Measuring the Ion Temperature of a Plasma Jet Using a Two-Dimensional Optical Fiber Array for an Improved Spectroscopic Analysis to Study the Possibility of Pre-heating During Plasma Compression

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Abstract

Outlined is our arrangement to measure the ion temperature of a plasma jet via Doppler-broadening spectroscopy to investigate the possibility of pre-heating plasma during plasma compression. The jet, formed by puffing a controlled amount of Argon gas into Embry-Riddle's cylindrical vacuum chamber and then ionizing it via high-voltage electronically switched capacitor banks, is regulated to undergo magnetohydrodynamic (MHD) current-driven instabilities and magnetic reconnection, and is ultimately terminally collided with a gas cloud [1]. Ion temperature measurement of plasma is inferred by spectroscopic analysis [2] [3]. To improve the fidelity of our spectroscopy, the presented method implements a unique assemblage of 54 optical fiber cables into a systematic two-dimensional array, broadening the area of observation. With this, we aim to develop our analysis of instability-induced ion heating and its contribution to collisional plasma heating, thus shedding light on the possibility of pre-heating the plasma during plasma compression.

Experimental Setup

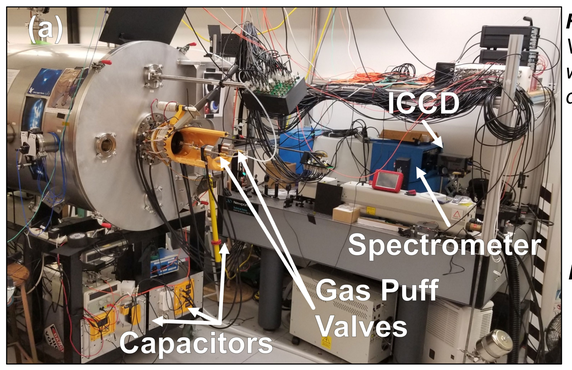


Figure 1. *(left) Vacuum chamber with relevant devices used.*

Figure 2. *(right) Optics set-up*

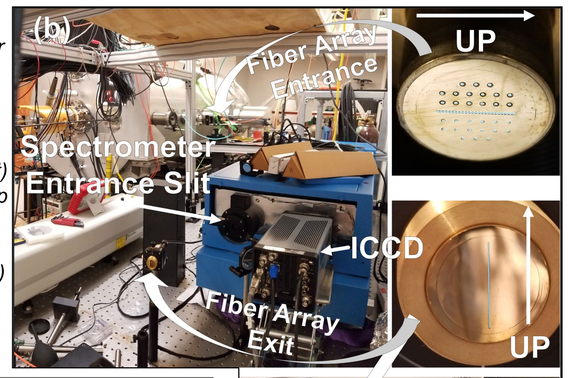
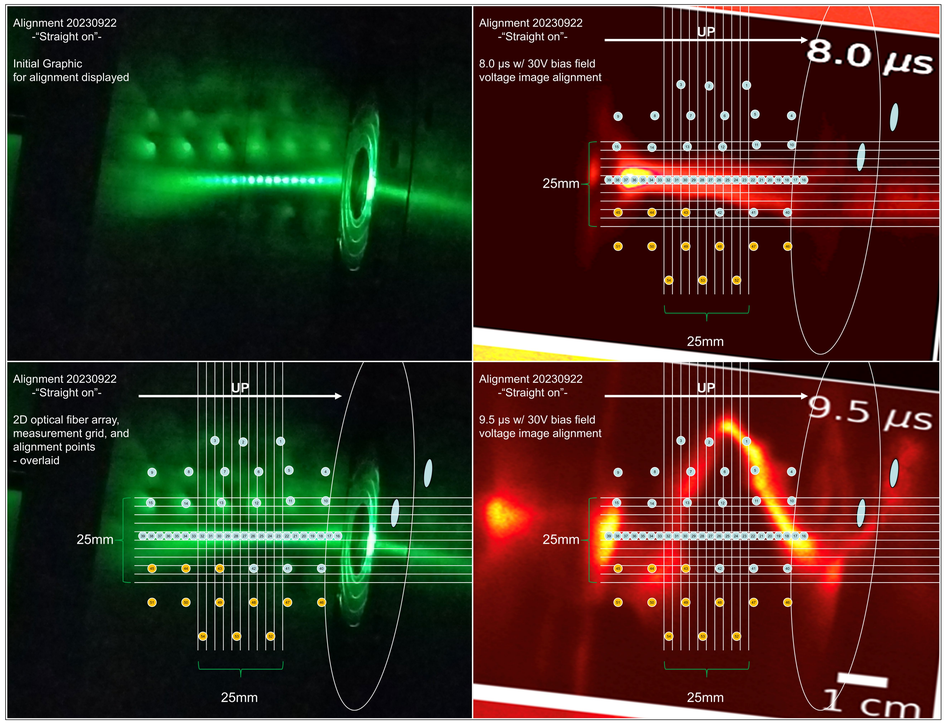
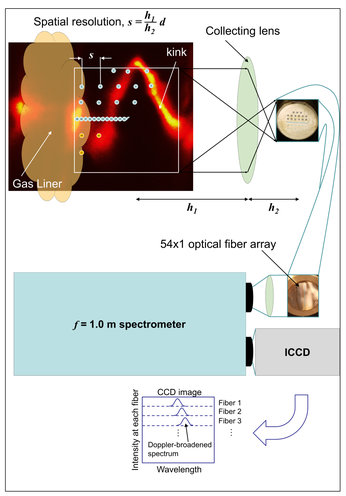


Figure 3. *(below) 54-Optical fiber array alignment with Plasma*





Preliminary Results

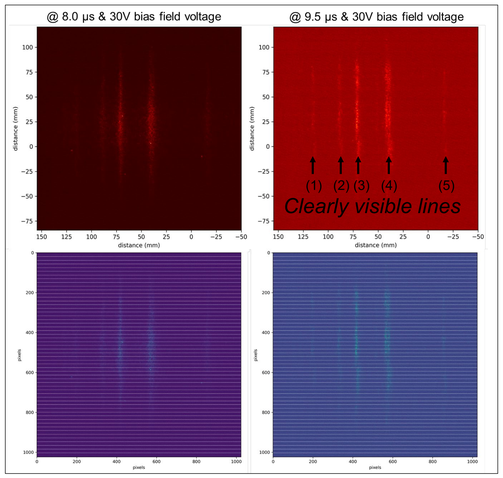


Figure 4. *(above) Images of Plasma Shot 1240 taken via ICCD at 8.0 and 9.5 μs, from Spectrometer, and sliced for 54 optical fibers. (Elected to focus on lines 3&4.)*

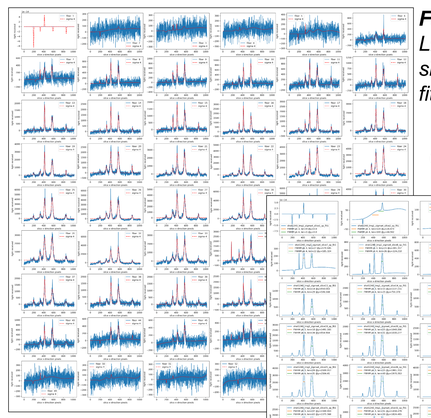


Figure 5 *(left) Light intensity of respective slices, with applied Gaussian fitted curves.*

Figure 6 *(below) Gaussian fitted curves used to determine FWHMs*

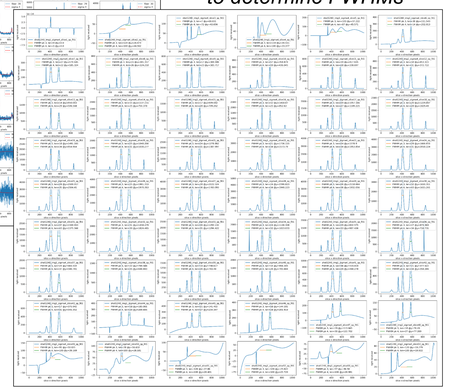
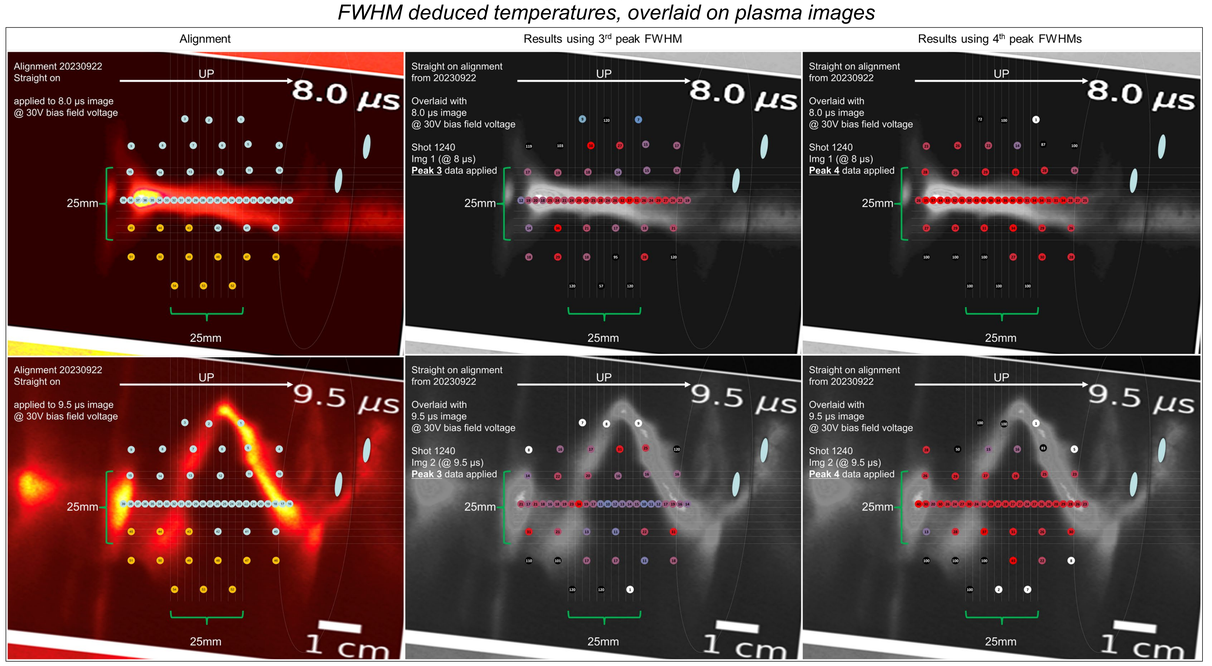


Figure 7. *(below) FWHM deduced temperatures, overlaid on plasma images*



References

[1] Seo B., Bellan P. M.; Experimental investigation of the compression and heating of an MHD-driven jet impacting a target cloud. Physics of Plasmas 1 November 2018; 25 (11): 112703.
[2] Bellan P. M., Magnetic Helicity, Spheromaks, Solar Corona Loops, And Astrophysical Jets. World Scientific, 2018.
[3] Hutchinson I. H., Principles of Plasma Diagnostics. Cambridge University Press, 2002.

Acknowledgements

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