News from MasterCode

Global Fit of Supersymmetry

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on behalf of the MasterCode Collaboration

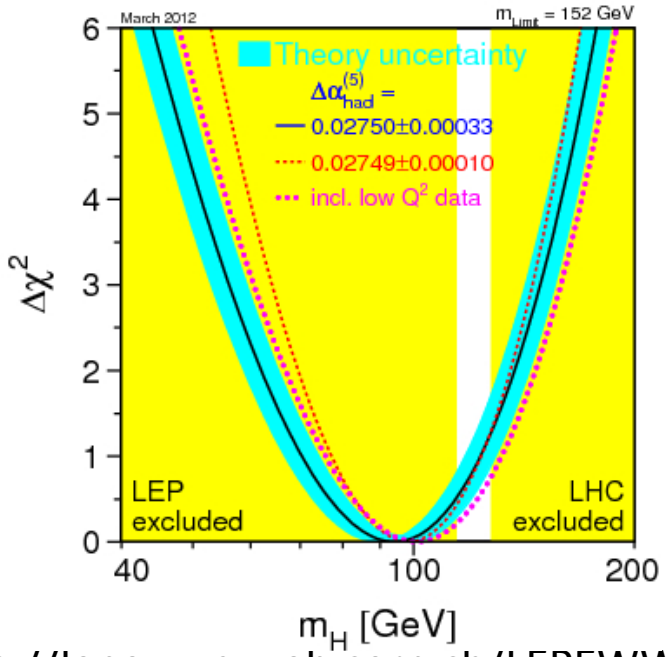
Exp **O. Buchmueller, R. Cavanaugh, M. Citron, A. De Roeck, H. Flacher, J. Marrouche, D. Martinez-Santos, S. Nakach, S. Rogerson, F.J. Ronga, K.J. de Vries**

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

1207.7315v1

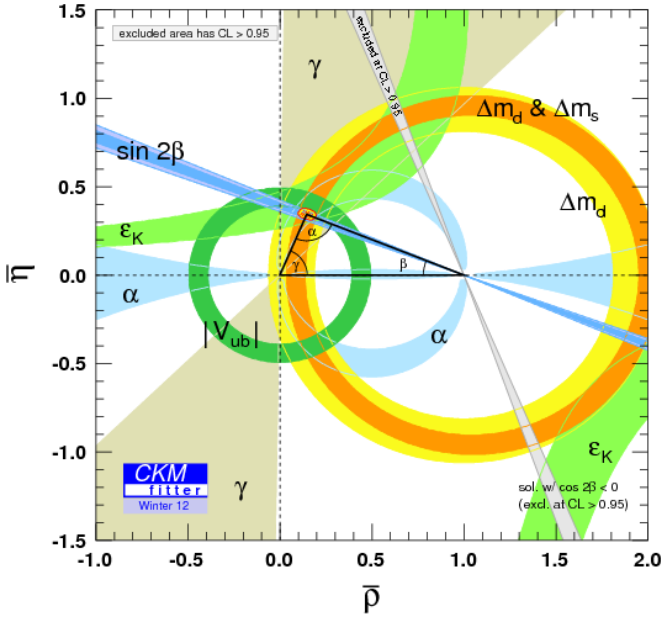
Other examples of global fits

- Combination of electroweak observables



http://lepewwg.web.cern.ch/LEPEWWG/

- Flavour physics



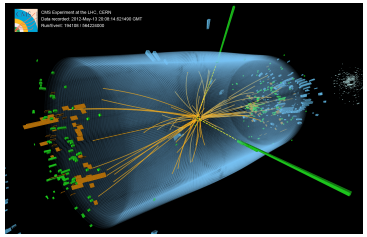
http://ckmfitter.in2p3.fr

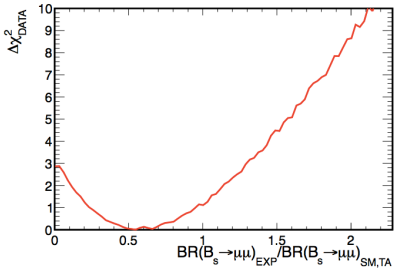
(Some!) other SUSY global fitting groups

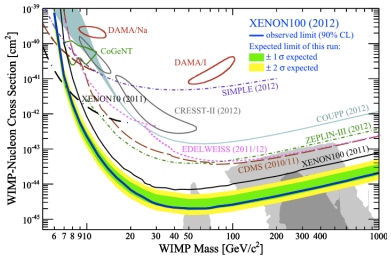
- Frequentist
  - Fittino: CMSSM & NUHM1
  - Mastercode: CMSSM & NUHM1
  - …
- Baysian
  - BayesFITS: CMSSM & NUHM1
  - …
- Flat Scan
  - A. Arbey et al. : pMSSM, CMSSM, GMSB, AMSB
  - …

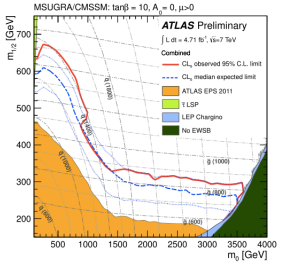
News from Mastercode

- Implications of latest experimental results for CMSSM and NUHM1









- New tool: Pythia + Delphes

Fit SUSY to data

- Recipe
  - Take measurements sensitive to SUSY
  - Confront with predictions
  - Predict
    - Best Fit parameters
    - Ranges for SUSY parameters, masses, other observables

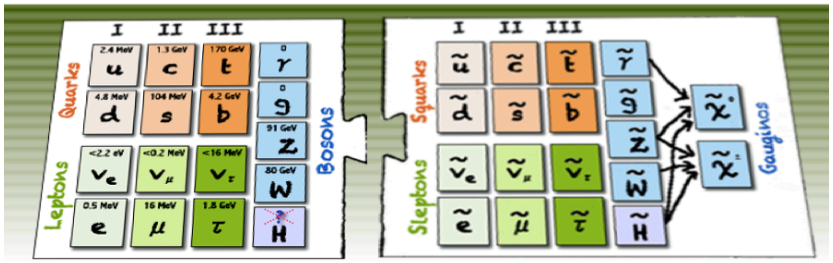
Measurements

- SUSY has to fit to all constraints
  - Flavour physics
    - $B_s \to \mu^+\mu^-$, $b \to s\gamma$, $B \to \tau\nu$, ΔM_{B_s} , ...
  - Electroweak precision observation
    - M_W, Γ_Z , $A_{fb}(b)$, ...
  - Cosmology (Dark Matter)
    - $\Omega_{CDM}h^2$, σ_p^{SI}
  - Higgs mass
  - SUSY searches
    - Jets + MET (+ leptons), $H/A \to \tau^+\tau^-$
- Nuisance parameters
  - m_t , M_Z , $\alpha_{had}^{(5)}(M_Z)$

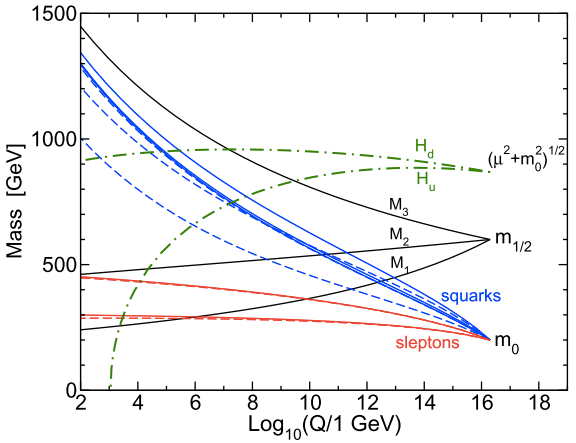
CMSSM and NUHM1

- MSSM

Supersymmetry

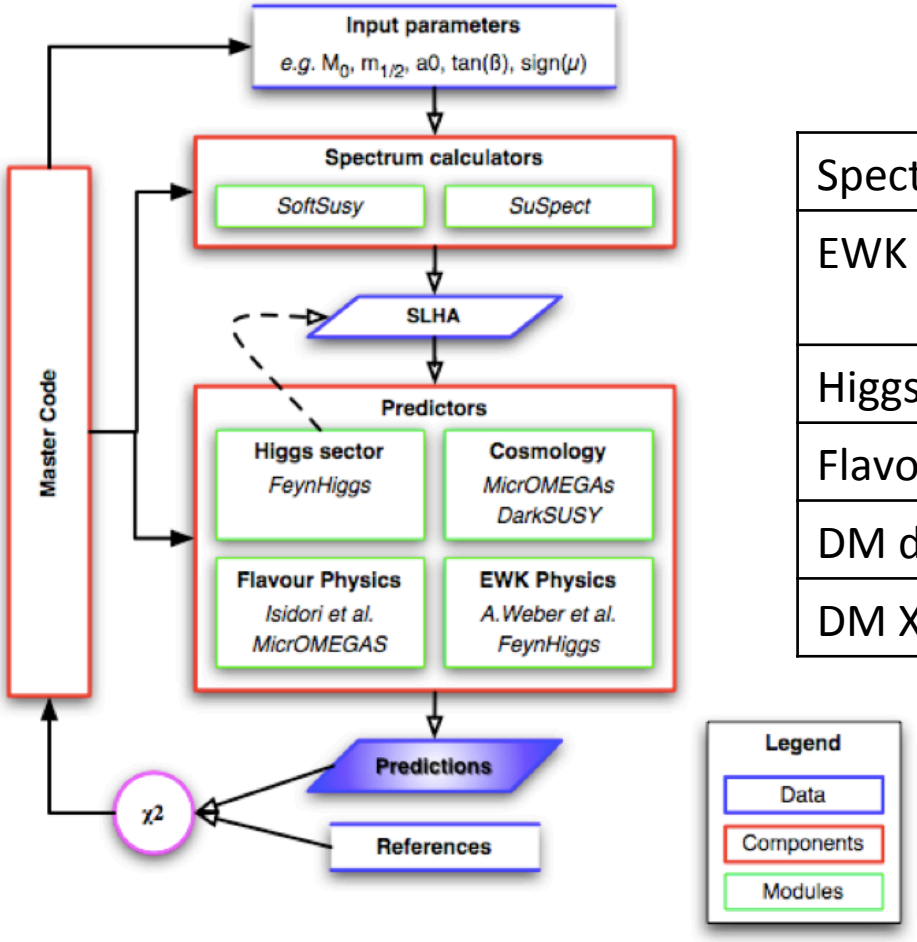


Xavier Portell



- CMSSM
  - Universal soft-SUSY breaking parameters $m_0 \quad m_{1/2} \quad A_0$
  - Ratio v.e.v.'s of Higgs doublets $\tan\beta$
- NUHM1
  - Lift degeneracy Higgs sector $m^2_{H_u} = m^2_{H_d} \neq m^2_0$

MasterCode predictions



	Mastercode	Fittino
Spectrum	SoftSusy	SPheno
EWK	FeynWZ, FeynHiggs	FeynHiggs
Higgs	FeynHiggs	FeynHiggs
Flavour	Sufla	SuperISO
DM density	MicroMEGAs	MicroMEGAs
DM X-section	SSARD	MicroMEGAs

Public
Private

X^2 definition and sampling

- χ^2 definition

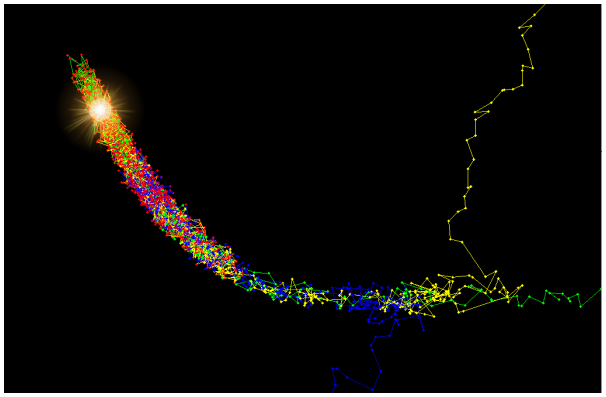
$$\chi^2 = \sum_i^M \frac{(f_{SM_i}^{obs} - f_{SM_i}^{fit})^2}{\sigma(f_{SM_i})^2} + \sum_i^N \frac{(C_i - P_i)^2}{\sigma(C_i)^2 + \sigma(P_i)^2} + \sum_i^K \Delta\chi_i^2(\text{experimental likelihood})$$

- Nuisance parameters

$$f_{SM} = \{\Delta\alpha_{had}(M_Z), m_t, M_Z\}$$

- P_i prediction (parameter dependent!)
- C_i central measured value
- σ standard deviation

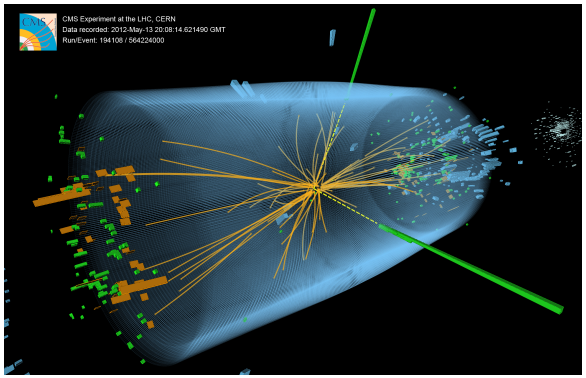
- Sampling



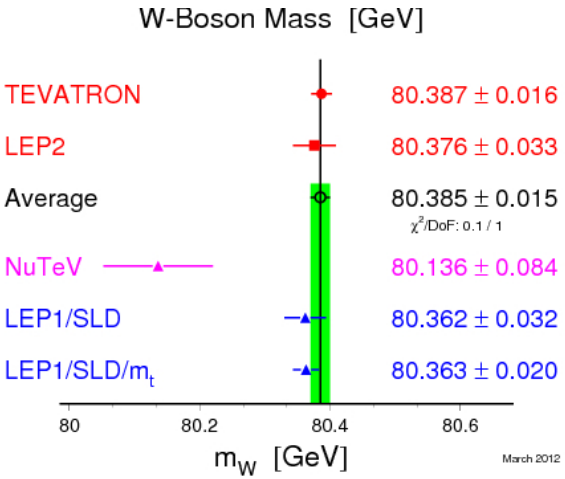
- Monte Carlo Markov Chain
  - Minimise χ^2
  - Good coverage
  - CMSSM: 95 M
  - NUHM1: 95 +126 M

Latest constraints

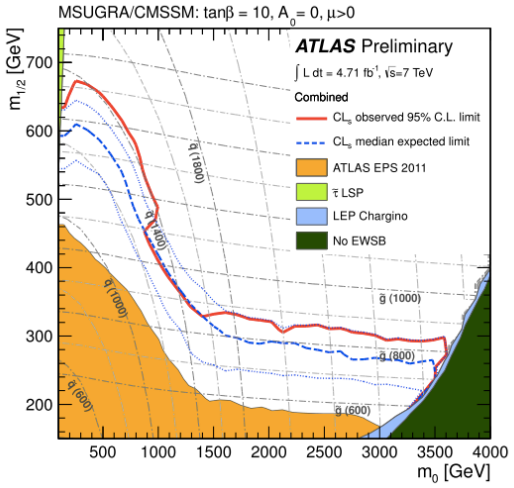
Gaussian

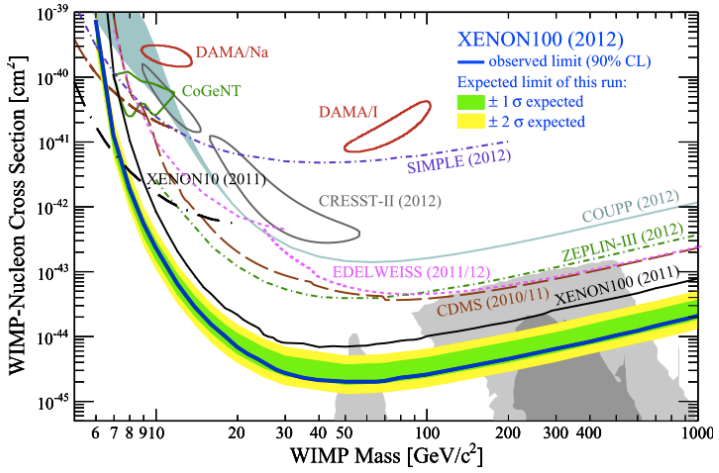


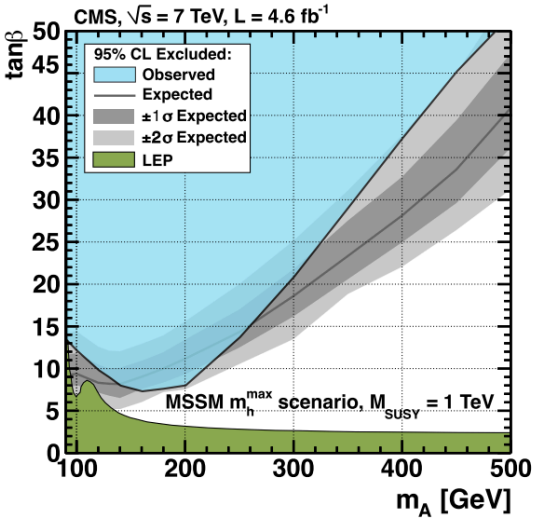
$M_h = 125 \pm 1 \pm 1.5$

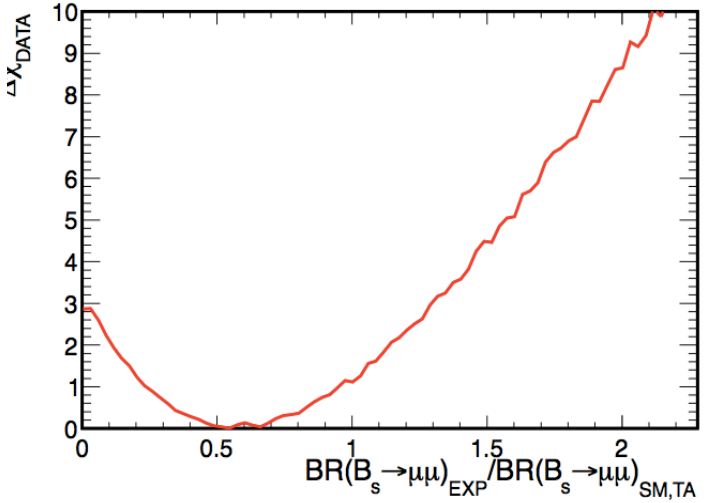


Likelihoods



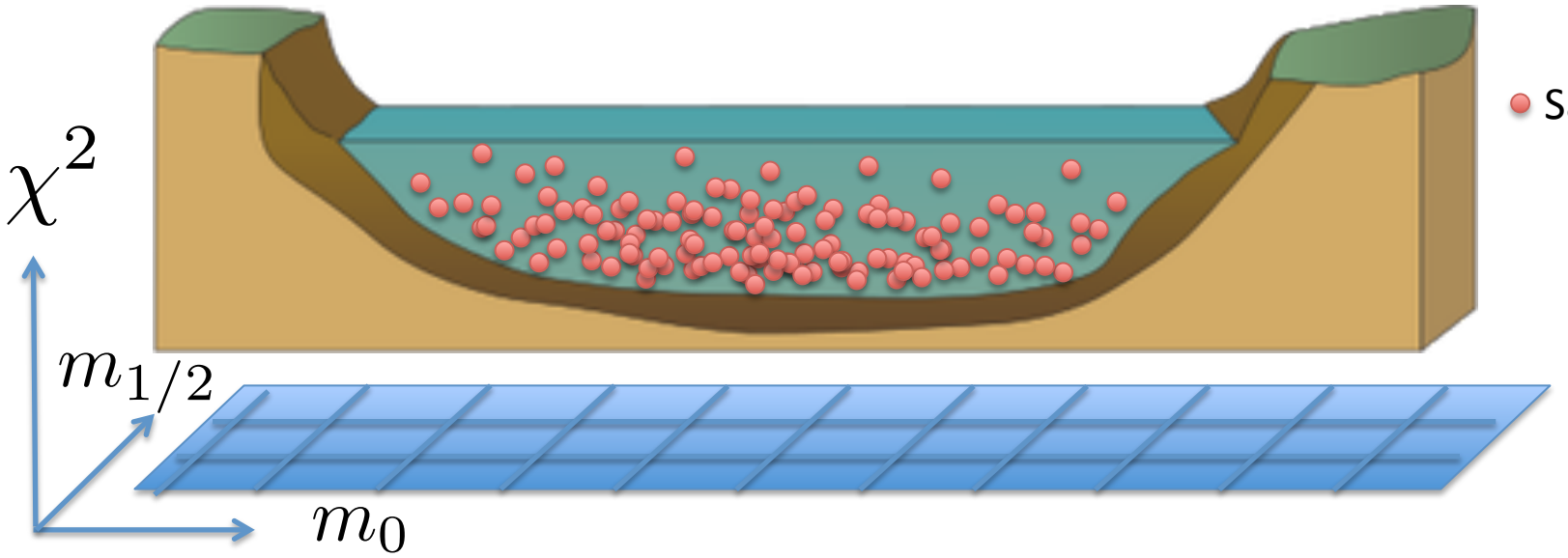






Frequentist

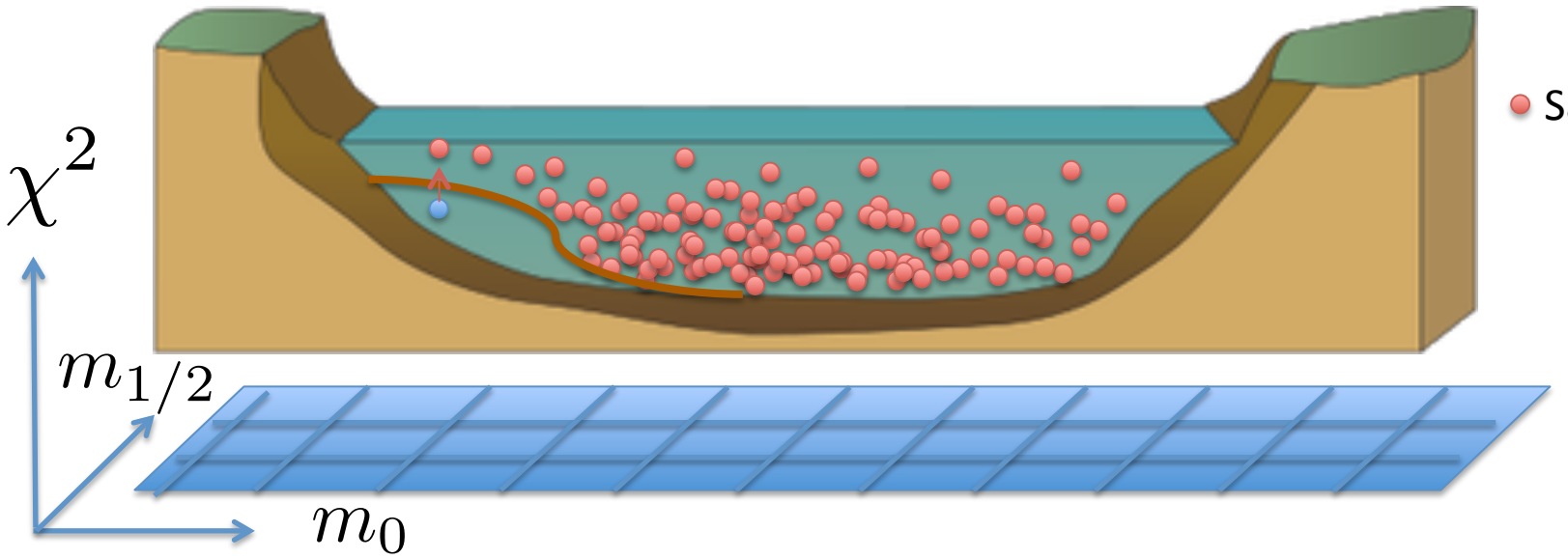
- Presentation of results



- Minimum χ^2 for fixed m_0 and $m_{1/2}$
  - Define bins
  - Show minimum χ^2 in each bin

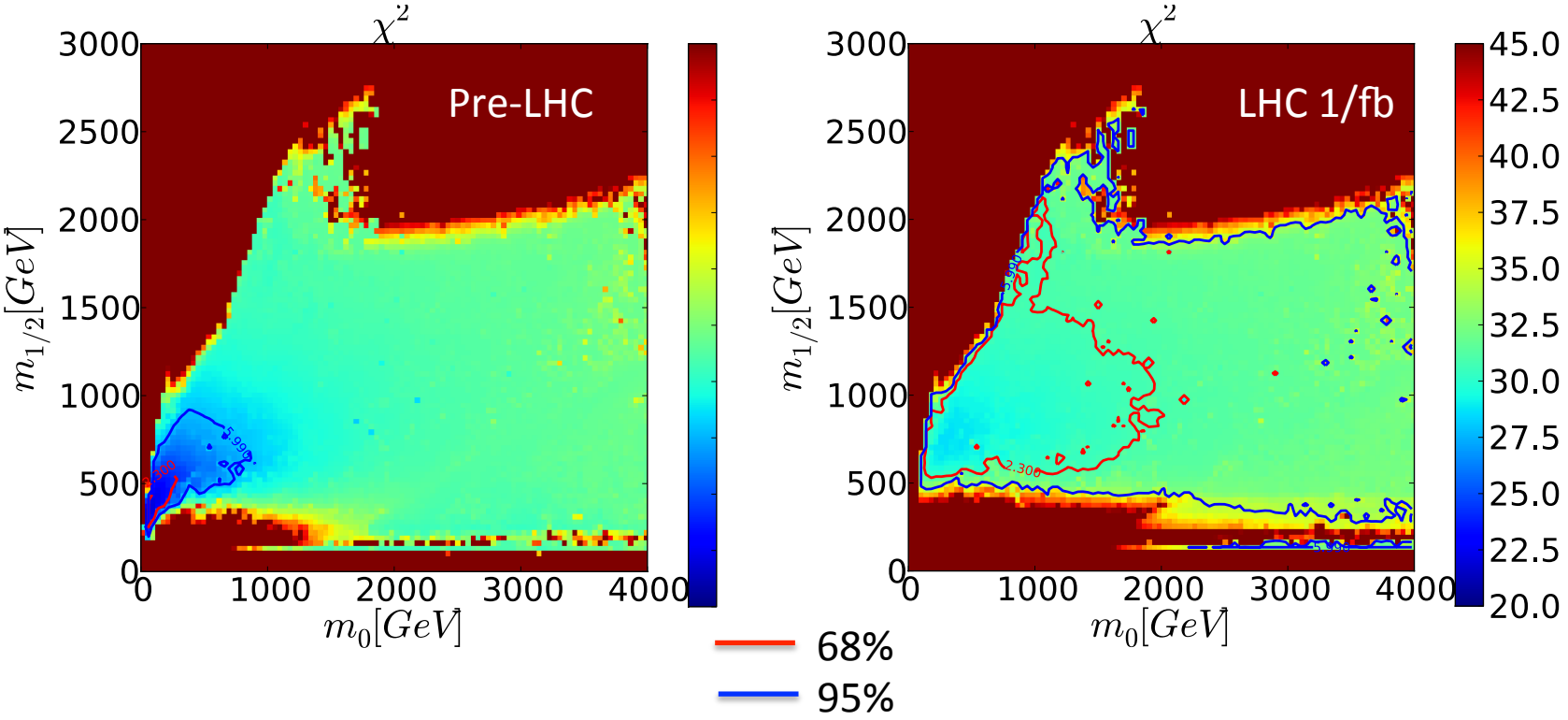
Effect of updating constraints

- Updating constraints



  - Change in χ^2
  - “Bottom of lake changes”

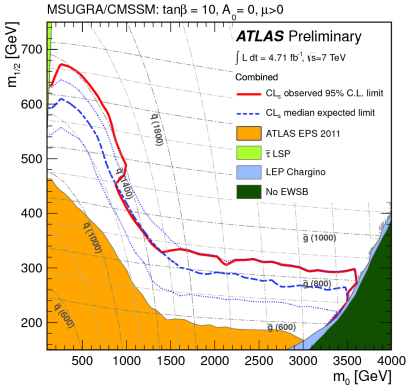
Example: CMSSM m_0-$m_{1/2}$



LHC

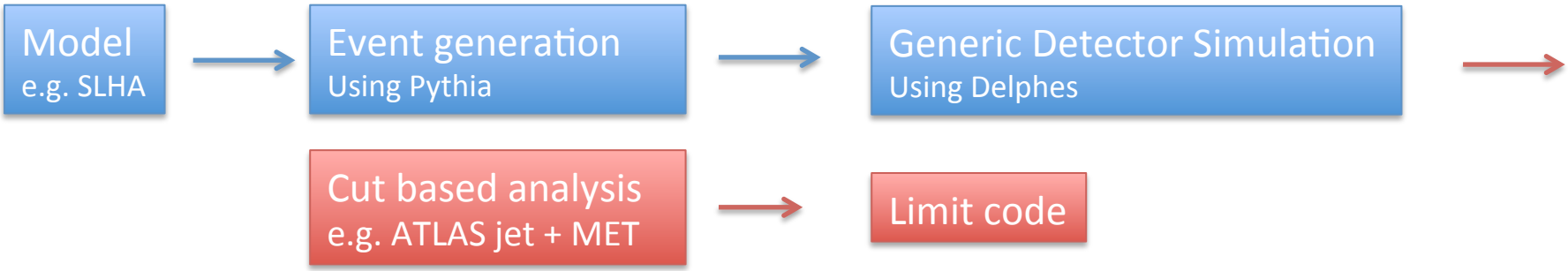
Implementation ATLAS constraint

- How?



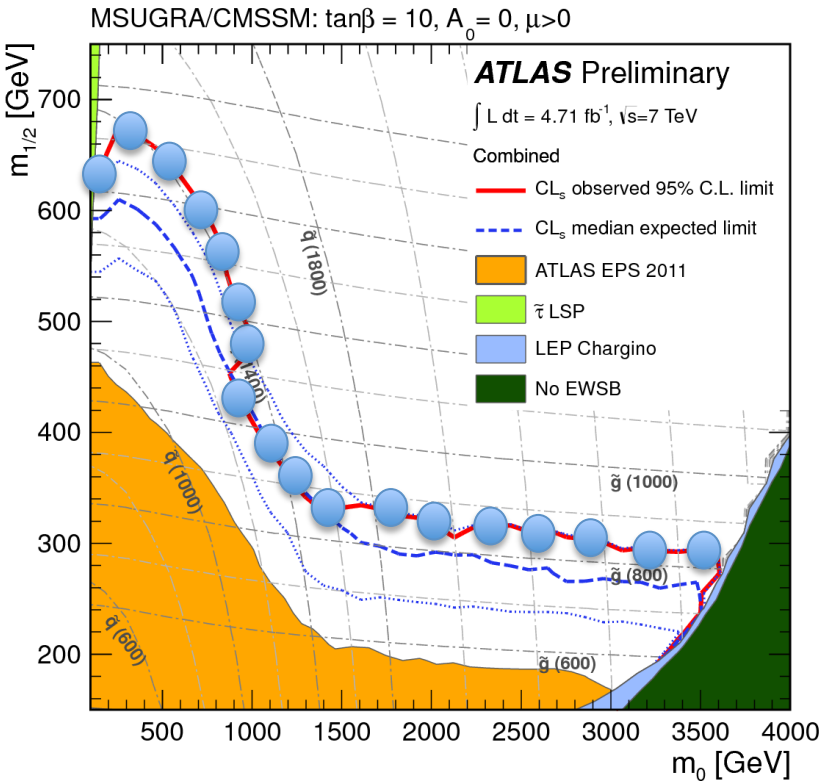
- 95% contour
- Other m_0 , $m_{1/2}$
- Dependence other parameters

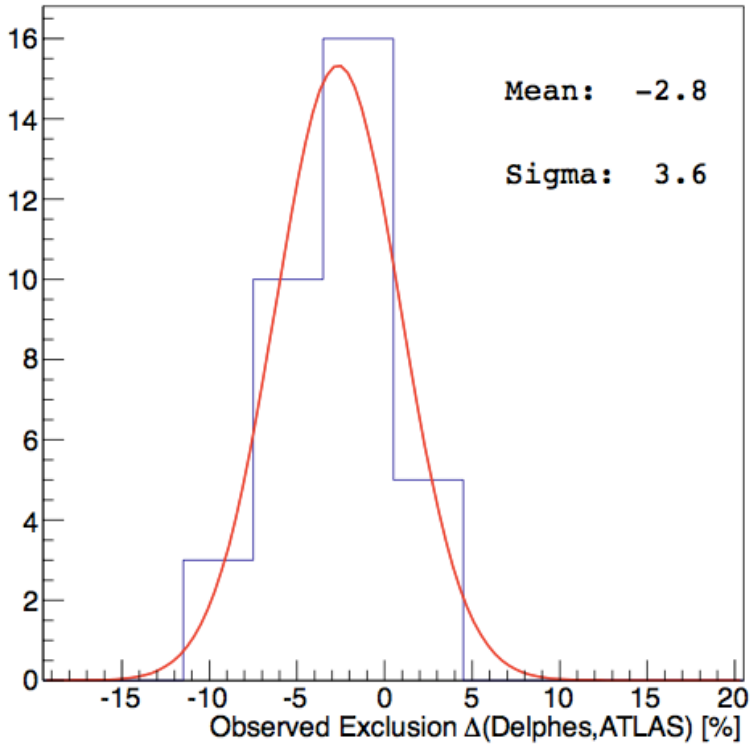
- New tool: Pythia + Delphes



95% confidence contour

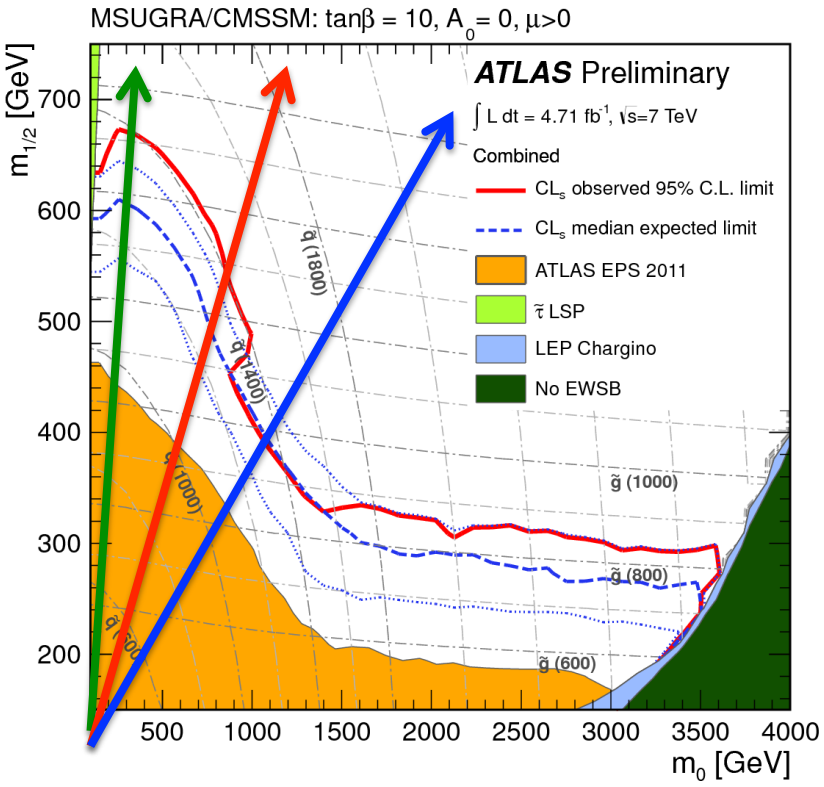
- Calculate CLs along the contour
  - Take 34 points

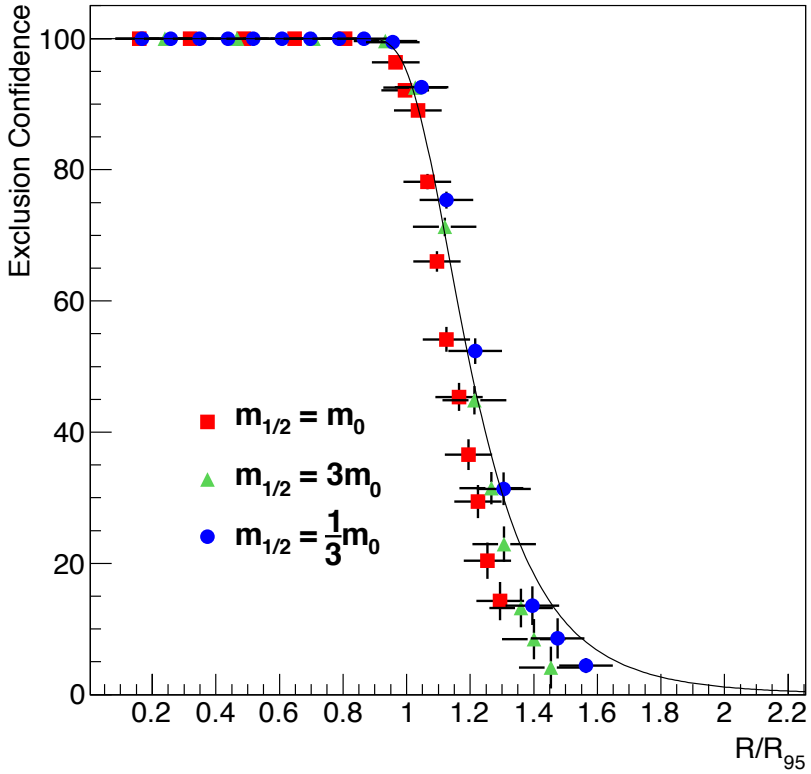




Other m_0, $m_{1/2}$

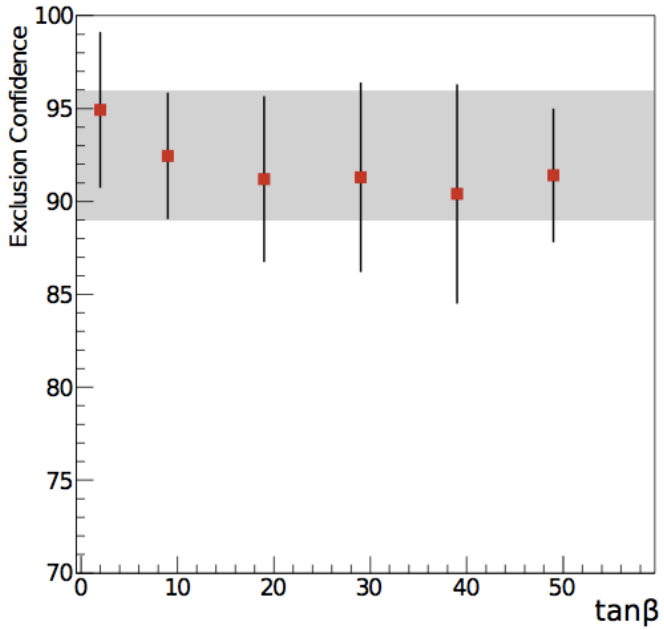
- Scaling law
  - # Events $\propto 1/R^4$

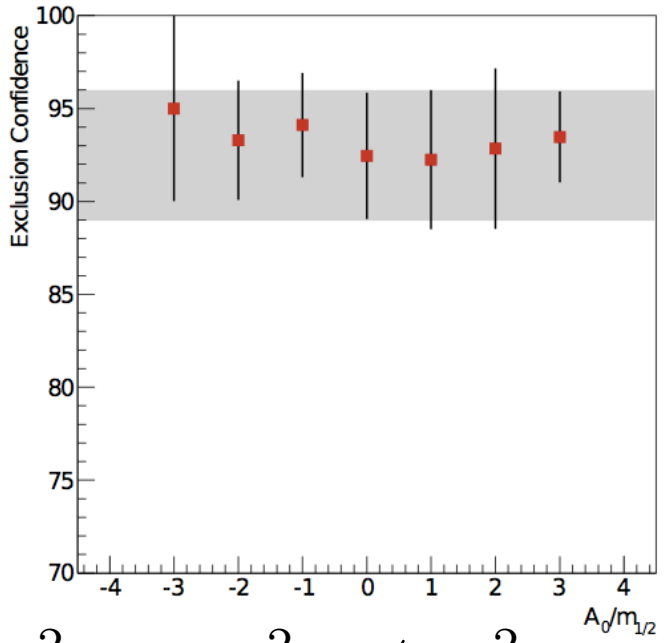




Dependence other parameters

- Dependence $\tan\beta$, A_0

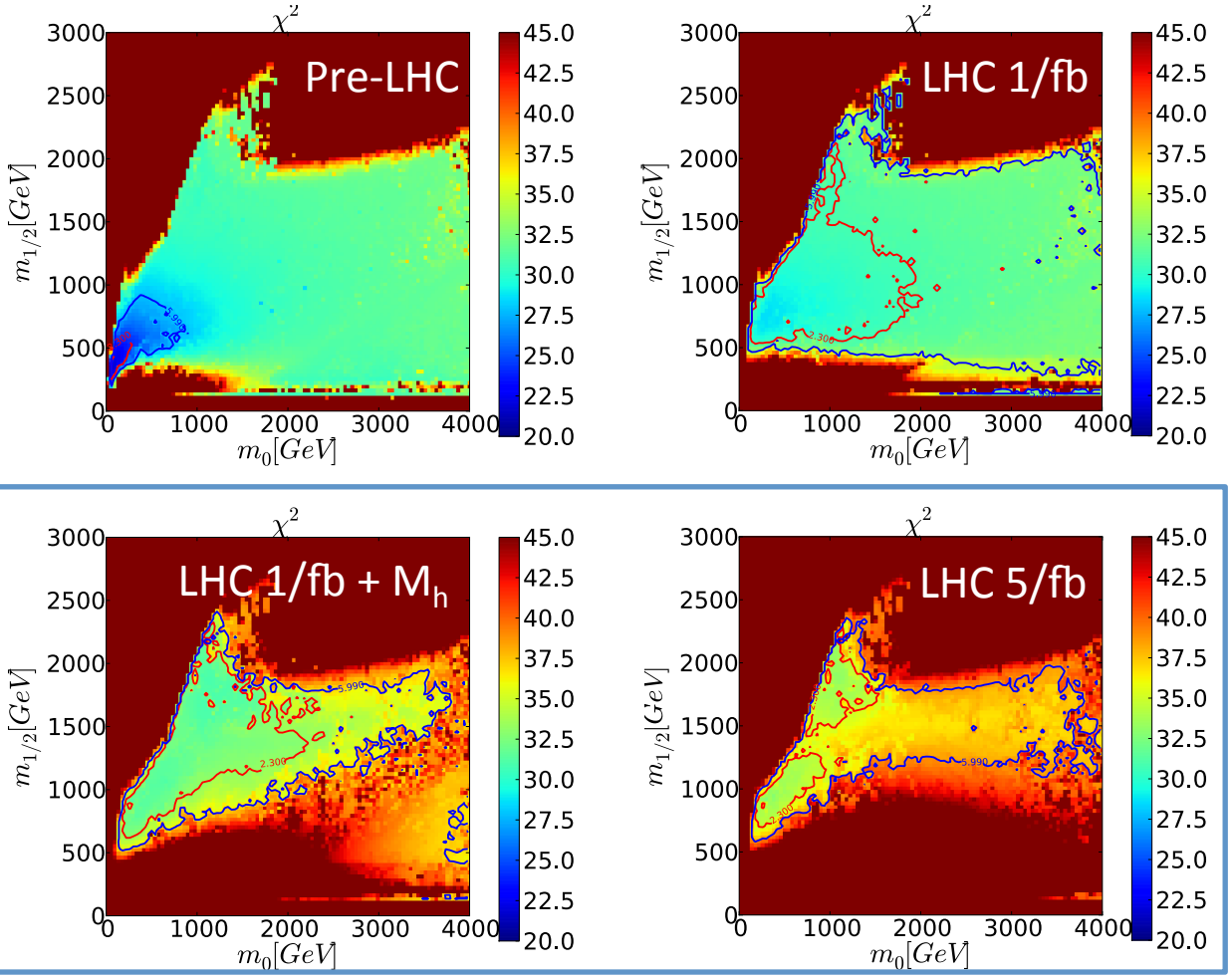




- Higgs non-universality $m^2_{H_u} = m^2_{H_d} \neq m^2_0$
  - Also consistent

Time evolution

- m_0 - $m_{1/2}$ plane in CMSSM



- Pre-LHC
  - No likelihoods
- LHC 1/fb
  - October 2011 likelihoods
- LHC 1/fb + M_h
  - October 2011 likelihoods
  - M_h = 125±1±1.5
- LHC 5/fb
  - July 2012 likelihoods
  - M_h = 125±1±1.5
  - M_W = 80.385±0.015

— 68%
— 95%

Time evolution

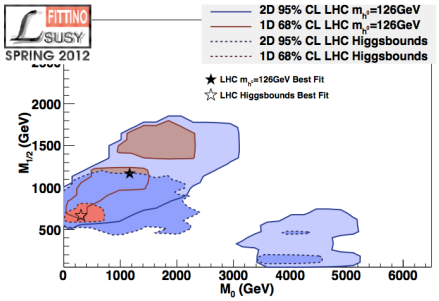
- Best fit points

	CMSSM		NUHM1	
Data set	$\chi^2/n_{d.o.f.}$	P-value	$\chi^2/n_{d.o.f.}$	P-value
Pre-LHC	21.9/20	35%	19.9/18	34%
LHC 1/fb	28.6/22	16%	27.0/21	17%
LHC 1/fb + Mh=125	31.0/23	12%	28.9/22	15%
Latest	32.8/23	8.5%	31.3/22	9.1%

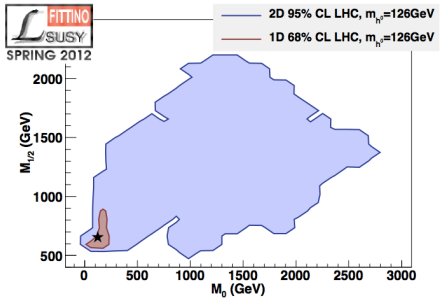
- $n_{d.o.f} = N_{meas} - N_{par}$
- Good consistency if $\chi^2/n_{d.o.f.} \approx 1$

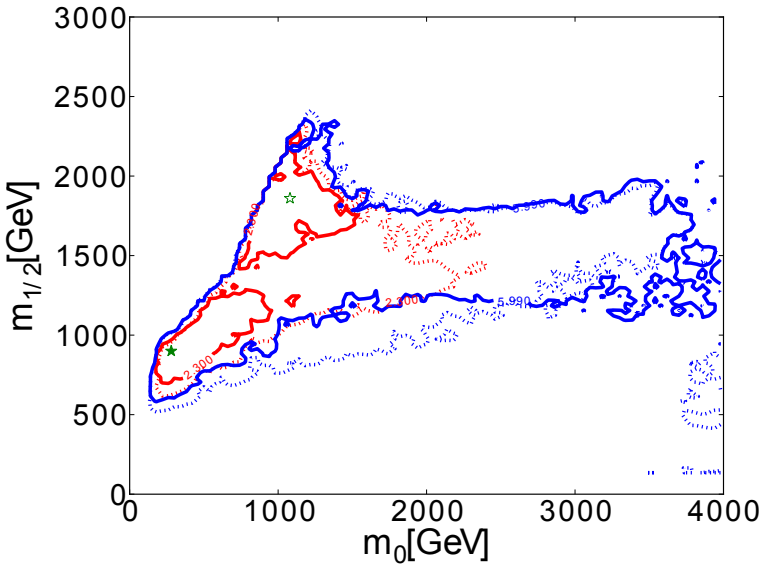
Parameter planes: m_0 - $m_{1/2}$

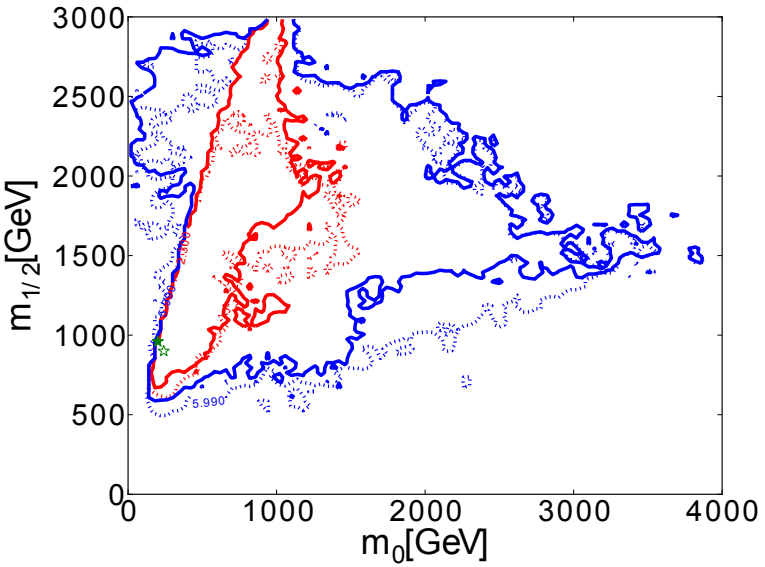
CMSSM



NUHM1





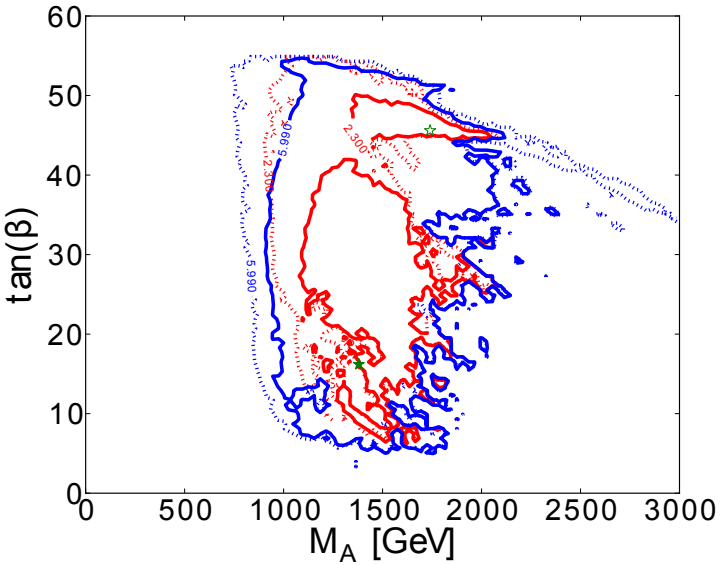


--- LHC 1/fb + M_h — 68%

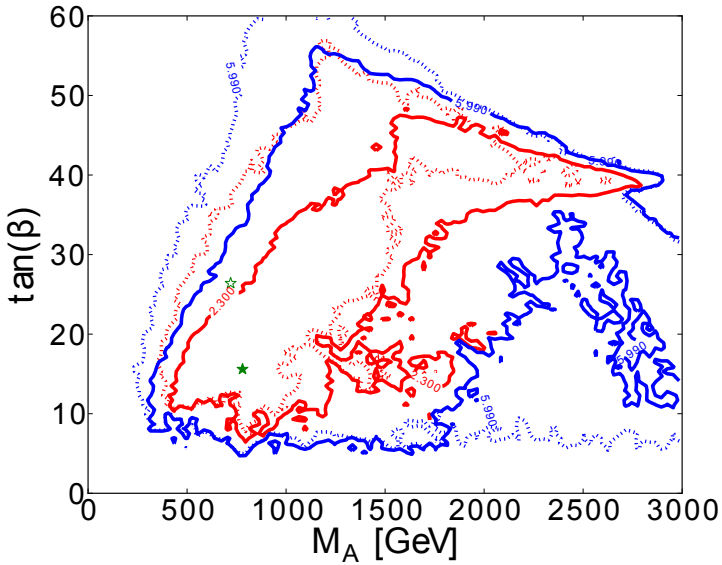
— LHC 5/fb — 95%

Parameter planes: M_A - tan β

CMSSM



NUHM1

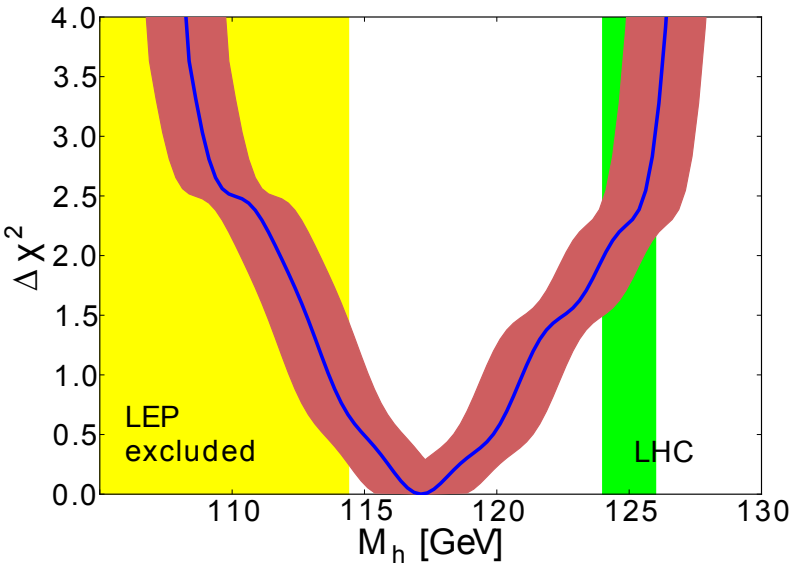


--- LHC 1/fb + M_h — 68%

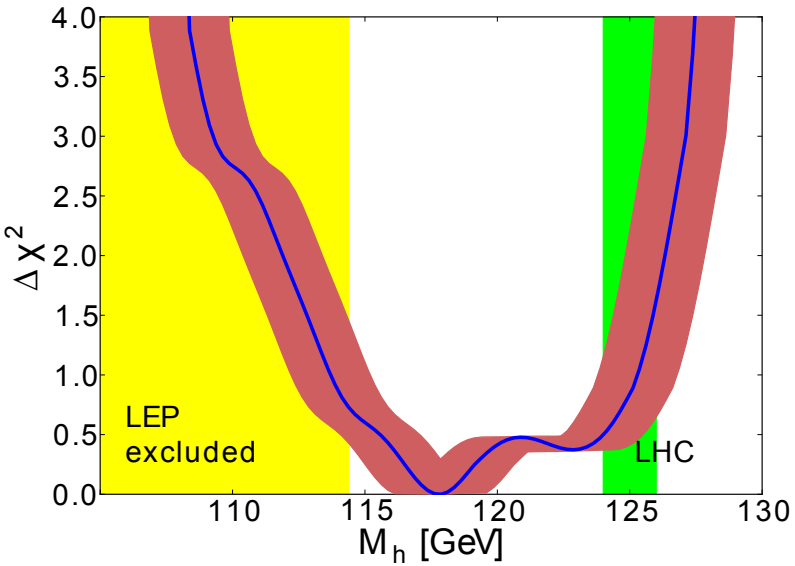
— LHC 5/fb — 95%

Predictions: M_h

CMSSM

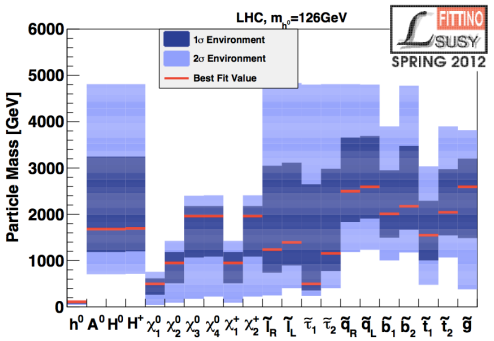


NUHM1

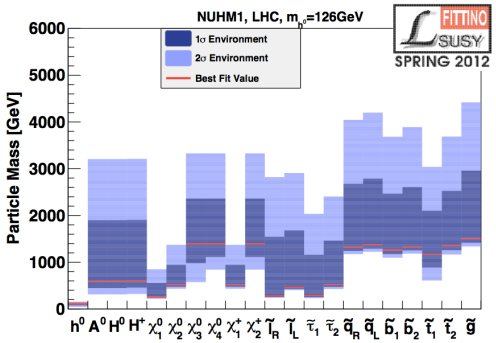


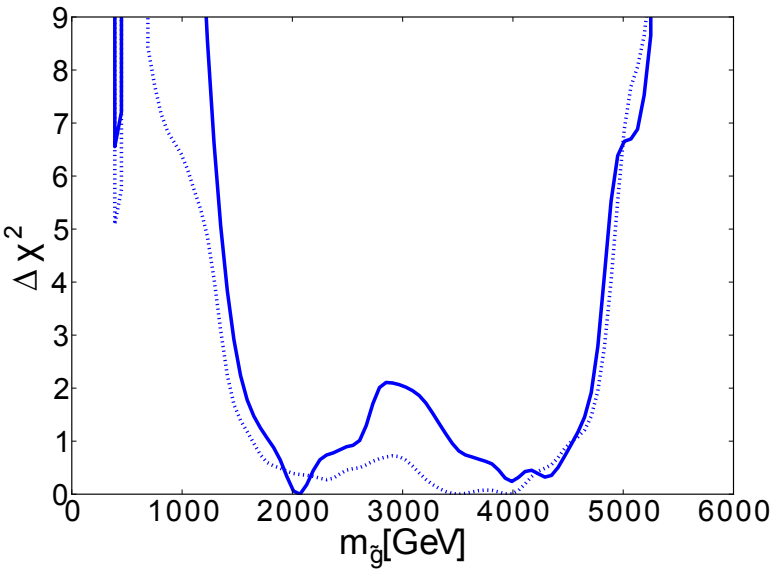
Predictions: gluino mass

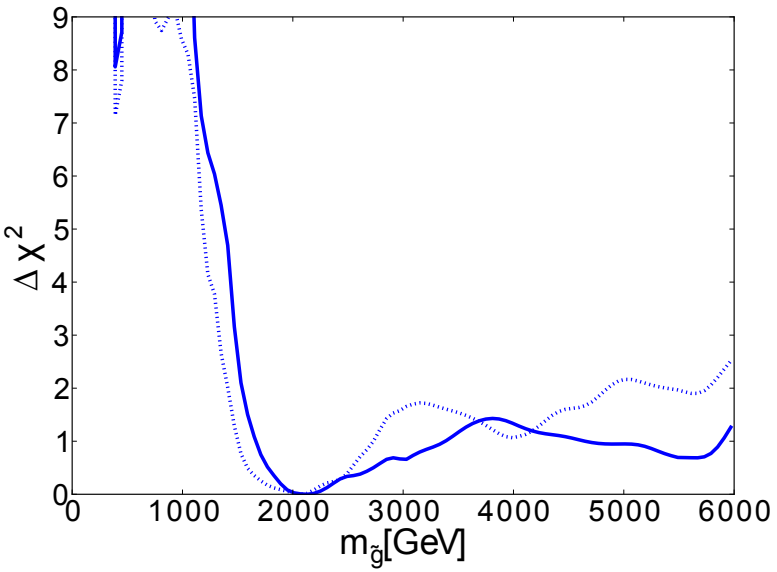
CMSSM



NUHM1





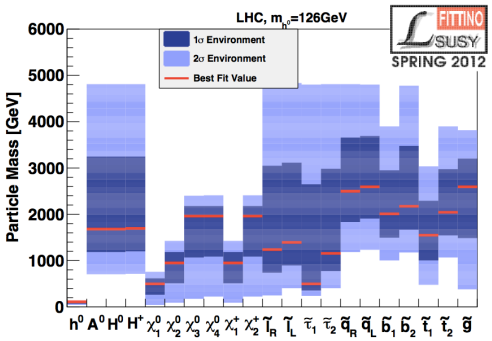


--- LHC 1/fb + M_h

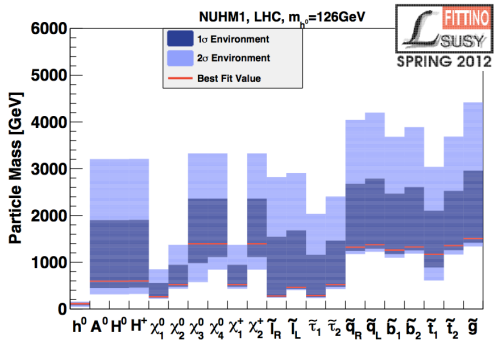
— LHC 5/fb

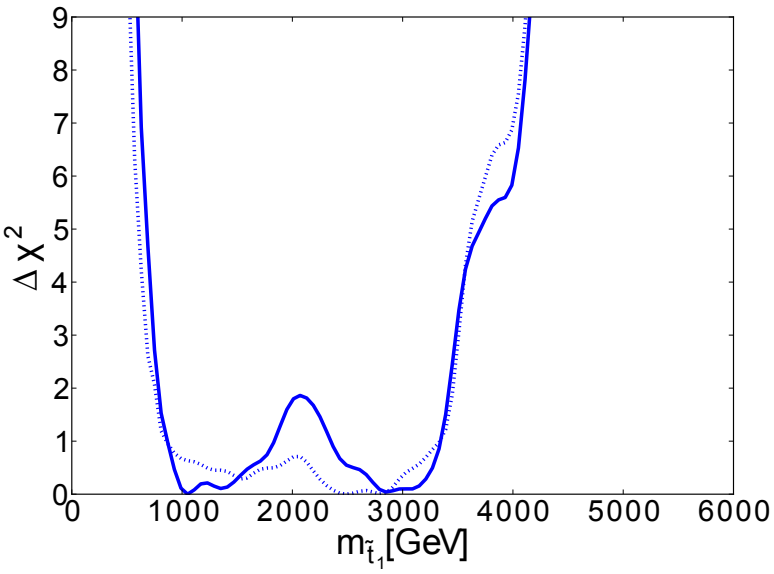
Predictions: stop mass

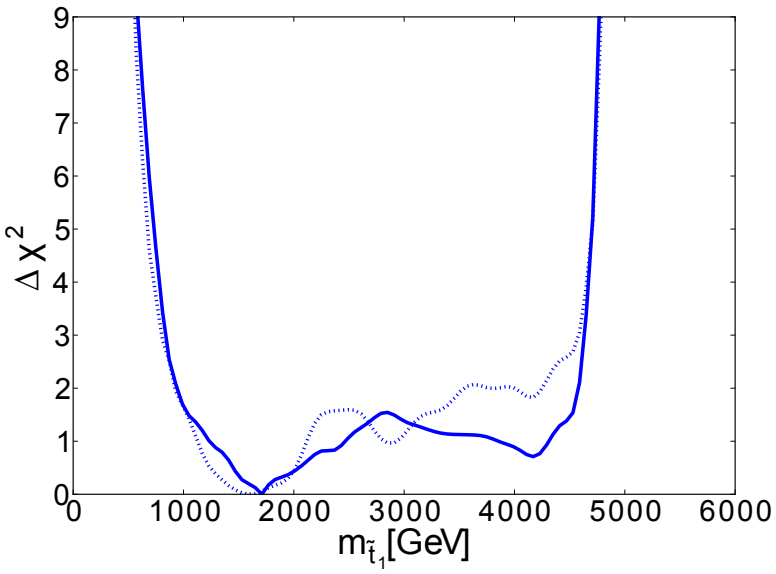
CMSSM



NUHM1





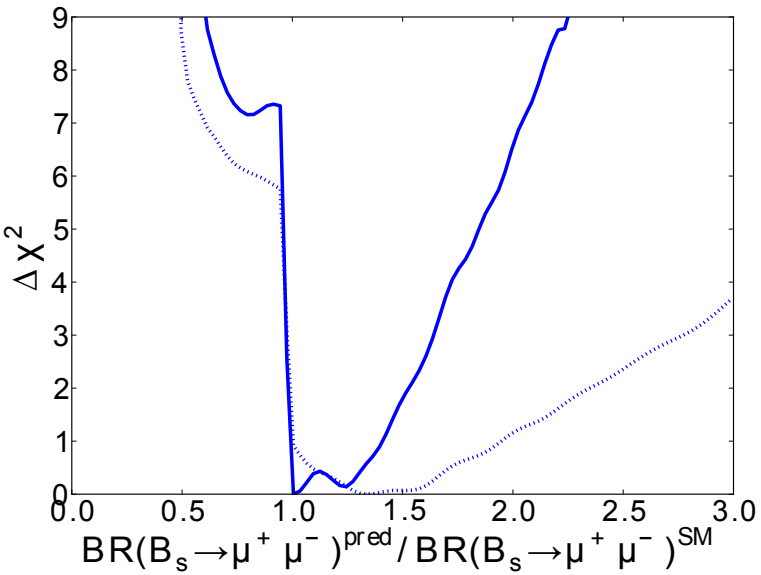


--- LHC 1/fb + M_h

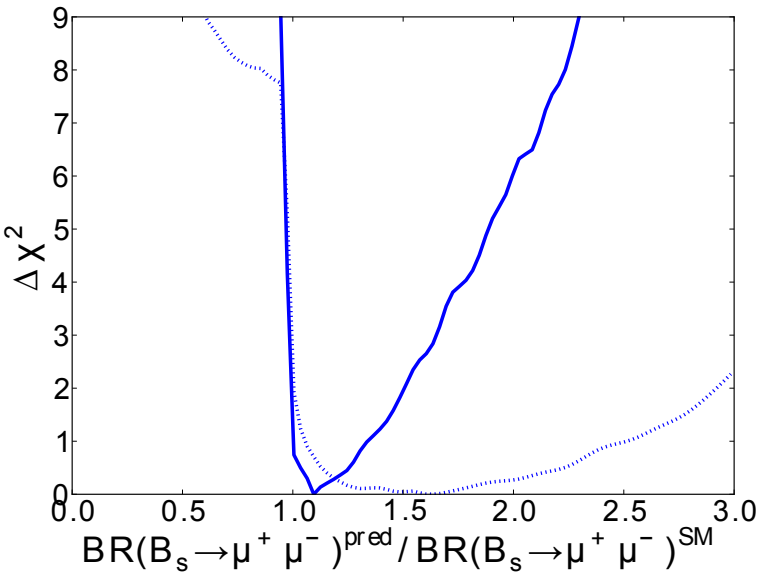
— LHC 5/fb

Predictions: B_s-> μμ

CMSSM

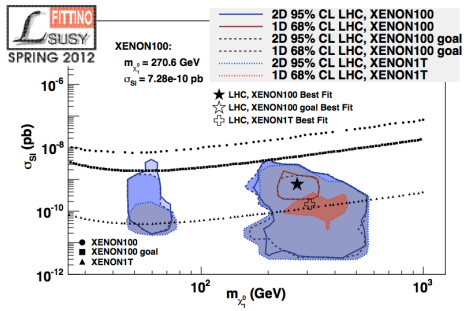


NUHM1

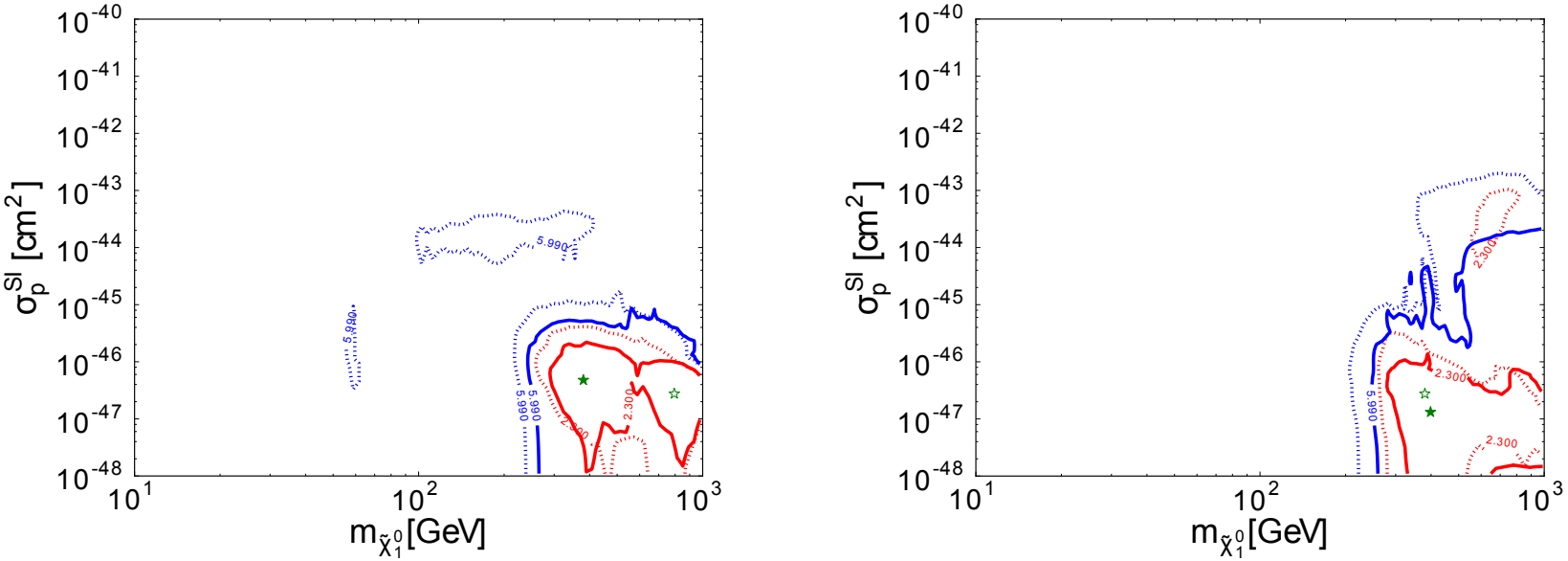


Predictions: Spin independent cross section

CMSSM



NUHM1



--- LHC 1/fb + M_h — 68%

— LHC 5/fb — 95%

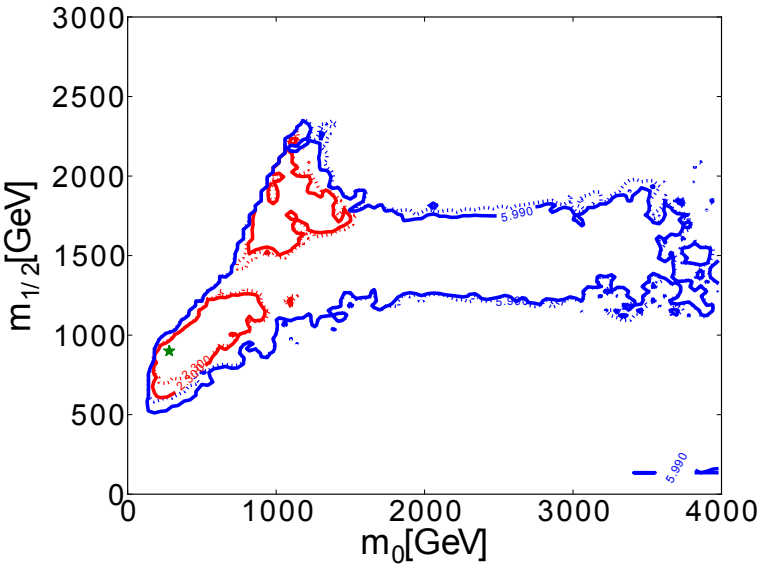
Conclusions

- Implications
  - Very shallow best fit regions
  - Similar results to Fittino
- New tool: Pythia + Delphes
  - Implementation ATLAS constraint validated
  - Generic model testing

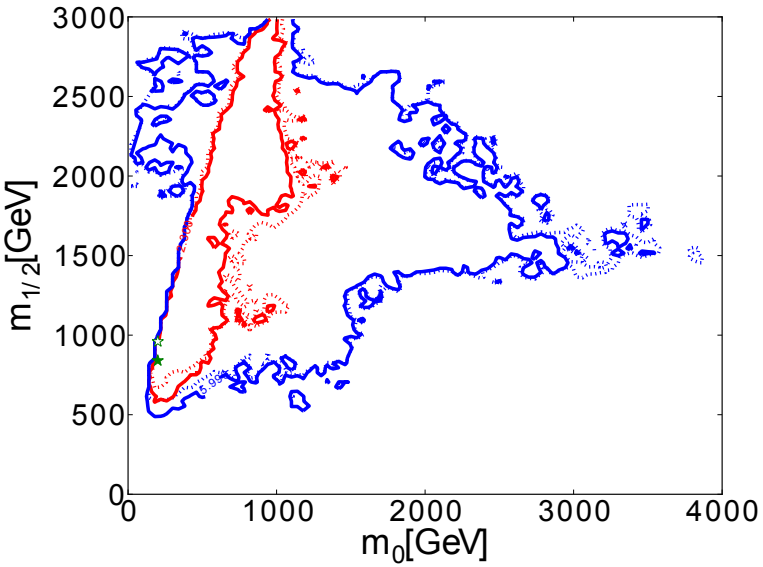
Backup slides

Drop ATLAS

CMSSM



NUHM1



--- LHC 5/fb

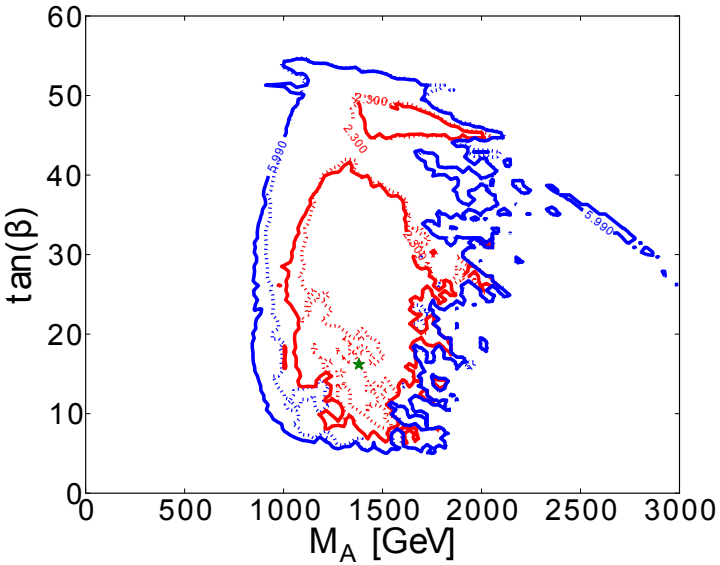
— LHC 5/fb, ATLAS 1/fb

— 68%

— 95%

Drop ATLAS

CMSSM



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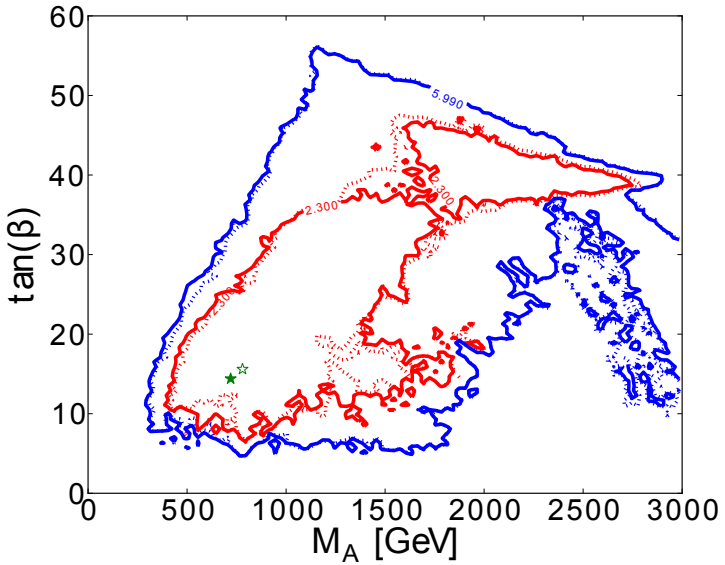


--- LHC 5/fb

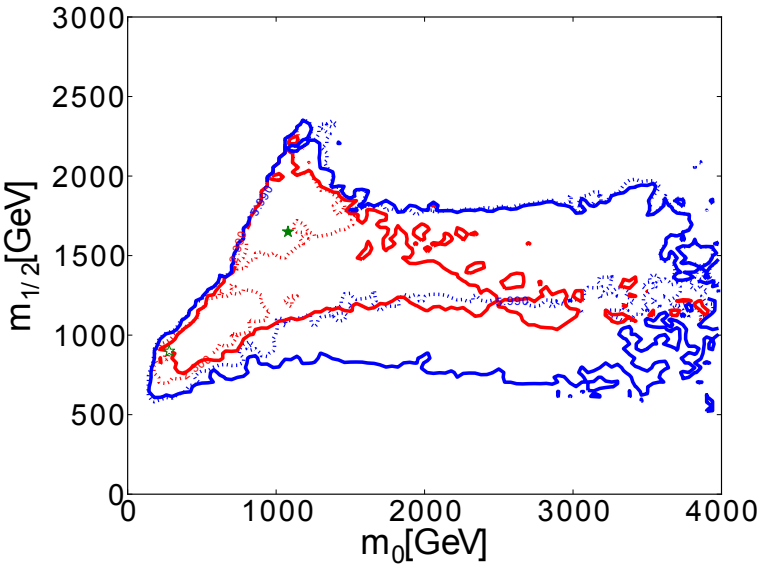
— LHC 5/fb, ATLAS 1/fb

— 68%

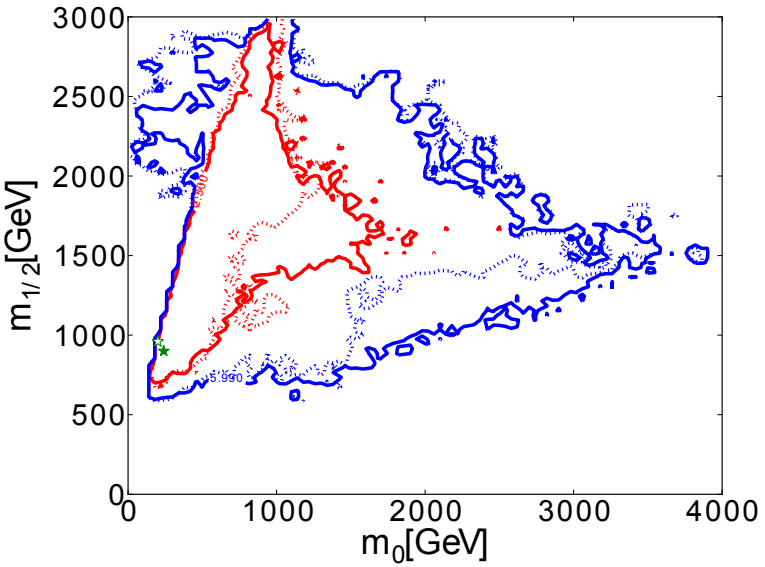
— 95%

Drop B_s-> μμ

CMSSM



NUHM1



--- LHC 5/fb

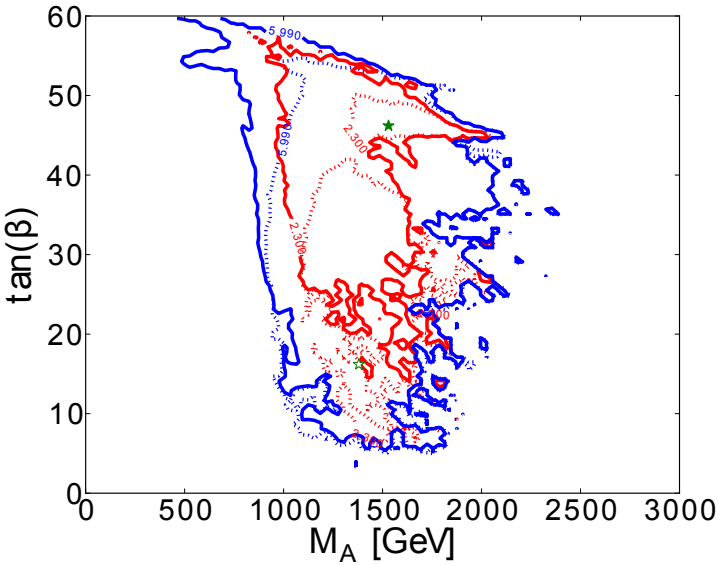
— LHC 5/fb, B_s-> μμ 1/fb

— 68%

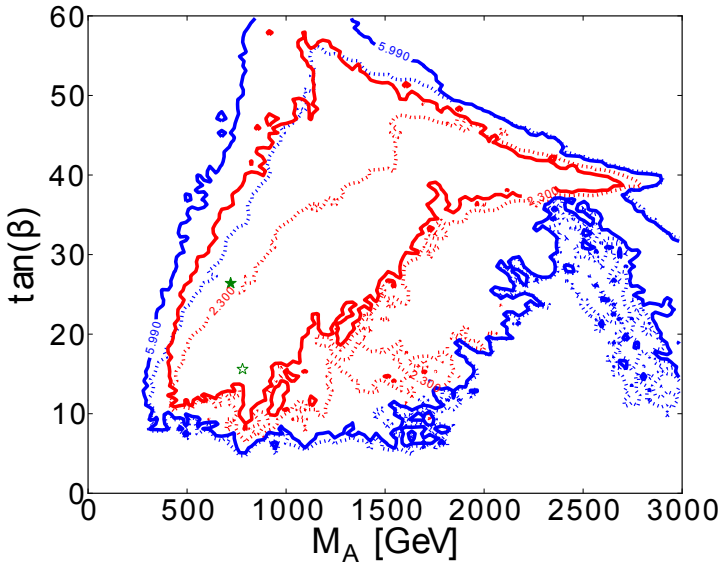
— 95%

Drop B_s-> μμ

CMSSM



NUHM1



--- LHC 5/fb

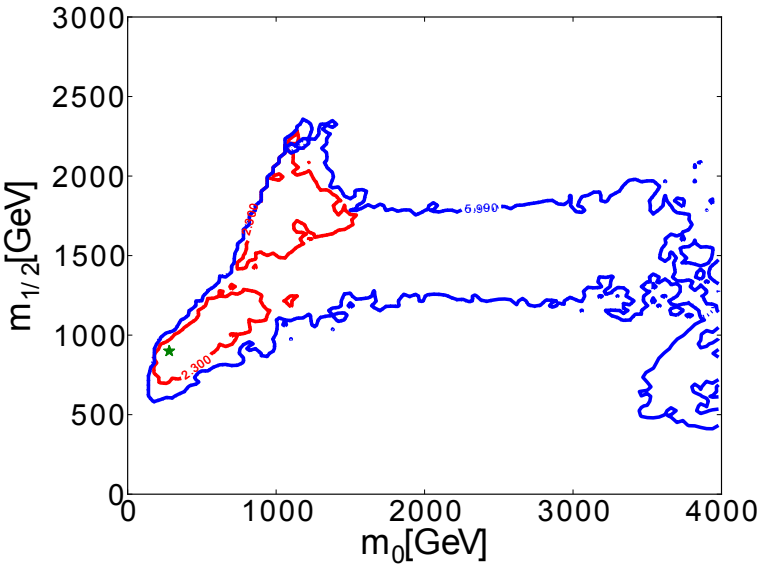
— LHC 5/fb, B_s-> μμ 1/fb

— 68%

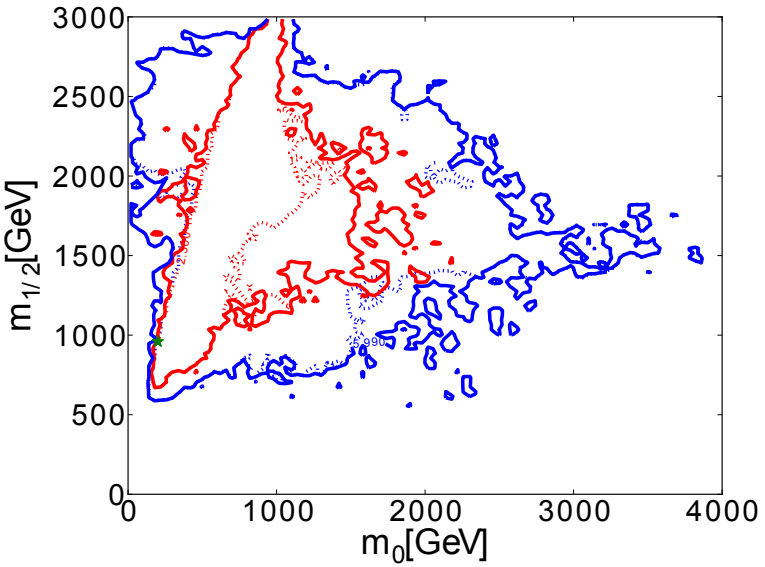
— 95%

Drop Xenon100 2012

CMSSM



NUHM1



--- LHC 5/fb

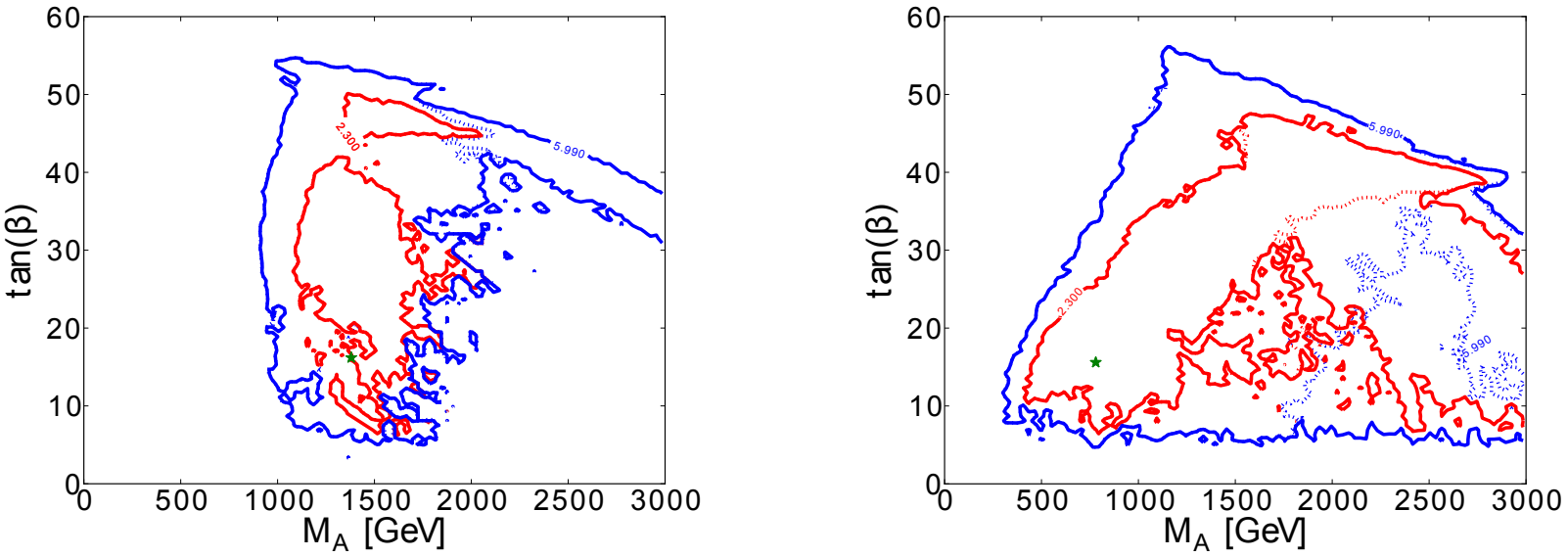
— LHC 5/fb, Xenon100 2011

— 68%

— 95%

Drop Xenon 2012

CMSSM **NUHM1**



--- LHC 5/fb

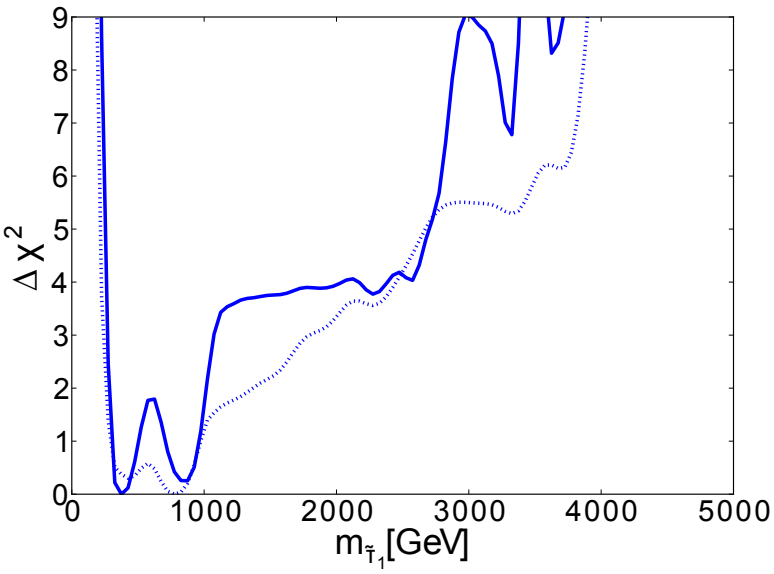
— LHC 5/fb, Xenon100 2011

— 68%

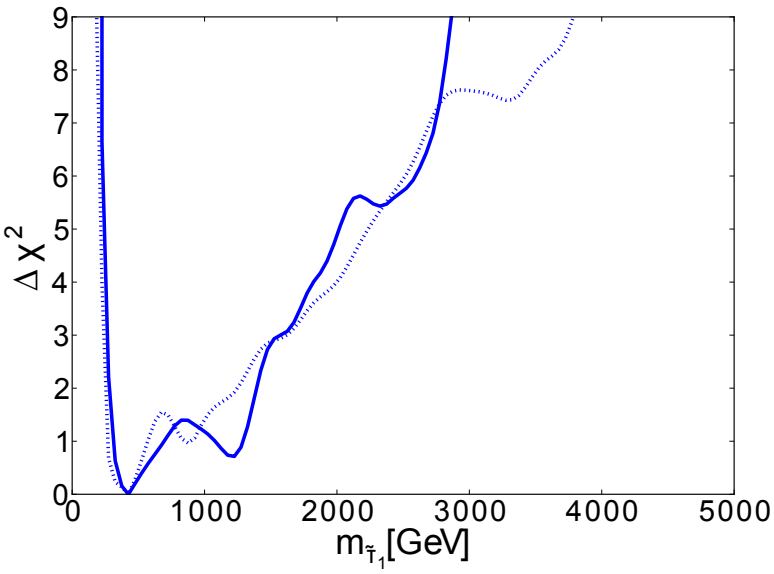
— 95%

Predictions: stau mass

CMSSM



NUHM1



--- LHC 1/fb + M_h

— LHC 5/fb