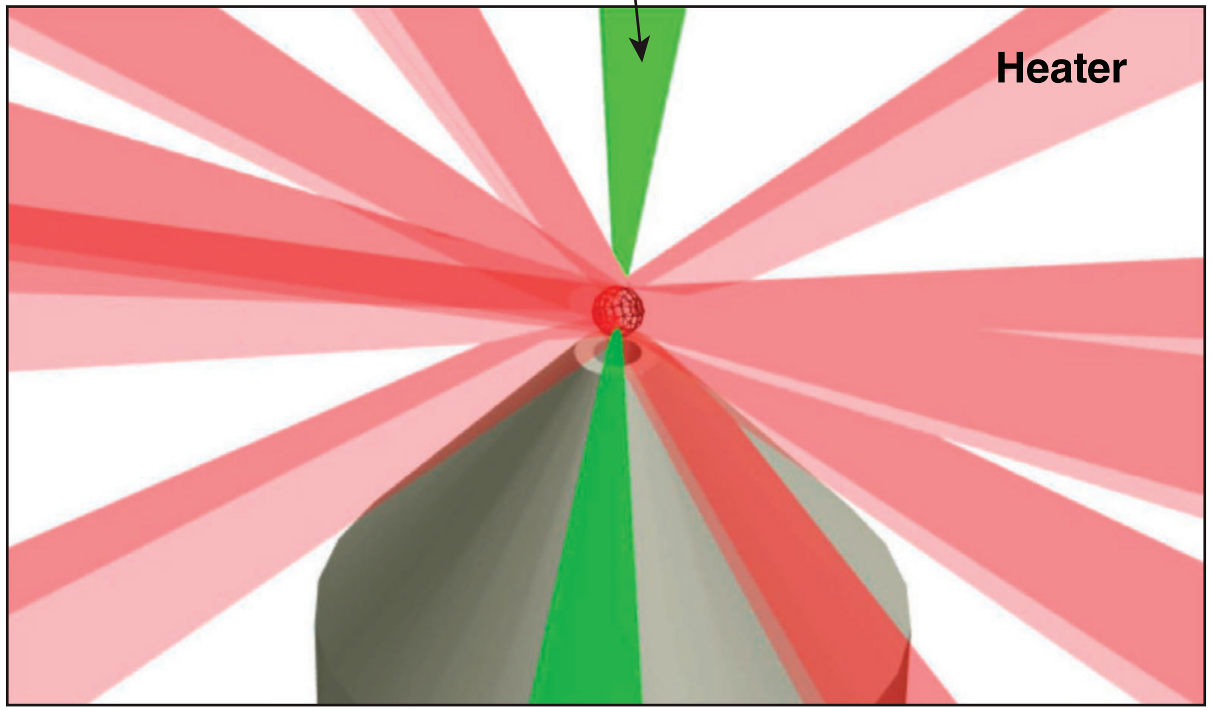
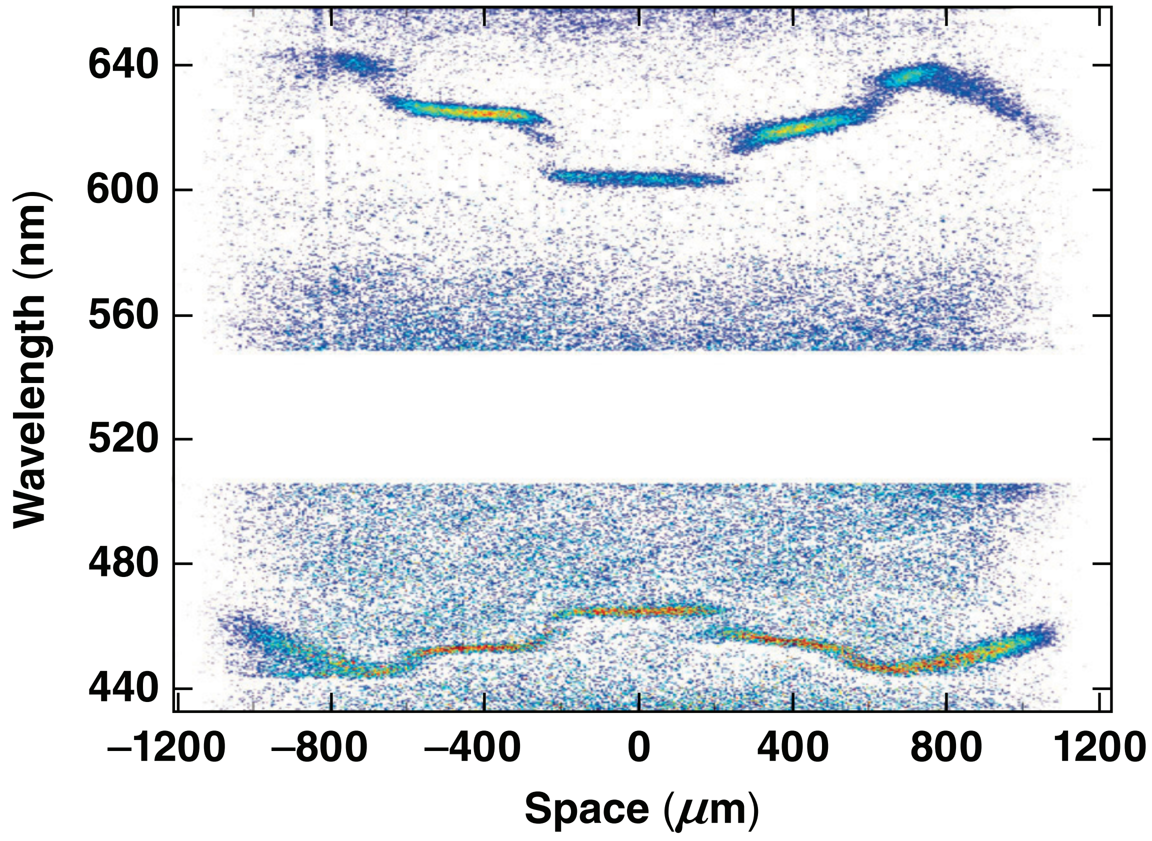
Plasma Characterization for the OMEGA Laser–Plasma Interaction Platform





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Summary

A laser–plasma interaction platform was activated on OMEGA and the target plasma was characterized with Thomson scattering

- The tunable OMEGA Port 9 (TOP9) system will explore multicolor cross-beam energy transfer (CBET) mitigation strategies with a wavelength tunable ($\pm$1-nm), 351-nm UV beam
- Filamentation limited the plasma parameter space in which Thomson scattering was effective
- Imaging Thomson scattering was performed and spatially resolved measurements of plasma conditions were made
- Spatial nonuniformities in the gas-jet plasma were measured and guided the design of new gas-jet nozzles

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Collaborators

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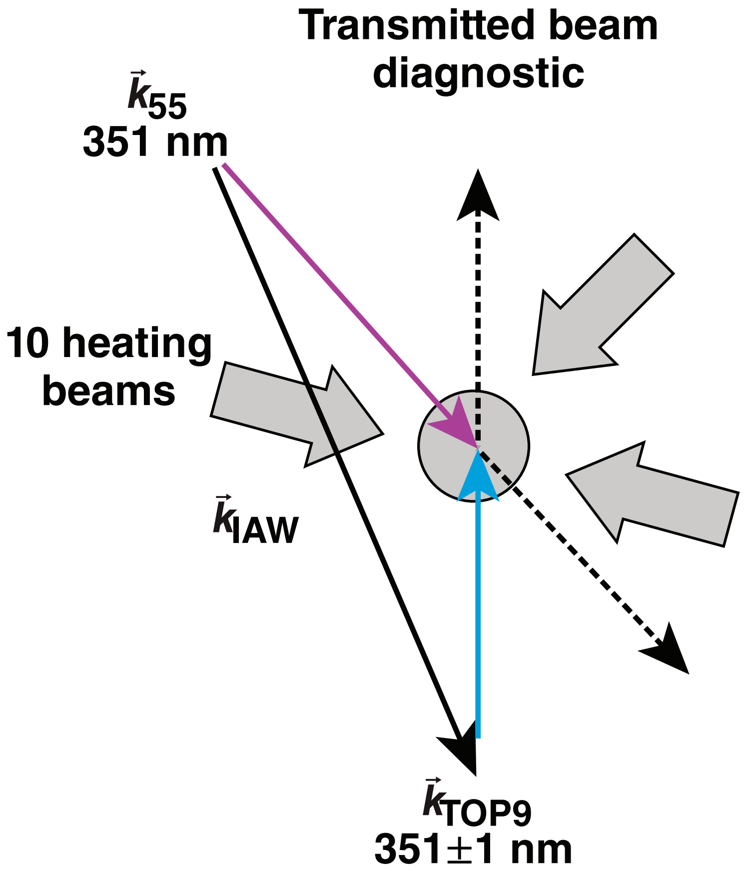
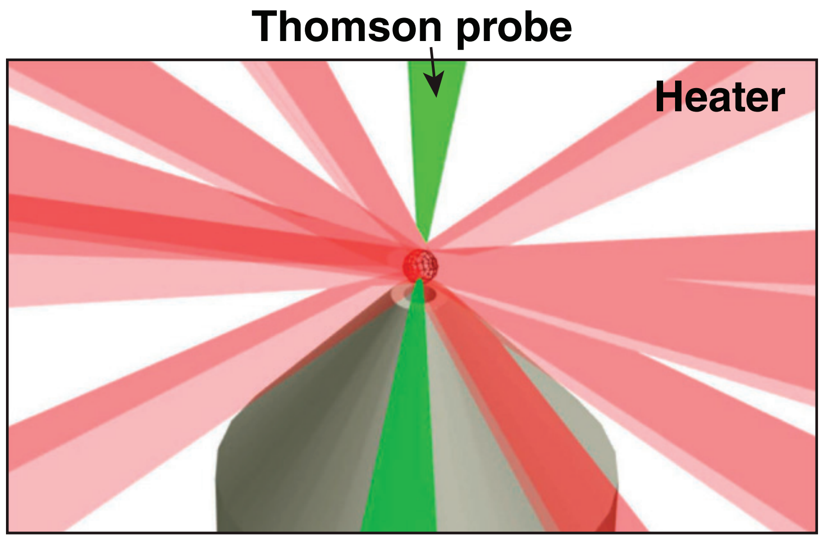
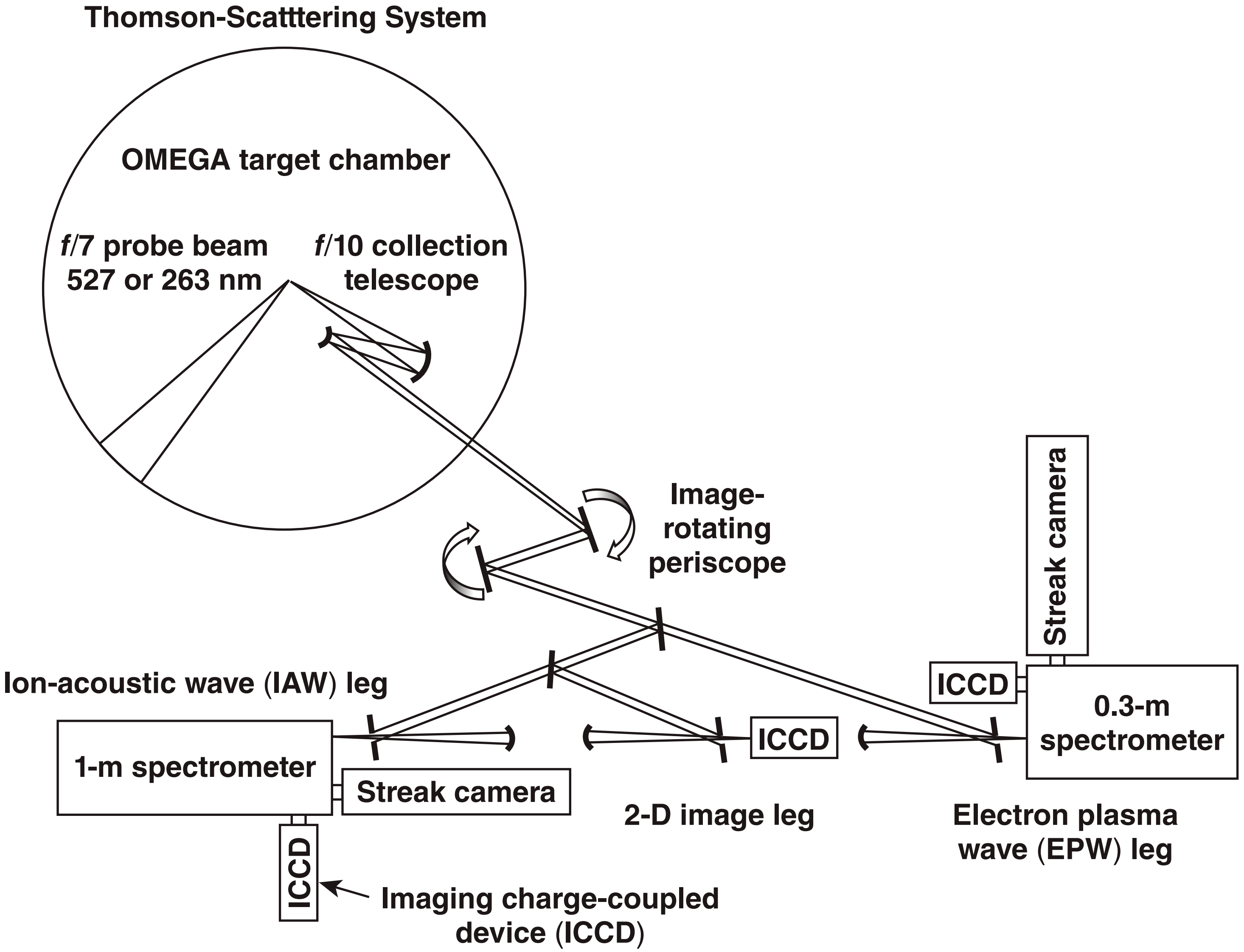
TOP9 will explore multicolor CBET mitigation strategies using a wavelength tunable (±1-nm), 351-nm UV beam

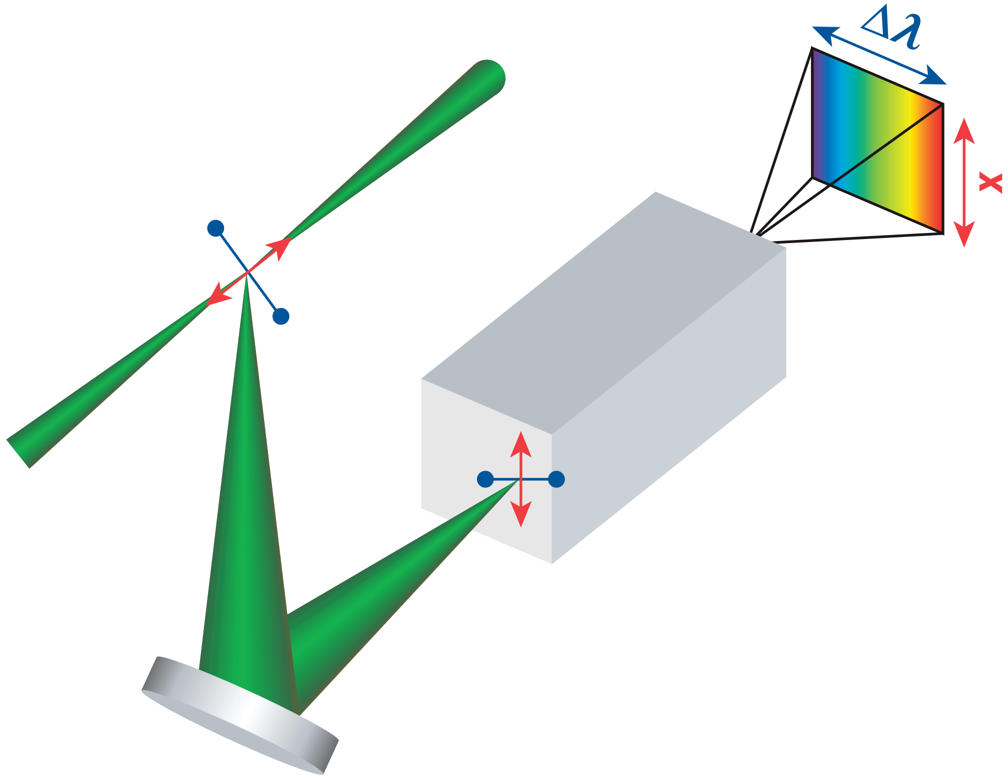
- A gas-jet and ten UV heating beams form the plasma before the interaction
  - plasma conditions were measured with Thomson scattering
- By tuning the wavelength of the TOP9 beam, the resonance between the crossed beams will be controlled
  - a $N_2 + H_2$ gas mix provides tuned Landau damping of ion-acoustic waves
- The transmitted beam diagnostic will measure gain in the CBET interaction with spatial and temporal resolution





The Thomson-Scattering System on OMEGA enabled simultaneous measurements of the electron, ion, and 2-D Thomson features





Thomson probe parameters: 20 J, 100 ps, 527 nm

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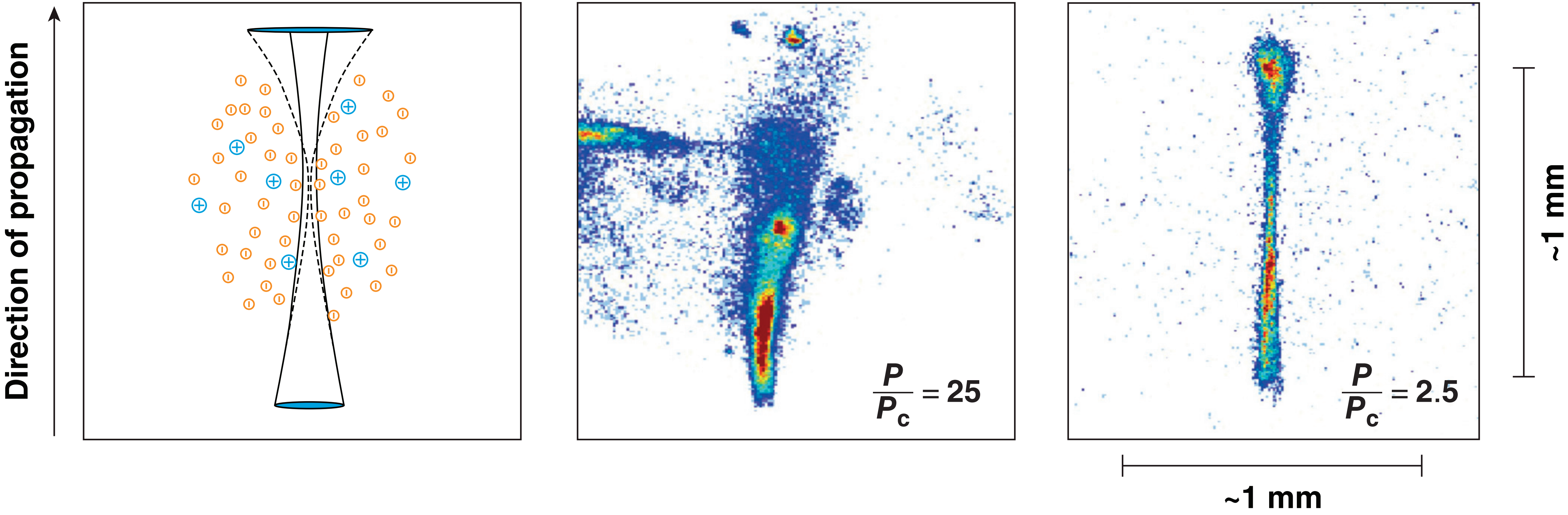
Filamentation limits the effectiveness of Thomson scattering in some regimes of plasma conditions and laser parameters



A fundamental relationship between Thomson-scattering signal to noise and electron temperature was derived using the self-focusing critical power

$$P_L = P_c = \frac{T_e[\text{keV}]}{3 \times 10^{-8}} \left(\frac{n_c}{n_e}\right)$$

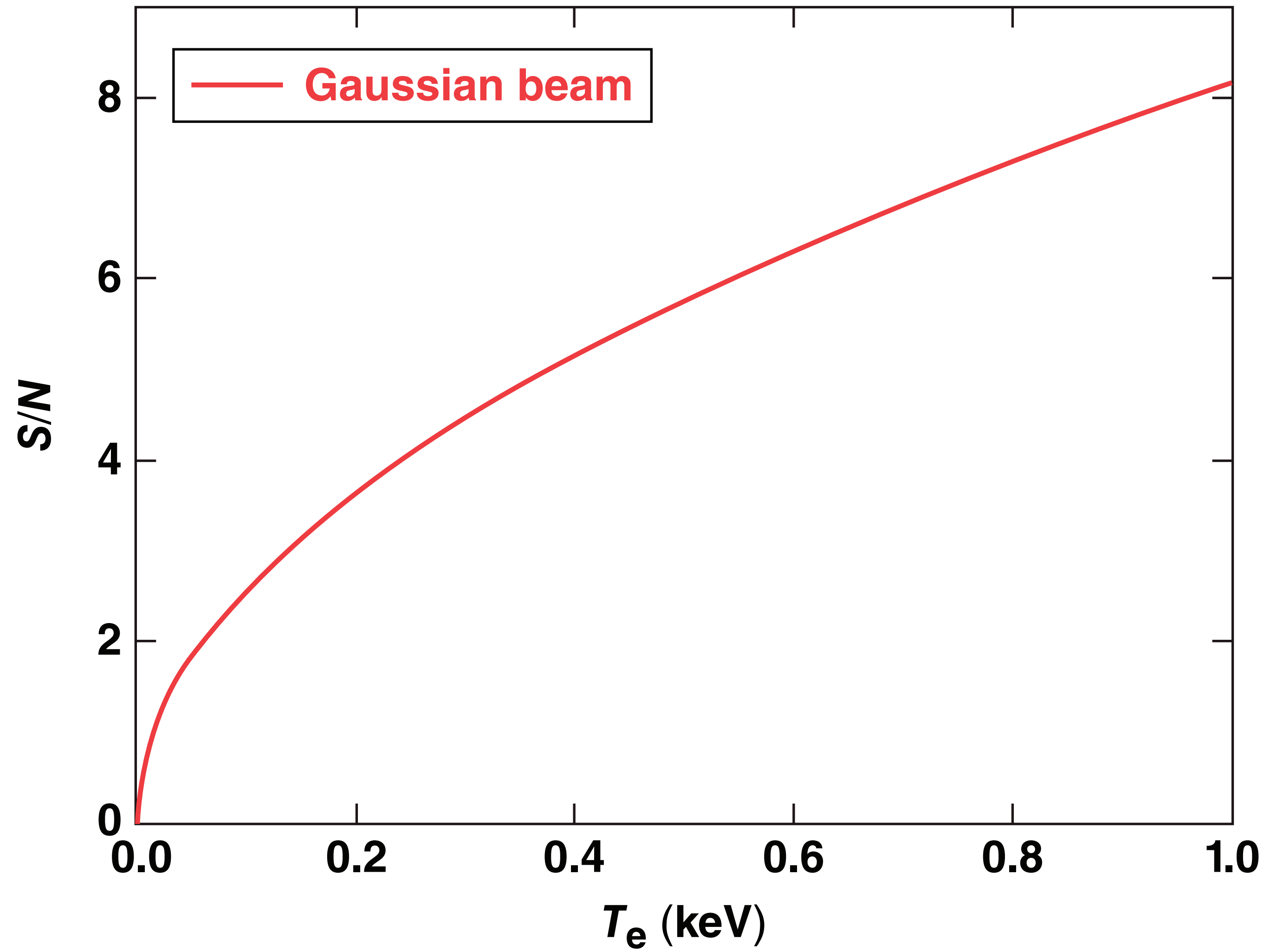
- Thomson scattering:

$$P \approx P_L n_e r_0^2 L \, d\Omega$$

- Signal to noise:

$$\frac{S}{N} = \frac{P}{\sqrt{P}} = \sqrt{P}$$

$$\frac{S}{N} = \sqrt{\frac{T_e[\text{keV}] r_0^2 L \Delta t \, d\Omega}{3 \times 10^2 \lambda hc}}$$



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A fundamental relationship between Thomson-scattering signal to noise and electron temperature was derived using the self-focusing critical power

$$P_{c\,(DPP)} = \frac{10^{13} A}{\lambda^2}\left(\frac{n_c}{n_e}\right)\left(\frac{T_e[\text{keV}]}{3}\right)\left(\frac{8}{f\#}\right)^2$$

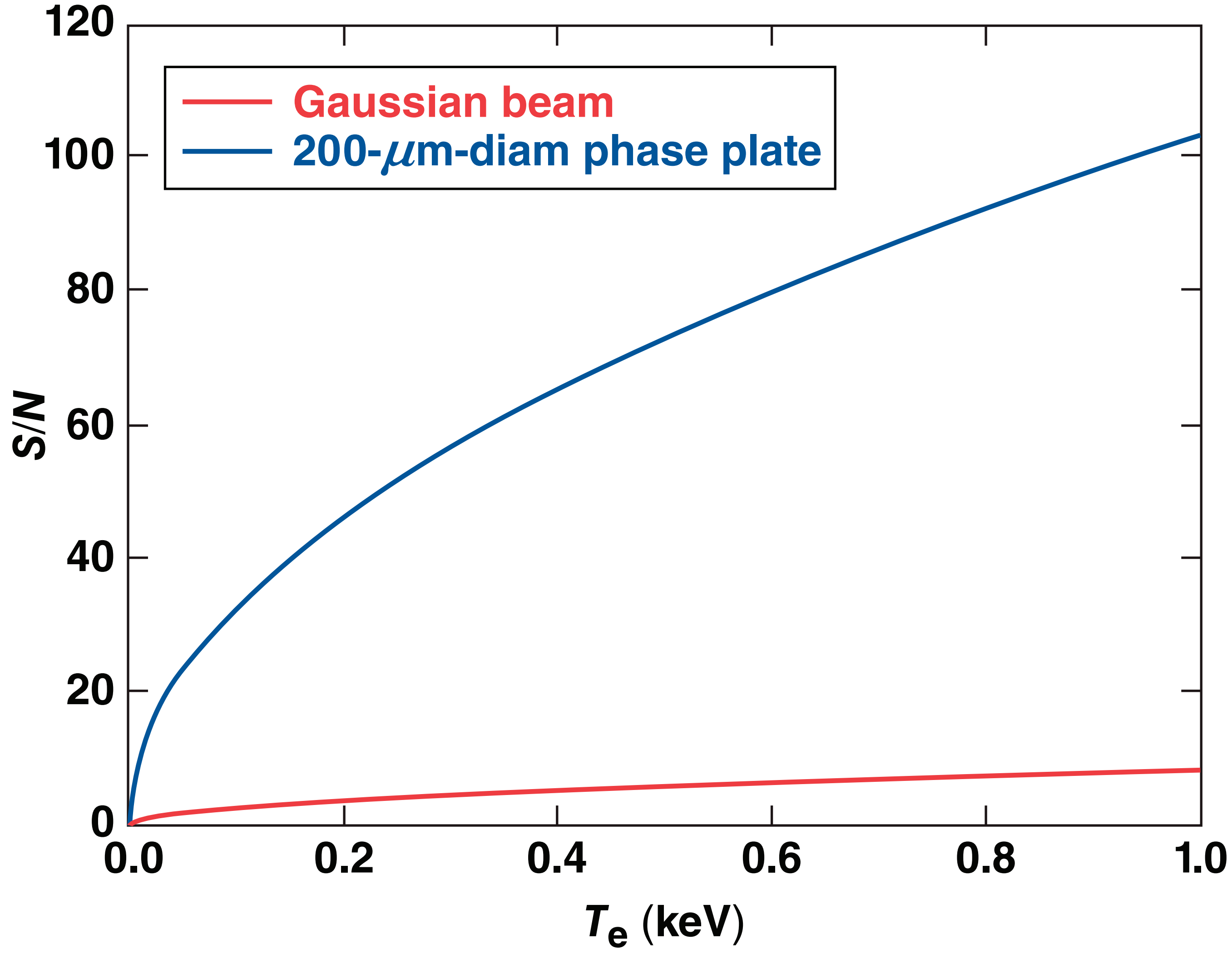
- **Thomson scattering:**

$$P \approx P_L n_e r_0^2 L\, d\Omega$$

- **Signal to noise:**

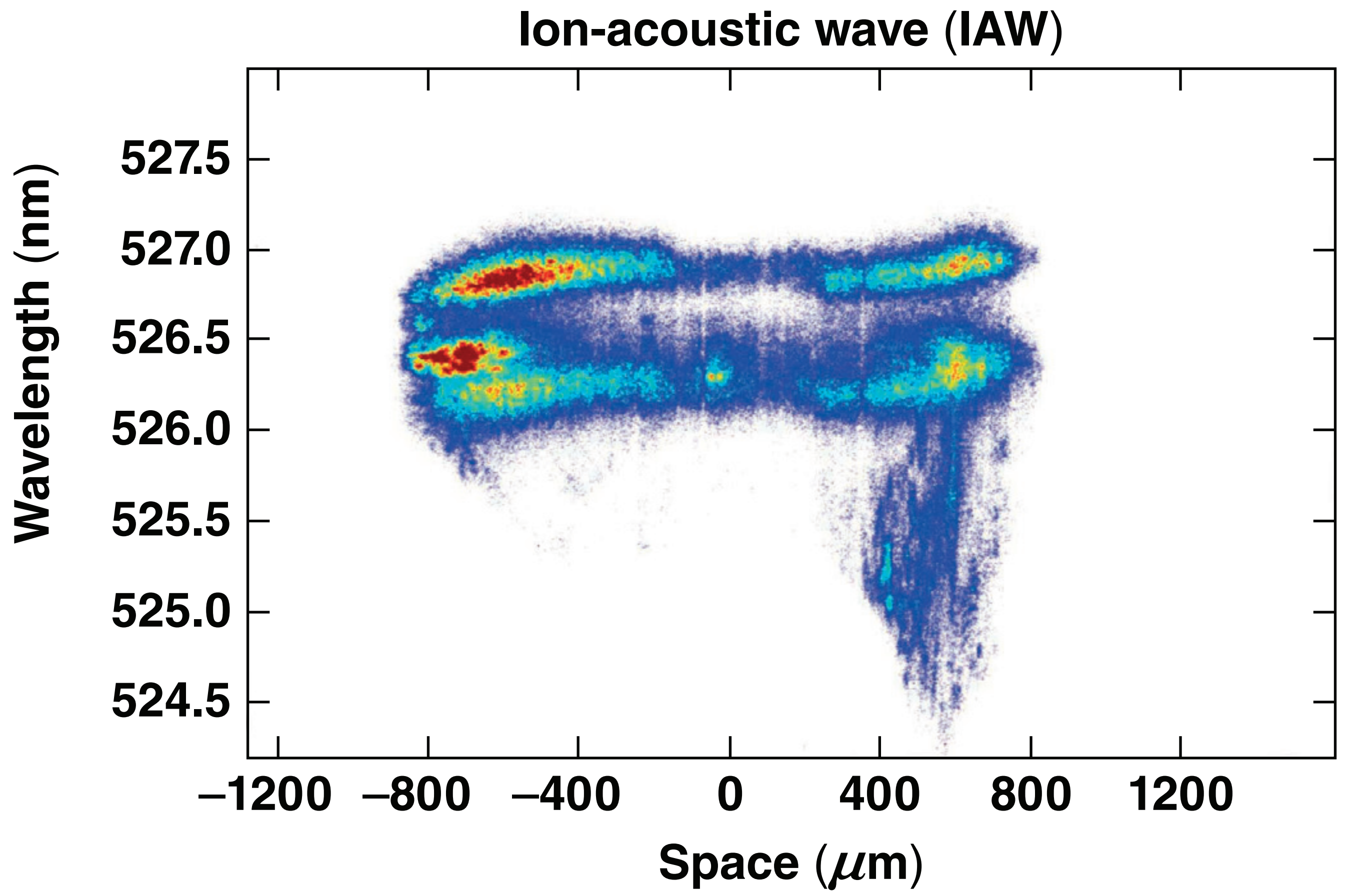
$$\frac{S}{N} = \frac{P}{\sqrt{P}} = \sqrt{P}$$

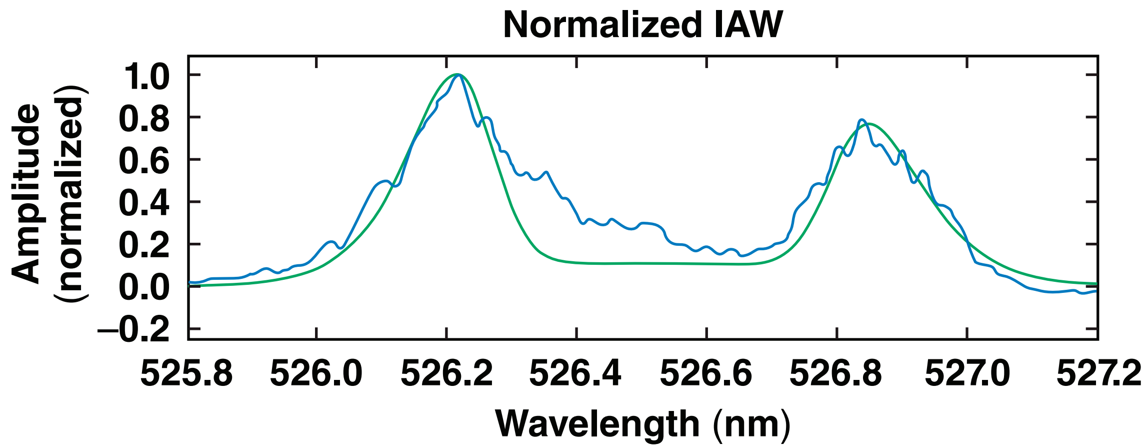
$$\frac{S}{N} = \sqrt{\frac{r_0^2 L \Delta t\, d\Omega}{hc}\frac{10^{12} A}{\lambda^2}\frac{n_c}{n_e}\frac{T_e[\text{keV}]}{3}\left(\frac{8}{f\#}\right)^2}$$

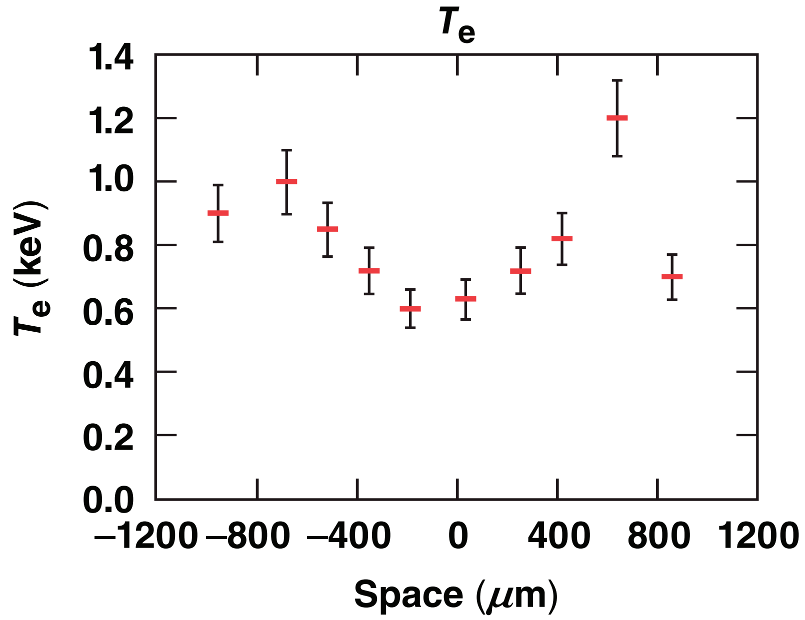


A 200-μm-diam phase plate was used to improve propagation.

Analysis of the ion feature shows variations in temperature across the plasma







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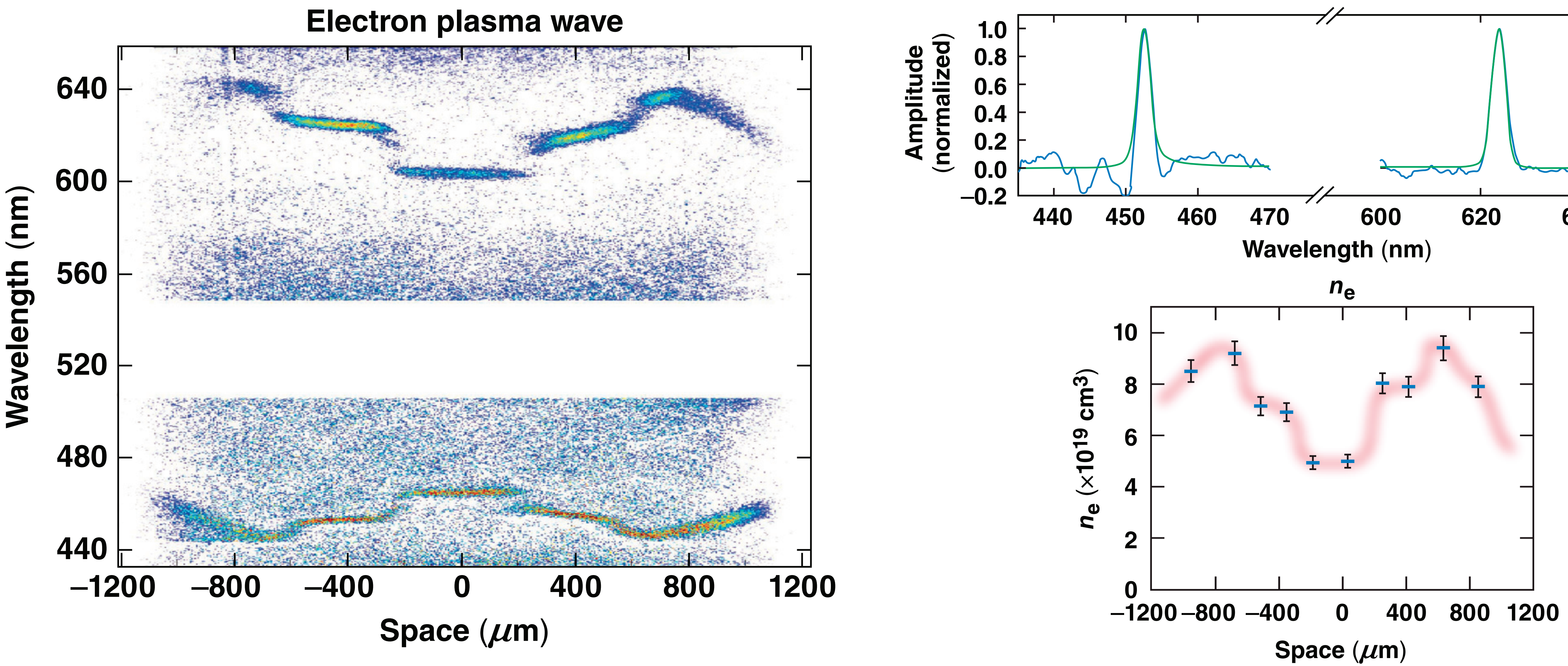
Large variations in density were measured across the gas-jet plasma using the electron feature



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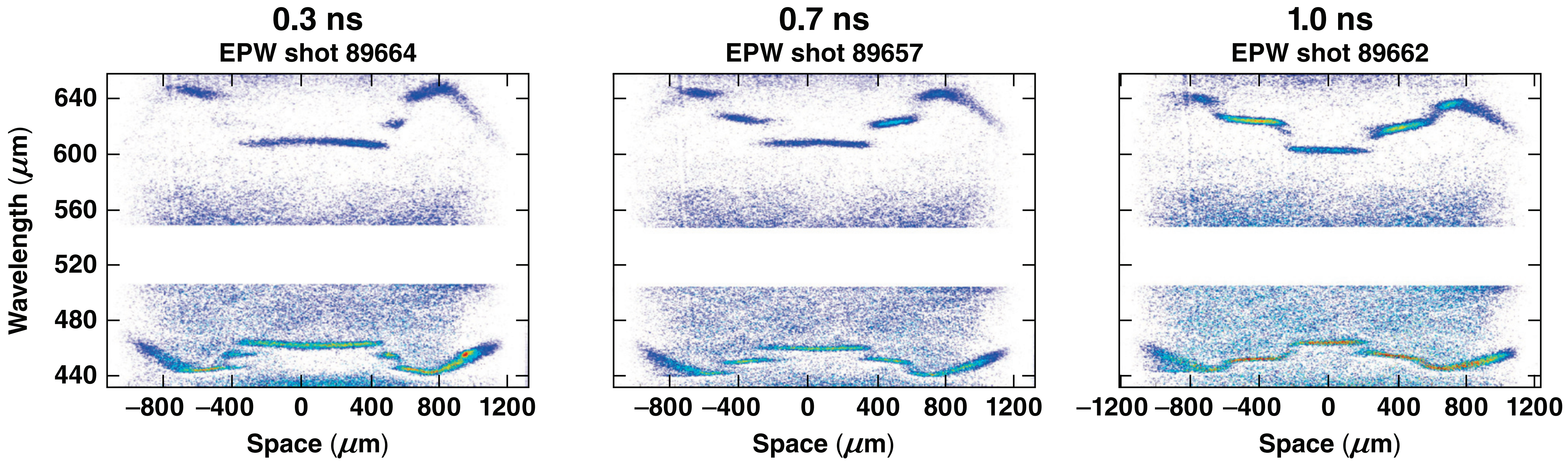
By varying the delay on the 100-ps Thomson probe, variations in the gas-jet plasma were observed to evolve over time



Density perturbations are caused by neutral density flow properties in the supersonic nozzle.

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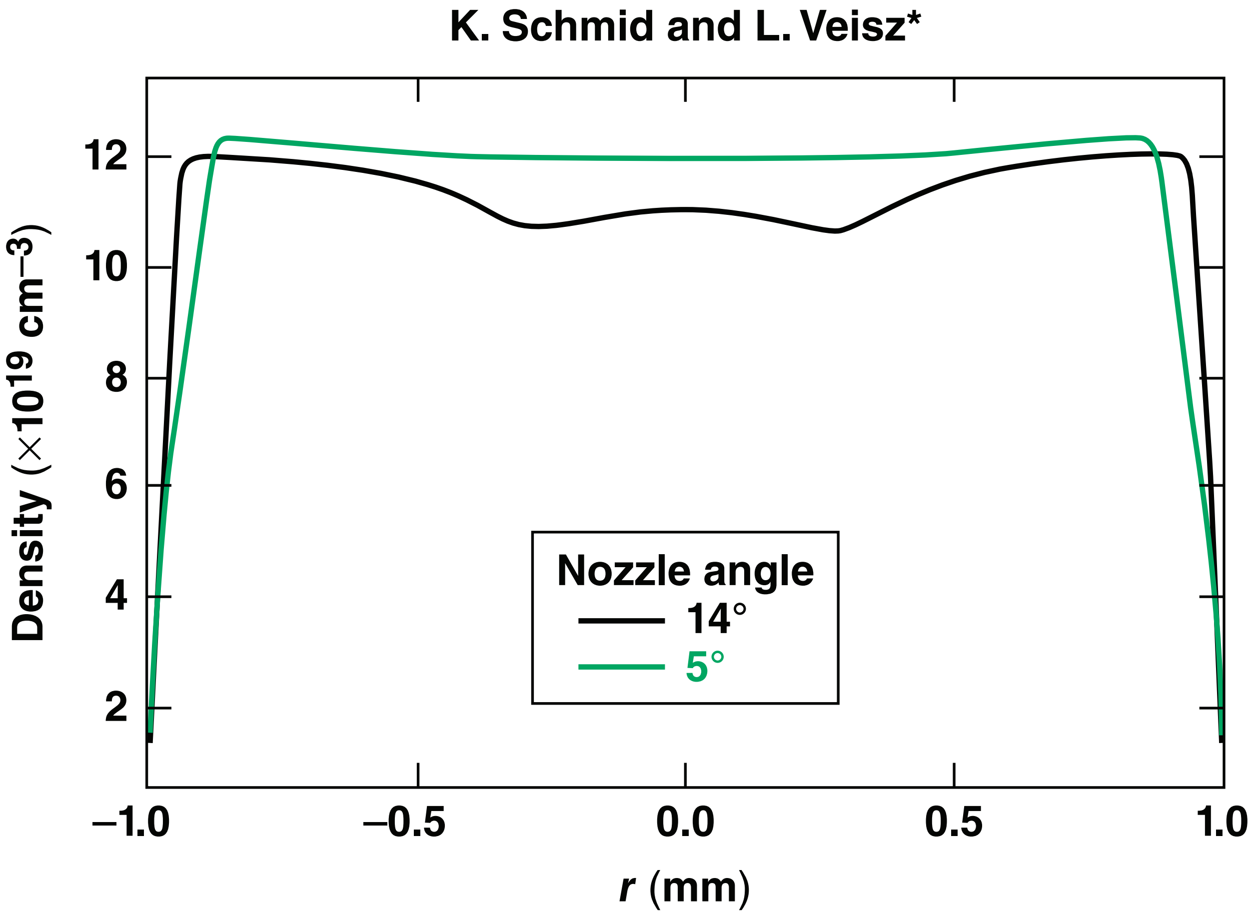
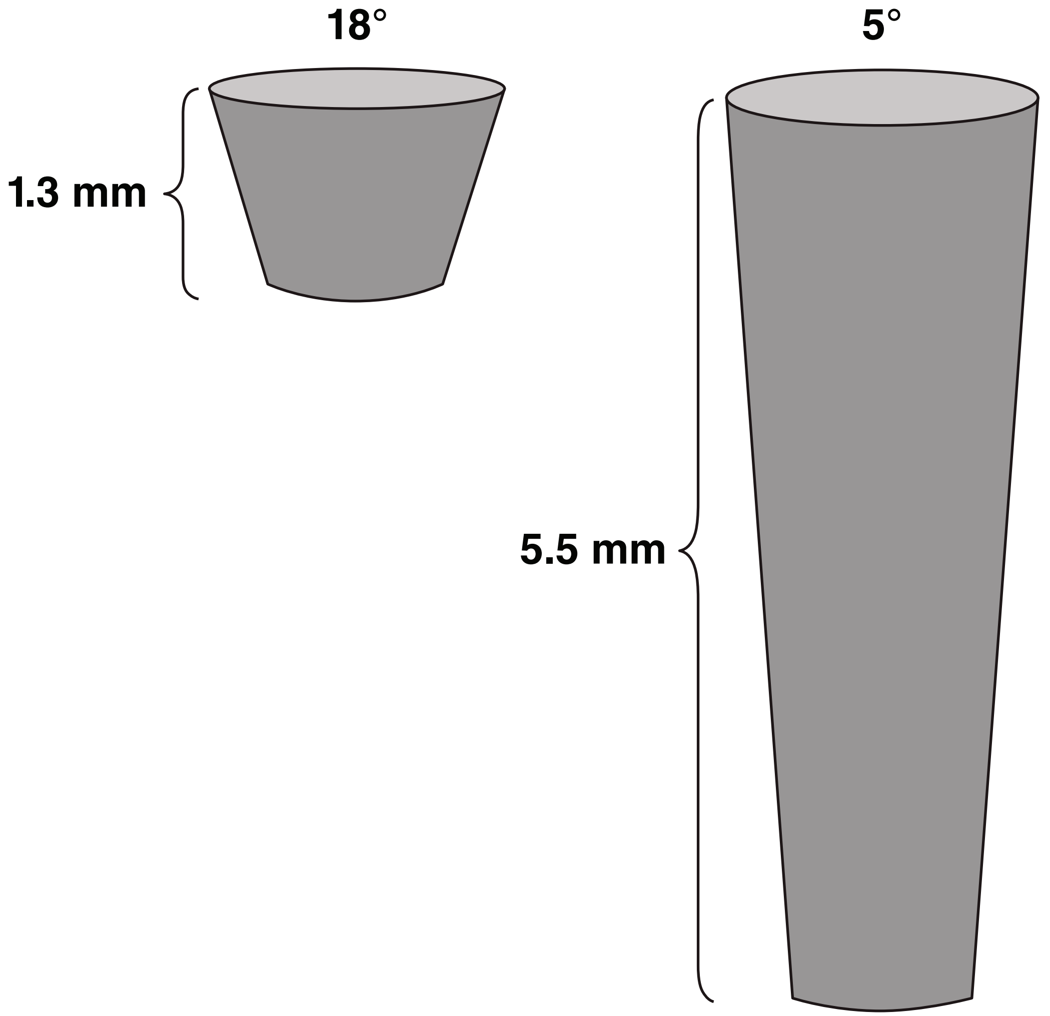
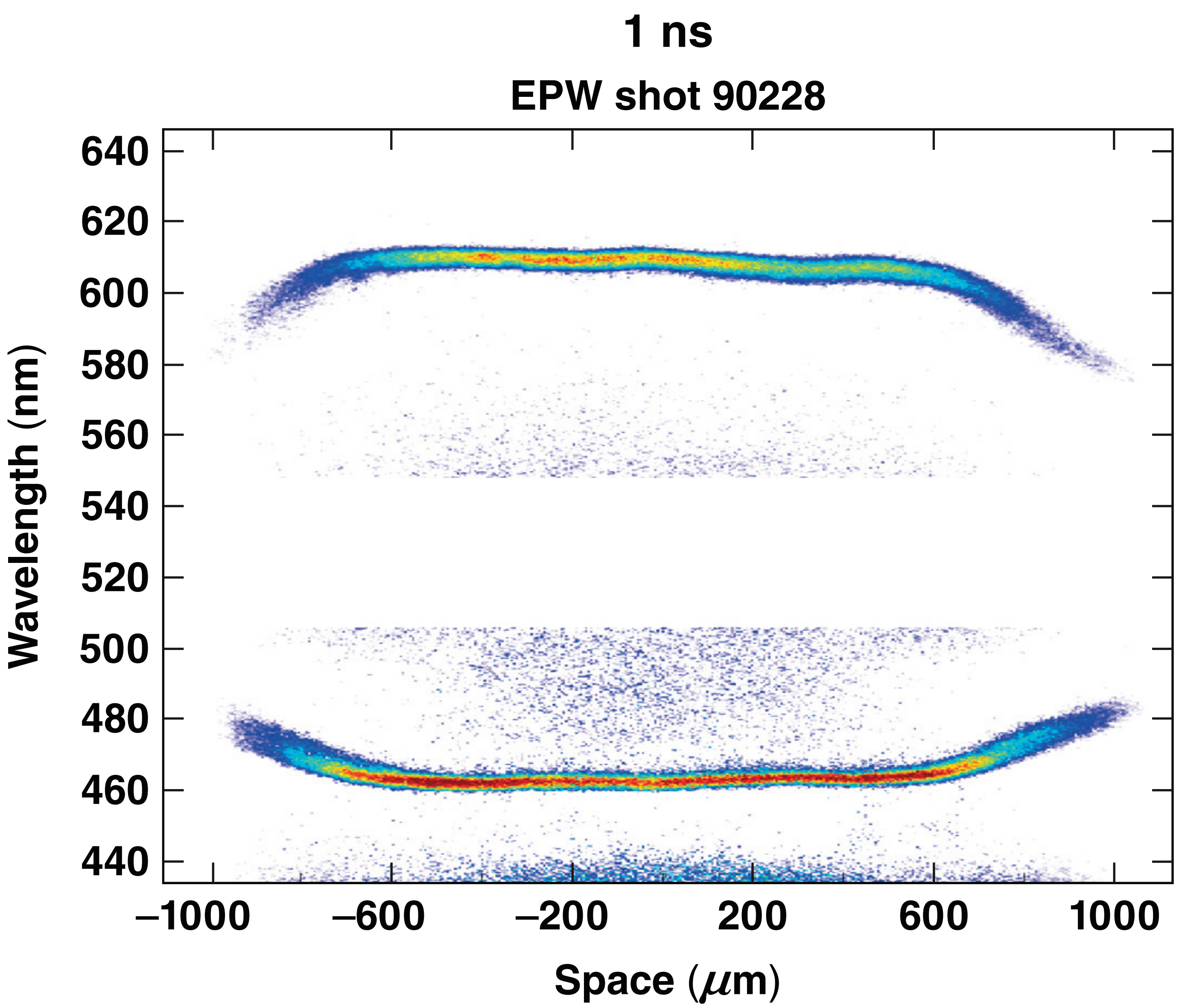
A new, longer-nozzle design was implemented to improve density uniformity





*K. Schmid and L. Veisz, Rev. Sci. Instrum. 83, 053304 (2012).

Thomson-scattering data demonstrate the density uniformity provided by the long nozzle design



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Summary/Conclusions

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