The LNLS Metrology Building

H. G. P. Oliveira, C. Esper-Neto, P. T. Fonseca, R. R. Geraldes, B. C. Meyer, M. A. Pereira, G. L. Rodrigues, L. Sanfelici, L. G. Silva, LNLS, Campinas, Brazil
L. Buccianti, M. H. A. Costa, C. Prudente, Biotec Soluções Ambientais, São José dos Campos, Brazil

henrique.oliveira@lnls.br – Brazilian Synchrotron Light Laboratory - LNLS

Abstract

The increasing demand of instrumentation projects for SIRIUS requires more sensitive equipment to be developed and characterized in the micro and nanometer scale. To achieve this level of precision it is necessary to work within a controlled environment, minimizing instabilities and disturbance effects such as temperature variation and vibrations. Based on metrology labs as those at BESSY, ESRF, DLS and others, a new facility is currently under final construction stage at the LNLS, it will be dedicated to high precision optical and mechanical metrologies. The building itself is an 840 m² thermally isolated shed kept within ±1,5°C. Inside this shed there are two 100 m2 inertial bases, around them, four rooms were erected: two rooms for general assemblies, vacuum tests and dimensional analysis; and other two for mechanical and optical metrology. The assembly rooms have relaxed environmental requirements (±0,5°C and ±10% RH), whereas both of the metrology laboratories are more restrict (±0,1°C and ±5% RH). The optical lab is also an ISO7 cleanroom.

Inertial Bases

In 2013, a study was held at LNLS in order to define the Sirius tunnel floor foundation, aiming for a high level of stability. First, the site soil geophysics conditions and natural vibration were analyzed. Then, two special blocks prototypes were proposed and constructed, based on the MAXIV and DLS ring floor foundation. Several vibrational tests were carried out on the prototypes. Both bases perform very well concerning external vibration attenuation, but the MAX-based performed better (faster) on dissipating vibrations generated internally, which led to the choice of this foundation type to be used at Sirius.

As vibrational issues are an important matter for metrology purposes, it was decided that the LNLS metrology building would be erected around these inertial bases, being the assembly rooms around the DLS-based floor and the metrology laboratories around the MAXIV-based foundation.

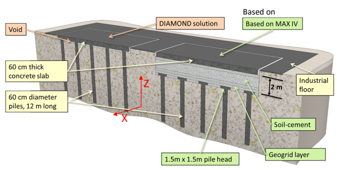

Figure 1: Schematic section view of the inertial slabs prototypes.

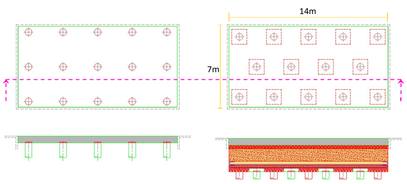

Figure 2: Slabs blue print and section view.

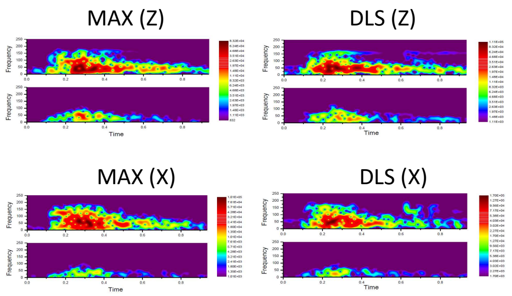

Figure 3: Frequencies excited by external impact and dissipation over time.

The impact main contribution is at low frequencies (15-150Hz). The graphs shows that what passes to the slabs are, mainly, disturbances below 100Hz, with a considerable attenuation of its amplitudes and reduction of dissipation time.

Table 1: Attenuation factor for external impact

Slab	Vertical	Horizontal
MAX	5.1	8.8
DLS	5.3	6.9

Layers Concept

The LNLS Metrology Building was designed following a layer-based architecture, in which the outer layers have a proper environmental control that contributes for the stability of the inner ones. The goal of this architecture is to preserve the laboratories (inner layers) highly stable environment, minimizing the influence of the large thermal and humidity variation that may naturally occur outside the building in 24h. There are three levels of layers: the machine room, the building itself and the laboratories, that can be seen in Fig. 4. Each layer has one or more rooms, which may have different stability parameters, controlled by independent air conditioning units (ACUs).

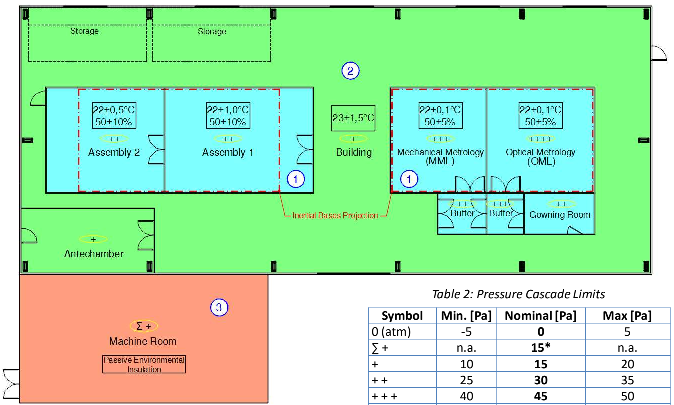

Figure 4: Layers layout and pressure cascade.

Table 2: Pressure Cascade Limits

Symbol	Min. [Pa]	Nominal [Pa]	Max [Pa]
0 (atm)	-5	**0**	5
∑ +	n.a.	**15***	n.a.
+	10	**15**	20
+ +	25	**30**	35
+ + +	40	**45**	50
+ + + +	55	**60**	65

Table 3: Outside Conditions.

Season	Dry Bulb Temp.[°C]	Wet Bulb Temp.[°C]	Relative Humidity
Summer	33.0	11.0	48.7%
Winter	24.0	10.2	92.0%

Table 4: Control Requirements for each environment.

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

HVAC System & Automation Strategy

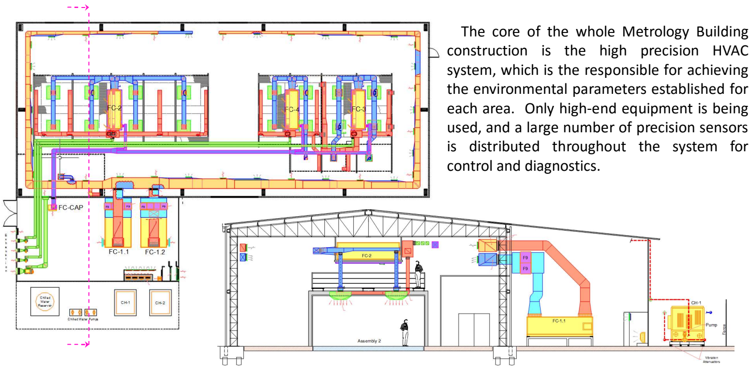

Figure 5: (Top) Blue print and (Bottom) section view of HVAC system ducts and equipment.

The core of the whole Metrology Building construction is the high precision HVAC system, which is the responsible for achieving the environmental parameters established for each area. Only high-end equipment is being used, and a large number of precision sensors is distributed throughout the system for control and diagnostics.

Each fan-coil system has a cooling and a heating capacity, to control both temperature and humidity for the supplied area. There are four controlled areas and an automation panel for each one, with a high number of sensors and transmitters, centering information on an individual Siemens PLC for each panel. All parameters are available at a local supervisory, which is integrated with the Building Monitoring System (BMS).

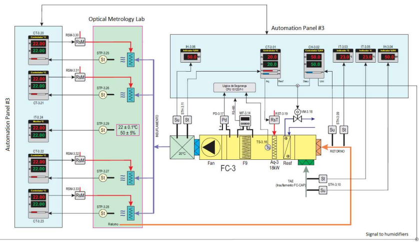

Figure 6: Optical Metrology Lab automation diagram

Utilities

The building will be supplied with mechanical utilities (process fluids) and electrical utilities, which are the electrical network and DC&S, available inside and outside the rooms.

Electrical Utilities
220V / 1 Phase
220V / 3 Phase
UPS – 220V / 1 ph.
Stabilized circuit
IT Rack
Surveillance
Lighting

Mechanical Utilities
Compressed Air
Gaseous N_2
Demineralized Water

Pressure and temperature also controlled!

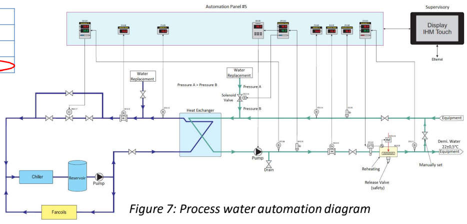

Figure 7: Process water automation diagram

Status

- ✓ Shed Conditioning: operational since Sep. 2;
- ✓ OML Conditioning: should be ready at Sep. 12;
- ✓ All automation panels installed: until Sep. 30;
- ✓ Fine tuning and adjustments: end of 2016

Figure 8: Mechanical Metrology Lab

Figures 9: Inside of the Metrology Building

Acknowledgement

The LNLS team would like to thanks all the involved with the development of the Metrology Building, to the colleagues at BESSY, ESRF, NSLS2, APS, ALBA and DLS for elucidative discussions about metrology laboratories and precision HVAC; and also the Biotec company, which was responsible for the HVAC system design and execution.

References

[1] V. V. Yashchuk *et al.*, "Advanced environmental control as a key component in the development of ultrahigh accuracy ex situ metrology for x-ray optics", Optical Engineering, vol. 54, no. 10, p.104104, Oct. 2015.
[2] B. Meyer, "Conceptual design report (CDR): Metrology equipment of the LAMOX", unpublished.
[3] M. Idir *et al.*, "Current Status of the NSLS-II optical metrology laboratory", Nuclear Instruments and Methods in Physics Research A, vol. 710, pp. 17-23, May 2013.

MEDSI 2016
MECHANICAL ENGINEERING DESIGN OF SYNCHROTRON RADIATION EQUIPMENT AND INSTRUMENTATION

MINISTÉRIO DA CIÊNCIA, TECNOLOGIA, INOVAÇÕES E COMUNICAÇÕES
BRASIL GOVERNO FEDERAL