COST MP0601

Short Wavelength Laboratory Sources

Summary of WG3 activities

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Paris November 2011

INTEGRATED SYSTEMS

EUV-XUV-SXR-HXR Laboratory Sources

X-ray tube, Laser plasma, Capillary Discharge plasma, Gas-Puff plasma, Other Plasma, Liquid Metal Jet plasma, Inverse Compton Scattering, HHG, Coherent, Non Coherent,

EUV-XUV-SXR-HXR Optics and Optical Systems

Reflective – Grazing Incidence Single Bounce and Multi Bounce, Polycapillaries, Multilayer Structures
Refractive – Compound Lenses
Diffractive – Gratings, Fresnel Lenses, Bragg-Fresnel Lenses, Crystals
Imaging, Non Imaging

EUV-XUV-SXR-HXR Detectors

Number of Pixels, Time resolution, Space resolution, Spectral Range, Sensitivity, Gas, Electron Multiplication, Semiconductor, Scintillator

WG3 Summary Paris 2011

WG 3. Integrated Systems: Sources, Optics and Detectors

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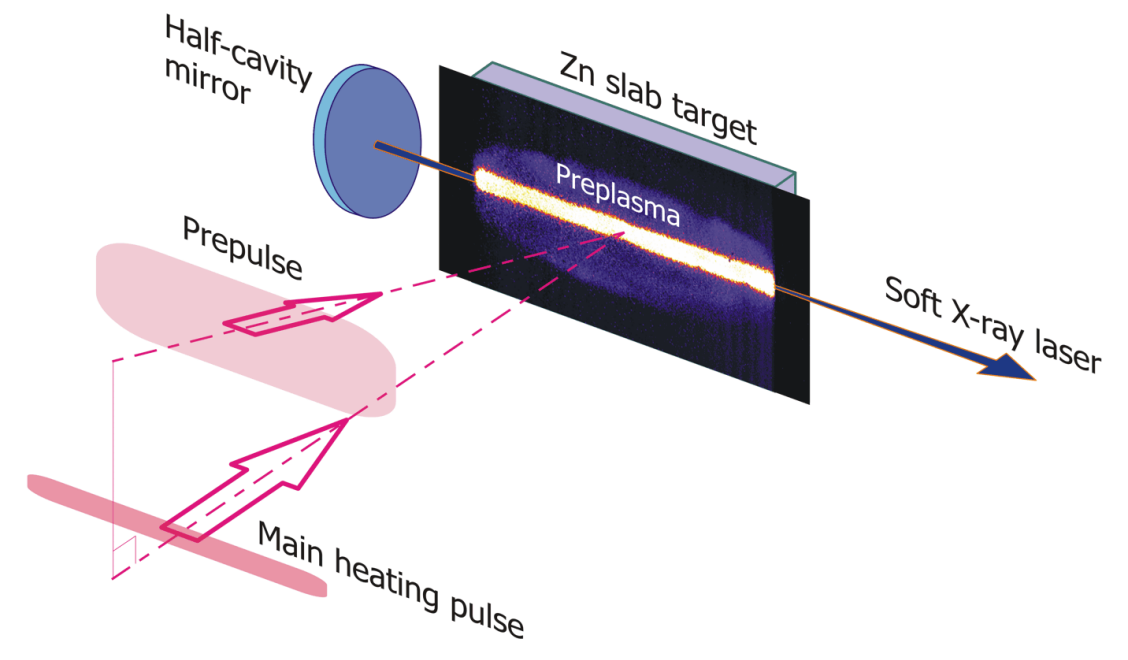
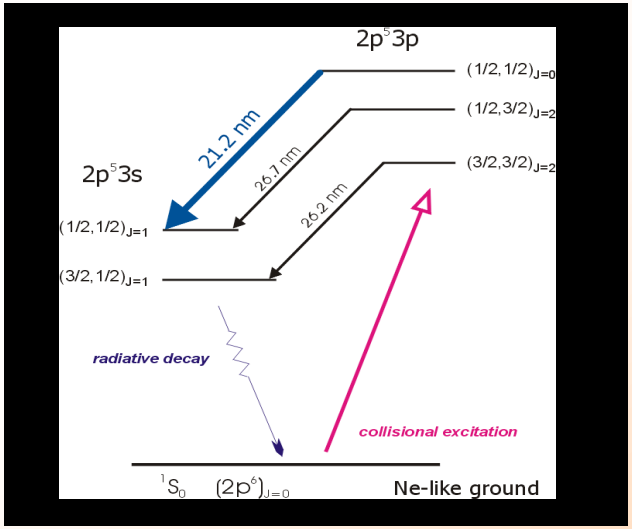
Ne-like collisionally pumped zinc soft X-ray laser



Ne-like zinc Grotrian



Pump: 300-ps laser pulses, wavelength 1.3 μm

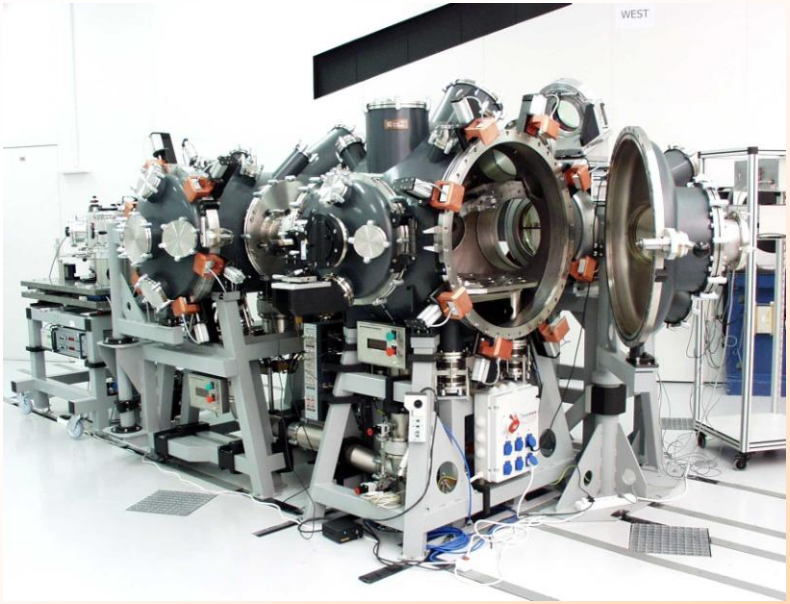
Weak prepulse (<10^{11} Wcm^{-2}) applied 10 or **50 ns** ahead of the main pulse

Main pulse produces ~4x10^{13} Wcm^{-2}

Hydrodynamics / atomic kinetics of plasmas produced by two laser pulses separated by very long delay is largely unexplored

PALS iodine laser facility

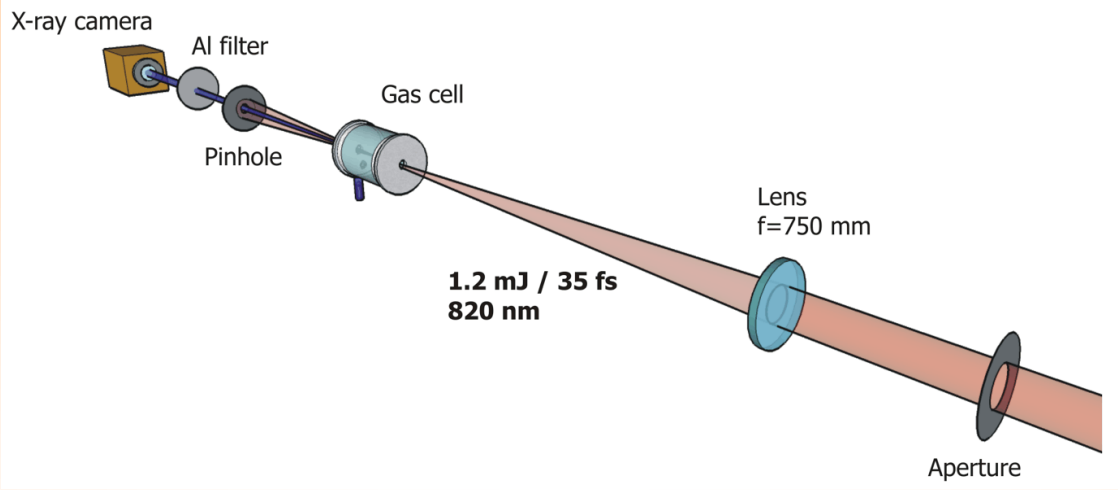
1kJ/1.3um/300 ps available in one main + 2 aux beamlines



- "standard" facility for laser-matter interaction experiments
- programmatic user applications of multi-mJ soft X-ray laser

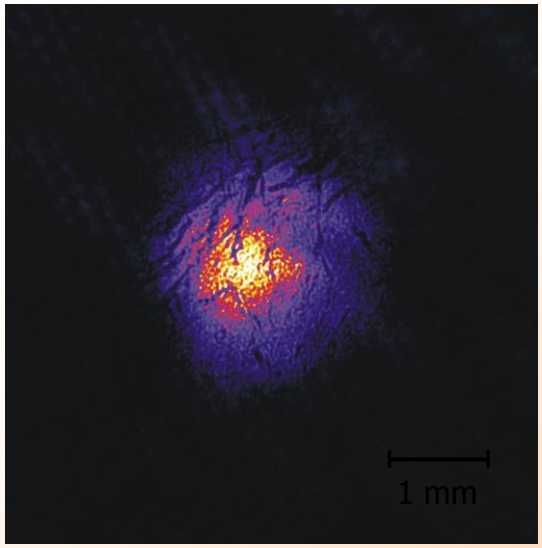
HHG generation using Ti:Sapph front end @ 1 kHz

Experimental setup



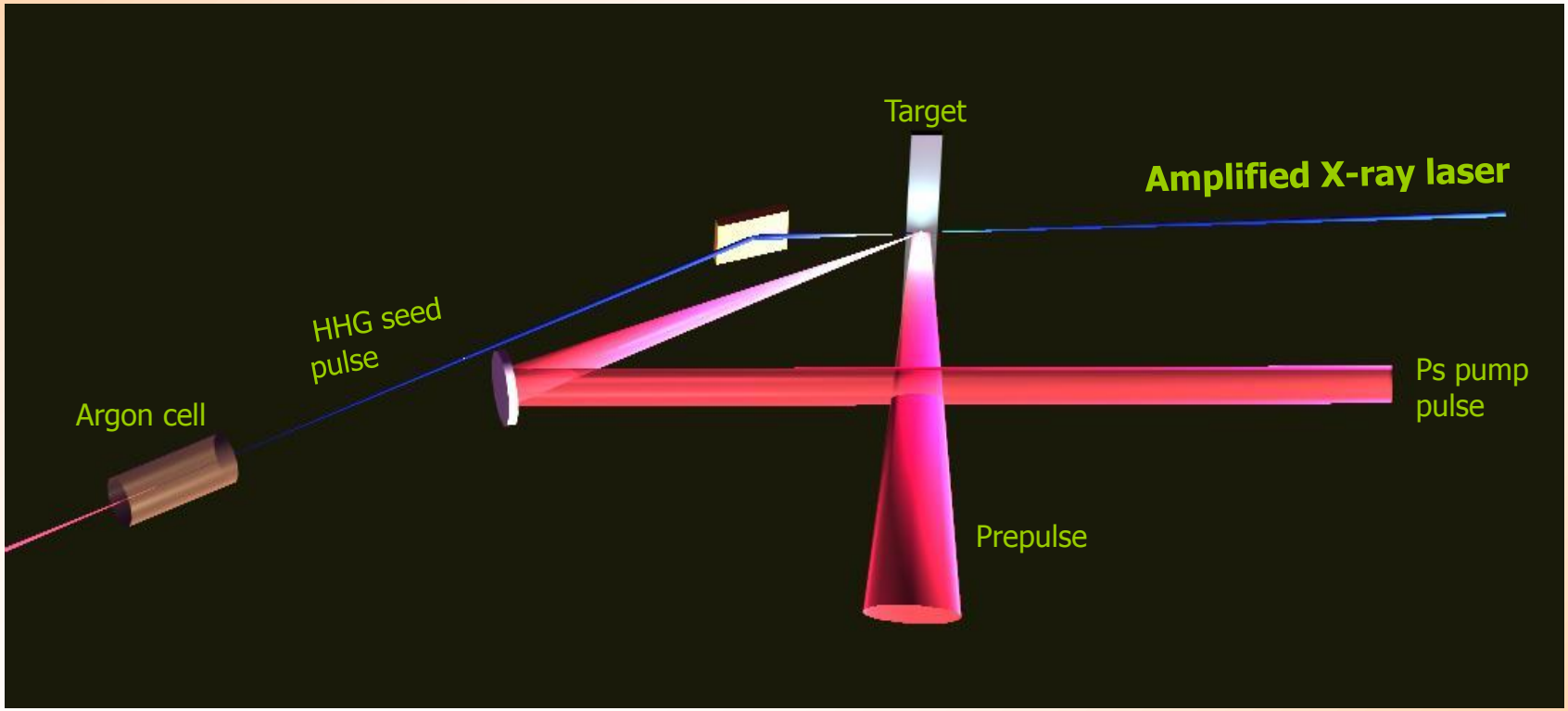
HHG beam footprint

spectrally integrated, λ_c~ 30 nm



40 mbar Ar, 12 mm cell length
~100 shots

Injector – Amplifier scheme

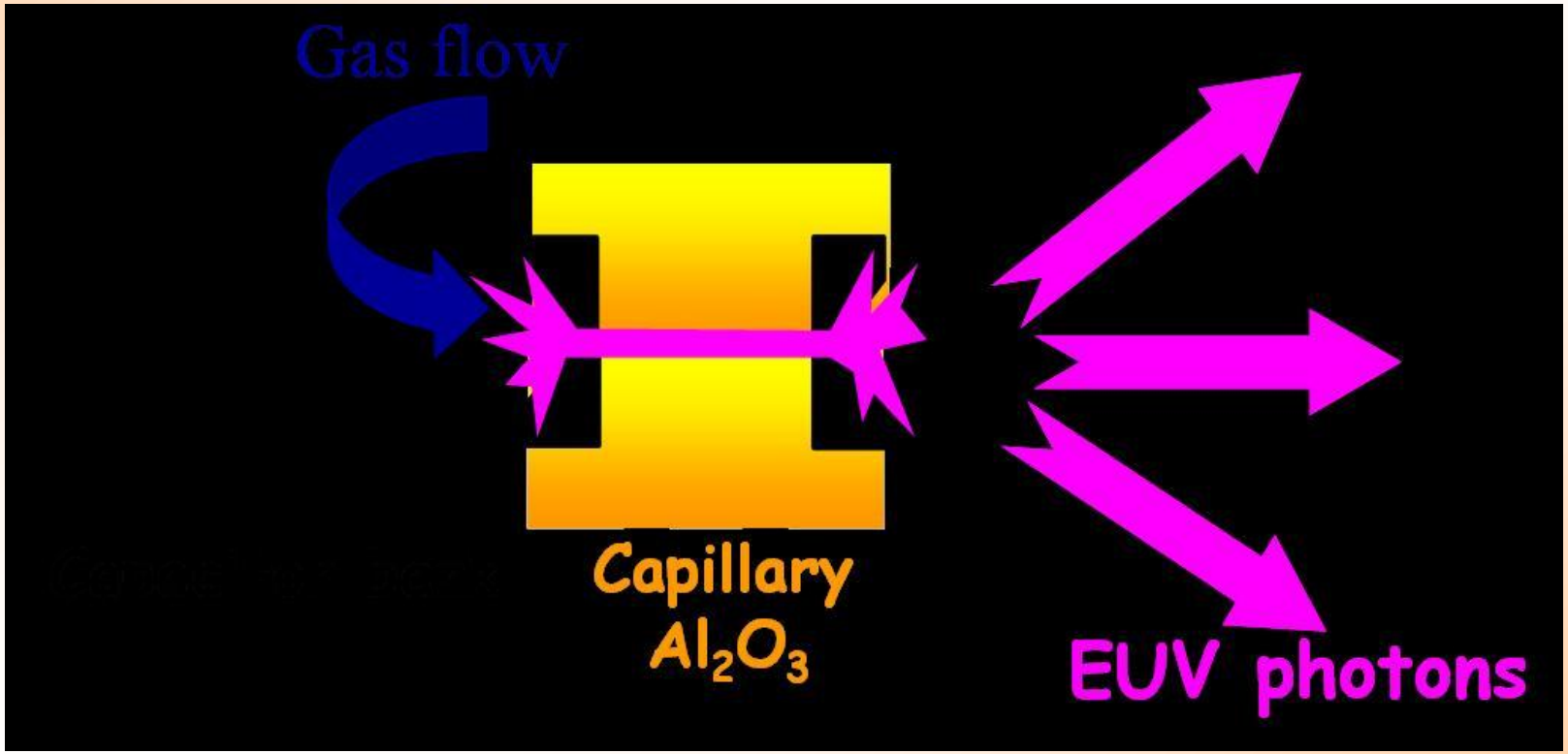


J.J. Rocca, University of Colorado (2006/7)

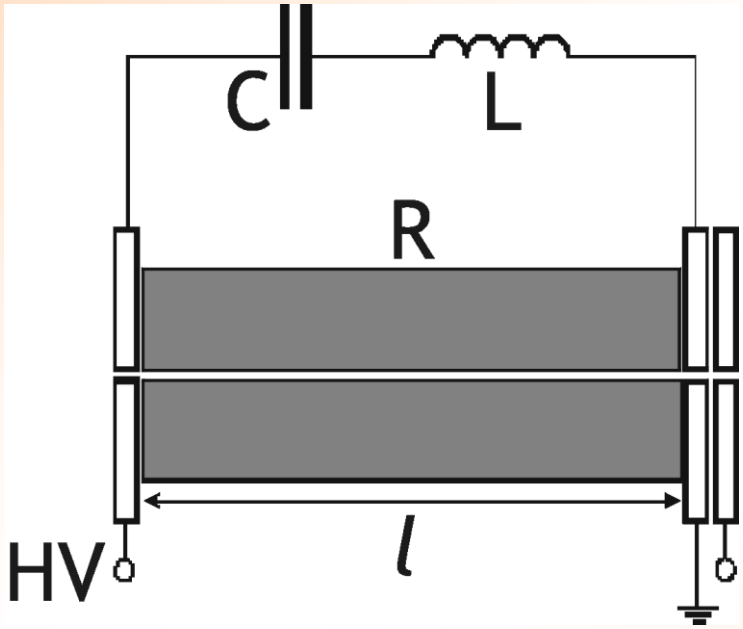
XUV beam features

- nearly 100% space coherence
- low divergence (1 mrad)
- fs pulse

Pinching Capillary Discharge (CD)

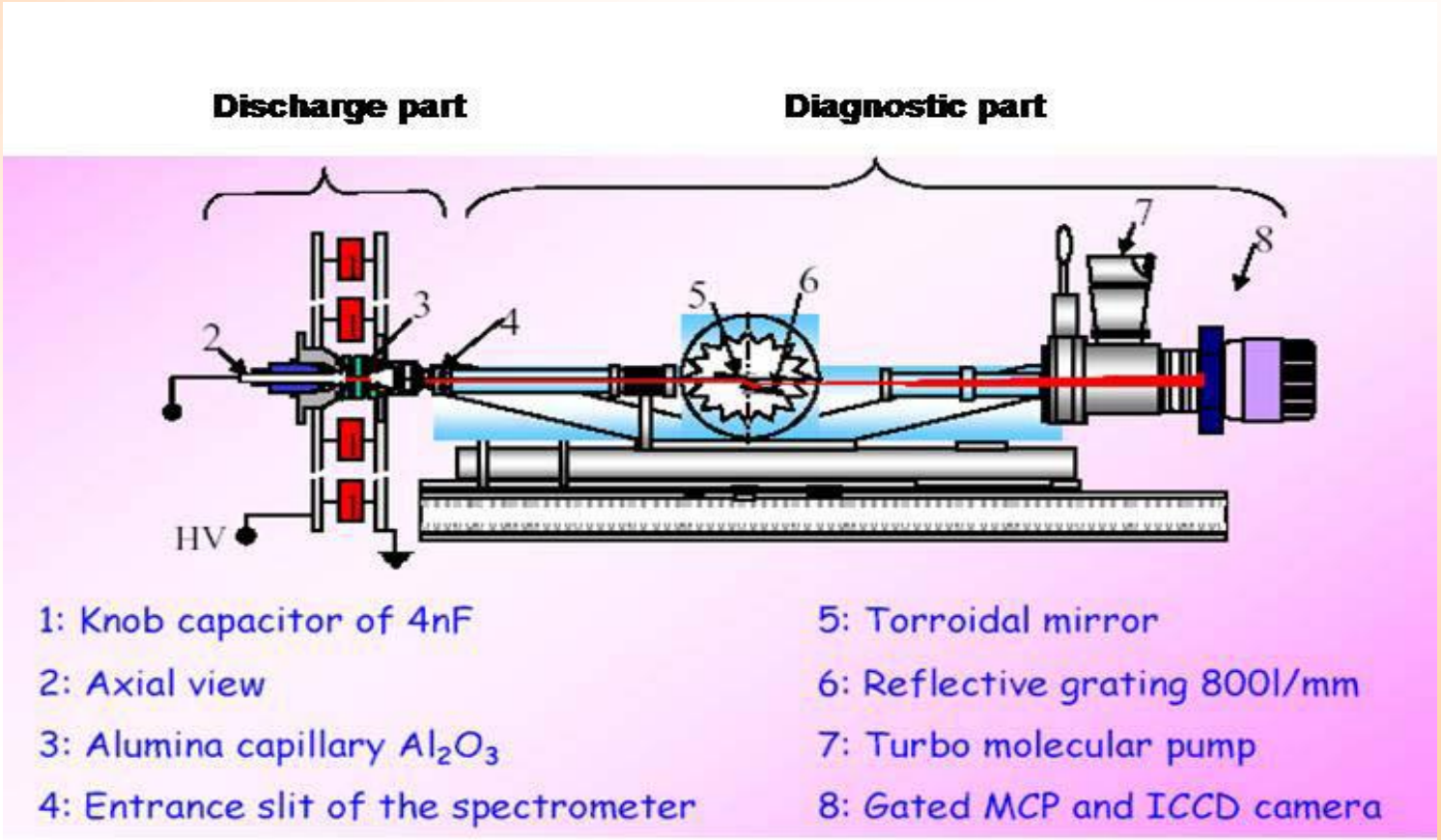


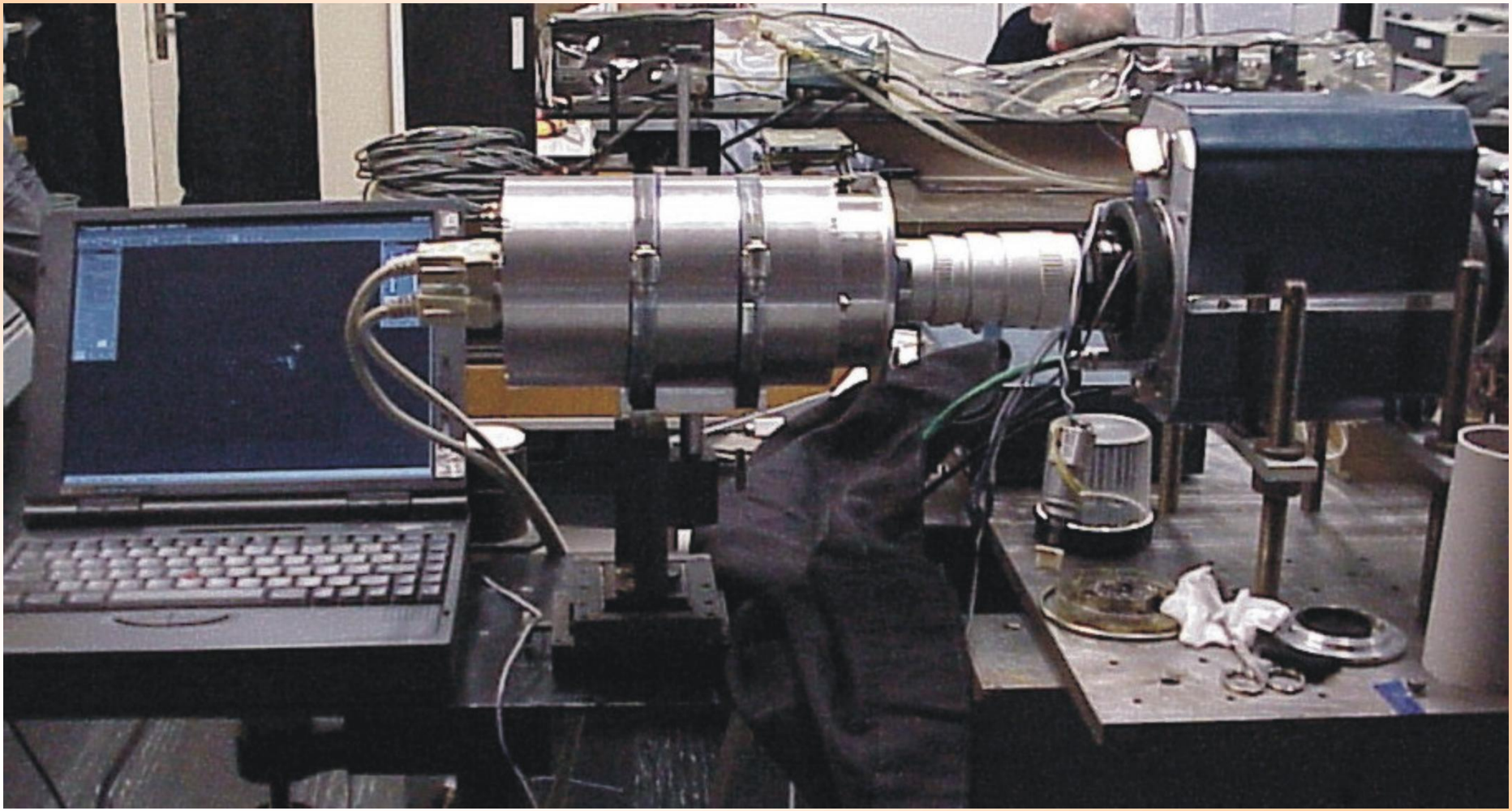
Capillary discharge



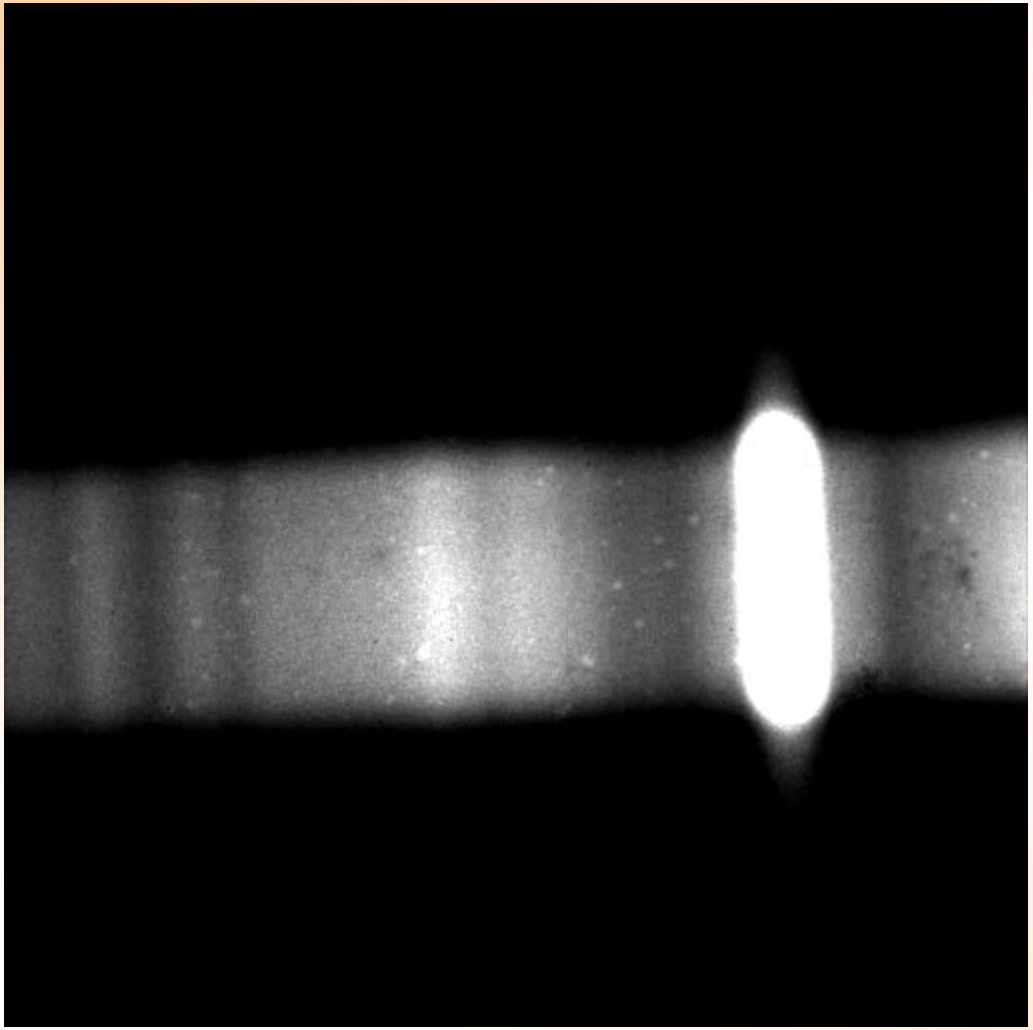
- Alumina capillary
  (l = 5 cm, r_0 = 0.5-1.5 mm) is mounted in axial position of capacitor bank
- The RLC discharge circuit is under critically dumped with the half-period $T_{1/4}$ = 40 ns
- Maximum peak current
  I_{max} = 50 kA.

CTU
Capillary Discharge System
40 kV, 15 kA





XUV SPECTRUM OF CD RADIATION



Energy Range

30 eV to 120 eV

Capillary Discharge

TGS

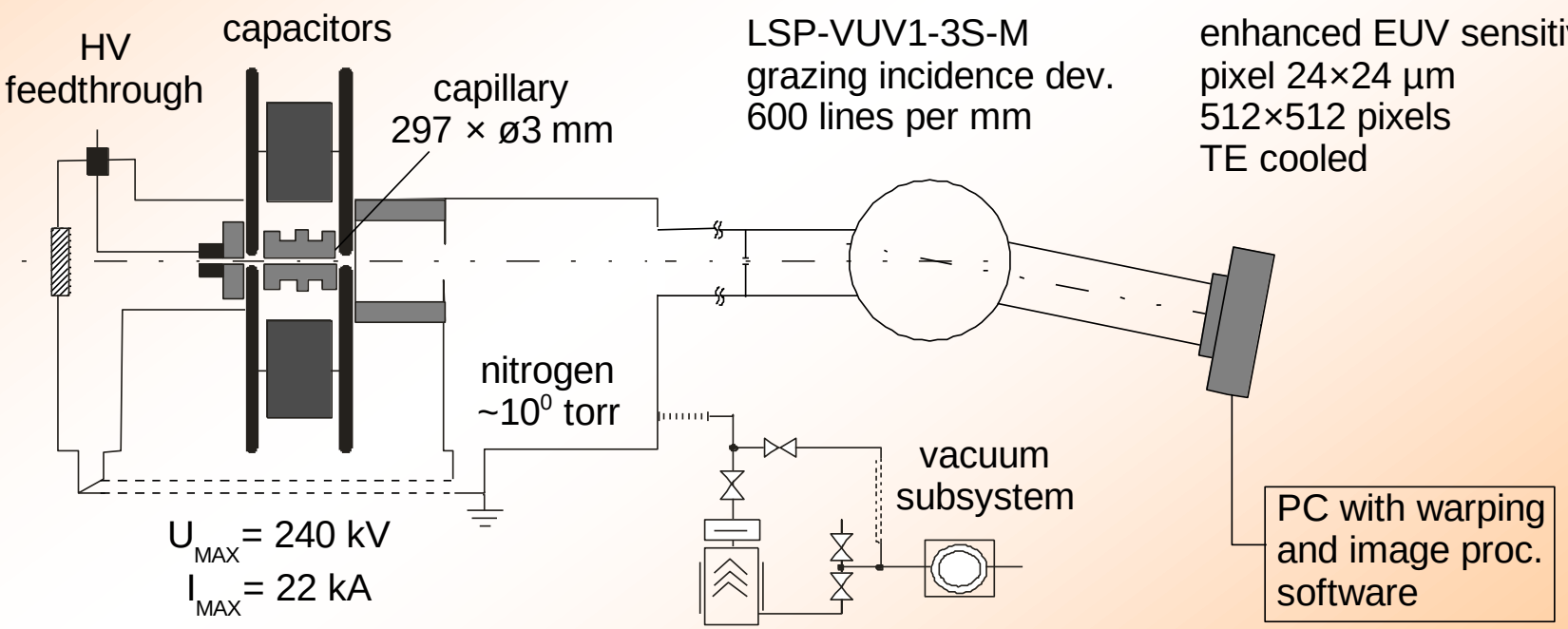
Czech Tech. Univ. Prague

CTU Diagnostics at l'Aquila Capillary Discharge System

Capillary source

Spectrograph

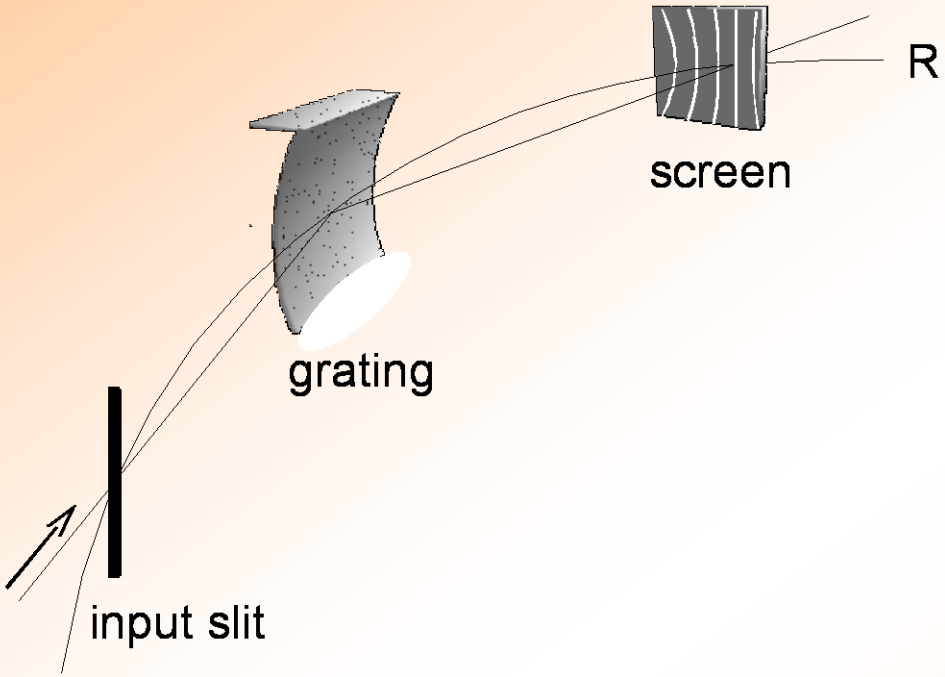
CCD



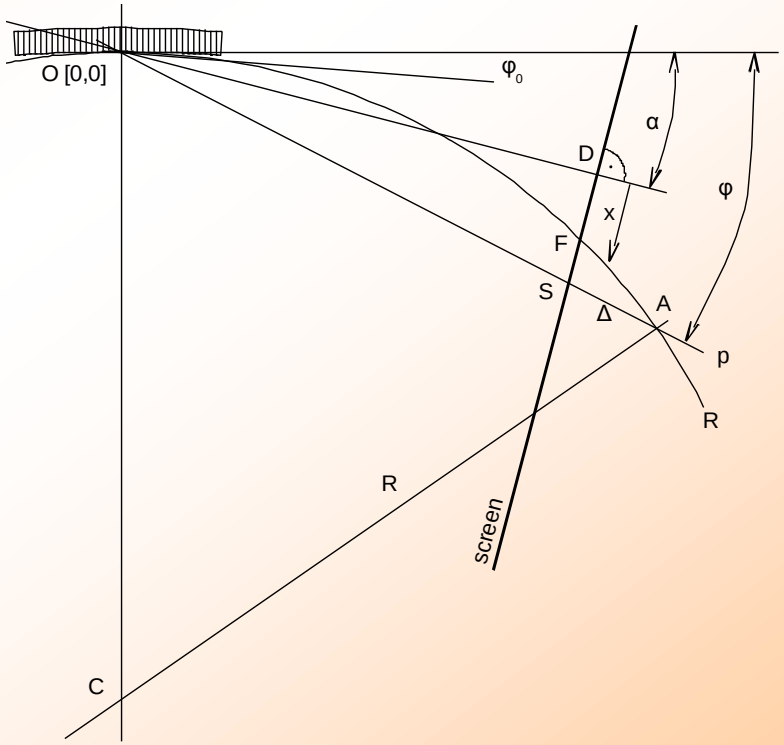
LSP-VUV1-3S-M
grazing incidence dev.
600 lines per mm

enhanced EUV sensitivity
pixel 24×24 µm
512×512 pixels
TE cooled

Imaging EUV spectrometer

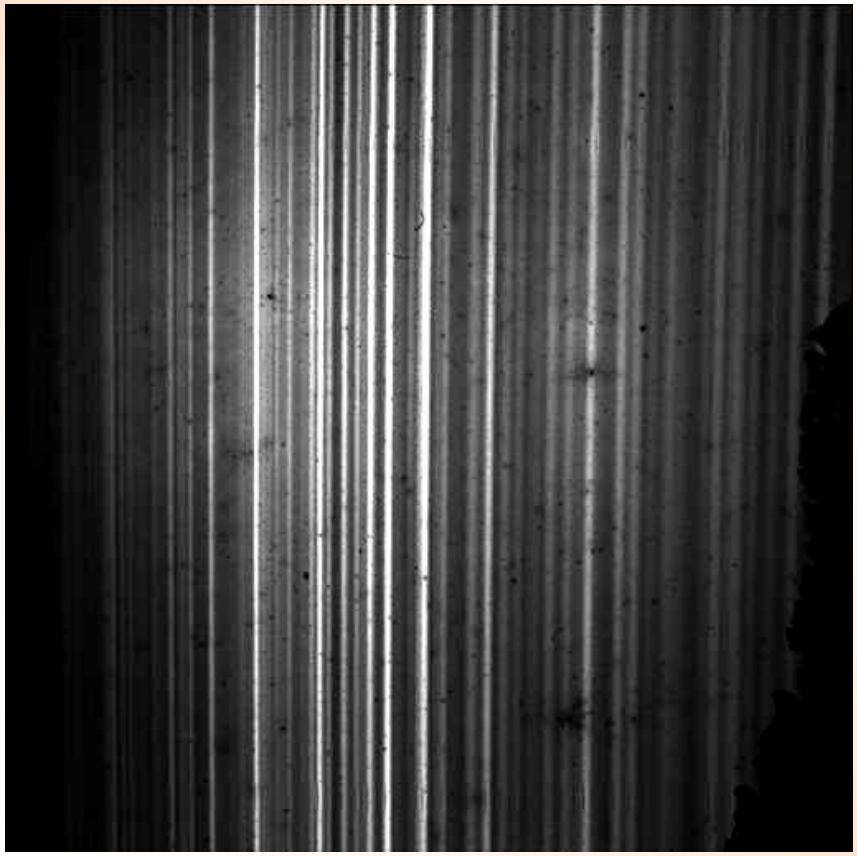


Reflection grating EUV spectrometer with the slit, torroidal grating and BI CCD detector placed on a Rowland circle.



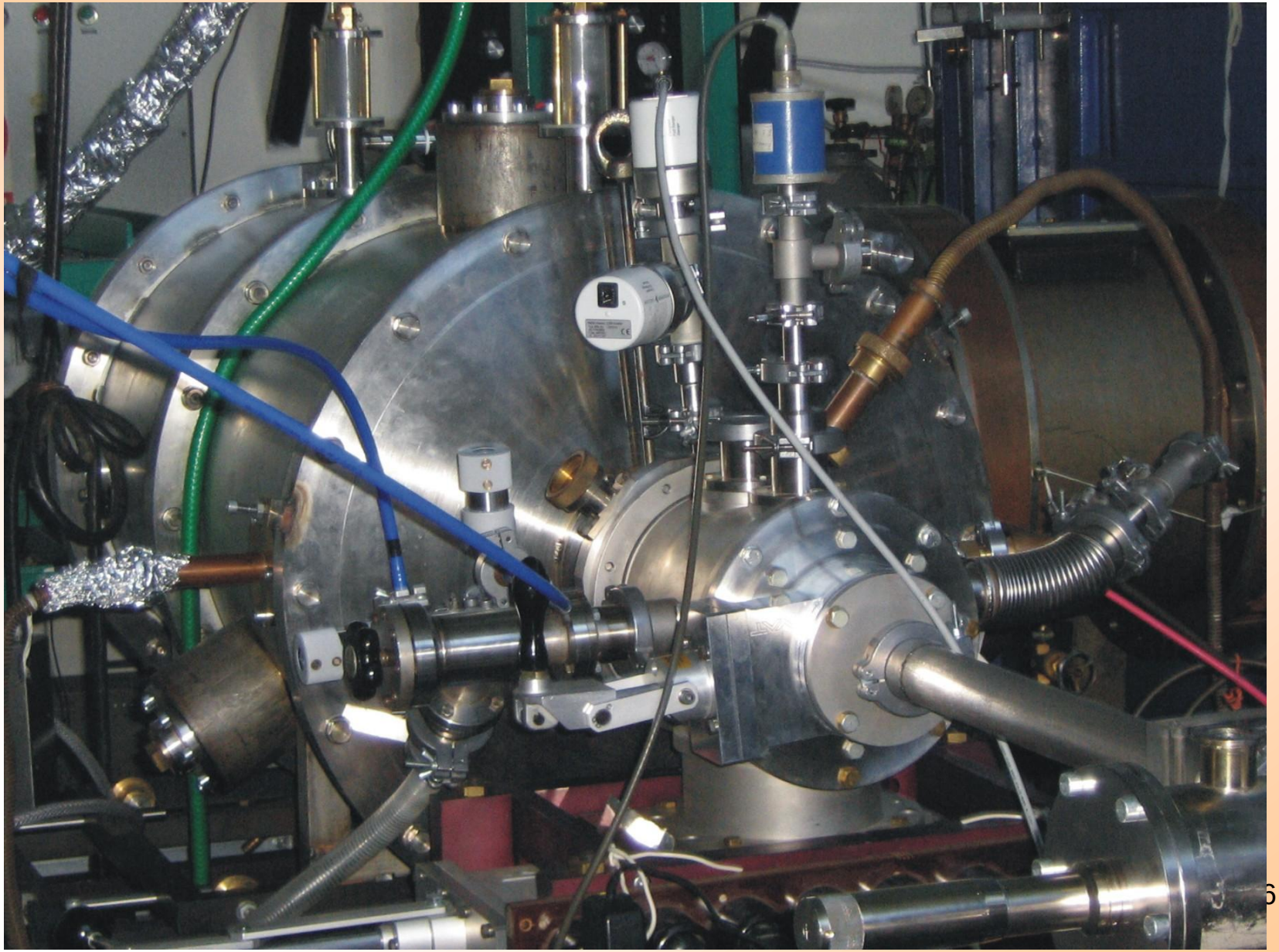
Rowland geometry in imaging spectrometer.

EUV spectra detection, restoration and peaks identification



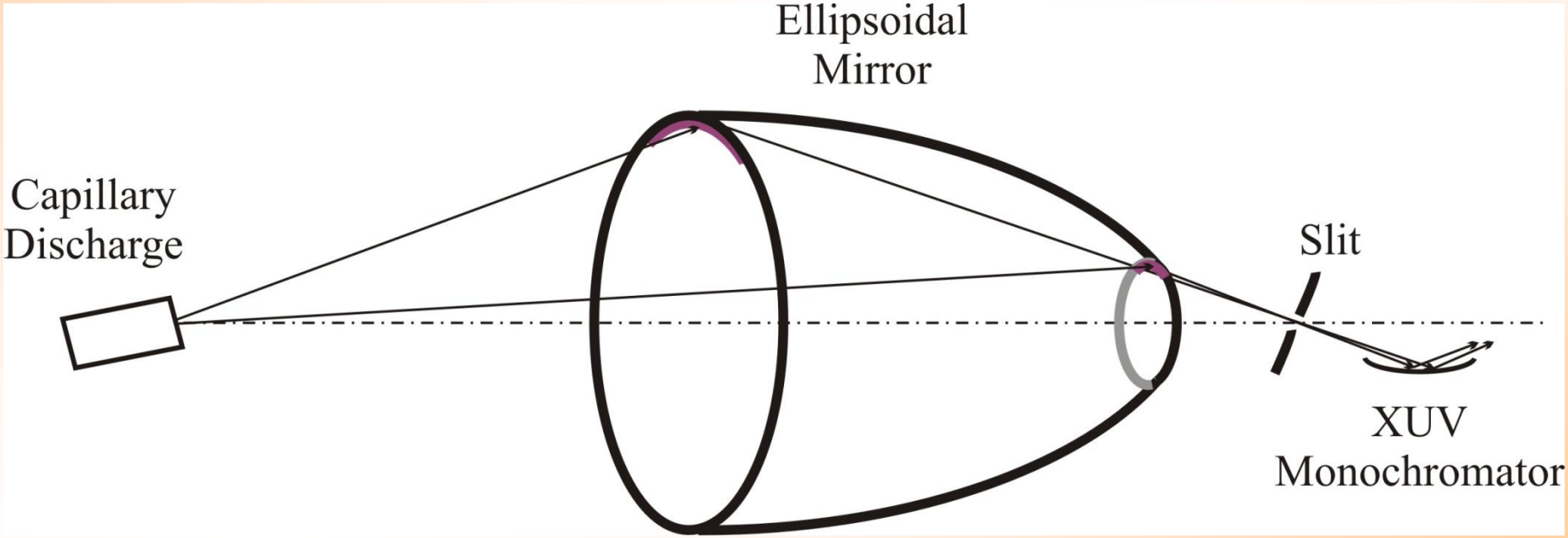
BI CCD image of time integrated spectral lines in the range from 10 nm to 30 nm (Nitrogen filled capillary). Wavelength is on horizontal axis and space coordinate along the input spectrometer slit is on vertical axis.

IPP CAS CAPEX Capillary Discharge Experimental Setup



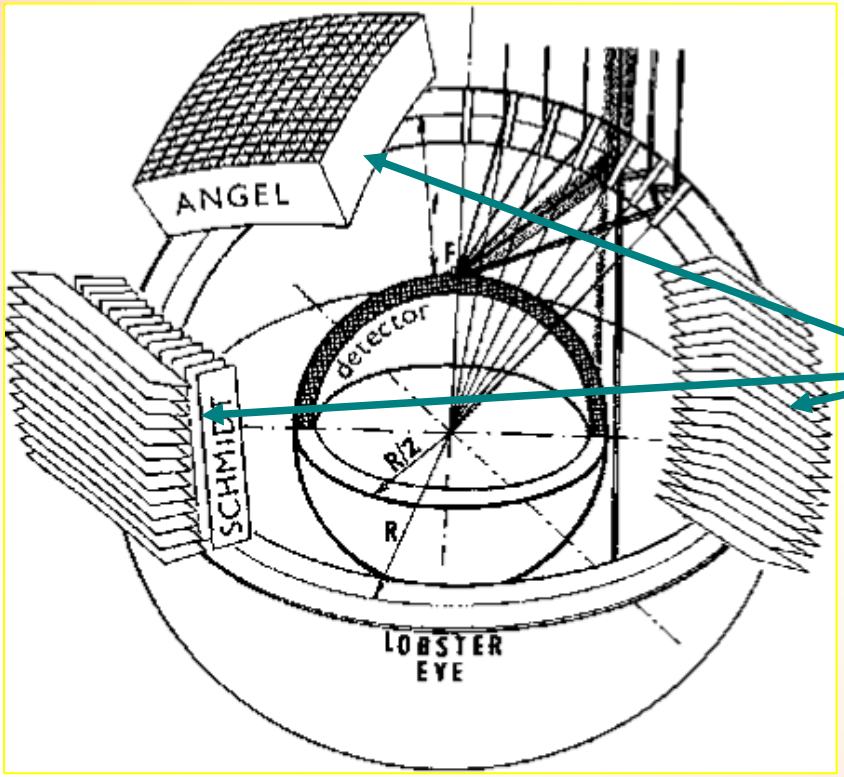
Fast scintillator & photomultiplier detector unit for CD time diagnostics

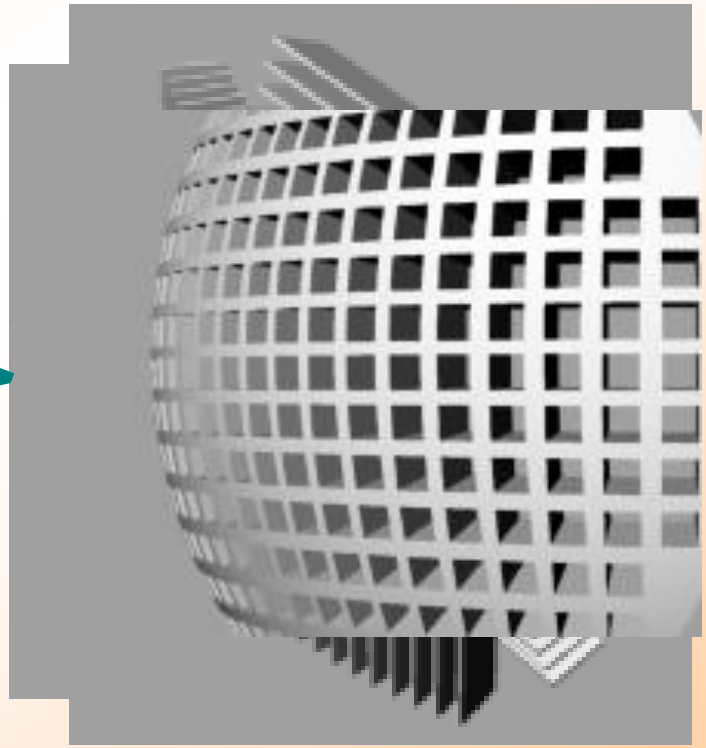
Experimental Arrangement of XUV Spectrometer with XUV Optics



XUV ELLIPSOIDAL MIRROR for 50 to 120 eV range

Lobster Eye Optic Concept

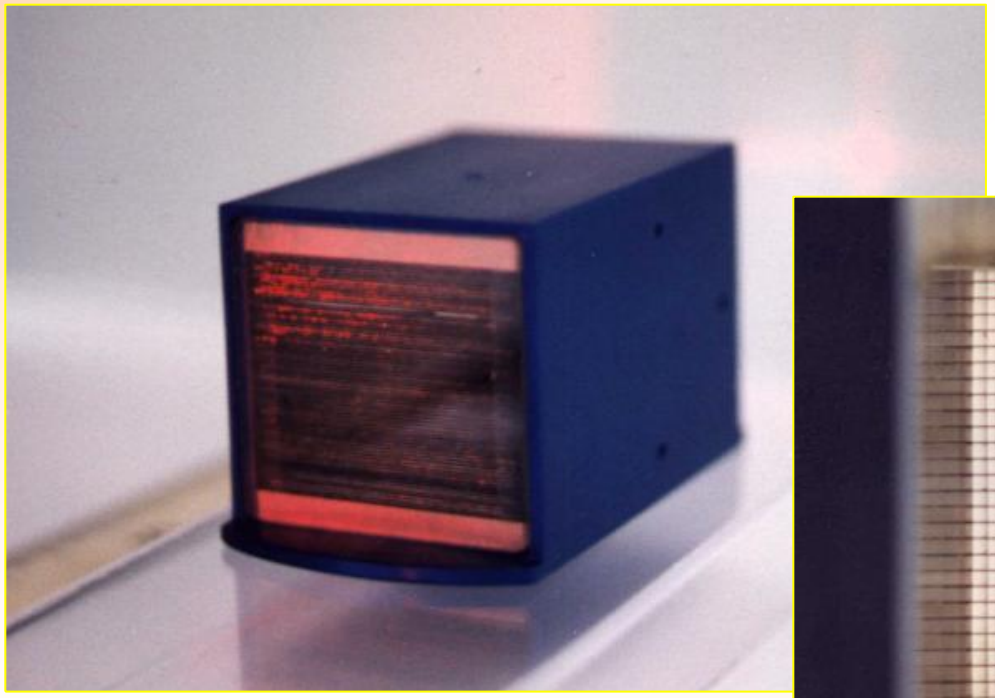


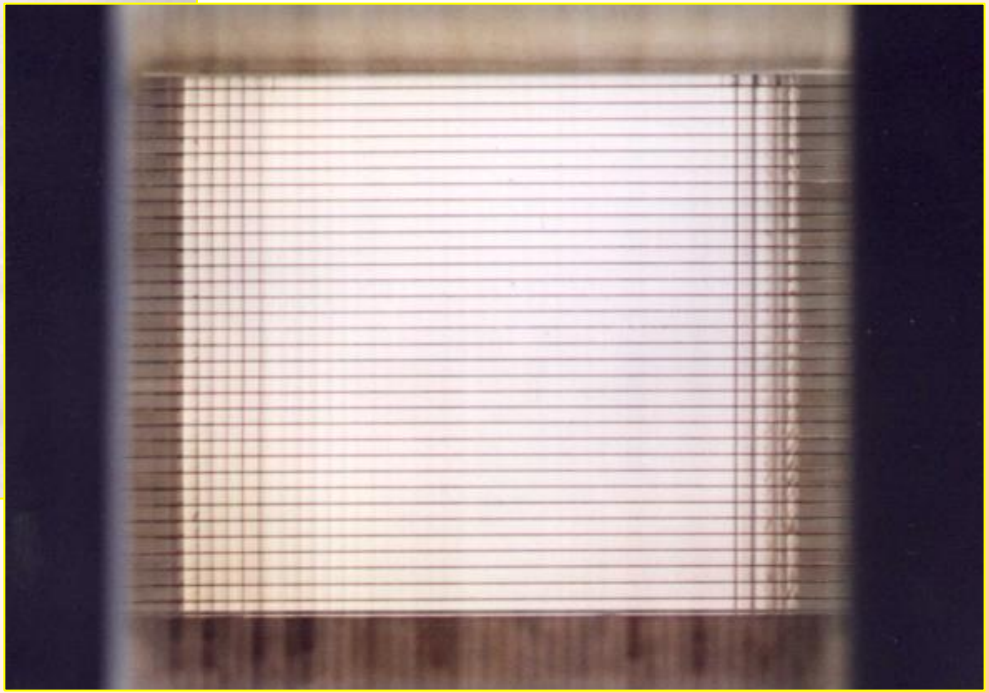


Multi-Foil Optic – Lobster Eye

MFO in Schmidt
Lobster Eye arrangement

- additional coatings
- thin foils
- shape variations

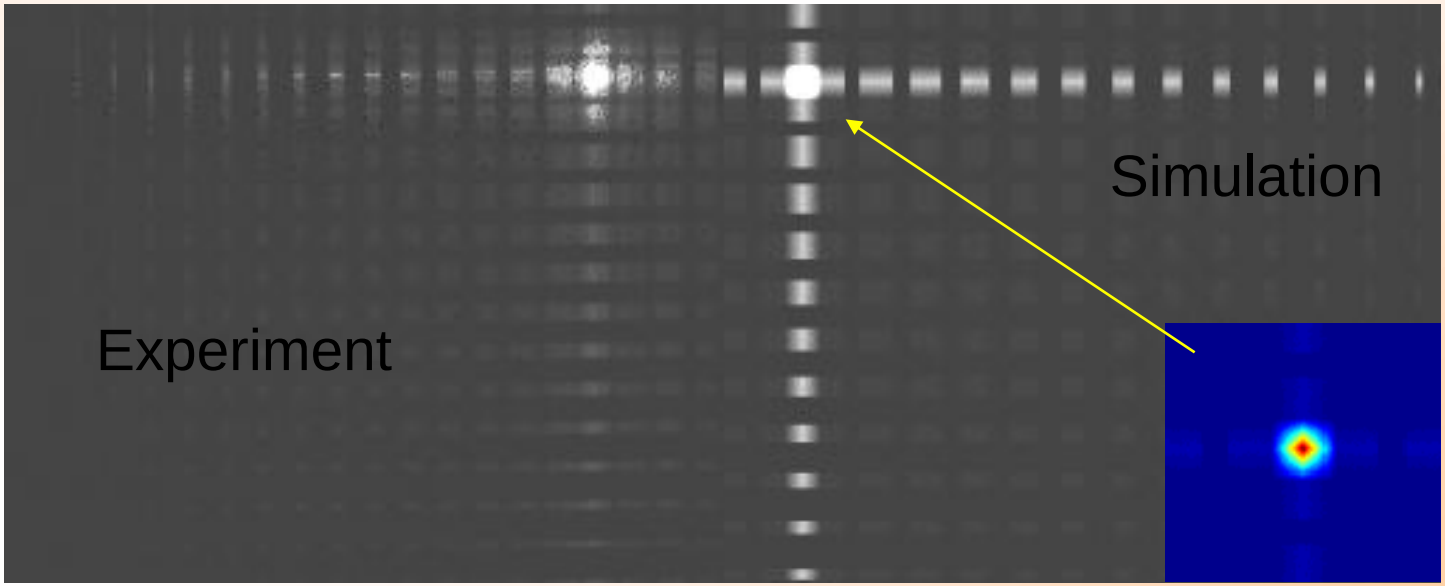




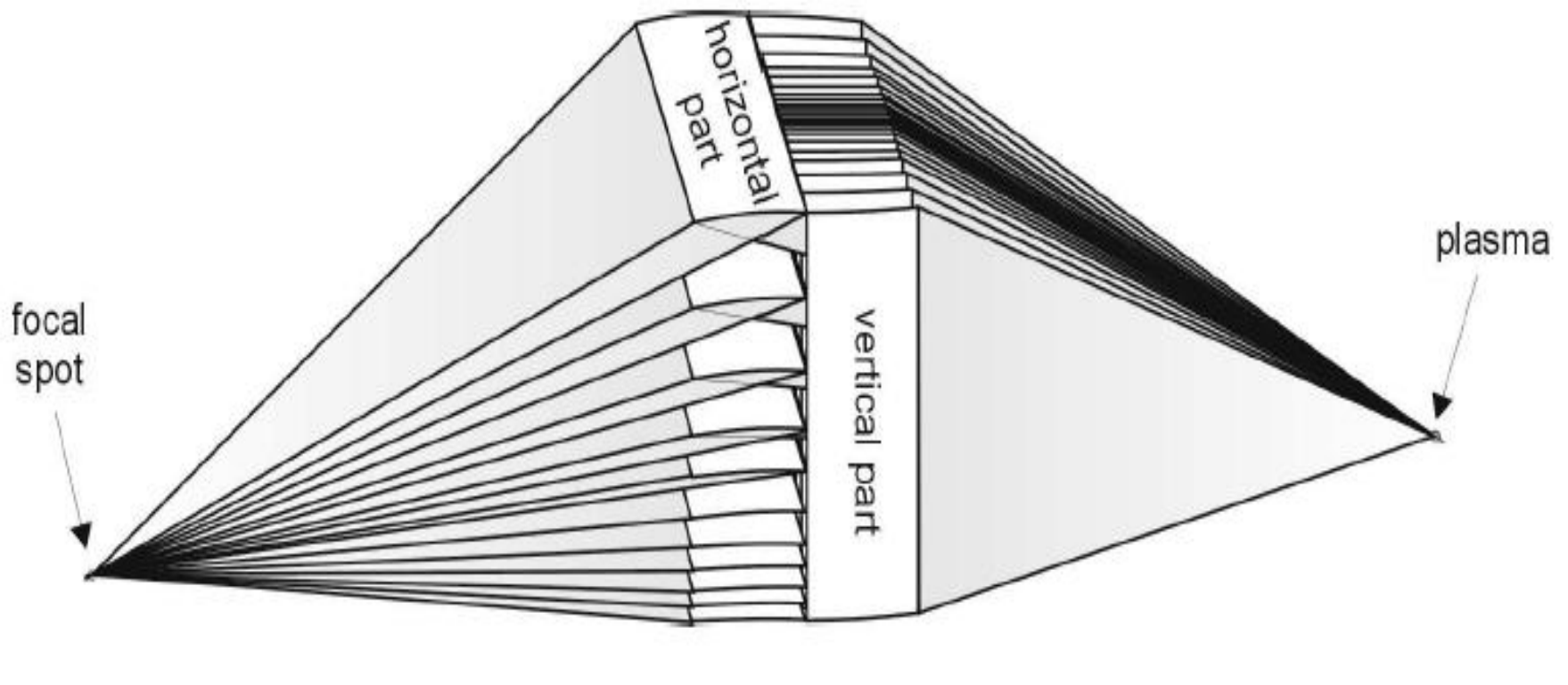
20 x 20 mm front area
100 μm thickness, 300 μm spacing

LE for X-ray focusing

- Point-to-point focusing system
- Source: 50 μm size, 8 keV photons
- Source-detector distance: 1.2 m, 8 keV photons
- Detector: 512x512 pixels, 24x24 μm pixel size
- Gain: ~570 (experiment) vs. ~584 (comp. simulation)

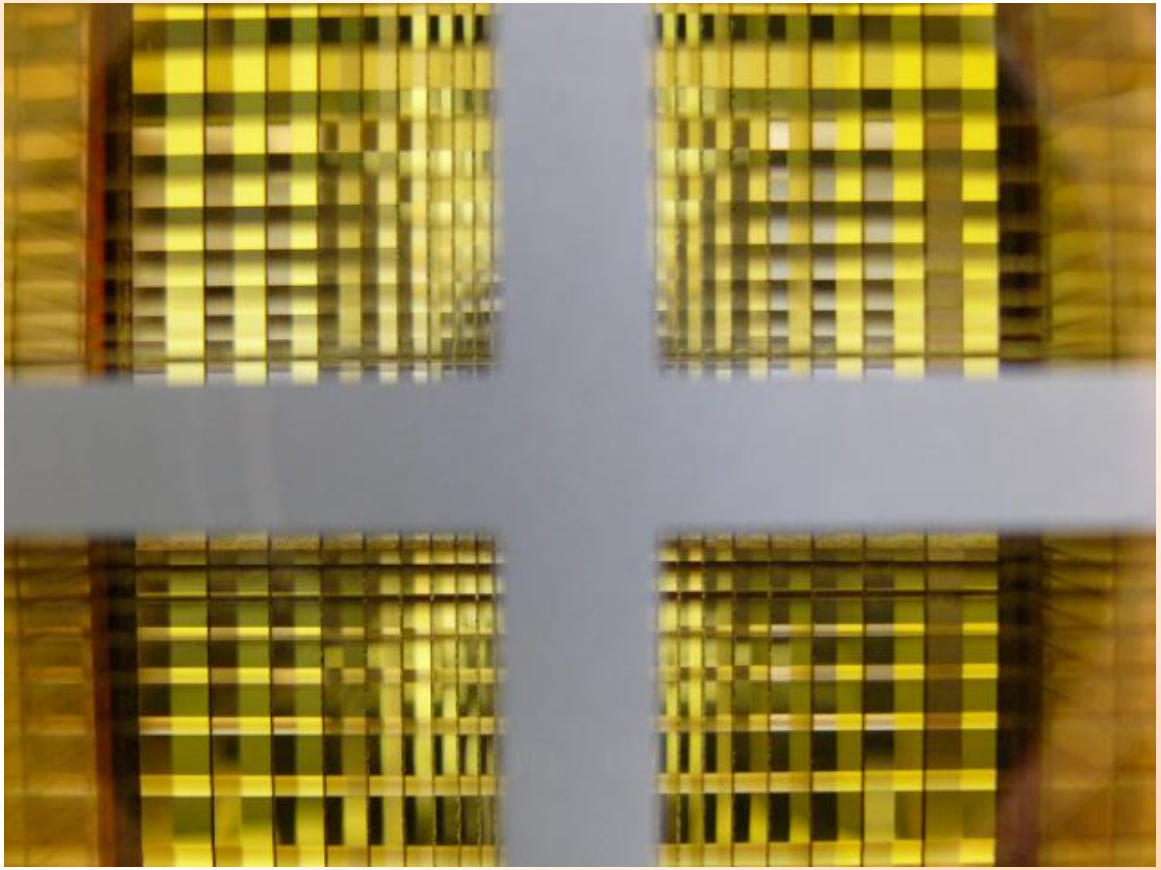


MFO - XUV Elliptic Kirkpatrick-Baez Condenser



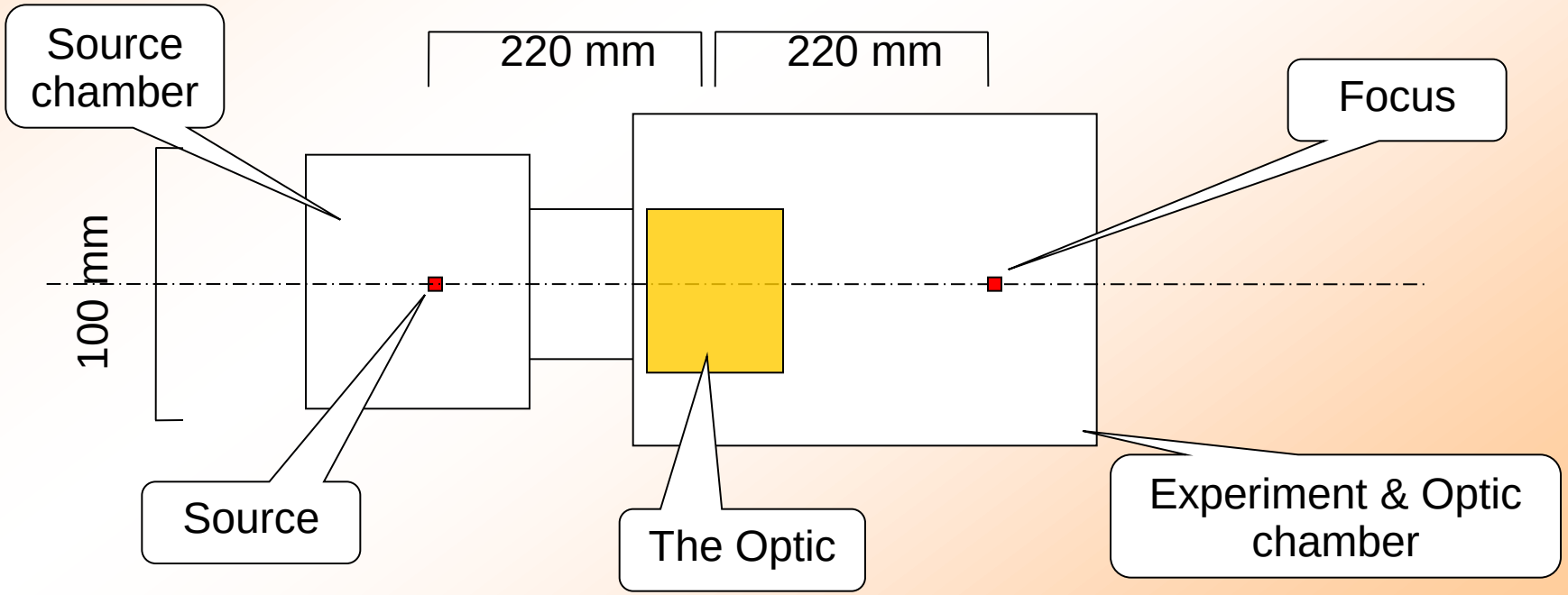
Schematic view of one half of the multi–foil (MFO) XUV bifacial Kirkpatrick-Baez condenser.

Lobster Eye EUV Optics



MFO - XUV Elliptic Kirkpatrick-Baez Condenser

- Focusing X-Rays from the source to the point ~44 cm distant
- Working for 13.5 nm photons
- Source diameter ~100-500 μm
- Focus diameter < 1000 μm
- Dimensions limitation to ~10x10 cm



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Thank You