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Search for new physics phenomena in eq contact interactions at HERA

H1 Collaboration

Abstract

Deep-inelastic $e^{\pm}p$ scattering at high momentum transfer Q^2 is used to search for eq contact interactions associated to scales not directly accessible at HERA. The cross section measurements $\mathrm{d}\sigma/\mathrm{dQ}^2$, corresponding to integrated luminosities of $16.4\ \mathrm{pb}^{-1}$ of e^-p data and $98.6\ \mathrm{pb}^{-1}$ of e^+p data, are well described by the Standard Model and are analysed to set constraints on new phenomena. For conventional contact interactions lower limits can be set on compositeness scales Λ at $1.8 - 5.4$ TeV and on couplings to leptoquarks and R-parity violating squarks of $M/\lambda > 0.3 - 1.4$ TeV. A search for low scale quantum gravity effects in models with large extra dimensions gives limits on the effective Planck scale of $M_S > 0.8$ TeV. A form factor analysis yields a radius of $R_q < 0.8 \cdot 10^{-18}$ m for the light quarks.

Explanation of the Measurement

The results presented in this contribution correspond to an update of our earlier publication [1]. Background information on contact interaction phenomenology can be found in that publication. The experimental method is almst identical to that described there. The results presented in [1] were based on an integrated luminosity smaller than those presented here by a factor of approximately three. The full available H1 data from the first phase of HERA running is now used, including data from both e^+p and e^-p running.

Figure 1 shows comparisons of H1 high Q^2 neutral current deep-inelastic scattering cross sections with standard model predictions. Figure 2 shows limits on compositeness scale parameters for various chiral structures. In figure 3, the Q^2 dependence of the ratio of the data to the standard model prediction is shown and also compared with the modified predictions based on VV models with compositeness scales at the limits of those excluded. Figures 4 and 5 show the same thing for various leptoquark scenarios and for large extra dimension models respectively. Limits on compositeness scales, leptoquark masses, R-parity violating couplings to supersymmetric squarks, the scale M_s of models with large extra dimensions and quark radii are given in tables 1-5.

References

[1] H1 Collaboration, C. Adloff et al., Phys. Lett. **B479** (2000) 358.

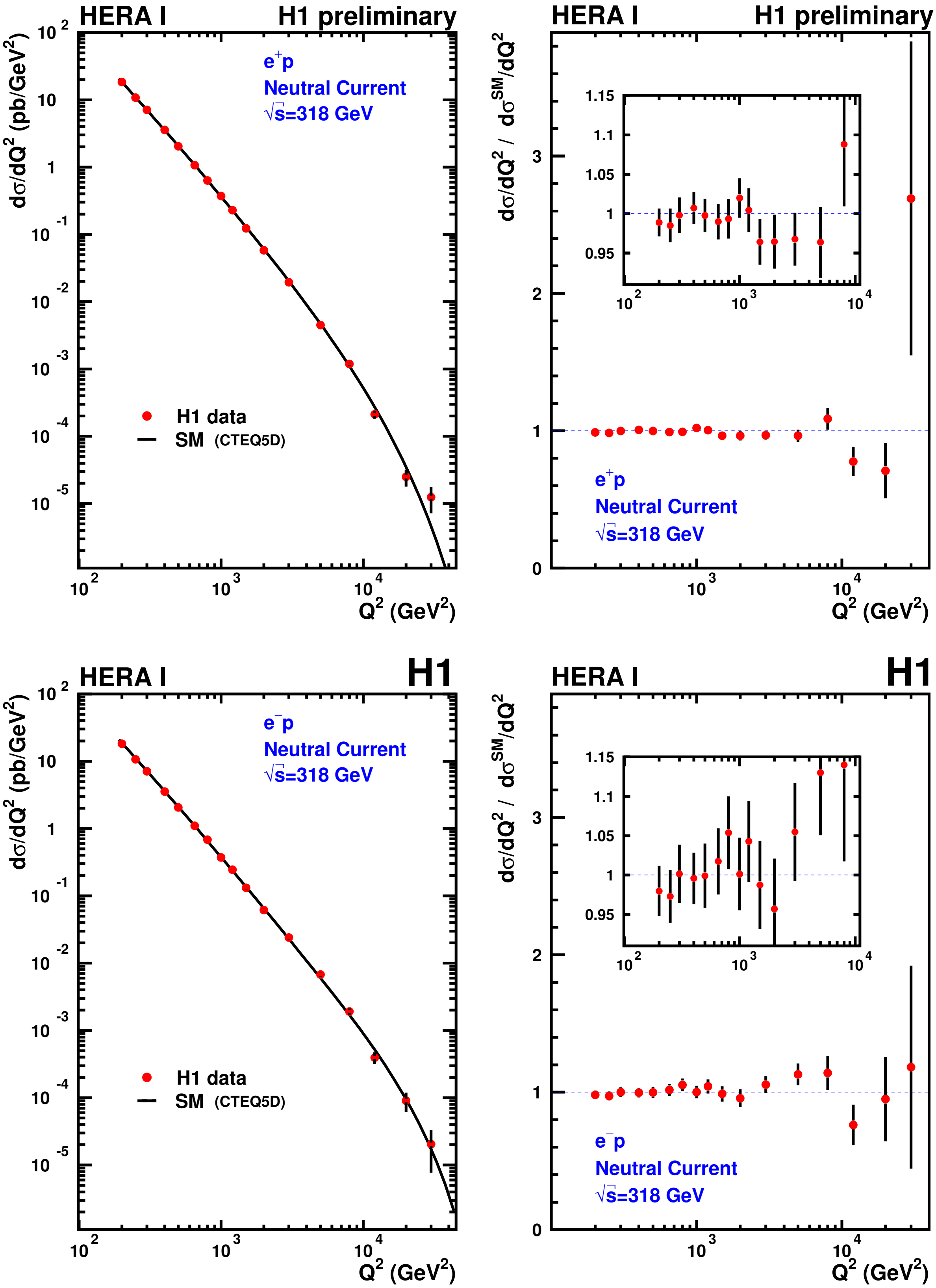

Figure 1: Differential cross sections $\mathrm{d}\sigma/\mathrm{d}Q^2$ at $\sqrt{s} = 318$ GeV for $e^-p \to e^-X$ scattering (top) and $e^+p \to e^+X$ scattering (bottom). H1 data are compared with Standard Model expectations using CTEQ5D parton distributions. The errors include statistics and uncorrelated experimental systematics. The normalisation uncertainties are 3% (e^-p data) and 1.5% (e^+p data).

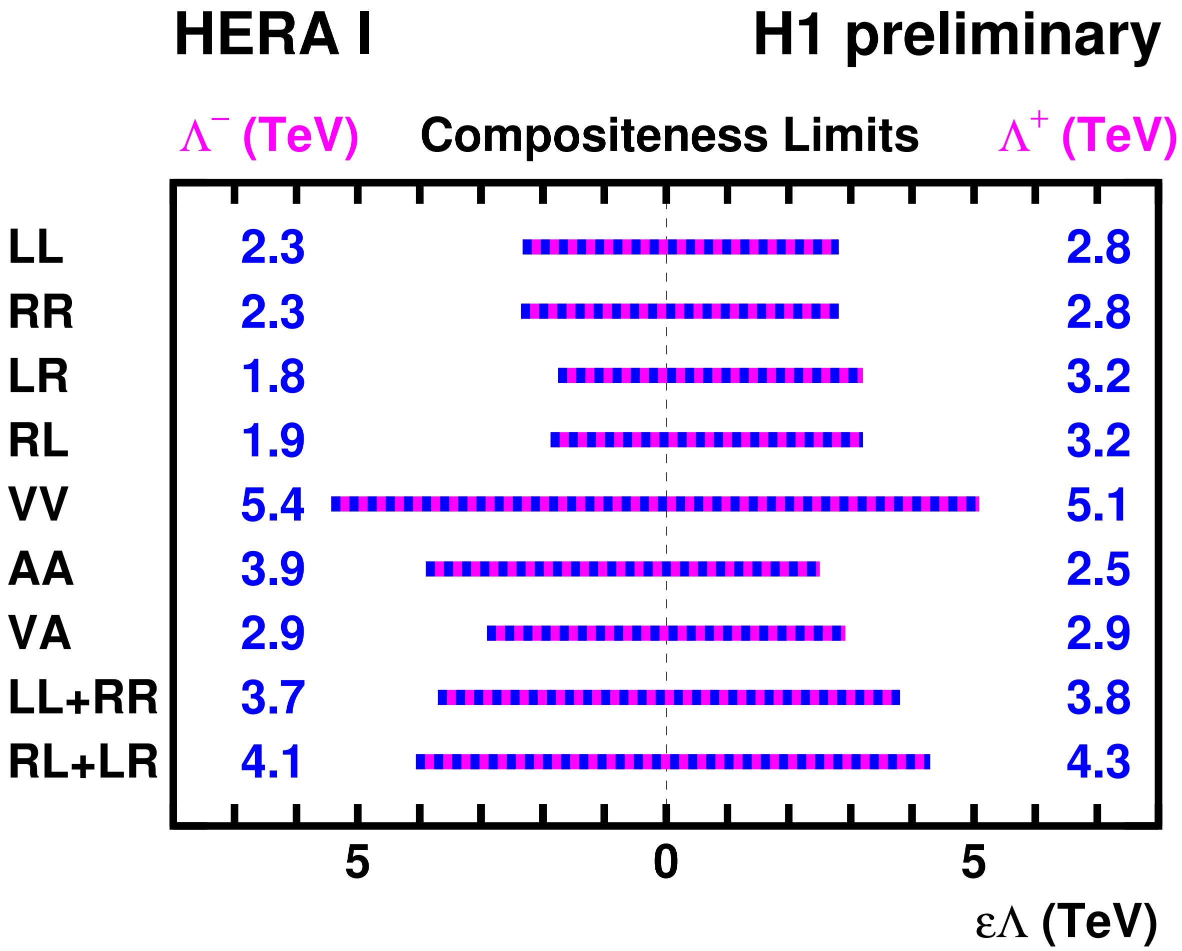

Figure 2: Lower limits on compositeness scale parameters $\Lambda^{\pm}$ (95% CL) from fits to the combined $e^{+}p$ and $e^{-}p$ data.

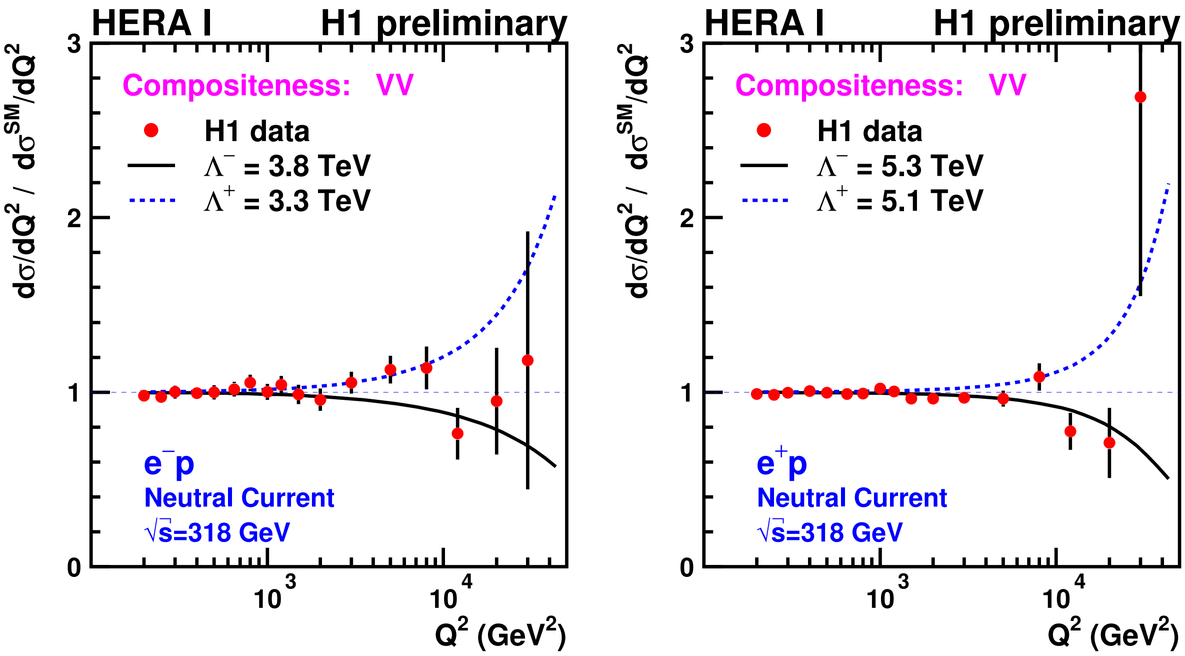

Figure 3: NC cross section $\mathrm{d}\sigma/\mathrm{d}Q^2$ at $\sqrt{s} = 318$ GeV normalised to the Standard Model expectation. H1 data of e^-p and e^+p scattering are compared with VV compositeness models corresponding to 95% CL exclusion limits of Λ^+ and Λ^-. The errors represent statistics and uncorrelated experimental systematics.

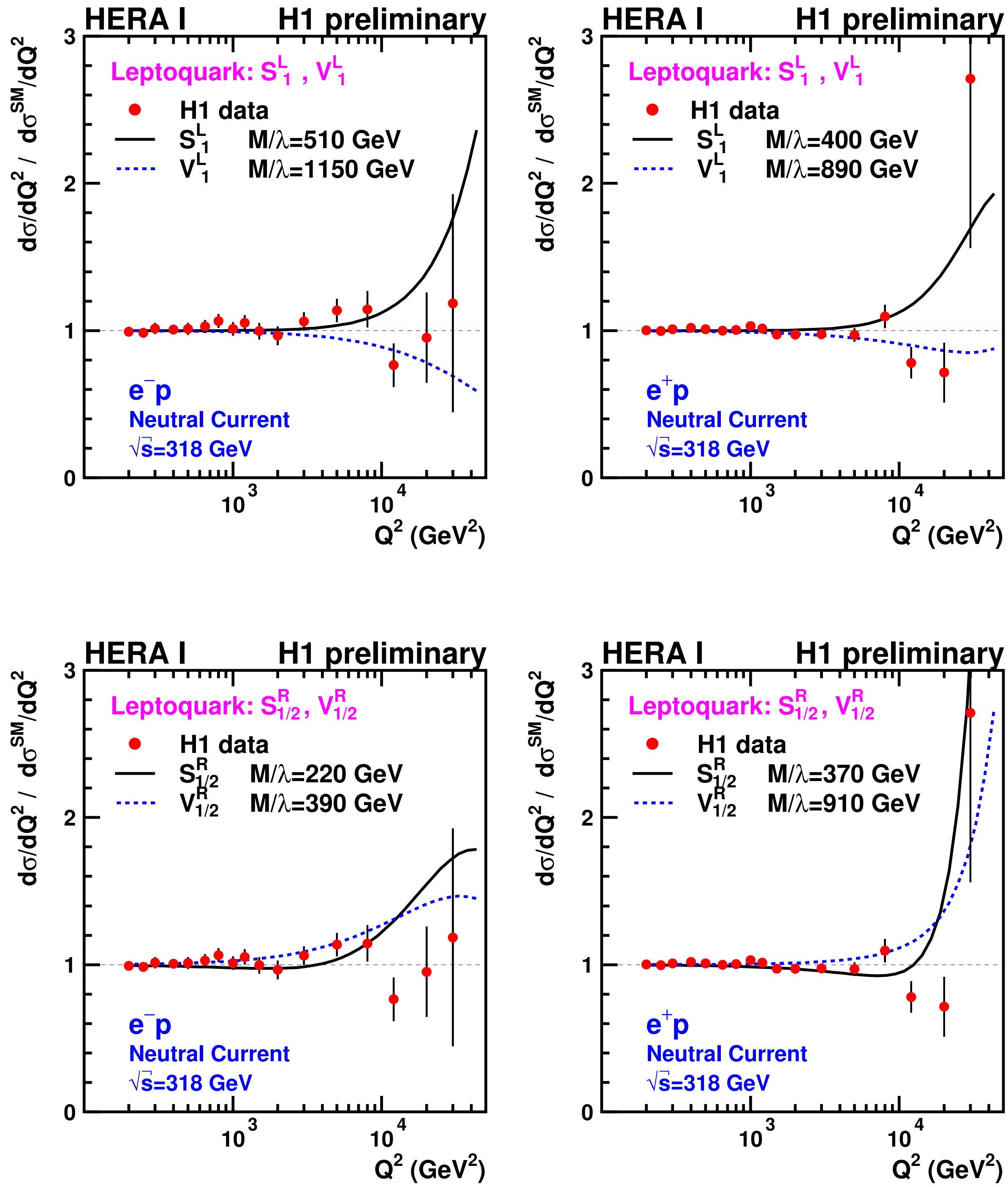

Figure 4: NC cross section $\mathrm{d}\sigma/\mathrm{d}Q^2$ at $\sqrt{s} = 318$ GeV normalised to the Standard Model expectation. H1 data of e^-p and e^+p scattering are compared with 95% CL exclusion limits of leptoquarks S_1^L and V_1^L (top), respectively $S_{1/2}^R$ and $V_{1/2}^R$ (bottom). The errors represent statistics and uncorrelated experimental systematics.

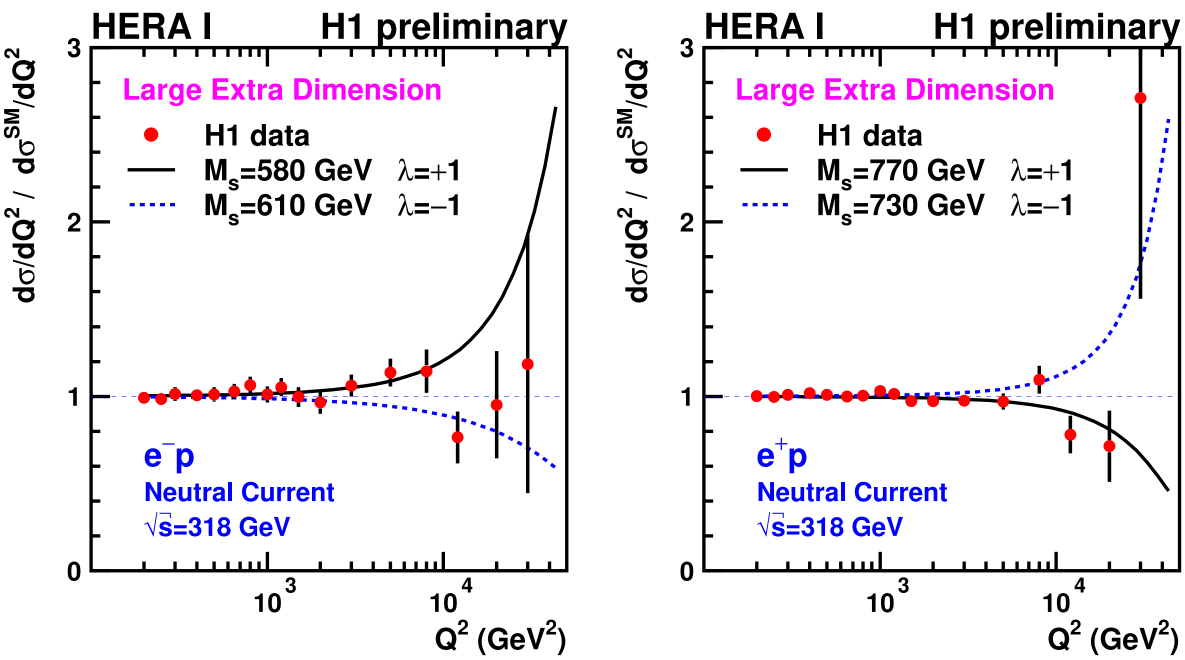

Figure 5: NC cross section $\mathrm{d}\sigma/\mathrm{d}Q^2$ at $\sqrt{s} = 318$ GeV normalised to the Standard Model expectation. H1 data of e^-p and e^+p scattering are compared to gravitational effects of large extra dimensions at scales M_S (95% CL lower limits) with positive ($\lambda = +1$) and negative ($\lambda = -1$) coupling. The errors represent statistics and uncorrelated experimental systematics.

H1 preliminary

coupling	Λ^+ [TeV]	Λ^- [TeV]
LL	2.8	2.3
RR	2.8	2.3
LR	3.2	1.8
RL	3.2	1.9
VV	5.1	5.4
AA	2.5	3.9
VA	2.9	2.9
$LL+RR$	3.8	3.7
$RL+LR$	4.3	4.1

Table 1: Compositeness scale parameters $\Lambda^\pm$ (95% CL lower limits) for various chiral structures. Results are given for a combined analysis including all HERA I data.

H1 preliminary

LQ	F	all e^+p & e^-p M_{LQ}/λ [GeV]
S_0^L	2	720
S_0^R	2	670
$\tilde{S}_0^R$	2	330
$S_{1/2}^L$	0	870
$S_{1/2}^R$	0	370
$\tilde{S}_{1/2}^L$	0	430
S_1^L	2	480

H1 preliminary

LQ	F	all e^+p & e^-p M_{LQ}/λ [GeV]
V_0^L	0	770
V_0^R	0	640
$\tilde{V}_0^R$	0	1000
$V_{1/2}^L$	2	420
$V_{1/2}^R$	2	940
$\tilde{V}_{1/2}^L$	2	1020
V_1^L	0	1380

Table 2: Fermion number F and 95% CL lower limits on M_{LQ}/λ for scalar (S) and vector (V) leptoquarks. Results are given for a combined analysis including all HERA I data. Notation: *L, R* is the lepton chirality, subscript $I = 0,\ 1/2,\ 1$ is the weak isospin, $\tilde{S}$ and $\tilde{V}$ differ by two units of hypercharge from S and V. Quantum numbers and helicities are given for e^-q and $e^-\bar{q}$ states.

H1 preliminary

$R\!\!\!/_p$ coupling		η^q $[\lambda'^2/M_{\tilde{q}}^2]$	all e^+p & e^-p $M_{\tilde{q}}/\lambda'$ [GeV]
λ'_{11k}	$e^+\bar{u} \to \bar{\tilde{d}}^{(k)}$	$\eta^u_{LL} = +\frac{1}{2}$	720
λ'_{1j1}	$e^+d \to \tilde{u}^{(j)}$	$\eta^d_{LR} = -\frac{1}{2}$	430

Table 3: Coefficients η^q_{ab} and 95% CL lower limits on $M_{\tilde{q}}/\lambda'$ for R_p violating couplings to squarks. Results are given for a combined analysis including all HERA I data.

H1 preliminary

coupling	e^-p (318 GeV) M_S [TeV]	e^+p (318 GeV) M_S [TeV]	all e^+p & e^-p M_S [TeV]
$\lambda = +1$	0.58	0.77	0.83
$\lambda = -1$	0.61	0.73	0.79

Table 4: Lower limits (95% CL) on the gravitational scale M_S assuming positive ($\lambda = +1$) and negative ($\lambda = -1$) coupling from the present analysis of e^-p and e^+p data and from a combined analysis including all HERA I data.

H1 preliminary

form factor	all e^+p & e^-p R $[10^{-18}$ m$]$
$f_e \equiv 1$	0.82
$f_e = f_q$	0.57

Table 5: Lower limits (95% CL) on the quark radius assuming point-like leptons ($f_e \equiv 1$) or common form factors ($f_e = f_q$) for the analysis including all HERA I data.