PARAMETRIC STUDY OF LOW-DIVERGENCE X-RAYS FROM A LASER-PLASMA-LENS

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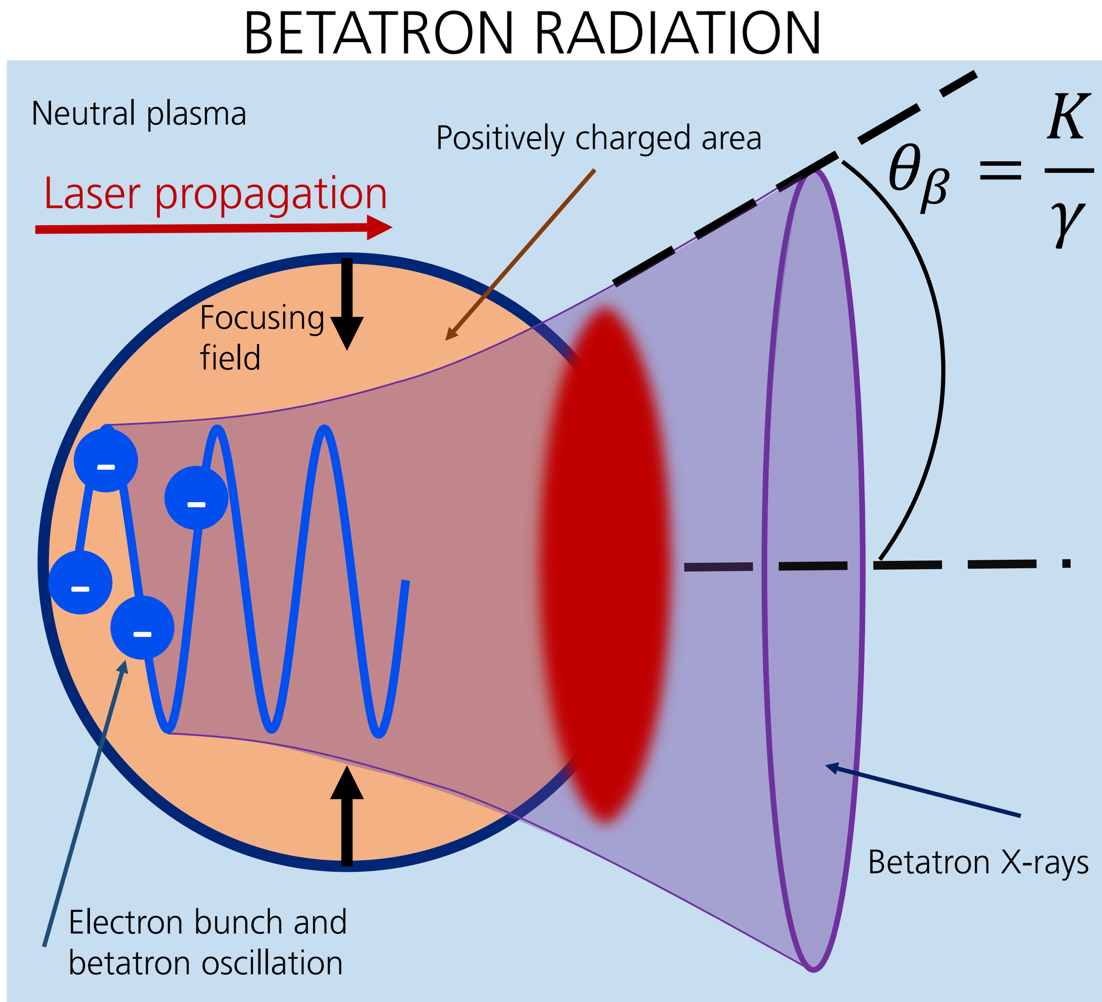
MOTIVATION AND KEY-CONCEPT

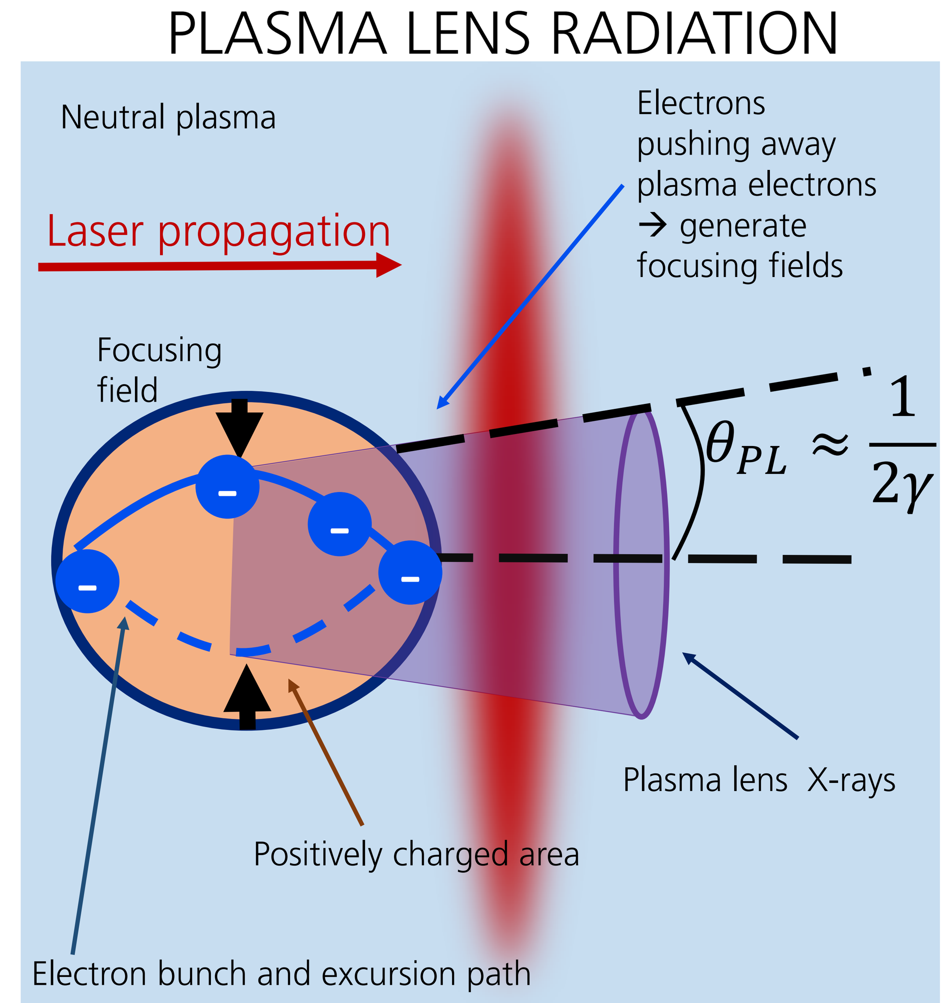
Betatron radiation from laser wakefield accelerators (LWFA) is a powerful X-ray source, proven useful in several applications, e.g. in medical imaging and tomography, X-ray absorption spectroscopy for warm dense matter among others. Due to the strong focusing fields the undulator strength parameter is typically on the order of a multiple of ten, which yields a r.m.s. divergence, θ_β on the order of tens of mrad. An effective beam transport to the sample and subsequent detection therefore becomes challenging which limits the signal to noise ratio.

BETATRON RADIATION

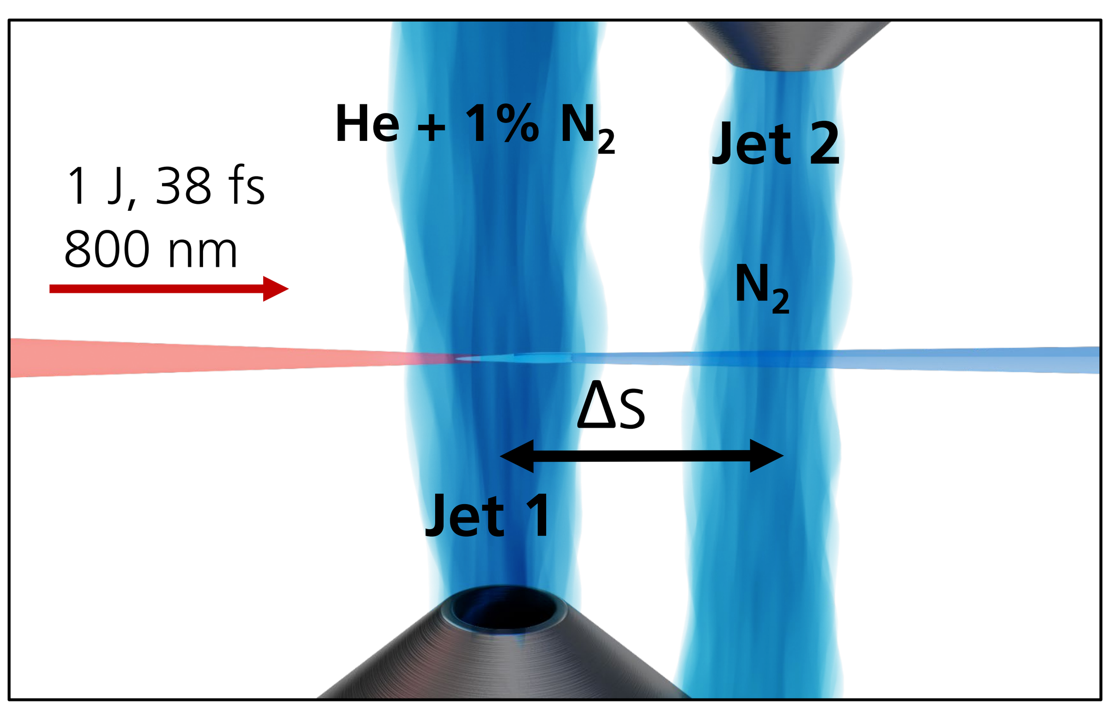


The X-ray divergence can be significantly reduced by utilising a passive plasma lens, here consisting of a gas ionised by the drive laser itself. As the accelerated electrons propagate through this second plasma they generate strong transverse fields, which focus the beam such that only a partial oscillation occurs, and the most energetic electrons are emitting at the crest of the envelope, thus limiting the divergence [1]. These bright X-rays make efficient beam transport possible, hence allow applications requiring an X-ray source which can be manipulated. In this work, new experimental results of the plasma lens radiation.

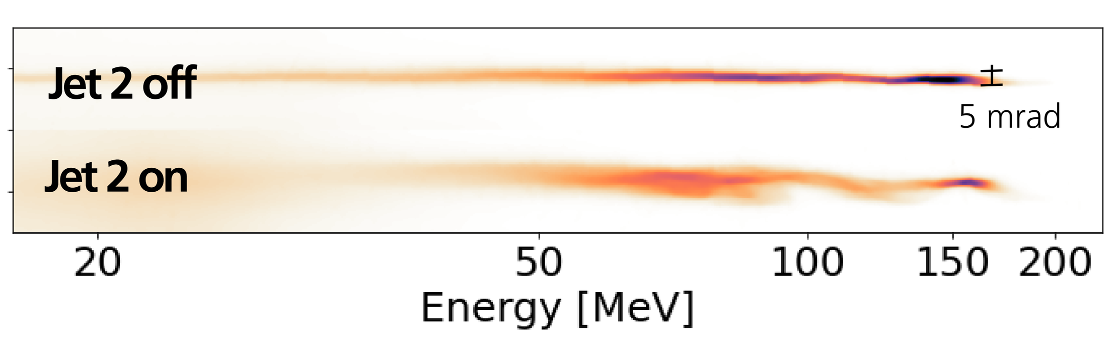
PLASMA LENS RADIATION



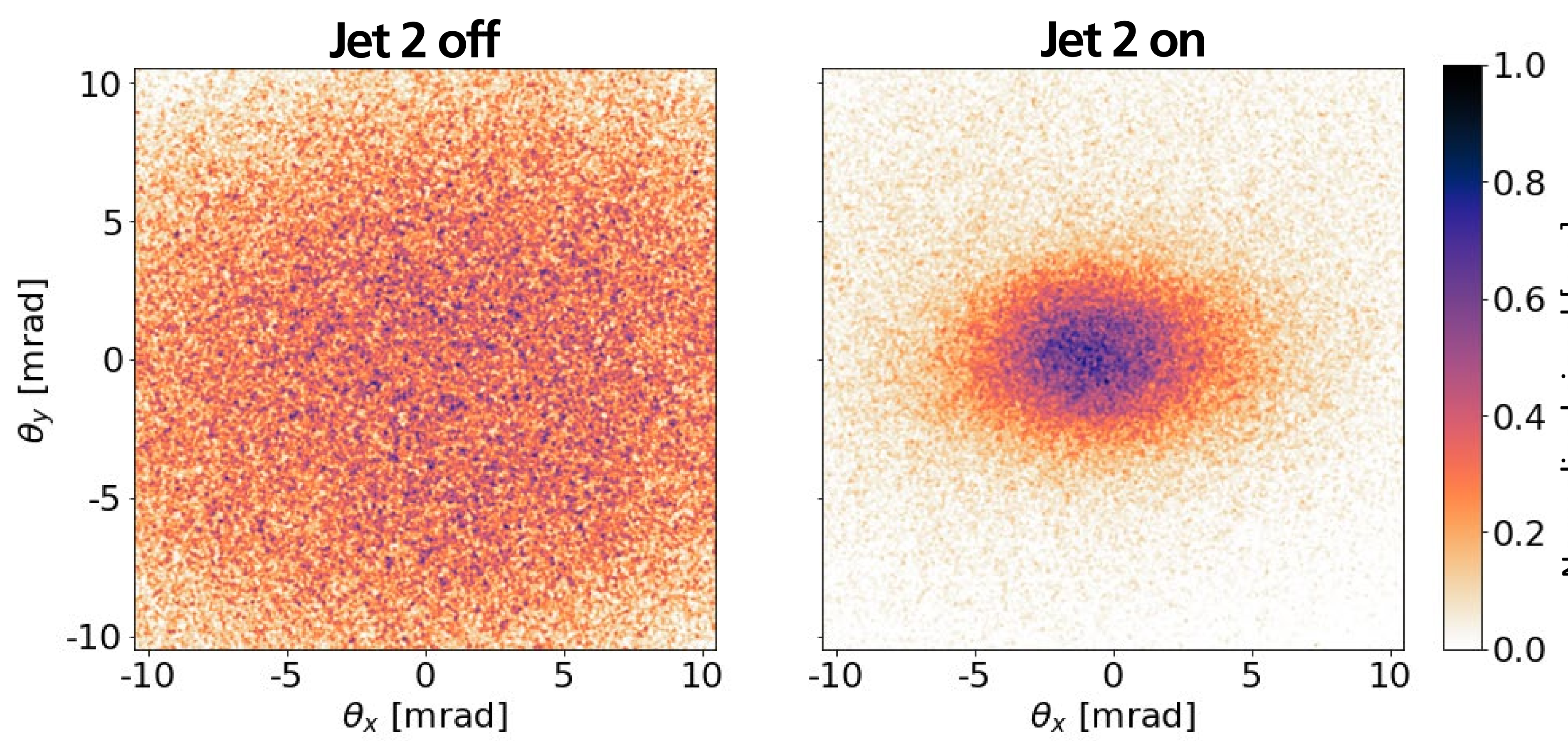
THE INFLUENCE OF THE PLASMA LENS



The electrons are injected through ionization injection [2], and accelerated over the length of jet 1. The laser then ionizes the gas in jet 2. The electrons are focused by the self-generated wakefields in jet 2, leading to the low-divergence plasma lens radiation.



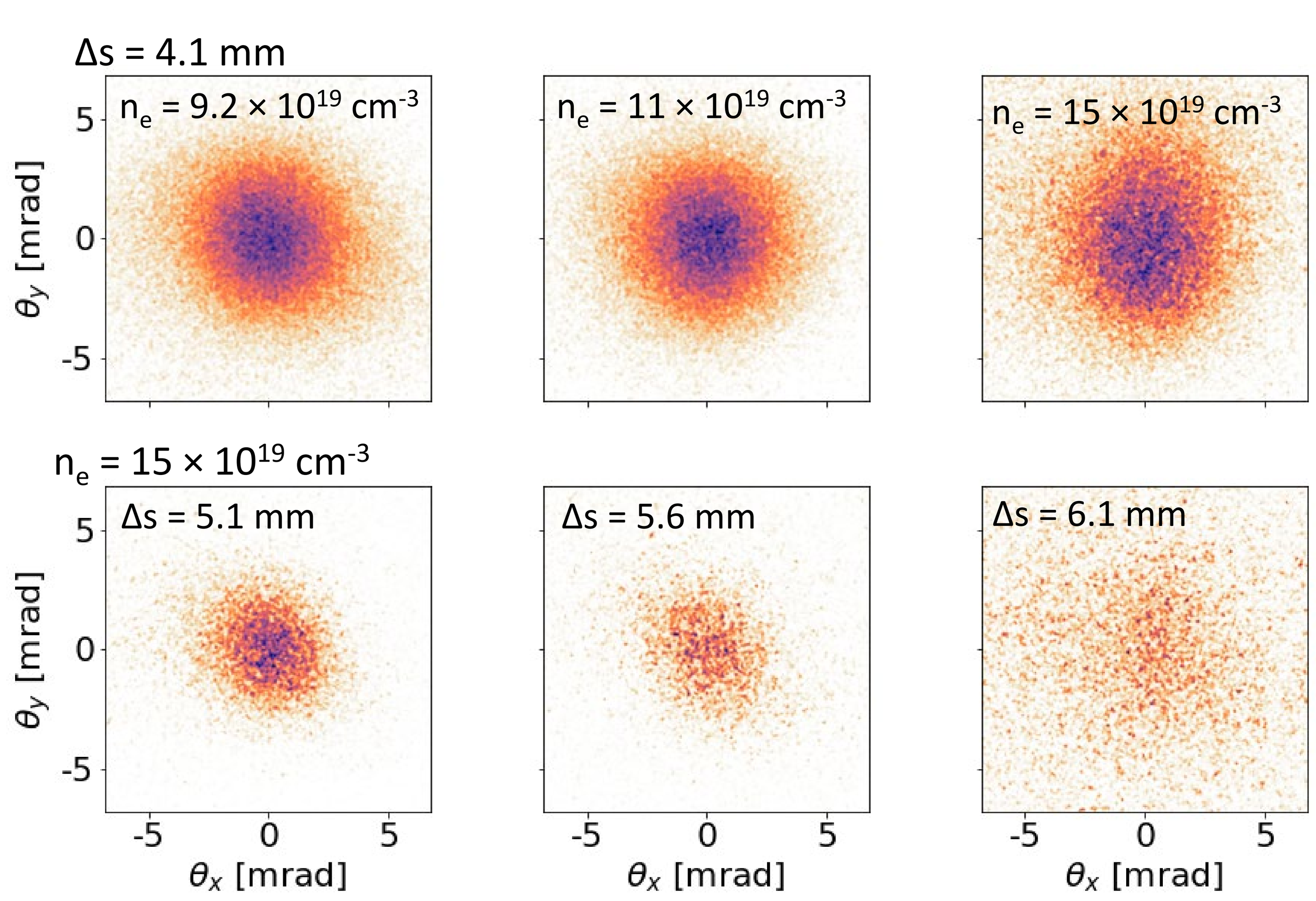
Typically obtained electron spectra. A strong defocusing of low energetic electrons are observed when Jet 2 is on.

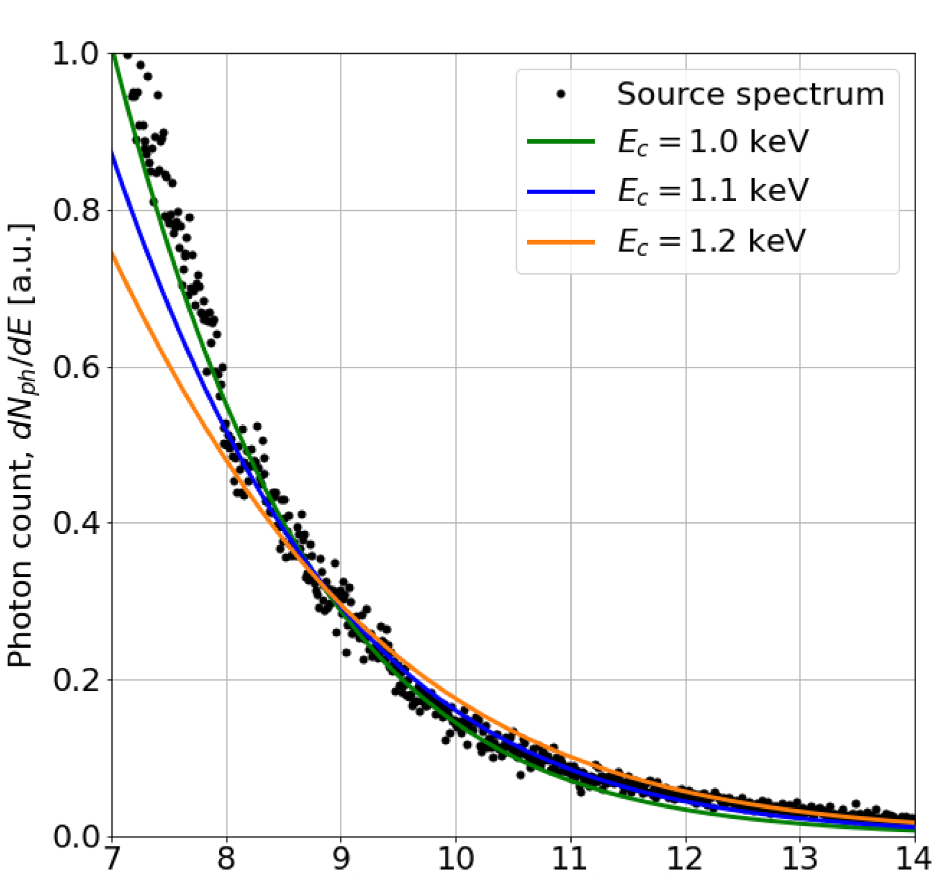


The observed X-ray profile at the detector when Jet 2 is off and on. θ_x and θ_y refer to the calibrated X-ray divergence in the horizontal and vertical plane on the detector.

PLASMA LENS RADIATION DATA

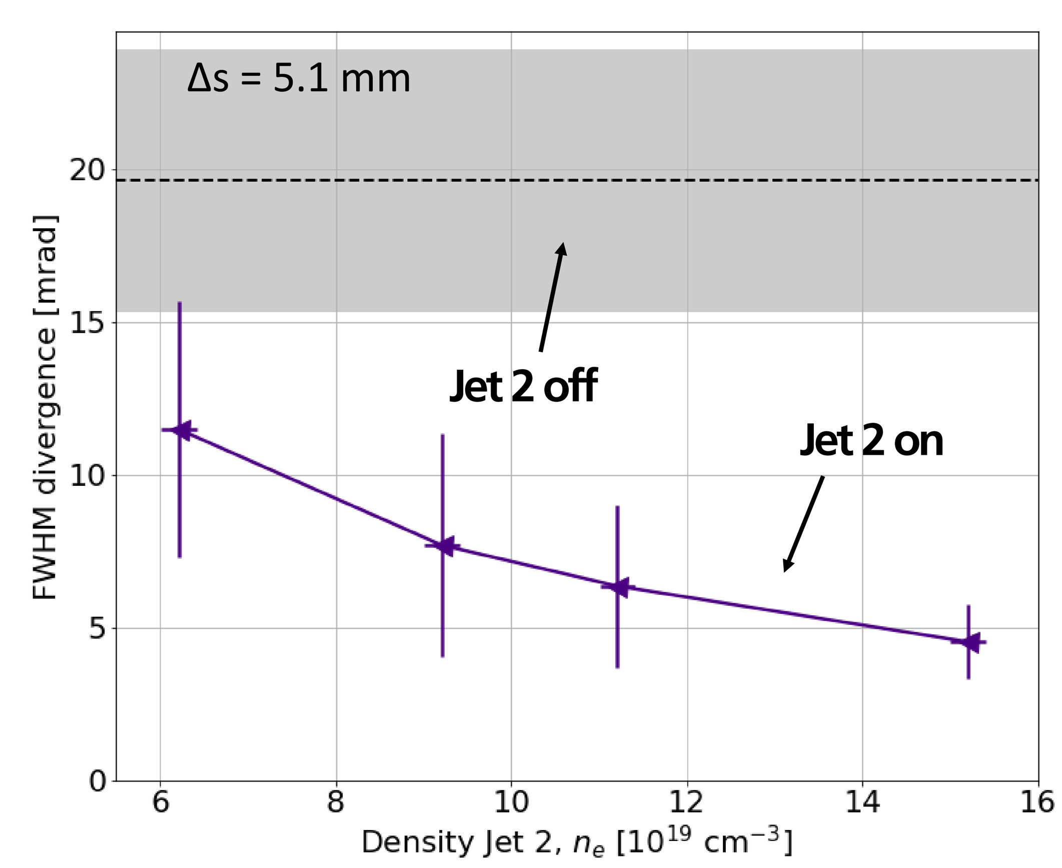
Selection of parametric data, showing the full profile of the plasma lens radiation. Top row: Constant distance between the jets. Bottom row: Constant density of jet 2.

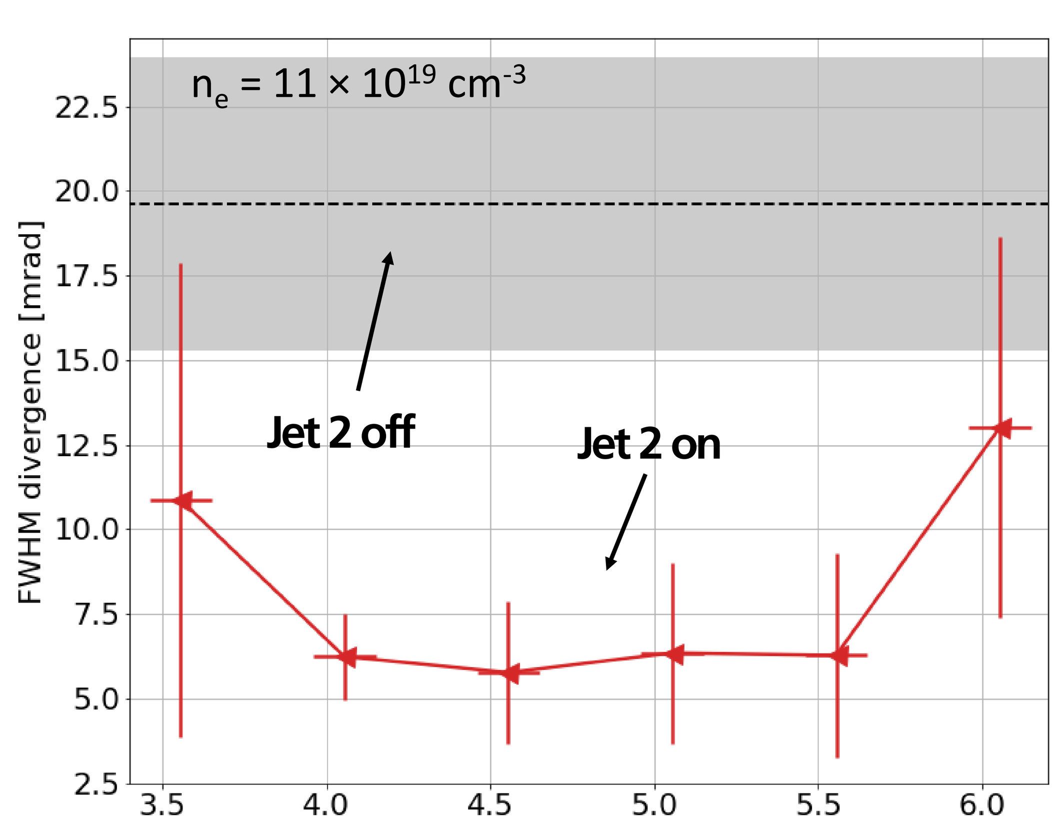




The obtained renormalized X-ray spectrum at the source using single-photon counting at the detector when jet 2 is on, and fit of a synchrotron spectrum for different critical energies, Ec.

The transverse FWHM divergence (θ_y) of the X-ray beam profile. The dashed black and lines are the θ_y of the X-ray beam when jet 2 is off and the shaded area the r.m.s. deviation from the mean. The vertical error bars denote the r.m.s. deviation from the mean FWHM divergence, and the horizontal the accuracy of the density and jet separation respectively. At short distances, the jet flows are slightly mixed, giving rise to turbulence. At large distances, the electrons have diverged and thus the bunch charge density is lower upon entering the plasma lens, leading to a less efficient wake excitation.





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