Influence of proton bunch and plasma parameters on the AWAKE experiment

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Plasma-based accelerators are strong candidates for a highly anticipated generation of compact particle accelerators. A plasma-based accelerator transfers energy from a relativistic particle bunch or ultra-intense laser pulse driver to the plasma, through the excitation of strongly nonlinear plasma waves, and from the plasma waves to an accelerated particle beam. Assuming that the efficiency of the process is fixed, increasing the driver energy will lead to an increase in the final energy of the accelerated beam. As drivers, the proton beams from the LHC at CERN contain more energy than any other particle or laser beam produced to date. Simulations demonstrate that these beams could then be used to accelerate electrons to 600 GeV in a 600m-long plasma [1].

A proton-driven plasma wakefield experiment (the AWAKE experiment [2]) at CERN will test the underlying concept using long proton beams that undergo the self-modulation instability [3]. The effectiveness of the experiment hinges on the successful and predictable development of this instability, which fragments the initial proton bunch into smaller beamlets with lengths of the order of the plasma wavelength. Since the initial parameters of the experiment inevitably vary from event to event, this work will aim to understand the correlation between these variations and the resulting wakefield. Using both theoretical models and numerical particle-in-cell simulations, the influence of variations in initial bunch charge, bunch dimensions, bunch energy and plasma density profile on the excited accelerating gradients and on the final energies reached by the witness particles will be investigated.

References