GGM at Colliders: An Overview

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Meade, Reece & DS: **0911.4130, 1006.4575**
Ruderman & DS: **1009.1665**

also work in progress with
Josh Ruderman, Scott Thomas, Michael Park, Yue Zhao...

Gauge Mediation

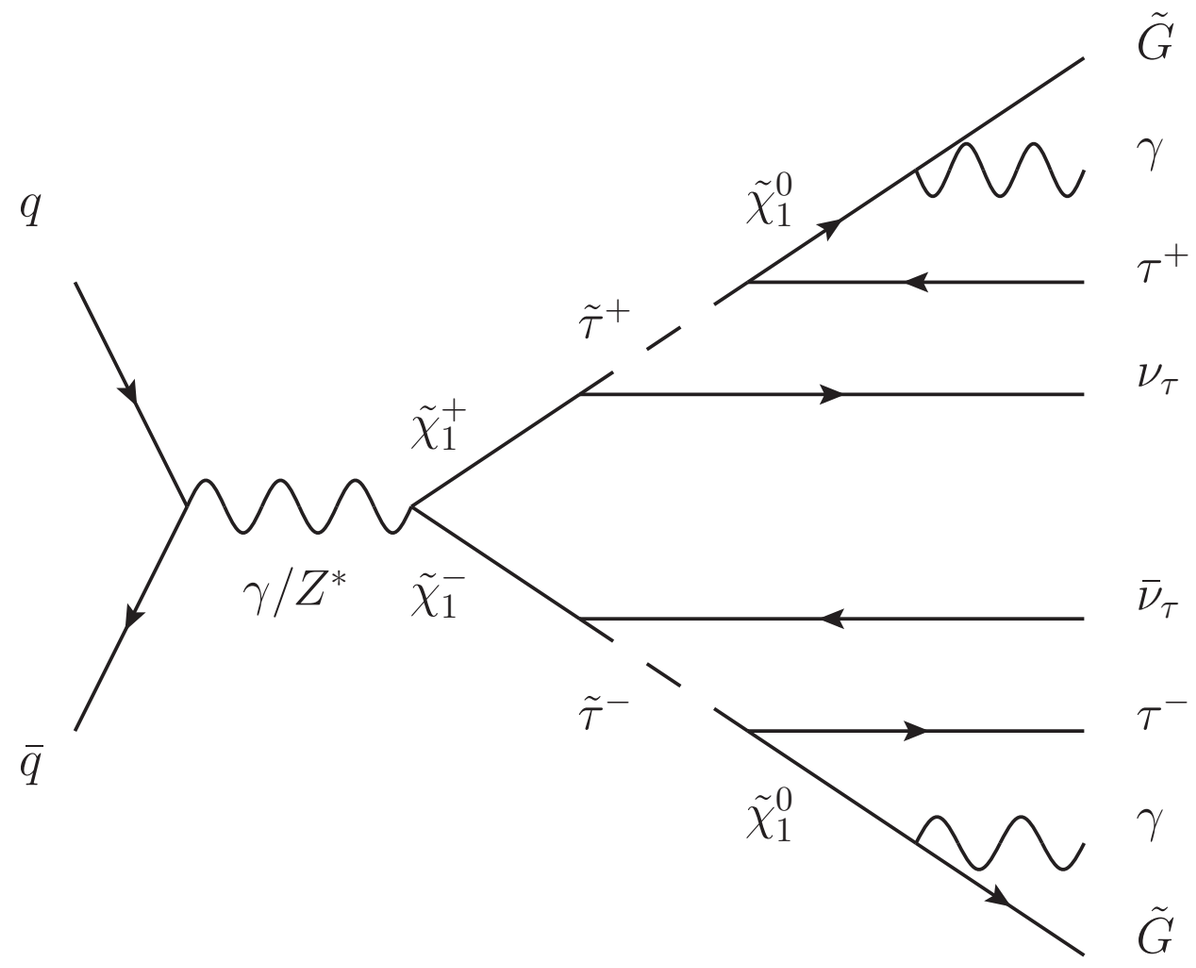
- Gauge mediation provides an attractive solution to the MSSM flavor problem. It guarantees flavor-diagonal soft masses at the messenger scale.
- Its phenomenology is distinctive: gravitino is the LSP.

$$m_{\tilde{G}} \ll m_{weak}$$

- Lightest MSSM superpartner is the NLSP. It decays to the gravitino plus its SM superpartner.

$$\tilde{X}_{NLSP} \to \tilde{G} + X$$

Gauge Mediation



- All SUSY cascade decays pass through the NLSP.
- So all events contain high pT objects determined by the NLSP type, plus missing energy. (Or displaced decays.)

Minimal Gauge Mediation

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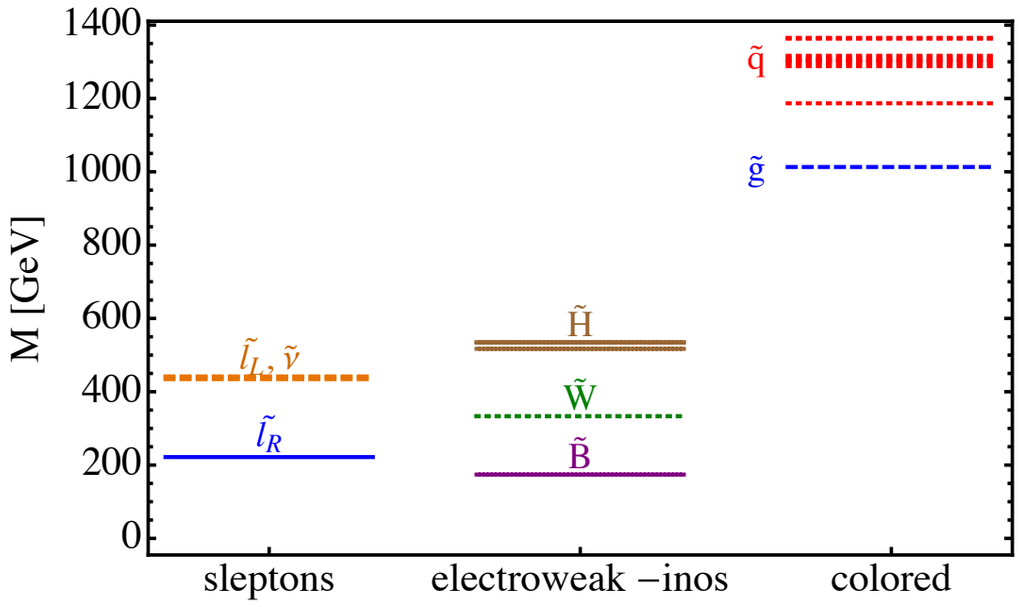
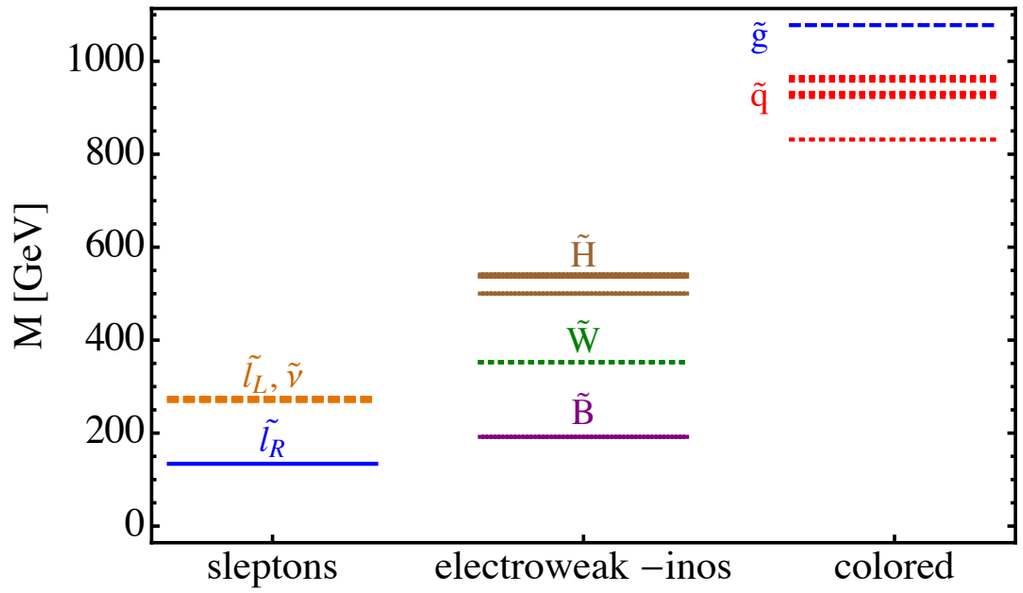
- In the early days of GMSB, the collider signatures of "Minimal Gauge Mediation" were extensively studied.





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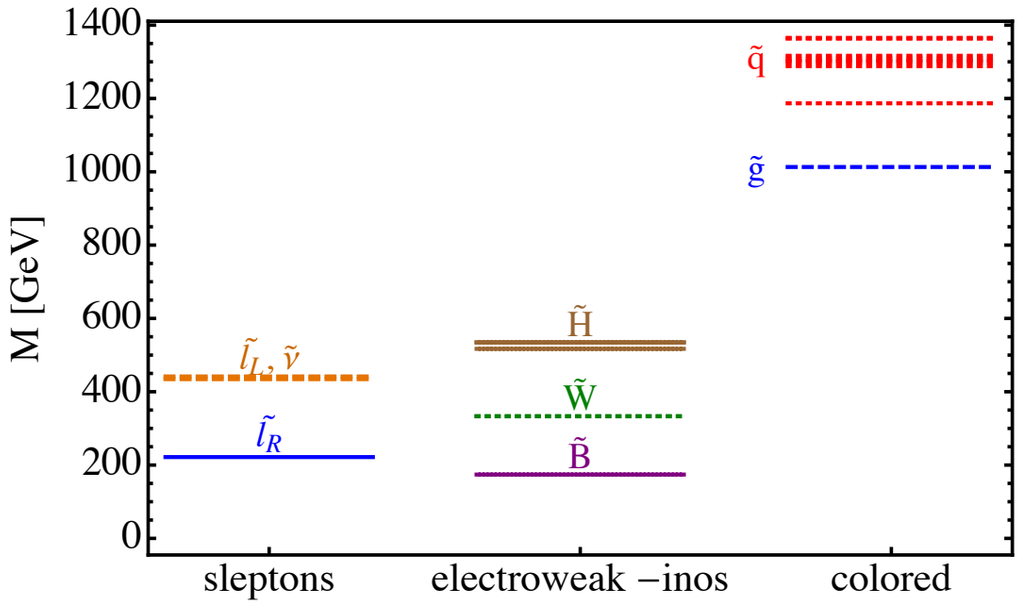

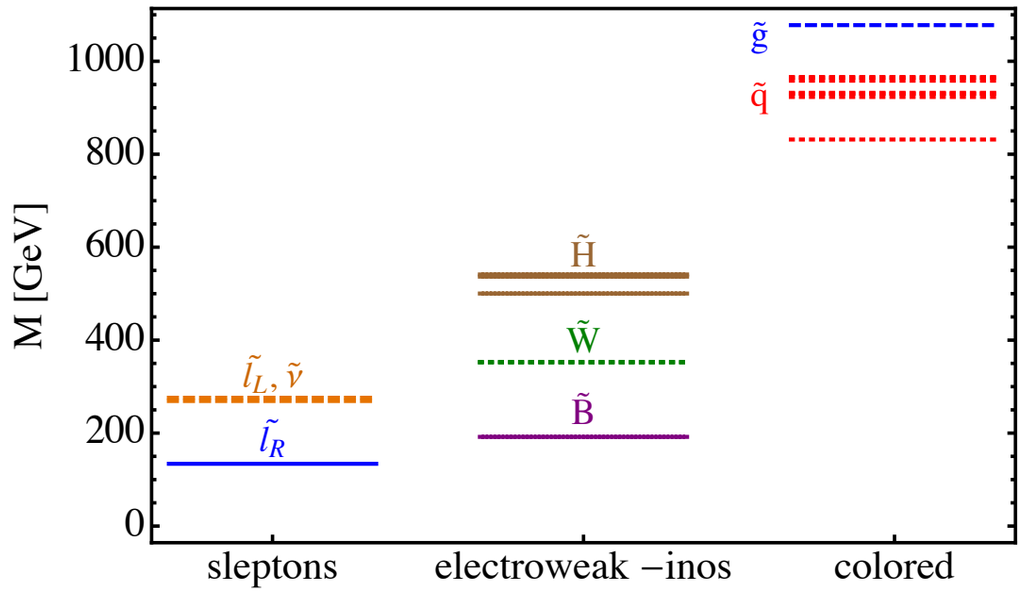

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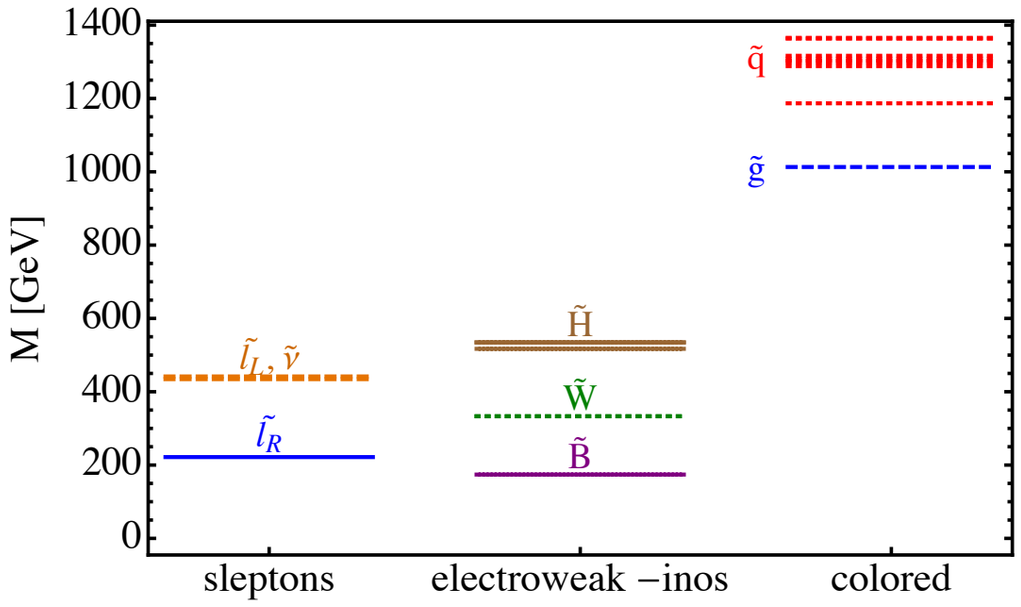

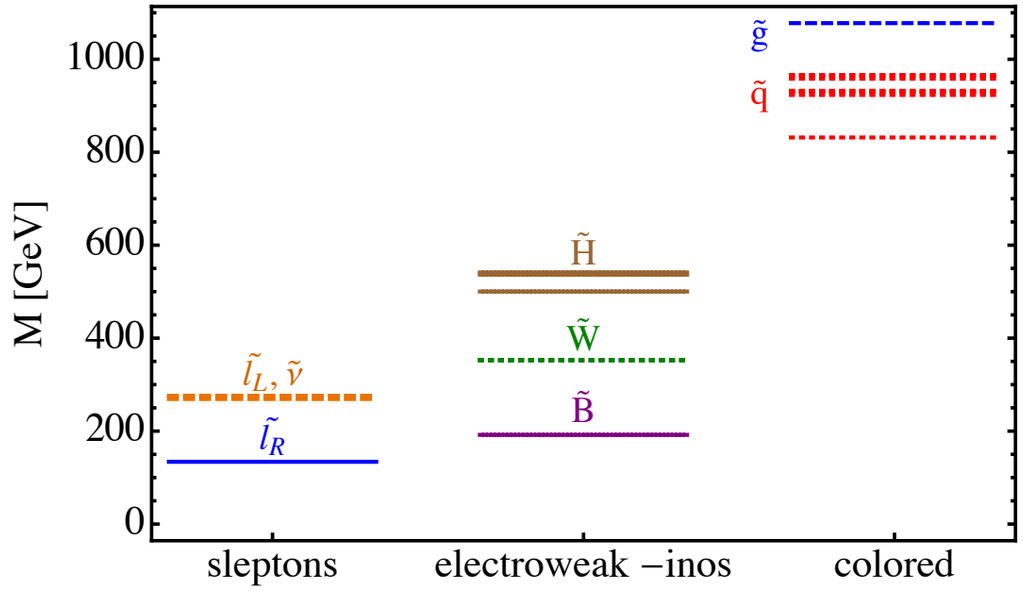

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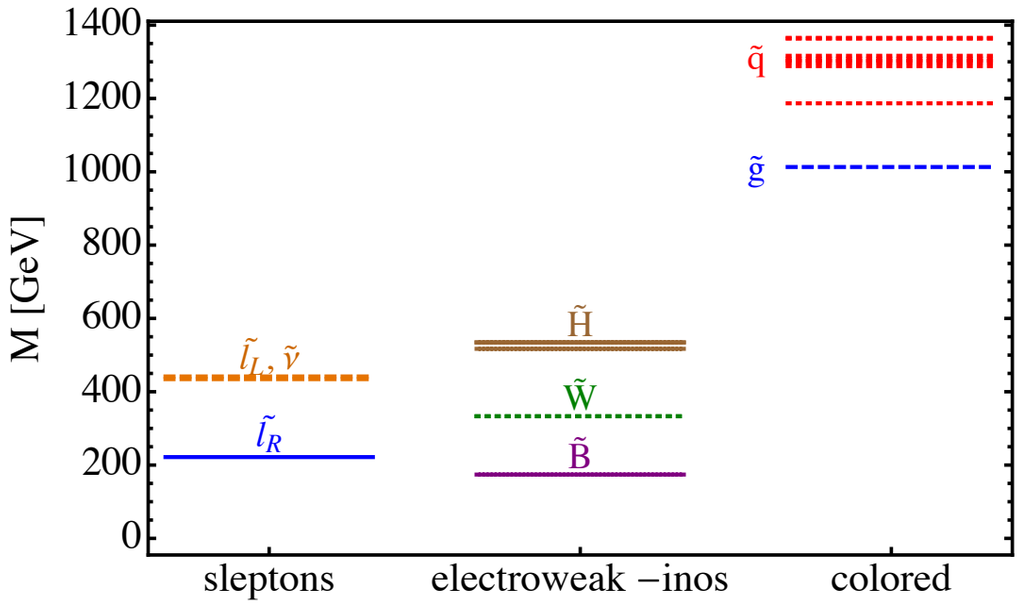

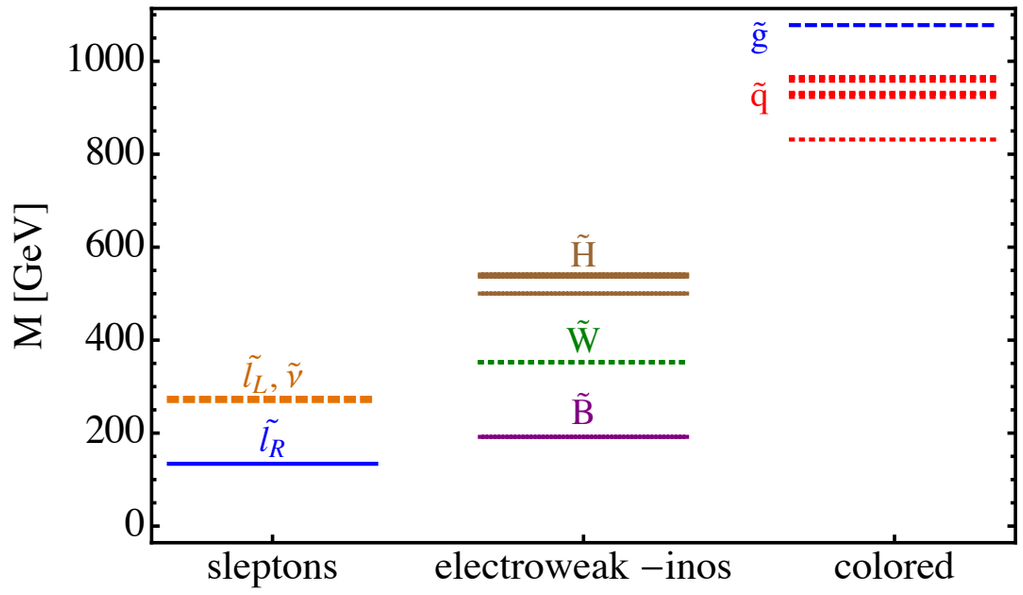

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- M1: M2: M3 ~ 1: 2 : 7

Beyond MGM?

- Additionally, a variety of different signatures beyond MGM were catalogued and studied by many authors.
- However, experimental searches for GMSB have focused almost entirely on MGM signatures.
  - diphoton+MET
  - displaced photons+MET
  - long-lived staus
  - OS dilepton+MET (LEP only)
  - ....
  - EW production only...

General Gauge Mediation

- Recently, a general, model-independent framework for gauge mediation was formulated, in terms of currents and their correlation functions. (Meade, Seiberg, DS)

- Using this, the full parameter space of gauge mediation at the messenger scale was shown to be:
  - Three unconstrained gaugino masses: $M_1,\ M_2,\ M_3$
  - Five sfermion masses $m^2_{\tilde{Q}},\ m^2_{\tilde{u}},\ m^2_{\tilde{d}},\ m^2_{\tilde{L}},\ m^2_{\tilde{e}}$ subject to two sum rules

- A messenger model was constructed which covers the entire parameter space (Buican, Meade, Seiberg & DS; see also Carpenter, Dine, Festuccia & Mason)

- So the entire parameter space is physical! No point in parameter space should be preferred over any other.

NLSPs in GGM

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- In GGM parameter space, the NLSP can be nearly anything:
  - neutralino NLSP (bino, wino or Higgsino)
  - gluino NLSP
  - squark NLSP
  - right-handed slepton NLSP
  - sneutrino NLSP
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- Phenomenological possibilities go far beyond MGM!

GMSB ≠ MGM

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- Goals:
  - Want to characterize minimal inclusive signatures for early discovery. Not necessary to include every particle from every possible decay chain.
  - Want to provide new benchmark spaces to experimentalists for exploration, optimization and limit-setting. These should be carefully chosen to be as comprehensive and bias-free as possible.

Minimal Parameter Spaces

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- Our approach: minimal spectra, classified by NLSP type
  - Minimal particle content for signature and production. At LHC, focus on strong SUSY production (gluinos for simplicity).
  - Inclusive signatures primarily controlled by NLSP type
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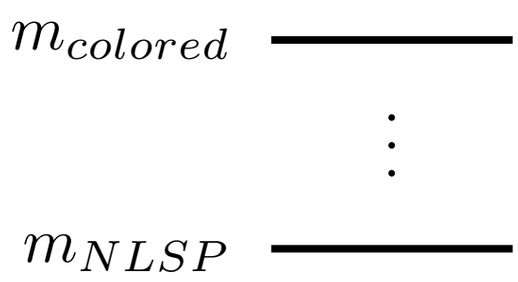
- Simple 2D spaces: NLSP mass and production mode mass.



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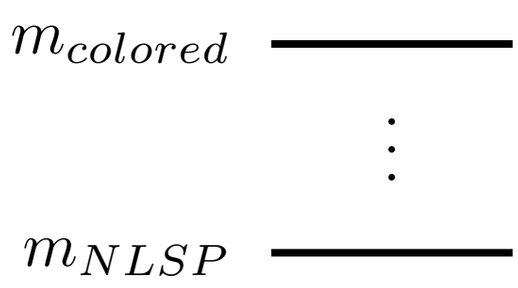
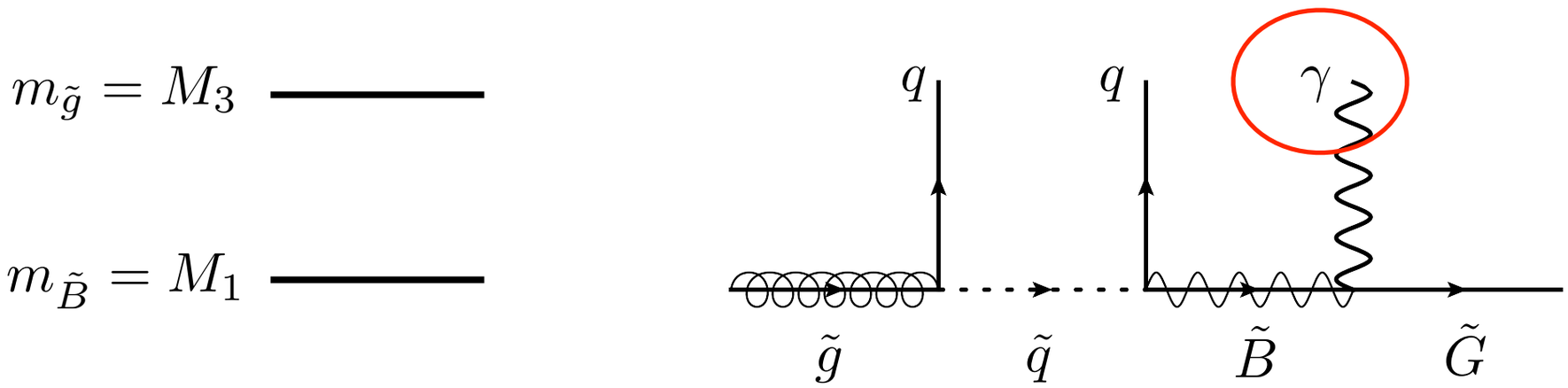


- More complicated spectra will contain these minimal parameter spaces. Well suited for inclusive searches.

Examples

- See Josh Ruderman's talk for our approach applied to slepton co-NLSPs.
- Here I will illustrate with general neutralino NLSPs.

Example #1: Bino NLSP



- Minimal spectrum for bino NLSP.
- Decouple all other sparticles (squarks, sleptons, winos and Higgsinos) for simplicity.
- Inclusive final state: $\gamma\gamma + \text{jets} + \text{MET}$

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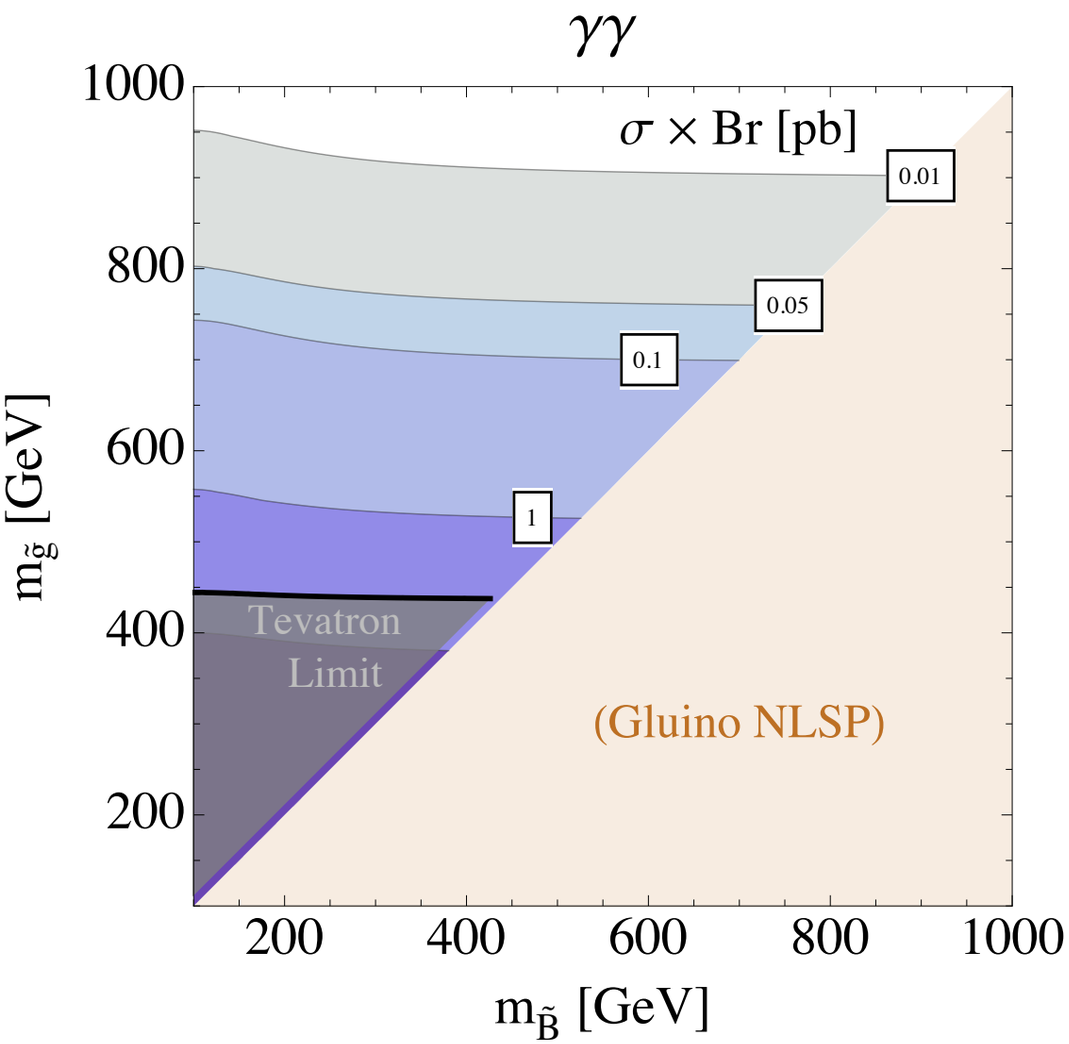
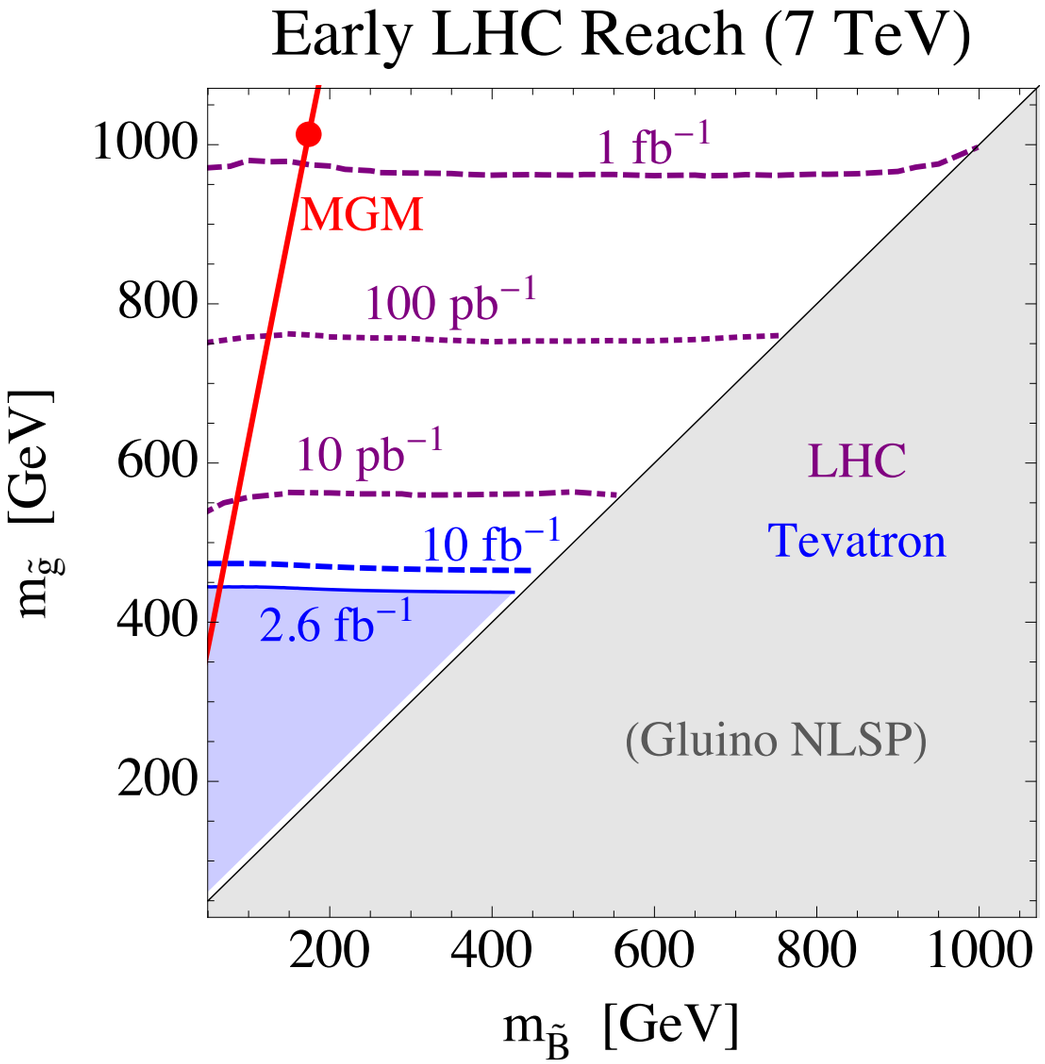


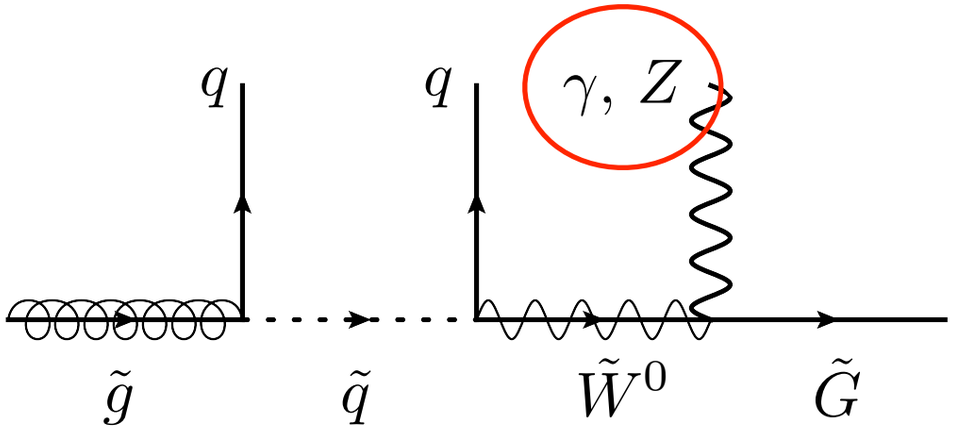


Much more discovery potential than MGM!
Tevatron surpassed after just 10/pb !

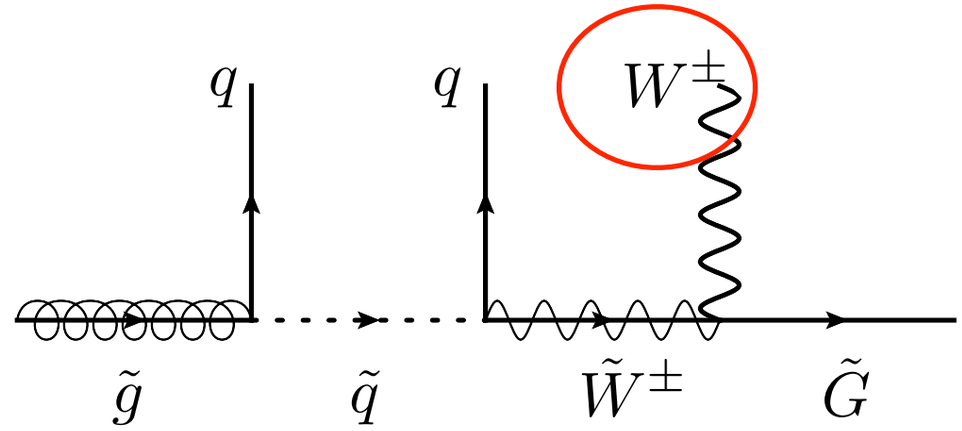
Example #2: Wino co-NLSP

$$m_{\tilde{g}} = M_3$$

$$m_{\tilde{W}^0} = m_{\tilde{W}^\pm} = M_2$$



$\mathrm{Br}(\tilde{g} \to \tilde{W}^0 + \mathrm{jets}) \approx 40\%$



$\mathrm{Br}(\tilde{g} \to \tilde{W}^\pm + \mathrm{jets}) \approx 60\%$

- Minimal parameter space for wino co-NLSP.
- Inclusive final states: $\gamma\gamma + \mathrm{jets} + \mathrm{MET},\ W(\ell\nu)\gamma + \mathrm{jets} + \mathrm{MET},\ \ldots$

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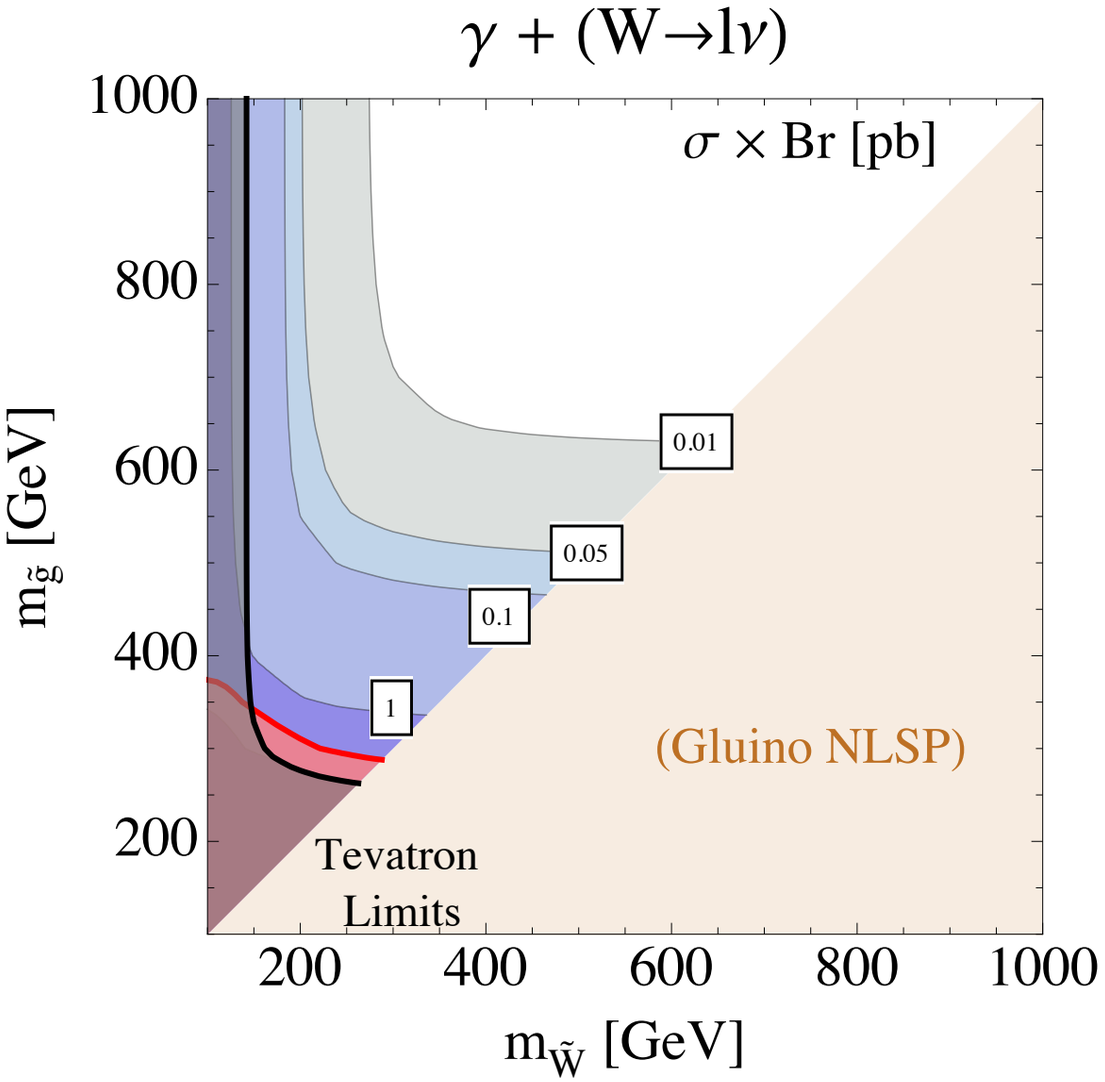

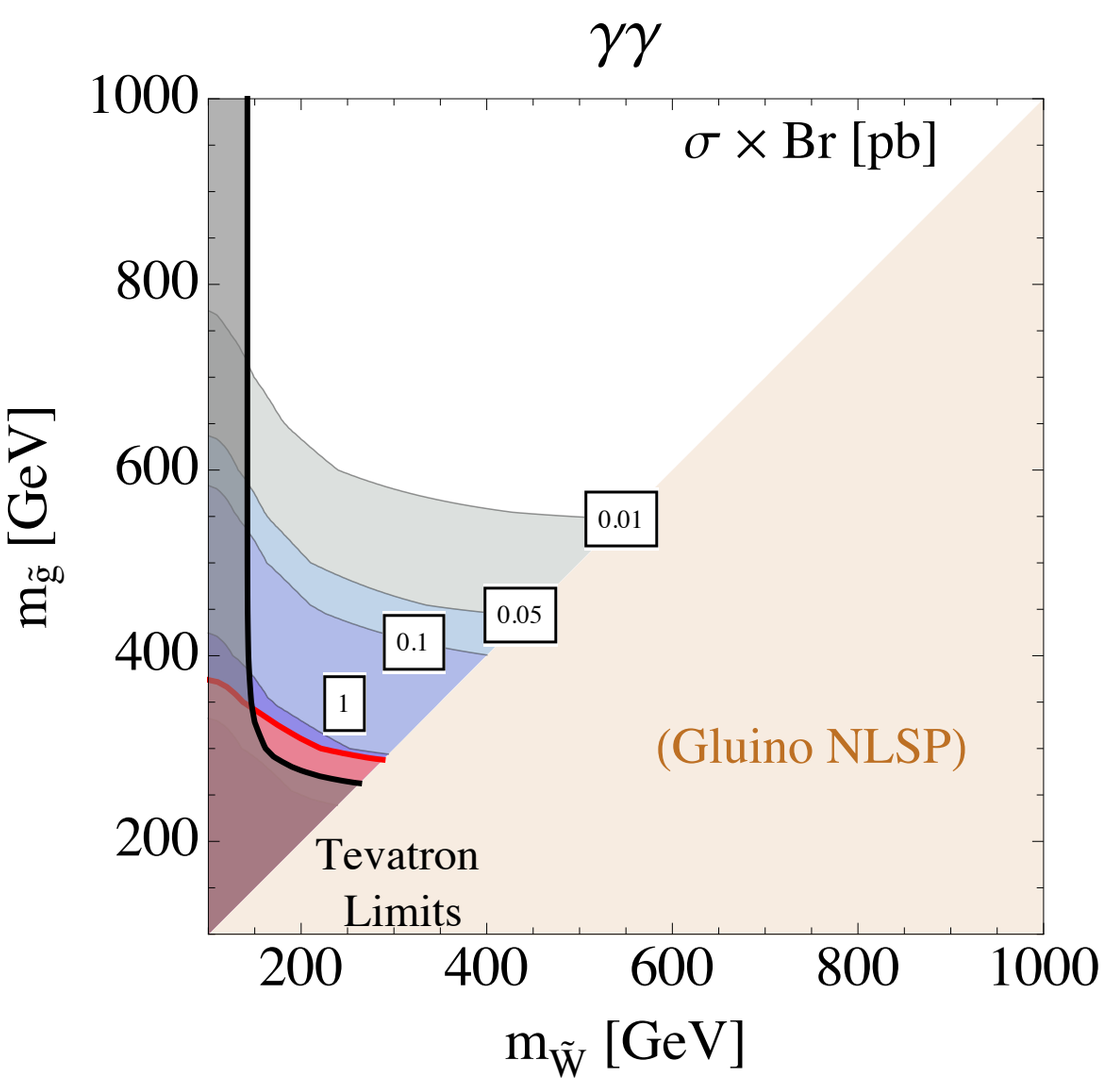

Discovery potential
depends on backgrounds.
Work in progress....

Conclusions

- We are in the process of formulating minimal parameter spaces for each NLSP type in GGM.
- These will characterize all the relevant signatures for early discovery of GMSB (with prompt decays).
- These can serve as minimally-biased, model-independent benchmarks for early LHC searches. We hope that experimentalists will find them useful.
- If we are to discover or rule out GMSB at the LHC, we must move beyond MGM!
- LHC has excellent reach for colored production; should surpass Tevatron with only ~10-100/pb!