Interpreting the results of CMS SUSY searches
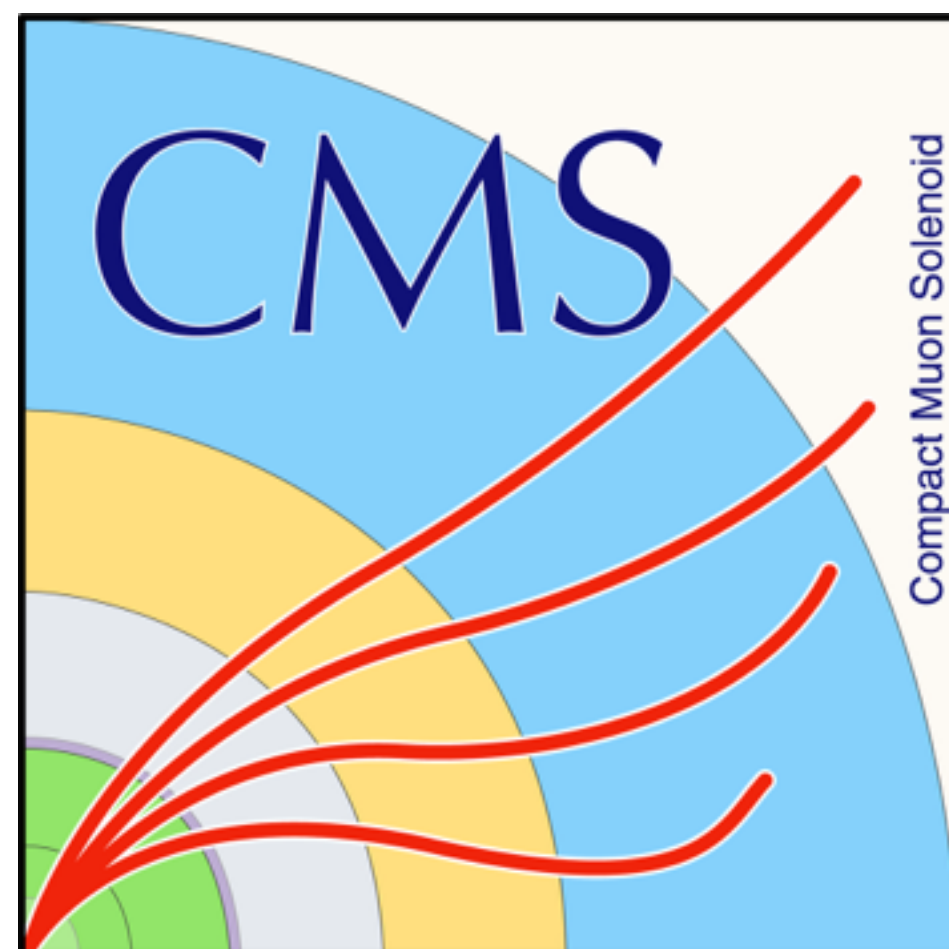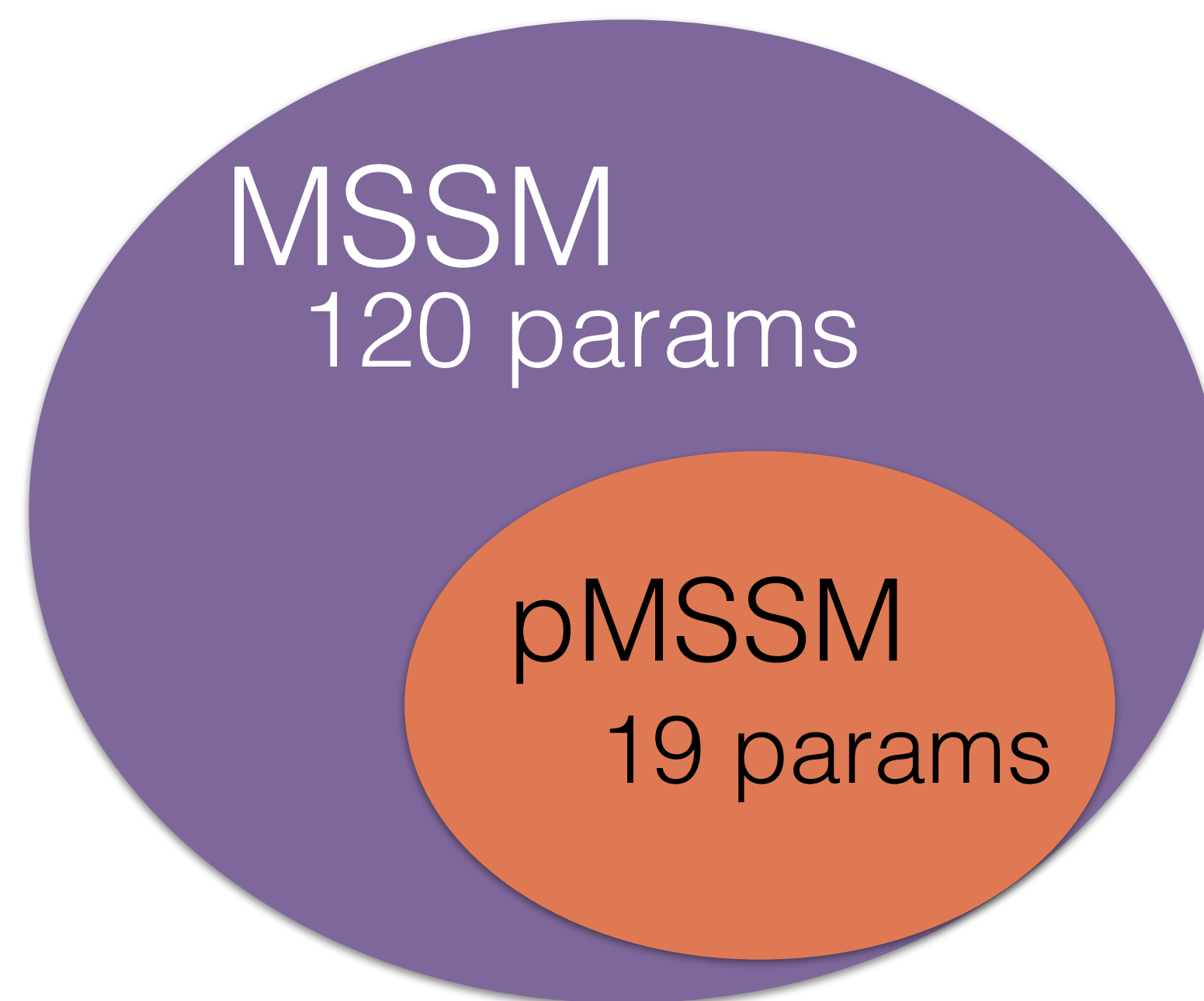
A good submodel for the MSSM

"Realistic" MSSM sub-model

MSSM
120 params

pMSSM
19 params

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 supersymmetric particle is the neutralino χ_1^0

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

Phenomenological MSSM interpretation of CMS searches in pp collisions at sqrt(s) = 7 and 8 TeV

CMS Collaboration (Vardan Khachatryan (Yerevan Phys. Inst.) *et al.*). Jun 11, 2016.

Bayes' theorem

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

Phenomenological MSSM interpretation of CMS searches in pp collisions at sqrt(s) = 7 and 8 TeV

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pre-CMS results

$$\mathcal{B}(\text{b} \rightarrow \text{s}\gamma) \quad \alpha_s \quad \text{B}_s \rightarrow \mu\mu$$

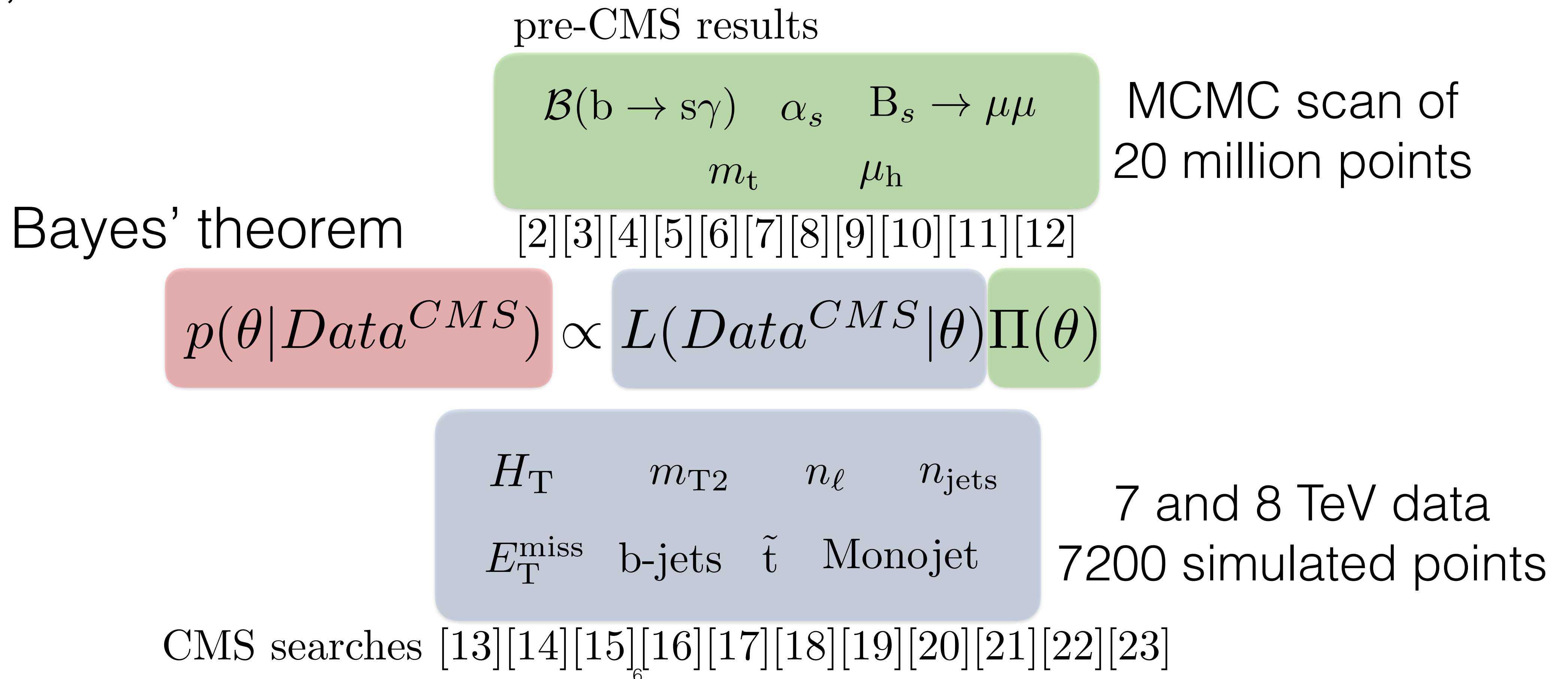$$m_{\text{t}} \qquad \mu_{\text{h}}$$

MCMC scan of 20 million points

Bayes' theorem

[2][3][4][5][6][7][8][9][10][11][12]

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

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MCMC scan of 20 million points

Bayes' theorem   [2][3][4][5][6][7][8][9][10][11][12]

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

$$H_{\mathrm{T}} \quad m_{\mathrm{T2}} \quad n_\ell \quad n_{\mathrm{jets}}$$
$$E_{\mathrm{T}}^{\mathrm{miss}} \quad \text{b-jets} \quad \tilde{\mathrm{t}} \quad \text{Monojet}$$

7 and 8 TeV data
7200 simulated points

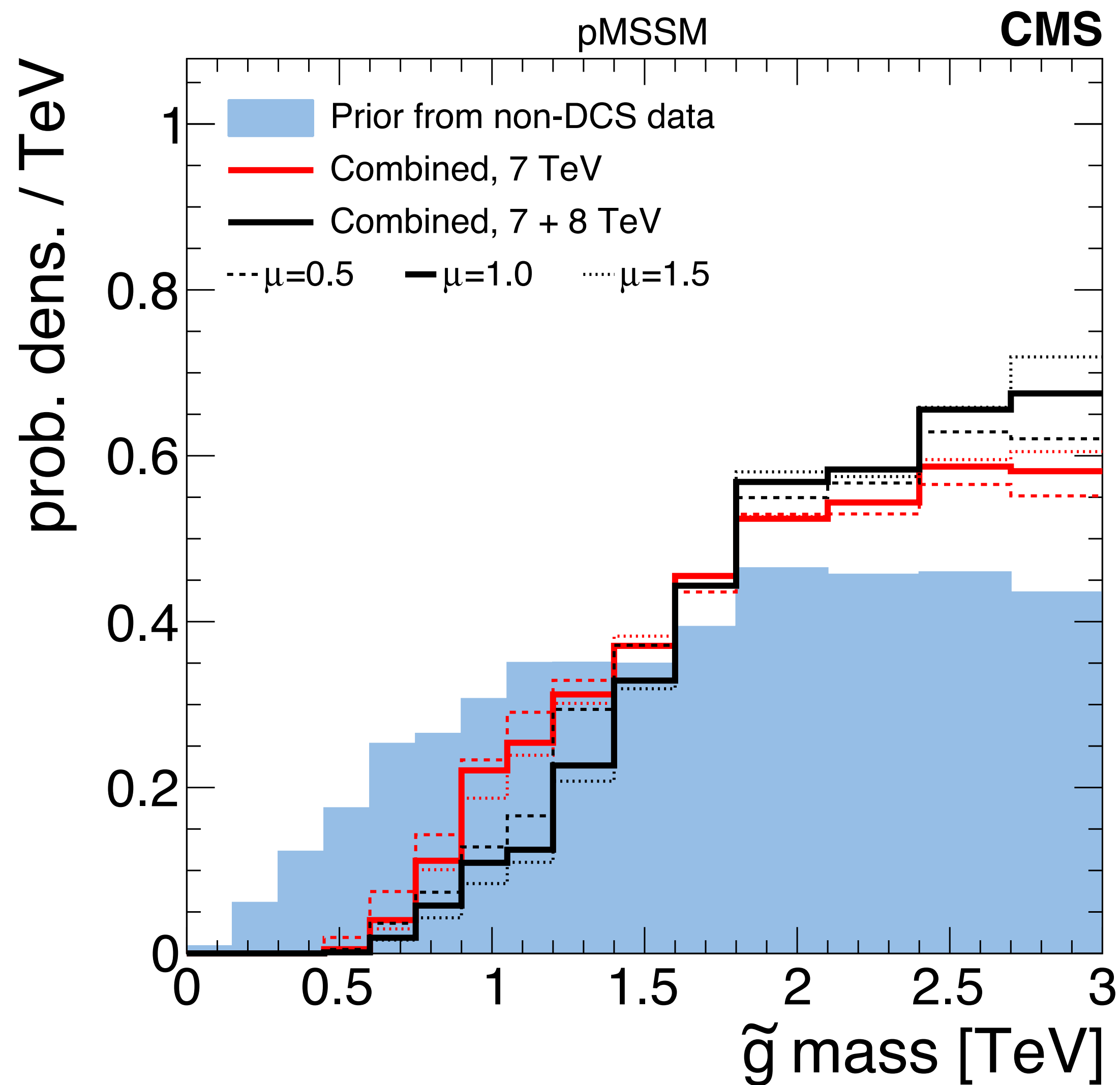CMS searches [13][14][15][16][17][18][19][20][21][22][23]

Why this approach?

CMS uses the Bayesian approach because

1. The result can be interpreted as a probability density for hypotheses of mass spectra

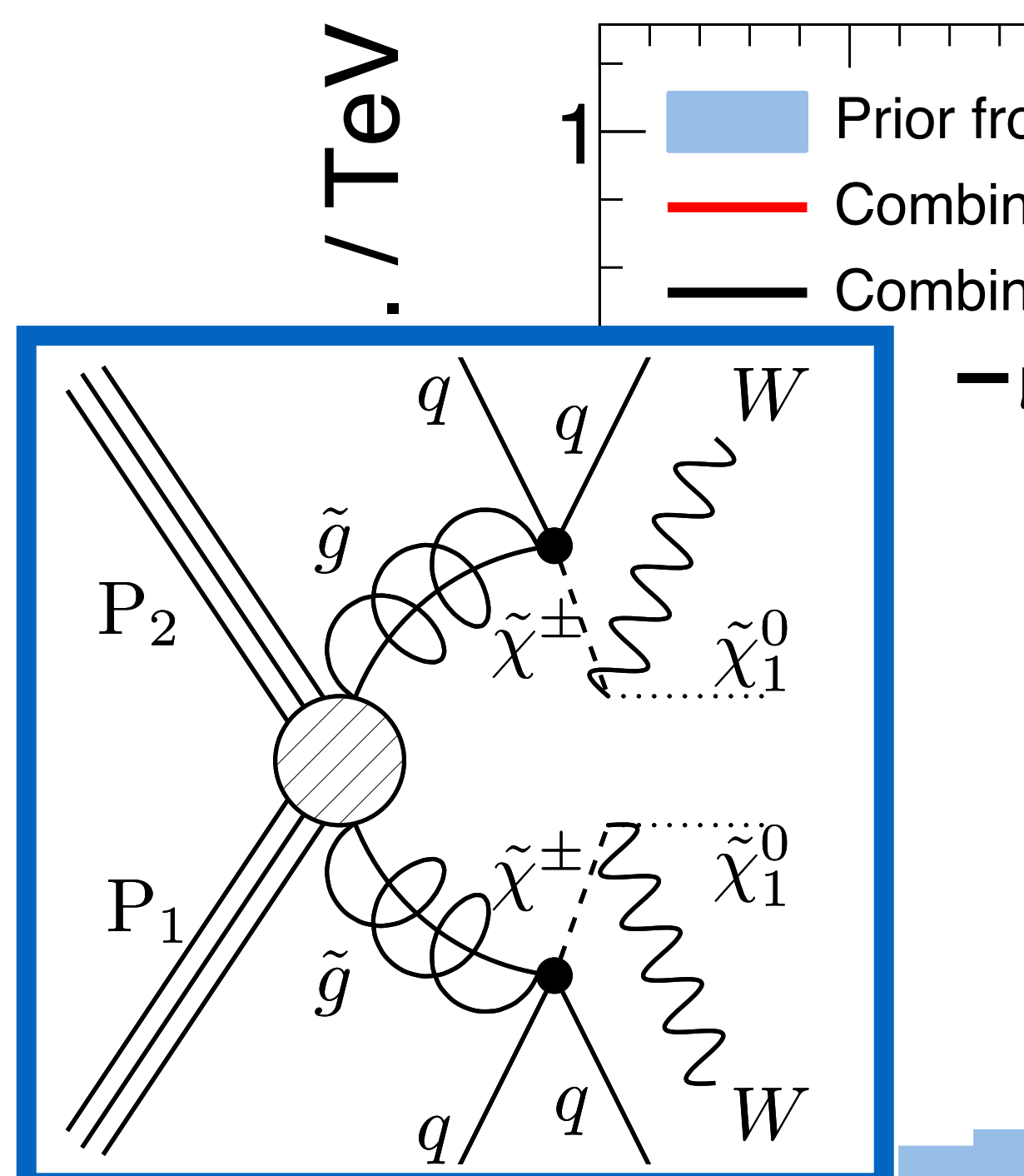2. It allows us to sample the interesting regions of the pMSSM subspace with a higher density

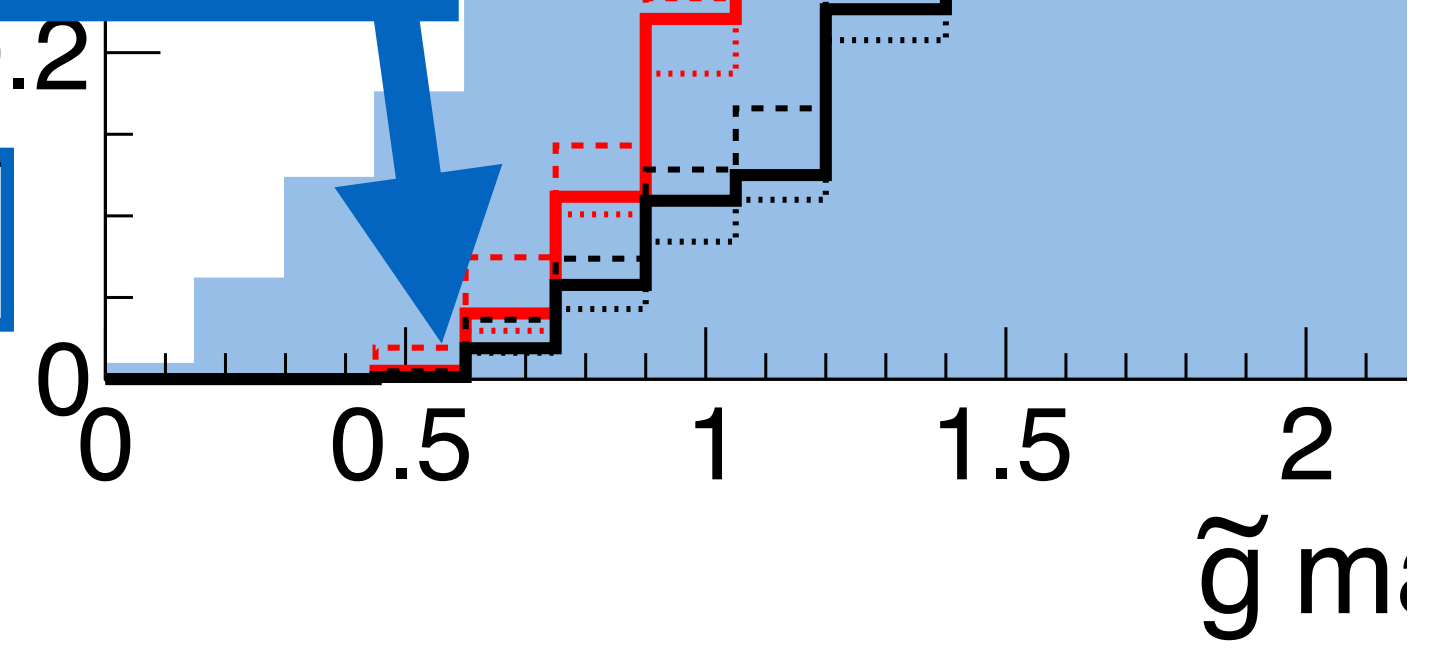# Gluino mass
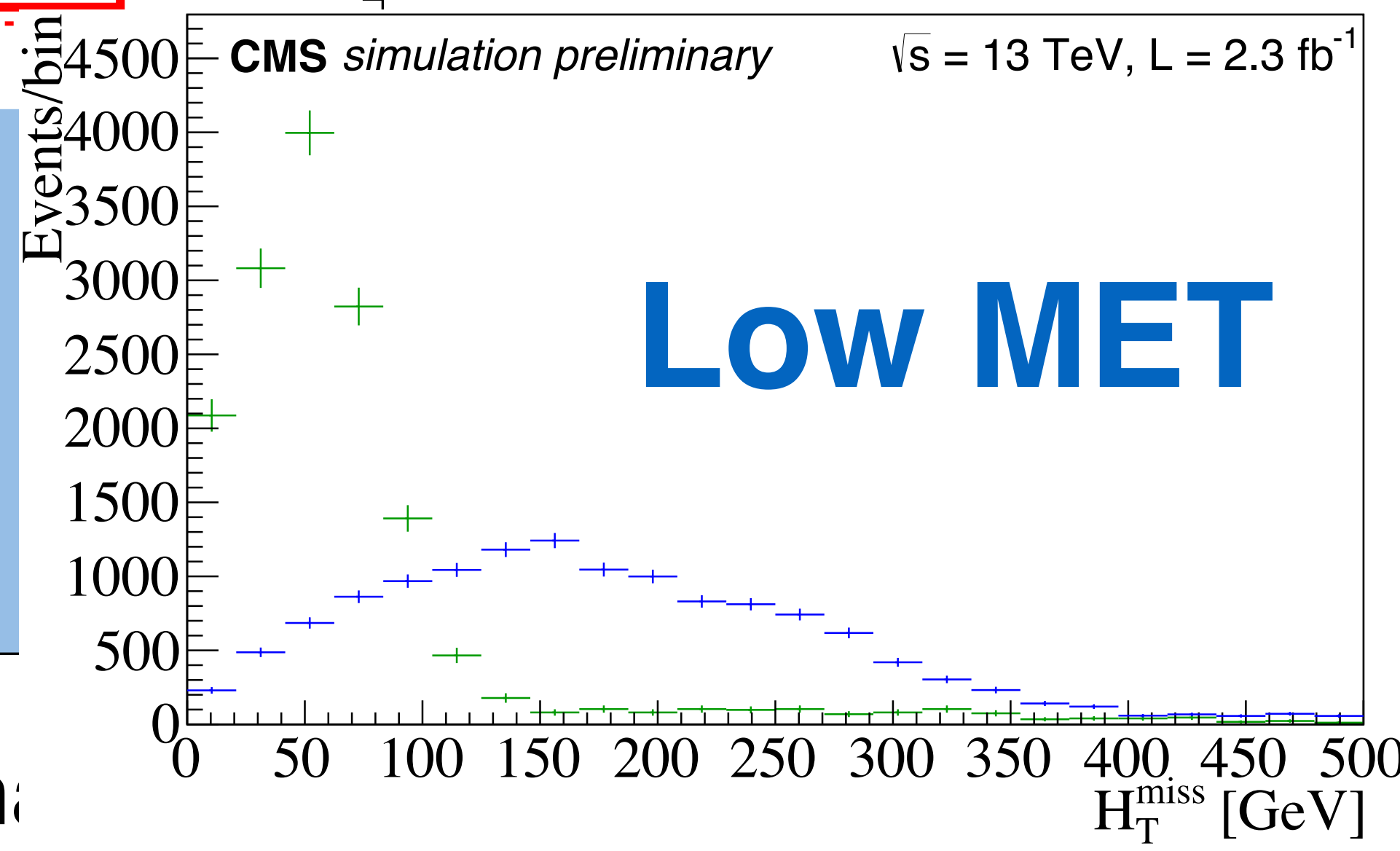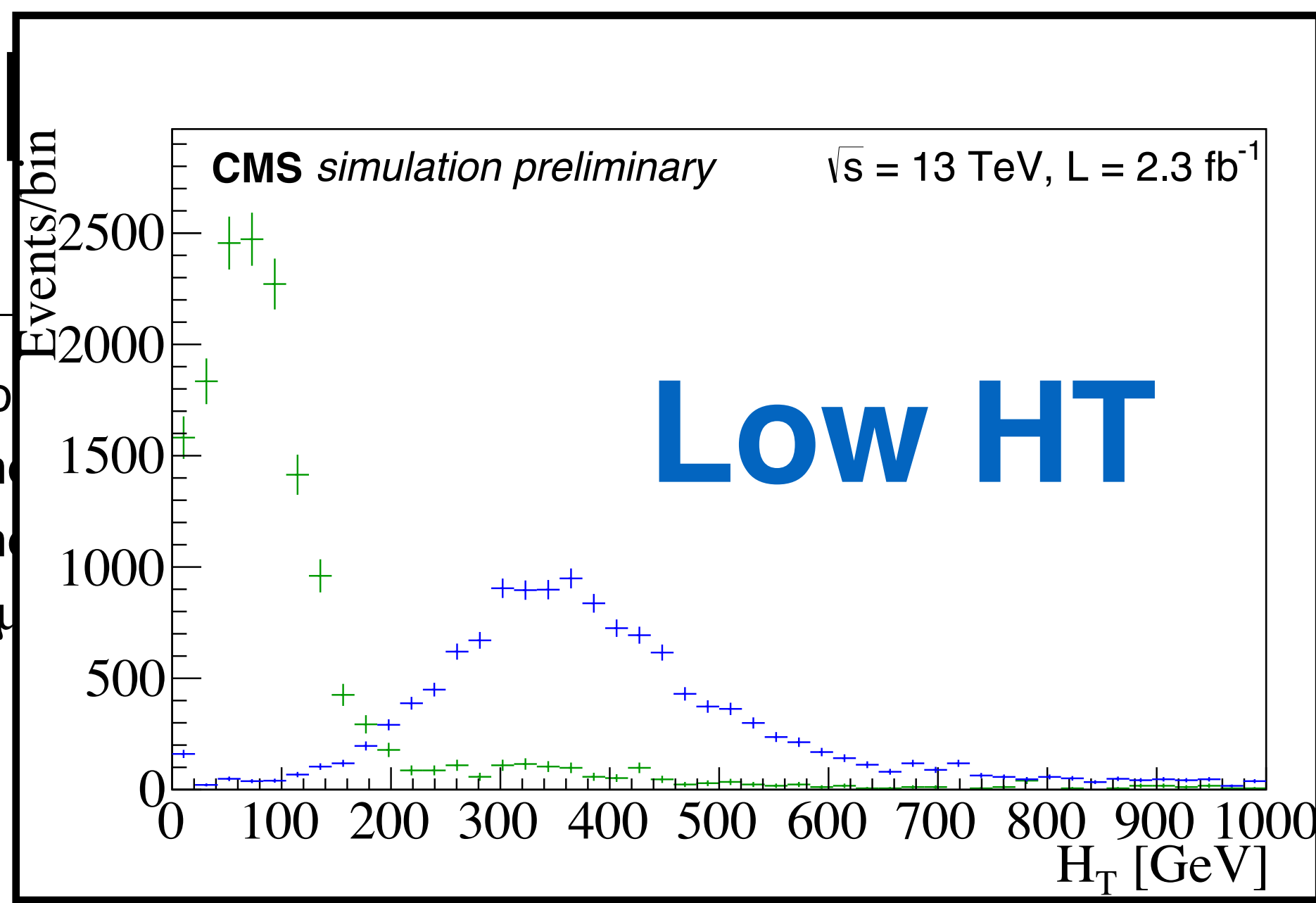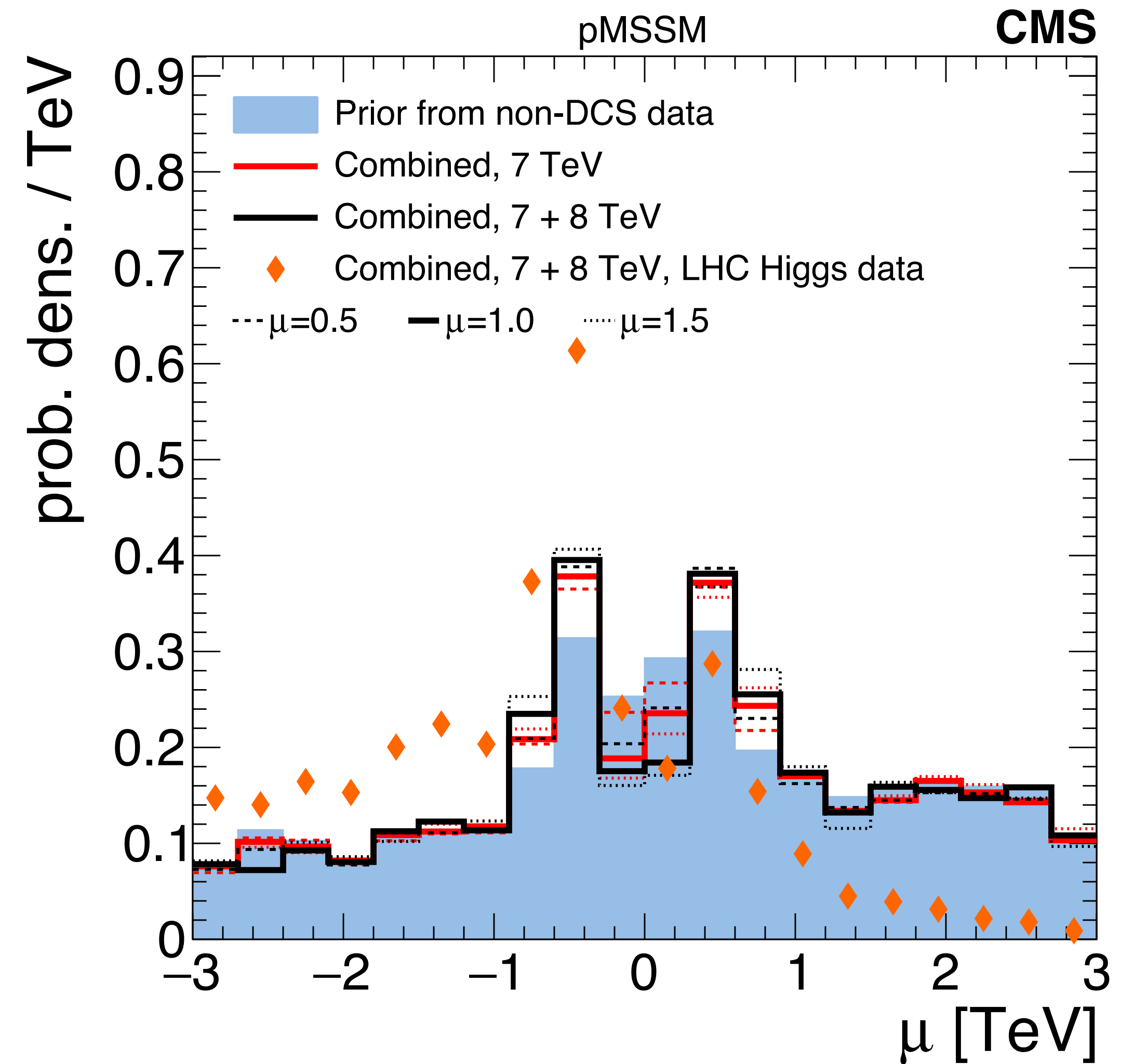
Probability density for gluino mass

7200 pMSSM points

Glui...

survivor

$m_{\tilde{g}} = 644$ GeV

Low HT

Low MET

CMS *simulation preliminary* $\sqrt{s} = 13$ TeV, L = 2.3 fb⁻¹

CMS *simulation preliminary* $\sqrt{s} = 13$ TeV, L = 2.3 fb⁻¹

H_T [GeV]

H_T^{miss} [GeV]

Events/bin

Events/bin

Prior fro

Combin

Combin

$\tilde{g}$ m

Other observables impacted

10

Sam Bein, CMS (University of Hamburg)
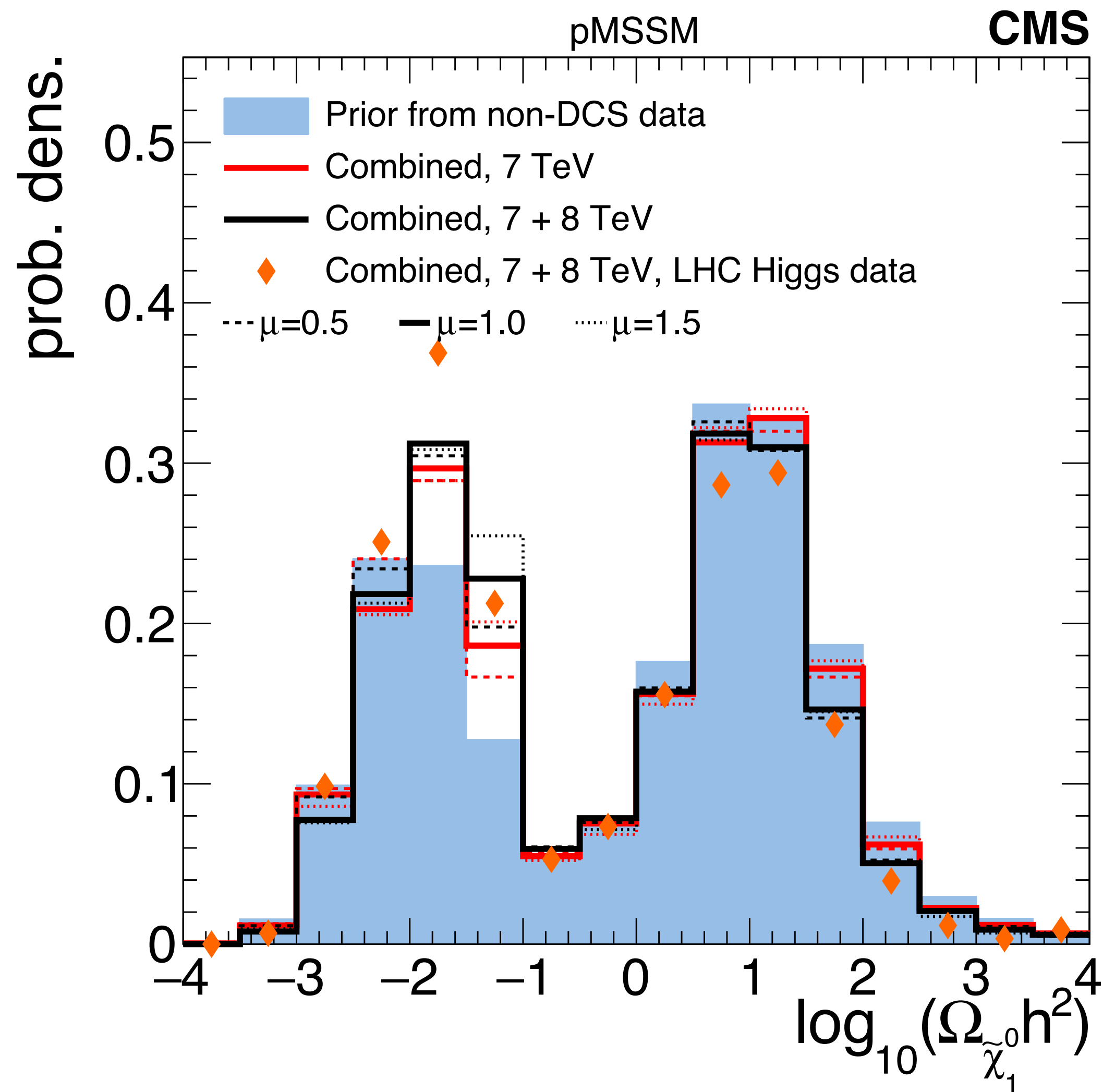
Signatures of non-excluded points

Describing the most common scenarios that survived CMS Run-1 searches.

11 Sam Bein, CMS (University of Hamburg)

Parallel Coordinates

m_e m_μ m_τ m_u m_d m_s m_c m_b m_t m_h vev θ_{12} θ_{23} θ_{13} δ g_1 g_2 g_3 θ_{QCD}
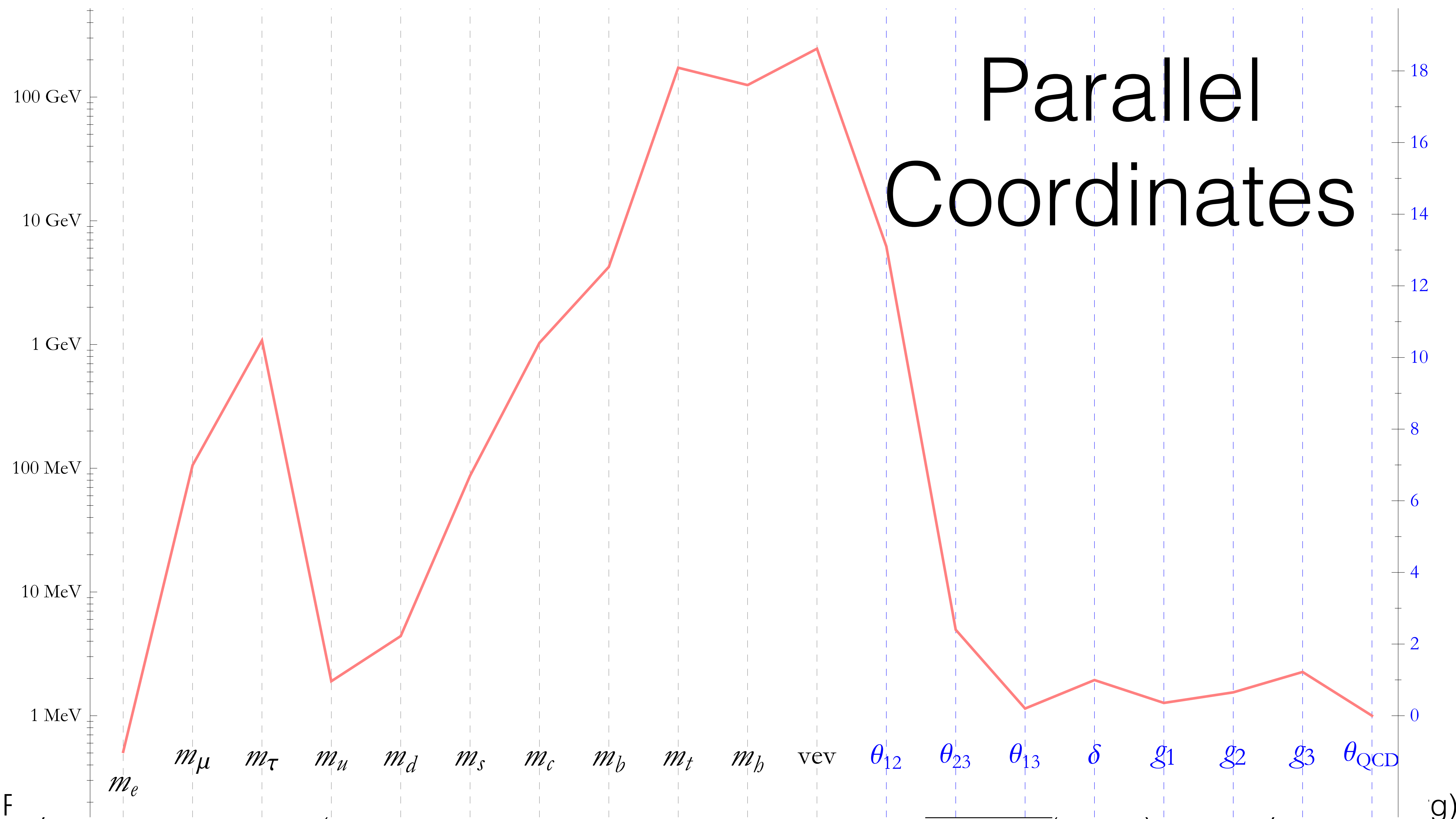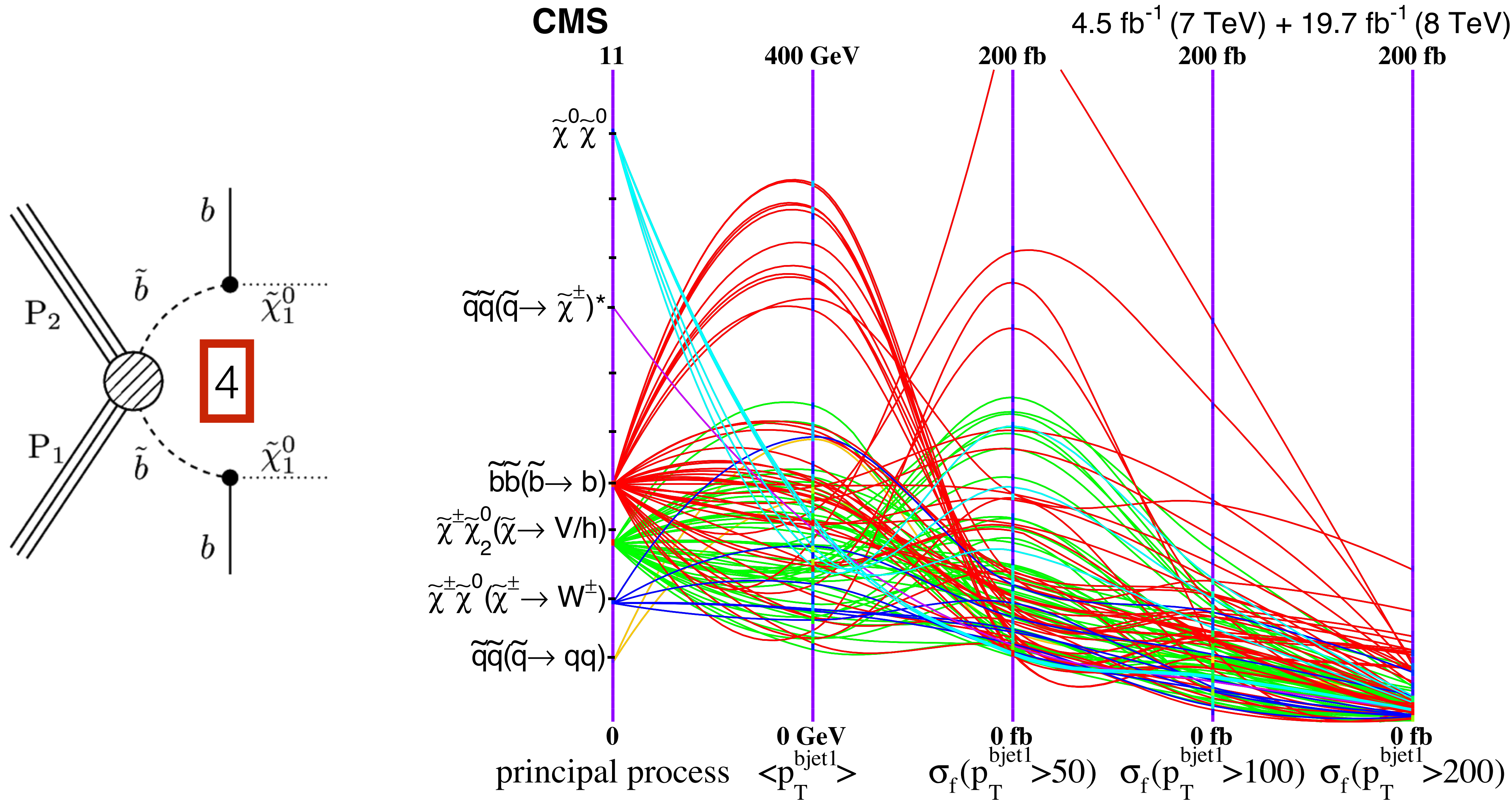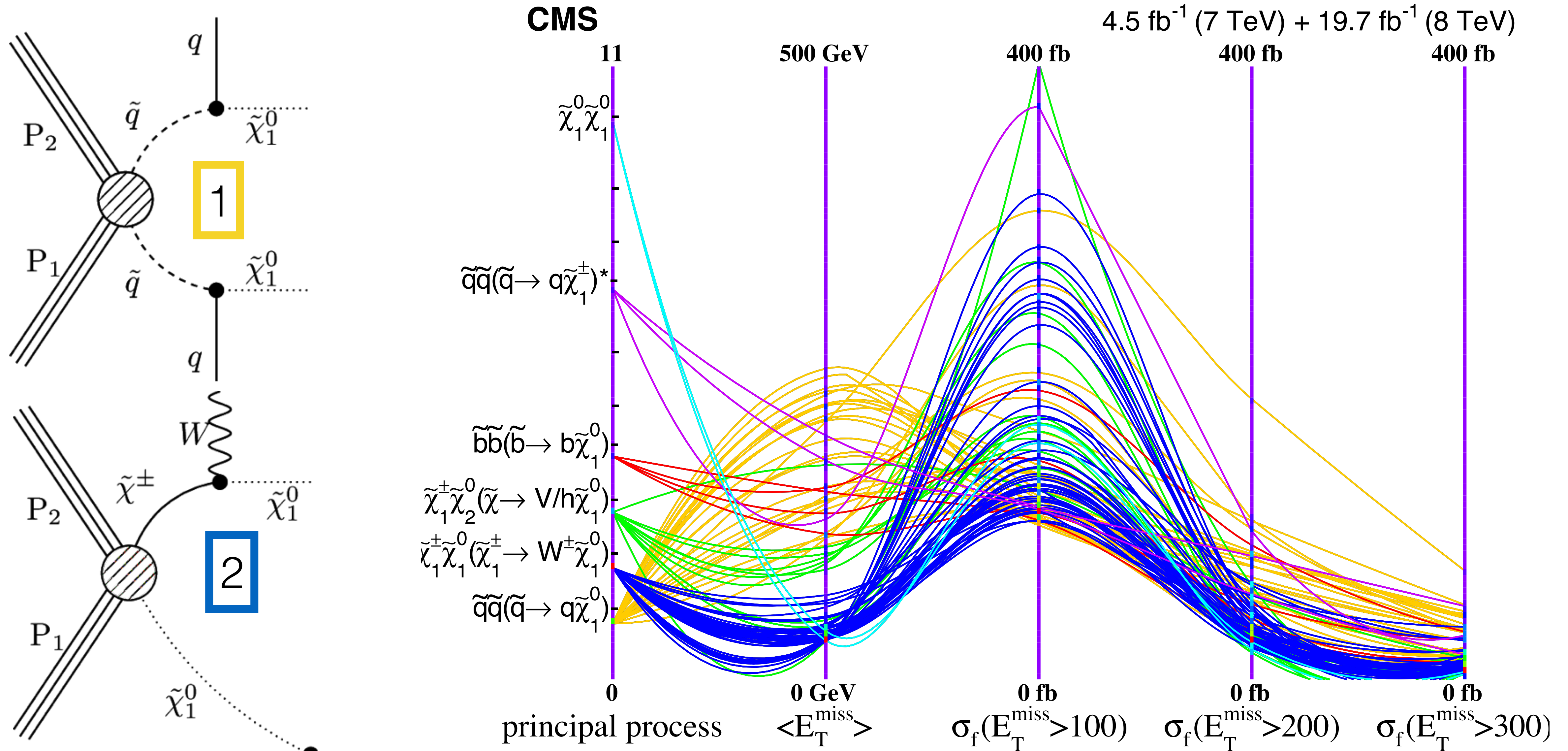
F
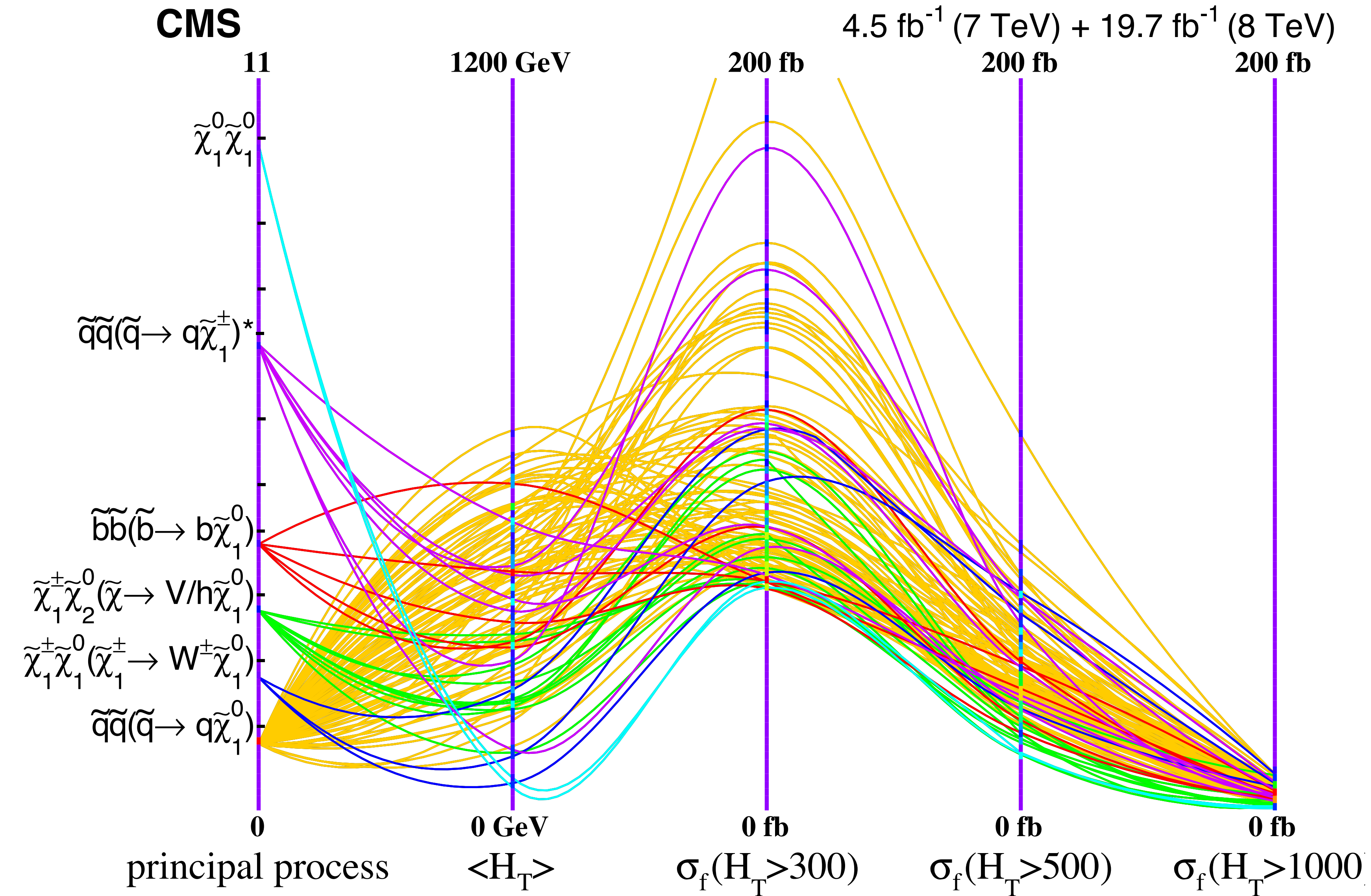
g)

Scenarios with leptons
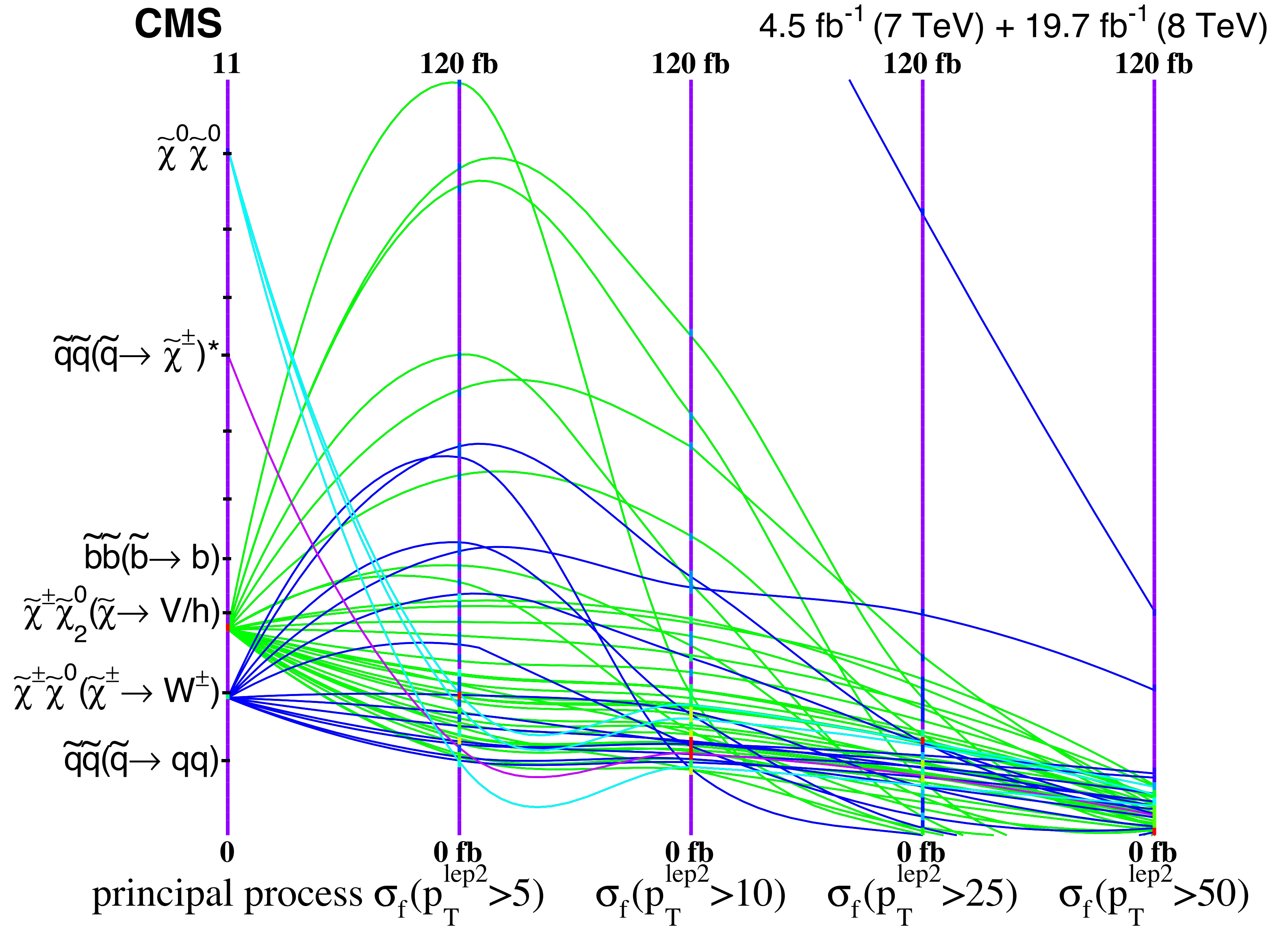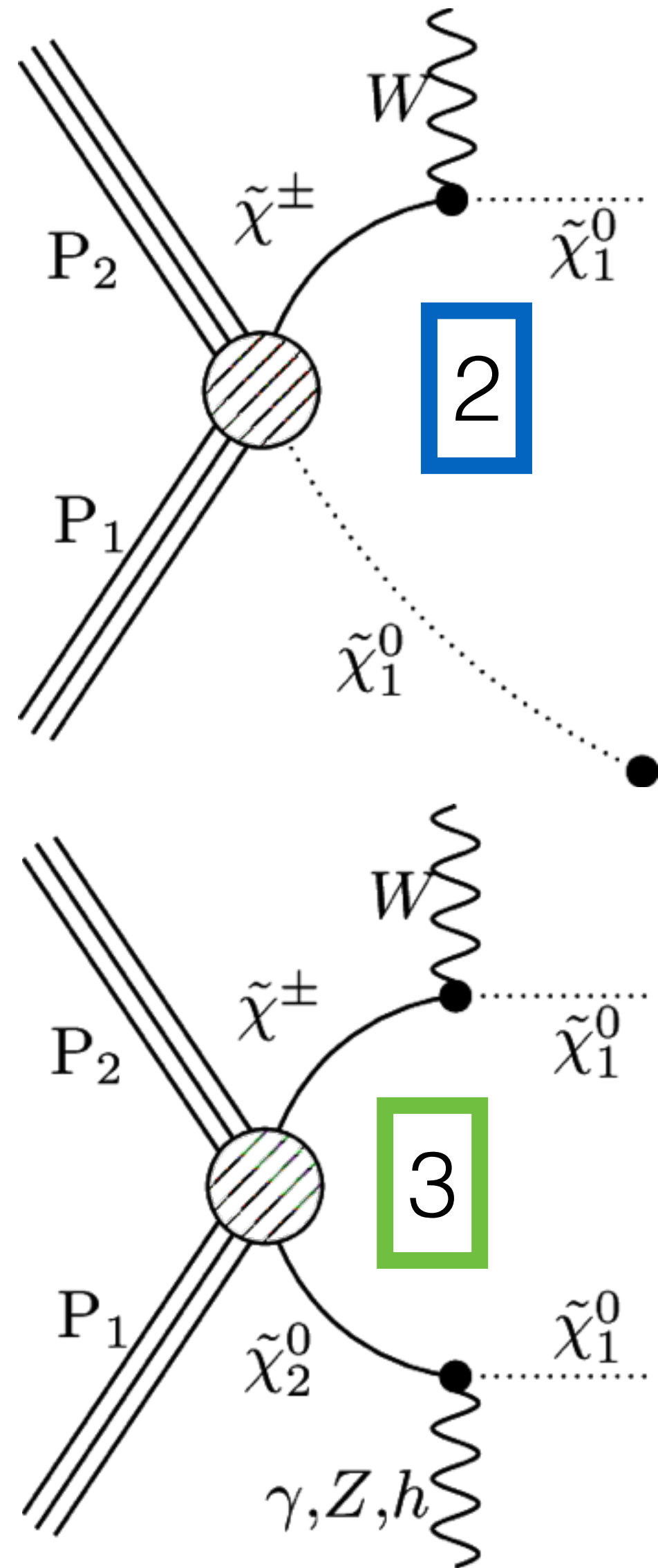
Scenarios with b-jets

Scenarios with MET

Scenarios with HT
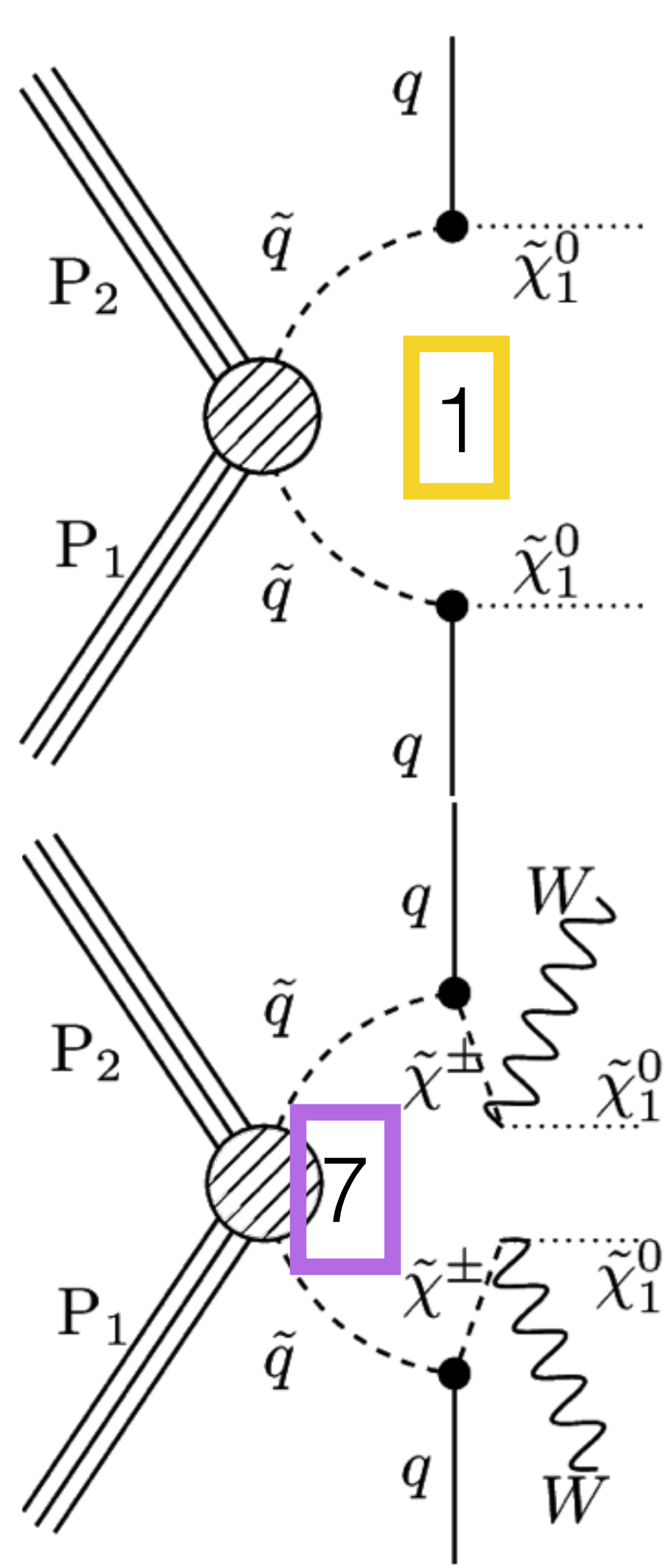
Lightest surviving mg topologies

1. mg=581 GeV

2. mg=644 GeV

Topology 18

q q γ, Z, h

$\tilde{g}$

P_2

$\tilde{\chi}_2^0$ $\tilde{\chi}_1^0$

mChi02=533 GeV

$\tilde{\chi}_2^0$ Z $\tilde{\chi}_1^0$

P_1

$\tilde{g}$

q q γ, Z, h

mLSP=528 GeV

Topology 34

q q W

$\tilde{g}$

P_2

$\tilde{\chi}^\pm$ $\tilde{\chi}_1^0$

mChiPM=400.8 GeV

$\tilde{\chi}^\pm$ Z $\tilde{\chi}_1^0$

P_1

$\tilde{g}$

q q W

mLSP=400.4 GeV
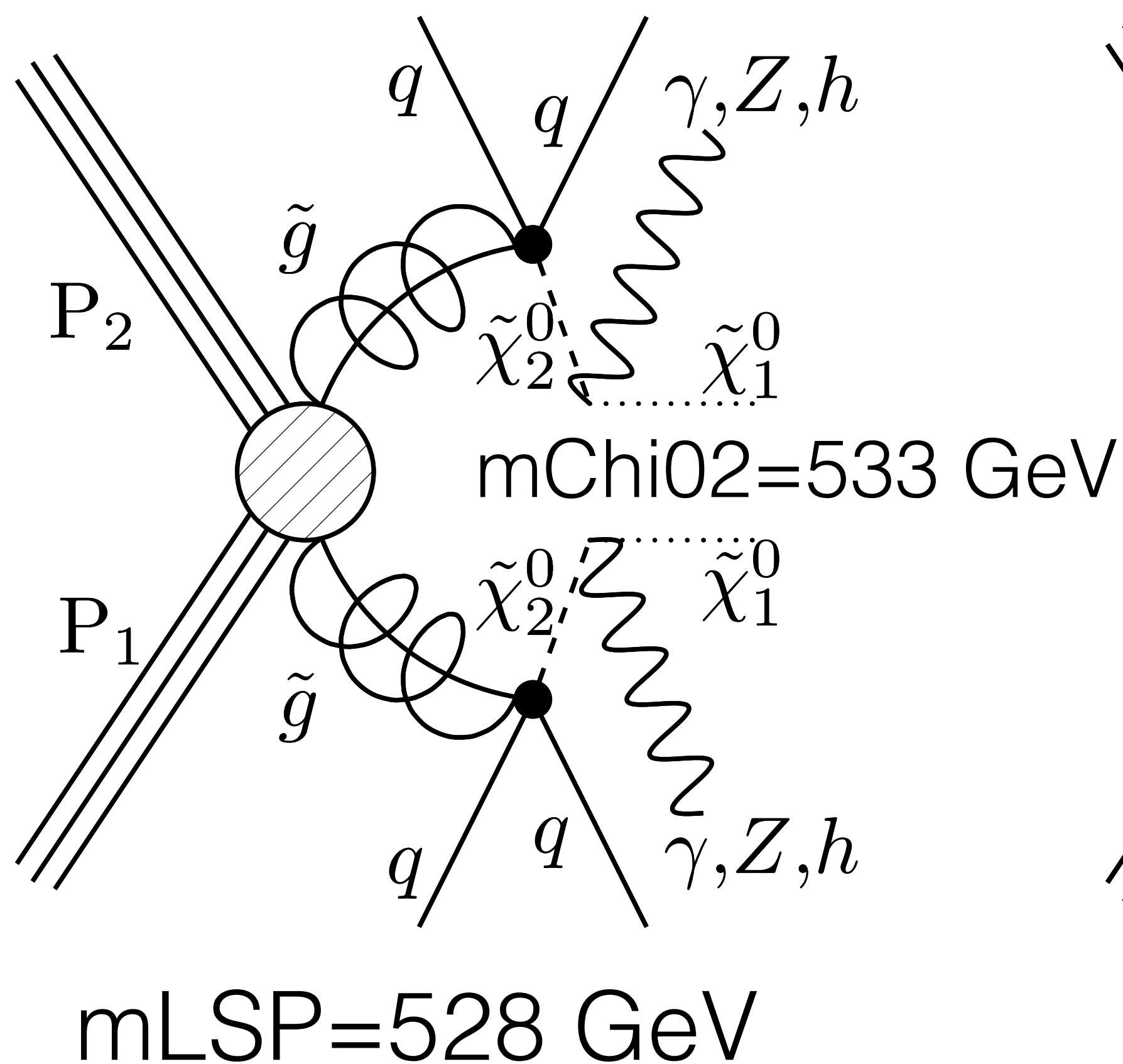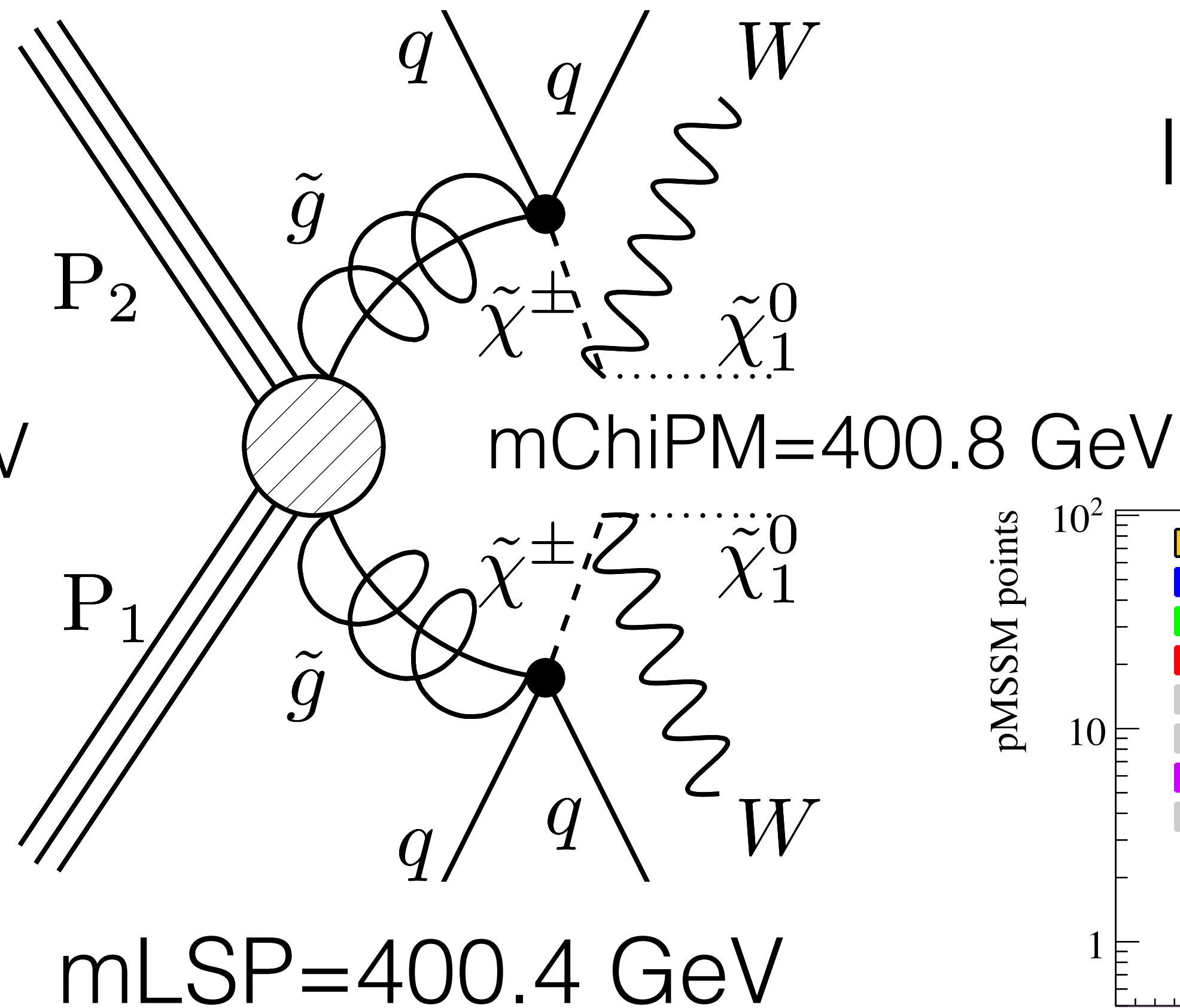
low gluino mass survivors

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Summary

- SUSY is plentiful in where it predicts mainly soft objects

- Low-MET and low-HT excesses describe surviving scenarios with small low-gluino mass, often featuring cascade decays with nearly degenerate electroweak gauginos
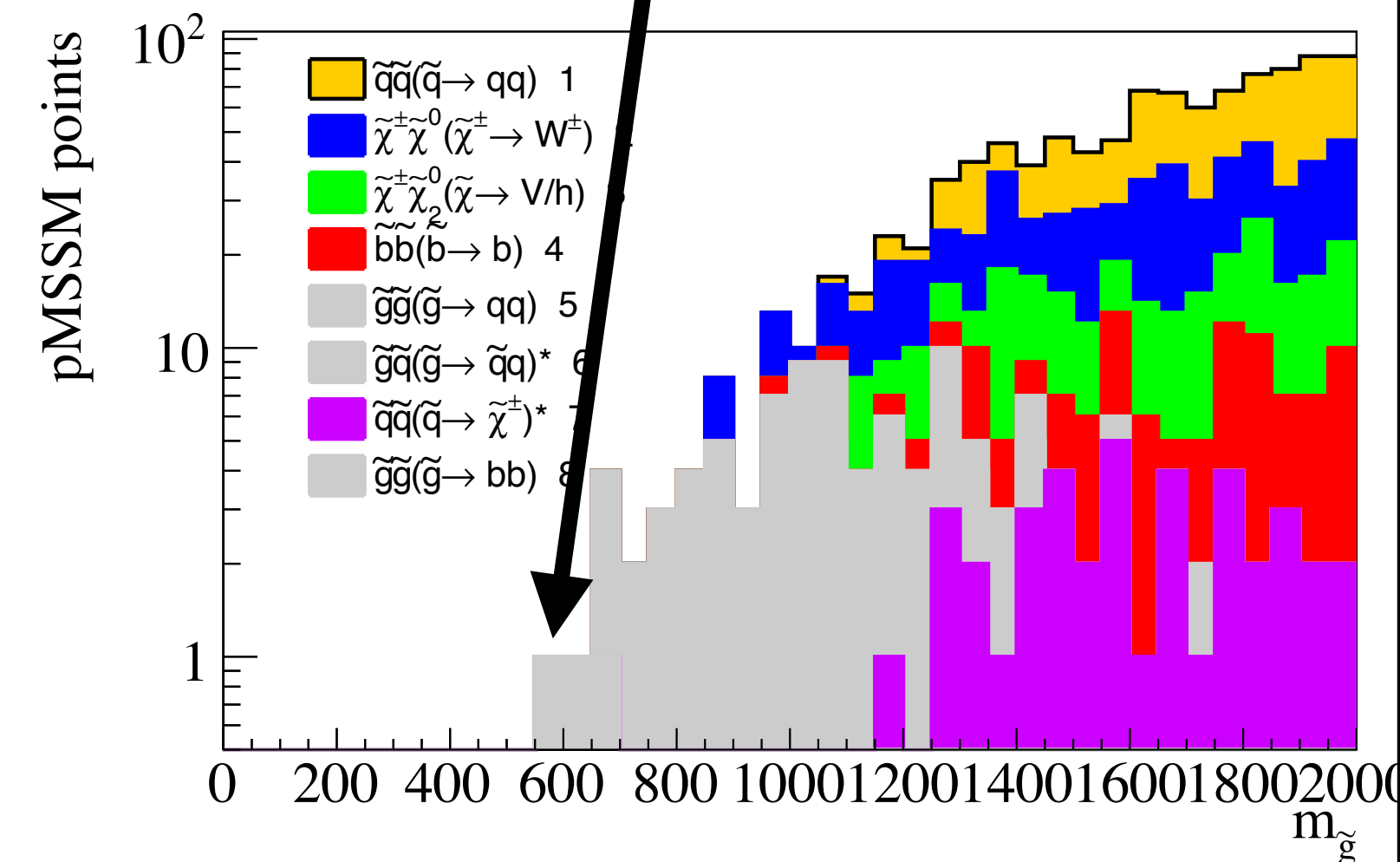
- ISR + tag searches will be key to chasing down the MSSM in the long run.

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Principal processes

21
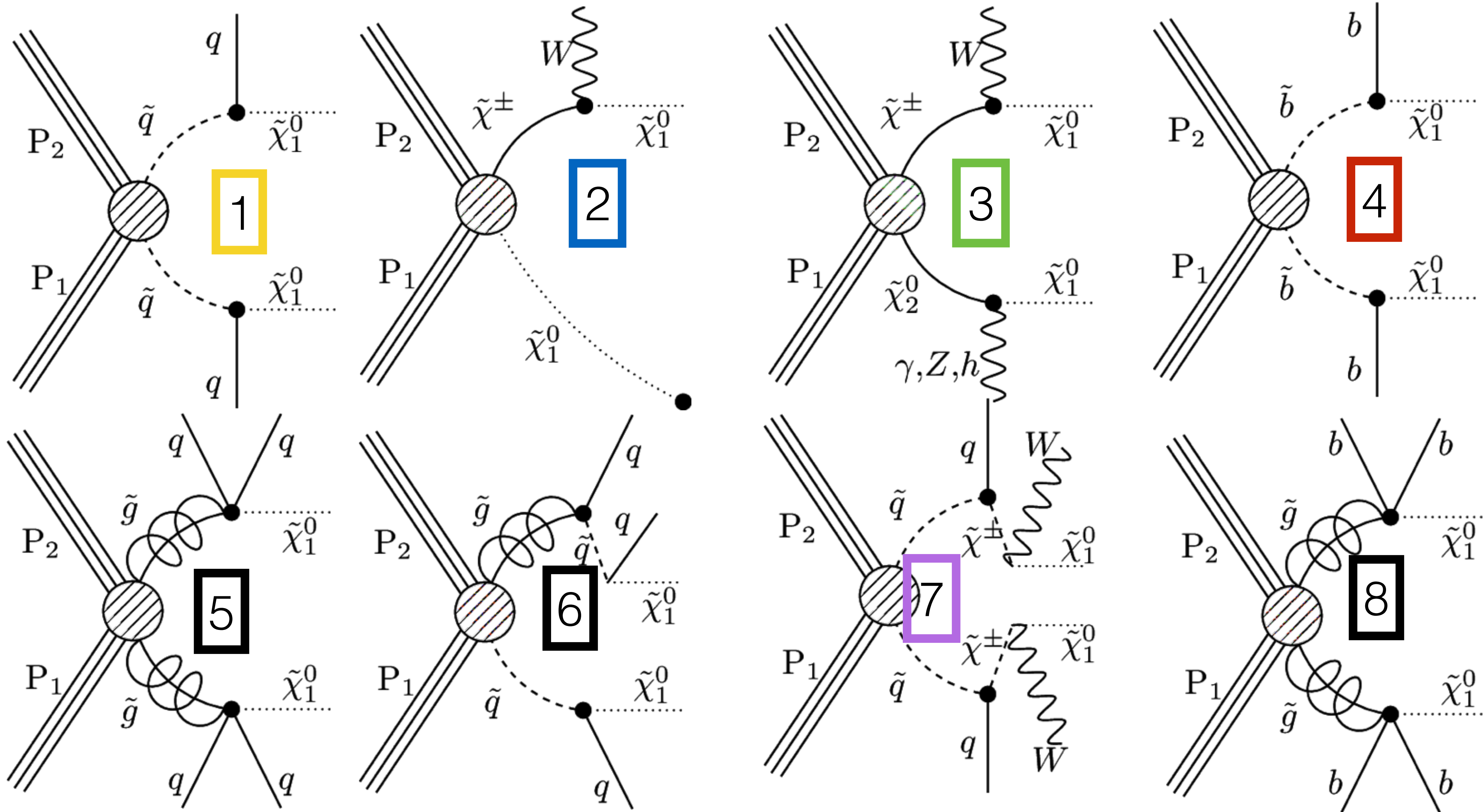
Scan boundaries

$$-3 \leq M_1, M_2 \leq 3 \, \text{TeV},$$
$$0 \leq M_3 \leq 3 \, \text{TeV},$$
$$-3 \leq \mu \leq 3 \, \text{TeV},$$
$$0 \leq m_A \leq 3 \, \text{TeV},$$
$$2 \leq \tan \beta \leq 60,$$
$$0 \leq m_{\tilde{Q}_{1,2}}, m_{\tilde{U}_{1,2}}, m_{\tilde{D}_{1,2}}, m_{\tilde{L}_{1,2}}, m_{\tilde{E}_{1,2}}, m_{\tilde{Q}_3}, m_{\tilde{U}_3}, m_{\tilde{D}_3}, m_{\tilde{L}_3}, m_{\tilde{E}_3} \leq 3 \, \text{TeV}$$
$$-7 \leq A_t, A_b, A_\tau \leq 7 \, \text{TeV},$$