

# Adiabatic Focusing of a Long Proton Bunch in Plasma

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We show in experiments that a long, relativistic  $p^+$  bunch is focused by the plasma adiabatic response. The free plasma electrons migrate so as to neutralize the space-charge field of the bunch [1], and the bunch is therefore focused by the azimuthal magnetic field generated by its own current, that is not balanced by the radial electric field [2, 3, 4]. Since the length of the bunch is much longer than the plasma electron wavelength, the bunch also undergoes the self-modulation instability [5, 6]. Thus, the amplitude of the wakefields grows along the bunch and along the plasma, and the defocusing effect of the self-modulation can become dominant over the adiabatic focusing effect. We show that, when seeding the self-modulation with a preceding  $e^-$  bunch [7], the transition between the effect of the adiabatic response and that of the self-modulation depends on the amplitude of the seed wakefields.

## References

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