The LNLS Metrology Building – Environmental Results

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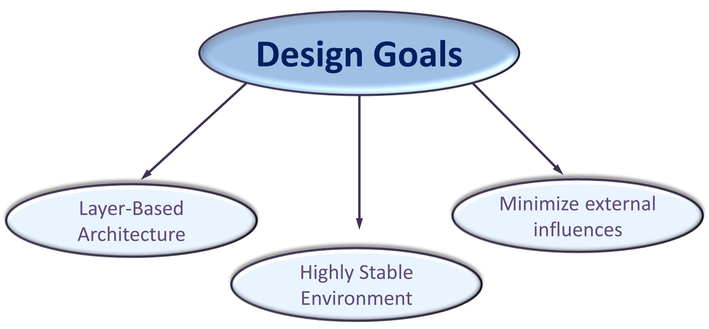
Abstract

Modern synchrotron light sources require high mechanical stability throughout its facilities, frequently demanding characterization processes in the micro and nanometer scales. In this context, the Brazilian Synchrotron Light Laboratory (LNLS) built a new laboratory with several controlled environment rooms to minimize disturbances during optical and mechanical metrology procedures and to support advanced instrumentation development for the new Sirius' beamlines. The building design imposed very strict requirements regarding temperature, humidity and cleanliness. This work presents the environmental control validation results and the floor vibration assessment enlightening the influence of the building machinery. Temperature variations below ± 0,1 °C were successfully achieved for all rooms, relative humidity is also better than 50 ± 5 % and the floor RMS displacement did not exceed 50 nm. The building is fully operational since 2017 and currently hosting several tests on monochromators, mirrors, front-ends and many other systems for the Sirius beamlines.

Project Review



The LNLS Metrology Building was designed following a layer-based architecture: the outer layers have a proper environmental control that contributes for the stability of the inner ones. The goal is to provide the laboratories (inner layers) a highly stable environment, minimizing the influence of the large thermal and humidity variations that may occur outside the building

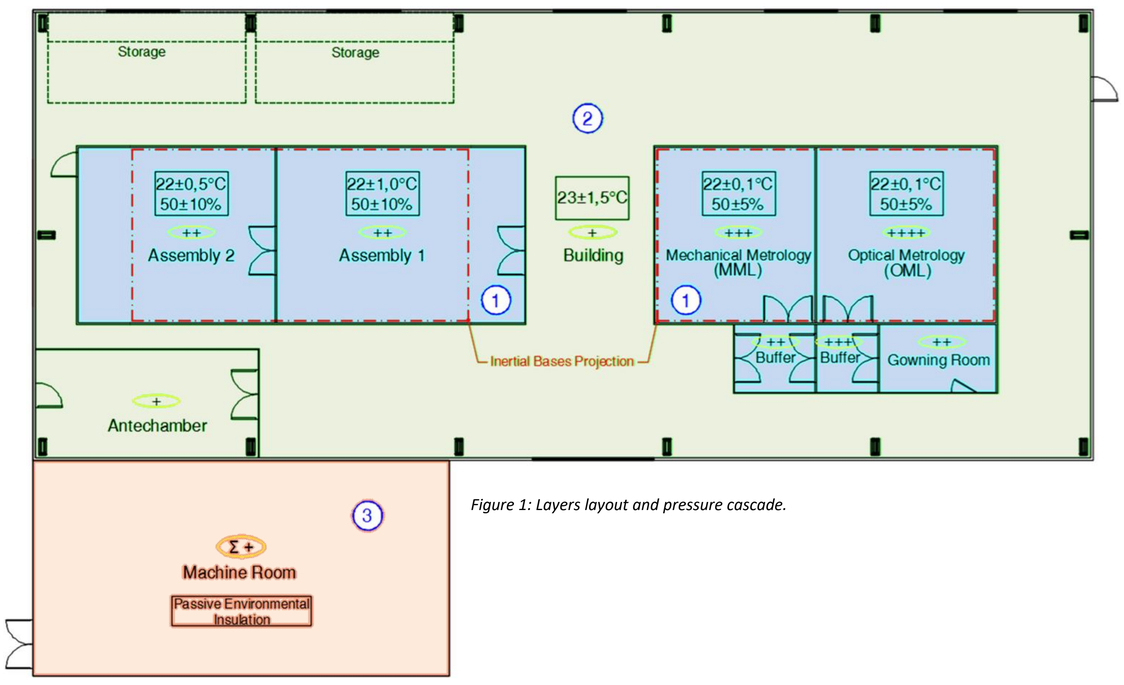


Figure 1: Layers layout and pressure cascade.

The building contains three layers: each of them has one or more rooms controlled by independent air handling units (AHUs). The design requirements for each area are:

Room	T [°C]	RH [%]	Clean Room Class
Building Shed	23±1.5	-	-
Assembly 1	22±1.0	50±10	-
Assembly 2	22±0.5	50±10	-
Mech. Metrology	22±0.1	50±5	-
Gowning Room and Buffers	22±0.1	50±5	ISO 8
Opt. Metrology	22±0.1	50±5	ISO 7

Environmental Control Results

All the measurements were taken by the Building automation sensors used to monitor and control humidity and temperature. The figures shows the areas environmental control over one day cycle.

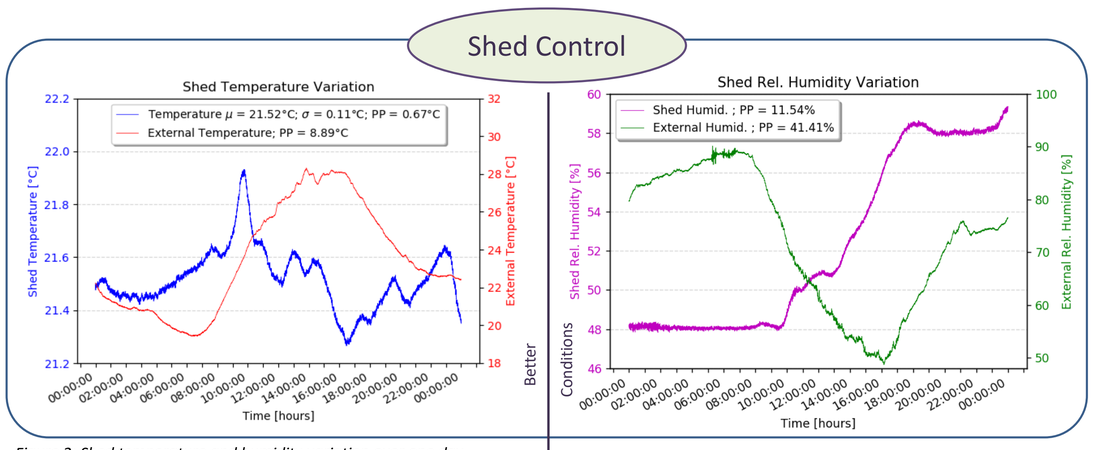


Figure 2: Shed temperature and humidity variation over one day.

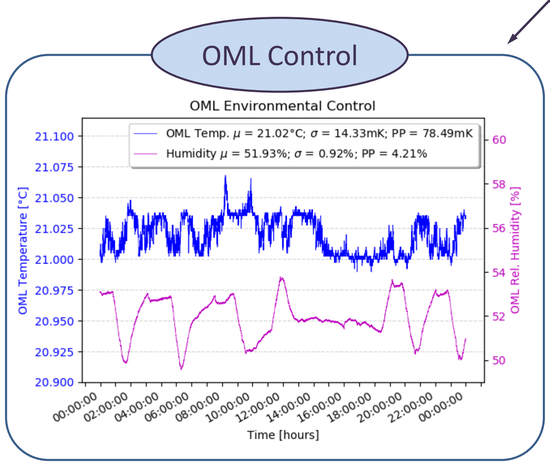


Figure 3: OML temperature and humidity variation over one day.

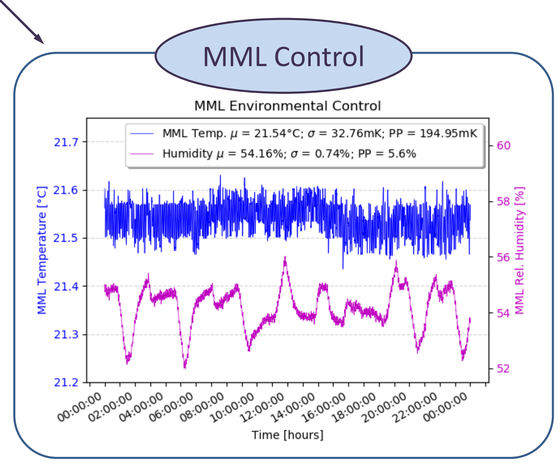


Figure 4: MML temperature and humidity variation over one day.

Although the other rooms had more relaxed requirements, equivalent results were achieved regarding temperature and humidity control when avoiding people flow during a certain period.

Opt. Metrology Lab. – LTP Upgrade

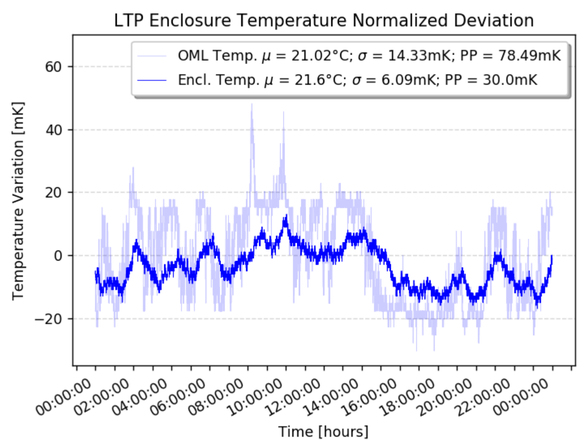


Figure 5: Normalized Temperature Variation at the OML room and inside the LTP enclosure

One problem faced during the OML commissioning was that the Long Trace Profiler (LTP) was installed right below one of the air diffusers, consequently being affected by the air flow. To circumvent that situation, an enclosure was installed around the LTP bench, providing a passive thermal insulation to the area and physically blocking the air flow.

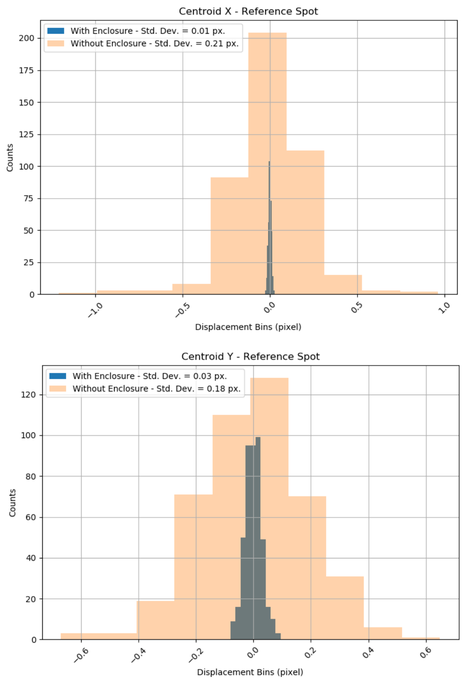


Figure 6: Comparison between position stability during a short period measurement of a reference mirror, inside and outside the LTP enclosure

Vibration Assessment

Another aspect that could influence on the metrology results is the vibration transmission throughout the floor. In order to very the building machinery influence, measurements of the machines sequential start were carried out on five distinct regions.

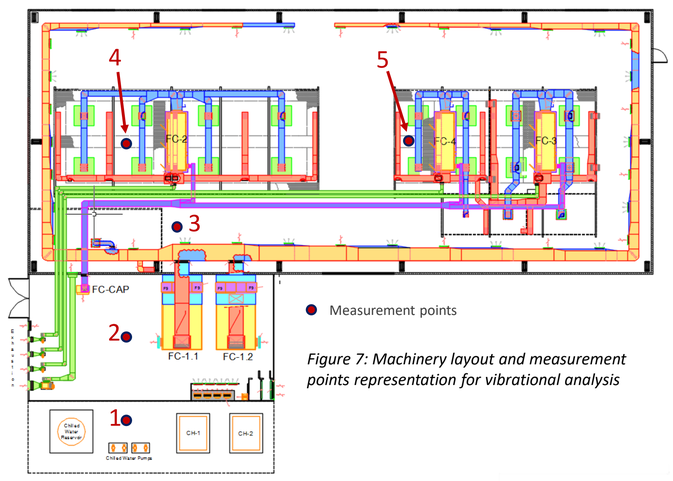


Figure 7: Machinery layout and measurement points representation for vibrational analysis

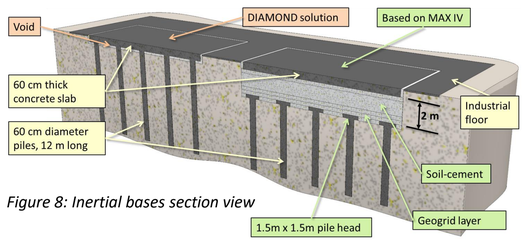


Figure 8: Inertial bases section view

Table 2: Integrated RMS Displacement (1-450Hz) with HVAC machinery turned on and off

Room	RMS Displacement [nm]	Cultural Noise [nm]
Pump Hall	70	7
Machine Room	50.2	4.5
Building Shed	33.6	2.2
Assembly Rooms	12.7	1.25
Mech. Metrology	11.5	1.1

For each region, the measurement consisted in a 30 minutes acquisition at a rate of 1kHz, starting the machines one by one and giving each one time to reach permanent regime before starting the next. The results demonstrate that the RMS displacement did not exceed 15nm at the special foundations, with an attenuation factor of 3 compared to the industrial floor.

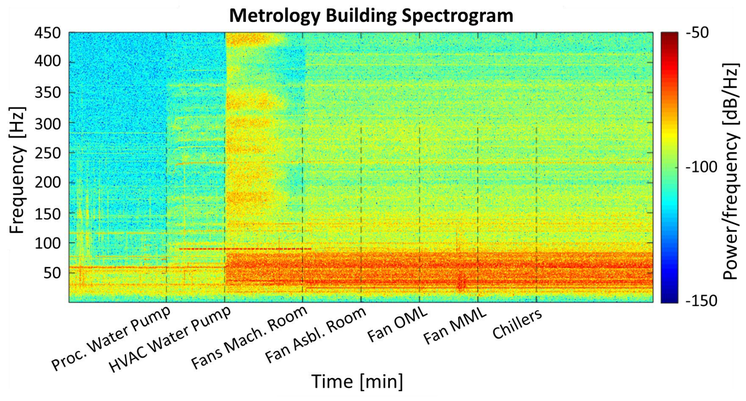
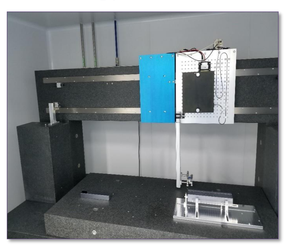


Figure 9: Frequency contribution analysis on HVAC machinery sequential start

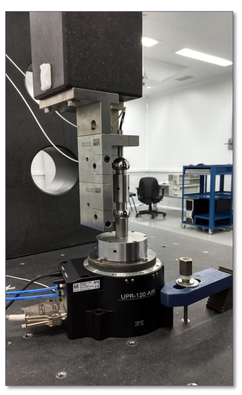
Status

Metrology Rooms External View

- ✓ Building fully operational since 2017
- ✓ High end metrology equipment installed
- ✓ In-house developments being tested in the building
- ✓ The metrology building has become substantial for Sirius instrumentation developing and characterization



LTP (left) and Fizeau Interferometer (right) at the OML



Spindle Error Analyzer (left) and Coordinates Measuring Machine (right)

Acknowledgements

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MECHANICAL ENGINEERING DESIGN OF SYNCHROTRON RADIATION EQUIPMENT AND INSTRUMENTATION
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