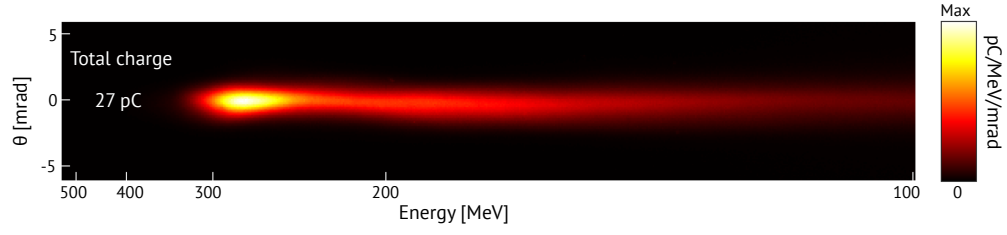
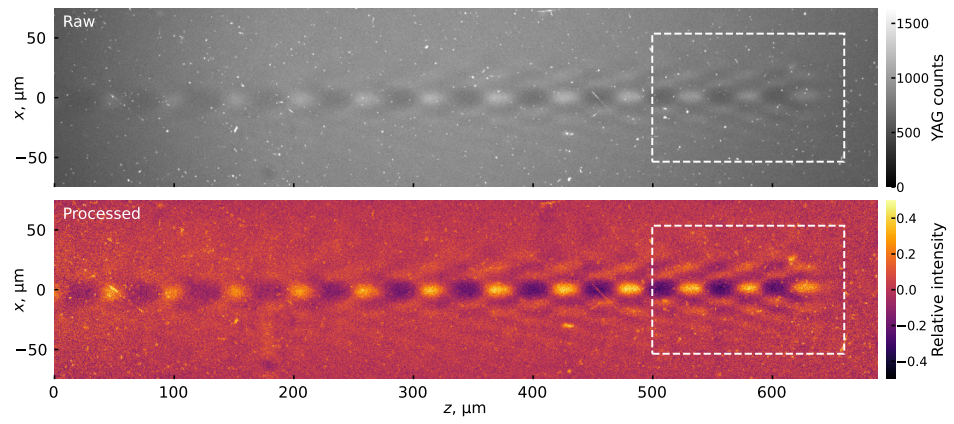


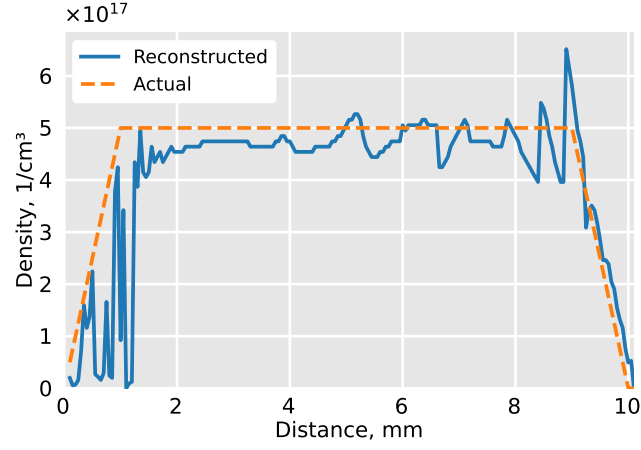
Supplementary



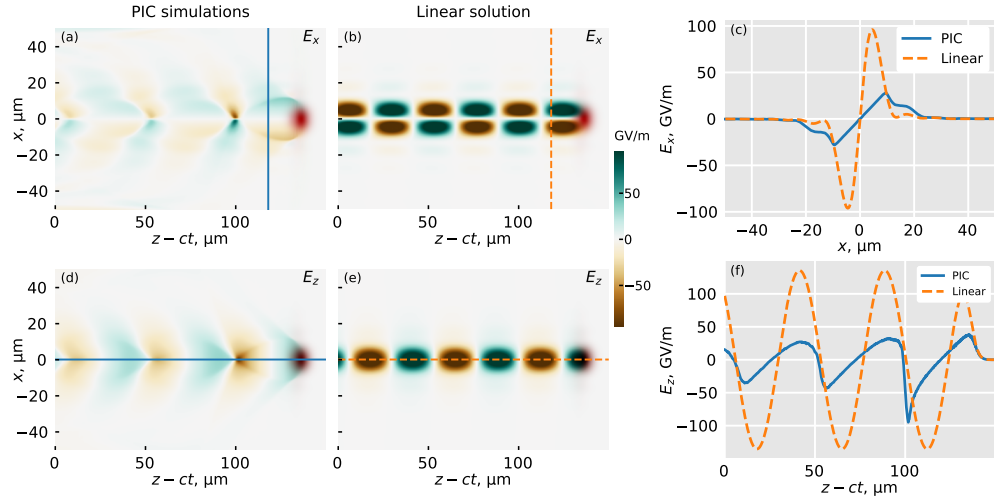
Supplementary Figure 1 Sample angularly resolved spectrum of the electrons accelerated by beam 2.



Supplementary Figure 2 Raw (top) and processed (bottom) FREM images corresponding to the case in Fig. 2(b). The white rectangle shows the crop used in Fig. 2(b).



Supplementary Figure 3 Comparison of density reconstructed from simulated probe images to the density profile used in PIC simulations.



Supplementary Figure 4 Comparison of the spatial distribution of the transverse electric field E_x between (a) the PIC simulation for the parabola-reflected pulse and (b) the corresponding calculated linear solution. (c) Transverse distribution of E_x for a slice $z - ct = 118 \mu\text{m}$ shown with vertical lines in (a–b). Comparison of the longitudinal electric field E_z for (d) the PIC simulation and (e) the linear solution. (f) On-axis longitudinal distributions of E_z . The red color in (a–b, d–e) shows the distribution of the laser pulse intensity.