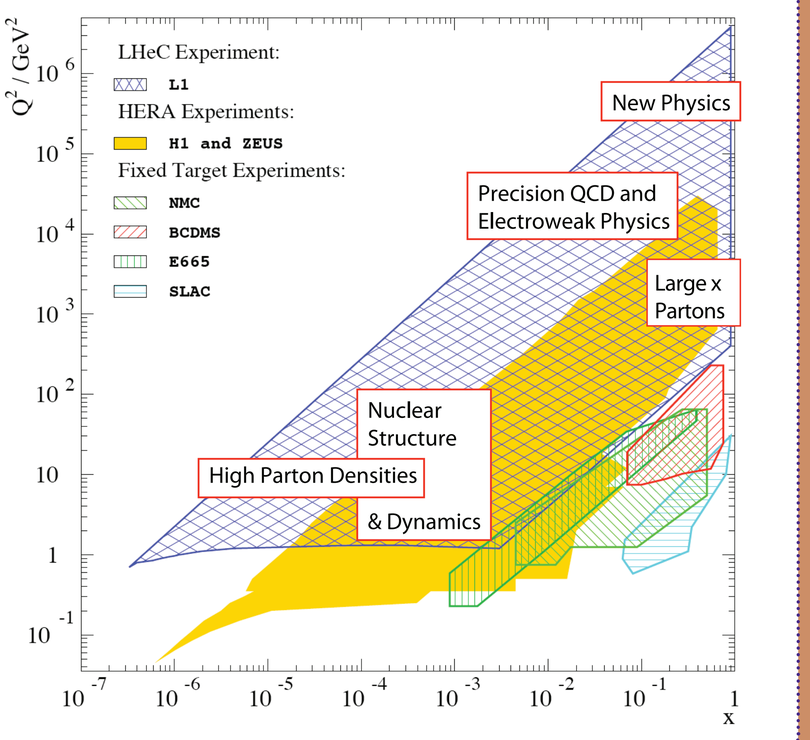
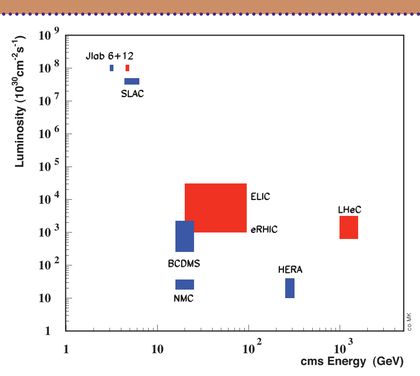
Electron-Nucleon Scattering at the Tera Scale

CERN-ECFA-NuPECC: Preparing a Conceptual Design Report on the LHeC

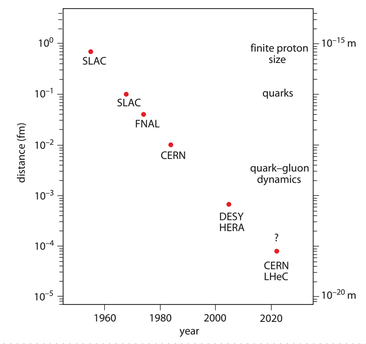
The Large Hadron Electron Collider (LHeC) is a new colliding beam facility, based on the LHC at CERN, exploiting Tera scale cms energies in the electron-quark system in order to pursue a rich and luminous programme of inelastic, polarised electron/positron -proton, deuteron and heavy ion scattering measurements. By reaching momentum transfer squared values of Q^2 above 10^6 GeV^2 and correspondingly low values of Bjorken x, the LHeC is seen as a natural complement to the LHC and to an envisaged new lepton collider. This poster illustrates part of the still ongoing work on the machine, interaction region and detector designs as well as on the physics potential of the LHeC at high scales, high parton densities and with high precision eq measurements. This work, pursued in a wide international collaboration under the auspices of CERN, ECFA, NuPECC and a Scientific Advisory Committee, is directed to a Conceptual Design Report by 2010, as part of the deliberations of the HEP community on its future programme of exploring the energy frontier with accelerators, which is reminiscent to the exploration of the Fermi scale with HERA, the Tevatron and LEP. More information on the LHeC is collected at ***www.lhec.org.uk****. The next workshop will be held at Divonne 1-3.9.2009.*



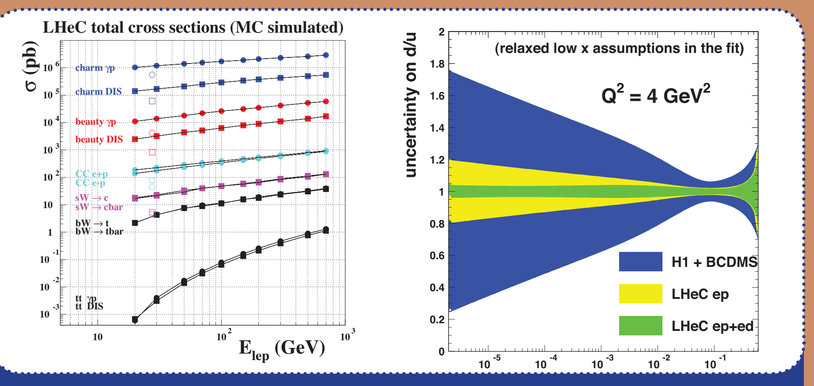
LHeC Physics and Kinematics - Kinematic plane in Bjorken-x and resolving power Q^2, showing the coverage of fixed-target experiments, HERA and the LHeC. The mapping of the planned physics programme onto this plane is also indicated.



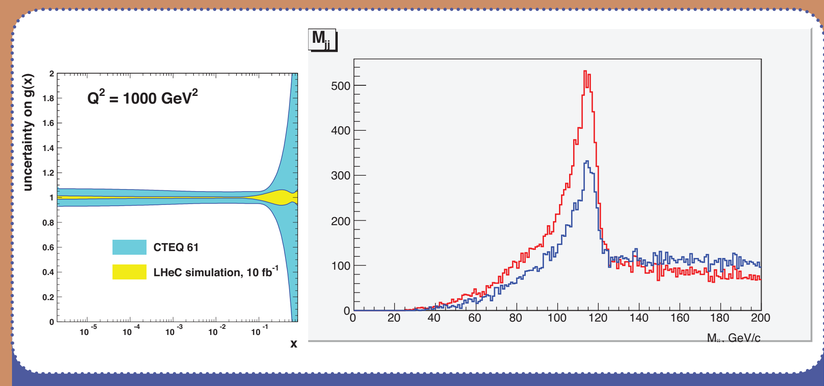
Lepton-Proton Scattering - Comparison of the energies and luminosities of selected previous (blue) and proposed future (red) lepton–proton scattering facilities. The LHeC moves DIS into the Terascale with about 100 times the luminosity of HERA.



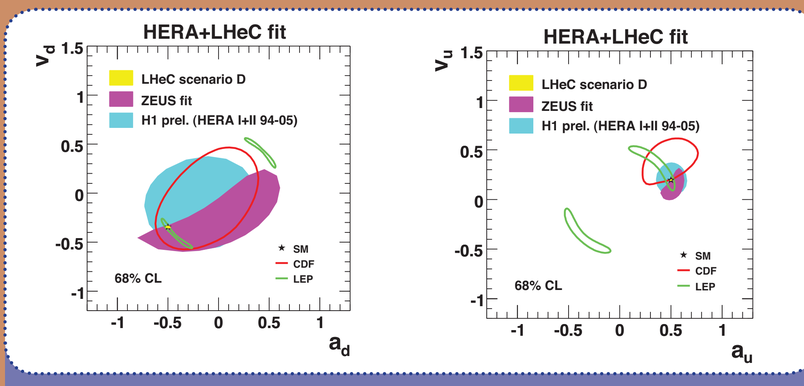
Resolving Proton's Structure - Distance scales resolved in successive lepton–hadron scattering experiments since the 1950s, and some of the new physics revealed. The LHeC will resolve distances below 10^{-19}m, more than a 10.000 times smaller than the proton's radius and 10 times below HERA.



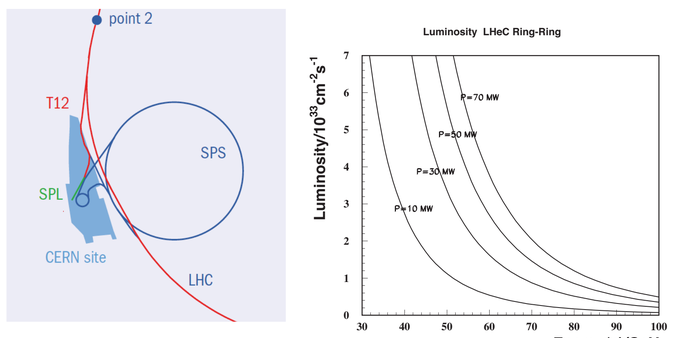
Direct Measurement of Partons - The LHeC permits the complete resolution of the light and heavy quark structure of the nucleon. It will make precision measurements of the beauty density, the first ever measurements of strange and anti-strange quark densities or the u/d densities at low and at large x . The LHeC is a single top and anti-top-quark factory.



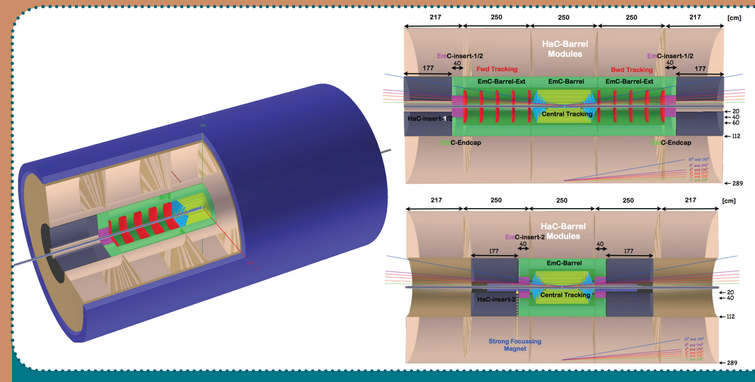
Complementing the LHC - The LHeC complements the LHC with precision measurements e.g. on the gluon density or the investigation of the Higgs. With the LHeC, new physics phenomena possibly occurring at the LHC can be distinguished reliably from mere variations of partonic behaviour, currently subject to extrapolation and parameterisation uncertainties.



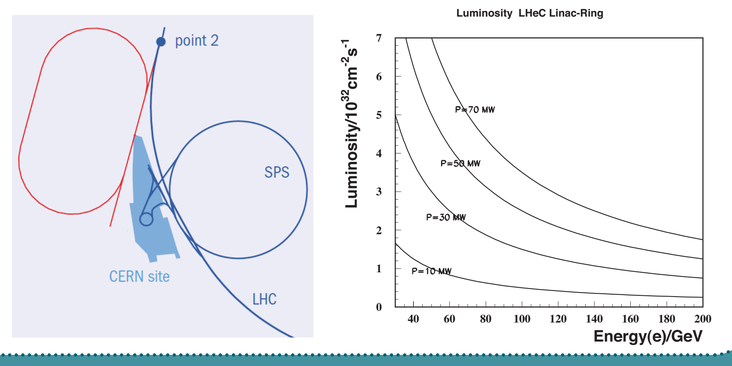
Exploring Multi-TeV Scales - Exploration of ultrahigh energy scales with precision measurements in electroweak and strong interactions. Precision determination of light quark weak neutral current couplings. Unification of coupling constants at the Planck scale may be tested with alpha_s measured an order of magnitude more accurately than so far.



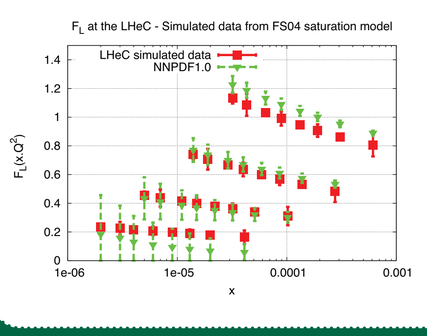
LHeC as Ring-Ring Collider - The LHeC as a Ring-Ring Collider may use the SPL as an injector and will have bypasses around LHC experiments, in which the rf may be placed. A new type of dipole magnet is considered for installation on top of the proton ring. The luminosity is estimated to be above 10^{33}cm^{-2}s^{-1} with an assumed limit of 100 MV wall plug power.

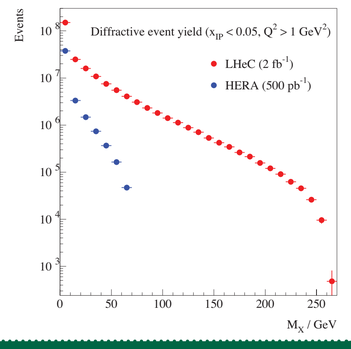


A New Detector for ep/eA - The detector is modular for fast installation down the pit and to cope with the requirements of high luminosity and of large acceptance near the beam axis. Design work is ongoing on the interaction region to allow for simultaneous operation of pp (LHC) and ep (LHeC) beams.

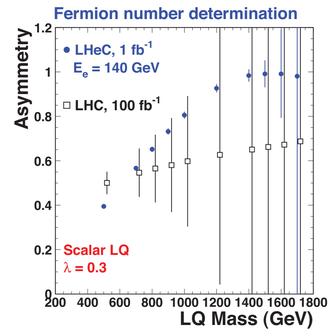


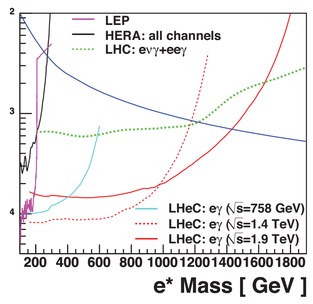
LHeC as Linac-Ring Collider - The LHeC as a Linac-Ring Collider is considered to possibly use a racetrack arrangement of ILC type superconducting cavities. The luminosity is in excess of 10^{32}cm^{-2}s^{-1} with a power limit of 100MW, based on the sLHC upgrade. It may be enlarged with energy recovery techniques. The luminosity diminishes as 1/E with the electron beam energy and the linac may therefore surpass the energy reach of the ring.



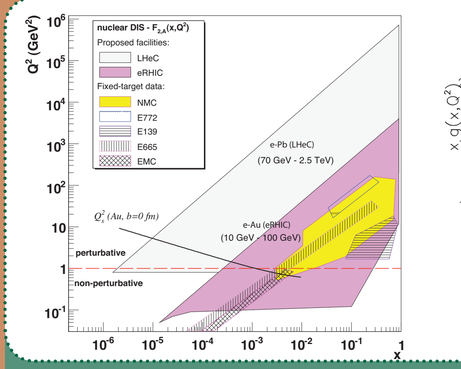


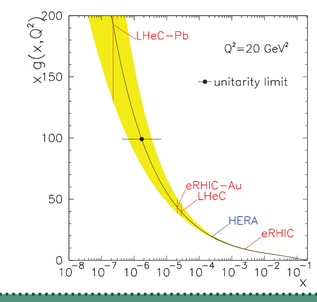
Saturation of Parton Densities - At small Bjorken x the rise of the parton densities is predicted to be limited by unitarity. A new phase of matter appears governed by modified parton dynamics with relations to nuclear and neutrino astrophysics. This may be discovered in ep with precision measurements of F_2 and F_L, vector meson measurements or diffractive scattering in a hitherto unexplored range of phase space and phenomena.





New Physics in eq Scattering - Singly produced new states, such as eq resonances or excited leptons, have a much higher cross section at an ep machine than in pp, which will allow the determination of quantum numbers of new states and possibly give access to a complementary phase space. If leptons and hadrons are 'one form of matter' (A.Salam), an eq collider is most suited for its exploration.





Partonic Structure of Nuclei - The LHeC extends the experimental knowledge on the partonic structure of nuclei by nearly 4 orders of magnitude in DIS. The predicted enhancement of the gluon density ~$A^{1/3}$ and the very high energies at the LHeC allow parton saturation effects to be studied both in ep and eA interactions and thus to uniquely separate nuclear from unitarity effects in deep inelastic scattering.

Compiled by M.Klein and F.Marcastel - 10 July 09