Inclusive SUSY searches at CMS

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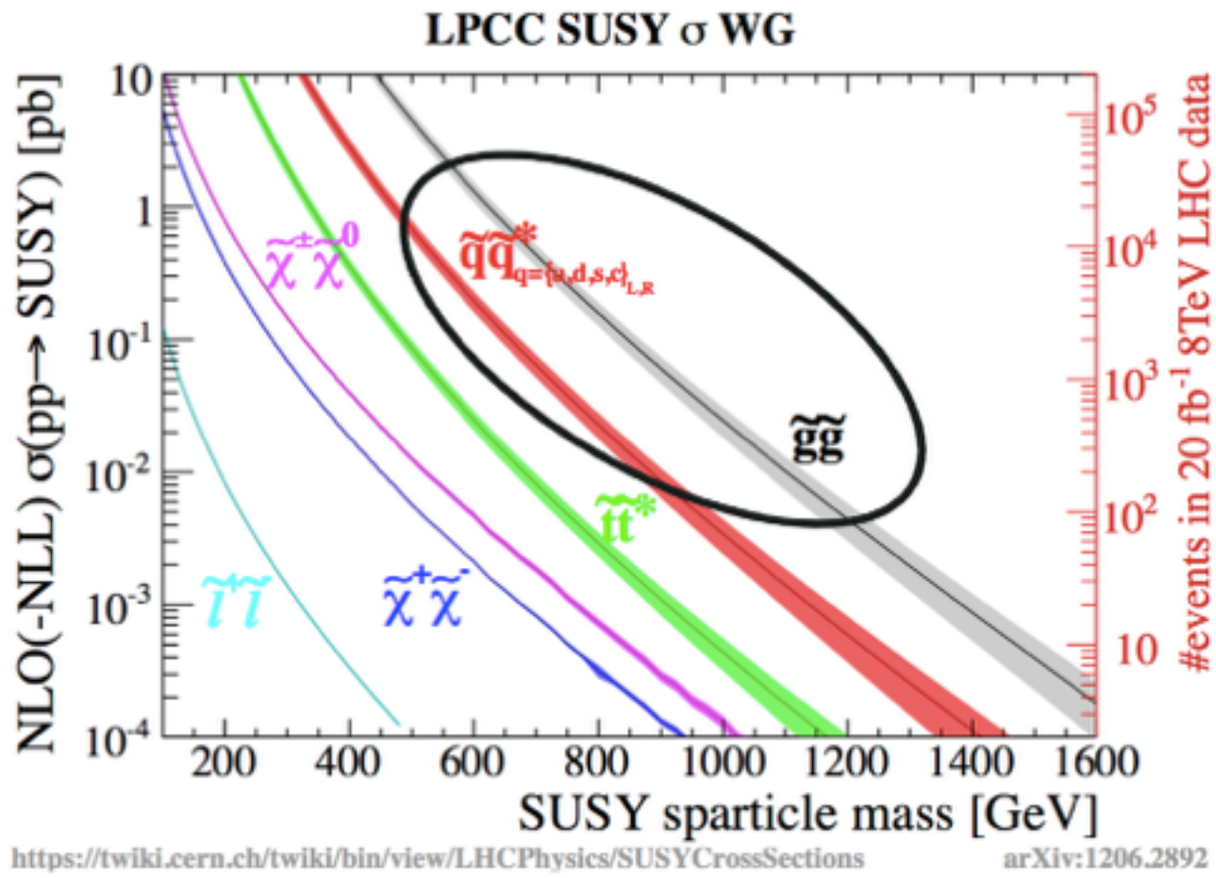
Inclusive Searches

- Searches probing broad range of coloured sparticle production and decay modes

- Usually in fully hadronic channels, sometimes extended with photon and lepton channels



General Strategy

- Study events with large hadronic activity and genuine momentum imbalance
- Most generic discriminators:

$$\mathrm{HT} = \sum_{\mathrm{jet}} |p_{\mathrm{T}}^{\mathrm{jet}}|$$

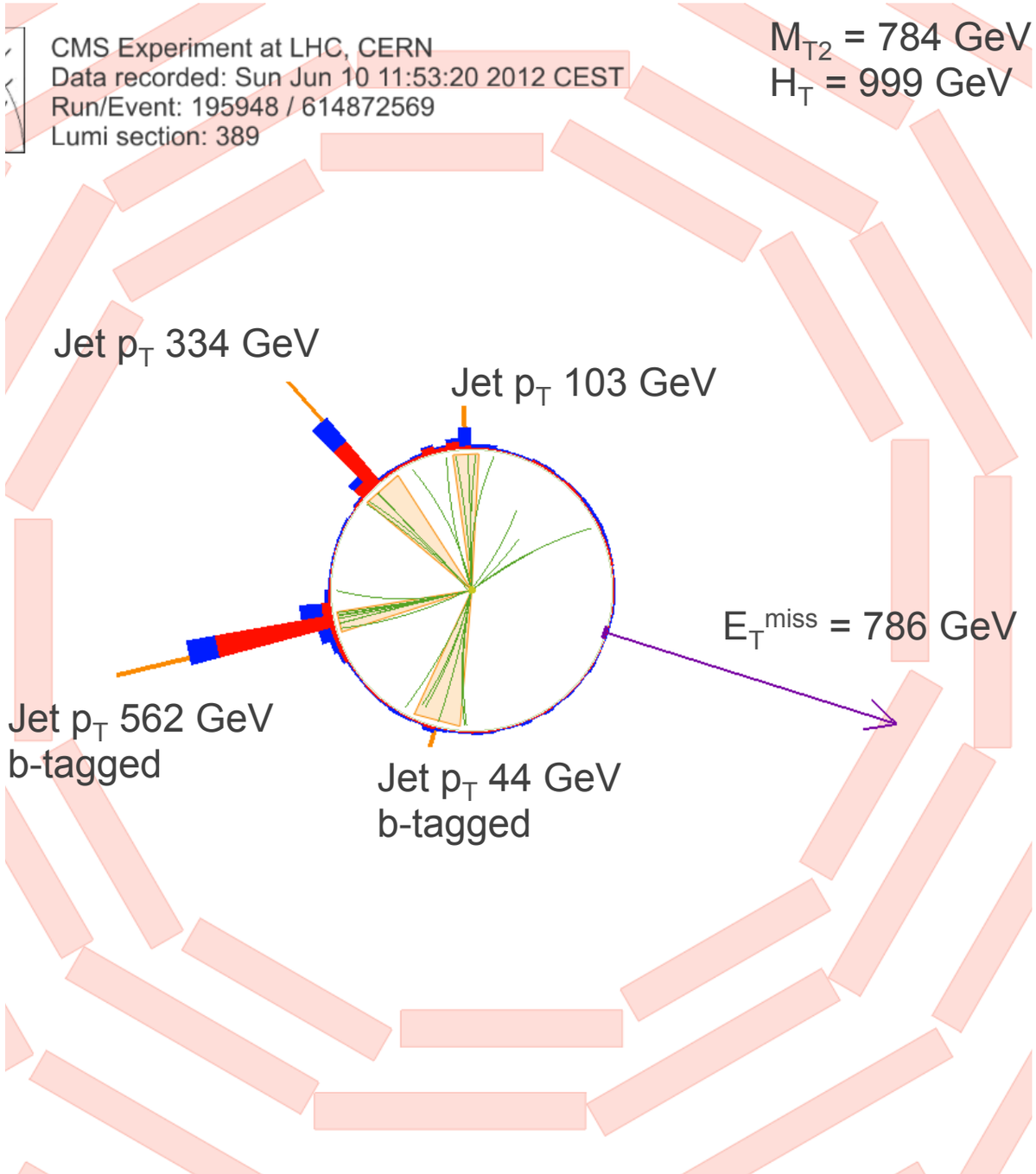
probes masses in hard interaction

$$|\vec{\mathrm{MET}}| = |-\sum_{\mathrm{part}} \vec{p}_{\mathrm{T}}^{\,\mathrm{part}}|$$

estimates momentum imbalance

$$\Delta\Phi(\mathrm{jet}, \mathrm{MET})$$

against fake imbalance



Outline

CMS' 8 TeV Inclusive Searches

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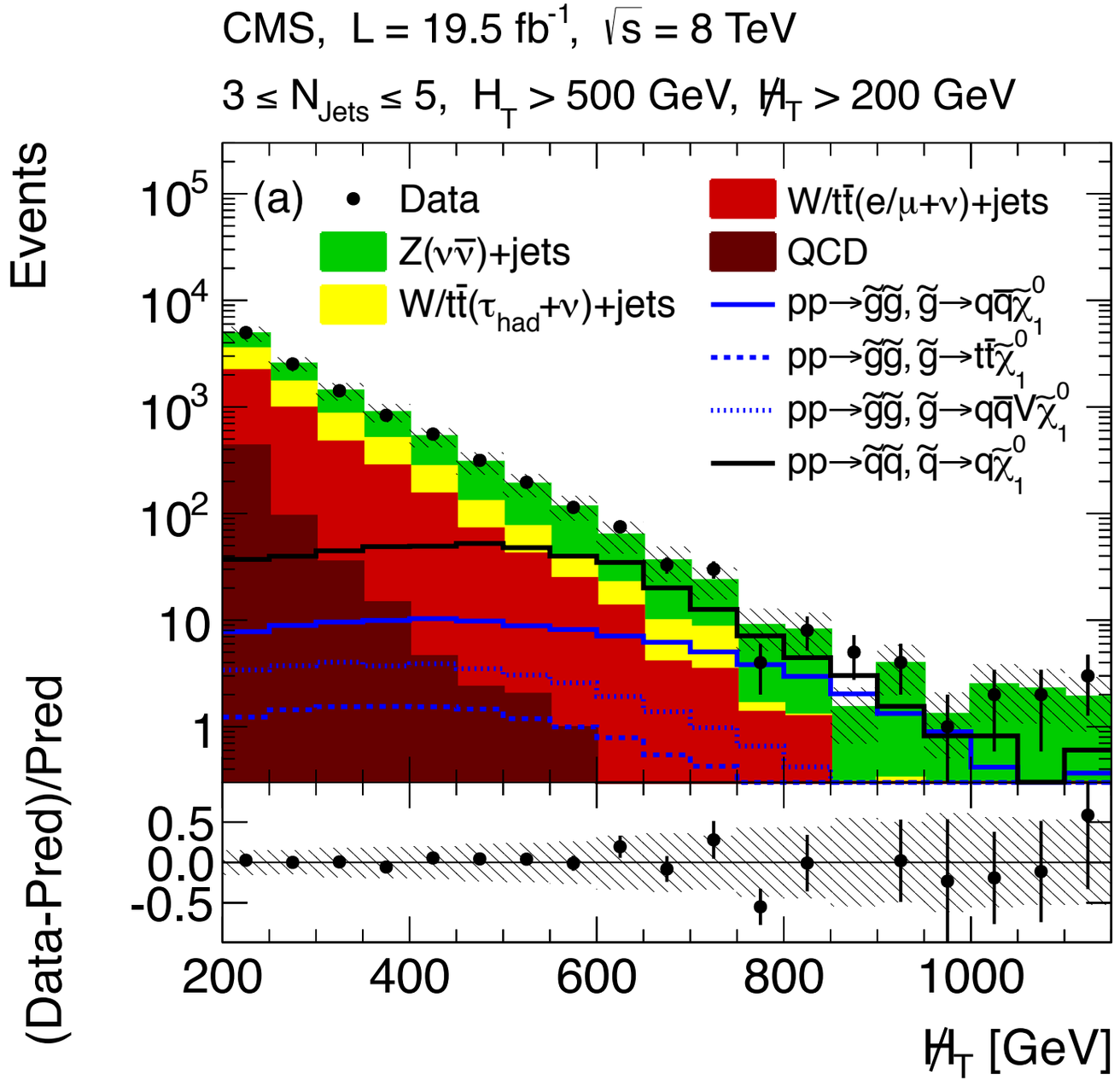
Their Interpretation

HT + MHT Search

CMS-PAS-SUS-13-012
JHEP 06 (2014) 055, arXiv:1402.4770

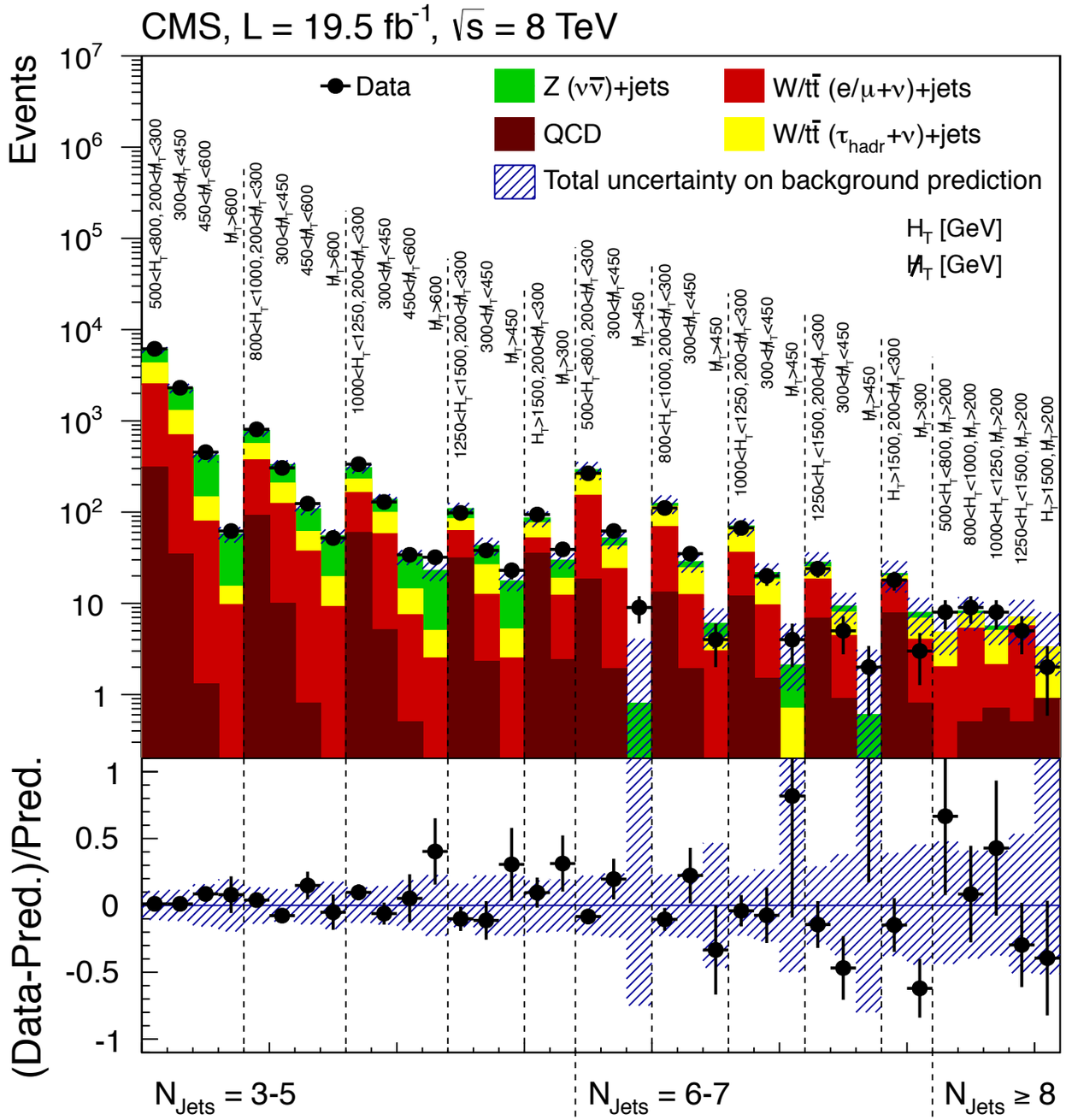
Event Selection

- simplest search, in terms of discriminating variables
- ≥ 3 jets, pt > 50 GeV
- HT > 500 GeV
- $\mathrm{MHT} = |\sum_{\mathrm{jet}} \vec{p}_{\mathrm{T}}^{\,\mathrm{jet}}|$ > 200 GeV
- 3 leading jets:
  $\Delta\Phi(\mathrm{jet}, \mathrm{MHT}) > 0.5, 0.5, 0.3$
- veto e/mu, pT > 10 GeV



Search Regions and Results

- bin in # of jets: [3,5], [6,7], ≥ 8
- bin further in HT and MHT
- a data-driven background estimate is performed
- data shows no significant excess



The $M_{\mathrm{T}2}$ Search

CMS-PAS-SUS-13-019

http://cds.cern.ch/record/1646394

The M_{T2} Variable

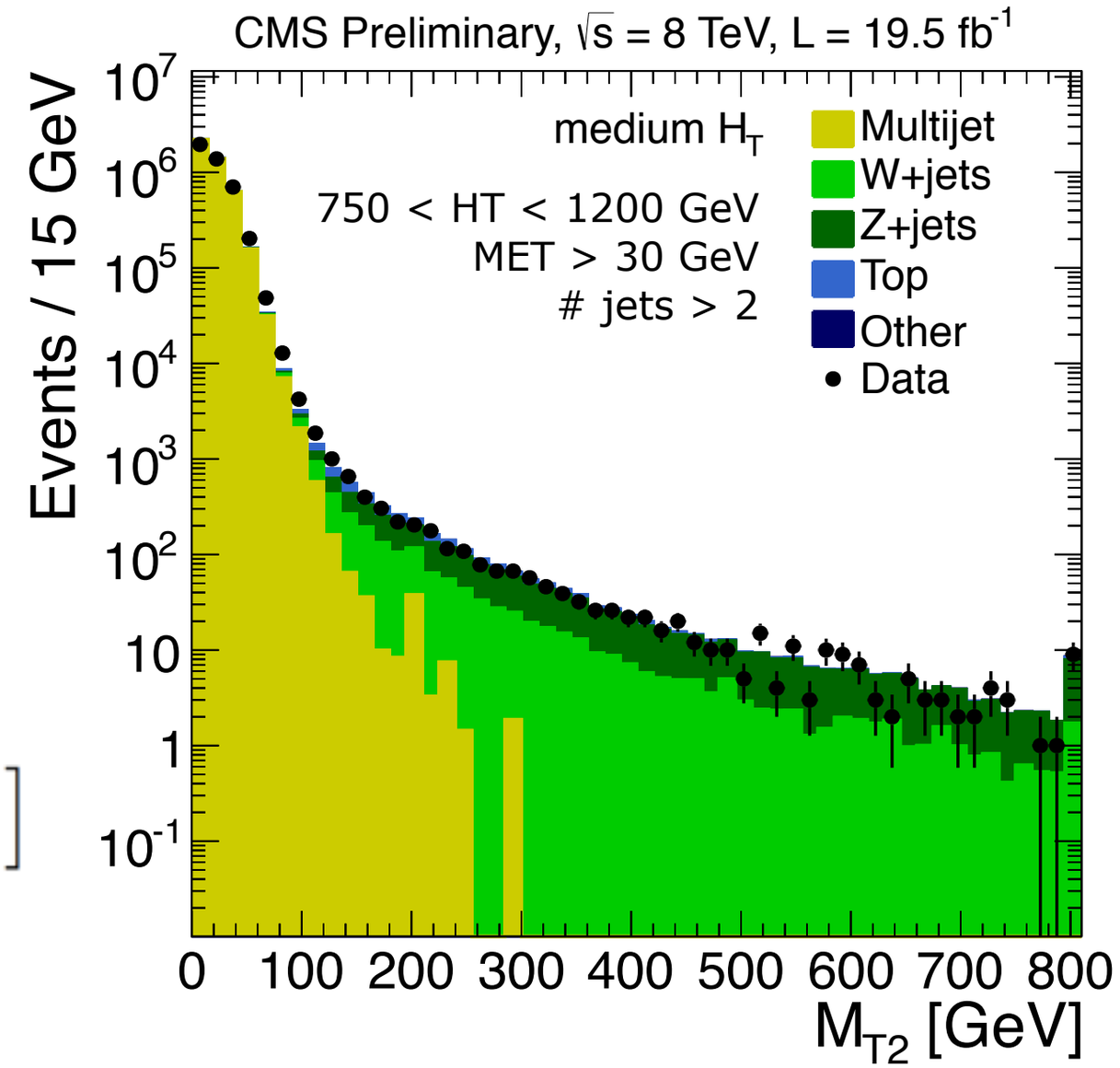
Assume in each event a process

$$pp \to X^{(1)} X^{(2)}, \quad X^{(i)} \to \tilde{\chi}^{(i)} + \mathrm{jet}^{(i)}$$

with $\tilde{\chi}^{(i)}$ invisible

Estimate transverse mass of X

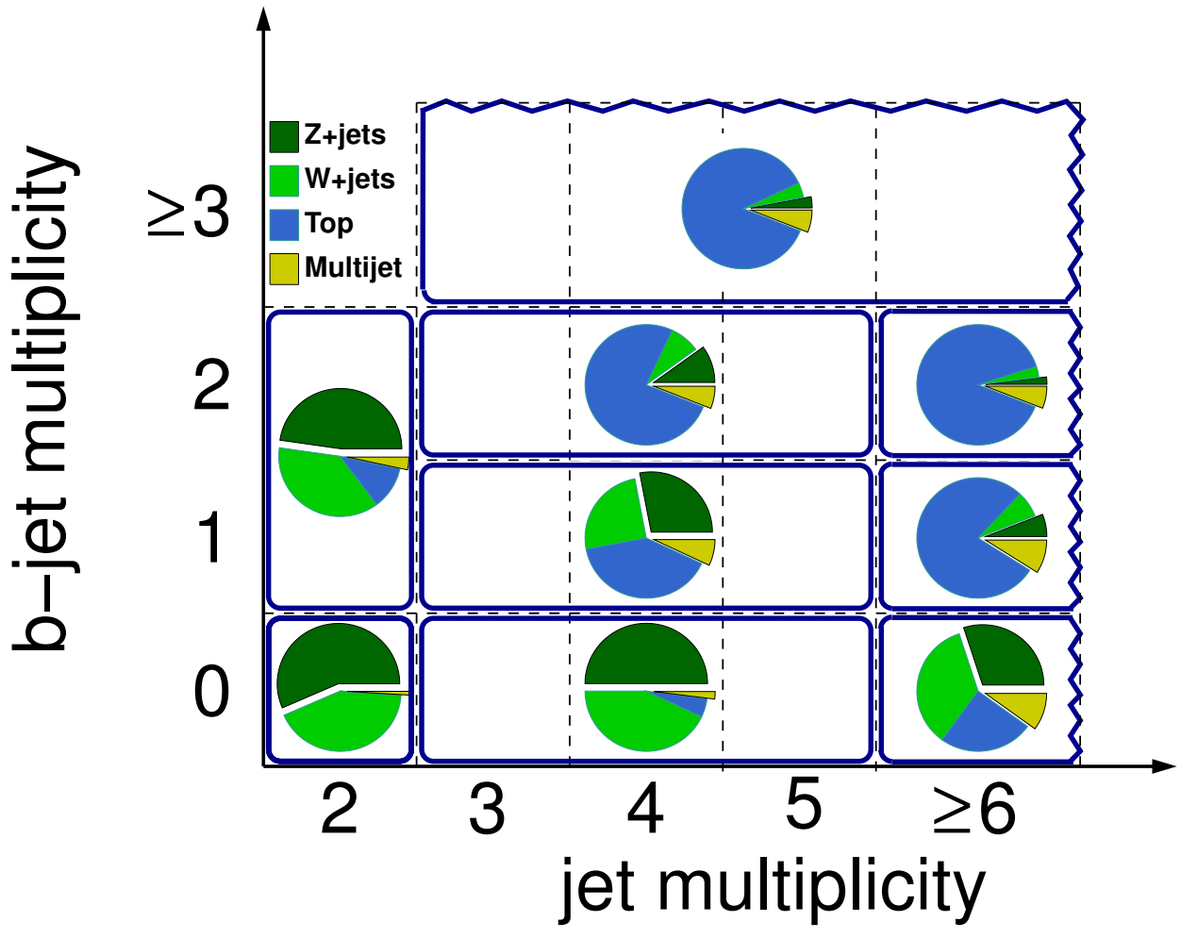
$$M_{\mathrm{T2}}(m_{\tilde{\chi}}) = \min_{\vec{p}_{\mathrm{T}}^{\tilde{\chi}(1)} + \vec{p}_{\mathrm{T}}^{\tilde{\chi}(2)} = \vec{p}_{\mathrm{T}}^{\mathrm{miss}}} \left[\max \left(M_{\mathrm{T}}^{(1)}, M_{\mathrm{T}}^{(2)} \right) \right]$$



very sensitive to genuine MET

Search Regions

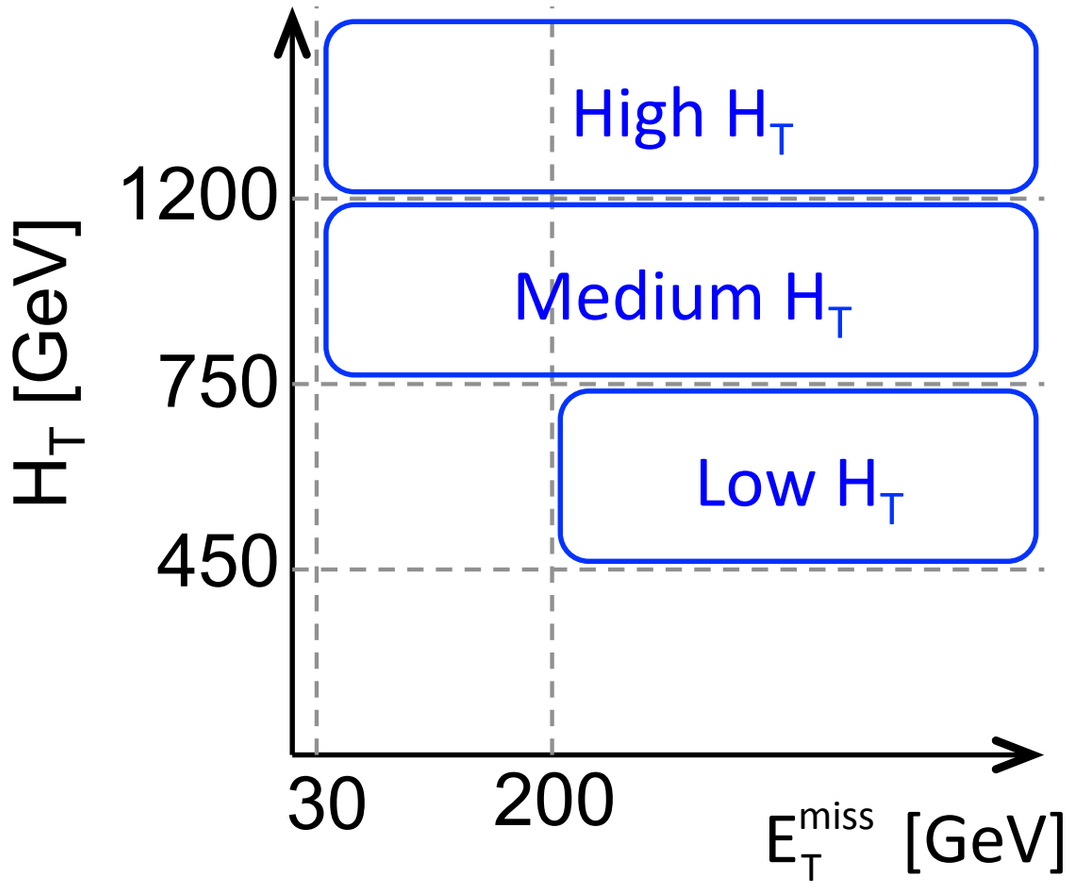
- veto e/mu/tau, pt > 10/10/20 GeV
- leading 2 jets, pt 100 GeV
- leading 4 jets,
  $\Delta\Phi(\mathrm{jet}, \mathrm{MET}) > 0.3$
- count (b-)jets with pt > 40 GeV



bin in # jets and b-jets

Search Regions

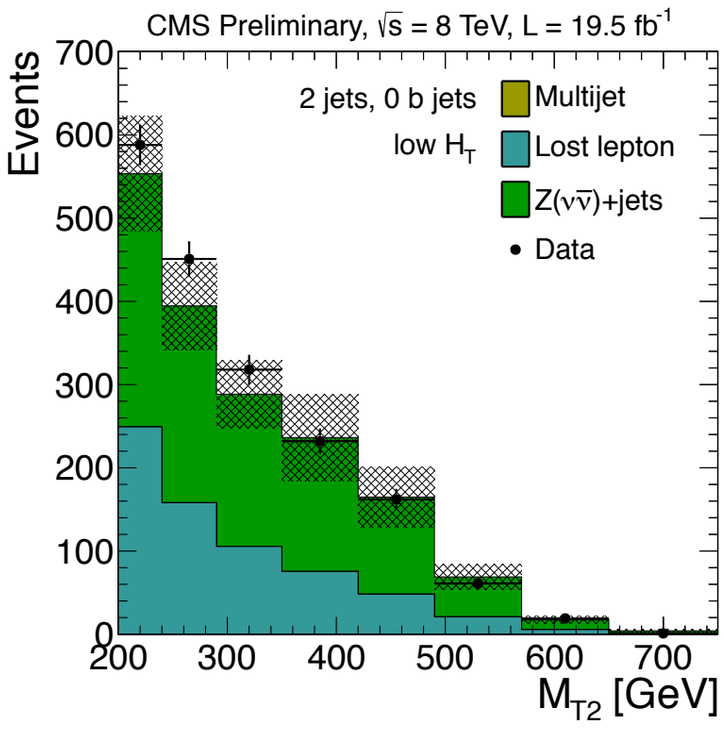
- Jets (pT > 20 GeV) clustered in 2 pseudojets
- derive M_{T2}

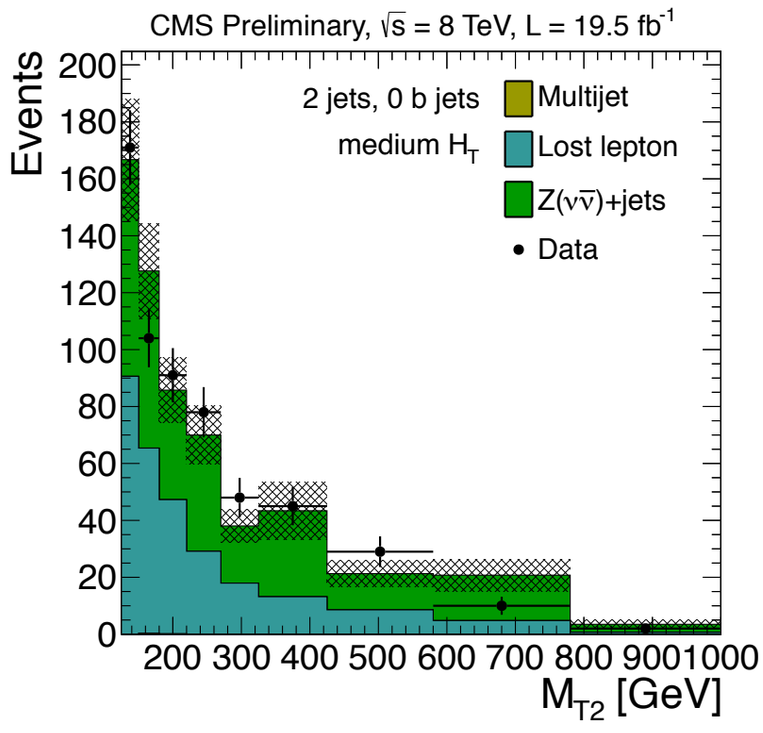


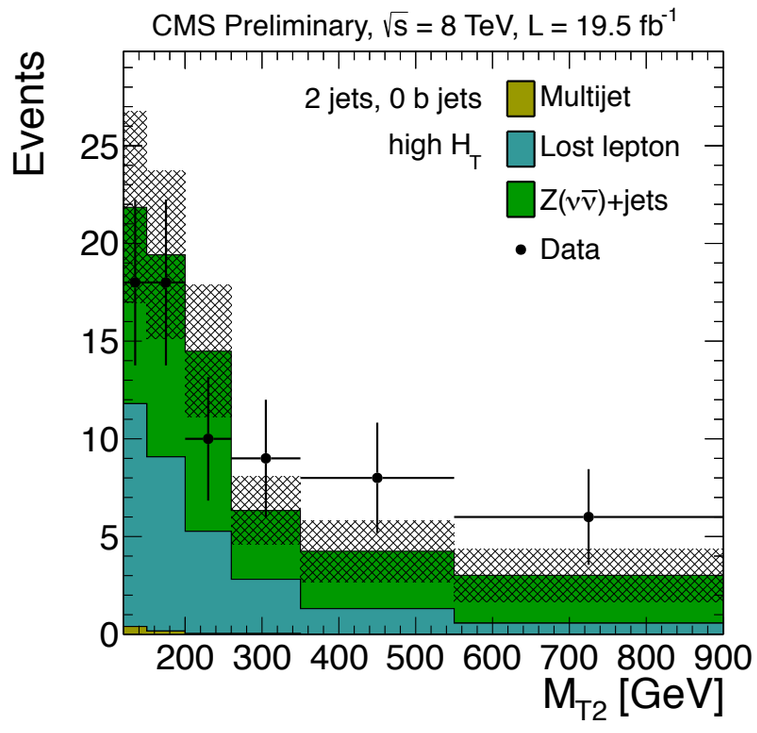
further binning in HT
per bin M_{T2} thresholds against QCD

Results

further binning in M_{T2}







123 search regions provide sensitivity to broad range of BSM processes

data-driven bkg estimates, no global significant excess

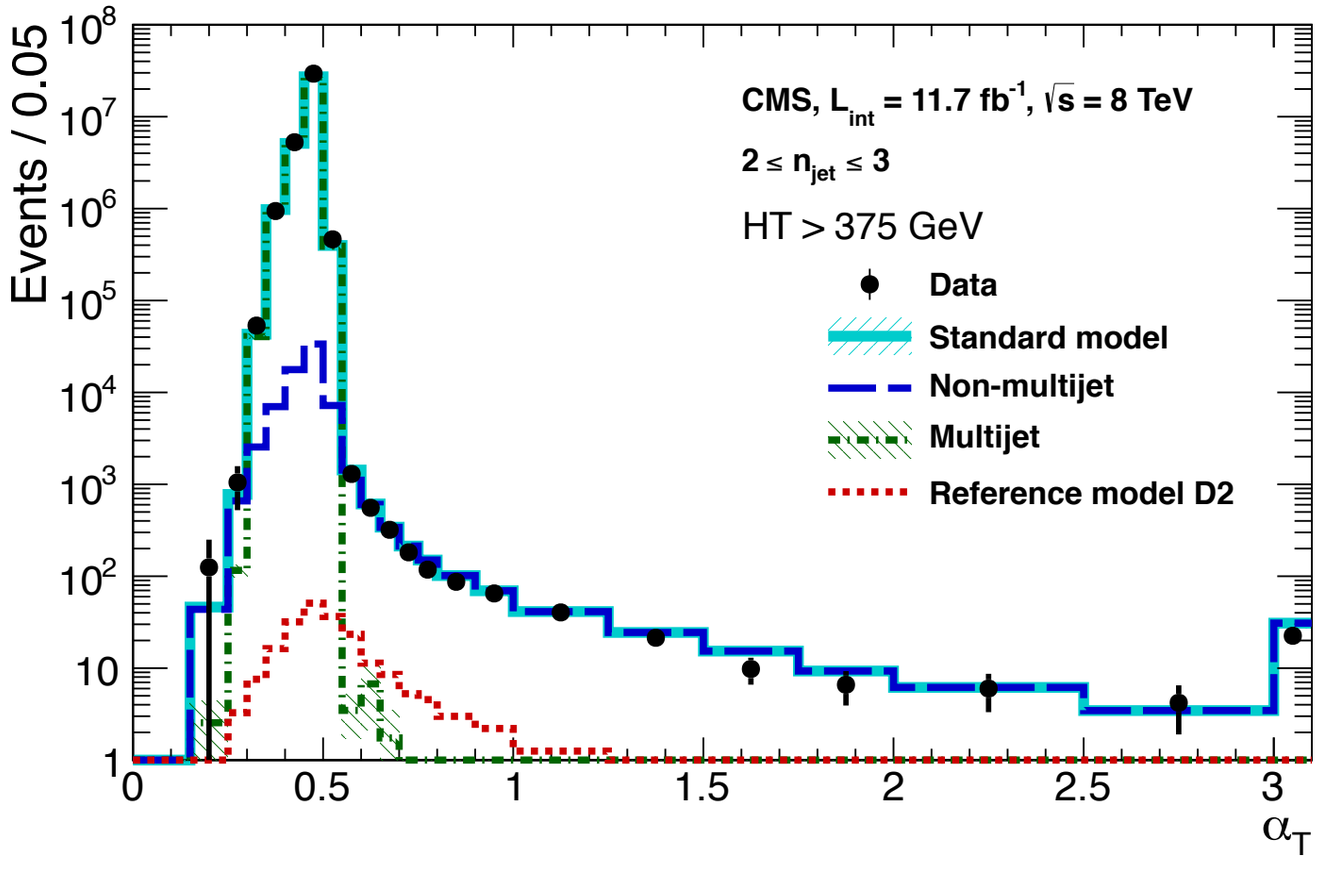
The α_{T} Search

CMS-PAS-SUS-12-028
EPJC 73 (2013) 2568, arXiv:1303.2985

The α_{T} Variable

Cluster jets into 2 pseudo-jets

$$\alpha_{\mathrm{T}} = \frac{E_{\mathrm{T}}^{j_2}}{M_{\mathrm{T}}(j_1, j_2)}$$

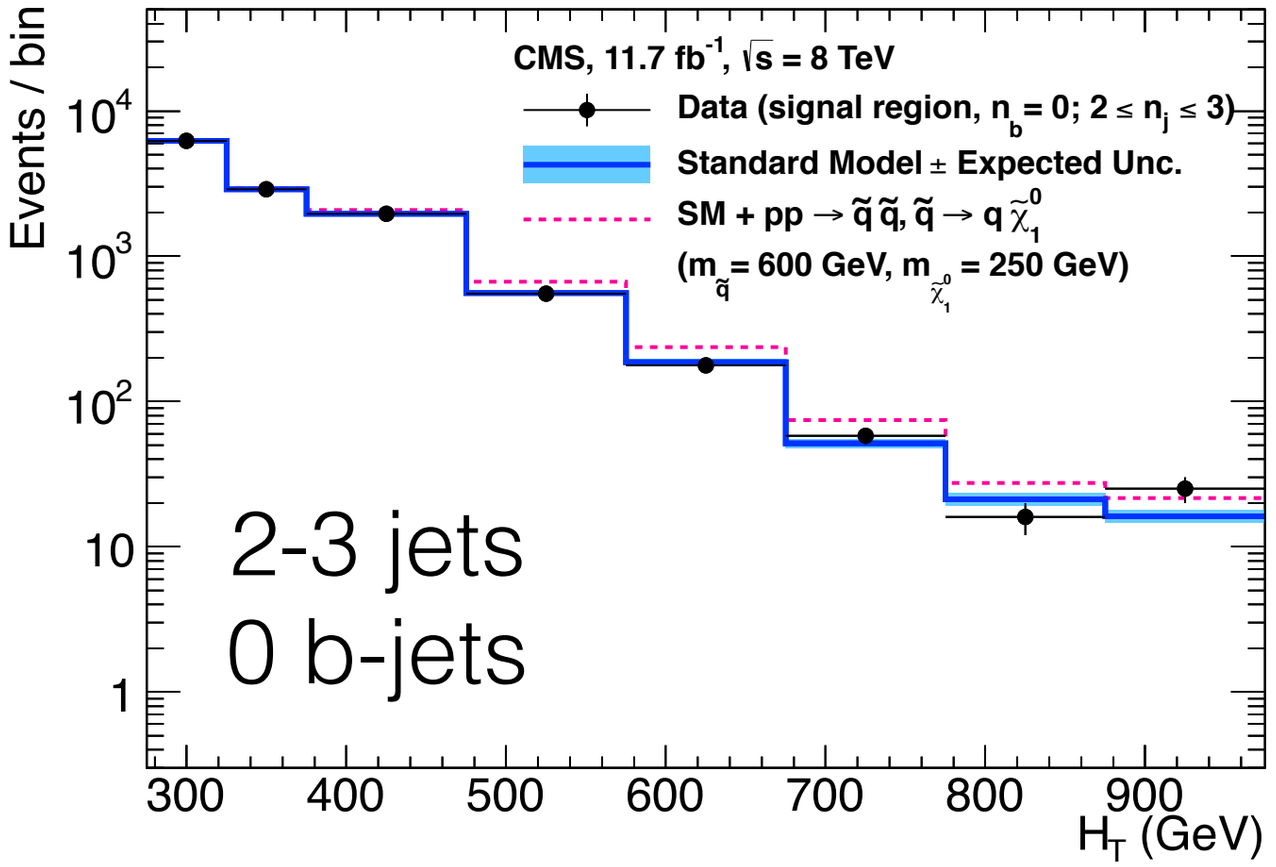


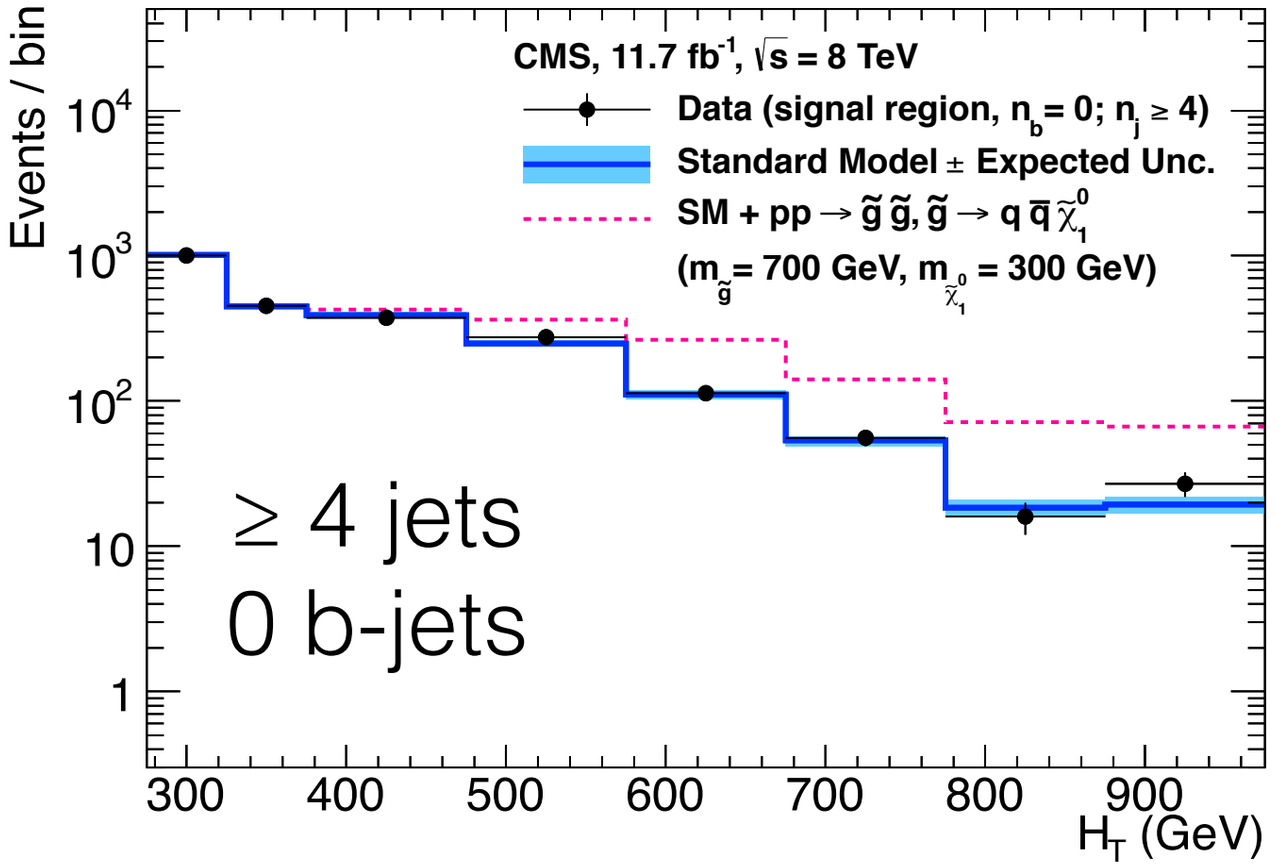
Sharp cutoff at 0.5
for events w/o genuine MET

Search Regions & Results

- veto e/mu/γ, pt > 10/10/25 GeV
- leading 2 jets, pt > 100 GeV
- $\alpha_T > 0.55$
- bin in # jets and b-jets
- bin further in HT, HT > 275 GeV

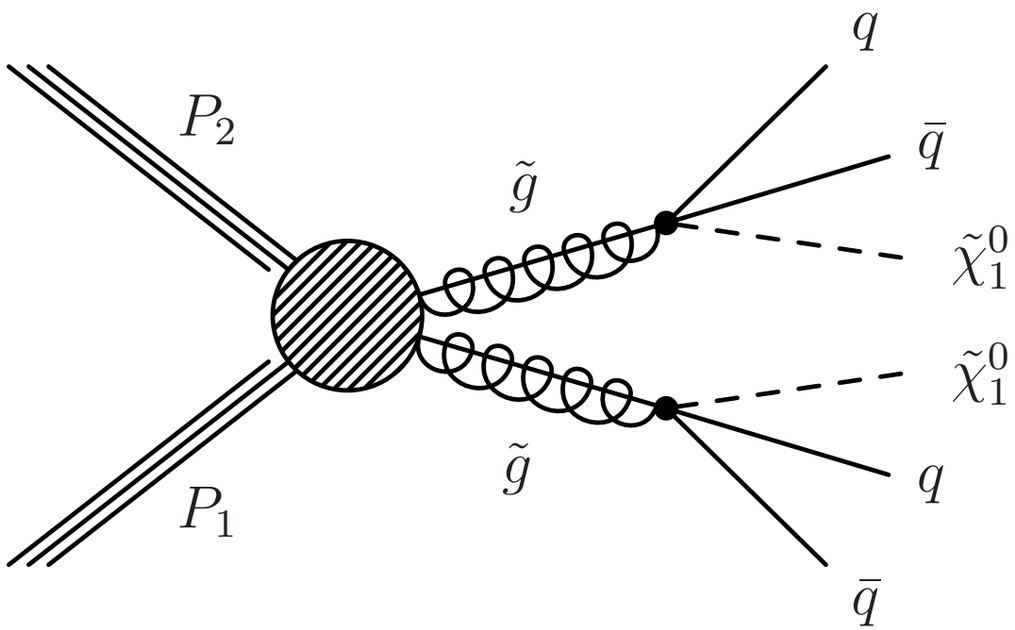
data-driven bkg estimates, no global significant excess



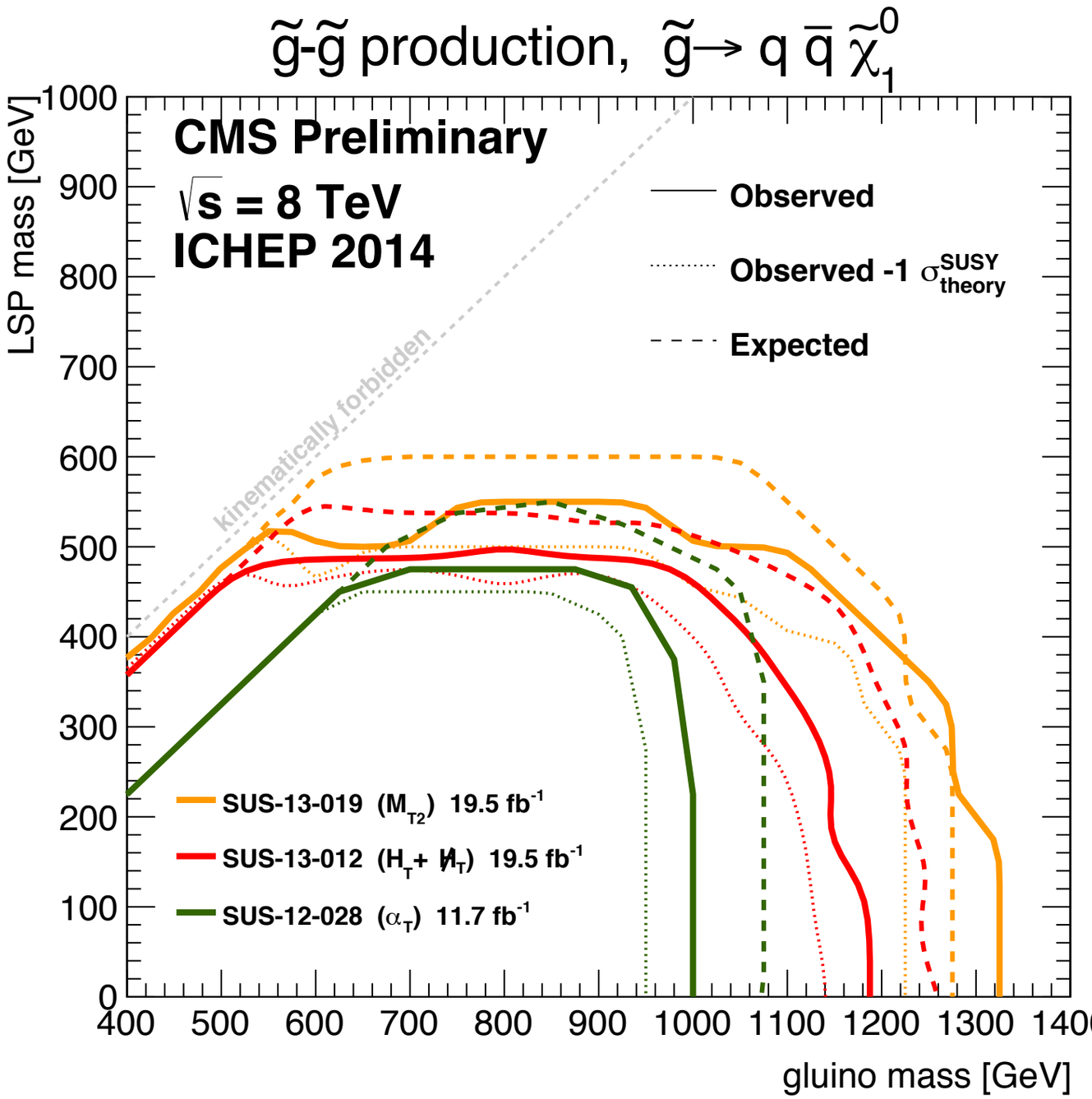


Simplified Model Interpretation

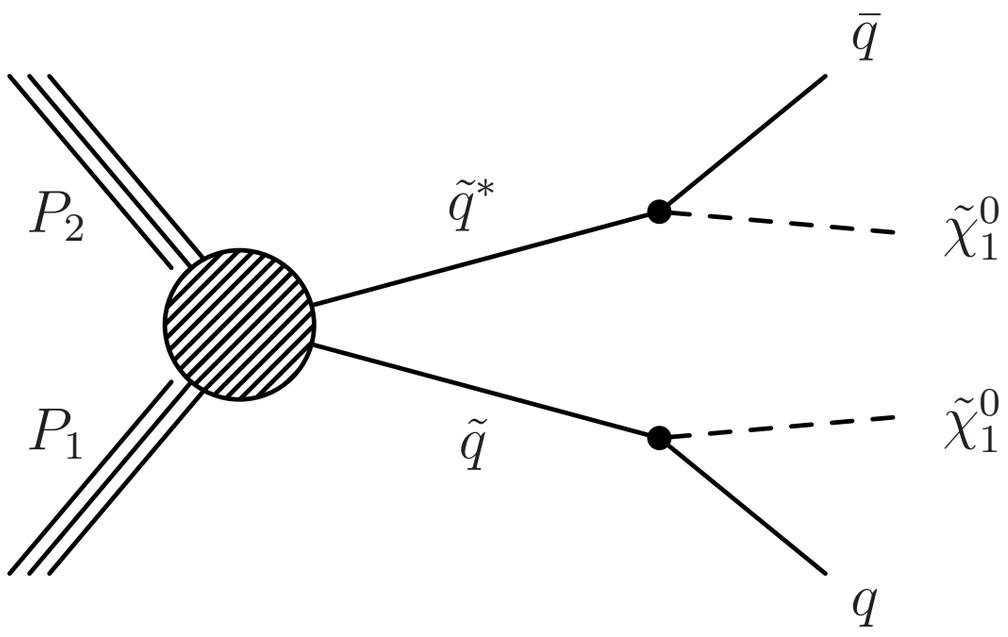
Gluino Pair Production



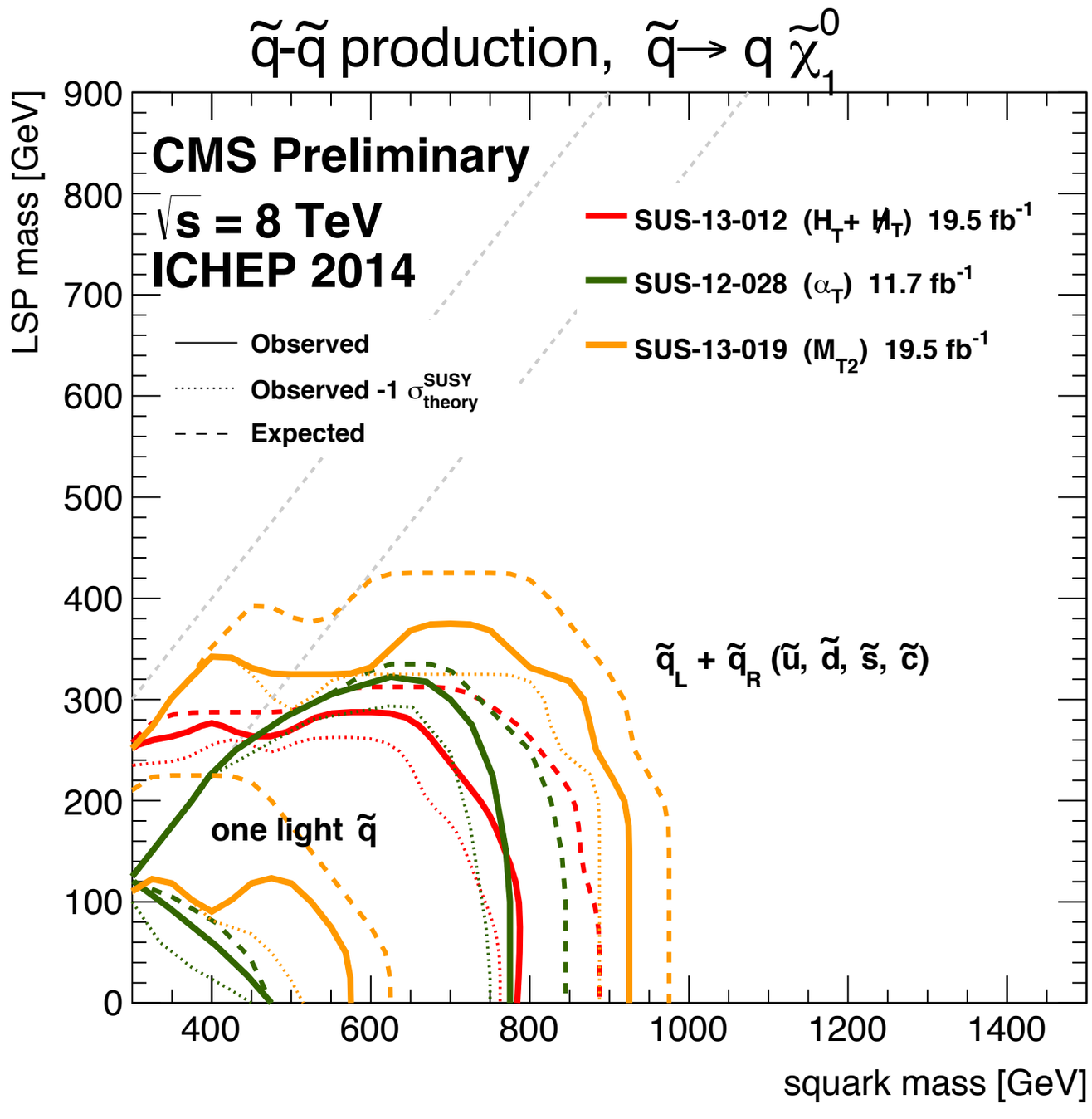
excluding
- gluinos up to 1300 GeV
- LSPs up to 500 GeV



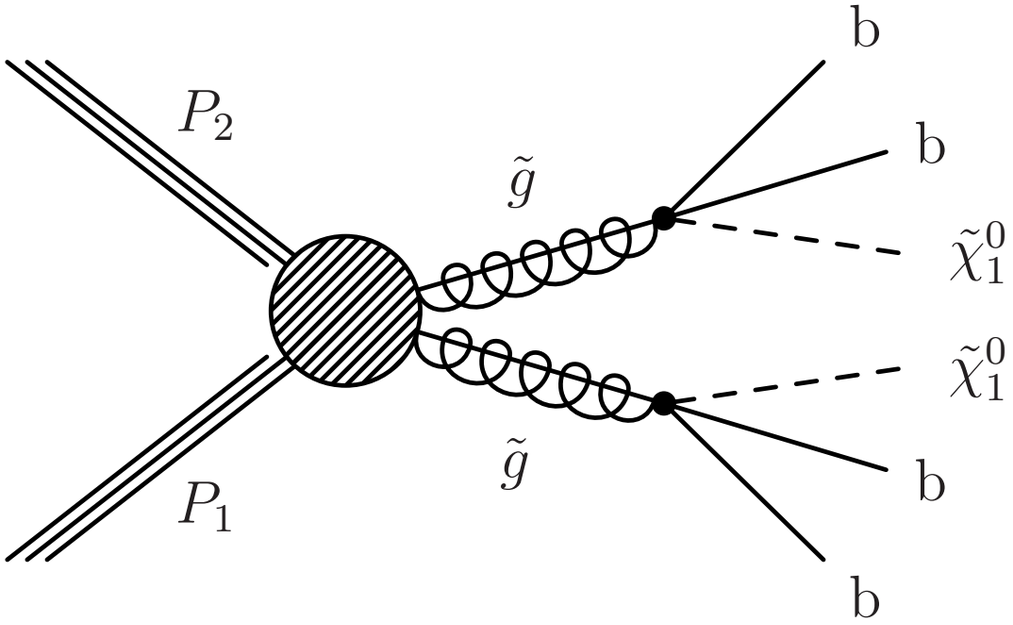
Squark Pairs



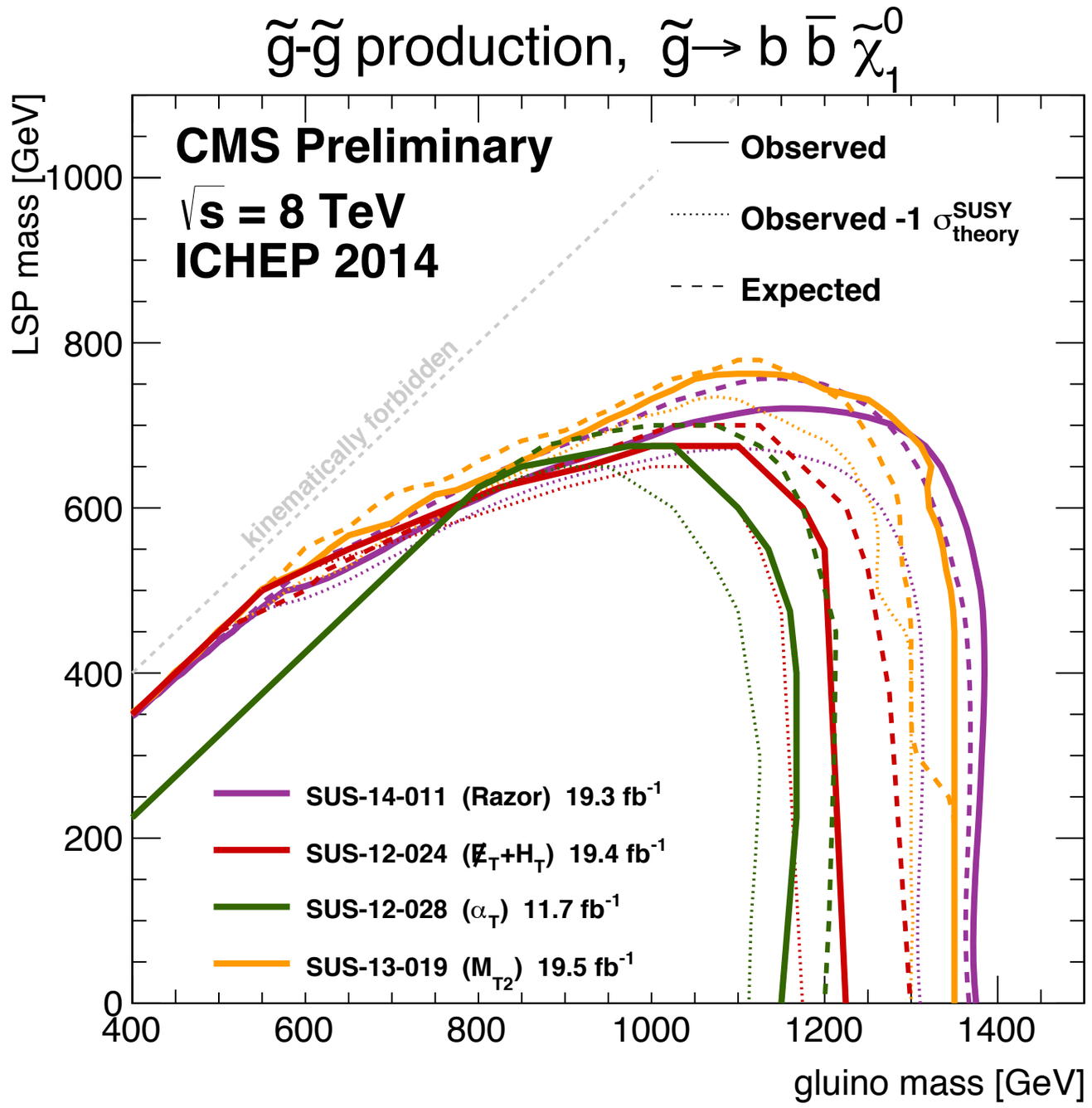
excluding
- squarks up to 900 GeV
- LSPs up to 300 GeV



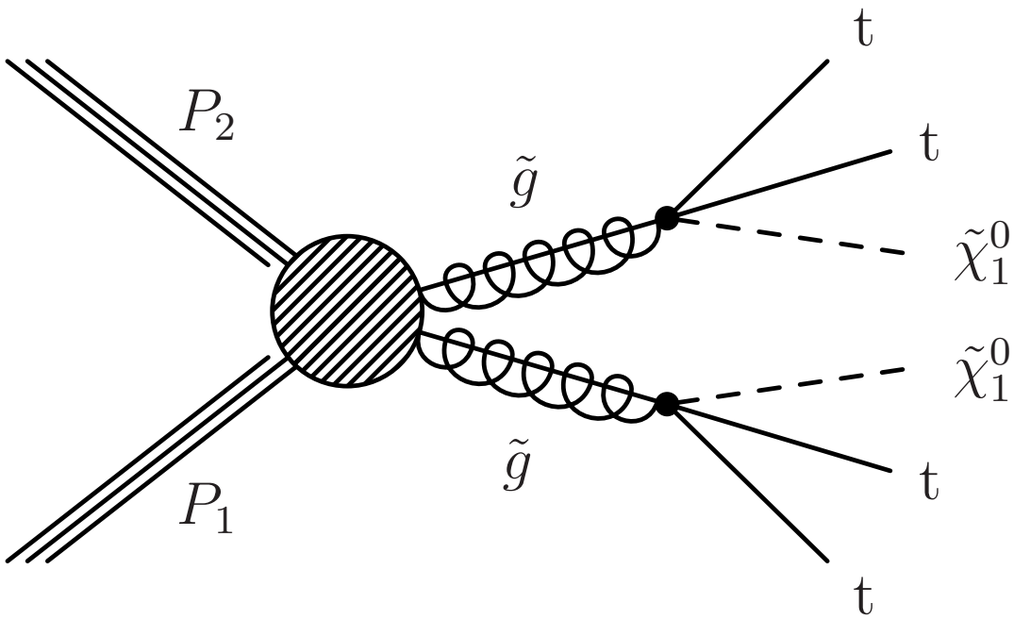
3rd Generation



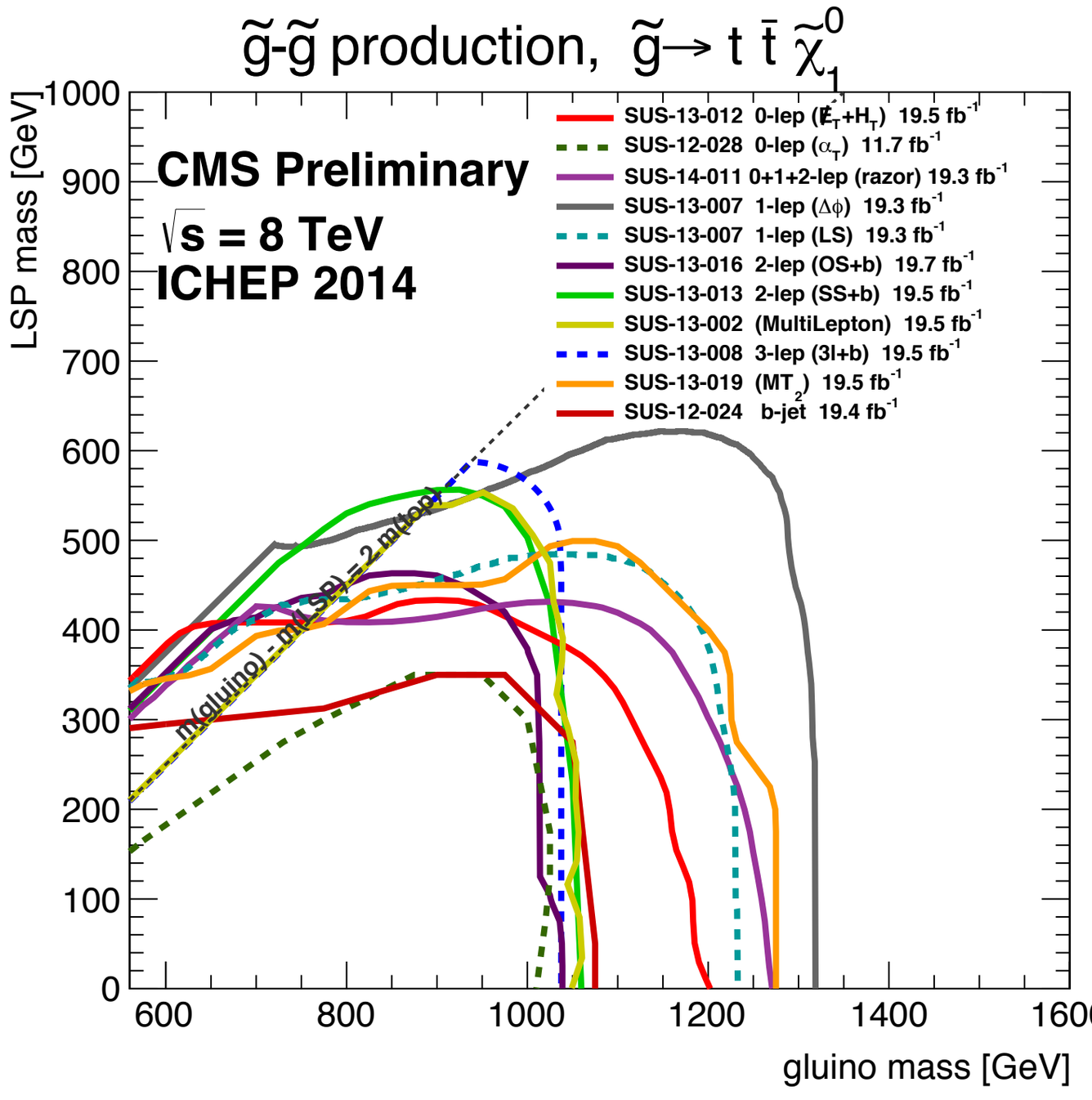
excluding
- gluinos up to 1350 GeV
- LSPs up to 700 GeV



3rd Generation



top final states usually better probed by dedicated searches



Phenomenological MSSM (pMSSM) Interpretation

CMS-PAS-SUS-13-020

http://cds.cern.ch/record/1693148

pMSSM: 19 dimensional MSSM model with "minimal" assumptions

7000 points drawn in "3 TeV box" from preCMS prior

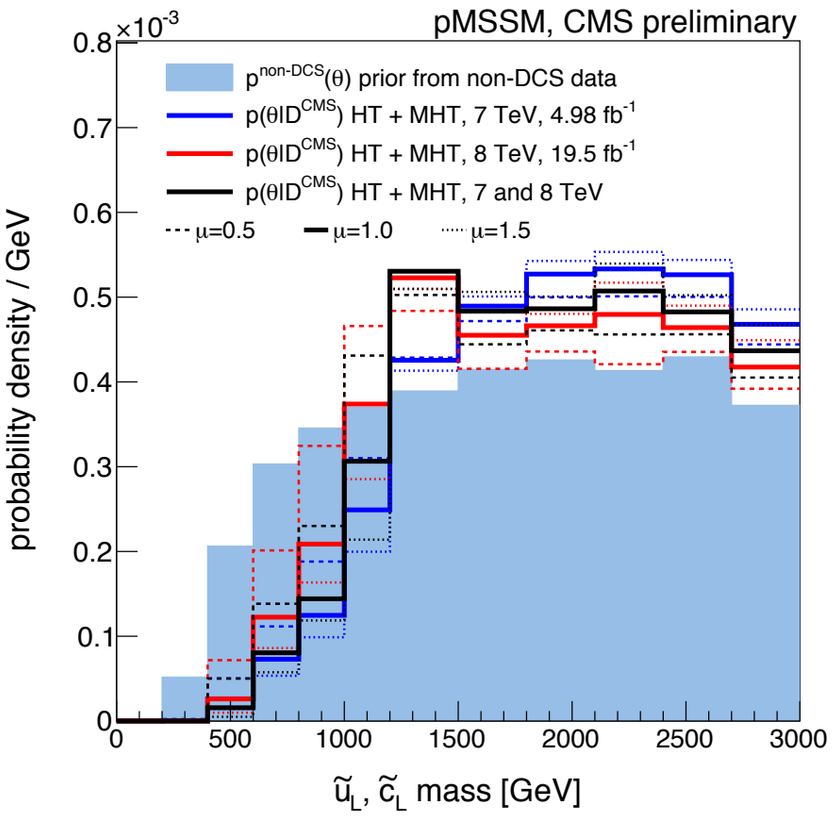
i	Observable $\mu_j(\theta)$	Constraint $D_j^{\text{non-DCS}}$	Likelihood function $L(D_j^{\text{non-DCS}}\|\mu_j(\theta))$	MCMC / post-MCMC
1a	$BR(b \to s\gamma)$	$(3.55 \pm 0.23^{\text{stat}} \pm 0.24^{\text{th}} \pm 0.09^{\text{sys}}) \times 10^{-4}$	Gaussian	MCMC
1b	$BR(b \to s\gamma)$	$(3.43 \pm 0.21^{\text{stat}} \pm 0.24^{\text{th}} \pm 0.07^{\text{sys}}) \times 10^{-4}$	Gaussian	reweight
2a	$BR(B_s \to \mu\mu)$	observed CLs curve from	$d(1-CLs)/d(BR(B_s \to \mu\mu))$	MCMC
2b	$BR(B_s \to \mu\mu)$	$(2.9 \pm 0.7 \pm 0.29^{th}) \times 10^{-9}$	Gaussian	reweight
3a	$R(B_u \to \tau\nu)$	1.63 ± 0.54	Gaussian	MCMC
3b	$R(B_u \to \tau\nu)$	1.04 ± 0.34	Gaussian	reweight
4	Δa_μ	$(26.1 \pm 6.3^{\text{exp}} \pm 4.9^{\text{SM}} \pm 10.0^{\text{SUSY}}) \times 10^{-10}$	Gaussian	MCMC
5a	m_t	$173.3 \pm 0.5^{\text{stat}} \pm 1.3^{\text{sys}}$ GeV	Gaussian	MCMC
5b	m_t	$173.20 \pm 0.87^{\text{stat}} \pm 1.3^{\text{sys}}$ GeV	Gaussian	reweight
6	$m_b(m_b)$	$4.19^{+0.18}_{-0.06}$ GeV	Two-sided Gaussian	MCMC
7	$\alpha_s(M_Z)$	0.1184 ± 0.0007	Gaussian	MCMC
8a	m_h	pre-LHC: $m_h^{low} = 112$	1 if $m_h \geq m_h^{low}$ 0 if $m_h < m_h^{low}$	MCMC
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 $m_h > m_h^{up}$	reweight
9	sparticle masses	LEP (via micrOMEGAs)	1 if allowed 0 if excluded	MCMC

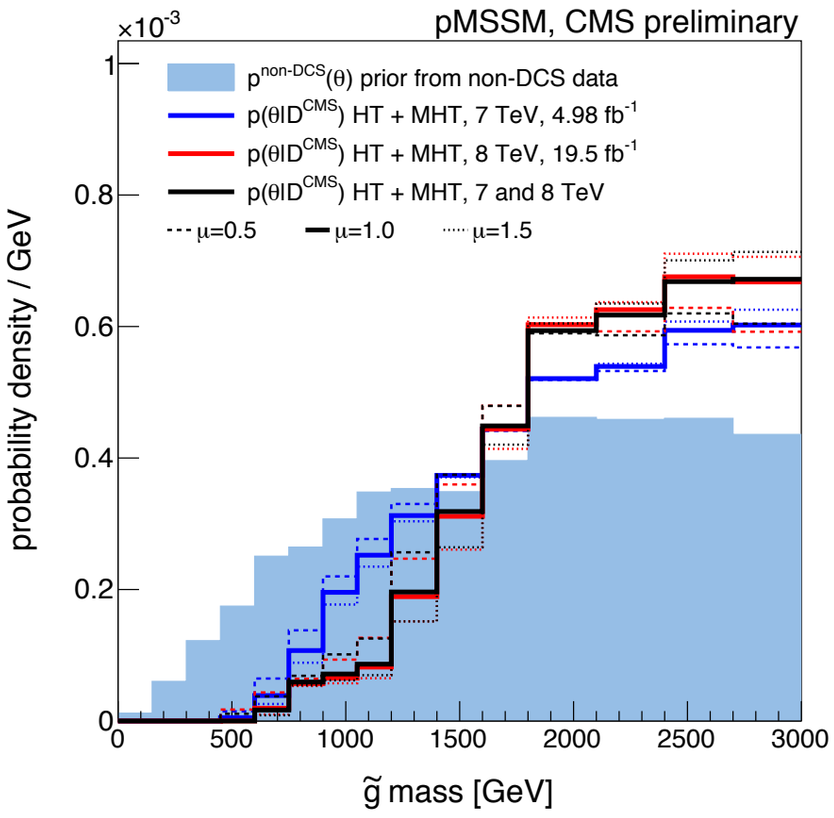
=> very generic SUSY interpretation

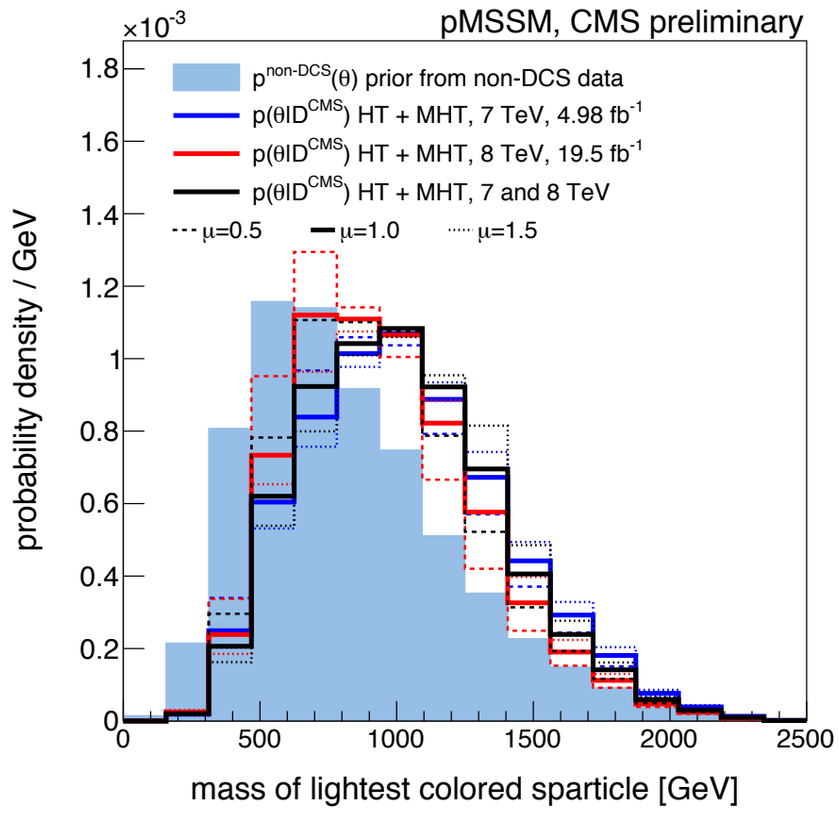
=> considers search and precision data

Prior vs Posterior Distributions

Bayesian Analysis

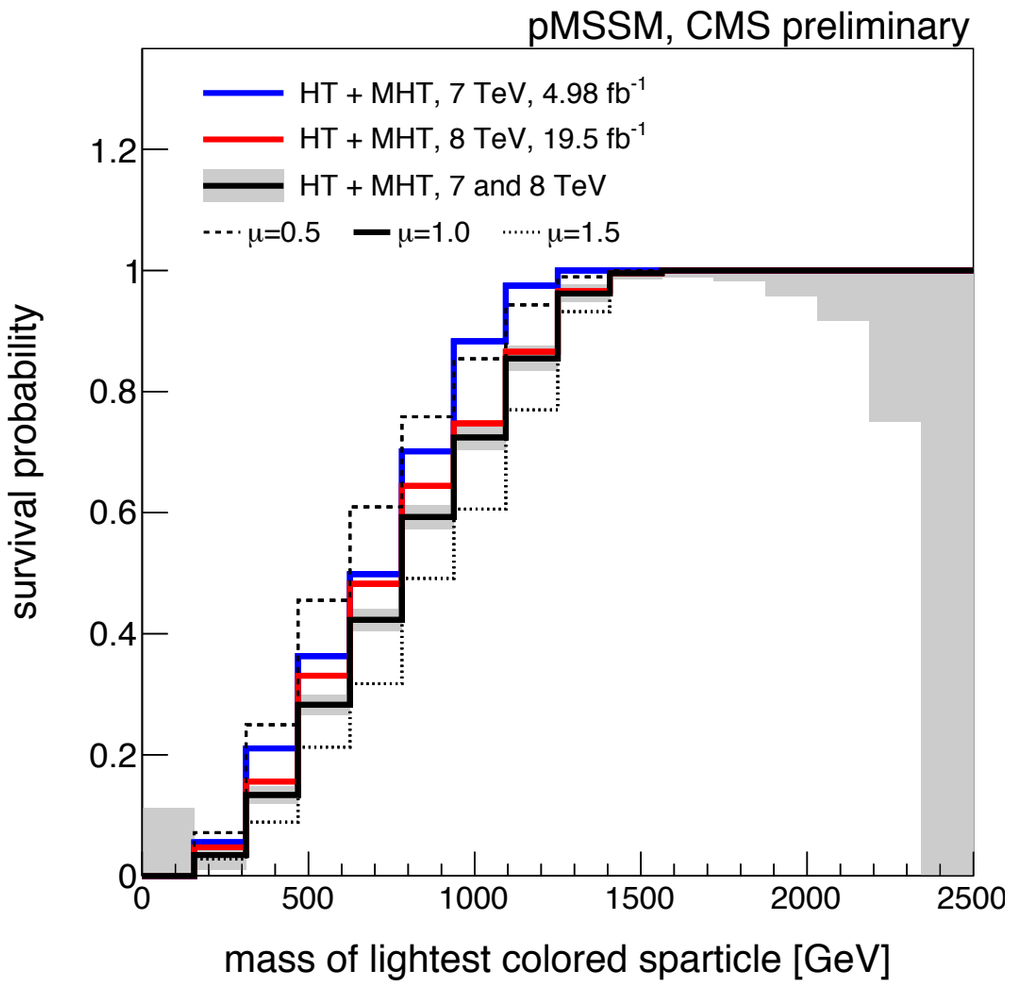


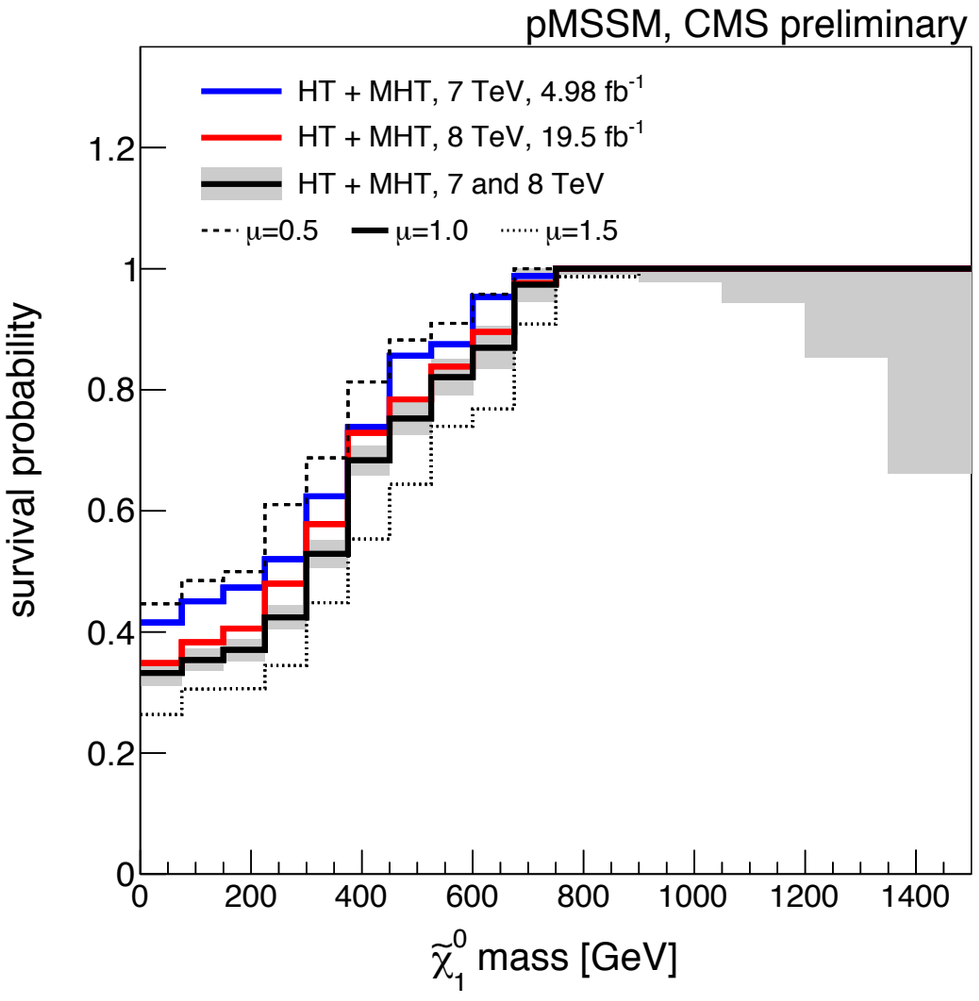




HT + MHT data disfavours low mass regions

Survival Rate of pMSSM Points





HT + MHT is probing
- coloured particles up to 1200 GeV
- LSP masses up to 700 GeV

Overal survival rate: ~50%

Conclusion

- CMS has developed a nice set of inclusive SUSY searches

- No significant excesses observed

- Interpretation in SMSs and “full” pMSSM models

  => Probing coloured particles up to 1300 GeV
  => Probing LSPs up to 700 GeV