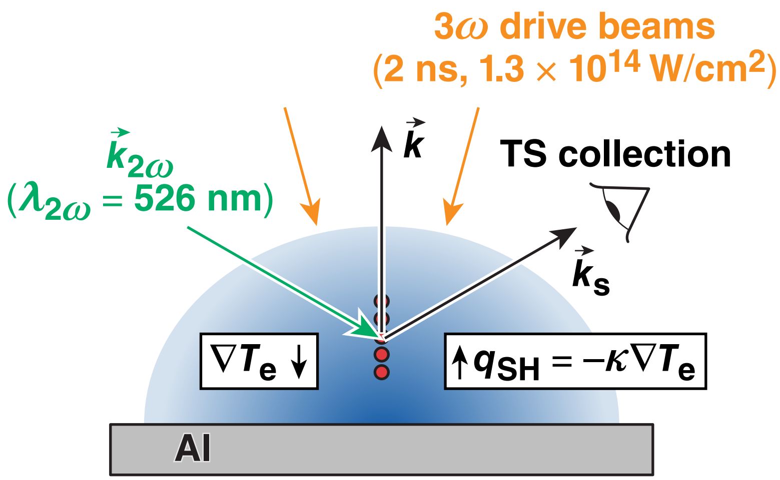
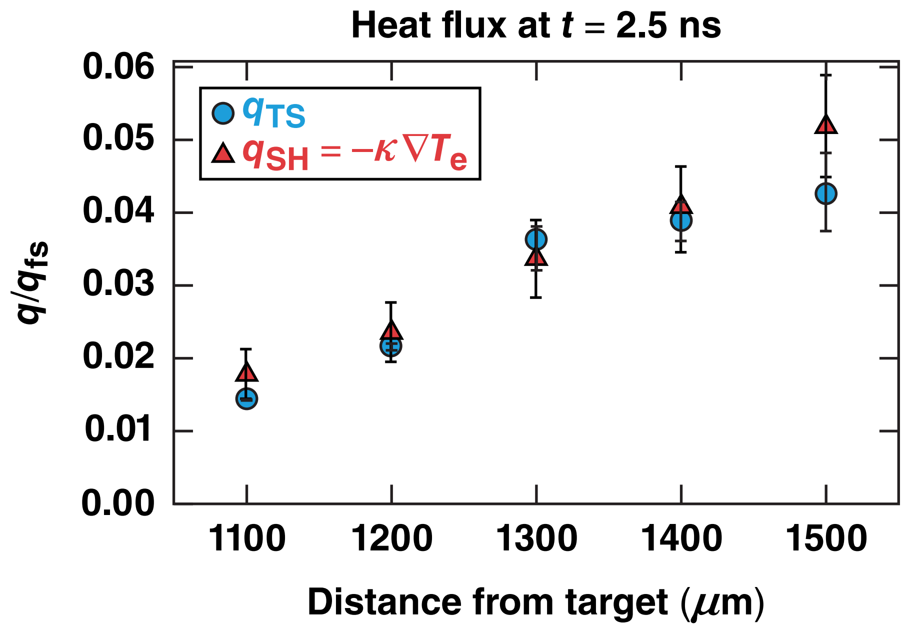
Heat-Flux Measurements from Collective Thomson-Scattering Spectra





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Summary

Thomson scattering from ion-acoustic waves (IAW's) and electron plasma waves (EPW's) was 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

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Collaborators

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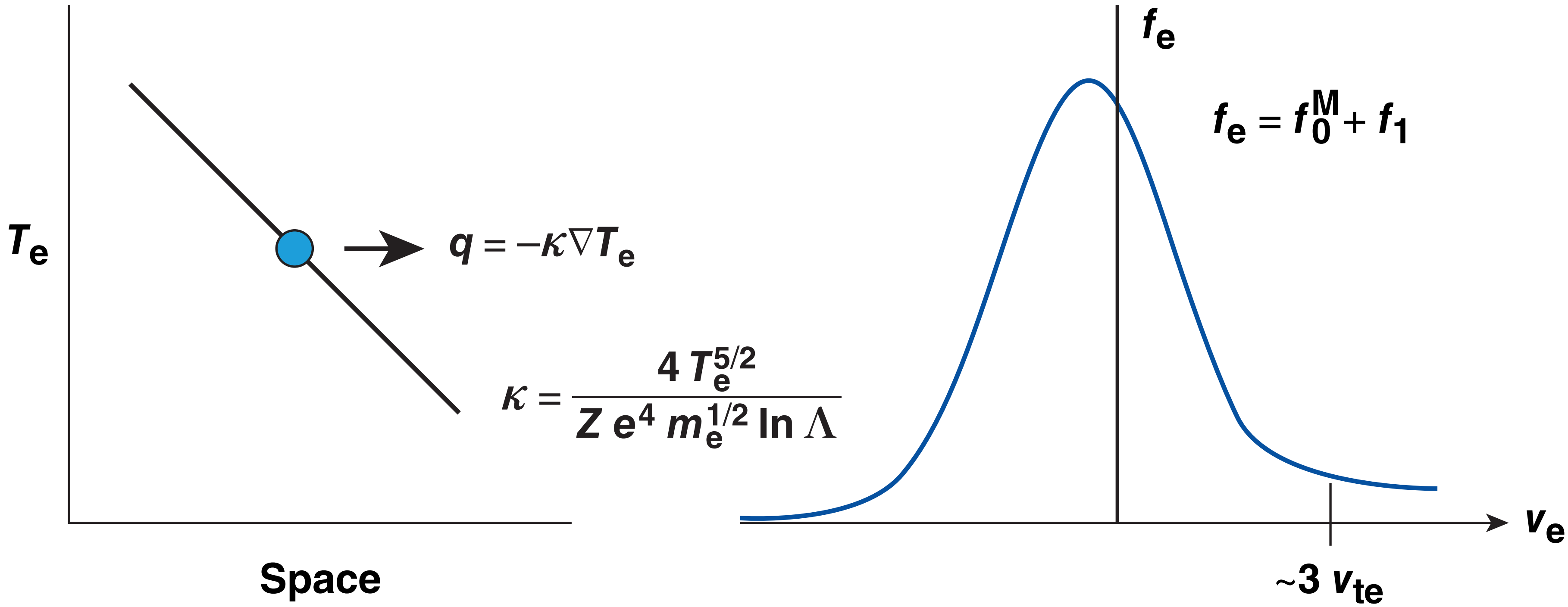
An experiment was designed to test Spitzer–Härm thermal transport in laser-produced coronal plasmas



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

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

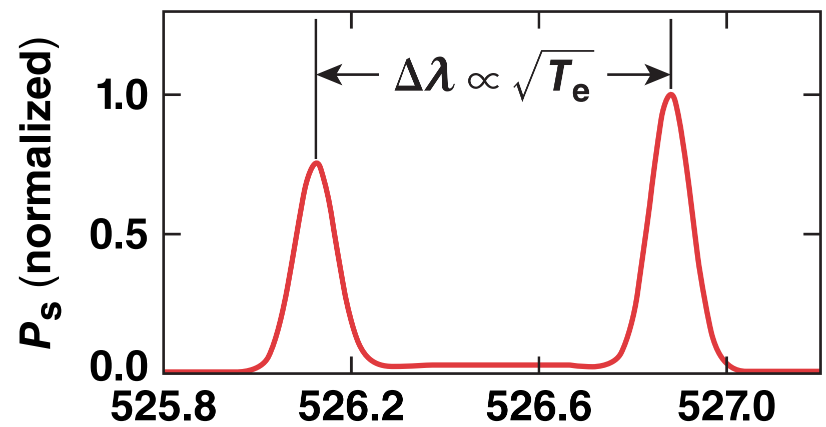
$$P_s \propto \left(1 + \frac{2\omega}{\omega_i}\right) S(k,\omega)$$

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

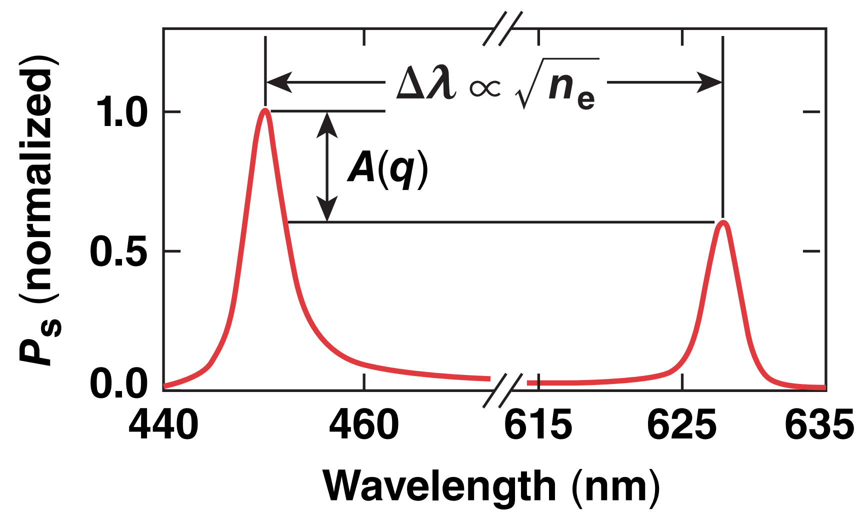
$$\chi_e = \int_{-\infty}^{\infty} dv \frac{4\pi e^2 n_e}{m_e k^2} \frac{k \cdot \frac{\partial f_e}{\partial v}}{\omega - k \cdot v - i\gamma}$$

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

Thomson scattering from IAW's (calculated)



Thomson scattering from EPW's (calculated)



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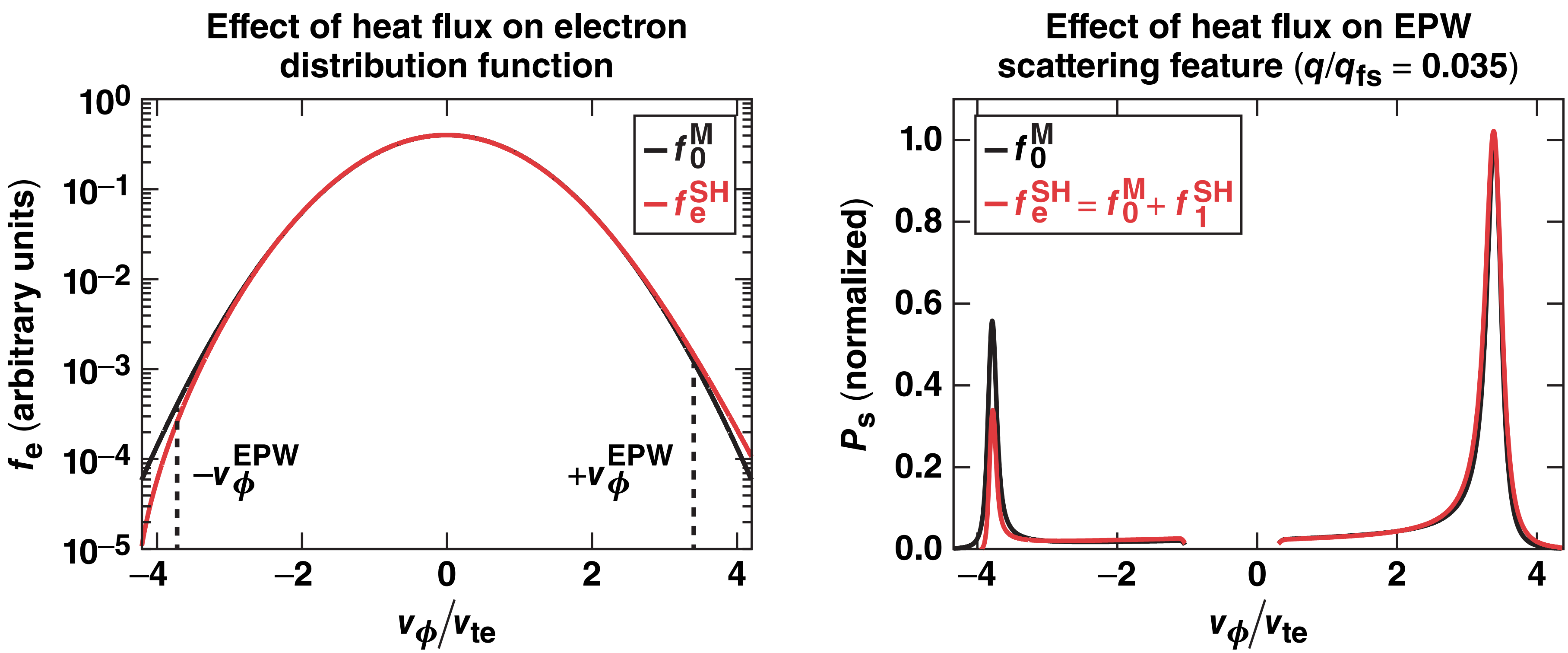
Changes in the electron distribution function caused by heat flux affect the Thomson scattering from EPW's



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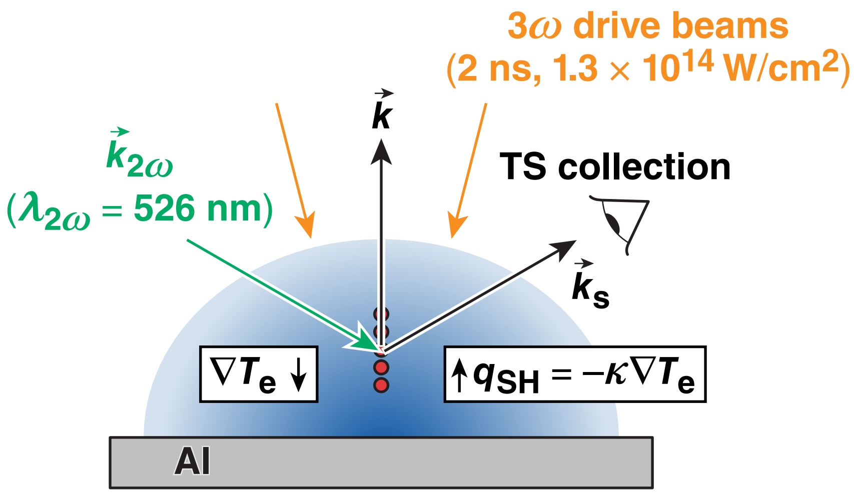
Thomson scattering was used to measure the heat flux, electron temperature, and electron density in coronal plasmas



- Thomson scattering (TS) provides local measurements of T_e, n_e, and q in an $\approx 50 \times 50 \times 50\text{-}\mu\text{m}^3$ 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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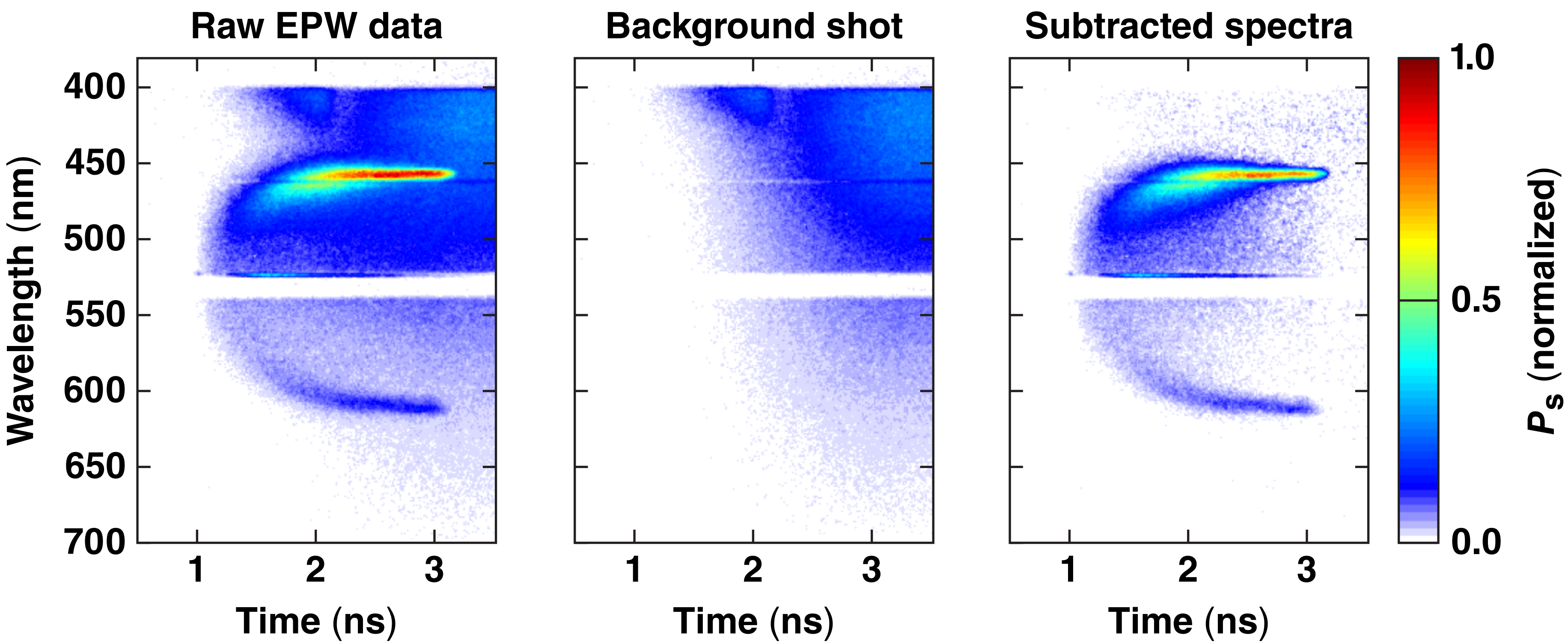
The up- and downshifted EPW features were measured with a large signal-to-background ratio



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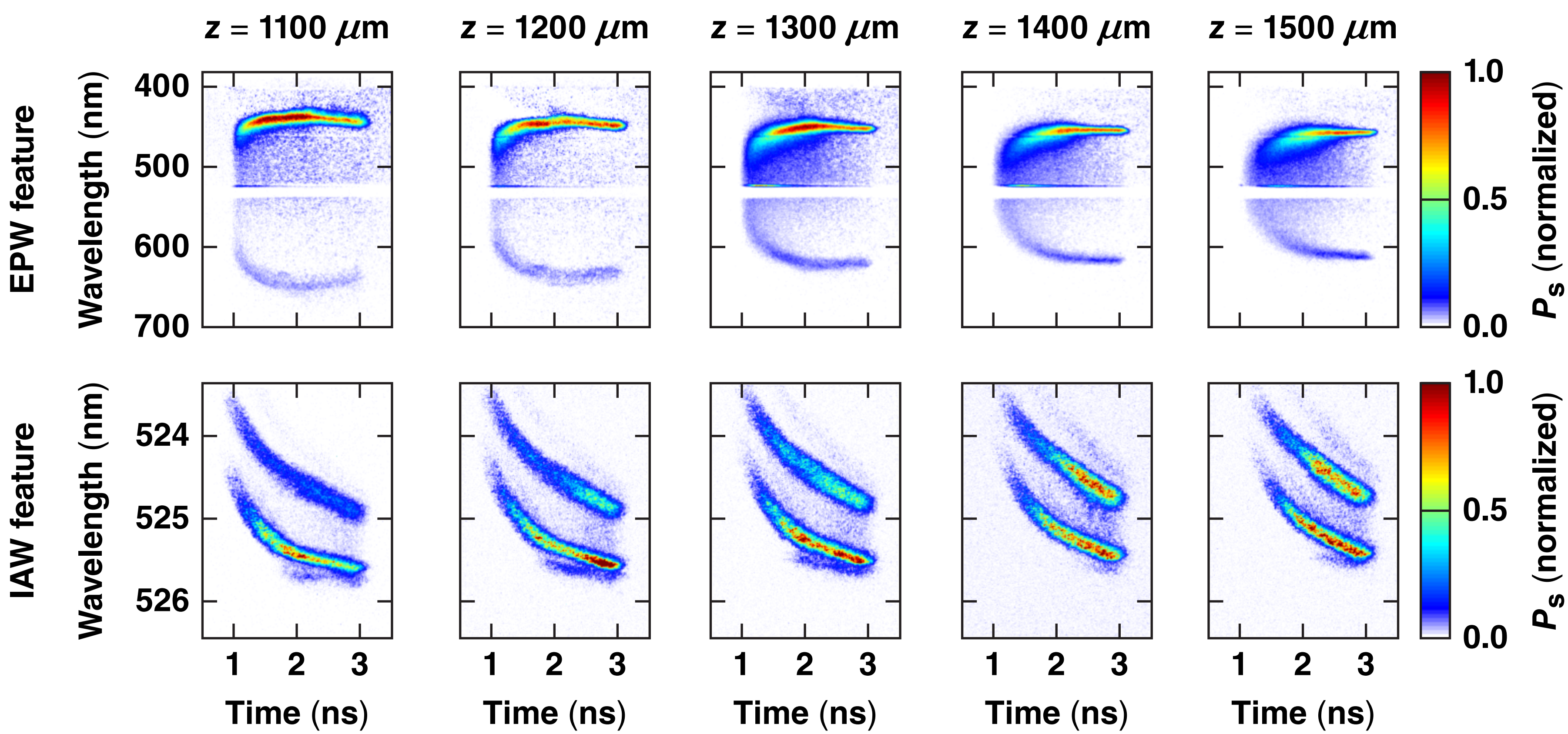
Thomson-scattering spectra obtained at five locations in the corona were used to measure the heat flux



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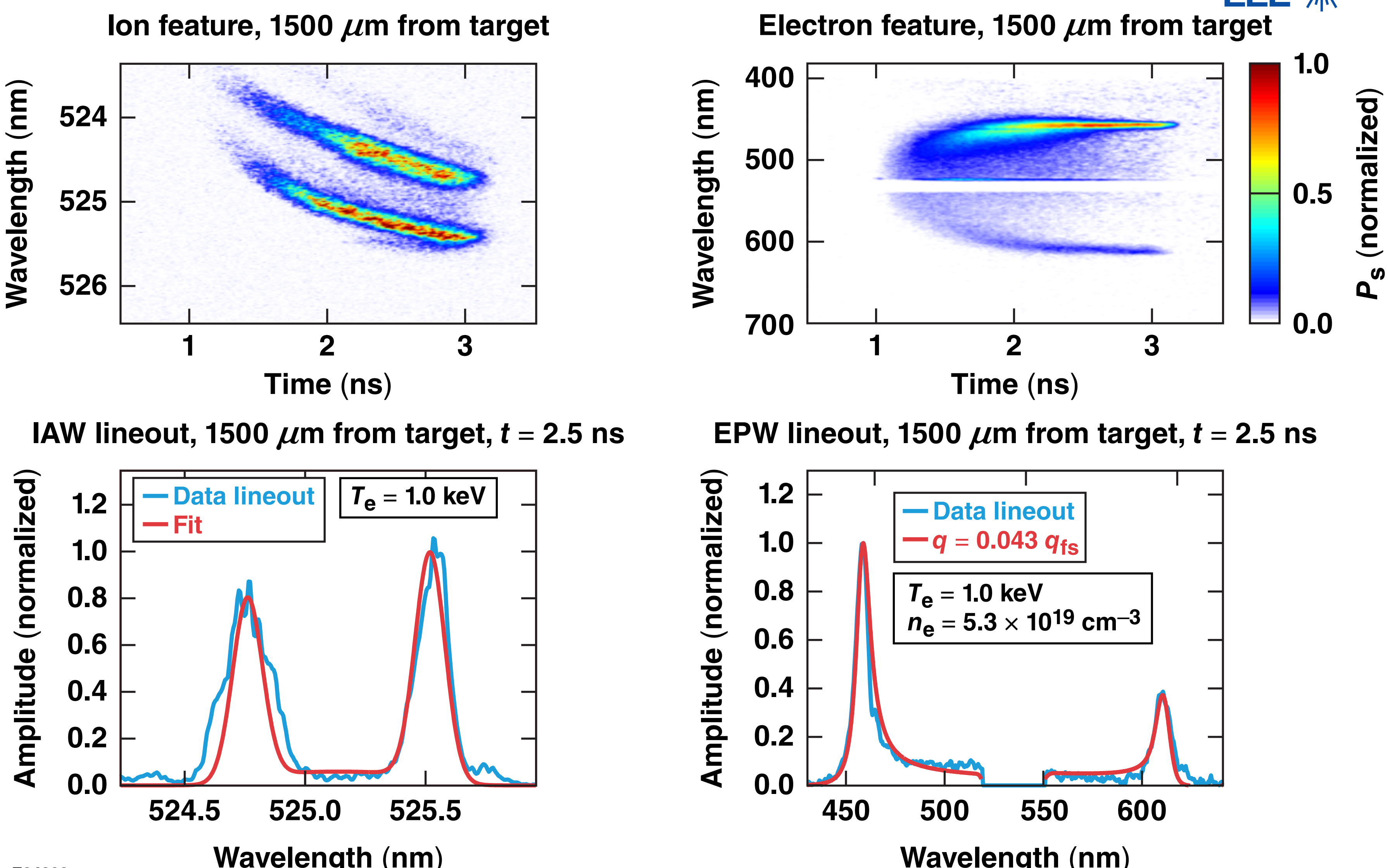
The scattering spectra are fit to determine the electron temperature and density



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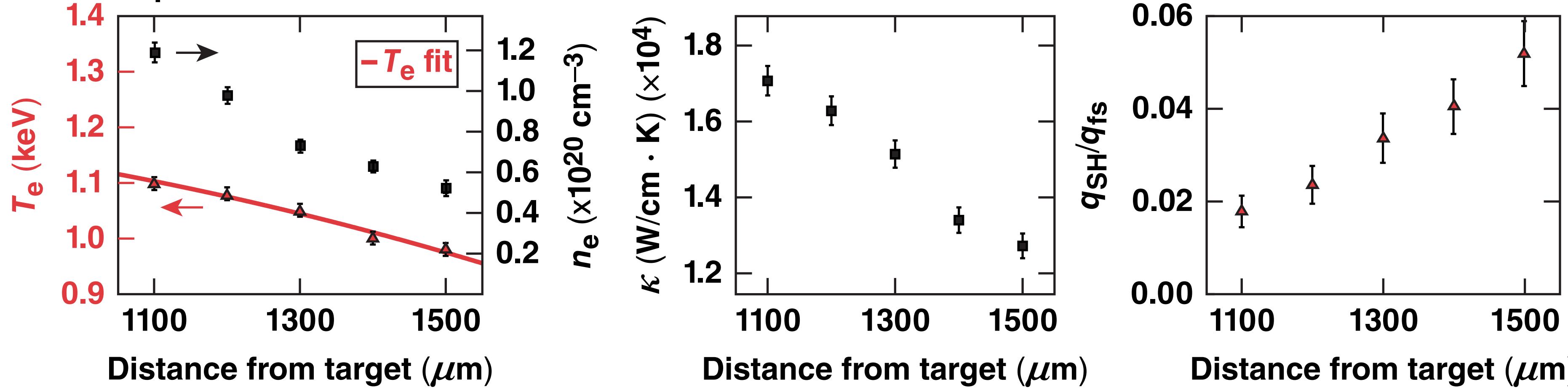
The electron temperature and density measurements are used to infer the heat flux

Electron temperature and density profiles at t = 2.5 ns

Thermal conductivity at t = 2.5 ns

SH heat flux at t = 2.5 ns



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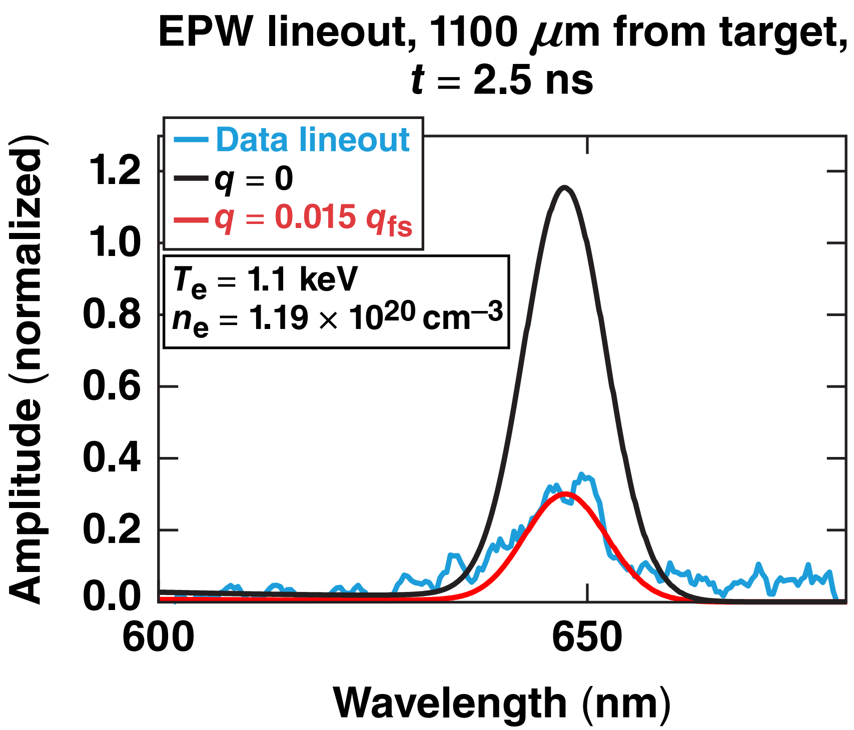
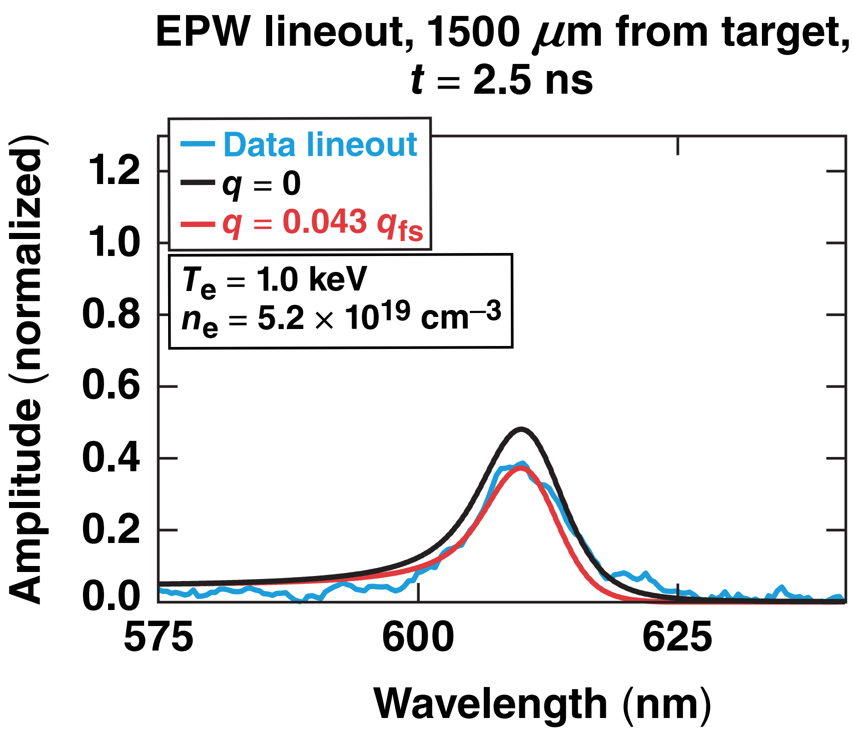
The relative amplitudes of the EPW scattering features were used to measure heat flux





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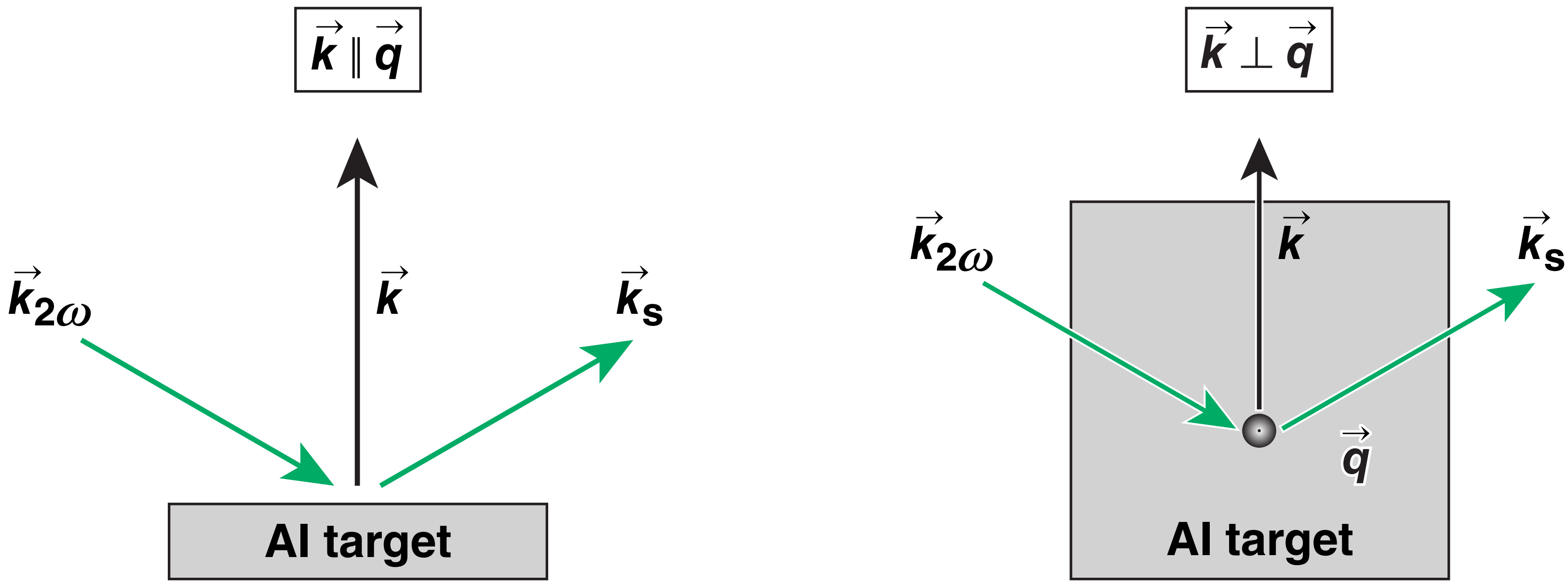
Two experimental configurations measured heat flux parallel and perpendicular to the target normal



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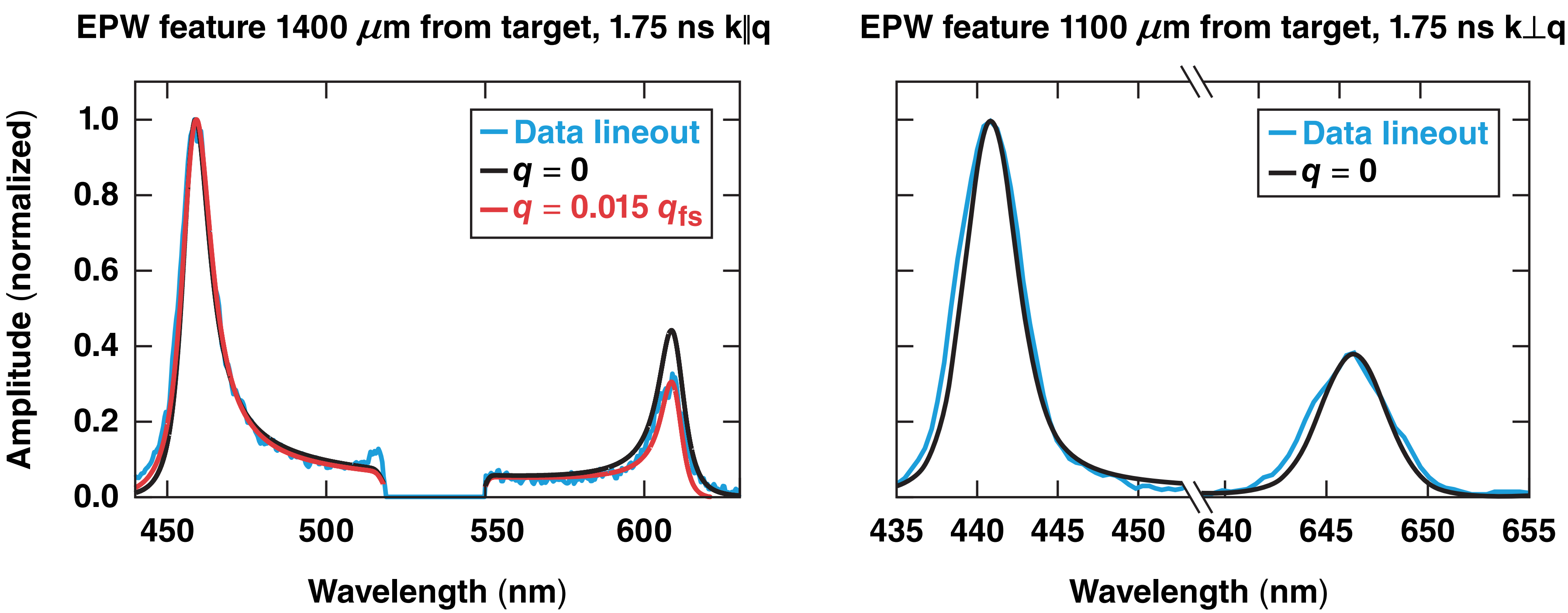
Differences in the relative amplitudes of the EPW scattering features between the two configurations show the effect of heat flux



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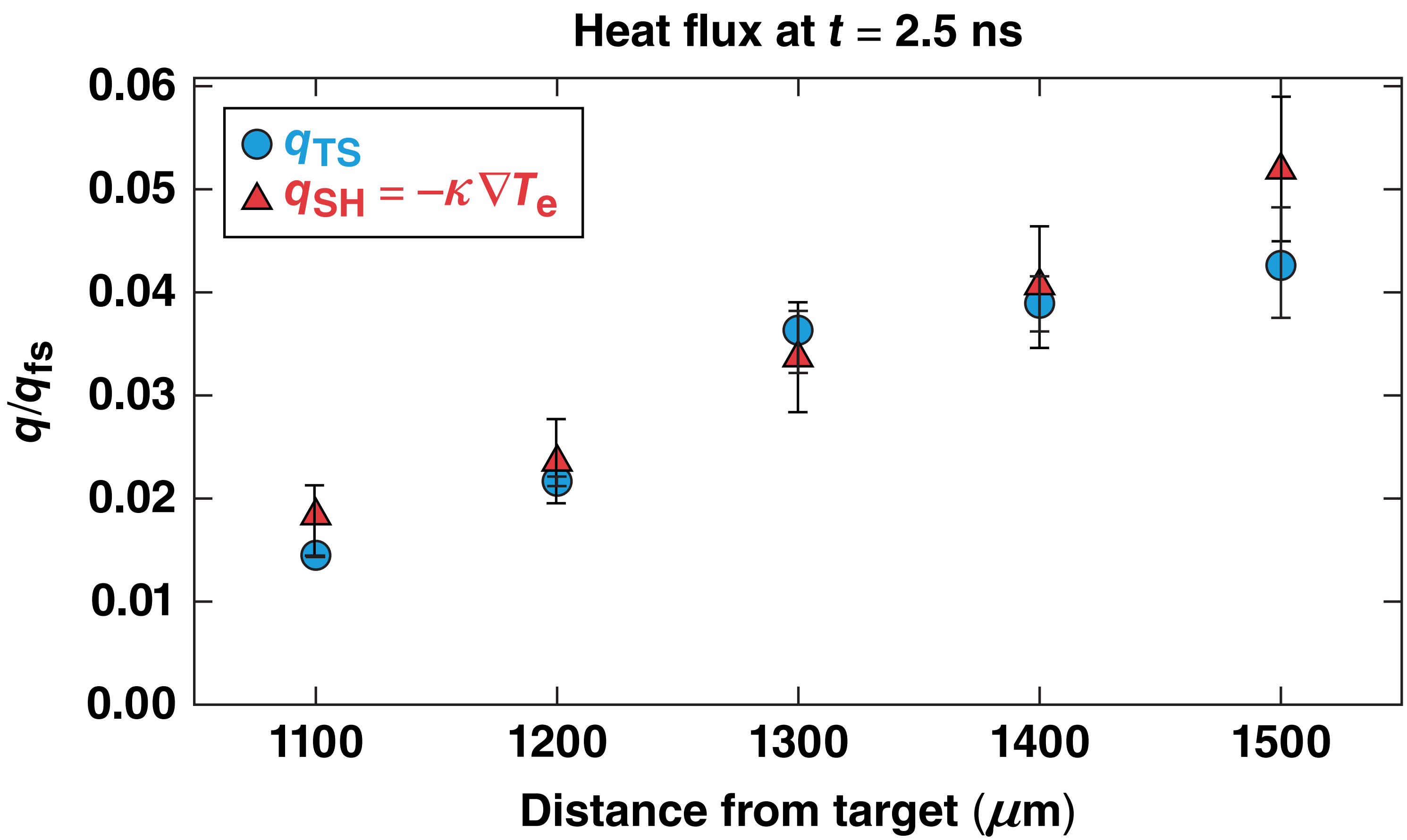
The heat-flux values obtained by matching electron feature amplitudes are in good agreement with the temperature-gradient measurements



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Summary/Conclusions

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