High-precision stabilization of copper rotary target motion for application in a laser-driven x-ray source

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Introduction

- Laser-based x-ray sources have unique properties and a promising range of applications however are very sensitive to small movements in the position of the target surface with respect to the laser focus
- A 700μJ laser with a 32fs pulse duration at 1kHz repetition rate is focused through a microscope objective onto a copper target
- Factors such as the wobble in the rotational motion of the target and small curvatures in the target material are sufficient to move the target surface outside the Rayleigh length (13μm) of the laser by at least an order of magnitude
- In order to make the x-ray source viable, a focal correction is applied to maintain the position of the target surface within the Rayleigh length of the laser pulses

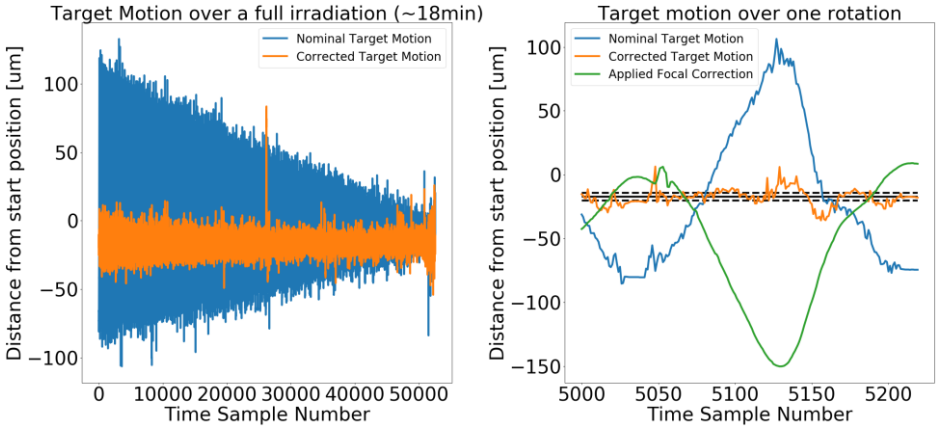

Figure 1: (Left) The variation in the target surface motion without focal correction and with focal correction. (Right) Target surface motion over a single rotation of the target. The solid and dashed black lines show the mean and standard deviation of the corrected motion

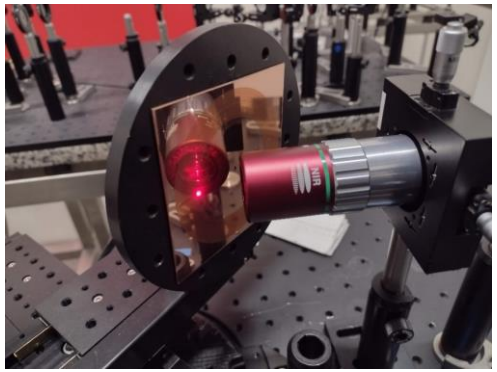

Figure 2: The copper target is mounted on a rotary stage. A microscope objective focusses the high intensity laser pulses onto the target producing x-ray radiation

Target Stabilization

- Standard deviation in target focal motion of **37.5μm** without correction
- Standard deviation in target focal motion of **6.2μm** with correction
- The majority of the laser shots therefore impact the target surface within the Rayleigh length

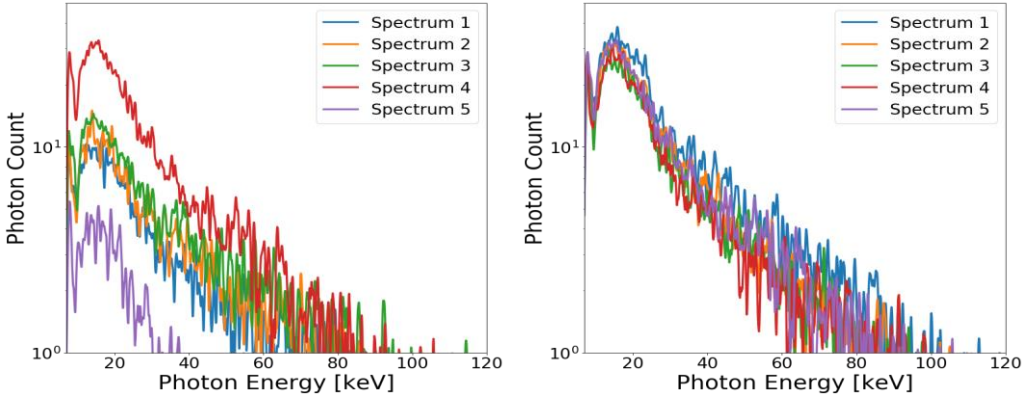

Figure 3: (Left) Five spectra without focal correction (Right) Five spectra with focal correction

Focal-corrected spectra

- More consistent spectral shape and photon flux
- Standard deviation in hot temperature reduced from 3.8keV to 2.9keV (24% reduction)
- Standard deviation in cold temperature reduced from 3.8keV to 0.5keV (87% reduction)

Conclusions

- This work has demonstrated the stability of a laser-generated x-ray source, through both position sensor measurements as well as spectral measurements
- Its stability allows us to exploit its unique properties for applications in phase contrast imaging

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