

Energy-frontier lepton-hadron collisions at CERN: the LHeC and the FCC-eh

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The Large Hadron-electron Collider (LHeC) is the prime candidate for future electron-hadron (proton and ion) collisions at the energy frontier. It will be the world's cleanest high-resolution microscope of the substructure of matter and a first high-precision Higgs facility with a large discovery potential running synchronously to the LHC's pp and heavy ion physics. It will provide electron-proton collisions with a center-of-mass energy of 1.3 TeV and instantaneous luminosity of order $10^{34} \text{ cm}^{-2}\text{s}^{-1}$. In electron-lead scattering, luminosities of about $10^{33} \text{ cm}^{-2}\text{s}^{-1}$ per nucleon are in reach. The talk presents an overview of the ongoing LHeC developments focussing on the energy recovery linac (ERL) configuration of a polarised 60 GeV electron beam. We will show recent studies on the civil engineering, beam-beam effects, the interaction region and the design of a high-precision eh detector based on modern technology. The talk also informs about the development of an ERL demonstrator, projected to be built at LAL Orsay, and about the use of a 60 GeV ERL for an eh configuration of 3.5 TeV center-of-mass energy running synchronously with FCC-hh. Further, we will present the unique, exciting LHeC and FCC-eh energy frontier physics program that can be roughly bundled into five topics: (i) Precision QCD, with an accurate determination of parton densities including the complete flavour decomposition and a per mille determination of the strong coupling constant; (ii) SM Higgs physics, with e.g. anticipated precisions of 0.2 (0.5%) and 1.8 (4%) for Higgs couplings to bb^- and cc^- at FCC-eh (LHeC); (iii) BSM physics, with a variety of possible discovery channels both in QCD, exotic Higgs, RPV SUSY, and sterile or right-handed neutrinos; (iv) High precision top and electroweak physics, with prospects for measurements such as top quantum numbers, anomalous and CKM couplings, and the W mass to $\mathcal{O}(10)\text{MeV}$ precision in ep; (v) Nuclear dynamics probed in electron-ion scattering in the TeV regime, with unprecedented opportunities to resolve nuclear structure and dynamics in a hugely extended kinematic range. The LHeC and the FCC-eh studies are being prepared for presentation to the update in Europe's HEP strategy and beyond.

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