The status of constrained SUSY and implications from the Higgs boson

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Fittino

- C++ program for **SUSY model testing** and **SUSY parameter analysis**
- Currently supported SUSY models:

  CMSSM, GMSB, AMSB, MSSM24, NMSSM, NUHM1, NUHM2
- Measurements from low/high energy experiments, direct SUSY search

  LEP/SLC, Tevatron, cosmology, LHC and LC, $(g\text{-}2)_\mu$, B, K,...
- Use public theory codes: **SPheno, Superslo, Micromegas, FeynHiggs, HDecay**
- Parameter analysis using

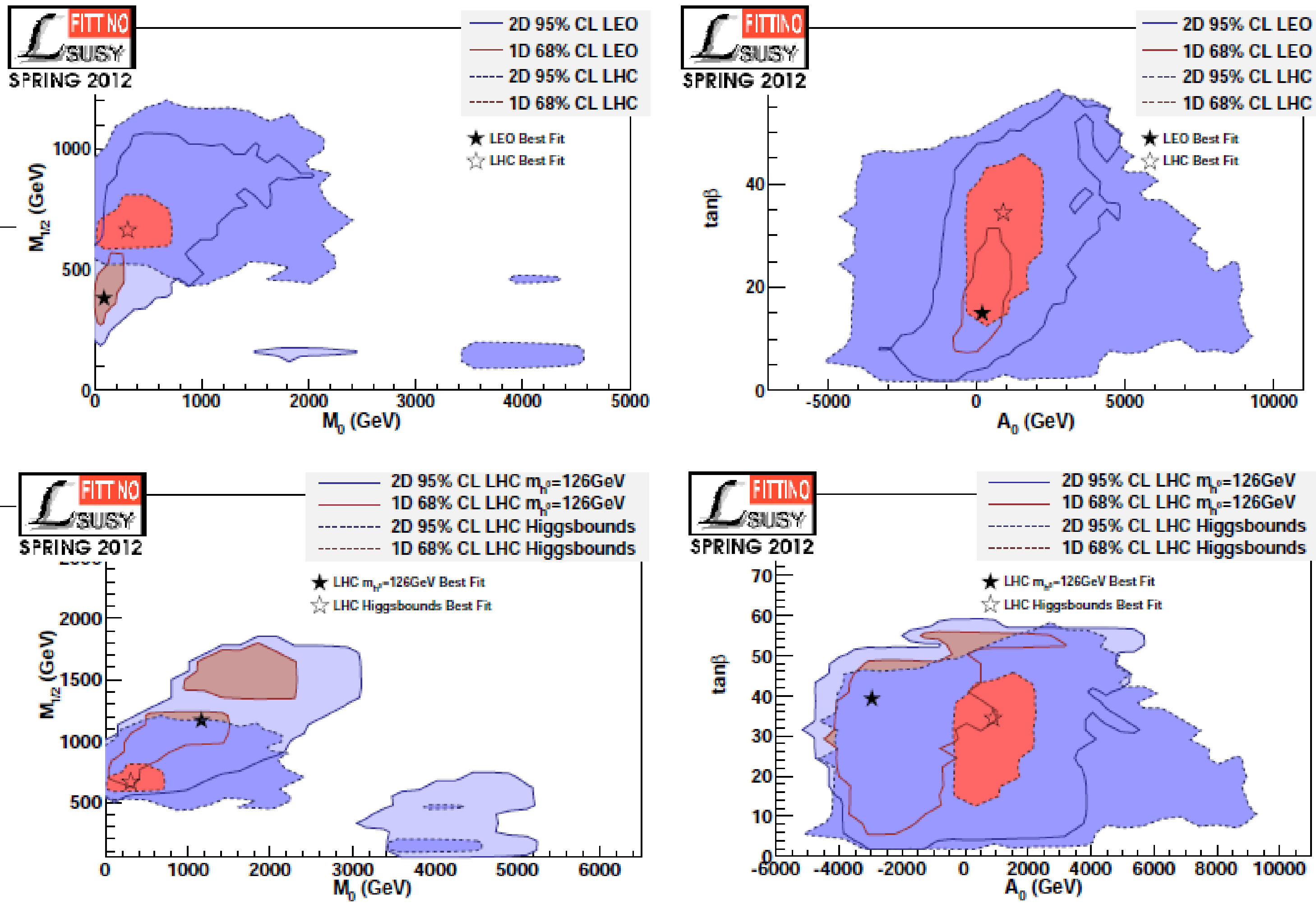
  Auto-adaptive Markov Chain Monte Carlo (MCMC)
- Previous publications:

  arXiv:0412012 [hep-ph], arXiv:0511006 [hep-ph], arXiv:0907.2589 [hep-ph] arXiv:0909.1820 [hep-ph], arXiv:1105.5398 [hep-ph], arXiv:1102.4693 [hep-ph], arXiv:1204.4199 [hep-ph]

The CMSSM getting into trouble

arXiv:1204.4199

	χ^2/ndf
LEO	10.3/8
LHC	13.1/9
m_h	18.4/9



Updated Observables

$BR(b \rightarrow s\gamma)$	(3.55 ± 0.24 ± 0.09 ± 0.23) x 10^{-4}
$BR(B_s \rightarrow \mu\mu)$	(3.2 ± 1.5 ± 0.76) x 10^{-9}
$BR(B \rightarrow \tau\nu)$	(0.72 ± 0.25 ± 0.11± 0.07) x 10^{-4}
Δm_{B_s}	(17.719 ± 0.043 ± 4.2) ps^{-1}
$a_\mu - a_\mu^{SM}$	(28.7 ± 8.0 ± 2.0) x 10^{-10}
m_W	(80.385 ± 0.015 ± 0.010) GeV
$sin^2 \theta_{eff}$	0.23113 ± 0.00021
$\Omega_{CDM} h^2$	0.1187 ± 0.0017 ± 0.01187
m_t	(173.18 ± 0.94) GeV

+ Xenon 100 limit via ***AstroFit***

+ LEP chargino limit

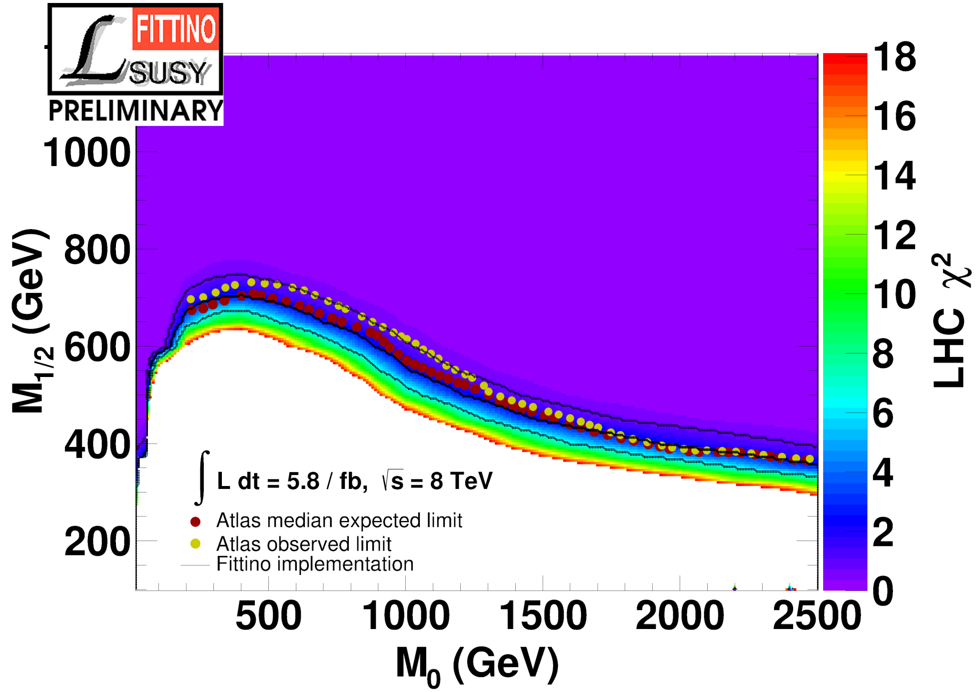
+ LHC exclusion from L_{int} = 5.8 fb^{-1}

+ Higgs limits via ***HiggsBounds***

+ Higgs signals via ***HiggsSignals***

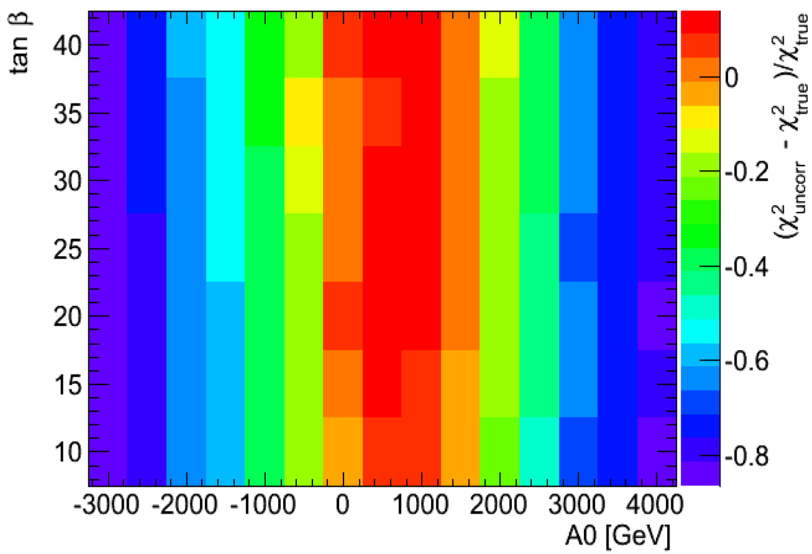
LHC SUSY searches

χ^2 grid in $M_0 - M_{1/2}$
for A_0=0 und tan β = 10
matching ATLAS exclusion



Grid creation using
Herwig++, Delphes, Prospino

M_0 = 1.4 TeV, $M_{1/2}$ = 455 GeV



Along exclusion line grid of correction factors in A_0 – tan β in order to take dependence on these parameters into account .

HiggsSignals

Full available data set (Moriond 2013)

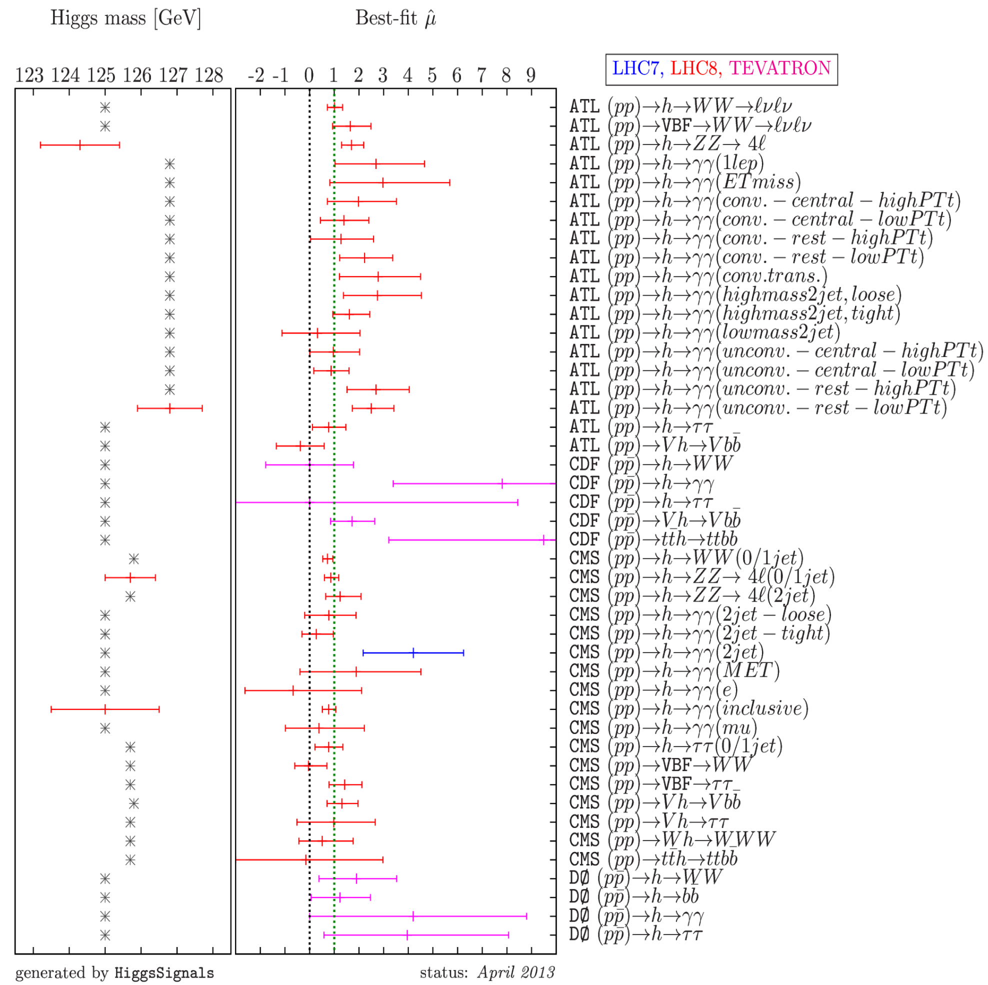
Philip Bechtle, Sven Heinemeyer,
Oscar Stål, Tim Stefaniak, Georg Weiglein

arXiv:1305.1933 [hep-ph]

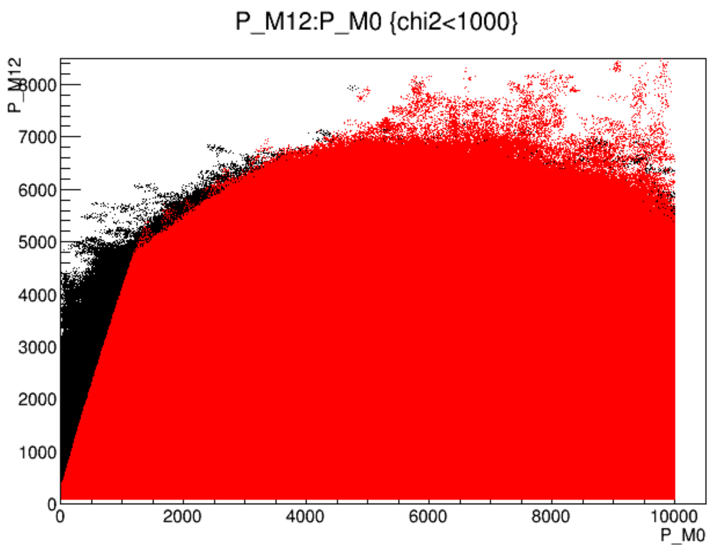
http://higgsbounds.hepforge.org/

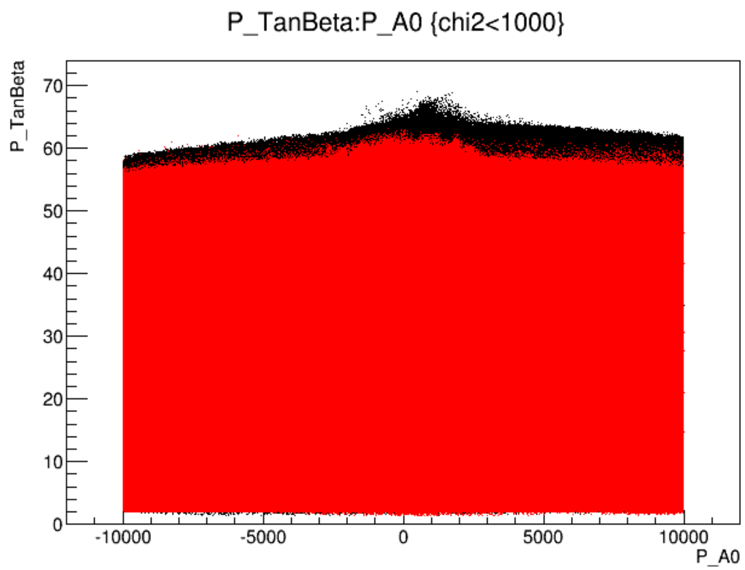
χ^2 from Higgs mass and signal strength measurements

Takes correlations of major systematic uncertainties into account:
- rate predictions
- mass predictions
- luminosity



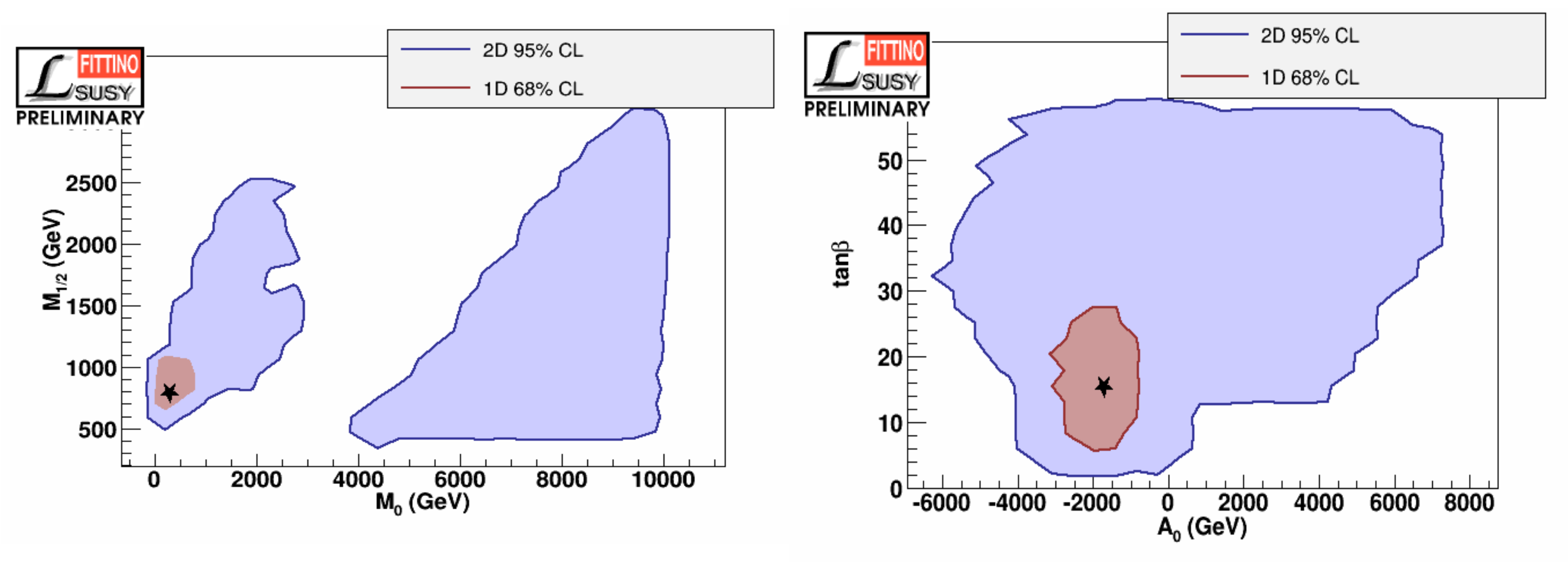
Statistics





	CMSSM	NUHM1
different points	660 949 345	500 767 757
χ<1000	244 815 736	148 743 886

Simple Higgs implementation



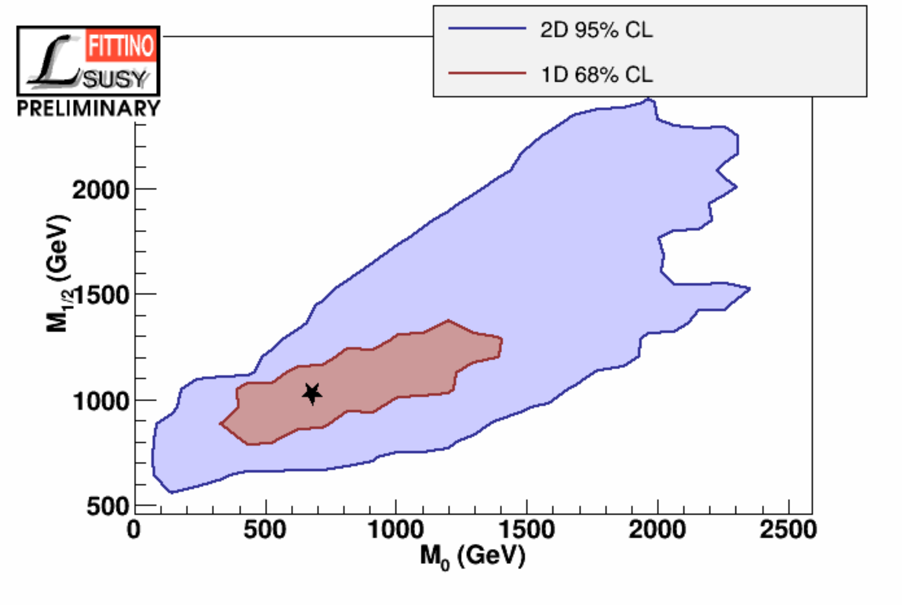
Assume $m_h = (125.5 \pm 2 \pm 3)$ GeV.

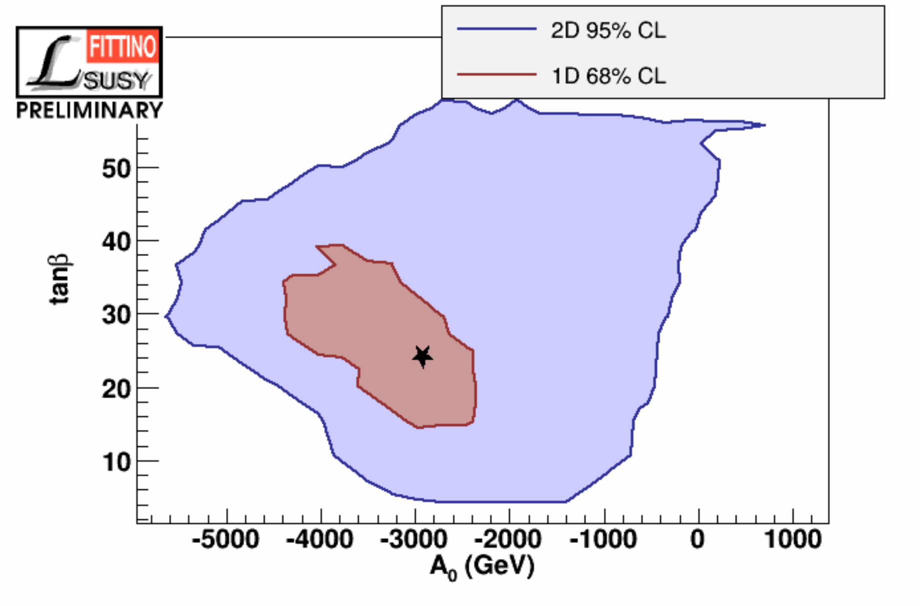
χ^2 / ndf = 14.0 / 9

Higher masses / focus-point & funnel-region allowed due to floating of scale Q at which predictions are calculated

Better fit quality due to new measurement of $B \rightarrow \tau\nu$.

Using HiggsSignals



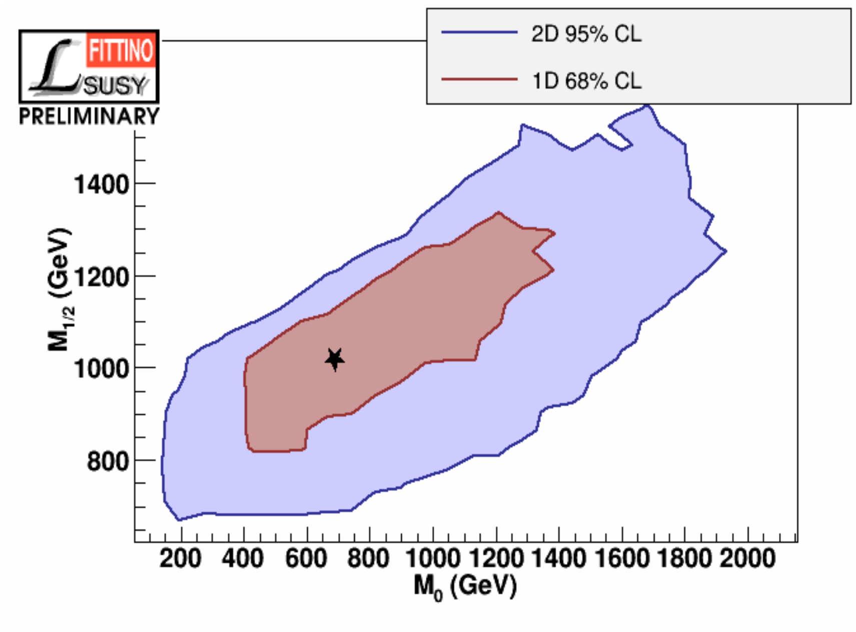


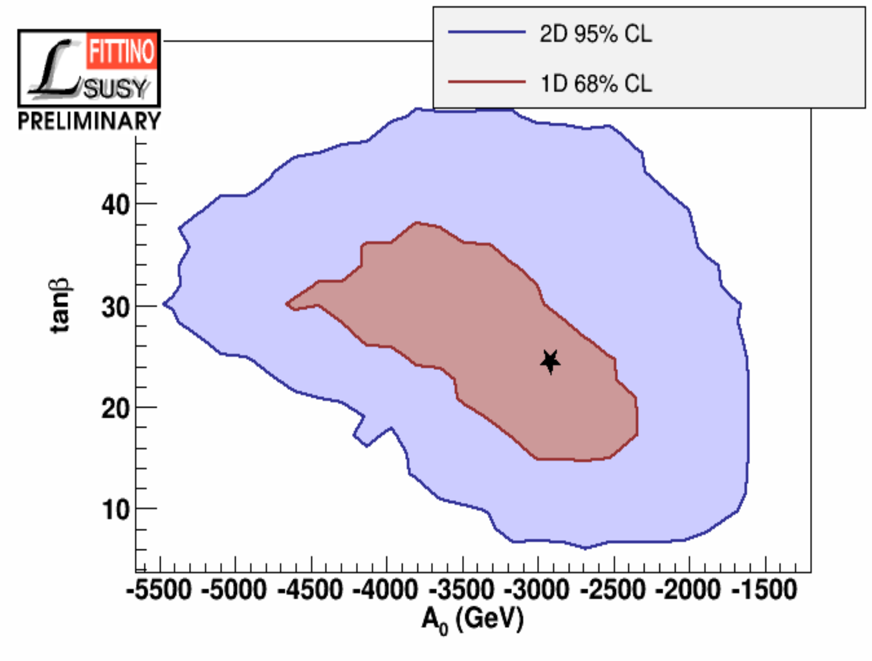
χ^2 / ndf = 48.6 / 57

Focus-point & funnel region vanish.

Fit quality improves because the SM like rate measurements can be well described by a SM like Higgs.

Reducing the mass theory uncertainty

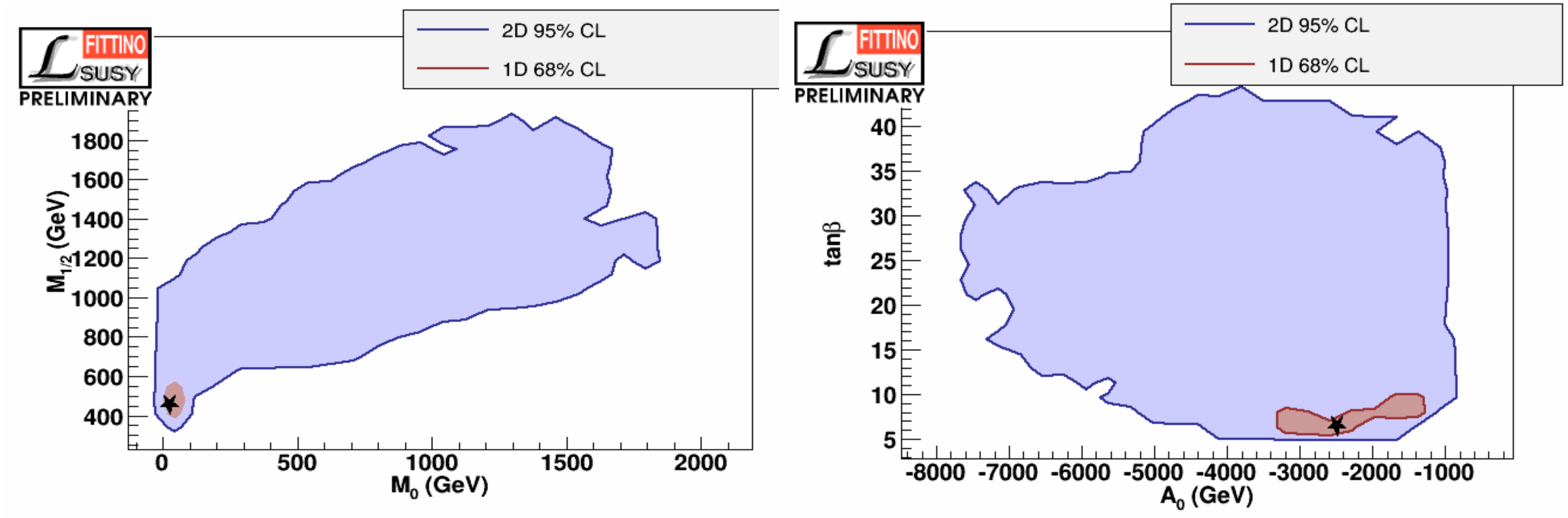




χ^2 / ndf = 48.9 / 57

Reducing the mass theory uncertainty to 1.5 GeV has minor effect on a 1 sigma region but shrinks 2 sigma region.

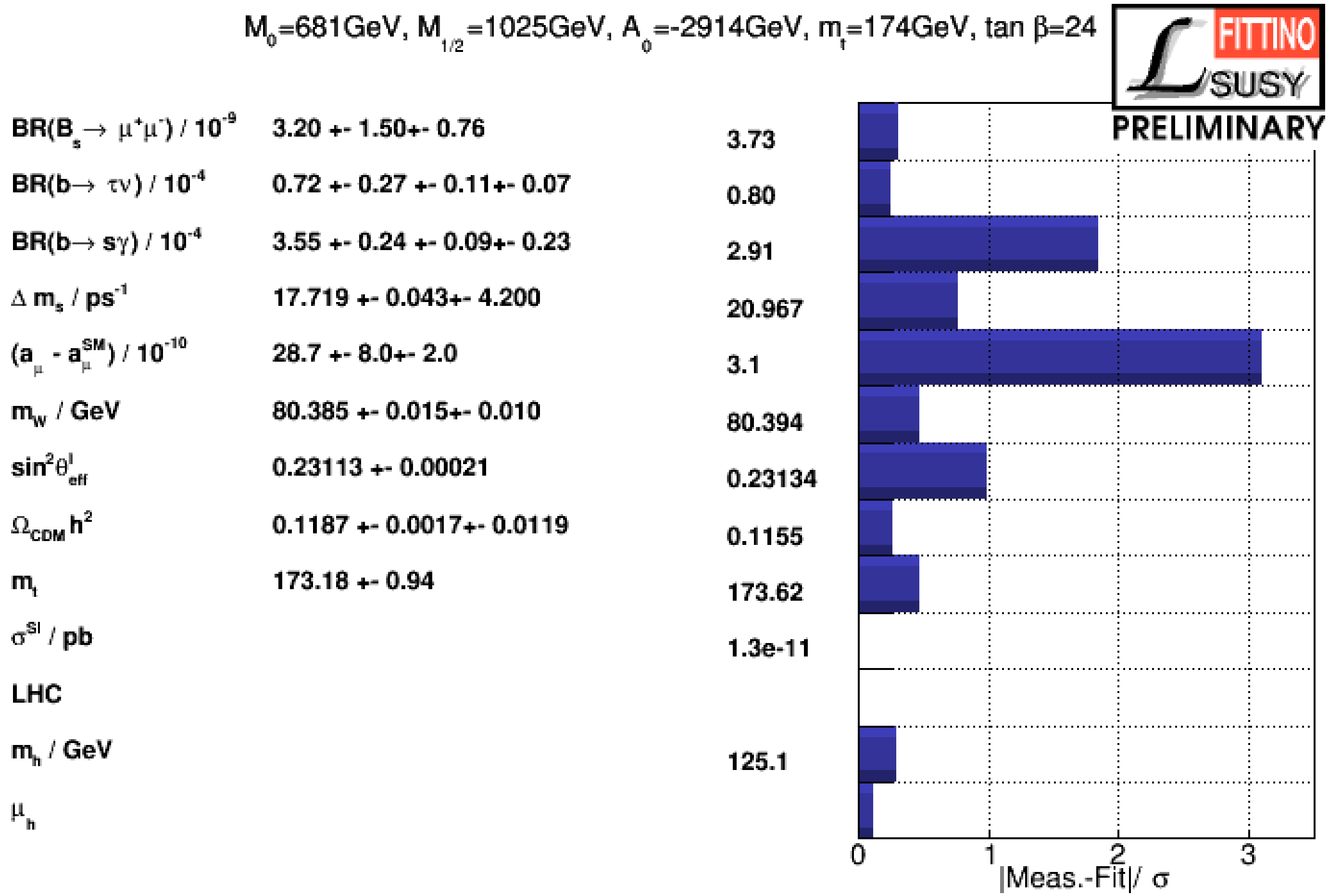
NUHM1



χ^2 / ndf = 45.4 / 56

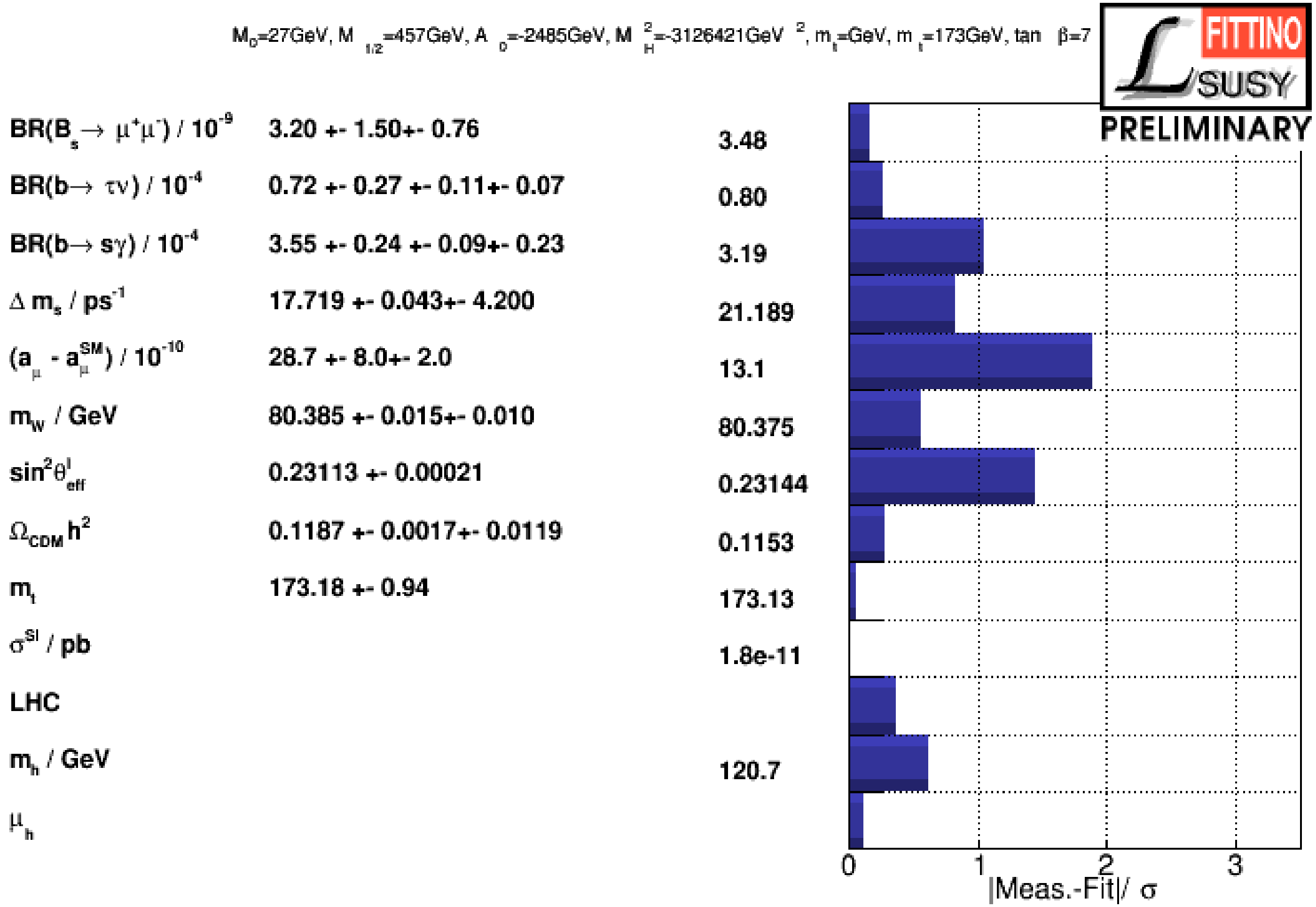
Lower values of M_0 , $M_{1/2}$ and tan β preferred.

Individual pull: CMSSM



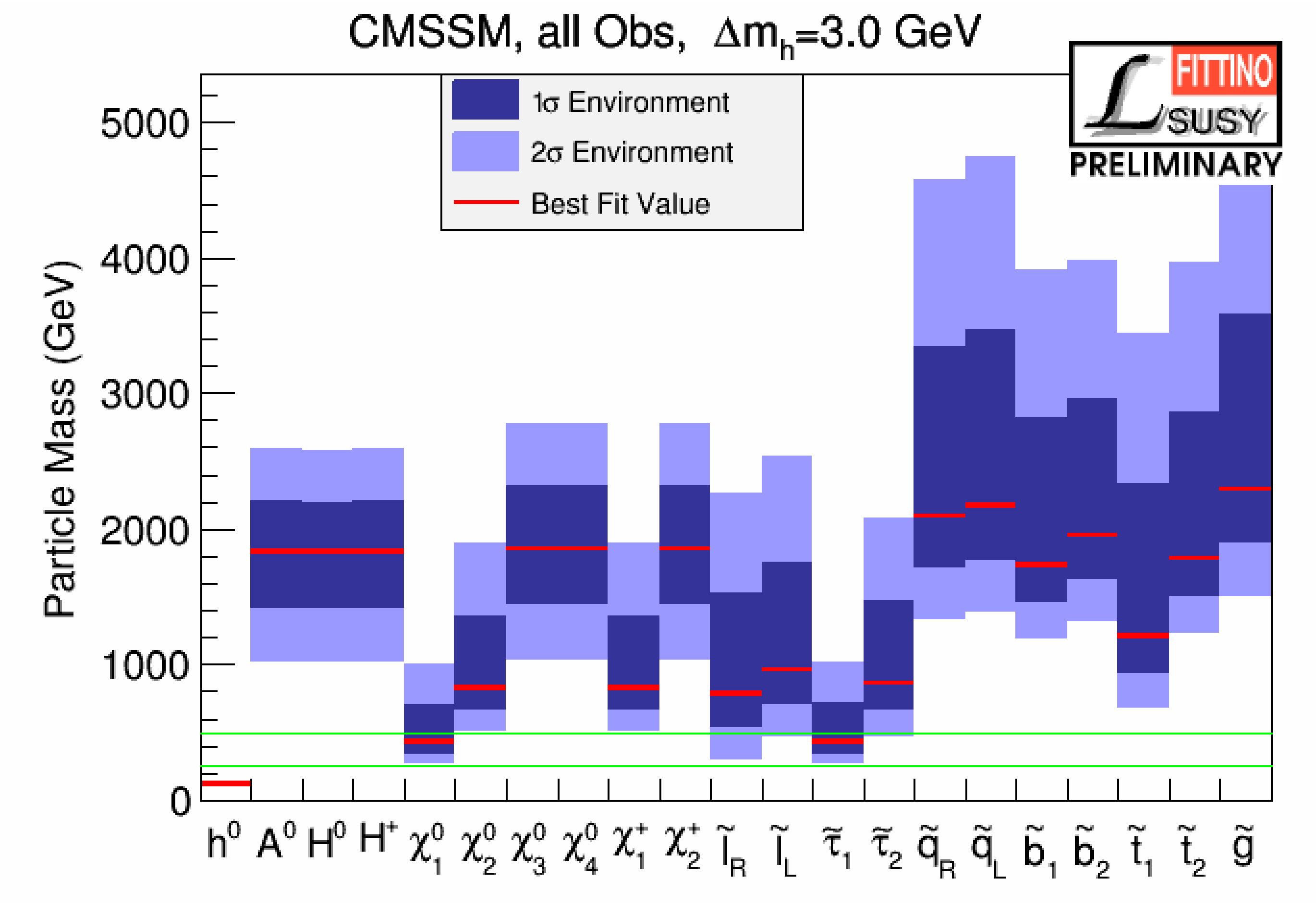
Main contribution coming from g-2.

Individual pull: NUHM1



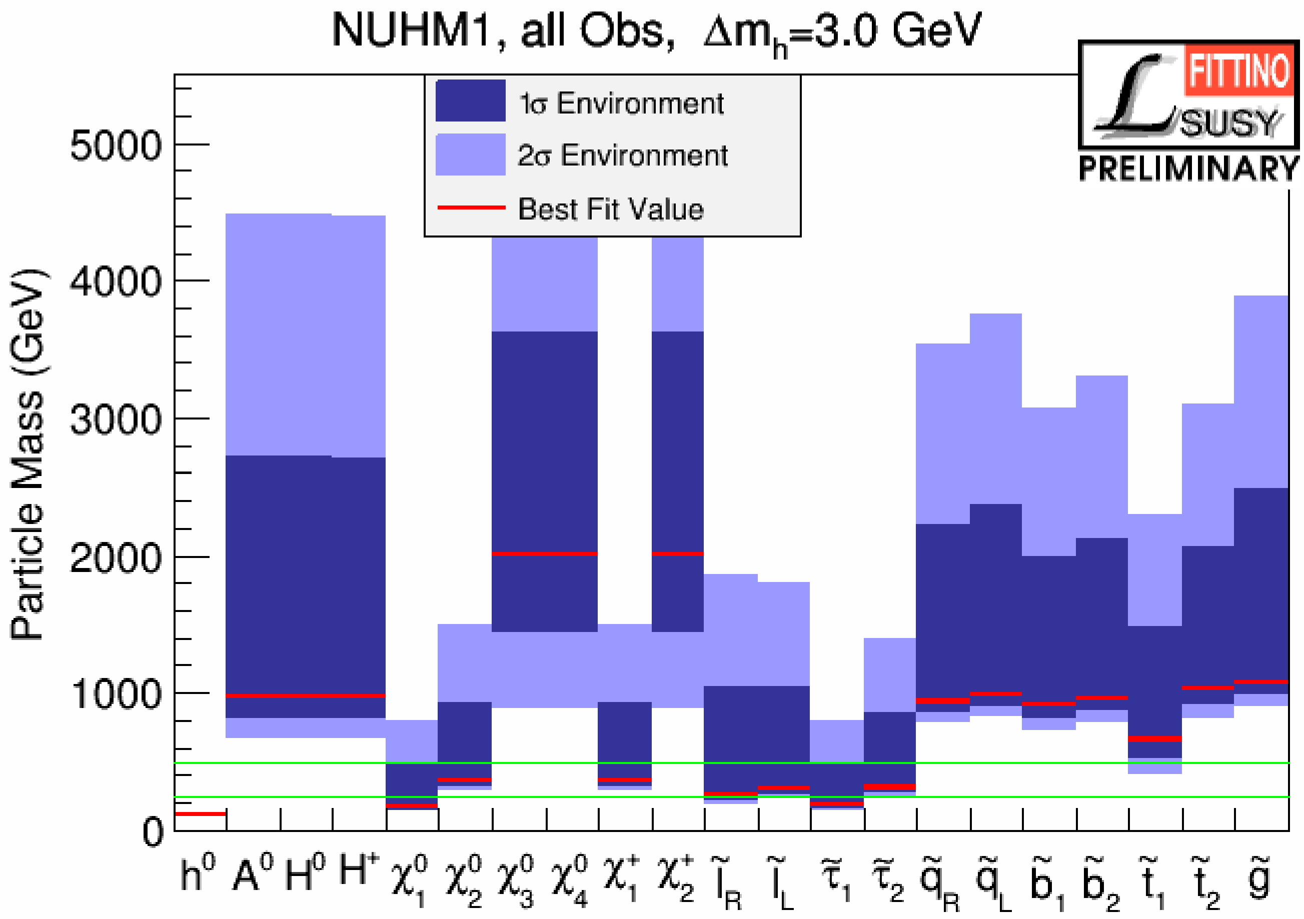
Reduced contribution from g-2 due to lower mass scale.

Predicted mass spectrum: CMSSM



Lower bound of 250 GeV on spartlicle masses.

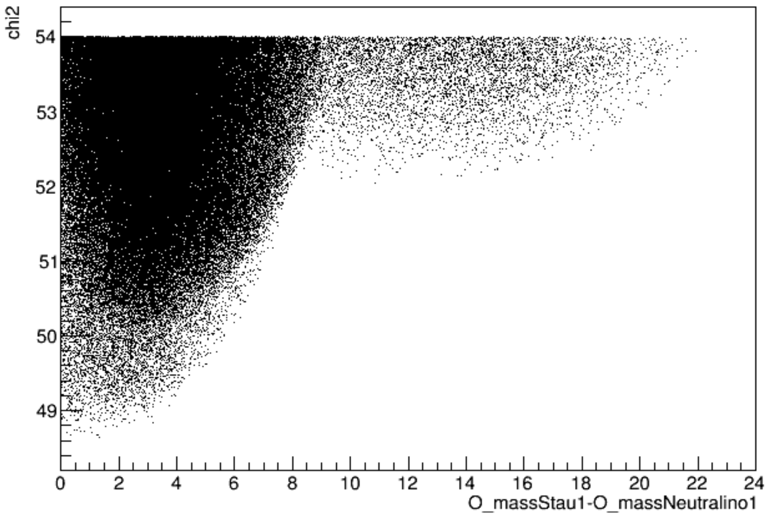
Predicted mass spectrum: NUHM1



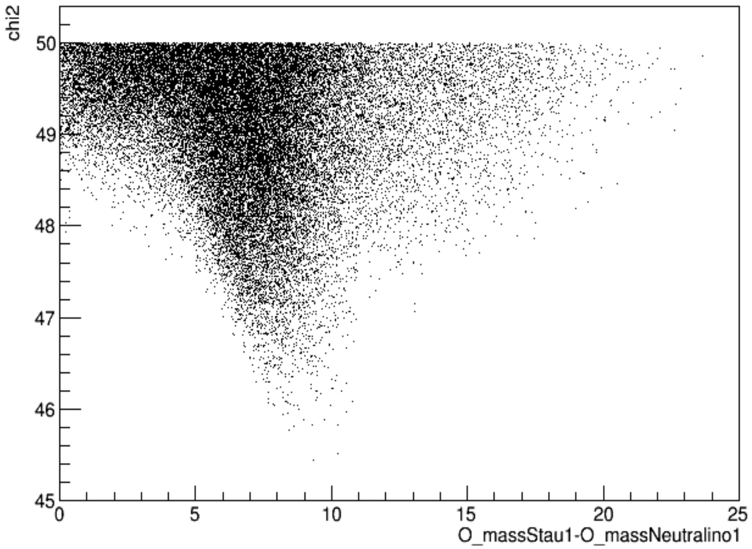
Best fit values for mass of sleptons, staus and light chargino within 500GeV.

NSLP-LSP mass difference

CMSSM



NUHM1



Preliminary χ^2-profiles showing the point density.

CMSSM: minimum at $\Delta m \sim 0$ GeV
NUHM1: minimum at $\Delta m \sim 10$ GeV

How well does constrained SUSY do ?

χ^2 / ndf
= 43.4 / 56

"The fit is good if this number is roughly one"

This is because the mean value of a $\chi 2$ distribution
is the number of degrees of freedom.

However our χ^2 function is not necessarily χ^2 distributed:

$$\chi^2 = (M - O(P))^T cov^{-1} (M - O(P))$$

χ^2 distributed if
(1) *M* Gaussian distributed
(2) dependence *O(P)* linear

P-value

What is the p-value?

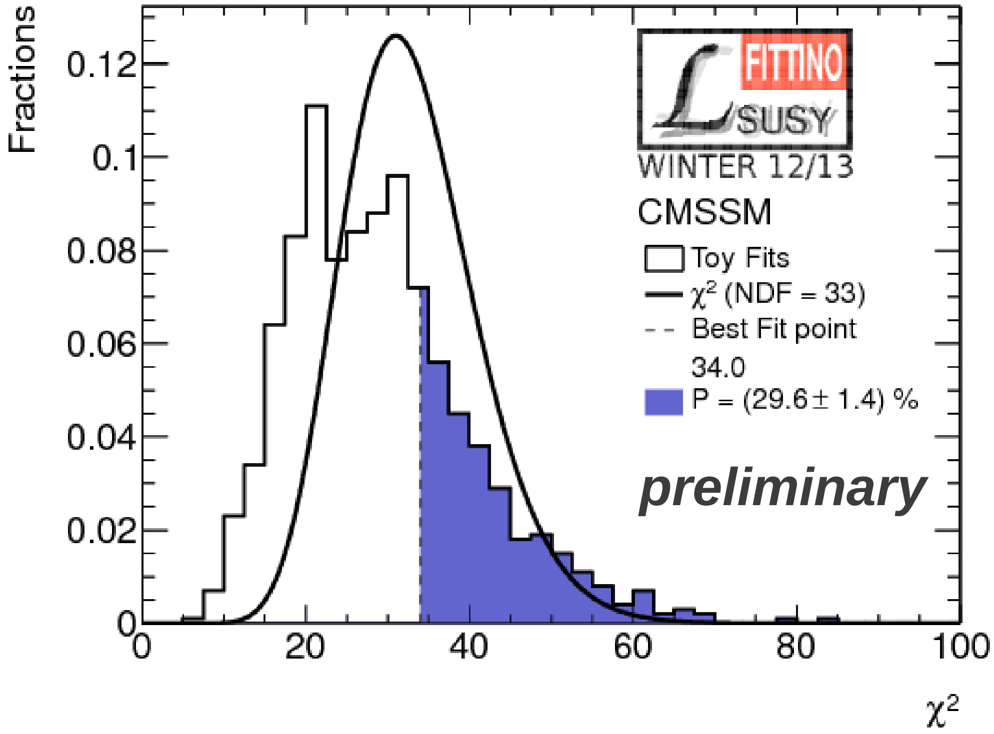
Assuming the best fit point found is the real one,
if measurements are repeated,
how often do you get agreement at least as bad as the one observed?

Computation of the p-value of the best fit point with toys:

- Take the observable values at the best fit point
- Smear the observables values
- Calculate the χ^2 for these new pseudo-measurements
- Spot the new best fit point
- Repeat that procedure many times
- Integrate the distribution for $\chi^2 \geq \chi^2$(best fit point)

P-value

We had a very first look at this...



naive P-Value: 41%
overestimates goodness of fit

Update to current measurements is work in progress.

Summary

We fit **CMSSM / NUHM1** to all kind of available measurements.

New measurement of $\mathbf{B \rightarrow \tau \nu}$ improves fit quality significantly.

Special care taken to include Higgs measurements properly via ***HiggsSignals***.

CMSSM and NUHM1 are both capable to describe given data
→ have to go to SM like region of parameter space.

The first **real frequentist p-values** for constrained SUSY are work in progress.

Detailed predictions on Higgs rate measurements and couplings coming soon.