FIRST YEAR OPERATION OF THE BRAZILIAN SYNCHROTRON LIGHT SOURCE

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Abstract

The Brazilian Synchrotron Light Source (LNLS), based on a 1.37 GeV electron storage ring, has been operating routinely with external users since July 1997 and now, one year later, we can store 240 mA at 120 MeV and ramp 170 mA to 1.37 GeV. In this report we describe the main results achieved in this first year of routine operation for users.

1 INTRODUCTION

The Brazilian National Synchrotron Light Laboratory, LNLS, operates a 1.37 GeV electron storage ring with a 120 MeV injector Linac. The storage ring was commissioned during 1996 and commissioning of the first beamlines started in October of the same year. Routine operation for external users started in July 1997[1]. Stored beam current and lifetime have improved during this period as the average vacuum pressure decreased with washing of the chamber with high energy photons. From July 1997 to May 1998, 1925 hours were scheduled for user’s shifts. The machine was not operational during about 7% of this time but additional 16.5 % were offered in extra shifts. In this same period, 1286 hours were dedicated to commissioning and machine study sessions and 538 hours to maintenance or improvement of the equipment.

The currently achieved performance parameters already exceed those specified during design, as shown in Table I. Also reliability has improved with changes in several subsystems.

The Synchrotron Light Source is composed of a low energy injector Linac, a transport line and the UVX storage ring. The Linac is a standard SLAC-type, with four 3 m long accelerating sections which are powered by two 25 MW klystrons reaching a maximum energy of 125 MeV.

The storage ring consists of 6 double-bend achromatic arcs, with a circumference of 93.2 m (311 ns). The 12 dipoles operate at 0.15 T at 120 MeV injection energy and 1.67 T at 1.37 GeV operation energy. There are 36 quadrupoles, 18 sextupoles and 29 orbit correctors. The theoretical emittance for the standard operation mode is 99.8 nm.rad at 1.37 GeV and the nominal tunes are ν_x=5.27 and ν_y=2.17.

The bending magnets produce synchrotron radiation with 2.1 keV critical energy. Up to 24 beamlines can be installed in the bending magnets and there are four 3-meter long straight sections for insertion devices. At present there are 9 beam lines in operation: toroidal grating monochromator, spherical grating monochromator, soft x-ray spectroscopy, XAFS, x-ray diffraction, small angle x-ray scattering, protein crystallography, x-ray fluorescence and x-ray instrumentation. Another three lines are currently under construction: microfabrication, x-ray powder diffraction and a second XAFS line. Design studies are being made of a superconducting 7 Tesla wavelength shifter and a 40-period permanent magnet undulator.

Figure 1 shows a picture of the storage ring hall by May 1998.

Table I: Specified and achieved machine performance parameters.

Parameter	Specified	Achieved		
		July/97	May/98	
Energy	1.15	1.37	1.37	GeV
Current	100	75	170	mA
Lifetime	7	2.2	11	hours

2 MACHINE PERFORMANCE

2.1 Beam current and lifetime

Figure 2 shows the evolution of the accumulated charge and beam lifetime at two current levels, 60 mA and 80 mA, for the last year of operation. The sharp decrease of the lifetime around November 1997 was due to the opening of the vacuum chamber during the summer shutdown.

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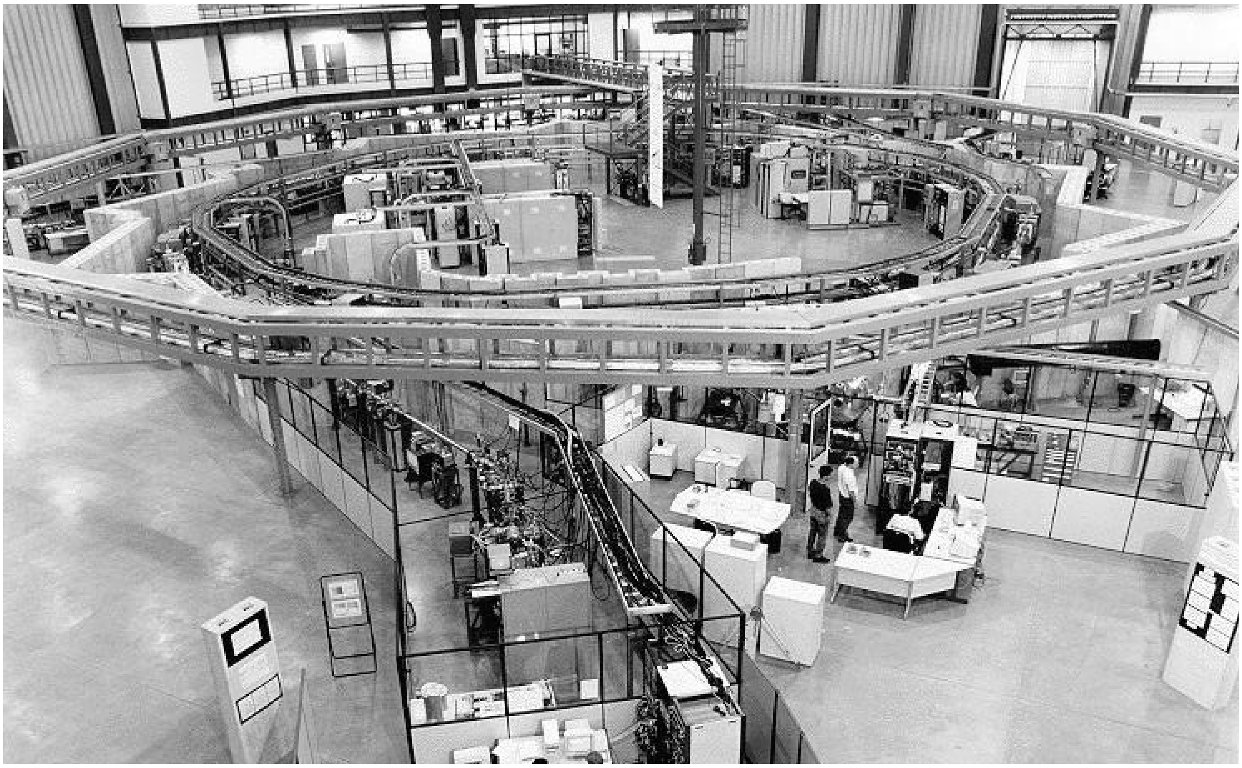

Figure 1:View of the storage ring hall by August 1997.

At present, the beam lifetime at 1.37 GeV is no longer determined mainly by vacuum. In fact, we routinely use the skew quadrupoles to change the beam emittance coupling from 0.3 % to 3% and increase the beam lifetime.

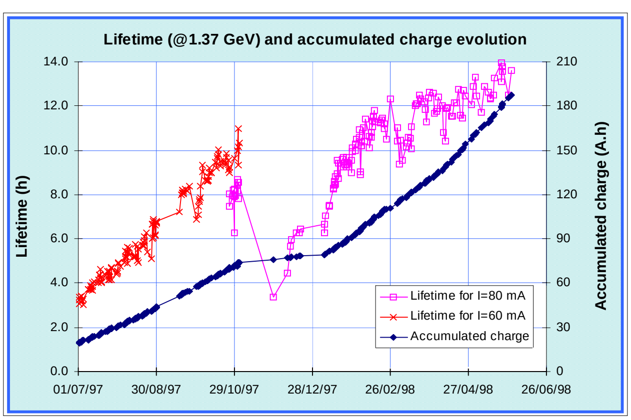

Figure 2: Evolution of beam lifetime and accumulated charge in the LNLS first year of operation.

2.2 Injection efficiency

In the last summer shutdown, the DC thin septum was replaced by a pulsed thin septum which has the advantage of a better magnetic shielding and a thinner septum wall (1 mm). The improved injection efficiency revealed itself in a larger injected current per pulse and a larger accumulated current at low energy. These improvements were such that a previously planned upgrade of the injector (Linac) energy from 120 MeV to 170 MeV was canceled.

2.3 Ramping efficiency

Typically above 80% of the current injected at low energy (120 MeV) can be successfully ramped to the operation energy (1.37 GeV). This improvement in ramping efficiency is mainly due to changes in the RF ramp procedure[1] which is now synchronized to the magnet power supply ramp by means of a single master clock.

2.4 Orbit correction

Improvements in the orbit correction system to increase the vertical orbit reproducibility and stability were recently implemented in the storage ring. On the one hand the number of vertical correctors was increased from 12 to 24 by powering some of the correction coils already available at the quadrupoles. In this way higher orbit harmonics can be compensated. On the other hand a water heating system was installed to reduce the temperature drift of the storage ring magnets.

[1] The gap voltage and cavity detune must follow an empirically determined ramping curve.

Orbit reproducibility from fill to fill is now better than 5 μm. We expect to be able to obtain orbit stability better than 20 μm along a complete user run (approximately 5 hours) as the magnet temperature stabilisation system is commissioned.

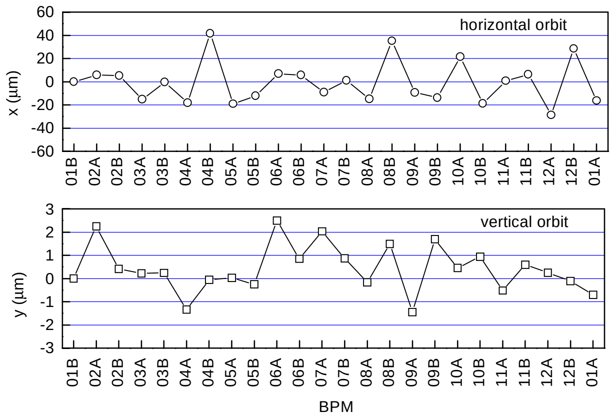

Figure 3: Reproducibility of the horizontal (top) and vertical (bottom) orbits after correction to a reference orbit.

2.5 Control system

The high level control system uses Intel based PC's running applications developed in Delphi under the Windows 95 operation system. During the summer shutdown the whole system was upgraded from 16 to 32 bit version which allows an expansion of the number of control networks as well as network nodes. This is important to allow future upgrades of the facility with the inclusion of new controlled hardware.

Also the overall reliability of the system is improved by making the various applications less interdependent.

2.6 Planned upgrades

An upgrade of the injection energy to 500 MeV by means of a synchrotron booster is under way. This should allows us to operate the storage ring with small gap insertion devices[2].

3 BEAMLINE STATUS

As the only synchrotron light source in Latin America and as a national facility for materials research, LNLS serves mainly research Universities in Brazil and countries in South America as demonstrated by the number and country of origin of the projects submitted to LNLS, shown in Table II. The projects are distributed among the seven operational beam-lines as shown in Table III.

Table II: Number and country of origin of the projects submitted to LNLS during the first year of operation.

Country	# of projects
Brazil	261
Argentina	44
France	5
Uruguay	3
Chile	3
Russia	3
United States	2
United Kingdom	1
Germany	1
Italy	1
Total	324

Table III: Number of proposals submitted to the LNLS beam lines in the first year of operation.

Beam Line	Spectrum	# of Projects
Toroidal Grating Monochromator	12 - 300 eV	22
Spherical Grating Monochromator	0.2 - 1.5 keV	23
Soft X-Ray Spectroscopy	0.8 - 4 keV	16
XAFS	2 - 11 keV	79
X-Ray Diffraction	2 - 18.5 keV	70
Small Angle X-Ray Scattering	6 - 12 keV	58
Protein Crystallography	6 - 12 keV	41
X-Ray Fluorescence	2 - 11 keV	15

4 CONCLUSIONS

During the first year of operation of the LNLS Light Source all machine performance parameters have met or surpassed the design specifications. The scientific community in Brazil and neighboring countries has clearly demonstrated its interest and ability to use this new research instrument.

REFERENCES

[1] A.R.D. Rodrigues et al, 'Commissioning and Operation of the Brazilian Synchrotron Light Source', PAC 1997, Vancouver.

[2] A.R.D. Rodrigues et al, 'Design of a Booster for the Brazilian Synchrotron Light Source', these Proceedings.