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Electron acceleration behind self-modulating proton beam in plasma with a density gradient

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Presently available high-energy proton beams in circular accelerators carry enough momentum to accelerate high-intensity electron and positron beams to the TeV energy scale over several hundred meters of plasma with a density of ~1e15 1/cm^3. However the plasma wavelength at this density is 100-1000 times shorter than the typical longitudinal size of the high-energy proton beam. Therefore the self-modulation instability (SMI) of a long (~10 cm) proton beam in plasma should be used in order to create the train of micro-bunches which would then drive the plasma wake resonantly. Changing the plasma density profile offers a simple way to control the development of SMI and the acceleration of particles during this process. We present the simulations of the possible use of plasma density gradient as a way to control the injection and acceleration of electron beam during the development of the SMI of 400 GeV proton beam in 10 m long plasma. This work is done in the context of the AWAKE project – the proof of principle experiment on proton driven plasma wakefield acceleration at CERN.

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