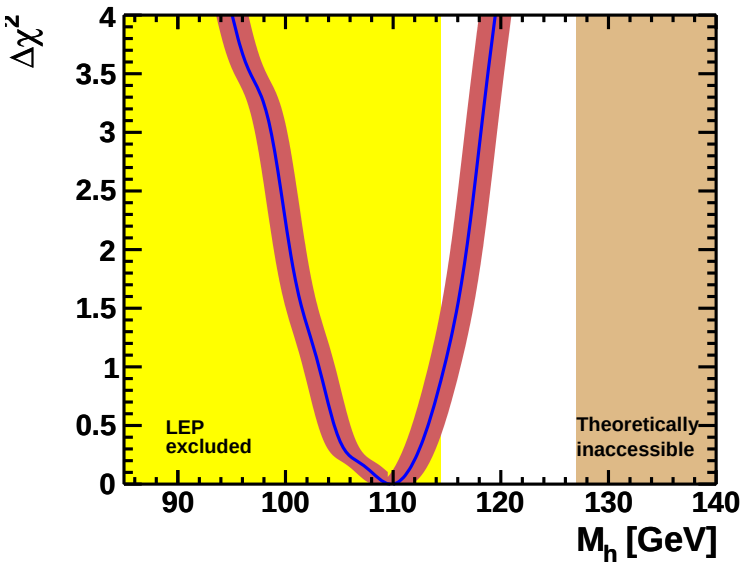
What do we get

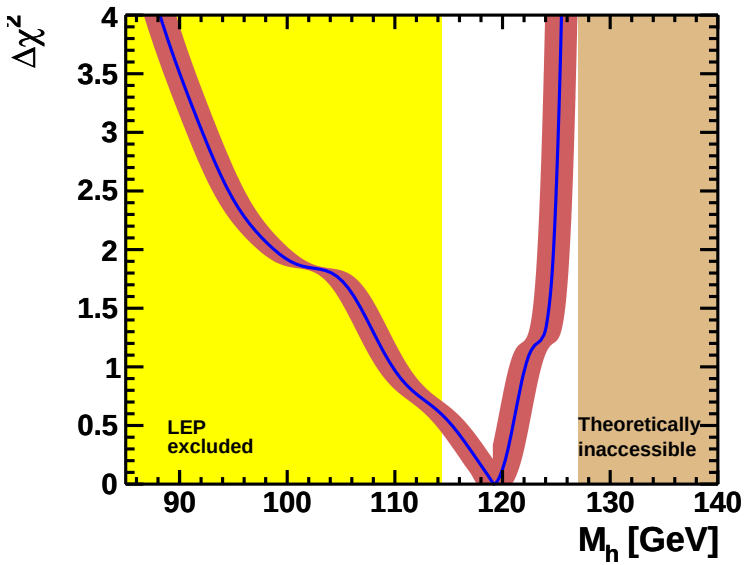






What about the Higgs Sector?





What can we learn

- As expected, low mass SUSY is preferred
- Higgs mass in phenomenologically preferred area

Important values for phenomenology