THE LNLS METROLOGY BUILDING*

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Abstract

The increasing demands of instrumentation projects for SIRIUS require 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, which will be dedicated to high precision optical and mechanical metrologies. This work describes in detail the project of the new LNLS Metrology Building.

INTRODUCTION

Sirius [1] is a 3 GeV synchrotron light source that is currently being built by the Brazilian Synchrotron Light Laboratory (LNLS), with a high brilliance beam which size could be as small as 9.5x3.5 µm and with a natural emittance of 0.25 nm·rad. Most of its beamlines have the requirements for a micrometric beam size up to 50 µm. To achieve these specifications, it is necessary to work with high-end mechanical and optical elements able to guarantee the stability and precision, like the new high-dynamics monochromator under developing at LNLS, aiming a final stability of 10 nrad at the Bragg angle [2]. Moreover, besides the designing and machining steps, it is necessary to validate the mechanisms as a whole, which is achieved with precision metrology. Also, to make reliable measurements, several parameters must be taken into account, like the accuracy and uncertainties of the measurement equipment, the test setup and the environmental disturbances, which could be temperature stability, air convection and turbulence, air cleanness, atmospheric pressure and humidity, and vibration [3]. This paper describes the main design aspects of the new LNLS Metrology Building, with four rooms: Assembly 1 and Assembly 2 for general assemblies, vacuum tests and dimensional analysis, a Mechanical Metrology Lab (MML) and an Optical Metrology Lab (OML); with an advanced environmental control and vibrational stability by means of a high precision HVAC system and inertial blocks with special foundations. The building itself is an 840 m² thermally isolated shed kept within ±1,5°C. Inside there are two 100 m² inertial bases and, around them, the mentioned four rooms were erected. 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.

The authors recommend being with the poster when reading this paper, as they are complementary documents.

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 analysed. 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.

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 provide the laboratories (inner layers) a highly stable environment, minimizing the influence of the large thermal and humidity variations that may naturally occur outside the building. There are three layers: the machine room (MR), the building itself and the laboratories, that can be seen in Figure 1. Each layer has one or more rooms controlled by independent air handling units (AHUs). The environmental requisites for each room are presented in Table 1:

Table 1: Environmental Parameters

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	-
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

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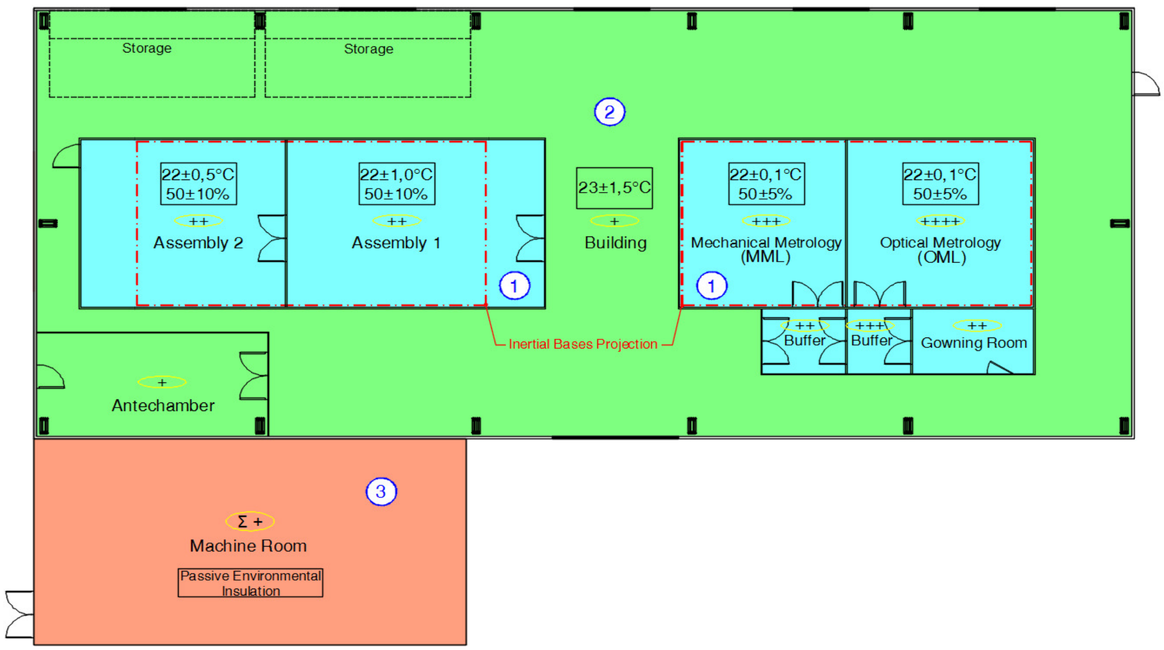

Figure 1: HVAC system architecture based on layers.

The MR operates admitting external air, working as a source of fresh air to make the necessary volume renewal. It is made of 100 mm thick Polyurethane (PU) isopanels walls and roof tiles for passive thermal insulation and it has an air exchange rate of 7 volumes/h. Three AHUs are installed in the MR, responsible for the shed conditioning and pre-treating the other AHUs air intake.

The building is also insulated with the same PU panels at walls and roof and, moreover, it has an active temperature control provided by the AHUs at the MR, with a maximum of temperature variation of ±1,5 °C, providing passive stability to the inner layer. Also, the AHUs designated to the laboratories are installed inside the building, suspended at the ceiling in order to not touch the flour around the inertial bases to prevent vibration coupling. Worth to mention that, regardless of being in the building layer, the labs AHUs fresh air supply comes from the unit named FC-CAP, at the MR.

The metrology laboratories and assembly rooms are where the fine environmental control take place and, despite of being physically separated, constitute the inner layer. The rooms and laboratories wall is made of 50 mm Polystyrene isopanels, for passive thermal insulation. The assembly rooms have a shared AHU, but the temperature control is independent, as the air is reheated directly on the diffusers. The mechanical and optical metrology rooms have individual AHUs, since the control is challenging and much finer than the others, and also because the optical lab is an ISO7 clean room.

HVAC SYSTEM

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. For the system dimensioning, the following parameters for the city of Campinas, Brazil, at 685 m of altitude, were considered in Table 2.

Table 2: External Environmental 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%

Equipment

In all fronts of the HVAC system, only high-end equipment is being used. For the production of chilled water, two Trane air-cooled chillers are being employed, with 50 RT of cooling capacity each one. Both were planned to operate simultaneously, but in case of failure, the system can manage to operate with only one most part of the year. For the chilled water circuit, the system counts with Grundfos vertical pumps, installed in concrete inertial bases. Either the chillers and the pumps bases are supported by vibration attenuators. Also, there is a 15000 l tank for thermoaccumulation and regulation for chilled water, insulated with a 75 mm thick PU layer. All this equipment is located on an open area, outside the building.

Inside the MR, there is a filtering cabinet (G4 class) with a fan for external air intake and humidifiers.

The entire HVAC systems is composed by six customized AHUs from Trox. To supply the main shed (system 1), there are two AHUs (FC1.1 and FC1.2) that may work in parallel or, in case of failure, alone. The assembly rooms (system 2) share the same AHU (FC2), as their environmental requirements are more relaxed, and each one of the metrology labs has its own AHU (FC3 and FC4, systems 3 and 4). Also, it has a fan-coil (FC CAP) dedicated to the fresh air intake of FCs 2, 3 and 4.

Pressure Arrangement and Exchange Rates

Besides general architecture, Figure 1 also shows the pressure cascade that must be followed to insure cleanliness and temperature stability. Either the area is classified or not, the pressure balancing for each room must be within the tolerances shown in Table 3.

Table 3: Pressure 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

The symbol used at the MR (∑+) indicates a positive pressure, but without defined tolerances. It does not have an effective control, but it ensures that the air flows from inside the room to the external ambient.

Table 4 indicates the exchange rates for each area. The actual value must be within 10% and 20% of the nominal.

Table 4: Rooms' Exchange Rate

Room	Volume [m³]	Exchange Rate (vol/h)
Machine Room	151.3	7
Building/Shed	4711.7	8
Assembly 1	238.7	15
Assembly 2	190.1	20
Mech. Metrology	142.6	25
Opt. Metrology	159.3	35

Filtering System

The main requirement for a high class filtering system is the optical metrology clean room specified as class 10.000 (ISO 7). Still, there is a long "chain" of filters through the entire system to guarantee a high quality supplied air for all the areas. Figure 2 shows it in detail:

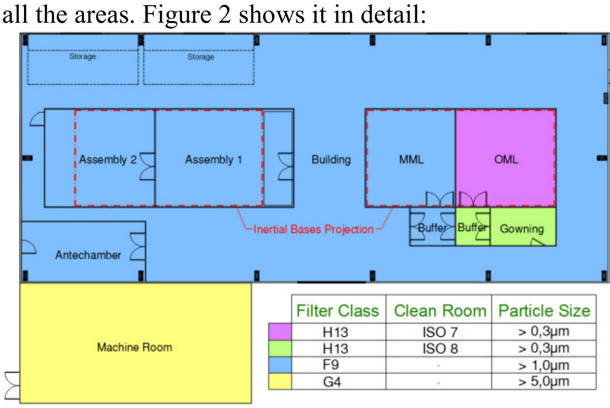

Figure 2: Filtering specs for each area.

Temperature and Humidity Control

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 actuators, concentrating information on an individual Siemens PLC for each panel. All parameters are available at a local supervisory, which is integrated with the LNLS Building Monitoring System (BMS). The automation panels and the IT rack are powered by an UPS circuit, as well as sensitive instrumentation inside the labs, following the same strategy intended for the Sirius building and beamlines.

For the shed temperature control, sensors are localized on the return ducts, and its readings implies on a signal sent to 2-way valves and/or heaters. The other areas have a quite different control strategy. The temperature sensors are at the air supply duct and its control point is set lightly below the desired temperature, because the fine adjustment is made by heaters located inside each air diffuser. Precision temperature transmitters are strategically positioned inside the rooms and send signal to the PLC, which controls solid state relays in order to define the power output supplied to the heaters. For the humidity control, the sensors are in the return ducts and the system acts through the coil control valve if it needs to condensates the water vapour, or at the humidifiers if the air is too dry.

STATUS AND FUTURE WORK

By now, the LNLS Metrology Building is at the final steps of its entirely conclusion. The first automation panel arrived at September 2, which enable the shed conditioning (second layer). The OML should be ready at September 12, and the other areas until the end of the month. Even with the complete installation, it will be necessary three more months to make general tests and the fine tuning of the HVAC system, so the Metrology Building should be fully functional by the end of 2016. Until there, the LNLS team is expanding its metrology capacity by acquiring new equipment such as capacitive sensors, CMM, laser trackers, AFM, long trace profiler, micro-interferometer, Fizeau interferometer, optical tables, among others [4,5].

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