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Grant PID2020-113341RB-I00 funded by:
GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN
AGENCIA ESTATAL DE INVESTIGACIÓN
EUROPEAN UNION European Regional Development Fund
PCTI ASTURIAS
Gobierno del Principado de Asturias

CMS Compact Muon Solenoid

SEARCHES FOR TOP SQUARKS AND GLUINOS WITH THE CMS DETECTOR

Andrea Trapote Fernández

(On behalf of the CMS Collaboration)

- SUSY2022 -

27 June – 2 July 2022

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CMS SEARCH PROGRAM FOR GLUINOS / STOPS

CMS-PAS-SUS-21-007	Search for supersymmetry in final states with a single electron or muon using angular correlations and heavy object tagging in proton-proton collisions at $\sqrt{s} = 13$ TeV		March 2022
CMS-PAS-SUS-21-002	Search for electroweak production of supersymmetric particles in final states containing hadronic decays of WW, WZ, or WH and missing transverse momentum	Submitted to PLB	August 2021
CMS-PAS-SUS-20-004	Search for higgsinos in channels with two Higgs bosons and missing transverse momentum in proton-proton collisions at $\sqrt{s} = 13$ TeV	JHEP 05 (2022) 014	July 2021
CMS-PAS-SUS-21-001	Search for direct pair production of supersymmetric partners to the τ lepton in the all-hadronic final state at $\sqrt{s} = 13$ TeV		July 2021
CMS-PAS-SUS-20-002	Combined searches for the production of supersymmetric top quark partners in proton-proton collisions at $\sqrt{s} = 13$ TeV	EPJC 81 (2021) 970	March 2021
CMS-PAS-SUS-20-003	Search for chargino-neutralino production in final states with a Higgs boson and a W boson	JHEP 10 (2021) 045	March 2021
CMS-PAS-SUS-18-004	Search for physics beyond the standard model in final states with two or three soft leptons and missing transverse momentum in proton-proton collisions at 13 TeV	JHEP 04 (2022) 091	March 2021
CMS-SUS-19-010	Search for top squark production in fully-hadronic final states in proton-proton collisions at $\sqrt{s} = 13$ TeV	PRD 104 (2021) 052001	1 March 2021
CMS-PAS-SUS-19-012	Search for electroweak production of charginos and neutralinos in proton-proton collisions at $\sqrt{s} =$ 13 TeV	JHEP 04 (2022) 147	February 2021
CMS-SUS-19-004	Search for top squarks in final states with two top quarks and several light-flavor jets in proton-proton collisions at $\sqrt{s} = 13$ TeV	PRD 104 (2021) 032006	13 February 2021
CMS-PAS-SUS-19-011	Search for top squark pair production in the dilepton final state using 137 fb^{-1} of proton-proton collision integrated luminosity at $\sqrt{s} = 13$ TeV	EPJC 81 (2021) 3	May 2020
CMS-PAS-SUS-19-009	Search for direct top squark pair production in events with one lepton, jets and missing transverse energy at 13 TeV	JHEP 05 (2020) 032	July 2019

http://cms-results.web.cern.ch/cms-results/public-results/publications/SUS/index.html

- Many SUSY searches have been published by CMS in the last few years.

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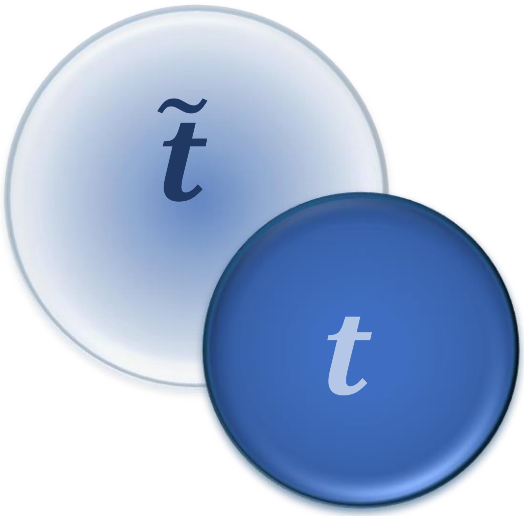
http://cms-results.web.cern.ch/cms-results/public-results/publications/SUS/index.html

- Many SUSY searches have been published by CMS in the last few years.
- Several of them targeting gluinos and stops.

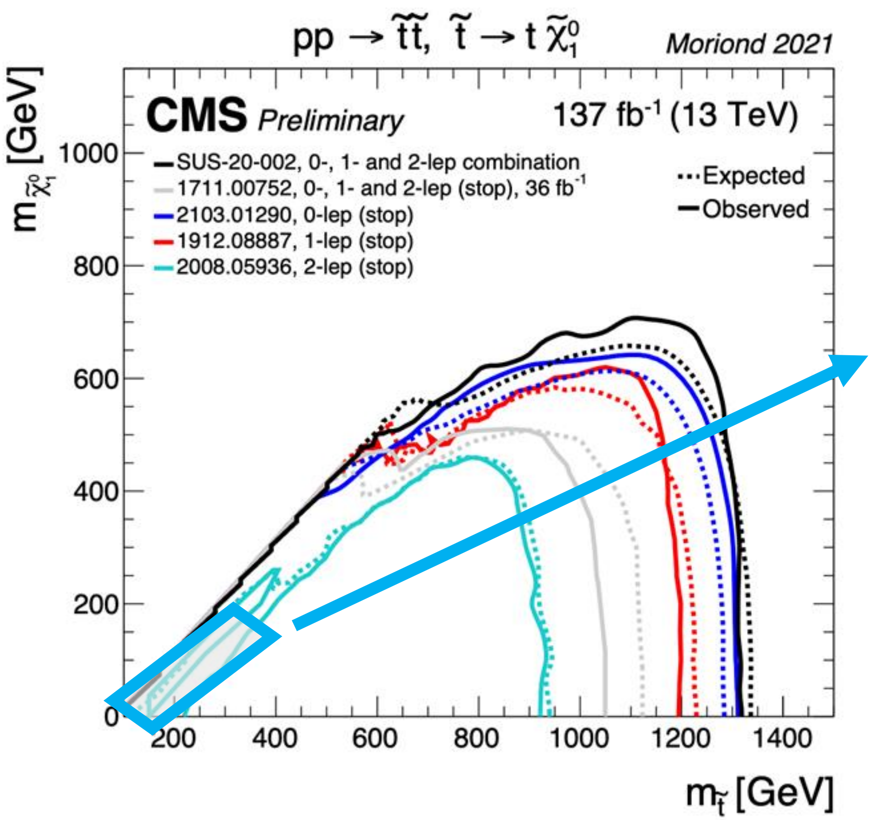
Stop searches



HIGH p_T^{miss} SEARCHES

Eur. Phys. J. C 81 (2021) 970

- The **stop quark** plays an essential role in understanding the **SUSY models**.
- Several searches with the full **Run 2 dataset** have been performed by the CMS Collaboration, but the so-called "**top corridor**" requires special care because…



TOP CORRIDOR

- The mass difference between stop and neutralino is close to the **top mass**.
- Signal and $t\bar{t}$ background have **similar kinematics**, especially at low neutralino masses.
- Signal events can only be detected as an **excess on the $t\bar{t}$ cross section**.
- The **accurate estimation of $t\bar{t}$** process is very important to have sensitivity.

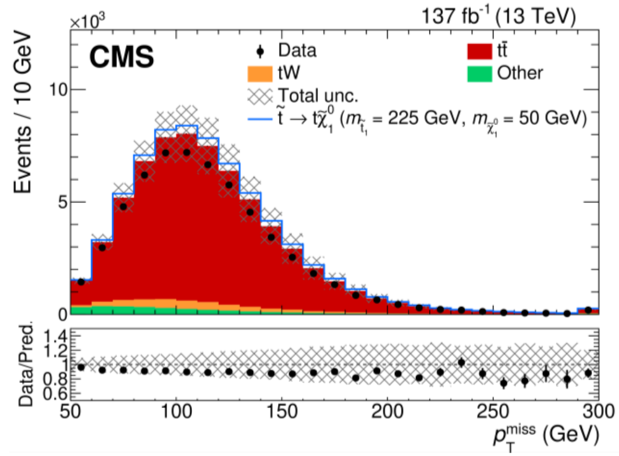
- **Combination** with three previous searches with 0, 1 and 2 leptons in the final state is also presented in this paper:
  - Hadronic: *Phys. Rev. D 104 (2021) 052001*
  - Single lepton: *JHEP 05 (2020) 032*
  - Dileptons: *Eur. Phys. J. C81(2021) 3*

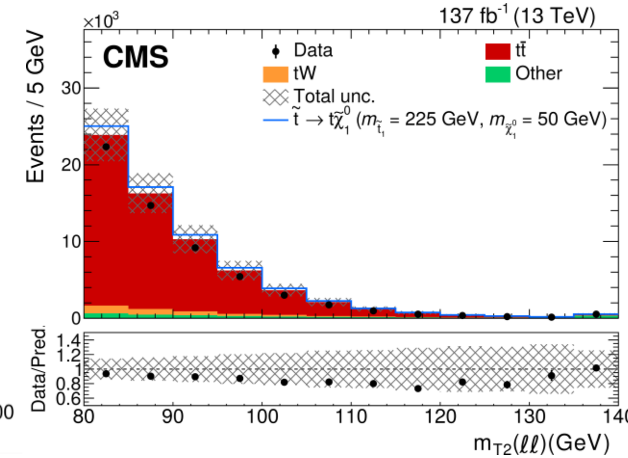
TOP CORRIDOR ANALYSIS

Eur. Phys. J. C 81 (2021) 970

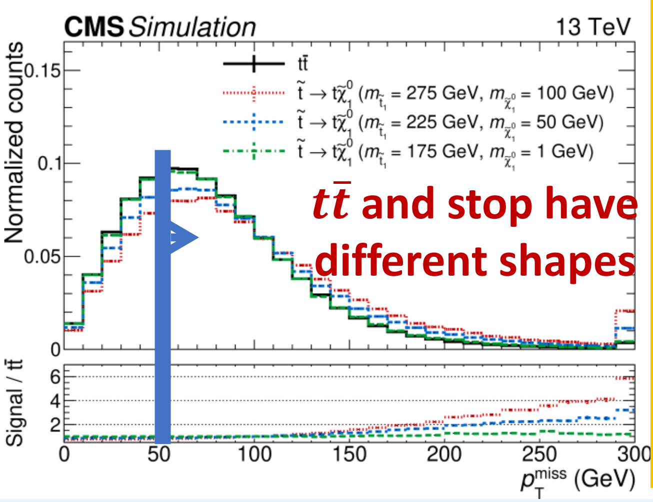
- **Event selection:** $\ell\ell$, $\geq$ **2 jets,** $\geq$ **1 b-tagged jet,** $p_T^{miss} \geq$ **50 GeV,** $m_{T2} \geq$ **80 GeV.**

- **Backgrounds:** The main background is $t\bar{t}$ due to the similar kinematics with the signal process in this region. It is estimated from MC with an accurate knowledge.



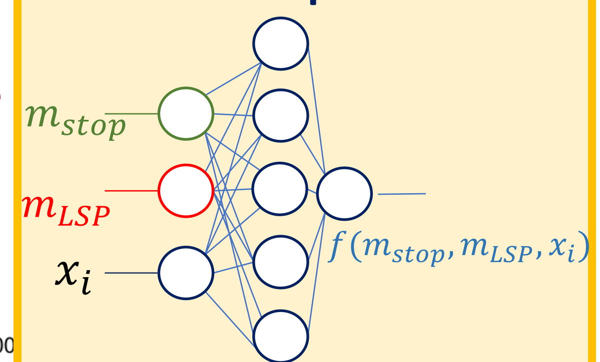


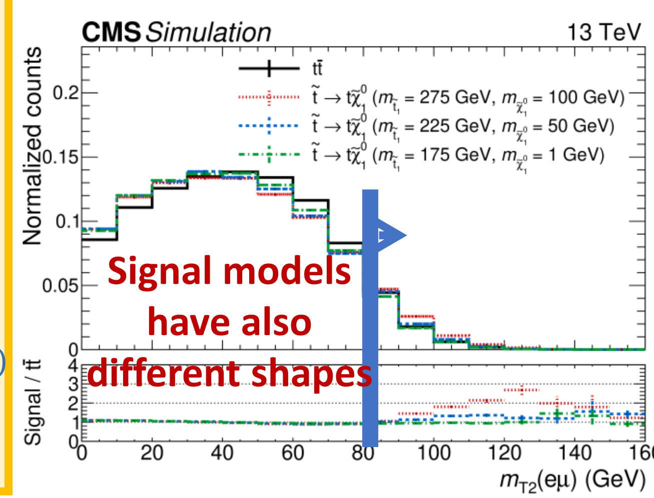
- **Main strategy:** use a **parametric Deep Neural Network** to separate signal from background. By introducing **stop and LSP masses** in the training we exploit the kinematic differences to **maximize sensitivity**.



$t\bar{t}$ and stop have different shapes

With one DNN we have an specific model for each mass point!



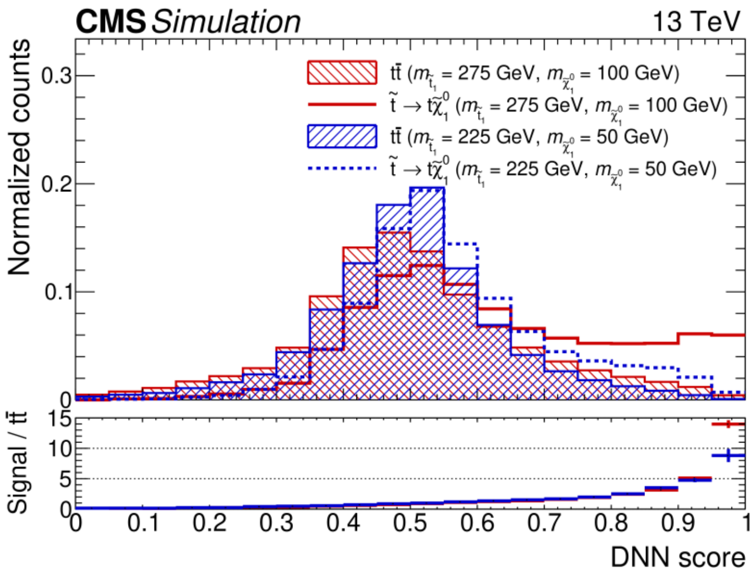


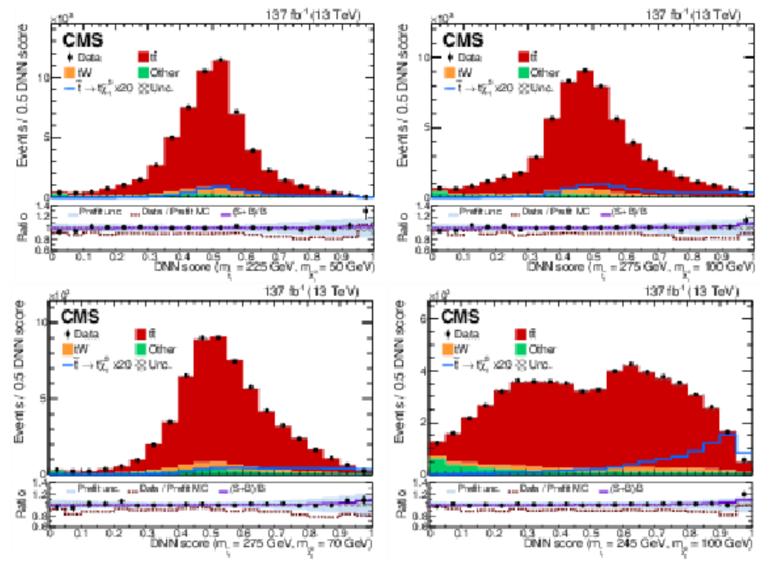
Signal models have also different shapes

TOP CORRIDOR RESULTS

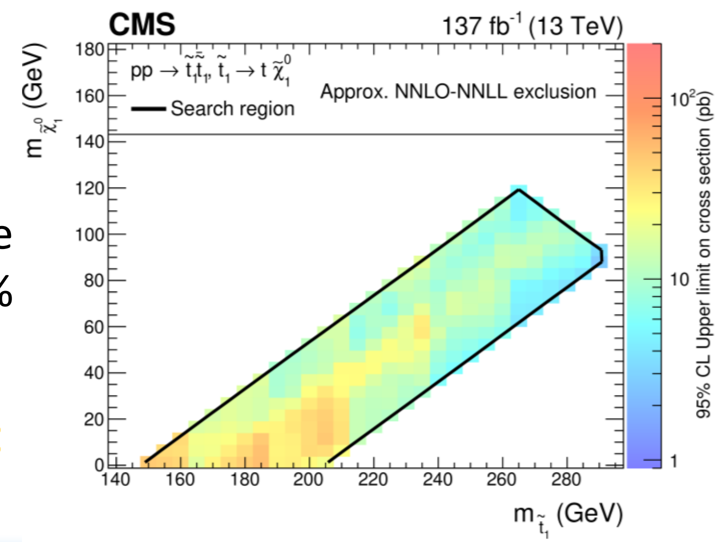
Eur. Phys. J. C 81 (2021) 970

- The DNN score has different shapes due to the parametric training: **there is one signal and one background distribution for each mass point**.





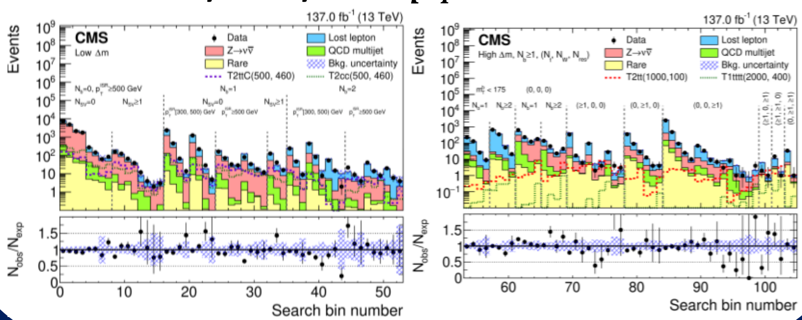
- **No excess** is observed and for the signal extraction the DNN output is used.
- Results are presented in terms of **upper limits** on the production cross section of top squark pairs at 95% confidence level for the T2tt model.
- **Full top corridor region is excluded for the first time by CMS!**



COMBINATION ANALYSES

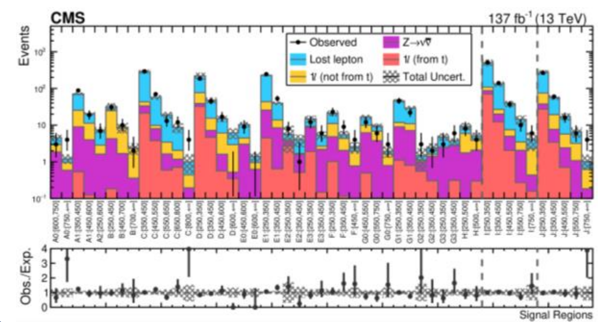
Fully hadronic analysis:
[Phys. Rev. D 104 (2021) 052001](#)

- High Δm: advanced jet tagging algorithms to identify hadronically decaying top quarks and W bosons.
- Low Δm: dedicated algorithm to identify very low p_T B hadrons.



Single lepton analysis:
[JHEP 05 (2020) 032](#)

- M_T to suppress $t\bar{t}$+jets/W+jets.
- Modified topness (t_{mod}) to discriminate against $t\bar{t}$.
- Hadronic top tagger categories (unmerged, merged and resolved).

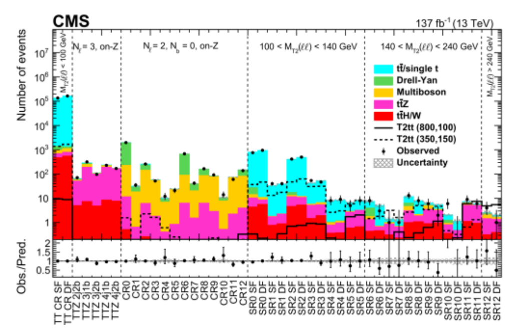


	N_J	t_{mod}	$M_{\ell b}$ [GeV]
A	2-3	> 10	≤ 175
B	2-3	> 10	> 175
C	≥ 4	≤ 0	≤ 175
D	≥ 4	≤ 0	> 175
E	≥ 4	0-10	≤ 175
F	≥ 4	0-10	> 175
G	≥ 4	> 10	≤ 175
H	≥ 4	> 10	> 175

I: $N_J \geq 5$, $N_{b,med} \geq 1$
J: $N_J \geq 3$, $N_{b,soft} \geq 1$

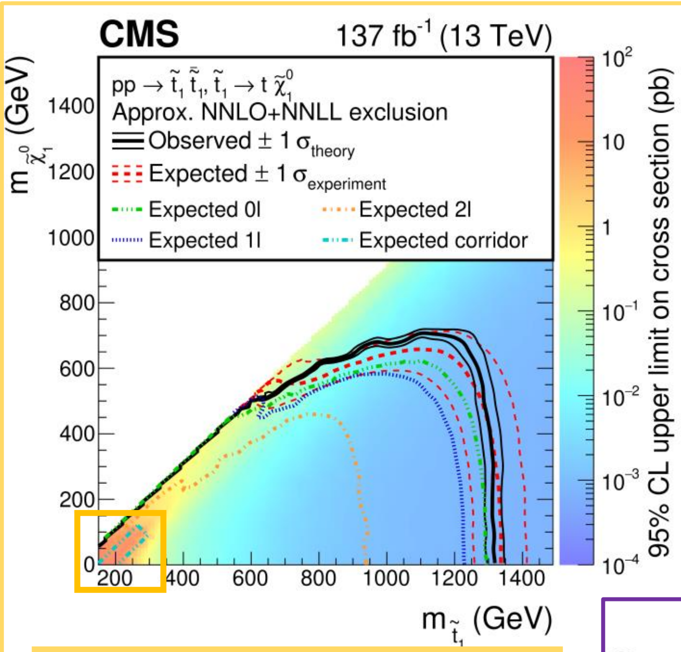
Dilepton analysis:
[Eur. Phys. J. C. 81(2021) 3](#)

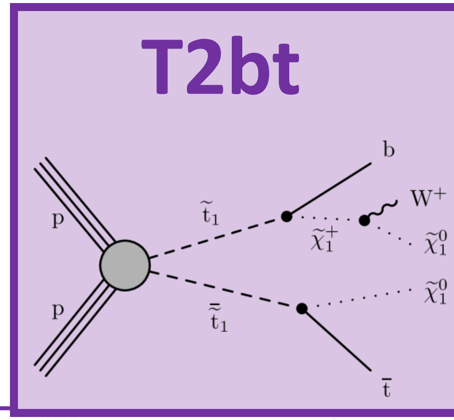
- p_T^{miss} Significance to supress Drell-Yan.
- $m_{T2}(\ell\ell)$ and $m_{T2}(b\ell b\ell)$ to suppress $t\bar{t}$+jets.
- ttZ(Z→inv) main irreducible background.

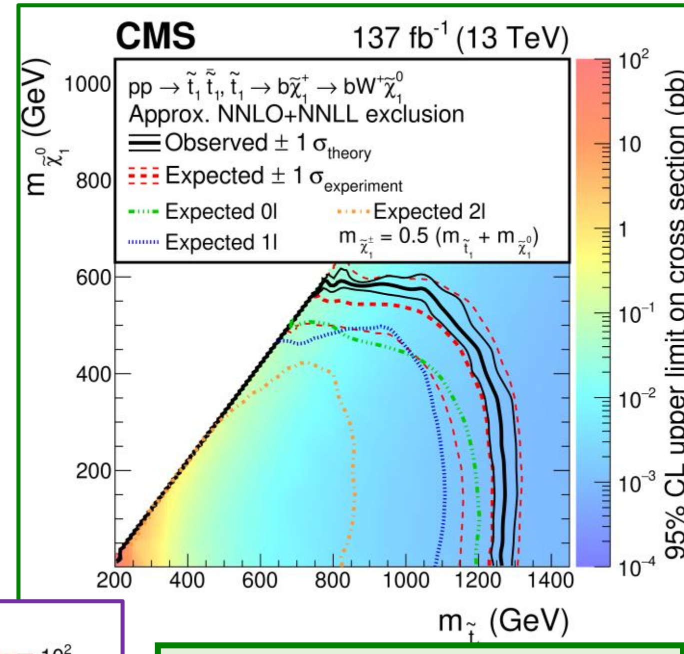


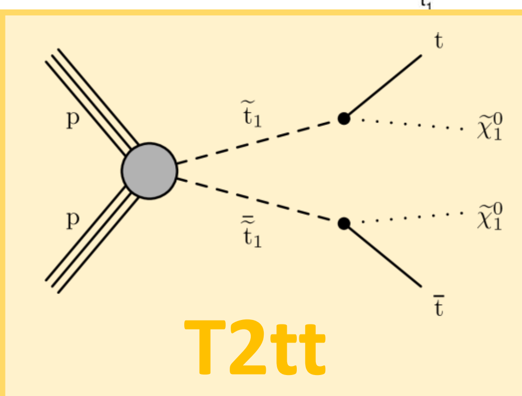
COMBINATION RESULTS

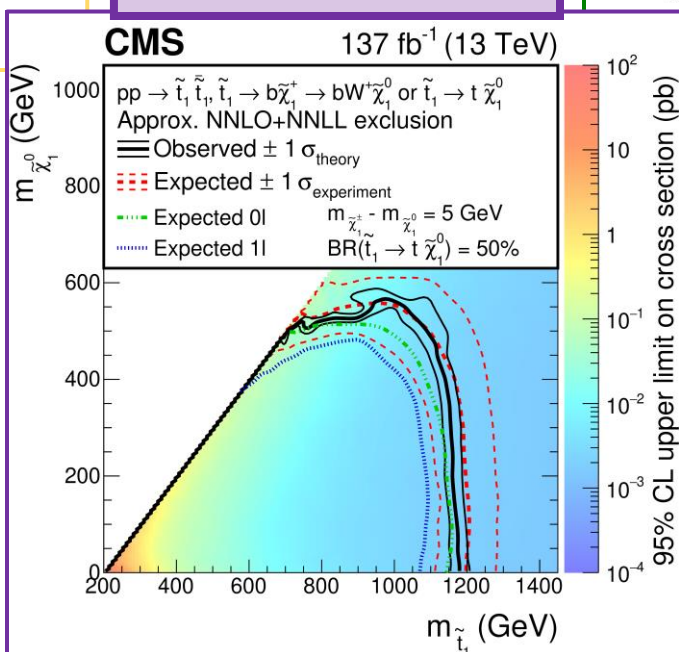
Eur. Phys. J. C 81 (2021) 970

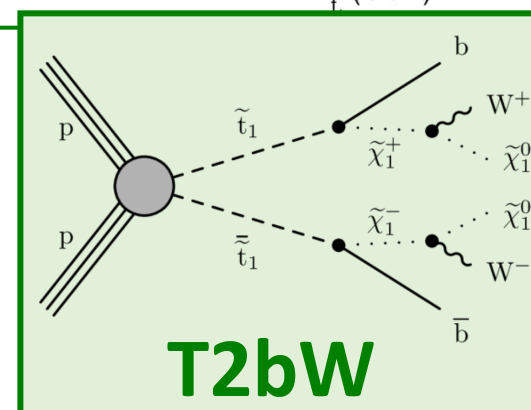












Top corridor region excluded!

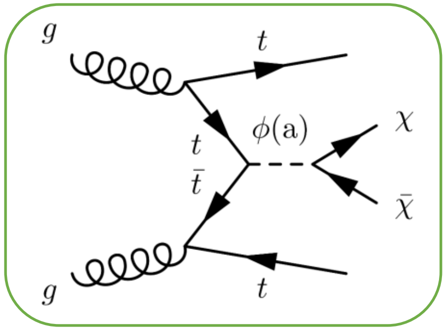
Exclusion limits are improved by over 50 GeV wrt. previous analyses!

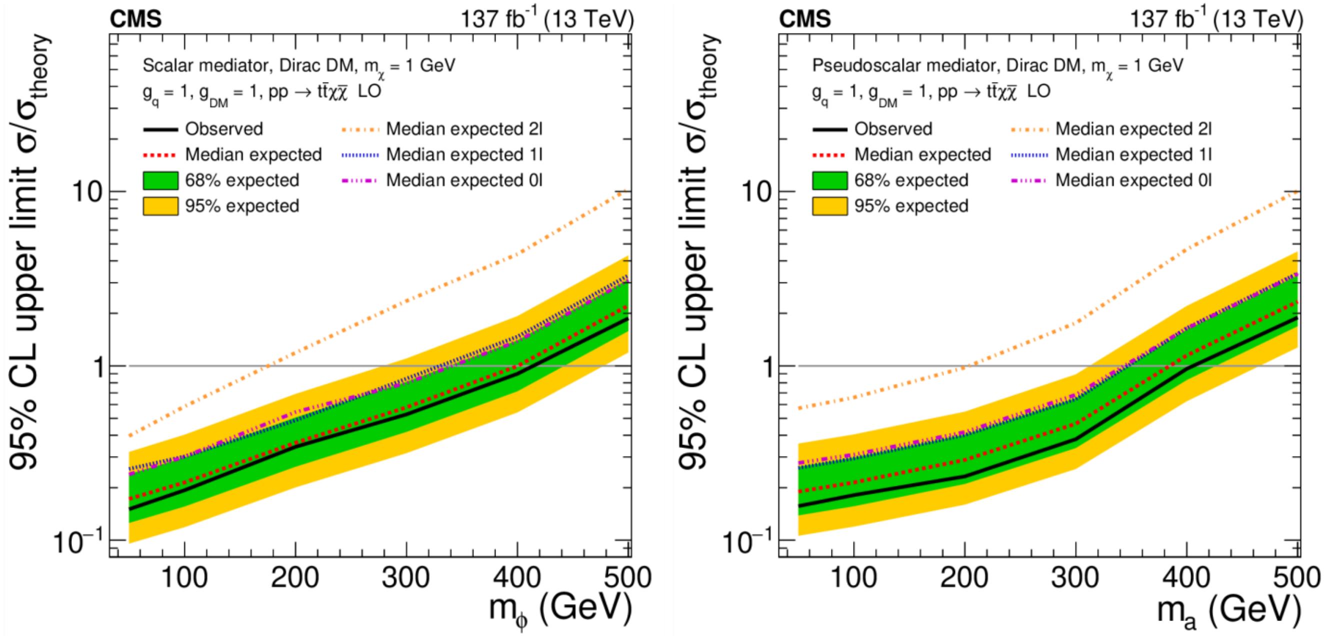
DARK MATTER INTERPRETATION

Eur. Phys. J. C 81 (2021) 970

- The results of the inclusive top squark searches are also interpreted in an alternative **DM signal model** where a **scalar** (ϕ) or **pseudoscalar** (a) particle mediates the interaction between the DM candidate particle and SM quarks.

- Prior searches excluded ϕ and a mediator particles with a mass of up to 290 and 300 GeV, respectively.





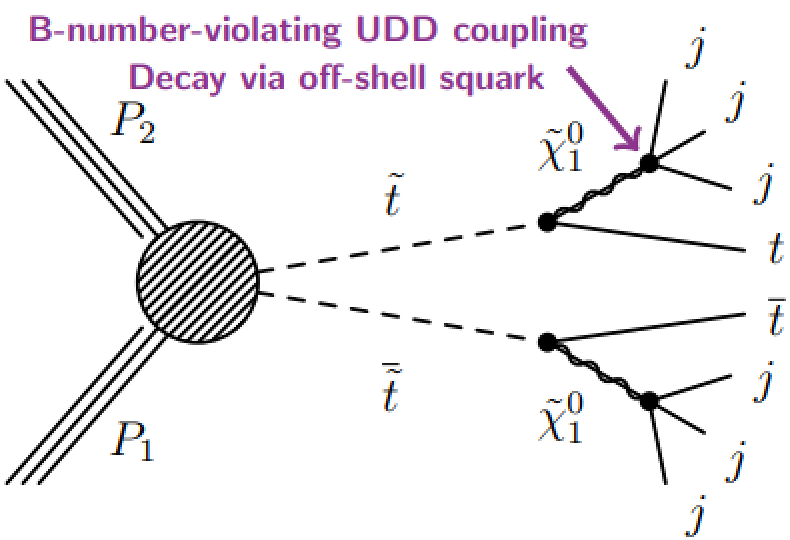
- m_χ = 1 GeV and $g_q = g_{DM}$ = 1 are assumed.
- Limits are set on σ(tt+ϕ/a→χχ).

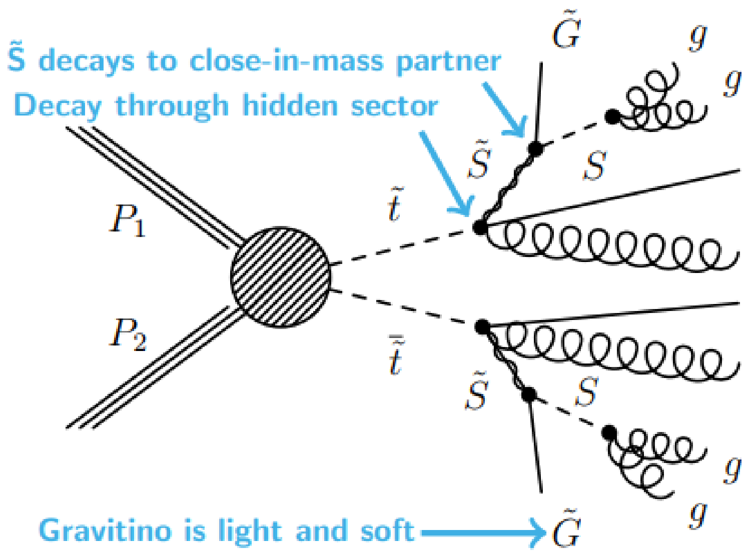
Scalar and pseudoscalar mediators with a mass up to 400 GeV and 420 GeV are excluded, respectively.

RPV / STEALTH STOP SEARCHES

Phys. Rev. D 104, 032006 (2021)

- **R-parity Violating SUSY**: LSP is not stable and decays to SM ➔ stop production would not end in large p_T^{miss}.
- **Stealth (SYY) SUSY**: Consider a hidden sector which simply contains a sfermion and a scalar partner and are very close in mass ➔ stop decays through this hidden sector.





- Final state: $t\bar{t}$ + jets with very **high jet multiplicity**.
- Focused on (largely unexplored) **low p_T^{miss}** topologies of stop decays.

DETAILS OF THE ANALYSIS

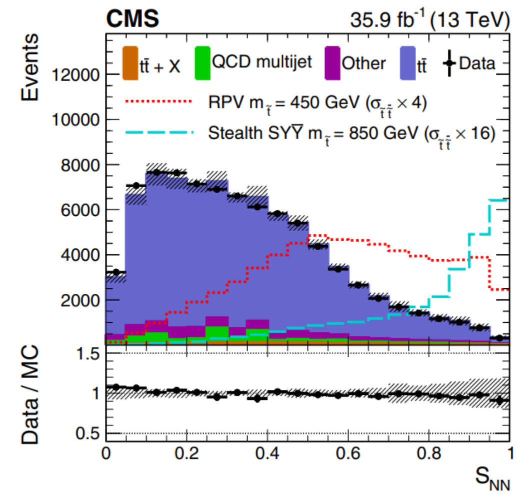
[Phys. Rev. D 104, 032006 (2021)]

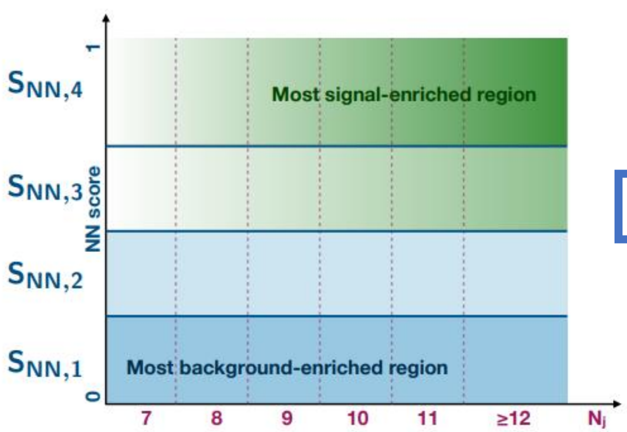
➢ Event selection

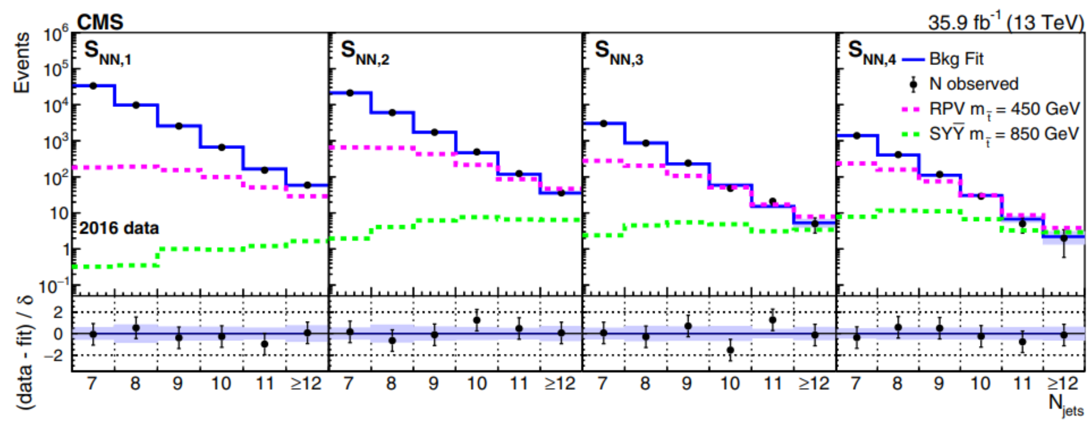
- Exactly **one electron or muon**, to reduce QCD background.
- Events are required to have **at least 7 jests** and large H_T.
- To reduce non $t\bar{t}$ + jets backgrounds, **at least one b-jet** and 50 < $M_{b,l}$ < 250 GeV are required.

➢ Strategy

- A **Neural Network** (NN) is trained to enhance the discrimination between signal and the **primary background $t\bar{t}$ + jets**.
- Events are then divided into **four NN score** (SNN) signal regions and **categorized by N_{jets}**.





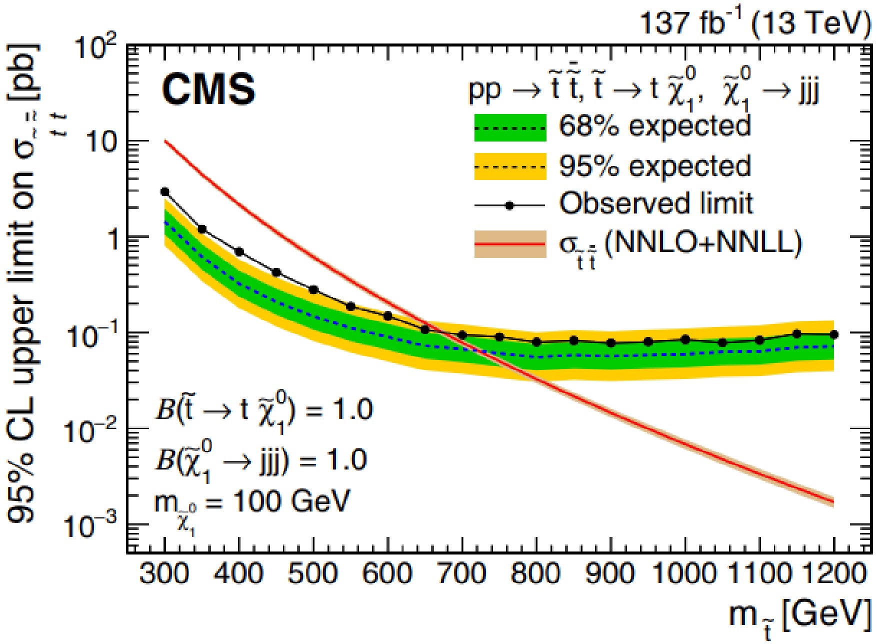


RESULTS

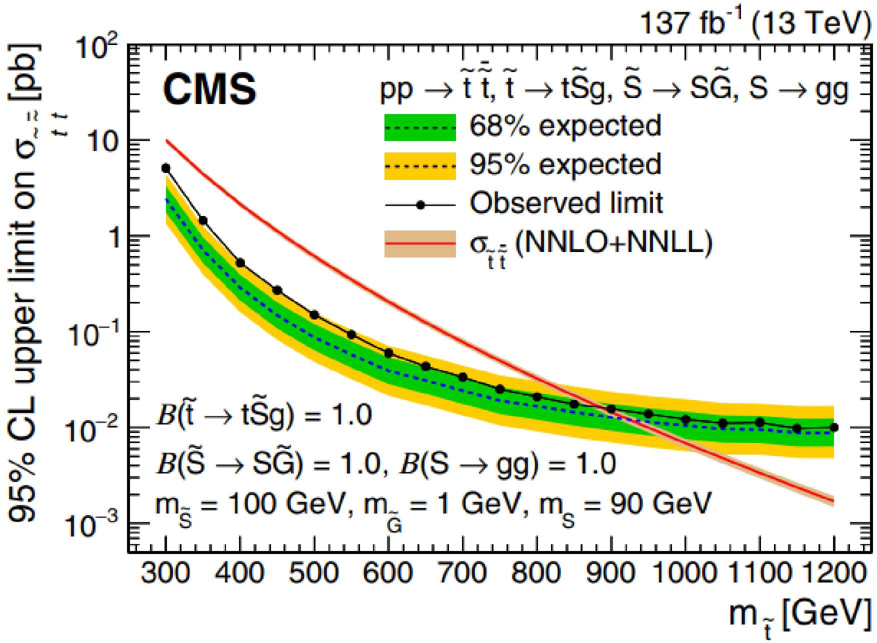
Phys. Rev. D 104, 032006 (2021)

- No significant deviations from SM predictions and results are interpreted in terms of **exclusion limits on $\sigma_{\tilde{t}\bar{\tilde{t}}}$** at the 95% CL.

R-parity Violating SUSY

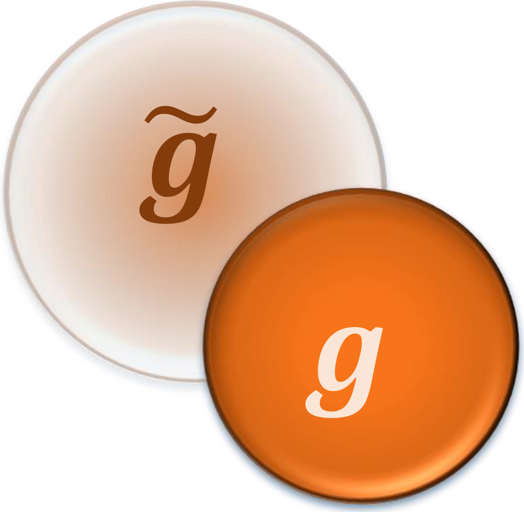


Stealth (SYY) SUSY



- Stop masses up to **670 GeV** are excluded for the **RPV** model.
- Stop masses up to **870 GeV** are excluded for the **Stealth** model.

Gluino searches



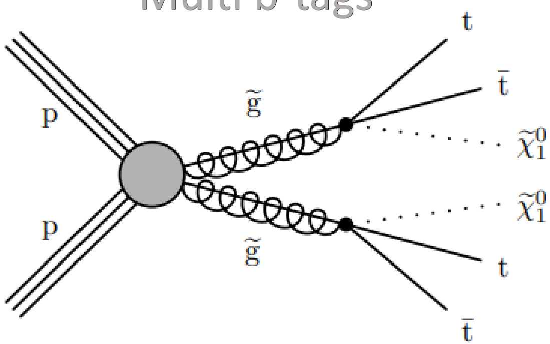
MOTIVATION

CMS-PAS-SUS-21-007

- **Two** gluino-pair production **simplified models** are explored in this analysis.

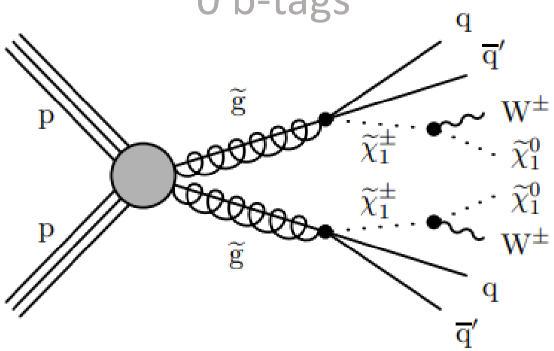
$\tilde{g} \rightarrow t\,\bar{t}\,\tilde{\chi}^0_1$

Multi b-tags

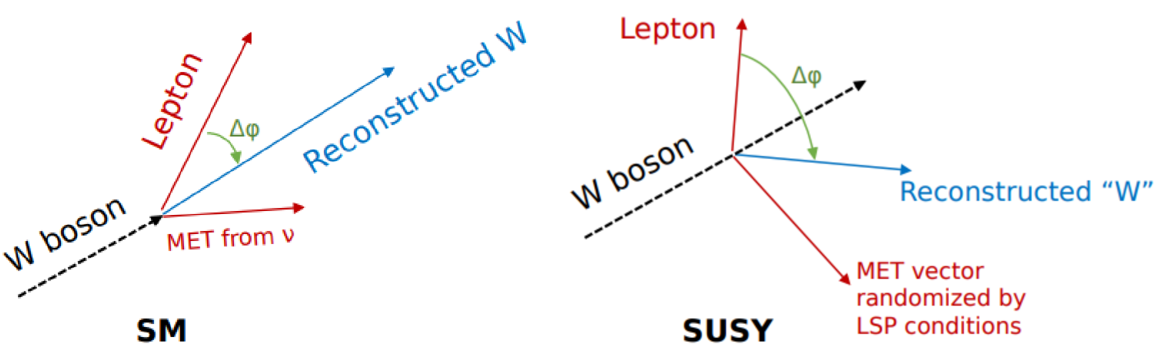


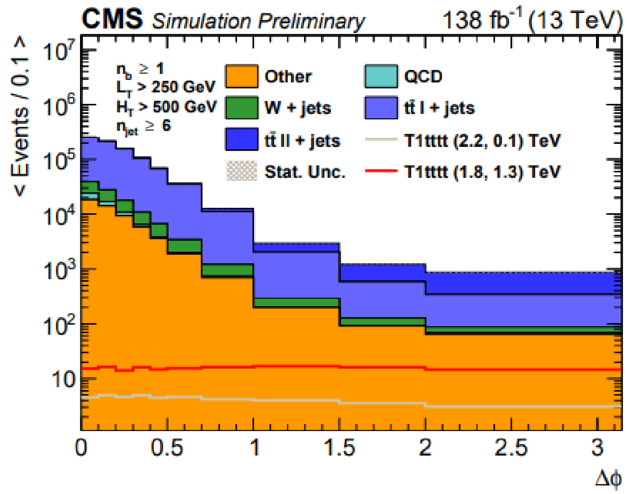
$\tilde{g} \rightarrow q\,\bar{q}\,W\,\tilde{\chi}^0_1$

0 b-tags



- The **main discrimination variable** between signal and SM events is the azimuthal angle between the lepton momentum and the reconstructed leptonic W boson candidate: **$\Delta\phi(W_{reco}, \ell)$**





DETAILS OF THE ANALYSIS

CMS-PAS-SUS-21-007

➢ Event selection

- **Exactly one electron or muon.**
- Events are required to have **at least 3 jets**, and the two leading with $\boldsymbol{p_T}$ **> 80 GeV**.
- Events in the **multi-b** analyses are additionally required to contain **at least one top tag.**
- **Large $\boldsymbol{H_T}$ and $\boldsymbol{L_T}$** to be not only sensitive to events with high p_T^{miss}, but also to signal events with very small p_T^{miss} but higher lepton p_T.

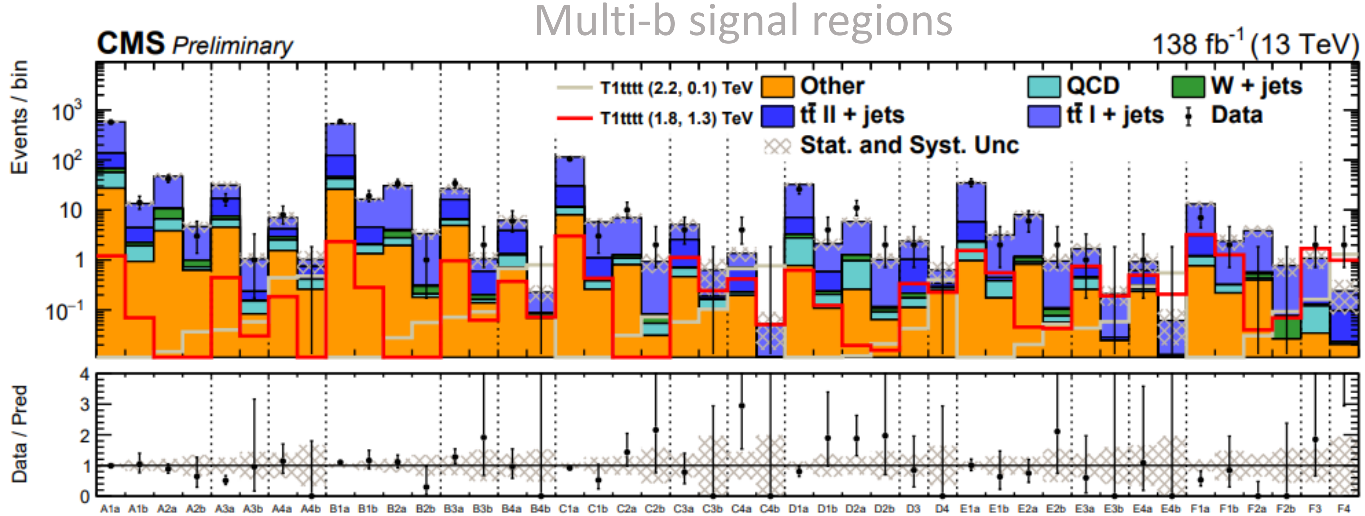
➢ Strategy

- The **Δϕ** variable is used to further suppress the background contributions.
- The search region is split into bins of N_{jets} , N_{b-jets} , L_T , and H_T , and further categorized by N_{top} (N_W) for the multi-b (zero-b) analysis.

➢ Backgrounds

- The main backgrounds arise from **top quark pair production and W+jets production**.

Multi-b signal regions



RESULTS

CMS-PAS-SUS-21-007

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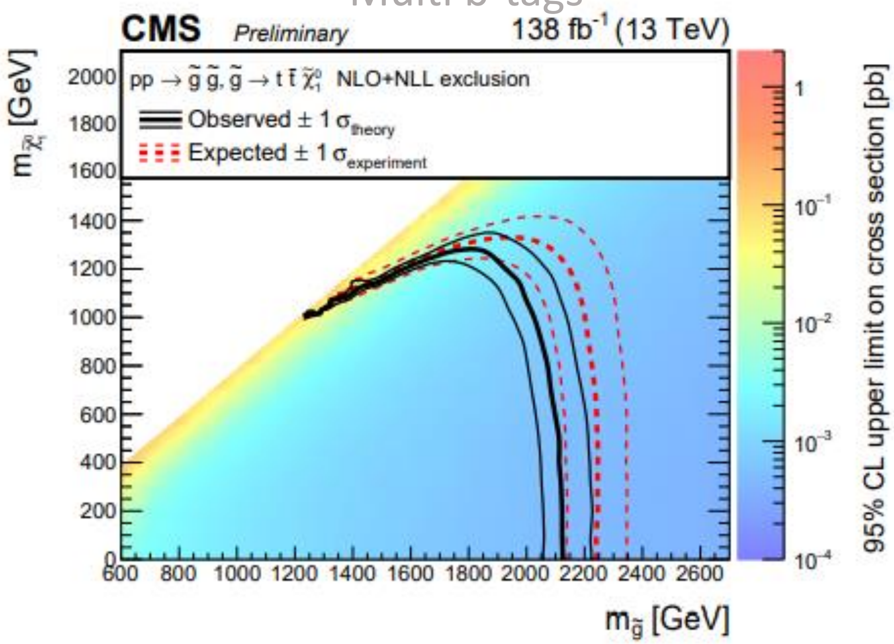
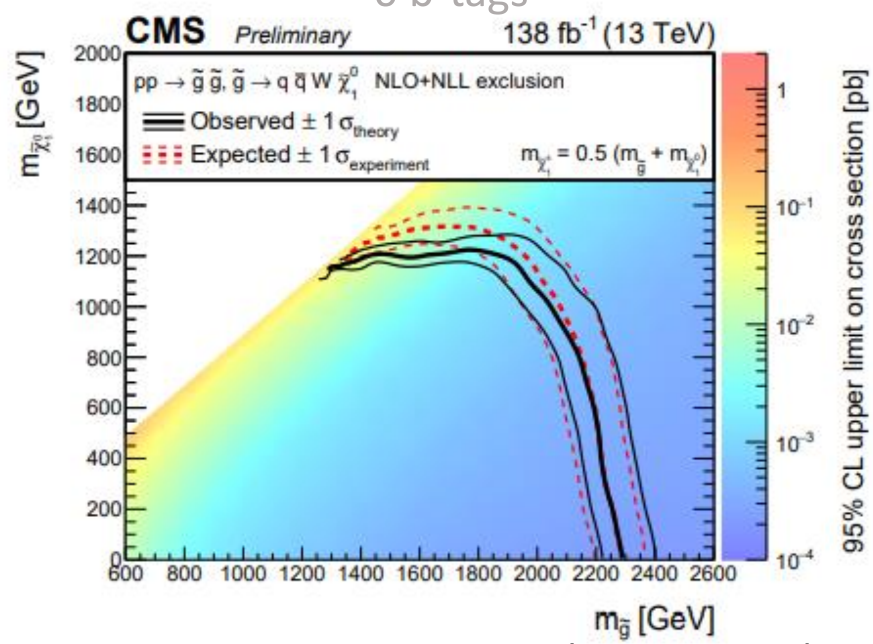
$\tilde{g} \to t\,\bar{t}\,\tilde{\chi}_1^0$

Multi b-tags



$\tilde{g} \to q\,\bar{q}\,W\,\tilde{\chi}_1^0$

0 b-tags

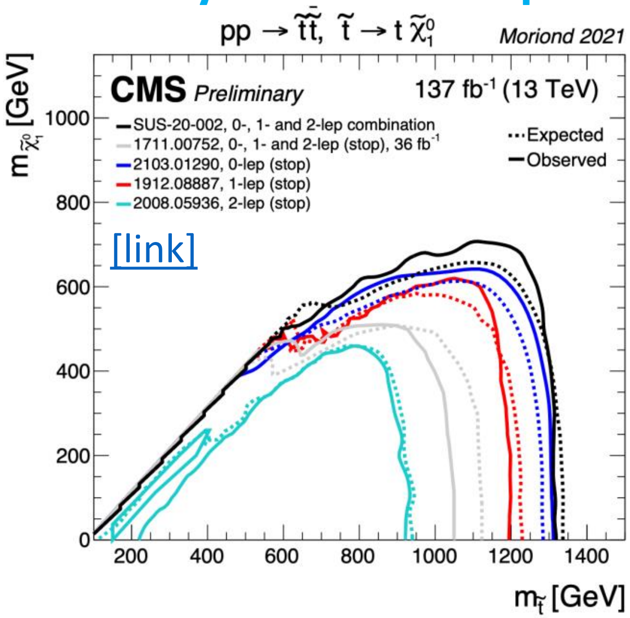


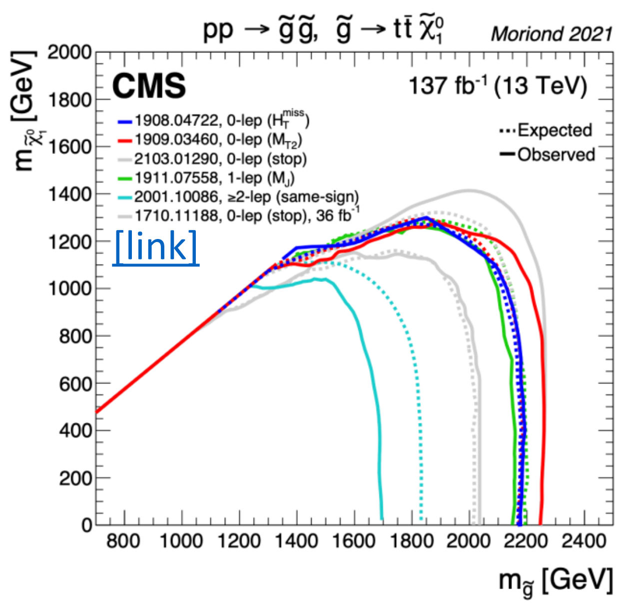
- The excluded gluino (neutralino) masses reach up to **2130 (1270) GeV**. Improvement of about 320 (170) GeV on the gluino (neutralino) masses.

- The excluded gluino (neutralino) masses reach up to **2280 (1220) GeV**. Improvement of about 380 (270) GeV on the gluino (neutralino) masses.

SUMMARY

- Several recent results with Run 2 dataset collected by the CMS experiment have been summarized.
- A very varied program of searches has been completed in different final states and with different interpretations.
- These results significantly extend the existing exclusion limit.
- There are many more results published and on the way, stay tuned!





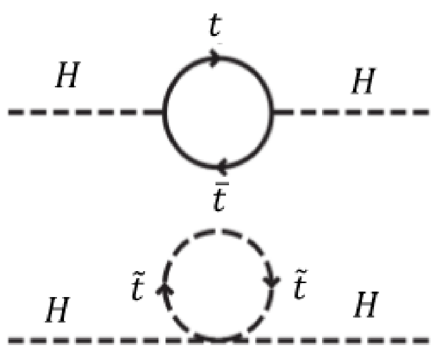
CMS Public SUSY Results:
http://cms-results.web.cern.ch/cms-results/public-results/publications/SUS/index.html

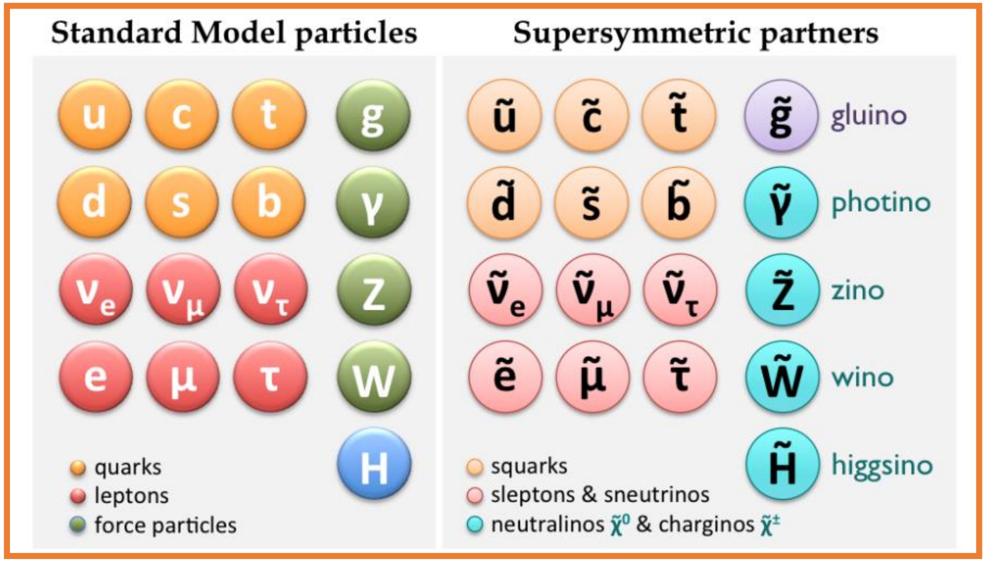
Back up

INTRODUCTION

- **Supersymmetry** is an extension of the SM that assigns a new particle (**superpartner**) to every SM particle differing only in ½ of spin.

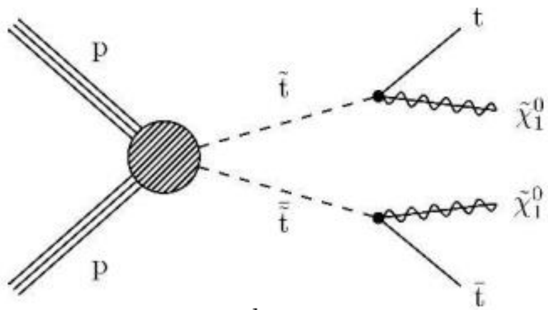
- This model can solve several shortcomings of the SM:
  - The **hierarchy problem** of the quantum loop corrections to the Higgs mass, due mainly to the top quark, can be compensated by the effect of the top quark superpartner.
  - If R-parity is conserved, the lightest supersymmetric particle (**LSP**) is stable and potentially massive, providing a good candidate for **Dark Matter**.
  - **Unification.**

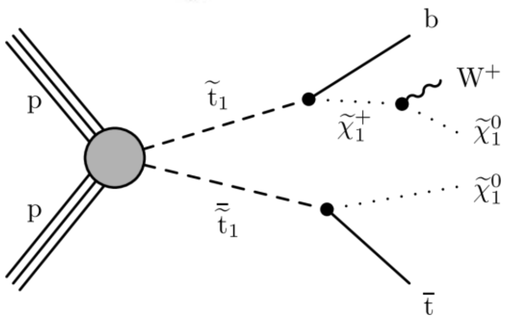


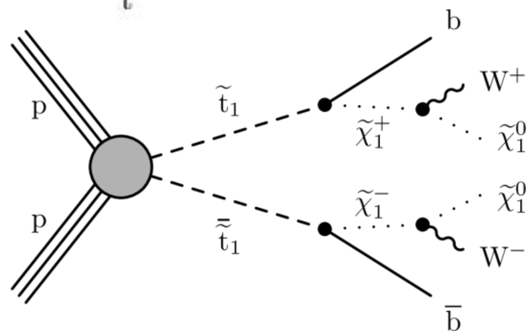


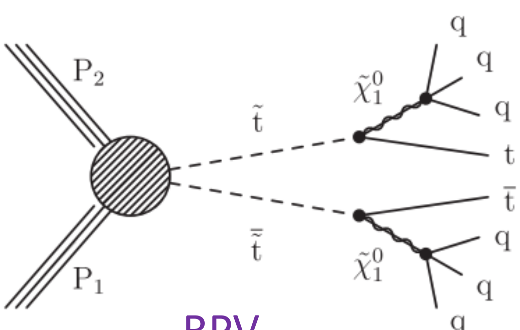
TARGET MODELS

STOPS

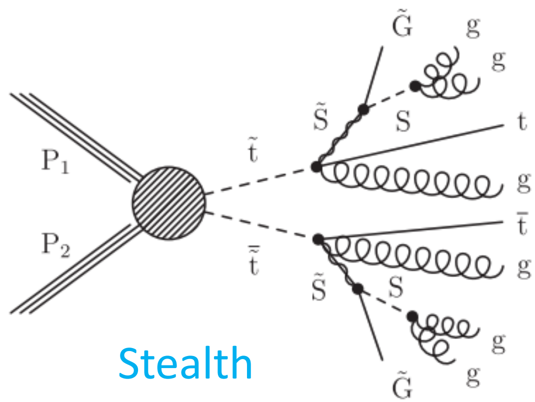






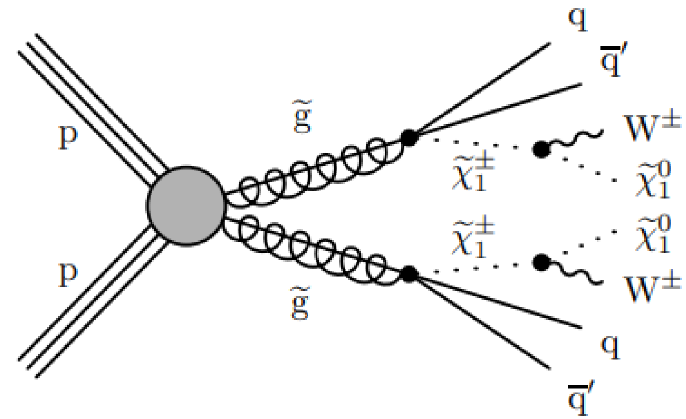


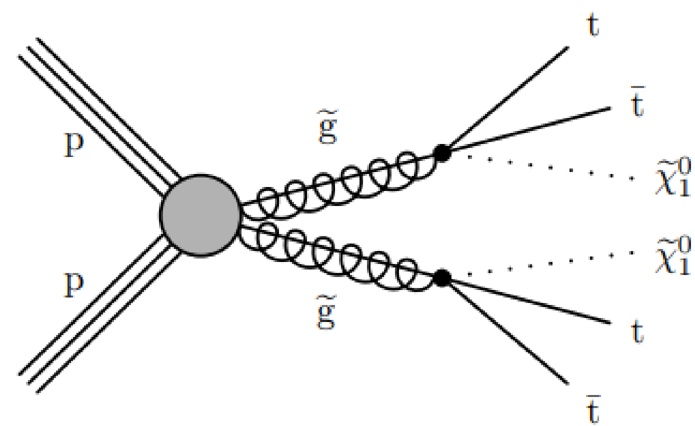
RPV



Stealth

GLUINOS





M_{T2} variable

$$M_{\mathrm{T2}} = \min_{\vec{p}_{\mathrm{T},1}^{\mathrm{miss}} + \vec{p}_{\mathrm{T},2}^{\mathrm{miss}} = \vec{p}_{\mathrm{T}}^{\mathrm{miss}}} \left(\max \left[m_{\mathrm{T}}(\vec{p}_{\mathrm{T}}^{\ell 1}, \vec{p}_{\mathrm{T},1}^{\mathrm{miss}}), m_{\mathrm{T}}(\vec{p}_{\mathrm{T}}^{\ell 2}, \vec{p}_{\mathrm{T},2}^{\mathrm{miss}}) \right] \right)$$

RPV/STEALTH STOPS

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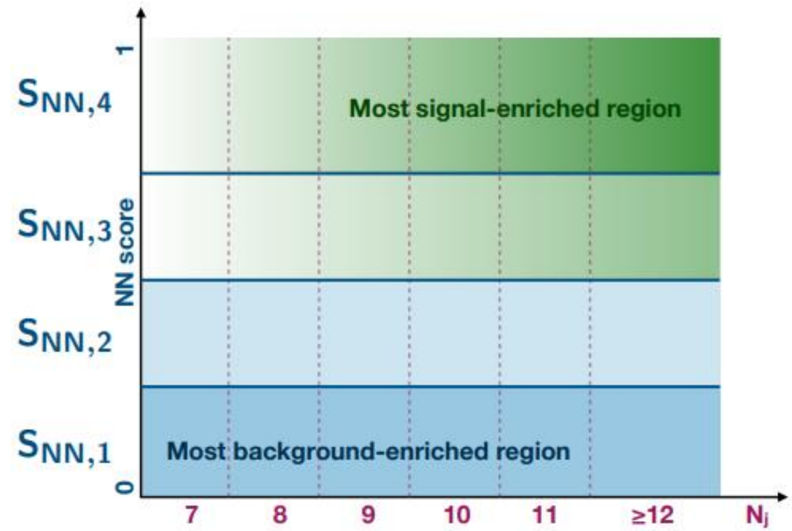
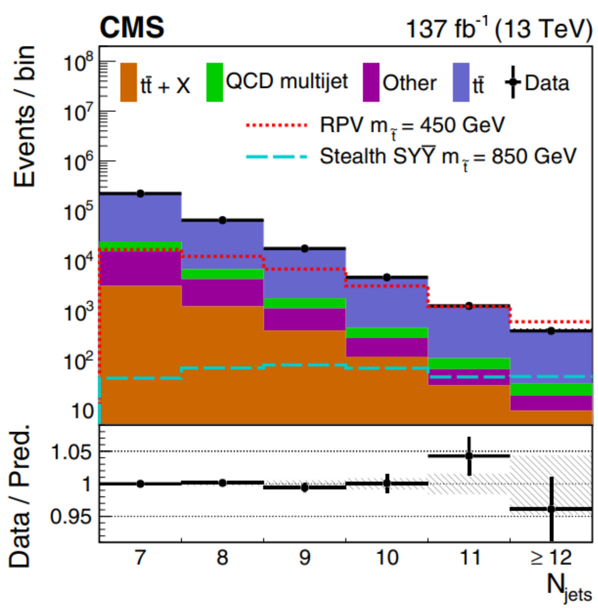
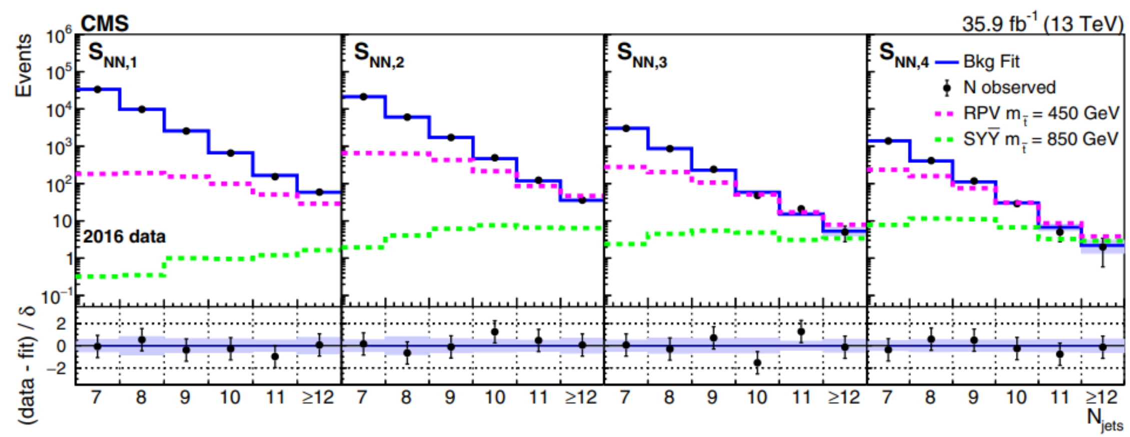
- The network uses gradient reversal to avoid correlation with Njets.
- A simultaneous fit over all SNN bins of the total Njets shape is performed, where the ttbar Njets shape is constrained to be the same in each region.







GLUINOS

CMS-PAS-SUS-21-007

Multi b-tags

n_{jet}	n_b	L_T [GeV]	H_T [GeV]	n_t	Bin name	T1tttt signal events (1.8, 1.3) TeV	T1tttt signal events (2.2, 0.1) TeV	Predicted background events	Observed events
[6, 8]	1	[250, 450]	[500, 1500]	1	A1a	1.2 ± 0.1	<0.1	576 ± 29	570
				≥2	A1b	0.07 ± 0.02	<0.1	13 ± 2	14
			≥1500	1	A2a	<0.1	0.01 ± 0.01	47 ± 7	42
				≥2	A2b	<0.1	0.04 ± 0.01	5 ± 1	3
		[450, 600]	≥500	1	A3a	0.44 ± 0.06	0.04 ± 0.01	31 ± 6	16
				≥2	A3b	0.03 ± 0.02	0.06 ± 0.01	1.0 ± 0.3	1
		≥600	≥500	1	A4a	0.18 ± 0.04	0.44 ± 0.02	7 ± 2	8
				≥2	A4b	<0.1	0.48 ± 0.02	1.0 ± 0.5	0
	2	[250, 450]	[500, 1500]	1	B1a	2.3 ± 0.1	0.01 ± 0.01	532 ± 26	586
				≥2	B1b	0.28 ± 0.04	0.01 ± 0.01	16 ± 2	19
			≥1500	1	B2a	<0.1	0.03 ± 0.01	30 ± 5	34
				≥2	B2b	<0.1	0.06 ± 0.01	3.4 ± 0.8	1
		[450, 600]	≥500	1	B3a	1.0 ± 0.1	0.07 ± 0.01	27 ± 6	34
				≥2	B3b	0.06 ± 0.02	0.09 ± 0.01	1.1 ± 0.5	2
		≥600	≥500	1	B4a	0.37 ± 0.05	0.67 ± 0.03	6.2 ± 1.6	6
				≥2	B4b	0.07 ± 0.02	0.80 ± 0.03	0.23 ± 0.08	0
	≥3	[250, 450]	[500, 1500]	1	C1a	3.0 ± 0.1	0.01 ± 0.01	115 ± 7	105
				≥2	C1b	0.43 ± 0.06	<0.1	6 ± 1	3
			≥1500	1	C2a	0.01 ± 0.01	0.03 ± 0.01	7 ± 2	10
				≥2	C2b	<0.1	0.07 ± 0.01	1.0 ± 0.4	2
		[450, 600]	≥500	1	C3a	1.1 ± 0.1	0.06 ± 0.01	5 ± 1	4
				≥2	C3b	0.24 ± 0.04	0.10 ± 0.01	0.63 ± 0.43	0
		≥600	≥500	1	C4a	0.42 ± 0.05	0.67 ± 0.02	1.4 ± 0.4	4
				≥2	C4b	0.05 ± 0.02	0.76 ± 0.03	0.05 ± 0.04	0
≥9	1	[250, 450]	[500, 1500]	1	D1a	0.62 ± 0.06	<0.1	32 ± 3	26
				≥2	D1b	0.12 ± 0.03	<0.1	2.1 ± 0.6	4
			≥1500	1	D2a	0.02 ± 0.01	0.01 ± 0.01	6 ± 1	11
				≥2	D2b	0.02 ± 0.01	0.02 ± 0.01	1.0 ± 0.3	2
		[450, 600]	≥500	≥1	D3	0.34 ± 0.05	0.04 ± 0.01	2.3 ± 0.6	2
		≥600	≥500	≥1	D4	0.23 ± 0.04	0.40 ± 0.02	0.6 ± 0.3	0
	2	[250, 450]	[500, 1500]	1	E1a	1.5 ± 0.1	0.01 ± 0.01	35 ± 3	35
				≥2	E1b	0.55 ± 0.06	<0.1	3.2 ± 0.7	2
			≥1500	1	E2a	0.05 ± 0.02	0.02 ± 0.01	8 ± 2	6
				≥2	E2b	0.04 ± 0.02	0.05 ± 0.01	1.0 ± 0.4	2
		[450, 600]	≥500	1	E3a	0.75 ± 0.07	0.04 ± 0.01	1.7 ± 0.5	1
				≥2	E3b	0.19 ± 0.03	0.06 ± 0.01	0.2 ± 0.1	0
		≥600	≥500	1	E4a	0.50 ± 0.05	0.30 ± 0.02	0.9 ± 0.4	1
				≥2	E4b	0.21 ± 0.04	0.55 ± 0.02	0.06 ± 0.04	0
	≥3	[250, 450]	[500, 1500]	1	F1a	3.2 ± 0.1	0.01 ± 0.01	13 ± 2	7
				≥2	F1b	1.27 ± 0.08	<0.1	2.4 ± 0.8	2
			≥1500	1	F2a	0.04 ± 0.02	0.03 ± 0.01	4 ± 1	0
				≥2	F2b	0.07 ± 0.02	0.09 ± 0.01	0.7 ± 0.3	0
		[450, 600]	≥500	≥1	F3	1.7 ± 0.1	0.16 ± 0.01	1.1 ± 0.4	2
		≥600	≥500	≥1	F4	1.0 ± 0.1	1.30 ± 0.03	0.2 ± 0.2	2

0 b-tags

n_{jet}	L_T [GeV]	H_T [GeV]	$\Delta\phi$	n_W	Bin name	T5qqqqWW signal events (1.8, 1.3) TeV	T5qqqqWW signal events (2.2, 0.1) TeV	Predicted background events	Observed events
5	[250, 350]	[500, 750]	>1	0	G0a	1.2 ± 0.1	<0.1	342 ± 24	333
				≥1	G0b	0.46 ± 0.08	<0.1	70 ± 8	77
		750		0	G1a	0.35 ± 0.07	0.03 ± 0.01	292 ± 22	304
				≥1	G1b	0.14 ± 0.04	0.02 ± 0.01	69 ± 10	62
	[350, 450]	[500, 750]	>1	0	G2a	1.8 ± 0.2	<0.1	71 ± 8	63
				≥1	G2b	0.60 ± 0.09	<0.1	14 ± 5	25
		750		0	G3a	0.44 ± 0.08	0.04 ± 0.01	66 ± 8	44
				≥1	G3b	0.24 ± 0.06	0.03 ± 0.01	14 ± 4	13
	[450, 650]	[500, 750]	>0.75	0	G4a	2.1 ± 0.2	<0.1	52 ± 7	45
				≥1	G4b	1.1 ± 0.1	<0.1	12 ± 3	9
		[750, 1250]		0	G5a	0.9 ± 0.1	0.03 ± 0.01	42 ± 6	35
				≥1	G5b	0.35 ± 0.07	<0.1	10 ± 3	6
		≥1250		0	G6a	<0.1	0.17 ± 0.02	16 ± 3	19
				≥1	G6b	<0.1	0.13 ± 0.02	3 ± 1	3
	≥650	[500, 1250]	>0.5	0	G7a	1.3 ± 0.1	0.13 ± 0.02	33 ± 8	32
				≥1	G7b	0.30 ± 0.06	0.04 ± 0.01	7 ± 2	8
		≥1250		0	G8a	0.15 ± 0.05	1.78 ± 0.07	11 ± 3	8
				≥1	G8b	0.04 ± 0.02	1.08 ± 0.05	0.6 ± 0.4	2
[6, 7]	[250, 350]	[500, 1000]	>1	0	H1a	2.6 ± 0.2	<0.1	281 ± 22	292
				≥1	H1b	1.3 ± 0.1	<0.1	71 ± 9	71
		≥1000		0	H2a	0.23 ± 0.06	0.05 ± 0.01	121 ± 11	121
				≥1	H2b	0.18 ± 0.05	0.02 ± 0.01	29 ± 5	21
	[350, 450]	[500, 1000]	>1	0	H3a	3.1 ± 0.2	<0.1	51 ± 6	71
				≥1	H3b	1.6 ± 0.2	0.01 ± 0.01	12 ± 3	15
		≥1000		0	H4a	0.31 ± 0.07	0.09 ± 0.01	31 ± 7	21
				≥1	H4b	0.12 ± 0.04	0.08 ± 0.01	6 ± 2	6
	[450, 650]	[500, 750]	>0.75	0	H5a	3.1 ± 0.2	<0.1	19 ± 4	17
				≥1	H5b	1.6 ± 0.2	<0.1	5 ± 2	9
		[750, 1250]		0	H6a	2.8 ± 0.2	0.01 ± 0.01	29 ± 4	18
				≥1	H6b	1.4 ± 0.1	<0.1	7 ± 2	4
		≥1250		0	H7a	0.4 ± 0.07	0.45 ± 0.03	15 ± 3	14
				≥1	H7b	0.2 ± 0.05	0.33 ± 0.03	3 ± 1	1
	≥650	[500, 1250]	>0.5	0	H8a	2.5 ± 0.2	0.09 ± 0.01	13 ± 3	17
				≥1	H8b	0.9 ± 0.1	0.05 ± 0.01	4 ± 1	4
		≥1250		0	H9a	0.8 ± 0.1	3.9 ± 0.1	9 ± 3	6
				≥1	H9b	0.34 ± 0.07	2.44 ± 0.08	2 ± 1	1
≥8	[250, 350]	[500, 1000]	>1	0	I1a	0.8 ± 0.1	<0.1	23 ± 5	25
				≥1	I1b	0.33 ± 0.07	<0.1	7 ± 3	5
		≥1000		0	I2a	0.30 ± 0.07	0.04 ± 0.01	22 ± 5	23
				≥1	I2b	0.16 ± 0.05	0.01 ± 0.01	8 ± 2	12
	[350, 450]	[500, 1000]	>1	0	I3a	0.8 ± 0.1	<0.1	3.0 ± 0.7	10
				≥1	I3b	0.36 ± 0.07	<0.1	1.1 ± 0.4	0
		≥1000		0	I4a	0.57 ± 0.09	0.07 ± 0.01	5 ± 1	5
				≥1	I4b	0.36 ± 0.07	0.06 ± 0.01	3 ± 1	2
	[450, 650]	[500, 1250]	>0.75	0	I5a	1.5 ± 0.1	<0.1	3.4 ± 0.9	4
				≥1	I5b	1.0 ± 0.1	<0.1	0.5 ± 0.3	1
		≥1250		0	I6a	0.40 ± 0.07	0.26 ± 0.03	2.6 ± 0.8	2
				≥1	I6b	0.18 ± 0.05	0.17 ± 0.02	0.5 ± 0.3	2
	≥650	[500, 1250]	>0.5	≥0	I7	1.4 ± 0.1	0.02 ± 0.01	1.5 ± 0.6	2
		≥1250			I8	1.4 ± 0.1	3.58 ± 0.09	1.5 ± 0.7	1

GLUINOS

CMS-PAS-SUS-21-007

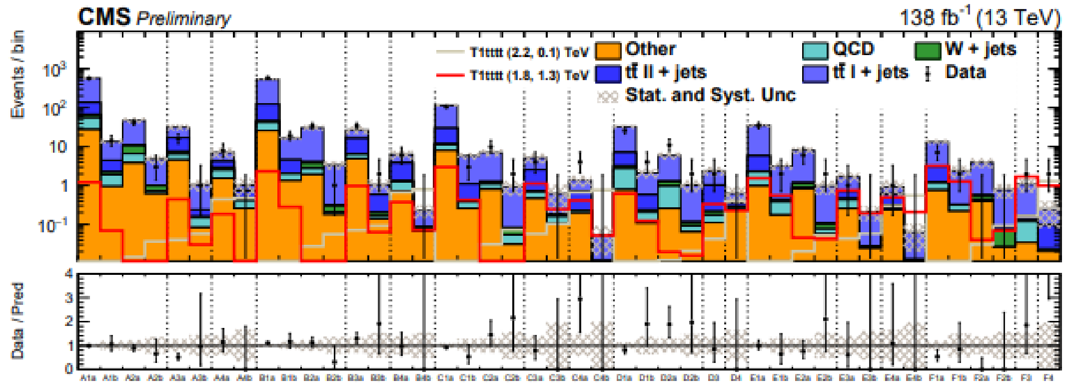


Figure 8: Observed event yields in the MB SR of the multi-b analysis compared to signal and background predictions, for all three years combined. The relative fraction of the different SM EW background contributions determined in simulation is shown by the stacked, colored histograms, normalized so that their sum is equal to the background estimated using data control regions. The QCD background is predicted using the L_P method. The signal is shown for two representative combinations of gluino/neutralino masses with large (2.2 TeV/0.1 TeV) and small (1.8 TeV/1.3 TeV) mass differences.

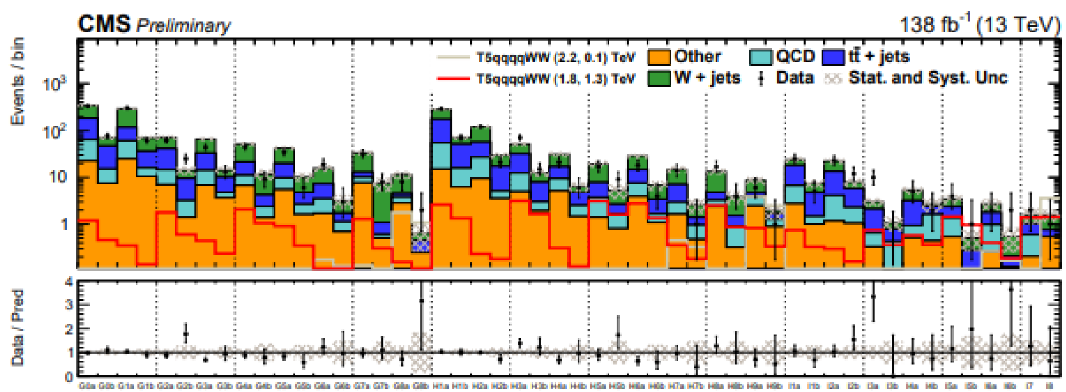


Figure 9: Observed event yields in the MB SR of the zero-b analysis compared to signal and background predictions, for all three years combined. The W+jets, $t\bar{t}$, and QCD predictions are extracted from data control samples, while the other background contributions are estimated from simulation. The signal is shown for two representative combinations of gluino/neutralino masses with large (2.2 TeV/0.1 TeV) and small (1.8 TeV/1.3 TeV) mass differences.