# GGM at Colliders: Multilepton Signatures

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Princeton University

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JTR and David Shih, **1009.1665**

and work in progress with,
Michael Park, David Shih, Scott Thomas, and Yue Zhao.

# General Gauge Mediation

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GGM provides a framework for the model-independent study of gauge mediation collider physics.

For a more detailed overview, catch David Shih's talk on Friday.

# Phenomenological Gauge Mediation

We choose to specify soft parameters at the weak scale,

$$M_1, M_2, \mu, \tan\beta$$
$$m_{e_L}, m_{e_R}, m_{\tau_L}, m_{\tau_R}$$
$$M_3$$

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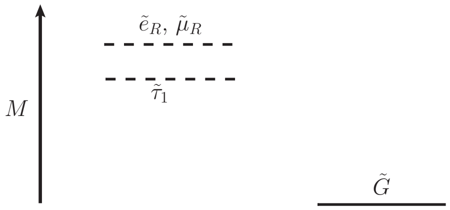
The NLSP decays to the gravitino and its superpartner.

$$\Gamma = \frac{m_{NLSP}^5}{16\pi F^2} = (0.1\ \mathrm{mm})^{-1} \times \left(\frac{m_{NLSP}}{100\ \mathrm{GeV}}\right)^5 \left(\frac{100\ \mathrm{TeV}}{\sqrt{F}}\right)^4$$

For this talk, I'm interested in prompt multilepton signatures so I choose right-handed slepton NLSPs and low scale breaking, $\sqrt{F} \sim 100$ TeV

# Slepton co-NLSPs



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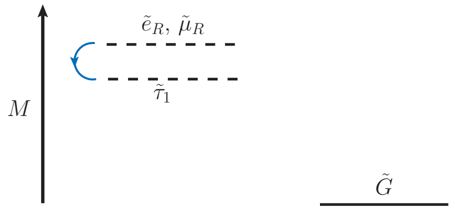
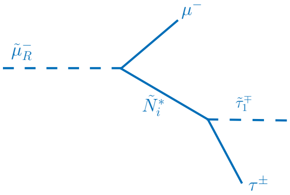



## Stau NLSP



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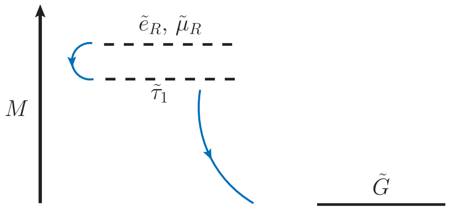


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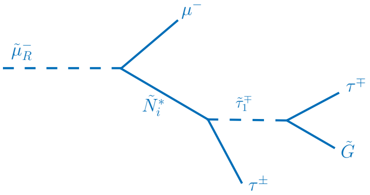

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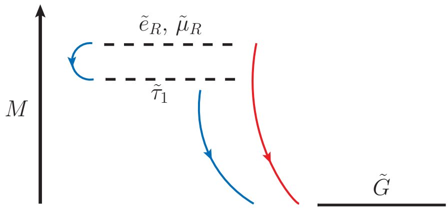
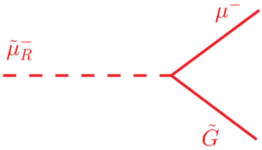
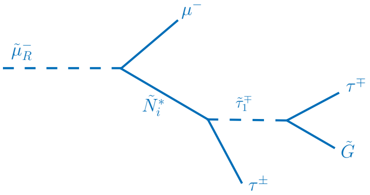



Slepton co-NLSP




Stau NLSP




Slepton co-NLSP corresponds to $\delta m = m_{\tilde{e}_R} - m_{\tilde{\tau}_1} \lesssim 10$ GeV.

Every event has at least two $e, \mu$, or $\tau$, plus MET.

# Slepton co-NLSPs in MGM

A popular example is minimal gauge mediation (MGM),

$$W = \lambda X \phi_i \bar{\phi}_i$$

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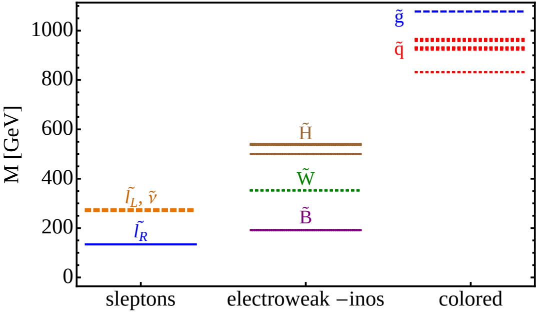
The spectrum pretty much always looks like,




But in GGM there are many different possible spectra.

# Multilepton Signatures

The collider signature depends on the production mode:

1. Direct $l_R\tilde{l}_R$ production $\to$ OS dilepton + MET
   LEP2 sets the limit, $m_{\tilde{e}_R} = m_{\tilde{\mu}_R} > 96$ GeV, $m_{\tilde{\tau}_1} > 87$ GeV.

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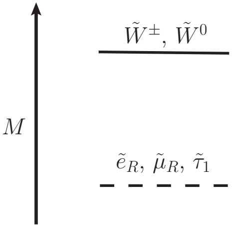
2. Electroweak production $\rightarrow$ multileptons + MET
   Tevatron has advantage for now

3. Colored production $\rightarrow$ multileptons + jets + MET
   Early LHC will soon have discovery reach

# Prequel: Simplified Models for the Tevatron

Wino production, $p\bar{p} \rightarrow \tilde{W}^0 \tilde{W}^{\pm}$



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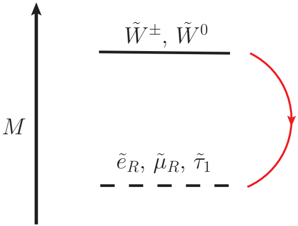


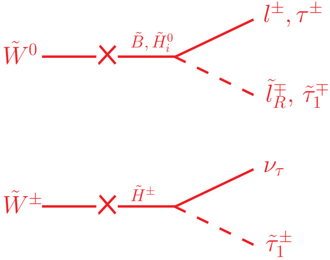


The signal is trileptons plus MET with 1 or 3 tau.

**Parameters**: $m_{\tilde{W}}, m_{\tilde{l}_R}, \mathrm{Br}(\tilde{W}^0 \rightarrow \tilde{\tau}_1)$

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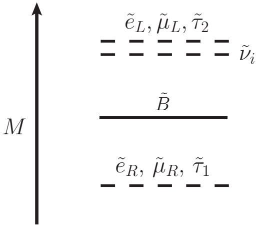
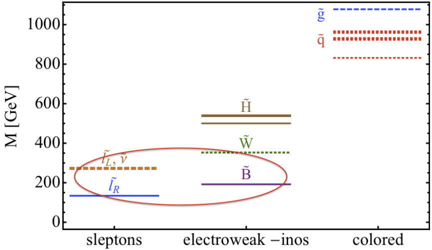
MGM-like spectrum: left-handed slepton production



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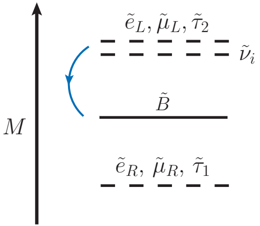


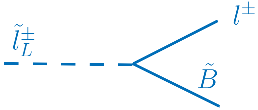

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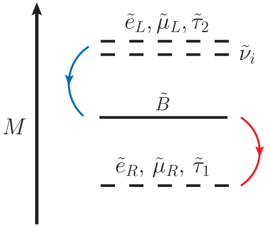
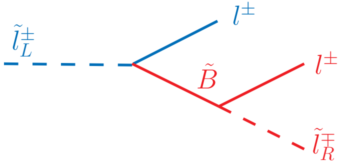


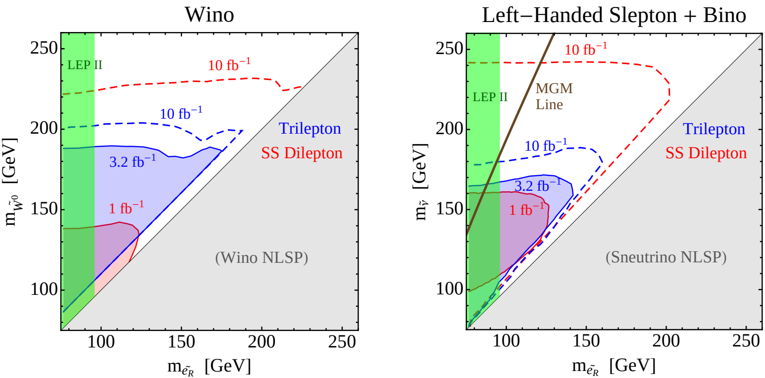




Up to six leptons per event.

**Parameters**: $m_{\tilde{l}_L}$, $m_{\tilde{B}}$, $m_{\tilde{l}_R}$

# Tevatron Limits

To determine the limits and reach, we simulated CDF same-sign dilepton and trilepton searches with pythia and PGS.

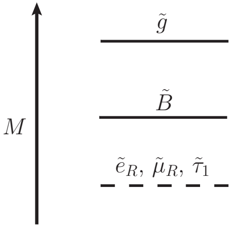



Here we fix,

$$\mathrm{Br}(\tilde{W}^0 \to \tilde{\tau}_1) = 1/3 \qquad m_{\tilde{B}} = \frac{1}{2}(m_{\tilde{l}_L} + m_{\tilde{l}_R})$$

# Simplified Model for the Early LHC

For the early LHC lets consider colored production.



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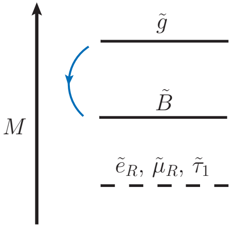


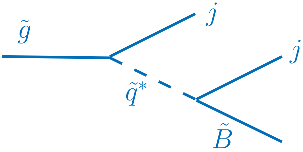

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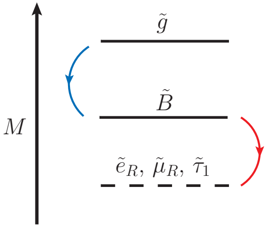
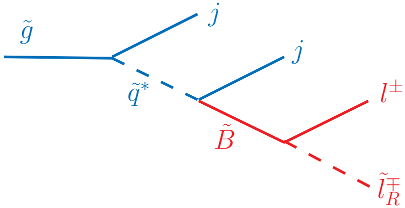
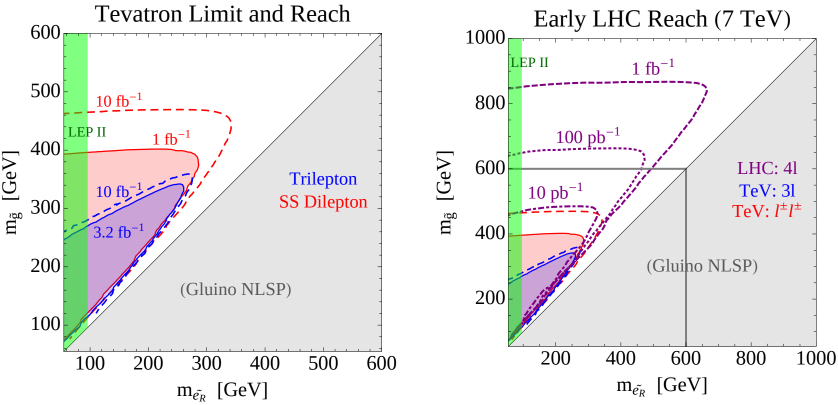



The signal is: $4l + \mathrm{jets} + MET$

**Parameters**: $m_{\tilde{g}},\ m_{\tilde{B}},\ m_{\tilde{l}_R}$

# Tevatron Limit and Early LHC Reach




Here we fix

$$m_{\tilde{B}} = \frac{1}{2}(m_{\tilde{g}} + m_{\tilde{l}_R})$$

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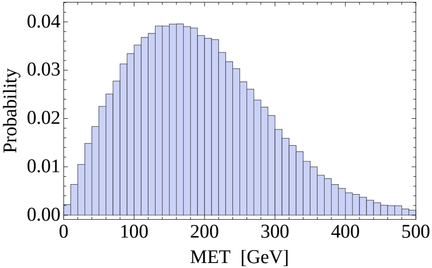
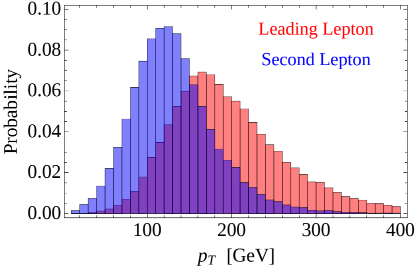
- There's a lot of mass reach left at the Tevatron for electroweak production.
- The LHC will cover new ground for colored production by the winter conference.

# Backup Slides

# Signal Kinematics




$m_{\tilde{g}} = 600$ GeV

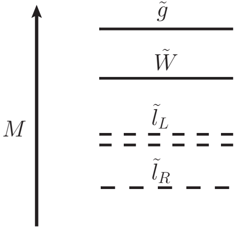
$m_{\tilde{B}} = 450$ GeV

$m_{\tilde{l}_R} = 300$ GeV

# A Less-Simplified Model for Early LHC

A danger of simplified models is a bias towards low multiplicity final states.

So how about a less-simple model?



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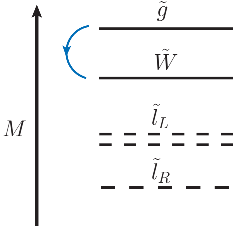


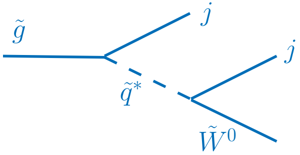

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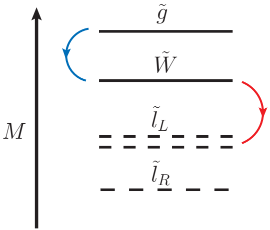


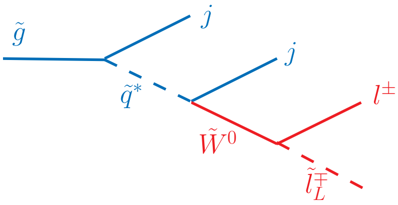

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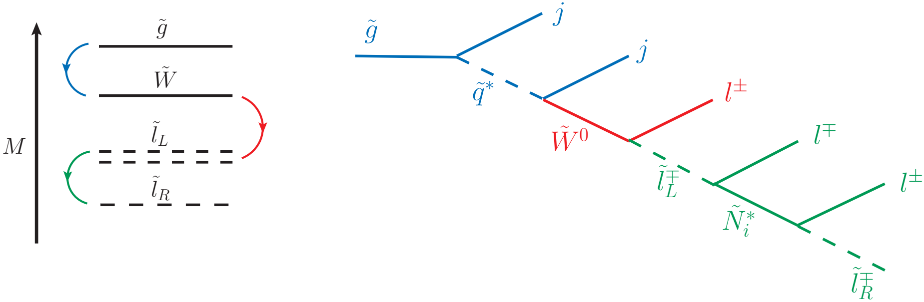


The signal is up to $8l + \mathrm{jets} + MET$

**Parameters**: $m_{\tilde{g}}$, $m_{\tilde{W}}$, $m_{\tilde{l}_L}$, $m_{\tilde{l}_R}$, $\mathrm{Br}(\tilde{l}_L \to \tilde{\tau}_1)$

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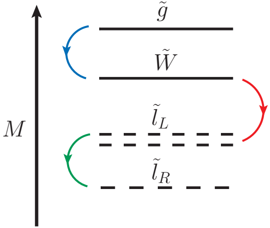


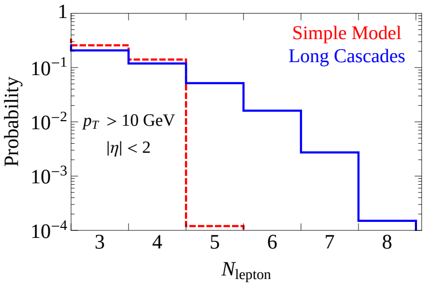


$m_{\tilde{g}} = 600$ GeV, $\quad m_{\tilde{l}_R} = 300$ GeV

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