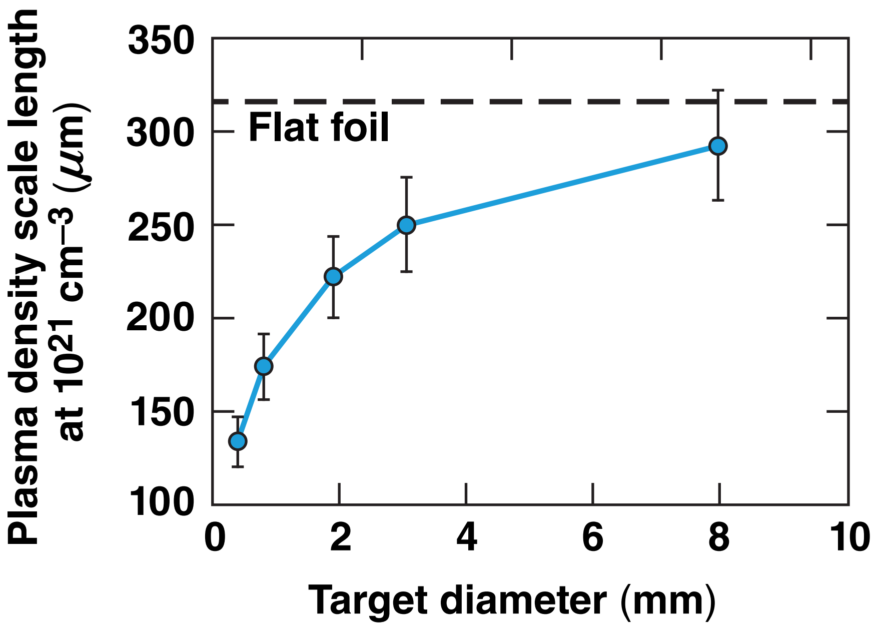
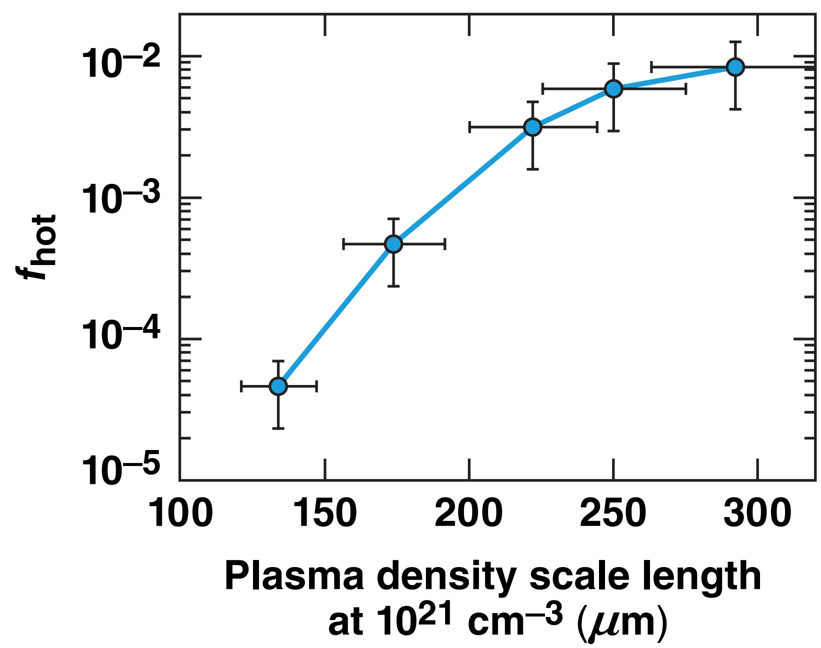
Measurement of Long-Scale-Length Plasma Density Profiles for Two-Plasmon Decay Studies





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Summary

The dependence of two-plasmon decay (TPD) on the plasma scale length is isolated by using targets of varying radii

- Angular filter refractometry (AFR) was developed to measure high-density, long-scale-length plasmas
- AFR measures the refractive contour map of the probe beam from which the density is calculated up to ~10^{21} cm^{-3} ($n_e = 0.1\ n_{cr}$)
- The scale length is measured to increase from 150 to 300 μm as the target diameter is increased from 0.4 to 8 mm
- The hot-electron production is found to increase rapidly with the measured plasma density scale length

Collaborators

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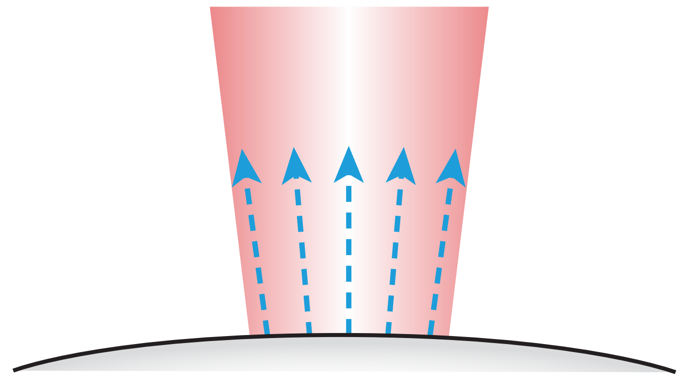
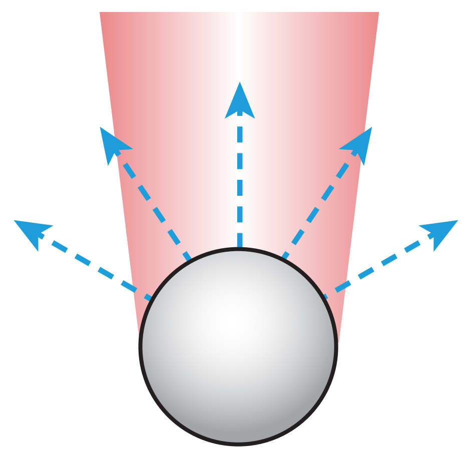
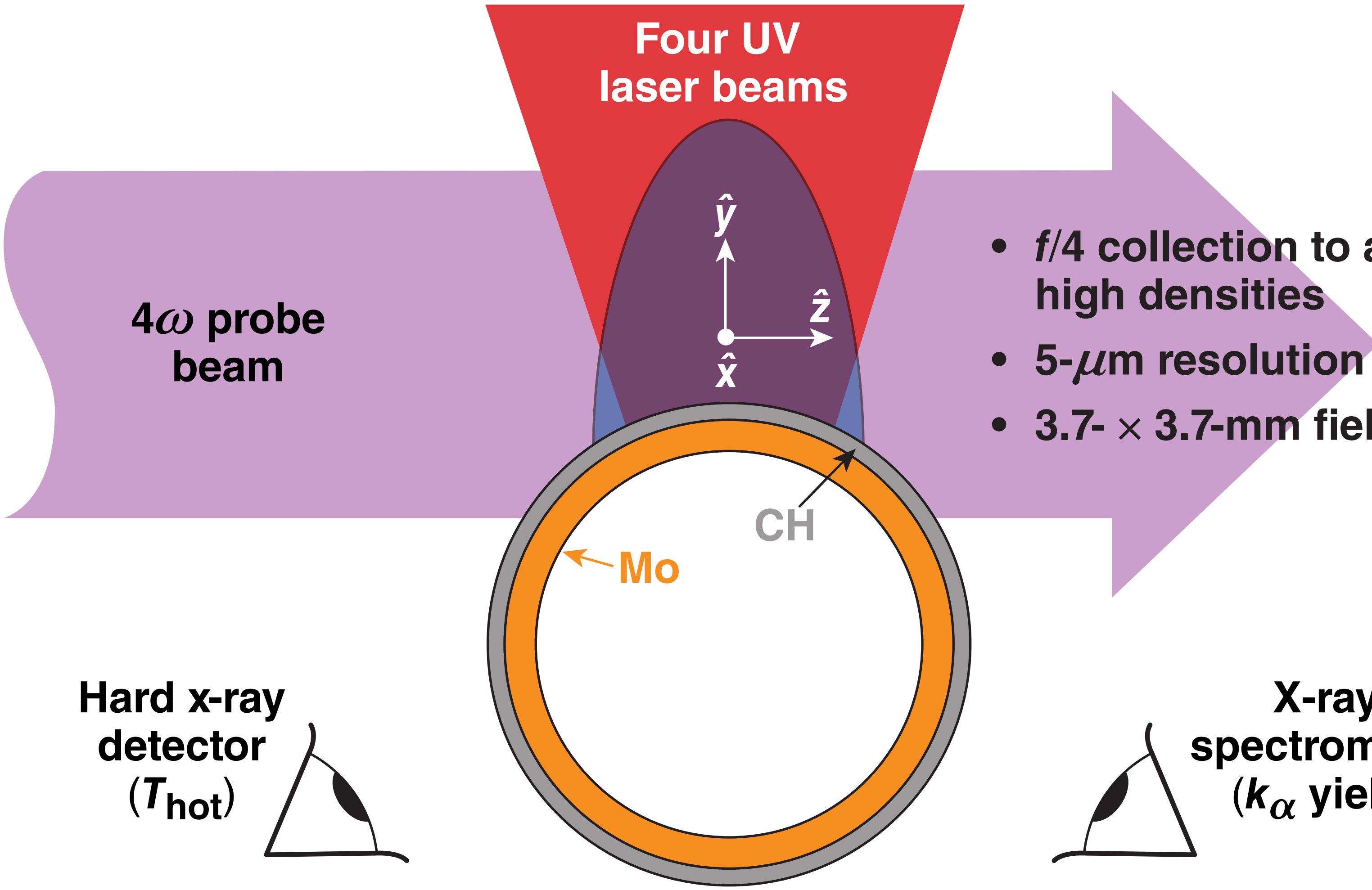
The dependence of TPD on the plasma scale length is isolated by using targets of varying radii on OMEGA EP

- The TPD gain is proportional to IL_n/T_e (at $n_{cr}/4$)
  - I: laser intensity
  - L_n: plasma density scale length
  - T_e: thermal electron temperature
- Simulations show that I/T_e is approximately constant for these experiments
- By decreasing the radius of a spherical target, L_n decreases as the plasma expansion becomes more divergent





The experiment measures the plasma density scale length and the hot-electron production

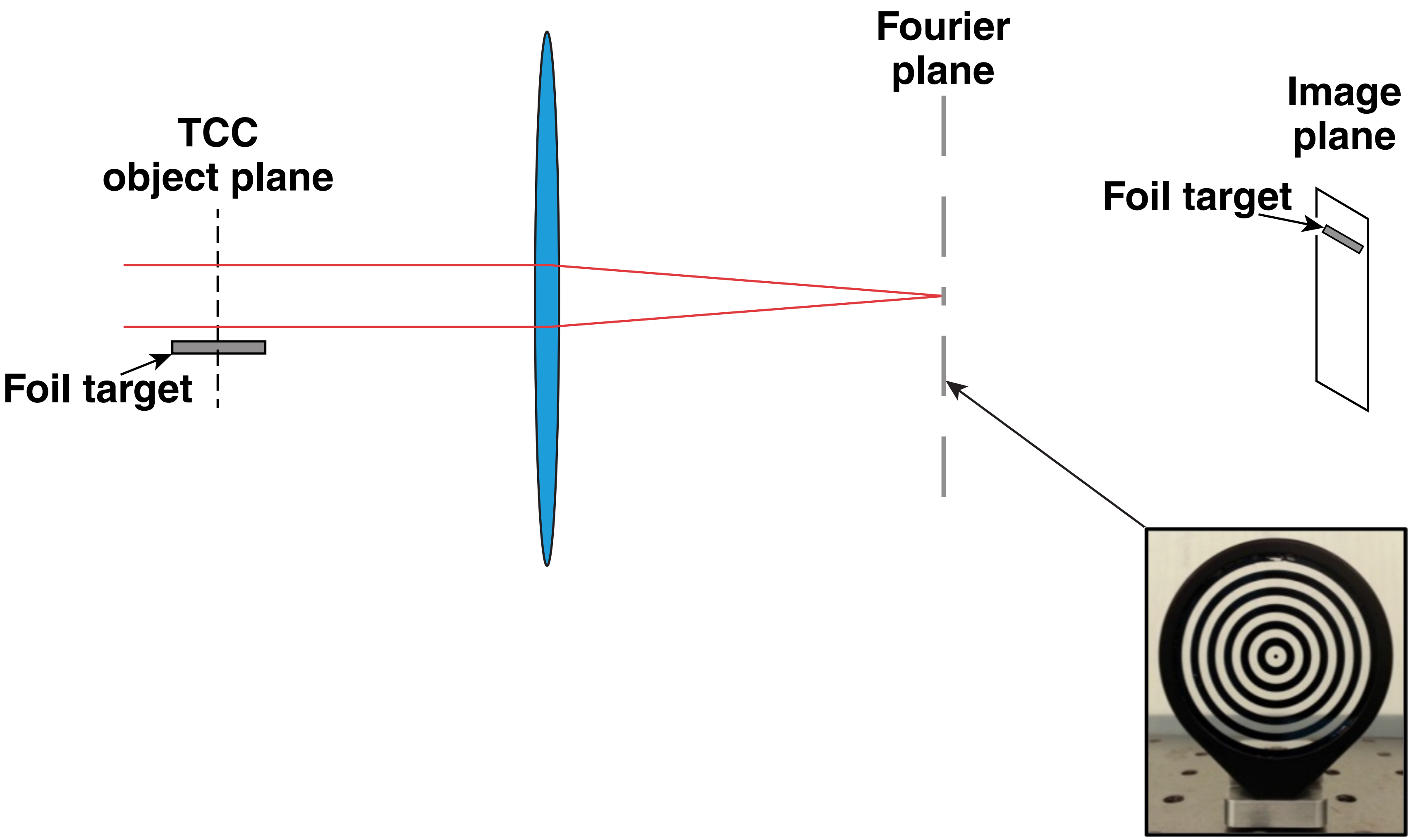


- *f*/4 collection to access high densities
- 5-μm resolution
- 3.7- × 3.7-mm field of view

The plasma density scale length is measured with a new diagnostic based on refractometry.

E22055a

Angular filter refractometry (AFR) maps the refraction of the probe beam at target chamber center (TCC) to contours in the image plane



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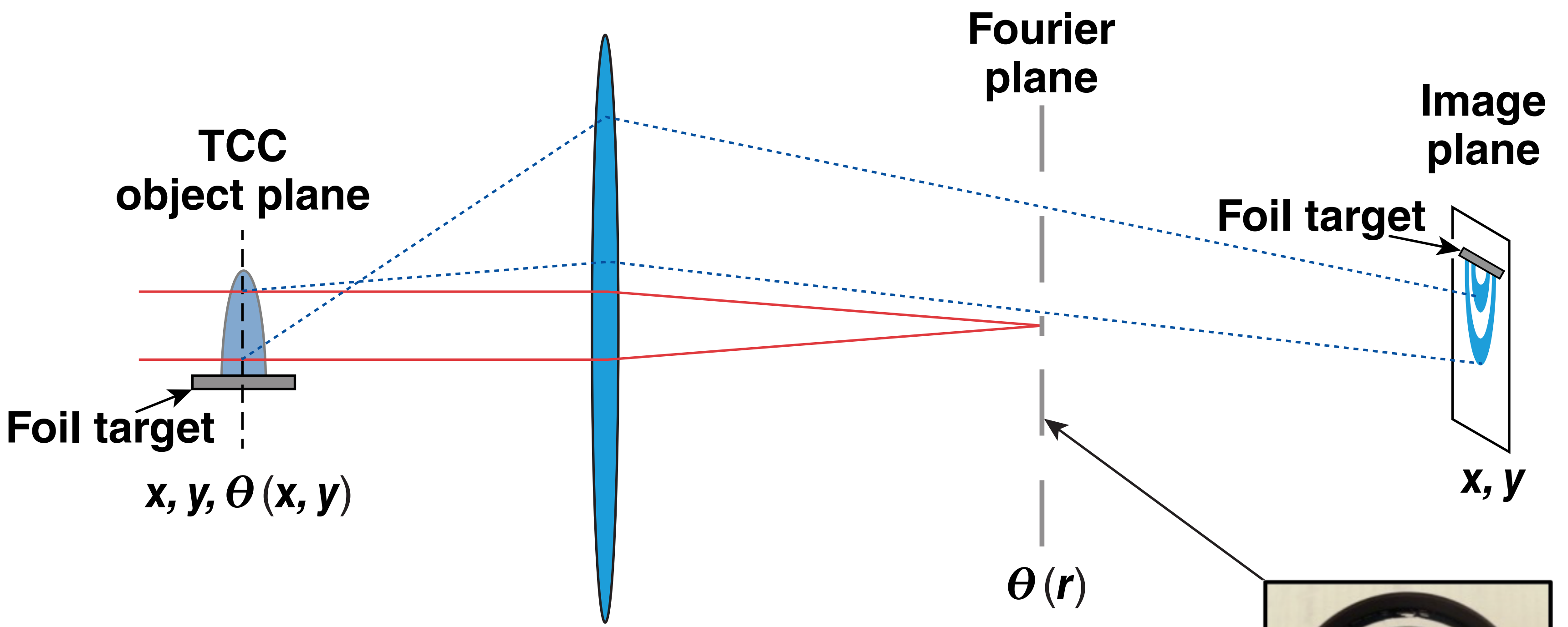
Angular filter refractometry (AFR) maps the refraction of the probe beam at target chamber center (TCC) to contours in the image plane



The edges of the rings map a certain refraction angle to the spatial location in the object plane.

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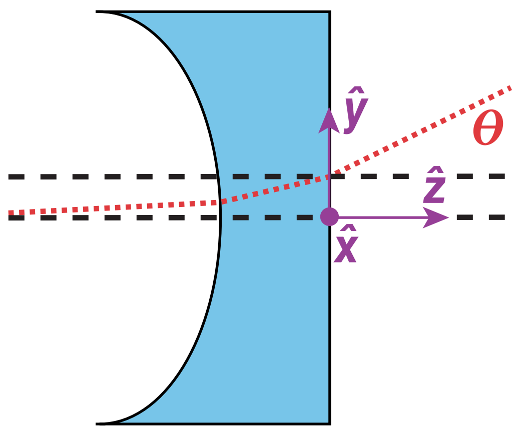
The diagnostic is calibrated using a negative lens, which has a well-defined $\theta\,(x, y)$

Negative spherical lens at TCC



Round beam shape at Fourier plane

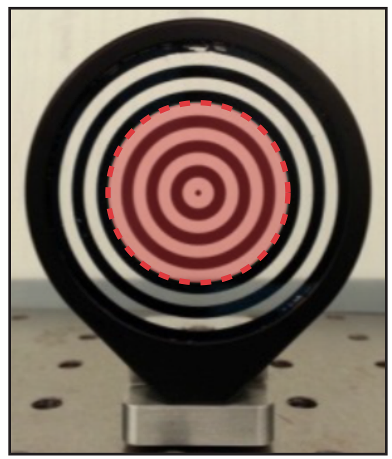
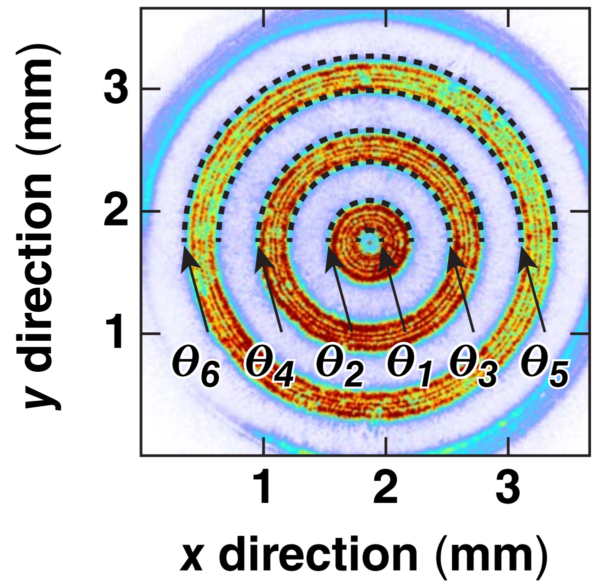


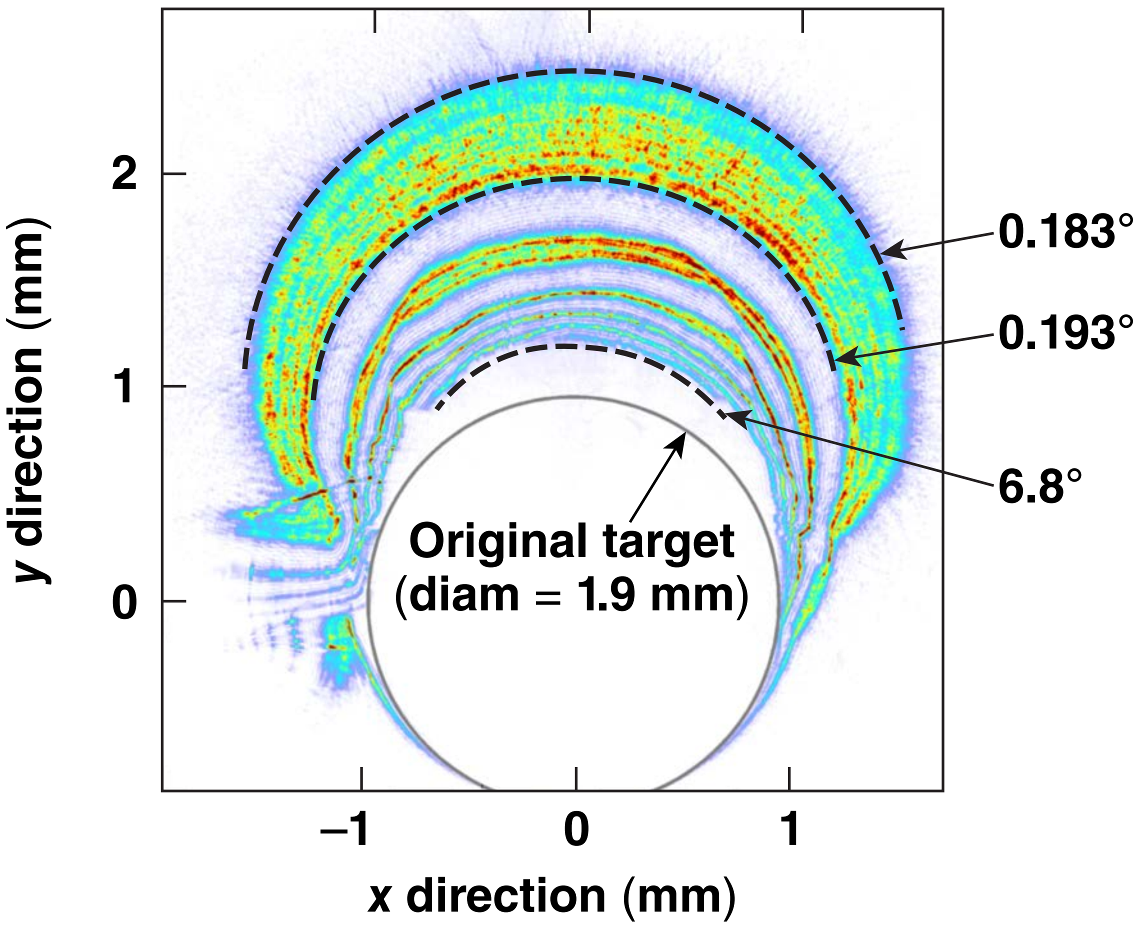
Image plane using a spherical lens



The association of these angles with the specific angular spectral filter bands can be applied to a plasma to measure its refraction profile.

The experimental AFR images are analyzed using the calibration angles

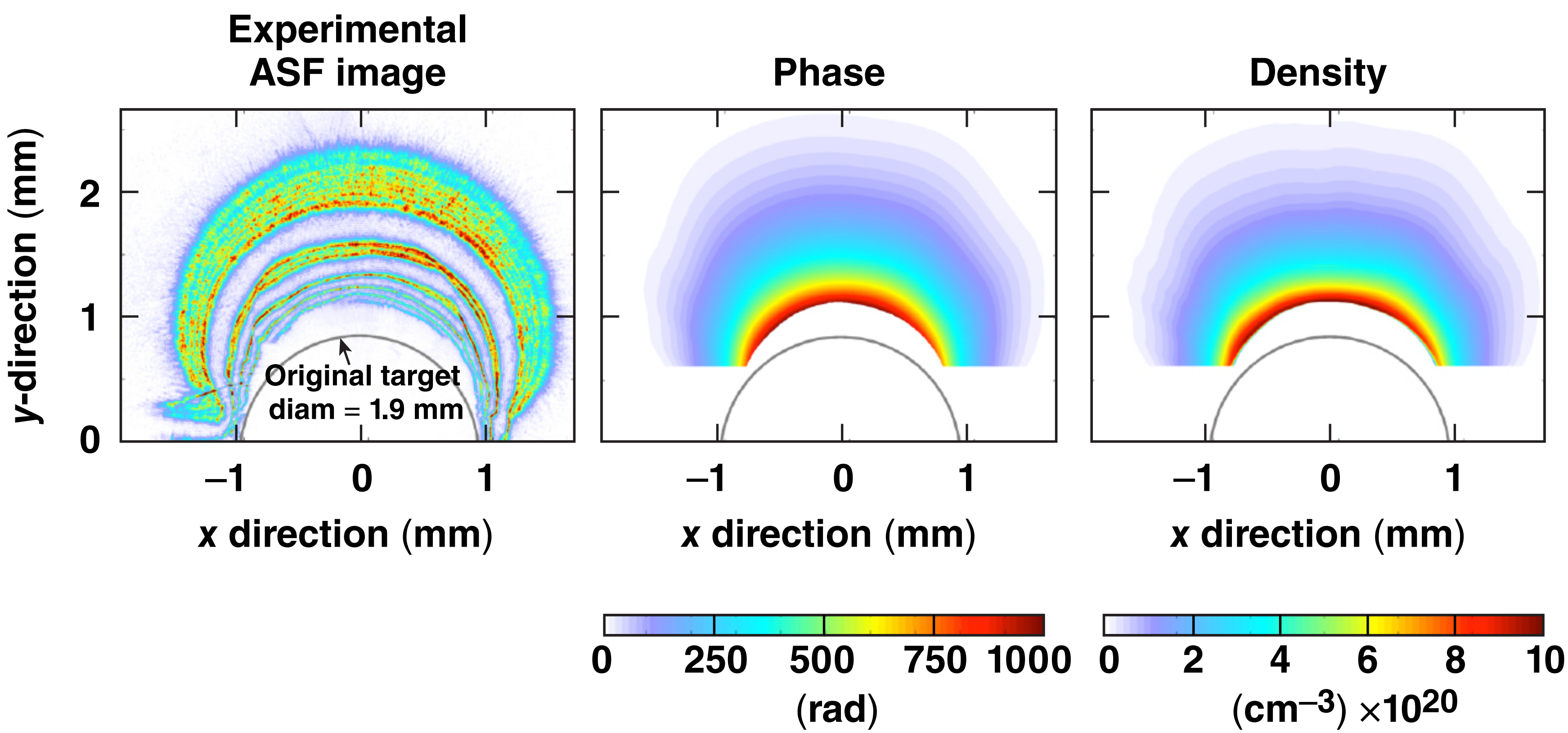
Experimental AFR image



Processing of the experimental AFR images creates a contour map of the refraction angle.

The plasma density profile can be deduced from the refractive contour map

$$\theta_r \qquad \phi = \frac{2\pi}{\lambda}\int \theta_r \, dr \qquad \phi = \frac{2\pi}{\lambda}\int_{-\infty}^{\infty}\left(\frac{n_e}{2n_{cr}}\right)d\ell$$



The 2-D density map has an error of ±15%.

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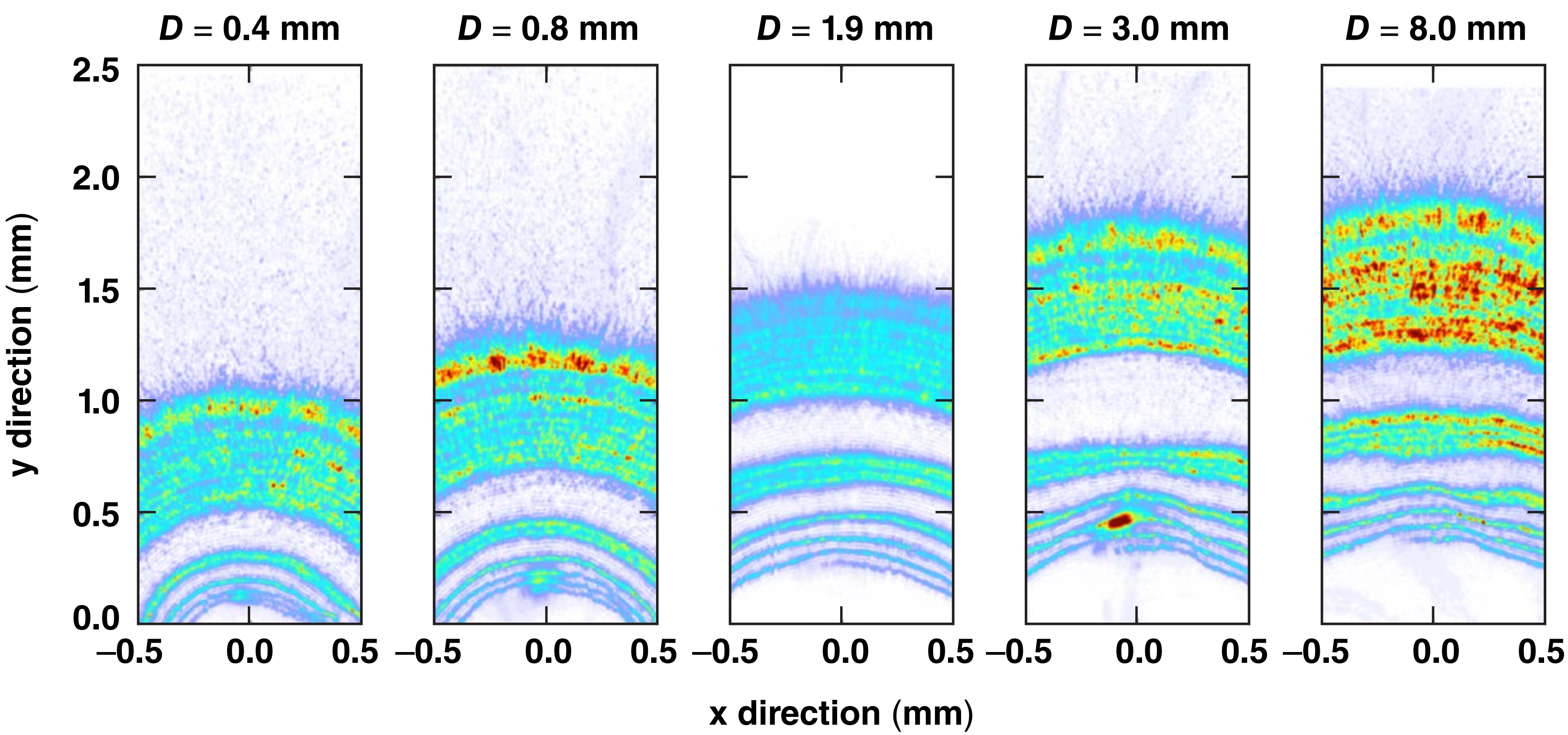
The AFR images show refractive contours moving away from the target surface as the target diameter increases

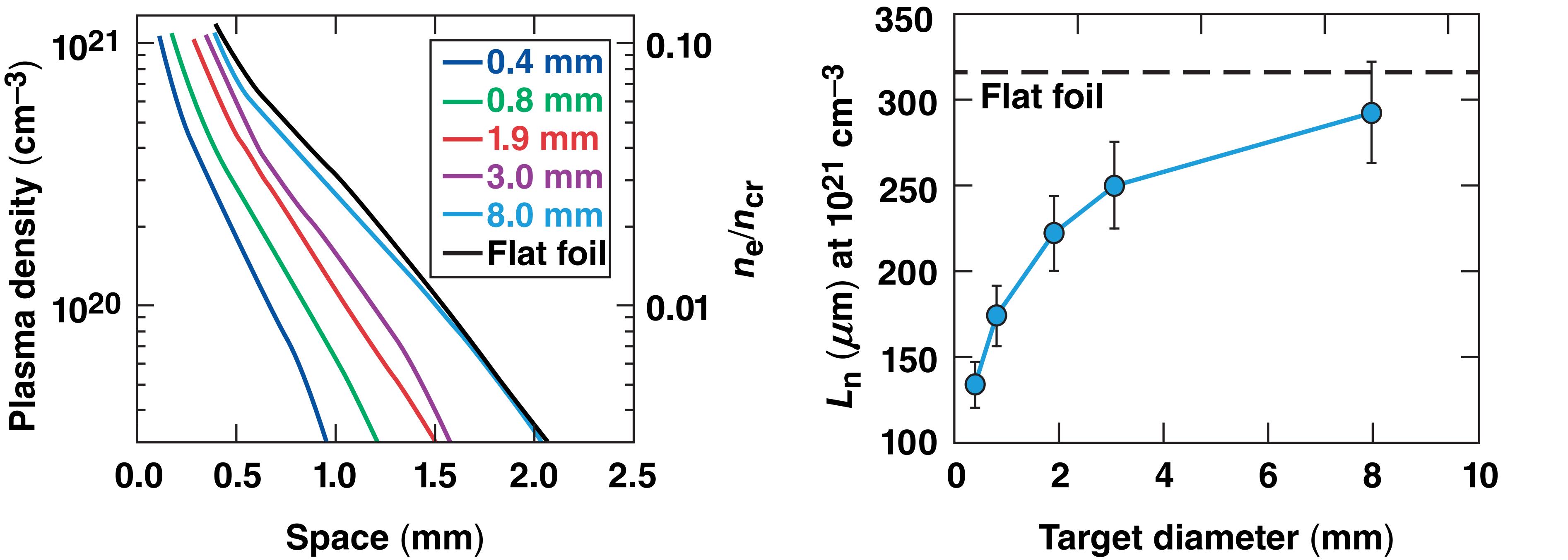
Laser: 2 ns square pulse, probe timing: 1.5 ns



E22183

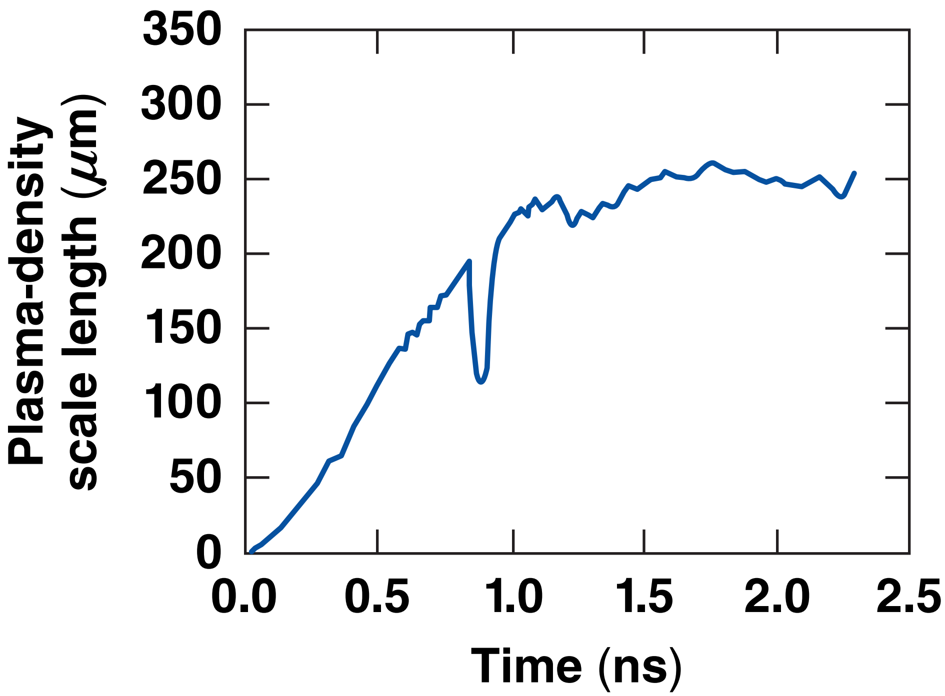
Analysis of the AFR images shows the plasma expansion is confined as the target diameter is increased

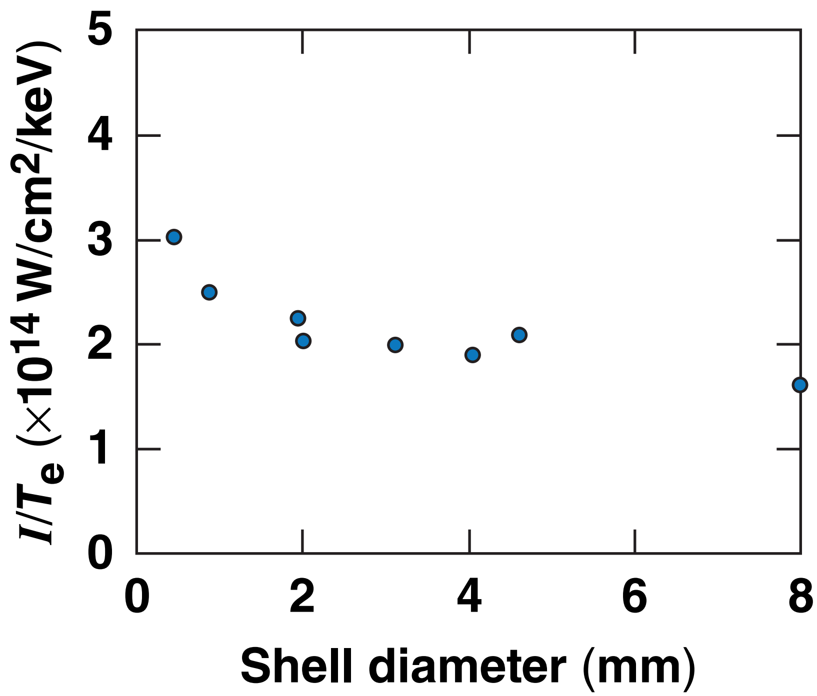
Laser: 2 ns square pulse, probe timing: 1.5 ns



E22184

Two-dimensional flux-limited ($f = 0.06$) hydrodynamic simulations show that the density scale length at $n_{cr}/4$ saturates after about 1 ns





At 1.5 ns, the I/T_e varies little over the range of targets tested.

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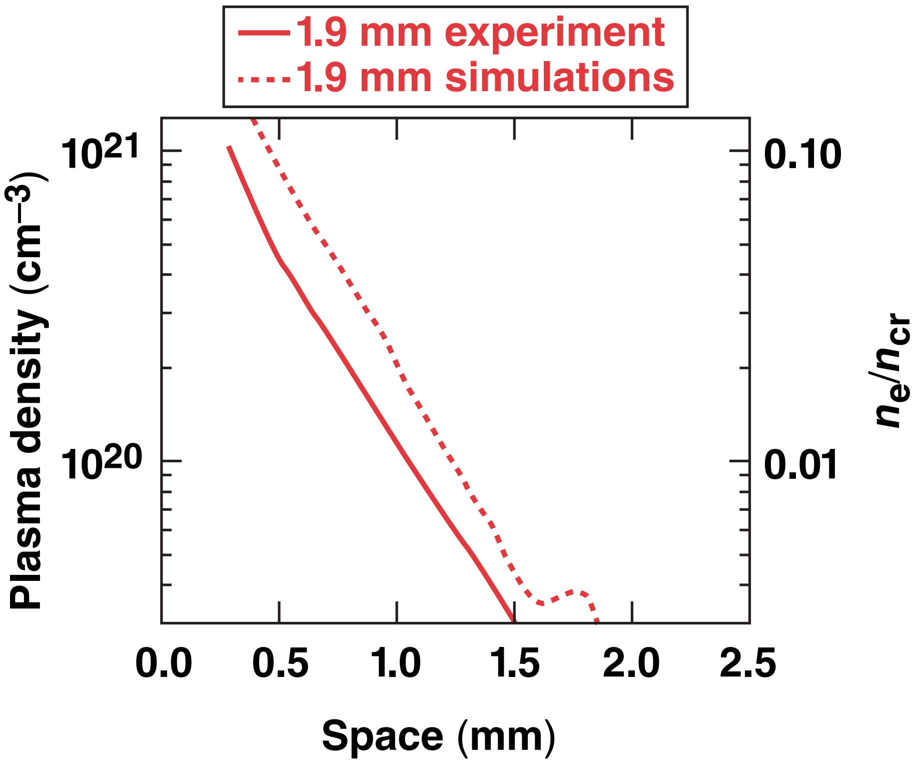
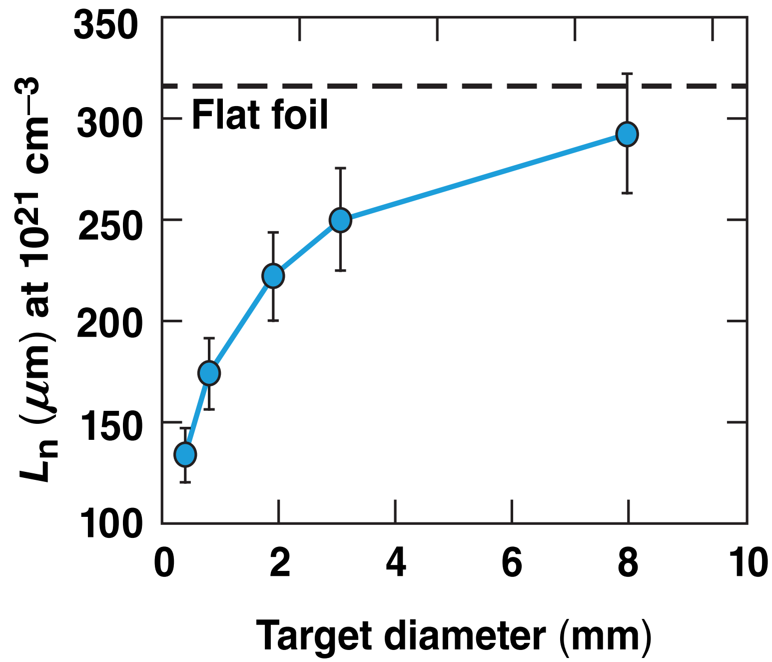
Comparisons of the experimental data to *DRACO* hydrodynamic simulations show significant differences

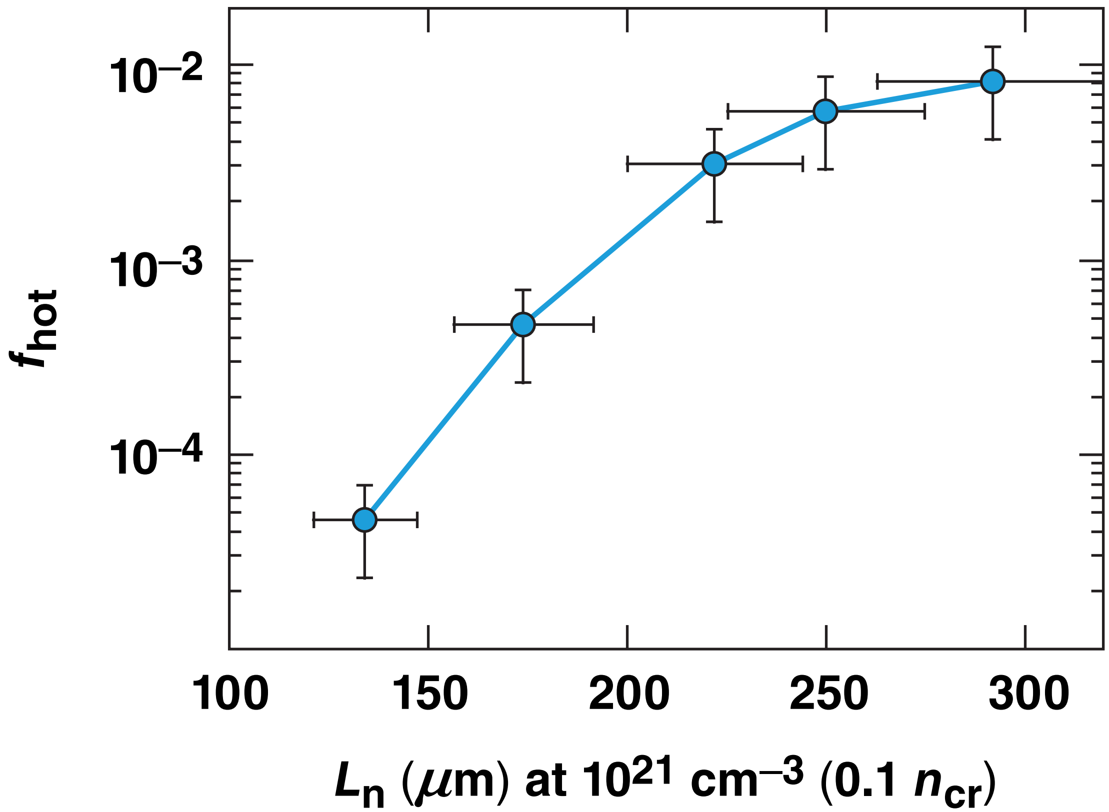




Hydrodynamic simulations overestimate the density and scale length compared to measurements at $n_{cr}/10$ at 1.5 ns.

E22228

The hot-electron fraction is measured to increase rapidly with the plasma density scale length



The fraction of hot electrons increases from ~0.005% to 1% while increasing L_n from 150 to 300 μm.

E22185

Summary/Conclusions

The dependence of two-plasmon decay (TPD) on the plasma scale length is isolated by using targets of varying radii

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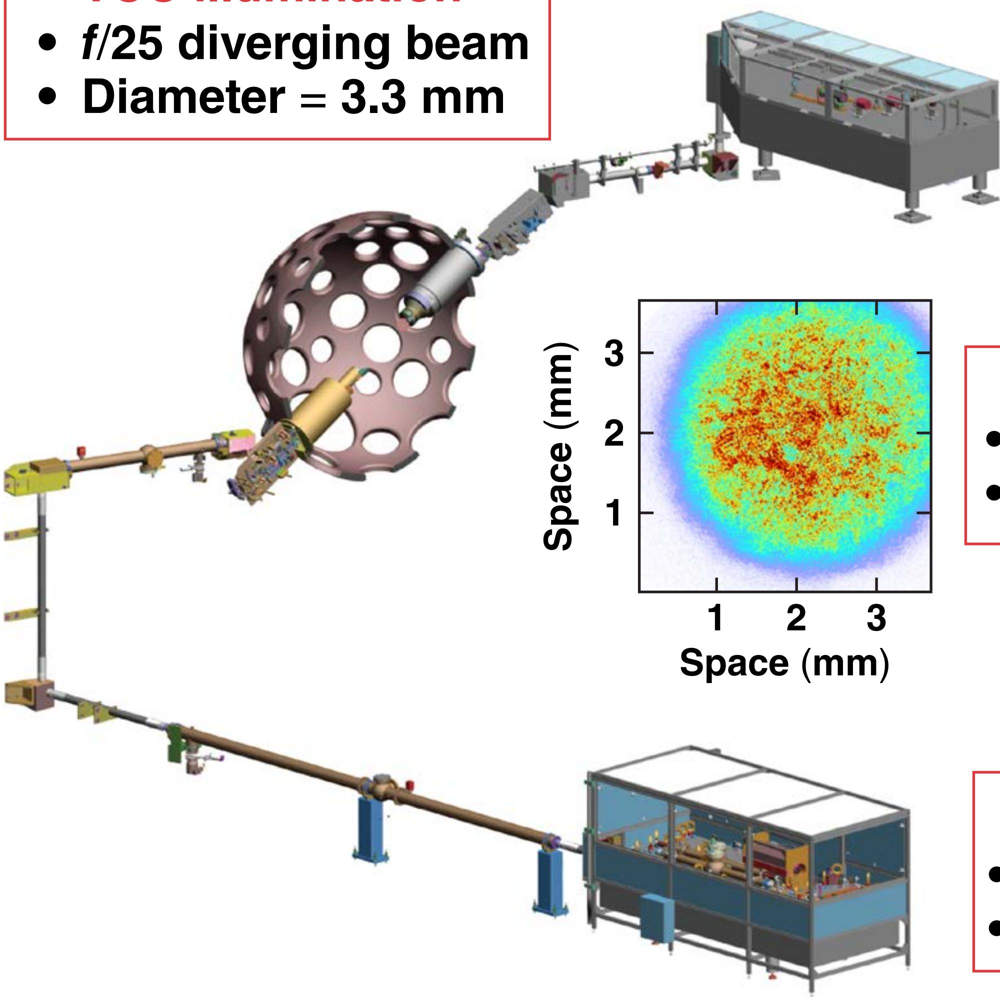
The 4ω probe laser system delivers a 3.3-mm spot to target chamber center (TCC) with picosecond timing accuracy

TCC illumination
- *f*/25 diverging beam
- Diameter = 3.3 mm

Diagnostic table
- 5-μm resolution
- 3.7 × 3.7-mm field of view



Timing
- ±25-ps accuracy
- ±5-ps post-shot measurement

Nd:glass laser
- 4ω (263 nm) ~ 20 mJ
- Pulse width = 10 ps

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