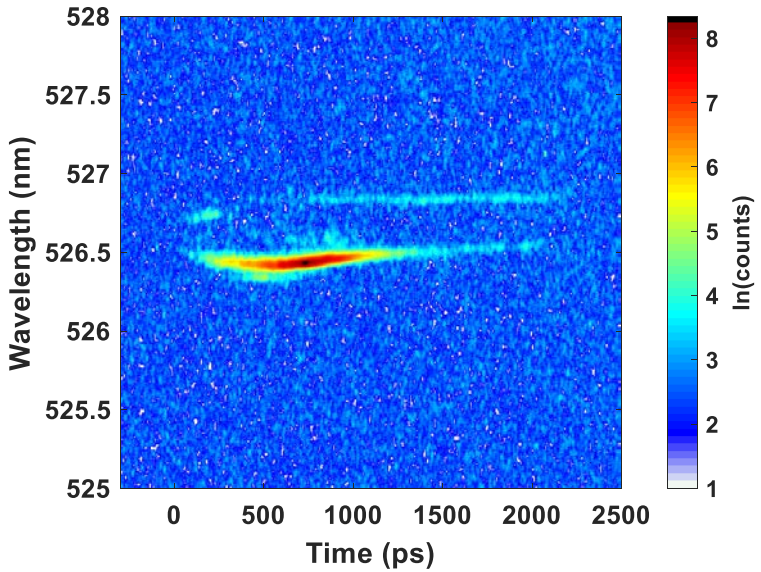
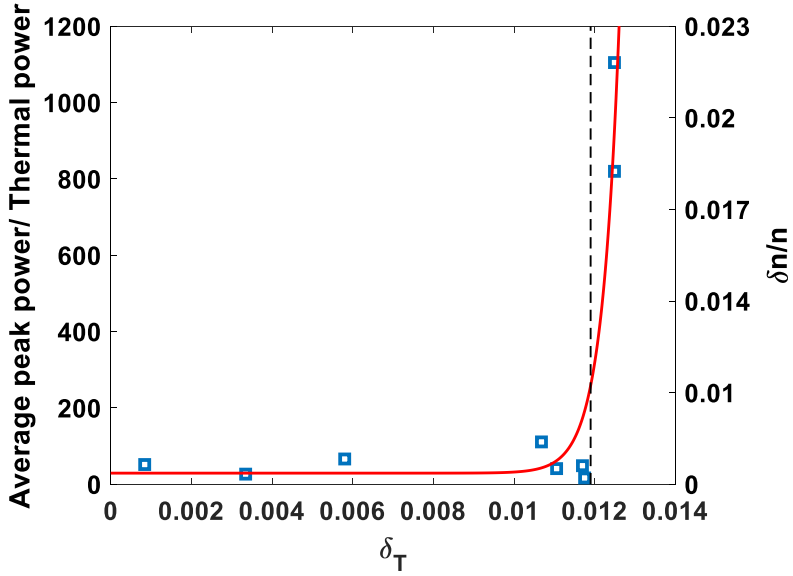
Measurements of the Return-Current Instability with Ion-Acoustic Thomson Scattering





A. L. Milder
University of Rochester
Laboratory for Laser Energetics

63rd Annual Meeting of the American Physical Society Division of Plasma Physics
Pittsburg, PA
8-12 November 2021

Summary

Ion acoustic waves driven by return current instability (RCI) have been observed

- Return current instability was driven by a temperature gradient at the edge of the plasma
- EPW Thomson scattering measurements of plasma conditions at multiple radial locations agree with predictions
- RCI threshold is being investigated by comparing IAW growth rates

Initial analysis show the threshold for the instability at $\delta_T \approx 0.012$

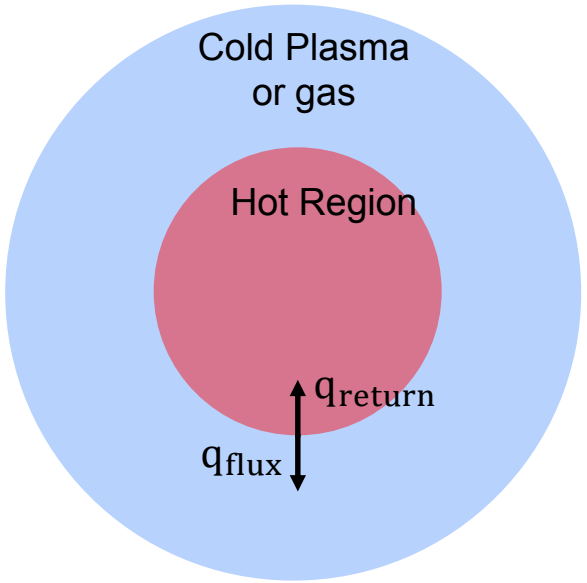
Collaborators

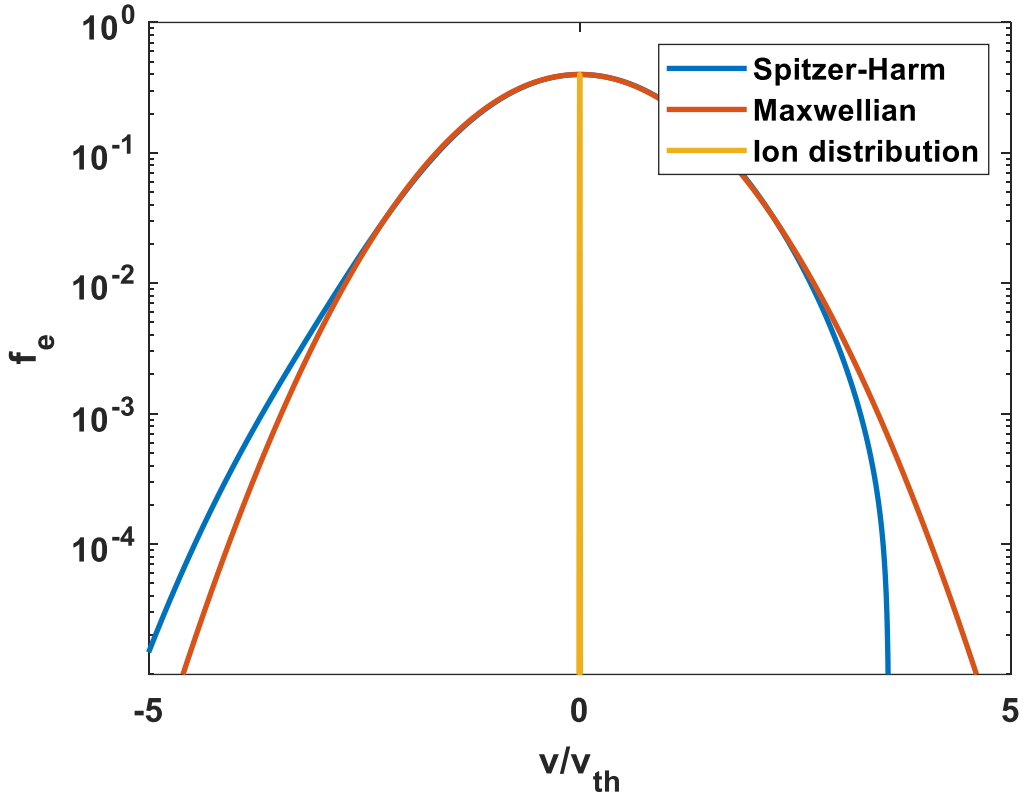
J. Katz, J. P. Palastro, D. H. Edgell, A. M. Hansen, D. Turnbull, and D. H. Froula
Laboratory for Laser Energetics

M. Sherlock
Lawrence Livermore National Lab

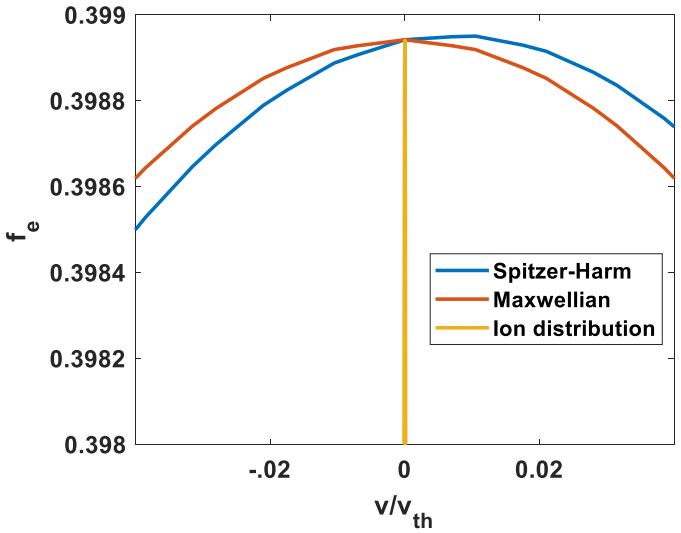
W. Rozmus
University of Alberta

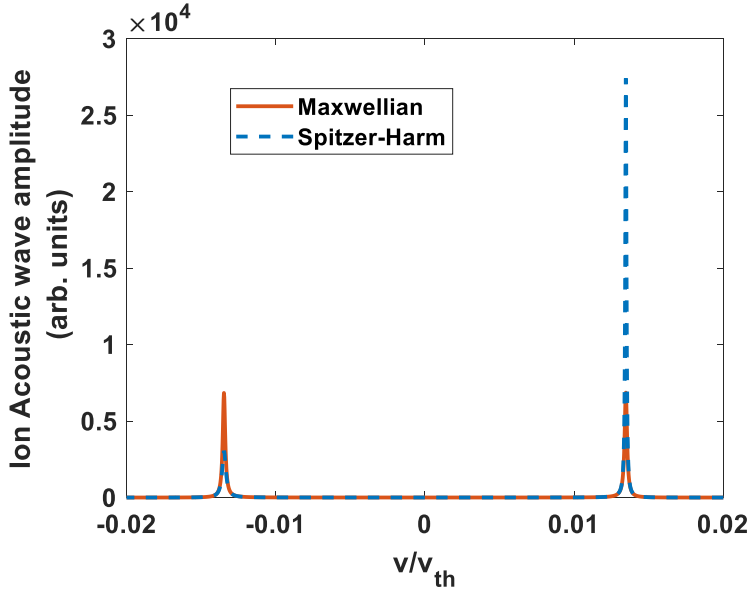
Return Current Instability (RCI) is caused by a cold current returning to the hot region to neutralize the heat flux





Electrons appear to be drifting relative to the ions, enhancing fluctuations along the drift

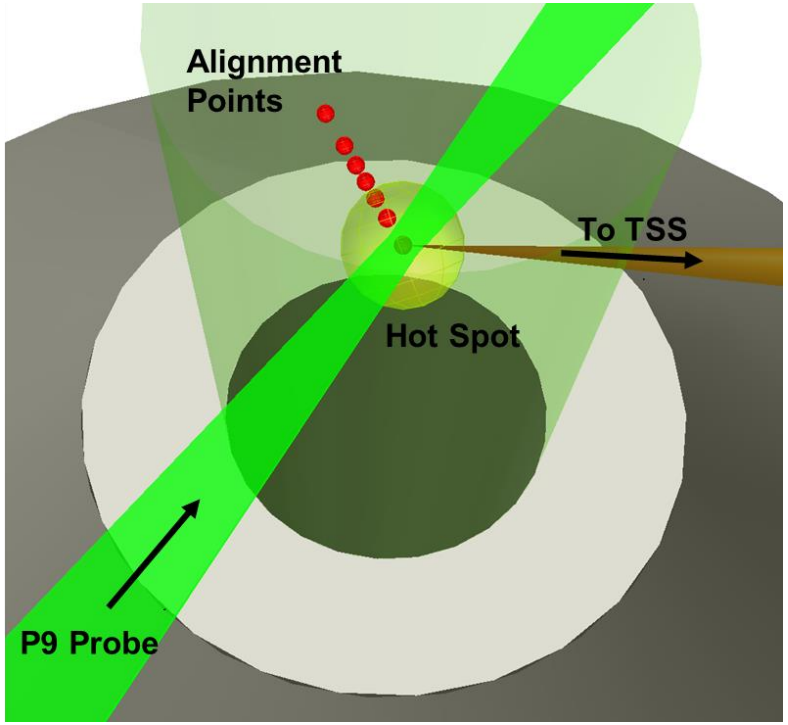


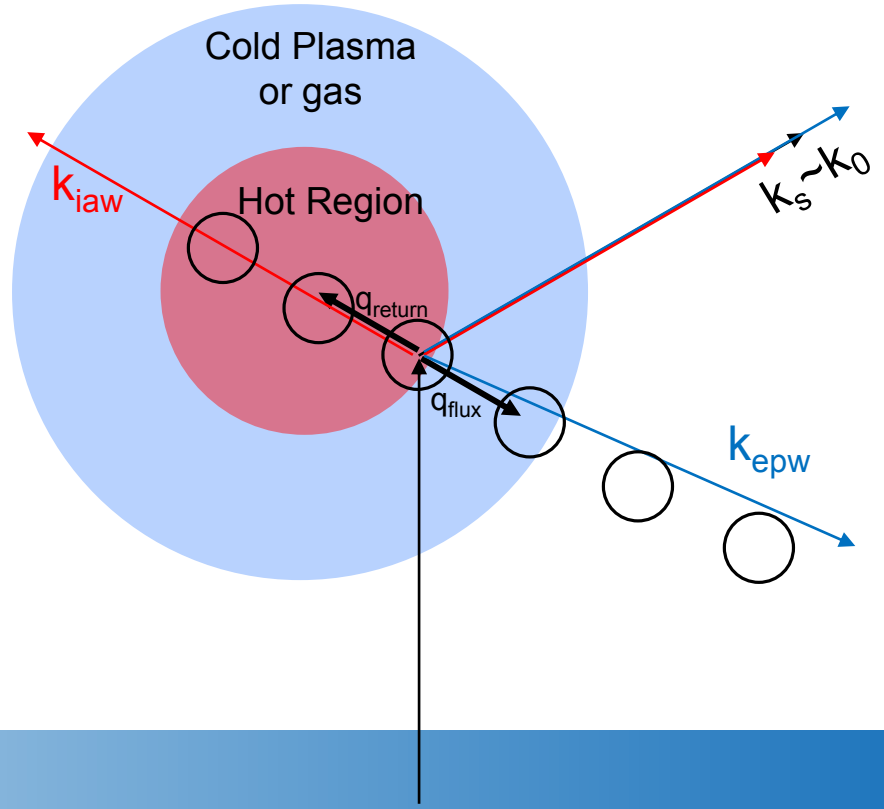


$$\delta_T = \frac{\lambda_{ei}}{L_T} = \lambda_{ei}|\nabla \ln(T_e)|$$

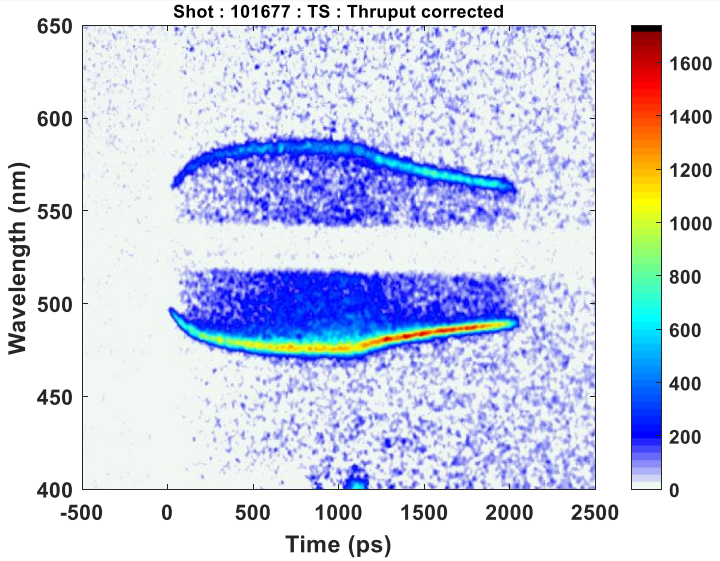
Ion-acoustic wave Thomson-scattering was used to measure the wave amplitude as a function of temperature gradient

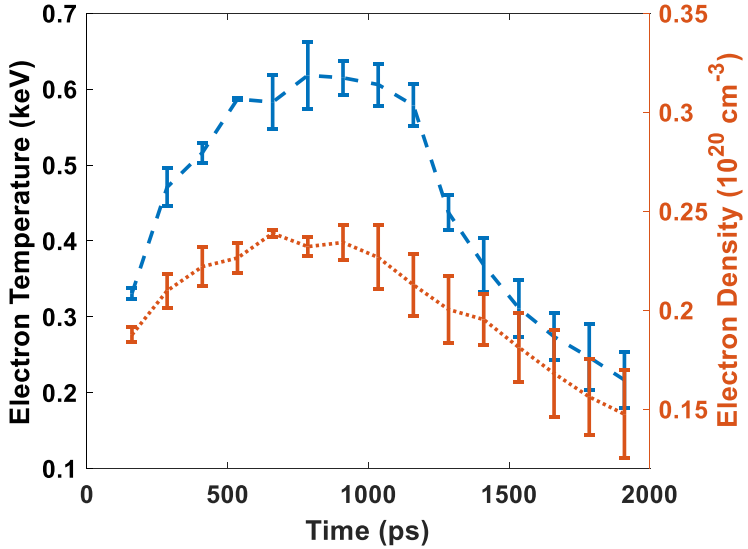
The temperature gradient and heat flux were controlled by varying the TS position radially



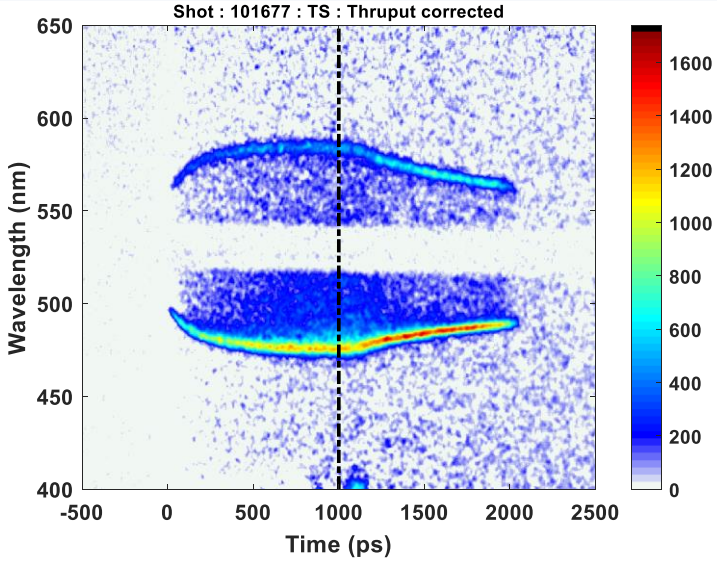


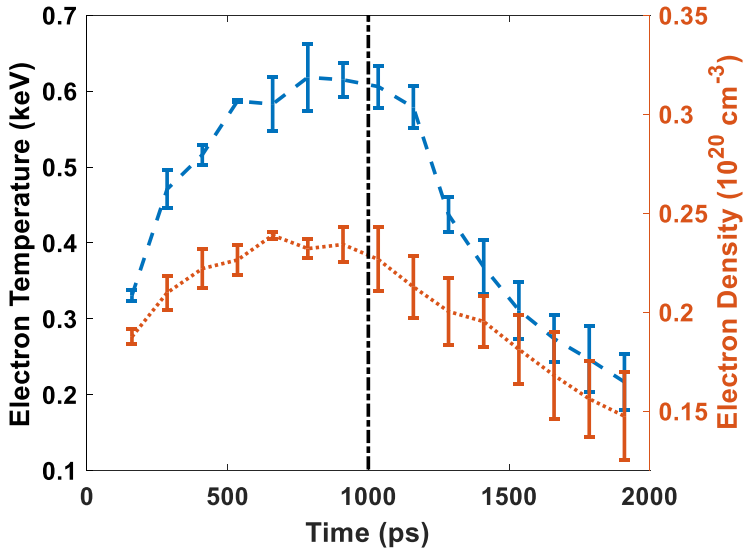
Electron plasma wave Thomson scattering allowed measurement of plasma conditions as a function of time

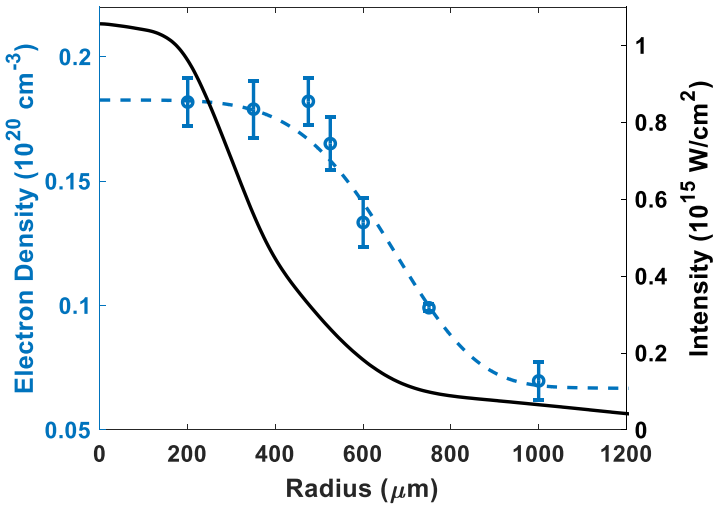


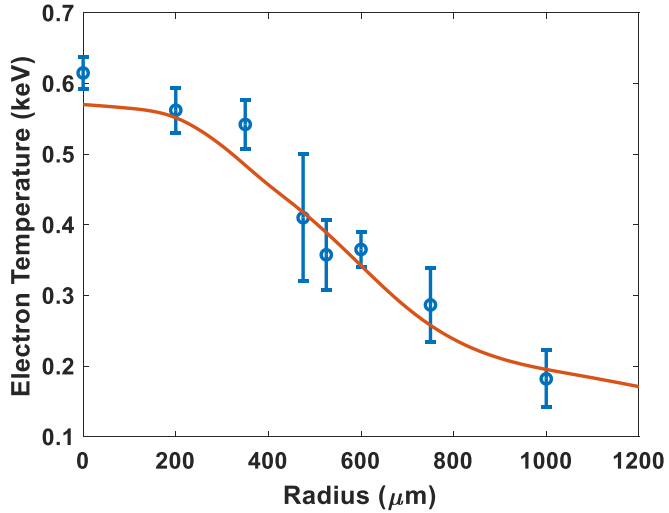


Electron plasma wave Thomson scattering allowed measurement of plasma conditions as a function of time and space



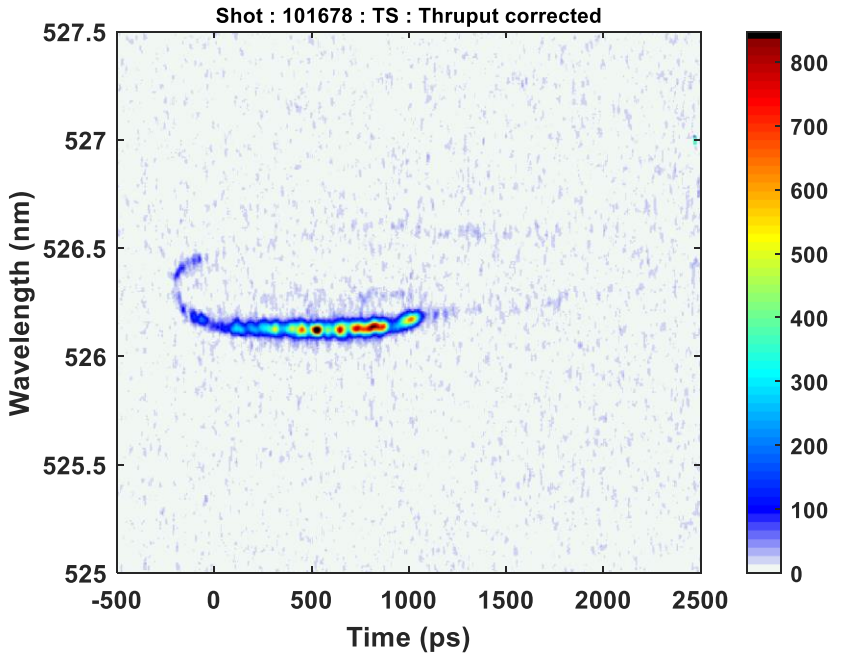


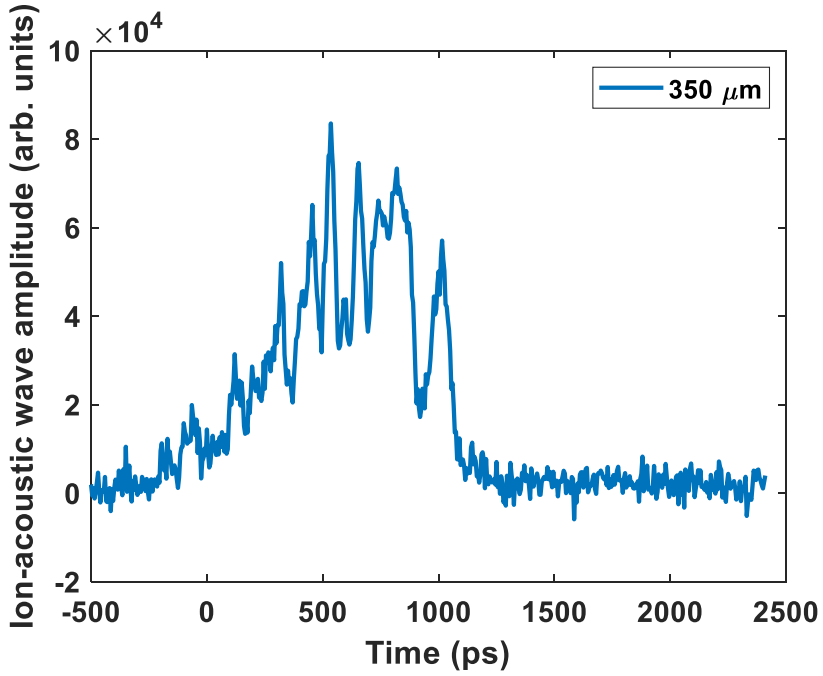




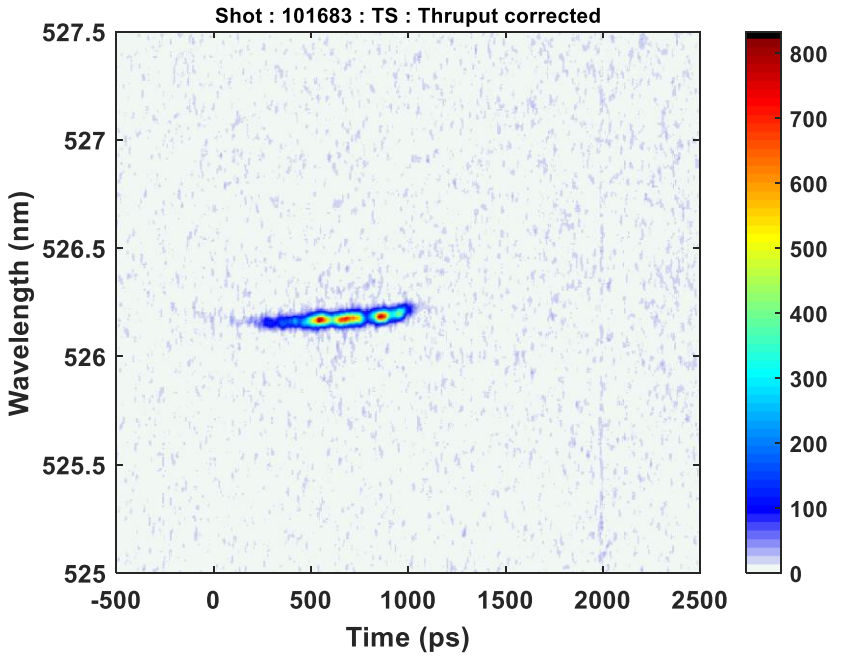
$$k_B T_e = \left(\frac{5}{4} \frac{r_0^2}{c} \frac{n_e Z^2 e^8 \ln(\Lambda)^2}{3.2 \cdot 72 \pi^3 \varepsilon_0^4} \frac{\omega_p^2}{\omega_0^2} I \right)^{1/5}$$

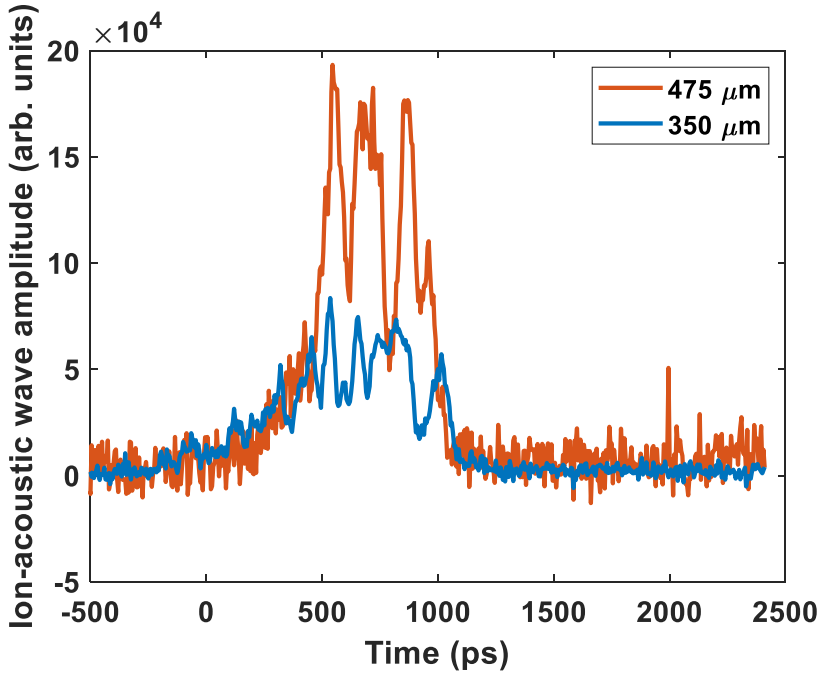
Ion-acoustic wave Thomson scattering shows waves driven by return current



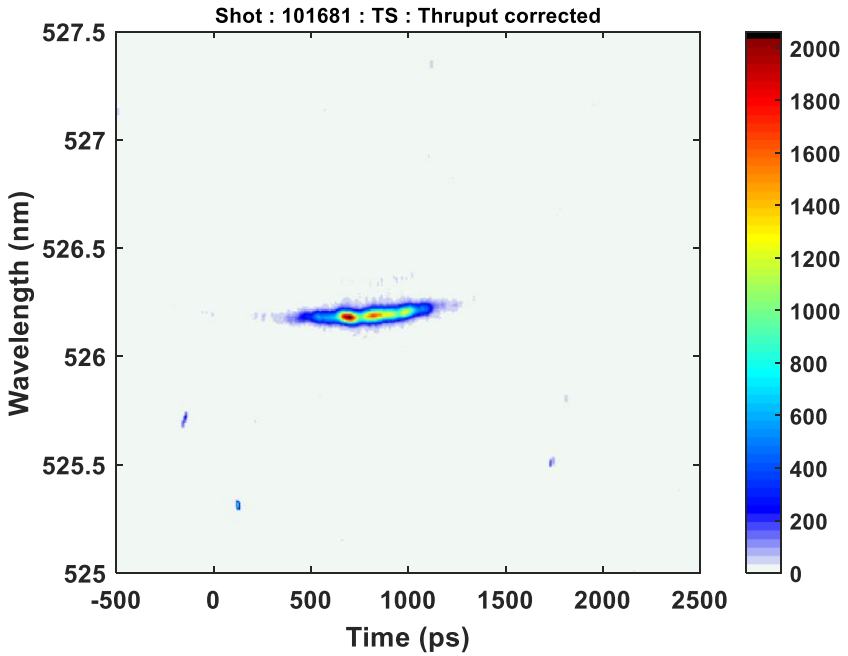


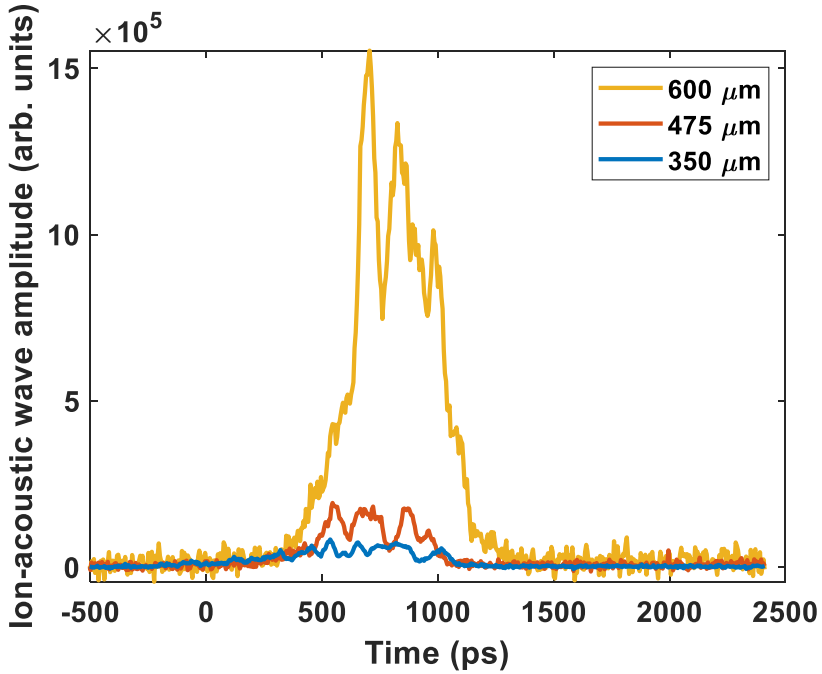
Ion-acoustic wave Thomson scattering shows waves driven by return current



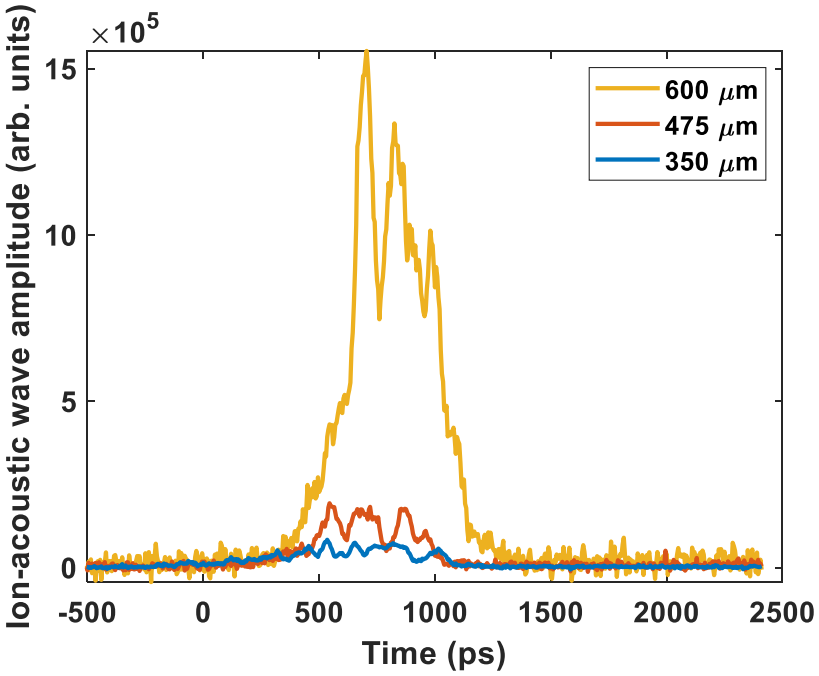


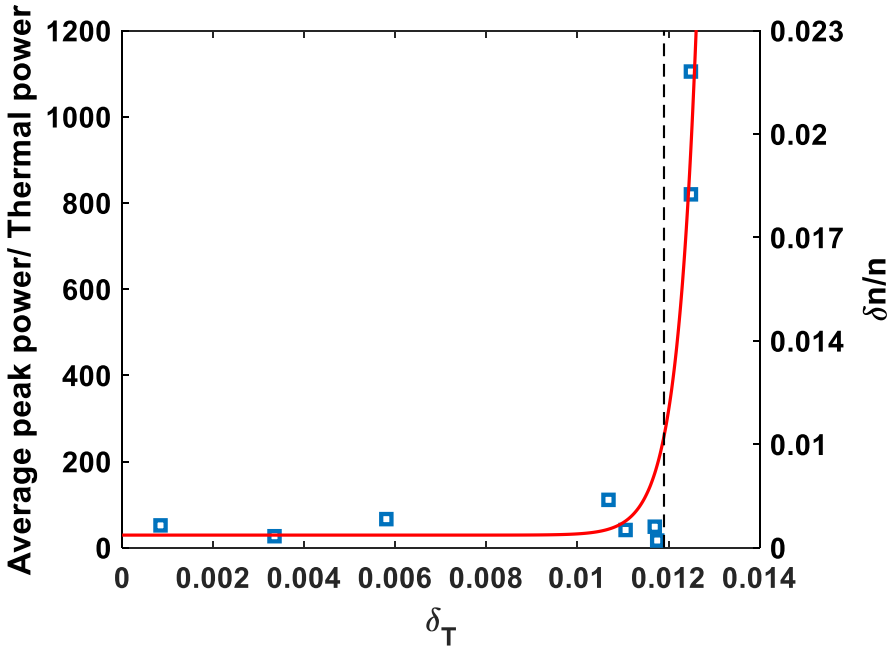
Ion-acoustic wave Thomson scattering shows waves driven by return current





Ion-acoustic wave Thomson scattering shows waves driven by return current





Initial analysis show the threshold for the instability at $\delta_T \approx 0.012$

Summary

Ion acoustic waves driven by return current instability (RCI) have been observed

- Return current instability was driven by a temperature gradient at the edge of the plasma
- EPW Thomson scattering measurements of plasma conditions at multiple radial locations agree with predictions
- RCI threshold is being investigated by comparing IAW growth rates

Initial analysis show the threshold for the instability at $\delta_T \approx 0.012$