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Natural noise and external wake field seeding in a proton-driven plasma accelerator

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We discuss the level of natural shot noise in a proton bunch-driven plasma accelerator. The required seeding for the plasma wake field must be larger than the cumulative shot noise. This is the necessary condition for the axial symmetry of the generated wake and the acceleration quality. We develop an analytical theory of the noise field and compare it with multi-dimensional simulations. It appears that the natural noise wake field generated in plasma by the available at CERN super-protons-synchrotron (SPS) bunches is very low, at the level of a few 10 kV/m. This fortunate fact eases the requirements on the seed. Our three dimensional simulations show that even a few tens MeV electron bunch precursor of a very moderate intensity is sufficient to seed the proton bunch self-modulation in plasma.

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