SUSY Heavy Flavor Simplified Models at the LHC

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w/ Rouven Essig, Jared Kaplan, and Jay Wacker

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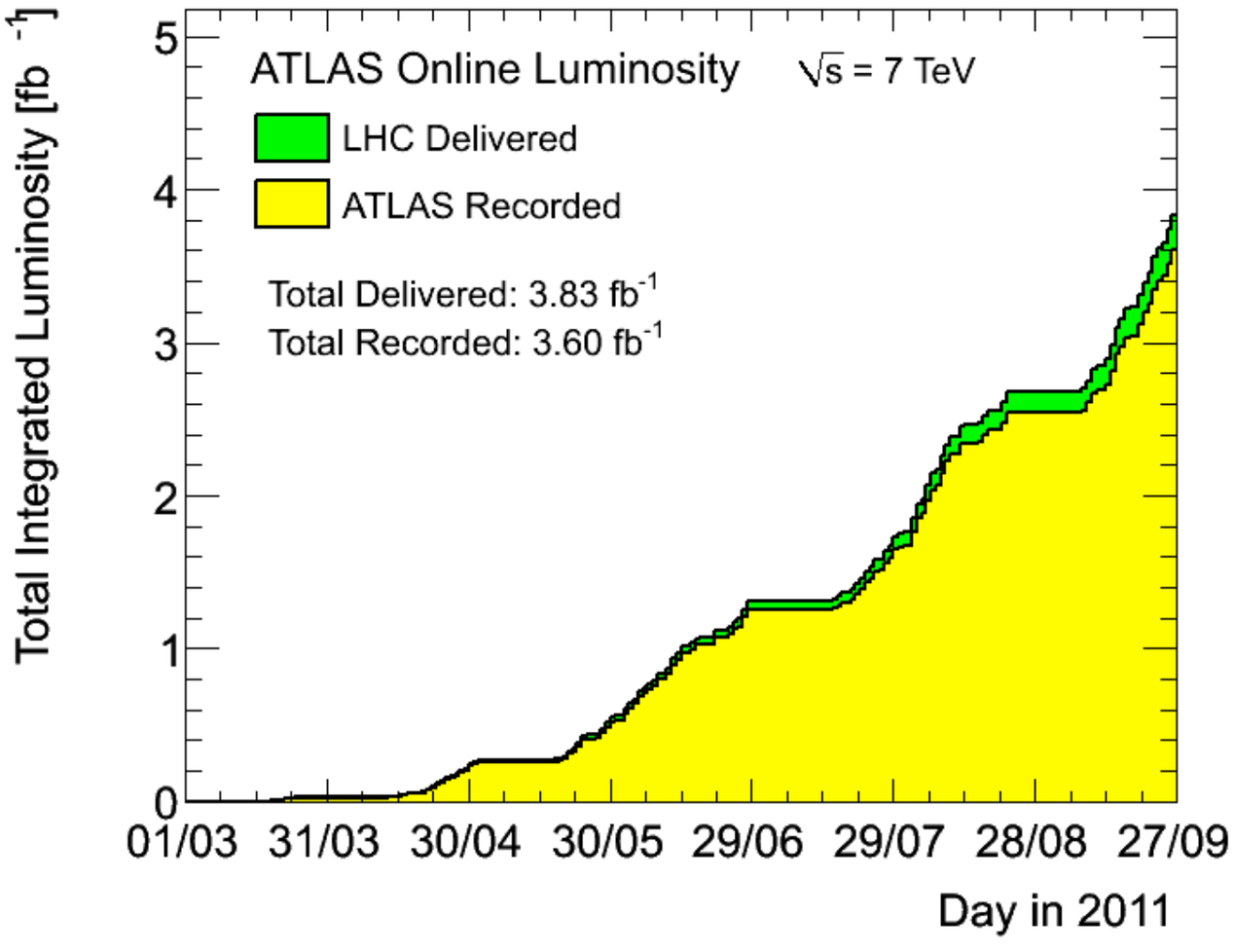
The LHC is opening the energy frontier!

- 2011 run expected to conclude with ~ 5 fb^{-1} of data
- Resume in 2012 and run @ ? TeV through the end of the year



- Shut down during 2013 to retrain magnets (?)
- Turn it on again in 2014 @ ~ 14TeV (?)

Outline

- Simplified Models
- Prospects for the 7 TeV run

Simplified Models

Models are created to solve problems or demonstrate mechanisms
Realistic ones tend to be complicated and most details are irrelevant for searches

Simplified Model: Minimal particle content and free parameters

Can translate limits to other theories
Only keep particles and couplings relevant for searches

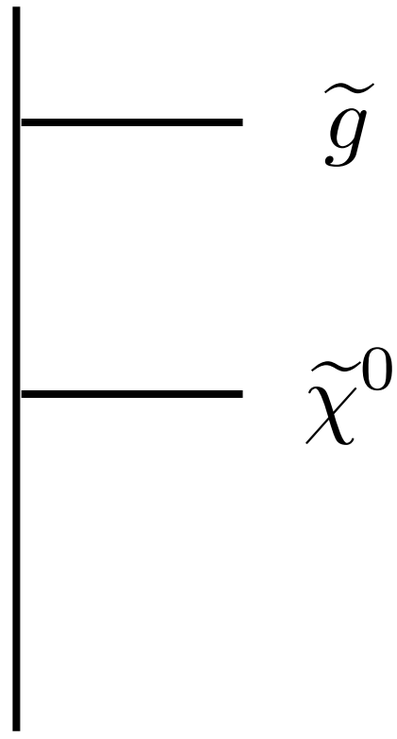
Captures specific models (MSSM, UED, etc)

Easy to notice & explore kinematic limits

Simplified Models

w/ Daniele Alves and Jay G. Wacker

An example:



$$\widetilde{g} \to q\bar{q}\widetilde{\chi}^0$$

Free parameters

$$\mathcal{B} \times \sigma_{pp\to\widetilde{g}\widetilde{g}} \;\; m_{\widetilde{g}} \;\; m_{\widetilde{\chi}^0}$$

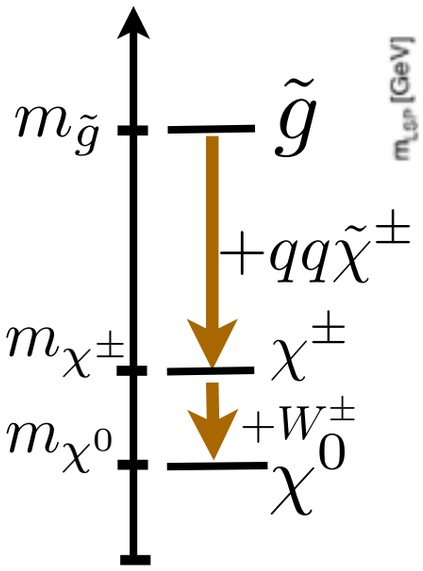
In published analyses so far, search regions have been optimized for particular benchmarks, e.g. mSugra

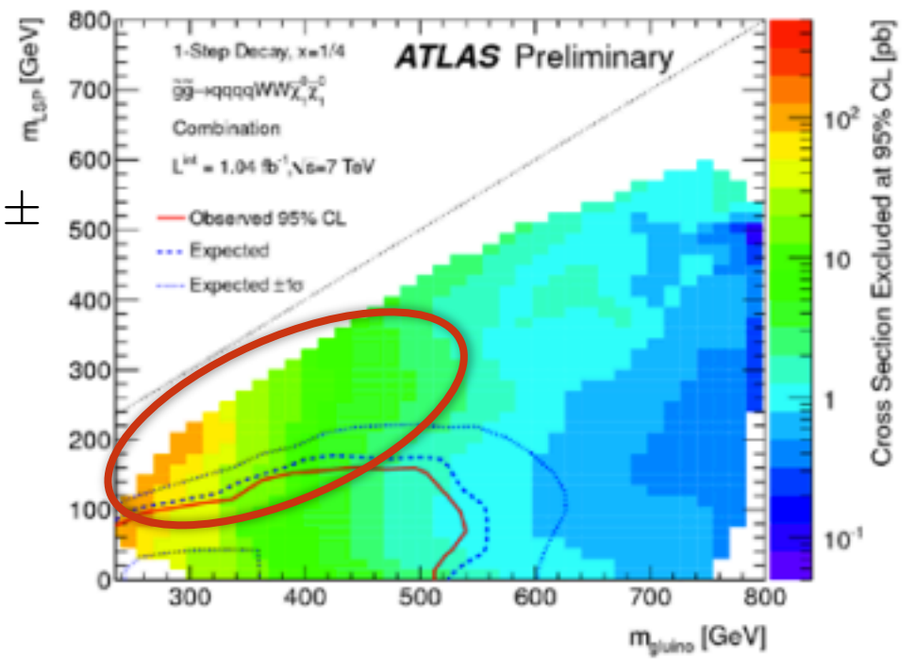
But experiments have begun presenting limits in terms of simplified models
Very useful!

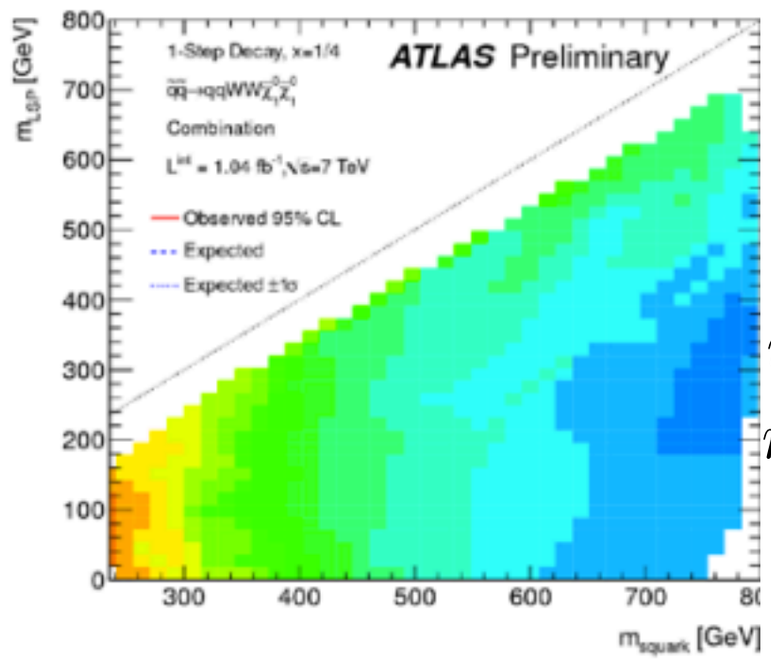
Simplified Models can also be used to create and evaluate search strategy

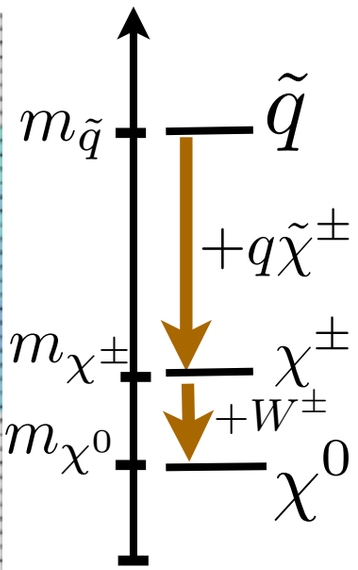
Can be used to spot search deficiencies

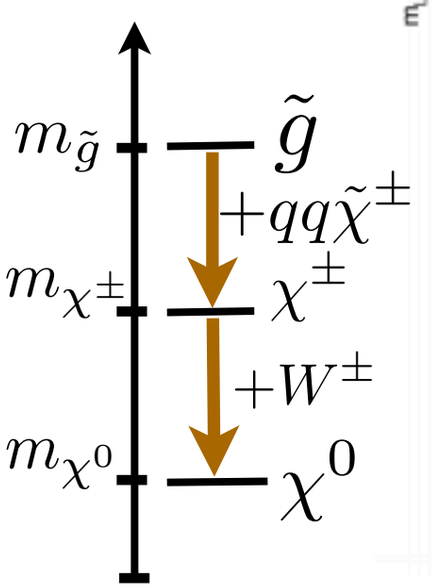
$$1\ell + \mathrm{nj} + \not{E}_T$$

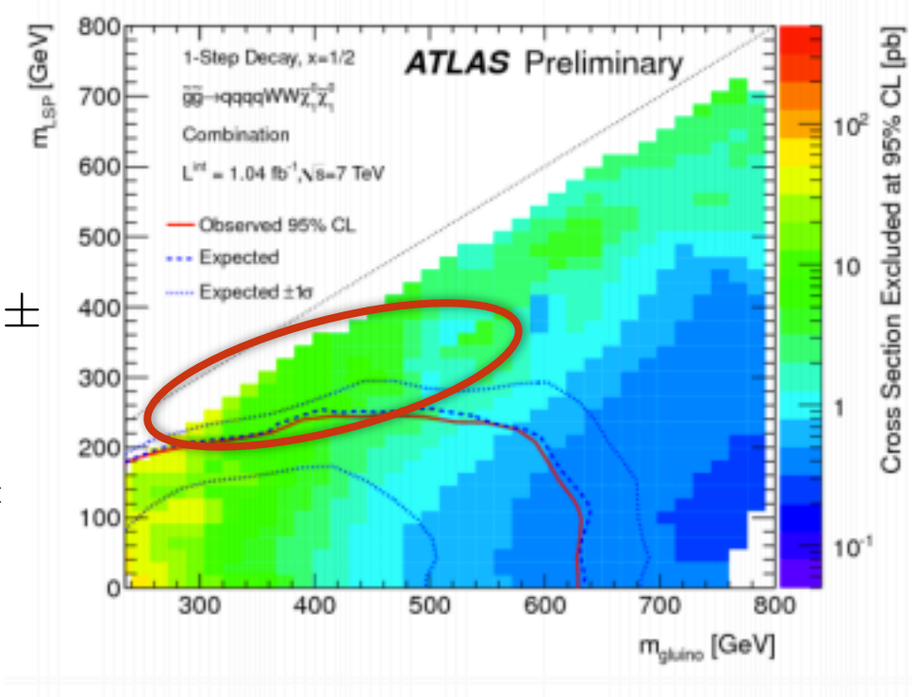


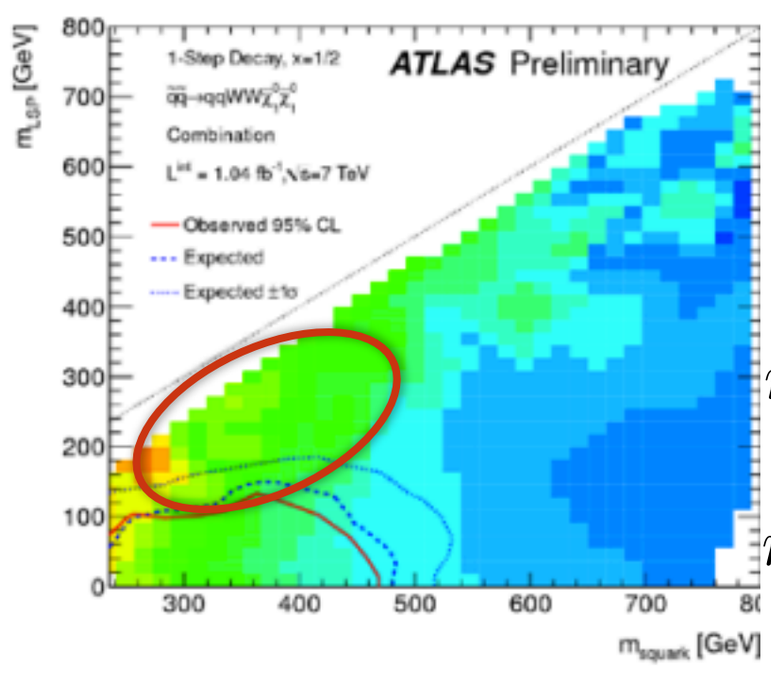


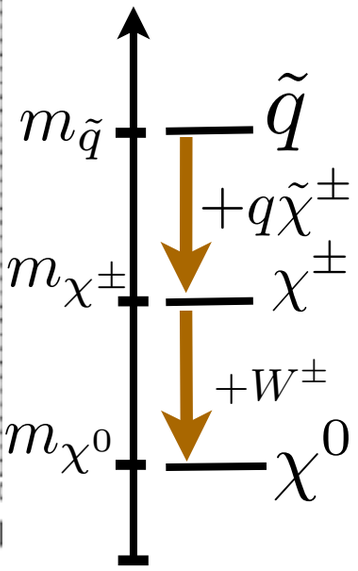












R. Brunelière, CERN workshop “Implications of LHC results for TeV-scale physics”

Heavy flavor Simplified Models

Generic signature: $b_{\text{jets}} + \ell's + \not{E}_T$

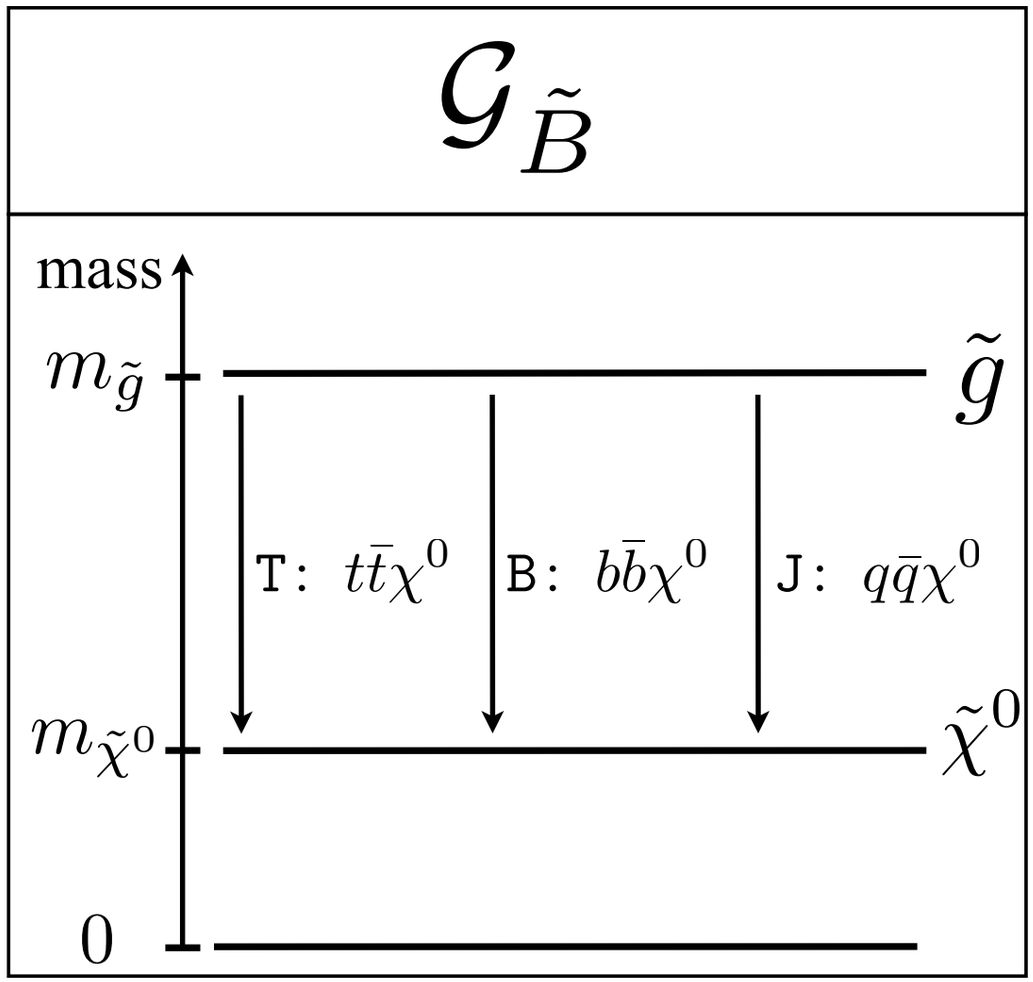
What theories to search for in this channel?
Not a one-to-one correspondence

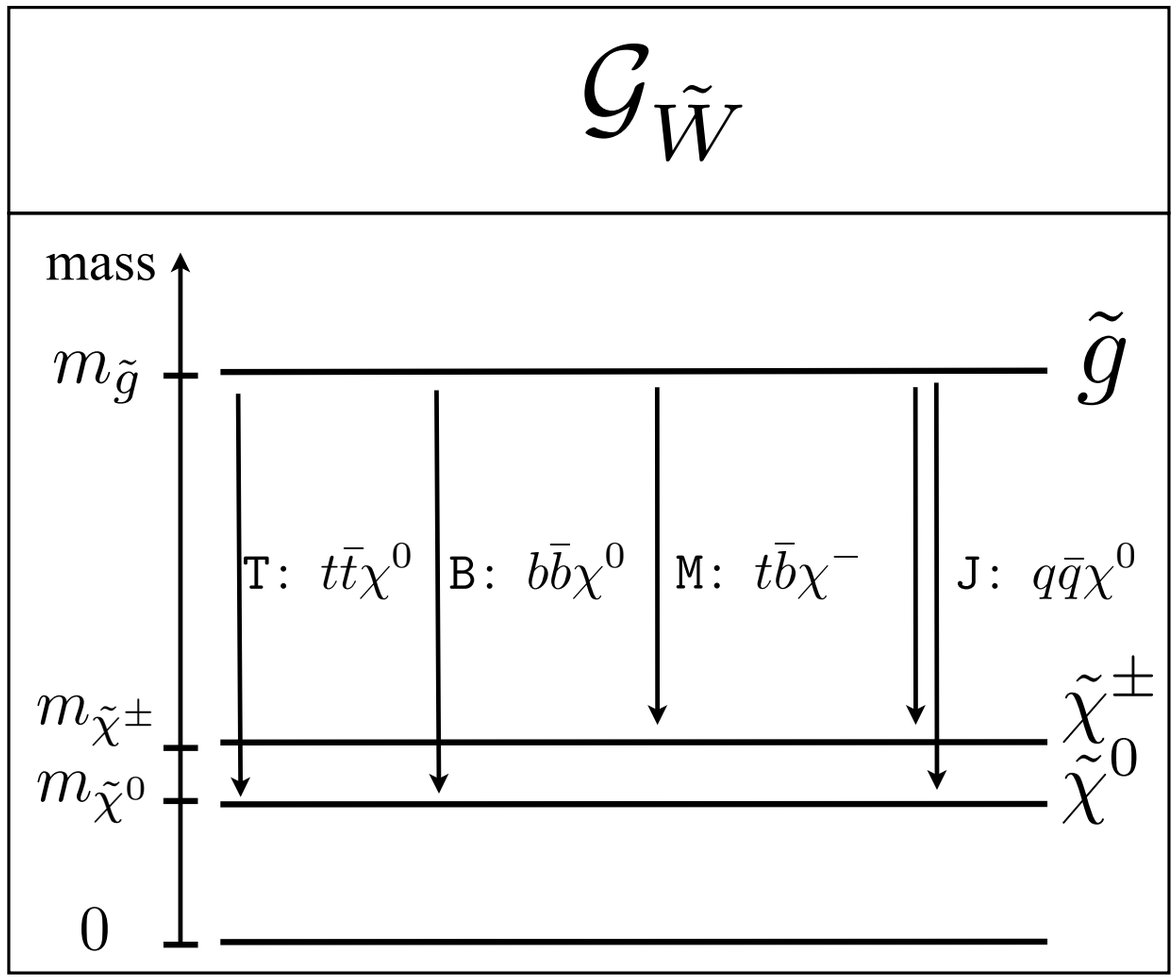
Approach:

Use a set of simple topologies (Simplified Models) to design a search strategy and present results in a useful way

Heavy flavor Simplified Models

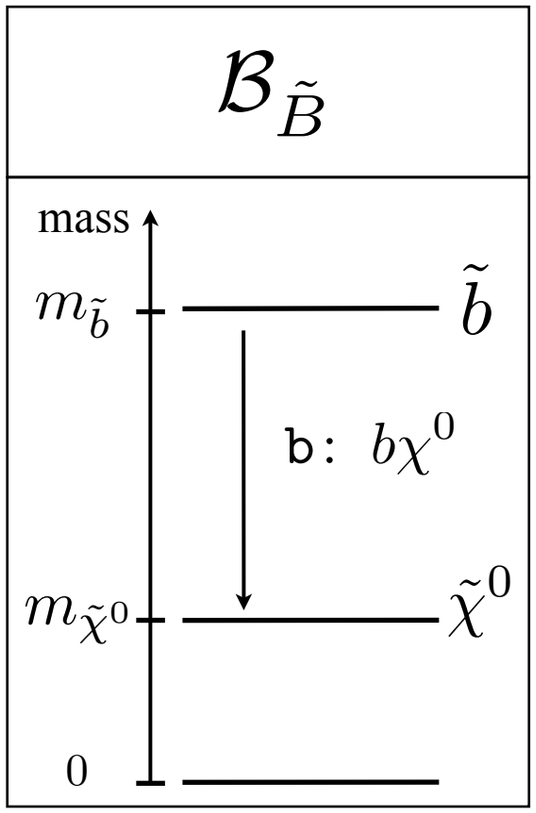
Gluino-like: Assume squarks decoupled

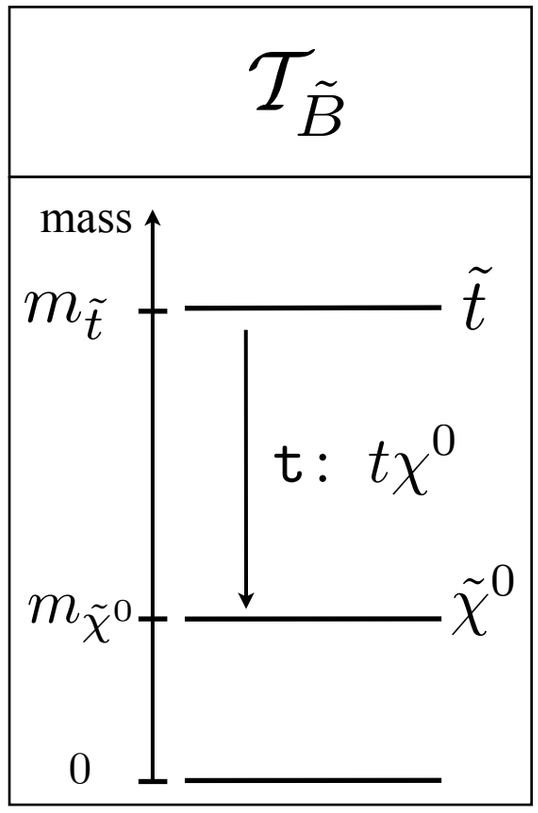




Heavy flavor Simplified Models

Squark-like: Assume gluinos decoupled





Heavy flavor Simplified Models

12 Simplified Models in total

"Pure" topologies: $pp \to (\tilde{g} \to t\bar{t}\chi^0)(\tilde{g} \to t\bar{t}\chi^0)$

"Mixed" topologies: $pp \to (\tilde{g} \to t\bar{t}\chi^0)(\tilde{g} \to b\bar{b}\chi^0)$

$\sim$ 2500 points in model space: $(m_{\mathrm{High}}, m_{\mathrm{Low}})$

$$m_{\mathrm{High}} \in \{m_{\tilde{g}}, m_{\tilde{q}}\}$$

$$m_{\mathrm{Low}} \in \{m_{\tilde{\chi}^\pm}, m_{\tilde{\chi}^0}\}$$

Assume $m_{\chi^\pm} \simeq m_{\chi^0}$

Search strategy

Design a search strategy that ensures optimal coverage
to the space of Simplified Models

Find a set of "search regions" or
"cuts" of the form:

$$(N_j, N_b, N_\ell, H_T, \not{E}_T)$$

No single cut covers all the space of models
because the kinematics vary widely

Ideally, would like to find a minimal number of search regions

Search strategy

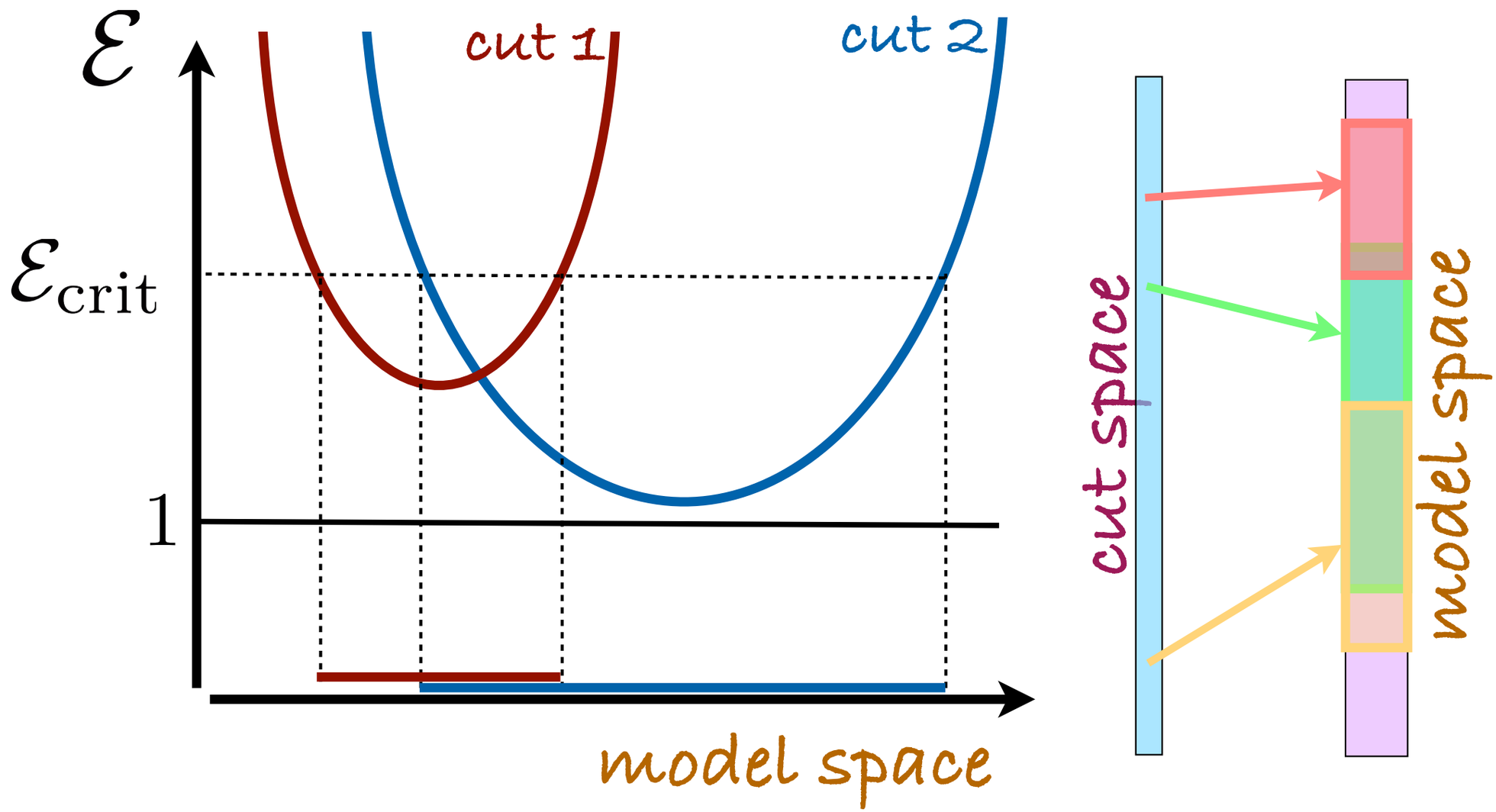
How do we quantify how effective a cut is?

For each $(N_j, N_b, N_\ell, H_T, \not{E}_T)$

$$\text{Efficacy of a cut } \mathcal{E}_i = \frac{\sigma_{\text{cut } i}}{\sigma_{\text{optimal}}}$$

Search strategy

Pick a set of cuts so that combined cover the whole of model space



Search regions found

For $\mathcal{E}_{\text{crit}} = 2$

	Search Region	N_j	N_ℓ	N_{bjet}	$\not{E}_T$	H_T
High HT	1	4^+	0	0	300	1000
High MET	2	4^+	0	0	400	500
1 b Low multiplicity	3	2^+	0	1^+	400	400
1 b High HT	4	4^+	0	1^+	300	800
1 b High MET	5	4^+	0	1^+	400	500
2 b High MET	6	3^+	0	2^+	250	400
3 b High MET	7	3^+	0	3^+	250	600
3 b Low MET	8	4^+	0	3^+	150	300
b SSDL	9	2^+	SSDL	1^+	0	200

2 Normal Light Flavor

4 Normal Heavy Flavor

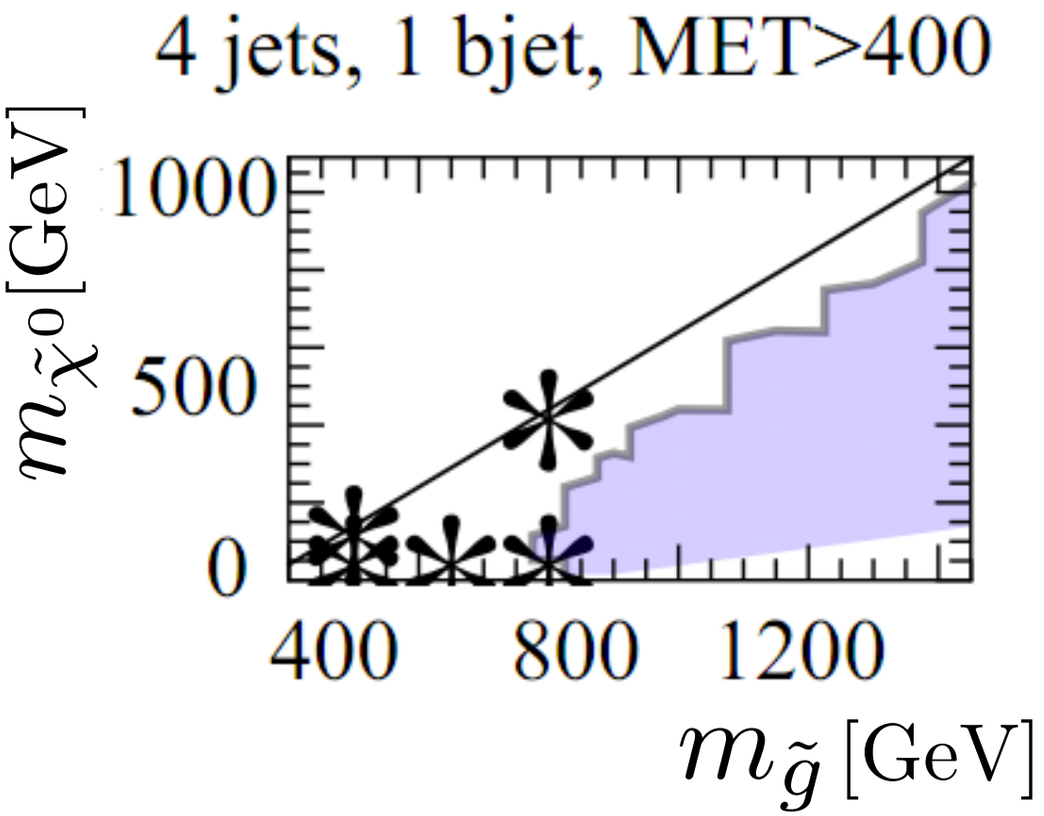
3 Low BG Heavy Flavor

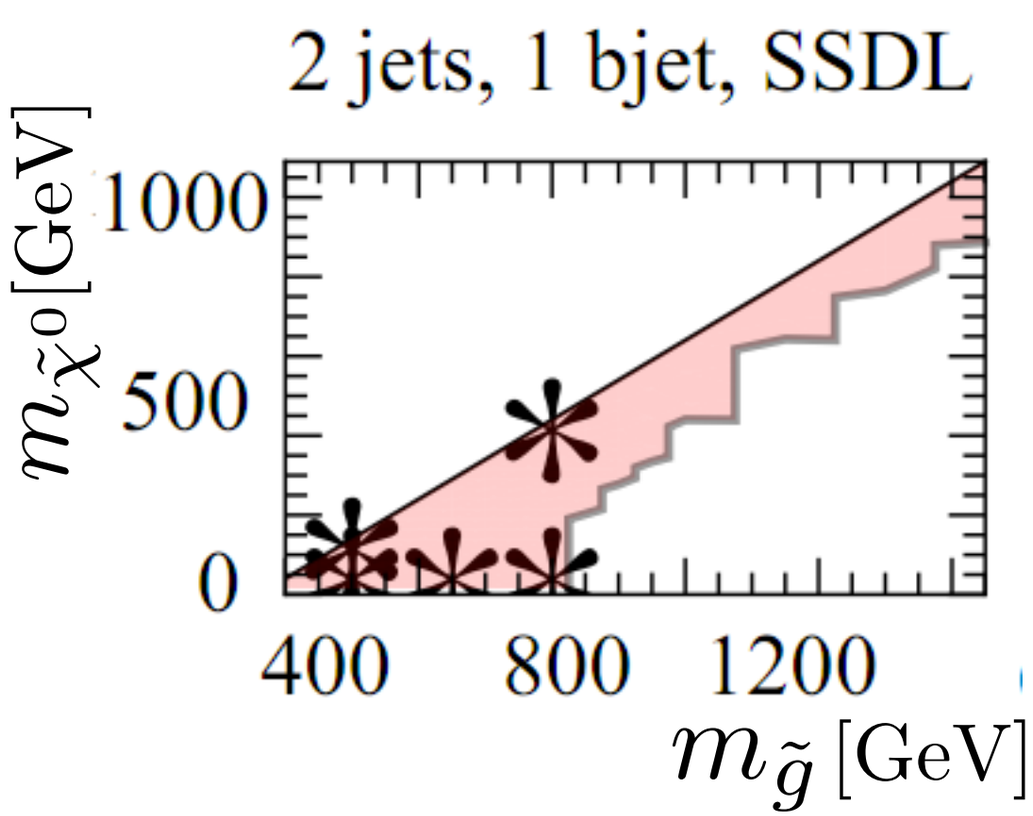
MultiRegion Search Strategy for Heavy Flavor

4 tops + MET

$$pp \to \tilde{g}\tilde{g} \to (t\bar{t}\chi^0)(t\bar{t}\chi^0)$$

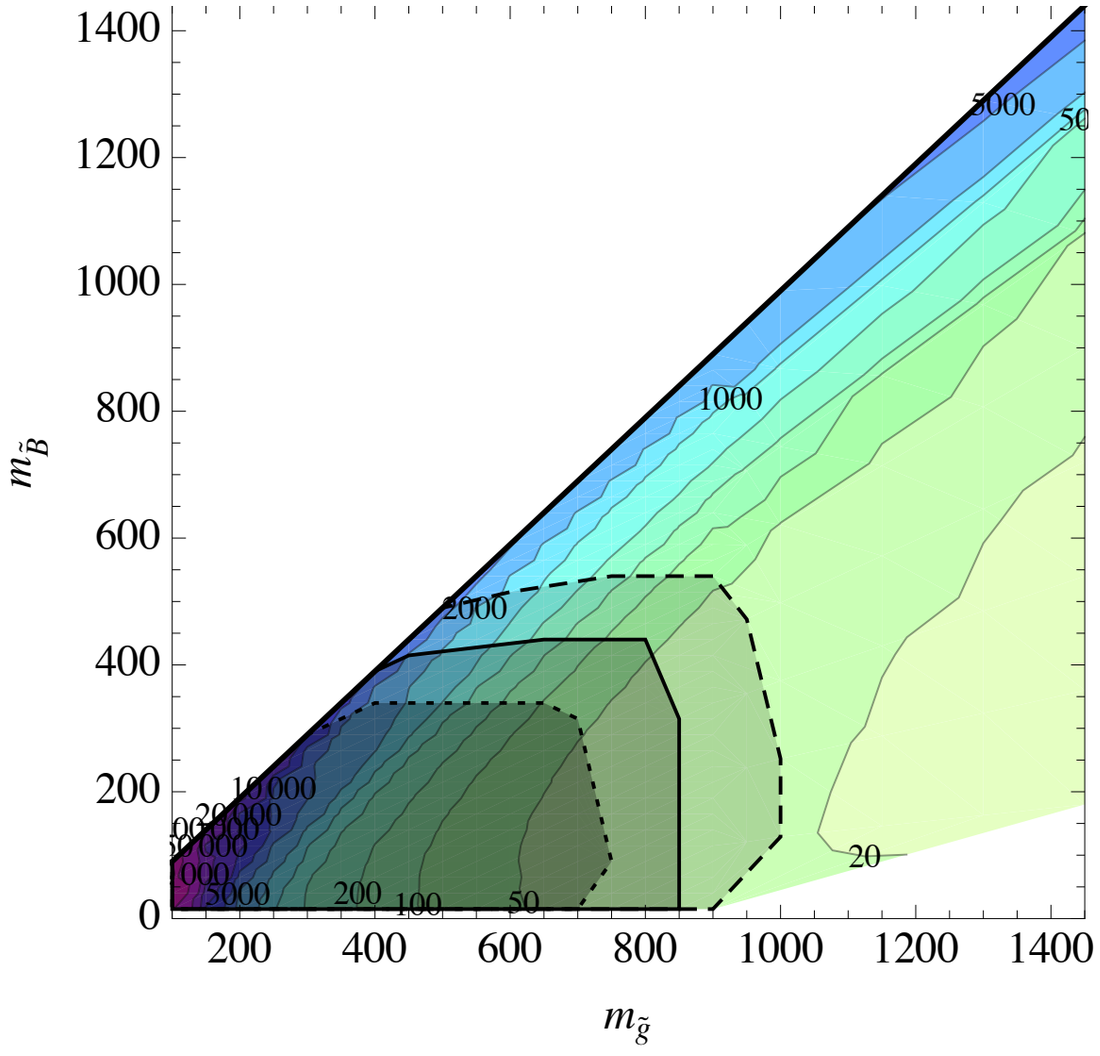
2 search regions cover everything at 1fb^{-1}



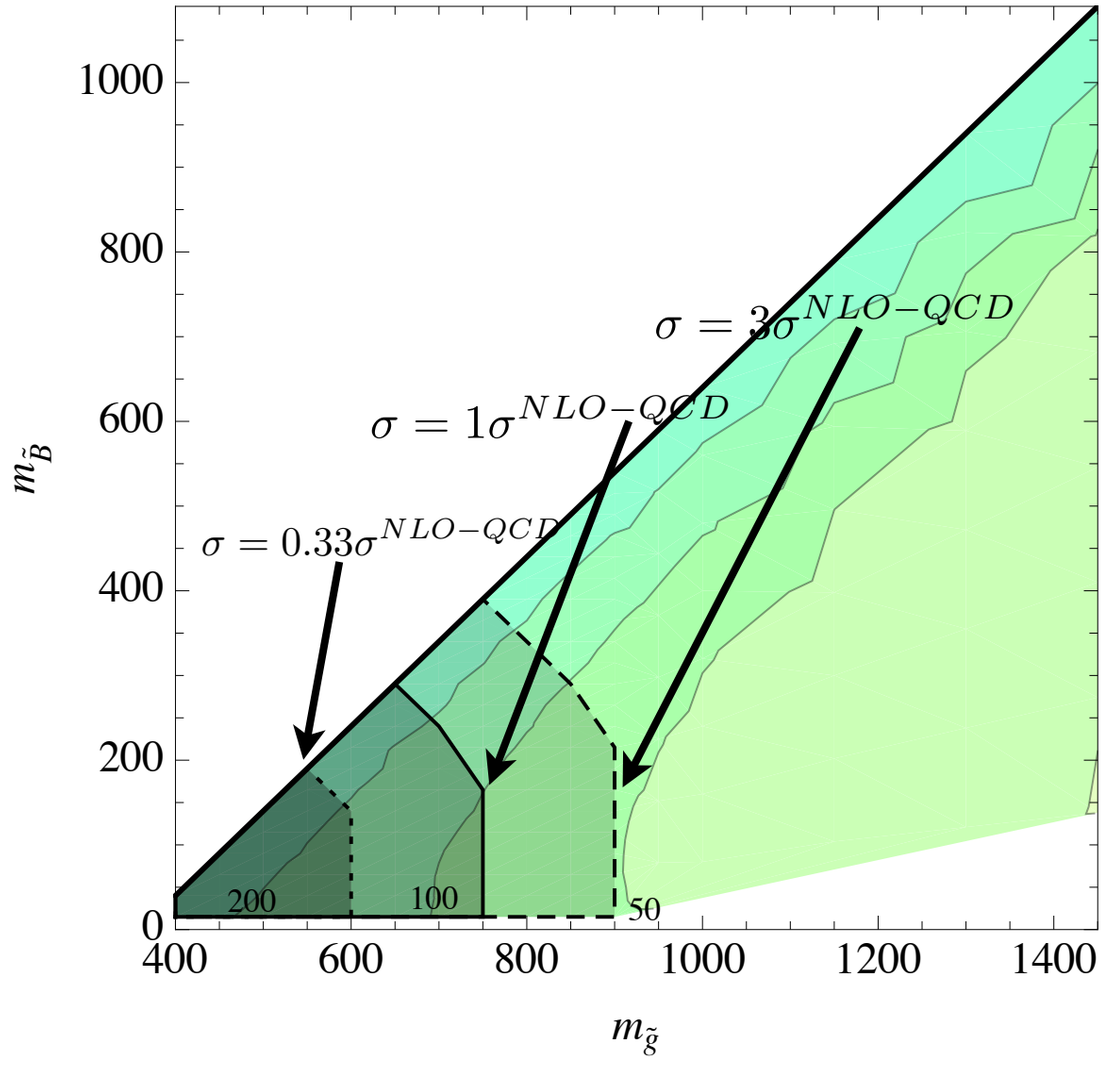


Estimated reach at L=1/fb

$4b + \not{E}_T$



$4t + \not{E}_T$



Search regions found

We shouldn't expect the search regions found to be used by experimentalists

We have relied on theorists' attempts at understanding the LHC detectors (e.g. using PGS...)

This procedure would have to be validated by the experimentalists

Not an easy task since they use full detector simulator
Can be slow on ~ 2500 model points

Found 60 (kinematically) different benchmark points
from the space of ~ 2500 points that when optimized w/r
to them give ~ 9 search regions that cover entire model space

Conclusions

The LHC has opened up the energy frontier. Discoveries may be just around the corner.

It's important that the experiments look in many places.
New physics may be hiding in previously unexplored corners.

Simplified Models provide a framework for casting a wide net on new physics

Thank you