Shock-Wave Acceleration of Ions on OMEGA EP

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Summary

Tailored plasma profiles suitable for shock-wave acceleration (SWA) on OMEGA EP have been produced and characterized

- SWA experiments at the University of California, Los Angeles (UCLA)
  - use a 10-μm laser in a H_2 gas jet
  - produce 20-MeV protons with narrow energy spreads
  - have a normalized vector potential of $a_0 < 2.5$
- Plasma profiles with a sharp rise to a near-critical peak density and a long exponential decay are key to successful SWA
- SWA plasma profiles have been produced on OMEGA EP using the thermal emission from an Au-driven target to irradiate 2-μm CH foils

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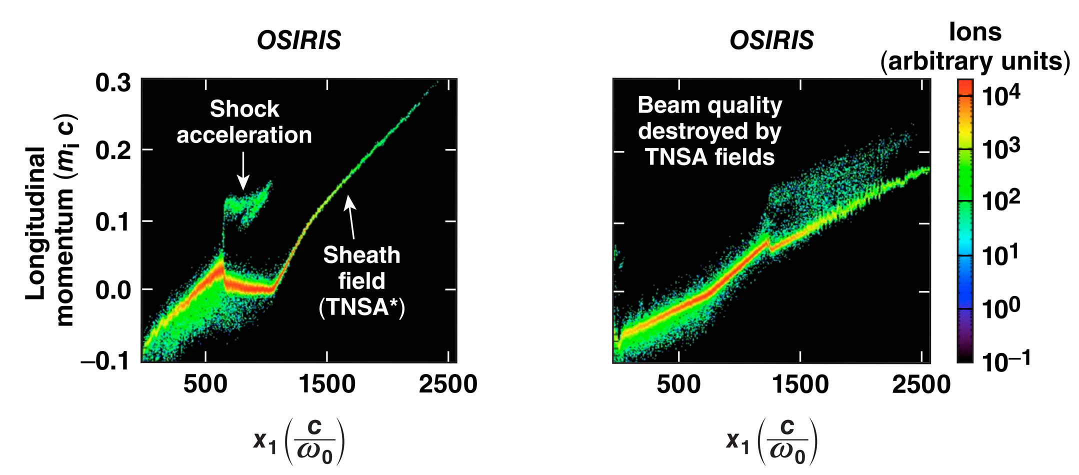
The plasma density profile strongly affects the spectrum of the accelerated ions



Sheath fields that exist at the sharp plasma–vacuum boundary can smear the energy spread of accelerated ions.

*TNSA: target normal-sheath acceleration

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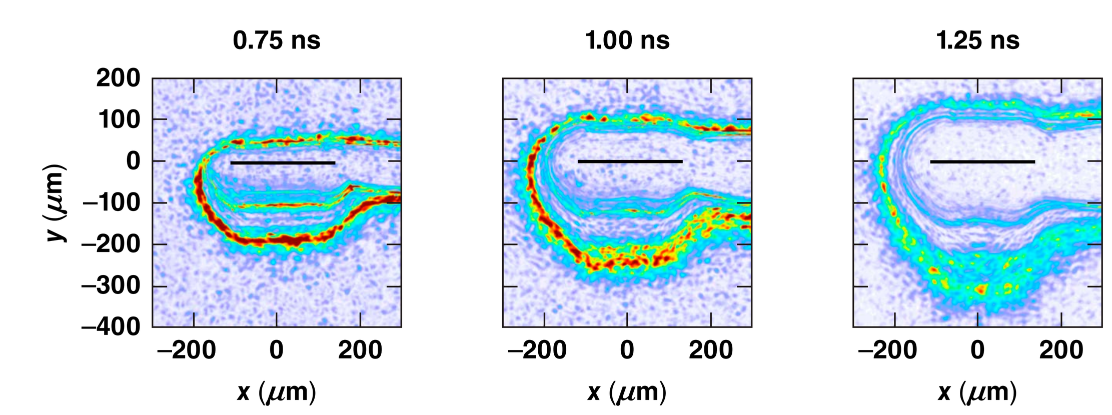
Optical probing shows clear evidence of an asymmetric expansion of the 2-μm CH foil target

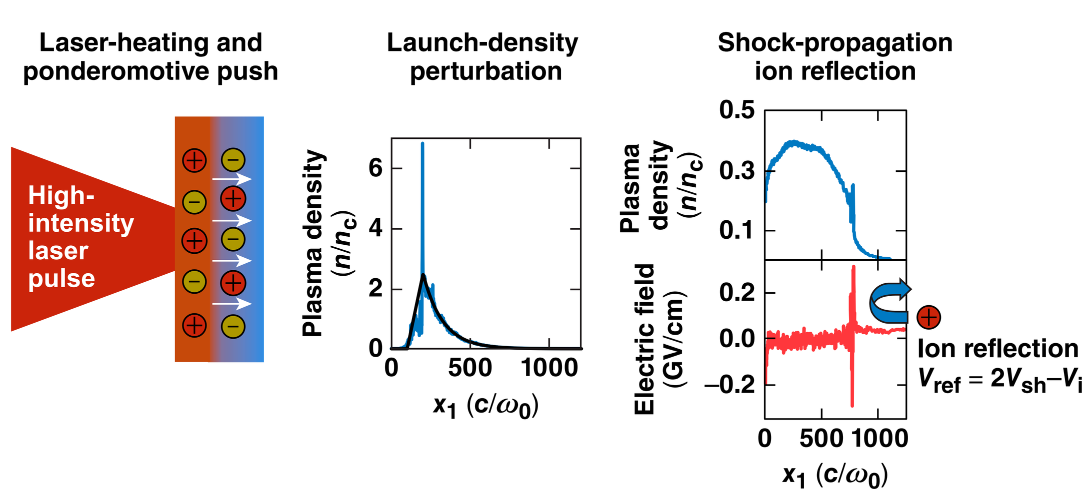
- Angular filter refractometry (AFR)* measures the refraction of a probe beam passing through a plasma



*D. Haberberger *et al.*, Phys. Plasmas 21, 056304 (2014).

E24650a

Lasers incident on overcritical plasmas can create conditions for shock-wave generation



*F. Fiuza *et al.*, Phys. Rev. Lett. 109, 215001 (2012).

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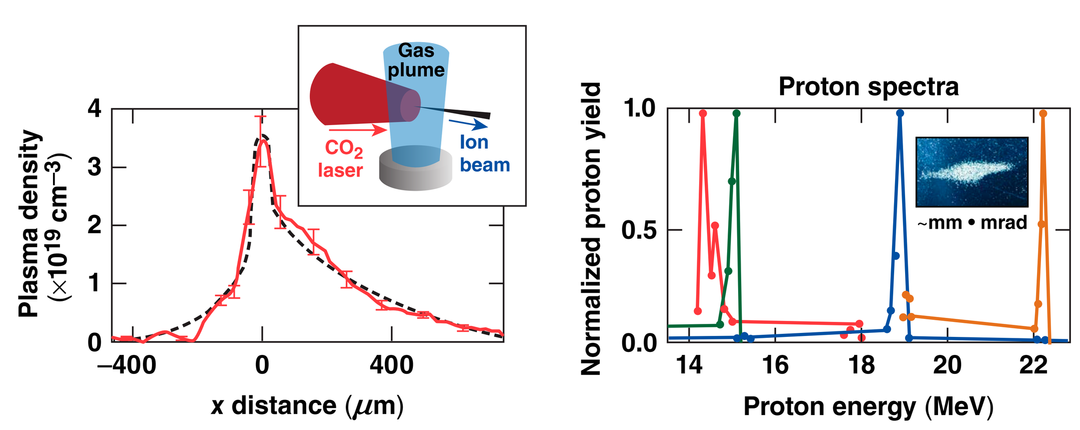
A sharp rise to overcritical densities with a longer exponential tail can be created with a gas jet for 10-μm light



CO_2 systems are limited in peak power as compared to 1-μm lasers.

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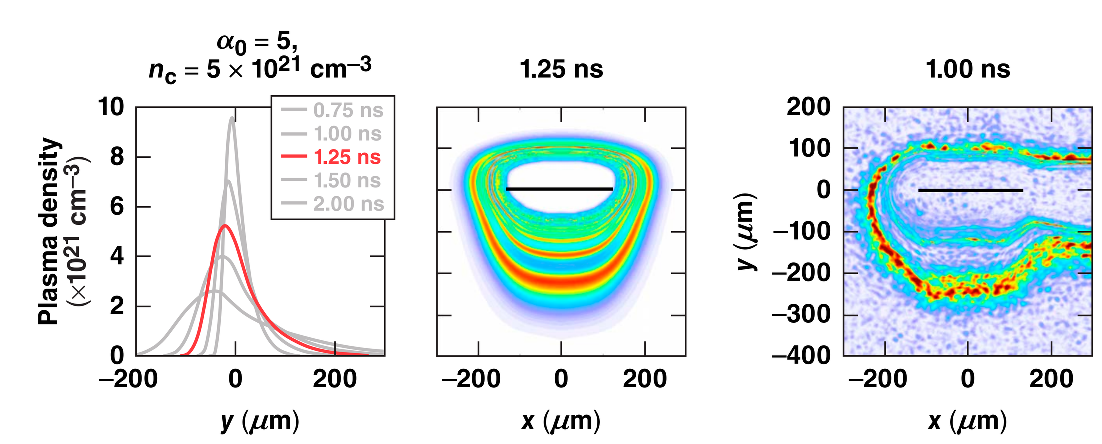
A comparison between the experimental AFR images and simulated AFR images using the hydrodynamic profiles shows an optimal peak density at ~1 ns



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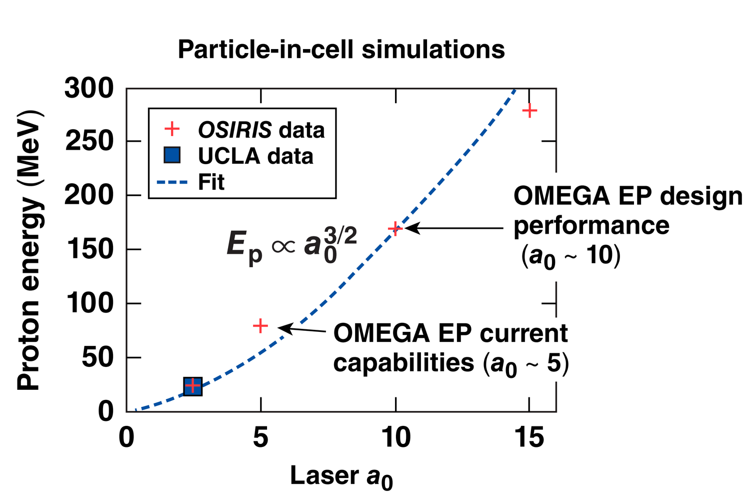
Simulations predict strong scaling of the SWA mechanism with laser intensity



Scaling the SWA mechanism to the 1-μm OMEGA EP Laser System allows for the production of narrow-energy-spread ion beams in the 80- to 150-MeV/amu range.

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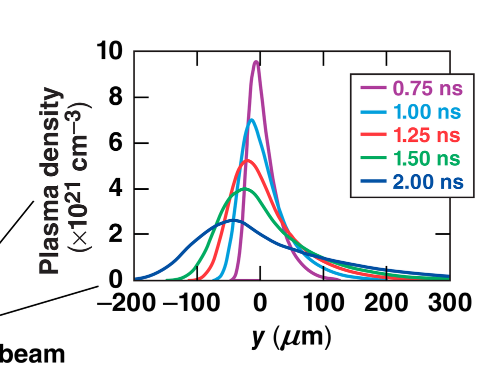
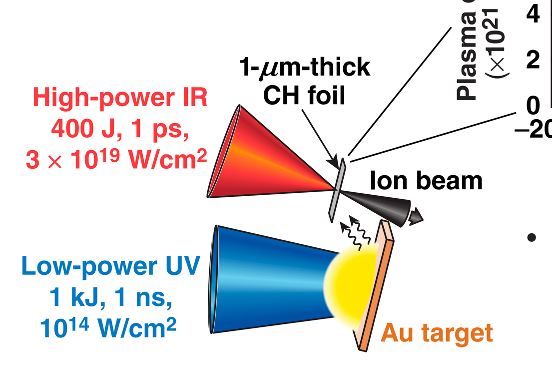
Scaling SWA to the 1-μm-wavelength range requires a tailored high-density profile





- 2-D *HYDRA* simulations
  - UV absorption in Au (~90%)
  - plasma thermal emission (175 eV)*
  - absorption in 2-μm CH foil (C K-shell)
  - hydrodynamic expansion

*Static pinhole camera array with differential filters used to guide blackbody temperature

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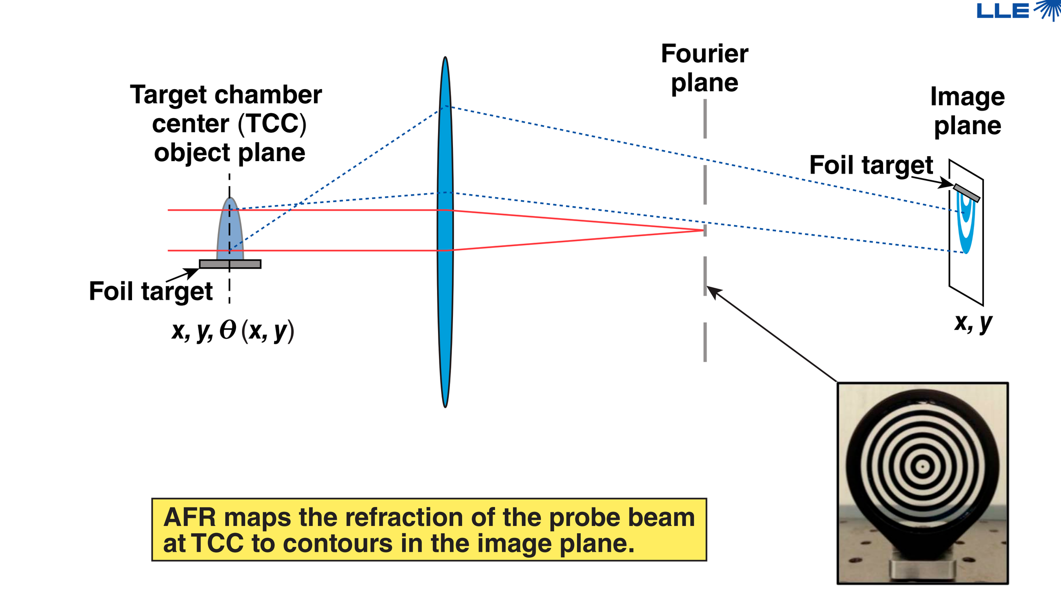
In the presence of a plasma, certain angle ranges of the refracted light pass through the filter and form bands in the image plane



AFR maps the refraction of the probe beam at TCC to contours in the image plane.

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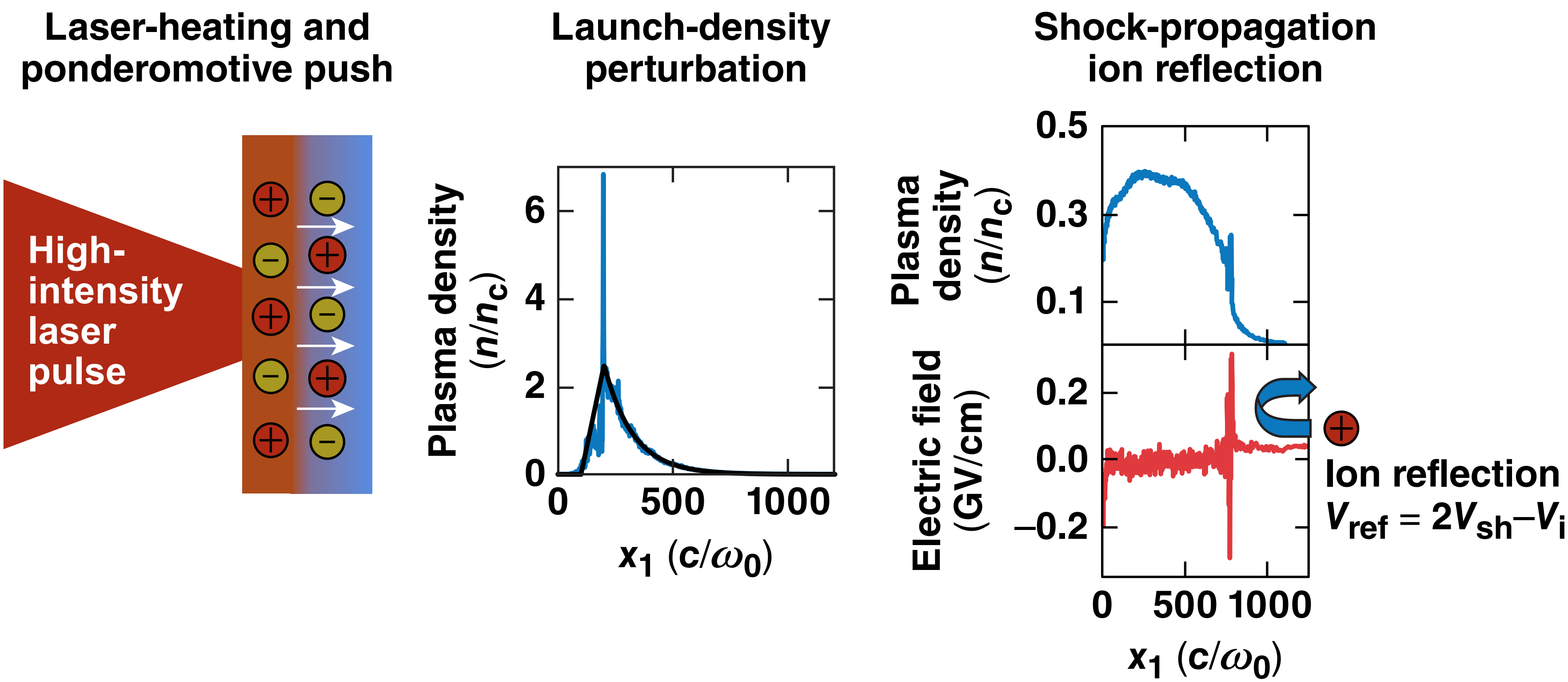

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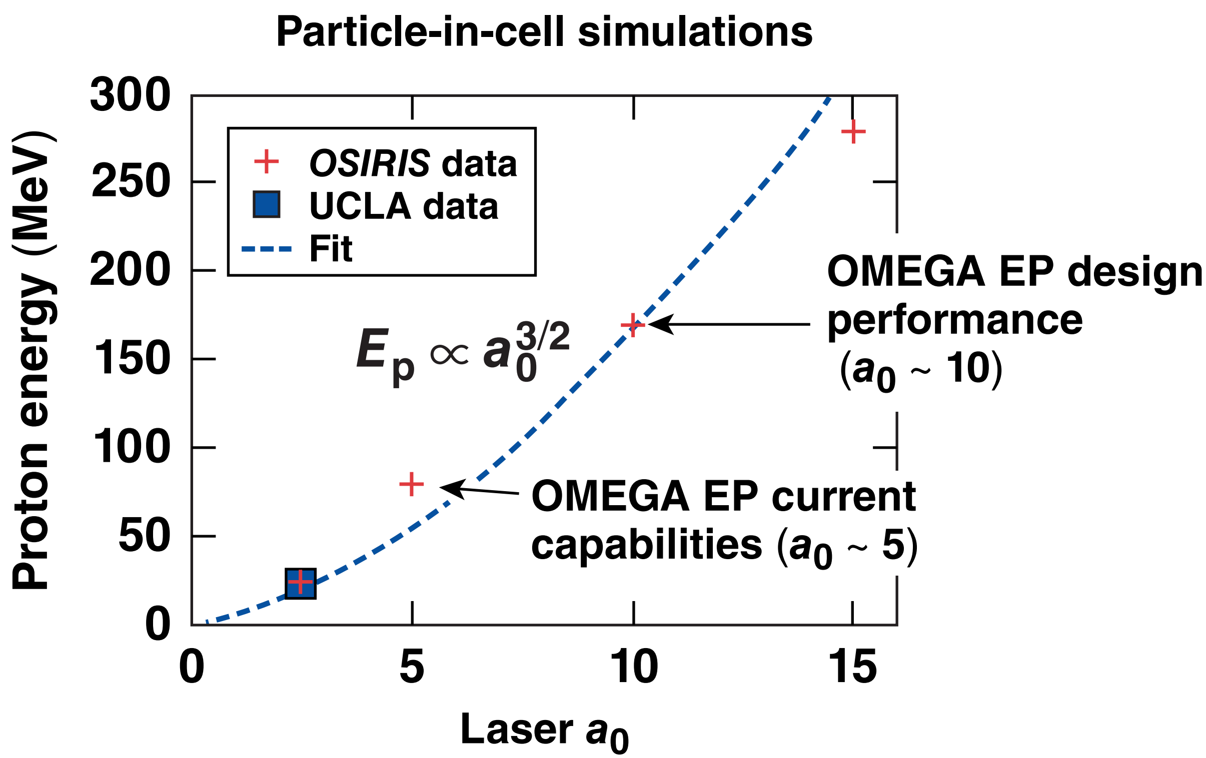

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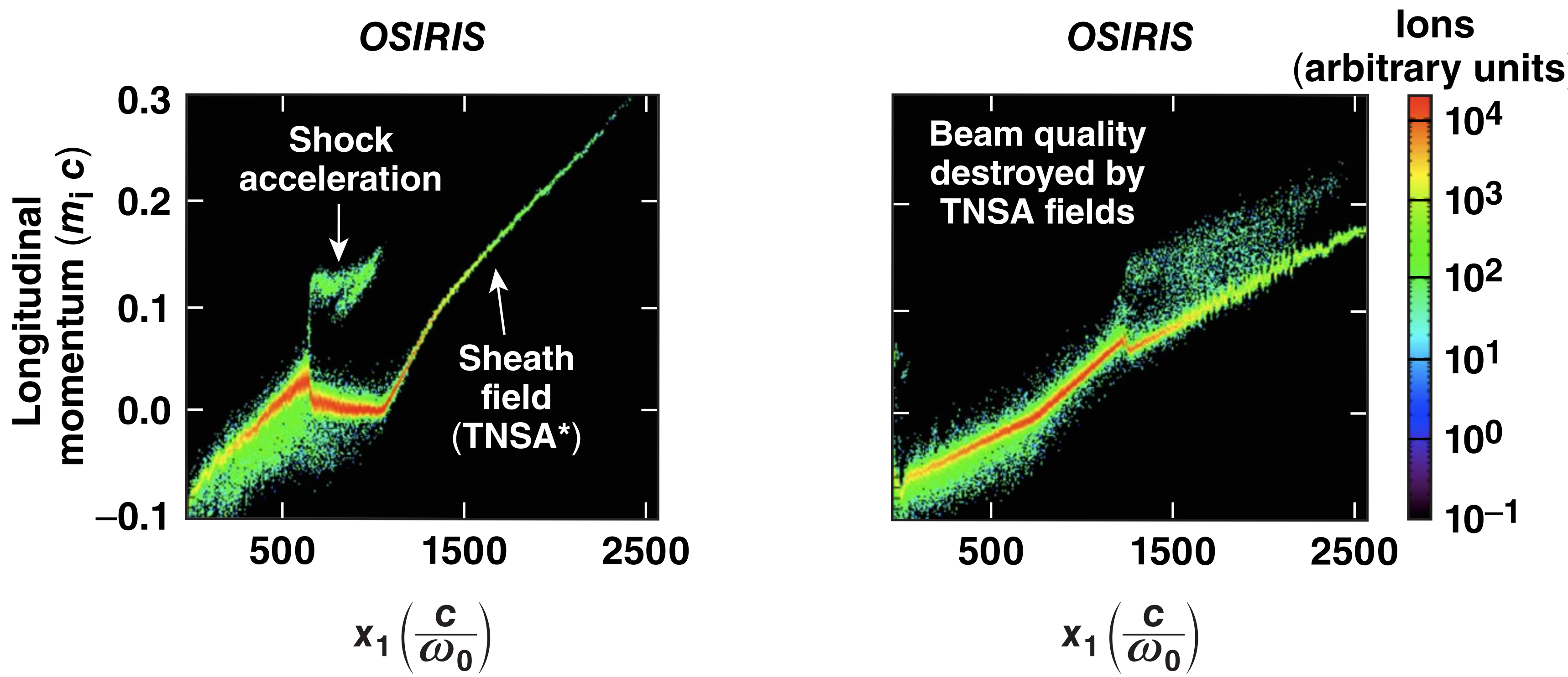

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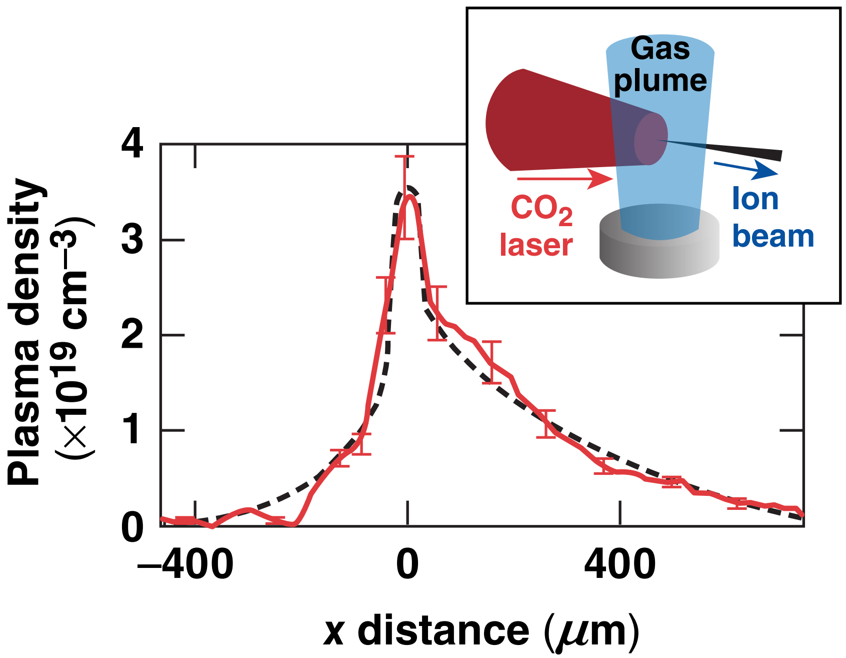

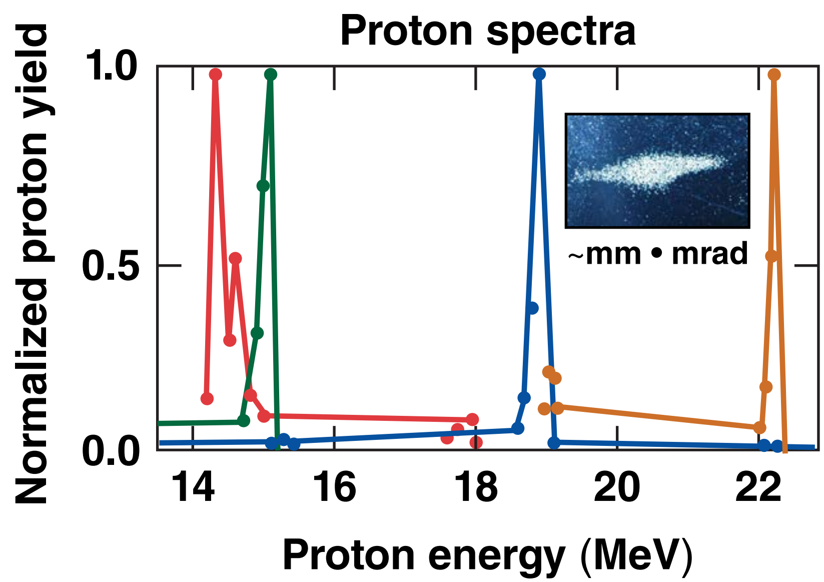

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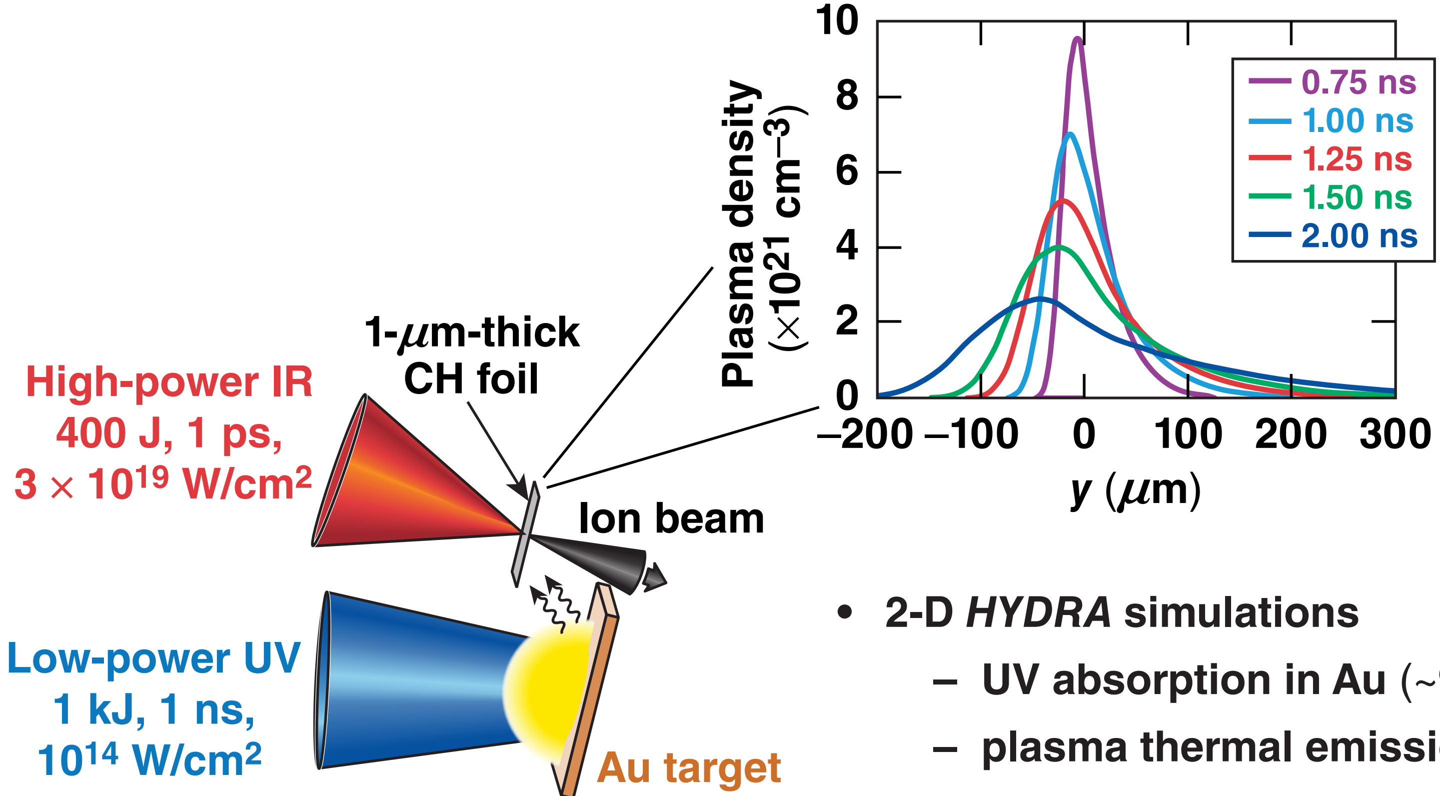

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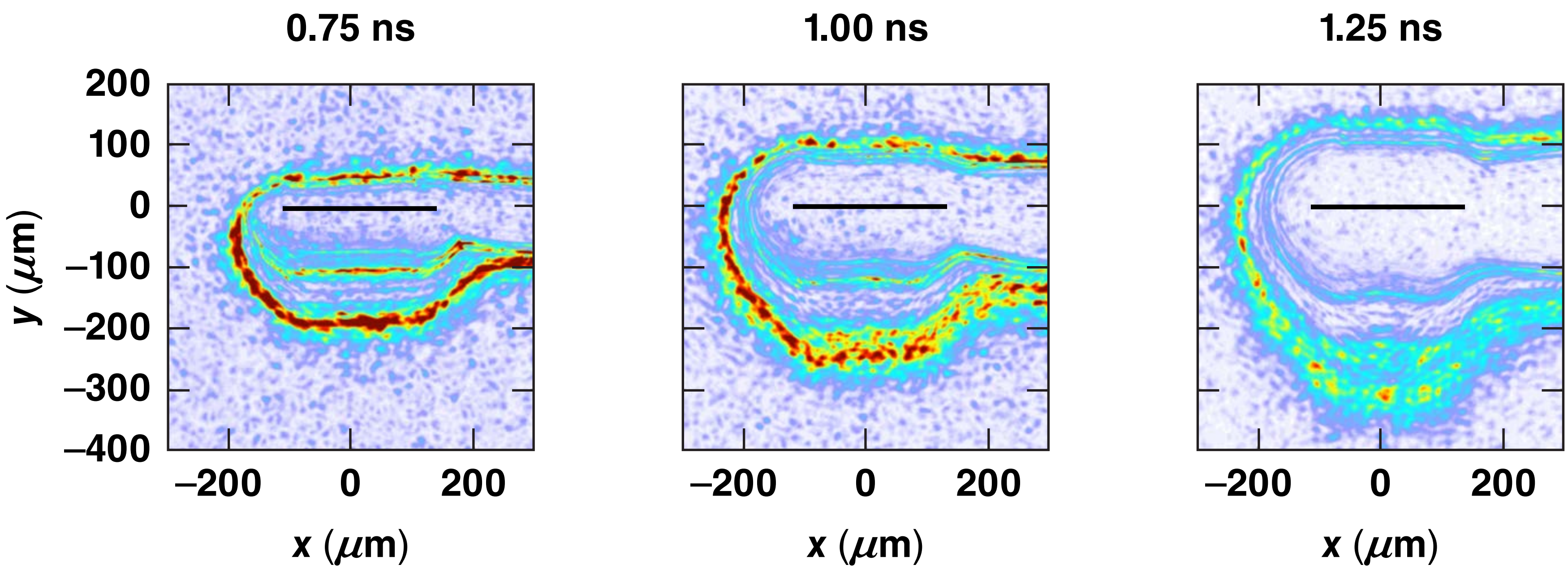

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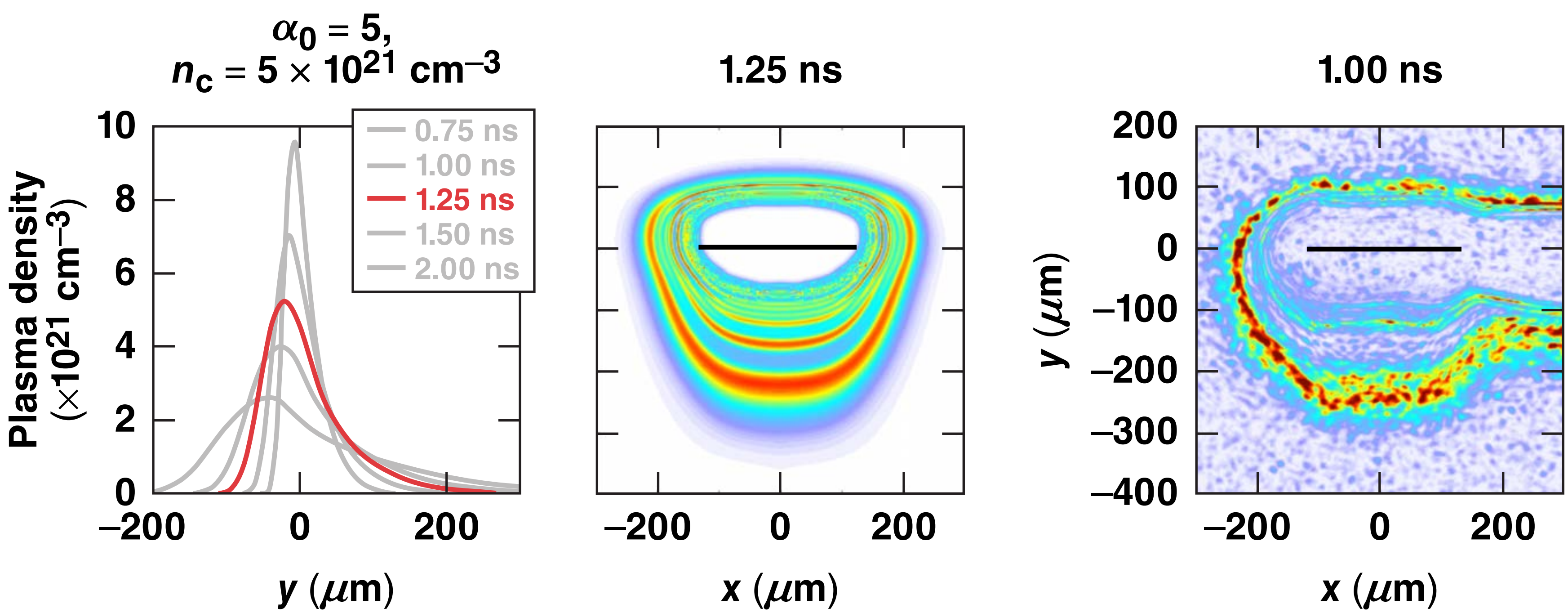

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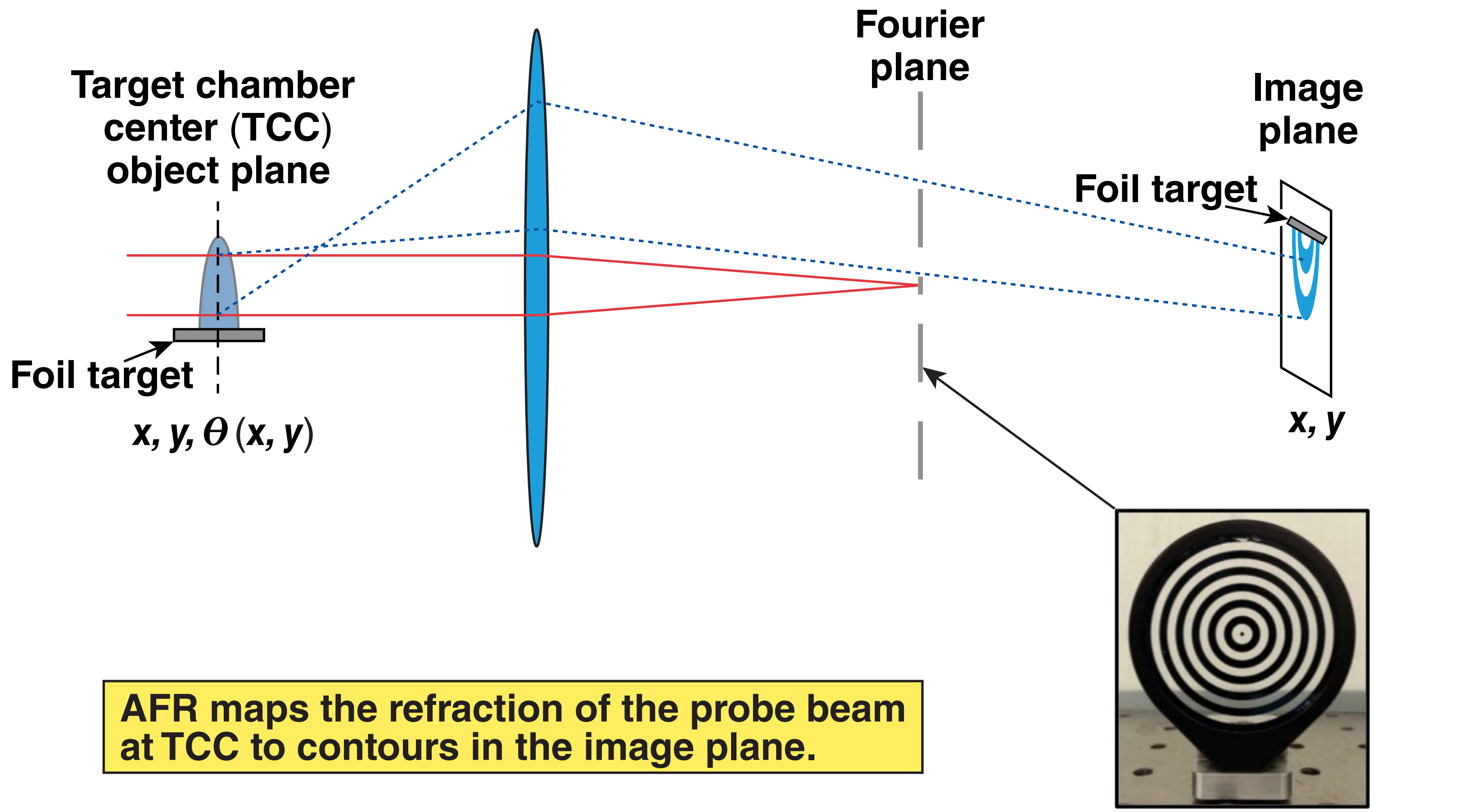

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