Signatures of compressed SUSY

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- Introduction
- Compressed gluinos: kinematic variables for attacking the problem
- Conclusions

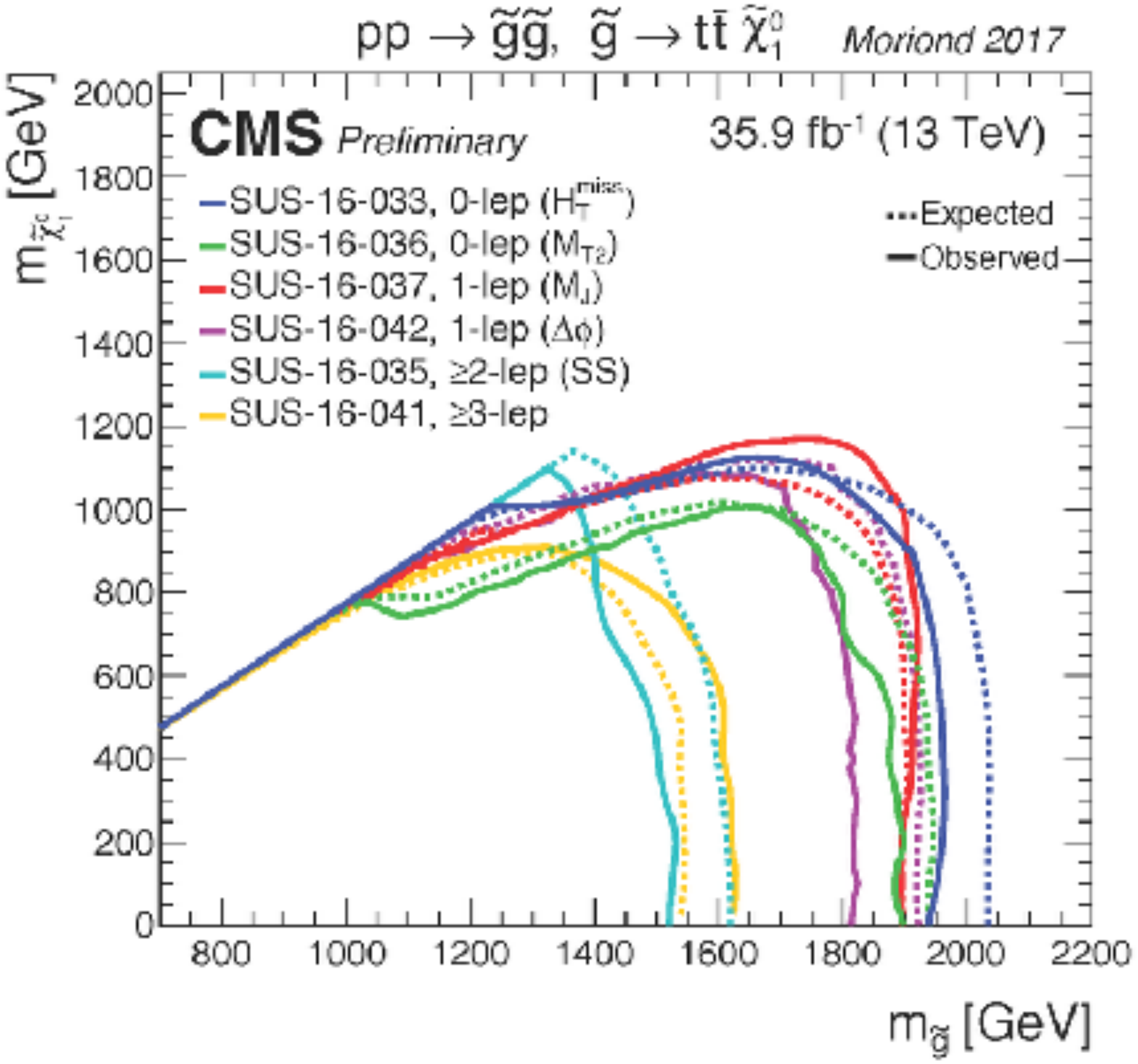
Worked based on:
AD, A. Martin, Nirmal Raj arXiv:1605.06479

Introduction

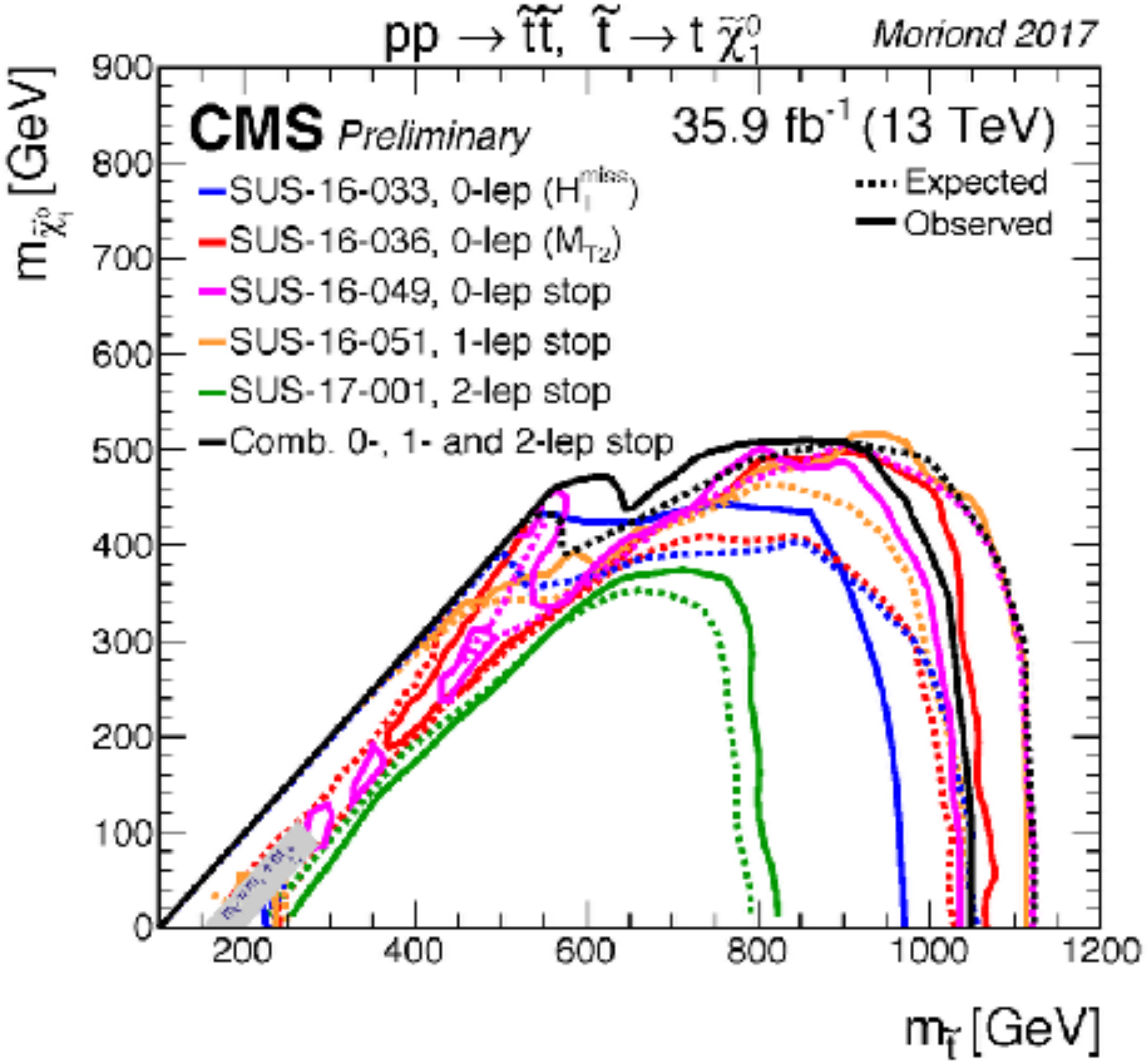
- With the discovery of the Higgs the SM is now a complete description for particle physics (forgetting DM).
- On the other hand that same discovery by itself makes the theory fine-tuned.
- The lack of any other experimental evidence makes us believe that either the SM is the only theory above the Fermi scale or....

- Any model aiming to explain the hierarchy problem has to remain ‘natural’ while being able to satisfy experimental bounds that are starting to be somewhat ‘unnatural’…….

- One possibility for SUSY models to escape the bounds on superparners is to suppose that the spectrum is compressed.



$pp \to \tilde{g}\tilde{g},\ \tilde{g} \to t\bar{t}\,\tilde{\chi}^0_1$
Moriond 2017
CMS Preliminary
35.9 fb^{-1} (13 TeV)
SUS-16-033, 0-lep (H_T^{miss})
SUS-16-036, 0-lep (M_{T2})
SUS-16-037, 1-lep (M_J)
SUS-16-042, 1-lep ($\Delta\phi$)
SUS-16-035, ≥2-lep (SS)
SUS-16-041, ≥3-lep
Expected
Observed
$m_{\tilde{\chi}^0_1}$ [GeV]
0
200
400
600
800
1000
1200
1400
1600
1800
2000
800
1000
1200
1400
1600
1800
2000
2200
$m_{\tilde{g}}$ [GeV]



$pp \to \tilde{t}\bar{\tilde{t}},\ \tilde{t} \to t\,\tilde{\chi}^0_1$
Moriond 2017
CMS Preliminary
35.9 fb^{-1} (13 TeV)
SUS-16-033, 0-lep (H_T^{miss})
SUS-16-036, 0-lep (M_{T2})
SUS-16-049, 0-lep stop
SUS-16-051, 1-lep stop
SUS-17-001, 2-lep stop
Comb. 0-, 1- and 2-lep stop
Expected
Observed
$m_{\tilde{\chi}^0_1}$ [GeV]
0
100
200
300
400
500
600
700
800
900
200
400
600
800
1000
1200
$m_{\tilde{t}}$ [GeV]

- I will study a compressed scenario based on DM.
- In this case it will be a situation where the mass of the gluino is only around O(100 GeV) larger than the one of the LSP.
- DM is then obtained via co-annihilation

Compressed Gluinos

- A way of achieving the relic abundance in the MSSM is when the LSP is the Bino which interacts very weakly and there is another particle almost degenerate in mass whose co-annihilations could reproduce the right value for Ωh^2.

- In this scenarios the splitting between the LSP and the NLSP is the one that sets the relic abundance.
- Of all the possible superparners the one with larger interactions are the gluinos.
- Larger interactions means that the splitting will be also larger.

- For the case of the gluino, the splitting needed to correctly explained the relic abundance is:

$$\Delta M \simeq 100 \text{ GeV}$$

- One may wonder in which UV theories that can be achieved, it requieres non-universal gaugino masses but that is all I will talk about this…..

- In order to present the analysis I am going to decouple the rest of the supersymmetric spectrum.

- Therefore the process to study is:

$$p\,p \to \widetilde{g}\,\widetilde{g} \to 2(\widetilde{q})^{*} + 2j \to 2\widetilde{\chi}_1^0 + 4j$$

- Since the mass difference between the gluino and the neutralino is small then:
    - Jets coming from the gluinos are soft.
    - There is not a lot of MET since the gluinos are produced almost at rest and both neutralinos are almost back to back.

- Of course there will also be ISR jets in our events.

- We will distinguish ISR-jets from jets coming from gluinos (honest jets) by the energy.

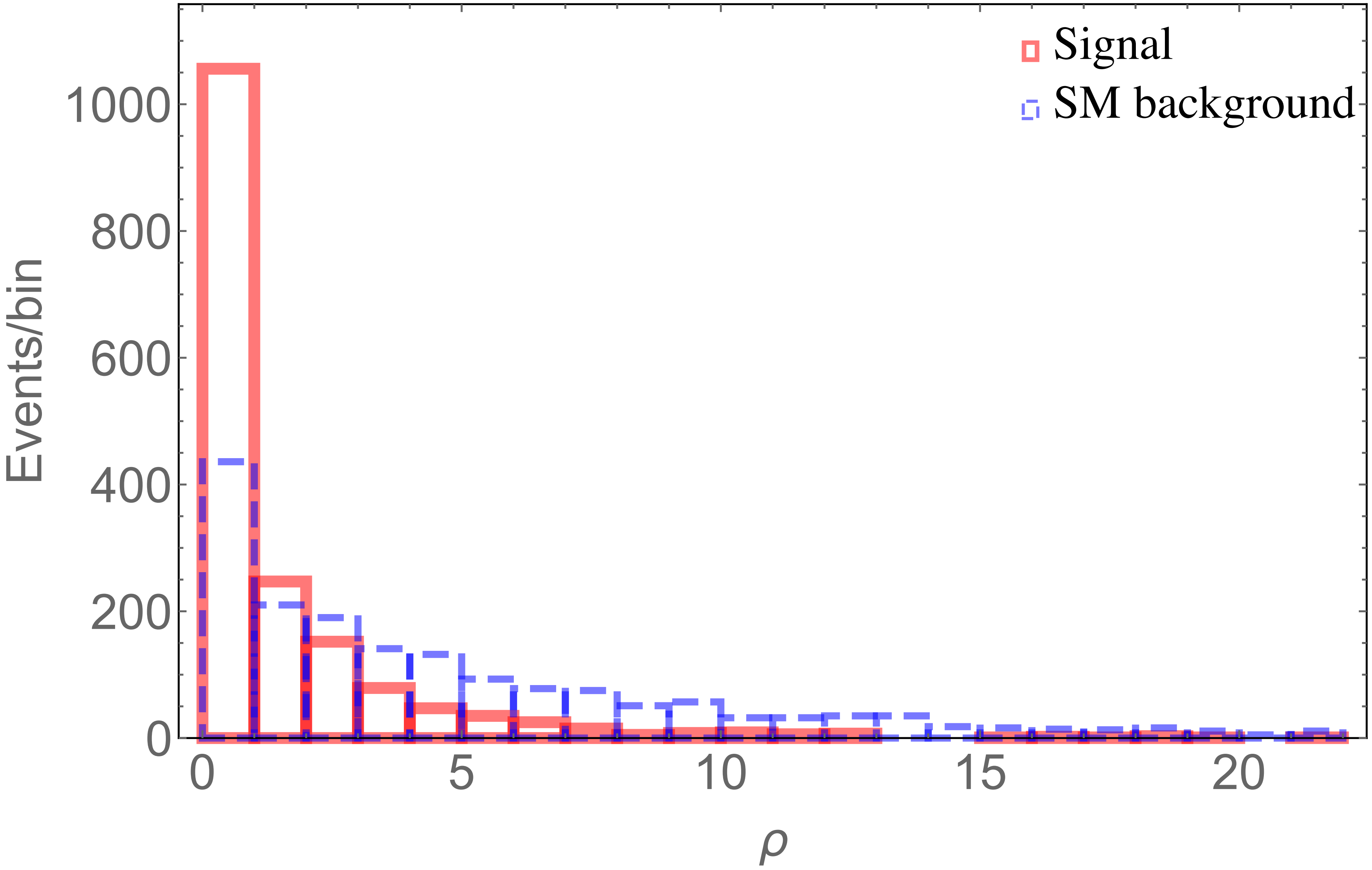
- $E_{jet} > \Delta M$ ISR, $E_{jet} < \Delta M$ honest

- We expect $N_{ISR} < N_{honest}$

- Main backgrounds are:
    - Z+4j
    - Lost leptons: W+4j, t-tbar, single top
- There is a multijet QCD background with miss measured MET that we relay on the experimentalists to calculate.
- We will trigger in MET:
    - EF trigger with MET>60 (90) GeV, L2>40 GeV, L1>35 GeV for 8 (13) TeV

- Event are generated using Madgraph demanding the following:
  - MET> 60 (90) GeV for 8 (13) TeV
  - p_T>40 GeV $|\eta|<2.5$
  - b-veto (50% efficient)

- We implement the following cuts:
  - N$_{\text{honest}}$ >4
  - Angle: $||\Delta\phi(\not{E}_T, j_{\text{ISR,max}})| - \pi| \leq 1.5$
  - Energy: $\rho \equiv \frac{\sum_{i=0}^{N_{\text{ISR}}} E^i_{\text{ISR}}}{\not{E}_T} \frac{N_{\text{ISR}}}{N_{\text{honest}}} \leq k(\sqrt{s}, m_{\tilde{g}})$ ~2



Values of ρ for the signal and background

Cut	Signal cross-section (fb)	$Z + 4j$ cross-section (fb)	"Lost leptons" cross-section (fb)
Basic cut + trigger	5.77 ± 0.06	1390 ± 13	2282 ± 46
Cut I	3.05 ± 0.04 (53%)	393 ± 7 (28%)	544 ± 22 (24%)
Cut II	2.72 ± 0.04 (47%)	288 ± 6 (21%)	393 ± 18 (17%)
Cut III	2.24 ± 0.04 (39%)	145 ± 4 (10%)	242 ± 15 (10%)

Cut flow for m_g=1 TeV MET-cut=60 GeV at 8 TeV

$\sqrt{s} = 8$ TeV, $\mathcal{L} = 20$ fb^{-1}

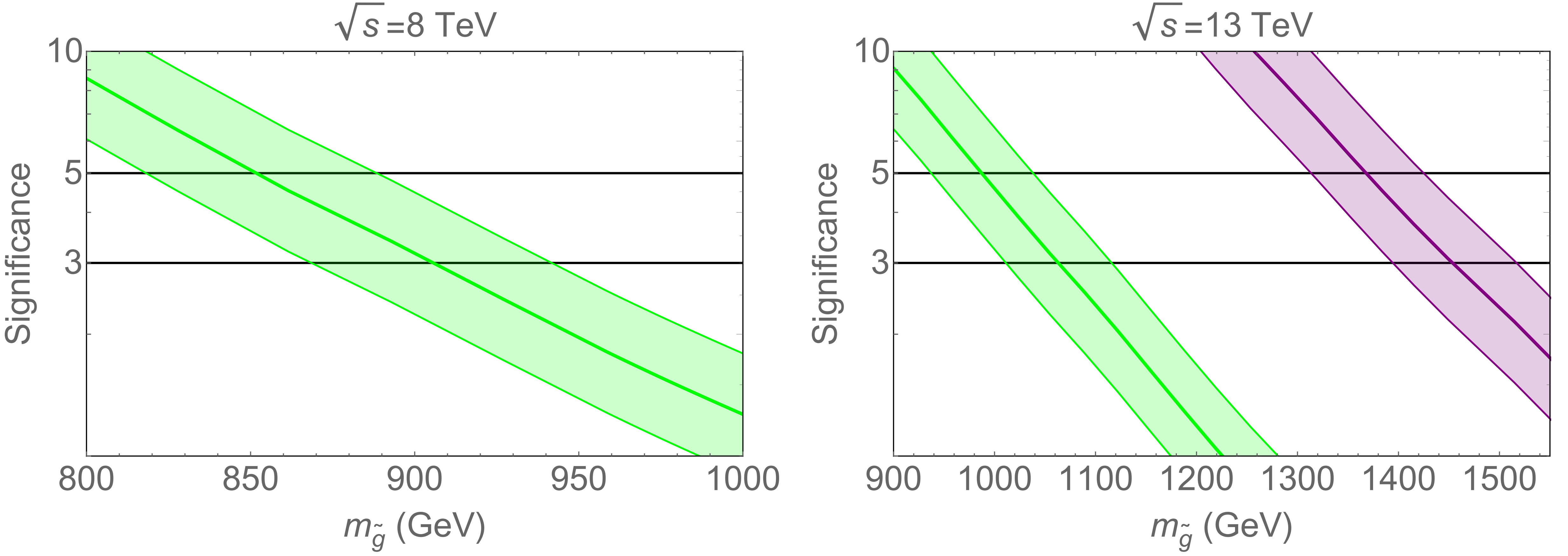
$\not{E}_{T,8}^{\rm cut}$	3σ	5σ
60 GeV	900 GeV	850 GeV
100 GeV	890 GeV	840 GeV
140 GeV	880 GeV	825 GeV

$\sqrt{s} = 13$ TeV, 5σ reach

$\not{E}_{T,13}^{\rm cut}$	$\mathcal{L} = 20$ fb^{-1}	$\mathcal{L} = 3$ ab^{-1}
90 GeV	990 GeV	1370 GeV
180 GeV	980 GeV	1360 GeV

Results for 8 TeV and 13 TeV

(reminder the reach with usual search for 8 TeV is around 650 GeV)



The band accounts for a systematic error of around 75%

- We are able to put bounds of around 900 GeV for 8 TeV which is better than ~700 GeV that you get with the usual technique.
- The larger the splitting the less efficient our analysis is.
- For 13 TeV one can get to 1.5 TeV masses.

Conclusions

- In this talk I have studied the possibility of an alternative way of discovering gluinos with compressed spectrum motivated by DM

- Production of two gluinos with a subsequent decay into two jets and a MET using angular and energy variables may provide the handle for mass differences around 100 GeV.

- This kind of studies may be very important for a future hadron collider.