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Electron beam setup for seeding of the self-modulation process of a long proton bunch in high density plasma for AWAKE Run 2b

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The Advanced Wakefield Experiment (AWAKE) at CERN uses CERN SPS bunches to develop proton-driven plasma wakefield acceleration. However, to excite ~GV/m wakefields, the long SPS bunches must undergo self-modulation (SM) in plasma. SM is a beam-plasma instability and the instability can be seeded to ensure wakefield reproducibility. During Run 2a (2021–2022), AWAKE demonstrated SM seeding using wakefields driven by an electron bunch ahead of the proton bunch in plasma. In these experiments, the electron bunch length was shorter than the plasma wavelength, and asymmetry in the resulting SM was frequently observed, likely caused by beam misalignment. In this contribution, two approaches to improve the seeding process are investigated. First, challenges related to beam alignment are addressed, and strategies and potential solutions presented. Second, seeding with an electron bunch longer than the plasma wavelength is experimentally explored. This is interesting as higher plasma electron densities yield higher acceleration gradients, however, have shorter plasma wavelengths and sub-picosecond electron bunches needed for the seeding at these high densities are not readily available.

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