Search for new physics using events with two same-sign isolated leptons in the final state at CMS

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Event Selection

We select events with 2 same-sign leptons (electron, muon) with p_T > 20 GeV (high-p_T) and at least 2 identified jets (E_T > 40 GeV).

Veto events with an additional lepton making a Z candidate or low mass resonance. We define three baseline regions (BRS) as a function of the number of b-jets.

28 exclusive Search Regions defined on top of this BSR by impossing tighter cuts on: number of jets, scalar sum of the jets E_T (H_T) and missing E_T. Targeting different models..

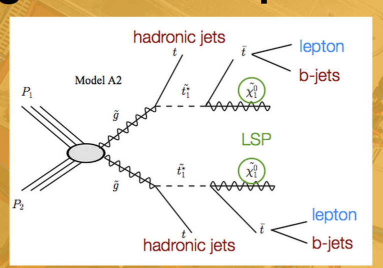
$N_{\text{b-jets}}$	E_T^{miss} (GeV)	N_{jets}	$H_T \in [200, 400]$ (GeV)	$H_T > 400$ (GeV)
= 0	50-120	2-3	SR01	SR02
		≥ 4	SR03	SR04
	> 120	2-3	SR05	SR06
		≥ 4	SR07	SR08
= 1	50-120	2-3	SR11	SR12
		≥ 4	SR13	SR14
	> 120	2-3	SR15	SR16
		≥ 4	SR17	SR18
≥ 2	50-120	2-3	SR21	SR22
		≥ 4	SR23	SR24
	> 120	2-3	SR25	SR26
		≥ 4	SR27	SR28

Search Regions definition.

Motivation!

Same sign dilepton events are very rare in SM but appear naturally in many new physics scenarios.

This signature, accompanied by b quarks, can arise from SUSY models with lighter third-generation squarks.



As the SUSY cascade is dominated by strong production so we expect high jet multiplicity. The decay ends with the LSP (missing E_T).

Data Driven Backgrounds

Charge mis-identification:

(5-10% of total background)

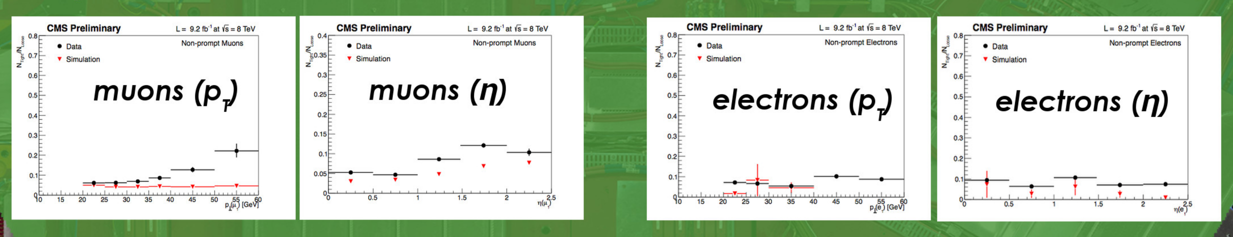
Events with opposite-sign leptons where one of the leptons' (electron) charge is badly measured.

Estimated by re-weighting the opposite sign events passing the selection by the charge missassignment probability (~0.02% in barrel and 0.2% in endcap) measured in the Z peak.

Non prompt leptons (e/μ):

(40-60% of total background)

Processes with one or two leptons coming from heavy flavour decays, misidentified hadrons or unidentified photon conversions.



Estimated by measuring yields in sidebands with looser isolation requirements and re-weighted by measured fake ratios (in a QCD enriched control sample).

50% syst. uncertainty

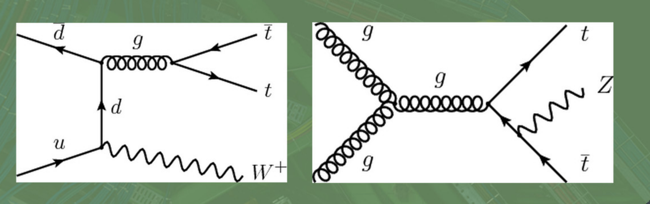
MC Estimated Backgrounds

Rare SM:

(20-60% of total background)

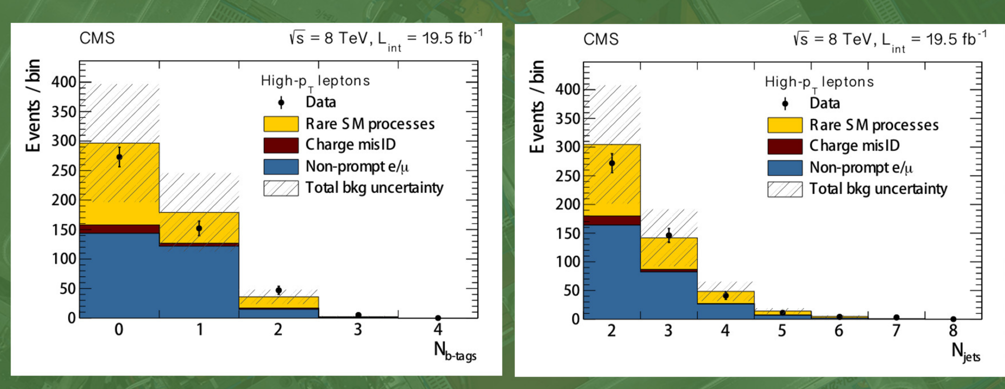
Processes that yield two same-sign prompt leptons, such as ttW and ttZ.

Estimated from validated MC when possible. 50% systematic uncertainty assigned due to unknown cross-sections.

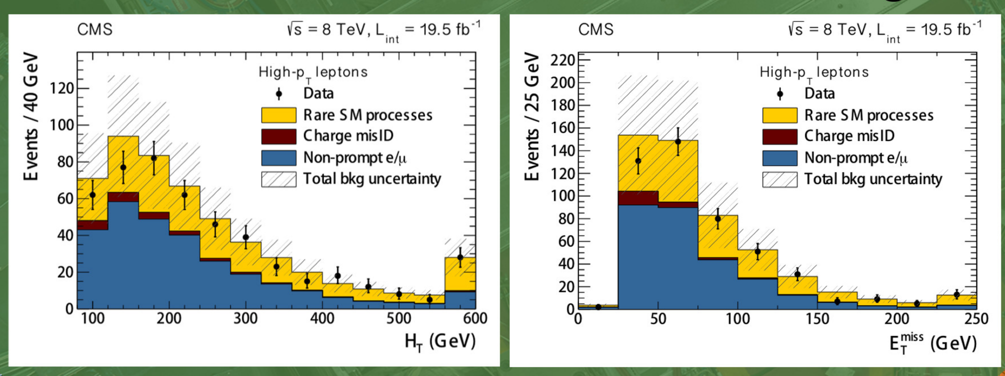


Background Estimation Validation

We prove the validity of these methods in a control region in data which is background dominated.



Good agreement between predicted and observed yields in all relevant observables for the definition of signal regions.



We proceed to apply these methods on the signal regions.

Results

We apply our background estimation methods to our signal regions.

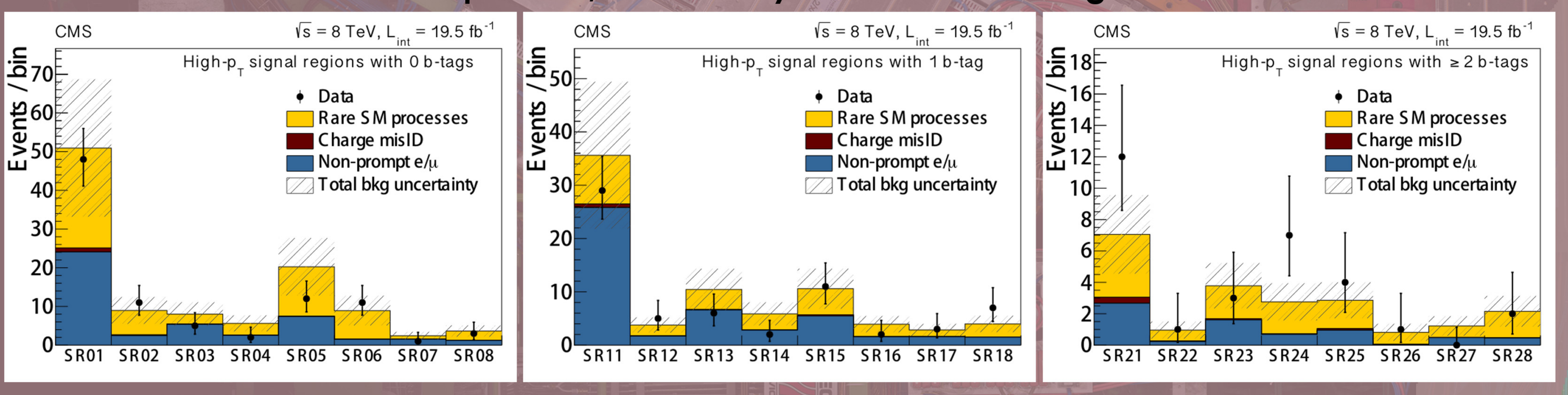
No excess over SM predictions.
Unfortunately no evidence for new physics yet.

Region	High-p_T Expected			High-p_T Observed
SR01	51	±	18	48
SR02	9.0	±	3.5	11
SR03	8.0	±	3.1	5
SR04	5.6	±	2.1	2
SR05	20	±	7	12
SR06	9	±	4	11
SR07	2.4	±	1.0	1
SR08	3.6	±	1.5	3

Region	High-p_T Expected			High-p_T Observed
SR11	36	±	14	29
SR12	3.8	±	1.4	5
SR13	10	±	4	6
SR14	5.9	±	2.2	2
SR15	11	±	4	11
SR16	3.9	±	1.5	2
SR17	2.8	±	1.1	3
SR18	4.0	±	1.5	7

Region	High-p_T Expected			High-p_T Observed
SR21	7.1	±	2.5	12
SR22	1.0	±	0.5	1
SR23	3.8	±	1.4	3
SR24	2.8	±	1.2	7
SR25	2.9	±	1.1	4
SR26	0.8	±	0.5	1
SR27	1.2	±	0.6	0
SR28	2.2	±	1.0	2

Expected / observed yields for Search Regions



A summary of the systematic uncertainties associated with the acceptance and signal efficiency for this analysis is shown below:

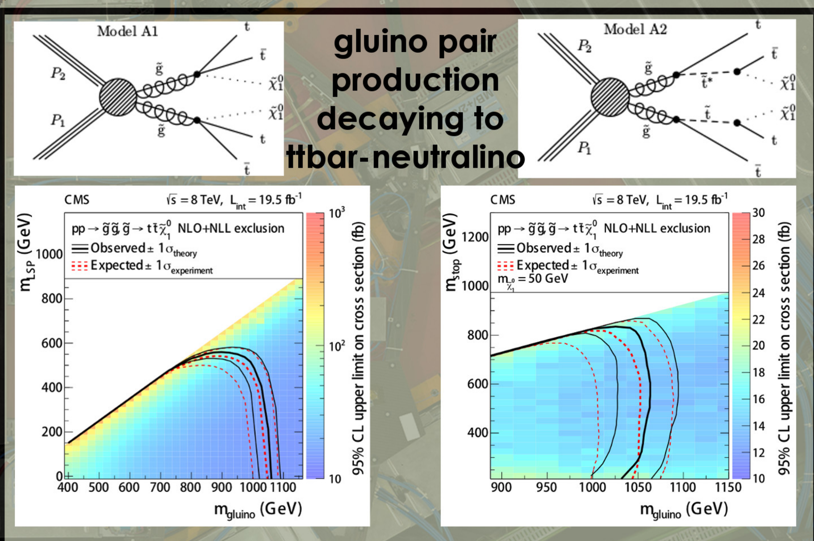
Source	%
Luminosity	2.6
Modelling of lepton selection (ID and isolation)	10
Modelling of trigger efficiency	6
Pileup modelling	5
Jet energy scale	1–10
Jet energy resolution	0–3
b-jet identification	2–10
ISR modelling	3–15
Total	13–25

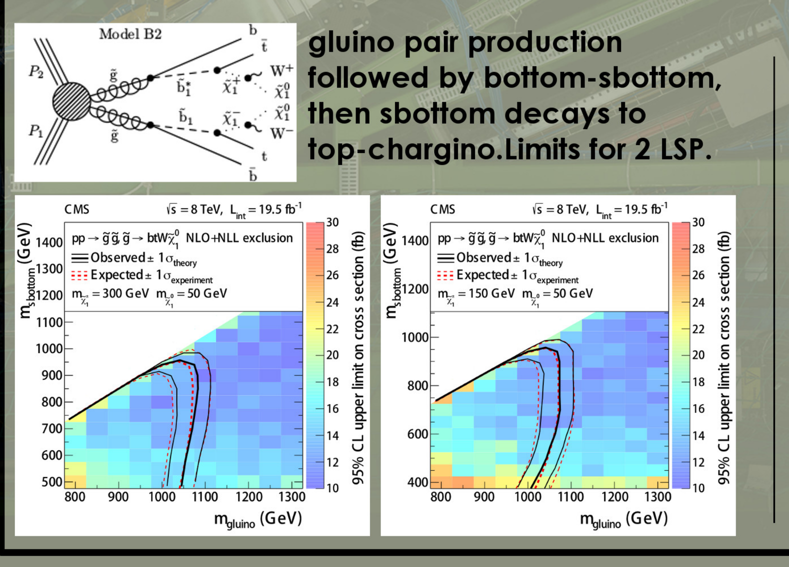
We interpret our results on several models.

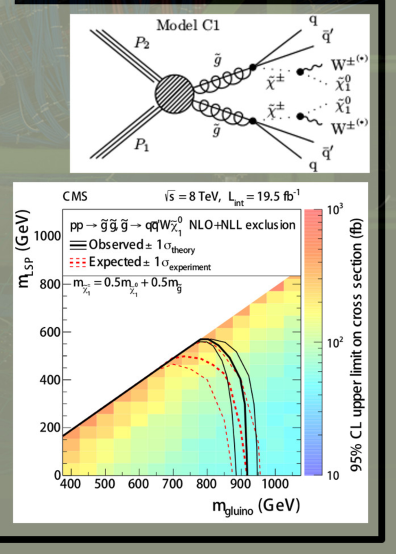
Interpretations

The results are used to constrain specific models of new physics. Limits are derived from the signal region expected to give the most stringent limit for a given model.

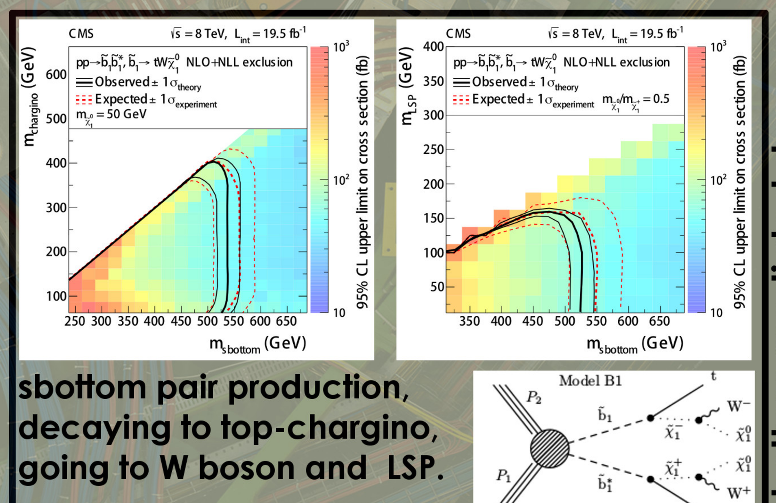
gluino mediated decays







sbottom mediated decays



Model	Constraints on parameters	Analysis	Signal regions used
A1		high-p_T	21–28
A2	$m_{\tilde{\chi}_1^0} = 50$ GeV	high-p_T	21–28
B1	$m_{\tilde{\chi}_1^0} = 50$ GeV	high-p_T	11–18, 21–28
B1	$m_{\tilde{\chi}_1^0}/m_{\tilde{\chi}_1^\pm} = 0.5$	high-p_T	11–18, 21–28
B2	$m_{\tilde{\chi}_1^0} = 50$ GeV, $m_{\tilde{\chi}_1^\pm} = 150$ GeV	high-p_T	21–28
B2	$m_{\tilde{\chi}_1^0} = 50$ GeV, $m_{\tilde{\chi}_1^\pm} = 300$ GeV	high-p_T	21–28
C1	$m_{\tilde{\chi}_1^\pm} = 0.5 m_{\tilde{\chi}_1^0} + 0.5 m_{\tilde{g}}$	high-p_T	01–08

Signal regions used for limit setting for the new physics models considerer in this analysis

Gluino masses up to 1050 GeV and sbottom masses up to 500 GeV are probed. Gluino massses up to 900 GeV in when they do not decay to third generation squarks. More to come at 13 TeV

Reference: *JHEP 01 (2014) 163*