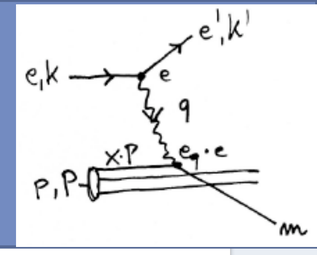
EPS HEP 2013 – Stockholm, 18-24 July 2013

New Physics with the LHeC

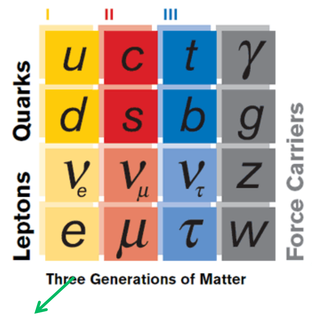


Abstract

The Large Hadron Electron Collider (LHeC) is a proposed facility which will exploit the new world of energy and intensity offered by the LHC through collisions with a new 60 GeV electron beam. The LHeC has an important potential for the search for new physics in the context of Contact Interaction, R-parity Violating Supersymmetry and Extra-Dimension, to accompany possible findings of new particles or phenomena at the LHC and for the implications of precision measurements of parton dynamics and the strong coupling in the understanding of multi-TeV physics phenomena

Searching for New Physics

The Standard Model has been so far remarkably successful describing the known phenomens, while intense searches are pursued for new physics:



Extra Dimensions

- Large, warped, or universal extra dimensions
- Might provide:
  - Dark Matter candidate
  - Solution to Hierarchy problem
  - Unification of forces

Supersymmetry

- Introduce heavy superpartners, scalar particles, light neutral Higgs
- More than100 parameters even in MSSM

Strong EW symmetry breaking

- Modern variants of Technicolor
- Search for compositness

→ Composite Higgs, new heavy vector bosons (Z', W'…), 4th generation of quarks

Quark Compositness & Contact Interaction

At small scales new phenomena not directly detectable may become observable as deviations from the Standard Model predictions.
A convenient tool: effective four-fermion contact interaction (CI)

4-fermion interaction $\Rightarrow M_{eq\to eq} \sim \Lambda^{-2}$

Observed as modification of the Q^2 dependence → all information in $d\sigma/dQ^2$
Also parametrized as form factors

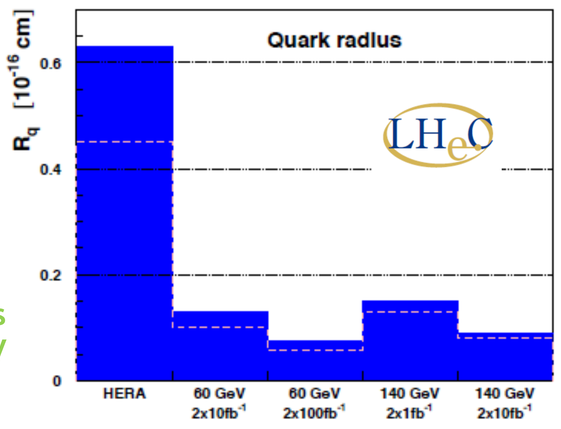
Λ : Compositeness scale

If contact terms originate from a model where fermions are composite, scale proportional to composite object radius

$$f(Q^2) = 1 - \frac{1}{6}\langle r^2\rangle Q^2 ,$$

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

Radius (→ distribution of EWK charge within q) **reach below 10^{-19} cm**



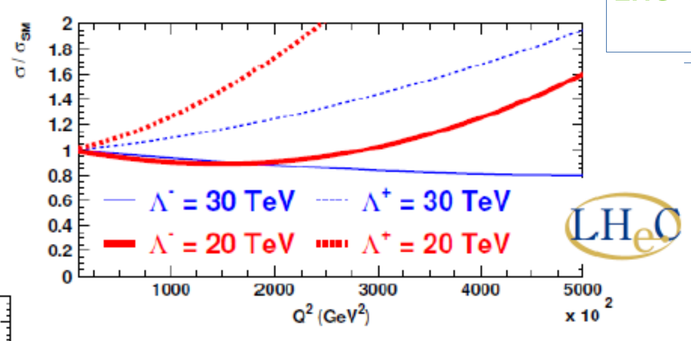
ATLAS and CMS constraints on 4-quarks CI (expected @ few 10's TeV for 14 TeV LHC → not directly related to EWK R)

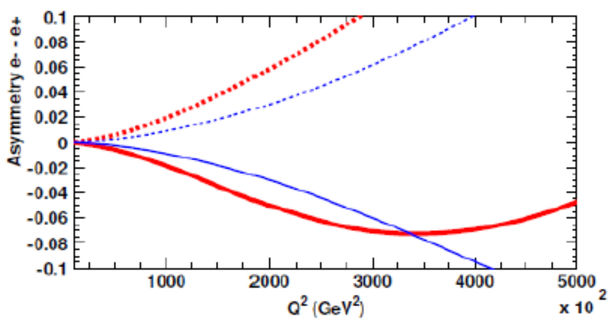
CI and High Mass Drell Yan

At the LHC expect to use variation of DY cross section for CI model. However, cannot determine simultaneously Λ and the sign of interference of the new amplitudes wrt SM (ε)

Ex: negative interference too small to be disentagled

At LHeC: can determine the sign ε from asymmetry of σ/σ_{sm} in e+p and e-p data

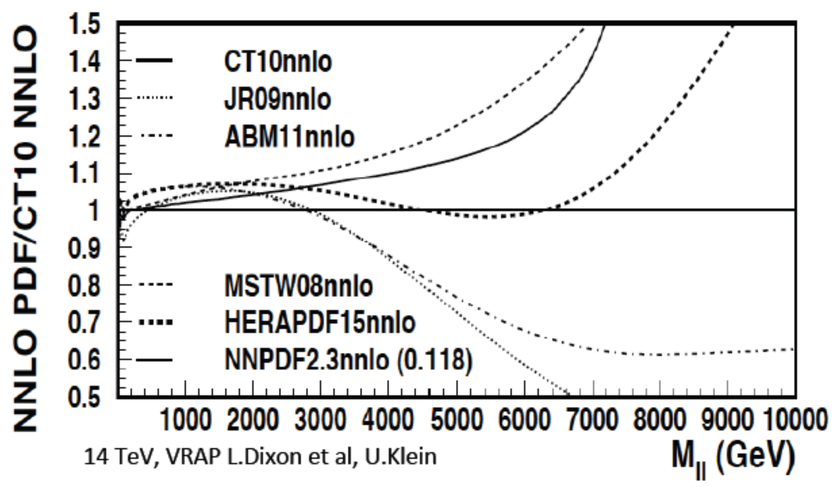




Deviations in DY also sensitive to ED (non resonant / interference effects)

→fundamental to understand tails

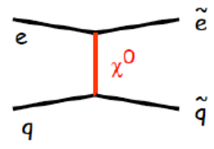
→ important interplay with High-Luminosity (HL) LHC (precision measurements of PDF)



Searches for Supersymmetry

Direct searches for Supersymmetry at the LHeC can be performed in the context of R-parity conserving or violating scenarios:

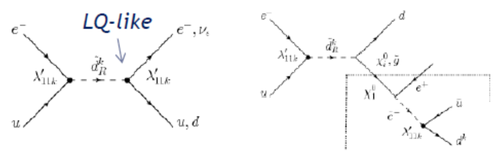
- R-parity = $(-1)^{3(B-L)+2s}$ (R = 1 for SM particles, -1 for MSSM partners)
- If conserved:
  - Sensitivity for selectron-squark production
  - Exclusion limits set by the LHC depend on the SUSY mass hierarchy assumed
  - Relevance of these searches will depend on LHC findings



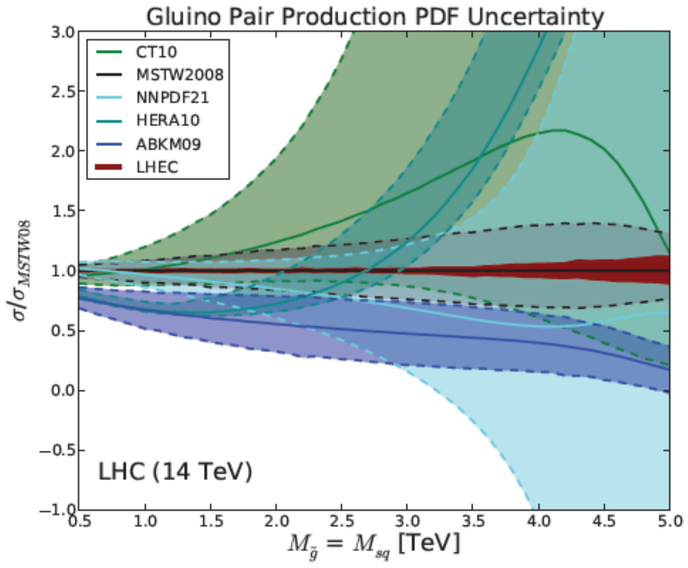
- If violated, various terms arising from superpotential

$$\lambda_{ijk} L_i L_j \overline{E}_k + \lambda'_{ijk} L_i Q_j \overline{D}_k + \lambda''_{ijk} \overline{U}_i \overline{D}_j \overline{D}_k$$

- Reach up **to 1.2 TeV squark masses**
- Via LeptoQuark (LQ)-like decays, measurement of properties feasible
  - For squark production:
    - λ' couplings relevant in e-p production
  - Decays: direct or via cascade

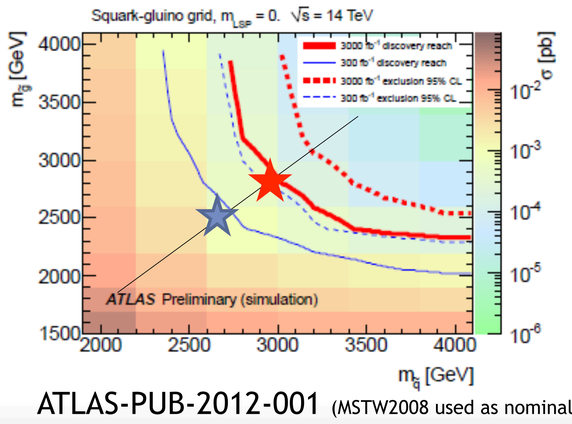


If no evidence for RPC SUSY is found in Run II, SUSY particles may be out of reach for LHeC → interplay in terms of PDF fundamental for HL-LHC



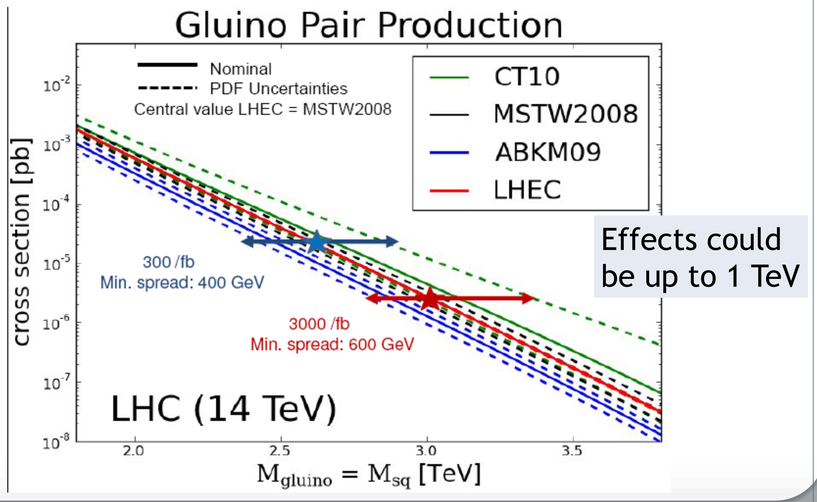
Strong impact of improved PDF fits on the theoretical predictions for SUSY process at high sparticle masses.

Ex.: gluino pair production (m_gl = m_sq)



ATLAS-PUB-2012-001 (MSTW2008 used as nominal)

Dependence on discovery potential and exclusion limits at 300 and 3000 /fb for 14 TeV c.o.m. at the LHC



Effects could be up to 1 TeV

G. Azuelos, M. D'Onofrio, R. Klees, M. Klein, U. Klein, E. Perez and V. Radescu on behalf of the LHeC Study Group

References: J. L. A. Fernandez et al. [LHeC Study Group Collaboration], J. Phys. G 39 (2012) 075001 [arXiv:1206.2913]; arXiv:1211.4831; arXiv:1211.5102.