Explored and Unexplored MSSM Signatures

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Goals

make robust, comprehensive statements about SUSY

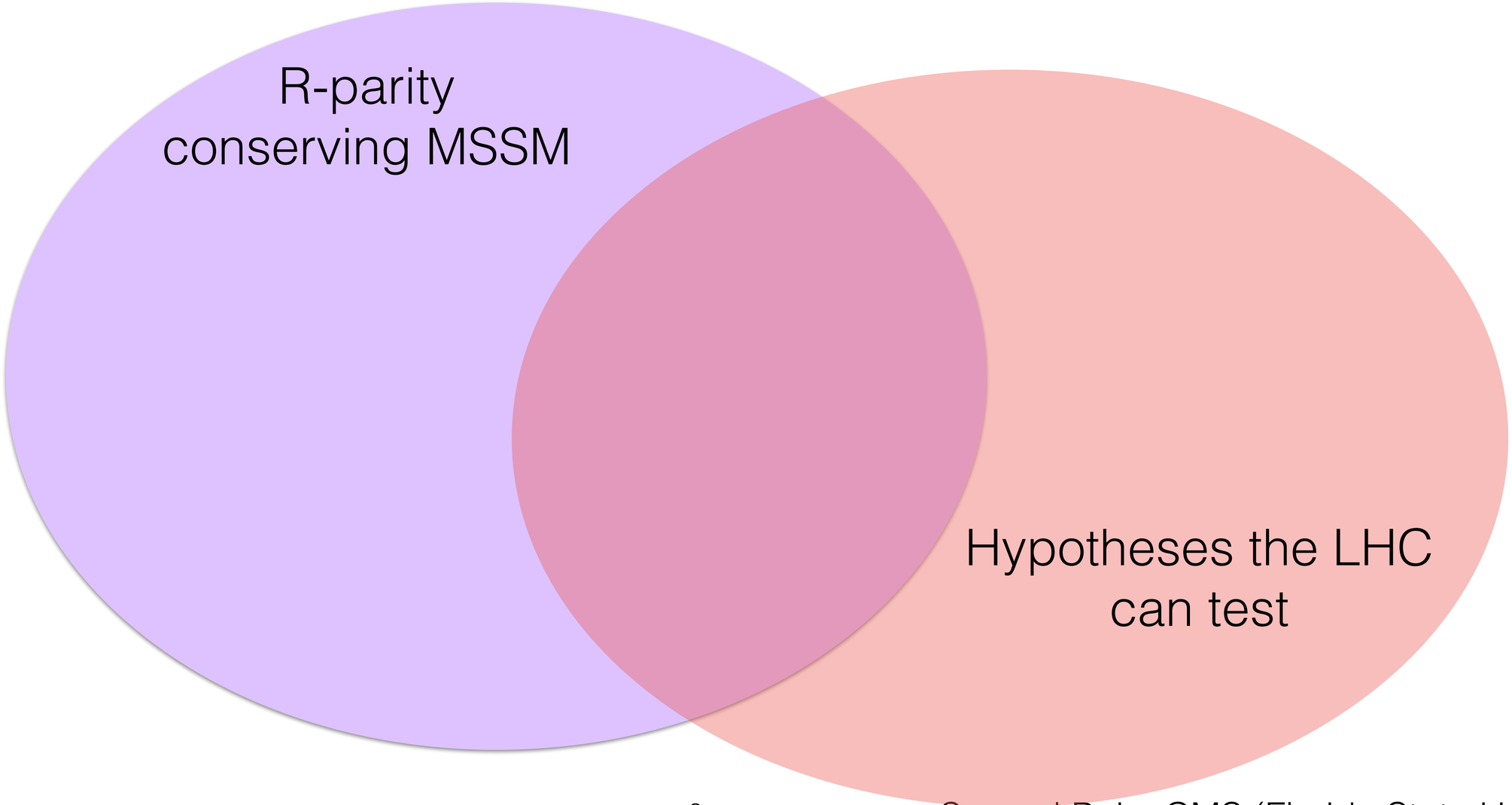
guide the next generation of measurements

parameter estimation in case of discovery

CMS PAS SUS-13-020

Phenomenological MSSM interpretation of the CMS 7 and 8 TeV results

The Challenge



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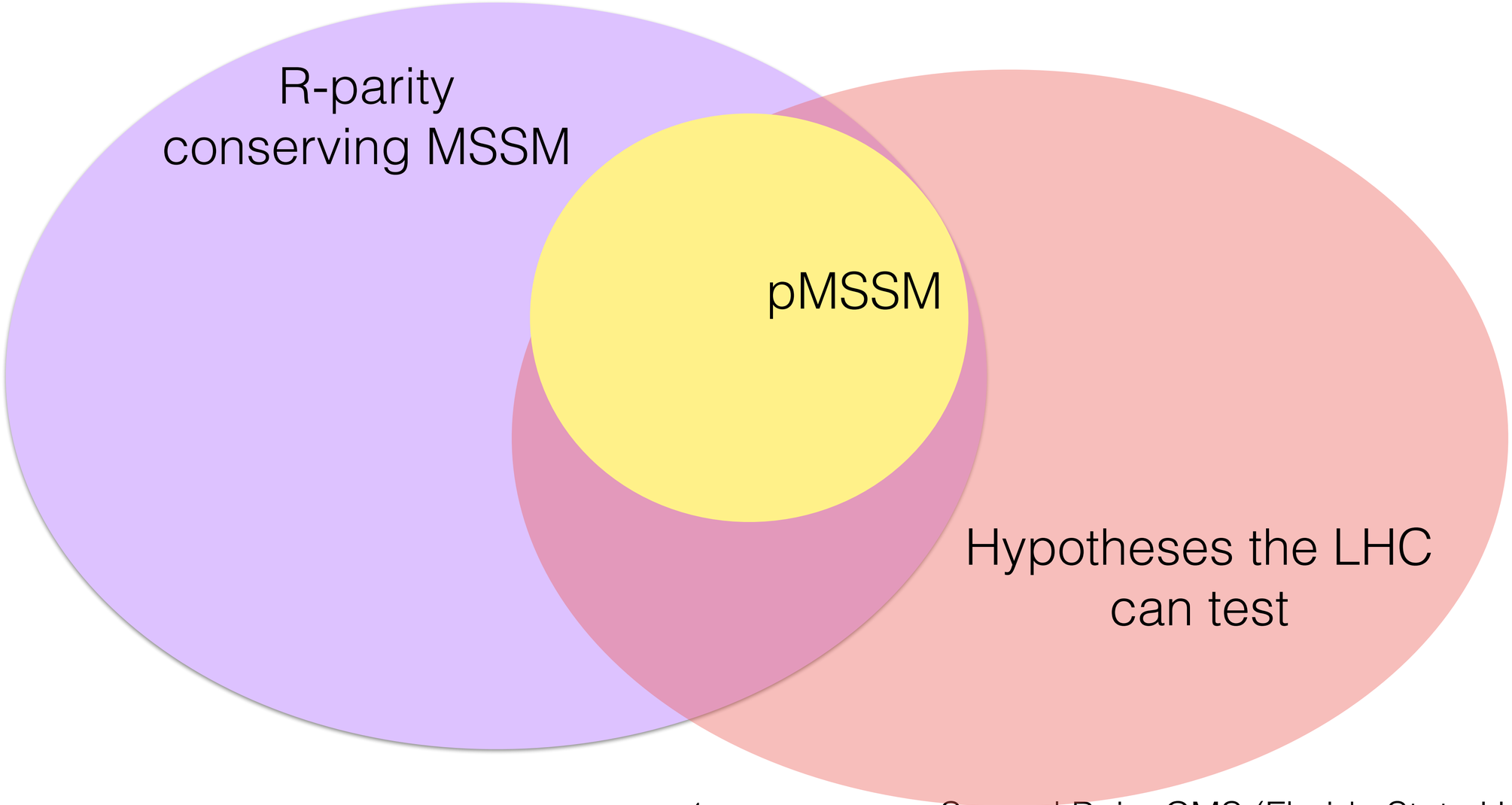
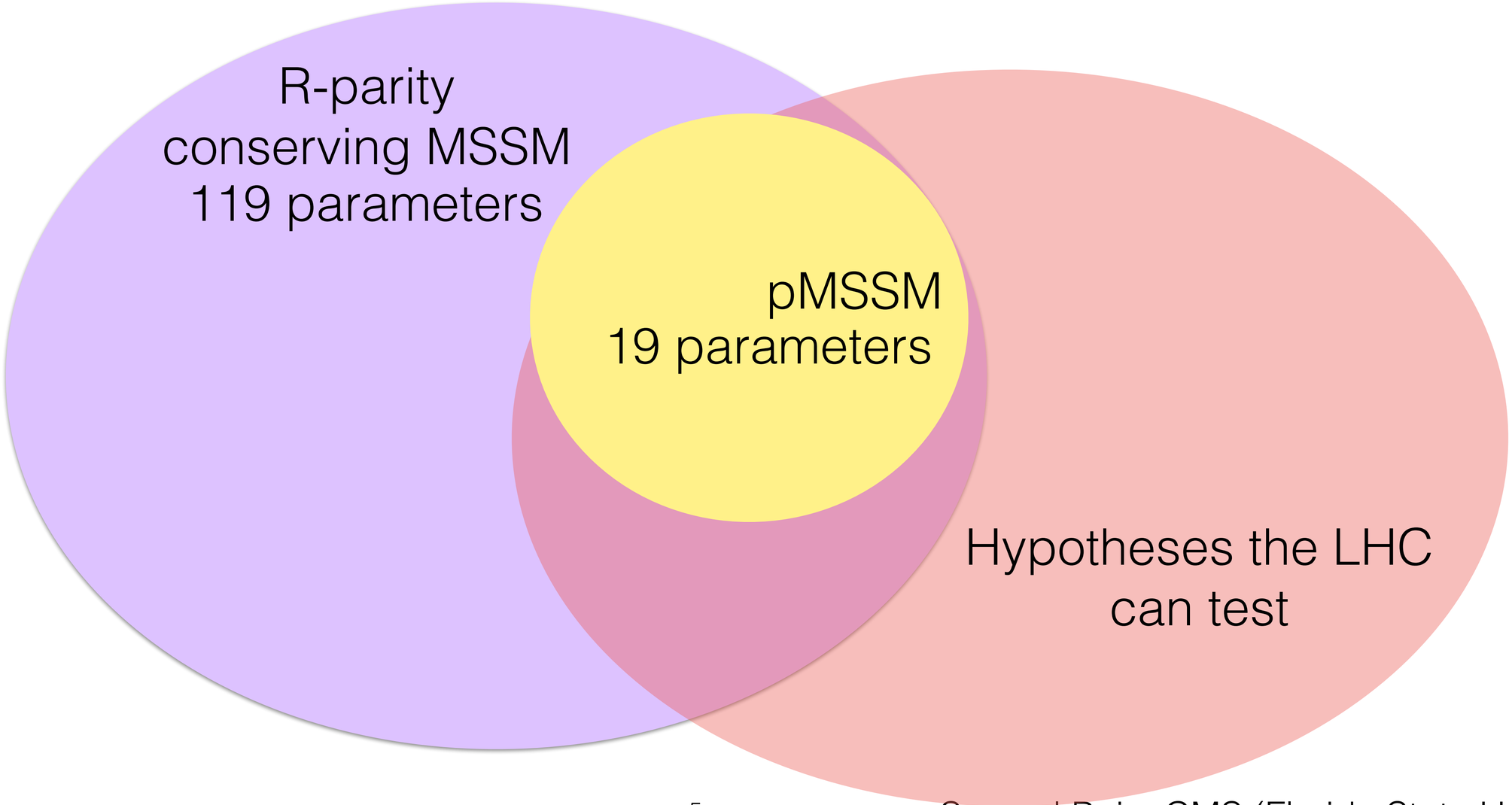


The Phenomenological (p)MSSM



The Phenomenological (p)MSSM

A realization of the R-parity conserving MSSM with

*no new sources of CP violation

*no flavor changing neutral currents

*1st and 2nd generation squarks are degenerate

*lightest SUSY particle is the neutralino

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19 Parameters

Gaugino mass parameters M_1, M_2, and M_3

Higgs sector parameters $\tan(\beta)$, μ, and m_A

10 sfermion mass parameters m_i

Trilinear couplings A_t, A_b, and A_τ

Strategy

- incorporate relevant prior information

(10 previous results)

- scan parameter space with

(7200 points)

- draw conclusions in a probabilistic framework

Parameter Ranges

$$-3\,\text{TeV} \leq M_1, M_2 \leq 3\,\text{TeV}$$

$$0 \leq M_3 \leq 3\,\text{TeV}$$

$$-3\,\text{TeV} \leq \mu \leq 3\,\text{TeV}$$

$$0 \leq m_A \leq 3\,\text{TeV}$$

$$2 \leq \tan\beta \leq 60$$

$$0 \leq \tilde{Q}_{1,2}, \tilde{U}_{1,2}, \tilde{D}_{1,2}, \tilde{L}_{1,2}, \tilde{E}_{1,2}, \tilde{Q}_3, \tilde{U}_3, \tilde{D}_3, \tilde{L}_3, \tilde{E}_3 \leq 3\,\text{TeV}$$

$$-7\,\text{TeV} \leq A_t, A_b, A_\tau \leq 7\,\text{TeV},$$

Determinants of the Prior

i	Observable $\mu_j(\theta)$	Constraint D_j^{preCMS}	Likelihood function $L(D_j^{\text{preCMS}}\|\mu_j(\theta))$
1	$BR(b \to s\gamma)$	$(3.55 \pm 0.23^{\text{stat}} \pm 0.24^{\text{th}} \pm 0.09^{\text{sys}}) \times 10^{-4}$	Gaussian
2a	$BR(B_s \to \mu\mu)$	observed CLs curve from	$d(1-CLs)/dx$
2b	$BR(B_s \to \mu\mu)$	$3.2^{+1.5}_{-1.2} \times 10^{-9}$	2-sided Gaussian
3	$R(B_u \to \tau\nu)$	1.63 ± 0.54	Gaussian
4	Δa_μ	$(26.1 \pm 8.0^{\text{exp}} \pm 10.0^{\text{th}}) \times 10^{-10}$	Gaussian
5	m_t	$173.3 \pm 0.5^{\text{stat}} \pm 1.3^{\text{sys}}$ GeV	Gaussian
6	$m_b(m_b)$	$4.19^{+0.18}_{-0.06}$ GeV	Two-sided Gaussian
7	$\alpha_s(M_Z)$	0.1184 ± 0.0007	Gaussian
8a	m_h	pre-LHC: $m_h^{low} = 112$	1 if $m_h \geq m_h^{low}$ 0 if $m_h < m_h^{low}$
8b	m_h	LHC: $m_h^{low} = 120$, $m_h^{up} = 130$	1 if $m_h^{low} \leq m_h \leq m_h^{up}$ 0 if $m_h < m_h^{low}$ or $m_h > m_h^{up}$
9	sparticle masses	LEP via micrOMEGAs	1 if allowed 0 if excluded
10	prompt $\tilde{\chi}_1^\pm$	$c\tau(\tilde{\chi}_1^\pm) < 10$ mm	1 if allowed 0 if excluded

CMS SUSY Analyses

Analysis	$\sqrt{s}$ [TeV]	L [fb^{-1}]
Hadronic HT + MHT search	7	4.98
Hadronic HT + MET + b-jets search	7	4.98
Leptonic search for EW prod. of $\tilde{\chi}^0, \tilde{\chi}^{\pm}, \tilde{l}$	7	4.98
Hadronic HT + MHT search	8	19.5
Hadronic M_{T2} search	8	19.5
Hadronic HT + MET + b-jets search	8	19.4
Monojet searches	8	19.7
Hadronic stop search	8	19.4
Opposite sign di-lepton (OS ll) search (count experiment only)	8	19.4
Like-sign di-leptoin (LS ll) search (only channels w/o 3rd lepton veto)	8	19.5
Leptonic search for EW prod. of $\tilde{\chi}^0, \tilde{\chi}^{\pm}, \tilde{l}$ (only ss, 3l, and 4l channels)	8	19.5

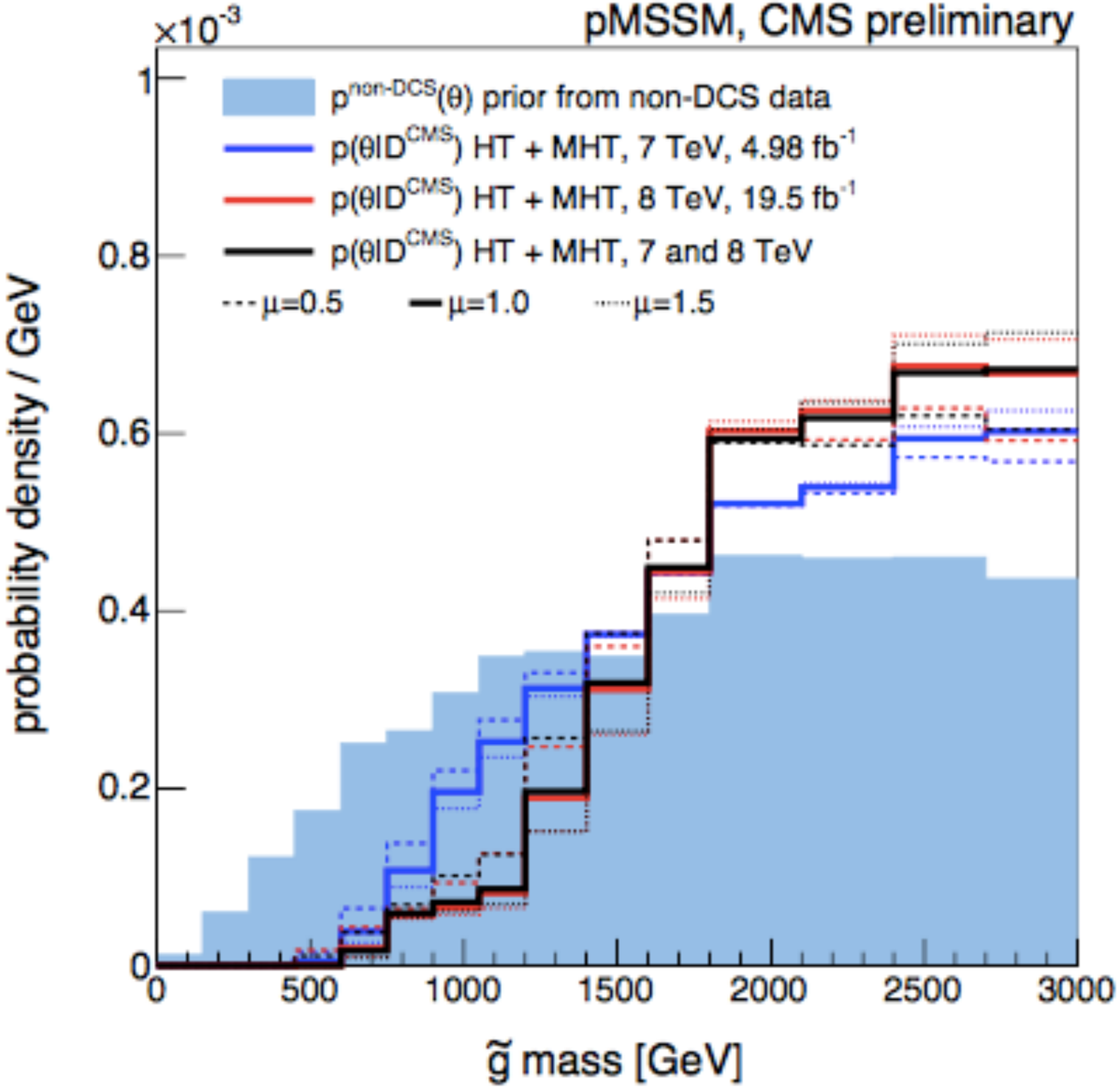
Posterior Density

$$p(\theta|Data^{CMS}) \propto L(Data^{CMS}|\theta)\Pi(\theta)$$

- Expected signal counts estimated by simulation for each signal region

Results

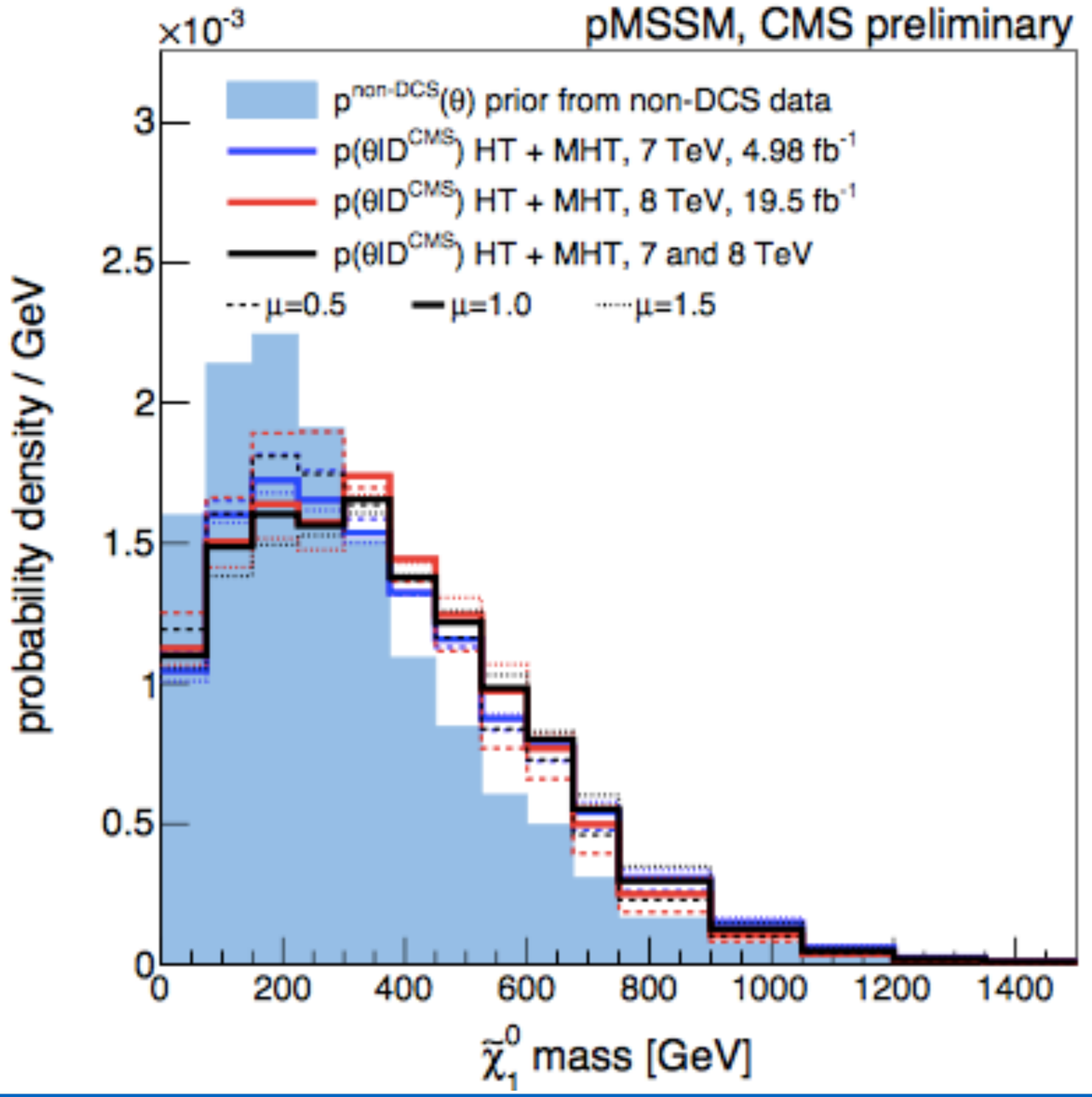
Gluino



posterior

prior

LSP

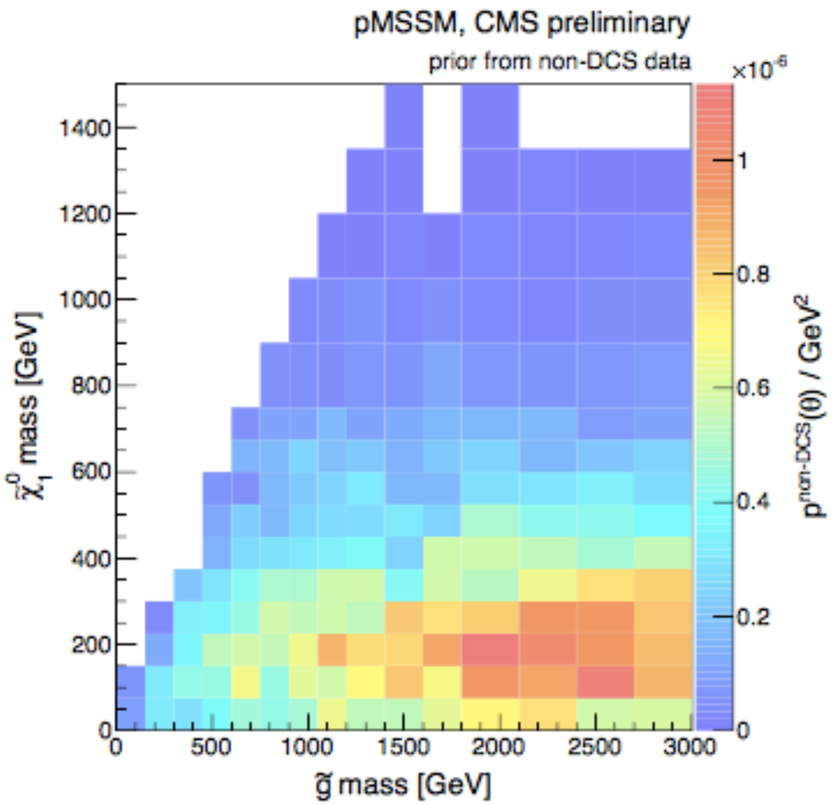


posterior

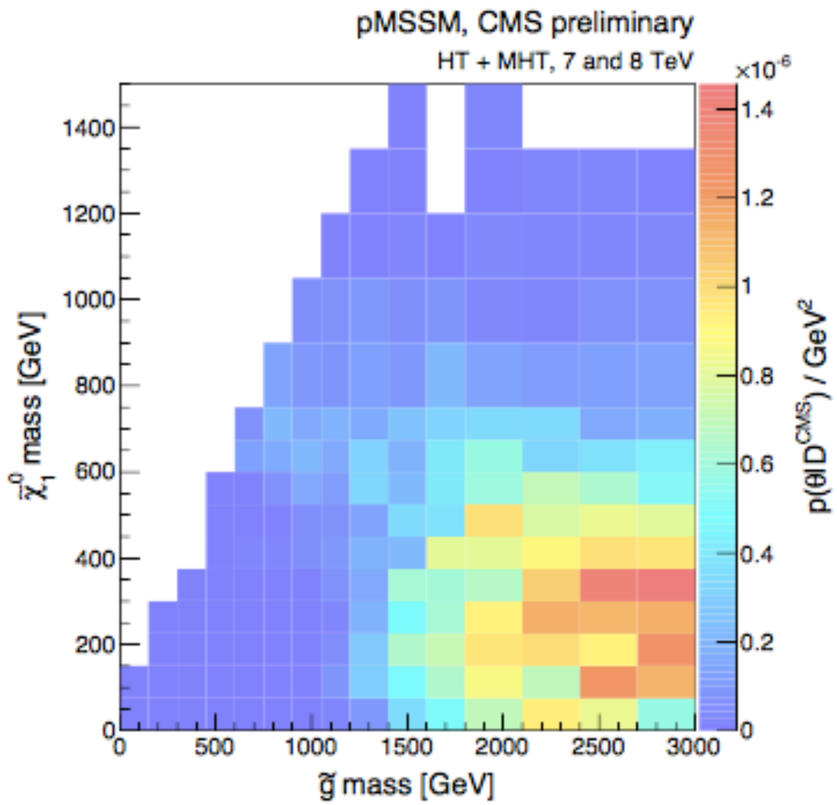
prior

LSP vs Gluino

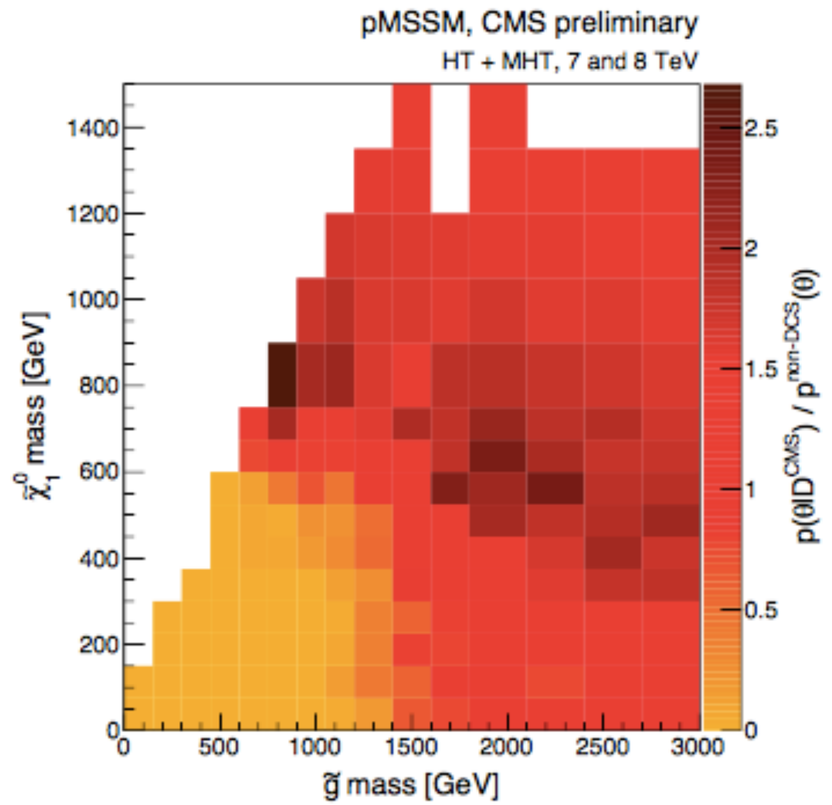
prior

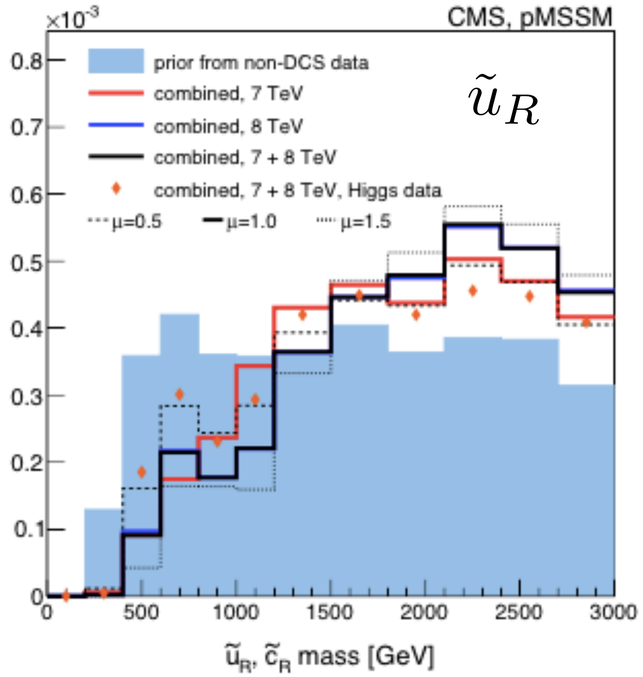


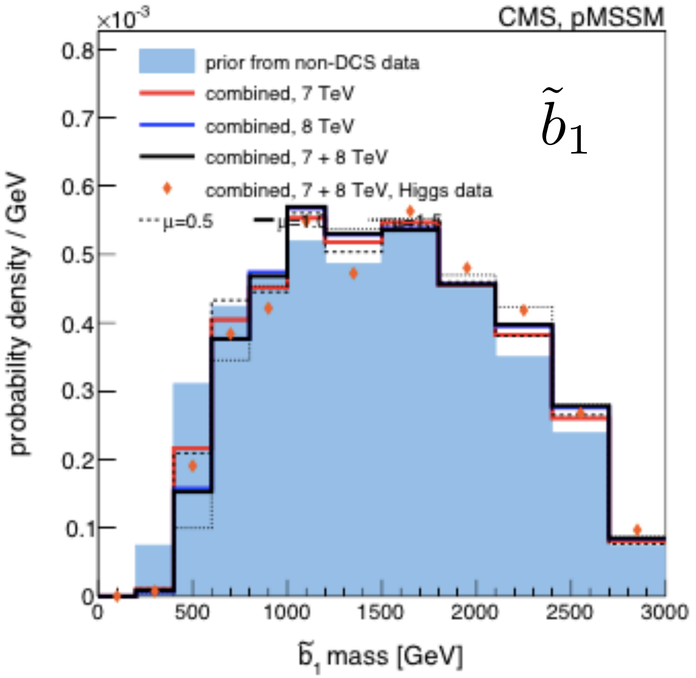
posterior

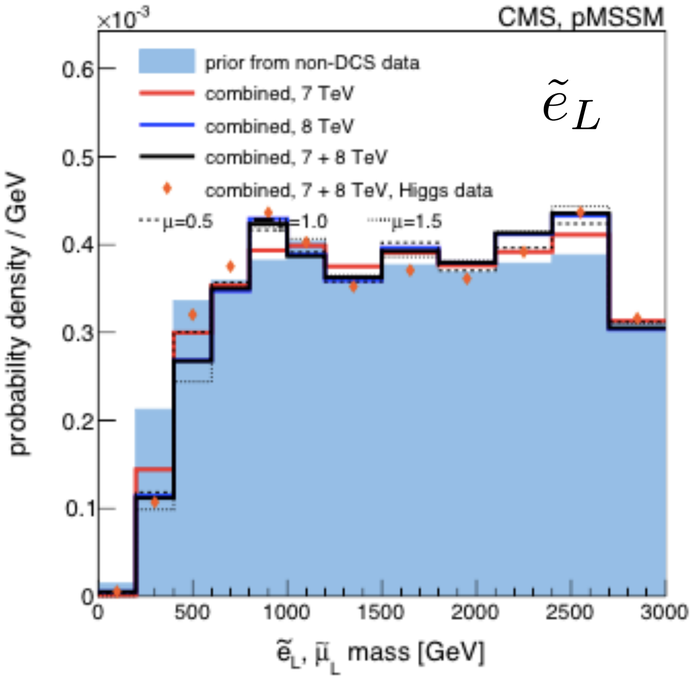


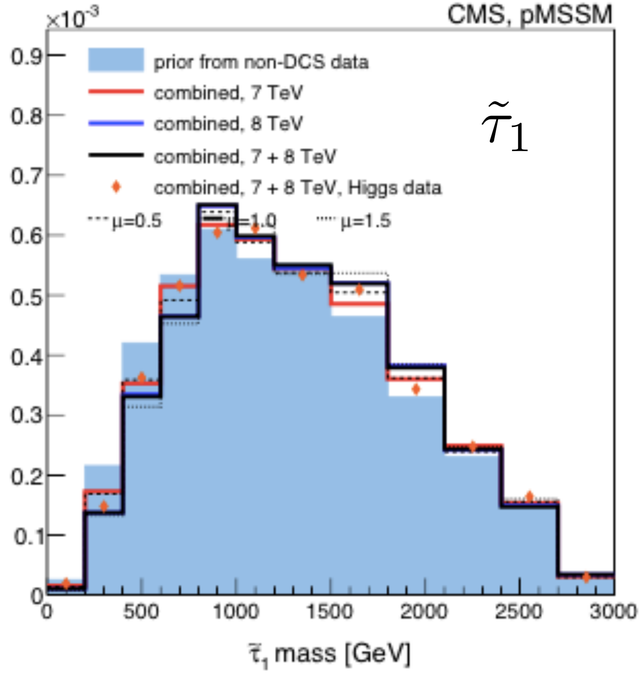
posterior/prior

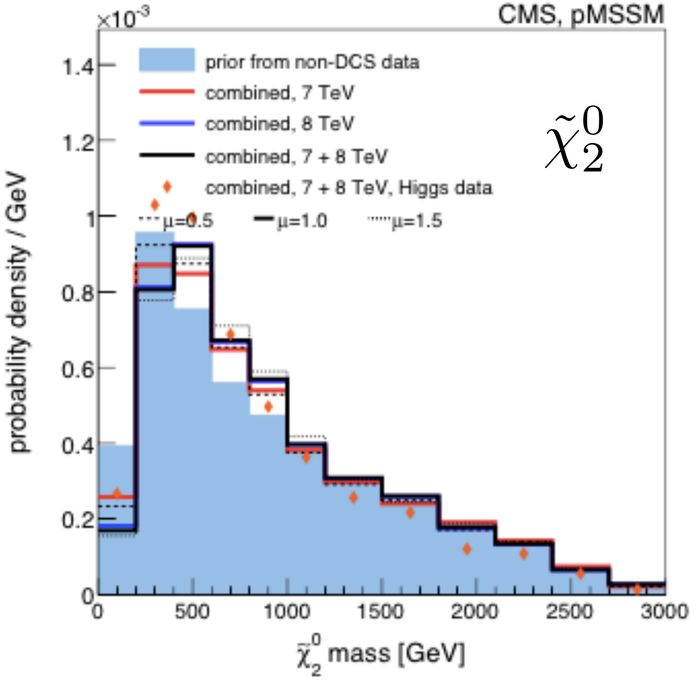


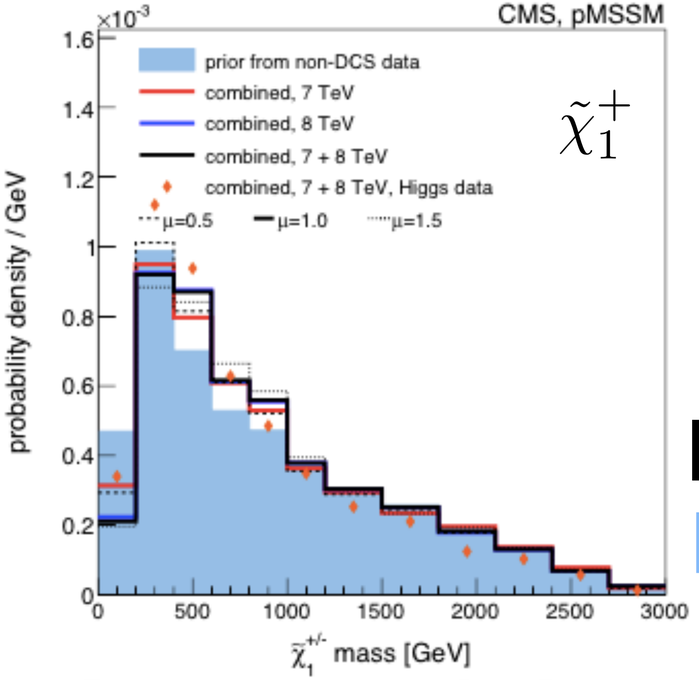












posterior

prior

State University)

Non-excluded parameter space

Convenient re-mapping of the Bayes factor:

Bayes factor: $B_{10} = L(Data|H_1)/L(Data|H_0)$

Z-signficiance: $Z = \mathrm{sign}(\log(B_{10}))\sqrt{2|\log(B_{10})|}$

Z <= -1.64 (excluded)

Z > -1.64 (non-excluded)

Non-excluded parameter space

Out of 7195 studied pMSSM points:

- 3,516 points have been excluded by direct CMS SUSY searches

over 50% of the non-excluded points have a total production cross section greater than 10 fb.

Dominant pair production mode

- High Cross section
- Non-excluded

Mode	no. points
$\tilde{\chi}_1^+$	917
$\tilde{d}$	573
$\tilde{u}$	228
$\tilde{b}_1$	96
$\tilde{g}$	53
$\tilde{\chi}_1^0$	48
$\tilde{l}$	33
$\tilde{t}_1$	22
$\tilde{\nu}$	20
$\tilde{\chi}_2^0$	3
total	1993

Conclusion

- we have investigated the impact of a set of 7 and 8 TeV SUSY searches on the pMSSM
- gluino masses below 500 GeV are excluded
- low mass LSPs cannot be ruled out
- the non-excluded pMSSM features must be studied

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