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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.

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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.

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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

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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.

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$\not{R}_p$ coupling		η^q $[\lambda'^2/M_{\tilde{q}}^2]$	all e^+p & e^-p $M_{\tilde{q}}/\lambda'$ [GeV]
λ'_{11k}	$e^+\bar{u} \rightarrow \bar{\tilde{d}}^{(k)}$	$\eta^u_{LL} = +\frac{1}{2}$	720
λ'_{1j1}	$e^+d \rightarrow \tilde{u}^{(j)}$	$\eta^d_{LR} = -\frac{1}{2}$	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.

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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.

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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.

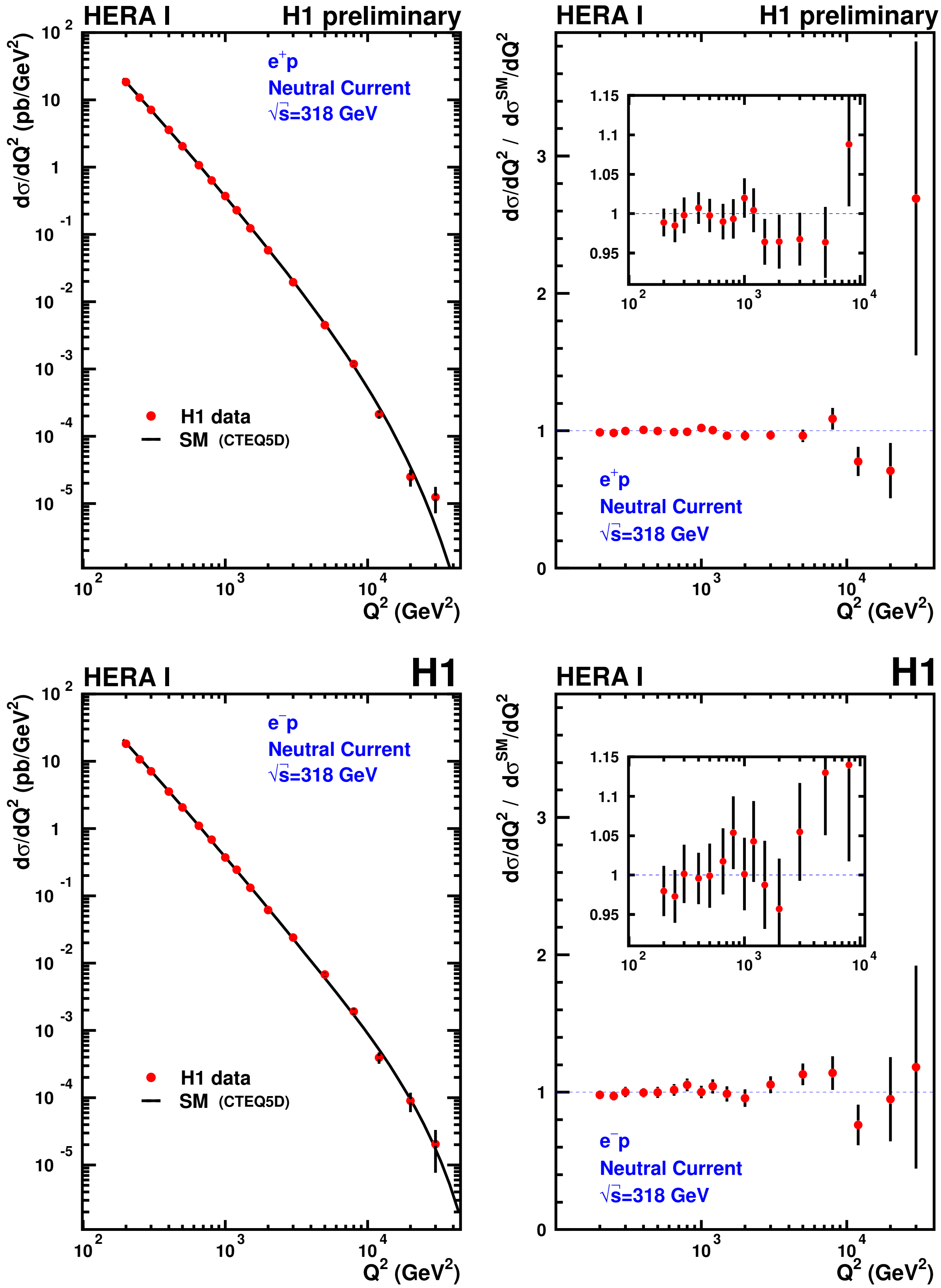

Figure 1: Differential cross sections $\mathrm{d}\sigma/\mathrm{d}Q^2$ at $\sqrt{s} = 318$ GeV for $e^-p \rightarrow e^-X$ scattering (top) and $e^+p \rightarrow e^+X$ scattering (bottom). H1 data are compared with Standard Model expectations using CTEQ5D parton distributions. The errors include statistics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

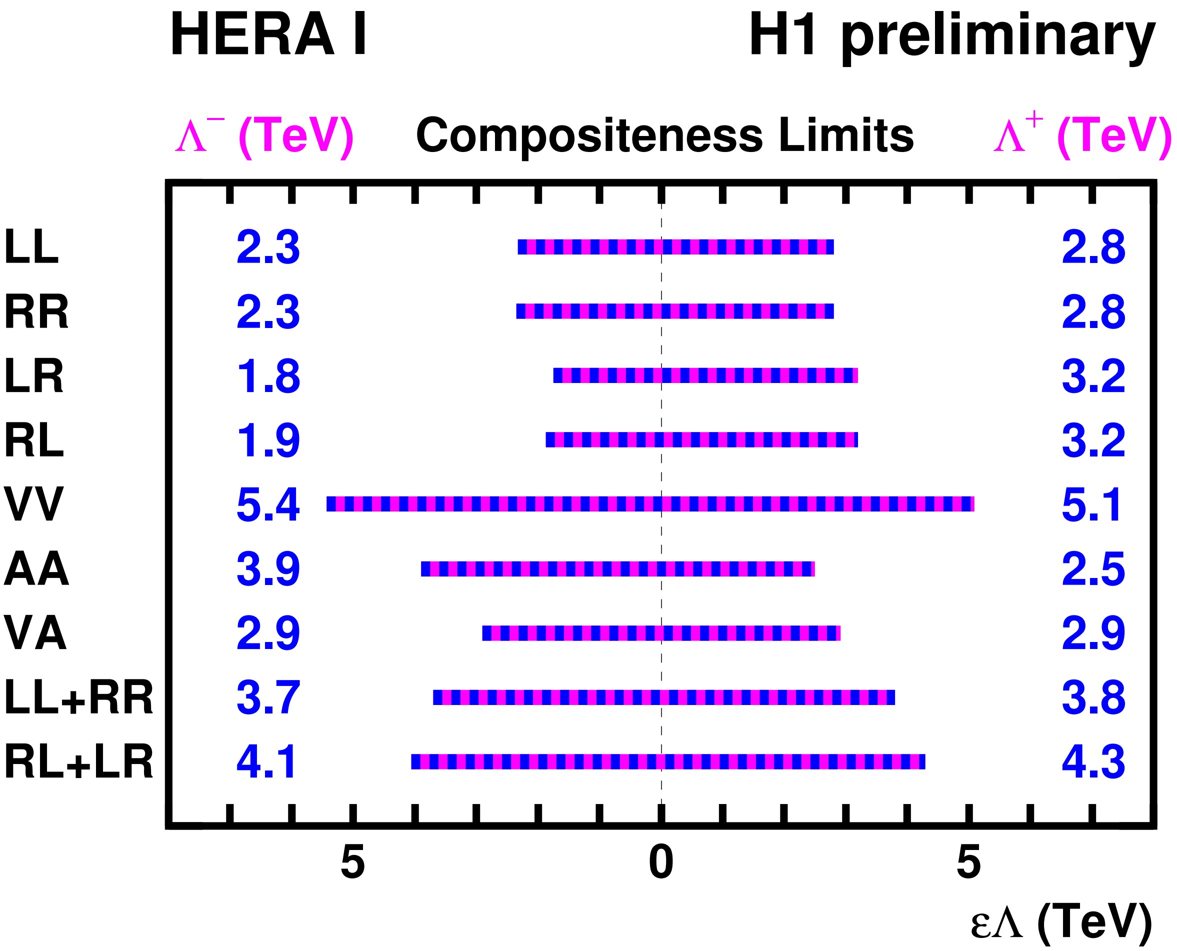

Figure 2: Lower limits on compositeness scale parameters $\Lambda^{\pm}$ (95% CL) from fits to the combined e^+p and e^-p data.

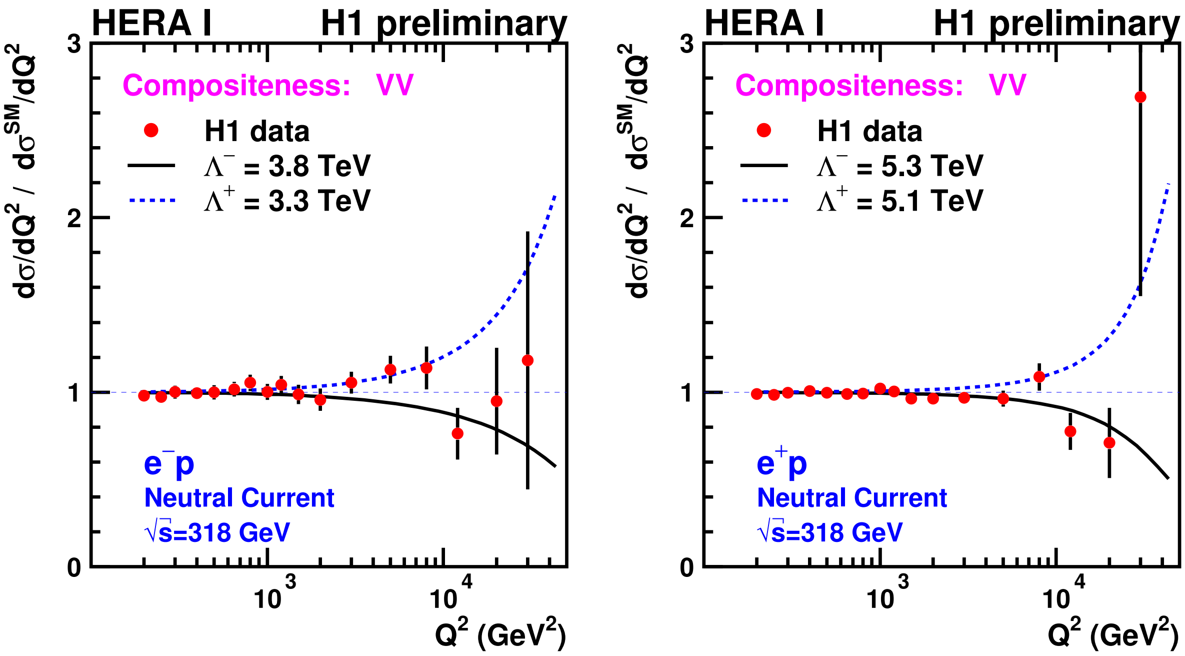

Figure 3: NC cross section $\mathrm{d}\sigma/\mathrm{d}Q^2$ at $\sqrt{s} = 318$ GeV normalised to the Standard Model expectation. H1 data of e^-p and e^+p scattering are compared with VV compositeness models corresponding to 95% CL exclusion limits of Λ^+ and Λ^-. The errors represent statistics and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

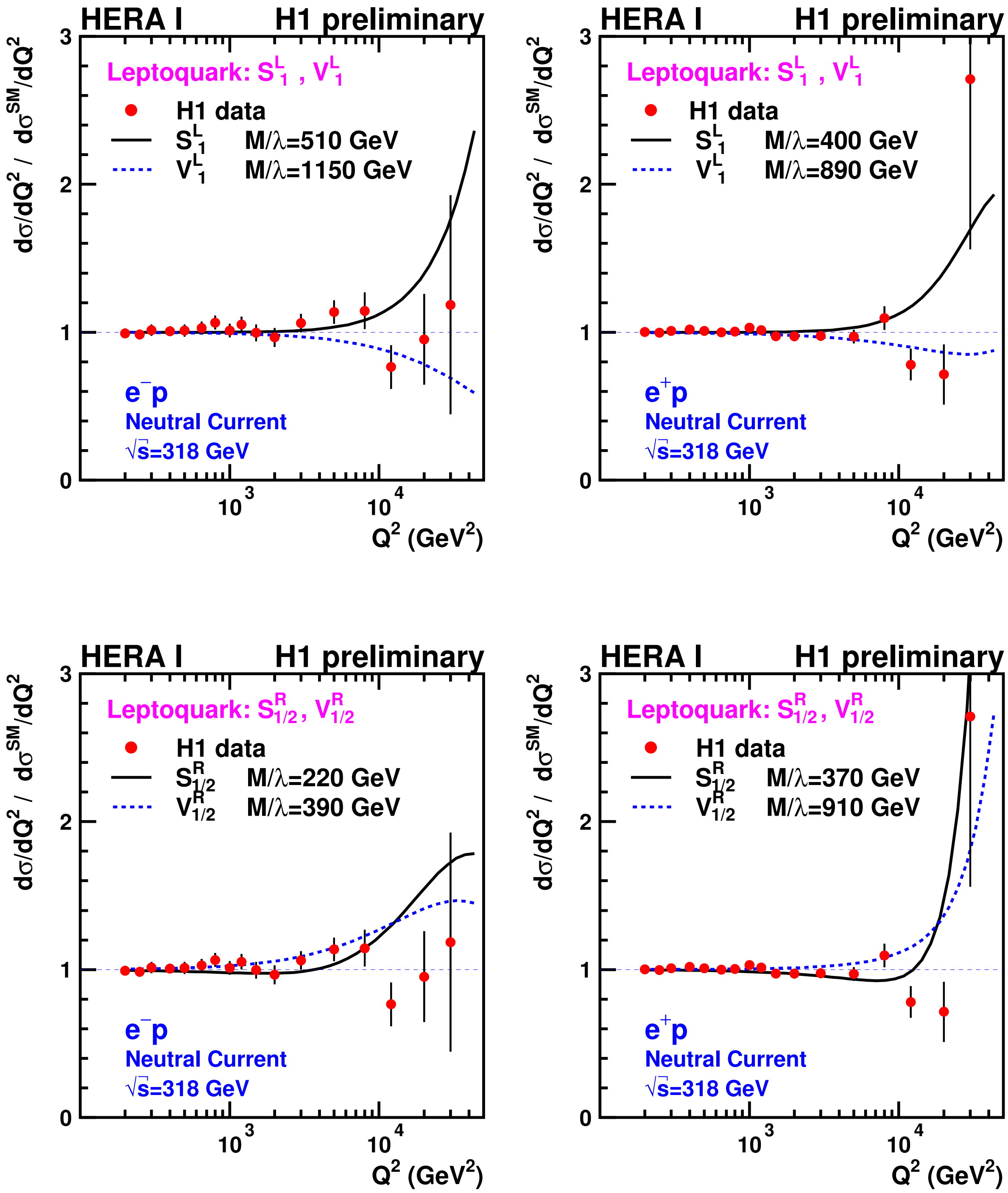

Figure 4: NC cross section $\mathrm{d}\sigma/\mathrm{d}Q^2$ at $\sqrt{s} = 318$ GeV normalised to the Standard Model expectation. H1 data of e^-p and e^+p scattering are compared with 95% CL exclusion limits of leptoquarks S_1^L and V_1^L (top), respectively $S_{1/2}^R$ and $V_{1/2}^R$ (bottom). The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

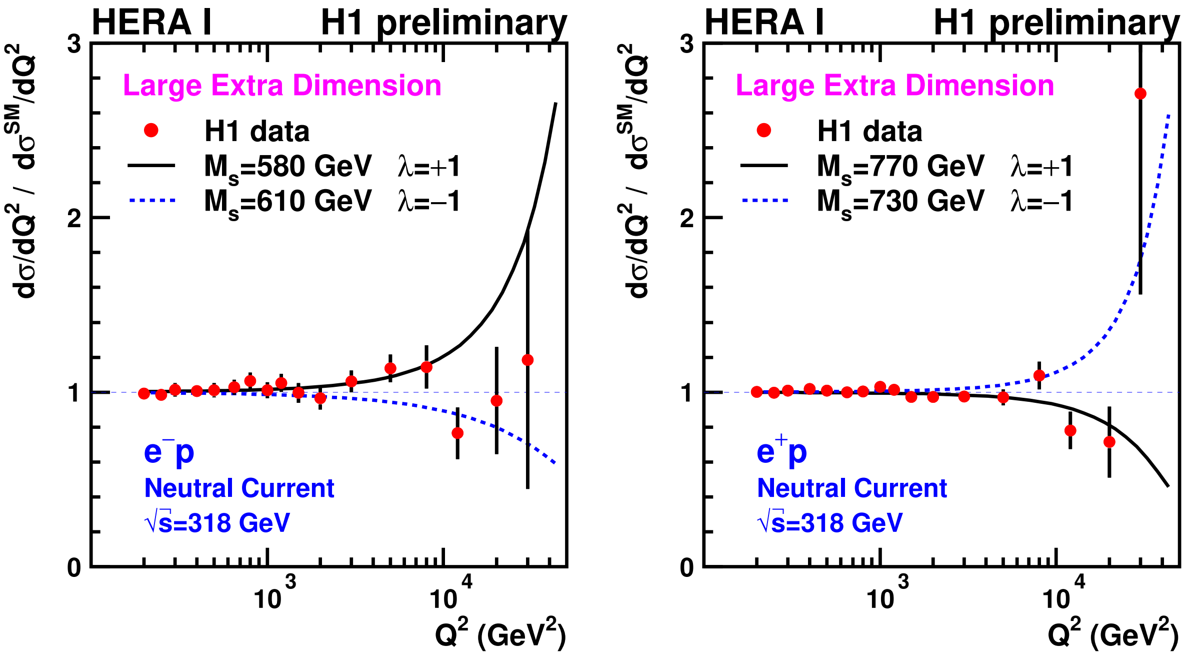

Figure 5: NC cross section $\mathrm{d}\sigma/\mathrm{d}Q^2$ at $\sqrt{s} = 318$ GeV normalised to the Standard Model expectation. H1 data of e^-p and e^+p scattering are compared to gravitational effects of large extra dimensions at scales M_S (95% CL lower limits) with positive ($\lambda = +1$) and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