PIEZO MOTOR BASED HARDWARE TRIGGERED NANO FOCUS CAUSTIC ACQUISITION

L. B. C. Campoi, L. E. P. Vecina, G. S. R. Costa, G. B. Z. L. Moreno, N. L. Archilha,
Brazilian Synchrotron Light Laboratory (LNLS),
Brazilian Center for Research in Energy and Materials (CNPEM)

1. Introduction

Mogno is a micro and nano tomography beamline designed to provide users the flexibility to execute both high-resolution and large FOV experiments, via a cone beam geometry (zoom tomography), at one of the two energy configurations available: 22 and 39 keV simultaneously, or 67.5 keV. The main beamline source is a nano focus of 120 x 120 nm^2, produced by a set of multilayer elliptical mirrors in a Kirkpatrick-Baez (KB) system, which enables the energy selection and high resolution [1].

Based on the work done during the commissioning of the beamline's pre-KB mirror [2], a 2D scan along the horizontal and vertical planes was developed, where a Au sample of known width is scanned across the focus and the fluorescence signal is collected by a SDD (silicon drift detector). The acquired spectra at each point is then integrated around the L-alpha peak, resulting in a pixel count value used to build the beam's profile known as a caustic. Analyzing the caustics at different mirror's angular positions it is possible estimate and refine the focus size.

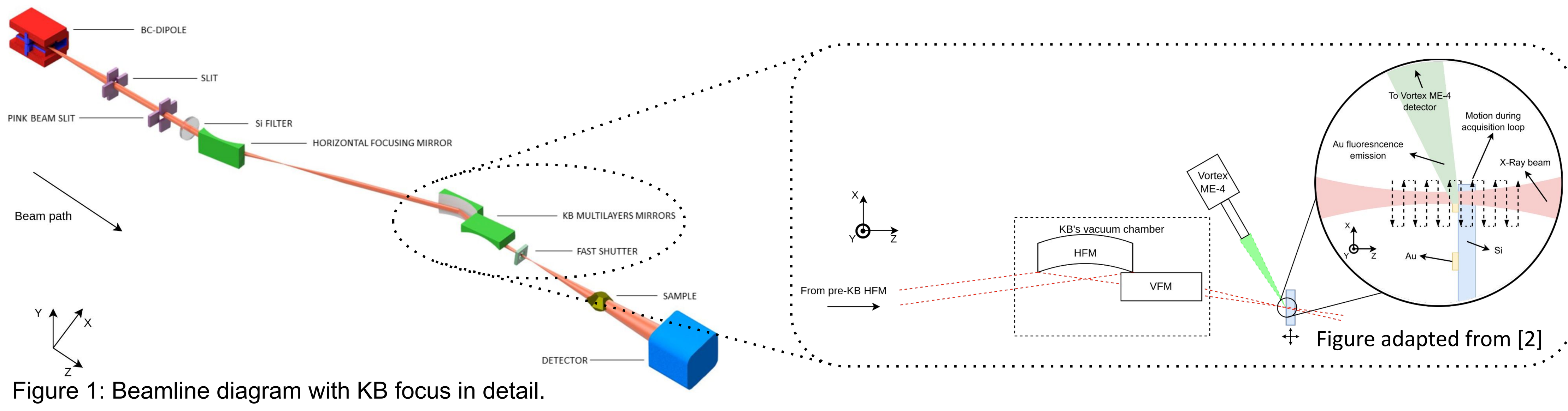

Figure 1: Beamline diagram with KB focus in detail.

2. Mechanical assembly

- The motion system is composed by Physik Instrumente (PI) QMotion series piezo stages, mounted over a UPR-160 Air rotational stage;
- Sample has 4 DOF: X, Y, Z and Ry;
- Coordinated motion along beamline's axis required the use of kinematics to compensate for the beam to sample stage's deviation (Rx and Ry) and the mounting angle of the YZ stage.

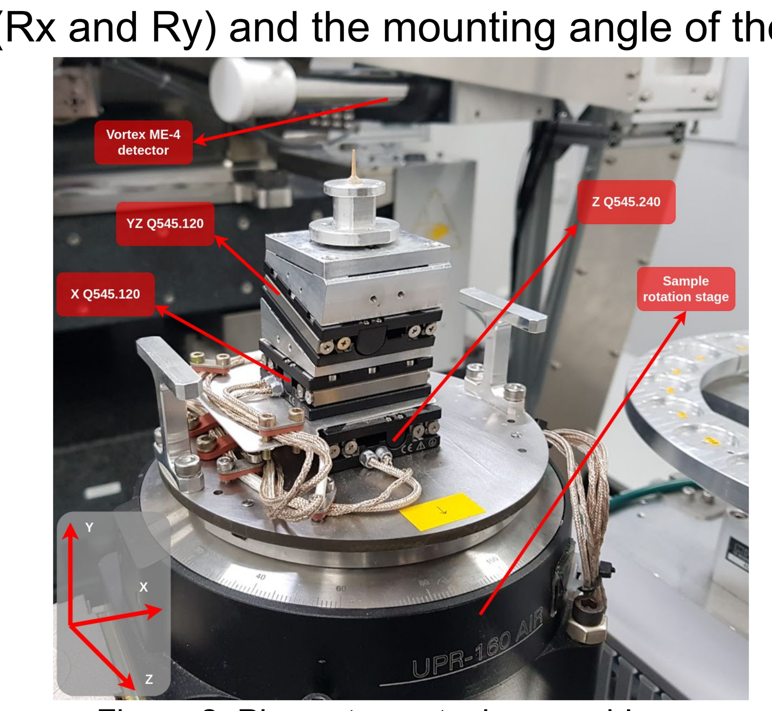

Figure 2: Piezo stage stack assembly.

3. Control system

- Each 2D scan is composed by a series of 1D scans and steps along the Z axis:
  - Fast 1D scans along X and Y axis are done via hardware triggered step scan;
  - Steps along the Z axis are done via software (EPICS).
- Each 1D scan is executed via controller macros:
  - Each piezo stage has a separate controller with their macros;
  - X axis scans are executed via a single macro that controls the motion loop;
  - Y axis scans use 2 macros that communicate via digital signals with each other, one for the Z stage and another for the YZ stage.
- TATU is a in-house software that runs on a NI cRIO, and is used to manage digital pulses [3];
- A high level Python package was developed to configure scan variables and devices (heavily rooted in OOP principles!).

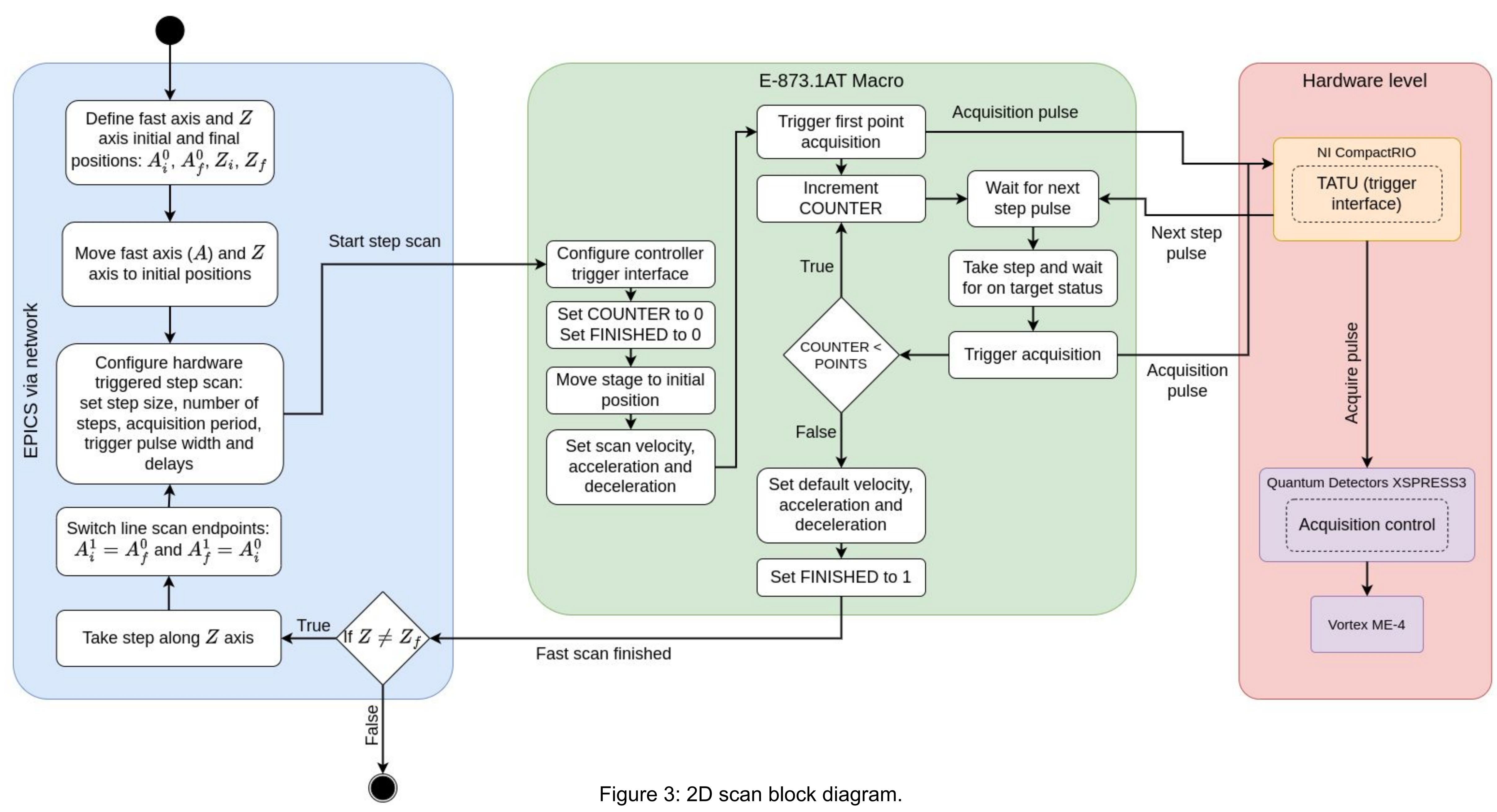

Figure 3: 2D scan block diagram.

4. Control system evaluation

The system's performance while executing the motion loop were evaluated taking into account the target configurations for 1D scans. During an experiment, the scans are usually executed with:

- Step size = 20 nm;
- Acquisition time = 200 ms;
- Velocity = 1 mm/s;
- Acceleration = 1 mm/s^2.

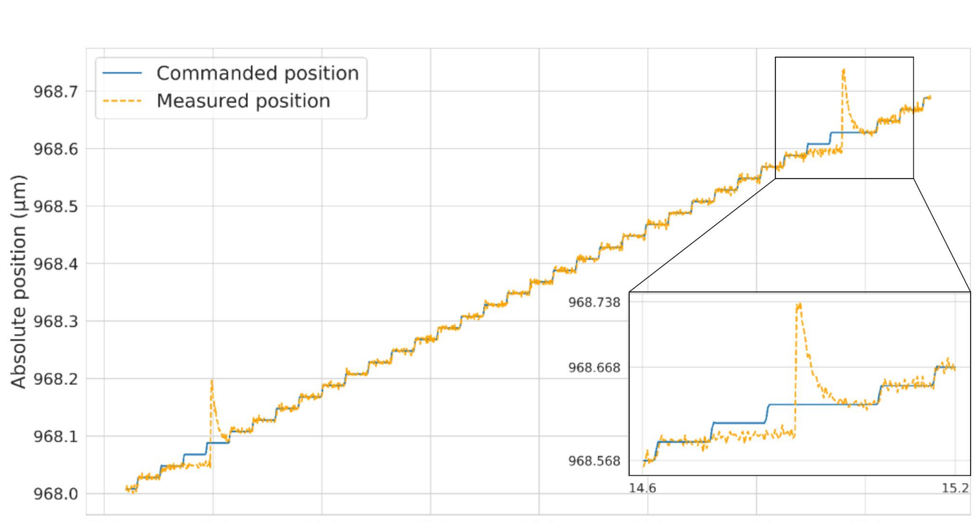

Figure 4: Commanded and measured position during motion along X axis, where it is possible to see a periodic error due to the stage's mechanism.

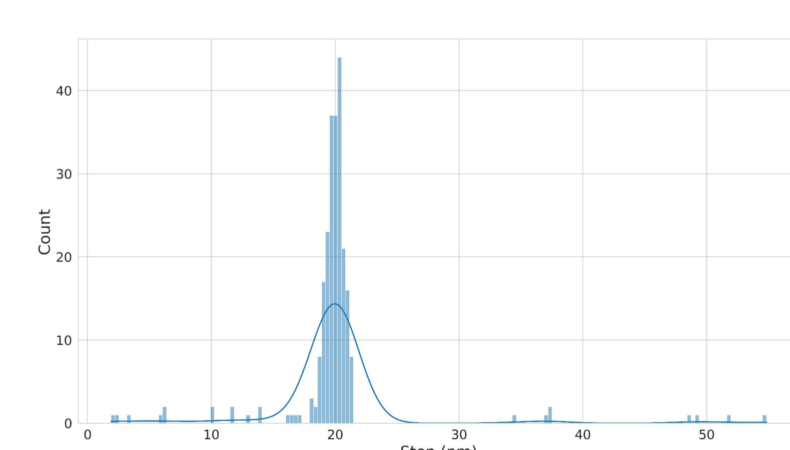

Figure 5: Step size distribution during X axis fast scan.

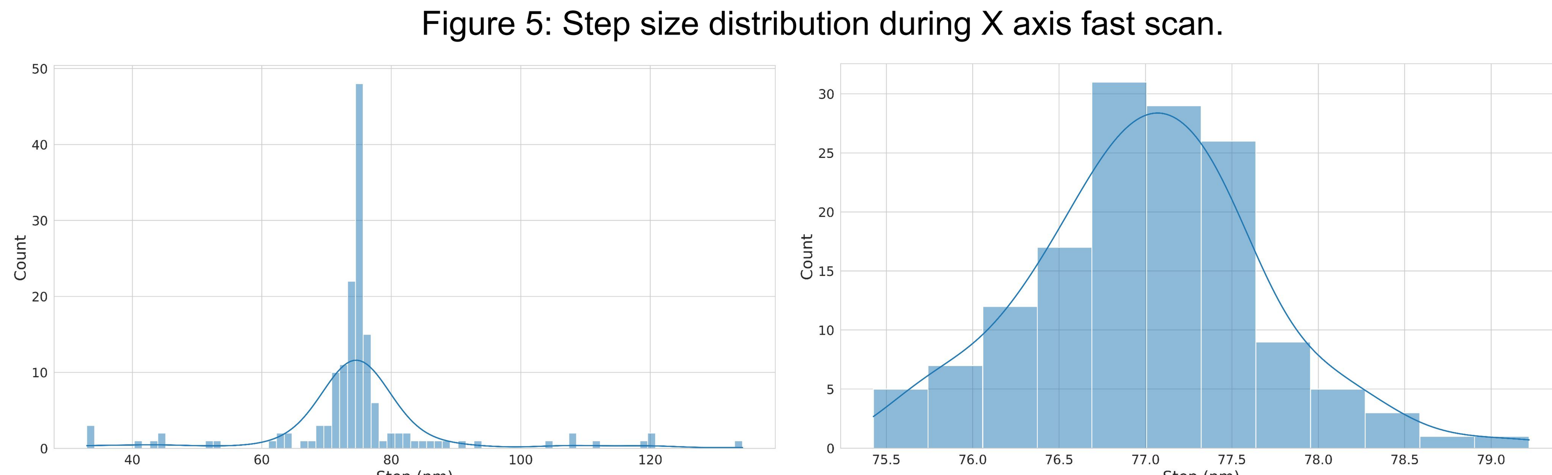

Figure 6: Step size distribution during Y axis fast scan. Z stage distribution on the left and YZ stage on the right.

5. KB focus caustics

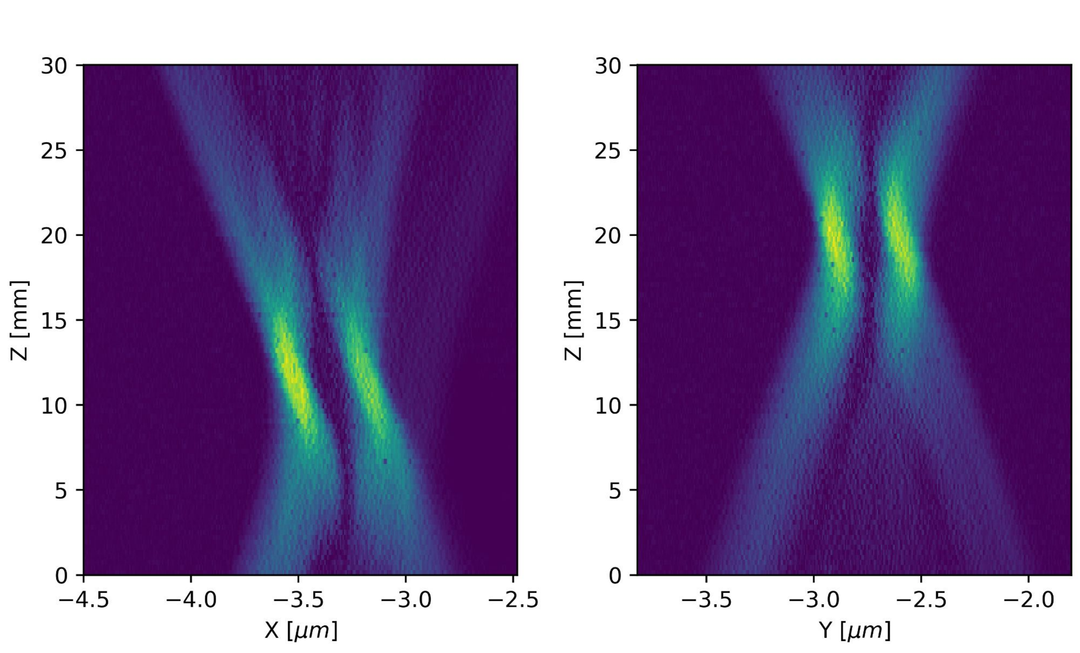

Figure 7: Gradient of caustics acquired in the XZ and YZ planes, respectively, along the direction perpendicular to the beam.

At the energy configuration of 22 and 39 keV, the focus size measured via the FWHM of the gradient along X and Y, respectively, resulting in: **416 x 480 nm^2**.

6. Final remarks

- With the proposed system, it was possible to acquire caustics in both XZ and YZ planes, however it also enables scans in the XY plane;
- The scan resolution achieved with the system is adequate to evaluate the nano focus at Mogno at lower energies;
- Although the acquisition time made it possible to iterate over the mirrors' positions to generate caustic profiles, the dead time is still high: up to 23% for XZ and 35% for YZ, where a step motion approximately 25ms;
- The focus size of approximately 416 x 480 nm is still being refined, and full field imaging is also being used to evaluate the beamline resolution.

Acknowledgements

The authors thank Mogno group and all the LNLS technical support groups for the valuable discussions and great support in the assembly and commissioning of the beamline, specially the control, software, projects and optics groups. The authors also thank Equinor Brazil. This work is supported by the Brazilian Center for Research in Energy and Materials (CNPEM), under the supervision of the Ministry of Science, Technology, and Innovation (MCTI).

References

1. Archilha N L, Costa G R, Ferreira G R B, Moreno G B Z L, Rocha A S, Meyer B C, Pinto A C, Miqueles E X S, Cardoso M B and Jr H W 2022 Journal of Physics: Conference Series 2380 012123 URL https://dx.doi.org/10.1088/1742-6596/2380/1/012123
2. Campoi L B C, Costa G S R, Moreno G B Z L, Pinto A C, Martinez-Zelaya V R, Ferreira T R, Carvalho M, Archilha N L, Horita A Y, Segalla L F, Gobbi A L, Piazzetta M H O, Baraldi G L and Tolentino H C N 2022 Journal of Physics: Conference Series 2380 012089 URL https://dx.doi.org/10.1088/1742-6596/2380/1/012089
3. Piton J, Alnajjar D, Araujo D, Neto J B, Carmo L D, Guedes L and Moraes M 2022 TATU: A Flexible FPGA-Based Trigger and Timer Unit Created on CompactRIO for the First Sirius Beamline Proc. ICALEPCS'21 (International Conference on Accelerator and Large Experimental Physics Control Systems no 18) (JACoW Publishing, Geneva, Switzerland) pp 908–911 ISBN 978-3-95450-221-9 ISSN 2226-0358 URL https://jacow.org/icalepcs2021/papers/thpv021.pdf