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Metrology Tools for Characterization and Control of a Laser Plasma EUV Source Based on a Gas Puff Target

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In the paper various metrology tools for the spectral, spatial, and temporal characterization of a laser plasma EUV source, developed in the frame of the EUV sources development project under the MEDEA+ programme, are presented. The source is based on a gas puff target approach [1,2]. To measure the spectral characteristics of EUV emission two grating spectrometers have been developed. The reflection grating spectrometer equipped with the varied line-spacing grating (Hitachi) and the back-illuminated camera CCD camera (Roper) allows to measure EUV spectra with relatively high resolution. The transmission grating spectrograph with the 1000 line/mm grating in a pinhole (Heidenhaim) and the back-iluminated CCD (Reflex) can be used for the spatial characterization of the source. The detection systems based on the absolutely calibrated semiconductor detectors (IRD) are used for the temporal measurements of EUV pulses and the absolute measurements of EUV production. Results on characterization measurements of the laser plasma EUV source using the developed instruments are presented.

1. H. Fiedorowicz, A. Bartnik, P. Parys, Z. Patron, Appl. Phys. Lett. **62**, 2778 (1993)
2. H. Fiedorowicz, A. Bartnik, R. Jarocki, R. Rakowski, M. Szczurek, Appl. Phys. B **70**, 305 (2000)

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OUTLINE

- INTRODUCTION
  - double-stream gas puff target
  - laser-plasma EUV source
- EXPERIMENTAL ARRANGEMENT
  - model of a laser-plasma EUV source with a double valve system
  - metrology tools to measure EUV emission
- GRATING SPECTROMETERS
  - flat-field spectrometer
  - transmission grating spectrometer
  - EUV measurements
- DETECTION SYSTEMS WITH SILICON PHOTODIODES
  - fast detector
  - monitoring system with the signal registration and data acquisition
  - EUV measurements
- CONCLUSIONS

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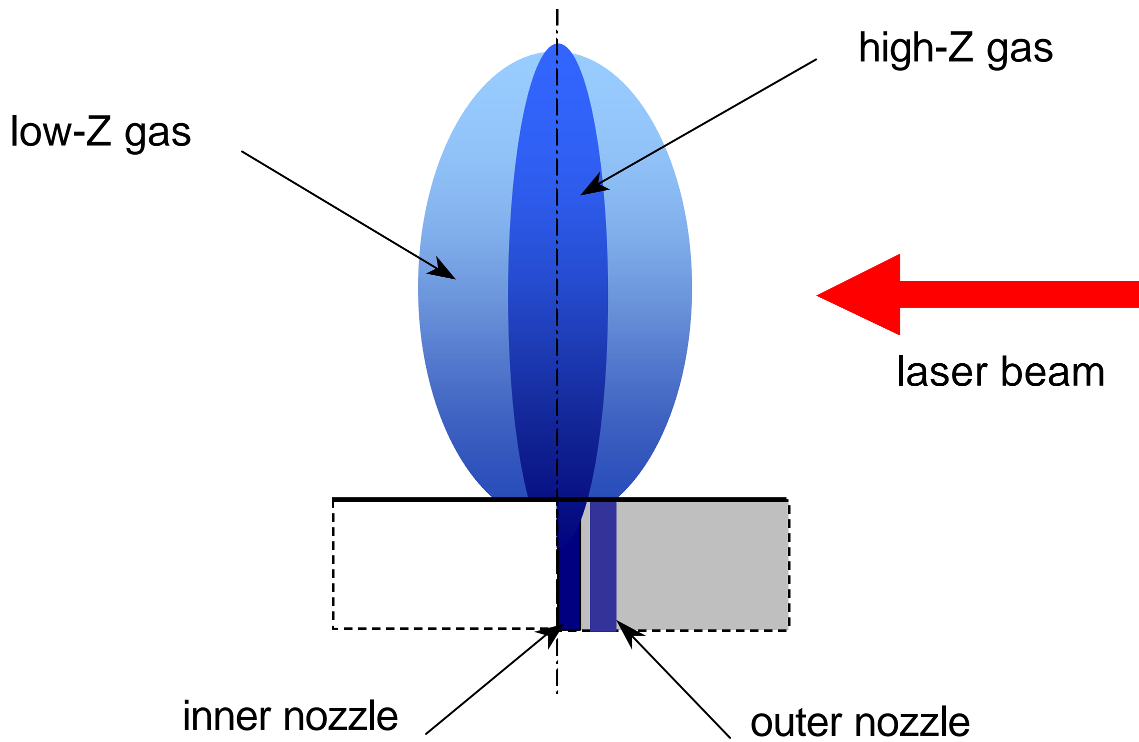
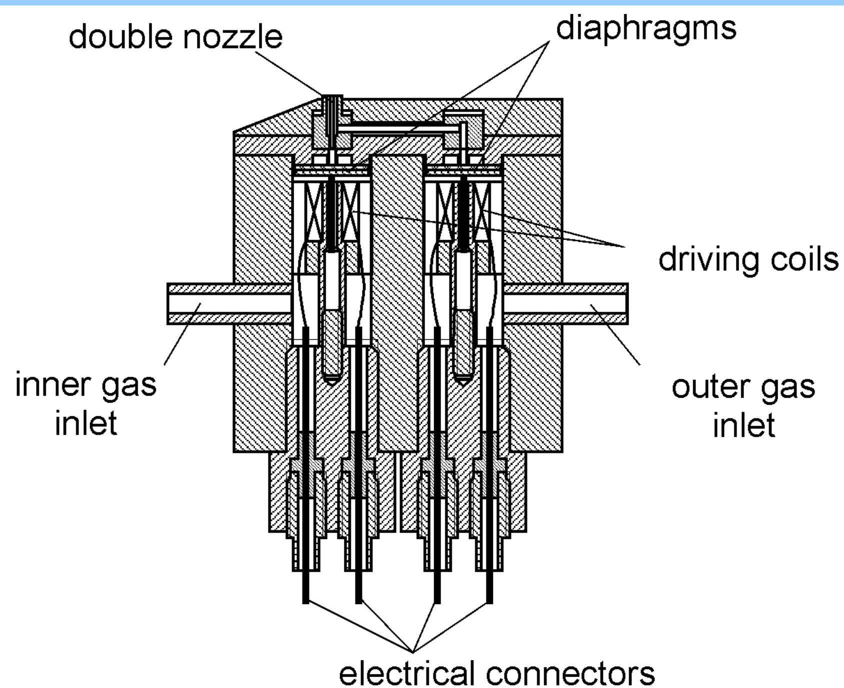
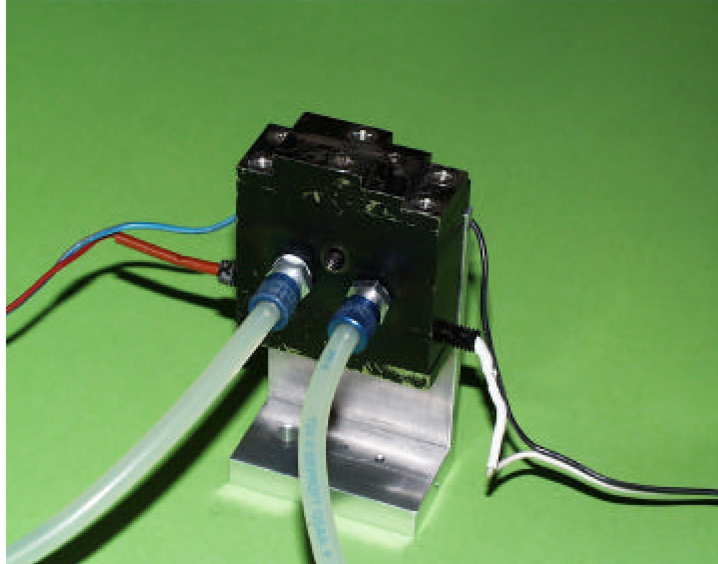
DOUBLE-STREAM GAS PUFF TARGET





DOUBLE-STREAM GAS PUFF TARGET

- valve system to form a double-stream gas puff target



- gas puff valve power supply and synchronization unit

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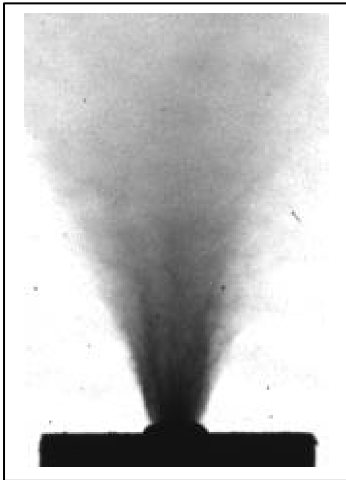
GAS PUFF TARGET CHARACTERISTICS

- x-ray backlighting images

10 bar

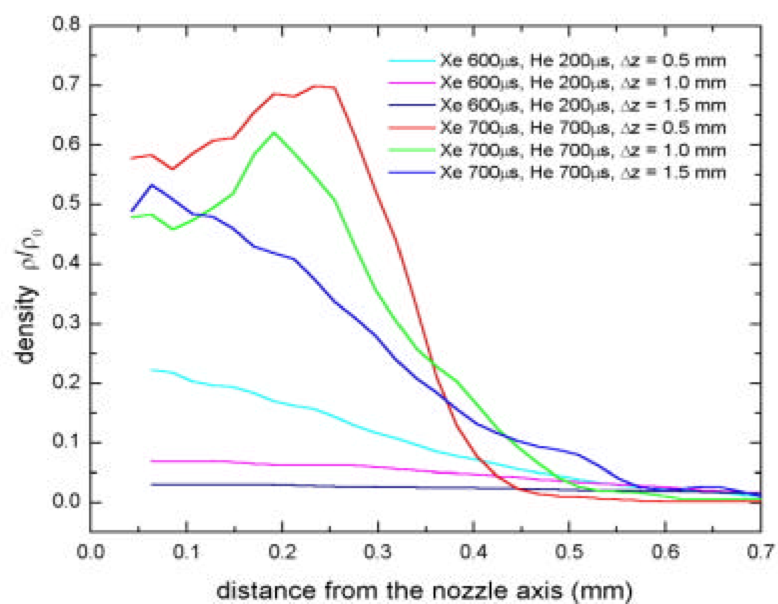


$\Delta t_{Xe} = 800\ \mu s$
$\Delta t_{He} = 400\ \mu s$

$\Delta t_{Xe} = 800\ \mu s$
$\Delta t_{He} = 800\ \mu s$

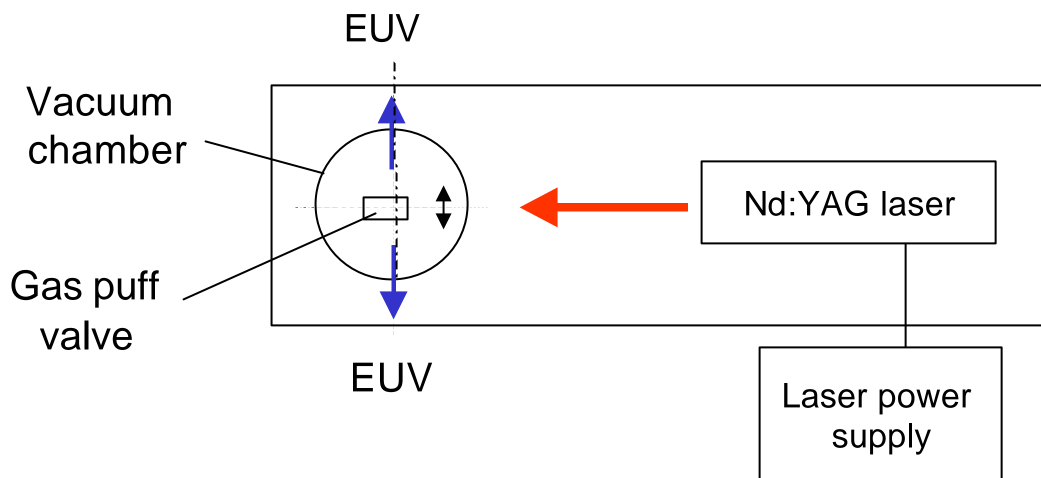
$\Delta t_{Xe} = 600\ \mu s$
$\Delta t_{He} = 600\ \mu s$

- gas density profiles

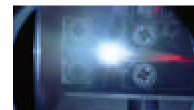


LASER-PLASMA EUV SOURCE

- schematic of the source



- laboratory model of a laser-plasma EUV source



plasma produced with a gas puff target

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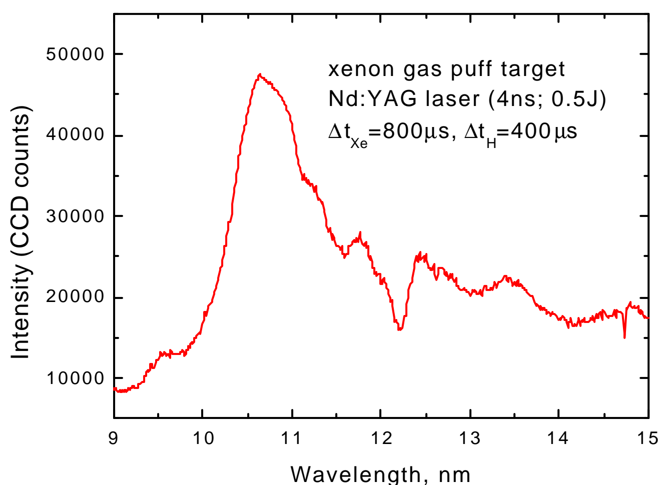
REFLECTION GRATING SPECTROMETER

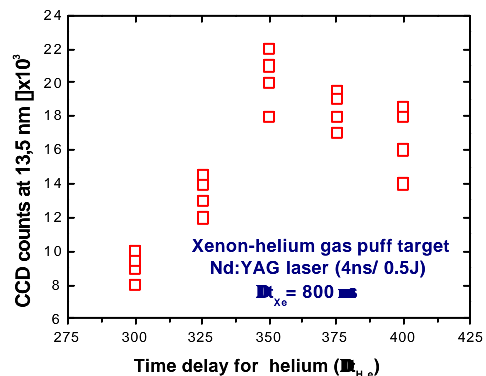
- flat-field spectrometer with a 1200 line/mm Hitachi grating

1200 l/mm grating (Hitachi)

back-illuminated CCD camera (Roper)

- EUV spectral measurements for xenon targets





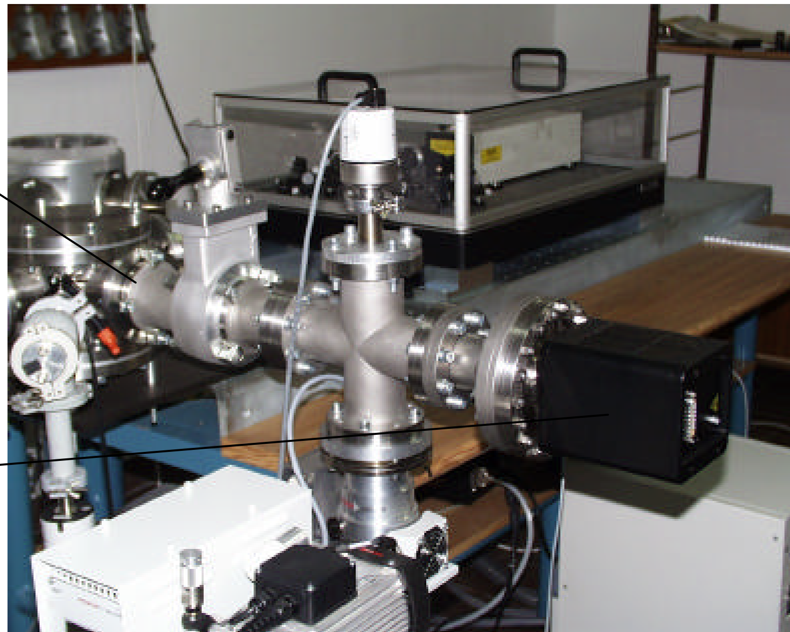
Dependence of EUV production at 13.5 nm on the time delay of the helium valve for the optimum time delay for the xenon valve

TRANSMISSION GRATING SPECTROMETER

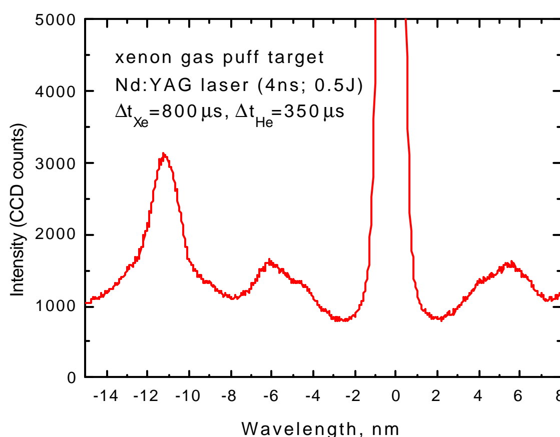
- spectrometer with a 1000 line/mm transmission grating

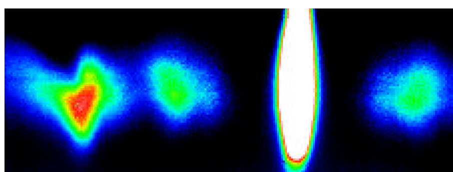
1000 l/mm grating in a pinhole (Heidenhain)

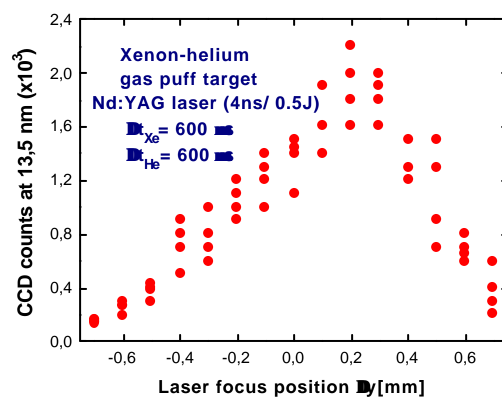
back-illuminated CCD camera (Roper)



- EUV spectral measurements for xenon targets



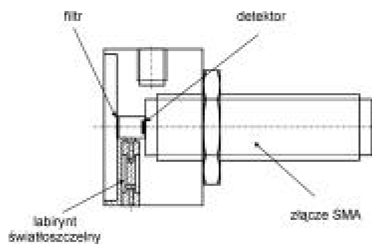


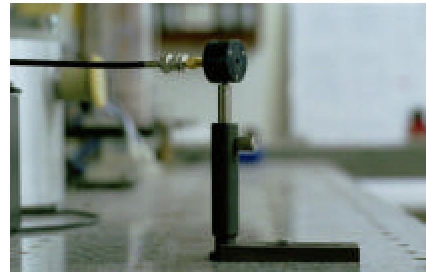


Dependence of EUV production at 13.5 nm on the position of the laser focus to the nozzle output

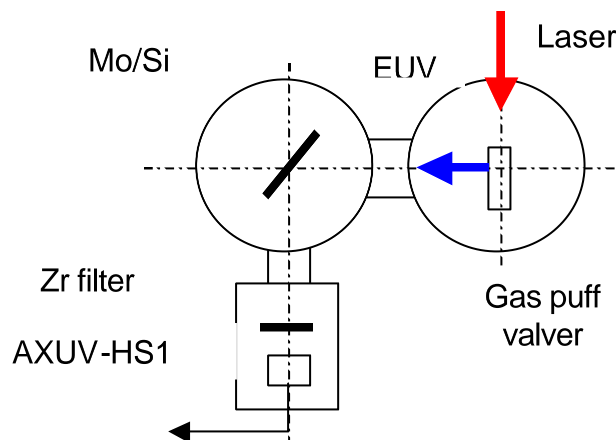
FAST SILICON PHOTODIODES

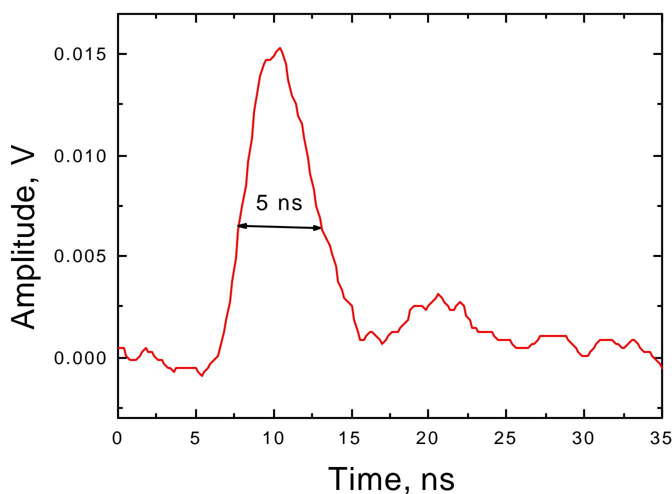
- detection head with the AXUV-HS1photodiode (IRD)





- experimental setup to measure EUV pulses





Measured EUV yield at 13.5 nm

8.7×10^{13} ph/sr
$E_{EUV} = 8$ mJ/2π
$\eta = 1.6\%$

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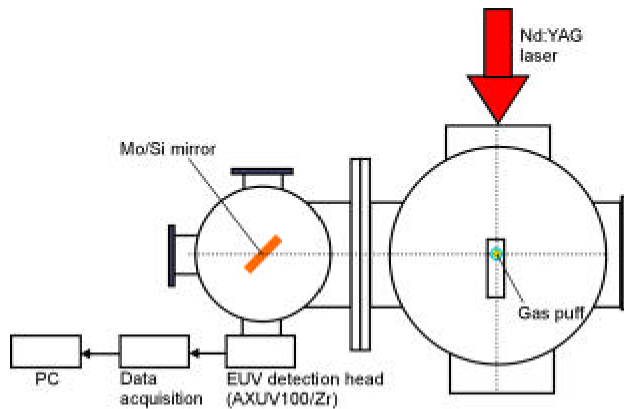
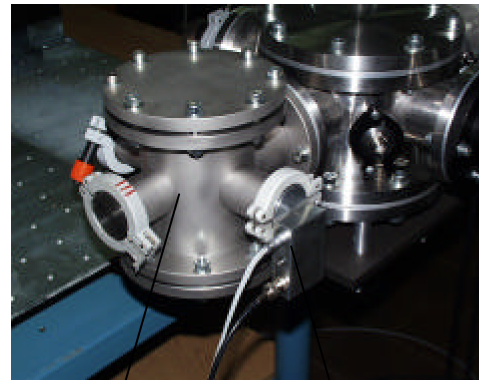
EUV MONITORING SYSTEM

Schematic of the EUV monitoring system





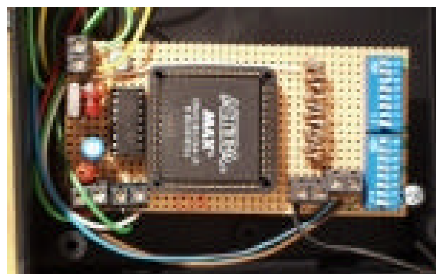
Detection head

Mo/Si mirror

Detection head

Data acquisition and processing system

Trigger circuit



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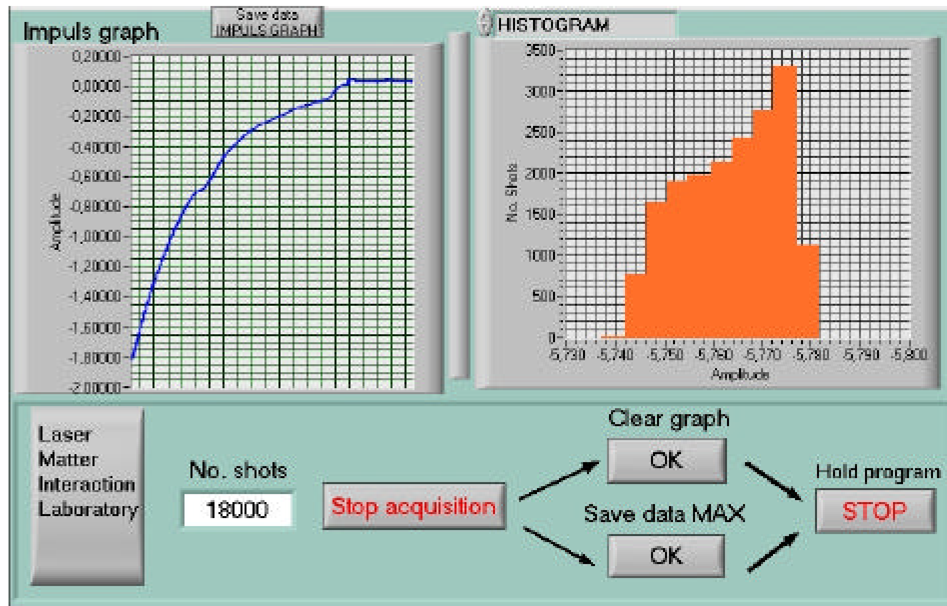
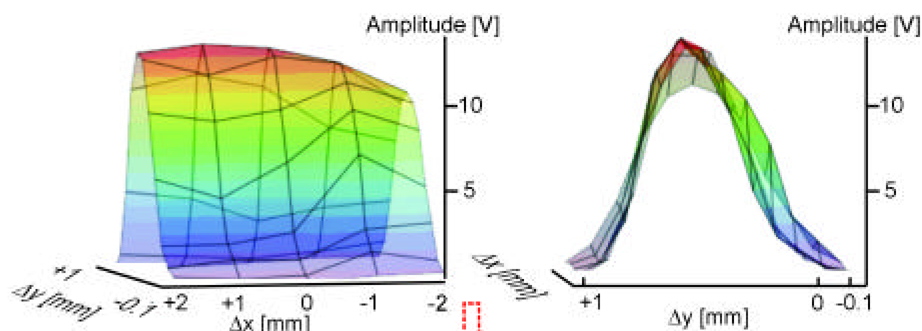
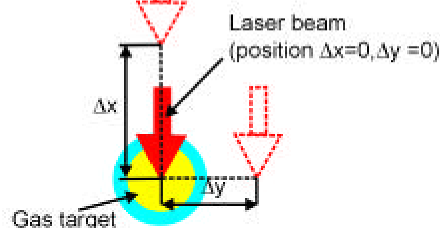
MONITORING OF EUV EMISSION

Control panel of the EUV monitoring system



EUV emission measurements





Measured EUV yield at 13.5 nm

5.3×10^{13} ph/sr

$E_{EUV} = 5$ mJ/2π

η = 1%