Laboratoire d'Optique Appliquée

Palaiseau – FRANCE

Interferometric measurement of thin plasma density gradient on solid targets

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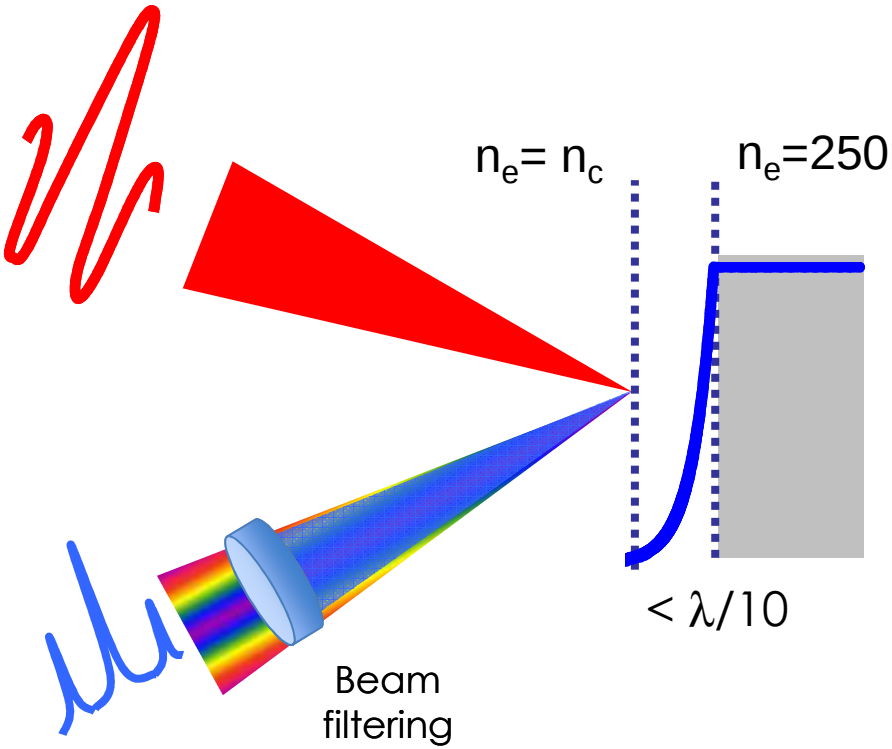
HHG from plasma mirrors

$I_{laser} > 10^{16}$ W/cm^2



$$n_c = \frac{m\varepsilon_0\omega_p^{\ 2}}{e^2}$$

silica
$800nm$
$N_c = 1.75x10^{21} cm^{-3}$

Phase-locked harmonics

Dromey & *al.*, Nature Physics 2 (2006)

Thaury & *al.*, Nature Physics 3 (2007)

Tarasevitch & *al.*, PRL 98 (2007)

Nomura & *al.*, Nat. Phys. 5, 124 (2009)

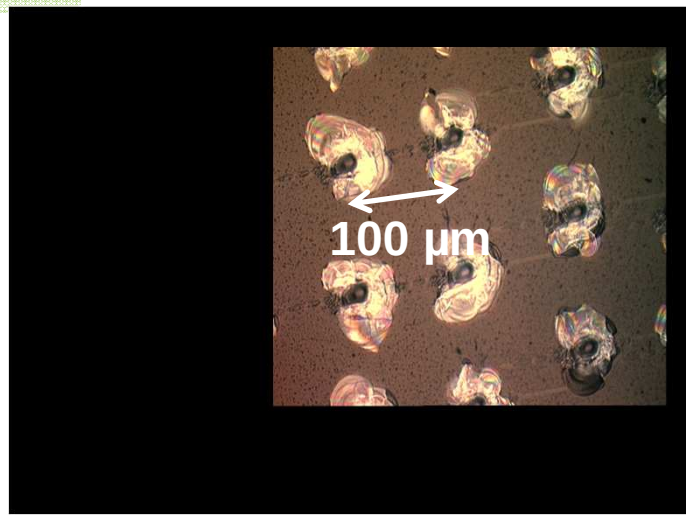
A. Borot & *al.*, Nat. Phys (2012)

10^{18} W/cm^2, 800 nm

Laser field~ 1TV/m

Electron energies~ few 100keV

Solid target requirements

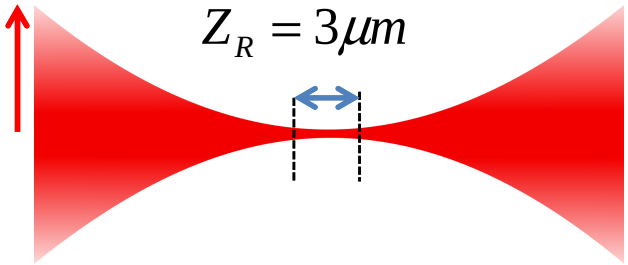


- kHz experiment
- Micrometric precision

$w_{0,foc} = 0.89\mu m$

$Z_R = 3\mu m$

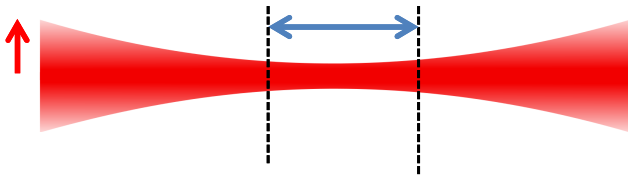
$w_0 = 15mm$



$w_{0,foc} = 2.6\mu m$

$Z_R = 27.3\mu m$

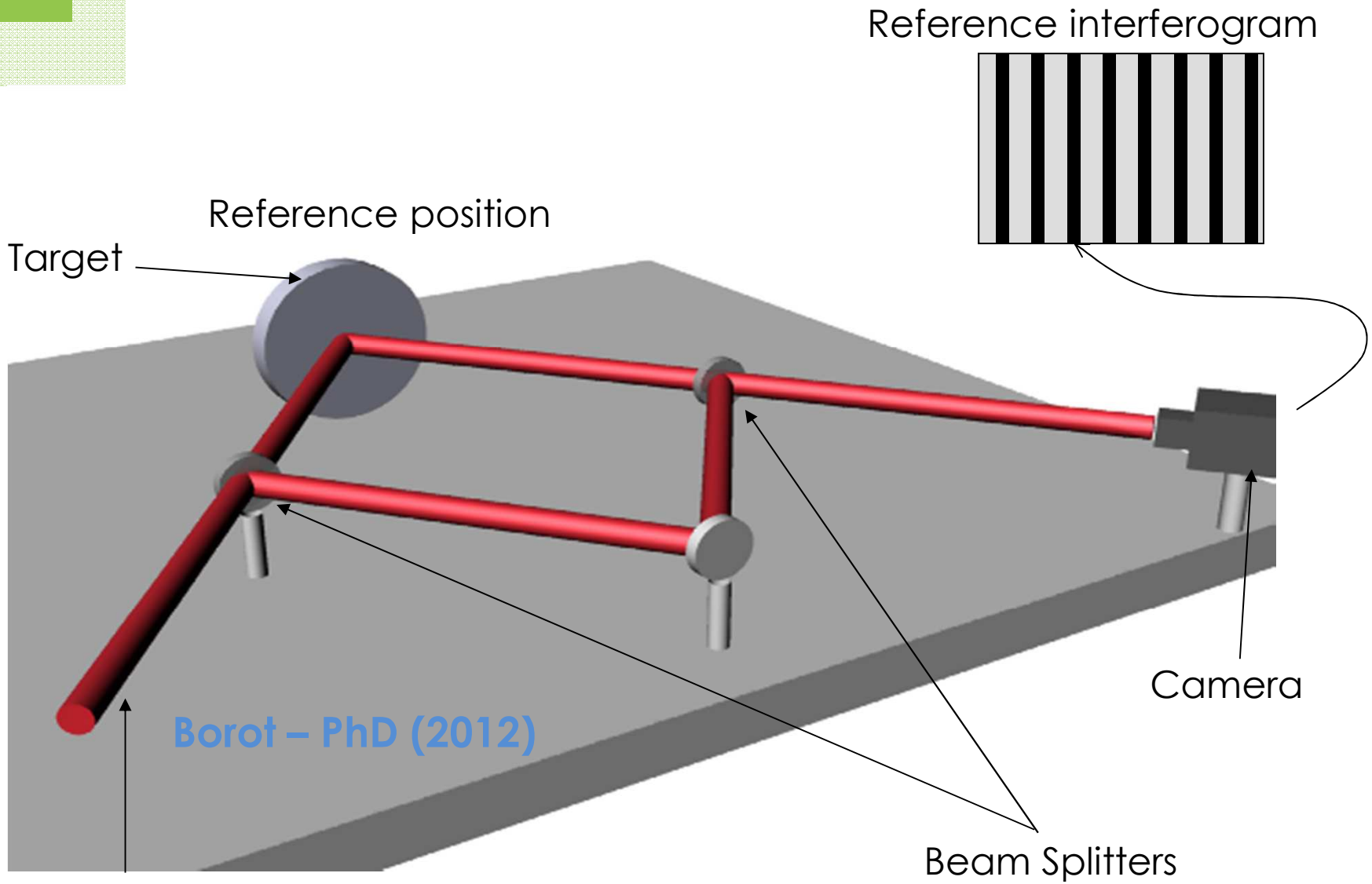
$w_0 = 5mm$



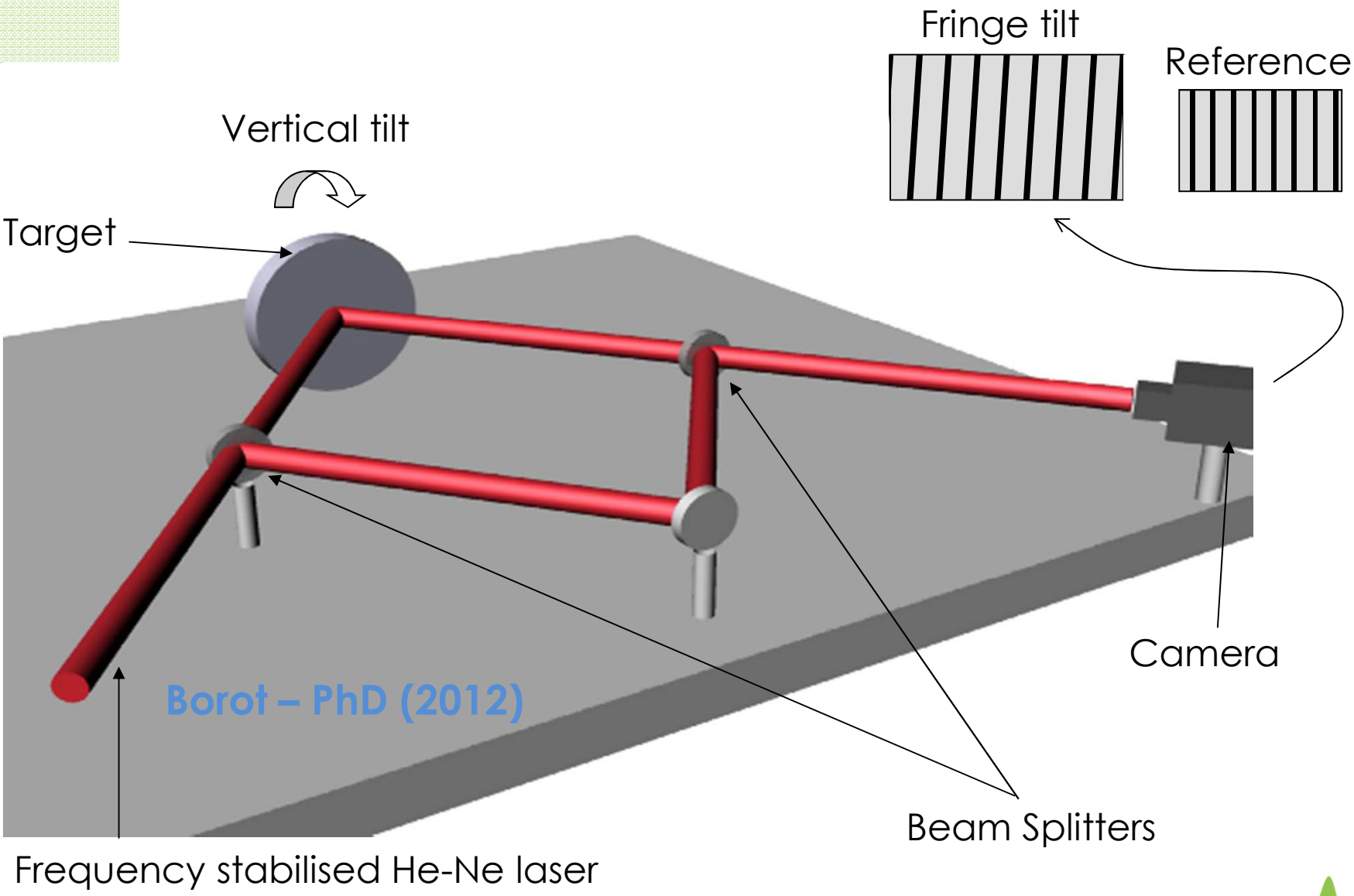
Borot – PhD (2012)

SourceLAB

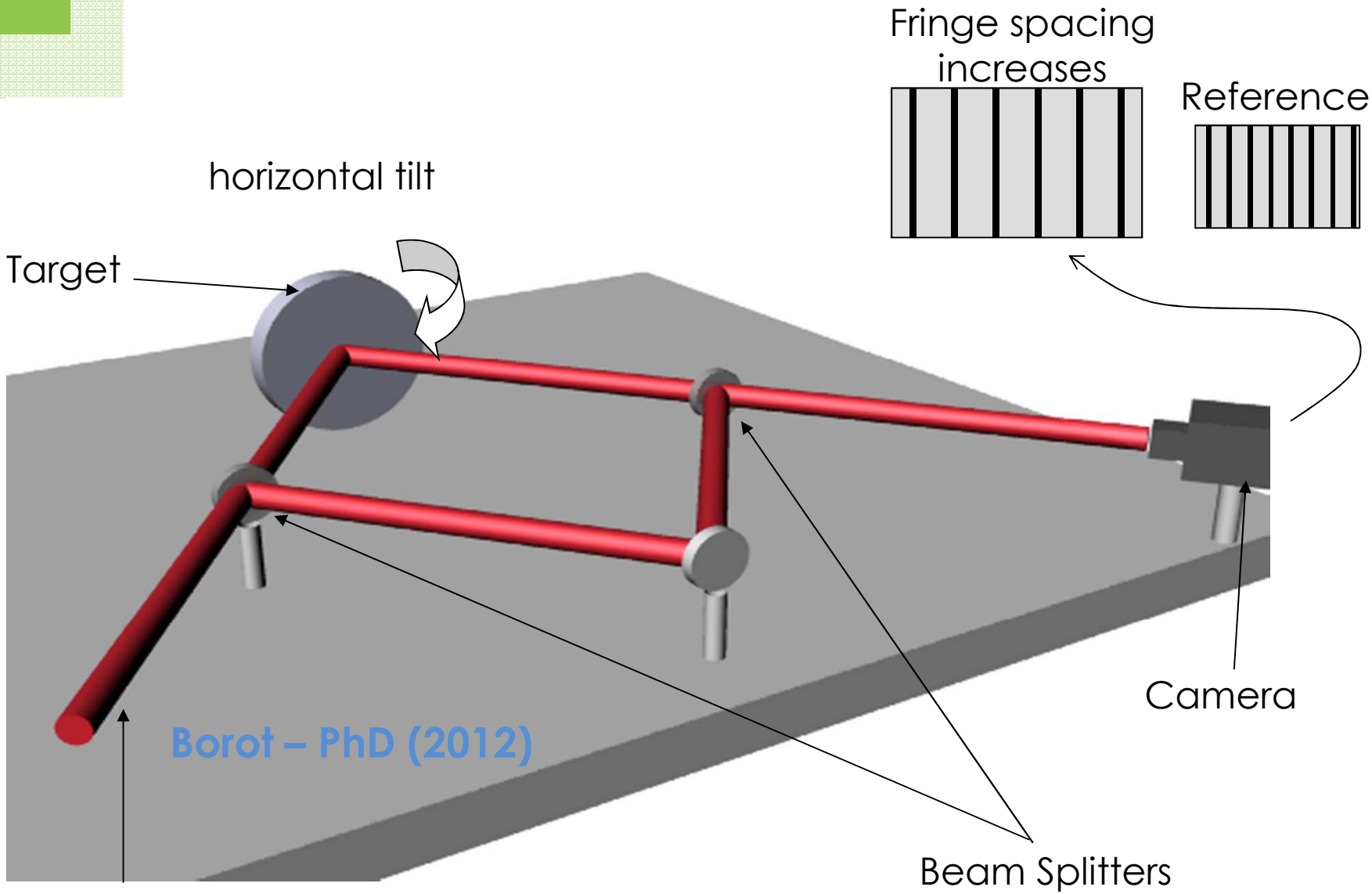
Stabilization of target



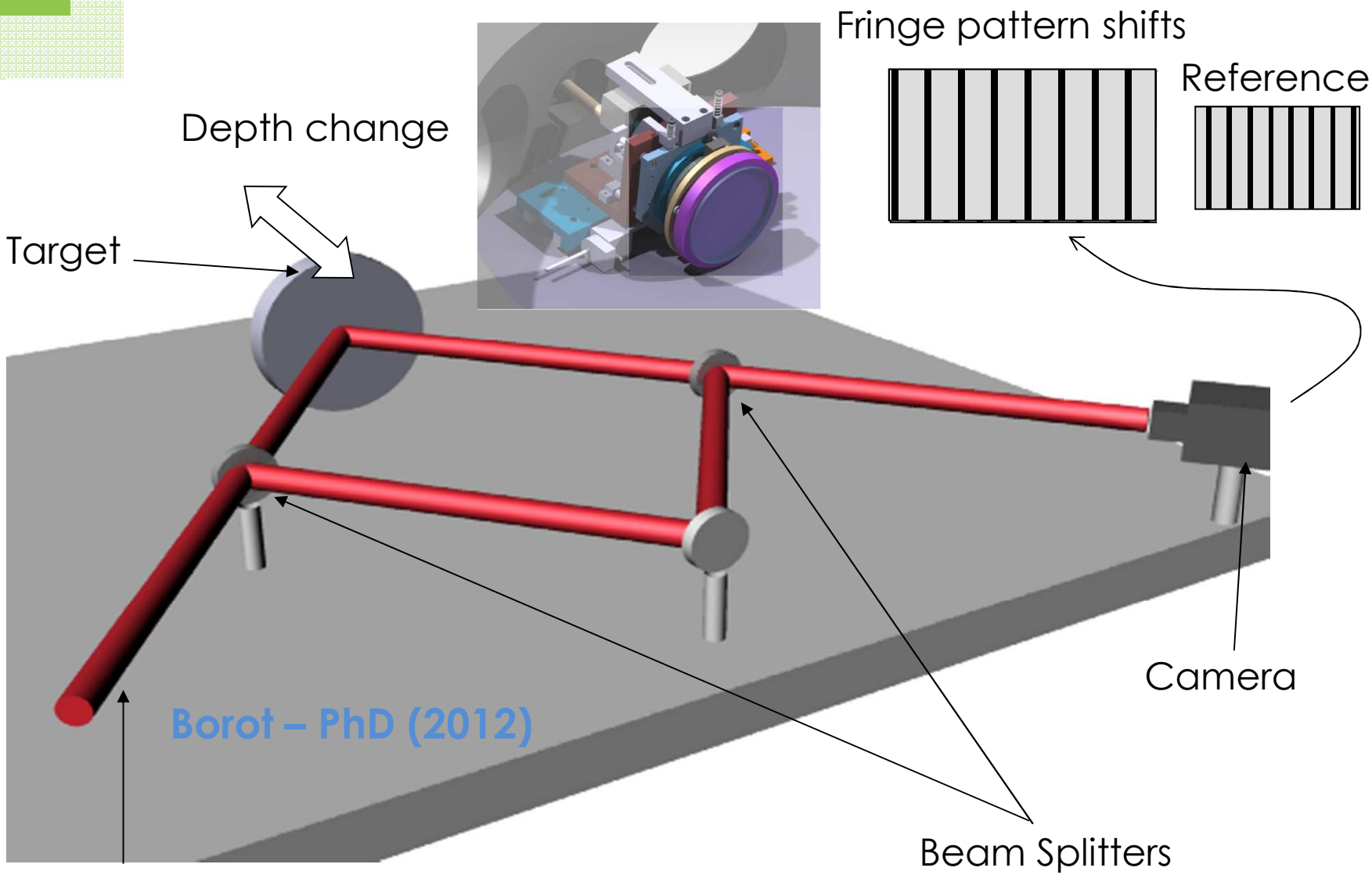
Mach-Zender interferometer



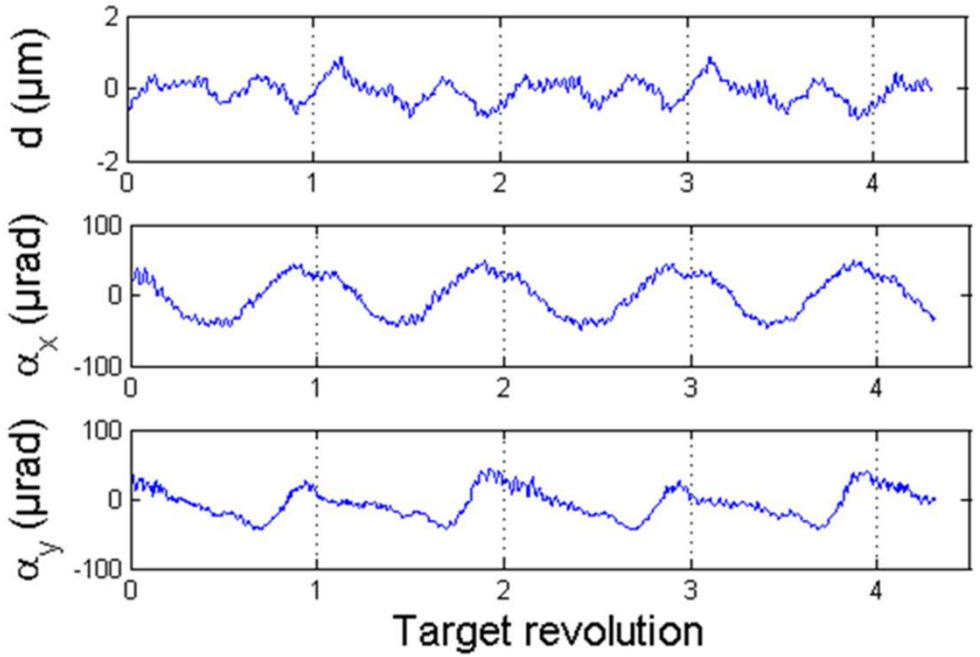
Mach-Zender interferometer



Mach-Zender interferometer



Passive stabilization

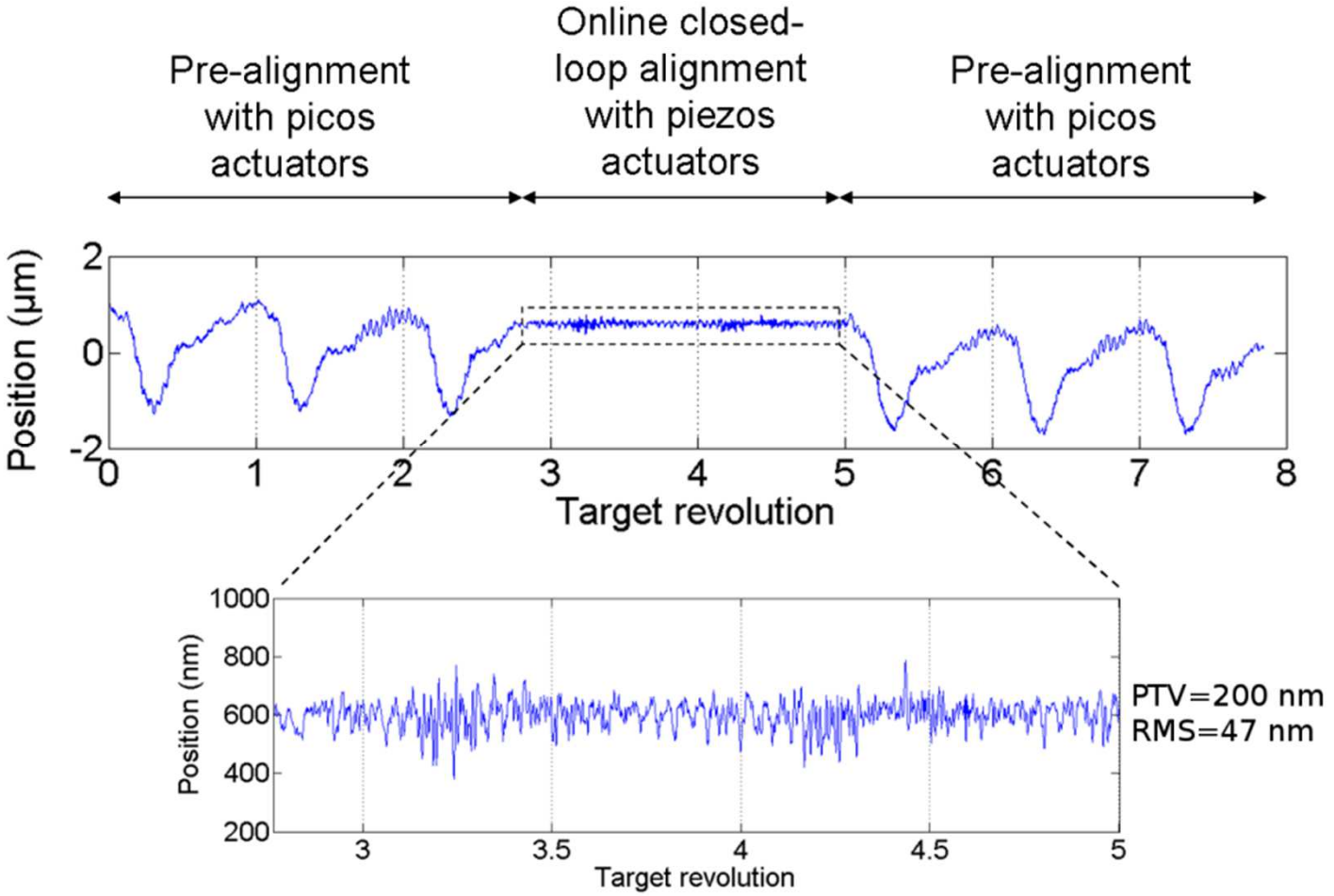


Depth

Horizontal angle

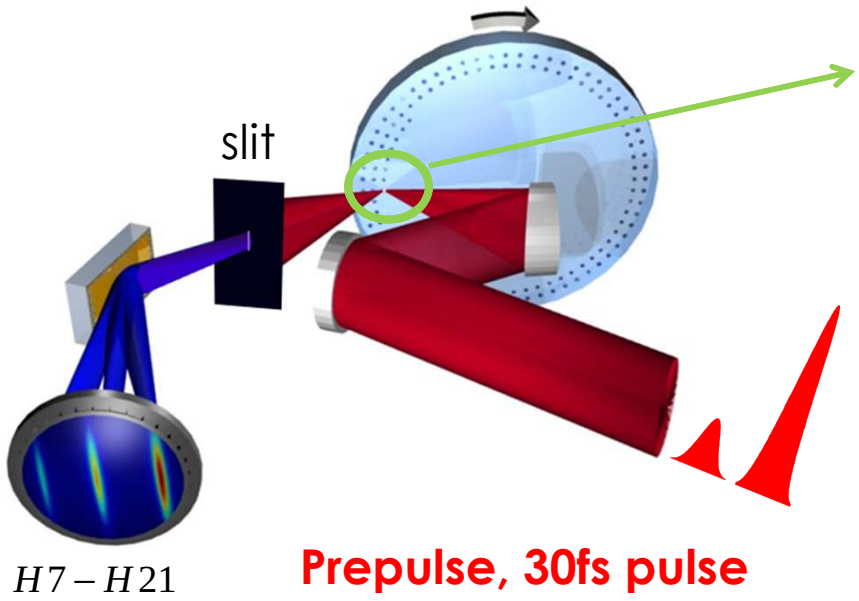
Vertical angle

Active stabilization



Experiment

Gradient control



$H7 - H21$

Prepulse, 30fs pulse
30-100 uJ , kHz

Main pulse, 30fs pulse
1-3 mJ , kHz

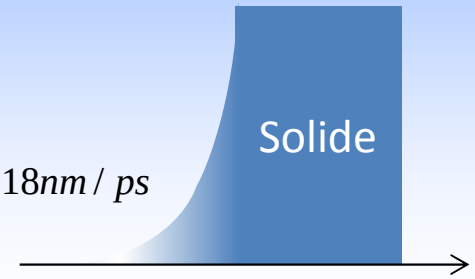
Isothermal expansion model :

Kruer 1988

$k_b T_e = 100eV$

silica

$c_S = \sqrt{\frac{Zk_b T_e}{m_i}} = 18nm/ps$



Prepulse : $\tau_{fwhm} = 9\mu m$

Generation of plasma $I_{pump} > 10^{14} W/cm^2$

Main pulse : $\tau_{fwhm} = 1.7\mu m$

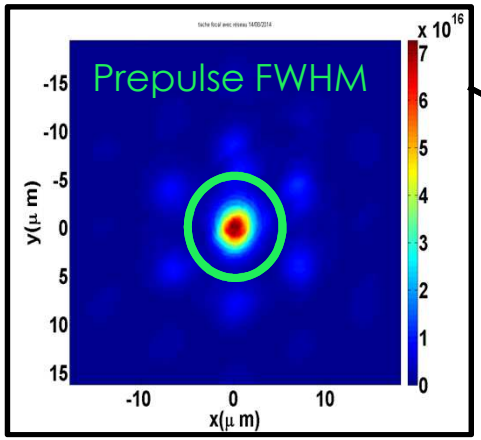
plasma non linear response $I_{probe} > 10^{18} W/cm^2$

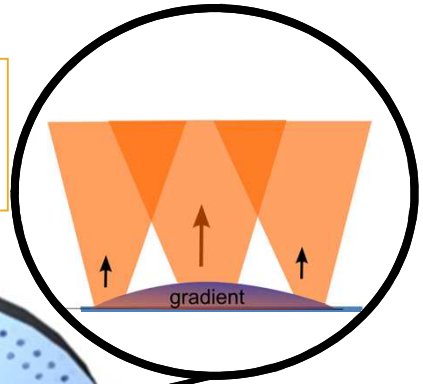
Experiment

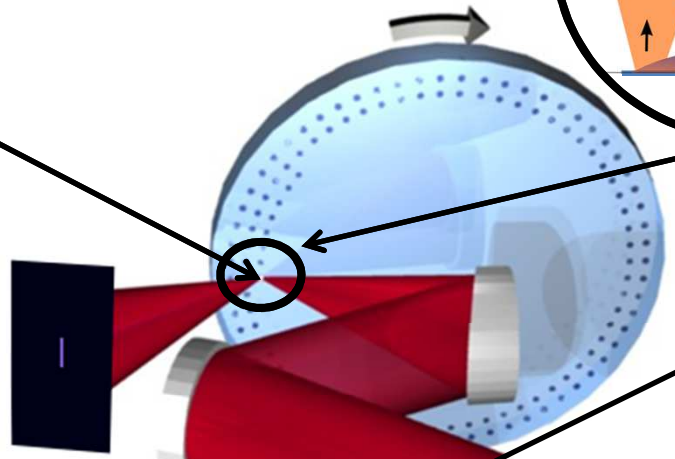
Gradient control

Central Phase Shift

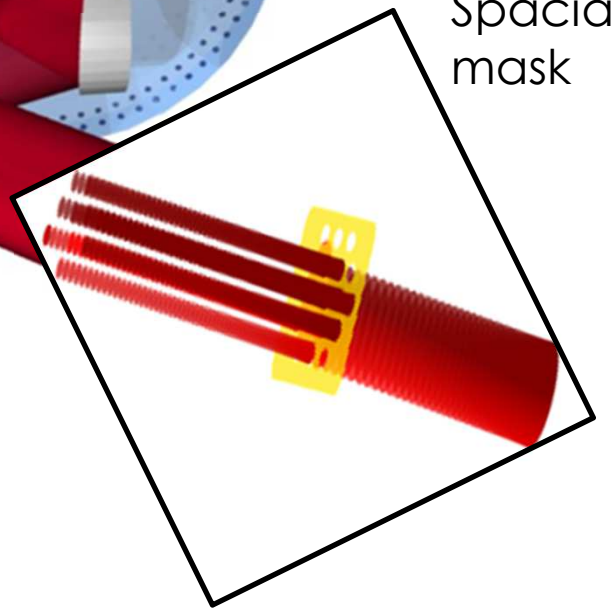
$$\frac{dL}{dt} \approx 10nm / ps$$



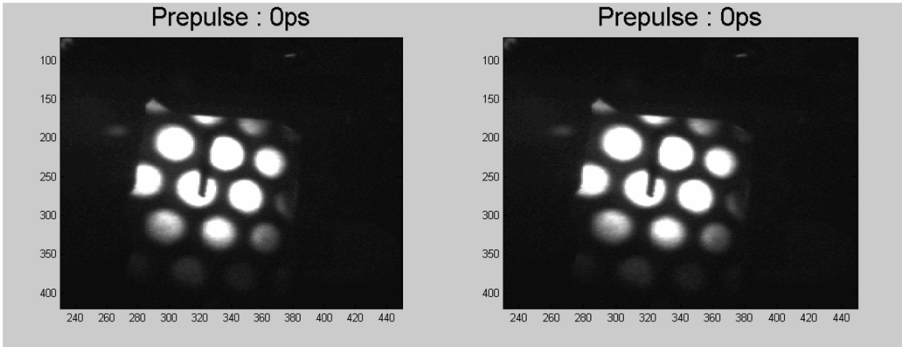




Spacial mask

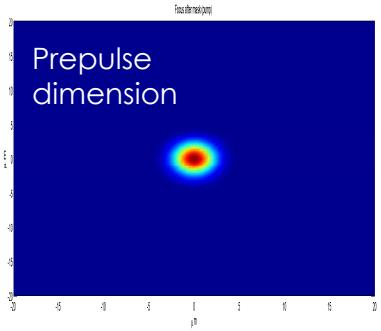


Direct camera



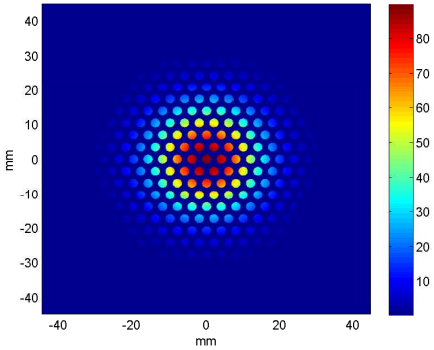
Simulation of CPS traces

Exemple of gaussian simulated Far field reflected profil:

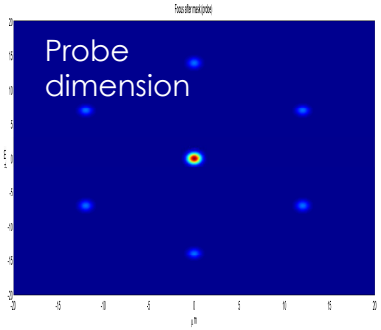


$$T_{plasma} = |T| e^{i\varphi_T}$$

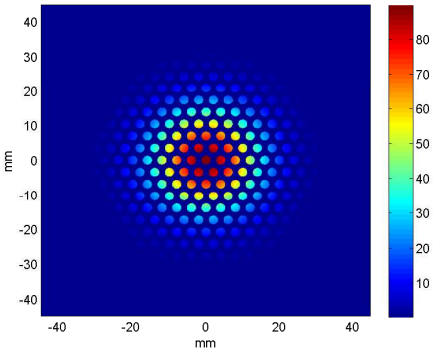
Reference with no prepulse



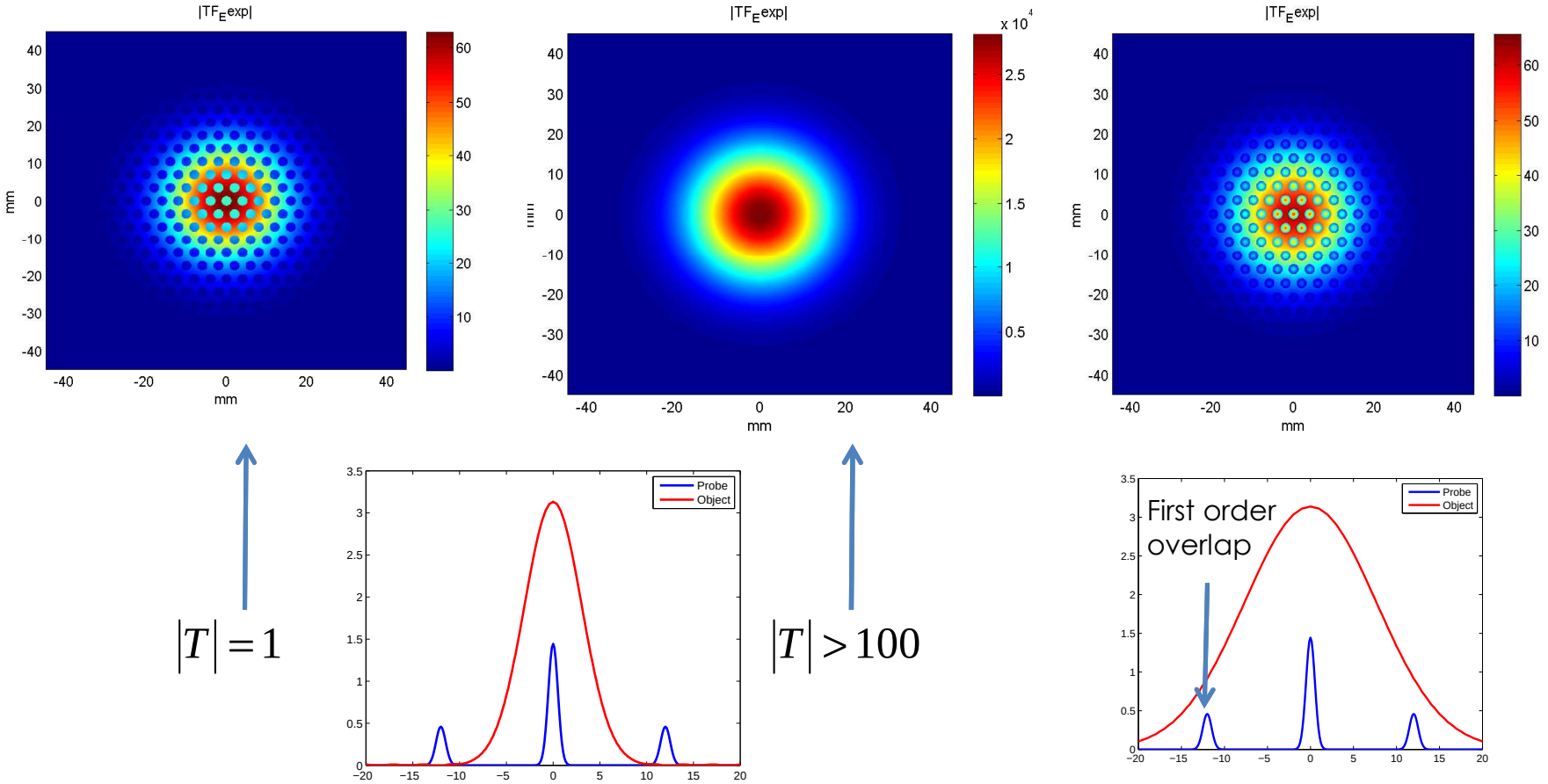
Fourier plane



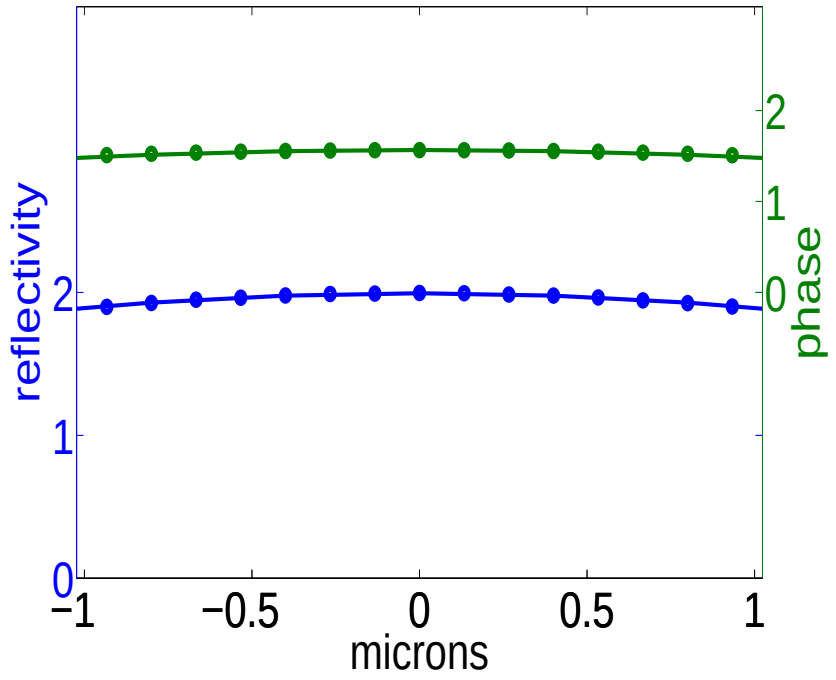
Inverse Fourier plane

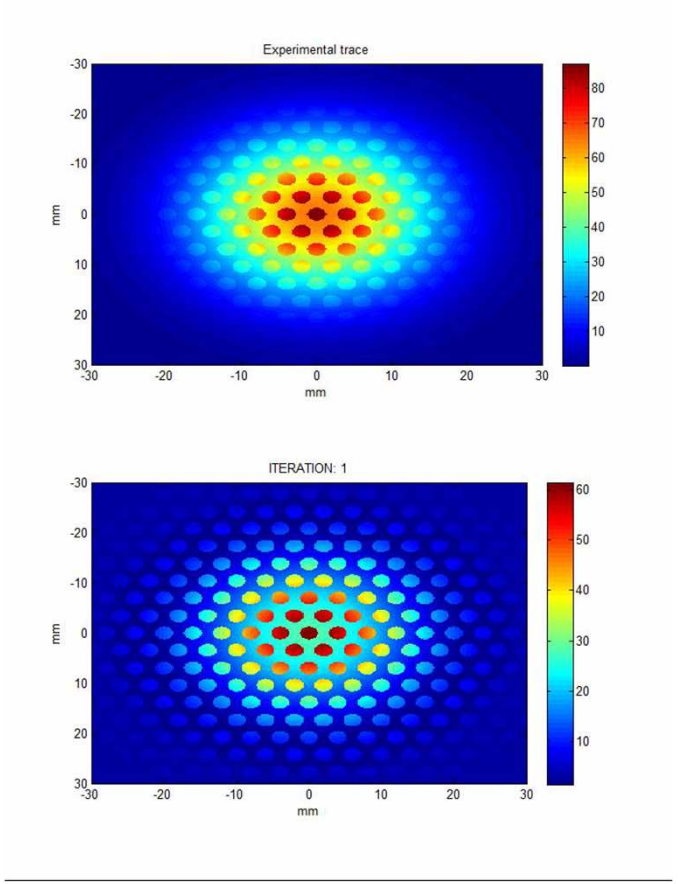


Simulation of CPS traces

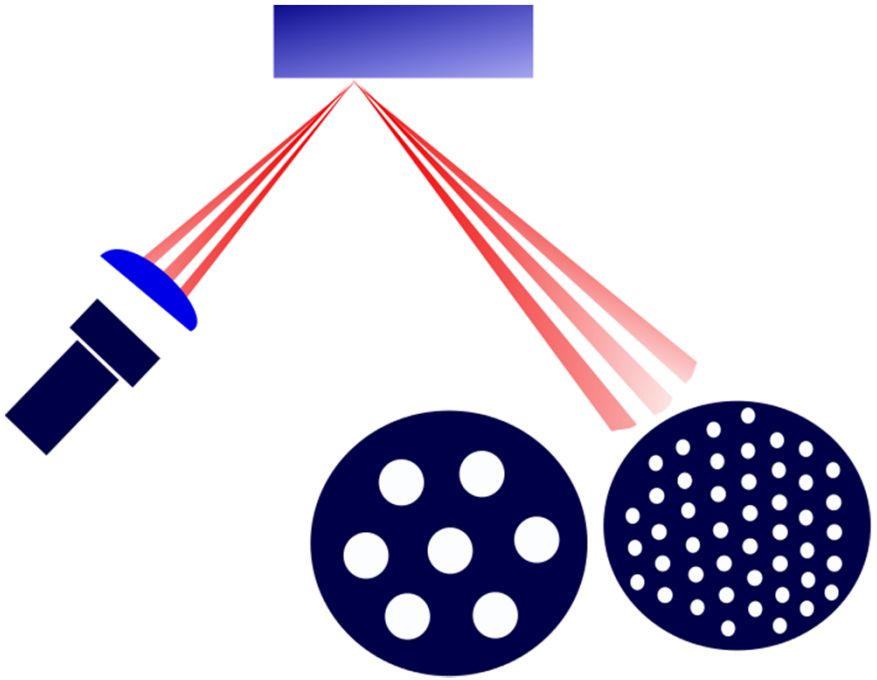


Phase retrieval algorithm





CPS upcoming experiment



Conclusion:

- Simple estimate of plasma expansion on kHz rotating solid target
- First implementation of phase retrieval algorithm

Perspectives:

- Proper imaging of reflected beam
- Working on retrieval algorithm
- Testing different mask geometries
- Probe reflectivity evolution at early stages of ionisation

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