The dark sector and high energy electron-proton scattering -- new experiments using the AWAKE acceleration scheme

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New particle acceleration schemes open up exciting opportunities, potentially providing more compact or higher energy accelerators. The AWAKE experiment at CERN will be taking data over the next two years to establish the method of proton-driven plasma wakefield acceleration. An R&D programme is being formulated for a second phase to demonstrate that bunches of about 10^9 electrons with an energy of 10 GeV accelerated in about 10 m of plasma are achievable and that the energy gain is scalable with length. Given a clean electron beam of O(50 GeV) and of a much higher rate than currently available at CERN, new and improved fixed-target or beam-dump experiments are possible. In particular, the NA64 experiment which is searching for hidden sector physics such as dark photons using could be significantly improved. With the expectation of being able to increase the rate of electrons on target by a factor of 1000 using an AWAKE-like beam, sensitivity to new physics is greatly extended. An electron beam of O(50 GeV) is also planned for an electron-proton collider, the LHeC, which under the AWAKE scheme could be achieved in a plasma cell of ~50 m in length, although with modest luminosities. This could open up the possibility of an LHeC-type project at relatively low cost and focusing on studies of the strong force. An ultimate goal using proton-driven plasma wakefield acceleration is to produce an electron beam of 3 TeV and collide with an LHC proton beam. This very high energy electron-proton collider would probe a completely new regime in which the structure of matter is completely unknown. Again, this would be relatively low luminosity, but this is offset by the rapidly rising cross sections in this kinematic region. The status of AWAKE, the physics of the dark sector and of electron-proton collisions as well as the possible experiments will be presented.