Design and Commissioning of the TARUMÃ Station at the CARNAÚBA Beamline at Sirius/LNLS

Brazilian Synchrotron Light Laboratory

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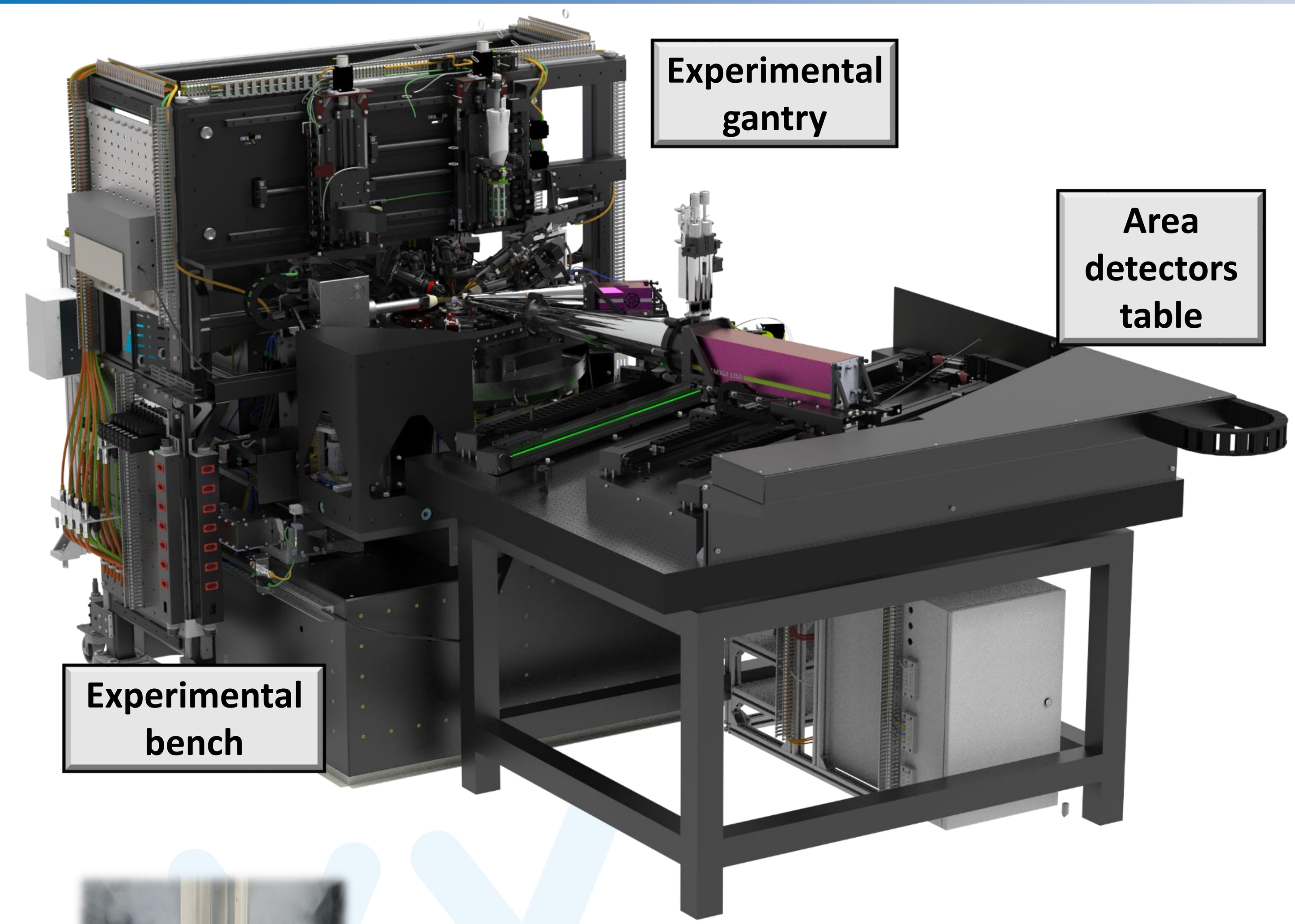
CNPEM Brazilian Center for Research in Energy and Materials



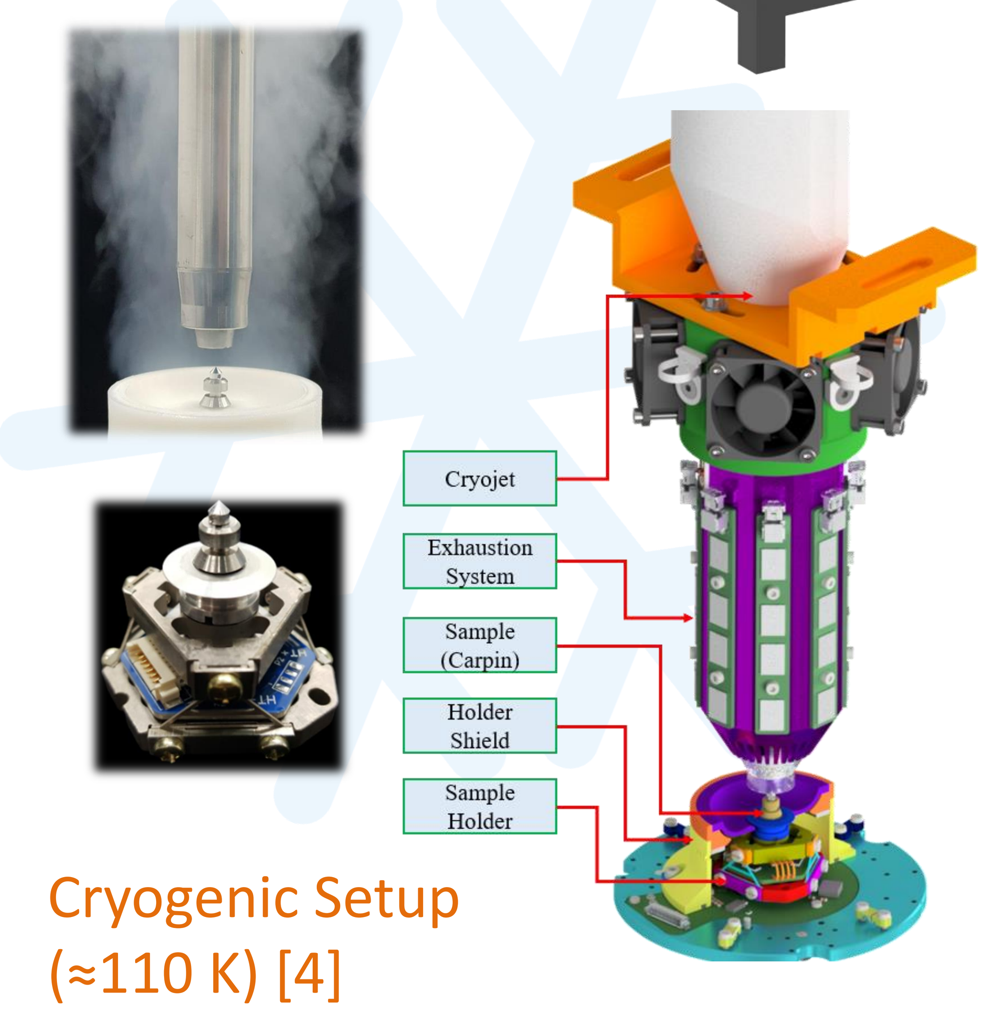
Abstract

TARUMÃ is the sub-microprobe station at CARNAÚBA (Coherent X-Ray Nanoprobe Beamline) at Sirius Light Source at the Brazilian Synchrotron Light Laboratory (LNLS), being designed to allow for simultaneous multi-analytical X-ray techniques both in 2D and 3D [1,2]. A systemic approach, heavily based on precision engineering concepts and predictive design, has been adopted for first-time-right development, effectively achieving al-together: the alignment and stability requirements of the large KB mirrors with respect to the beam and to the sample [3]; and the nanometer-level positioning, flyscan, tomographic and setup modularity requirements of the samples. This work presents the overall station architecture, the key aspects of its main components, and the first commissioning results.

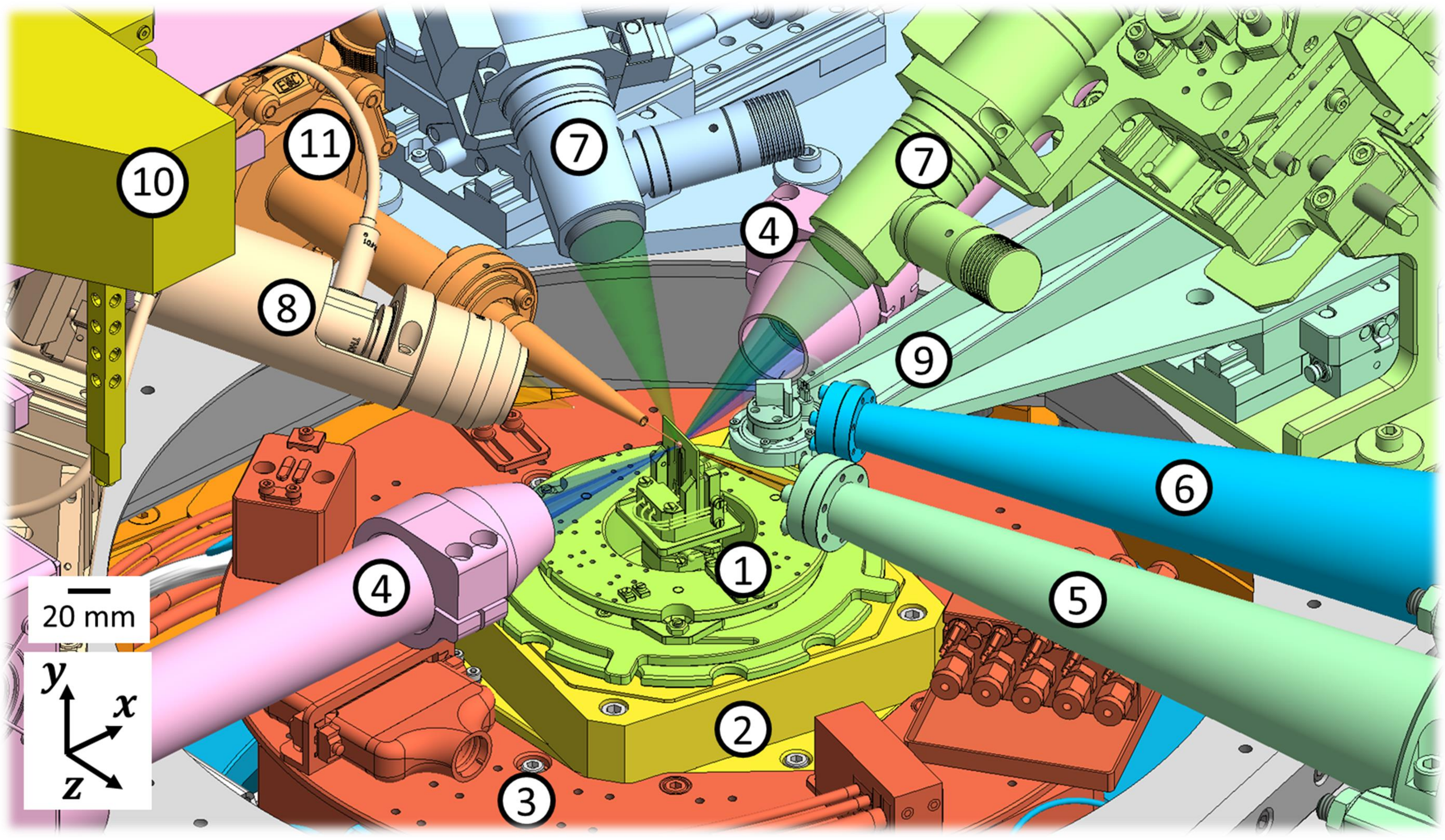
Optics Overview:
- ❑ **Undulator source;**
- ❑ **2.05 to 15 keV;**
- ❑ **Four-bounce monochromator;**
- ❑ **All-achromatic optics;**
- ❑ **Flux up to 1e11 ph/s/100 mA;**
- ❑ **KB focusing: 550 to 120 nm;**
- ❑ **Large working distance: 440 mm.**

Features:
- ❑ **Simultaneous multi-analytical X-ray techniques;**
- ❑ **Macro and micro sample holders: from centimeter range samples to microscopy standards;**
- ❑ **Special sample setups: cryogenic, Rhizomicrocosm, electrochemistry, electrocatalysis, batteries, etc ;**
- ❑ **Sub-millisecond hardware integration;**
- ❑ **High-speed flyscan mapping;**

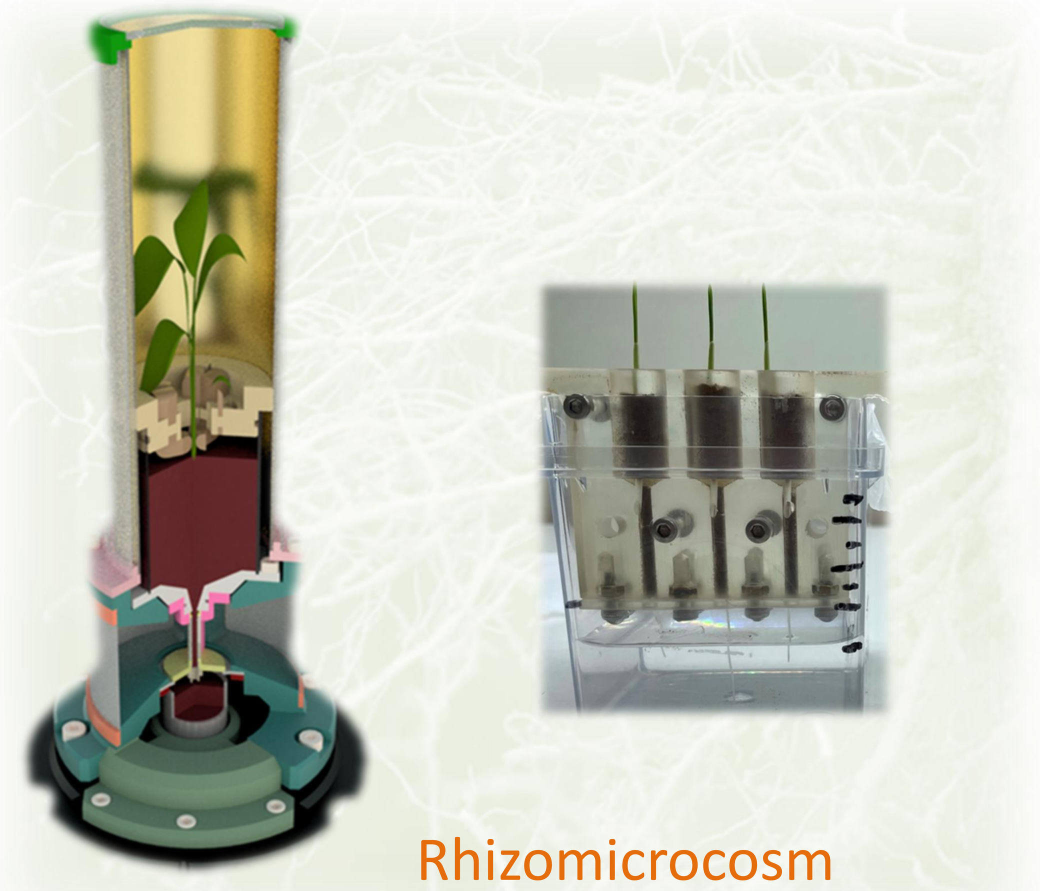
Techniques:
- ❑ **XRD**
- ❑ **XAS**
- ❑ **XRF**
- ❑ **XEOL**
- ❑ **Ptycho-CDI**
- ❑ **Ptycho-Bragg-CDI**
- ❑ **Tomography**



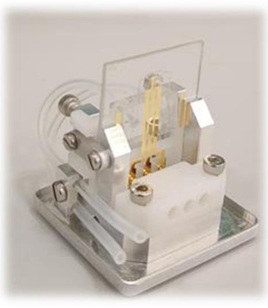
Cryogenic Setup (≈110 K) [4]



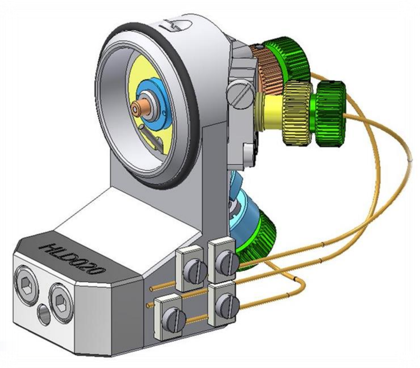
1. Sample setup;
2. XYZ piezo stage;
3. Rotary stage;
4. Fluorescence detectors;
5. Transmission area detector;
6. Diffraction area detector;
7. Optical microscopes;
8. XEOL optics;
9. Crystal analyzer;
10. Pick-and place gripper;
11. KB vessel exit port.



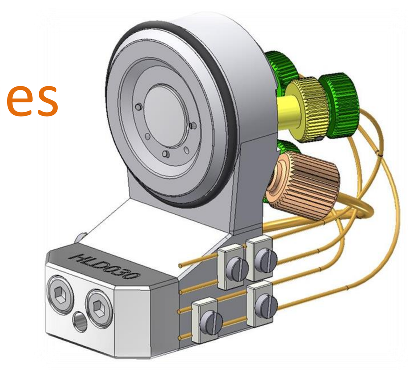
Rhizomicrocosm



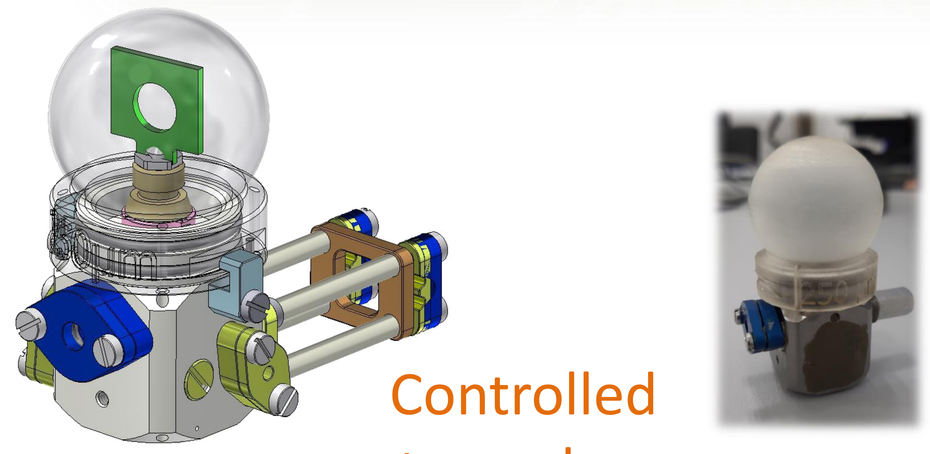
Microfluidics [5]



Electrochemistry [5]

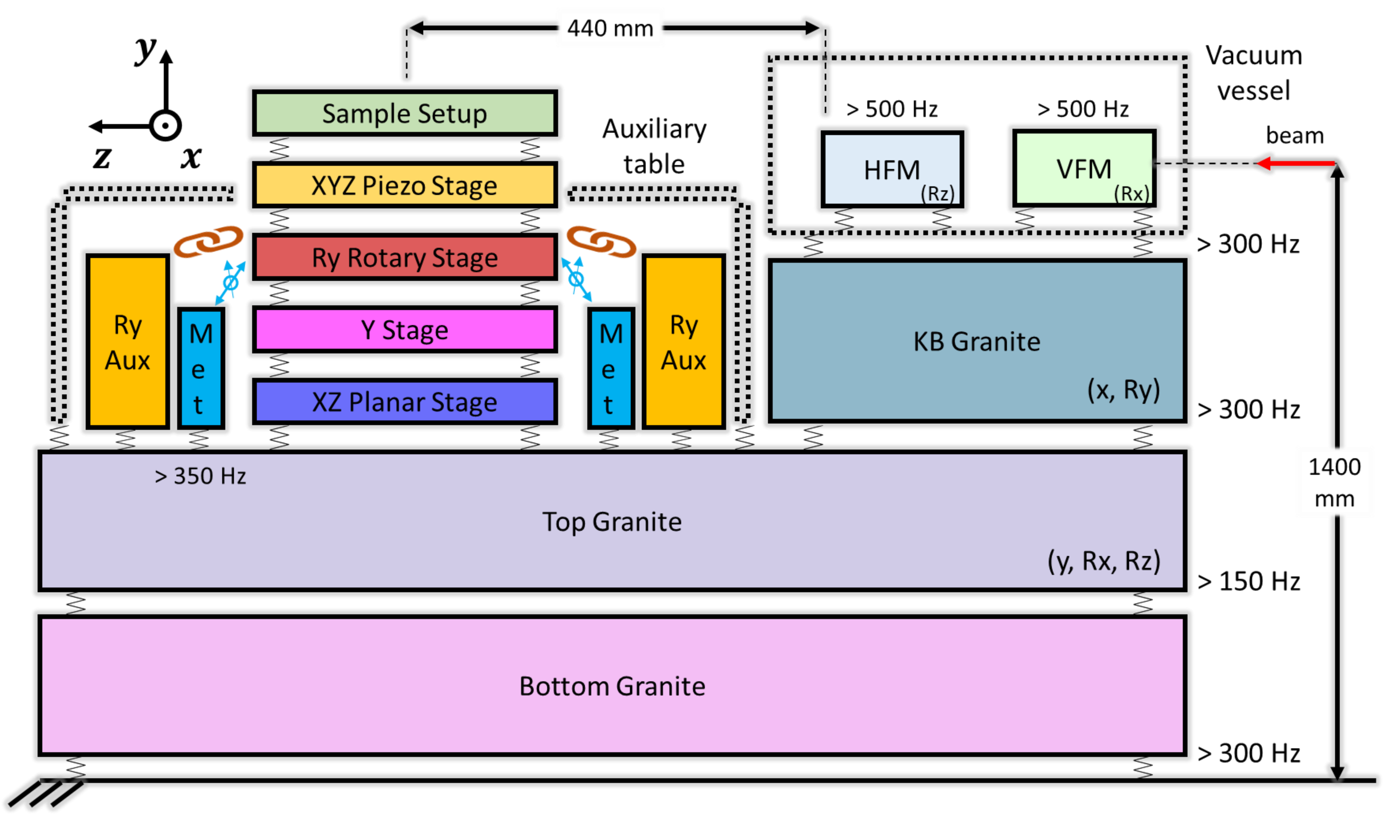


Batteries



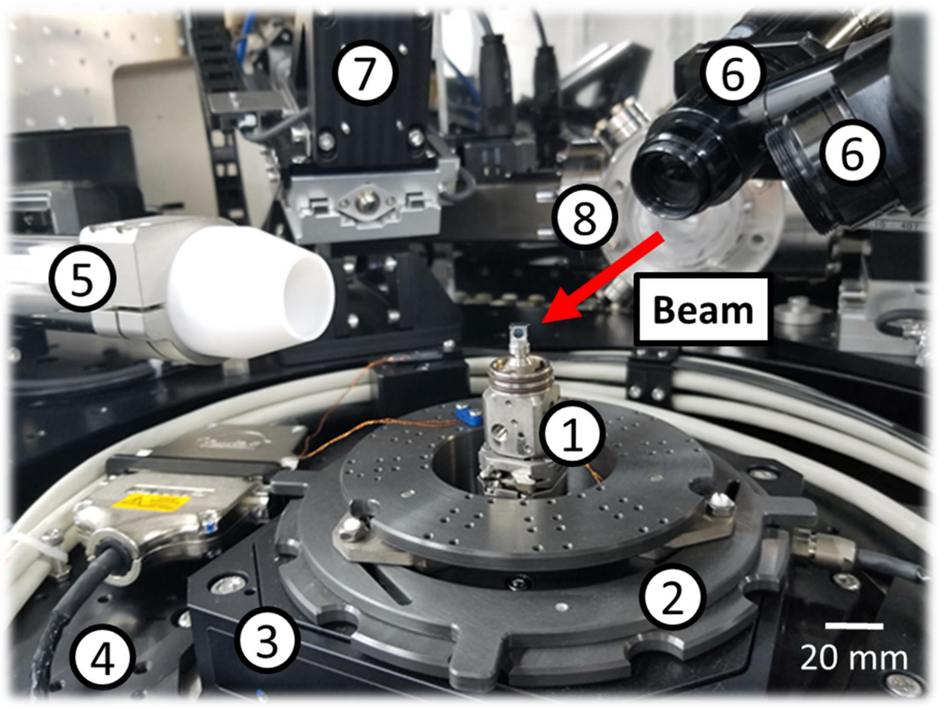
Controlled atmosphere

Architecture

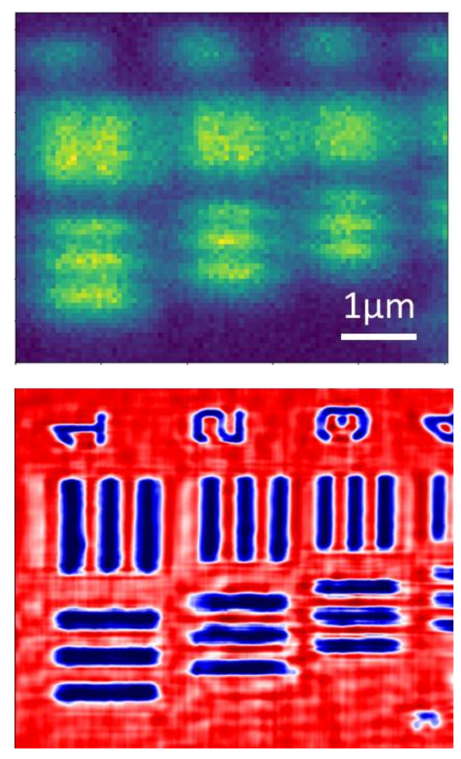


Schematic of the experimental bench of TARUMÃ [6], highlighting some of the links and the dynamic characteristics of the main components, including: the granite parts, the KB mirrors (VFM and HFM), the sample stage, the auxiliary rotary stage and the metrology frame.

Commissioning



1. Sample holder;
2. Interface plate;
3. XYZ piezo stage;
4. Rotary stage;
5. Fluorescence detector;
6. Optical microscope;
7. XEOL stage;
8. KB vessel



3-minute 5x5µm^2 flyscan measurements of X-ray fluorescence and ptychography, with spatial resolutions of about 800 x 300 nm^2 and 200 x 70 nm^2, respectively.

Conclusions

TARUMÃ has been fully designed and built in-house, according to the same precision engineering concepts and predictive design principles that have led to a whole series of innovative instruments for Sirius beamlines. A complex sceneario results from the achromatic optics, with large KB mirrors and working distances, vacuum-air separation, and multiple techniques and setups, but the successful initial results build confidence in the current workflow, at the same time that bring valuable lessons for the ongoing and forthcoming projects. The unique features of TARUMÃ are expected to be open for users in the second half of 2021.

Acknowledgements

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References

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[2] Bueno, C.S.N.C., et al. "Vibration Assessmento at the CARNAÚBA Beamline at Sirius/LNLS," presented at MEDSI 2020, Chicago, USA, 2021, this conference.

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