

# Recent HERA Results on Leptoquarks and other SUSY related Signatures

Stefan Schmitt (DESY) on behalf of the H1 and ZEUS collaborations

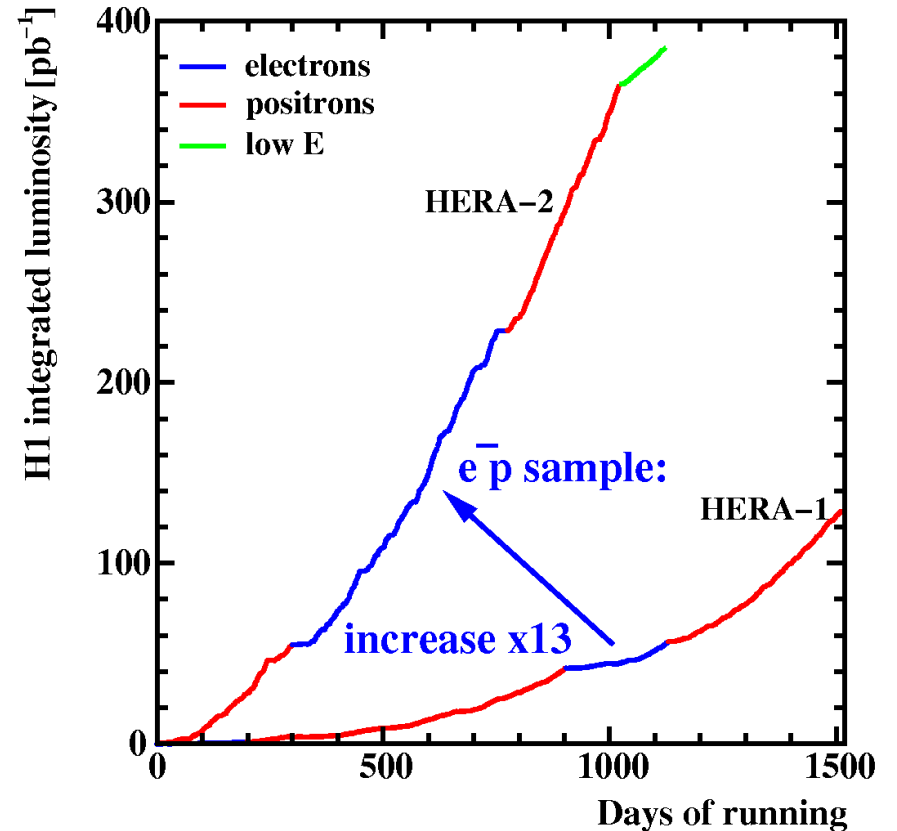
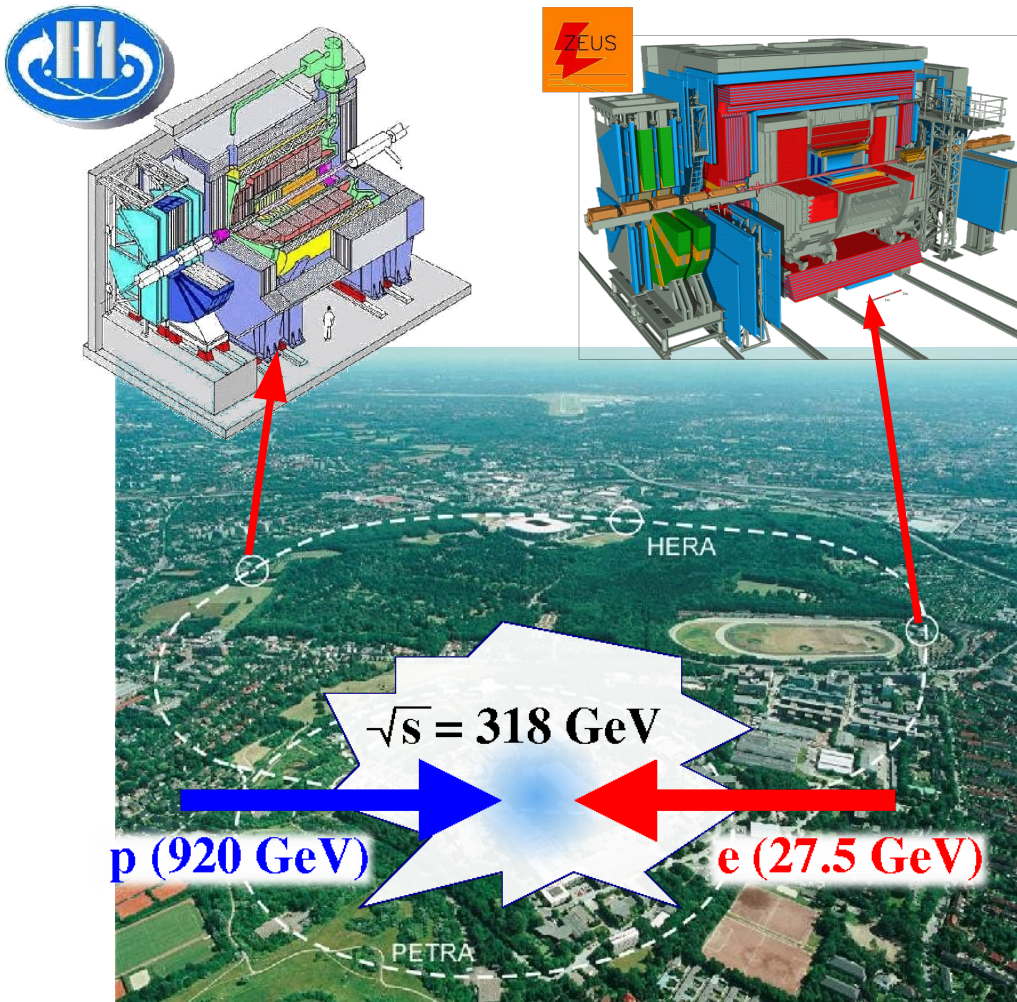
SUSY08 conference, Seoul



- Leptoquarks
- Isolated Lepton and Multilepton Signatures
- General Search

# The HERA ep Collider at DESY

4 $\pi$  coverage, excellent lepton ID+calorimeters

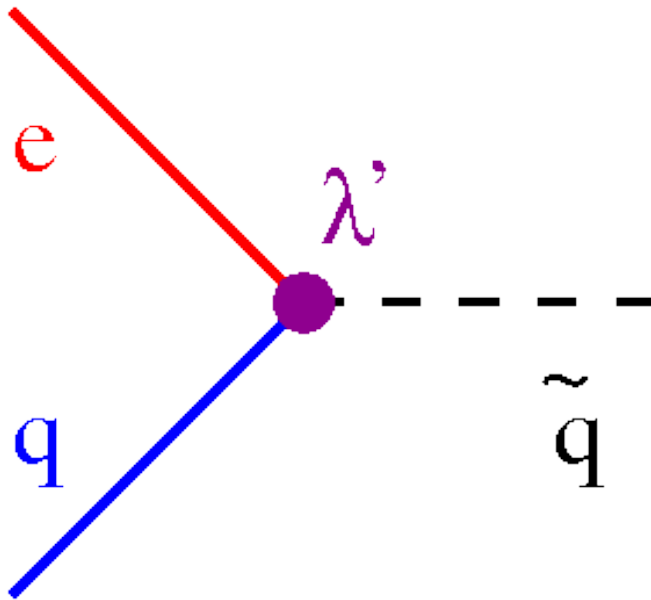


Two experiments H1, ZEUS

HERA-1: 1994-2000: 2x120 inv.pb  
 HERA-2: 2003-2007: 2x350 inv.pb  
 + longitudinally polarized e-beam

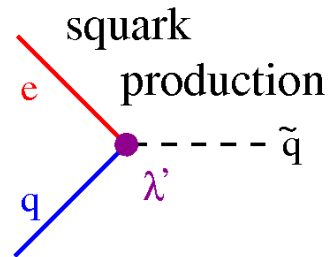
# Squark Production at HERA

- ep initial state -> pair-production searches disfavoured
- HERA analyses focussed on R-parity violating models

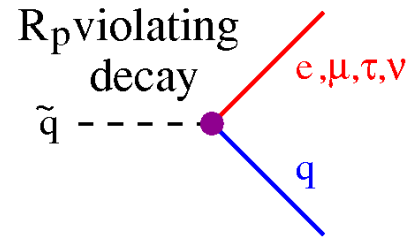


- Resonant production of Squarks with R-parity violating coupling  $\lambda'$
- Search strategy depends on the decay modes allowed for a specific SUSY model

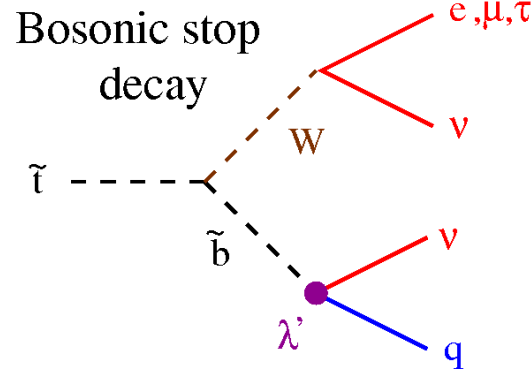
# Squark Searches at HERA



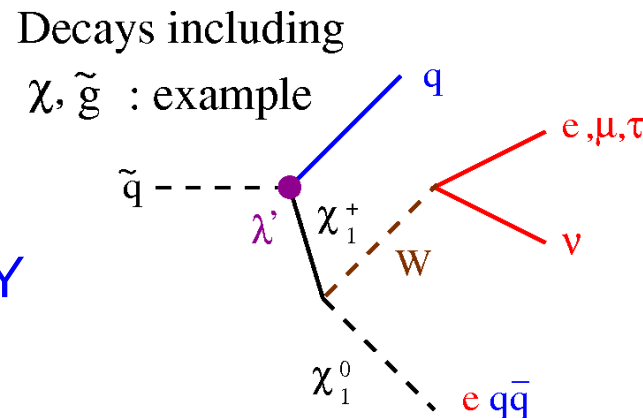
- HERA-1 data: dedicated scan of SUSY parameter space
- This conference: new results on Leptoquark searches and final states with isolated leptons
- No new results from SUSY model parameter scans



Lepton+jet:  
Leptoquark searches



Lepton+missing  
transverse momentum

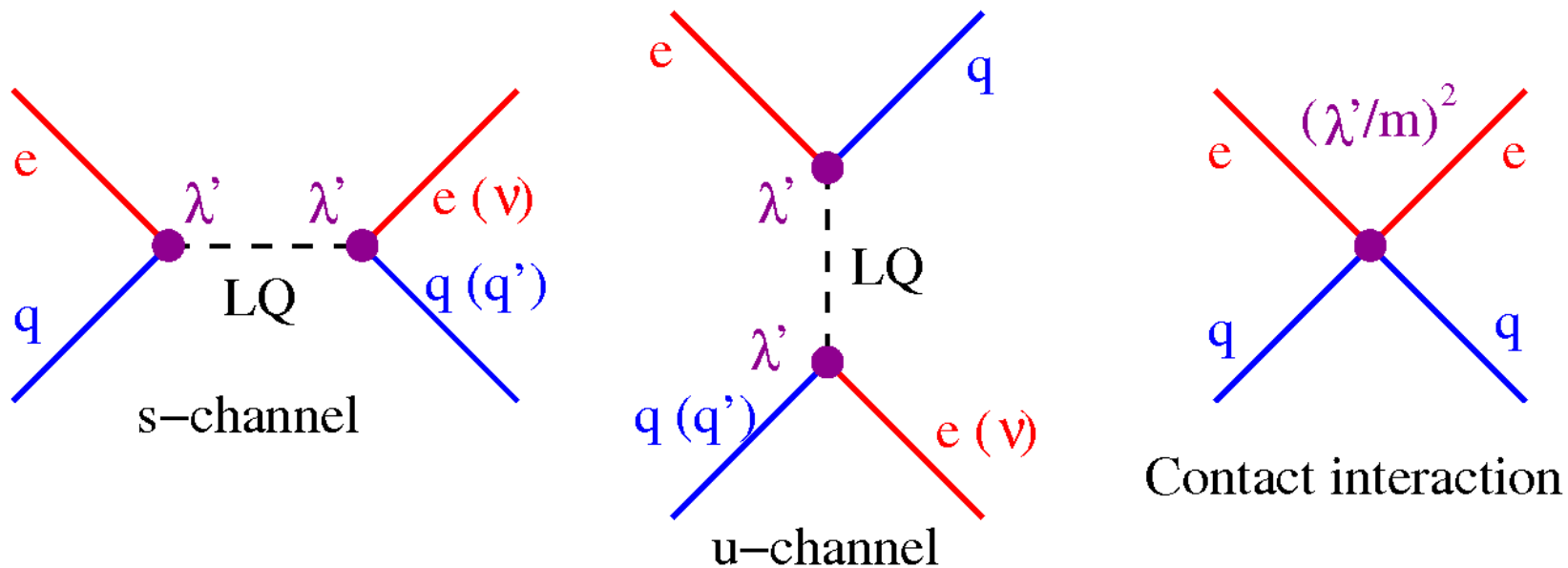


Final states with  
leptons and jets

# HERA Leptoquark Searches

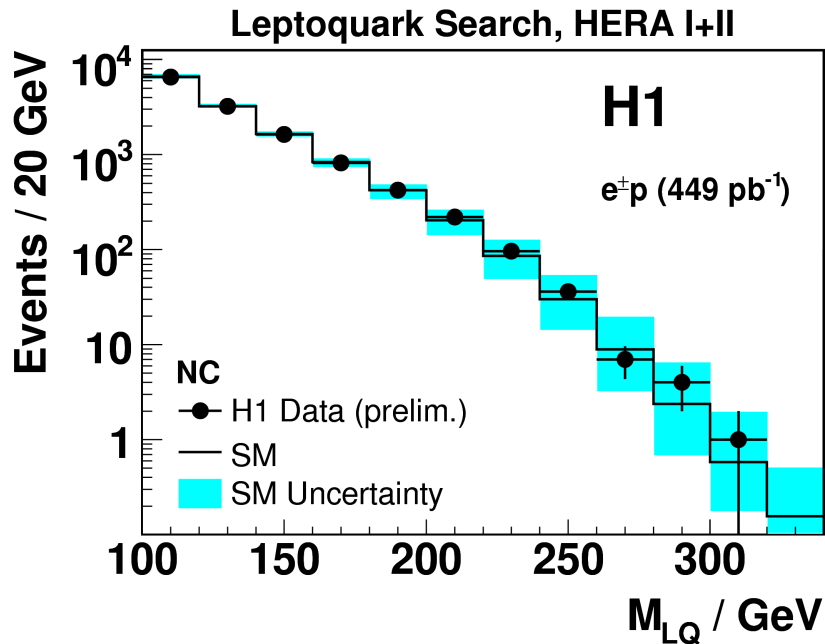
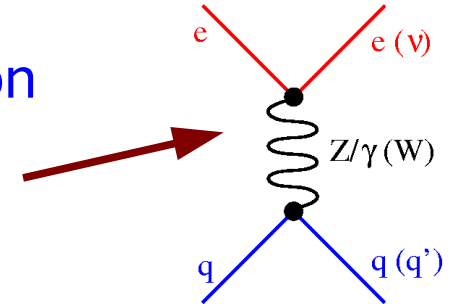
- Leptoquarks at HERA: **s-channel resonant production** possible
- At high masses: **contact-interaction**, independent of branching ratio
- Interference term with  $\gamma/Z$  exchange included in analysis
- **SUSY application: Rp-violating Squarks**

LQ Limits are valid for Squarks if the Rp-violating decay dominates or in case of Contact interactions ( $m > \sqrt{s}$ )

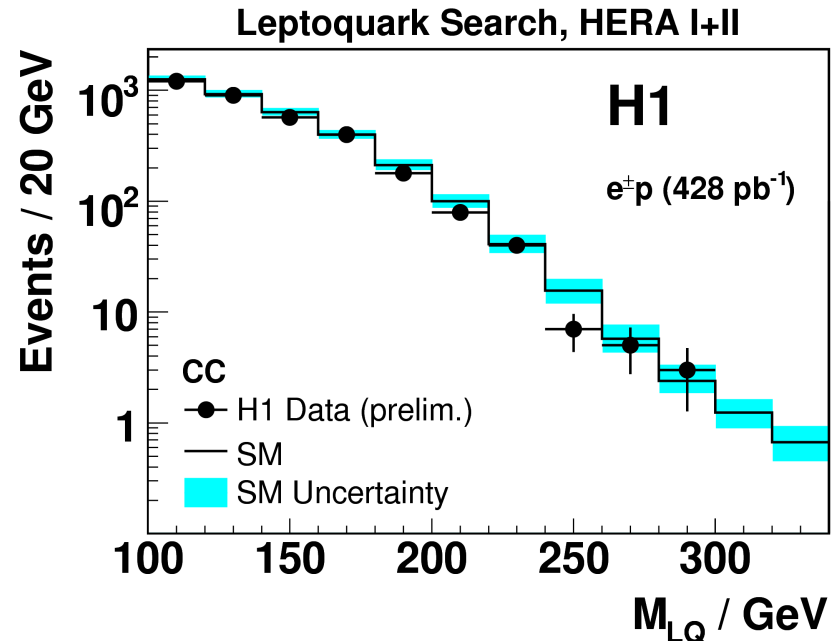


# H1 leptoquark search

- Search for resonant structure in LQ mass distribution
- Spectra are dominated by Deep-inelastic scattering
- No leptoquarks observed, set limits



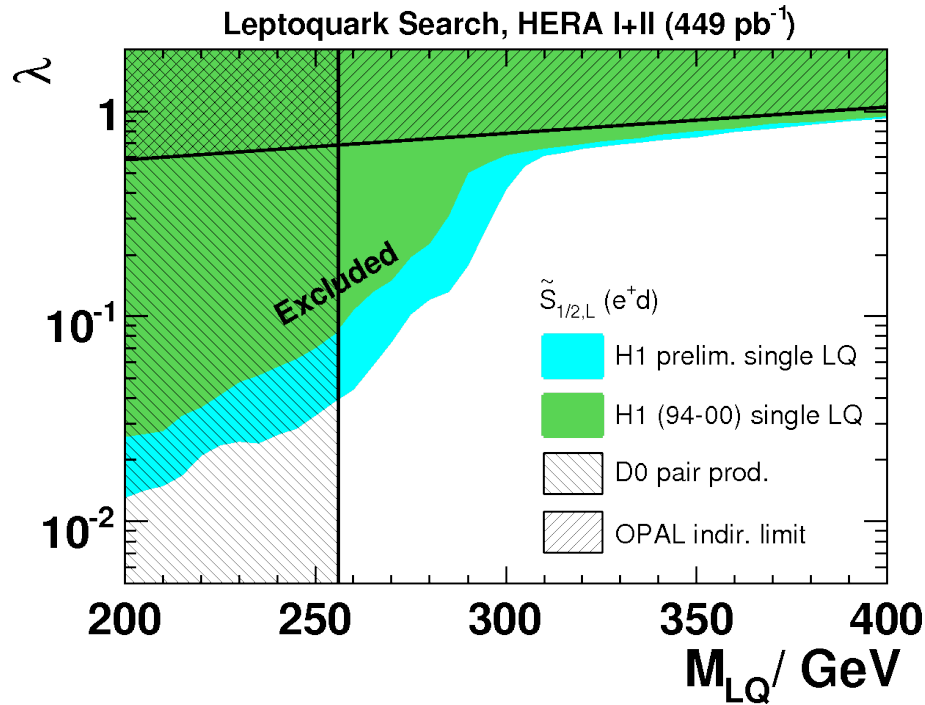
$ep \rightarrow eX$



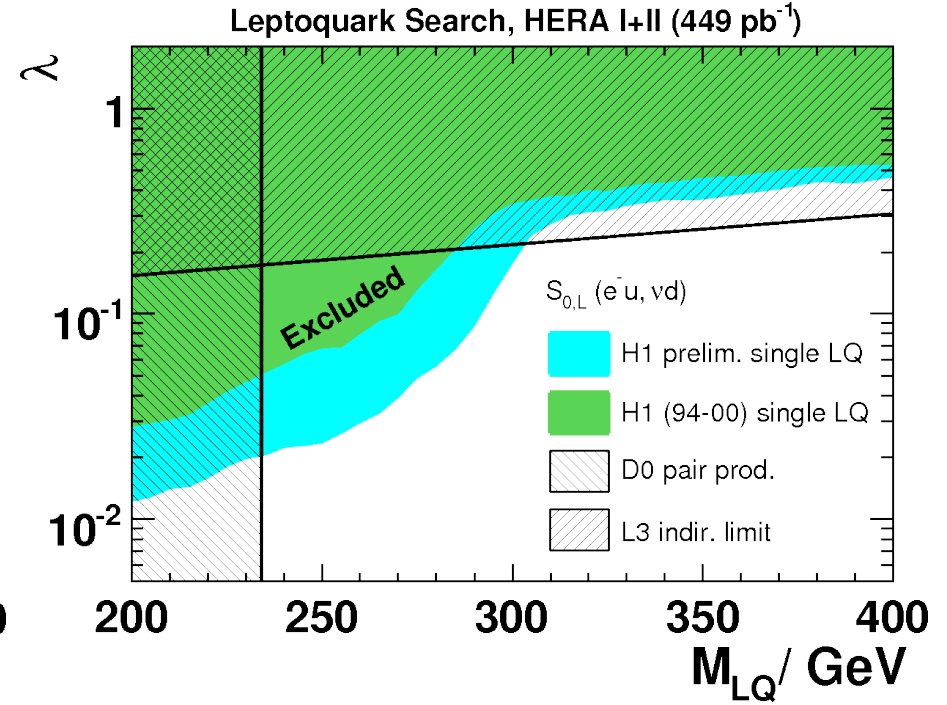
$ep \rightarrow \nu X$

# H1 Leptoquark Limits

- 14 types of Leptoquark models investigated
- Shown: the two models which are relevant for Rp violating SUSY



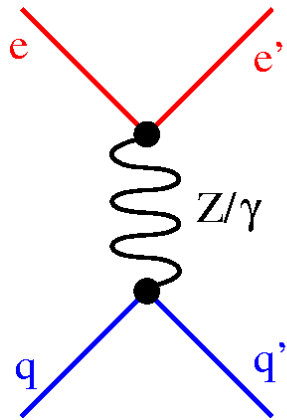
U-type squark, decay to  $ed$   
Rp-violating coupling  $\lambda'_{1j1}$



D-type squark, decay to  $eu, \nu d$   
Rp-violating coupling  $\lambda'_{11k}$

LQ limits are valid for squark searches if  $\text{Br}(\text{RpV}) \approx 100\%$  or if  $M > 300$  GeV

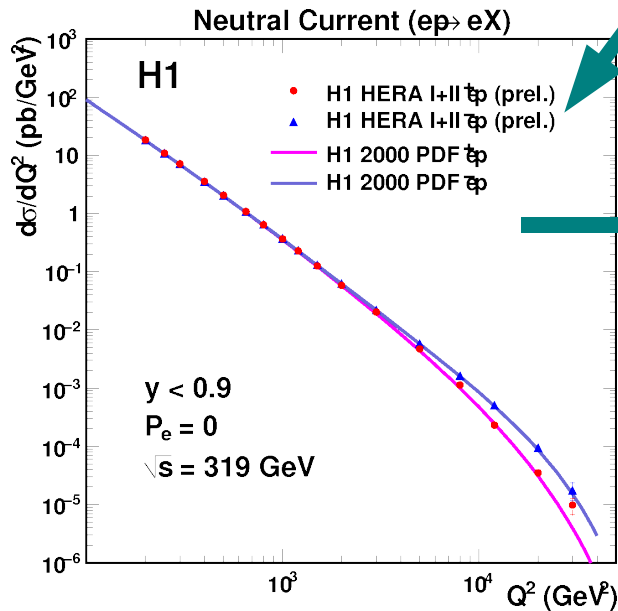
# LQ Limits from Contact-Interactions



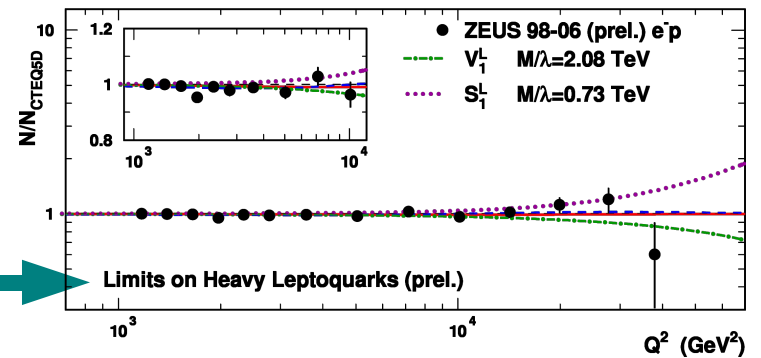
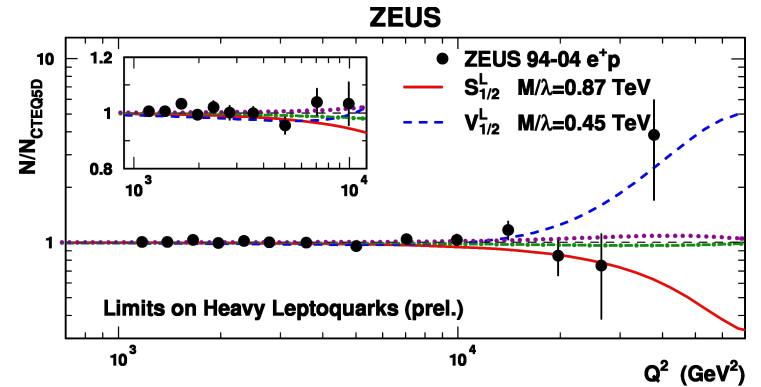
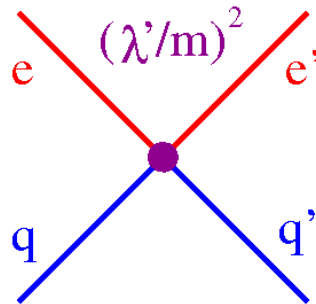
Deep-inelastic scattering  
Momentum transfer

$$Q^2 = -(e-e')^2$$

Measure single-differential  
cross-section  $\frac{d\sigma}{dQ^2}$



cross-section is altered by contact interactions

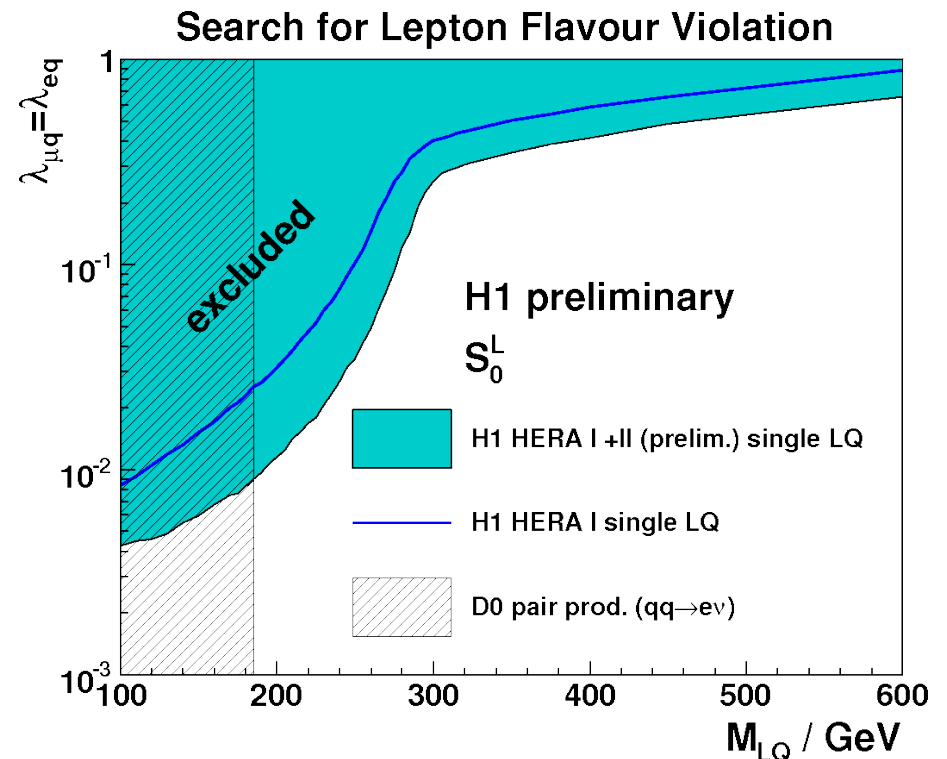
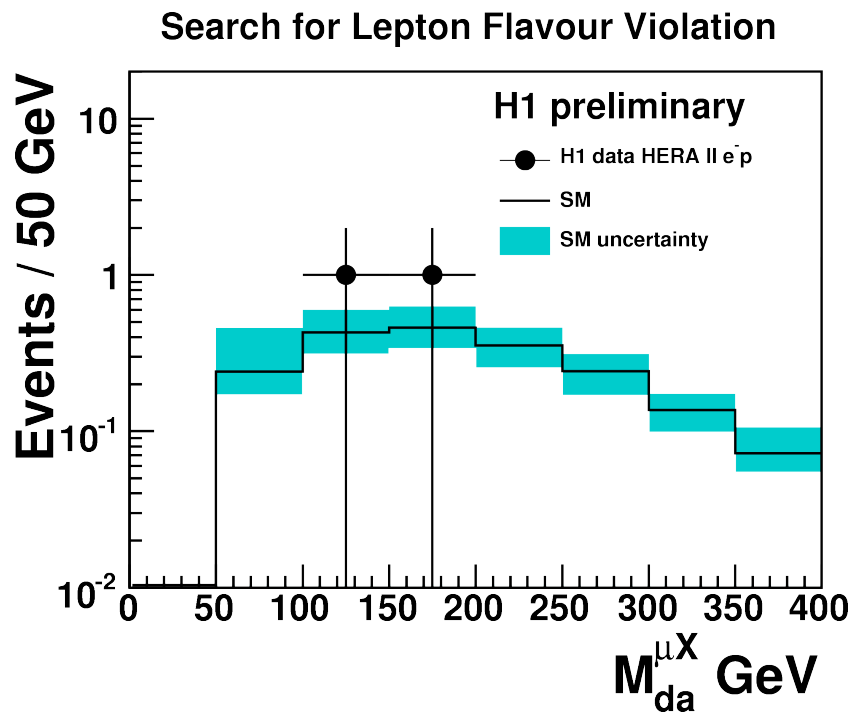
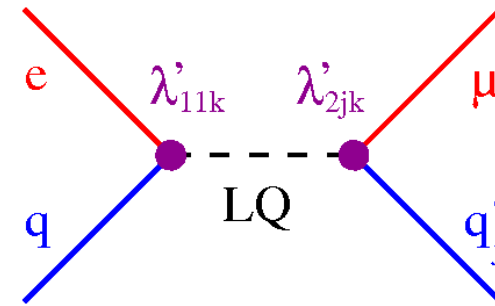


- D-type Squark ( $\tilde{S}_{1/2}$ ):  
 $M / \lambda'_{11k} > 0.96 \text{ TeV}$
- U-type Squark ( $S_{0L}$ ):  
 $M / \lambda'_{1j1} > 0.44 \text{ TeV}$



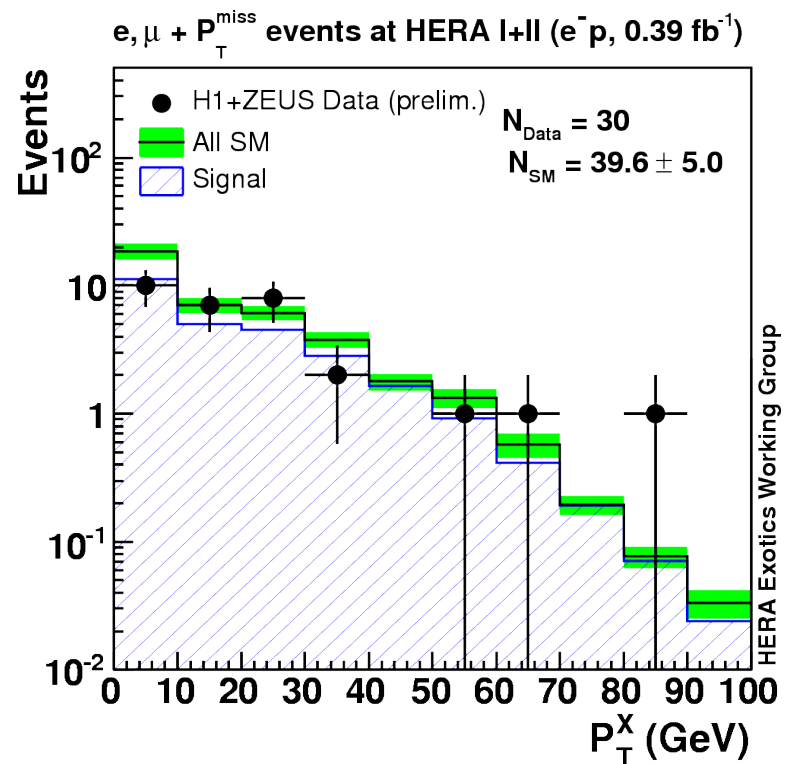
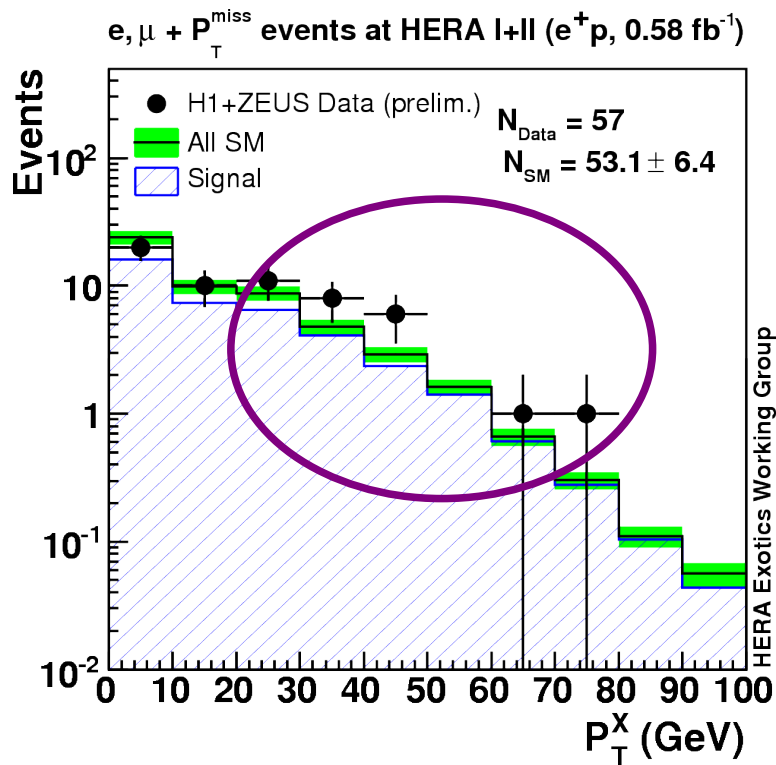
# Lepton flavour violating Leptoquarks

- Study LQ decay to  $\mu$ +jet
- New HERA-2 results
- Limit on  $\lambda'_{11k}, \lambda'_{2jk}$
- Rp-violation: probe off-diagonal couplings



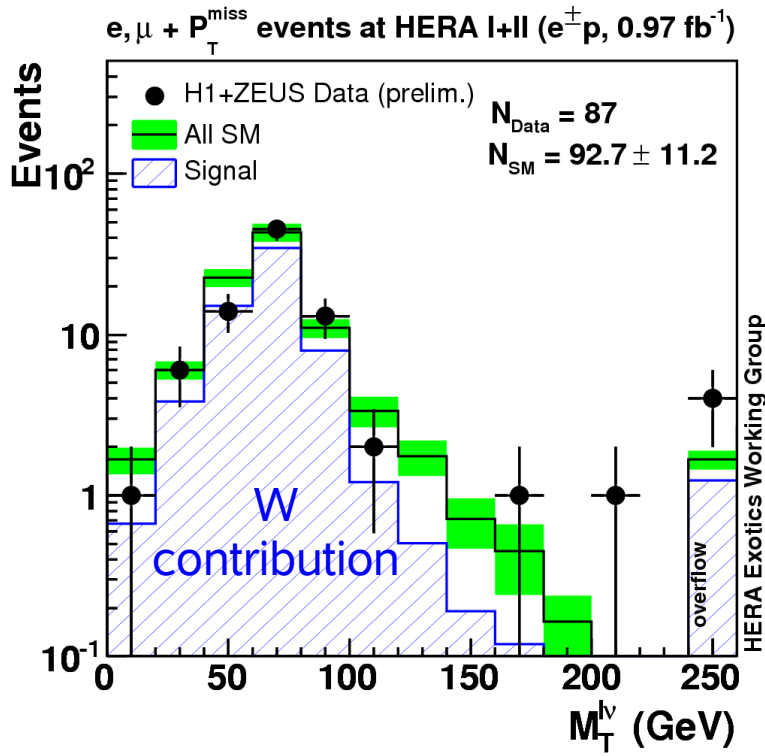
# Isolated leptons with missing $P_T$

- Select events with isolated lepton ( $e, \mu, \tau$ ) and missing  $P_T$
- Hadronic activity:  $X$ , transverse momentum from hadrons:  $P_T^X$
- New: combined H1/ZEUS results for ( $e, \mu$ ) using all HERA data
- Excess of events in  $e^+p$  at  $P_T^X > 25$  GeV: **23 observed** /  $14.6 \pm 1.9$  expected



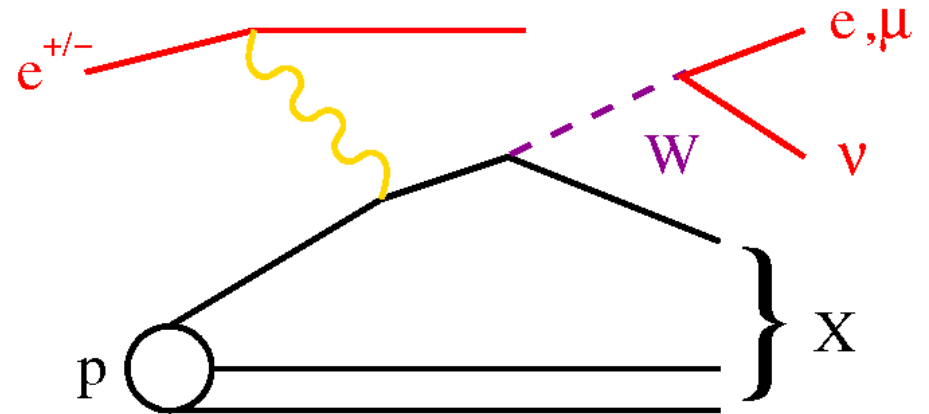
# Isolated leptons and missing $P_T$ (2)

Peak in transverse mass  
 → events are from W decay

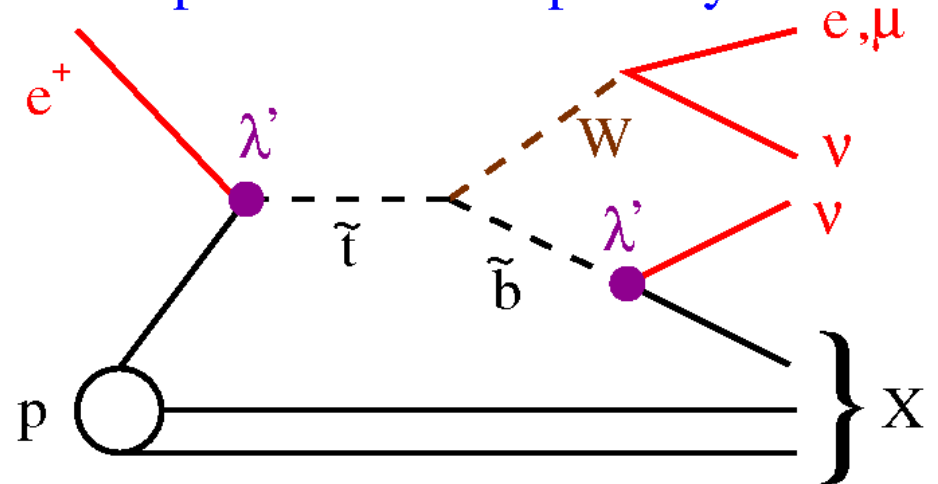


Excess at high  $P_T^X$ : not enough data to judge whether it is just a fluctuation.

Standard-model W production

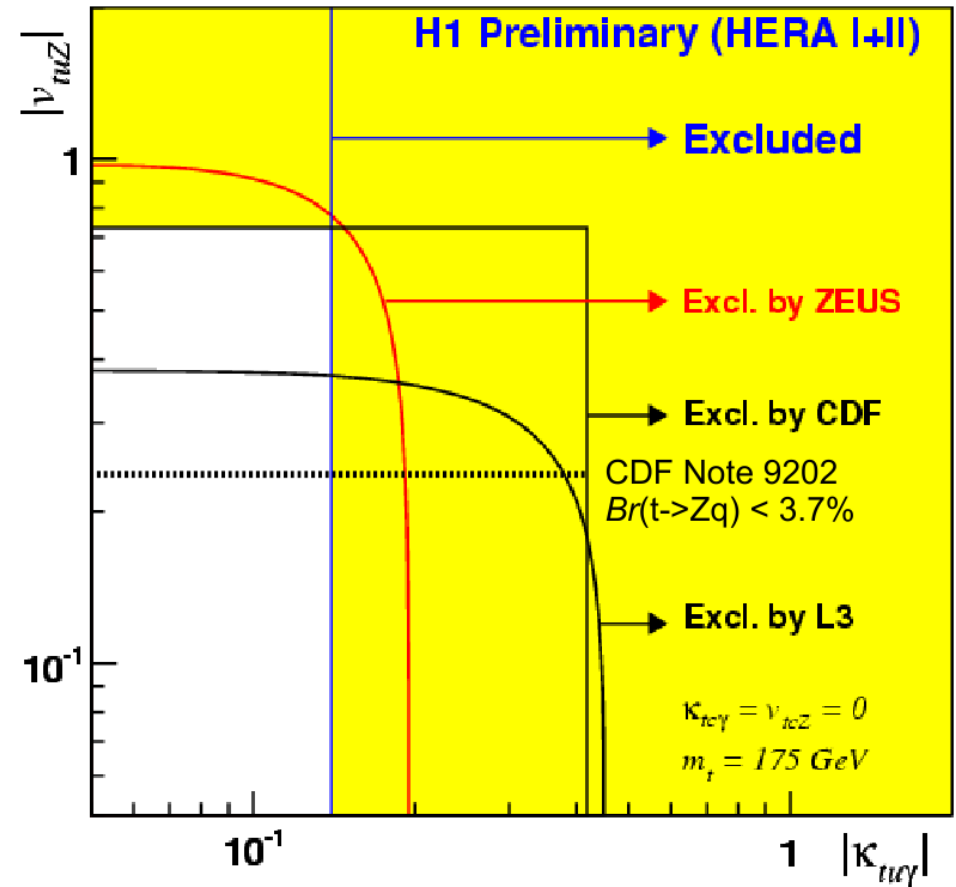
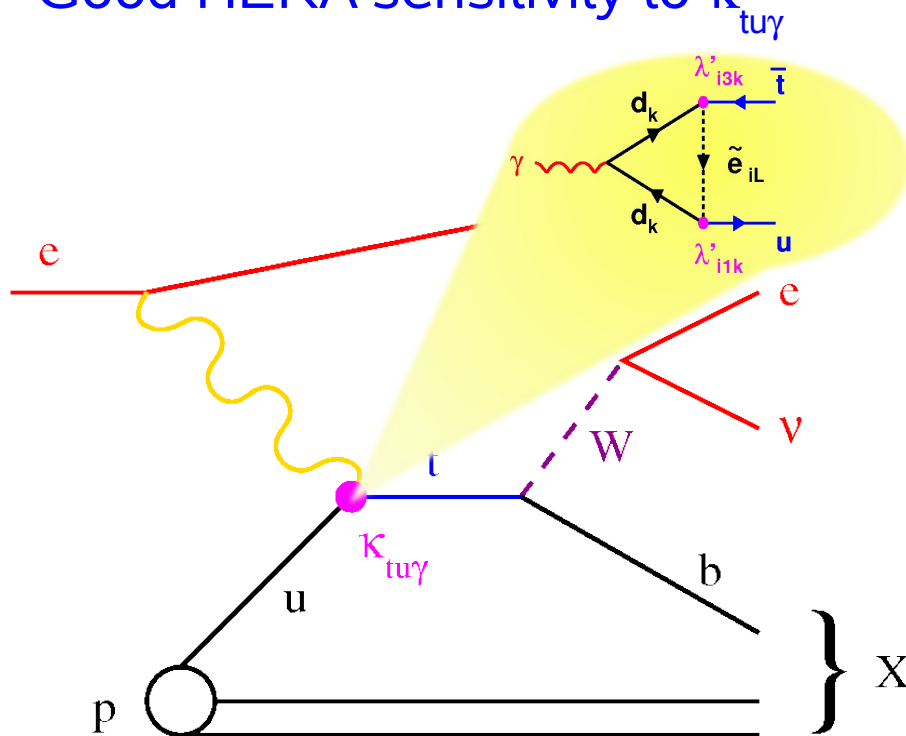


Example: bosonic stop decay



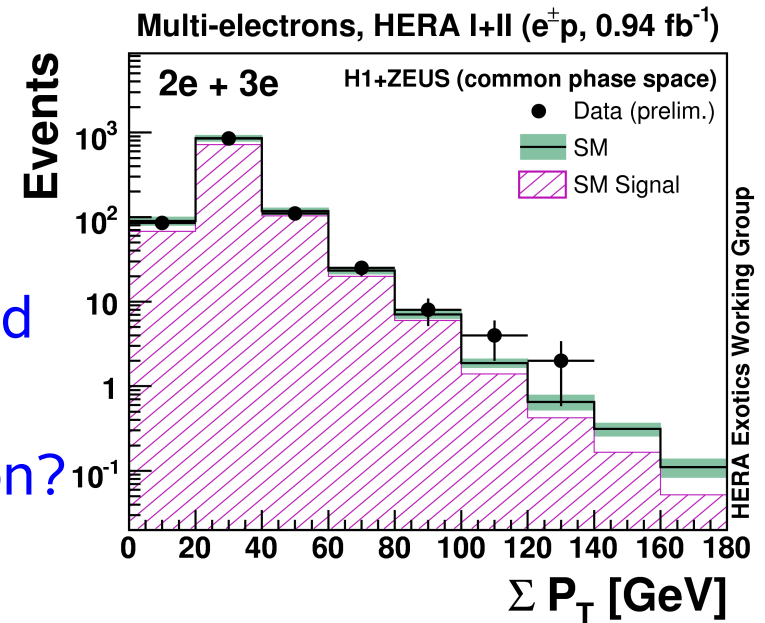
# Anomalous Top Production

- Hypothesis:  $W$  events originating from top production
- Probe anomalous top couplings
- Good HERA sensitivity to  $\kappa_{t\gamma}$



# Multiepton Events

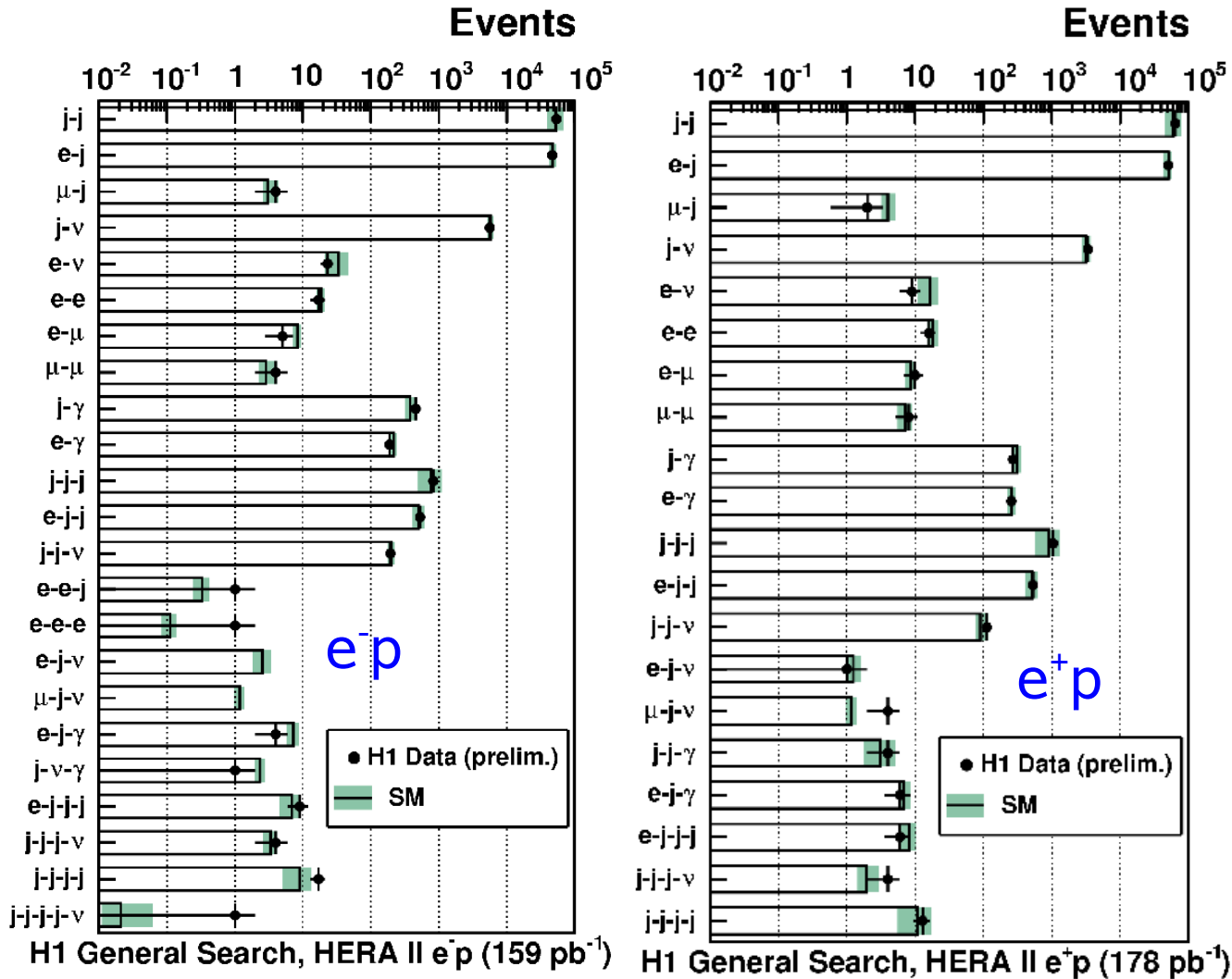
- Events with 2 or 3 electrons
- Study exotic resonances, e.g. doubly-charged Higgs
- **New:** combined results from ZEUS and H1 for electrons
- Excess at high  $P_T$ : statistical fluctuation?



H1+ZEUS Multi-electron analysis HERA I+II ( $0.94 \text{ fb}^{-1}$ , preliminary)

$\Sigma P_T > 100 \text{ GeV}$				
Data sample	Data	SM	Pair Production	NC-DIS + Compton
$e^+p$ ( $0.56 \text{ fb}^{-1}$ )	5	$1.82 \pm 0.21$	$1.28 \pm 0.16$	$0.54 \pm 0.10$
$e^-p$ ( $0.38 \text{ fb}^{-1}$ )	1	$1.19 \pm 0.14$	$0.79 \pm 0.09$	$0.40 \pm 0.08$
$e^\pm p$ ( $0.94 \text{ fb}^{-1}$ )	6	$3.00 \pm 0.34$	$2.07 \pm 0.24$	$0.94 \pm 0.16$

# H1 general Search



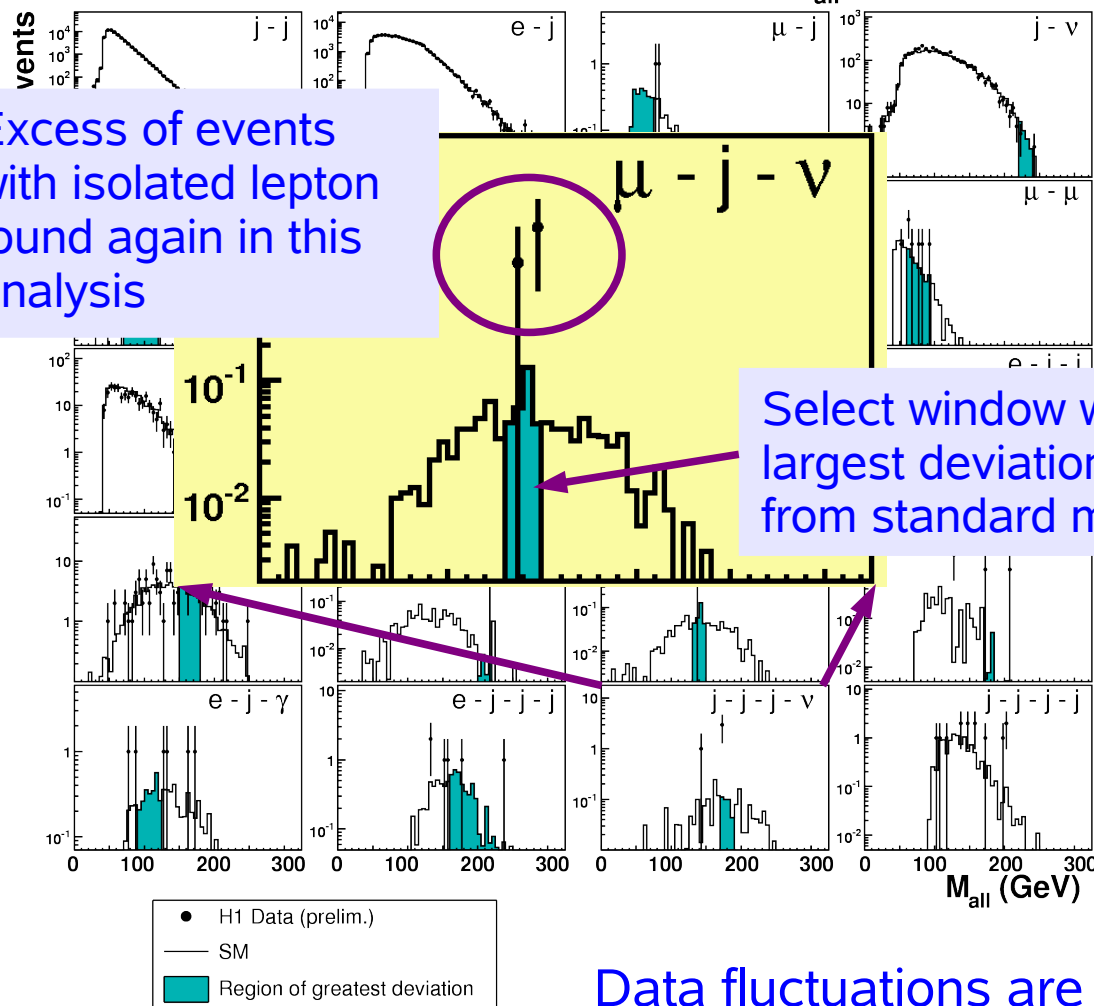
look into many final states with high  $P_T$  objects

$P_T > 20$  GeV

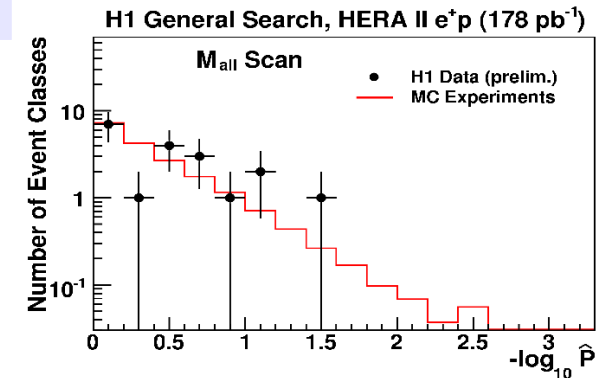
- Overall good agreement with Standard Model in all search channels
- For each channel: look into invariant mass and  $\Sigma P_T$  spectra

# H1 general Search (2)

H1 General Search, HERA II  $e^+p$  ( $178 \text{ pb}^{-1}$ ) -  $M_{\text{all}}$  Distributions



- Statistical analysis of all search channels
- Select window with largest deviation from Standard model
- Determine fluctuation probability of each channel



Data fluctuations are compatible with expectations

# Summary

- HERA has finished data-taking last Summer
- **New results from analyzing the full HERA data**
- Leptoquark searches and contact interactions
  - Limits on **squark production** in **Rp-violating SUSY**
- **Combined H1+ZEUS results** on isolated leptons + missing  $P_T$
- **Combined H1+ZEUS results** multi-leptons
- H1 general search: global survey of all high  $P_T$  search channels

Final HERA analyses ongoing, still more to come for the next years