

Searches from ep energy frontier at HERA

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The latest results on a variety of searches for new physics at HERA by the H1 and ZEUS Collaborations are presented. HERA, the world's only ep collider, was ideally suited for searches for physics beyond the Standard Model due to its unique initial state. The searches use the complete HERA data sample of the H1 and ZEUS experiments corresponding to a total integrated luminosity of about $0.5fb^{-1}$ per experiment. The following topics are covered: a search for $e\bar{q}eq$ contact interactions, a search for first generation leptoquarks, a search for lepton flavour violation, and a search for single-top production. The data is in a good agreement with the Standard Model predictions and limits on various new physics models are derived

1 Introduction

HERA, the world's only ep collider, provides a unique opportunity to search for new physics beyond the Standard Model. Two collider experiments, the H1 and ZEUS, have collected $0.5fb^{-1}$ of data each during the operation time from 1994 till 2007. HERA operation was divided in two phases. HERA I phase (1994 – 2000) followed by an upgrade of the collider which increased the significantly luminosity. Another innovation during the HERA II running phase (2003 – 2007) was that the lepton beam got a longitudinal polarisation which together with higher luminosity increased the sensitivity of the experiments to new physics.

2 Search for Contact Interactions

New physics may modify the neutral current (NC) deep inelastic scattering cross section at the highest values of the negative four-momentum transfer squared (Q^2). The concept of four-fermion contact interactions provides a convenient method to investigate those effects.

Searches for deviations from the Standard Model (SM) predictions in measured NC cross sections are performed by the H1 and ZEUS collaborations^{1,2}. Since data show good agreement with the SM predictions various new physics models are constrained. Limits at 95% confidence level (CL) are derived on the effective mass scale Λ in compositeness models ($\Lambda > 3.8 - 8.9$ TeV), on the effective Planck-mass scale in models with large extra dimensions ($M_S > 0.90 - 0.94$ TeV) and on the electroweak charge distribution radius of the quark ($R_q < 0.63 \cdot 10^{-18}$ m). Both H1 and ZEUS limits are comparable. Exclusion ranges for different compositeness models obtained by H1 are shown on Figure 1.

3 Search for First Generation Leptoquarks

The full H1 and ZEUS data sample is analysed in a search for first generation scalar and vector leptoquarks^{3,4}. No evidence for the production of leptoquarks is observed. Limits on the

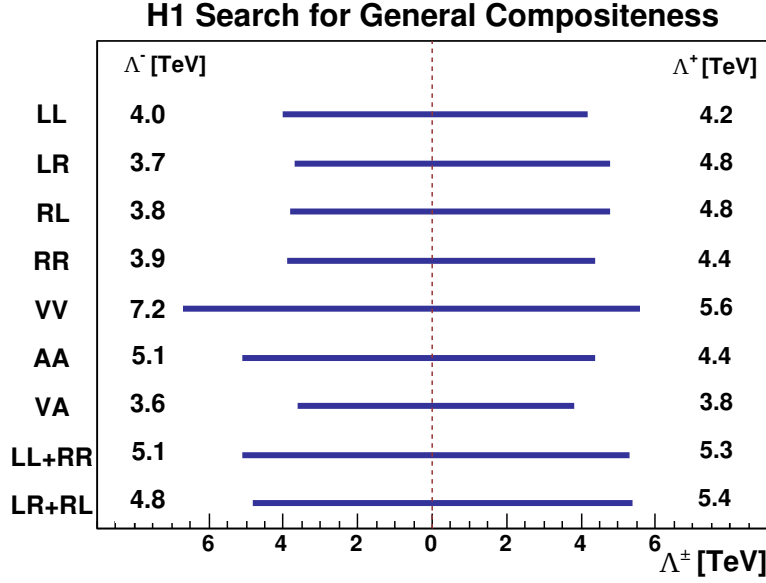


Figure 1: Lower limits on the compositeness scale Λ for both interference signs obtained by the H1.

masses and the couplings of leptoquarks in the Buchmüller-Rückl-Wyler (BRW) framework are derived. Exclusion limits on the coupling λ as a function of the leptoquark mass for vector type leptoquarks are shown on Figure 1. Assuming a coupling of electromagnetic strength ($\lambda \approx 0.3$) leptoquarks with masses up to 800 GeV are excluded.

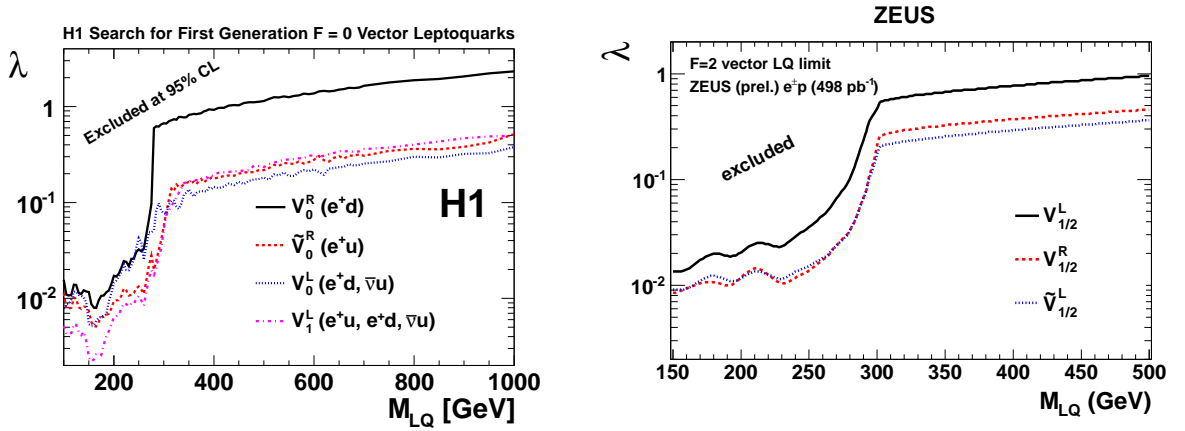


Figure 2: Exclusion limits for vector type leptoquarks described by the Buchmüller, Rückl and Wyler (BRW) model. The 95%CL limits on the coupling λ as a function of leptoquark mass are shown. The left plot corresponds to the limits set by the H1 and the right plot indicates the limits obtained by ZEUS collaboration.

4 Search for Lepton Flavor Violation

Second and third generation leptoquarks, appearing in extensions of the BRW model, might induce lepton flavour violating (LFV) processes in ep collisions. A search for the processes $ep \rightarrow \mu X$ and $ep \rightarrow \tau X$, is performed by the H1⁵ using a data sample corresponding to an integrated luminosity of $0.41 fb^{-1}$. The data is consistent with the SM expectations and the results are interpreted in terms of exclusion limits on the masses and the couplings of second

and third generation leptoquarks. Exclusion limits of coupling λ as a function of leptoquark mass for both channels are shown in Figure 3.

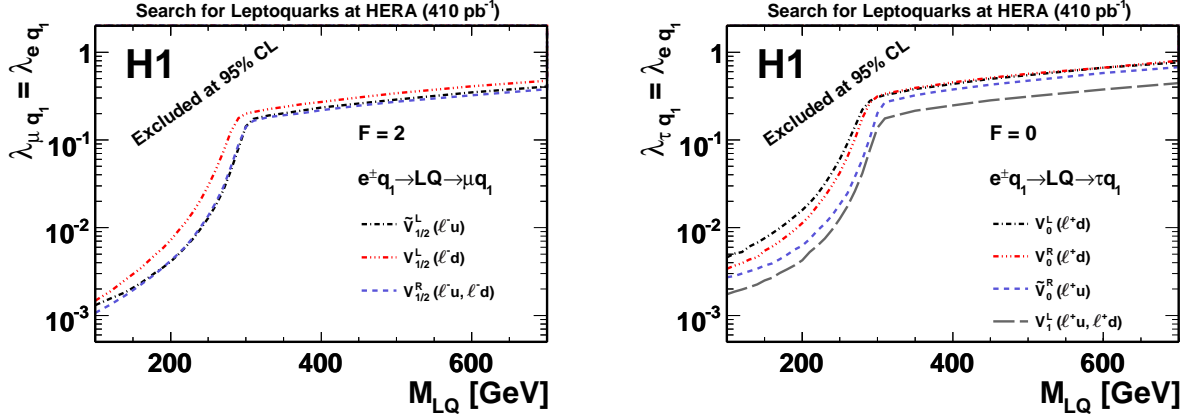


Figure 3: Exclusion limits on the coupling constants $\lambda_{\mu q} = \lambda_{e q}$ (left plot) and $\lambda_{\tau q} = \lambda_{e q}$ (right plot) as a function of the leptoquark mass M_{LQ} for vector type LQs. Regions above the lines are excluded at 95% CL. The notation $q1$ indicates that only processes involving first generation quarks are considered. The parentheses after the LQ name indicate the fermion pairs coupling to the LQ, where pairs involving anti-quarks are not shown.

5 Search for Single-top Production

The cross section of the single top quark production at HERA predicted by the SM is very small (less than $1fb$). However flavour changing neutral current (FCNC) processes could enhance the top production. The full data sample collected by ZEUS is used in a search for deviations from the SM due to FCNC top production⁶. No significant deviation from the SM expectations is observed and the results are used to set constraints on anomalous top production. An upper limit for a single-top production cross section at HERA is set $\sigma < 0.13pb$. Limits on the top anomalous branching ratios to the up quark and a photon ($BR_{u\gamma}$) or a Z boson (BR_{uZ}) is shown in the Figure 4.

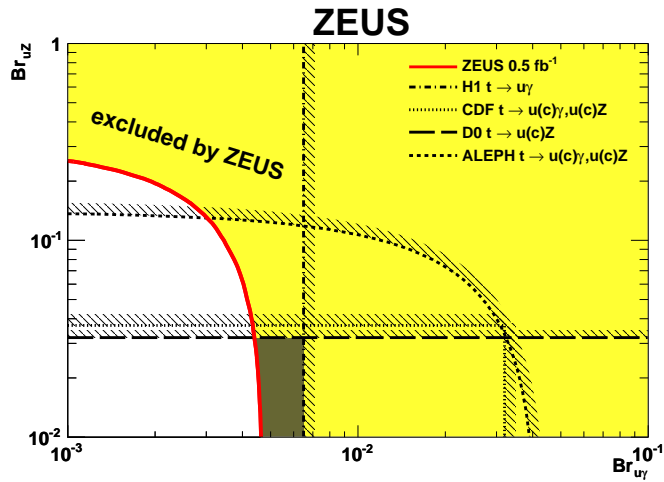


Figure 4: ZEUS boundary in the $(BR_{u\gamma}, BR_{uZ})$ plane. Also shown are the boundaries of the H1, CDF, D0, ALEPH experiments. The shaded area is excluded. The dark shaded region denotes the area uniquely excluded by ZEUS.

6 Summary

The complete HERA data sample of the H1 and ZEUS experiments with a total integrated luminosity of about $0.5fb^{-1}$ per experiment is analyzed in searches for new physics. The data show good agreement with the SM predictions. Limits on contact interactions, first generation leptoquarks, lepton flavour violating processes are derived.

References

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