A Water Window Source for Soft X-Ray Microscopy and other Applications

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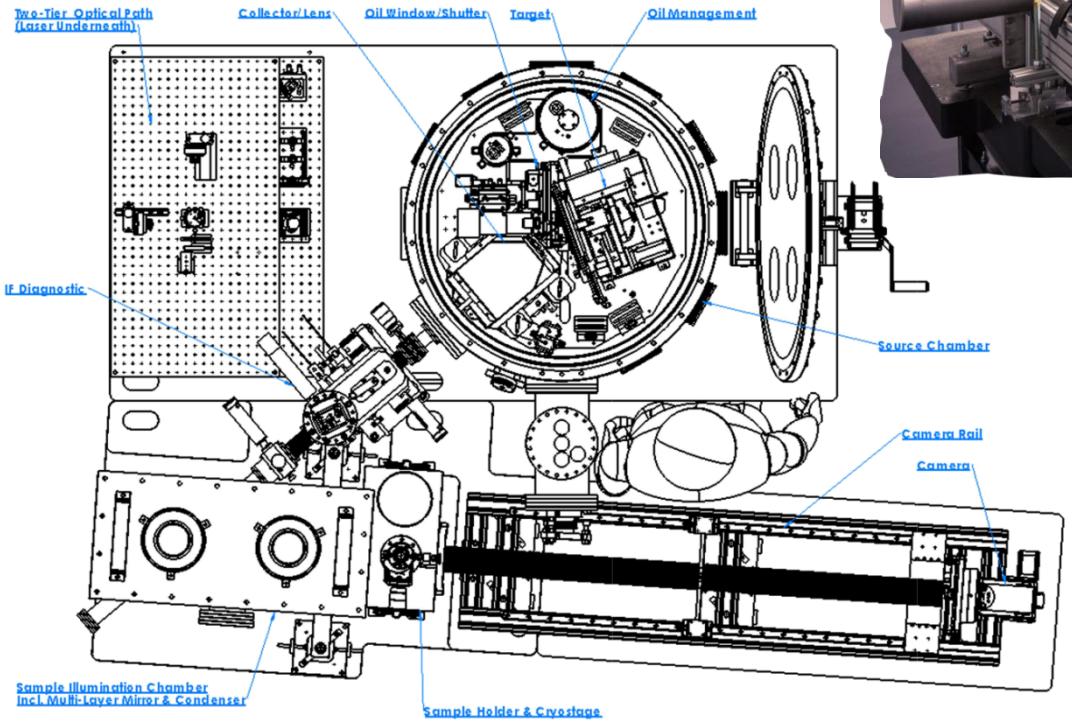
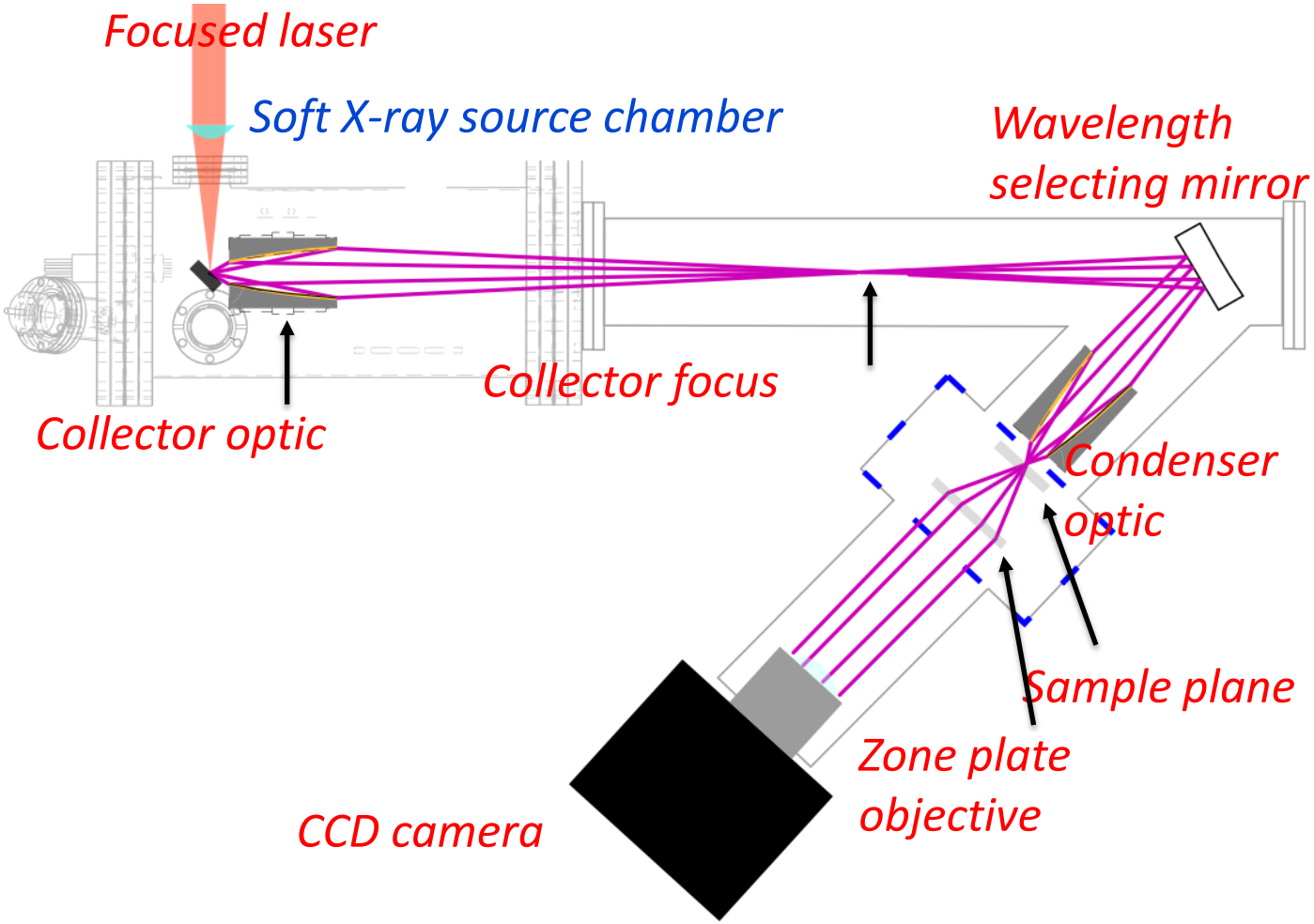
Cryo Soft X-ray Microscope



Microscope Layout

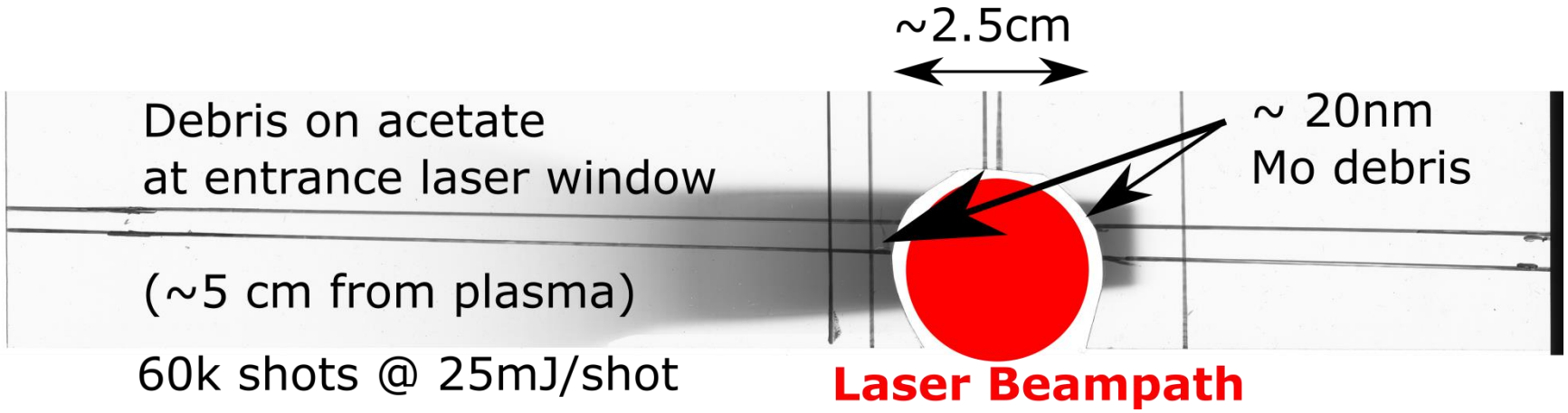


SiriusXT microscope schematic.

Driving Laser

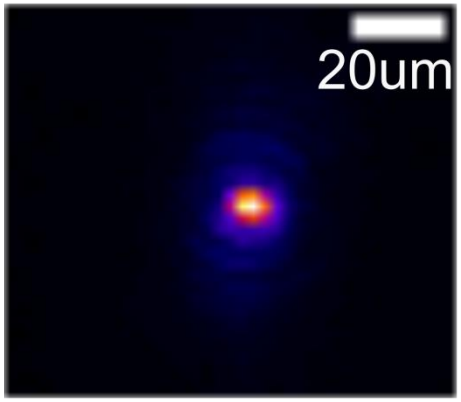
Edgewave IS
Pulse Energy 25 mJ
Pulse Length ~ 6ns
Rep Rate up to 5kHz
M2 < 1.5

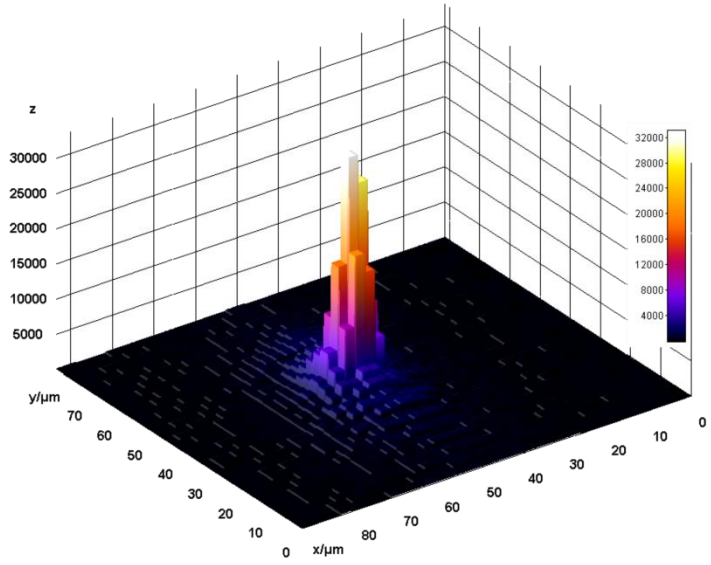
Laser Beamline Debris



~20 nm of debris per minute at window at 1kHz laser rep rate

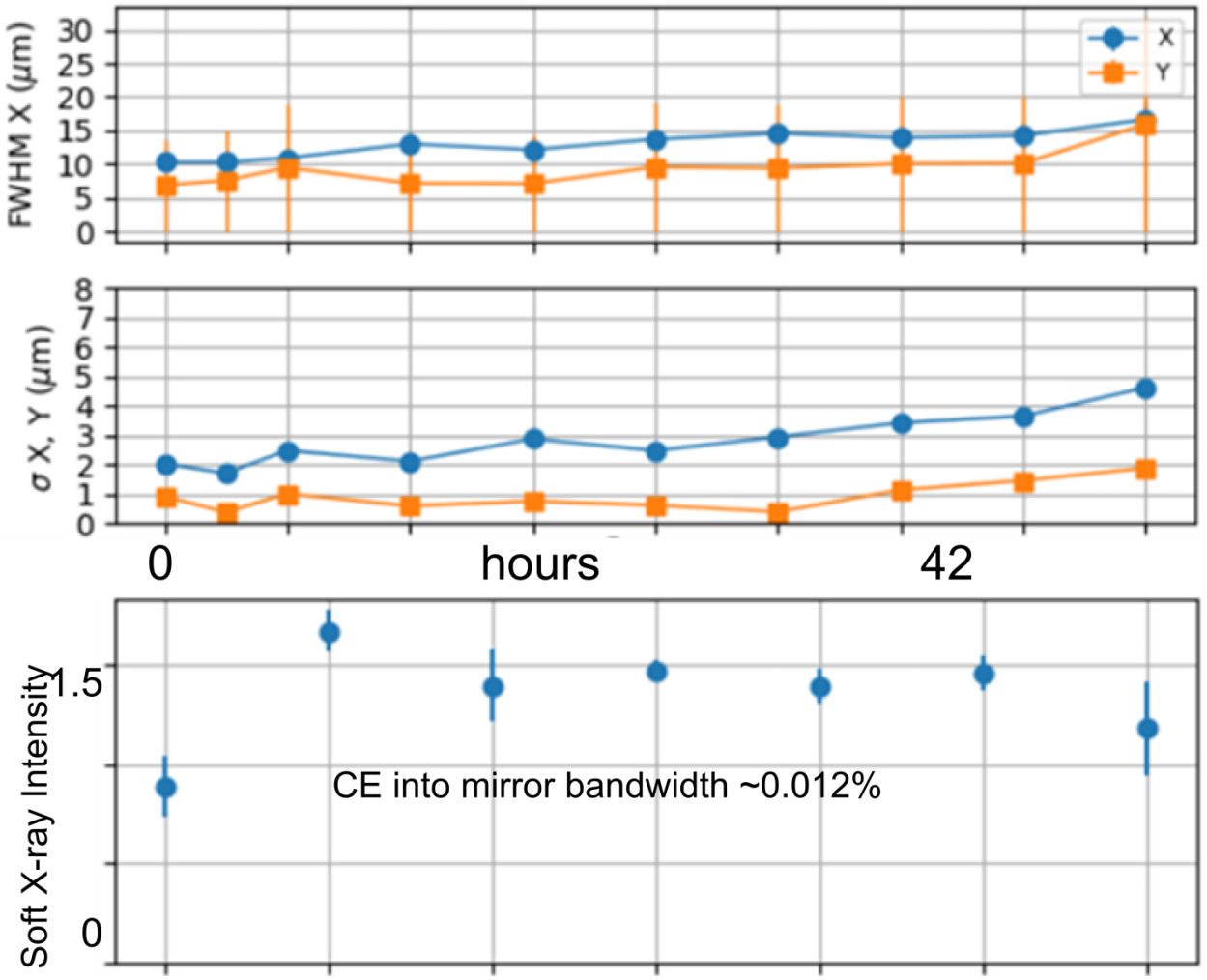
Laser Focus Through Window





Laser Illumination NA ~ 0.25
1/e2 diameter ~ 10µm x 13µm

Output testing

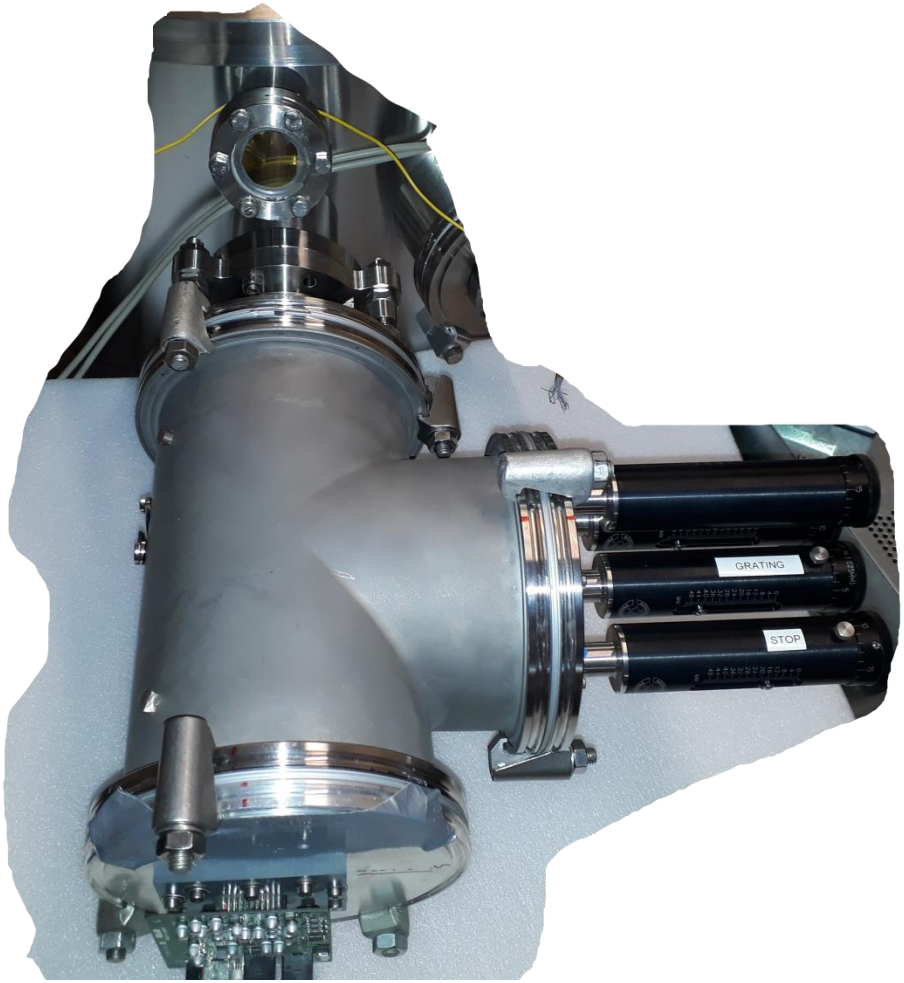


Source Spectroscopy

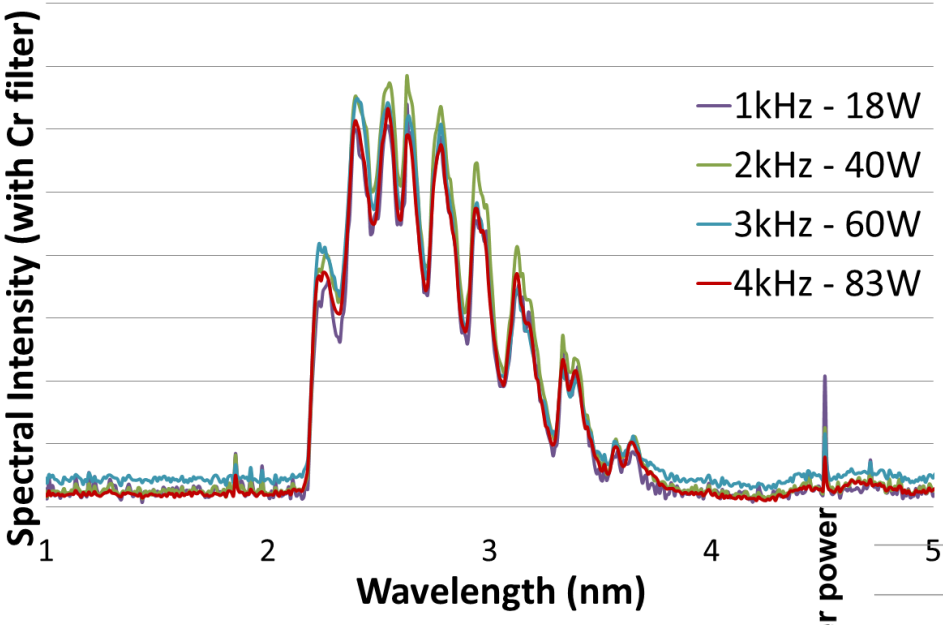
10000 lpmm
Transmission Grating
Variable Filters

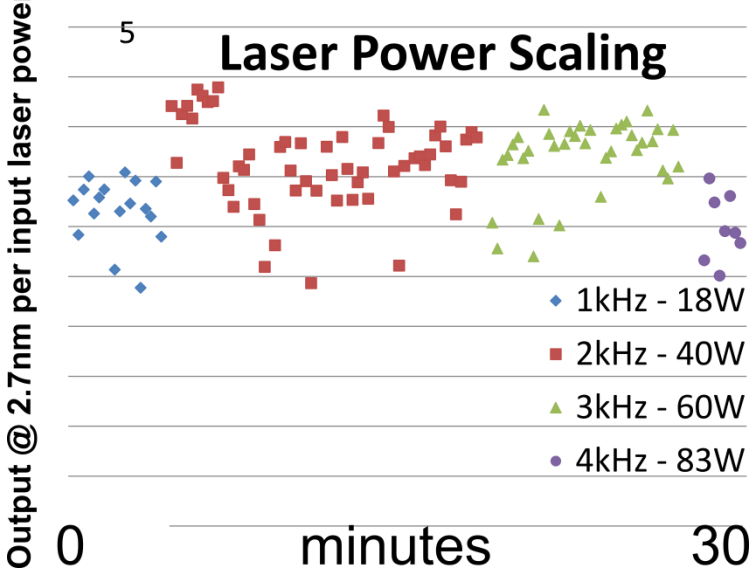
Hamamatsu Line CCD
(Cheap, not cooled,
not so sensitive)

Good S/N for 200ms at
~15 mJ input laser at
~ 0.75m to CCD



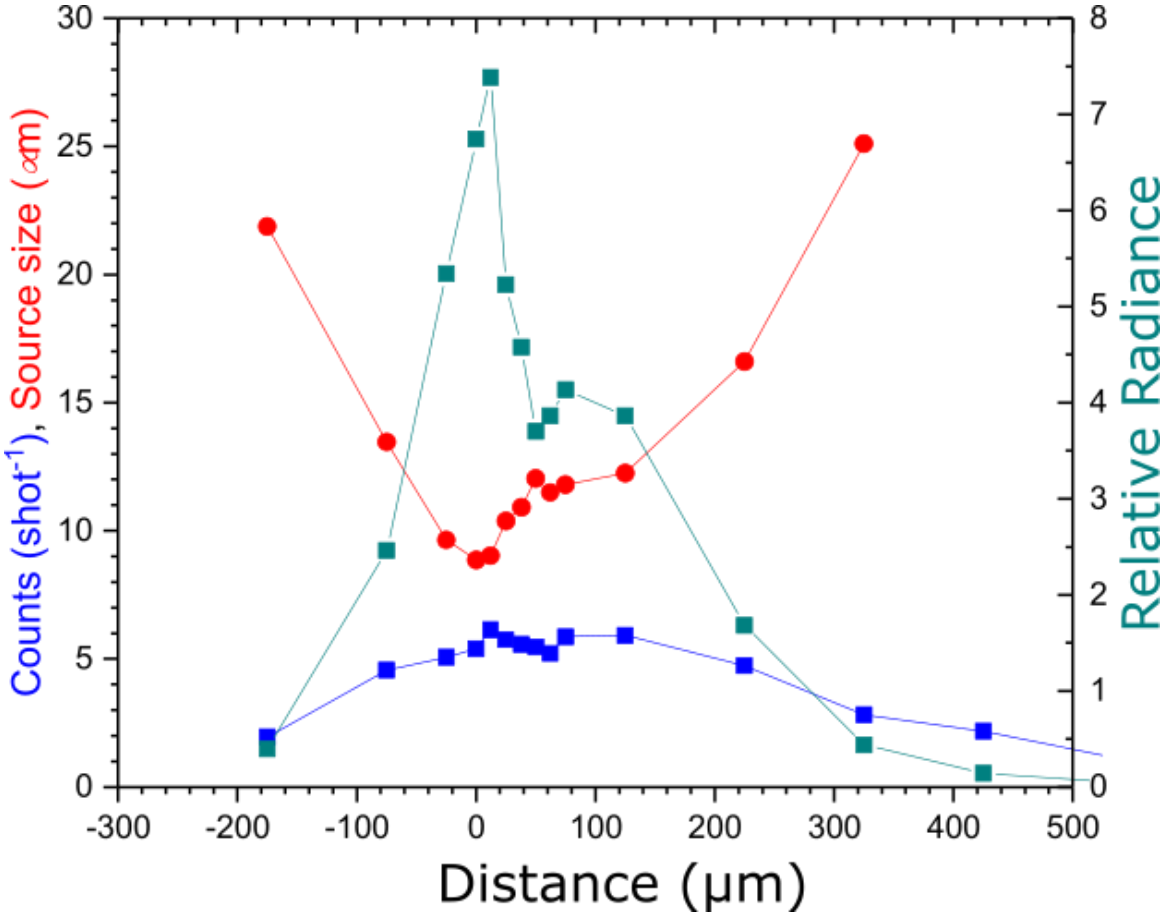
Power Scaling



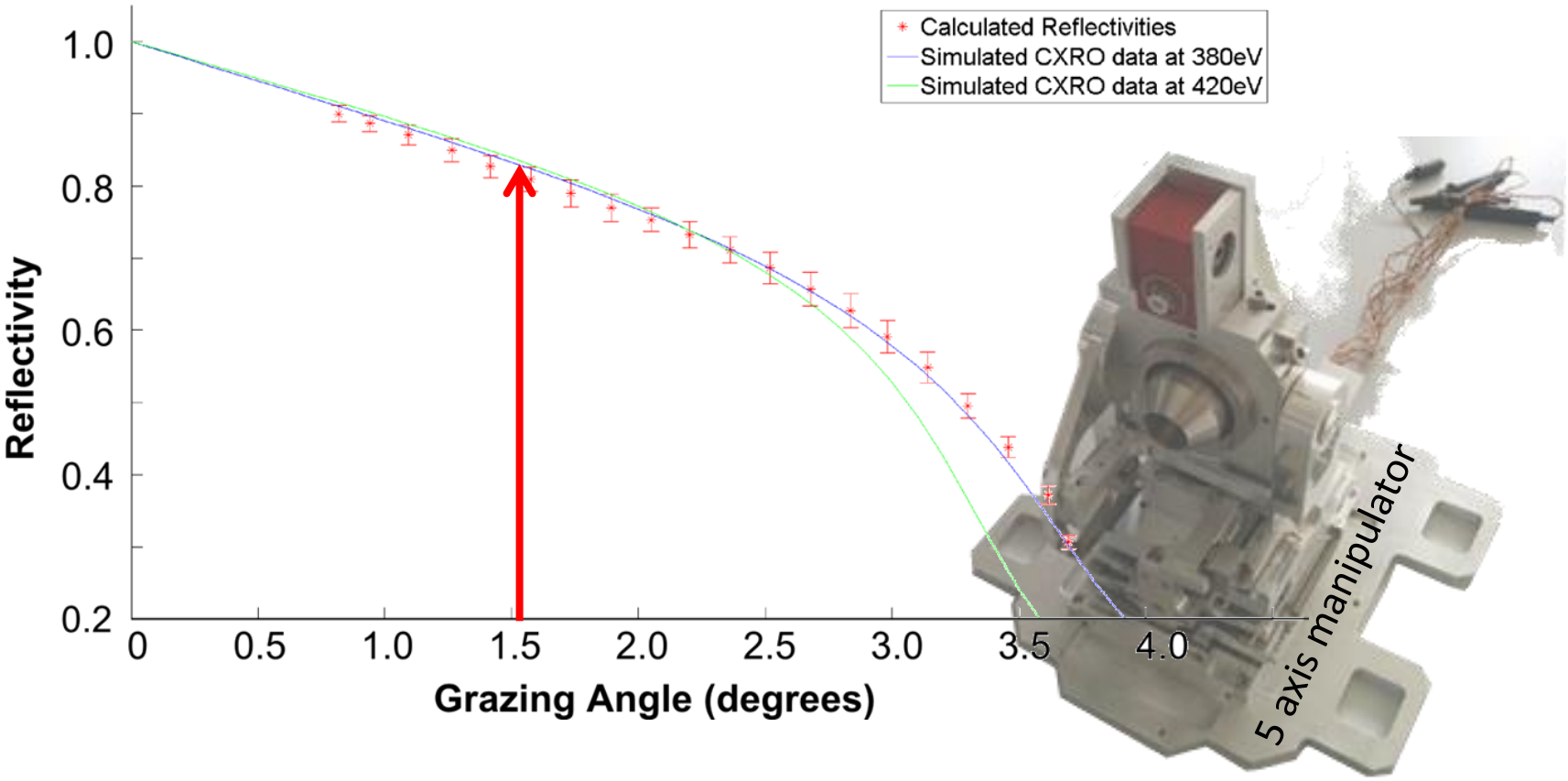


Radiance Focal Dependence

At 2.7nm with ~ 13 mJ on Mo target

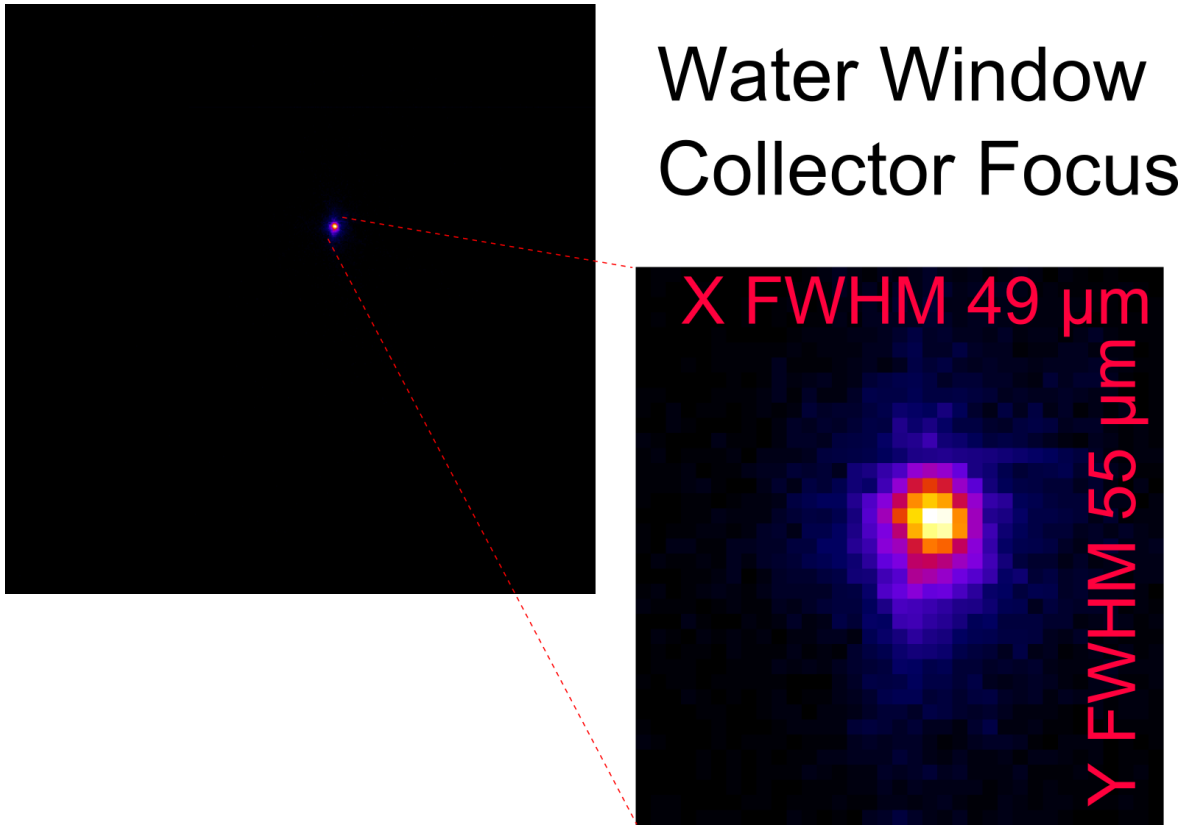


Collector Optic



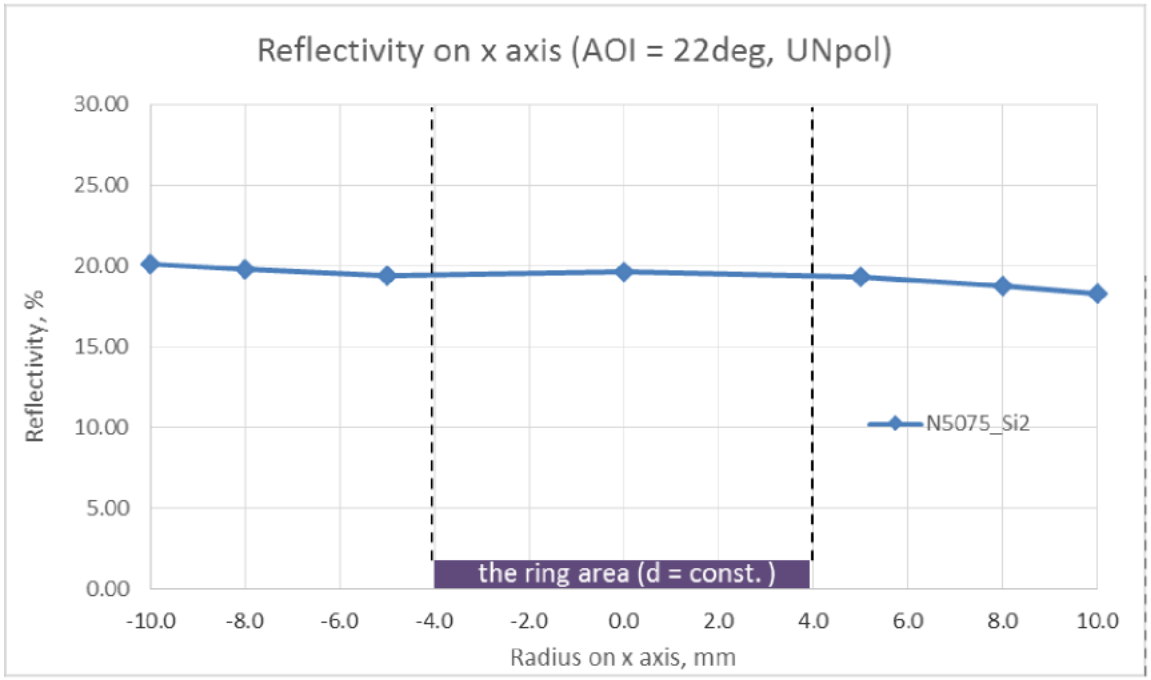
Focal Length = 1 m

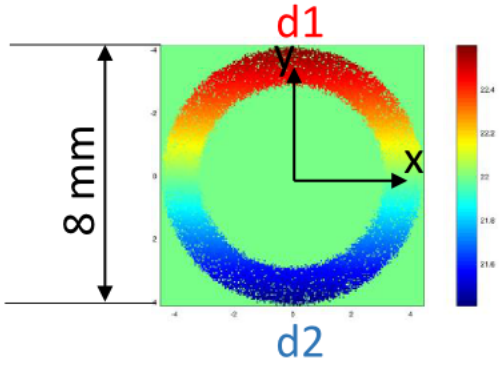
IF Focal Plane



Multilayer Mirror

PTB results on mirrors (UNpol. reflectivity x axis):





Reflectivity

20% at 2.73 nm

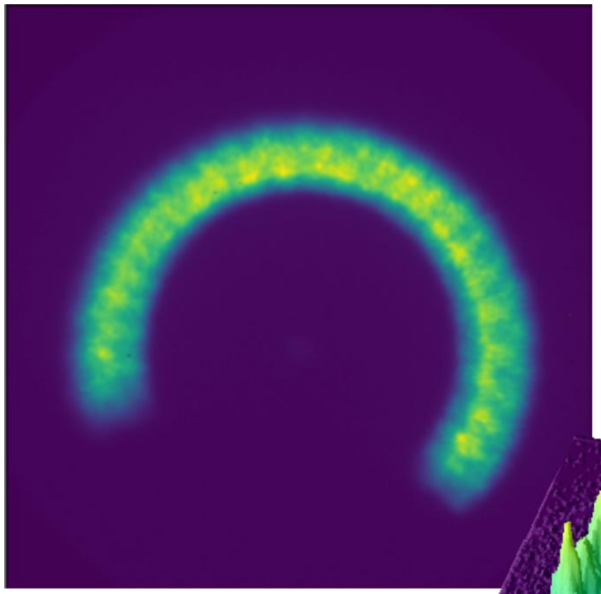
17% at 2.42 nm

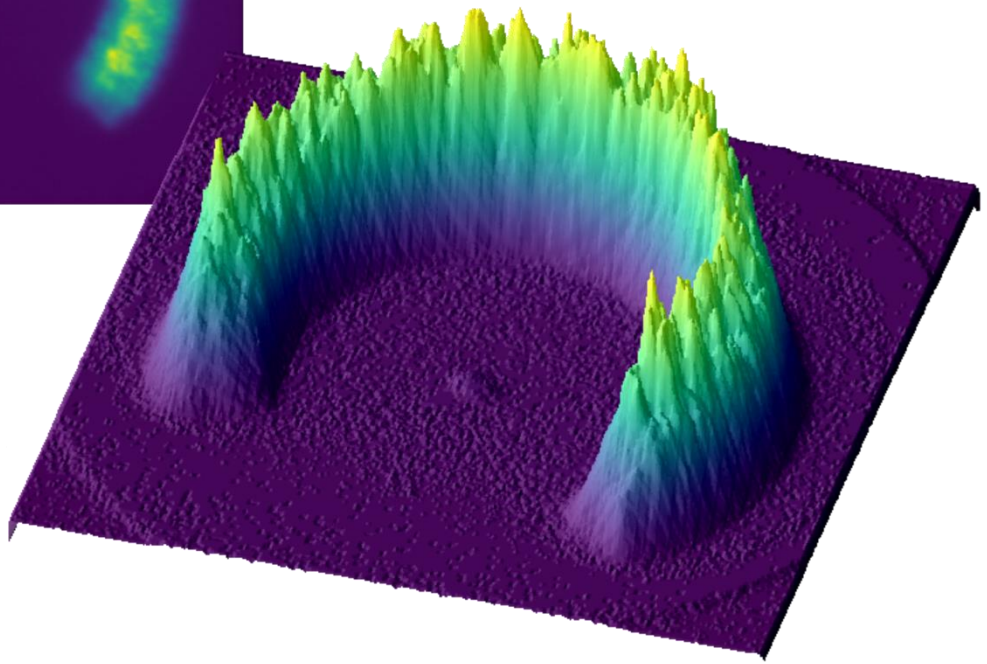
Peak reflectivity within -5 mm < r < 5 mm:

Substrate N5075_Si2: R_{unpol} = (19.48 ± 0.17)%

optiX fab.

Post Multilayer Annular





Photons after Multilayer
~2E9/sec

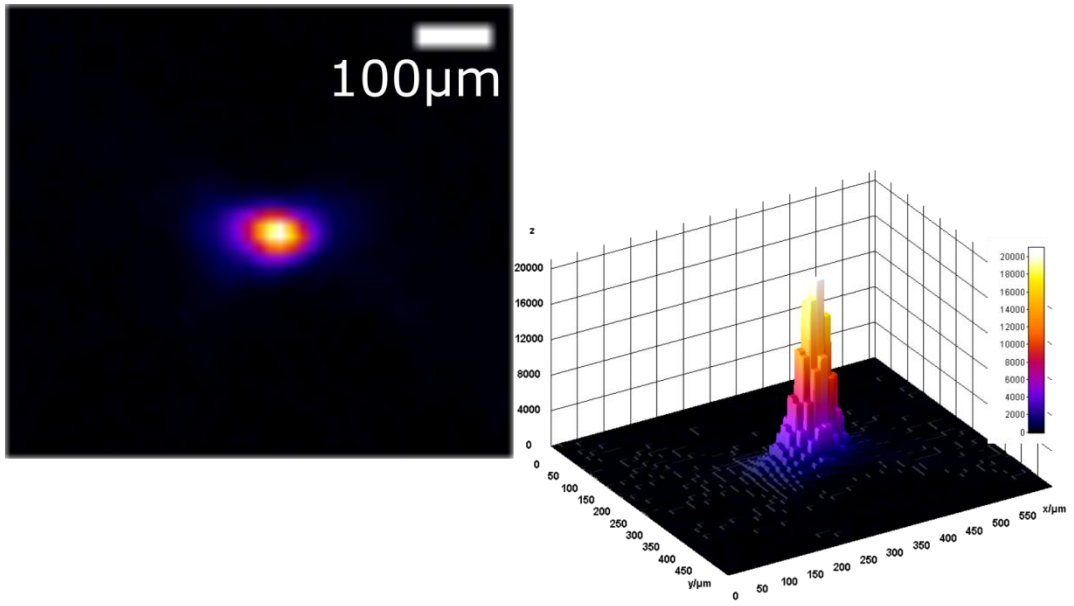
Uses graded MLM to maintain
$\lambda/\Delta\lambda > 300$

Sample Plane

Photons at Sample Plane
~8E8 ph/sec

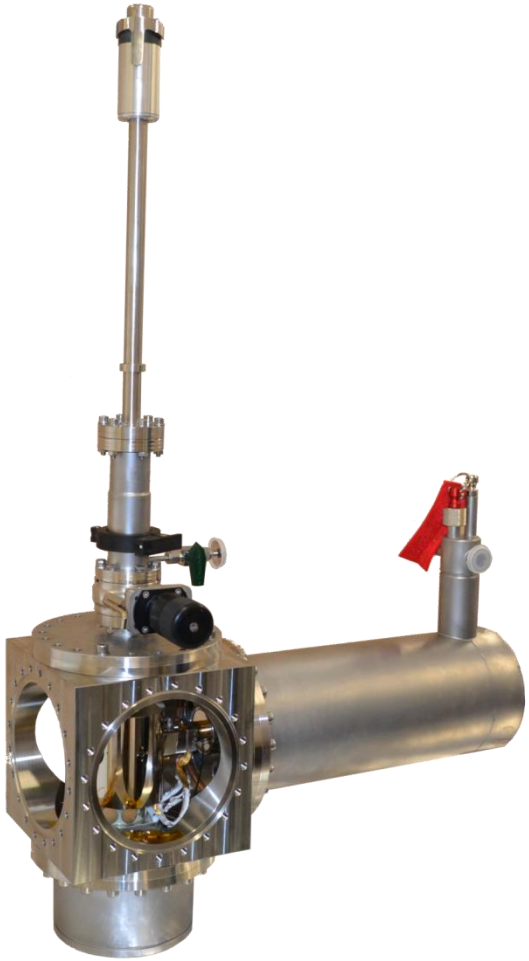
Condenser Focus
Best 30µmx50µm FWHM
Average 36µmx61µm FWHM

Photons in 1 pixel
~1E6 ph/sec

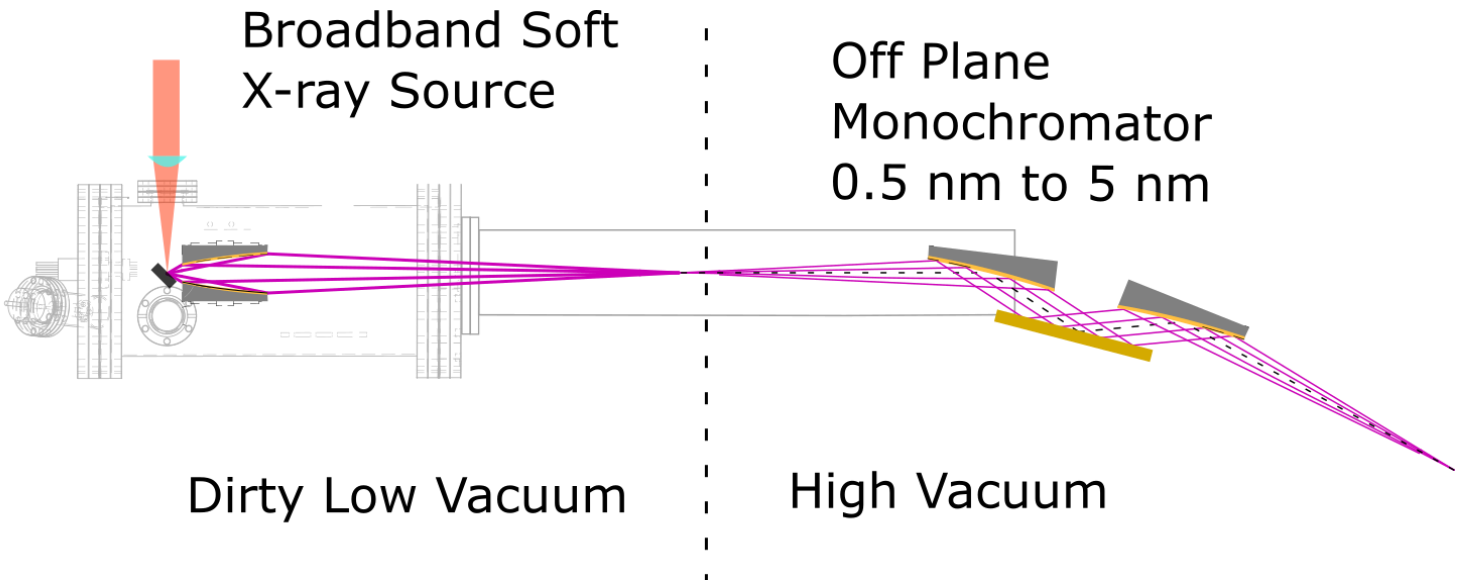


High Resolution Cryostage

- Cryostage with sample transfer load-lock and LN2 dewar.
- Sample motion is closed loop controlled to ±1 nm.
- Sample holder is designed for 3 mm TEM grids initially.

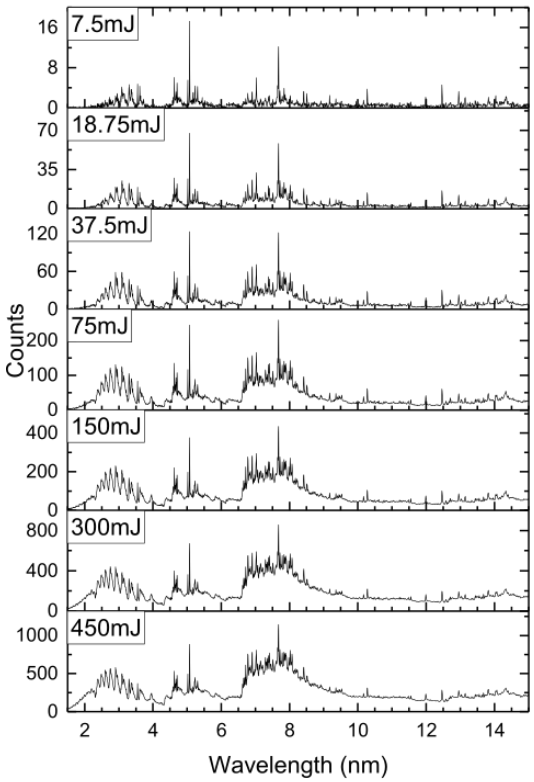


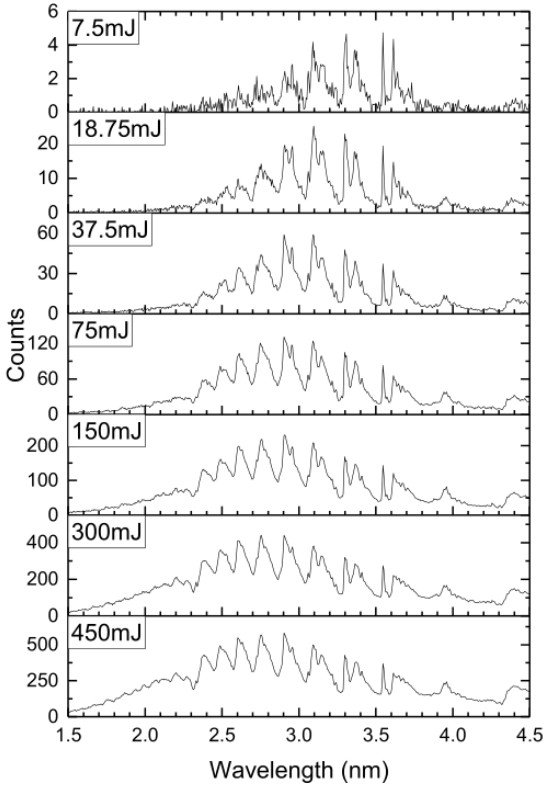
Beamline Below 5nm

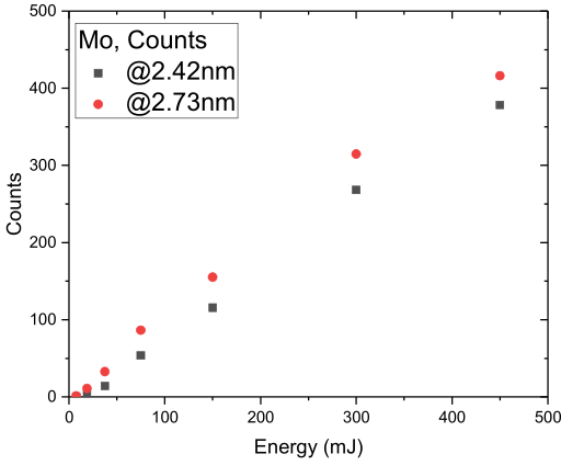


- Target $\lambda/\Delta\lambda > 1000$
- Initial experiments planned in Photoelectron Spectroscopy and
- NEXAFS imaging
- Optically delayed laser for pump probe experments

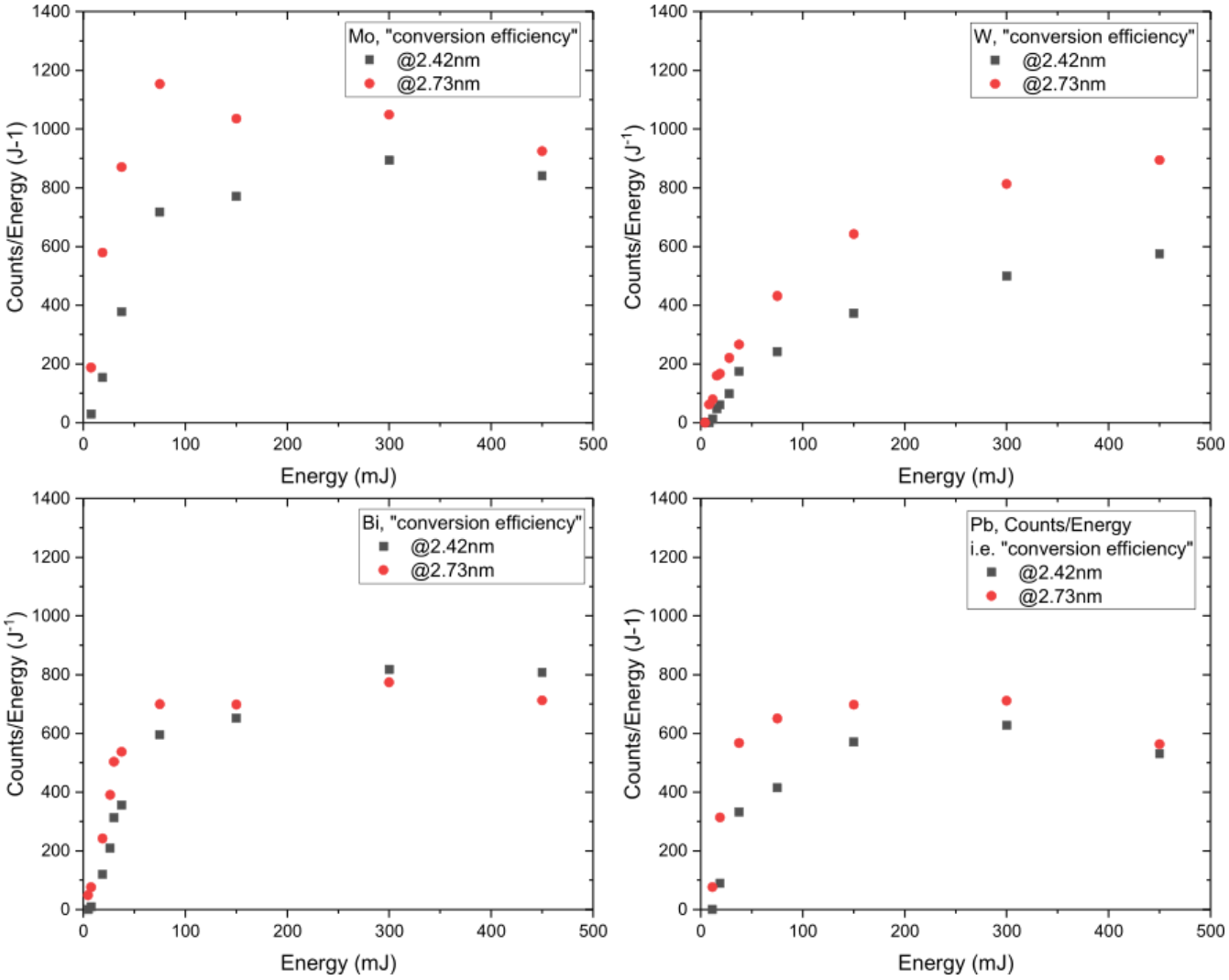
Mo Spectra vs Energy



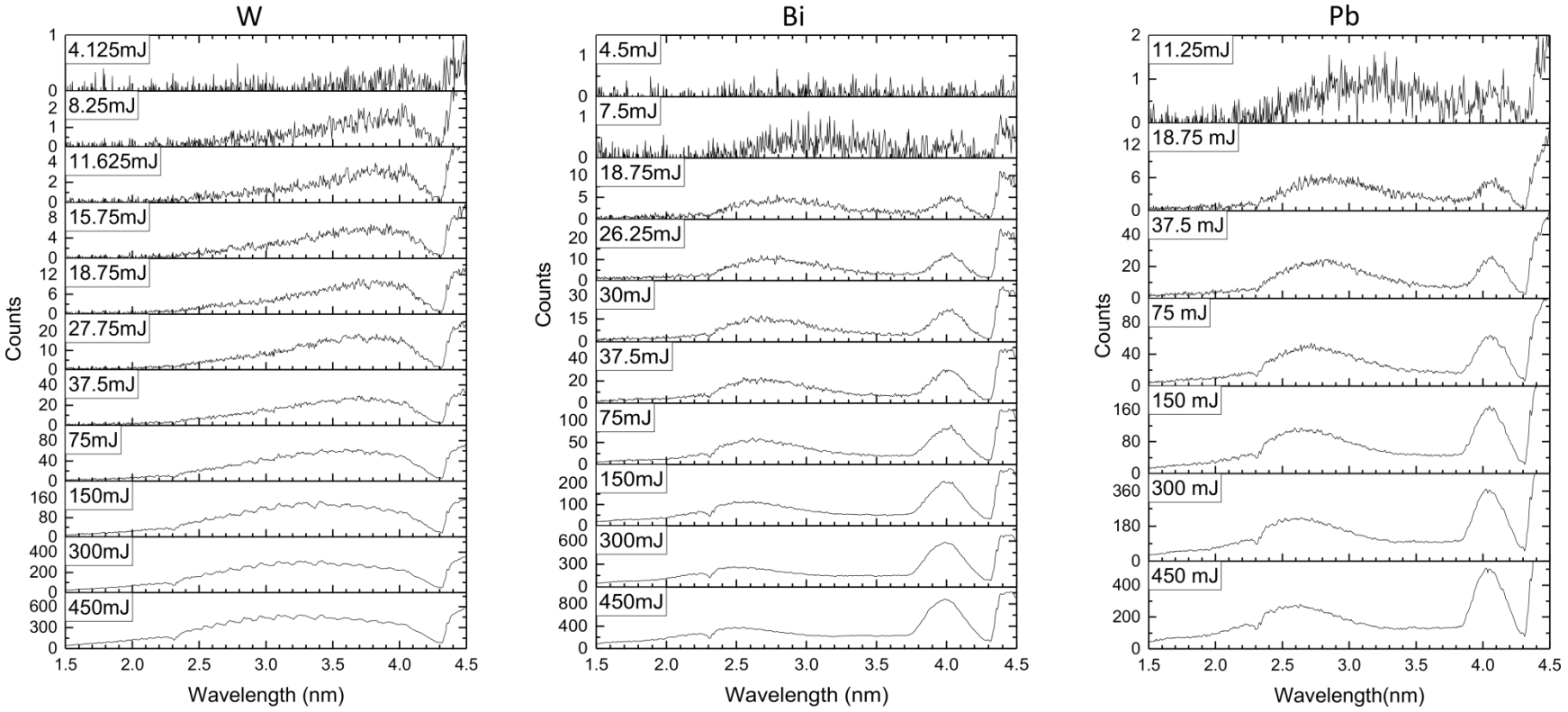




CE Scaling

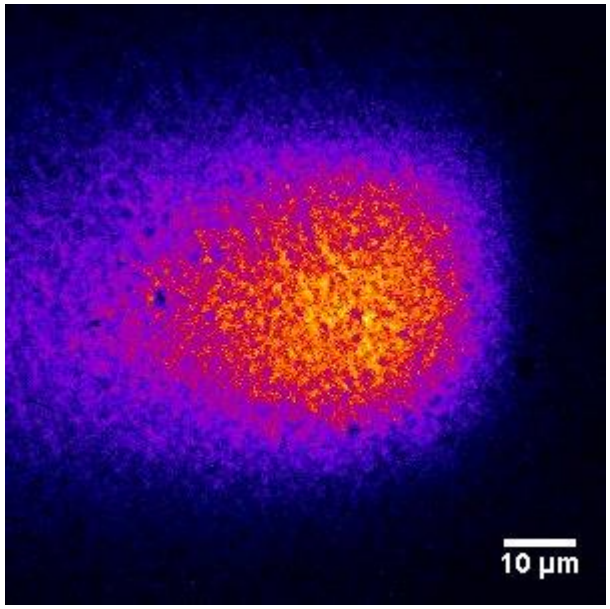

Mo, "conversion efficiency"
@2.42nm
@2.73nm
Counts/Energy (J-1)
Energy (mJ)
W, "conversion efficiency"
@2.42nm
@2.73nm
Counts/Energy (J^{-1})
Energy (mJ)
Bi, "conversion efficiency"
@2.42nm
@2.73nm
Counts/Energy (J^{-1})
Energy (mJ)
Pb, Counts/Energy
i.e. "conversion efficiency"
@2.42nm
@2.73nm
Counts/Energy (J-1)
Energy (mJ)

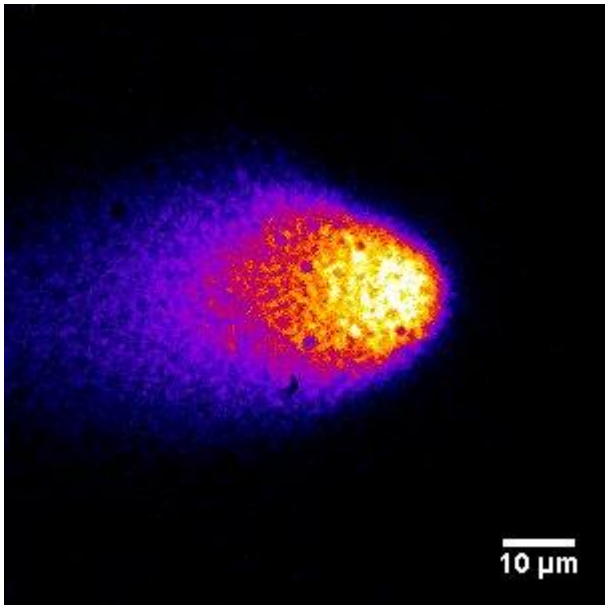
Smooth Spectra from 1.5 nm to 4.5 nm



Small High Energy Plasmas

550mJ – 1064 nm Mo Target





FWHM 33 µm
Illumination NA ~ 0.18

FWHM 18 µm
Illumination NA ~ 0.45

Radiance Improvement of > 3

Acknowledgements

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Investing in your future