385. Wilhelm and Else Heraeus Seminar
‚Laser-Particle-Acceleration', 13 Feb. 2007

Ionization front propagation in gaseous targets induced by sub-ten femtosecond laser pulses

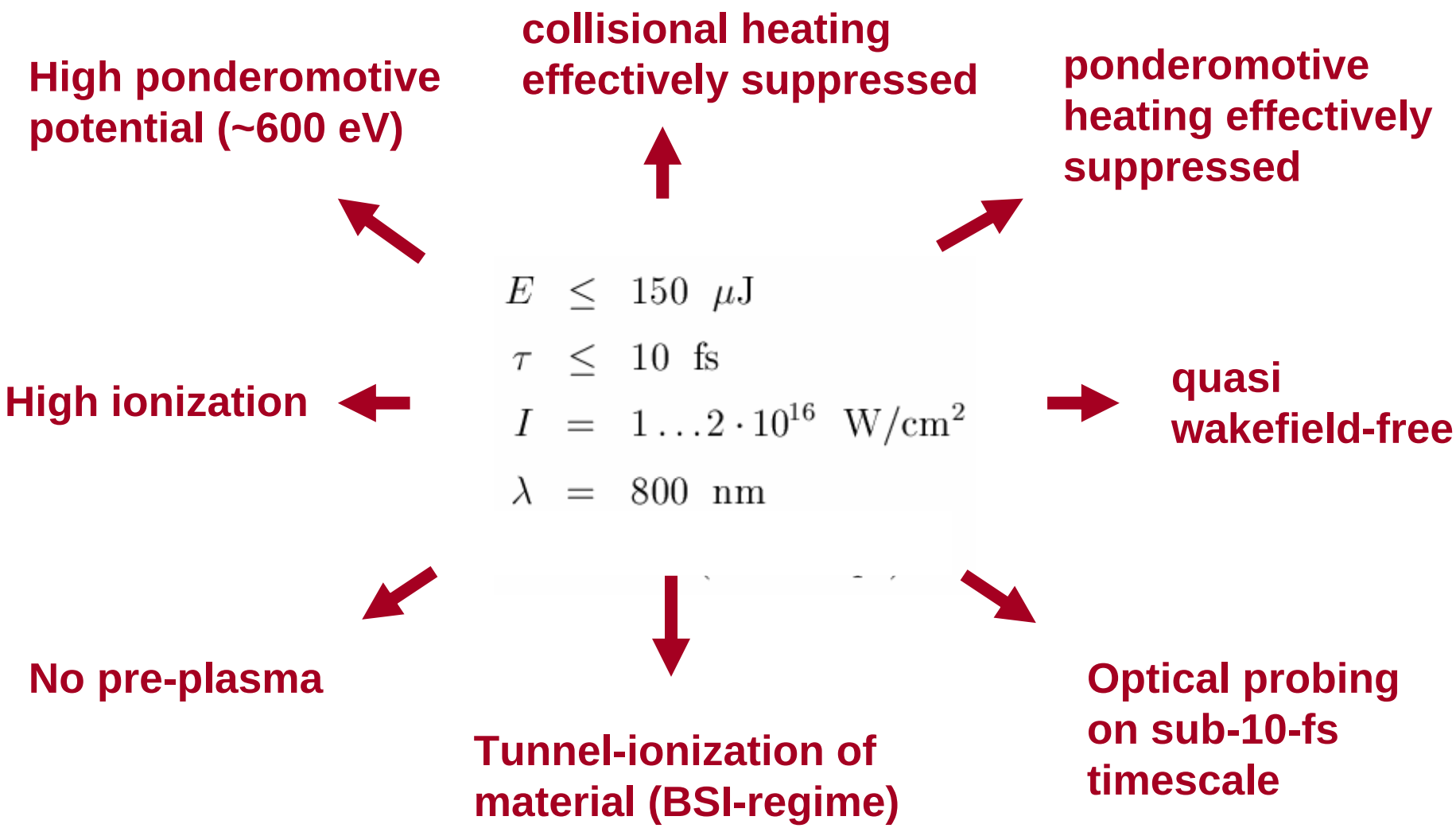
Ralph Jung, Monika Omieczynski, Toma Toncian,
Thomas Fischer, Andreas Kemp, Hartmut Ruhl, Oswald Willi

Institute for Laser and Plasma Physics
Heinrich-Heine-University Düsseldorf

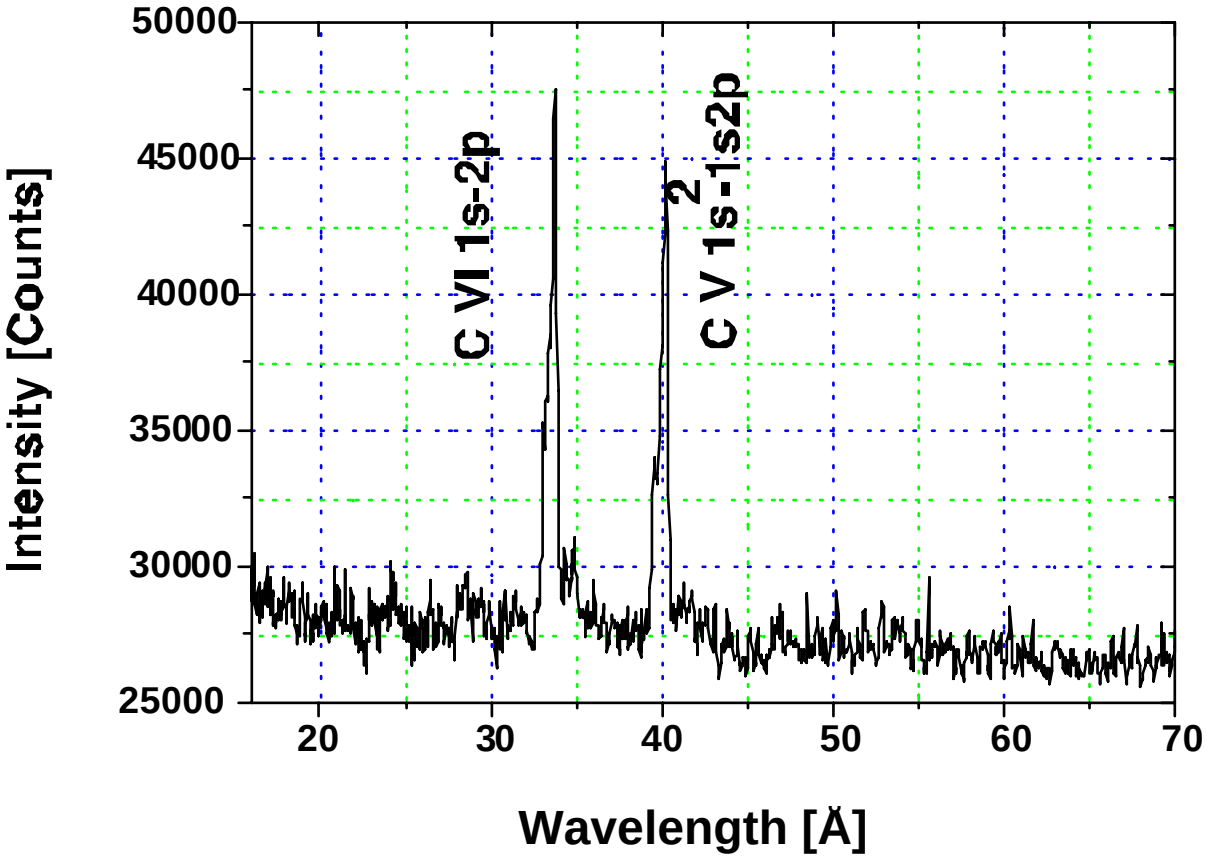
Summary

- A high-intensity (10^{16} W/cm^2), ultra-short (sub-10-fs) laser pulse was focused onto the edge of a supersonic, high-density gas jet
- The ionization front and subsequent plasma channel evolution was studied using an ultra-short optical probe beam via focused shadowgraphy
- Due to the parameter regime, pump-pulse is a delta-excitation of the medium (energy transfer and relaxation times >> τ_{laser})
- 3D-PIC simulations have been performed in order to interpret the experimental data

The laser parameters provide ideal conditions for the study of ionization dynamics in gases



Carbon spectrum on solid targets
- a close-to-solid density plasma is observed -

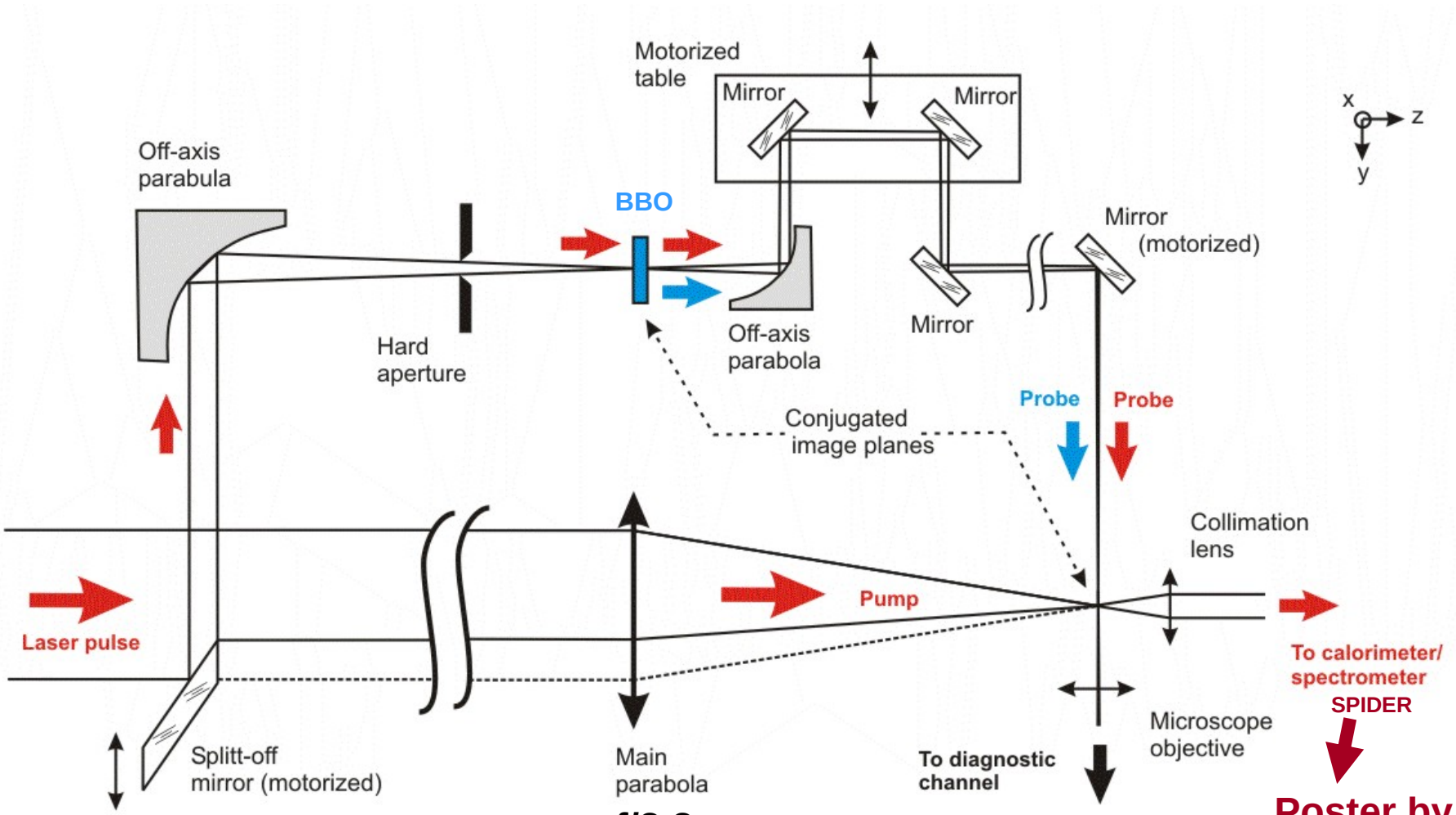


300 µJ in 8 fs

J. Osterholz *et al.*, *Phys. Rev. Lett.* **96**, 085002 (2006)

Poster by
M. Cerchez *et al.*

Generation and delay of 400 nm, ultra-short optical probe pulse



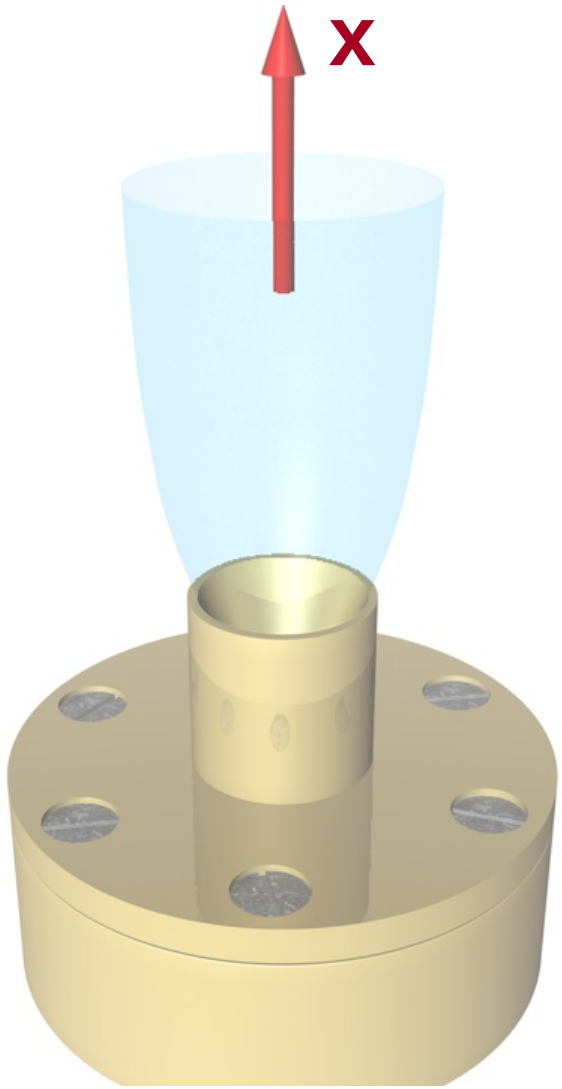
Poster by Th. Fischer

Setup of pump-probe experiment

Gases:

Helium, Neon, Argon, Nitrogen

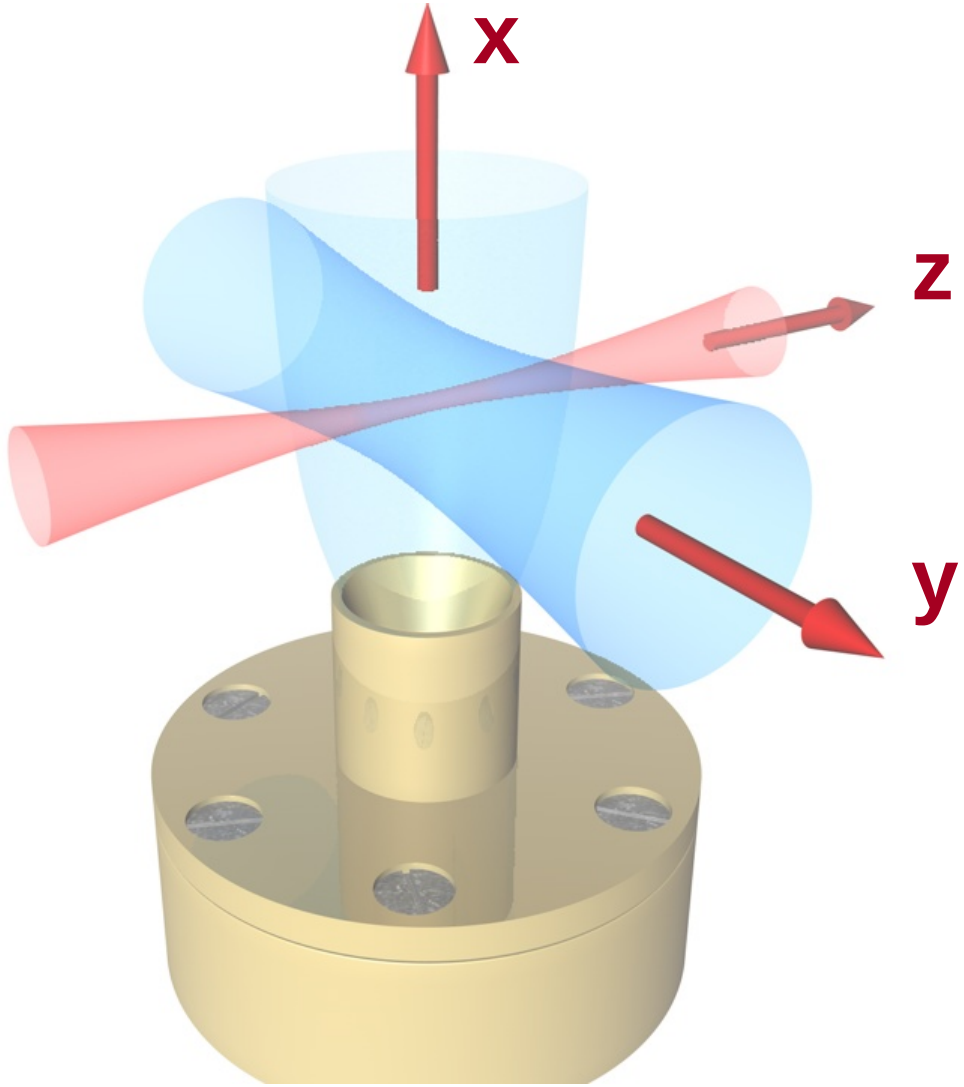
$$n_0 = 1 \cdot 10^{19} \ \ \mathrm{cm}^{-3}$$



Supersonic expansion:

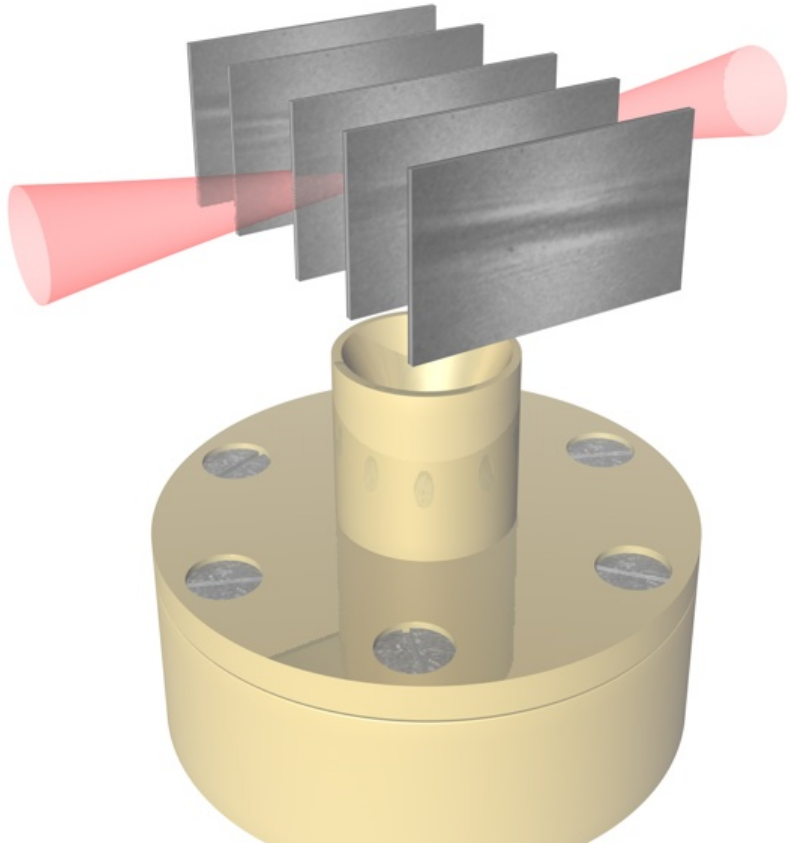
Mach 3.3, up to 50 atm. backing pressure

Setup of pump-probe experiment

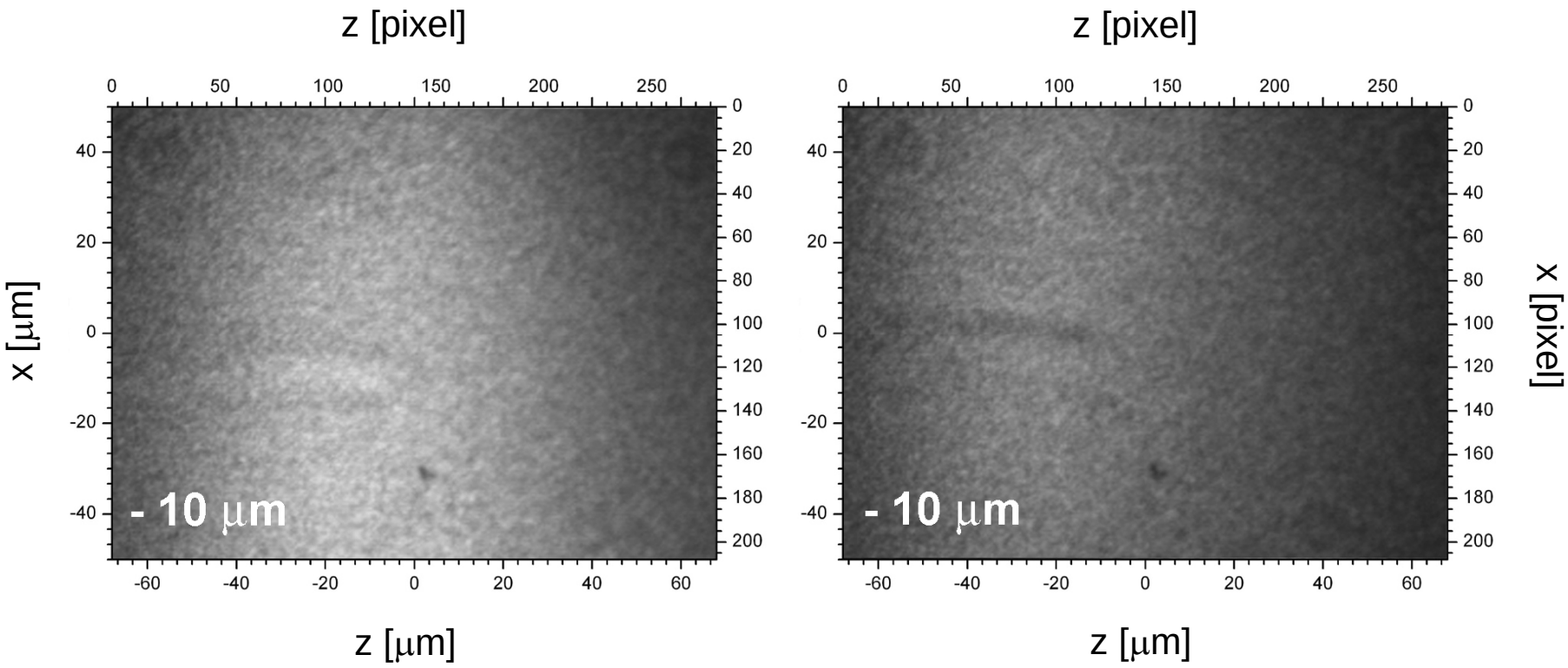


Focused shadowgraphy

$$\frac{\Delta I}{I_0} = \frac{\partial \alpha}{\partial x} \cdot \Delta y \propto \frac{\partial^2 n_e}{\partial x^2} \cdot \Delta y$$

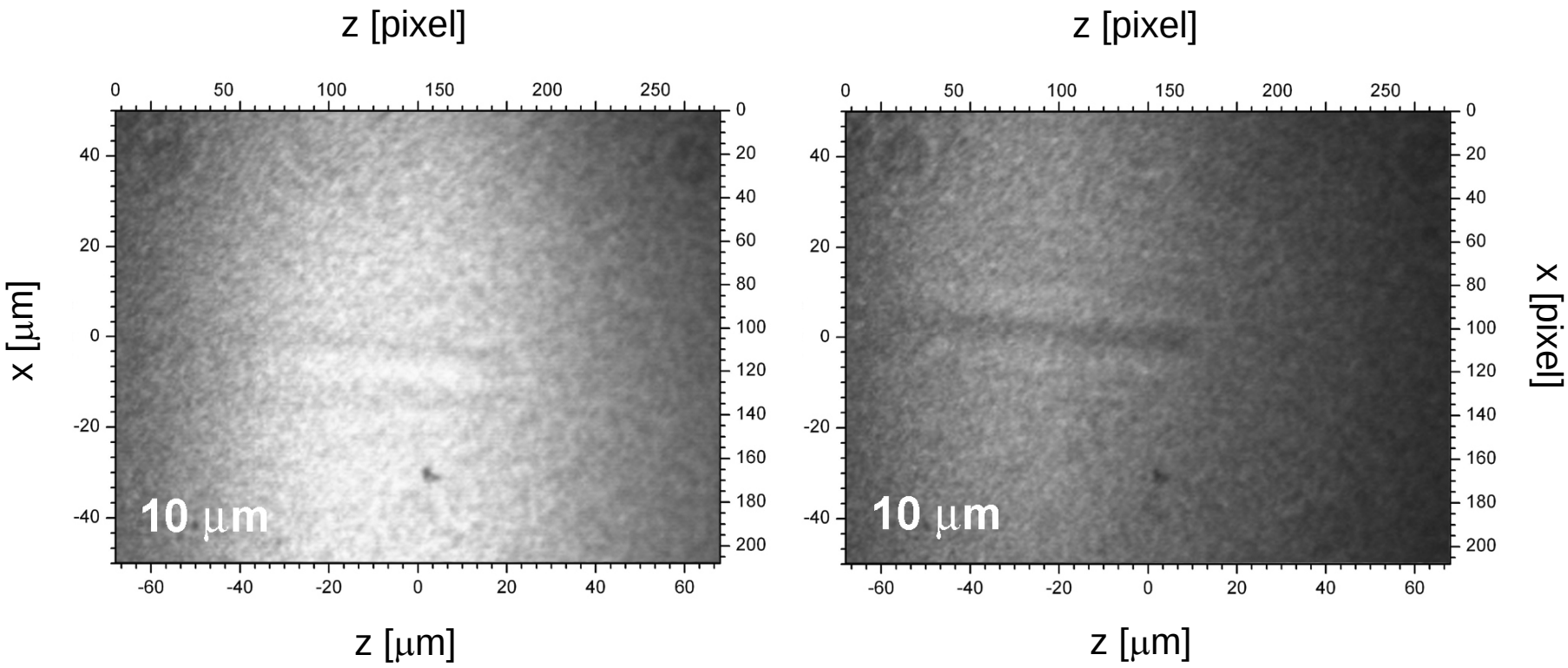


Images of ionization front obtained by focused shadowgraphy



Spatial resolution ~ 1 μm, temporal resolution ~ 10 fs

Images of ionization front obtained by focused shadowgraphy



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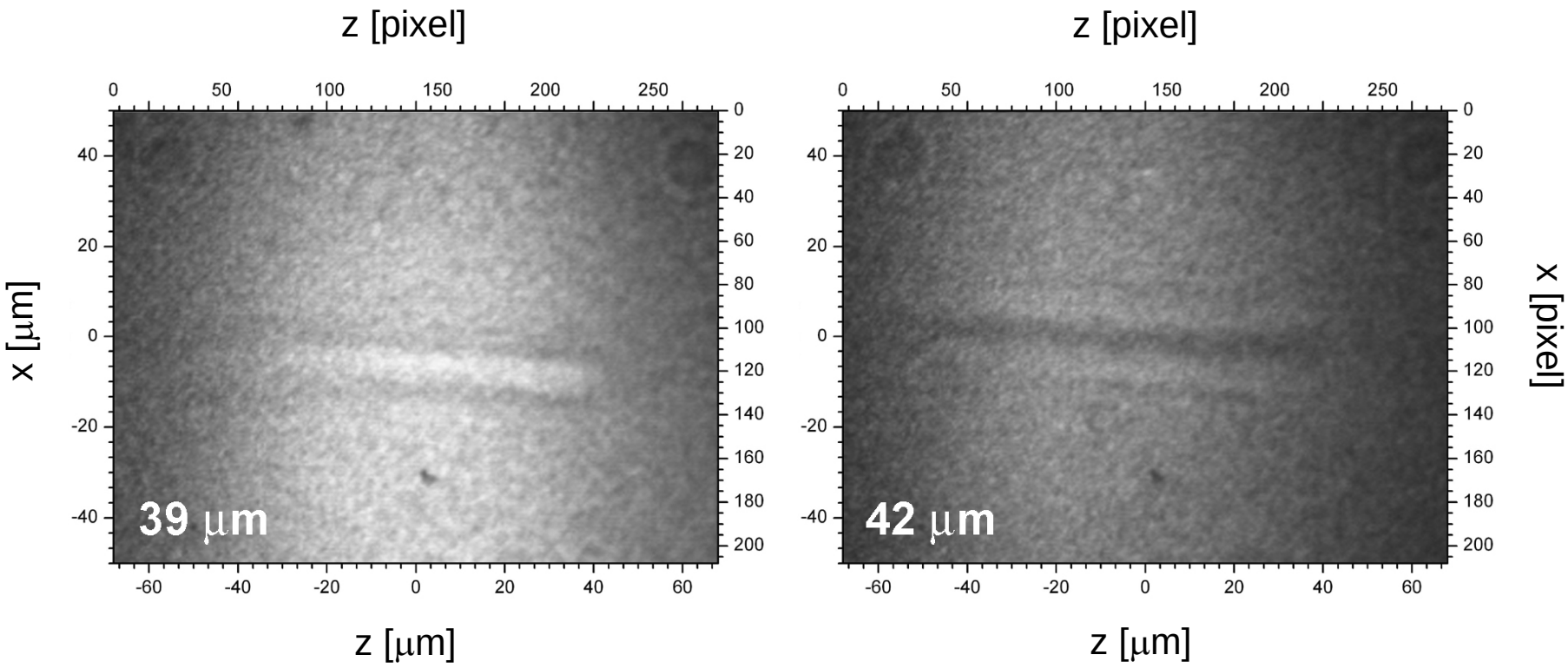

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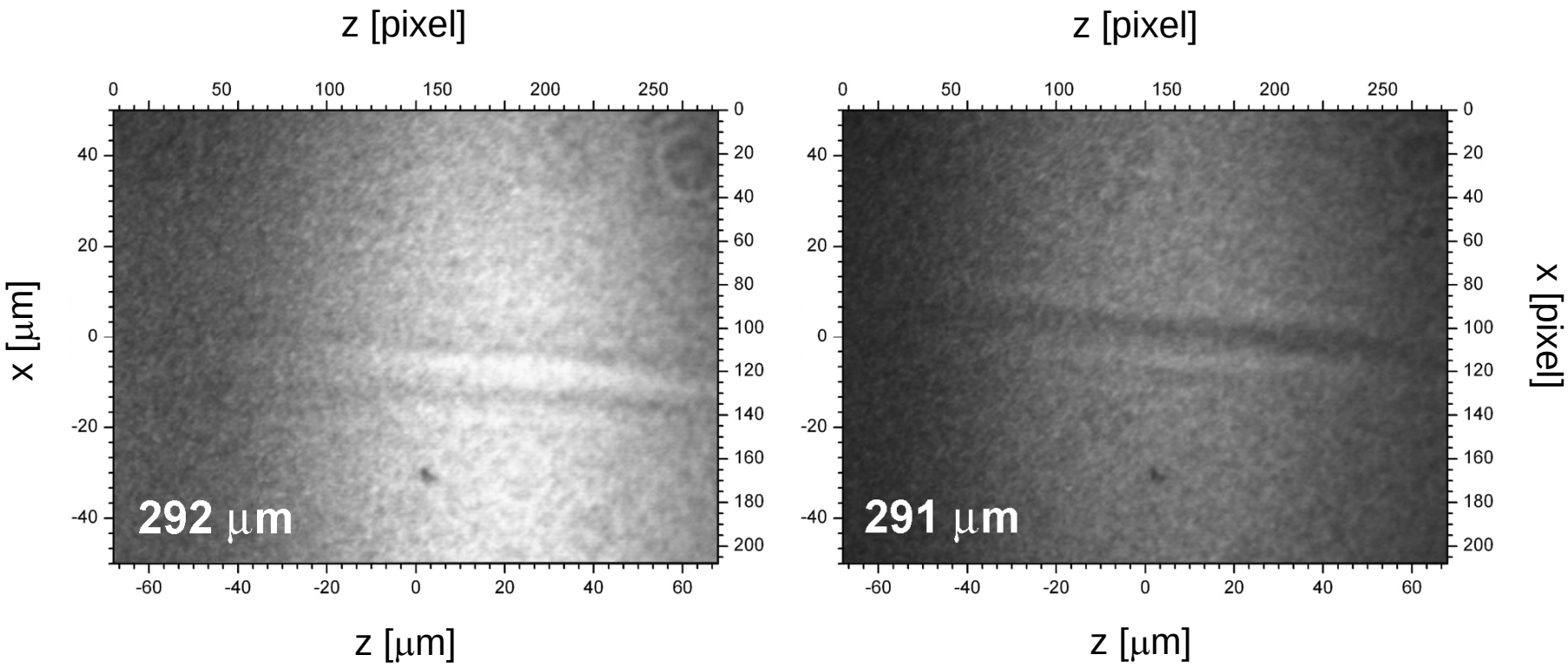

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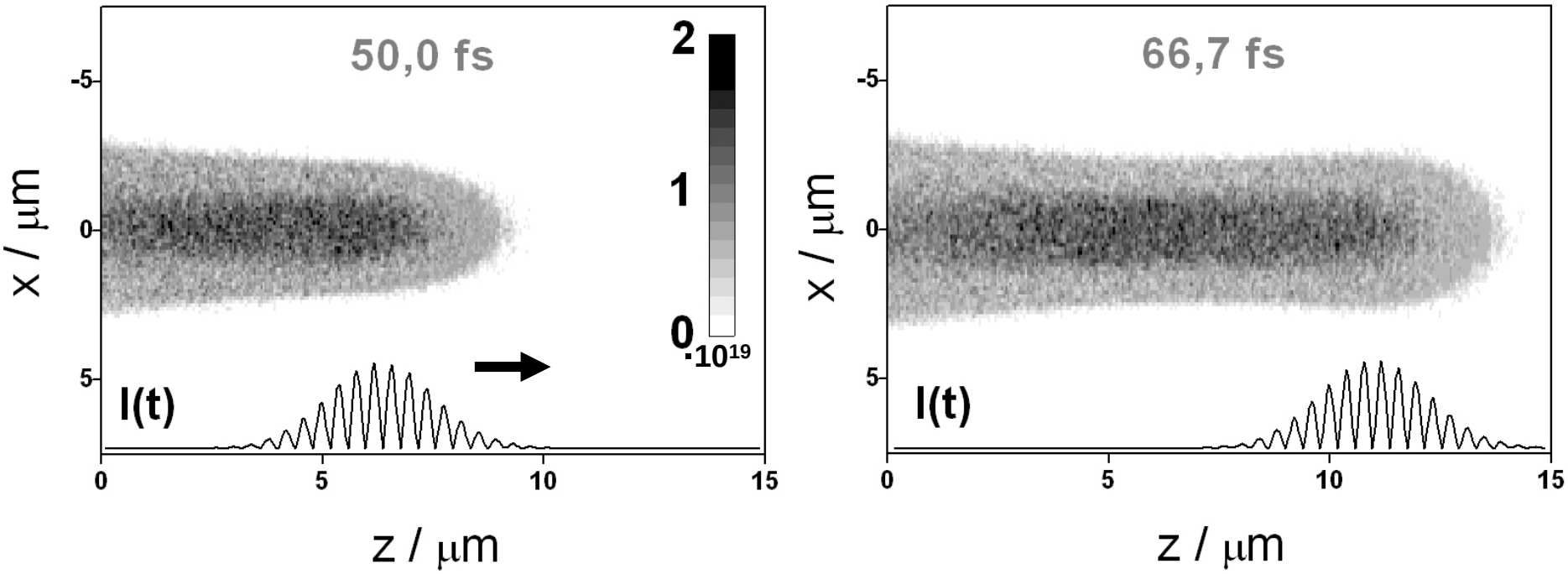
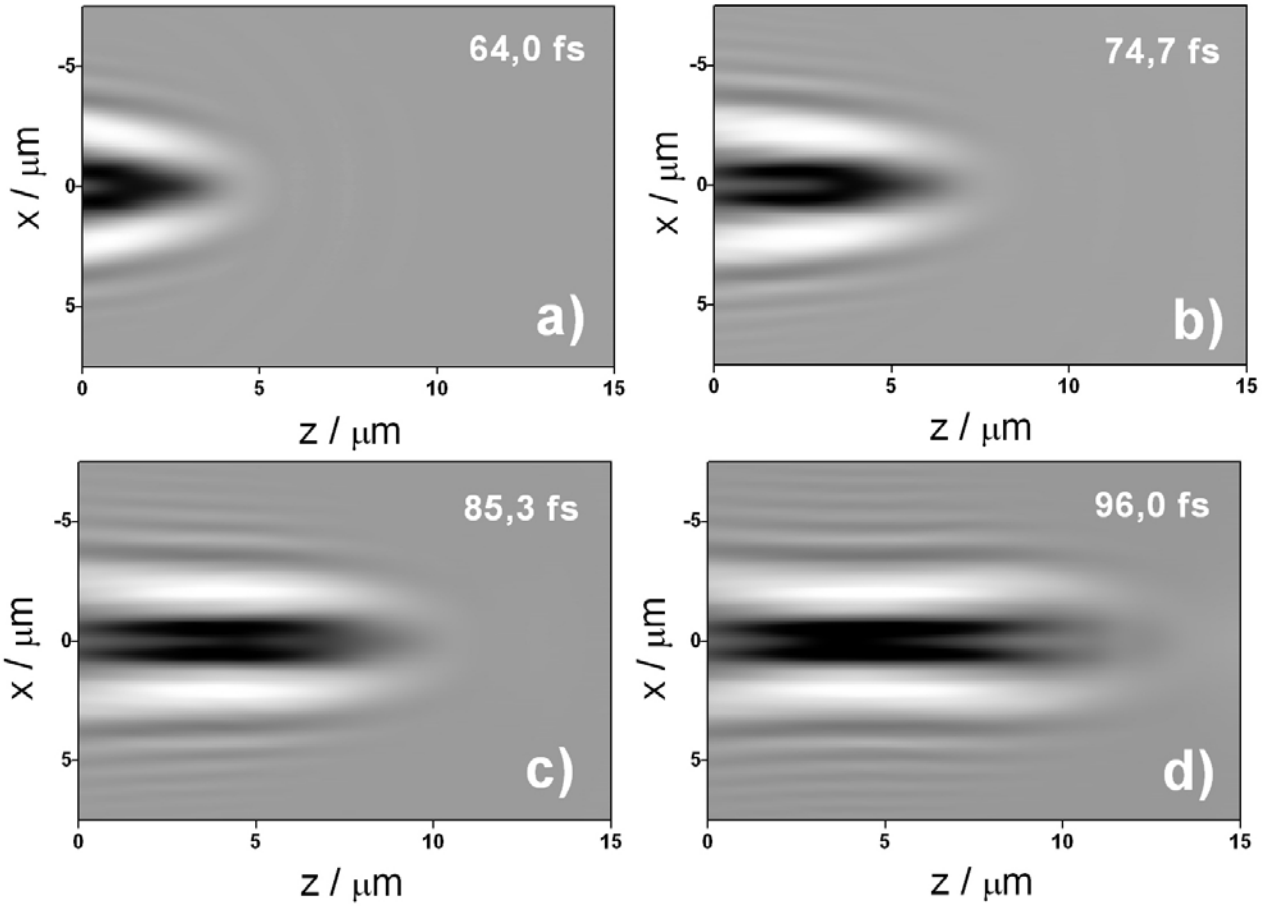
3D-Particle-In-Cell simulations of ionization front

Plasma-Simulation-Code (PSC) by Hartmut Ruhl

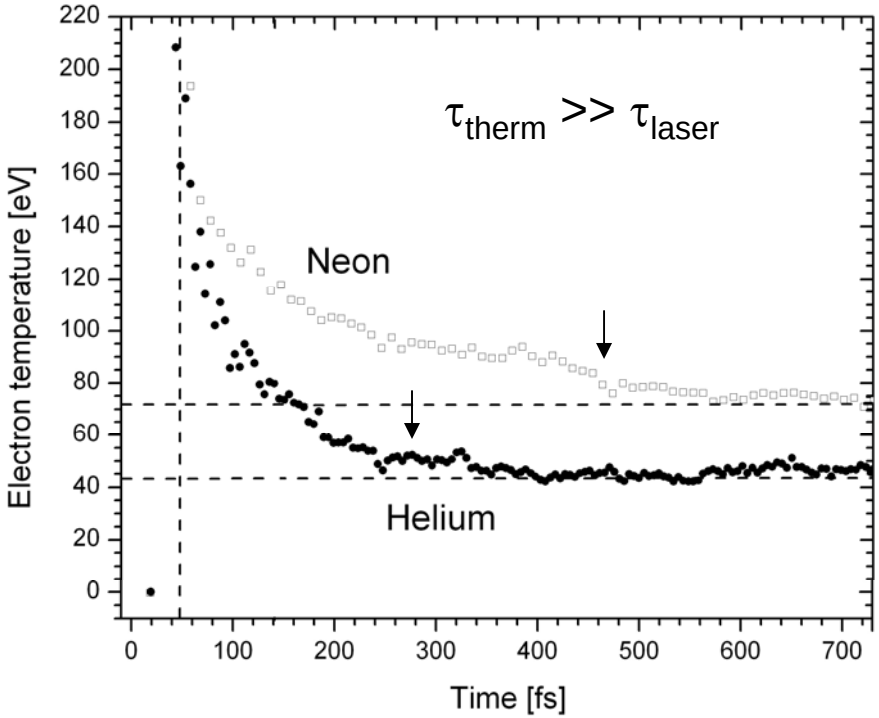


3D-Particle-In-Cell simulations of ionization front



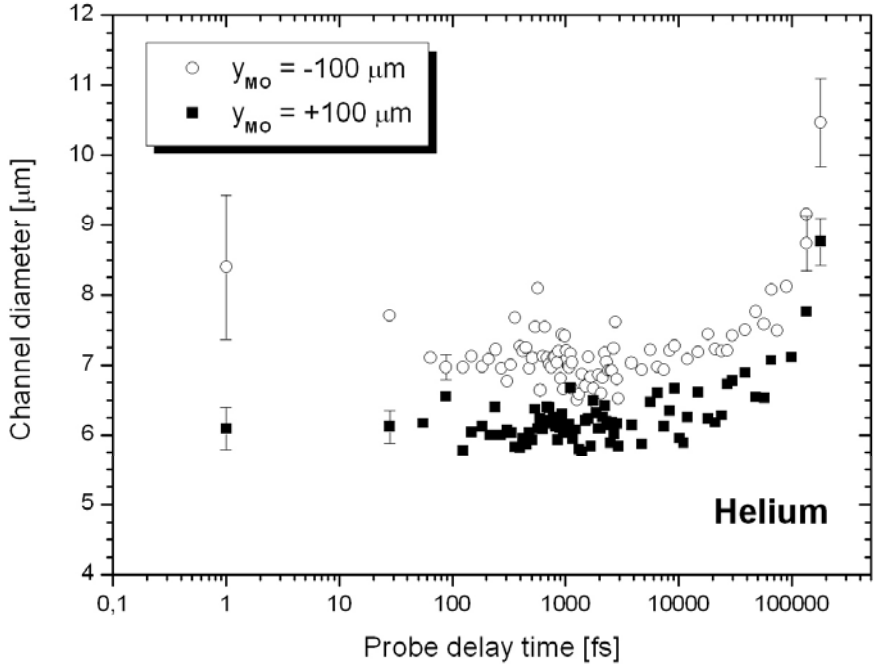
Both in the experiment and simulation the speed of light is observed as the propagation velocity.

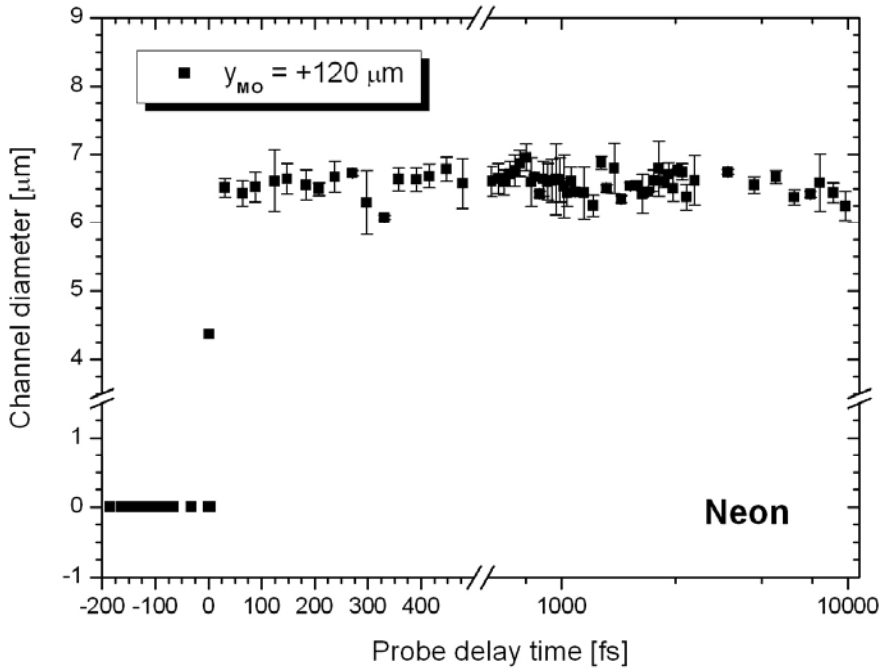
Electron temperatures obtained from collisional 1D-PIC simulation



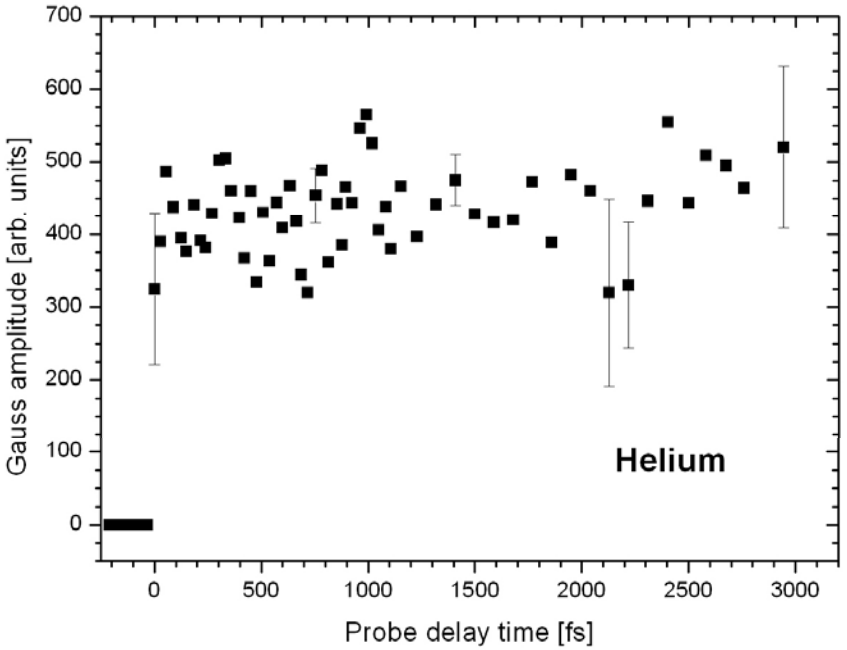
Temperatures obtained by fit to dN(E)/dy slope

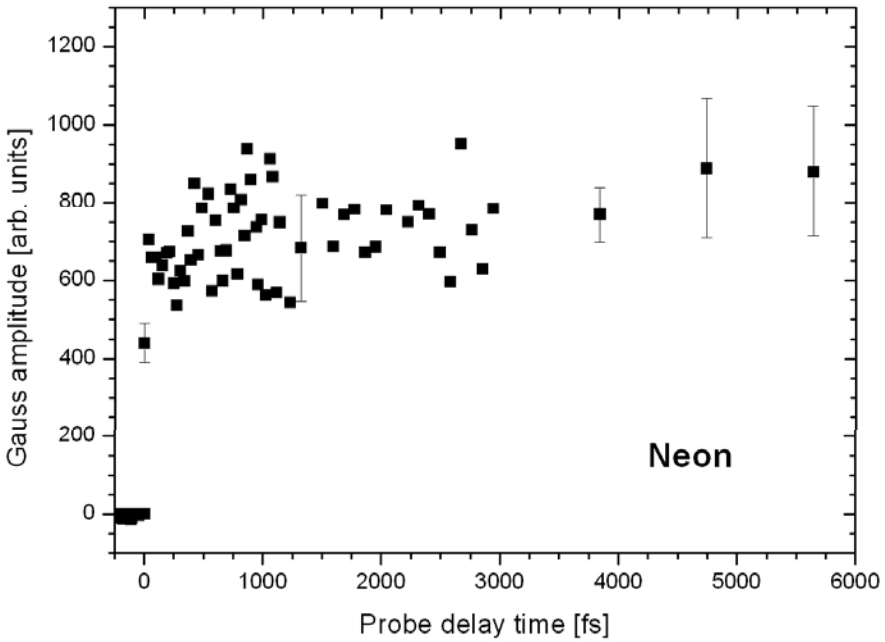
Channel dynamics on longer time scales





Evolution of electron densities obtained by shadowgraphy





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- The ionization front and subsequent plasma channel evolution was studied using an ultra-short optical probe beam
- Due to the parameter regime, pump-pulse is a delta-excitation of the medium
- 3D-PIC simulations have been performed in order to interpret shadowgrams
- Late time dynamics of the plasma channel was measured

Ionization front propagation in gaseous targets induced by sub-ten femtosecond laser pulses

Thank you for your attention

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