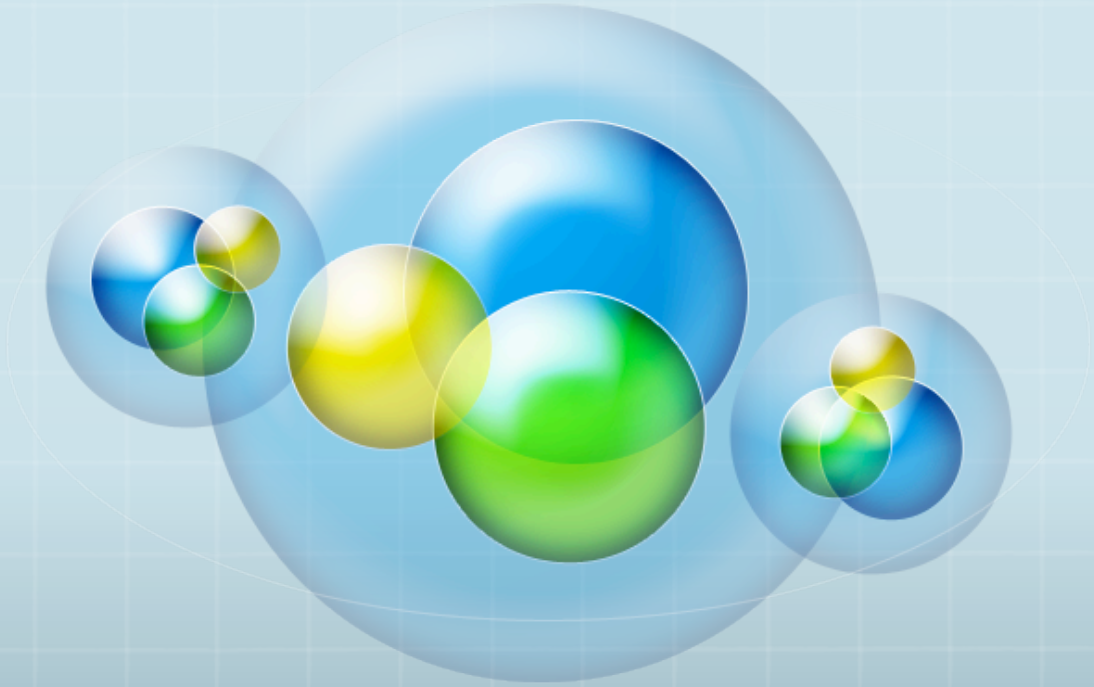


Stealth SUSY

JiJi Fan
Princeton University
BF 2011

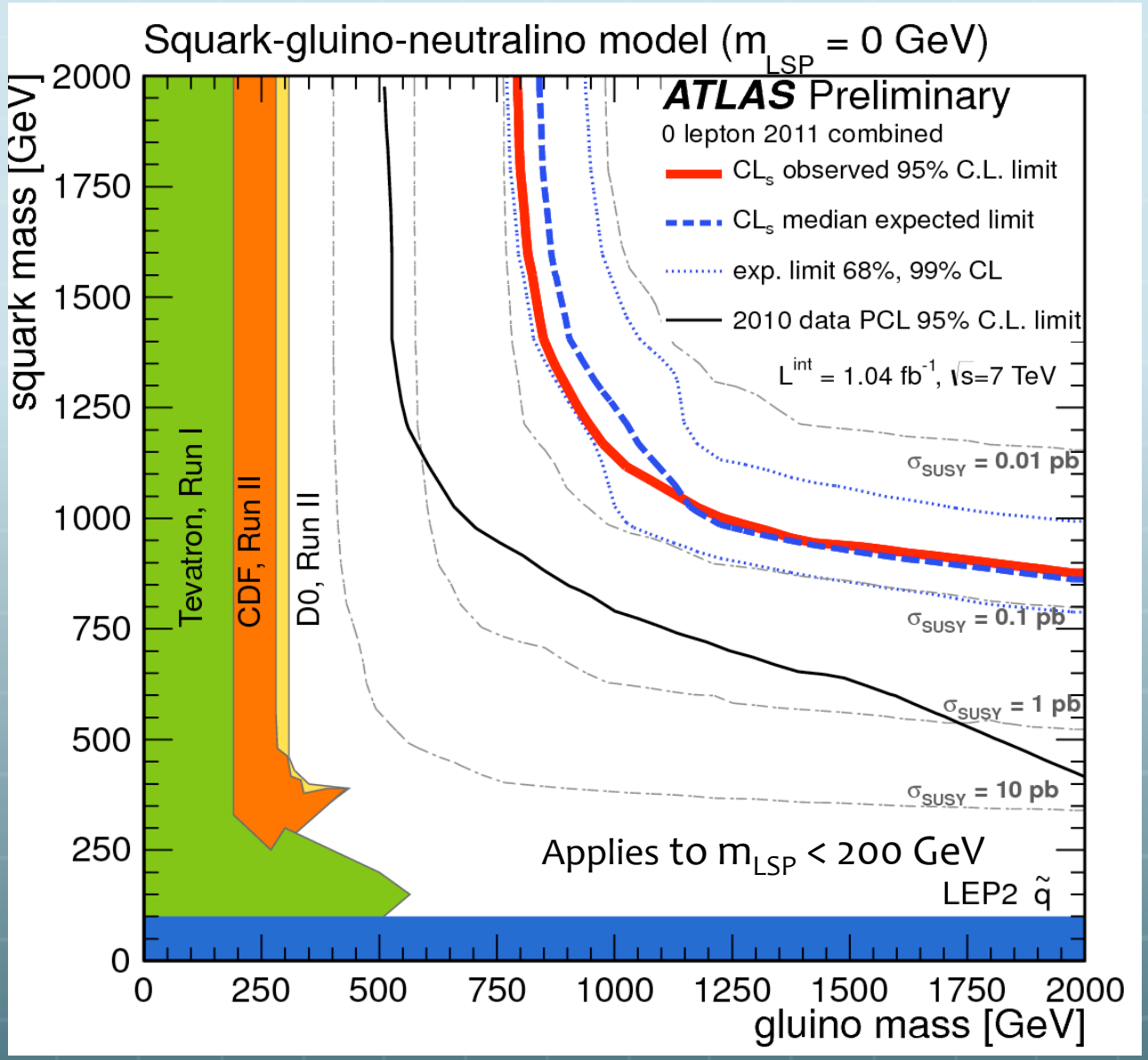
Based on work with Matt Reece and Josh Ruderman
arXiv:1105.5135 [hep-ph], work in progress

Outline

- Motivation
- Mechanism
- A simple example model
- Spectrum and collider signals

- So far Jets+ MET search at the LHC has already placed strong limits on the colored MSSM superpartners in R-parity conserving scenarios

M_{gluino} > 800 GeV (with decoupled squark)



Taken from
Henri Bachacou,
Lepton-Photon 2011

SUSY variants

- **The bounds have several known exceptions:**

  R-parity violation, squeezed MSSM spectrum, long cascade decay chains

- A simple and natural exception: SUSY without MET

  No R-parity violation;

  No artificial tuning: SUSY hides SUSY;

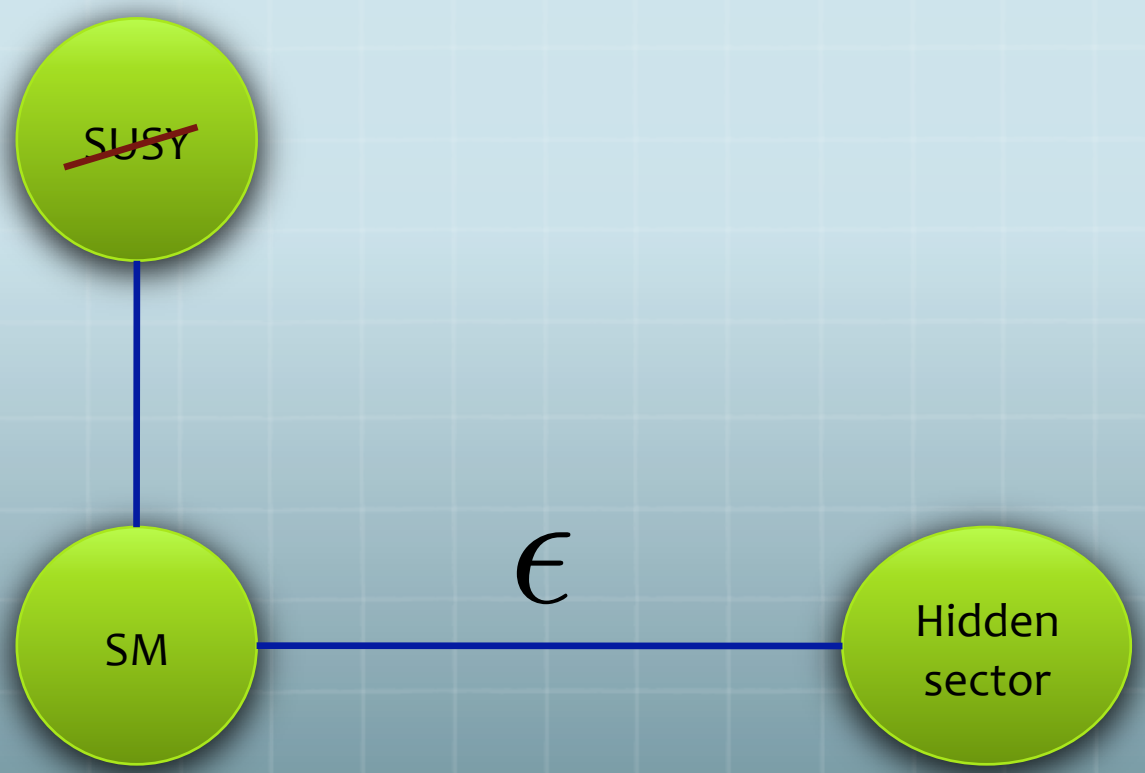
- An electroweak scale hidden sector with a naturally squeezed spectrum (as a result of an approximate SUSY)

  Different from MSSM with a squeezed spectrum (e.g., gluino mass close to bino mass, which requires tuning)

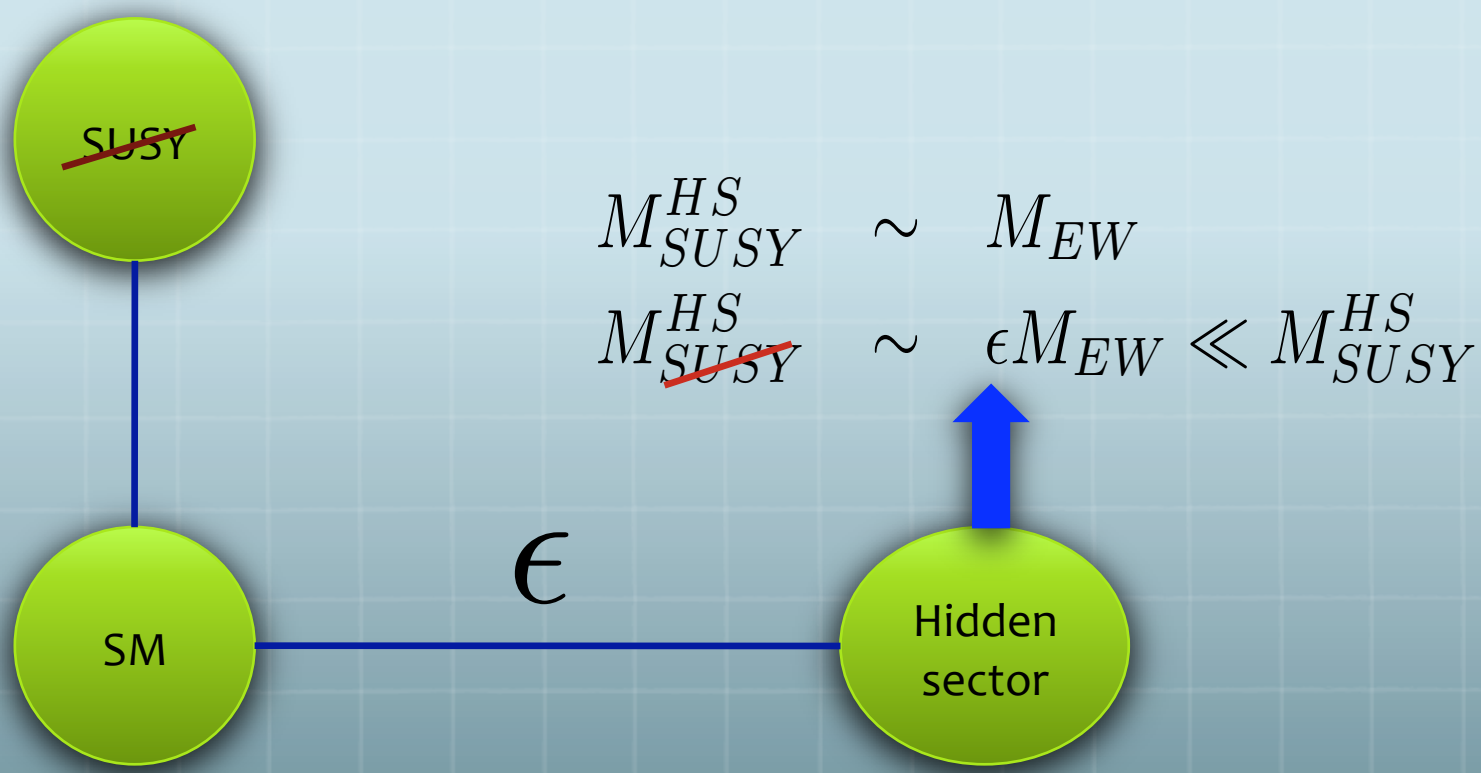
- Simplest possibility: a chiral superfield S

  many more theoretical possibilities: z', vector-like confinement sector; compatible with different SUSY breaking mechanisms.

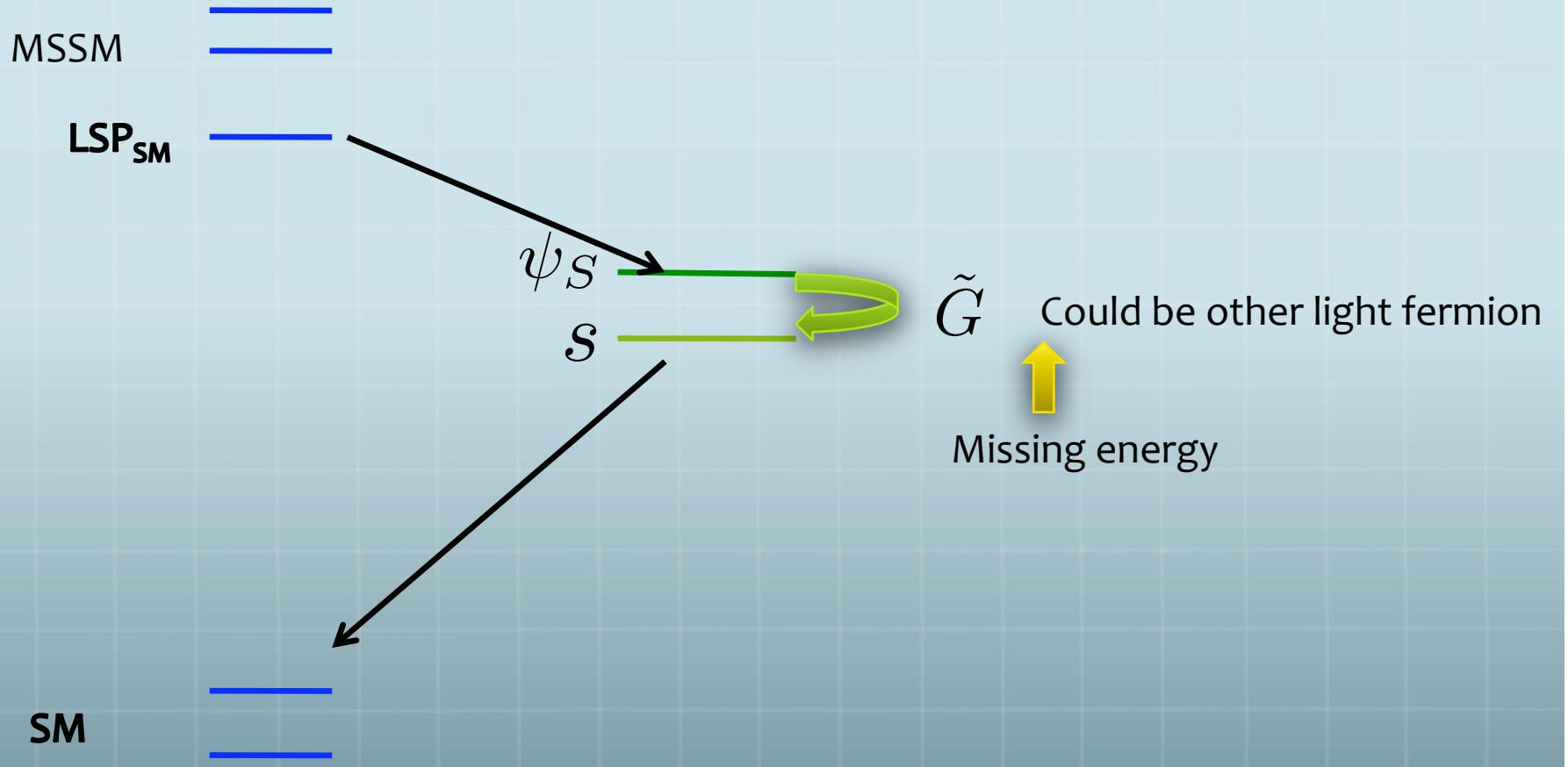
Mechanism

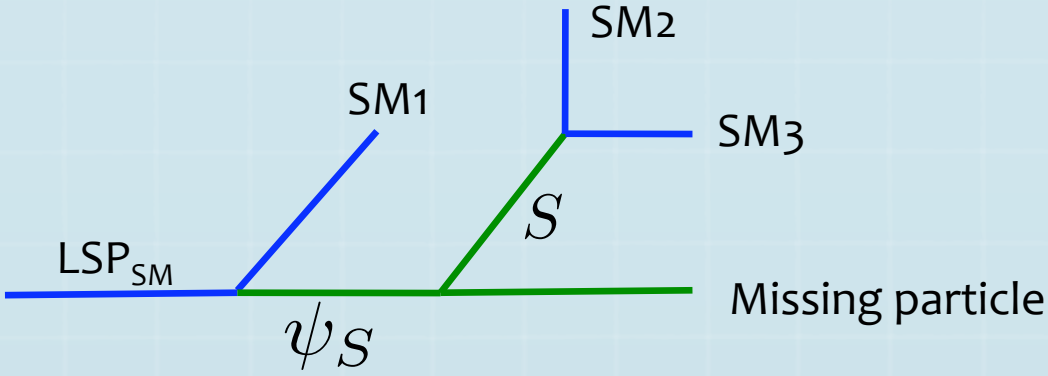


Mechanism


SUSY
SM
ϵ
Hidden sector
$M^{HS}_{SUSY} \sim M_{EW}$
$M^{HS}_{SUSY} \sim \epsilon M_{EW} \ll M^{HS}_{SUSY}$

E.g., Low-scale gauge mediation with a singlet S





Fermion mass Scalar mass

$$\delta m \equiv m_{\tilde{S}} - m_S$$

In the ψ_S rest frame,

$$E_{missing} = \frac{m_{\tilde{S}}^2 - m_S^2}{2m_{\tilde{S}}} \approx \delta m$$

In the lab frame,

$$E_{missing} = \gamma \delta m \approx \frac{m_{LSP_{SM}}}{m_{\tilde{S}}} \delta m$$

$$\delta m \to 0, E_{missing} \to 0$$

An example model

- **Portal:** $Y, \bar{Y} \quad 5 + \bar{5}$ **under SM SU(5)**
- **Model:**

$$W = \lambda S Y \bar{Y} + m_S S^2 + m_Y^2 Y \bar{Y}$$

m_S is taken to be 100 GeV

- **Soft mass of S is generated at one-loop (in gauge mediation)**

$$m_s^2 \sim -\frac{|\lambda|^2}{(4\pi)^2} \left(6\tilde{m}_D^2 + 4\tilde{m}_L^2\right) \log \frac{M_{\rm mess}^2}{m_Y^2}$$

$$W = \lambda S Y \bar{Y} + m_S S^2 + m_Y^2 Y \bar{Y}$$

$SY\bar{Y}$	
$m = 100$ GeV	$m_{\tilde{s}} = 100$ GeV
$\lambda = 0.2$	$m_{s,a} = 91$ GeV
$m_Y = 1000$ GeV	$\Gamma_{s,a} = 2 \times 10^{-7}$ GeV
$\tilde{m}_D = 300$ GeV $\quad \tilde{m}_L = 200$ GeV	$\mathrm{Br}_{s,a \to \gamma\gamma} = 4 \times 10^{-3}$
$M_{\mathrm{mess}} = 100$ TeV	

$$\lambda \lesssim 0.1 - 0.2 \quad \delta m \lesssim 10 GeV$$

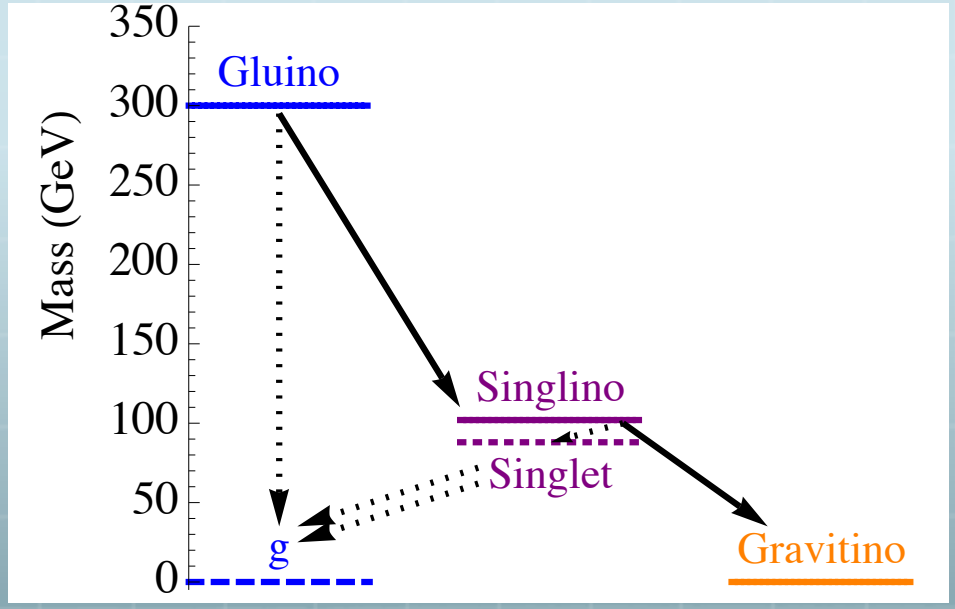
- **Integrating out ``messengers" Y's,**
- **Portal in** $\lambda^a \sigma_{\mu\nu} G^{a\mu\nu} \psi_S$

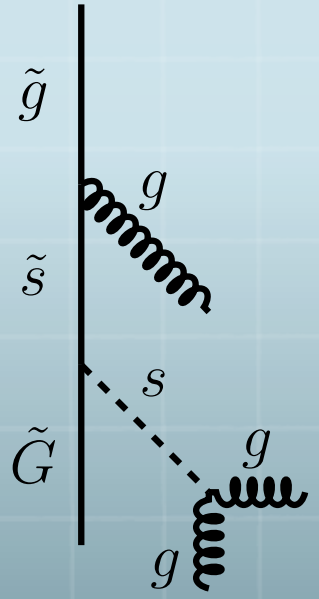
  $\tilde{g} \to g + \psi_S$

  $\tilde{B} \to \gamma + \psi_S$
- **Portal out** ${}_sG^a_{\mu\nu} G^{a\mu\nu}$

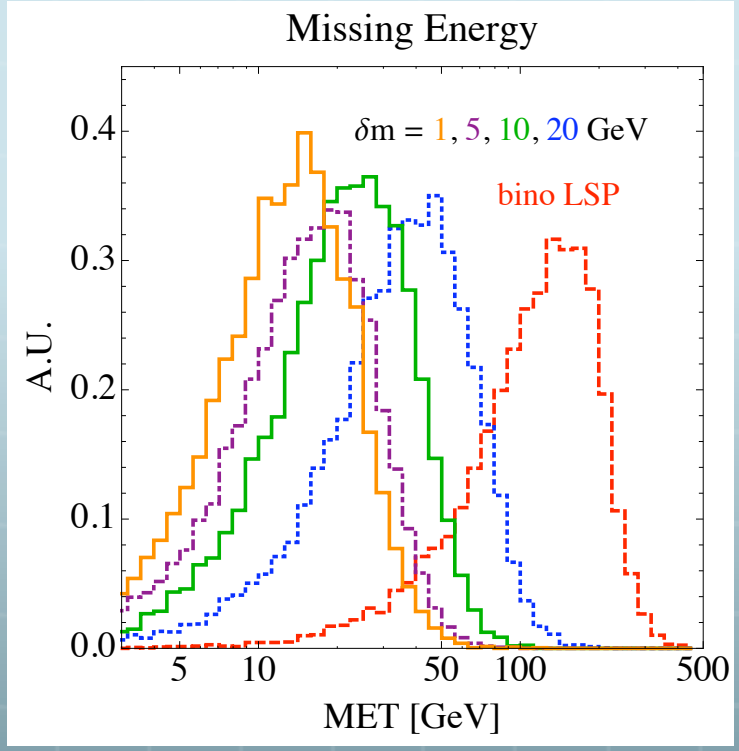
  $s \longrightarrow gg$

Spectrum and decay chain

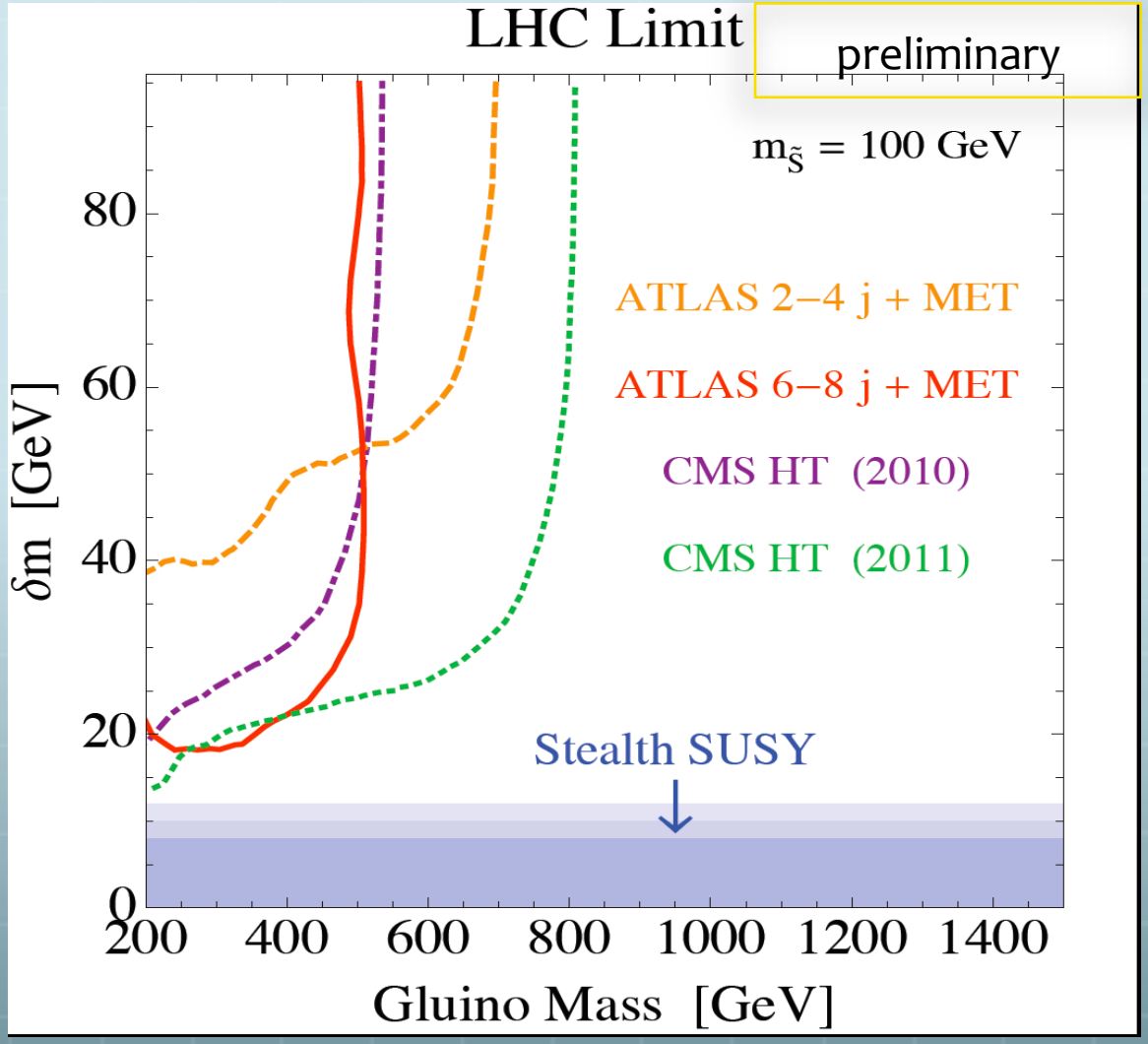




Missing energy spectrum



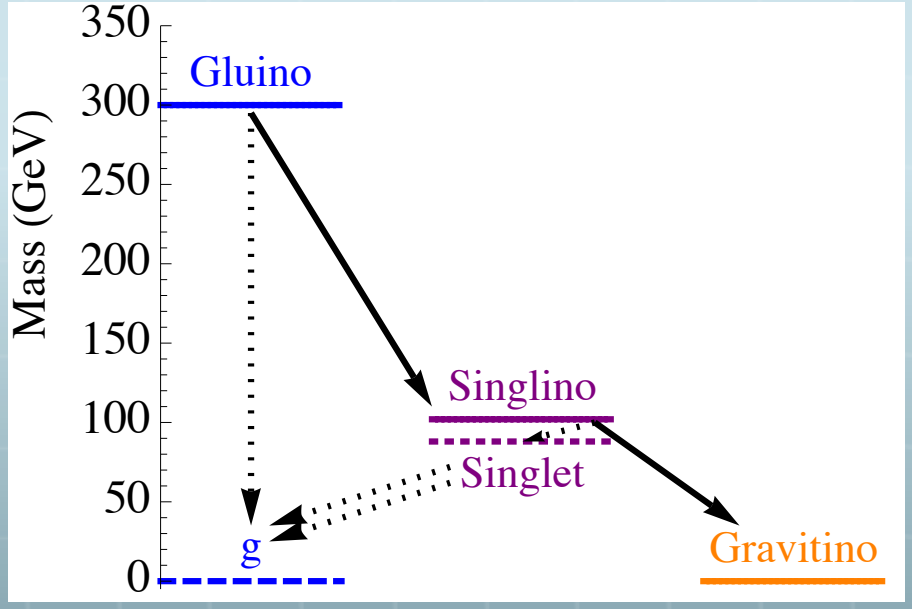
Missing E_T> 130 GeV, ATLAS

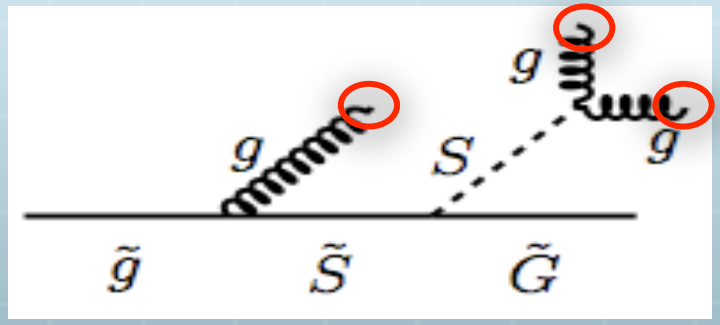


Bottom line:

current limits do not apply to stealth SUSY with mass splitting smaller than 10 GeV !

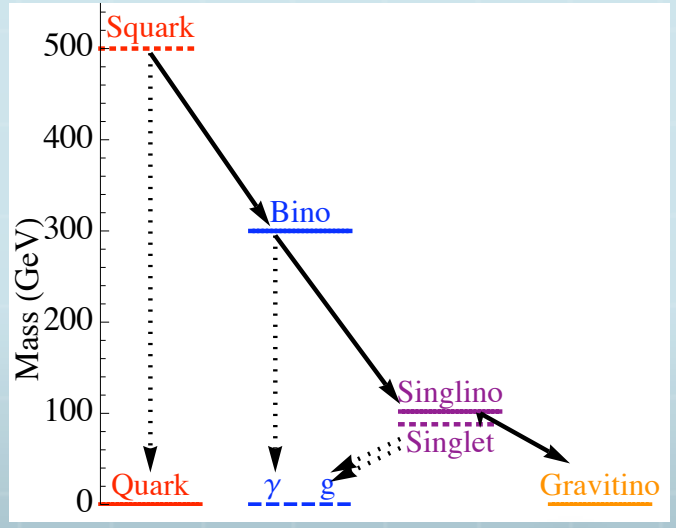
False resonance of jets

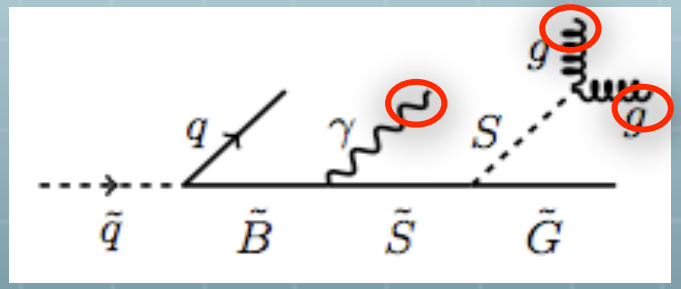




Search at CDF and CMS motivated by RPV on resonance of 3 jets also applies here!

False resonance of jets





Search at CDF and CMS motivated by RPV on resonance of 3 jets also applies here!

More searching strategies

- **Displaced vertex:** $\tilde{s} \longrightarrow s + \tilde{G}$

Decay length ranging from mm to several cm;

- **High multiplicity (of b jets) : Model dependent**

$$\tilde{g} \longrightarrow \tilde{b} \longrightarrow \tilde{B} \longrightarrow \tilde{s} \longrightarrow s + \tilde{G}$$

$$\tilde{b} \longrightarrow b \qquad \tilde{B} \longrightarrow b \qquad \tilde{s} \longrightarrow h \qquad s \longrightarrow b + \bar{b}$$

$$h \longrightarrow b + \bar{b}$$

In model where S mixes with SM Higgs: SH_uH_d

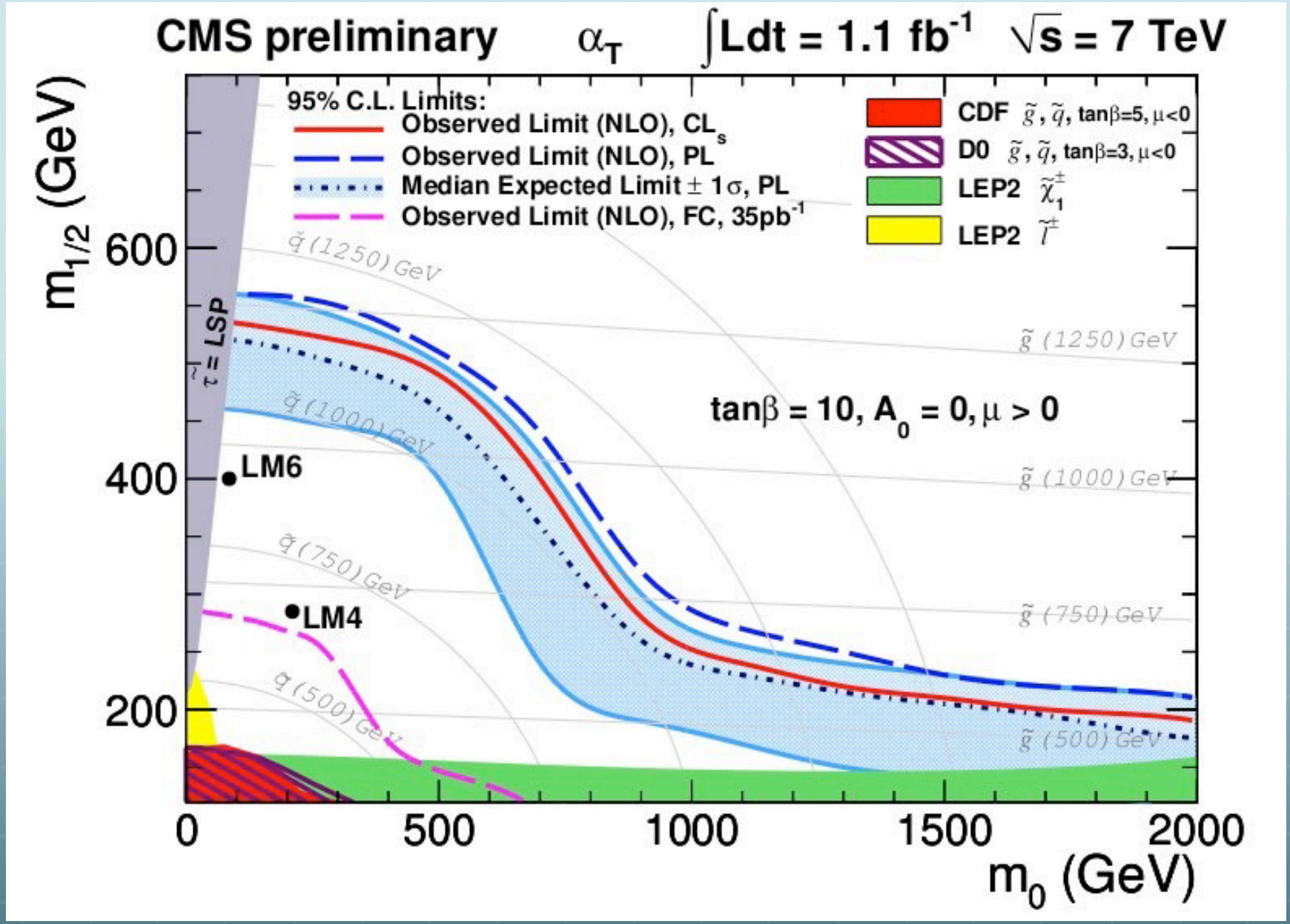
Conclusion

- We present a broad class of natural supersymmetric models that preserve R-parity but lack missing energy signatures.
- The main feature is the presence of nearly degenerate fermion-boson pairs at the electroweak scale due to an approximate supersymmetry.

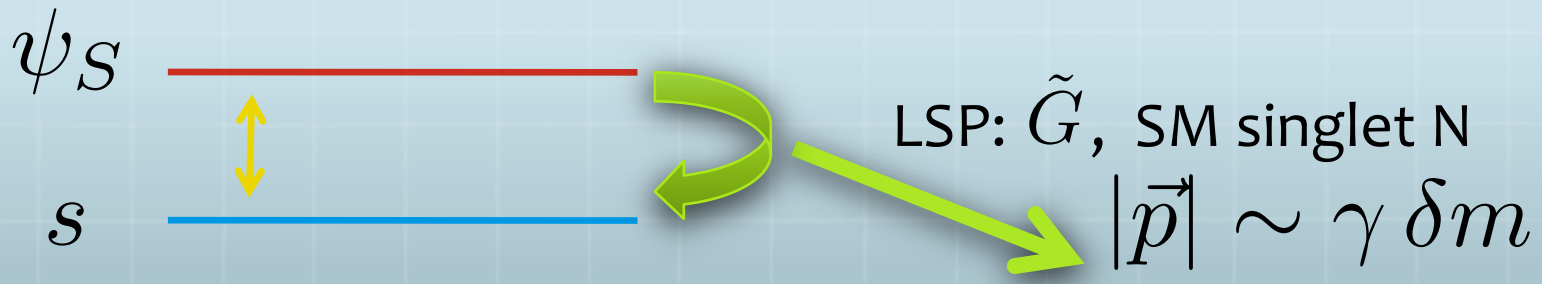
  Even MSSM may have a form of stealth supersymmetry, if the right handed stop and top have nearly degenerate masses.
- It opens up more possibilities for model building and searching strategies at the LHC.

Thank you!

Backups


CMS preliminary
α_T
$\int$Ldt = 1.1 fb^{-1}
$\sqrt{s}$ = 7 TeV
95% C.L. Limits:
Observed Limit (NLO), CL$_s$
Observed Limit (NLO), PL
Median Expected Limit ± 1σ, PL
Observed Limit (NLO), FC, 35pb^{-1}
CDF $\tilde{g}$, $\tilde{q}$, tanβ=5, μ<0
D0 $\tilde{g}$, $\tilde{q}$, tanβ=3, μ<0
LEP2 $\tilde{\chi}_1^{\pm}$
LEP2 $\tilde{l}^{\pm}$
$\tilde{\tau}$ = LSP
$\tilde{q}$ (1250) GeV
$\tilde{g}$ (1250) GeV
$\tilde{q}$ (1000) GeV
$\tilde{g}$ (1000) GeV
$\tilde{q}$ (750) GeV
$\tilde{g}$ (750) GeV
$\tilde{q}$ (500) GeV
$\tilde{g}$ (500) GeV
tanβ = 10, A$_0$ = 0, μ > 0
LM6
LM4
m$_{1/2}$ (GeV)
m$_0$ (GeV)
0
500
1000
1500
2000
200
400
600

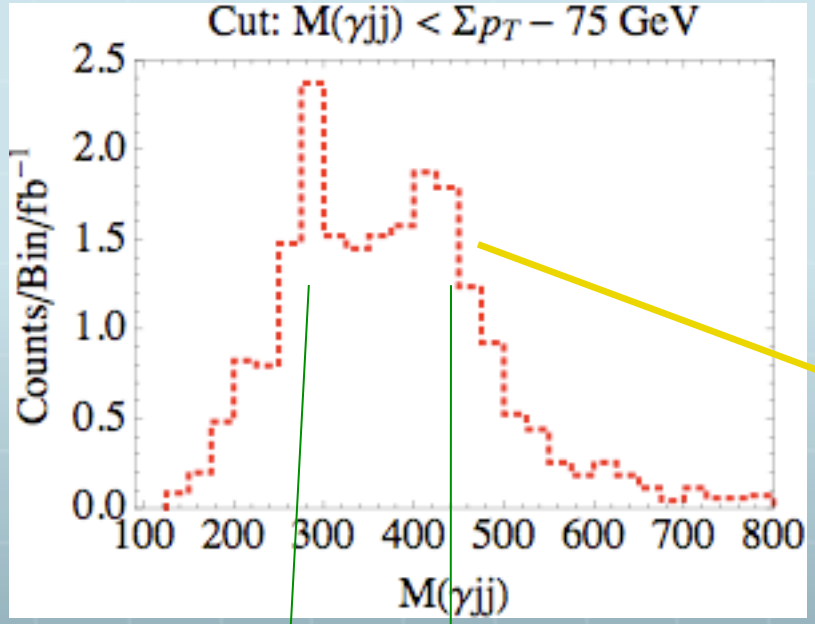
- **A simple and natural exception: SUSY without MET**
- **A EW scale hidden sector with a squeezed spectrum**
- **Simplest possibility: a chiral superfield S**

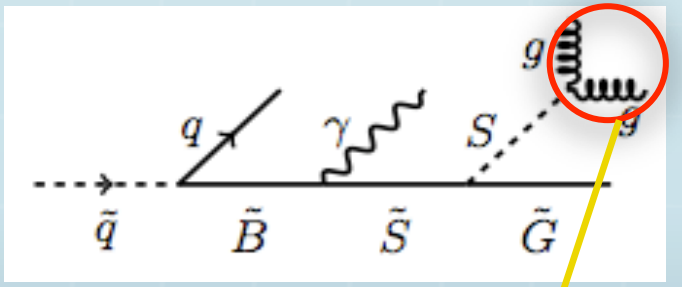


$$m_S \sim \mathcal{O}(100\,GeV)$$

$$\delta m \sim \epsilon\, m_{EW} \sim \mathcal{O}(10 GeV)$$

Small splitting inside the hidden sector could come from SUSY breaking transmitted through SM Higgs portal or additional EW scale SM charged messengers

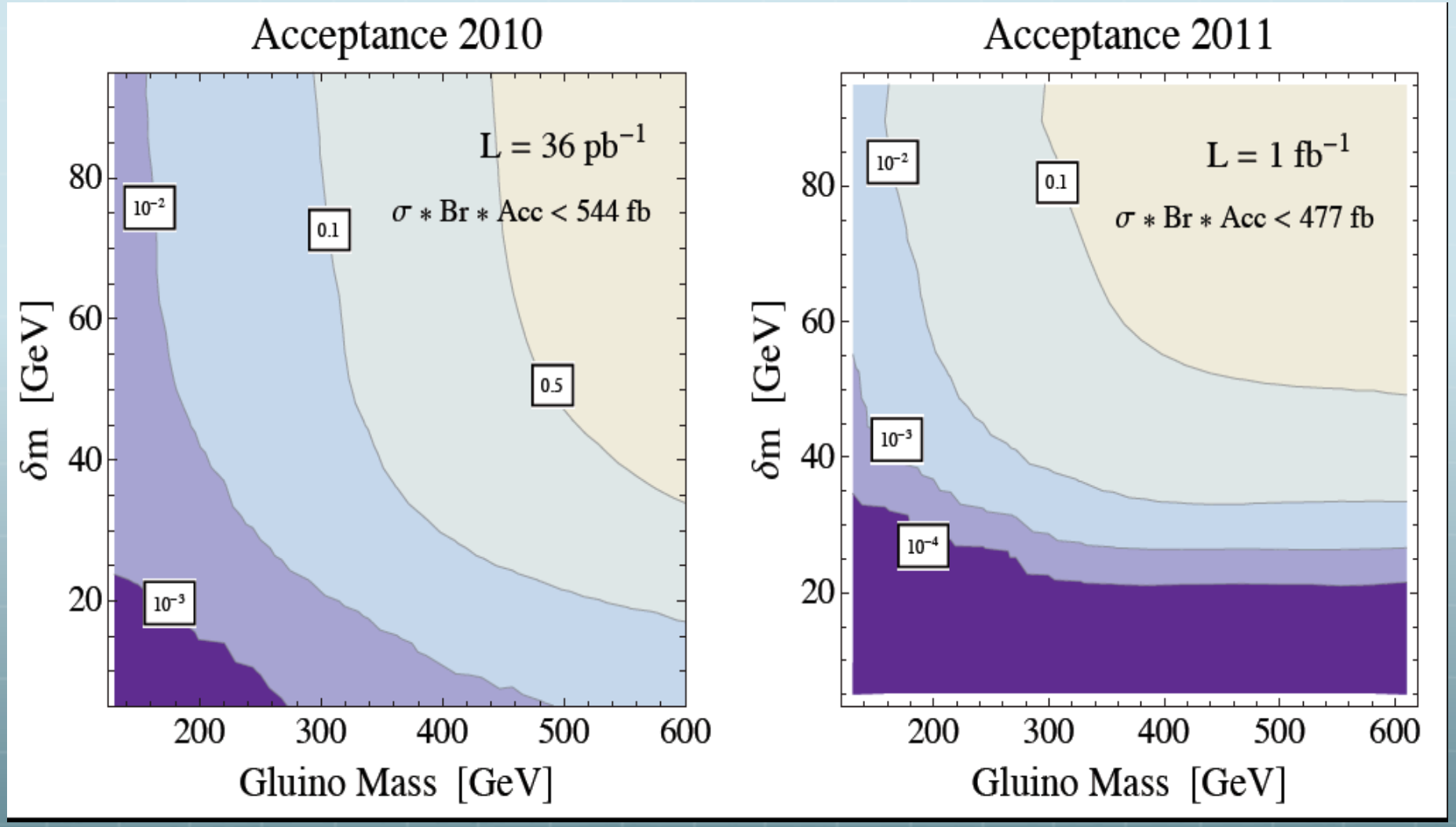




Two jets collimated into one

$\tilde{B}$ $\tilde{q}$

Substructure could help!


Acceptance 2010
L = 36 pb^{-1}
σ * Br * Acc < 544 fb
10^{-2}
0.1
0.5
10^{-3}
δm [GeV]
Gluino Mass [GeV]
Acceptance 2011
L = 1 fb^{-1}
σ * Br * Acc < 477 fb
10^{-2}
0.1
10^{-3}
10^{-4}
δm [GeV]
Gluino Mass [GeV]