

Ionization Waves of Arbitrary Velocity

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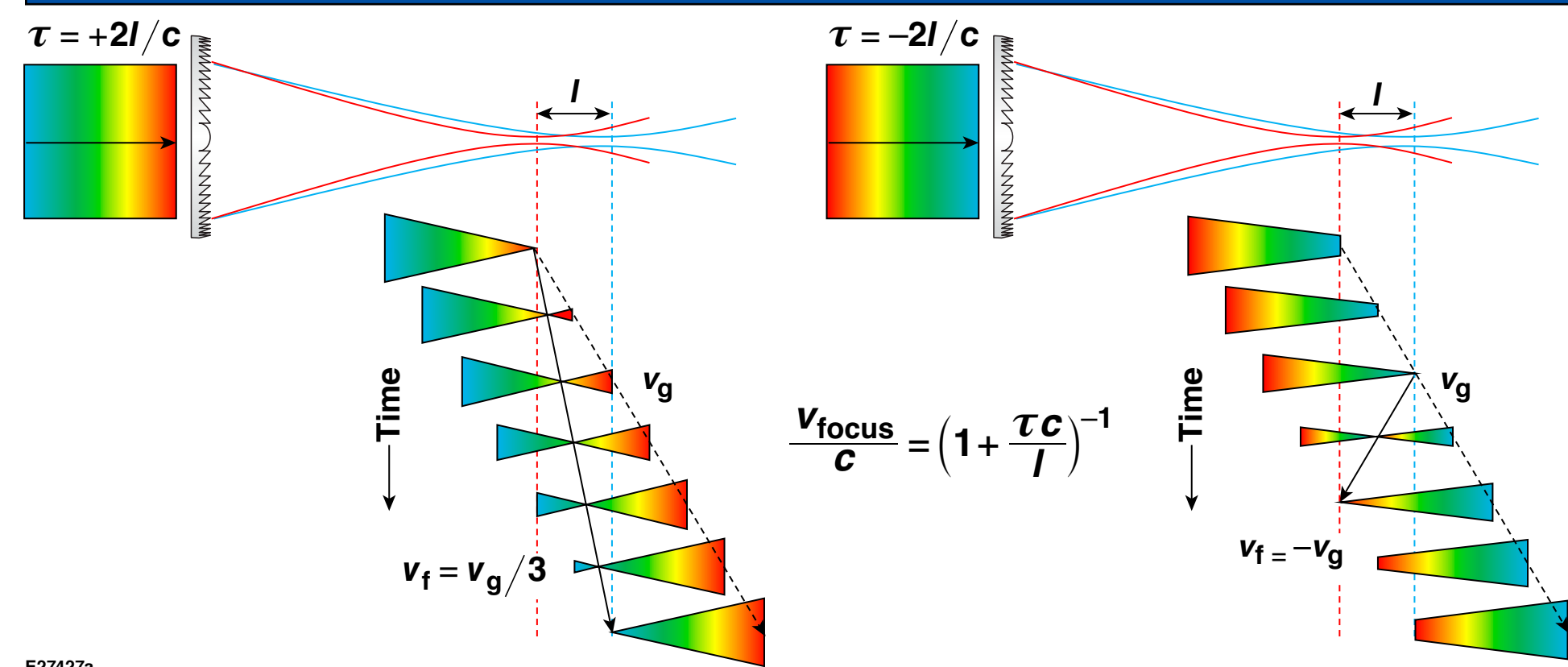
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Summary

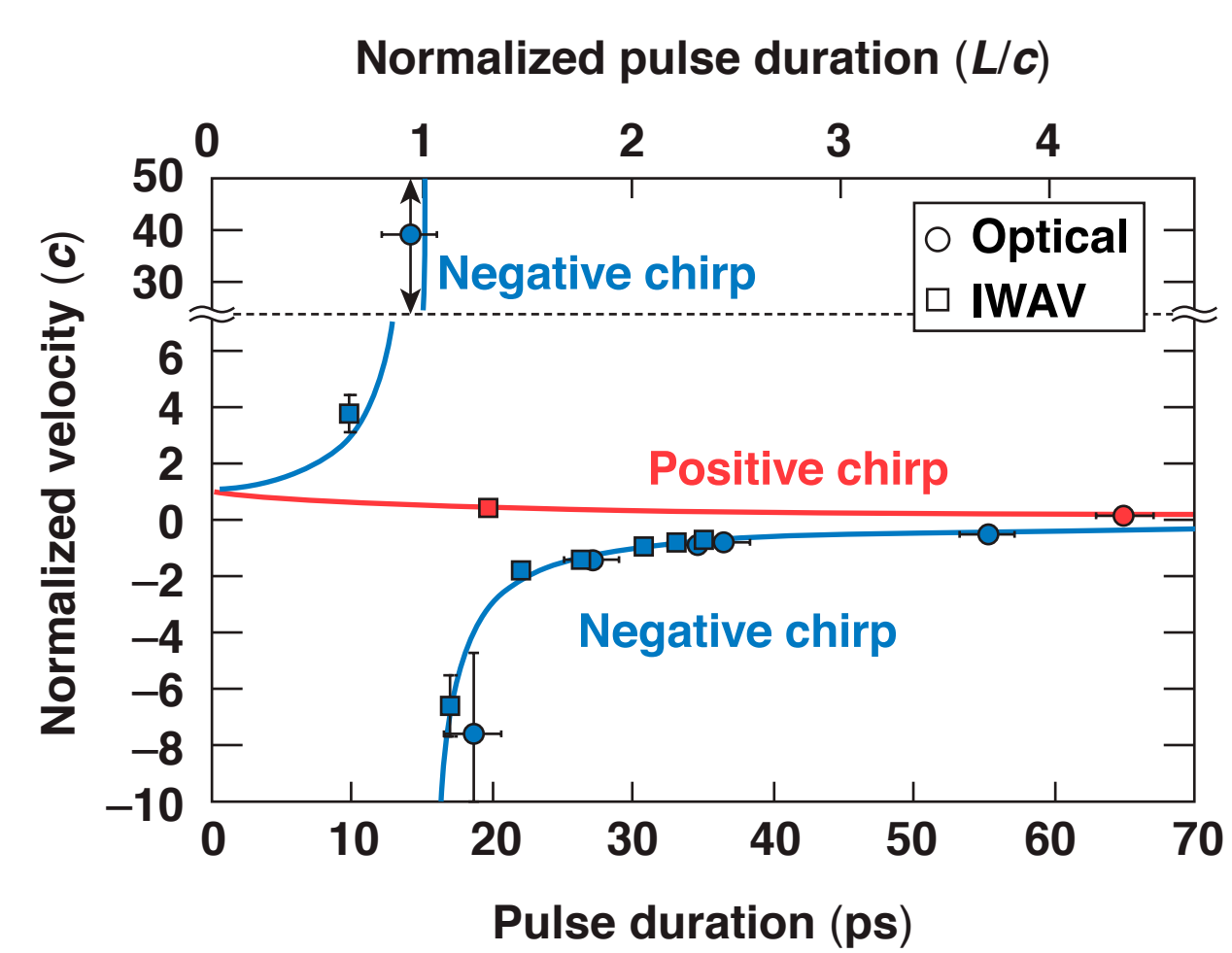
- The flying focus (FF) allows for unprecedented dynamic control of a laser's focus such that the peak laser intensity can propagate at an arbitrary velocity over distances much greater than the Rayleigh length*
- An ionization front will track the intensity isosurface at the ionization threshold of a background gas, resulting in an ionization wave of arbitrary velocity (IWAV) that propagates at the FF velocity**†
- A split-step Fourier propagation code with an ionization package was used to explore the IWAV dynamics in the far field and quasi-far field†
- IWAV's were demonstrated experimentally in the far field using spectrally resolved schlieren with a linearly chirped probe beam**
- IWAV's were demonstrated in the quasi-far field using a novel spectrally resolved interferometry diagnostic that also makes it possible to characterize the density scale lengths of the ionization front
- The effect of ionization-induced refraction (IIR) is mitigated for forward-superluminal and backward-FF velocities, which allows for the formation of long, uniform plasma channels**††

*D. H. Froula et al., Nat. Photonics 12, 262 (2018).
**D. Turnbull et al., Phys. Rev. Lett. 120, 225001 (2018).
†J. P. Palastro et al., Phys. Rev. A 97, 033835 (2018).

The flying focus decouples the laser's peak intensity from its group velocity

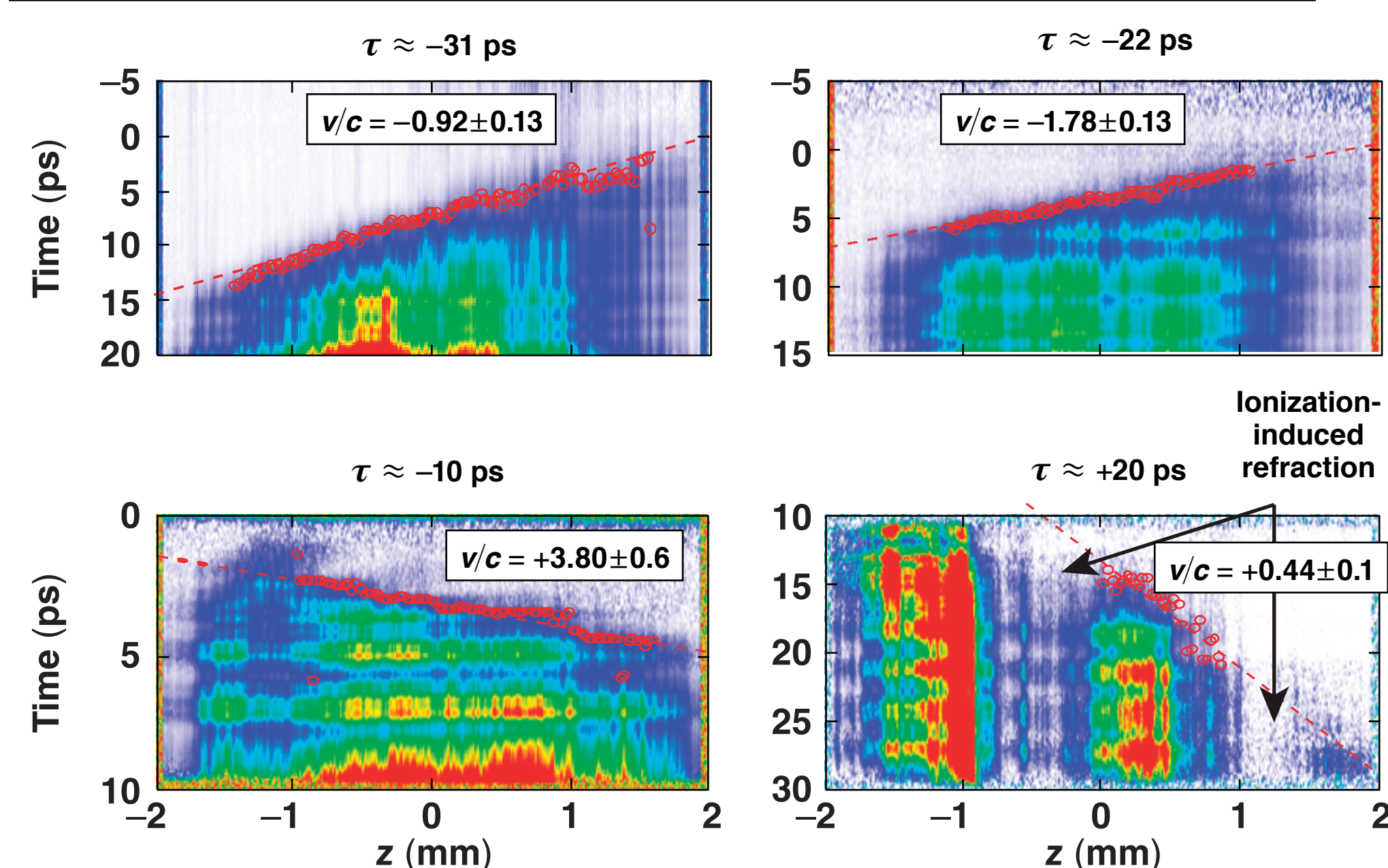


Measured IWAV velocities agree with analytic predictions of the FF velocity



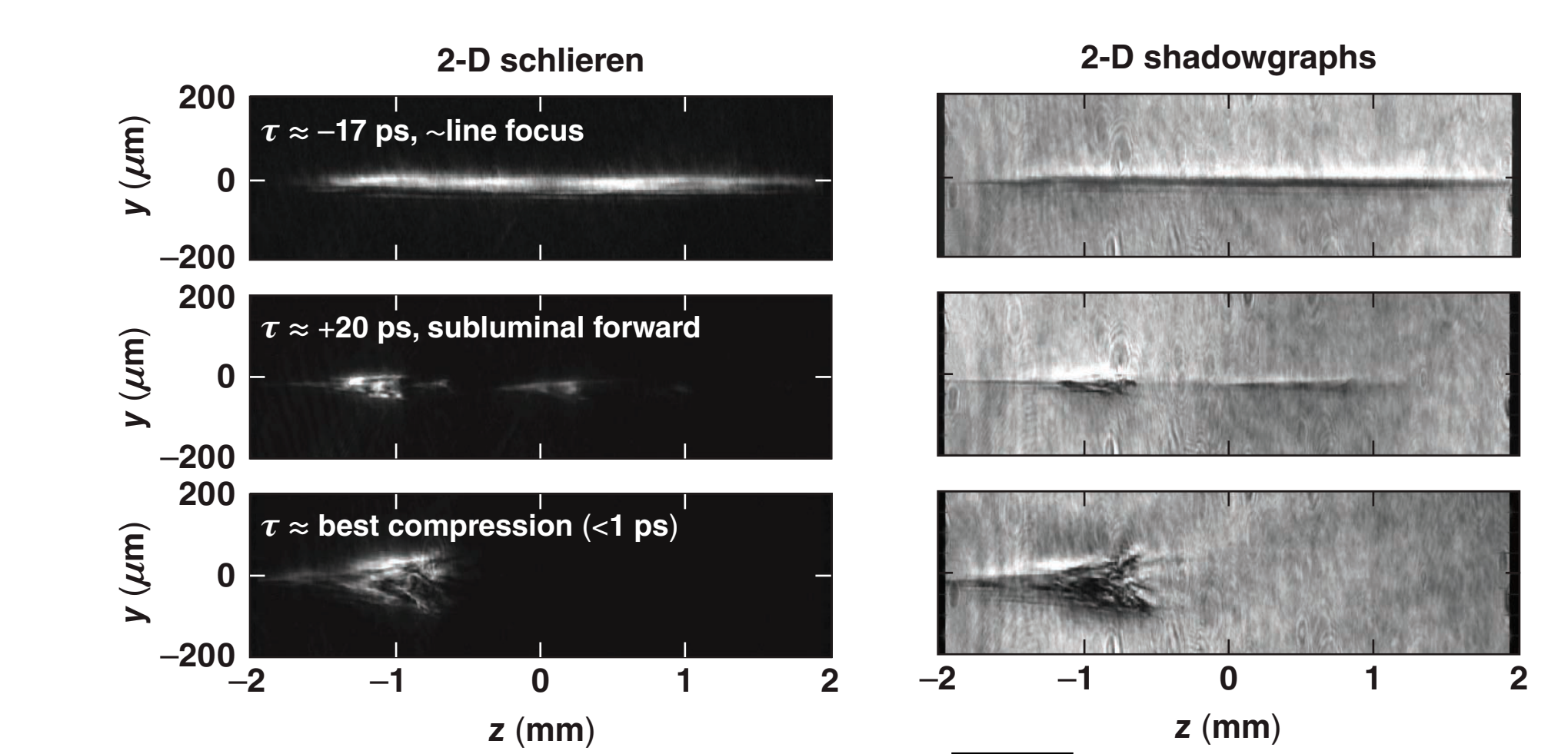
D. Turnbull et al., Phys. Rev. Lett. 120, 225001 (2018);
D. H. Froula et al., Nat. Photonics 12, 262 (2018).

A spectrally resolved schlieren diagnostic was used to diagnose IWAV velocities in the far field



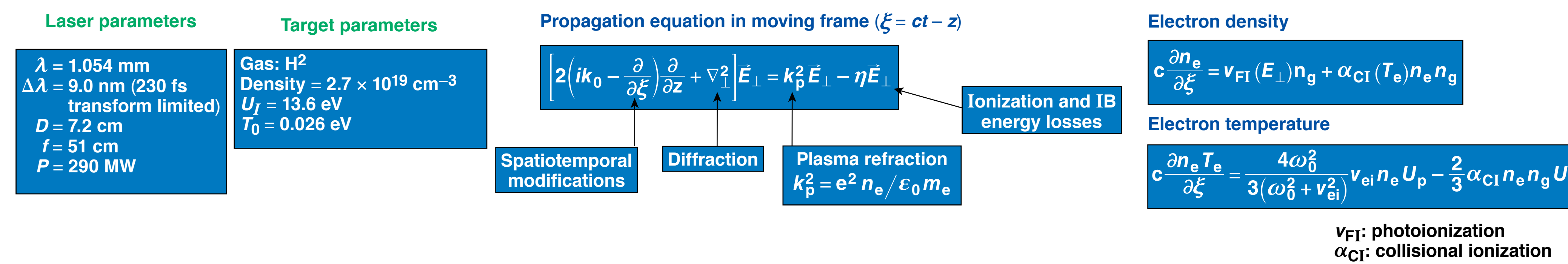
D. Turnbull et al., Phys. Rev. Lett. 120, 225001 (2018).

Two-dimensional data in both regimes show that IIR can be mitigated and uniform channels can be produced over many millimeters, with large diameters achieved in the quasi-far field

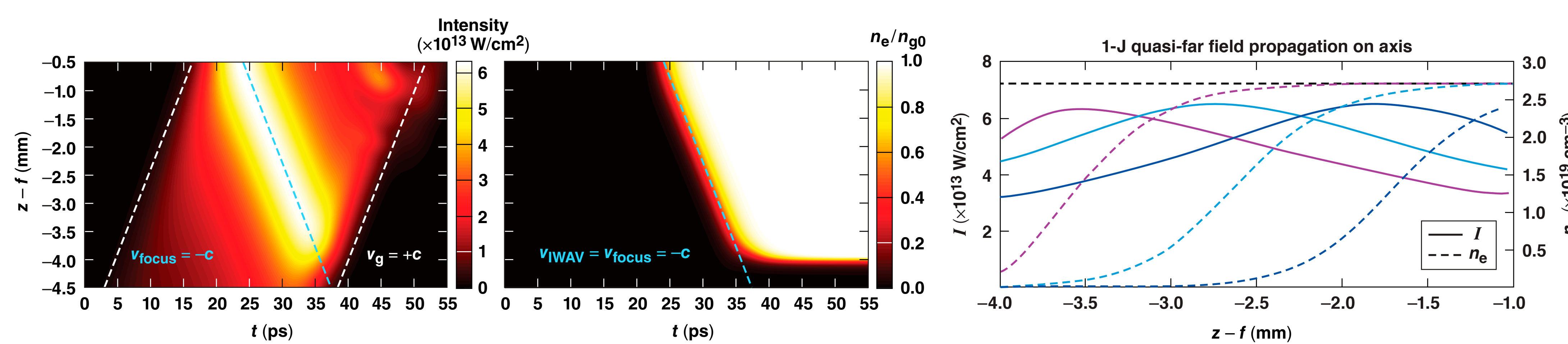


D. Turnbull et al., Phys. Rev. Lett. 120, 225001 (2018).

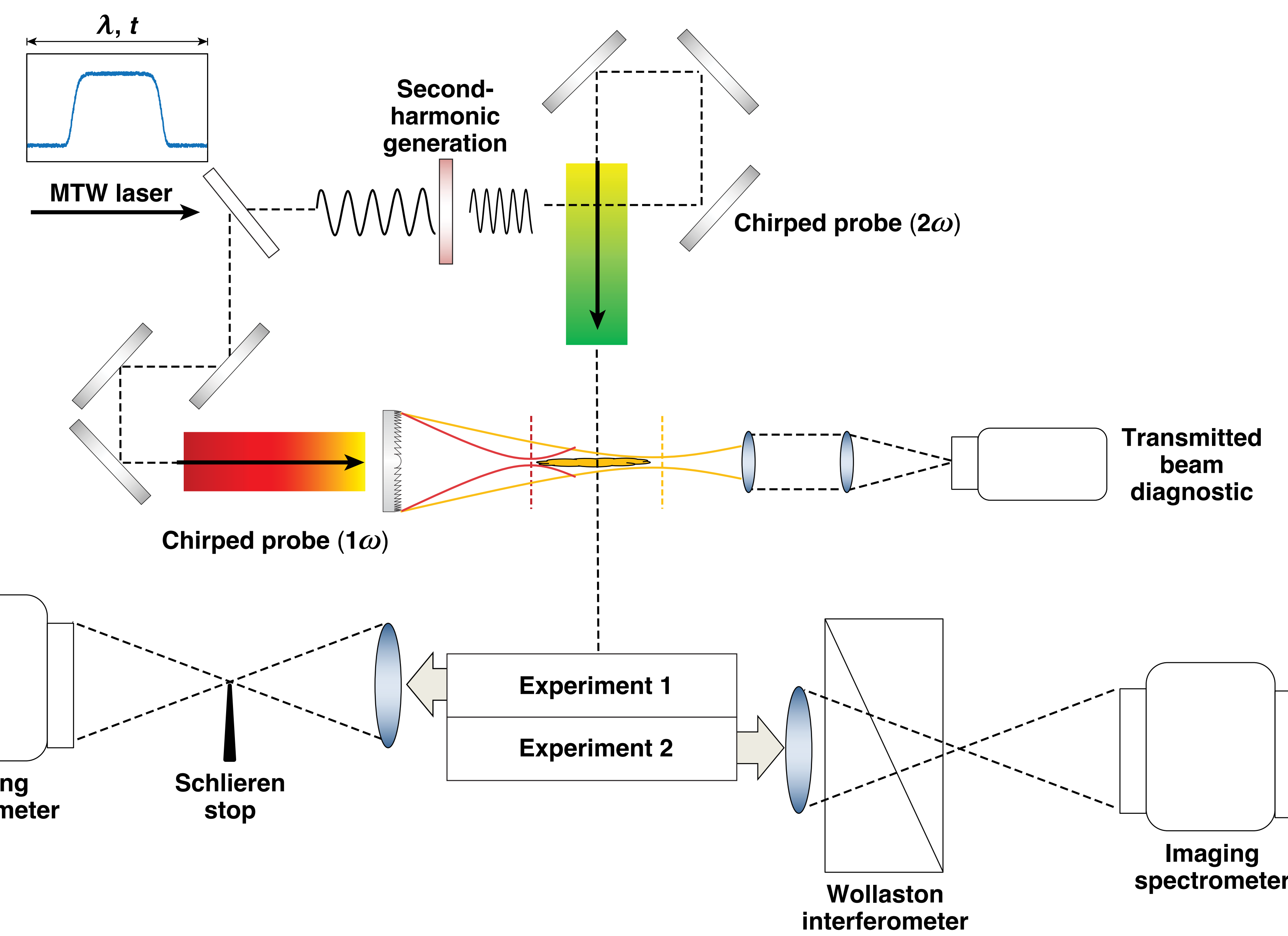
A laser propagation and ionization model successfully predicts IWAV dynamics



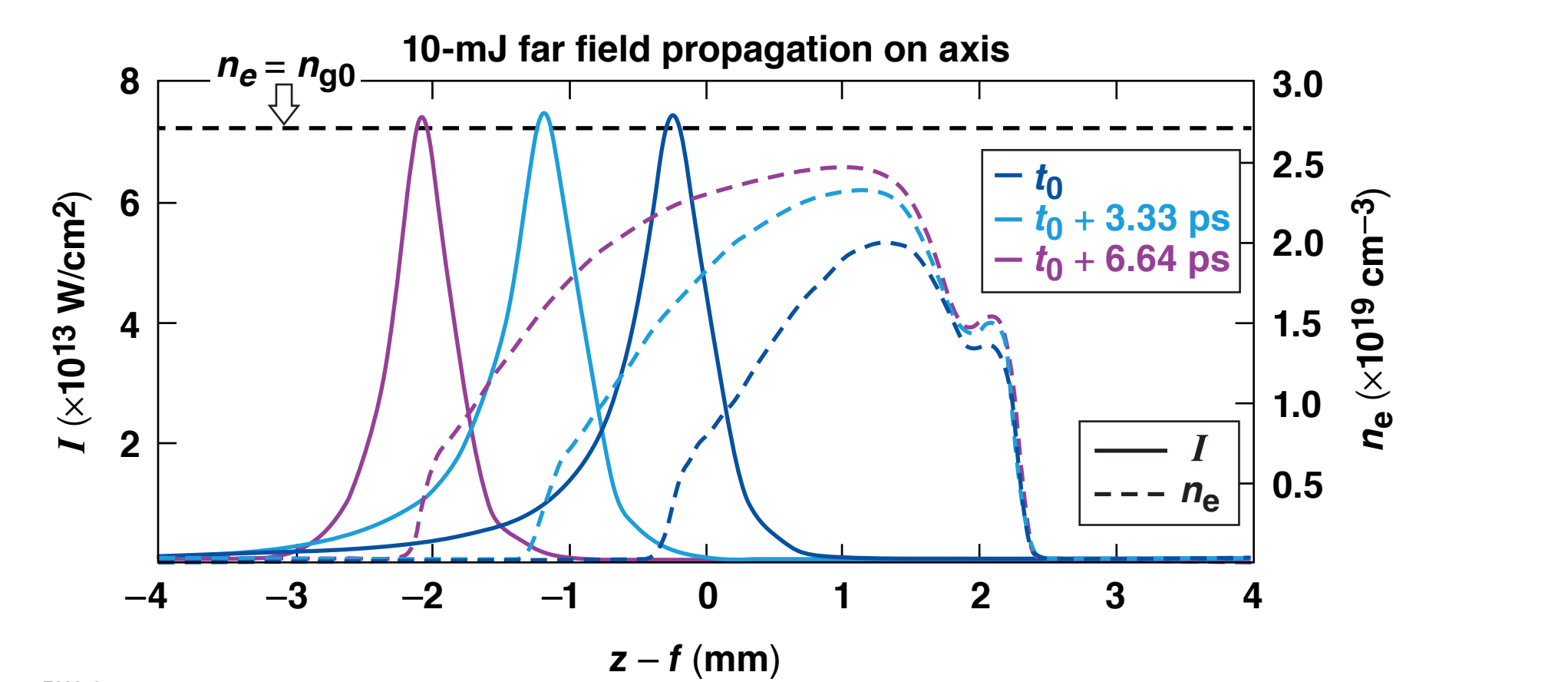
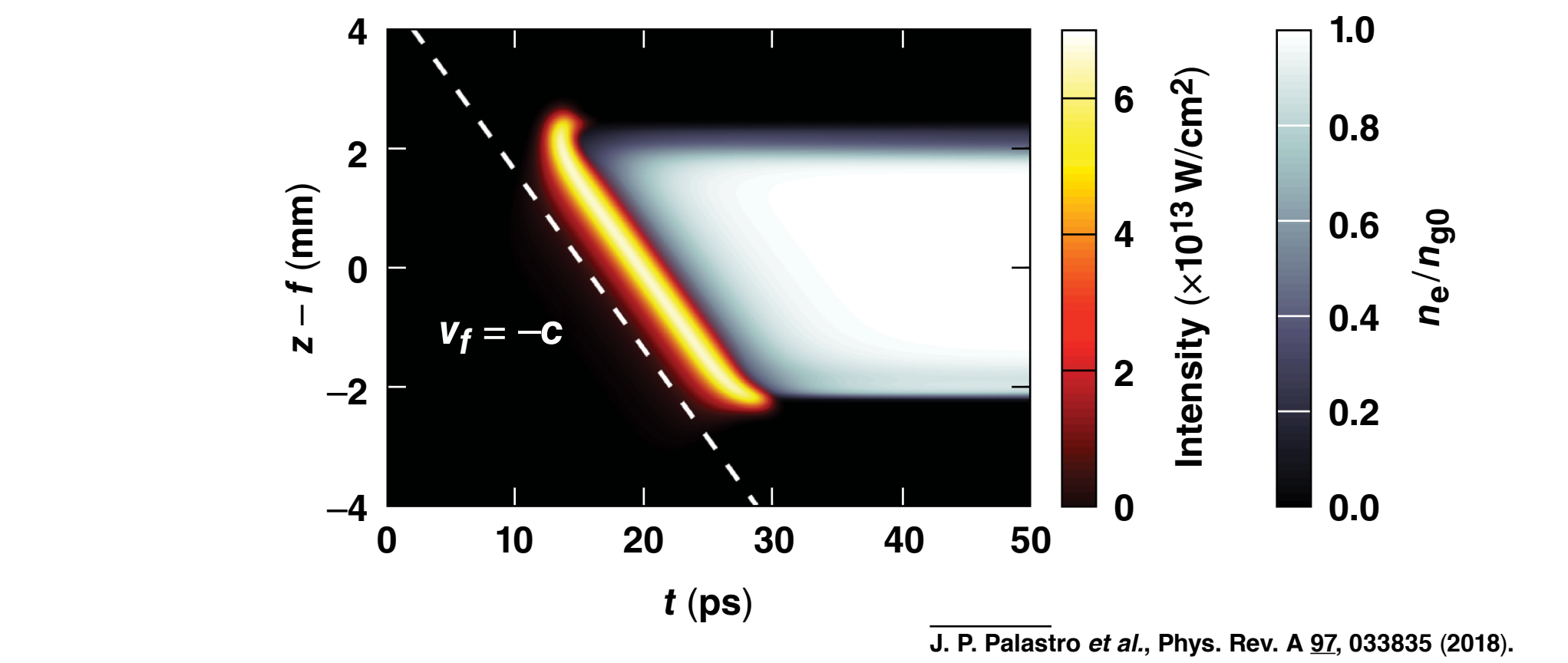
IWAV dynamics persist into the quasi-far field



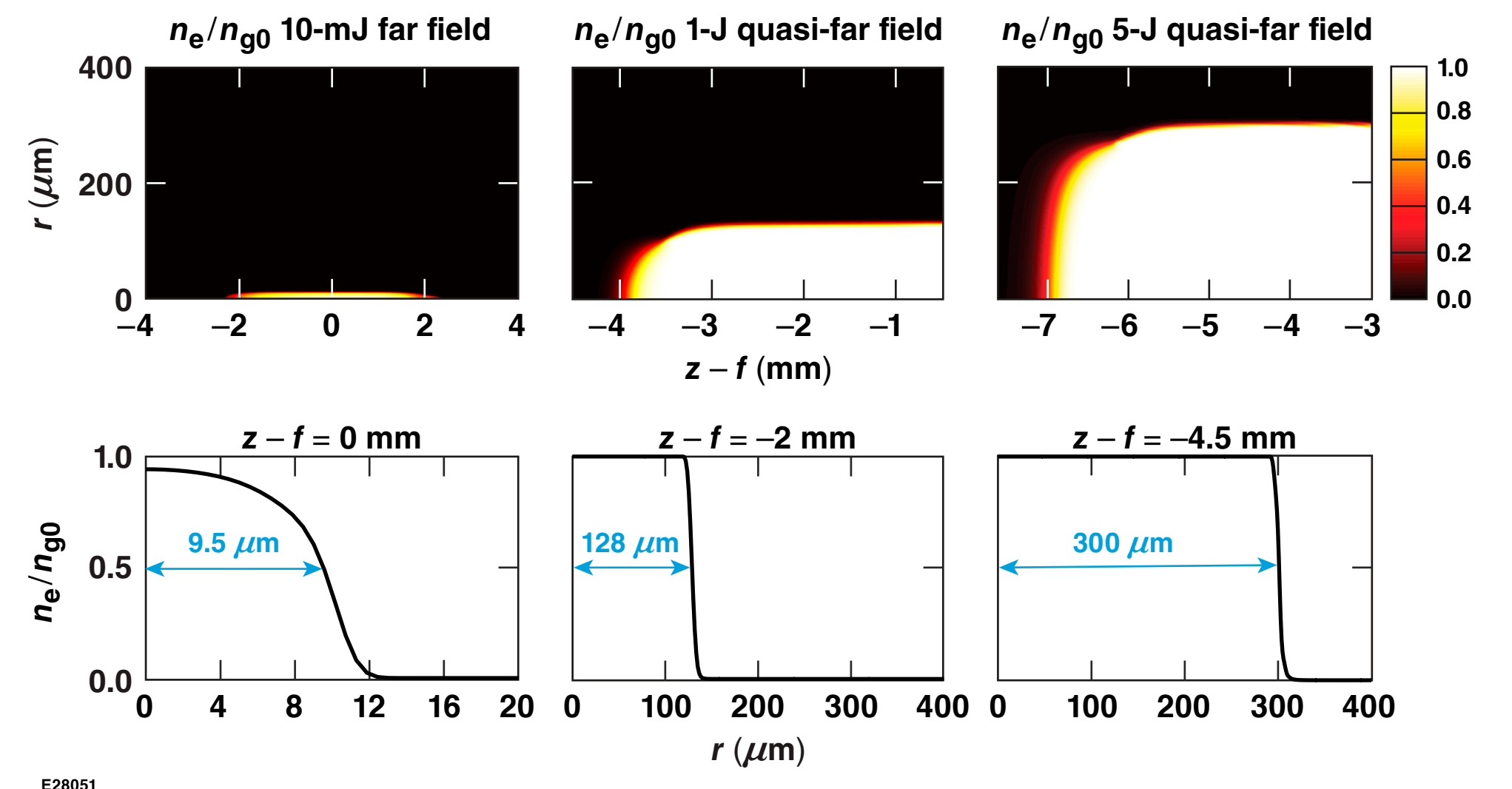
An experimental platform was developed to explore IWAV dynamics on the Multi-Terawatt (MTW) Laser



The IWAV tracks the FF peak intensity in the far field



Operation in the quasi-far field allows for the formation of large-diameter channels



Data from a novel spectrally resolved interferometry diagnostic will be used to diagnose IWAV velocities and density scale lengths in the quasi-far field

