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arXiv:1206.0264 [hep-ph]

BayesFits
The CMSSM Favoring New Territories: The Impact of New LHC Limits and a 125 GeV Higgs

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BayesFITS methodology

- We fit the CMSSM to experimental data with **Bayesian statistics**
- Frequentist statistics considers the likelihood — the probability of obtaining the experimental data given the CMSSM's parameters
- **Bayesian statistics considers the the posterior** — the probability of the CMSSM's parameters given the experimental data
- Find the posterior with Bayes' theorem;

$$p(m_0, m_{1/2}, A_0, \tan\beta | d) \propto \mathcal{L}(m_0, m_{1/2}, A_0, \tan\beta) \times \pi(m_0, m_{1/2}, A_0, \tan\beta)$$

- Requires that we articulate our prior knowledge of the CMSSM's parameters in the prior, $\pi(m_0, m_{1/2}, A_0, \tan\beta)$
- We use an updated version of SuperBayeS package to perform a Bayesian analysis of the CMSSM's parameter space

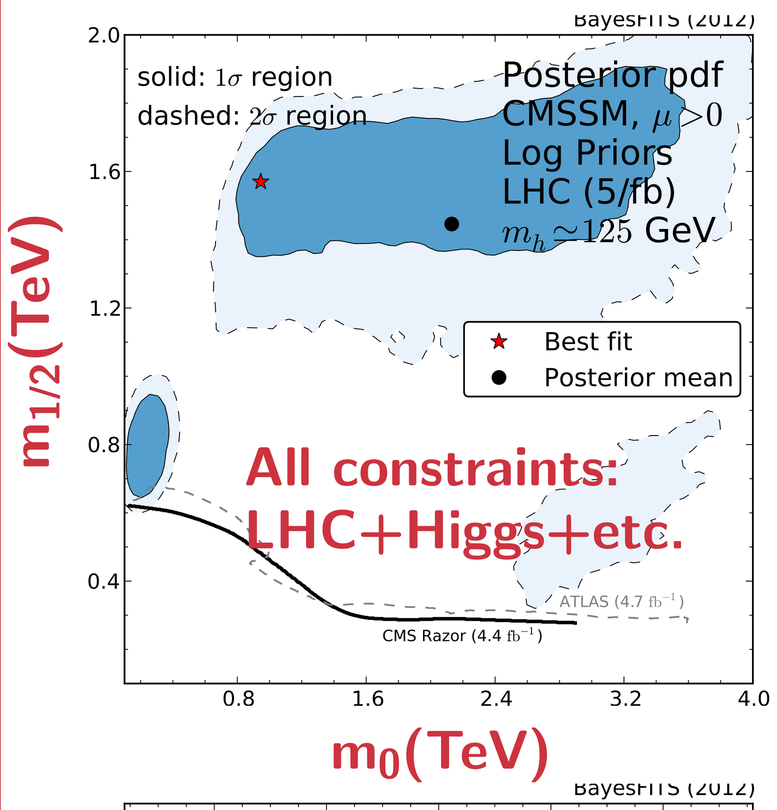
CMS razor 4.4/fb SUSY search

- CMS looked for **jets and missing energy** in 4.4/fb at $\sqrt{s} = 7$ TeV
- Discriminated against SM backgrounds with kinematic razor variables
- Resulting in exclusion on $(m_0,\ m_{1/2})$ plane of CMSSM
- We simulated expected numbers of CMSSM events in the hadronic bins at the **event level**
- Calculated the likelihood at each point on the whole $(m_0,\ m_{1/2})$ plane — **our likelihood map** — with Poisson: $\mathcal{L} = e^{-s+b}(s+b)^o/o!$
- **Incorporated important systematic errors** on SM background predictions
- Our 95% exclusion contour with the PL method with $\Delta\chi^2 = 5.99$ in **good agreement**

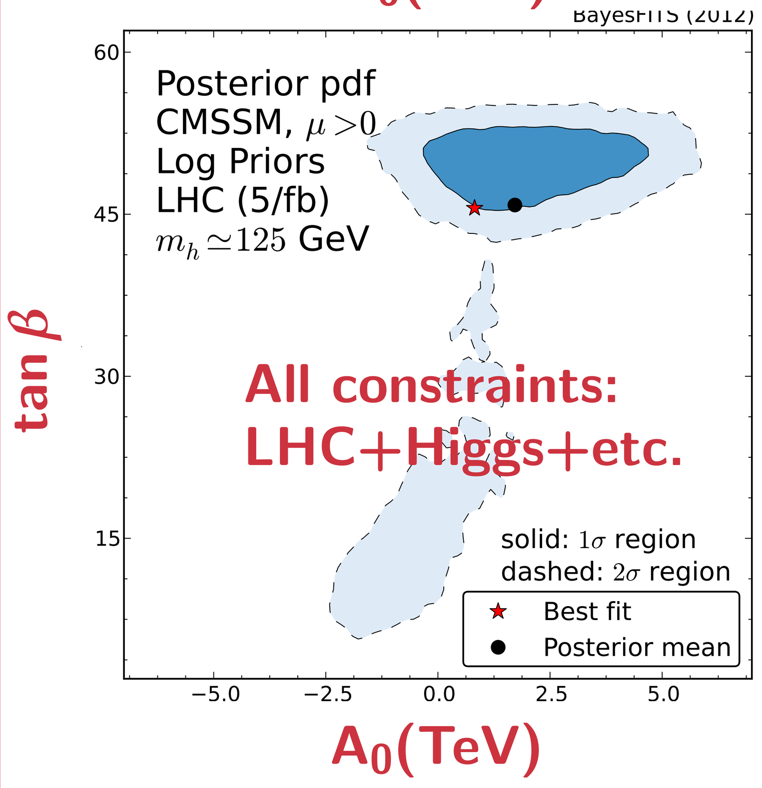
Priors

- **Log** priors for $100\,\text{GeV} < m_0 < 4\,\text{TeV}$ and $100\,\text{GeV} < m_{1/2} < 2\,\text{TeV}$
- **Linear** priors for $3 < \tan\beta < 62$ and $-7\,\text{TeV} < A_0 < 7\,\text{TeV}$
- **Gaussian** priors, representing experimental measurements, for $m_t = 172.9 \pm 1.1\,\text{GeV}$ etc.

68% and 95% Bayesian credible regions for the CMSSM



- The 68% (■) and 95% (- - -) Bayesian credible regions on CMSSM's $(m_0, m_{1/2})$ plane
- From a scan that included **all constraints**
- Two modes at 68% - the **stau-coannihilation** and the **A-funnel**
- **Focus point** region at 95%
- Labeled by dominant dark matter annihilation mechanism



- The 68% (■) and 95% (- - -) Bayesian credible regions on CMSSM's $(A_0, \tan\beta)$ plane
- High $\tan\beta$ at 68% corresponds to **A-funnel**
- Low $\tan\beta$ at 95% corresponds to **stau-coannihilation**
- Slight preference for negative A_0

Likelihood from Higgs searches

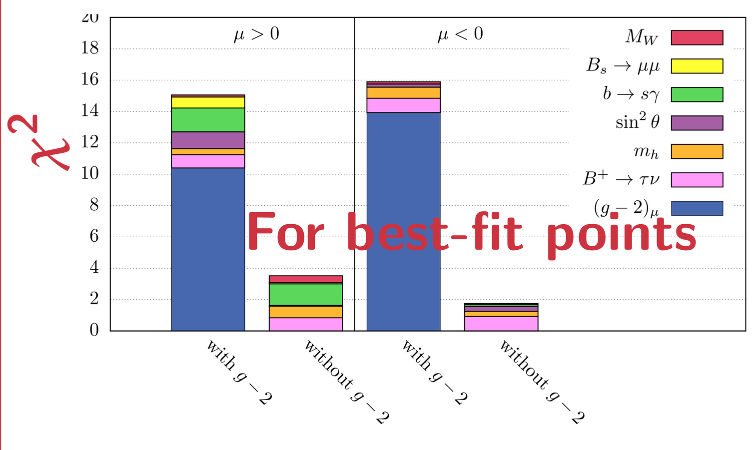
- Interpreted resonance as **lightest Higgs in CMSSM**
- Implemented result as Gaussian likelihood, with $\mu = 125\,\text{GeV}, \sigma = 2\,\text{GeV}$.
- Appreciable theory error in CMSSM Higgs mass calculation from e.g. missing orders, included as $\tau = 2\,\text{GeV}$

Likelihoods from Non-LHC constraints

- WMAP7 constraint on the relic density of the neutralino, $\Omega_\chi h^2$
- Loop contributions to Δa_μ, $b \to s\gamma$ and $B_s \to \mu^+\mu^-$
- EWPO, e.g. M_W and $\sin\theta_{\text{eff}}$

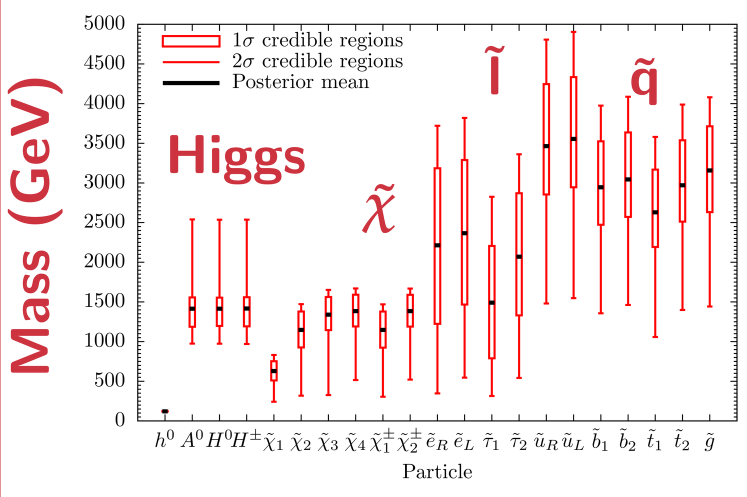
These constraints are included with Gaussian likelihood functions.

χ^2 breakdown

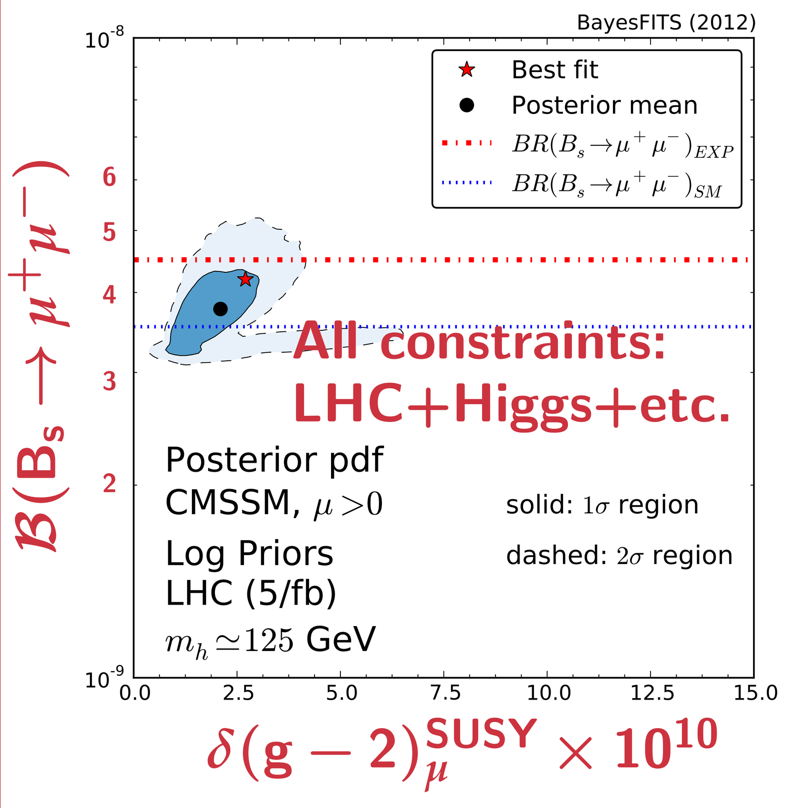


- The $\chi^2 = -2\ln\mathcal{L}$ for best-fit points in four CMSSM scans
- **Dominant contribution is from $\delta(g-2)^{\text{SUSY}}_\mu$**, which is a poor fit
- So also **consider sgn $\mu = -1$** and drop $\delta(g-2)^{\text{SUSY}}_\mu$ constraint

Mass spectrum and predictions



- Bayesian credible intervals (candlesticks) and posterior means for **sparticle mass spectrum**
- Higgs $\mathcal{O}(1.5\,\text{TeV})$
- Sleptons $\mathcal{O}(2.5\,\text{TeV})$
- Squarks $\mathcal{O}(3.5\,\text{TeV})$
- Gluino $\mathcal{O}(3\,\text{TeV})$



- Scans do not include latest LHCb $\mathcal{B}(B_s \to \mu^+\mu^-) = 3.2^{+1.5}_{-1.2} \times 10^{-9}$ result
- Include previous best LHCb upper limit
- 68% and 95% **credible regions will shrink, but should survive**
- Best-fit point (⋆) will move and its **χ^2 will increase**