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2D theory of wakefield amplification by active medium

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ABSTRACT

A train of microbunches generates in a passive dielectric-loaded waveguide an electromagnetic wake which propagates at the speed of the particles. This wake consists of propagating modes provided the electrons exceed the Cerenkov velocity. If the material is replaced with an active dielectric, identical to that of a laser, the wake is amplified. Another train of bunches, lagging many wavelengths behind, may be accelerated by this amplified wake. The gradient is limited by breakdown and saturation of the medium. Beam loading may be partially or even completely compensated by the gain along the trailing bunch. Preliminary results of a linear theory will be presented, assuming a 300 MeV beam and high-pressure CO_2 mixture as an active medium. In spite of many hundreds of modes excited by the front beam, the spectrum of the amplified field corresponds to a monochromatic wave determined primarily by the bandwidth of the medium. The analytic approach facilitates simple assessment of the effect of the various parameters on the accelerating gradient.