Contact Interaction Studies in H1 at HERA

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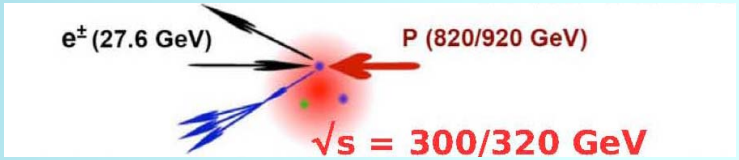
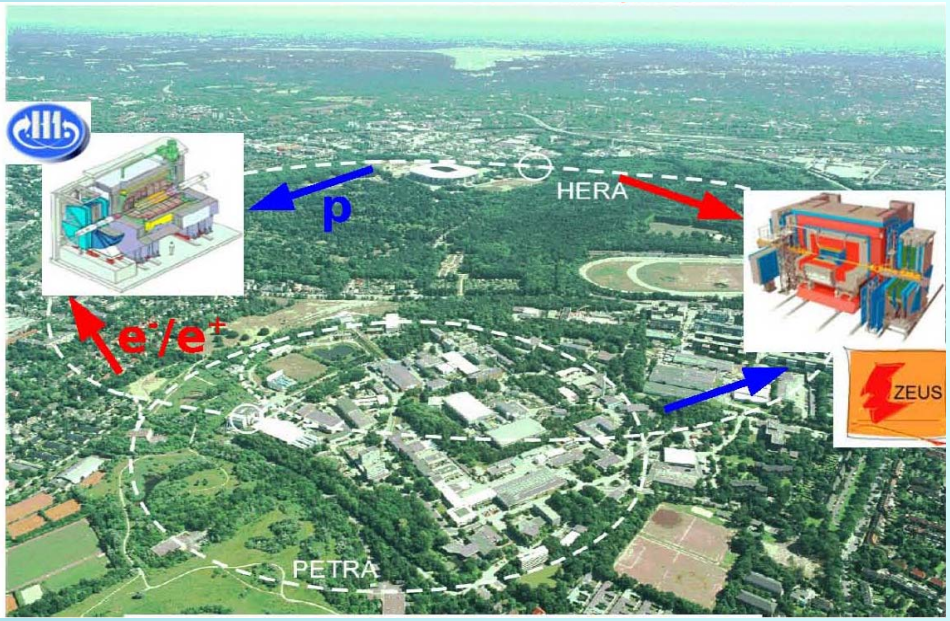
Finite Quark Radius Model

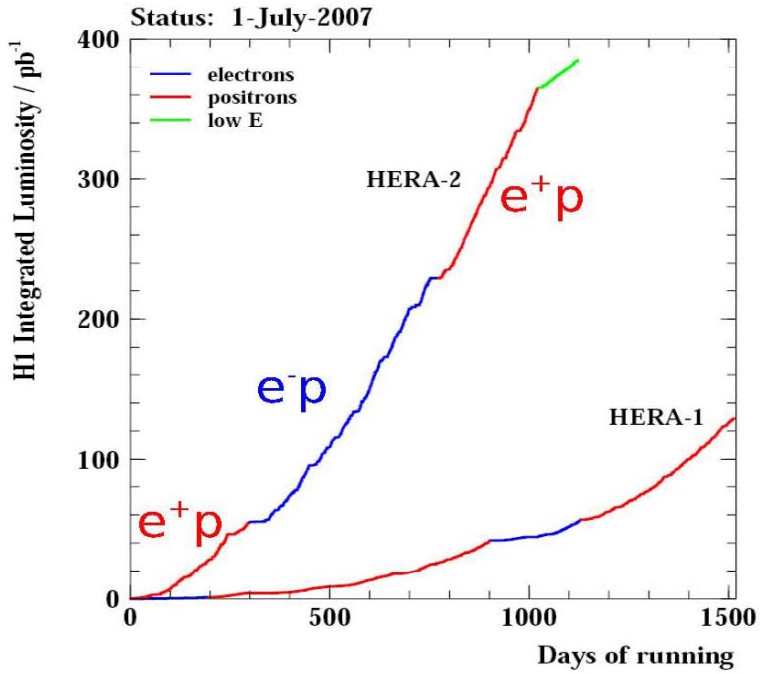
Topics:

- HERA Physics
- Contact interactions: Finite quark radius model
- Previous limits
- Results
- Conclusions & Plans

The HERA Collider







HERA I: 1992-2000, **L ~ 120 pb^{-1}**

HERA II: 2003-2007, **L ~ 360 pb^{-1}**

luminosity upgrade and polarized lepton beams

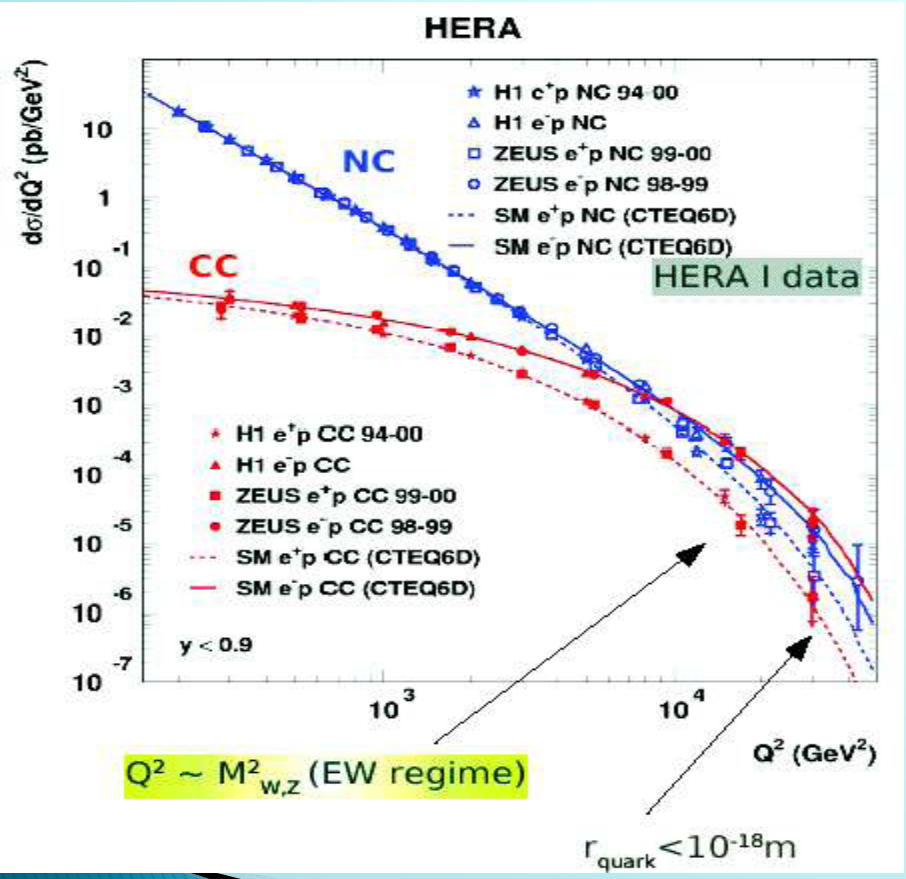
~10 x more e-p data than in HERA I

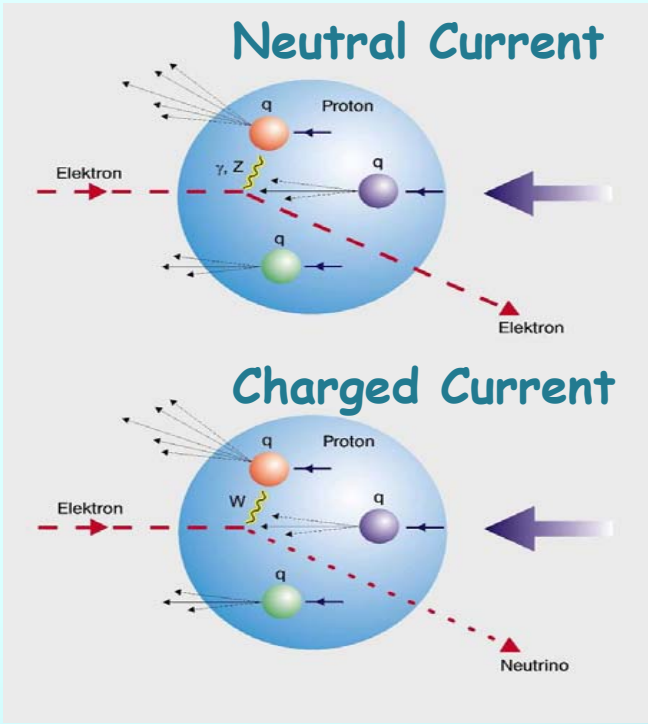
HERA's operation ended on July 2007

In total H1 & ZEUS together accumulated: ~ 1fb^{-1}

The HERA Physics

- **measure** the structure of the proton
- **study** fundamental interactions between particles
- **search** for physics beyond the Standard Model of the elementary particles





- the neutral current cross-section is compared to that of the charged current.
- the two cross-sections become about the same at the scale of $Q^2 \approx 10^4$ GeV^2 giving an explicit demonstration of the electro-weak unification.

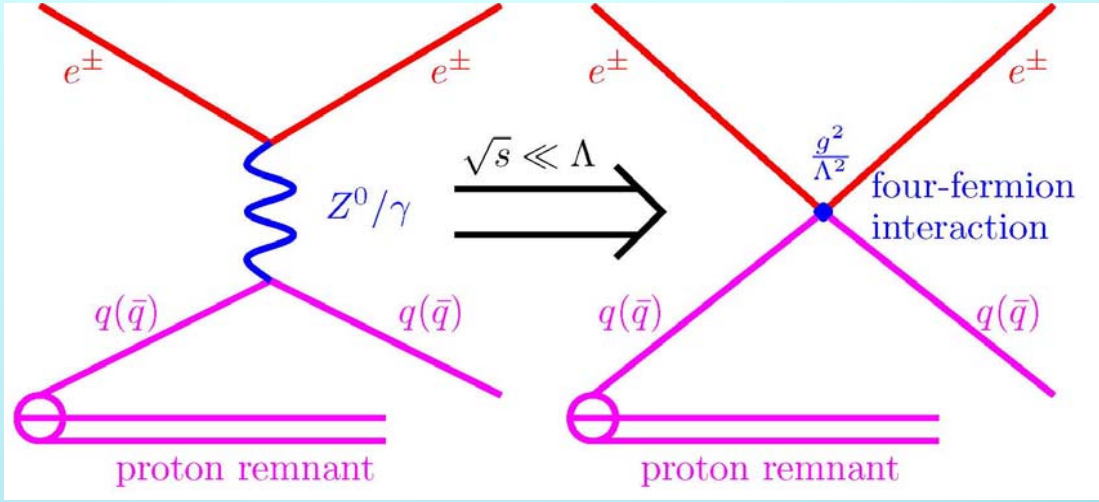
Hints for New Physics at HERA

1. **Model dependent searches for new particles**
   Test models and verify predicted signatures;
   if non-observation: limits set
   - Leptoquarks
   - **Excited Fermions**
   - Single Top Quark
   - **Contact Interactions**
   - R_p - violating SUSY

2. **Model independent searches for new physics**
   Compare data vs. SM, reveal anomalies above small SM contribution
   - W Production ($W \rightarrow e, \mu$)
   - Isolated Tau Events with missing P_T
   - Multi-Lepton Final States
   - **A General Search**

Contact Interactions

- Contact interaction formalism allows for indirect searches of physics beyond SM at large scales $\Lambda >> \sqrt{s}$
- Four-fermion eeqq contact interactions → convenient method to investigate the interference of any new particle field associated to large scales with γ and Z fields of the Standard Model
- General models considered:
  - **Finite Quark Radius Model**
  - Compositeness
  - Heavy Leptoquarks
  - Large Extra Dimensions
- To study contact interaction models the process $e^{\pm}p \rightarrow e^{\pm}X$ is investigated
- No significant deviation from the SM is found
- Limits on the relevant parameters of these models are derived



Finite Quark Radius Model

- simplest model on physics beyond the standard model: Quark Radius
- "classical" method to look for possible fermion (sub)structures
- the differential cross section is modified by introducing electron and quark form factors:

$$\frac{d\sigma}{dQ^2} = \frac{d\sigma^{SM}}{dQ^2} f_e^2(Q^2) f_q^2(Q^2)$$

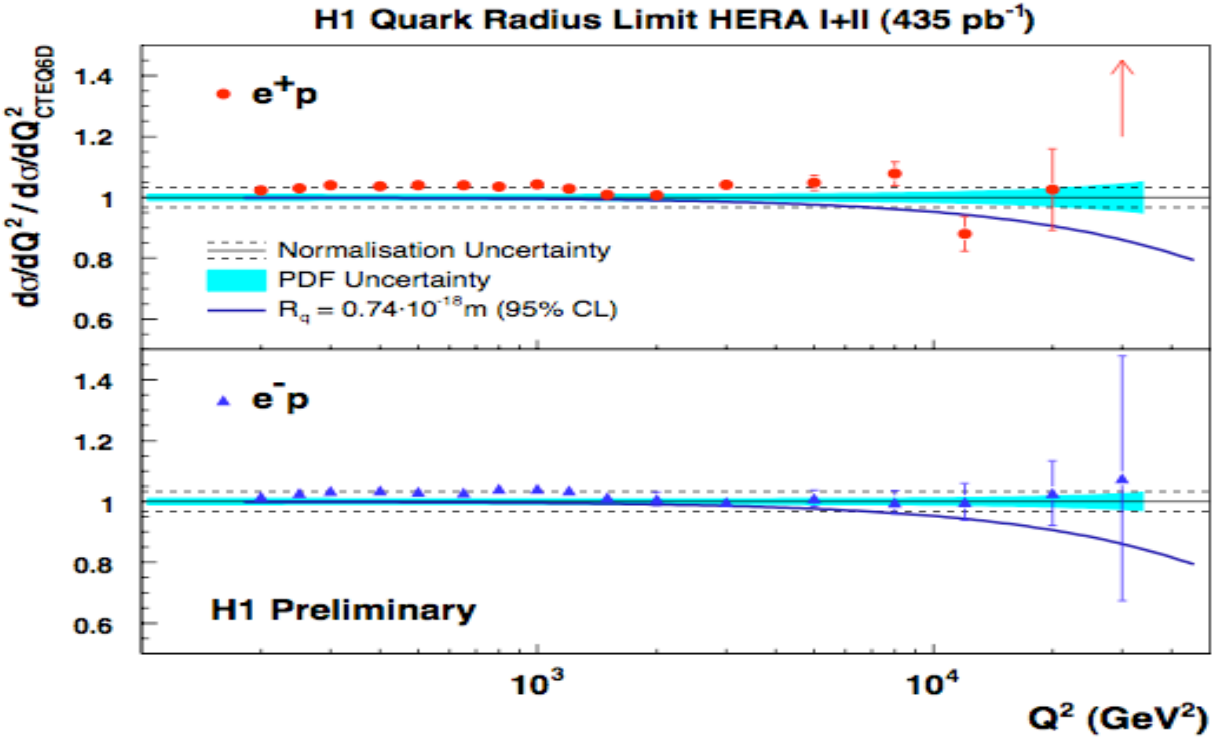
- point-like electrons $f_e \equiv 1$
- introduce classical form factors for non point-like quark:

$$f_q(Q^2) = 1 - \frac{1}{6} R_q{}^2 Q^2$$

R_q is the RMS radius of the EW charge distribution of the quark

- if a quark has finite size→the cross section decreases at high momentum transfer

Finite Quark Radius Model



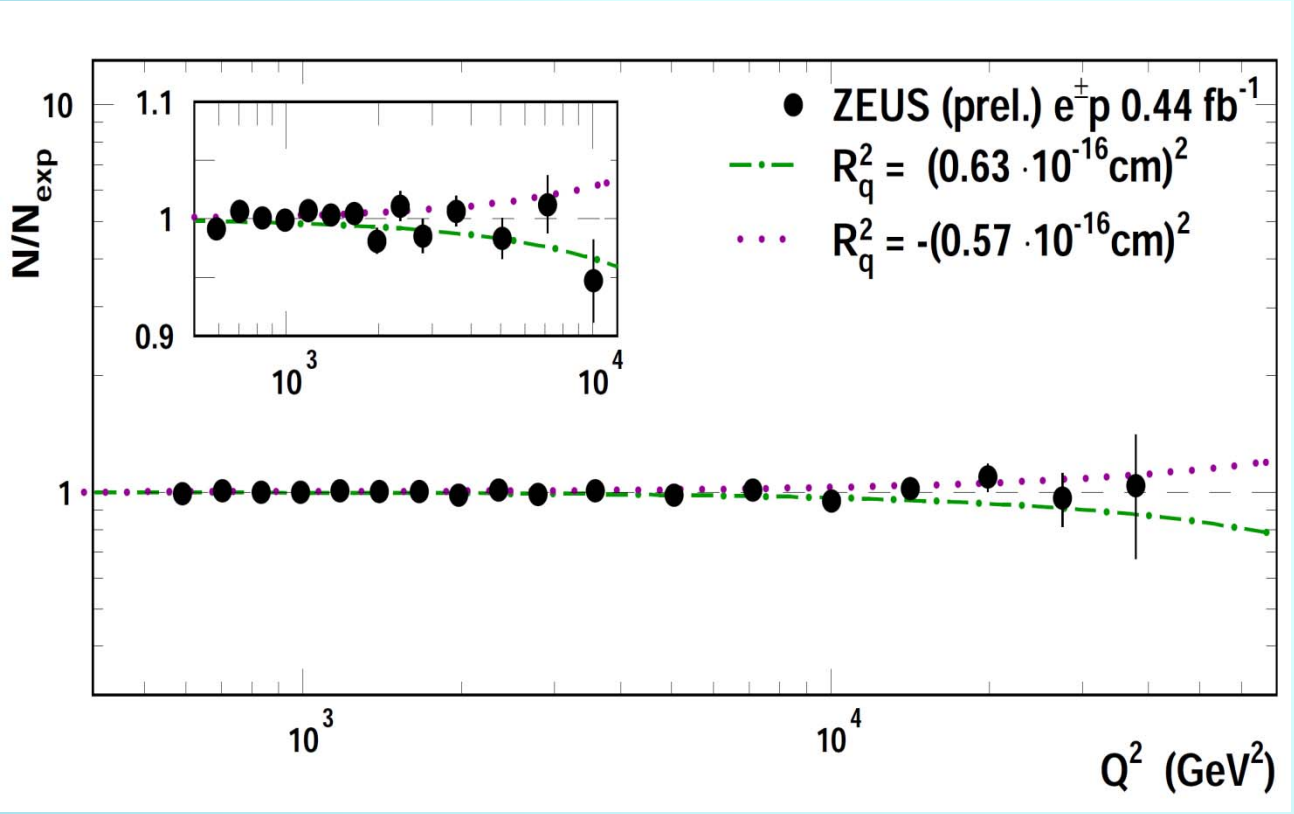
H1prelim-07-141

limits

$R_q < 0.74 \times 10^{-16}$ cm
(H1 Preliminary)

The NC cross section $d\sigma/dQ^2$ normalized to the Standard Model expectation determined from CTEQ6D for e^+p and e^-p scattering. The curves represent the corrections to the SM prediction due to a hypothetical finite quark radius of $0.74 \cdot 10^{-18}$m, the 95% CL exclusion limit obtained from a combined form factor analysis of the data.

Finite Quark Radius Model



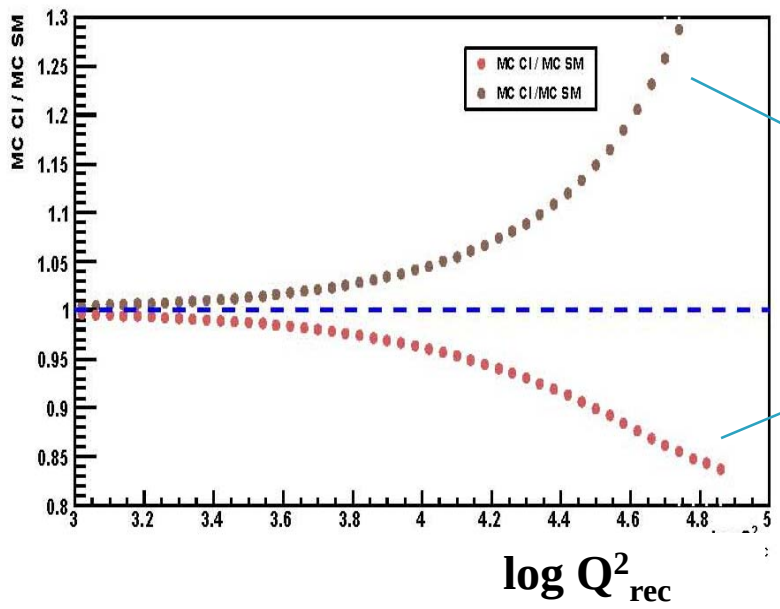
ZEUSprelim-09-013

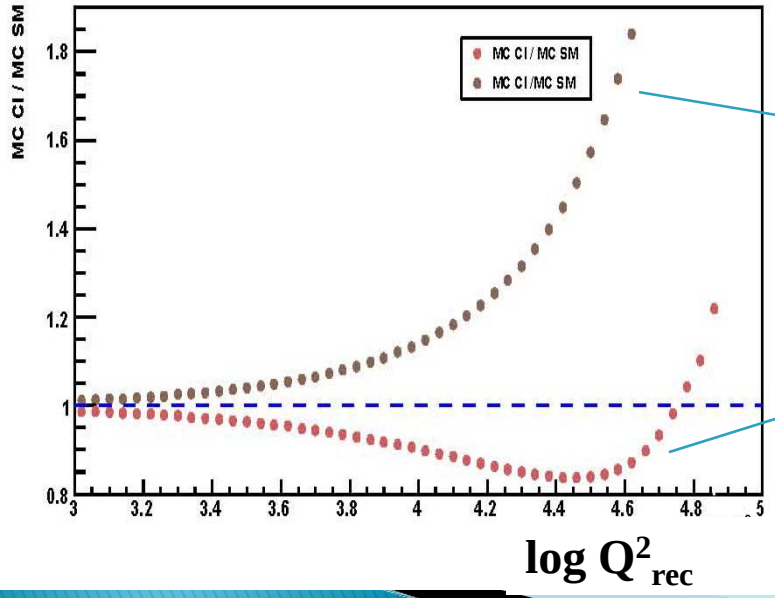
limits

$R_q < 0.63 \times 10^{-16}$ cm
(ZEUS Preliminary)

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 compared to the Standard Model expectations calculated using the CTEQ5D parton distributions.

Finite Quark Radius Model





The Q^2 dependence of the squared quark form factor

$R_q^2 = -(0.7 \times 10^{-18})^2\ m^2$

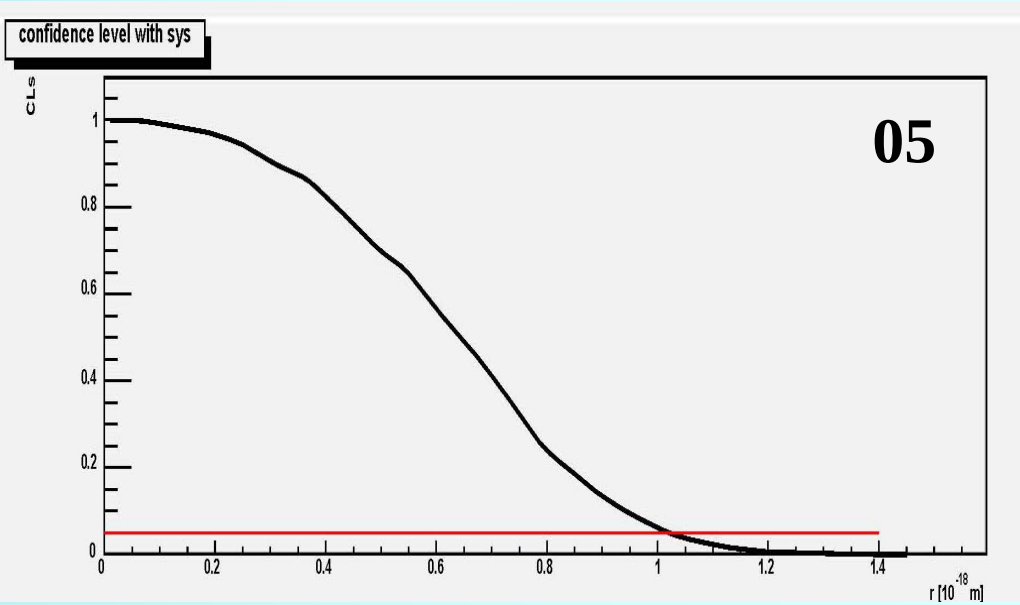
$R_q^2 = (0.7 \times 10^{-18})^2\ m^2$

$$f_q^{\,2}(Q^2) = \left(1 - \frac{1}{6} R_q^{\,2} Q^2\right)^2$$

$R_q^2 = -(1.2 \times 10^{-18})^2\ m^2$

$R_q^2 = (1.2 \times 10^{-18})^2\ m^2$

Finite Quark Radius Model



Assuming the electron to be point-like ($R_e = 0$), the 95% C.L. upper limit on the effective quark-charge radius of

$$R_q < 1.02 \times 10^{-18} \text{ m}$$

Summary & Outlook

- The NC selection was implemented
- Quark radius limit obtained for 05 Data
- To do:
  - -- use all data sets, systematic errors
  - -- obtain limits for other data sets and compare them to the previous results
  - -- include other models