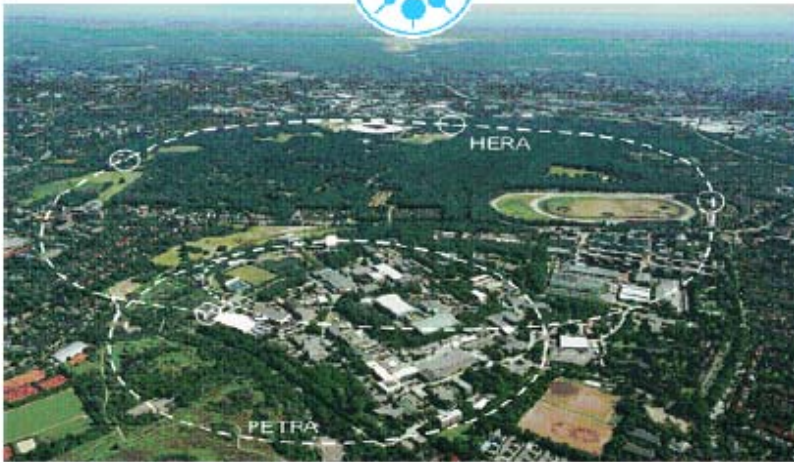


Leptoquark Searches at H1

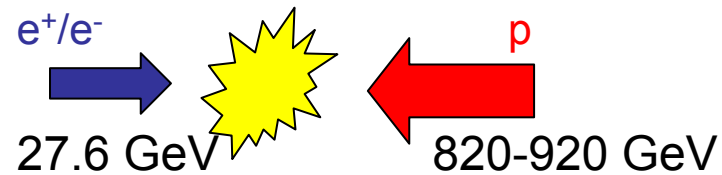
Ilias Panagoulas
NTU Athens



- H1 at HERA
- The leptoquark model
- Leptoquarks at HERA
- First generation LQs
- LFV LQ decays
- Summary

**16th International Workshop on Deep Inelastic Scattering
University College, London 7-11/4/2008**

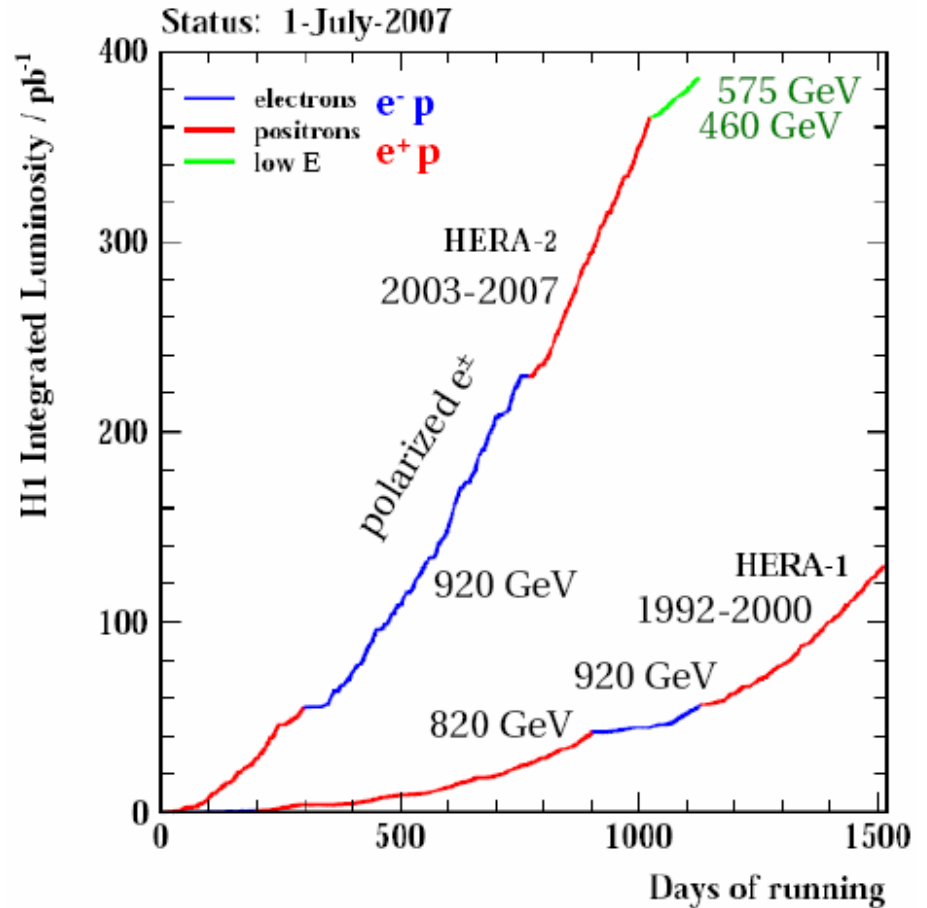
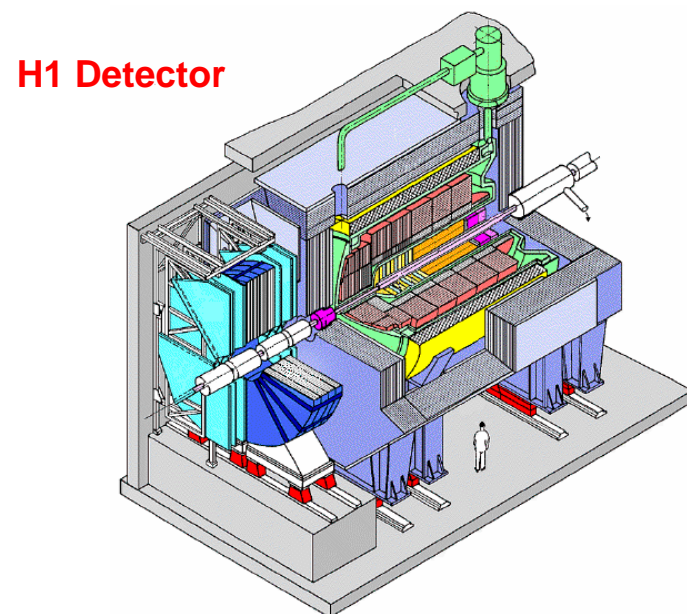
The H1 experiment at HERA



HERA

An unique ep collider (1992-2007)

Two large collider detectors H1 and ZEUS with asymmetric design



$\sim 0.5 \text{ fb}^{-1}$ luminosity balanced in e^+ & e^-

HERA II data with longitudinal polarisation (30-40%)

Introduction to the Leptoquark Model

LEPTOQUARKS

Hypothetical bosons which appear in many SM extensions to explain symmetry between leptons and quarks

- LQs are coupled to both **leptons** and **quarks** and carry SU(3) **colour**, fractional electrical **charge**, **baryon** (B) and **lepton** (L) numbers
→ **Fermion number** $F = 3B + L = 0, 2$

Buchmuller-Ruckl-Wyler Model

- ✓ $SU(3)_C \times SU(2)_L \times U(1)_Y$ invariance
- ✓ Lepton and baryon number conservation
- ✓ Strong bound from rare decays → either left- or right-handed couplings
- ✓ Family diagonal; if not LFV is introduced
- ✓ decay to $l^\pm q$ or $\nu_l q'$ with branching ratios $\beta_l, \beta_\nu = 0, 0.5, 1$ depending on the quantum numbers

⇒ 7 scalar and 7 vector LQs

Introduction to the Leptoquark Model

couple to $\mathbf{l}^- \mathbf{q}$

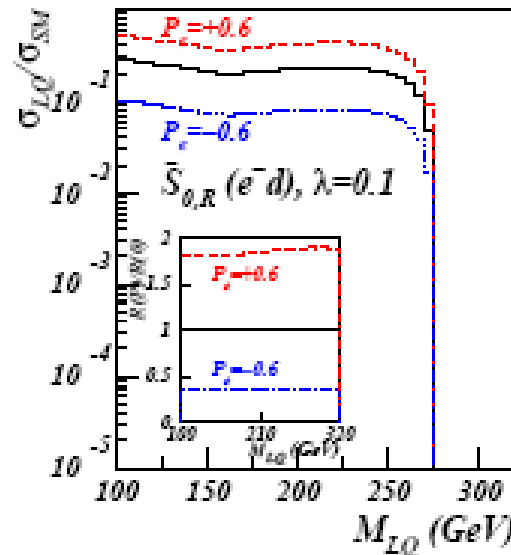
couple to $\mathbf{l}^+ \mathbf{q}$

| F | spin | species |
|-----|------|--|
| 2 | 0 | $S_{0,L}; S_{0,R}; \tilde{S}_{0,R}; S_{1,L}$ |
| 2 | 1 | $V_{1/2,L}; V_{1/2,R}; \tilde{V}_{1/2,L}$ |
| 0 | 0 | $S_{1/2,L}; S_{1/2,R}; \tilde{S}_{1/2,L}$ |
| 0 | 1 | $V_{0,L}; V_{0,R}; \tilde{V}_{0,R}; V_{1,L}$ |

labeled by weak isospin and lepton helicity

Leptoquarks are chiral particles

- Gain in sensitivity for leptoquark search when the lepton beams are longitudinally polarized



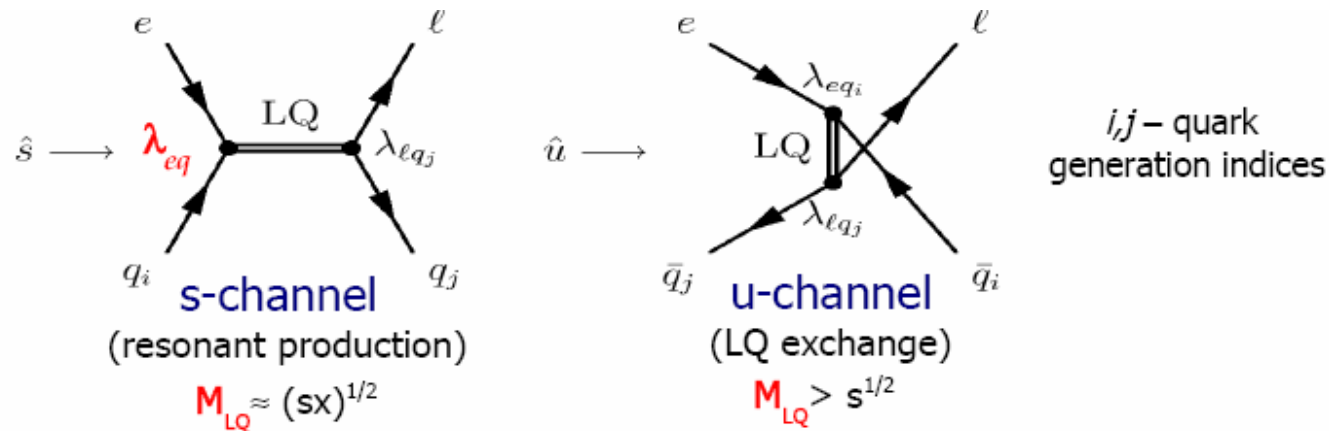
- Resonance width

$$\Gamma \sim \lambda^2 \cdot M_{LQ}$$

- Each LQ characterized by two free parameters:

- LQ mass, M_{LQ}
- LQ-l-q Yukawa coupling, λ

Leptoquarks at HERA

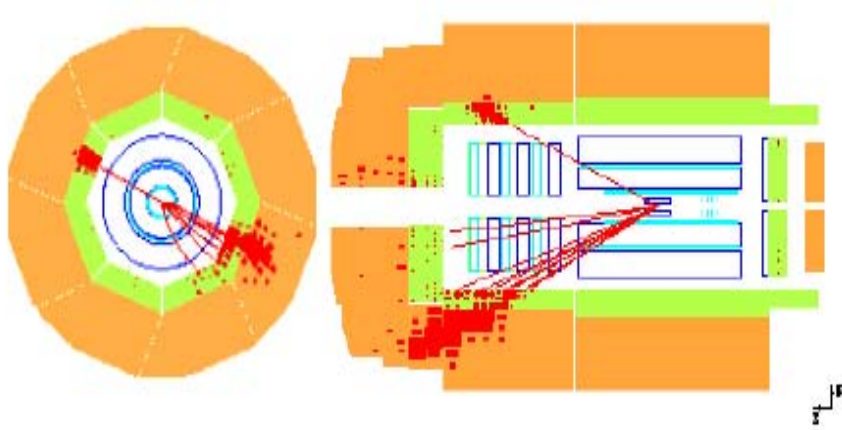


If $LQ \rightarrow eq$, Lepton Flavor Conserving (LFC) decays

If $LQ \rightarrow \mu q / \tau q$, Lepton Flavor Violating (LFV) decays

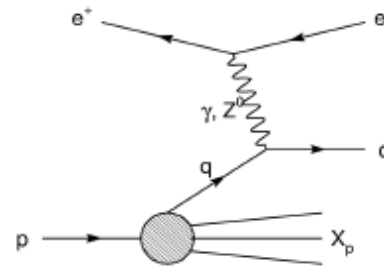
- resonant production in s-channel
- exchange in u-channel
- signature one jet & one l/ν
- final state indistinguishable from SM NC/CC DIS for 1st generation LQs (LFC)
- clear signal if we assume LFV

Search for first generation LQ at HERA



Neutral Current sample

Signature $ep \rightarrow eX$

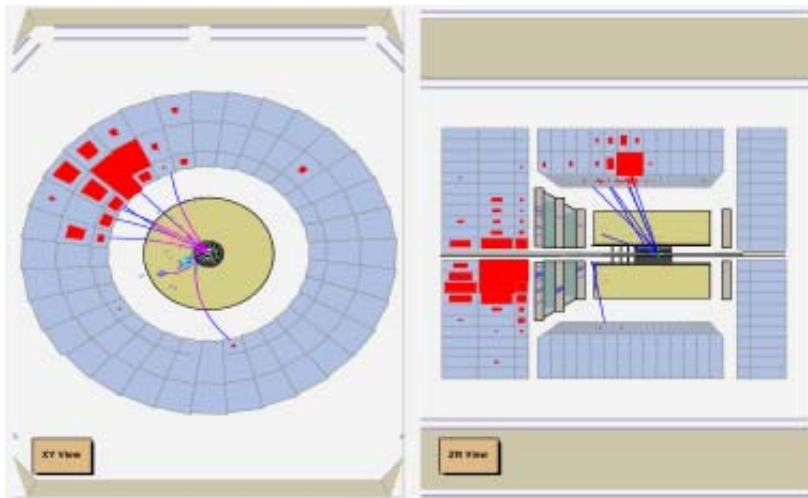


Selection

Isolated e, $E_e = 11 \text{ GeV}$

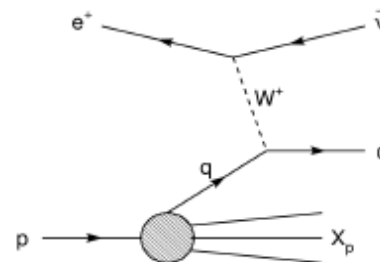
$Q^2 > 1000 \text{ GeV}^2$

$0.1 < y_e < 0.9$



Charged Current sample

Signature $ep \rightarrow \nu X$



Selection

$P_{T, \text{miss}} > 12 \text{ GeV}$

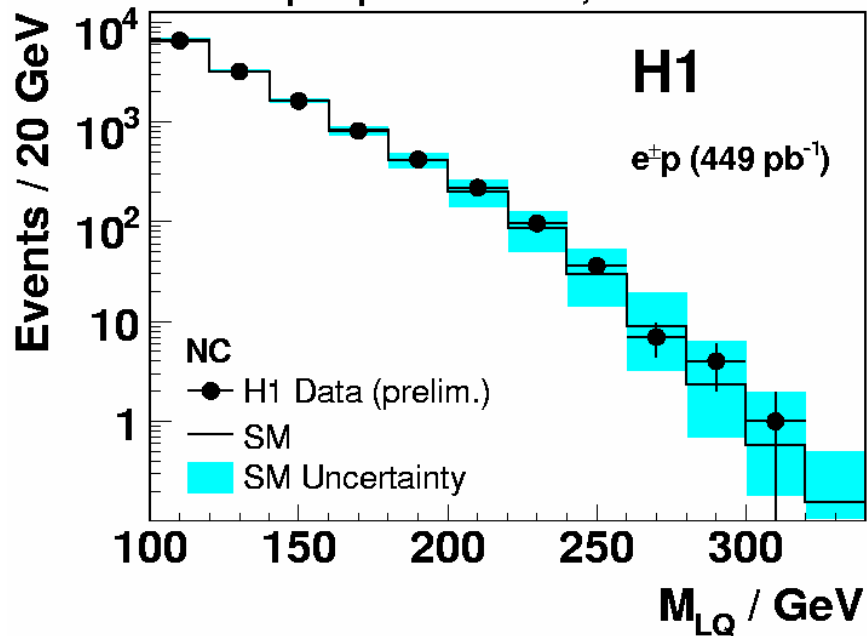
$Q^2 > 500 \text{ GeV}^2$

$0.1 < y_h < 0.9$

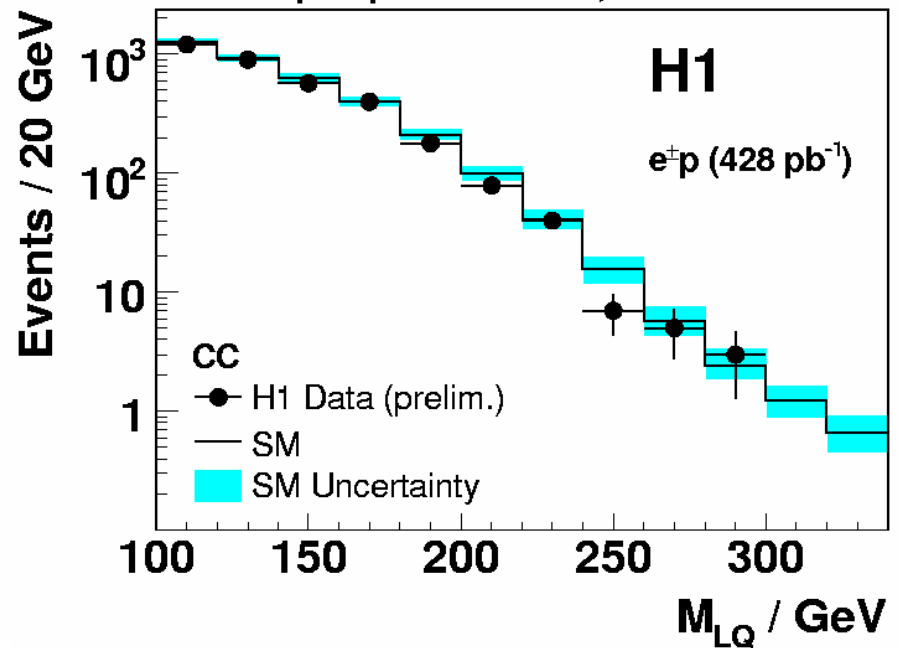
Search for first generation LQ at HERA

Complete H1 e^+p/e^-p data analysed, $L \sim 0.5 \text{ fb}^{-1}$

Leptoquark Search, HERA I+II

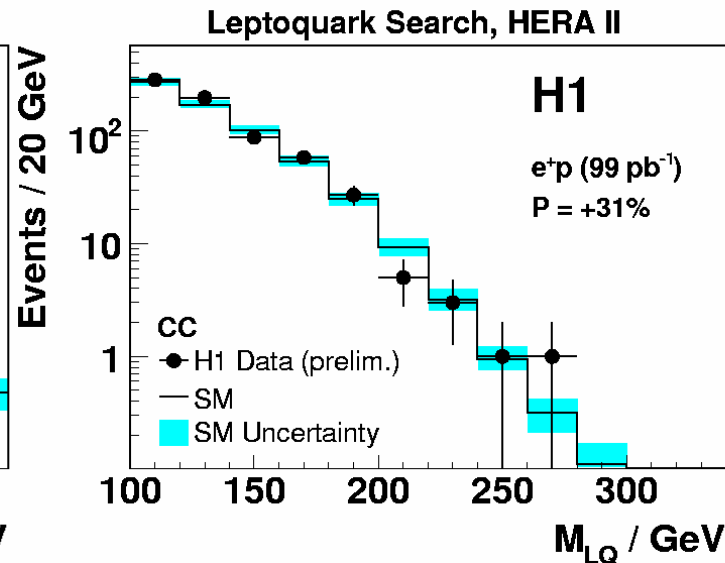
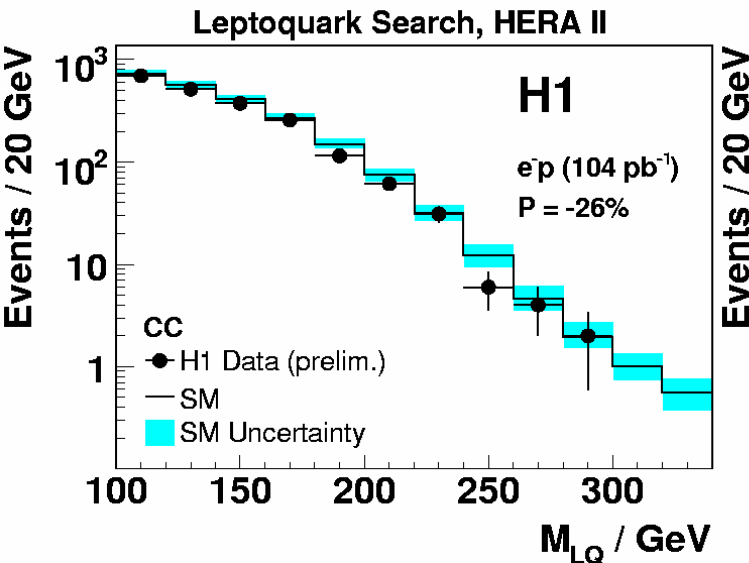
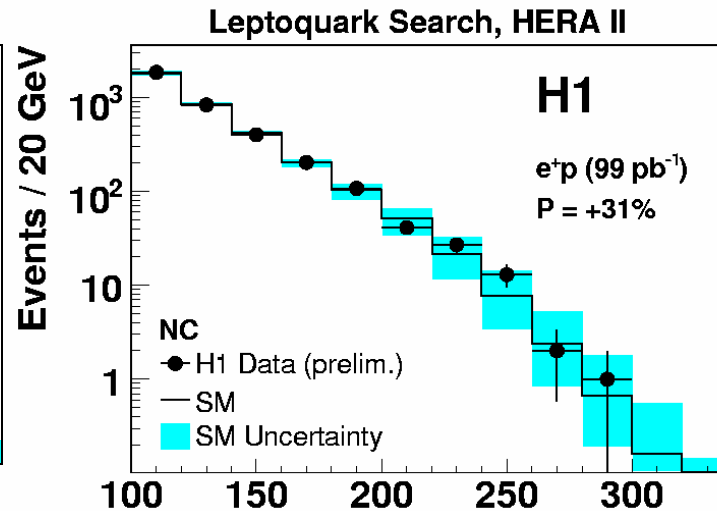
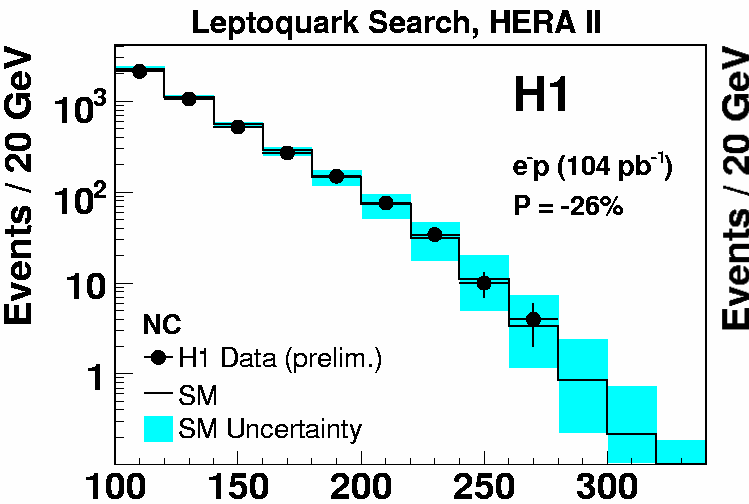


Leptoquark Search, HERA I+II



Good description of data by SM prediction

Search for first generation LQ at HERA

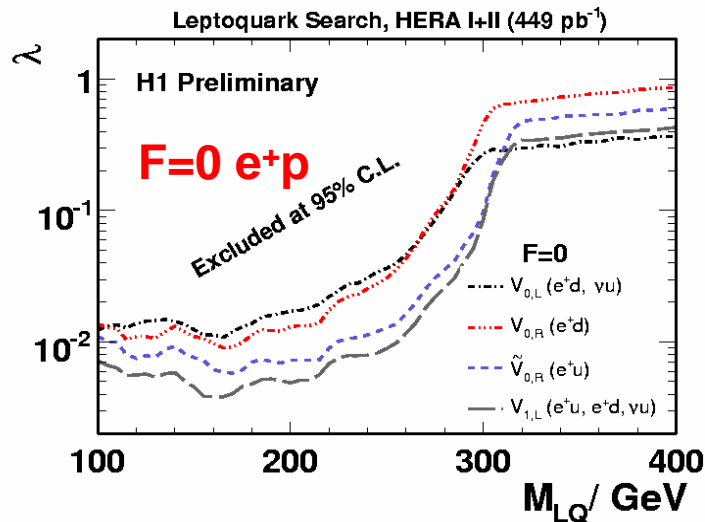
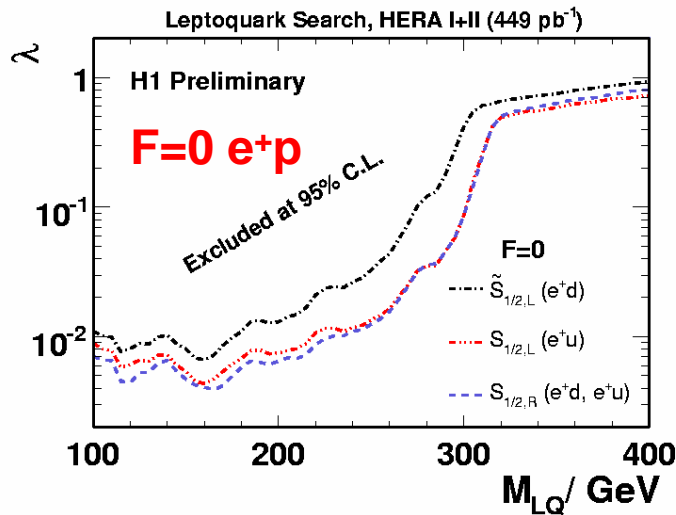


- Data analysed taking into account the different polarization periods

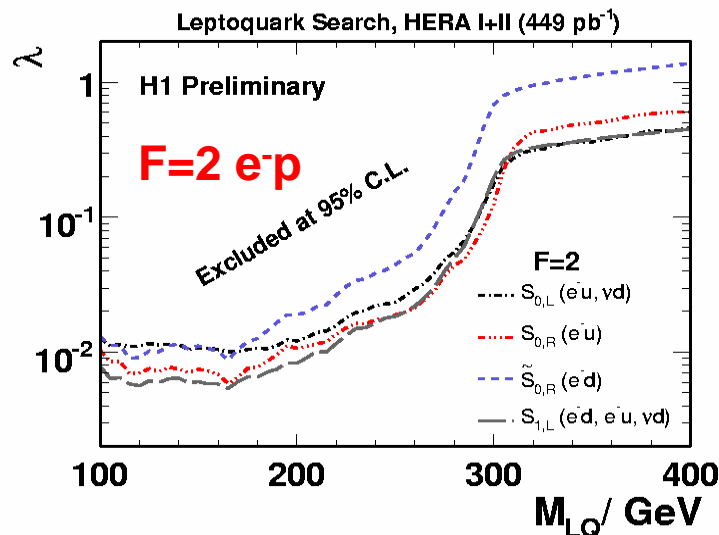
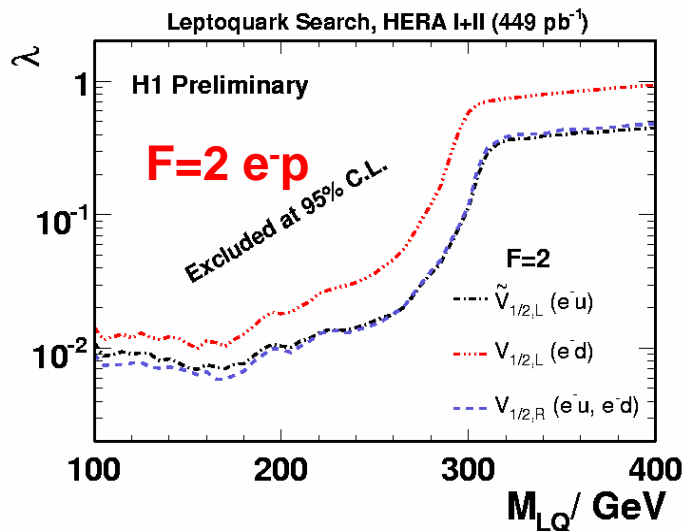
- No evidence for signal → interpretation in terms of exclusion limits

Search for first generation LQ at HERA

Limits on Yukawa coupling λ as a function of M_{LQ}

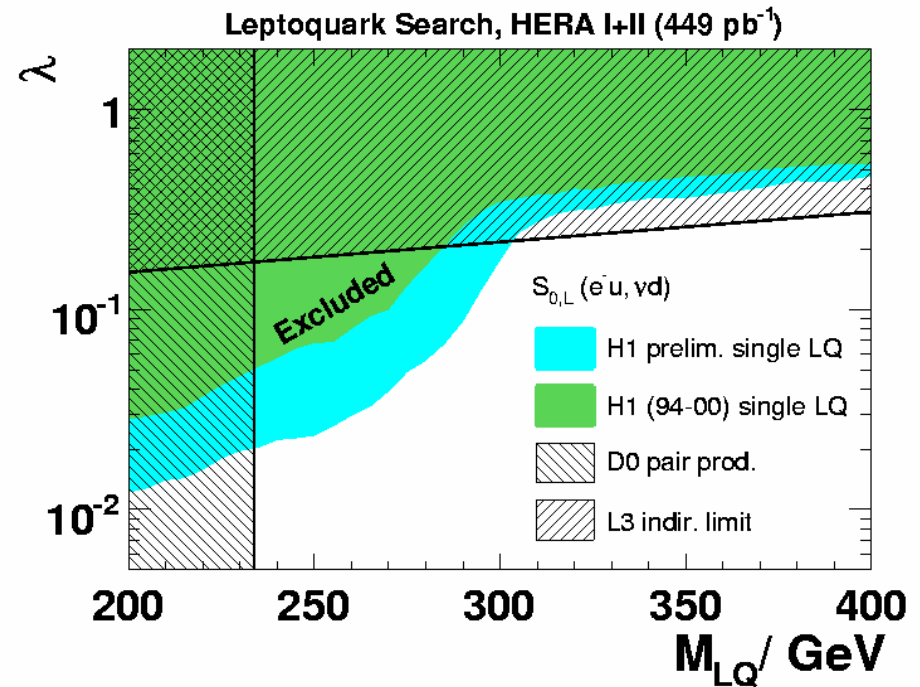
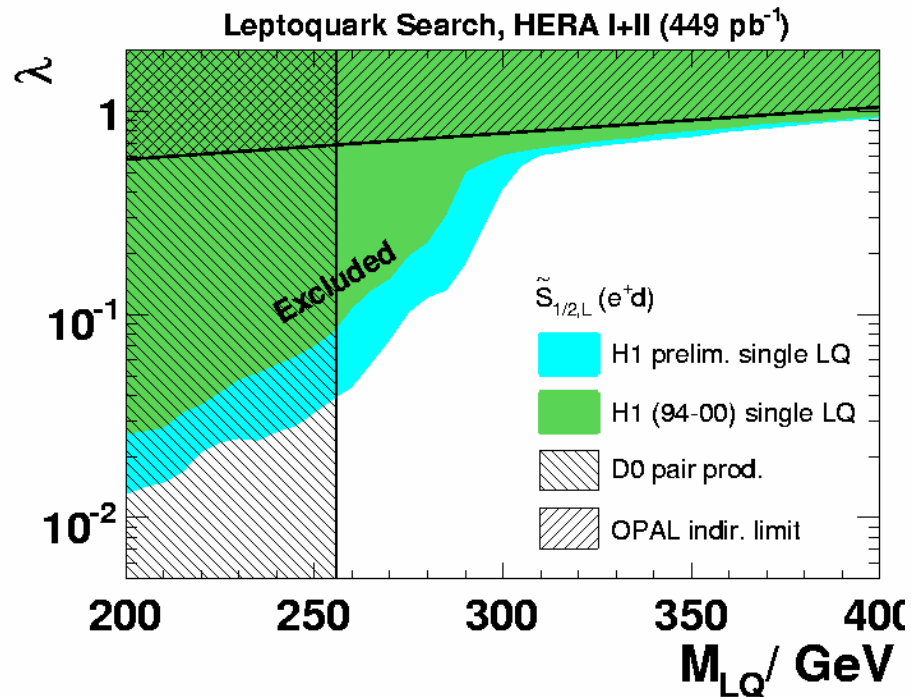


- $M < 300$ GeV resonant production, strong limits
- $M > 300$ GeV u-channel



For electromagnetic strength $\lambda=0.3$
 $M_{LQ} < 291-330$ GeV
 can be ruled out

Comparison with LEP&Tevatron



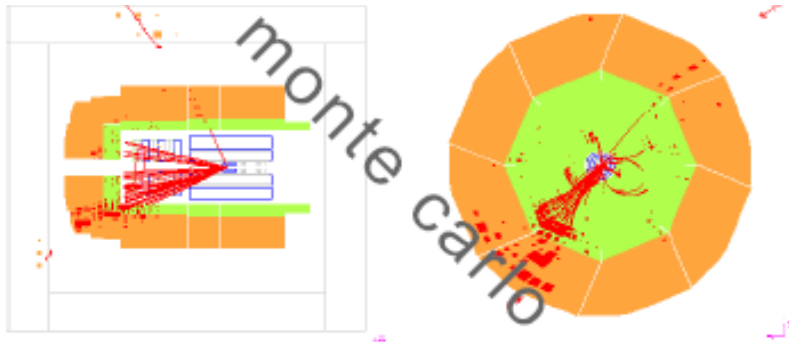
LEP (OPAL, L3) : indirect constraints from $e^+e^- \rightarrow qq$

TEVATRON (D0) : qq annihilation or gg fusion (pair production), limit independent of λ

HERA extends the excluded domain

Search for Lepton Flavor Violation

LFV can be mediated by leptoquarks assuming the outgoing lepton is a muon or a tau (instead of electron)



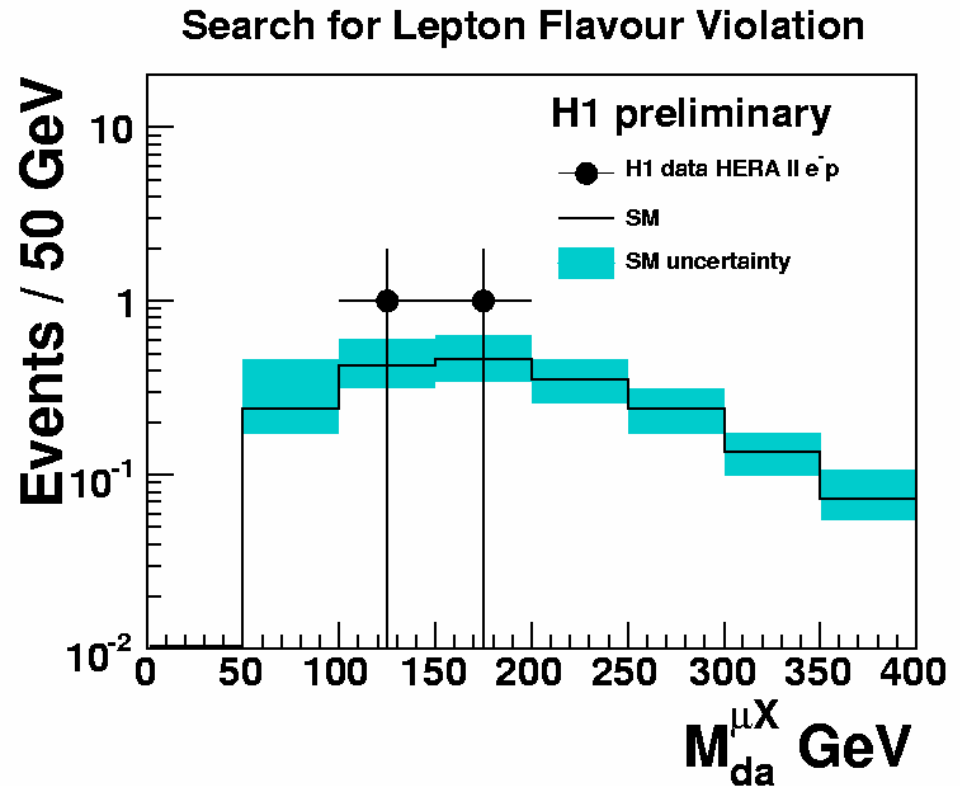
Signature $ep \rightarrow \mu X$

Selection

Isolated muon

$P_{T, \text{calo}} > 20 \text{ GeV}$

back to back topology

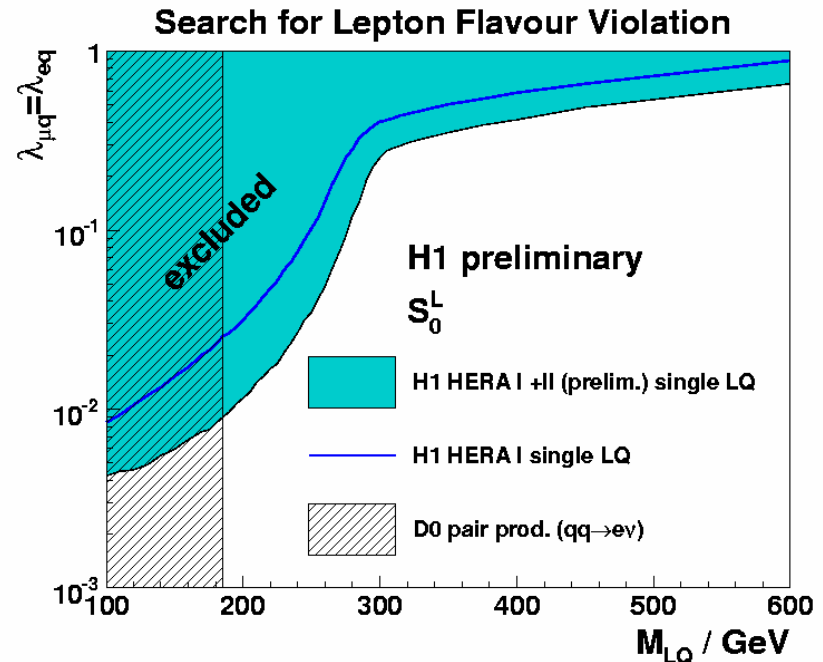
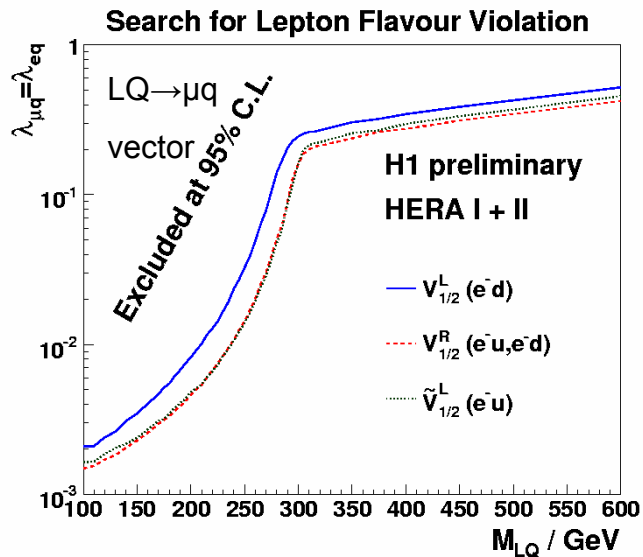
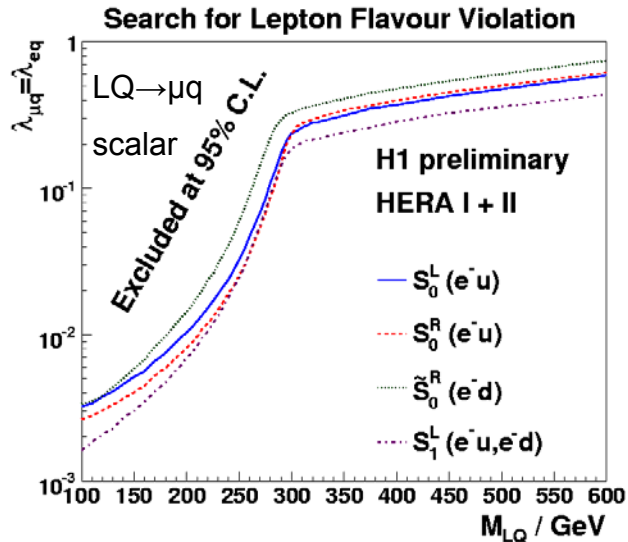
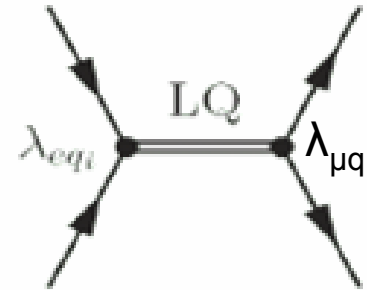


HERA II e^-p sample

2 events seen/ 2.2 ± 0.6 expected

Search for Lepton Flavor Violation

Limits on Yukawa coupling λ ,
assuming $\lambda_{eq} = \lambda_{\mu q}$



HERA II e-p : 10 times more luminosity
than HERA I

Summary

- HERA offers a unique possibility to search for resonant production of new particles coupling directly to a lepton and a parton (leptoquarks)
- Results on leptoquark decays are updated by H1 experiment including HERA II (polarised) data
 - LFC LQs : The complete data collected by H1 analysed
 - LFV LQs : New results based on HERA II e-p sample published
 - ✓No significant sign of new physics found with respect of SM prediction
 - ✓Stricter limits are set on all LQs types, comparing to LEP, TEVATRON analysis
- Stricter limits will be obtained soon combining H1 and ZEUS data