Production of quasimonoenergetic electron bunches in the interaction of a laser pulse with an inhomogeneous plasma

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Scheme of 3D PIC simulations

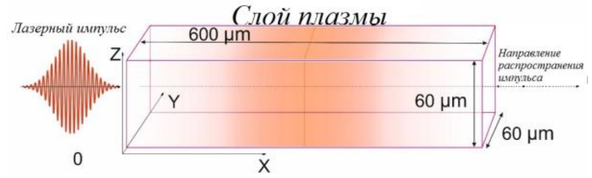

Fig. 1. PIC modeling scheme.

The lower limit of the electron injection

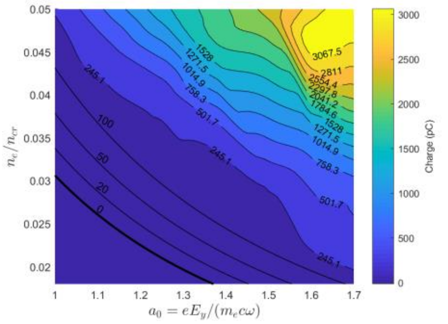

Fig. 2. The dependence of the charge of the ejected electrons with an energy greater than 2 MeV on a_0 and n_0. Charge is expressed in picoculons.

Approximation: $n(a_0) = A(Q)a_0^{\kappa(Q)}$

Boundary formula (bold black line): $n(a_0) > 0.03a_0^{-1.7}$

Quasi-monoenergetic electron bunch after optimization of the plasma profile

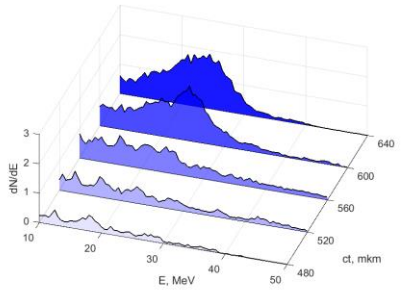

Fig. 5. The dependence of the electron energy distribution on time for a_0 = 1, n_0/n_{cr} = 0.04 before optimizing the coordinate of the transition point from the Gaussian profile to the plateau.

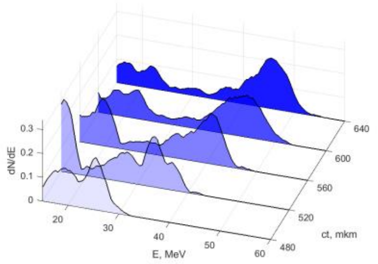

Fig. 6. The dependence of the electron energy distribution on time for a_0 = 1, n_0/n_{cr} = 0.04 after optimizing the coordinate of the transition point from the Gaussian profile to the plateau..

Parameters of 3D PIC simulations

Laser pulse length, *D*	7.64 mkm
L_y, L_z	8.25 mkm
Pulse duration, τ	30 fs
Pulse energy, W	< 130 mJ
Intensity on focus, I_0	$<4 \times 10^{18}\ W/cm^2$
Characteristic size of the target *l*	100 - 200 mkm

$$e(x,y,z) = e_0 \exp\left(-\frac{x^2}{D^2} - \frac{y^2}{L_y^2} - \frac{z^2}{L_z^2}\right) \qquad a_0 = \frac{e|E|}{mc\omega_0}$$

$n = n_0 \exp\left(-\frac{(x-x_0)^2}{l^2}\right)$ (first approximation of the electron density distribution)

Range of a_0 : $1 < a_0 < 1.7$

Range of n_0/n_{cr} (dimensionless density): $0.017 < n_0/n_{cr} < 0.045$

Modification of the plasma profile

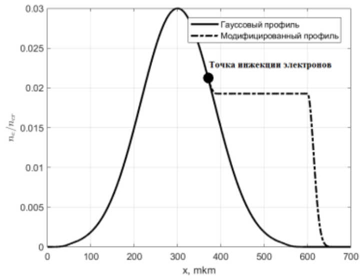

Fig. 3. Example of modifying the plasma profile to increase the acceleration length and electron energy.

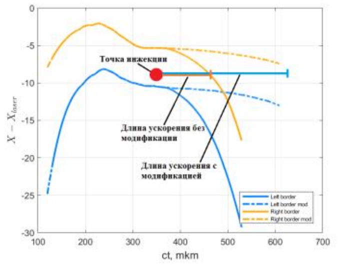

Fig. 4. Effect of increasing the acceleration length of captured electrons by modifying the plasma profile beyond the injection point

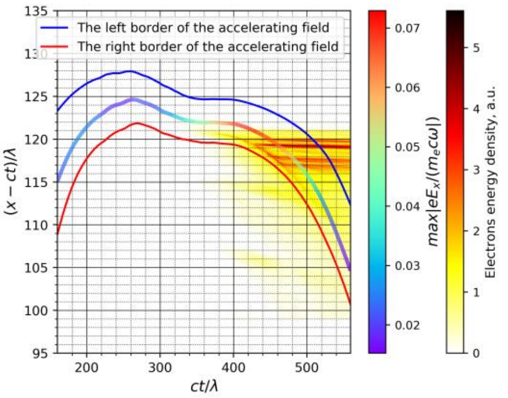

Fig. 7. A combined graph of the dependence of the associated coordinates of the left (red curve) and right boundaries (blue curve) of the accelerating field of the first (main) period of the plasma wave on time, as well as the energy density of the accelerated electrons. The color line indicates the maximum of the accelerating field (the color shows the value of the maximum)

Conclusions

The dependence of the characteristics of the ejected electrons on the amplitude of the laser pulse and the peak density of plasma electrons during the interaction of a laser pulse of subterawatt power with a plasma jet was studied. A method for obtaining quasi-monoenergetic electron bunches and increasing the energy of ejected electrons by varying the plasma density profile was proposed and tested.

References

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