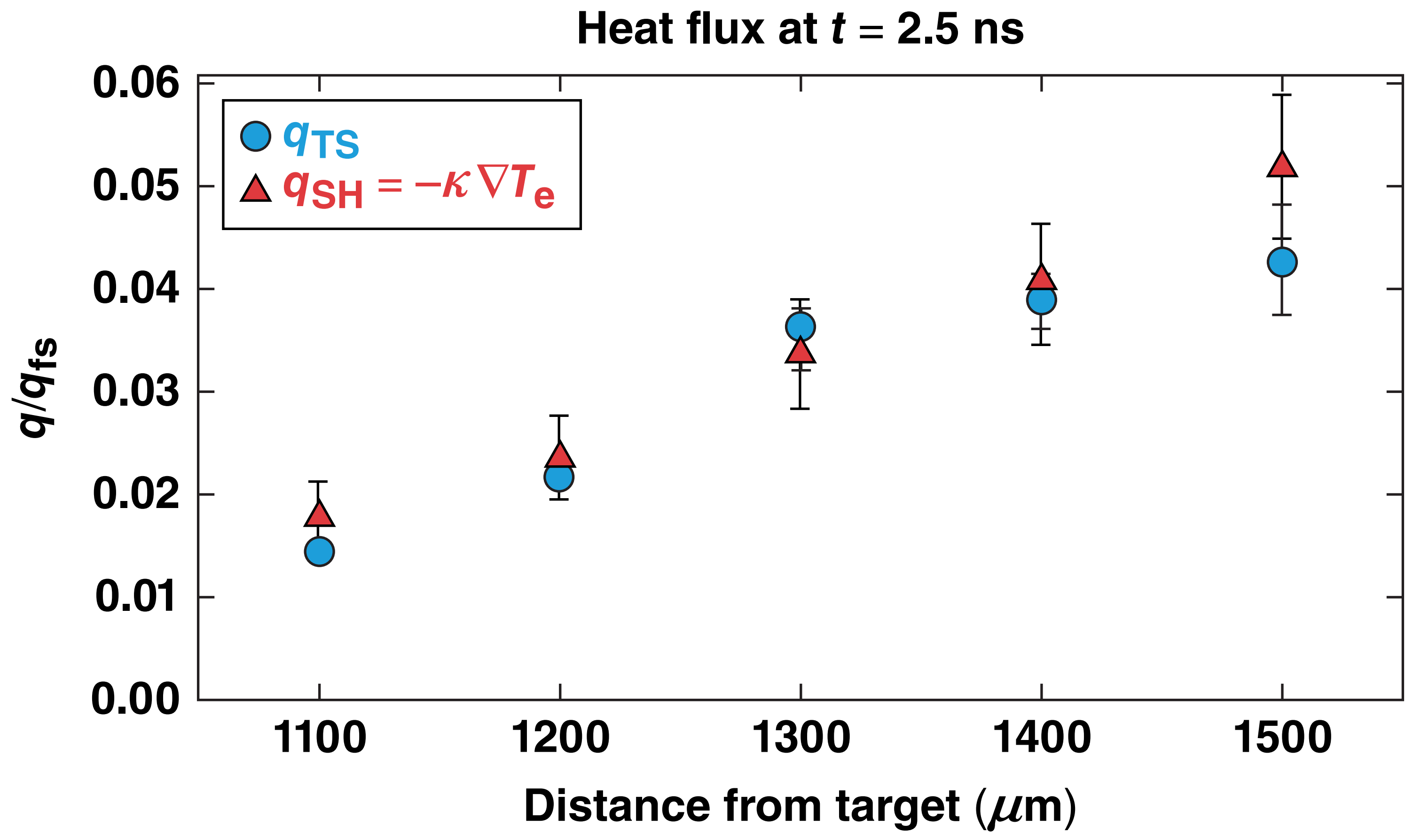
Heat-Flux Measurements from Thomson-Scattering Spectra



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Summary

Thomson scattering from ion-acoustic waves (IAW's) and electron plasma waves (EPW's) were used to measure heat flux in coronal plasmas

- Changes in Landau damping caused by heat flux were seen in the relative amplitudes of Thomson-scattering spectra from IAW's and EPW's
- Local plasma conditions obtained from Thomson scattering provide an independent measurement of the heat flux using the Spitzer–Härm (SH) thermal-transport model
- The two methods of measuring the heat flux are in good agreement over the locations probed

Collaborators

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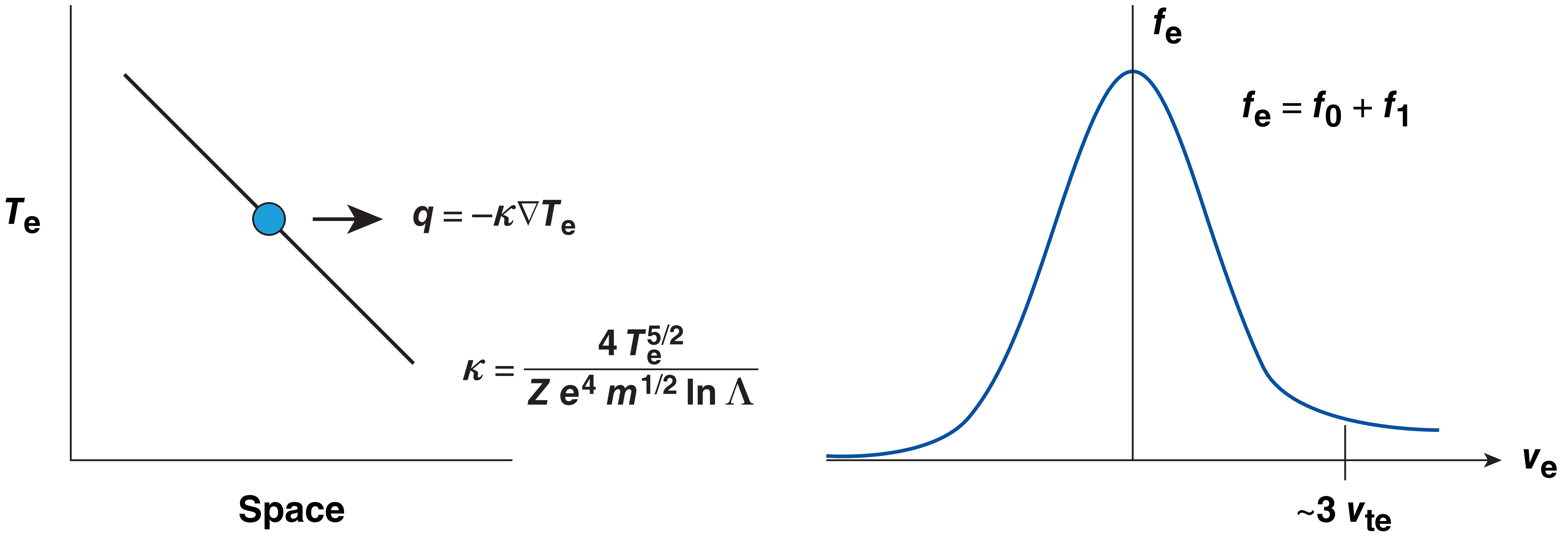
An experiment was designed to test Spitzer–Härm thermal transport in laser produced coronal plasmas



These experiments measured the heat flux, electron temperature, and density as a function of space in a coronal plasma.

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Collective Thomson scattering can measure the heat flux and the local plasma conditions

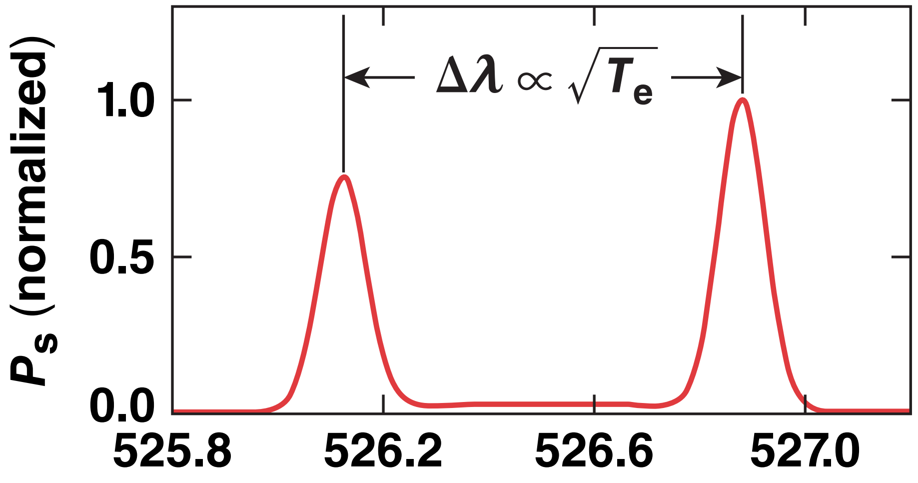
$$P_s \propto \left(1 + \frac{2\omega}{\omega_i}\right) S(k,\omega)$$

$$S(k,\omega) = \frac{2\pi}{k}\left|1 - \frac{\chi_e}{\varepsilon}\right|^2 f_e\left(\frac{\omega}{k}\right) + \frac{2\pi Z}{k}\left|\frac{\chi_e}{\varepsilon}\right|^2 f_i\left(\frac{\omega}{k}\right)$$

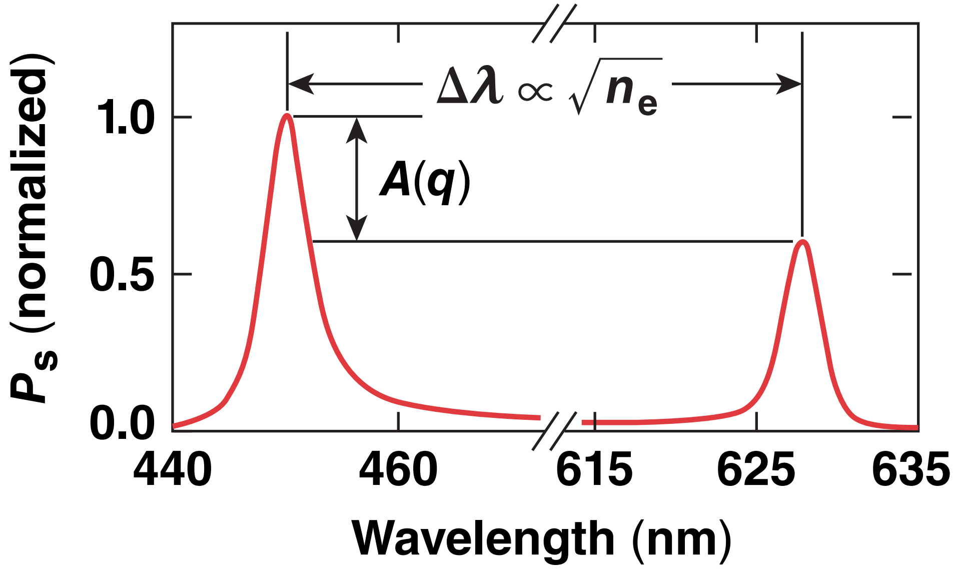
$$\chi_e = \int_{-\infty}^{\infty} dv \frac{4\pi e^2 n_e}{m_e k^2} \frac{k \cdot \frac{\partial f_e}{\partial v}}{\omega - k \cdot v - i\gamma}$$

$$f_e = f_0 + f_1^{SH}$$

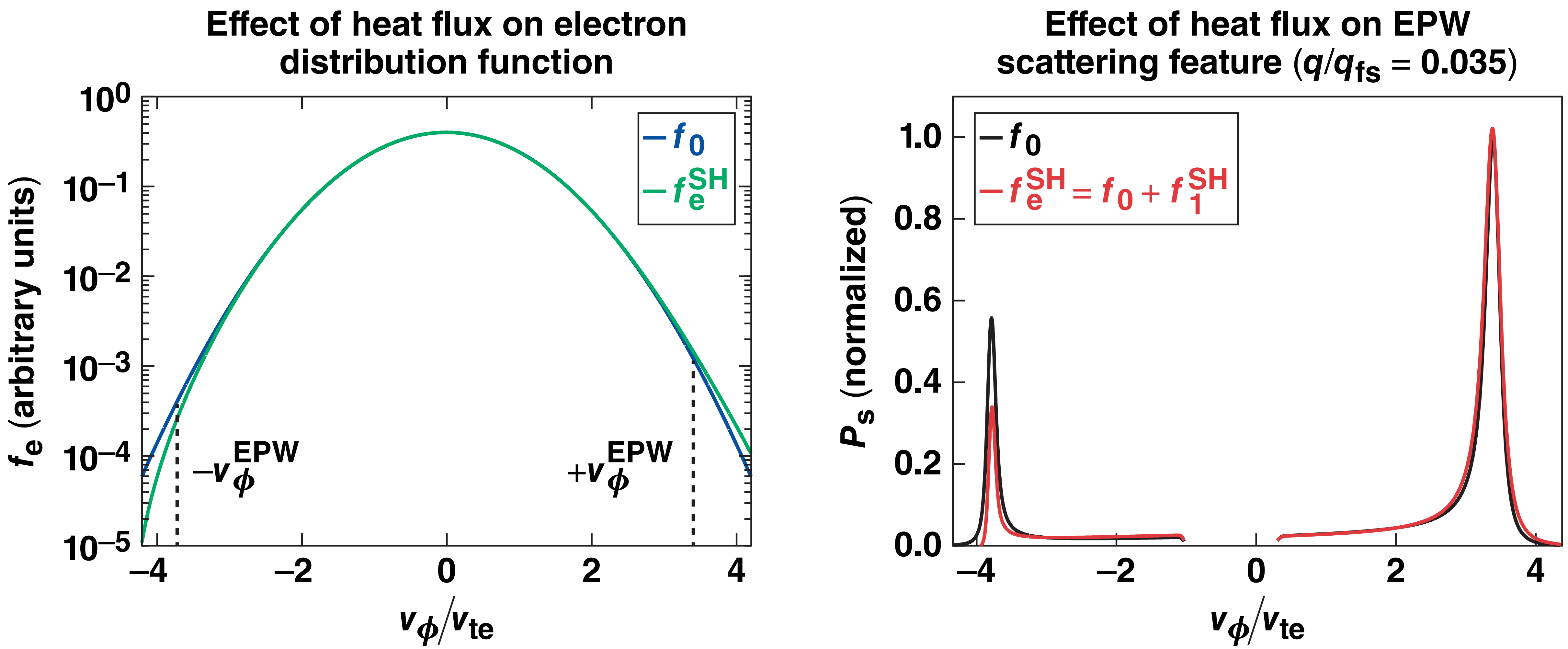
Thomson scattering from IAW's (calculated)



Thomson scattering from EPW's (calculated)



Changes in the electron distribution function caused by heat flux affects the scattering spectrum of Thomson scattering from EPW's



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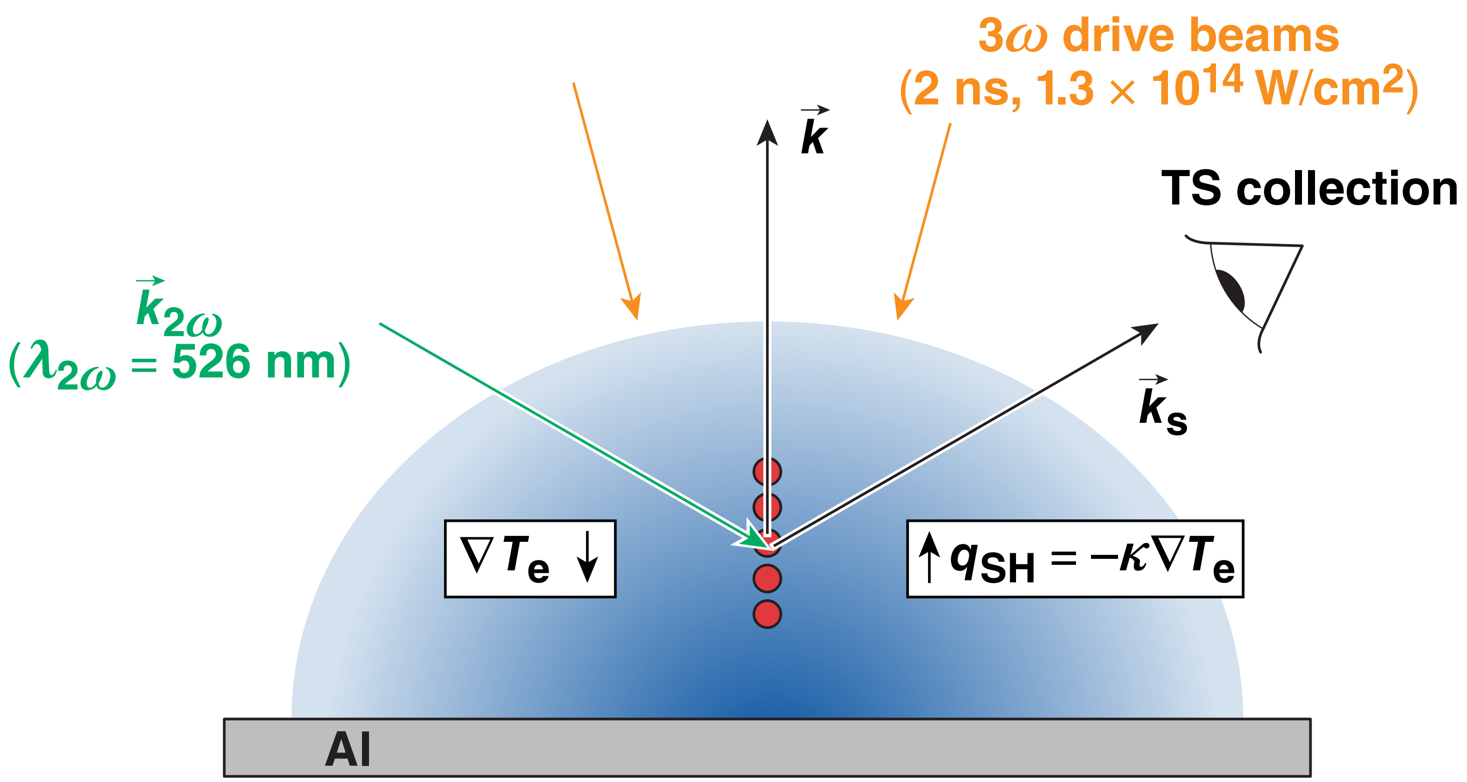
Thomson scattering was used to measure the heat flux, electron temperature, and electron density in coronal plasmas



- Thomson scattering (TS) provides local measurements of T_e, n_e, and q in a 50 × 50 × 50-μm^3 volume
- Probing five different locations provides values for ∇T_e
- An independent measure of q is obtained from T_e, n_e, and ∇T_e

Thomson scattering provides two separate measurements of heat flux by probing plasma waves along the direction of the temperature gradient.

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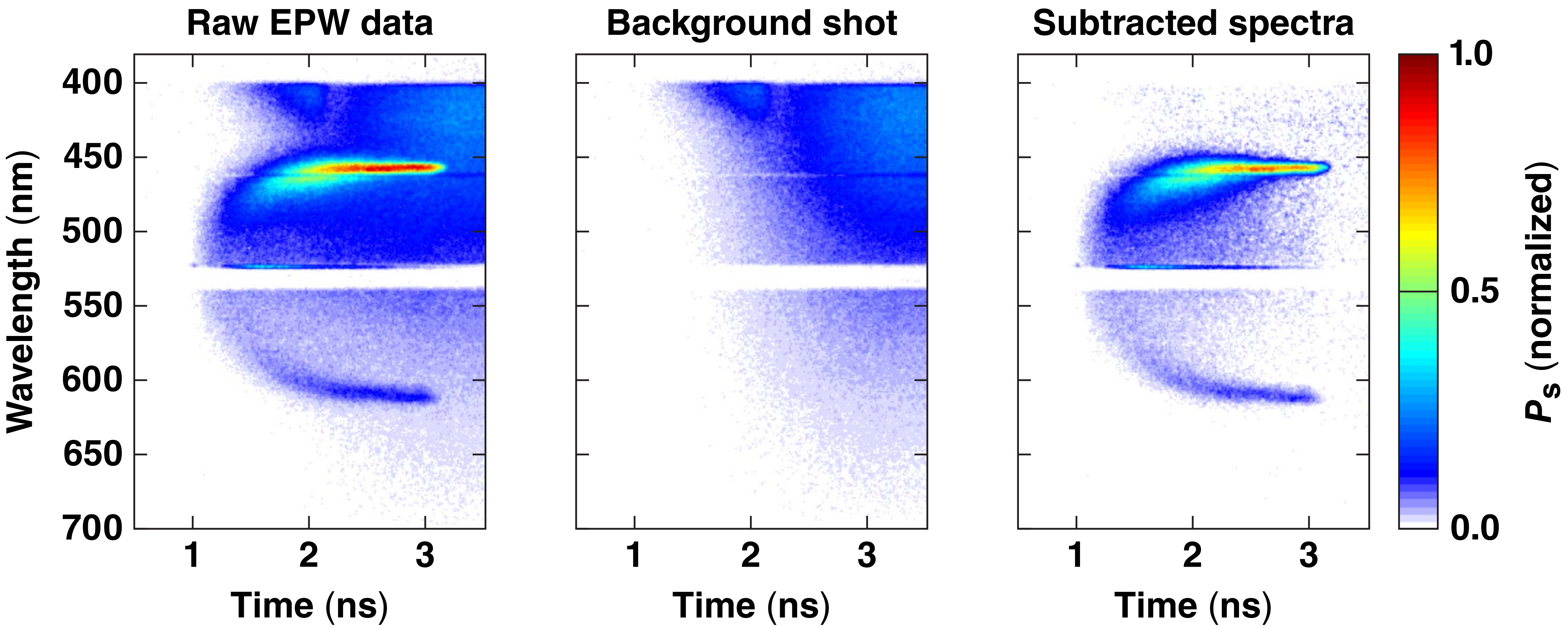
The up- and down-shifted EPW features were measured with a large signal-to-noise



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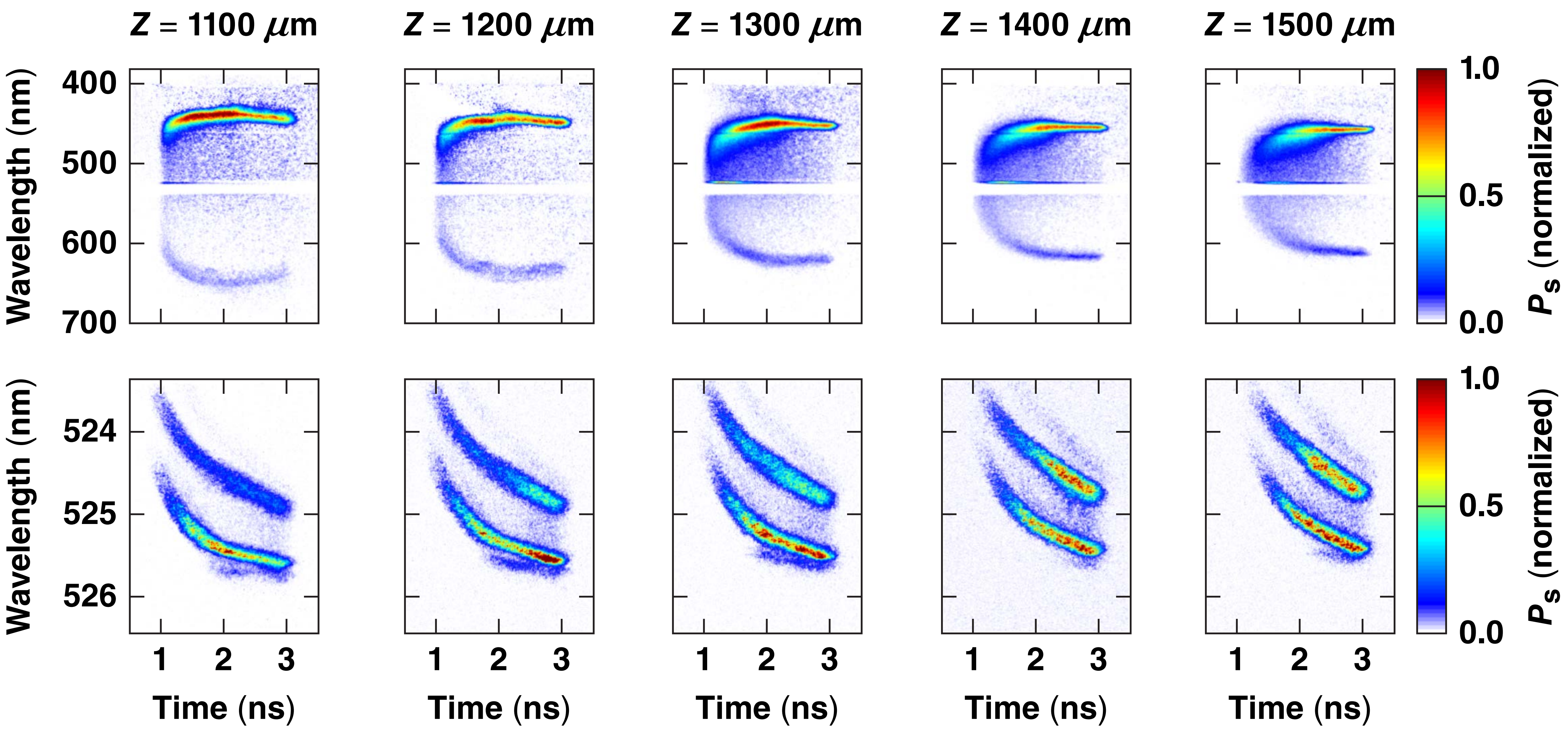
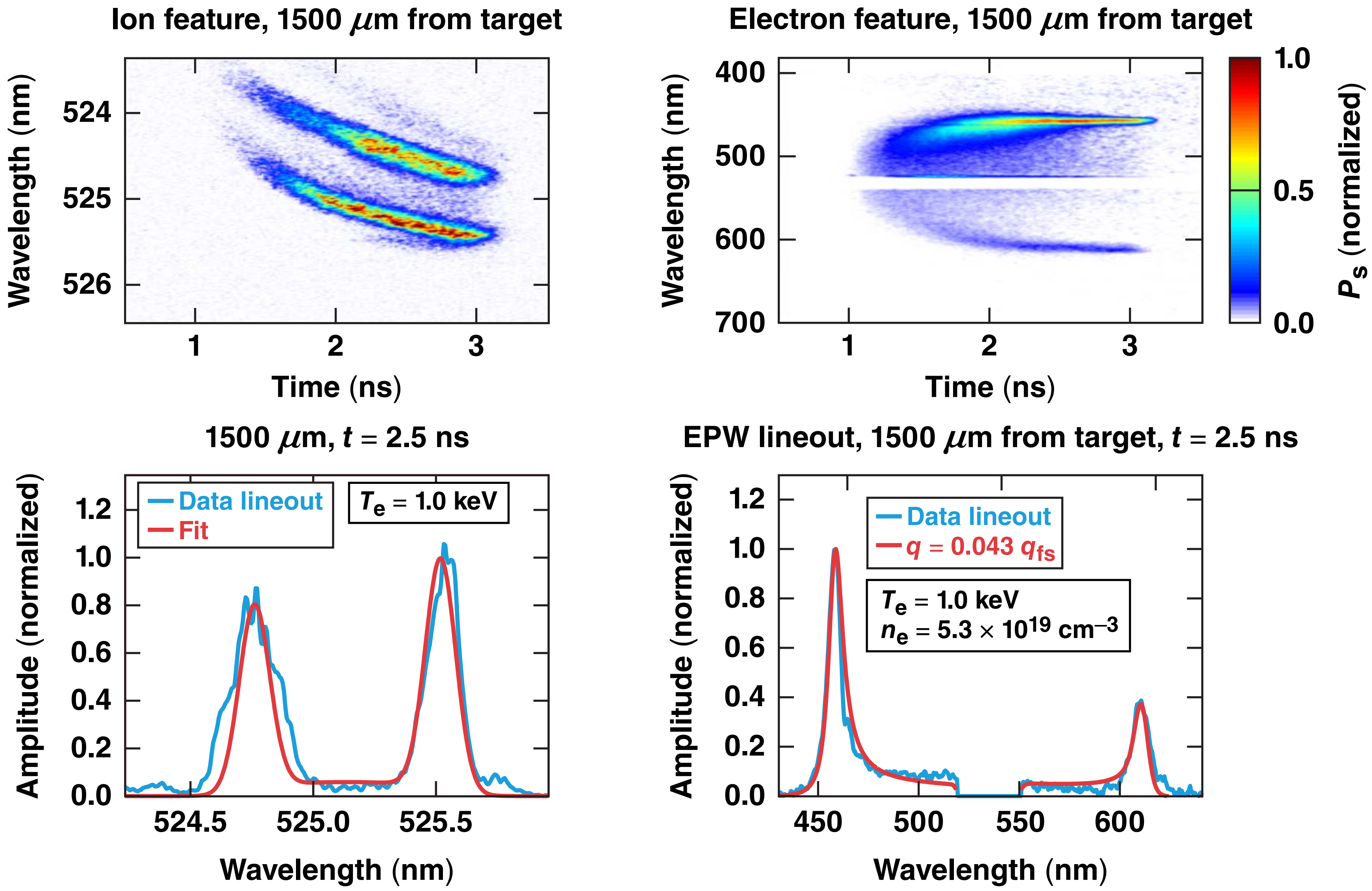
Thomson-scattering spectra obtained at five locations in the corona were used to measure heat flux



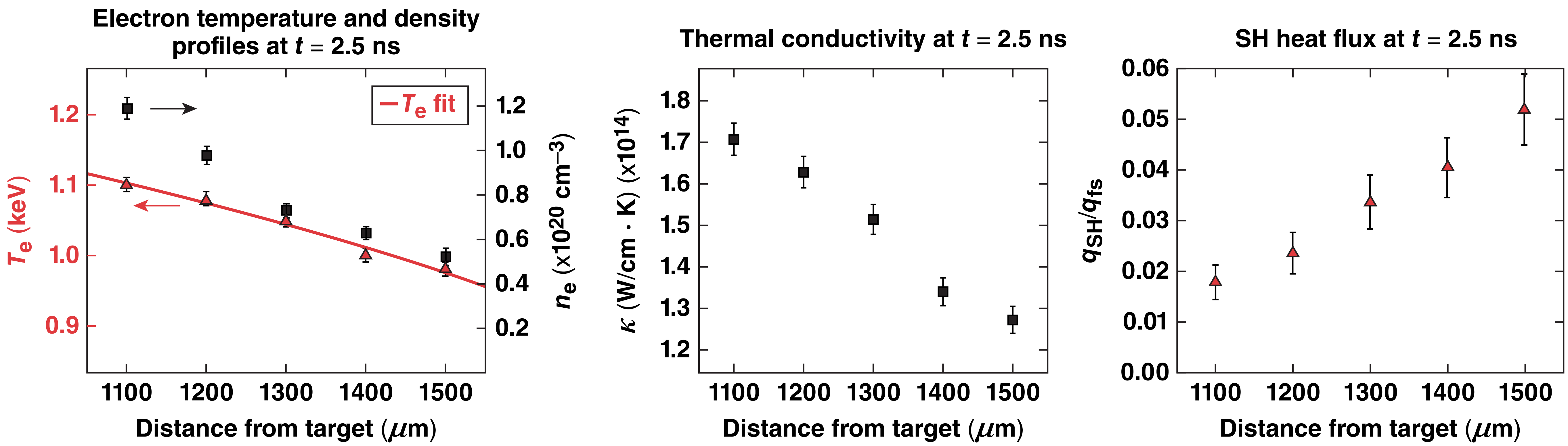
E24098

The scattering spectra are fit to determine the electron temperature and density



E24099

The electron temperature and density measurements are used to infer the heat flux



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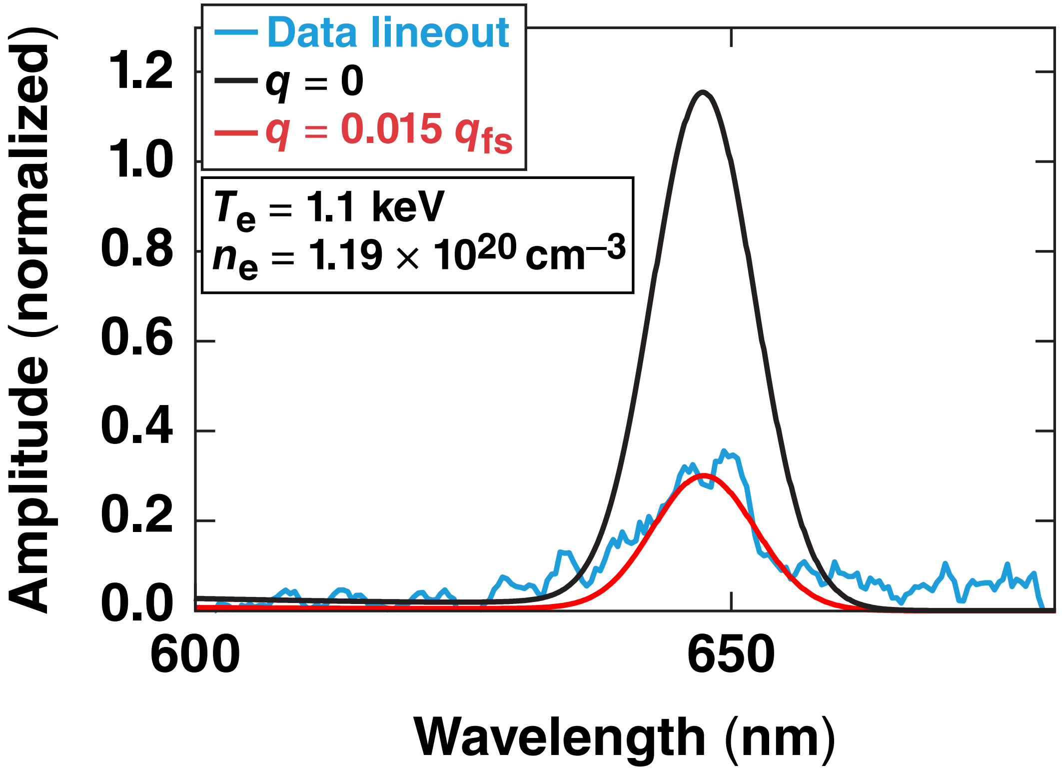
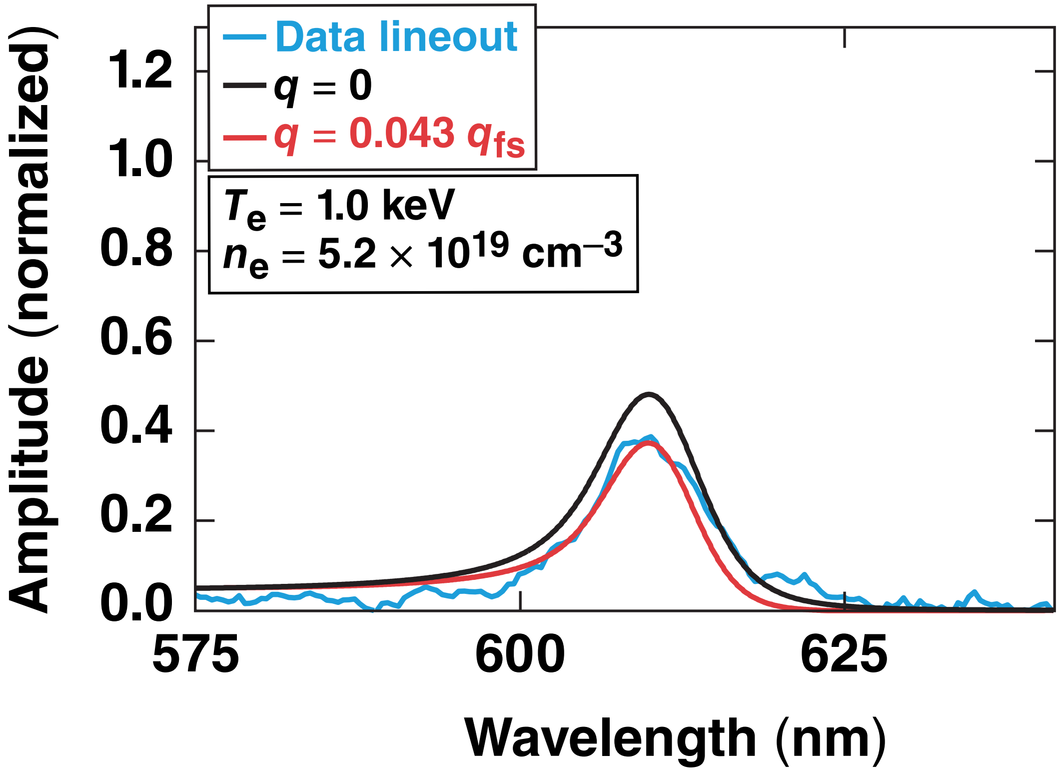
The relative amplitudes of the EPW scattering features were used to measure heat flux

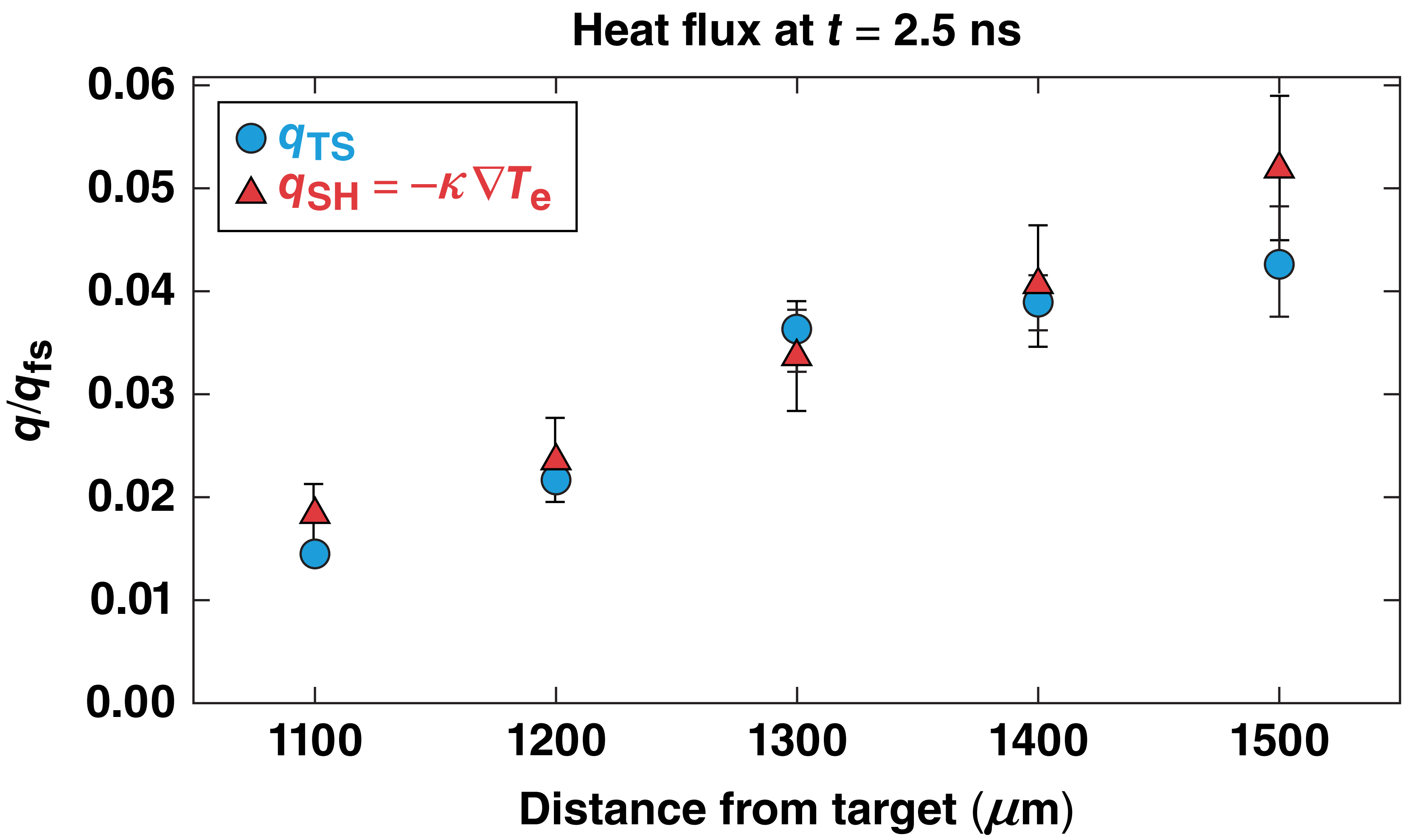
EPW lineout, 1100 μm from target, t = 2.5 ns



EPW lineout, 1500 μm from target, t = 2.5 ns



The heat-flux values obtained by matching electron feature amplitudes are in good agreement with the temperature gradient measurements



E24103

Thomson scattering from ion-acoustic waves (IAW's) and electron plasma waves (EPW's) were used to measure heat flux in coronal plasmas

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