Model-independent limits from missing energy searches

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with

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Problem Statement

- We have no idea what any new physics beyond the Standard Model might look like
- Any models we come up with needs to be compared with experimental data from LHC and Tevatron
- The experimentalists have limited manpower
- How can data be communicated between experiments and theorists to allow comparison for any model, as well as providing maximum information useful to theorists?

Presenting experimental data

Twofold problem:

- How to analyze/report limits on cross sections in a way that can be compared (by theorists) with any model?

J.A., Le, Lisanti, Wacker [arXiv:0809.3264]

- How to analyze/report/characterize stable excesses over background in a way that can be compared to any model and give relevant information on the underlying physics without bias to a certain model?

J.A., Schuster, Toro [arXiv:0810.3921]

Presenting experimental data

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This talk

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Next talk

Present approaches

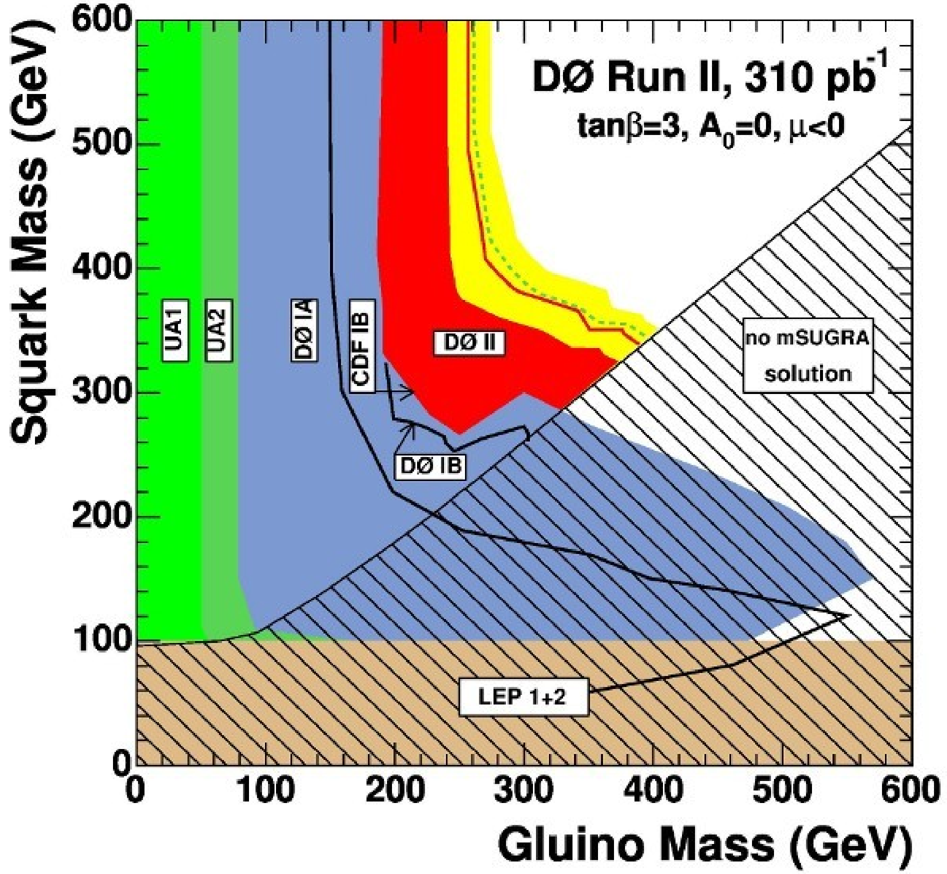
- Exclusions in model space of minimal model (mSUGRA/mGMSB/mAMSB) with few (~4) parameters
- Signature-based exclusions (cross section limits given some “standard” set of cuts)
- In case of excesses: Plots of data vs. backgrounds
- In case of excesses: Scans of SUSY space (~20 param) using high-level kinematical information

Present approaches

- Exclusions in model space of minimal model (mSUGRA/mGMSB/mAMSB) with few (~4) parameters
- Problems:
  - Fixed relations between parameters, e.g. $m_{\tilde{g}}:m_{\tilde{W}}:m_{\tilde{B}} \sim 6:2:1$
    LSP
  - Fixed decays and branching ratios
  - Not all possible parameter space covered

Present approaches

- Exclusions in model space of minimal model (mSUGRA/mGMSB/mAMSB) with few (~4) parameters



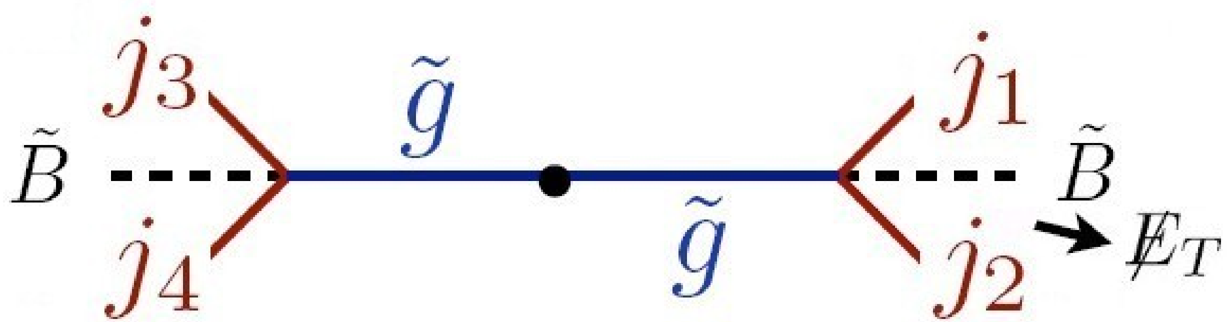
Present approaches

- Signature-based exclusions (cross section limits given some “standard” set of cuts)
  - Restricted in scope, reduced power
- In case of excesses: Plots of data vs. backgrounds
  - Detector deconvolution difficult/impossible
- In case of excesses: Scans of SUSY space (~20 param) using high-level kinematical information and rate information
  - Assumes SUSY, needs high-statistics data

Non-standard scenarios

Example: Non-unified/non-standard SUSY scenarios can have free ratio $m_{\tilde{g}}:m_{\tilde{B}}$

- $m_{\tilde{g}}:m_{\tilde{B}} \sim 1 \rightarrow$ gluino decays to 2 soft jets and LSP
  - No hard jets, small missing transverse energy



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Example: Non-unified/non-standard SUSY scenarios can have free ratio $m_{\tilde{g}}:m_{\tilde{B}}$

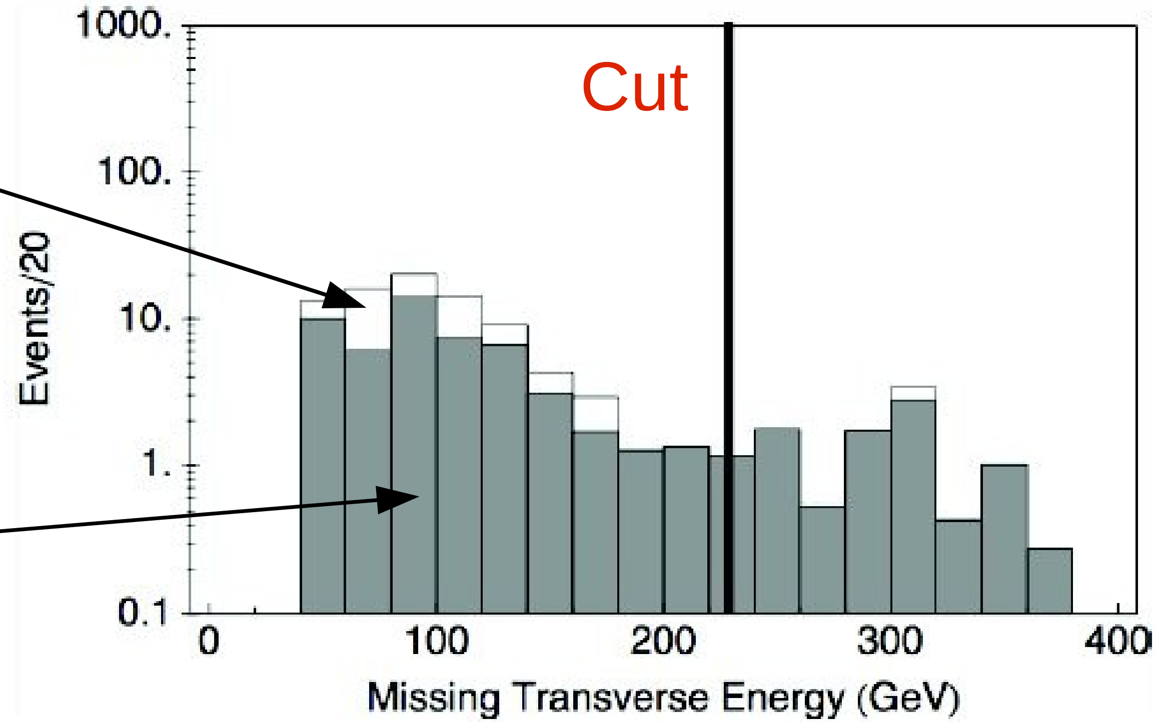
- $m_{\tilde{g}}:m_{\tilde{B}} \sim 1 \rightarrow$ gluino decays to 2 soft jets and LSP
  - No hard jets, small missing transverse energy
- Unclear where Tevatron is sensitive
- Difficult/impossible to find limits outside collaboration

Non-standard scenarios

- Example: m_g = 210 GeV and m_B = 100 GeV
- DØ dijet cuts, based on mSUGRA scenario: $H_T > 300$ GeV, $\not{E}_T > 225$ GeV

Signal

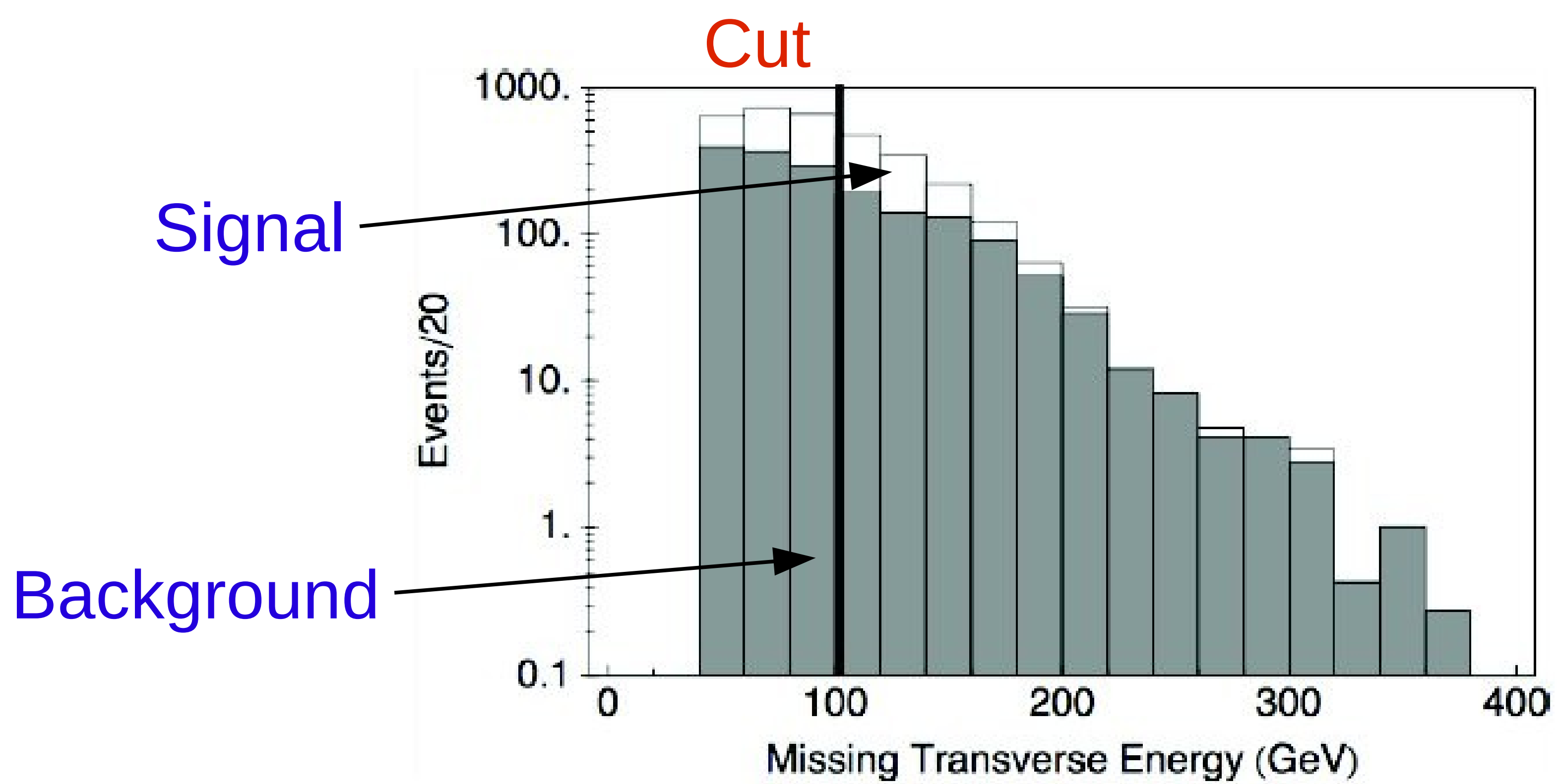
Background



Standard cuts remove signal as well as background

Non-standard scenarios

- Example: m_g = 210 GeV and m_B = 100 GeV
- Optimized cuts: H_T > 150 GeV, $\not{E}_T$ > 100 GeV



Optimized cuts allow much improved S/B

Cross section limits

Our suggestion to experimentalists:

- Provide differential cross section limits for multiple phase space bins (in relevant variables) for mutually exclusive searches (1j+MET, 2j+MET, ...)
- Provide detector simulation and event generation chain verified to allow comparison in relevant phase space regions
- Note! Only applicable for “hard” signals, where details of detector not crucial

Cross section limits

Our suggestion to experimentalists:

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Dijet

H_T \ $\not{E}_T$	100–150	150–200	200–250	250–300	300–350
500–600	$0.5\oplus0.1$	$0.5\oplus0.1$	$0.5\oplus0.0$	$0.5\oplus0.0$	$0.5\oplus0.0$
400–500	$0.9\oplus0.7$	$0.5\oplus0.1$	$0.5\oplus0.1$	$0.5\oplus0.1$	$0.5\oplus0.0$
300–400	$1.1\oplus1.3$	$0.7\oplus0.3$	$0.7\oplus0.4$	$0.7\oplus0.4$	$0.8\oplus0.5$
200–300	$2.6\oplus14$	$2.1\oplus8.5$	$1.6\oplus5.0$	$1.0\oplus1.1$	
100–200	$7.6\oplus120$	$3.0\oplus19$			

1σ limits in fb for 4 fb^{-1} at the Tevatron

Cross section limits

- Then, easy for theorists to generate the corresponding model cross sections (using generation setup) and compare, point-by-point in parameter space, to get exclusion region

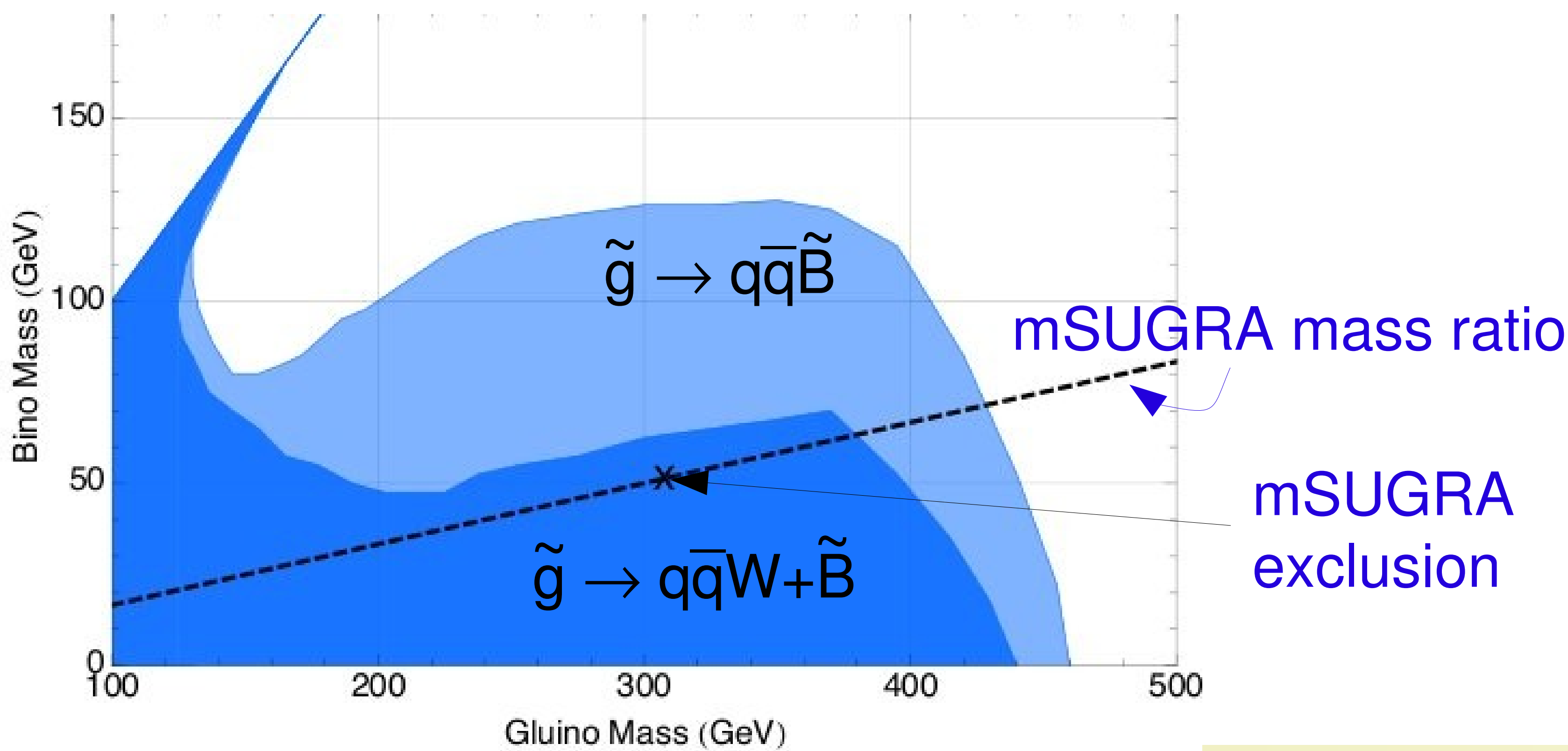
Dijet

H_T \ $\not{E}_T$	100–150	150–200	200–250	250–300	300–350
500–600	0	0	0	0	0
400–500	0.2	0.2	0.1	0	0
300–400	0.6	0.7	0.6	0.4	0.1
200–300	1.4	1.9	1.6	0.3	
100–200	0.9	0.5			

Cross sections in fb, 340 GeV gluino, 100 GeV LSP

Cross section limits

- Examples:
  - Gluinos decaying to $q\bar{q}$+LSP
  - Gluinos decaying to $q\bar{q}W$+LSP (with $m_{\tilde{W}}-m_{\tilde{B}} \sim m_W$)



Conclusions

- Idea to allow theorists to find (approximate) exclusion region for any model (with missing E_T signature) based on experimental searches
  - Provide grid of differential cross sections in number of jets and different missing E_T and H_T cuts
  - Provide authorized detector simulation and event generation parameters
- Can be easily and naturally extended to any high-p_T signatures

Backup slides

Searches at the Tevatron

	$1j + \not{E}_T$	$2j + \not{E}_T$	$3j + \not{E}_T$	$4^+j + \not{E}_T$
$E_{T\ j_1}$	≥ 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

two hardest jets $|\eta| \leq 0.8$ other jets $|\eta| \leq 2.5$

Statistics

$$\langle S^{\rm excl}(B)\rangle = \sum_{N_m=0}^{\infty} S^{\rm excl}(N_m,B)\frac{e^{-B}B^{N_m}}{N_m!}$$

$$\lim_{B\to\infty}\langle S^{\rm excl}(B)\rangle = \sqrt{B}.$$

$$\lim_{B\to 0}\langle S^{\rm excl}(B)\rangle = -\ln(0.16)\approx 1.8$$

$$\chi^2_N = \sum_{j=1}^{N}\frac{S_j^2}{({\rm SL}_j)^2+(\epsilon_{\rm sys}\times B_j)^2}\times\frac{1}{N}$$

- Include only measurements with expected significance > S^{crit} (e.g. 0.5)