Simulations of the possible AWAKE Run-2 experiment at CERN
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Abstract
The AWAKE Run-2 is a possible extension of the current AWAKE experiment on the proton driven plasma wakefield acceleration using the 400 GeV beam from the CERN SPS accelerator. The current AWAKE experiment is aimed at the proof-of-principle demonstration of electron acceleration driven by a self-modulating proton beam in plasma, while the focus of the proposed AWAKE Run-2 experiment will be on application of this technology for acceleration of electron bunch with a reasonably high quality and intensity. A better quality of accelerated electron beam can be achieved by injecting the short and intense electron bunch after the stabilization of self-modulating proton beam over the first 7-10 m of plasma. 2D and 3D quasi-static PIC simulations of the proposed experiment are presented.

Plasma density step to stabilize the wakefield:
In order to accelerate significant electron charge (large enough to load the wakefield) with a small energy spread electron beam should be injected into the stable wakefield after the saturation of the SMI.

The small density step in the first plasma section allows one to increase the stable accelerating field in the second section by a factor of 3-5 depending on the width of the gap. The higher electric field is excited by the larger number of micro-bunches driving the wakefield resonantly.

The larger the number of micro-bunches used, the tighter the tolerances on the precision of the required density profile. In the case of the highest achievable accelerating electric field the number of proton beam micro-bunches is around 60. This requires the precision of the control over the plasma density profile (from shot to shot) at the level of 0.2%.

Electron injection schemes currently under consideration:

The major challenge in this configuration is to deal with a strong nonlinear electron beam defocusing at low plasma density. It is induced by the plasma electrons pulled on-axis by the long train of proton micro-bunches.