Model-Independent Gluino Searches at the Tevatron and LHC

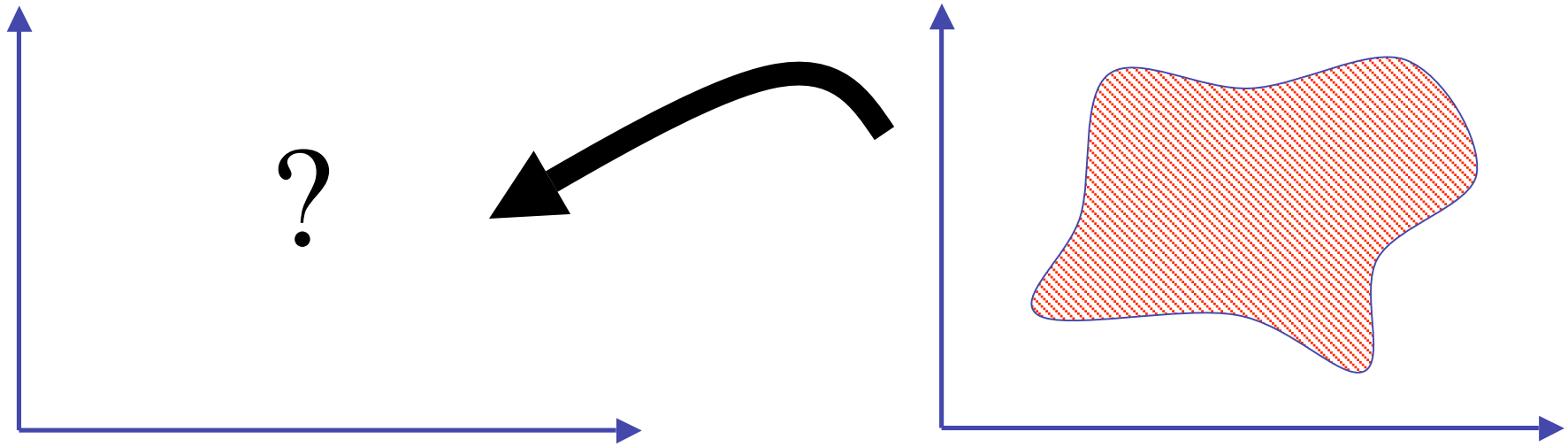
Mariangela Lisanti

J. Alwall, M-P. Le, J. G. Wacker

Stanford University, SLAC

Parameter Space

Signature Space



i.e., mass, coupling, branching fraction

i.e., momentum, missing energy, invariant mass

Many theories for new physics give the *same* experimental signature. How do we distinguish?

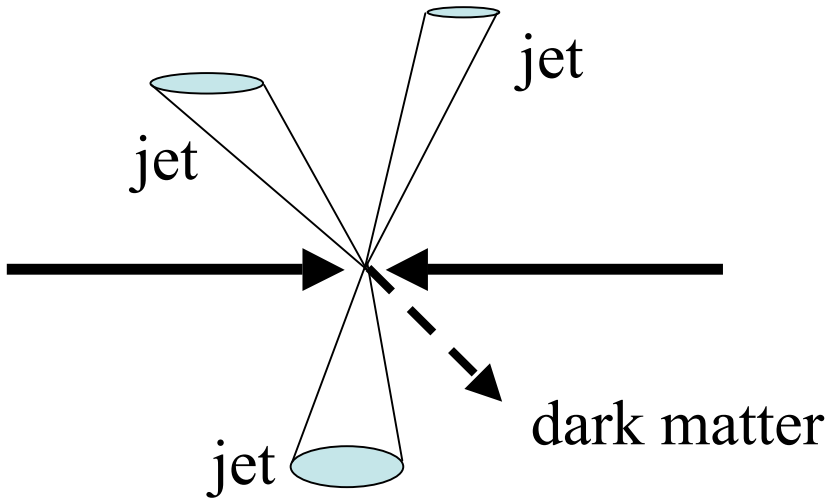
Can we place meaningful bounds in parameter space in a model-independent manner?

Jets + MET

Signature of a new colored particle decaying into dark matter

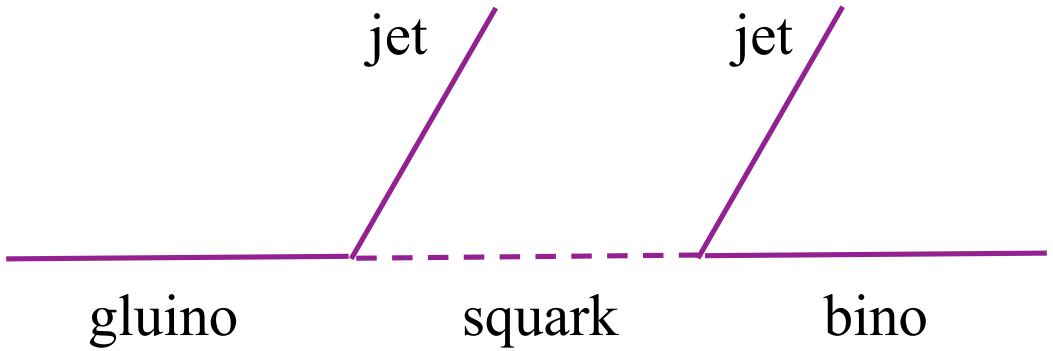
Promising signature for new physics

(UED, SUSY, Little Higgs)



Jets + MET

Currently, jets + MET searches at the Tevatron are based on the MSSM



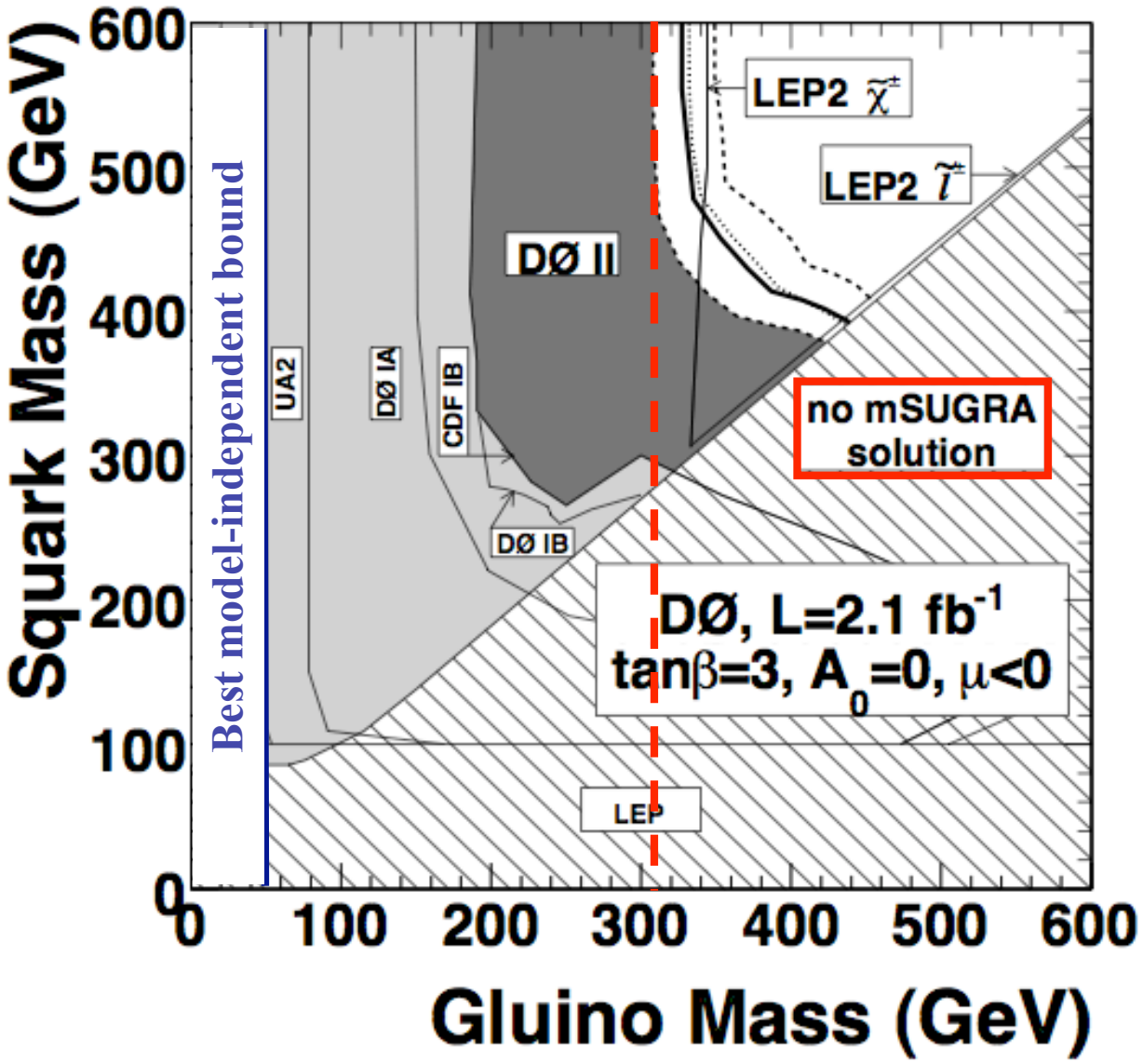
…but the MSSM has *hundreds* of parameters…

mSugra

…so simplifying assumptions are made…

In mSugra, 5 parameters determine all observables, making it easier to set bounds.

Jets + MET



Model-Dependent Bound

Jets + MET

- mSUGRA is not representative of all supersymmetric models
  - ratio of gluino & bino masses is approximately constant

$$m_{\tilde{g}} : m_{\tilde{B}} \simeq 6 : 1$$

- other models of susy breaking give different ratios - i.e.,
  - anomaly mediation

$$m_{\tilde{g}} : m_{\tilde{B}} \simeq 1 : 1$$

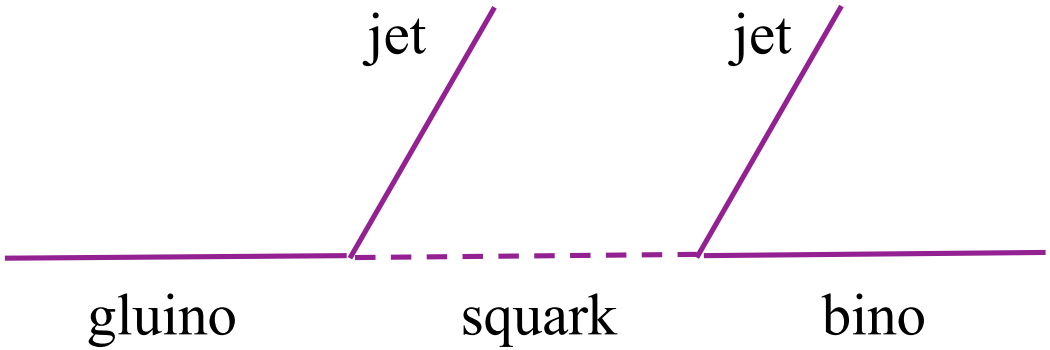
  - mirage mediation

$$m_{\tilde{g}} : m_{\tilde{B}} \simeq 7 : 3$$

Jets + MET

There is a large range of kinematically-accessible gluinos where there are no known limits

Kinematics



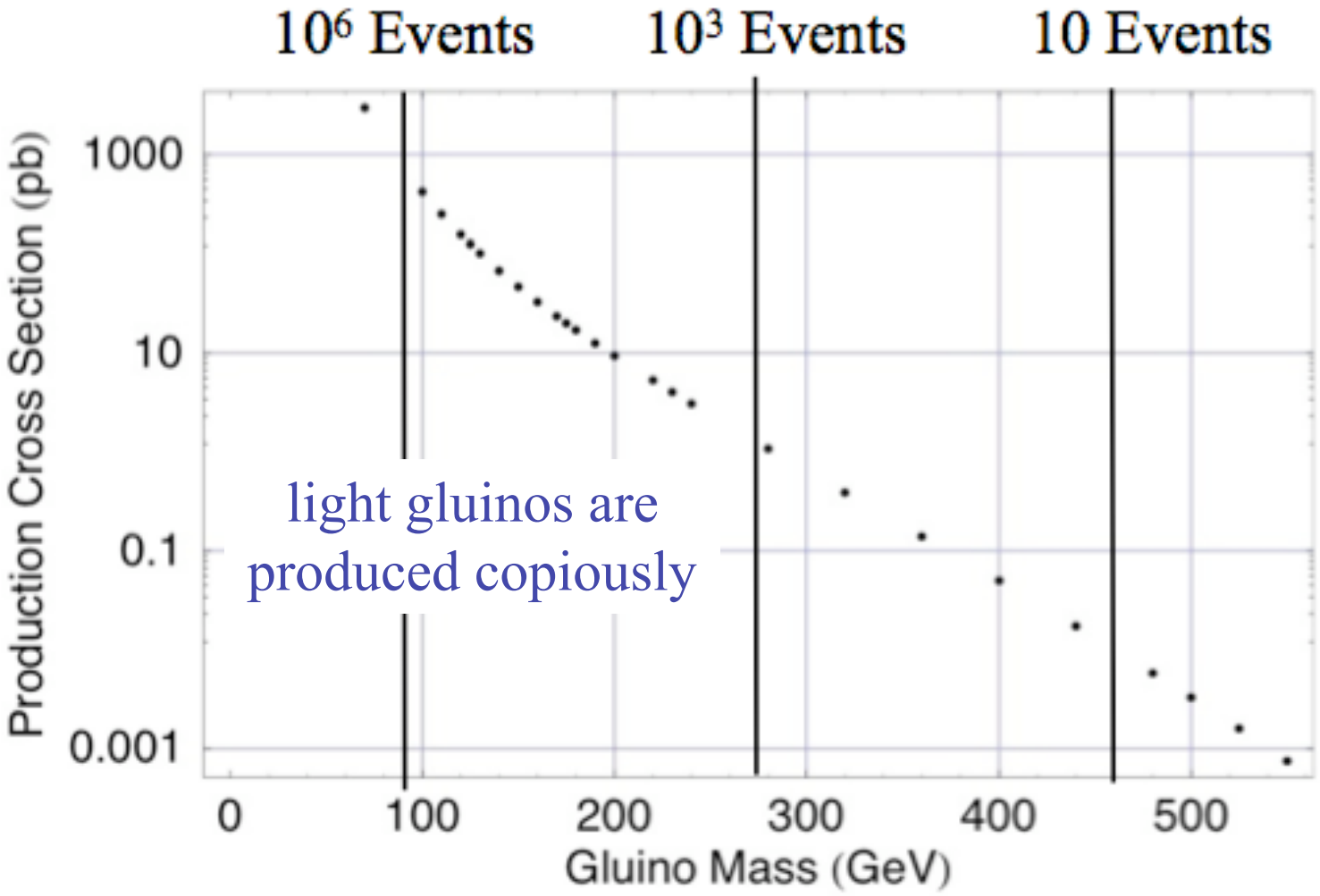
Mass difference between gluino and bino is relevant quantity

$m_{\tilde{g}} \gg m_{\tilde{B}}$ hard, well-separated jets

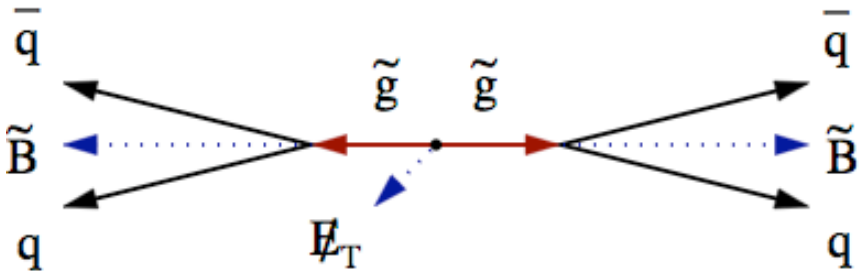
$m_{\tilde{g}} \sim m_{\tilde{B}}$ jets will not be as energetic, challenging to see

Let's focus on the degenerate case for the moment…

Kinematics


10^6 Events
10^3 Events
10 Events
Production Cross Section (pb)
1000
10
0.1
0.001
0
100
200
300
400
500
Gluino Mass (GeV)
light gluinos are
produced copiously

Kinematics



A challenge to see because

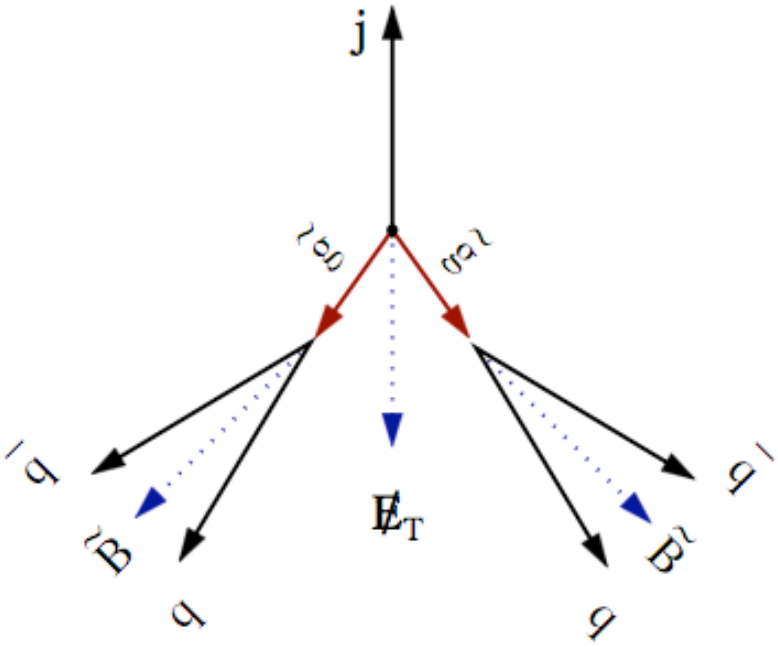
- jets are soft
- bino momenta cancel when reconstructing MET

Kinematics

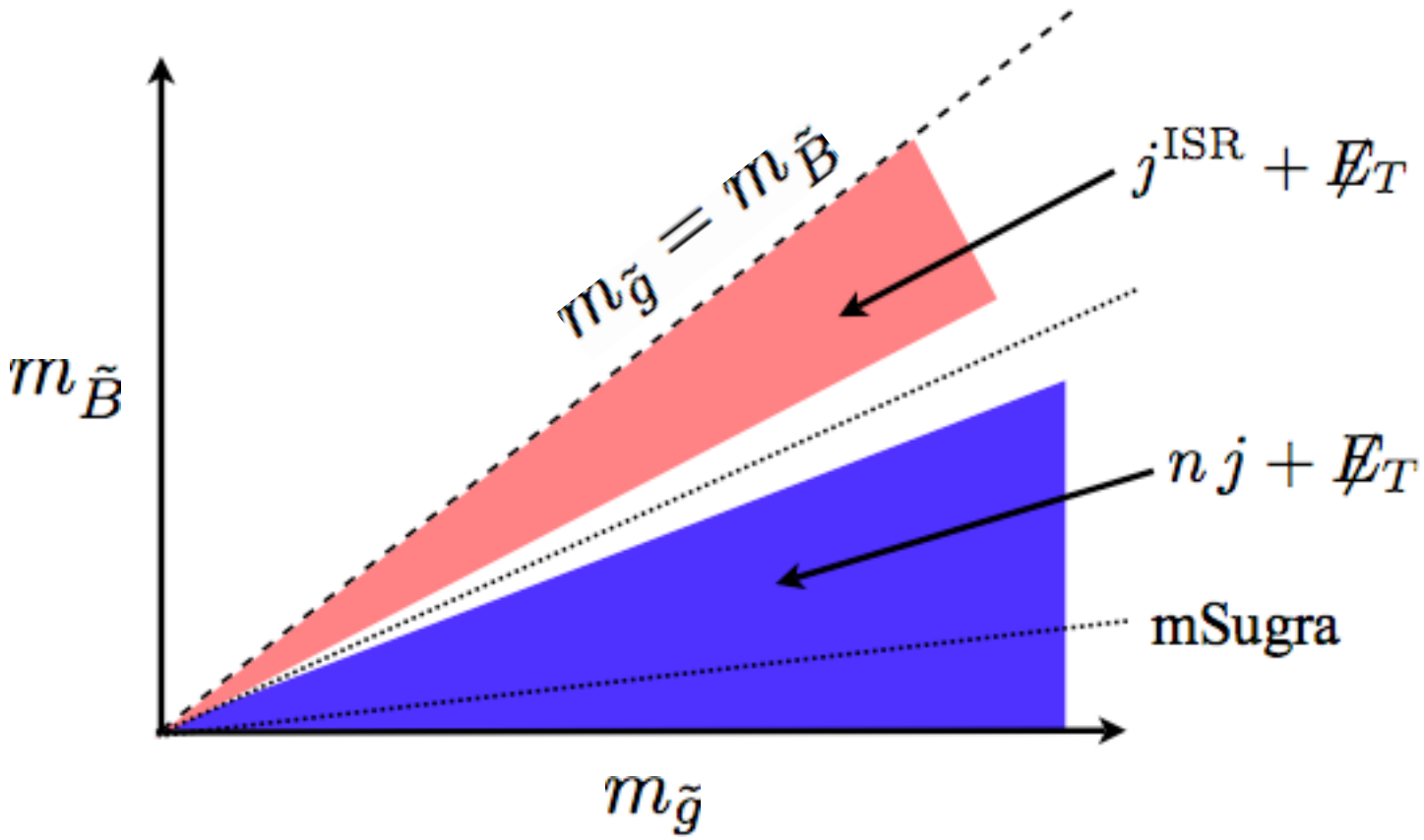
The trick:

Boost the gluinos with initial-state radiation…

…this increases the MET of the event



Exclusion Region



Event Generation

MadGraph/MadEvent to generate signal and backgrounds

PYTHIA for parton-showering and hadronization

PGS for detector simulation

Backgrounds

The Standard Model backgrounds for jets + MET searches are

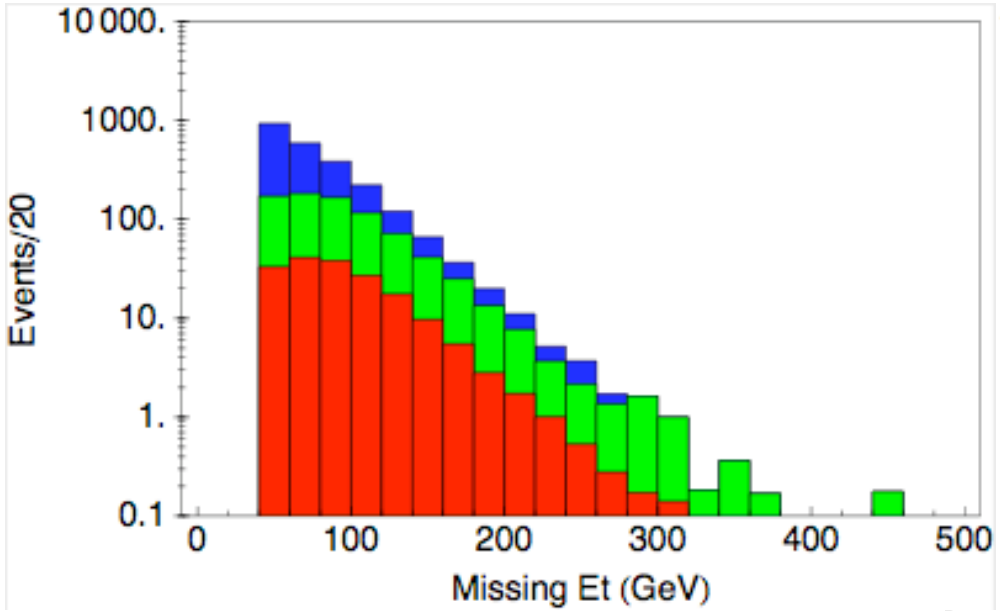
- $Z^0 + nj \qquad \left(Z^0 \to \nu\nu\right)$
- $W^{\pm} + nj \qquad \left(W^{\pm} \to l^{\pm}\nu\right)$
- $t\bar{t} \qquad \left(t \to j + W^{\pm}\right)$

- QCD : not simulated here

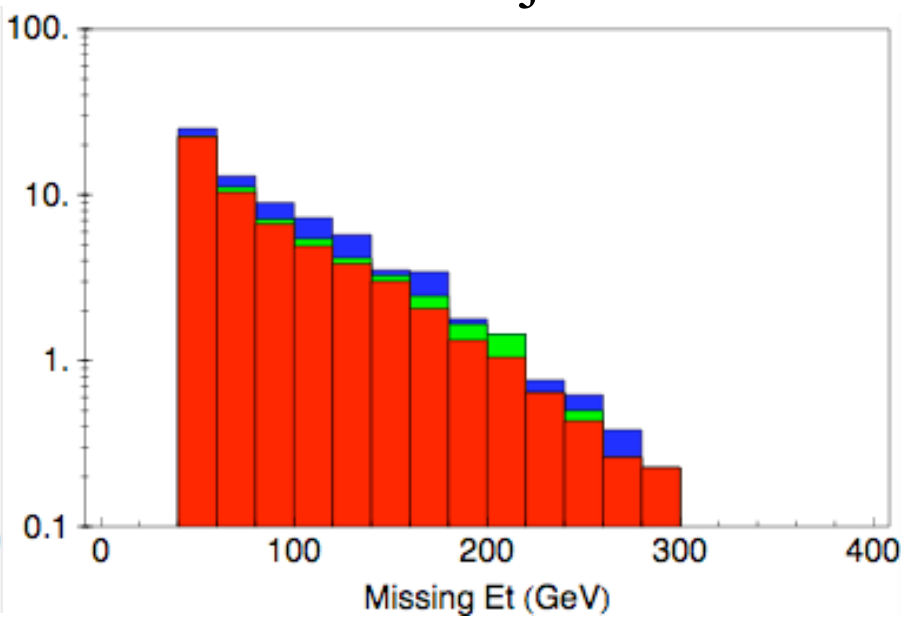
Backgrounds

Different backgrounds dominate for different searches

Dijet



Multijet



{ Red: top Green: Z Blue: W }

Game Plan

Currently, at DØ…

Run 4 *inclusive* searches (1j, 2j, 3j, 4+j)

- Optimize each for a "characteristic" point in mSUGRA space

	Gg	$\tilde{q}\tilde{q}$	$\tilde{q}\tilde{g}$	$\tilde{g}\tilde{g}$
	$1j + \not{E}_T$	$2j + \not{E}_T$	$3j + \not{E}_T$	$4j + \not{E}_T$
$E_{T\,j_1}$	≥ 150	≥ 35	≥ 35	≥ 35
$E_{T\,j_2}$	< 35	≥ 35	≥ 35	≥ 35
$E_{T\,j_3}$			≥ 35	≥ 35
$E_{T\,j_4}$				≥ 20
$\not{E}_T$	≥ 150	≥ 225	≥ 150	≥ 100
H_T	≥ 150	≥ 300	≥ 400	≥ 300

(Not exclusive searches)

$$H_T = \sum E_{T\,j}$$

Game Plan

Hopefully, for the future…

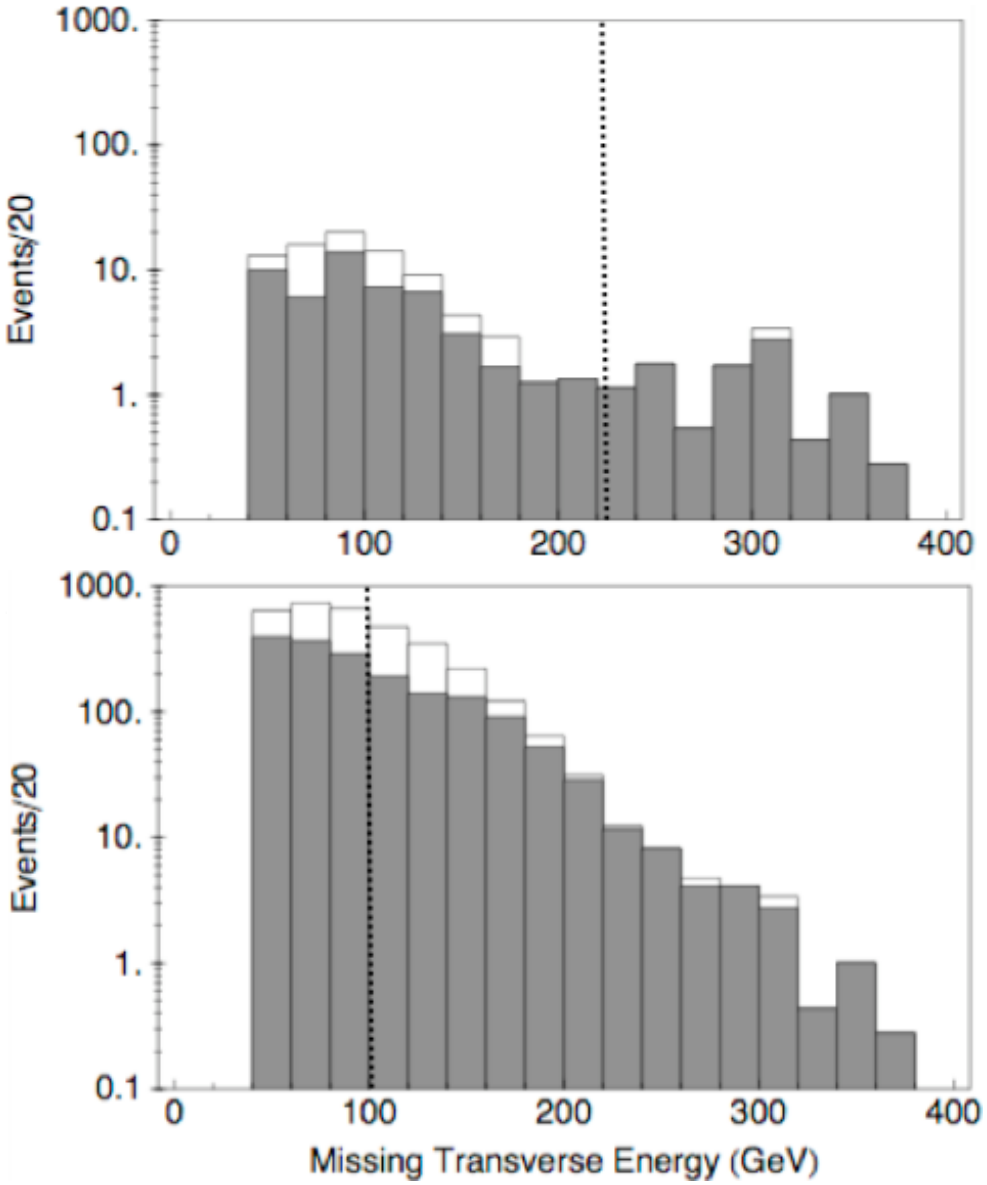
Run 4 *exclusive* searches (1j, 2j, 3j, 4+j)

- Optimize each individually
  - Maximize significance for each gluino-bino mass point

	$1j + \not{E}_T$	$2j + \not{E}_T$	$3j + \not{E}_T$	$4j + \not{E}_T$
$E_{T\,j_1}$	≥ 150	≥ 35	≥ 35	≥ 35
$E_{T\,j_2}$	< 35	≥ 35	≥ 35	≥ 35
$E_{T\,j_3}$	< 35	< 35	≥ 35	≥ 35
$E_{T\,j_4}$	< 20	< 20	< 20	≥ 20
$\not{E}_T$				
H_T				

Maximize significance for each $m_{\tilde{g}}, m_{\tilde{B}}$

Optimized Cuts

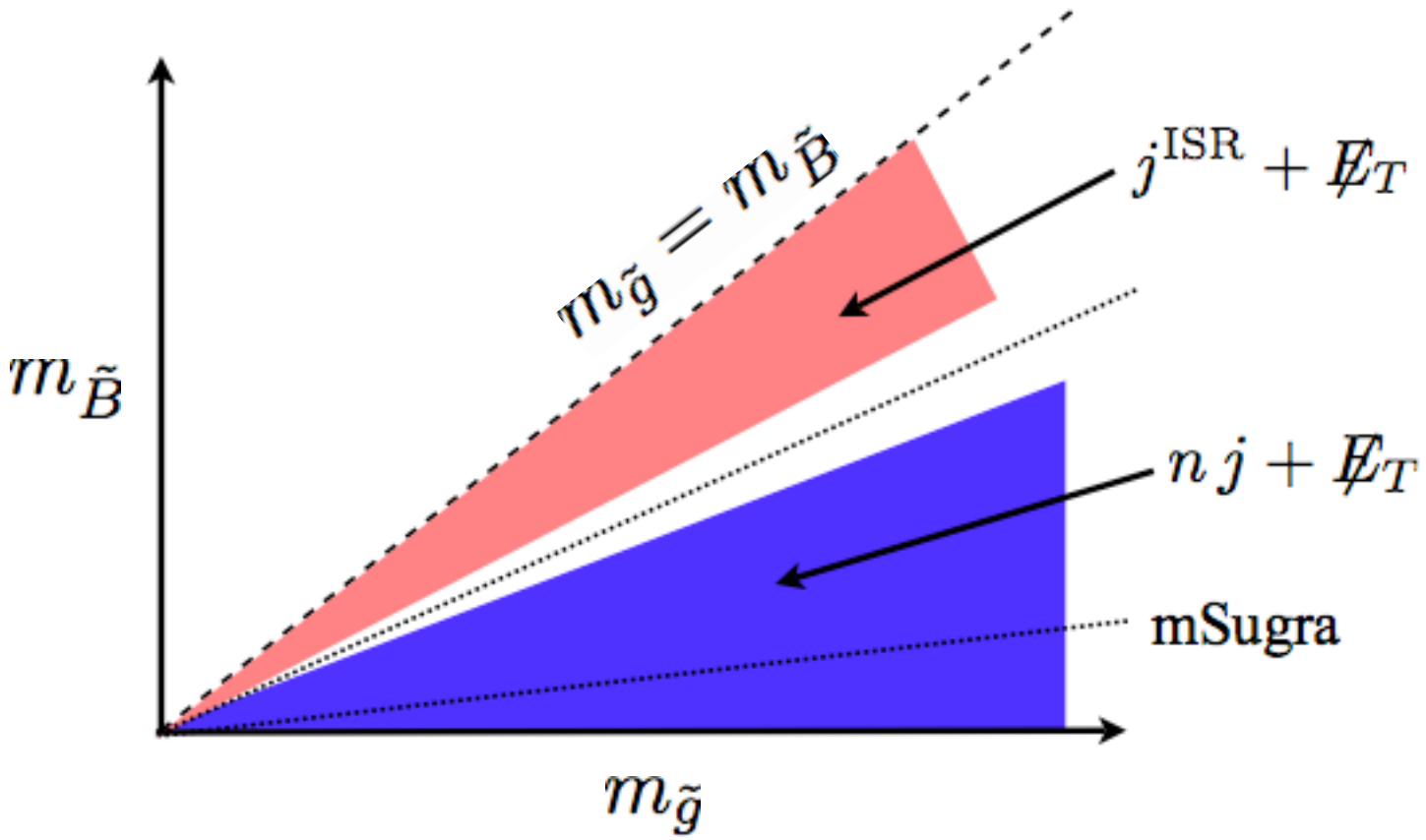


with non-optimized DØ cuts

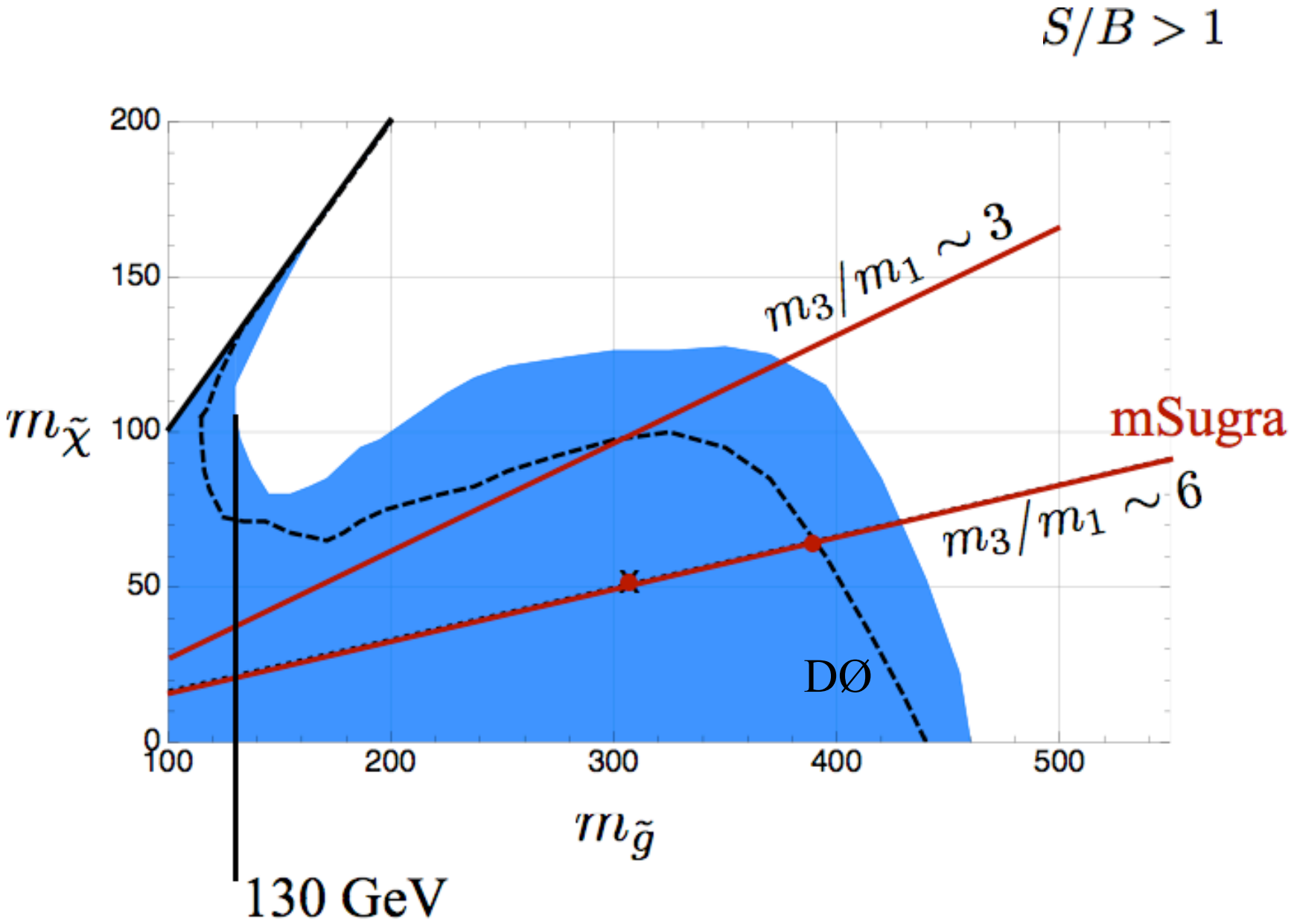
with optimized cuts

{ Gray: Background
White: Signal }

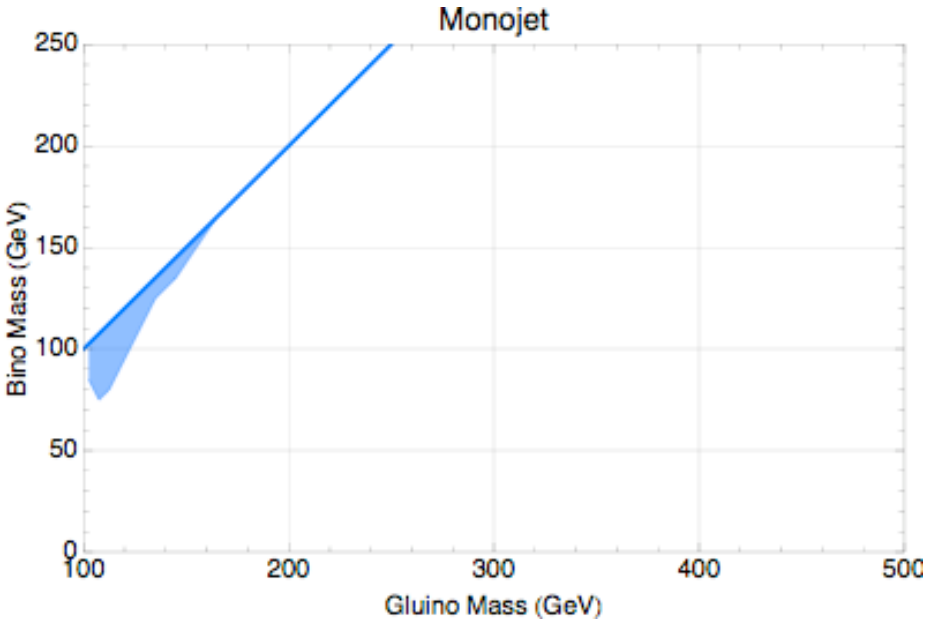
Exclusion Region

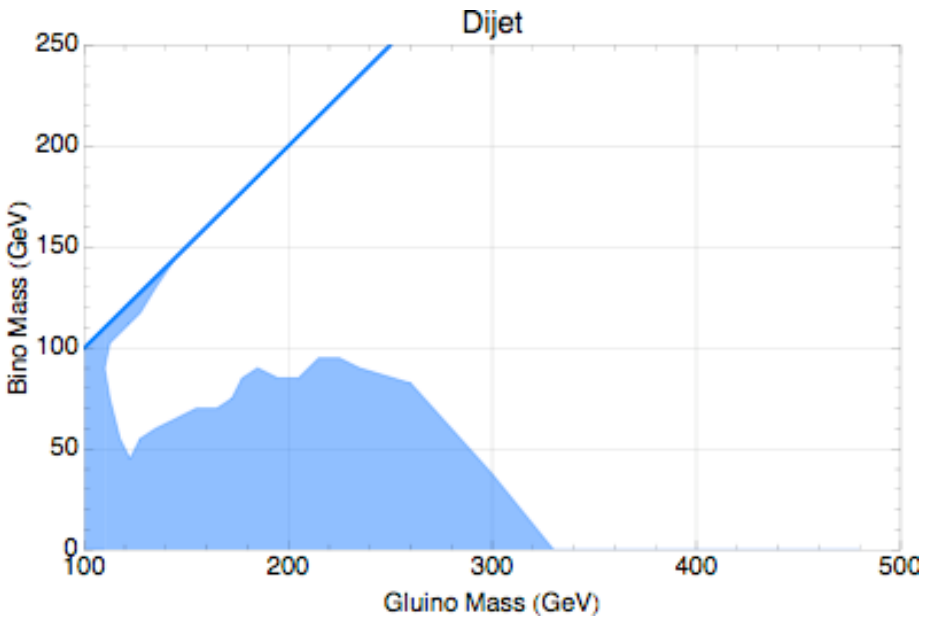


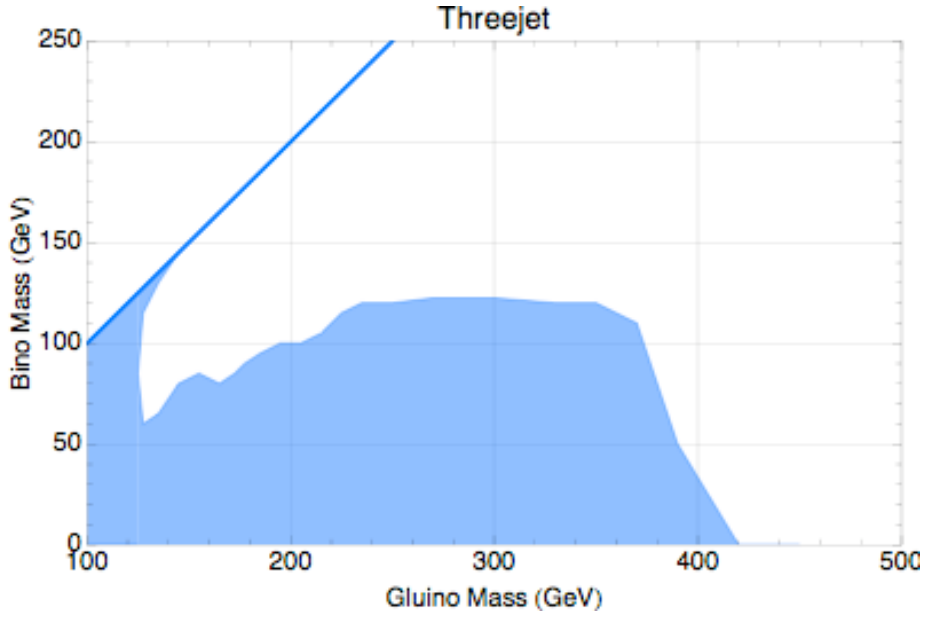
Exclusion Limits

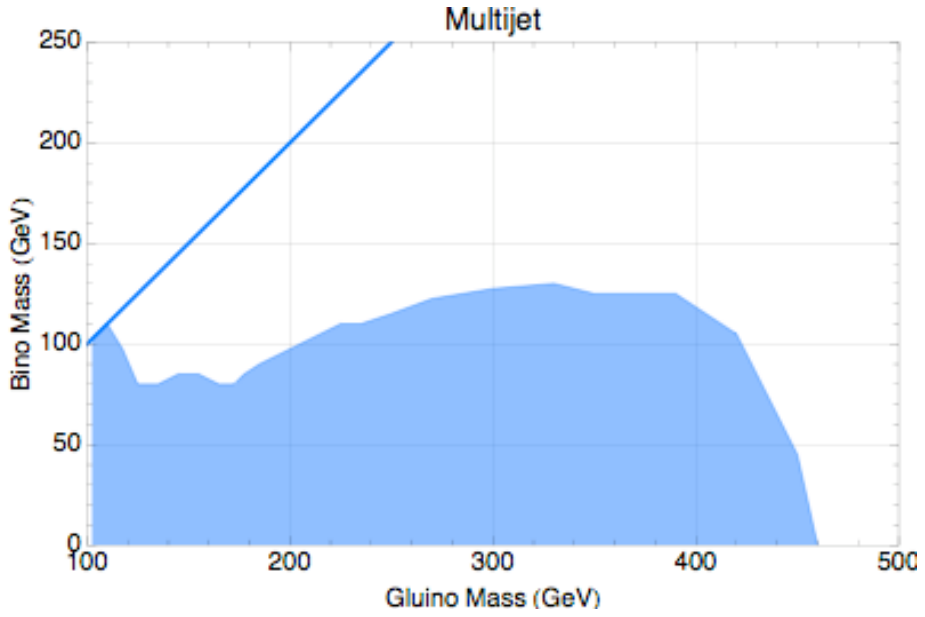


Exclusive Searches









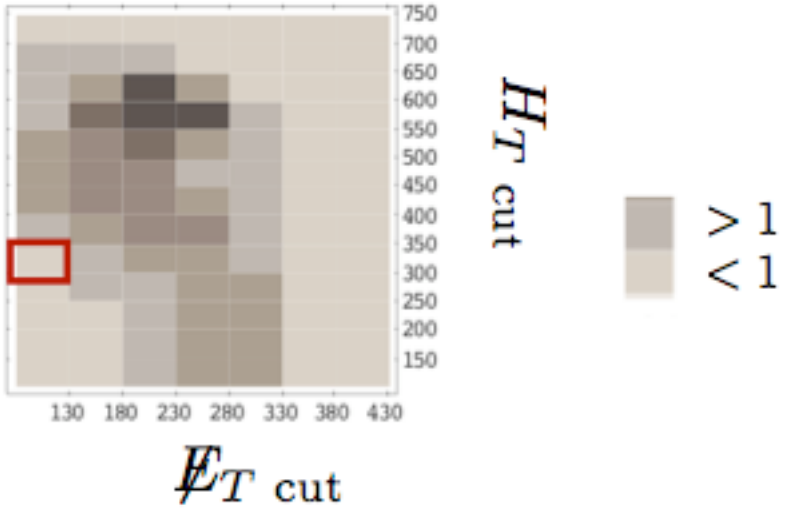
Conclusions

- Model-independent search for jets + MET
  - exclusive searches with optimized HT & MET cuts
  - provides significant coverage beyond mSUGRA-motivated searches
- Methodology can easily be applied to LHC
  - modify cuts on jet p_T and MET

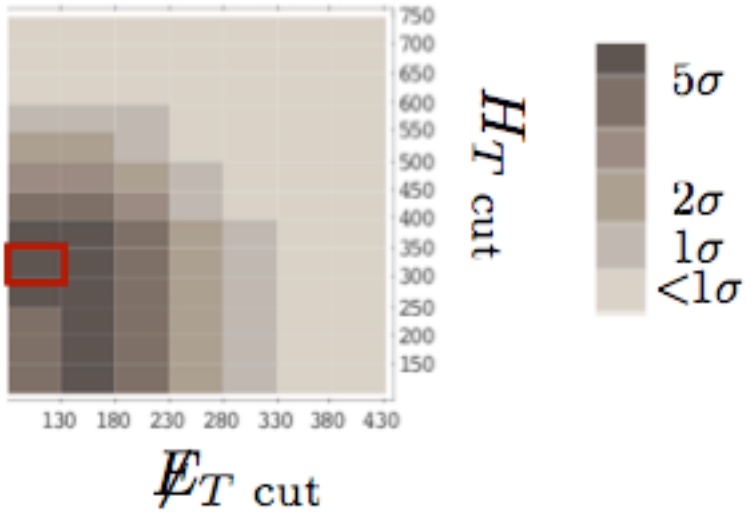
Extra Slides

Optimized Cuts

S/B



$S/\sqrt{B}$



For *each* mass point, find

$$(\mathrm{MET}, H_T)_{\mathrm{cut}}$$

that gives

$$S/B > 1 \text{ and } S/\sqrt{B} > 2$$