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VHEeP: A very high energy electron-proton collider based on proton-driven plasma wakefield acceleration

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Based on current CERN infrastructure, an electron-proton collider is proposed at a centre-of-mass energy of about 9 TeV. A 7 TeV LHC bunch is used as the proton driver to create a plasma wakefield which then accelerates electrons to 3 TeV, these then colliding with the other 7 TeV LHC proton beam. The basic parameters of the collider are presented, which although of very high energy, has integrated luminosities of the order of 10 pb^{-1}/year. For such a collider, with a centre-of-mass energy 30 times greater than HERA, parton momentum fractions, x, down to about 10^{-8} are accessible for Q^2 of 1 GeV^2 and could lead to effects of saturation or some other breakdown of DGLAP being observed. The total photon-proton cross section can be measured up to very high energies and also at different energies as the possibility of varying the electron beam energy is assumed; this could have synergy with cosmic-ray physics. Other physics which can be pursued at such a collider are contact interaction searches, such as quark and electron substructure, and measurements of the proton structure as well as other more conventional measurements of QCD at high energies and in a new kinematic regime. The events at very low x will lead to electrons and the hadronic final state produced at very low angles and so a novel spectrometer device will be needed to measure these. First ideas of the physics programme of such a collider are given.

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