1P27

Numerical Simulation of Collective Ion Accelera-
tion in the Laser Controlled Collective Accelerator,* R. L.
Yao, C. D. Striffler, and W. W. Destler, University of Mary-
land, College Park, MD 20742. — In the Laser Controlled
Collective Accelerator, an intense electron beam is injected
at a current above the vacuum space charge limit into an ini-
tially evacuated drift tube. A plasma channel, produced by
time-sequenced, multiple laser beam ionization of a solid tar-
get on the drift tube wall, provides the necessary neutraliza-
tion to allow for effective beam propagation. By controlling
the rate of production of the plasma channel as a function of
time down the drift tube, control of the electron beamfront
can be achieved. Initial experiments[1] have demonstrated the
controlled acceleration of protons at a rate of 40 MeV/m over
a distance of 50 cm, in good agreement with experimental de-
sign values.

In order to understand and to optimize ion acceleration in
this system, we have developed the 1D electrostatic PIC code
CIA. Simulations performed with this code give the following
general picture for the initial phase of the acceleration pro-
cess. Soon after the electron beam is injected into the drift
tube, a virtual cathode forms near the injection plane. Ion-
ization of the neutral gas causes the virtual cathode to move
downstream to the end of the gas cloud. During this move-
ment of the virtual cathode, ions produced by ionization of
the neutral gas are accelerated to energies several times the
injected electron-beam energy. For example, for a 1 MeV, 20
kA electron beam injected into a cloud of hydrogen gas at
500 mTorr, the maximum ion energy is about 3 MeV when
the gas cloud is 3-4 cm wide.

Following the initial phase of ion acceleration, the ions
are further accelerated during the propagation of the elec-
tron beam front down the plasma channel. In the PIC code
we model this process by assuming that the laser produces
a space-charge neutralizing channel which sweeps down the
drift tube at a rate controlled by the laser. Initial results with
the model agree with the experimental results as regards rate
of sequencing for enhanced acceleration, and peak enhanced
ion energy. In addition, the code demonstrates the erosion
of the strong beam front electric field as well as the decrease
in the number of ions accelerated over the channel length.
Limits on this process obtained from the PIC code will be
discussed.

[1]P.G. O'Shea, W.W. Destler, J. Rodgers, and Z. Segalov,
Appl. Phys. Lett. 49, 1696 (1986).