Search for scalar top and gluino in fully hadronic final state in CMS

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On behalf of CMS Collaboration

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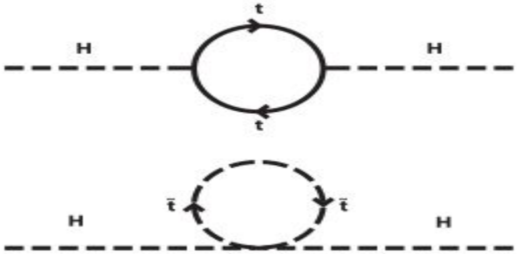
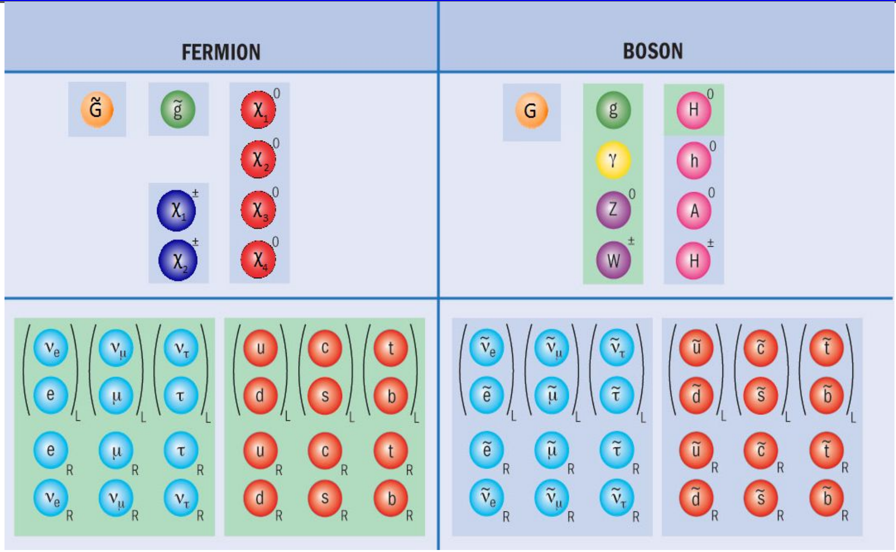
Supersymmetry

- Symmetry between fermions and bosons
- New particles from SUSY
- 3rd generation squarks, in particular top squark (***stop***) is important to resolve fine tuning problem

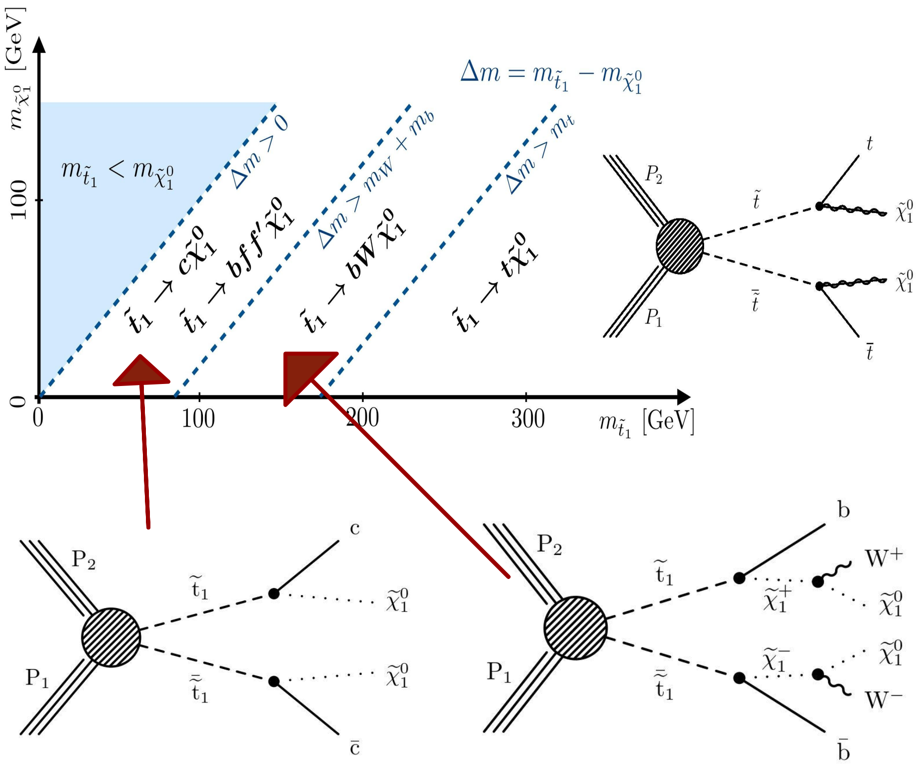




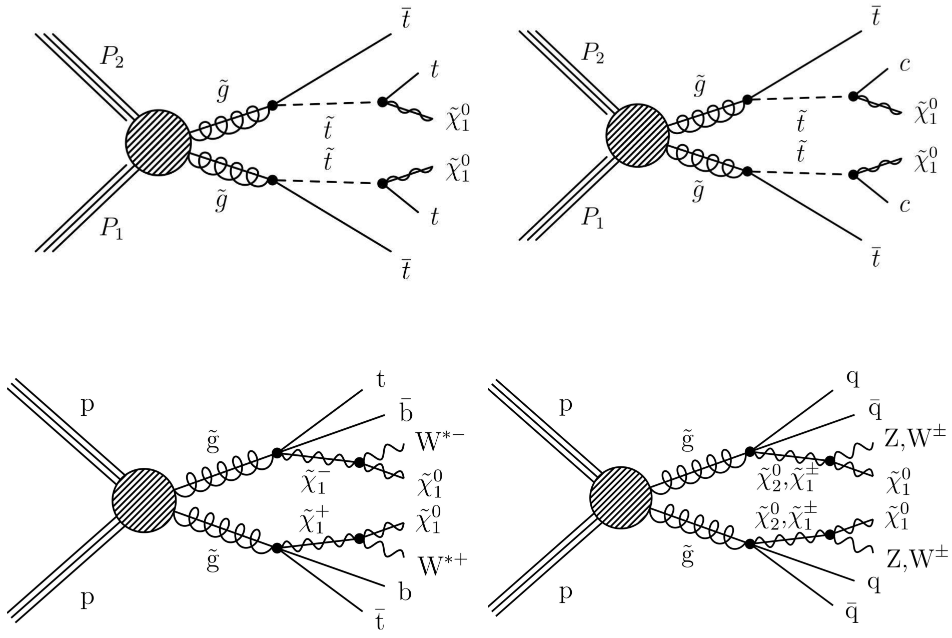
- Natural susy leads to searches for light 3rd generation squarks and **gluino**
- Lightest Supersymmetric Particle (LSP) could be DM candidate

Stop and Gluino signal models

Stop pair Production



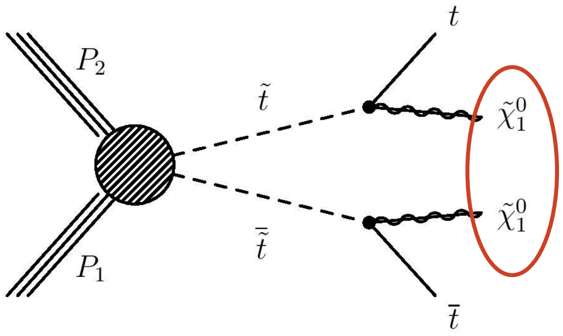
Gluino pair Production

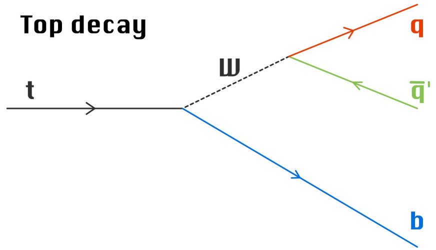


Experimental signature in final state

Hadronic signal topology

- Multiple jets, b-tagged jets
- Missing transverse momentum (MET or p_T^{miss}) from neutralinos
- More challenging as mass splitting becomes smaller (less MET, soft jets)





Typical backgrounds

- Lost Lepton: Missing leptons (e and μ) or hadronically decaying τ, real MET from W decay
- Z($\rightarrow \nu\nu$)+jets: real MET from ν
- QCD multijets events: mis-reconstruction of jets results in MET
- $t\bar{t}Z$ and other subdominant processes

Hadronic search at a glance

- ❑ Data selection with hadronic trigger
- ❑ Two basic search variables, N_{jets} and MET
- ❑ More discriminating hadronic variables
- ❑ Heaving object like b and top quark and W tagging

Commonly used variables

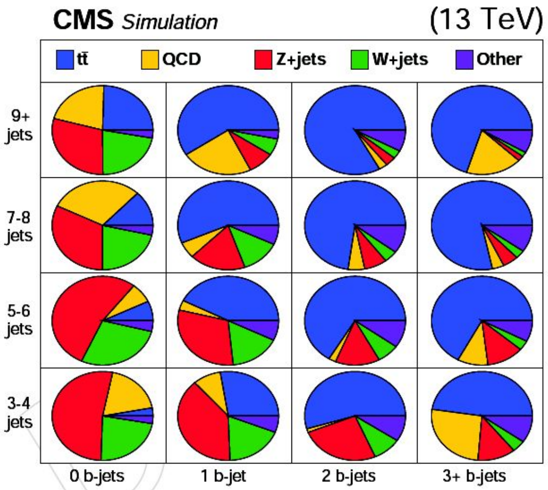
MET or p_T^{miss} $\quad \left|\sum_{\text{Reconstructed Particles}} -\vec{p_T}\right|$

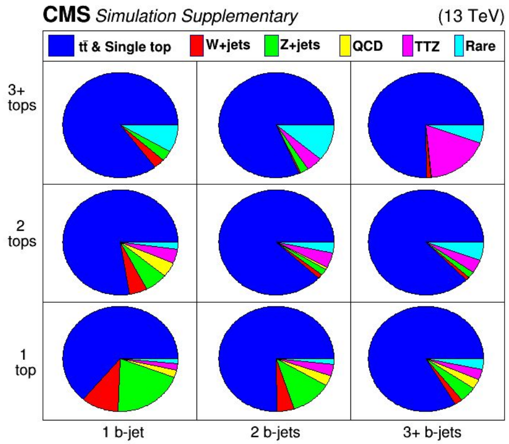
HT $\quad \sum_{jets} |\vec{P_T}|$

MHT or H_T^{miss} $\quad \left|\sum_{\text{Jets}} -\vec{p_T}\right|$

MT2 $\quad \min_{\vec{p}_T^{X(1)}+\vec{p}_T^{X(2)}=\vec{p}_T^{miss}} \left[\max\left(M_T^{(1)}, M_T^{(2)}\right)\right]$

α_T $\quad \frac{1}{2}\frac{\mathcal{E}_T-\Delta\mathcal{E}_T}{\sqrt{(\mathcal{E}_T)^2-(H_T^{miss})^2}}$ $\quad \mathcal{E}_T=\sum_{i=1}^{N_{jet}} E_T^{j_i}$





★ Search region (SR) binning for more sensitivity.

CMS Hadronic SUSY analyses

Hadronic stop & gluino searches

Search variables

N_{jets}, N_{b-jets}, HT and MHT

SUS-16-033

PhysRevD.96.032003

Principal search variable

MT2

SUS-16-038

Eur.Phys.JC77(2017)710

Principal search variable

α_T

SUS-16-036

JHEP05(2018)025

Using Tagged Top quark

SUS-16-050

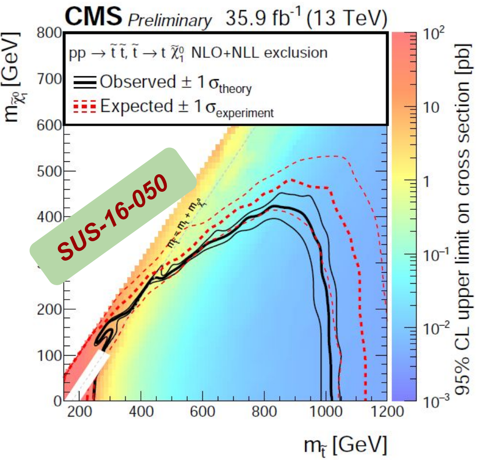
PhysRevD.97.012007

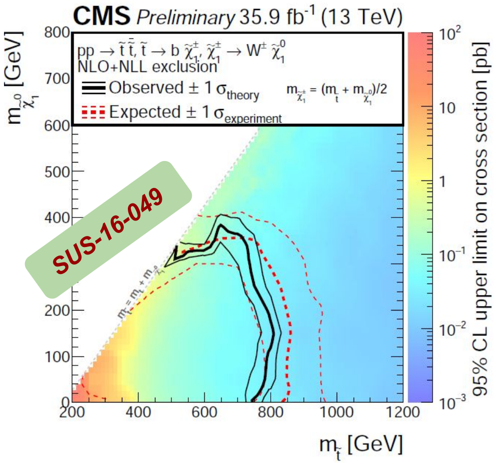
Using tagged top, W and ISR jet

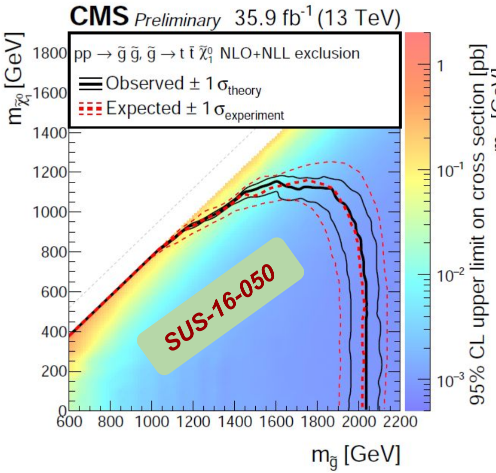
SUS-16-049

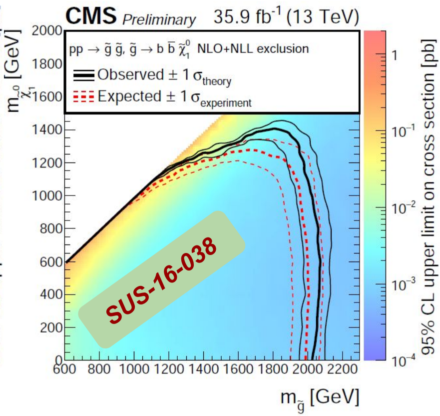
JHEP10(2017)005

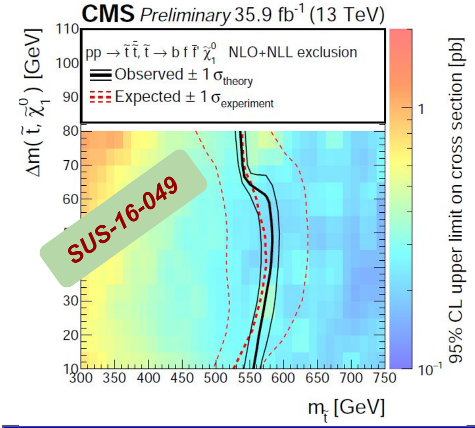
Results from 2016 data



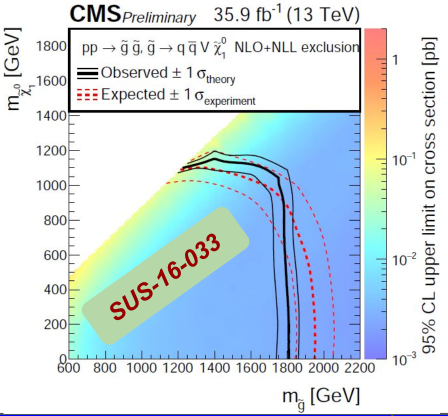








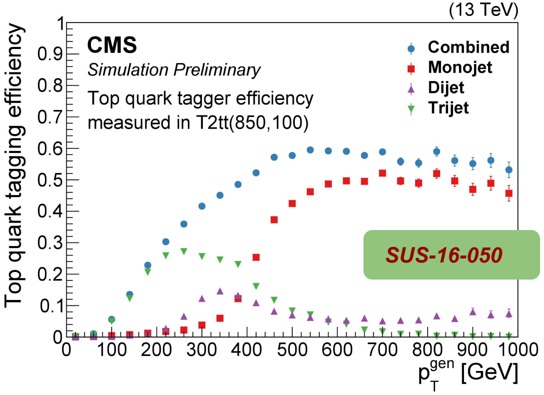
Stop is excluded upto 1 TeV

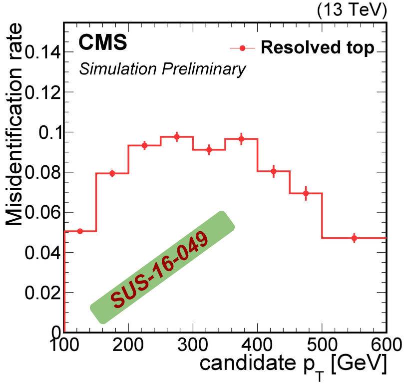


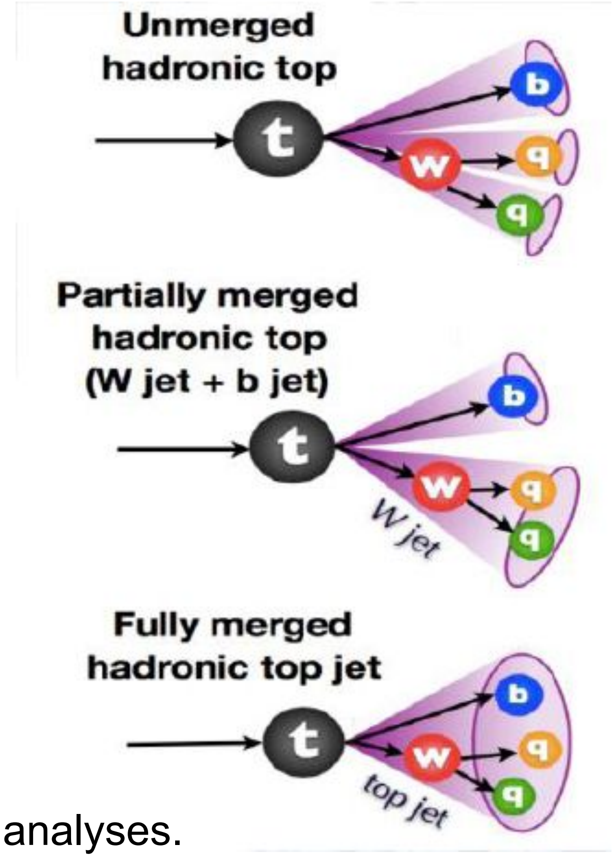
Gluino is excluded upto 2 TeV

Top quark tagging

- Resolved or unmerged scenario: trijet
  Trijet combination of anti-kT4 jets
- Semi boosted or partially merged: dijet
  anti-kT8 jet as W, combine with an anti-kT4 jet
- Boosted or merged: monojet
  A single anti-kT8 jet tagged as top quark







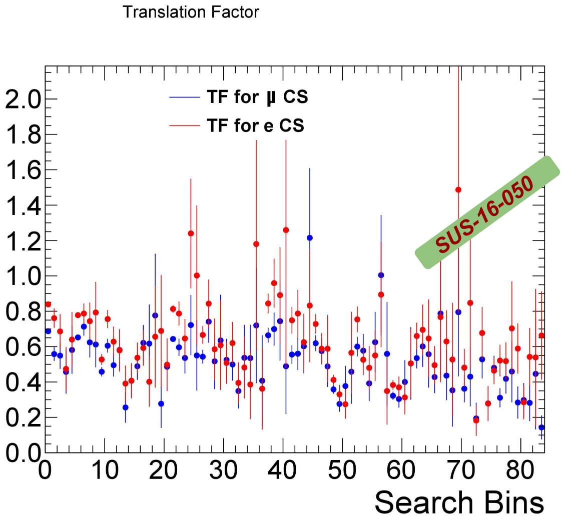
★ **DNN** based tagging algorithm in full run 2 dataset analyses.

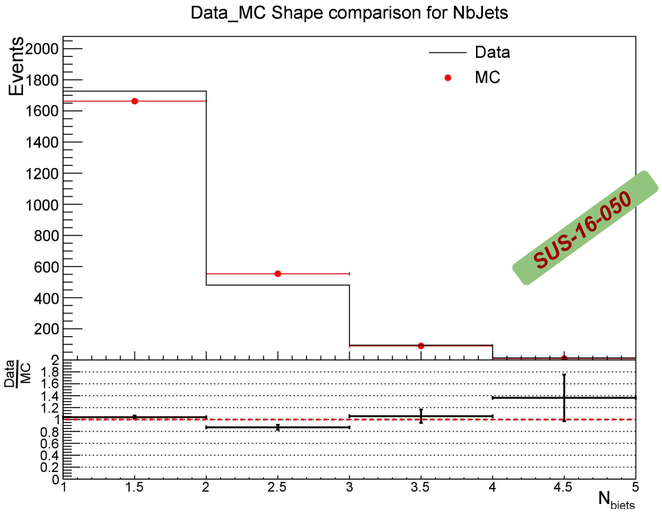
Lost Lepton background from W decay

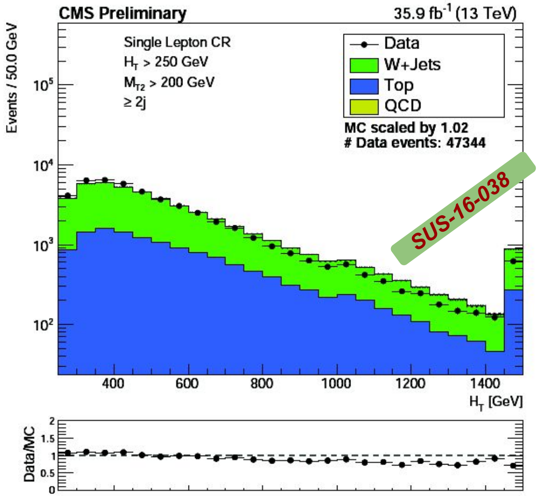
- Mainly comes from $t\bar{t}$, W + jets and single top processes
- Estimation from single lepton (e/μ + jets) data control sample (CS) using translation factor (TF)
- TF from simulated events with corrections to account for data-MC differences

$$N^{SR}_{Data} = TF_{simulation} * N^{CS}_{Data}$$

$$TF_{simulation} = \frac{N^{SR}_{simulation}}{N^{CS}_{simulation}}$$



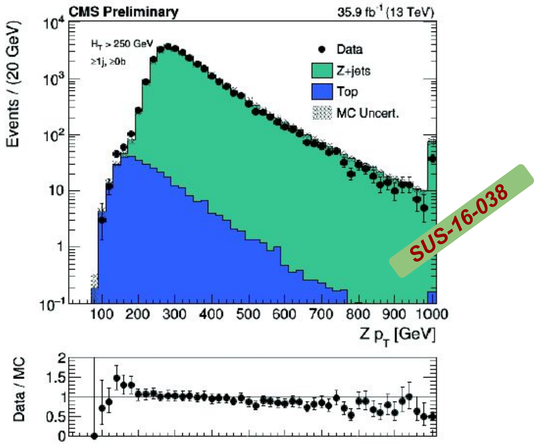


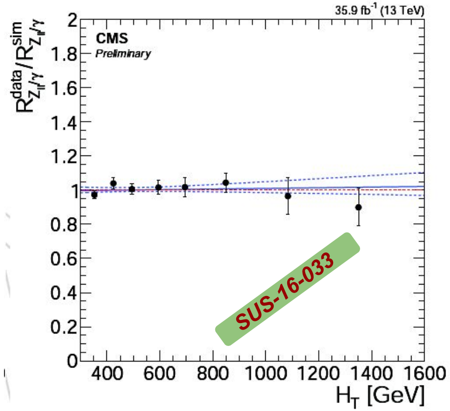


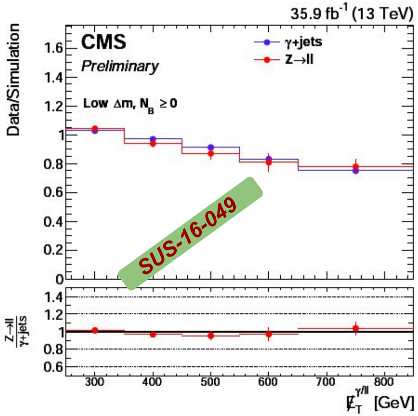
$Z_{\nu\nu}$ background

- From di-lepton (Z→ll) data CS
  - Estimation using transfer factor, Z→ll/Z→$\nu\nu$
- From Z→$\nu\nu$ simulated events
  - Shape and overall data normalization using Z→ll data CS
- From γ + jets data CS.
  - Using transfer factor, $Z_{\nu\nu}$ + jets/γ + jets
  - Corrected with double ratio,

$$\frac{\mathcal{R}^{\text{obs}}_{Z\to\ell^+\ell^-/\gamma}}{\mathcal{R}^{\text{MC}}_{Z\to\ell^+\ell^-/\gamma}}$$



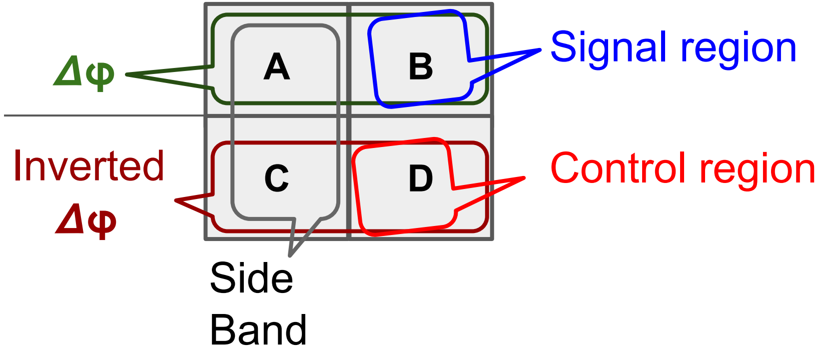


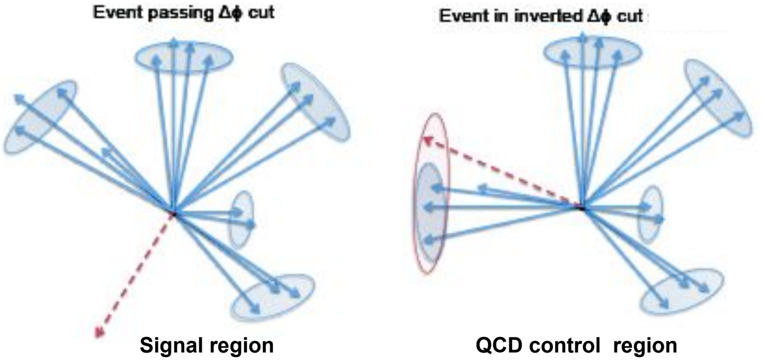


Method I

Use ABCD method:

★ **Estimation in B from D using A/C**

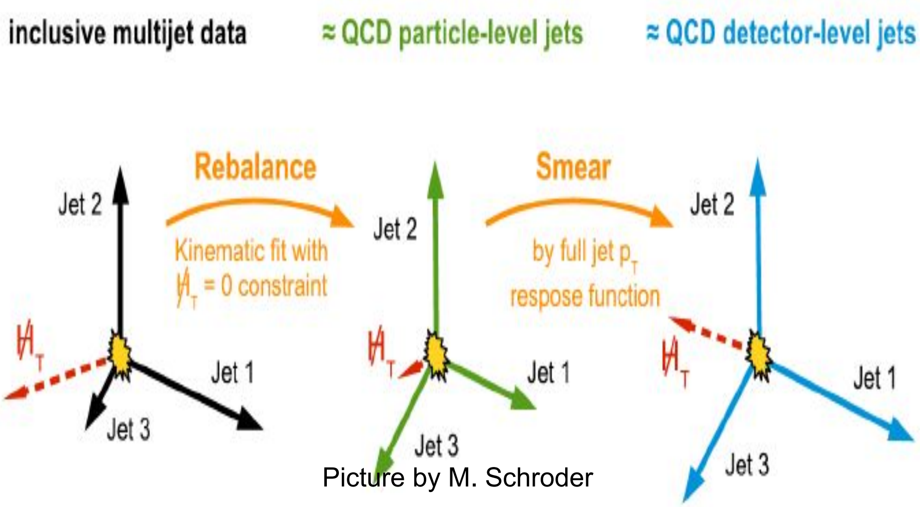




Method II

Use rebalance and smear (R & S) technique:

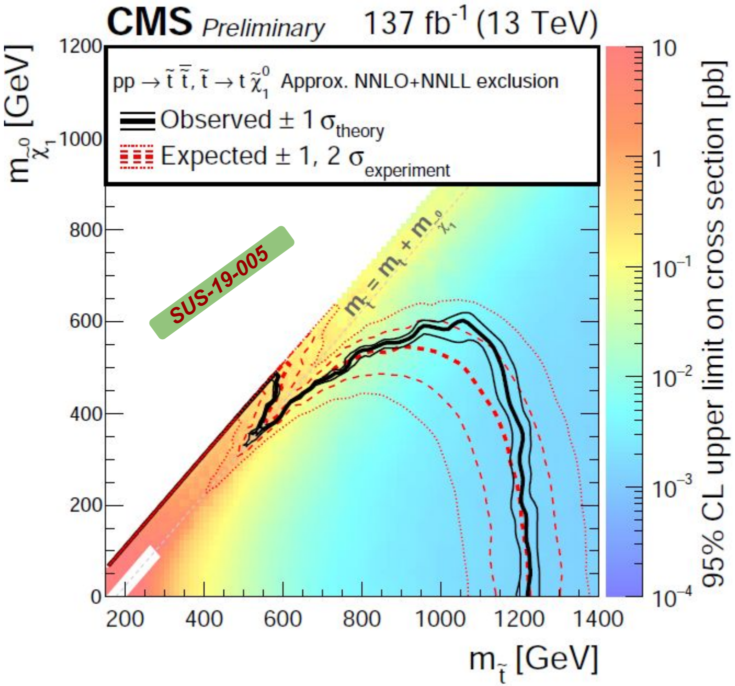
- ❑ "Rebalance" events by adjusting jet p_T to minimize MET
- ❑ "Smear" many times according to templates of p_T^{RECO}/p_T^{GEN}
- ❑ R & S method validated in inverted ***Δφ*** region.

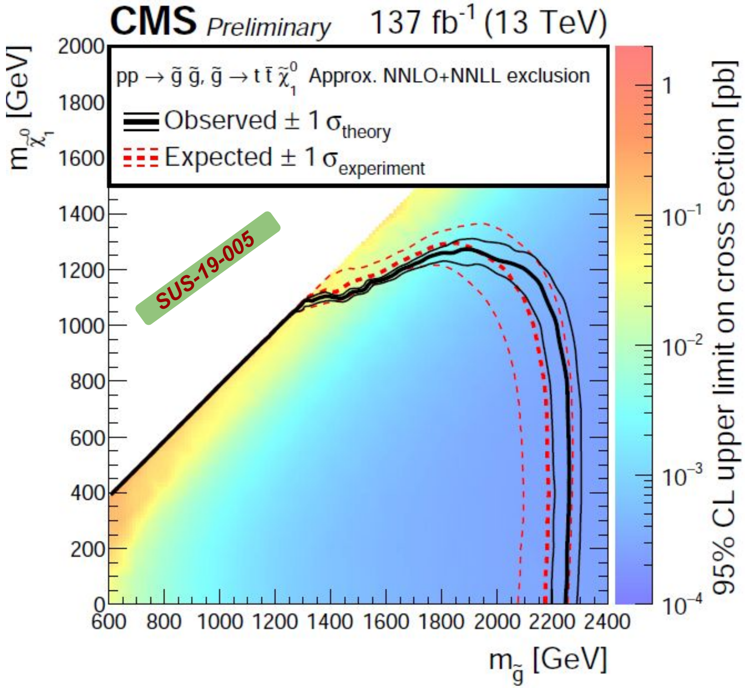


Picture by M. Schroder

Results

- ❑ Dedicated hadronic stop and gluino searches with full run 2 dataset in pipeline
- ❑ Latest results from MT2 group shed the light on stop and gluino mass limit





❖ Limit extended by **200 GeV** compared to 2016 dataset results

Summary

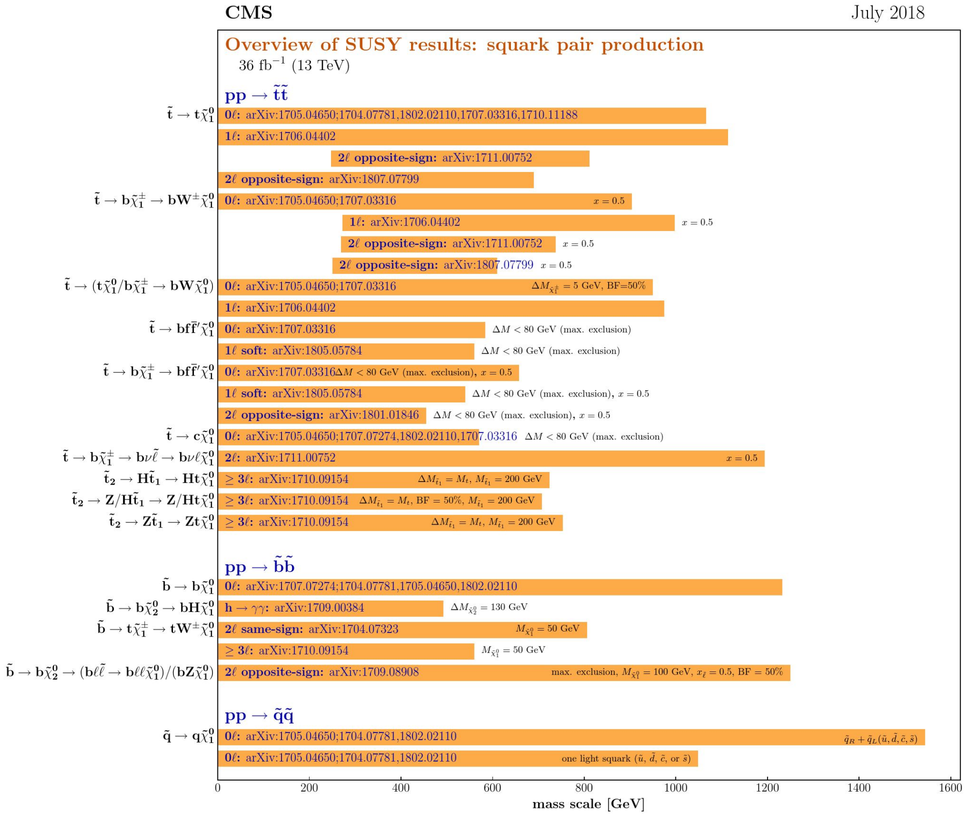
- No indication of excess so far in the latest result with full run 2 data
- Stop and gluino are excluded upto 1.2 TeV and 2.2 TeV respectively
- Scope of probing more unchartered territories
- Stay tuned for more update from all the hadronic SUSY searches with full run 2 data

Keep on hunting,
until we succeed!

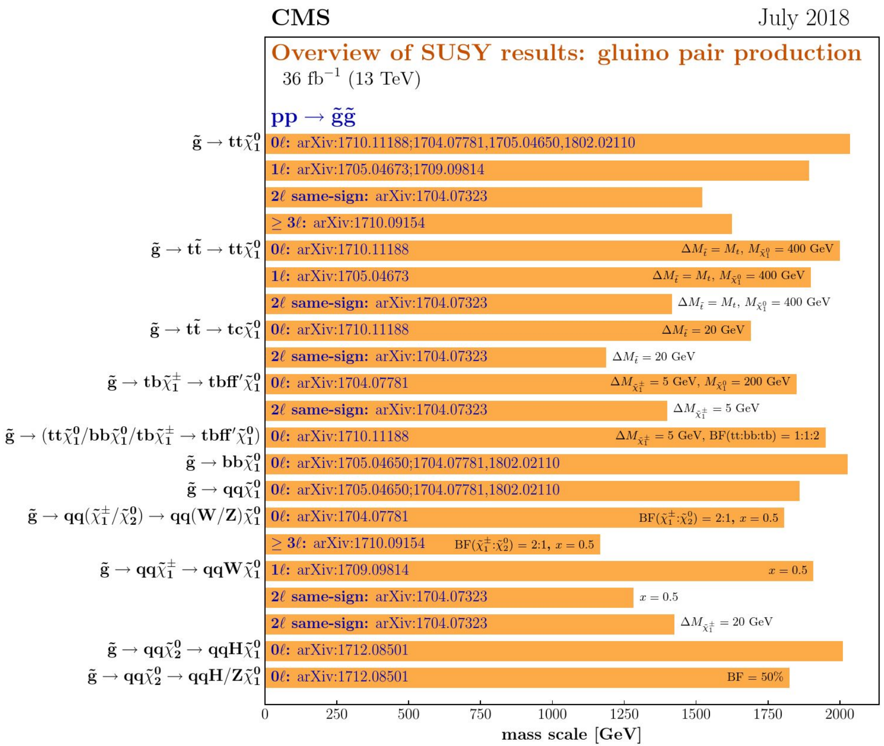
Thank You!

Back Up

Stop and gluino search results with 2016 dataset



Selection of observed limits at 95% C.L. (theory uncertainties are not included). Probe **up to** the quoted mass limit for light LSPs unless stated otherwise. The quantities ΔM and x represent the absolute mass difference between the primary particle and the LSP, and the difference between the intermediate sparticle and the LSP relative to ΔM, respectively, unless indicated otherwise.



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