

Supplementary Information

High-resolution sampling of beam-driven plasma wakefields

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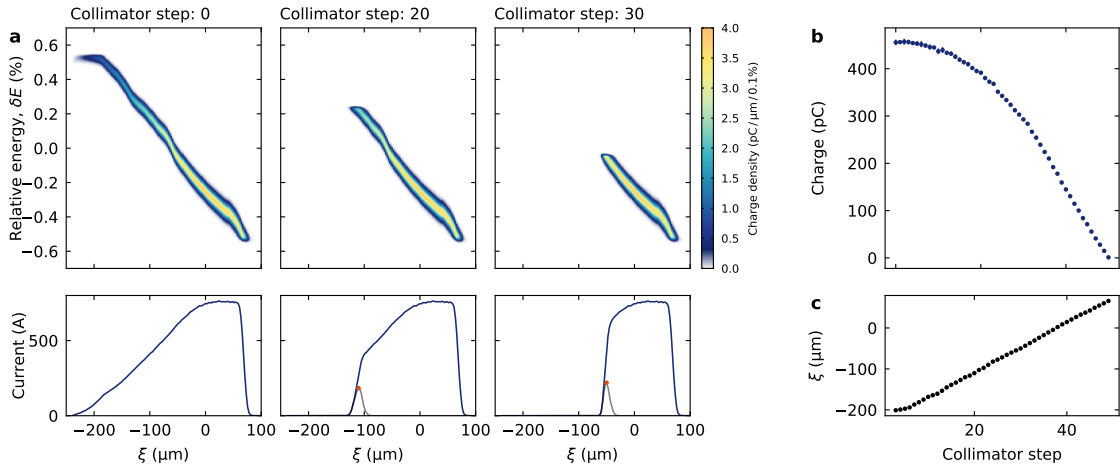
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Supplementary Figure 1	2
Supplementary Figure 2	3
Supplementary References	4

Supplementary Figure 1

Temporal calibration of tail-collimator from the measured longitudinal-phase-space distribution. **a**, A virtual tail-collimator scan is performed on the reconstructed longitudinal phase space to identify the longitudinal position of each energy slice. **b**, The remaining (uncollimated) charge at each step of the actual tail-collimator scan (Fig. 3) is compared to the cumulative charge below each energy in the virtual tail-collimator scan. **c**, This allows the longitudinal slice position of each tail-collimator step to be determined.

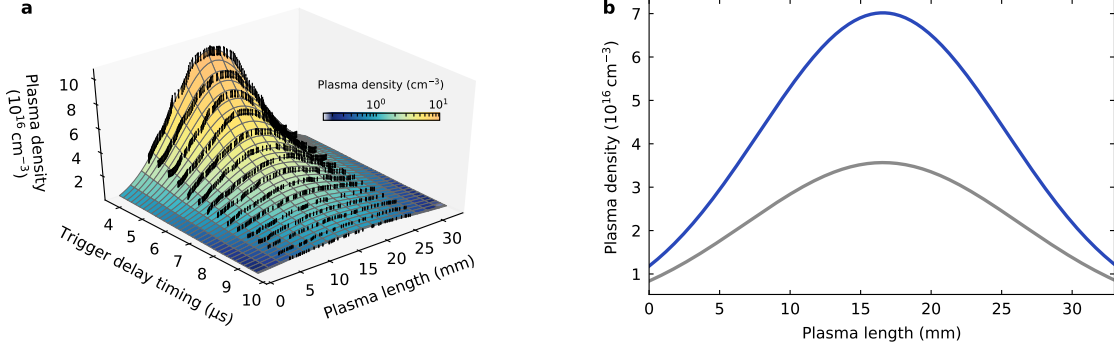


Supplementary Figure 2

Modelling the plasma density profile. **a**, Longitudinally resolved on-axis plasma density (black error bars) in a 95–5% argon–hydrogen mixture (percentage by number density) measured for times between 4 and 10 μs . The coloured surface represents a fitted function of the form

$$n(z, t) = \frac{1}{2}A(t) \left[\operatorname{erf} \left(\frac{z - c_1}{\sqrt{4c_3(t + c_4)}} \right) - \operatorname{erf} \left(\frac{z - c_2}{\sqrt{4c_3(t + c_4)}} \right) \right],$$

where z is the longitudinal position, t is the trigger delay timing, and the constants are $c_1 = 14.1$ mm, $c_2 = 18.4$ mm, $c_3 = 2.97 \text{ mm}^2 \mu\text{s}^{-1}$, $c_4 = 4.16 \mu\text{s}$. $A(t)$ represents a scaling factor that ensures that each measurement set has the appropriate average density. This functional form has been chosen because of its close association with the one-dimensional diffusion equation for an initially uniform source.¹ **b**, The fitted surface is linearly interpolated to the discharge trigger delay timings of the measurements 7.5 μs / 9.3 μs and scaled to an average density of $4.4 \times 10^{16} \text{ cm}^{-3}$ (blue curve) / $2.4 \times 10^{16} \text{ cm}^{-3}$ (grey curve) respectively.



Supplementary References

- ¹ Morse, P. M. C. & Feshbach, H. *Methods of theoretical physics*. International Series in Pure and Applied Physics (McGraw-Hill, 1953).