SUSY fits: Implications of LHC data on Constrained SUSY Models

Albert De Roeck

on behalf of the Mastercode collaboration

Exp **O. Buchmueller, R. Cavanaugh, M. Citron, A. De Roeck , H. Flacher, J. Marrouche, D. Martinez-Santos, S. Nakach, S. Rogerson, F.J. Ronga, K.J. de Vries**

Theo **M. Dolan, J. Ellis, S. Heinemeyer, G. Isidori, K. Olive, G. Weiglein**

Based on J. Marrouche's talk for TOOLS2012

MasterCode

- Project for SUSY studies
  - Use broad range of observables to determine preferred phenomenology for constrained models of SUSY
  - Understand the impact and scope of the LHC data
  - Combine with other results impacting SUSY parameter space

- Determine new preferred regions and probability of fit for these models
  - Best fit points
  - Ranges for Higgs mass (now a constraint!)
  - Ranges for SM parameters
  - Ranges for SUSY masses -> LHC

Study History

- Collaboration started in 2007
- Main aim to prepare a tool for SUSY studies - other data constraints
- 10th paper in preparation
  - Prediction for the Lightest Higgs Boson Mass in the CMSSM using Indirect Experimental Constraints: arXiv:0707.3447
  - Predictions for Supersymmetric Particle Masses using Indirect Experimental and Cosmological Constraints: arXiv:0808.4128
  - Likelihood Functions for Supersymmetric Observables in Frequentist Analyses of the CMSSM and NUHM1. arXiv:0907.5568
  - Predictions for mt and mW in minimal supersymmetric models arXiv:0912.1036
  - Frequentist analysis of the parameter space of minimal supergravity: arXiv:1011.6118
  - Implications of Initial LHC Searches for Supersymmetry. arXiv:1102.4585
  - Supersymmetry and Dark Matter in Light of LHC 2010 and Xenon100 Data: arXiv:1106.2529
  - Supersymmetry in Light of 1/fb of LHC Data: arXiv:1110.3568
  - Higgs and Supersymmetry arXiv:1112.3564
  - The CMSSM and NUHM1 in light of 5/fb of LHC data: arXiv:12xx.xxx

Which observables?

- Pick those which have sensitivity to new physics
  - Flavour physics
    - Bs->mumu, b->sgamma, B->taunu
  - Cosmology (Dark Matter)
    - Relic Density, Spin independent cross-section
  - Others
    - Delta(g-2)mu
  - EWPO
    - mW, GammaZ, Afb
  - Nuisance parameters
    - mTop, mZ…

How to determine preferred regions of parameter space

- Frequentist approach
  - Build up a Chi^2 for each point

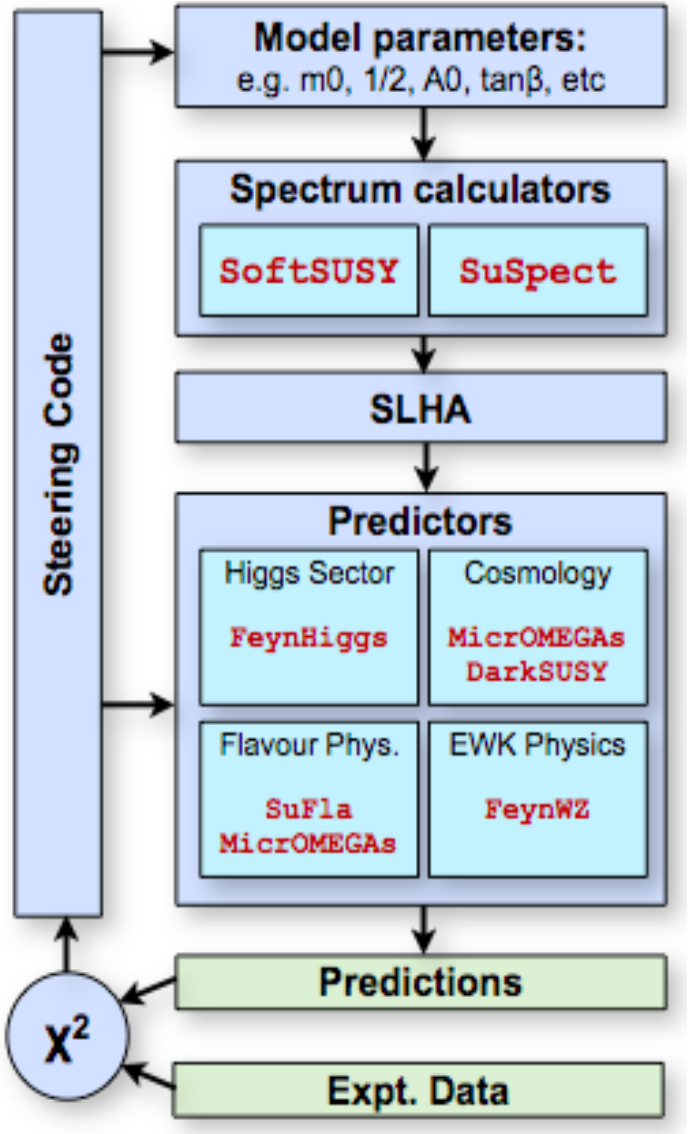
$$
\begin{aligned}
\chi^2 = & \sum_i^N \frac{(C_i - P_i)^2}{\sigma(C_i)^2 + \sigma(P_i)^2} \\
+ & \chi^2\left(M_h\right) + \chi^2\left(\mathrm{BR}\left(B_s \to \mu\mu\right)\right) \\
+ & \chi^2\left(\text{SUSY search limits}\right) \\
+ & \sum_i^M \frac{\left(f_{SM_i}^{\text{obs}} - f_{SM_i}^{\text{fit}}\right)^2}{\sigma\left(f_{SM_i}\right)^2} \\
+ & \chi^2(\text{LHC + Xenon })
\end{aligned}
$$

- Feed to Markov Chain Monte Carlo, try to minimise Chi^2
  - Used as a sampling tool
  - SUSY models multi-dimensional

Models considered

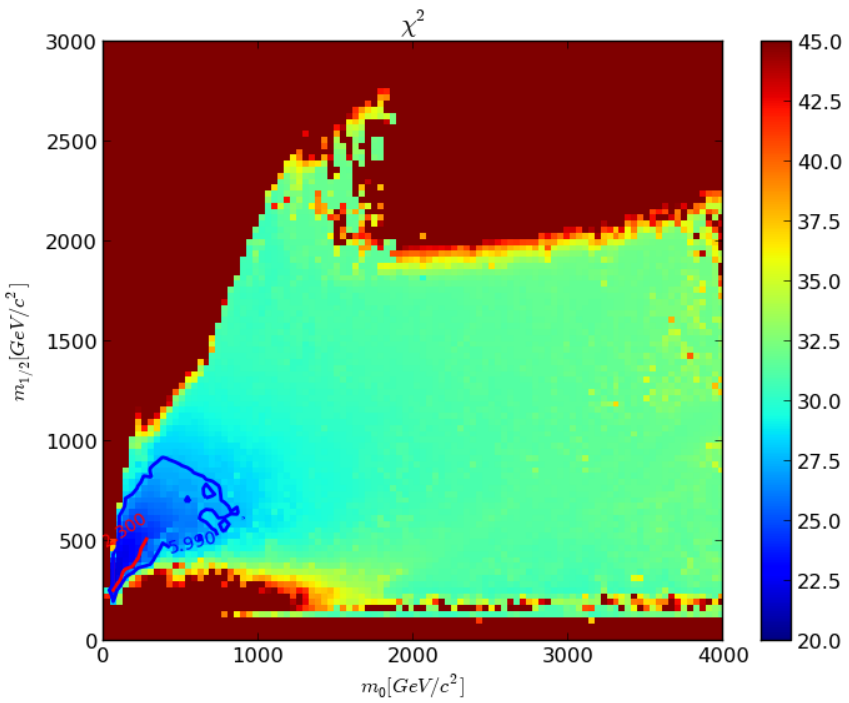
- Sampling large multi-dimensional spaces hard and computationally expensive
- Start with the simplest of constrained models defined at the GUT scale
  - CMSSM: m0, m12, tanB, A0, sign(mu)
  - NUHM1: break m0 = mH^2 degeneracy
  - Earlier studies also: mSUGRA and VCMSSM (pMSSM under study)
- We have sampled O(10^8) points for each model

The MasterCode Principle

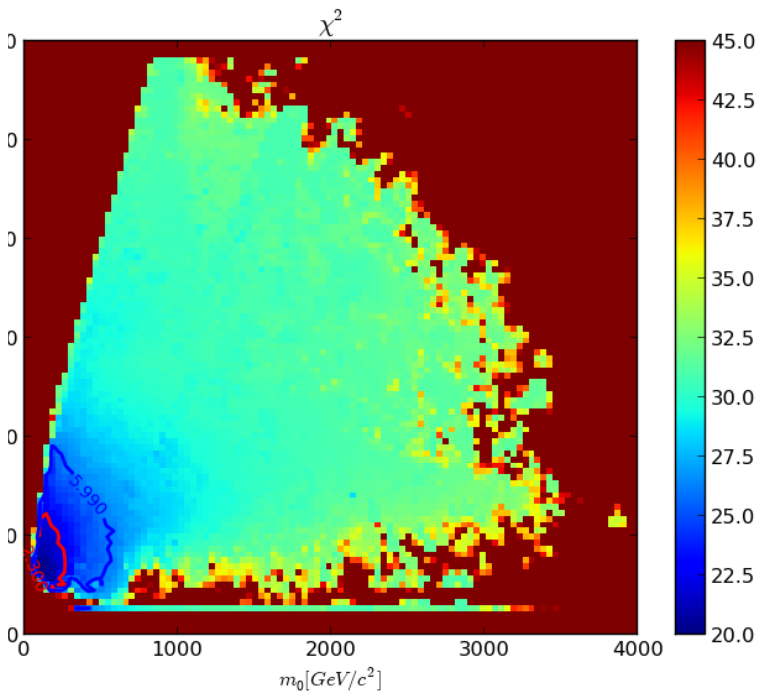


The pre-LHC era

CMSSM



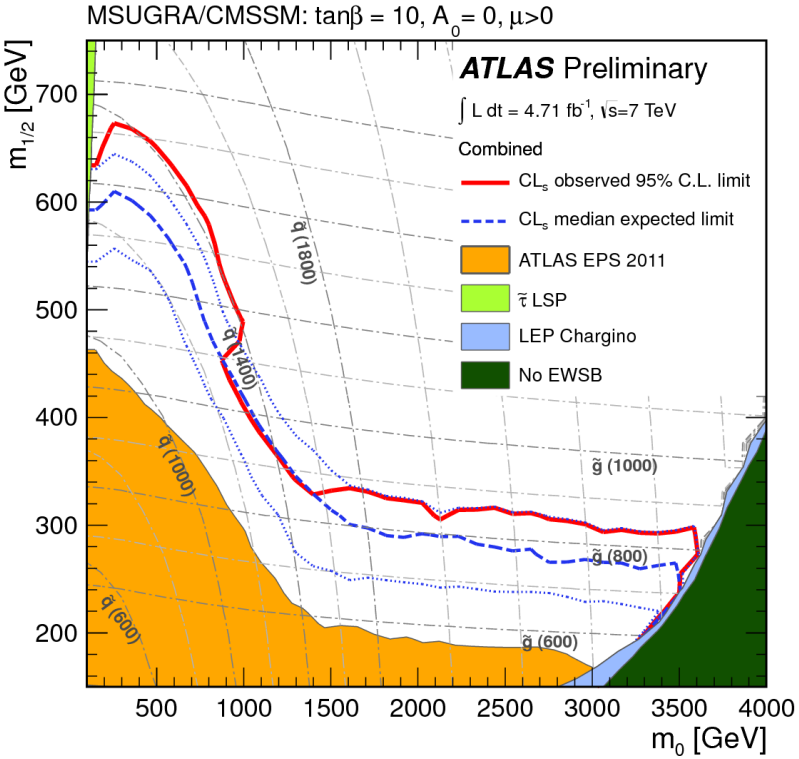
NUHM1

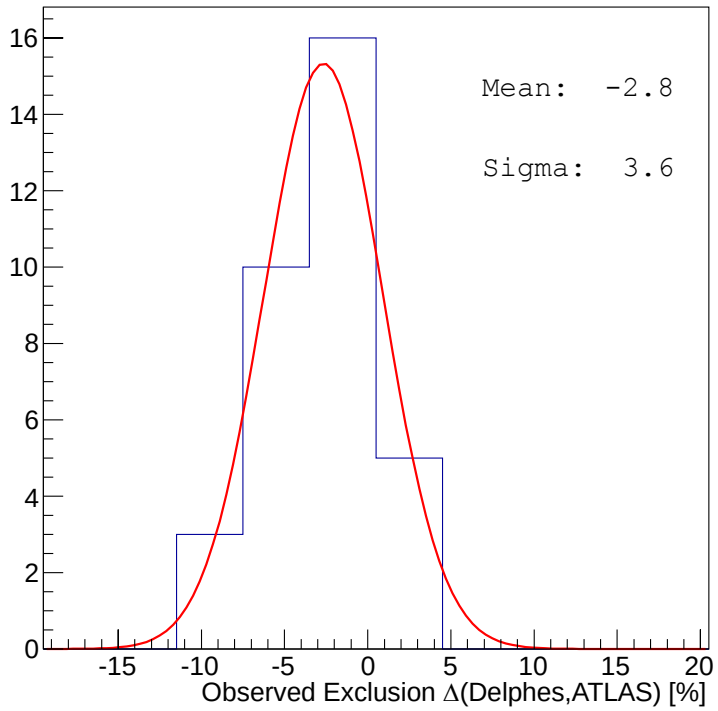


Model	Min χ^2	Prob	$m_{1/2}$	m_0	A_0	tan β
CMSSM	21.5	37%	360	90	400	15
NUHM1	20.8	29%	340	110	-520	13

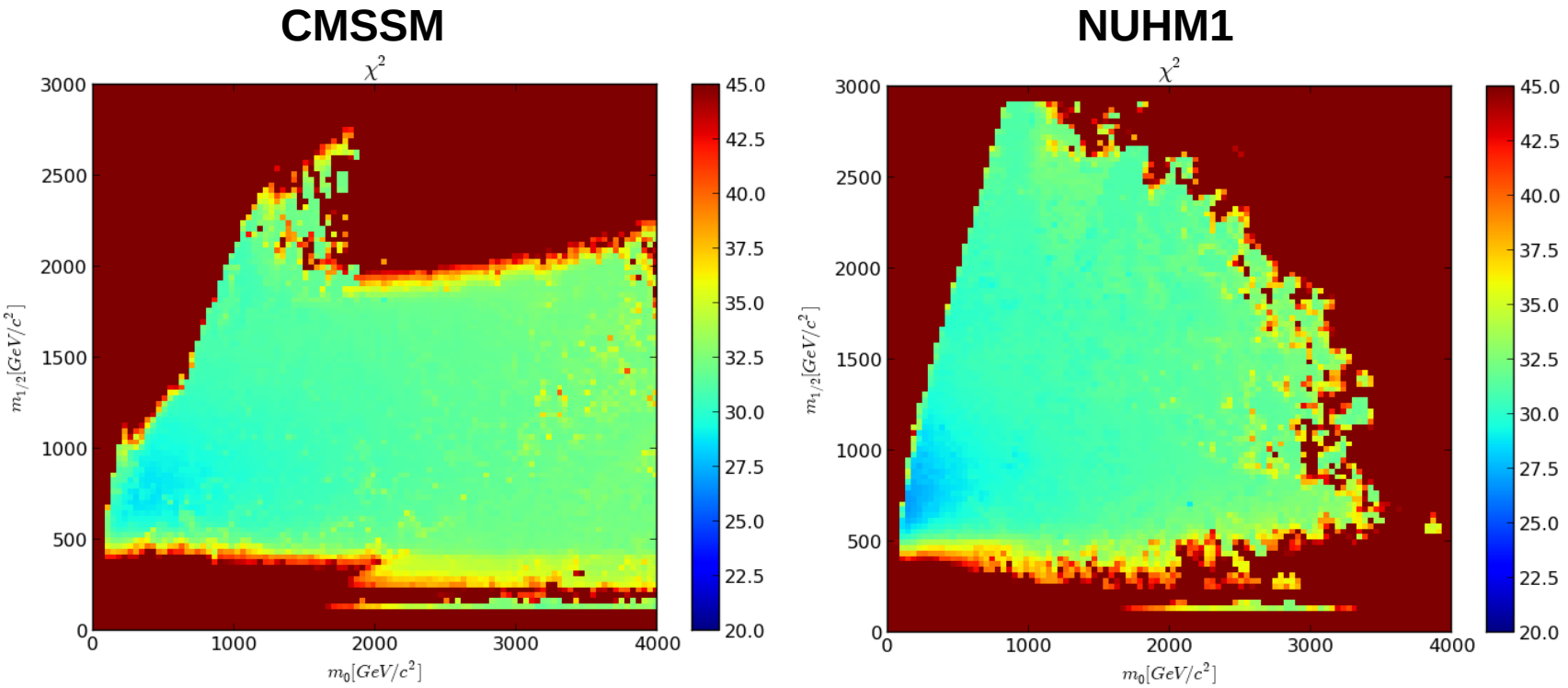
Aside: Validation for ATLAS 5/fb search

- Use generator (PYTHIA) + fast-simulation code (DELPHES) to reproduce experiment signal yields and repeat interpretation
  - If ok, vary parameter space and come up with generic scaling laws
  - Extend to other parameter space (eg other tan β values) and NUHM1 (allow for non-universal Higgs masses)



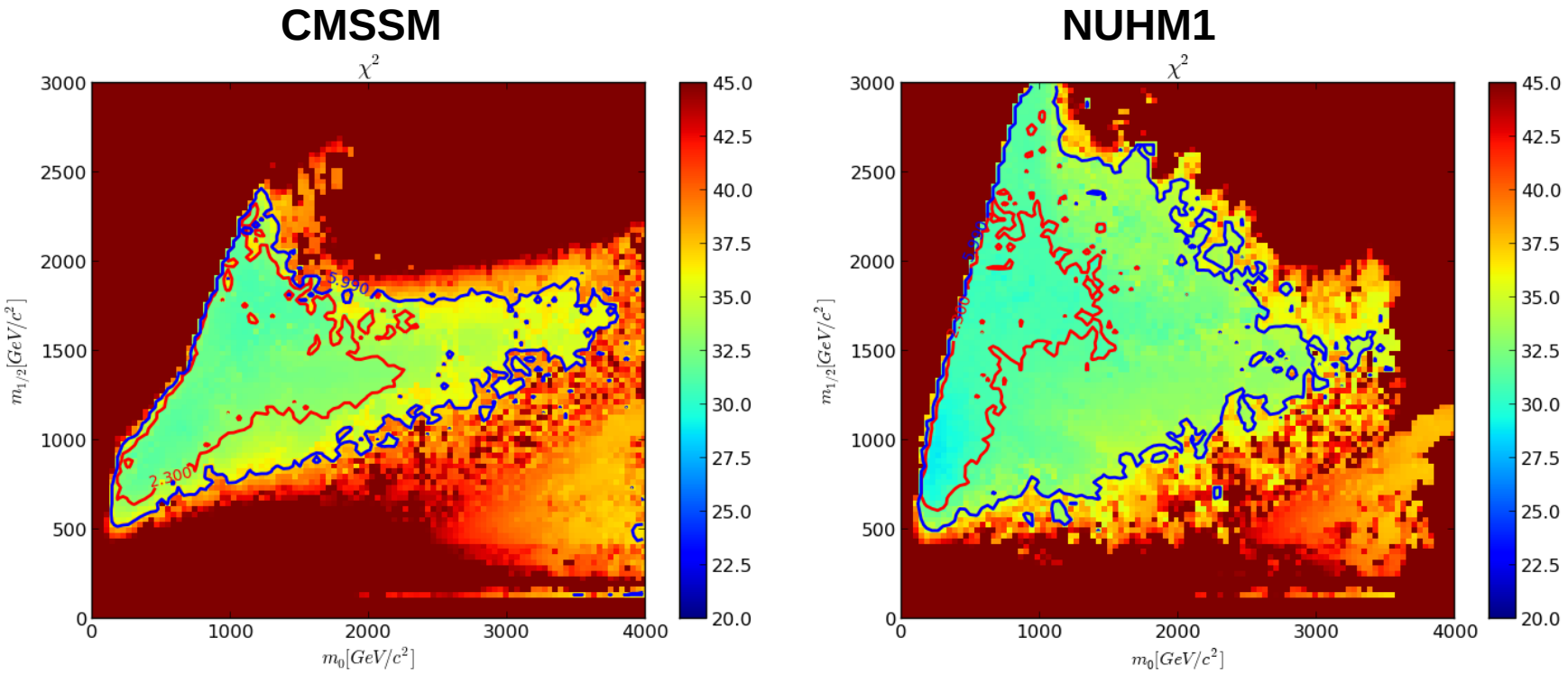


The "pre-Higgs" era after 1/fb



- Chi^2 increases
  - Shifting to higher masses, larger tanβ
  - Plane relatively flat

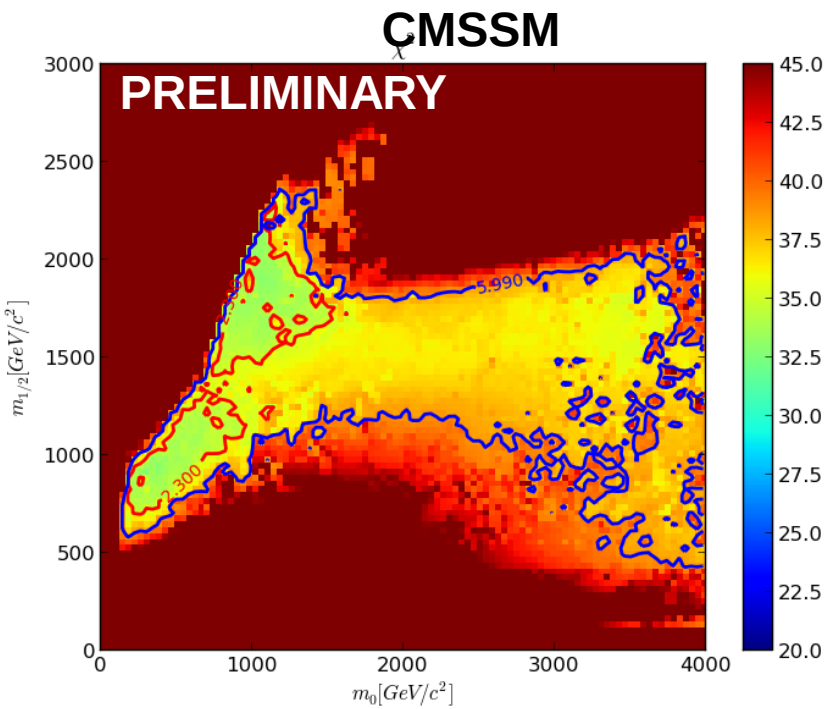
The "post-Higgs" era

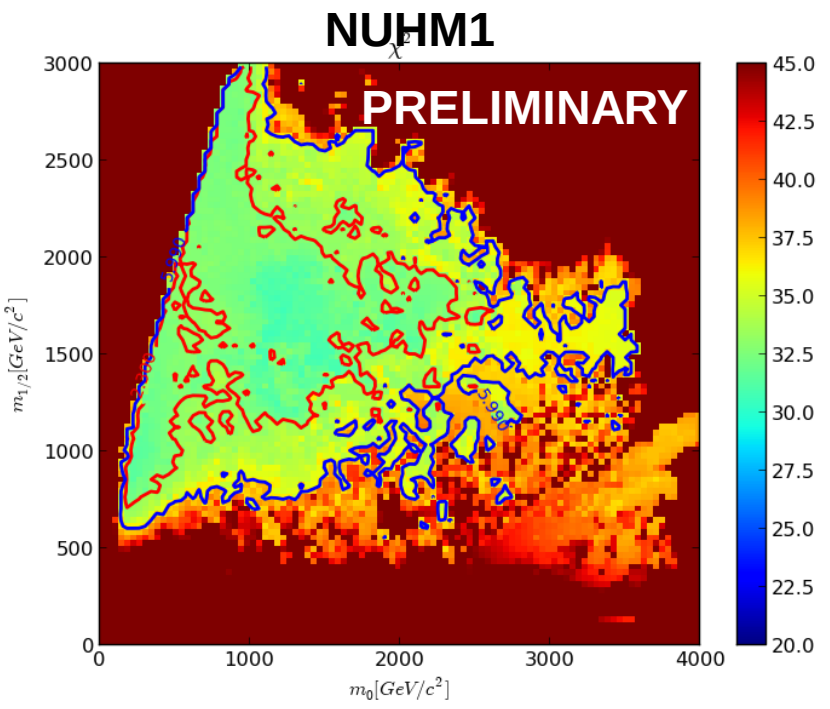


- Assume a putative measurement of m_H=125 +/- 1.5 +/- 1.0 GeV
  - Further reduction in potential phase-space!

Further experimental constraints

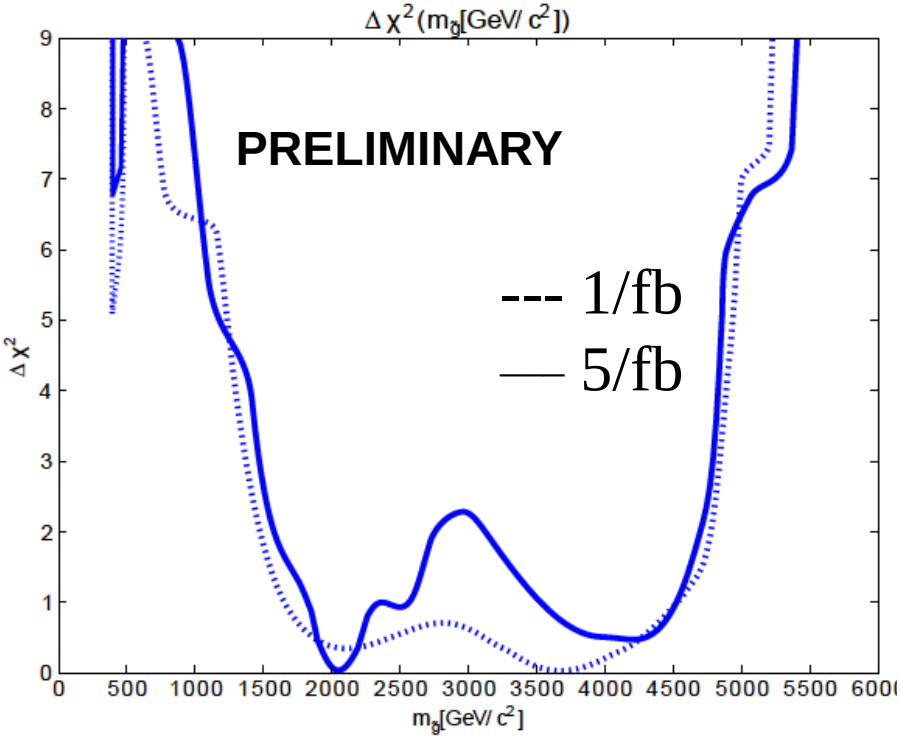
- Updated with
  - 5/fb direct search results
  - Updated BR(Bs-> μμ) combination from the LHC (May 2012
- Prospects look bleak for constrained models
  - p-value ~10%



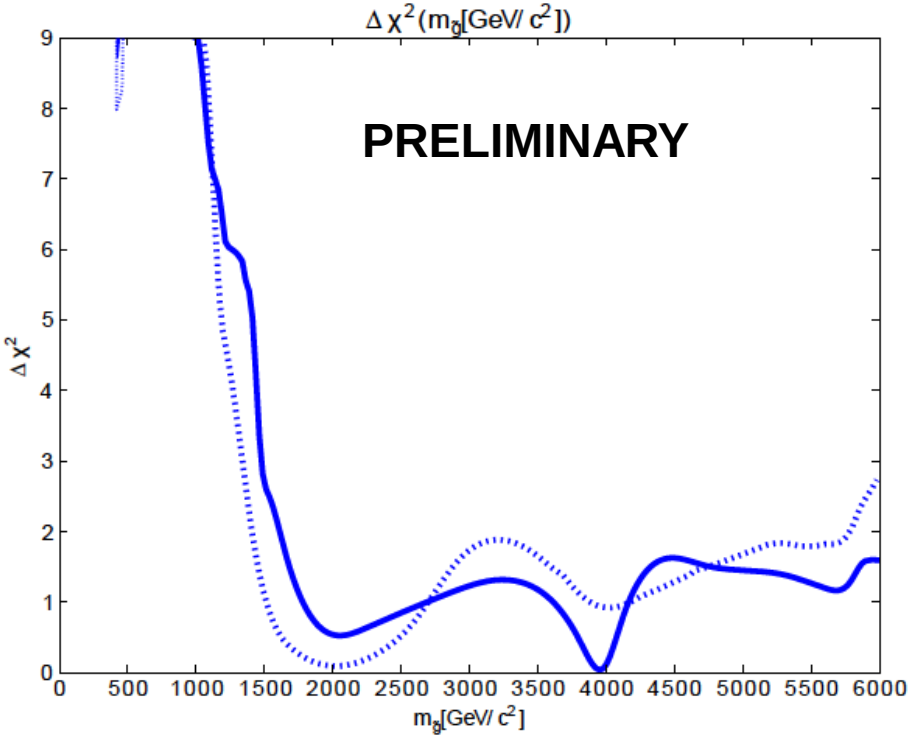


Gluino masses

CMSSM



NUHM1

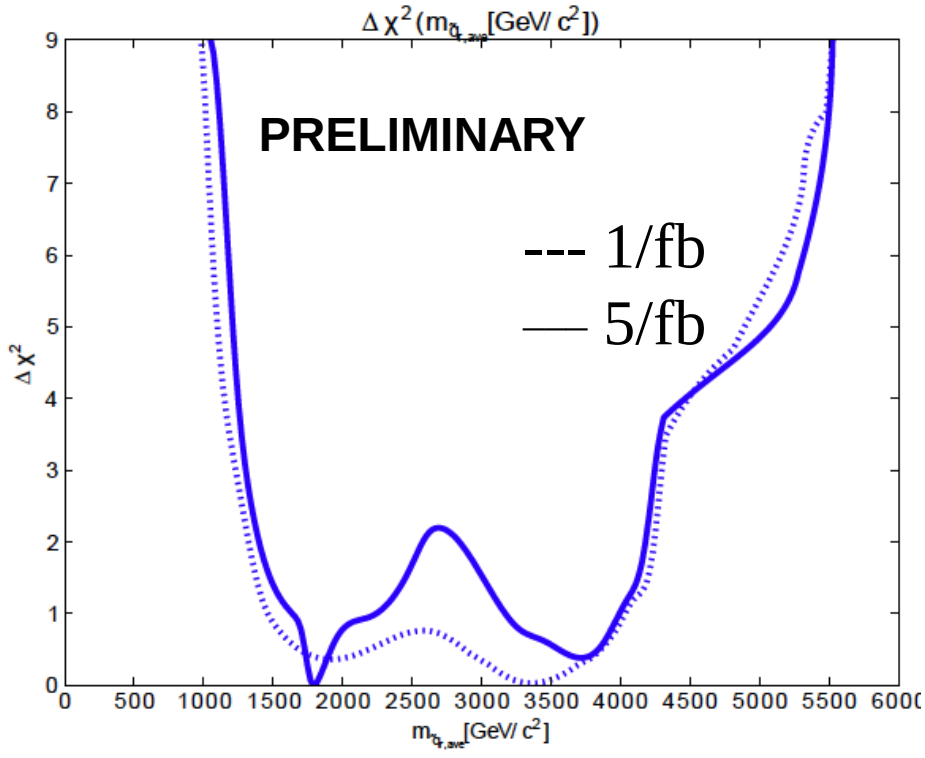


CMSSM: 1500 GeV - 4800 GeV

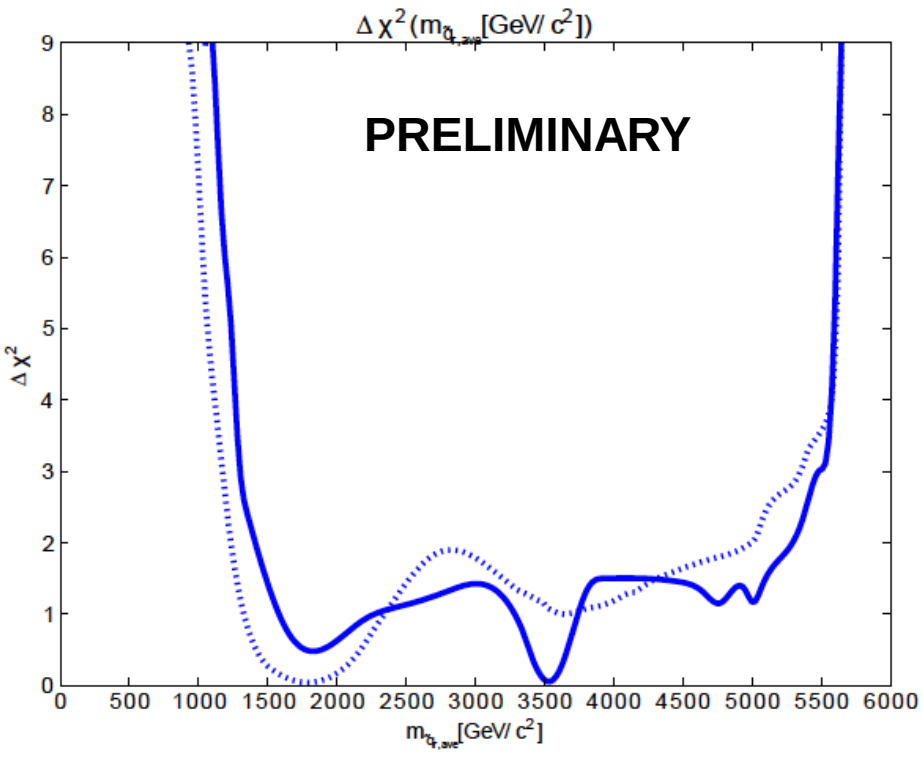
NUHM1: >1500 GeV

Squark masses

CMSSM



NUHM1

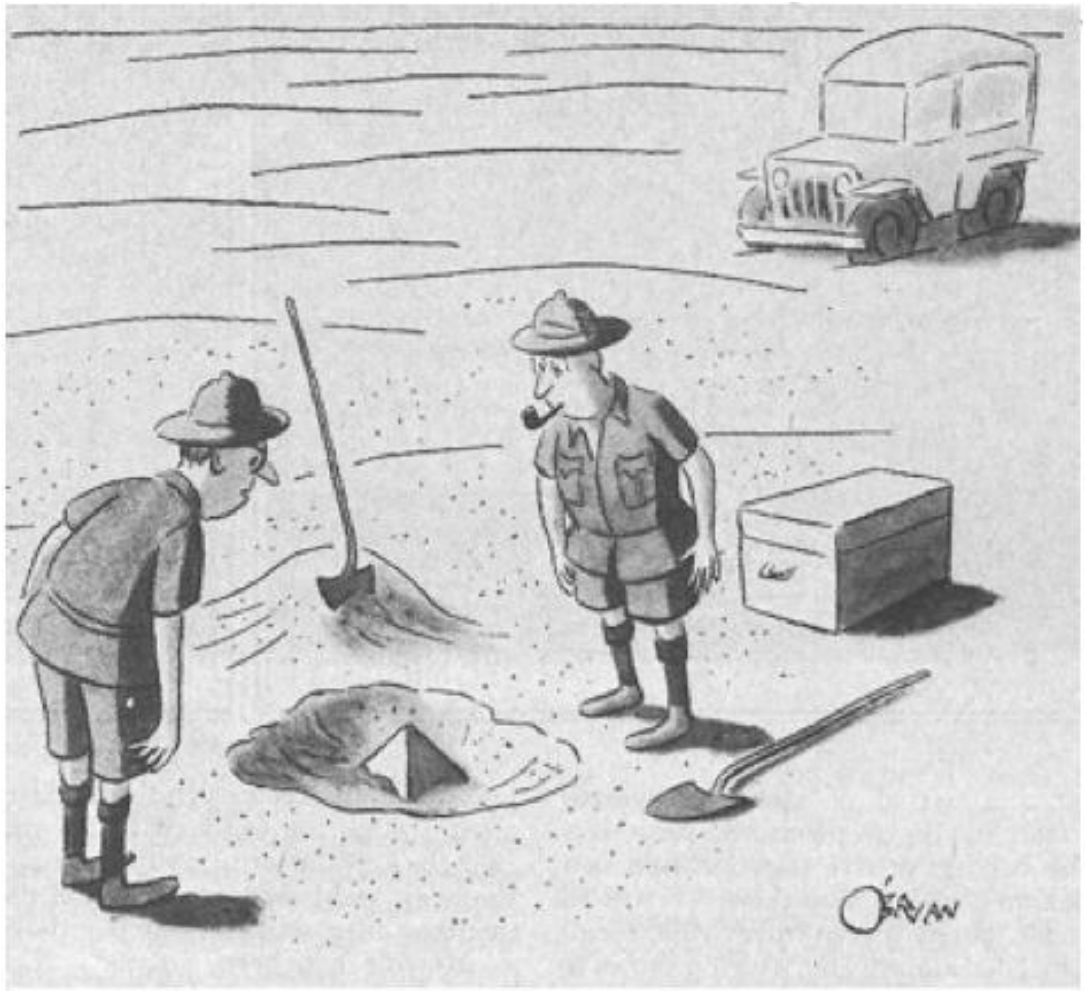


And more results in upcoming paper: on stau, Bs->μμ, Higgs, σ^{SI}_{p}

Conclusions

- Constrained models in trouble
  - but not yet killed off
- Interpreting data important outside the context of constrained models
  - Use generator + fast-simulation tools to approximate likelihoods
- Extensions to other models important to study
  - e.g. NUHM2, pMSSM will possess different features, in progress

Discoveries take time



"This could be the discovery of the century.