Recent highlights of supersymmetry searches from CMS

PABLO MATORRAS-CUEVAS

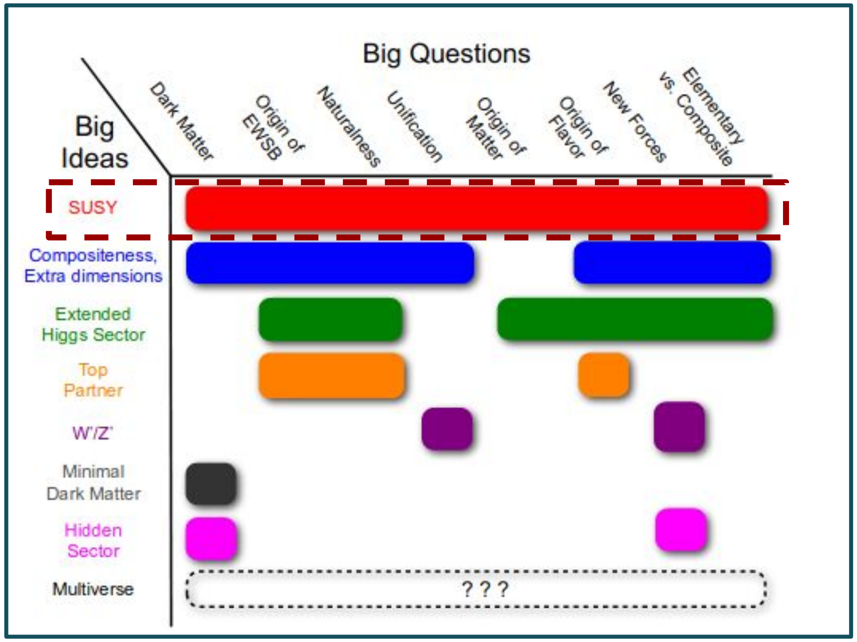
Instituto de Física de Cantabria (CSIC-Universidad de Cantabria)

On behalf of the CMS collaboration

XXXI International Workshop on Deep Inelastic Scattering (DIS24)

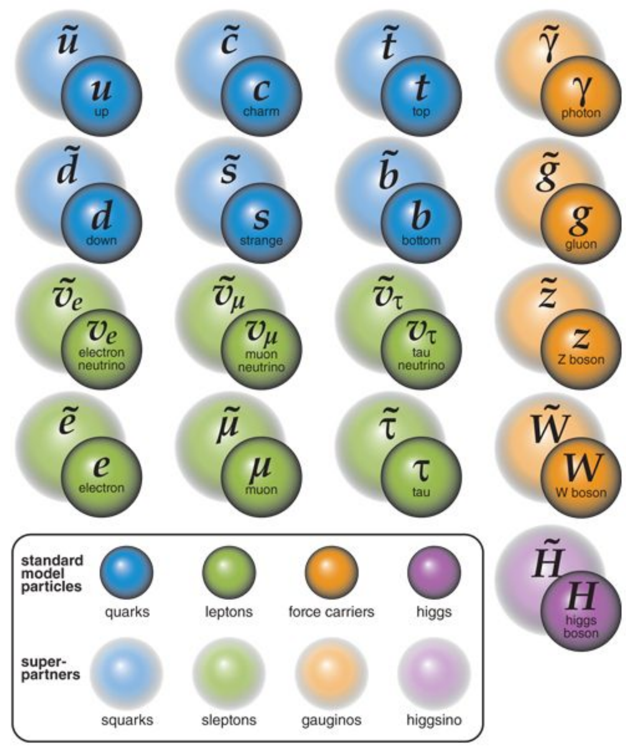
Grenoble, France, 10th April, 2024

Supersymmetry:
why, what?



- Supersymmetry (**SUSY**) can solve multiple open questions both theoretical (great unification theory) or experimental (dark matter (DM) candidate)

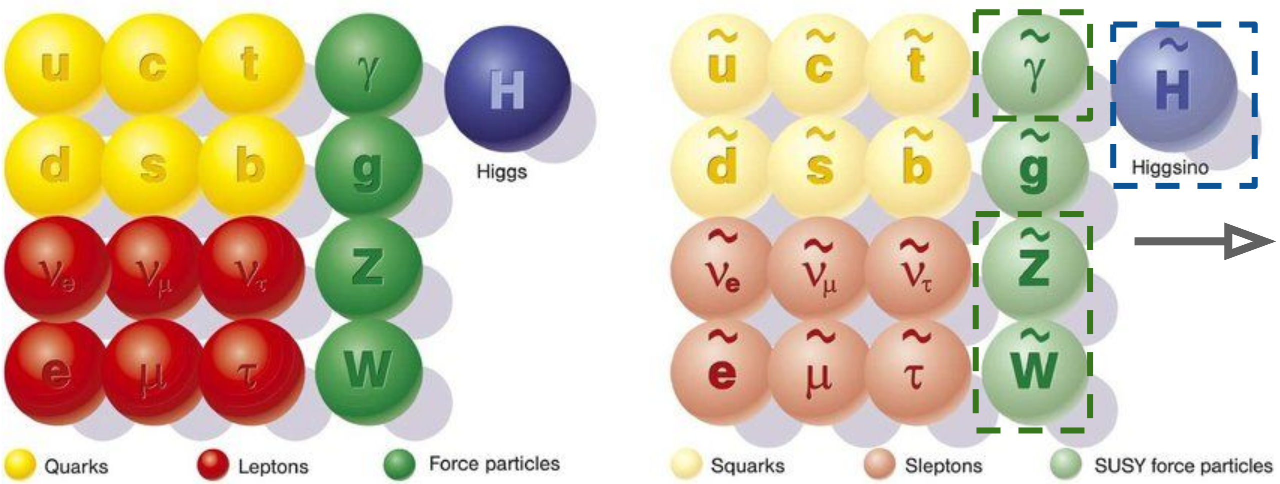
- A new space time symmetry ➞ one superpartner companion per standard model (SM) particle.
- If R parity conserved ➞ produced in pairs, Lightest supersymmetric particle (LSP) stable
- Naturalness ➞ gluinos, top squark (stop), charginos and neutralinos at TeV scale

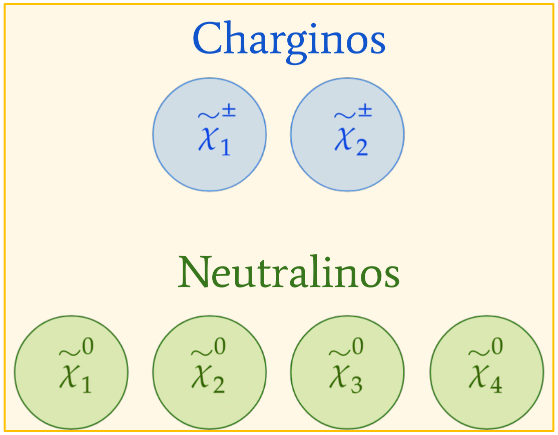


Supersymmetry:
Electroweak SUSY in a nutshell

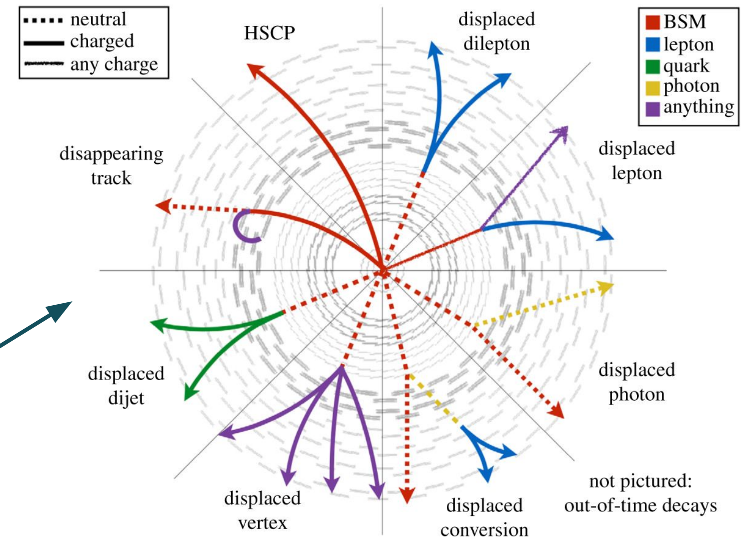
- In general SUSY is constructed as an extension of the standard model
  - → Electroweakinos are mixtures of Winos, Zinos, photinos and higgsinos, whose mass eigenstates are charginos and neutralinos
- Relevant due to:
  - Contribute to large corrections of the Higgs mass
  - Its LSP, typically the neutralino, is a good dark matter candidate
  - Masses accessible by the LHC (~order of the TeV)

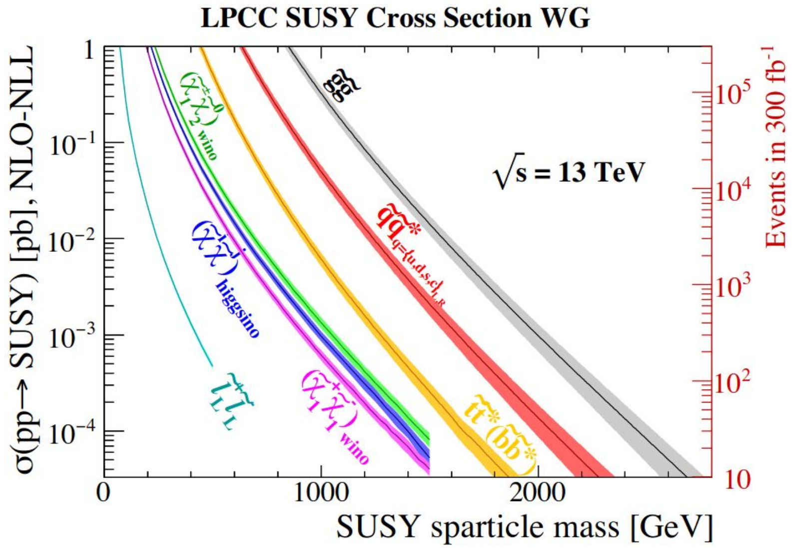
SM **MSSM** **Electroweakinos**





- R-Parity not conserved?
  → **CMS PAS SUS-23-015**
- Hidden (Stealth) SUSY Sector?
  → **CMS SUS-19-001**
- New particles with longer lifetimes?
  → **CMS SUS-21-006**
- Are SUSY particles just heavier/its cross-section is smaller than what's been probed? Combination of "Conventional" SUSY searches (with high p_T^{miss} from LSPs)
  → **CMS SUS-21-008**
- Full list in **CMS webpage**



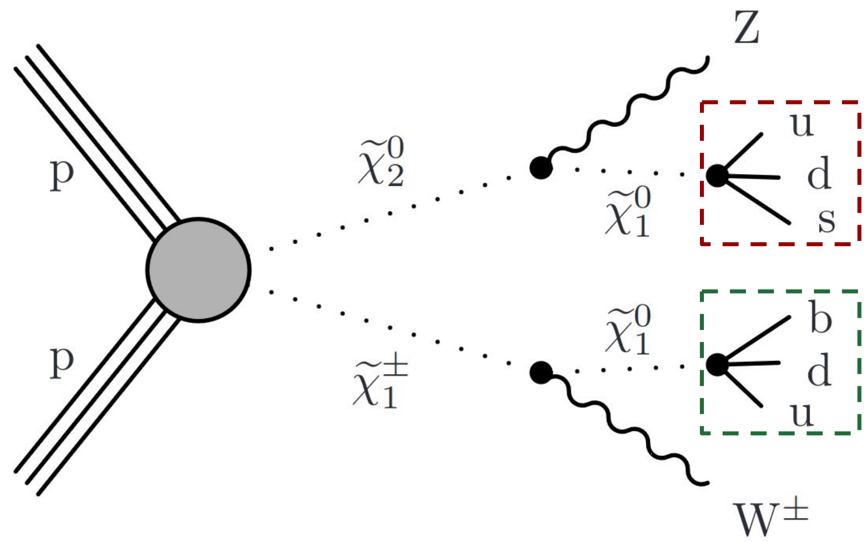


RPV SUSY with weak production and strong decay

New!

CMS PAS SUS-23-015

- Target the production of electroweakinos in final states involving W and Z bosons and an R-Parity violating neutralino (LSP) decaying to:
  - RPVq: LSP decaying to uds
    - → Final states including W,Z+6 light quark jets
  - RPVb: LSP decaying to udb:
    - → Final states with W,Z +4 light jets and 2b quark jets

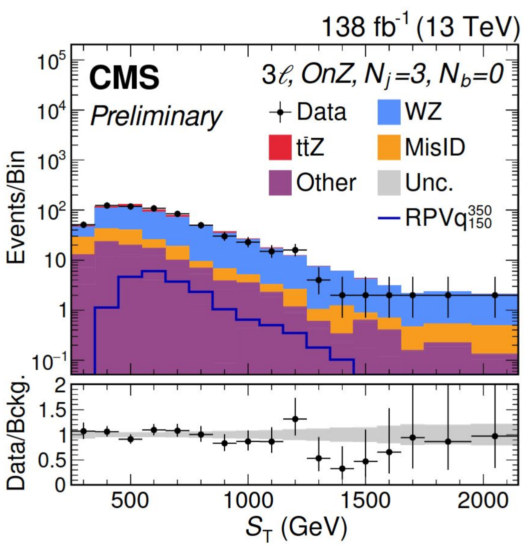


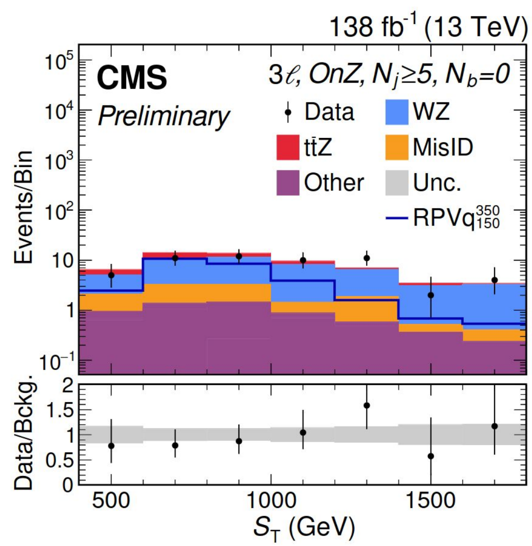
- Use number of jets (n_{jets}) as a discriminating variable
- Main backgrounds expected to be WZ (low n_{jets}) and ttZ (high n_{jets}).
- Electroweakinos expected to be at the electroweak scale

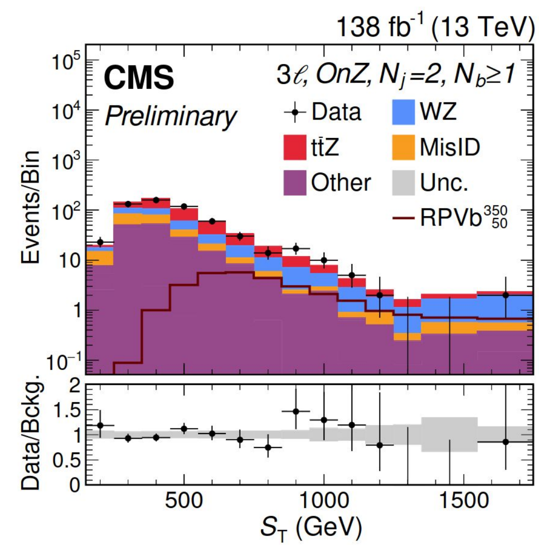
RPV SUSY with weak production and strong decay

New! CMS PAS SUS-23-015

- Signal events require 3 isolated leptons with p_T>10 GeV and up to 6 jets with p_T>30 GeV. Two of the leptons need to have an invariant mass consistent with a Z boson (76<m_{ll}<106 GeV)
- Signal Regions (SRs) defined in terms of n_{jets}, the number of b quark jets (n_{bjets})
- Distributions studied using the sum of all objects p_T (S_T) as variable.
- Control Regions (CRs) defined by varying requirements on number of leptons







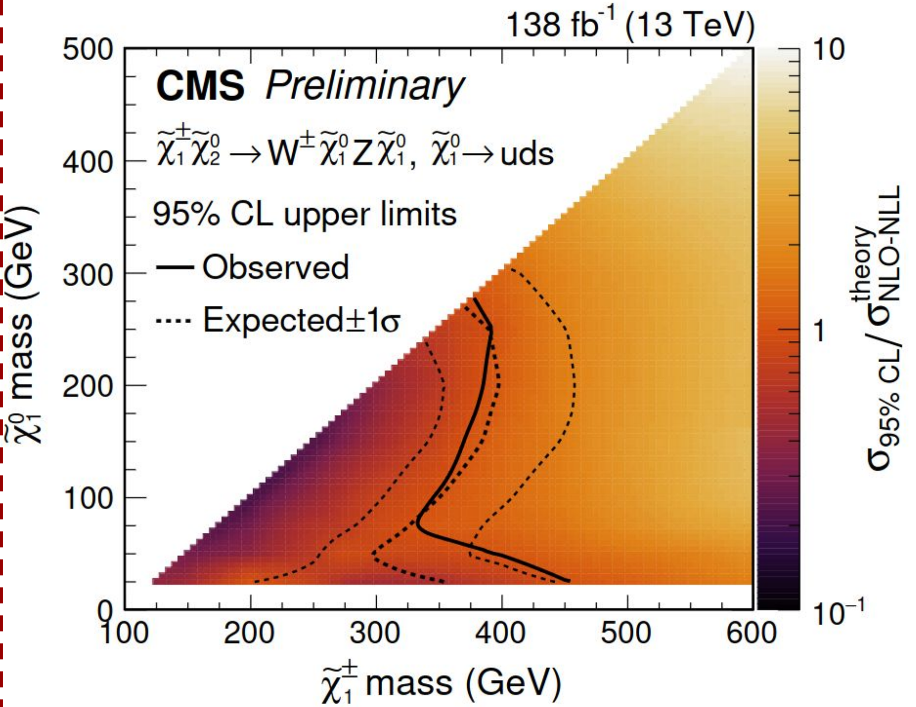
RPV SUSY with weak production and strong decay
Results

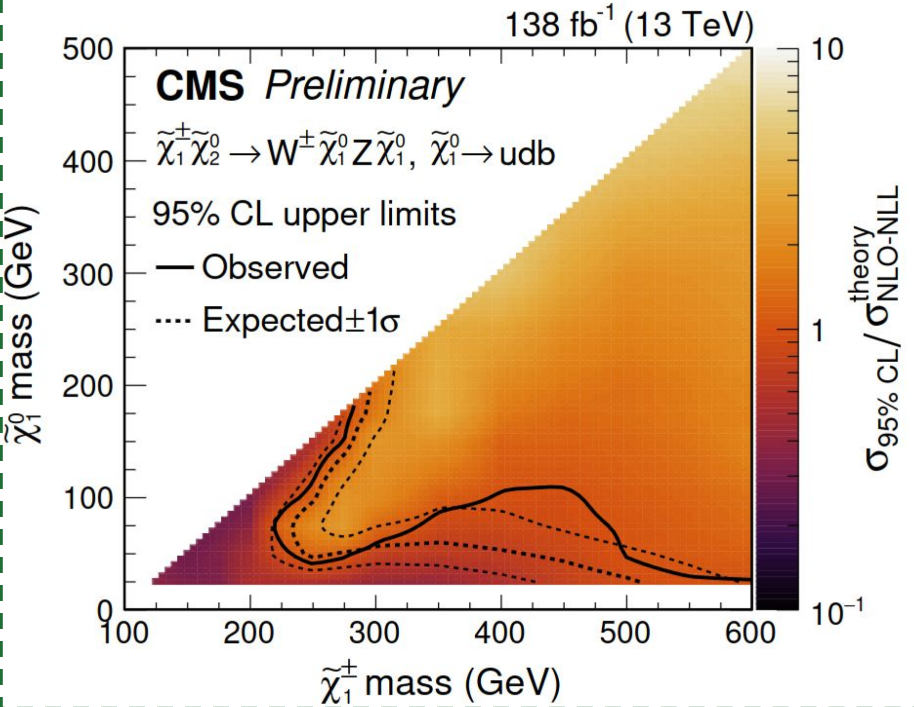
New! CMS PAS SUS-23-015

No statistically significant deviations were found

95% exclusion limits were placed:

- RPVq: Chargino mass at ~350 GeV for compressed scenario, up to 450 GeV for low LSP mass
- RPVb: Chargino mass at ~275 GeV for compressed scenario, up to 600 GeV for low LSP mass





Stealth SUSY with diphotons, jets and low MET

CMS SUS-19-001

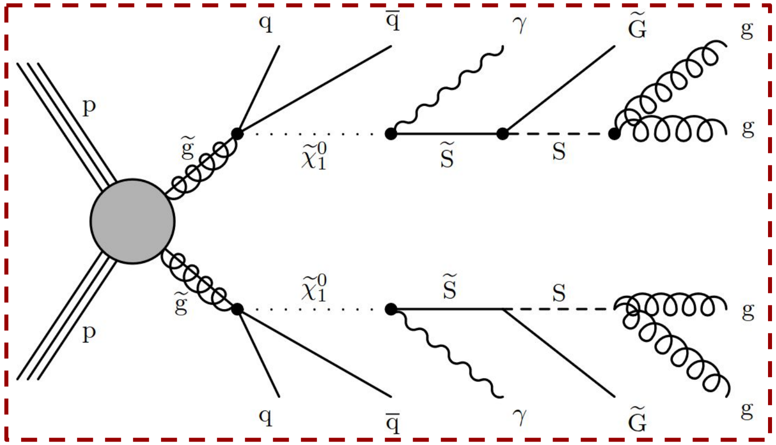
Stealth SUSY: Hidden SUSY sector ($\tilde{S}$)only broken via a weak portal:

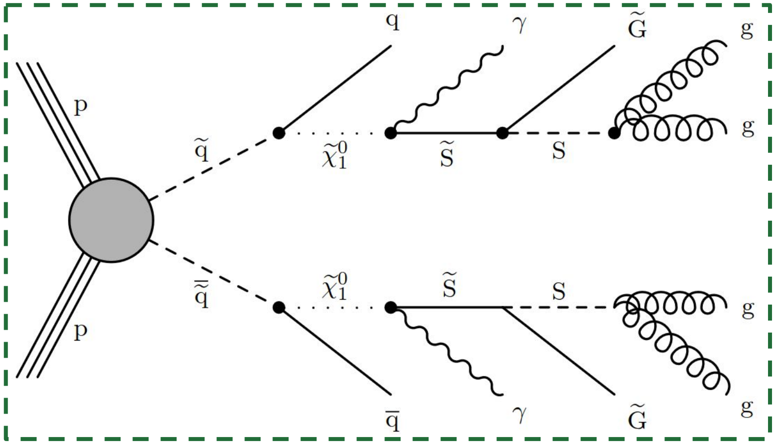
- Superpartners nearly mass degenerate and low LSP p_T .
- $\tilde{S}$ decays to its hidden partner S, with a gravitino as LSP
- Production studied via gluino and squark production

Models with conserved R-parity and no special fine-tuning

Events selected with two or more jets and S_T>1200 GeV:

- CRs with 2 non isolated photons and with only 1 photon



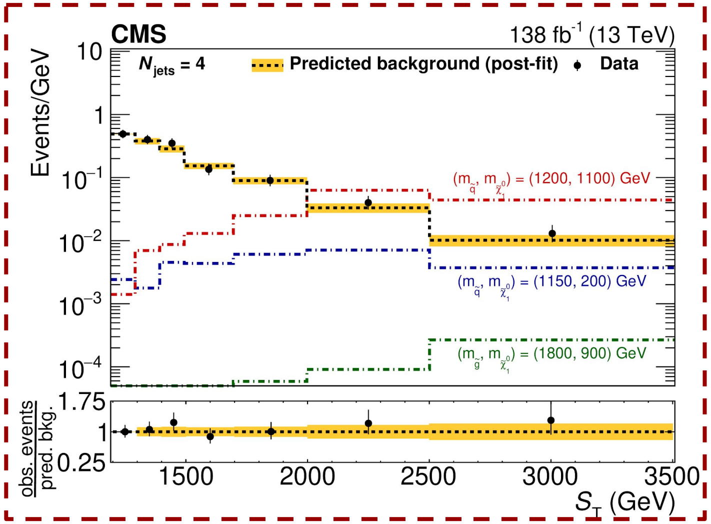


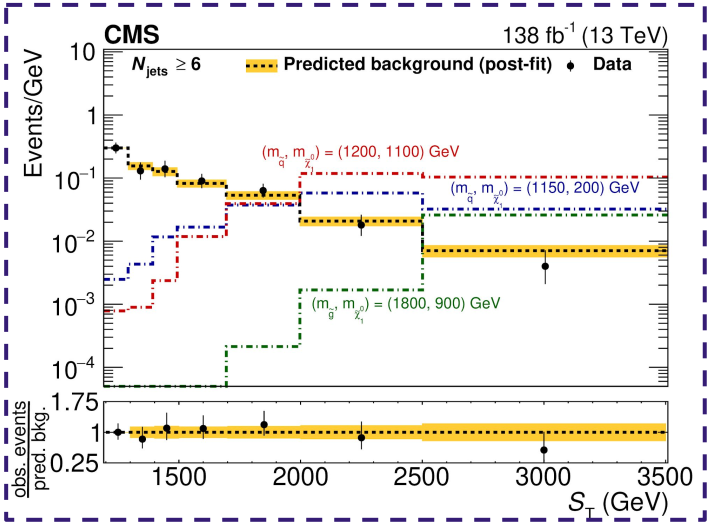
Stealth SUSY with diphotons, jets and low MET

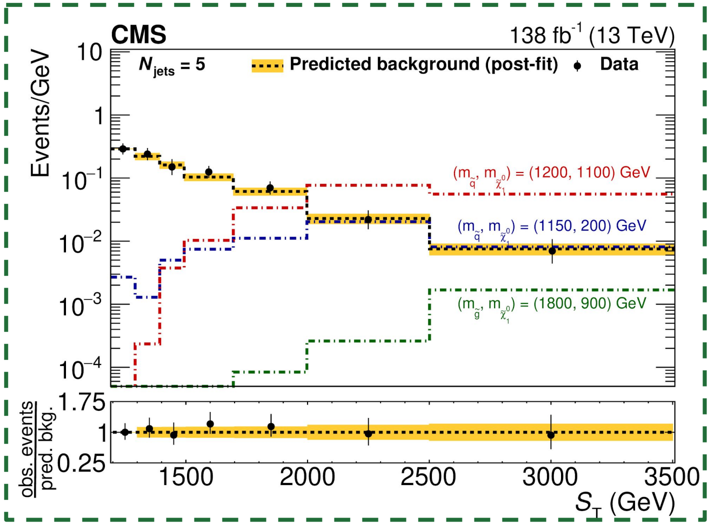
CMS SUS-19-001

- SR with 2 isolated photons with $p_T^{\gamma 1}$>35 GeV, $p_T^{\gamma 1}$>25 GeV, $m_{\gamma\gamma}$>90 GeV, S_T>1200 GeV and N_{Jets}≥4
- Background estimated via a data driven method (+ info in backup)
- Distributions presented in terms of S_T for N_{jets}=4, N_{Jets}=5 and N_{Jets}≥6

No significant deviations were found in data





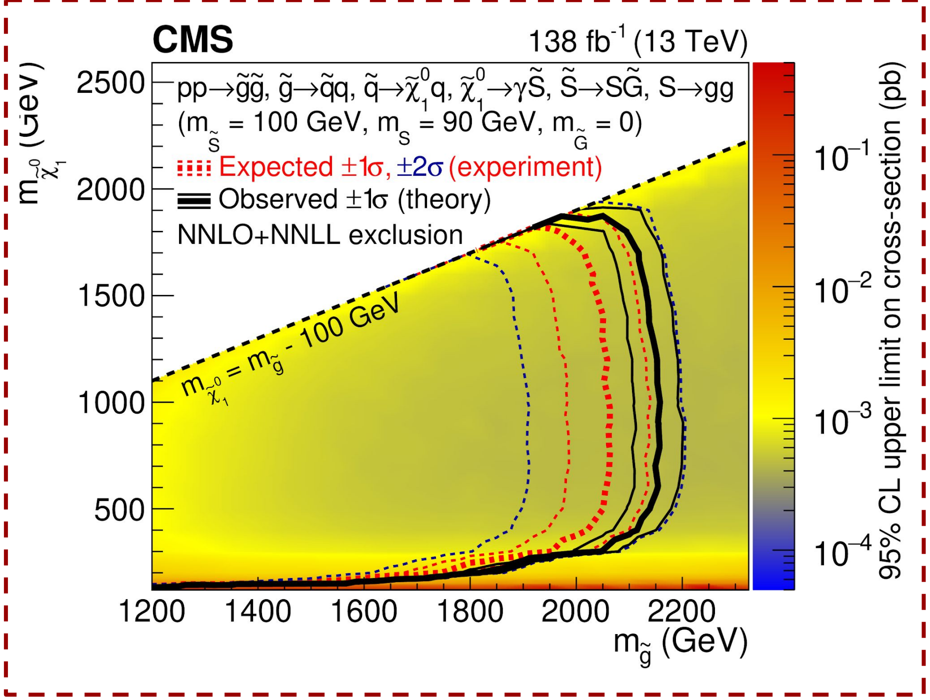


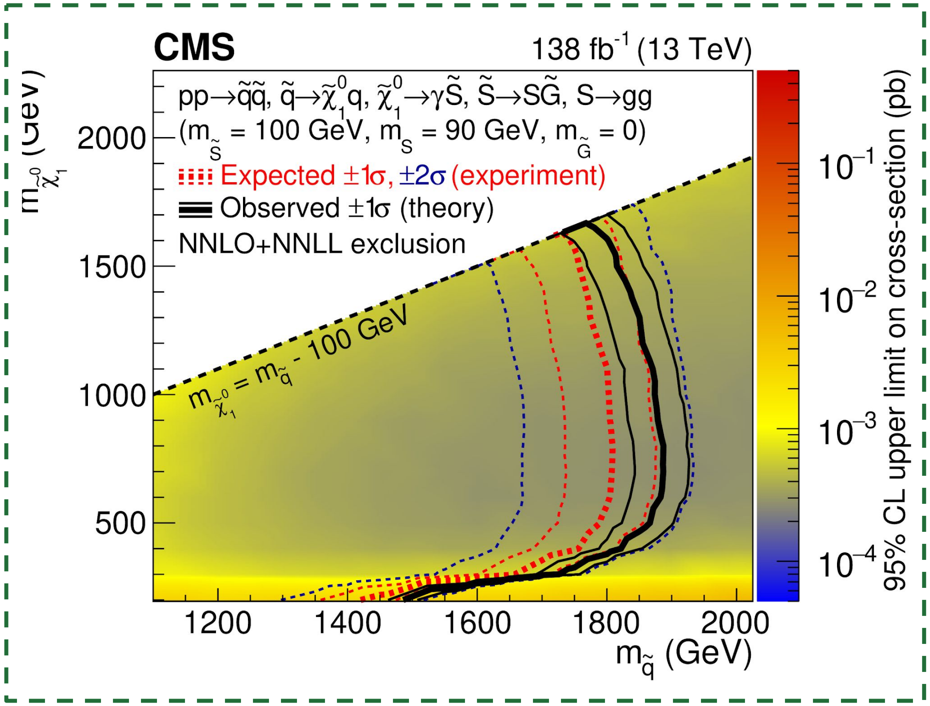
Stealth SUSY with diphotons, jets and low MET
Results

CMS SUS-19-001

95% exclusion limits were placed:

- Gluino production: gluino mass up to 2.1 TeV for neutralino masses from 300 to 1800 GeV
- Squark production: squark mass up to 1.85 TeV for neutralino masses from 500 to 1600 GeV





SUSY with disappearing tracks

CMS SUS-21-006

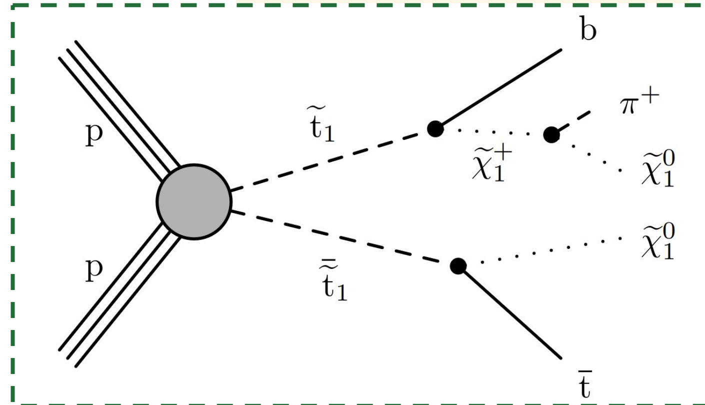
Several simplified models in events with missing tracks:

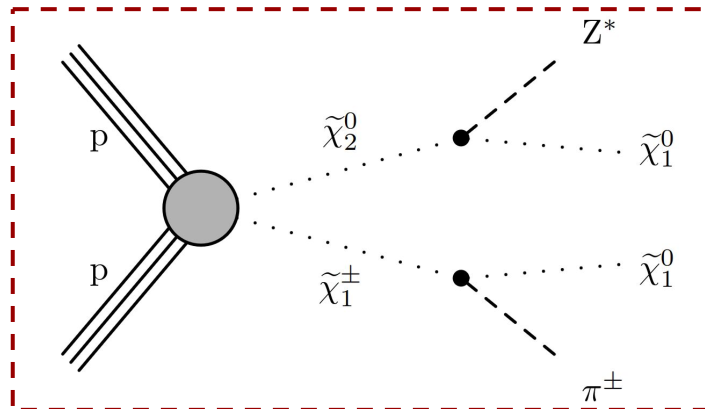
- Production of top/bottom squarks or gluinos
- Electroweakino production with a nearly pure higgsino/wino LSP and a weak boson (TChiWZ, TChiWW, TChiW)
  - Good dark matter model

Two cτ considered:

- cτ = 10 cm (pure higgsino/wino states)
- cτ = 200 cm

Both short and long missing tracks are considered



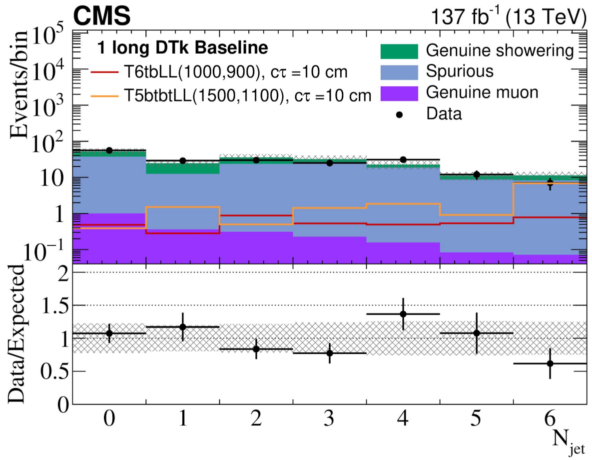


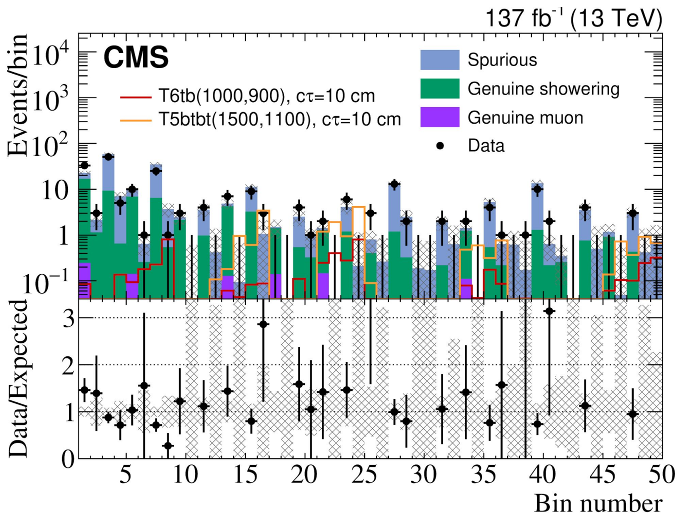
+ Other models in backup

SUSY with disappearing tracks

CMS SUS-21-006

- Signal regions divided into a hadronic, a muon, an electron and a multiple missing tracks channel.
- Each SR is further divided in terms of the p_T^{miss}, $N_{b\text{-}jets}$, N_{Jets} the number of short and long tracks and the ionisation energy loss of the candidate tracks.
- Main backgrounds coming from detector effects:
  - Evaluated in dedicated CRs
- A boosted decision tree is used to improve the purity of the disappearing tracks using several impact and isolation parameters as input.

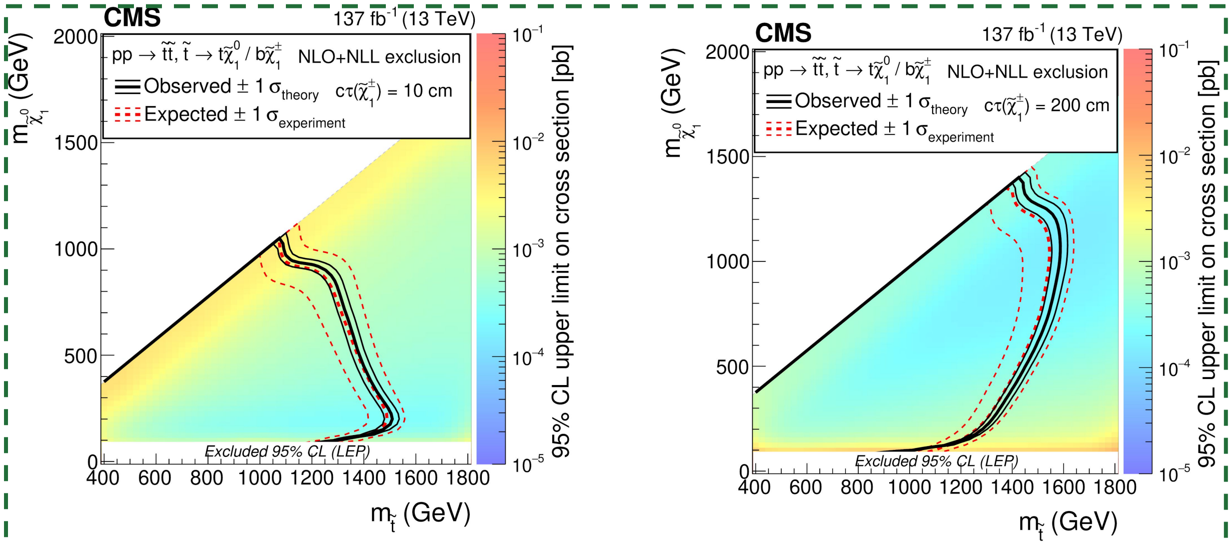


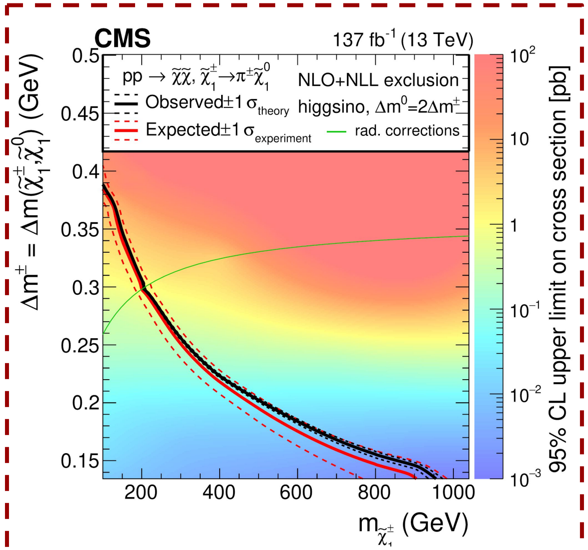


SUSY with disappearing tracks
Results

Exclusion on particle's masses of: [CMS SUS-21-006]

- Top squark: masses up to 1500 GeV, and chargino masses up to 850 GeV (cτ =10 cm) and 1150 (cτ =200 cm)
- Bottom squark: masses up to 1600 GeV; LSP up to1050 (1450) GeV for cτ =10 cm (cτ =200 cm)
- Gluino: Gluinos excluded up to 2300 GeV; LSP up to 1.5 (2.0) TeV for cτ =10 cm (cτ =200 cm)
- LSP masses excluded up to 650 GeV for the wino DM model and 210 GeV for the Higgsino model (shown in terms of the mass splitting of the two SUSY particles)



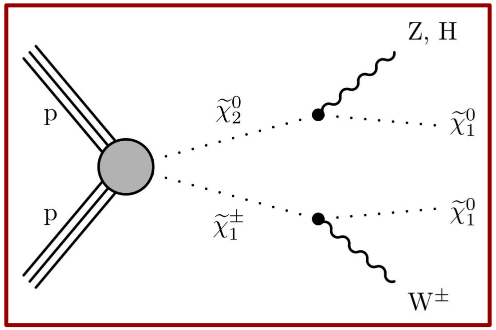


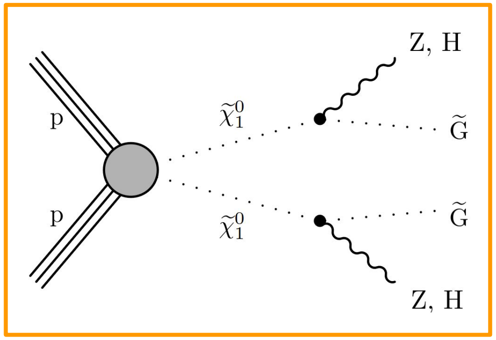
+ Other models in backup

Electroweakino Combination:
Considered Models

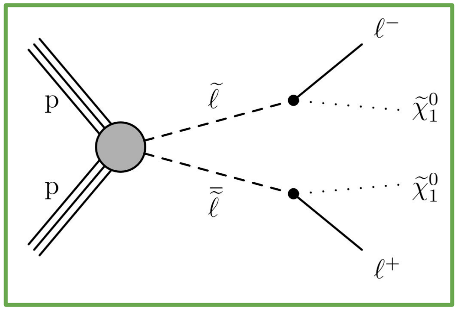
CMS SUS-21-008

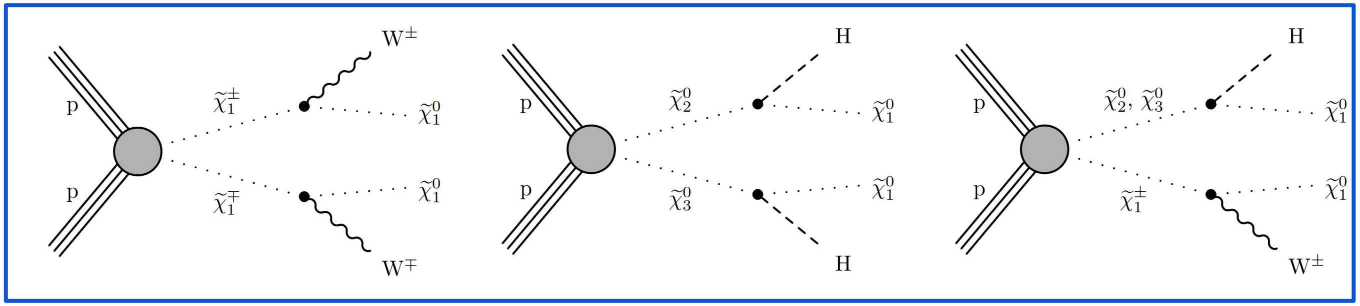
- An improvement respect the previous Eletroweakino Combination (JHEP03(2018)160) using 2016 data that targeted the production of:
  - Wino-like chargino and neutralino, decaying via a bino like LSP neutralino
  - Neutralino pair production in Gauge-Mediated SUSY breaking (GMSB), quasi degenerate Higgsinos





- Revisit the same interpretation with Run 2 data, including some improvements
- New interpretations also considered:
  - Chargino/neutralino production in a Higgsino-bino interpretation.
  - Slepton pair production





Electroweakino Combination:
Combination strategy

Leptonic analyses:

- 2/3l soft: JHEP04(2022)091
- 2l on-Z/non res: JHEP04(2021)123
- ≥3l: JHEP04(2022)147

Hadronic/Semihardronic analyses:

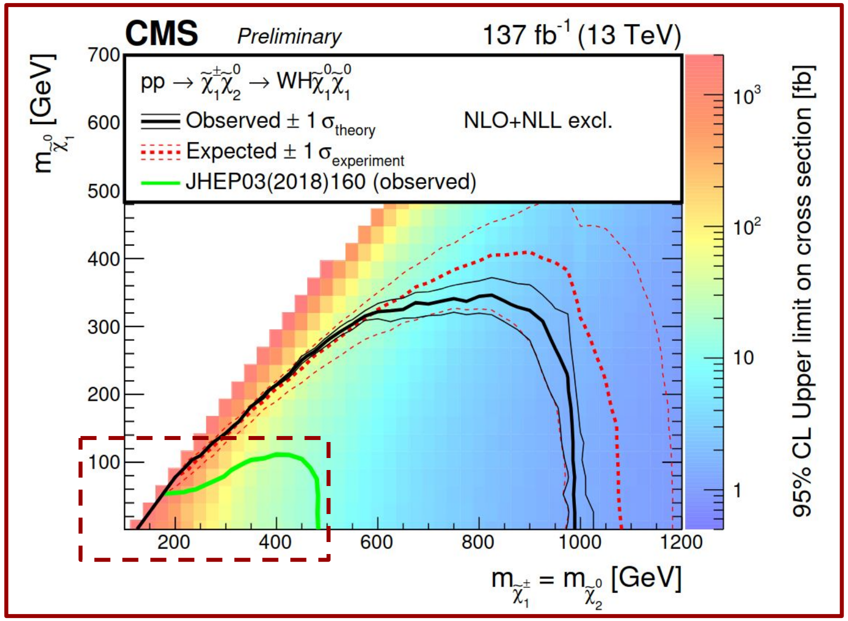
- 1l 2b: JHEP10(2021)045
- 4b: JHEP05(2022)014
- Hadr. WX: Phys.Lett.B 842 (2023) 137460

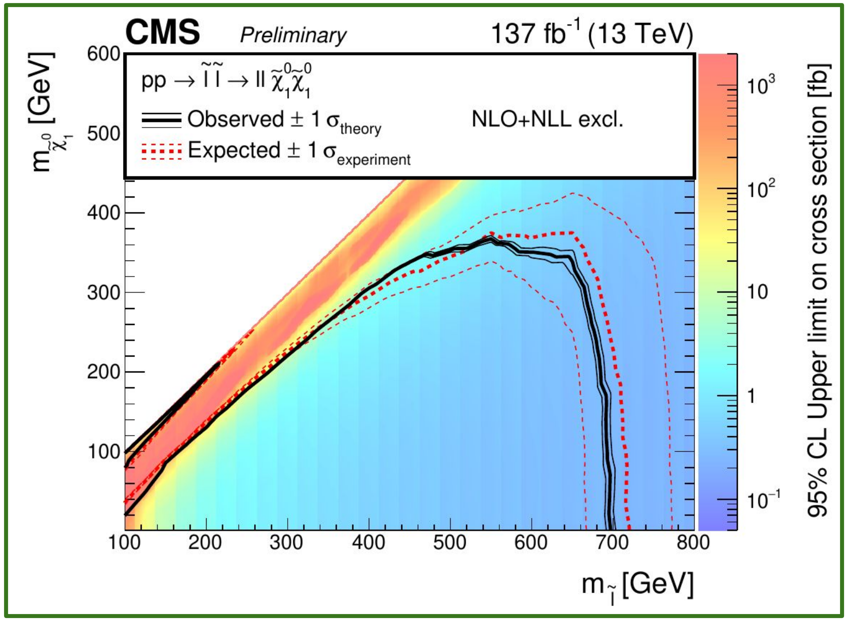
Search	Gaugino		GMSB			Higgsino-bino			Sleptons
	WZ	WH	ZZ	ZH	HH	WW	HH	WH	$\ell^+\ell^-$
$2/3\ell$ soft	✓								✓
2ℓ on-Z	✓		✓	✓					
2ℓ non-res.									✓
$\geq 3\ell$	✓	✓	✓	✓	✓			✓	
1ℓ2b		✓						✓	
4b					✓		✓		
Hadr. WX	✓	✓				✓		✓	

n.b. Overlaps between analyses' Signal Regions (SR) accounted for in combination

Electroweakino Combination:
Results

- ★ More sensitivity and new models considered wrt **previous combination**
- ★ **No significant deviations** from expectation found
- ★ **Chargino** excluded up to **1 TeV**, and **Higgsino** to **990 GeV**
- ★ **Slepton** mass excluded up to **215 GeV** for **Δm=5 GeV** and **110-720 GeV** for **Δm=50 GeV**





+ Other models in backup

Summary and outlook

Several analyses have been presented:

★ RPV SUSY with weak production and strong decay: **CMS PAS SUS-23-015**

★ Stealth SUSY with diphotons, jets and low MET: **CMS SUS-19-001**

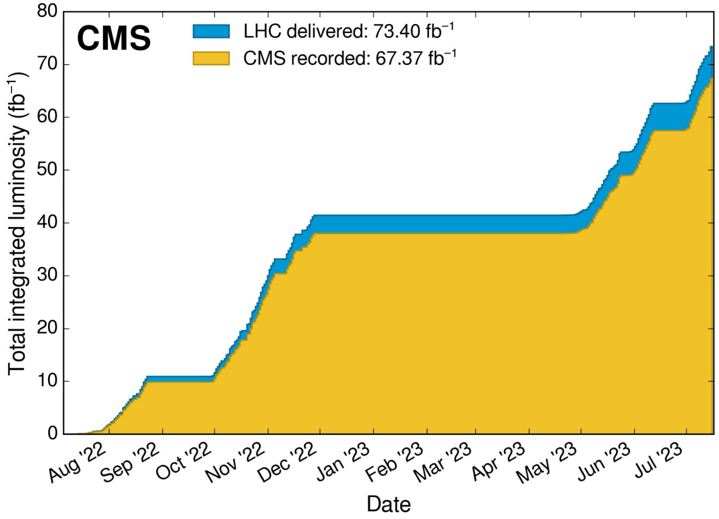
★ SUSY with disappearing tracks: **CMS SUS-21-006**

★ Electroweakino combination: **CMS SUS-21-008**

😞 **No significant deviations** from expectation found

➞ But there always is hope!

- Current exclusions come under assumptions that could be proven wrong.
- Currently on Run-3 data taking period
  ➞ (Expect **~3x more luminosity** than Run-2!)
- New phase spaces will become available (compressed area, even more boosted scenarios…).



Stay Tuned!

Thanks for your attention

BACKUP

New!

CMS SUS-19-001

Background model calculated as:

$$b\left(\mathrm{N_{Jets}},\, S_{\mathrm{T}}\ \mathrm{bin}\ i\right) = \mathrm{Nevts}\left(\mathrm{N_{Jets}},\, 1200 < S_{\mathrm{T}} < 1300\ \mathrm{GeV}\right) \times f^{\mathrm{AGK}}\left(S_{\mathrm{T}}\ \mathrm{bin}\ i\right) \times r\left(\mathrm{N_{Jets}},\, S_{\mathrm{T}}\ \mathrm{bin}\ i\right),$$

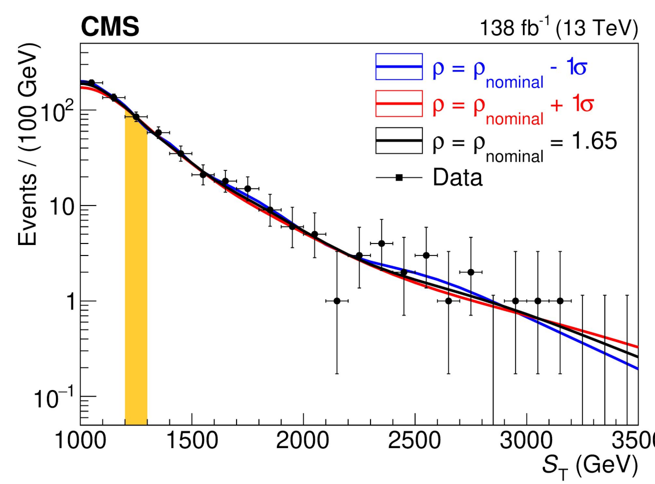
Where:

- b(N_{Jets}, S_T bin *i*) is the expected background for a given (N_{Jets} S_T)
- Nevts is the number of events in a low S_T normalisation bin for each N_{Jets}
- f^{AGK}(S_T bin *i*) is a shaep template from data for N_{Jets} =2
- r(N_{Jets}, S_T bin *i*) is a correction to the shape template estimated from simulation

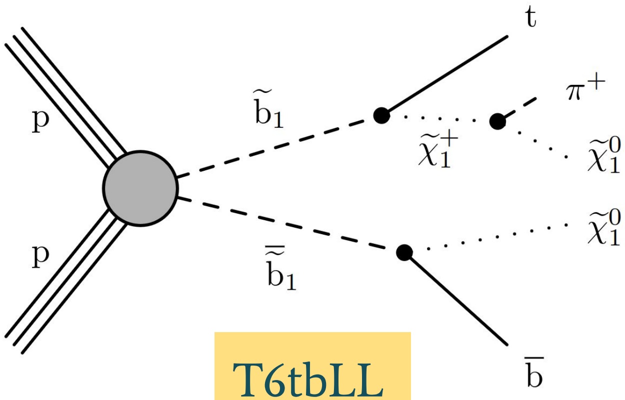
S_T shape adjusted by: $$\left[A + m\left(\frac{S_{\mathrm{T}}}{S_{\mathrm{T}}^{\mathrm{norm}}} - 1\right)\right]$$

Where

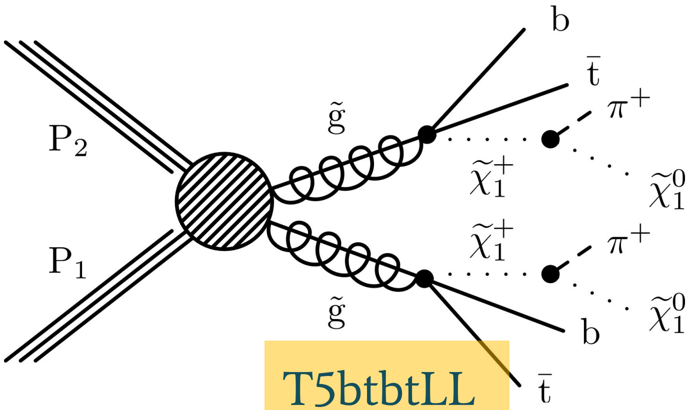
Best-fit values	A	m
nJets = 3	1.05 ± 0.02	0.26 ± 0.07
nJets = 4	1.04 ± 0.03	0.75 ± 0.09
nJets = 5	0.99 ± 0.04	1.30 ± 0.15
nJets ≥ 6	1.11 ± 0.06	2.42 ± 0.23



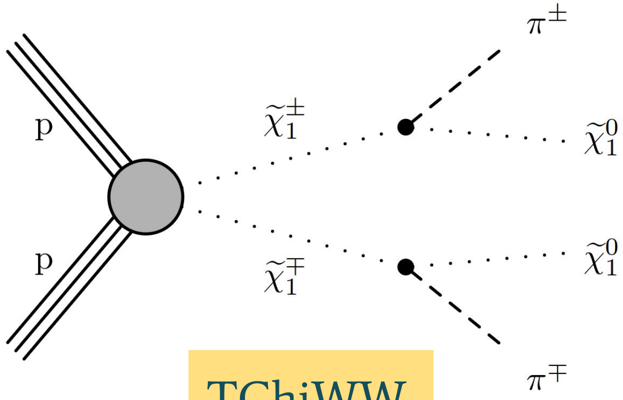
CMS SUS-21-006



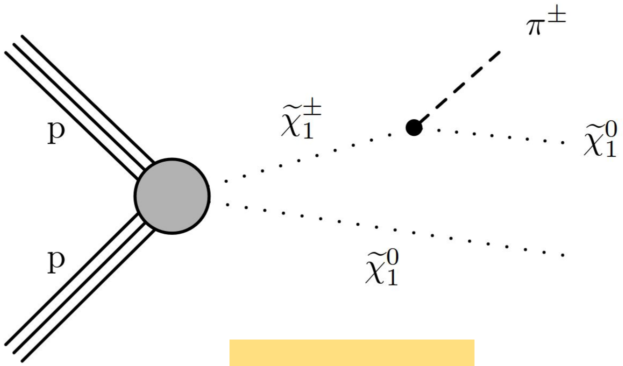
T6tbLL



T5btbtLL



TChiWW

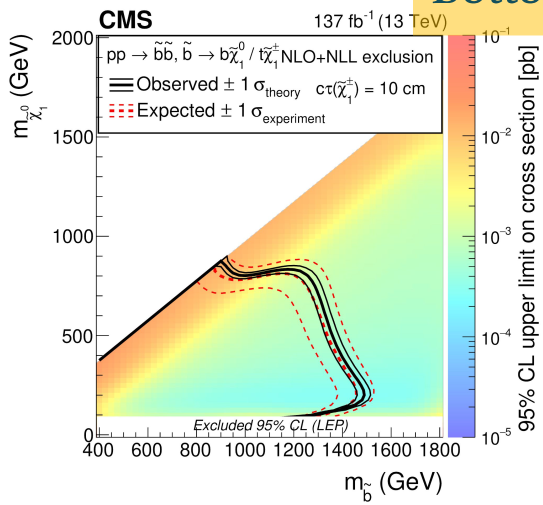


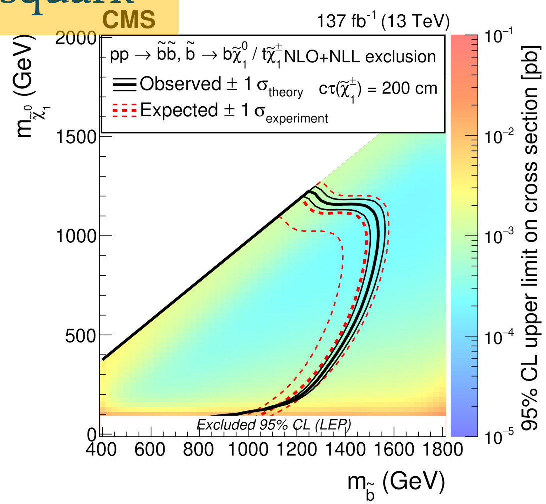
TChiW

SUSY with disappearing tracks
Additional Results

CMS SUS-21-006

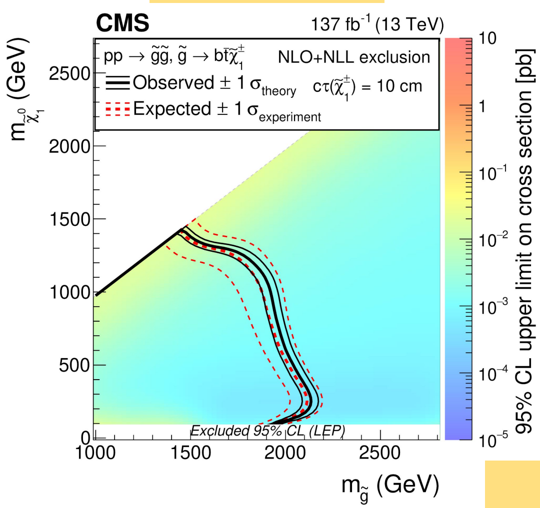
Bottom squark

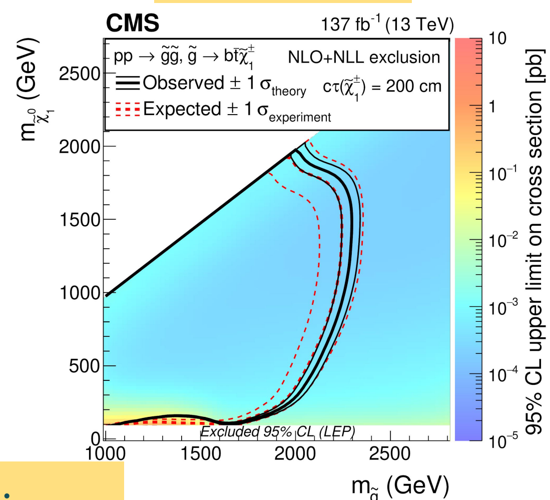




cτ = 10 cm

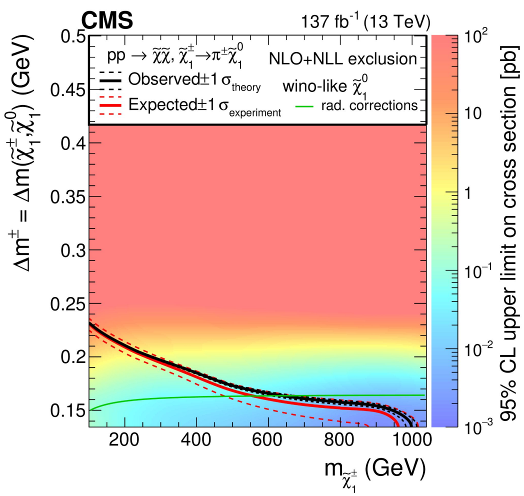
cτ = 200 cm





gluino

DM Wino model



Electroweakino Combination:
Leptonic input analyses

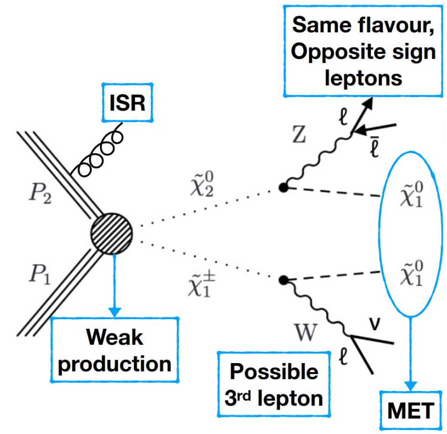
Leptonic analyses:

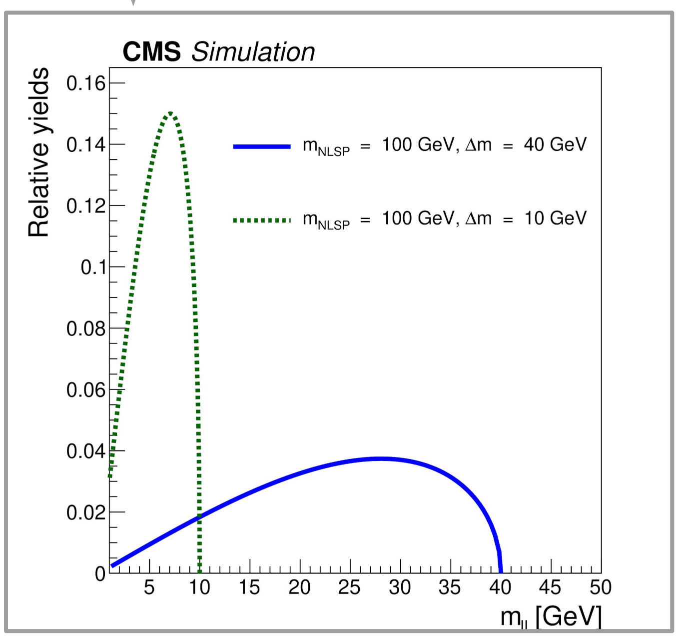
- **2/3l soft**: JHEP04(2022)09 (Compressed)
  - "2l bin": Two opposite sign (OS) same flavour (SF) lepton pair,
  - "3l bin": One additional SF lepton (e, μ)
  - 3.5 (5) < p_T(lep)<30 GeV for 2l (3l) bins and an ISR jet.
  - Further binned in terms of p_T^{miss} and m_{ll}
  - → New parametric signal extraction to improve sensitivity
- **2l on-Z/non res**: JHEP04(2021)123 (Boosted)
  - Two OS SF leptons (ee/μμ), with SR split in terms of p_T^{miss}.
  - on Z analysis: $86<m_{ll}<96$ GeV, using standard jet (AK4) & wider (AK8) jet reconstructions, further splitting in terms of b-jet content.
  - off Z analysis: $20<m_{ll}<65$ GeV & $m_{ll}>120$ GeV
- **≥3l**: JHEP04(2022)147 (Intermediate)
  - ee/μμ or 3/4l with up to 2 hadronic taus (τ_h).
  - $p_T^{l1}>25$ GeV, $p_T^{l2}>20$ GeV

Search	Gaugino		GMSB			Higgsino-bino		
	WZ	WH	ZZ	ZH	HH	WW	HH	WH
2/3ℓ soft	✓							
2ℓ on-Z	✓		✓	✓				
2ℓ non-res.								
≥ 3ℓ	✓	✓	✓	✓	✓			✓

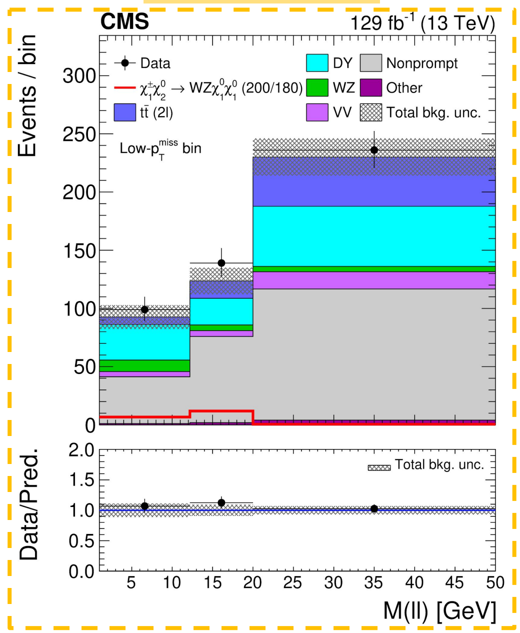
Electroweakino Combination:
Optimisation of 2/3ℓ soft analysis

- Each mass hypothesis has different kinematics
  - Optimise binnings per each mass splitting wrt JHEP04(2022)09
  - Use $m_{\ell\ell}$ as discriminating variable
    - → Individual binning for each Δm and SR.
  - Expected exclusion of Next to LSP improved by ~5-25 GeV

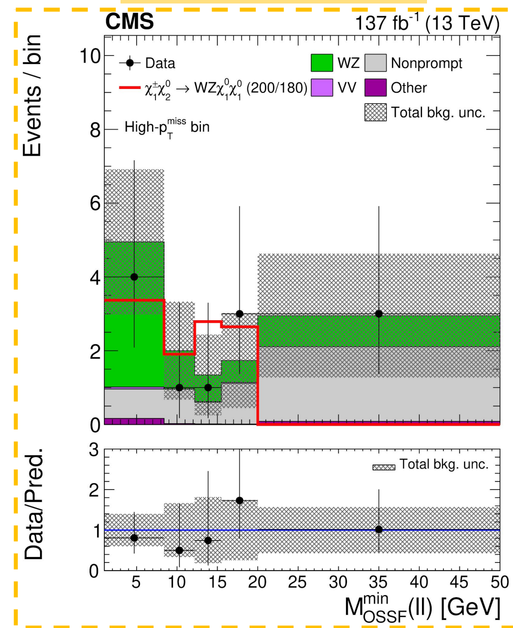




low p_T^{miss}, 2ℓ



high p_T^{miss}, 3ℓ



Electroweakino Combination:
Hadronic & semihadronic input analyses

Hadronic & Semihadronic analyses:

- **1l 2b**: JHEP10(2021)045
  - p_T^{l1}>30 GeV, 2 b-tagged jets consistent with the Higgs boson mass, and large p_T^{miss}.
- **4b**: JHEP05(2022)014
  - No leptons. Two Higgs boson, each H→bb
  - SRs based on $N_{b\text{-jets}}$.
  - Also considering boosted topologies (with AK8 jets)
- **Hadr. WX**: Phys.Lett.B 842 (2023) 137460
  - At least 2 AK8 jets, compatible with W, Z and H bosons.
  - 2-6 AK4 jets
  - → New for Run 2 combination

→ Additional sensitivity in the uncompressed spectra

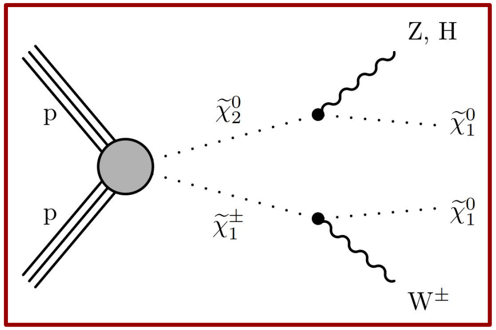
Search	Gaugino		GMSB			Higgsino-bino		
	WZ	WH	ZZ	ZH	HH	WW	HH	WH
$1\ell 2b$		✓						✓
4b					✓		✓	
Hadr. WX	✓	✓				✓		✓

Electroweakino Combination:

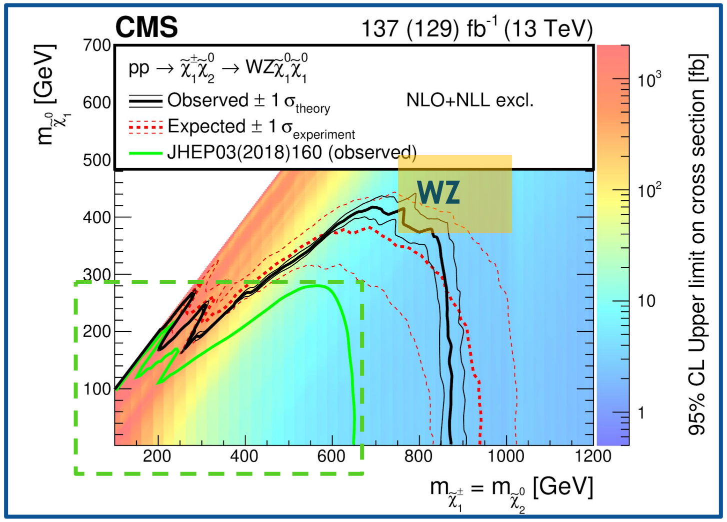
Chargino/neutralino production in WZ/WH final states

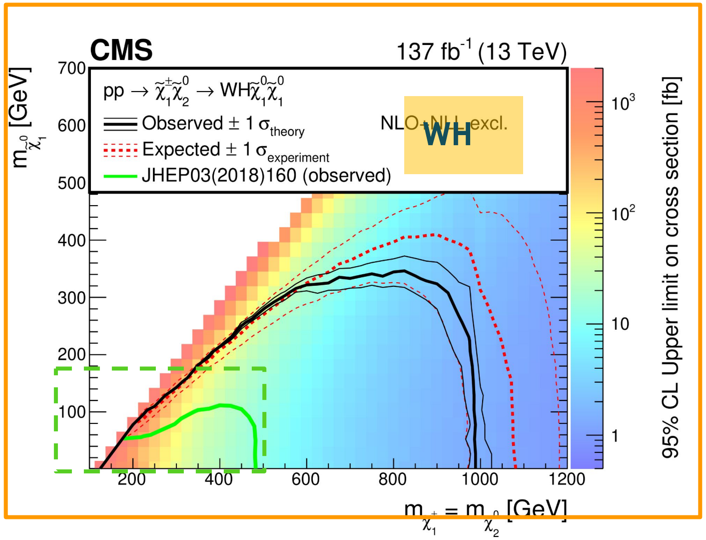
Several analyses contribute to the combined limit (more information in <u>next slides</u>):

- Uncompressed region: dominated by Hadr WX analysis.
- Compressed region: 2/3l soft analysis (≥3l) in the **WZ** (**WH**) models.
- Expected limit significantly improved with respect to the **2016 combination**



Search	Gaugino	
	WZ	WH
2/3ℓ soft	✓	
2ℓ on-Z	✓	
2ℓ non-res.		
≥ 3ℓ	✓	✓
1ℓ2b		✓
4b		
Hadr. WX	✓	✓

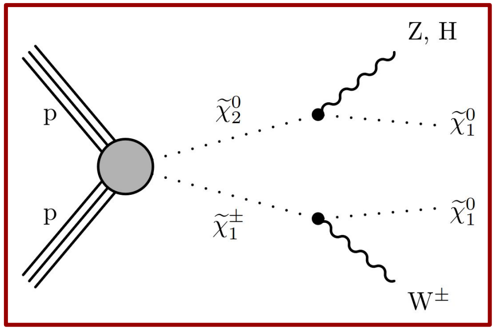


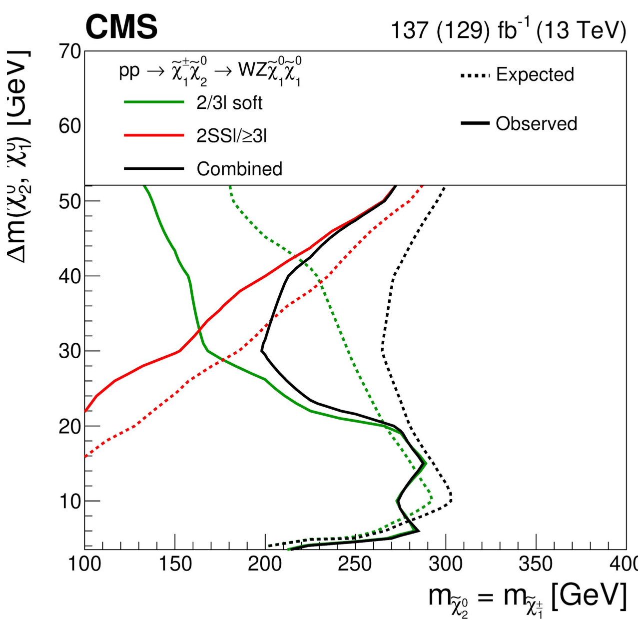


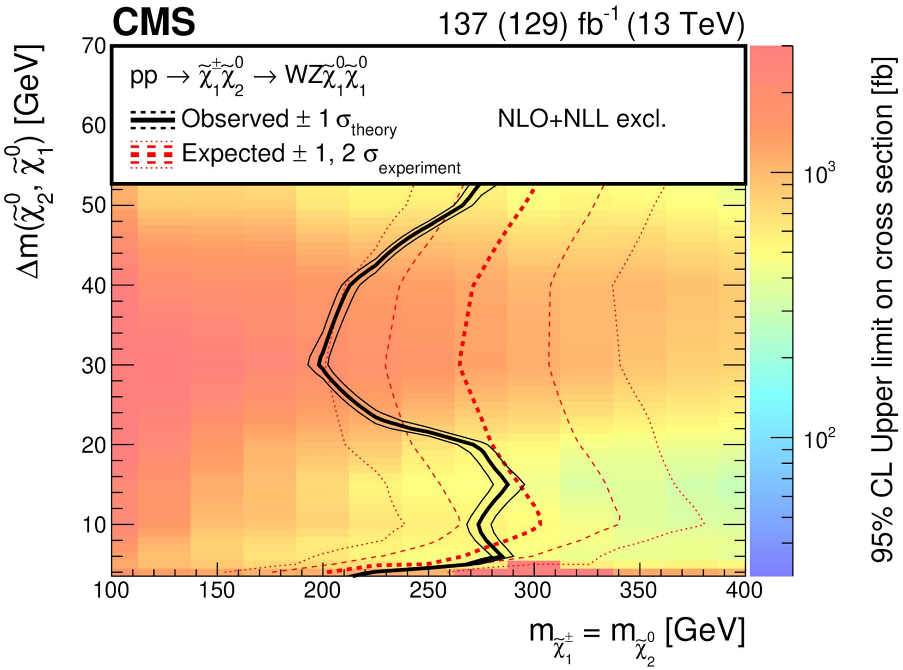
Electroweakino Combination:
Chargino/neutralino production in WZ/WH final states (Compressed)

More challenging ➞ Required full Run2 data as well as novel techniques

- **2/3l soft** and **≥3l** analyses complement each other.
  - Orthogonal lepton p_T
  - Different discriminant variables
- Expected limits close gap at Δm~40 GeV, where a mild (2σ) excess is found



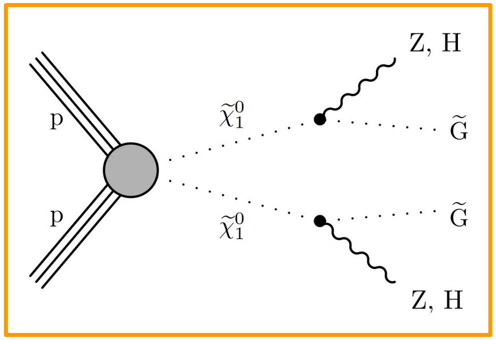




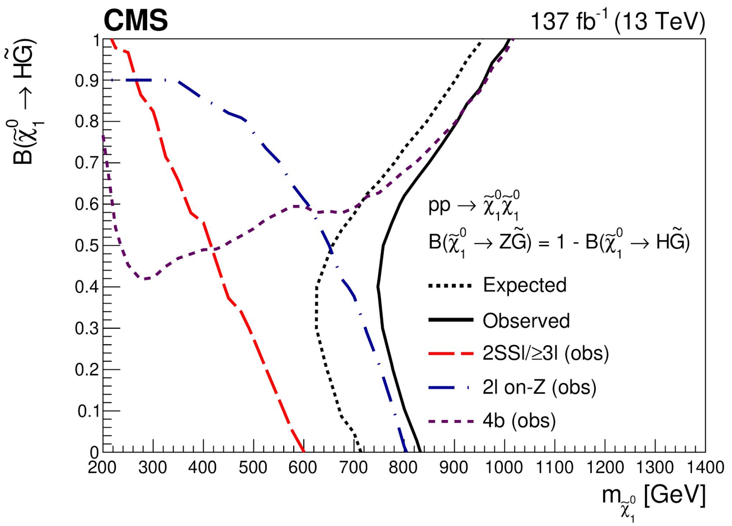
Electroweakino Combination:
Chargino/neutralino production in GMSB models

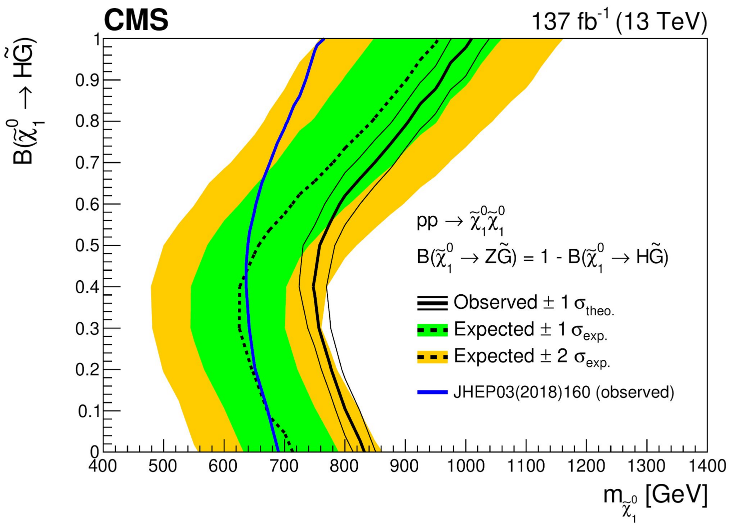
In GMSB models, $\chi_1^{\pm}$, χ_1^0 and χ_2^0 have minimal mass splitting:

- Models can be reduced to χ_1^0 pair production, decaying to:
  - Gravitino $\tilde{G}$ with $m_{\tilde{G}}$=1 GeV (LSP)
  - SM neutral boson (Z or H)
- Exclusion limits in terms of $B(\chi_1^0 \rightarrow H\tilde{G})$:
  - **4b** analysis more sensitive at large $B(\chi_1^0 \rightarrow H\tilde{G})$
  - Small $B(\chi_1^0 \rightarrow H\tilde{G})$ dominated by **2l on Z** analysis



Search	GMSB ZZ	GMSB ZH	GMSB HH
2/3ℓ soft			
2ℓ on-Z	✓	✓	
2ℓ non-res.			
≥ 3ℓ	✓	✓	✓
1ℓ2b			
4b			✓
Hadr. WX			

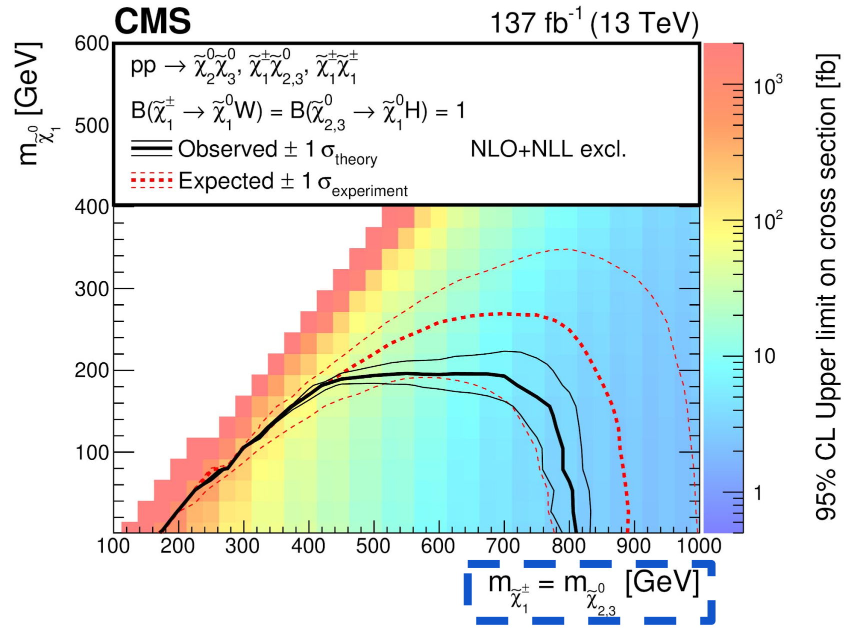


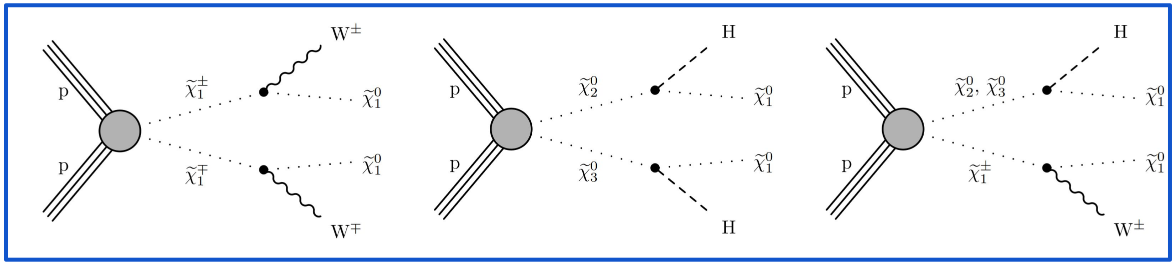


Electroweakino Combination:
Chargino/neutralino production in Higgsino-bino models

New interpretation wrt JHEP04(2022)09

- χ_1^0 as LSP, and a **mass degenerate Higgsino triplet**:
- Target either WW, HH or WH final states with:
  - $B(\chi_1^\pm \rightarrow W\chi_1^0) = 100\%$
  - $B(\chi_{2,3}^0 \rightarrow H\chi_1^0) = 100\%$
- More sensitive to the uncompressed phase space

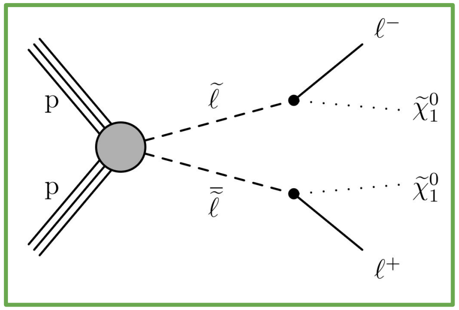




Search	Higgsino-bino		
	WW	HH	WH
2/3ℓ soft			
2ℓ on-Z			
2ℓ non-res.			
≥3ℓ			✓
1ℓ2b			✓
4b		✓	
Hadr. WX	✓		✓

Electroweakino Combination:
Slepton production

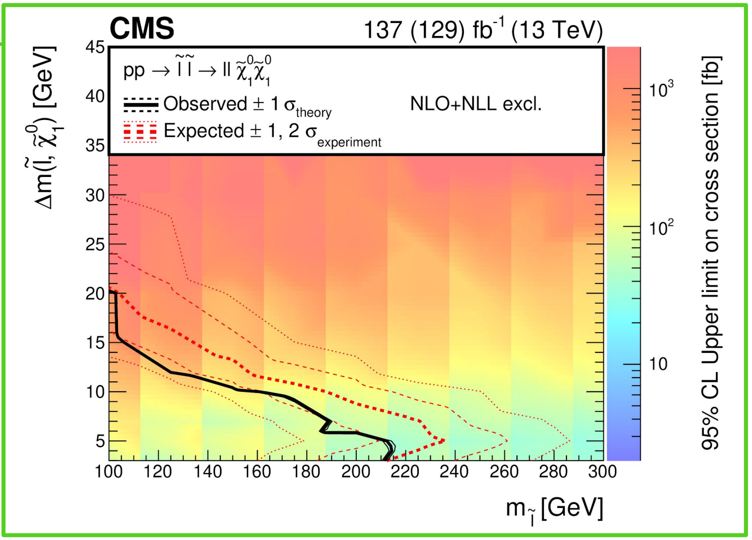
Particularly difficult due to their small cross sections.
- Slepton as Next to LSP with lightest neutralino as LSP
- 1st & 2nd generation (3rd covered in CMS-PAS-SUS-21-001)

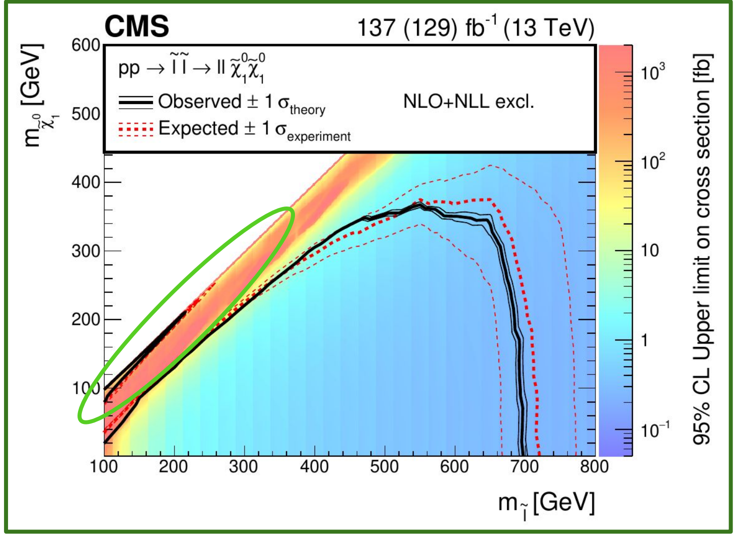


2/3l soft analysis targeting compressed signatures:
- Similar SR as for Wino-bino interpretation
- $m_{T2}(ll,\chi)$ as discriminant variable:

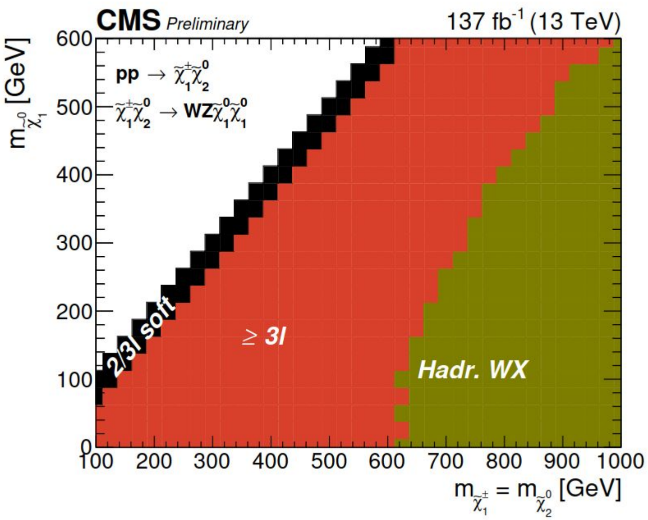
$$m_{T2}(\ell\ell,\chi) = \min_{\vec{p}_T^{miss(1)}+\vec{p}_T^{miss(2)}=\vec{p}_T^{miss}} \left[\max\left(M_T^1(m_\chi), M_T^2(m_\chi)\right)\right]$$

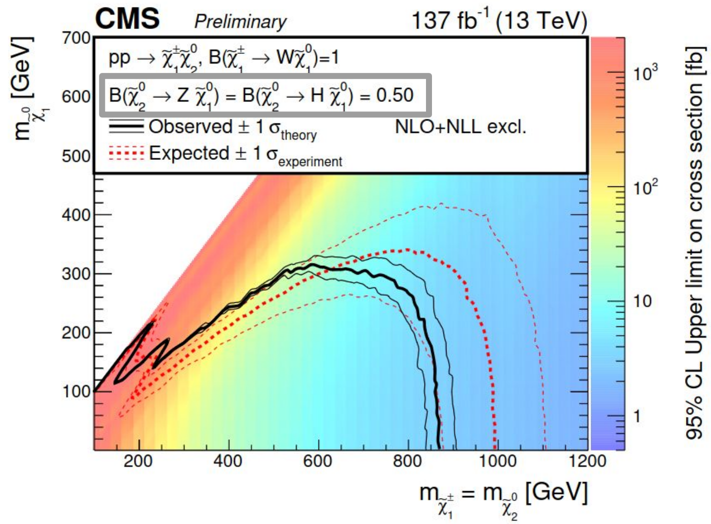
2l non resonant used for non compressed scenario:
- Equivalent SR as before

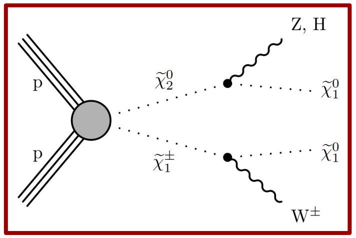


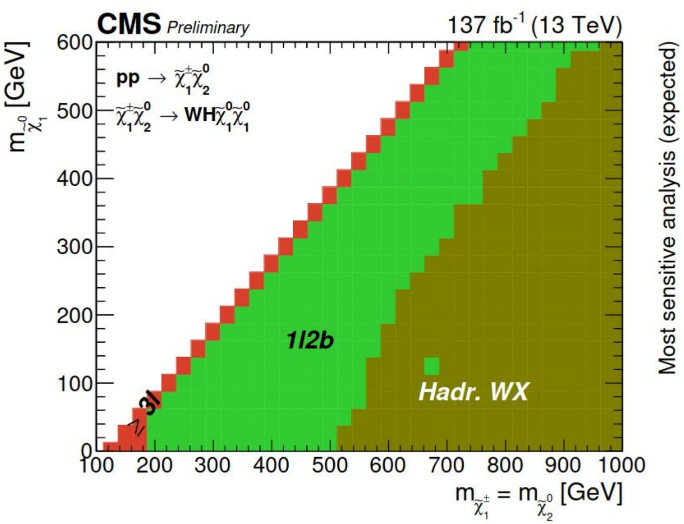


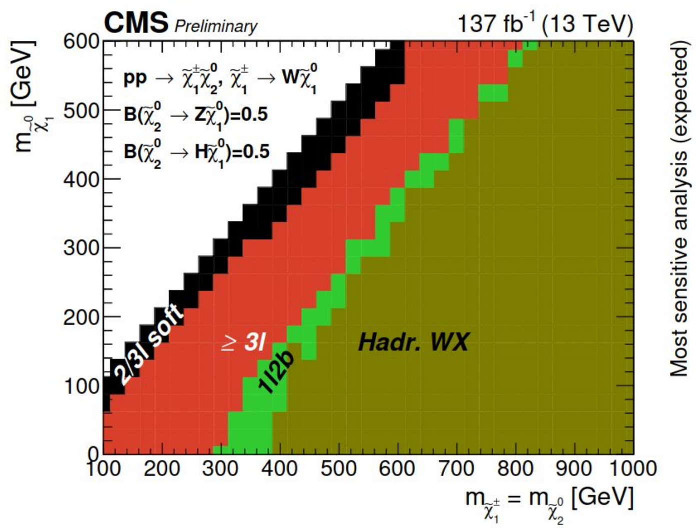
Chargino/neutralino production in WZ/WH final states:
Best exclusion limit per mass point + additional interpretations



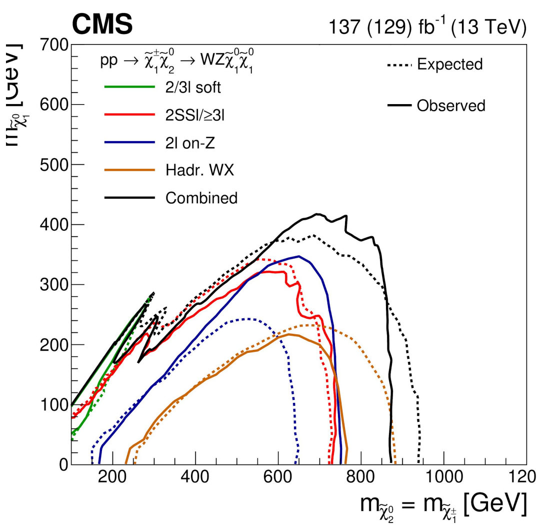


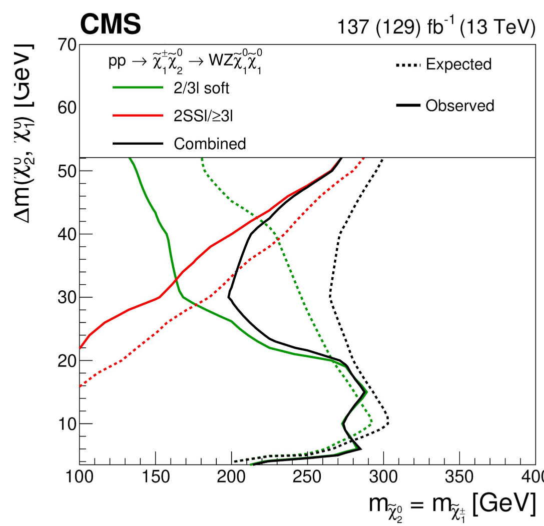


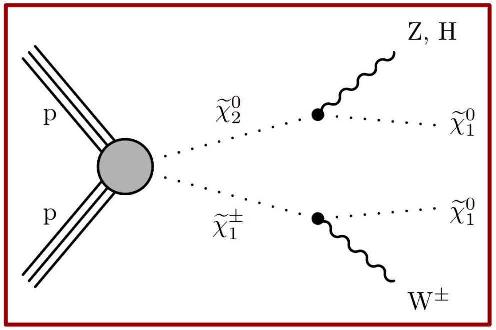




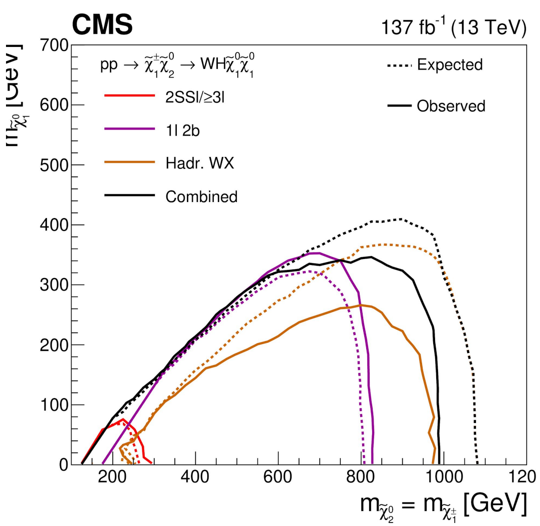
Chargino/neutralino production in WZ/WH final states:
Exclusion contours

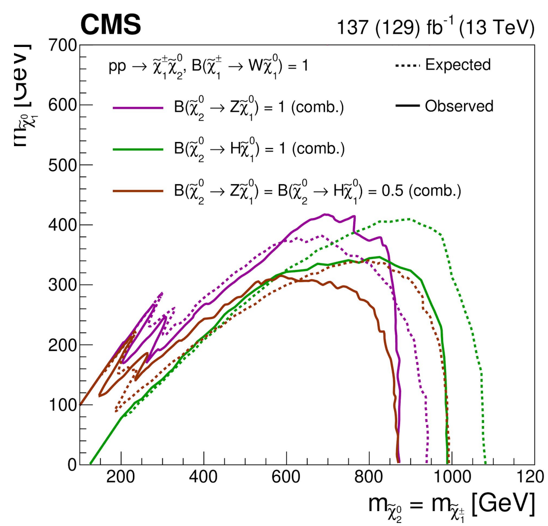






Search	Gaugino	
	WZ	WH
2/3ℓ soft	✓	
2ℓ on-Z	✓	
2ℓ non-res.		
≥ 3ℓ	✓	✓
1ℓ2b		✓
4b		
Hadr. WX	✓	✓



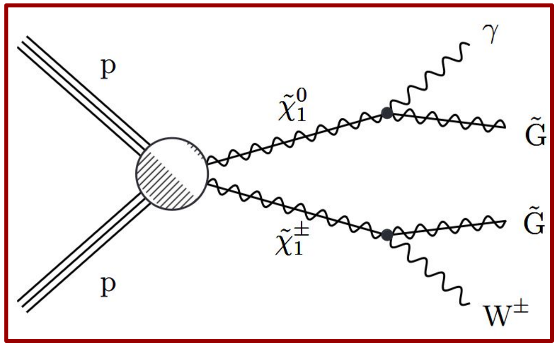


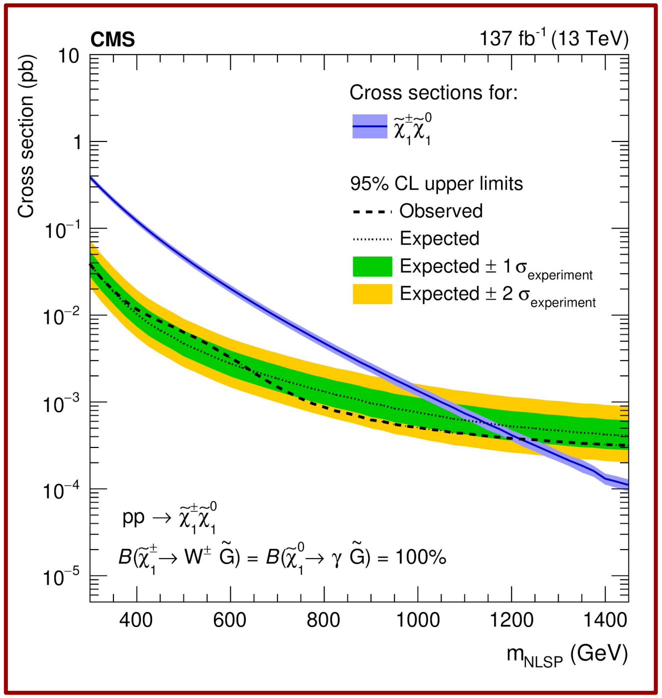
Search targeting final states with a photon, jets and large MET

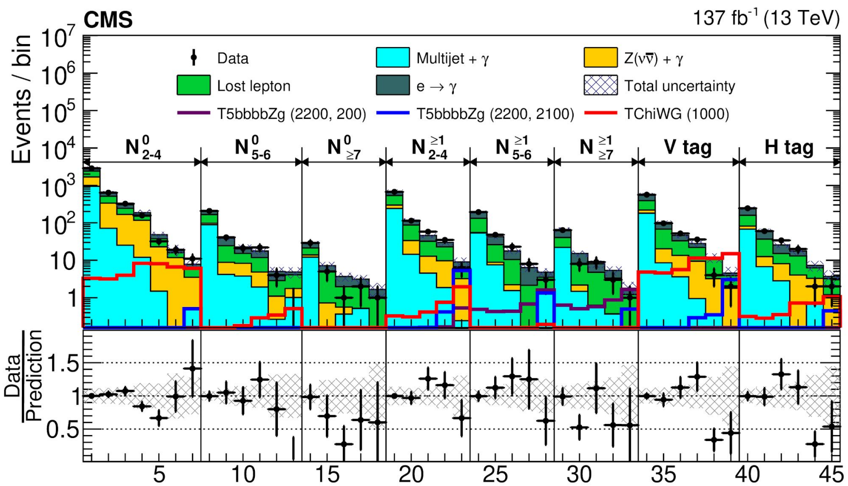
CMS-PAS-SUS-21-009

Analysis exploring gauge-mediated SUSY breaking (GMSB)

- Several EWK SUSY models considered, in final states with the gravitino as the LSP .
- Events selected with no leptons and at least 1 photon, two jets, large p_T^{miss} and large S_T: $S_T = \sum_{jets} p_T + p_T^{\gamma}$
- Split in Signal Region (SRs) depending on the tagging of W/Z/H bosons, and further split in terms of p_T^{miss} and N_{jets}.
- Main backgrounds: Wγ+jets, ttγ+jets
  - Estimated via data driven methods
- Chargino/neutralino masses excluded up to 1.3 TeV for the **TChiWG** model (more models in the next slide)

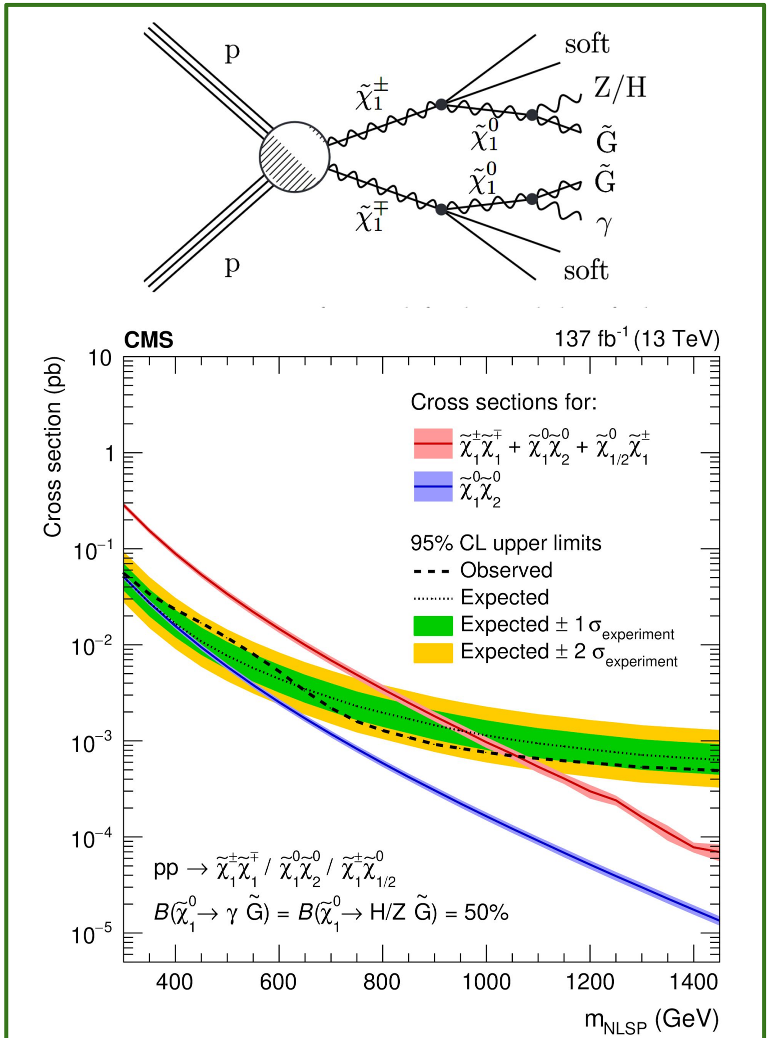




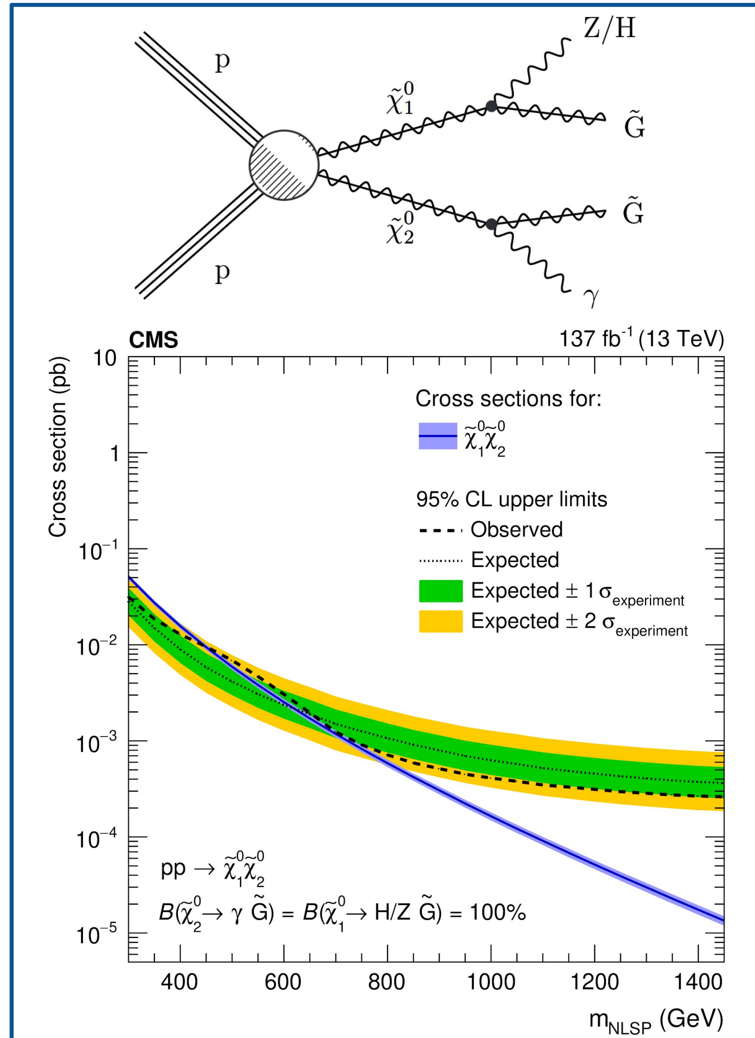


Search targeting final states with a photon, jets and large MET: Other models

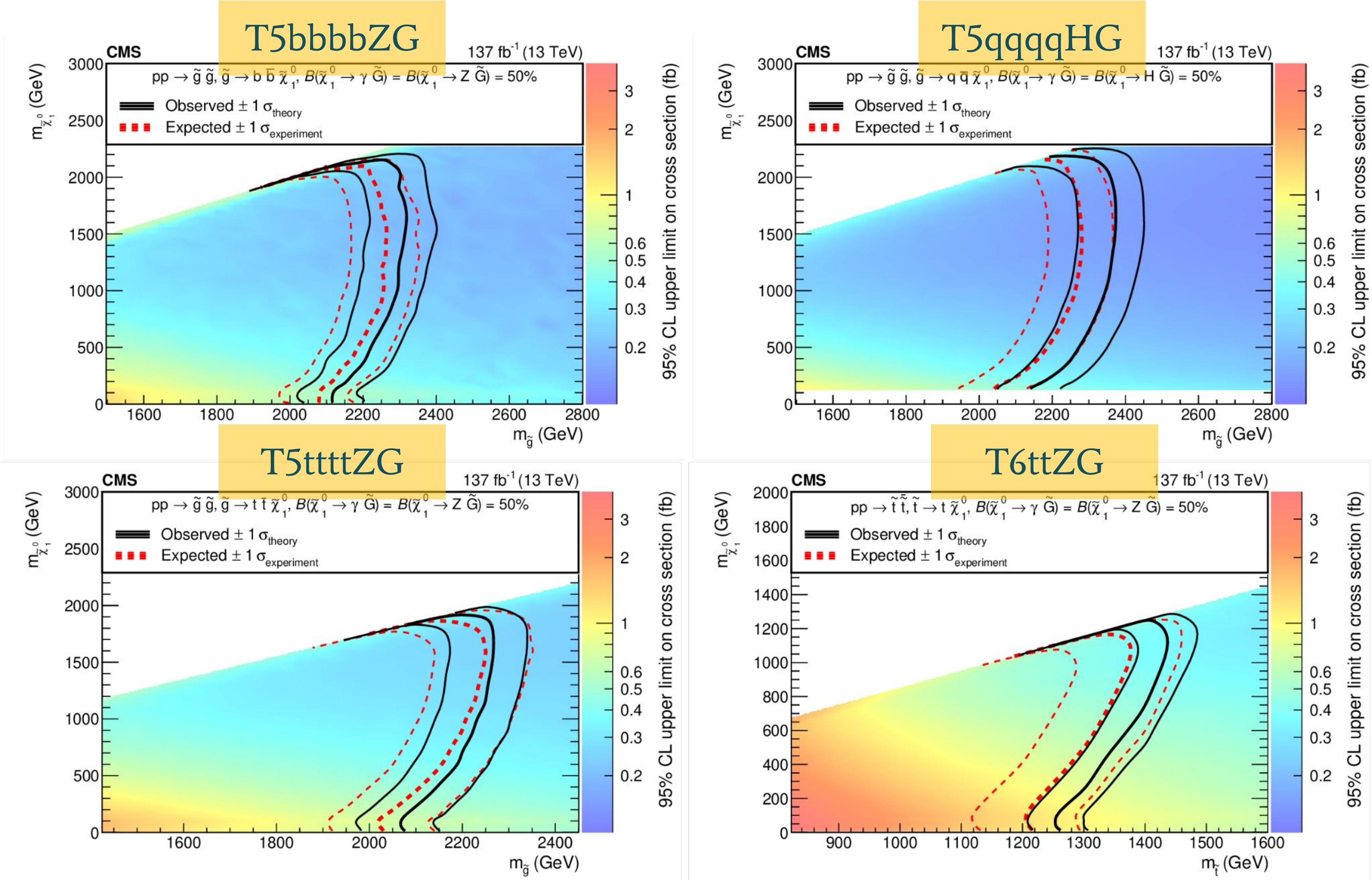
TChiNG model



TChiNGnn model



Search targeting final states with a photon, jets and large MET: Other models



Event variables' definition

- H_T: scalar p_T sum of all jets.
- Transverse mass:

$$m_T = \sqrt{2 p_T p_T^{miss}(1 - \cos\Delta\phi)}$$

- m_{T2}: Stransverse mass

$$m_{T2} = \min_{\vec{p}_T^{X(1)} + \vec{p}_T^{X(2)} = \vec{p}_T^{miss}} \left[\max\left(m_T^{(1)}, m_T^{(2)} \right) \right]$$

- $m_{T2}(ll,\chi)$ (slepton production in 2/3l soft lepton):

$$m_{T2}(\ell\ell,\chi) = \min_{\vec{p}_T^{miss\,(1)} + \vec{p}_T^{miss\,(2)} = \vec{p}_T^{miss}} \left[\max\left(M_T^1(m_\chi), M_T^2(m_\chi) \right) \right]$$

- d_0: the distance of closest approach in the transverse plane of the helical trajectory of the track with respect to the beam axis. +info here

Combination strategy

Leptonic analyses:

- 2/3l soft: JHEP04(2022)091
- 2l on-Z/non res: JHEP04(2021)123
- 3l: JHEP04(2022)147

Hadronic/Semihardronic analyses:

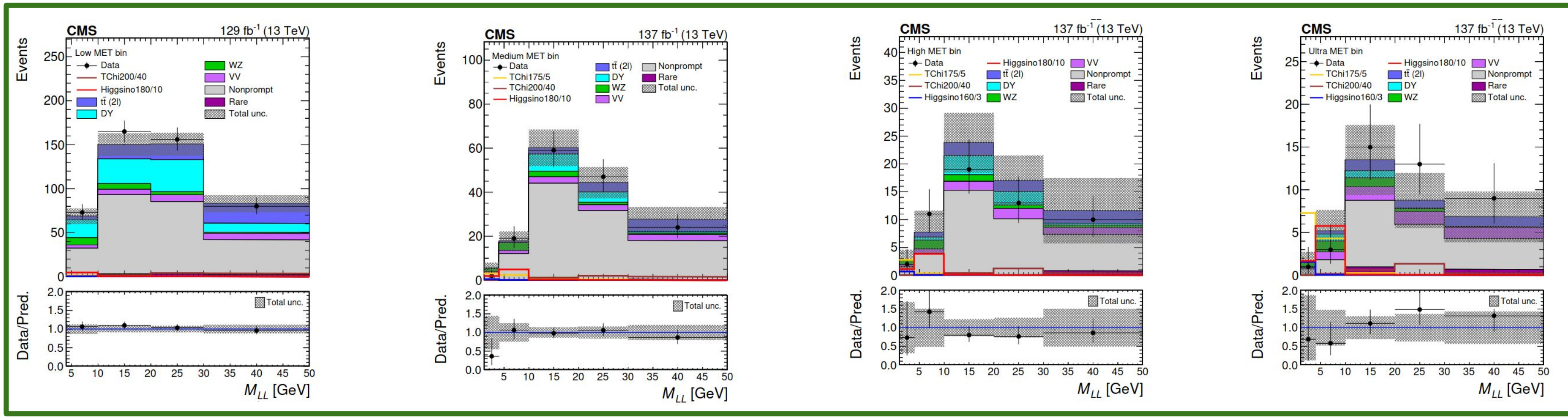
- 1l 2b : JHEP10(2021)045
- 4b: JHEP05(2022)014
- Hadr. WX: Phys.Lett.B 842 (2023) 137460

Search	Gaugino		GMSB			Higgsino-bino			Sleptons
	WZ	WH	ZZ	ZH	HH	WW	HH	WH	$\ell^+\ell^-$
2/3ℓ soft	all								2ℓ soft
2ℓ on-Z	EW		EW	EW					
2ℓ non-res.									Slepton
$\geq 3\ell$	SS, A(NN)	SS, A–F	all	all	all			SS, A–F	
1ℓ2b		all						all	
4b					all		3-b, 4-b, 2-bb		
Hadr. WX	all	b-tag				b-veto		b-tag	

EWK SUSY Combination
Input analyses

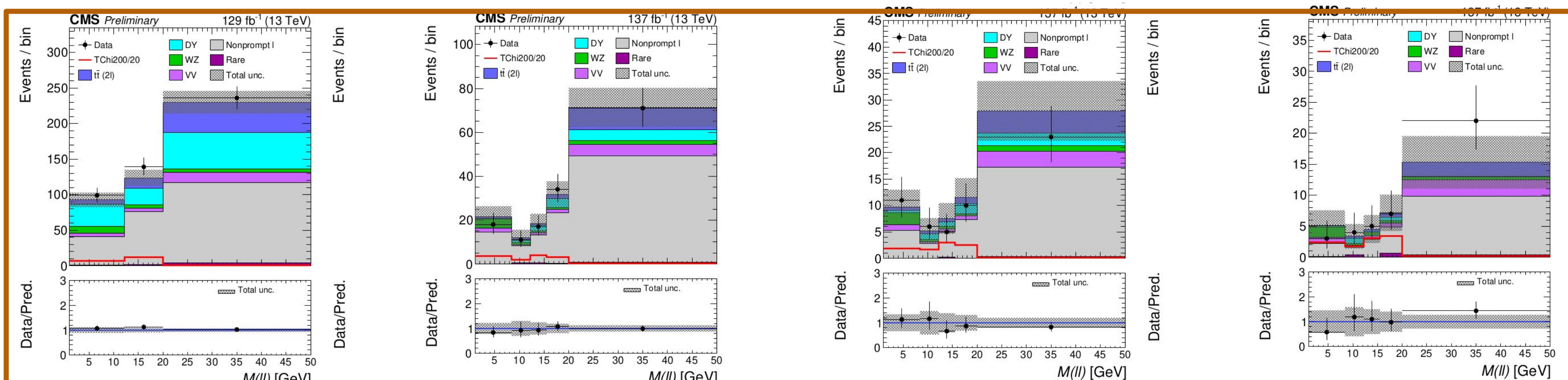
2/3l soft search:
Binning change in 2l soft SR

JHEP04(2022)091



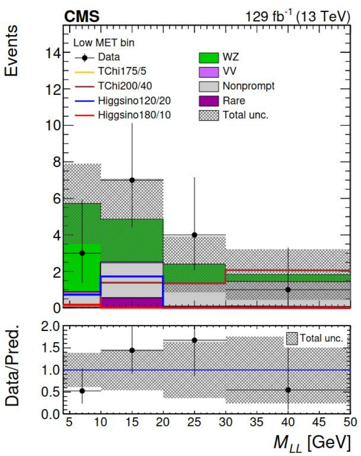
2l Low MET | 2l med MET | 2l high MET | 2l ultra MET

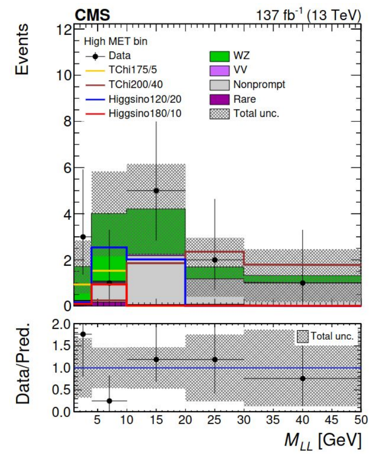
Updated binning



2/3l soft search:
Binning change in 3l soft SR and binning for slepton production

JHEP04(2022)091

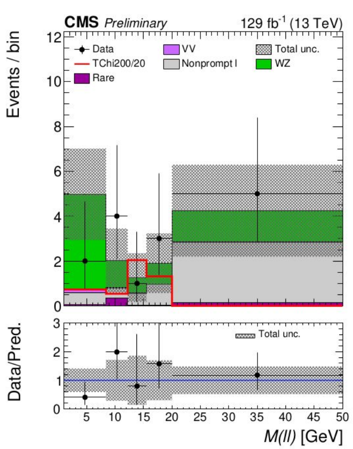


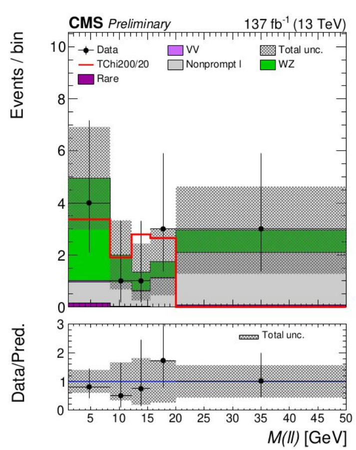


3l Low MET

3l med MET

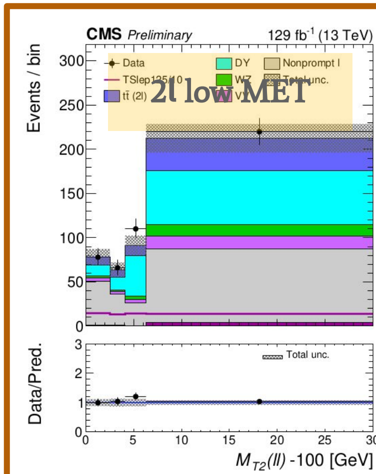
Updated binning

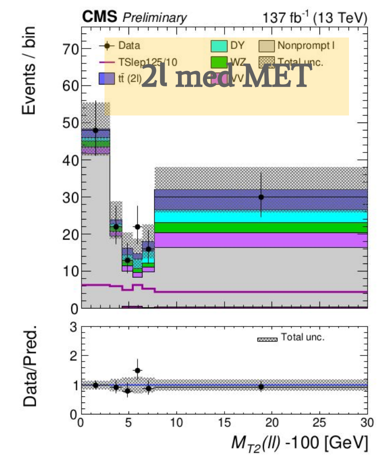


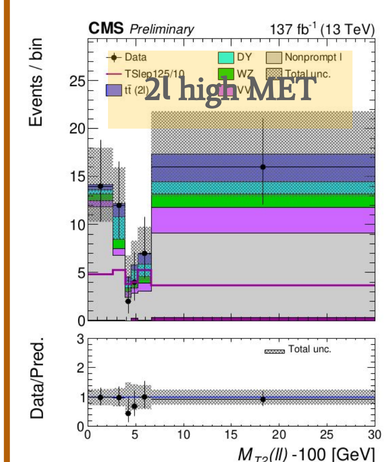


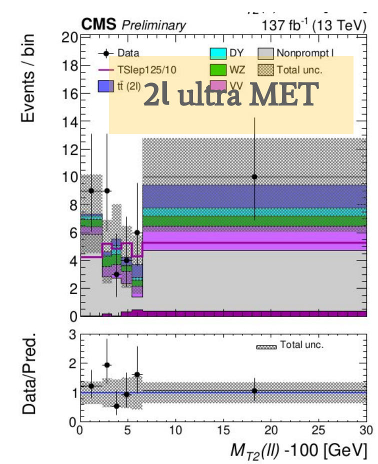
Binning for slepton production:

M_{ll} not meaningful: use M_{T2} with M_X=100 GeV

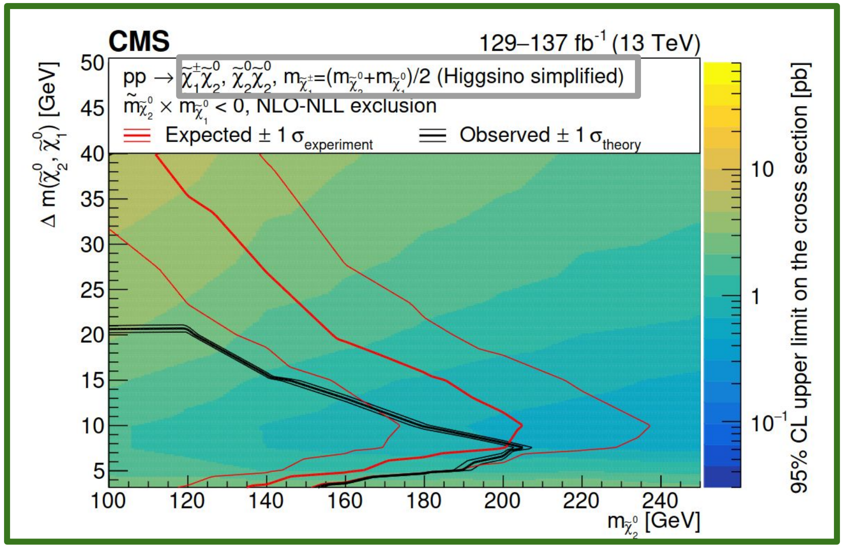


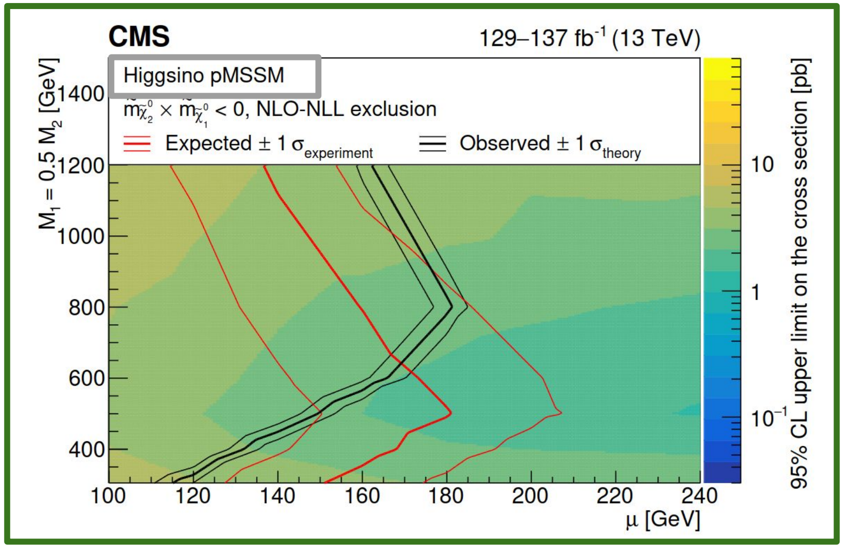


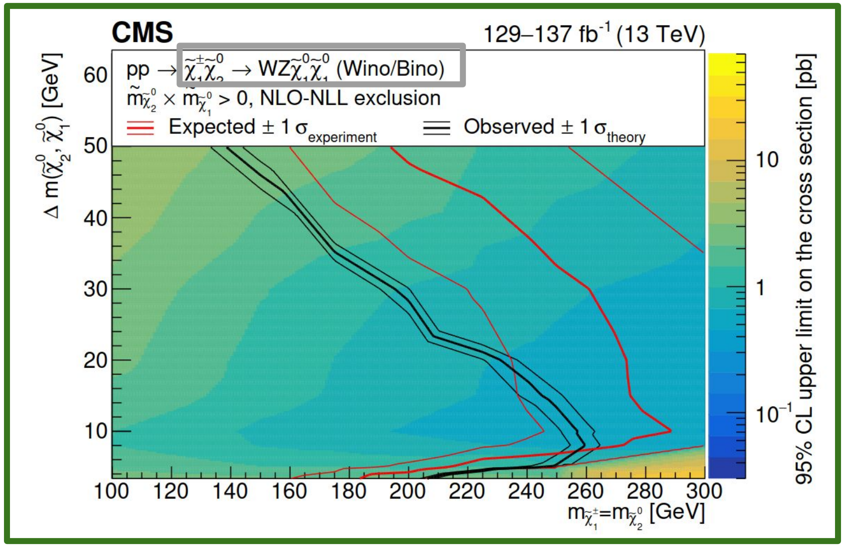


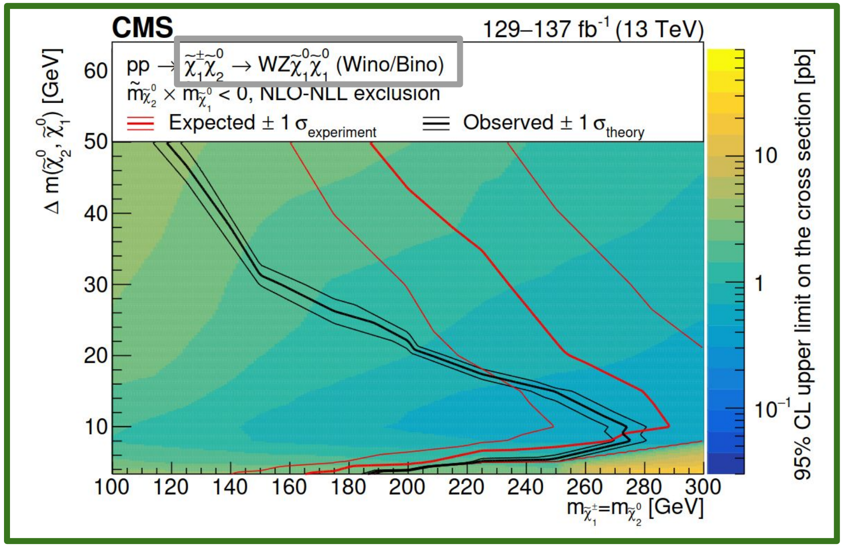


2/3l soft search:
Expected & Observed limits (JHEP04(2022)091)





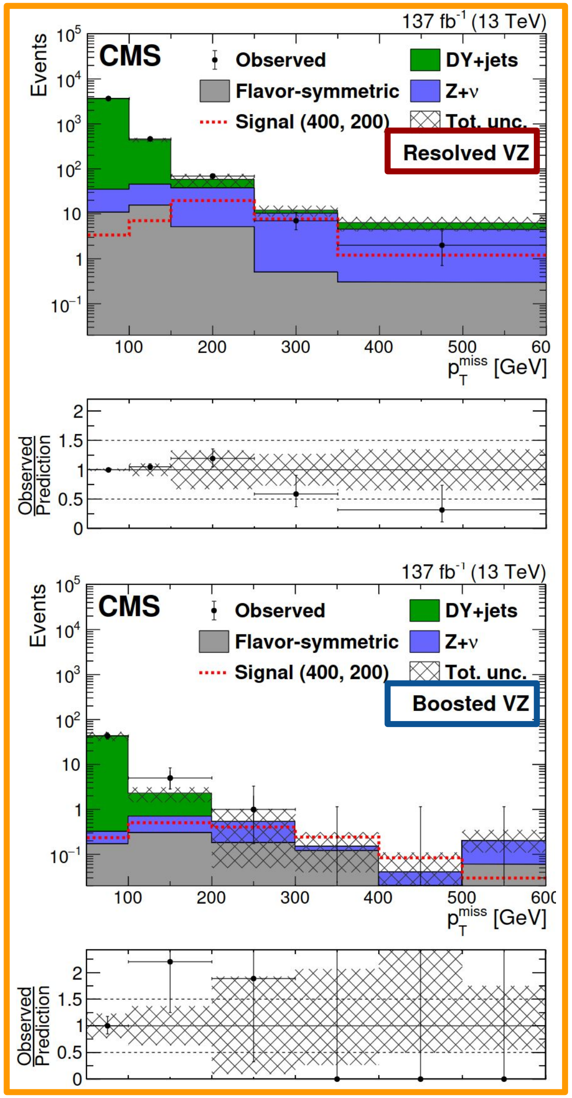


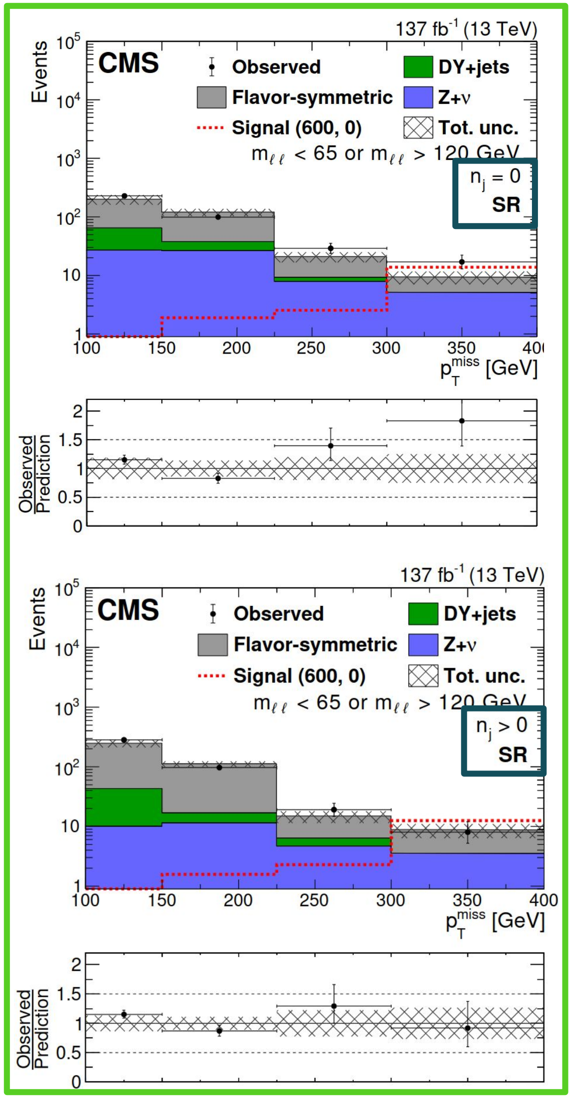


2l on Z/non resonant search:
Signal region strategy (JHEP04(2021)123)

2l on-Z/non res: (Boosted)

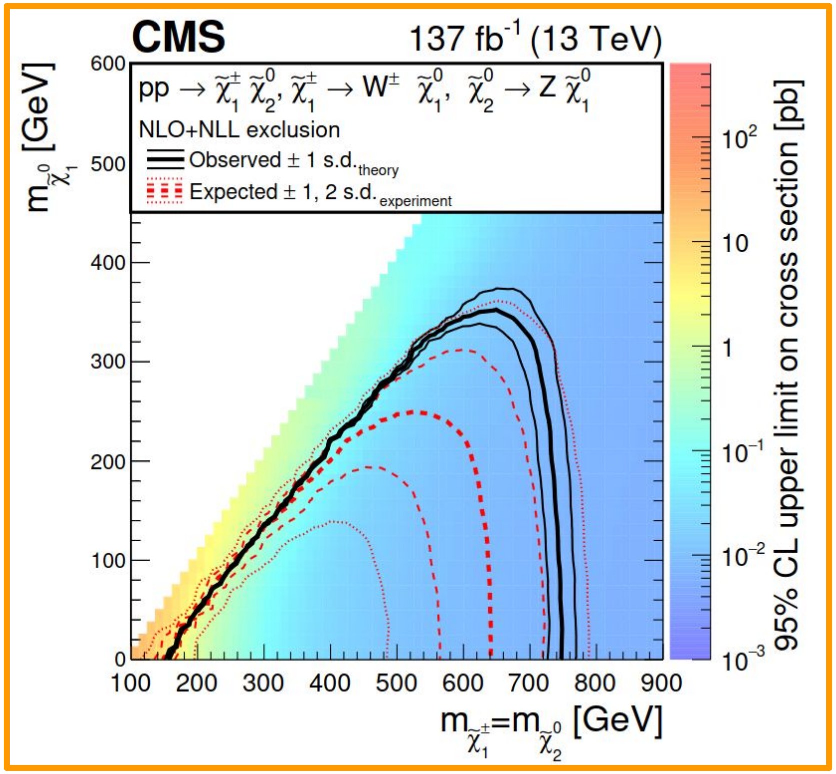
- Two OS SF leptons (ee/μμ), with SR split in terms of p_T^{miss}.
- on Z analysis (slepton production): $86<m_{ll}<96$ GeV, standard (AK4) & wider (AK8) jet reconstructions, further splitting in terms of **jet content.**
- off Z analysis (GMSB models): $20<m_{ll}<65$ GeV & $m_{ll}>120$ GeV. SR split in resolved and boosted topologies



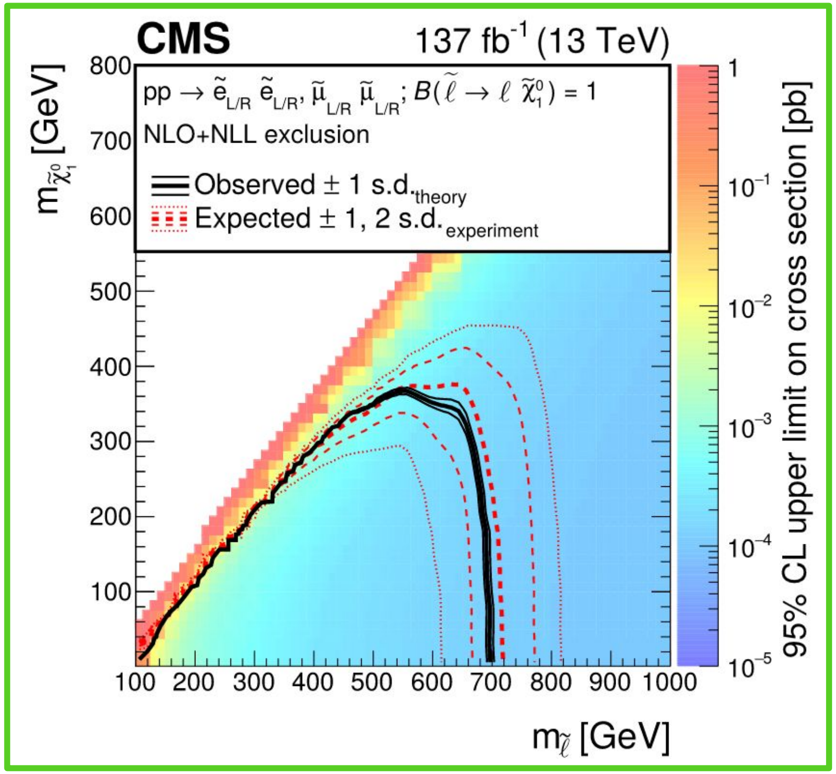


2ℓ on Z/non resonant search:
Expected & Observed limits (JHEP04(2021)123)

GMSB models



Slepton production



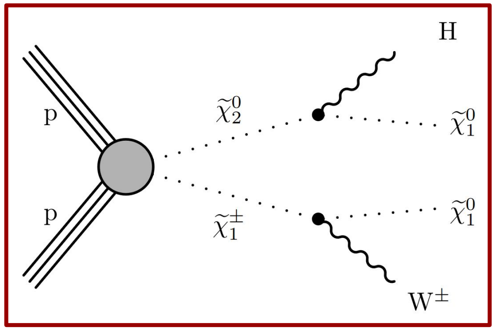
1l 2b search:
Signal selection and observed/expected limits (JHEP10(2021)045)

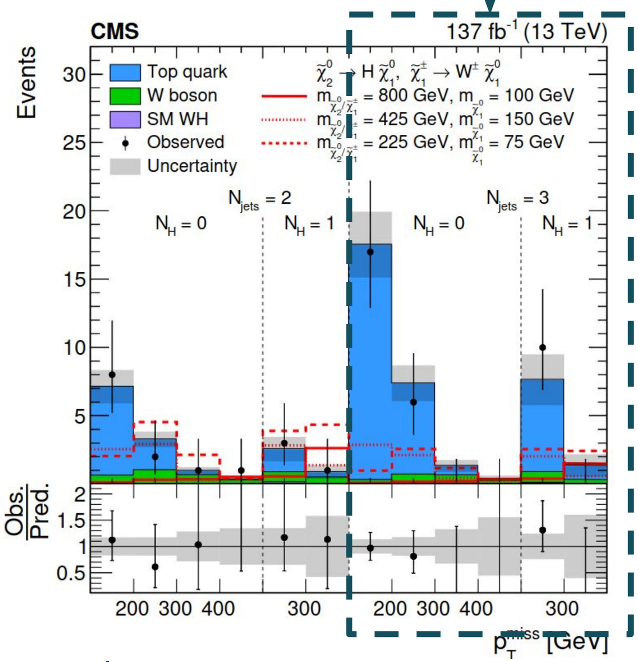
Targeting WH final states by selecting:

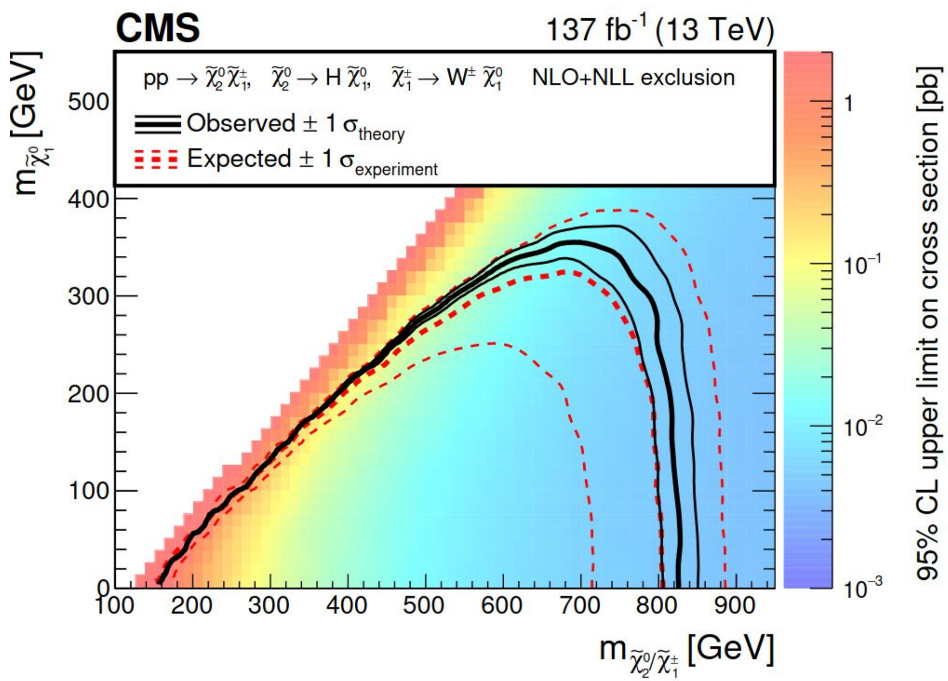
- p_T^{l1}>30 GeV, 2 b-tagged jets consistent with the Higgs boson mass, and large p_T^{miss}.

Improvements wrt analysis using 2016 data (JHEP11(2017)029):

- Use of a booster tagger
- Higher p_T^{miss} binning
- An additional **3 jet SR**



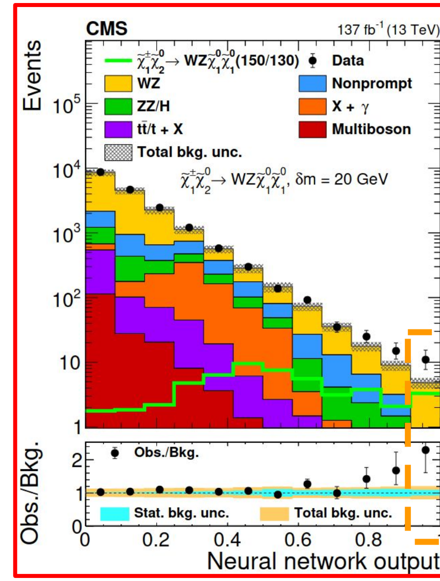


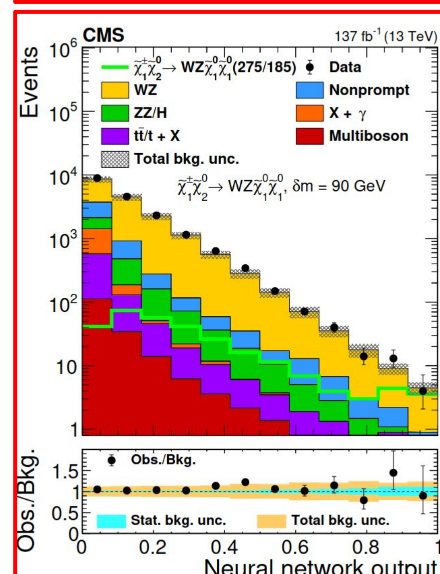


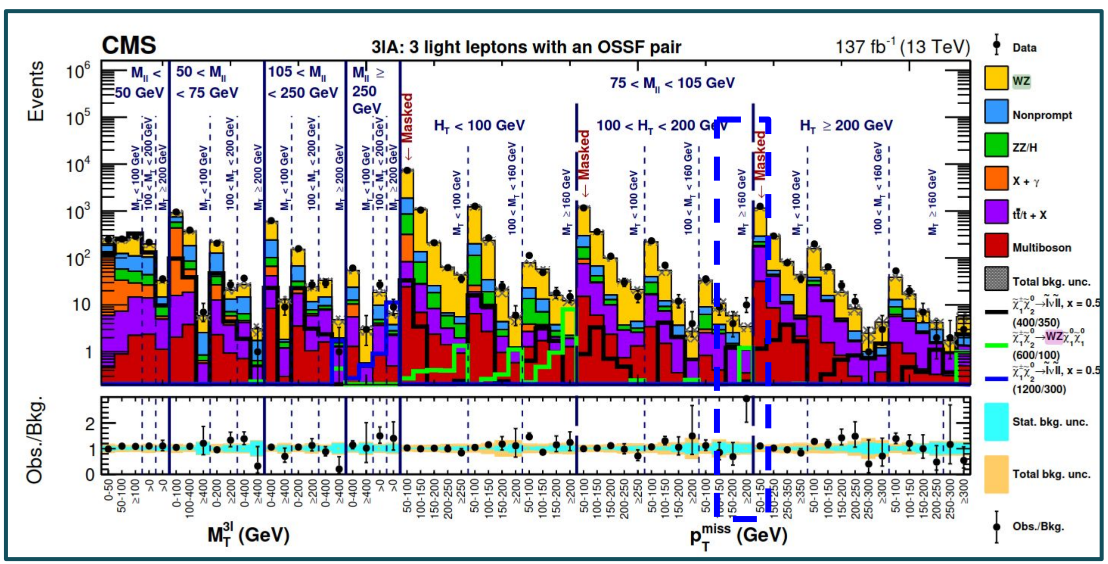
≥3l search:
Signal selection (JHEP04(2022)147)

A search that targets neutralino production in diboson final states:

- 2l SS leptons (compressed region
- 3l and 4l: up to 2 hadronic taus τ_h.
  - $p_T^{l1}>25$ GeV, $p_T^{l2}>20$ GeV
- Uses parametric neural networks (NN) with the mass splitting ($\Delta m=m_{NLSP}-m_{LSP}$) as variable, trained per each signal hyptothesis.
  - Gaining ~50 GeV wrt SR analysis
  - Mild excesses found at low Δm in the NN case and in bins of high p_T^{miss} and $100<H_T<200$ GeV in the SR case



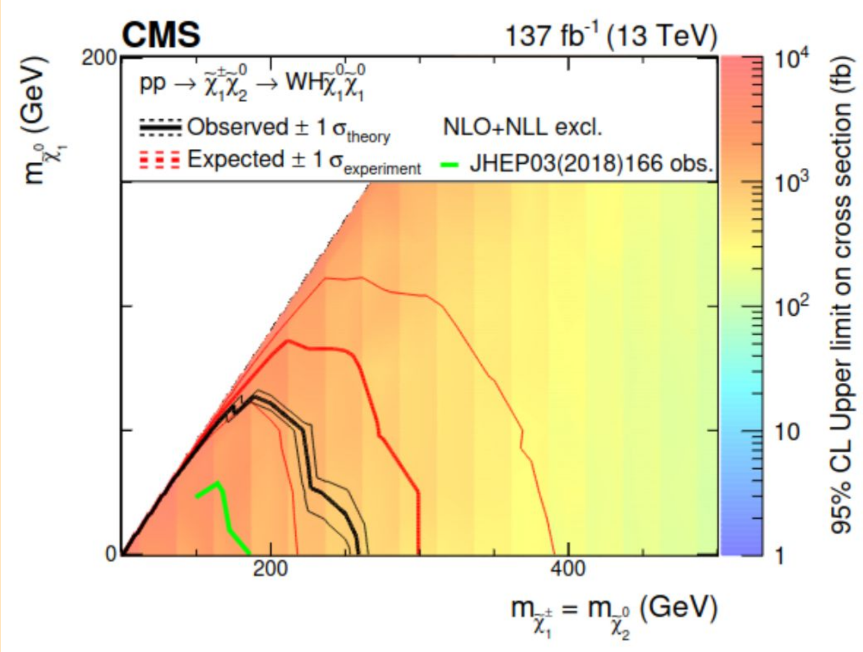




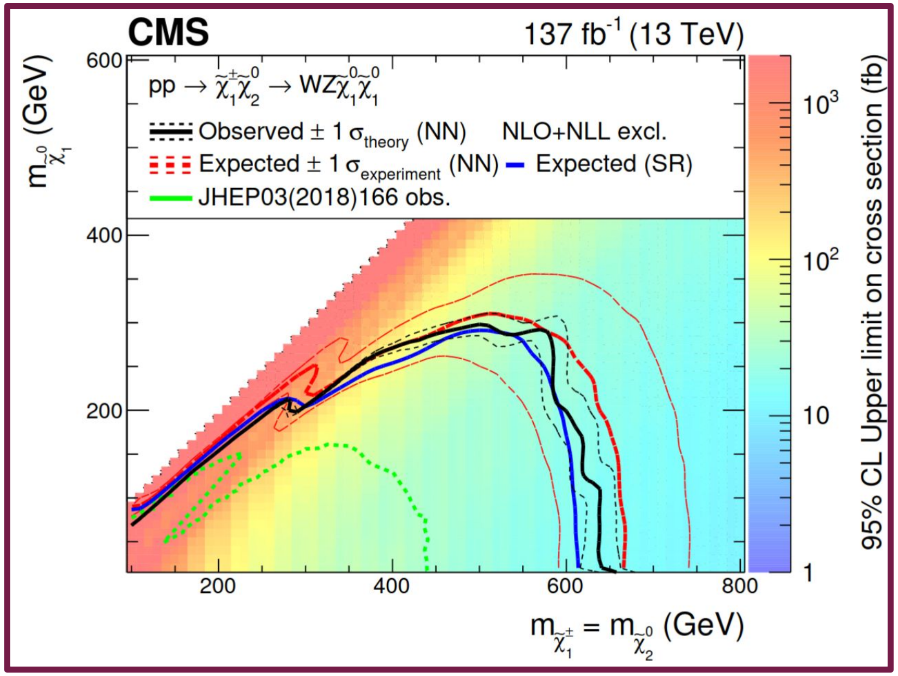
≥3l search:
Observed/expected limits (JHEP04(2022)147)

$\chi_1^{\pm}\chi_2^{0}$ production in:

WH mediated decays



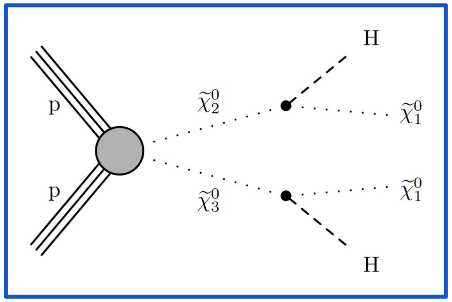
WZ mediated decays

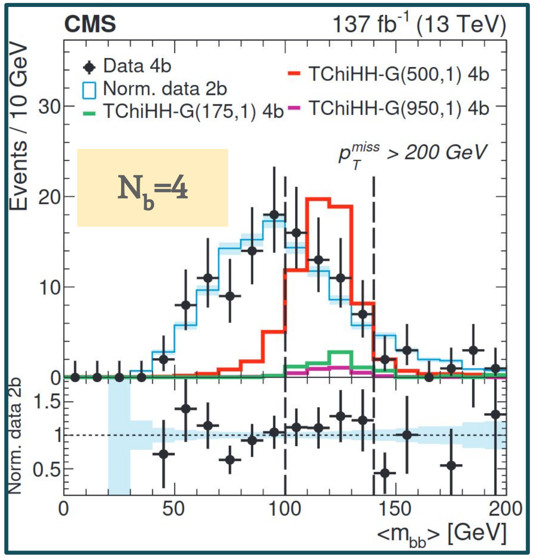


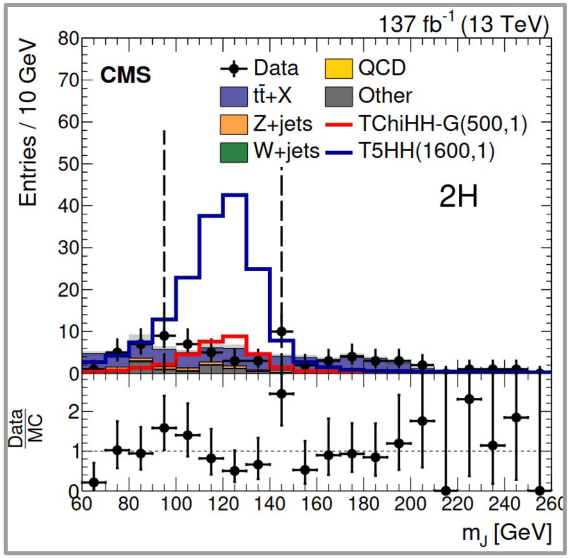
4b search:
Signal selection (JHEP05(2022)014)

Targeting HH final states that considers both resolved and boosted scenarios, with no leptons

- **Resolved** scenario: 2 separate AK4 b-tagged jets.
  - Signal extracted in terms of the $<m_{bb}>$ of the two b jets and $N_{b\text{-jets}}$
- **Boosted** scenario: 2b jets into an AK8 jet
  - Signal extracted in terms of the AK8 mass m_J and its n_H
- Main background, tt+X estimated with data driven ABCD method.

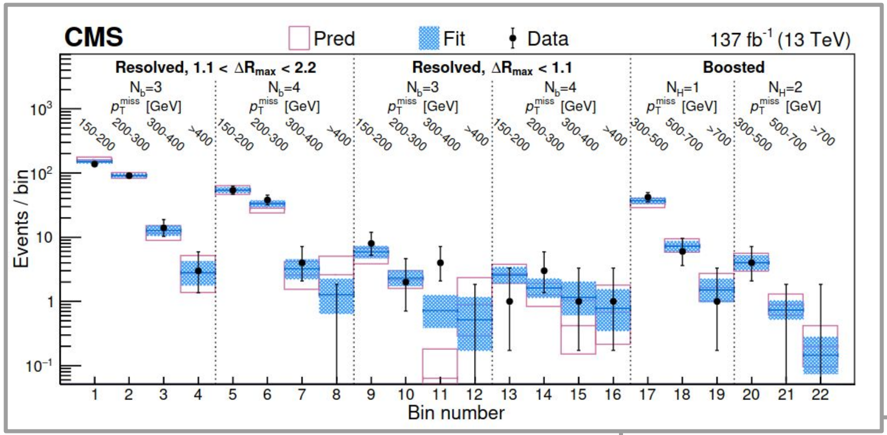


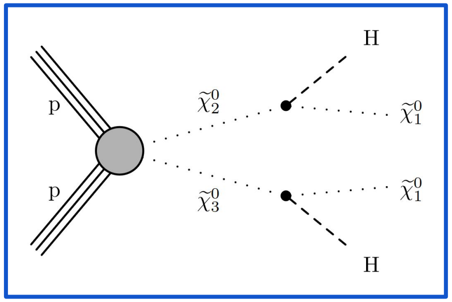


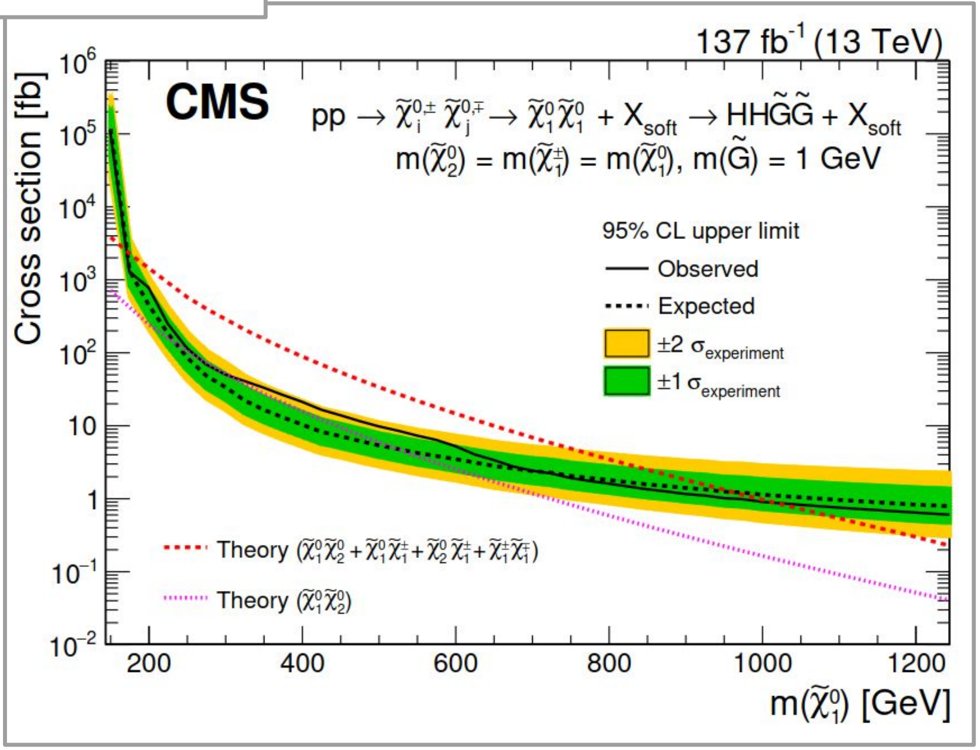


4b search:

Observed/expected yields and limits (JHEP05(2022)014)



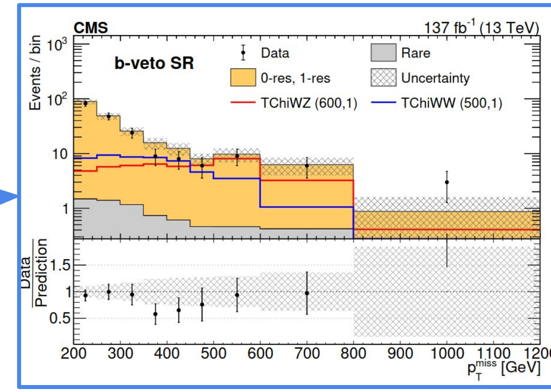


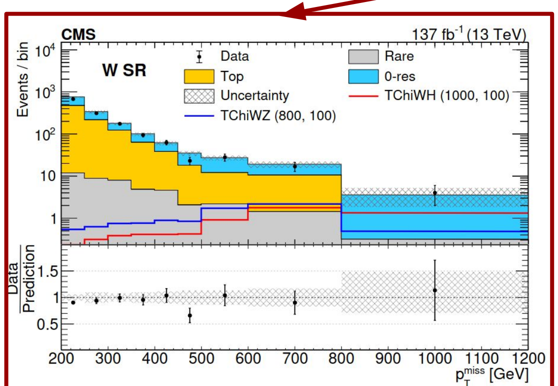


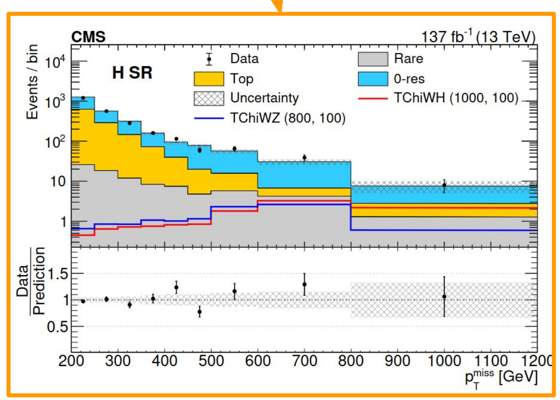
Hadr WX search:
Signal strategy and observed/expected yields (Phys.Lett.B 842 (2023) 137460)

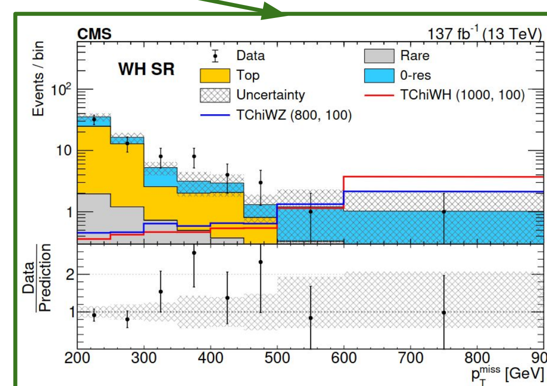
Hadr. WX: Fully hadronic final state

- At least 2 AK8 jets, compatible with W, Z and H bosons (Using machine learning algorithms).
- 2-6 AK4 jets
- Split in terms of b content:
  - **B-Veto SR**: AK8 jets with $65 < m_J < 105$ GeV
    - → ≥1 compatible with W and ≥1 with W/Z.
  - **B-Tag SR**: Subsplit in terms of the tagging
    - → AK8 jets compatible with **W**,**H** or **WH**, where H→bb.







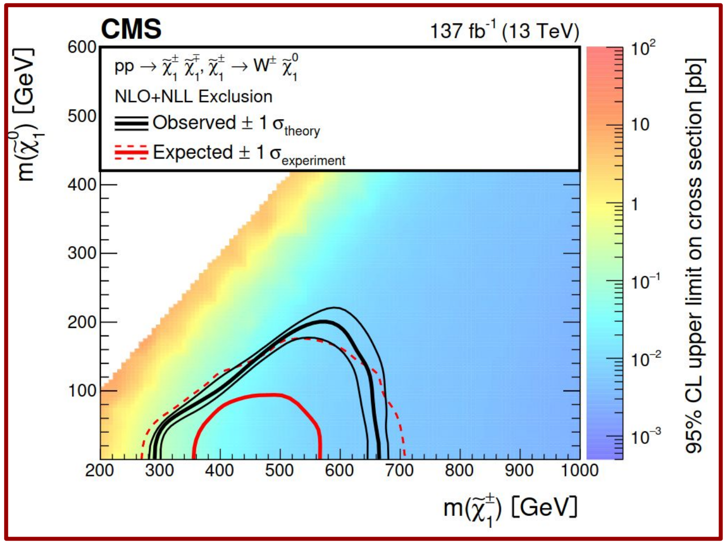


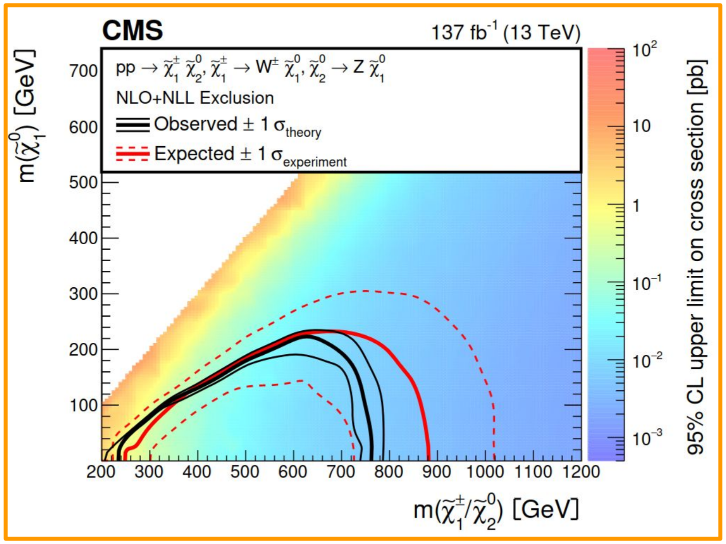
Hadr WX search:

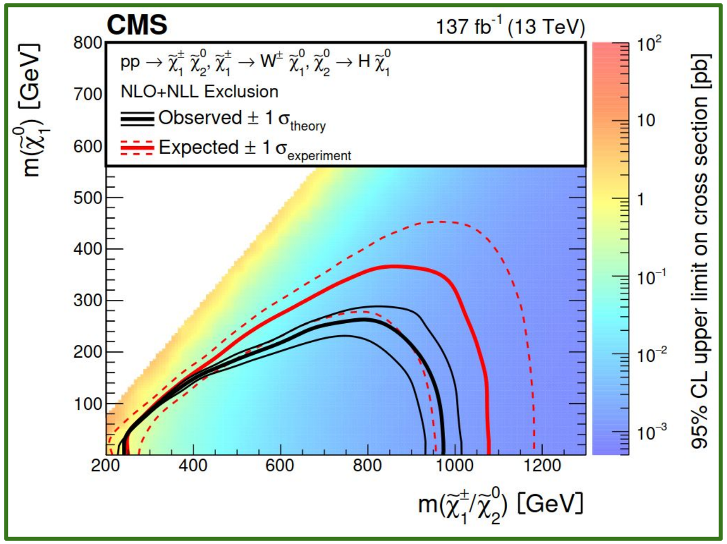
Observed/expected yields and limits (Phys.Lett.B 842 (2023) 137460)

Limits obtained for :

- $\chi_1^{\pm}\chi_2^0$ decaying via **WW** bosons
- $\chi_1^{\pm}\chi_2^0$ decaying via **WZ** bosons
- $\chi_1^{\pm}\chi_2^0$ decaying via **WH** bosons







Electroweakino Combination: overlaps

CMS SUS-21-008

Two big overlaps existing between 3l regions of 2/3l soft analysis, and those in the 3l categories in the ≥3l analysis:

- 3l WZ CR of 2/3l soft overlaps with the SR category of ≥3 l
  - WZ CR removed from the fit, constrained through a nuisance parameter
- 3l soft SR (p_T^{l1}<30 GeV) with ≥3l analysis (p_T^{l1}>25 GeV)
  - Updated the p_T^{l1} selection of ≥3l analysis,
  - Only slight changes in the sensitivity (highest in the compressed WZ, ~1-10% in 20<Δm<70 GeV)