SUSY Searches at H1

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Abstract.
The deep inelastic collisions produced at HERA provide and ideal environment to search for new particles and physics Beyond the Standard Model (BSM) and three such analyses performed by the H1 experiment are presented here. A search for bosonic stop decays in R-parity violating SUSY finds no significant deviation from the Standard Model (SM) and sets competitive limits, excluding the existence of stop quarks at 95% CL with masses up to 275 GeV for a Yukawa coupling λ' of electromagnetic strength. Secondly, a search for light gravitinos in events with photons and missing transverse momentum sets the first constraints from HERA on SUSY models independent of the squark sector, ruling out neutralino masses up to 112 GeV at 95% CL for $\lambda' = 1$. Finally, a model independent general search for new phenomena finds good agreement between the H1 data and the SM, the most significant deviation found being a previously reported observation.

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A SEARCH FOR BOSONIC STOP DECAYS IN R-PARITY VIOLATING SUSY IN E$^+$P COLLISIONS AT HERA

H1 has previously performed a search for squarks ($\tilde{q}$), the scalar supersymmeteric (SUSY) partners of quarks, in models with R–parity violation ($\not{R}_p$) [1]. This analysis, which uses H1 e^+p data corresponding to an integrated luminosity of 106 pb^{-1}, complements the previous analysis and focuses on resonant stop quark production in e^+q fusion which proceeds via an $\not{R}_p$ coupling λ', with the subsequent bosonic stop decay $\tilde{t} \to \tilde{b}W$ [2]. The R–parity violating decay of the sbottom quark $\tilde{b} \to d\bar{\nu}_e$ and leptonic and hadronic W decays are considered. The $\not{R}_p$ decay $\tilde{t} \to eq$ is also examined in order to cover all possible stop decay modes. The bosonic stop decay leads to three different final state topologies depending on the decay of the W boson; a jet, a lepton (electron or muon)[1] and missing transverse momentum ($je\not{P}_\perp$ channel and $j\mu\not{P}_\perp$ channel) or, if the W decays to jets, three jets and missing transverse momentum ($jjj\not{P}_\perp$ channel).

A slight excess of events compared to the SM prediction is observed in the $j\mu\not{P}_\perp$ channel, confirming the results of a previous H1 analysis [3]. All of the other channels are found to be in good agreement with the SM. Assuming the presence of a stop mass $M_{\tilde{t}}$ decaying bosonically, the observed event yields are used to determine the allowed range for a stop production cross section $\sigma_{\tilde{t}}$, as illustrated in figure 1 (left). It can

[1] The W decay into $\nu_\tau\tau$, where $\tau \to$ hadrons $+\nu$ is not investgated in this analysis.

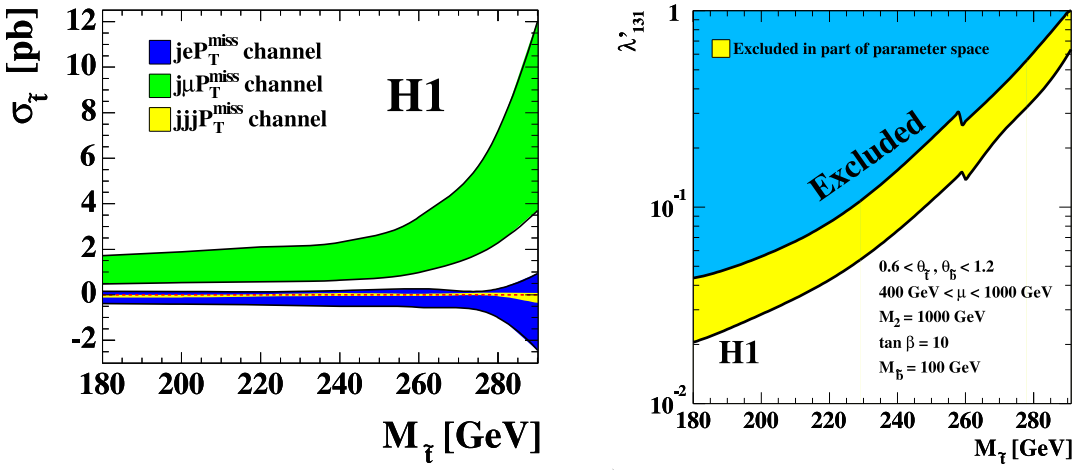

FIGURE 1. Left: Bands representing the allowed stop cross section regions $\sigma_{\tilde{t}} \pm \Delta\sigma_{\tilde{t}}$ as a function of the stop mass as obtained from the analysis of each bosonic stop decay channel. Right: Exclusion limits at the 95% CL on the $\not{R}_p$ coupling λ'_{131} as a function of the stop mass for $M_{\tilde{b}} = 100$ GeV.

be seen that the excess in the $j\mu\not{P}_\perp$ channel is not supported by the other channels, and hence no evidence for stop production is observed. The results from the different channels are combined to derive constraints on stop quarks decaying bosonically in the Minimal Supersymmetric Standard Model (MSSM). The resulting limits projected on the ($M_{\tilde{t}}$, λ'_{131}) plane for $M_{\tilde{b}} = 100$ GeV are shown in figure 1 (right). In a large part of the model parameter space the existence of stop quarks coupling to an e^+d pair with masses up to 275 GeV is excluded at 95% CL for a Yukawa coupling λ'_{131} of electromagnetic strength.

A SEARCH FOR LIGHT GRAVITINOS IN EVENTS WITH PHOTONS AND MISSING TRANSVERSE MOMENTUM AT HERA

The fermion–boson symmetry in SUSY models leads to an extention of the particle spectrum by associating each SM particle to a super symmetric partner, with different spin by half a unit. The masses of the new particles are related to the symmetry breaking mechanism and in Gauge Mediated Supersymmetry Breaking (GMSB) models, new "messenger" fields are introduced which couple to the source of the symmetry breaking. The gravitino, $\tilde{G}$ is the lightest supersymmetric particle (LSP) and the next–to–lightest supersymmetric particle (NLSP) is generally either the lightest neutralino $\tilde{\chi}_1^0$ or a slepton $\tilde{l}$, which decays accordingly to the stable gravitino. This analysis, which uses H1 $e^\pm p$ data corresponding to an integrated luminosity of 78 pb^{-1}, investigates $\not{R}_p$ SUSY in a GMSB scenario and searches for resonant single neutralino production $\tilde{\chi}_1^0$ via t–channel selectron exchange, $e^\pm p \to \tilde{\chi}_1^0 q'$, where it is assumed the $\tilde{\chi}_1^0$ is the NLSP and the subsequent decay $\tilde{\chi}_1^0 \to \gamma\tilde{G}$ occurs with an unobservably small lifetime [4]. The experimental signature is thus a photon, a jet from the struck quark and missing

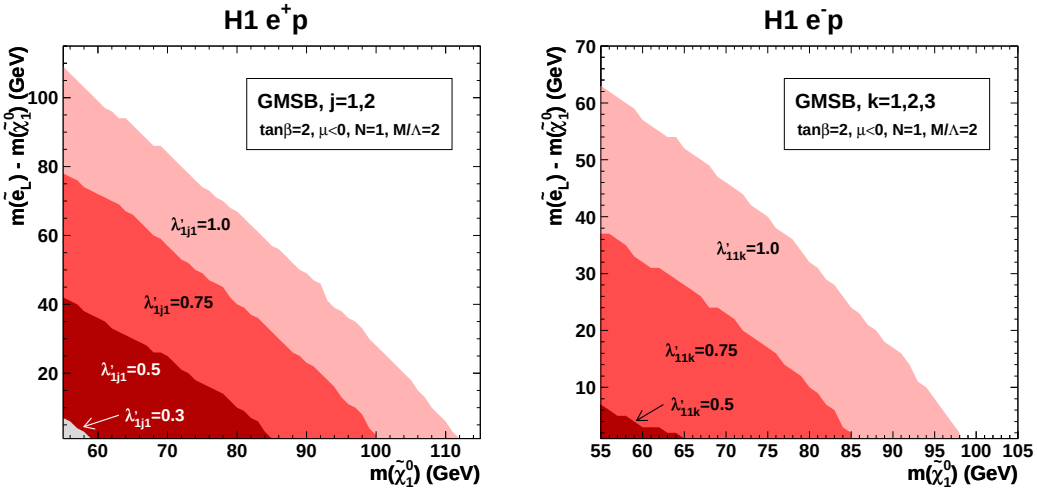

FIGURE 2. Excluded regions at the 95% CL in the $\Delta m = m(\tilde{e}_L) - m(\tilde{\chi}_1^0)$ and $m(\tilde{\chi}_1^0)$ plane for various values of λ'_{1j1} ($j = 1,2$) and λ'_{11k} ($k = 1,2,3$).

transverse momentum due to the gravitino. The main SM background is due to radiative charged current deep inelastic scattering.

In the search for light gravitinos in events with photons and missing transverse momentum no significant deviation from the SM is observed. The results are used to derive constraints on GMSB models for different values of the $\not{R}_p$ coupling λ' for fixed values of the SUSY parameters $tan\beta$ (the ratio of the Higgs vacuum expectation values), N (the number of sets of messenger particles) and μ (the sign of the Higgs sector mixing parameter). Figure 2 displays excluded regions in the ($m(\chi_1^0)$, $m(\tilde{e}_L)$–$m(\chi_1^0)$) plane derived from the H1 e^+p (left) and e^-p (right) data for various values of λ'. It can be seen that for small mass differences between the neutralino and selectron, neutralino masses up to 112 GeV are ruled out at 95% CL for $\not{R}_p$ coupling $\lambda' = 1$. Furthermore, for neutralino masses close to 55 GeV, λ'_{1j1} Yukawa couplings of electromagnetic strength are excluded. These are the first constraints from HERA on SUSY models independent of the squark sector.

A GENERAL SEARCH FOR NEW PHENOMENA IN EP SCATTERING AT HERA

A model independent general search for deviations from the SM is performed using the complete H1 HERA I data sample (1994-2000), corresponding to an integrated luminosity of 117 pb^{-1} [5]. All high transverse momentum (P_T) final state configurations involving electrons (e), muons (μ), jets (j), photons (γ) or neutrinos (ν) are considered. All final state configurations containing at least two such objects with $P_T > 20$ GeV in the central region of the detector are investigated and classified into exclusive event classes, for example e–j, μ–j–ν, j–j–j and so on.

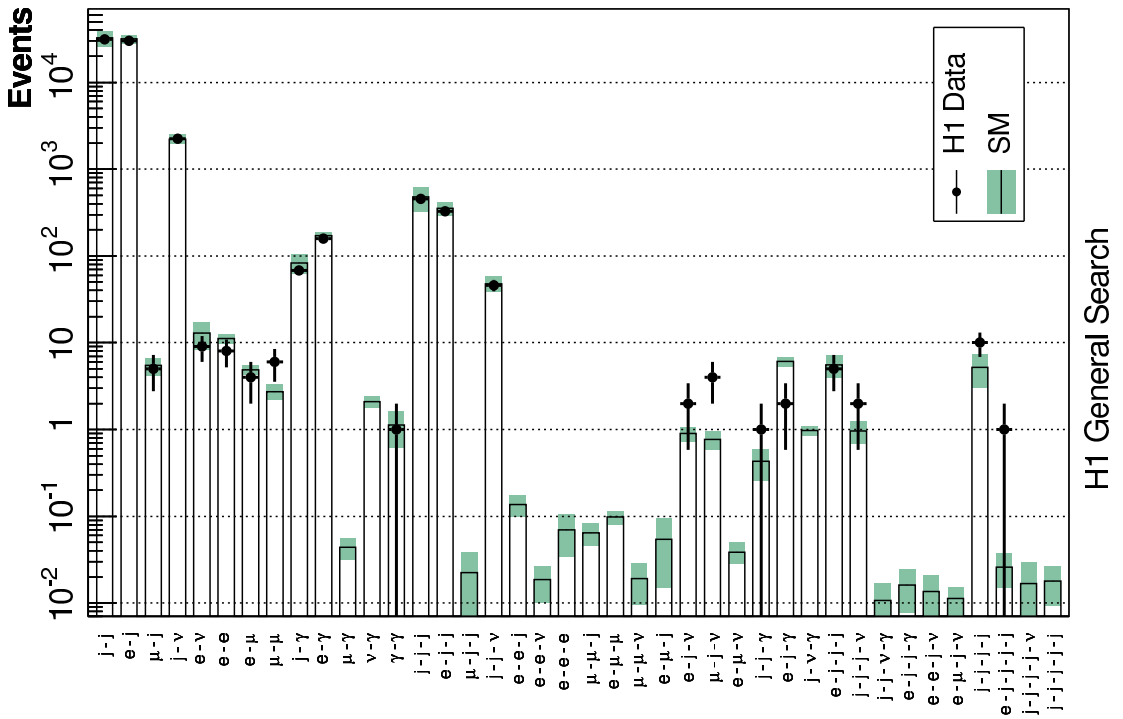

FIGURE 3. The data and the SM expectation for all event classes with a SM expectation greater than 0.01 events. The error bands on the predictions include model uncertainties and experimental systematic errors added in quadrature.

Data events are found in 22 such event classes and good agreement is observed between data and the SM expectation in most event classes, as can be seen in figure 3. The dominant high P_T processes at HERA, namely photoproduction of jets (j–j class) and neutral and charged current deep inelastic scattering (e–j and j–ν classes respectively) are seen to dominate the observed rates. The observed data excess in the μ–j–ν event class, where 4 data events are observed compared to a SM expectation of 0.8 ± 0.2, was previously reported in [3]. Additionally, in the e–j–j–j–j event class 1 event is observed in the data compared to a SM prediction of 0.026 ± 0.011.

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