PROCEEDINGS OF SCIENCE

The Search for New Physics at HERA

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The latest results on a variety of searches for new physics at HERA by the ZEUS and H1 Collaborations are presented. HERA, the world's only *ep* Collider at DESY, Hamburg, running 1991 – 2007 at centre-of-mass energies up to 320 GeV, was ideally suited for searches for physics beyond the Standard Model due to its unique initial state. The H1 and ZEUS experiments with their asymmetric design provided 4π Coverage, excellent lepton ID and HFS reconstruction to detect any exotic signatures. The searches use the complete HERA data sample corresponding to a total integrated luminosity of about 1 fb^{-1} (0.5 fb^{-1} per experiment) and including combined H1+ZEUS results. Topics covered include a search for *eqeq* contact interactions, a general search for new phenomena at HERA, a search for lepton flavour violation, a search for isolated leptons in events with missing transverse momentum, a search for single top production, a search for excited fermions and a search for squark production in MSSM and mSUGRA models. The results are competitive and complementary to results from other colliders.

35th International Conference of High Energy Physics
July 22-28, 2010
Paris, France

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PoS(ICHEP 2010)384

1. Signature Searches

1.1 A General Search for New Phenomena at HERA

A model-independent search for deviations from the Standard Model (SM) prediction is performed [1]. All event topologies involving isolated electrons, photons, muons, neutrinos and jets with transverse momenta above 20 GeV are investigated in a single analysis. Events are assigned to exclusive classes according to their final state. Figure 1 shows the event yields in each of the classes for e^+p (a) and e^-p (b) collisions separately. Overall the data agree well with the SM expectation within the total uncertainties. A dedicated algorithm is used to search for deviations from the SM in the distributions of the scalar sum of transverse momenta or the invariant mass of final state particles and to quantify their significance. Variables related to angular distributions and energy sharing between final state particles are also introduced to study the final state topologies. No signicant deviation from the SM expectation is observed in the phase space covered by the analysis. Many channels are also investigated in dedicated analyses, some of which are summarised below.

1.2 Isolated Leptons in Events with Missing P_T.

A search for events containing isolated leptons (electrons or muons) and missing transverse momentum is performed by the H1 and ZEUS experiments in a common phase space [2]. The observed event yields are compared to the prediction from the Standard Model which is dominated by single W production. Figure 2 shows the transverse momentum of the hadronic final state in events with isolated leptons and missing transverse momentum for e^+p collisions (a) and e^-p collisions (b). In general good agreement is found. The total single W boson production cross section is measured to be 1.07 ± 0.18 pb, in agreement with the SM expectation of 1.26 ± 0.19 pb.

At high P_T^X the isolated leptons signature is the same as for single top production. Inspired by events observed in the region $P_T^X > 25$ GeV by H1 [3] this observation is studied assuming non-zero anomalous effective FCNC couplings $\kappa_{tu\gamma}$, ν_{tuZ} [4] leading to anomalous single top production. The resulting HERA limits on $\kappa_{tu\gamma}$ explore a domain not covered by other colliders.

2. Model Searches

2.1 A Search for Contact Interactions using a Fit to the Inclusive DIS Cross Section.

A search for deviations of the measured inclusive neutral current cross sections from the SM prediction at high Q^2 is performed by the H1 and ZEUS collaborations independently [5, 6]. Since no significant deviations are observed, various BSM models can be constrained. Limits are derived on the effective mass scale Λ in *eqeq* contact interactions ($\Lambda > 3.7 - 8.9$ TeV), on the mass to the Yukawa coupling ratio for heavy-leptoquark models ($M_{LQ}/\lambda_{LQ} > 0.63 - 1.94$ TeV), on the effective Planck-mass scale in models with large extra dimensions ($M_S > 0.90 - 0.94$ TeV) and on the quark charge radius ($R_q < 0.63 - 0.65 \cdot 10^{-16}$ cm).

2.2 Search for Lepton Flavor Violation.

A search for the lepton flavour violating processes $ep \to \mu X$ and $ep \to \tau X$, mediated by leptoquarks, is performed by H1 [7] using a data sample corresponding to an integrated luminosity

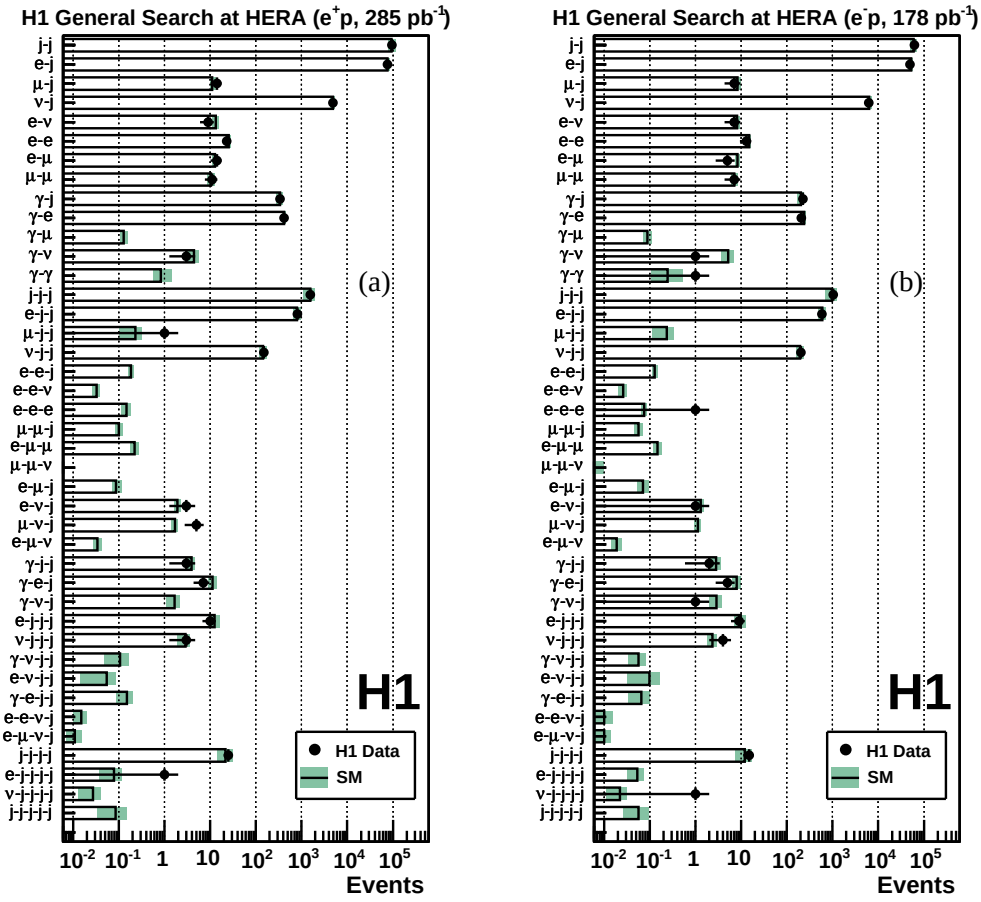

Figure 1: The data and the SM expectation for all event classes with observed data events or a SM expectation greater than 0.01 events for e^+p collisions (a) and e^-p collisions (b). The error bands on the predictions include model uncertainties and experimental systematic errors added in quadrature.

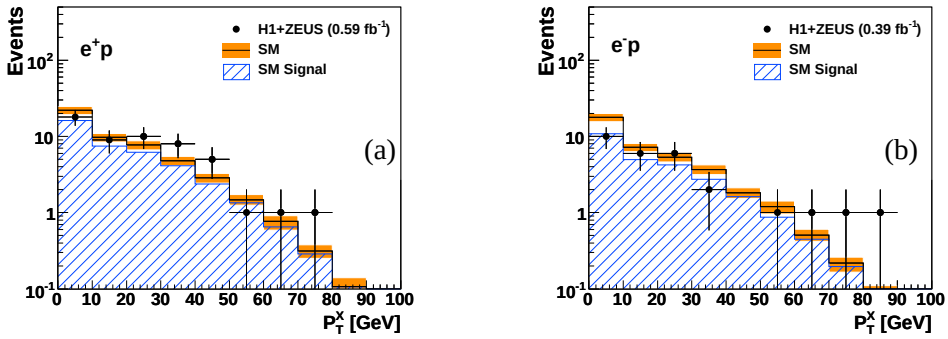

Figure 2: Hadronic transverse momentum P_T^X in events with isolated leptons and missing transverse momentum for e^+p collisions (a) and e^-p collisions (b). The error bands on the predictions include model uncertainties and experimental systematic errors added in quadrature.

of 0.41 fb^{-}1. No evidence for lepton flavour violation is found in final states with a muon or tau-lepton and a hadronic jet. Limits are derived on the mass and the couplings of leptoquarks inducing lepton flavour violation in an extension of the Buchmüller-Rückl-Wyler effective model. For a coupling λ of electromagnetic strength leptoquarks with a mass below $304-530$ GeV and $272-450$ GeV in the muon and tau channels, respectively, can be excluded.

2.3 Search for Excited Fermions

A search for excited fermions (electrons, neutrinos and quarks) is performed [8, 9, 10]. The interactions are described by an effective Lagrangian for gauge mediated models where the excited fermions couple to the electroweak and strong gauge groups, parametrised by coupling parameters f, f' and f_s, respectively.

All decay channels are considered for all fermion types. No evidence for excited fermion production is found. Mass dependent exclusion limits on excited fermion production cross sections and on the ratio f/Λ of the coupling to the compositeness scale are derived. These limits extend the excluded region compared to previous excited fermion searches.

2.4 Search for Squark Production at HERA

A search for squarks in MSSM and mSUGRA models with *R*-parity violation is performed [11]. The resonant production of squarks via a Yukawa-type coupling λ' is considered, taking into account direct and indirect *R*-parity violating decay modes. No evidence for squark production is found in the (multi-)lepton and (multi-)jet final state topologies investigated. Squarks of the first and second generation with masses up to 275 GeV are excluded in the considered part of the parameter space for a Yukawa-type coupling of electromagnetic strength at 95% confidence level.

References

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