

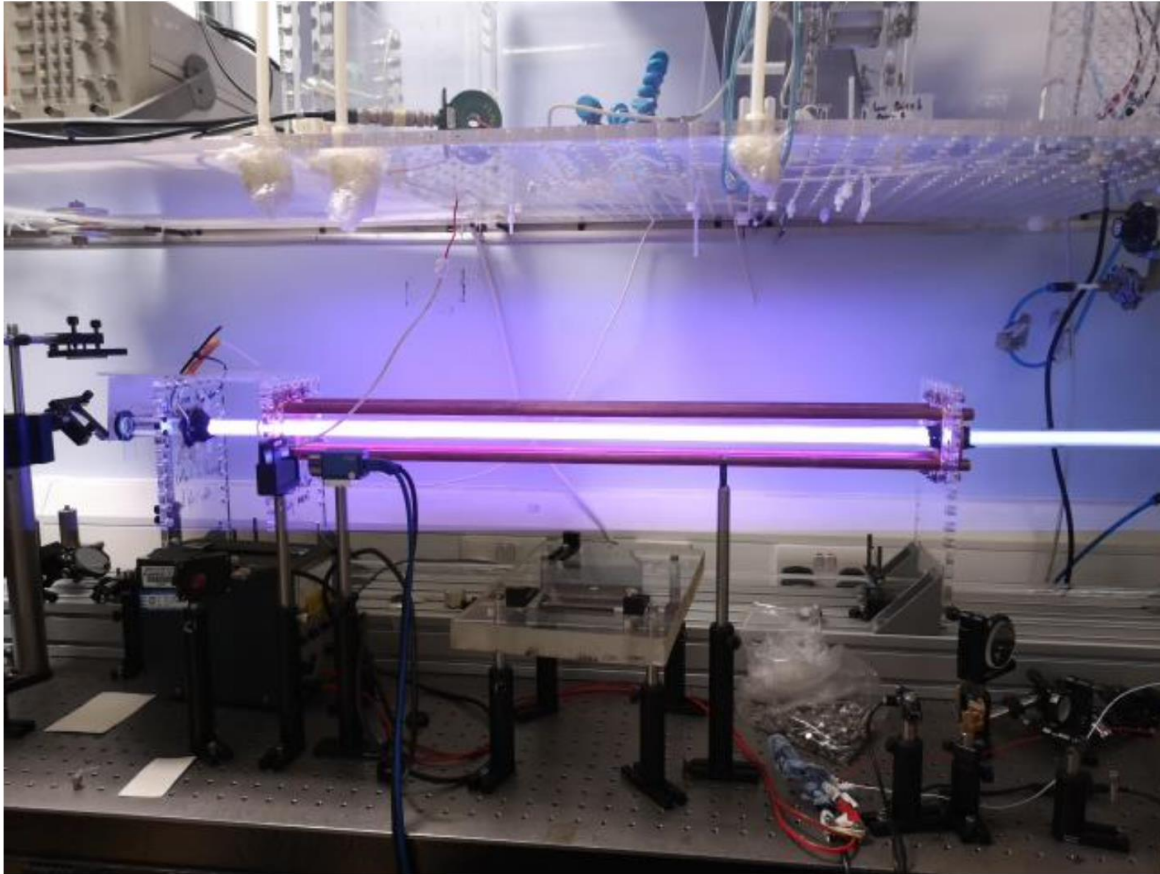
IMPERIAL



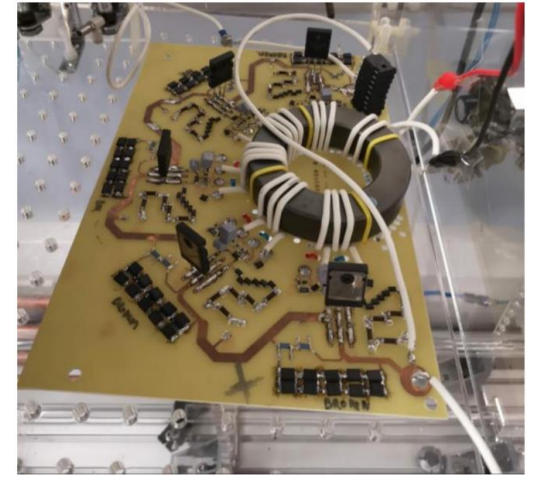
Diagnosis of a discharge plasma source

Claudia Cobo, Lewis Kennedy, Ben Chen and Zulfikar Najmudin

Discharge Plasma Source at ICL



Currently limited to 6 kV while we upgrade the discharge switch



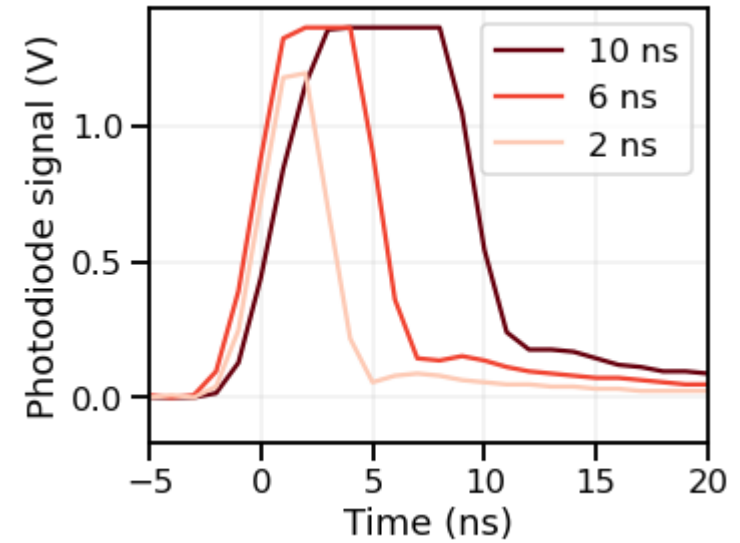
Parameter	Value	Unit
Tube length	1	m
Diameter	19.5	mm
Discharge gap	15	cm
Gas pressure	0.01 – 1.5	mbar
Discharge current	~ 470	A
Discharge time	~ 10	μs
Plasma electron density	1 – 100	10^{20} m^{-3}
Ionisation degree	~ 0.1	%

Plasma Diagnostics

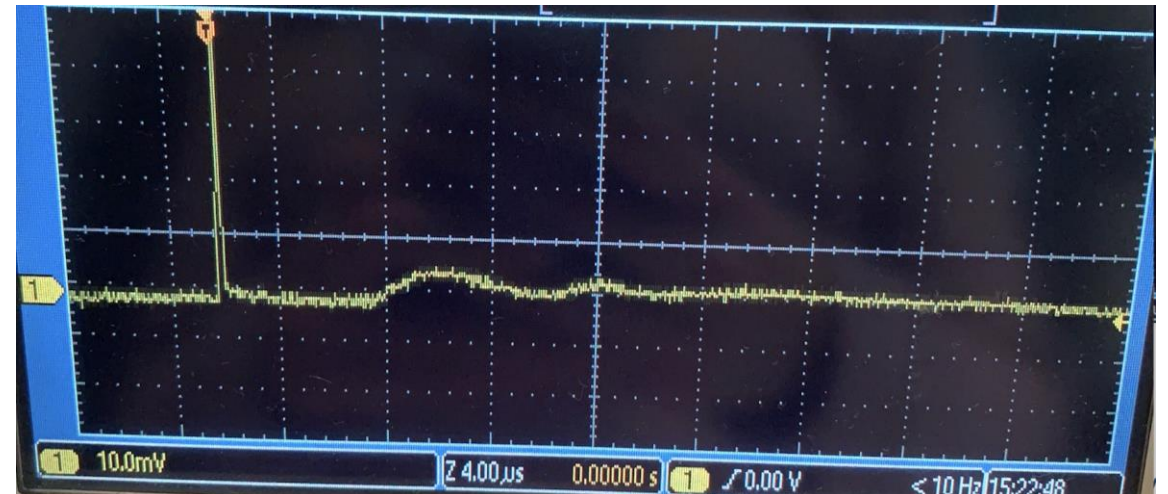
Fibre Laser



Parameter	Value	Unit
Max pulse energy	500	μJ
Pulse duration	2 – 500	ns
Wavelength	1064	nm
Beam diameter	7	mm
Dimensions	245 x 200 x 65	mm
Weight	4.8	kg

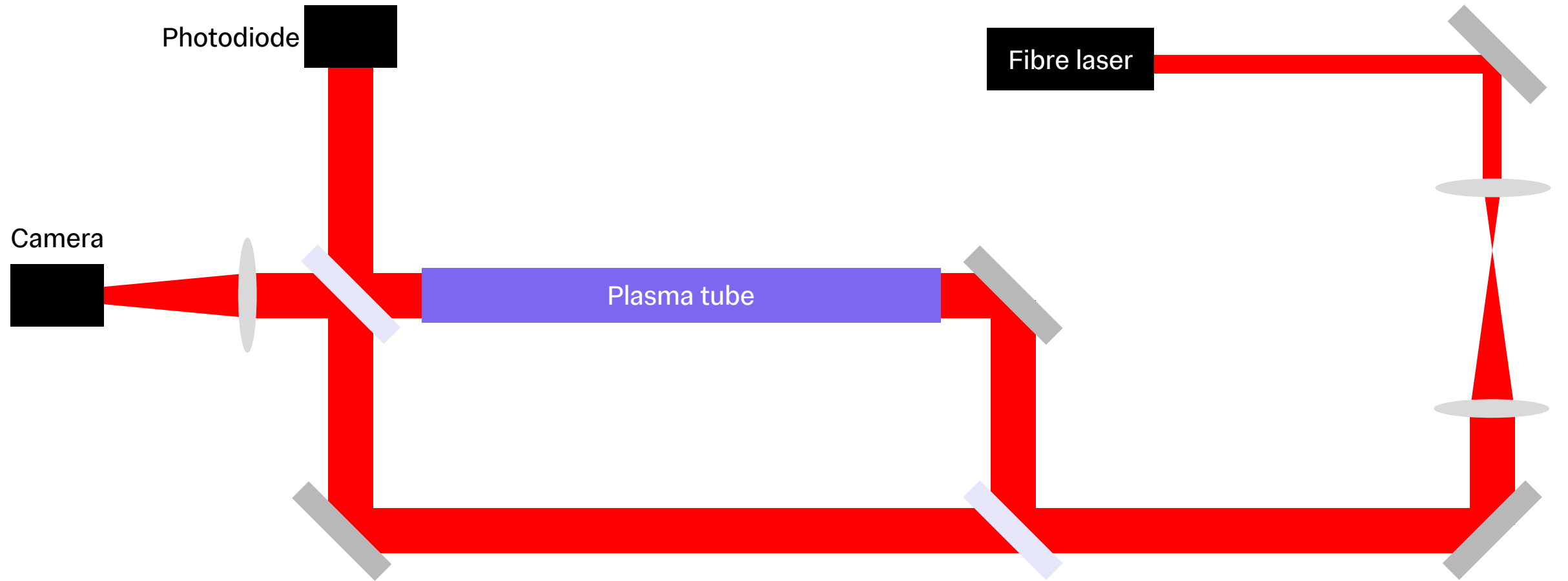


Timing set on Arduino and monitored with a photodiode



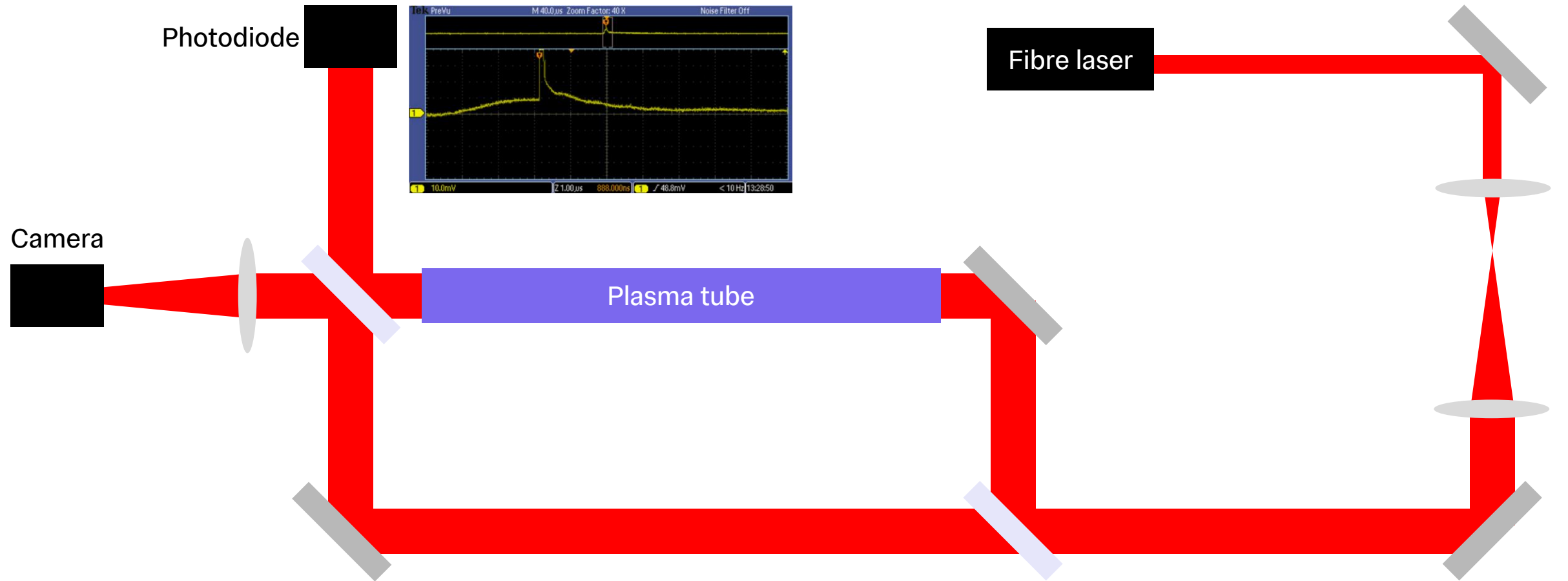
Longitudinal Interferometry

Mach-Zehnder Setup



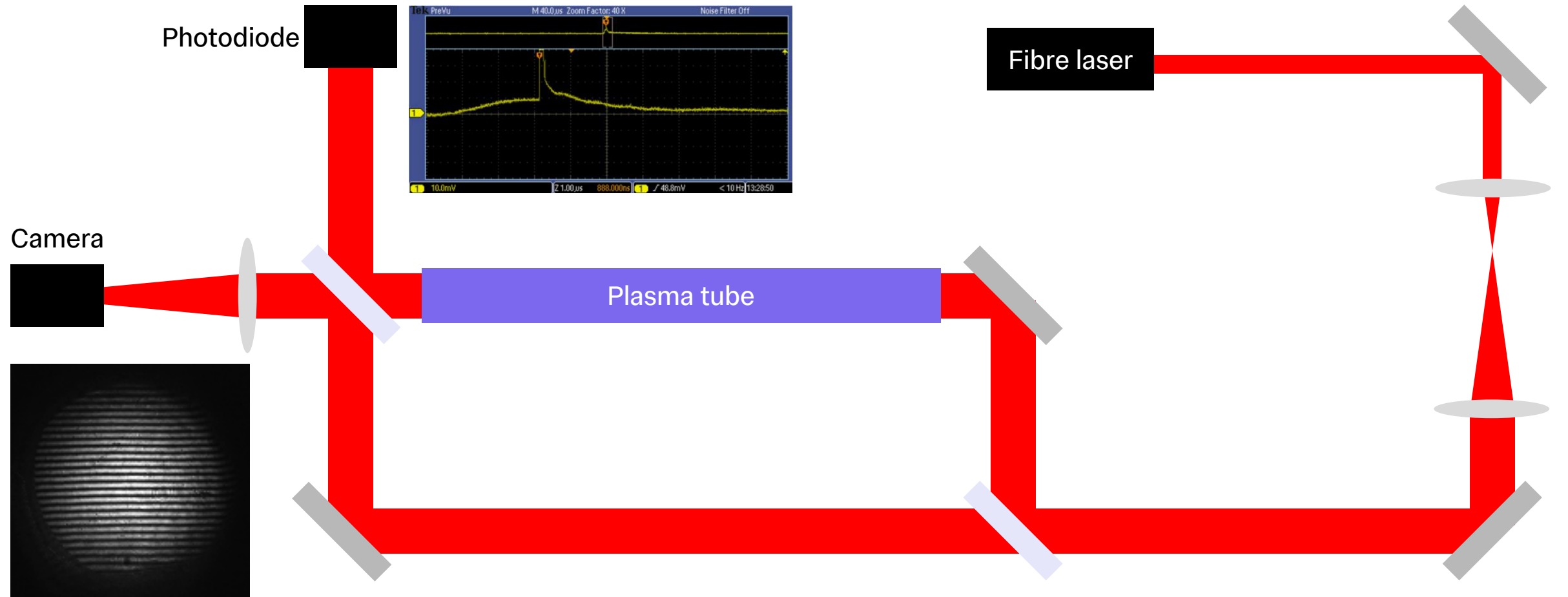
Longitudinal Interferometry

Mach-Zehnder Setup



Longitudinal Interferometry

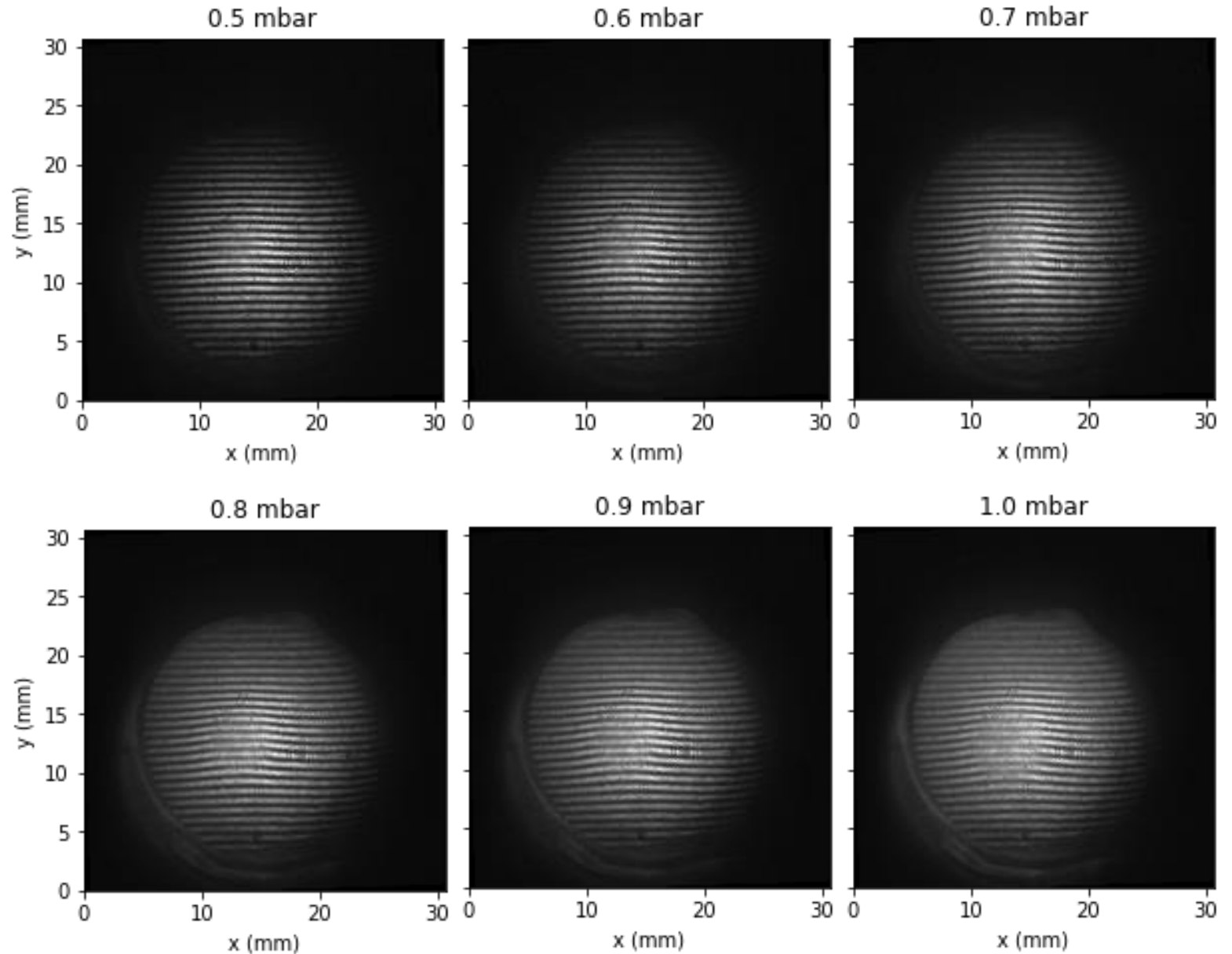
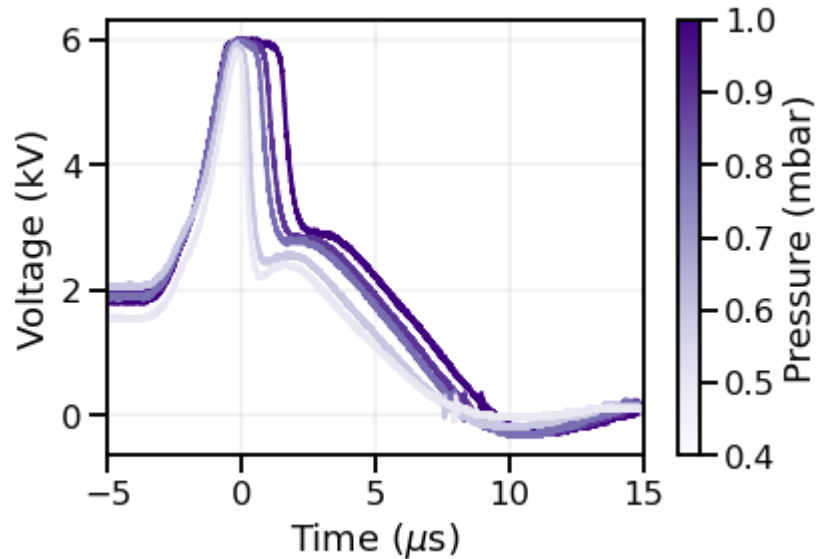
Mach-Zehnder Setup



Longitudinal Interferometry

Pressure scan

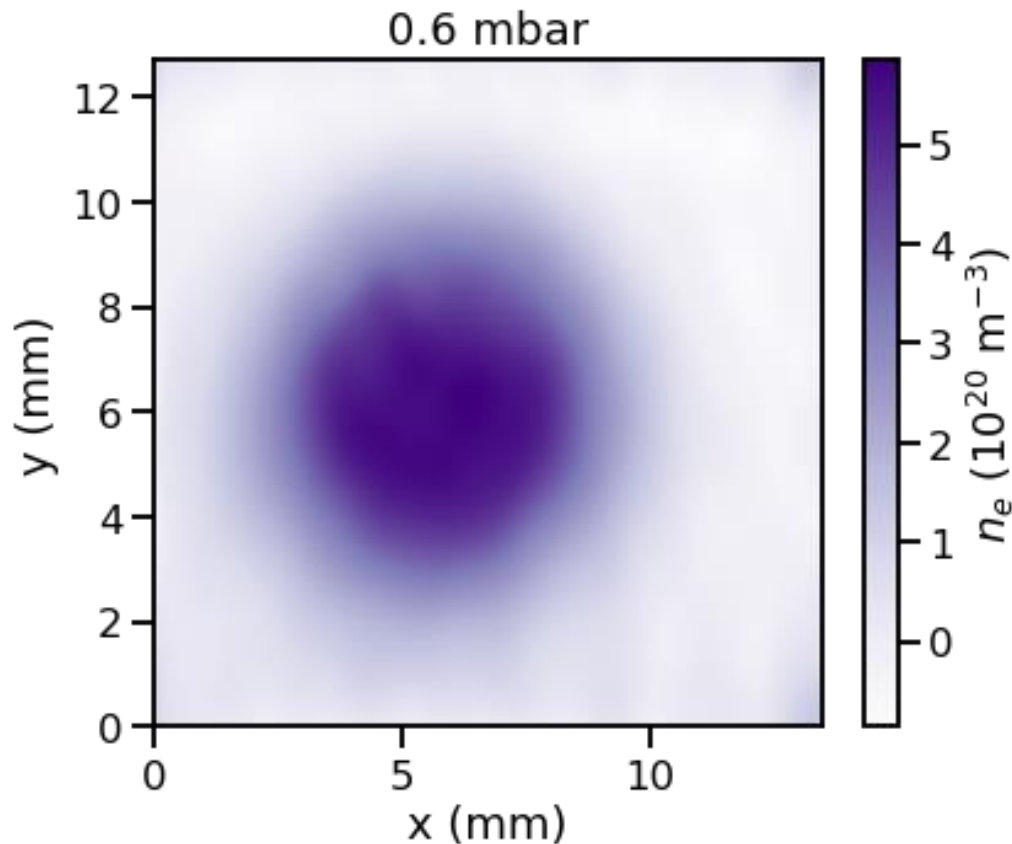
Argon
6 kV discharge
10 ns laser pulse



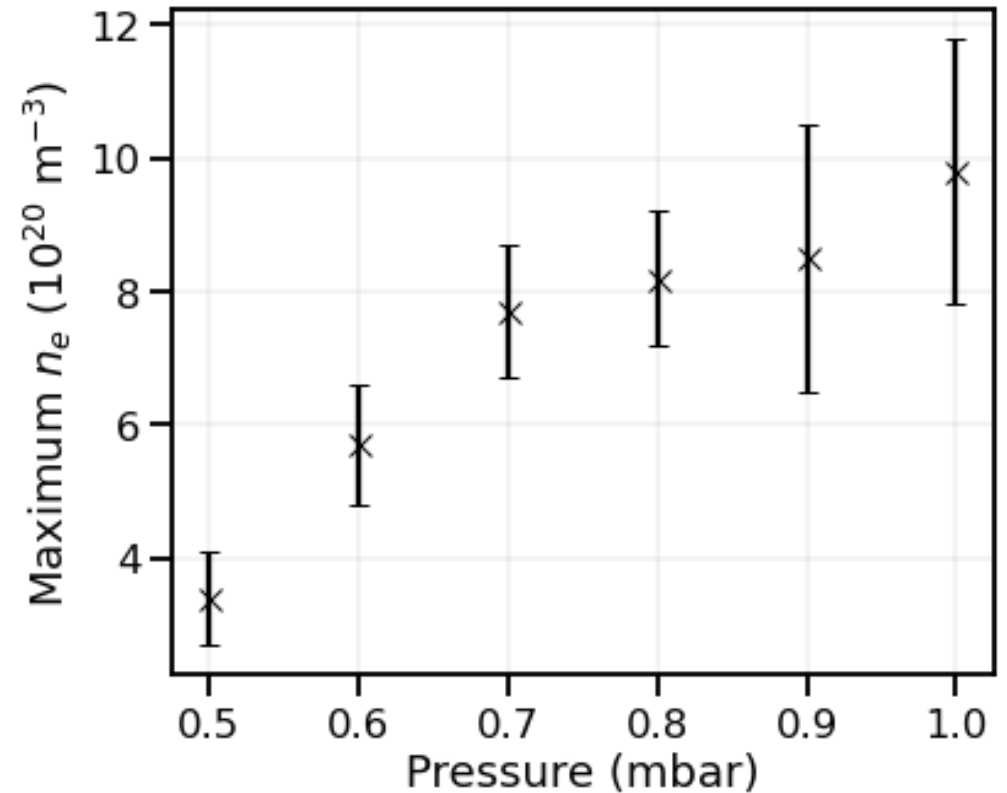
Longitudinal Interferometry

Density Retrieval

$$\Delta\phi(y, z) \approx \frac{\lambda_0 e^2}{4\pi c^2 m_e \epsilon_0} \int n_e(x, y, z) dx$$



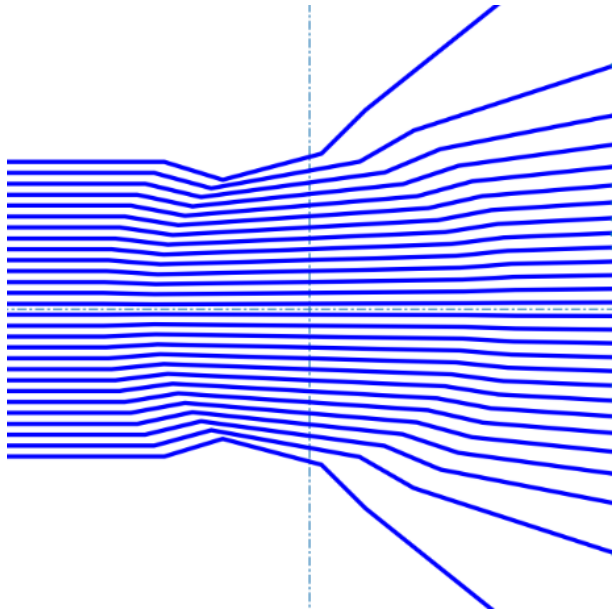
Pressure Scan



Expect $n_e \sim 10^{20} \text{ m}^{-3}$ at $P \sim 0.01 \text{ mbar}$
Ionisation degree $\sim 1\%$

Transverse Diagnostics

Complications

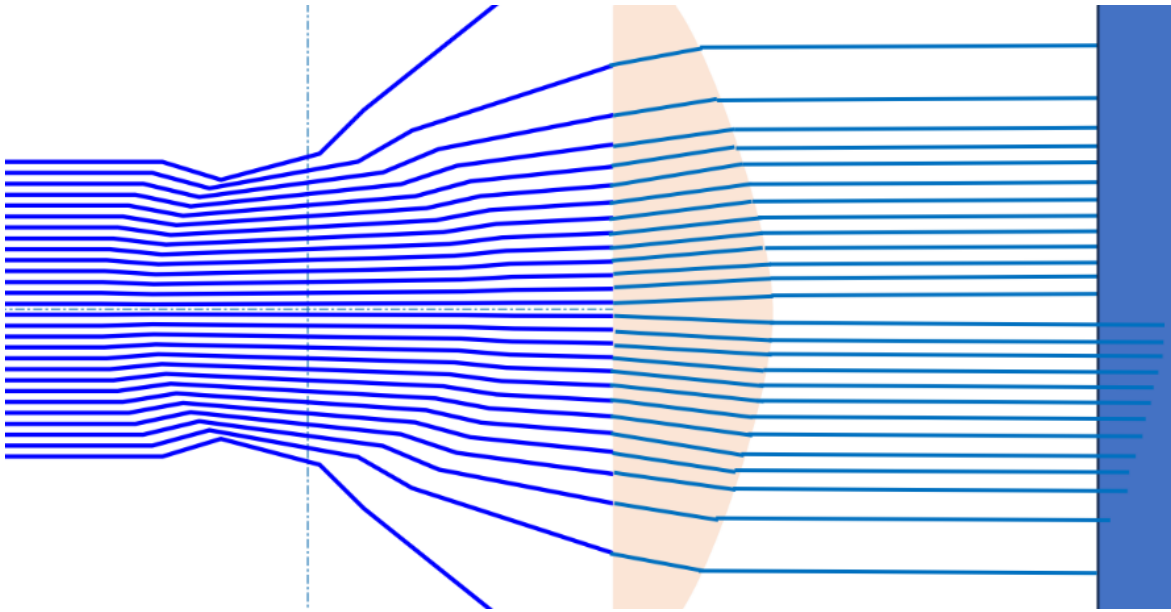


DPS tube acts as a defocusing optic

- Effective $f \approx -59.5$ mm

Transverse Diagnostics

Complications

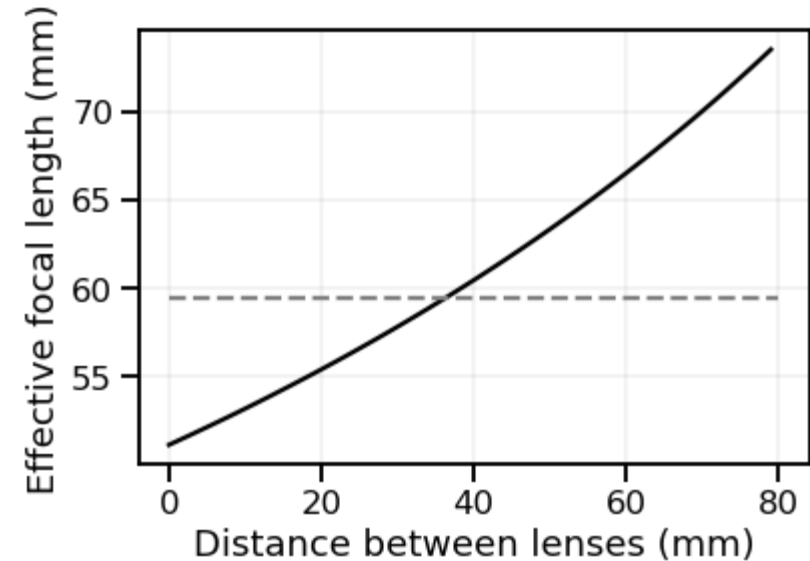


DPS tube acts as a defocusing optic

- Effective $f \approx -59.5$ mm

Building a system with cylindrical lenses to compensate for defocusing effect

- $f = 190$ mm and $f = 70$ mm



Transverse Diagnostics

Deflectometry

Shack-Hartmann wavefront sensor

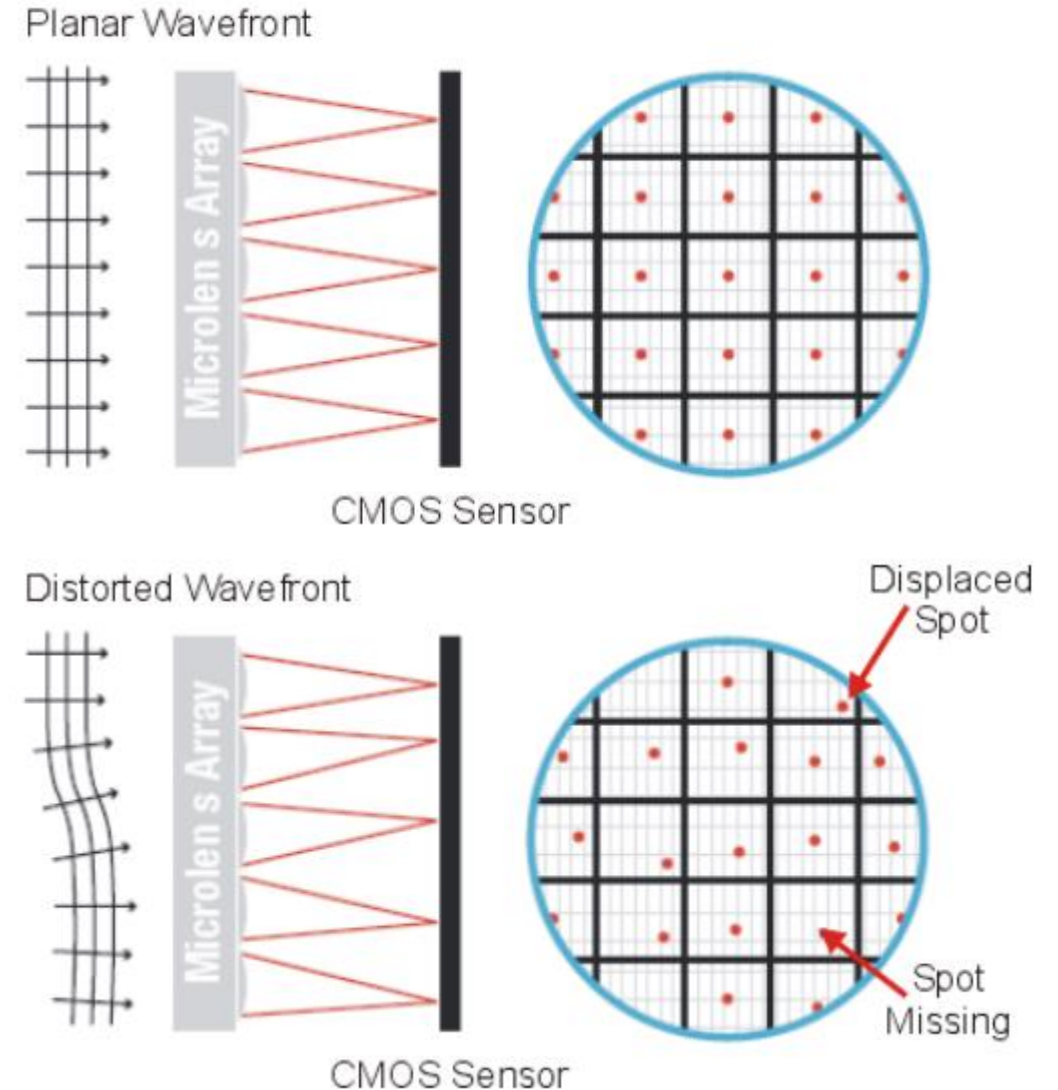
- 5 x 7 mm field of view
- Wavefront sensitivity $\sim \lambda/100$

WFS density measurement used for gas jet and gas cell targets for LWFA

REVIEW OF SCIENTIFIC INSTRUMENTS 81, 033108 (2010)

Wavefront-sensor-based electron density measurements for laser-plasma accelerators

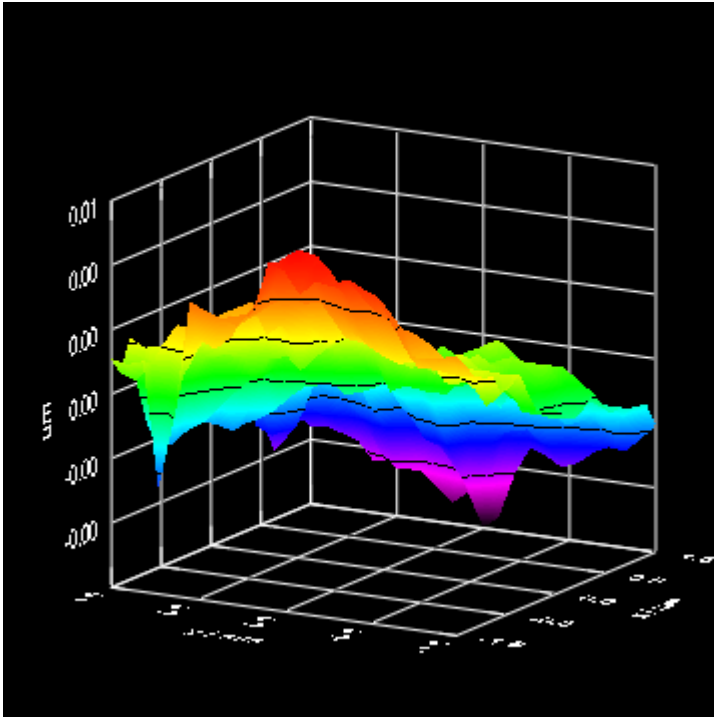
G. R. Plateau,^{a)} N. H. Matlis, C. G. R. Geddes, A. J. Gonsalves, S. Shiraishi, C. Lin, R. A. van Mourik, and W. P. Leemans^{b)}
LOASIS Program, Lawrence Berkeley National Laboratory (LBNL), 1 Cyclotron Road, Berkeley, California 94720, USA



Transverse Diagnostics

Testing the wavefront sensor

Collimated beam into WFS

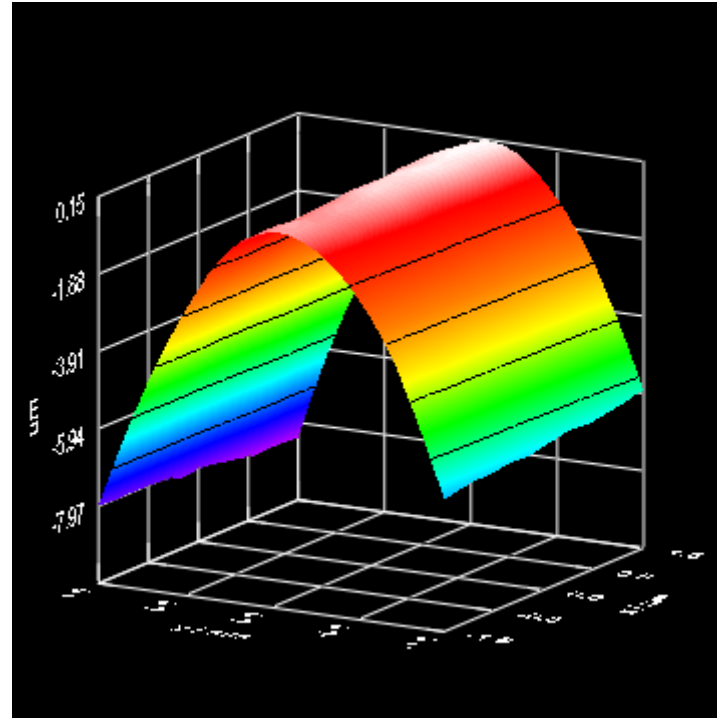
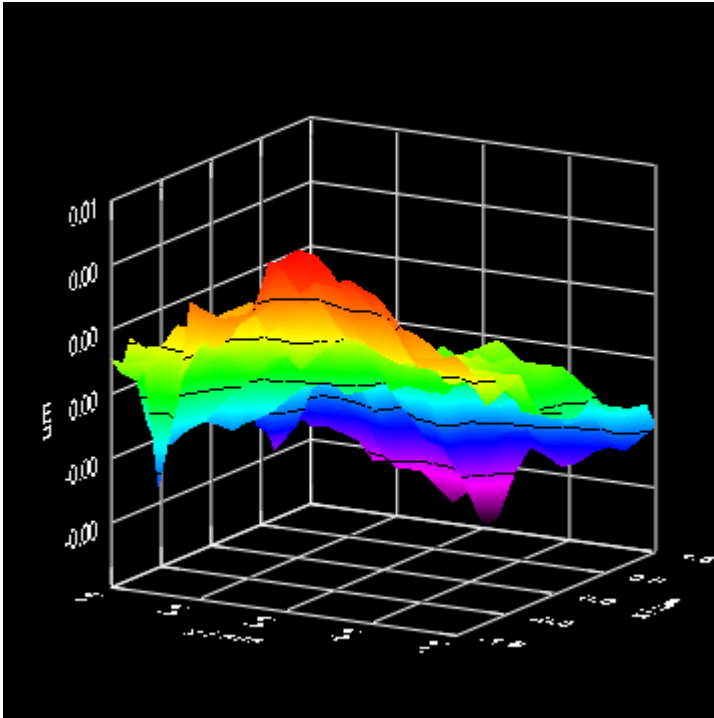


Transverse Diagnostics

Testing the wavefront sensor

Collimated beam into WFS

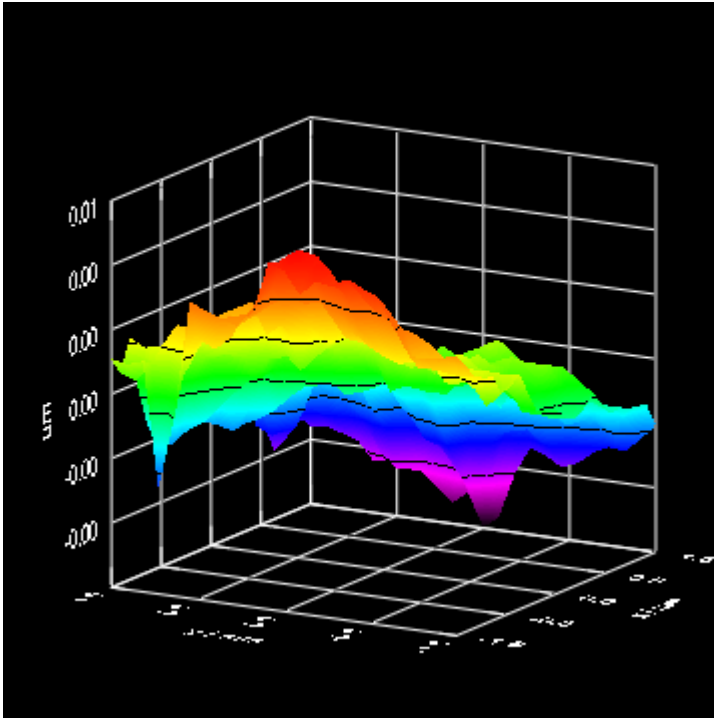
Beam passing through tube



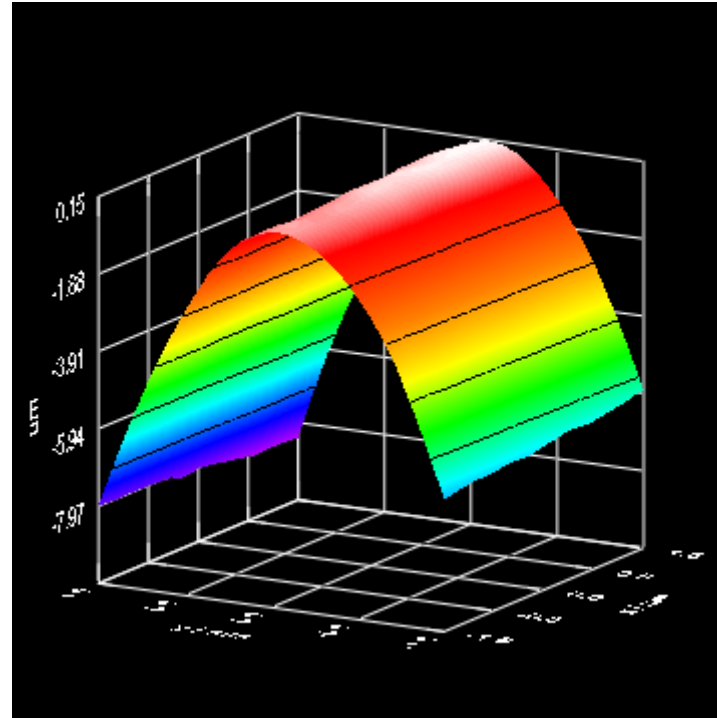
Transverse Diagnostics

Testing the wavefront sensor

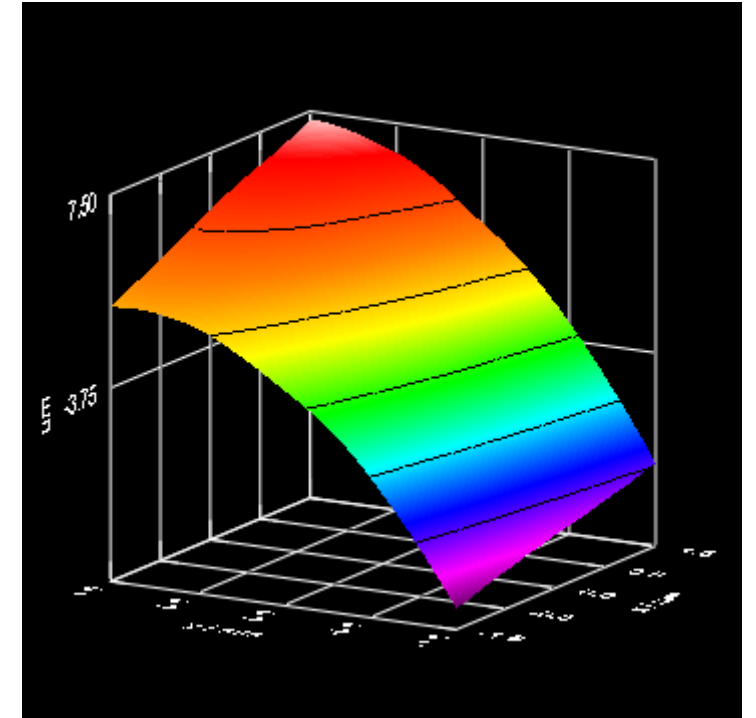
Collimated beam into WFS



Beam passing through tube



Beam passing through tube and $f = 190$ mm cylindrical lens



DPS diagnosis summary

Longitudinal interferometry demonstrated
for 1 m DPS

- $n_e \sim 10^{20} \text{ m}^{-3}$
- Sensitivity measurements and optimisation are in progress

Transverse deflectometry is planned and
implementation is under development

Improvements of the discharge switch are
underway

