SEARCHES FOR NEW PHYSICS AT HERA

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HERA is the only high energy electron–proton collider in the world today and hence has unique opportunities to search for physics beyond the Standard Model. Results are presented for searches for processes involving direct electron–quark interactions (leptoquarks and R–parity violating SUSY), generic coupling models (contact interactions and large extra dimensions) and exclusive final states (isolated leptons and missing P_T, and single top production). Exclusion limits on proposed models are set where no deviation from Standard Model predictions are found.

1. Introduction

Between 1994 and 2000 HERA collided 27.5 GeV electrons or positrons and 920 GeV protons[a], delivering an integrated luminosity of over 130 pb^{-1} to each of its *ep* collision experiments H1 and ZEUS. Thus *ep* collisons at HERA have a centre of mass of 318 GeV with squared four momentum transfers (Q^2) reaching 3.10^4 GeV^2, allowing competitive searches for exotic heavy particles and small scale physics to be performed.

2. Direct electron–quark interactions

2.1. *Leptoquarks*

Both Neutral Current (NC) and Charged Current (CC) high Q^2 data are examined for evidence of leptoquark (LQ) production via either s or u channel exchanges. This is done in the framework of the BRW[1] model which predicts 7 scalar and 7 vector LQs. The eq coupling is parameterised by the Yukawa coupling λ and the branching ratios are fixed. The data[2,3] show

*On behalf of the H1 and ZEUS collaborations
[a]820 GeV before 1998

good agreement with the Standard Model (SM) prediction and exclusion limits in terms of λ and LQ mass M_{LQ} are set. One such result is shown in figure 1, with the complementary LEP and TeVatron results.

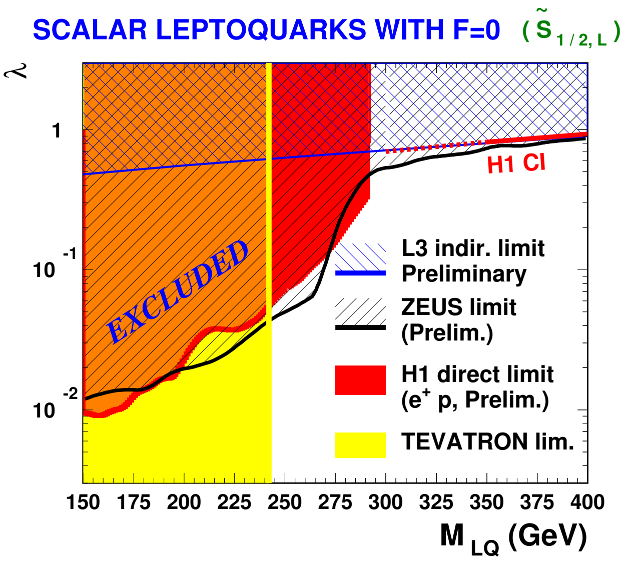


Figure 1. Exclusion limits on the Yukawa coupling λ as a function of leptoquark mass M_{LQ}.

2.2. *R–parity violating SUSY*

Since R–parity (R_p) is even (+1) for all SM particles and odd (-1) for their supersymmetric (SUSY) partners, its violation implies that SUSY particles may be singly produced and that the lightest SUSY particle (LSP) is not stable. Resonant squark production is searched for in the framework of both the minimally SUSY SM (MSSM) and the minimal supergravity (mSUGRA) models. Some cascade decays result in background-free channels. No evidence[4,5] for such processes is found allowing mass and coupling limits to be set with the free variation of the MSSM parameters μ, M_2 and $\tan\beta$. One such result is shown in figure 2.

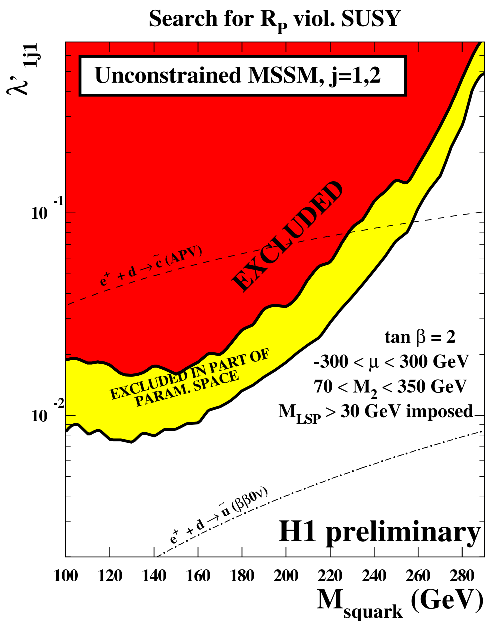


Figure 2. Exclusion limits on the Yukawa coupling as a function of squark mass.

3. Generic coupling models

3.1. *Contact interactions*

These models parameterise a coupling for the virtual exchange of particles with masses beyond the direct access of the collider, but whose interference with SM exchanges (γ, Z° and $W^{\pm}$) could nevertheless be measureable. No deviations in the agreement of the highest Q^2 NC data and the SM expectation are observed. These results also set limits on finite quark radii. The ZEUS collaboration set an upper limit of $0.73.10^{-18}$m at 95% C.L.

3.2. *Large extra dimensions*

High Q^2 data may also be examined in the context of large extra dimensions (LEDs). It has been suggested[6] that whilst SM particles propagate in 4-D, gravitons may inhabit (4+n)-D. These extra dimensions are proposed to be "curled up" such that their presence might only become apparent at large mass scales. Fits to NC data have produced 95% C.L. exclusion limits on the mass scale of the order of 0.8 TeV.

4. Exclusive final states

4.1. *Isolated leptons and missing P_T*

The H1 Collaboration has recently reported[7] an excess of events containing an isolated electron or muon and missing transverse momentum. Within the SM such events of this topology are expected to be mainly due to the production of a W boson and its subsequent leptonic decay, particularly when the hadronic system has high P_T (large P_T^X). Recent work[8] has calculated the dominant QCD corrections to the SM prediction at next-to-leading order (NLO). The ZEUS Collaboration has also performed a search for such events[9]. The results of these searches are presented in table 1.

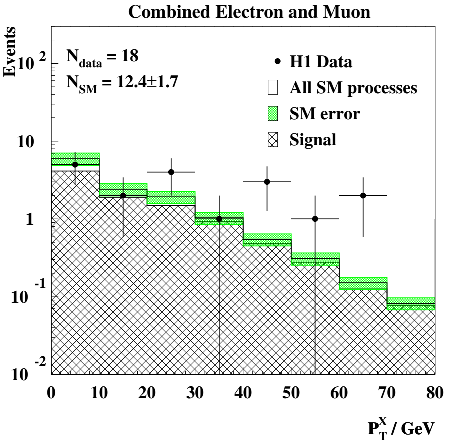
Table 1. Observed and expected number of events with an isolated electron or muon and missing transverse momentum. The percentage of the SM expectation composed of W production is also given.

H1 94-00 e^+p 105 pb^{-1}	Electrons Observed/exp'd (W)	Muons Observed/exp'd (W)
$25 < P_T^X < 40$ GeV	1 / 0.95±0.14 (86%)	3 / 0.89±0.14 (87%)
$P_T^X > 40$ GeV	3 / 0.54±0.11 (83%)	3 / 0.55±0.12 (93%)
ZEUS preliminary 94-00 $e^\pm p$ 130 pb^{-1}	Electrons Observed/exp'd (W)	Muons Observed/exp'd (W)
$P_T^X > 25$ GeV	2 / $2.90^{+0.59}_{-0.32}$ (45%)	5 / $2.75^{+0.21}_{-0.21}$ (50%)
$P_T^X > 40$ GeV	0 / $0.94^{+0.11}_{-0.10}$ (61%)	0 / $0.95^{+0.14}_{-0.10}$ (61%)

The number of events with an isolated electron or muon observed by H1 overshoots the SM prediction, in particular at high P_T^X. The distribution of events observed by H1 is shown in figure 3 (left) with respect to P_T^X. Additionally, the ZEUS Collaboration has searched in the tau channel, finding 2 candidate events at $P_T^X > 25$ GeV compared to a SM expectation of 0.12 ± 0.02.

4.2. *Single top production*

An event topology of an isolated lepton, missing P_T and a high P_T hadronic jet may also be the signature of single top production, where the top quark decays to a b quark and a W. This rate of process is, however, negligible in the SM, due to the flavour changing neutral current (FCNC) vertex required. The anomalous coupling at the two relevant vertices $tu\gamma$ and tuZ, is parameterised by the magnetic coupling $\kappa_{tu\gamma}$ and the vector coupling v_{tuZ} respectively. Both collaborations have also searched for hadronic decays of single top quarks, but the large background from other multi-jet processes severely restricts the contribution of this channel to the analysis.



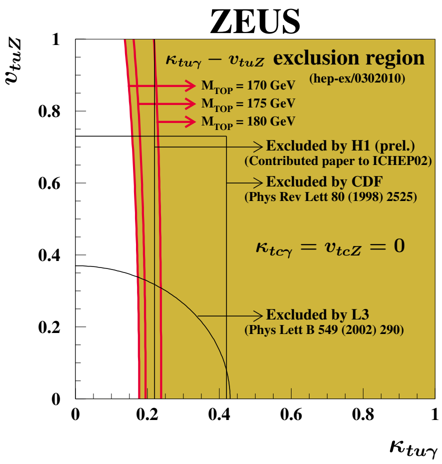


Figure 3. (Left) Number of events with isolated leptons (electrons or muons) and missing transverse momentum as a function of P_T^X, the transverse momentum of the hadronic system. (Right) Excluded regions of the anomalous coupling $\kappa_{tu\gamma}$-v_{tuZ} plane.

The combined results[10,9], in terms of exclusion limits for the anomalous couplings $\kappa_{tu\gamma}$ and v_{tuZ}, are shown in figure 3 (right).

References

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