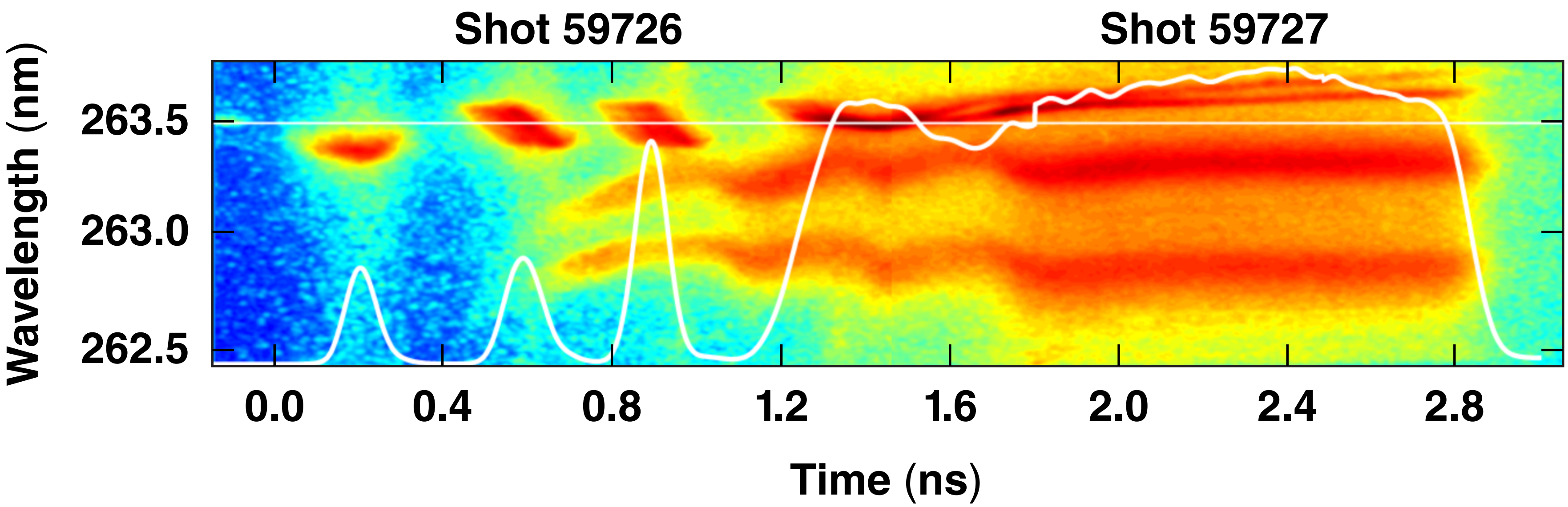
Thomson-Scattering Study of the Coronal Plasma Conditions in Direct-Drive Implosions



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Summary

The electron and ion temperatures measured with Thomson scattering show agreement with nonlocal simulations

- A robust direct-drive-ignition design will require accurate modeling of the underdense plasma to allow laser–plasma instabilities (LPI) mitigation
- Thomson scattering is used to validate our nonlocal hydrodynamic model in the coronal plasma
  - simulations agree well with electron and ion-temperature measurements made 400 μm from the initial target surface
  - simulations over-estimate the fluid velocity by 20%
- Future experiments will explore regimes closer to the critical surface

These are the first measurements of direct drive coronal conditions.

Collaborators

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Two primary laser–plasma instabilities are a concern for direct drive and require an understanding of the underdense hydrodynamics

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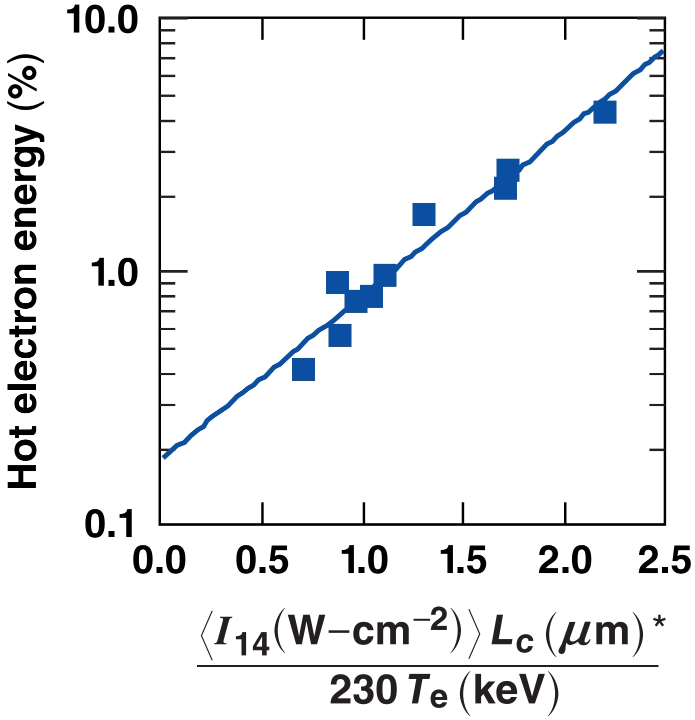
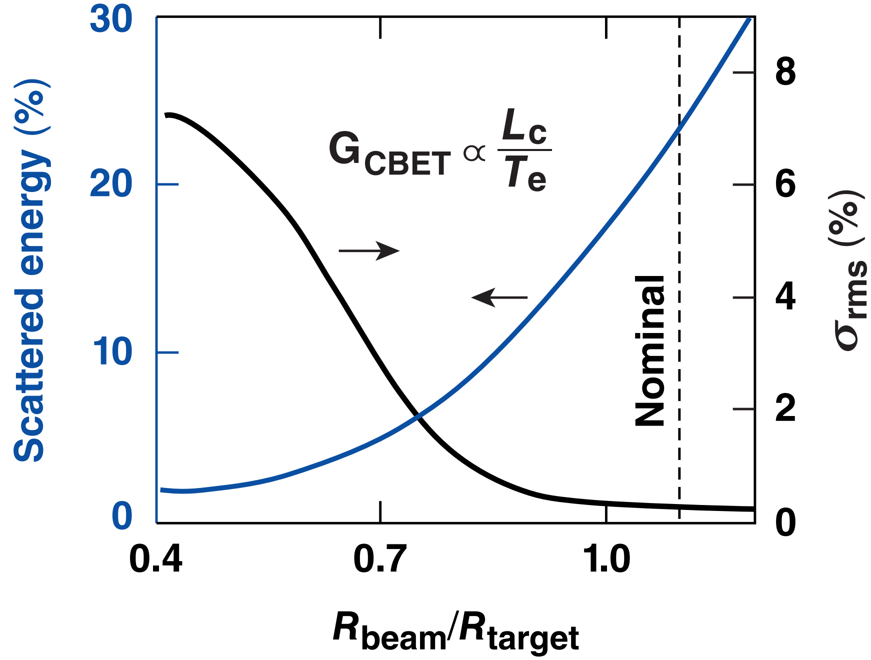
Two-plasmon decay scales with hydrodynamic properties at $n_{cr}/4$



S. X. Hu, "Simulation and Analysis of Long Scale-Length Plasma Experiments at the Omega EP Laser Facility," this conference.

Calculations suggest an optimum spot size where CBET is minimized



W. Seka, "Reducing the Cross-Beam Energy Transfer in Direct-Drive Implosions Through Laser-Irradiation Control," this conference.

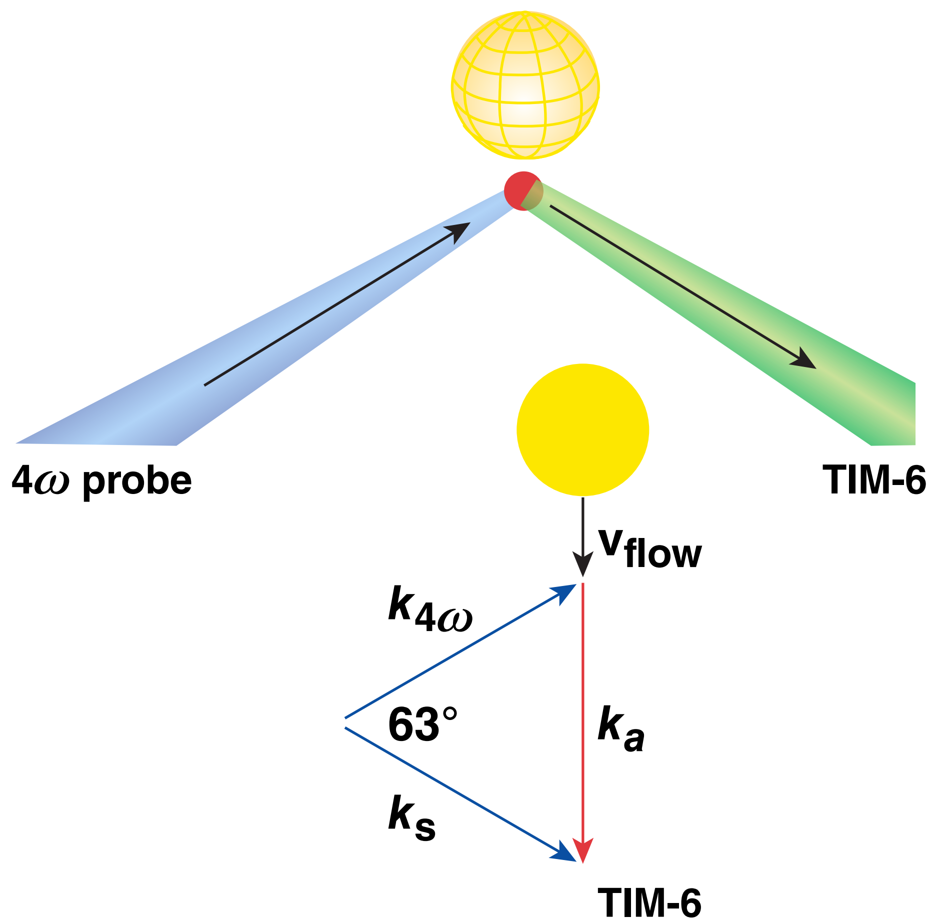
A robust direct-drive-ignition design will require accurate modeling of the underdense plasma to allow LPI mitigation.

E19921

*A. Simon *et al.*, Phys. Fluids 26, 3107 (1983).

Thomson-scattering measurements were performed on direct-drive low-adiabat-implosion experiments

- 20 kJ of 351-nm light (59 beams) is used to drive a standard implosion
- Triple-picket pulse shape is designed for a low adiabat
- A 263-nm probe beam is used for Thomson scattering
- Scattered light is collected from a 60-μm × 75-μm × 75-μm volume 400 μm from the initial target surface
- Ion-acoustic waves propagating along the target radius are probed



$$k_a = 2\, k_{4\omega}\ \sin(63/2) = 1.0\, k_{4\omega}$$

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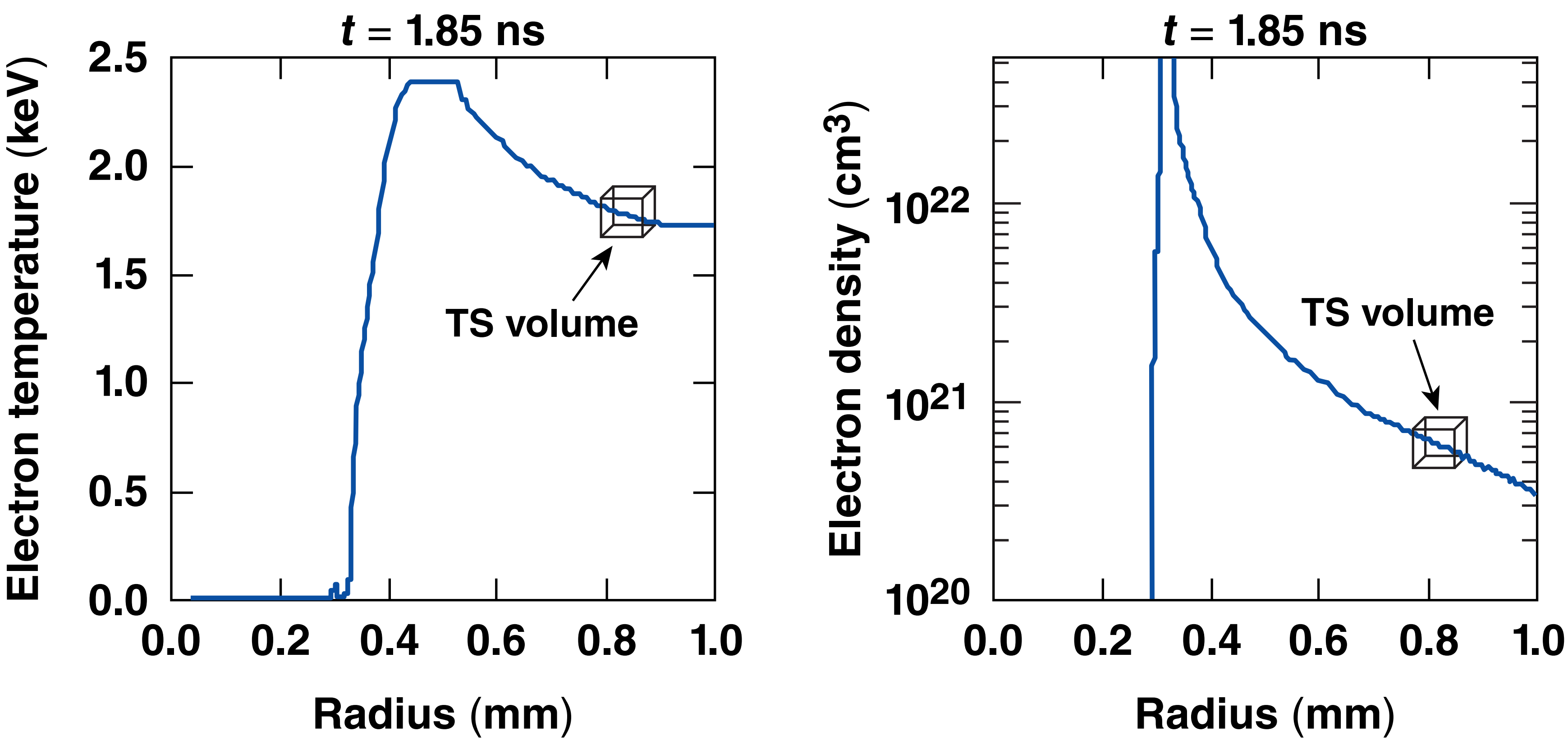
Nonlocal hydrodynamic simulation parameters in the coronal plasma



The initial Thomson scattering measurements are made 400 μm from the initial target surface.

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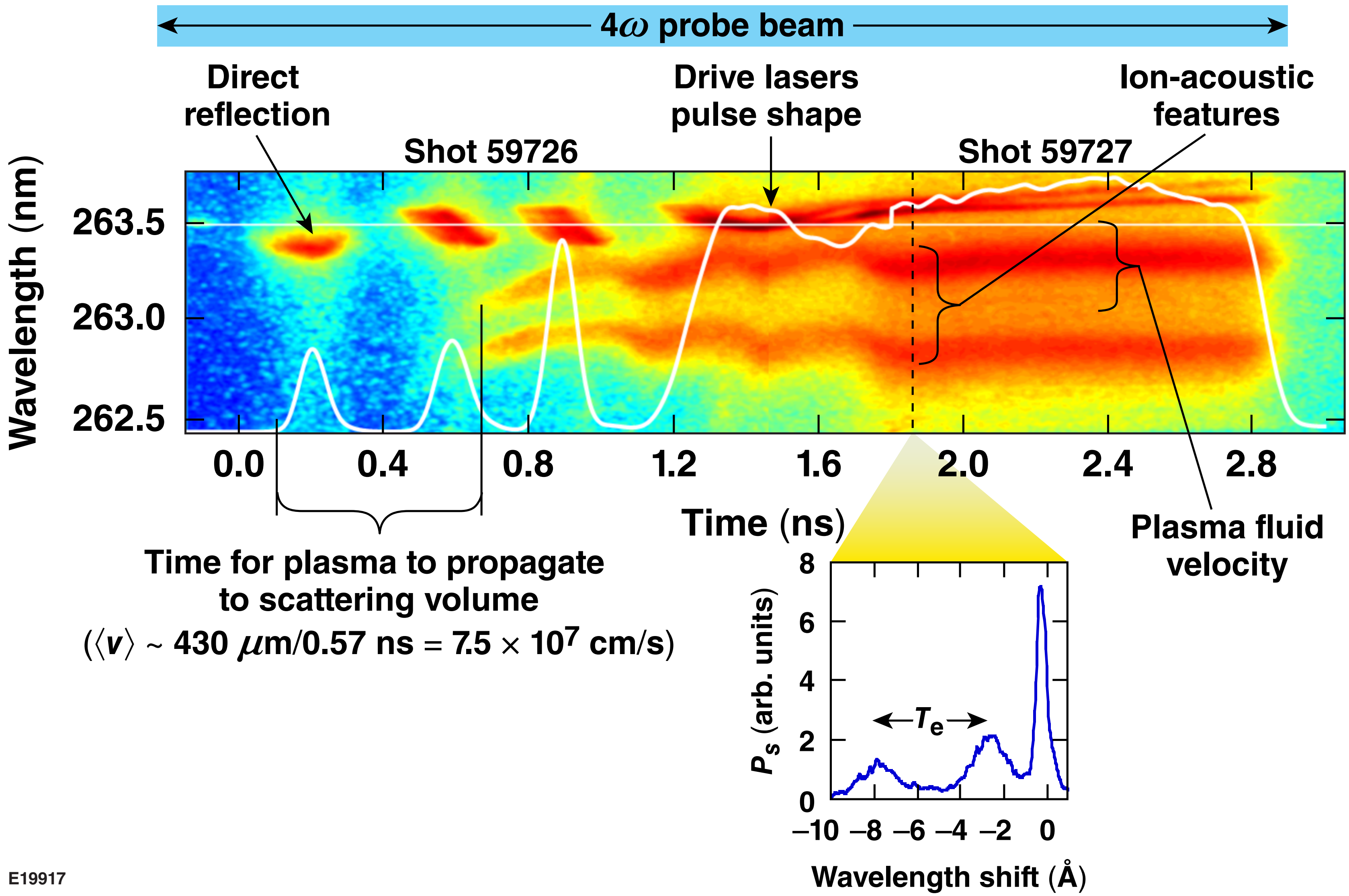
Thomson scattering from the ion-acoustic waves in CH plasmas provides a measure of T_e, T_i, V_f



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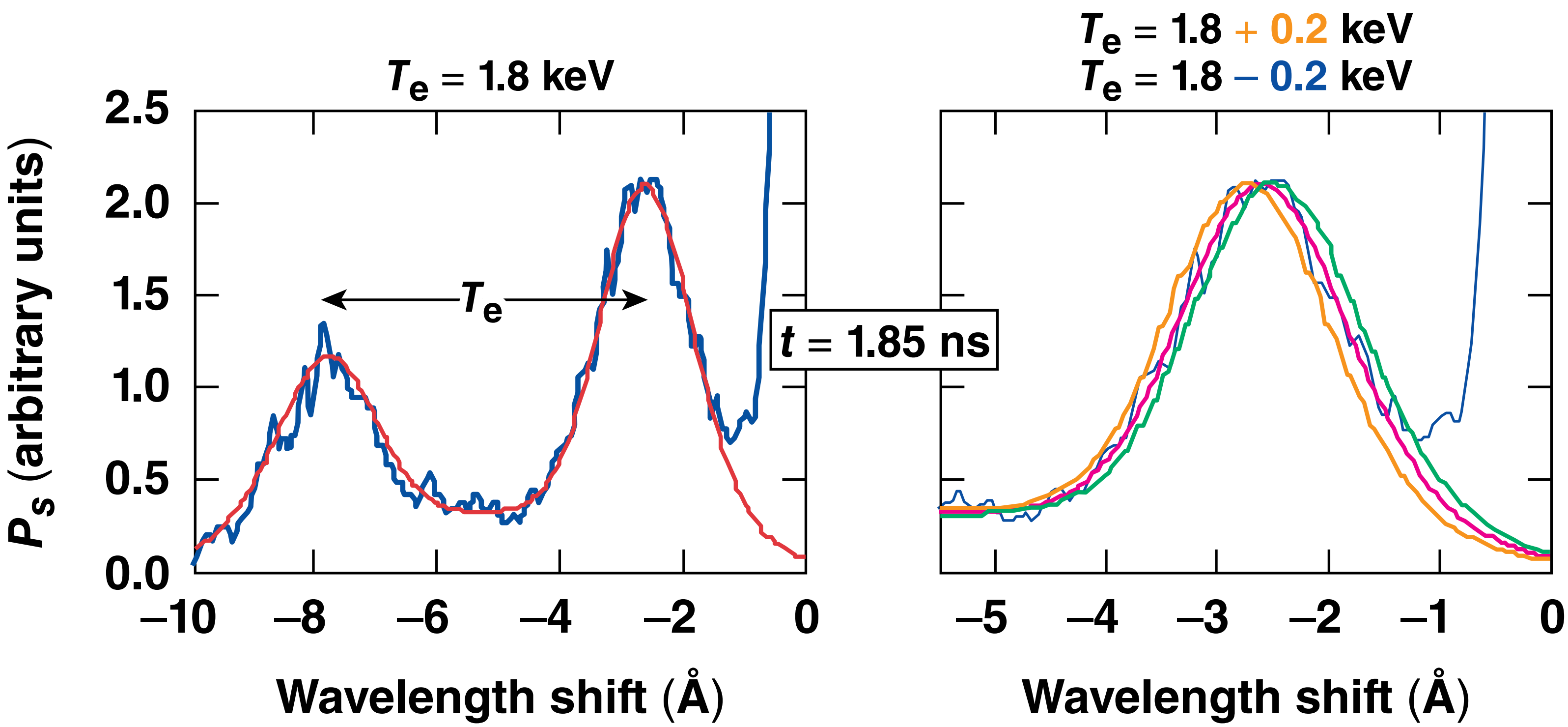
The electron temperature is determined from the wavelength separation in the ion-acoustic features

- The electron temperature is given by the wavelength separation of the ion-acoustic features
- The electron temperature is measured to within 20%



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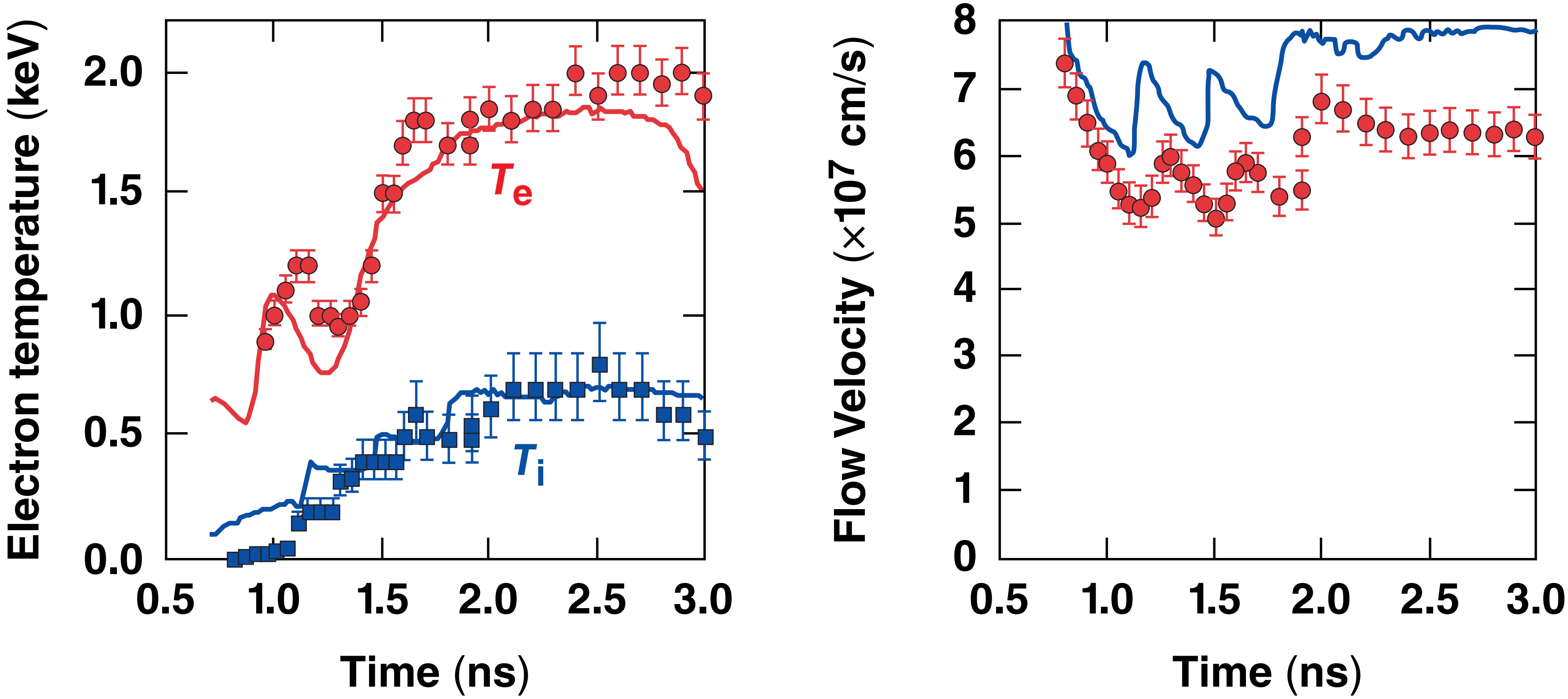
The measured electron and ion temperatures are in good agreement with nonlocal hydrodynamic modeling

- Late-time temperature discrepancies indicate anomalous absorption
- Simulations over estimate the flow velocity by 20%



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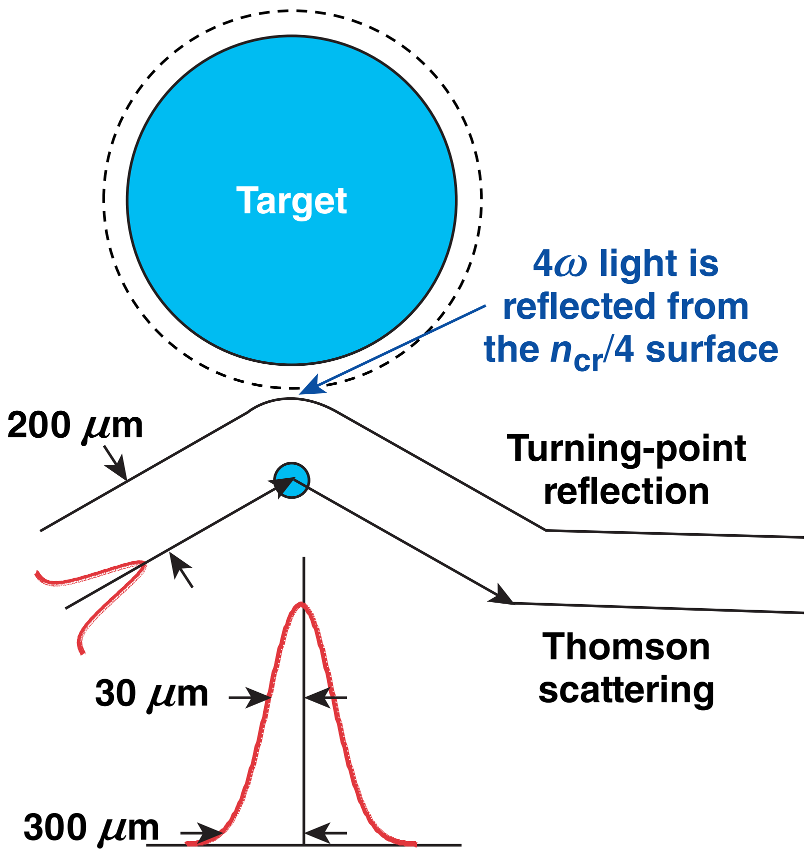
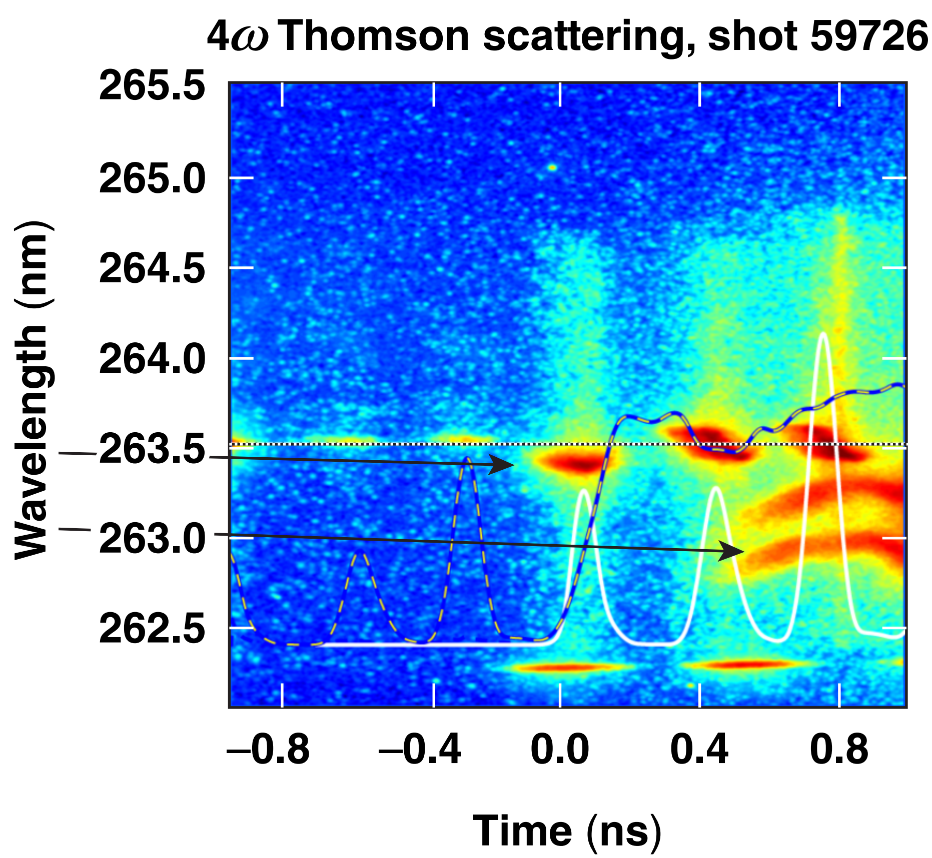
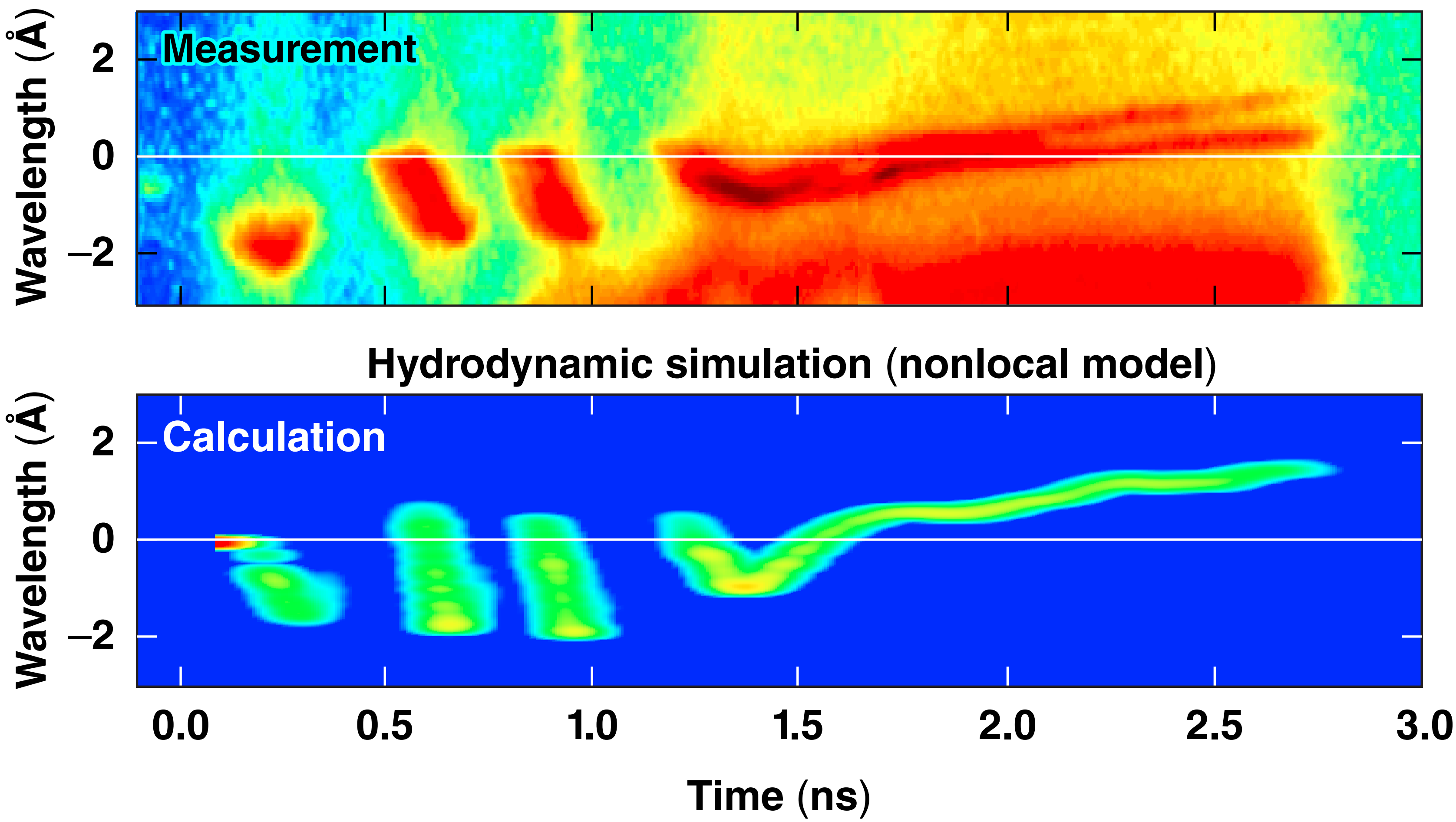
4ω light reflected from the target probes plasma properties at the $n_{cr}/4$ surface





$$\frac{I(300\ \mu\text{m})}{I_0} = \exp\left[-\left(\frac{200\ \mu\text{m}}{\sqrt{2}\ 30\ \mu\text{m}}\right)^2\right] \approx 10^{-10}$$

The wavelength shift and absorption of light propagating through the turning point is modeled



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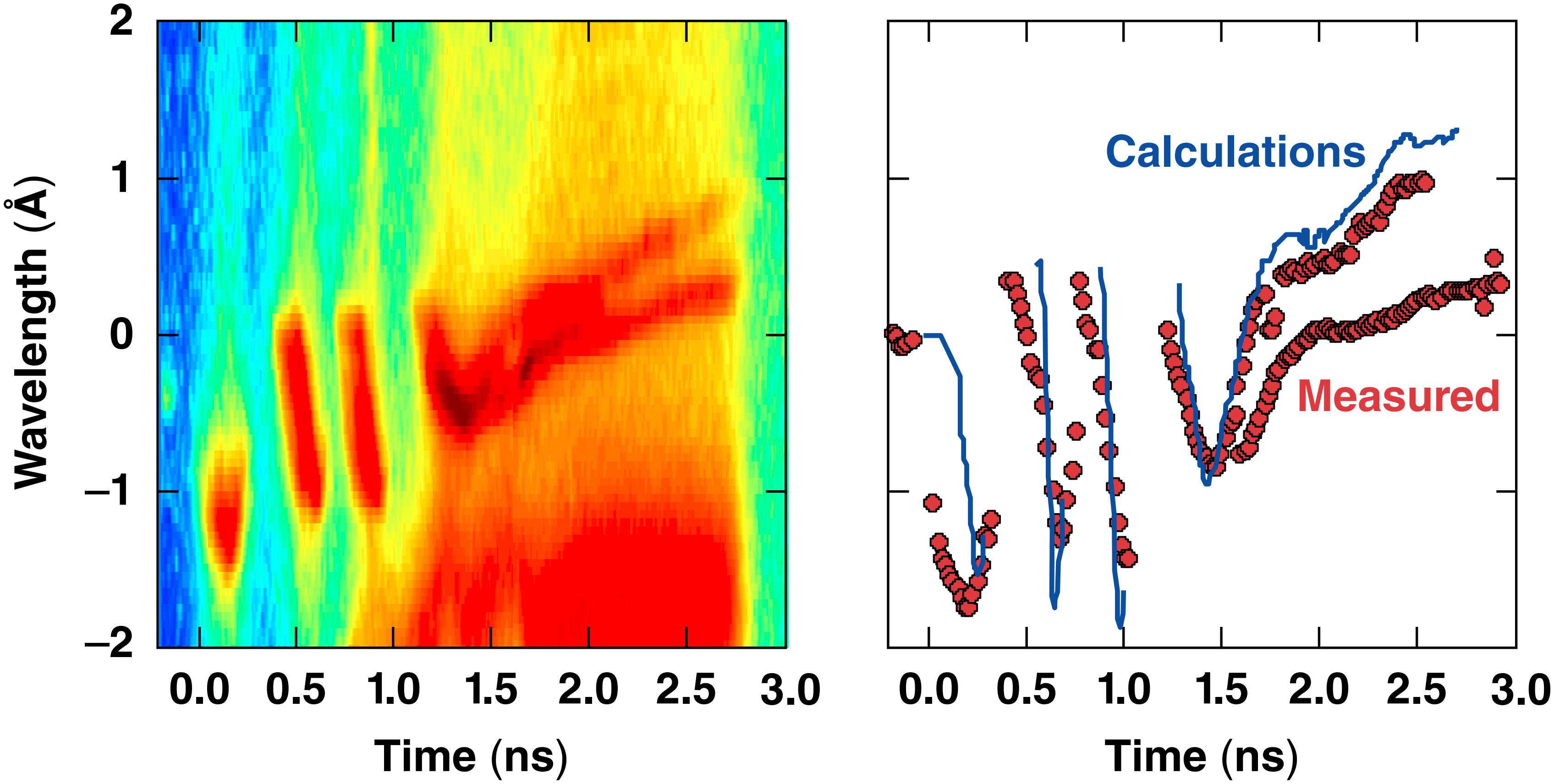
Many of the main features are reproduced by the simulations, but late-time discrepancies indicate over-estimated flow



Scattered light provides information about the hydrodynamic properties at the $n_{cr}/4$ surface.

E19920a

Summary/Conclusions

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