Vibration Assessments at the CARNAÚBA Beamline at Sirius/LNLS

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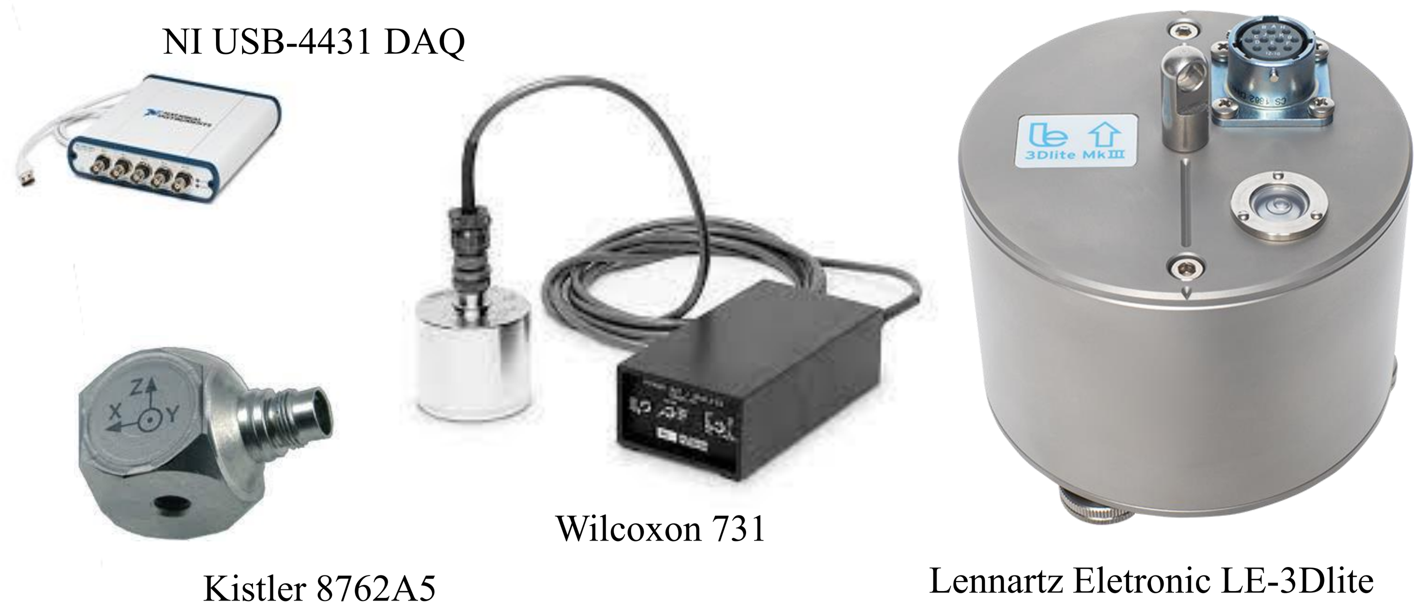
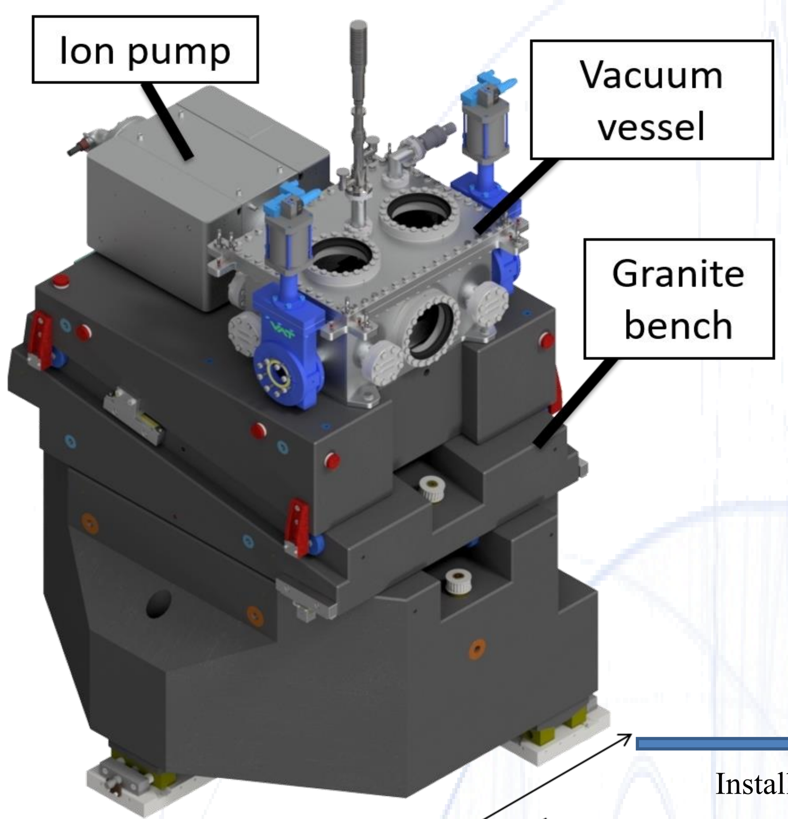
Abstract

CARNAÚBA (Coherent X-Ray Nanoprobe Beamline) [1] is the longest beamline at Sirius Light Source at the Brazilian Synchrotron Light Laboratory (LNLS), working in the energy range between 2.05 and 15 keV and hosting two stations: the sub-microprobe TARUMÃ and the nanoprobe SAPOTI, with coherent beam size varying from 500 to 30 nm. In this work we present a comprehensive set of measurements of both floor stability and modal analyses for the main components, including: two side-bounce mirror systems (M1 and M2) [2,3]; the four-crystal monochromator (4CM) [4]; the Kirkpatrick-Baez (KB) [5] focalizing optics; and the station bench and the sample stage at TARUMÃ [6]. To complement the components analyses, we also present synchronized long-distance floor acceleration measurements that make it possible to evaluate the relative stability through different floor slabs: the accelerator slab, experimental hall slab, and the slabs in the satellite building, consisting of three inertial blocks lying over a common roller-compacted concrete foundation [7]. In addition to assessing the stability across this beamline, this study benchmarks the in-house design of the recently installed mirrors, monochromators, and end-station.



Modal Analysis



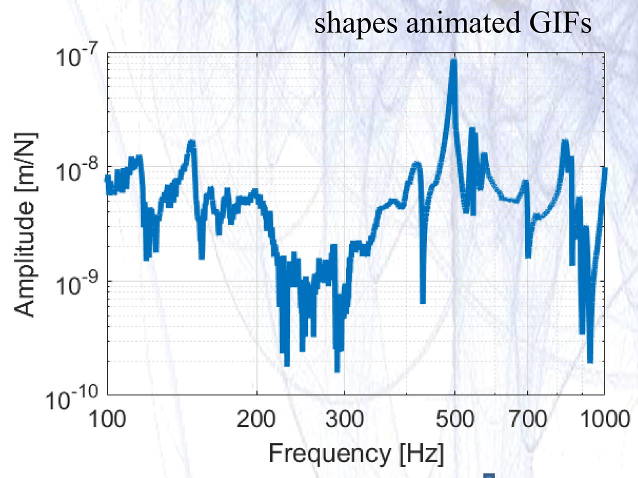
CAD drawing of a Sirius mirror system

Mirror bench installed at the beamline

Installation

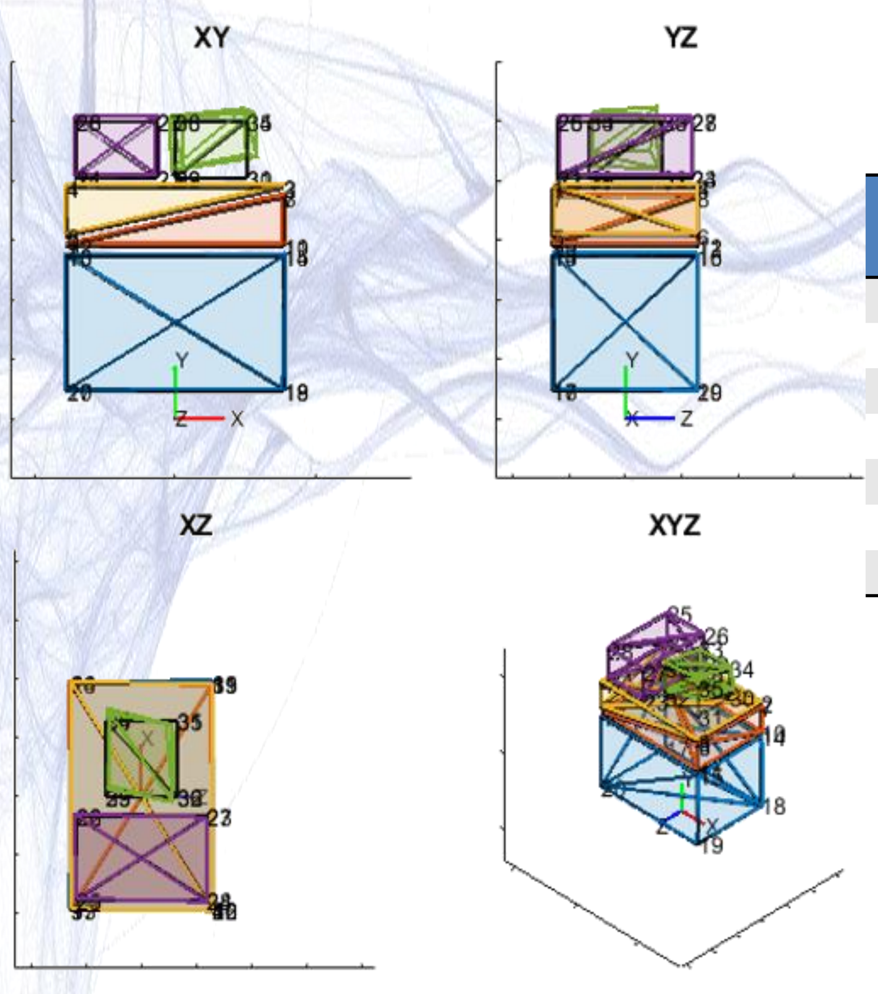
Experimental modal analysis

Example of a Frequency Response Function (FRF) measurement of the installed mirror benches, which is used to construct the mode shapes animated GIFs



Mode shapes

42 Hz



In-house developed MATLAB® toolbox.

Representation of an animated mode shape for the M1 modal analysis. The components represented are the bottom granite (purple), the bottom granite wedge (red), the top granite wedge (yellow), the vacuum chamber (purple) and the ion pump (green).

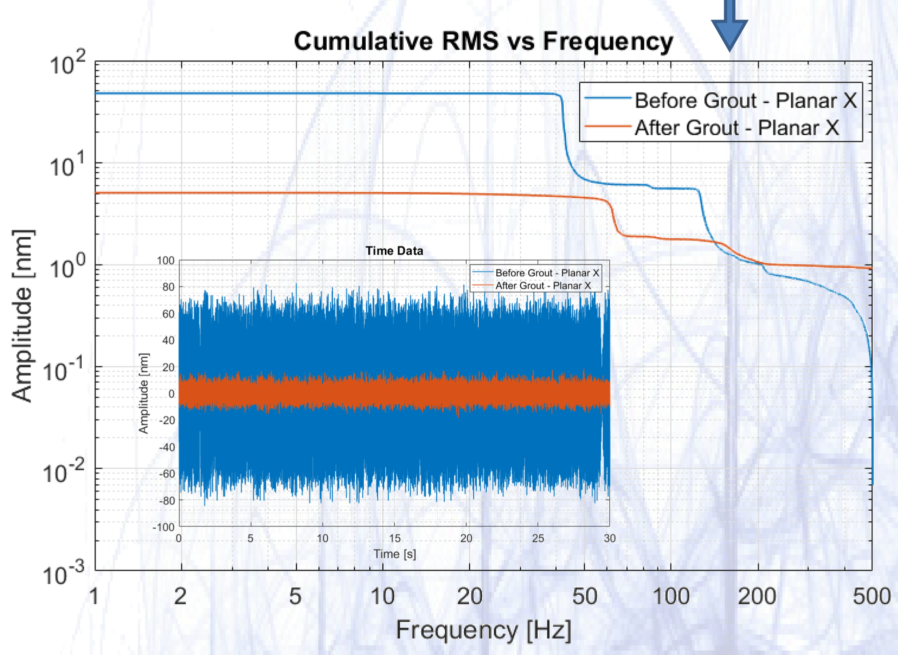
The seven first natural frequencies, in Hz, for all CARNAÚBA opto-mechanical system installed. The acronyms BG and AG stand for Before grouting and After grouting, respectively.

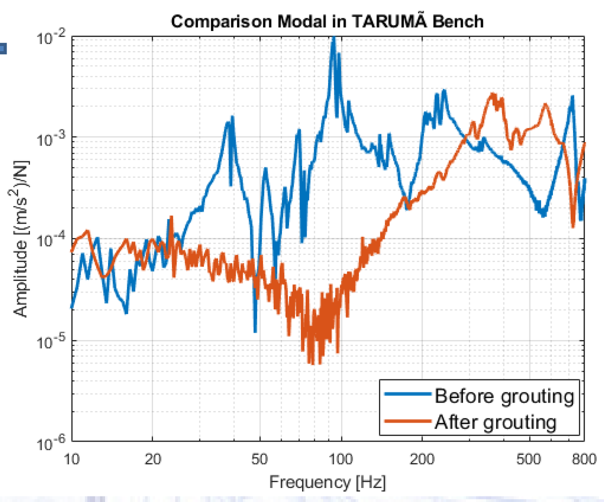
M1	M2	4CM	TARUMÃ BG	TARUMÃ AG
42*	42*	39*	40	180
56*	46*	44*	52	215
64	51	55*	62	317
78	64	60*	70	402
91	70	74*	94	498
148	104	109	107	529
170	130	137	213	631

*Modes related only to the ion pump on the granite bench, not the bench itself.

Engineering solutions

Assessment of critical resonances

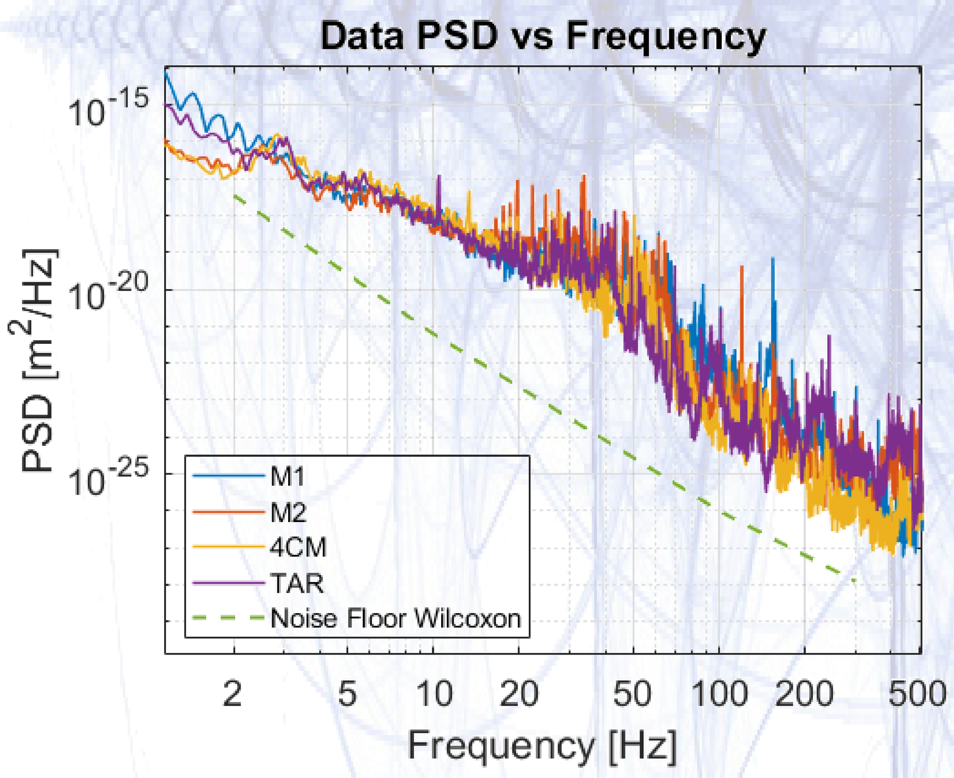




Comparison between the Frequency Response Function (FRF) for TARUMÃ bench in the scenarios: Before Grouting and After Grouting.

Comparison between the time data and cumulative amplitude spectrum (CAS) for TARUMÃ sample stage in the scenarios: Before Grouting and After Grouting.

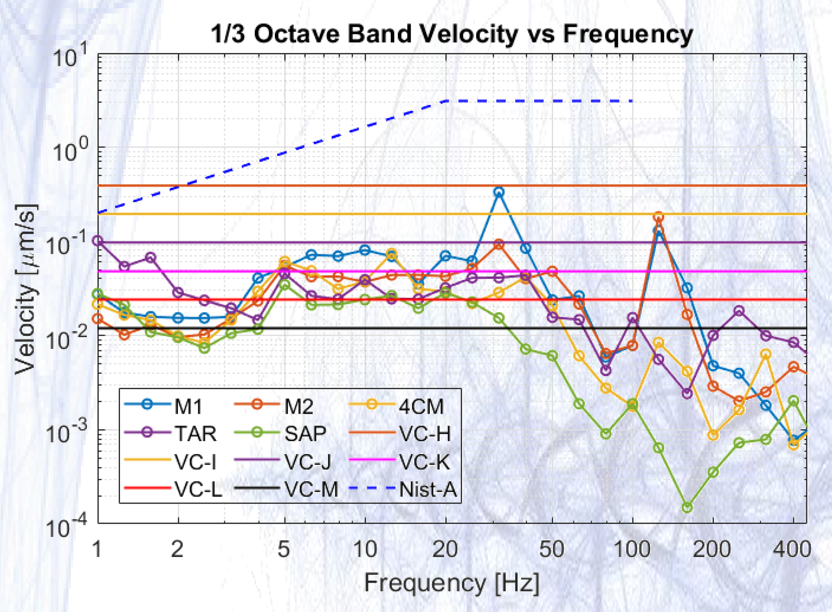
Stability Measurements



Horizontal Displacement Power Spectrum Density (PSD) measurements for some of the opto-mechanical systems at the CARNAÚBA beamline.

Cumulative Amplitude Spectrum from 2 to 450Hz, in nm and nrad, for 6 DoF floor stability around opto-components and 3 DoF translations in the granite benches.

	M1	M2	4CM	TARUMÃ	SAPOTI
X Floor	8.17	7.77	10.71	9.04	12.42
Y Floor	7.2	7.69	7.53	5.34	5.67
Z Floor	7.32	6.64	13.87	16.37	9.58
Rx Floor	1.97	2.46	6.51	10.31	9.31
Ry Floor	1.30	1.78	11.60	3.95	5.35
Rz Floor	1.47	1.79	1.31	1.49	3.49
X Bench	9.39	9.17	11.71	10.59	-
Y Bench	7.58	8.07	8.06	7.33	-
Z Bench	7.63	6.98	15.07	17.38	-

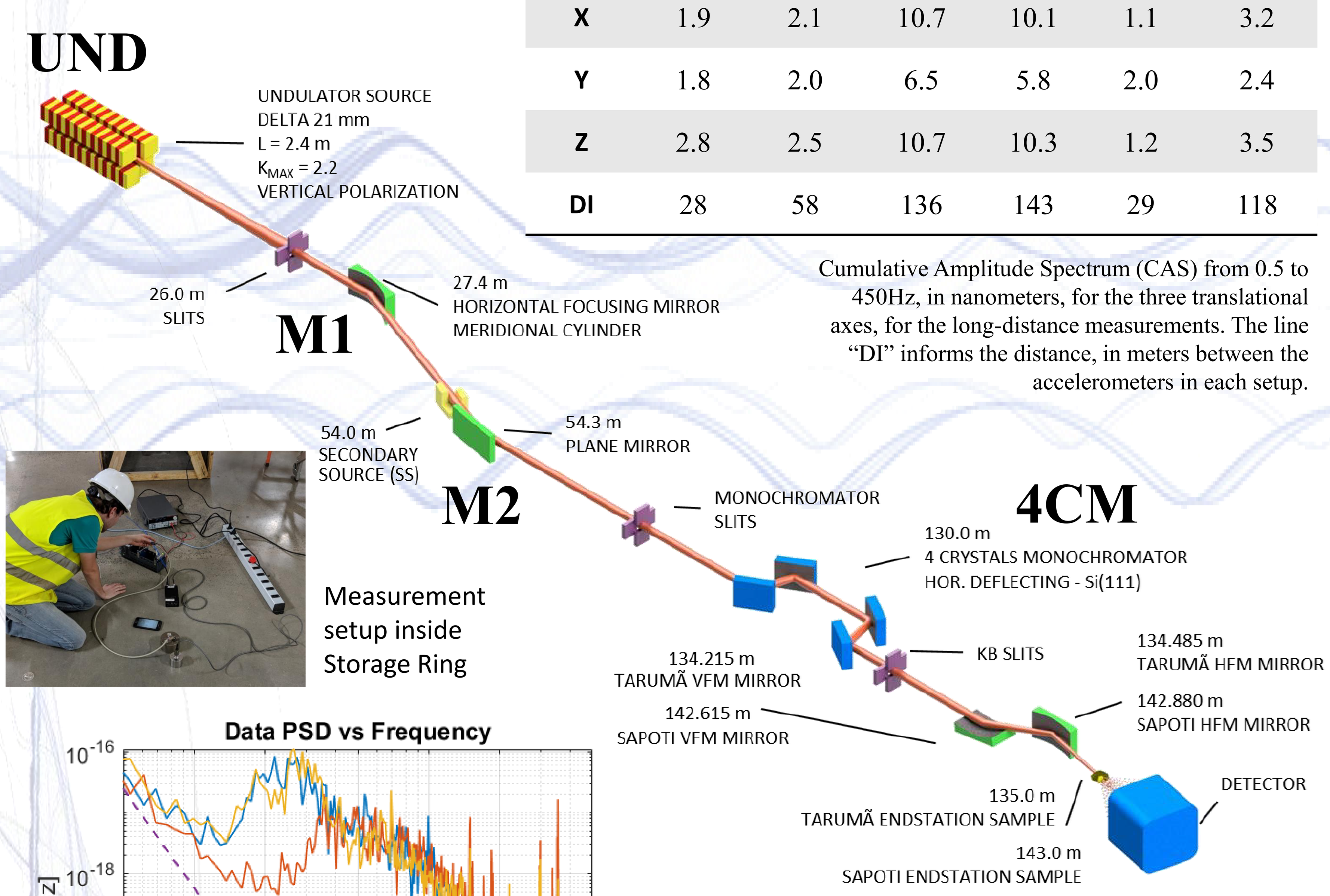


Comparison of floor vertical one third octave bands velocities with Vibration Criteria Curves (VC) and NIST-A standard. At least one data was collected in with one of the floors types: Storage ring especial floor, experimental hall floor and satellite building slabs.

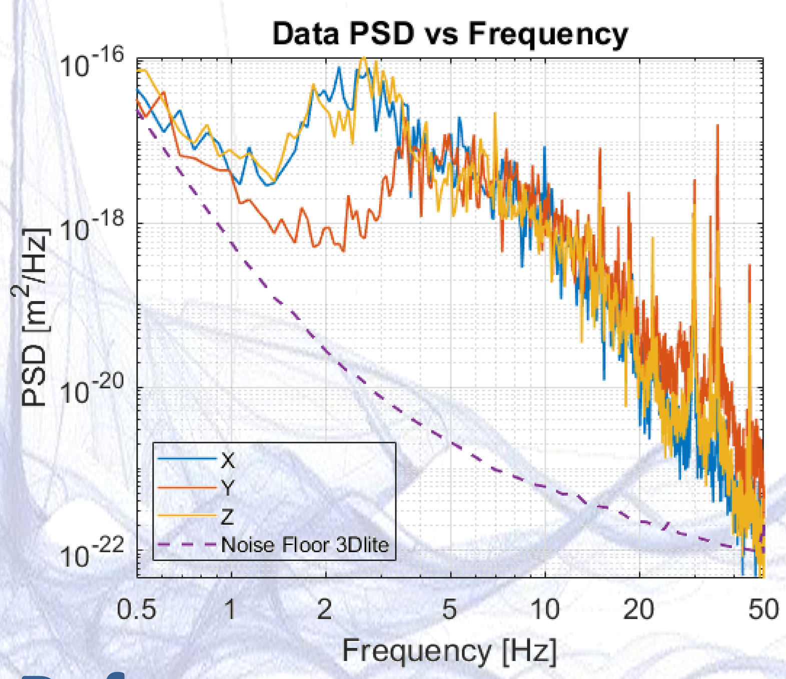
Long-Distance Relative Stability Measurements

	UND-M1	UND-M2	UND-TARUMÃ	UND-SAPOTI	M1-M2	M1-TARUMÃ
X	1.9	2.1	10.7	10.1	1.1	3.2
Y	1.8	2.0	6.5	5.8	2.0	2.4
Z	2.8	2.5	10.7	10.3	1.2	3.5
DI	28	58	136	143	29	118

Cumulative Amplitude Spectrum (CAS) from 0.5 to 450Hz, for the three translational axes, for the long-distance measurements. The line "DI" informs the distance, in meters between the accelerometers in each setup.



Measurement setup inside Storage Ring



Relative Displacement Power Spectrum Density (PSD) for the long-distance measurement between Undulator and SAPOTI slab (143m).

Conclusions

A full set of instruments and methods has been used for stability and dynamic analyses at CARNAÚBA, the longest beamline at Sirius that also hosts its the first nanoprobe TARUMÃ. The floor stability in all locations is remarkably well placed with respect to the common NIST-A and VC curves, with integrated displacement between 2 and 450 Hz below in the range from 5 to 15 nm RMS in XYZ. At the same time, the relative measurements over the long distances proved to be below 10 nm RMS, already partly limited by sensor noise. Finally, the granite benches of the opto-mechanical systems are validated, having achieved robust dynamic performances that do not amplify the cultural noise and providing suitable stands for the most sensitive beamline elements.

Acknowledgements

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