Search for Bosonic Stop Decays in R-Parity Violating Supersymmetry in e^+q Collisions at HERA

H1 Collaboration

Abstract

A search for scalar top quarks in R-parity violating supersymmetry is performed in e^+p collisions at HERA using the H1 detector. The data taken at $\sqrt{s} = 319\,\text{GeV}$ and $\sqrt{s} = 301\,\text{GeV}$, correspond to an integrated luminosity of $105.8\,\text{pb}^{-1}$. The resonant production of scalar top quarks $\tilde{t}$ in positron quark fusion via a Yukawa coupling λ' is considered with the subsequent bosonic stop decay $\tilde{t} \to \tilde{b}W$. The R-parity violating decay of the sbottom quark $\tilde{b} \to d\bar{\nu}_e$ is considered and leptonic and hadronic W decay channels are analysed. No evidence for stop production is found in the bosonic stop decay nor in the direct R-parity violating decay $\tilde{t} \to eq$. Mass dependent limits on λ' are obtained in the framework of the Minimal Supersymmetric Standard Model. Stop quarks with masses below $275\,\text{GeV}$ are excluded at 95% confidence level in a large part of the parameter space for a Yukawa coupling of electromagnetic strength.

Channel	Decay processes	Signature
	$\tilde{t} \to \tilde{b}\, W$	
	$\overset{\lambda'}{\hookrightarrow} d\bar{\nu}_e$	
$je\not{P}_\perp$	$W \to e\nu_e$	jet + e + $\not{P}_\perp$
	$\to \tau\nu_\tau \to e\nu\nu\nu$	
$j\mu\not{P}_\perp$	$W \to \mu\nu_\mu$	jet + μ + $\not{P}_\perp$
	$\to \tau\nu_\tau \to \mu\nu\nu\nu$	
$jjj\not{P}_\perp$	$W \to q\bar{q}'$	3 jets + $\not{P}_\perp$
ed	$\tilde{t} \overset{\lambda'}{\to} ed$	jet + high P_T e

Table 1: Stop decay channels in $\not{R}_p$ SUSY analysed. The $\not{R}_p$ process is indicated by the coupling λ'.

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Channel	$\sqrt{s} = 301\,\text{GeV}$		$\sqrt{s} = 319\,\text{GeV}$		all	
	data	SM expectation	data	SM expectation	data	SM expectation
$je\not{P}_\perp$	1	1.16 ± 0.28 (W: 0.75 ± 0.12)	2	2.68 ± 0.64 (W: 1.80 ± 0.29)	3	3.84 ± 0.92 (W: 1.55 ± 0.25)
$j\mu\not{P}_\perp$	4	0.84 ± 0.14 (W: 0.57 ± 0.09)	4	1.85 ± 0.33 (W: 1.36 ± 0.22)	8	2.69 ± 0.47 (W: 1.93 ± 0.31)
$jjj\not{P}_\perp$	1	1.91 ± 0.54	4	4.33 ± 1.21	5	6.24 ± 1.74
ed	366	383.5 ± 44.9	734	736.2 ± 86.3	1100	1119.7 ± 131.3

Table 2: Total number of selected events for the e^+p H1 data set of the stop decay channels at $\sqrt{s} = 301\,\text{GeV}$, $\sqrt{s} = 319\,\text{GeV}$ and the combined data set. For the $je\not{P}_\perp$ channel and the $j\mu\not{P}_\perp$ channel the SM expectation arising from W-production are given in brackets.

SUSY Parameter Range
$M_2 = 1000\,\text{GeV}$
$400\,\text{GeV} < \mu < 1000\,\text{GeV}$
$\tan\beta = 10$
$180\,\text{GeV} < M_{\tilde{t}_1} < 290\,\text{GeV}$
$100\,\text{GeV} < M_{\tilde{b}_1} < 210\,\text{GeV}$
$0.6\,\text{rad} < \theta_{\tilde{t}}, \theta_{\tilde{b}} < 1.2\,\text{rad}$
$A_t = A_b = -100\,\text{GeV}$

Table 3: The chosen SUSY parameter range in the unconstrained MSSM.

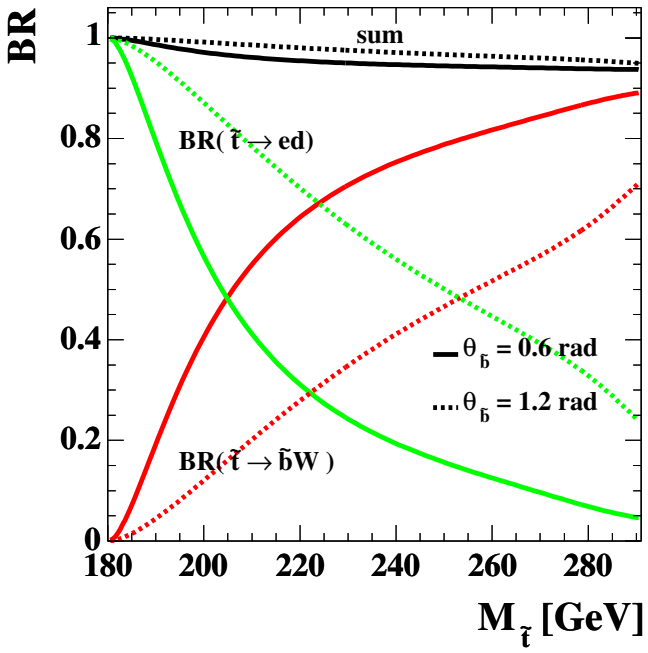

Figure 1: An example of the branchig ratios of stop decay modes for $M_{\tilde{b}} = 100\,\text{GeV}$ and $\lambda'_{131} = 0.3$ as a function of the stop mass, when the gauge fermionic decay modes of the stop are kinematically not allowed. The solid lines show the branchig ratios for $\theta_{\tilde{b}} = 0.6$ rad and the dashed lines for $\theta_{\tilde{b}} = 1.2$ rad.

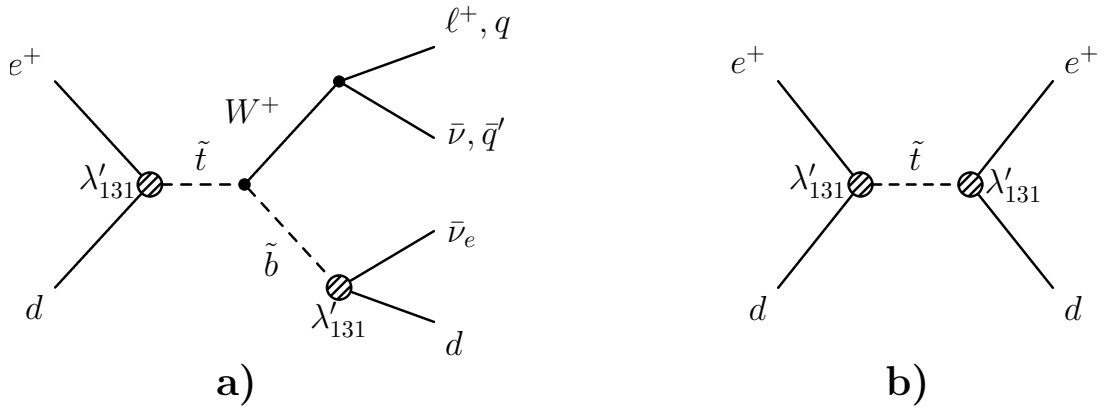

Figure 2: Lowest order s channel diagram for $\not{R}_p$ stop production at HERA followed by a) the bosonic decay of the stop and b) the $\not{R}_p$ decay of the stop.

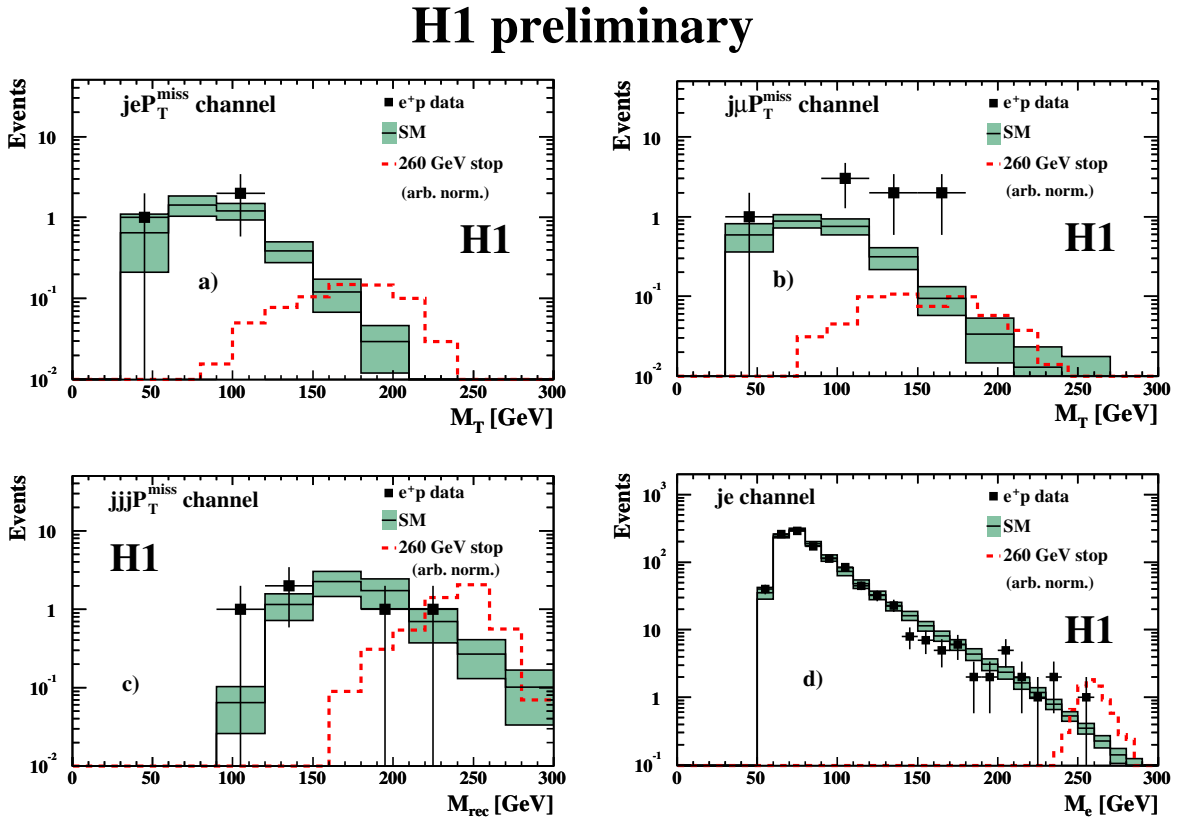

Figure 3: Mass spectra for the e^+p H1 data set: a) transverse mass of the $je\not{P}_\perp$ channel; b) transverse mass of the $j\mu\not{P}_\perp$ channel; c) reconstructed mass of the $jjj\not{P}_\perp$ channel; d) M_e distribution of the ed channel. The shaded error band indicates the systematic uncertainty on the SM background.

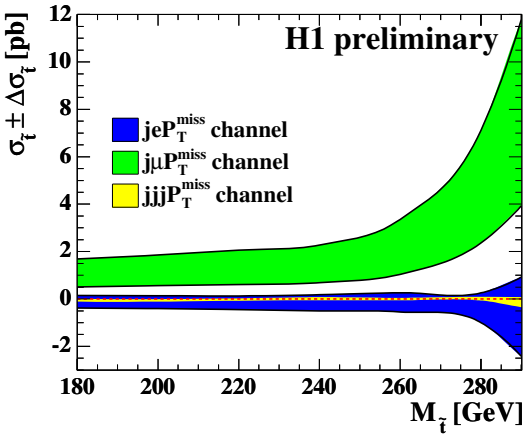

Figure 4: Allowed stop cross section regions $\sigma_{\tilde{t}} \pm \Delta\sigma_{\tilde{t}}$ depending on the stop mass for all bosonic stop decay channels. Only statistical errors are shown.

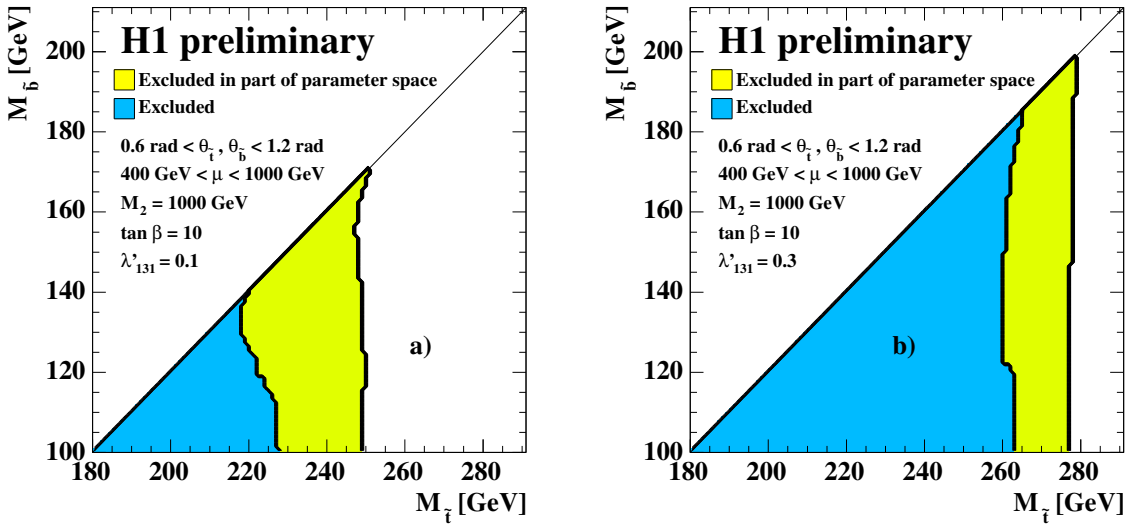

Figure 5: Exclusion limits at 95% CL in the $(M_{\tilde{t}}, M_{\tilde{b}})$ plane for a) $\lambda'_{131} = 0.1$ and b) $\lambda'_{131} = 0.3$ from a scan of the MSSM parameter space as indicated in the figures. The two full curves indicate the strongest and the weakest limits on the masses in the parameter space investigated.

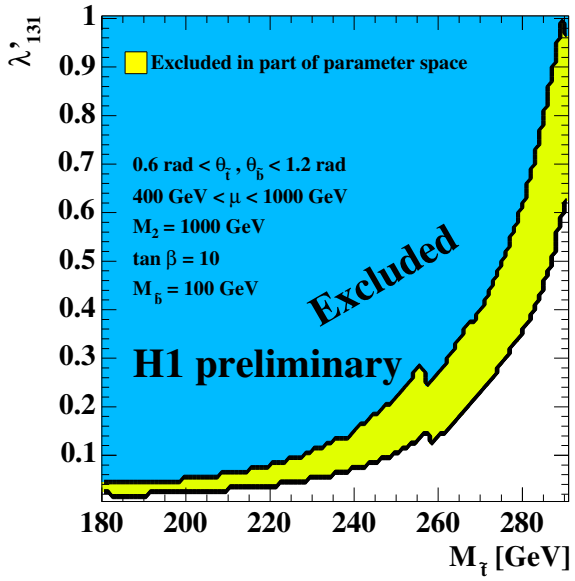

Figure 6: Exclusion limits at 95% CL on the $\not{R}_p$ coupling λ'_{131} as a function of the stop mass from a scan of the MSSM parameter space as indicated in the figure. The sbottom mass is set to $M_{\tilde{b}} = 100\,\text{GeV}$. The two full curves indicate the strongest and the weakest limits on λ'_{131} in the parameter space investigated.