ZEUS High-Q^2 and BSM group. Summary of the group results to be presented at the EPS 2007 Conference

Physics beyond the SM and searches

1 Physics beyond the SM and searches

1.1 W production and the search for events with an isolated high-energy lepton and missing transverse momentum at HERA

A search for events with isolated high transverse energy leptons and large missing transverse momentum has been performed with the ZEUS detector at HERA using samples taken during the 1996-2006 running period. The measured yields agree well with Standard Model predictions.

Figures and Tables: Figs. 1 and 2 and Table 1
Comments: Preliminary results presented at the DIS 2007 Workshop. For additional informations see K. Korcsak-Gorzo presentation [1] at DIS 2007.
Updated results, including the ZEUS analysis with the full ZEUS data sample as well as a 1 fb^{-1}-based H1 and ZEUS combined analysis, are likely to become available in time for EPS 2007.

1.2 Multi-lepton production

Multi-electron production has been studied in $e^{\pm}p$ collisions with the ZEUS detector at HERA. The data were collected during 1996-2007 and correspond to an integrated luminosity of 446 pb^{-1}. The results are compared with Standard Model predictions and deviations at high multi-electron invariant mass are searched for.

Figures and Tables: Fig. 3 to Fig. 5 and Table 2
Comments: Preliminary results presented at the DIS 2007 Workshop. For additional informations see O. Ota presentation [2] at DIS 2007.
Updated results may become available in time for EPS 2007.

1.3 Search for contact interactions, leptoquarks, large extra dimensions and finite quark radius in ep collisions at HERA

A search for signatures of physics beyond the Standard Model has been performed with the $e^{+}p$ and $e^{-}p$ data collected by the ZEUS Collaboration in the years 1994-2005. No significant deviation from Standard Model predictions was observed and 95% C.L. limits were obtained for the relevant parameters of the models studied. For the contact-interaction models, limits on the effective mass scale, Λ (i.e. compositeness scale), ranging from 2 to 7.5 TeV have been obtained. Limits ranging from 0.32 to 1.91 TeV have been set for the ratio of the leptoquark mass to the Yukawa coupling, M_{LQ}/λ_{LQ}, in the limit of large leptoquark masses, $M_{LQ} \gg \sqrt{s}$. Limits were derived on the mass scale parameter in models with large extra dimensions: for positive (negative) coupling signs, scales below 0.88 TeV (0.86 TeV) are excluded. A quark-charge radius larger than $0.67 \cdot 10^{-16}$ cm has been excluded, using the classical form-factor approximation.

Figures: Fig. 6 to Fig. 9 and Tables 3 and 4

Comments: Preliminary results presented at the ICHEP06. For additional information see the ZEUS contributed paper [3] to ICHEP06.

References

[1] K. Korcsak-Gorzo, *Events with an isolated lepton and missing transverse momentum at ZEUS*. Presented on behalf of the ZEUS Collaboration to the DIS 2007 Workshop, available on
`http://indico.cern.ch/contributionDisplay.py?contribId=123&sessionId=9&confId=9499`.

[2] O. Ota, *Dilepton production in ep collisions at ZEUS*. Presented on behalf of the ZEUS Collaboration to the DIS 2007 Workshop, available on
`http://indico.cern.ch/contributionDisplay.py?contribId=125&sessionId=9&confId=9499`.

[3] ZEUS-prel-06-018, contributed paper to ICHEP 2006, available on
`http://www-zeus.desy.de/physics/phch/conf/ichep06/hiq2/8/ZEUS-prel-06-018.pdf`.

Isolated e candidates	$12 < P_T^X < 25$ GeV	$P_T^X > 25$ GeV
ZEUS (prel.) 98-06 e^-p (204 pb^{-1})	$6/2.9 \pm 0.5$ (56%)	$5/3.8 \pm 0.6$ (55%)
ZEUS (prel.) 96-06 e^+p (228 pb^{-1})	$4/2.8 \pm 0.5$ (63%)	$1/3.2 \pm 0.4$ (75%)
ZEUS (prel.) 96-06 $e^\pm p$ (432 pb^{-1})	$10/5.7 \pm 0.7$ (60%)	$6/7.0 \pm 0.7$ (64%)

Isolated μ candidates	$12 < P_T^X < 25$ GeV	$P_T^X > 25$ GeV
ZEUS (prel.) 98-06 e^-p (204 pb^{-1})	$2/2.2 \pm 0.3$ (68%)	$2/2.2 \pm 0.3$ (86%)
ZEUS (prel.) 96-06 e^+p (228 pb^{-1})	$3/2.6 \pm 0.5$ (68%)	$3/3.1 \pm 0.5$ (80%)
ZEUS (prel.) 96-06 $e^\pm p$ (432 pb^{-1})	$5/4.8 \pm 0.5$ (68%)	$5/5.3 \pm 0.6$ (82%)

Table 1: *Summary of the results of the search for events with an isolated electron (top) or muon (bottom) and missing transverse momentum. The number of observed events is compared to the SM prediction (observed/expected) in two P_T^X regions. The signal component of the SM expectation (W production) is given as a percentage in parentheses. The quoted errors contain statistical and systematic uncertainties added in quadrature. A 15% uncertainty on the NLO prediction for W production is also included.*

Topology	Data	SM	GRAPE	QEDC	NC
$M_{12} > 80\,\mathrm{GeV}$					
"ee"	15	14.0 ± 1.1	5.7 ± 0.6	6.0 ± 0.6	2.2 ± 0.4
"eee"	3	$3.4^{+0.6}_{-0.3}$	3.4 ± 0.3	< 0.2	< 0.5
$M_{12} > 100\,\mathrm{GeV}$					
"ee"	5	4.3 ± 1.1	1.1 ± 0.2	2.3 ± 1.1	0.9 ± 0.2
"eee"	1	$1.1^{+0.5}_{-0.1}$	1.1 ± 0.1	< 0.02	< 0.5

Table 2: *The observed and predicted multi-electron event yields for the "ee" and "eee" samples. The results are shown separately for $M_{12} > 80$ GeV and $M_{12} > 100$ GeV regions. The quoted uncertainties include the uncertainty on the energy scale, the one from the luminosity measurement as well as the statistical uncertainty of the MC. Upper limit of 68% CL are given where no MC event remained after the event selection.*

ZEUS Preliminary 1994-2005 $e^{\pm}p$			
	Coupling structure	95% C.L. (TeV)	
Model	$[\epsilon_{LL},\epsilon_{LR},\epsilon_{RL},\epsilon_{RR}]$	Λ^-	Λ^+
LL	$[+1, 0, 0, 0]$	4.2	4.2
LR	$[0,+1, 0, 0]$	2.0	3.6
RL	$[0, 0,+1, 0]$	2.3	3.6
RR	$[0, 0, 0,+1]$	4.0	3.8
VV	$[+1,+1,+1,+1]$	7.5	6.3
AA	$[+1,-1,-1,+1]$	5.9	6.3
VA	$[+1,-1,+1,-1]$	3.3	3.5
X1	$[+1,-1, 0, 0]$	4.3	4.7
X2	$[+1, 0,+1, 0]$	5.1	4.7
X3	$[+1, 0, 0,+1]$	5.9	5.3
X4	$[0,+1,+1, 0]$	5.4	4.8
X5	$[0,+1, 0,+1]$	5.1	4.5
X6	$[0, 0,+1,-1]$	4.3	4.1
U1	$[+1,-1, 0, 0]^{eu}$	5.2	5.5
U2	$[+1, 0,+1, 0]^{eu}$	6.1	5.2
U3	$[+1, 0, 0,+1]^{eu}$	7.1	6.1
U4	$[0,+1,+1, 0]^{eu}$	6.1	5.0
U5	$[0,+1, 0,+1]^{eu}$	6.2	5.0
U6	$[0, 0,+1,-1]^{eu}$	4.5	4.7

Table 3: *Relations between couplings $[\epsilon_{LL}, \epsilon_{LR}, \epsilon_{RL}, \epsilon_{RR}]$ for the compositeness models and the 95% C.L. limits on the compositeness scale, Λ, resulting from the ZEUS analysis of 1994-2005 $e^{\pm}p$ data. Each row of the table represents two scenarios corresponding to $\eta > 0$ (Λ^+) and $\eta < 0$ (Λ^-). The same coupling structure applies to d and u quarks, except for the models U1 to U6, for which the couplings for the d quarks are zero.*

ZEUS Preliminary 1994-2005 $e^{\pm}p$		
Model	Coupling Structure	95% C.L. (TeV) M_{LQ}/λ_{LQ}
$S_{\circ}^{L}$	$a_{LL}^{eu} = +\frac{1}{2}$	0.96
$S_{\circ}^{R}$	$a_{RR}^{eu} = +\frac{1}{2}$	0.82
$\tilde{S}_{\circ}^{R}$	$a_{RR}^{ed} = +\frac{1}{2}$	0.32
$S_{1/2}^{L}$	$a_{LR}^{eu} = -\frac{1}{2}$	0.88
$S_{1/2}^{R}$	$a_{RL}^{ed} = a_{RL}^{eu} = -\frac{1}{2}$	0.46
$\tilde{S}_{1/2}^{L}$	$a_{LR}^{ed} = -\frac{1}{2}$	0.44
S_{1}^{L}	$a_{LL}^{ed} = +1,\ a_{LL}^{eu} = +\frac{1}{2}$	0.74
$V_{\circ}^{L}$	$a_{LL}^{ed} = -1$	0.80
$V_{\circ}^{R}$	$a_{RR}^{ed} = -1$	0.62
$\tilde{V}_{\circ}^{R}$	$a_{RR}^{eu} = -1$	1.33
$V_{1/2}^{L}$	$a_{LR}^{ed} = +1$	0.46
$V_{1/2}^{R}$	$a_{RL}^{ed} = a_{RL}^{eu} = +1$	1.00
$\tilde{V}_{1/2}^{L}$	$a_{LR}^{eu} = +1$	1.10
V_{1}^{L}	$a_{LL}^{ed} = -1,\ a_{LL}^{eu} = -2$	1.91

Table 4: *Coefficients a_{ij}^{eq} defining the effective leptoquark couplings in the contact-interaction limit $M_{LQ} \gg \sqrt{s}$ and the 95% C.L. lower limits on the leptoquark mass to the Yukawa coupling ratio M_{LQ}/λ_{LQ} resulting from the CI analysis of the ZEUS 1994-2005 $e^{\pm}p$ data, for different models of scalar (upper part of the table) and vector (lower part) leptoquarks.*

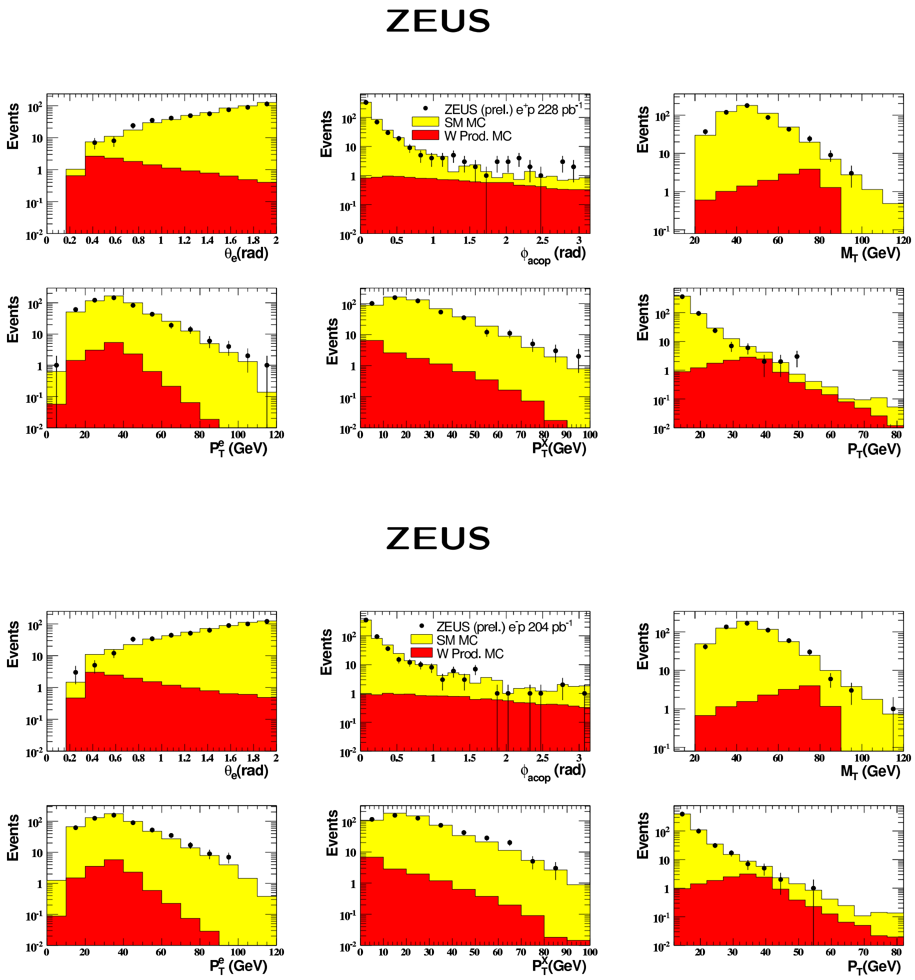


Figure 1: *Isolated electron data (dots) compared to absolutely-normalized MC for the e^+p (top) and e^-p (bottom) collisions after the initial event selections. The light shaded histograms represents the SM MC prediction, the dark shaded area the signal $ep \rightarrow eWX$ prediction.The variables shown are*

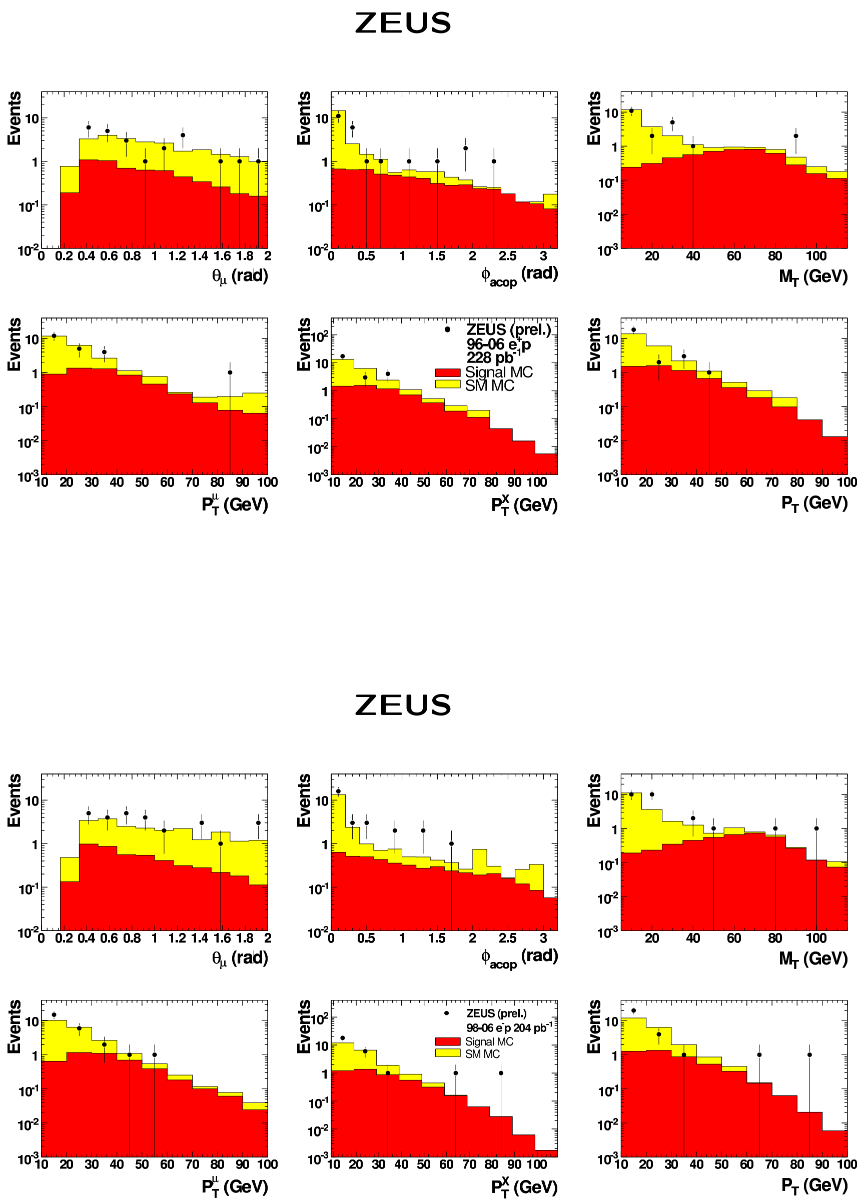


Figure 2: *Isolated muon data (dots) compared to absolutely-normalized MC for the e^+p (top) and e^-p (bottom) collisions after the initial event selections. The light shaded histograms represents the SM MC prediction, the dark shaded area the signal $ep \rightarrow eWX$ prediction.*

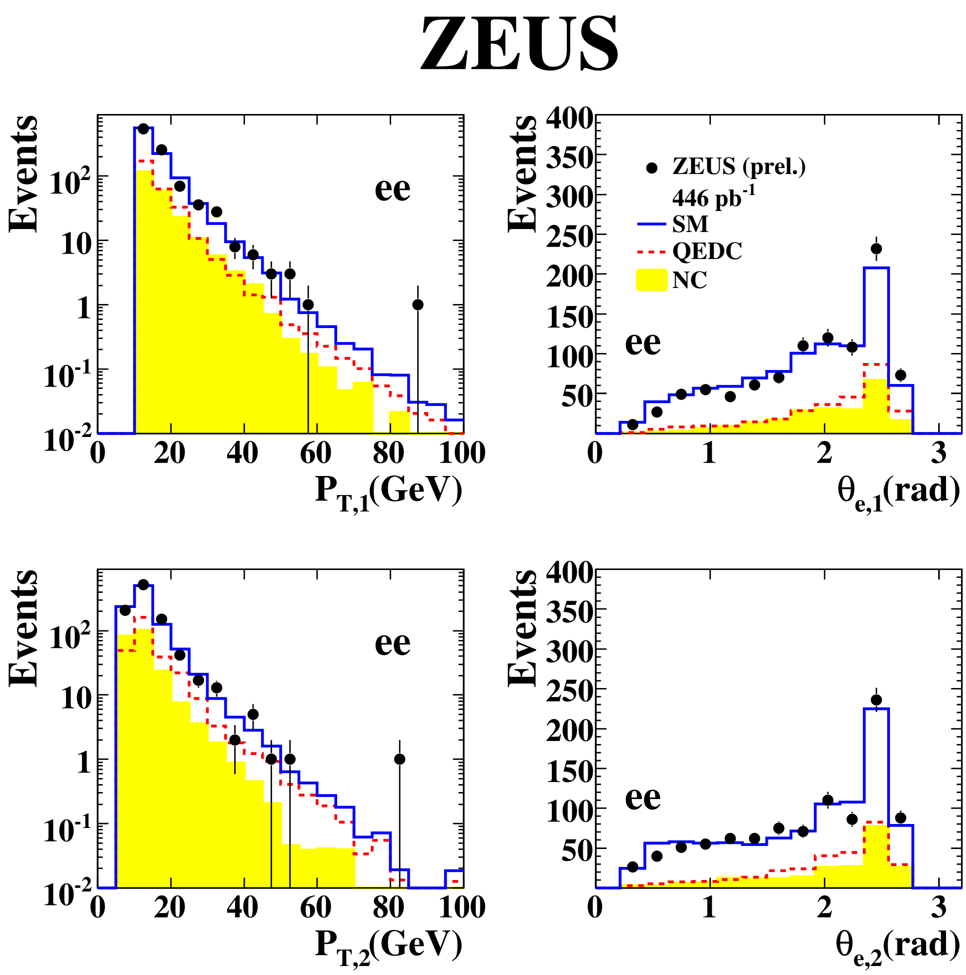


Figure 3: *"ee" sample: Comparison of the measured trasverse momentum and polar angle distributions of the two high-P_T electrons (dots) with the SM expectations (solid line). The contributions due to QED Compton and NC DIS processes are also shown as dashed and shaded histograms, respectively.*

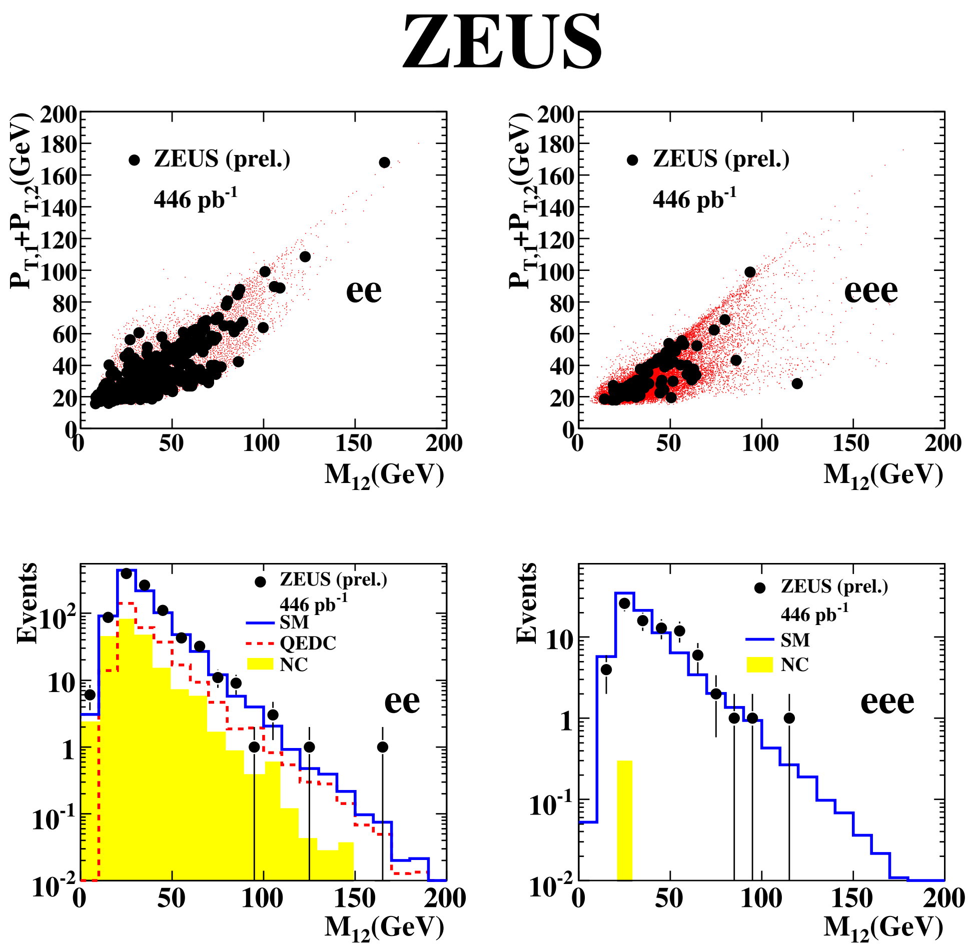
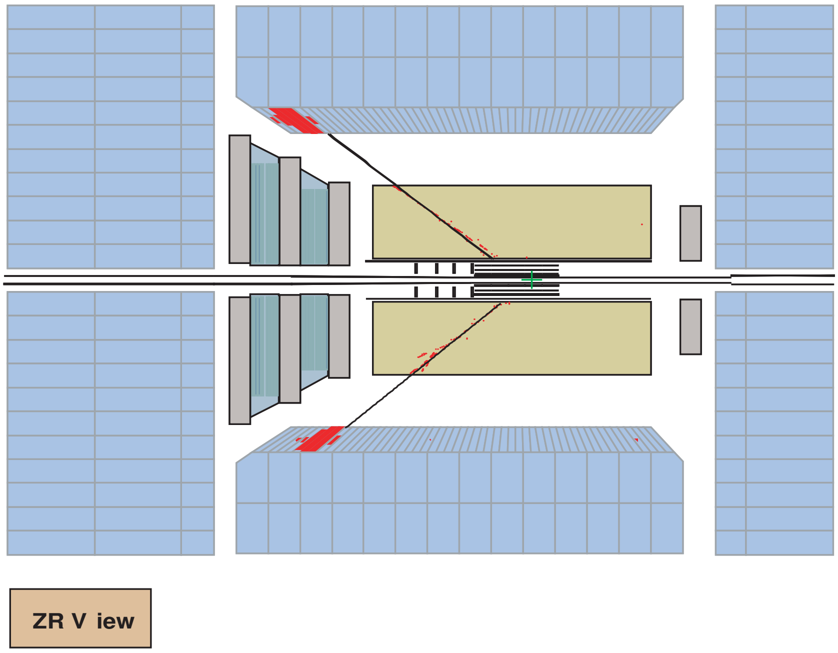


Figure 4: *The measured distributions of the invariant mass, M_{12}, of the two high-P_T electrons (bottom) and the correlation of M_{12} with the scalar sum of the P_T's of the electrons (top) compared with the SM expectation for the "ee" and "eee" samples. Other details as in the caption to Fig. 3.*



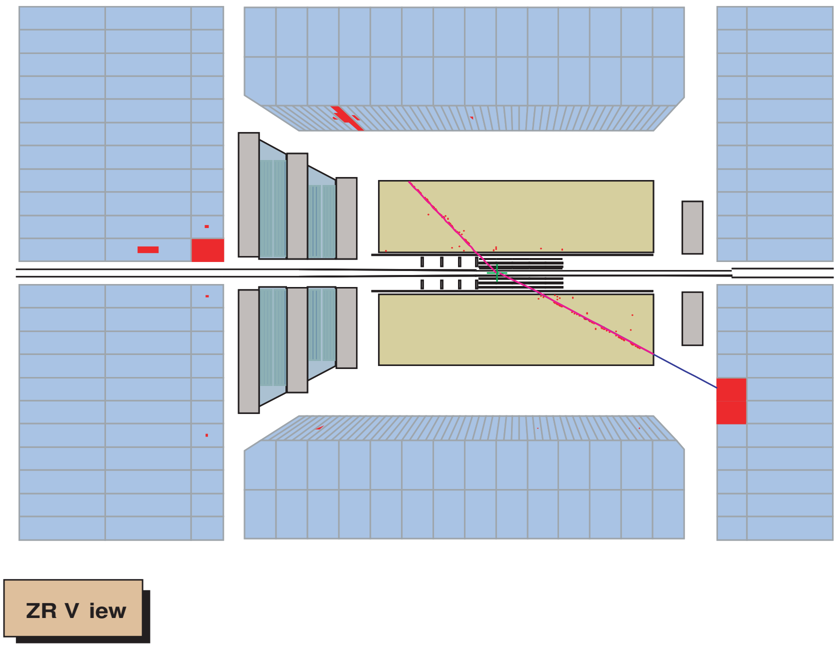


Figure 5: *(Top) Display of the highest M_{12} event of the "ee"sample. (Bottom) Display of the highest M_{12} event of the"eee"sample.*

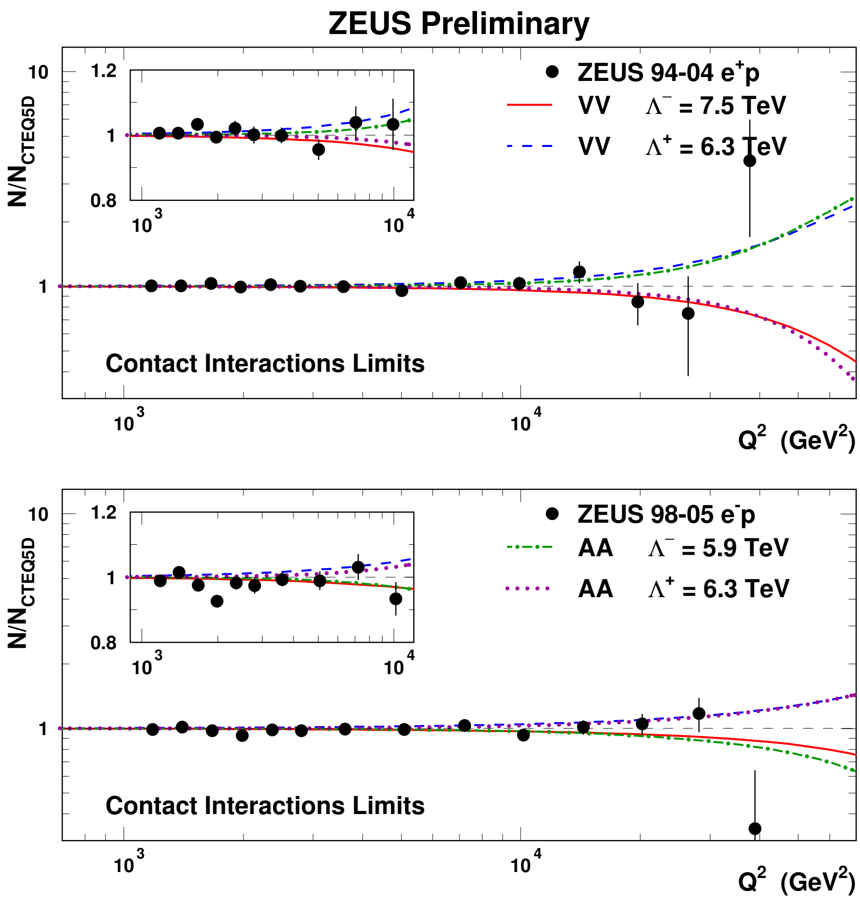


Figure 6: *ZEUS data compared with 95% C.L. exclusion limits for the effective mass scale in the VV and AA contact-interaction models, for positive (Λ^+) and negative (Λ^-) couplings. Results are normalized to the Standard Model expectations calculated using the CTEQ5D parton distributions. The insets show the comparison in the $Q^2 < 10^4$ GeV^2 region, with a linear ordinate scale.*

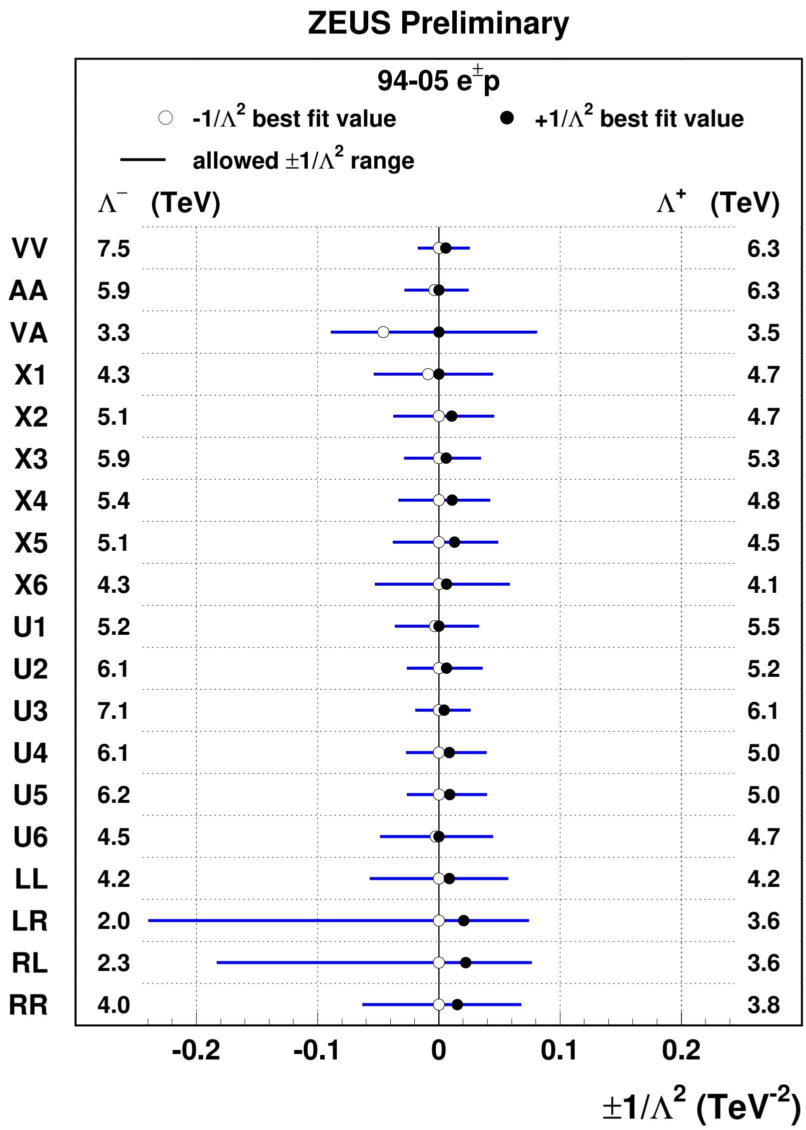


Figure 7: *Confidence intervals of* $\pm 1/\Lambda^2$ *at 95% C.L. for general CI scenarios studied in this paper (dark horizontal bars). The numbers at the right (left) margin are the corresponding lower limits on the mass scale* Λ^+ (Λ^-)*. The filled (open) circles indicate the positions corresponding to the best-fit coupling values, for positive (negative) couplings.*

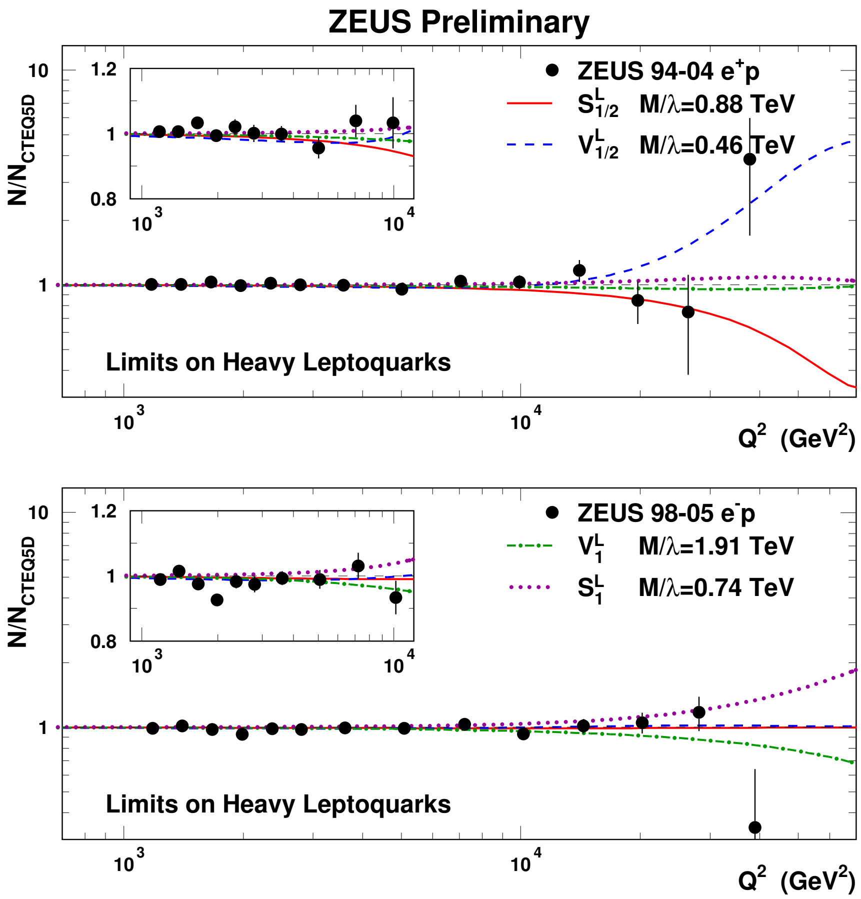


Figure 8: *ZEUS data compared with 95% C.L. exclusion limits for the ratio of the leptoquark mass to the Yukawa coupling, M/λ, for the $S^L_{1/2}$, S^L_1, V^L_1 and $V^L_{1/2}$ leptoquarks. Results are normalized to the Standard Model expectations calculated using the CTEQ5D parton distributions. The insets show the comparison in the $Q^2 < 10^4$ GeV^2 region, with a linear ordinate scale.*

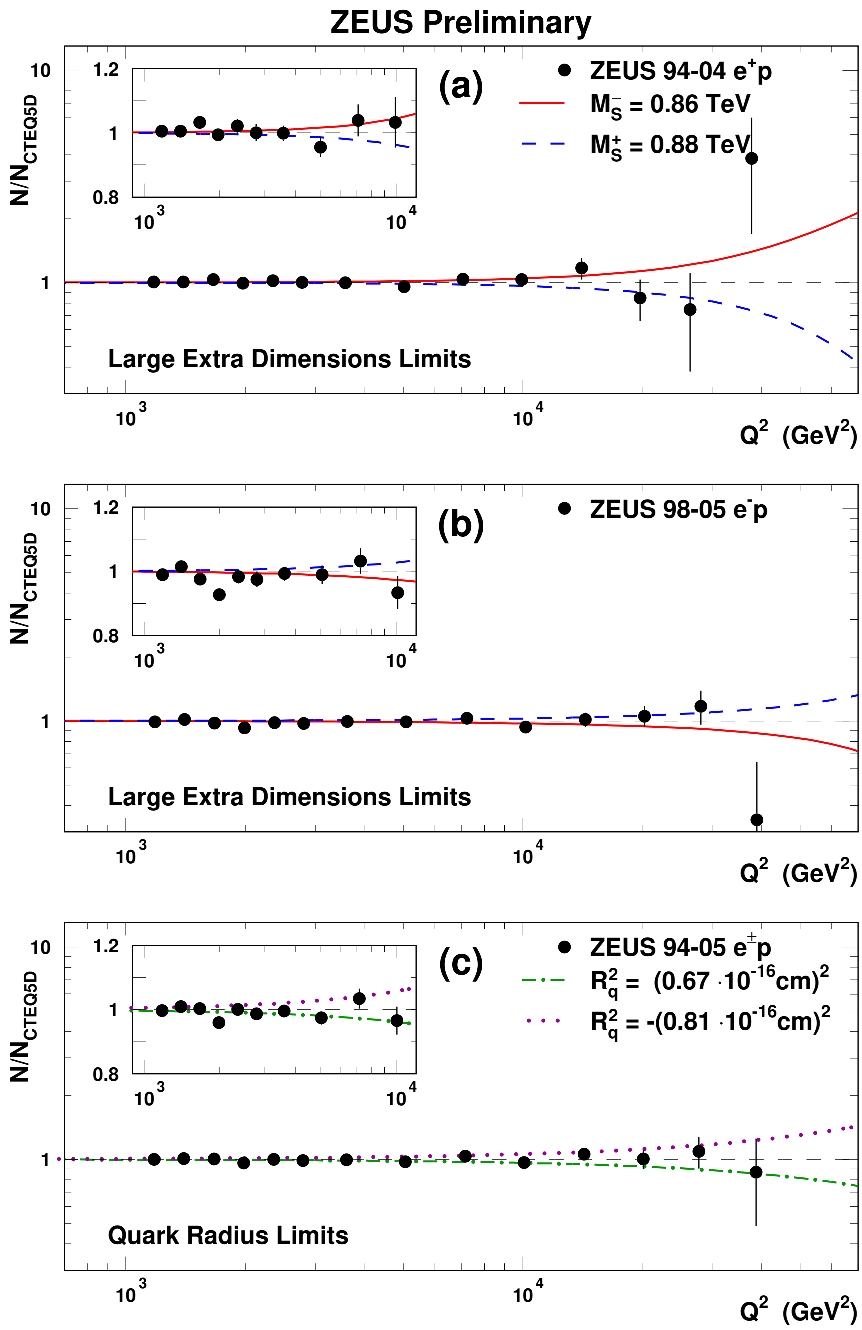


Figure 9: *ZEUS e^+p data (a) and e^-p data (b) compared with 95% C.L. exclusion limits for the effective Planck mass scale in models with large extra dimensions, for positive (M_S^+) and negative (M_S^-) couplings. (c) Combined 1994-2000 data compared with 95% C.L. exclusion limits for the effective mean-square radius of the electroweak charge of the quark. Results are normalized to the Standard Model expectations calculated using the CTEQ5D parton distributions. The insets show the comparison in the $Q^2 < 10^4$ GeV^2 region, with a linear ordinate scale.*