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Resonant Excitation of Plasma Wakefields using Multiple Electron Bunches

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Abstract. We plan to resonantly excite plasma wakefields using a train of electron bunches separated by an integer number of plasma wavelengths. The multiple electron bunches are generated by a photocathode based RF gun by splitting the laser beam into temporally separated pulses. The amplitude of the wakefields generated by the sequence of bunches is expected to be higher than that generated if all charge had been in only one bunch, because this single bunch would be considerably longer than the individual sub-bunches due to space charge effects in our gun.

INTRODUCTION

High charge short electron bunches are needed to achieve high accelerating gradients in electron beam driven plasma wakefield accelerators. Electron bunches generated by photocathode based RF guns in general become longer as the bunch charge is increased. An attractive alternative to generating high charge single electron bunches is to generate a train of bunches separated by a plasma wavelength (1). In this way the plasma wakefield is resonantly excited by the bunch train and each bunch can be kept short because the total charge is distributed over many bunches.

GENERATION OF MULTIPLE BUNCHES

We can generate multiple electron bunches from our photocathode based RF gun simply by splitting the laser beam into a sequence of temporally separated pulses. The delay between the pulses needs to be equal to the plasma wavelength, which in our case is about 6 mm (assuming a plasma density of 3×10^{13} cm^{-3}). This delay between the laser pulses will introduce an energy difference between the various electron bunches in the train, as they will be emitted from the photocathode at different phases of the RF power that is present in the gun. However, since our RF gun operates at 1.3

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DISCLAIMER

THE AWA ELECTRON GUN PERFORMANCE

It is obviously easier to generate shorter electron bunches when the bunch charge is smaller. As we increase the bunch charge, space charge forces become more intense, in general making the bunch longer. We have measured the dependence of bunch length on charge for the AWA drive gun (2). Figure 2 shows the result of this measurement. Bunch length was measured with an aerogel Cerenkov radiator and a streak camera (Hamamatsu M1952/C1587). Bunch charge was measured with an integrating current transformer (Bergoz ICT-082-070-20:1). The plot shows the FWHM of the bunch length and also the 95% RMS values (i.e. the RMS calculated using only the section of the pulse profile with intensity within 95% of the peak value, with the purpose of discarding the effect of the small background noise at the wings of the distribution). The ratio between the 95% RMS and the FWHM values shows that the pulses are not gaussian. Each point on the graph corresponds to the average of three pulses. The large fluctuation in the FWHM of the pulses also shows that the detailed shape of the temporal profile varies considerably from pulse to pulse.

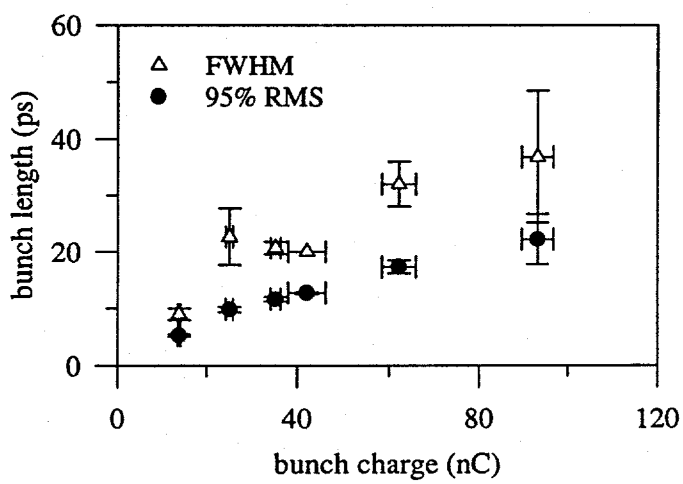

FIGURE 2. Measurements of electron bunch length as a function of bunch charge. The error bars indicate the standard deviation of the average of three pulses.

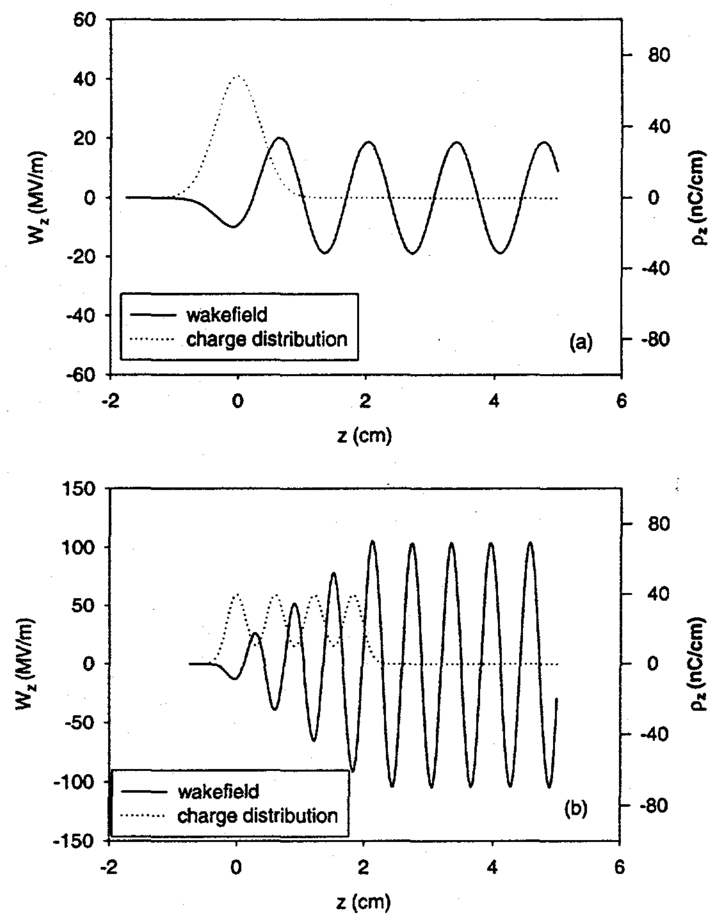

Figure 3. Wakefield amplitude and bunch charge distribution: (a) single 60 nC drive bunch with σ_z = 3.5 mm; plasma density is 6×10^{12} cm^{-3}; (b) train of four 15 nC bunches with σ_z = 1.5 mm; plasma density is 3×10^{13} cm^{-3}.

REFERENCES

1. Russian paper.

2. M.E. Conde, W. Gai, R. Konecny, X. Li, J. Power, P. Schoessow, and N. Barov, *Phys. Rev. ST-AB* **1**, 041302 (1998).