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Development of a Density-Tapered Gas Cell for Laser Wakefield Acceleration

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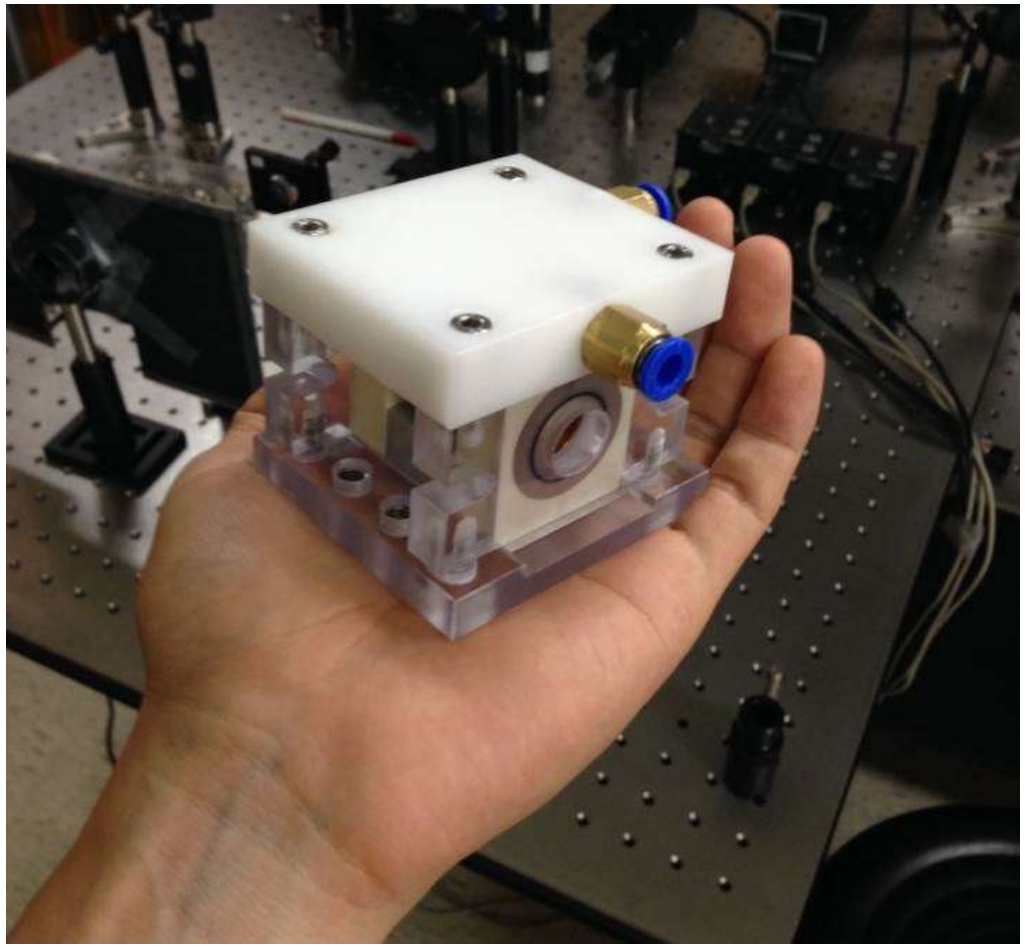
Gas Jet, Discharge Capillary, Gas Cell

- **Gas jet**
  - pros : simple and easy to use
  - cons : shock wave, nonuniform density, diffraction

- **Discharge capillary**
  - pros : optical guiding
  - cons : unstable, difficult to align

- **Gas cell**
  - pros : stable, rather uniform density
    - ➔ density-tapered gas cell along the longitudinal direction to suppress the dephasing problem
  - cons : diffraction
    - ➔ relativistic self-focusing using a high-intensity laser beam

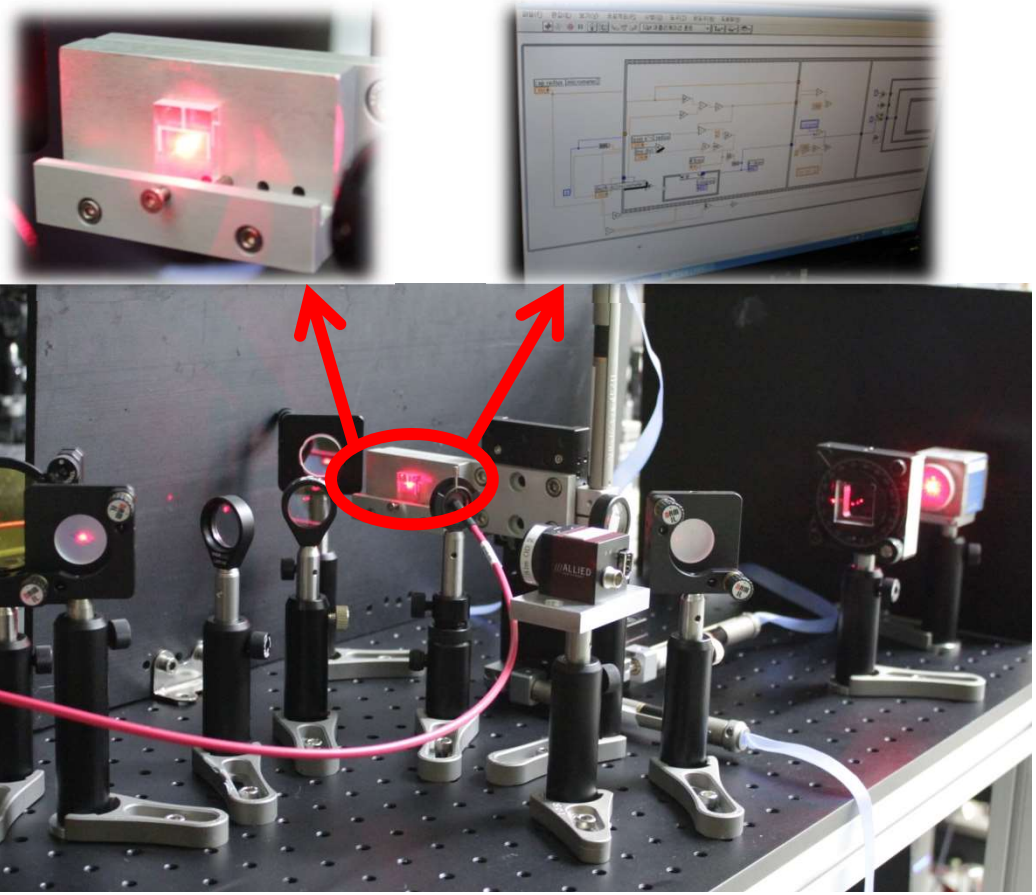
Gas Cell/Discharge Capillary at GIST

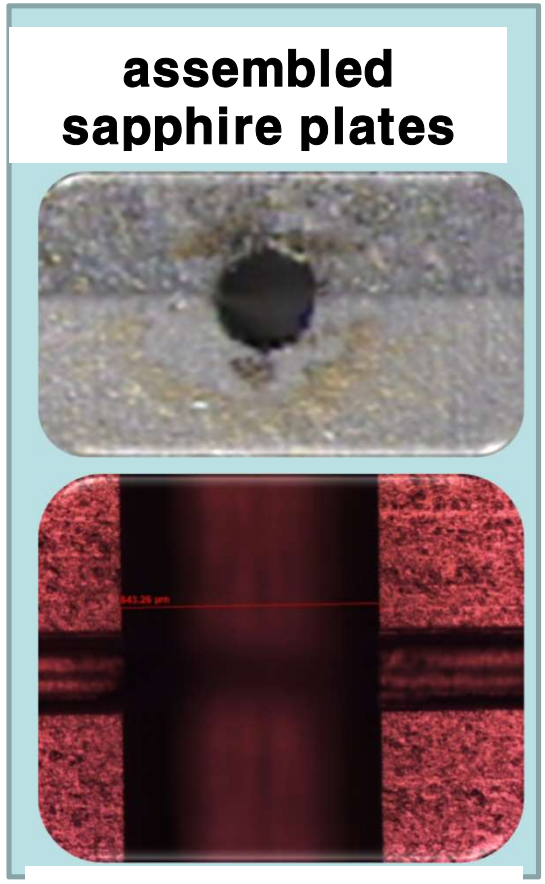


If it is discharged → discharge capillary (plasma waveguide)
If it is not discharged → gas cell

fs Laser Micro-machining

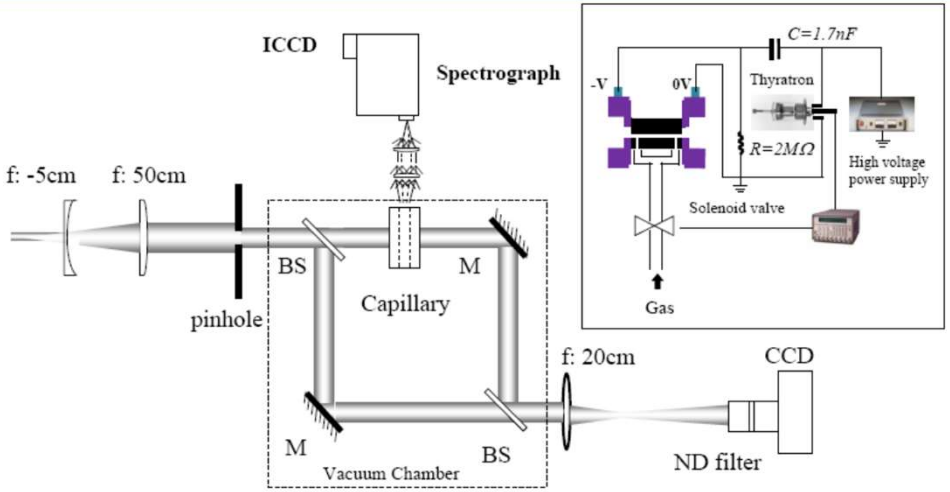
LabView controller



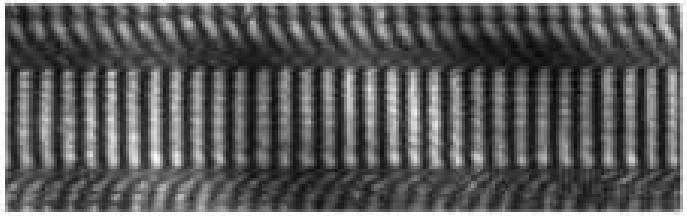


micro-machined
sapphire

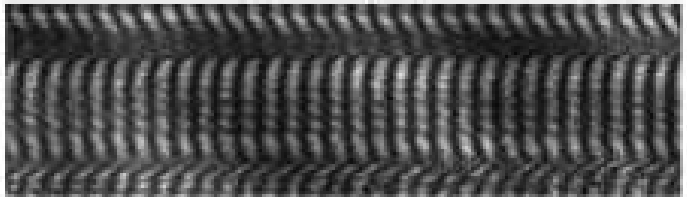
Plasma Density Measurement in a Discharged Capillary

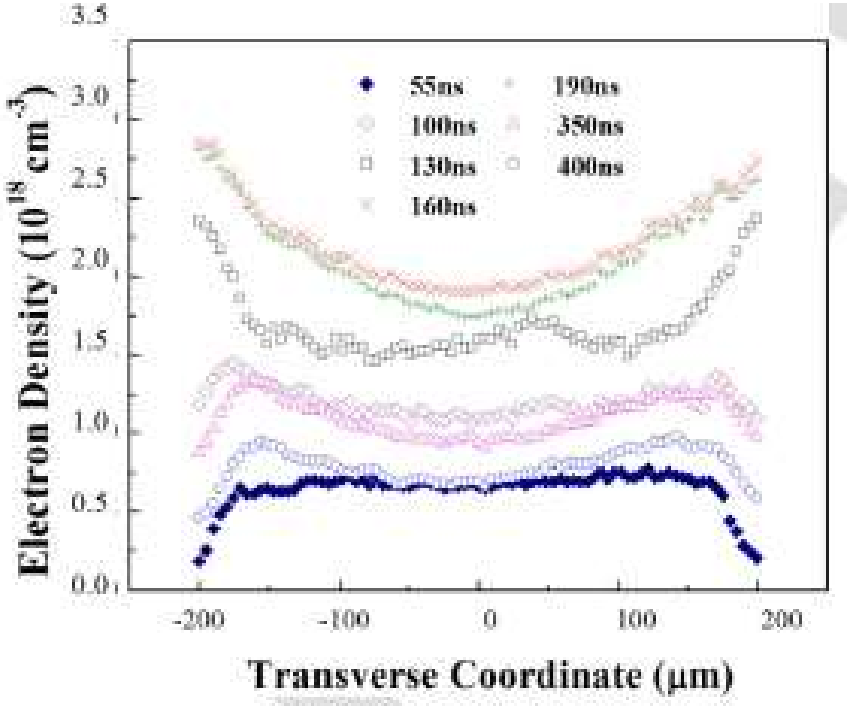


no discharged fringe pattern

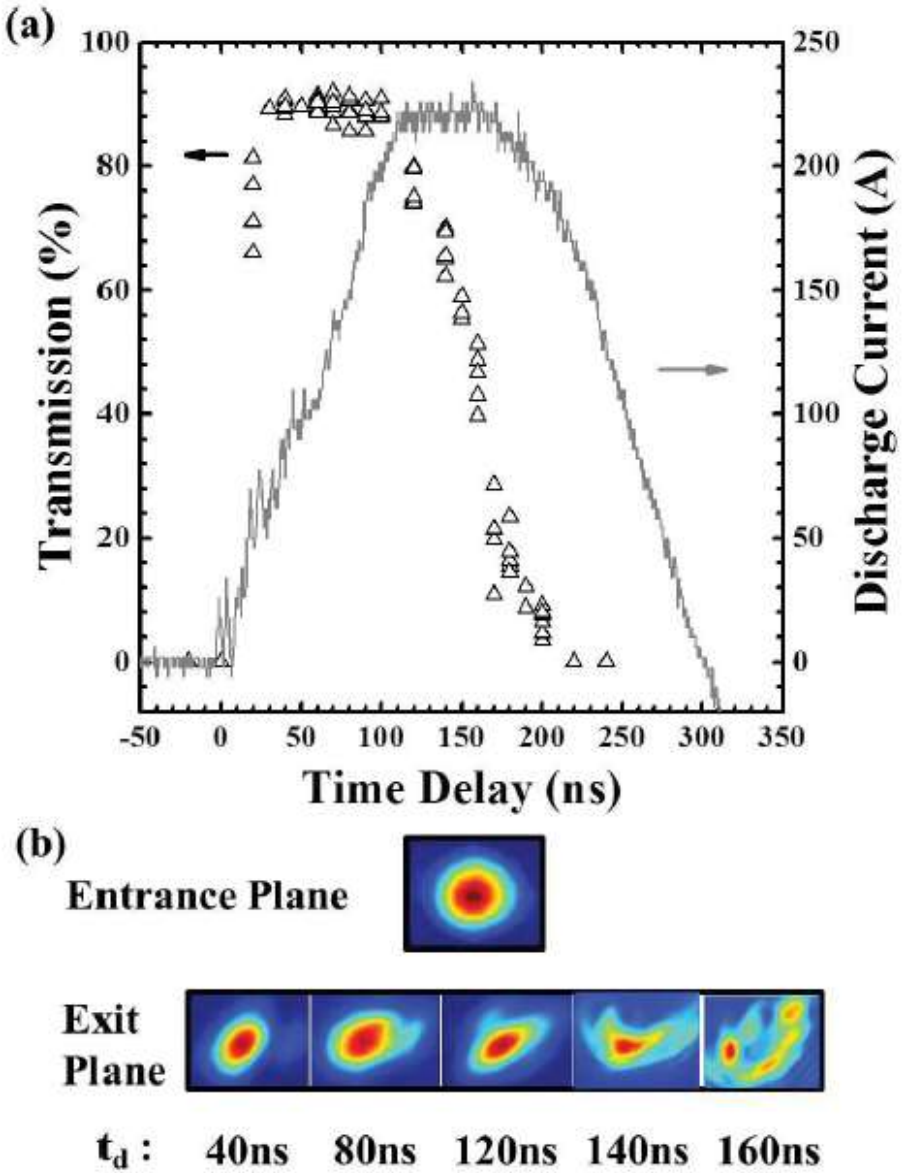


discharged fringe pattern



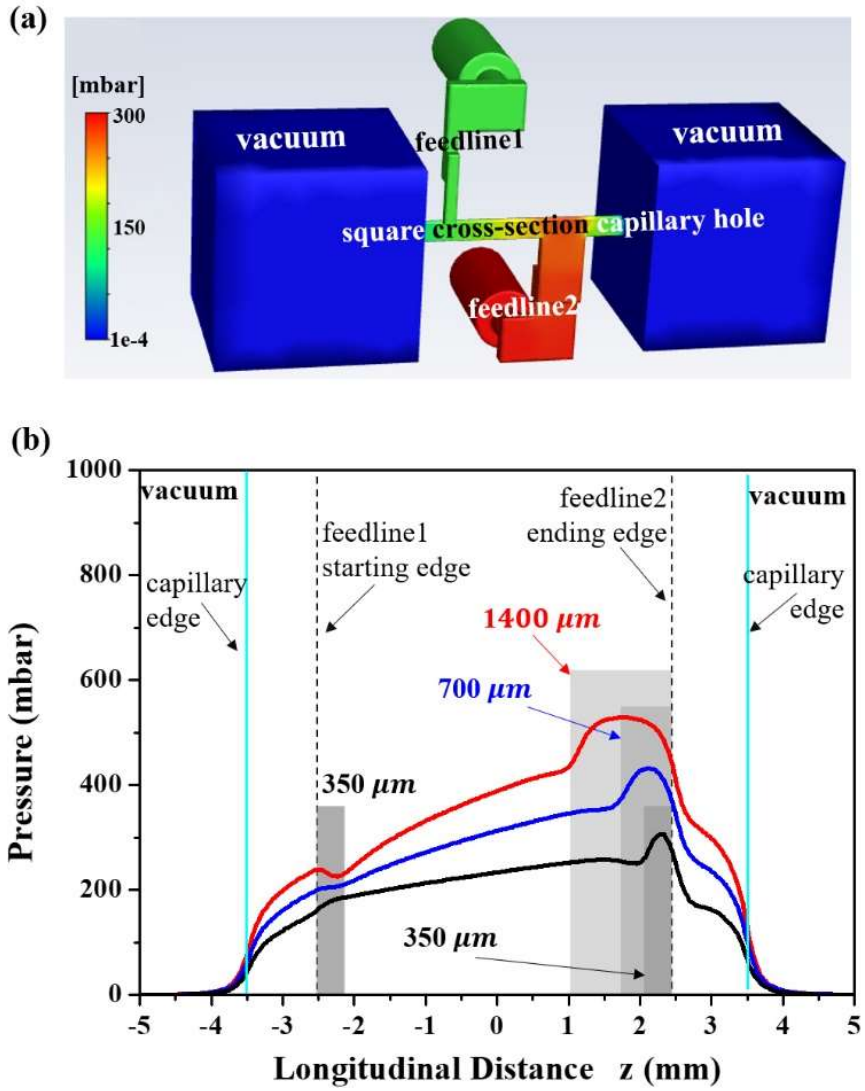


Transmission with a Discharge Capillary

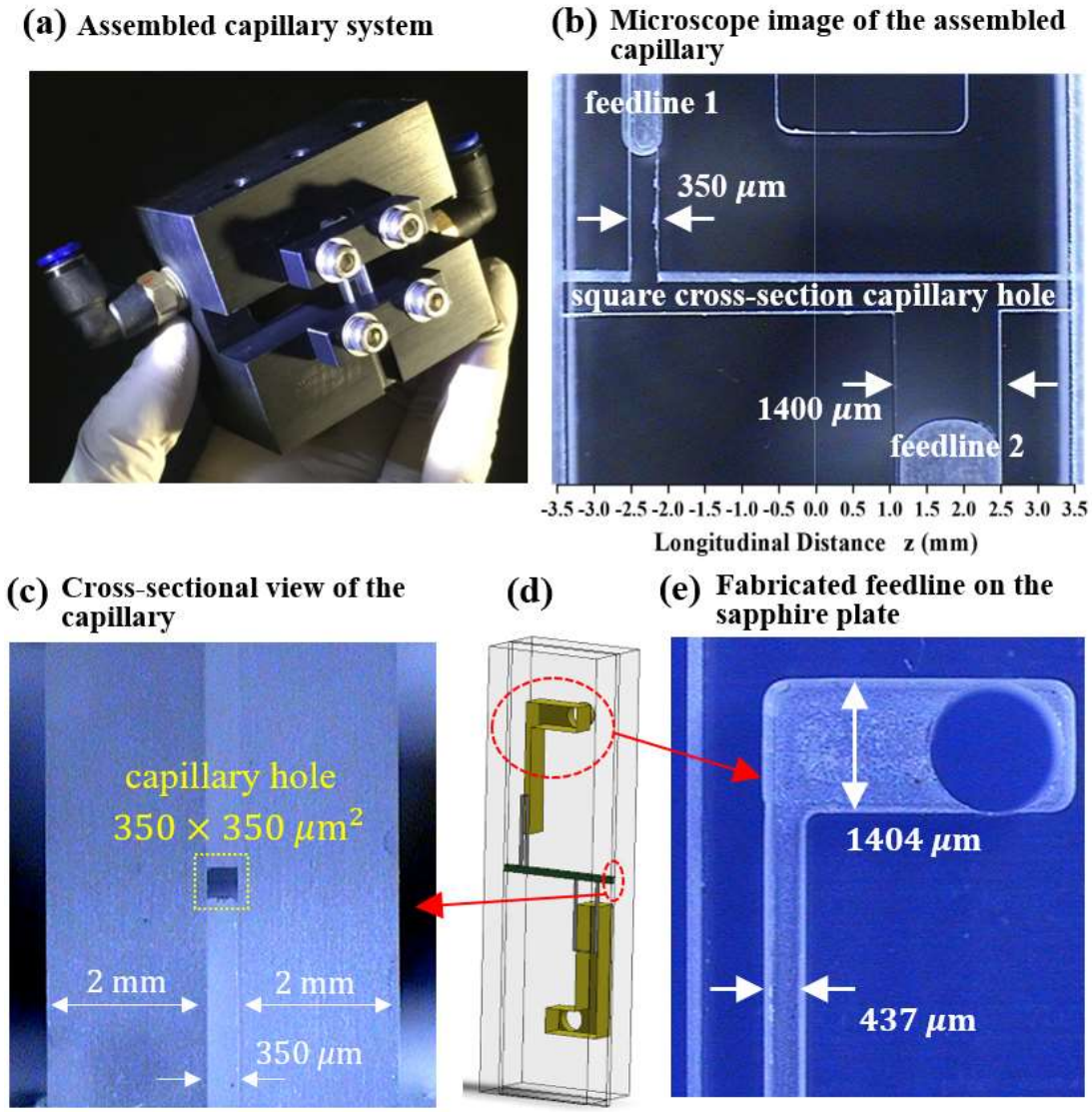


P=150 Torr, HV=2.8 kV
Gas: hydrogen
Capillary length=15 mm

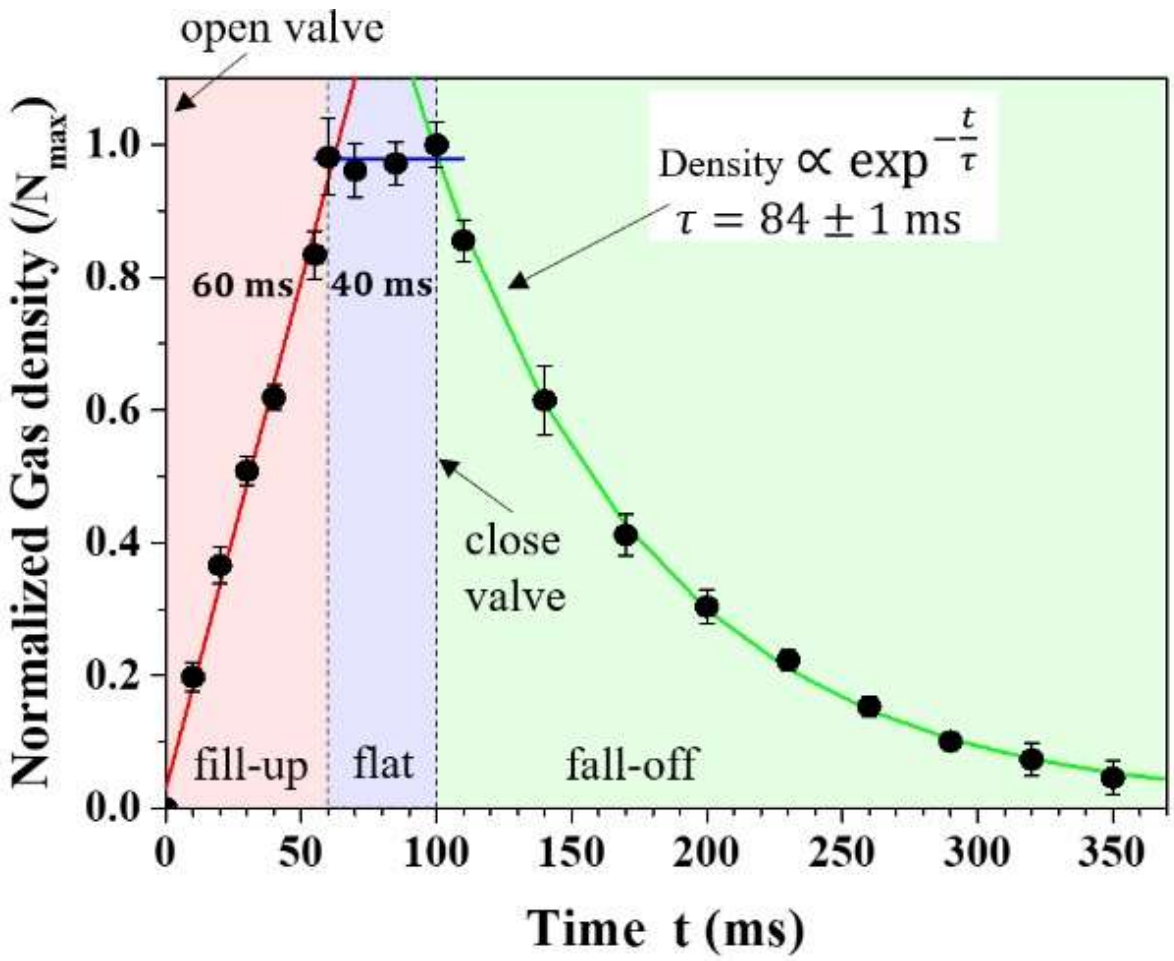
3-D CFD Simulations for Gas Cell Design



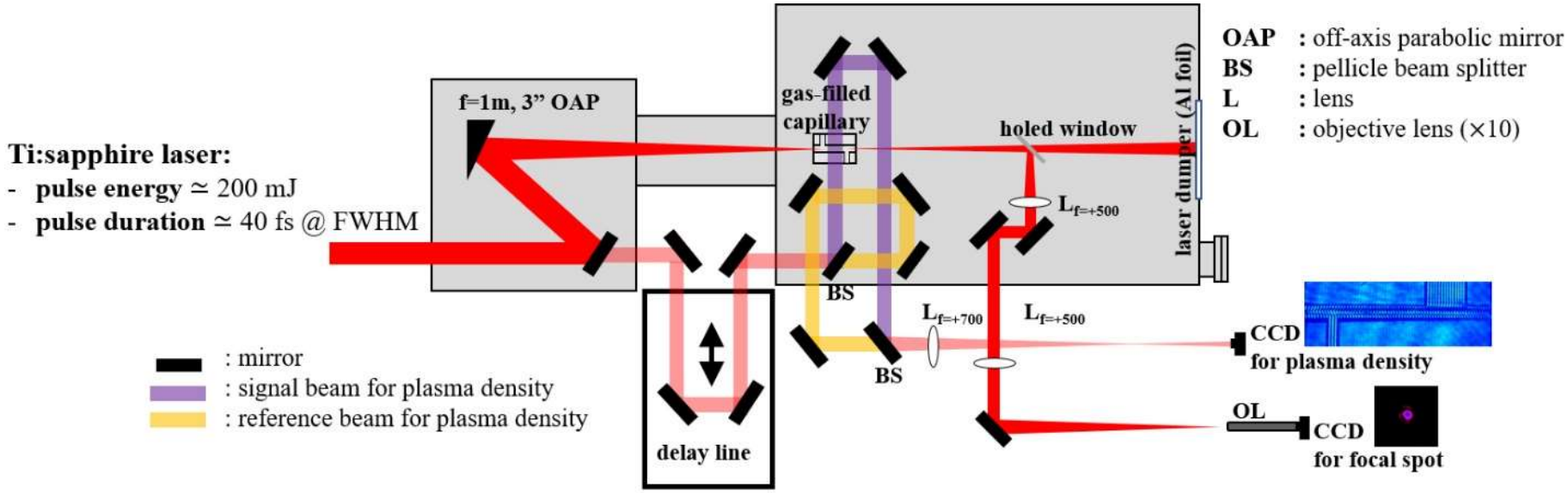
Detailed Pictures of the Capillary Gas Cell



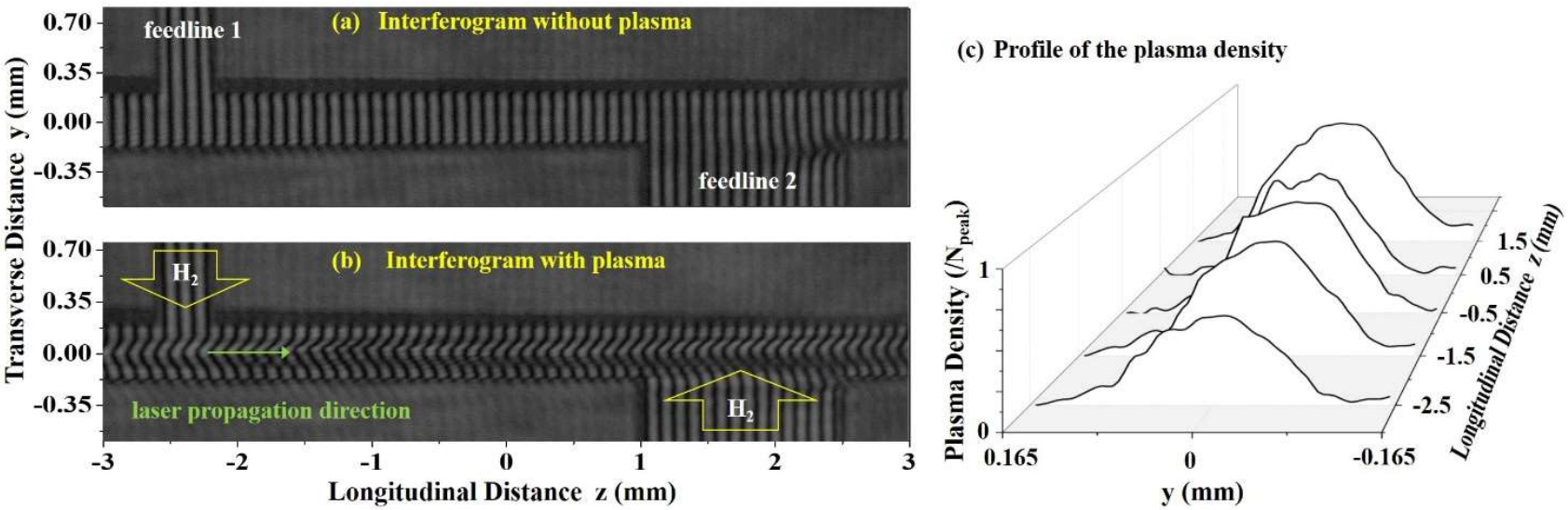
Gas Density Temporal Evolution in the Gas Cell



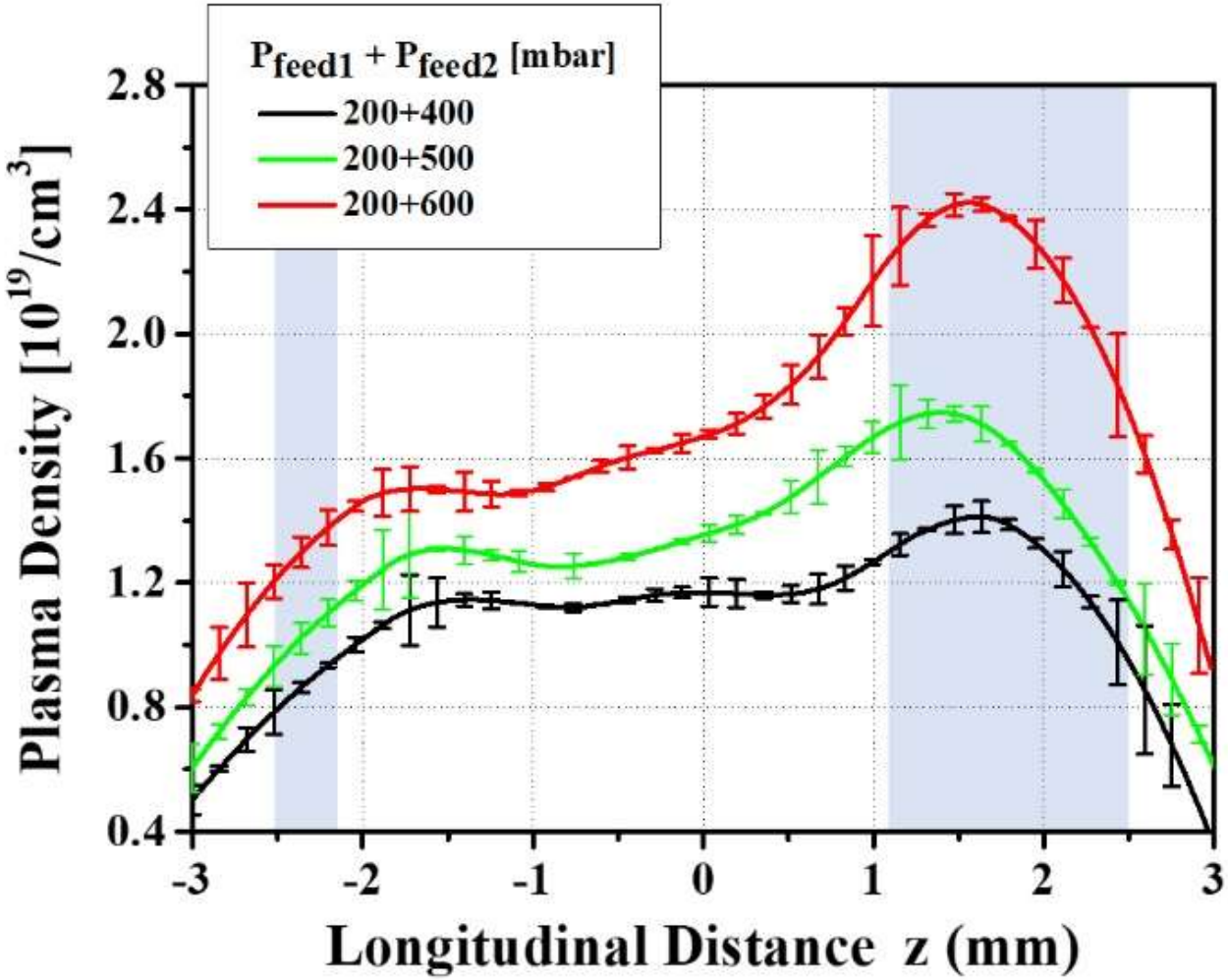
Setup for Plasma Density Measurement in the Gas Cell



Plasma Density Measurement in the Gas Cell

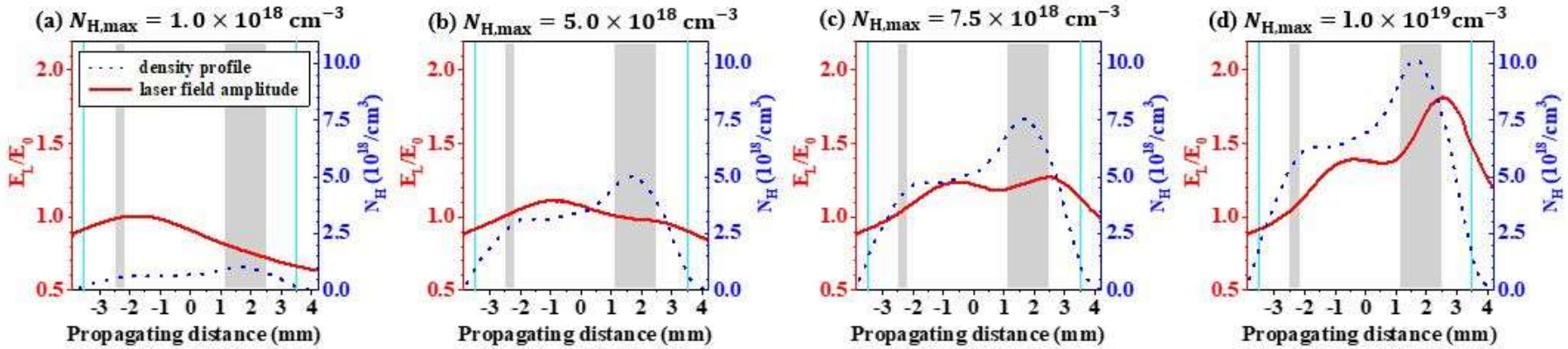


Longitudinal Plasma Density Profile

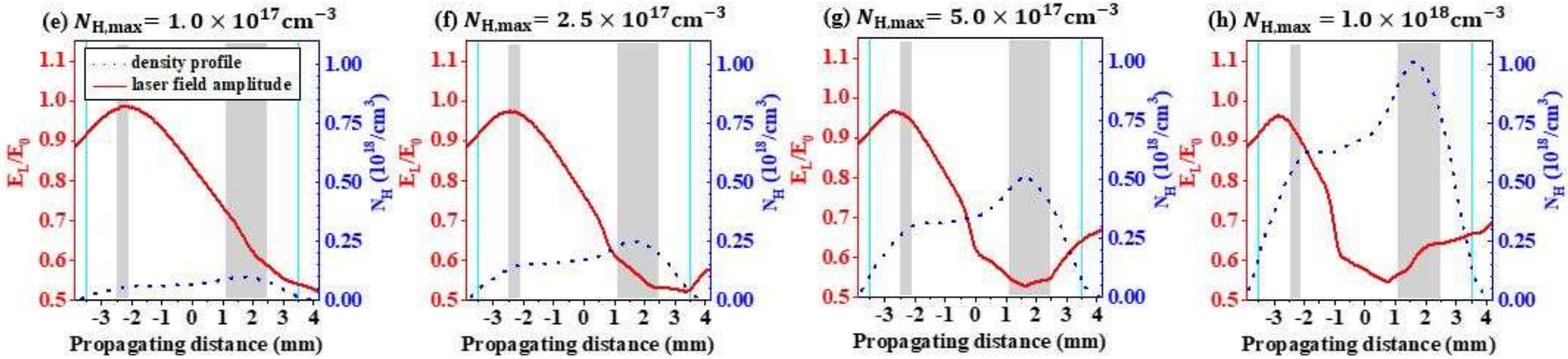


Propagation of the Laser Pulse in the Gas Cell

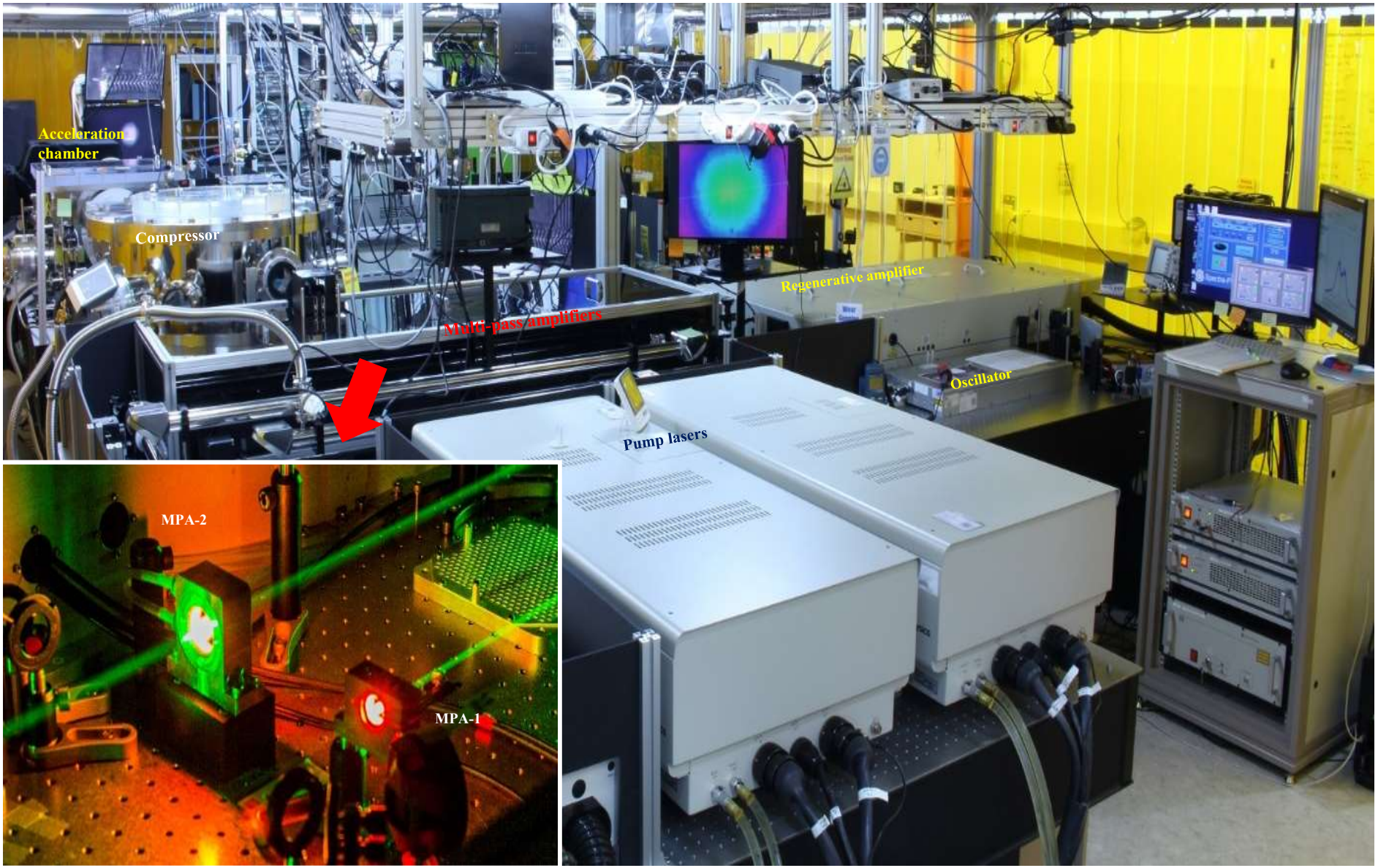
(i) High intensity, $I_0 = 4 \times 10^{17}$ W/cm^2



(ii) Low intensity, $I_0 = 2.5 \times 10^{14}$ W/cm^2



20 TW/35 fs Ti:S Laser System for LWFA



Conclusions

- A density-tapered gas cell was developed successfully and its detailed characteristics were studied

- It can be used for LWFA, radiation sources (X-rays) and other purposes