



Searches for Contact Interactions and First Generation Leptoquarks at H1

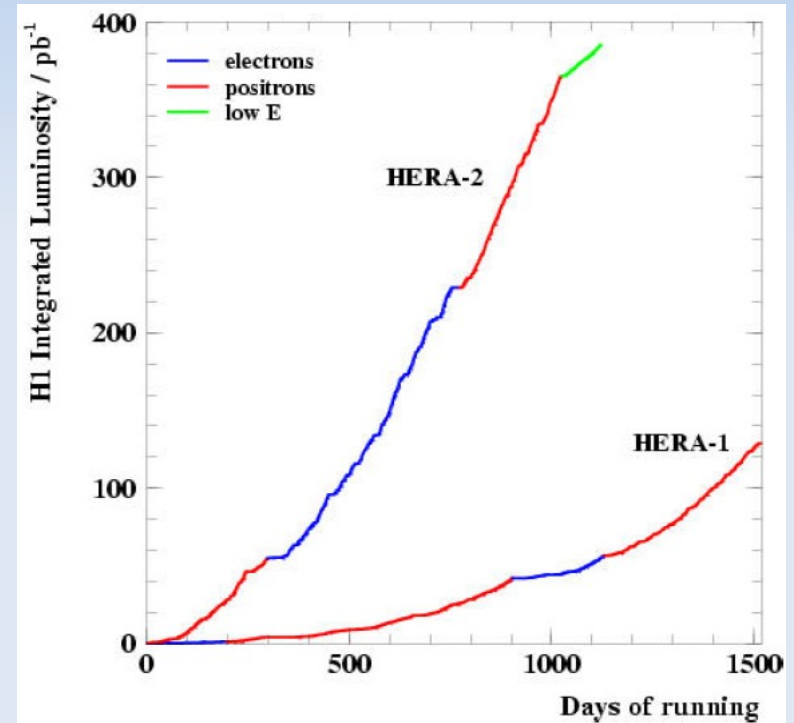
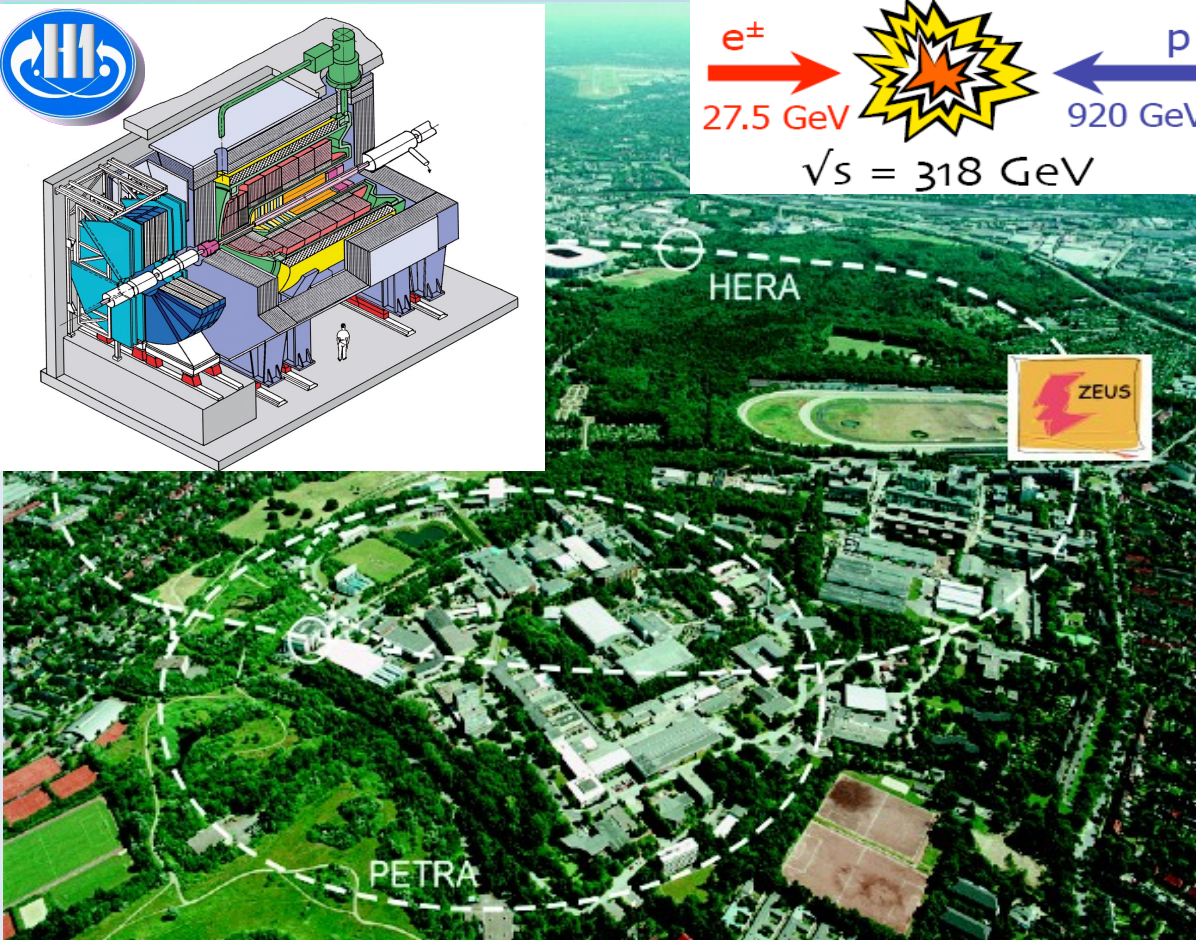
*Hayk Pirumov (PI Heidelberg)
On behalf of the H1 Collaboration*

Outline:

- HERA Collider
- Search for Contact Interactions (CI)
- First Generation Leptoquarks(LQ)
- Summary

The HERA Collider

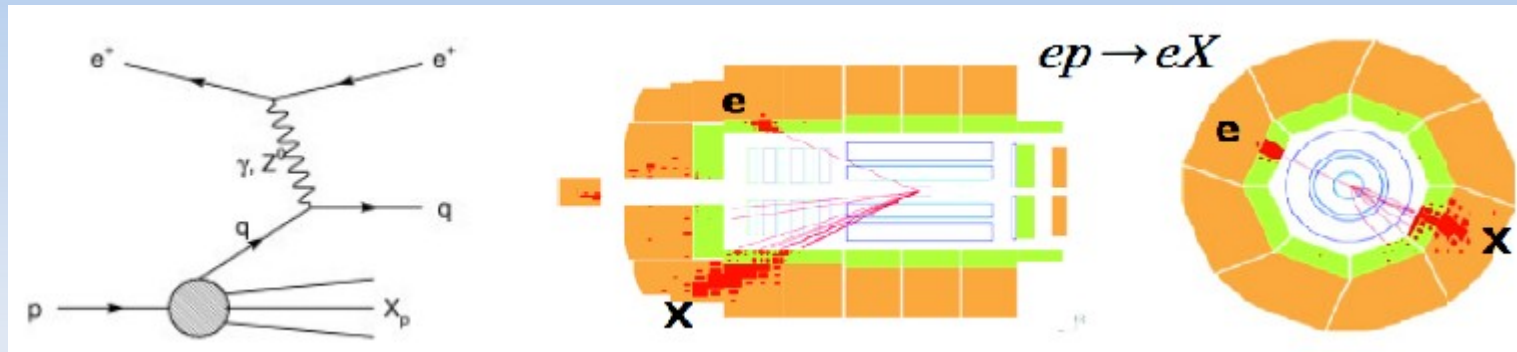
- World's only electron proton collider, at DESY, Hamburg.
- HERA I (1992 – 2000): $\sim 130 \text{ pb}^{-1}$ / exp, mainly e^+p .
- HERA II (2003 – 2007): lumi upgrade, longitudinally polarized lepton.



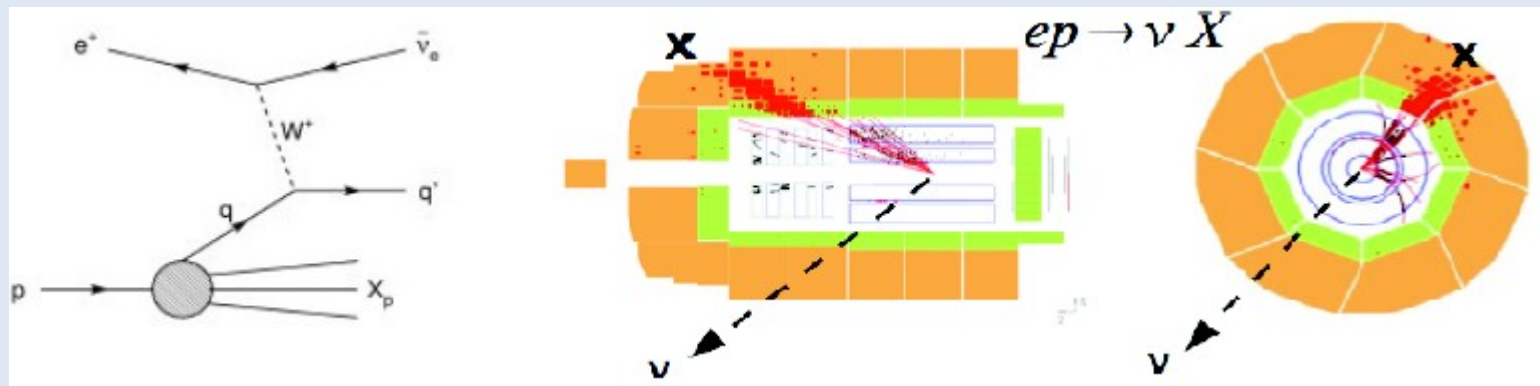
- H1 multipurpose detector operated 1992 - 2007.
- Collected about 0.5 fb^{-1} of data.

Deep Inelastic ep Scattering

Neutral Current (NC)



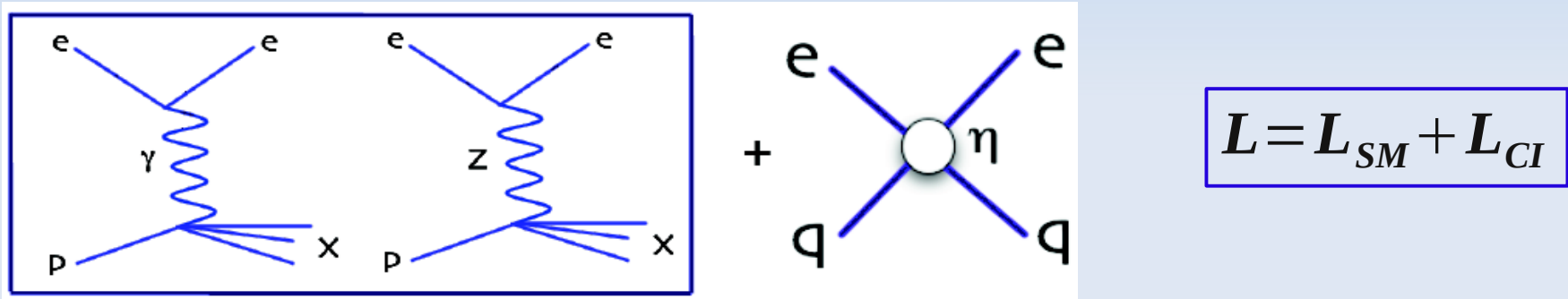
Charged Current (CC)



- NC and CC data are investigated for deviations from Standard Model predictions

Contact Interactions

- Possible new interactions between e and q could modify the DIS cross section at high Q^2 via virtual effects.
- Four-fermion $eeqq$ contact interactions (CI)** → convenient method to investigate the interference of new fields.



- Effective Lagrangian for neutral current vector-like contact interactions:

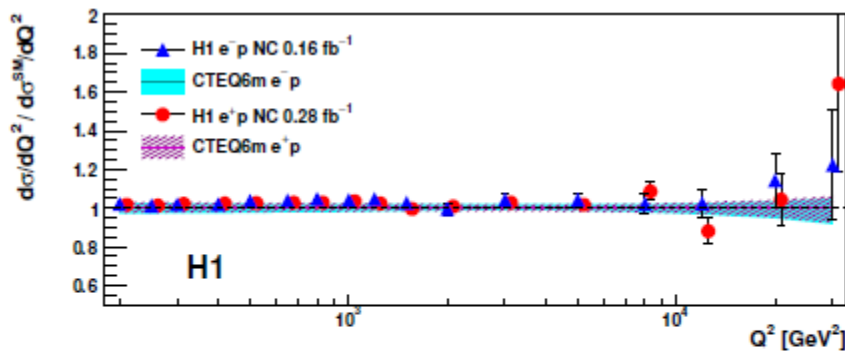
$$L_{CI} = \sum_{i,j=L,R} \eta_{ij}^{eq} (\bar{e}_i \gamma_\mu e_i) (\bar{q}_j \gamma^\mu q_j)$$

4 possible couplings for each q flavor

- Various models can be constructed by appropriate choice of the coupling η

Search for Contact Interactions at HERA

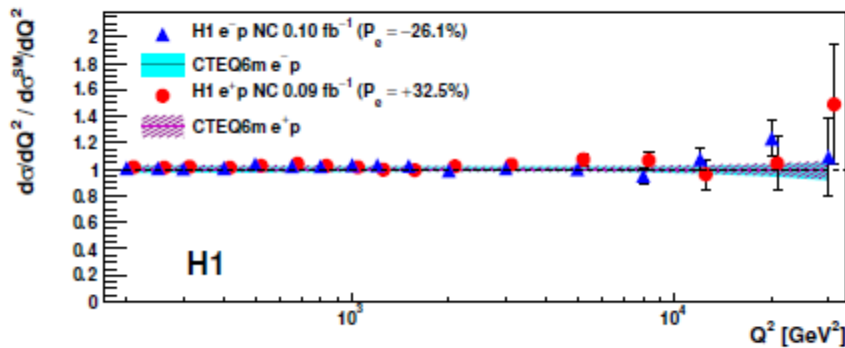
Phys. Lett. B 705 (2011) 52-58



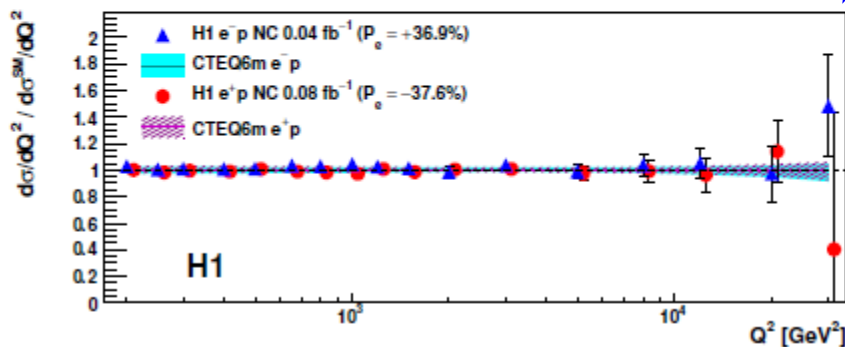
- H1 NC cross section measurements are well described by Standard Model.

◆ H1 HERA I, unpolarized

◆ H1 HERA II, polarized



- Full HERA neutral current data (0.44 fb⁻¹) are used to set constraints at 95% CL on various CI models.



Search for Contact Interactions at HERA

Phys. Lett. B 705 (2011) 52-58

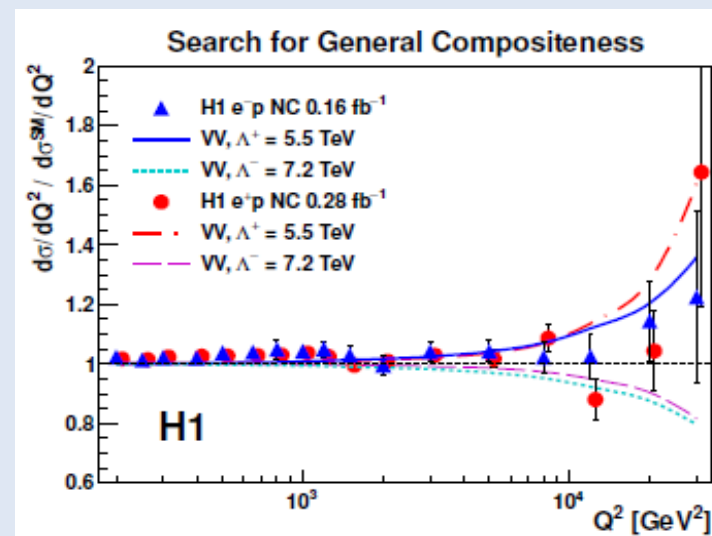
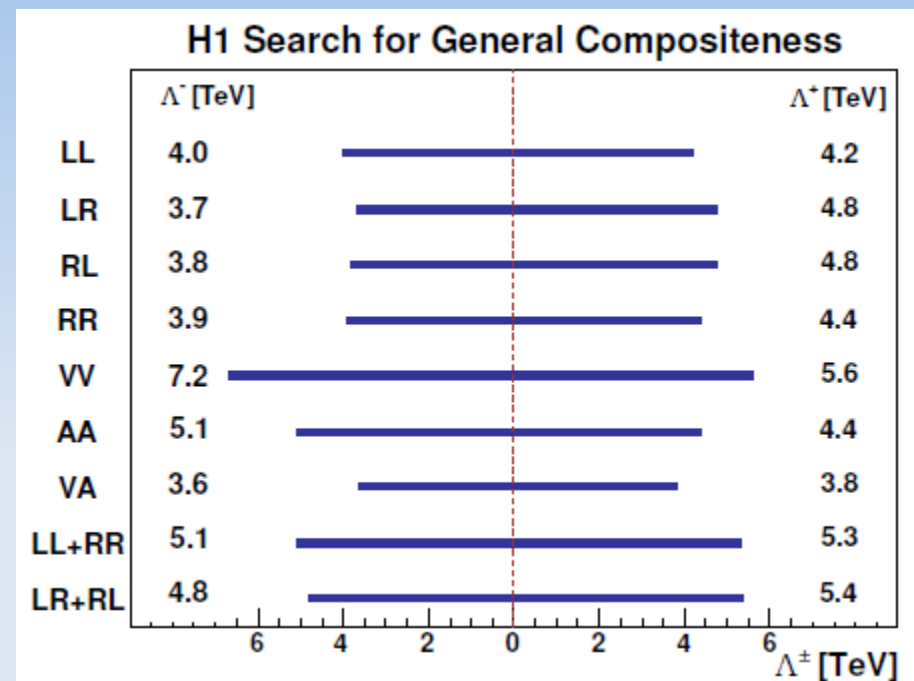
General Compositeness

- CI couplings related to the mass scale:

$$\eta_{ab}^{eq} = \frac{\pm 4\pi}{\Lambda^2}$$

- Different models assume different helicity structure of new interactions, given by a set of η couplings
- Limit on effective mass scale:

$$\Lambda > 3.2 - 7.2 \text{ TeV}$$



Search for Contact Interactions at HERA

Phys. Lett. B 705 (2011) 52-58

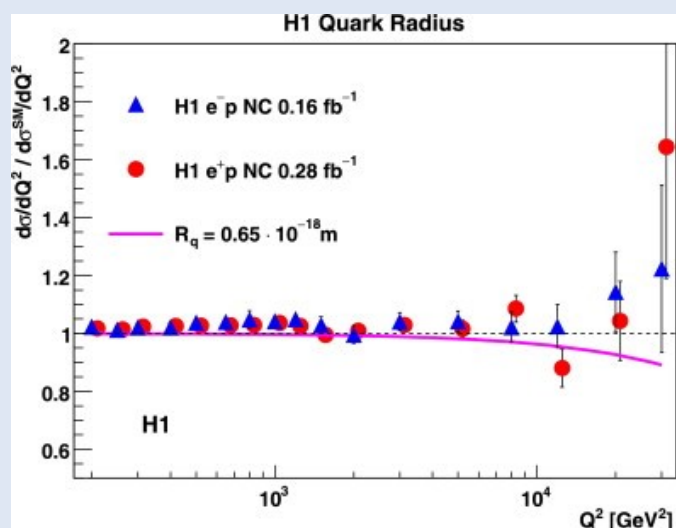
Quark Radius

- Assuming spatial distribution of the electroweak charge of quark:

$$\frac{d\sigma}{dQ^2} = \frac{d\sigma_{SM}}{dQ^2} \cdot \left(1 - \frac{R^2}{6} \cdot Q^2\right)^2$$

- Upper limit on quark radius:

$$R < 0.65 \cdot 10^{-18} \text{ m}$$



DIS2012 , March 27

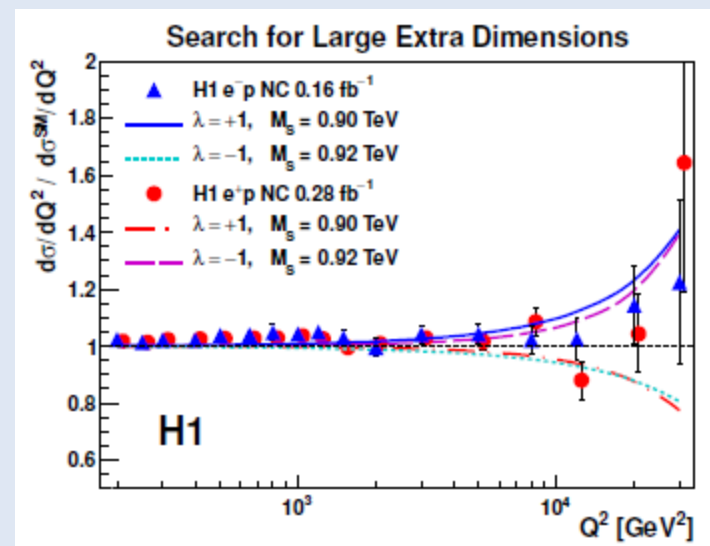
Large Extra Dimensions

- ADD model: 4+n dimensions.
- Effective CI type coupling with scale M_s :

$$\eta_G \sim \lambda / M_s^4$$

- Lower limit on gravitational scale:

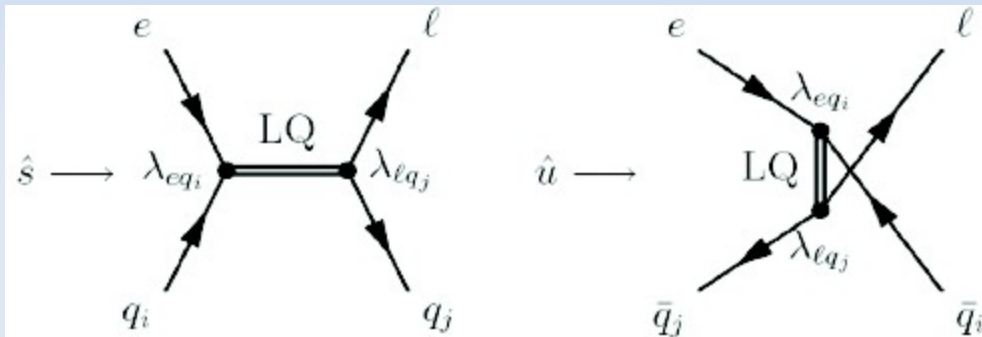
$$M_s > 0.90 - 0.91 \text{ TeV}$$



Hayk Pirumov

Leptoquarks at HERA

- Leptoquarks (**LQ**), compound states of leptons and quarks
Fermion number $F = L+3B$ $F = 2 (e^-p)$ $F = 0 (e^+p)$
- Buchmüller-Rückl-Wyler** framework: 14 different types (7 scalar, 7 vector)
- LQ at HERA:



1st gen: $eq \rightarrow LQ \rightarrow e(\nu)q$ (*Phys. Lett. B* 704 (2011) 388-396)

2nd gen: $eq \rightarrow LQ \rightarrow \mu(\nu)q$ (*DESY 11-044*)

3rd gen: $eq \rightarrow LQ \rightarrow \tau(\nu)q$ (*DESY 11-044*)

s-channel:
(resonant production)

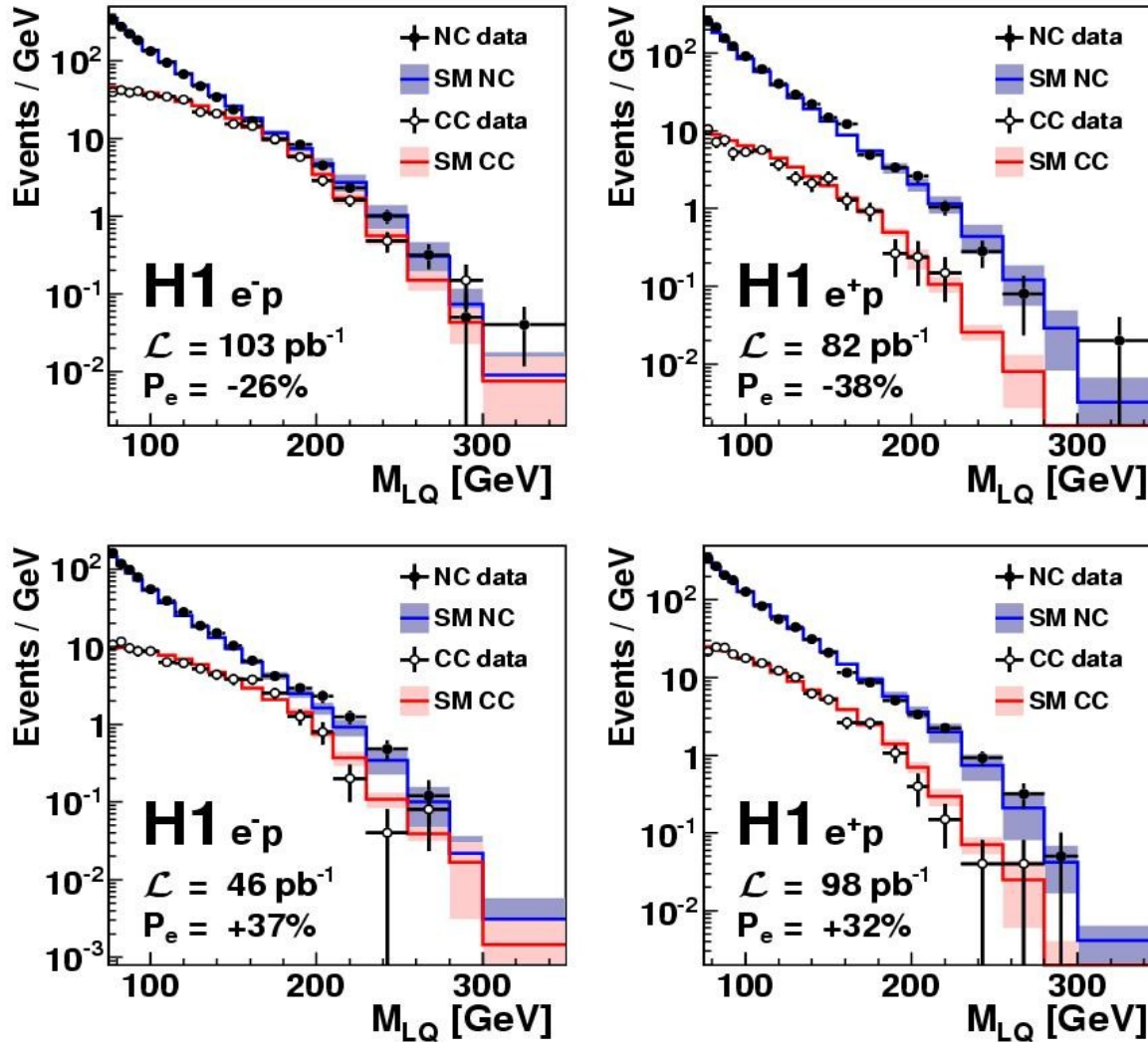
u-channel:
(LQ exchange)

- Signature is similar to NC or CC DIS.
- Leptoquarks are chiral particles → additional sensitivity at HERA due to polarised lepton beam

Search for First Generation LQs

Phys. Lett. B 704 (2011) 388-396

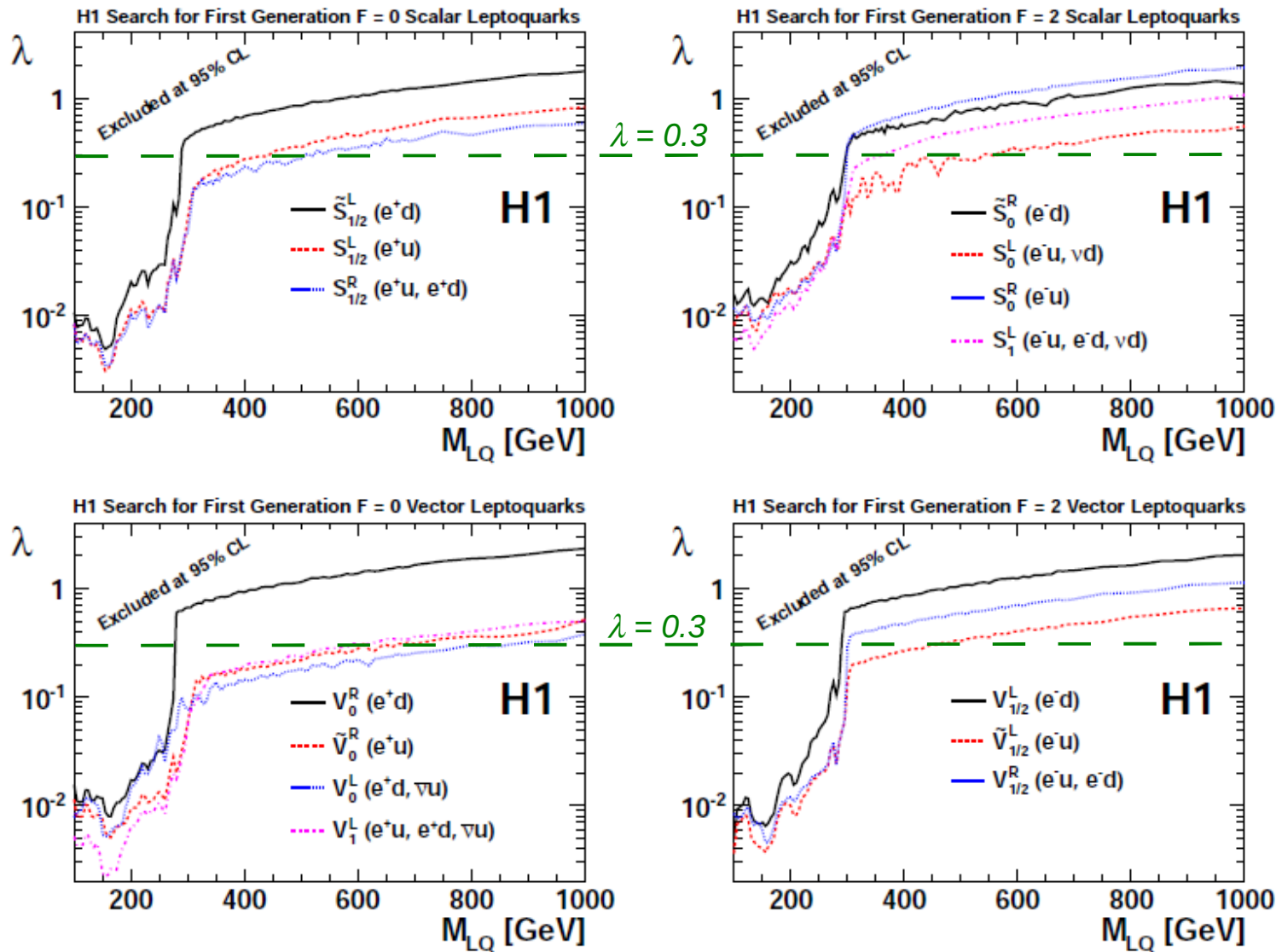
H1 Search for First Generation Leptoquarks



- Full HERA NC and CC data were analyzed by H1.
- No evidence for LQ signal found \rightarrow results are interpreted in terms of exclusion limits.

Search for First Generation LQs

Phys. Lett. B 704 (2011) 388-396

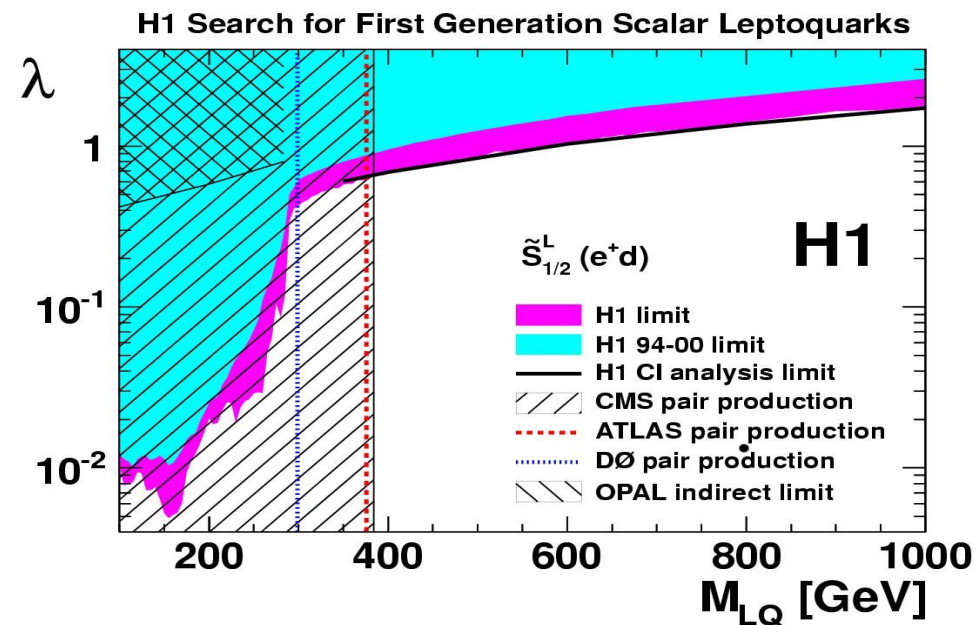
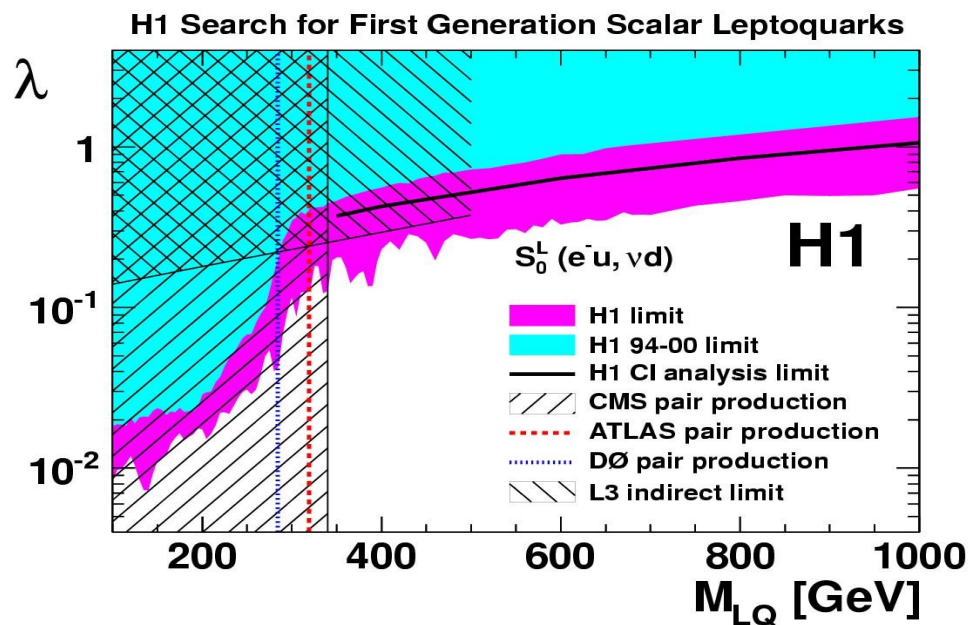


- The exclusion ranges for scalar and vector type leptoquarks from H1.
- $eq \rightarrow LQ \rightarrow e(\nu)q$ excluded by H1 up to 800 GeV for $\lambda = 0.3$ (EM coupling strength).

Search for First Generation LQs

Phys. Lett. B 704 (2011) 388-396

- The exclusion ranges for two scalar type leptoquarks compared to results from different experiments.
- Limit obtained from H1 CI analysis is also indicated at the plots



Summary

- Searches based on the full HERA data performed by the H1 collaboration.
- Data show **good agreement** with the Standard Model predictions.
- Exclusion limits at 95% *CL* are determined for
 - **Compositeness (3.2 - 7.2 TeV)**
 - **Large Extra dimensions (0.91 TeV)**
 - **Quark Radius ($0.65 \cdot 10^{-18}$ m)**
 - **First Generation LQs (up to 800 GeV)**
- HERA provides limits **competitive** with the rest of the world.