

Recent searches for SUSY with CMS

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	SU SU	SY in Cl	MS Run Gluir	2
	SUS-19-001 Stealth Photons SUS-24-006 Photon Hbb SUS-20-001 OS-SF Dilepton Boosted Z	SUS-19-006 Jets + MHT SUS-19-005 MT2+DTk SUS-21-007 $1L + \Delta Phi$ SUS-21-009 $1\gamma + MET$ SUS-21-006 SUSY Dtk	SUS-19-007 1L + MJ SUS-21-005 1L RPV SUS-19-010 Hadronic Stop SUS-23-014 Razor boost	(13) EX Ultra SUS-2 Light S SUS-2 ηγ + Ν SUS-1 RPV/s
E	(18) W SUS-18-004 Soft 2LOS/3L Soft 2LOS/3L SUS-20-003 EWK WH EV SUS-20-004 HH(4b)+MET HH(4b)+MET HH(4b)+MET	ino SUS-23-002 SUS-23-002 Stop/Chargino 2LC US-19-012 K Multilepton SUS-23-003 Ompressed RJR O02 onic EXO-23-0	9-008 SUS-21 - in 2LSS SUSY D SUS-23-015 OS RPV nLep SUS-20-001 OS-SF Dilepton SUS-23-014 Razor Boost 17 SUS-24- tron ISR+Soft	-006 Tk SUS-23-006 Z' to chinos SUS-24-01 Lep+pho+ME EXO-18-002 HSCP 009 Tau



CMS continues a rich and lively SUSY search program:

- 34 public results with full CMS Run 2 data covering a wide range of SUSY signatures.
- Inclusive, multi-bin searches looking at multiple final states
- Dedicated searches targeting specific final states, specific models:
 - Compressed spectra (S. Bein's talk), low cross sections (e.g. sleptons), long-lived particles, low p_T^{miss} (e.g. RPV, stealth), boosted objects,
- Developing methodologies to increase sensitivity to challenging final states:
 - Machine learning, refined object identification, analysis combinations, ...

In this talk: 3 most recently public CMS non-compressed SUSY results.

- RPV search in 1 lepton events with multi jets, multi b-jets, and large radius jets
- Inclusive search in hadronic and leptonic final states with highly Lorentz-boosted objects Z to charginos search in 2 oppositely-charged leptons + pT^{miss}



1 lep + large jet

Search for R-parity violating SUSY, where SUSY particles decay to SM particles through baryon number violating interactions -> no p_T^{miss} .

- Search in 1lepton + multijets + multi b-jets.
- Signal separation with large anti-k_T jets with R = 1.2, clustered from AK4 jets and leptons.
- $M_{\rm J} > 500 \text{ GeV}$ where





CMS-PAS-SUS-21-00



Lepton from top quark decays

$$W = \frac{1}{2}\lambda^{ijk}L_iL_j\bar{\mathbf{e}}_k + \lambda'^{ijk}L_iQ_j\overline{\mathbf{d}}_k + \mu'^iL_iH_u + \frac{1}{2}\lambda''^{ijk}\overline{\mathbf{u}}_i\overline{\mathbf{d}}_j\overline{\mathbf{d}}_k$$

Π	5
U	J

1 lep + large jet: SRs, CRs, backgrounds

- Events binned in n_b, n_{jet}.:
 - signal-enriched (SR) and signaldepleted (CR) regions.
- Backgrounds: QCD, tt, W+jets.
- Simultaneous fit to MJ templates across SRs and CRs —> data determines shape and normalization.
 - M_J templates obtained from MC
 - Correct M_J templates per process using κ-factors: data / MC ratios of adjacent M_J bin yields (measured in dedicated regions, and constrained in the global fit).

NEW!

CMS-PAS-SUS-21-005

) T		
N_1	$N_{\rm b}$	N _{jet}			
lep		4 - 5	6 - 7	≥ 8	
	0	CR	CR	CR	
	1	CR	CR	CR	
1	2	CR	CR	SR	
	3	CR	SR	SR	
	≥ 4		SR	SR	





1 lep + large jet: Results, interpretation





CMS-PAS-SUS-21-005



Razor boost

Inclusive search for heavy SUSY particles with large mass differences.

- Final states with highly Lorentz-boosted objets:
 - hadronic W, Z (V), H(\rightarrow bb), top: reconstructed via ParticleNet.
 - leptonic jets: nonisolated lepton in an AK8 jet first time in a SUSY search.
- Razor kinematic variables: Signal peaks on smoothly falling SM background. Cluster event into 2 megajets.



Recent

CMS-PAS-SUS-23-014





Boosted leptonic jets in 2 RPV decays.





- 3 categories: hadronic, leptonic, leptonic jet.
- 25 search regions in n_{jet}, n_{bjet}, n_{lep}, n_{top}, n_V, n_H, n_{lepJet}.
- 151 search bins in (M_R-800)x(R²-0.08).
- Backgrounds: 1) Multijet (jet mismeasurements); 2) top, W in leptonic decays lost lepton); 3) $Z(\rightarrow vv)$ +jets.
- Background estimation:
 - Define data control regions by reverting selection criteria
 - derive data / MC correction factors via simultaneous fits to control regions.
 - Z -> vv using a template fit method.
 - Validate in signal-like validation regions.



CMS-PAS-SUS-23-014

CMS Prelimina 138 fb⁻¹ (13 TeV) Events / bin VR S'Top tt+jets Data W+jets Ζ→νν VV(V)+tĪX Z→ll H+jets 10° Data/MC Stat. unc. Stat. + syst. unc $(M_{B}-800) \times (R^{2}-0.08) (GeV)$ CMS Preliminar 138 fb⁻¹ (13 TeV) Events / bin VR lowM 🕈 Data 📃 tī+iets W+jets Multijet Z→II VV(V)+tTX γ+jets Ζ→νν 10² 10⁻¹ Data/MC Stat. unc. Stat. + syst. unc. $(M_{\rm R}^{-800}) \times (R^{2} - 0.08) (GeV)$ 50





Razor boost: Results, signals



Sensitive to a large variety of models: R-parity conservingand violating



CMS-PAS-SUS-23-014

 $\Rightarrow \Rightarrow \Rightarrow R2bbqqlv: \tilde{b}\tilde{b}, \tilde{b} \rightarrow b\tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow q\bar{q}\ell/q\bar{q}\nu$

Data are consistent with SM.

Arrow size indicates category contribution to sensitivity.





Razor boost: Interpretation



Recent

CMS-PAS-SUS-23-014







Z' to charginos in $l^+l^- + p_T^{miss}$

Heavy neutral gauge boson Z':

- Appears in well-motivated MSSM U(1)' extensions.
- leptophobic (usual Z' to dilepton decays highly suppressed) -> decays to chargino pairs.



CMS-PAS-SUS-23-006



First time at the LHC!

- Selection: $e^+e^- / \mu^+\mu^- / e\mu$, Leading / subleading $e/\mu p_T > 80, 40 \text{ GeV}$ $m_{\ell\ell} > 100 \text{ GeV}, p_T^{miss} > 100 \text{ GeV}, n_b = 0.$
- Parametric DNN for signal extraction:
 - Input features: $p_T(\ell_1)$, $p_T(\ell_2)$, $m_{\ell\ell}$, p_T^{miss} , $|\vec{p}_T(\ell\ell) + \vec{p}_T^{\text{miss}}|$, $|\vec{p}_{T}(\ell\ell) + \vec{p}_{T}^{\text{miss}}| - p_{T}(\ell\ell), m_{T}(\ell\ell, p_{T}^{\text{miss}}), m_{T2}(\ell, \ell). +$ angular separation variables.
 - Z' and chargino masses as input parameters.
 - Trained separately for the 3 channels.
- $m_{\ell\ell}$: Input feature with the highest discriminating power.





Z' to charginos in $\ell^+\ell^- + p_T^{miss}$: Results, limits

Backgrounds, fit:

- tt+jets, W+jet, Drell-Yan: obtain normalization from simultaneous fit to signal + control regions.
- Final fit to PNN score.
- eµ channel has the highest sensitivity.



PNN score

Interpretation: Upper limit on Z' effective cross section. m(Z') excluded up to 3.5 TeV, • m($\tilde{\chi}_1^{\pm}$) excluded for [0.4-1.4] TeV for m(Z') = 2.9 TeV. $138 \text{ fb}^{-1} (13 \text{ TeV})$ **CMS** *Preliminary* 138 fb⁻¹ (13 TeV) $m_{\widetilde{\chi}_1^{\pm}} \left[\text{GeV} \right]$ combined • Data $1800 \vdash pp \rightarrow Z' \rightarrow \widetilde{\chi}_{1}^{+} \widetilde{\chi}_{1}^{-}, \ \widetilde{\chi}_{1}^{\pm} \rightarrow W^{\pm} \widetilde{\chi}_{1}^{0}, \ W \rightarrow hv$ Bkg. fit $1600 \stackrel{|}{\models} BR(Z' \rightarrow \widetilde{\chi}_{1}^{+} \widetilde{\chi}_{1}) = BR(\widetilde{\chi}_{1}^{\pm} \rightarrow W^{\pm} \widetilde{\chi}_{1}^{0}) = 1$ Pre-fit 15.69 16.88 $m_{z\pm}=2m_{0}$ m(Z') = 2.5 TeV.1400 m(χ[±]) = 345 Ge√ 19.47 17.04 17.75 Observed — Exp. median 1200 ---- Exp. (68%) 20.65 17.58 16.37 1000 19.57 17.97 800

600 - 62.99 400 142.40 83.76 57.3**5** 42.54 32.92 27.22 22.70 4000 2000 2500 3000 3500 1500 m_{7'} [GeV]







To conclude...

- CMS continues to explore every corner of the SUSY parameter space.
- Presented 3 most recent Run 2 (non-compressed) results:
 - explored using large radius jets.
 - 2 RPV models, and those with Higgs in decay chains.
 - chargino exclusion up to 1.4 TeV.
- Exploration continues more searches are on the way!

• RPV 1 lepton + jets + b jets + large jets: A SUSY search with no p_T^{miss} selection,

 Inclusive search with boosted objects: Disjoint channels with boosted top, W/Z, Higgs. First use of boosted leptonic jets in a SUSY search. Interpreted in 8 models including

• Z' to charginos in dilepton + p_T^{miss} : First time at LHC. Probed Z' up to 3.5 TeV. Indirect

